TPC readout with GridPix

Group 6

Victoria Bashu[1], Diego Rodas[2], Giorgio Canezin[3], Maximilian Spors[4]

1. The Australian National University, Canberra, Australia
2. AstroCeNT, CAMK PAN, Warsaw, Poland
3. Laboratory of Instrumentation and Experimental Particle Physics, Coimbra, Portugal
4. University of Bonn, Germany

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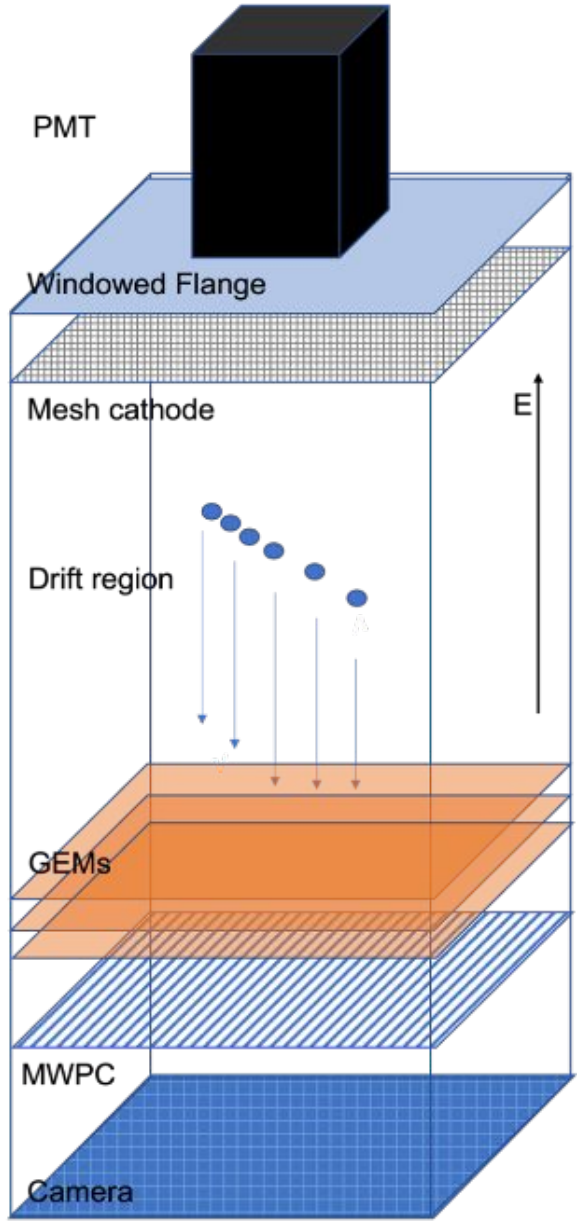
Outline

- TPC and GridPix Basics
- Experimental Setup
- Results
- Conclusions

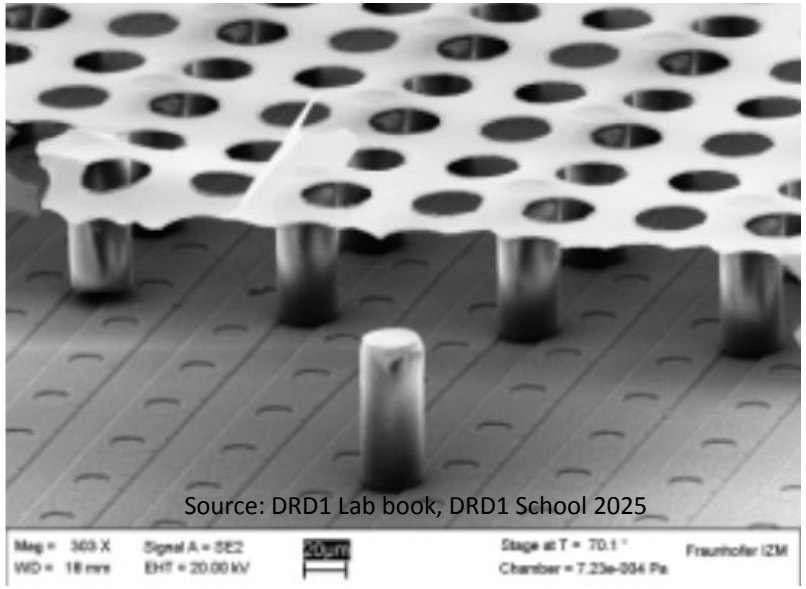
TPC and GridPix Basics

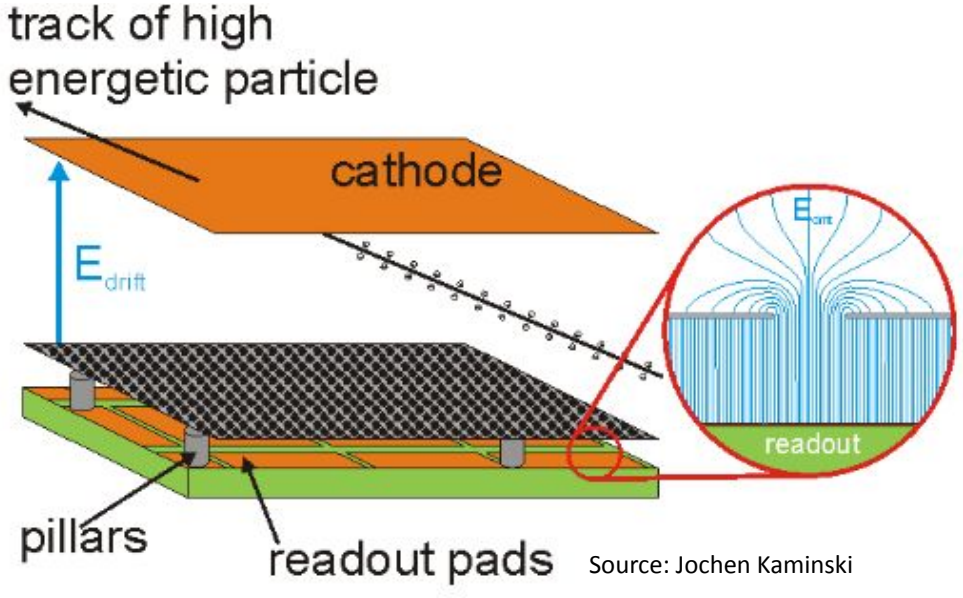
- **Time Projection Chamber**
  - **Components:** A TPC consists of a large conversion and drift volume made of only gas, and a segmented readout plane;
  - **Working principle:** Incoming particles passing or converting into charge particles ionize the molecules or atoms, the electrons drift to the readout plane;
  - **Key Features:** Provides 3D tracking and particle identification by measuring the drift time and charge deposition (dE/dx).



TPC and GridPix Basics

- **GridPix**
  - **Components:** Combination of a highly pixelated readout ASIC and an integrated Micromegas Grid (InGrid);
  - **Working principle:** Primary electron from the drift region enters a hole, gas amplification takes place and the complete avalanche is collected by a single pixel;
  - **Key Features:** Provides excellent spatial and energy resolutions.

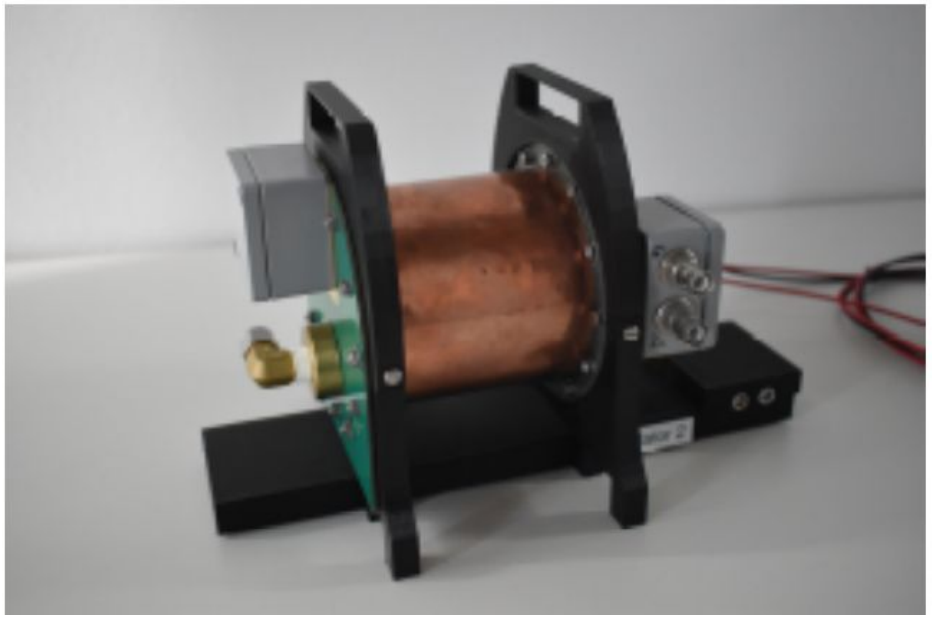




Source: Jochen Kaminski

Experimental Setup

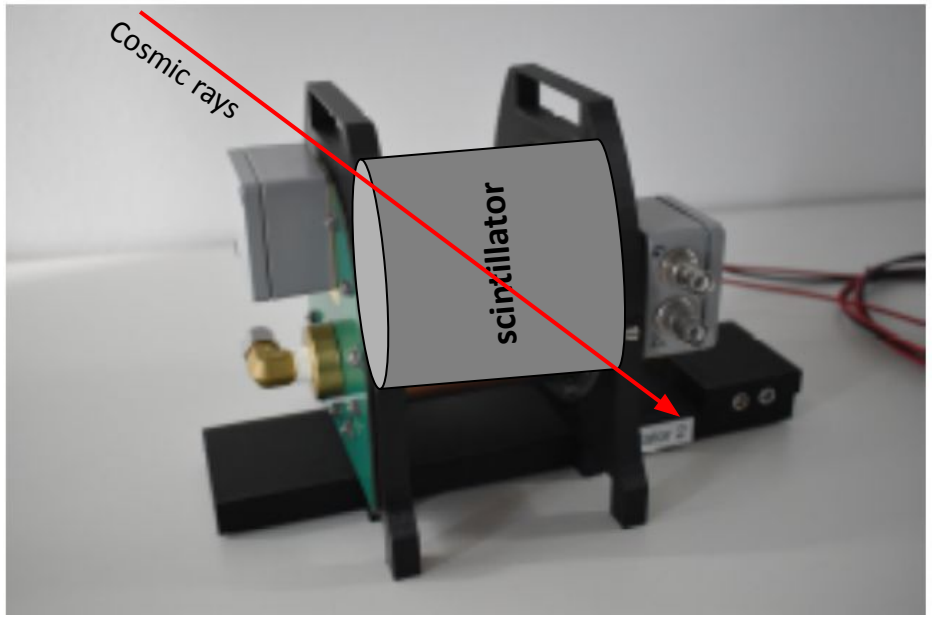
- **CLassroom Experiment On PArticle TRAcking (CLEOPATRA detector)**
  - The maximum drift length is 10 cm and the inner diameter of the drift volume is 8 cm,
  - The anode side is equipped with 4 GridPix detectors, which are read out with the Scalable Readout System (SRS)
  - Cosmic ray and radioactive source measurements



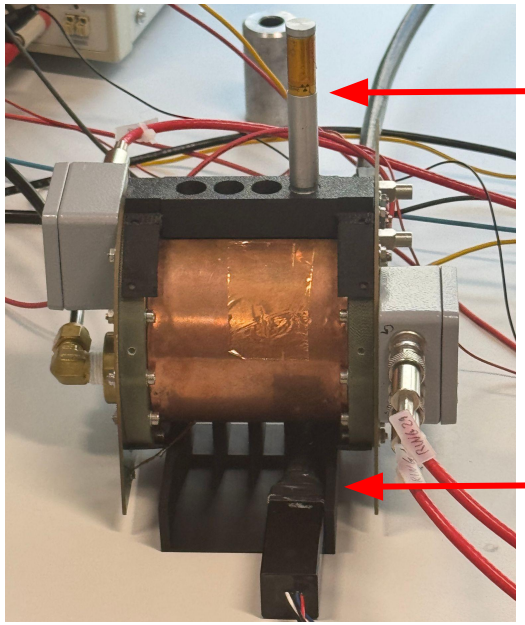
CLEOPATRA detector

Experimental Setup

- **Cosmic ray measurements**
  - Scintillator surrounding the drift volume to trigger from the Cosmic rays



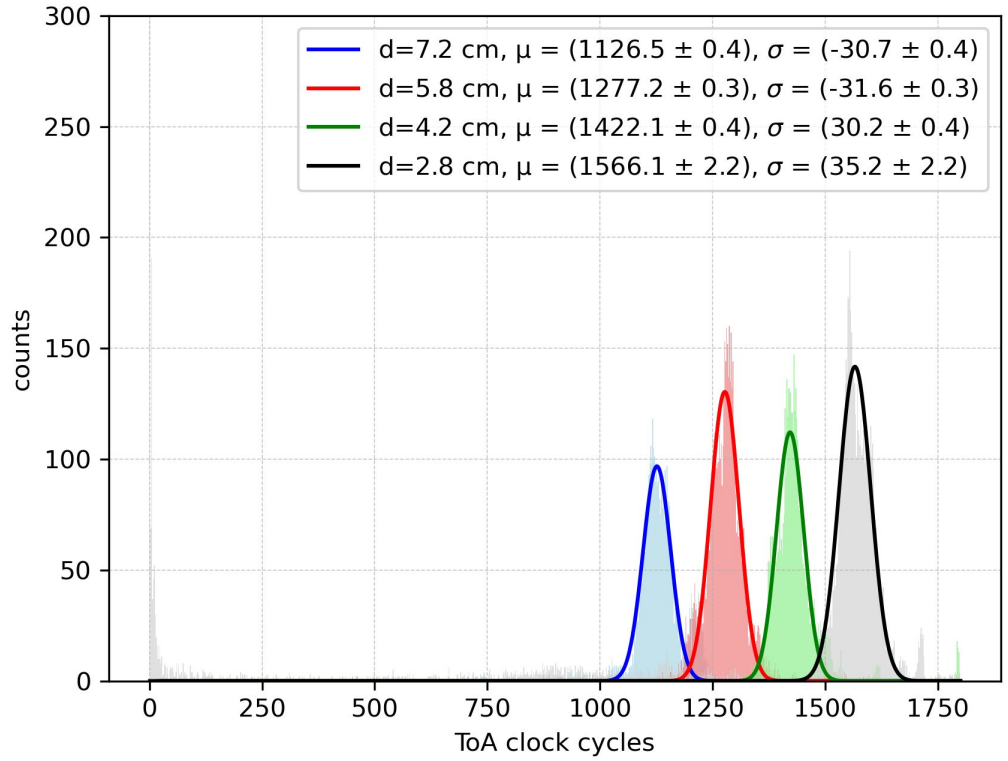
Cosmic ray set up

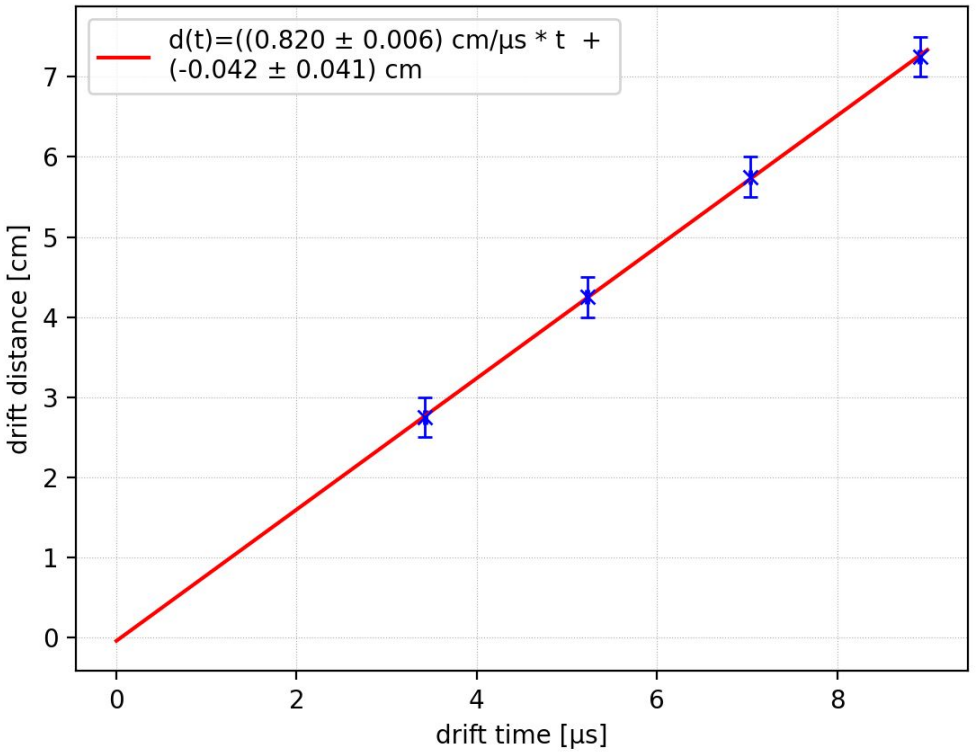


Setup with radioactive source

Results

- **Drift velocity measurements with radioactive source Ar:CO2 82:18**





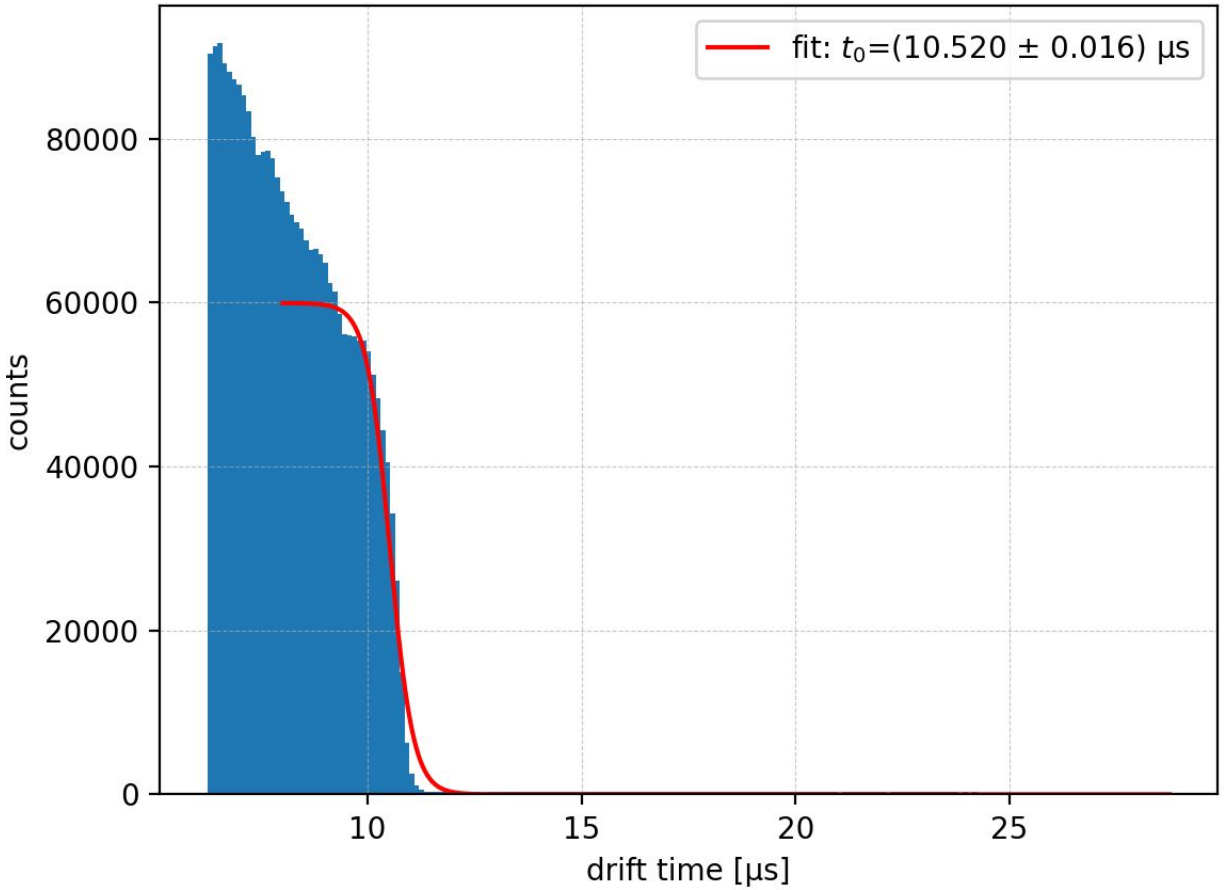
Big thanks to Jochen Kaminski and Jan Glowcz

Results

- **Drift velocity from cosmic ray**

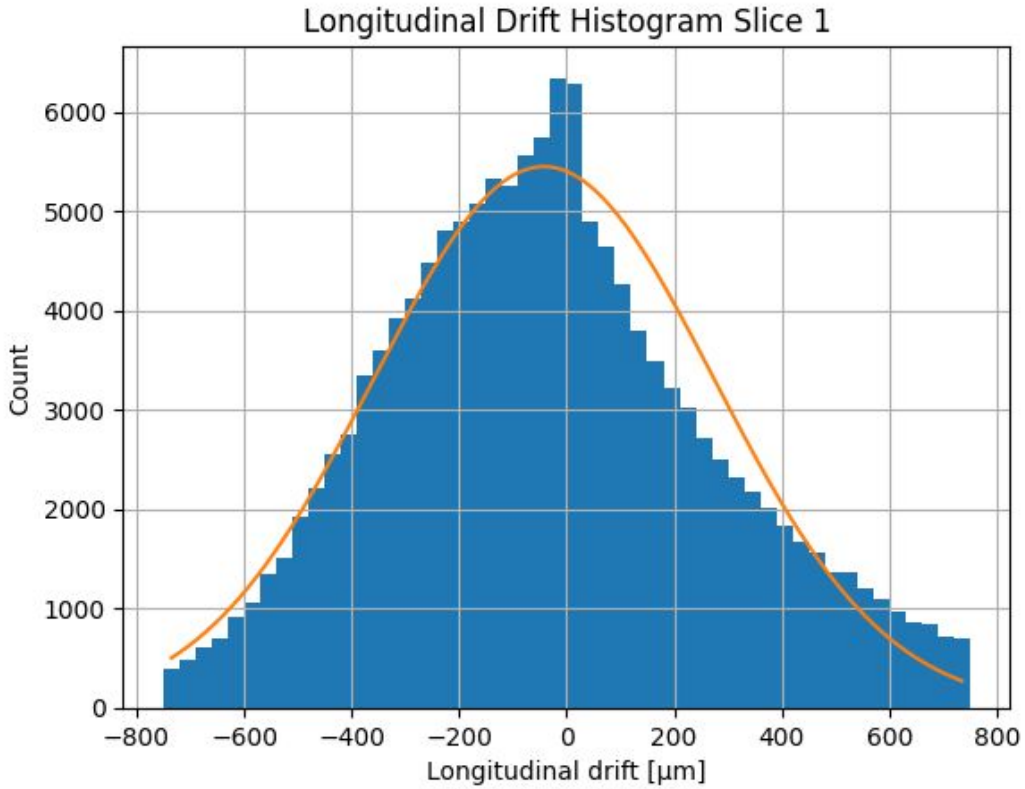
  - Fit S-curve to find maximum drift time
  - Start fit at t> 8 µs to exclude distorted regions
    - Reasons:
      - Electron attachment (<1000 ppm Water present)
      - Trigger inefficiencies for larger track

$$v_{\mathrm{Drift}} = \frac{l_{\mathrm{max}}}{t_0} = (0.9506 \pm 0.00015)\frac{\mathrm{cm}}{\mu\mathrm{s}}$$

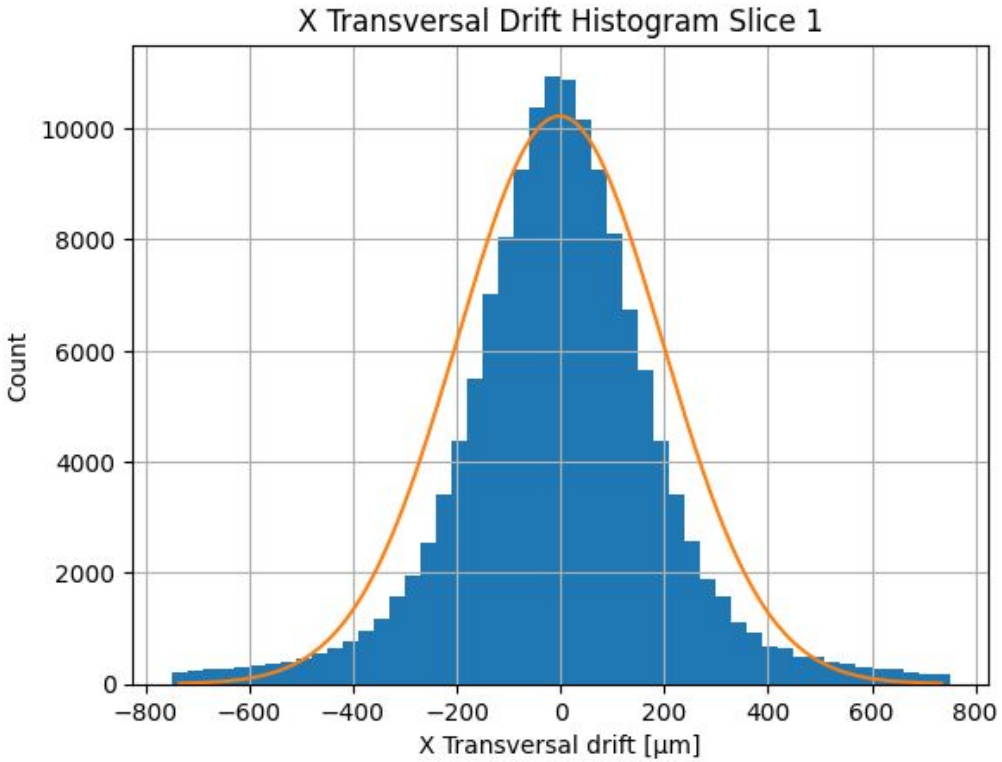


Results

- **Diffusion constants with cosmic ray dataset**



Difference between drift time and time of arrival from the trigger



Pixel hit distance from the central cosmic ray track that is found by a track finding algorithm

Results

- **Diffusion constants**

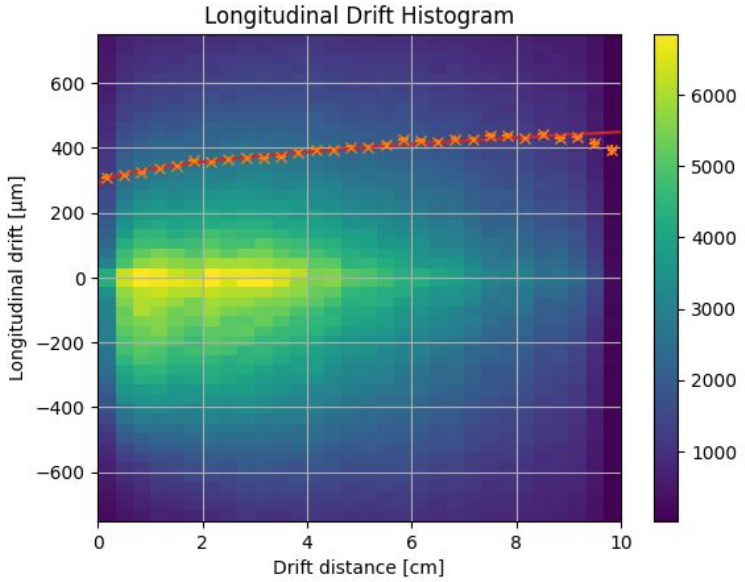
- Charge distribution centered around 0
- Orange points: spread of the gaussian of the corresponding slice (1D fit)

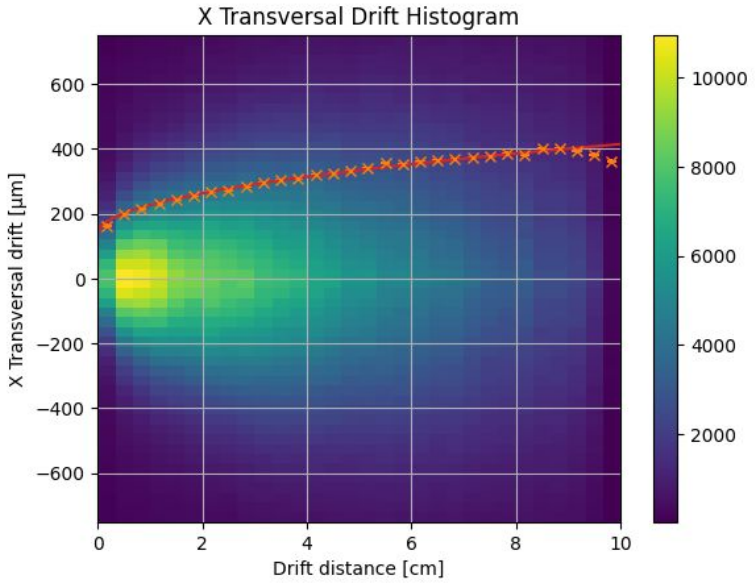
$$\sigma \propto \sqrt{2D\frac{l}{v_{\text{Drift}}}}$$

$$D_{\text{long}} = (53.00 \pm 0.24)\frac{\mu\text{m}}{\sqrt{\text{cm}}}$$

$$D_{\text{trans}} = (86.80 \pm 0.27)\frac{\mu\text{m}}{\sqrt{\text{cm}}}$$

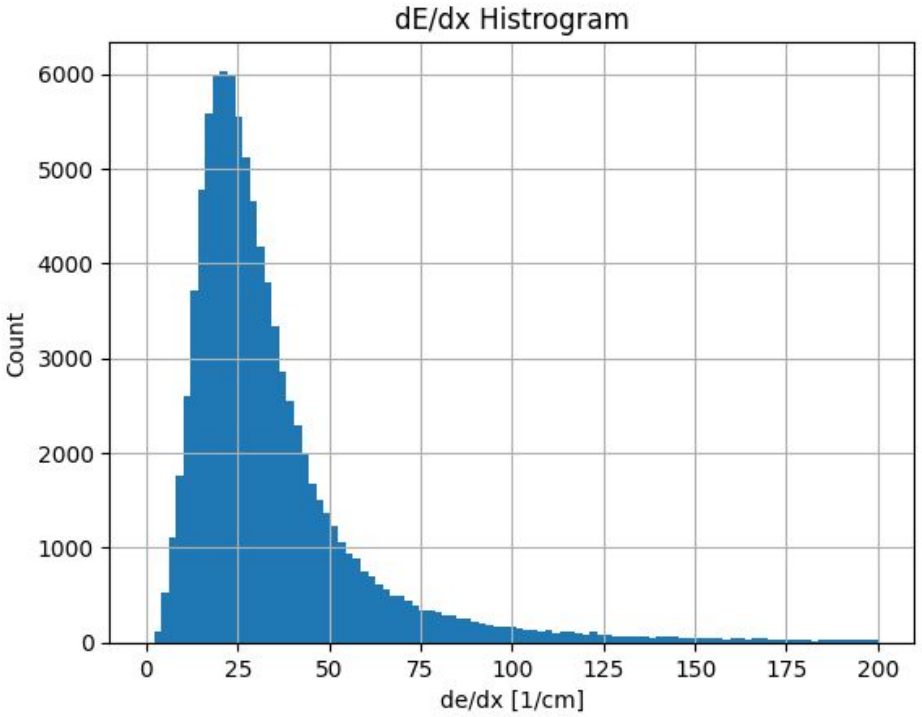
Readout pixel pitch 55 micron





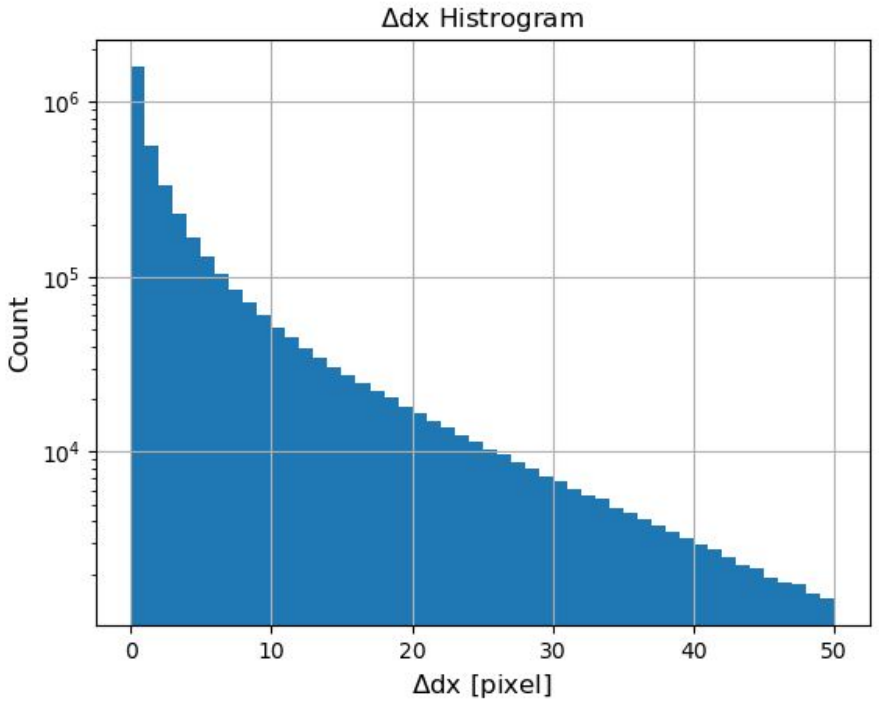
Results

- **Energy resolution**



Energy deposition has Landau distribution and not Polya as the amplification fluctuation is taken out by being able to count the primary ionised electrons from the track

- **Pixel hits distances with respect to the central track**



Another way of viewing the spread of pixel hits from the central track
Closer to the track has most of the pixel hits

Thank you

Big shout out to the organisers for this exciting and insightful experience