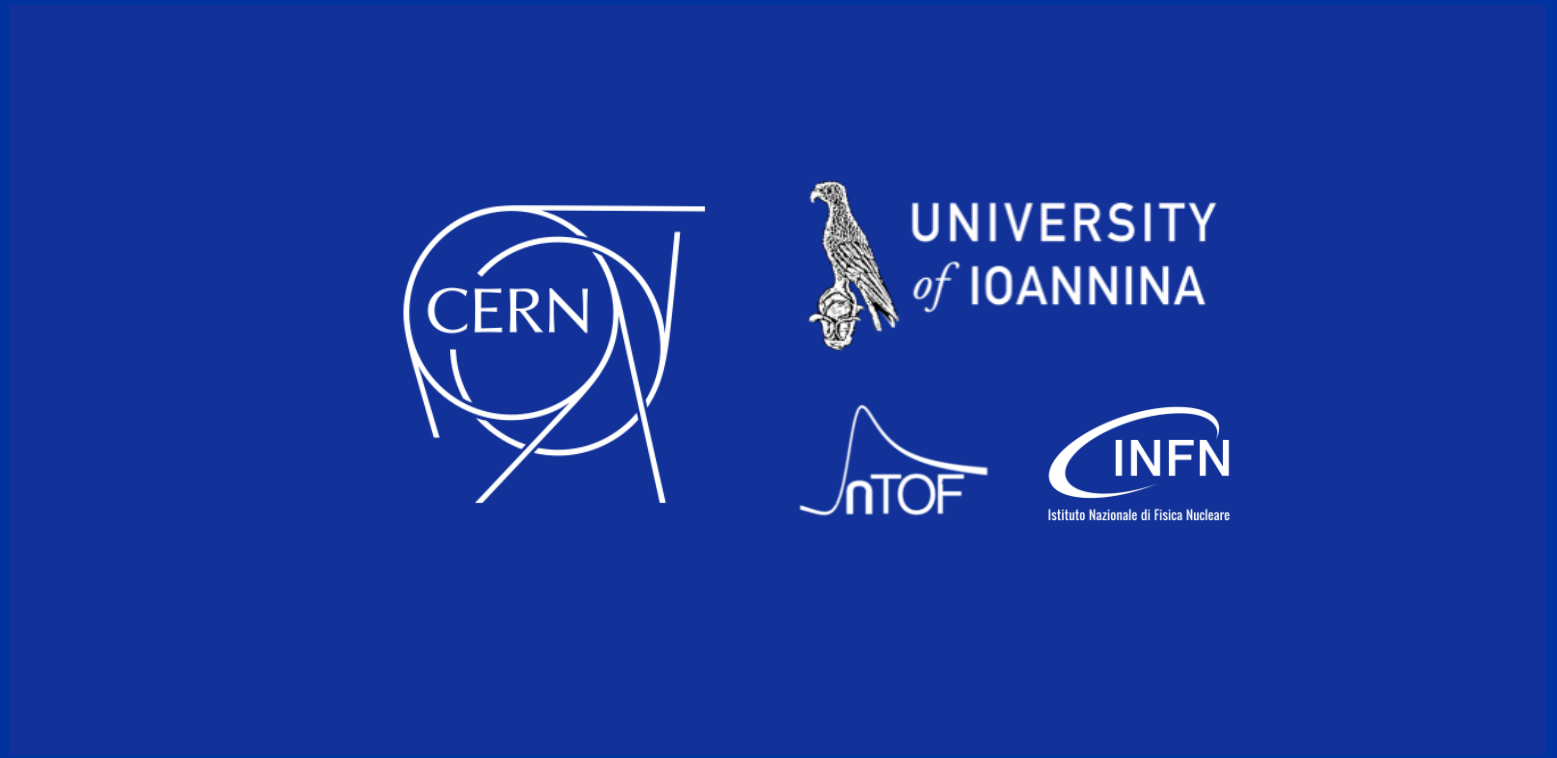
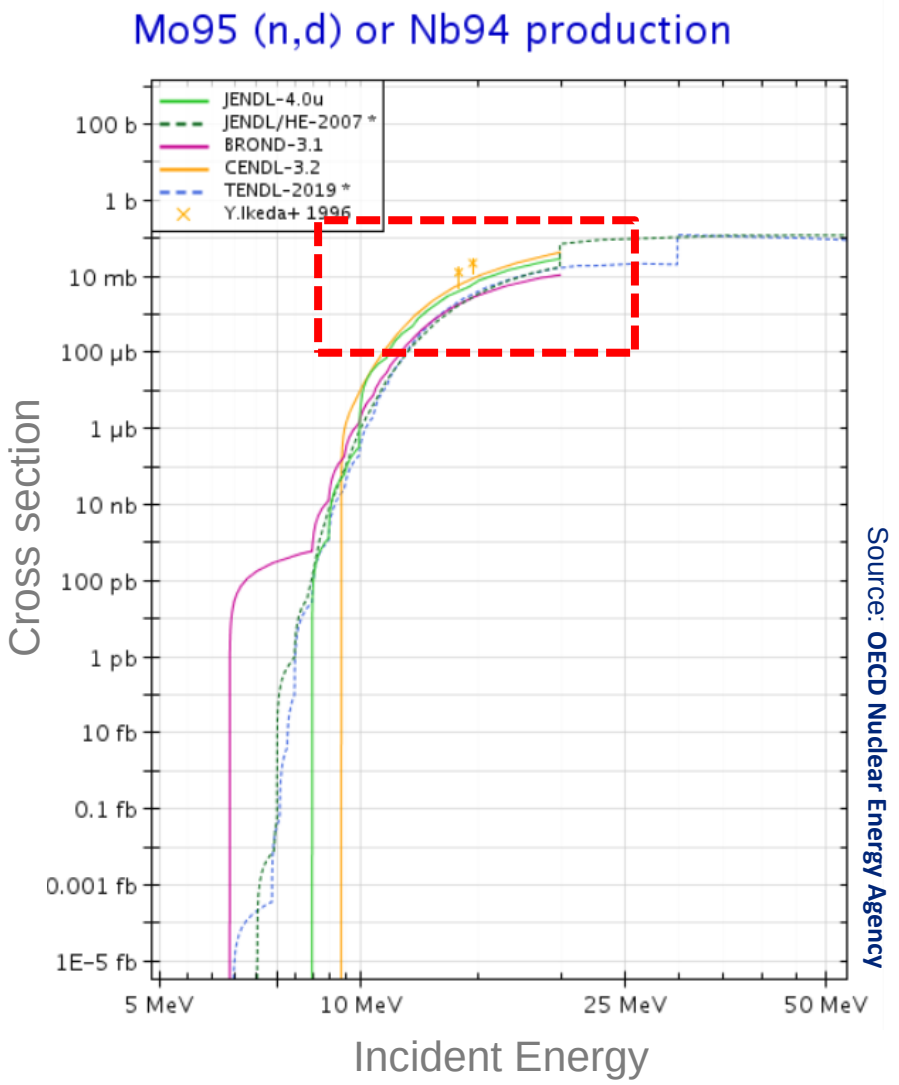


12C(n, cp) physics cases: Validation of the nTD a-Si prototype using digital PSA

Physics motivation

Pressing need for (n, lcp) determination

- **Nuclear Fusion**
  - Neutron interactions with structural material cause **displacement**, **transmutation**, and **gas formation**
- **Safety/Waste management**
  - **Scarce/Discrepant/Limited-energy-range** data points available in online libraries, like FENDL(fusion), EAF (activation cross-sections), IRDFF (dosimetry)
- **Theoretical models**
  - **Uncertainties up to 100%!**
  - Refine calculations, especially for the emission of light-charged particles



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  - **Uncertainties up to 100%!**
  - Refine calculations, especially for the emission of light-charged particles

For this development we have:

New Hardware

New Software

New PSA

Physics motivation

Pressing need for (n, lcp) determination

- **Nuclear Fusion**

Scope of this presentation:

First quality checks of Experimental Data accompanied by MC simulations

- **Uncertainties up to 100%!**
- Refine calculations, especially for the emission of light-charged particles

New Hardware

New Software

New PSA

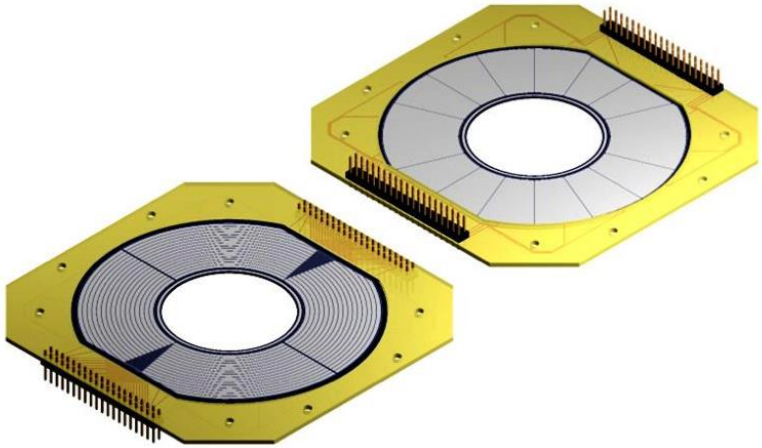
Annular Silicon Detector

Producer: MICRON Semiconductor

Advantages:

- **High-spatial resolution**
  - Precise angular distribution (~ 2 ^{O})
- **Reduced** Dead Space:
  - The ring-shaped configuration maximizes the active detection area

Characteristics:



Si-wafer	nTD
Thickness	305μm
Inner diameter	48 mm
Outer diameter	96 mm
Metal coverage	0.5 μm
Interstrip gap	SiO_2 layer
Active area	4 x16 strips
	16 sectors

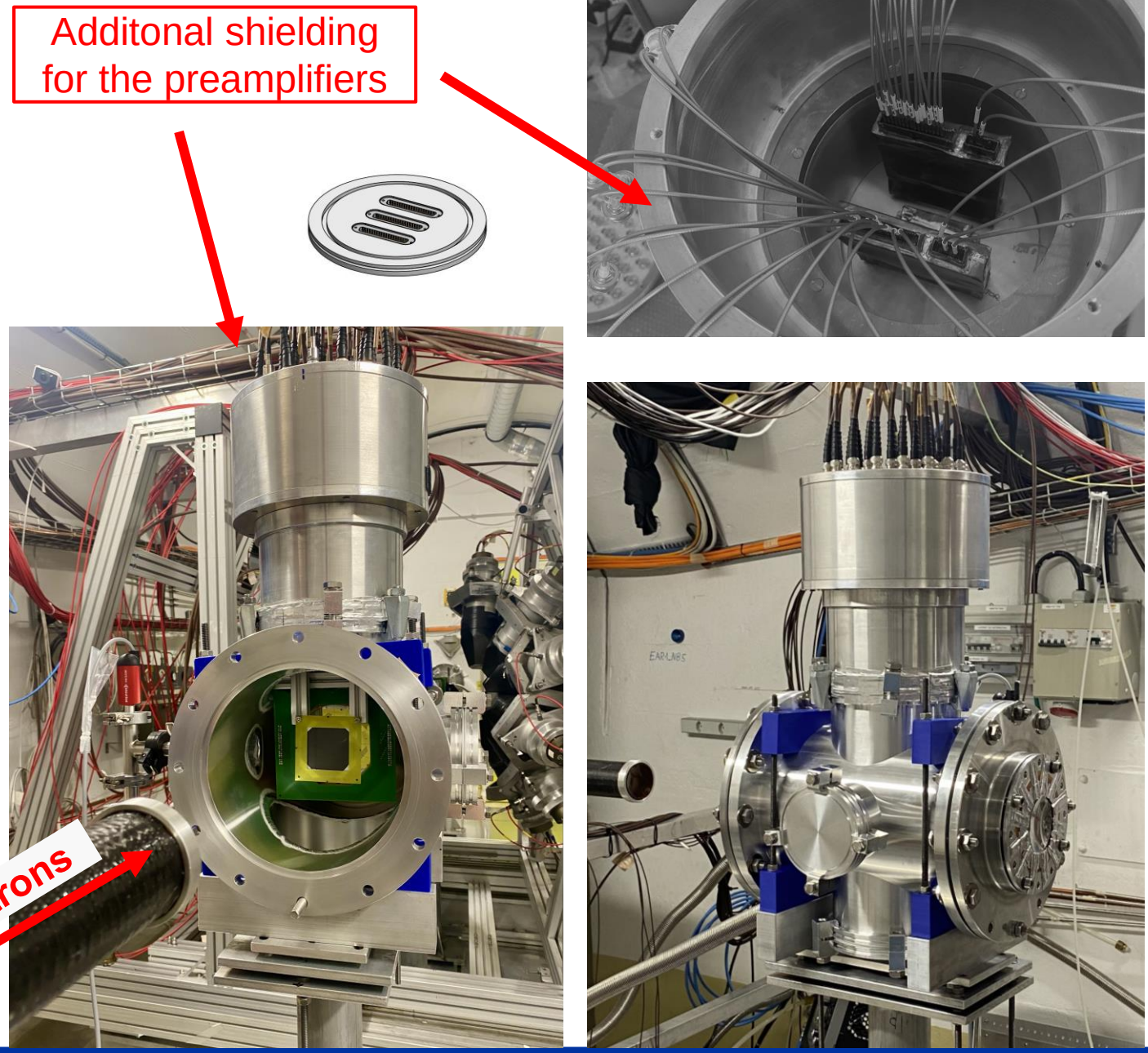
Setting up @ EAR1

Proposal: May 2022 **INTC-P-629**

Experiment on Sept 2023 with**:**

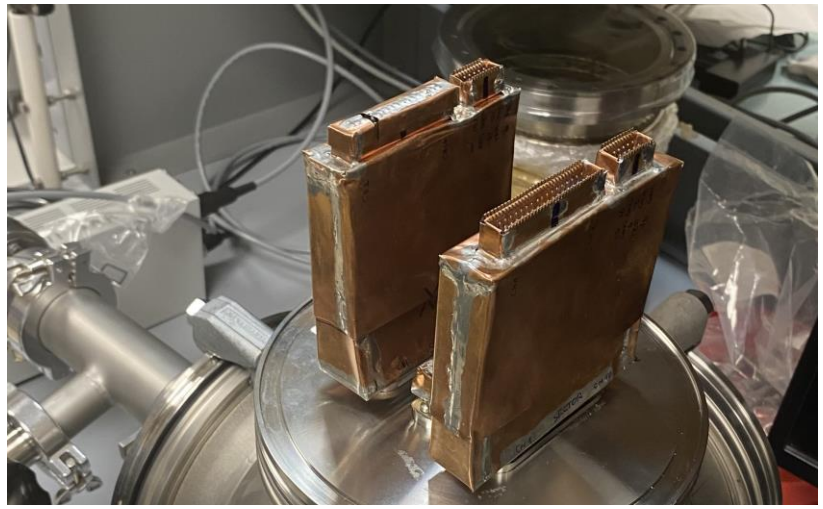
- Total protons: **1.75E+18 onto 5x5 cm2 targets**
  - **PE** (1mm) & **LiF** (400nm)
  - **Rigid Graphite (**0.25 & 0.5 mm)
  - **Empty**

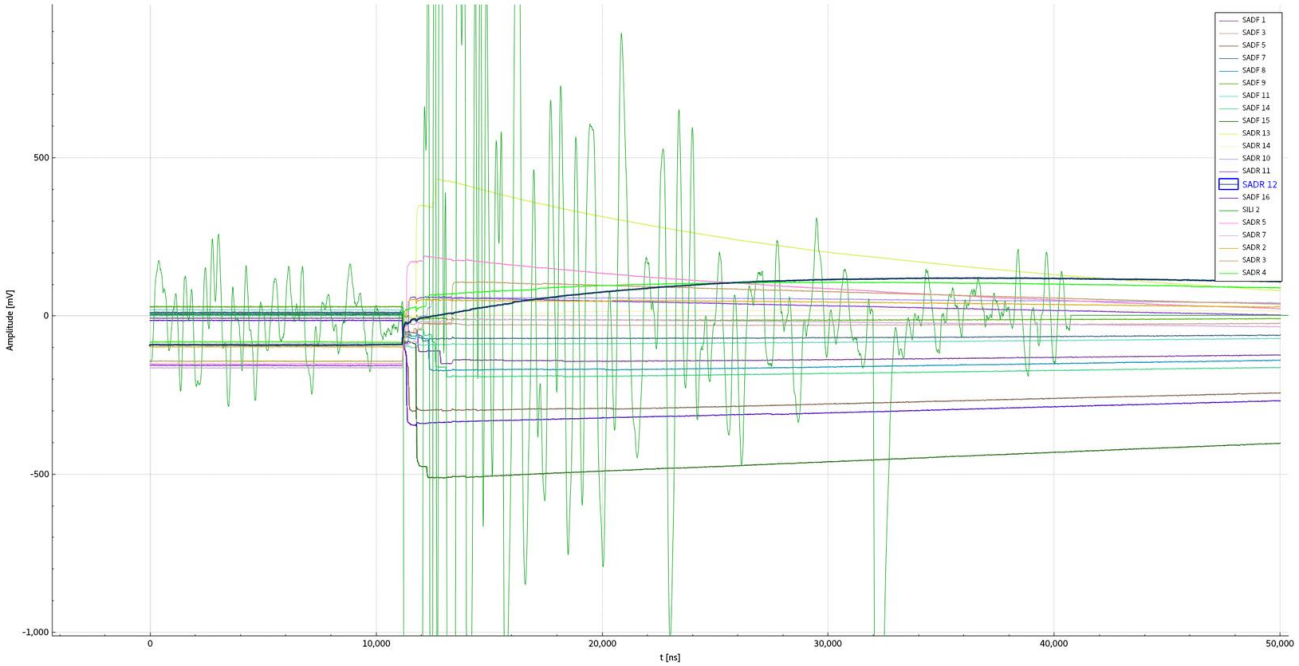
- Sample-to-detector distance**: 5 cm**
- θ**: ~ 25 - 44 º**
- **Reversed-injection** configuration
- Full-Depletion Voltage (FDV) @ 47V
- **32 channels** in total (16 sectors/strips)

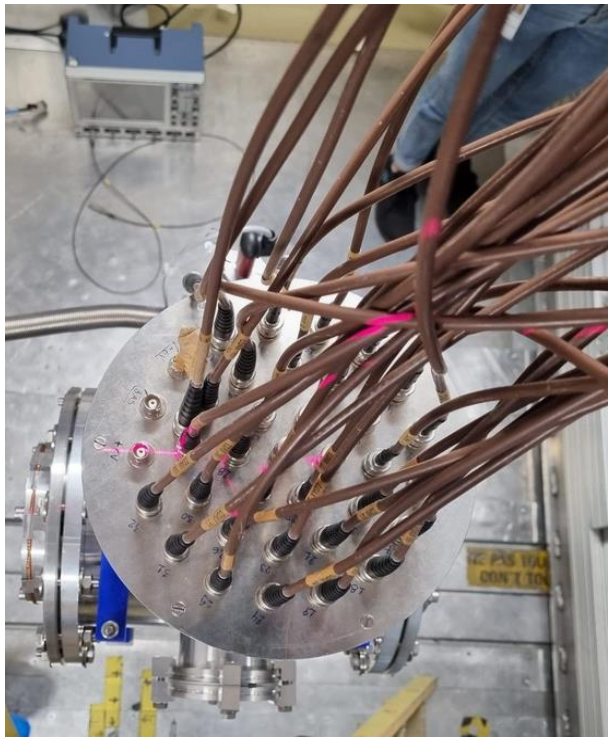


Setting up @ EAR1

- Cable ringing problem
  - Solved for the annular but **not for all detectors**



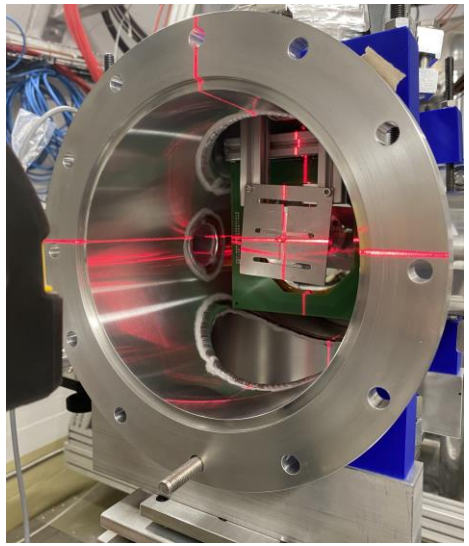


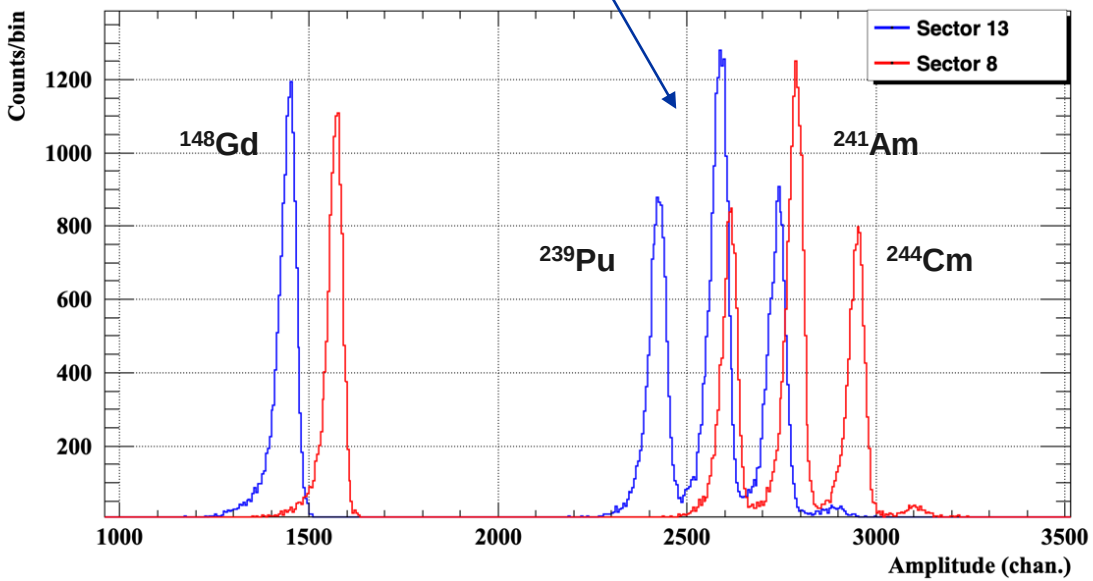


Energy Calibration @ EAR1

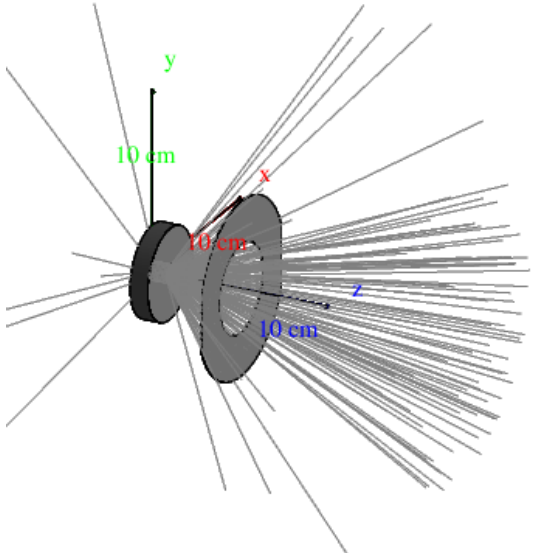
- **Fully realistic conditions** during setting up the on-line experiment
  - The source was placed in the center of the sample position
  - Unsealed α-source with an active diameter of 7 mm
  - Composed of four α-emitting isotopes with a total activity of 8 kBq

Isotope	Energy (keV)	Intensity (%)
^{148}Gd	3182.690(24)	100
^{239}Pu	5156.59(14)	73.3(8)
	5144.3(8)	15.1(8)
	5105.5(8)	11.5(8)
^{241}Am	5485.6(12)	85.2(8)
	5442.90(13)	12.8(2)
	5388(1)	1.4(2)
^{244}Cm	5804.82(5)	76.4(2)
	5762.70(3)	23.6(2)
	5664(3)	0.022(1)

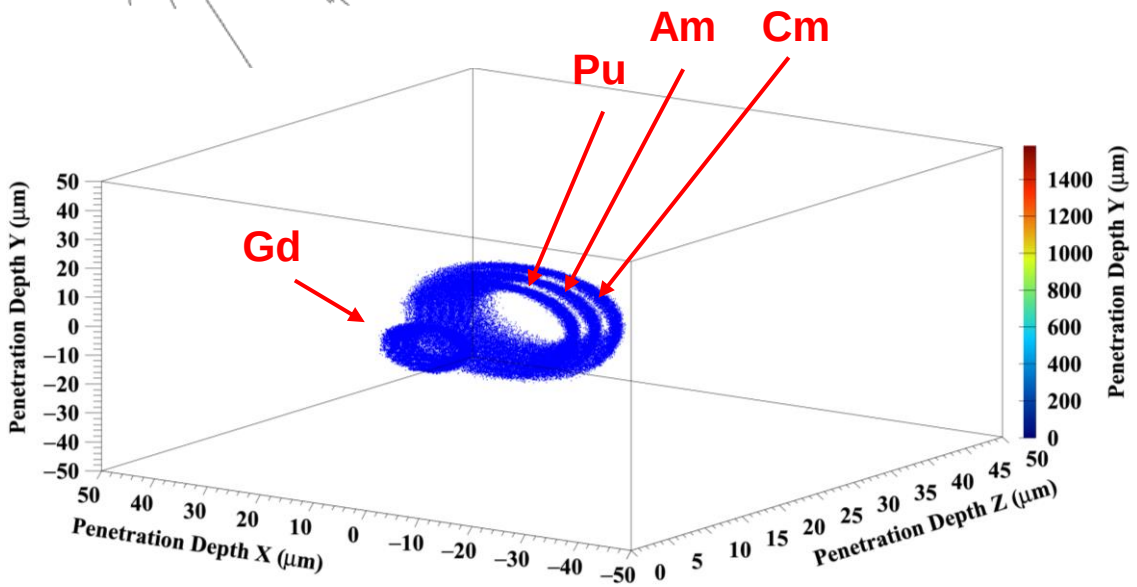




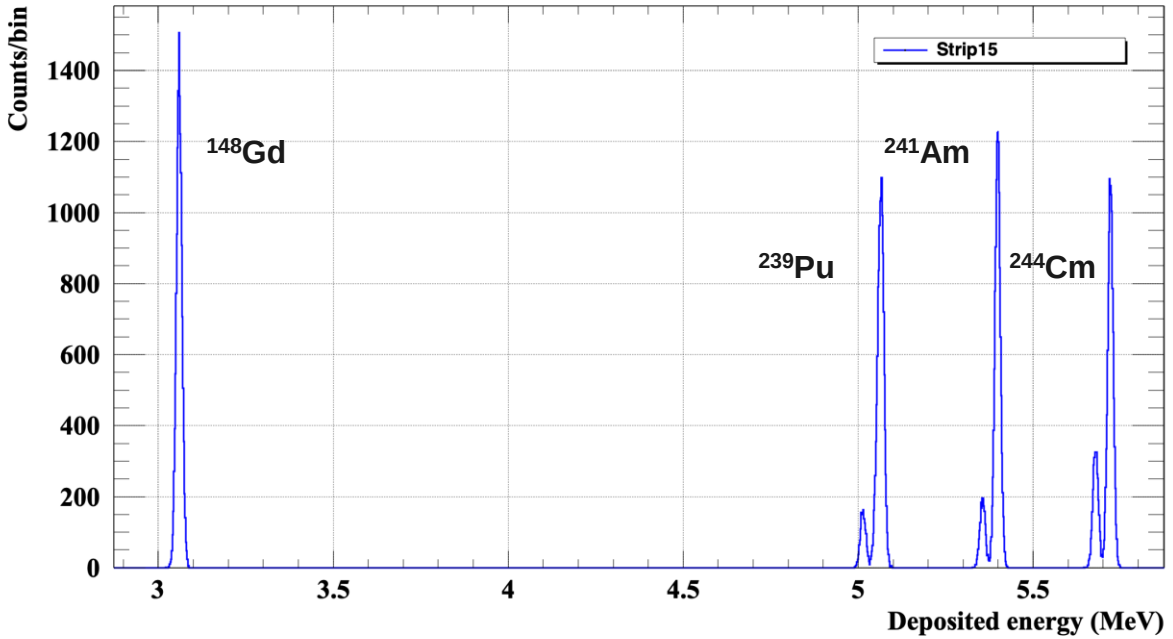
Energy Calibration @ GEANT4



Source: α particles from a circle surface source

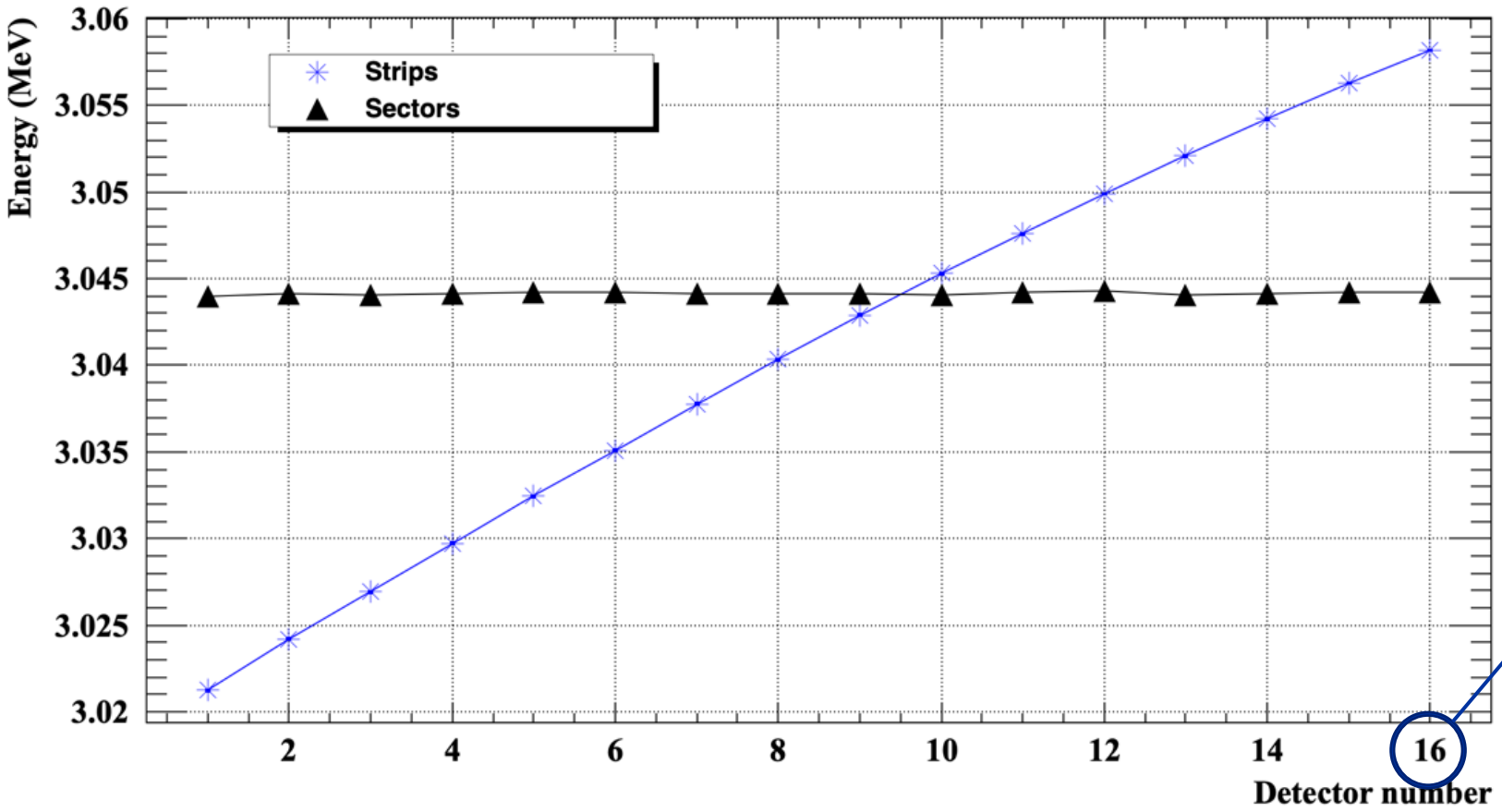


Strip 15: **2nd strip** counting from the **inner part** of the Si

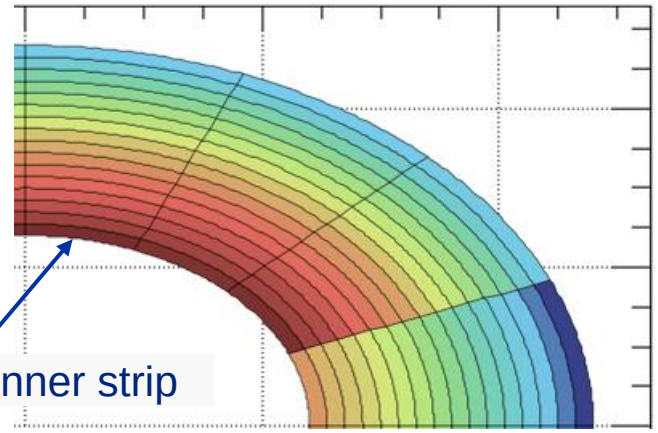


Response function of the detector to be implemented!

Energy Calibration @ GEANT4

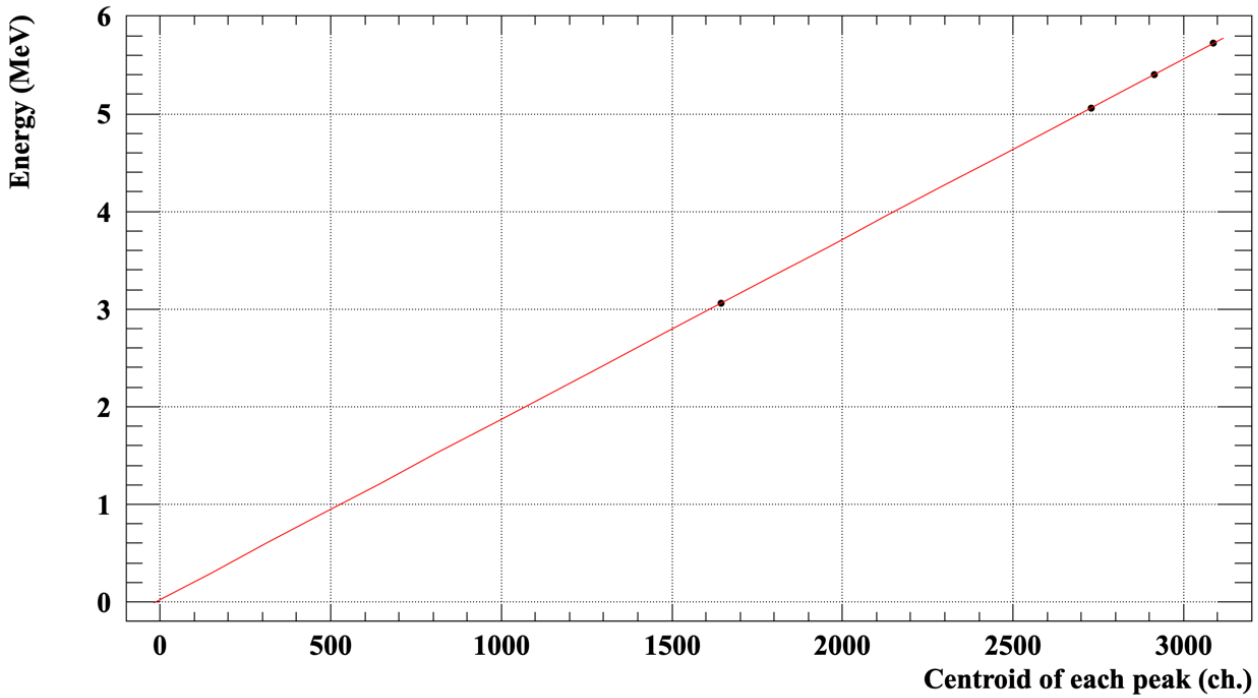


- **Deposited energy (Gd):**
  - sectors: ~ 3.044 Mev
  - strips: ~ 3.02 – 3.06 MeV



Al dead-layer: **decreases** the deposited energy of the particles **inside the active volume**

Performance of the DSSSD @ Energy matching



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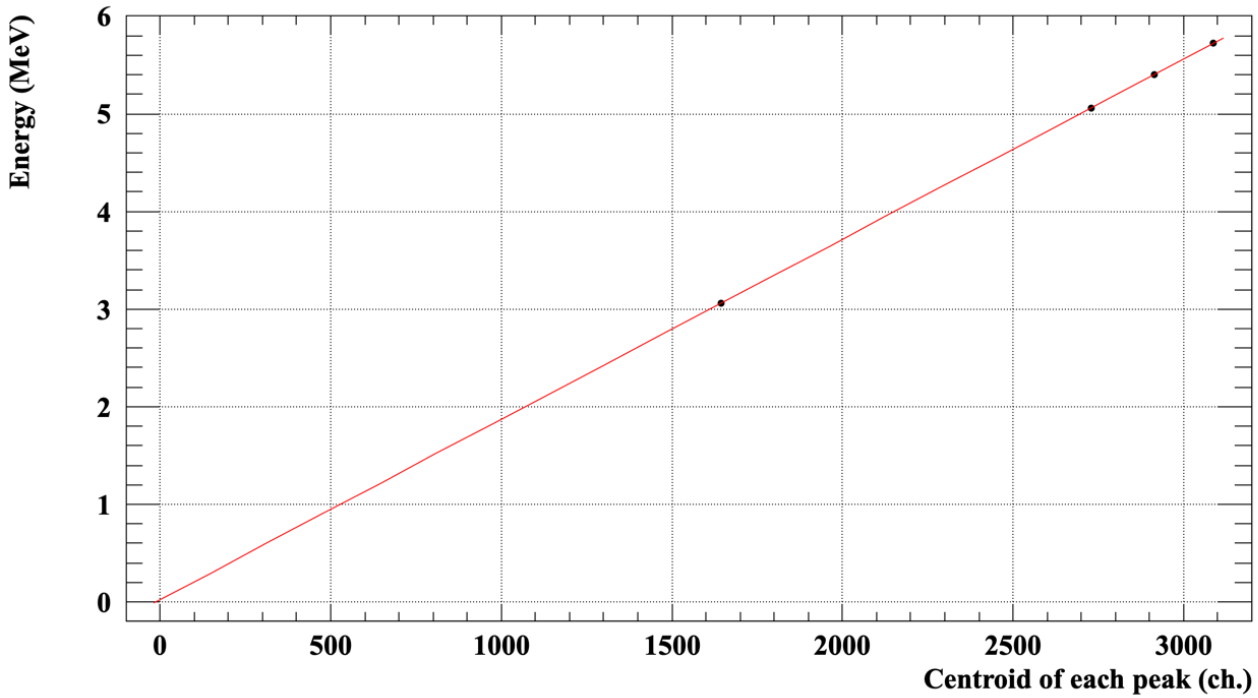

Average offset:

- ~ 20 keV

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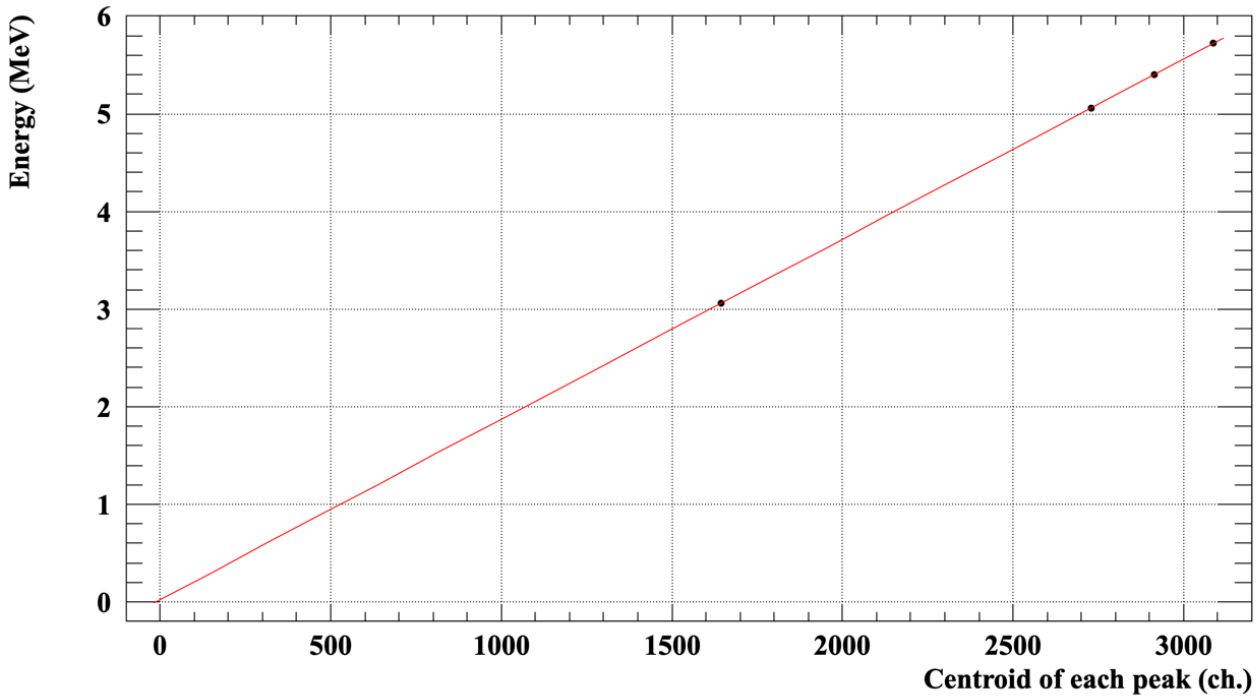

Average offset:

- ~ 20 keV

Thickness of the mixed-nuclei drop?

Energy loss for a traversing 50nm material: ~ 30 keV!

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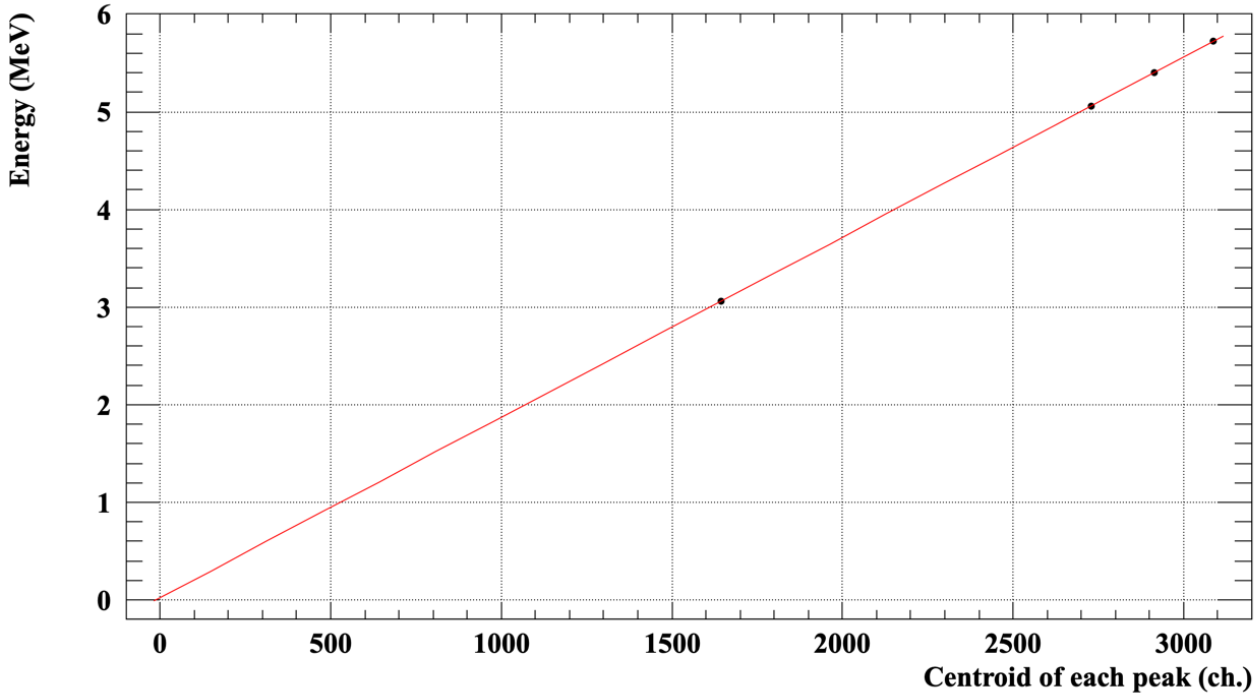

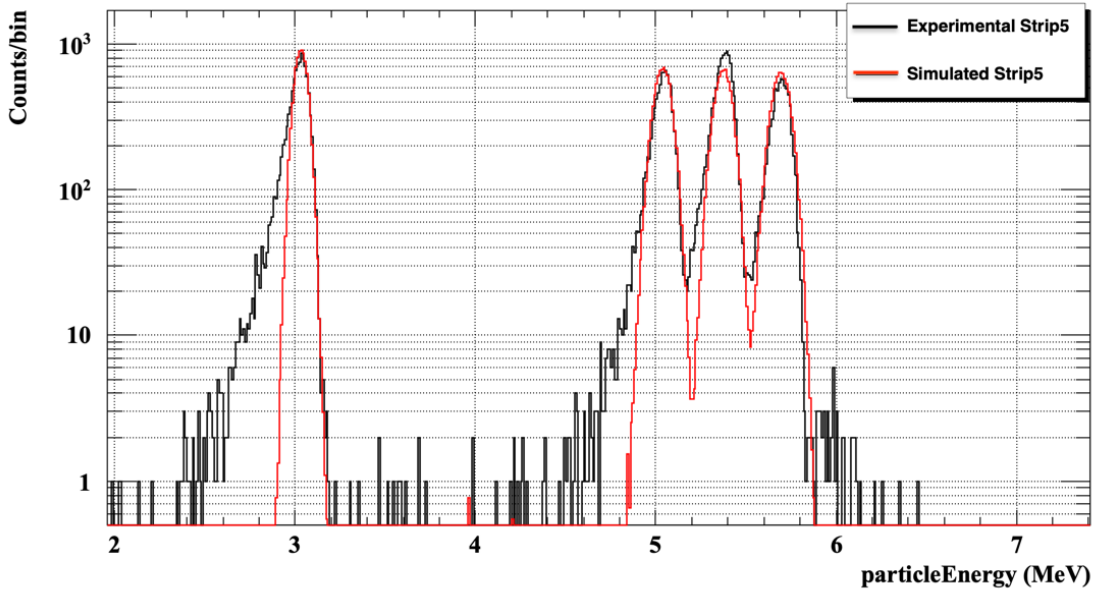

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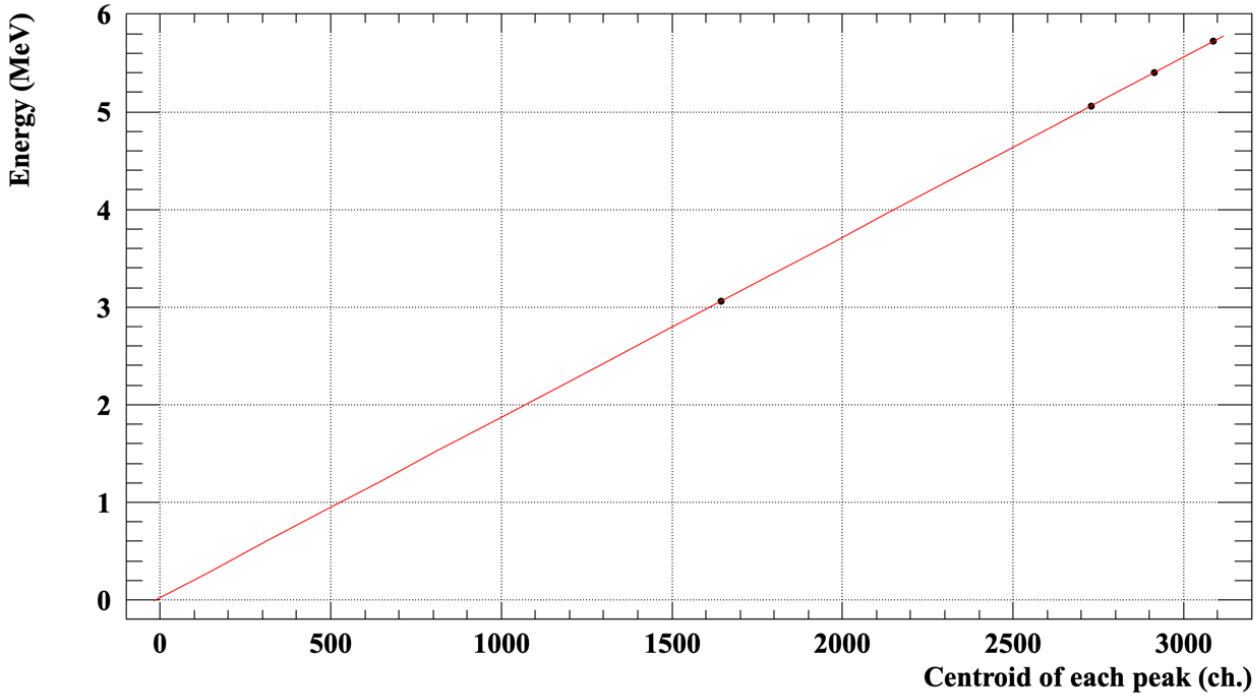

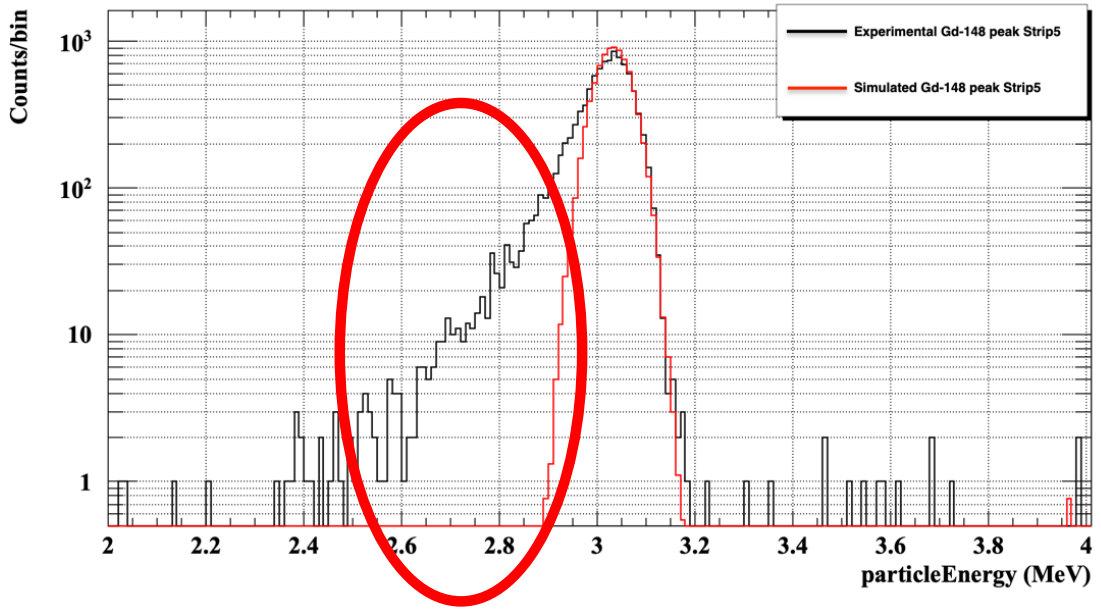

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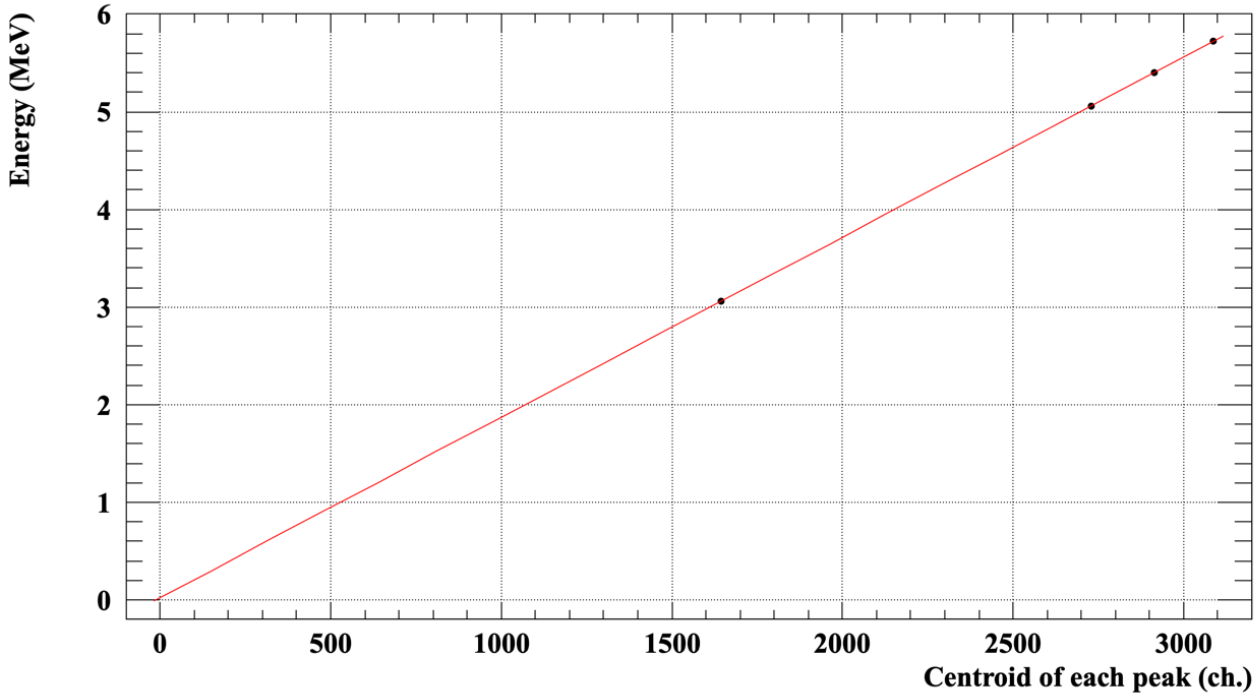
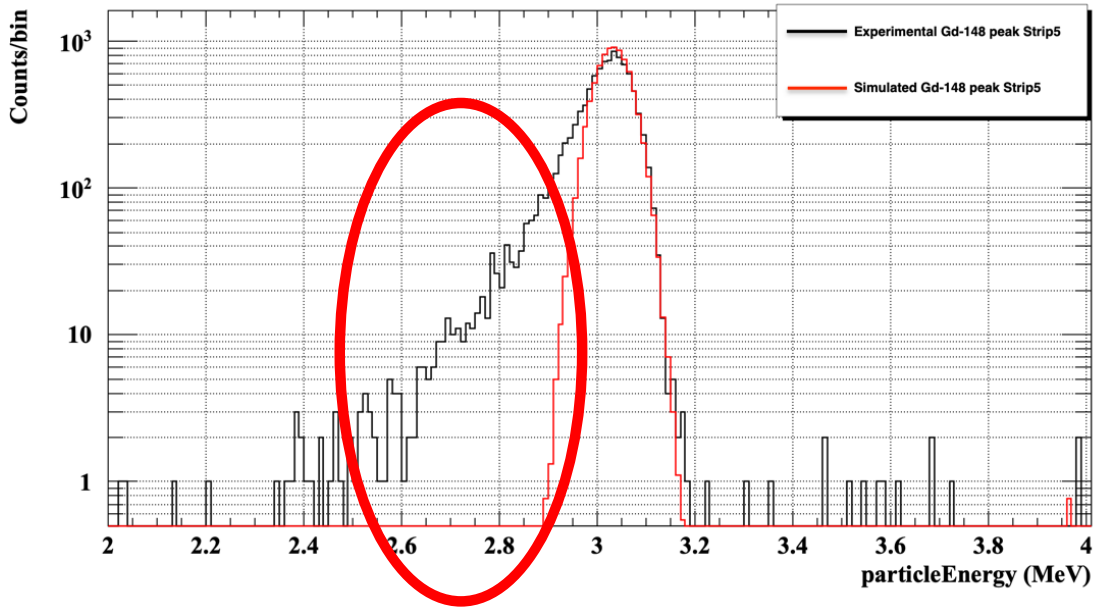




Average offset:

- ~ 20 keV

Thickness of the mixed-nuclei drop?
Energy loss for a traversing 50nm material: ~ 30 keV!

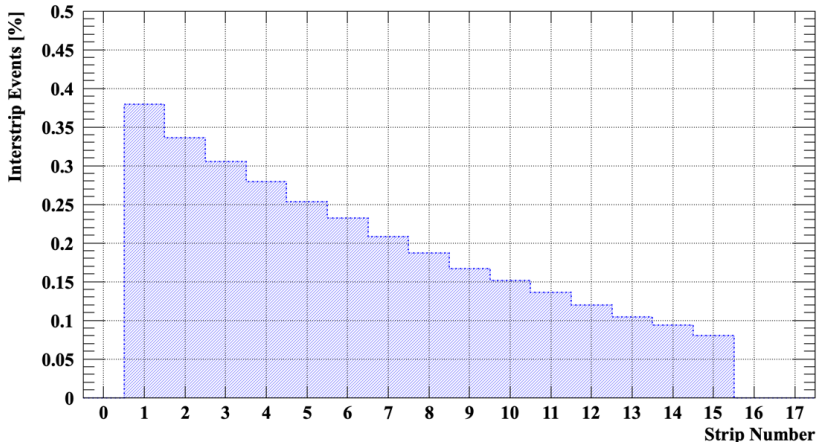
Possible explanations:

- Insulator of SiO_2 between the strips?
- Incomplete charge collection?

Coincidences procedure

Principle of operation:

- One event gives rise to two signals simultaneously.
- Majority of events: same deposited energy
- The others? How much is the percentage?



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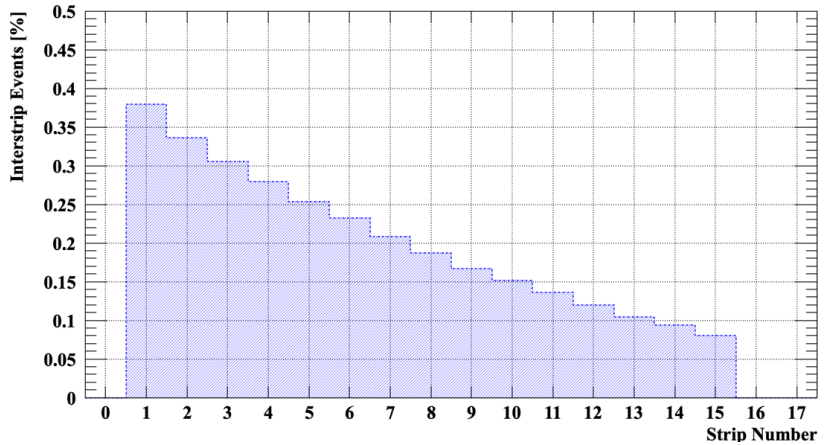
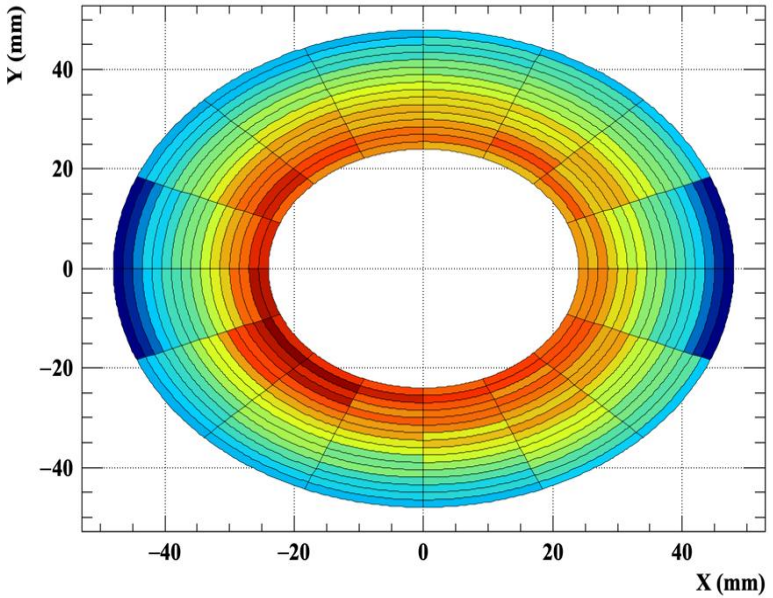


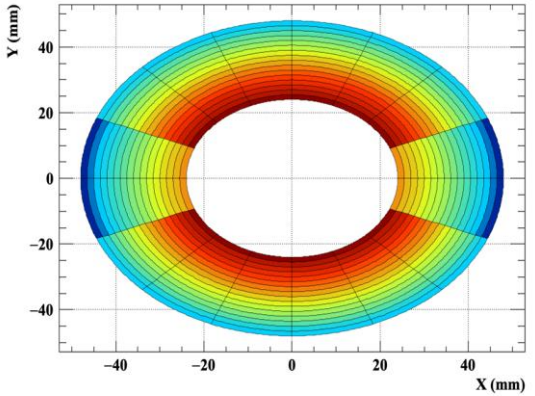
By plotting the difference of the energy one can set an energy limit window

Applying this condition we **keep > 96%** of the statistics!



experimental

Small misalignment!



simulated

12C Experimental Campaign:

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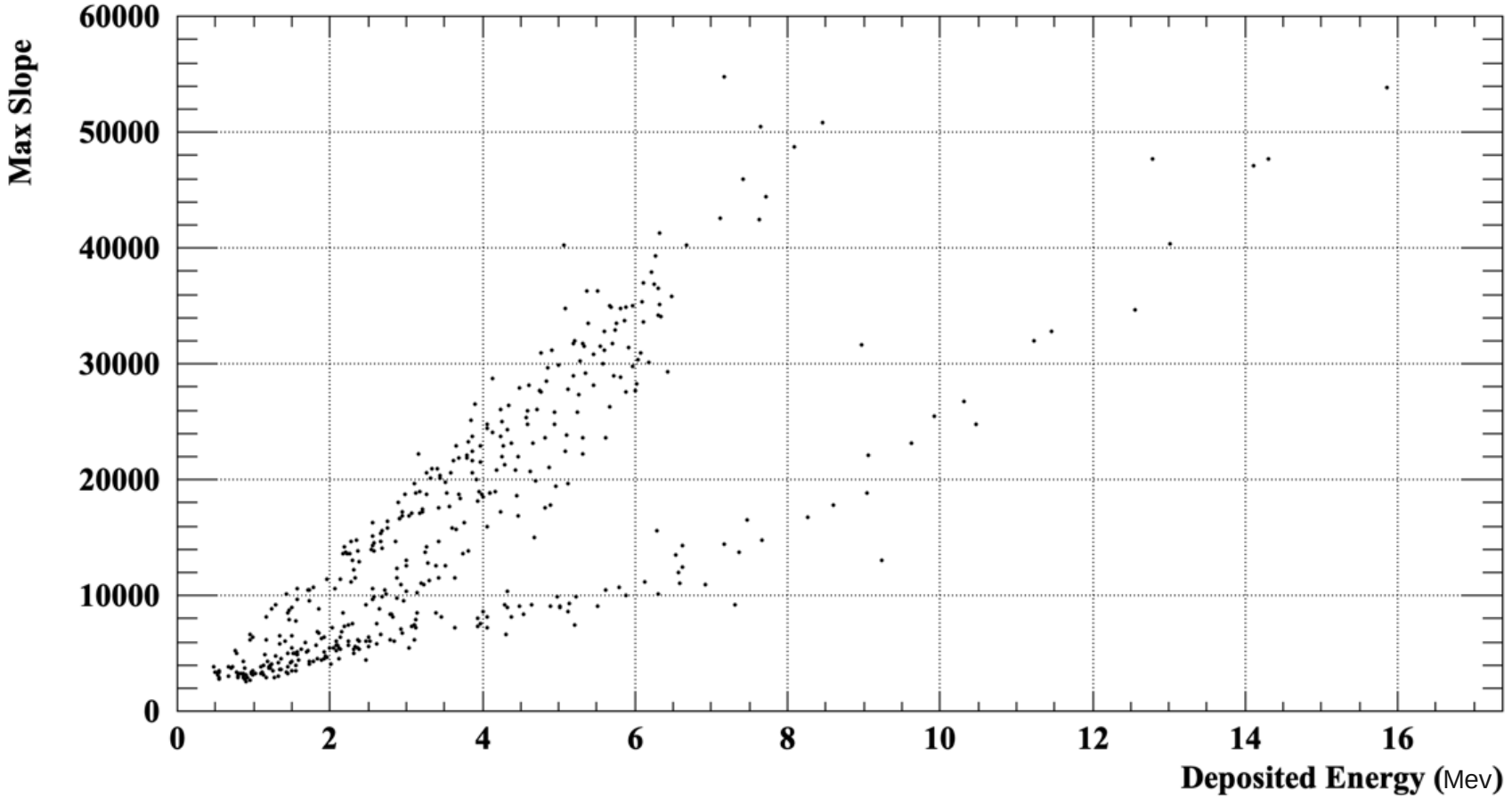
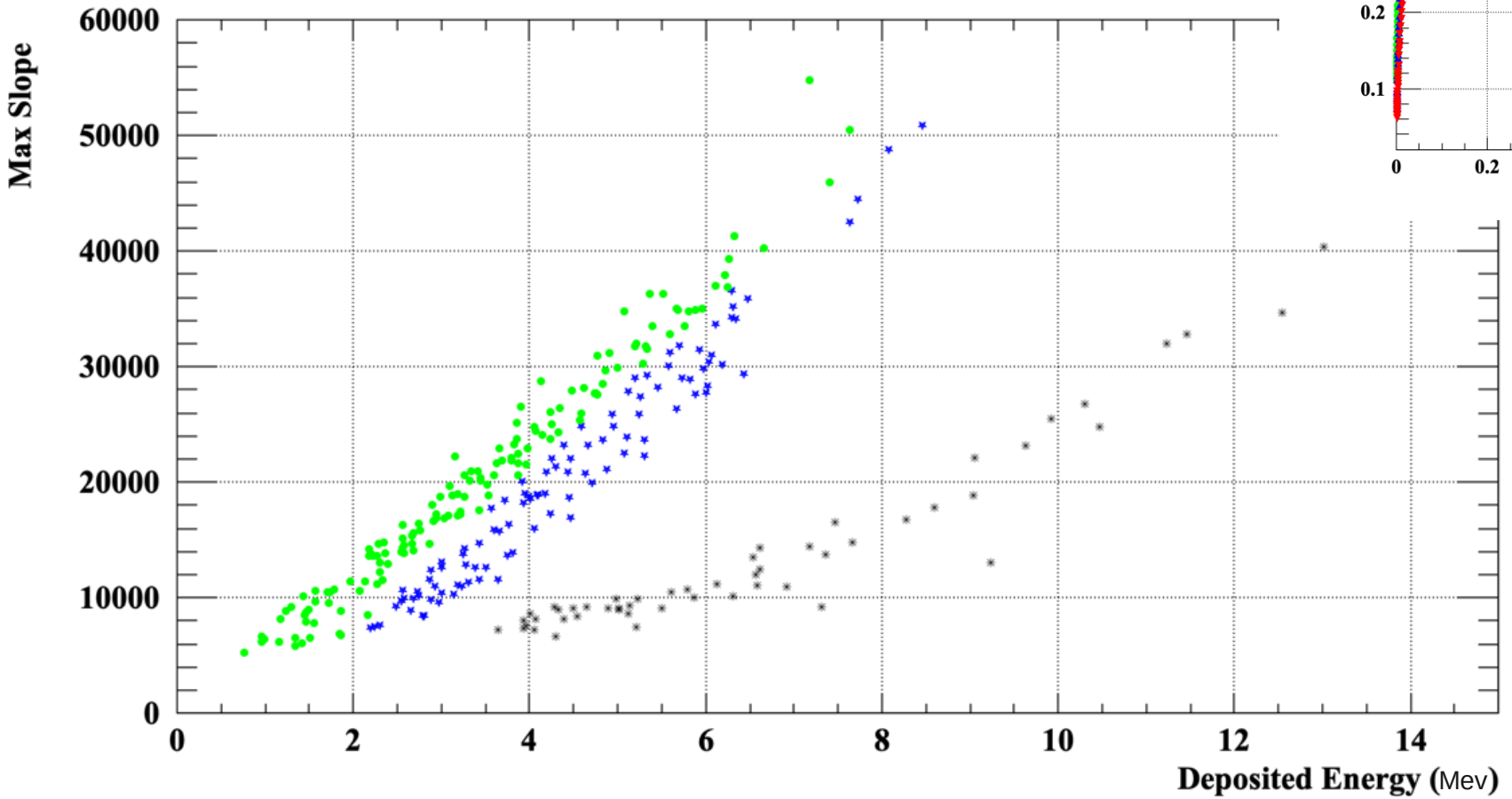
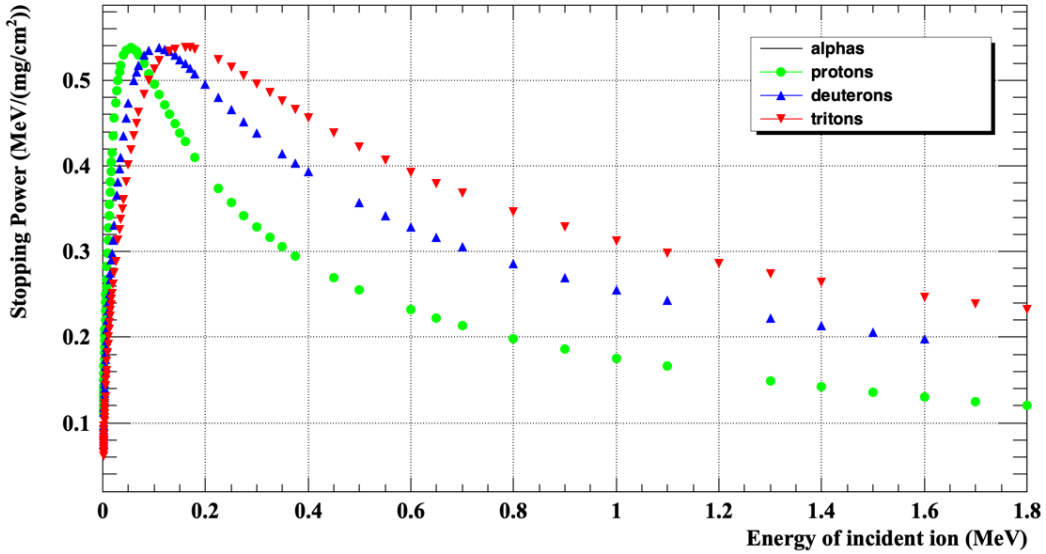


Energy loss per distance unit:

$$-\frac{dE}{dx} \propto \frac{A\,Z^2}{E}$$

12C Experimental Campaign:





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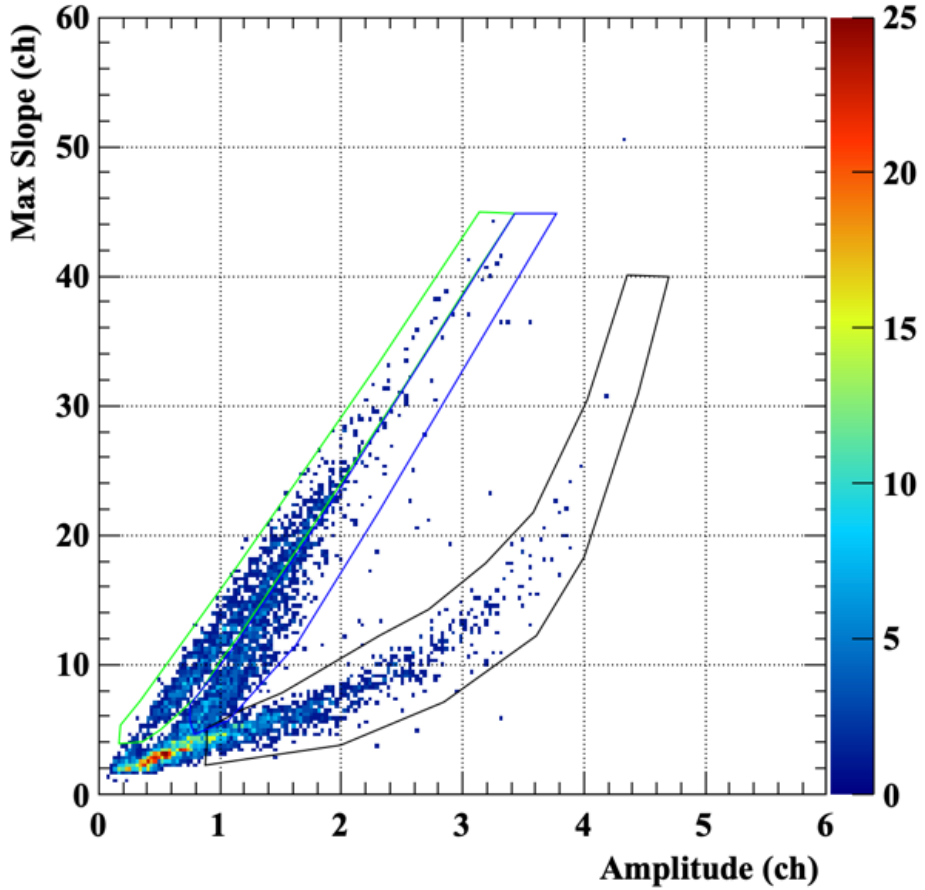
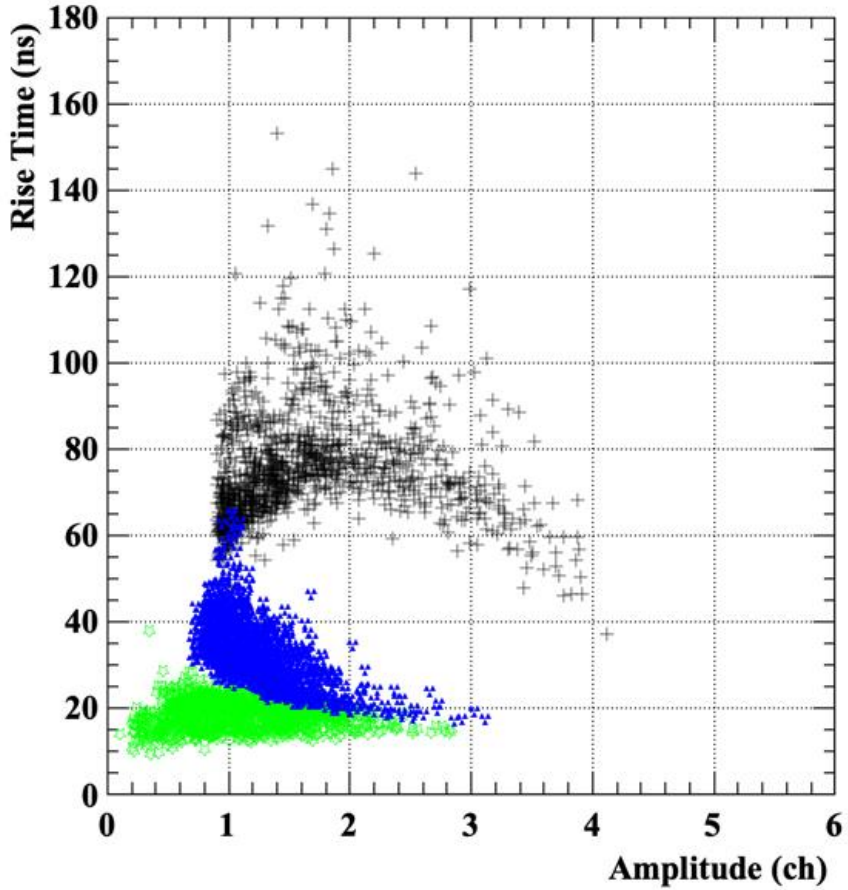




Summary

- **Ringing issue: Solved for the annular detector**
- **First results from the experimental campaign detector: very promising**
- **Hardware and Software (analysis) are in extremely good shape**
- **Experimental campaign at ILL to collect waveform of light charge particles for developing the pulse shape routine and study the technique**
- **Next steps :**

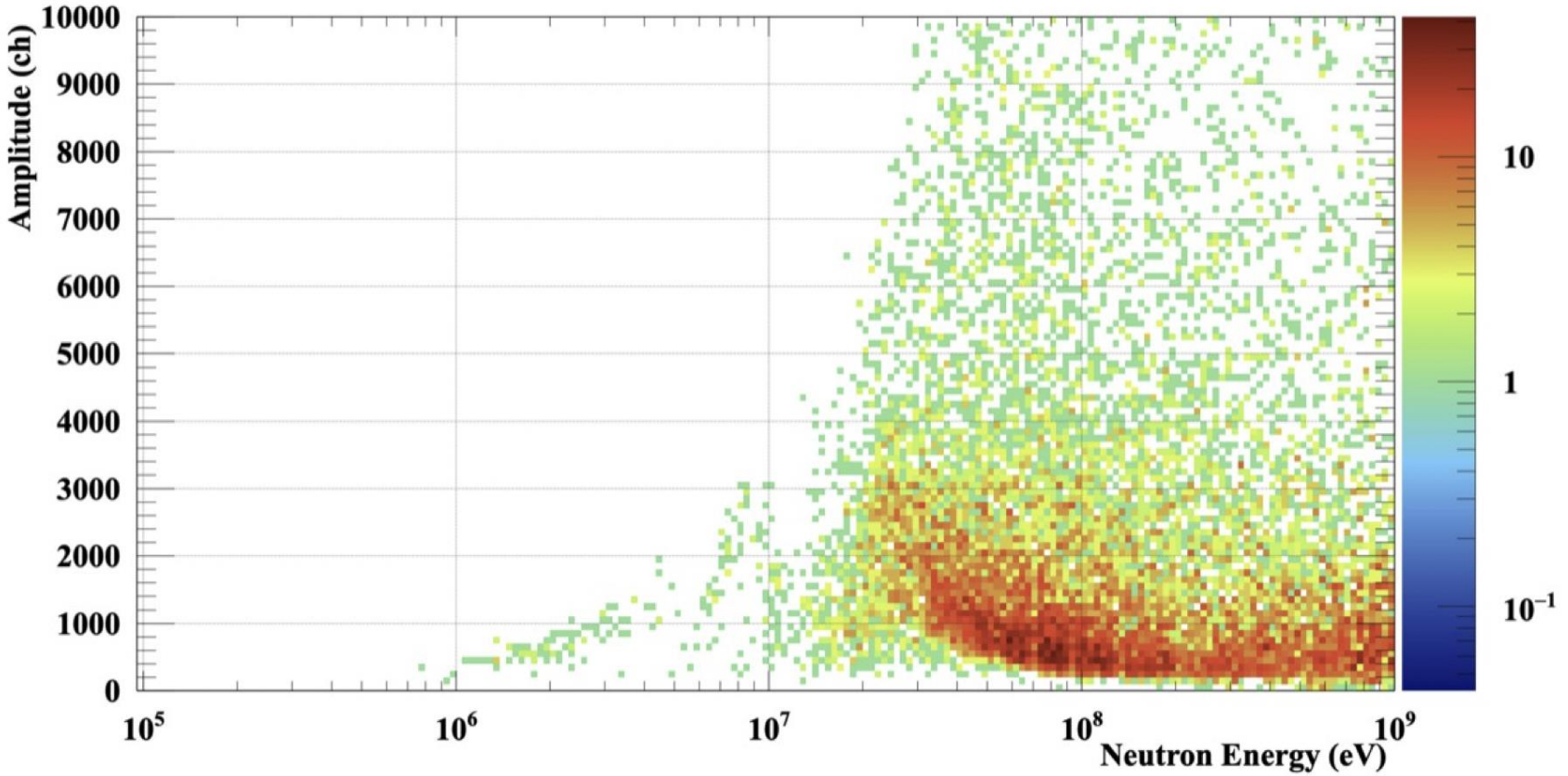
  A. **Refine** GEANT4 Simulations (energy cal. Instrumental for the analysis)

  B. GEANT4 Simulation for the **reproduction of the exact placement** of the interaction point

  C. Extraction of the **energy/angular distribution** for each reaction channel

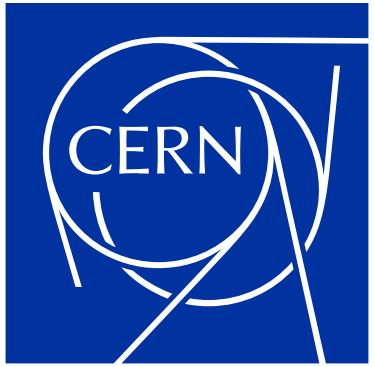
  D. **Comparison** with evaluated data and theoretical calculations (**TALYS**)

tof to energy conversion: VERY preliminary!



Thank you!

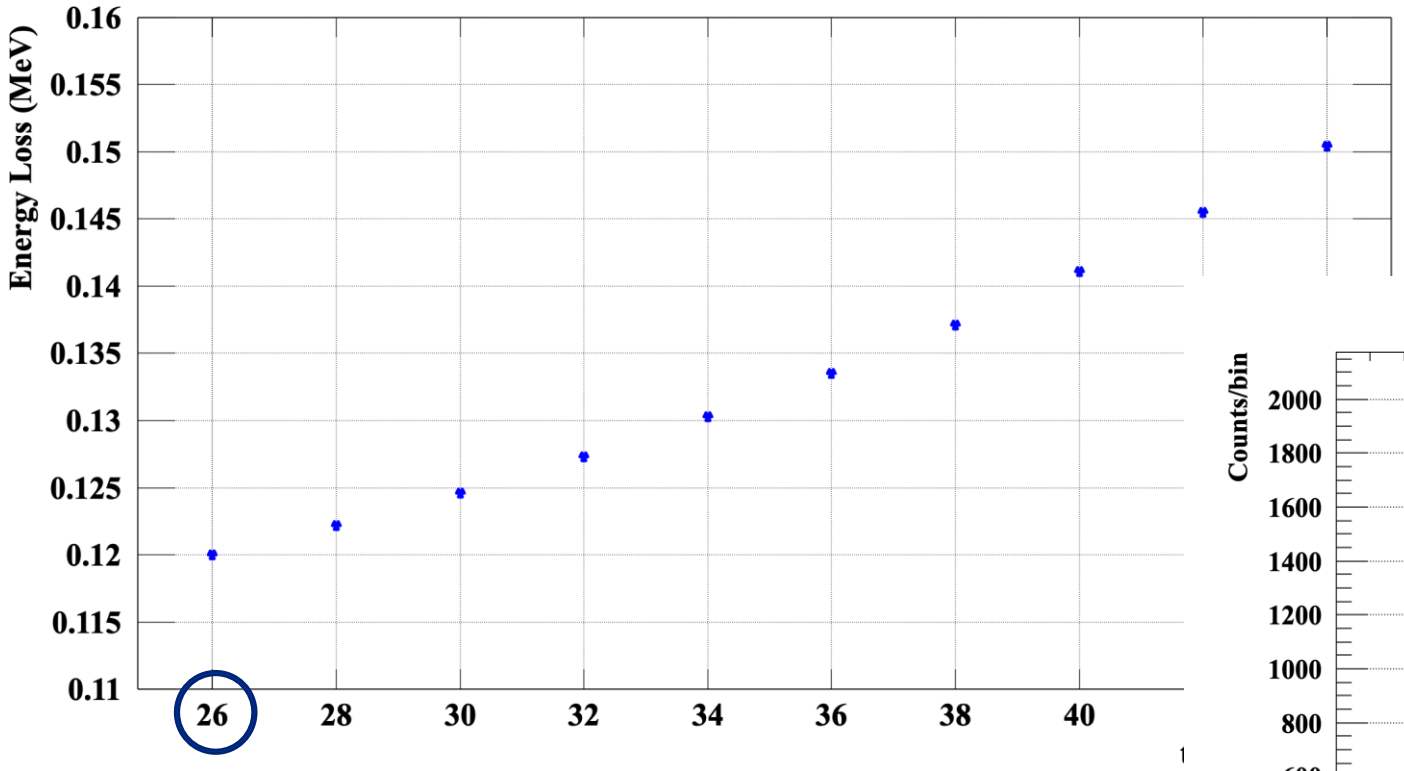
This project has received funding from the Euratom research and training program 2014-2018 under grant agreement No 847594 (ARIEL).



styliani.goula@cern.ch

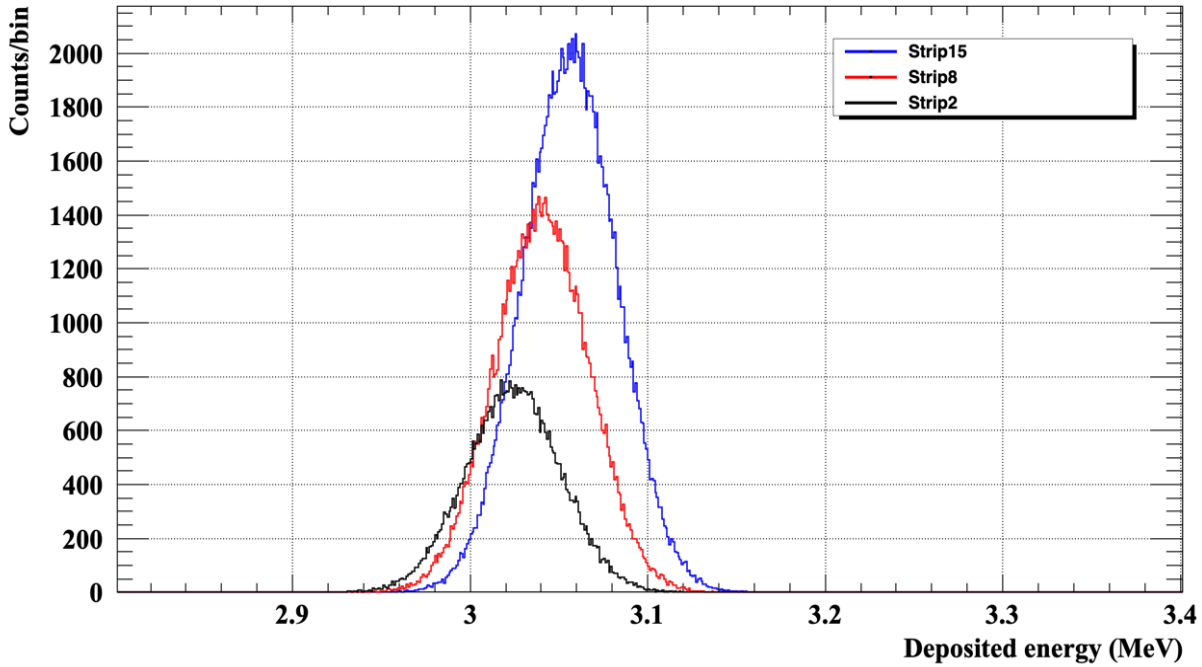
home.cern

Energy Calibration @ GEANT4



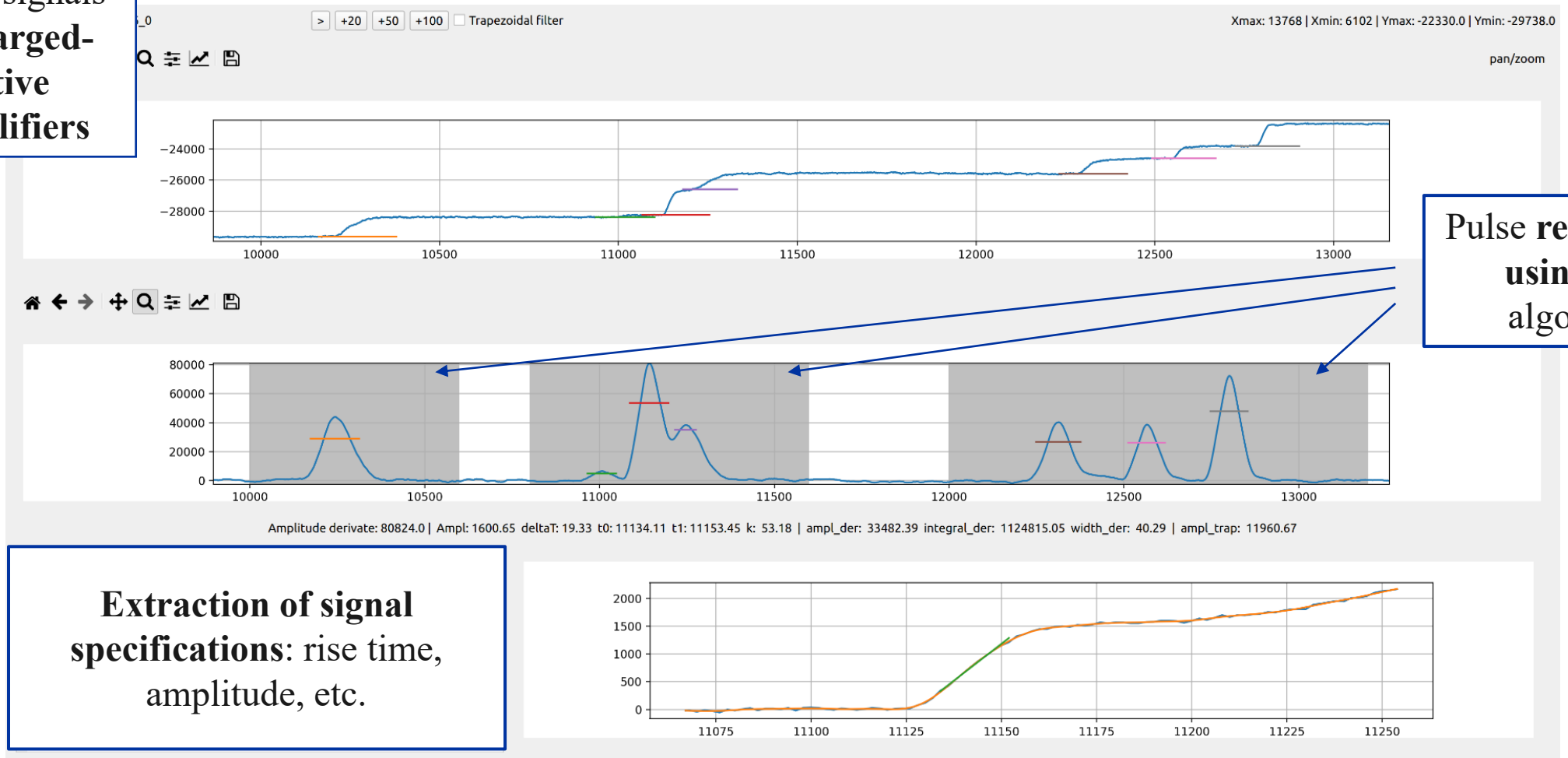
inner strip

The **correction of the emission angle** along the strip **is necessary!**



Particle Discrimination technique

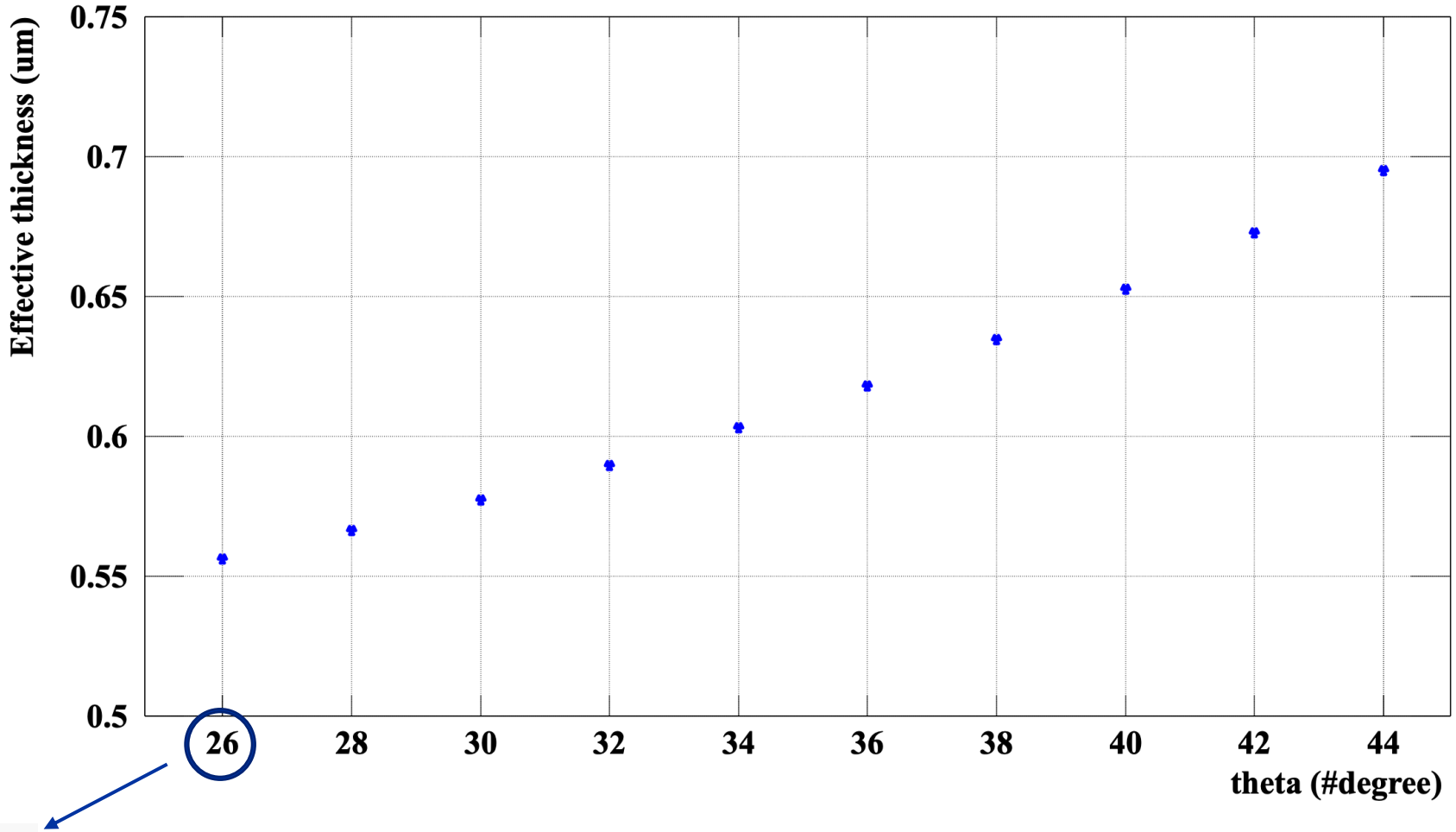
Input the signals from **charged-sensitive preamplifiers**



Pulse **recognition using ML** algorithm

Extraction of signal specifications: rise time, amplitude, etc.

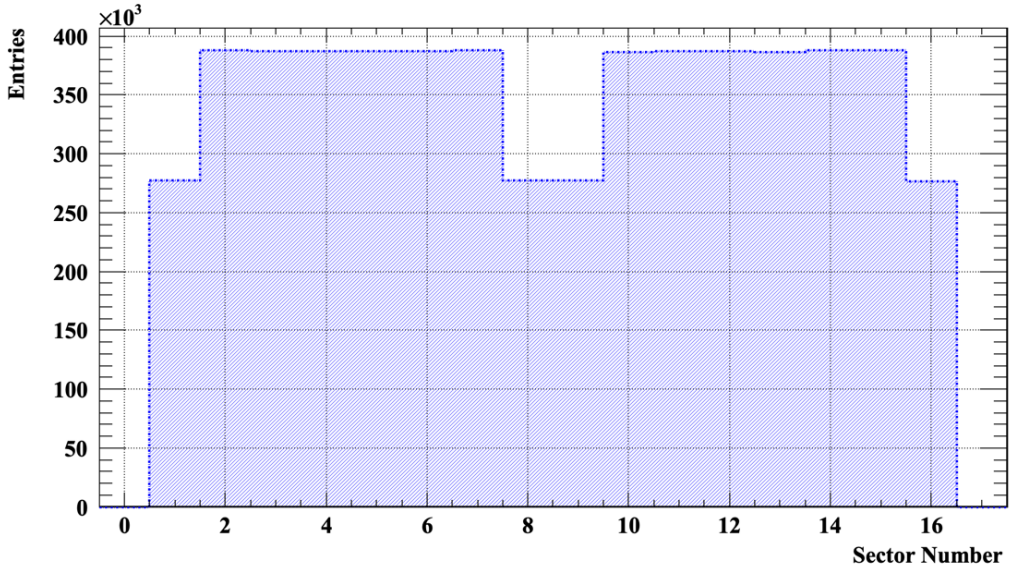
Effective thickness



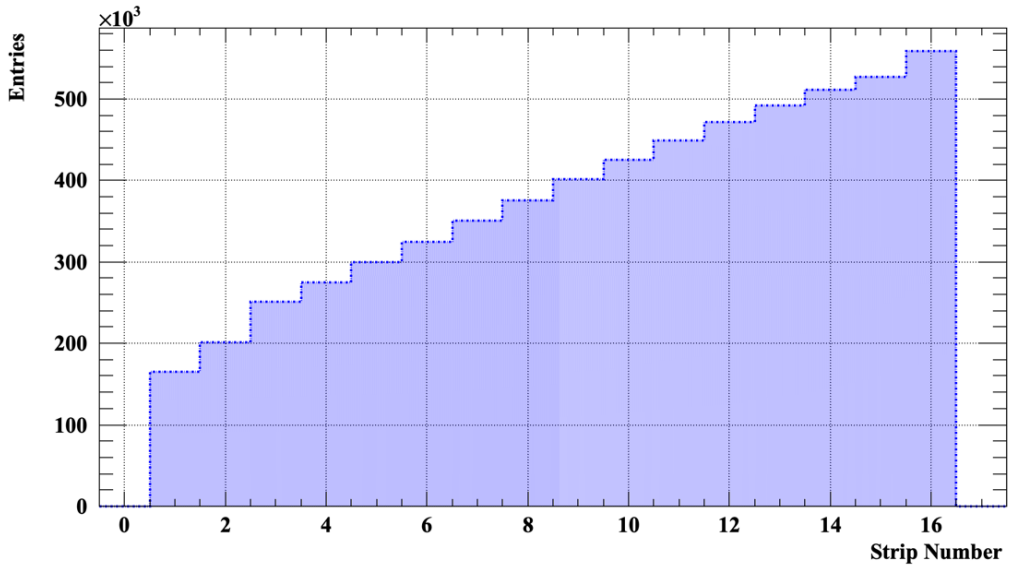
inner strip

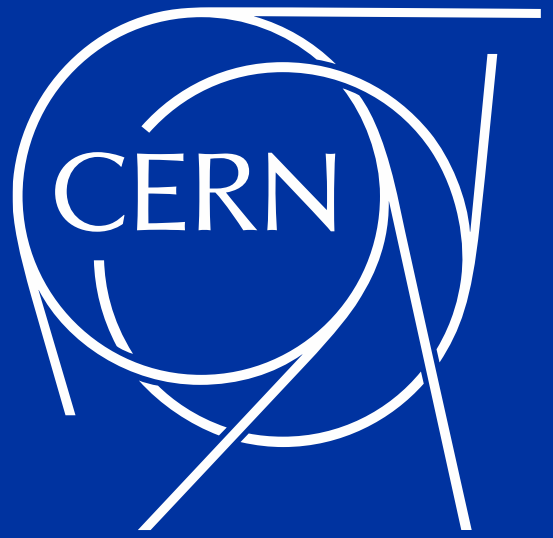
MC simulations: Full-energy-events recorded

Sectors



Strips




CERN