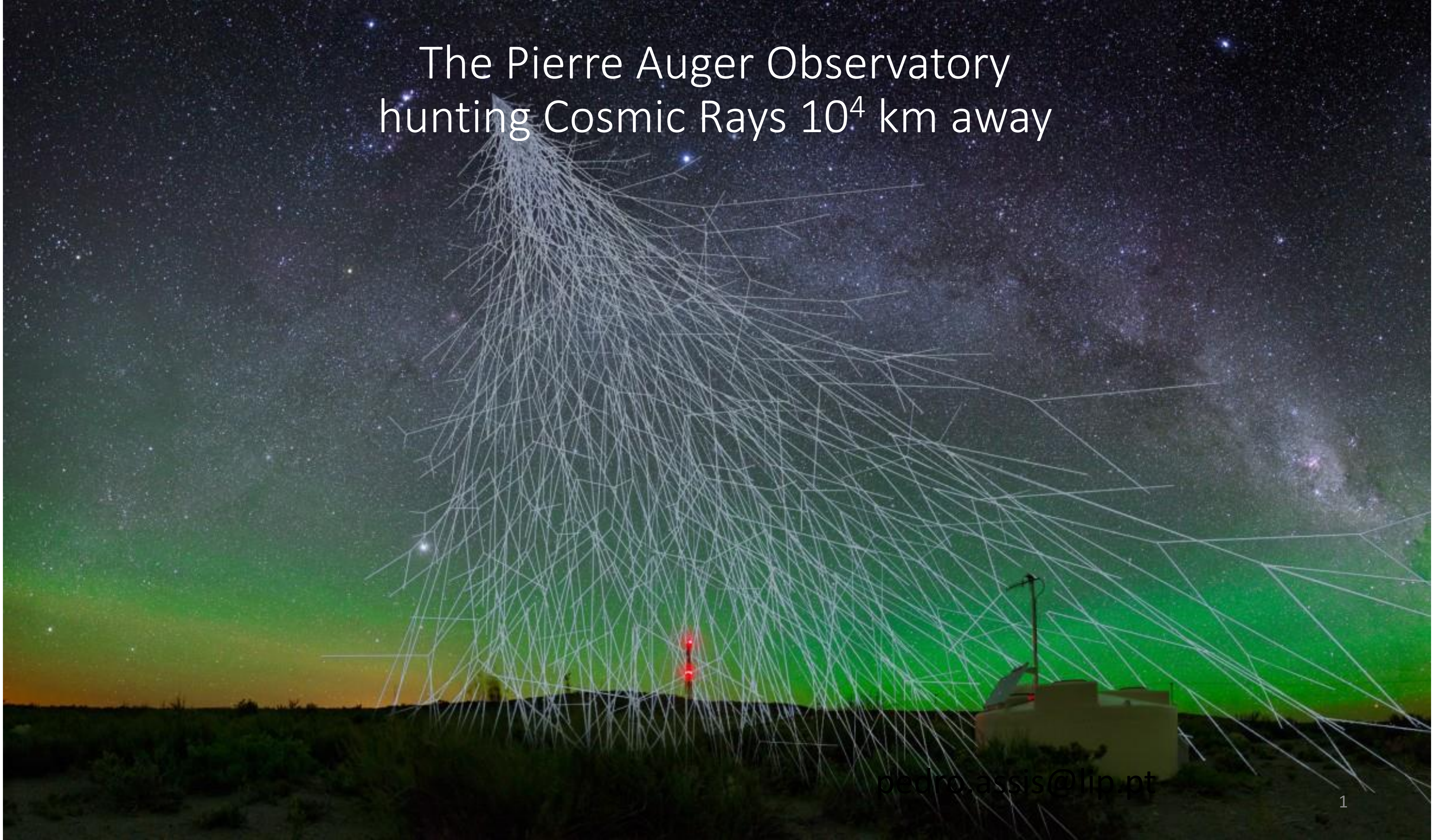
The Pierre Auger Observatory hunting Cosmic Rays 10^4 km away

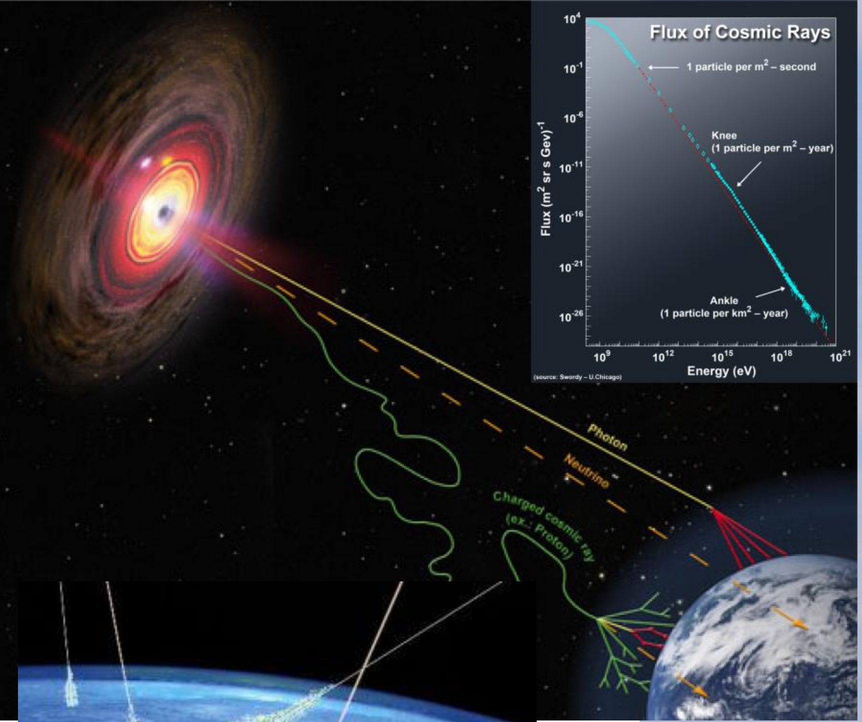


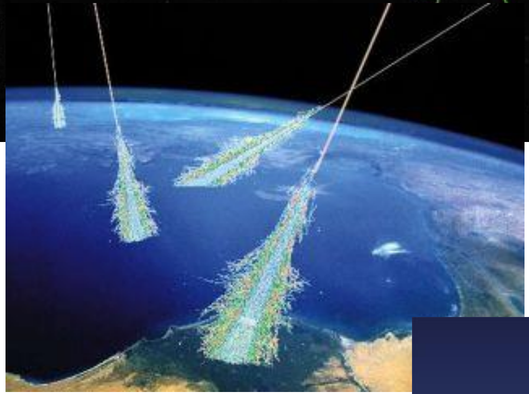
pedro.assis@lip.pt

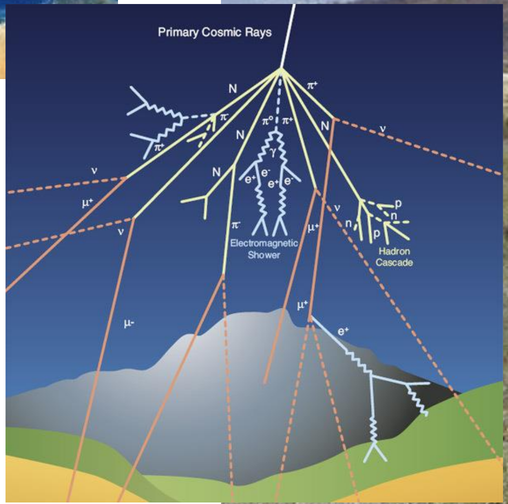
The Pampa Argentina

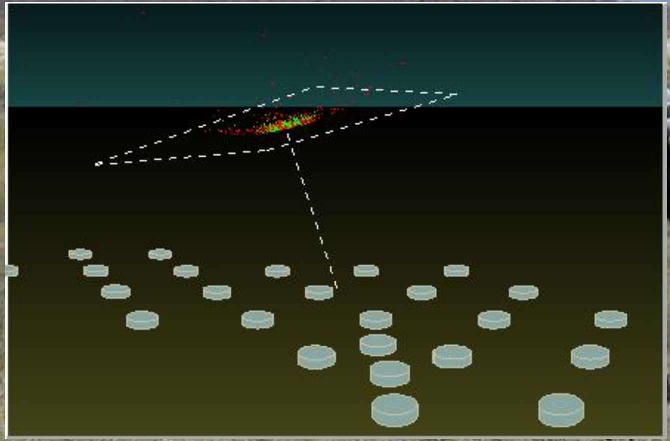
The Detector field

The Cosmic Ray and the detectors







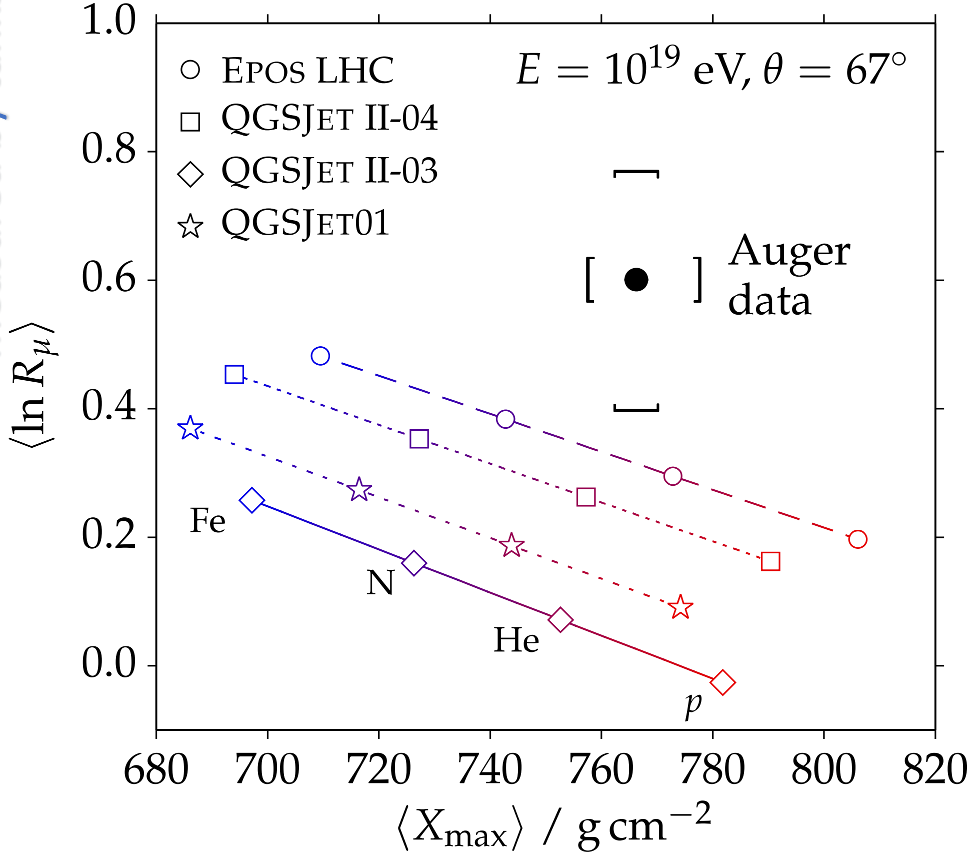


The LIP group:

- Understand the CR phenomenology and precise measurements
- Improve the measurement quality

The muons “problem” and result from the first interactions

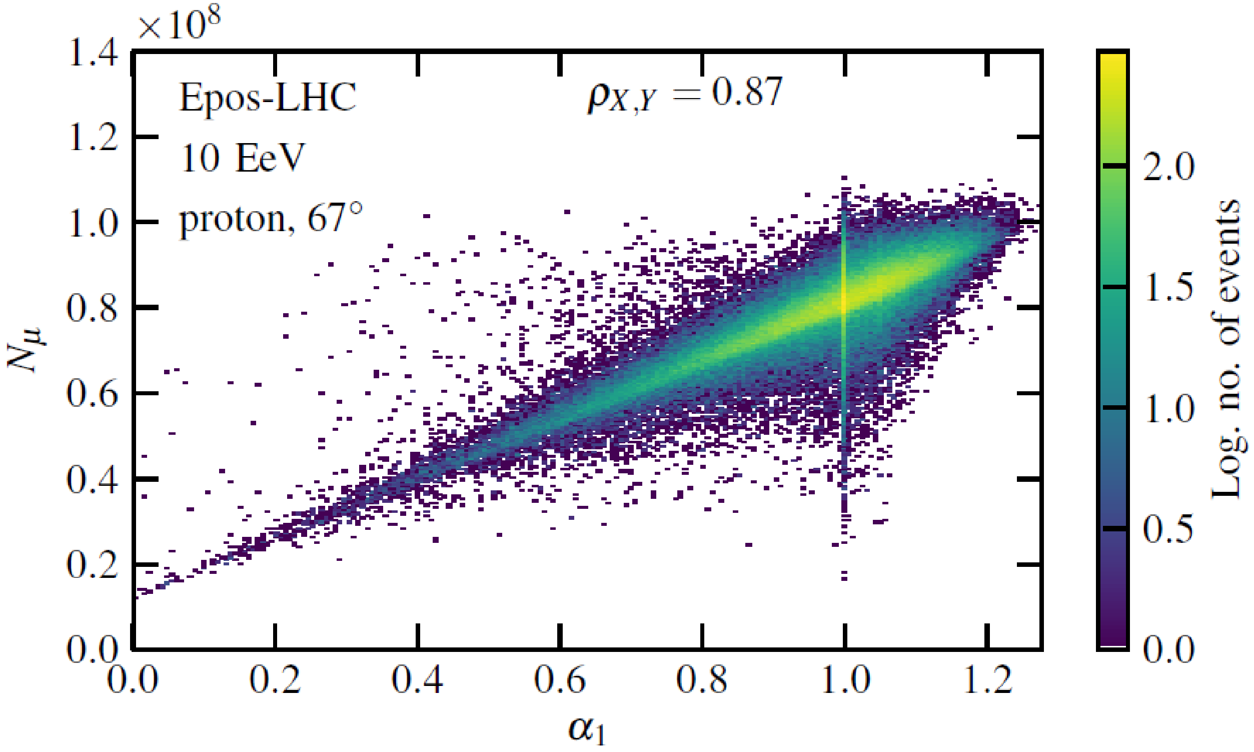
“number” of muons
Measured by tanks



Depth of shower – Measured by FD

Probing the properties of the first interaction of Ultra-High-Energy Cosmic Rays through the muon content of Extensive Air Showers

Lorenzo Cazon, Ruben Conceição, and Felix Riehn*

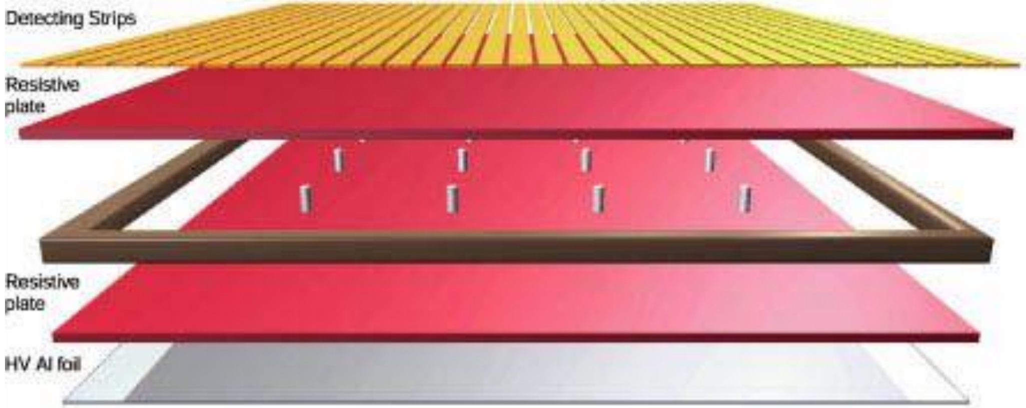


In this letter it has been demonstrated that the number of muons in EAS is connected with a variable (α_1) of the first interaction. This variable is related to the fraction of energy carried by the hadronic particles that sustain the hadronic cascade. Using this knowledge, it was shown

Improve Detection

Only muons get there!

RPCS



Put RPCs in there

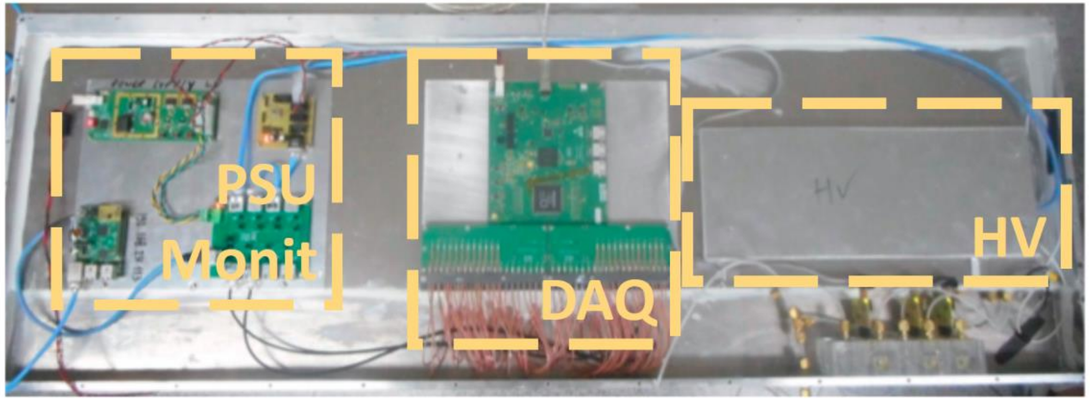
The Office

...Work

The Pierre Auger Observatory
Central Campus

Improving detection capabilities:
New detectors with LIP expertise

All electronics: LIP



Electronics box (1285 x 407 mm^2)

Must develop the detector, electronics, slow control, logistics, ...


DD-20C
25AMP VOLTAGE DROPPER
CLEAN

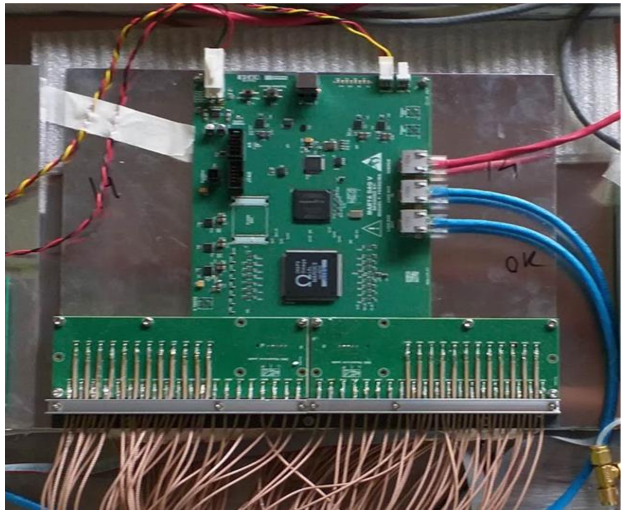

PETER MAZUR

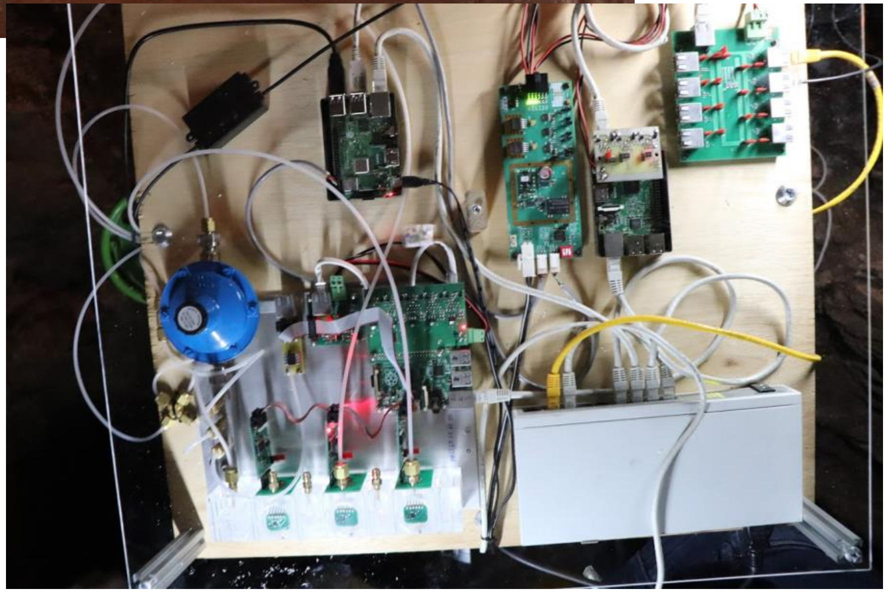
November 2019…

Spin-offs

Instrumentation and detectors of radiation

Geological Survey in mine using “Auger technology”

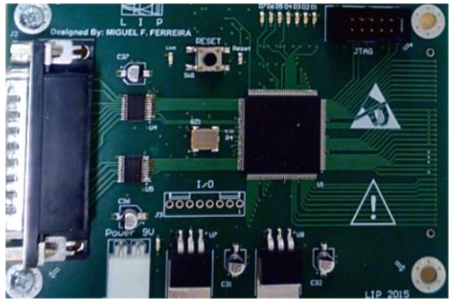




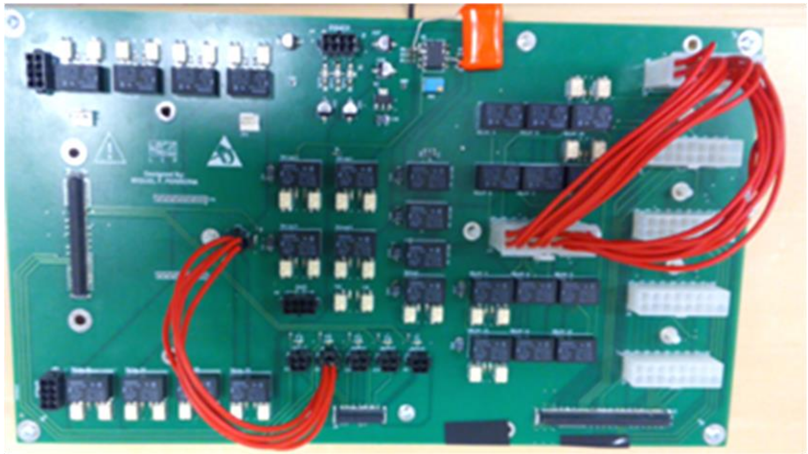
eCo-60: Test of componentes response to radiation for ESA

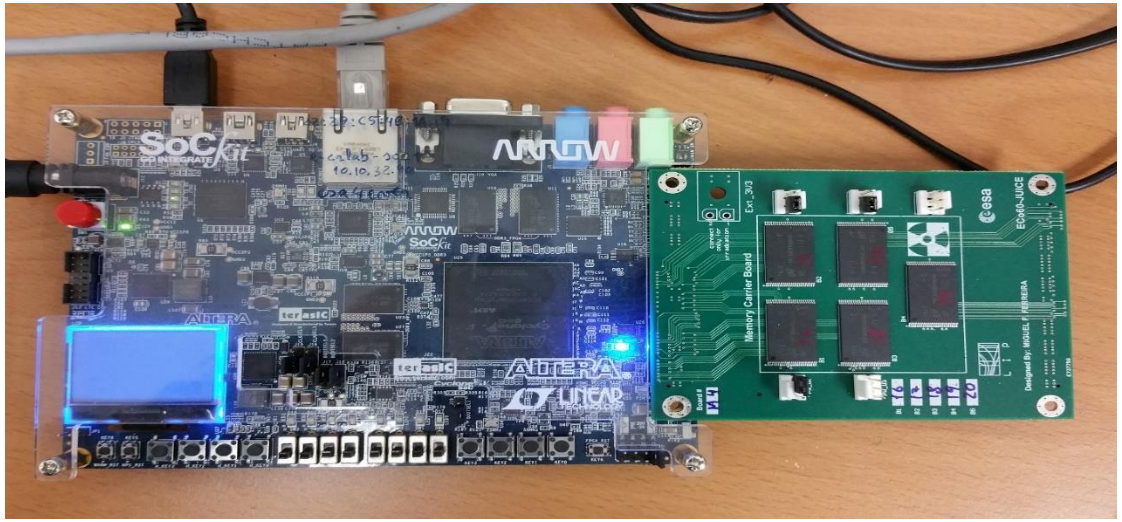
Measuring Units

Control Board

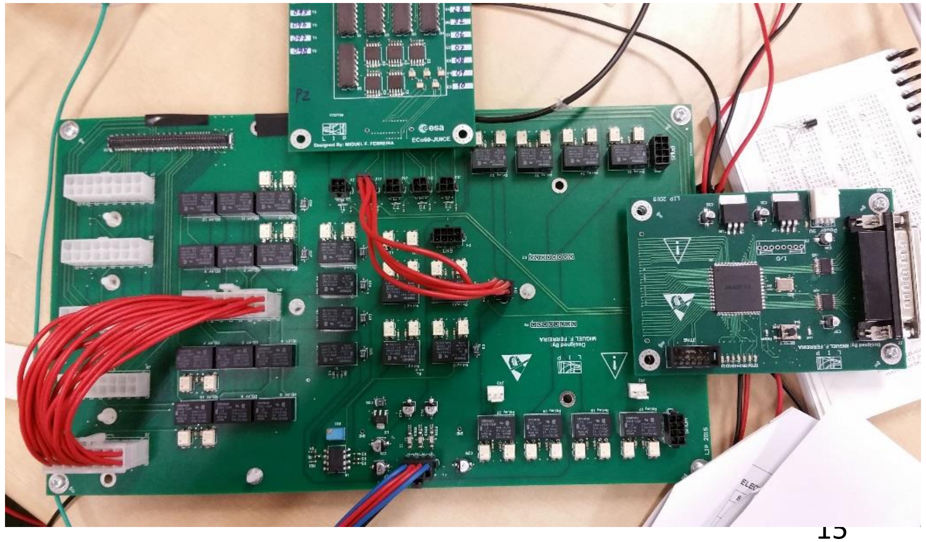


Test Board



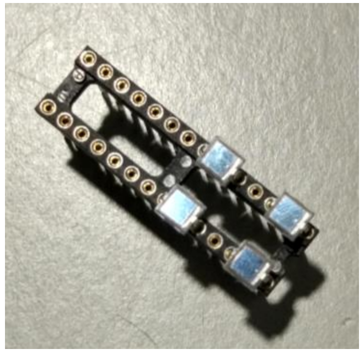
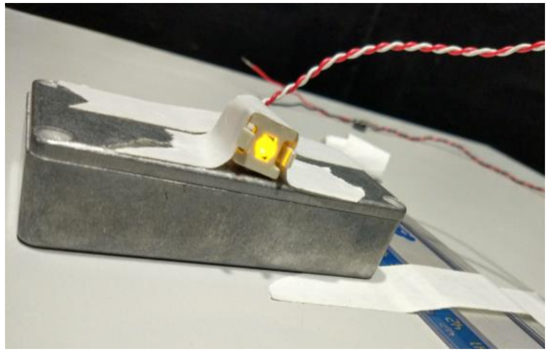
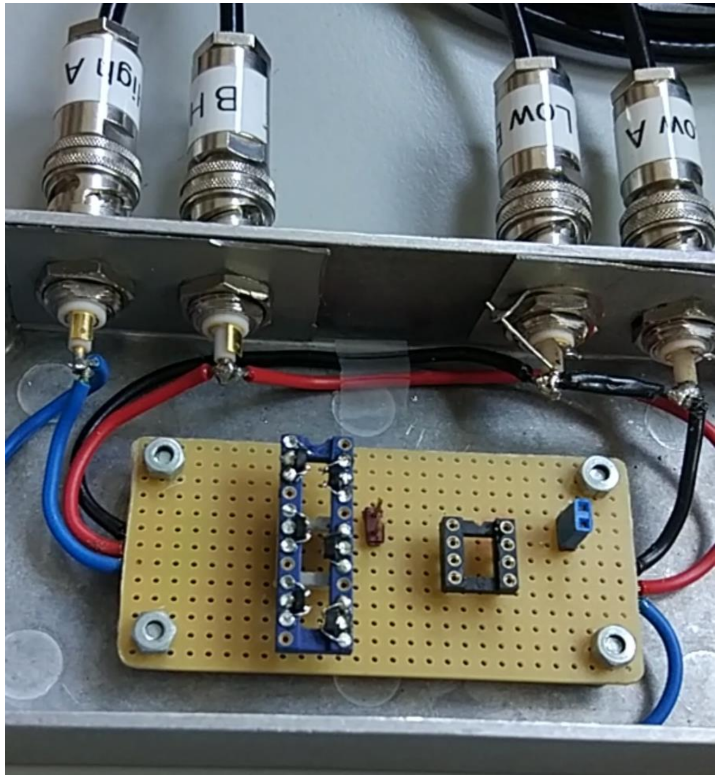


SOC development board from ARROW/ALTERA

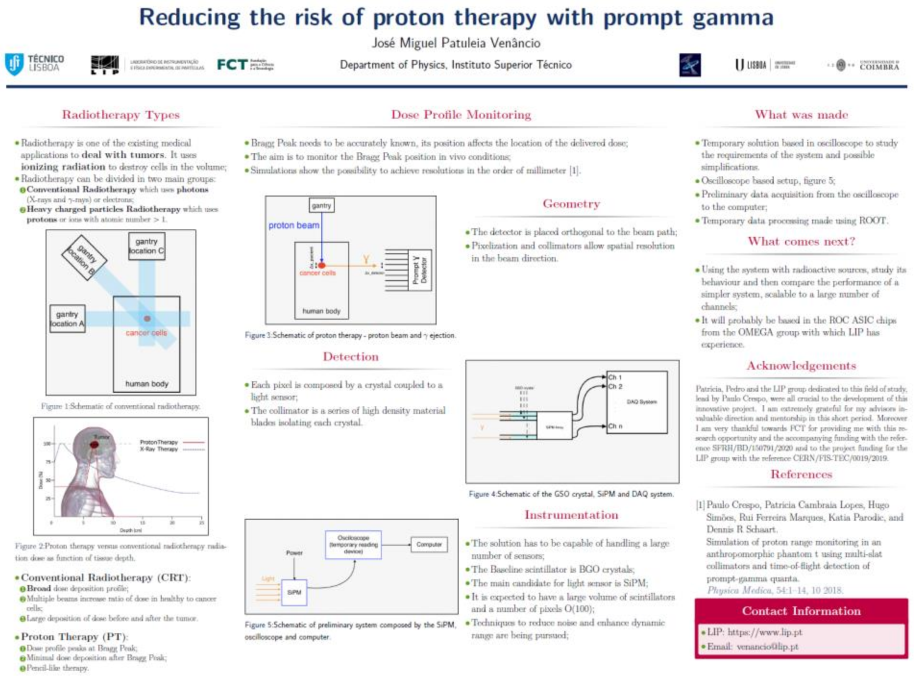


Instrumentation and detectors of radiation

- Test of response of componentes to radiation
- Study the possibility to use COTS devices for radiation monitoring

Instrumentation and detectors of radiation for proton therapy



Reducing the risk of proton therapy with prompt gamma

José Miguel Patuleia Venâncio
Department of Physics, Instituto Superior Técnico

Radiotherapy Types

- Radiotherapy is one of the existing medical applications to **deal with tumors**. It uses **ionizing radiation** to destroy cells in the volume;
- Radiotherapy can be divided in two main groups:
  1. **Conventional Radiotherapy** which uses **photons** (X-rays and γ-rays) or electrons;
  2. **Heavy charged particles Radiotherapy** which uses **protons** or ions with atomic number > 1.

Figure 1:Schematic of conventional radiotherapy.

Figure 2:Proton therapy versus conventional radiotherapy radiation dose as function of tissue depth.

- **Conventional Radiotherapy (CRT):**
  1. **Broad** dose deposition profile;
  2. Multiple beams increase ratio of dose in healthy to cancer cells;
  3. Large deposition of dose before and after the tumor.
- **Proton Therapy (PT):**
  1. Dose profile peaks at Bragg Peak;
  2. Minimal dose deposition after Bragg Peak;
  3. Pencil-like therapy.

Dose Profile Monitoring

- Bragg Peak needs to be accurately known, its position affects the location of the delivered dose;
- The aim is to monitor the Bragg Peak position in vivo conditions;
- Simulations show the possibility to achieve resolutions in the order of millimeter [1].

Figure 3:Schematic of proton therapy - proton beam and γ ejection.

Geometry

- The detector is placed orthogonal to the beam path;
- Pixelization and collimators allow spatial resolution in the beam direction.

Detection

- Each pixel is composed by a crystal coupled to a light sensor;
- The collimator is a series of high density material blades isolating each crystal.

Figure 4:Schematic of the GSO crystal, SiPM and DAQ system.

Figure 5:Schematic of preliminary system composed by the SiPM, oscilloscope and computer.

Instrumentation

- The solution has to be capable of handling a large number of sensors;
- The Baseline scintillator is BGO crystals;
- The main candidate for light sensor is SiPM;
- It is expected to have a large volume of scintillators and a number of pixels O(100);
- Techniques to reduce noise and enhance dynamic range are being pursued;

What was made

- Temporary solution based in oscilloscope to study the requirements of the system and possible simplifications.
- Oscilloscope based setup, figure 5;
- Preliminary data acquisition from the oscilloscope to the computer;
- Temporary data processing made using ROOT.

What comes next?

- Using the system with radioactive sources, study its behaviour and then compare the performance of a simpler system, scalable to a large number of channels;
- It will probably be based in the ROC ASIC chips from the OMEGA group with which LIP has experience.

Acknowledgements

Patricia, Pedro and the LIP group dedicated to this field of study, lead by Paulo Crespo, were all crucial to the development of this innovative project. I am extremely grateful for my advisors invaluable direction and mentorship in this short period. Moreover I am very thankful towards FCT for providing me with this research opportunity and the accompanying funding with the reference SFRH/BD/150791/2020 and to the project funding for the LIP group with the reference CERN/FIS-TEC/0019/2019.

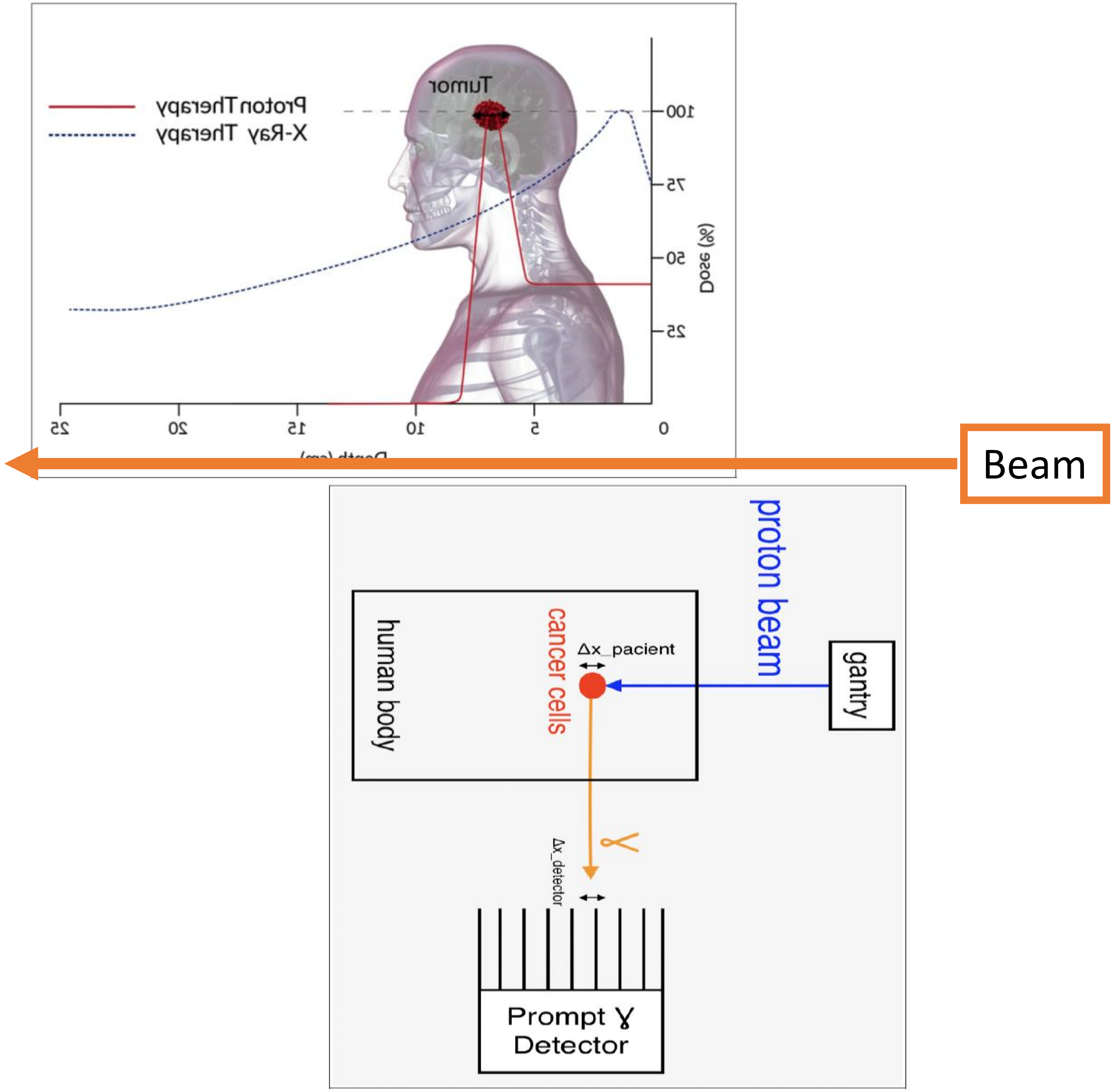
References

[1] Paulo Crespo, Patricia Cambraia Lopes, Hugo Simões, Rui Ferreira Marques, Katia Parodic, and Dennis R Schaart. Simulation of proton range monitoring in an anthropomorphic phantom t using multi-slat collimators and time-of-flight detection of prompt-gamma quanta. *Physica Medica*, 54:1–14, 10 2018.

Contact Information

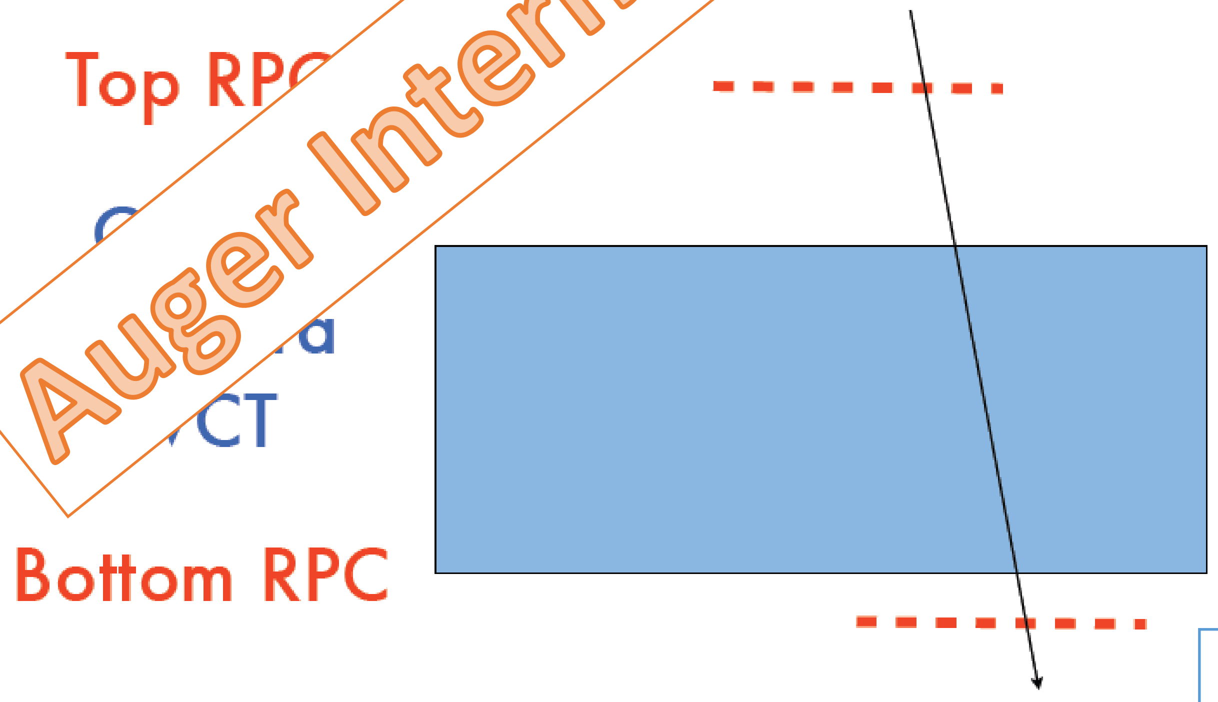
- LIP: https://www.lip.pt
- Email: venancio@lip.pt

Poster by J. Venâncio



Spin-offs

RPC tele[illegible]e & tank data



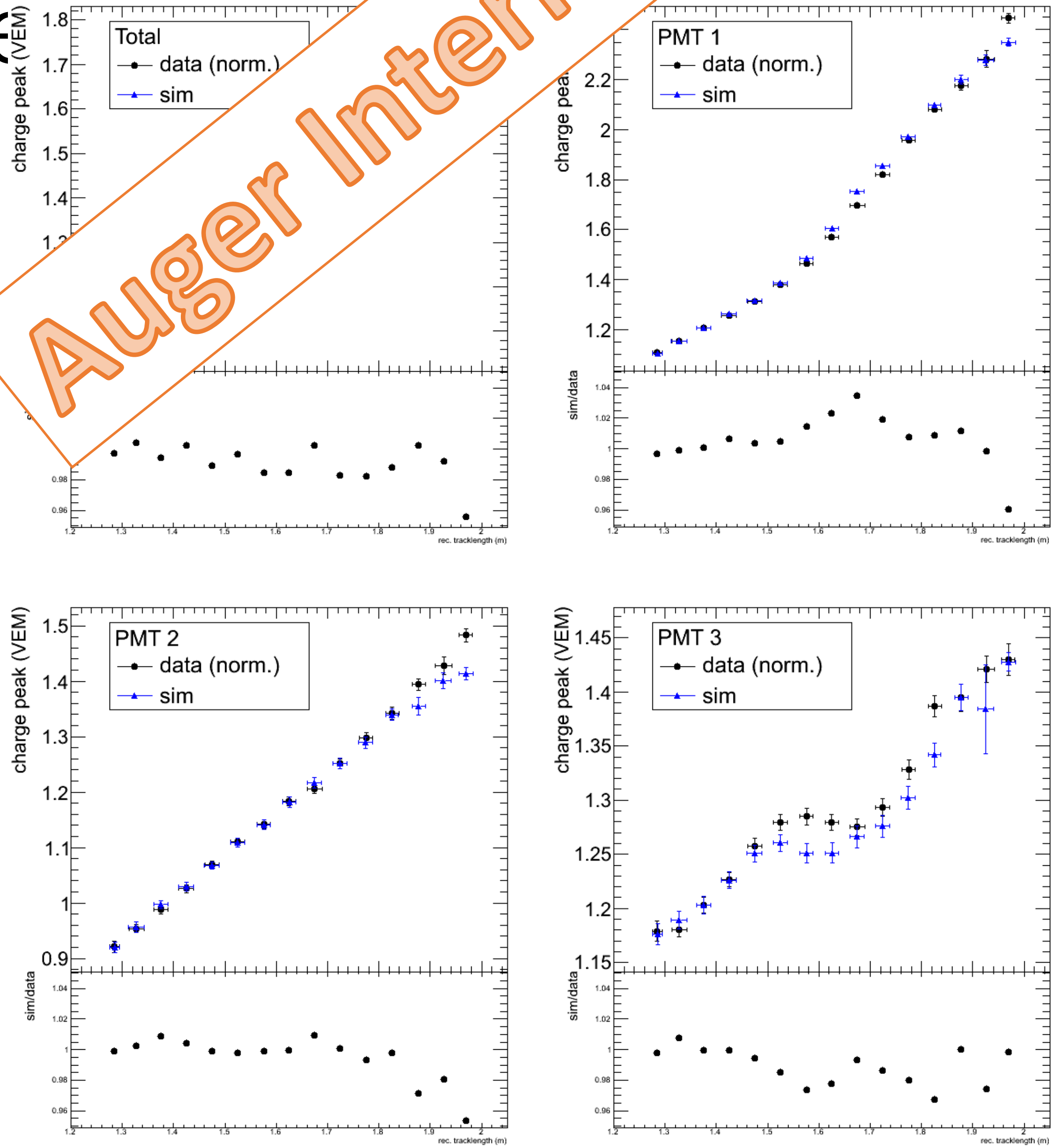
Data acquired in coincidence :

- 3 PMTS :
  Low/high gain traces
  Calibration histograms
- 2 RPCs
- id of pads with hit

Coincidence trigger from
RPCs (~400ns window)
Trigger sent to tank

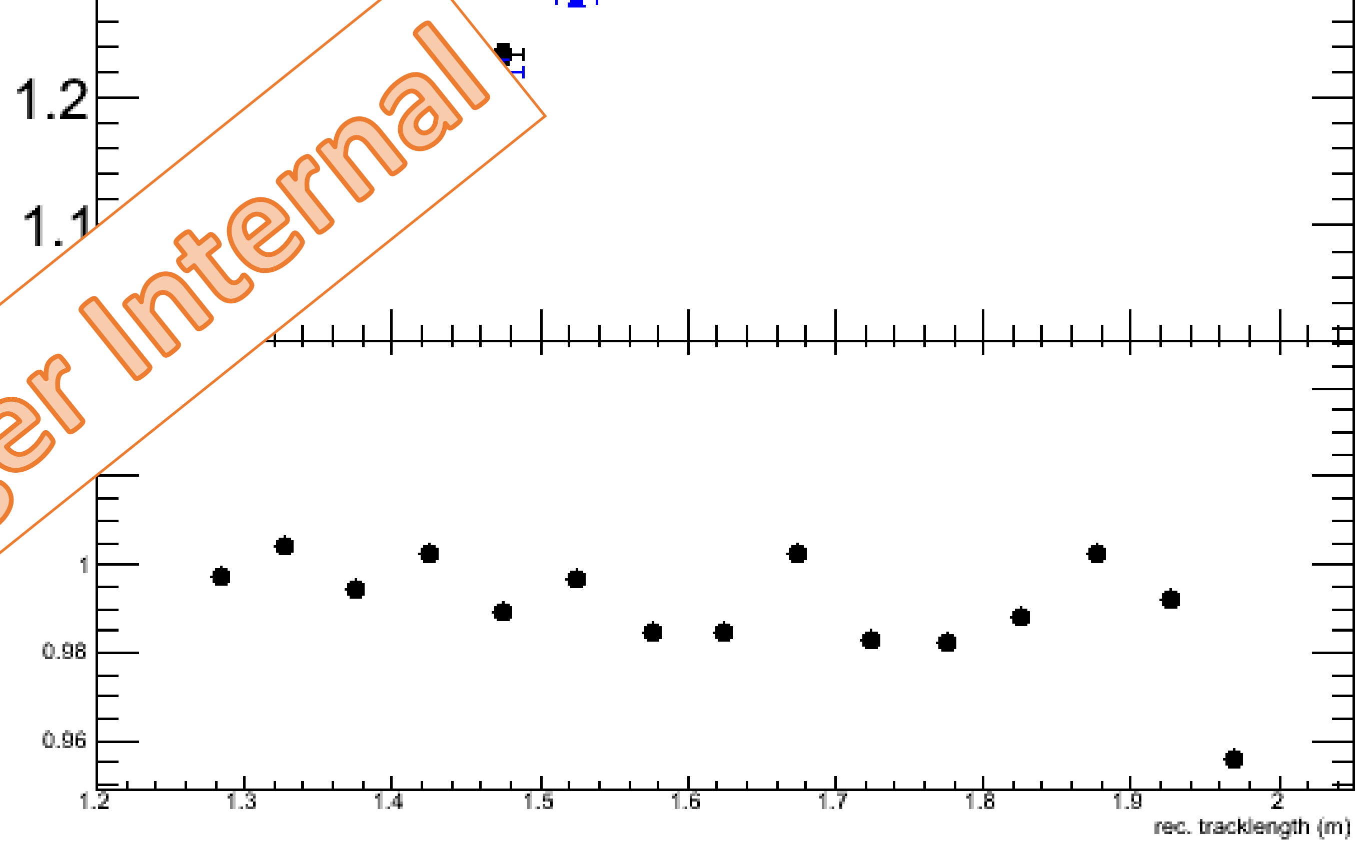
Tank trigger sent to motherboard
(RPCs acquired in coincidence)
Read hits in 1μs window
Use the RPC segmentation to define
muon trajectories and study tank response

Pre



Charge vs tracklength

Previc



1.2
1.1
Auger Internal
1
0.98
0.96
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
rec. tracklength (m)

We also need heavy machinery

Sometimes, let me drive!

Pedro Assis

Researcher at LIP
Specialized in Experimental Particle Physics, Data Acquisition Systems, Cosmic Rays
Works in instrumentation for particle physics detector: Cosmic Rays, Space radiation, Proton Therapy

Member of the SWGO: South Wide Field of view Gamma Observatory

Coordinator of the Portuguese group in the Pierre Auger Observatory
Principal investigator in 2 FCT fundings (150k€ + 135k€)

Increase the measurement capabilities of the Observatory by a direct measurement of muons: The Marta Project: RPC detectors at stations

2019: First station deployed. On hold for pandemia and travel restrictions

Head of the e-CRLab: electronics for Cosmic Ray laboratory

Supervisor of PhD R. Luz in the instrumentation of MARTA (completed)
Supervisor of PhD J. Venâncio in instrumentation for Ortho CT for proton therapy

First MARTA station deployed in the pampa Argentina

Selected publications

- MARTA: a high-energy cosmic-ray detector concept for high-accuracy muon measurement,
  Abreu, P., Andringa, S., Assis, P. et al. Eur. Phys. J. C (2018) 78: 333.
  https://doi.org/10.1140/epjc/s10052-018-5820-2
- The MARTA (Muon Array with RPCs for Tagging Air showers) Front-End acquisition system;
  P. Assis et al; IEEE Transactions on Nuclear Science, 65, 12, 2920 (2018)
  https://doi.org/10.1109/TNS.2018.2879089
- Studies on the response of a water-Cherenkov detector of the Pierre Auger Observatory to atmospheric muons using an RPC hodoscope,
  A. Aab et al. (The Pierre Auger Collaboration), JINST 15 P09002 (2020)
  https://doi.org/10.1088/1748-0221/15/09/P09002
- Design and expected performance of a novel hybrid detector for very-high-energy gamma-ray astrophysics,
  P. Assis, U. Barres de Almeida, A. Blanco, et al., Astropart Phys, 99 (2018) 34-42
  https://doi.org/10.1016/j.astropartphys.2018.02.004
- Towards sealed Resistive Plate Chambers,
  Lopes, L; Assis, P; Blanco, A; Fonte, P; Pimenta, M, JINST 15, C11009,
  https://doi.org/10.1088/1748-0221/15/11/C11009

Leccionação

UCs de Física Geral

UC|Tipo Aula		QUC
Mecânica e ondas (2018/2019, 2º Semestre MEAer)	L	8,12
Mecânica e Ondas (2018/2019, 1ºSemestre, LEIC-A)	P	8,62
Mecânica e Ondas (2017/2018, 2ºSemestre, MEAer)	L	8,12
Mecânica e Ondas (2017/2018, 2ºSemestre, LEGM, LMAC, MEBiom)	L	9
Mecânica e Ondas (2017/2018, 1ºSemestre, LEIC-A)	P	8,44
Electromagnetismo e Óptica (2017/2018, 1ºSemestre, LEGM, MEC)	L	9
Mecânica e Ondas (2016/2017, 2ºSemestre, LEGM, LMAC, MEBiom)	L	8
Mecânica e Ondas (2016/2017, 2ºSemestre, MEAer)	L	7,88

UCs de MEFT

UC|Tipo Aula		QUC
Laboratório de Física das Radiações e Atómica (MEFT) Responsible2020/21 (S1)	T/L	na
Laboratório de Física das Radiações e Atómica (MEFT) Lecturer (Laboratory)2019/20 (S1)	L	8,12
Laboratório de Física das Radiações e Atómica (MEFT) Lecturer (Laboratory)2018/19 (S1)	L	7,88
Responsável UC de opção do MEFT: Projecto e Controlo em Lógica Digital (2016/2017, 17/18, 18/19)	T/L	na