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Aryabhatta Bhavan Deapartment of Physcis, Central University of South Bihar

Book of Abstracts

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A Simulation Study of Hadron Therapy (Proton Therapy) Using GAMOS: A Geant4-Based Simulation Toolkit and Biological Dose Modeling

Author: Pankaj Pal[1]

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Cancer remains a critical healthcare challenge in India, necessitating advanced treatment modalities that maximize tumor control while minimizing radiotoxicity to healthy tissues. While conventional photon radiotherapy is widely accessible, it is limited by significant exit doses. Proton therapy has emerged as a superior alternative, leveraging the Bragg peak for precise energy deposition. However, its clinical efficacy depends not only on physical dose conformity but also on the variations in Relative Biological Effectiveness (RBE), which are often simplified in clinical settings.

In this work, we utilize the GAMOS (Geant4-based Architecture for Medicine-Oriented Simulations) toolkit to simulate proton beam interactions within a realistic voxelized patient phantom, moving beyond simplified geometries. We investigate the depth-dose distributions and organ-specific energy deposition. Furthermore, we extend the study to biological dose modeling by incorporating the Linear-Quadratic (LQ) model and the variable RBE formalism proposed by McNamara et al. (2015).

This study demonstrates the critical role of Monte Carlo simulations in bridging the gap between nuclear physics instrumentation and clinical application. By accurately modeling the complex interplay between physical dose and biological response, this work contributes to the optimization of treatment planning systems and supports the growing infrastructure of hadron therapy in India.

2

The Dual Legacy of Nanoscience &Nanotechnology: Pioneering the Next Generation of Materials

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The nanomaterials are defined as those materials having at least one dimension in nanometer scale and size is of the order of De Brogle wavelength of electron. It can be categorized as zero, one, two and three dimensional. In nano scale size all materials have a significant substantial surface to volume ratio. Due to conversion of bulk material into nanomaterials there is drastic change in the mechanical, electrical, magnetic, thermal, optical, and chemical properties. Due to availability of large number of free electron on the surface of the nanomaterilas drastic change in the activity of nanomaterials has been detected. It is not possible to visualize the naomaterials with the naked eye. Even use of optical microscope is not strong enough to capture the nanometer dimension. But the discovery of electron microscope has made it possible to determine the size of nanometerials. Nanomaterials are present in nature in different forms.
The nanoscience and nanotechnology are hitherto new terms coined by the Norio Taniguchi in 1974 to deal with the science and technology of nanomaterials, however the concept of nanomaterial was initially given by Rechard Feynman (1959). The invention of electron microscope made it possible to visualize these tiny materials. The nanomaterials can be synthesized through top down and bottom up approaches. I had also synthesized the nanomaterials using both of these methods. The graphene oxide, reduced graphene oxide and curcumin quantum dots were synthesized via top down approach namely chemical reduction method in the controlled environment. These materials were characterized first and then used for the detection of endogenous neurotoxic molecule, quonolinic acid. The nitrogen doped cabon quantuom dots were synthesized via bottom up approach and have been used for detection of neurotoxic molecule, quinolinic acid and malachite green in water. Although these

nanomaterilas have many potential applications in the field agriculture and biomedical sciences, they may have adverse effect on the environment also. Therefore the judicious choice is needed to limit the use of the nanomaterilas having harmful effect on environment.

3

Event-Shape Dependence of Identified Particle Production in Oxygen-Oxygen Collisions at $\sqrt{s_{NN}}$ = 7 TeV : An AMPT Study

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We present a study of identified particle production in Oxygen–Oxygen (O–O) collisions at $\sqrt{s_{\rm NN}} =$ 7 TeV using the string-melting version of the AMPT model. Transverse spherocity is employed as an event-shape observable to separate events into jetty (hard-QCD dominated) and isotropic (soft-QCD dominated) categories. This classification enables a differential investigation of $p_{\rm T}$ spectra, mean transverse momentum ($\langle p_{\rm T}\rangle$), and integrated yields (dN/dy) for pions, kaons, and protons across centrality intervals. The results reveal a clear event-shape dependence: isotropic events dominate particle production at low $p_{\rm T}$, while jetty events contribute significantly at high $p_{\rm T}$, with the spectral crossover shifting with particle mass and collision centrality. We further examine the influence of different nuclear density profiles—Woods–Saxon, harmonic oscillator, and α-clustered—on bulk observables. Notably, α-clustered configurations exhibit enhanced radial flow–like behavior in central collisions.

Overall, the observed variations in $\langle p_{\rm T}\rangle$ and yields indicate stronger collective effects in central events and for heavier hadrons. The study demonstrates the utility of spherocity in isolating soft and hard processes and highlights the sensitivity of final-state observables to the initial-state geometry. These results provide valuable theoretical input for O–O collision measurements at the LHC.

4

Mass Spectra and Leptonic Decays of D and B Mesons in a Relativistic Independent Quark Model.

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Abstract :
We look at the mass spectra of the Dˆ±,Dˆ(±),D_sˆ(±),D_sˆ±,Bˆ±,Bˆ(±),B_sˆ(0),B_sˆ0,B_cˆ(±),B_cˆ(0±) mesons using a relativistic-independent quark model with a square root potential, U_q(r) = ½ (1+γ_0) 〖(a〗 ˆ(3⁄2) rˆ(½)+U_0). Before we can look at the mass spectra, we have to figure out the model parameters, which are U0 = -0.894 GeV and a=0.711 GeV. The calculated results of 〖D〗 ˆ±,Dˆ(±) (2.014 Gev),D_sˆ(±),D_sˆ± (2.112 GeV), Bˆ±,Bˆ(±)(5.3377 GeV), 〖B〗 _sˆ(0*),B_sˆ0 (5.411 GeV) are very close to the experimental and other theoretical values. In addition, we obtain values for leptonic decay width and branching fraction of these mesons that align with data from experiments and theories. The calculated values of leptonic decays,Dˆ±⟶μˆ± ν ⊠_μ (2.231× 〖10〗 ˆ(-4))
,Dˆ±⟶τˆ± ν ⊠_μ (3.114× 〖10〗 ˆ(-3)), Dˆ±⟶eˆ± ν ⊠_μ (5.212× 〖10〗 ˆ(-9)) and are very close to the experimental and some theoretical model.

Key Words: Mass Spectra and Leptonic Decays and Branching Fractions

5

Performance and Imaging Capabilities of GEM Detectors for Security Inspection and Agricultural Soil Characterisation

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Gas Electron Multiplier (GEM) detectors are becoming key components in advanced imaging systems due to their high detection efficiency, fast timing response, and excellent spatial resolution. Their scalability to large areas makes them well-suited for cargo and security screening, soil imaging, geophysical studies, and other industrial applications. We provide an overview of GEM detector operation and show how their layered, gas-filled structure with perforated foils enables precise localisation of ionising radiation.
Integrated into imaging setups, GEM detectors provide sub-millimetre spatial resolution, enabling the accurate reconstruction of object dimensions, material identification, and analysis of internal features. In agriculture, GEM-based imaging can quantitatively measure soil density and moisture levels —key indicators of crop health. Preliminary results from our prototype systems demonstrate spatial resolution better than 1 mm, material identification uncertainty below 1%, and promising outputs from agricultural soil studies, including clear differentiation of soil types and moisture conditions. This talk will present these early results and discuss the expanding potential of GEM detectors in both security and agricultural applications.

6

Stress testing of fast reconstruction pipelines using machine learning

Author: Swagata Ghosh[None]

Scientific domains, including high energy physics and medical imaging, widely use fast reconstruction and detector-simulation pipelines, where full experimental or device-level simulation is often impractical. These pipelines mainly depend on simplified response models which assume reconstruction uncertainty relies on local input properties, avoiding the influence of global data context. This work introduces a domain-agnostic, context-aware stress-testing framework to probe the robustness of such assumptions and allows reconstruction response to depend on global structural characteristics such as data complexity and imbalance. Lightweight machine learning methods are used solely for unsupervised identification of broad context regimes, without optimization objectives. Using fully simulation-based case studies, we demonstrate that, context dependent response modelling can alter reconstructed feature distributions, offering a diagnostic methodology for testing reconstruction assumptions in fast analysis pipelines.

7

Probing low scale leptogenesis through gravitational wave

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The quest for a common origin of neutrino mass and baryogenesis is one of the longstanding goals in particle physics. A minimal gauge extension of the Standard Model by U(1)B-L symmetry provides a unique scenario to explain the tiny mass of neutrinos as well as the observed baryon asymmetry, both by virtue of three right-handed neutrinos (RHNs). Additionally, the U(1)B-L breaking scalar that generates mass of the RHNs can produce a stochastic gravitational wave background (SGWB) via cosmological first-order phase transition. In this work, we systematically investigate TeV-scale leptogenesis considering flavor effects that are crucial in low temperature regime. We also explore all possible RHN production channels which can have significant impact on the abundance of RHNs, depending on the value of U(1)B-L gauge coupling. We demonstrate that the strong dependence of U(1)B-L gauge sector on the baryon asymmetry as well as SGWB production can be utilized to probe a region of the model parameter space. In particular, we find that U(1)B-L gauge boson with mass ˜ 10 TeV and gauge coupling ˜ 0.1 can explain the observed baryon asymmetry and produces detectable SGWB in future detectors as well. Importantly, this region falls beyond the reach of the current collider sensitivity.

8

Ehrenfest's theorem for two potential gauge theories of gravito-dyons

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The Hamiltonian of Dirac fields in presence of gravito-dyons (particle carrying simultaneously the gravitational and heavisidian charge) we have discussed the validity of Ehrenfest's theorem for gravitational and heavisidian charge. The equation of motion of gravito-dyons may be visualized as the generalization of Ehrenfest's theorem for gravito-dyons moving in generalized gravito-heavisidian fields. The Lagrangian formulation for the gravito-heavisidian fields in a minimum coupled source which justifies the conserved Dirac current for gravito-dyons. Applying the Gupta subsidiary condition, we have also reproduced the classical equation of motion and the validity of Ehrenfest's theorem to abelian quantum field theory and the quantum equation of motion reproduces the classical equation of motion which is the generalized form of the Ehrenfest's theorem in quantum field theory for gravito-dyons.

Keywords: gravito-dyons, Ehrenfest's theorem, gravito-heavisidian fields, Abelian field theory.

9

Belle II TOP detector: Operation and Performance

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We present the construction, operation and performance of the Time-of-Propagation (TOP) detector using 400 fb-1 of Belle II data. The TOP detector is a part of the particle identification(PID) subsystem of the Belle II experiment at the SuperKEKB e+ e- collider. The detector is situated at the barrel region of Belle II and works on the principle of Cherenkov Radiation. It consists of 16 modules, each comprising a fused silica (quartz) bar and finely segmented micro-channel-plate photomultiplier tubes (MCP-PMTs). When charged particles enter the quartz bar, they produce Cherenkov photons, which suffer from total internal reflection and eventually reach the MCP-PMTs. To reduce chromatic aberration and focus the Cherenkov photons onto the PMTs, a focusing mirror is used at the other end of the MCP-PMTs, thereby increasing the light collection efficiency. The TOP detector can effectively discriminate between pions, kaons, and protons with momenta up to 4GeV/c by

measuring the propagation time of the photon and the hit position, which are directly related to the Cherenkov angle. Our work highlights the successful operation of this system in a high-luminosity environment and its vital contribution to the physics program of the Belle II experiment.

10

Status of Coherent Elastic Neutrino-Nucleus Scattering at Reactors

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In recent years, several experiments have achieved the sensitivity to probe the low-energy neutrino interactions. The large cross-section of neutrino scattering with nucleus (νAel) offers the prospects of studying quantum mechanical coherency effects, neutrino floor for dark matter detection, a probe to beyond the Standard Model (BSM), study of neutron density distribution, etc. We will highlight the status and results of the νAel searches with point contact Germanium detectors at the Kuo-Sheng Neutrino Laboratory (KSNL). The studies of analytical formulation of coherency in νAel and the constraints on the experiments will also be presented.

11

Fabrication and Characterization of Triple GEM Detectors For HEP experiments

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Gas Electron Multiplier (GEM) detectors are advanced micro-pattern gaseous devices designed for particle detection in high-radiation harsh environments. The central feature of GEM detector is a thin metal-clad polymer (usually Kapton) foil chemically etched with a high density of microscopic bi-conical holes, where each hole acts as an individual proportional amplifier. Triple-GEM designs have been adopted in several CERN experiments, including CMS, LHCb, TOTEM, COMPASS and future collider R&D projects. Panjab University is one of the GEM chamber production sites designated by the Compact Muon Solenoid (CMS) experiment at CERN-LHC. Fabrication of triple-GEM modules is done in a dedicated Class-100 cleanroom facility. All the assembled modules subsequently undergo CMS-recommended Quality Control chain, comprising QC-2: fast electrical cleaning and resistance checks, QC-3: gas leak testing, QC-4: HV divider linearity verification and noise measurement, QC-5a: effective gas gain measurement using X-ray setup, and QC-5b: gain uniformity measurements. These tests are crucial to ensure detector uniformity, reliability, long term stability, and safe operation before integration into CMS and future HEP experiments. This presentation will provide an overview of collaborative GEM fabrication and characterization activities performed at the Panjab University site.

12

Geoeffectiveness and Magnetic properties of the CME with Carrington rotation events 2125 and 2165 from CORHEL-MAS_WSA_ENLIL Model

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Coronal mass ejections (CMEs) are massive eruptions of plasma and magnetic fields from the Sun that can disrupt Earth's magnetosphere and trigger geomagnetic storms (GMSs). To improve space weather forecasting accuracy, it is crucial to comprehend how they propagate and interact with the solar wind. The interplanetary evolution of CMEs with Carrington rotations of 2125 and 2165 that were seen on July 12, 2012, and June 22, 2015, as well as their interactions with Earth's magnetosphere, are investigated in this paper using numerical simulations. In this approach, we simulate CME propagation from the inner boundary of the heliosphere (~ 0.1 AU) to 1 AU using the CORHEL-MAS WSA ENLIL modeling framework within the Community Coordinated Modeling Center (CCMC). In this framework, the Wang–Sheeley–Arge (WSA) coronal model, driven by Wilcox Solar Observatory magnetograms, provides the background solar wind and magnetic field structure, which is then propagated using the ENLIL heliospheric model with a hydrodynamic cone CME representation. These events' plasma region, magentic properties, and global geoeffectiveness signatures have also been determined from their propagation. These findings highlight the importance of continuous monitoring and advanced modeling for accurate space weather prediction and protection of the technological infrastructure.

13

Probing PeV Cosmic-Ray Composition with Radio Emission Using BURSTT

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The Bustling Universe Radio Survey Telescope in Taiwan (BURSTT) is primarily designed to detect bright, nearby fast radio bursts (FRBs), but its wide field of view and dense antenna layout also make it a promising instrument for the radio detection of cosmic-ray–induced extensive air showers (EAS). In this work, we investigate the capability of BURSTT to reconstruct the mass composition of cosmic rays in the PeV energy range (1–100 PeV) using radio emission alone.

We focus on the depth of shower maximum, X_{max}, and its event-by-event fluctuations, $\sigma(X_{max})$, which are robust observables sensitive to the mass of the primary particle. Using realistic detector noise, proton-induced showers, and air-shower simulations run using CORSIKA v7.7550 using the SIBYLL high-energy and UrQMD low-energy hadronic interaction models, we demonstrate that BURSTT is capable of an energy resolution of ˜0.18 dex (˜45%) and an X_{max} resolution of ˜31 g cm^{-2} at zenith angles up to 37.5° using actual detector noise and proton-induced showers. These performance levels complement both sparse arrays like AERA and Tunka-Rex and dense arrays like LOFAR, and they are competitive with current radio experiments.

As predicted by air-shower physics, our data demonstrate a distinct separation between light and heavy primary, with $\langle X_{max} \rangle$ rising and $\sigma(X_{max})$ broadening for lighter nuclei. In addition to establishing

BURSTT as a feasible radio-only instrument for composition-sensitive cosmic-ray measurements in the PeV range, this study offers a prediction framework for analysing its future observational data.

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Digital Simulation and Modelling for Forensic Analysis: A Case Study on Footprint Impression

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Crime investigation involves a thorough inspection of the scene to find potential evidence, particularly fingerprints and footprints. The crime scene involves potential evidence such as DNA, shoe marks, tool marks, ink, hair, nails, gunshot residue, fibre, etc.. Footprints or fingerprints are more prevalent at crime scenes compared to other forms of trail evidence. In most of the crime scenes, these footprint impressions are incomplete, distorted or partially destroyed. These impressions are very crucial, particularly in the case of robbery and murder, but most of the time they can't be reconstructed as prime evidence due to the lack of use of technology. The retrieval of foot impressions can be used to validate information along with other evidence to isolate the number of suspects. Traditional casting or scanning methods often capture these imperfections, resulting in inaccurate or misleading replicas. It is in this pursuit that digital simulation and modelling are proposed for the identification of footprints using additive manufacturing technology in forensic science.

This study proposes the application of 3D printing technology for model reconstruction of incomplete or distorted footprints, shoe impressions without tampering the original site scene using a 3D scanner (Model: SHINING 3D EINSCAN PRO 2X V2) and 3D Printer (Model: 4DS SMART ONE PLUS). The experimental results endorse the proximity analysis of footprint evidence. The technique significantly improves the surface three-dimensional modalities for preservation, restoration, and conservation of evidence. Thus, this study proposes a rapid prototype model development for footprint impression, adding reliability and admissibility of the evidence in forensic instrumentation.

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Advanced instrumentation for InDEx Phase-II dark matter experiment at JUSL

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Advanced instrumentation for InDEx Phase-II dark matter experiment at JUSL
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Indian Dark matter search Experiment (InDEx) is a direct detection experiment for dark matter that is situated at Jaduguda Underground Science Laboratory (JUSL) in Jharkhand, India. InDEx detectors are superheated droplet detectors with active liquid of C2H2F4 that are fabricated at the Saha Institute of Nuclear Physics (SINP) laboratory. In Phase I of InDEx, experiments were conducted at various detector thresholds, ranging from 5.87 keV to 1.95 keV. The experimental setup consisted of two 500ml detectors inside a temperature controller system (TCS) and an FPGA-based data acquisition system (DAQ). The next experimental upgrade will be Phase II of InDEx, in which the primary goal is to increase experimental exposure while reducing background. Three key upgrades have been implemented for this purpose, including the fabrication system, TCS, and DAQ.
In part of the fabrication, the expected detector number in Phase II is five times that of Phase I, which requires a large-volume pressure reactor for fabrication. For this purpose, a large-volume pressure reactor system with higher-level technology is incorporated. It has a 10-litre volume chamber and a chiller-based cooling system where chilled water is circulated around the chamber. In the multistage fabrication process of detectors, one of the vital tasks is cooling down the gel matrix before and after liquid transfer. Since the detector active target is a superheated liquid, maintaining the temperature and pressure is a crucial part of the fabrication processes. This new cooling system will provide greater temperature stability than the previous one, which relied on an ice bath.
Next upgradation is done on TCS, both in numbers and temperature range, with stability. Three new TCSs are made in two different dimensions to accommodate a large number of detectors. Each TCS contains two internal heaters and is made up of stainless steel and glass wool. They have a wide temperature range of 30°C-60°C. A testing trial at 5°C temperature variations shows excellent stability (±1⁰C fluctuation) over an extended duration of 6 hours. The DAQ is also upgraded to ten read-out channels from two, with a lower gain than in the previous case. During the previous runs of InDEx at lower threshold experiments, some events showed saturation. To overcome this problem, the gain is optimised to 350, where earlier it was 515. Along with these three upgrades, to reduce the background, the simulation and experimental works are ongoing to design the shielding. Primary simulation with polyethylene and paraffin has been explored for neutron shielding and high-density polyethylene has been chosen for the shielding design.
The first run in Phase II of InDEx at a 1.95 keV threshold will start shortly with ten 500ml detectors with all new TCSs, DAQ and neutron shielding. This will probe the improved sensitivity of InDEx, on the order of about 10-42 cm2 (SI cross section), to explore the lower mass of dark matter and make it competitive with other dark matter experiments.

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TCAD study of proton irradiation effects in LGADs with varying boron implantation doses

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Low Gain Avalanche Detectors (LGADs) play a crucial role in precision tracking and timing measurements at the High Luminosity Large Hadron Collider (HL-LHC), providing a superior signal-to-noise ratio and time resolution compared to conventional PIN detectors. Due to their proximity to the collision point, LGADs are subjected to intense radiation, with proton irradiation causing particularly severe degradation arising from high non-ionizing energy loss (NIEL) and enhanced Coulomb interactions. Radiation-induced defects lead to trap formation and degradation of the gain layer, resulting in reduced charge multiplication. Since the gain-layer implantation dose critically influences both intrinsic gain and radiation tolerance, this work investigates its impact using SILVACO TCAD simulations. Proton-induced damage is modeled for LGADs with boron implantation doses of 1.8×10^{13} and $2.0 \times 10^{13}\,\mathrm{cm}^{-2}$. The radiation damage modeling incorporates three key

mechanisms to reproduce gain-voltage characteristics: trap defects incorporated using the Delhi University Proton Damage Model, acceptor removal implemented through reduced gain-layer concentration, and irradiation-induced changes in impact ionization parameters. The evolution of the peak electric field at the gain layer junction after irradiation is also analyzed. In addition, the radiation tolerance of thinner LGADs is investigated by reducing the active thickness from 285 μm to 50 μm. This comparative simulation study provides insight into the interplay between gain-layer dose, sensor thickness, and radiation damage. It offers a simulation-based framework for optimizing LGAD designs to improve radiation tolerance under HL-LHC conditions.

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Simulation Study of Effective Gain and Ion Backflow in a Quadruple GEM Detector

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Quadrupole GEM detectors are well-suited for Time Projection Chambers (TPCs) operating under high particle flux and repetition rates, where space-charge accumulation degrades specific energy loss ($\mathrm{d}E/\mathrm{d}x$) measurements and spatial resolution. Owing to their strong ion-backflow suppression and high effective gain achieved at relatively low GEM voltages (ΔV_{GEM}) through multi-stage cascading, such detectors are proposed to be used in upgraded ALICE TPC or sPHENIX and are under consideration for future facilities, including Antiproton Annihilation at Darmstadt (PANDA) at the Facility for Antiproton and Ion Research (FAIR) and the International Linear Collider (ILC). In this simulation study, electric field and geometric configurations obtained from ANSYS are coupled with the Garfield++ framework to perform electron and ion endpoint analyses, enabling the estimation of effective gain and ion backflow fraction (IBF). Simulations are carried out for an argon-carbon dioxide gas mixture 70:30 over a range of ΔV_{GEM} values, and the dependence of IBF on the drift electric field (E_d) is investigated. The simulated results are compared with experimental measurements to evaluate the reliability of the simulation framework. While the simulations reproduce the overall experimental trends in effective gain and IBF, deviations in absolute values are observed, which are attributed to the known intrinsic limitations of the simulation framework. These results provide qualitative insight into gain and ion-backflow behavior in quadrupole GEM detectors and serve as a useful tool for optimizing multi-layered GEM configurations for future collider experiments.

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Optimization of SiO_2/Si_3N_4 Bilayer Dielectric and Electrode Geometry for Enhanced Signal Response in AC-LGAD Sensors Using TCAD

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Low-Gain Avalanche Detectors (LGADs) are being actively adopted in high-energy collider experiments due to their excellent time resolution; however, their spatial resolution is limited by non-multiplying regions between neighboring n^+ electrodes, which reduce the effective fill factor. AC-coupled LGADs (AC-LGADs) mitigate this limitation by enabling simultaneous high-precision timing and improved spatial resolution, making them promising candidates for future tracking and timing detectors, including those at the Electron Ion Collider.

In AC-LGADs, a continuous gain layer covers the active area, and an insulating dielectric layer between the aluminum readout electrodes and the n-type resistive layer allows signals to be coupled capacitively. Compared to DC-LGADs, the resistive n-type layer in AC-LGADs is doped at a lower concentration, leading to improved gain uniformity and an effective fill factor approaching 100%.
In this work, Technology Computer-Aided Design (TCAD) simulations are employed to explore key aspects of the dielectric stack and electrode geometry of an AC-LGAD sensor fabricated on a 50 μm-thick p-type substrate. The device incorporates a bilayer dielectric structure consisting of SiO_2 and Si_3N_4. The dielectric thickness (0.1–0.2 μm) and electrode thickness (0.5–1.0 μm) are systematically varied to investigate their impact on transient current response, signal sharing, and charge collection as a function of laser hit position. The simulation results identify favorable dielectric and electrode configurations that may enhance spatial uniformity while maintaining good timing performance, providing practical design guidance for future AC-LGAD sensor development.

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Design and Operation of the Belle II ARICH Detector

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The Aerogel Ring Imaging Cherenkov (ARICH) detector is located in the forward region of the Belle II experiment and used for particle identification. Its main purpose is to separate kaons and pions for momenta up to 4 GeV/c. The detector uses a double-layer silica aerogel as a radiator and Hybrid Avalanche Photo Detectors (HAPDs) for photon detection. Cherenkov photons form ring patterns on the HAPDs, which are used to calculate particle identification likelihoods. The operational status of the ARICH is summarized, including HAPD stability and ongoing efforts to improve DAQ efficiency. Currently small discrepancies are observed between the assumed and actual positions of gaps between aerogel tiles. This study focuses on extracting aerogel tile alignment corrections from high-energy muon data by comparing observed and expected gap positions. These corrections will further improve the particle identification performance of ARICH.

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Aging and Performance Studies of Gas Electron Multiplier(GEM) foils

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Gas Electron Multiplier (GEM) is a gaseous detector composed of a thin Kapton foil clad with copper on both sides and perforated with a high density of microscopic holes. Owing to its excellent spatial resolution, high rate capability, and flexible detector design, GEM detectors have found wide applications in modern particle and nuclear physics experiments. Its operation is based on the ionization of gas induced by traversing charged particles, followed by charge amplification within the GEM structure. In this work, we investigate the aging effects in GEM foils by comparing performance characteristics of foils manufactured in 2007 with newly fabricated ones. Two triple-GEM detectors were assembled using these sets of foils, and fundamental quality control measurements were carried out to check possible degradation over time. The results provide insight into the long-term stability and reliability of GEM foils for sustained detector operation. Such studies are crucial for ensuring the reliability of GEM-based detectors in long-term physics experiments and space-based exploration missions.

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Development of Trans-Stilbene based Fast Neutron Detector for nuclear application

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Abstract
Measurement of fast neutron in presence of gamma radiation is a one of the key issue in various nuclear fields like fission reactors, fusion reactors and accelerators etc. The detectors used to detect neutron need to be either insensitive to gamma radiation or able to discriminate it from neutrons. Crystalline organic scintillators meet most of the criteria to detect fast neutron in gamma background. Recently trans-stilbene single crystal based scintillator has received revived interest for neutron detection due to excellent pulse shape discrimination (PSD), fast response, high light output and growth in larger size. Scintillation characteristics of Bridgeman grown Stilbene crystal has been investigated in the present work.
Single crystals of 25 mm diameter and 50 mm length were grown successfully by Bridgman technique using commercially available Sigma-Aldrich make stilbene. The crystalline nature was confirmed by the XRD and transmission was found to be around 70-80% with absorption edge around 355nm. Crystal shows photoluminescence emission around 382 nm for 273 nm excitation.
For neutron and photon response, stilbene crystals were coupled to a PMT and anode signal was recorded using CAEN730 digitizer with a sampling rate of 500 MS/s. Detector was calibrated using 137Cs, 22Na gamma sources and exposed to 252Cf neutron source for PSD. Charge comparison method was used for PSD, in which, the neutron/gamma separation is achieved on the basis of the ratio of charge, R=QTail/QTotal, for the two different time intervals, tail and total. Quality of PSD was measured by calculation of figure of merit (FoM)=S/(δgamma+δneutron), where S is the separation between gamma and neutron peaks, and δ gamma and δ neutron are full widths at half maximum of the corresponding peaks. Crystal showed FoM 2.23 and 2.49 for two different energy ranges of 500-550 keVee and 700-750 keVee respectively. The excellent PSD capability indicates that developed Transe-stilbene based detector can be used as a solid-state detector for fast neutron detection.

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On the scaling properties of fluctuations and correlations in partonic matter in relativistic heavy-ion collisions

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We study the occurrence of pion fluctuations and correlations in the multiparticle produc- tion in 16O-AgBr interactions at 60A and 200A GeV/c energies. The presence of dynamical fluctuations is

investigated in terms of the behaviour of the normal factorial moments. The correlation is looked into using the factorial cumulants of second and third order. This pro- vides us a tool to understand the comparative strength of the two-particle and three-particle correlation.
The normalized factorial moments in rapidity are found to exhibit power-low scaling when partitioning with the same number of bins, indicating that the fluctuations are isotropic, i.e. the fractality is self-similar in multiparticle production of central nucleus-nucleus collisions. Further, we investigate the occurrence of the Ginzburg–Landau type of phase transition in terms of the parameter ν A comparison of our results with the AMPT and UrQMD models has also been performed.

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Measurement of the ^{108}Cd$(p,\gamma)^{109}$In Cross-Section Using Activation Technique

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This study presents the experimental measurement of the proton capture cross-section of $^{108}\mathrm{Cd}(p,\gamma)^{109}\mathrm{In}$ which is an inverse reaction of $^{109}\mathrm{In}(\gamma,p)$, responsible for the production of the $^{108}\mathrm{Cd}$, a rare proton-rich cadmium isotope (natural abundance: 0.89\%), within the Gamow window for temperatures relevant to the \textit{p}-process nucleosynthesis ($T_9 =$ 3-4 GK). Using the activation technique with 66.3\% enriched $^{108}\mathrm{Cd}$ targets and a HPGe detector, cross-sections were recorded at proton laboratory energies from $E_p^{\mathrm{Lab}} = 2.26 \pm 0.12$ MeV to 6.84 ± 0.03 MeV. The corresponding astrophysical S-factor was also determined.
The results were compared to the predictions of the Hauser-Feshbach statistical model using TALYS-1.96, which incorporates various nuclear level densities (NLDs) and γ-ray strength functions. By adjusting the proton-optical potential, theoretical predictions achieved good agreement with experimental data. The team extrapolated the reaction rates and benchmarked them against the REACLIB database.

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Optimization of Crystal Shapes and geometries for efficient design of Total-Body PET

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Total-Body PET scanners hold significant importance in medical diagnostics with remarkable sensitivity and spatial resolution. Our study is based on Monte Carlo simulation toolkit Geant4 to assess detector crystals of various configurations and materials. We focus on critical parameters like sensitivity, coincident time resolution, and energy resolution with various crystal designs and geometric variant across standard LYSO, and GAGG crystals. In our study, pyramid-shaped
LYSO crystals demonstrated superior performance with an impressive CTR of 42 ps. On the other hand, GAGG crystals showed a 6% poorer intrinsic CTR as compared to LYSO. However, GAGG

outperformed LYSO in energy resolution by 25%. Our findings illustrate how various crystal materials and geometries affect PET scanner performance, highlighting the trade-offs between sensitivity, coincidence time resolution, and energy resolution. These insights can lead to efficient design of total-body PET systems in future.

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Muon Scattering Tomography for Non-Destructive Imaging of Spent Nuclear Fuel in Dry Storage Casks

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Muon scattering tomography is necessary for spent nuclear fuel because traditional safeguards can lose continuity of knowledge when monitoring systems fail, requiring re-verification of sealed casks without opening them. It provides a non-invasive and non-destructive way to look inside heavily shielded dry storage containers that are otherwise inaccessible. Unlike conventional NDA tools, which struggle due to strong self-shielding and complex material distributions, cosmic muons penetrate large thicknesses and their scattering or absorption reveals fuel presence and density differences. This allows inspectors to confirm whether fuel assemblies(UO2 rods) are present or replaced with dummy elements, improving nuclear safeguards and security compliance. Using GEANT4, we have replicated the design of the CASTOR-100 dry storage cask, with six detector layers placed above and below the cask region. Incoming and outgoing particle tracks were reconstructed by propagating Monte Carlo (MC) particles through the cask. The scattering locations within the Region of Interest (ROI) were determined using the POCA and Kalman filter algorithms. Subsequently, the ML/EM algorithm was applied to obtain a three-dimensional reconstruction of the cask image.
In parallel, toward developing a similar experimental imaging setup, we are fabricating Thick-GEM detectors in collaboration with Indian PCB manufacturers. Several prototype detectors have been produced, characterized, and tested for muon detection efficiency and position resolution.

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Implementation of a multi-dimensional extension of the Hough Transform(MDHT) in track-finding into the GPU and the FPGA

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Future particle colliders will require fast and efficient track-finding algorithms to cope with very high hit densities. In this work, we study the implementation of a multi-dimensional extension of the Hough Transform (MDHT) on parallel hardware platforms such as GPUs and FPGAs. Unlike many conventional tracking algorithms whose execution time increases rapidly with hit density, the MDHT approach has a key advantage: its processing time scales linearly with the number of detector hits, making it well-suited for high-occupancy environments. The algorithm is trained using a large set of simulated tracks, allowing it to adapt easily to different detector geometries without modifying

the core logic. Thanks to its intrinsic parallel structure, the MDHT can be efficiently mapped onto modern hardware architectures, enabling large-scale parallel processing. With current technology operating at GHz frequencies, this approach opens the possibility of reconstructing tracks from events containing millions of hits within millisecond timescales. Preliminary GPU implementations demonstrate promising performance, indicating that MDHT is a scalable and powerful solution for future real-time and offline tracking applications.

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Design and Development of 30 MeV Electron Linear Accelerator for radio-isotope generation

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SAMEER is successful in developing S-Band side coupled standing wave Linear Accelerators (LINAC) operated in π/2 mode [1]. Study suggests that 30 MeV energy electrons will give sufficient bremsstrahlung photons to knock out neutrons for desired (e,⊠) and (⊠ ,n) reaction based medical radio-isotopes e.g. 99mTc, 67Cu etc.[2]. Therefore, 30 MeV LINACs with an average beam current of 350 µA is proposed for radio isotopes production[3].
Electron beam dynamics calculations using MATHEMATICA are carried out to study the field distribution and the energy gain in each resonant cavity. Maximum efficiency for various dimensions of drift space were studied and cavities were fabricated accordingly. Simulation shows a 47 cell LINAC will give ˜34 MeV energy output and a 35 cell LINAC will give ˜27 MeV energy at the exit. The input power estimations, beam loading characteristics and the transient responses of the cavity were all simulated for optimum energy and beam power.
Two LINACs in series operation was decided and therefore it was very crucial to tune the individual LINAC resonant frequencies so that the π/2 of the second LINAC is within 50-100 kHz difference. The resonant cavities were carefully selected, tuned and integrated in the LINAC. Klystron with a peak power of 7.5 MW and an average power of 38 kW serve as the RF source for individual LINACs. Beam diagnostics were carried out independently for both LINAC and parameterizations were carried out. Energy measurements using Aluminium wedge [4] was carried out in electron mode and obtained ˜18 MeV and ˜12 MeV from first and second respectively as expected from simulations. Other diagnostics like beam size measurements using wire scanner [5], current measurements using Faraday Cup and ACCT were carried out for both LINACs. A detailed report of the simulations and experimental results are covered in the paper.

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Design and Development of Bending Magnet and Coils for High Energy Electron Linear Accelerator

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Medical radio-isotopes are used in non-invasive nuclear diagnostic imaging techniques. Technetium-99m is the most widely used radio-isotope eluted from Molybdenum-99. For this purpose, an economical and green technology using electron linear accelerator is being developed at SAMEER where 30 MeV electron/photon beam will be used to irradiate 100Mo to generate 99mTc [1]. Various coils and magnet have been designed and developed to be incorporated in the beamline for accurate beam positioning and diagnostics.

For achieving a 30 MeV electron beam two separate 15MeV LINAC structures [2] are to be operated in serial mode [3] using two independent RF sources. To attain a high beam power, maximum number of electrons are to be injected from one LINAC structure to another with minimal loss. To ensure this, beam focusing and corrections are crucial, which is carried out using Solenoid magnet and Steering coils. From beam optics simulation a solenoidal field of ˜2000 G was required to achieve beam focusing across the 4 m beamline. A water-cooled solenoid coil of length 300 mm with an inner diameter of 180 mm was designed in Opera-3d [4]. This coil comprises of 6 pancake coils connected in series with a constant current supply. In order to maintain the nominal trajectory of the electron beam, steering coils are placed at different position in the beam line to correct the beam position in transverse plane. Steering coils were designed for a maximum field of 100 G, in two different dimensions based on their placement in the beamline. A water cooled dipole bending magnet was included in the beamline for precise measurement of electron beam energy and the energy spread. Sector dipole was simulated with a bending angle and radius of 90° and 200 mm respectively in Opera-3d. The magnet is designed for a Bmax of 5000 G and a pole gap of 25 mm [5].

Coils and Magnet were manufactured according to the designed parameters. Electrical and water cooling manifolds were developed for the testing and measurement of the same. Measured values were corroborated with the design parameters. Effects of solenoid and steering coils were studied during the beam trials of the LINAC.

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Performance and Stability Studies of a Single-Mask Triple GEM Detector Using an X-ray Source

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The Gas Electron Multiplier (GEM) is a micro-pattern gaseous detector used for tracking in high-rate heavy-ion experiments. It provides good spatial resolution and operates efficiently at high particle rates. Before using a GEM detector in any experiment, its performance must be carefully studied. Important performance parameters include detector efficiency, gain, energy resolution, and long-term stability under radiation.

In this work, a single-mask triple GEM chamber prototype is studied using a ^{55}Fe X-ray source. The detector is operated with a premixed Argon/CO_2 gas mixture in a 70/30 volume ratio. Detector efficiency, effective gain, energy resolution, and stability are measured. In particular, the stability study of the detector under continuous irradiation using a radioactive source is presented and discussed in detail.

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Simulation of Space Charge Effects in Micromegas Detectors Using neBEM

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Micro-Pattern Gaseous Detectors (MPGDs) such as Micromegas are widely employed in nuclear and high-energy physics as well as medical imaging applications due to their excellent spatial resolution and rate capability. However, under sustained irradiation or high-rate operation, the accumulation of ions can lead to space charge effects that distort the local electric field, affecting gain stability, charge transport, and overall detector performance. A reliable quantitative description of these effects is therefore essential for detector design and optimization.
In this work, we present an ongoing study of space charge effects in a Micromegas detector using the nearly exact Boundary Element Method (neBEM) within the Garfield++ simulation framework. The approach enables accurate electrostatic field calculations in realistic Micromegas geometries and allows the inclusion of time-dependent space charge distributions arising from avalanche processes. Using representative detector configurations and operating conditions, we examine how space charge induced field distortions influence key performance-related quantities such as the amplification field and effective gain.
The current study focuses on establishing a robust simulation framework capable of self-consistently incorporating space charge effects. Different space charge representation models are currently being explored for improved physical realism and computational efficiency. The presented methodology provides a valuable tool for interpreting experimental observations related to gain suppression and field non-uniformities and supports the optimization of Micromegas detectors for advanced instrumentation in nuclear physics, high-energy physics, and medical imaging experiments.

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Pulse-shape study of Gaseous Drift-tube detector and Spherical Proportional Counter with Garfield++

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Gaseous detectors play a central role in detector physics due to their versatility, scalability and ability to provide detailed information on particle interactions through ionization signals. In particular,Drift-tube detectors are widely used in high-energy physics, nuclear physics, and astro-particle experiments because of their excellent tracking capabilities. Drift-tubes form the basic building blocks of large tracking systems such as Muon detectors and time projection chambers (TPCs), while Spherical Proportional Counters (SPCs) are especially suited for low energy rare-event searches including Dark-Matter detection, coherent elastic neutrino-nucleus scattering (CEνES) and neutron measurements. SPCs are also used in low energy thresholds, and intrinsic particle identification potential.

In this work, we aim to study and compare the pulse-shape characteristics of gaseous drift tube detectors and spherical proportional counters using detailed simulations performed with Garfield++. The detector response is investigated for commonly used gas mixtures, focusing on the impact of gas composition, electric field configuration, and detector geometry on signal formation. Simulations are carried out for different types of ionizing particles, including alpha particles, beta particles,muons, and pions, in order to understand how their distinct energy loss mechanisms influence the resulting current and voltage pulses.
The poster will present a systematic study of pulse-shape features relevant for particle identification (PID) and energy resolution in gaseous detectors. Emphasis will be placed on identifying the key detector and gas parameters that govern pulse evolution and discrimination power between different particle species. This study provides insight into optimizing SPCs performance for applications requiring precise PID and low-background operation.

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Background Study of Natural Radioactivity in Above-Ground Reactor Antineutrino Detection

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Accurate characterization and mitigation of background radiation are essential for achieving high signal-to-noise ratios and reliable performance in neutrino detection experiments. This study investigates various sources of background noise affecting the Indian Scintillator Matrix for Reactor Anti-Neutrino (ISMRAN) detector at BARC, a segmented plastic scintillator array designed for reactor antineutrino measurements. The presence of radioactive isotopes and environmental gamma-rays could mimic the antineutrino signal. We perform Monte Carlo simulations to understand the contributions from external gamma-rays and the radioactive decay chains of uranium-238 and thorium-232. These efforts are intended to contribute to improved background handling in above-ground reactor-based neutrino experiments like ISMRAN, supporting enhanced precision in antineutrino detection.

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Large Area Picosecond PhotoDetectors for Fast-Timing Photon Detection

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Large Area Picosecond PhotoDetectors (LAPPDs) are an emerging class of advanced photosensors that combine large-area coverage with fast timing (of order picoseconds) and spatial resolution. Based on micro-channel plate (MCP) amplification and stripline anode readout geometry, LAPPDs offer capabilities beyond those of conventional photo-multiplier tubes (PMTs), making them attractive for next-generation detector systems requiring precise photon detection. The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) at Fermilab is the first neutrino detector to deploy LAPPDs in a beam-based environment. ANNIE is a 26-ton gadolinium-loaded water Cherenkov detector located on the Booster Neutrino Beam (BNB), with physics goals that include measurements of neutron multiplicity arising from neutrino-nucleus interactions. In this talk, I will give an overview of the ANNIE experiment, focusing on the design principles and practical integration of LAPPDs, and conclude with a brief outlook on their potential applications in medical imaging.

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Development of indigenous conductive paint for high-energy physics applications

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Conductive coatings are required for Nuclear, High-Energy Physics and Medical sciences experiments.
Conductive paints are widely used across multiple scientific and technological domains due to their ability to provide uniform electrical conductivity and effective electromagnetic shielding. In high-energy physics experiments, they are applied to electrode surfaces of particle detectors such as resistive plate chambers (RPCs), gaseous detectors, and time-of-flight systems to ensure stable high-voltage distribution, efficient signal collection, and reduced electronic noise. Conductive coatings also play a crucial role in radio-frequency and electromagnetic interference (RF/EMI) shielding by forming continuous conductive layers that reflect and absorb electromagnetic radiation, and are therefore commonly employed in Faraday enclosures, shielded laboratories, and sensitive electronic housings. In medical science, conductive paints are used for electromagnetic shielding in diagnostic and therapeutic environments, including MRI suites and EEG and ECG laboratories, where they help suppress RF interference, enhance measurement accuracy, and ensure compliance with electromagnetic compatibility (EMC) and patient-safety standards. Additionally, in aerospace and automotive industries, conductive coatings are applied for EMI shielding and electrostatic discharge (ESD) control, contributing to improved electromagnetic compatibility, system reliability, and protection of sensitive onboard electronics.
In this study the development of a indigenous conductive paint for Resistive Plate Chamber (RPC) and electromagnetic/radio frequency shielding. The resistivity of the coating was measured by the two-probe method. Experimental observations show that the resistivity of the paint changes during drying, due to the evaporation of the dispersing agent and the settling of the graphite particles, after which the resistivity stabilizes once drying is complete. Lower graphite concentrations result in higher resistivity, while increasing the amount of graphite gradually decreases the resistivity. Environmental parameters such as temperature and humidity, as well as the thickness of the coatings, affect the resistivity.
This decrease in resistivity can be attributed to factors such as the drying of the coating, improved connectivity between particles, and moisture absorption, all of which enhance the movement of charge carriers through the coating. Therefore, the experiment confirms that the resistivity of the coating paint is time-dependent and decreases with increasing time. It also depends on the thickness of the coating.

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Study with HFO gas in Ar/CO2 based gas mixture in GEM Detectors.

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Gaseous detectors are vital components of particle detection systems in High Energy Physics (HEP) experiments, with the Gas Electron Multiplier (GEM) detector being widely employed due to its excellent timing resolution, high-rate capability, good spatial resolution, and radiation tolerance. The performance of GEM detectors strongly depends on the choice of gas mixture used as the ionizing medium, where fluorine-based gases such as CF_4 have traditionally been used to enhance timing performance; however, environmental concerns have driven the search for eco-friendly alternatives. In this work, we explore the feasibility of using hydrofluoroolefin (HFO) gas as a replacement for CF_4 in Ar/CO_2-based gas mixtures for GEM detectors. The study focuses on evaluating the timing resolution, noting that while CF_4 improves the timing resolution to the order of a few nanoseconds, GEM detectors operated with only Ar/CO_2 typically achieve timing resolutions below 10 nanoseconds(ns). We assess the potential of HFO gas to improve the timing performance while maintaining detector efficiency and offering a more environmentally sustainable solution.

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Temperature-dependent Afterglow Studies of Alkali Halide Scintillation Crystals Using a Controlled Cooling System

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Alkali-halide crystals such as thallium-doped sodium iodide (NaI:Tl) and cesium iodide (CsI:Tl) are Widely used inorganic scintillators for X-ray and γ-ray detection due to their high light output and mature performance. For example, NaI:Tl and CsI:Tl produce on the order of 4×10ˆ4 and 5×10ˆ4 photons/MeV of absorbed energy, and have been employed for decades in applications from medical imaging and nuclear spectroscopy to space-based and underground-based radiation experiments.

these materials also exhibit long-lived luminescence (afterglow)following excitation (glow), arising from charge carriers that become trapped at defects and recombine slowly. It produces persistent light pulses well after the primary scintillation, which can increase dead time, raise the effective energy threshold, baseline distortion, pulse pile-up, and degrade energy resolution or image quality. The trapping and de-trapping processes responsible for afterglow are strongly temperature dependent. At higher temperatures, trapped charge carriers are thermally released more rapidly, resulting in shorter afterglow decay times. Conversely, at lower temperatures, trap release is suppressed, leading to longer persistent emission. So temperature dependent study of Afterglow
become essential.

Although afterglow has been previously studied, systematic measurements under precisely controlled and stable temperature conditions—especially using compact thermoelectric cooling—are limited. Such Cooling system help us to investigating the effect of temperature on afterglow and resolution of crystal for different energy of radiation (like Cs137, Na22, Co60) and type of radiation(like alpha and gamma). For Which a detailed study on Peltier Module had been carried out with and without Crystal. Therefore, this work aims to quantitatively study the temperature dependence of afterglow parameters using a controlled cooling system and modern pulse analysis.

This poster presents the characterization of a cooling module with and without a crystal load at different temperatures. Data acquisition from the cooling module was performed using a temperature sensor (DS18B20), a Hall-effect-based current sensor (ACS712), and a resistor-divider-based voltage sensor within an Arduino Uno framework using PySerial and Python. The effects of temperature on afterglow components and energy resolution were investigated. Raw scintillation pulses from the

crystals were recorded to study afterglow characteristics, with a focus on thermoelectric cooling, afterglow behaviour, and a two-component decay model. These results provide systematic insight into thermally activated trapping mechanisms in alkali halide scintillators.

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Design and Performance Study of a Portable Scintillator-SiPM Radiation Detector

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Compact and efficient radiation detectors are essential for applications ranging from fundamental nuclear and particle physics to medical diagnostics and environmental monitoring. This work presents the design, construction, and performance evaluation of a portable radiation detection unit based on a plastic scintillator optically coupled to silicon photomultipliers (SiPMs). Plastic scintillators were selected for their fast response and adequate photon yield, while SiPMs provide a modern alternative to photomultiplier tubes, offering small size, low bias voltage, mechanical durability, and economical operation.

The detector was experimentally tested using naturally occurring cosmic-ray muons. Detailed performance studies, including signal quality, noise behavior, and pulse shape characteristics, were carried out using a digital storage oscilloscope. The measured cosmic muon flux shows good agreement with established reference values, confirming the reliable operation, stability, and suitability of the developed detector system.

The results highlight the suitability of scintillator–SiPM–based detectors as lightweight, modular, and adaptable instruments for radiation measurements. Such systems are promising candidates for deployment in laboratory experiments, educational setups, radiation surveillance, and medical imaging technologies, supporting the ongoing development of next-generation compact detector platforms.

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Impact of Target Deformation on Incomplete Fusion in Radionuclide Synthesis

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A significant amount of research has been dedicated to study the heavy-ion (HI) fusion reactions. The research works serve as a valuable tool for unveiling details about the nuclear structure and examining the prospect of synthesizing heavy and super-heavy elements (SHE) [1-2]. However, complexity in synthesizing the SHEs may happen due to the occurrence of breakup fusion (BUF) [3,4]. Investigations of complete fusion (CF) and incomplete fusion (ICF) induced by heavy ions at energies ≈ 3-8 MeV/A, have been highlighted [5, 6]. Thus, it is essential to have a thorough understanding of ICF dynamics in order to obtain adequate knowledge of nuclear reactions. Various reaction channels may open in the interaction of heavy ions with the target nucleus. At projectile energy above the Coulomb barrier (EC.B.), both CF and ICF are the dominant modes of reactions. In this respect, the measurement of excitation functions (EFs) of evaporation residues (ERs) to investigate the CF and ICF dynamics is a unique tool. The present study has been carried out to examine the role of target deformation (β2) on ICF by measuring EFs of ERs in 14N + 148Nd system and

at projectile energy regimes ≈ 3-7 MeV/A. As such, an experiment has been performed using the 15UD Pelletron Accelerator at Inter-University Accelerator Centre, New Delhi, India. In these measurements, offline stacked foil activation technique was employed. The ERs were identified by their characteristic γ-rays followed by their decay curve analysis. In order to understand the role of β2 on ICF dynamics, the deduced ICF fraction for the present systems along with some other systems at a constant value of relative velocity (Vrel) for different projectiles as a function of β2. The detailed description and formulation of β2 have been taken from [7,8]. An attempt has been made to observe the dependence of ICF dynamics on combined parameters like ZPZTβ2, ZPZT/(1-β2), etc.

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Simulation of Gamma-Ray Interaction and Energy Deposition in Scintillation Detectors for PET using GEANT4

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Positron Emission Tomography (PET) is a widely used nuclear imaging technique that relies on the accurate detection of 511 keV annihilation gamma photons. The interaction of these photons within the scintillation detectors and their subsequent energy deposition characteristics have a significant impact on a PET system's performance. In this work, gamma-ray interactions and energy deposition in widely used scintillation detectors for PET applications have been analysed through a Monte Carlo simulation study using the Geant4 toolkit.
Geant4 was used to model a simplified detector geometry that included a scintillation crystal coupled to a gamma-ray source. To investigate their interaction processes within the detector material, such as photoelectric absorption, Compton scattering, and secondary particle production, monoenergetic 511 keV gamma photons were simulated. The energy deposition spectrum and interaction behaviour were obtained by recording and analysing the energy deposited in the scintillator. Visualisation tools available in Geant4 were used to verify the geometry and to qualitatively observe photon trajectories and interaction points inside the detector.
The simulation framework provides a clear understanding of photon-matter interactions that are important to PET detector systems. The initial results show that Geant4 can accurately model energy deposition and detector response. Future work will address more detailed PET detector simulations, such as efficiency optimisation, geometry studies, and coincidence detection, which this work provides the foundation for.

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A Universal Python GUI for Photodetector Quality Assurance: From Underground Dark Matter Searches to Astroparticle Cherenkov

telescope cameras

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Silicon Photomultipliers (SiPMs) have established themselves as a premier sensing technology, increasingly finding applications in next-generation experiments across diverse fields. These include High Energy Physics (e.g., the CMS Hadron Calorimeter upgrade), Astroparticle Physics (e.g., MAGIC), Neutrino Observatories (e.g., DUNE), and Dark Matter search experiments (e.g., DarkSide). Despite the distinct goals of these fields—ranging from measuring TeV-scale collisions to detecting rare, low-energy recoil events—the fundamental requirement for rigorous sensor quality assurance (QA) remains universal.Currently, the characterization of these photodetectors relies heavily on fragmented or expensive proprietary software (e.g., LabVIEW, CAEN HERA), which creates financial barriers for smaller institutions and hampers the standardization of testing protocols across diverse collaborations. In this work, we present a versatile, open-source Graphical User Interface (GUI) developed in Python, designed to address the characterization needs of the broader particle physics community. By leveraging the PyVISA library, our software provides a hardware-agnostic control environment that integrates High Voltage source meters (e.g., Keithley) and digital oscilloscopes into a single, synchronized workflow. This allows for the automated acquisition of correlated DC (leakage current) and AC (pulse shape) data, essential for determining breakdown voltage (V_{bd}), gain uniformity, and dark count rates (DCR).We demonstrate the software's practical utility in the development of low-background experimental setups. Specifically, the tool is currently being deployed to characterize SiPM-coupled plastic scintillator modules for a portable muon veto system, designed to map the background radiation environment at the Jaduguda Underground Science Laboratory (JUSL) for upcoming Dark Matter search experiments. Furthermore, the framework can be utilized for the mass characterization of SiPMs used in Cherenkov telescope cameras in astroparticle physics, where the automated equalization of gain across high-granularity pixel arrays is critical for detecting atmospheric showers. By providing a cost-free, transparent, and platform-independent alternative to commercial suites, this tool aims to streamline detector R&D and ensure reproducibility across the global physics community.

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Pulse Shape Analysis of Cosmic Muons and Gamma Radiation Using a Portable Scintillator-SiPM Detector System

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The identification and discrimination of different types of radiation using compact detector systems is of growing importance in particle physics experiments, radiation monitoring, and educational instrumentation. This work reports on the development of a compact and portable radiation detection system based on plastic scintillators coupled with silicon photomultipliers (SiPMs). Three detector modules were constructed and integrated with custom front-end electronics, including amplification, discrimination, and FPGA-based coincidence logic. The setup was primarily used to record naturally occurring cosmic muons and to study pulse characteristics using a digital storage oscilloscope and offline Python-based analysis. Parameters such as pulse height, width, and charge were extracted to investigate signal behavior and radiation-induced features. The use of three-fold coincidence significantly improved muon event selection and background suppression. The results demonstrate the suitability of the developed system for compact cosmic-ray experiments and pulse shape–based radiation studies.

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Advancing Ultra-Low Background Spectroscopy for Clinical and Radiopharmaceutical Applications

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A unified GEANT4-based simulation framework is developed for HPGe detectors that allows precise modeling of
radioactive backgrounds, providing a robust methodology for medical physics applications such as radiopharmaceu-
tical purity analysis and ultra-low-level clinical spectroscopy. By implementing a high-fidelity Monte Carlo model
that accounts for the detector geometry, shielding, and intrinsic materials, the framework identifies and quantifies
trace contaminants including primordial 238 U, 232 Th, and 235 U decay chains within front-end electronics , along-
side anthropogenic and environmental isotopes such as 137 Cs, 60 Co, 54 Mn, and 135 Xe. To ensure clinical relevance
and spectral√accuracy, simulated energy depositions are convolved with an energy-dependent resolution function,
σE (E) = α E + β , effectively replicating the finite response of high-purity germanium (HPGe) detectors used in
sensitive bioassays. The results demonstrate that iterative optimization of isotopic activities allows the simulation
to reproduce measured spectra with high precision, offering a predictive tool to characterize activation products in
radiotherapy environments and enhance detection limits for rare radiological events.

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Toward Precision Medical Physics with Point-Contact HPGe Technology

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Point-contact HPGe detectors (PCGe) are valued in medical and biomedical physics primarily for their exceptional energy resolution, ultra-low detection threshold, and excellent peak-to-Compton discrimination. Drawing upon the established use of PCGe detectors in fundamental research across diverse fields, this work seeks to adapt the technology for medical physics applications where ultra-high-resolution gamma spectroscopy is essential. Scintillator-based detectors are the backbone of modern nuclear medicine and clinical imaging due to their efficiency and timing performance, while PCGe technology provides a complementary, high-precision solution for radiopharmaceutical quality control and ultra-low-level gamma spectroscopy, enabled by its exceptional energy resolution

and pulse-shape discrimination. Despite their limited applicability to large-area imaging and fast-timing requirements, PCGe detectors offer unmatched energy resolution and background discrimination, making them powerful complementary tools to scintillator-based systems. Their potential impact is particularly significant in preclinical validation, precision dosimetry, isotope production monitoring, and regulatory-quality assurance. The present work delineates a forward-looking roadmap for the development and deployment of PCGe-based techniques in these emerging medical physics applications.

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Experimental Validation of simulated α Tracks in the Prototype SATTPC

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Accurate simulation and reconstruction of charged-particle tracks
are essential for the design and optimization of Active Target Time
Projection Chambers (AT-TPCs) used in low-energy nuclear physics.
In this work, we present a detailed study of α-particle track formation based on both hydrodynamic and particle modeling approaches, followed by experimental validation using a prototype Saha Active Target Time Projection Chamber (SATTPC).
Primary ionization produced by α-particles is simulated with Geant4. The electron and ion transport parameters are obtained using MAGBOLTZ within the Garfield++ framework. The subsequent charge transport and signal formation are modeled in COMSOL using both hydrodynamic and particle-based approaches. The hydrodynamic model describes the collective evolution of charge densities, including diffusion and space-charge effects, while the particle model tracks individual charge carriers to capture microscopic transport behavior and to validate the hydrodynamic approximation. Together, these approaches provide realistic predictions of charge drift, electric-field distortions, and signal induction on the segmented anode. Experimental validation is carried out with a SATTPC prototype equipped with a Micromegas readout. The detector is characterized using a ^{55}Fe X-ray source and tested for α-particle tracking with a ^{241}Am source in an Ar:CO_2 (90:10) gas mixture. The measured track lengths, charge deposition profiles, and signal characteristics show good agreement with both hydrodynamic and particle-based simulation results.

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Experimental Determination of Angular Correlation of Gamma Rays from 60Co Using NaI(Tl) Scintillators

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Gamma gamma angular correlation measurements provide a tool for probing nuclear structure, and characterizing radiation detection systems. In this work, we performed an experimental investigation of the angular correlation between successive gamma rays emitted in the radioactive decay of a ^{60}Co source using a scintillation-based coincidence setup. Two NaI(Tl) scintillation detectors coupled with photomultiplier tubes were arranged on an angular correlation table with the radioactive source positioned at the center. One detector was kept fixed while the second detector was rotated to vary the relative detection angle between 90° and 180°.

The detection system was calibrated using gamma ray energy spectra, and timing discrimination was optimized using single channel analyzers and coincidence electronics. Coincidence counting rates were recorded at discrete angular positions over fixed counting intervals, and background measurements were performed by removing the radioactive source. The normalized angular correlation function W(θ)/W(90°) was extracted and compared with theoretical predictions based on cascade gamma transitions and Legendre polynomial expansion coefficients. The experimental results show the expected angular dependence for quadrupole gamma transitions, with minor deviations attributed to finite detector solid angle, statistical uncertainties, and alignment errors. Overall, the results confirm the feasibility of the scintillation coincidence setup for resolving angular correlation effects in cascade gamma-ray transitions.

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A Hybrid Quantum–Classical Framework for Image Analysis and Facial Expression Recognition

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Abstract
Context: Image analysis and boundary detection are critical in diagnostic and monitoring systems where intensity variations must be resolved under noise and limited resolution. Quantum image processing, using superposition and interference principles, offers novel representations and operations for structured analysis, which can complement classical approaches in imaging-intensive experimental setups.
Purpose: This study investigates a hybrid quantum–classical framework for facial image analysis and facial expression recognition, explicitly motivated by applications where accurate detection of spatial patterns is crucial for experimental diagnostics and monitoring.
Methods: Facial images are enhanced using histogram equalization and adaptive thresholding to maximize contrast and improve separability prior to quantum-inspired processing. The enhanced images are then encoded using a gridding-based representation analogous to block-based quantum image models, enabling localized subsystem analysis. Facial expressions are characterized through graph-based observables derived from facial landmark points, and classification is performed using classical and quantum-inspired classifiers.
Findings: Thresholding-based preprocessing improves image quality by enhancing contrast and segmentation boundaries, while gridding-based segmentation enables localized analysis and stable feature extraction. Experiments conducted on a subset of the FFHQ dataset achieve approximately 90% accuracy in small-scale evaluations. The workflow demonstrates potential for reliable pattern recognition in image-intensive diagnostic environments.
Significance: The results demonstrate that hybrid quantum–classical frameworks can effectively bridge classical image processing and quantum-inspired algorithms, providing scalable and robust tools for monitoring, diagnostics, and structured analysis in imaging-intensive experimental systems.
Keywords: Quantum image processing; hybrid quantum–classical frameworks; quantum-inspired models; image gridding; experimental diagnostics; pattern recognition

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Quantum Edge Detection: A Technical Survey of Methods and Approaches

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Abstract
Context: Edge detection is critical in image-based diagnostics where intensity variations must be resolved under low resolution and noisy conditions. Quantum image processing, using superposition and interference, offers alternative approaches to classical gradient-based methods.
Purpose: This study surveys quantum Hadamard-based and classical edge detection techniques, explicitly motivated by diagnostic tasks where accurate boundary identification from detector images is essential.
Methods: A classically simulated quantum model is applied to 8×8 binary images using amplitude encoding, single-qubit Hadamard operations, and permutation unitaries to highlight intensity transitions. Classical methods (Canny, Sobel, Laplacian) are applied independently. The workflow—image selection, quantum encoding, circuit simulation, and post-processing—is implemented in Python using Jupyter Notebook, Google Colab, and IBM Quantum simulators.
Findings: Quantum detection captures subtle boundaries via interference, even at low resolution. Orthogonal scans provide complementary features forming coherent edge maps. Canny detection localizes edges precisely with noise suppression, Sobel captures general patterns, and Laplacian highlights rapid changes but introduces spurious responses. Quantum simulations require moderate resources; classical methods are efficient on standard hardware.
Significance: Quantum and classical methods have complementary strengths, suggesting hybrid approaches could enhance edge continuity, robustness, and interpretability in precision imaging. This provides a foundation for future hybrid pipelines and large-scale, error-mitigated quantum-assisted analysis.
Keywords: Quantum image processing; quantum edge detection; hybrid quantum–classical methods; interference-based imaging; diagnostic image analysis.

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Outgassing studies in UHV for the new ALICE 3 experiment

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The ALICE3 experiment at the CERN LHC aims to explore the quark-gluon plasma with unprecedented pointing resolution. This requires a next-generation vertex detector with enhanced spatial resolution, radiation hardness, and material budget optimization. The ALICE 3 experiment, under development to take data starting from LHC Run 5, includes in its inner tracker an ultra-light MAPS-based vertex detector, inside the LHC beam pipe.
The present work focuses on experimental methodologies for developing novel detector technologies and optimization strategies for the vertex detector design.
For the same, we developed an ultra-high vacuum (UHV) facility for the outgassing studies of the components of the vertex detector. To avoid contaminating the expected UHV conditions, all detector components must meet strict outgassing requirements. For example, the ultralight reticulated vitreous carbon (RVC) foam, characterized by considerable radiation length, has been proven to be a good material for the mechanical support of silicon sensors. However, its high surface area and porous nature lead to significant H2O adsorption.
In addition to RVC foam, this ITS3 vertex detector includes many other components, such as optical fiber, electrical connectors for powering & communication, MAPS sensors, wire bonding, gluing, and other types of foam, all of which need to be investigated to ensure they are vacuum-compatible with the LHC beam pipe vacuum line. Moreover, the idea is to investigate the temperature-dependent outgassing behavior under UHV conditions, characterize its desorption kinetics, and propose mitigation strategies to minimize contamination in the LHC environment.
In this contribution, an overview of the vertex detector will be shown, along with the dedicated studies in the vacuum described above.