IMPRS PhD position interview
July 18/19, 2022

Personal research experience

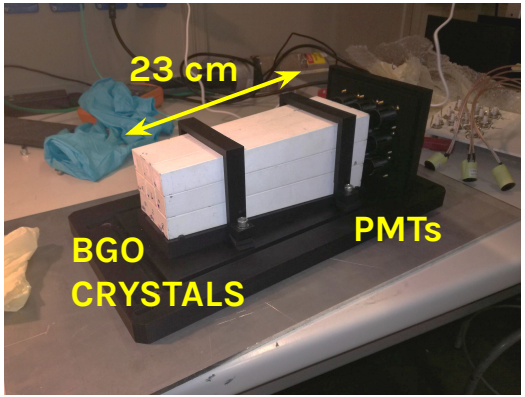
Federico Ronchetti
Università degli Studi dell'Insubria

Summary

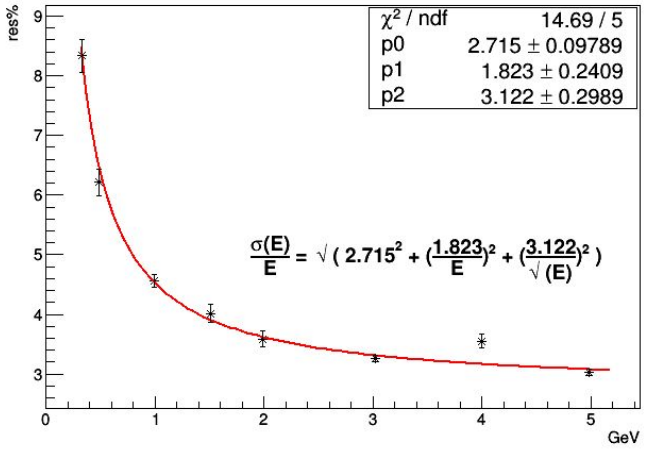
- Bachelor degree and **bachelor thesis work**
- Master degree and **master thesis work**
- **Laboratory** work
- **Beam test** activities
- Laboratory **tutoring**

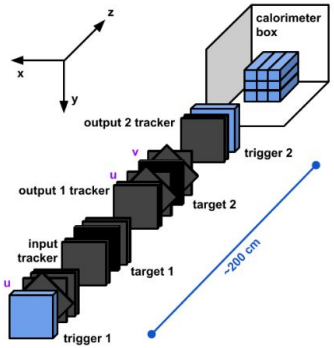
Bachelor degree in Physics (2019)

Thesis: Characterization of a BGO calorimeter with electron and muon beams



- **Original work** → test of the BGO calorimeter (GENNI) at low energies
  - Tutor: Prof. Michela Prest
  - 9 crystals from L3 (INFN Frascati) + 9 PMT Photonis XP1912
  - **Beam test at T9 PS** beamline
- GENNI used at the M2 SPS beamline → **Feasability test of the MUonE experiment**
  - Thesis, Soldani: "*MUonE: a high-energy scattering experiment to study the muon g-2*"
  - G. Abbiendi et al., "*A study of muon-electron elastic scattering in a test beam*", Journal of Instrumentation, vol. 16, no. 06, p. P06005, 2021





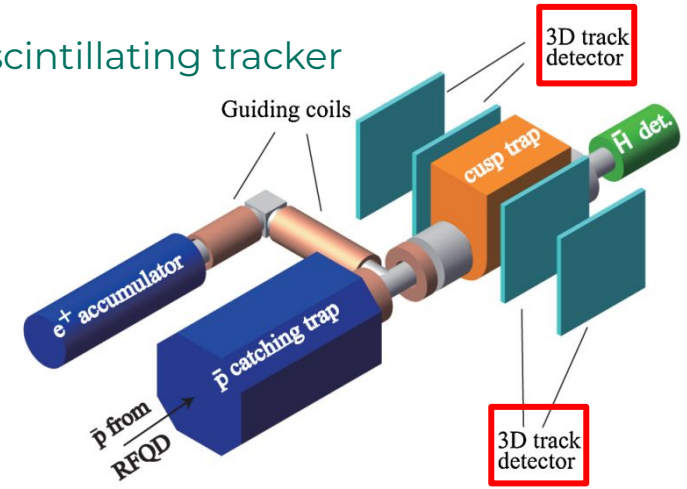
Master degree in Physics (2022)

Thesis: The new readout system of the ASACUSA scintillating tracker

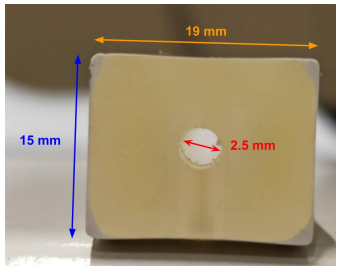
Tutor: Prof. Michela Prest

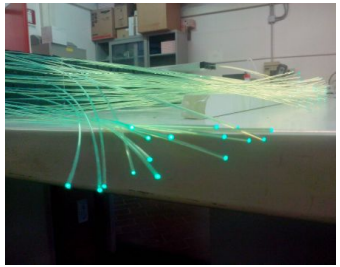
ASACUSA (**A**tomic **S**pectroscopy **A**nd **C**ollisions **U**sing **S**low **A**ntiprotons) antimatter experiment at **AD/ELENA facility**

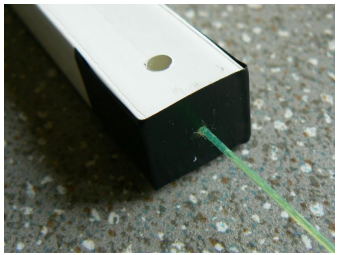
→ Hyperfine spectroscopy of the **antihydrogen**

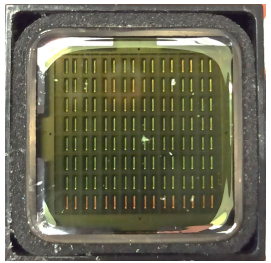


The **DANTE** detector









Scintillating bars by FNAL

- Length: 96 cm, section: 1.5 x 1.9 cm^2
- Coating: TiO_2

WLS Fibers Kuraray Y-11

- Diameter: 1 mm
- Attenuation length: > 3.5 m
- E30 epoxy glue

2008/2011 versions

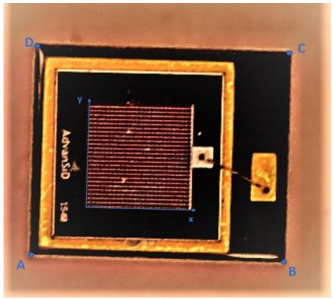
- The fibers were read out by Hamamatsu multi-anode PMTs

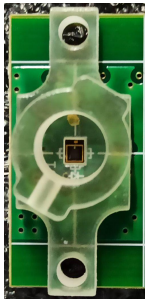
2021 Upgrade to Silicon PhotoMultipliers

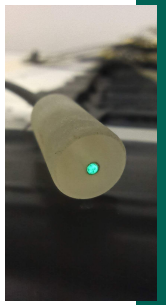
Master degree in Physics (2022)

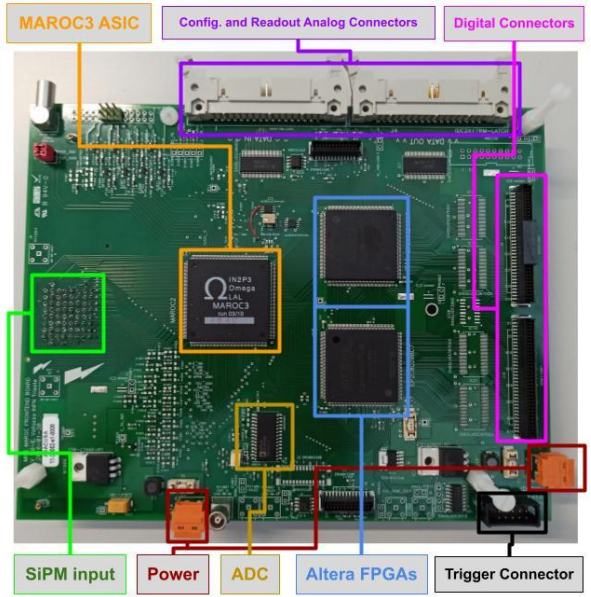
Thesis: The new readout system of the ASACUSA scintillating tracker

AdvanSiD
ASD-RGB1S-P
SiPM active area: 1 x 1 mm^2
Cell dimension: 40 µm
N cells: 625
Quenching resistance: 550 kΩ
Breakdown voltage @ 25 °C: 28 V





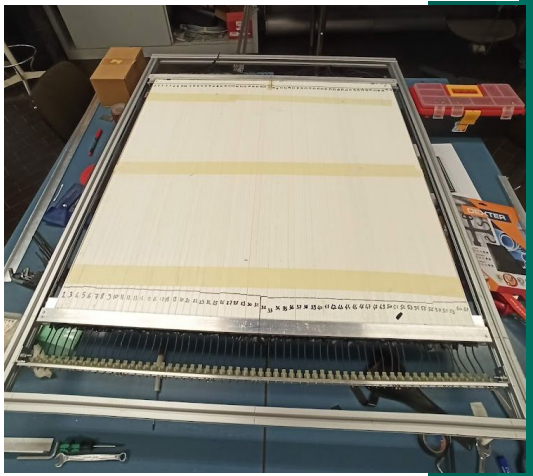




Front End electronics:

- Dual-stage amplifier on the SiPM FEB
- **MAROC3 ASIC** by Omega (LAL)
- **64** pre-amplified channels:
  - **Analog part**: slow shaper + Sample&Hold and 5 MHz multiplexed output to the ADC
  - **Digital part**: 2 fast shaper + discriminator

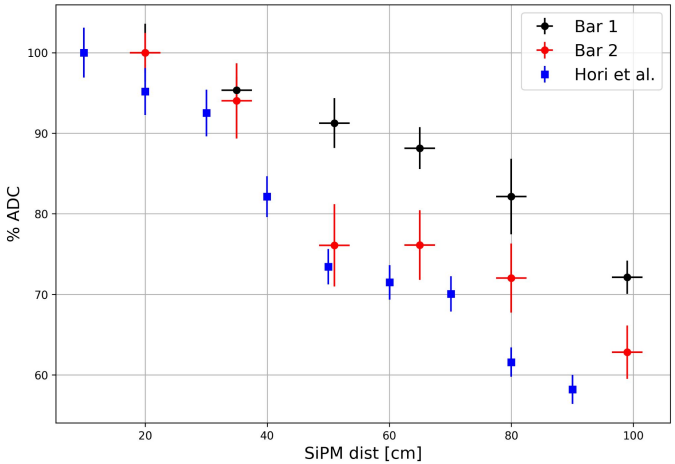
First plane upgraded!



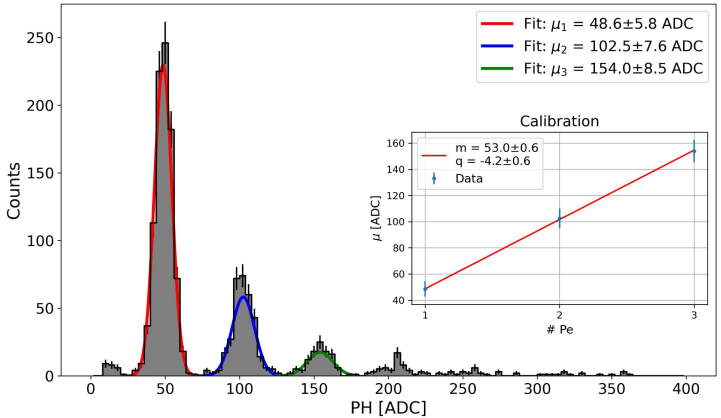
Master degree in Physics (2022)

Thesis: The new readout system of the ASACUSA scintillating tracker

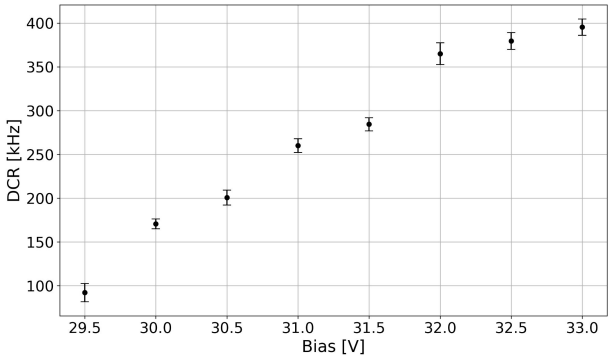
Light attenuation

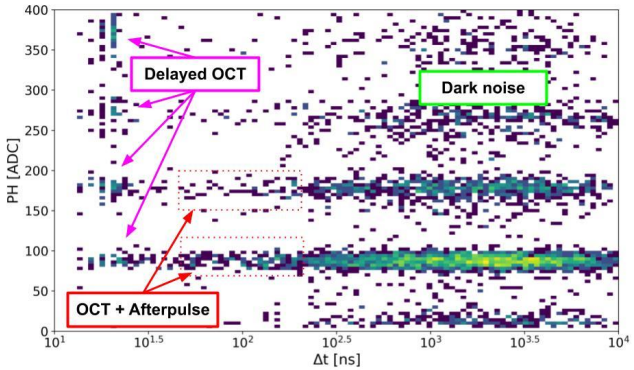


SiPM characterization



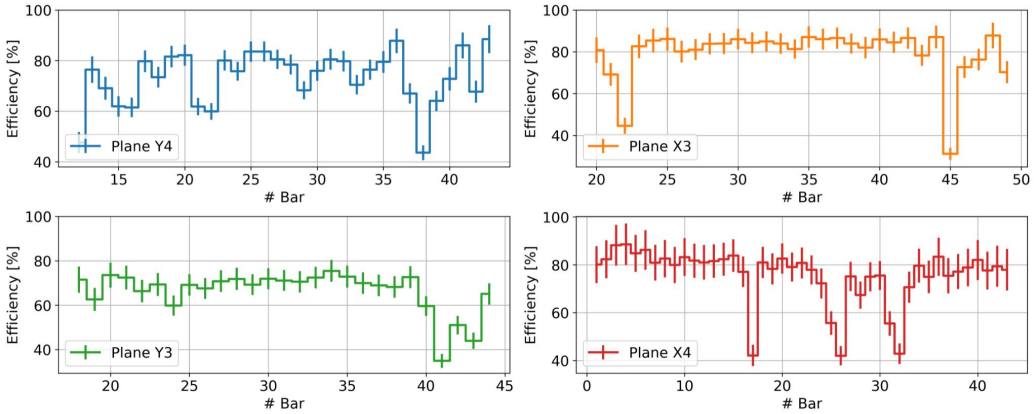
- Data analysis in Python → numpy, matplotlib, scipy and lmfit

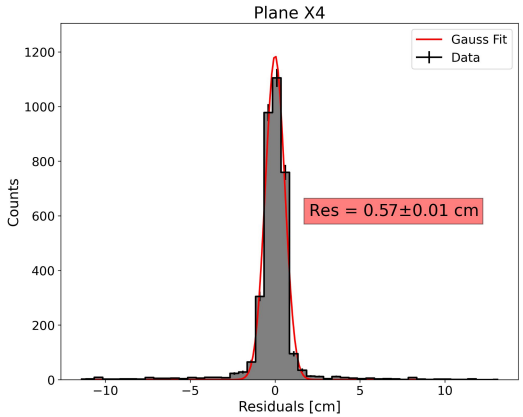




Master degree in Physics (2022)

Thesis: The new readout system of the ASACUSA scintillating tracker





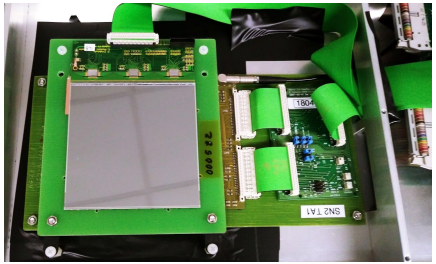
Plane	Spatial Resolution
Y4	(0.56 ± 0.02) cm
X4	(0.57 ± 0.01) cm
Y3	(0.63 ± 0.01) cm
X3	(0.69 ± 0.01) cm

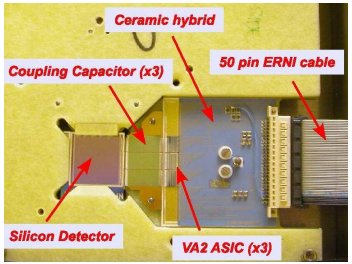
- Planes efficiency bar per bar
  - ROC curve technique for best threshold determination
- Residuals method → spatial resolution measurement

Laboratory work

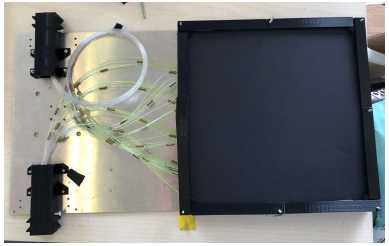
Design, building and characterization of particle detectors

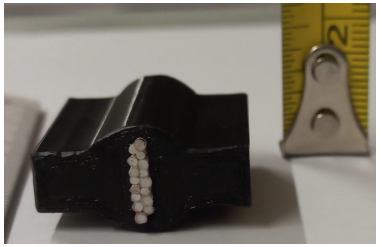
Silicon microstrip trackers





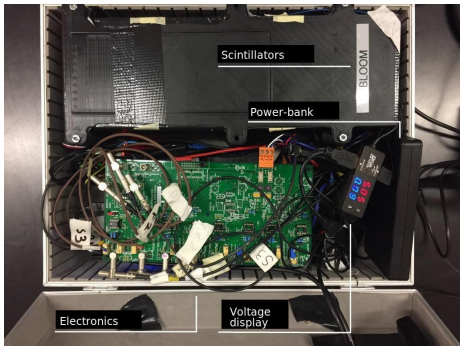
Active photon converter & triggers



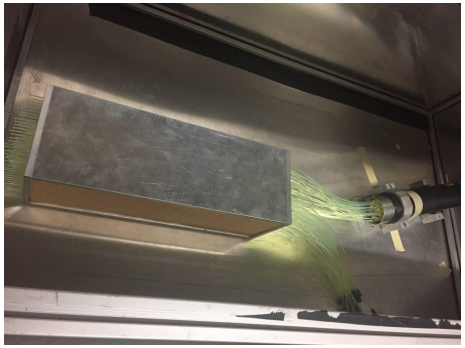


Cosmic rays detectors

→ L. Bomben et al., "*A portable cosmic ray detector for school education*," Journal of Instrumentation, vol. 16, p. P12008, dec 2021



Electromagnetic calorimeters

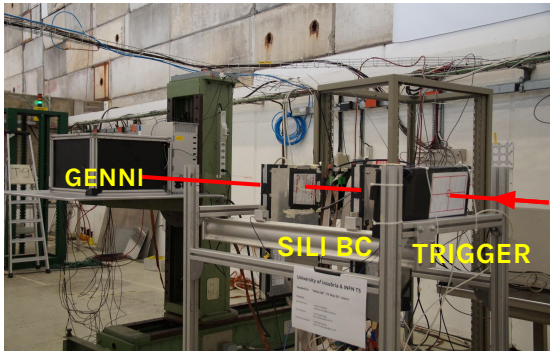


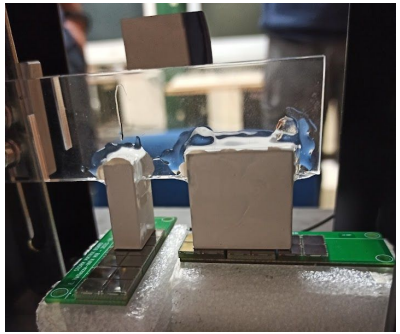
Beam test activities

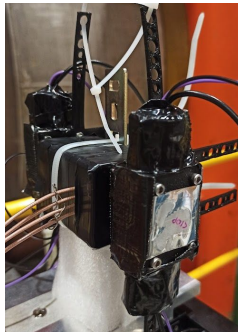
CERN SPS and PS extracted beamlines

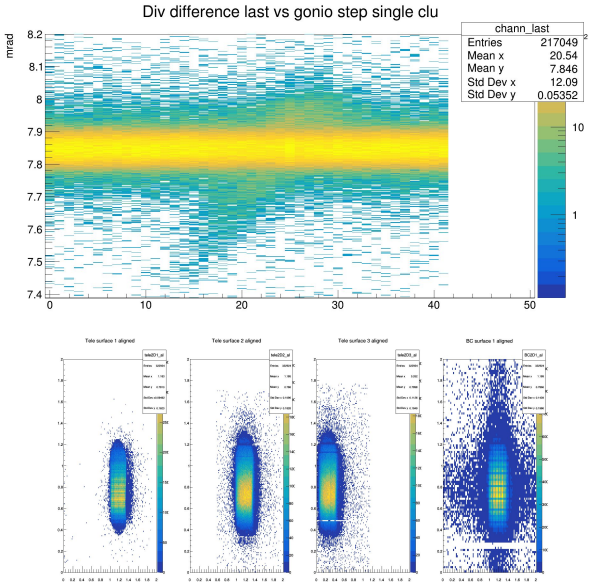
- **PS T9** beamline: detector tests (Silicon BeamChambers, Calorimeters, Triggers)
- **SPS** beamlines:
  - **H2** ⟶ STORM, KLEVER
  - **H8** ⟶ SELDOM

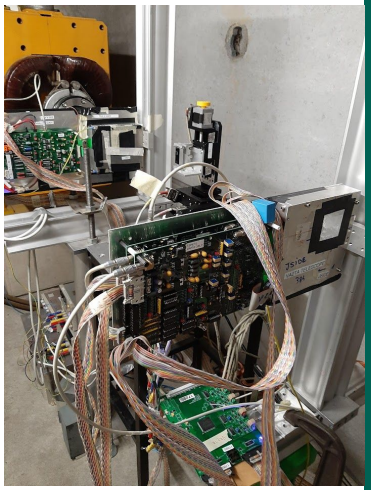
⟶ tests of **oriented crystals**





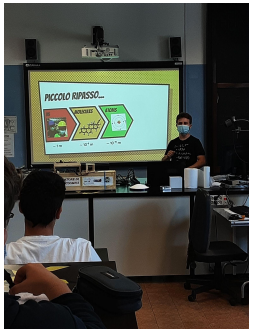






Laboratory tutoring and Physics communication

- **Bachelor degree laboratories**: Laboratory of Modern Physics, Laboratory of Nuclear and Subnuclear Physics
- Opendays
- High school activities
- High school seminars
- 2 Bachelor thesis **co-tutor**

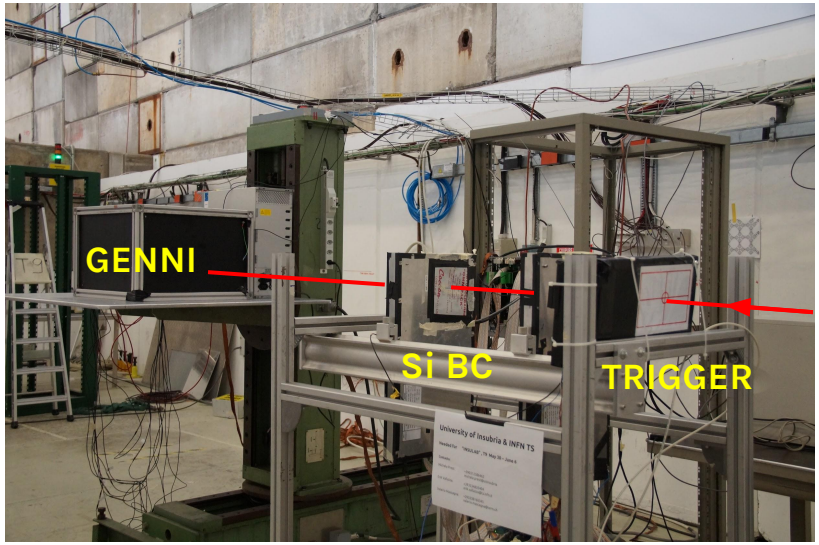


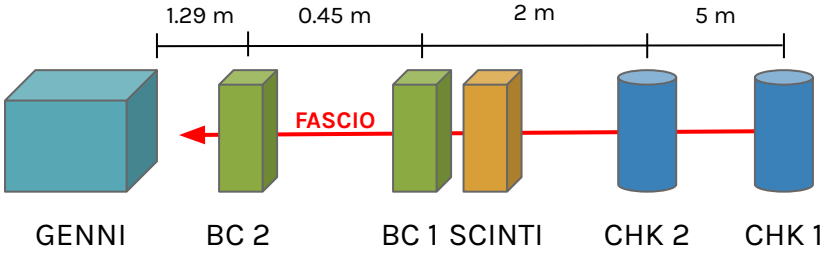
Particles, accelerators and detectors, Federico Ronchetti for high schools

Thank you!

Backup slides

Experimental setup at T9 (Bachelor Thesis)



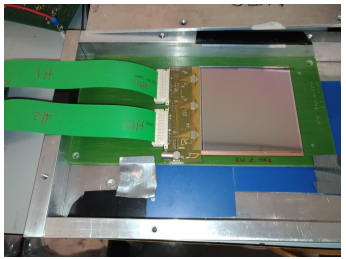


2 CO_2 Cherenkov

Plastic scintillator 10 x 10 cm^2

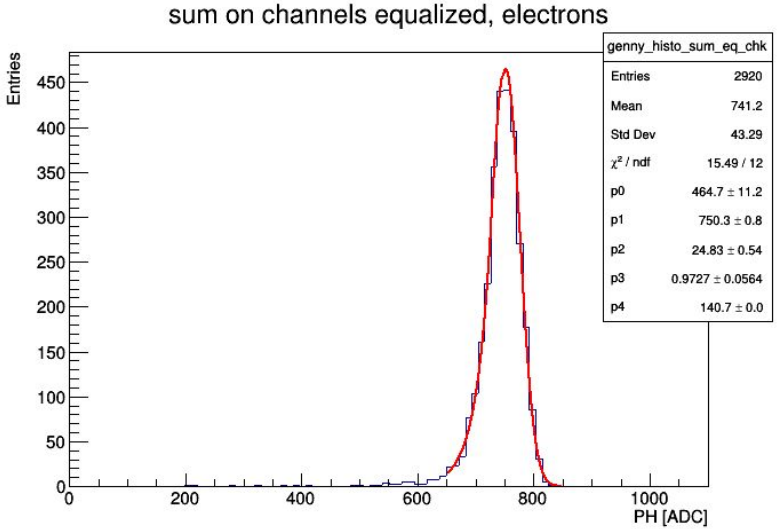
2 Beam Chambers xy AGILE
- 9.5 x 9.5 x 0.041 cm^3
- Spatial resolution ~ 35 μm
- Pitch 242 μm

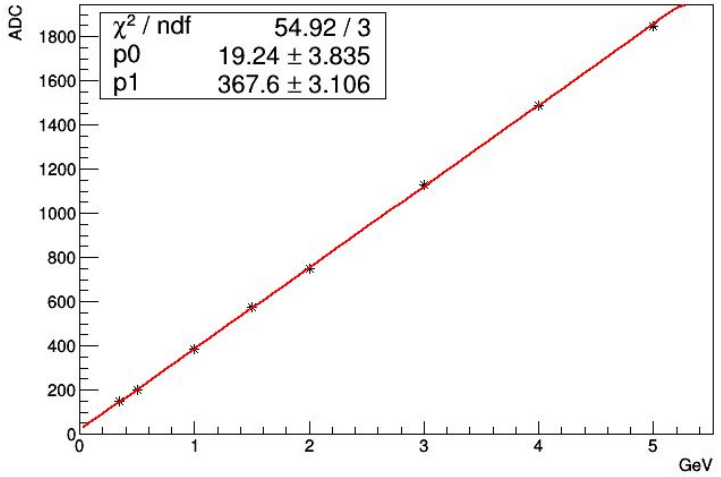
Calorimeter GENNI + digitizer PH/Time



Bachelor Thesis

Calibration



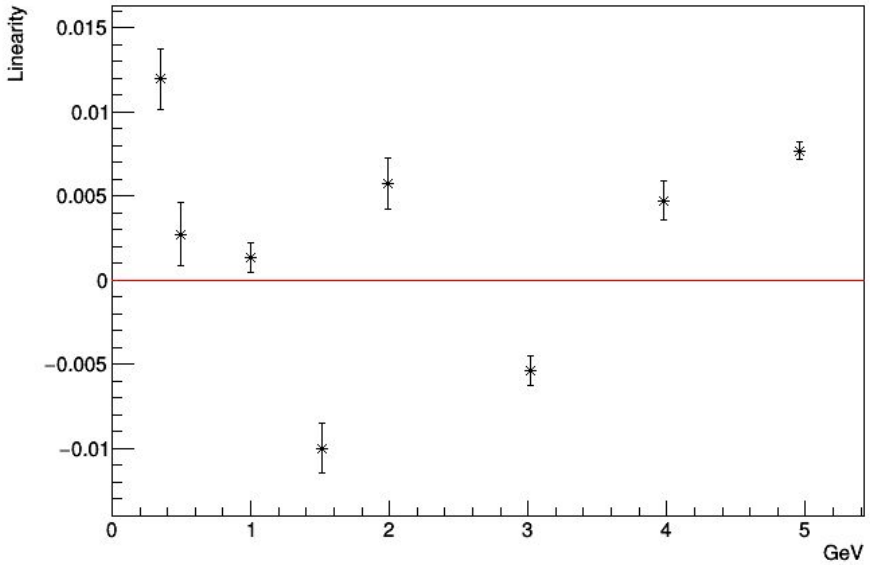


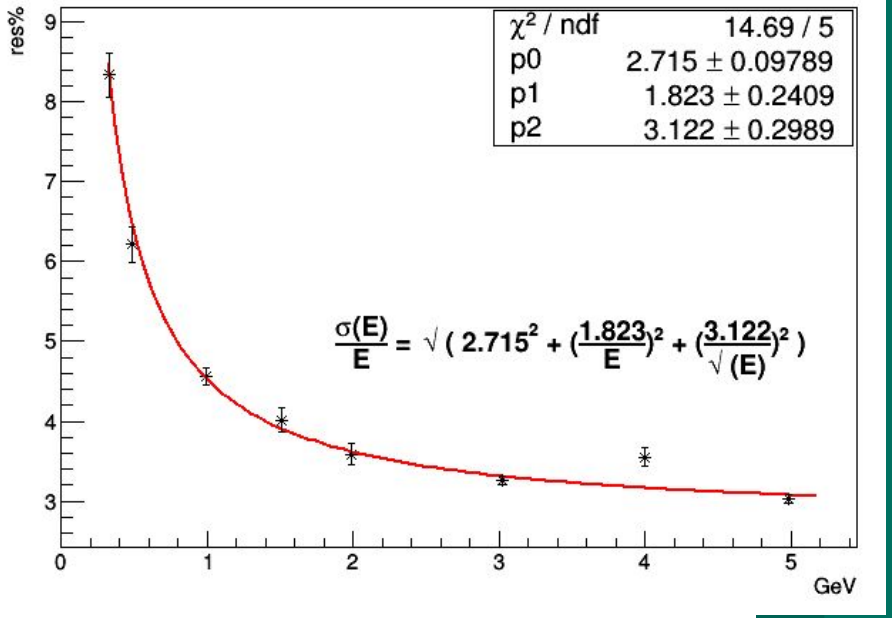
CrystalBall Function

$$f(x,\alpha,n,\bar{x},\sigma) = N \begin{cases} \exp\left(-\frac{(x-\bar{x})^2}{2\sigma^2}\right) & \frac{(x-\bar{x})^2}{2\sigma^2} > -\alpha \\ A\left(B - \frac{x-\bar{x}}{\sigma}\right)^n & \frac{(x-\bar{x})^2}{2\sigma^2} \leq -\alpha \end{cases}$$

Bachelor Thesis

Linearity and energy resolution



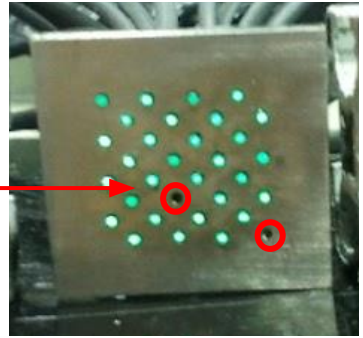


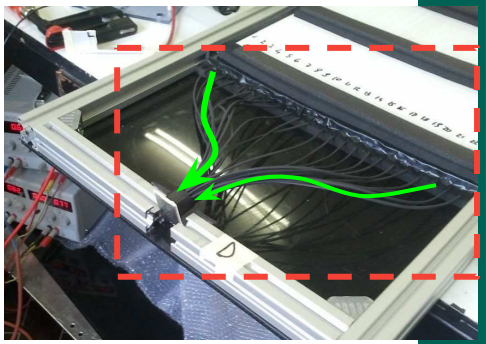
- Measurement of the response linearity and of the energy resolution with electrons in the 0.250-5 GeV energy range
- Data analysis with fortran/PAW and C++/ROOT

Master Thesis

Why the detector upgrade?

- Hamamatsu MAPMT H7546-B → sensitive to the magnetic field
- High voltage supply (HV)
- Fragile mechanics → the efficiency got worse during the years





Upgrade with new light sensors

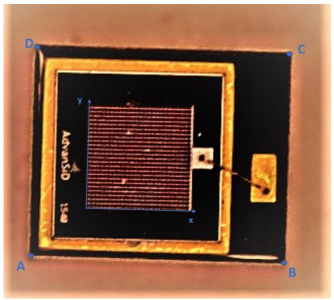
Silicon PhotoMultipliers

- Insensitive to the magnetic field
- No HV supply
- Compact devices and easier coupling with the fibers

BUT

- Response temperature dependance
- Dark noise

AdvanSiD
ASD-RGB1S-P
SiPM active area: 1 x 1 mm^2
Cell dimension: 40 µm
N cells: 625
Quenching resistance: 550 kΩ
Breakdown voltage @ 25 °C: 28 V

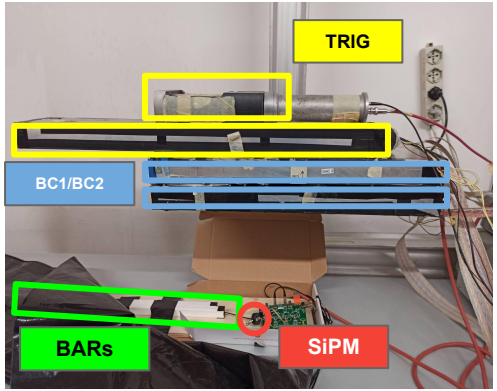


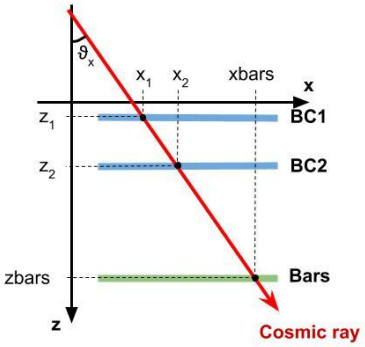
Characterization to control the SNR

Master Thesis

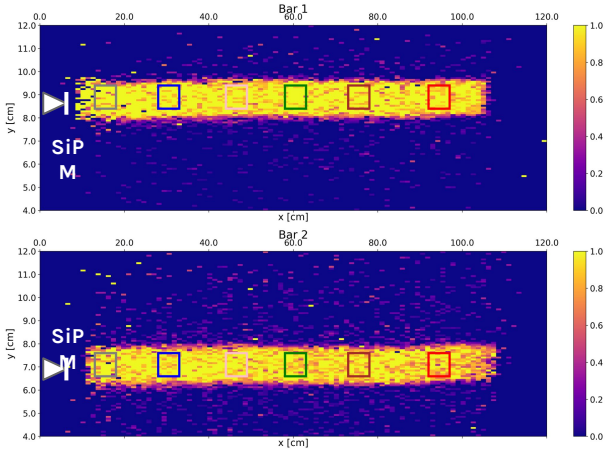
Light attenuation along the bars

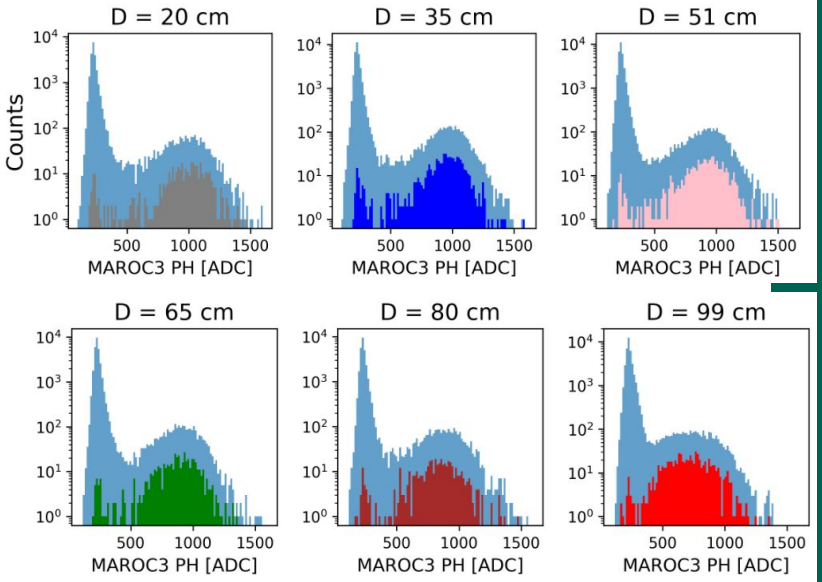
Experimental setup





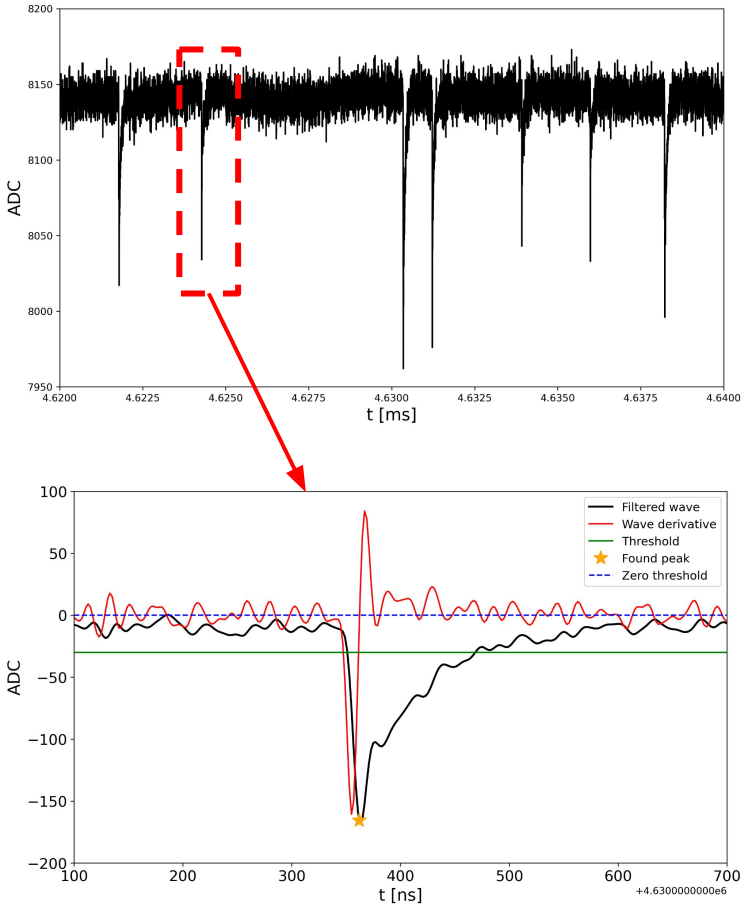
- Trigger scintillators
- Silicon microstrips (AGILE detectors) for the cosmic rays tracking (σ~35 μm)
- 2 test SiPM (FBK 400) + MAROC3





Master Thesis

SiPM dark counts: peak finding algorithm



10 ms dark waveform @26 °C and different biases, acquired by a CAEN DT5730 14 bit digitizer @500 MS/s

Low-pass filter and signal derivative

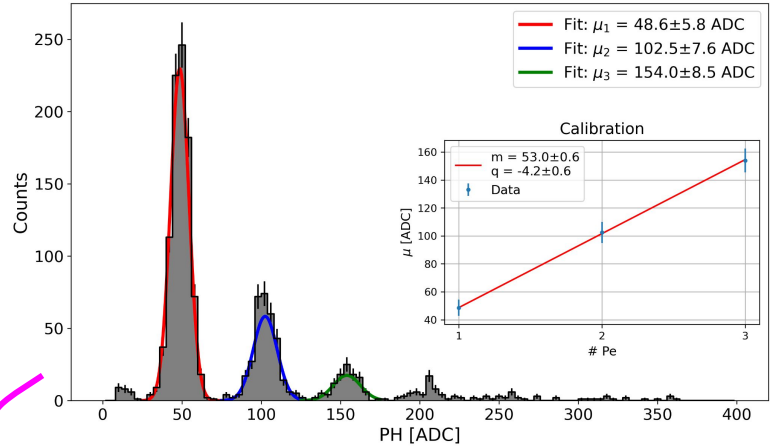
If the derivative is above the given threshold → subsequent cross from 0

Derivative integration ↓ Peak amplitude

Time between subsequent peaks

Master Thesis

Photoelectrons per MIP

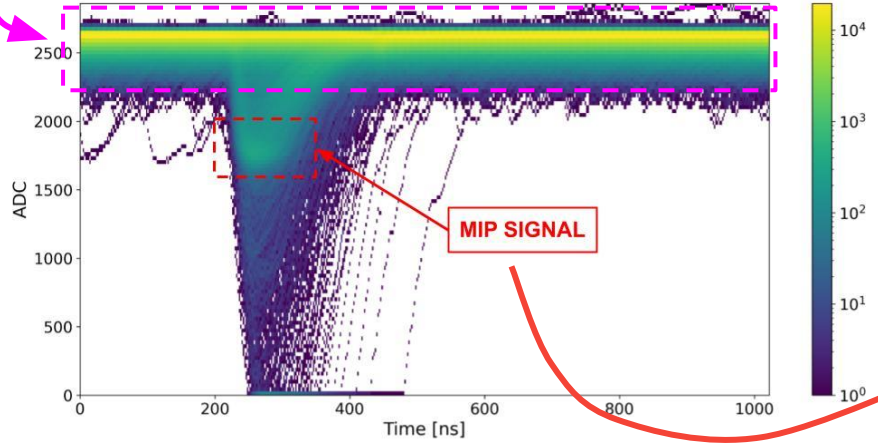


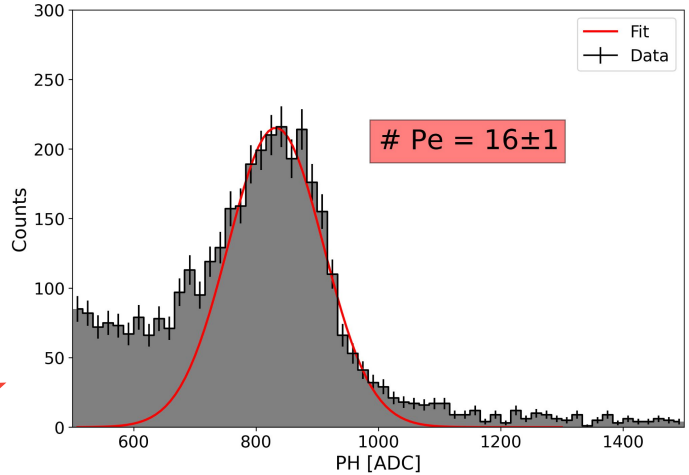
Multiphoton spectrum

- 1, 2, 3 Pe peaks gaussian fit
- ADC - #Pe calibration
- Bars + SiPM @31 V

 # Pe calibration

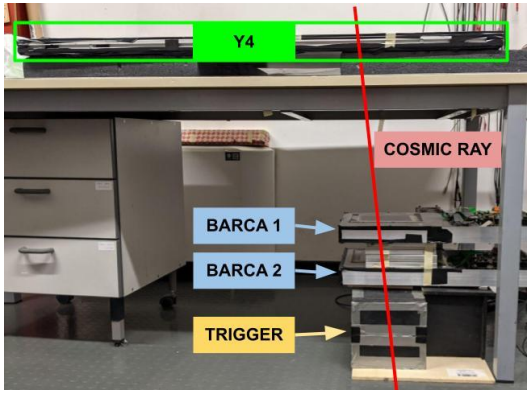
- CAEN DT5730 14 bit digitizer @500 MS/s
- 1024 ns acquisition window
- Peak finding algorithm
- Gaussian fit of the MIP and calibration



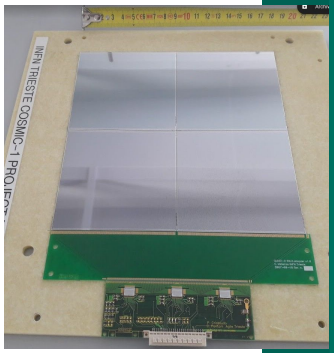


Master Thesis

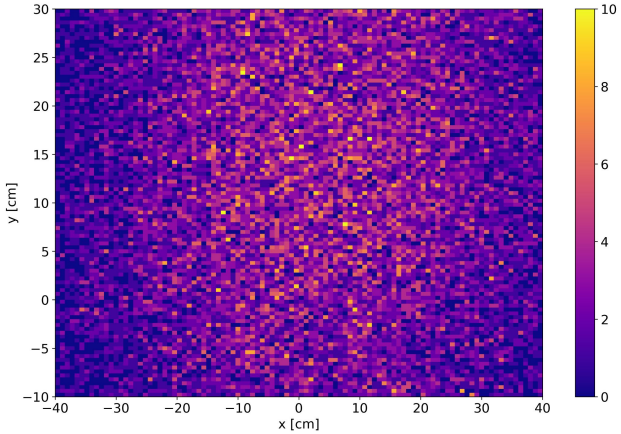
Bars efficiency measurement



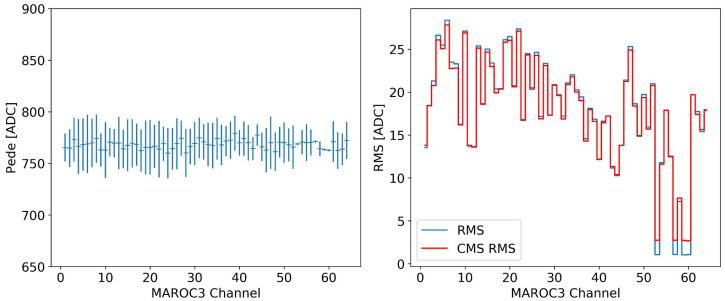
- 4 DANTE modules
- 2 trigger scintillators
- 4 silicon microstrip trackers (Barca1 e Barca2), 18 x 18 cm^2, 410 μm thick and 60 μm resolution

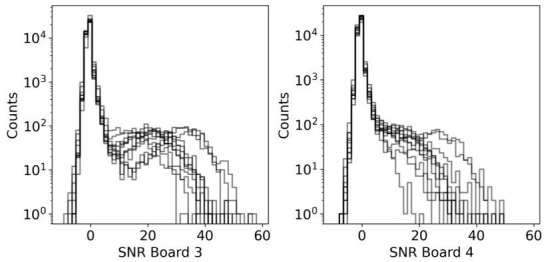


Tracks projection



Pedestal

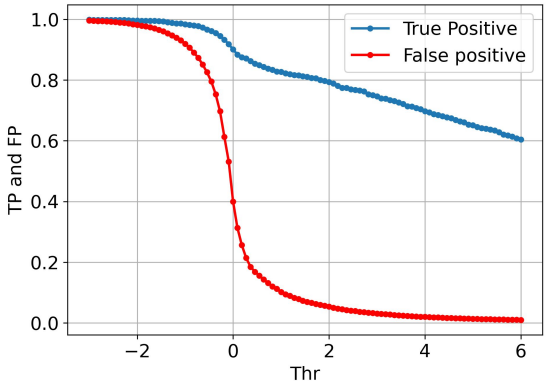


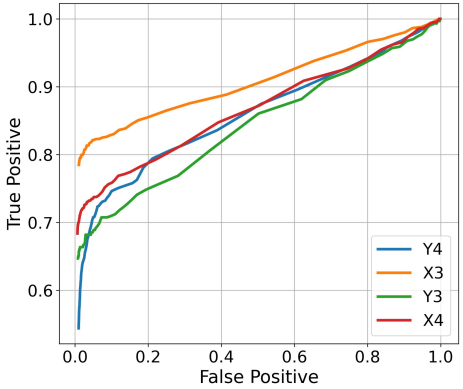


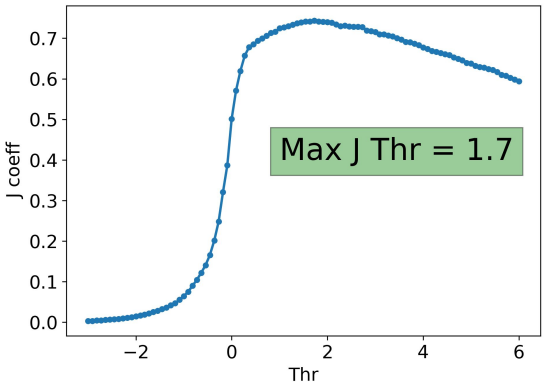
$$\text{Threshold} = n \times \text{RMS}_{\text{pede}}$$

Master Thesis

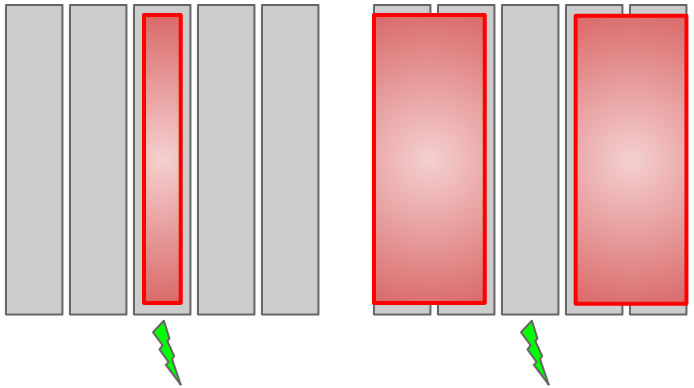
Bars efficiency measurement: ROC method for the best threshold







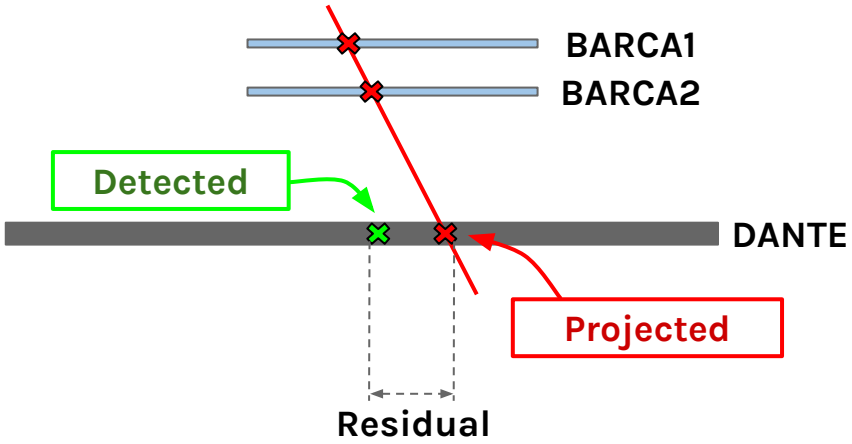
True Positives (TP) **False Positives (FP)**

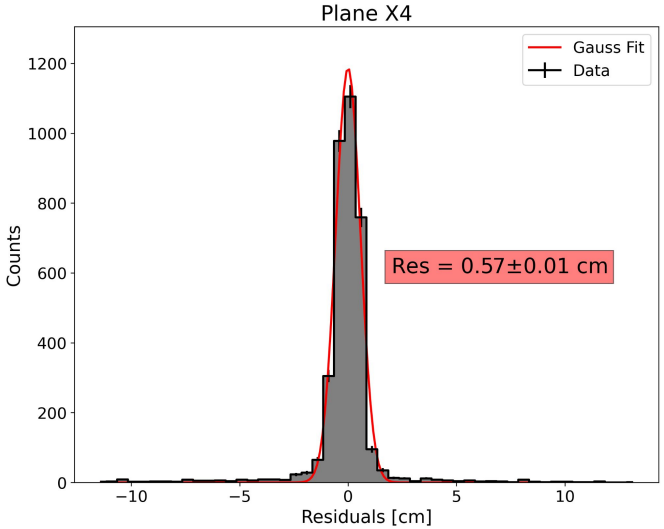


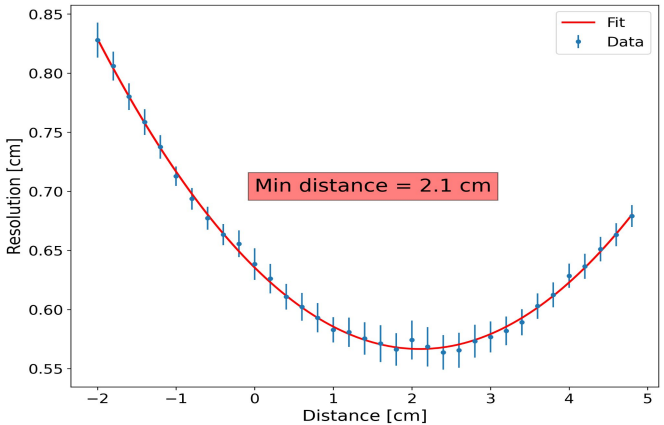
- True Positives and False Positives estimate
- ROC curves for every modules
- Youden coefficient J estimate → distance between the ROC curve and the 1st quadrant bisector
- Maximum J calculation

Master Thesis

Spatial resolution measurement: residuals method and minimization





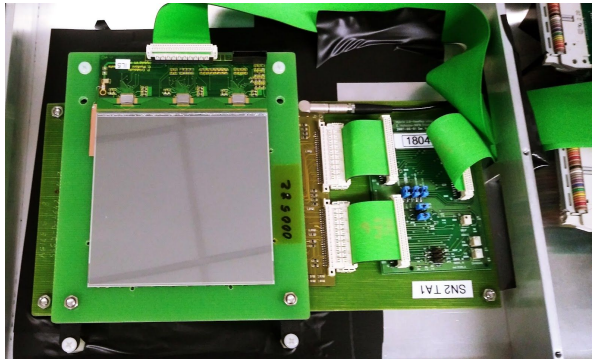


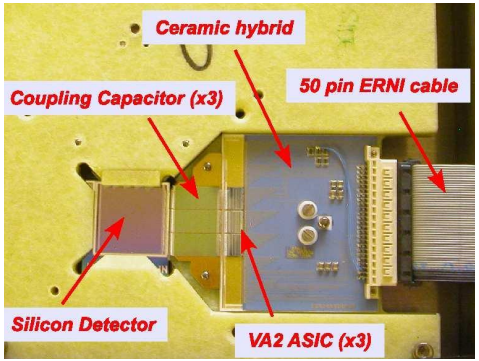
Residuals minimization

Plane	Spatial Resolution
Y4	(0.56 ± 0.02) cm
X4	(0.57 ± 0.01) cm
Y3	(0.63 ± 0.01) cm
X3	(0.69 ± 0.01) cm

The INSULAB silicon detectors

Beam Telescopes (Tele) and Beam Chambers (BC)





- single side AGILE spare sensors → 2 layers per module with different vistas
- **large active area**: **~9.29×9.29cm²**
- 384 channels per side with physical pitch 121μm and readout pitch 242μm → **spatial resolution is ~30μm**
- thickness is 410μm per layer → 820μm per module
- same **robustness** (direct bonding, ASICs and sensor on the same fiberglass board) and **low voltage requirement** as the single side telescope modules

- double side CSEM sensors
- **1.92cm×1.92cm**×300μm → **low material budget**
- 384 channels per side – physical pitch is 25μm on junction side (½ floating) and 50μm on ohmic side → **high spatial resolution: Jside 5.6 μm & Oside 11.6 μm**
- full depletion in (36,54)V → **low voltage requirement**, along with the ±5V levels for the electronic chain

Interesting bibliography:

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- F. Ronchetti, The new readout system of the ASACUSA scintillating tracker, Master Degree in Physics, 2022, The new readout system of the ASACUSA scintillating tracker - CERN Document Server
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