Fundamentals Of Working With Timepix3 Detectors for Registration Of Charged Particles

FLNR - FOBOS - Multibody decay of heavy Nuclei

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Particle Definitions

Alpha Particles (α):

- Helium-4 nuclei: 2 protons + 2 neutrons
- Charge: +2e, Mass: 4u

Fission Fragments (FF):

- Fragments from nuclear fission (e.g., ^{235}U)
- Masses $\sim$95u (Krypton) and $\sim$137u (Barium)
- High kinetic energy ($\sim$170 MeV total)
- Extremely high ionization density

Aims & Objectives

Aims:

- To understand the interaction of α-particles and FF with matter under different experimental conditions

Objectives:

- Establish energy calibration standards for both particle types
- Compare detector responses under vacuum vs. air conditions
- Using pixel clustering for extracting spatial distribution
- Rutherford scattering using collimators and thin foils.
- Investigate coincidence events (α-FF, α-α)

Timepix3 detector

Table 1. Summary of Timepix3 features.

CMOS technology	130 nm, 8-metal stack
Pixels	256×256
Pixel size	$55 \times 55\ \mu m^2$
Acquisition modes	Charge and time Time only Event counting and integral charge
Zero suppressed readout	YES
Dead time per pixel	ToT Pulse time + 475 ns
Timing resolution	1.5625 ns (640 MHz)

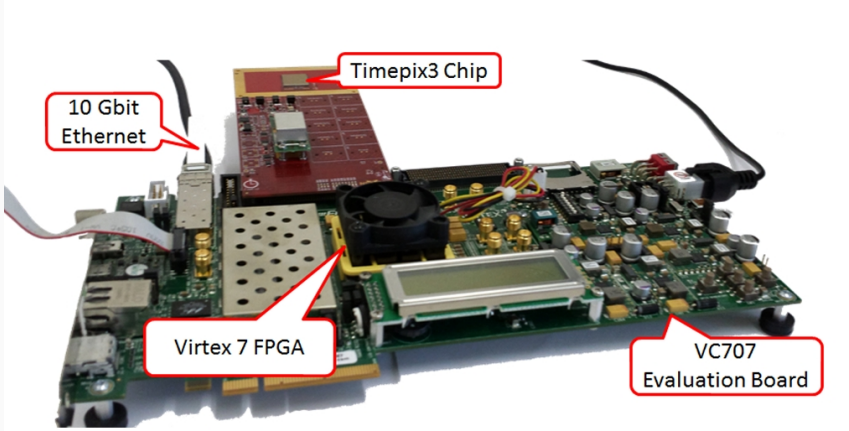


Figure 5. The test setup (Nikhef and CERN) for Timepix3 used to read out.

- **Uses:**
  X-ray imaging
  Particle track reconstruction
  Gas-filled detectors

- **Limitations:**
  Better response due at low energy ranges

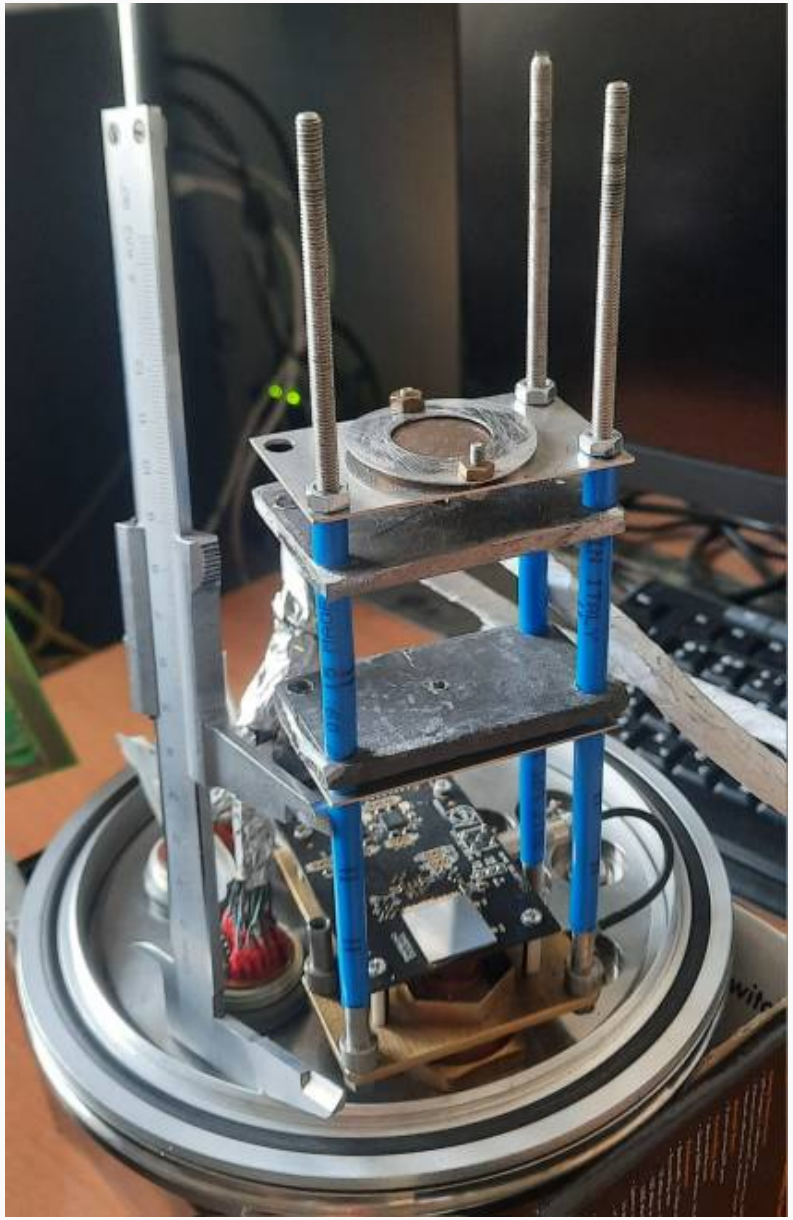
Methodology

Experimental Setup:

- ^{233}U, ^{239}Pu ^{238}Pu
- Timepix3 detector (256×256 pixels)
- Vacuum chamber ($< 10^{-3}$ mbar)
- Variable collimators and scattering foils

Software Tools:

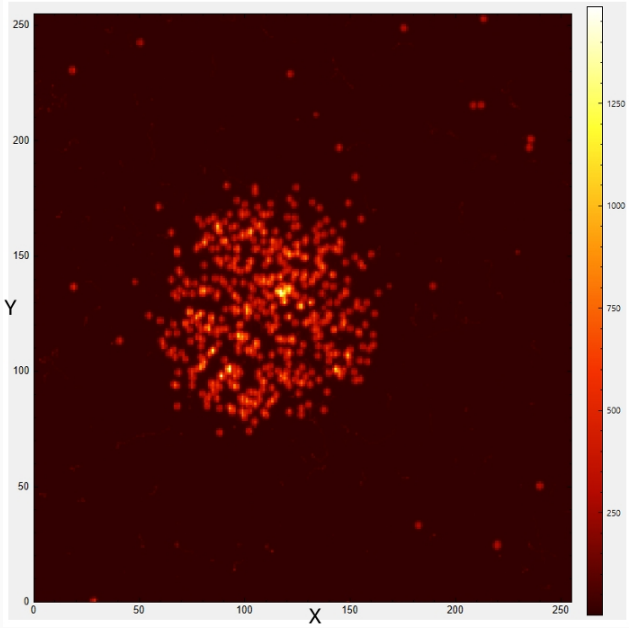
DT4800, CAEN MC^2 Analyzer, Multi-cluster, Cluster Viewer, Python, Origin, Obrabotka, Analiz



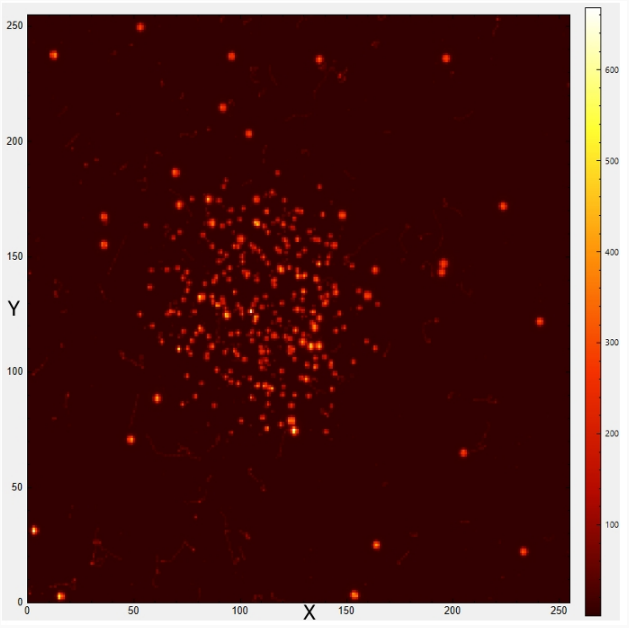
Results: Vacuum vs. Air

Vacuum Conditions:

Dense region of particles

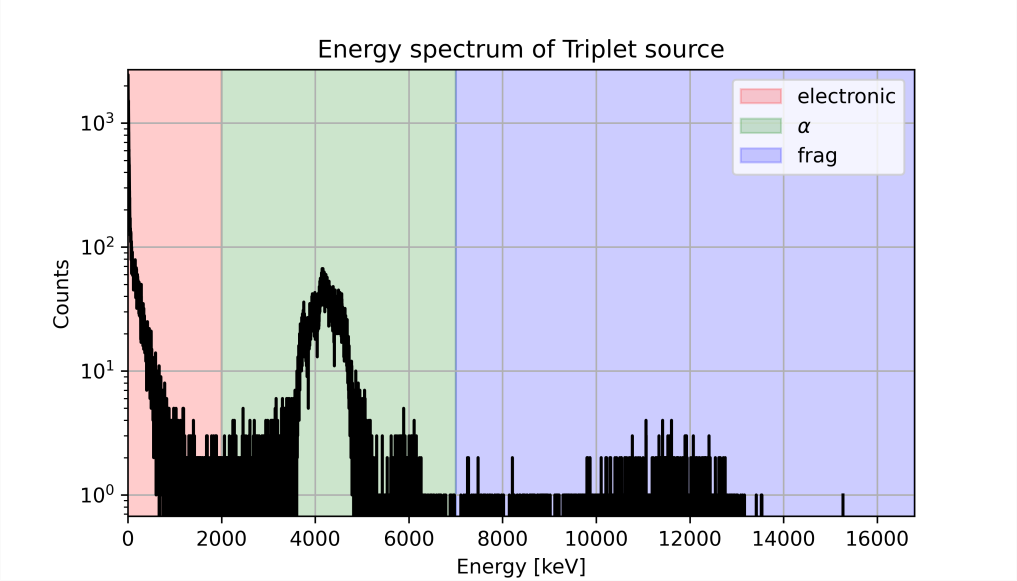


Air Conditions: Less particles, lower energy



Vacuum Practice:

Results: Pixel vs Total Energy



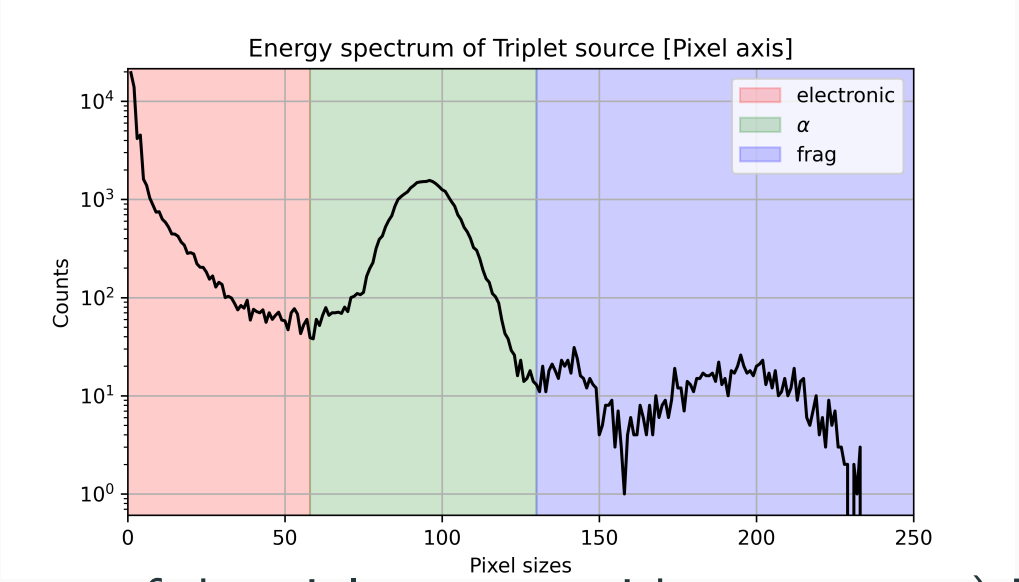
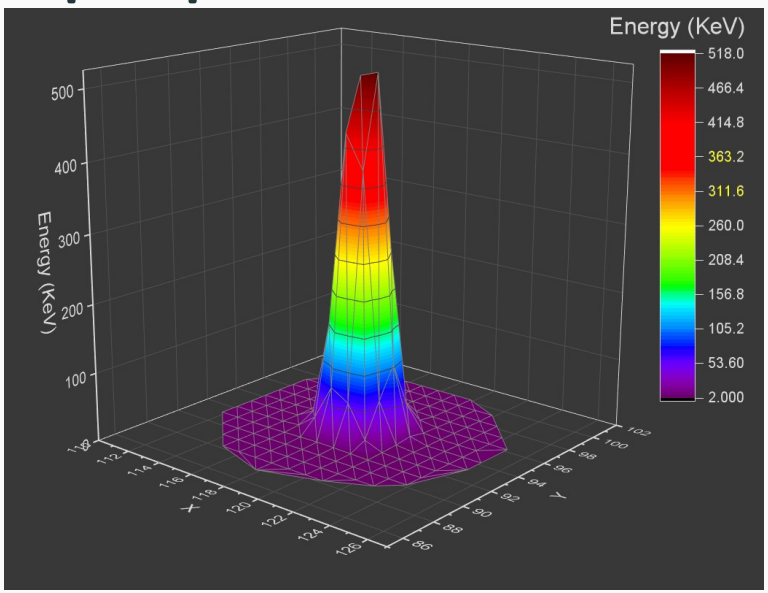


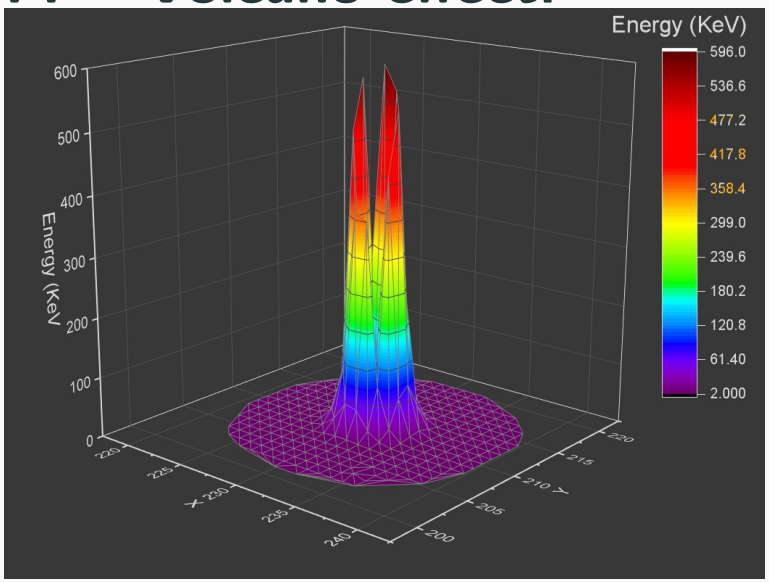
Figure 1: Spectra of the triplet source with respect to a) Energy b) Pixel size

Results: Spatial distribution

Alpha particle:

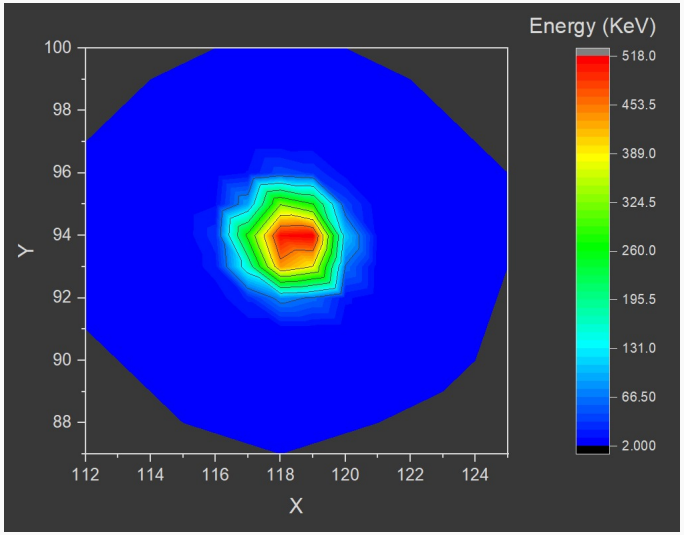


FF - Volcano effect:



Results: 2D projections

Alpha particle:



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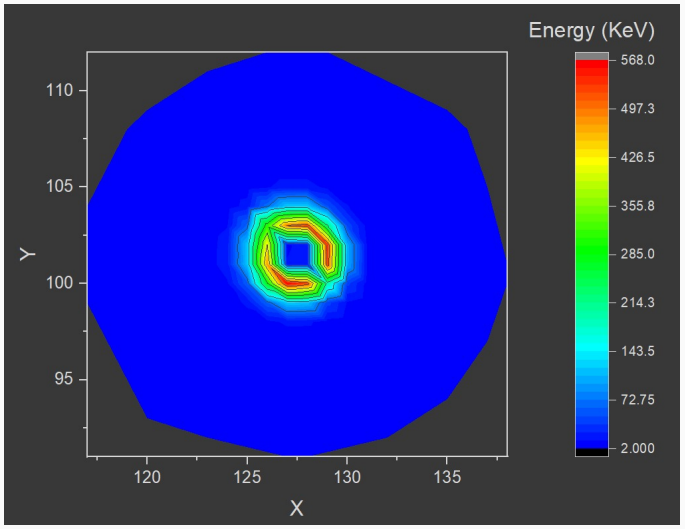
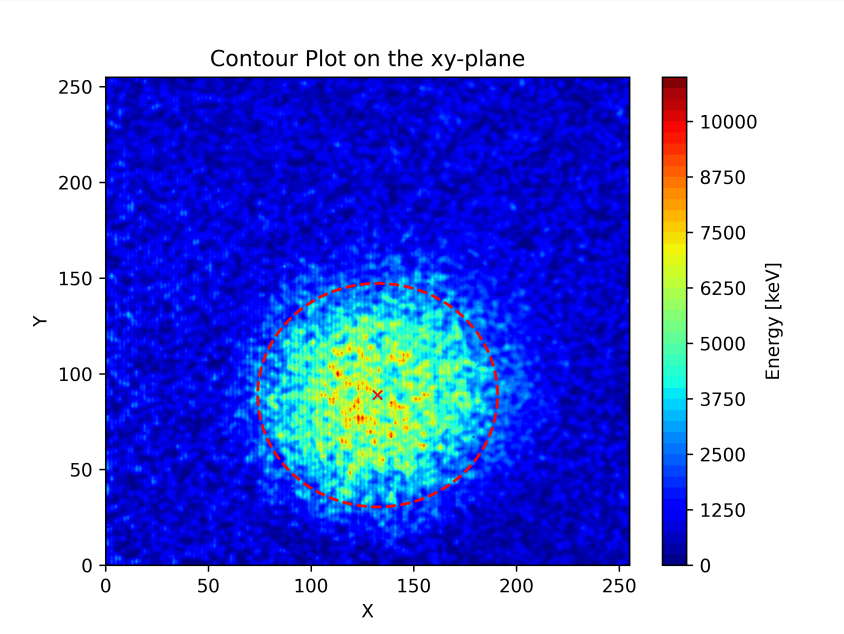


Results: Collimation & Scattering

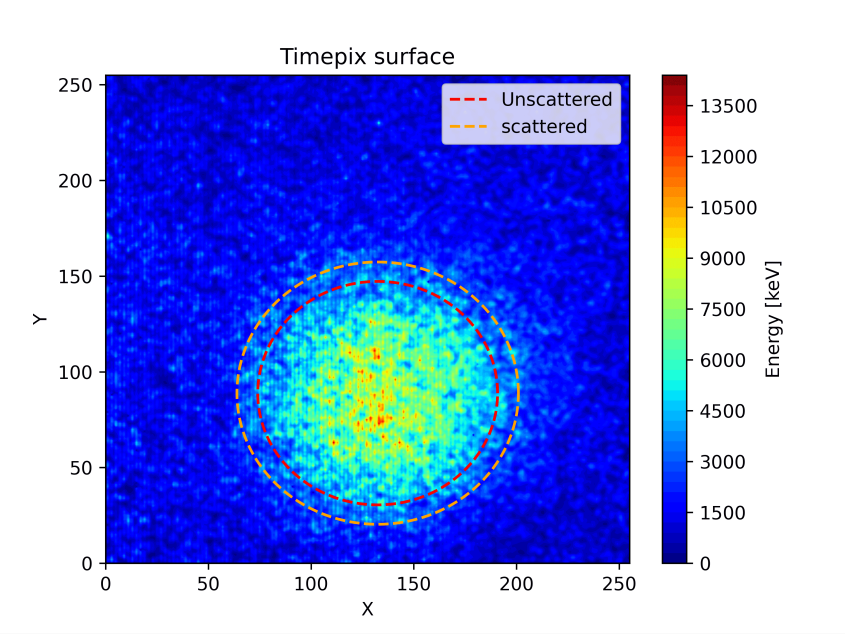
Collimator Comparison:



R = 58.36 pixels

- Circular confined reduced effective area

Foil Scattering:

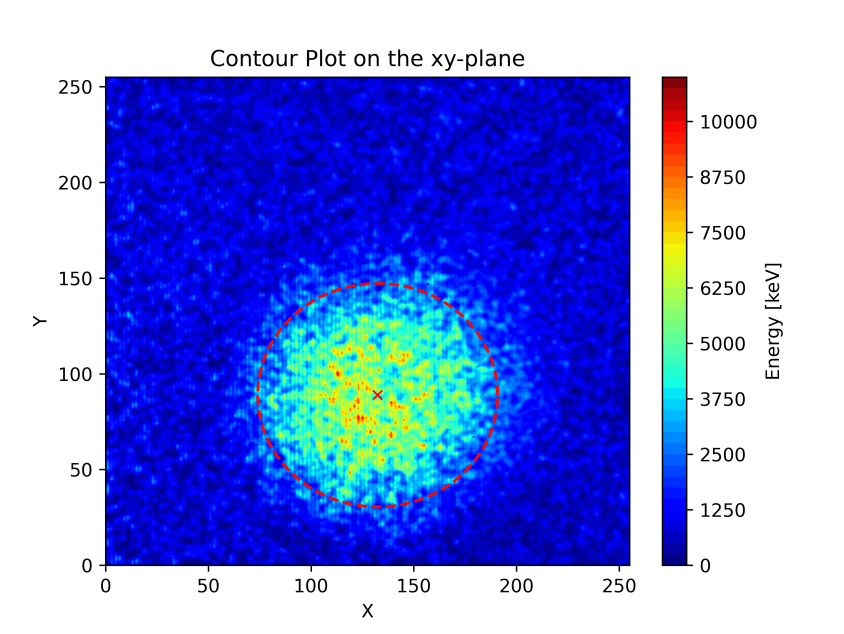


R = 68.50 pixels

- Gold foil for α and FF scattering

Results: Collimation & Scattering

Collimator Comparison:



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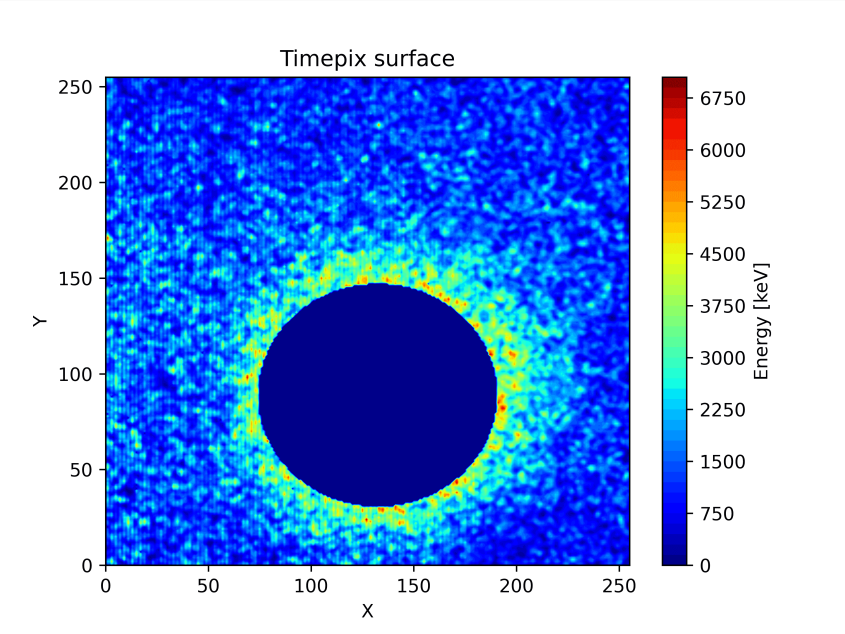
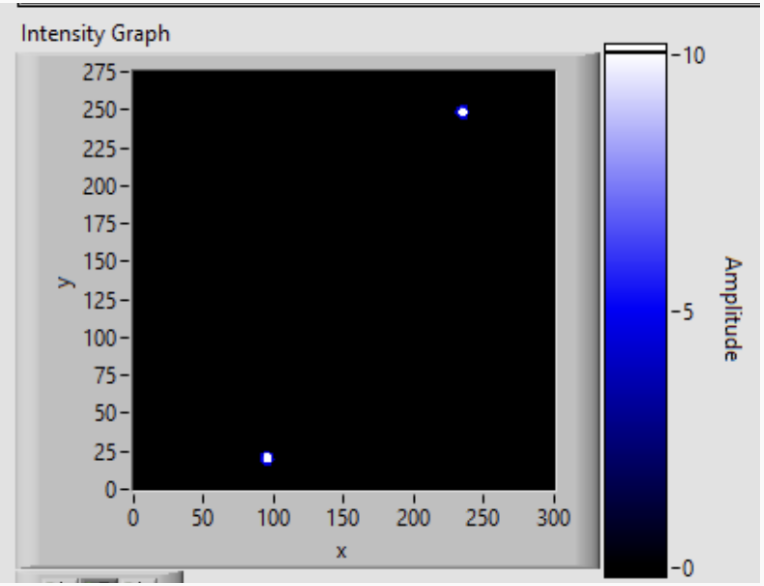


R = 68.50 pixels

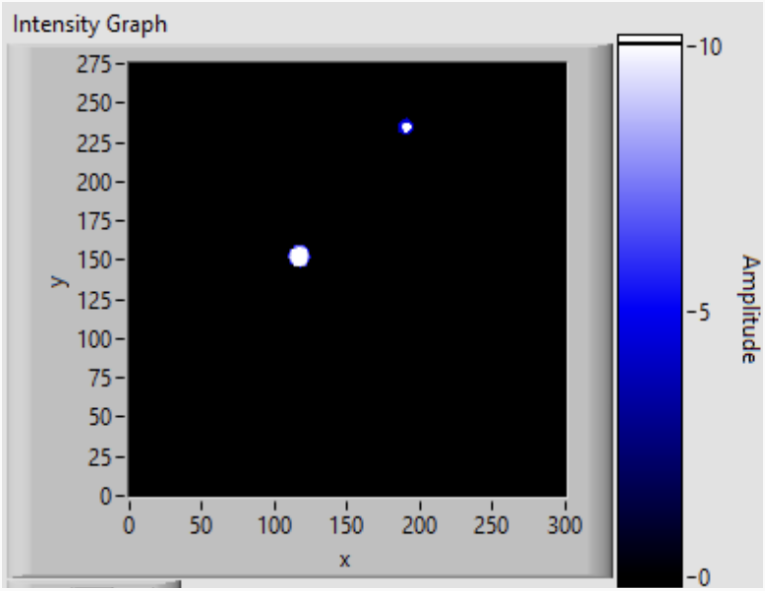
- Gold foil for α and FF scattering

Results: Coincidence Events

Alpha-Alpha:



Alpha-Fission:

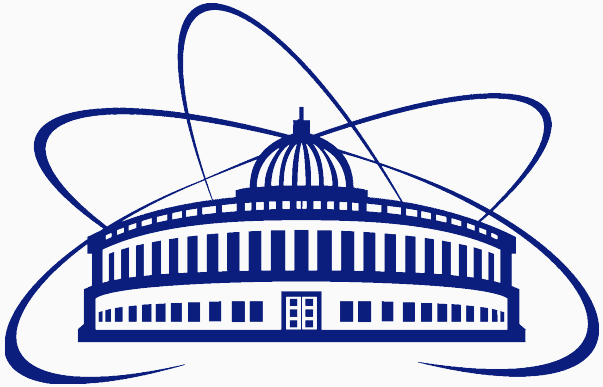


- $P_{ij} = I_i I_J \Delta t T$
- $P_{\alpha,\alpha} \sim 40$
- $P_{\alpha,FF} \sim 1$

Conclusion

- Timepix3 successfully resolved α and FF signatures:
  - α: Compact clusters, monoenergetic peak
  - FF: Large clusters, continuous energy spectrum
- Vacuum is necessary for effective detective
- Foils allow Rutherford scattering
- Coincidence measurements validate fission dynamics

Acknowledgments



Thank you... Any Questions