RPC R&D group activities 2020-2022

A. Blanco
On behalf of the RPC group

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RPC R&D lines of work

RPC R&D group cooperates with several other LIP groups (**Neutron Detectors, AUGER, SWGO, HADES, SHiP/SND, NUC-RIA**) supporting their RPC-related activities.

RPC-PET

Develop RPC technology for PET imaging. **Pre-clinical, human brain PET** and full body human PET (dream ….).

Timing and Position Sensitive RPCs.

Develop timing RPCs for **high energy physics experiments** and in combination with position measurement to be applied in **muon tomography**. Both modalities, transmission (e.g. volcano and mine imaging) and scatter tomography (container scanning)

Developing RPC based technology **for SHiP/R3B and HADES collaboration.**

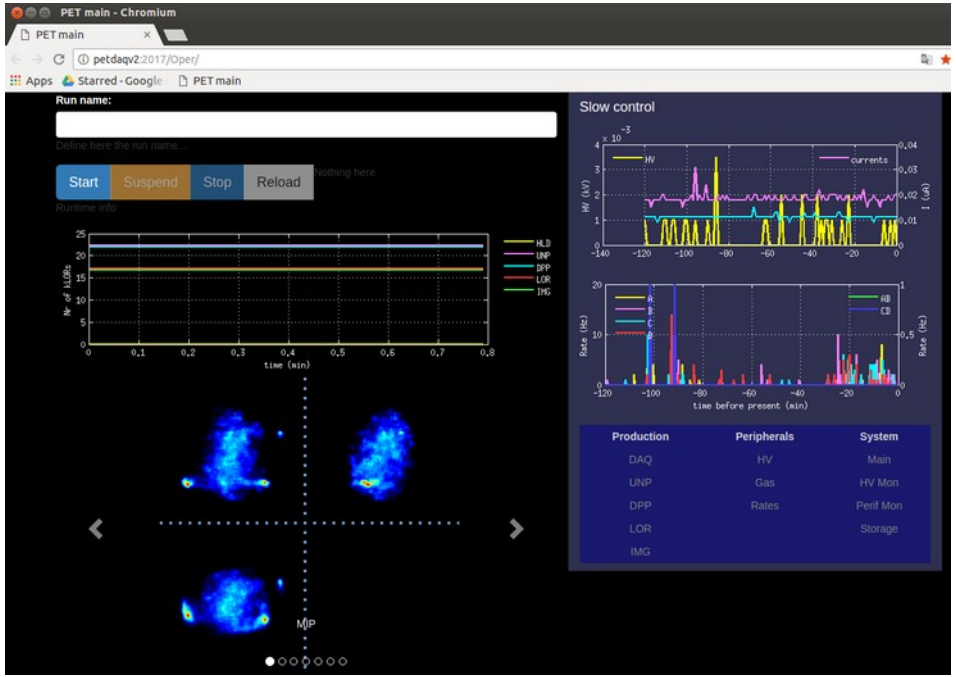
STRATOS and **TRISTAN** cosmic ray telescopes, both dedicated to the precise measurement of cosmic ray flow, and **MUTOM** (together with the AUGER group) for muon tomography in mines.

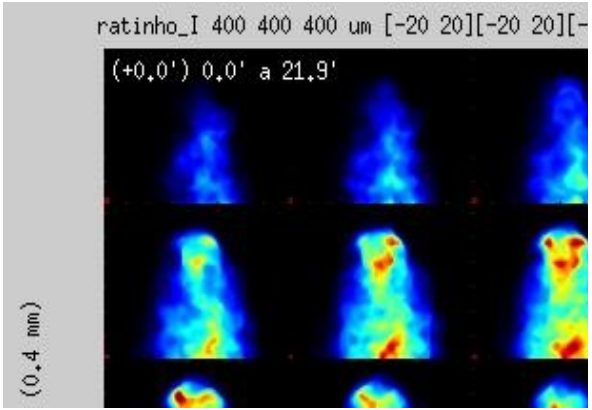
Autonomous RPCs.

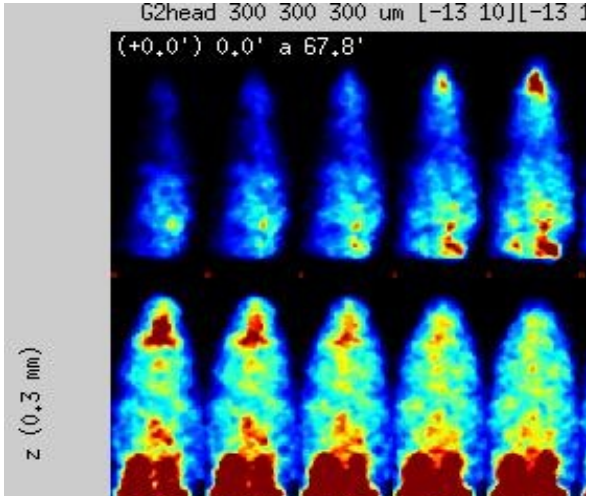
Outdoor, reliable, high performance, solar panel powered, auto-operated, low gas consumption and eventually sealed RPCs for **cosmic ray measurement.**

RPCs operated at high altitude (SWGO project) and operation of **RPCs in an ultra low gas flow regime** (eventually sealed).

Continuous support of **routine bio-research activities** @ ICNAS (hundred of mice scans). First biological results appeared => **system is really working.**



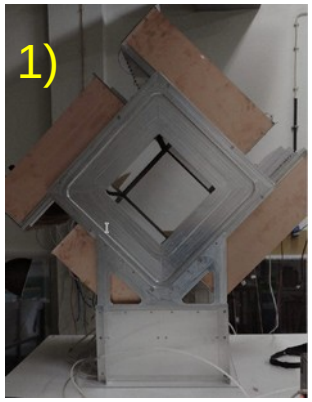


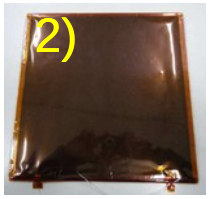


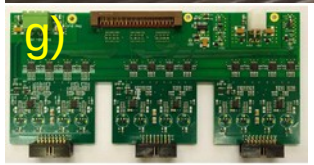
HiRezBrainPET: an RPC-PET brain scanner with sub-millimeter spatial resolution

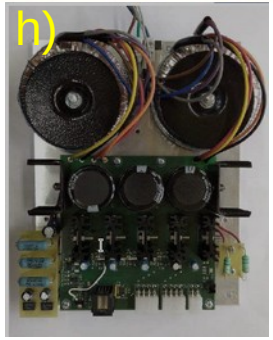
Co-promotion project financed by COMPETE2020 involving:
ICNAS Produção (project leader) / Instituto Politécnico de Coimbra / LIP

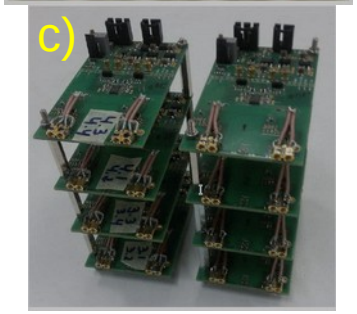
1) Mechanics
2) Detectors
b. i) Monitoring
c,f,g) Front End Electronics
d) DAQ from GSI.
e) High Voltage
h) Low Voltage
j) Gas system

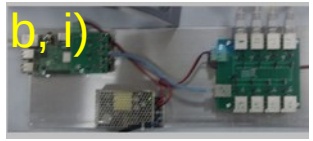


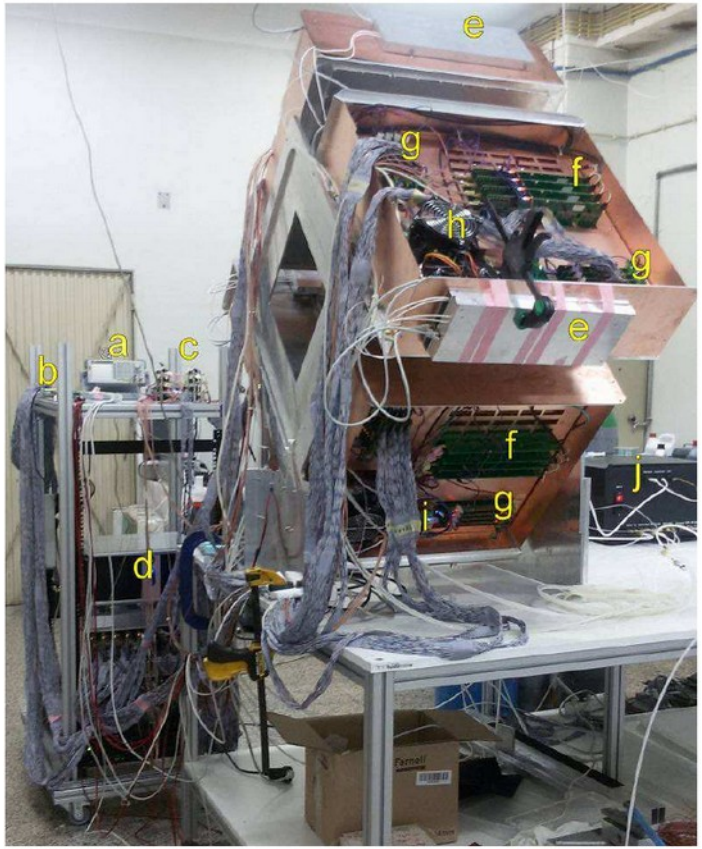








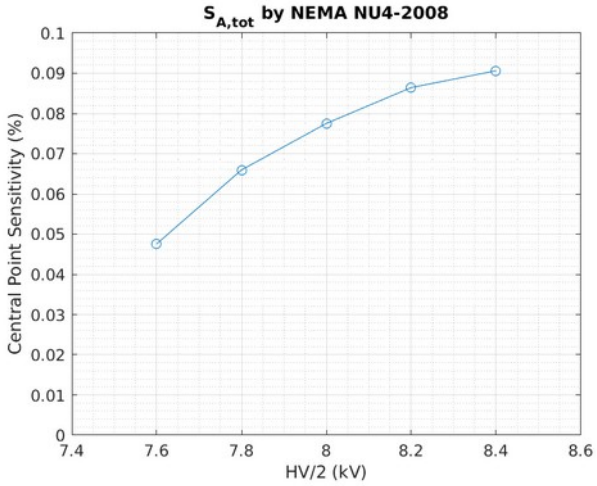




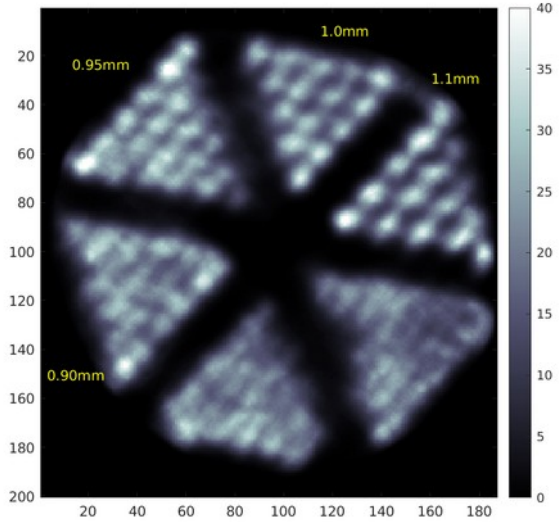
HiRezBrainPET: an RPC-PET brain scanner with sub-millimeter spatial resolution

Co-promotion project financed by COMPETE2020 involving:
ICNAS Produção (project leader) / Instituto Politécnico de Coimbra / LIP

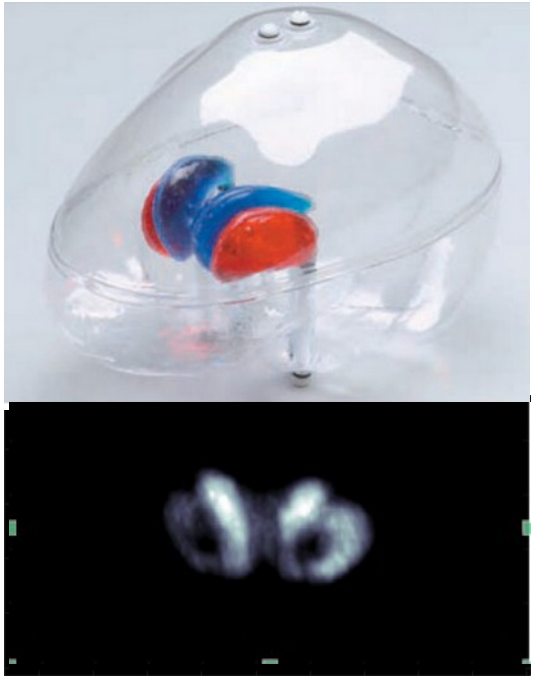
Only 50 % of RPC installed, fully instrumented => x3 in **sensitivity**



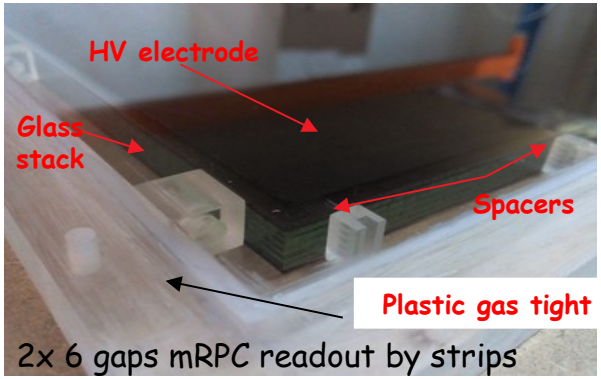
< 1 mm **spatial resolution** limited by photon non-co-linearity, with cosmic < 100 um.



Striatal Phantom - Radiology Support Devices Inc



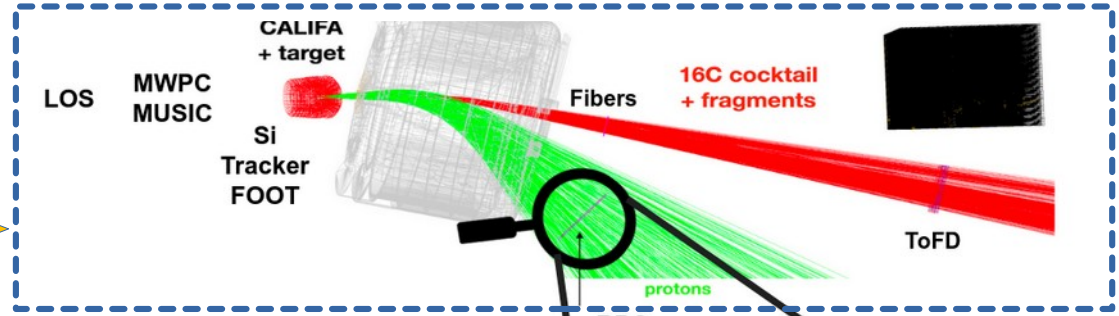
GOAL: precise timing for proton momentum determination @ R3B, experiment S522



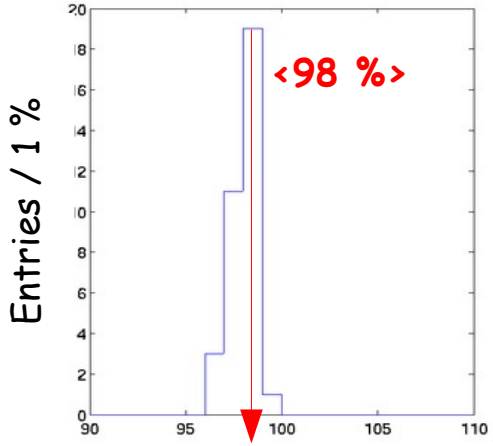
Re-use of SHiP timing detector prototype

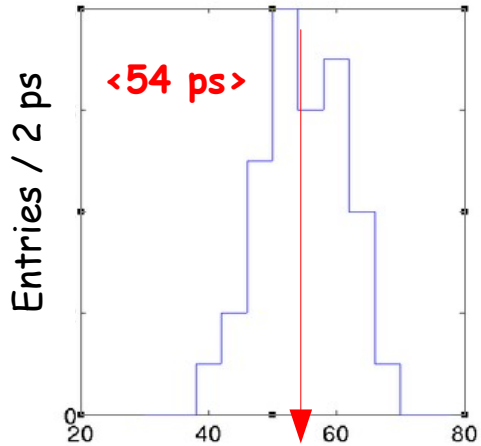
https://www.r3b-nustar.de/

S522 setup @ R3B



A. Blanco et al 2020 JINST 15 C10017





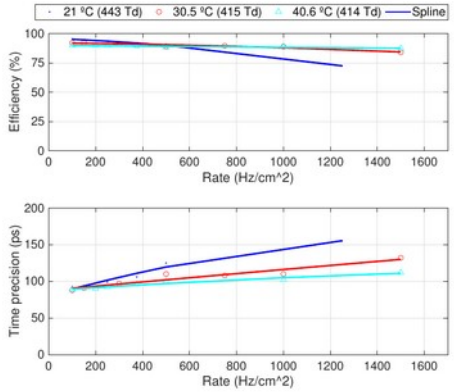
Area ~ 2 m²

GOAL: precise timing for Particle Identification (PID) @ HADES experiment

Design and construction of the RPC-TOF-FD.

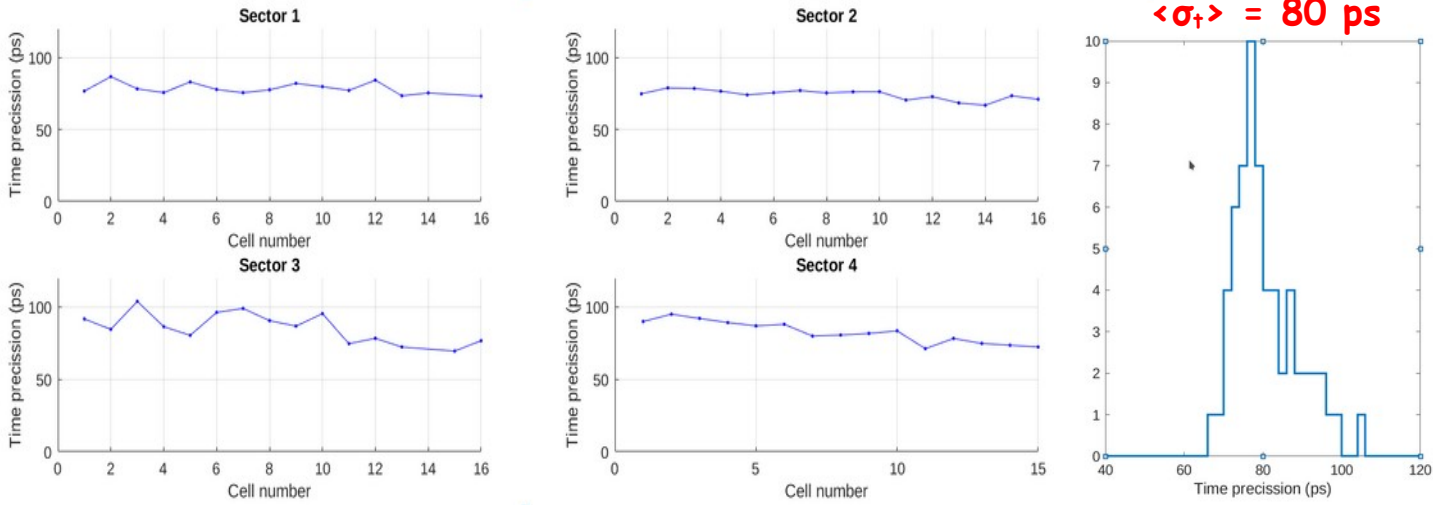
Operated above ambient temperature to improve the counting rate capability of the system.

http://arxiv.org/abs/2206.12199



Overview of the RPC-TOF-FD

Timing precision during production beam time



$\langle \sigma_t \rangle$ = 80 ps

https://hades.gsi.de/

TRISTAN GOAL: precise measurement of cosmic ray flow

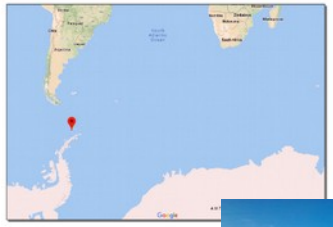
Three layers MARTA RPC + HADES like readout telescope
3x latitudinal survey and one year in Antarctic

TRISTAN Detector

3 RPC planes to study Secondary Cosmic Rays

Designed to be part of the **ORCA Observatory**[1] in the Livingston Island[2]

Before installation in the Antarctic base, the detector made a **Latitude Survey** from Vigo (Spain) to Punta Arenas (Chile)

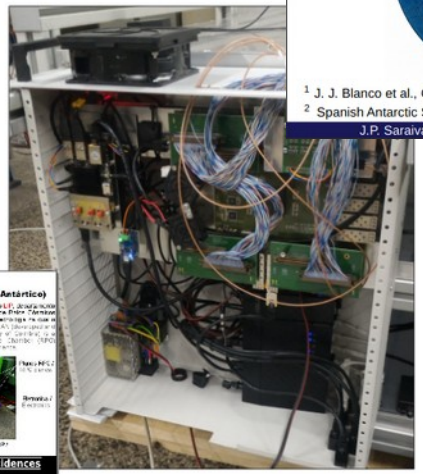


[1] J. J. Blanco et al., ORCA (Antarctic Cosmic Ray Observatory): 2018 latitudinal survey, ICRC 2019
[2] Spanish Antarctic Station "Juan Carlos I" in the Livingston Island - Antarctica

J.P. Saraiva (LIP) | The TRISTAN Detector - RPC2020 | February 10

DAQ System – main features

- **System Fully Autonomous**
  - Data acquisition starts automatically
  - Hardware power-cycle in case of failure
  - Log analysis, search out of range values
- **Alarms** sent via email in case of issue
- **Daily Reports** sent via email
- **Rates & Coincidences** sent every 30 minutes



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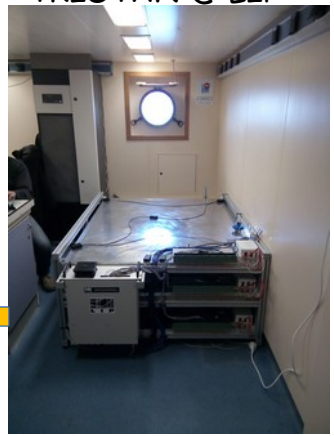
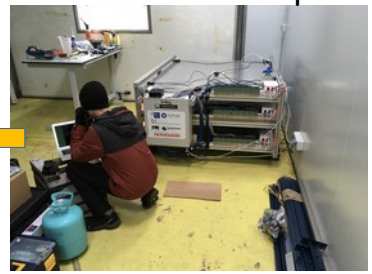
J.P. Saraiva (LIP) | The TRISTAN Detector - RPC2020 | February 10-14, 2020

Fully autonomous system with almost 100% duty cycle

TRISTAN @ LIP



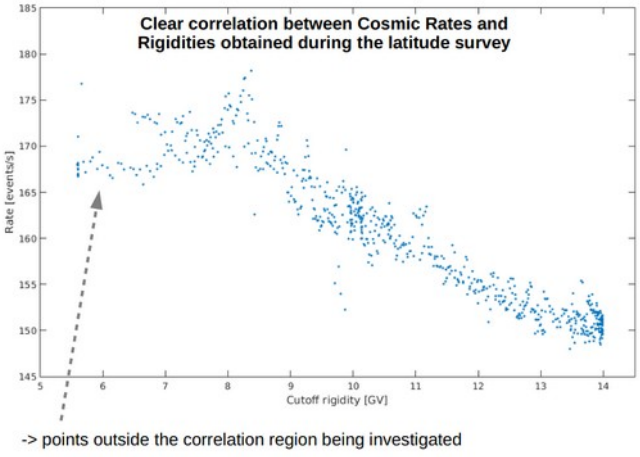
TRISTAN @ Ship



TRISTAN @ Antarctic

TRISTAN GOAL: precise measurement of cosmic ray flow

Three layers MARTA RPC + HADES like readout telescope
3x latitudinal survey and one year in Antarctic



-> points outside the correlation region being investigated

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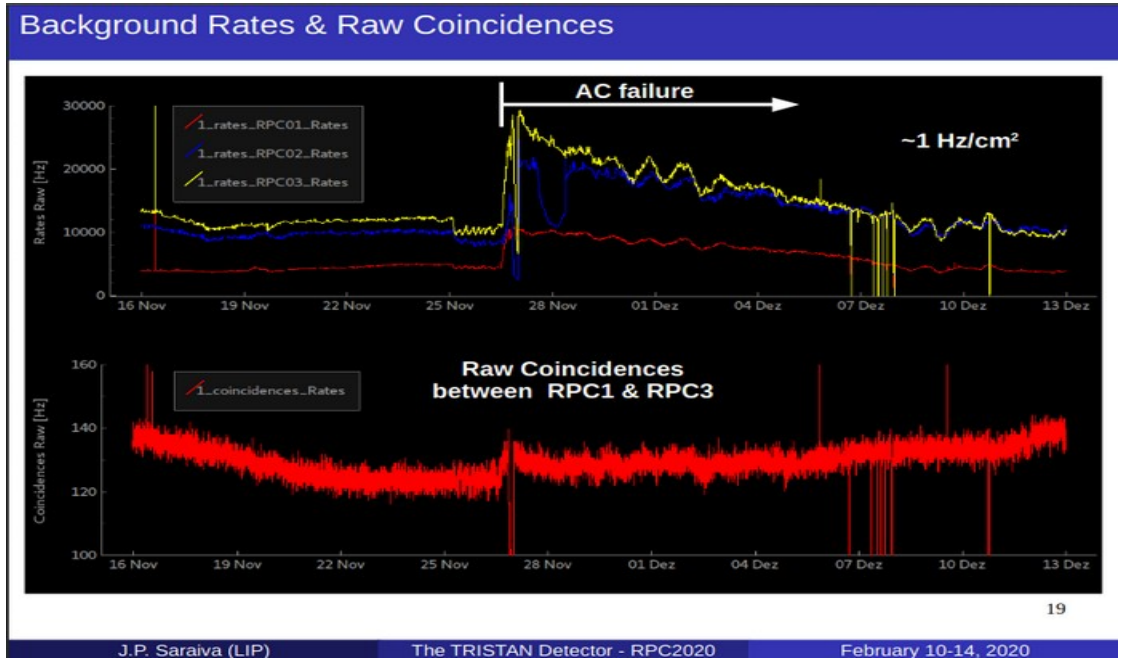
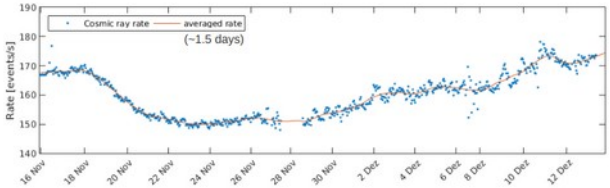
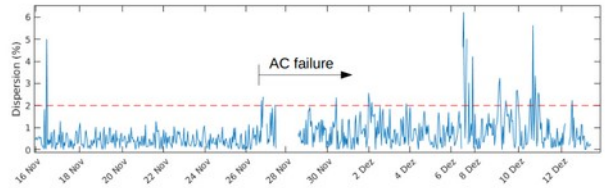
Clear correlation with rigidity

J.P. Saraiva et al 2020 JINST 15 C09024



Stability better than 1 % in 1 h time





More than 99% of measurements are below a 2% dispersion
-> can be even better with controlled temperature

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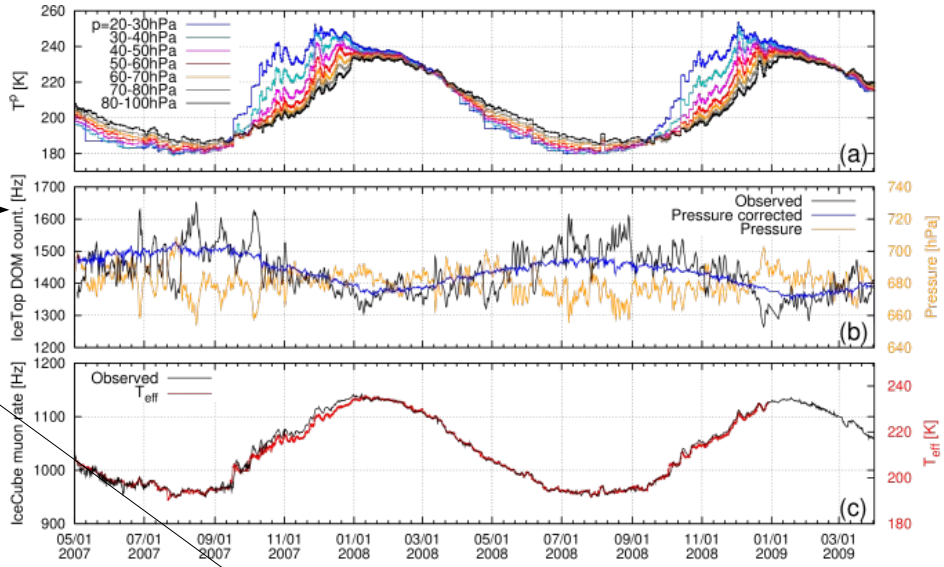
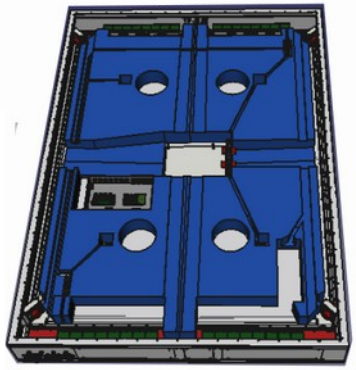
Project is now finished except for some publications and one PhD

STRATOS

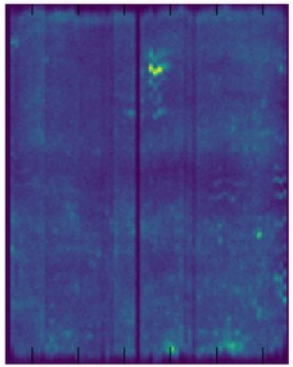
2x four plane RPC telescope meant for the **precise measurement of cosmic ray flow**, in order to **address the temperature of the stratosphere**, but a pre-prototype of macro scanner (scatter muon tomography) detector.



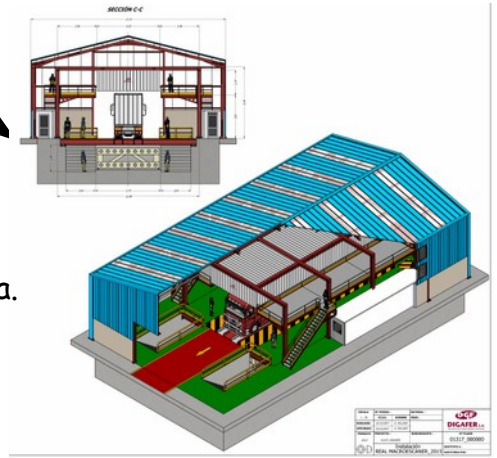


CAD project

Real device



Hit position map



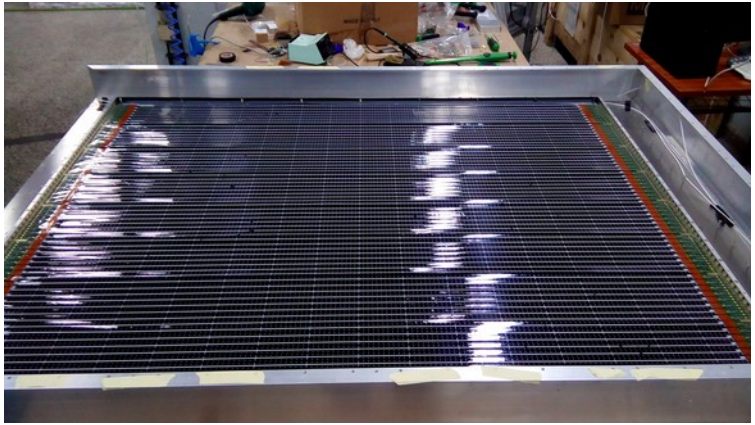
- **Industrial design** to work in all type of environments (fully integrated in a single box). 2 m² active area.
- **300 ps** and **10 mm** timing and position precision together with a high efficiency **(> 98%)** for MIPs.
- Very low gas consumption (**< 1 cc/min/m²**).
- **Autonomous operation.**

STRATOS

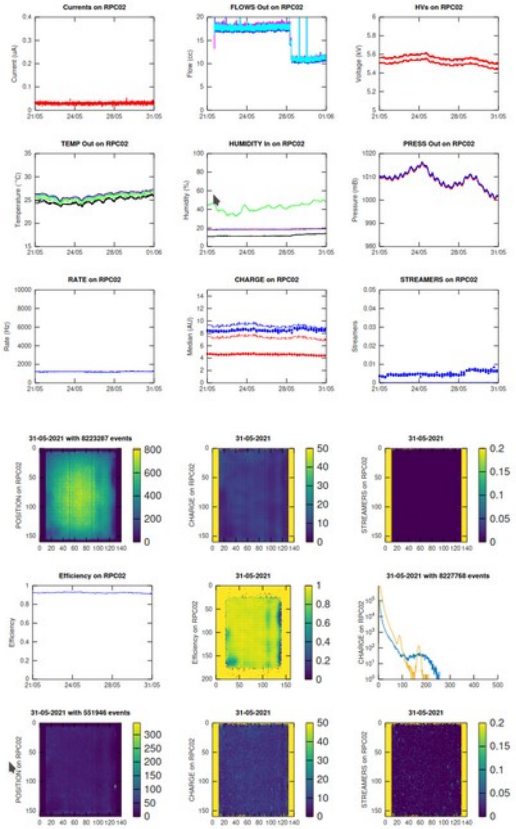
Single plane. Just connections for gas, power and communications

STRATOS ONE telescope

Strip readout



Inner view

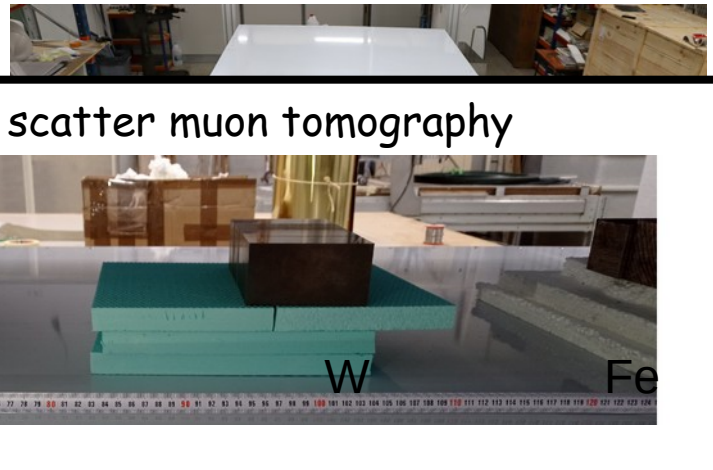


Automatic monitoring

STRATOS

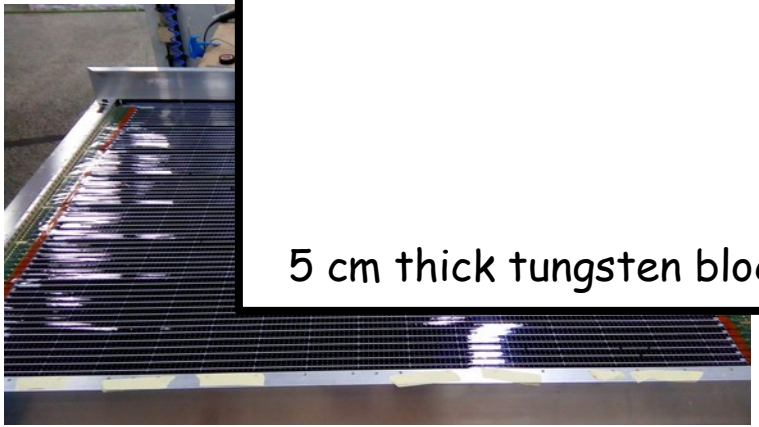
Single plane. Just connections for gas, power and communications

STRATOS ONE telescope

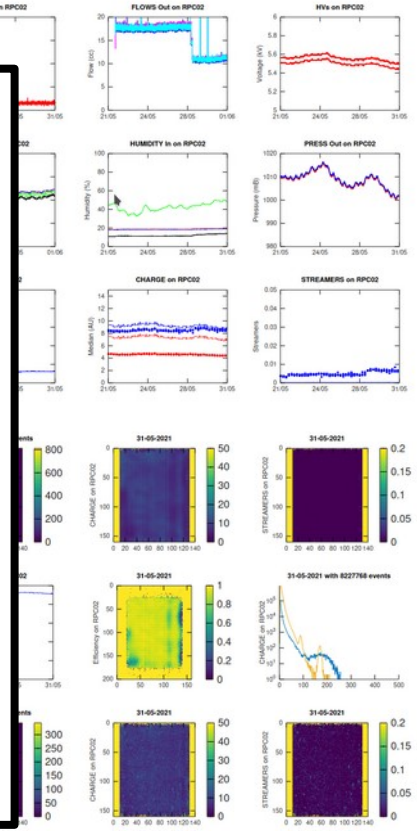


Preliminary results !!! in scatter muon tomography

Strip



5 cm thick tungsten block (20-10 cm^2), + Fe and Al blocks



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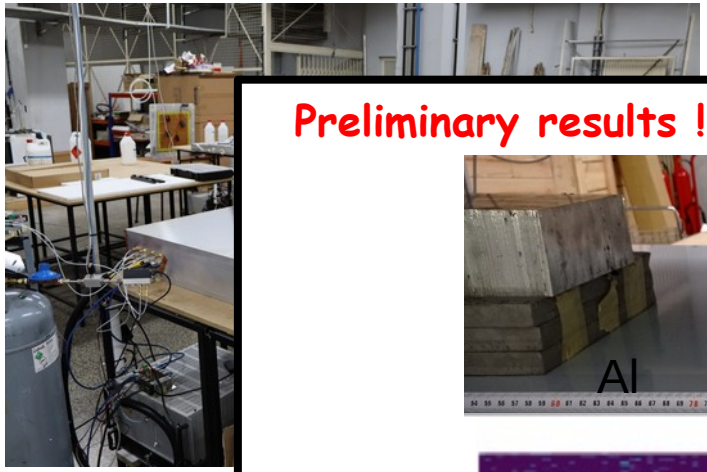
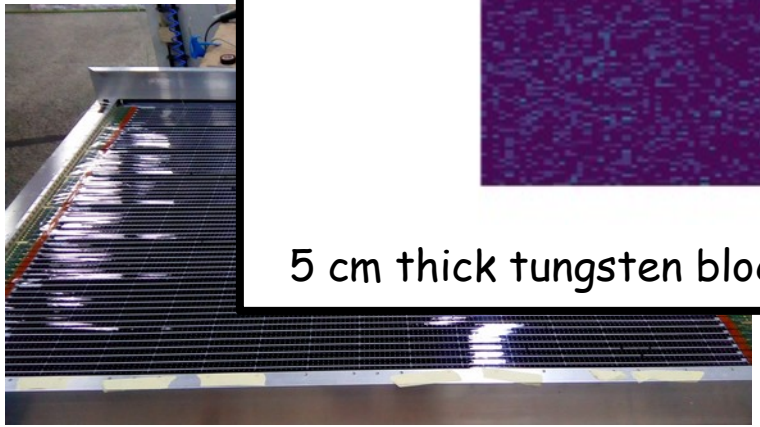


STRATOS ONE telescope

Strip



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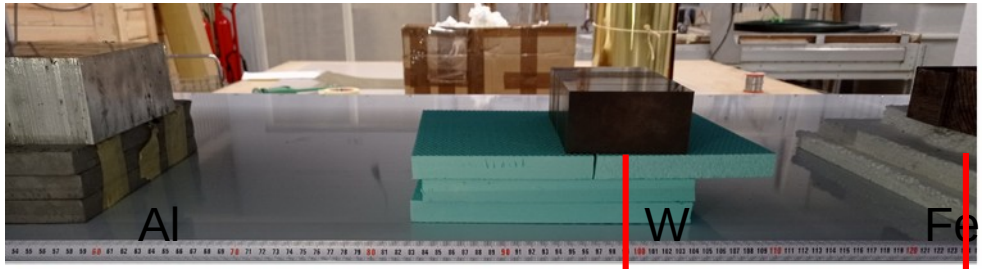

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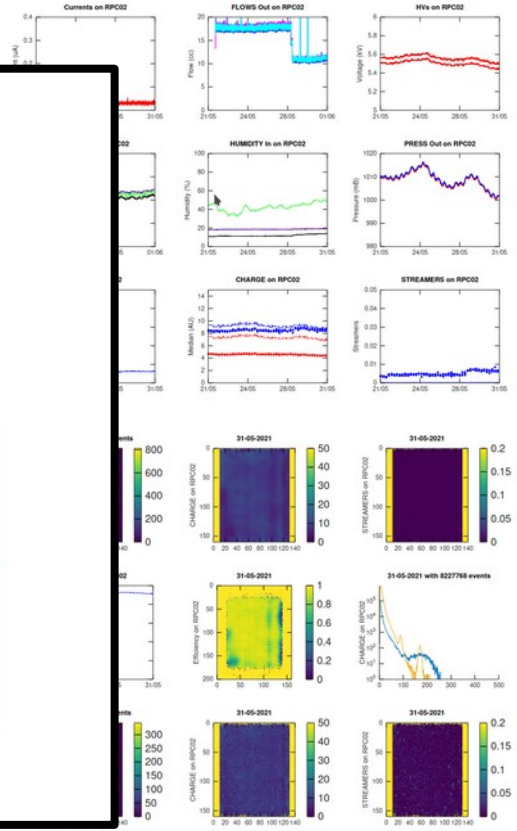
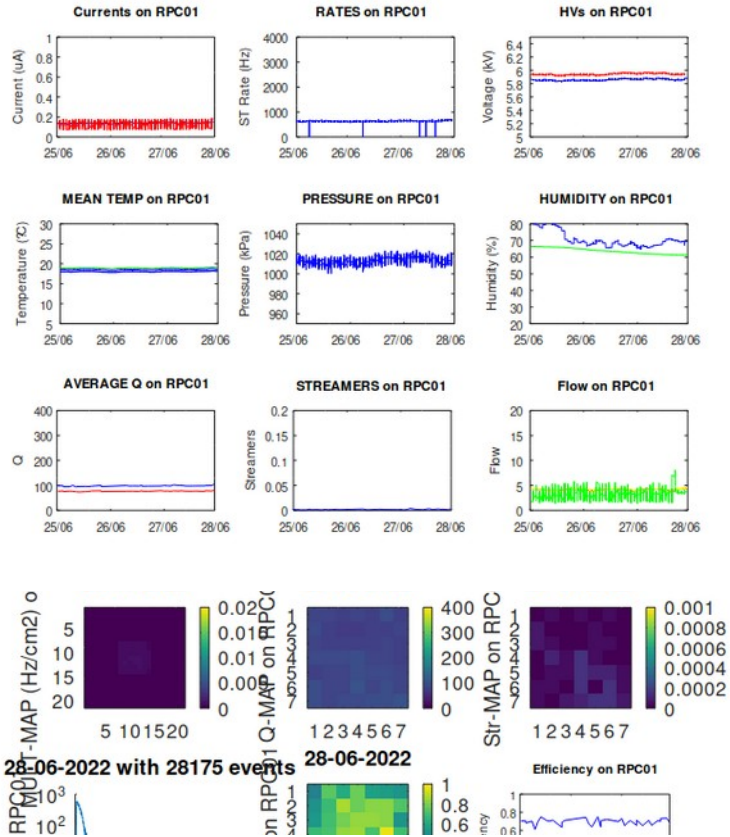


Automatic monitoring

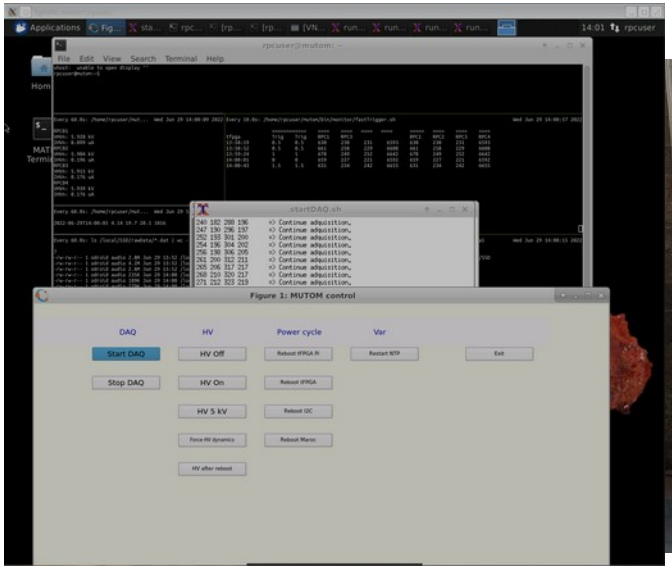
MUTOM GOAL. Transmission tomography at the Lousal mine.

Four layers RPC telescope based on MARTA-like modules and DAQ

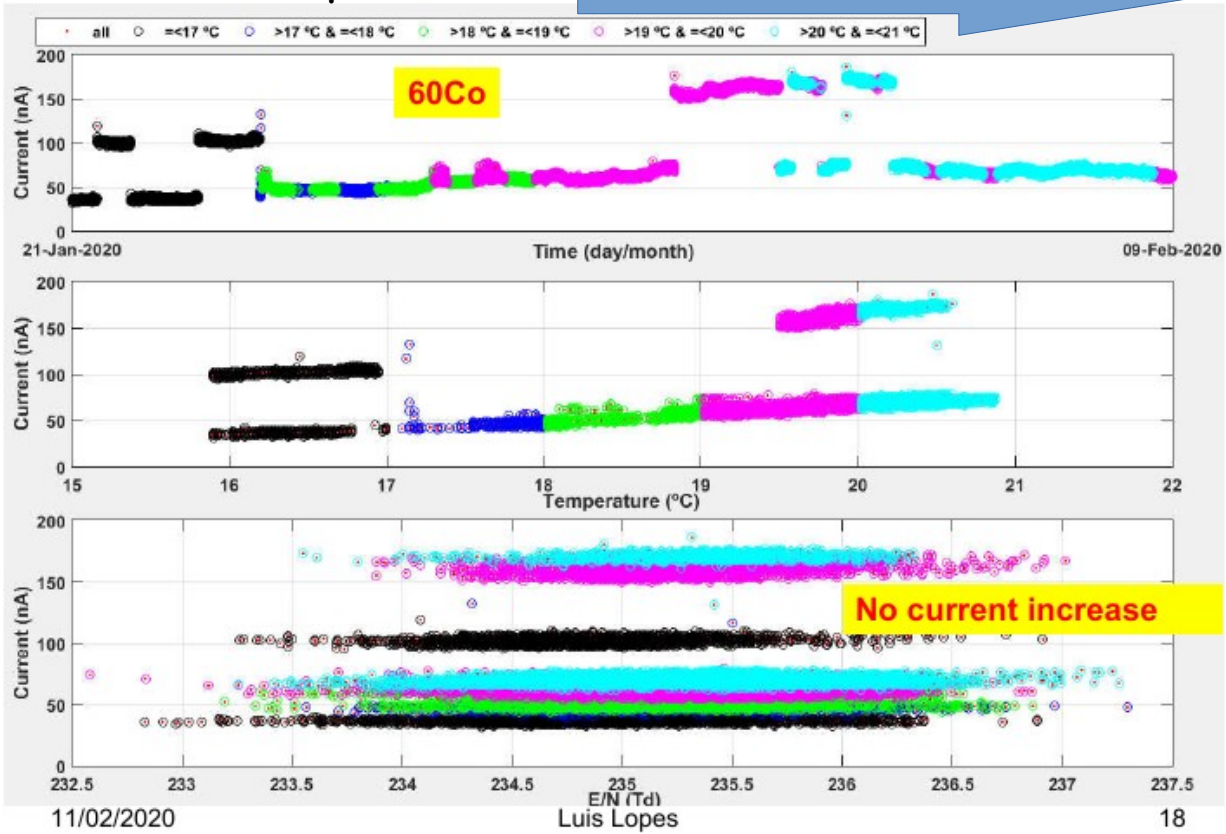
Tested @ LIP and now in the mine.

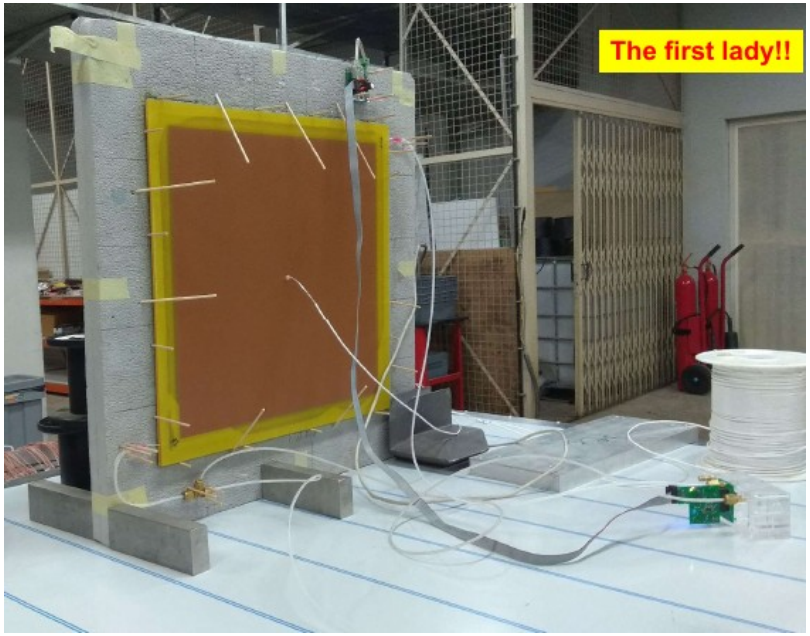


Automatic monitoring



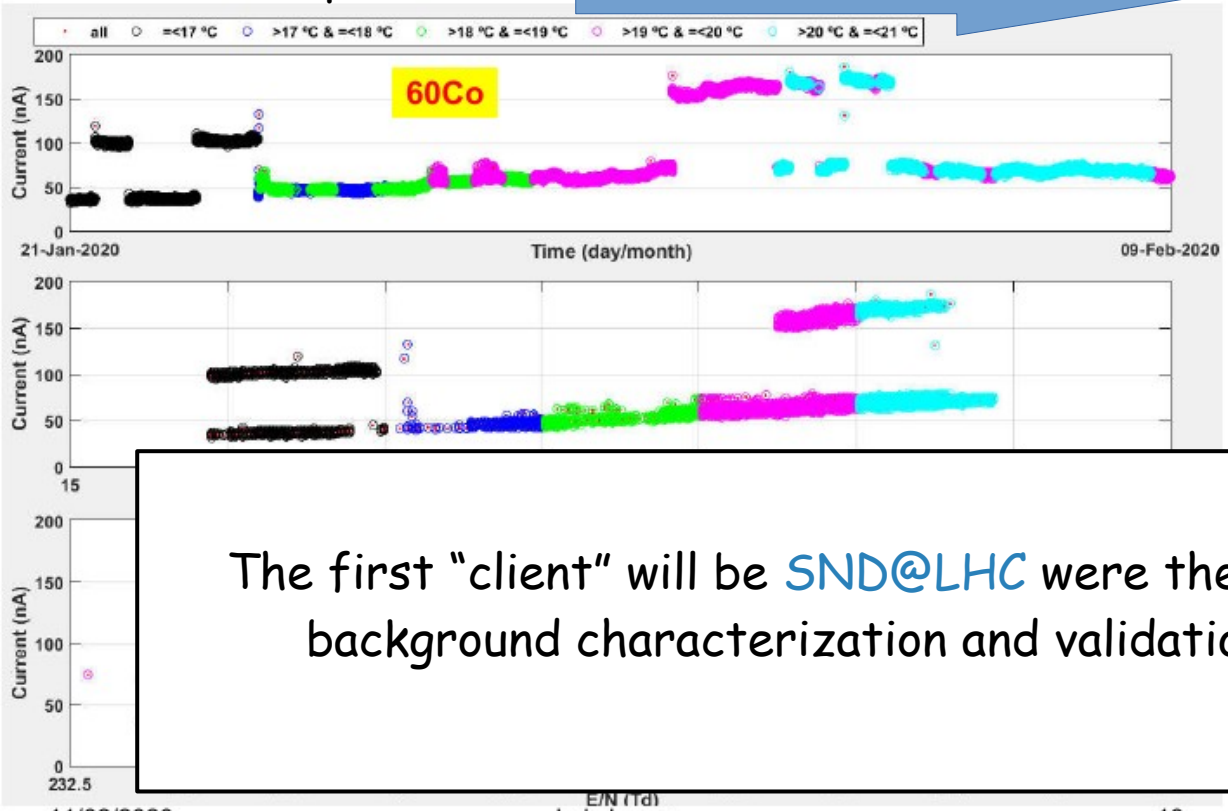
RPC sealed chamber seems to have a promissory behavior After six months the chambers continue with stable operation

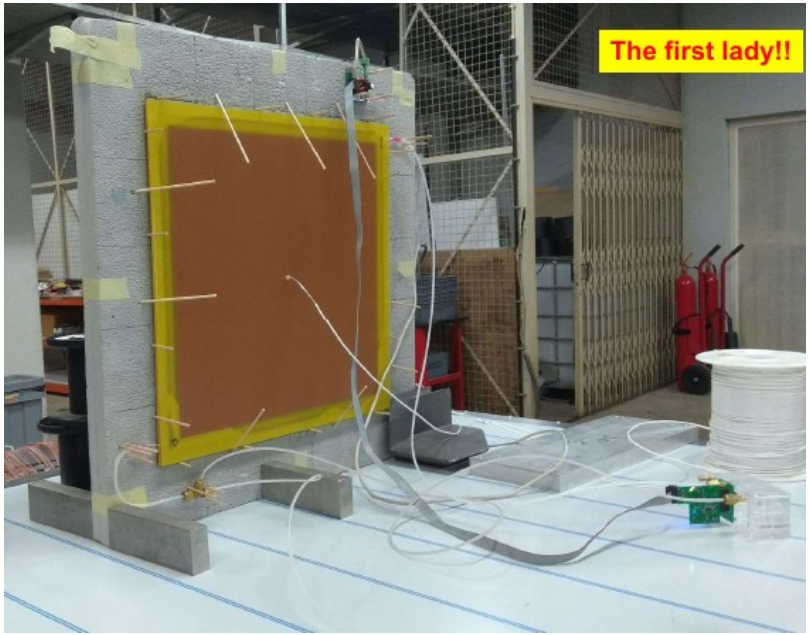




It will bring a **breakthrough** in HEP and particularly in Astroparticle experiments, **opening up new possibilities**, for example, by making possible i**nstallation of stations equipped with RPC detectors in unattended remote locations in future experiments.**

RPC sealed chamber seems to have a promissory behavior After six months the chambers continue with stable operation





The first "client" will be SND@LHC were these chambers will be used for background characterization and validation of beam line simulations.

HEP and
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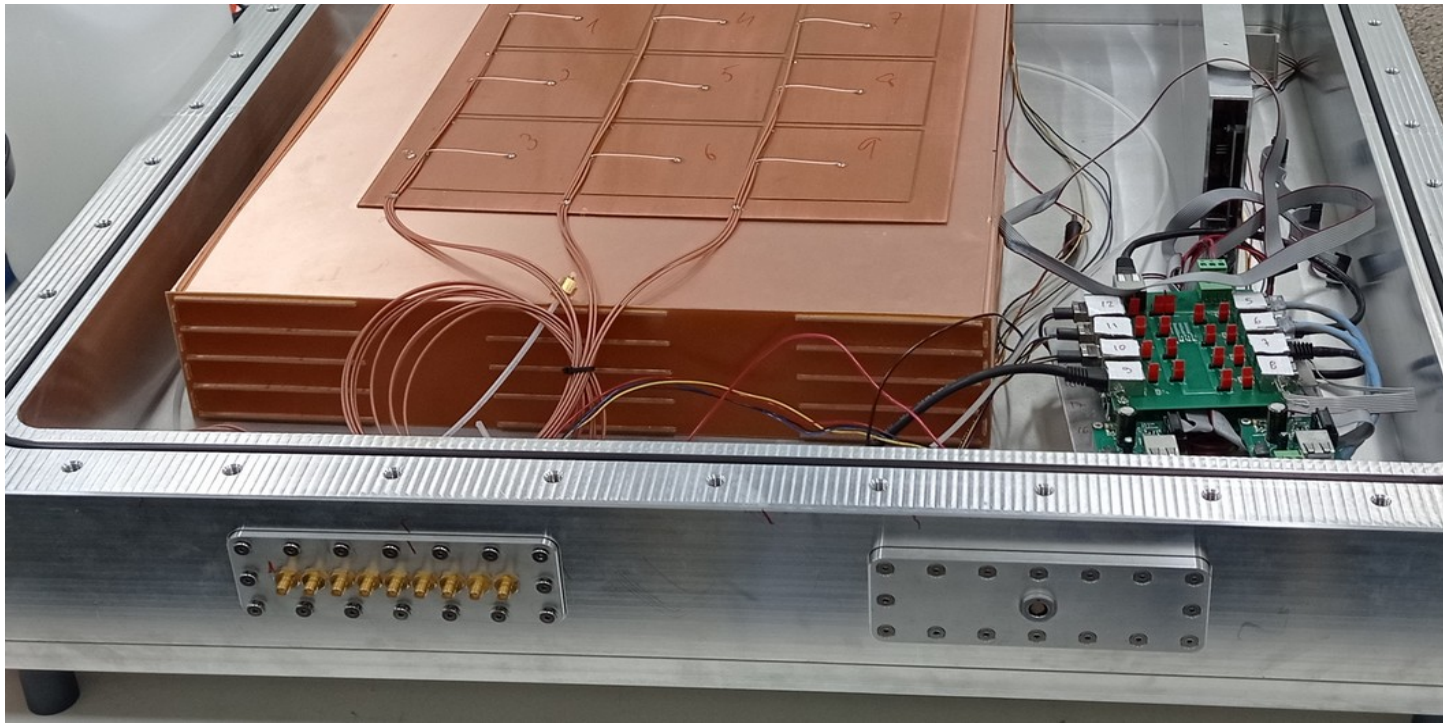
example,
stations
ors in
future
experiments.

Development of **RPC operated @ high altitude** (low pressure)



Hypobaric chamber for low pressure RPC operation

Very close collaboration with the **Neutron Detector group** with projects funded with people from both teams …. => see specific talk.

Near future & plans.

- Finalize the evaluation of the **HiRezBrainPET.**
- Finalize the R&D of **large area timing RPCs** by calibrating and analyzing the data gathered in the S522 experiment.
- Explore the capabilities of **STRATOS** (one station will remain @ LIP).
- Continue with the successful operation of **MUTOM.**
- Continue with the development of **sealed RPCs** and the **RPC operated @ high altitude** (SWGO).

. Continue with some other fundamental R&D within approved projects

RPC-Innova (22-24). Readout schemes for RPCs with **accurate and simultaneous measurement of time and 2D** position and Development of ultra-low gas consumption and sealed RPCs.

AIDA-Innova (21-25) **high Rate RPCs.**