Large area Resistive Plate Chambers at LIP-Coimbra

L. Lopes
On behalf of the RPC group

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+ Detector Laboratory
Mechanical Workshop

RPC R&D group

The RPC group cooperates with several other LIP groups (Neutron Detectors, AUGER, LATTES, HADES, RPC-PET), supporting their RPC-related activities.

Lines of work

- Very large area/channel tRPCs.
- Shielded tRPCs for robust multi-hit capability in dense arrays.
- The use of ceramic materials and warm glass for enhanced count-rate capability
- Application of RPCs to animal and human Positron Emission Tomography (RPC-PET)
- Simultaneous high-resolution measurement of positions and times (TOF-Tracker)
- Very low maintenance, environmentally robust, RPCs for deployment in remote locations
- Large area fast-neutron TOF detectors
- Epi-thermal neutron detectors with ^{10}B converters

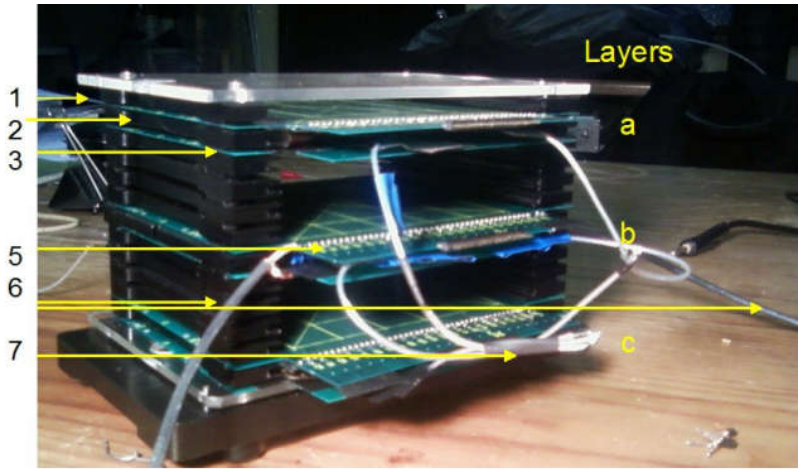
TOF-Tracker RPCs

Basic idea. Extent the capability of the RPCs to measure **simultaneously time (< 100 ps)** and **2D position (< 1 mm)**.

Applications:

- Particle Identification in High Energy Physics Experiments.
- Muon tomography
- PET

80 x 80 mm^2



TOFtracker: gaseous detector with bidimensional tracking and time-of-flight capabilities

2012 JINST

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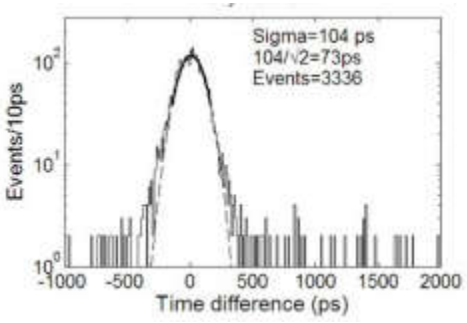
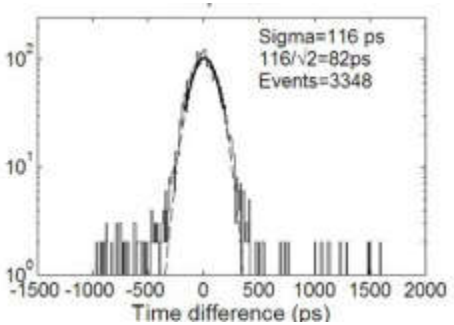
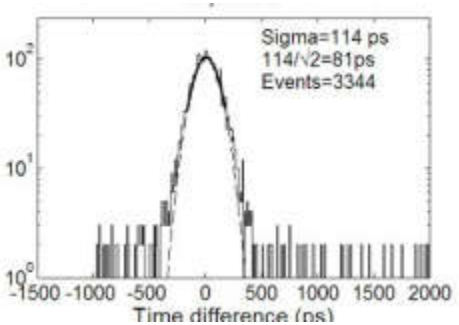
ABSTRACT: Particle identification by time-of-flight requires the si passing time and the trajectory of particles. It may be usefull that

Single layer precision = 77 ps σ 38 μm σ







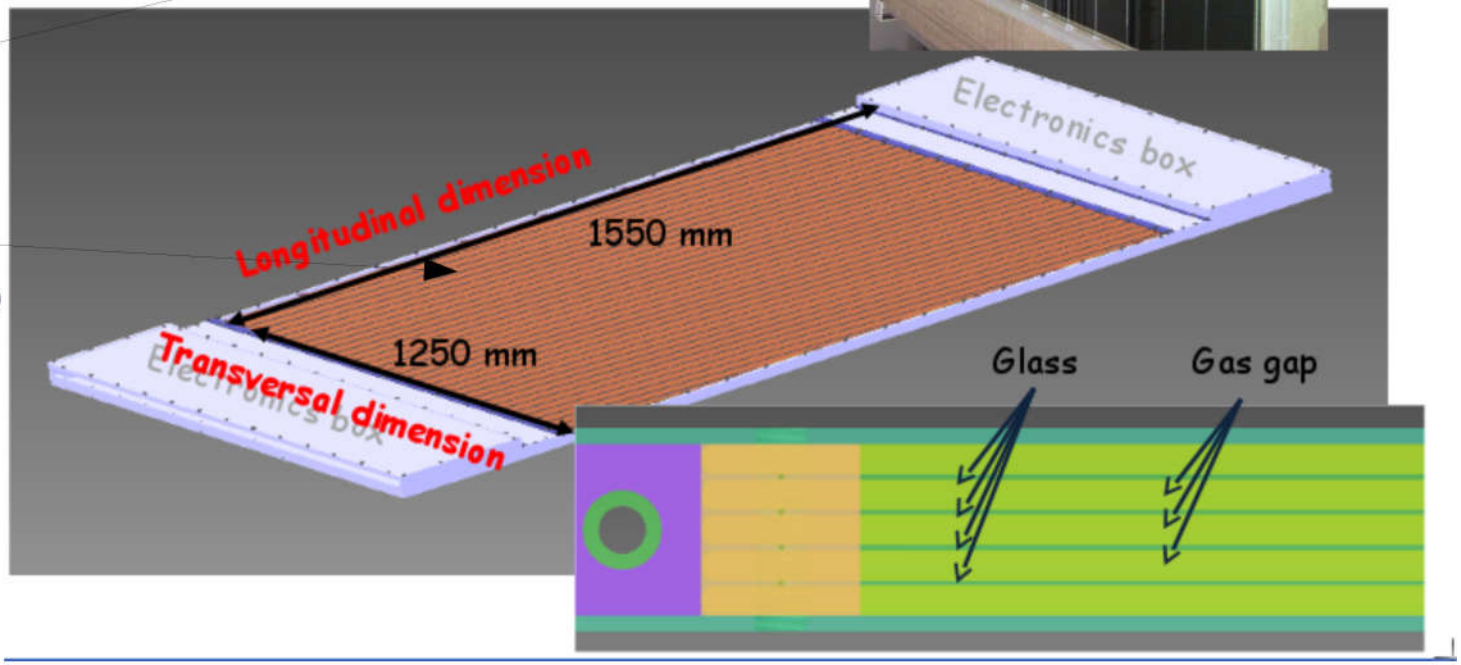
TOF-Tracker RPCs

Basic idea. Extent the capability of the RPCs to measure **simultaneously time (< 100 ps)** and **2D position (< 1 mm)**.

2016-2017.

Application of the concept to large area devices ~2m².

- Sensitive RPC volumes with 6x300 um gaps.
- 2D (cathode-anode) strip readout.
- Economics in FEE due to codification of the readout

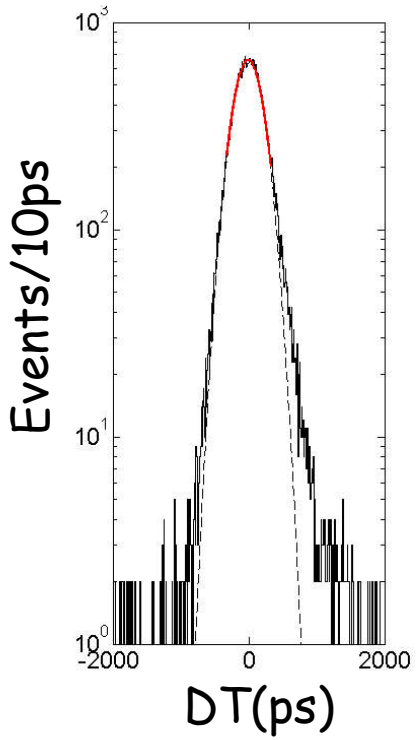


TOF-Tracker RPCs. MASTER. A muon telescope for RPC and related detectors testing

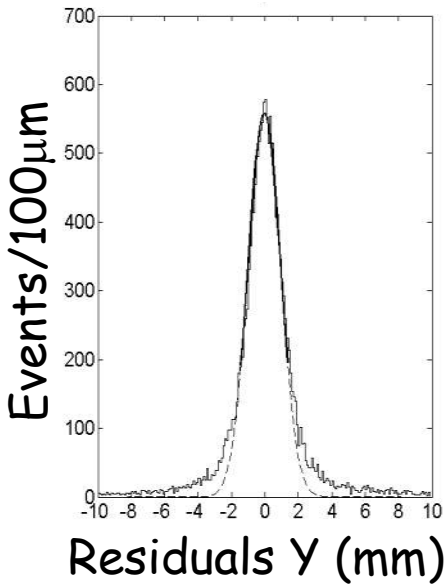
Muon telescope composed of 3 layer of TOF-Tracker RPCs delivering around 1 mm² and 200 ps σ spatial and time resolution.

[JINST 11 C1002]

σ_t ~ 215 ps



σ_y ~ 1.3 mm



Currently under commissioning in Rio CBPF

TOF-Tracker RPCs. Muon tomograph for the scanning of cargo containers in search of smuggling of nuclear material

Muon telescope composed of 4 layer of TOF-Tracker RPCs with similar performance.

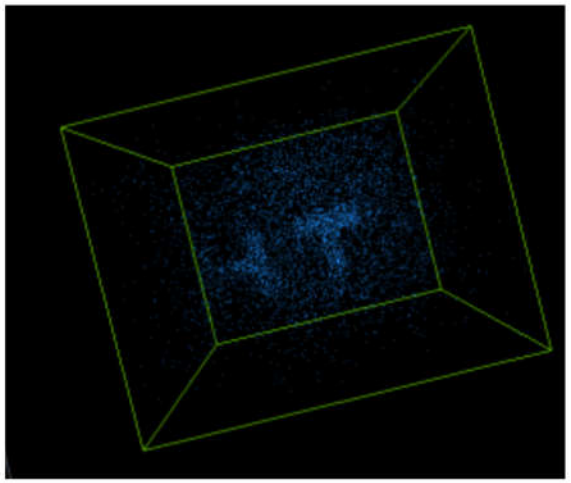
In Coimbra

Work together with Industry

TOF-Tracker RPCs. Muon tomograph for the scanning of cargo containers in search of smuggling of nuclear material

Muon telescope composed of 4 layer of TOF-Tracker RPCs similar performance.

Station up
2 TOF-Tracker



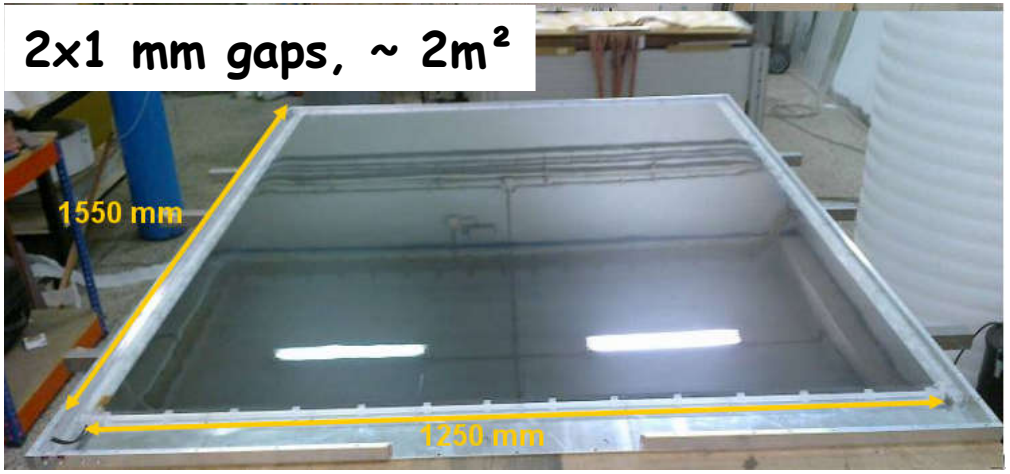
Lead target reconstruction

Station down
2 TOF-Tracker

RPC devices for cosmic ray measurements

Basic idea. Developing **large-area**, **autonomous**, **environmentally robust**, ultimately **sealed RPCs** with good time and position capabilities for cosmic ray measurements.

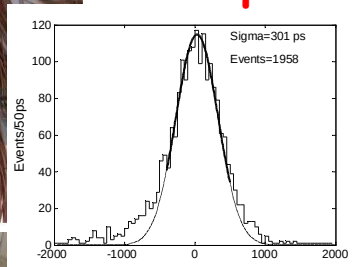
2x1 mm gaps, ~ 2m²



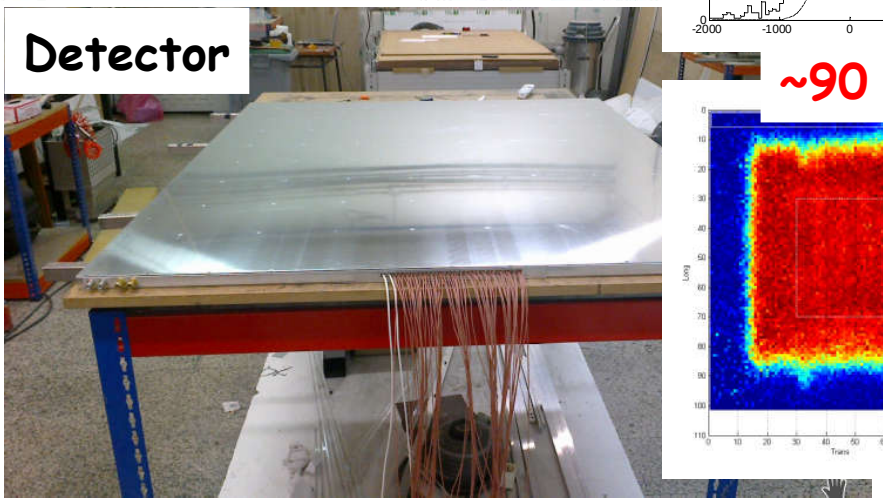
Assembly

Pad readout

~300 ps



Detector



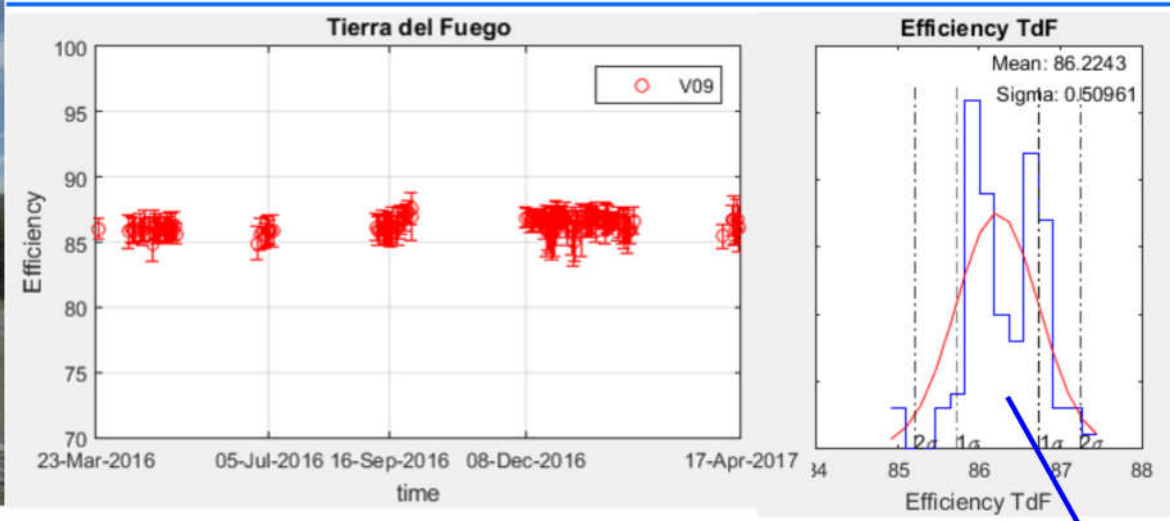
~90 %

RPC devices for cosmic ray measurements. AUGER (MARTA) and LATTES.

2016-2017 to be finished in 2019

[JINST 11 C09011]

Performing



Very stable efficiency over more than a year at continuous operation. Good indication about the reliability of RPCs for remote outdoor standalone applications.!!

2 "peaks" probably due to different HV power supply offsets

Periods without data due to daq failure

- **MARTA**. Production and deployment of 40 RPC units, 10 Auger tanks.
- **LATTES**. Under consideration

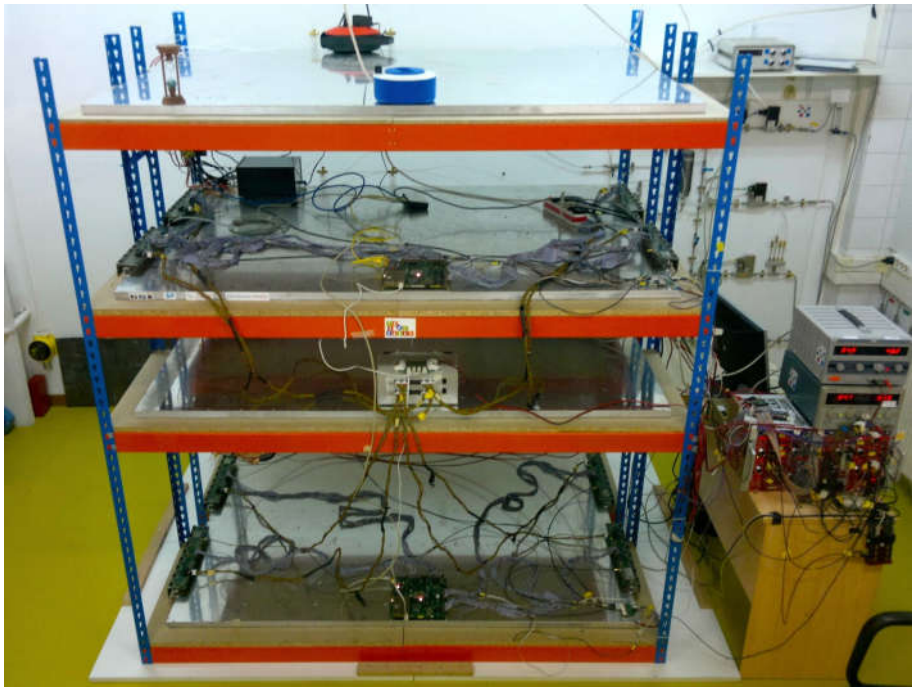
Robust and reliable

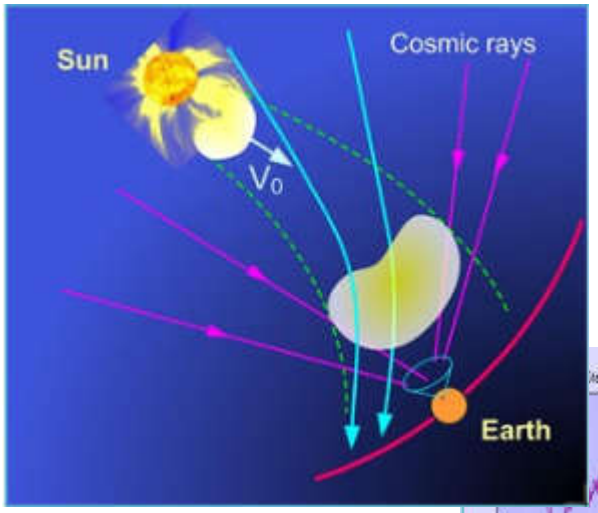
See Raul talk after lunch for details

RPC devices for cosmic ray measurements. TRAGALDABAS.

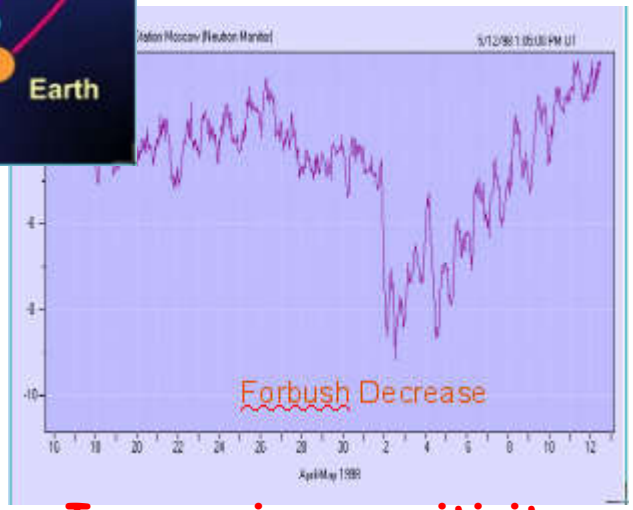
2016-2017

4 Plane RPC telescope operated continuously in **Santiago of Compostela** with the aim of accurately measuring the **cosmic ray flux** in order to study **solar physics** but much more.





[ECRS 632 12010]



After **two year of data taking** the setup is being **upgraded**: new trigger, new LV and HV system.

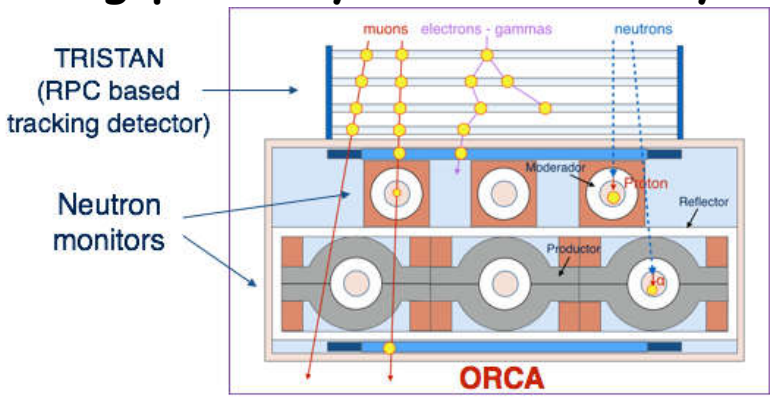
Impressive sensitivity to Forbush decrease

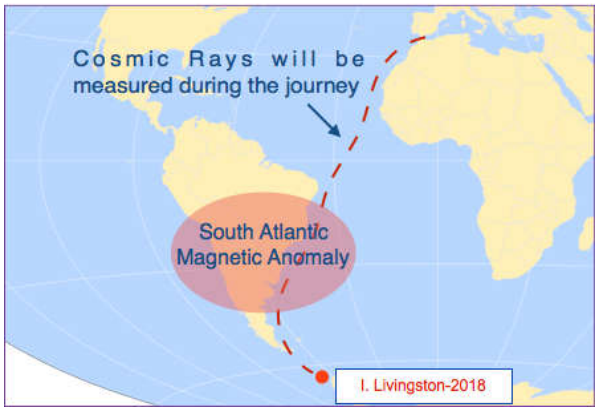
See Juan Garzon talk after lunch for details

RPC devices for cosmic ray measurements. ORCA. TRISTAN

2018

An hybrid cosmic ray detector will be installed at the end of 2018 in the Spanish Antarctic base at the Livingston Island (1500 km south Ushuaia) with the aim of measuring precisely the cosmic ray flux on place and during journey.





See Juan Garzon talk after lunch for details

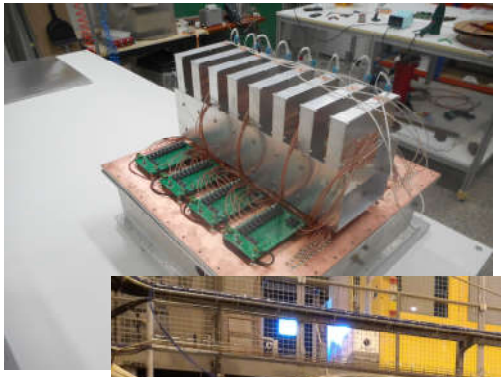
TRISTAN at Detector Laboratory at LIP

Development of High rate RPCs detectors

Basic aidea: Develop the RPC technology for **high rate** (> 1 kHz/cm^2) applications by using new low resistivity materials.

Lip-Coimbra, Beneficiary of WP 13.2.1 - **Establishing new resistive materials for high rate RPCs**

8 chambers built with Low resistivity candidate materials



Data under analysis

Test and data taking @ CERN with pion and muon beams

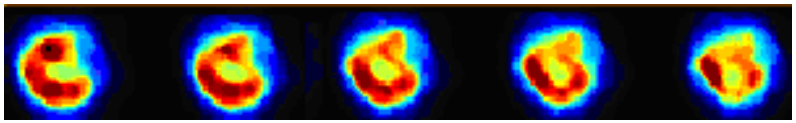
Test setup @ Coimbra DL

AIDA 2020

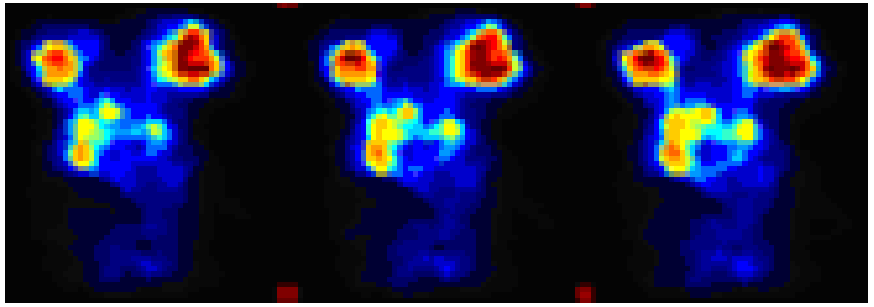
Advanced European Infrastructures for Detectors at Accelerators

RPC-PET a very high position resolution PET scanner for small animals

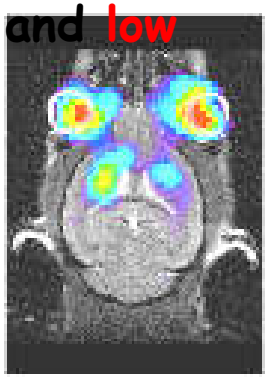
Basic aidea: Develop the RPC technology to be used in **Positron Emission Tomography**, taking advantage of the **extraordinary position accuracy** and **low price.**



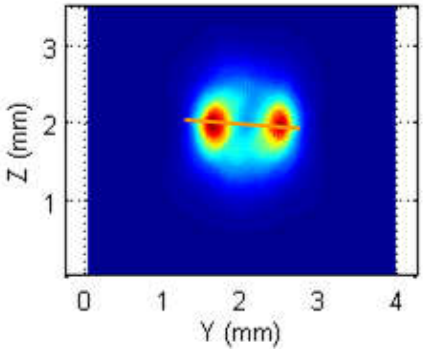
Live heart transaxial sections with ^{18}FDG



Harderian glands and left striatum with ^{11}C-raclopride

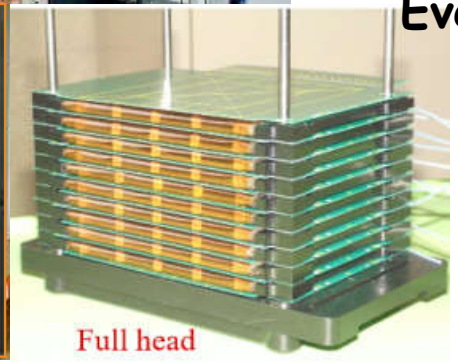


Co-registration with MRI



0.4mm FWHM 170 mm σ position resolution

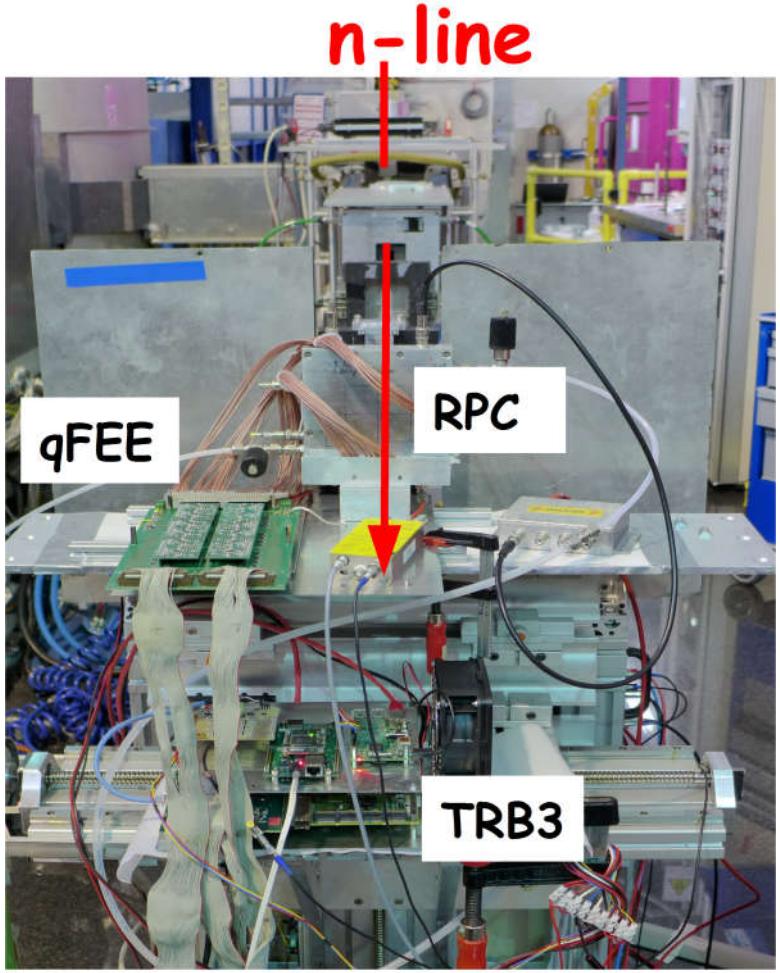
Currently under deep upgrade.
Everything new except the RPCs



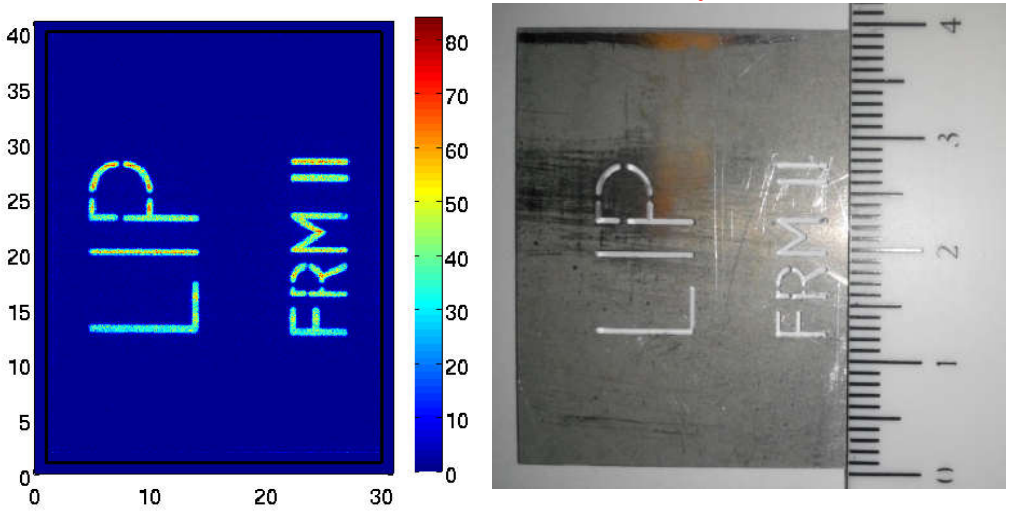
World's first RPC-PET tomograph. Now installed at ICNAS, University of Coimbra

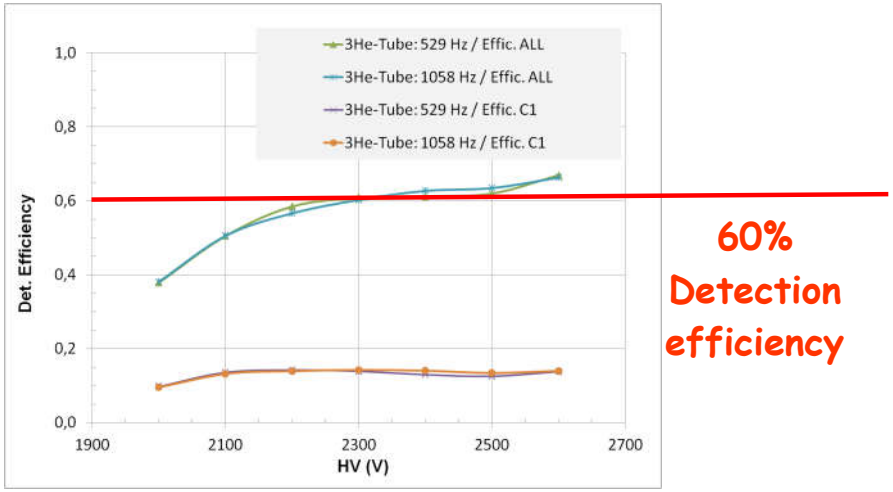
Position sensitive epi-thermal neutron detectors based on RPC with ^{10}B converters.

Basic aidea: Develop the RPC technology to be used as a position sensitive thermal neutron detector, taking advantage of the extraordinary position accuracy and low price, by using ^{10}B converter plates.



0.25 mm FWHM 0.100 mm σ position resolution

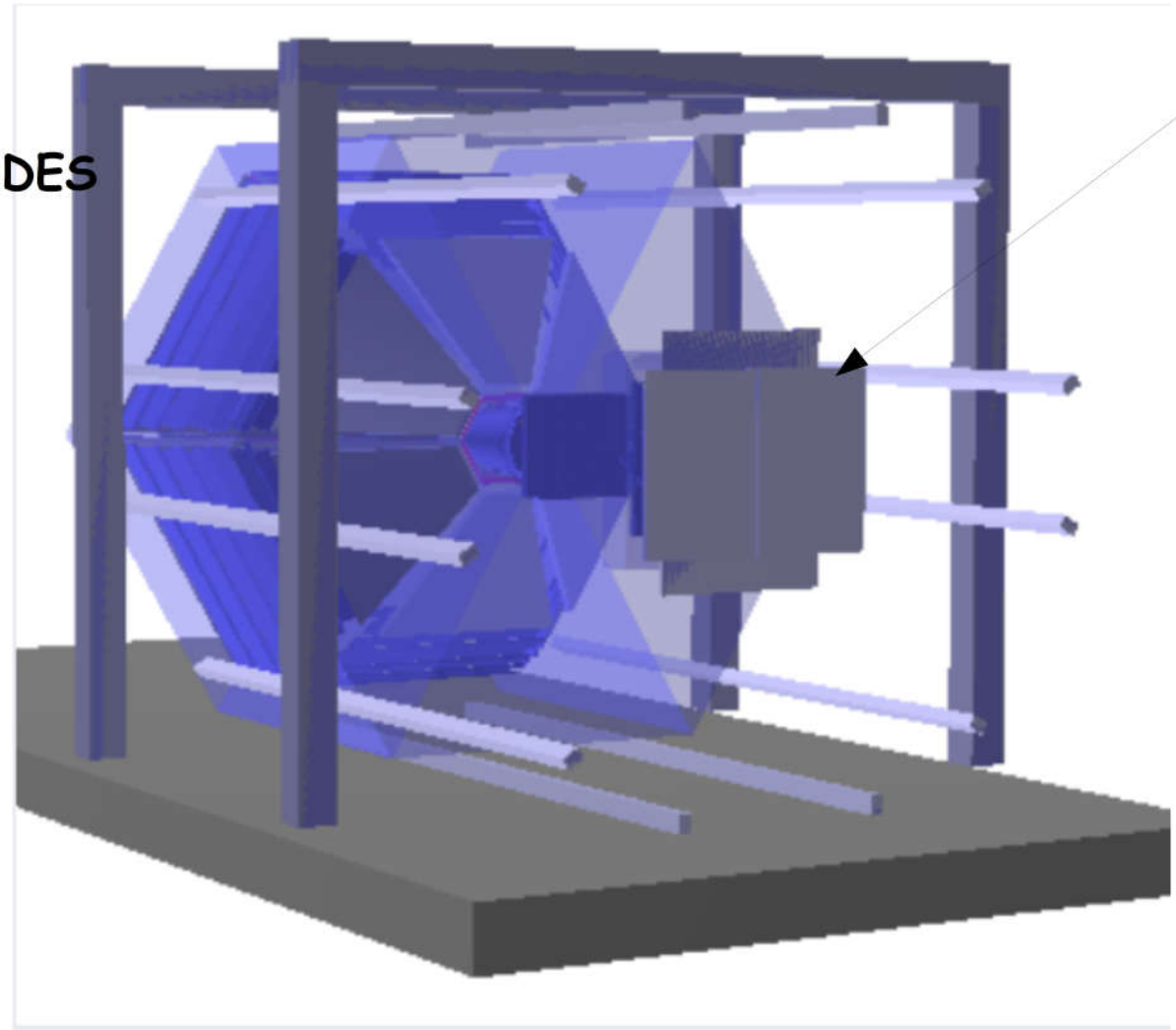


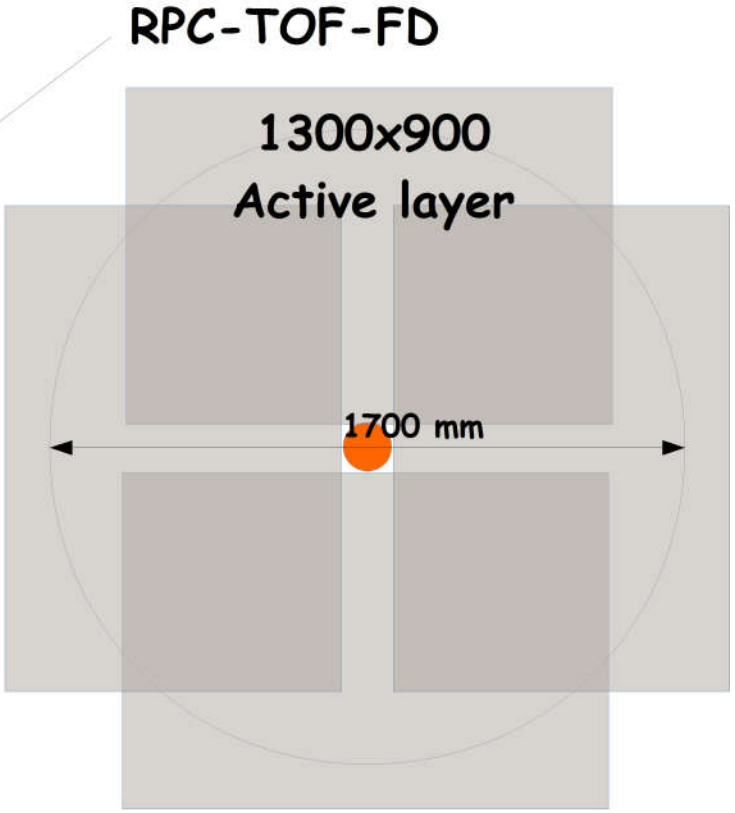


60% Detection efficiency

New HADES RPC-TOF Forward Detector

Basic aidea: Develop an RPC with a time resolution < 100 ps or better to be used in a low multiplicity environment (P, π) to cover the low polar angle region of HADES.



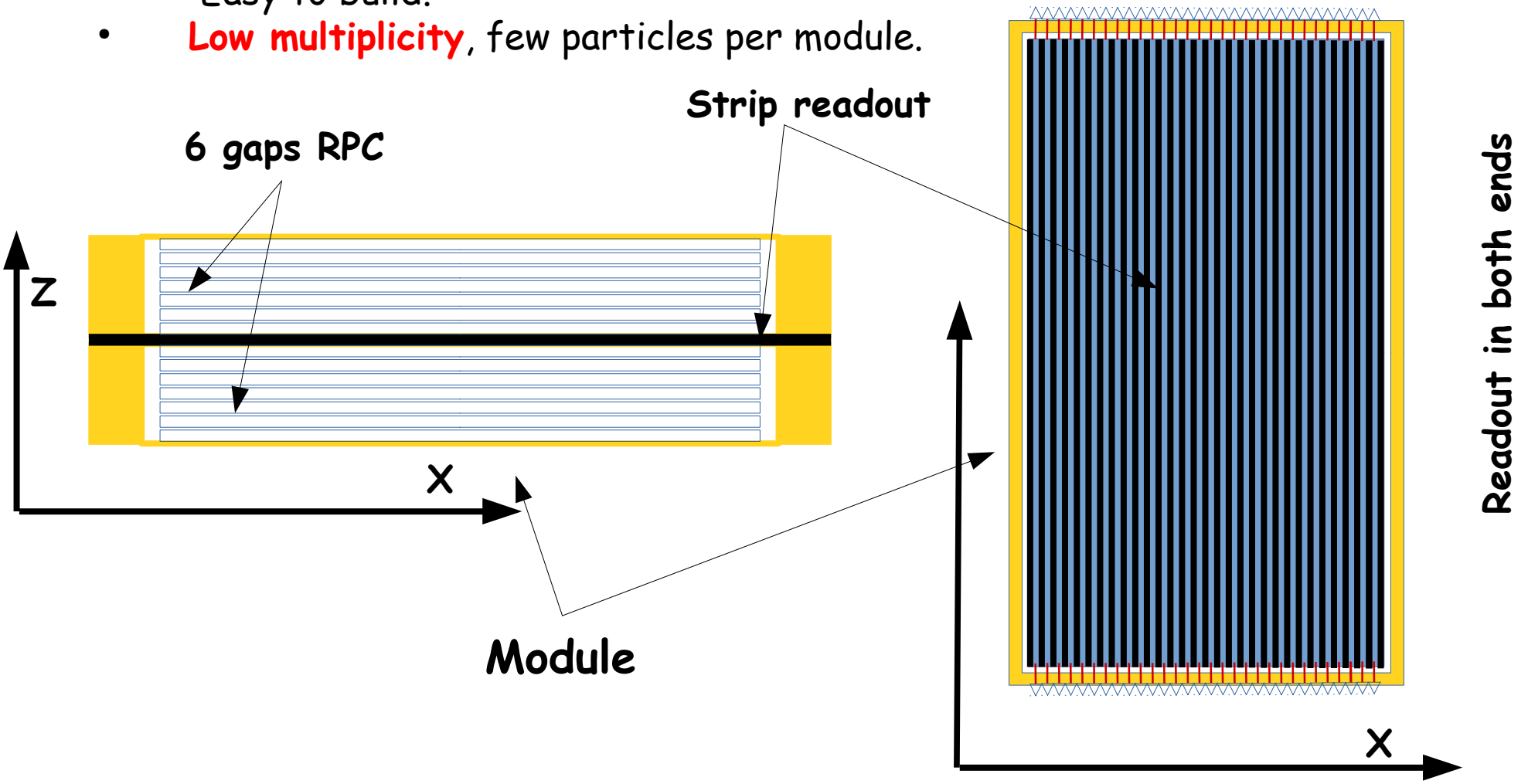


Four RPC modules

New HADES RPC-TOF Forward Detector

Modules of two 6 gaps RPCs with a strip readout in the middle

- **Good time resolution,** < 100 ps σ.
- **Good efficiency,** > 95 %.
- Easy to build.
- **Low multiplicity**, few particles per module.



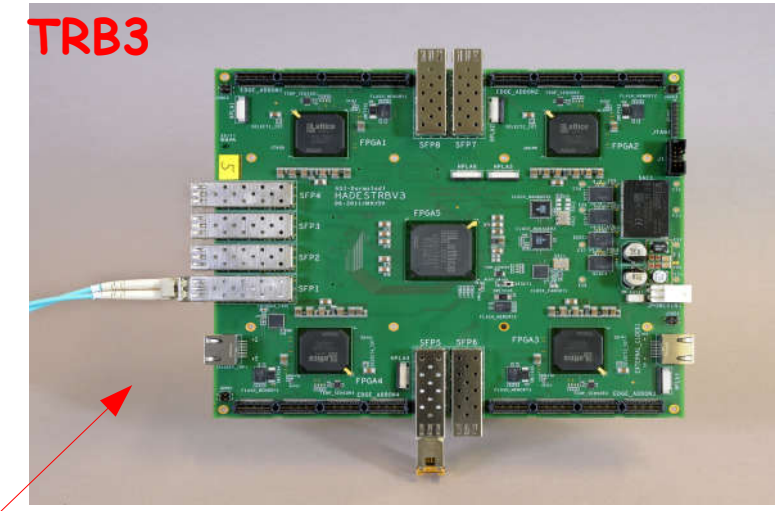
New HADES RPC-TOF Forward Detector

October 2018 test beam @ CERN. Setup.

DAQ.

Each FPGA reads one MB = 32 ch

TRB3



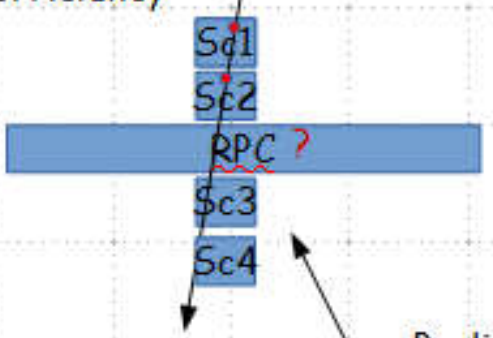
RPC-FD => 2 TRB3 or 8 TRBsc

New HADES RPC-TOF Forward Detector

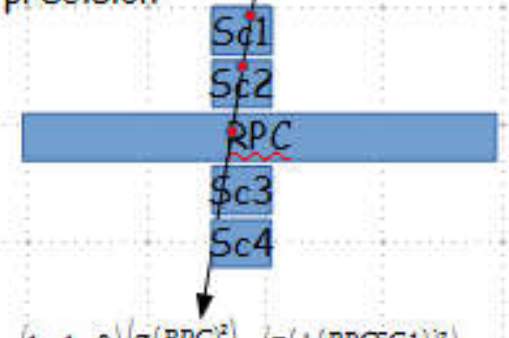
October 2018 test beam @ CERN. Efficiency and time precision

All measurements made with negative 8 GeV pions

Efficiency



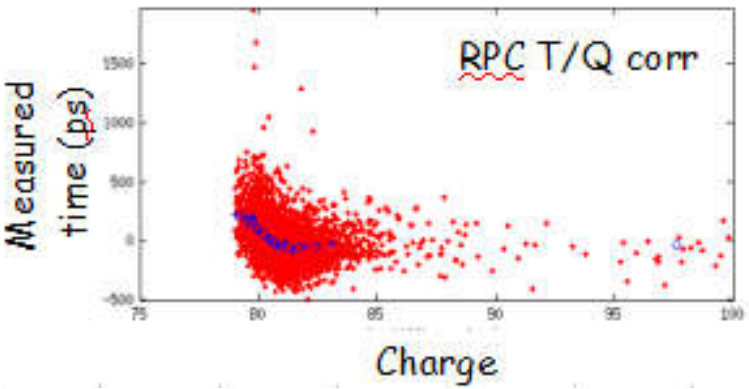
Timing precision

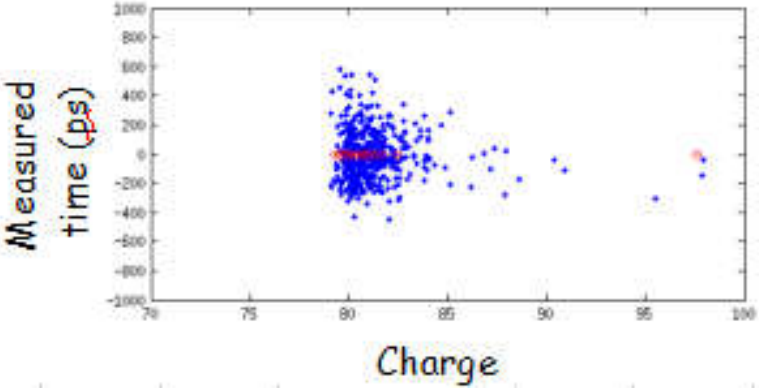


Preliminary analysis
only include two scintillators

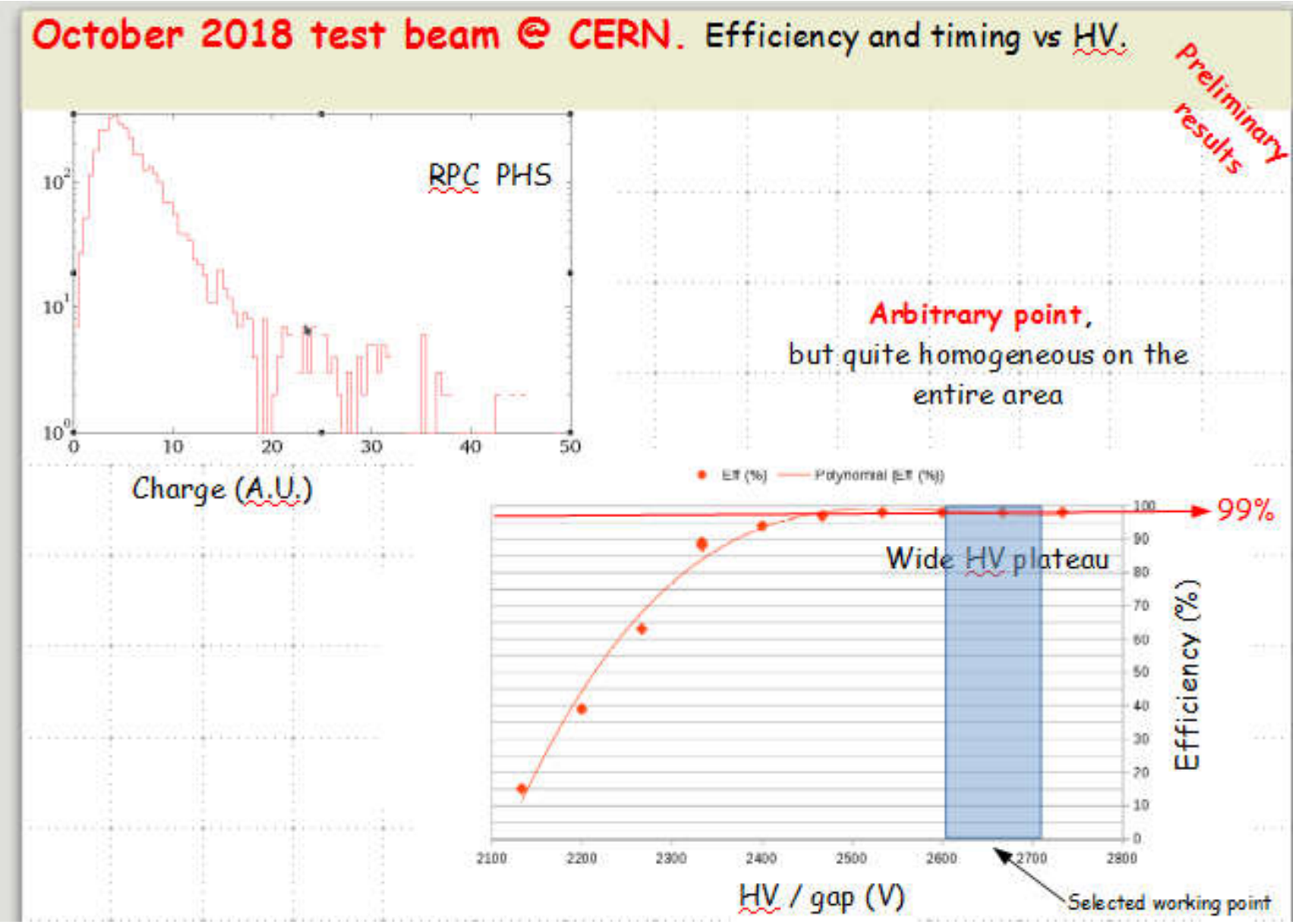
$$\begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{pmatrix} \begin{pmatrix} \sigma(RPC)^2 \\ \sigma(SC1)^2 \\ \sigma(SC2)^2 \end{pmatrix} = \begin{pmatrix} \sigma(\Delta(RPCSC1))^2 \\ \sigma(\Delta(RPCSC2))^2 \\ \sigma(\Delta(SC1SC2))^2 \end{pmatrix}$$

Time from RPC and scintillators are corrected by charge. Walk correction.

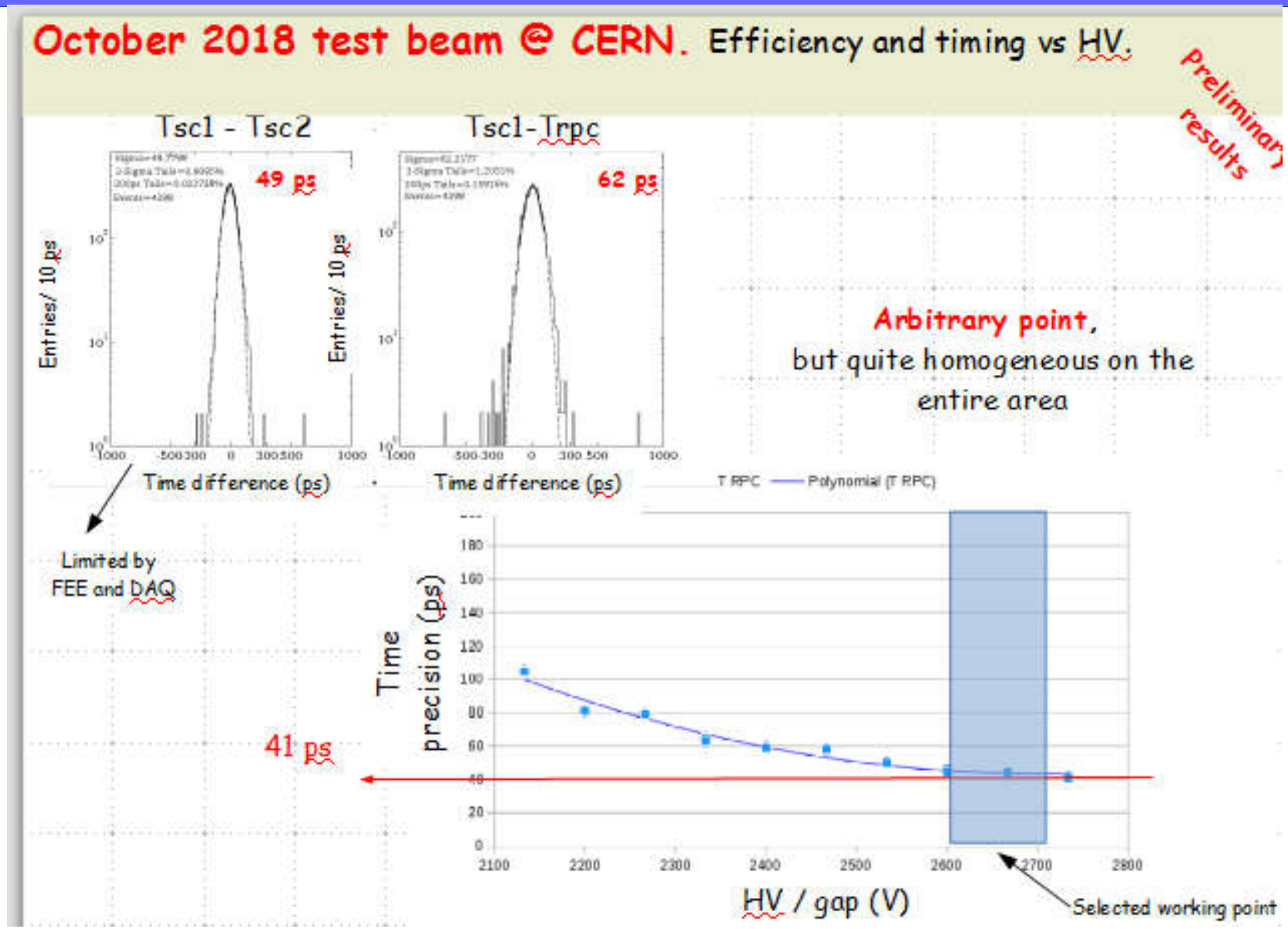




New HADES RPC-TOF Forward Detector



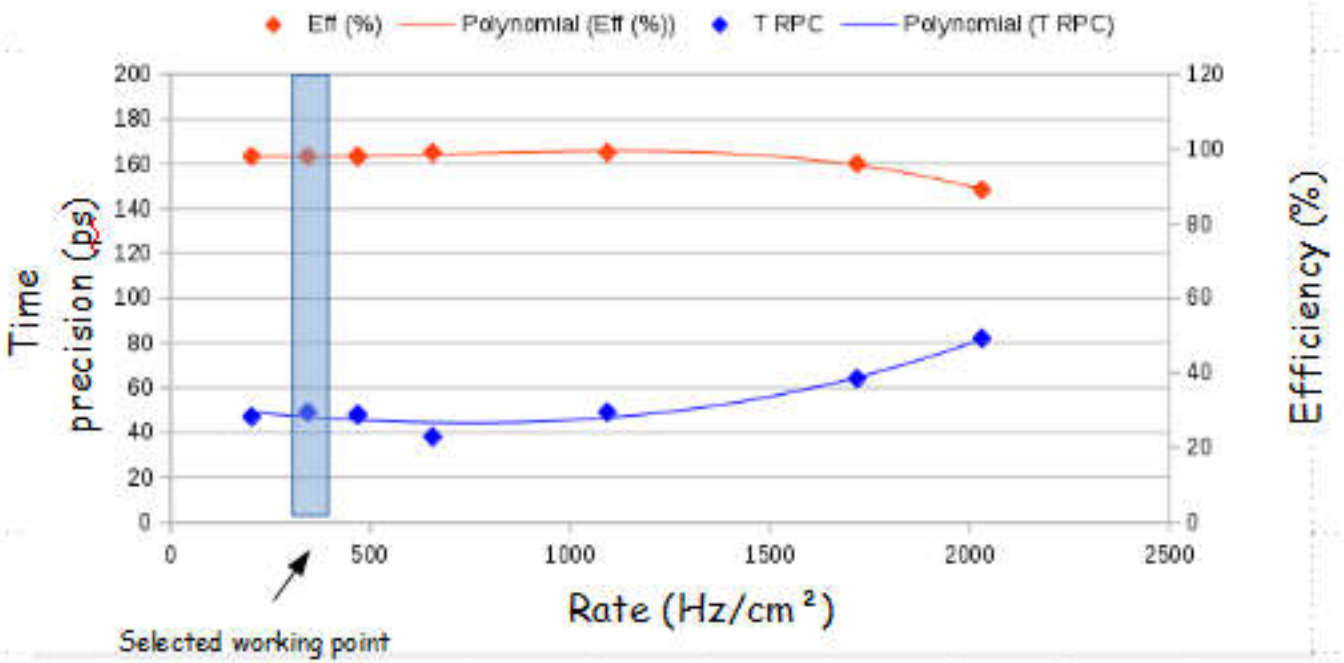
New HADES RPC-TOF Forward Detector



New HADES RPC-TOF Forward Detector

October 2018 test beam @ CERN. Rate capability

Preliminary results

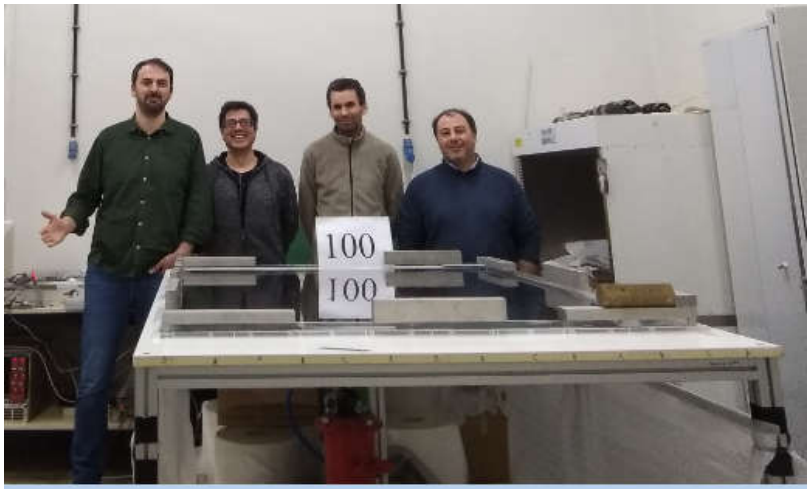


But the short spill at CERN (0.4 sec) is quite favourable for RPC =>
in continuous irradiation or spill > 1-2 sec results get worse

To be in the safe side we want to warm up a little the RPC

Resume

- Group with more than 20 years experience, last 10 with large area detectors:
  - Timing and Trigger RPCs
  - From ps to ns time resolution
  - Sub-millimetre position resolution
  - Indoor and outdoor experience
- DL and MW
  - Experience staff and appropriated machinery
  - Large experience in "all" support and monitoring systems.
- More than 100 large are detectors were developed, constructed and deployed.



NEXT VETO LIP-IGFAE

- Conditions and requirements
  - Low cosmic rays counting rate 
  - Large area, low price 
  - Readout strips 
  - Low gas consumption and/or close loop 
  - 300 ps time resolution 
  - Position resolution <1 cm 

We know what we need and how to build it!!...