Event Reconstruction for Heavy-Ion Collision Experiments with SπRIT-TPC

Jung Woo (Korea University)
for SπRIT-Collaboration

Contents

Physics Motivation

$$\delta = (\rho_n - \rho_p)/\rho$$

$$E(\rho,\delta) = E(\rho,0) + E_{sym}(\rho)\cdot\delta^2 + \mathcal{O}(\delta^4)$$

$$E_{sym}(\rho) \approx E(\rho,1) - E(\rho,0)$$

- Study on symmetry energy with model calculations and recent experiments has large uncertainty.
- Analysis on SπRIT experiment will constrain on the symmetry energy using RI-beams at RIKEN-RIBF.
- SπRIT experiment is built to focus on detecting low energy charged pions which is one of the most sensitive observable in RI collision events.

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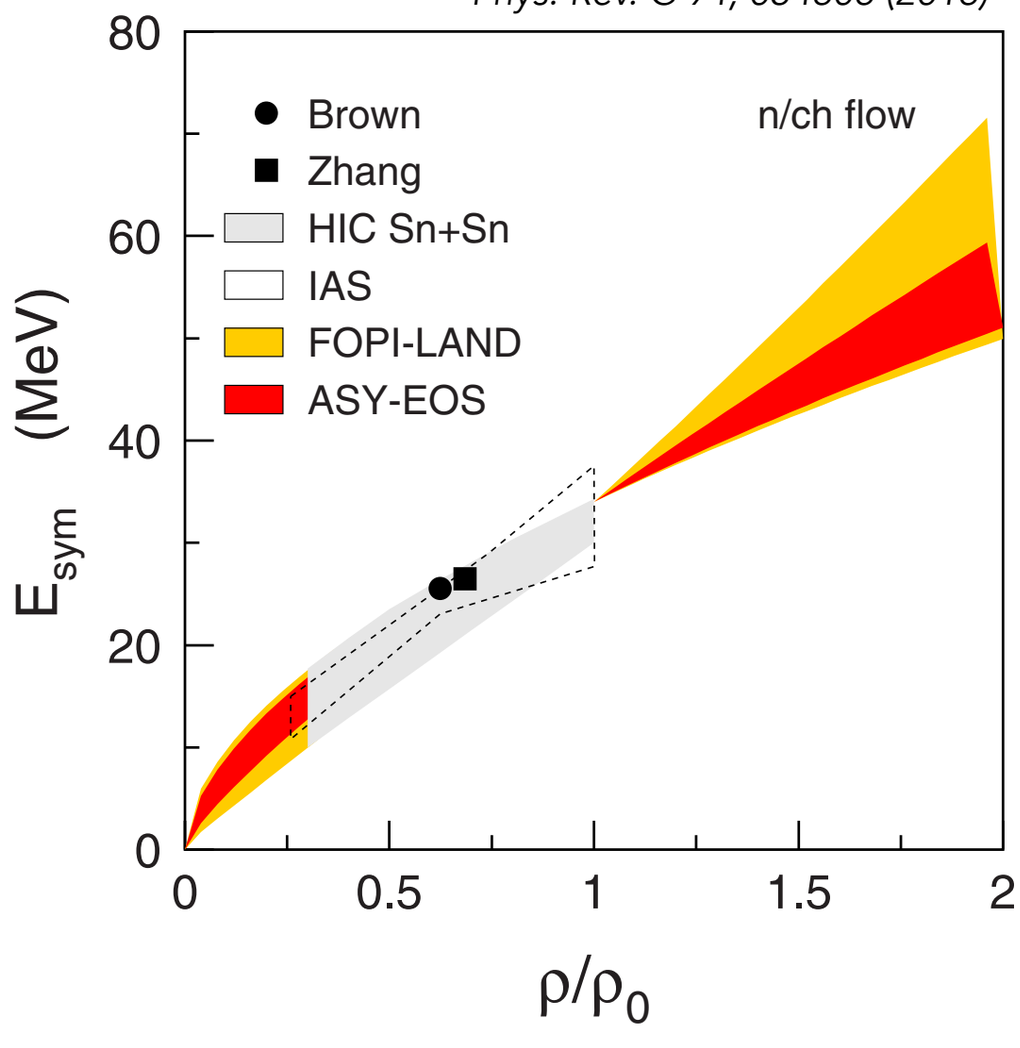
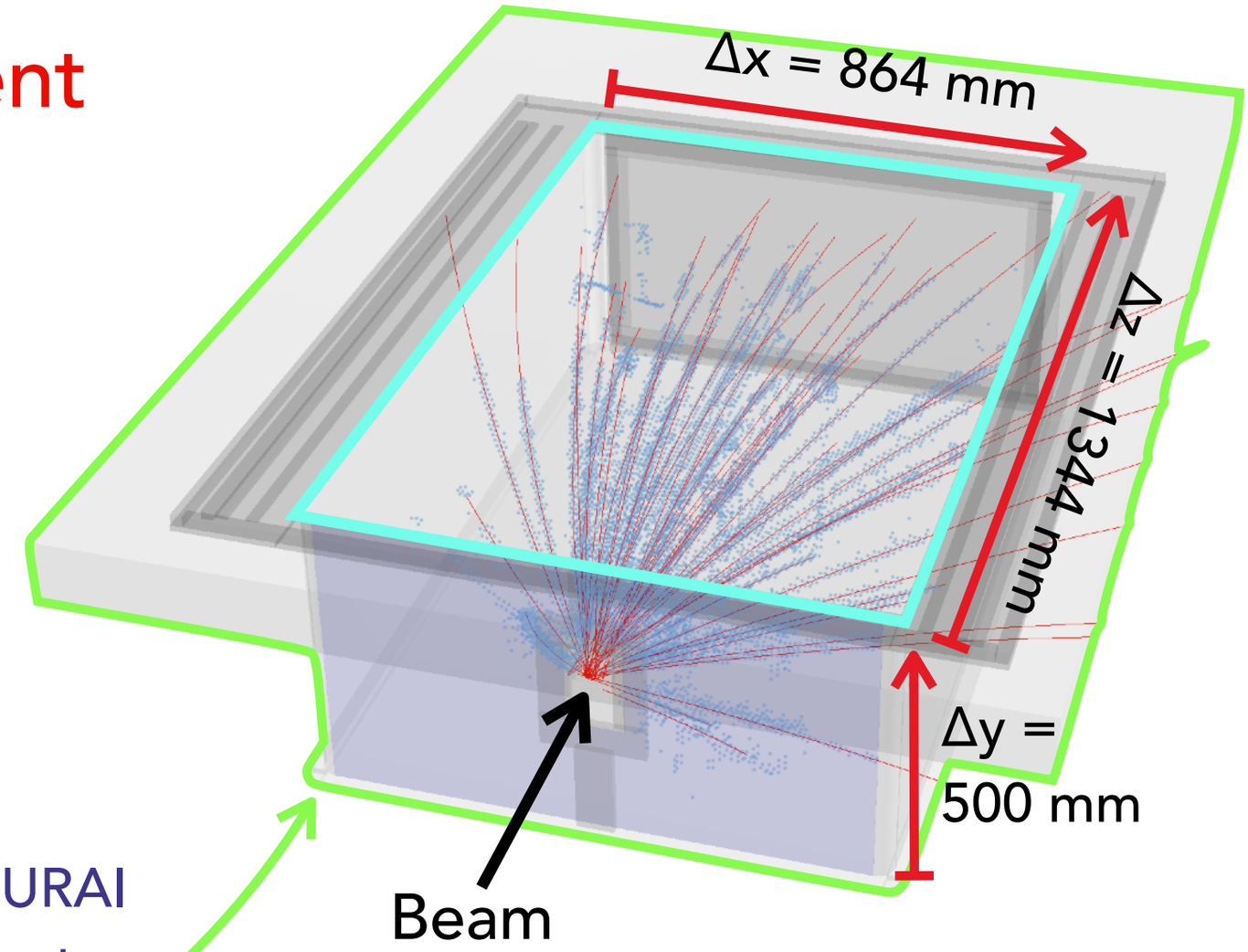
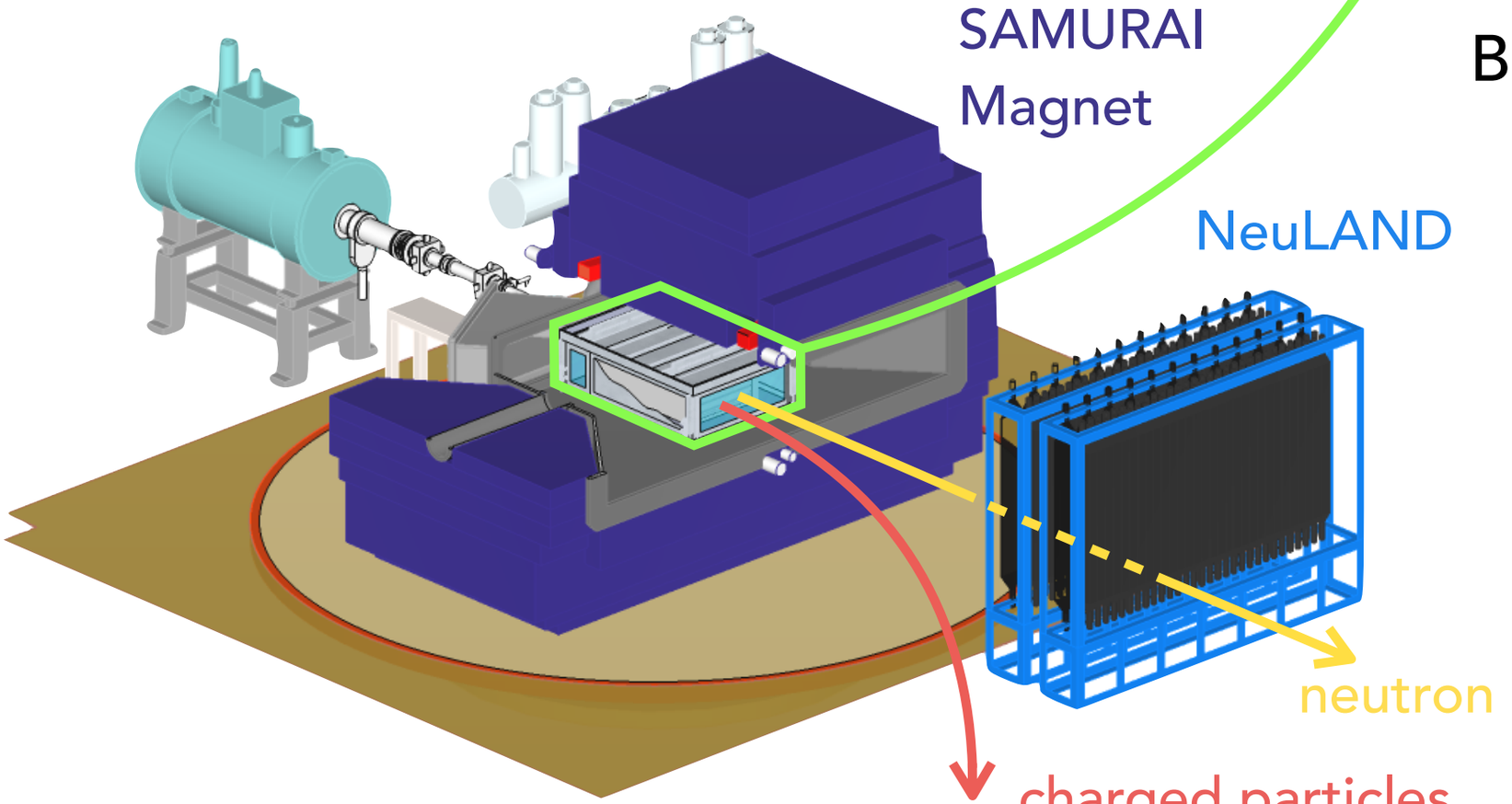


SπRIT TPC and Experiment

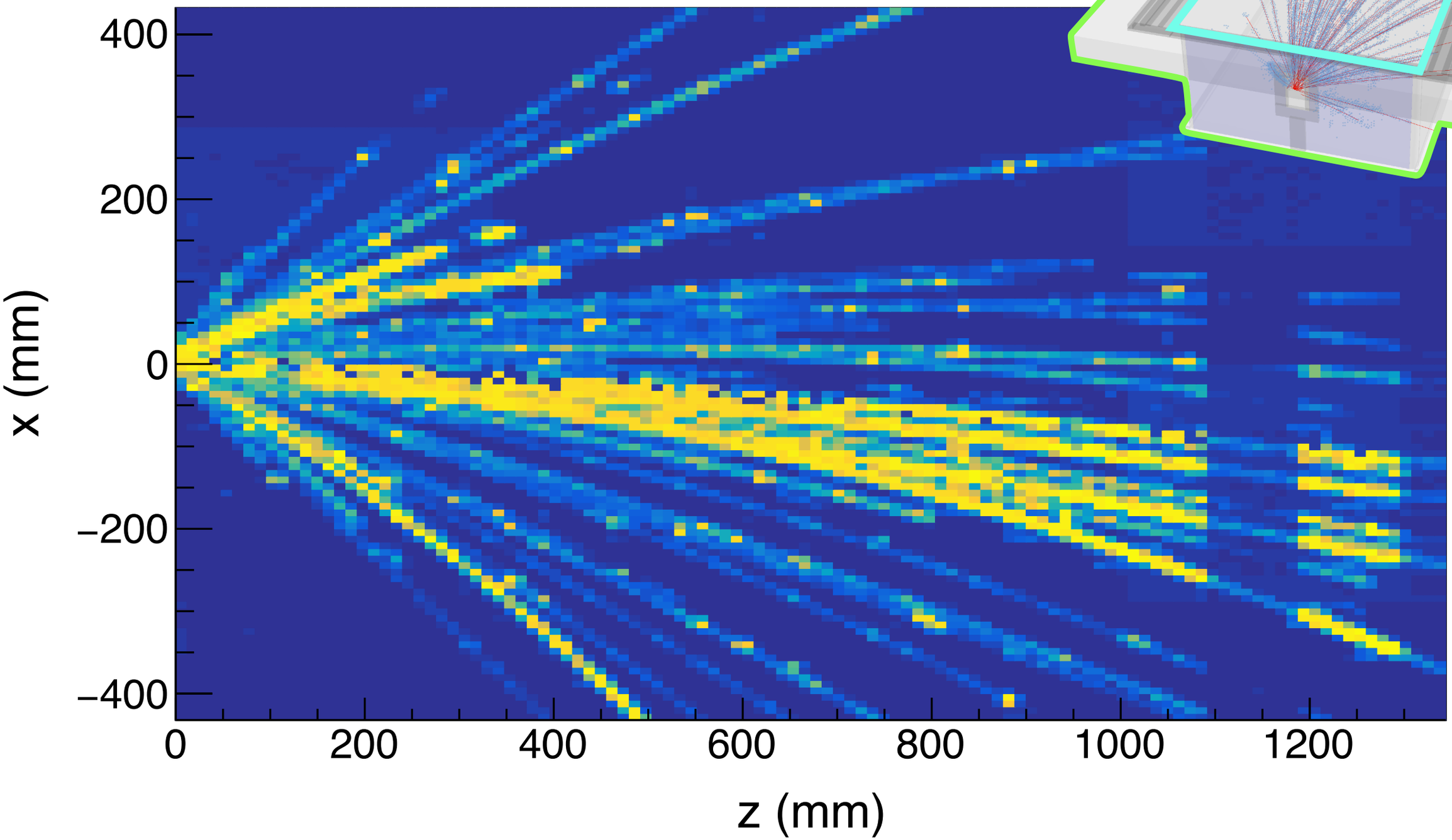
- Reaction (270 AMeV)
  - 132Sn + 124Sn, 124Sn + 112Sn
  - 108Sn + 124Sn, 108Sn + 112Sn
- Typical Event
  - Particles: π, p, d, t, 3He, 4He
  - Collision event: 20~60 tracks
  - Momentum range: 50 ~ 3000 (MeV/c)





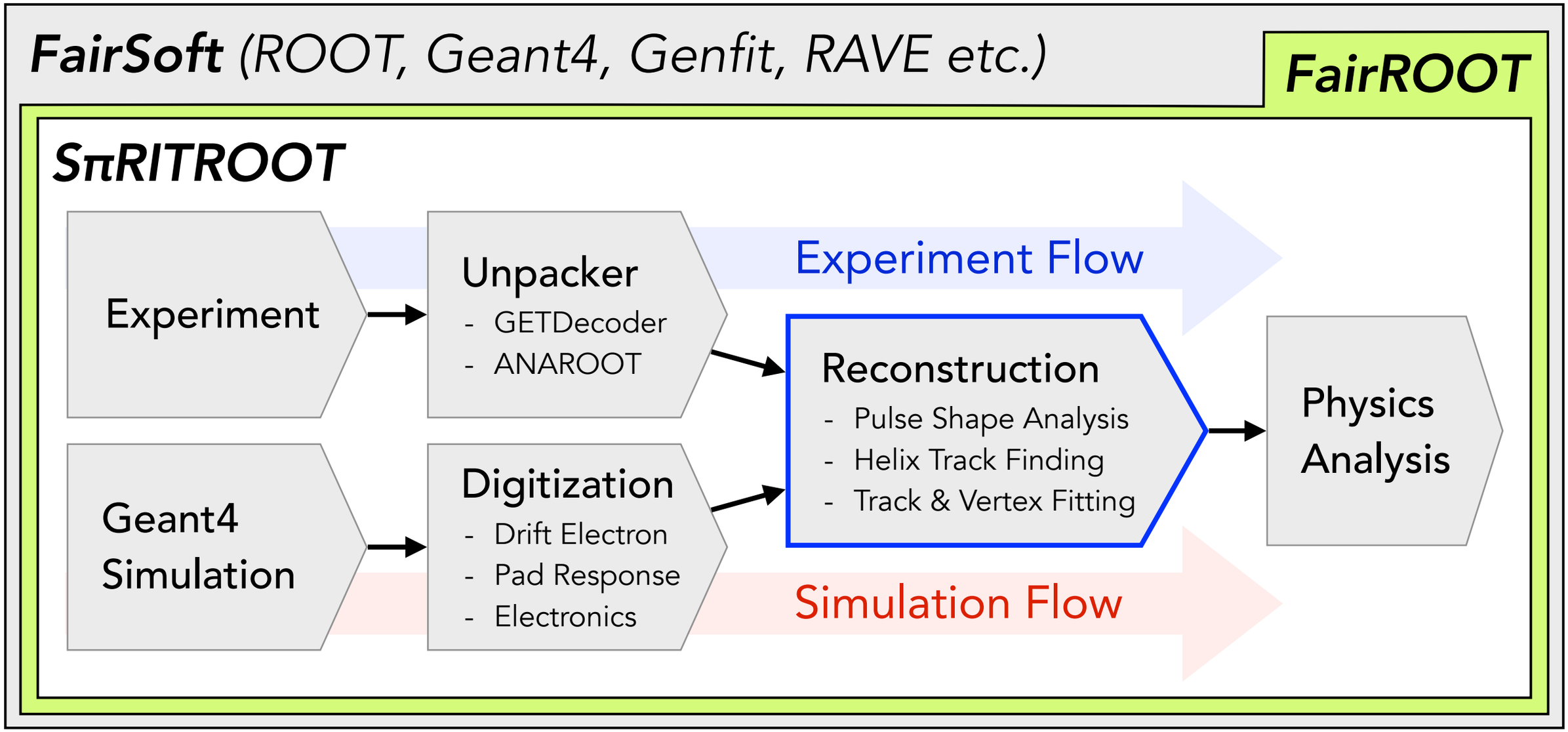
- Pad plane
  - Size: 864 mm × 1344 mm
  - Contains 108×112 pads
- Pad
  - Size:8 mm × 12 mm

Typical Events in SπRIT TPC

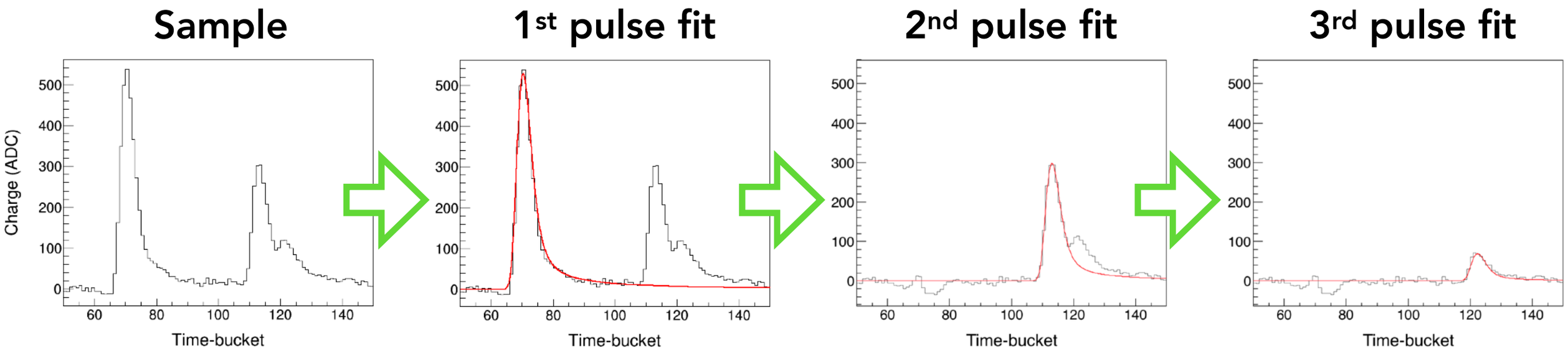


SπRITROOT

- SπRITROOT is framework for SπRIT-0TPC simulation, data reconstruction and analysis.
- Developed using FairSoft(software package), FairROOT(ROOT based framework). Mainly used packages are ROOT, Geant4, GENFIT and RAVE.



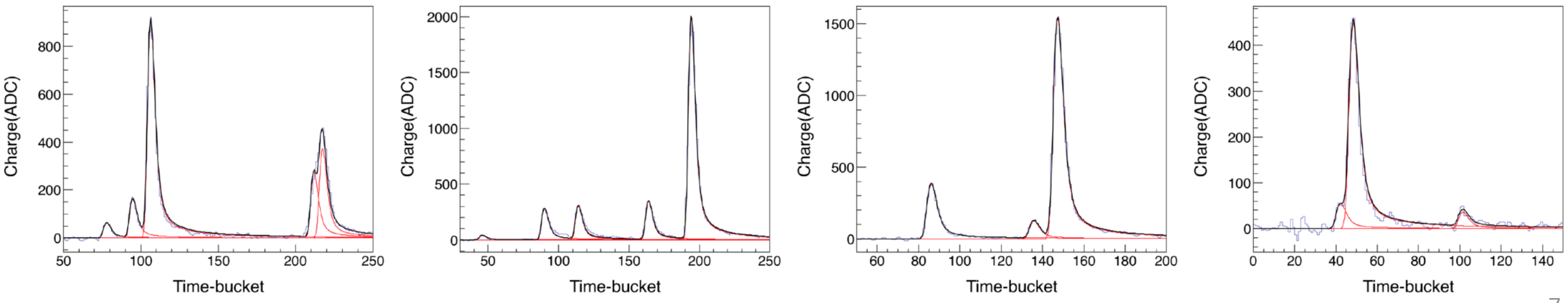
Hit Finding Algorithm



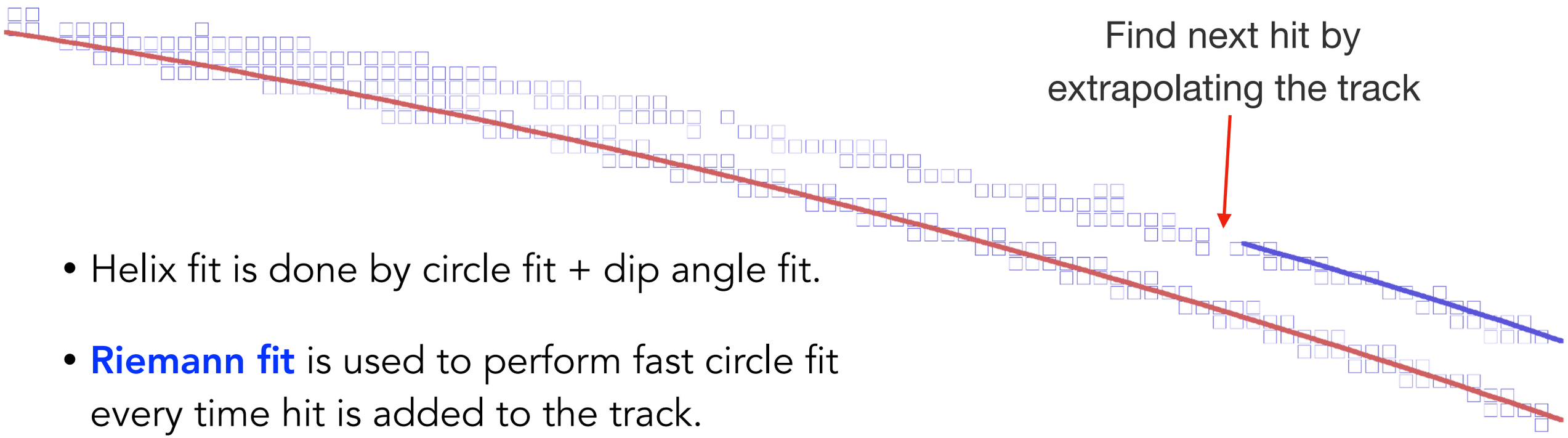
- Signal is fitted with **reference pulse** made from average of pulse data.
- Hit is found from early time signal to later time bin signal.
- Each pulse is removed after fit.

Examples of multi-pulse fit:

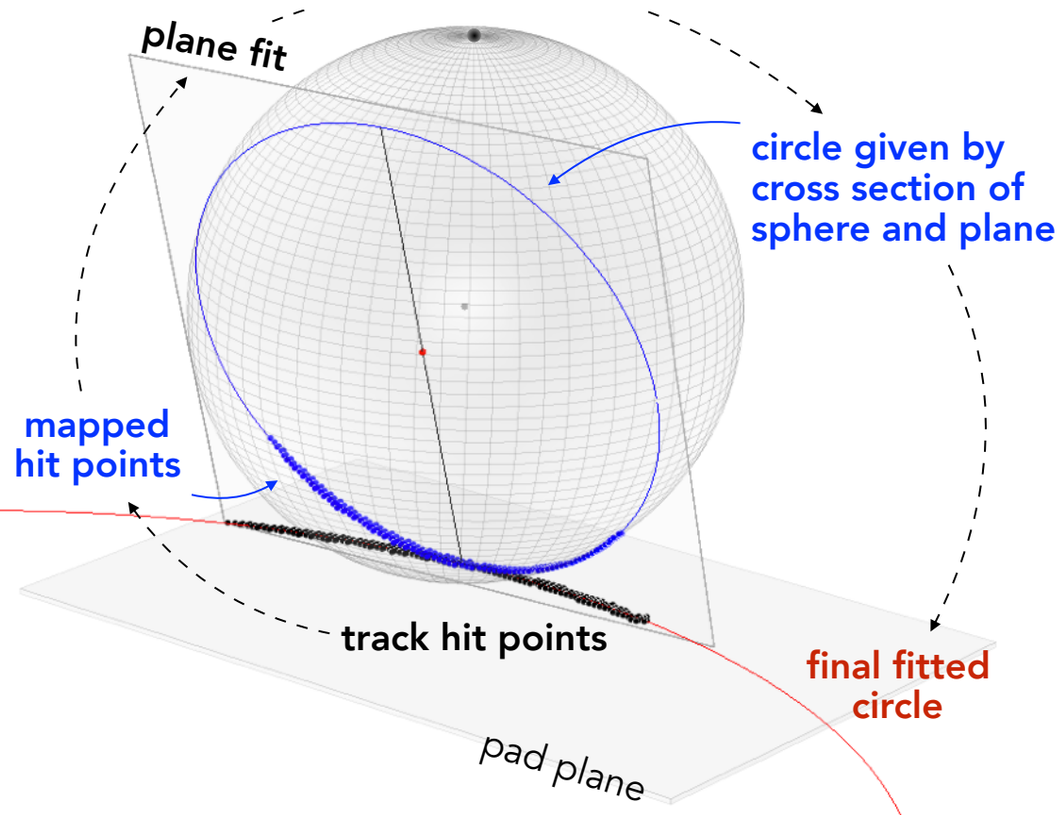
*Black line is sum of all pulse fits



Track Finding Algorithm

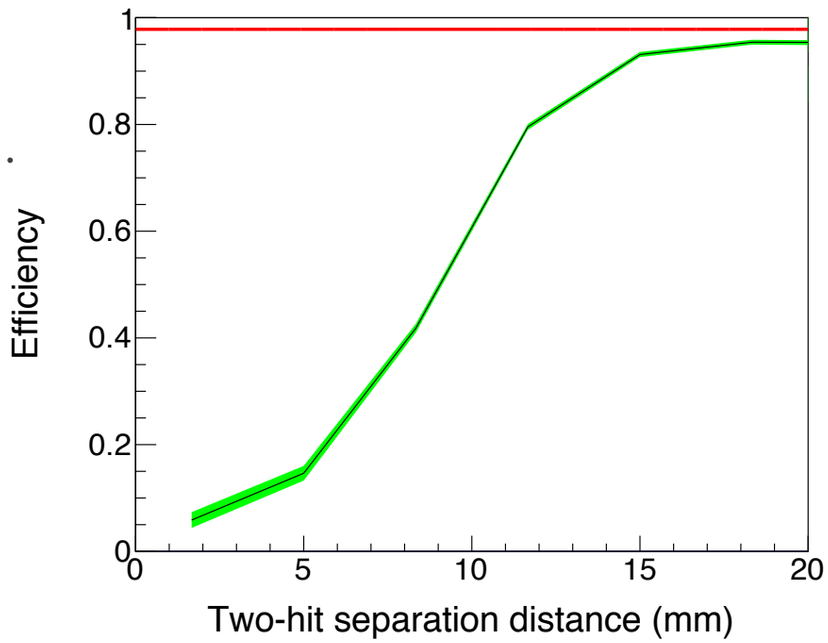


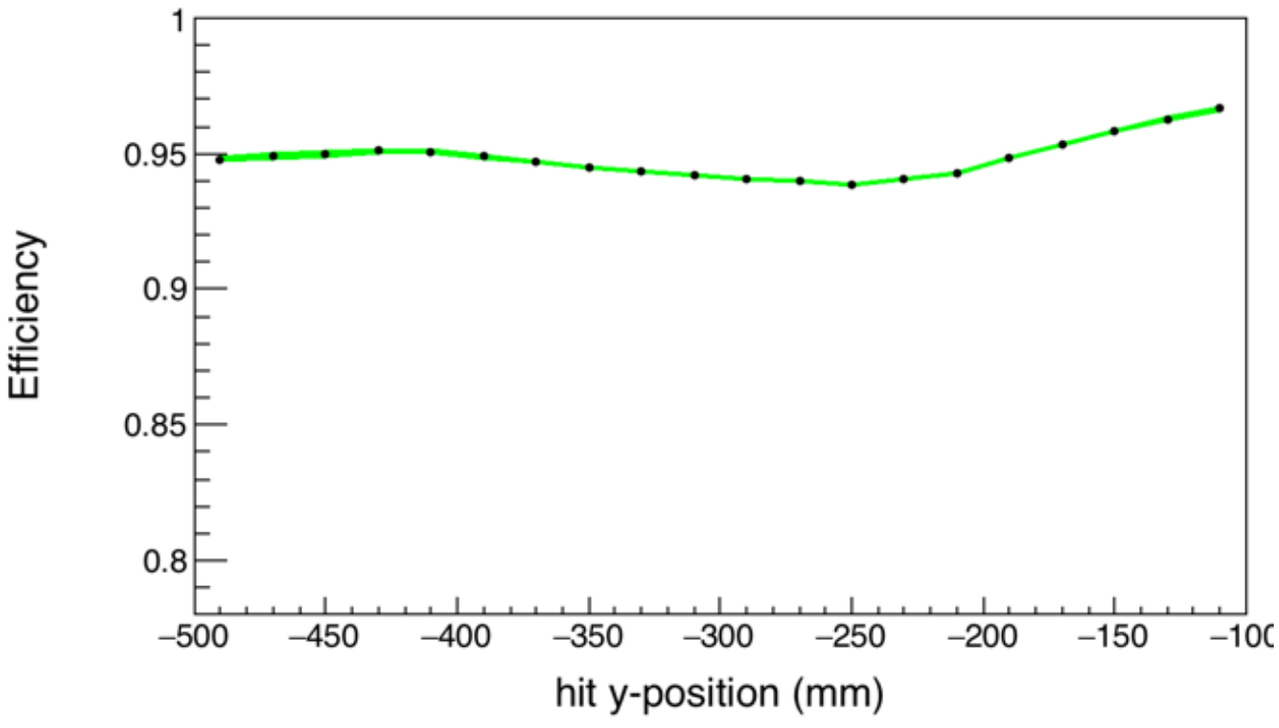
- Helix fit is done by circle fit + dip angle fit.
- **Riemann fit** is used to perform fast circle fit every time hit is added to the track.
- This enables to extrapolate helix line to find new hit from pad-plane map, even if the track is broken.
- Helix track finding method shows 90% track finding efficiency.

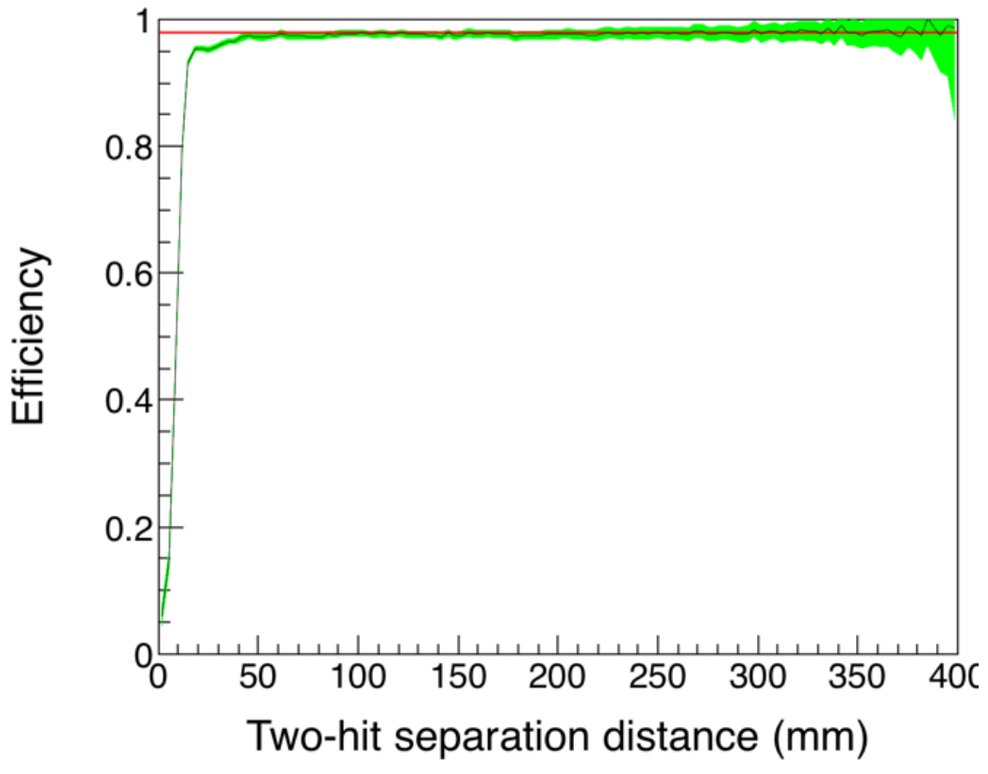


Hit Reconstruction Efficiency

- Single-hit finding efficiency
  - Measured from pads with single-track going through.
  - Efficiency falls as y-position is close to beam spot; y~220 mm.
  - Overall efficiency is around 95 %.
- Two-hit separation efficiency
  - Measured from pads with two-track going through.
  - Efficiency is counted from number of found second hit.



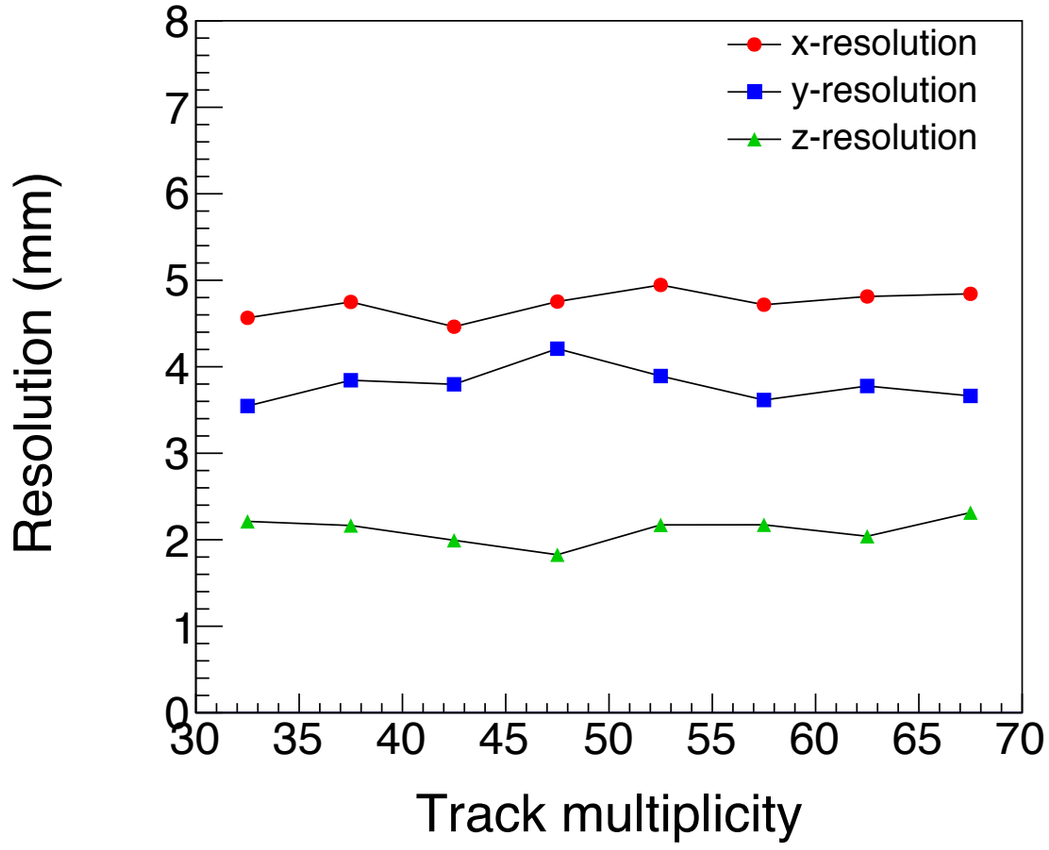




GENFIT and RAVE

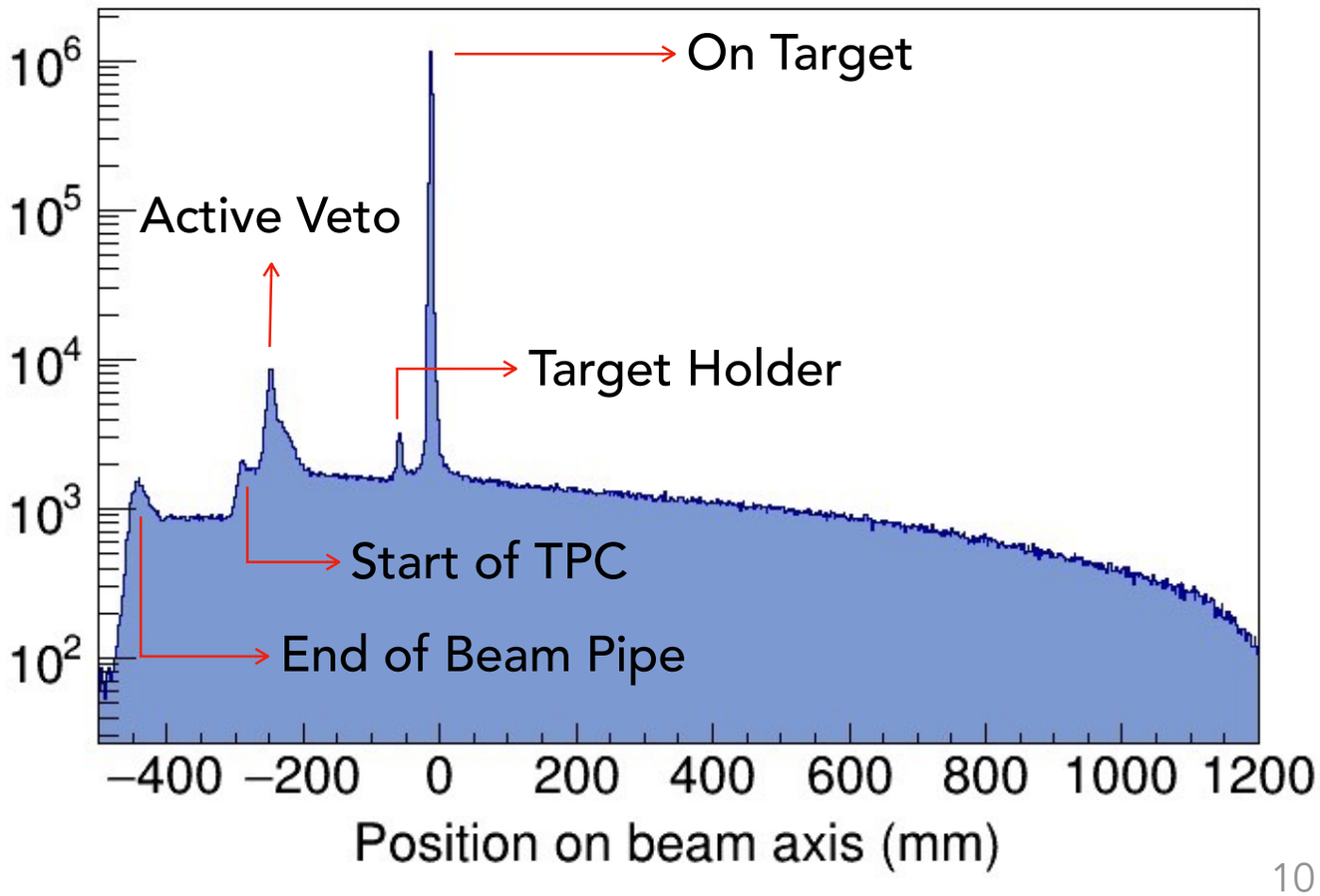
- GENFIT, a generic track-fitting tookit and RAVE, a vertex reconstruction toolkit.

- Both packages are free c++ packages and mainly been used for cylinderical shape detector system.



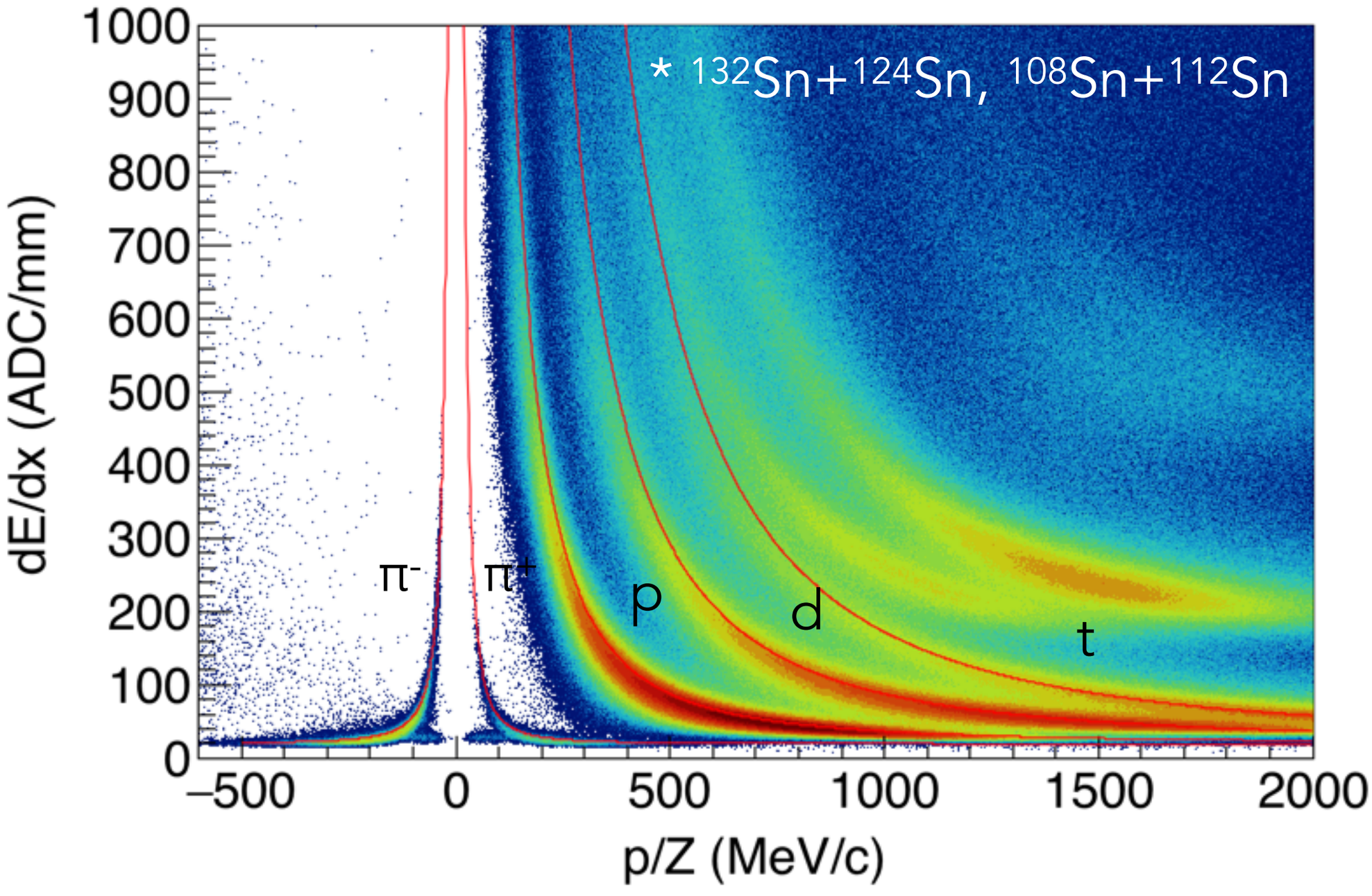
- SπRITROOT has successfully applied two tookits in rectangular detector system.

- Measured vertex resolution:
  - x-axis ~ 4.73 mm.
  - y-axis ~ 3.79 mm.
  - z-axis ~ 2.11 mm.



Particle Identification

Bethe-Bloch: $$\left\langle \left| \frac{dE}{dx} \right| \right\rangle = C_1 \frac{Z'}{A'} \frac{Z^2}{\beta^2} \left[\frac{1}{2} \ln \frac{2 m_e c^2 \beta^2 \gamma^2 W_{\max}}{I^2} - \beta^2 - C_2 \right]$$



Summary

- For study of symmetry energy, SπRIT experiment was done in 2016 summer at RIKEN-RIBF using SπRIT-TPC. Four main collisions(132Sn + 124Sn, 124Sn + 112Sn,108Sn + 124Sn, 108Sn + 112Sn) data was taken.

- SπRITROOT software is developed on top of FairROOT framework for simulation, reconstruction and data analysis.

- Hit track finding efficiency is measured ~ 90 %.

- Reconstruction efficiency is measured ~ 95%.

- GENFIT and RAVE are implemented to rectangular detector system for first time.

- Vertex resolution was measuered (4.73, 3.79, 2.11) (mm) for each axis.

- Energy loss spectrum in function of momentum agree with Bethe-Bloch formula.

- π, p, d, t are distinguishable.