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ATOMKI@LNL

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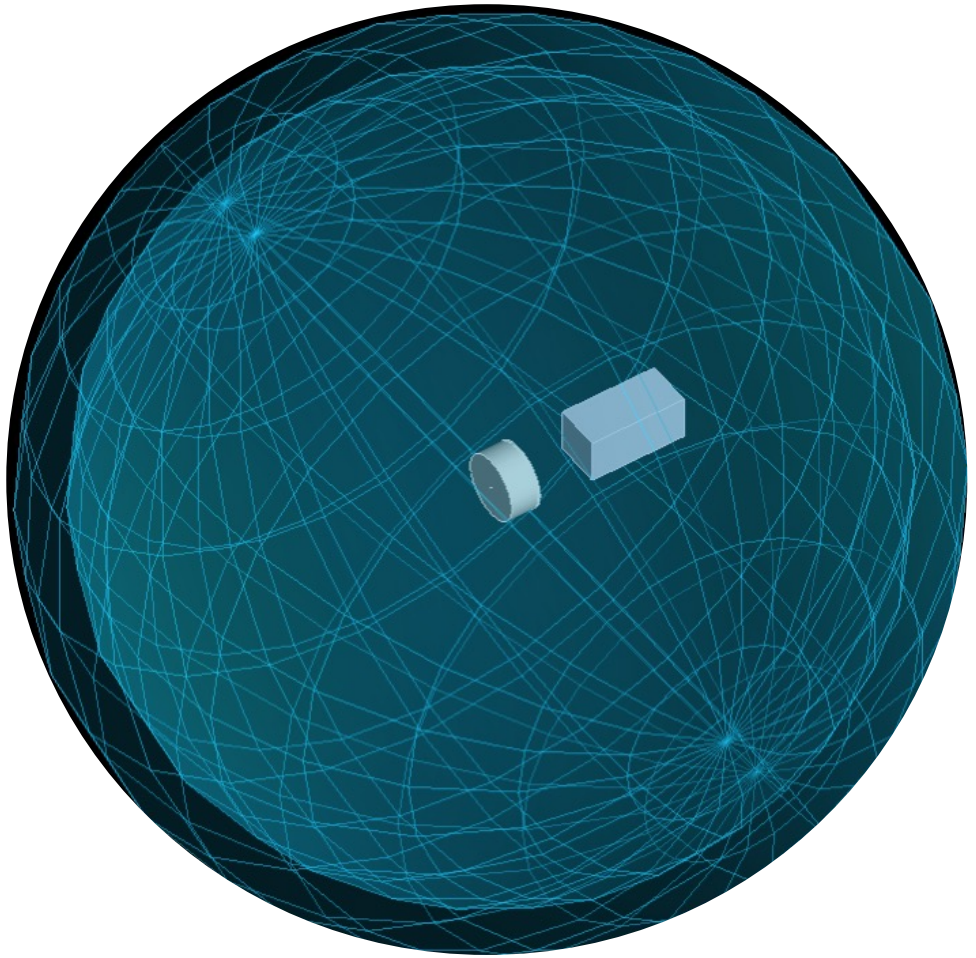
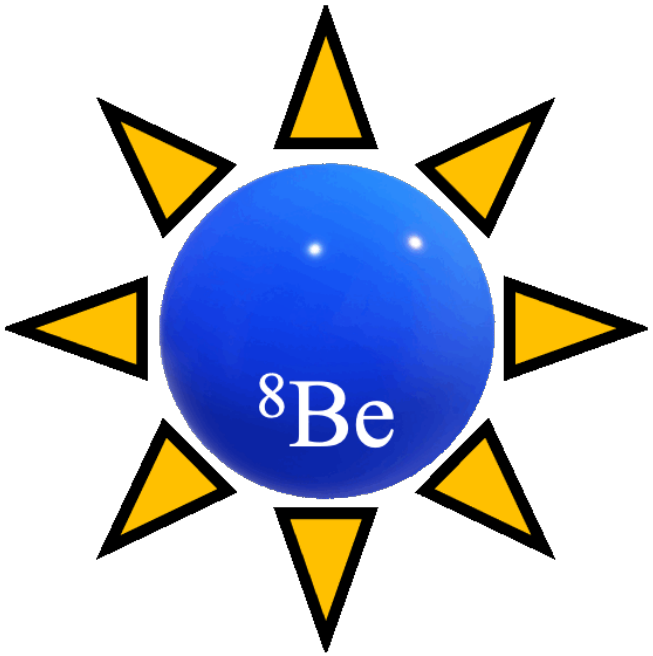
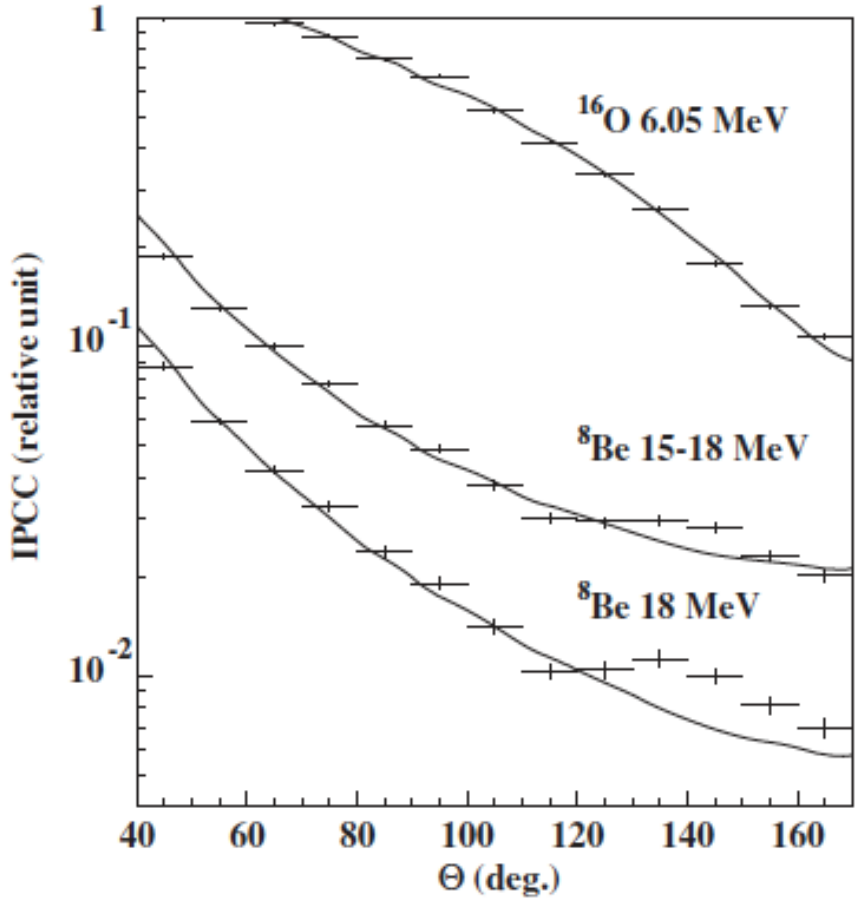
Outline

- Introduction:
  - Internal Pair Creation in ^{8}Be
  - Challenges in the $e^{+}e^{-}$ angular correlation distribution measurements
- Setup Construction @INFN-LNL:
  - General characteristics
  - Muon measurement
  - Future work
- Summary



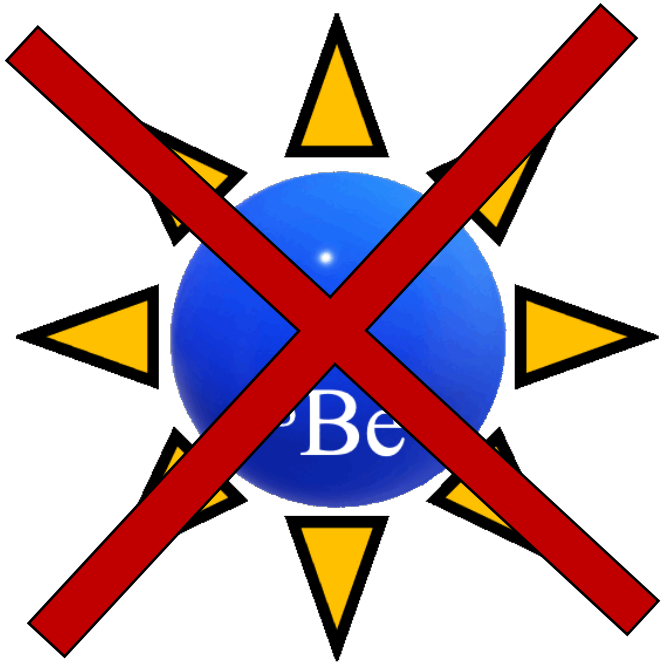
Internal Pair Creation in ^{8}Be

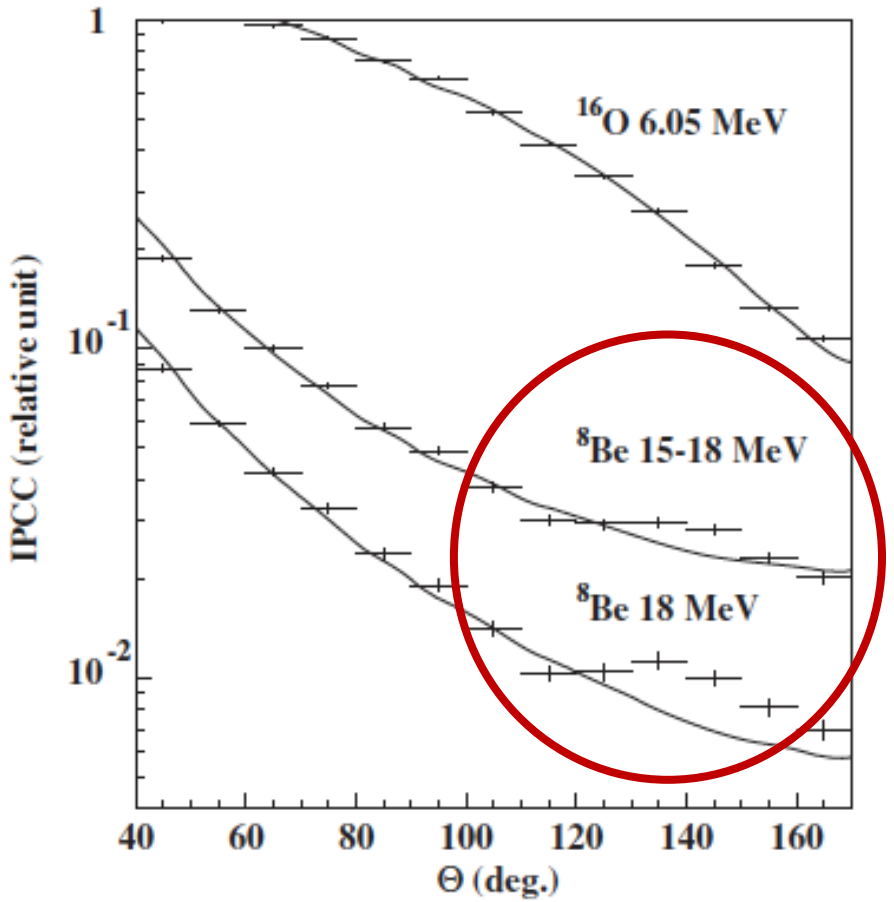




A. J. Krasznahorkay et al., Phys. Rev. Lett. 116, 042501 (2016).

Internal Pair Creation in ^{8}Be





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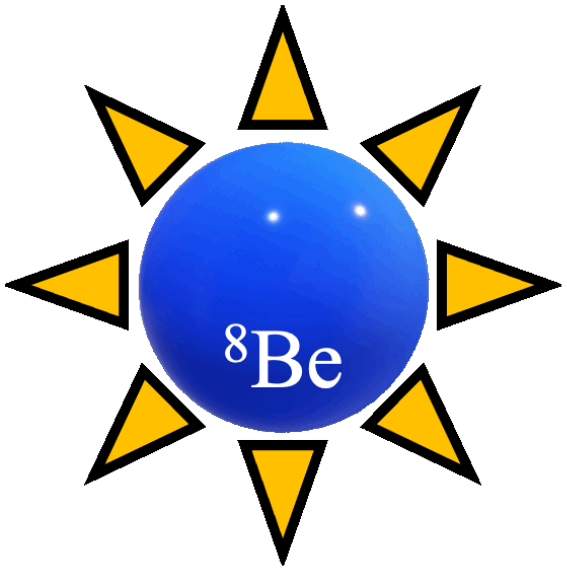
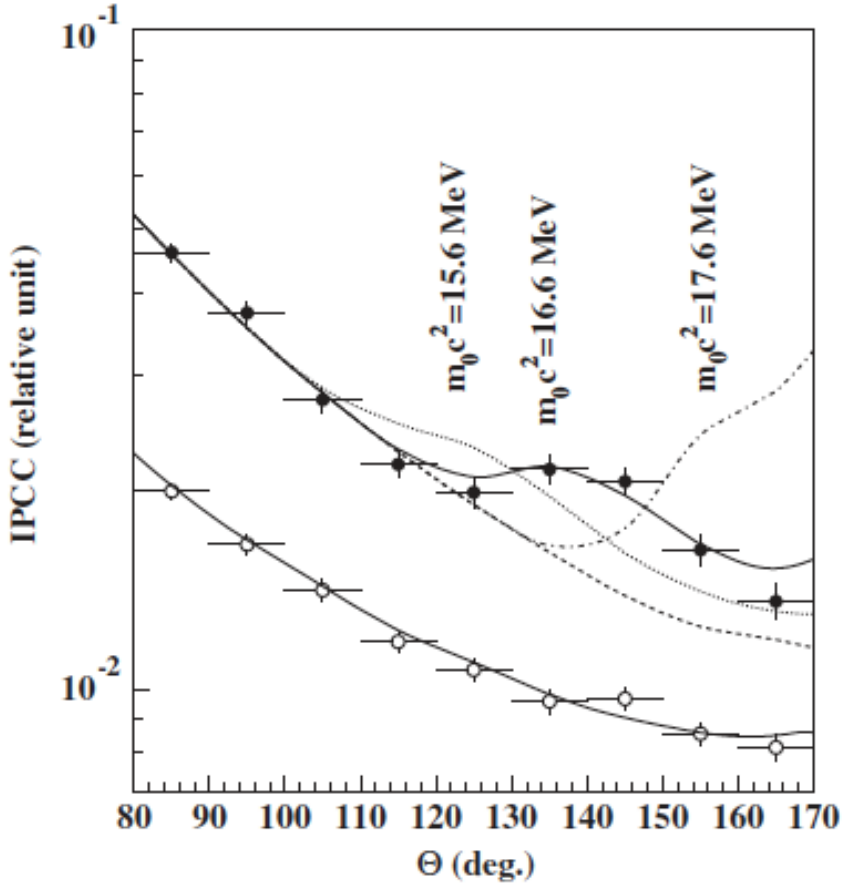
Emission of a Neutral Boson





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Challenges in the e^+ e^- angular correlation distribution measurements

- Low probability of the pair emission
- Higher electron/positron emission energy than in beta decay
- High angular resolution is needed
- The tortuous path of electrons/positrons inside materials

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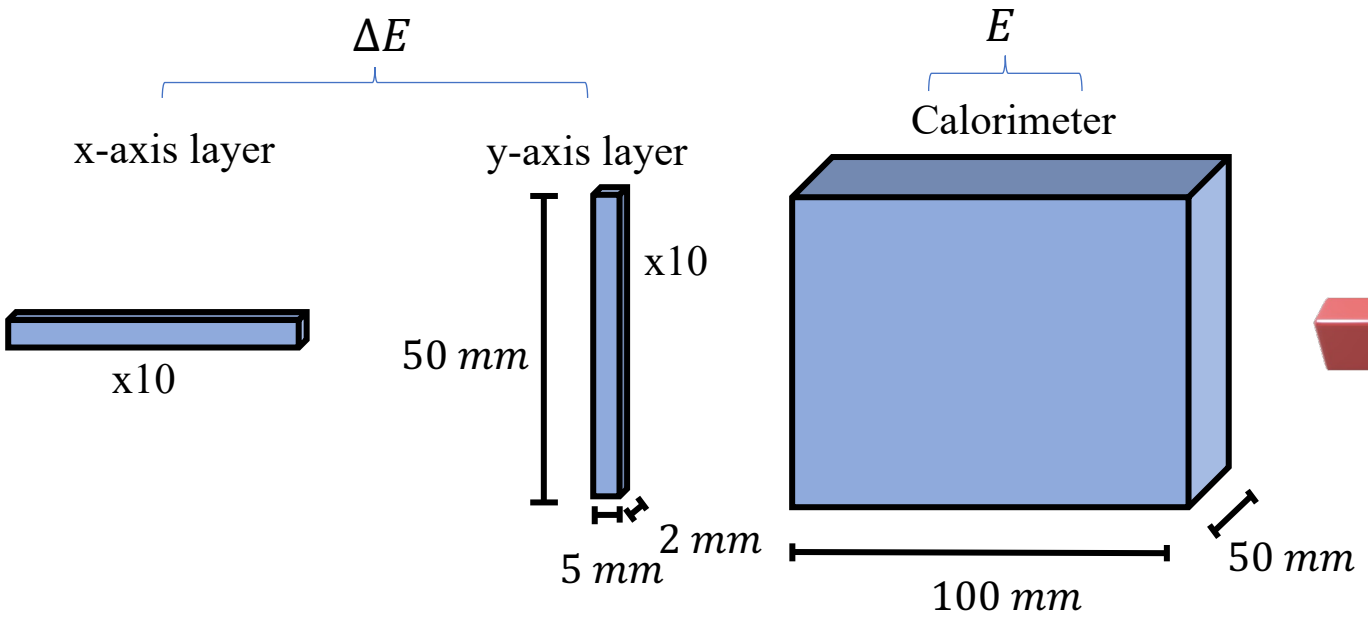
Challenges in the e^+ e^- angular correlation distribution measurements

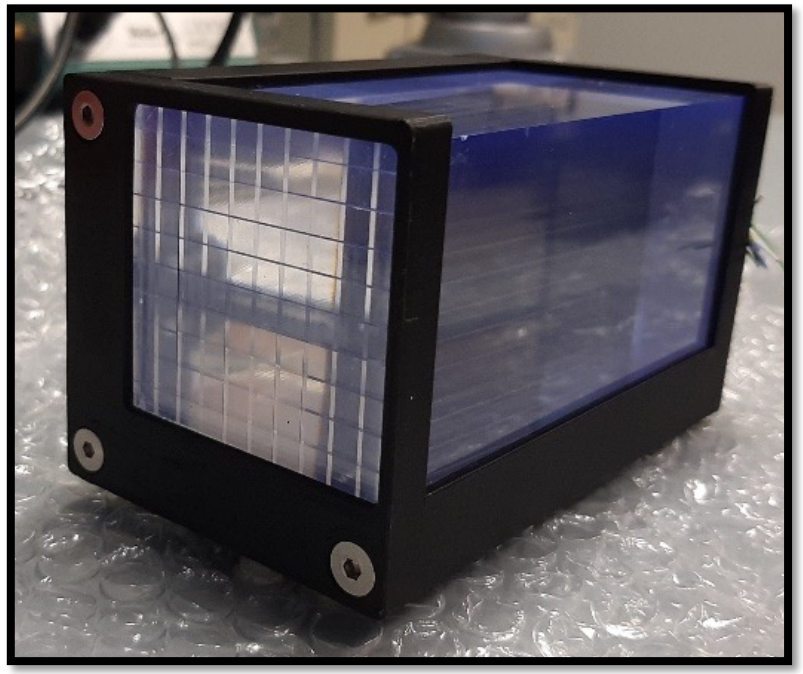
- Charge identification
- Background discrimination
- Calibration of the detectors

Aim

The present project aims to build a setup able to measure e^+e^- pair in coincidence to measure the e^+e^- angular correlation distribution in the internal pair creation of ^8Be.

Telescope Design



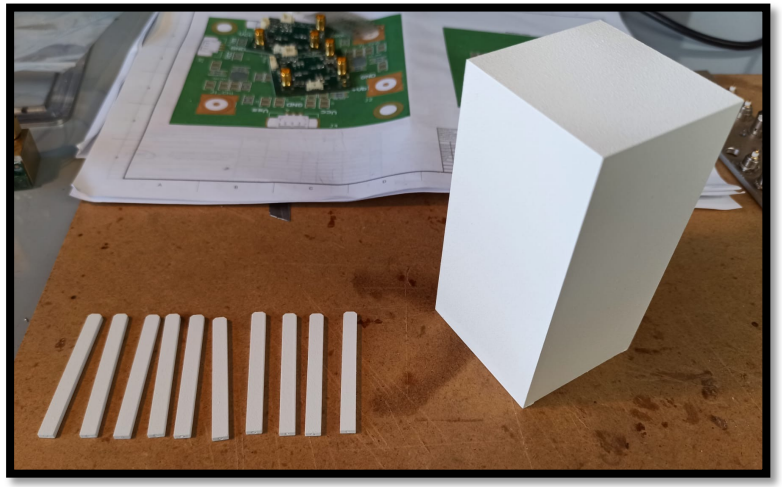


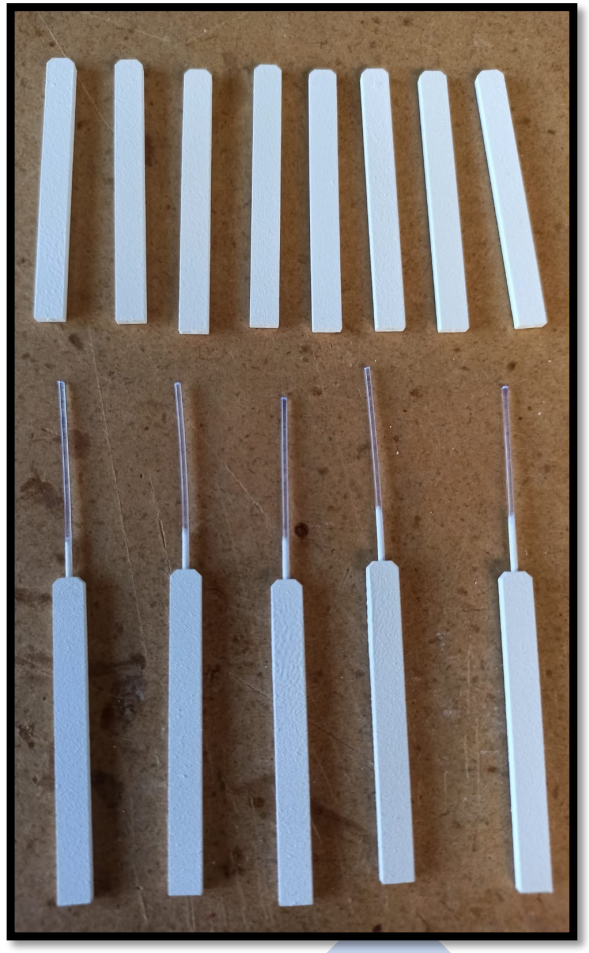
Plastic scintillator: EJ-200

Preparation of the components

Refractive Paint EJ-510

Every element is painted



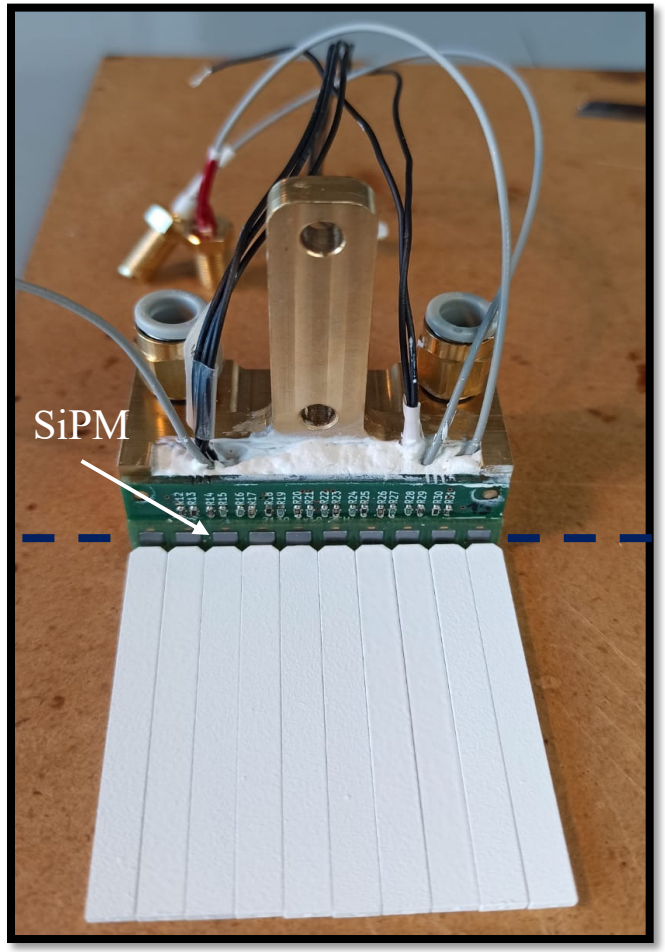


Optical fibers inside the bars

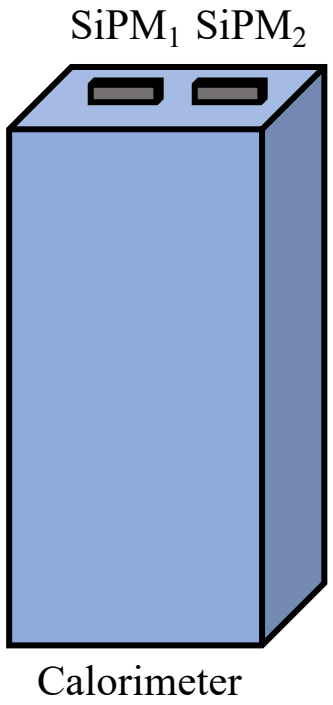
Position Incidence Calculation

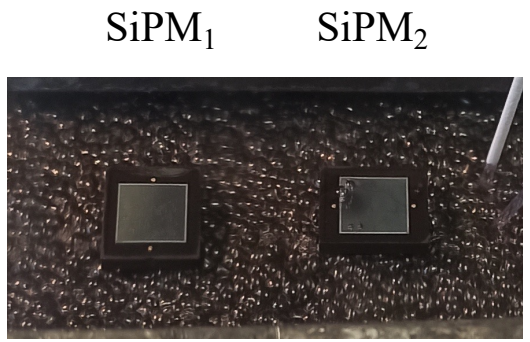
$$Positon:\ x = \frac{E_r - E_l}{E_r + E_l}$$

$$Deposited\ Energy:\ E = E_r + E_l$$



Deposited Energy in the Calorimeter





$$Deposited\ Energy: \quad E = E_{SiPM\_1} + E_{SiPM\_2}$$

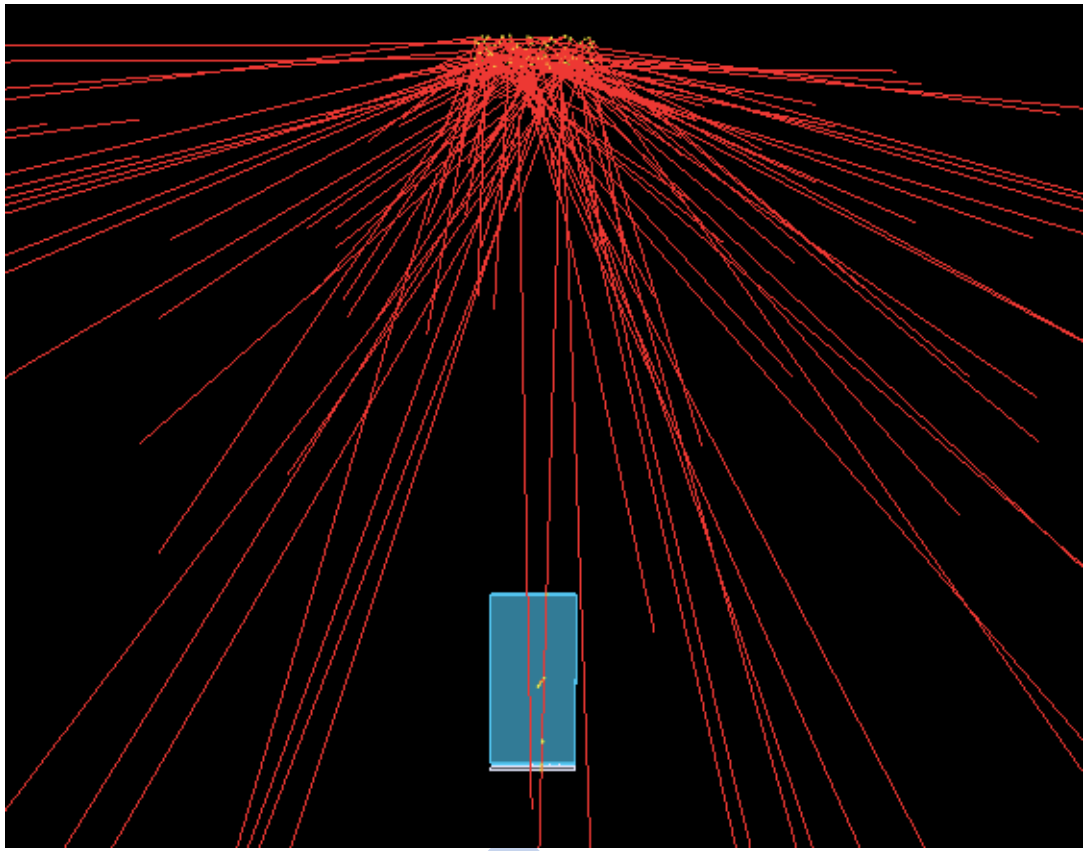
Muon Test: Simulation & Experiment

- To study the detector behavior at energies close to the range of interest
- These particles are frequently arriving on the surface of the Earth
- Even when their energy is very high (~4 GeV), they deposit around 2 MeV/cm in the scintillator material.
- To test the position incidence sensitivity of the telescope

Challenge: Select the muons passing through the telescope in straight paths

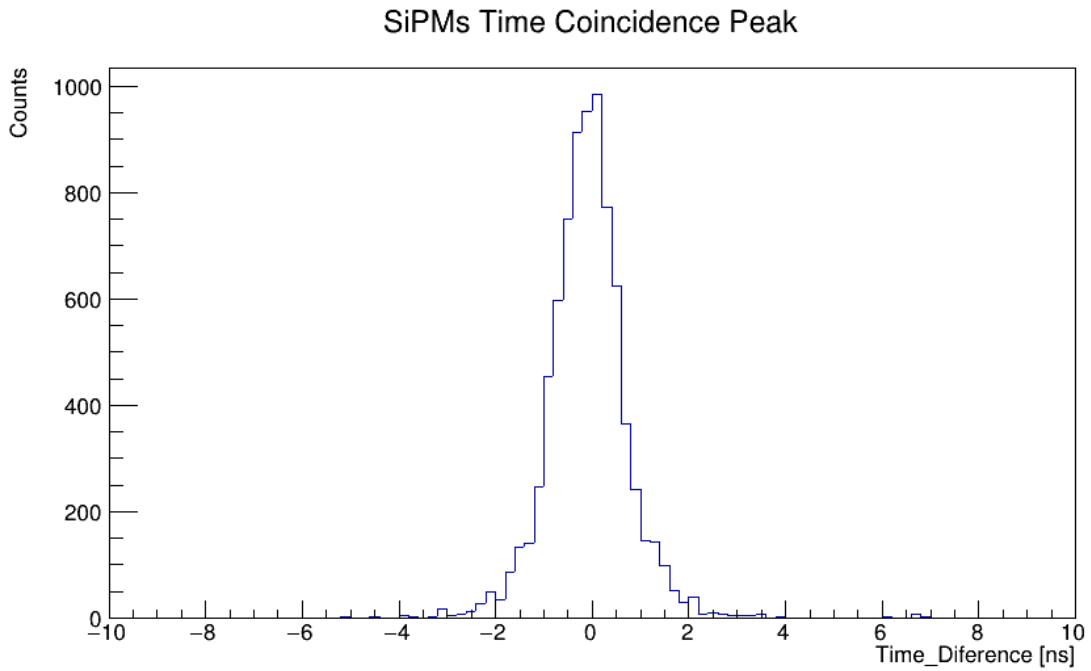
Muon Test: Simulation & Experiment

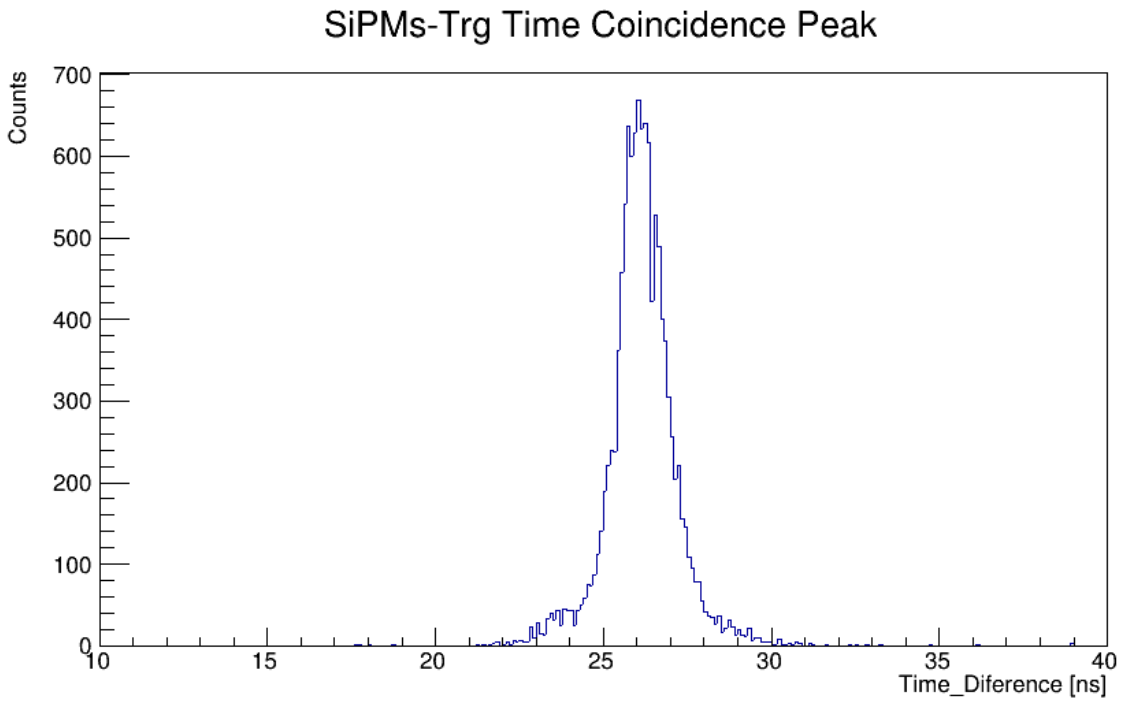
- Muons passing through a trigger scintillator from 32 cm above the telescope
- The simulation and experiment were carried out with one telescope.
- Efficiency:
  - Geant4 simulation: (0.91 ± 0.01) %
  - Experiment: (1.02 ± 0.10) %



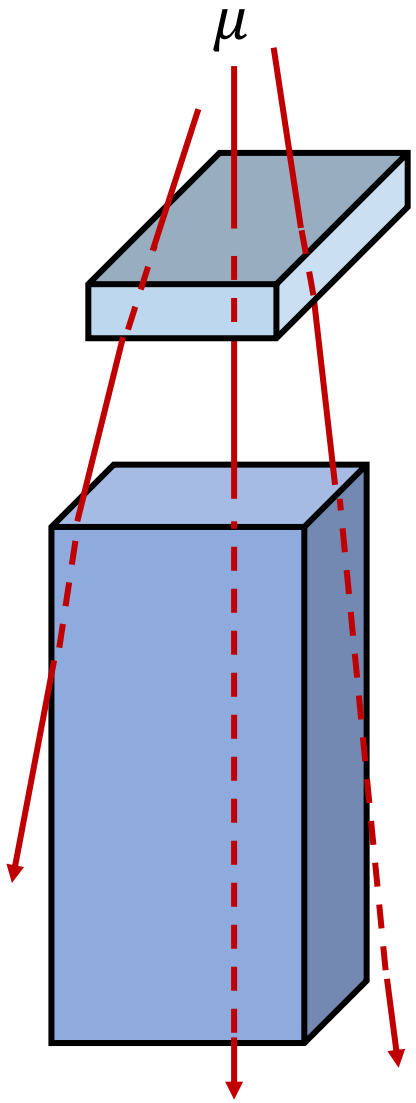
Muon Test: Simulation & Experiment

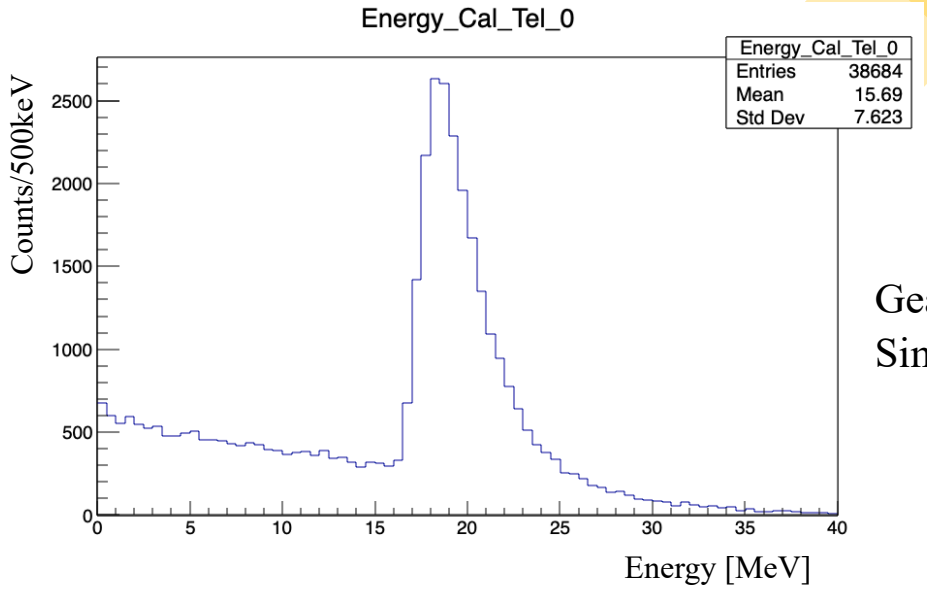
Discrimination of events of interest via coincidence time gates:



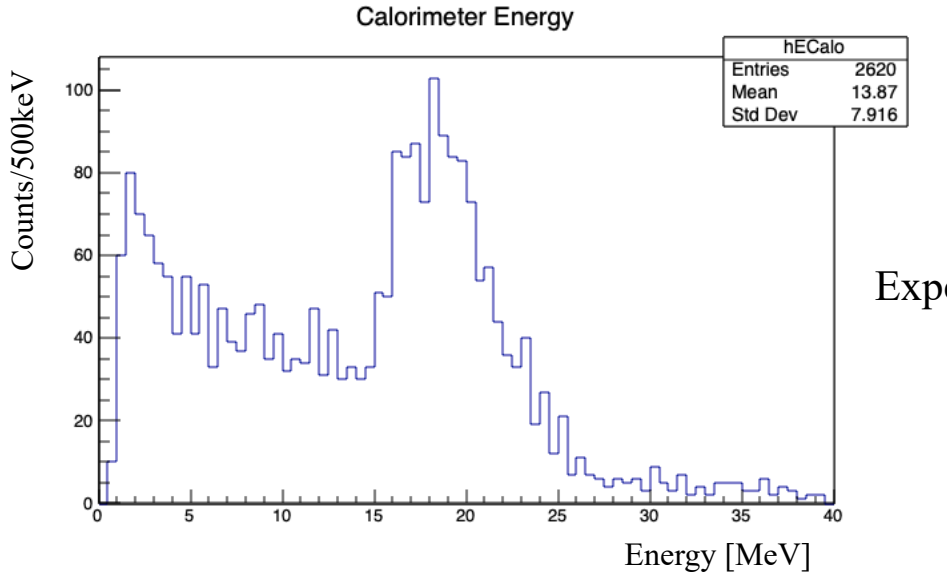


Cosmic Muons Measurement



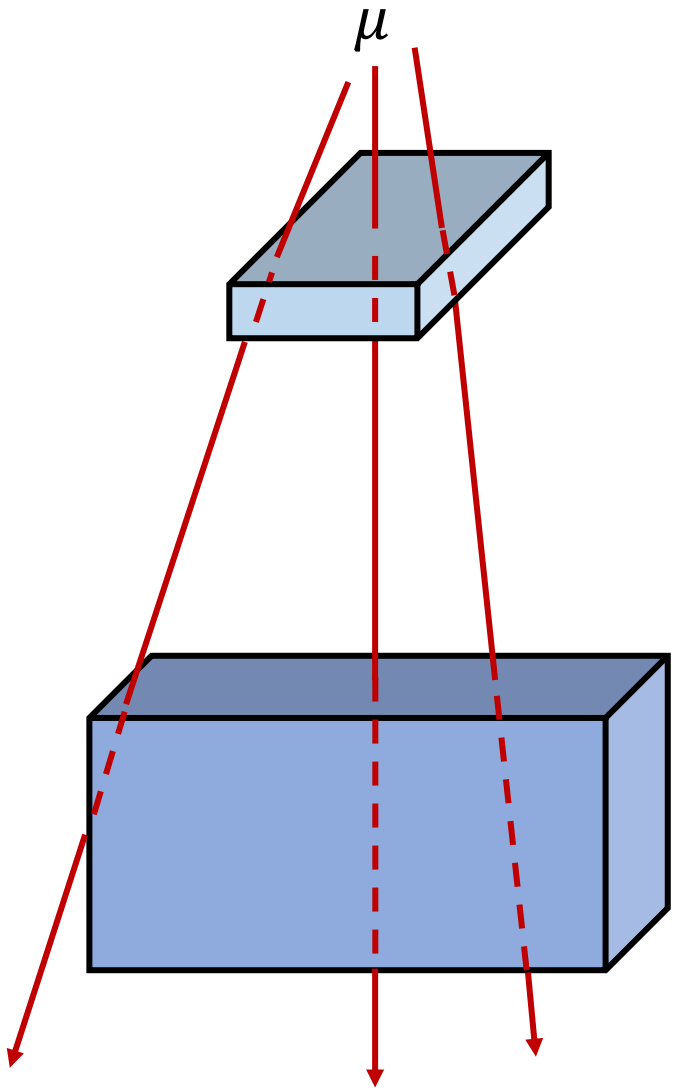


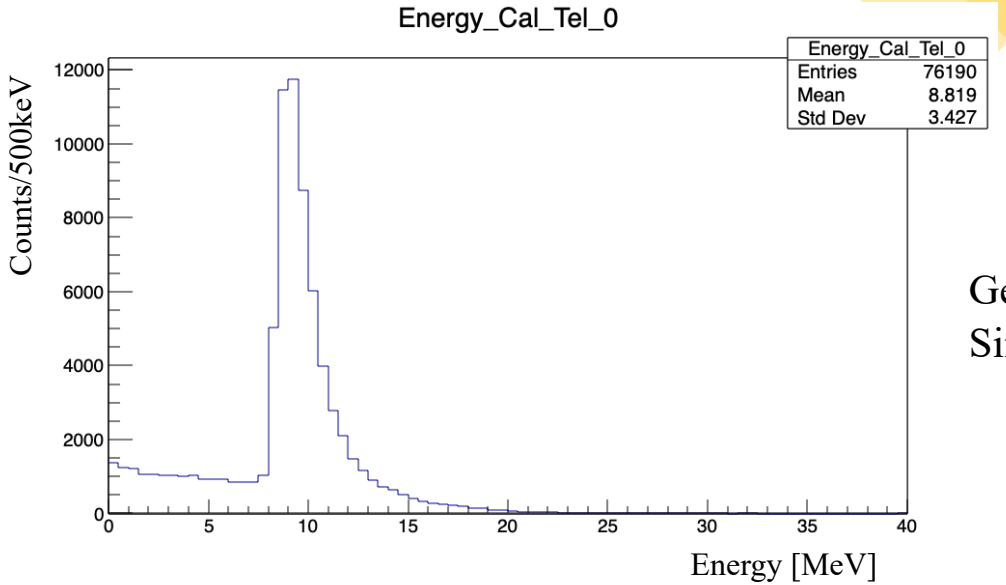
Geant4 Simulation



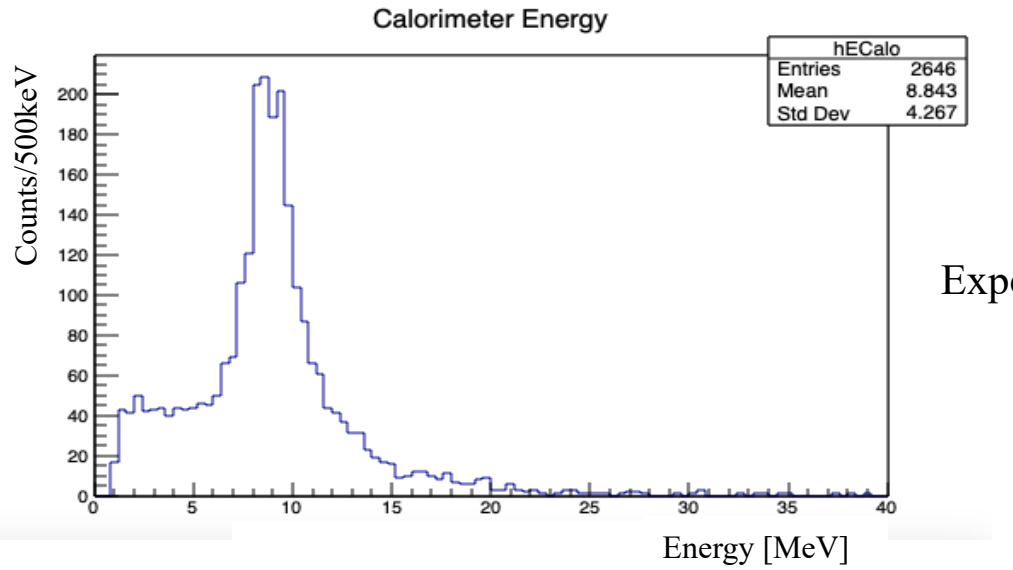
Experiment

Cosmic Muons Measurement





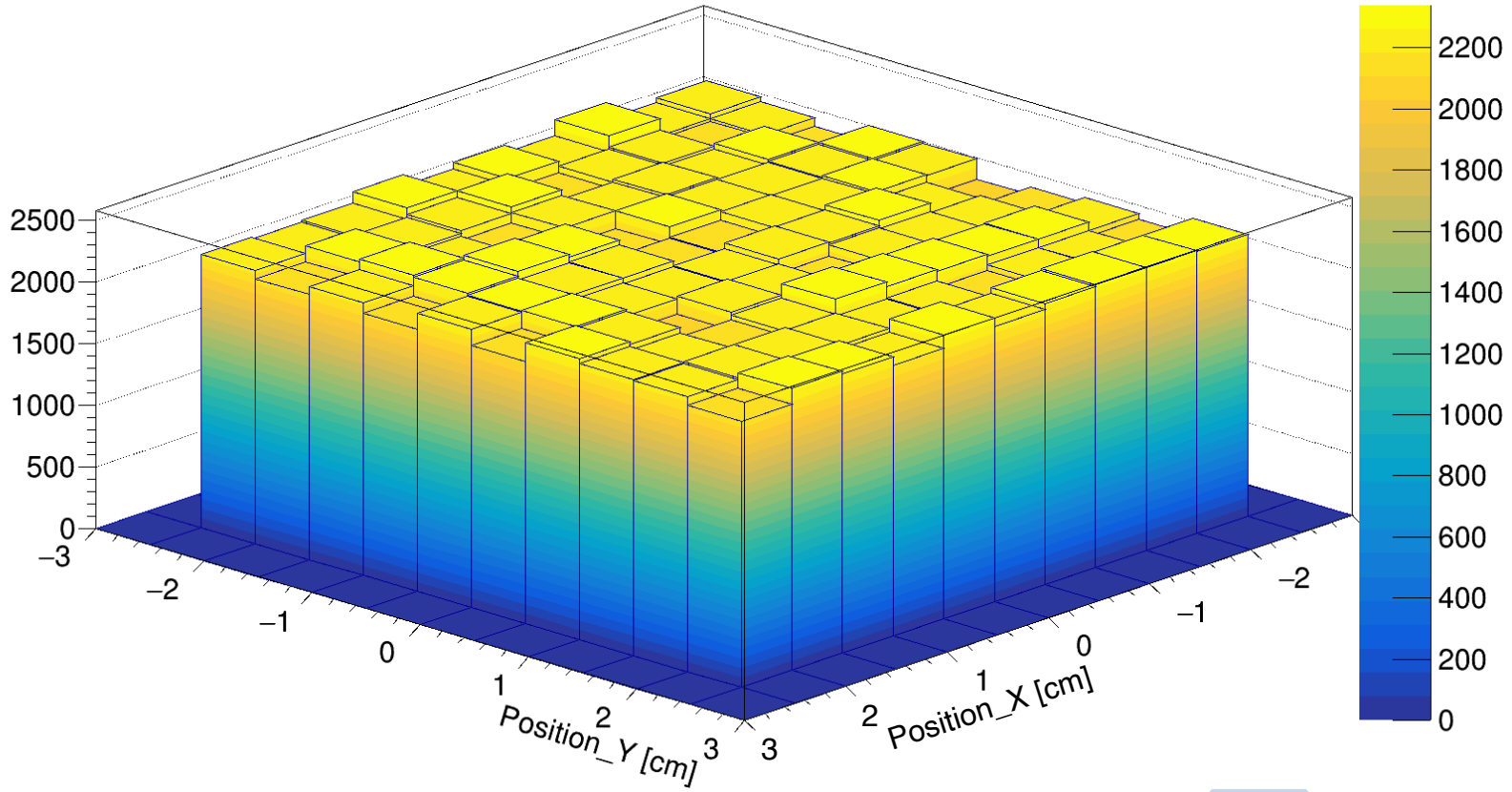
Geant4 Simulation



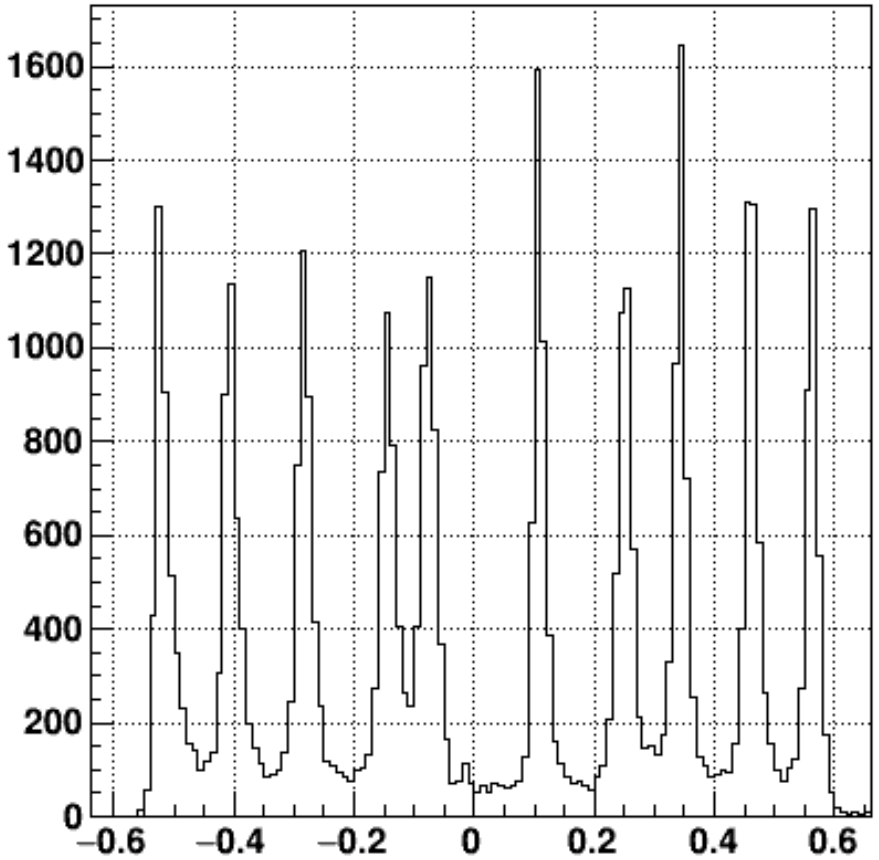
Experiment

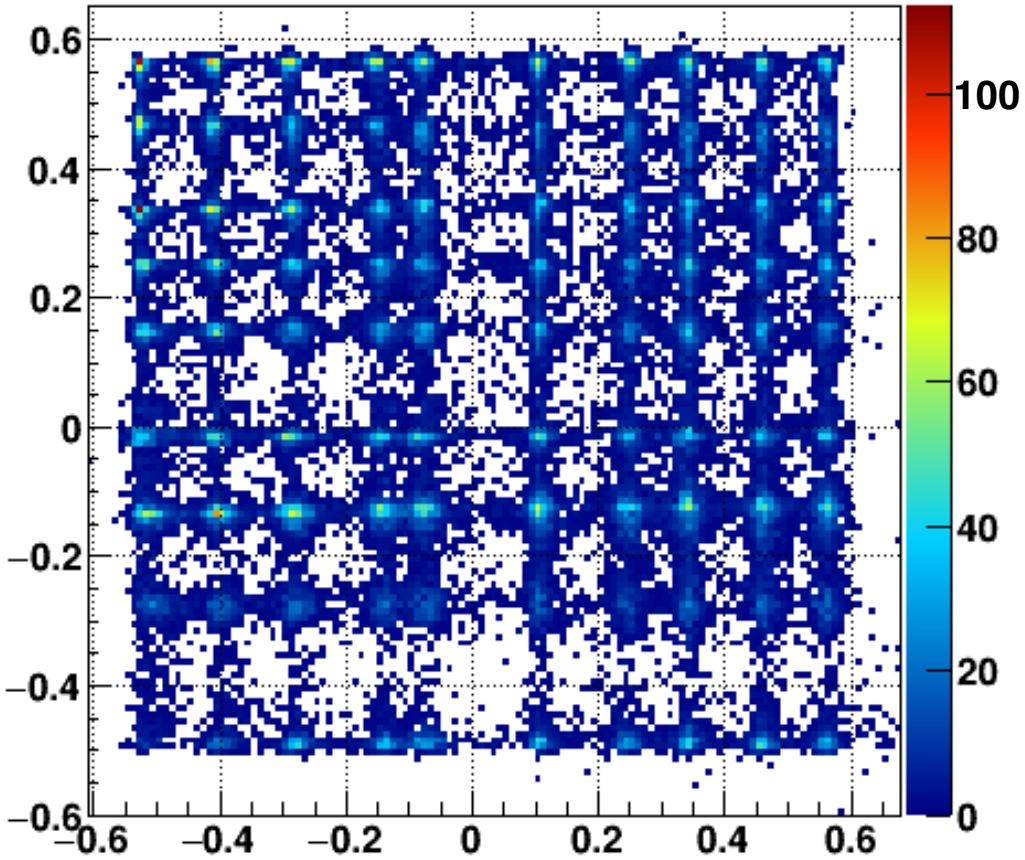
Muon Test: Simulation & Experiment

Position incidence Geant4 Simulation

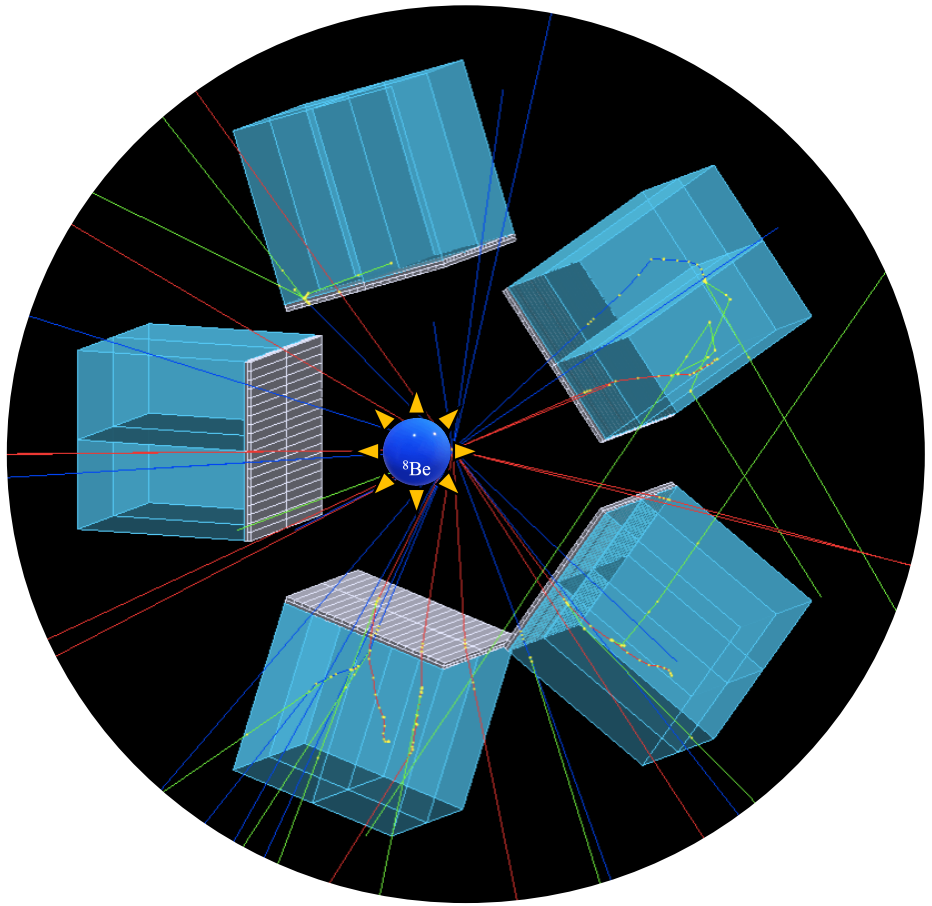


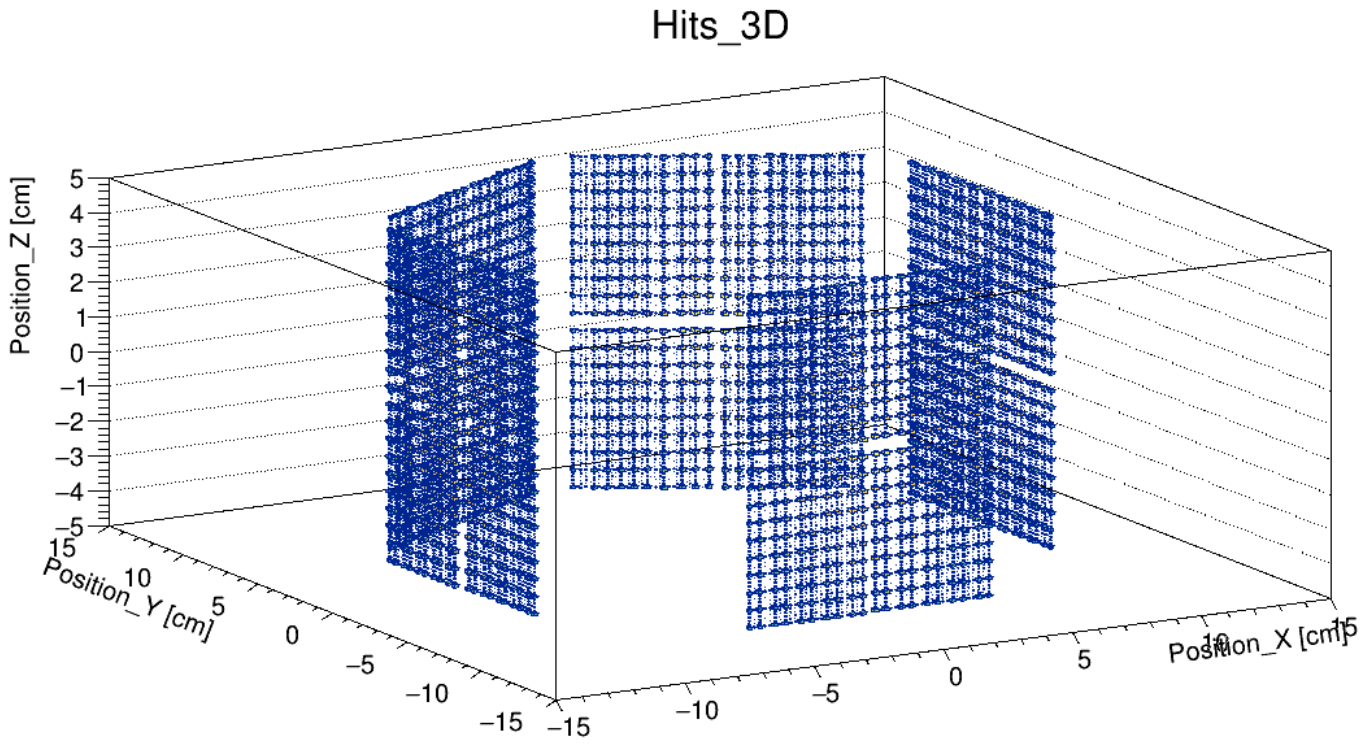
Muons Test: Simulation & Experiment





Complete Setup for the First Experiment





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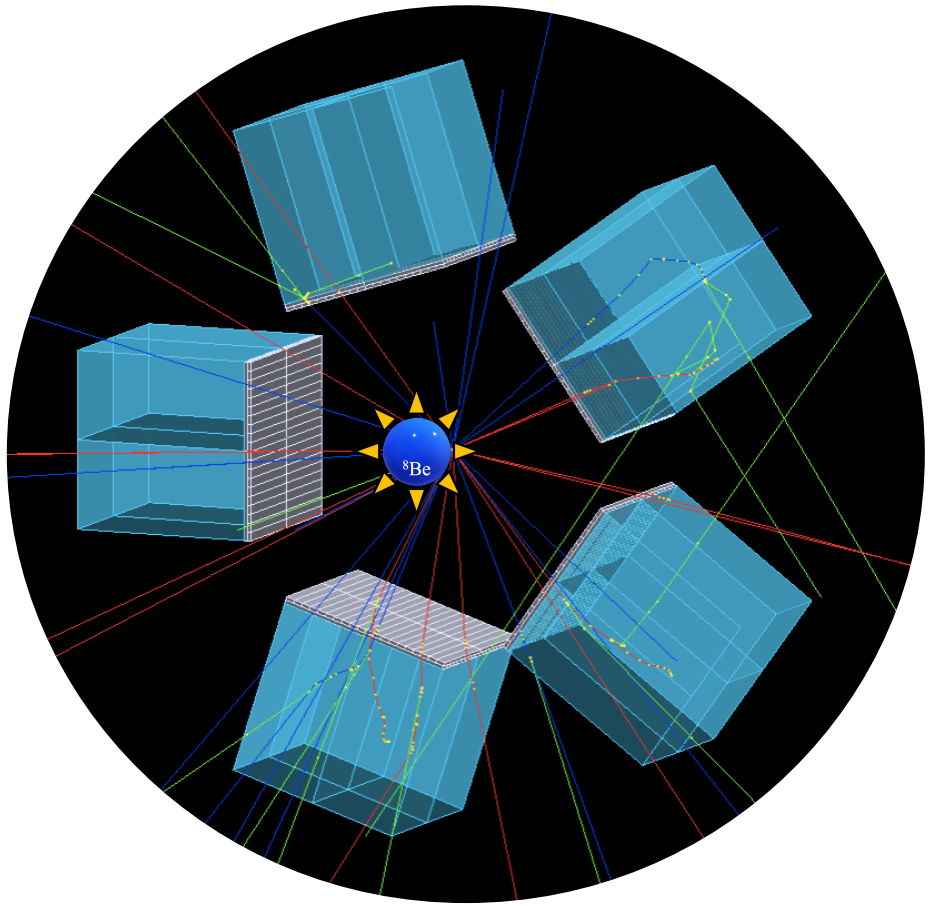

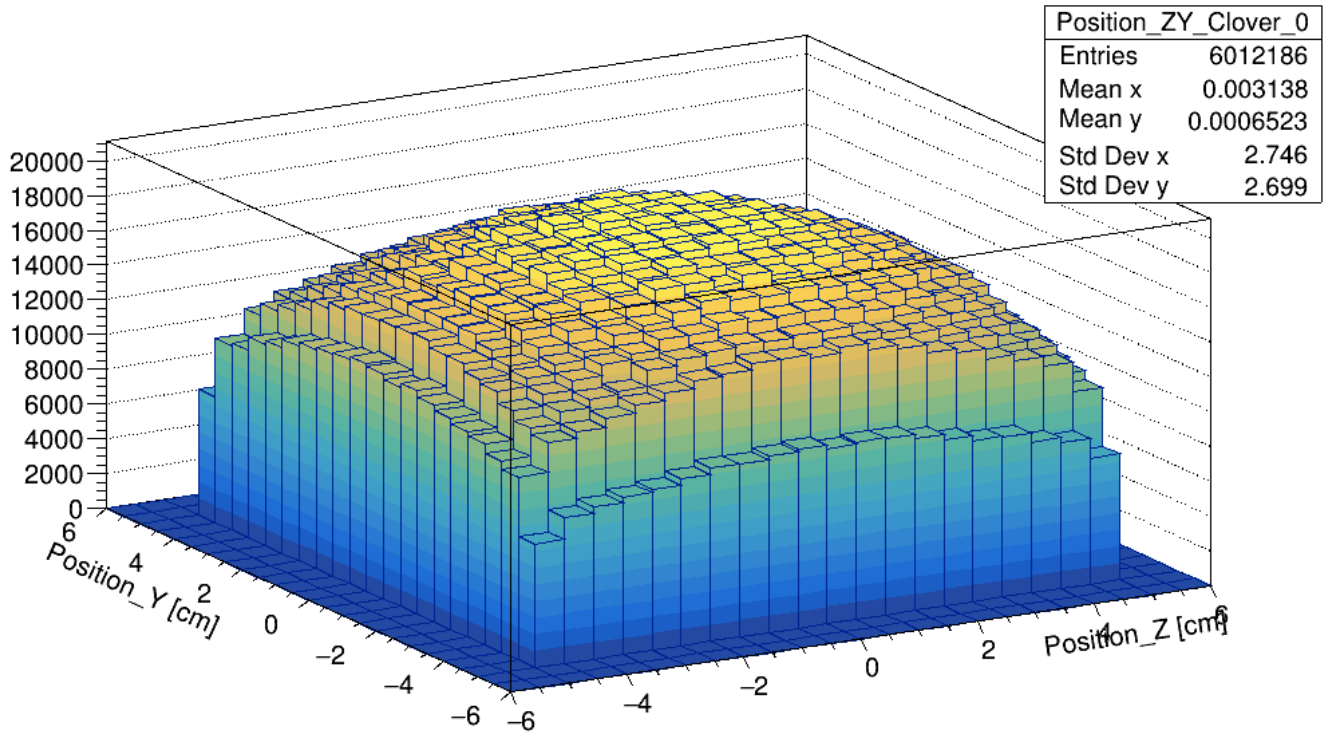

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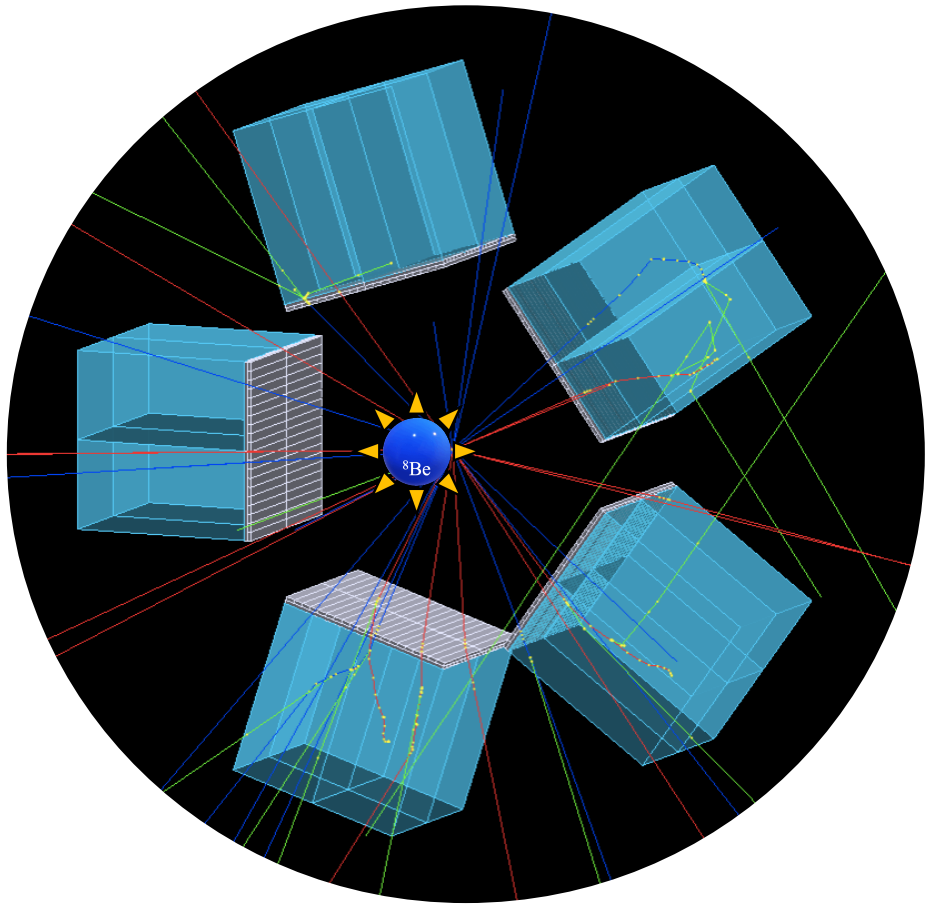

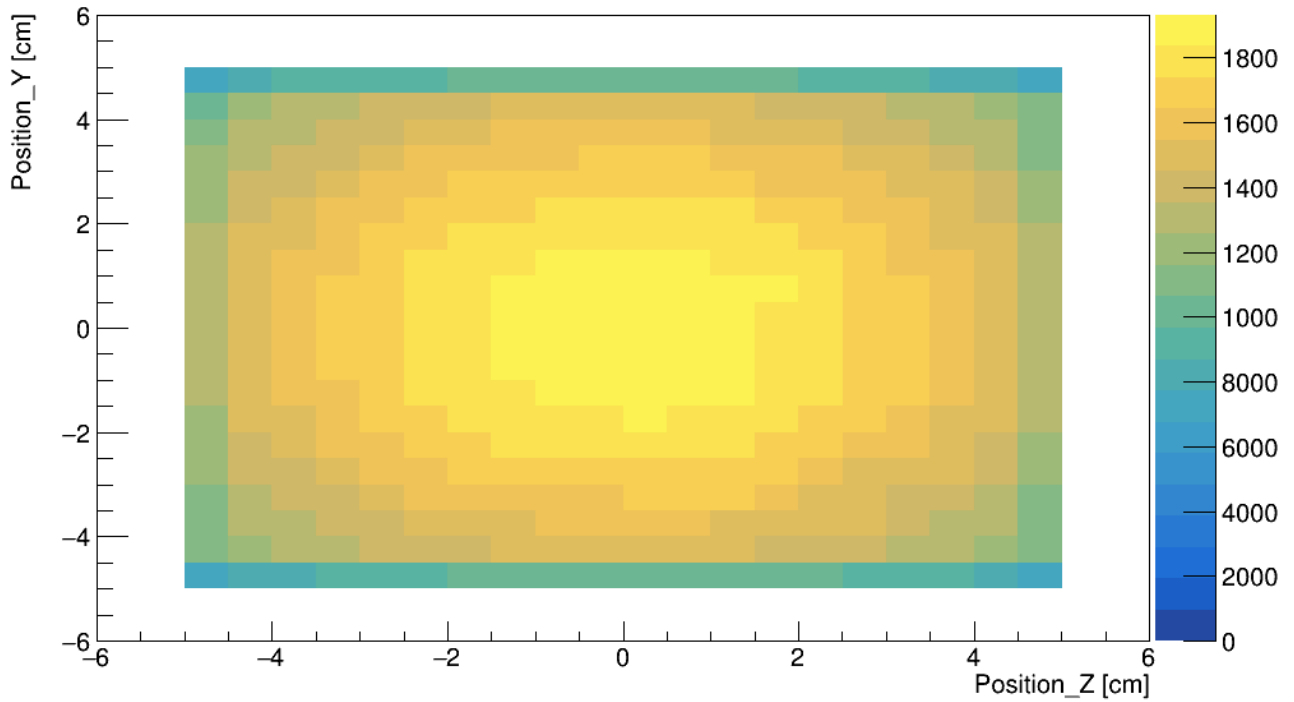

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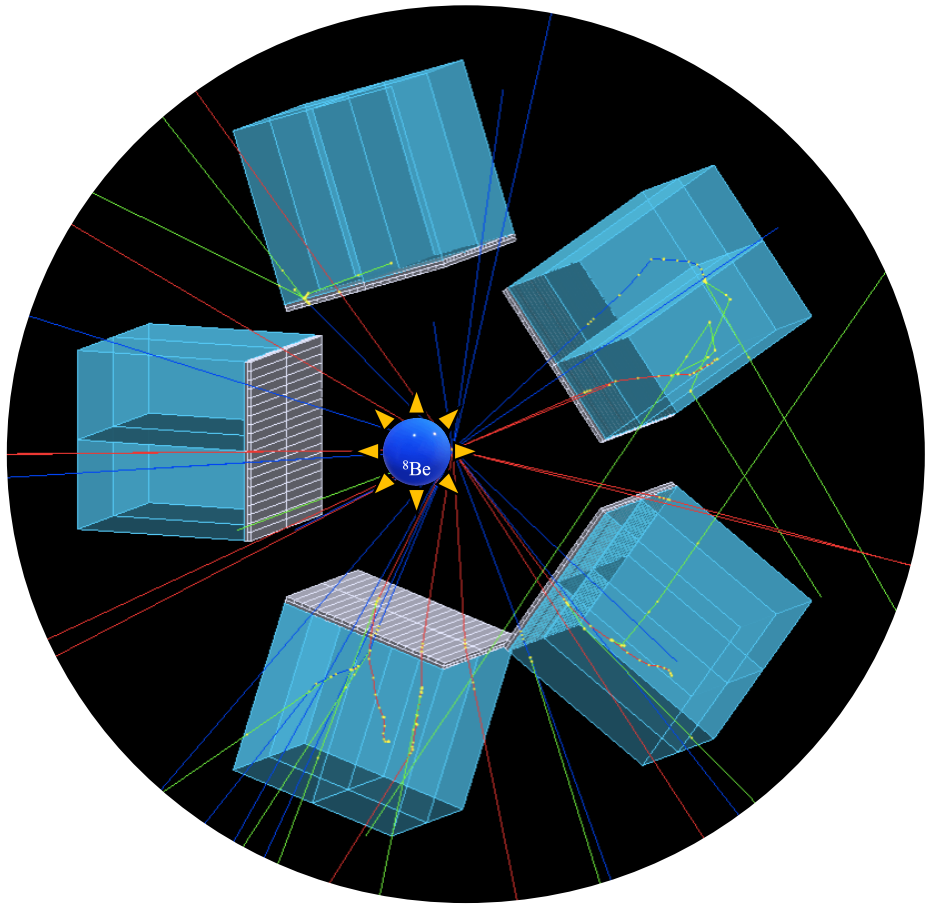
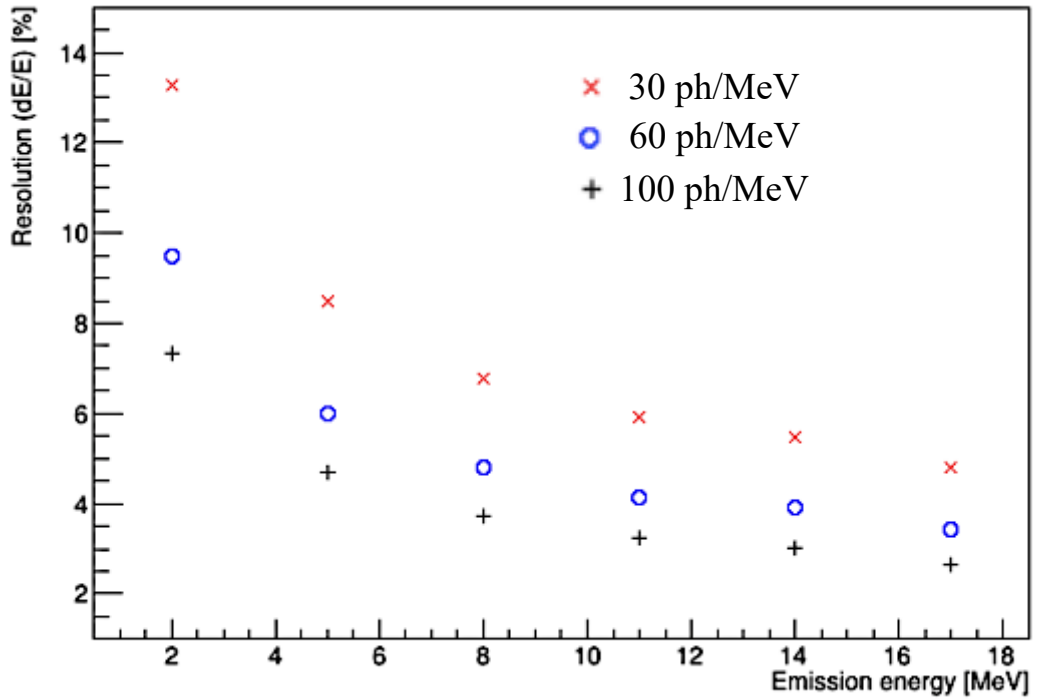
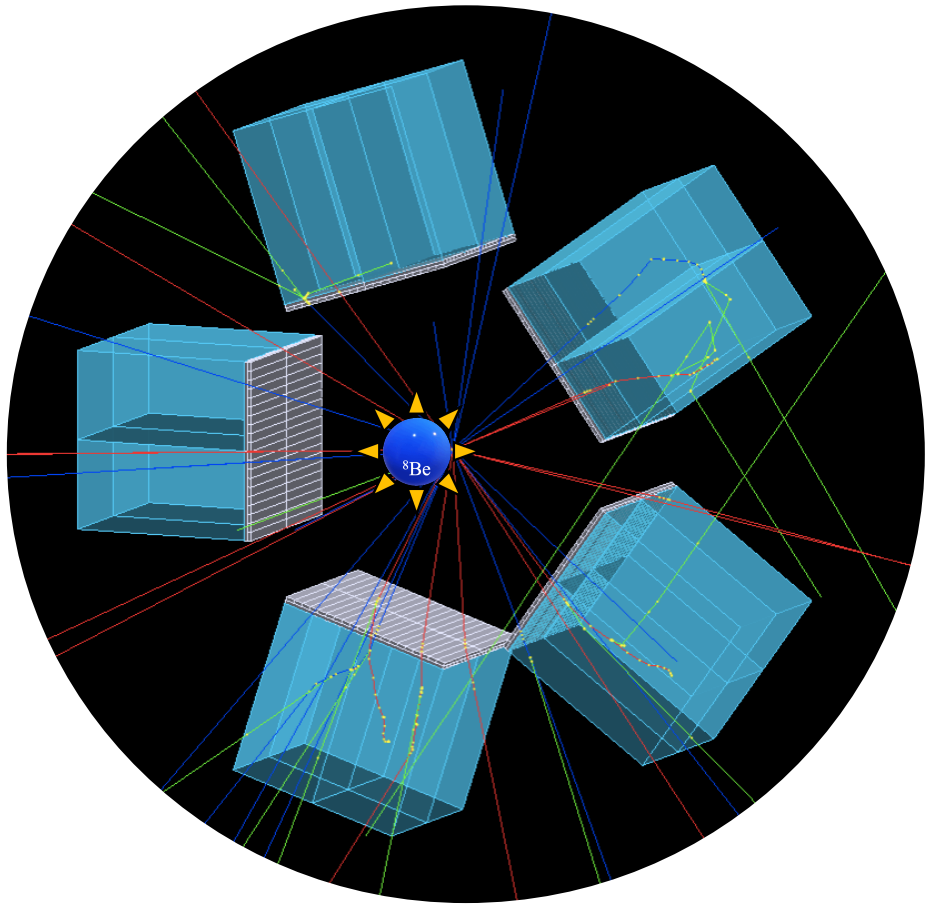
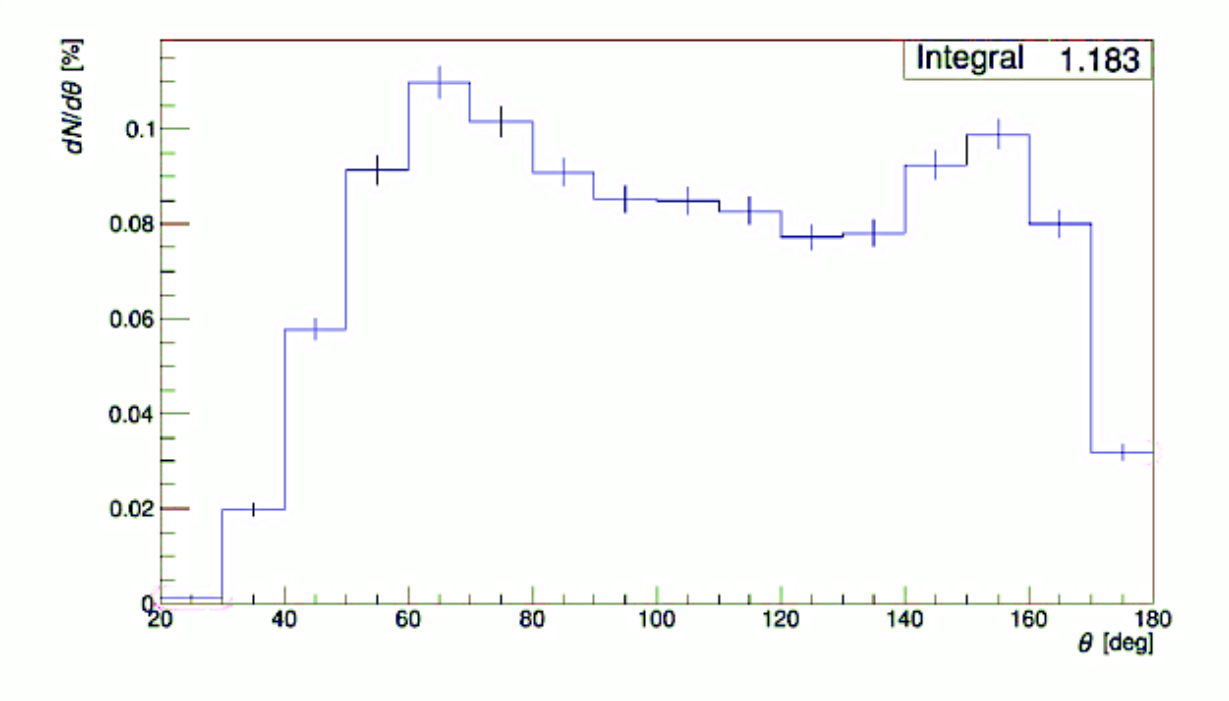




R. Bolzonella. Master Thesis. UniPD 2021

Complete Setup for the First Experiment





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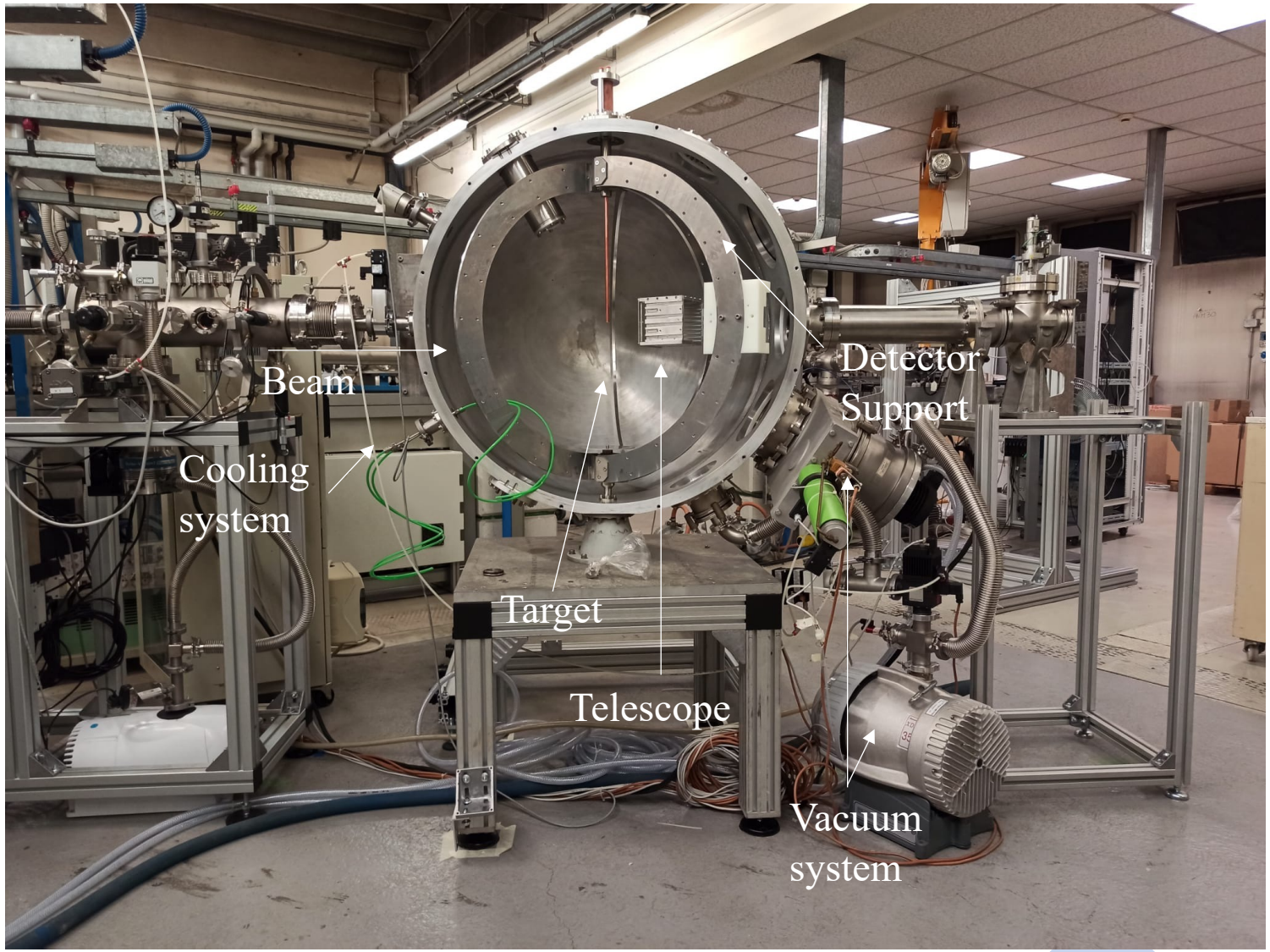
Future Work

- Detector test in an electron beam facility

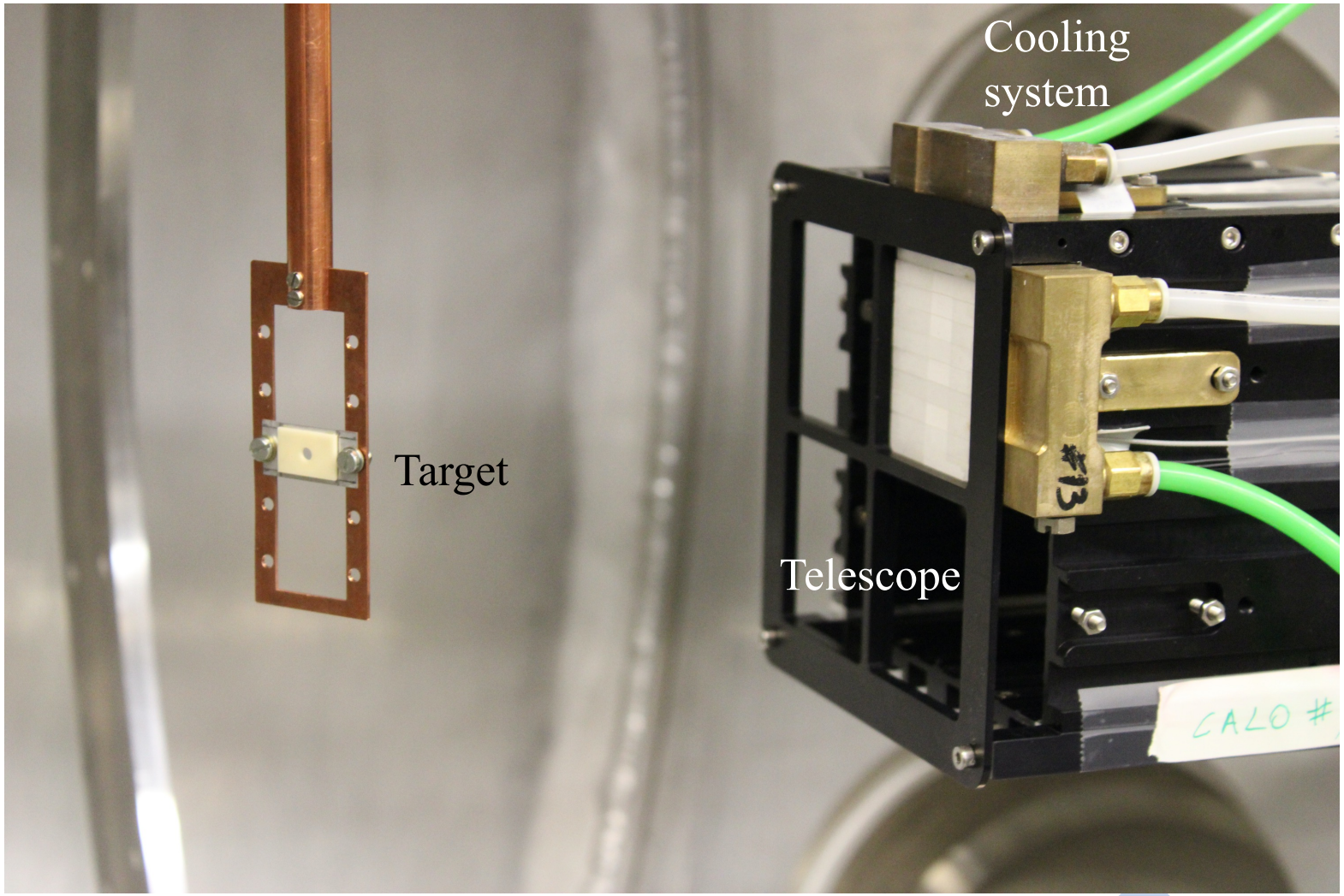
- In-beam test @ AN2000 accelerator (LNL-INFN):
  - Nuclear reaction of interest: $^{7}Li(p, e^{+}e^{-})\ ^{8}Be$
  - Target: Li_2F on Cu backing

- First correlation angle distribution measurement.

Setup @ AN2000, LNL-INFN



Setup @ AN2000, LNL-INFN



Summary

- The project aims to measure an independent e^+e^- angular correlation distribution in the IPC of ^{8}Be.

- At the LNL-INFN, a new setup based on plastic scintillators is in progress. The telescopes has the following important characteristics:

  - Incidence position sensitivity
  - Detectors compatibles with vacuum and magnetic fields
  - The setup is placed inside the reaction chamber
  - Angular resolution $\sim 1^o$
  - Energy detection range few keV - 20 MeV

Collaboration members:

LNL-INFN
- ❑ T. Marchi
- ❑ M. Cicerchia
- ❑ M. Cinausero
- ❑ A. Cogo
- ❑ L. Domenichetti
- ❑ B. Gongora-Servin
- ❑ F. Gramegna
- ❑ A. Mengarelli

S. Roma Tre-INFN
- ❑ D. Tagnani
- ❑ A. Passeri

UniFE
- ❑ R. Bolzonella

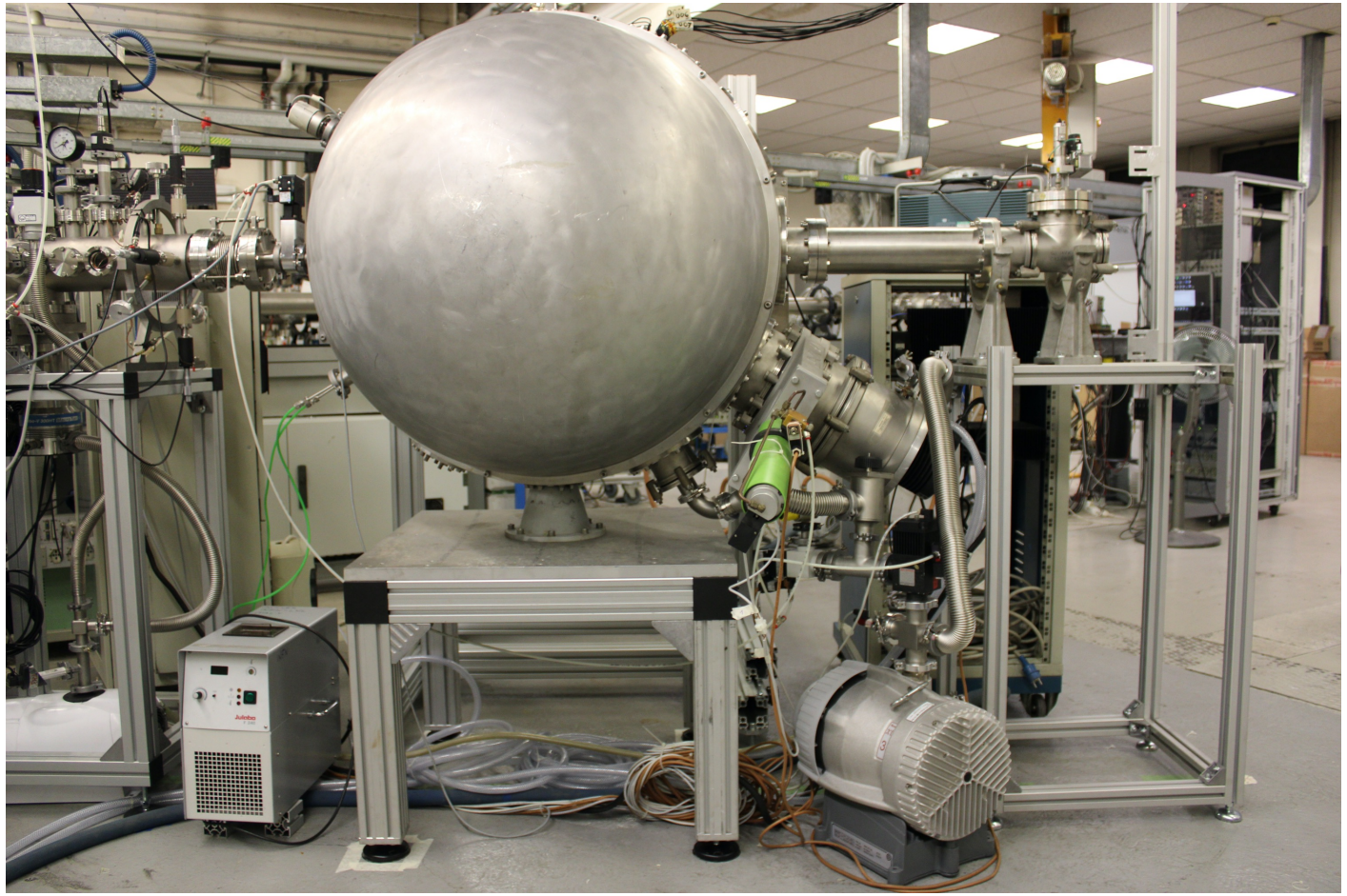
UniPD
- ❑ G. Collazuol

S. Firenze-INFN
- ❑ S. Barlini
- ❑ G. Casin
- ❑ A. Celentano
- ❑ C. Frosin
- ❑ G. Pasquali
- ❑ S. Piantelli

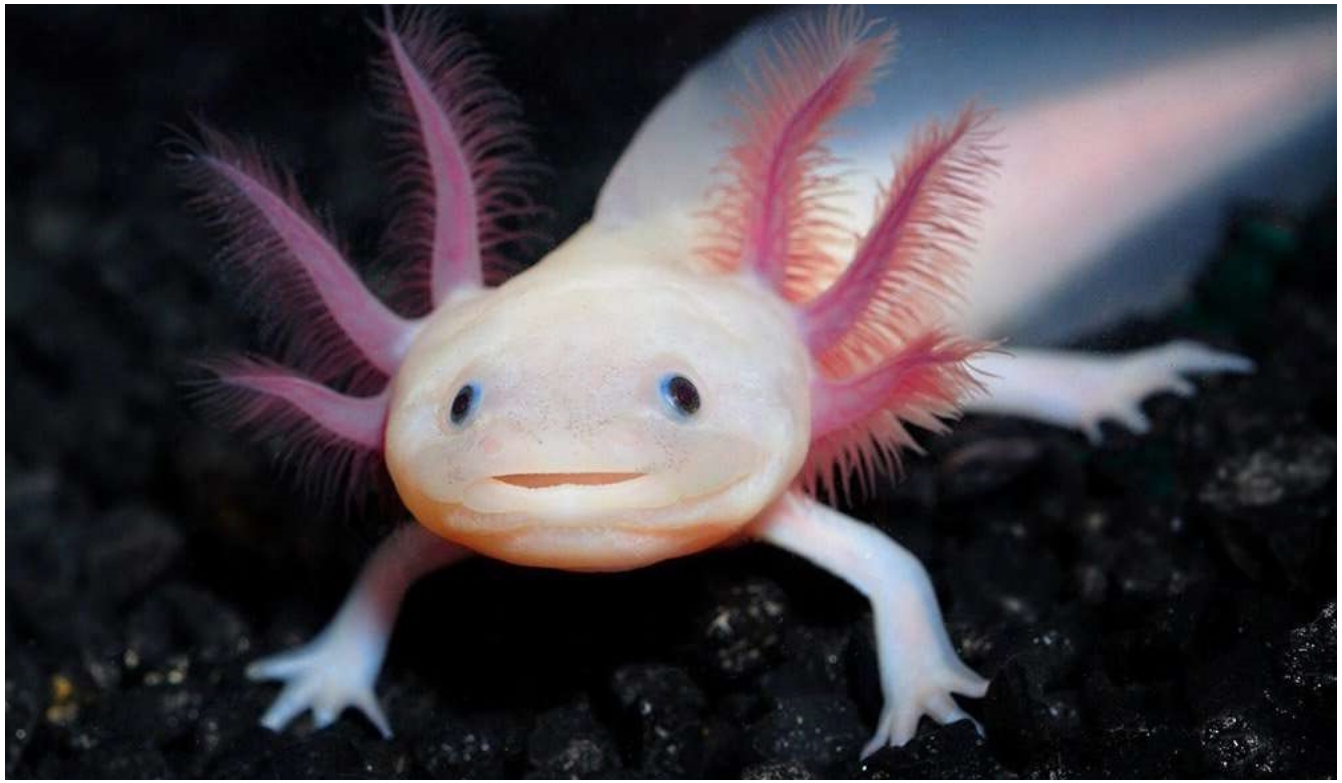
S. Padova-INFN
D. Fabris

S. Catania-INFN
- ❑ I. Lombardo

S. Napoli-INFN
- ❑ M. Vigilante



To be continued…



Thank you for your attention!

*Ajolote: Salamander endemic from Mexico