Development of LAMPSROOT

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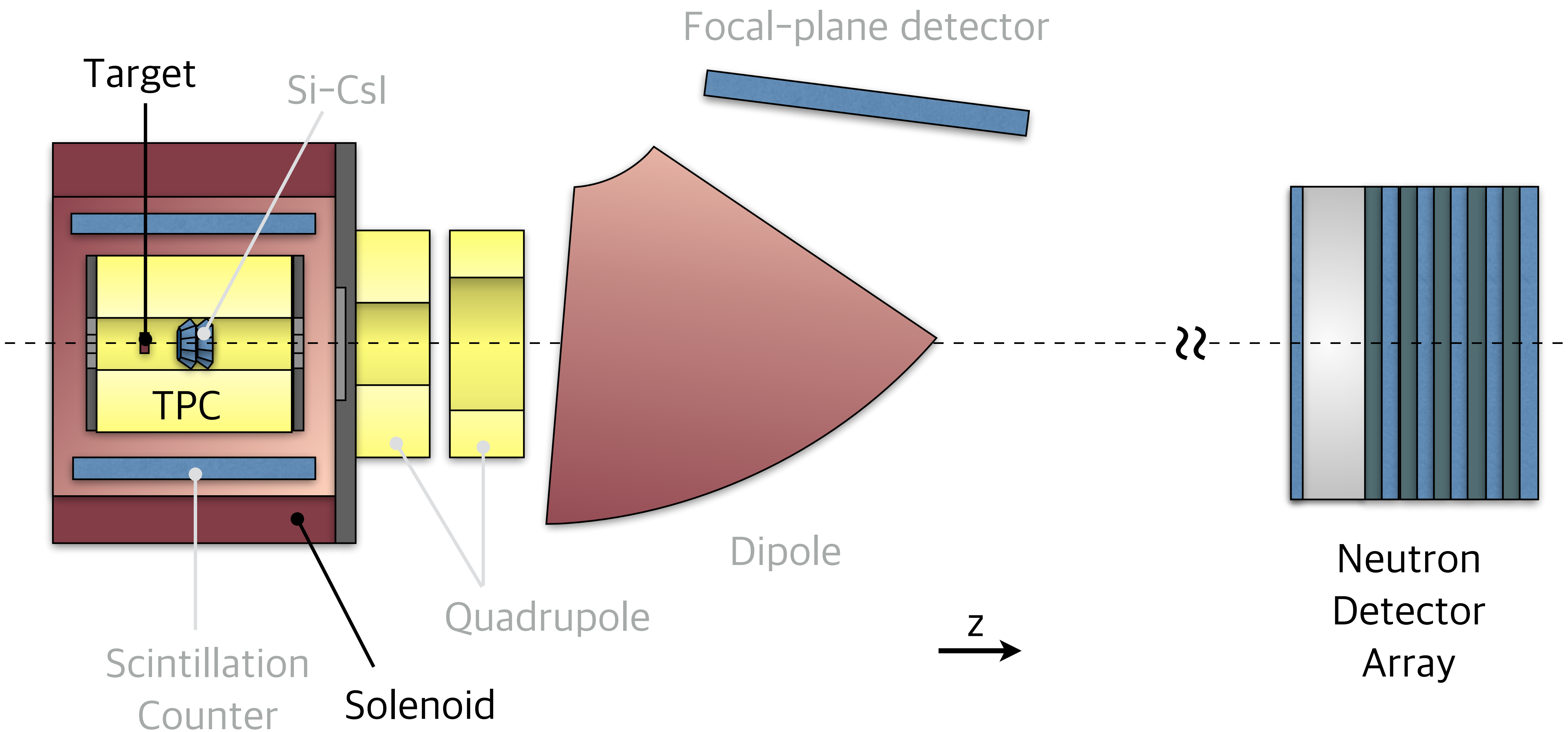
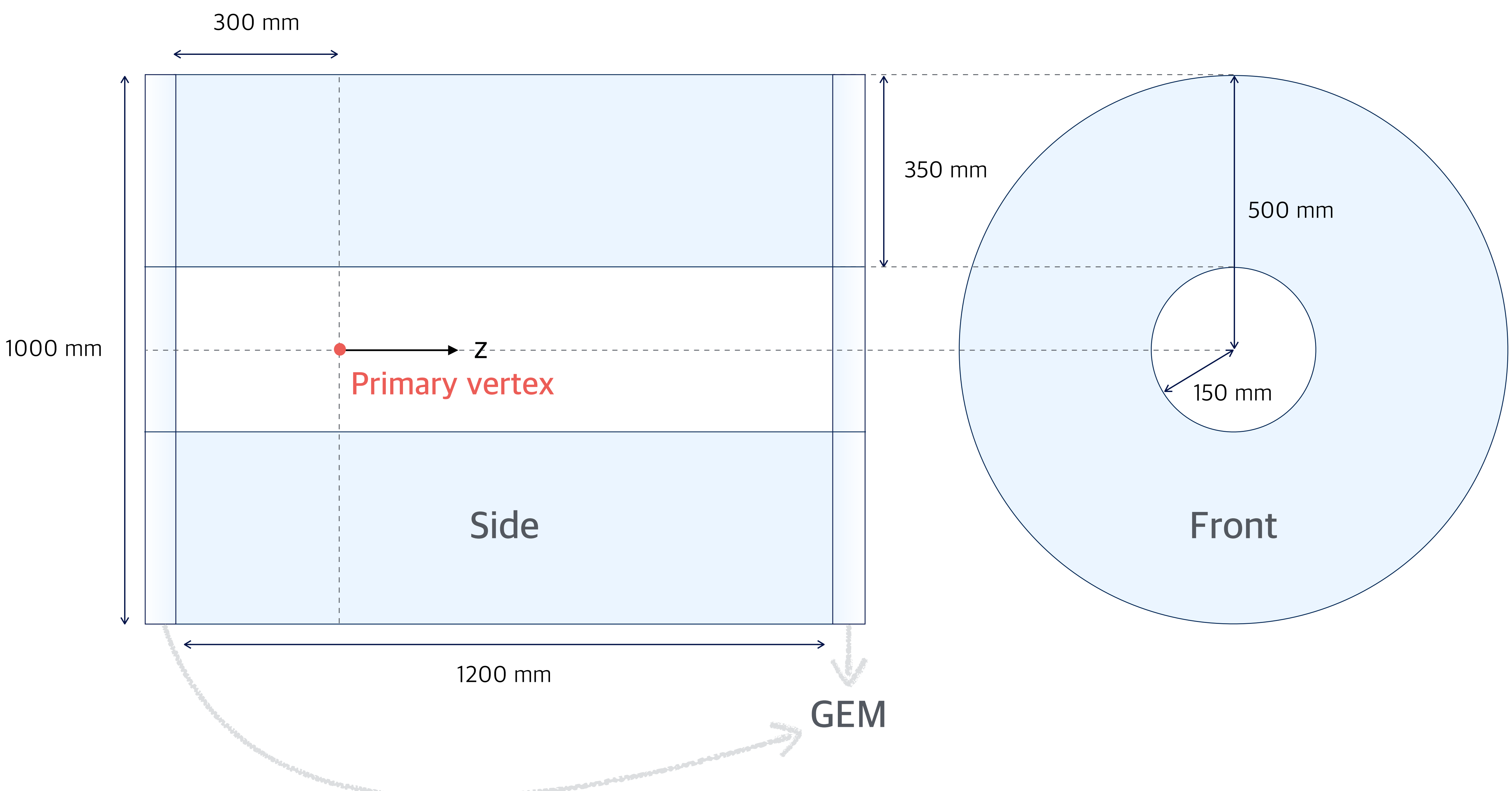
LAMPS-High

- LAMPS(Large Aceptance Multi Purpose Spectrometer) for high energy to be built in RAON.
- TPC, Neutron detector array is planned.
- Example reaction is ^{132}Sn + ^{124}Sn (~250 AMeV).
- Probes: π−/π+, n/p, ^{3}H/^{3}He ratios.



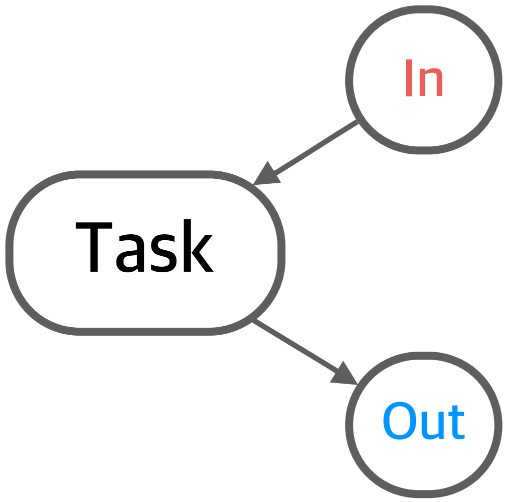
LAMPS-TPC

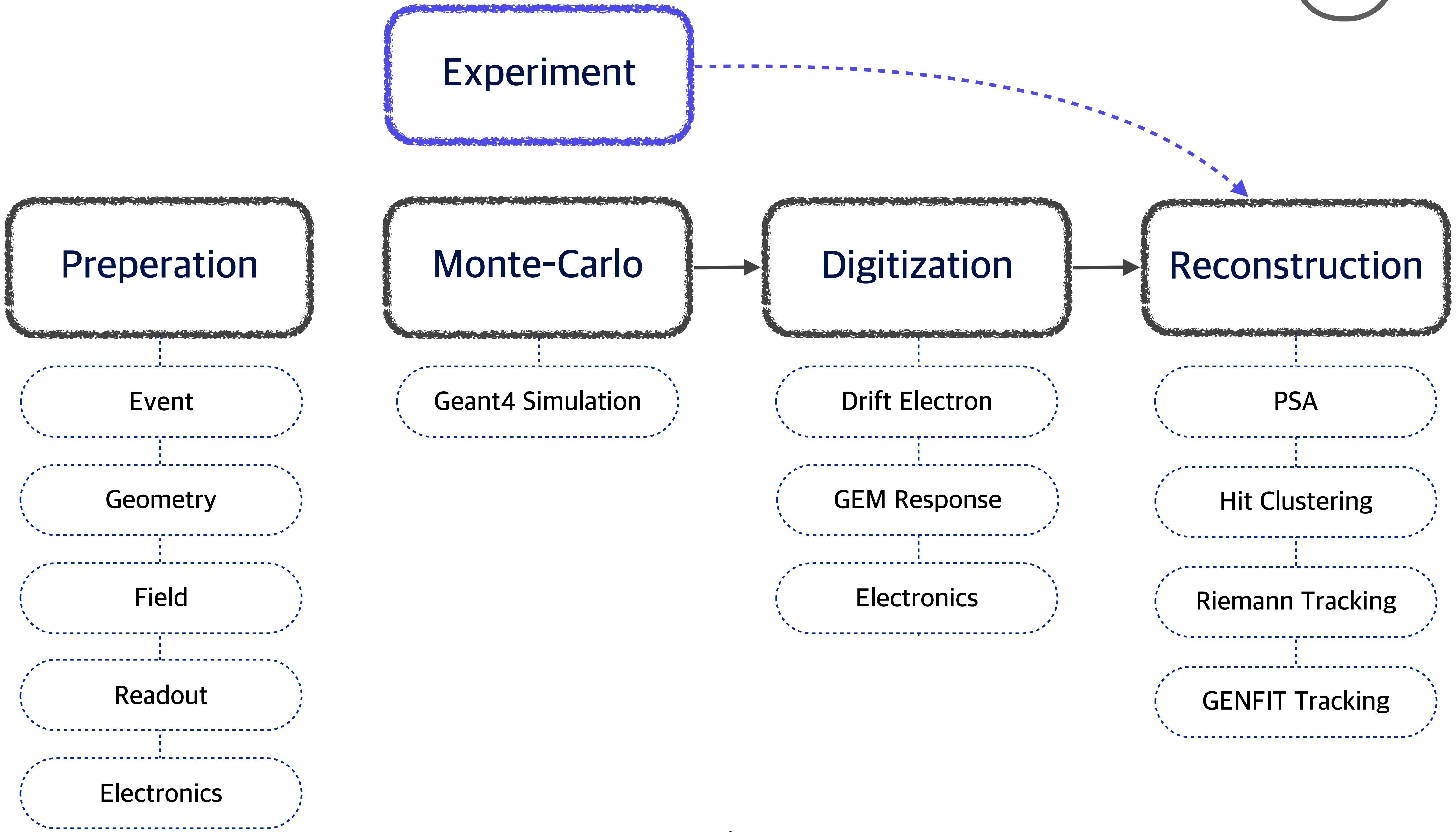
- Detect charged particles with large angle(25° ~ 140°).
- 0.5 Tesla B-field, z-direction.
- Triple-GEM amplication.



LAMPSROOT

- LAMPSROOT is simulation and analysis frame work for LAMPS-TPC.
- **FairSoft :** Collection of packages (Geant4, ROOT, GENFIT etc.)
- **FairROOT :** Frame work tool with task based modules.

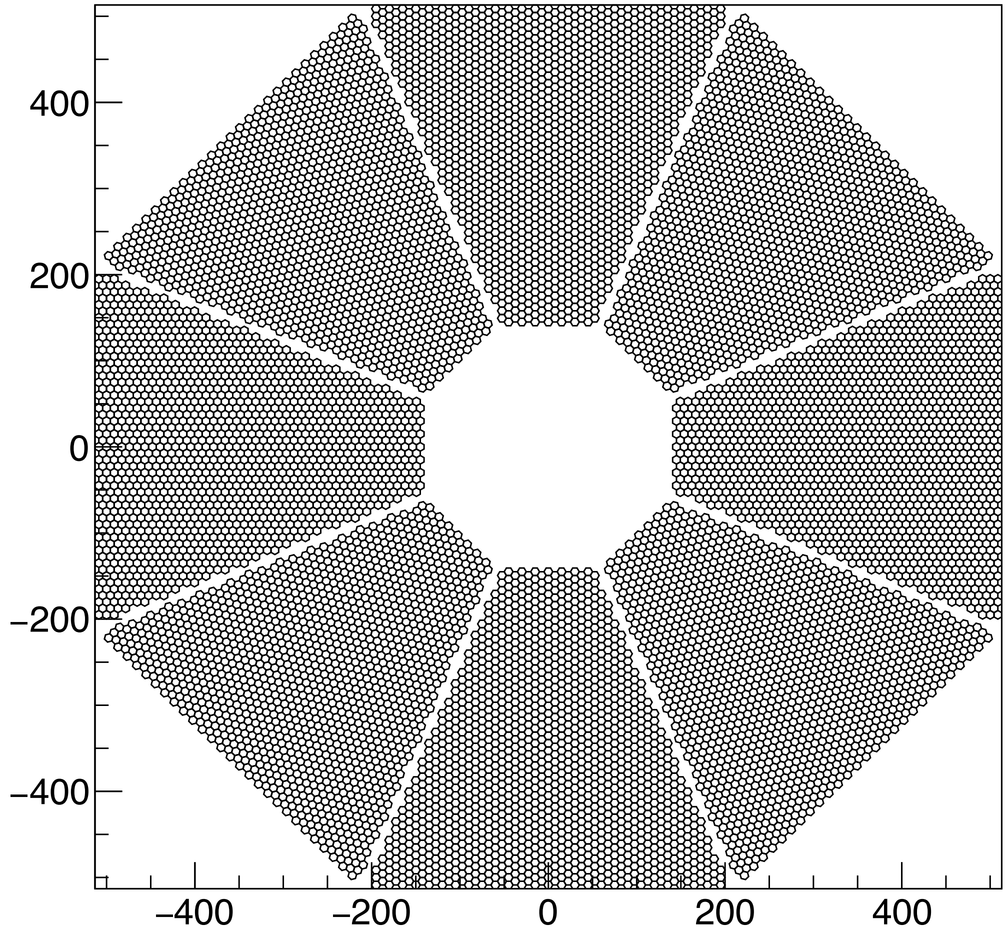




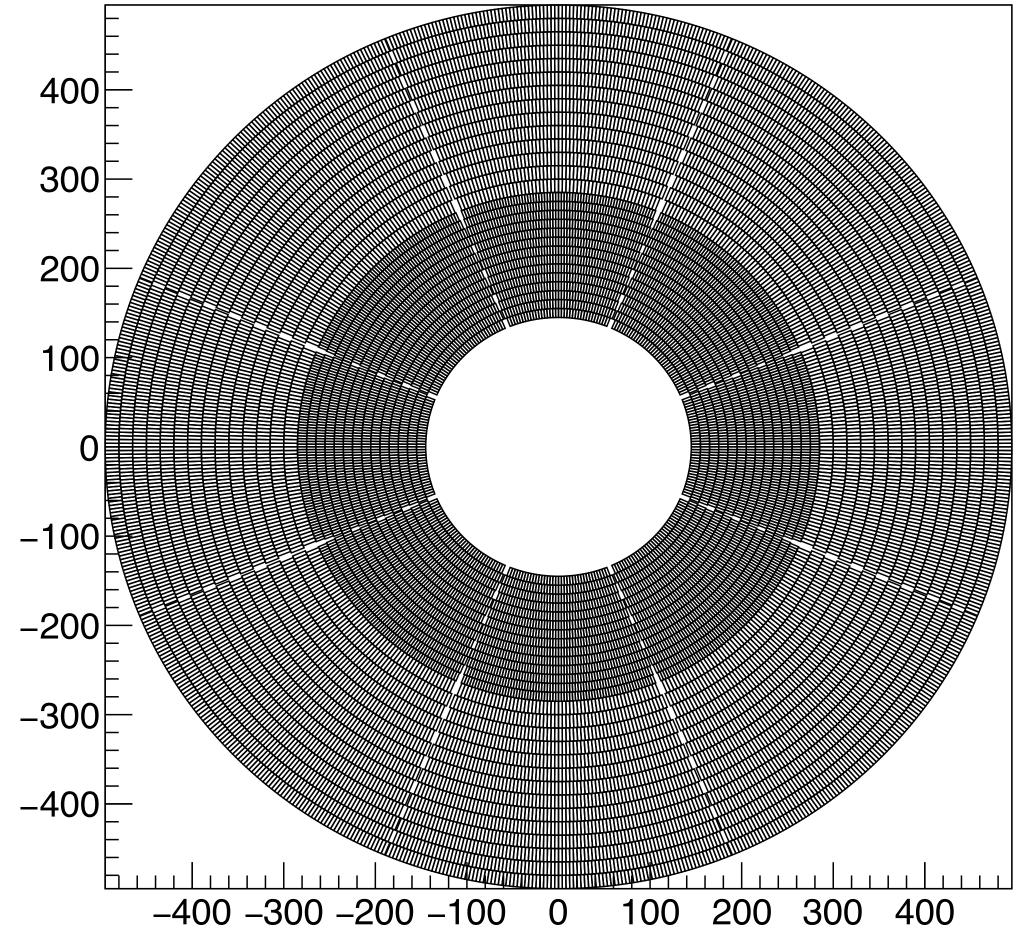
Readout Padplane

- Pad plane exist on the each end of TPC.
- Maximum number of pads we can handle : 50400.
- Different type of pads are being tested – honeycomb, fan shapes.

Hexagonal Pad 5 mm (#23136)

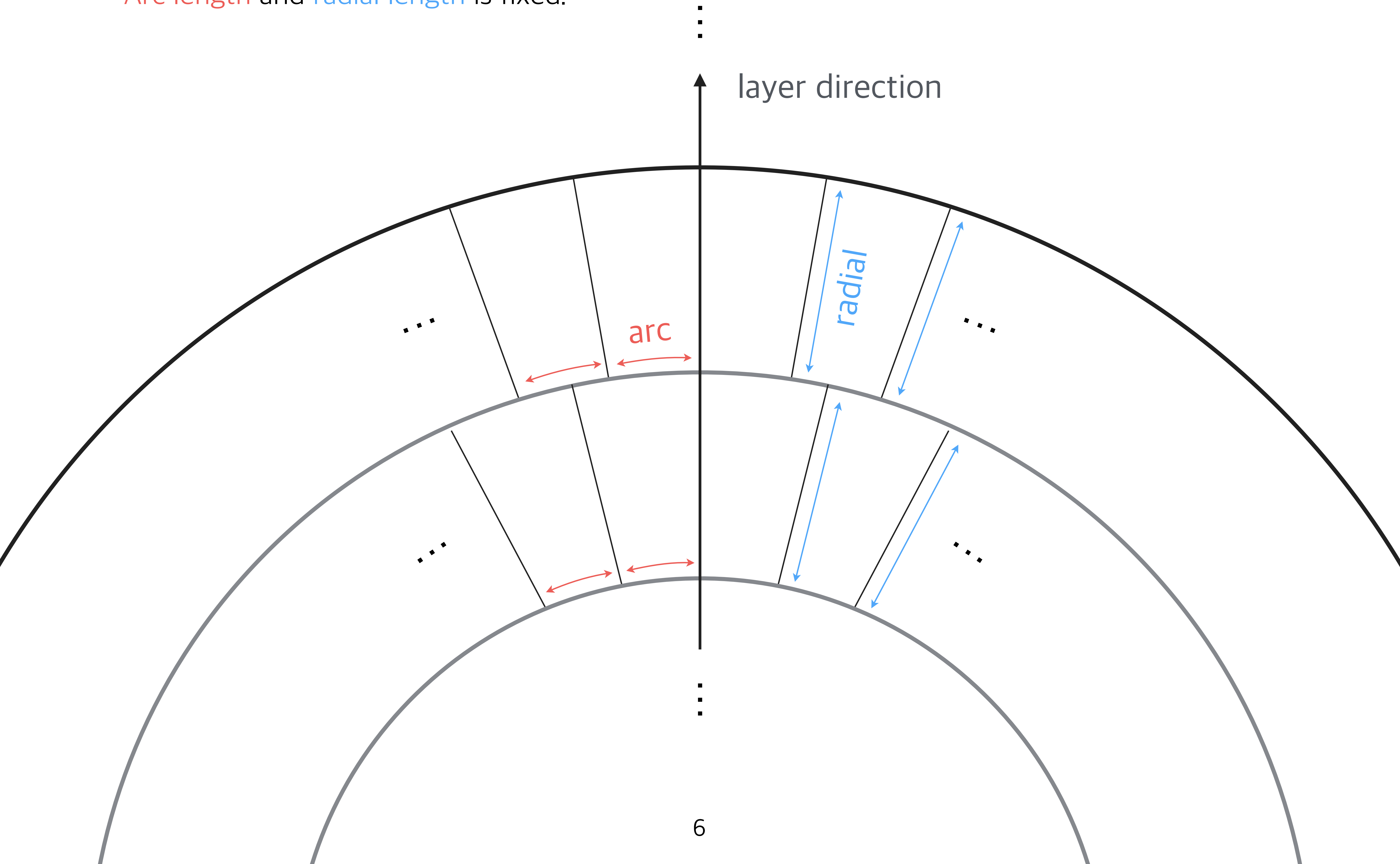


Fan Pad 3x10, 4x15 mm (#30816)



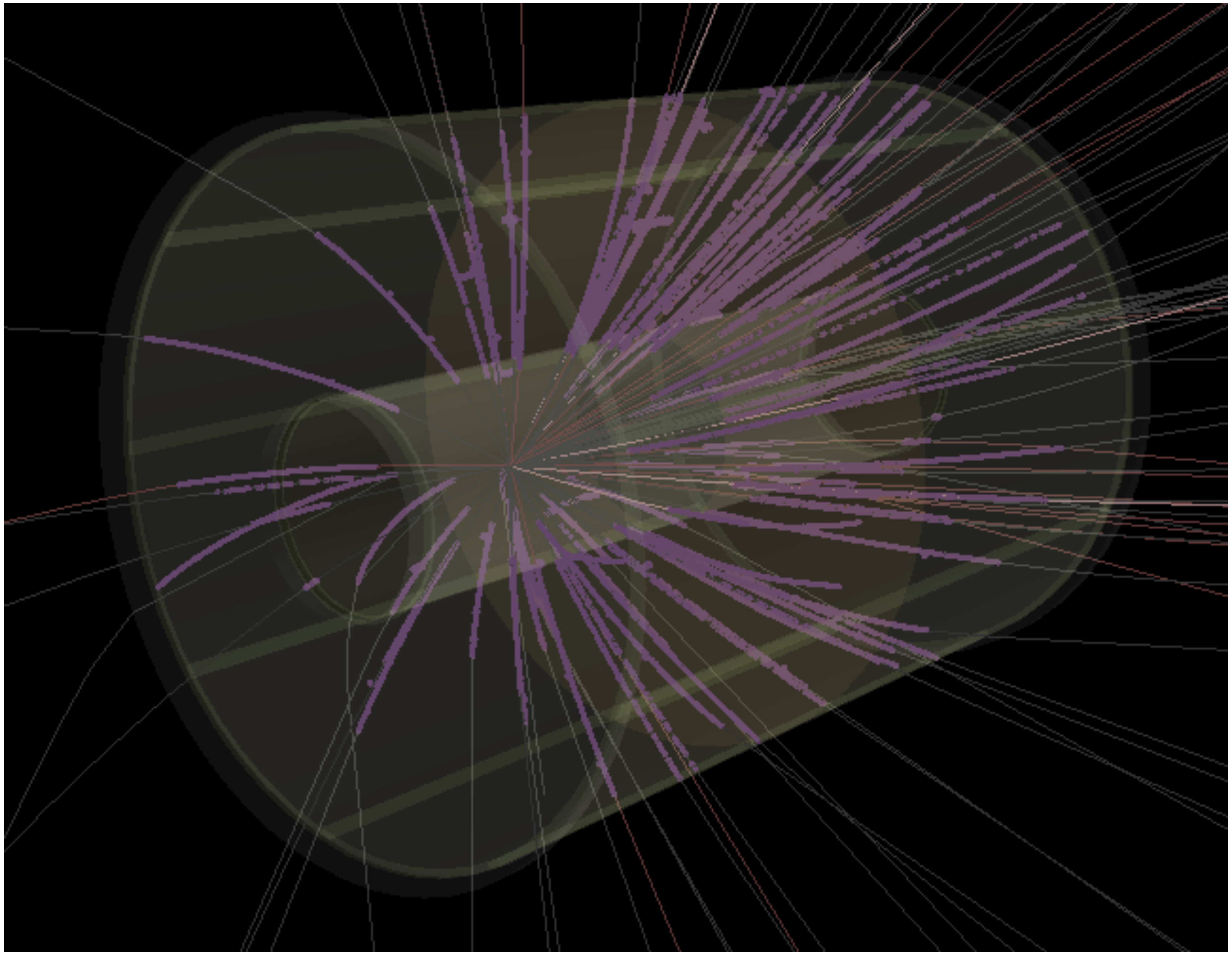
Fan Shape Pad

- Arc length and radial length is fixed.



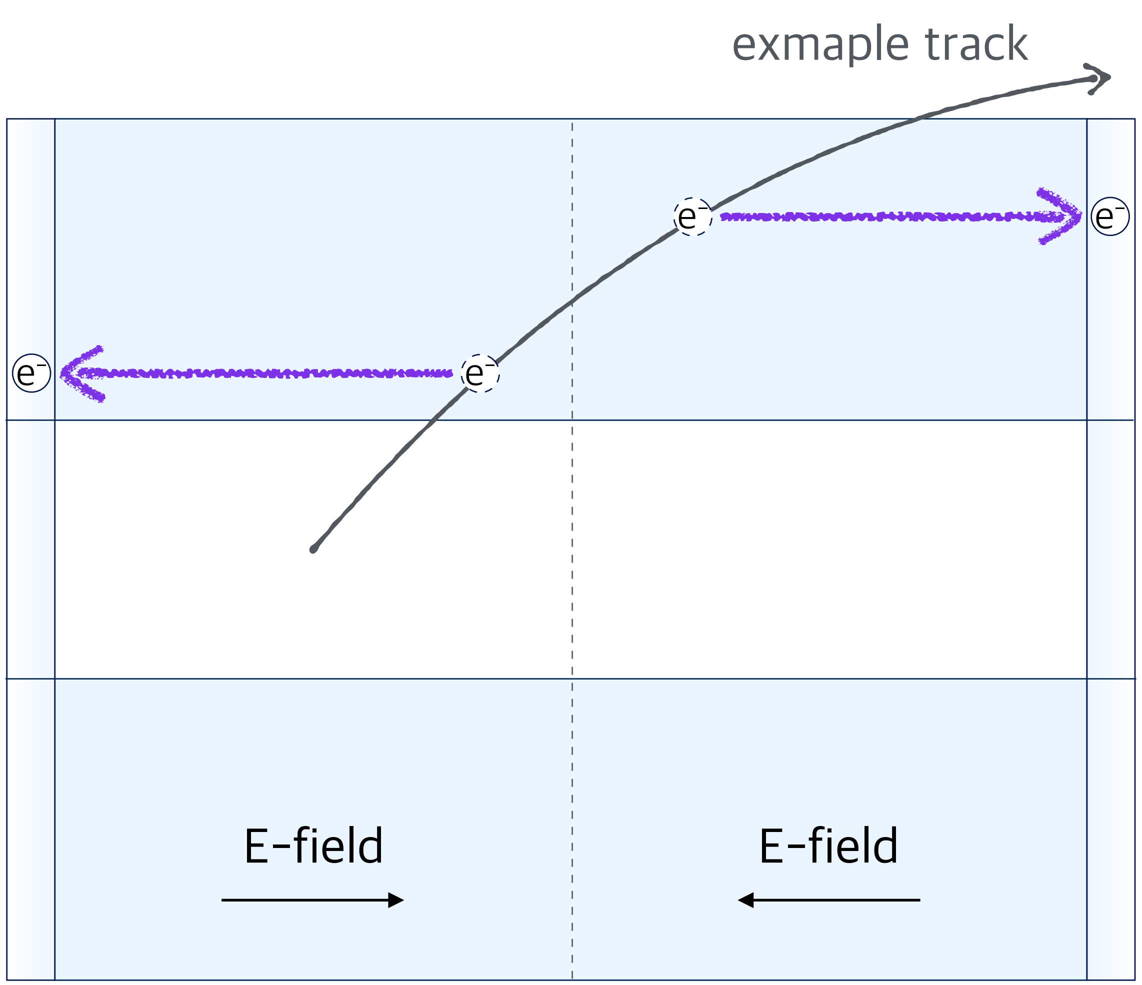
Geant4 Simulation

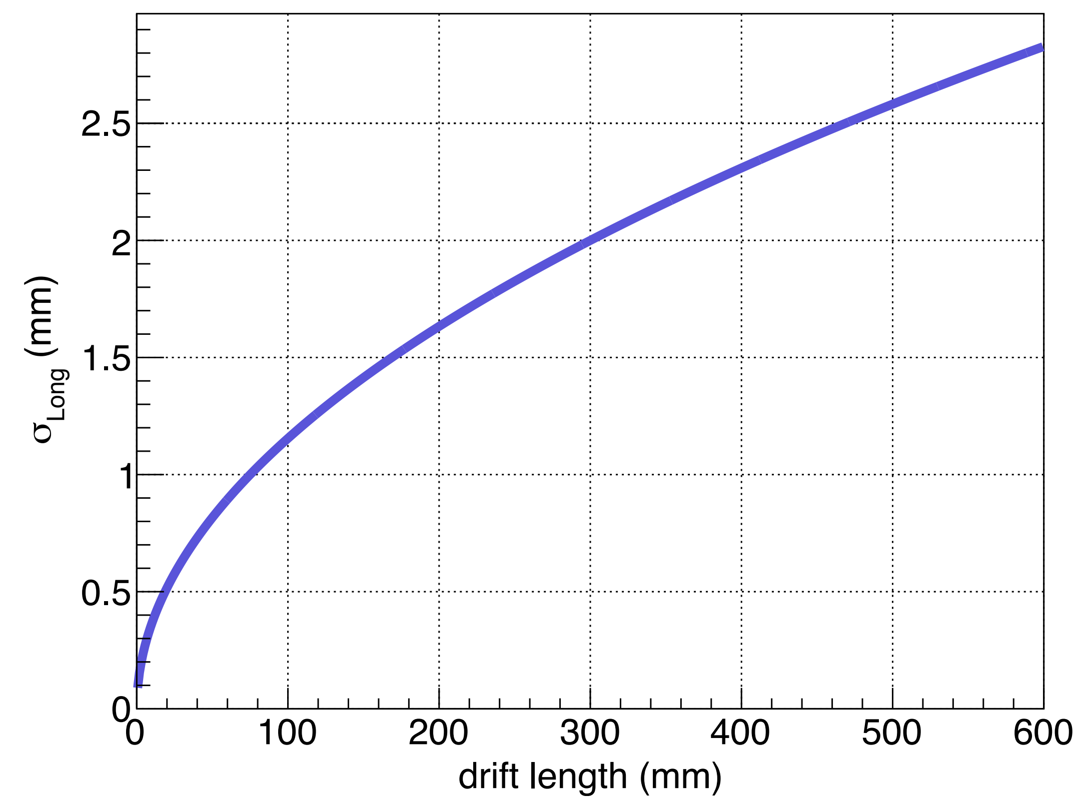
Monte-Carlo Simulation is done by Geant4. Position, time and energy loss inside the TPC is collected from the simulation.

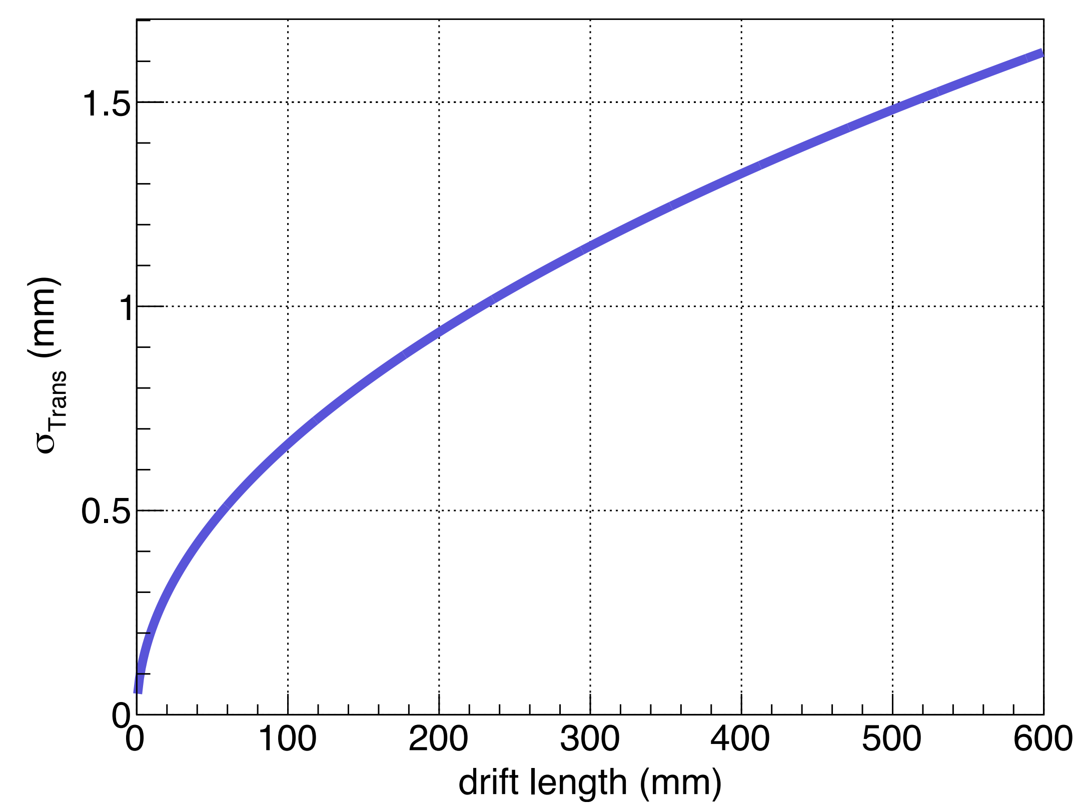


Drift Electron

The number of produced electrons is calculated by (MC energyloss) / (mean ionization energy). Electrons will then drift to the end of TPC. Using the diffusion constants obtained by Garfield++, drift time and diffused position from MC hit to GEM plane is calculated.

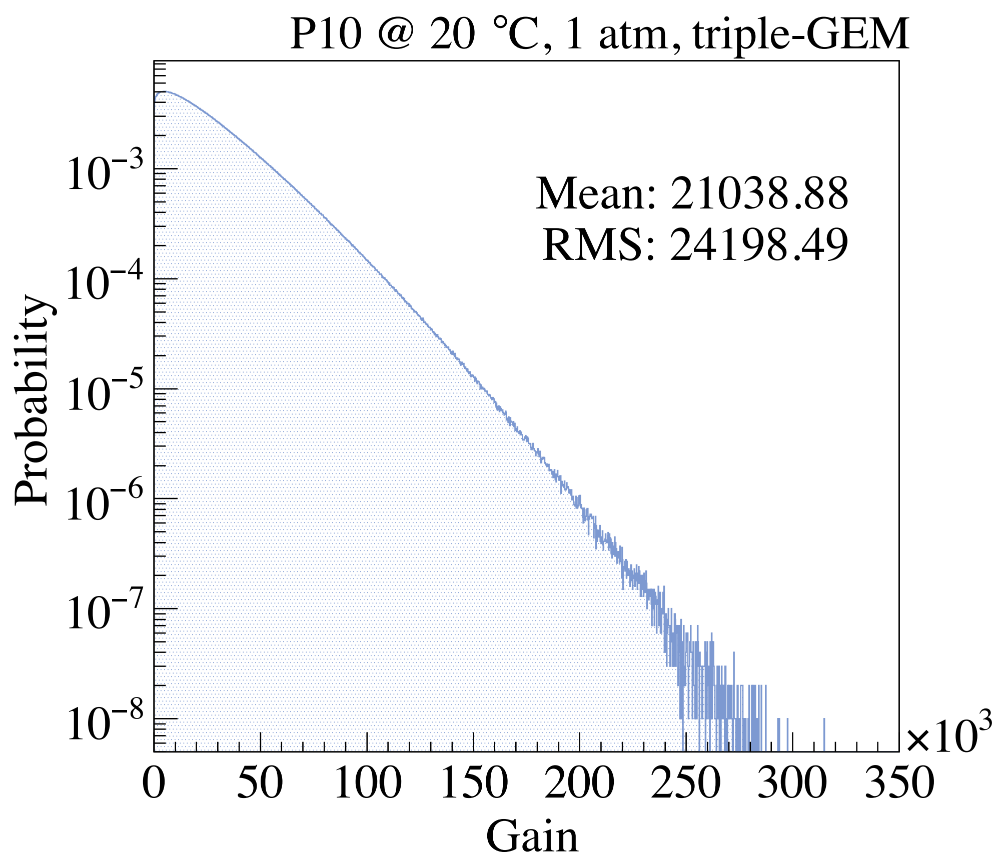


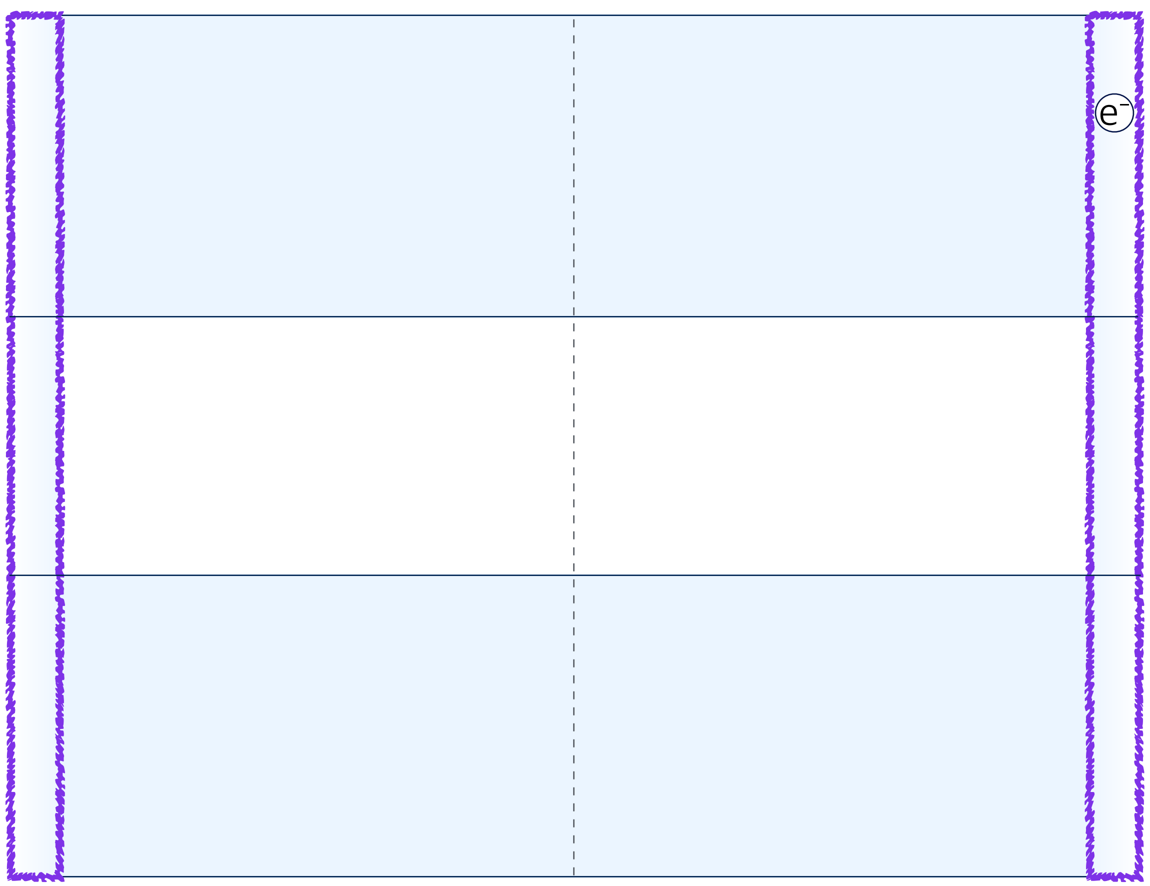


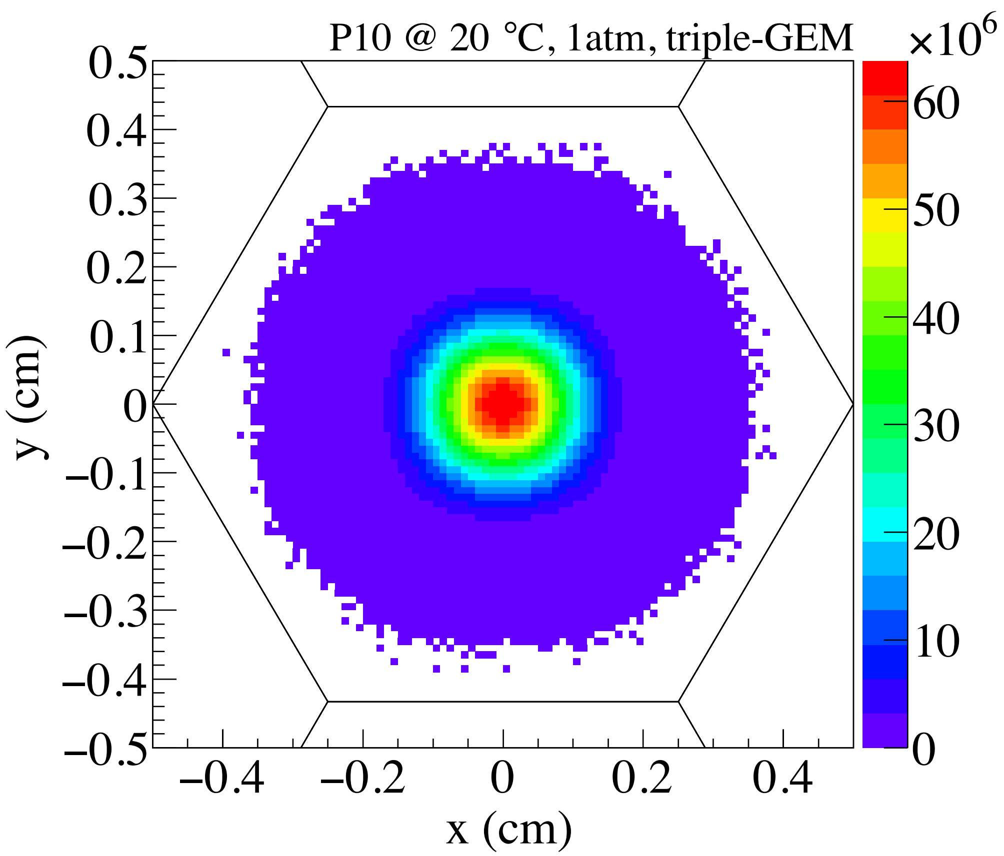


GEM Response

Triple-GEM simulation is done with Garfield++. GEM is positioned at the each end of the TPC. Before going into the pad, electron is amplified and diffuse by the GEM. Each GEM is 60 μm thick, has 2 mm spacing with 350 V operating voltage.



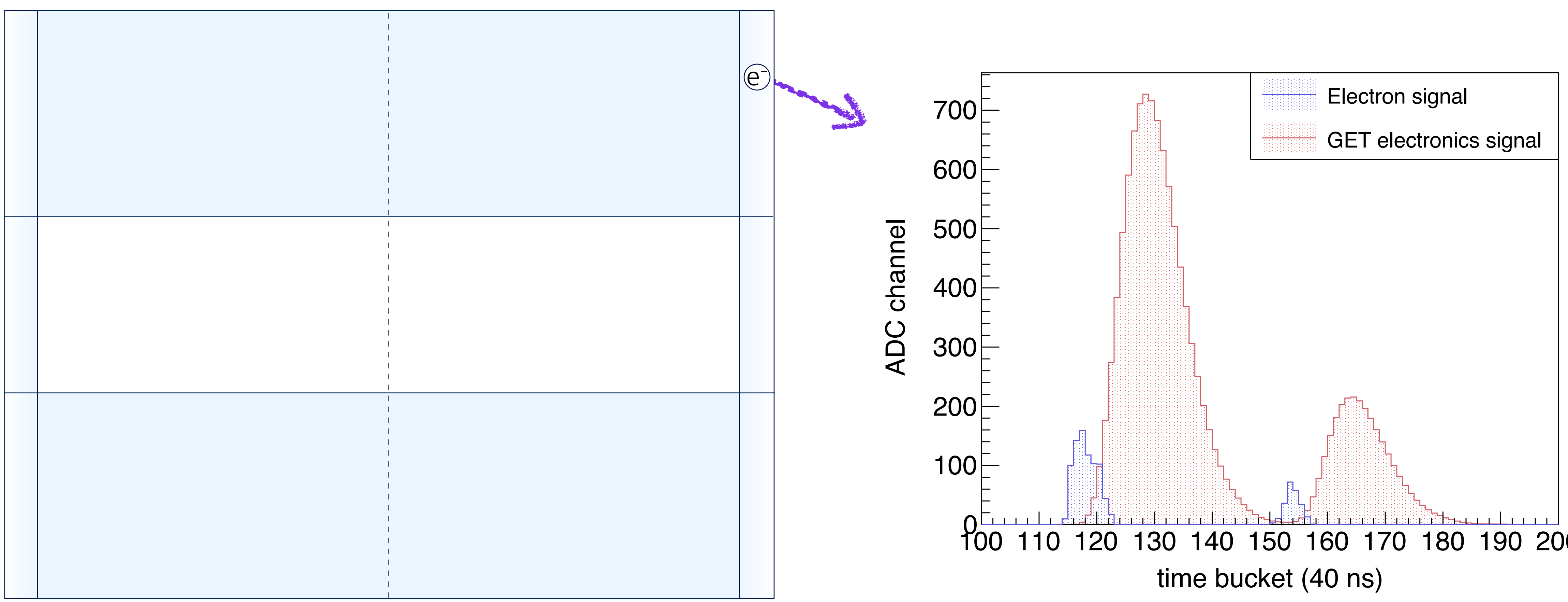




Electronics Response

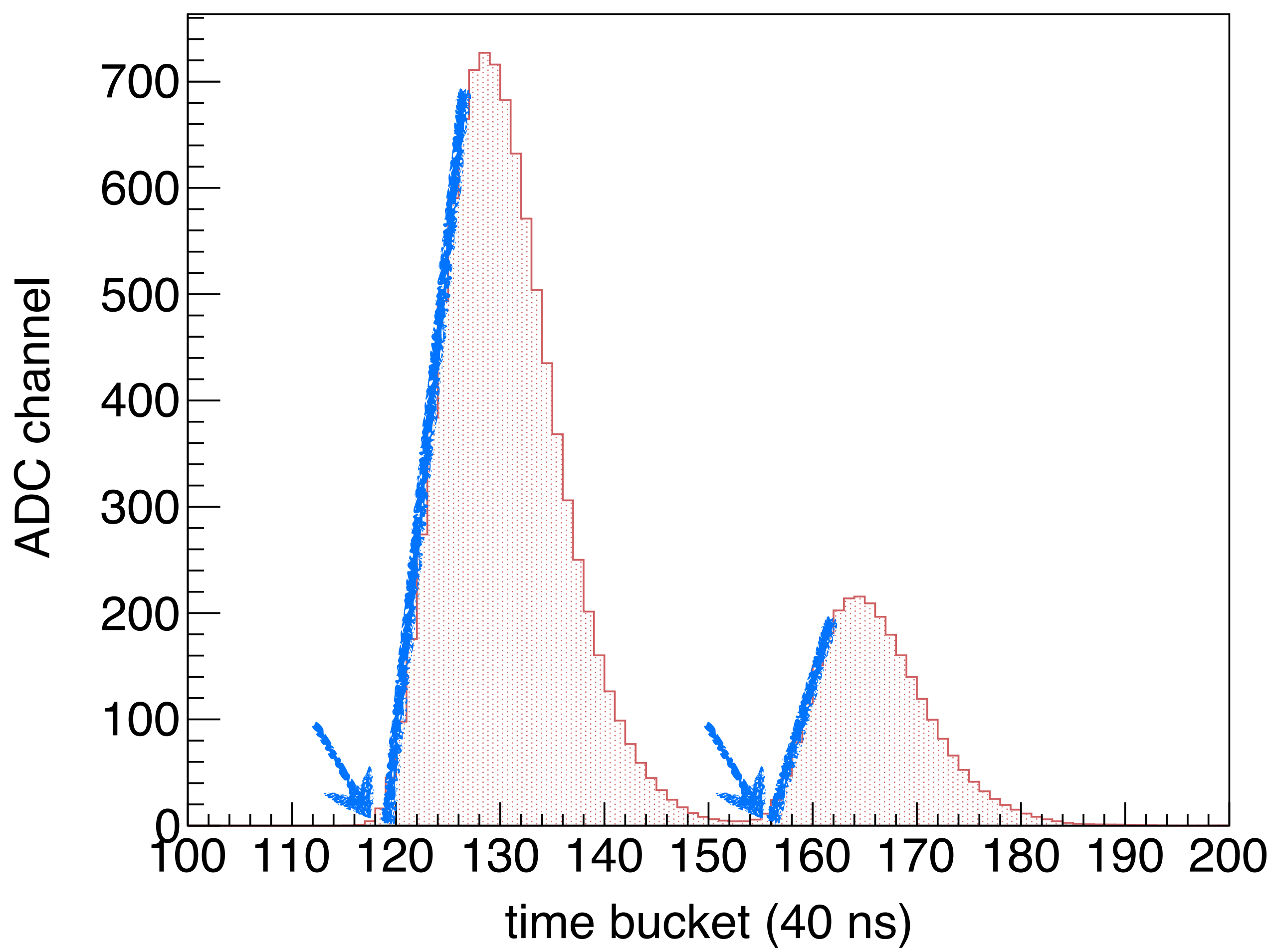
In each pad, the input electron charge is distributed along the time bucket. The GET electronics signal will be produced by the charge input. GET electronics produce signal with to electron signal. Signal height is proportional to the input charge. The pulse shape of GET electronics is obtained from the experimental data.

(One time bucket is 40 ns in time, maximum ADC value is 4095)



PSA & Clustering

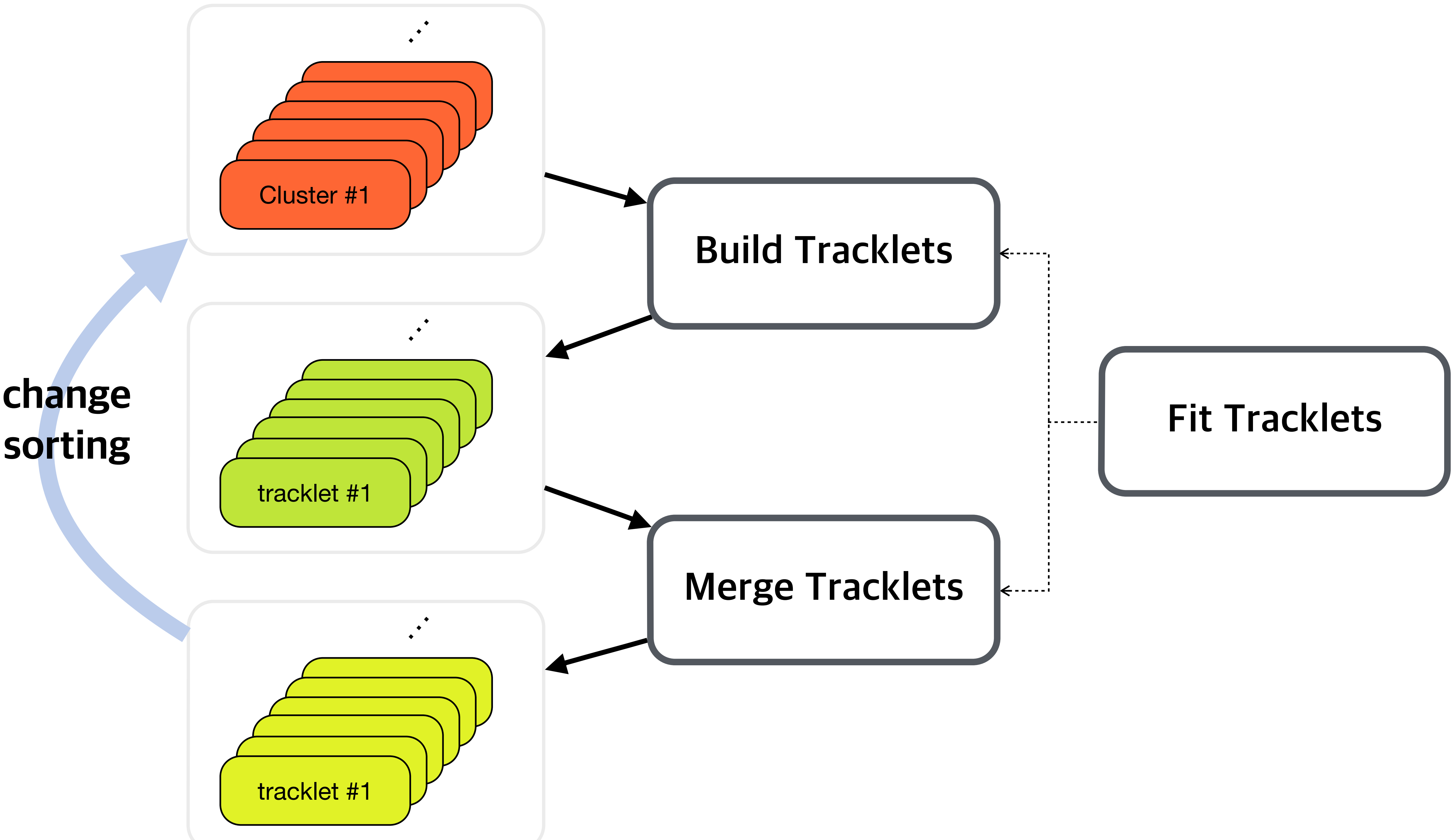
For all pulses, fit the rising part of pulse with a linear function in range between bins with heights corresponding to 10% and 90% of the peak value. The x intercept of this linear function is defined as a hit time. Charge of hit is defined by height of the peak. Clustering is done simply by gathering the hits to cluster having sigma lower than sigma-cut.



Riemann Tracking

* Implemented from FOPIROOT

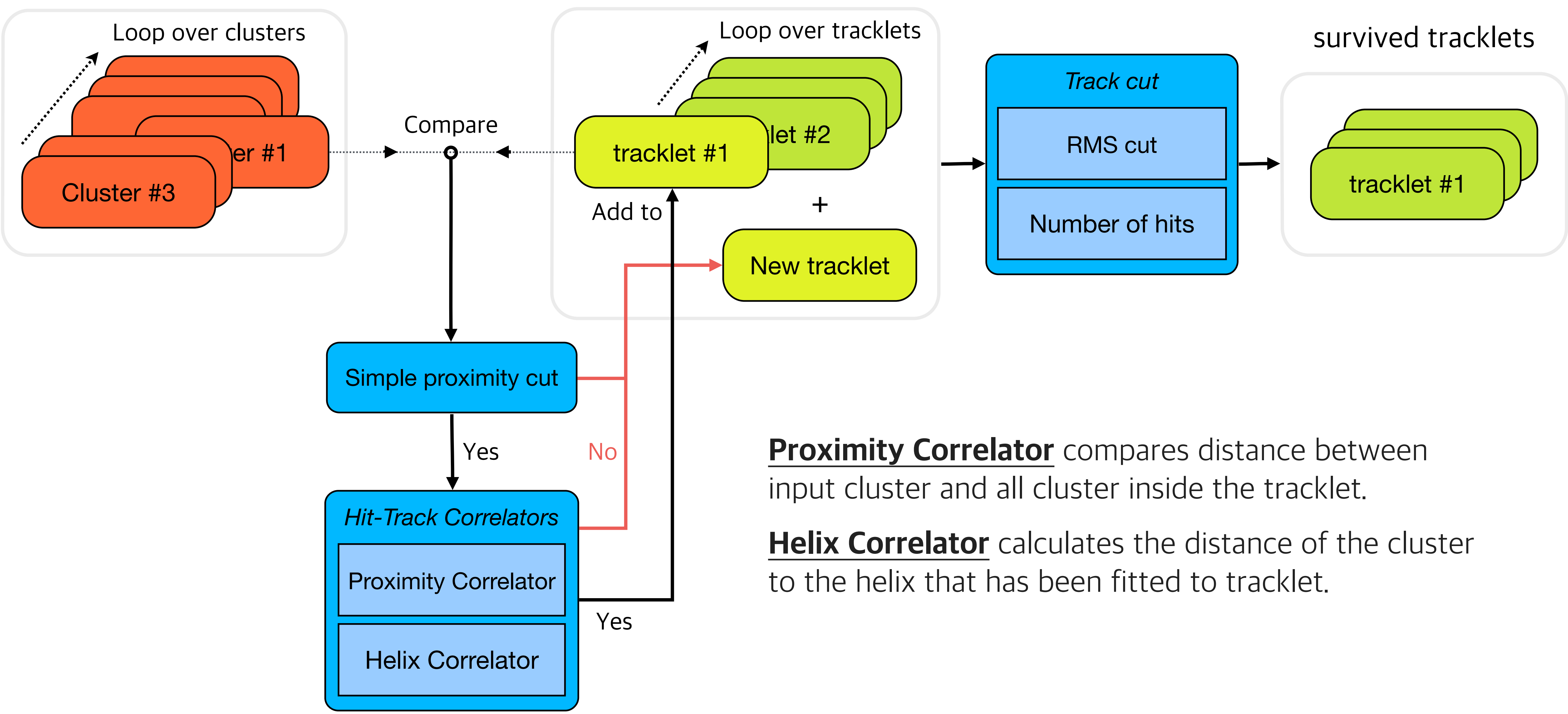
Aim of Riemann tracking is to group clusters into tracks. Riemann tracking is performed in two big step: building and merging. For these jobs, fitting is are done every time tracklets are updated.



Riemann Tracking - Building

Hits are sorted in r, z, φ. Loop over sorted hits and compare with all tracklets. Correlators will decide wheter to add cluster into tracklet or to make new tracklet.

If loop is over, tracklets go into track cut correlator and sort out satisfied tracklets. Those tracklets that are not satisfied by track cut returns clusters back. Then change sorting of clusters and process are repeated.

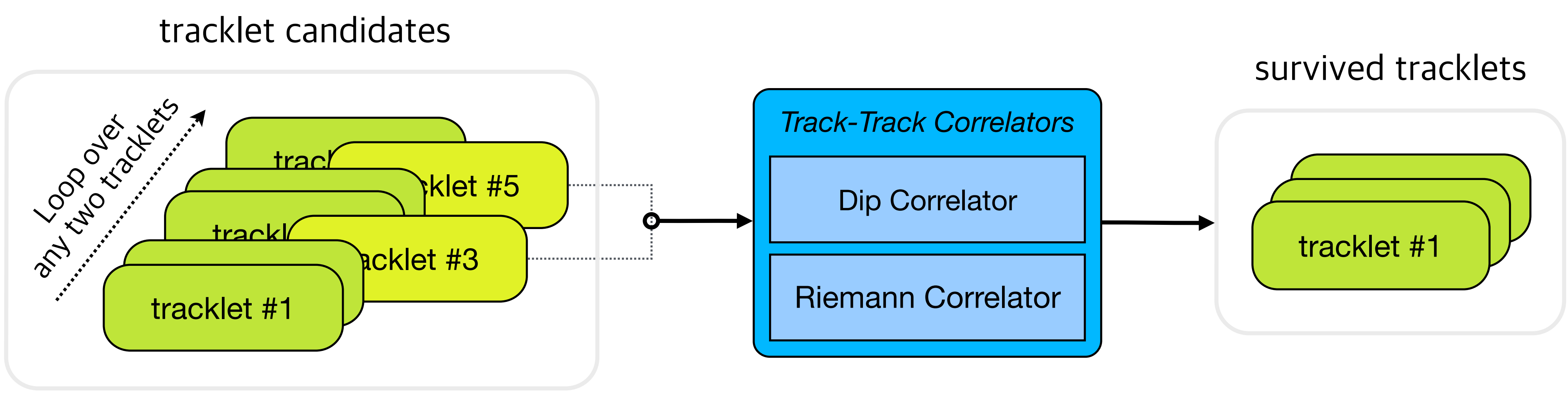


Proximity Correlator compares distance between input cluster and all cluster inside the tracklet.

Helix Correlator calculates the distance of the cluster to the helix that has been fitted to tracklet.

Riemann Tracking - Merge

In merging process, tracklets found in building process are merged respect to Track-Track Correlators.



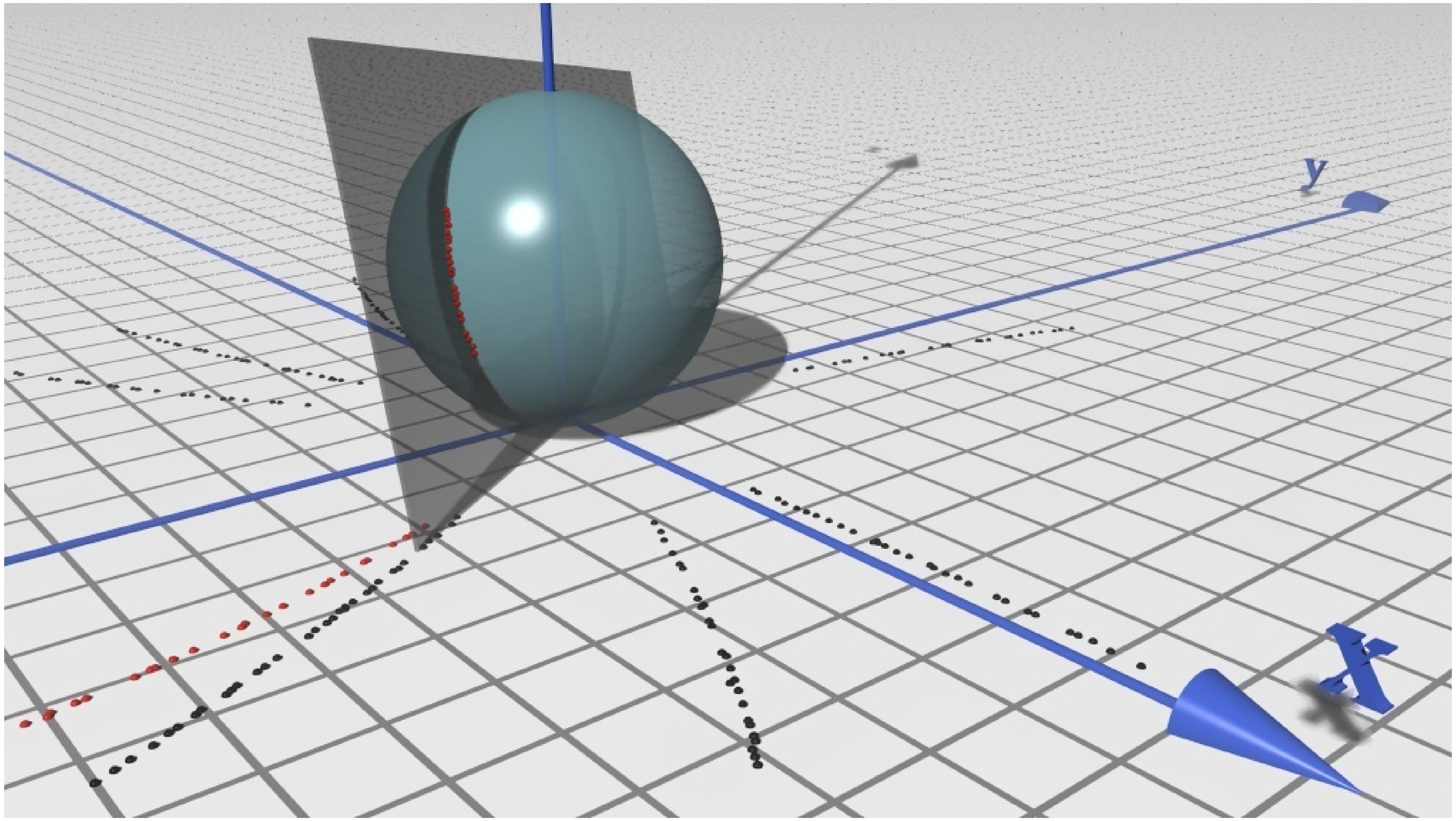
Dip Correlator compares the difference between dip angles of two tracklets. Dip angle is defined as angle between a line parallel to the z-axis and a tangent on a helix.

Helix Correlator merge two tracklets temporarily and calculate RMS of distance of the clusters to the fitted helix. RMS is compared with RMS cut.

Riemann Tracking - Fitting

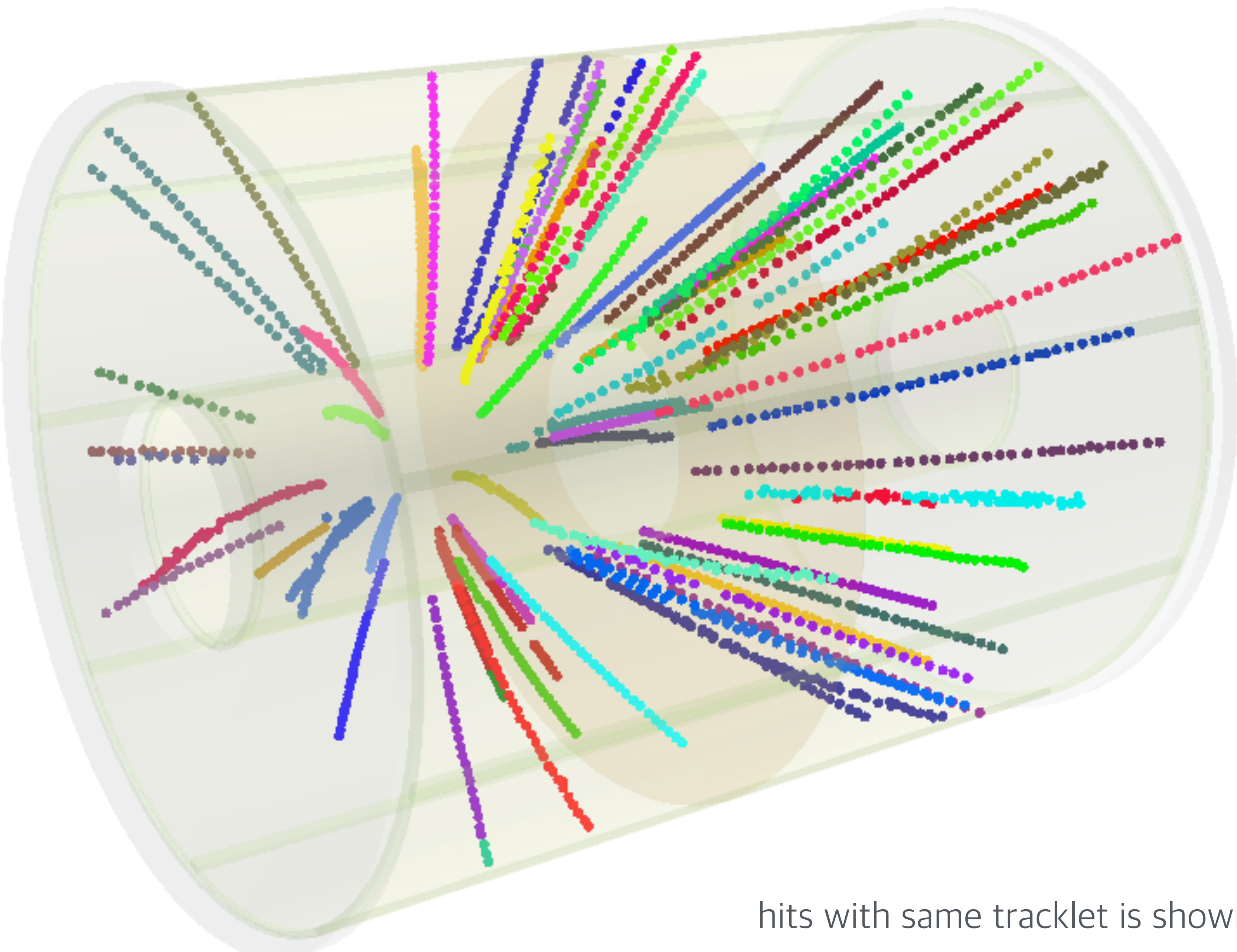
Fitting helix is done in xy-plane(circle fit) first and simple linear fit is done next. For the circle fit, we use Riemann transform (known as stereographic projection) of cluster position to Riemann sphere. This makes problem of circle-fit in xy plane into plane-fit in Riemann sphere.

Plane fit in Riemann sphere can be solved analytically which has big advantage in speed comparing to fitting based on iteration algorithm.



Riemann Tracking

Riemann tracking parameters highly depend on pad shape, gas(diffusion), and clustering method. Every time other method chages best fitting parameter for Riemann tracking is also changed.

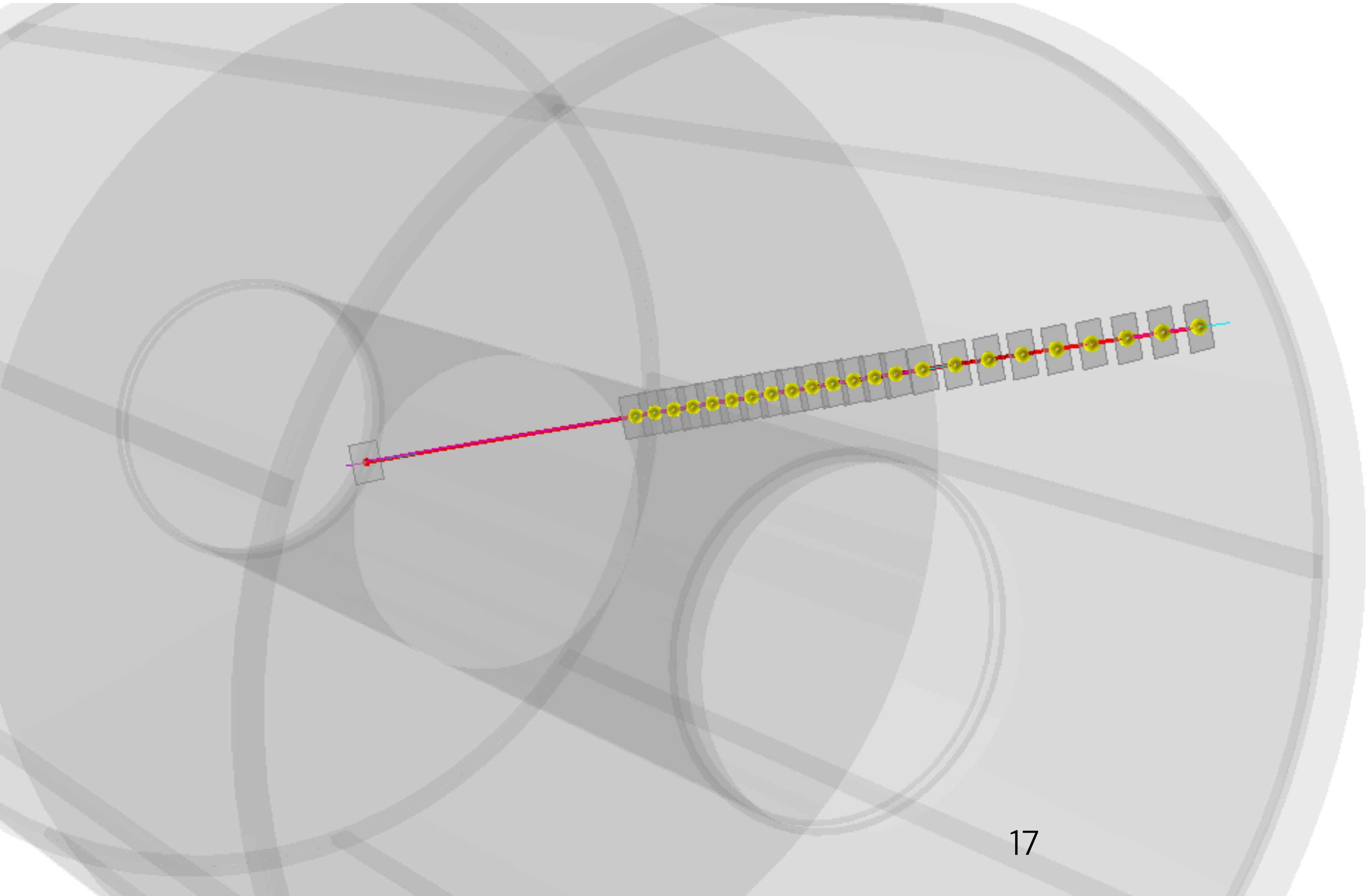


hits with same tracklet is shown in same color.

GENFIT

genfit.sourceforge.net/Main.html

A generic toolkit for track reconstruction for experiments in particle and nuclear physics. GENFIT use Kalman Filter method and capable of considering energy loss of charged particle(Bethe Block formula), multiple scattering and Bremsstrahlung. With given input(position, error, geometry, material, field and initial parameter) from Riemann tracking task, GENFIT calculates momentum, track length, vertices.

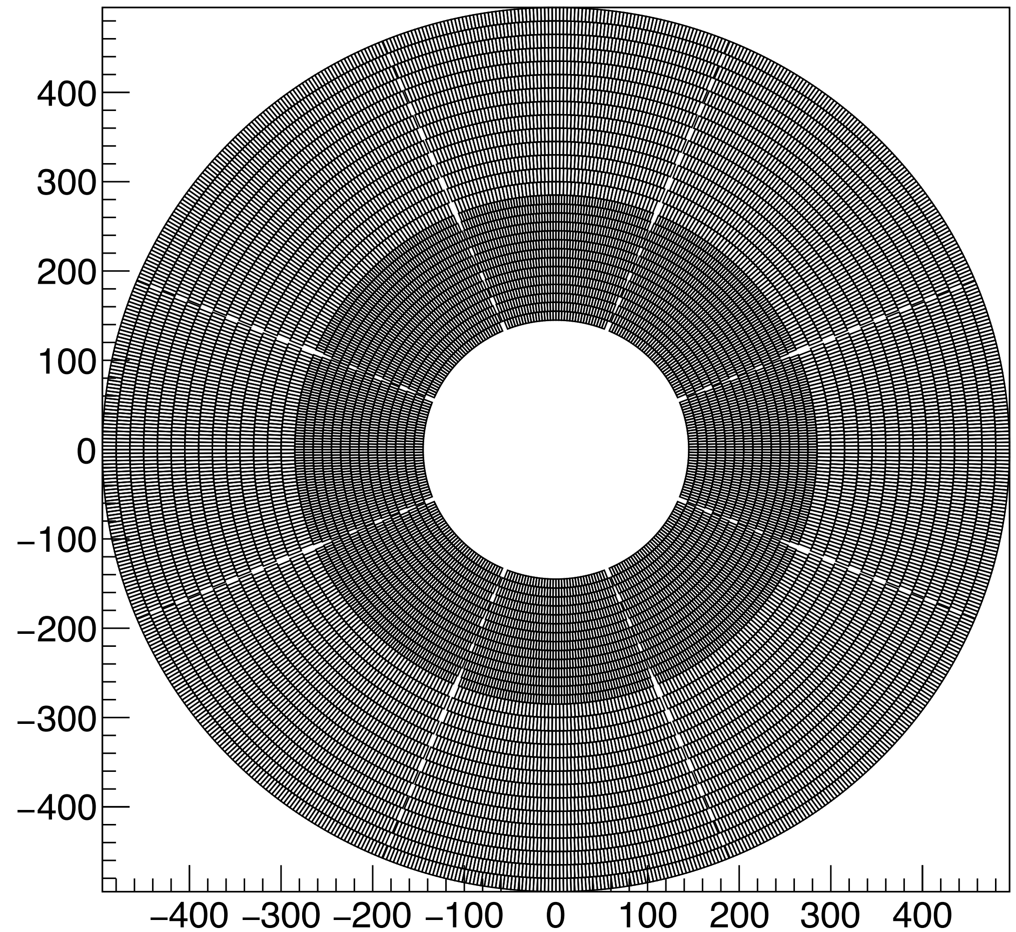


p_T resolution performance

Momentum resolution test was done to see the resolution of p_T(did not considered resolution in z-direction) for proton and poin. Below are conditions we used.

- Fan shape pad
  - inner layer : (arc, length) = (3 mm, 10 mm)
  - outer layer : (arc, length) = (4 mm, 15 mm)
  - total number of pad is 30,816.
- Sinlge track of proton and π^+ in angle 25° ~ 90°.
- P10 gas with density 1.56 g/cm^{-3}.
- No Riemann tracking task.
- Momentum reconstruction with clusters using GENFIT tracking.
- 10,000 tracks per p_T (180, 360, 540, 720, 900, 1080 MeV/c).

Fan Pad 3x10, 4x15 mm (#30816)



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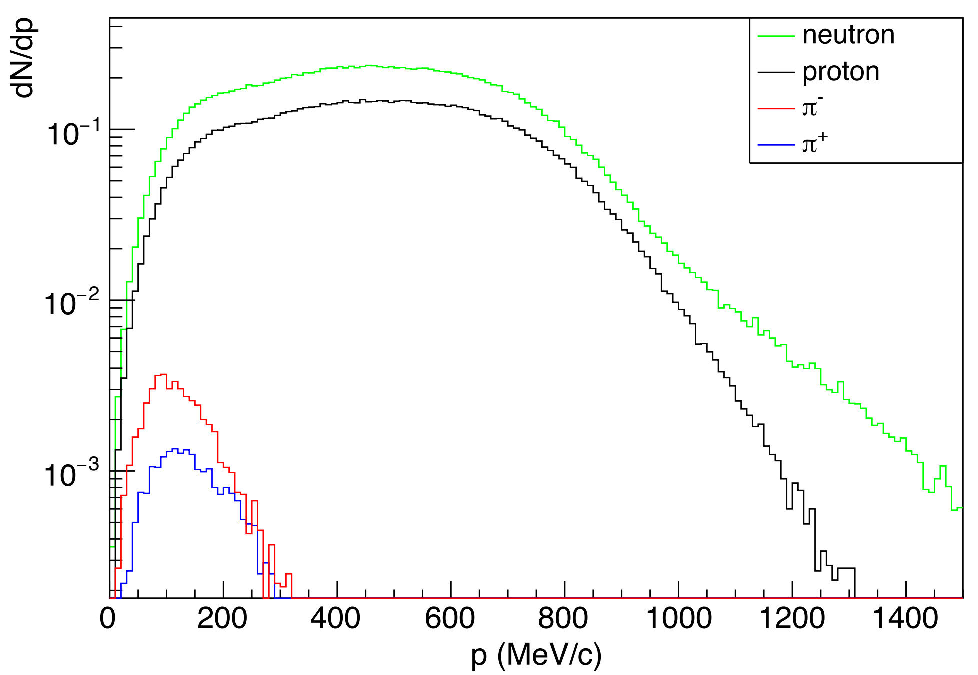
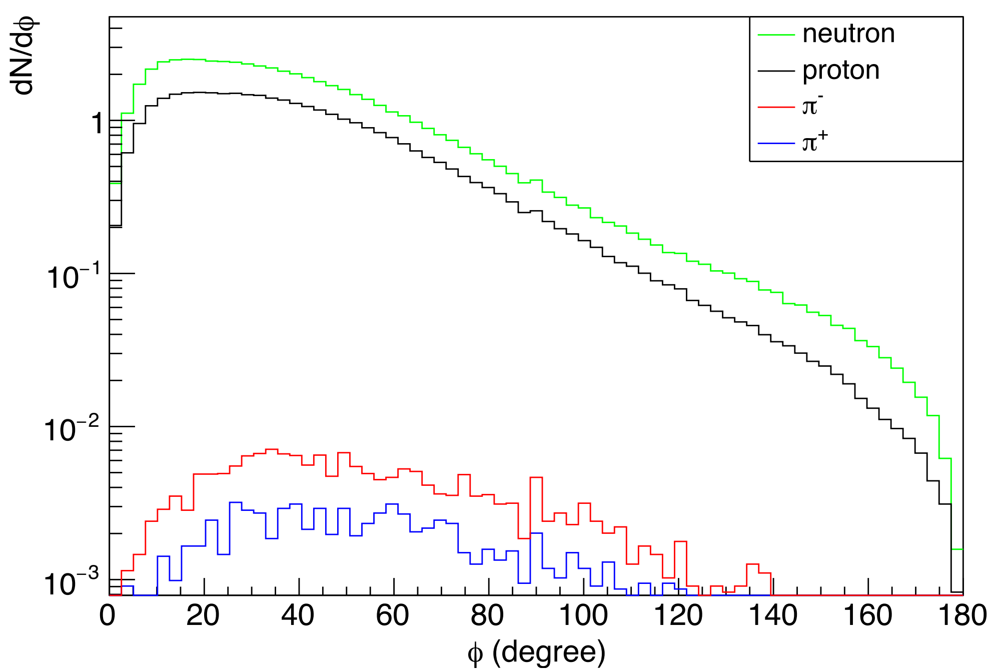
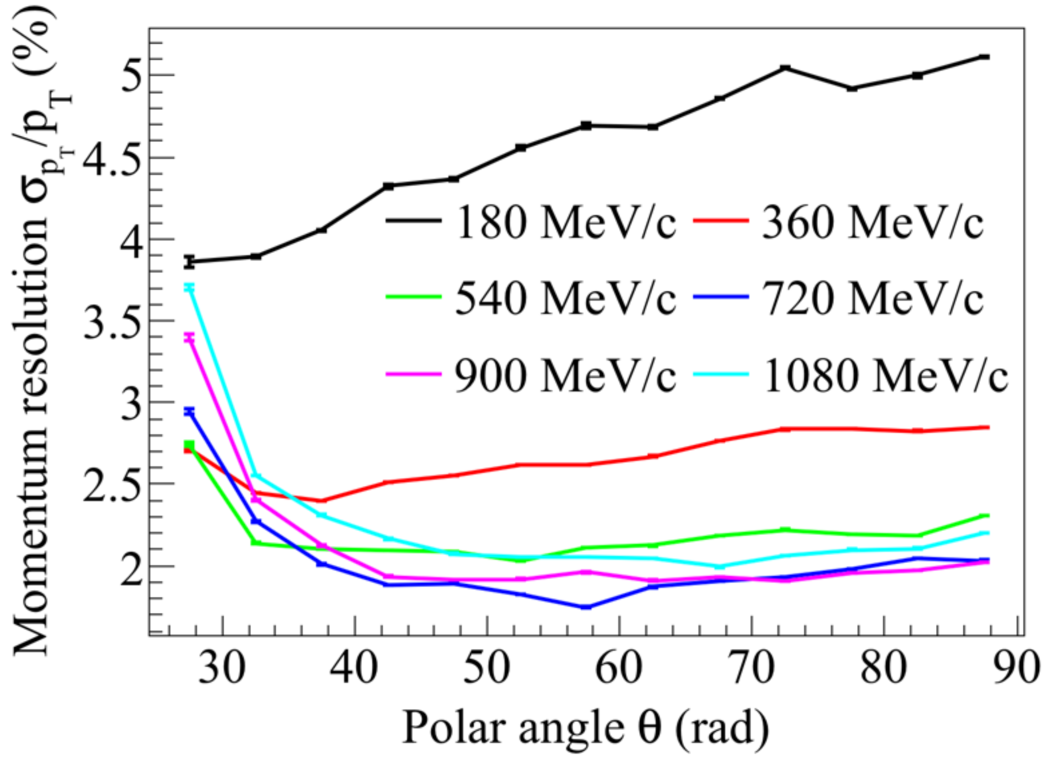
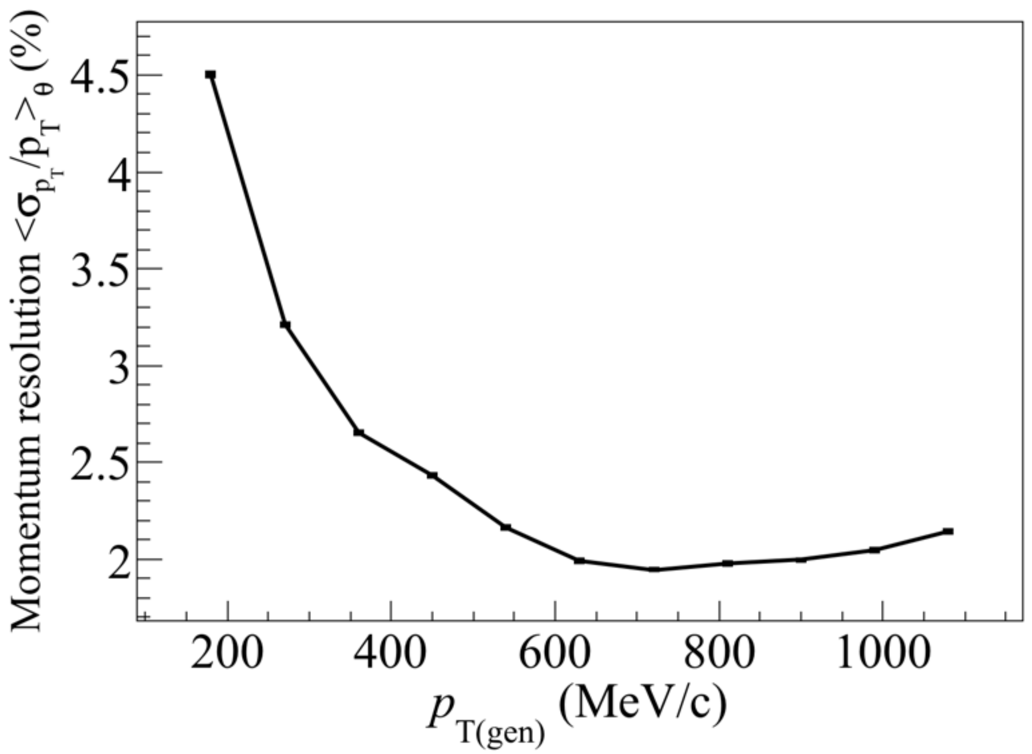




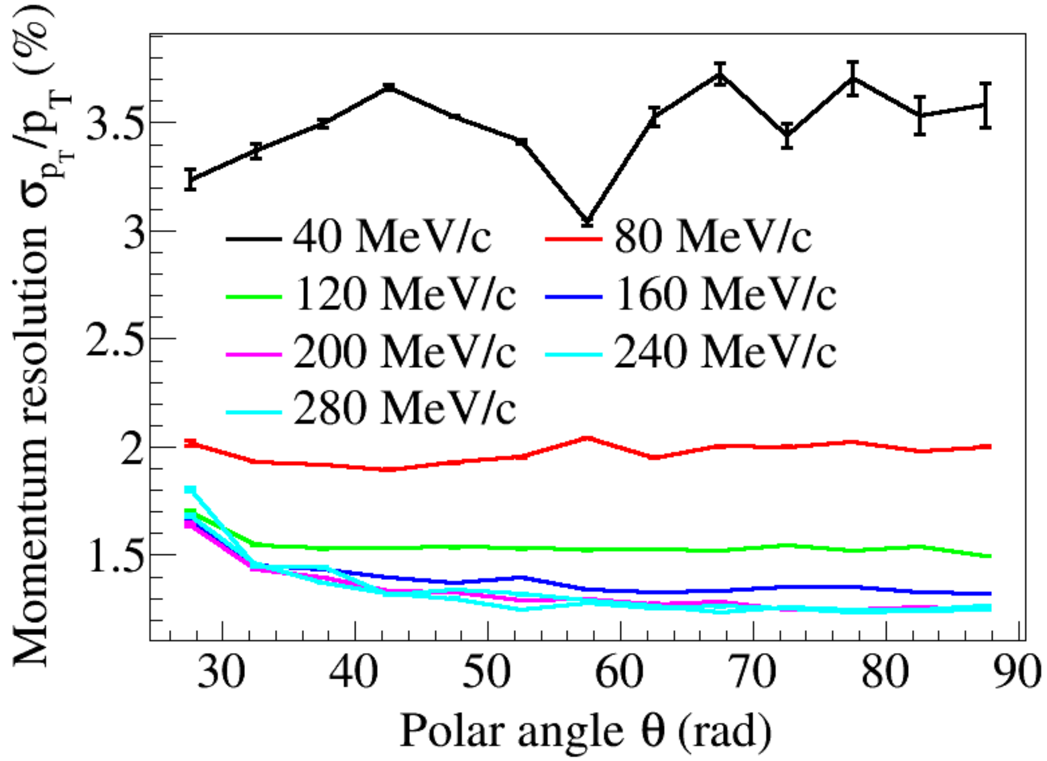
IQMD (Isospin Quantum Molecular Dynamics),
Au+Au, 250 (A MeV), Soft Model.

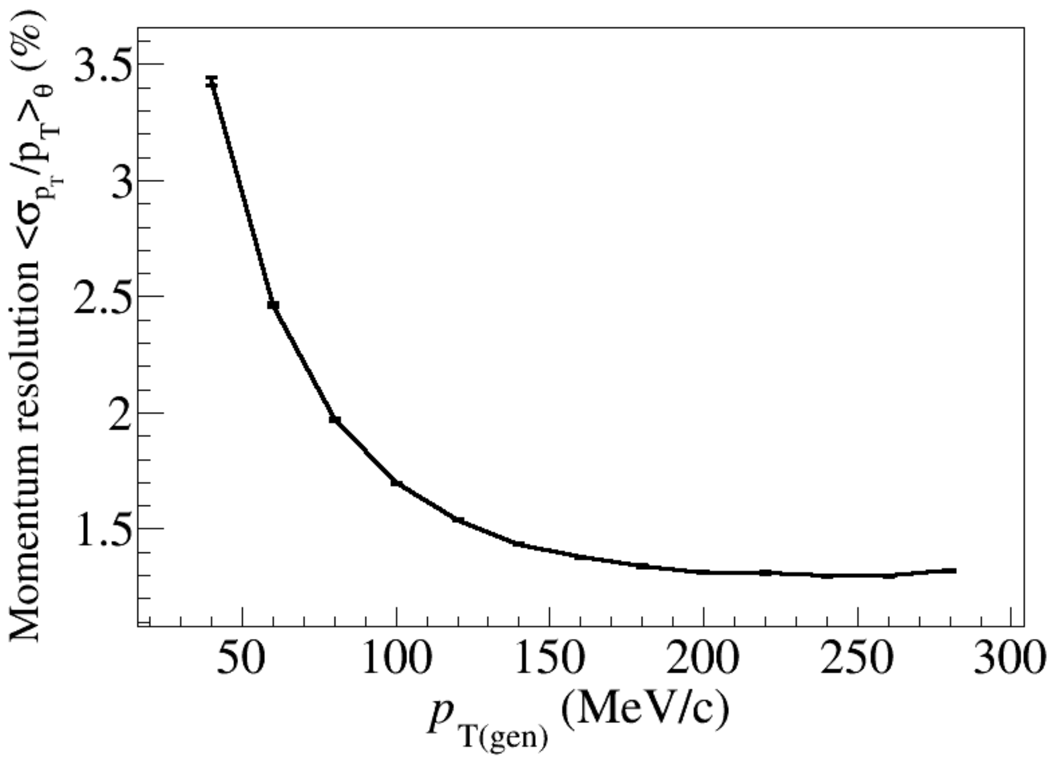
p


Momentum resolution σ_{p_T}/p_T (%)
Polar angle θ (rad)
180 MeV/c
360 MeV/c
540 MeV/c
720 MeV/c
900 MeV/c
1080 MeV/c


Momentum resolution $<\sigma_{p_T}/p_T>_\theta$ (%)
$p_{T(gen)}$ (MeV/c)

π^+


Momentum resolution σ_{p_T}/p_T (%)
Polar angle θ (rad)
40 MeV/c
80 MeV/c
120 MeV/c
160 MeV/c
200 MeV/c
240 MeV/c
280 MeV/c


Momentum resolution $<\sigma_{p_T}/p_T>_\theta$ (%)
$p_{T(gen)}$ (MeV/c)

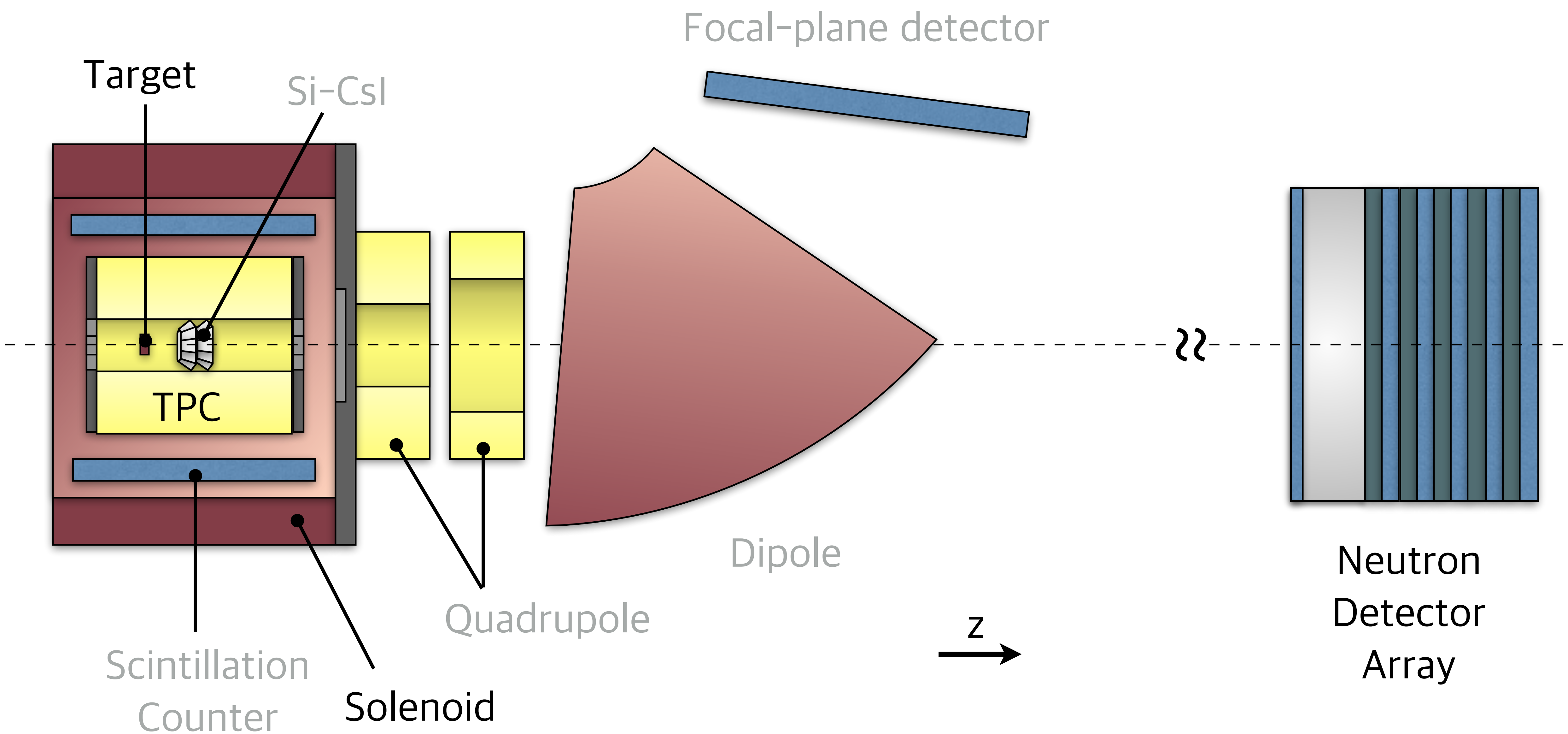
Summary

- LAMPSROOT is developed for simulation and analysis for LAMPS-TPC.
- Capable of full simulation from Monte-Carlo to traking.
- Different type of pads are being tested.
- p_T resolution of recent simulation shows < 5% for proton and < 3.5% for pion.

BACKUP

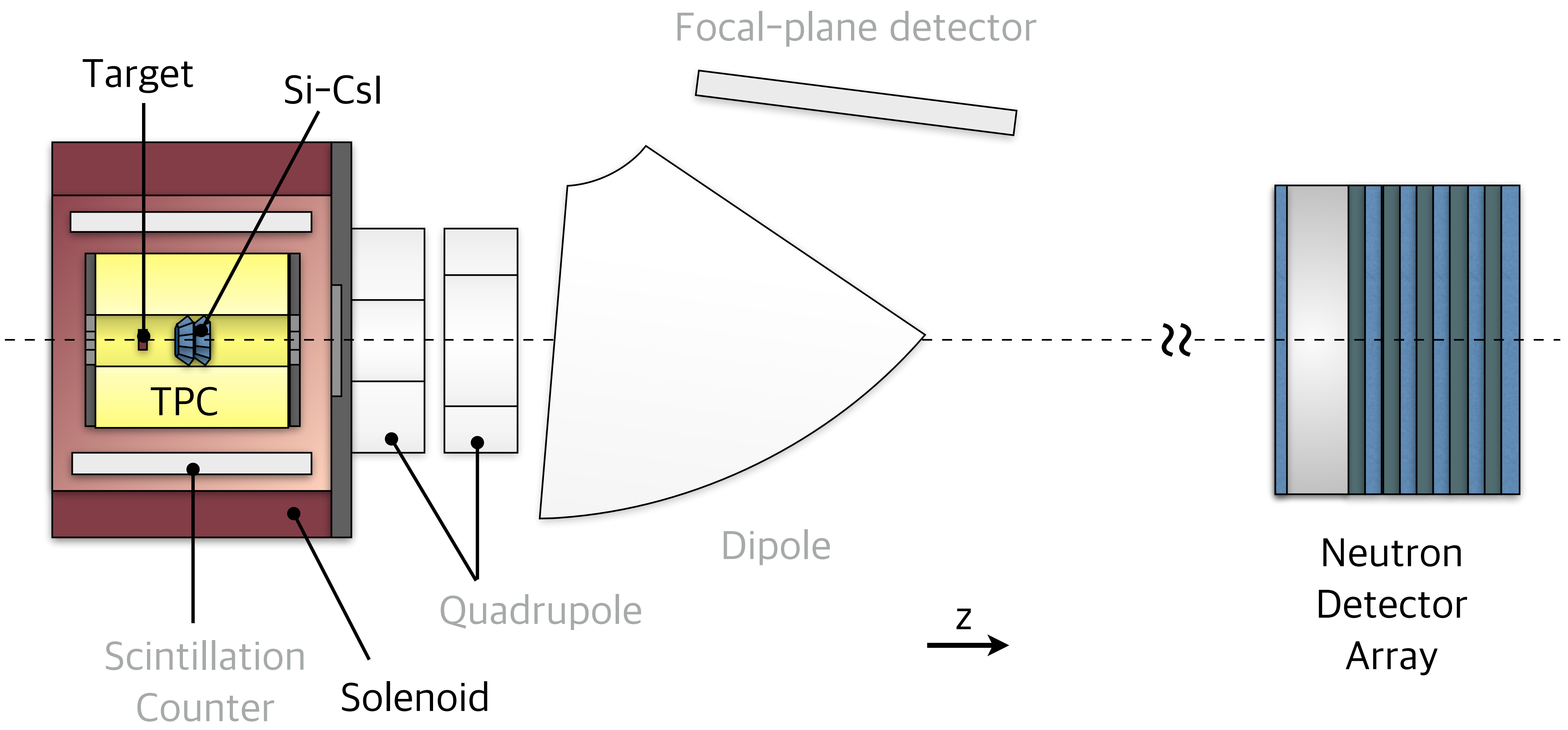
LAMPS-High

- TPC, Neutron detector array is planned.
- Example reaction is $^{132}Sn + ^{124}Sn$.
- Probes: π^-/π^+, n/p, $^{3}H/^{3}He$ ratios.



LAMPS-High Configuration

- TPC, Si-CsI and Neutron detector array is planned
- Example reaction is $^{132}Sn + ^{124}Sn$.
- Probes: π−/π+, n/p, $^{3}H/^{3}He$ ratios



STAR-TPC

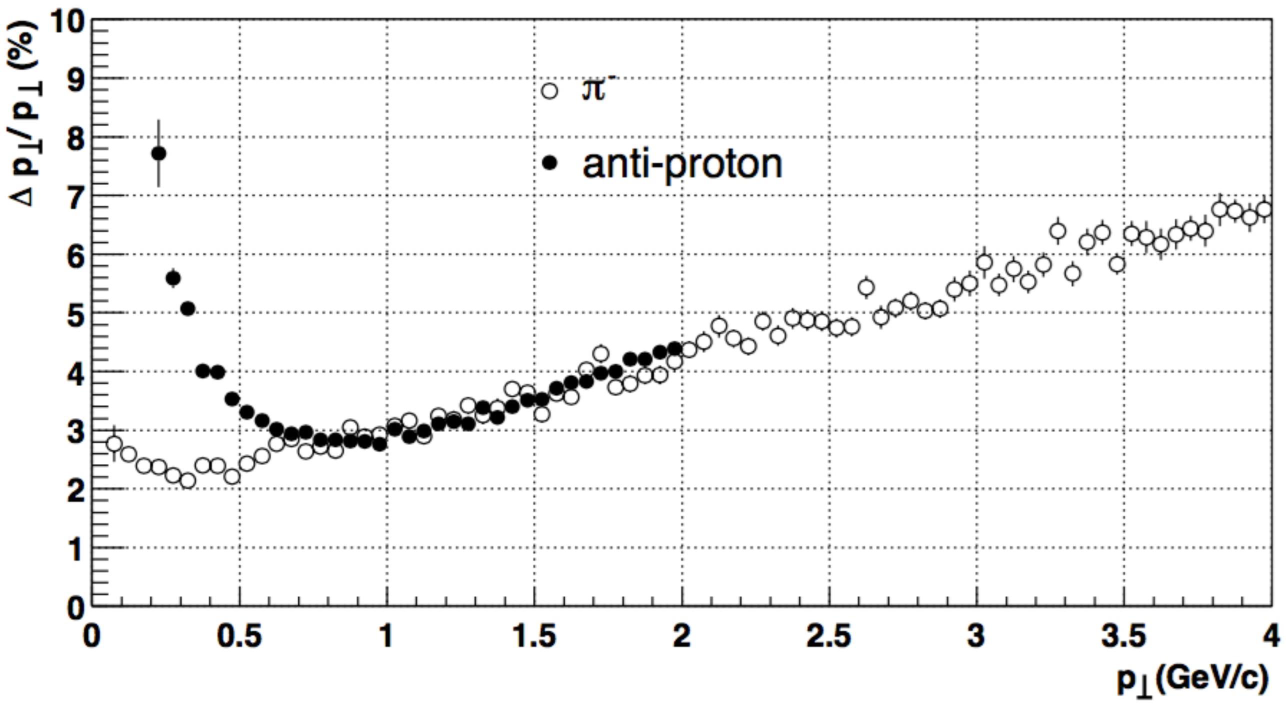


Fig. 10. Transverse momentum resolution of the STAR TPC for π^- and anti-protons in the 0.25 T magnetic field. Tracks are required to be formed by more than 15 hits. Tracks are embedded in minimum bias events. The momentum resolution is calculated as the Gaussian $sigma$.

ALICE-TPC

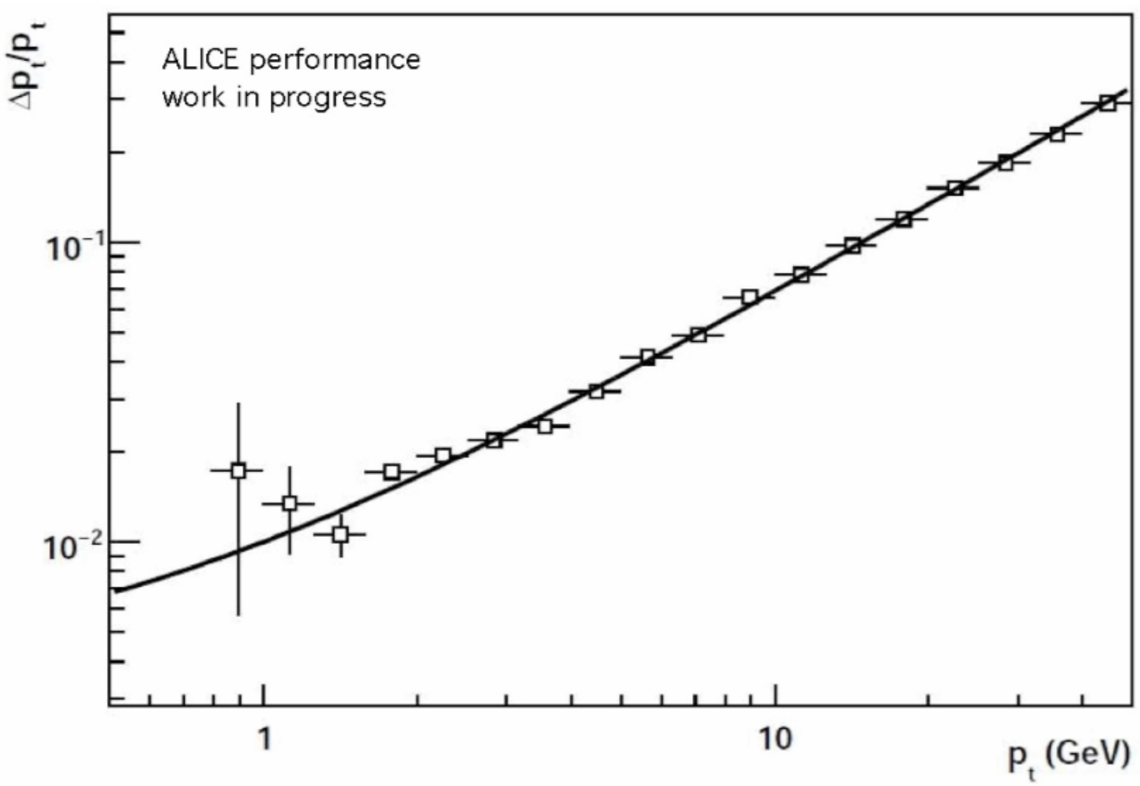


Figure 7. Transverse momentum resolution obtained from cosmics tracks.