Cluster Reconstruction of Tracker on STCF

Jiajun Tang (on behalf of STCF software working group)

University of Science and Technology of China

Nov 19, 2024

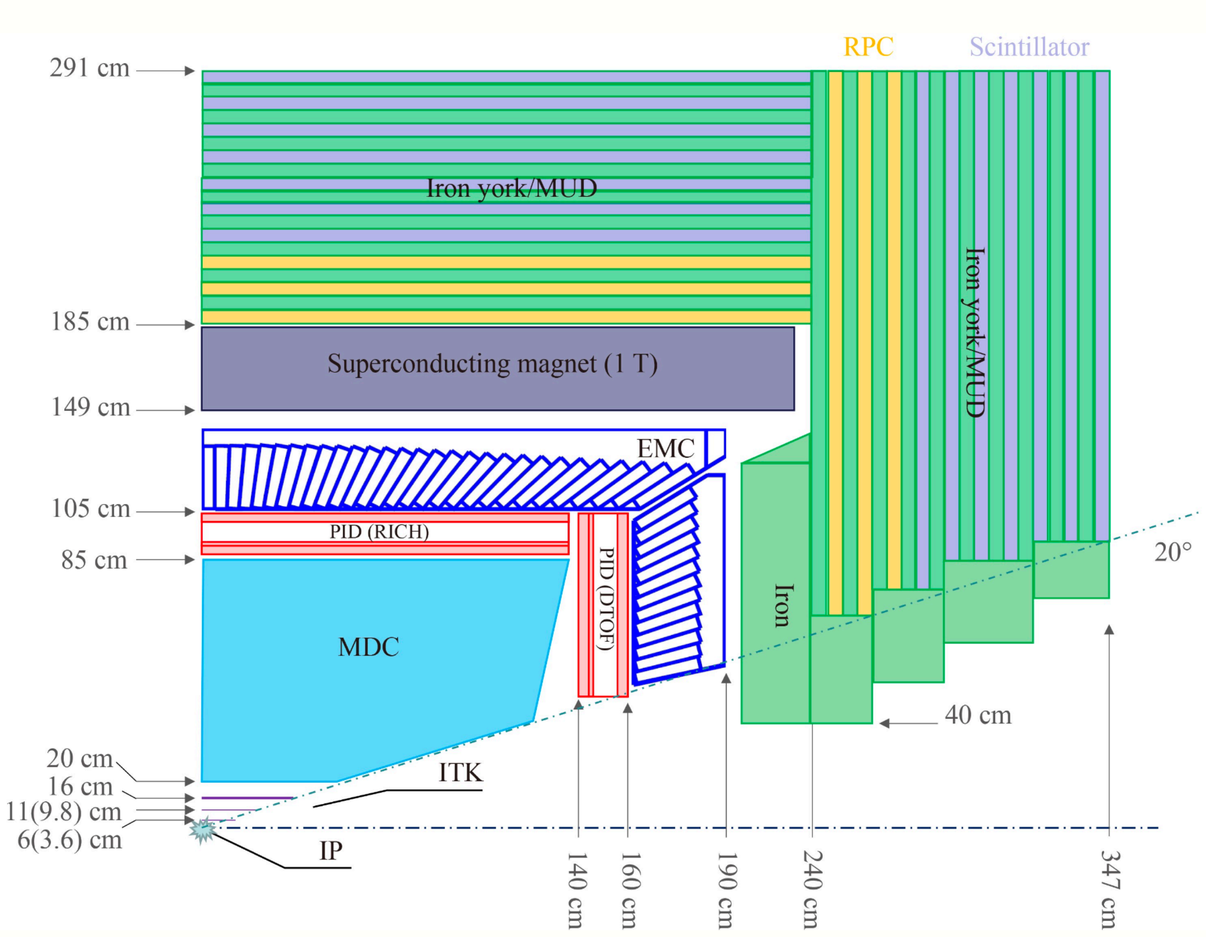
Outline

- Introduction
- ITKW
- ITKM
- MDC
- Summary

Introduction

STCF is an e^+e^- collider operating at $\sqrt{s} = 2 \sim 7$ GeV with a peak luminosity of 0.5×10^{35}cm^{-2}s^{-1}

- QCD and hadronic physics
- Flavor physics and CP violation
- Forbidden/Rare decay and New Particle



Introduction

Tracking system

Inner tracker(ITK)

ITKW: Cylindrical MPGD

ITKM: Silicon detector

Drift chamber(MDC)

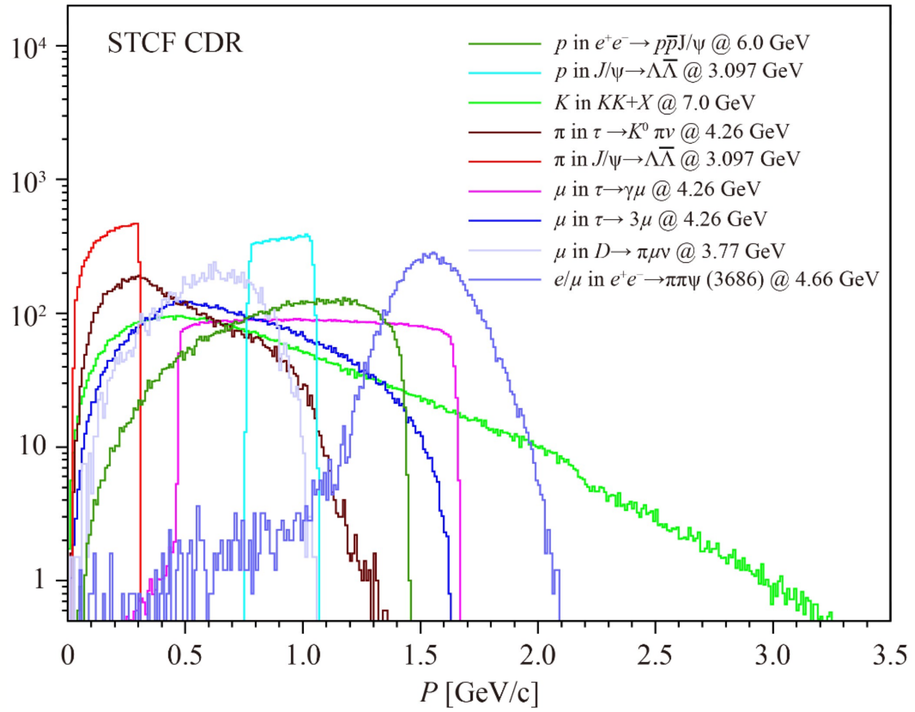
Performance requirements

Low material budget: about $0.25\,\%$ for each ITK layer

Spatial resolution: better than 100 μm in $r-\phi$

Detector occupancy: not exceeding a few percent

Momentum resolution: $\sigma_p/p < 0.5\,\%$ @1 GeV

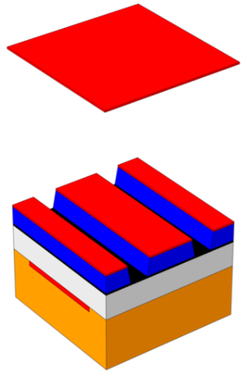


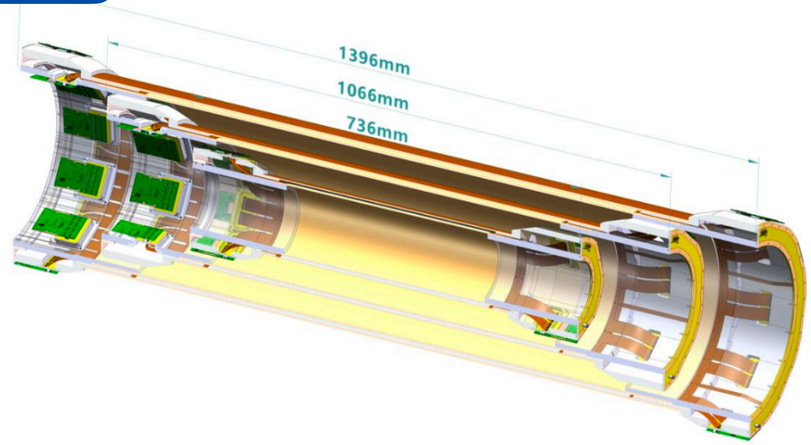
ITKW

Geometry

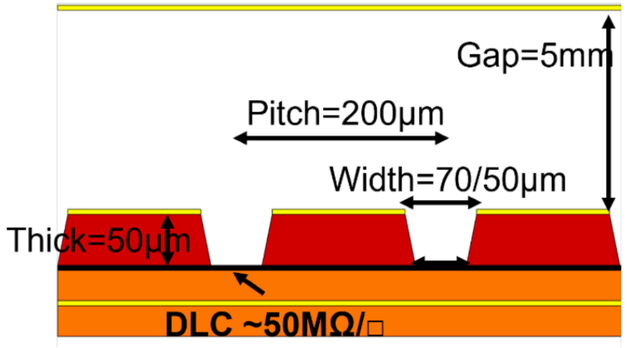
MPGD-based ITK

μRWELL → μRGroove





Planar prototype



single-amplification stage MPGD

three cylindrical detector layers

covering polar angle: $20^\circ - 160^\circ$

Ar-based gas

2D strip readout without charge sharing

ITKW

Reconstruction

Cluster finding: successive hits' strip ID difference ≤ 2

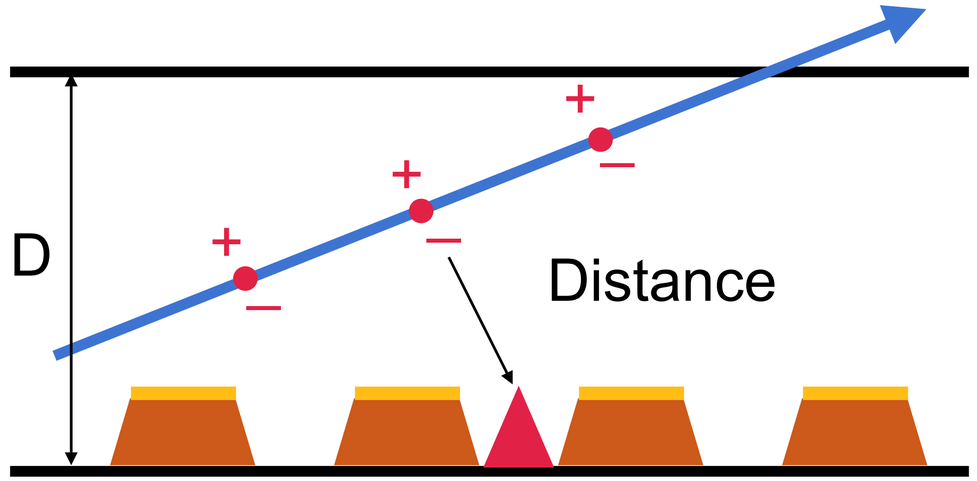
Cluster position: μ-TPC & CC

Charge center

$$\frac{\Sigma_i X_i Q_i}{\Sigma_i Q i} \rightarrow \text{cluster pos}$$

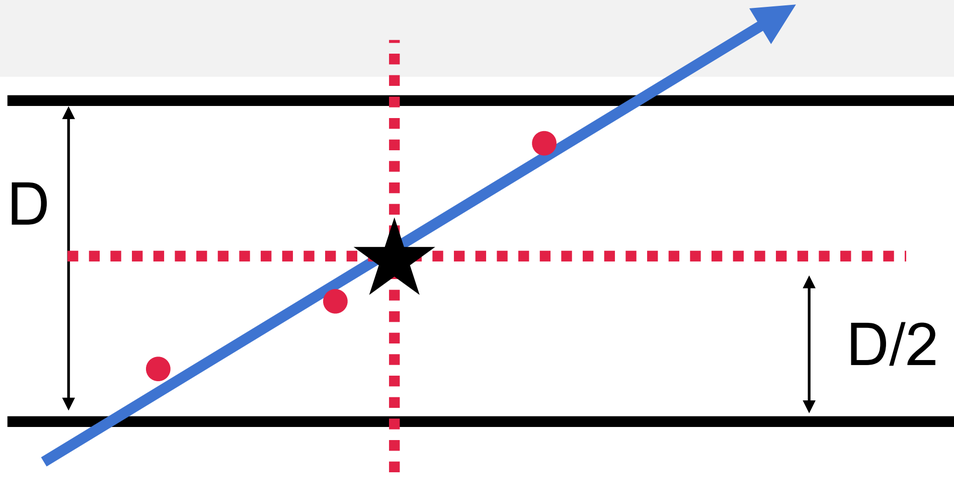
μ-TPC

$v_{\text{drift}} \cdot T_{\text{drift}} \rightarrow$ Position of points $\rightarrow$ Fit to get pos



ITKW

μ-TPC

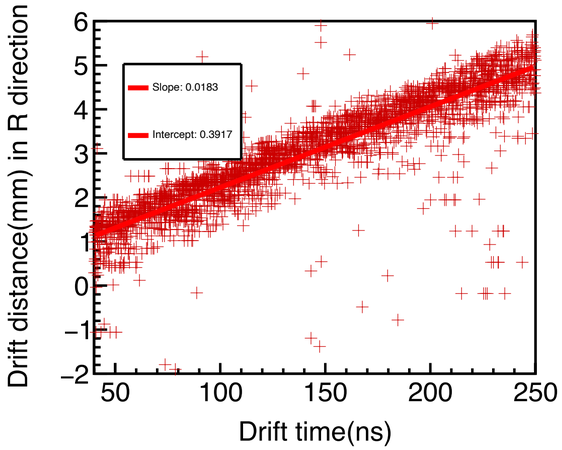


At least 3 digit signals

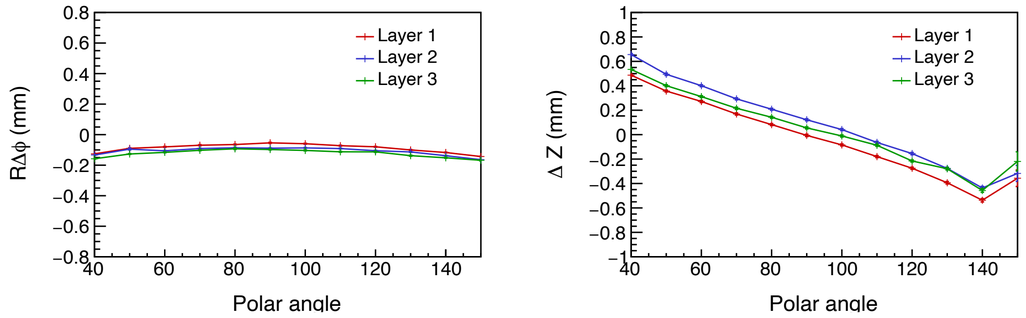
Coordinates be putted into fitting: (StripID, Drift Distance)

Linear fit, then get the strip ID of the middle point

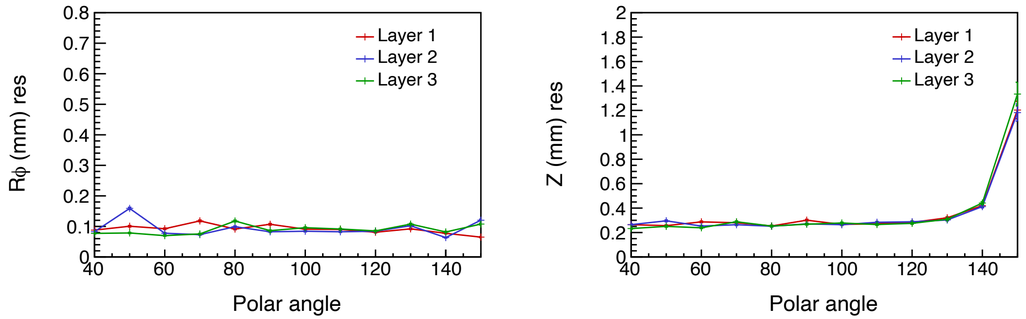
v_{drift}: get from simulation



Deviation:



Resolution:

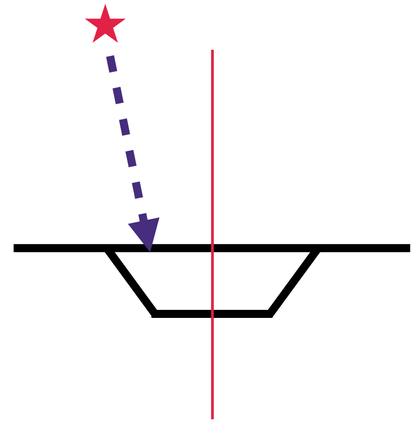


ITKW

μ-TPC correction

★： reach point is not the center of the strip

the T_{drift} is determined by the first one



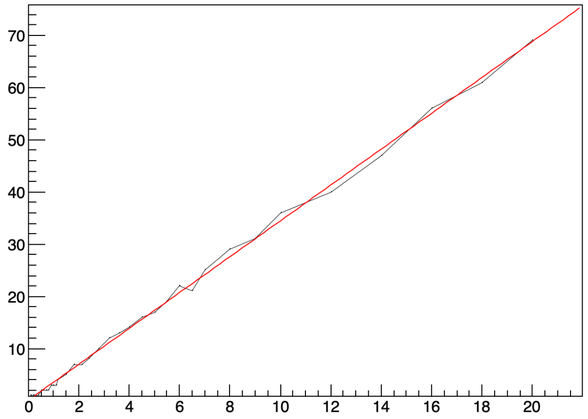
if N_e is number of primary ionization collected by one strip

correction： $ID = ID + (\frac{1}{2} - \frac{1}{N_e + 1}) \times D_{E_w}$

D_{E_w} : Width of weighting field

N_e: Estimated from sensing charge

Q~N_e relation



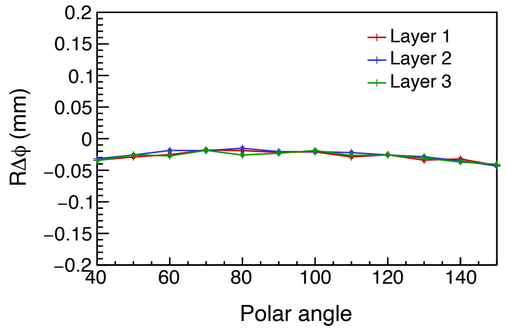
ITKW

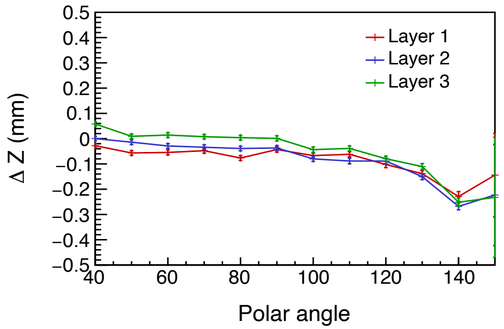
Performance

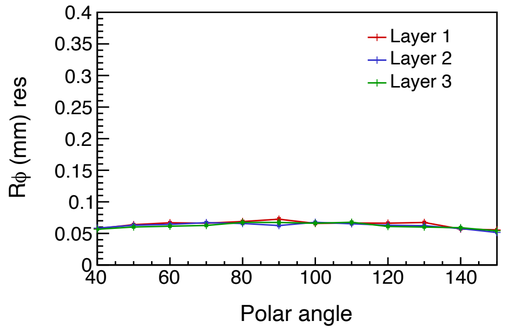
Deviation

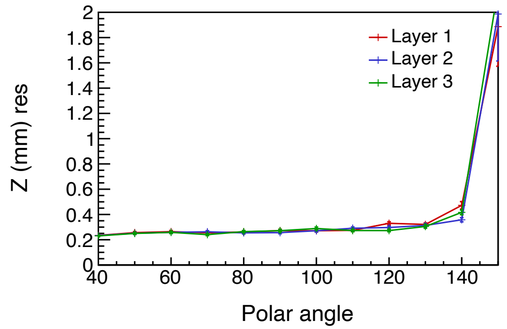
Resolution

μ-TPC

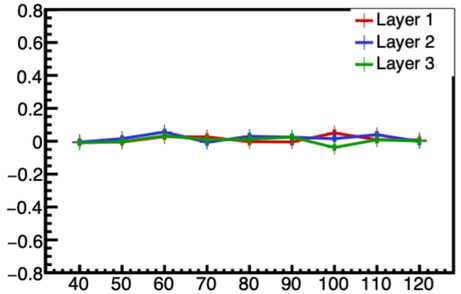


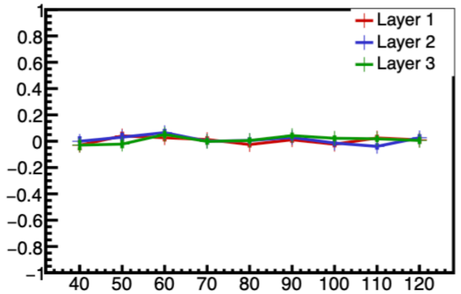


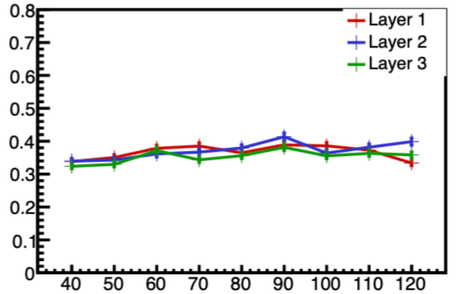


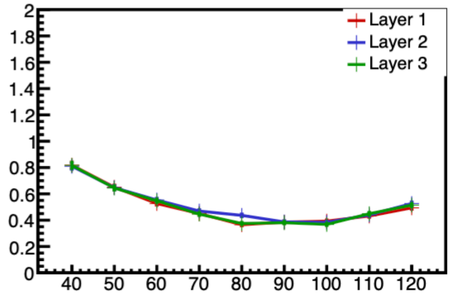


CC









ITKM

Geometry

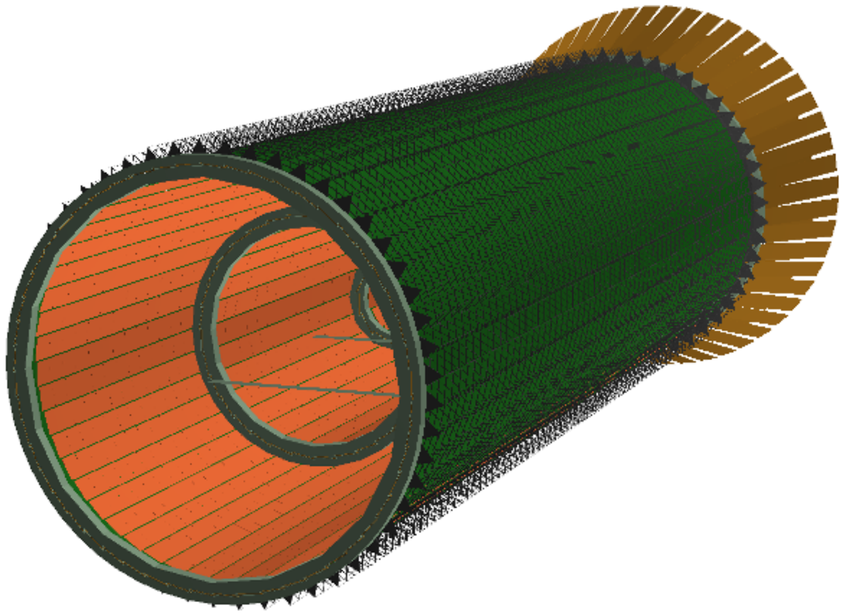
MAPS-based ITK

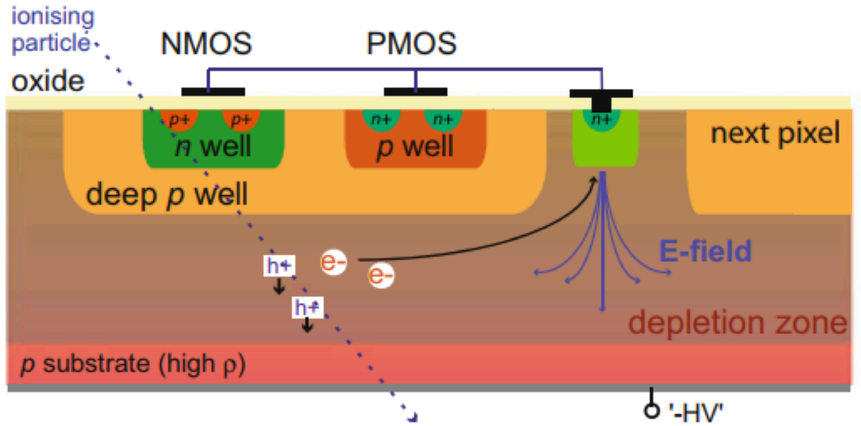
Monolithic active pixel sensor

three layers of silicon pixel detectors

pixel size: $170\ \mu m \times 30\ \mu m$

covering polar angle: $20^\circ - 160^\circ$



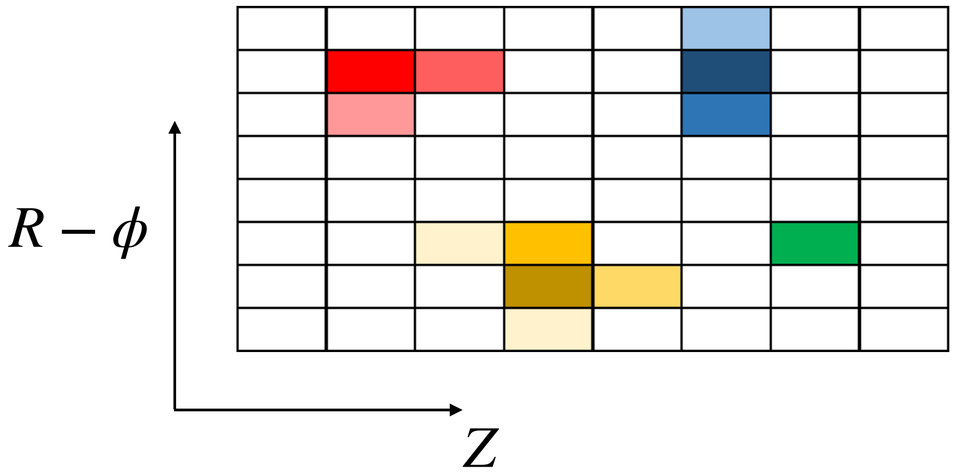


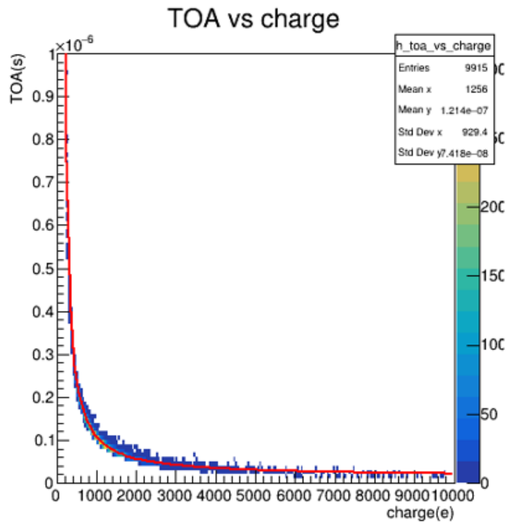
ITKM

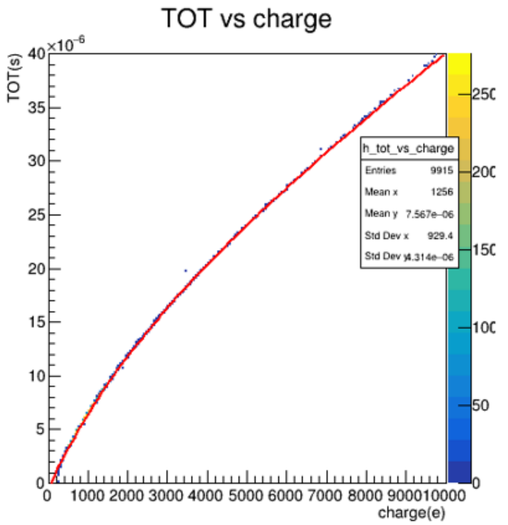
Reconstruction

Cluster finding: hit pixels inside 3×5 $(z \times \phi)$ range classified as one cluster

Cluster position: charge centering (TOT converted to charge)







ITKM

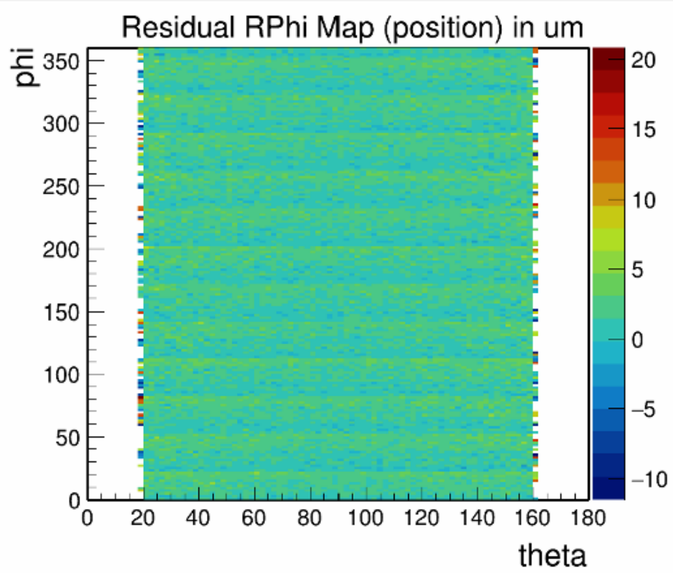
Performance

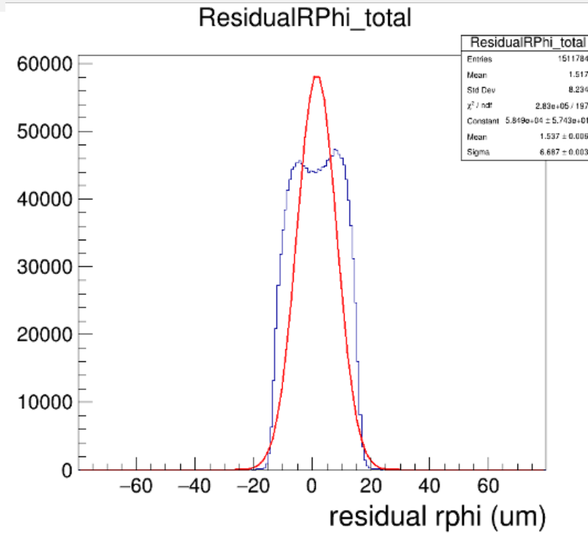
A nearly constant bias on $r-\phi$ direction, ~ 2 μm

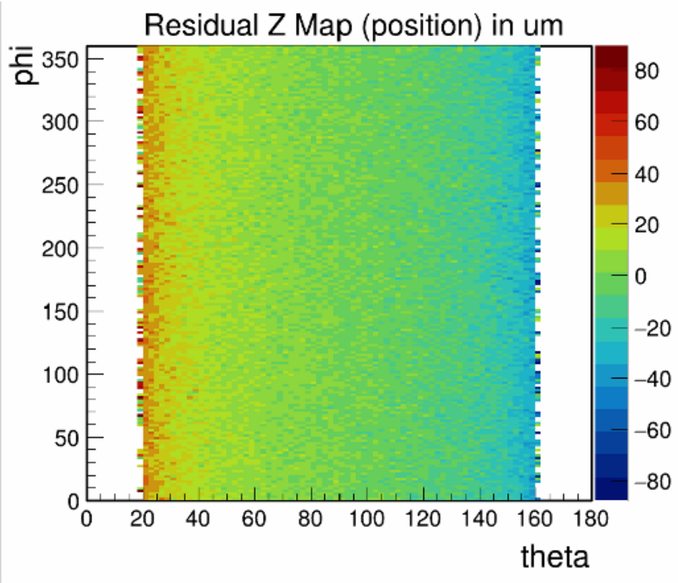
Bias on z direction varies with polar angle, a maximum of 25 μm at the end regions

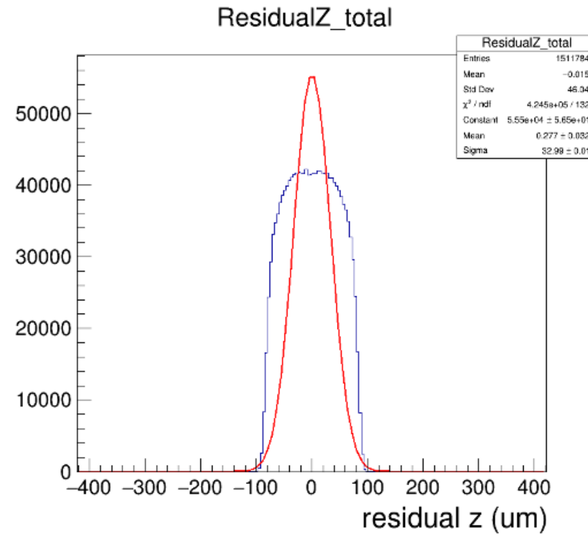
Resolution: $\sigma_{r\phi} = 6.69$ μm, $\sigma_z = 32.99$ μm

(better than $\frac{\text{pixel pitch}}{\sqrt{12}}$)









MDC

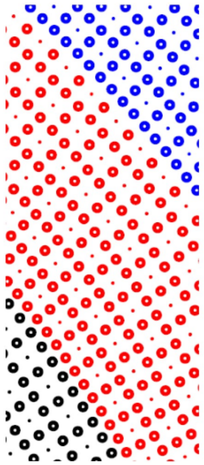
Geometry

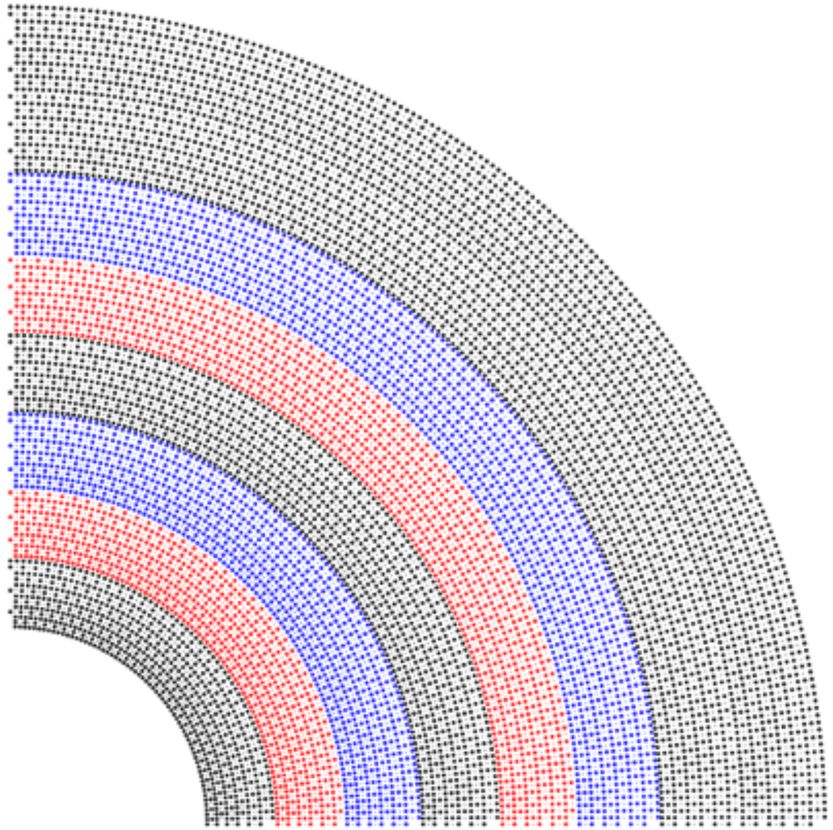
8 superlayers each with 6 layers of drift cells

open circles: field wires

dots: sense wires

drift cell: square-shaped





MDC

Reconstruction

MDC could acquire drift time

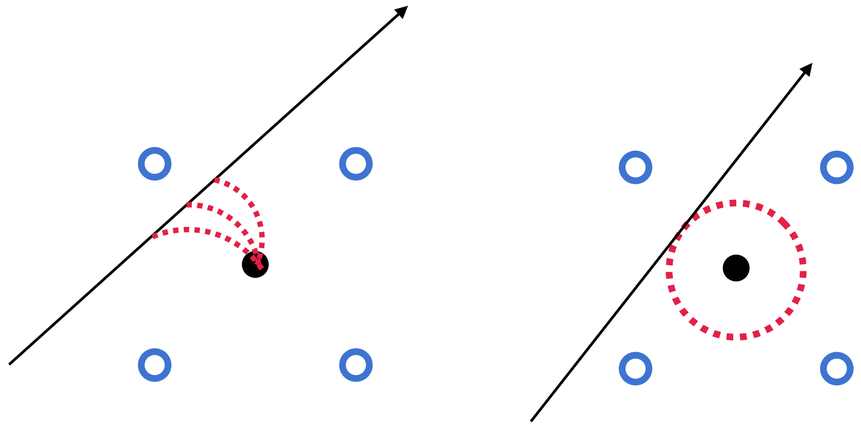
→ get drift distance according to T-X relation

→ constrain hit position on a cylindrical surface

→ used by track fitting

X: distance of POCA to signal wire

T: drift time



MDC

T-X relation

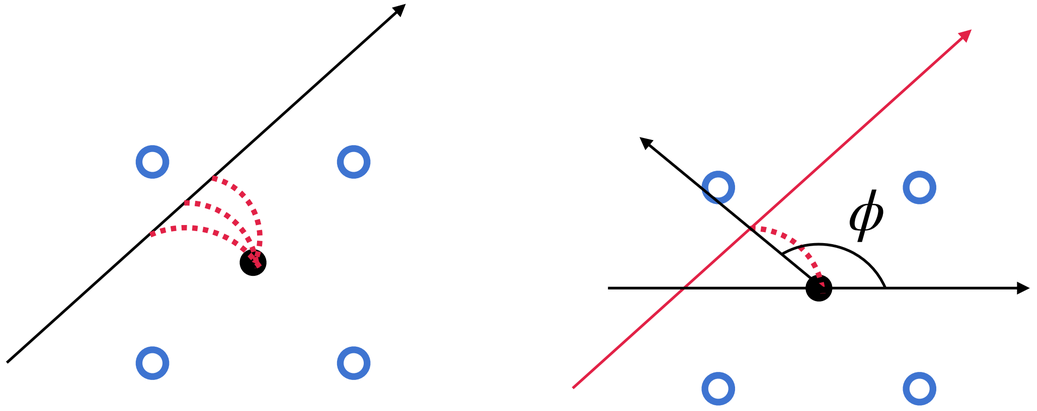
Waveform classification algorithm

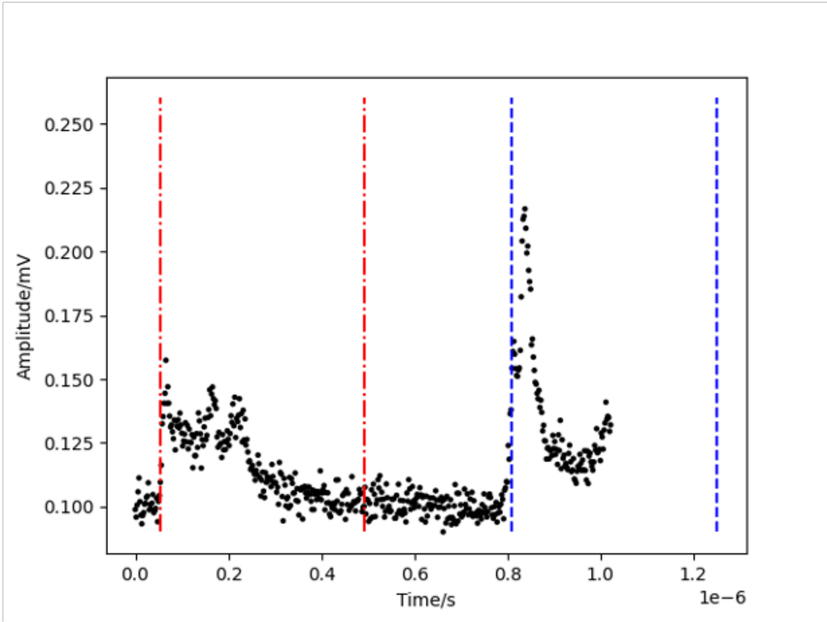
→ get the initial position of two waveforms

→ using threshold to get the drift time of the POCA

Complicate electric field

→ the relative angle ϕ should also be recorded



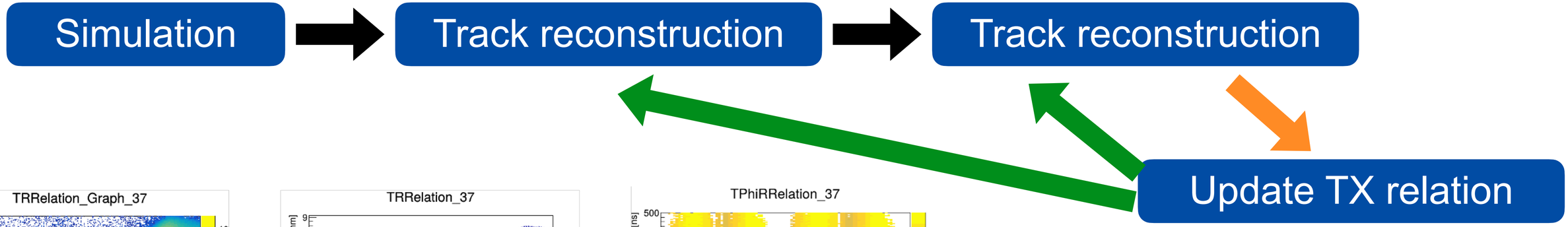


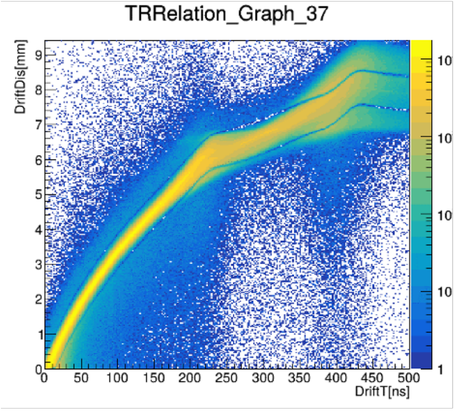
MDC

T-X relation

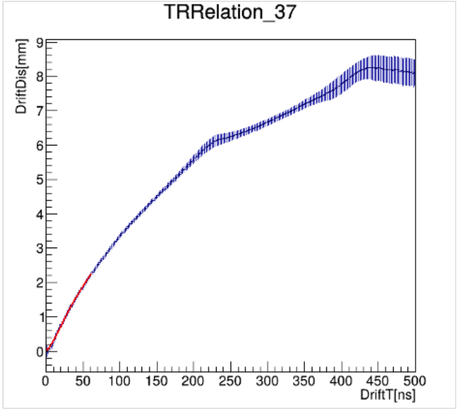
$\psi(3686) \rightarrow \pi\pi J/\psi(\rightarrow \mu\mu)$ sample is used

Initial T-X relation is artificial

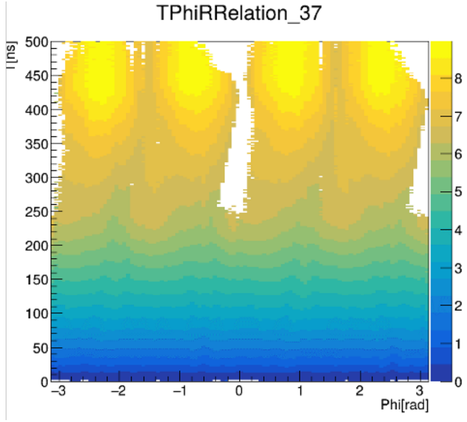




T-X distribution



1D T-X relation

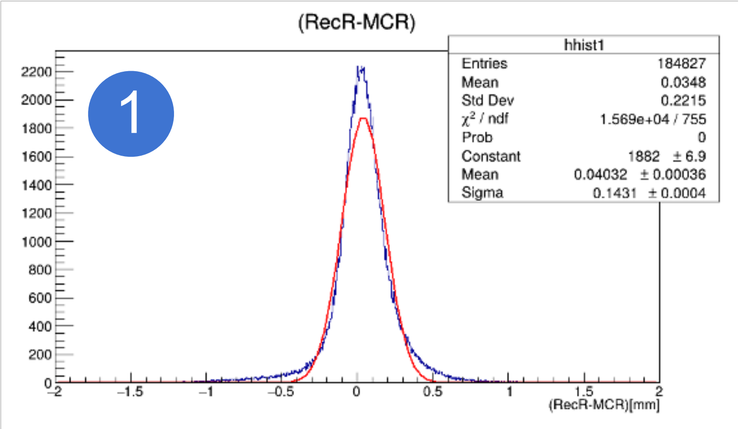


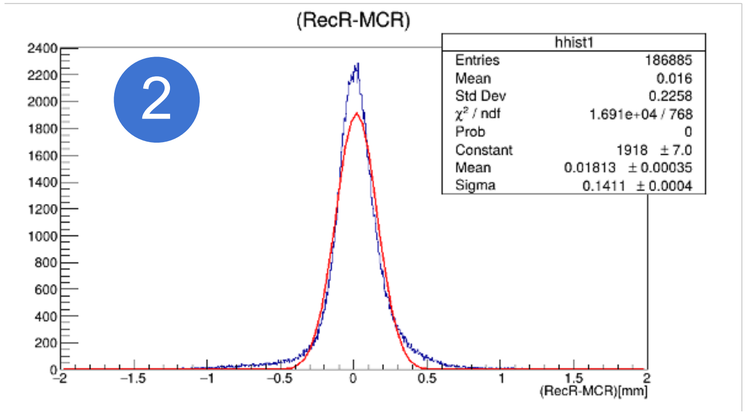
2D T-X relation

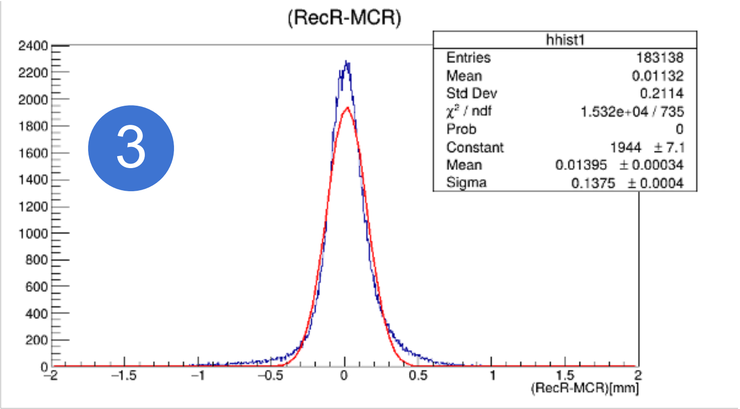
MDC

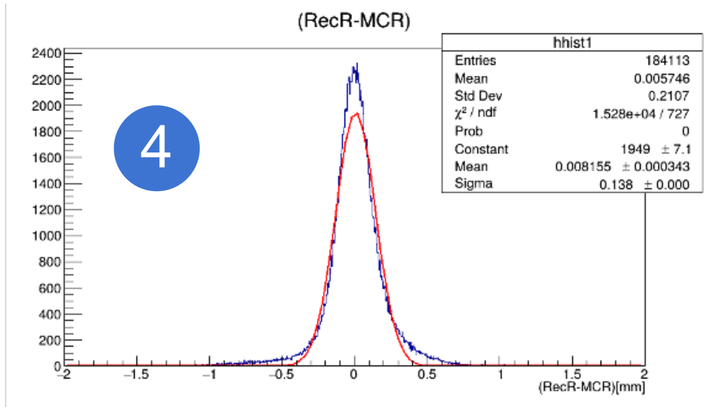
Performance

Reconstructed position deviation with different iteration times









Summary

- ITKW:

  resolution of $r-\phi$ direction meets the requirement

  only works for simple signal sample, needs updates to be used in high counting rate conditions

- ITKM:

  Reached good position resolution

  Calibration according to pixel position may further improve

- MDC:

  Iteration could improve the accuracy of T-X relation

  Next will reconstruct more events, give the performance by layer

Thanks for listening