PSD12: The 12th International Conference on Position Sensitive Detectors

Sunday 12 September 2021 - Friday 17 September 2021

University of Birmingham

Book of Abstracts

Contents

1

Registration (Edgbaston Park Hotel)

Your name:

email:

Title:

Nationality:

Institute:

2

Informal Welcome (Edgbaston Park Hotel)

Your name:

email:

Title:

Nationality:

Institute:

Detectors for FELS, Synchrotrons and Other Advanced Light Sources / 3

Detectors for FELS, Synchrotrons and Other Advanced Light Sources

Author: heinz graafsma[1]

[1] *DESY*

Corresponding Author: heinz.graafsma@desy.de

Your name:

email:

Title:

Nationality:

Institute:

Gas-based Detectors 1 / 4

PSD and Micro Pattern Gas Detectors technologies

Author: Eraldo Oliveri[1]

[1] *CERN*

Corresponding Author: eraldo.oliveri@cern.ch

Micro Pattern Gas Detectors, used today in several experiments and applications, are recognized as a mature and successful technology. The ability to adapt to a wide range of requirements is offered by the variety of micro patterns solutions available, their reciprocal compatibility, the achieved skills in manufacturing processes and the continuous advancement in readout technologies. This aspect is a key ingredient behind the various and diversified R&D lines involving MPGD and behind the current dissemination of these technologies in numerous fields.

The keynote will try to highlight, via examples, possibilities and strategies in position sensitive detector based on MPGD technologies. Large prominence will be given to the readout stage, touching aspects that are not exclusives of MPGD technologies. Potential and promising future developments in the field will be outlined.

Your name:

Eraldo Oliveri

email:

eraldo.oliveri@cern.ch

Title:

Nationality:

Italian

Institute:

CERN

Applications in Particle Physics 1 / 5

Novel Ionising Radiation Detector Systems

Author: Cinzia Da Via[1]

[1] *University of Manchester (GB)*

Corresponding Author: cinzia.da.via@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Medical Applications of Position Sensitive Detectors 1 / 6

Medical Applications of Position Sensitive Detectors

Author: Reinhard Schulte[1]

[1] *LLU*

Corresponding Author: rschulte@llu.edu

Your name:

email:

Title:

Nationality:

Institute:

7

Reception at Industrial Exhibition

Corresponding Author: academic.conferences@contacts.bham.ac.uk

8

Industrial Exhibition

Corresponding Authors: tony.price@cern.ch, academic.conferences@contacts.bham.ac.uk

(Same venue as catering provided)

9

Industrial Exhibition

Corresponding Authors: tony.price@cern.ch, academic.conferences@contacts.bham.ac.uk

(Same venue as catering provided)

10

BBQ at the Mason Lounge and Garden, University of Birmingham

14th September. From 18.30: BBQ at the Mason Lounge and Garden, University of Birmingham (between R15 and R16 in the red zone on the attached map).

Your name:

email:

Title:

Nationality:

Institute:

11

Poster Session

Session 13 / 12

Afternoon and Evening Trip to Straford-upon-Avon Including Performance of Shakespeare's The Comedy of Errors from 6.30pm at The Royal Shakespeare Company

13

Poster Session 4

14

Reception and Conference Dinner at the Birmingham Botanical Gardens

15

Poster Session

16

Poster Prize (with thanks to Nature Review Physics), Announcement of PSD13 Location, Optional Packed Lunch and Farewells

Corresponding Authors: tony.price@cern.ch, daniela.bortoletto@cern.ch, philip.patrick.allport@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Applications in Astronomy, Planetary and Space Science 1 / 17

Applications in Astronomy, Planetary and Space Science (in-person)

Author: Andrew Holland[1]

[1] *The Open University*

Corresponding Author: andrew.holland@open.ac.uk

Your name:

email:

Title:

Nationality:

Institute:

Position Sensitive Fast Timing Detectors 1 / 18

Position Sensitive Fast timing Detectors

Author: Nicolo Cartiglia[1]

[1] *INFN Torino (IT)*

Corresponding Author: cartiglia@to.infn.it

Your name:

email:

Title:

Nationality:

Institute:

Applications in Nuclear Physics and Nuclear Industry; X-ray and Gamma Ray Detectors 1; Medical Applications of Position Sensitive Detectors 2 / 19

Applications in Nuclear Physics and Nuclear Industry (in-person)

Corresponding Author: c.wheldon@bham.ac.uk

Your name:

email:

Title:

Nationality:

Institute:

Detectors for Neutron Facilities; Gas-based Detectors 2 / 20

Detectors for Neutron Facilities

Author: Richard Hall-Wilton[1]

[1] *ESS - European Spallation Source (SE)*

Corresponding Author: richard.hall-wilton@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Advances in Pixel Detectors and Integration Technologies I / 21

Advances in Pixel Detectors

Author: Tomasz Hemperek[1]

[1] *University of Bonn (DE)*

Your name:

email:

Title:

Nationality:

Institute:

Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science 2 / 22

Applications of Astro-particle Physics Position Sensitive Detectors

Author: Robert Johnson[1]

[1] *Santa Cruz Institute for Particle Physics (SCIPP)*

Corresponding Author: johnson@scipp.ucsc.edu

Your name:

email:

Title:

Nationality:

Institute:

Applications in Life Sciences and Biology; Applications in Particle Physics 3 / 23

(Some) applications of the Medipix and Timepix ASICS in Life Sciences and Biology

Author: Michael Campbell[1]

[1] *CERN*

Corresponding Author: michael.campbell@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Applications in Condensed Matter; Position Sensitive Fast Timing Detectors 2 / 24

X-ray detectors at the Diamond Light Source, evolution and future challenges (in-person)

Author: Nicola Tartoni[1]

[1] *Diamond*

Your name:

email:

Title:

Nationality:

Institute:

X-ray and Gamma Ray Detectors 2 / 25

X-ray and Gamma Ray Detectors (in-person)

Corresponding Author: h.c.boston@liverpool.ac.uk

Your name:

email:

Title:

Nationality:

Institute:

Applications in Particle Physics 2 / 26

Applications in Particle Physics

Corresponding Author: petra.riedler@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Applications in Security and Environmental Imaging; Advances in Pixel Detectors and Integration Technologies 2 / 27

Applications in Security and Environmental Imaging

Author: Vincent SCHOEPFF[1]

[1] *CEA*

Corresponding Author: vincent.schoepff@cea.fr

Your name:

email:

Title:

Nationality:

Institute:

Detectors for High Radiation and Extreme Environments / 28

Detectors for High Radiation and Extreme Environments

Author: Gregor Kramberger[1]

[1] *Jozef Stefan Institute (SI)*

Corresponding Author: gregor.kramberger@ijs.si

Your name:

email:

Title:

Nationality:

Institute:

Applications in Particle Physics 1 / 33

Module development for the ATLAS ITk Pixel Detector

Author: Kenneth Wraight[None]

In HL-LHC operation the instantaneous luminosity will reach unprecedented values, resulting in about 200 proton-proton interactions in a typical bunch crossing. The current ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk). The innermost part of ITk will consist of a state-of-the-art pixel detector.
Several different silicon sensor technologies will be employed in the five barrel and endcap layers. Based on first modules assembled using the RD53A prototype readout chip, numerous issues are being studied. These include production issues like bump bonding of large area, thin modules, as well as layout issues like optimization of the bandwidth and sharing of links between multiple chips and modules. The talk will present results of many of these studies, which directly impact the construction and assembly of modules with using the first production version of the readout chip ITKpixV1, which will become available shortly

Your name:

Jens Weingarten

email:

jens.weingarten@tu-dortmund.de

Title:

Nationality:

Institute:

TU Dortmund

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 35

Pixelated silicon detectors for the measurement of small radiation fields in proton therapy

Authors: Jens Weingarten[1]; Isabelle Schilling[2]

[1] *Technische Universitaet Dortmund (DE)*

[2] *TU Dortmund*

Corresponding Author: isabelle.schilling@tu-dortmund.de

Advanced imaging and treatment techniques in proton therapy allow conformal high dose irradiation of the target volume with high precision using pencil beam scanning or beam shaping apertures. These irradiation methods increasingly include small radiation fields with large dose gradients at the edges, which require the development of new micro dosimetry systems with precise spatial resolution and small sensitive volume for quality assurance.
Based on their good spatial resolution and high rate compatibility, pixelated silicon detectors could meet the new requirements.
To assess their usability for micro dosimetry in proton therapy, as well as to determine the absolute proton flux, ATLAS Pixel detectors with Silicon sensors are used to measure transverse beam profiles of different irradiation modes at WPE in Essen, Germany.

The aim is to compare these with the expected expansions and to draw conclusions about the dose gradient at the field edges.
The possibility of determining the proton flux as well as the energy distribution of the irradiation fields with pixelated silicon sensors shall be evaluated under consideration of the characterizing results.

Your name:

Jens Weingarten

email:

jens.weingarten@tu-dortmund.de

Title:

Nationality:

Institute:

Detectors for High Radiation and Extreme Environments / **38**

Compact LumiCal prototype tests for future e+e- collider

Author: Veta Ghenescu[1]

[1] *Institute of Space Science*

Corresponding Author: ghenescu@spacescience.ro

The FCAL collaboration is preparing large-scale prototypes of special calorimeters to be used in the very forward region at a future electron-positron collider for a precise and fast luminosity measurement and beam-tuning. LumiCal is designed as silicon-tungsten sandwich calorimeter with very thin sensor planes to keep the Moliere radius small, facilitating such the measurement of electron showers in the presence of background. Dedicated FE electronics has been developed to match the timing and dynamic range requirements.
A partially instrumented prototype was investigated in a 1 to 5 GeV electron beam at the DESY II synchrotron. In the recent beam tests, a multi-plane compact prototype equipped with thin detector planes fully assembled with readout electronics were installed in 1 mm gaps between tungsten plates of one radiation length thickness. High statistics data were used to perform sensor alignment, and to measure the longitudinal and transversal shower development in the sandwich. In addition, Geant4 MC simulations were done and compared to the data.

Your name:

Veta Ghenescu

email:

ghenescu@spacescience.ro

Title:

Dr

Nationality:

romanian

Institute:

Institute of Space Science

42

Current-voltage characteristics of Iron-implanted silicon based Schottky diodes.

Authors: Joseph Bodunrin[1]; Sabata Moloi[1]

[1] *Department of Physics, College, Science, Engineering and Technology, University of South Africa, Private Bag X6, Florida, 1710, South Africa*

Corresponding Authors: molois@unisa.ac.za, bodunrinjoseph01@gmail.com

Current-voltage (I-V) measurements were carried out on undoped and Iron (Fe) doped n- silicon to establish and study a change in electrical properties of the material-based diodes with Fe doping concentration. Fe doping was achieved by implantation at the energy of 160 keV to fluences of 10ˆ15, 10ˆ16 and 10ˆ17 ion/cmˆ2. The obtained results indicated that the Au/n-Si/Al and Au/Fe-n-Si/Al diodes were well fabricated and Fe doping resulted to diode behaviour changing from normal exponential to ohmic I-V behaviour. This ohmic behaviour was explained in terms of Fe-induced defect levels that were positioned at the centre of the energy gap. An I-V ohmic region increase with fluence indicating that the density of defect levels increases with Fe implantation fluence. The obtained (I-V) properties of Fe doped silicon-based diodes were similar to those of the diodes that were fabricated on radiation-hard materials indicating that Fe, too, is a promising dopant in a quest to improve radiation-hardness of Si to be used in high energy physics experiments.

Your name:

Joseph Bodunrin

email:

bodunrinjoseph01@gmail.com

Title:

Mr

Nationality:

Nigerian

Institute:

University of South Africa

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 43

"RIPTIDE"–An innovative recoil-proton track imaging detector

Authors: Agatino Musumarra[1]; Cristian Massimi[2]; Francesco Leone[3]; Maria Grazia Pellegriti[4]; Francesco Romano[4]; Roberto Spighi[5]; Mauro Villa[2]

[1] *University of Catania, Dipartimento di Fisica e Astronomia and INFN sezione di Catania*

[2] *University of Bologna, Dipartimento di Fisica e Astronomia and INFN sezione di Bologna*

[3] *University of Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica*

[4] *INFN sezione di Catania*

[5] *INFN sezione di Bologna*

Corresponding Authors: francesco.romano@ct.infn.it, mauro.villa@bo.infn.it, roberto.spighi@bo.infn.it, cristian.massimi@bo.infn.it, musumarra@lns.infn.it, mariagrazia.pellegriti@ct.infn.it, francesco.leone@inaf.it

Neutron detectors perform key tasks in the development of many research fields, as nuclear, particle and astroparticle physics as well as neutron dosimetry, radiotherapy, and radiation protection. Until now, no neutron detector exhibits tracking capability (i.e., full neutron-momentum reconstruction) even if several projects are in progress [1-7]. To address this deficiency, we aim at developing a novel RecoIl-Proton Track Imaging DEtection system "RIPTIDE", in which the light output of a fast scintillation signal is used to perform a complete reconstruction in space and time of the neutron-proton elastic scattering. Preliminary Geant4 simulations of the proposed set-up show up a good detection efficiency in a compact active volume. In addition, the proposed electronic readout can be easily adapted according to a specific application (event-by-event mode or integration mode). In principle, the system can be also rescaled by increasing the detection volume or by combining several detection modules. Finally, further development of the basic detection technique can be adapted for fast charged particle detection tracking.
In this contribution, we will present the RIPTIDE concept together with some preliminary results.
[1] J. Hu, J. Liu, Z. Zhang, et al., Sci. Rep. 8, 13363(2018);
DOI:10.1038/s41598-018-31711-z
[2] S.M. Valle, et al., NIM A 845(2017)556;
DOI:10.1016/j.nima.2016.05.001
[3] E.Gioscio, et al., NIM A 958(2020)162862;
DOI:10.1016/j.nima.2019.162862
[4] G. Wang,L. Zhang,W. Song, et al., J. Appl Spec. 87(2020)911; DOI:10.1007/s10812-020-01088-x
[5] M. Marafini, et al., Phys. Med. Biol. 62(2017)3299;
DOI:10.1088/1361-6560/aa623a
[6] R. Combe, et al., EPJ Web Conf. 170(2018)09001; DOI:10.1051/epjconf/201817009001
[7] T.J. Langford, et al., JINST 11(2016)P01006;
DOI:10.1088/1748-0221/11/01/P01006

Your name:

Agatino Musumarra

email:

musumarra@lns.infn.it

Title:

Prof

Nationality:

Italy

Institute:

University of Catania, Dipartimento di Fisica e Astronomia and INFN sezione di Catania

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 45

Investigation of Mixed Bulk Radiation Damage Effects in p-MCz Thin Silicon Microstrip Detector for Phase 2 Upgrade of the new CMS Tracker Detector at HL-LHC

Authors: Shilpa Patyal[1]; Nitu Saini[1]; Balwinder Kaur[2]; Ajay kumar Srivastava [1]

[1] *Chandigarh University*

[2] *Chandigarh UNIVERSITY*

Corresponding Authors: balwinderkaur0091@gmail.com, kumar.uis@cumail.in, shilpa31296@gmail.com, saininitu94@gmail.com

A lot of R & D work is carried out in the CERN RD50 Collaboration to find out the best material for the Si detectors that can be used in the harsh radiation environment of HL-LHC, n and p-MCz Si was identified as one of the prime candidates as a material for n in p strip detector that can be chosen for the phase 2 upgrade plan of the new Compact Muon Solenoid tracker detector in 2026.
For the very first time, an advanced four level deep-trap mixed irradiation model for p-MCz Si is proposed by the comparison of experimental data on the full depletion voltage and leakage current to the Shockley Read Hall recombination (SRH) statistics results on the mixed irradiated p-MCz Si PAD detector.
In this work, we have determined the effective introduction rate ηeff of shallower donor deep trap E30 K using SRH theory calculations for exp. Neff and that can be shown the behaviour of space charges and electric field distribution in the p-MCz Si strip detector and compared its value with the ηeff of shallower donor deep trap E30 K in the n-MCz Si microstrip detector.
Prediction uncertainty in the p-MCz Si radiation damage mixed irradiation model considered in the full depletion voltage and leakage current. A very good agreement is observed in the experimental and SRH results. This p-MCz Si radiation damage model is used to extrapolate the value of the full depletion voltage at different mixed (proton + neutron) higher irradiation fluences for the thin p-MCz Si microstrip detector.

Your name:

Shilpa

email:

shilpa31296@gmail.com

Title:

Ms

Nationality:

Indian

Institute:

University Institute of Sciences, Department of Physics, Chandigarh University, Mohali, India

Poster Session 3 (Applications in Particle Physics) / 48

Tracker alignment of the CMS detector

Author: Nazar Bartosik[1]

[1] *Universita e INFN Torino (IT)*

Corresponding Author: nazar.bartosik@cern.ch

The positions of the nearly **twenty-thousand silicon sensors** of the CMS central tracking system must be determined with a precision better than their intrinsic resolution in order to provide an optimal reconstruction of charged particle trajectories. The procedure, referred to as alignment, includes also the adjustment of the orientations and the determination of the deviation from flatness of the sensor surfaces.

Data-driven methods used to carefully align the detector and validate the alignment will be presented with CMS Run-2 data, collected from 2016 to 2018. Systematic distortions such as weak modes are discussed, as well as the impact of the variation of the conditions during data taking over time, in particular **effects related to the radiation damage**.

Finally, we illustrate the impact on physics of the recent developments included in the legacy reprocessing, which was performed with the aim to greatly **improve the physics potential for precision measurements**, such as the reconstruction of the invariant mass spectrum of the dilepton systems.

Your name:

Nazar Bartosik

email:

nazar.bartosik@to.infn.it

Title:

Nationality:

Ukraine

Institute:

INFN Torino, Italy

Poster Session 3 (Applications in Particle Physics) / 49

2S-module prototyping and qualification for the CMS Outer Tracker upgrade at the HL-LHC

Author: Fengwangdong Zhang[1]

Co-authors: Alan Honma [2]; Alessandro La Rosa [3]; Alexis Kalogeropoulos [4]; Georges Blanchot [3]; Mark Istvan Kovacs [3]; Sam Higginbotham [5]; Sarah Seif El Nasr [6]

[1] *University of California Davis (US)*

[2] *Brown University (US)*

[3] *CERN*

[4] *Princeton University*

[5] *Princeton University (US)*

[6] *University of Bristol (GB)*

Corresponding Authors: sarah.storey@cern.ch, alan.honma@cern.ch, georges.blanchot@cern.ch, alessandro.larosa@cern.ch, shigginb@cern.ch, alexis.kalogeropoulos@cern.ch, mark.istvan.kovacs@cern.ch, fengwangdong.zhang@cern.ch

In preparation for the High Luminosity LHC, the whole tracker detector of the CMS experiment will be exchanged within the Phase-2 Upgrade until 2027. The new outer tracker will be made of approximately 13000 silicon sensor modules called 2S modules (consisting of two parallel mounted silicon strip sensors) and PS modules (one pixel and a strip sensor combined in a module). These modules provide tracking information to the Level 1 trigger by correlating the hit information of both sensor layers and, thus, allowing to discriminate particle tracks by their transverse momentum. To guarantee successful operation during data-taking, the production of the outer tracker modules has to fulfill strict requirements. This talk will present practical procedures about assembly, electrical, thermal and vibration tests performed at CERN for supporting the 2S module development and qualification.

Your name:

Feng Wangdong Zhang

email:

fengwangdong.zhang@cern.ch

Title:

Dr

Nationality:

Institute:

University of California, Davis

Advances in Pixel Detectors and Integration Technologies I / 50

Characterization of planar and 3D pixel sensors for the inner tracker of the CMS experiment (in-person)

Authors: Andrea Garcia Alonso[1]; Mohammadtaghi Hajheidari[2]

[1] *Universidad de Cantabria and CSIC (ES)*

[2] *Hamburg University (DE)*

Corresponding Authors: mohammadtaghi.hajheidari@desy.de, garciaa@ifca.unican.es

The Compact Muon Solenoid (CMS) experiment is expected to collect an integrated luminosity of 3000 or even 4000fbˆ-1 in the ultimate scenario during the High Luminosity phase of the Large Hadron Collider (HL-LHC). This scenario comes with a high number of collisions per bunch crossing, and in turn, a high level of radiation for the inner layer of the CMS tracker. The simulations estimate a 1-MeV neutron equivalent fluence, phi_eq, of 2.3\times 10ˆ16 cmˆ-2 at a distance of 2.8 cm from the collision point (for the integrated luminosity of 3000 fbˆ-1). The inner tracker of the CMS detector is required to withstand this range of fluence and maintain its track-finding functionality.

Planner and 3D pixel sensors with an active thickness of 150 um and pixel sizes of 25 \times 100 umˆ2 or 50 \times 50 umˆ2 have been produced by Hamamatsu Photonics (HPK), Fondazione Bruno Kessler (FBK), and Microelectronic National Center(CNM). The sensors were bumped bonded to the RD53A readout chip prototype. The sensor-chip modules were irradiated with 23 MeV and 24 GeV protons to the fluence of up to 2.4 \times 10ˆ16 cmˆ-2 the Karlsruhe Institute of Technology (KIT) and PS-IRRAD proton facility.

The modules were tested in the DESY II beam test facility. The hit efficiency and spatial resolution as a function of the incidence angle of pixel sensors were determined from these measurements. It has been shown that for the highest fluence, the planar modules still reach 99\% hit efficiency, required for the Phase-2 IT, at bias voltages below 800V. For 3D sensors, no significant change in efficiency was observed after irradiation. This talk presents the results for planar and 3D sensors before and after irradiation.

Your name:

Andrea García Alonso

email:

agarciaa@cern.ch

Title:

Ms

Nationality:

Spanish

Institute:

IFCA

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 51

A 14-Gbps VCSEL Driving ASIC in 55 nm for Particle Physics Experiments

Authors: Cong Zhao[1]; Di Guo[1]

Co-authors: Qiangjun Chen [1]; Zengtao Guo [1]; Yujing Gan [1]; Liwen Yi [1]; xiangming sun [1]

[1] *Central China Normal University*

Corresponding Authors: 1620364076@qq.com, qjchen1206@163.com, sphy2009@gmail.com, 649694421@qq.com, 1055262787@qq.com, zhaocong@mails.ccnu.edu.cn, diguo@mail.ccnu.edu.cn

Low power consumption, high bandwidth and radiation tolerant VCSEL driving ASICs have been prevailingly researched and used in particle physics experiments. This paper presents the design and the test results of a 14-Gbps VCSEL driving ASIC fabricated in 55 nm CMOS technology.
The whole ASIC includes four independent channels, and each channel has the fixed channel height of 250 μm to keep the whole ASIC as the array form fitting with a four channel VCSEL array. The 14-Gbps VCSEL driver is implemented as one of the four channels. The 14-Gbps VCSEL driver ASIC consists of an equalizer stage, a pre-driver stage and a novel output driver stage. The equalizer stage adopts the Continuous Time Linear Equalizer (CTLE) structure to compensate for the high frequency loss. To obtain the high bandwidth, a shared inductance-peaking technique is used in the pre-driver stage. The proposed the novel output driver stage raises the supply voltage and employ the stacked PMOS current source structure to increase the swing amplitude of the driving current to the VCSEL. Besides, two feedforward compensation capacitors are utilized to improve the bandwidth of output driver stage.
The whole ASIC features a size of 2 mm x 2 mm. The 14-Gbps VCSEL driver has a size of 2 mm x 0.25 mm. Widely-open 14-Gbps eye has been observed at the typical settings of 2 mA bias current and 5 mA modulation current in the post layout simulation. The chip has been taped out and the tests are planned to be conducted in this May. The driver ASIC will use chip on board (COB) measurement setup, and is wire bonded to an 850 nm VCSEL. The optical test, electrical test and total ionizing dose (TID) test will be performed. The test results will be reported in the meeting.

Your name:

email:

zhaocong@mails.ccnu.edu.cn

Title:

Nationality:

Institute:

Poster Session 3 (Applications in Particle Physics) / 52

A radiation tolerant 16 Gbps 1:16 Deserializer for High-Energy Physics Experiments

Authors: Qiangjun Chen[1]; Di Guo[1]

Co-authors: Cong Zhao [1]; Yujing Gan [1]; Zengtao Guo [1]; Ni Fang [1]; xiangming sun [1]

[1] *Central China Normal University*

Corresponding Authors: diguo@mail.ccnu.edu.cn, 1620364076@qq.com, 649694421@qq.com, 948584100@qq.com, sphy2009@gmail.com, qjchen1206@163.com, zhaocong@mails.ccnu.edu.cn

Deserializer with high speed and radiation tolerant features is used as key component of data transmission system in high-energy physics experiments. It is mainly used in the downlink transmission to realize serial-to-parallel conversion of data. This paper presents the design and test results of a 16 Gbps 1:16 deserializer chip fabricated in 55 nm CMOS technology. The chip adopts a tree-type tap structure, consisting of an input equalizer stage, four levels of half-rate 1:2, 2:4, 4:8, 8:16 Demultiplexer (DEMUX) modules, corresponding frequency dividers. The input equalizer stage is used to compensate for the high frequency loss caused by the transmission line on PCB and the bonding wire. The first 1:2 DEMUX receives the 16Gbps CML signals from the equalizer stage, performs the first 1:2 transform, then transmits to the following levels. The final 8:16 DEMUX outputs 16 parallel data with 1 Gbps. The frequency divider divides the externally input 8GHz clock to provide a half-rate clock for each stage of DEMUX. In order to improve the bandwidth of the high-speed 1:2 DEMUX and high-frequency divider, and save voltage margin, their latches adopt a CML structure without tail current source. We designed duty cycle correction circuit and clock alignment circuit to recover duty cycle and align clock edges in clock path.
The whole chip consumes 305 mW when working at 16 Gbps. The dimension of the designed deserializer chip is 2mmX3mm, including 58 PADs. The post-layout simulation results demonstrate that the whole chip work functionally at the target speed and 16 wide-open eyes are verified at the all output channels. The total jitter (TJ) of each output channel (1 Gbps/ch) is 28.2ps averagely. This chip has been taped out and the tests are planned to be conducted in this March. The test results will be reported in the meeting.

Your name:

email:

qjchen1206@163.com

Title:

Nationality:

Institute:

Poster Session 3 (Applications in Particle Physics) / 53

A 4.5GHz to 5.6GHz PLL in 55 nm CMOS for High-Energy Physics Experiments

Authors: Cong Zhao[1]; Di Guo[1]

Co-authors: Qiangjun Chen [1]; Zengtao Guo [1]; Yujing Gan [1]; Liwen Yi [1]; xiangming sun [1]

[1] *Central China Normal University*

Corresponding Authors: zhaocong@mails.ccnu.edu.cn, diguo@mail.ccnu.edu.cn, sphy2009@gmail.com, 1620364076@qq.com, 649694421@qq.com, 1055262787@qq.com, qjchen1206@163.com

Low jitter and radiation tolerant Phase-Lock-Loop (PLL) has been prevailingly researched and used in high-energy physics experiments. This paper presents the design and test results of a radiation tolerant, 4.5GHz to 5.6GHz PLL ASIC fabricated in 55 nm CMOS technology. The PLL ASIC consists of a phase frequency detector (PFD) circuit, a charge pump (CP) circuit, a low pass filter circuit (LPF), a LC voltage controlled oscillator circuit (LCVCO) with capacitor array, a feedback divider circuit and SPI module. In order to obtain low DC leakage current (about 500 pA) and reduce dynamic mismatch, the CP uses two unity-gain feedback operational amplifiers to keep the charge pump output common mode voltage constant. To obtain a wide range of frequency, the LCVCO can change the oscillation frequency by adjusting the capacitance value of the novel capacitor array. The tuning capacitor array consists of MOM capacitor units with three binary controlled NMOS switches and two big resistors. Besides, the LCVCO can improve the Q factor degradation due to the source/ drain leakage current from the binary controlled NMOS transistor.
The whole ASIC features a size of 1200 μm x 900 μm. The PLL covers a wide-frequency range from

4.5GHz to 5.6GHz, consuming a total power of 25 mW from the post layout simulation. At 5.12 GHz, the phase noise is -115 dBc/Hz @ 1MHz offset. The chip has been taped out and the tests are planned to be conducted in this May. The ASIC die will be glued and bonded to a high- frequency print circuit board (PCB) to which the DC supply voltage, SPI control signal and reference clock input can be applied. The electrical test and total ionizing dose (TID) test will be performed. The test results will be reported in the meeting.

Your name:

email:

zhaocong@mails.ccnu.edu.cn

Title:

Nationality:

Institute:

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 54

Instrumentation Challenges of the strong-field QED experiment LUXE at the European XFEL

Author: Kyle Fleck[1]

[1] *Queen's University Belfast*

Corresponding Author: kfleck02@qub.ac.uk

The LUXE experiment aims at studying high-field QED in electron-laser and photon-laser interactions, with the 16.5 GeV electron beam of the European XFEL and a laser beam with power of up to 350 TW. The experiment will measure the spectra of electrons and photons in non-linear Compton scattering where production rates in excess of 109 are expected per 1 Hz bunch crossing. At the same time positrons from pair creation in either the two-step trident process or the Breit-Wheeler process will be measured, where the expected rates range from 10-3 to 103 per bunch crossing, depending on the laser power and focus. These measurements have to be performed in the presence of low-energy high radiation-background. To meet these challenges, for high-rate electron and photon fluxes, the experiment will use Cherenkov radiation detectors, scintillator screens, sapphire sensors as well as lead-glass monitors for backscattering off the beam-dump. A four-layer silicon-pixel tracker and a compact electromagnetic tungsten calorimeter with GaAs sensors will be used to measure the positron spectra. The layout of the experiment and the expected performance under the harsh radiation conditions will be presented.

Your name:

Jenny List

email:

jenny.list@desy.de

Title:

Dr.

Nationality:

German

Institute:

DESY

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 55

Simulations of charge collection of a gallium-nitride-based pin thin-film neutron detector

Authors: Zhongming Zhang[1]; Michael Aspinall[1]

[1] *Lancaster University*

Corresponding Authors: z.zhang56@lancaster.ac.uk, m.d.aspinall@lancaster.ac.uk

The development of new fast neutron reactors and nuclear fusion reactors requires new neutron detectors in extreme environments. Due to its wide bandgap (3.4 eV) and radiation resistance capability, gallium nitride (GaN) is a candidate for neutron detection in extreme environments. In this study, a GaN-based pin thin-film thermal neutron detector with lithium fluoride (LiF) converter layer is modelled by Geant4. After obtaining the neutron energy deposition distribution in the sensitive volume of the detector, the Hecht equation is used to calculate the charge collection efficiency at different position of the detector under a uniform electric field. In addition, considering charge recombination processes, the Shockley-Ramo theorem is applied to obtain more accurate simulation results. The result of the charge collection simulations is used to study its influence on the californium-252 (^{252}Cf) energy spectrum measurement of the detector.

Your name:

Zhongming Zhang

email:

z.zhang56@lancaster.ac.uk

Title:

Mr

Nationality:

Institute:

Lancaster University

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 56

Comparison study of heavily irradiated dielectrics for AC-coupled pixel detectors

Author: Shudhashil Bharthuar[1]

Co-authors: Akiko Gädda [2]; Aneliya Karadzhinova-Ferrer [3]; Eija Tuominen [1]; Jaakko Harkonen [4]; Jennifer Ott [1]; Jens Erik Brucken [1]; Maria Golovleva ; Mihaela Bezak [3]; Nikita Kramarenko [5]; Panja Luukka [6]; Stefanie Kirschenmann [1]

[1] *Helsinki Institute of Physics (FI)*

[2] *Helsiki Institute of Physics*

[3] *Rudjer Boskovic Institute (HR)*

[4] *Ludong University*

[5] *Helsinki Institute of Physics*

[6] *Lappeenranta University of Technology (FI)*

Corresponding Authors: eija.tuominen@cern.ch, panja.luukka@cern.ch, jennifer.ott@helsinki.fi, shudhashil.bharthuar@cern.ch, stefanie.kirschenmann@cern.ch, maria.golovleva@lut.fi, mihaela.bezak@cern.ch, akiko.gadda@helsinki.fi, nikita.kramarenko@helsinki.fi, erik.brucken@cern.ch, aneliya.karadzhinova@cern.ch

The motivation of this study is the development of next generation capacitively coupled (AC-coupled) pixel sensors with coupling insulators having good dielectric strength and radiation hardness simultaneously. The AC-coupling insulator thin films were aluminum oxide (Al2O3) and hafnium oxide (HfO2) grown by Atomic Layer Deposition (ALD) method. The Al2O3 thin films were patterned for finely segmented structures by traditional wet etching, whilst HfO2 was patterned by Chemical Mechanical Polishing (CMP) into structures defined by Reactive Ion Etching (RIE).
The results focus on a comparison study based on the dielectric material used in MOS, MOSFET and AC-pixel sensors processed on high resistivity p-type Magnetic Czochralski silicon (MCz-Si) substrates. These test structures were irradiated with 10 MeV protons up to a fluence of 5e15 p/cm2. Capacitance-voltage measurements of MOS and MOSFET test structures indicate negative oxide charge accumulation induced by proton irradiation. These studies are coherent to numerical simulations, as well as gamma irradiated MOSFET samples. Furthermore, current-voltage (I-V) measurements indicate very good dielectric strength performance in both the materials, even after proton irradiation. Electrical characterisation to study the impact of different dielectric-silicon interfaces on the functionality of the AC-pixel sensors was further investigated by edge-TCT (Transient Current Technique) method. The negative oxide charge during the irradiation is an essential prerequisite of radiation hardness resiliency of n+/p−/p+(n on p) particle detectors widely intended to be used in future high-luminosity experiments.

Your name:

Shudhashil Bharthuar

email:

shudhashil.bharthuar@helsinki.fi

Title:

Mr.

Nationality:

Institute:

Helsinki Institute of Physics

Applications in Life Sciences and Biology; Applications in Particle Physics 3 / 57

Development of Compton-PET hybrid imaging system with CeBr3-SiPM arrays

Authors: Mizuki Uenomachi[1]; Kenji Shimazoe[2]; Kei Kamada[3]; Tadashi Orita[2]; Miwako Takahashi[4]; Hiroyuki Takahashi[2]

[1] *RIKEN*

[2] *The University of Tokyo*

[3] *Tohoku University*

[4] *National Institutes for Quantum and Radiological Science and Technology*

Corresponding Authors: leo@n.t.u-tokyo.ac.jp, mizuki.uenomachi@riken.jp

Positron emission tomography (PET) and single photon emission computed tomography (SPECT) has played an important role in nuclear medicine. While PET can only visualize a positron emitter by detecting annihilation gamma-rays, SPECT is used for low energy gamma-ray imaging (50-400 keV) by using a Pb-based collimator. It is difficult to integrate these modalities because SPECT requires collimators to determine the direction of incoming gamma-rays. Against this backdrop, we proposed a Compton-PET hybrid camera, which can provide images of PET and SPECT nuclides simultaneously by PET imaging and Compton imaging without any collimators. Recently, we succeeded the simultaneous in vivo imaging of ^{18}F-FDG and ^{111}In antibody with a GAGG- silicon photomultipliers (SiPM) based camera. In this study, we have developed a $CeBr_3$-SiPM based Compton-PET hybrid camera to improve time resolution potentially for time-of-flight PET imaging and evaluated the performance of PET imaging and Compton imaging.

The $CeBr_3$ scintillator has first decay time (20 ns), excellent light output (˜70000 photons/MeV), and great energy resolution (˜4%@662 keV when coupled with APD). The 8×8 arrays of $CeBr_3$ scintillator were fabricated by C&A corporation. The pixel size is 2.5 mm × 2.5 mm, and the pitch size is 3.2 mm. Each pixel was separated with the BaSO4 powder reflector. The arrays were hermetically sealed in an aluminum package with a quartz window and were coupled to 8×8 arrays of SiPMs (Hamamatsu MPPC S13361-3050). The charge signals from SiPMs were processed through time-over-threshold (ToT)-based application specific integrated circuits with the intrinsic time resolution of 50 ps. The time resolution of 198.7 ps was achieved with 1 mm thick $CeBr_3$ array detectors by using a digital oscilloscope. In addition, the angle resolution of a $CeBr_3$ Compton camera with the dynamic ToT method was 5.5° at 662 keV. In the presentation, we will report the evaluation in detail.

Your name:

Mizuki Uenomachi

email:

mizuki.uenomachi@riken.jp

Title:

Nationality:

Japan

Institute:

RIKEN

Medical Applications of Position Sensitive Detectors 1 / 58

Position sensitive detectors in proton therapy: online monitoring of the beam position

Author: Robert Michael Schäfer[1]

Co-authors: Oxana Actis [2]; Michael Eichin [3]; Stefan König [4]

[1] *PSI - Paul Scherrer Institut*

[2] *Center for Proton Therapy, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland*

[3] *PSI - Paul Scherrer Institute*

[4] *PSI*

Corresponding Authors: michael.eichin@psi.ch, stefan.koenig@psi.ch, oxana.actis@psi.ch, robert.schaefer@psi.ch

In the last decades, the number of Proton Therapy centers has increased substantially in Asia, in the US and lately in Europe. The characteristics of the Bragg-peak allows precise longitudinal confinement of the prescribed dose to the tumor. Laterally, this is achieved by using narrow pencil beams to scan the tumor volume. This however requires precise control of the position in the plane perpendicular to the beam axis (by means of scanning magnets), enabling high treatment quality.

The Center for Proton therapy at PSI operates a strip ionization chamber (position sensitive detector) to monitor the pencil beam position for safety reasons as one of the final beamline elements. Emphasis of the PSD design was on high robustness due to quasi-continuous usage, but low in maintenance –a detector breakdown is a showstopper for daily patient treatments. Using online beam position monitoring as a safety feature, fast signal generation, processing and transfer to the control system are required.

The beam position detector in one of our Gantries operated stable and well for almost ten years, but the now outdated front-end electronics and dwindling stock parts call for maintenance work. This is an opportunity to upgrade our position detector with a new chip (ADAS from analog devices), adding new features to the detector (sampled readout, online gain control). The task brings a challenging replacement procedure along, as this is the first maintenance work since its commissioning ten years ago.

This contribution intends to give an introduction into one of the proton therapy facilities at PSI. The main topic covers the task of online beam monitoring with a planar strip ionization chamber in a clinical environment and the imposed demands with emphasis on detector design and signal processing. Eventually, upgrading and exchanging this position detector in our clinical environment will be detailed.

Your name:

Robert Schäfer

email:

robert.schaefer@psi.ch

Title:

Dr.

Nationality:

German

Institute:

PSI

60

Very Forward Calorimetry at the FCC

Authors: Yasar Onel[1]; James William Wetzel[1]

[1] *University of Iowa (US)*

Corresponding Authors: yasar.onel@cern.ch, james.william.wetzel@cern.ch

The success of any particle detector at a collider experiment depends on its ability to measure both the trajectories and energies of particles exiting the interaction point. Especially important and difficult is measuring the trajectories and energies of particles in the very forward region - particles that exit the detector with very shallow angles compared to the beam line. The difficulty with measuring these particles with high precision is related to the high radiation this area is exposed to, making robust instrumentation a challenge. This area becomes more important with increasing beam energy.

We propose a radiation hard, precise, and highly resolved tracking calorimeter that addresses all of these challenges. The design uses highly segmented radiation resistant quartz tiles coupled to replaceable radiation resistant photomultiplier tubes. Charged particles entering the quartz array will generate Cherenkov light in proportion to their energy, and this light will be measured with photomultiplier tubes. Tracks can be drawn between coinciding signals, and trajectories measured. Neutral particles will leave no initial track in the quartz, but layers of absorber between the quartz tiles will initiate a shower, making it possible to measure all types of particles and energies using this detector. Neural nets can be used to identify particles and tracks. Our simulations show that this detector has excellent tracking, excellent electromagnetic energy resolution, and excellent hadronic energy resolution. Its radiation tolerant materials make it well suited for high radiation environments, but its energy resolution properties mean it can used in varying geometries at any location around the interaction point.

Your name:

Yasar Onel

email:

yasar.onel@cern.ch

Title:

Professor

Nationality:

USA

Institute:

University of Iowa

61

NEW RADIATION-HARD SCINTILLATORS FOR FCC DETECTORS

Authors: Yasar Onel[1]; Burak Bilki[2]

[1] *University of Iowa (US)*

[2] *Beykent University (TR), The University of Iowa (US)*

Corresponding Authors: yasar.onel@cern.ch, burak.bilki@cern.ch

Future circular and linear colliders as well as the Large Hadron Collider in the High-Luminosity era have been imposing unprecedented challenges on the radiation hardness of particle detectors that will be used for specific purposes e.g. forward calorimeters, beam and luminosity monitors.
We performed research on the radiation-hard active media for such detectors, particularly calorimeters, by exploring intrinsically radiation-hard materials and their mixtures.The initial samples that we probed were thin plates of Polyethylene Naphthalate (PEN) and Polyethylene Terephthalate (PET) and thin sheets of HEM. The previous studies indicate towards promising performance under high radiation conditions. We will report on the necessary process of mixing the PEN and PEN for optimized scintillation and signal timing properties preserving the high radiation resistance.
Recently we developed a new plastic scintillator material. The scintillation yield of SX sample was compared to a BGO crystal using a setup with 90Sr source and a Hamamatsu R7525-HA photomultiplier tube (PMT). The SX was measured to yield roughly 50% better light production compared to the BGO crystal.sample SX was irradiated at the CERN PS radiation facility with 24 GeV/c protons. The samples received a fluence of 1.2 x 1015 p/cm2 which corresponds to 4 x 105 Gy radiation doses.

The comparison of the transmission spectra of SX sample before and after the irradiation exhibits a loss of roughly 7% light transmission after 4 x 105 Gy proton irradiation

Your name:

Yasar Onel

email:

yasar.onel@cern.ch

Title:

Professor

Nationality:

USA

Institute:

University of Iowa

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 62

AGIPD systems for the European XFEL, development and upgrades.

Authors: Annette Delfs[1]; Roberto Dinapoli[2]; Peter Goettlicher[3]; heinz graafsma[1]; Dominic Greiffenberg[4]; Helmut Hirsemann[1]; Stephanie Jack[1]; Alexander Klyuev[5]; Hans Krueger[6]; Sabine Lange[7]; alessandro marras[5]; Davide Mezza[2]; Aldo Mozzanica[8]; Bernd Schmitt[2]; Joern Schwandt[9]; Igor Sheviakov[1]; Xintian Shi[10]; Sergej Smoljanin[1]; Ulrich Trunk[1]; Jiaguo Zhang[2]; Manfred Zimmer[1]; Torsten Laurus[11]; Stephan Stern[1]

[1] *DESY*

[2] *Paul Scherrer Institut*

[3] *Deutsches Elektronen-Synchrotron (DE)*

[4] *PSI - Paul Scherrer Institute*

[5] *Deutsches Elektronen-Synchrotron*

[6] *University of Bonn*

[7] *Desy*

[8] *PSI - Paul Scherrer Institut*

[9] *Hamburg University (DE)*

[10] *Paul Scherrer Institute*

[11] *Deutsches Elektronen-Synchrotron DESY*

Corresponding Authors: alexander.klyuev@desy.de, sabine.lange@desy.de, dominic.greiffenberg@psi.ch, peter.goettlicher@desy.de, torsten.laurus@desy.de, davide.mezza@psi.ch, manfred.zimmer@desy.de, joern.schwandt@cern.ch, bernd.schmitt@psi.ch, xintian.shi@psi.ch, sergej.smoljanin@desy.de, heinz.graafsma@desy.de, hans.krueger@cern.ch, jiaguo.zhang@psi.ch, alessandro.marras@desy.de, ulrich.trunk@desy.de, roberto.dinapoli@psi.ch, aldo.mozzanica@psi.ch

The European XFEL is one of the newest X-ray facilities in the world with a very demanding requirements for the detectors operating at the experimental stations and recording high quality scientific data. Those requirements include high dynamic range from single up to 10⁴ 12.5 keV-photons. The accelerator operates with a very specific time structure producing bunch trains of 2700 pulses at 4.5 MHz repetition rate. The trains are repeated with an infra-frequency of 10 Hz. These key features enable the conduction of modern physical experiments and at the same time put challenging requirements on the detectors.

The AGIPD (Adaptive Gain Integrating Pixel Detector) developed for the European XFEL is based on hybrid pixel technology using direct photon conversion in a semiconductor sensor bump-bonded to the front-end microelectronics. Each pixel of the AGIPD ASIC uses a charge-sensitive preamplifier with adaptive gain and 352 random-access memory cells in order to record as many images as possible from the bunch train, and transfer them to the back-end electronics between the bursts. The data is then transferred to the acquisition system via 16 10Gbit optical links. The detector is running in vacuum and also subject to considerable radiation dose.
The first 1-megapixel system was delivered to the SPB instrument in summer 2017 and started operation already in September 2017. The second 1-megapixel was used for first experiments at the MID instrument in the early 2019. Two 2nd generation systems (4 and 1 megapixels) are to be delivered to SFX and HED instruments, utilizing modern back-end electronics and the latest version (1.2) of the AGIPD ASIC. Efforts on enhancement of the front-end hybrid production yield, upgrades of the 1st generation systems and the status of newer developments for AGIPD will be presented.

Your name:

Alexander Klujev

email:

alexander.klyuev@desy.de

Title:

Dr

Nationality:

Germany

Institute:

DESY

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 63

Tristan10M detector: Characterization of a large area detector for time resolved experiments based on Timepix3 chip

Authors: Zongde CHEN[1]; Giulio Crevatin[None]; Ian Horswell[2]; Jonathan Spiers[3]; David Omar[3]; Scott Williams[2]; Nicola Tartoni[None]

[1] *diamond light source*

[2] *Diamond Light Source*

[3] *Diamond Light Source Ltd*

Corresponding Authors: zongde.chen@diamond.ac.uk, david.omar@diamond.ac.uk, nicola.tartoni@diamond.ac.uk, jonathan.spiers@diamond.ac.uk, ian.horswell@diamond.ac.uk, scott.williams@diamond.ac.uk, giulio.crevatin@diamond.ac.uk

Tristan10M is a 10 million pixel area detector based on the Timepix3 chip, a member of the Medipix family of ASICs for X-ray and particle imaging and detection developed by the Medipix collaboration led by CERN. The Timepix3 ASIC can work in event driven mode in addition to the standard frame based mode. Event driven mode enables the chip to send out a data packet containing the pixel coordinate, time over threshold and time of arrival immediately after each hit is processed by a pixel. Thanks to these capabilities of the Timepix3 ASIC, the Tristan detector is ideal for time-resolved experiments. The Tristan 10M detector is organized in a 5 x 2 module matrix, each module being made up of sixteen Timepix3 chips bump-bonded to a monolithic pixelated silicon sensor. In this contribution, we will report on the status of the detector development, and characterization results in terms of threshold equalization, energy calibration, and flat-field correction. A number

of initial commissioning experiments have been carried out on the small molecule single crystal diffraction beamline I19 at Diamond light source, which we will also report on here. In particular, X-ray powder diffraction from a standard sample, LaB6, was performed to evaluate the inter-module alignment in six degrees of freedom and to produce a correction matrix suitable for application to future experimental data.

Your name:

Zongde CHEN

email:

zongde.chen@diamond.ac.uk

Title:

Mr

Nationality:

Institute:

Diamond light source

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 64

Design and prototype performance of Macro-Pixel Sub-Assemblies for the CMS Outer Tracker upgrade

Author: Jennet Elizabeth Dickinson[1]

[1] *Fermi National Accelerator Lab. (US)*

Corresponding Author: jdickins@cern.ch

The CMS silicon tracker will be replaced for the HL-LHC run of the experiment during LS3. The outer part of the new tracker is called Outer Tracker and consists of six barrel layers and endcap disks. Two types of modules have been designed, 2S modules (made up of two strip sensors) and PS modules (made of one strip, one macro-pixel sensor). The macro-pixel part of the PS module is called Macro-Pixel Sub-Assembly, or MaPSA. We will present the design of the MaPSA and show results from an extensive prototyping phase with multiple bump-bonding vendors. Plans for production will also be discussed.

Your name:

Jennet Dickinson

email:

jennetd@fnal.gov

Title:

Dr.

Nationality:

American

Institute:

Fermilab

Poster Session 3 (Applications in Particle Physics) / 65

CMS Phase-1 Pixel detector refurbishment during LS2 and readiness towards the LHC Run-3

Author: Lars Noehte[None]

The CMS Phase-1 pixel detector was extracted from the underground cavern after the end of the LHC Run-2 in 2019 and has been kept cold to protect the silicone sensors during the long shutdown period (LS2) in 2019-2021. The LHC is now preparing for the next installment of the data taking beginning 2022. The Phase-1 pixel detector is scheduled to be installed this year and is going through a series of refurbishment and repairs to improve the quality of the collected data and enhance the operational experience. The innermost barrel layer has been replaced with new modules and features improved readout chips (PROC600v4), front-end ASICs (TBM10d), and circuit boards to rectify the issues discovered during the previous data taking. The forward pixel detector has been equipped with new cooling inlets for safe handling and features a revised high-voltage power distribution scheme to better match the low-voltage granularity. All the DC-DC converters have been replaced with a new production, consisting of an improved ASIC (FEAST2.3) to prevent them from breaking during operation. Overall, this talk will summarize the refurbishment work of the pixel detector during LS2, and highlight the readiness towards the LHC Run-3 after installation and commissioning.

Your name:

Atanu Modak

email:

atanu.modak@cern.ch

Title:

Mr

Nationality:

Indian

Institute:

Kansas State University

Gas-based Detectors 1 / 66

High rate capability studies of triple-GEM detectors for the ME0 upgrade of the CMS muon spectrometer

Author: Luis Felipe Ramirez Garcia[1]

Co-authors: Michele Bianco [2]; Francesco Fallavollita [2]; Davide Fiorina [3]; Antonello Pellecchia [4]; Nicole Rosi [5]

[1] *Universidad de Antioquia (CO)*

[2] *CERN*

[3] *Universita & INFN Pavia*

[4] *Universita e INFN, Bari (IT)*

[5] *Universita and INFN (IT)*

Corresponding Authors: francesco.fallavollita@cern.ch, antonello.pellecchia@cern.ch, nicole.rosi@cern.ch, luis.felipe.ramirez.garcia davide.fiorina@cern.ch, michele.bianco@cern.ch

The high-luminosity LHC (HL-LHC) upgrade sets a new challenge for particle detector technologies. In the CMS muon system gaseous detectors, the increase in luminosity will produce a particle background ten times higher than at the LHC. To cope with the high rate environment and maintain performance, the triple-Gas Electron Multiplier (GEM) technology was chosen for the high-rate capable detectors for the CMS ME0 upgrade project in the innermost region of the forward muon spectrometer. An intense $R\&D$ and prototype phase is ongoing to verify that such technology meets the stringent performance requirements of highly efficient particle detection in the harsh background environment expected in the innermost ME0 region. We describe recent rate capability studies on triple-GEM detectors operated with an $Ar/CO_2\,(70/30)$ gas mixture at an effective gas gain of 2×10^4 by using a high-intensity $22\,\mathrm{keV}$ X-ray generator. In light of these rate capability studies, a novel foil design for the ME0 detectors was developed based on double-sided segmented GEM-foils and a high voltage distribution and filtering system. We describe the impact of the new design on detector performance and present a summary of ongoing R&D activities.

Your name:

Luis Felipe Ramirez Garcia

email:

luis.felipe.ramirez.garcia@cern.ch

Title:

Nationality:

Colombian

Institute:

Universidad de Antioquia

Poster Session 3 (Applications in Particle Physics) / 67

Cylindrical GEM Inner Tracker for the BESIII experiment

Author: Sara Morgante[1]

[1] *INFN Fe - IHEP*

Corresponding Author: sara.morgante@to.infn.it

A ten years extension of the data taking of the BESIII esperiment, recently approved, motivated an upgrade program both for the leptonic collider BEPCII (Beijing Electron Positron Collider II), that host the experiment, and for some of the subdetectors, that compose the spectrometer.
This presentation will focus on the upgrade foreseen for the inner tracker. The present multilayer drift chamber is suffering of ageing and the standing proposal is to replace it with a detector based on Cylindrical GEM (Gas Electron Multiplier) technology. This Inner Tracker is composed of three layers of cylindrical triple-GEMs. The CGEM-IT will not only restore the design efficiency, but also improve the secondary vertex reconstruction and the radiation tolerance. The custom developed mechanic and electronic design will guarantee excellent performance in the wide range of incident angles in a 1 Tesla magnetic field.
The front-end electronics is composed by 64 channels ASIC featuring a fully digital output that allow to be operated in trigger-less mode and can provide analog charge and time measurements. All these components, together with optimized gas mixture, gain value settings and reconstruction algorithms, will allow to reach a position resolution to the level of ~130 µm in the transverse plane and better than 350 µm along the beam direction. In this presentation, the general status of the project will be presented, with a particular focus on the recent preliminary results from the cosmic data taking and the future plans.

Your name:

Ilaria BALOSSINO

email:

balossino@fe.infn.it

Title:

Dr

Nationality:

Italian

Institute:

INFN - IHEP Fellow

Position Sensitive Fast Timing Detectors 1 / 68

A High-Granularity Timing Detector for the ATLAS Phase-II upgrade

Corresponding Authors: simone.michele.mazza@cern.ch, hasko.stenzel@cern.ch

The increase of the particle flux (pile-up) at the HL-LHC with instantaneous luminosities up to L ˜ 7.5 × 10ˆ34 cmˆ-2sˆ-1 will have a severe impact on the ATLAS detector reconstruction and trigger performance. The end-cap and forward region where the liquid Argon calorimeter has coarser granularity and the inner tracker has poorer momentum resolution will be particularly affected. A High Granularity Timing Detector (HGTD) will be installed in front of the LAr end-cap calorimeters for pile-up mitigation and luminosity measurement.

The HGTD is a novel detector introduced to augment the new all-silicon Inner Tracker in the pseudo-rapidity range from 2.4 to 4.0, adding the capability to measure charged-particle trajectories in time as well as space. Two silicon-sensor double-sided layers will provide precision timing information for minimum-ionising particles with a resolution as good as 30 ps per track in order to assign each particle to the correct vertex. Readout cells have a size of 1.3 mm × 1.3 mm, leading to a highly granular detector with 3.7 million channels.
Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides enough gain to reach the large signal over noise ratio needed.

The requirements and overall specifications of the HGTD will be presented as well as the technical design and the project status. The on-going R&D effort carried out to study the sensors, the read-out ASIC, and the other components, supported by laboratory and test beam results, will also be presented.

Your name:

Hasko Stenzel

email:

Hasko.Stenzel@cern.ch

Title:

Dr

Nationality:

german

Institute:

JLU Giessen

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 69

Performance of LGAD sensors for the ATLAS High-Granularity Timing Detector

Author: Han CUI[1]

[1] *CERN*

Corresponding Author: han.cui@cern.ch

We report on the layout and performance of Low-Gain Avalanche Detectors (LGAD) produced for the ATLAS High Granularity Timing Detector (HGTD) foreseen for the HL-LHC upgrade of the ATLAS experiment. The HGTD is a multi-layer silicon-based detector with a total active area of 6.4 m2 covering the pseudo-rapidity region between 2.4 and 4.0 with timing sensors with primary resolution of at least 50 ps/hit, and capable of providing 30-50 ps/track time resolution. This represents the first large scale application of the LGAD technology.

Sensors with an active thickness of 50 µm and 35 µm were produced with common masks and different combinations of doping profile of the gain layer. The power dissipation and breakdown voltage are determined from I-V measurement, doping profile of the gain layer and the bulk from C-V data. The dynamic properties of the LGADs were determined by charge collection measurements using laser and charged particles. Samples of the sensors are irradiated with neutrons, protons and gammas to study the radiation-hardness. The dependence of the gain and of the time resolution on bias voltage and fluences and the early results of the LGADs bump-bonded to the ALTIROC1 chip will also be presented.

Your name:

Hasko Stenzel

email:

Hasko.Stenzel@cern.ch

Title:

Dr

Nationality:

German

Institute:

JLU Giessen

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 70

Upgrade of the ATLAS Muon Spectrometer with high-resolution Drift Tube Chambers (sMDT) for LHC Run-3

Author: Elena Voevodina[1]

Co-authors: Oliver Kortner [1]; Hubert Kroha [1]; Gregor Hieronymus Eberwein [1]; Marian Benedikt Rendel [2]; Patrick Rieck [1]; Daniel Soyk [1]; Verena Maria Walbrecht [1]

[1] *Max-Planck-Institut fur Physik (DE)*

[2] *Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D*

Corresponding Authors: rendel@mpp.mpg.de, kroha@mppmu.mpg.de, patrick.rieck@cern.ch, elena.voevodina@cern.ch, g.eberwein@cern.ch, kortner@mppmu.mpg.de, verena.maria.walbrecht@cern.ch, soyk@mpp.mpg.de

The Monitored Drift Tube detector technology is used in the ATLAS experiment for the very accurate, reliable muon tracking and momentum measurements in the barrel and endcap regions. Already in Run 2 of the LHC they had to cope with very high background counting rates up to 500 Hz/cm^2 in the inner endcap layer. At High-Luminosity LHC, the background rates are expected to increase by almost a factor of 10. New small (15 mm) diameter Muon Drift Tube detectors have been developed in the Max Planck Institute for Physics in Munich for the upcoming upgrade of the ATLAS muon spectrometer. New chambers will provide about an order of magnitude higher rate capability and allow for the installation of additional thin gap RPC trigger technology in the transition region ($1.0 < |\eta| < 1.3$) of the ATLAS muon system for HL-LHC runs. A smaller size project, known as BIS78 (Barrel Inner Small sectors), is developed with a foreseen installation during the LHC Long Shutdown 2 (2019-2021). This pilot project will reinforce the fake muon rejection and the selectivity of the muon trigger in the problematic transition region by adding new BIS78 muon stations which are composed of 16 sMDT chambers with 32 RPC triplets (BIS7 and BIS8). In this contribution, we will describe the new BIS78 sMDT detector design, the quality assurance and certification path, as well as will present the overview of the chamber's validation and installation, their cavern commissioning status and performance in the ATLAS combined runs during Milestone weeks.

Your name:

Elena VOEVODINA

email:

elena.voevodina@cern.ch

Title:

Nationality:

Russian

Institute:

Max Planck Institute for Physics

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 71

A programmable readout system for 3He/BF3 neutron detectors

Author: Yuri Venturini[1]

Co-authors: Massimo Venaruzzo [1]; Carlo Tintori [1]; Andrea Abba [2]

[1] *CAEN SpA*

[2] *Nuclear Instruments Srls*

Corresponding Authors: abba@nuclearinstruments.eu, y.venturini@caen.it, c.tintori@caen.it, m.venaruzzo@caen.it

Neutron sources are currently becoming a standard to investigate the structures of various materials at mesoscopic scale using elastic scattering techniques, which are applied across a wide spectrum of scientific disciplines such as physics, biology, materials science. Moreover, having the capability of detecting neutrons is a common request of Radioprotection and Security fields, especially in those applications where you need to locate a potentially hazardous neutron emitter, measure its energy and reconstruct its position.
Typical neutron physics experiments carried out at Neutron Spallation Sources and other laboratories (like ESS, SNS, CSNS, ISIS, ILL, ⋯) make use of large arrays of 3He/BF3 position-sensitive tubes to detect neutrons. On the other hand, Nuclear Security main players need more compact systems with standalone electronics to bias and read out neutron detectors.
CAEN SpA has developed a 19”rack-mount solution for the readout of 3He/BF3 tubes, which can be tailored for both above mentioned scenario, including neutron physics experiments and environmental/security monitoring system. It is a scalable system allowing to put together few to hundreds neutron detectors. It can be composed starting from three basic building blocks: R803x High Voltage board, R1443 Charge Sensitive Preamplifier specifically designed for 3He/BF3 tubes and R5560 14-bit 125MS/s open FPGA Digitizer. Thanks to its firmware programmability, this readout system can perform specific filtering to achieve the best charge, timing and position measurements.
CAEN provides a DAQ software to remotely manage the system and acquire waveforms, energy, ToF spectra and perform position reconstruction. Moreover, the R5560 offers the possibility to use SCI-Compiler, a block-diagram-based software which allows to easily implement custom pulse processing algorithms in the board FPGA.

Your name:

Yuri Venturini

email:

y.venturini@caen.it

Title:

Mr

Nationality:

Italian

Institute:

CAEN SpA

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 72

An introduction to DAMIC-M experiment

Authors: Georgios PAPADOPOULOS[1]; Antoine Letessier-Selvon[2]

[1] *DAMIC*

[2] *LPNHE CNRS/In2p3*

Corresponding Authors: gpapadop@lpnhe.in2p3.fr, antoine.letessier-selvon@in2p3.fr

The DAMIC-M project is devoted to the exploration of the hidden sector and the search for light Dark Matter particles using Charge-Coupled Devices (CCDs). It follows the DAMIC at SNOLAB experiment which pioneered the detection of new particles through their interaction with the nucleus or the electrons of the bulk silicon of fully depleted CCDs.. A kilogram-sized target mass will be installed at the Modane underground laboratory (LSM, France) which offers an excellent low background environment for rare-event search. DAMIC-M detectors demonstrate several technological advancements including the implementation of the skipper technique, and custom front-end control and read-out electronics. Skipper CCDs can perform multiple non-destructive measurements of the pixel charge that allow for a read-out noise of a fraction of an electron. With a 15μm x 15μm pixel area, 675μm thickness and the ability of 3D reconstruction using the diffusion of the particle track, the spatial resolution of our CCDs allows for the follow-up of radioactive chains, a powerful tool to discriminate genuine particle interaction from in situ radioactive decays. Together with an extremely careful fabrication procedure that controls the contaminant and the generation of bulk radioactive contamination by cosmic ray spallation, the single electron resolution will guarantee a detection energy threshold of only a few eVs, pushing the sensitivity of DAMIC-M by at least one order of magnitude better than previous experiments. I will present the current status of DAMIC-M describing our technological challenges and the solutions we have adopted. I will introduce our method to measure and mitigate the bulk radioactive contamination and discuss the ongoing assembly of a prototype detector (the Low Background Chamber) aiming at validating our design options.

Your name:

Georgios PAPADOPOULOS

email:

gpapadop@lpnhe.in2p3.fr

Title:

Mr

Nationality:

Greek

Institute:

LPNHE

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 73

TCAD Simulation of Radiation Hard n-MCz and n-Fz Si Microstrip Detector for the HL-LHC

Authors: Dr. Ajay Kumar Srivastava[1]; Balwinder Kaur[1]; Nitu Saini[1]; Shilpa Patiyal[1]; Ekta Jasrotia[2]

[1] *Chandigarh University*

[2] *Chandigarh Univerity*

Corresponding Authors: ektajasrotiamsc@gmail.com, shilpa31296@gmail.com, saininitu94@gmail.com, balwinderkaur0091@gmail kumar.uis@cumail.in

Radiation damage of the silicon strip detectors in the HL-LHC experiments pretenses a major task for its reliable long –term operation of the experiment. Radiation hard Si detectors have used in the new CMS tracker detector at HL-LHC in 2026. It has been observed that n-MCz and n-Fz Si as a material can be used for the Si microstrip detector. The strip detector design for this material should be simulated using TCAD simulation and optimized to get the high CCE. In order to understand the charge collection behavior of the n-MCz/n-Fz Si detector, we have compared the radiation damage effects in the mixed irradiated n-MCz Si and neutron irradiated n-Fz Si microstrip detector equipped with metal overhang and multiple guard rings.
In this paper, we have shown an optimal design of the radiation hard n-MCz Si/n-Fz Si strip detector design for the HL-LHC experiment in order to get high CCE.

Your name:

Balwinder Kaur

email:

balwinderkaur0091@gmail.com

Title:

Mrs

Nationality:

Indian

Institute:

Department of Physics (UIS), Chandigarh University, Gharuan, Mohali, India

74

The ATLAS ITk Strip Detector System for the Phase-II LHC Upgrade

Authors: William Trischuk[1]; Alessandra Ciocio[2]

[1] *University of Toronto (CA)*

[2] *Lawrence Berkeley National Lab. (US)*

Corresponding Authors: william.trischuk@cern.ch, a_ciocio@lbl.gov

ATLAS is preparing for the HL-LHC upgrade, where integrated and instantaneous luminosity will reach unprecedented values. For this, an all-silicon Inner Tracker (ITk) is under development with a pixel detector surrounded by a strip detector. The strip system consists of 4 barrel layers and 6 endcap disks. After completion of FDRs in key areas, such as Sensors, Modules, Front-End electronics and ASICs, prototyping has been completed successfully. Pre-production is about to start. We present an overview of the Strip System, and highlight the final design choices of sensors, module designs and ASICs. We will summarise R&D results achieved during prototyping, including irradiated modules demonstrating the radiation hardness achieved. In addition, we will outline the current status of pre-production on various detector components, with an emphasis on QA and QC procedures. We will also discuss the plans for the pre-production and production phase distributed over many institutes.

Your name:

William Trischuk

email:

william@physics.utoronto.ca

Title:

Nationality:

Institute:

University of Toronto, Department of Physics

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 75

Development, construction and qualification tests of the Mu2e electromagnetic calorimeter mechanical structures

Author: Daniele Pasciuto[None]

Co-author: Simone Donati [1]

[1] *University of Pisa and Istituto Nazionale di Fisica Nucleare*

Corresponding Authors: simone.donati@pi.infn.it, daniele.pasciuto@pi.infn.it

The Mu2e experiment at Fermilab will search for the CLFV neutrino-less coherent conversion of a muon into an electron in the field of an aluminum nucleus. The observation of this process would be the evidence of physics beyond the Standard Model. Mu2e comprises a straw-tracker, an electromagnetic calorimeter and an external veto for cosmic rays. The calorimeter provides electron identification, a fast trigger and aids track reconstruction. It is a state-of-the-art crystal calorimeter and employs 1340 pure CsI crystals readout by UV-extended SiPM and fast electronics. The design consists of two identical annular disks positioned at the relative distance of 70 cm downstream the target.
The hostile Mu2e conditions (total ionizing dose of 12 krad and a neutron fluence of 5x1010 n/cm2 @ 1 MeVeq (Si)/y, 1 T magnetic field and vacuum level of 10ˆ-4 Torr) posed tight constraints on the mechanical structures and materials choice. The support structure of the two crystal matrices employs two aluminum hollow rings and parts made of open-cell vacuum-compatible carbon fiber. SiPMs and front-end electronics for each crystal are assembled in one mechanical unit inserted in a machined copper holder. The units are supported by a plate made of vacuum-compatible material. The plate integrates the cooling system made of a network of copper lines flowing a low temperature fluid and placed in thermal contact with the copper holders. The DAQ is hosted in aluminum crates positioned on the lateral surface of the disks. The crates also integrate the DAQ electronics cooling system. We review the constraints on the calorimeter structures design, the development of all the structural components, including the simulations that have determined the materials and technological choices and the specifications of the cooling station, components production and quality assurance tests, the procedures for detector assembly, transportation and installation in the experimental area.

Your name:

Simone Donati

email:

simone.donati@pi.infn.it

Title:

Nationality:

Italian

Institute:

University of Pisa and Istituto Nazionale di Fisica Nucleare - Pisa (Italy)

Poster Session 3 (Applications in Particle Physics) / 76

Serial powering and signal integrity characterisation for the TEPX detector for the Phase-2 CMS Inner Tracker

Author: The Tracker Group of the CMS Collaboration[None]

Co-authors: Kyle James Read Cormier [1]; Stefanos Leontsinis [1]; Anna Macchiolo [1]; Arne Christoph Reimers [1]; Yuta Takahashi [1]; Florencia Canelli [1]

[1] *Universitaet Zuerich (CH)*

Corresponding Authors: kyle.james.read.cormier@cern.ch, stefanos.leontsinis@cern.ch, anna.macchiolo@cern.ch, canelli@physik.uzh.ch, arne.reimers@cern.ch, yuta.takahashi@cern.ch

The entire CMS silicon pixel detector will be replaced for operation at the High Luminosity LHC. The novel scheme of serial powering will be deployed to power the pixel modules and new technologies will be used for a high bandwidth readout system. In this contribution the new TEPX detector will be presented, with particular focus on a novel concept to provide both power and data connectivity to the modules through a disk shaped PCB. As TEPX also features the longest serial powering chains in the CMS Inner Tracker, an emphasis on serial powering results will be shown, together with signal integrity and data transmission performance.

Your name:

Kyle Cormier

email:

kyle.james.read.cormier@cern.ch

Title:

Nationality:

Canadian

Institute:

University of Zurich

Detectors for Neutron Facilities; Gas-based Detectors 2 / 80

Composite GYAGG-based scintillation screen for neutron detection

Author: Ilia Komendo[1]

Co-authors: Mikhail Korjik [2]; Georgy Dosovitskiy [1]; Andrei Fedorov [2]; Vladimir Gurinovich [3]; Ekaterina Gordienko [1]; Valentina Smyslova [1]; Vitaly Mechinsky [2]; Vladimir Guzov [3]; Vladimir Kozhemyakin [3]; Dmitry Kozlov [2]; Andrei Lopatik [2]

[1] *NRC "Kurchatov Institute" - IREA (RU)*

[2] *Byelorussian State University (BY)*

[3] *ATOMTEX SPE*

Corresponding Authors: mikhail.korjik@cern.ch, vitaly.mechinsky@cern.ch, georgy.dosovitskiy@cern.ch, ilia.komendo@cern.ch, andrei.fedorov@cern.ch

The present work deals with obtaining neutron sensitive scintillation screens and their evaluation. We have used cerium doped garnet Gd1.2Y1.8Ga2.5Al2.5O12:Ce (GYAGG) as a scintillator since quaternary garnets with the optimized ratio of cations have demonstrated high light yield under γ-quanta and α-particles excitation, 50 000 ph/MeV and 12 000 ph/MeV respectively, with fast decay time (˜50 ns).
We have performed modelling of α-particles and tritons absorption in GYAGG and 6LiF using GEANT 4 software. Then the pathlengths of these particles in GYAGG and 6LiF media were estimated, allowing to calculate of the desired sizes of the scintillator and 6LiF particles and distances between them. Translucent GYAGG ceramic tablets were prepared and grounded to the required particle size to obtain scintillation pigment. Screens samples with dimensions of 12x12x0.2 mm and phosphor density of ˜50 mg/cm2 with the filling of 90% vol were prepared for light yield evaluation tests under

α-particles. 241Am was used as an α-particles source. Scintacor ND neutron screen (6LiF/ZnS:Ag-based) was used as a reference. Pulse height spectra were recorded and peak positions were found to be ˜ 900 channel for ND screen, and ˜111 for GYAGG milled ceramics. ZnS(Ag) light yield under a-particles is known to be 49400 ph/MeV, so considering different PMT efficiency at the emission wavelengths of ZnS(Ag) and GYAGG:Ce3+, we can conclude that the light output of samples made of GYAGG milled ceramics is about 9700 ph/MeV.
The samples for tests under neutrons were prepared according to the simulation results. The composition was: 10 vol.% of scintillator, 30 vol.% of 6LiF, 60 vol.% of a binder. Phosphor layer density was 20 mg/cm2. Pulse height spectra were recorded against the reference screen (Scintacor ND). The total counts in neutron spectra for our best sample and the reference sample were found to be 321 and 299 respectively.

Your name:

Ilia Komendo

email:

ilia.komendo@cern.ch

Title:

Dr

Nationality:

Ru

Institute:

NRC "Kurchatov Institute" - IREA (RU)

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 81

A hybrid pixel detector with 4D information for dynamic synchrotron radiation applications

Authors: Wei Wei[1]; Jie Zhang[2]; Mujin Li[2]; Shanshan Cui[2]; Zhenjie Li[2]; Xiaoshan Jiang[2]; Kejun Zhu[2]; Peng Liu[2]; Zheng Wang[2]

[1] *IHEP, CAS, China*

[2] *IHEP, CAS*

Corresponding Authors: limujin@ihep.ac.cn, liup@ihep.ac.cn, sscui@ihep.ac.cn, jiangxs@ihep.ac.cn, wz@ihep.ac.cn, zhukj@ihep.ac.cn, weiw@ihep.ac.cn, lizj@ihep.ac.cn, zhj@ihep.ac.cn

In this paper, a new concept of detector is proposed for dynamic synchrotron radiation applications. It is based on the conventional hybrid pixel detector architecture, while the readout chip is designed with hit-driven readout scheme rather than frame refreshing. Based on ToT (Time over Threshold) structure, each pixel can acquire 4D information, including 2D position, timing, and energy of every incoming photon. This not only enhances the detector timing performance to several tens of nanosecond compared to the typical millisecond by photon counting, but also enables the possibility of wide-band X-ray imaging while typical synchrotron radiation experiments usually only deal with monochrome energy.
The pixel readout chip, TETPIX, was designed using a CMOS 130nm technology and taped out with a full mask engineering run. It integrates a 64×32 pixel array with a pixel size of 150µm×150µm. The readout scheme is based on a "column-drain"architecture, that simultaneous incoming hits in every column will be sequentially readout controlled by a priority arbitrary logic in the pixel. The time stamps of both edges of ToT pulses will be latched in pixel registers, where the leading edge corresponds to the hit time and the difference between the both edges represents the energy. Data

are readout by a high speed serializer off chip.
A sensor measures 1.92cm×1.92 cm was bump bonded with 2×2 readout chips, and the module was then wire bonded to a readout PCB. Preliminary test results on BSRF (Beijing Synchrotron Radiation Facility) showed that the module can achieve a energy resolution better than 20% in the full range of BSRF from 8keV to 16keV, and the timing performance was about 20ns with 50MHz clock frequency. With this capability, the fine architecture of the bunch crossing of the accelerator can clearly be seen. Other experiment results are also discussed in this paper.

Your name:

Wei Wei

email:

weiw@ihep.ac.cn

Title:

Dr

Nationality:

China

Institute:

IHEP, CAS

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 82

Precision tracking micro-pattern gaseous detectors at Budker INP

Authors: Timofei Maltsev[1]; Lev Shekhtman[2]; Vasily Kudryavtsev[2]

[1] *Budker Institute of Nuclear Physics (RU)*

[2] *Budker INP*

Corresponding Authors: v.n.kudryavtsev@inp.nsk.su, l.i.shekhtman@inp.nsk.su, timofei.maltsev@cern.ch

Micro-pattern gaseous detectors (MPGDs) can operate at very high particle flux demonstrating consistently high efficiency and coordinate resolution in tens microns scale. Tracking MPGDs are developed and applied in several experiments at Budker INP.
Eight two-coordinate cascaded Gas Electron Multiplier based detectors (GEM-detectors) have been working at the Tagging System of KEDR experiment (TS KEDR) at VEPP-4M electron-positron collider since 2010. TS KEDR is dedicated to two-photon physics.
Three triple-GEM-detectors are integrated into Photon Tagging System of the DEUTERON facility at VEPP-3 storage ring. Strip pitch of the readout structure is 500 um and the spatial resolution was measured to be less than 50 um. The material budget of each detector is low - about 0.3% of radiation length, which suppresses multiple scattering.
Triple-GEM detectors having orthogonal strips with a pitch of 250 um and low material budget were assembled for the Test Beam Facility and demonstrated excellent efficiency above 99% and spatial resolution better than 50 um.
Cascaded GEM-detector with pad readout has been mounted for the laser polarimeter for precise energy measurements at VEPP-4M collider.
MPGD is proposed for upgraded tracking system of the CMD-3 detector at VEPP-2000 collider. The upgraded system will include a new cylinder tracking and trigger detector as well as two end-cap discs. Micro-RWELL technology is used for the upgrade. The first two end-cap discs are assembled and results of the first tests will be reported.
The cylindrical detector and end-cap discs for CMD-3 are considered as the prototypes for the Inner Tracker of future Super Charm-Tau Factory. Compact Time Projection Chamber (TPC) is considered

as one of the options for the Inner Tracker with the readout detector based on MPGD technology. The prototype of the TPC is being assembled and the first tests with the prototypes of the readout plane will follow soon.

Your name:

Timofei Maltsev

email:

timofei.maltsev@cern.ch

Title:

Mr

Nationality:

Institute:

Budker INP

Poster Session 3 (Applications in Particle Physics) / 83

A congestion awareness and Fault-tolerance Readout Network ASIC for High-Density Electrode Array Targeting Neutrinoless Double-Beta Decay Search in TPC

Author: bihui you[1]

[1] *Central China Normal University*

Corresponding Author: bhyou@foxmail.com

Among the current and planned experiments of neutrinoless double-beta decay (0νββ), the high-pressure gaseous TPC stands out for its excellent energy resolution, low radioactive background and good scalability. Moreover, high position resolution can be maintained with an appropriate charge readout scheme for TPC to further suppress the background through ionization imaging. A low noise sensor, Topmetal-S, is being developed which, even without gas gain, the energy resolution requirement could be met. To realize a ton-scale TPC, approximately 100,000 Topmetal-S need to be laid on a meter-sized plane with a pitch of 5˜10mm. The one of greatest challenges is reliable high-density sensor readout. A readout network ASIC is implemented and will be integrated into Topmetal-S as a router. A sensor network is built by establishing local connection among nearby sensors to ensure the tightness and radioactive purity of the high-pressure TPC. As a node of the network, each sensor not only generates and transmits its own data, but also forwards data from nearby sensors, and data is finally transferred to the edge of the network and received by a computer. The test results of the first porotype of readout network ASIC show that the risk of data loss increased in the nearby sensors of the fault sensors. In addition, if the sensor in the same line is hit four or more times, it will cause data loss. Therefore, this paper proposed a distributed, self-organizing, fault-tolerance, and congestion awareness readout network ASIC and a distributed, adaptive and fault-tolerance-XY routing algorithm. The simulation shows that the throughput of the readout network reaches 8252.16 Mbit/s and the latency of the network is less than 120 us. Then the design has been verified and tested on the FPGA. The ASIC is implementing on a 130 nm CMOS process now and submitted it in May 2021.

Your name:

you

email:

bhyou@mails.ccnu.edu.cn

Title:

Mr

Nationality:

China

Institute:

Applications in Security and Environmental Imaging; Advances in Pixel Detectors and Integration Technologies 2 / 84

Allpix Squared - Silicon Detector Monte Carlo Simulations for Particle Physics and Beyond

Authors: Paul Schütze[1]; Simon Spannagel[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

Corresponding Authors: paul.schuetze@desy.de, simon.spannagel@cern.ch

Allpix Squared is a versatile, open-source simulation framework for silicon pixel detectors. Its goal is to ease the implementation of detailed simulations for both single sensors and more complex setups with multiple detectors. While originally created for silicon detectors in high-energy physics, it is capable of simulating a wide range of detector types for various application scenarios, e.g. through its interface to Geant4 to describe the interaction of particles with matter, and the different algorithms for charge transport and digitization. The simulation chain is arranged with the help of intuitive configuration files and an extensible system of modules, which implement the individual simulation steps. Detailed electric field maps imported from TCAD simulations can be used to precisely model the drift behavior of the charge carriers, bringing a new level of realsim to the Monte Carlo simulation of particle detectors.

Recently, Allpix Squared has seen major improvements to its core framework to take full advantage of multi- and many-core processor architectures for simulating events fully parallel. Furthermore, new physics models such as charge carrier recombination have been introduced, further extending the application range. This contribution provides an overview of the framework and its components, highlighting the versatility and recent developments.

Your name:

Simon Spannagel

email:

simon.spannagel@desy.de

Title:

Nationality:

german

Institute:

DESY

Detectors for FELS, Synchrotrons and Other Advanced Light Sources / 85

Prototype Characterization of a Charge-integrating Pixel Detector Readout Chip with In-pixel A/D conversion

Authors: Mujin LI[1]; Wei Wei[2]; XIAOSHAN JIANG[3]; Shanshan CUI[1]

[1] *IHEP,CAS*

[2] *IHEP, CAS, China*

[3] *IHEP*

Corresponding Authors: jiangxs@ihep.ac.cn, limujin@ihep.ac.cn, weiw@ihep.ac.cn

The HYLITE (High dYmamic range Laser Imaging deTEctor) is a new hybrid pixel detector readout chip, which is designed for advanced light sources such as X-ray Free Electron Laser (XFEL) and diffraction-limited storage rings. These X-ray sources produce beams with high intensities, high repetition frequency and good coherence. In order to make use of these excellent properties, the detector system with higher dynamic range and readout speed is needed. HYLITE is a charge-integrating readout chip which has three gains for different dynamic ranges and automatic gain switching function. The full dynamic range covered by HYLITE is 1~10000 photons at 12keV for each pixel in every shot. In-pixel ADC is designed to achieve front-end digitalization and 10 kHz continuous frame rate.

HYLITE 0.1 is the first prototype chip designed using CMOS 0.13 mm technology to verify basic pixel functions. The pixel array consists of 6×12 pixels. The size of each pixel is 200μm×200μm and will be improved to 100μm×100μm in the future. Six different design variations of pixels with different integrating capacitance and structures were designed to help optimize between area and performance. The test results showed that the non-linearity of the pre-amplifier is 0.16%, 0.51%, and 1.11% in high, medium and low gain mode, respectively. A 10bits Wilkinson ADC is integrated in each pixel to digitalize the output of pre-amplifier. The linear feedback shift register (LFSR) is used as the ADC clock counter as well as the readout shifter for compacting the layout area. By front-end digitalizing, analog signal transmission of long distance is avoided and frame rate of 10 kHz was also tested and proved.

Your name:

Li Mujin

email:

limujin@ihep.ac.cn

Title:

Ms

Nationality:

China

Institute:

IHEP,CAS

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 86

HEPS-BPIX4: A Prototype Pixel Readout Chip Working in Single Photon Counting Mode with a Novel Charge Sharing Suppression

Scheme

Authors: Shanshan Cui[None]; Wei Wei[None]; Mujin Li[None]; Zheng Wang[None]

Corresponding Authors: limujin@ihep.ac.cn, wz@ihep.ac.cn, sscui@ihep.ac.cn, weiw@ihep.ac.cn

HEPS-BPIX4 is a hybrid pixel detector readout chip for X-ray applications for the High Energy Photon Source (HEPS) in China. The prototype readout chip contains an array of 20 × 32 pixels with a pixel size of 55 μm × 55 μm, working in single photon counting mode. Each pixel handles with both positive and negative input charge signals and has a counting depth of 11 bits. The chip could work at a 160 Mbps output data rate with zero dead time.
Besides the chip design description, this paper also proposes a novel architecture aiming at eliminating the spectral distortion caused by the charge sharing effect due to the fine pixel pitch. It is based on charge summing and centroid arbitration among adjacent pixels. In every cluster grouped by 3×3 pixels in the chip, charge deposited in four pixels by a single photon is concentrated into the center pixel and added together. Then it is compared with the energy threshold for discrimination. In the meantime, the center pixel is also judged by a secondary comparator with a minimum threshold. Then the arbitrator decides if the charge of the center pixel is the maximum. Only those two matched conditions give a photon counting pulse to the digital part.
Compared with reported schemes that transmitted more than ten signals, the proposed scheme reduced the complexity of communicated pixels interconnection in the layout. There are only seven signals including three analog signals and four digital signals received by the center pixel from the adjacent four pixels. Besides, it improved the charge sharing decision precision to be as high as 99% and has been verified by python modelization simulation. The chip has been manufactured and tested. Detailed results, especially the charge sharing cancellation test in the pixel array, is given in this paper.

Your name:

Shanshan Cui

email:

sscui@ihep.ac.cn

Title:

Nationality:

Institute:

Institute of High Energy Physics, Chinese Academy of Sciences

87

Radiation Damage to Pixel Sensors in the ATLAS Detector: measurements and modelling

Author: Clara Troncon[1]

[1] *Milano Universita e INFN (IT)*

Silicon pixel detectors are at the core of the current and planned upgrade of the ATLAS detector at the Large Hadron Collider (LHC). As the closest detector component to the interaction point, these detectors will be subjected to a significant amount of radiation over their lifetime: prior to the High-Luminosity LHC (HL-LHC), the innermost layers will receive a fluence of 1-5 10**15 1 MeV neq/cm2 and the HL-HLC detector upgrades must cope with an order of magnitude higher fluence integrated over their lifetimes. Simulating radiation damage is critical in order to make accurate predictions for current future detector performance. A model of pixel digitization is presented that includes radiation damage effects to the ATLAS pixel sensors for the first time. In addition to a thorough

description of the setup, predictions are presented for basic pixel cluster properties alongside measurements with LHC Run 2 proton-proton collision data which validate the methodology.

Your name:

email:

clara.troncon@cern.ch

Title:

Nationality:

Institute:

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 88

Operational Experience and Performance with the ATLAS Pixel detector at the Large Hadron Collider at CERN

Author: Andreas Kirchhoff [1]

[1] *Goettingen University (Germany)*

Corresponding Author: andreas.kirchhoff@cern.ch

The tracking performance of the ATLAS detector relies critically on its 4-layer
Pixel Detector
The key status and performance metrics of the ATLAS Pixel Detector are
summarised, and the operational experience and requirements to ensure
optimum data quality and data taking efficiency will be described, with special emphasis to radiation damage experience.
By the end of the proton-proton collision runs in 2018, the innermost layer IBL,
consisting of planar and 3D pixel sensors, had received an integrated fluence of approximately Φ = 1× 10**15 1 MeV neq/cm2.
The ATLAS collaboration is continually evaluating the impact of radiation on the Pixel Detector. A quantitative analysis of charge collection, dE/dX, occupancy reduction with integrated luminosity, under-depletion effects with IBL, effects of annealing will be presented and discussed, as well as the operational issues and mitigation techniques adopted during the LHC Run2 and the ones foreseen for Run3.

Your name:

email:

clara.troncon@cern.ch

Title:

Nationality:

Institute:

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 90

Novel Thin-Scintillator Ion Beam Imagers

Author: Peter Friedman[1]

Co-authors: Vladimir Bashkirov [2]; Claudio Ferretti [3]; Thomas Ginter [4]; Daniel Levin [3]; Nicholas Ristow [3]; Reinhard Schulte [2]

[1] *Integrated Sensors, LLC*

[2] *Loma Linda University*

[3] *University of Michigan*

[4] *Facility for Rare Isotope Beams*

Corresponding Authors: nristow@umich.edu, rschulte@llu.edu, dslevin@umich.edu, peter@isensors.net, ginter@frib.msu.edu, claudio.ferretti@gmail.com, vbashkirov@llu.edu

The thin-scintillator ion beam imager (SIBI) is a novel charged particle imaging detector developed by our group for various applications. It uses proprietary high light-yield, very thin (<500 µm) hybrid inorganic scintillator sheets or ultra-thin (3-200 µm) organic scintillator films. The scintillation elements are coupled by low f-number optics to high sensitivity, low-noise or ultra-low noise machine vision cameras. The initial application is for beam imaging and profile analysis at the U.S. DOE Facility for Rare Isotope Beams (FRIB) and other ion beam laboratories. For FRIB, we are developing the SIBI towards maximizing sensitivity to low rate and low energy ion beams with real-time feedback while limiting beam degradation for moderate energy FRIB beams over a large dynamic range from single particles up to ˜10ˆ10 pps. The SIBI has demonstrated detection sensitivity to single 5 MeV alpha particles with a position resolution of 5 µm, while for heavier ions, the position resolution is ˜2 µm. Other SIBI applications are being developed for conventional proton/ion beam therapy and for the newly emerging cancer treatment modality known as FLASH radiotherapy (RT), which delivers approximately four (4) orders-of-magnitude higher dose rates than conventional RT. The SIBI is intended to provide dosimetric and imaging capabilities necessary for FLASH-RT clinical trials to proceed. We will describe system designs and report preliminary performance results.

Your name:

Peter Friedman

email:

peter@isensors.net

Title:

Dr

Nationality:

U.S.

Institute:

Integrated Sensors, LLC

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 91

Online control of the gain drift with temperature of SiPM arrays used for the readout of LaBr3:Ce crystals

Authors: Marco Prata[1]; Massimo Rossella[2]; Maurizio Bonesini[3]; Roberto Bertoni[4]

[1] *Sezione INFN Pavia*

[2] *Universita and INFN (IT)*

[3] *Universita & INFN, Milano-Bicocca (IT)*

[4] *Univ. + INFN*

Corresponding Authors: massimo.rossella@cern.ch, bertoni@mi.infn.it, maurizio.bonesini@cern.ch

LaBr3:Ce crystals have been introduced for radiation imaging in medical physics, with photomultiplier or single SiPM readout.
An R&D was pursued with 1/2" and 1" LaBr3:Ce, from different producers, to realize
compact large area detectors (up to some cm2 area) with SiPM array readout, aiming at high light yields, good energy resolution, good detector linearity and fast time response for low-energy X-rays. A natural application was found inside the FAMU project at RIKEN-RAL muon facility, that aims at a precise measure of the proton Zemach radius to solve the so-called "proton radius puzzle", triggered by the recent measure of the proton charge radius at PSI. The goal is the detection of characteristic X-rays around 130 KeV. Other applications may be foreseen in medical physics, such as PET, and gamma-ray astronomy. A limiting factor is the gain drift of SiPM arrays with temperature, that may give a major deterioration of the FWHM detector's energy resolution. To solve this problem a custom NIM module was developed, based on CAEN A7585D digital power supplies, with temperature feedback. Up to eight channels may be powered by a single 2-slots NIM module. The control of this module was implemented via either a FDTI USB-I2C converter or an Arduino Nano chip. Three modules (with which up to 24 channels may be powered) were realized and are linkable in daisy chain, via the I2C protocol. Test results of the correction of gain drift with temperature for SiPM arrays from Advansid, Sensl, Hamamatsu will be presented, together with the ones obtained on energy resolution, detector linearity, … for the realized LaBr3:Ce detectors.
As an example, at the Cs137 peak, an energy resolution better than 3 % was obtained, using Hamamatsu S13461 arrays , that compares well with best available results obtained with a PMTs.
~

Your name:

Maurizio Bonesini

email:

Maurizio.Bonesini@mib.infn.it

Title:

Prof.

Nationality:

Italian

Institute:

Sezione INFN Milano Bicocca/Dipartimento di Fisica G. Occhialini, Universita' Milano Bicocca

Applications in Particle Physics 2 / 92

New beam position detectors for NA61/SHINE experiment

Author: Yuliia Balkova[1]

[1] *University of Silesia (PL)*

Corresponding Author: yuliia.balkova@cern.ch

NA61/SHINE is a multi-purpose fixed-target experiment located at the Super Proton Synchrotron at CERN. The main goals of the experiment include studies for physics of strong interactions, neutrino physics, and cosmic-rays physics. After the upgrade of the detector system, scheduled to be completed this year, the experiment will collect data up to 1 kHz event rate (factor 10 increase).

The development of new beam position detectors, used to measure the positions of incoming beam particles in the transverse plane, is a crucial part of the upgrade. The previous set of beam position detectors was based on the proportional gas chambers.

Instead, two new kinds of beam position detectors are prepared and tested. One of them is the scintillating fibre detector with a multi-anode photomultiplier readout. It is built of two perpendicularly arranged ribbons, each consisting of two shifted layers of green-emitting scintillating fibres with a diameter of 250 μm. The second type of detector is based on the single-sided silicon strip detector (Hamamatsu S13804).

The talk will give an overview of both detectors' concepts and will present the results of tests and commissioning experiments.

Your name:

Yuliia Balkova

email:

yuliia.balkova@cern.ch

Title:

Ms

Nationality:

Ukrainian

Institute:

University of Silesia in Katowice

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 93

Organic Electronic-based Neutron Detectors

Authors: Adrian Bevan[1]; Cozmin Timis[2]; Fani Eirini Taifakou[3]; Joanna Borowiec[3]; Muhammad Ali[3]; Theo Kreouzis[3]

[1] *Queen Mary University of London (GB)*

[2] *University of London (GB)*

[3] *Queen Mary University of London*

Corresponding Authors: muhammad.ali@qmul.ac.uk, f.taifakou@qmul.ac.uk, j.borowiec@qmul.ac.uk, a.j.bevan@qmul.ac.uk, t.kreouzis@qmul.ac.uk, c.timis@qmul.ac.uk

We report on the potential use of organic electronic devices applied to radiation detection applications. In recent decades organic electronics has entered the mainstream of consumer electronics. Driven by innovations in scalability and low power applications, and low-cost fabrication methods. The potential for using organic semiconductor electronic devices as radiation detectors, and in particular for neutron detection is reported. We report results of laboratory tests using α, β, and γ sources, and results on response to neutrons using the National Physical Laboratory Van de Graff generator. GEANT4 simulations are being used to provide a detailed understanding of the performance and potential of this emerging technology for radiation detection. Some preliminary results of those simulations are also reported.

Your name:

Adrian Bevan

email:

a.j.bevan@qmul.ac.uk

Title:

Prof

Nationality:

British

Institute:

QMUL

Detectors for FELS, Synchrotrons and Other Advanced Light Sources / 94

Timepix4 timestamping detector for synchrotron applications

Authors: David Pennicard[1]; Jonathan Correa[1]; Sabine Lange[2]; Sergei Fridman[1]; Sergej Smoljanin[3]; Vahagn Vardanyan[1]; heinz graafsma[1]

[1] *DESY*

[2] *Desy*

[3] *X-Spectrum GmbH*

Corresponding Authors: heinz.graafsma@desy.de, sergei.fridman@desy.de, jonathan.correa@desy.de, david.pennicard@desy.de, sabine.lange@desy.de

Timepix4 is a versatile readout chip with 55 µm pixels, recently developed by CERN on behalf of the Medipix4 collaboration. It can operate both in a photon counting mode with frame readout, and a timestamping mode with event readout. Both of these modes offer higher performance than existing Medipix3 and Timepix3 chips. This makes Timepix4 appealing to a wide range of X-ray experiments at synchrotrons. For example, while X-ray diffraction experiments are normally done with framing detectors, the ability to switch to timestamping mode can offer extreme time resolution (down to individual synchrotron bunches) in experiments with moderate flux or specific regions of interest.

At DESY, a new readout system is being developed that is designed to cope with the chip's high readout bandwidth (up to 162 Gbps per chip). Firstly, a single chip carrier board has been designed, produced and tested. The layout, flat and with the chip at the edge of the board, enables a number of experimental set-ups, and also allows for 2-chip tiled systems. For this first iteration, a commercially available readout board hosting a powerful Zynq UltraScale+ System on Chip has been chosen, due the large number of high speed transceivers available. Data is transferred to a control PC over Firefly optical links. Firmware and software development and chip testing are in progress.

In the long term, multi-megapixel systems composed of multiple chips will be developed. New detector head boards and also custom readout boards will be needed. Furthermore, recent developments on Through Silicon Via (TSV) technology will make it possible to operate the chip without wire bonds, thus greatly reducing the dead gaps between modules.

Your name:

David Pennicard

email:

david.pennicard@desy.de

Title:

Dr

Nationality:

UK

Institute:

DESY

95

Tracking TeV-PeV Cosmic Rays in Space

Authors: Andrii Tykhonov[1]; Andrii Kotenko[2]

[1] *Universite de Geneve (CH)*

[2] *University of Geneva*

Corresponding Authors: andrii.tykhonov@cern.ch, andrii.kotenko@cern.ch

The astroparticle field is experiencing a new dawn of precision measurements with the rise of space-borne instruments for direct detection of Cosmic Rays at extreme TeV—PeV energy range. In particular, DArk Matter Particle Explorer (DAMPE) mission, launched in December 2015, has recently reported the measurements of Cosmic Ray electron, proton and helium spectra at multi-TeV energies with unprecedented energy resolution.

Tracker is a key sub-detector of DAMPE and of the successor next-generation instrument, High Energy Radiation Detection (HERD) facility. Track reconstruction poses a fundamental challenge due to the complex nature of TeV—PeV interactions in the detector, which vastly obscure the sought signal. As a result, track reconstruction becomes a key limiting factor affecting measurement accuracy. The development of novel tracking techniques is therefore critical in order to fully uncover the science potential of DAMPE and HERD missions.

In this talk, we present the first findings of the ERC PeVSPACE project with the goal of employing state-of-the-art Artificial Intelligence techniques to qualitatively improve the accuracy of particle tracking at the highest energies. We also give a brief overview of the DAMPE mission, focusing on its Silicon Tracker sub-detector, and demonstrate the first application of the developed techniques to the analysis of the DAMPE data.

Your name:

Andrii Tykhonov

email:

andrii.tykhonov@unige.ch

Title:

Prof

Nationality:

Ukraine, Slovenia

Institute:

University of Geneva

X-ray and Gamma Ray Detectors 2 / 96

Spectroscopic X-ray Imaging at MHz Frame Rates –The HEXITEC$_{MHz}$ ASIC

Authors: Adam Barcock[1]; Lawrence Jones[1]; Chris Lyford[1]; David Sole[1]; Ivan Church[1]; Lydia Jowitt[1]; Mark Prydderch[1]; Matt Roberts[1]; Matt Wilson[1]; Matthew Hart[1]; Matthew Veale[1]; Paul Seller[1]; Rhian Mair Wheater[1]; Stephen Bell[1]; Thomas Gardiner[1]; Tim Nicholls[1]

[1] *UKRI STFC*

Corresponding Authors: thomas.gardiner@stfc.ac.uk, mark.prydderch@stfc.ac.uk, matt.wilson@stfc.ac.uk, stephen.bell@stfc.ac.uk, ivan.church@stfc.ac.uk, rhian-mair.wheater@stfc.ac.uk, matt.roberts@stfc.ac.uk, chris.lyford@stfc.ac.uk, lydia.jowitt@stfc.ac.uk, paul.seller@stfc.ac.uk, matthew.veale@stfc.ac.uk, david.sole@stfc.ac.uk, adam.barcock@stfc.ac.uk, tim.nicholls@stfc.ac.uk, lawrence.jones@stfc.ac.uk, mark.hart@stfc.ac.uk

The HEXITEC$_{MHz}$ ASIC has been developed for the HEXITEC$_{MHz}$ Detector System, to deliver spectroscopic x-ray imaging at frame rates up to 1MHz for future high-flux-rate applications. Optimised for sensing electron signals from detector materials such as CdTe, CZT, GaAs, Ge and p-type silicon detectors, the design has an array of 80x80 pixels on a pitch of 250μm, with each pixel capable of measuring single x-ray photons up to energies of 200keV, with a resolution of 1keV FWHM.

Further improvements in the spatial and spectroscopic resolution are possible due to the pixel's ability to simultaneously sense positive signals up to 20keV induced by internal weighting potential effects from electron signals on neighbouring pixels.

A count rate limit of around 10^6 photons s^{-1} mm^{-2} is achieved by converting the signals from all pixels every 1μs using 12-bit time-to-digital converters –an improvement of two orders of magnitude over previous HEXITEC ASICs. To save power, each converter is shared between groups of eight pixels.

Each 76.8kbit data frame is Aurora 64b/66b encoded and serialised over 20 lanes of differential CML, all operating in parallel at 4.1Gbps.

In this paper, we present details of the design, and possibly preliminary test results from the ASIC.

Your name:

Lawrence Jones

email:

lawrence.jones@stfc.ac.uk

Title:

Mr

Nationality:

British

Institute:

UKRI STFC

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 97

Proton-range verification in proton radiation therapy using PET

Authors: Narayan Sahoo[1]; Andrei Mozorov[2]; Stefaan Tavernier[3]; Carlos Leong[4]; Christopher Layden[5]; David R. Grosshans[1]; Falk Poenisch[1]; Francisco Caramelo[6]; Hugo Simões[2]; Joao Varela[4]; Jose Carlos Rasteiro Da Silva [4]; Jose Sampaio[7]; Karol Lang[5]; Kyle Klein[5]; Luis Ferramacho[4]; Marek Proga[5]; Margarida N Simões[2]; Miguel Silveira[4]; Nuno Ferreira [6]; Patrícia Gonçalves[8]; Paulo Crespo[2]; Ricardo Bugalho[4]; Rui Silva[4]; William Matava[5]

[1] *UT MD Anderson Proton Therapy Center, Houston, USA*

[2] *LIP and Departamento de Física, Universidade de Coimbra, Portugal*

[3] *Vrije Universiteit Brussel (BE)*

[4] *PETsys Electronics S. A., Portugal*

[5] *Department of Physics University of Texas at Austin Austin, TX 78712, USA*

[6] *ICNAS, Instituto de Ciências Nucleares Aplicadas à Saúde, Portugal*

[7] *LIP and FCUL- Faculdade de Ciências, Universidade de Lisboa, Portugal*

[8] *LIP and IST-Instituto Superior Técnico, Universidade de Lisboa, Portugal*

Corresponding Authors: lang@physics.utexas.edu, jsampaio@lip.pt, patricia@lip.pt, proga@physics.utexas.edu, rbugalho@petsyselectronics.com, fcaramelo@ibili.uc.pt, cplayden777@utexas.edu, nsahoo@mdanderson.org, nuno@ibili.uc.pt, cleong@petsyselectronics.com, stefaan.tavernier@petsyselectronics.com, crespo@lip.pt, rsilva@lip.pt, andrei@coimbra.lip.pt, msilveira@petsyselectronics.com, joao.varela@petsyselectronics.com, hugo.simoes@coimbra.lip.pt, fpoenisch@mdanderson.org, lferramacho@petsyselectronics.com, jc.silva@petsyselectronics.com, kyle.klein@utexas.edu, williammatava123@gmail.com, dgrossha@mdanderson.org

We will report first performance results for a prototype PET system designed for proton rage verification in proton therapy. This prototype will later be evaluated with phantoms and animals at the proton therapy center of MD Anderson Cancer Centre in Houston, Texas, USA.
The PET system consists of two detector module assemblies in the shape of angular sections of a cylinder with an inner diameter of 325 mm and axial length 105 mm. The two angular sections cover 99 degrees each. Because of the partial angular coverage, optimization the time resolution is essential in this application. Each PET detector module consists of an 8x8 LYSO array with 3x3x15 mm3 pixels in one-to-one coupling to one Hamamatsu MPPC array S14161-3050HS-08 with 3x3 mm2 pixels. The readout electronics is developed by PETsys Electronics and is based on the PETsys TOFPET2 ASIC. The complete PET system will has 96 detector modules and 6144 electronic readout channels. The interface to the DAQ computer is based on a DAQ module using the PXI express bus, and receiving data from the front-end part through two optical links at 6 Gbit/s.
A Clock&Trigger module located near the detectors will distribute clock signals and allow selecting system wide coincidence events selection in the front end firmware. The complete readout can be divided in a configurable number of trigger regions, and events without a coincidence partner in a different trigger region will not be transmitted to the DAQ computer. This will reduce the data rate to the computer by about one order of magnitude.
We will also report the results of a study of radiation damage to the detectors in this application. The study is based on Geant4 simulation.

Your name:

Stefaan Tavernier

email:

stefaan.tavernier@petsyselectronics.com

Title:

Prof

Nationality:

Belgian

Institute:

PETsys Electronics S. A., Portugal

Position Sensitive Fast Timing Detectors 1 / 98

Overview of CNM LGAD results with B, Ga and C diffused Si-on-Si and epitaxial wafers (in-person)

Authors: Albert Doblas Moreno[None]; Chiara Grieco[1]; Giulio Pellegrini[2]; Jairo Antonio Villegas Dominguez[None]; Lucia Castillo Garcia[3]; Neil Moffat[4]; Salvador Hidalgo[5]; Sebastian Grinstein[3]

[1] *Istitut de Fisica d'Altes Energies (IFAE) - Barcelona (ES)*

[2] *Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES)*

[3] *IFAE - Barcelona (ES)*

[4] *Consejo Superior de Investigaciones Cientificas (CSIC) (ES)*

[5] *Instituto de Microelectronica de Barcelona (IMB-CNM-CSIC)*

Corresponding Authors: neil.moffat@cern.ch, albert.doblas.moreno@cern.ch, chiara.grieco@cern.ch, jairo.villegas@imb-cnm.csic.es, sgrinstein@ifae.es, hidalgo.salvador@cern.ch, lucia.castillo.garcia@cern.ch, giulio.pellegrini@csic.es

Low Gain Avalanche Detectors (LGADs) are n-on-p silicon sensors with an extra doped p-layer below the n-p junction which provides signal amplification. When the primary electrons reach the amplification region new electron-hole pairs are created that drift towards the p+ region increasing the generated signal. The moderate gain of these sensors, together with the relatively thin active region, provide excellent time performance for minimum ionization particles. To mitigate the effect of pile-up at the HL-LHC by both the ATLAS and CMS experiments have chosen the LGAD technology for their High Granularity Timing Detector (HGTD) and for the End-Cap Timing Layer (ETL) respectively. A full characterization of LGAD sensors fabricated at CNM before and after neutron irradiation up to 2.5E15 neq/cm2 will be presented. Sensors produced in epitaxial and Si-on-Si wafers and doped with Boron and Gallium and also diffused with Carbon have been studied. The results include their electrically characterization (IV, CV and bias voltage stability) and performance studies with a Sr-90 radioactive source setup. Also the behaviour of the Inter-Pad region for 2x2 LGAD arrays with Transient Current Technique (TCT) at different fluences will be shown.

Your name:

Chiara Grieco

email:

cgrieco@ifae.es

Title:

Ms

Nationality:

Italian

Institute:

IFAE Barcelona

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 99

Dynamic Imaging of moving radiotracers using combined PET and Compton camera system with scintillation pixel detectors

Authors: Kenji Shimazoe[1]; Donghwan Kim[2]; MIZUKI UENOMACHI[3]; Hiroyuki Takahashi[1]

[1] *The University of Tokyo*

[2] *University of Tokyo*

[3] *RIKEN*

Corresponding Authors: mizuki.uenomachi@riken.jp, kdhkdh0711@gmail.com, shimazoe@bioeng.t.u-tokyo.ac.jp, leo@n.t.u-tokyo.ac.jp

Monitoring and imaging the moving radioisotope are required in several clinical situations, such as the tracer injection and its leakage monitoring in PET scan procedure. We have designed and developed a combined Compton camera and PET coincidence system to monitor the moving radioisotope using 3 mm pixel 8 x 8 GAGG scintillation crystal arrays coupled to SiPM arrays with time-over-threshold (ToT) based individual readout circuits and its dynamic imaging performance is compared. The measured resolution of PET and Compton camera is 3.2 mm and approximately 14 degrees for 22Na point source respectively. The radiotracers with the activity from 12.5 MBq to 100 MBq moving with the speed of 1 mm/s to 10 mm/s mimicking the blood flow are used in the experiment. In PET coincidence imaging, images are successfully visualized for all the activities with the resolution of 5.5 mm to 7.8 mm. In Compton imaging, images are correctly reconstructed only with the activity less than 25 MBq with the resolution of 20 mm because of the random coincidence events. PET showed better tracking capability of activity and speed of radiotracers up to 100 MBq. On the other hand, Compton imaging has wider field-of-view to monitor the large area compared with the limited FOV in PET system. The detail detector performance and imaging results will be shown in the conference.

Your name:

Kenji Shimazoe

email:

shimazoe@bioeng.t.u-tokyo.ac.jp

Title:

Dr

Nationality:

Japan

Institute:

The University of Tokyo

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 100

Random and scatter noise reduction in PET imaging using entangled annihilation gamma photons with Compton PET pixel detectors

Authors: Donghwan Kim[1]; MIZUKI UENOMACHI[2]; Kenji Shimazoe[3]; Hiroyuki Takahashi[3]

[1] *University of Tokyo*

[2] *RIKEN*

[3] *The University of Tokyo*

Corresponding Authors: leo@n.t.u-tokyo.ac.jp, shimazoe@bioeng.t.u-tokyo.ac.jp, kdhkdh0711@gmail.com, mizuki.uenomachi@riken.jp

Reduction of random and scatter events contributing to the background on the reconstructed image is important in PET imaging. Two gamma rays from annihilation of para-positronium containing anti-parallel spins are entangled and have orthogonal linear polarization. The orthogonal linear

polarization in two correlated photons results in the difference between azimuthal scattering angles of two photons tend to be 90˚. Its correlation shows larger amplitude at polar scattering angle near 81˚. Non correlated photons will show no preferred azimuthal angle difference when one of the photons is scattered before reaching detectors or two photons are not originated from the same annihilation event. In the experiment we take coincidence events from double Compton scattering whose azimuthal angle difference is near 90˚ to get larger proportion of true signals with reduced random and scatter events.
Experiment was conducted to characterize the distribution of azimuthal angle differences in double Compton scattering events with pixelated Ce:GAGG-SiPM detectors forming Compton PET scanner. Octagon shaped 8 arrays were used for the experiment. Measured azimuthal angle indicates strong difference intensity at around 90˚ and low intensity at 0˚ and 180˚ as expected from the theory. These correlations can be applied to the reduction of scatter and random coincidence events and the improvement in PET imaging will be reported.

Your name:

email:

kdhkdh0711@gmail.com

Title:

Nationality:

Institute:

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 101

Detection module based on position-sensitive large-area Silicon photomultipliers

Authors: Fabio Acerbi[1]; Andrii Nagai[2]; Stefano Merzi[3]; Ana Ventura Barroso[2]; Domenico Della Volpe[4]; Alberto Gola[5]

[1] *Fondazione Bruno Kessler (FBK)*

[2] *Universite de Geneve (CH)*

[3] *FBK*

[4] *Universitè de Genève*

[5] *Fondazione Bruno Kessler*

Corresponding Authors: andrii.nagai@cern.ch, smerzi@fbk.eu, gola@fbk.eu, domenico.della.volpe@cern.ch, acerbi@fbk.eu, ana.ventura.barroso@cern.ch

Silicon Photomultipliers are compact single-photon-sensitive detectors, widely used in many applications. In FBK (Trento, Italy) we developed large area SiPMs (up to 10x10mm^2), based on different technologies and we are also focusing on the position-sensitive SiPM (PS-SiPM) technology based on charge-sharing approach. These are based on the so called "linearly-graded, LG"technology, exploiting a weighted current dividers on vertical and horizontal axis, to obtain signals (left, right, top and bottom signals) with amplitude and charge proportional to the light-absorption position.
Such large area detector with position sensitivity is very interesting in applications like ultra-high spatial resolution, MR-compatible PET and in the creation of a compact gamma and beta cameras with a reduced number of channels, for radio-guided surgery or other clinical decision support tool for diagnostic imaging.
In this contribution, we illustrate the project developed in collaboration with the University of Geneva for a detection module based on a 2×2 tile of large-area PS-SiPMs, including front-end amplifiers and shaped like a "handable"probe. Total area is 1.6x1.6 cm^2. The PS-SiPMs are connected in a smart configuration, maintaining a very low number of channels. Indeed, while for a single LG-SiPM there are 4 output, for a 2×2 tile, we have just 6 outputs. The measured position resolution

(measured with a pulsed LED, scanned over active area) is better than 0.5 mm.
Finally, we performed an estimation of the performance of such module when used as a gamma camera for tumor detection. With OpenGate simulation, we proved that for a radio-tracer emitting gamma of lower energy, as 99mTc, the gamma camera could achieve an excellent performance. Superficial tumors, of about 2 mm, could be well reconstructed in less than 20 seconds. Tumors bigger than 6 mm in radius could be detected at 30 mm deep within about 10 seconds.

Your name:

Fabio Acerbi

email:

acerbi@fbk.eu

Title:

Dr

Nationality:

Institute:

FBK

102

The Development of Novel Pulse Shape Analysis Algorithms for the Advanced Gamma Tracking Array (AGATA)

Authors: Daniel Judson[1]; Fraser Holloway[None]; Laura Harkness-Brennan[1]; Vitaliy Kurlin[1]

[1] *The University of Liverpool*

Corresponding Authors: fraser.t.m.holloway@gmail.com, vitaliy.kurlin@gmail.com, d.s.judson@liverpool.ac.uk, laura.harkness@liverpool.ac.uk

The Development of Novel Pulse Shape Analysis Algorithms for the Advanced Gamma Tracking Array (AGATA)

F. Holloway[1], LJ. Harkness-Brennan[1], D. Judson[1], V. Kurlin[1]
[1]The University of Liverpool, UK

I. INTRODUCTION

Standing at the forefront of Gamma-Ray Spectroscopy, the Advanced GAmma Tracking Array (AGATA) provides insight into a wide variety of Nuclear Physics, by employing Gamma-Ray Tracking (GRT) AGATA provides significant improvements to efficiency, doppler correction and position resolution.

As all tracked photons occur solely within the germanium volume without the need of additional ancillaries a critical component of GRT the field of Pulse Shape Analysis (PSA) is required. PSA uses characteristics of the measured signals from the segmented electrodes of each crystal to directly infer the positions of the gamma-ray interactions.

II. DEVELOPMENT OF NEW PSA TECHNIQUES

The use of Convolutional Neural Networks for regression was investigated and offers a viable solution on experimental data offering reasonable prediction accuracy and operating at 3kHz.

Utilising graph accelerated k-Nearest Neighbour algorithms for Fold-1 interaction prediction combined with Manifold-Learning assisted dimensionality reduction has allowed for a significant improvement in processing rate with little loss to prediction accuracy. In particular the algorithms, FAISS, HNSWLIB, MKS and Nanoflann were profiled on various embeddedings.

Adaptions were made to extend these methods to work on High-Fold data utilising hierachical restrictive geometry. Precomputation of these scenarios into hyper-efficient hierarchical structures provides a robust, dynamic and efficient approach to High-Fold PSA.

III. EXPERIMENTAL CHARACTERISATION

In order to profile the performance of these algorithms the algorithms were assessed blindly using experimental data collected at Liverpool and IPHC Strasbourg. Data from ^{137}Cs, ^{241}Am & ^{152}Eu sources was used to evaluate PSA performance. The full position and energy dependence of these PSA methods is evaluated and compared against the industry standard.

Your name:

Fraser Holloway

email:

f.holloway@student.liverpool.ac.uk

Title:

Dr

Nationality:

British

Institute:

The University of Liverpool

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 103

Evaluation of the performance of the CCD236 Swept Charge Devices in lunar orbit using in-flight data.

Authors: Lawrence Jones[1]; Chiaki Crews[1]; Andrew Holland[1]; James Endicott[1]

[1] *The Open University*

Corresponding Authors: chiaki.crews@open.ac.uk, lawrence.jones@open.ac.uk, andrew.holland@open.ac.uk, james.endicott@open.ac.uk

India's Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS), launched in 2019 aboard the Chandrayaan-2 spacecraft, has now spent an extended period of time in lunar orbit. CLASS is currently mapping the elemental composition of the lunar surface using X-ray spectrometry.

Building on the heritage of earlier instruments, CLASS employs 16 CCD236 Swept Charge Devices (SCDs) similar in structure to Charge Coupled Device (CCD) image sensors. The CCD236 permits X-ray detection over a large surface area, intended to improve low flux performance, with simplified control interfaces and reduced temperature requirements. These devices were the subject of ground testing and performance evaluation before flight. Data recently made available by the Indian Space Research Organisation (ISRO) has permitted the analysis of the performance of the CLASS SCDs after over a year of operations around the Moon. Of particular interest is the change in device performance and behaviour during transit and in lunar orbit. Preliminary analysis has indicated that the instrument FWHM, representing the aggregate response of most devices, has increased less than predicted by ground irradiation.

The authors will present the latest results from the analysis of instrument data with comparisons to earlier work completed on similar devices.

Your name:

Lawrence Jones

email:

lawrence.jones@open.ac.uk

Title:

Mr

Nationality:

British

Institute:

The Open University

Advances in Pixel Detectors and Integration Technologies I / 104

LHCb VELO upgrade

Authors: Kazuyoshi Carvalho Akiba[1]; Paula Collins[2]

[1] *Nikhef*

[2] *CERN*

Corresponding Author: kazu.akiba@cern.ch

The Vertex Locator (VELO), surrounding the interaction region of the LHCb experiment, reconstructs the collision points (primary vertices) and decay vertices of long-lived particles (secondary vertices). The upgraded VELO will be composed of 52 modules placed along the beam axis divided into two retractable halves. The modules will each be equipped with 4 silicon hybrid pixel tiles, each read out with by 3 VeloPix ASICs, glued onto a thin silicon plate with embedded micro-channels that allow the circulation of liquid CO_2. The silicon sensors must withstand an integrated fluence of up to $8{\times}10^{15}$ 1 MeV n_{eq}/cm^2, a roughly equivalent dose of 400 MRad. The highest occupancy ASICs will have pixel hit rates of 900 Mhit/s and produce an output data rate of over 15 Gbit/s.

The design of the VELO upgrade will be presented with the results from the latest R\&D and detector construction.

Your name:

Kazu Akiba

email:

kazu.akiba@nikhef.nl

Title:

Nationality:

Institute:

Nikhef

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 105

Future Upgrade for LHCb VELO

Author: Jakob Haimberger[1]

[1] *CERN*

Corresponding Author: jakob.haimberger@cern.ch

LHCb has recently submitted a physics case to upgrade the detector to be able to run at instantaneous luminosities of $2\times10^{34}cm^{-2}s^{-1}$, an order of magnitude above Upgrade I, and accumulate a sample of more than 300 fb^{-1}. At this intensity, the mean number of interactions per crossing would be 56, producing around 2500 charged particles within the LHCb acceptance. The LHCb physics programme relies on an efficient and precise vertex detector (VELO) to correctly identify the origin point of the b/c decays. To meet this challenge it is necessary to use temporal precision on each hit at the pixel detector region. To achieve this goal a new 4D hybrid pixel detector with enhanced rate and timing capabilities in the ASIC and sensor will be developed. Improvements in the mechanical design will be needed to allow periodic module replacement and lower detector material.

The early stages of R\&D and conceptual design of a 4D VELO will be presented, together with extensive simulation studies showing the prospects of the 4D-tracking approach on physics measurements, compared to typical 3D and timing plane alternatives.

Your name:

Kazu Akiba

email:

kazu.akiba@nikhef.nl

Title:

Nationality:

Institute:

nikhef

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 106

Measurement of angular correlations in positronium decay using GaGG scintillator matrices with single-side readout by silicon photo-multipliers

Authors: Siddharth Parashari[None]; Damir Bosnar[1]; Ana Marija Kožuljević[2]; Mihael Makek[3]

[1] *Faculty of Science*

[2] *University of Zagreb*

[3] *Faculty of Science, University of Zagreb*

Corresponding Authors: amk@phy.hr, bosnar@phy.hr, siddharthparashri5@gmail.com, makek@phy.hr

Gamma-ray polarization is of prime interest in many areas of physics. One particular is biomedical imaging with positron emission tomography (PET). Two orthogonally polarized, entangled gamma-rays are emitted in an event of para-positronium annihilation thus they are strongly correlated. When they undergo Compton scattering, the initial correlation dominantly results in their orthogonal azimuthal scattering. This correlation can be used in PET as an additional criterium for distinguishing a true coincidence event from the background where such correlation is lacking. In a previous study we showed a moderate azimuthal correlation could be observed via Compton scattering in system of two 4x4 Lutetium Fine Silicate (LFS) scintillation matrices. The goal of the present study is to increase the detector sensitivity to azimuthal correlation, where one of the important parameters is the energy resolution. Hence, we measured azimuthal correlations of annihilation quanta with two 8x8 matrices of Gadolinium Aluminum Gallium Garnet doped with Cerium (GaGG:Ce). Each detector matrix contains 64 crystals of size 3 mm x 3 mm x 20 mm and it is read-out by a single Silicon Photo-multiplier (SiPM) array, with one SiPM matching one pixel. The studied single-side readout concept keeps the modules compact and cost-efficient on a large scale. Coincidence events were recorded using a Na-22 source placed between the modules and the mean energy resolution at 511 keV was 9.7% ± 0.5% and 11.3% ± 0.7% for the two modules, respectively. We clearly identified and reconstructed the Compton scattering events and we observe the excess of orthogonally scattered gammas over the ones with the parallel azimuthal angles. We present the measured azimuthal modulation factors for several kinematic selection criteria and different inter-pixel distances and we compare them to previous findings with 4x4 LFS scintillators. Finally, we discuss the perspective of using the presented concept in PET.

Your name:

Siddharth Parashari

email:

siddharthparashri5@gmail.com

Title:

Dr

Nationality:

Indian

Institute:

Department of Physics, Faculty of Science, University of Zagreb, Bijenička cesta 32, 10000, Zagreb

Applications in Particle Physics 1 / 107

Status of the upgrade project of the CMS Tracker for HL-LHC

Author: Ernesto Migliore[1]

[1] *Universita e INFN Torino (IT)*

Corresponding Author: ernesto.migliore@cern.ch

The CMS experiment is currently preparing the upgrade of the tracking system for the High-Luminosity LHC operations (HL-LHC), scheduled to start in 2027, which ultimately will bring the instantaneous luminosity up to 7.5x10^{34} cm^{-2} s^{-1}. To achieve its physics goals the new detector needs to include

selectively tracking information in the first level trigger stage and improve the tracking resolution while operating at up to 200 interactions per beam crossing and up to 4000 fb^{-1} of integrated luminosity over a decade. In this talk, the layout of the new detector, the main technological choices together with highlights on the current status of the main detector components will be presented.

Your name:

Ernesto Migliore

email:

migliore@to.infn.it

Title:

Nationality:

Italian

Institute:

Universita‘ di Torino and INFN

X-ray and Gamma Ray Detectors 2 / 108

New developments on FBK position sensitive silicon photomultipliers

Authors: Stefano Merzi[1]; Fabio Acerbi[None]; Alberto Gola[2]; Giovanni Paternoster[3]; Nicola Zorzi[4]

[1] *FBK*

[2] *Fondazione Bruno Kessler*

[3] *Fondazione Bruno KEssler*

[4] *FBK - Fondazione Bruno Kessler (IT)*

Corresponding Authors: gola@fbk.eu, acerbi@fbk.eu, zorzi@fbk.eu, smerzi@fbk.eu, paternoster@fbk.eu

Silicon Photomultipliers (SiPMs) are solid-state single photon detectors that show excellent performance in a wide range of applications. In 2015 FBK (Trento, Italy) developed a position sensitive SiPM technology, called "linearly-graded"(LG-SiPM), that showed position reconstruction resolution below 250 µm on an 8x8 mm² device area with only four readout channels and minimal distortions. This technology was proven effective in the readout and discrimination of pixelated LYSO crystals for PET applications (J. Du 2018) and in the 3D reconstruction of alpha particle tracks in an optically readout TPC (A. Gola 2020). Both these applications employed multiplexing techniques to reduce the number of readout channels for a 2x2 SiPM arrays while maintaining the position sensitivity across the surface.
In this work we present the new developments on LG-SiPM. In particular the new SiPMs have a larger active area (10x10 mm²) and they are based on NUV-HD technology, having a peak photon detection efficiency at 420 nm, as opposed to the older technology with peak sensitivity around 550 nm. With these SiPMs we aim to demonstrate the readout channel multiplexing technique applied to larger areas, up to 3x3 elements arrays for a total surface of 30x30 mm².
We also present a one-dimensional position sensitive detector developed for the readout of scintillating fiber mats or for X ray spectroscopy detectors. This sensor is rectangular, with a form factor of 10:1, and it has position sensitivity across the longest dimension. The second dimension is kept small in order to reduce the dark counts and improve the spatial resolution also at low light levels. As in the previous device the 1D version provides high resolution with a low number of readout channels and can be combined into linear arrays with channel multiplexing.

Your name:

Stefano Merzi

email:

smerzi@fbk.eu

Title:

Nationality:

Italy

Institute:

FBK, Fondazione Bruno Kessler

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 109

The development and evaluation of Compton camera (Gri+) for medical imaging applications

Author: Hamed Alshammari[1]

Co-authors: Laura Harkness-Brennan [2]; Andrew Boston [1]; Daniel Judson [2]; Ellis Rintoul [1]; Adam Caffery [1]; Emily Fittock [3]; Jaimie Platt [1]; Thomas Woodroof [1]; Sarah Kalantan [1]; Paul Nolan [1]

[1] *University of Liverpool*

[2] *The University of Liverpool*

[3] *Norfolk and Norwich University Hospitals NHS Foundation Trust*

Corresponding Authors: d.s.judson@liverpool.ac.uk, pjn@ns.ph.liv.ac.uk, ajb@ns.ph.liv.ac.uk, e.rintoul@liverpool.ac.uk, laura.harkness@liverpool.ac.uk, hamed.a.alshammari@gmail.com

To improve medical treatment, the medical imaging field needs to develop more accurate imaging modalities. Using a Compton camera that has the ability to image a wide energy gamma-ray, has a wide field of view with a good angular resolution and electronically collimated, could help to improve medical treatments. To investigate physiological bodily functions, nuclear medicine imaging uses a low-energy gamma-ray, which is emitted from radiotracers. The distribution of the radiotracer material in the body is commonly imaged using a single-photon emission computed tomography (SPECT) system. However, SPECT systems are inherently limited in terms of their spatial resolution and sensitivity. This is due to SPECT systems being scintillation detection systems equipped with a mechanical collimator. Furthermore, imaging the prompt gamma-ray (up to 10MeV) during proton therapy has emerged as a real-time technique for verifying and monitoring the dose delivered.
The University of Liverpool has developed a Compton camera imaging system (Gri+) consisting of two position-sensitive semiconductor detectors and one coaxial detector; this imaging system is electronically collimated. The double-sided Si(Li) planar strip serves as a scatter detector with 13 orthogonal strips on each side. This detector has a sensitive position resolution of 5x5x8 mm3. Additionally, the HPGe double-sided planar strip serves as an absorber detector. This detector has 12 orthogonal strips on each side with a sensitive position resolution of 5x5x20 mm3. The coaxial HPGe serves as an additional absorber for high energy gamma-rays.
The current study evaluates method used by the Gri+ system and its ability to image a range of gamma-ray energies, commonly used in medical applications. Two point-like sources of 166 keV (139Ce) and 1.8 MeV (88Y) and medical phantom were used to evaluate the system performance and the Gri+ imaging ability. Further analyses are in progress to investigate a higher energy gamma-ray such as 4.4 MeV.

Your name:

Hamed Alshammari

email:

H.alshammari@liverpool.ac.uk

Title:

Mr

Nationality:

Institute:

University of Liverpool

X-ray and Gamma Ray Detectors 2 / 111

Improving Position Resolution in Pixelated CZT Detectors through Collimated Gamma-Ray Scanning for use in Molecular Breast Imaging Applications

Author: Ellis Rintoul[1]

Co-authors: Hannah Brown [1]; Christopher Everett [1]; Laura Harkness-Brennan [1]; Daniel Judson [1]; David Wells [1]; Ian Baistow [2]; Alexander Cherlin [2]

[1] *The University of Liverpool*

[2] *Kromek Group*

Corresponding Authors: d.s.judson@liverpool.ac.uk, c.everett@liverpool.ac.uk, e.rintoul@liverpool.ac.uk, alex.cherlin@kromek.com, ian.baistow@kromek.com, sghbrow2@liverpool.ac.uk, drwells@liverpool.ac.uk, laura.harkness@liverpool.ac.uk

Current breast cancer screening techniques suffer from reduced diagnostic performance for patients with mammographically dense breasts. An alternative screening method that overcomes this is Molecular Breast Imaging (MBI), which uses the 140.5 keV gamma-emitting tracer technetium-99m in conjunction with a gamma-camera to image breast tissue.

A gamma-camera is being developed for this application that makes use of a room-temperature pixelated CZT detector in conjunction with a collimator mask. The detecting crystal was taken from a Kromek D-Matrix gamma-ray imager and is 22 x 22 x 5 mm, with a planar cathode and 11 x 11 pixelated anode. This a provided an intrinsic position resolution of 2 x 2 x 5 mm. Pulse Shape Analysis (PSA) techniques can be applied to the signals to improve the position resolution further. The D-Matrix unit provided only timing and energy information via ASIC coupling, so a readout system was designed and constructed that enabled the digitisation and analysis of the raw signals.

Characterisation of the crystal's signal response was performed using high-precision collimated gamma-ray scanning. A cobalt-57 source and a tungsten collimator were used to produce a tightly collimated beam of 122.1 keV gamma rays, analogous to those from technetium-99m, to map the signal response as a function of interaction position. A database of signals from constrained positions was thus formed and used to characterise the charge collection and transient signal response of the crystal. Signal-parameterisation based PSA methods were developed using this database and implemented in order to achieve sub-voxel position resolution both laterally and in depth. The developed algorithms are intended for implementation in the digital ASICs of future detecting systems.

Your name:

Ellis Rintoul

email:

E.Rintoul@Liverpool.ac.uk

Title:

Dr

Nationality:

British

Institute:

The University of Liverpool

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 113

Testbeam performance results of bent ALPIDE MAPS in view of the ALICE Inner Tracking System 3

Author: Bogdan Mihail Blidaru[1]

[1] *ALICE Collaboration*

Corresponding Author: m.blidaru@cern.ch

The ALICE Inner Tracking System (ITS) has been recently upgraded to a full silicon detector consisting entirely of Monolithic Active Pixel Sensors (MAPS), arranged in seven concentric layers around the beam pipe. Further ahead, during the LHC Long Shutdown 3, ALICE intends to replace the three innermost layers of this new ITS with a novel vertex detector. To accomplish this, the proposed design features wafer-scale, ultra-thin, truly cylindrical MAPS. The new sensors will be thinned down to 20-40 μm, featuring unprecedented low material budget of below 0.05% X0 per layer and will be arranged concentrically around the beam pipe, as close as 18 mm from the interaction point.

Anticipating the first prototypes in the new 65 nm technology node, an active R&D programme is underway to test the response to bending of existing 50 μm-thick ALPIDE sensors. A number of such chips were successfully bent, even below the targeted innermost radius, without signs of mechanical damage, while retaining their full electrical functionality in laboratory tests. The curved detectors were subsequently tested during particle beam campaigns, where their particle detection performance was assessed.

In this contribution, testbeam highlights from the data analysis of bent ALPIDE sensors, will be presented. It was proved that the current ALPIDE 180 nm technology retains its properties after bending. The results show an inefficiency that is generally below 10^{-4}, independent of the inclination and position of the impinging beam with respect to the sensor surface. This encouraging outcome proves that the use of curved MAPS is an exciting possibility for future silicon detector designs, as the sensor can not only survive the bending exercise, but its performance as a vertex detector is comparable to that in the flat state.

Your name:

Bogdan Blidaru

email:

m.blidaru@cern.ch

Title:

Mr

Nationality:

Institute:

Ruprecht Karls Universitaet Heidelberg (DE)

Advances in Pixel Detectors and Integration Technologies I / 114

ALICE ITS3: the first truly cylindrical inner tracker

Corresponding Authors: domenico.colella@cern.ch, magnus.mager@cern.ch

The high integration density of Monolithic Active Pixel Sensors (MAPS), with silicon sensor and readout electronics implemented in the same device, allows very thin structures with strongly reduced material budget. Thicknesses of O(50um), values at which silicon chips become flexible, are readily used in many applications. In addition, MAPS can be produced in sensors of wafer size by a process known as stitching. This in turn allows to build detector elements that are large enough to cover full tracker half-layers with single bent sensors.

The ALICE ITS3 project is planning to build a new vertex tracker based on truly cylindrical wafer-scale sensors, with <0.05% X0 per layer and as close as 18 mm to the interaction point. R&D on all project aspects (incl. mechanics for bent wafer-scale devices, test beams of bent MAPS, design of stitched sensors) is rapidly progressing with the aim for installation during LHC LS3.

This contribution will summarise the project motivation, its R&D schedule, and will show selected highlights of recently accomplished project milestones, including full-scale engineering prototypes with dummy chips and small-scale, fully functional assemblies of functional, bent MAPS.

Your name:

email:

Magnus.Mager@cern.ch

Title:

Nationality:

Institute:

Detectors for Neutron Facilities; Gas-based Detectors 2 / 115

High Granularity Resistive Micromegas for high particle rates environment.

Authors: Camilla Di Donato[1]; Fabrizio Petrucci[2]; Givi Sekhniaidze[1]; Maria Teresa Camerlingo[2]; Mariagrazia Alviggi[1]; Massimo Della Pietra[1]; Mauro Iodice[3]; Paolo Iengo[4]; Roberto Di Nardo[5]; Stefano Franchellucci[6]; Vincenzo Canale[1]

[1] *Universita e sezione INFN di Napoli (IT)*

[2] *Universita e INFN Roma Tre (IT)*

[3] *INFN - Sezione di Roma Tre*

[4] *CERN*

[5] *Università e INFN Roma Tre (IT)*

[6] *Universite de Geneve (CH). It was Universita e INFN Roma Tre (IT)*

Corresponding Authors: stefano.franchellucci@cern.ch, givi.sekhniaidze@cern.ch, maria.teresa.camerlingo@cern.ch, mariagrazia.alviggi@cern.ch, roberto.di.nardo@cern.ch, camilla.di.donato@cern.ch, vincenzo.canale@cern.ch, paolo.iengo@cern.ch, fabrizio.petrucci@cern.ch, massimo.della.pietra@cern.ch

We present the latest performance studies of high-granularity resistive Micromegas (MM) detectors for tracking applications in high-rate environment. Nowadays MM are being used as tracking detectors in HEP experiment upgrades as in ATLAS experiment at LHC. To fulfill the requirements of stable and efficient operations up to particle fluxes as high as 10 MHz/cm2 coming from future High Energy Physics experiments, we produced and characterized several prototypes of resistive MM detectors with high granularity readout plane, with 1x3 mm2 size pads, and different resistive protection schemes, exploiting a pad-patterned layer or two uniform Diamond Like Carbon (DLC) layers.
In the pad-patterned layout each pad is totally separated from the neighbors. The anode pads are overlaid by resistive pads, both interconnected by intermediate "embedded"resistors.
In the double uniform resistive layers layout, each layer is obtained by a thin sputtering deposition of DLC on insulating foils. The two resistive layers are interconnected between them and to the readout pads with a network of conducting links with a few mm pitch, to evacuate the charge.
Characterization, performances, and stability studies of many prototypes have been carried out by means of radioactive sources, X-Rays, and particle beams. A comparison of the performance obtained with the different resistive layouts is reported, focusing on the response under high irradiation and high-rate exposure leading to an assessment of their potential. To cope with the high number of readout channels and allow for the size scalability of the detector avoiding dead areas, we are studying the integration of the readout electronics in the back of the detector. Preliminary results obtained with the first prototype with embedded front-end chip will also be presented.

Your name:

Massimo Della Pietra

email:

massimo.della.pietra@cern.ch

Title:

Prof.

Nationality:

Italian

Institute:

University of Naples "Federico II" and INFN-Naples

Gas-based Detectors 1 / 116

Micromegas sectors for the ATLAS Muon Upgrade, towards the installation of the New Small Wheel in 2021

Author: Luca Martinelli[1]

Co-author: Mauro Iodice [2]

[1] *Sapienza Universita e INFN, Roma I (IT)*

[2] *INFN - Sezione di Roma Tre*

Corresponding Author: luca.martinelli@cern.ch

The ATLAS experiment is currently upgrading the first muon station in the high-rapidity region with the construction of new detector structures, named New Small Wheels (NSW), based on large-size multi-gap resistive strips Micromegas technology and small-strip Thin Gap Chambers (sTGC).

The NSW system will be installed in the ATLAS underground cavern during the LHC long shutdown 2 to enter in operation for Run3.
128 Micromegas quadruplets, each of which provides four measurements of a particle track, are needed to build the two New Small Wheels, covering a total active area of about 1280 m2. The construction of all MM modules, carried out in France, Germany, Italy, Russia and Greece, is completed. Their mechanical integration into sectors, the installation of on-detector services and electronics, for the first NSW is also completed, along with all validation and acceptance tests. The preparation of the second NSW is very well advanced.
The advanced status of the project, in view of the imminent installation of the two NSW in ATLAS by the fall of 2021 will be reported.
The presentation will describe the integration workflow of Micromegas detector into sectors and will focus on their cosmic rays results of the final validation tests.

Your name:

Mauro Iodice

email:

mauro.iodice@cern.ch

Title:

Nationality:

Italian

Institute:

INFN - Roma Tre

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 117

Small-Strip Thin Gap Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment

Author: Xinfei Huang[1]

[1] *University of Michigan*

Corresponding Author: xinfei.huang@cern.ch

The instantaneous luminosity of the Large Hadron Collider at CERN will be increased by about a factor of five with respect to the design value by undergoing an extensive upgrade program over the coming decade. The largest phase-1 upgrade project for the ATLAS Muon System is the replacement of the present first station in the forward regions with the New Small Wheels (NSWs) during the long-LHC shutdown in 2019-2021. Along with Micromegas, the NSWs will be equipped with eight layers of small-strip thin gap chambers (sTGC) arranged in multilayers of two quadruplets, for a total active surface of more than 2500 m^2. To retain the good precision tracking and trigger capabilities in the high background environment of the high luminosity LHC, each sTGC plane must achieve a spatial resolution better than 100 μm to allow the Level-1 trigger track segments to be reconstructed with an angular resolution of approximately 1mrad. The sTGC structure consists of a grid of gold-plated tungsten wires sandwiched between two resistive cathode planes at a small distance from the wire plane. The precision cathode plane has strips with a 3.2mm pitch for precision readout and the cathode plane on the other side has pads for triggering. The sTGC design, performance, construction and integration status will be discussed, along with results from tests of the chambers with beams, cosmic rays and high-intensity radiation sources. The status of commissioning the sTGC for ATLAS installation will also be updated

Your name:

Mauro Iodice

email:

mauro.iodice@cern.ch

Title:

Nationality:

Italian

Institute:

INFN - Roma Tre

Advances in Pixel Detectors and Integration Technologies I / 118

Latest developments and characterisation results of the MALTA sensors in TowerJazz 180nm for High Luminosity LHC

Author: Andrea Gabrielli[1]

Co-authors: Abhishek Sharma [1]; Carlos Solans Sanchez [1]; Craig Buttar [2]; Daniela Bortoletto [3]; Dominik Dobrijevic [4]; Florian Dachs [1]; Francesco Piro [5]; Heidi Sandaker [6]; Heinz Pernegger [1]; Ignacio Asensi Tortajada [7]; Jose Torres Pais [7]; Leyre Flores Sanz De Acedo [2]; Mateusz Dyndal [8]; Milou Van Rijnbach [6]; Patrick Moriishi Freeman [9]; Petra Riedler [1]; Philip Patrick Allport [10]; Roberto Cardella [11]; Tomislav Suligoj [12]; Valerio Dao [1]; Walter Snoeys [1]

[1] *CERN*

[2] *University of Glasgow (GB)*

[3] *University of Oxford (GB)*

[4] *University of Zagreb (HR)*

[5] *EPFL - Ecole Polytechnique Federale Lausanne (CH)*

[6] *University of Oslo (NO)*

[7] *Univ. of Valencia and CSIC (ES)*

[8] *AGH UST Krakow*

[9] *University of Birmingham (GB)*

[10] *University of Birmingham (UK)*

[11] *Universite de Geneve (CH)*

[12] *University of Zagreb*

Corresponding Authors: heidi.sandaker@cern.ch, milou.van.rijnbach@cern.ch, andrea.gabrielli@cern.ch, patrick.moriishi.freeman@cern.ch, dominik.dobrijevic@cern.ch, walter.snoeys@cern.ch, ignacio.asensi@cern.ch, jose.torres@uv.es, roberto.cardella@unige.ch, craig.buttar@glasgow.ac.uk, philip.patrick.allport@cern.ch, tomislav.suligoj@fer.hr, valerio.dao@cern.ch, heinz.pernegger@cern.ch, mateusz.dyndal@cern.ch, abhishek.sharma@cern.ch, leyre.flores.sanz.de.acedo@cern.ch, petra.riedler@cern.ch, francesco.piro@cern.ch, florian.dachs@cern.ch, carlos.solans@cern.ch, daniela.bortoletto@cern.ch

MALTA is a novel monolithic active pixel CMOS sensor chip designed in TowerJazz 180nm imaging technology which targets radiation hard applications for the HL-LHC and beyond. Several process modifications and front-end improvements have been investigated and have resulted in radiation hardness up to 2e15 n/cm2 with time resolution below 2 ns. Further improvements to detector efficiency have been explored by changing the starting material for these sensors and using Czochralski instead of epitaxial silicon. This contribution will present the results from latest submission from the extensive lab testing and the characterization in particle beam tests with special focus on the new MALTA2 sensor.

Your name:

andrea gabrielli

email:

andrea.gabrielli@cern.ch

Title:

Dr

Nationality:

Institute:

CERN

Applications in Condensed Matter; Position Sensitive Fast Timing Detectors 2 / 119

A Novel Ultra-High-Speed CMOS Image Sensor Implementation with Variable Spatial and Temporal Resolution using Temporal Pixel Multiplexing

Author: Deividas Krukauskas[1]

Co-authors: Ben Marsh [2]; Seddik Benhammadi [3]; Nicola Carlo Guerrini ; Iain Sedgwick [3]

[1] *Science and Technology Facilities Council*

[2] *Rutherford Appleton Laboratory*

[3] *STFC*

Corresponding Authors: ben.marsh@stfc.ac.uk, nicola.guerrini@stfc.ac.uk, seddik.benhammadi@stfc.ac.uk, iain.sedgwick@stfc.ac.u deividas.krukauskas@stfc.ac.uk

Temporal Pixel Multiplexing (TPM) is a new imaging modality allowing one CMOS image sensor to do the job of both high-resolution still photography and high-speed video with equal ease. Based on the desired trade-off between the number of frames in a high-speed burst and the video resolution, the sensor splits the pixel array into multi-pixel sub-groups defined prior to image capture. The current TPM design provides a high degree of flexibility in setting the size of these sub-groups, e.g., 2x2, 3x3, etc., and evenly distributes the resulting pixel groups across the entire array. When acquiring a single image frame, all pixels are exposed with the same integration time using a global shutter operation. Data is then readout as in a standard CMOS image sensor. When high-speed video is to be acquired, each pixel in a sub-group is exposed with a different integration time. These times have the same length, but can be offset from each other, resulting in each pixel acquiring a different frame of the high-speed video. The sensor presented here can offset these times by as little as 100ns. Therefore, for example, a 9x9 sub-group can acquire 81 frames of 10Mfps video footage. The resulting output is a single high-resolution image that can be post-processed into a short movie, formed from an ultra-high-speed sequence of lower resolution frames, consisting of pixels which have been exposed at the same time and collected together. This demonstrates the key benefit of the TPM technique - the capability to retrieve both a high-resolution image and a high-speed image sequence from a single picture with no added readout noise.

We present the first silicon implementation of a CMOS sensor employing the TPM imaging technique. The presentation covers the TPM sensor architecture, performance and functionality test results, and application benefits of the TPM method.

Your name:

Deividas Krukauskas

email:

deividas.krukauskas@stfc.ac.uk

Title:

Mr

Nationality:

Lithuanian

Institute:

UKRI-STFC

Medical Applications of Position Sensitive Detectors 1 / 120

Upstream MLC leaf position detection in complex radiotherapy fields

Authors: Jordan Pritchard[1]; Jaap Velthuis[1]; Lana Beck[1]; Yutong Li[1]; Chiara De Sio[1]; Richard Hugtenburg[1]

[1] *University of Bristol*

Corresponding Authors: jordan.pritchard@bristol.ac.uk, yutong.li@bris.ac.uk, jaap.velthuis@bris.ac.uk, r.p.hugtenburg@swansea.ac.uk, chiara.desio@bris.ac.uk, lana.beck@bristol.ac.uk

Multileaf collimators (MLC) are an integral component in modern radiotherapy as they dynamically shape the MV photon treatment field and therefore need to be closely monitored to ensure correct treatment delivery. Currently, MLC leaves are calibrated to ±1 mm every 3 months, however leaves can drift beyond this during calibration dates and treatment verification only occurs post-treatment. MAPS detectors are radiation hard for photon and electron irradiation, have high readout speeds and low attenuation which makes them ideal upstream radiation detectors. Previously, we reported on leaf position reconstruction for single leaves using the Lassena, a 12x4 cm2, three side buttable MAPS suitable for clinical deployment. Sobel filter-based methods were used for edge reconstruction. It was shown that correspondence between reconstructed and set leaf position was excellent and resolutions ranged between 60.6±8 and 109±12 µm for a single central leaf with leaf extensions ranging from 1 to 35 mm using 0.3 sec of treatment beam time. Here, we report on leaf edge reconstruction using Sobel filter-based methods in complex leaf configurations, as in clinical use with extensions ranging up to 120 mm. The Lassena detector was placed in the treatment field of an Elekta Agility LINAC with MLC leaves of width 0.5 cm extended into the field creating various leaf configurations. Results show that leaf positions can be reconstructed with resolutions between 78±7 and 149±14 µm at the iso-centre using 0.15 sec long treatment segments. These resolutions significantly exceed current calibration standards.

Your name:

Jordan Pritchard

email:

Jordan.Pritchard@bris.ac.uk

Title:

Mr

Nationality:

British

Institute:

University of Bristol

Poster Session 3 (Applications in Particle Physics) / 121

Precision Antihydrogen Annihilation Reconstructions using the ALPHA-g Apparatus

Author: Pooja Woosaree[1]

[1] *University of Calgary*

Corresponding Author: pooja.woosaree@ucalgary.ca

The ALPHA (Antihydrogen Laser PHysics Apparatus) experiment aims to provide a possible solution to the baryonic asymmetry problem by testing CPT (charge conjugation, parity reversal, time reversal) theory and observing whether antimatter follows Einstein's Weak Equivalence Principle (WEP), where the acceleration due to gravity that a body experiences is independent of its structure or composition. A measurement of this nature has never been done before, as previous experiments used charged particles which meant the experiments were dominated by electromagnetic forces. The ALPHA-g apparatus will use electrically neutral antihydrogen produced in a vertical Penning-Malmberg trap and hold the antihydrogen in a magnetic well. Once the antihydrogen is released, the position of the resulting annihilation can be reconstructed with a radial TPC (time projection chamber) surrounding the trapping volume [1].

Position information can be determined by the signal generated by the products of the annihilations as they travel through the TPC. Tracing these products accurately to their point of origin is imperative to understanding the direction of antihydrogen. I will focus on how these calculations are done through simulations, and how the process will compare to real data. This data will be used to measure the gravitational mass of antihydrogen, making this a crucial step in testing the fundamental symmetry of matter and antimatter. The ALPHA-g apparatus is currently being commissioned at CERN, and the first gravitational measurements of antihydrogen are expected to begin in October 2021.

[1] Capra, A., et al. "Design of a Radial TPC for Antihydrogen Gravity Measurement with ALPHA-g."Proceedings of the 12th International Conference on Low Energy Antiproton Physics (LEAP2016).

Your name:

Pooja Woosaree

email:

pooja.woosaree@ucalgary.ca

Title:

Ms

Nationality:

Institute:

University of Calgary

Applications in Security and Environmental Imaging; Advances in Pixel Detectors and Integration Technologies 2 / 122

X-ray/Neutron Flat-Panel Detector using LCD Technology (in-person)

Author: Mohammad Hamdan[1]

Co-authors: Yutaka Otaka ; Yuki Mitsuya [1]; Kenji Shimazoe [1]; Hiroyuki Takahashi [1]; Takanori Tsunashima [2]; Atsunori Ooyama [3]; Marina Mochizuki [3]; Isao Suzumura [3]; Tomoyuki Ito [3]

[1] *The University of Tokyo*

[2] *Device Development Department, R&D Division, Japan Display Inc.*

[3] *Device Development Department, R & D Division, Japan Display Inc.*

Corresponding Authors: leo@n.t.u-tokyo.ac.jp, shimazoe@bioeng.t.u-tokyo.ac.jp, moh-hamdan@g.ecc.u-tokyo.ac.jp, tomoyuki.ito.sm@j-display.com, yukimitsuya@tokai.t.u-tokyo.ac.jp

In this study, we present the results of our evaluation of a newly created flat panel detector. We have adapted the liquid crystal display technology to create an array of thin-film transistors and photodiodes, which can be used for flat-panel detector for radiation imaging. Our prototype flat-panel detector has a pixel size of 50 µm square and 252 x 256 pixels. By combining this panel with a scintillator, we implemented a flat panel detector for X-rays and neutrons. The scintillator was ZnS/LiF with a thickness of 0.4 mm. First, we evaluated the spatial resolution of the flat-panel detector using X-ray. The X-ray tube voltage was set to 30-160 kV and the tube current to 3 mA. The time for total area scanning were 227 ms, and we repeated 1000 times for averaging the images. The spatial resolution was measured up to 2.5 LP/mm. Secondly, we evaluated the flat-panel detector using neutron beam in Japan Proton Accelerator Research Complex (J-PARC) MLF BL-10. The neutron intensity at BL-10 was $4.8{\times}10^7 n/s/cm^2$ with neutron energies below 0.4 eV at the sample position. The total-area scanning was repeated 1000 times and images were integrated as in the case of X-rays. As a result, the images were successfully obtained for the neutron beam as well. We evaluated the spatial resolution using a Gd resolution gauge. As a result, 0.2 mm pitch (2.5 LP/mm) strips could be discriminated, and the spatial resolution was comparable to that of the X-ray cases.

Your name:

Mohammad Hamdan

email:

moh-hamdan@g.ecc.u-tokyo.ac.jp

Title:

Mr

Nationality:

Indonesia

Institute:

The University of Tokyo

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 123

The coordinate sensitive detector based on the MA-20 multianode PMT with high space and time resolution

Authors: Alexandre Gorin[None]; Valeri Brekhovskikh[1]; Mickael Medynsky[None]; Vladimir Dyatchenko[None]; Vladimir Rykalin[None]

[1] *Institute for High Energy Physics of NRC Kurchatov Institute (R*

Corresponding Author: valeri.brekhovskikh@cern.ch

The work is dedicated to the discussion of the possibility of creating a position-sensitive detector with both high coordinate reconstruction and time resolution. The work is presented the simulation results and the experimentally obtained data for a prototype detector on the basis of a multianode PMT MA-20 and a linear assembly of scintillating crystal or plastic strips.

The multianode position-sensitive PMT MA-20 has a semitransparent bi-alkaline photocathode with the size of the sensitive area of $10 \times 200\ mm^2$, 20 evaporated type bi-alkaline dynodes of the same length and 20 separate anodes.

An assembly of scintillating strips made of GSO (gadolinium orthosilicate) crystals with an element size of $3 \times 10 \times 50\ mm^3$, or of BGO (bismuth germanate) crystals with an element size of $5 \times 15 \times 40\ mm^3$ also, and finally set of plates made of a plastic scintillator were used for experimental measurement of a coordinate resolution of the detector prototype. Coordinate resolution was determined by the position of the center of gravity of charges from neighboring dynodes.

The use of a multi-anode photomultiplier in combination with the array of crystal or plastic scintillators allows one to get the detector with a high performance in both spatial and time resolution and also a low level of intrinsic noise in comparison, for example, with silicon PMT's. An ideal resolution simulation was performed for a system consisting of a one-dimensional array of scintillation strips. The experimental dependencies of the signal value versus position of optical fiber with a diameter of 1 mm on the photocathode of the 20 anode PMT were also measured. As a result of processing the collected data, space resolution was obtained at level of $\pm 0.7\ mm$, with a time resolution of around $\pm 1.0\ ns$.

Your name:

Valery

email:

brekhovs@ihep.ru

Title:

Dr

Nationality:

Russian

Institute:

NRC "Kurchatov Institute"–IHEP

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 124

Flexible X-Ray Imaging Detectors Using Scintillating Fibers

Authors: Christos Anastopoulos[1]; Kristin Lohwasser[1]; Scott Wilbur[1]; Giorgos Asfis[2]; Jannis Koch[3]; Martin Angelmahr[3]

[1] *University of Sheffield (GB)*

[2] *TWI Hellas*

[3] *Fraunhofer Heinrich Hertz Institute*

Corresponding Authors: s.h.wilbur@sheffield.ac.uk, kristin.lohwasser@cern.ch, christos.anastopoulos@cern.ch

We will present designs and simulations of a novel X-ray imaging detector. The intent of the FleX-RAY project is to create a digital X-ray detector that is capable of producing high-resolution images, is flexible enough to produce an image on a curved surface, and is capable of self-reporting its final shape.

The X-rays will be detected on a sheet of scintillating optical fibers, which will guide the scintillation light to single-photon avalanche photodiodes. This setup allows the electronics and hardware to be moved out of the path of the X-ray beam, limiting the need for additional shielding. Self-shape-reporting will be achieved using a flexible ultra-thin glass foil substrate with optical waveguides and Bragg gratings, processed by femtosecond laser point-by-point writing. The functionalized glass substrate allows precise measurement of strains, which can be used to calculate the shape.

This presentation will describe the results of simulations of the detector using a range of materials, geometries, and X-ray sources. By modifying these parameters, we can optimize the detector for various applications.

Your name:

Scott Wilbur

email:

s.h.wilbur@sheffield.ac.uk

Title:

Dr

Nationality:

USA

Institute:

University of Sheffield

Detectors for FELS, Synchrotrons and Other Advanced Light Sources / 125

Advancing the JUNGFRAU detector towards low-energy X-ray applications

Authors: Aldo Mozzanica[1]; Andre Al Haddad[2]; Bernd Schmitt[2]; Dmitry Ozerov[2]; Kirsten Andrea Schnorr[2]; Viktoria Hinger[2]

Co-authors: Anna Bergamaschi [3]; Carlos Lopez Cuenca [1]; Davide Mezza [2]; Dominic Greiffenberg [4]; Erik Fröjdh [4]; Jiaguo Zhang [2]; Konstantinos Moustakas [1]; Martin Brückner [1]; Pawel Kozlowski [1]; Rebecca Barten [2]; Roberto Dinapoli [2]; Sabina Chiriotti Alvarez [1]; Shqipe Hasanaj [2]; Thomas King [2]

[1] *PSI - Paul Scherrer Institut*

[2] *Paul Scherrer Institut*

[3] *PSI*

[4] *PSI - Paul Scherrer Institute*

Corresponding Authors: konstantinos.moustakas@psi.ch, andre.al-haddad@psi.ch, shqipe.hasanaj@psi.ch, anna.bergamaschi@psi.ch, erik.froejdh@psi.ch, davide.mezza@psi.ch, aldo.mozzanica@psi.ch, dominic.greiffenberg@psi.ch, viktoria.hinger@psi.ch, carlos.lopez-cuenca@psi.ch, sabina.chiriotti-alvarez@psi.ch, pawel.kozlowski@psi.ch, bernd.schmitt@psi.ch, dmitry.ozerov@psi.ch, martin.brueckner@psi.ch, roberto.dinapoli@psi.ch, jiaguo.zhang@psi.ch, thomas.king@psi.ch, rebecca.barten@psi.ch, kirsten.schnorr@psi.ch

The charge integrating hybrid silicon pixel detector JUNGFRAU has found widespread use for hard X-ray applications at free-electron laser (FEL) and synchrotron facilities. Equipped with three dynamic switching gains at pixel level, the most recent version of JUNGFRAU offers single photon resolution from at least 1.2 keV and a high dynamic range of 10^4 12 keV photons at a maximum frame rate of 2 kHz. The detector hardware is modular with a single module comprising 0.5 megapixels at a pixel size of 75×75 μm^2. Owing to the low noise performance, high dynamic range, position resolution, and easy scalability of the JUNGFRAU system, the detector is of high interest for applications in soft X-ray science.

Recently, a four-megapixel (4M) JUNGFRAU camera has been installed at the Maloja end station of the low energy beamline Athos of the Swiss free-electron laser (SwissFEL). The beamline operates at a photon energy range from 250 eV to 2 keV, making the current JUNGFRAU system applicable for experiments at the higher end of the available energy spectrum. At energies below ~1 keV, the readout capacitance of the hybrid detector limits the capability of resolving single photons. Signal amplification at sensor level could overcome this limitation and allow the JUNGFRAU system to significantly extend its low energy range.

In this contribution, we present first results of the Maloja JUNGFRAU 4M system, demonstrating the capabilities of the current detector version for soft X-ray science, and provide an outlook on efforts to couple the JUNGFRAU readout ASIC with LGAD sensors to achieve single photon resolution at energies below 1 keV.

Your name:

Viktoria Hinger

email:

viktoria.hinger@psi.ch

Title:

Nationality:

Institute:

Paul Scherrer Institut

Detectors for High Radiation and Extreme Environments / 126

First results from thin silicon sensors irradiated to extreme fluence

Author: Valentina Sola[1]

Co-authors: Arianna Morozzi [2]; Daniele Passeri [3]; Federico Siviero [1]; Francesco Moscatelli [4]; Giacomo Borghi [5]; Giovanni Paternoster [6]; Giulia Gioachin [7]; Luca Menzio [1]; Marco Ferrero [1]; Marco Mandurrino [8]; Marta Tornago [1]; Matteo Centis Vignali [9]; Maurizio Boscardin [10]; Nicolo Cartiglia [11]; Patrick Asenov [12]; Roberta Arcidiacono [1]; Simona Giordanengo [13]; Tommaso Croci [14]

[1] *Universita e INFN Torino (IT)*

[2] *INFN, Perugia (IT)*

[3] *Universita e INFN Perugia (IT)*

[4] *IOM-CNR and INFN, Perugia (IT)*

[5] *Fondazione Bruno Kessler*

[6] *Fondazione Bruno KEssler*

[7] *Università degli Studi di Torino (IT)*

[8] *INFN*

[9] *FBK*

[10] *FBK Trento*

[11] *INFN Torino (IT)*

[12] *Universita e INFN, Perugia (IT)*

[13] *Istituto Nazionale di Fisica Nucleare*

[14] *INFN - National Institute for Nuclear Physics*

Corresponding Authors: valentina.sola@cern.ch, tommaso.croci@pg.infn.it, gborghi@fbk.eu, boscardi@fbk.eu, cartiglia@to.infn.it, patrick.asenov.asenov@cern.ch, giulia.gioachin@edu.unito.it, francesco.moscatelli@cern.ch, giordane@to.infn.it, marco.mandurrino@to.infn.it, marta.tornago@cern.ch, roberta.arcidiacono@cern.ch, arianna.morozzi@pg.infn.it, daniele.passeri@unipg.it, marco.ferrero@cern.ch, paternoster@fbk.eu, luca.menzio@edu.unito.it, federico.siviero@edu.unito.it, matteo.centis.vignali@cern.ch

In this contribution, we present a new development of radiation-resistant silicon sensors produced by the Fondazione Bruno Kessler (FBK, Italy). The design of the sensors exploits the recently observed saturation of radiation damage effects on silicon, together with the usage of thin substrates, intrinsically less affected by radiation. To cope with the small signal coming from thin sensors, the internal multiplication of the charge carriers will be used. At FBK, Low-Gain Avalanche Diodes (LGADs) have been produced on 25 and 35 μm thick p-type epitaxial substrates: when new, the signal multiplication will occur due to the gain layer typical of the LGAD design; after irradiation, the loss of gain resulting by the deactivation of the gain layer atoms will be compensated by the increase of the operating bias. The goal is to prove that the new sensors can efficiently operate up to fluences of 1E17 1MeV neutron equivalent/cm^2.

Your name:

Valentina Sola

email:

valentina.sola@cern.ch

Title:

Dr

Nationality:

Italian

Institute:

INFN Torino

Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science 2 / 127

Charge-to-light signal conversion in liquid xenon for future TPC detectors

Author: Fabian Kuger[1]

Co-author: Adam Brown [1]

[1] *Albert-Ludwigs-Universität Freiburg*

Corresponding Authors: fabian.kuger@physik.uni-freiburg.de, adam.brown@physik.uni-freiburg.de

Proportional scintillation of electrons in liquid noble gases is a promising signal amplification mechanism for future time projection chamber experiments (TPC) with liquid xenon targets. The detection of the charge signal in state-of-the-art multi-tonne dark matter experiments, like XENONnT or LZ,

relies on the extraction of the electrons into a thin gas phase where proportional scintillation occurs in electrical fields of O(10 kV/cm). In our approach, scintillation photons are produced in liquid xenon within a few μm of thin wires, where electrical fields of O(500 kV/cm) can easily be obtained. Omitting the gas phase overcomes technical challenges limiting the performance of large detectors and allows alternative design approaches with potentially increased science reach.
We discuss the paradigm change in charge signal reconstruction using this amplification method with respect to the traditional dual phase scheme. Exemplary aspects with significantly improved detector performance will be shown.
Furthermore, we report on experimental measurements showcasing position sensitive event reconstruction capability in a small scale R&D detector.

Your name:

Fabian Kuger

email:

Fabian.Kuger@physik.uni-freiburg.de

Title:

Nationality:

german

Institute:

University of Freiburg

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 128

Towards 2D Dosimetry using Monolithic Active Pixel Sensors and a Copper Grating

Authors: Chiara De Sio[1]; Jaap Velthuis[1]; Lana Beck[1]; Jordan Pritchard[1]; Richard Hugtenburg[2]; Yutong Li[1]

[1] *University of Bristol*

[2] *Swansea University*

Corresponding Authors: jaap.velthuis@bristol.ac.uk, chiara.desio@bristol.ac.uk, lana.beck@bristol.ac.uk, yutong.li@bristol.ac.uk, jordan.pritchard@bristol.ac.uk, r.p.hugtenburg@swansea.ac.uk

Higher energy and intensity X-ray radiotherapy treatments are coming into wider use, having the benefit of requiring fewer treatment fractions and fewer hospital visits per patient. However, small percentage errors in MLC positioning and dose become bigger problems with higher doses per fraction. Hence, real-time treatment verification becomes essential. Where devices downstream from the patient suffer from scattering in the patient, upstream devices can disturb the therapeutic beam. Here, a method is proposed for performing dosimetry using Monolithic Active Pixel Sensors, which can be made thin enough to disturb the beam by <1%. To calculate the dose to the tumour, a verification device needs to make a measurement of the photon field. Some photons will Compton scatter an electron in the silicon and generate a signal. However, this signal is obscured by energy deposits from contamination electrons, originating from Compton scattering in the accelerator head and air. Often extensive build-up material is added to verification devices to reduce the electron contamination and enhance the photon signal. However, this leads to degradation of the beam intensity to the patient. Instead we propose using thin strips of 50 um thick copper in a grating pattern and measuring the difference in the signal with and without it. The contamination electrons are relatively undisturbed by the presence of the thin copper strips and the photon signal generated via Compton scattering is enhanced. Hence the difference in the two signals mostly consists of energy deposits originating from the therapeutic photons. From this the dose to the patient can be derived. Using

this technique, we show that the electron contamination signal can be reduced from 38% of the total signal to 2.6%. This allows to extract the photon signal only from the data and thus the dose to patient with a very thin upstream detector.

Your name:

Lana Beck

email:

lana.beck@bristol.ac.uk

Title:

Dr

Nationality:

Institute:

University of Bristol

Medical Applications of Position Sensitive Detectors 1 / 130

LGAD-based detectors for monitoring therapeutic proton beams

Authors: Anna Vignati[1]; Mohammed Abujami[2]; Cosimo Galeone[3]; Sara Garbolino[4]; Simona Giordanengo[5]; Omar Hammad Ali[6]; Oscar Ariel Marti Villarreal[1]; Felix Mas Milian[7]; Gianni Mazza[4]; Richard James Wheadon[8]; Roberto Cirio[4]; Roberto Sacchi[9]; Vincenzo Monaco[4]

[1] *Università degli Studi di Torino and INFN - National Institute for Nuclear Physics*

[2] *Università degli Studi di Torino and INFN - National Insitute for Nuclear Physics*

[3] *Università degli Studi di Torino*

[4] *Universita e INFN Torino (IT)*

[5] *Istituto Nazionale di Fisica Nucleare*

[6] *Fondazione Bruno Kessler (FBK)*

[7] *Università degli Studi di Torino and INFN*

[8] *INFN - National Institute for Nuclear Physics*

[9] *Universita e INFN (IT)*

Corresponding Authors: omar.hammadali@to.infn.it, oscar.martivillarrea@edu.unito.it, cosimo.galeone@unito.it, mohammed.abujami@unito.it, richard.wheadon@to.infn.it, anna.vignati@to.infn.it, giordane@to.infn.it, roberto.sacchi@cern.ch, monaco@to.infn.it, sara.garbolino@cern.ch, cirio@to.infn.it, mazza@to.infn.it

Purpose. Two prototypes for beam monitoring in particle therapy are being developed based on LGAD technology, aiming at improving and enriching the performances of state-of-the-art gas detectors. The results of tests on clinical proton beams are presented.
Methods. A proton counter for online fluence beam monitoring is made of sensors featuring 3.0x0.5 cm^2, 30 strips (150 μm pitch), 50 μm active thickness, readout using 40 dB amplifiers and a 5 Gs/s digitizer. Counting inefficiencies due to signal pile-up are mitigated combining two neighboring strips counts. A 2.7x2.7 cm^2 sensor (146 strips) with dedicated front-end board, readout with FPGAs, will be the final counter at the project end. The second prototype sets two thinned sensors (70 μm total thickness, 11 strips of 2.2 mm^2 area each) in a telescope for measuring the Time of Flight (ToF) and derive the beam energy. The signals are readout through dedicated front-end boards, acquired with a 5Gs/s digitizer and processed with MALTAB. A high-precision positioning system allows changing the sensors relative distance in the telescope with 10 μm precision. The counter prototype was tested at Trento Proton Therapy Center (Italy) at different beam energies with different beam currents, while the ToF prototype was tested at both Trento and CNAO (Pavia, Italy).

Results. The error on the counting efficiency is < 1% up to a proton fluence rate of 1x10^8 Hz/cm^2 and, after pile-up corrections, 5x10^8 Hz/cm^2. A calibration procedure of the telescope prototype allows measuring the beam energy with deviations of a few hundred keV for most of the energies in the clinical range (60-230 MeV), corresponding to less than 1 mm range difference.
Conclusion. Preliminary tests of LGAD sensors segmented in strips demonstrate their capabilities as beam monitors, for both counting and beam energy measurement purposes. Future required developments will be reported.

Your name:

Anna Vignati

email:

anna.vignati@to.infn.it

Title:

Dr

Nationality:

Italian

Institute:

Università degli Studi di Torino and INFN - National Institute for Nuclear Physics

Applications in Nuclear Physics and Nuclear Industry; X-ray and Gamma Ray Detectors 1; Medical Applications of Position Sensitive Detectors 2 / 131

Characterization of a large LGAD sensor for proton counting in particle therapy

Authors: Oscar Ariel Marti Villarreal[1]; Giuseppe Peroglio Carus[2]; Mohammed Abujami[2]; Matteo Centis Vignali[3]; Marco Ferrero[4]; Cosimo Galeone[2]; Simona Giordanengo[5]; Omar Hammad Ali[1]; Felix Mas Milian[2]; Anna Vignati[1]; Roberto Cirio[4]; Vincenzo Monaco[4]; Roberto Sacchi[6]

[1] *INFN - National Institute for Nuclear Physics*

[2] *UNITO*

[3] *FBK*

[4] *Universita e INFN Torino (IT)*

[5] *Istituto Nazionale di Fisica Nucleare*

[6] *University of Torino*

Corresponding Authors: cosimo.galeone@unito.it, cirio@to.infn.it, matteo.centis.vignali@cern.ch, marco.ferrero@cern.ch, oscar-ariel.marti-villarreal@to.infn.it, giordane@to.infn.it, felix.masmilian@unito.it, roberto.sacchi@unito.it, monaco@to.infn.it, mohammed.abujami@unito.it, giuseppe.perogliocar@edu.unito.it, omar.hammadali@to.infn.it, anna.vignati@to.infn.it

Purpose:
Based on LGAD technology, a fast proton counter prototype is being developed for the online monitoring of the fluence rate of therapeutic proton beams. The laboratory characterization of dedicated LGAD sensors segmented in strips covering an area of 2.7x2.7 cmˆ2 is reported.
Methods:
The LGAD sensor is segmented into 146 strips (160 um width, 26260 um length, 180 um pitch, 2 strips without gain, 144 strips with gain, and a nominal inter-strip distance of 66 um). A dedicated production at Fondazione Bruno Keeler (FBK, Trento, Italy) in 2020 consisted of 14 wafers with two different active thicknesses (55 um Si-Si wafers, 45 um for the Epi ones), with shallow gain implants, two p-gain doses, boron- low diffusion, co-implanted with a dose of carbon to improve the radiation resistance. Laboratory characterization of this production was performed at the University of Torino

and at FBK, using a probe station, connected with a power devices analyzer for static DC electrical test, and the TCT to study dynamic properties of our sensors.
Results:
A global yield ratio between working strips over the total number of strips measured in the entire production of 89.4% and a mean breakdown voltage for good sensors (sensors without bad strips) measured on the backplane of about 212 V were found. The average full depletion voltage obtained was 22.12-23.47 V and 34.98 V for Si-Si and Epi wafers, respectively. Furthermore, the ratio between the 90/10 percentile for the leakage current at 160 V was lower than 1.6 for all the cases. The inter-strip distance measured was 80.8 um, 22% larger than the nominal no-gain distance, as previously observed by other groups.
Conclusion:
The laboratory characterization showed good results and prepared the groundwork for the selection of the best set of sensors to be tested on clinical proton beams.

Your name:

Oscar Ariel Marti Villarreal

email:

martivil@to.infn.it

Title:

Dr

Nationality:

Cuban

Institute:

Universita e INFN Torino (IT)

Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science 2 / 132

The CMOS pixel sensors particle tracker for the CSES-02 space experiment

Authors: Enrico Serra[1]; Roberto Iuppa[2]; Silvia Coli[3]; Stefania Beole[3]; Ester Ricci[4]; Giuseppe Gebbia[5]; Lorenzo De Cilladi[3]; Paolo Zuccon[2]

[1] *INFN - National Institute for Nuclear Physics*

[2] *Universita degli Studi di Trento and INFN (IT)*

[3] *Universita e INFN Torino (IT)*

[4] *Universita degli Studi di Trento and INFN (IT)*

[5] *Università di Trento*

Corresponding Authors: coli@to.infn.it, beole@to.infn.it, roberto.iuppa@cern.ch, giuseppe.gebbia@unitn.it, lorenzo.de.cilladi@cern.ch, enrico.serra@tifpa.infn.it, paolo.zuccon@cern.ch, ester.ricci@cern.ch

The CSES (China Seismo-Electromagnetic Satellite) mission will put into orbit satellites to study perturbations in the ionosphere, possibly correlated with the occurrence of seismic events. The first satellite is successfully operated since 2018, and the launch of the second is scheduled for the end of 2022. CSES-02 will be supplied with a High-Energy Particle Detector (HEPD), designed for the detection of electrons (protons) in the 3-150 (30-250) MeV energy range.
Its tracker is based on the innovative monolithic pixel sensors ALPIDE, developed for the ALICE experiment, at CERN. This technology has never been used in the space environment. This talk will describe the spatialisation process carried out by the HEPD-02 tracker team, which has adapted the operation mode of the ALPIDE sensor to build a modular and compact particle detector. The tracker

is made of 5 turrets, each one containing 3 stacked sensitive planes. All of 150 ALPIDE sensors are interconnected with wire bonds to Flex Printed Circuits, used to transmit power, control, and readout data. The mechanical support consists of Carbon Fiber Reinforced Plastics structures, to which the chips are glued. We describe in detail the HEPD-02 tracker project, demonstrating the possibility of using MAPS in space and manifesting the pioneering nature of the project for next-future larger size space missions.

Your name:

Stefania Beole'

email:

stefania.beole@unito.it

Title:

Prof.

Nationality:

Italian

Institute:

University of Torino

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 134

Characterization of passive CMOS strip detectors

Author: Marta Baselga[1]

Co-authors: Arturo Rodriguez Rodriguez [2]; Dennis Sperlich [2]; Ingrid-Maria Gregor [3]; Jan Cedric Honig [2]; Leena Diehl [2]; Liv Wiik-Fuchs [2]; Marc Hauser [2]; Surabhi Sharma [1]; Tianyang Wang [4]; Tomasz Hemperek [4]; Ulrich Parzefall [2]

[1] *Deutsches Elektronen-Synchrotron (DE)*

[2] *Albert Ludwigs Universitaet Freiburg (DE)*

[3] *DESY & Bonn University*

[4] *University of Bonn (DE)*

Corresponding Authors: leena.diehl@cern.ch, tianyang.wang@cern.ch, jan.cedric.honig@cern.ch, surabhi.sharma@cern.ch, marta.baselga@cern.ch, themperek@cern.ch, dennis.sperlich@cern.ch, arturo.rodriguez.rodriguez@cern.ch, ulrich.parzefall@cern.ch, liv.antje.mari.wiik@cern.ch, marc.hauser@cern.ch, ingrid.gregor@desy.de

Silicon detectors are currently filling the trackers of largest particle accelerators and colliders. Their radiation hardness, spatial resolution and availability in large volume foundries make silicon the best candidate for tracking detectors. Current experiments such as ATLAS in the LHC and future experiments foresee to populate the innermost tracking layers with silicon detectors. But not so many foundries are capable of fabricating large area silicon detectors with a production line, therefore CMOS foundries are excellent candidates to be explored.

Here we study the performance of passive strip detectors fabricated in a CMOS foundry with a 150 nm technology process and 150 µm thick wafer. The strips have two different lengths with three or five stitching points, produced using two different reticles. It will be presented the electrical characterization, studies with a radioactive source and testbeam results for the passive CMOS strip sensors before and after irradiation. We will demonstrate that stitching strips do not have any negative effect on their performance.

Your name:

email:

marta.baselga@desy.de

Title:

Nationality:

Institute:

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 135

A Monte Carlo study for system development in low dose Molecular Breast Imaging (MBI)

Author: Hannah Brown[1]

[1] *University of Liverpool*

Corresponding Author: sghbrow2@liverpool.ac.uk

Molecular Breast Imaging (MBI) is a diagnostic technique which uses the radioisotope Technetium-99m to identify lesions within the breast. Cadmium Zinc Telluride (CZT) is a desirable detector material for use in MBI primarily due to its good position resolution. This property makes the detector highly sensitive to 141 keV gamma rays and therefore allows for an isotope of lower activity to be administered to patients without compromising the image quality. The DMatrix Nuclear Imager is a pixelated CZT detector which has been developed by Kromek for applications including Medical Imaging. The detector has previously been characterised at the University of Liverpool for high activity application in Molecular Therapy. We are currently investigating the application of the system towards low activity measurements in MBI.

One of the primary aims of MBI is to optimise a detector system that minimises the dose delivered to the patient. The system consists of both a CZT detector and an imaging collimator, whose properties both contribute to the overall system performance. The collimator is required in order to reconstruct the path of the detected gamma-rays. It is desired that the collimator is optimised such that it complements the sub mm3 resolution achieved (through PSA) within the CZT. The desired imaging properties of good position resolution and high sensitivity are conflicting requirements in terms of collimator design and hence the collimator must be designed such that this trade-off is surmounted.

A Geant4 simulation has been developed to model Kromek's DMatrix system and explore its response to irradiation of 141 keV gamma rays. The simulation has also been used to model and compare the imaging performance of various collimator designs. The Monte-Carlo study is complemented by a suite of ongoing experimental work. In this talk, the results of the Monte-Carlo study will be presented.

Your name:

Hannah Brown

email:

sghbrow2@liverpool.ac.uk

Title:

Ms

Nationality:

British

Institute:

University of Liverpool

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 136

Single-Photon Avalanche Diode detector for Raman spectroscopy with time-gated fluorescence suppression.

Authors: Herman Larsen[1]; Iain Sedgwick[2]; Luca Ciaffoni[2]; Pavel Matousek[2]; Nick Waltham[2]; Nicola Carlo Guerrini[None]

[1] *Science and Technology Facilities Council*

[2] *STFC*

Corresponding Authors: nicola.guerrini@stfc.ac.uk, pavel.matousek@stfc.ac.uk, iain.sedgwick@stfc.ac.uk, nick.waltham@stfc.ac.uk, luca.ciaffoni@stfc.ac.uk, herman.larsen@stfc.ac.uk

Single-photon avalanche diode (SPAD) detectors are revolutionising modern imaging and spectroscopy thanks to detection capabilities at the level of individual photons and ultrafast response times. Very recently, time-gated cameras based on SPAD technology have been proposed for improving the performance and applicability of Raman spectrometers through addressing the suppression of fluorescence interference in the most commonly used, near infrared spectral region –one of the greatest, largely unmet, challenges in modern Raman spectroscopy. The effectiveness of existing solutions is at present restricted to a small subset of samples and regimes of operations due to their poor near-infrared (>800 nm) sensitivities, low frame rates and small 1D array formats.

To deliver a step-change in Raman detection capabilities, we propose the development of a SPAD sensor chip having near-infrared enhanced sensitivity (optimised for 750-950 nm), larger format (architecture scalable up to 1000x250 pixels) and timing resolution on the order of a few hundred picoseconds. The chip which will combine SPAD devices with an on-chip Delay Locked Loop (for timing accuracy), advanced counting architecture (for high light level applications) and a high speed readout (for high frame rates up to 40 Mfps). The design of the chip has been completed and submitted for fabrication in a 180 nm CMOS Image Sensor process. In this paper, we present the architecture of the device and discuss plans for future testing.

Your name:

Herman Larsen

email:

herman.larsen@stfc.ac.uk

Title:

Mr

Nationality:

Norwegian

Institute:

STFC

137

The ATLAS Muon spectrometer upgrade for the High Luminosity LHC using a new generation of Resistive Plate Chambers

Author: Mauro Iodice[1]

[1] *INFN - Sezione di Roma Tre*

The muon trigger of the ATLAS muon barrel is obtained using Resistive Plate Chambers (RPC). The legacy RPCs used in the experiment were designed to work to a reference luminosity of 10ˆ34 cm-2 s-1 with a safety factor of 5, with respect to the expected background rates, corresponding to about 300 fb-1 integrated luminosity. It is expected that HL-LHC will reach a 7.5 times higher luminosity, working until at least 2040, leading to an integrated luminosity of 5000 fb-1, which is far beyond the conditions the RPC were supposed to face.
In order to cope these conditions, a major RPC upgrade project is foreseen by ATLAS. A new full coverage layer of 272 new generation RPC triplet chambers, will be installed in the inner barrel (BI), increasing the redundancy, the selectivity and the acceptance of the trigger.

The new RPCs will have a rate capability and longevity extended by a factor of 10 thanks to a new integrated design of front end electronics and detector faraday cage. The RPC gas gap is halved with respect to legacy RPC providing a correspondingly increased time resolution exploited by the embedded electronics capable to transmit at deterministic latency digitized RPC hits with 60 ps precision.

This new layer of RPC will lead to a more redundant and flexible trigger algorithm, allowing at the same time to operate the legacy RPCs at lower tensions, in order to extend their longevity until to all HL-LHC duration.
The first prototypes of the new RPCs, using the newly designed gas gaps have been already produced and tested this year.
The state of art of the upgrade project, as well as the first performance results on the prototypes of the new generation RPCs will be presented.

Your name:

Mauro Iodice

email:

mauro.iodice@cern.ch

Title:

Nationality:

Italian

Institute:

INFN - Roma Tre

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 140

CMOS pixel sensors optimized for large ionizing dynamic

Authors: Christian Finck[1]; Jerome Baudot[2]; Christine Guo Hu[3]; Christoph Schuy[4]; Claire-Anne Reidel[4]; Eleuterio Spiriti[5]; Luca Federici[6]; Maciej Kachel[7]; Uli Weber[8]; WEIPING REN[9]; yue zhao[9]

[1] *Laboratoire de Physique Subatomique et des Technologies Associees*

[2] *IPHC - Strasbourg*

[3] *Centre National de la Recherche Scientifique (FR)*

[4] *GSI - Darmstadt*

[5] *INFN*

[6] *LNF, INFN-Frascati*

[7] *IPHC CNRS*

[8] *GSI Helmholtzzentrum*

[9] *IPHC*

Corresponding Authors: wpren@mails.ccnu.edu.cn, eleuterio.spiriti@lnf.infn.it, maciej.kachel@iphc.cnrs.fr, christine.guo.hu@cern.ch, c.a.reidel@gsi.de, luca.federici@lnf.infn.it, c.schuy@gsi.de, baudot@in2p3.fr, u.weber@gsi.de, yue.zhao@iphc.cnrs.fr, finck@subatech.in2p3.fr

Monolithic active pixel sensors (MAPS) are now well established as a technology for tracking charged particles, especially when low material budget is desirable. For such applications, the design of the sensor focus mainly on optimizing the spatial resolution. Small pixels with coarse charge measurement and digital outputs are well suited for this purpose.
Within the European Union's STRONG project that focuses on experiments using hadrons, the TI-IMM joint research activity intends to expand granular MAPS capacity to energy-loss (ΔE) measurement. The project targets to develop sensors for a wide input signal range. Covering energies from minimum ionization particles up to heavily ionization ions, such as carbon at few 100s MeV/u. The foreseen MAPS will combine tracking and identification.

The design challenge lies in the implementation of the front-end electronics in a small pixel (about 40 µm x 40 µm) that will be capable of operation with a wide dynamic range of the input signals (of the order of 1:105). .
TIIMM exploits recent advances in CMOS pixel sensors, where the sensitive layer is fully or partially depleted, allowing faster and more efficient charge collection.
in order to explore the tradeoff between fluctuations of the released charge and the minimization of multiple scattering.

The pixel architecture contains a charge sensitive amplifier with a Krummenacher feedback, a comparator and the digital logic performing the time-over-threshold measurements with 6-bit precision. First sensor prototype has been fabricated in the Tower-Jazz 180nm technology in 2020. The second corrected version is foreseen for a submission in Q3 2021. Both sensors feature different analogue front-end designs that affect the extent of the dynamic range (in excess of 105 e- equivalent input charge) and the fluctuation of the time-over-threshold output.
This contribution will detail the result of the analogue design optimization and initial tests of the first prototypes.

Your name:

email:

jerome.baudot@iphc.cnrs.fr

Title:

Nationality:

Institute:

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 141

Performance Measurements from Cosmic Muon Data using the Outer Barrel of the New ALICE Inner Tracking System

Author: James Philip Iddon[1]

[1] *University of Liverpool (GB)*

Corresponding Author: james.philip.iddon@cern.ch

The upgraded Inner Tracking System (ITS) of ALICE consists of 7 concentric layers of a custom monolithic active pixel sensor design known as ALPIDE. The ALPIDE-based detector design reduces the material budget to 0.35 % X_0 per layer for the innermost three layers (Inner Barrel), and to 1.0 % X_0 per layer for the outermost four layers (Outer Barrel), compared to 1.14 % X_0 per layer in the previous ITS. The readout rate has been improved to 100 kHz for Pb-Pb interactions, the radius of the first layer of the ITS reduced from 39 mm to 23 mm and the pixel pitch reduced to O(30 μm) $\times$ O(30 μm). These changes will improve the impact parameter resolution and tracking efficiency of heavy-flavour hadrons and dileptons at low transverse momenta, launching ALICE into the precision era of hot QCD physics.
The Outer Barrel was constructed at 10 sites around the world before being fully assembled into the intended barrel geometry and integrated into the readout electronics at CERN by the end of 2019. In the first half of 2020, the Outer Barrel underwent a series of verification tests to explore the performance of the finalised system. In the latter half of 2020, roughly 5 million cosmic muon events were measured by the Outer Barrel to further characterise the detector performance and provide a data set to be used for spatial alignment. This contribution will include a summary of the performance measurements made so far with the Outer Barrel, including a first measurement of the detector efficiency.

Your name:

James Philip Iddon

email:

james.philip.iddon@cern.ch

Title:

Mr

Nationality:

British

Institute:

University of Liverpool

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 142

The Hyperbolic drift chamber for ALERT

Author: Gabriel Charles[1]

[1] *Université Paris-Saclay (FR)*

Corresponding Author: gabriel.charles@cern.ch

A Low Energy Recoil Tracker (ALERT) experiment will occur in Hall B at Jefferson Laboratory, Virginia, USA. It will study the partonic structure of bound nucleons in He-4. The ALERT detector must track and identify low energy nucleons and light nuclei of momenta ranging from 70 MeV/c to 250 MeV/c at a rate up to 60 MHz. It will be used in tandem with the already installed CLAS12 spectrometer in Hall B to detect the scattered electrons.

ALERT is composed of a tracker and a time of flight detector (TOF). The tracker is designed to minimize the amount of material before the particles reach the TOF. This talk will present the ALERT Hyperbolic Drift Chamber developed for the tracker. It will detail the readout, mechanical and mounting challenges posed by the wire density of 24 wires/cm2. It will be followed by the resolutions expectations compared to the performance of prototype obtained during beam tests performed at a accelerator facility (ALTO) in Orsay, France.

Your name:

Gabriel CHARLES

email:

gabriel.charles@ijclab.in2p3.fr

Title:

Dr

Nationality:

French

Institute:

IJCLab

Poster Session 3 (Applications in Particle Physics) / 143

High-performance HV-CMOS sensors for future particle physics experiments - An overview

Authors: Chenfan Zhang[1]; Gianluigi Casse[1]; Matthew Lewis Franks[None]; Jan Patrick Hammerich[1]; Nissar Karim[2]; Samuel Powell[1]; Eva Vilella Figueras[1]; Joost Vossebeld[1]

[1] *University of Liverpool (GB)*

[2] *University of Liverpool*

Corresponding Authors: nissar.karim@liverpool.ac.uk, matthew.lewis.franks@cern.ch, joost.vossebeld@cern.ch, gianluigi.casse@cern.ch, chenfan.zhang@cern.ch, j.hammerich@cern.ch, vilella@hep.ph.liv.ac.uk, samuel.powell@cern.ch

Traditional hybrid silicon sensors are the most common tracking sensor technology in current particle physics experiments with high rates. However the limitations imposed by their composite structure make them unsuitable for many future experiments that require low material budget and high spatial resolution. High Voltage-CMOS (HV-CMOS) sensors, due to their significant advantages, are emerging as a prime candidate for future tracking applications that have extreme requirements on the material budget, granularity, time resolution and radiation tolerance.

HV-CMOS sensors integrate both the silicon sensor and readout ASIC into the same silicon substrate, thus eliminating the need for complex and laborious bump-bonding. The high voltage, at which the substrate is biased, creates a wide depletion region for fast charge collection by drift and high radiation tolerance. The feasibility of integrating analog and digital readout electronics on the same chip allows the production of fully monolithic HV-CMOS sensors. Therefore, HV-CMOS sensors have become a promising solution for future particle physics experiments, such as the Mu3e experiment, future upgrades of the Large Hadron Collider (LHC) and the Circular Electron Positron Collider (CEPC).

Despite the major improvements already demonstrated by HV-CMOS sensors, the enormous challenges set by future experiments demand substantial research to achieve further enhancements. The main goal of our R&D programme at Liverpool is to push the boundaries of HV-CMOS sensors to achieve a step-change improvement in their performance, especially in terms of single point resolution, fast-timing capability and radiation tolerance. This talk will give an overview of the latest developments in HV-CMOS sensors done by our group and present the design and measured results of a new HV-CMOS prototype chip. This chip is designed to further improve the radiation tolerance and time resolution of HV-CMOS sensors.

Your name:

email:

chenfan@hep.ph.liv.ac.uk

Title:

Nationality:

Institute:

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 145

Timing techniques with picosecond-order accuracy for novel gaseous detectors

Authors: Ioannis Manthos[1]; Kostas Kordas[2]; Maria Evanthia Tsopoulou[None]; Spyros Tzamarias[2]

[1] *University of Birmingham (GB)*

[2] *Aristotle University of Thessaloniki (GR)*

Corresponding Authors: ioannis.manthos@cern.ch, spyros.tzamarias@cern.ch, kostas.kordas@cern.ch

To meet the needs arising from the high-rate environments in current and future accelerators, detectors with high precision timing capabilities are of utmost importance. Dedicated R&D effort is carried out, resulting in novel detector technologies with excellent timing capabilities. Gaseous detectors instrumentation contributes to this effort and an example is the PICOSEC-Micromegas, which has demonstrated the ability to time 150GeV muons with 25ps timing resolution and photons beams (~70p.e.) with 6.8ps.
However, during R&D phase, the full waveform is usually used for the extraction of the timing information from the signal, increasing the data amount and requiring expensive, energy-consuming and bulky fast oscilloscopes. Towards forward applications and large-scale detectors, front-end electronics are of paramount importance to undertake the data acquisition. For each detection technology data acquisition should retain the signal timing characteristics and consequently the timing resolution on the particle's arrival time.
This work investigates the potential of timing techniques, alternative to the Constant Fraction Discrimination applied on the full digitised waveform, used in the data analysis of prototype detectors (i.e. for the PICOSEC Micromegas). More specifically, we investigate the adequacy of Time-over-Threshold timing technique using multiple constant thresholds, on experimental data. This method introduces a "time walk"that impinges on the timing resolution. We mitigate the effect of time walk using two different methods. In the first, the required correction is applied using the Time-over-Threshold value, while in the second approach the fraction of the area of the pulse that lies above the appropriately selected constant threshold value is used to parameterize the time walk correction. The results of this study prove the feasibility of the Time-over-Threshold timing technique using multiple thresholds for data acquisition and achieving resolution 10ths of picoseconds. We also demonstrate that similar results can be achieved using machine learning approaches.

Your name:

email:

maria-evanthia.tsopoulou@cern.ch

Title:

Nationality:

Institute:

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 146

Investigating machine learning solutions for a 256 channel TC-SPC camera with sub-70 ps single photon timing per channel at data rates > 10 Gbps.

Authors: Amelia Markfort[1]; Alexander Baranov[2]; Thomas Conneely[3]; Ayse Duran[4]; Jon Lapington[2]; James Milnes[4]; William Moore[4]; Andrey Mudrov[2]; Ivan Tyukin[2]

[1] *Photek*

[2] *University of Leicester*

[3] *Photek LTD*

[4] *Photek Ltd*

Corresponding Authors: ayse.duran@photek.co.uk, tom.conneely@photek.co.uk, james.milnes@photek.co.uk, ab155@leicester.ac.uk, jsl12@leicester.ac.uk, i.tyukin@leicester.ac.uk, will.moore@photek.co.uk, am405@leicester.ac.uk, amelia.markfort@photek.co.uk

The development of a Time Correlated Single Photon Counting (TCSPC) camera with 256 channels has enabled several applications where single photon sensitivity is crucial, such as LiDAR, Fluorescent Lifetime IMaging (FLIM) and Quantum Information Systems. The microchannel plate-based Multi-Anode Photo-Multiplier Tube (MAPMT) is a 16 × 16 array of 1.656 mm pitch pixels with an active anode area of 26.5 × 26.5 mm^2. Each pixel can time single photons with an accuracy of 60 ps rms at a maximum photon rate of 480 KHz.
The timing electronics are capable of measuring 120 Mcps, producing huge volumes of data for processing, in the region of 10 Gbps per detector. Limitations in algorithmic data analysis techniques are critical for this application so in this paper we demonstrate a machine learning (ML) model which can determine the photon event coordinates with the objective of processing each one photon per ˜10 µs. The model applies calibrations for the detector and electronics such as amplitude walk, and charge measurement and channel to channel threshold variation. Optimisation of the model is detailed within the paper, including training hyperparameters, the clustering of coincident events and compression of the model through pruning techniques.
The ML model is trained and tested on a simulation of the microchannel plate (MCP) PMT with timing electronics configured for use as a TCSPC camera, utilising charge sharing techniques to further improve the spatial resolution of the detector. We assess the performance of this approach compared to algorithmic approaches and introduce statistical reasoning of the robustness of the model. Further objectives of the research are to test the model on detector data, allowing assessment on the variance of accuracy between simulated and real data.

Your name:

Amelia Markfort

email:

amelia.markfort@photek.co.uk

Title:

Nationality:

Institute:

Photek

Position Sensitive Fast Timing Detectors 1 / 147

Optimization of gain layer doping, profile and carbon levels on HPK and FBK sensors

Authors: Abraham Seiden[1]; Michal Tarka[2]; Simone Michele Mazza[1]; Bruce Andrew Schumm[1]; Carolyn Gee[1]; Eric Ryan[3]; Francesco Ficorella[4]; Giacomo Borghi[5]; Gian Franco Dalla Betta[6]; Giovanni Paternoster[7]; Gregor Kramberger[8]; Hartmut Sadrozinski[1]; Hartmut Sadrozinski[9]; Igor Mandic[8]; Lucio Pancheri[10]; Marco Ferrero[11]; Marko Mikuz[8]; Marko Zavrtanik[8]; Matteo Centis Vignali[12]; Maurizio Boscardin[13]; Mohammad Nizam[14]; Nicolo Cartiglia[15]; Rene Padilla[16]; Roberta Arcidiacono[11]; Valentina Sola[11]; Vladimir Cindro[8]; Yuzhan Zhao[1]

[1] *University of California,Santa Cruz (US)*

[2] *UCSC*

[3] *University of California, Santa Cruz*

[4] *Fondazione Bruno Kessler, via Sommarive 18, 38123, Povo (TN), Italy*

[5] *Fondazione Bruno Kessler*

[6] *Universita degli Studi di Trento and INFN (IT)*

[7] *Fondazione Bruno KEssler*

[8] *Jozef Stefan Institute (SI)*

[9] *SCIPP, UC santa Cruz*

[10] *University of Trento and TIFPA-INFN*

[11] *Universita e INFN Torino (IT)*

[12] *FBK*

[13] *FBK Trento*

[14] *University of California Santa Cruz*

[15] *INFN Torino (IT)*

[16] *UC Santa Cruz*

Corresponding Authors: carolyn.mei.gee@cern.ch, boscardi@fbk.eu, remopadi@ucsc.edu, valentina.sola@cern.ch, gborghi@fbk.eu, cartiglia@to.infn.it, nizamphys@gmail.com, matteo.centis.vignali@cern.ch, ficorella@fbk.eu, hartmut@ucsc.edu, paternoster@fbk.eu, igor.mandic@ijs.si, abraham.seiden@cern.ch, marko.zavrtanik@cern.ch, baschumm@ucsc.edu, hartmut@scipp.ucsc.edu, ejryan@ucsc.edu, marko.mikuz@cern.ch, tarka.physics@gmail.com, simone.michele.mazza@cern.ch, gregor.kramberger@ijs.si, yuzhan.zhao@cern.ch, roberta.arcidiacono@cern.ch, vladimir.cindro@ijs.si, lucio.pancheri@unitn.it, marco.ferrero@cern.ch, gian.franco.dalla.betta@cern.ch

Low Gain Avalanche Detectors (LGADs) are thin silicon detectors (ranging from 20 to 50 um in thickness) with moderate internal signal amplification (up to a gain of ˜50). LGADs are capable of providing measurements of minimum-ionizing particles with time resolution as good as 17 picoseconds. In addition, the fast rise time (˜500ps) and short full charge collection time (˜1ns) of LGADs are suitable for high repetition rate measurements in photon science and other fields. The first implementation of this technology will be with the High-Granularity Timing Detector (HGTD) in ATLAS and the Endcap Timing Layer (ETL) in CMS for the high luminosity upgrade at the Large Hadron Collider (HL-LHC). The addition of precise timing information from LGADs will help mitigate the increase of pile-up and improve the detector performance and physics sensitivity. Past publications have proven the vast improvement in term of radiation hardness of deep gain layer and carbon implantation in LGAD designs. In this contribution a study will be shown on the tuning of the doping concentration in the deep gain layer of HPK sensors to optimize the performance before and after radiation damage. Furthermore the effect of the combination of a deep gain layer and carbon implantation in FBK sensors will be shown alongside an optimization of the carbon concentration level. Results on electrical properties and charge collection will be shown on pre and post irradiation. Sensors were irradiated at JSI (Ljubljana, Slovenia) with neutrons and at CYRIC (KEK, Japan) with protons, then tested using the beta-scope setup and probe stations at UCSC.

Your name:

Simone Mazza

email:

simazza@ucsc.edu

Title:

Nationality:

Institute:

UC Santa Cruz

Applications in Particle Physics 2 / 148

Development of CMOS Pixel Sensor prototypes for the high-rate CEPC vertex detector

Author: Ying Zhang[1]

Co-authors: Wei Wei [2]; Tianya Wu [3]; Raimon Casanova Mohr [4]; Xiaomin WEI ; Xiaoting Li ; liang zhang ; Jianing Dong ; Jia Wang ; Zhijun Liang [5]; Sebastian Grinstein [4]; Joao Barreiro Guimaraes Da Costa [5]

[1] *IHEP, Chinese Academy of Sciences (CN)*

[2] *IHEP, CAS, China*

[3] *Institut de Fisica d'Altes Energies (IFAE)(ES)*

[4] *IFAE - Barcelona (ES)*

[5] *Chinese Academy of Sciences (CN)*

Corresponding Authors: jndong@sdu.edu.cn, twu@ifae.es, zhang.l@sdu.ede.cn, raimon.casanova.mohr@cern.ch, weiw@ihep.ac.cn, sgrinstein@ifae.es, zhijun.liang@cern.ch, jwang@nwpu.edu.cn, zhangying83@ihep.ac.cn, lixt@ihep.ac.cn, guimaraes@ihep.ac.cn, weixm@nwpu.edu.cn

The proposed Circular Electron Positron Collider (CEPC) imposes new challenges for the vertex detector in terms of material budget, spatial resolution, readout speed, and power consumption. CMOS Pixel Sensor (CPS), as one of the promising candidate technologies, has been studied within the CEPC vertex detector R&D activities since 2015. According to the latest collider design and study on the beam-induced background, the highest hit rate for the vertex detector is expected to be ˜107/cm2/s. The TaichuPix chip is a CMOS Pixel Sensor being developed to meet the highest hit rate requirement of CEPC vertex detector. Two small scale prototypes capable of achieving a hit rate up to 36 MHz/cm2, were developed in a 180 nm CMOS process. This talk presents the dedicated improvements on the design of in-pixel readout to achieve a pixel pitch of 25 μm and a fast readout capability of 40 MHz. Two new fast in-pixel digital readout designs, benefiting from the FE-I3 and ALPIDE approaches, have been implemented. The readout of the pixel array is based on a new proposed "column-drain"architecture. Pixels are arranged in double columns, with priority encoder within column and timestamp recorded at the end of double column (EOC). All the double columns are read out in parallel, in order to minimize the dead time. When a hit is detected in one of the pixels, the end of column circuitry stores the current time stamp with a resolution of 25 ns. The data whose timestamp matches with the trigger (with a time window of 175 ns) are buffered for output in case of trigger mode. The two TaichuPix prototypes were characterized with electrical and radioactive sources in laboratory. The test results on the chip functionality and the noise and threshold performance before and after ionizing radiation are reported.

Your name:

Ying ZHANG

email:

zhangying83@ihep.ac.cn

Title:

Nationality:

Institute:

Institute of high energy physics, Chinese Academy of Sciences

Applications in Condensed Matter; Position Sensitive Fast Timing Detectors 2 / 149

Precise timing and recent advancements with segmented anode PICOSEC Micromegas prototypes (in-person)

Author: Ioannis Manthos[1]

[1] *University of Birmingham (GB)*

Corresponding Author: ioannis.manthos@cern.ch

Emerging challenges in current and future accelerator facilities appoint timing as an important variable to resolve extremely large event multiplicities on particle detection systems. The PICOSEC Micromegas detector has demonstrated the ability to time 150GeV muons with sub-25ps precision. Driven by detailed simulation studies and a phenomenological model, which describes stochastically the dynamics of the signal formation in the detector, new PICOSEC designs were developed that significantly improve the timing performance of the detector. As an example, PICOSEC prototypes with reduced drift gap size (~ 119μm) reached a resolution of 45ps (in comparison to 76ps of the standard PICOSEC prototype) in timing single photons in laser beam tests.
Towards large area coverage detectors, the approach of a multi-pad PICOSEC prototype with a segmented anode has been selected and developed. Extensive tests in particle beams revealed that the multi-pad version of the PICOSEC achieve time resolution comparable with the single-pad detector, even when the MIP induced signal is shared among several neighbouring pads.
An overview of results, incorporating recent advancements on the PICOSEC instrumentation will be presented along with studies for new photocathode materials, resistive anode technologies as well as digitization electronics, for a scalable, radiation hard, resistive PICOSEC Micromegas detectors for very precise timing.

Your name:

Ioannis Manthos

email:

i.manthos@bham.ac.uk

Title:

Dr

Nationality:

Greek

Institute:

University of Birmingham

Gas-based Detectors 1 / 150

High-granularity optical and hybrid readout of gaseous detectors: developments and perspectives

Author: Florian Maximilian Brunbauer[1]

Co-authors: Antonija Utrobicic [1]; Djunes Janssens [2]; Eraldo Oliveri [1]; Jonathan Floethner [3]; Leszek Ropelewski [1]; Lucian Scharenberg [4]; Miranda Van Stenis [1]

[1] *CERN*

[2] *Vrije Universiteit Brussel (BE)*

[3] *University of Bonn (DE)*

[4] *CERN, University of Bonn (DE)*

Corresponding Authors: miranda.van.stenis@cern.ch, eraldo.oliveri@cern.ch, karl.jonathan.floethner@cern.ch, florian.maximilian.brunbauer@cern.ch, djunes.janssens@cern.ch, leszek.ropelewski@cern.ch, antonija.utrobicic@cern.ch, lucian.scharenberg@cern.ch

Modern imaging sensors and ASICs allow for high-sensitivity pixellated readout of gaseous detectors with good spatial resolution. Advances towards ultra-high-speed imaging sensors, low noise characteristics and internal amplification in combination with increasing pixel counts make scintillation light readout well-suited for the most demanding applications ranging from radiation imaging and beam monitoring to track reconstruction techniques including hybrid approaches with optical and electronic readout.

Building upon high-resolution imaging with optically read out gaseous detectors using different MicroPattern Gaseous Detector (MPGDs) technologies, developments towards a low material budget beam monitoring detector will be presented. This development takes advantage of intuitive pixellated readout enabled by imaging sensors and the possibility to guide light with optical elements and mirrors to locate readout devices outside of the beam path for minimising radiation exposure and material budget.

While frame rate capabilities have previously limited optical readout to low event rates or integrated imaging, novel ultra-fast CMOS sensors offer unprecedented readout speeds at moderate resolution. This not only enables rapid fluoroscopy limited only by incident radiation flux and the high rate capabilities of MicroPattern Gaseous Detectors, but may also be used for recording image sequences resolving drift time differences along tracks in TPCs. Developments towards direct 3D track reconstruction in optical TPCs with ultra-fast CMOS readout will be shown along perspectives for negative ion optical TPCs for superior depth resolution.
In addition, alternative hybrid TPC readout approaches combining detailed 2D imaging with timing information from fast photon detectors such as SiPMs or transparent electronic readout electrodes are presented.

The combination of the flexibility of gaseous detectors including different target densities and large detection areas with state-of-the-art pixellated sensors offers unprecedented possibilities for rare event searches, beam monitoring and rapid, high-resolution imaging.

Your name:

Florian Brunbauer

email:

florian.brunbauer@cern.ch

Title:

Nationality:

Institute:

CERN

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 151

CMS Improved Resistive Plate Chamber Studies in Preparation for the High Luminosity Phase of the LHC

Author: Cecilia Uribe Estrada[1]

[1] *Autonomous University of Puebla (MX)*

Corresponding Author: cecilia.uribe.estrada@cern.ch

The high luminosity expected from the HL-LHC will provide a great opportunity for precise physics measurements and searches for new physics. Nevertheless, the increased rate of particles coming from the collisions will pose a challenge for the CMS detectors.
To prepare the muon system for the challenging conditions during the high luminosity phase, several upgrades have been planned and are being developed. Thanks to their fast time and space resolution, the Resistive Plate Chambers form part of the trigger system and are installed both in the barrel and endcap regions as a subsystem of the muon detector.
As part of the upgrades, the muon forward region will be enhanced with two stations, called RE3/1 and RE4/1, equipped with improved Resistive Plate Chambers (iRPCs). These detectors use thinner electrodes, a narrower gas gap (1.4 mm compared to 2 mm in the current design) and improved front-end electronics. These features allow them to withstand particle rates up to few kHz/cm^2. Furthermore, they will extend the geometrical acceptance of the RPCs from a pseudorapidity of 1.9 to 2.4. In this work we present different studies related to the iRPC prototypes in preparation for the high luminosity phase of the LHC.

Your name:

Cecilia Uribe Estrada

email:

cecilia.uribe.estrada@cern.ch

Title:

Prof.

Nationality:

Institute:

Benemérita Universidad Autónoma de Puebla (BUAP)

Detectors for High Radiation and Extreme Environments / 152

Timing detectors with scCVD diamond crystals: the CMS Precision Proton Spectrometer timing system.

Author: Edoardo Bossini[1]

[1] *Universita & INFN Pisa (IT)*

Corresponding Author: edoardo.bossini@cern.ch

The intrinsic characteristics of CVD diamonds, their superior radiation hardness and the thermal properties make of them an ideal candidate for a timing and/or position detector operated in harsh condition, where high irradiation is foreseen or where appropriate cooling of the sensor surface is undesirable or impractical. Moreover, their fast response to the passing particle make them suitable for high rate environment. Different custom geometries can be implemented for the electrodes through metallization or graphitization in both planar and 3D architectures. The CMS Proton Precision Spectrometer (PPS) consists of 3D silicon tracking stations, measuring both the position and direction of protons scattered in the very forward region, as well as timing detectors based on planar single crystal CVD diamond, measuring the proton time-of-flight with high precision. The detectors are hosted in special movable vacuum chambers, the Roman Pot, which are placed in the primary vacuum of the LHC beam pipe. Detectors have to operate in a vacuum at few mm from the primary LHC beam and must be able to sustain and highly non-uniform irradiation, with local peak above $10^{16} neq/cm^2$. In this presentation, after an introduction to the diamond technology, we will describe the PPS timing system. The sensor architecture, with two diamond sensors read out in parallel by the same electronic channel, the dedicated amplification chain and the strategies used to digitize the signals will be described. Latest results on the timing detector performance during LHC Run 2, in terms of efficiency and time precision, will be reported. Timing detectors used in Run 2 have been dismounted and tested for efficiency and timing performance. The final results, here reported, are important to understand the effect of the radiation on such devices. The ongoing upgrades and consolidation activities for the upcoming LHC Run 3 will be finally discussed.

Your name:

Edoardo Bossini

email:

edoardo.bossini@cern.ch

Title:

Nationality:

Italy

Institute:

Universita & INFN Pisa (IT)

Applications in Particle Physics 1 / 153

The Silicon Vertex Detector of the Belle II Experiment

Author: Giulio Dujany[None]

Corresponding Author: giulio.dujany@iphc.cnrs.fr

In 2019 the Belle II experiment started data taking at the asymmetric SuperKEKB collider (KEK, Japan) operating at the Y(4S) resonance. Belle II will search for new physics beyond the Standard Model by collecting an integrated luminosity of 50 ab-1.
The Silicon Vertex Detector (SVD), consisting of four layers of double-sided silicon strip sensors, is one of the two vertex sub-detectors. The SVD extrapolates the tracks to the inner pixel detector (PXD) with enough precision to correctly identify hits in PXD belonging to the track. In addition the SVD has standalone tracking capability and utilizes specific ionization to enhance particle identification in the low momentum region.
The SVD is operating reliably and with high efficiency, despite exposure to the harsh beam background of the highest peak-luminosity collider ever built. High signal-to-noise ratio and hit efficiency have been measured, as well as the precise spatial resolution; all these quantities show excellent stability over time. Data-simulation agreement of some discrepancy on cluster properties has recently been improved through a careful tuning of the simulation. The precise hit-time resolution can be exploited to reject out-of-time hits induced by beam background, which will make the SVD more robust against higher levels of backgrounds.

During the first three years of running, radiation damage effects on strip noise, sensor currents, depletion voltage, have been observed, as well as some coupling capacitor failure due to intense radiation bursts. None of these effects cause significant degradation in the detector performance.

Your name:

Stefano Bettarini

email:

stefano.bettarini@pi.infn.it

Title:

Nationality:

Italy

Institute:

INFN and University of Pisa

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 154

Digital Trigger Module for Cherenkov Time of Flight Detector

Author: Jan Zich[1]

Co-authors: Vjaceslav Georgiev [1]; Michael Holík [2]; Ondrej Urban [1]; Pavel Valenta [3]; Ondrej Vavroch [1]

[1] *University of West Bohemia (CZ)*

[2] *FEE UWB in Pilsen; IEAP CTU in Prague*

[3] *University of West Bohemia*

Corresponding Authors: valpav@fel.zcu.cz, urbano@kae.zcu.cz, jan.zich@cern.ch, vjaceslav.georgiev@cern.ch, ondrej.vavroch@cern.ch, holikm@gapps.zcu.cz

The ATLAS Forward Proton (AFP) project extends the forward physics program of the multipurpose ATLAS detector located at LHC in CERN. The time-of-flight (ToF) detector measures the time delay of the detected high-energy protons (HEPs) during the multiple proton-proton collisions. Due to the high luminosity at LHC the number of events detected by ToF is enormous as well as the amount of data produced. The main purpose of the digital trigger module (DTM) is to select the events relevant to the ongoing physical experiment. The DTM input signals are compared with the remotely set logical conditions. Then the module decides whether the input signals will pass to the following chain of ToF detector or not. The secondary function of the device is to send the control commands to the data acquisition system which stores the data from the selected levels (modules) of the ToF chain. The DTM performs the high-speed signal processing of the signals with rate up to 40 MHz (bunch clock frequency). The selection of the relevant events takes approximately 9 ns. After the full testing procedure (including the test in DESY and at the CERN beam test facilities) the DTM will be installed at LHC.

Your name:

Jan Zich

email:

zichj@fel.zcu.cz

Title:

Mr

Nationality:

Czech

Institute:

University of West Bohemia

Poster Session 3 (Applications in Particle Physics) / 155

DAQ Control Signal Codec for Time of Flight AFP Detector

Author: Jan Zich[1]

Co-authors: Pavel Broulim [1]; Vjaceslav Georgiev [1]; Michael Holik [1]; Ondrej Urban [1]; Pavel Valenta [2]; Ondrej Vavroch [1]

[1] *University of West Bohemia (CZ)*

[2] *University of West Bohemia*

Corresponding Authors: vjaceslav.georgiev@cern.ch, valpav@fel.zcu.cz, michael.holik@utef.cvut.cz, ondrej.vavroch@cern.ch, urbano@kae.zcu.cz, pavel.broulim@cern.ch, jan.zich@cern.ch

The particle physics experiments produce the data in the order of tens GB per hour. Due to the limited resources for data storage and offline processing this amount has to be reduced with respect to the events strongly related to the ongoing experiment. Data acquisition (DAQ) system is the key component dedicated to data collecting and storing at different stages of the particle detector system. The Codec takes the commands from the Digital Trigger Module (DTM) in Time-of-Flight (ToF) detector chain at ATLAS Forward Proton (AFP) project. These commands are then encoded and prepared for the fast serial transfer via the 265 m long coaxial cable located between the CERN LHC accelerator and the rack room where the DAQ is placed. As the LHC operating frequency (bunch clock) is 40 MHz the transfer rate of the 5-bit data frames is set to 400 MHz. The received signal at the end of the coax is distorted mainly due to the parasitic capacitance and limited output power of the cable buffer of the transmitter. Therefore, the receiver implements the circuitry for the restoring of the input signal. Then the decoder processes the received data frame and prepares the signals for control of the DAQ. The system as a whole will be thoroughly tested in DESY and CERN and consequently installed at LHC.

Your name:

Jan Zich

email:

zichj@fel.zcu.cz

Title:

Mr

Nationality:

Czech

Institute:

University of West Bohemia

Position Sensitive Fast Timing Detectors 1 / 156

Timing and spatial performance of IHEP AC-LGADs

Authors: Joao Barreiro Guimaraes Da Costa[1]; Kewei Wu[1]; Lei Zhang[2]; Mei Zhao[1]; Mengzhao Li[1]; Wei Wang[3]; Xiaoxu Zhang[2]; Xuewei Jia[1]; Yunyun Fan[1]; Zhijun Liang[1]

[1] *Chinese Academy of Sciences (CN)*

[2] *Nanjing University (CN)*

[3] *Academia Sinica (TW)/Nanjing University (CN)*

Corresponding Authors: fanyunyun1228@gmail.com, mzli@ihep.ac.cn, xuewei.jia@cern.ch, mei.zhao@cern.ch, guimaraes@ihep.ac.cn, zhijun.liang@cern.ch, kewei.wu@cern.ch, xiaoxu.zhang@cern.ch, lei.zhang@cern.ch, wei.wang@cern.ch

AC-coupled Low- Gain Avalanche Detectors (AC-LGAD) are designed as detectors with 100% fill factor for high precision 4D-tracking, which have been studied and researched by many institutes including BNL、FBK et al. Their results show that timing resolution of AC-LGAD can be lower than 50ps and spatial resolution can be better than 10um. Standard LGAD sensors of the Institute of High Energy Physics (IHEP) already showed time resolution better than 35ps before irradiation. Recently IHEP developed our first AC-LGAD sensors. This talk will present the simulation and latest testing results about 50um thick IHEP AC-LGAD sensors. Simulation studies of process parameters including the n+ layer dose and oxide thickness and their effect to signal shape will be shown. Meanwhile, simulation studies about charge sharing between AC-LGAD pixels with different pad-pitch structures will also be shown. Time resolution for the sensors tested by using Beta source are better than 50ps which is close to standard LGADs with similar gain. Spatial resolution of sensors with different pad-pitch structures tested by using laser system will also been shown.

Your name:

Mei Zhao

email:

zhaomei@ihep.ac.cn

Title:

Dr

Nationality:

China

Institute:

Institute of High Energy Physics, Chinese Academy of Sciences, China

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 157

Novel zigzag and diamond pattern for Micromegas and Gas-based detector

Author: Maxence Revolle[1]

Co-authors: Alexander Kiselev ; Bob Azmoun [2]; Carlos Perez Lara [3]; Francesco Bossu [4]; Hugo Denis Antonio Pereira Da Costa [5]; Irakli Mandjavidze [5]; Martin Lothar Purschke [6]; Maxence Vandenbroucke [5]; Stephan Aune [5]

[1] *CEA*

[2] *Brookhaven National Laboratory*

[3] *Universita & INFN, Torino-Unknown-Unknown*

[4] *CEA-Saclay*

[5] *Université Paris-Saclay (FR)*

[6] *Brookhaven National Laboratory (US)*

Corresponding Authors: irakli.mandjavidze@cea.fr, stephan.aune@cern.ch, francesco.bossu@cea.fr, maxence.vandenbroucke@cern azmoun@bnl.gov, maxence.revolle@cea.fr, ay1964k@gmail.com, purschke@bnl.gov, pereira@hep.saclay.cea.fr, carlos.perez.lara@cern.ch

Gas-based detectors Micromegas are used in many high energy physics experiments to track charged particles. They can cover large areas with homogeneous gain, providing spatial resolution from millimeter to tenth of millimeter.
Micromegas can be read along one projection with strips (1D) or two projections with pads interconnected (2D), but the resolution highly depend of the density (pitch) of the pattern.
In the worse case, a particle hit a single pattern providing a resolution of pitch/$\sqrt{12}$.
To reduce this dependency, novel "zigzag" 1D pattern and "diamond" 2D pattern are tested and optimized to obtain the best resolution regardless of the pitch, in the context of the Electron-Ion Collider R&D on detectors.

Tested using a proton beam at Fermilab Test Beam Facility, zigzag and diamond geometries have been successfully characterized with Micromegas, showing $150 \mu m$ 1D spatial resolution with a pitch of $2mm$.
Identical readout have been tested with other gaseous detectors (μRWell, GEM) for a complete comparison. For Micromegas, the zigzag pattern have been tested on a full scale prototype of 40x40cm^2 with a pitch from 1 to 3mm.

In this presentation, it will be shown that zigzag and diamond patterns are efficient geometry for Micromegas and other gaseous detectors, compatible with future large detectors. Details on the characterization, detectors and technologies used will be discussed.

Your name:

Maxence Revolle

email:

maxence.revolle@cea.fr

Title:

Mr

Nationality:

French

Institute:

CEA-Irfu

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 158

A table-top Two Photon Absorption –TCT system: measurements of irradiated and non-irradiated silicon sensors

Author: Sebastian Pape[1]

Co-authors: Francisco Rogelio Palomo Pinto [2]; Ivan Vila Alvarez [3]; Marcos Fernandez Garcia [4]; Michael Moll [5]; Moritz Oliver Wiehe [6]; Raúl Montero Santos [7]

[1] *Technische Universitaet Dortmund (DE)*

[2] *Universidad de Sevilla (ES)*

[3] *Instituto de Física de Cantabria (CSIC-UC)*

[4] *Universidad de Cantabria and CSIC (ES)*

[5] *CERN*

[6] *Albert Ludwigs Universitaet Freiburg (DE)*

[7] *Universidad del Pais Vasco*

Corresponding Authors: raul.montero@ehu.eus, francisco.rogelio.palomo.pinto@cern.ch, michael.moll@cern.ch, ivan.vila@cern.ch, sebastian.pape@cern.ch, m.wiehe@cern.ch, marcos.fernandez@cern.ch

The Transient Current Technique (TCT) is widely used in the field of silicon particle detector development. So far, mainly Single Photon Absorption –Transient Current Technique (SPA-TCT) was performed, using laser wavelengths with a photon energy larger than or similar to the silicon band-gap. Recently, measurements employing two photon absorption for the testing of the silicon bulk properties were carried out for the first time. Excess charge carriers are generated only in a small volume (approx. 1 um x 1um x 20 um) around the focal point of the laser beam, so that resolution in all three spatial directions is achieved. Furthermore, compared to what is customary in SPA-TCT, the resolution perpendicular to the incident laser beam was increased one order of magnitude. Following the initial success of the method, a compact Two Photon Absorption –Transient Current Technique (TPA-TCT) setup has been developed and first measurements were performed. The current status of the setup and the results obtained on non-irradiated silicon strip and LGAD sensors as well as irradiated LGAD sensors will be covered in this talk.

Your name:

Sebastian Pape

email:

sebastian.pape@chern.ch

Title:

Mr

Nationality:

german

Institute:

CERN / TU Dortmund University

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 159

Generation and validation of a theoretical signal database for the Segmented Inverted-coaxial Germanium (SIGMA) Detector

Author: AHMED ALHARBI[1]

Co-authors: Daniel Judson [2]; Laura Harkness [3]; Robert Page [3]; Ellis Rintoul [3]; John Wright [3]; Fiona Jane Pearce [4]; David Radford [5]

[1] *University of Liverpool (Nuclear Group)*

[2] *The University of Liverpool*

[3] *University of Liverpool*

[4] *University of Liverpool (GB)*

[5] *Oak Ridge National Laboratory*

Corresponding Authors: e.rintoul@liverpool.ac.uk, rdp@liverpool.ac.uk, qu.c@hotmail.com, ljh@ns.ph.liv.ac.uk, d.s.judson@liverpool.ac.uk, fiona.pearce@liverpool.ac.uk

The prototype SIGMA detector is the first p-type segmented inverted-coaxial germanium detector to be manufactured for γ-ray tracking and imaging purposes [1,2]. The γ-ray tracking and imaging capability of SIGMA requires a high precision of measuring the interaction positions of γ-ray radiation with the detector which is strongly dependent upon the achieved position resolution. The γ-ray interaction position is determined by extracting the charge pulses from both a small p-type point contact on the rare face of the detector and the outer n-type electrode which is electrically segmented into 18 segments. In order to determine the position resolution of SIGMA, pulse shape analysis (PSA) methods using chi-squared minimisation technique will be applied which require a signal database of all possible positions of γ-ray interactions with the detector volume. For this reason, the detector response has been simulated using Agata Detector Library (ADL) [3] to generate theoretical pulse shapes for the SIGMA detector. The simulated signals were validated against their equivalent experimental signals at known positions in order to build such signal database which is currently being developed.

Your name:

Ahmed Alharbi

email:

A.A.Alharbi@liverpool.ac.uk

Title:

Mr

Nationality:

Saudi Arabia

Institute:

University of Liverpool

Applications in Life Sciences and Biology; Applications in Particle Physics 3 / 160

phenoPET: A PET scanner for Plants based on digital SiPMs

Author: Matthias Streun[1]

Co-authors: Hubert Gorke [2]; Carsten Hinz [2]; Liubova Jokhovets [2]; Robert Koller [2]; Ralf Metzner [2]; Holger Nöldgen [2]; Daniel Pflugfelder [2]; Jürgen Scheins [2]; Peter Wüstner [2]; Ulrich Schurr [2]; Stefan van Waasen [2]

[1] *Forschungszentrum Jülich GmbH*

[2] *Forschungszetrum Jülich GmbH*

Corresponding Authors: h.noeldgen@fz-juelich.de, c.hinz@fz-juelich.de, m.streun@fz-juelich.de, r.koller@fz-juelich.de, l.jokhovets@fz-juelich.de, u.schurr@fz-juelich.de, j.scheins@fz-juelich.de, s.van.waasen@fz-juelich.de, d.pflugfelder@fz-juelich.de, r.metzner@fz-juelich.de, p.wuestner@fz-juelich.de, h.gorke@fz-juelich.de

The PET scanner *pheno*PET is a system dedicated for plant research developed and used for phenotyping studies at the Research Center in Jülich. The scintillation detectors use LYSO scintillator crystals of 1.85 × 1.85 × 10 mm^3 size (Crystal Photonics, Inc.) and digital Silicon Photomultipliers as photodetectors (Philips DPC). 4×4 crystals share 2×2 photodetector pixels at a time. Controlled light spreading guarantees clear identification of the individual crystals.

The whole scanner is equipped with more than 36000 crystals. Unlike to clinical PET scanners the detectors are arranged in a horizontally oriented ring which allows scanning of plants in an upright position. The field of view measures 18 cm in diameter and 20 cm height.
A recent revision of firm- and software resulted in an increased bandwidth of the data acquisition system, allowing dynamic studies of up to 120 MBq in the field of view. For the sensitivity in the center field of view we now obtain a value of 9.2% (ΔE=250-750keV).

Your name:

Matthias Streun

email:

m.streun@fz-juelich.de

Title:

Nationality:

German

Institute:

Forschungszetrum Jülich

Applications in Particle Physics 2 / 162

Status and plans for the CMS High Granularity Calorimeter upgrade project

Author: Eva Sicking[1]

[1] *CERN*

Corresponding Author: eva.sicking@cern.ch

The CMS Collaboration is preparing to build replacement endcap calorimeters for the HL-LHC era. The new high-granularity calorimeter (HGCAL) is, as the name implies, a highly-granular sampling calorimeter with approximately six million silicon sensor channels (˜1.1cmˆ2 or 0.5cmˆ2 cells) and about four hundred thousand channels of scintillator tiles readout with on-tile silicon photomultipliers. The calorimeter is designed to operate in the harsh radiation environment at the HL-LHC, where the average number of interactions per bunch crossing is expected to exceed 140. Besides measuring energy and position of the energy deposits the electronics is also designed to measure the time of their arrival with a precision on the order of 50 ps. In this talk, the reasoning and ideas behind the HGCAL, the current status of the project, the many lessons learnt so far, and the challenges ahead will be presented.

Your name:

Eva Sicking

email:

eva.sicking@cern.ch

Title:

Nationality:

German

Institute:

CERN

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 163

Modelling CTI effects in irradiated Gaia CCDs

Authors: Saad Ahmed[None]; David Hall[None]; Jesper Skottfelt[1]; Cian Crowley[2]; Ben Dryer[3]; Jose Hernandez[4]; Andrew Holland[3]

[1] *Open University*

[2] *ESA/ESAC*

[3] *The Open University*

[4] *ESA*

Corresponding Authors: ben.dryer@open.ac.uk, saad.ahmed@open.ac.uk, jesper.skottfelt@open.ac.uk, jhernand@sciops.esa.int, david.hall@open.ac.uk, cian.crowley@esa.int, andrew.holland@open.ac.uk

The European Space Agency's Gaia spacecraft was launched in 2013 and has been in operation ever since. It has a focal plane of 106 Charge-Coupled Devices (CCDs) which are of the CCD91-72 variant, custom-designed by Teledyne e2v. The detectors have been making measurements of parallaxes, positions, velocities, and other physical properties of over one billion stars and other astronomical objects in the Milky Way. Whilst operating in space, CCDs undergo non-ionizing displacement damage from incoming radiation. This causes radiation induced defects to form in the silicon lattice which can trap electrons during readout and increase the charge transfer inefficiency (CTI) of the devices. From analysis of in-flight calibration data, Gaia's CTI values have been measured to be much lower than what was expected based on the on-ground pre-flight tests.

In this study, the CTI and trap landscape in both in-flight and irradiated on-ground devices are modelled to fit the new datasets. These results provide more insights into the nature of radiation damage and the resulting trap landscapes, both in space and from on-ground irradiations.

Your name:

Saad Ahmed

email:

saad.ahmed@open.ac.uk

Title:

Mr

Nationality:

Irish

Institute:

The Open University

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 165

Modelling the behaviour of microchannel plates using CST particle tracking software

Author: Emily Baldwin[1]

Co-authors: Jon Lapington [1]; Steven Leach [1]

[1] *University of Leicester*

Corresponding Authors: jsl12@le.ac.uk, sal41@le.ac.uk, ejb71@leicester.ac.uk

Photon counting detectors are essential for many applications, including astronomy, medical imaging, nuclear and particle physics. An extremely important characteristic of photon counting detectors is the method of electron multiplication.

In vacuum tubes such as photomultiplier tubes (PMTs) and microchannel plates (MCPs), secondary electron emission (SEE) provides electron multiplication through an accelerating field across the dynode. A significant electron cascade, with time resolution in the 10s of picoseconds, can be observed in these structures and are routinely used in industry and research. Both devices have been thoroughly tested experimentally.

Developing new MCP designs can be expensive and time consuming so the ability to simulate new structures will provide many advantages to instrument designers and manufacturers. There are, however, significant challenges in accurately simulating MCPs with many geometrical variables to consider as well as material SEE properties. The SEE process is probabilistic, and with MCPs having a very high gain, significant computational resource is required to simulate the resulting electron output for a model.

In our research we illustrate how this can be achieved by developing a MCP model using Computer Simulation Technology (CST) software. The model consists of a charged particle source, a small seven-pore MCP structure (including electrodes, resistive and emissive surfaces), as well as the readout anode, with appropriate potentials applied to the components of the model.

We present simulation results from the modelled MCPs, demonstrate electron multiplication performance, and compare these results with those predicted by theory and observed experimentally. Our goal is to expand this model and identify optimum MCP parameters for various science applications using novel materials to optimise detector performance.

Your name:

Emily Baldwin

email:

Ejb71@le.ac.uk

Title:

Ms

Nationality:

English

Institute:

University of Leicester

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 166

The Topmetal-CEE Prototype, a Direct Charge Sensor for the Beam Monitor of the CSR External-target Experiment

Authors: Bihui You[1]; Fangfang Huang[1]; Wanhan Feng[1]; Ping Yang[1]; Qingwen Ye[1]; Di Guo[1]; Zengtao Guo[1]; Guangming Huang[1]; Jun Liu[1]; Xiangming Sun[1]; Hulin Wang[1]; Le Xiao[1]; Chengxin Zhao[2]

Co-author: Chaosong Gao [1]

[1] *Central China Normal University*

[2] *Institute of Modern Physics, Chinese Academy of Sciences*

Corresponding Author: chaosonggao@mail.ccnu.edu.cn

The Cooler-Storage-Ring External-target Experiment (CEE) which is being constructed since 2020 is a spectrometer to study the properties of nuclear matter at high baryon density region. An online beam monitor that is based on the time projection chamber detection principle is being developed for the CEE to accurately determinate the beam incidence position. The Topmetal-CEE sensors are used as the anode array collecting electrons in the beam monitor.

The Topmetal-CEE prototype has been designed in a standard CMOS 130 nm process and is being fabricated. The sensor has 180 channels with a pitch of 100 μm. In each channel, electrons are collected by a charge collection electrode which is a top-most metal exposed the surrounding media, amplified by a charge sensitive amplifier, and then feed into a discriminator. The output of the discriminator is split into two path. One records time-of-arrival (ToA). The other records time-over-threshold (ToT). ToA information is recorded in a 8-bit register counter at 40 MHz and can be refined by a time-to-amplitude convertor (TAC). TOT is also recorded by a TAC. In order to reduce the dead time, 180 channels are split into two separate parts and then the information in each part is read out by a data-driving priority readout scheme independently. Each channel has its own address encoded by an address encoder. The analog amplitude of each TAC is digitized by a 13-bit pipeline Analog-to-Digital Convertor (ADC). The output codes of the ADC are grouped with the corresponding counter and address, and then they are transferred off chip with a serial speed of 4.4 Gbps.

In the conference, we will present the detailed design and preliminary test results of the Topmetal-CEE prototype.

Your name:

Chaosong Gao

email:

chaosonggao@mail.ccnu.edu.cn

Title:

Dr

Nationality:

Chinese

Institute:

Central China Normal University

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 167

A Novel Front-End Amplifier for Gain-less Charge Readout in High-Pressure Gas TPC

Authors: Danfeng Li[1]; Xiangming Sun[1]; Guangming Huang[1]

Co-author: Chaosong Gao [1]

[1] *Central China Normal University*

Corresponding Author: chaosong.gao@mails.ccnu.edu.cn

The search for Neutrinoless Double-Beta Decay (0νββ) at tonne-scale and beyond requires techniques that are capable of observing a sharp peak at Qββ in the total beta energy spectrum. A direct charge sensor, Topmetal-S, with only one charge collection electrode on a single sensor and with the intention to tile many such sensors on a large plane, is being developed for 0νββ experiments in a high-pressure gaseous Time Projection Chamber (TPC) without gas-electron avalanche. This scheme eliminates the conventional avalanche fluctuations but demands exceedingly low internal noise on the front-end amplifier to achieve sufficient energy resolution by charge measurement alone.

Given a power consumption and circuitry, the electronic noise of the front-end amplifier is proportional to the input capacitance primarily contributed by the Charge Collection Electrode (CCE), the input metal routing and the input transistor. An exposed hexagon metal with a diameter of 1mm is proposed as the CCE on the topmost layer. Its capacitance with respect to the ground is around 4pF. If the input capacitance is reduced, the electronic noise could be significantly decreased.

A novel front-end amplifier composed of a source-drain follower and a common-source amplifier is proposed. The potential on both the source and drain node of the input transistor follows its gate. Hence the effective input capacitance contributed by the input transistor is significantly reduced. If both the CCE and the input metal routing are also shielded and the shield is coupled to the source or drain node, the input capacitance can be greatly reduced. A test chip with the novel front-end amplifier and the CEE has been designed in a standard CMOS 130nm process and is being manufactured. The simulation shows that the equivalent noise charge is less than 30e-.

In the conference, we will present the detailed design and preliminary test results.

Your name:

Chaosong Gao

email:

chaosong.gao@mails.ccnu.edu.cn

Title:

Dr

Nationality:

Chinese

Institute:

Central China Normal University

Applications in Nuclear Physics and Nuclear Industry; X-ray and Gamma Ray Detectors 1; Medical Applications of Position Sensitive Detectors 2 / 168

Development of muon scattering tomography for a detection of reinforcement in concrete

Authors: Anna Kopp[1]; Chiara De Sio[1]; Jaap Velthuis[None]; Magdalena Dobrowolska[1]; Philip Pearson[2]; Ruaridh Milne[2]

[1] *University of Bristol*

[2] *Cavendish Nuclear*

Corresponding Authors: annakopp@hotmail.de, jaap.velthuis@bristol.ac.uk, chiara.desio@bristol.ac.uk, m.dobrowolska@bristol.ac.uk, ruaridh.milne@cavendishnuclear.com, philip.pearson@cavendishnuclear.com

Inspection of ageing, reinforced concrete structures is a world-wide challenge. Existing evaluation techniques in civil and structural engineering have limited penetration depth and don't allow to precisely ascertain the configuration of reinforcement within large concrete objects. The big challenge for critical infrastructure (bridges, dams, dry docks, nuclear bioshields etc.) is understanding the internal condition of the concrete and steel, not just the location of the reinforcement.
Muon scattering tomography is a non-destructive and non-invasive technique which shows great promise for high-depth 3D concrete imaging.
A method was presented to locate reinforcement placed in a large-scale concrete object. The reinforcement was simulated as two layers of 2 m long bars, forming a grid, placed at a fixed distance from each other inside a large concrete block. The technique exploits the periodicity of the bars in a reinforcement grid by considering the Fourier-transformed signal. The presence of a grid leads to peaks in the normalized Fourier frequency spectrum. Peaks locations are determined by the grid spacing and their amplitude by the bar diameters. It is therefore possible to estimate both bar diameter and spacing with this method.
Using only one week worth of data taking, bars with a diameter of 7 mm and larger, could easily be detected for a 10 cm spacing. The signal for 6 mm diameter bar exceeds the background and but becomes very clear after two weeks of data taking. Increasing the spacing to 20 cm results in a smaller amount of iron in the scanning area, thus longer data taking is required. It has been shown that this method enables the detection of the smallest bars in practical use within one or two weeks of data taking time and standard spacing. This is a very important result for non-destructive evaluation of civil structures.

Your name:

Magdalena Dobrowolska

email:

m.dobrowolska@bristol.ac.uk

Title:

ms

Nationality:

Polish

Institute:

University of Bristol

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 169

LGAD Development for the LHC's High-Luminosity Upgrade

Authors: Daniela Bortoletto[1]; Philip Patrick Allport[2]; Douglas Jordan[3]; Enrico Giulio Villani[4]; Ioannis Kopsalis[5]; Jonathan Mulvey[6]; Konstantin Stefanov[1]; Laura Gonella[2]; Martin Gazi[None]; Richard Plackett[1]; Stephen Mcmahon[7]

[1] *University of Oxford (GB)*

[2] *University of Birmingham (UK)*

[3] *Teledyne e2v*

[4] *STFC - Science & Technology Facilities Council (GB)*

[5] *University of Birmingham (GB)*

[6] *University of Birmingham*

[7] *Science and Technology Facilities Council STFC (GB)*

Corresponding Authors: jfm035@bham.ac.uk, martin.gazi@cern.ch, philip.patrick.allport@cern.ch, stephen.mcmahon@cern.ch, daniela.bortoletto@cern.ch, douglas.jordan@teledyne.com, enrico.villani@cern.ch, konstantin.stefanov@open.ac.uk, richard.plackett@cern.ch, laura.gonella@cern.ch, ioannis.kopsalis@cern.ch

The need for 4D (fast timing in addition to 3D resolution in space) silicon particle detectors has become very apparent with the introduction of the High-Luminosity (HL) upgrade at the LHC. Timings on the order of tens of picoseconds will allow better reconstruction of the ˜200 primary vertices along the beam line in every bunch crossing. Correct association of tracks with primary vertices is particularly difficult closer to the beam axis where the track density is greatest and reconstruction with 3D detectors alone is insufficient.
The University of Birmingham, University of Oxford, the Rutherford Appleton Laboratory, and the Open University are developing and testing new LGAD sensors. This project, aimed at developing Ultra-Fast Silicon Detectors (UFSD) of characteristics and performances suitable for use at HL-LHC High Granularity Timing Detector (HGTD), is being developed in collaboration with Teledyne e2v.
The first fabricated batch of 22 six-inch wafers, featuring 50 µm thick high resistivity epi layer with different gain layer implants was completed successfully.
We will present the LGAD design process and compare the results with Synopsys TCAD simulations. We will discuss I-V and C-V measurements across wafers for device sizes ranging between 1 mm, 2 mm, 4 mm and 2x2 arrays of 1 mm devices, and comparisons to PiN diodes where the gain layer is not present. Gain measurement using TCT laser injection on both PiN and LGAD individually packaged devices will be shown. Preliminary timing measurements and test results before and after proton irradiation will also be provided.

Your name:

email:

laura.gonella@cern.ch

Title:

Nationality:

Institute:

Applications in Condensed Matter; Position Sensitive Fast Timing Detectors 2 / 170

Development of a single-photon imaging detector with pixelated anode and integrated digital readout

Authors: Nicolo Vladi Biesuz[1]; Jerome Alexandre Alozy[2]; Michael Campbell[2]; Angelo Cotta Ramusino[1]; Massimiliano Fiorini[1]; Xavi Llopart Cudie[2]

[1] *Universita e INFN, Ferrara (IT)*

[2] *CERN*

Corresponding Authors: xavier.llopart@cern.ch, jerome.alozy@cern.ch, massimiliano.fiorini@cern.ch, angelo.cotta.ramusino@cern.ch, michael.campbell@cern.ch, nicolo.vladi.biesuz@cern.ch

We present the development of a single-photon detector and the connected read-out electronics.
This 'hybrid' detector is based on a vacuum tube, transmission photocathode, microchannel plate and a pixelated CMOS read-out anode encapsulating the analog and digital-front end electronics.
This assembly will be capable of detecting up to 10^9 photons per second with simultaneous measurement of position and time.

A microchannel plate with 5-10 μm pore spacing, operated at low gain and treated with atomic layer deposition, was chosen to allow a lifetime of more than $20\ \mathrm{C/cm^2}$ accumulated charge.
The pixelated read-out anode used is based on the Timepix4 ASIC (65 nm CMOS technology) designed in the framework of the Medipix4 collaboration.

This ASIC is an array of 512×448 pixels distributed on a $55\ \mu\mathrm{m}$ square pitch, with a sensitive area of $\sim 7\ \mathrm{cm}^2$.
It features 50-70 e^- equivalent noise charge, a maximum rate of $2.5\ \mathrm{Ghits/s}$, and allows to time-stamp the leading-edge time and to measure the Time-over-Threshold (\textit{ToT}) for each pixel.
The pixel-cluster position combined with its ToT information allows to reach 5-10 $\mu\mathrm{m}$ position resolution.
This information can also be used to correct for the leading-edge time-walk achieving a timing resolution of the order of $10\ \mathrm{ps}$.

The detector will be highly compact thanks to the encapsulated front-end electronics allowing local data processing and digitization.
An FPGA-based data acquisition board, placed far from the detector, will receive the detector hits using 16 electro-optical links operated at $10.24\ \mathrm{Gbps}$.
The data acquisition board will decode the information and store the relevant data in a server for offline analysis.

These performance will allow significant advances in particle physics, life sciences, quantum optics or other emerging fields where the detection of single photons with excellent timing and position resolutions are simultaneously required.

Your name:

Nicolò Vladi Biesuz

email:

biesuz@fe.infn.it

Title:

Nationality:

Institute:

INFN Ferrara

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 171

Picosecond imaging at high spatial resolution using TOFPET2 AISC v2d and Microchannel plate detectors

Author: Thawatchai Sudjai[1]

Co-authors: Jon Lapington [1]; Steven Leach [1]

[1] *University of Leicester*

Corresponding Authors: ts323@leicester.ac.uk, jsl12@leicester.ac.uk, sal41@le.ac.uk

Microchannel plate-based detectors provide advantages over their solid-state counterparts for applications where a combination of virtually zero noise photon-counting, large format, short wavelength sensitivity with high resolution timing and imaging are required. Solar-blind applications, Cherenkov detectors for high energy physics, and UV astronomy are such fields. The application to Cherenkov detection is particularly demanding, requiring time resolution below 100 picoseconds combined with imaging and high throughput. This requires the readout to combine high spatial and temporal event resolution at high rates necessitating a parallel readout approach. We describe a readout design comprising a pixellated readout array instrumented using multi-channel fast timing electronics and incorporating charge centroiding to achieve sub-pixel spatial resolution. We present

experimental results of the relationship between time over threshold and signal amplitude, the centroiding image obtained with an MCP detector using a pixellated readout geometry. The readout was optimised for a fast electronics implementation based on the TOFPET system, a multi-channel all-in-one ASIC originally designed for time-of-flight PET using silicon photomultipliers.

Your name:

Thawatchai Sudjai

email:

ts323@leicester.ac.uk

Title:

Mr

Nationality:

Thai

Institute:

University of Leicester

Poster Session 3 (Applications in Particle Physics) / 172

Interferometric techniques with high resolution emulsion detectors

Author: Eleonora Pasino[1]

[1] *Università degli Studi e INFN Milano (IT)*

Corresponding Author: eleonora.pasino@unimi.it

I will present an interferometric technique suitable for the measurement of particle masses. The goal of this study is to attain the capability of measuring particle-antiparticle mass ratio in a way that is independent of particle electric charges, a technique that is gaining interest in view of recent developments of experiments looking for CPT violations and antimatter gravitational fall.
In order to obtain an accurate estimate of the mass ratio, the proposed method relies on the possibility to have a very high-resolution detector which can reliably respond to low energy particles and antiparticles.
Nuclear emulsions are position sensitive detectors that feature these fundamental characteristics. Recently, super-fine-grained nuclear emulsions have been developed using a new method, which leads to a resolution up to 50 nanometers (A. Alexandrov et al; Sci. Rep. 2020, 10, 18773).
Furthermore, nuclear emulsions have already been successfully tested with antimatter: the capability to reconstruct antiproton annihilations with micrometric resolution has been demonstrated by the AEGIS collaboration; the high detecting efficiency for low energy antiparticles has been proved by the QUPLAS collaboration with the demonstration of positron interferometry (S. Sala et al; Sci. Adv. 2019, 5, eaav7610).
Therefore, thanks to the improved resolution of the nuclear emulsions and their tested response to low energy particles, the emulsion-based detector represents an ideal device for this quantum interferometry study, where micrometric fringes of the periodic spatial distribution generated by the interferometer have to be measured.

Your name:

Eleonora Pasino

email:

eleonora.pasino@unimi.it

Title:

Nationality:

Italy

Institute:

Università degli Studi di Milano e INFN Milano

Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science 2 / 174

Towards the first observation of the Migdal effect in nuclear scattering I. Design and construction of the MIGDAL experiment (in-person)

Authors: Mohammad Nakhostin[1]; Tom Neep[2]

[1] *Imperial College London*

[2] *University of Birmingham (GB)*

Corresponding Authors: tom.neep@cern.ch, m.nakhostin@imperial.ac.uk

The Migdal in Galactic Dark Matter Exploration (MIGDAL) experiment aims at making the first observation of the Migdal effect from fast neutron scattering. A Migdal event can be identified by two ionization tracks sharing the same vertex, one belonging to a nuclear recoil and the other to a Migdal electron. To detect this track topology in a low-pressure gas we are building an Optical Time Projection Chamber equipped with glass-GEMs operating in 50-Torr CF4, with light and change readout provided by a CMOS camera, a photomultiplier tube, and 120 anode-strip channels. This will allow precise three-dimensional reconstruction of the ionization tracks from electron and nuclear recoils down to 5 keV in electron equivalent energy. The detector will be exposed to intense neutron beams (109-1010 n/s) from DT and DD neutron generators, enabling us to investigate the Migdal effect in a wide energy range of nuclear recoils. We will report on the status of the design and construction of the experiment at the Neutron Irradiation Laboratory for Electronics (NILE) of the Rutherford Appleton Laboratory, UK.

Your name:

Mohammad Nakhostin

email:

m.nakhostin@imperial.ac.uk

Title:

Dr

Nationality:

British

Institute:

Imperial College London

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 175

Design and integration of CMOS tracker layers in digital tracking calorimeter for pCT application

Author: Shruti Mehednale[1]

[1] *on Behalf of Bergen pCT collaboration, University of Bergen, Bergen, Norway*

Corresponding Author: shruti.mehendale@uib.no

Proton Computed Tomography (pCT) is an emerging imaging modality in particle therapy as it enables direct reconstruction of 3D map of relative stopping power (RSP) values of the target. A typical pCT detector records the direction and position of every single particle before and after crossing the target and residual energy after crossing the target. A typical pCT detector is thus made of extra-thin tracking detectors and an energy/range detector.
Bergen pCT collaboration is building a prototype Digital Tracking Calorimeter (DTC) consisting of 43 layers of pixelated silicon radiation detectors. The first two layers, called as tracker layers, are used for tracking the position of the protons. The next 41 layers, separated by absorber Al plates are used as calorimeter. Each layer is made up of 108 CMOS Monolithic Active Pixel Sensors (MAPS), covering an area of 27 cm × 16.6 cm. Each sensor has almost half-million pixels of the size of 29.24 x 26.88 μm^2.
The tracker layers of DTC and their integration steps will be discussed in this paper. The task is extremely challenging due to the contradictive demands of minimization of multiple scattering vs. thermo mechanical stability. These large area tracking layers must have the least low-Z material budget possible, should be mechanically stable and maintained at reasonable working temperature conditions for MAPS. The following steps are included in the paper: 1. Fabrication of carbon fiber sheets with thermal conductivity comparable to aluminum, as a support and heat-transfer material on which MAPS will be mounted, 2. Single-point TAB ultrasonic bonding method used to mount the MAPS on aluminium-polyimide flexible microcables, 3. Details of the design of the mechanical support structure the layers and 4. First results of combined water and air cooling of the prototype tracking layers.

Your name:

Shruti Mehendale

email:

shruti.mehendale@uib.no

Title:

Dr.

Nationality:

India

Institute:

Department of physics and technology

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 176

Automatic detection of scintillation light splashes using conventional and deep learning methods

Authors: Yangfan Jiang[1]; Sarah Bugby[1]; Georgina Cosma[1]

[1] *Loughborough University*

Corresponding Authors: s.bugby@lboro.ac.uk, y.jiang@lboro.ac.uk, g.cosma@lboro.ac.uk

The Hybrid Gamma Camera (HGC) [Lees et al, Sensors, 17(3):554, 2017] has applications in intraoperative imaging guidance and nuclear decommissioning. The HGC gamma detector comprises an Electron Multiplying Charge-Coupled Device (EMCCD) coupled to a columnar CsI: Tl scintillator. Each absorbed gamma photon will produce a scintillation light splash on the EMCCD; the number, location, and size of these splashes on each frame is unknown. For real-time imaging, these splashes must be identified and characterised quickly (10fps) and with minimal processing overhead. The current technique used in the HGC is automatic scale selection [Hall et al, NIMA,604:207-210, 2009]. However, there alternative solutions including object recognition deep learning models may have superior performance.
Six automatic detection implementations - four traditional blob detection algorithms (two Laplacian of Gaussian (LoG) detectors: LoG(1) is our implementation of LoG algorithm based on the HGC' s automatic scale selection and LoG(2) is the LoG detector from Python scikit-image library, one Difference of Gaussian (DoG) detector, and one Hessian of Determinant (DoH) detector) and two Region-Based Convolutional Neural Networks (RCNNs) based on the VGG16 and ResNet-101 models were compared for the task of scintillation light splash identification.
An image dataset was simulated based on statistics of experimental data from the HGC for a range of radioisotopes. This provided ground truth values for location, intensity, and size of expected splashes for training RCNN models. The testing performance of each technique was compared based on results from 360 simulated images. The F1-scores obtained were: LoG(1): 69.98%, LoG(2): 98.85%, DoG: 94.03%, DoH: 32.05%, VGG16: 90.37% and ResNet-101: 89.95% . Their average speed for per frame was LoG(1): 0.358s/f, LoG(2): 0.024s/f, DoG:0.021s/f, DoH: 0.069s/f, VGG16: 0.057s/f, ResNet-101: 0.072s/f. We will discuss the physical parameters that affect algorithm accuracy and performance.

Your name:

Yangfan Jiang

email:

Y.Jiang@lboro.ac.uk

Title:

Ms

Nationality:

Chinese

Institute:

University of Loughborough

Poster Session 3 (Applications in Particle Physics) / 177

Results from ATLAS-ITk Strip Sensors Quality Assurance Testchip

Author: Èric Bach[1]

[1] *IMB-CNM, CSIC*

Corresponding Author: eric.bach@imb-cnm.csic.es

The pre-production of the strip sensors for the Inner Tracker (ITk) of the ATLAS Upgrade detector at CERN has finished, comprising about 5% of the total number of sensors to be fabricated during the 4-year production period (approximately 22000). All sensors are tested by the collaboration according to the Quality Control procedures. For Quality Assurance, a number of test structures, designed by the collaboration and put together in a full testchip, are produced in every wafer together with the

main sensors and the other QA test structures like mini sensors and large diodes by the foundry (HPK). Samples of these testchips are tested for every batch of sensors. One testchip is tested before irradiation for every batch fabricated in order to monitor the stability of the key technological and device parameters. Also for every batch, one test chip is irradiated either with gammas or protons in order to account for ionization damage. Additionally, one mini per batch is irradiated either with neutrons or protons to account for displacement damage effects. All this effort is carried out by 7 irradiation and test sites.

The results from about 100 testchips tested during the pre-production period will be shown and analyzed. The results of the pre-production batches show that all parameters remain under specifications before irradiation. After irradiation, all parameters remain under specifications except for some structures damaged by handling, for which replacement chips have been irradiated. Some of the newly designed structures show testing limitations for a few of the parameters.

These results help to accumulate enough statistics in order to establish what we call "soft"thresholds for those parameters that are not directly related to specifications. These soft thresholds will be used as Upper and Lower Control Limits (UCL and LCL) in the production control of the technological parameters for QA.

Your name:

Miguel Ullán

email:

miguel.ullan@imb-cnm.csic.es

Title:

Dr

Nationality:

Spain

Institute:

Centro Nacional de Microelectrónica (IMB-CNM-CSIC)

Poster Session 3 (Applications in Particle Physics) / 178

Application of material budget imaging for the design of the ATLAS ITk strip detector

Author: Jan-Hendrik Arling[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

Corresponding Author: jan-hendrik.arling@cern.ch

The technique of material budget imaging (MBI) allows to experimentally assess the material budget $\epsilon = x/X_0$ of a material with thickness x and its radiation length X_0. Here, multi-GeV electrons from a test beam facility such as the DESY-II test beam are used. This novel technique exploits the fact that the beam particles are deflected by multiple Coulomb scattering following a distribution of the deflection angle with a center at zero and a width depending on the traversed material. By reconstructing the individual kink angles from the measured particle trajectories in a high resolution beam telescope, the material budget can be extracted by applying appropriate models of multiple scattering theory, such as the Highland formula.
On the one hand, various materials with known material budgets were measured to calibrate the MBI technique and study also different systematic effects such as the beam telescope's acceptance and the variation of the beam energy. On the other hand, a number of material samples planned in the design of the local support structures of the new ATLAS Inner Tracker (ITk) strip detector were

investigated to extract the according radiation length values not known beforehand. Here, also the possibility of two-dimensional imaging of complex structures was successfully demonstrated for carbon-fiber based sandwich structure (the "petal core") allowing an even deeper analysis of the detector design.
Overall, the potential of the MBI technique covers a wide range of applications: from the design of high-energy particle detectors over industrial investigations of high-Z materials up to applications in medical imaging ("electron CT").

Your name:

Jan-Hendrik Arling

email:

jan-hendrik.arling@desy.de

Title:

Dr

Nationality:

Germany

Institute:

Deutsches Elektronen-Synchrotron (DESY)

Poster Session 3 (Applications in Particle Physics) / 179

Construction and Operation of the CMS Phase-1 Silicon Pixel Detector at the LHC

Author: Somnath Choudhury[1]

[1] *Indian Institute of Science (IN)*

Corresponding Author: somnath.choudhury@cern.ch

The CMS Phase-1 Pixel Detector was designed to cope with an instantaneous luminosity 2 x 10ˆ34 cm-2 s-1 and 25 ns bunch spacing with very small efficiency loss. The upgraded detector has 124M channels that features a 4-hit coverage in the tracking volume. DC-DC converters were used to deliver more power to the detector without the need of replacing the cable plant. CO2 based cooling was implemented and carbon based structures were used to reduce material in the tracking volume. The data acquisition system was upgraded to accept higher event rates and a digital data format from the detector front-ends. The detector was installed in early 2017 and has been successfully operated since then. In this presentation, the construction and assembly, operational experience and the performance of the pixel detector at the LHC will be discussed.

Your name:

Somnath Choudhury

email:

somnath.choudhury@cern.ch

Title:

Dr.

Nationality:

India

Institute:

Indian Institute of Science, Bangalore

Applications in Life Sciences and Biology; Applications in Particle Physics 3 / 180

First test beam of an all-silicon polarimeter demonstrator for proton EDM searches (in-person)

Author: James William Gooding[1]

Co-authors: Themis Bowcock [2]; Gianluigi Casse [1]; Eva Vilella Figueras [1]; Nikolaos Rompotis [3]; Joost Vossebeld [1]; Joe Price [4]

[1] *University of Liverpool (GB)*

[2] *CERN*

[3] *University of Liverpool (UK)*

[4] *University of Liverpool*

Corresponding Authors: joe.price@liverpool.ac.u, james.william.gooding@cern.ch, bowcock@liverpool.ac.uk, vilella@hep.ph.liv.ac.uk, gianluigi.casse@cern.ch, joost.vossebeld@cern.ch, nikolaos.rompotis@cern.ch

Permanent EDM (Electric Dipole Moments) of elementary particles are prime candidates for finding new physics beyond the Standard Model. Permanent EDM of charged particles can be measured in innovative storage rings by observing a polarisation change caused by interaction between a particles spin vector and stable electric fields.
The cpEDM (charged particle EDM) Collaboration aims to design an all-electric storage ring for proton EDM studies that could be either hosted at CERN or COSY (Cooler Synchrotron). To address this challenging project, the cpEDM Collaboration assumes a staged approach. The prototype ring stage, which serves as a proof-of-principle, uses protons with 30-45 MeV kinetic energy necessitating a low material budget polarimeter.
This contribution presents an all-silicon polarimeter for proton EDM searches. The polarimeter is comprised of one 100 μm layer of HV-CMOS (High Voltage-CMOS) sensors for high spatial resolution, surrounded by two layers of LGAD (Low Gain Avalanche Detectors) in a time of flight configuration to provide high energy resolution by means of picosecond timing resolution. The HV-CMOS layers will be used to accurately determine the scattered direction of the protons and for track reconstruction. Geant4 simulations have showed that such a system meets the energy resolution necessary for the experiment (less than 3%) whilst retaining a short time of flight length (less than 1 m).
We have designed a polarimeter demonstrator based on a prototype LGAD (USFD2), with 200 μm strip pitch. The polarimeter is read out using a TRB3 board featuring four FPGA-based TDCs (Time-to-Digital Converters) with <20 ps RMS (Root Mean Square) time precision between two individual channels. The positions of the timing layers can be reconfigured remotely to test the energy resolution obtained with different time of flight lengths. The application for pEDM studies, design and test beam evaluation at a medical proton therapy centre are presented.

Your name:

James Gooding

email:

J.R.Gooding@liverpool.ac.uk

Title:

Mr

Nationality:

British

Institute:

University of Liverpool

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 181

Longevity Study on the CMS Resistive Plate Chambers for HL-LHC

Author: Reham Aly[1]

[1] *Bari University - Italy*

Corresponding Author: reham.aly@cern.ch

The CMS Resistive Plate Chambers (RPC) system has been certified for 10 years of LHC operation. In the next years, during the High luminosity LHC (HL-LHC) phase, the LHC instantaneous luminosity will increase to factor five more than the nominal LHC luminosity. This will subject the present CMS RPC system to high background rates and operating conditions much higher with respect those for which the detectors have been designed. Those conditions could affect the detector properties and introduce a non-recoverable aging effects. A dedicated longevity test is set up in the CERN Gamma Irradiation Facility (GIF++) to study if the present RPC detectors can survive the hard background conditions during the HL-LHC running period.
During the irradiation test, the RPC detectors are exposed to a high gamma radiation for a long period and the detector main parameters are monitored as a function of the integrated charge. The results of the irradiation test after having collected a sufficient amount of the expected integrated charge will be presented.

Your name:

Reham Aly

email:

reham.aly@cern.ch

Title:

Ms

Nationality:

Egyptian

Institute:

universita, politecnico and infn bari - Italy

Detectors for Neutron Facilities; Gas-based Detectors 2 / 182

GridPix: the ultimate electron detector for TPCs (in-person)

Author: Harry Van Der Graaf[1]

Co-authors: Cornelis Ligtenberg [2]; Martin Van Beuzekom [1]; Yevgen Bilevych [3]; Klaus Desch [4]; Frederik Hartjes [1]; Kevin Heijhoff [1]; Jochen Kaminski [3]; Peter Kluit [1]; Naomi Van Der Kolk [5]; Gerhard Raven [1]; Jan Timmermans [1]

[1] *Nikhef National institute for subatomic physics (NL)*

[2] *Nikhef*

[3] *University of Bonn (DE)*

[4] *University of Bonn*

[5] *NIKHEF (NL)*

Corresponding Authors: f.hartjes@nikhef.nl, jochen.kaminski@cern.ch, gerhard.raven@nikhef.nl, cligtenb@nikhef.nl, desch@uni-bonn.de, bilevych@uni-bonn.de, jan.timmermans@cern.ch, kevin.heijhoff@cern.ch, kolk@nikhef.nl, vdgraaf@nikhef.nl, s01@nikhef.nl, martin.van.beuzekom@cern.ch

By means of "Integrated Grid"**InGrid** MEMS technology, a MicroMegas is created on top of the (spark protected) TimePix-3 chip. Units containing four chips "Quads"and their services (data and control transfer, power, cooling) can be placed together, forming an arbitrarily large active direction area. Data from UV laser tracks, from cosmic ray muons, and from test beams are presented.
By applying 1.4 % CS2 in the gas, the drifting electrons form drifting negative ions of which the ***two*** drift velocities are measured with high precision. Negative ion TPCs can self-provide Tzero for tracks, which is convenient in rare-event experiments.
An outlook is presented on applying the future TimePix-4 in the electron GridPix detector.

Your name:

Harry van der Graaf

email:

vdgraaf@nikhef.nl

Title:

Prof

Nationality:

Dutch

Institute:

Nikhef & TU Delft

Applications in Astronomy, Planetary and Space Science 1 / 183

The application of the Rasnik 3-point alignment system in seismic instrumentation (in-person)

Author: Harry Van Der Graaf[1]

Co-authors: Alessandro Bertolini [2]; Bram Bouwens [3]; Lennaert Otemann [4]; Nelson de Gaay Fortman [5]; Joris van Heijningen [6]

[1] *Nikhef National institute for subatomic physics (NL)*

[2] *Nikhef*

[3] *Amsterdam Scientific Instruments*

[4] *TU Delft*

[5] *AMOLF*

[6] *NIKHEF*

Corresponding Authors: jvvanheijningen@gmail.com, bram.bouwens@amscins.com, vdgraaf@nikhef.nl

For high-precision measurement of the momentum of muons, the alignment of three (inner, middle and outer) muon tracking detectors, placed at some mutual distance in the magnetised volume, is

essential. Since accurate alignment can not be realised mechanically, the alignment is continuesly monitored instead. For this, a back-illuminated coded mask is attached to the inner detector, and a positive lens, attached to the middle detector, projects an image of the mask pattern onto an image pixel sensor attached to the outer detector. The images from the sensor are analysed and contain high-precision info about the alignment. By correcting the measured muon sagittas with alignment data, the actual positions of the three muon trackers is no longer relevant.
Since 2008, some 8000 Rasnik systems are operational in the ATLAS experiment. The data suggests a much higher operational precision than the original ATLAS requirement of order 10 microns.
Simulations have revealed that spatial resolutions of order 1 nm ***per image*** can be expected, and that this precision is only limited by the quantum fluctuations of the light detected by the pixels of the image sensor. This precision was confirmed by a measurement using the MERCURY-41-302 sensor.
By replacing the positive singlet lens by a microscope objective (Newport M-20X), the magnification lever arm is expected to amplify the image displacement by a factor 20. With 275 fps, a value of 7 pm /sqrt(Hz) has been reached, and by applying new hardware a value of 0.2 pm /sqrt(Hz) is expected.
As a simple and straightforward 2D displacement monitor, Rasnik could be applied in the seismic instruments used in Gravitational Wave detectors, replacing commonly used interferometers.

Your name:

Harry van der Graaf

email:

vdgraaf@nikhef.nl

Title:

Prof

Nationality:

Dutch

Institute:

Nikhef & TU Delft

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 184

The transmission dynode (tynode) vacuum electron multiplier

Author: Harry Van Der Graaf[1]

Co-authors: Annemarie Theulings ; Hong Wah Chan ; Kees Hagen [2]; Violeta Prodanowic ; Pasqualina Sarro [3]; Shuxia Tao [4]

[1] *Nikhef National institute for subatomic physics (NL)*

[2] *TU Delft*

[3] *Delft University of Technology*

[4] *nikhef*

Corresponding Authors: vdgraaf@nikhef.nl, p.m.sarro@tudelft.nl, sxtao@nikhef.nl

With Atomic Layer Deposition (ALD) MEMS technology, thin multilayers have been realised which emit, after the absorption of an energetic electron at the top side, a multiple of secondary electrons at the bottom (emitting) side. In order to avoid charge-up effects, one of the layers has the function to replenish electrons and is therefore a conductor. With ALD MgO, a transmission secondary electron yield (TSEY) of 5.5 has been reached, enabling the single-electron sensitive Timed Photon Counter TipC in which a stack of 8 tynodes is placed on top of the TimePix3 or TimePix4 chip.
The alignment of 8 tynodes in a stack is obtained by applying grooves at both sides of a tynode:

a glass wire in the groove is sandwiched between adjacent tynodes, locking their mutual 3D position.

Your name:

Harry van der Graaf

email:

vdgraaf@nikhef.nl

Title:

Prof

Nationality:

Dutch

Institute:

Nikhef & TU Delft

Applications in Particle Physics 2 / 186

Towards MightyPix, an HV-MAPS for the LHCb Mighty Tracker Upgrade

Author: Jan Patrick Hammerich[1]

[1] *University of Liverpool (GB)*

Corresponding Author: j.hammerich@cern.ch

The Mighty Tracker is a proposed upgrade to the downstream tracking system of LHCb for operations at high luminosities starting with the LHC Run 5 data taking period. It foresees the replacement of the most central area of the scintillating fibre tracker with HV-CMOS pixel sensors. Due to the increased luminosity of the LHC, occupancy would be too high for track reconstruction in the fibre tracker and the fibres could no longer withstand the radiation damage. HV-CMOS sensors have demonstrated a significant radiation tolerance and good performance making them an ideal choice of technology for the LHCb experiment.
Monolithic active pixel sensors (MAPS) fabricated in HV-CMOS processes provide fast charge collection via drift and allow the implementation of the readout on the same die as the sensitive volume. Due the use of commercial processes, these sensors can be fabricated at low cost as no hybridisation with bump bonds is required. Since they are not fully depleted, the inactive volume can be thinned away.
A dedicated sensor called the MightyPix is developed for this programme. It is based on the successful HV-MAPS families MuPix and ATLASpix and tailored to the requirements of LHCb. To demonstrate the feasibility of this technology for the LHCb environment, prototypes have been irradiated. These sensors are investigated in terms of efficiency, time resolution and power dissipation in temperature controlled environments. Results of measurements are presented.

Your name:

Jan Hammerich

email:

j.hammerich@cern.ch

Title:

Mr

Nationality:

German

Institute:

University of Liverpool (GB)

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 187

Evaluation of Tomographic Image Reconstruction Techniques for Accurate Spent Fuel Assembly Verification

Author: Hyemi Kim[None]

Co-authors: Minjae Lee [1]; Hyung Joo Choi [1]; Hyun Joon Choi [2]; Chul Hee Min [1]

[1] *Department of Radiation Convergence Engineering, Yonsei University, Republic of Korea*

[2] *Department of Radiation Oncology, Wonju Severance Christian Hospital, Republic of Korea*

Corresponding Author: sisiisiii20@gmail.com

To realize the non-proliferation and security of nuclear material, the international atomic energy agency (IAEA) considers a tomographic image acquisition technique of spent fuel assemblies as a promising technique to accurately verify rod-by-rod spent fuel conditions stored in a water pool. Our previous research developed and experimentally validated a highly sensitive single-photon emission tomographic (SPECT) system to quickly evaluate the radioactivity distribution of test fuel rods in the Korea Institute of Nuclear Nonproliferation and Control (KINAC). In order to quickly verify the fuel assembly, it is important to develop the high-quality image reconstruction algorithm that enables image acquisition within a short time. The purpose of this study is to evaluate advanced tomographic image reconstruction techniques to accurately identify patterns of missing fuel rods.
Rotational projection image data sets were obtained for 16 patterns of test fuel rods for a total of 900 seconds using the SPECT system installed at KINAC. The projection images were acquired every 5 degrees while four 64-channel detectors rotated 90 degrees. The acquired images were reconstructed in the following methods: filtered back-projection (FBP), simultaneous iterative reconstruction technique (SIRT), order-subset simultaneous algebraic reconstruction technique (OS-SART), and maximum likelihood expectation maximization (MLEM). As a result of quantitative evaluation, the image quality of the MLEM showed the best performance. This algorithm preserved the image intensity and edge, and global homogeneity was significantly better with the reduced generative noise than that of other algorithms. Therefore, to accurately verify the patterns of fuel rods, we improved the signal-to-noise ratio of the tomographic image with the advanced image reconstruction technique. We expect that even for the low-quality measured data with the short-time scan of the SPECT system, this advanced technique will show better discriminability of the patterns of fuel rods in the assembly.

Your name:

Hyemi Kim

email:

ab120266@yonsei.ac.kr

Title:

Dr

Nationality:

Republic of Korea

Institute:

Department of Radiation Oncology, Wonju Severance Christian Hospital, Republic of Korea

Applications in Security and Environmental Imaging; Advances in Pixel Detectors and Integration Technologies 2 / 189

Characterization of irradiated RD53A pixel modules with passive CMOS sensors (in-person)

Authors: Arash Jofrehei[1]; Malte Backhaus[2]; Pascal Raffael Baertschi[1]; Florencia Canelli[1]; Yannick Manuel Dieter[3]; Jochen Christian Dingfelder[3]; Franz Glessgen[2]; Tomasz Hemperek[3]; Fabian Huegging[4]; Weijie Jin[1]; Ben Kilminster[1]; Anna Macchiolo[1]; Daniel Muenstermann[5]; David-Leon Pohl[None]; Arne Christoph Reimers[1]; Branislav Ristic[6]; Rainer Wallny[2]; Tianyang Wang[3]; Norbert Wermes[3]; Pascal Wolf[4]

[1] *Universitaet Zuerich (CH)*

[2] *ETH Zurich (CH)*

[3] *University of Bonn (DE)*

[4] *University of Bonn*

[5] *Lancaster University (GB)*

[6] *ETH Zurich*

Corresponding Authors: ben.kilminster@cern.ch, malte.backhaus@cern.ch, canelli@physik.uzh.ch, wolf@physik.uni-bonn.de, hemperek@physik.uni-bonn.de, pohl@physik.uni-bonn.de, huegging@physik.uni-bonn.de, arne.reimers@cern.ch, bristic@ethz.ch, rainer.wallny@cern.ch, yannick.manuel.dieter@cern.ch, weijie.jin@cern.ch, tianyang.wang@cern.ch, jochen.christian.dingfelder@cern.ch, anna.macchiolo@cern.ch, pascal.baertschi@uzh.ch, arash.jofrehei@cern.ch, daniel.muenstermann@cern.ch, wermes@uni-bonn.de, franzg@student.ethz.ch

We are investigating the feasibility of using CMOS foundries to fabricate silicon radiation detectors, both for pixels and for large-area strip sensors. The availability of multi-layer routing will provide the freedom to optimize the sensor geometry and the performance, with biasing structures in poly-silicon layers and MIM-capacitors allowing for AC coupling. A prototyping production of strip test-structures and RD53A compatible pixel sensors was recently completed at LFoundry in 150nm CMOS process. This presentation will focus on the characterization of irradiated and non-irradiated pixel modules, composed by a CMOS passive sensor interconnected to a RD53A chip. The sensors are designed with a pixel cell of 25×100 μm^2 in case of DC coupled devices and 50×50 μm^2 for the AC coupled ones. Their performance in terms of charge collection, position resolution, and hit efficiency was studied with measurements performed in the laboratory and with beam tests. The RD53A modules with LFoundry silicon sensors were irradiated to fluences up to 1016 neq/cm2.

Your name:

Arash Jofrehei

email:

arash.jofrehei@cern.ch

Title:

Nationality:

Iranian

Institute:

University of Zurich

Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science 2 / 190

Directional Dark Matter Search with NEWSdm

Author: Andrey Alexandrov[1]

Co-author: NEWSdm collaboration

[1] *Universita e sezione INFN di Napoli (IT)*

Corresponding Authors: andrey.alexandrov@na.infn.it, andrey.alexandrov@cern.ch

In spite of the extensive search for the detection of the dark matter (DM), experiments have so far yielded null results: they are probing lower and lower cross-section values and are touching the so-called neutrino floor. A way to possibly overcome the limitation of the neutrino floor is a directional sensitive approach: one of the most promising techniques for directional detection is nuclear emulsion technology with nanometric resolution. Nano Imaging Trackers (NIT) is the last generation of nuclear emulsions, designed on purpose for a directional DM search. It has an extremely high granularity, and it required the development of fast super-resolution imaging technique for its readout. The NEWSdm experiment, located in the Gran Sasso underground laboratory in Italy, uses the NIT emulsion acting both as the Weakly Interactive Massive Particle (WIMP) target and as the nanometric-accuracy tracking device. This would provide a powerful method of confirming the Galactic origin of the dark matter, thanks to the cutting-edge technology developed to readout sub-nanometric trajectories. In this talk we discuss the newly-developed super-resolution readout technique, the NEWSdm experiment design, its physics potential, the performance achieved in test beam measurements and the near-future plans.

Your name:

Andrey Alexandrov

email:

andrey.alexandrov@na.infn.it

Title:

Dr

Nationality:

Russian

Institute:

National Institute of Nuclear Physics (INFN) and University of Naples “Federico II”, Italy

Gas-based Detectors 1 / 191

Studies on tetrafluoropropene-CO2 based gas mixtures for the Resistive Plate Chambers of the ALICE Muon IDentifier

Author: Alessandro Ferretti[1]

[1] *Universita e INFN Torino (IT)*

Corresponding Author: ferretti@to.infn.it

Due to their simplicity and comparatively low cost, Resistive Plate Chambers are gaseous detectors widely used in high-energy and cosmic rays physics when large detection areas are needed. However, the best gaseous mixtures are currently based on tetrafluoroethane, which has the undesirable

characteristic of a large Global Warming Potential (GWP) of about 1400 and, because of this, it is currently being phased out from industrial use. As a possible replacement, tetrafluoropropene (which has a GWP close to 1) has been taken into account.
Since tetrafluoropropene is more electronegative than tetrafluoroethane, it has to be diluted with gases with a lower attachment coefficient in order to maintain the operating voltage close to 10 kV. One of the main candidates for this role is carbon dioxide. In order to ascertain the feasibility and the performance of tetrafluoropropene-CO2 based mixtures, an R&D program is being carried out in the ALICE collaboration, which employs an array of 72 Bakelite RPCs (Muon Identifier, MID) in order to identify muons. Different proportions of tetrafluoropropene and CO2, with the addition of small quantities of isobutane and sulphur hexafluoride, have been tested with 50x50 cm2 RPC prototypes with 2 mm wide gas gap and 2 mm thick Bakelite electrodes.
In the presentation, results from tests with cosmic rays will be presented, together with data concerning the current drawn by a RPC exposed to the gamma-ray flux of the Gamma Irradiation Facility (GIF) at CERN. Moreover, a beam test at GIF is scheduled in July, 2021 and some of its preliminary results will be shown.

Your name:

Alessandro Ferretti

email:

ferretti@to.infn.it

Title:

Prof.

Nationality:

Italian

Institute:

Università di Torino and INFN - Sezione di Torino

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 192

First results of an oncological brachytherapy fiber dosimeter

Authors: Agnese Giaz[1]; Massimo Caccia[2]; Michael Martyn[3]; Romualdo Santoro[4]; Samuela Lomazzi[5]; Simona Cometti[6]; Sinead O'Keeffe[7]; Wern Kam[8]

[1] *Università degli studi dell'Insubria*

[2] *Universita & INFN, Milano-Bicocca (IT)*

[3] *Dept. of Radiotherapy Physics, Galway Clinic, Galway, Ireland.*

[4] *Insubria University and INFN - MI*

[5] *University of Insubria*

[6] *Univerisità dell'Insubria, DISAT, Como, Italy.*

[7] *Optical Fibre Sensors Research Centre, University of Limerick, Ireland*

[8] *Optical Fibre Sensors Research Centre, University of Limerick, Ireland*

Corresponding Authors: sinead.okeeffe@ul.ie, massimo.caccia@uninsubria.it, wern.kam@ul.ie, romualdo.santoro@cern.ch, samuelalomazzi@gmail.com, michael.martyn@galwayclinic.com, agnese.giaz@mi.infn.it, simona.cometti@uninsubria.it

The ORIGIN project aims to deliver photonics-enabled, adaptive, and more effective diagnostics-driven brachytherapy for cancer treatment through advanced real-time radiation dose imaging and radioactive source localization. This goal will be achieved by developing a 16 to 32 optical-fiber-based system where scintillating light is detected by Silicon Photomultiplier. This work reports the results

achieved in laboratory and hospital conditions with single-sensor prototypes for low and high dose rate brachytherapy, requiring different specifications. The former requires high sensitivity and low minimum detectable signal, whereas an extended linearity range is crucial for the latter. Laboratory activities were essential to identify the optimal silicon photomultiplier. Preliminary tests, performed at the hospital premises for both treatments, assessed the viability of the proposed solution. The first results were also relevant to identify the ASIC-based readout system that will allow the project to reach the final goal of engineering a multi-fiber real-time dosimetry imager.

Your name:

Agnese Giaz

email:

agnese.giaz@uninsubria.it

Title:

Nationality:

Italian

Institute:

Università degli studi dell'Insubria

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 193

Bergen proton-CT project

Authors: Alexander Schilling[1]; Viljar Nilsen Eikeland[2]; Alexander Wiebel[3]; Arnon Songmoolnak[4]; Attiq Ur Rehman[2]; Boris Wagner[2]; Chinorat Kobdaj[4]; Christoph Garth[5]; Dieter Rohrich[6]; Ganesh Jagannath Tambave[2]; Georgi Genov[7]; Gergely Gabor Barnafoldi[8]; Grigori Feofilov[9]; Gábor Papp[10]; Haavard Helstrup[11]; Helge Egil Seime Pettersen[12]; Hesam Shafiee[13]; Hiroki Yokoyama[14]; Ihor Tymchuk[15]; Jarle Rambo Sølie[16]; Joao Seco[17]; Johan Alme[2]; Kjetil Ullaland[2]; Lennart Volz[None]; Maksym Protsenko[15]; Matthias Richter[18]; Max Aehle[19]; Monika Varga-Kofarago[20]; Nicolas Gauger[21]; Odd Odland[11]; Ola Grøttvik[None]; Pierluigi Piersimoni[22]; Raju Ningappa Mulawade[1]; Ralf Keidel[23]; Ren-Zheng Xiao[24]; Sebastian Zillien[25]; Serguei Igolkin[9]; Shiming Yang[2]; Shruti Mehendale[26]; Steffen Wendzel[27]; Thomas Peitzmann[14]; Tobias Kortus[1]; Ton Van Den Brink[14]; Viatcheslav Borshchov[28]; Viktor Leonhardt[19]

[1] *University of Applied Sciences Worms*

[2] *University of Bergen (NO)*

[3] *Center for Technology and Transfer (ZTT), University of Applied Sciences Worms*

[4] *Suranaree University of Technology (TH)*

[5] *Chair for Scientific Visualization Lab, Technische Universität Kaiserslautern*

[6] *Department of Physics & Technology-University of Bergen*

[7] *University of Bergen*

[8] *Wigner RCP Hungarian Academy of Sciences (HU)*

[9] *St Petersburg State University (RU)*

[10] *Eötvös University*

[11] *Department of Physics and Technology*

[12] *Haukeland University Hospital*

[13] *Western Norway University of Applied Sciences (NO)*

[14] *Nikhef National institute for subatomic physics (NL)*

[15] *National Academy of Sciences of Ukraine (UA)*

[16] *Department of Electrical Engineering, Western Norway University of Applied Sciences*

[17] *Department of Biomedical Physics in Radiation Oncology, German Cancer Research Center*

[18] *University of Oslo (NO)*

[19] *TU Kaiserslautern*

[20] *Wigner Research Centre for Physics (Wigner RCP) (HU)*

[21] *Chair for Scientific Computing, Technische Universität Kaiserslautern*

[22] *UNIVERSITETET I BERGEN*

[23] *Fachhochschule Worms (DE)*

[24] *College of Mechanical & Power Engineering, China Three Gorges University*

[25] *ZTT - HS Worms*

[26] *Department of Physics and Technology, University of Bergen*

[27] *Worms University of Applied Sciences*

[28] *Sci. Res. Tech. Inst. Instrum. Eng. (UA)*

Corresponding Authors: matthias.richter@cern.ch, szillien@hs-worms.de, johan.alme@uib.no, kortus@ztt.hs-worms.de, keidel@fh-worms.de, georgi.genov@uib.no, max.aehle@scicomp.uni-kl.de, aschilling@hs-worms.de, haavard.helstrup@ift.uib.no, helge.e.s.pettersen@gmail.com, wendzel@hs-worms.de, feofilov@hiex.phys.spbu.ru, olagrottvik@gmail.com, attiq.ur.rehman@cern.ch, kjetil.ullaland@ift.uib.no, mulawade@hs-worms.de, a.vandenbrink@uu.nl, serguei.igolkine@cern.ch, ganesh.jagannath.tambave@cern.ch, pierluigi.piersimoni@gmail.com, chinorat.kobdaj@cern.ch, hesam.shafiee@cern.ch, shiming.yang@cern.ch, v_leonhard09@cs.uni-kl.de, monika.kofarago@cern.ch, viljar.nilsen.eikeland@cern.ch, hiroki.yokoyama@cern.ch, boris.wagner@cern.ch, maksym.protsenko@cern.ch, ihor.tymchuk@cern.ch, dieter.rohrich@fi.uib.no, volz@physi.uni-heidelberg.de, borshchov@kharkov.ukrtel.net, arnon.songmoolnak@cern.ch, odland@subatech.in2p3.fr, thomas.peitzmann@cern.ch, pg@elte.hu, gergely.barnafoldi@cern.ch

Proton therapy is a treatment method that utilizes the energy deposition of heavy ions to concentrate the dose delivered to a patient during the treatment of the malignant tumor. The Bergen proton Computed Tomography (pCT) collaboration is constructing a prototype detector capable of both tracking and measuring the energy deposition of ions in order to minimize uncertainty in proton treatment planning.

The pCT detector designed by the Bergen pCT collaboration is a high granularity digital tracking calorimeter, where the first two layers will be used to obtain positional information of the incoming particle and act as tracking layers. The remainder of the detector will act as a calorimeter. The tracking layers will utilize a carrier made of ~200 μm thick carbon fleece, this is to minimize scattering effects. The calorimeter part of the detector will have the sensor chips mounted on aluminum carriers, there will also be a 3.5 mm aluminum layer in between each sensitive layer, which will act as absorber material. Each sensitive layer will be populated by 108 ALPIDE chip sensors, situated in a 12x9 grid to cover the entire 27 cm x 16.6 cm area of the detector. The ALPIDE chip was developed for the ITS2 upgrade at CERN and is a monolithic active pixel sensor manufactured using the 180 nm CMOS Imaging Sensor process by Tower Semiconductor. Each ALPIDE has a surface area of 30 mm x 15 mm and consists of a pixel-matrix with 512x1024 pixels.

This presentation will discuss the implementation of the design, present data taken with high-energetic (50-220 MeV/u) proton and ion beams at the Heidelberg Ion-Beam Therapy Center (HIT) in Germany, and present selected results from simulations.

Your name:

Viljar Nilsen Eikeland

email:

viljar.eikeland@uib.no

Title:

Mr

Nationality:

Norwegian

Institute:

Department of Physics and Technology, University of Bergen

194

An application-specific small field of view gamma camera for intraoperative dual-isotope parathyroid scintigraphy

Authors: Andrew Farnworth[None]; Kjell Koch-Mehrin[1]; Sarah Bugby[2]; Sabapathy Balasubramanian[3]

[1] *University of Leicester*

[2] *Loughborough University*

[3] *University of Sheffield, Sheffield Teaching Hospitals Foundation Trust*

Corresponding Authors: afarnworth91@gmail.com, s.bugby@lboro.ac.uk, kalkm1@leicester.ac.uk, s.p.balasubramanian@sheffield.a

99mTc-Sestamibi/123I dual-isotope scintigraphy is the gold standard for preoperative parathyroid gland localisation but is not currently possible intraoperatively. As parathyroid 99mTc-Sestamibi uptake is non-specific, physiological uptake, such as within thyroid tissue, often confounds parathyroid tissue identification. Simultaneous 99mTc-Sestamibi/123I imaging allows tissue differentiation by the thyroid-specific uptake of 123I. As parathyroidectomy success is strongly predicted by knowledge of parathyroid gland location, and preoperative imaging may not be sensitive enough or insufficient to enable localisation during surgery, there is potential to improve parathyroidectomy success rates by developing detector systems capable of intraoperative dual-isotope scintigraphy.

Dual-isotope parathyroid scintigraphy is a particularly challenging application. Excellent detector energy resolution is essential to resolve 140keV 99mTc and 159keV 123I energy peaks and achieve suitable image quality. Parathyroid tissue tracer uptake is discerned from the 140keV energy window image, which has increased background due to scattered 159keV photons. Poor detector energy resolutions reduce the proportion of 99mTc-decay photons collected, potentially compromising parathyroid gland conspicuity. Detector systems also require sufficient sensitivity to image without disrupting surgery, spatial resolution able to resolve ˜1mm parathyroid glands, and material properties suitable for surgical environments.

Compound semiconductor materials are promising for dual-isotope scintigraphy. Low charge-carrier creation energies allow excellent energy resolution, high atomic number and densities provide good sensitivity for small footprints, and wide band-gaps allow room temperature detector operation. CdZnTe bonded to the HEXITEC ASIC forms a pixelated, spectroscopic detector system with suitable footprint for intraoperative applications. Each pixel can record energy deposition per imaging frame, allowing excellent energy resolution to be achieved using charge-sharing correction algorithms.

This study investigates compound semiconductor detector suitability for dual-isotope parathyroid scintigraphy by simulating performance of a CdZnTe-HEXITEC detector system, using anthropomorphic phantom volumes and Monte Carlo simulation. The trade-offs between energy resolution and photon statistics are investigated, considering implications for application-specific detector system design.

Your name:

email:

a.farnworth@lboro.ac.uk

Title:

Nationality:

Institute:

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 197

Position reconstruction studies with GEM detectors and the charge-sensitive VMM3a ASIC

Author: Lucian Scharenberg[1]

Co-authors: Antonija Utrobicic [2]; Djunes Janssens [3]; Dorothea Pfeiffer [2]; Eraldo Oliveri [2]; Florian Maximilian Brunbauer [2]; Francisco Ignacio Garcia Fuentes [4]; Hans Muller [5]; Heikki Pulkkinen [4]; Hugo Natal da Luz [6]; Jerome Samarati [7]; Jona Bortfeldt [8]; Karl Flöthner [9]; Klaus Desch [10]; Leszek Ropelewski [2]; Marek Hracek [11]; Marta Lisowska [12]; Michael Lupberger [5]; Miranda Van Stenis [2]; Rob Veenhof [13]

[1] *CERN, University of Bonn (DE)*

[2] *CERN*

[3] *Vrije Universiteit Brussel (BE)*

[4] *Helsinki Institute of Physics (FI)*

[5] *University of Bonn (DE)*

[6] *Universidade de Sao Paulo (BR)*

[7] *ESS - European Spallation Source (SE)*

[8] *Ludwig Maximilians Universitat (DE)*

[9] *HISKP-Uni-Bonn*

[10] *University of Bonn*

[11] *Czech Technical University in Prague (CZ)*

[12] *University of Silesia (PL)*

[13] *Uludag University (TR)*

Corresponding Authors: marek.hracek@cern.ch, jonathan.bortfeldt@cern.ch, francisco.garcia@cern.ch, heikki.j.pulkkinen@gmail.com, djunes.janssens@cern.ch, marta.lisowska@cern.ch, hugo.nluz@cern.ch, eraldo.oliveri@cern.ch, jerome.samarati@cern.ch, floethner2@aol.com, rob.veenhof@cern.ch, lucian.scharenberg@cern.ch, florian.maximilian.brunbauer@cern.ch, michael.lupberger@cern.ch, miranda.van.stenis@cern.ch, antonija.utrobicic@cern.ch, desch@uni-bonn.de, hans.muller@cern.ch, dorothea.pfeiffer@cern.ch, leszek.ropelewski@cern.ch

Gas Electron Multiplier (GEM) detectors are a prominent example of Micro-Pattern Gaseous Detectors (MPGDs). One of their main features is that they provide a good spatial resolution over large areas (square metre sized detector modules). When the interacting particle deposits energy inside the detector volume, primary electrons are created that drift towards the readout anode (here: 9 mm drift distance). During the drift, the electron cloud diffuses (sigma of 250 µm) over fine pitch granularity readout electrodes (here strips with 400 µm pitch). With such granularities, spatial resolutions of about 100 µm are achieved. Due to the charge spread over several readout electrodes, even better spatial resolutions can be achieved (around 40 µm with high-energy MIPs in COMPASS-like GEM detectors) by using position reconstruction algorithms, like for example the centre-of-gravity (COG) method.

To apply the COG method, multi-channel charge-sensitive readout electronics is needed. For the here presented studies, the VMM3a ASIC was used, which will be briefly introduced. It records the charge information and allows a self-triggered high-rate, position and energy-sensitive readout of large area particle detectors.

Due to the discretised readout structure, a bias is introduced in the reconstructed position, which was similarly observed with Multi-Wire Proportional Chambers (MWPCs), indicating that a pure usage of the COG method may not be the optimal choice. In this presentation, a simple modification of the COG method to mitigate the bias effect is shown and its applicability is discussed. Further, a hardware feature of the VMM3a is presented, which allows to recover otherwise lost charge information in its threshold-based self-triggered readout scheme and thus improves the position reconstruction.

Your name:

Lucian Scharenberg

email:

lucian.scharenberg@cern.ch

Title:

Nationality:

German

Institute:

CERN, University of Bonn (DE)

Detectors for High Radiation and Extreme Environments / 198

A comprehensive overview of the extensive studies on the irreversible breakdown of the LGAD's behavior at ELI Beamlines in fs-laser beam-tests with the sensors irradiated at critical LHC-HL fluences

Author: Gordana Lastovicka Medin[1]

Co-authors: Gregor Kramberger [2]; Mateusz Rebarz [3]; Jakob Andreasson [3]; Kamil Kropielniczki [3]; Jiri Kroll [4]; Tomas Lastovicka [4]; Michal Tomasek [5]; Nicolo Cartiglia [6]; Valentina Sola [7]

[1] *University of Montenegro (ME)*

[2] *Jozef Stefan Institute (SI)*

[3] *Extreme Light Infrastructure*

[4] *Czech Academy of Sciences (CZ)*

[5] *Acad. of Sciences of the Czech Rep. (CZ)*

[6] *INFN Torino (IT)*

[7] *Universita e INFN Torino (IT)*

Corresponding Authors: tomas.lastovicka@cern.ch, michal.tomasek@cern.ch, mateusz.rebarz@eli-beams.eu, kamil.kropielnicki@el beams.eu, cartiglia@to.infn.it, valentina.sola@cern.ch, gregor.kramberger@ijs.si, gordana.lastovicka.medin@cern.ch, jiri.kroll@cern.ch, jakob.andreasson@eli-beams.eu

The HL-LHC presents unprecedented challenges and timing information that is expected to play a key role to mitigate the impact of pile-up in both CMS and ATLAS. Broadly speaking, a timing detector is considered to improve the assignment of tracks to vertices in the forward region, which impacts electron ID, jet reconstruction, missing transverse energy and b-tagging. For future accelerators, LGADs as timing sensors, are also an interesting option in lepton accelerators, where timing can improve performance in particular for PID. However, after irradiation timing performance degrades due to loss of gain. To recover, it is important to increase the HV bias. Some devices show am irreversible breakdown while operating in these conditions and this remains a serious concern for both, yield and the LGAD's operation stability. Many systematic studies and dedicated beam-tests at DESY, FNAL and CERN have been performed. Here we present an overview of the fatality tests performed in few dedicated test-campaigns on LGADs at ELI beamlines where we developed a powerful fs-laser based TCT-SPA/TPA experimental infrastructure. Both SPA and TPA were applied. Stable, unstable, critical, and irreversible breakdown phases were distinguished and safety HV bias thresholds set. The images of damaged sensors and HV threshold points for safety LGAD operation will be discussed as well as future strategies pointed out.

Your name:

Gordana Lastovicka-Medin

email:

gordana.medin@gmail.com

Title:

Prof

Nationality:

Montenegrin

Institute:

University of Montenegro

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 199

Characterisation of the spectroscopic properties of p-type Si sensors for X-ray spectroscopy

Author: Ben Cline[1]

Co-authors: Matthew Veale [2]; Matthew Wilson [3]; Mark Bullough [4]; Keith Richardson [4]; Hydon Thorpe [4]

[1] *Science and Technology Facilities Council*

[2] *STFC Rutherford Appleton Laboratory*

[3] *STFC*

[4] *Micron Semiconductor Ltd.*

Corresponding Authors: mark@micronsemiconductor.co.uk, ben.cline@stfc.ac.uk, matt.wilson@stfc.ac.uk, matthew.veale@stfc.ac.uk

To meet the requirements of next-generation light sources, STFC has begun work on a new generation of detector technology, capable of operating at MHz frame rates. Although readout electronics are key components of these systems, the choice of sensor material is critical, with high-density semiconductors such as CdZnTe (CZT) required for higher-energy operation. Whilst high-Z materials are commonly used to measure radiation >20keV, the lower electron-hole-pair-generation energy of Si (3.62eV cf. 4.67eV for CZT) offers the potential of improved spectral resolution at lower energies. However, unlike most Si sensors, these compound semiconductors are predominately electron-readout materials. The advantage of p-type-Si sensors is that they are electron readout, meaning a single electron-sensitive readout chip may be used in the measurement of both low- and high-energy X-rays; previously, detector groups were required to design separate versions of an application-specific integrated circuit (ASIC) or operate at sub-optimal performance. Crucially, this will enable a single ASIC technology to have applications across multiple instruments at these light sources.

In this paper, results relating to the characterisation of p-type-Si sensors, each pixelated on a 76×80 array of 300- or 500μm-thick material, and bonded to the STFC HEXITEC ASIC (Veale et al. 2018), are presented. Current-voltage measurements show low <165 pA mm^{-2} leakage currents up to an applied bias of -120V for 500μm-thick devices, and alongside excellent charge-transport properties this results in high-resolution spectroscopic performance. Results demonstrate highly-uniform room-temperature spectroscopic resolution can be obtained across the investigated energy range with average FWHM of <0.8keV measured at 13.81keV. Results are presented alongside studies into the temporal and temperature-based stability of such devices, and the effect of applied bias on energy resolution and charge sharing.

The results presented are highly promising and suggest p-type Si may be used alongside high-Z sensors for X-ray Imaging at future light sources.

Your name:

Ben Cline

email:

ben.cline@stfc.ac.uk

Title:

Mr

Nationality:

British

Institute:

Science and Technology Facilities Council

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 200

Improvement of three-material decomposition in spectral mammography using non-local means denoising

Author: Minjae Lee[1]

Co-authors: Hunwoo Lee [1]; Hyosung Cho [1]

[1] *Yonsei University*

Corresponding Authors: yiminjae583@yonsei.ac.kr, lawlee@yonsei.ac.kr

The accurate analysis of breast imaging is important because it has been reported that an increase in breast density of only 1% results in a 2% increase in the relative risk of breast cancer. The proteins, water, and lipids that determine breast density are important biomarkers in the diagnosis of breast cancer. In mammography, photon-counting detectors (PCDs) with energy-discrimination capabilities can cause errors in the measurement of chemical composition when the attenuation coefficient is small. This is typically the case with proteins, water, and lipids because of the low photon efficiency in each bin. In this study, a dual-energy technique for PCDs was developed based on a non-local means denoising technique for accurate material decomposition and the quantification of protein, water, and lipid content. To evaluate the proposed material decomposition algorithm, spectral images were acquired with a modeled PCD using the Geant4 Application for Tomographic Emission (GATE) version 6.0. Linear, quadratic, and rational models were used for three-material decomposition based on the spectral images acquired using the PCD. The proposed algorithm yielded the best results for the estimation of breast density, composed of three materials. It was determined that the developed approach improved the accuracy of three-material decomposition using a PCD with energy-discrimination capabilities. The presented material decomposition algorithm has the potential to improve the diagnostic accuracy of breast cancer detection based on the quantitative measurement of breast density using PCDs.

Your name:

Minjae

email:

yiminjae583@yonsei.ac.kr

Title:

Mr

Nationality:

Republic of Korea

Institute:

Yonsei University

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 203

Double injection studies on the RD53B-ATLAS chip

Author: Simon Kristian Huiberts[1]

Co-authors: Maurice Garcia-Sciveres [2]; Timon Heim [2]; Bjarne Stugu [1]; Magne Eik Lauritzen [1]

[1] *University of Bergen (NO)*

[2] *Lawrence Berkeley National Lab. (US)*

Corresponding Authors: bjarne.stugu@ift.uib.no, simon.kristian.huiberts@cern.ch, timon.heim@cern.ch, magne.eik.lauritzen@cern.ch, mgarcia-sciveres@lbl.gov

Operation at the High Luminosity LHC (HL-LHC) requires the pixel detectors of ATLAS and CMS to separate collisions occurring with an extremely high pile-up. Fast detectors with a small pixel size are therefore needed such that thousands of charged particles per event can be reconstructed with high fidelity and excellent vertexing resolution.

The RD53 collaboration has been working on the design of a dedicated readout chip to meet these goals, the RD53 chip. This chip will be part of a hybrid device composed of one or more readout chips bump-bonded to a silicon sensor. In this study, we have tested one of the pre-production versions, the RD53B-ATLAS chip.

This talk present charge injection tests performed on the RD53B-ATLAS chip, specifically looking at its response when a pixel is exposed to injections happening close in time. This was achieved by using a novel feature introduced in the RD53 chip. Here, one can perform two injections in rapid succession by utilizing the specialized charge injection circuit attached to each pixel input. In this way, we were able to inject two consecutive charge injections with varying magnitude with a time gap as small as 5 bunch crossings (125 ns).

The purpose is to study the behaviour of the analog front-end, focusing on events where charge deposition of a particle can happen so rapidly that a preceding hit affects the readout of a subsequent hit. These events are more likely to occur in a high-pile up environment.

Results show that the measured charge of an injection is changed by a preceding injection and that this effect scales with the injected magnitude. This is seen by the threshold and the precision Time over threshold values (pToT) measured on the subsequent injection. The results can be explained by the discharge rate of the primary injection.

Your name:

Simon Kristian Huiberts

email:

simon.k.huiberts@gmail.com

Title:

Mr

Nationality:

Norway

Institute:

University of Bergen

Poster Session 2 (X-ray and Gamma Ray Detectors; Applications in Nuclear Physics and Nuclear Industry; Detectors for FELS, Synchrotrons and Other Advanced Light Sources; Detectors for Neutron Facilities; Novel Ionising Radiation Detection Systems) / 204

An experimental study on frequency-dependent noise-resolution trade-off of an indirect x-ray detector

Author: Hunwoo Lee[1]

Co-authors: Jiyong Shim [1]; Minjae Lee [1]; Hyosung Cho [1]

[1] *Yonsei University*

Corresponding Authors: yiminjae583@yonsei.ac.kr, jiyong2155@yonsei.ac.kr, lhw1437@gmail.com, lawlee@yonsei.ac.kr

Noise and spatial resolution are two key intrinsic characteristics to describe the performance of an x-ray detector and quantified by the imaging performance metrics of noise power spectrum, modulation transfer function, and detective quantum efficiency (DQE). To improve two characteristics of an x-ray detector, image processing algorithms are widely used. However, there exists a trade-off between noise and spatial resolution due to the presence of noise-resolution uncertainty in imaging system. In this work, we investigated the influence of image processing on the frequency-dependent noise-resolution trade-off, which is defined as DQE multiplied by the ratio of a pixel size to spatial resolution, with different x-ray doses. We conducted an experiment using a tabletop setup and some linear image processing algorithms such as smoothing and sharpening filters. Measurements were made on a flat-panel detector, DR tech EVS 4343 at 70kVp. Experimental results showed that the frequency-dependent noise-resolution trade-off is hardly influenced by image processing and do not exceed the upper limit at a fixed incident x-ray dose.

Your name:

Hunwoo Lee

email:

lawlee@yonsei.ac.kr

Title:

Mr

Nationality:

South Korea

Institute:

Yonsei University

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 205

A slice-test demonstrator for the upgrade of the CMS Drift Tubes at High-Luminosity LHC

Author: Carlo Battilana[1]

[1] *Universita e INFN, Bologna (IT)*

Corresponding Author: carlo.battilana@cern.ch

Drift Tubes (DT) detectors equip the CMS muon system barrel region serving both as offline tracking and triggering devices. Existing DT chambers will operate throughout High-Luminosity LHC, but, in order to withstand event rates and integrated doses far beyond the initial design specification, an upgrade of the current readout and trigger electronics is planned. In the upgraded system, time-to-digital converters (TDCs) will stream hits to new back-end boards that, beyond event matching, will perform online tracking of trigger segments exploiting the ultimate DT cell resolution. During the second LHC long shutdown, prototypes of the aforementioned electronics were installed in four DT chambers with the same azimuthal acceptance, instrumenting a demonstrator of the HL-LHC DT upgrade (DT slice-test). In this report, the motivation for such an upgrade will be highlighted, and the status of the DT slice-test operation, as well as its performance measured with cosmic-ray events, will be presented. Plans towards future developments of the demonstrator throughout Run-3 will also be discussed.

Your name:

Carlo Battilana

email:

carlo.battilana@cern.ch

Title:

Nationality:

Italian

Institute:

Università di Bologna and INFN Bologna

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 206

ACHINOS: A multi-anode read-out for position reconstruction and tracking with spherical proportional counters

Authors: Ioannis Katsioulas[1]; Ioannis Manthos[2]; Jack Matthews[1]; Konstantinos Nikolopoulos[2]; Patrick Ryan Knights[1]; Robert James Ward[2]; Tom Neep[2]

[1] *University of Birmingham*

[2] *University of Birmingham (GB)*

Corresponding Authors: tom.neep@cern.ch, jpm602@bham.ac.uk, i.katsioulas@bham.ac.uk, ioannis.manthos@cern.ch, patrick.ryan.knights@cern.ch, robert.james.ward@cern.ch, konstantinos.nikolopoulos@cern.ch

The spherical proportional counter is a versatile gaseous detector with physics applications ranging from rare event searches to fast neutron spectroscopy. In its simplest form, the detector operates with a single channel readout and uses pulse-shape information to reconstruct the interaction radius, which is used for background discrimination and fiducialisation. Recent developments in the read-out instrumentation have enabled the use of a multi-anode read-out structure, ACHINOS. The multiple anodes provide information about the interaction position that, coupled with the radial information, can be used to reconstruct an ionisation track. This ability has implications for several applications of the detector, for example, background discrimination in rare event searches. Developments in the experimental implementation of ACHINOS will be discussed, along with simulations of the track reconstruction capability using a dedicated simulation framework.

Your name:

Patrick Knights

email:

p.r.knights@bham.ac.uk

Title:

Dr

Nationality:

Institute:

University of Birmingham

Applications in Nuclear Physics and Nuclear Industry; X-ray and Gamma Ray Detectors 1; Medical Applications of Position Sensitive Detectors 2 / 207

Proton CT application in X-CT calibration for treatment planning in proton therapy

Authors: Carlo Civinini[1]; Mara Bruzzi[2]; Monica Scaringella[1]; Francesco Fracchiolla[3]; Francesco Tommasino[4]; Marina Scarpa[4]; Paolo Farace[5]; Roberto Righetto[3]; Stefano Lorentini[3]

[1] *INFN Firenze (IT)*

[2] *Università di Firenze, Dipartimento di Fisica, Firenze (IT)*

[3] *Azienda Provinciale per i Servizi Sanitari APSS, Protontherapy Unit- Hospital of Trento, Trento (IT)*

[4] *Università di Trento, Dipartimento di Fisica, Trento (IT)*

[5] *Azienda Provinciale per i Servizi Sanitari (APSS), Protontherapy Unit- Hospital of Trento, Trento (IT)*

Corresponding Authors: paolo.farace@apss.tn.it, roberto.righetto@apss.tn.it, francesco.tommasino@unitn.it, francesco.fracchiolla@ marina.scarpa@unitn.it, mara.bruzzi@unifi.it, carlo.civinini@fi.infn.it, stefano.lorentini@apss.tn.it, scaringella@fi.infn.it

Treatment planning systems for proton therapy require accurate information about stopping power ratio (SPR), relative to water, of the biological tissues the patients are made of. This information, in the present clinical practice, are extracted from X-rays computed tomography (X-CT) images. In this context the inaccuracy introduced in the conversion between Hounsfield Units (HU) and SPR maps is one of the main sources of uncertainty on the estimated proton range limiting the accuracy of treatment planning. In the recent past, in the framework of INFN funded research projects, a 5x20 cm2 field of view proton CT (pCT) system, composed of a microstrip silicon tracker and a YAG:Ce calorimeter, has been built with the aim to directly measure SPR maps. Proton tomographies of test phantoms acquired with this apparatus at Trento Proton Therapy Centre showed an accuracy on SPR measurement of about 1% (2020, Phys. Med. Biol. 65 225012). Recently a novel X-CT calibration technique, that makes use of the INFN pCT apparatus, has been proposed to improve X-CT calibration accuracy (2021, Med. Phys. 48 (3) 1349-1355). The aim of this project (XpCalib) is to prepare a set of biological phantoms and to acquire both pCT and X-CT scans on each of them by the pCT and X-CT systems to eventually extract a SPR-HU calibration function. The use of biological phantoms is proposed instead of synthetic tissue equivalent materials, which fail in accurately mimicking the real biological tissues'properties. Another aspect that will be investigated is the possibilities to stabilize those phantoms, in order to be able to extend the calibration procedure to other proton therapy centers, even to those not equipped with a pCT scanner. In this contribution the proposed calibration method will be presented together with the main results of the pCT system.

Your name:

Monica Scaringella

email:

scaringella@fi.infn.it

Title:

Nationality:

Italian

Institute:

INFN Firenze (IT)

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 208

Study of LGAD for Timing Measurements in ILC Detectors

Authors: Mami Kuhara[1]; Taikan Suehara[2]; Tomoki Onoe[1]; Shusaku Tsumura[1]; Yu Kato[3]; Kiyotomo Kawagoe[2]; Tamaki Yoshioka[4]

[1] *Kyushu University*

[2] *Kyushu University (JP)*

[3] *The University of Tokyo*

[4] *ICEPP, Univ. of Tokyo*

Corresponding Authors: tyosioka@icepp.s.u-tokyo.ac.jp, kuhara@epp.phys.kyushu-u.ac.jp, suehara@phys.kyushu-u.ac.jp, kiyotomo.kawagoe@cern.ch, onoe@epp.phys.kyushu-u.ac.jp, katou@icepp.s.u-tokyo.ac.jp, tsumura@epp.phys.kyushu-u.ac.jp

The International Linear Collider (ILC) is an electron-positron collider planned to be constructed in Japan. The ILC detectors are designed with particle flow concept, which utilizes highly-granular calorimeters to separate showers in jets. We are studying to use Low Gain Avalanche Detectors (LGADs) for the sensitive layer of the electromagnetic calorimeter of ILC detectors. Timing resolution of a few 10 psec per hit, possible to be obtained with LGADs, enables particle identification of hadrons (pi/K/p separation) by Time-of-Flight method, and also improves shower clustering which is critical to the performance of particle flow. As the calorimeter application we need flat response over surface of multi-cell LGAD detectors. We are investigating possible usage of LGADs with gain layer at the opposite side of sensitive region, with which more uniform response than usual LGADs (with gain layer just below the readout electrodes) is expected. We will report the measurements with test sensors, including responses of charge and timing correlation with multiple sensors by penetrating positron beam.

Your name:

Mami Kuhara

email:

kuhara@epp.phys.kyushu-u.ac.jp

Title:

Ms

Nationality:

Japan

Institute:

Kyushu University

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 209

A hybrid deep-learning framework based on the Wasserstein-GAN with non-subsampled contourlet transform for noise reduction in low-dose CT

Author: Woosung Kim[1]

[1] *yonsei university*

Corresponding Author: wskim26@yonsei.ac.kr

Low-dose CT (LDCT) usually reduces the dose by reducing tube current compared to the normal dose CT (NDCT), and this behavior is affected by lowering the signal-to-noise ratio (SNR), resulting in poor image quality. LDCT has negative characteristic of different noises (e.g., photon noise, electronic noise, anatomical noise, etc.). Because the image quality of low-dose CT is dominated by noise, iterative reconstruction and image processing methods have been investigated. However, these methods are still challenging. Recently, the deep-learning based noise reduction results outperform the image performance of existing methods. In this study, as an alternative approach, we propose a hybrid deep-learning framework based on the Wasserstein-GAN (WGAN) with non-subsampled contourlet transform (NSCT) for enhanced noise reduction in low-dose CT. We trained the data separately with low- and high-frequency sub-bands using the NSCT. Our results indicated that the image characteristics of the noised reduction images were nearly close to that of the NDCT images, preserving superior image features and anatomical structures. Its effectiveness was validated by comparing image performance to those from other network methods such as CNN-MSE, WGAN-VGG for LDCT noise reduction. NSCT approach is useful for the dimensionality reduction for training and its strategy was optimized by means of separation of the frequency bands for various noise components in training

Your name:

woosung kim

email:

wskim26@yonsei.ac.kr

Title:

Mr

Nationality:

Institute:

Yonsei university

Poster Session 3 (Applications in Particle Physics) / 210

Background in the CMS Drift Tubes: measurements with LHC collision data and implications for detector longevity at HL-LH

Author: Lisa Borgonovi[1]

[1] *Universita e INFN, Bologna (IT)*

Corresponding Author: lisa.borgonovi@bo.infn.it

In the barrel region of the CMS muon spectrometer Drift Tubes (DT) are installed. They are used for offline tracking of muons and also provide standalone trigger capabilities. Though an upgrade of the DT system electronics is foreseen for High-Luminosity LHC (HL-LHC), the present DT chambers won't be replaced, hence they will be called to operate enduring integrated doses far beyond what they were initially designed for. Together with accelerated ageing studies, accurate measurements of the background-induced hit rates and currents observed over Run-2 are critical to assess the longevity of the DT chambers and to make projections of the expected performance of the system throughout HL-LHC. This report presents the state of the art of the studies about the background affecting the DT system, and links them to results from longevity studies performed exploiting the CERN high-intensity gamma irradiation facility (GIF++). Moreover it describes all measures that have been put in place, by the end of Run-2 and over LS2, to mitigate ageing and, where possible, reduce background level, with the aim of maximising the performance of the DT detector throughout HL-LHC.

Your name:

Lisa Borgonovi

email:

lisa.borgonovi@cern.ch

Title:

Nationality:

italian

Institute:

INFN Bologna - Italy

Applications in Security and Environmental Imaging; Advances in Pixel Detectors and Integration Technologies 2 / 211

Measurements of time and spatial resolution of AC-LGADs with different designs

Authors: Alessandro Tricoli[1]; Gabriele D'Amen[1]; Enrico Rossi[2]; Gabriele Giacomini[1]; Wei Chen[2]

[1] *Brookhaven National Laboratory (US)*

[2] *Brookhaven National Laboratory*

Corresponding Authors: erossi@bnl.gov, gabriele.d'amen@cern.ch, giacomini@bnl.gov, alessandro.tricoli@cern.ch, weichen@bnl.gov

AC-LGAD sensors are prime candidates for fast and precise measurement of charged particles in a variety of applications. In a fine-pitched pixel or strip AC-LGAD sensor, the signal generated by the passage of a particle is not localized in a limited volume in the sensor, but is shared among multiple electrodes. This signal sharing characteristic allows us to improve the spatial resolution of AC-LGAD sensors beyond the capabilities of common silicon trackers. Since the magnitude of the shared signal depends on the distance between the pixels or strips and the point of passage of the particle, signal sharing is strongly influenced by the geometry of the sensor. The electrode pitch and gap size as well as the shape can be fine tuned to maximize the space resolution, while keeping the detector granularity and the number of channels to be read out under control. Prototypes of AC-LGAD sensors produced at the Brookhaven National Laboratory covering a variety of possible geometries have been studied via Transient Current Technique using an Infrared laser, and the signal sharing, spatial resolution, and time resolution of the different topologies have been measured. These results have been compared with measurements performed in test-beams with 120 GeV protons at the Fermilab Test Beam Facility, or with beta particles generated in the decay of a ^{90}Sr source. A time resolution of $\sim$30 ps can be achieved using AC-LGAD sensors with a thickness of 50 μm, compatible

to that of standard DC-coupled LGADs, while presenting a far superior spatial resolution. This combination of high precision, fast timing capabilities, and low material budget makes AC-LGADs an ideal choice for a truly 4D detector.

Your name:

Gabriele D'Amen

email:

gdamen@bnl.gov

Title:

Nationality:

US

Institute:

Brookhaven National Laboratory

Applications in Particle Physics 1 / 212

The ATLAS AFP Proton Spectrometer (in-person)

Author: ATLAS Collaboration[None]

Corresponding Author: paul.richard.newman@cern.ch

A key focus of the physics program at the LHC is the study of head-on proton-proton collisions. However, an important class of physics can be studied for cases where the protons narrowly miss one another and remain intact. In such cases the electromagnetic fields surrounding the protons can interact producing high energy photon-photon collisions, for example. Alternatively, interactions mediated by the strong force can also result in intact forward scattered protons, providing probes of quantum chromodynamics (QCD).

In order to aid identification and provide unique information about these rare interactions, instrumentation to detect and measure protons scattered through very small angles is installed in the beam-pipe far downstream of the interaction point. We describe the ATLAS Forward Proton 'Roman Pot' Detectors (AFP and ALFA), including their performance to date and expectations for the upcoming LHC Run 3, covering Tracking and Time-of-Flight Detectors as well as the associated electronics, trigger, readout, detector control and data quality monitoring. The physics interest, beam optics and detector options for extension of the proogramme into the High-Luminosity LHC (HL-LHC) era are also discussed.

Your name:

email:

lydia.beresford@cern.ch

Title:

Nationality:

Institute:

Detectors for Neutron Facilities; Gas-based Detectors 2 / 213

Development and characterization of a novel alpha particle SOI pixel sensor for neutron detection

Authors: Emanuele Tosi[None]; Gian-Franco Dalla Betta[1]; Roberto Mendicino[2]; Matteo Perenzoni[2]; Yasuo Arai[3]

[1] *INFN and University of Trento*

[2] *Fondazione Bruno Kessler (FBK)*

[3] *High Energy Accelerator Research Organization (JP)*

Corresponding Authors: perenzoni@fbk.eu, emanuele.tosi93@gmail.com, yasuo.arai@kek.jp, mendicino@fbk.eu, gianfranco.dallabetta@unitn.it

Solid-state sensors have been initially proposed as direct replacement of ^3He gas detectors but recently raise the interest in imaging systems.
We have developed a monolithic sensor with high spatial granularity in SOIPIX technology for the detection of alpha particles of energy compatible with the reaction products of neutrons with converter materials. The chipset is composed by the main pixel matrix and the test structures needed for a better understanding of the chip functionality and for studying the electronic tuning strategies. The fabricated prototypes have been recently delivered and the first tests under alpha source have been performed.
We will present the proposed devices and the results of the experimental characterization.

Your name:

Roberto Mendicino

email:

mendicino@fbk.eu

Title:

Dr

Nationality:

Italian

Institute:

Fondazione Bruno Kessler

Poster Session 3 (Applications in Particle Physics) / 214

Development of position-sensitive silicon detector for ILC calorimeters

Author: Taikan Suehara[1]

[1] *Kyushu University (JP)*

Corresponding Author: suehara@phys.kyushu-u.ac.jp

Position-sensitive silicon detector (PSD) is a silicon pad sensor with resistive surface connecting to electrodes on corners of the cell. PSDs are widely used in laser optics, and also used as detectors for heavy ions, while the application to particle physics has been limited to smaller signal due to smaller energy deposit, which degrades position resolutions. We are investigating PSD for MIPs with thick

silicon sensors (650 um) to be used as sensors at innermost layers of highly-granular calorimeters to improve pointing resolution of incident particles. Basic measurements of the prototype sensors with lasers and radioisotopes will be presented. Application to ILC calorimeters, and further possibility to include an avalanche layer to improve the position resolution will also be discussed.

Your name:

Taikan Suehara

email:

suehara@phys.kyushu-u.ac.jp

Title:

Dr

Nationality:

Japan

Institute:

Kyushu University

Poster Session 7 (Detectors for High Radiation and Extreme Environments) / 215

Simulation of Pixel Silicon detectors for experiment at high luminosity colliders.

Authors: A. M. Rasso[1]; A. Messineo[1]; S. Parolia[2]

Co-authors: A. Bhardwaj [3]; C. Jain [3]; G. Jain [3]; K Androsov [4]; K. Ranjan [3]; M. A. Ciocci [1]; M.T. Grippo [5]

[1] *INFN and University of Pisa (IT)*

[2] *Universita & INFN Pisa (IT)*

[3] *University of Delhi (IN)*

[4] *Institute of Physics, Ecole Polytechnique Federale de Lausanne, Lausanne*

[5] *currently at Frontiers Media SA*

Corresponding Authors: shubhi.parolia@cern.ch, alberto.messineo@cern.ch

Silicon detectors are expected to suffer unprecedented radiation damage in future high-luminosity collider detectors. Device modelling is required for detailed understanding of the performance of silicon detectors over the lifetime of the detector and to set design rules to mitigate the detrimental effect provided by radiation damage.

In the present work, results of a comprehensive simulation of the silicon pixel detector, based on TCAD-Synopsys are presented. The simulation work focuses on the Pixel detector with a 25 micron pitch, the smallest pitch used for the main vertex detectors by the HL-LHC experiments.
A detailed simulation of the device has been implemented in order to study the operating conditions of the Pixel detector. This is done through the simulation of the leakage current and the total depletion voltage as well as to study the detection performance through the simulation of the charge collection efficiency and the point spatial resolution. Furthermore, the comparison of the results is carried out with measurement and simulation based on data published by TCAD-Silvaco.

Your name:

Shubhi Parolia

email:

shubhi.parolia@cern.ch

Title:

Ms

Nationality:

Institute:

INFN and University of Pisa, Italy

Poster Session 3 (Applications in Particle Physics) / 216

The upgrade and performance of the LHCb RICH detector system

Authors: Edoardo Franzoso[1]; LHCb RICH Collaboration[None]

[1] *Universita e INFN, Ferrara (IT)*

Corresponding Author: edoardo.franzoso@cern.ch

The LHCb experiment at CERN studies b- and c-hadron decays in the forward region. Physics analyses in LHCb rely on the Ring Imaging Cherenkov (RICH) detector system for the charged hadrons identification in a wide momentum range. The RICH system has provided particle identification with excellent performance during Runs 1 and 2 of LHC and it's currently undergoing a substantial upgrade to deal with the expected five-fold increase of luminosity in Run 3. The upstream RICH optics and mechanics will be improved and the photodetectors will be upgraded by installing multi-anode photomultiplier tubes. In addition, the new readout electronics will allow a 40 MHz continuous data taking. An overview of the RICH expected performance and a summary of the upgrade activities will be presented.

Your name:

Edoardo Franzoso

email:

edoardo.franzoso@cern.ch

Title:

Mr

Nationality:

Italian

Institute:

Universita e INFN, Ferrara (IT)

Medical Applications of Position Sensitive Detectors 1 / 217

MONOLITH –pico-second time-stamping in fully monolithic highly-granular pixel sensors

Authors: Antonio Picardi[1]; Chiara Magliocca[1]; Didier Ferrere[1]; Roberto Cardella[1]; D M S Sultan[1]; Fulvio Martinelli[2]; Giuseppe Iacobucci[1]; Holger Ruecker[3]; Lorenzo Paolozzi[4]; Magdalena Munker[4]; Matteo Milanesio[5]; Pierpaolo Valerio[4]; Sergio Gonzalez Sevilla[1]; Théo Moretti[6]; Yana Gurimskaya[1]

[1] *Universite de Geneve (CH)*

[2] *EPFL - Ecole Polytechnique Federale Lausanne (CH)*

[3] *ihp-microelectronics*

[4] *CERN*

[5] *University of Turin*

[6] *University of Geneva*

Corresponding Authors: antonio.picardi@cern.ch, matteo.milanesio@edu.unito.it, chiara.magliocca@cern.ch, didier.ferrere@cern.ch, lorenzo.paolozzi@cern.ch, fulvio.martinelli@cern.ch, sergio.gonzalez.sevilla@cern.ch, theo.moretti@etu.unige. d.m.s.sultan@cern.ch, yana.gurimskaya@cern.ch, magdalena.munker@cern.ch, pierpaolo.valerio@cern.ch, giuseppe.iacobucci@cern.c roberto.cardella@unige.ch

The MONOLITH H2020 ERC project aims at the development of fully monolithic highly granular pixel sensors with pico-second time-stamping capabilities. Using high-resistivity epitaxial layer material in combination with a continuous deep and thin gain layer, a pico-second fast detector response is achieved over the full pixel cell. The placement of the gain layer away from the pixel junctions additionally allows for a small pixel pitch of down to 50 micrometers, resulting in a high spatial precision. Making use of silicon-germanium BiCMOS technology, a ultra-fast and low noise front end has been implemented inside a large collection electrode design.
Various prototypes of this technology have been produced with different variations, including various doping levels and different complexity of in-pixel circuitry. The prototypes have been investigated in laboratory and test-beam measurements, with a focus on the sensor gain, time-stamping capability and detection efficiency.
This contribution will introduce the novel sensor concept and discuss the front-end that has been implemented in the SiGe BiCMOS technology. Results of laboratory measurements with radioactive sources will be presented, including measurements of the sensor gain with an iron source and timing measurements that have been performed with a strontium source.

Your name:

Magdalena Munker

email:

magdalena.munker@cern.ch

Title:

Nationality:

German

Institute:

University of Geneva

Applications in Astronomy, Planetary and Space Science 1 / 218

Review of single photon imaging techniques with fast timing for applications in space and particle physics, and the life sciences (in-person)

Authors: Jon Lapington[1]; Dhiren Kataria[2]

[1] *University of Leicester*

[2] *Mullard Space Science Laboratory, University College London*

Corresponding Authors: jsl12@le.ac.uk, d.kataria@ucl.ac.uk

There is an increasing demand for photon counting detectors capable of time-resolved imaging in many fields. In this paper we review the available detector and electronic technologies available and under development for applications such as Cherenkov imaging in particle physics and gamma-ray astronomy, and for wide-field fluorescence lifetime imaging in the life science field. While traditional vacuum tube devices such as the microchannel plate image intensifier still offer state of the art timing performance, the recent and rapid development of silicon photomultipliers, single photon avalanche detector arrays, and other hybrid devices are providing ever stronger competition. Advances in multichannel ASIC electronics for high throughput multichannel waveform capture and time to digital conversion have kept up with detector development and systems with 100 Mcount/s throughput at sub-100 ps single photon timing are becoming realistic. We discuss the requirements of various applications in terms of imaging, time resolution and throughput and compare the advantages and disadvantages of the competing technologies.

Your name:

Jon Lapington

email:

jsl12@le.ac.uk

Title:

Nationality:

Institute:

University of Leicester

Applications in Astronomy, Planetary and Space Science 1 / 219

Review of position sensing techniques in space-based particle instruments (in-person)

Authors: Dhiren Kataria[1]; Jon Lapington[2]

[1] *Mullard Space Science Laboratory, University College London*

[2] *University of Leicester*

Corresponding Authors: jsl12@leicester.ac.uk, d.kataria@ucl.ac.uk

Position sensing techniques are extensively used in space-based particle instruments for the detection of space plasmas and energetic particle radiation. Such instruments typically consist of electrostatic analysers at the low end of the energy range and solid state/scintillation detectors at the higher energy end. With a need for large fields-of-views and all-sky particle imaging, high resolution, low resource, position sensing detection systems are in increasing demand for these instruments. This paper will review position sensing techniques typically employed on space missions in the past, present future instrument requirements and discuss potential exploitation of emerging technologies.

Your name:

Dhiren Kataria

email:

d.kataria@ucl.ac.uk

Title:

Prof.

Nationality:

British

Institute:

Mullard Space Science Laboratory, University College London

X-ray and Gamma Ray Detectors 2 / 220

A monolithic silicon pixel sensor in SiGe BiCMOS for the FASER high granularity pre-shower detector.

Authors: Lorenzo Paolozzi[1]; Pierpaolo Valerio[1]; Giuseppe Iacobucci[2]; Marzio Nessi[1]; Fulvio Martinelli[3]; Antonio Picardi[2]; Ivan Peric[4]; Théo Moretti[5]; Roberto Cardella[2]; Chiara Magliocca[2]; Didier Ferrere[2]; Anna Sfyrla[2]; D M S Sultan[2]; Magdalena Munker[1]; Mateus Vicente Barreto Pinto[2]; Yana Gurimskaya[2]; Yannick Favre[2]; Matteo Milanesio[6]; Carlo Enrico Pandini[5]; Sergio Gonzalez Sevilla[2]

[1] *CERN*

[2] *Universite de Geneve (CH)*

[3] *EPFL - Ecole Polytechnique Federale Lausanne (CH)*

[4] *KIT - Karlsruhe Institute of Technology (DE)*

[5] *University of Geneva*

[6] *University of Turin*

Corresponding Authors: theo.moretti@etu.unige.ch, didier.ferrere@cern.ch, d.m.s.sultan@cern.ch, yana.gurimskaya@cern.ch, roberto.cardella@unige.ch, anna.sfyrla@cern.ch, carlo.enrico.pandini@cern.ch, antonio.picardi@cern.ch, magdalena.munker@cern.ch lorenzo.paolozzi@cern.ch, m.vicente@cern.ch, fulvio.martinelli@cern.ch, matteo.milanesio@edu.unito.it, sergio.gonzalez.sevilla@cern yannick.favre@unige.ch, giuseppe.iacobucci@cern.ch, marzio.nessi@cern.ch, pierpaolo.valerio@cern.ch, chiara.magliocca@cern.ch, ivan.peric@cern.ch

A monolithic silicon pixel detector is being designed in 130nm SiGe BiCMOS process of IHP to realize a pre-shower detector for the FASER experiment at CERN.
The pre-shower is designed to discriminate electromagnetic showers produced by two primary photons with an energy in the range 100 GeV to 1 TeV and with a separation as small as 200 micron. The monolithic ASIC will have hexagonal pixels of 65 micron of side, each capable to measure a charge in the range of 1 fC to 60 fC. To reconstruct the profile of the electromagnetic shower, the sensor must be able to read hundreds of pixels firing at the same time. The detector planes will have a time resolution of approximately 200 ps. The power budget is limited to less than 150 mW/cm2.
The pre-production prototypes, submitted in June 2021, implement two alternative architectures to enable the readout of many pixels with a very large dynamic range.

Your name:

email:

lorenzo.paolozzi@cern.ch

Title:

Nationality:

Institute:

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 221

Recent advances in MicroScint beam profiler technology

Authors: Michele Caldara[1]; Veronica Leccese[1]; Marcello Pagano[1]; Alessandro Mapelli[2]; Fabrizio Carbone[1]

[1] *EPFL*

[2] *CERN*

Corresponding Authors: fabrizio.carbone@epfl.ch, michele.caldara@epfl.ch, veronica.leccese@epfl.ch, marcello.pagano@epfl.ch, alessandro.mapelli@cern.ch

This work illustrates some recent advances based on the so-called MicroScint, a technology developed by CERN and EPFL in recent years aimed to realize a beam transverse profiler with high spatial resolution based on a microfluidic device, obtained by a standard Silicon microfabricated structure filled with an organic liquid scintillator. The signals at each channel's segments end are readout by a photodiodes array interfaced with a microcontroller. The Silicon microfabrication allows improving the detector spatial resolution (up to ˜30 μm in this work) with respect to commercial scintillating fiber-based devices, limited to the minimum available size of 250 μm. Different MicroScint geometries have been fabricated and are described in this paper, together with preliminary experimental results obtained with UV light at 260 nm. In the perspective to obtain a more robust and easy-to-fabricate detector, the paper also presents the development of scintillating resin-based devices, obtained through PDMS moulds. The new design achieves a spatial resolution of ˜15 μm. The same readout and characterization setup of the microfluidic devices has been used on these prototypes. Substituting the scintillating liquid with the resin opens up the possibility to 3D-print the active area of the scintillating devices without using any costly process. The developed detectors are designed to suit all types of proton or heavy ion accelerators, namely cyclotrons, synchrotrons, and linacs for beams starting from tens of MeV, DC or pulsed. In particular the simulations focused on a proton-therapy beam with typical intensity of 1.5e9 protons/s. The presented beam detectors could also be used for dosimetry, X-ray imaging or for fundamental physics experiments such as the generation of vortex beams and more generally for providing a novel diagnostic tool for experiments aimed at manipulating the wavefunction of fundamental particles.

Your name:

Michele Caldara

email:

michele.caldara@epfl.ch

Title:

Nationality:

Italian

Institute:

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 222

Gas electron tracking detector for beta decay experiments

Author: Dagmara Rozpedzik[1]

Co-authors: Lennert De Keukeleere [2]; Kazimierz Bodek [1]; Leendert Hayen [2]; Konrad Lojek [1]; Maciej Perkowski [3]; Nathal Severijns [2]

[1] *Jagiellonian University*

[2] *KU Leuven*

[3] *Jagiellonian University & KU Leuven*

Corresponding Author: dagmara.rozpedzik@uj.edu.pl

For 3D-tracking and identification of low-energy electrons a new type of gas-based detector was designed that minimizes scattering and energy loss.The current version of the detector is a combination of a plastic scintillator,serving as a trigger source,and a hexagonally structured multi-wire drift chamber(MWDC),filled with a mixture of helium and isobutane gas.The drift time information is used to track particles in the plane perpendicular to the wires,while a charge division technique provides spatial information along the wires.The gas tracker was successfully used in the miniBETA project as a beta spectrometer for the measurement of weak magnetism form factor in nuclear beta decay.The precision of the three-dimensional electron tracking,in combination with low-mass,low-Z materials and monitoring of backscattering from the electron energy detector,facilitated a reduction of the main systematics effects.

In the talk the results of the detector characterization will be presented.These results originate from performance studies with cosmic muons and low-energy electrons (<2 MeV) conducted for several pressures (300–700 mbar) and isobutane add-mixture percentages (10–50%).At certain conditions,a spatial resolution better than 0.5 mm was obtained in the plane perpendicular to the wires,while resolutions of 4–8 mm were recorded along wires.Thanks to precise tracking information,it is possible to eliminate electrons and other particles not originating from the desired decay with high efficiency.Additionally,using the coincidence between MWDC and trigger,background from gamma emission typically accompanying radioactive decays,was highly suppressed.An overview of the possible types of detector events will be provided together with the tracker's ability to correctly recognize them.The latter was done by Monte Carlo simulations with Geant4 and Garfield++.Finally,the preliminary results from the beta spectrum study will be reported as well.

The presented experimental technique is also applied to the beta decay correlation experiment for tracking of electrons in neutron beta decay (BRAND project).Furthermore,it could be implemented for cloud size monitoring in ion traps.

Your name:

Dagmara Rozpedzik

email:

dagmara.rozpedzik@uj.edu.pl

Title:

Dr

Nationality:

Poland

Institute:

Jagiellonian University

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 223

TRISTAN: A novel detector for searching keV-sterile neutrinos at the KATRIN experiment

Author: Korbinian Urban[1]

[1] *Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München, Germany; Physik-Department, Technische Universität München, D-85747 Garching, Germany*

Corresponding Author: kurban.mpp@gmail.com

The KATRIN (Karlsruhe Tritium Neutrino) experiment investigates the kinematic endpoint of the tritium β-decay spectrum to determine the effective mass of the electron anti-neutrino. The collaboration reported its first neutrino mass result in fall 2019: $m < 1.1$ eV (90% CL). Its unprecedented tritium source luminosity and spectroscopic quality make it a unique instrument to also search for physics beyond the standard model such as sterile neutrinos.

Therefore, we develop a new detector for the KATRIN experiment to detect the signature of a sterile neutrino in the keV mass regime. In order to obtain a high sensitivity to the sterile neutrino mixing angle, excellent spectroscopic properties at high rates are essential. The novel TRISTAN detector system will exploit the silicon drift detector technology, which meets these requirements due to its small anode capacitance of less than 200 fF, and scale this technology to a large array of more than 3000 pixels.

This poster will present the design and status of the new detector, where we recently reached an important milestone by operating one 47-pixel detector module. A special focus will be put on the characterization of inter-pixel effects, which play an important role in the highly integrated multi-pixel detector system.

Your name:

Korbinian Urban

email:

kurban@mpp.mpg.de

Title:

Mr

Nationality:

german

Institute:

Max Planck Institute for Physics, Föhringer Ring 6, D-80805 Munich, Germany

Posters Session 1 (Applications in Astro-particle Physics; Applications in Astronomy, Planetary and Space Science; Applications in Life Sciences and Biology) / 224

Extensive Air Shower Tracker using Cherenkov Detection

Author: Steven Leach[1]

[1] *University of Leicester*

Corresponding Author: sal41@le.ac.uk

Cosmic rays continuously bombard Earth's atmosphere triggering cascades of secondary particles. Many constituents progress to reach the surface and capturing these events can intrigue and awe young curious minds, opening them to the amazing world of physics. Cloud chambers are an established method of revealing the subatomic world; frequently used by universities to introduce cosmic rays to visitors and prospective students. Although their scientific use is limited, they provide a fascinating real-time display of the 'ghostly'particles showering upon those viewing.
Using the Cherenkov radiation detection technique, we have developed a novel, compact, Extensive Air Shower (EAS) particle tracking method that enhances the cloud chamber visualisation of cosmic

ray interactions towards a digital audience. Once digital, live event interaction can be streamed to multiple display devices presenting an immediate illustration of the event that showered in that location.
Our instrument hardware is built around Cherenkov optimised silicon photomultiplier sensors. Each single detection unit is able to monitor particle event rate, track incident angle and measure Cherenkov intensity, thereby enabling energy discrimination between low versus high-energy interactions. By operating multiple detection units in one location, we can record time correlated air shower events to monitor and generate information on primary cosmic rays.
We introduce first results, illustrating instrument response and EAS rate variations, compiled from the initial six month running period of our development instruments. We also present instrument simulations to assess and optimise the number and position of our photosensors.
With further development towards low-cost readout electronics, we aim to build a networked array of trackers, located around the campus, to expand data gathering ability and scientific potential. By tracking EAS in real-time we can estimate the local distribution of secondary particles, allow us to determine particle radiation levels, and provide atmospheric radiation monitoring locally, regionally and potentially UK-wide.

Your name:

Steven Leach

email:

sal41@le.ac.uk

Title:

Dr

Nationality:

British

Institute:

University of Leicester

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 225

The second production of RSD at FBK

Author: Marco Mandurrino[1]

Co-authors: Roberta Arcidiacono [2]; Giacomo Borghi [3]; Maurizio Boscardin [3]; Nicolò Cartiglia [1]; Matteo Centis Vignali [4]; Gianfranco Dalla Betta [5]; Marco Ferrero [6]; Francesco Ficorella [3]; Lucio Pancheri [5]; Giovanni Paternoster [3]; Valentina Sola [1]

[1] *INFN*

[2] *Università del Piemonte Orientale, CERN*

[3] *Fondazione Bruno Kessler, TIFPA*

[4] *Fondazione Bruno Kessler*

[5] *Università di Trento, TIFPA*

[6] *Università del Piemonte Orientale*

Corresponding Author: marco.mandurrino@to.infn.it

In this contribution we describe the second run of RSD (Resistive AC-Coupled Silicon Detectrors) designed by INFN Torino and produced by FBK, Trento.
RSD are n-in-p detectors intended for 4D particle tracking based on the LGAD technology that get rid of any segmentation implant in order to achieve the 100% fill-factor. They are characterized by three key-elements, (*i*) a continuous gain implant, (*ii*) a resistive n-cathode and (*iii*) a dielectric

coupling layer deposited on top, guaranteeing a good spatial reconstruction of the hit position while benefiting from the good timing properties of LGADs.
We will start from the very promising results of our RSD1 batch in terms of 4D-tracking and then we will move to the description of the design of the RSD2 run.
In particular, the principles driving the sensor design and the particular AC-electrode layout adopted to optimize the signal confinement will be addressed, also focusing our attention on other important detector figures-of-merit, such the role of substrate thickness, metal thickness and on the radiation-resistance properties.

Your name:

email:

marco.mandurrino@to.infn.it

Title:

Nationality:

Institute:

Applications in Astronomy, Planetary and Space Science 1 / 226

Development of a Penetrating particle ANalyzer for high-energy radiation measurements in space

Authors: Benedikt Bergmann[1]; Bruna Bertucci[2]; Daniel La Marra[3]; Frank Raphael Cadoux[3]; Giovanni Ambrosi[2]; Jerome Stauffer[3]; Lukas Meduna[4]; Maria Ionica[2]; Matteo Duranti[2]; Mercedes Paniccia[5]; Merlin Kole[3]; Michael Campbell[6]; Milan Malich[7]; Mirco Caprai[2]; Nicola Tomassetti[8]; Pengwei Xie[3]; Petr Burian[4]; Petr Manek[4]; Philipp Azzarello[3]; Pierre Alexandre Thonet[6]; Stanislav Pospisil[9]; Stefan Gohl[10]; Tomoya Iizawa[3]; Xin Wu[3]; Yannick Favre[3]; Yesid Mora[7]

[1] *Czech Technical Universtity in Prague*

[2] *Universita e INFN, Perugia (IT)*

[3] *Universite de Geneve (CH)*

[4] *Czech Technical University in Prague (CZ)*

[5] *Departement de Physique Nucleaire et Corpusculaire (DPNC)*

[6] *CERN*

[7] *Institute of Experimental and Applied Physics (IEAP), Czech Technical University in Prague*

[8] *Perugia University & INFN- Perugia*

[9] *Institute of Experimental and Applied Physics, Czech Technical University in Prague*

[10] *Institute of Experimental and Applied Physics, CTU in Prague*

Corresponding Authors: philipp.azzarello@cern.ch, franck.cadoux@unige.ch, michael.campbell@cern.ch, pierre.alexandre.thonet@cern.ch, yannick.favre@unige.ch, mercedes.paniccia@physics.unige.ch, petr.manek@cern.ch, bruna.bertucci@cern.ch, stefan.gohl@utef.cvut.cz, giovanni.ambrosi@cern.ch, merlin.kole@cern.ch, daniel.lamarra@unige.ch, lukas.meduna@cern.ch, mirco.caprai@cern.ch, benedikt.bergmann@utef.cvut.cz, nicola.tomassetti@cern.ch, petr.burian@cern.ch, xin.wu@cern.ch, stanislav.pospisil@utef.cvut.cz, maria.ionica@cern.ch, pengwei.xie@cern.ch, matteo.duranti@cern.ch, jerome.stauffer@unige.ch, tomoya.iizawa@cern.ch

The Penetrating Particle Analyzer (PAN) is an instrument conceived to precisely measure the flux, composition and arrival direction of highly penetrating particles in space of energy ranging from 100 MeV/n to 20 GeV/n. Precise measurements of their energy spectra and composition are of great interest to study Solar Modulation of Cosmic Rays, to characterise SEPs, as well as the radiation environment around planets and to improve Space Weather predictions for Deep Space travels.
The design is based on a modular magnetic spectrometer of small size, reduced power consumption and weight which make it suitable for deep space and interplanetary missions. The high-field

permanent magnet sectors are instrumented with high resolution silicon micro-strip detectors, Time-OF-Flight scintillator counters readout by SiPMs, and active Pixel detectors to maintain the detection capabilities in high rate conditions occurring during solar energetic particle events (SEPs) or when traversing radiation belts around planets. After the description of the PAN instrument, the development and tests of the mini.PAN demonstrator will be presented in this contribution.

Your name:

Philipp Azzarello

email:

philipp.azzarello@cern.ch

Title:

Nationality:

Institute:

Applications in Life Sciences and Biology; Applications in Particle Physics 3 / 227

Design and assembly of a fibre-type heterostructured scintillator for Time of Flight Positron Emission Tomography (in-person)

Authors: Etiennette Auffray[1]; Gregory Bizarri[2]; Iva Chianella[2]; Saurav Goel[3]; Francesco Gucci[2]; Nicolaus Kratochwil[4]; Phil Krause[2]; Fiammetta Pagano[5]; Edith Grace Rogers[2]

[1] *CERN*

[2] *Cranfield University*

[3] *Cranfield University & London South Bank University*

[4] *CERN & University of Vienna*

[5] *CERN & University of Milano-Bicocca*

Corresponding Author: edith.g.rogers@cranfield.ac.uk

Improving the performance of time of flight (ToF) positron emission tomography (PET) scintillators towards a coincidence time of 10 ps will enable real time imaging and a 16x increase in sensitivity [1], [2]. To achieve this both ultra-fast scintillation and short attenuation length are needed. Current monolithic inorganic scintillators are effective at capturing 511 keV gamma radiation but have decay times of 10s to 100's of nanoseconds, whilst plastic or nanoparticle loaded plastic scintillators have fast decay times but lack the attenuation length to be effective PET scintillators. To bypass these limitations a heterostructured scintillator has been proposed [3] which synergistically combines a dense single crystal matrix with a fast scintillator component. Gamma capture occurs primarily in the matrix and energy shared with the fast component through recoil electrons, leading to fast scintillation and effective gamma capture in one volume.
Here we present the fiber-based heterostructure detector: a single crystal matrix enclosing fast scintillator fibres. The scientific and engineering challenges involved are complex, ranging from the optimisation of scintillation properties to pixel manufacture. Simulations were used to map the available parameter space and thus guide pixel design and material choice. An initial layout was chosen and Bismuth germanate (BGO) selected as the matrix material. Machining this hard, brittle material is non-trivial, but could be optimised. We patterned BGO slices with channels, before assembling them into a matrix. This was then filled with a vinyltoluene based polymer scintillator to form a prototype fibre-type heterostructure. Preliminary scintillation performance of the pixel prototype will be presented.
This work was supported by the UK Engineering and Physical Sciences Research Council (EPSRC) grant EP/S013652/1 for Cranfield University. Part of the work was carried out in the framework of Crystal clear collaboration and supported by the CERN Budget for Knowledge Transfer to Medical Applications

Your name:

Edith Rogers

email:

Edith.G.Rogers@cranfield.ac.uk

Title:

Nationality:

Institute:

Cranfield University

Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies) / 228

Characterisation of HV-MAPS ATLASPix3 and its applications for future lepton colliders

Authors: Bianca Raciti[1]; Yanyan Gao[2]; Rudolf Schimassek[3]; Jaap Velthuis[4]; Harald Fox[5]; Attilio Andreazza[6]; Hongbo Zhu[7]; Juliette Martin[8]; Tim Jones[9]; Yiming Li[10]; Yubo Han[7]; Zirui Feng[4]; Hui Zhang[11]; Ivan Peric[3]

[1] *Università degli Studi di Milano*

[2] *University of Edinburgh (GB)*

[3] *KIT - Karlsruhe Institute of Technology (DE)*

[4] *University of Bristol*

[5] *Lancaster University (GB)*

[6] *Università degli Studi e INFN Milano (IT)*

[7] *Chinese Academy of Sciences (CN)*

[8] *University of Edinburgh*

[9] *University of Liverpool (GB)*

[10] *Institute of High Energy Physics, Chinese Academy of Sciences (CN)*

[11] *Karlsruhe Institute of Technology (KIT)*

Corresponding Authors: ivan.peric@cern.ch, hui.zhang@kit.edu, yubo.han@cern.ch, yiming.li@cern.ch, s1750765@sms.ed.ac.uk, h.fox@lancaster.ac.uk, yanyan.gao@cern.ch, tim.jones@cern.ch, zirui.feng@bristol.ac.uk, bianca.raciti@studenti.unimi.it, jaap.velthuis@bris.ac.uk, rudolf.schimassek@kit.edu, hongbo.zhu@cern.ch, attilio.andreazza@cern.ch

High voltage CMOS pixel sensors have been proposed in several future particle physics experiments for particle tracking. ATLASPix3 is the first full reticle size (2×2 cmˆ2) Monolithic Active Pixel high voltage CMOS sensor, developed in context of the ATLAS upgrade for High Luminosity Large Hadron Collider (HL-LHC). It is designed to meet the specifications of outer layers of the ATLAS inner tracker (ITk) pixel subsystem. ATLASPix3 has been implemented in a standard 180nm HVCMOS process, containing 132 x 372 pixels, each with an area of 150 x 50 µm². The readout electronics supports both triggered and triggerless readout with zero-suppression. The excellent position resolution, high readout rate (40 MHz), and high radiation tolerance make ATLASPix3 an ideal candidate for large-area tracking detector R&D of future collider experiments. It is under study for the Circular Electron Positron Collider (CEPC) silicon tracker. New versions tailored to different experiments are under development.

Results of electrical tests, sensor calibration and measurements with radioactive sources and lasers will be presented on individual chips and first multi-chip-modules. Multi-module readout architectures and large prototype demonstrator design concepts will be discussed.

Your name:

Yanyan

email:

yanyan.gao@ed.ac.uk

Title:

Dr

Nationality:

Institute:

Gao

Poster Session 5 (Gas-based Detectors; Medical Applications of Position Sensitive Detectors) / 229

Panel TOF-PET imager

Author: Rok Pestotnik[1]

Co-authors: Rok Dolenec [2]; Georges El Fakhri [3]; Stan Majewski [4]; Andrej Studen [1]; Gašper Razdevšek [5]; Samo Korpar ; Peter Krizan [5]

[1] *Jozef Stefan Institute (SI)*

[2] *Institut "Jožef Stefan"*

[3] *Massachusetts General Hospital*

[4] *University of California Davis*

[5] *University of Ljubljana*

Corresponding Authors: peter.krizan@ijs.si, rok.dolenec@ijs.si, andrej.studen@cern.ch, rok.pestotnik@cern.ch, samo.korpar@ijs.si

Positron emission tomography (PET) is one of the most important diagnostic tools in medicine, providing three-dimensional imaging of functional processes in the body. The method is based on detecting two gamma rays originating from the point of annihilation of the positron emitted being by radio-labelled agent, and used to follow the human's physiological processes. In Time-Of-Flight PET gamma rays' arrival time is measured in addition to their position. The coincidence timing resolution (CTR) of state-of-the art scanners is between 200 ps and 500 ps FWHM, which can already significantly improve the contrast in imaging large objects. To increase the sensitivity of the next-generation PET scanners timing accuracy should be substantially increased. By using latest advances multichannel system with improved CTR is becoming technologically possible. Generally 3D images from limited angle PET scanners are distorted and have artefacts. Fortunately, with improving timing resolution of PET gamma detectors, artefact free images can be obtained even by a very simplified detector. In the contribution we will show the simulation studies of the simple panel detector using gamma detectors with 50 ps coincidence timing resolution. With this new concept, the price of PET scanners for imaging single or multiple organs can be drastically decreased. We evaluated different panel detector arrangements by imaging different phantoms. We compared the reconstructed images with the image obtained with the Siemens Biograph Vision, state-of-the-art clinical PET scanner. We found comparable image quality parameters of both systems when the CTR approaches 50ps FWHM and also that good CTR can partially compensate for smaller gamma detection efficiency.

Your name:

Rok Pestotnik

email:

rok.pestotnik@ijs.si

Title:

Prof.

Nationality:

Slovene

Institute:

Jožef Stefan Institute

230

Reception and Conference Dinner at the Birmingham Botanical Gardens

Coaches leaving from the Conference Hotel at 19.00

Your name:

email:

Title:

Nationality:

Institute:

231

Welcome by University of Birmingham Pro-Vice-Chancellor for Science and Engineering

Corresponding Authors: academic.conferences@contacts.bham.ac.uk, philip.patrick.allport@cern.ch

Your name:

email:

Title:

Nationality:

Institute:

Poster Session 4 (Position Sensitive Fast Timing Detectors) / 232

The ATLAS Forward Proton Time-of-Flight detector: use and projected performance for LHC Run 3

Author: ATLAS Collaboration[None]

Co-author: Tomas Komarek [1]

[1] *Palacky University (CZ)*

Corresponding Author: tomas.komarek@cern.ch

The Time-of-Flight (ToF) detectors of the ATLAS Forward Proton (AFP) system are designed to measure the primary vertex z-position of the pp -> pXp processes by comparing the arrival times measured in the ToF of the two intact protons in the final state.

We present the results obtained from a performance study of the AFP ToF detector operation in 2017. A time resolutions of individual channels ranging between 20 ps and 40 ps are extracted, even though the AFP ToF efficiency is below 10%. The overall time resolution of each ToF detector is found to be 20(26) +- 4(5) ps for side A(C). This represents a superb time resolution for a detector operating at few milimeters from the LHC beams.

Events from ATLAS physics runs at moderate pile-up taken at the end of 2017 are selected with signals in ToF stations at both sides of ATLAS. The difference of the primary vertex z-position measured by ATLAS and the value obtained by the AFP ToFs is studied. The distribution of the time difference constitutes of a background component from combinatorics due to non-negligible pile-up, and significantly narrower signal component from events where protons from the same interaction are detected in ToF. The fits performed to the distribution of the reconstructed time difference yield the vertex position resolution (of about 6 mm +- 1 mm at best) that is in agreement with the expectation based on single-ToF channel resolutions.

Your name:

email:

Title:

Nationality:

Institute: