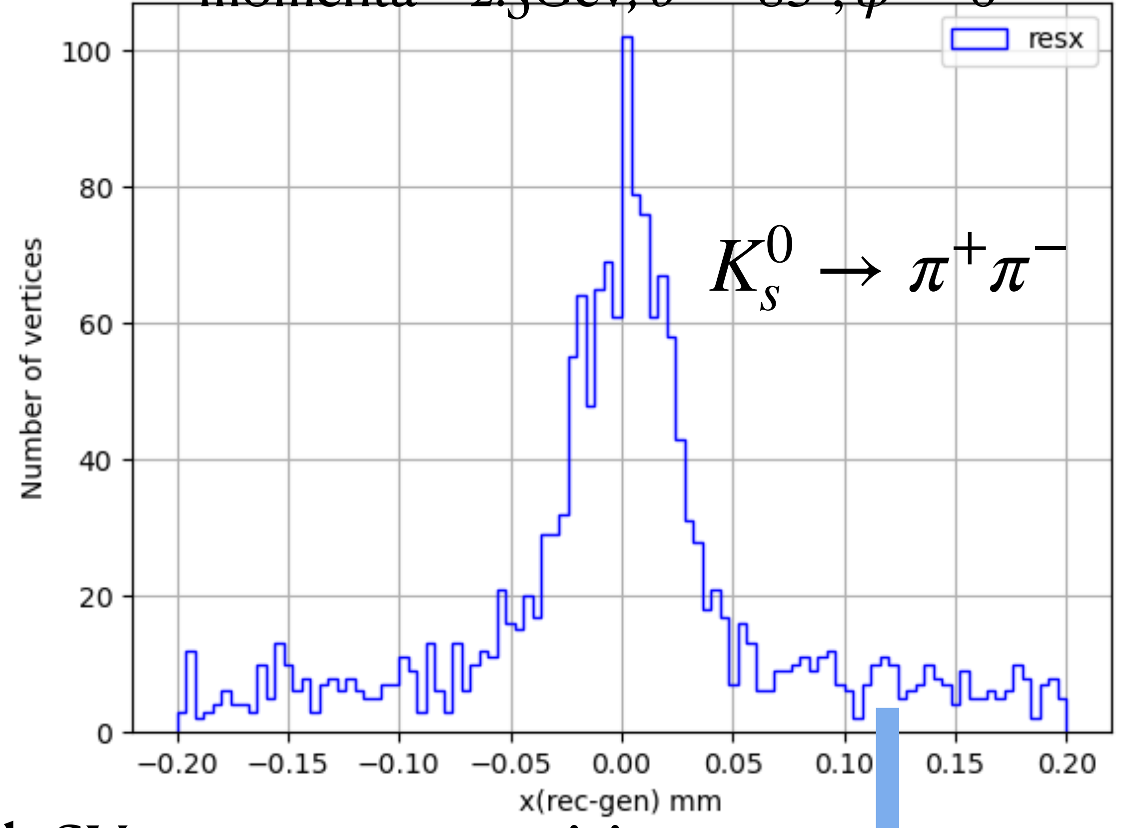
Vtx, PID

C.Zhang/23Dec2024

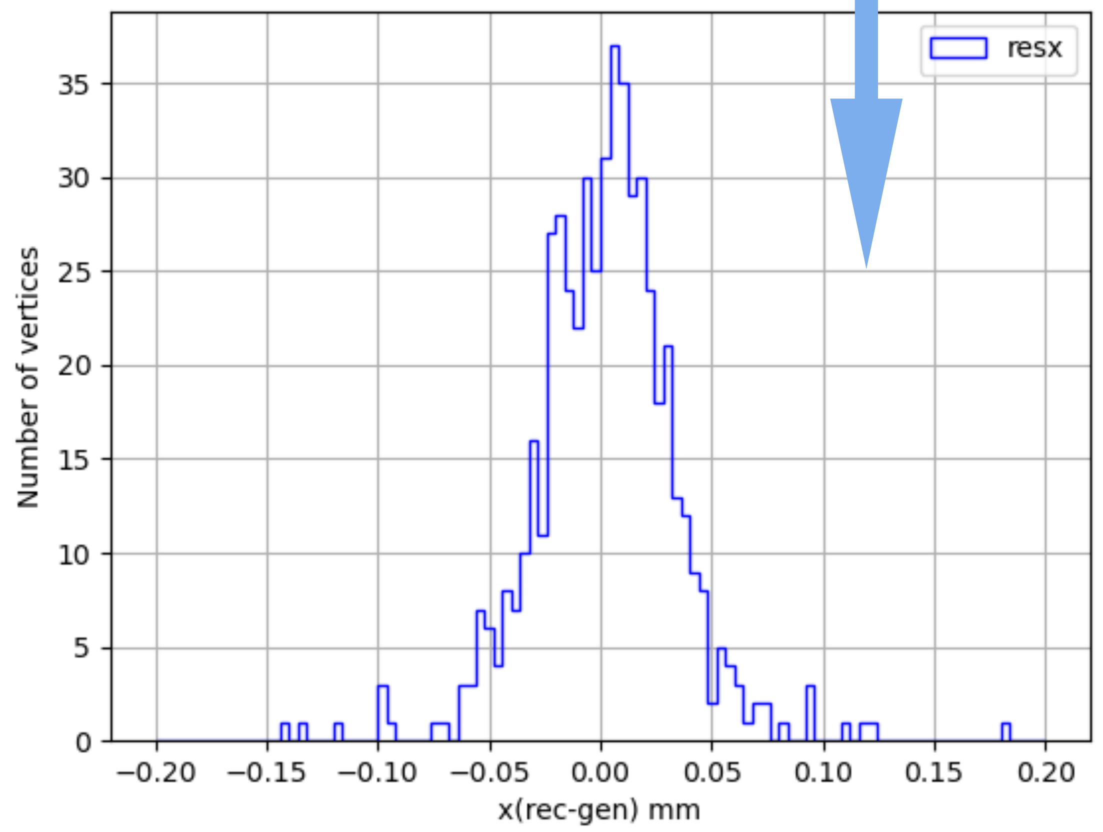
Precision of secondary-vertex

- Remaining question about SV precision
  - With $K_s^0 \to \pi^+\pi^-$ events, SV precision is worse by one order of magnitude compared to the primary vertex, and pull distribution has long tails
  - The long tails are due to the missing first hit

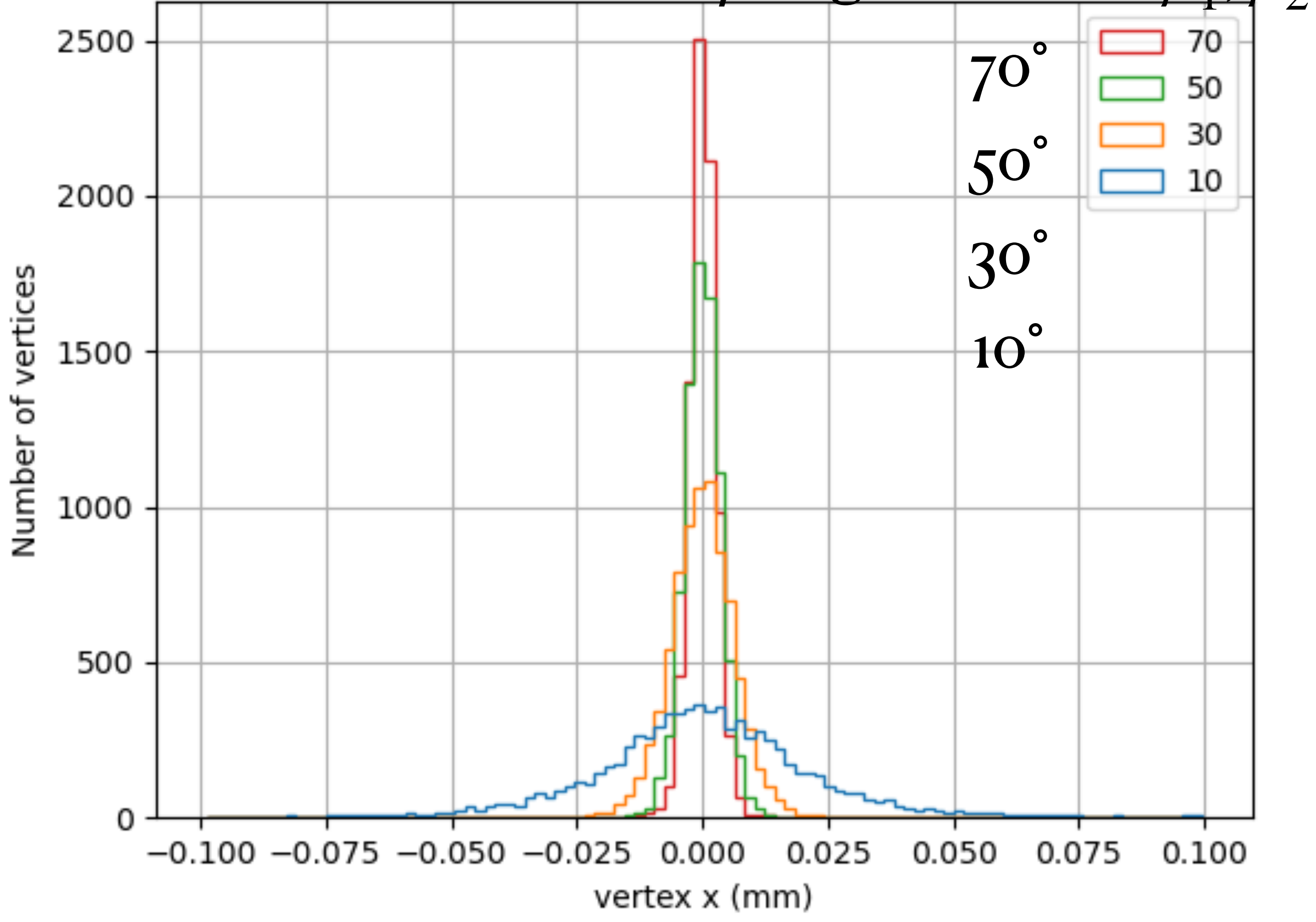
Particle -gun K_s^0 from (0,0,0),
momenta = 2.5GeV, $\theta = 85^\circ, \phi = 0^\circ$



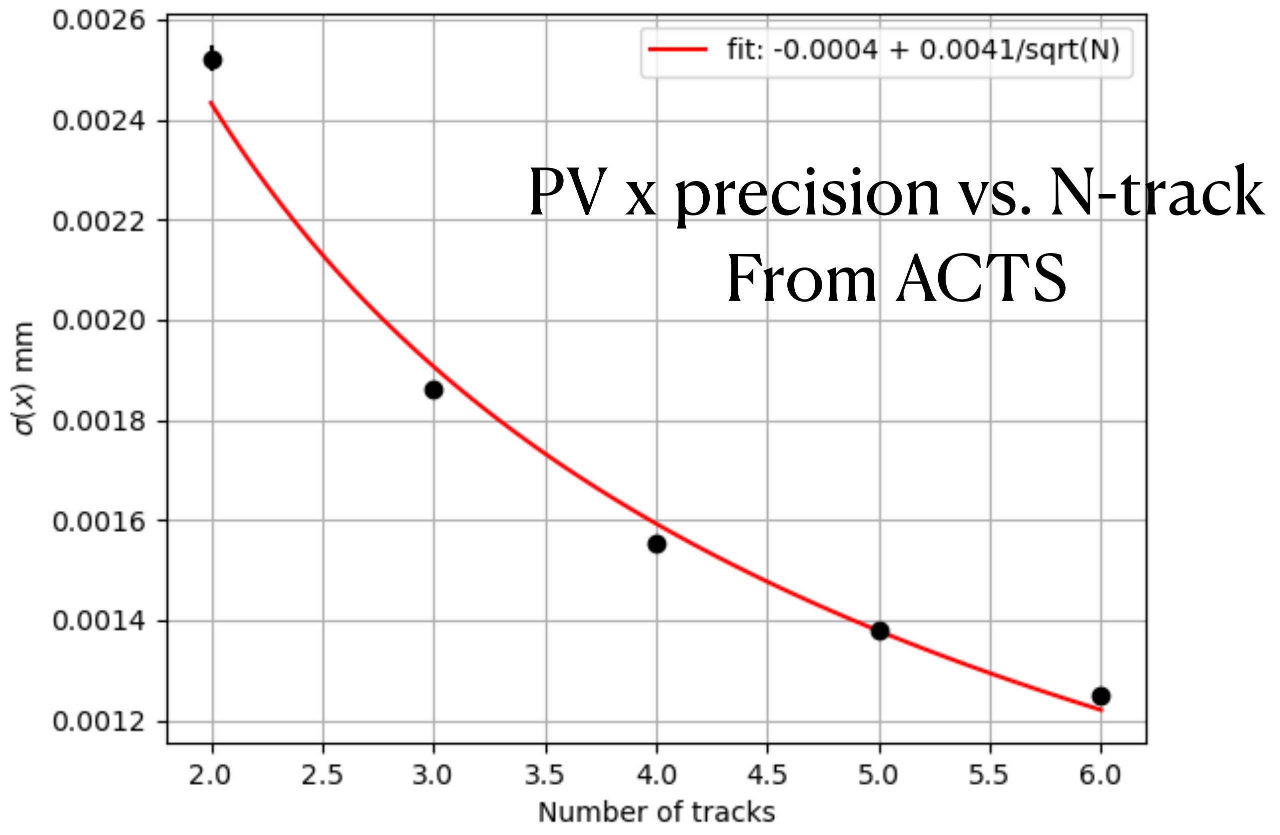
Ask SV transverse position
R<15mm (inside VXD-L2)

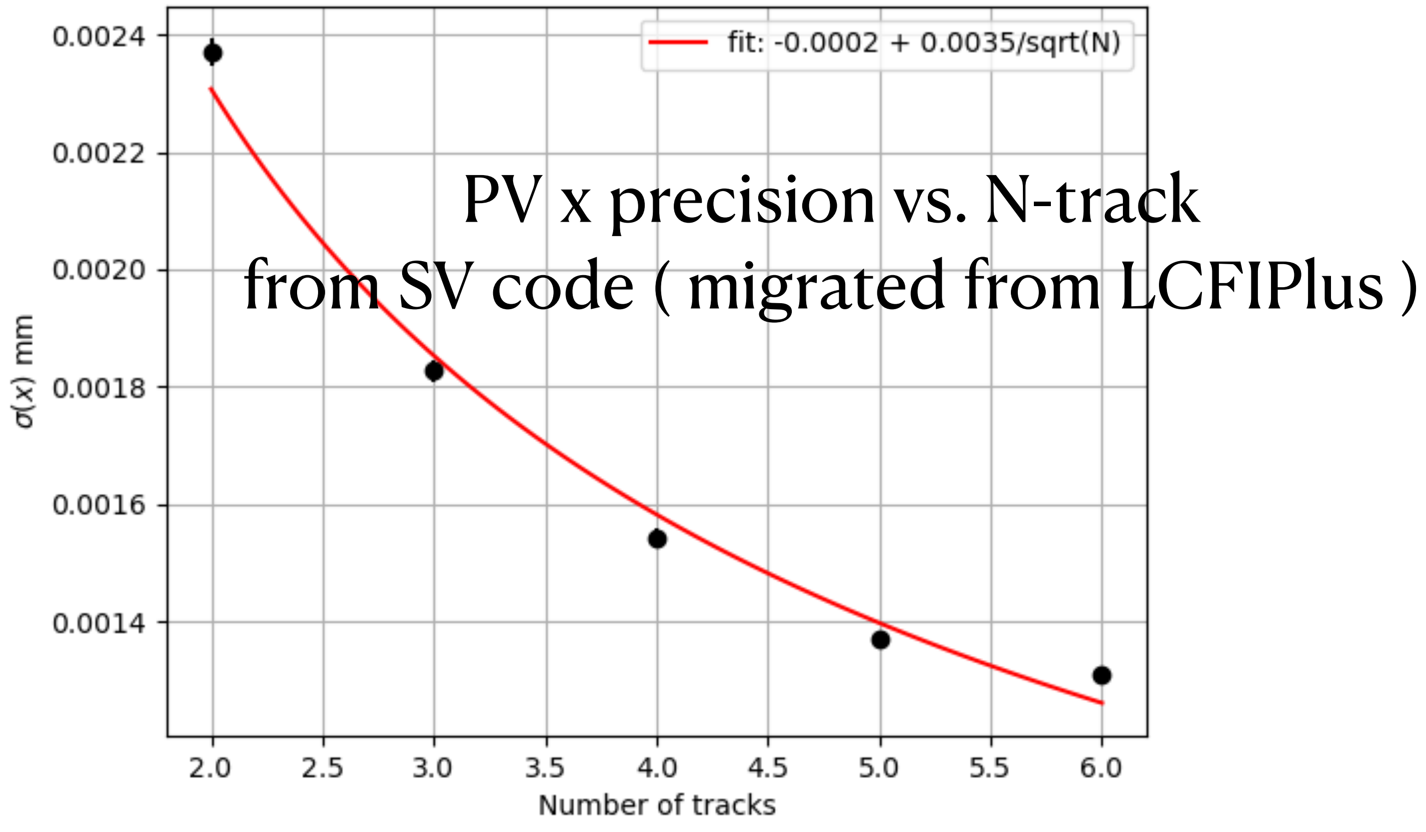


- After removing the first missing hit issue, SV precision is still worse than the primary vertex
  - Precision vs. angle between tracks
  - In the PV study, particle-gun phi direction was separated evenly, $\phi = 0^\circ \sim 60^\circ \sim 120^\circ \sim 180^\circ \sim \ldots\ldots$
  - Particle-gun muon pair
    - $\mu_1 : \theta = 85^\circ, \phi = 0^\circ \sim 10^\circ$
    - $\mu_2 : \theta = 85^\circ, \phi = i \times 10^\circ \sim (i+1) \times 10^\circ, i = 1,2,3,4\ldots$



- A cross-check between ACTS and the code used by SV was performed



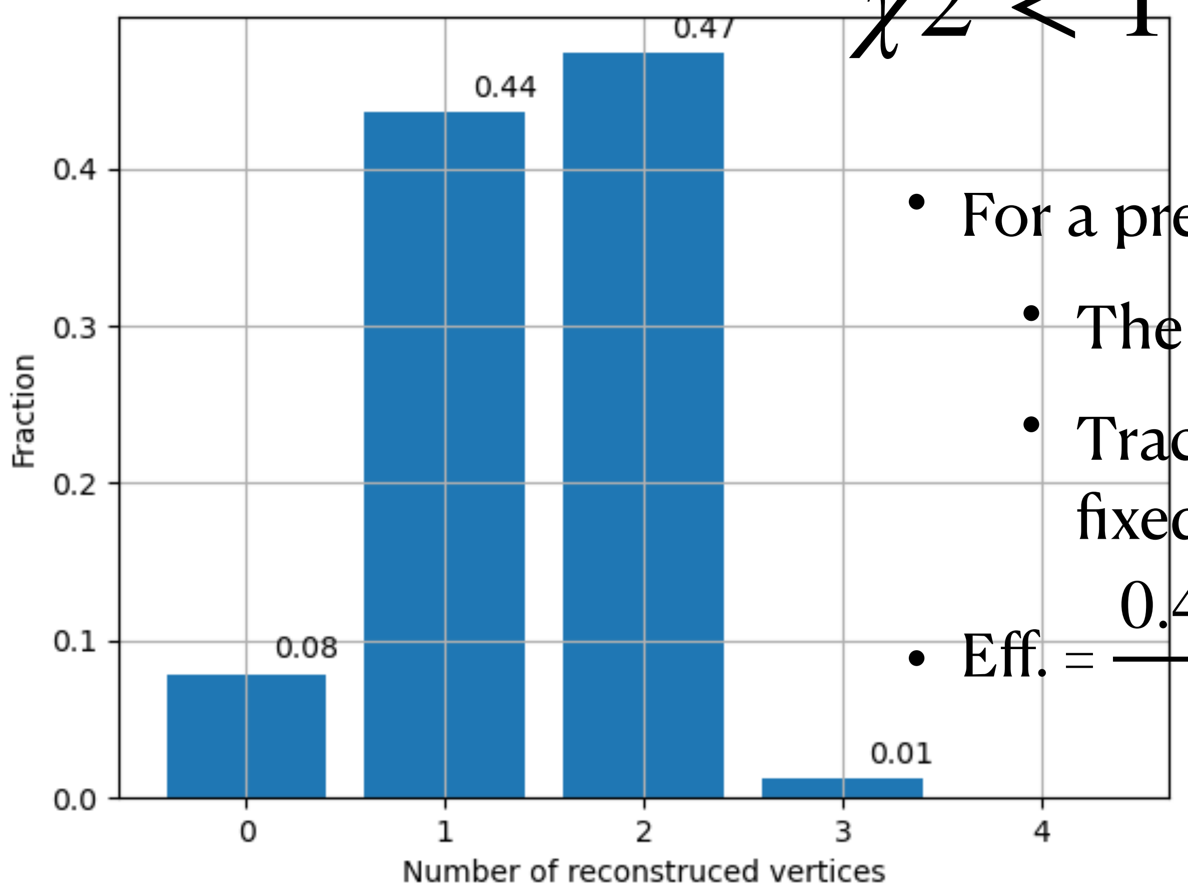


Summary & To do
- Study the missing first hit issue
- To understand how vertex precision changes with angles make plots for them
  - As already observed the precision of x, y and z is sensitive to ϕ, θ in different ways

SV inclusive reconstruction in jet

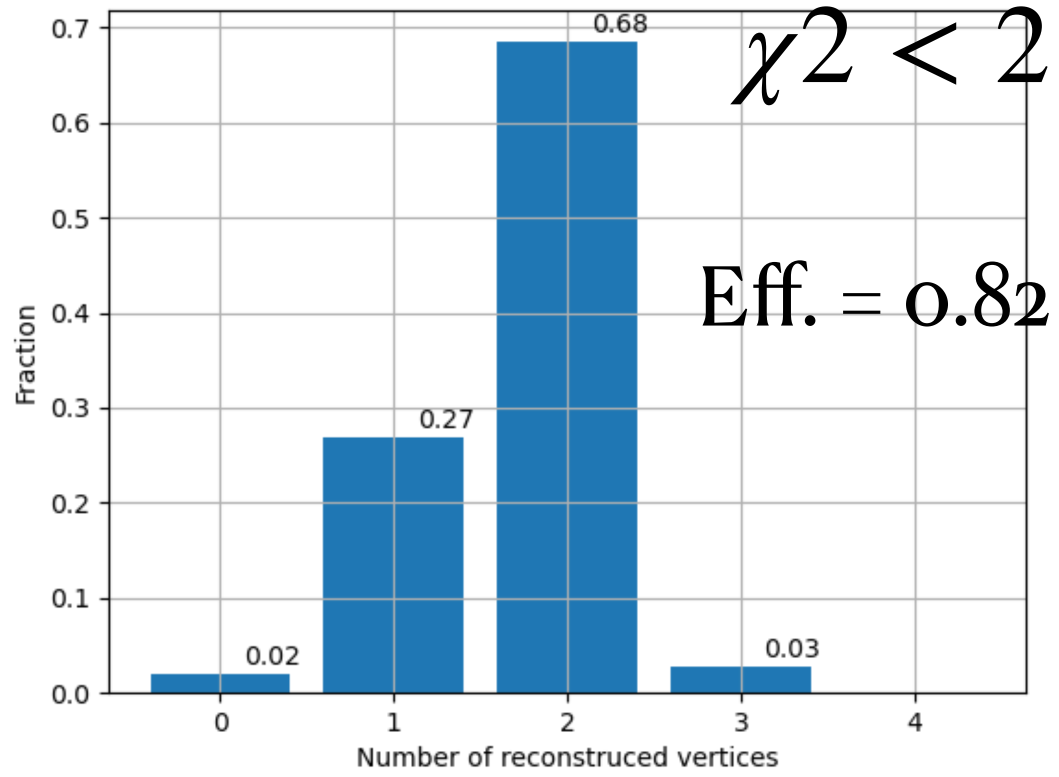
- No prior assumption about the vertex is available. The main focus is on identifying the tracks that originate from a vertex
- Particle-gun shoots a pair to the left from (0,0,0), and the other pair to the right from (0.3,0.2,0.2).
- Judge if a track should be associated with a vertex by applying a cut on $\chi 2 = \frac{\text{pca} - \text{vtx}}{\sigma(\text{pca} + \text{vtx})}$

$\chi 2 < 1$



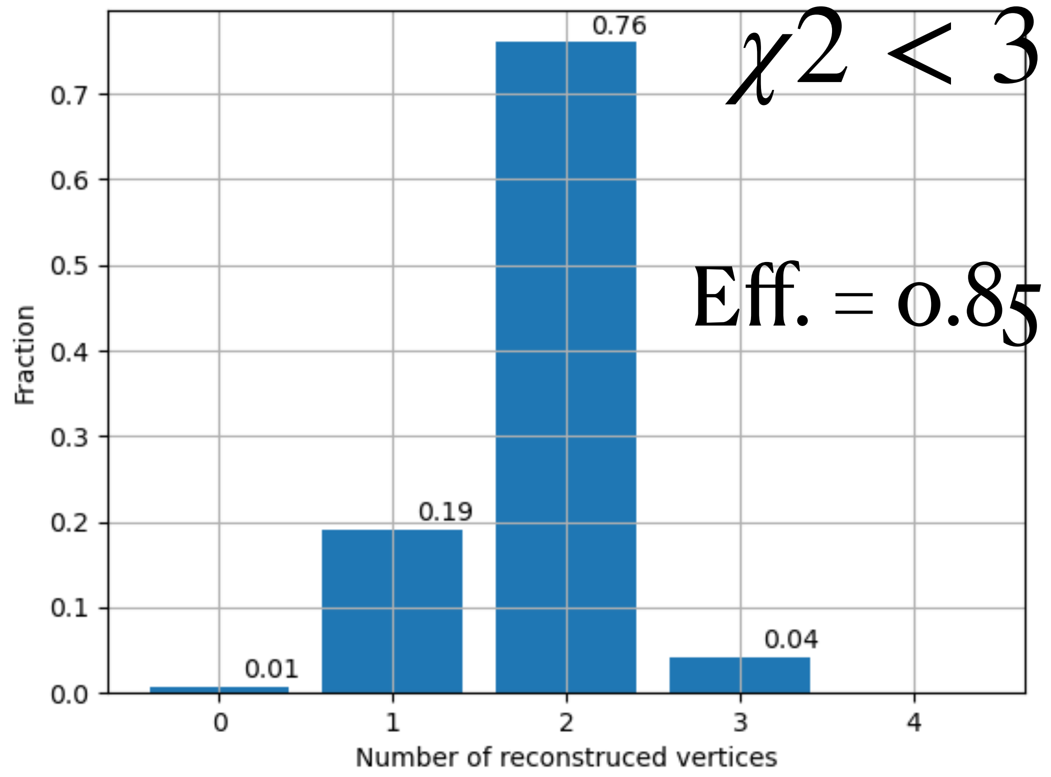
- For a preliminary understanding, lets ignore $N_{vtx} = 3$
  - The absolute size of with N=3 is small
  - Tracks are used more than once there, will be fixed soon
- Eff. $= \frac{0.44 + 2 \times 0.47}{2} = 0.61$

$\chi 2 < 2$



Eff. = 0.82

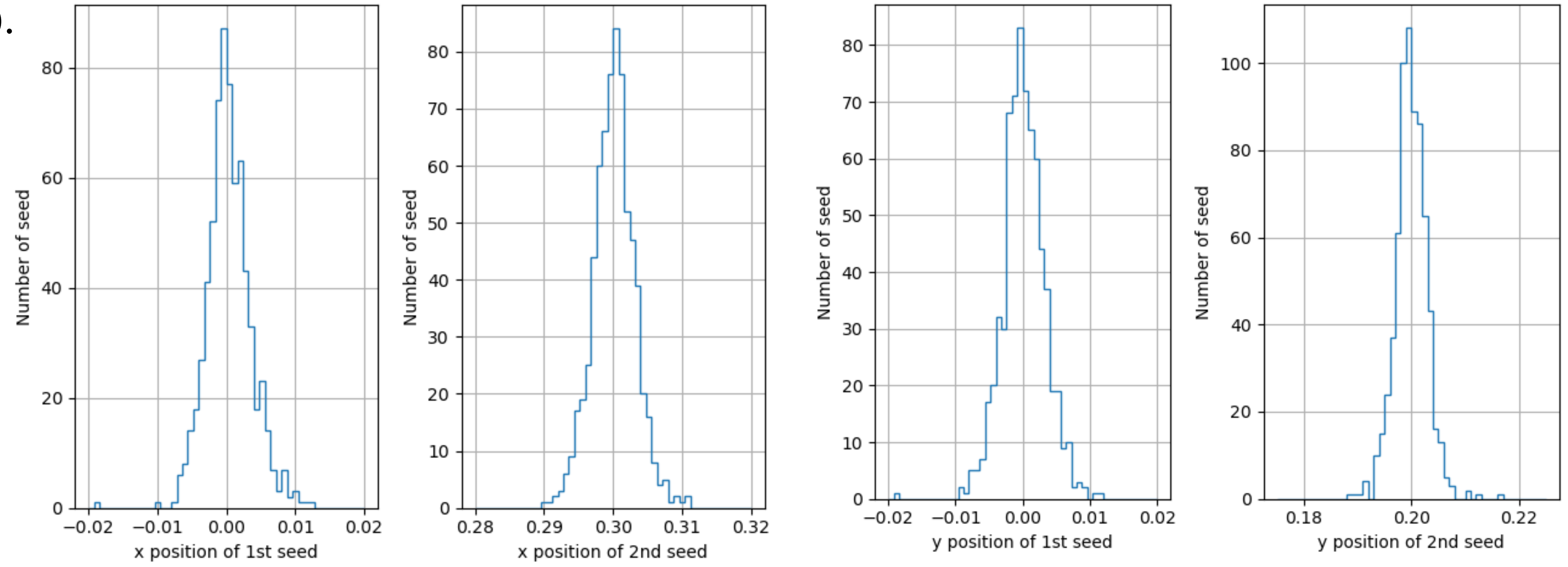
$\chi 2 < 3$



Eff. = 0.85

x positions of two vertices

y positions of two vertices



Summary & To do

- **Try to find tools that can be used directly**
- For $N_{vtx} = 3$, some reconstructed vertices are actually the same one, should be merged
- Evaluate fake vertex ratio and performance of track association
- Reduce the distance between two vertices by one order of magnitude, from 300 um to 30 um
- Move to real jets, SV could be easy after jet clustering
  - Official jet object is not available

SV reconstruction in exclusive decay

- Tried to test the algorithm with particle gun $B^{+} \to \pi^{+}\pi^{0}\bar{D}^{0}$.

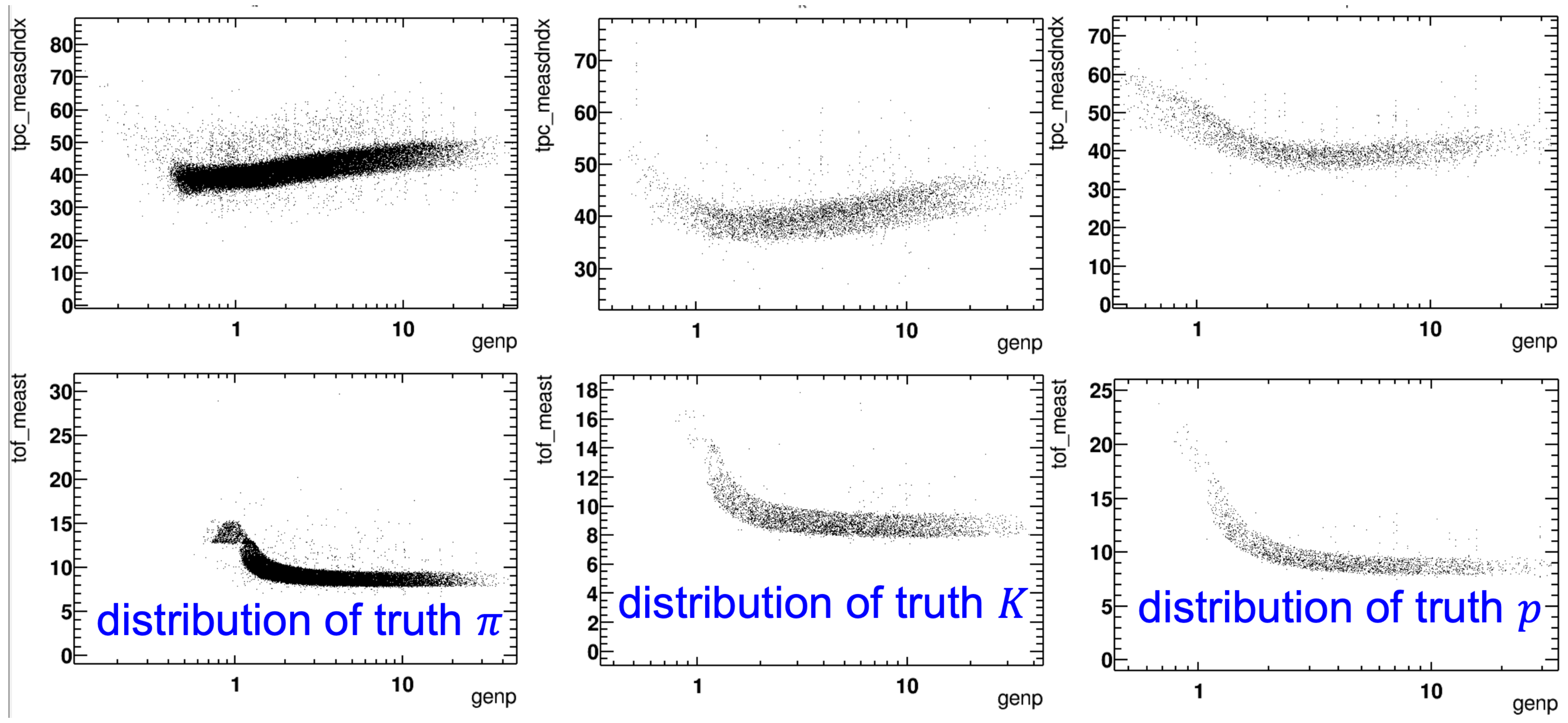
```
MCParticle      = (vector<edm4hep::MCParticleData>*)0x556f25201380
MCParticle.PDG  = 521, 211, 111, -421
MCParticle.generatorStatus = 1, 0, 0, 0
MCParticle.simulatorStatus = 201326593, 1073741824, 1073741824, 1073741824
MCParticle.charge = 0.000000, 1.000000, 0.000000, 0.000000
MCParticle.time = 0.000000, 0.000840, 0.000840, 0.000840
MCParticle.mass = 0, 139.57, 134.977, 1864.84
MCParticle.vertex.x = 0, -0.0212692, -0.0212692, -0.0212692
MCParticle.vertex.y = 0, -0.199971, -0.199971, -0.199971
MCParticle.vertex.z = 0, 0.0455068, 0.0455068, 0.0455068
MCParticle.endpoint.x = -0.0212692, -1389.7, -0.02124, -0.0738265
MCParticle.endpoint.y = -0.199971, -1304.02, -0.199992, -0.586076
MCParticle.endpoint.z = 0.0455068, 2263.07, 0.0455278, -0.0177253
MCParticle.momentum.x = -0.776017, -0.609544, 0.535444, -0.702096
MCParticle.momentum.y = -7.296922, -1.755202, -0.383862, -5.157839
MCParticle.momentum.z = 1.660535, 2.120303, 0.384929, -0.844697
MCParticle.momentumAtEndpoint.x = -0.776197, -0.000000, 0.535444, -0.702096
MCParticle.momentumAtEndpoint.y = -7.296903, -0.000000, -0.383862, -5.157839
MCParticle.momentumAtEndpoint.z = 1.660535, 0.000000, 0.384929, -0.844697
```

- Current SW doesn't record truth information for tertiary decays when the generator is set to be particle-gun
- To do: Will develop a tool to extract interesting events from Zqq. Like a real flavour analysis

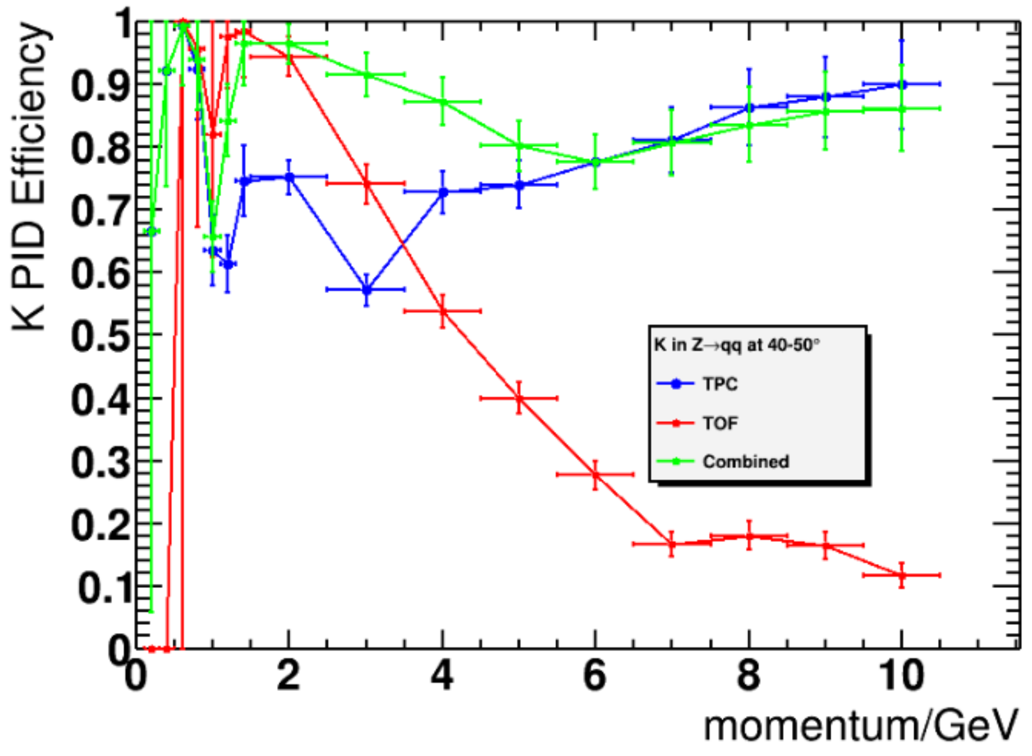
Hadron PID

Xiaotian Ma

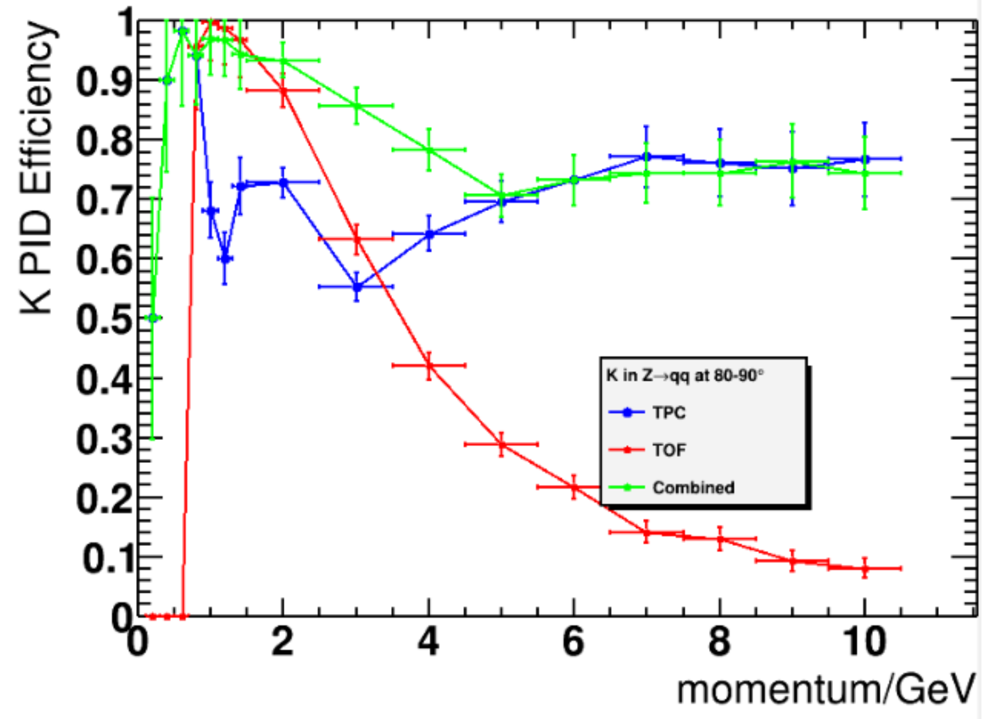
- Bug fix by Xiantian Ma for the code of ToF reconstruction
- PID performance between particle-gun and Zqq events is comparable
- To do
  - More concern for the low pT region
    - A strange behavior of ToF measurements has been observed in the low pT region
    - In high pT region combined PID is slightly worse than TPC only



PID efficiency comparison with ParticleGun

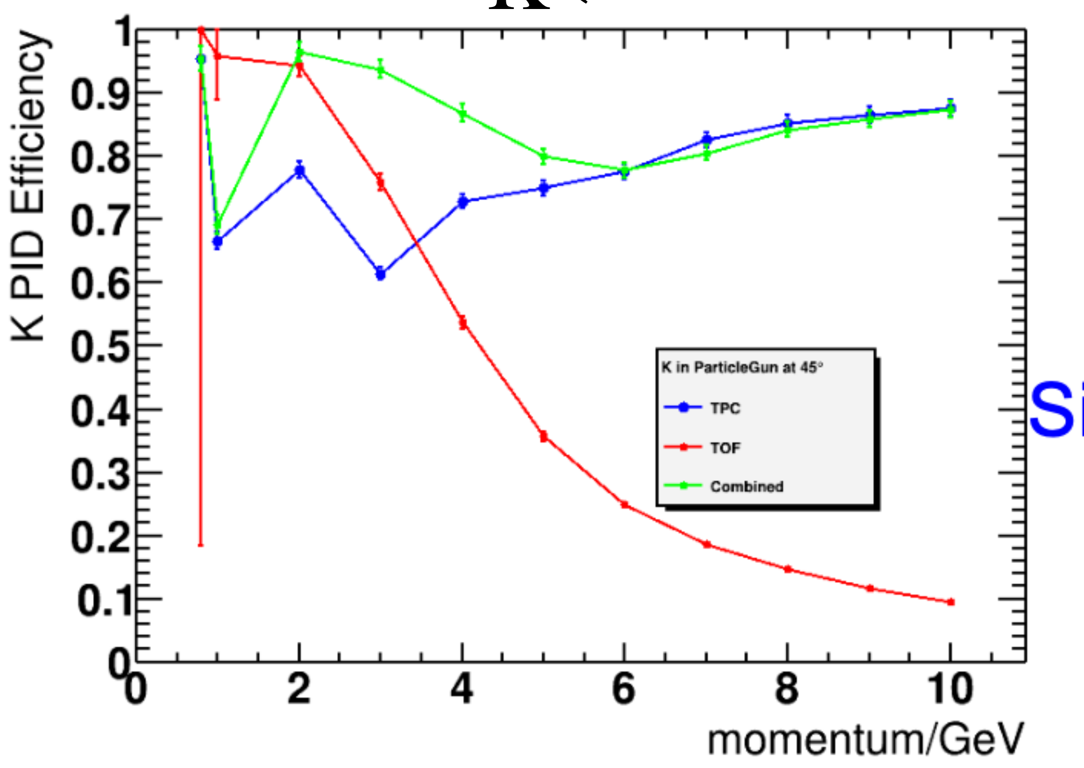


K in $Z \to qq$ efficiency
at 40-50 / 80-90 degree

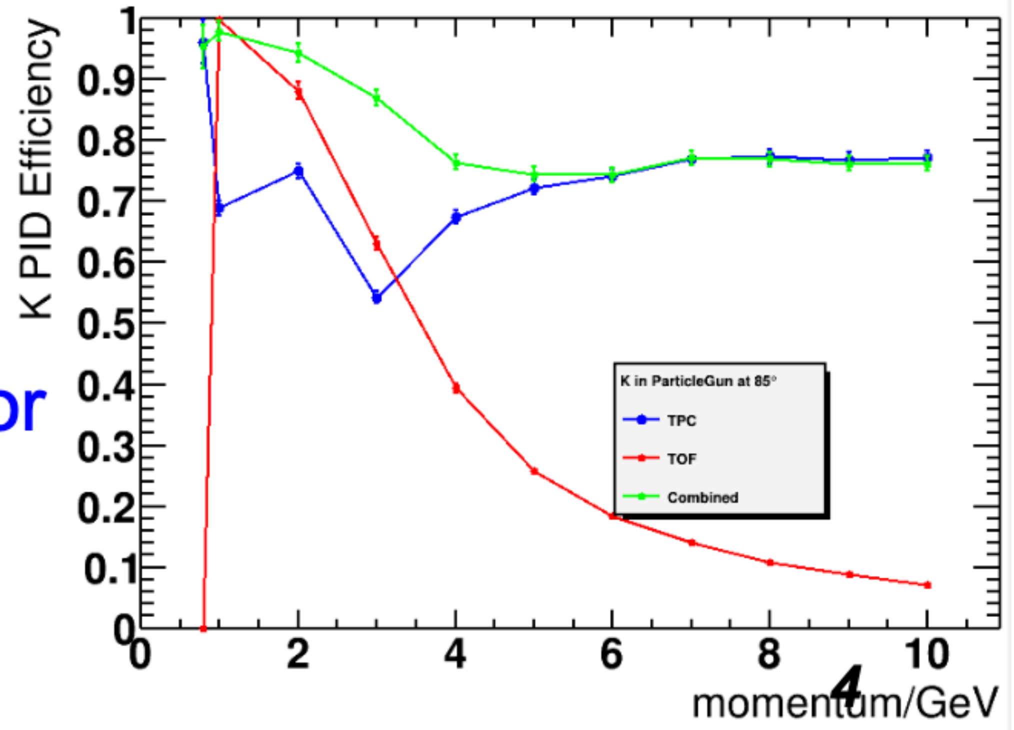


$$\varepsilon = \frac{N_K(\text{right ID})}{N_K(\text{has trk \& no decay})}$$

$$\text{has trk} = \text{ToF}||\text{TPC}$$



ParticleGun's K efficiency
at 45 / 85 degree
Single momentum with 0 error

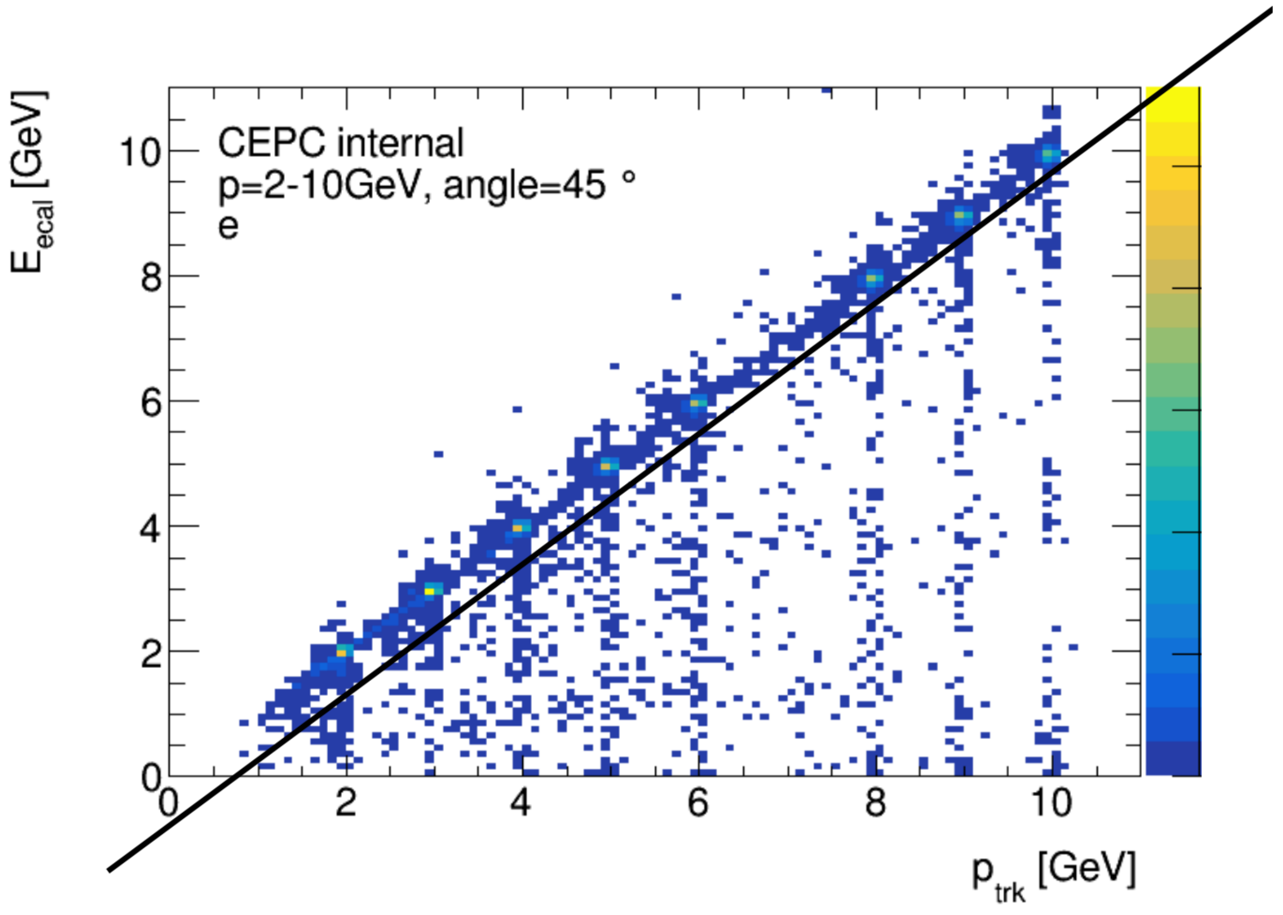


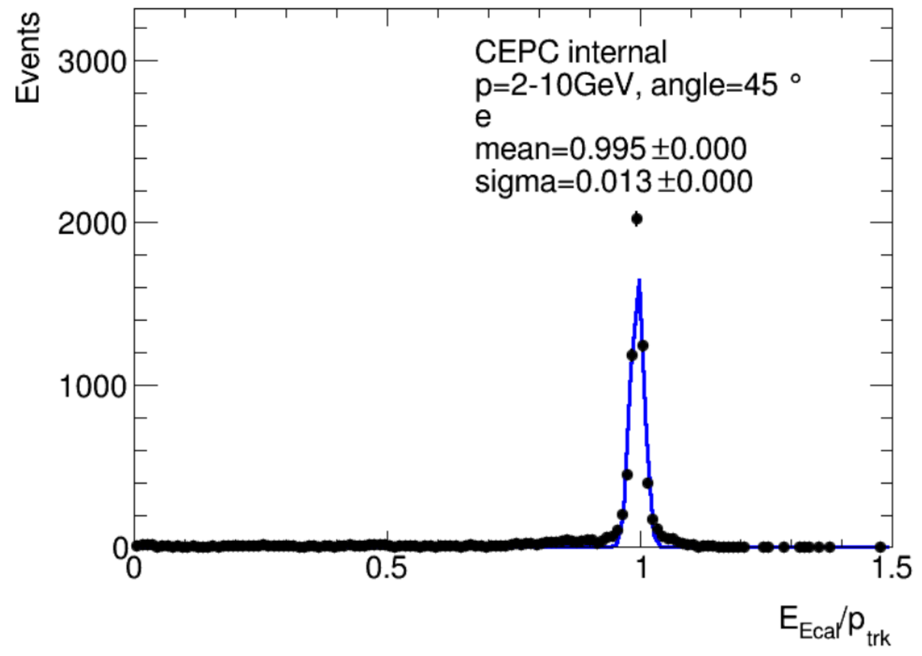
Lepton PID

Ligang Xia
(NJU)

- Identify electron using E_{ecal}/p_{trk}, muon using E_{Ecal}/E_{Hcal}
- Preliminary results look fine
- Todo
  - Some technique issues about truth-matching need to be understood
  - Discuss interface connecting this calorimeter PID with TPC+TOF PID

Electron Identification





Proposed Electron ID working point:
- definition: E(ecal)/p(trk) > 0.9
- efficiency: 81.8% at 2GeV and 82.7% at 10 GeV

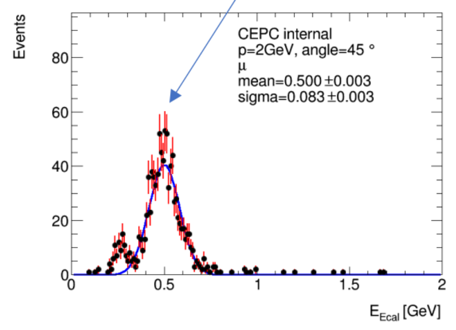
7

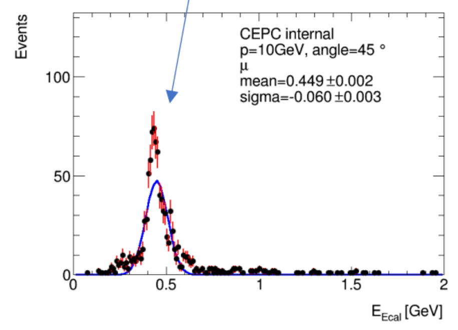
Muon Identification

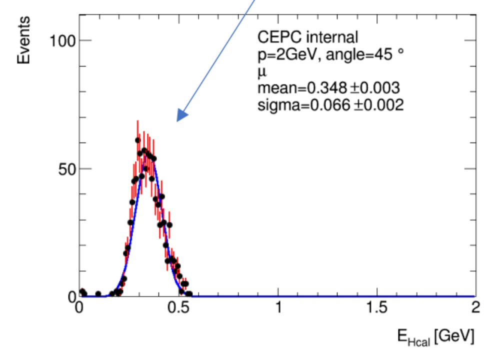
Proposed muon ID working point:
- definition: chi2_Ecal <3 and chi2_Hcal < 3 (~3sigma region)
- efficiency (2GeV): 74% (81% and 91% respectively)
- efficiency (10GeV): 57% (73% and 79% respectively)

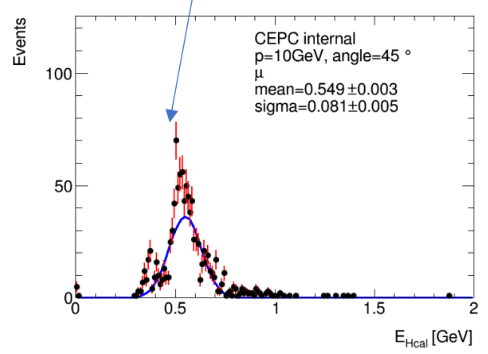
$$\chi^2_{Ecal}(2GeV) = \left(\frac{E_{Ecal} - 0.50}{0.083}\right)^2$$

$$\chi^2_{Hcal}(2GeV) = \left(\frac{E_{Hcal} - 0.348}{0.066}\right)^2$$









10