dE/dx study for new ILD detector models

Masakazu Kurata

09/09/2017

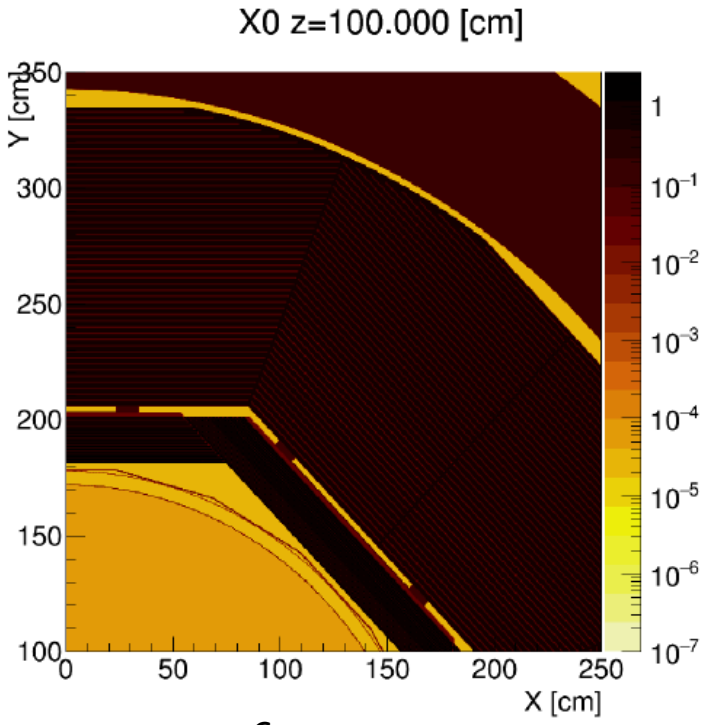
Introduction

- ILD collaboration starts “Re” optimization for new detector models
- There are 2 models for detector optimization
- For mass production, we need to check and re-tune any kinds of detector components
- dE/dx is one of them , which leads to particle Identification
- This is the first round for optimization

2 detector models

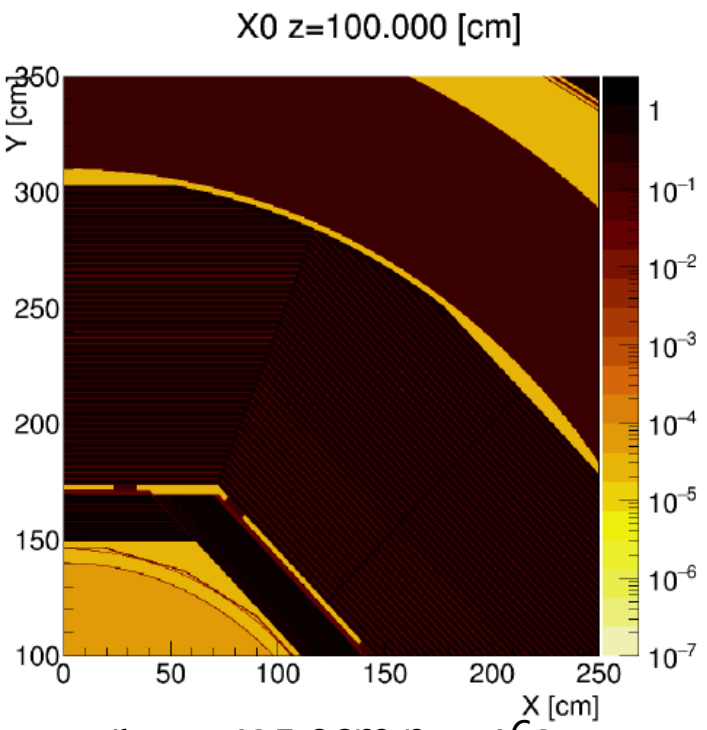
D.Jeans@AWLC2017

large
ILD_l4_v02



r_{TPC}~169.2cm, n_{hit}=220

small
ILD_s4_v02



r_{TPC}~135.0cm n_{hit}=163

thicker ECAL, reduced TPC, at different radii

DBD(01_v05): r_{tpc} =171.6cm, n_{hit}=222

Current status

- Use test samples
  - Plus signed fundamental particles
  - e+, mu+, pi+, K+, p
  - Use mono-energy test samples
    - 1, 2, 5, 10, 20, 50 GeV particles(100GeV not used)
  - Use angle-uniform samples

dE/dx

- Already include in ilcsoft standard reconstruction
  - Cannot use when using present DST samples (DBD ver.)
    - Because no TPC hit information is included
    - Need calculation of dE/dx from simulated(sim or rec) samples
- $\frac{dE}{dx} = \frac{energy\ deposit}{flight\ path\ in\ the\ hit(TPC)}$
  - Fright path can be calculated using reconstructed trajectory
  - Track dE/dx is calculated using truncation method
    - Upper 30% and lower 8% are discarded

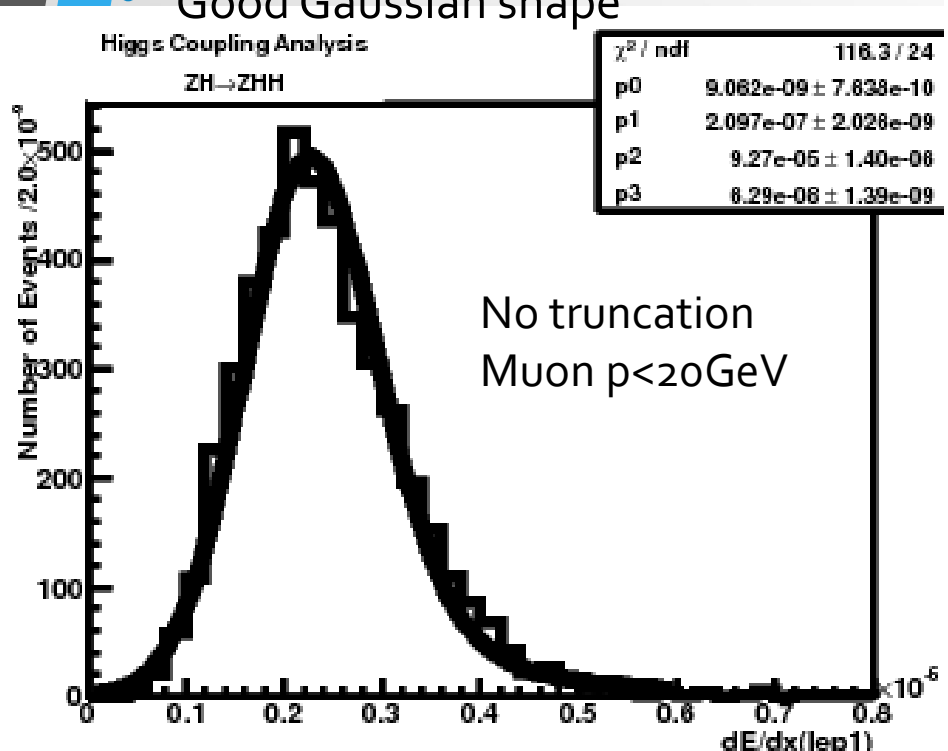
- dE/dx error
  - $\sigma\left(\frac{dE}{dx}\right) \propto l(m)^{-0.34} \cdot N^{-0.45}$

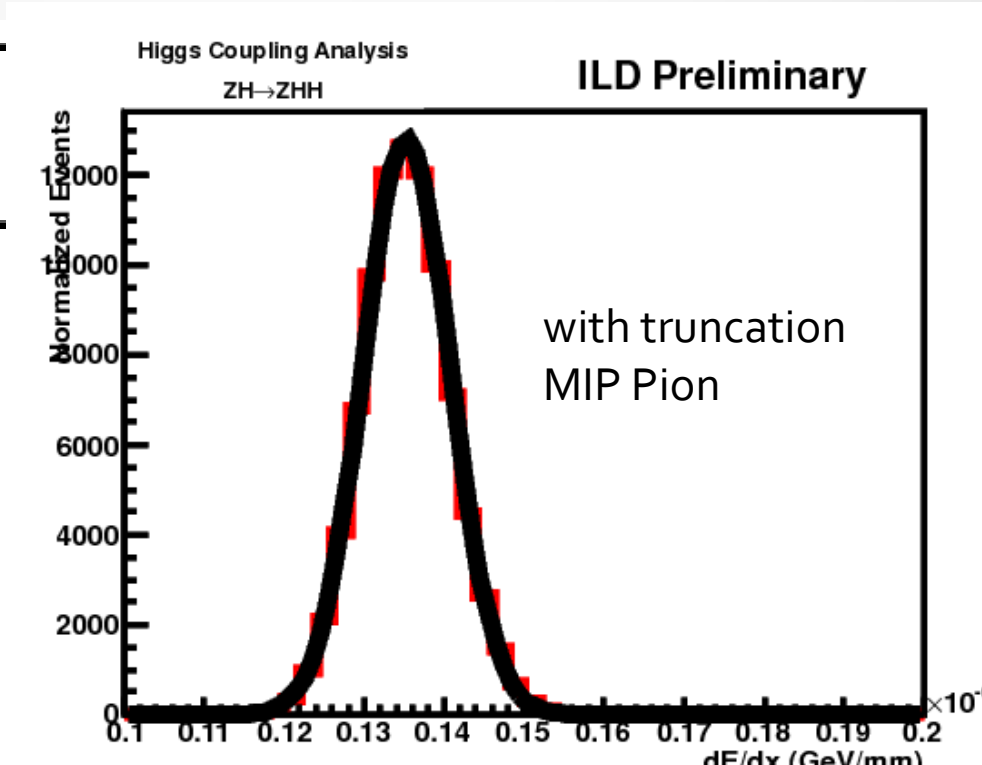
→ref. NIM. A379, Annika's slide, etc.

  - Coefficient: 5.70
    - Need more study
    - It is adjustable in steer file

Effect of Landau tail(01_v05)

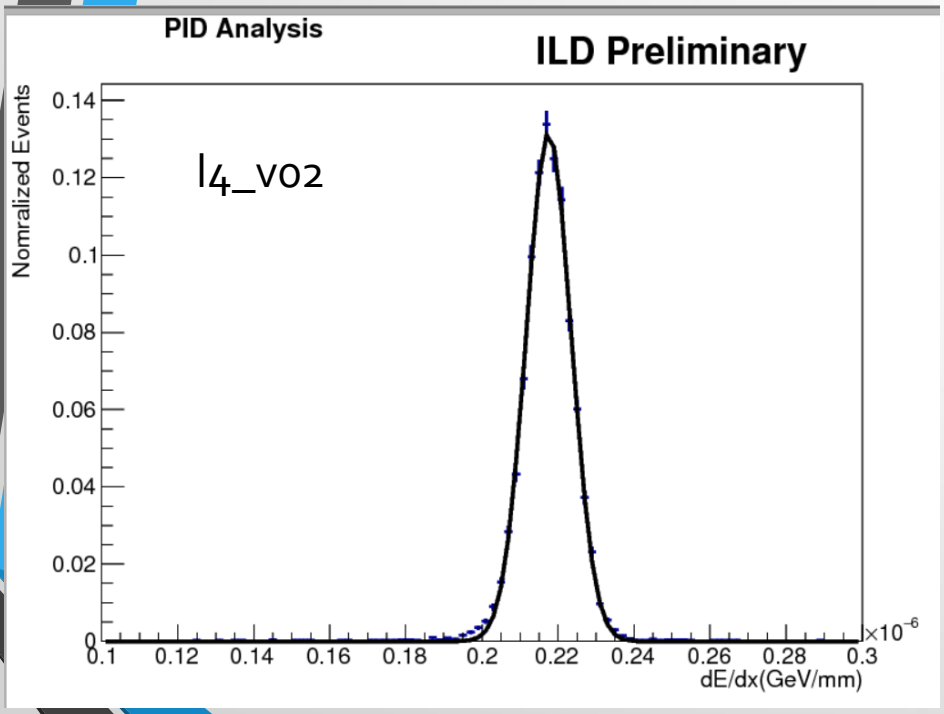
- Landau tail effect – muon tracks
  - dE/dx distribution of tracks
  - fitting - convolution of Gaussian and Landau
  - Tail can be seen in the case of no truncation
  - Agree with Astrid's study
- Truncated mean distribution – MIP pion(0.3GeV/c<p<0.6GeV/c)
  - Good Gaussian shape

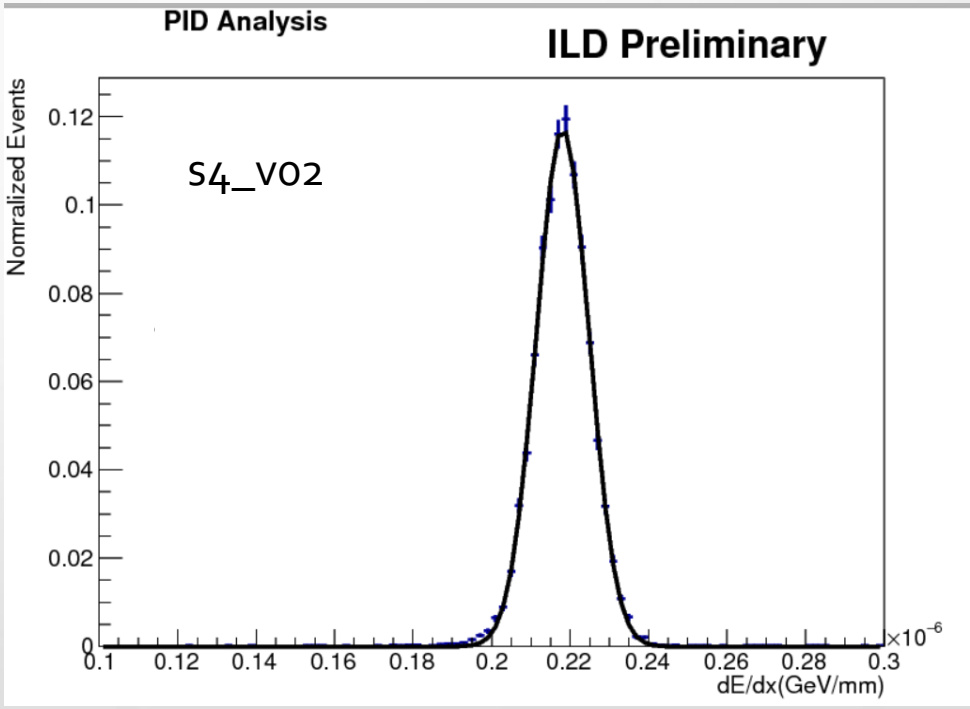




Truncation effect for new detector models

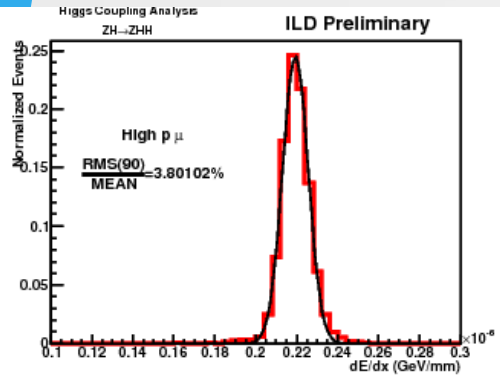
- Use e+ sample
- Both models keep good Gaussian shape
  - Truncation is reasonable

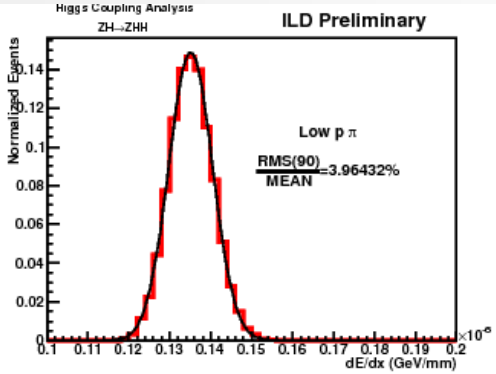


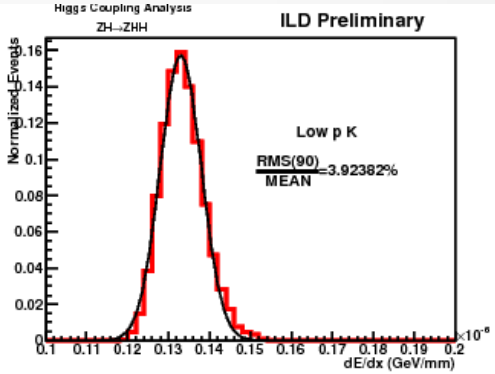


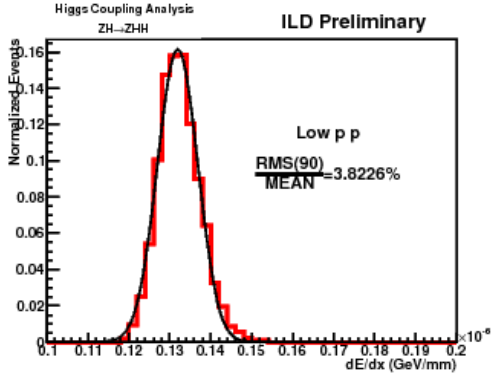
dE/dx fluctuation(01_v05)

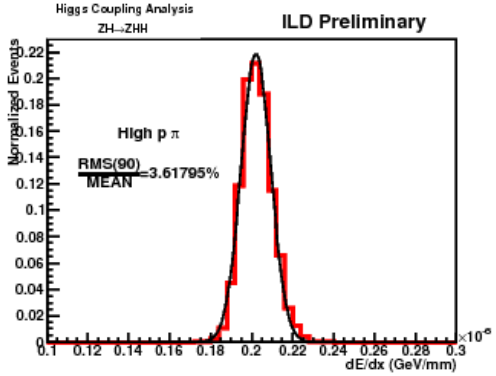
- Fluctuation of dE/dx using various type of tracks
  - Estimation from RMS(90)/MEAN

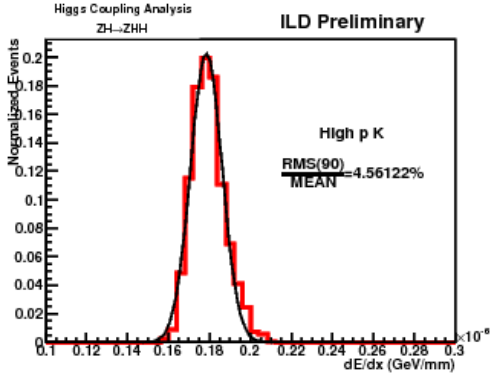


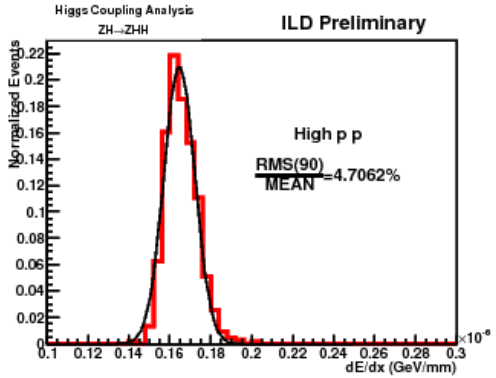












High: p >20GeV/c

Low: π 0.3GeV/c<p<0.6GeV/c

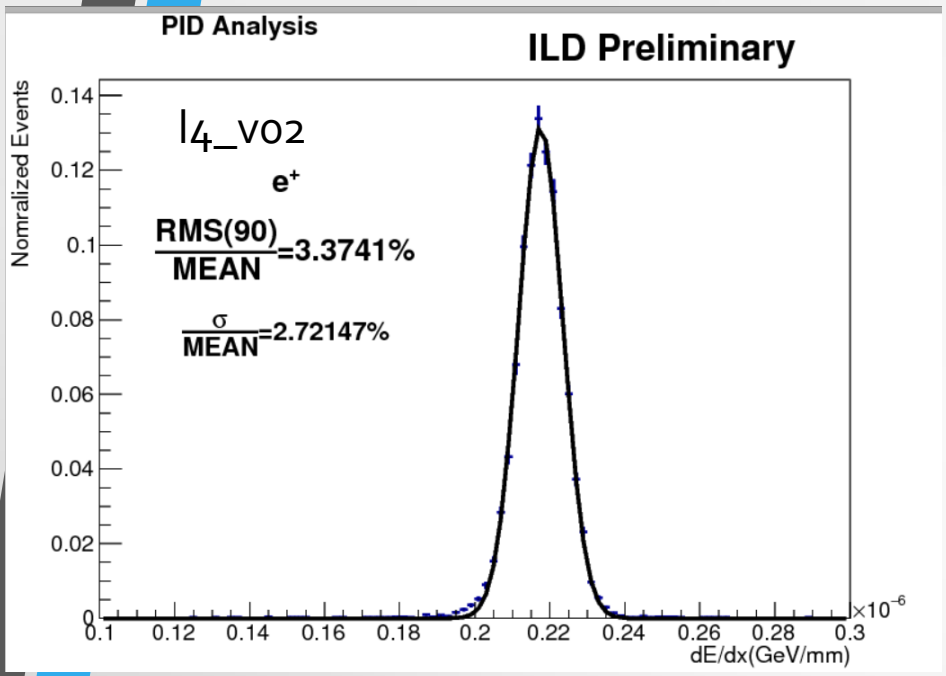
K 1.0GeV/c <p<3.0GeV/c

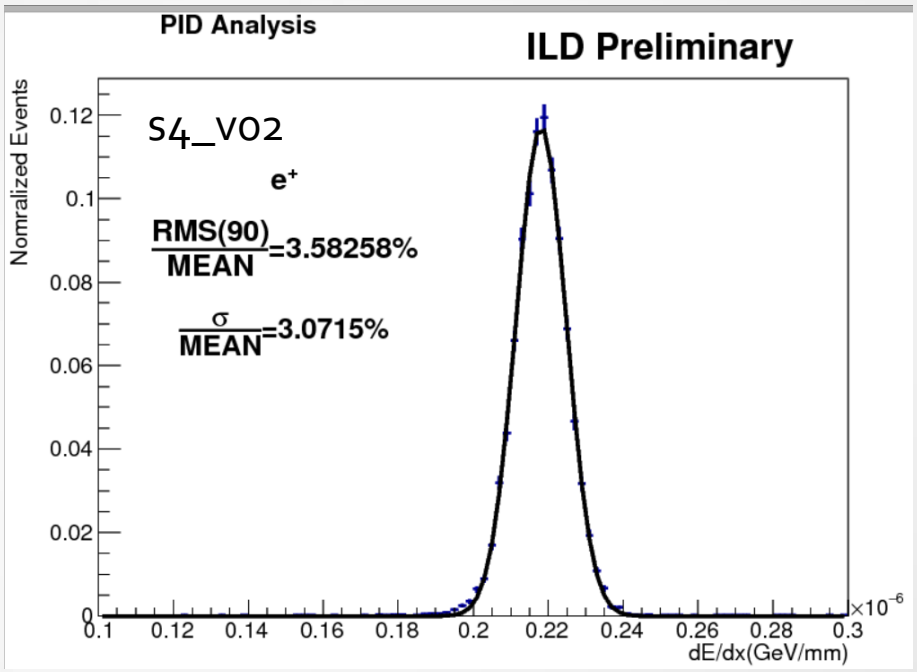
p 2.0GeV/c<p<4.0GeV/c

- Fluctuations of each particle/each momentum rage

3 – (<5)%!!

New detector models

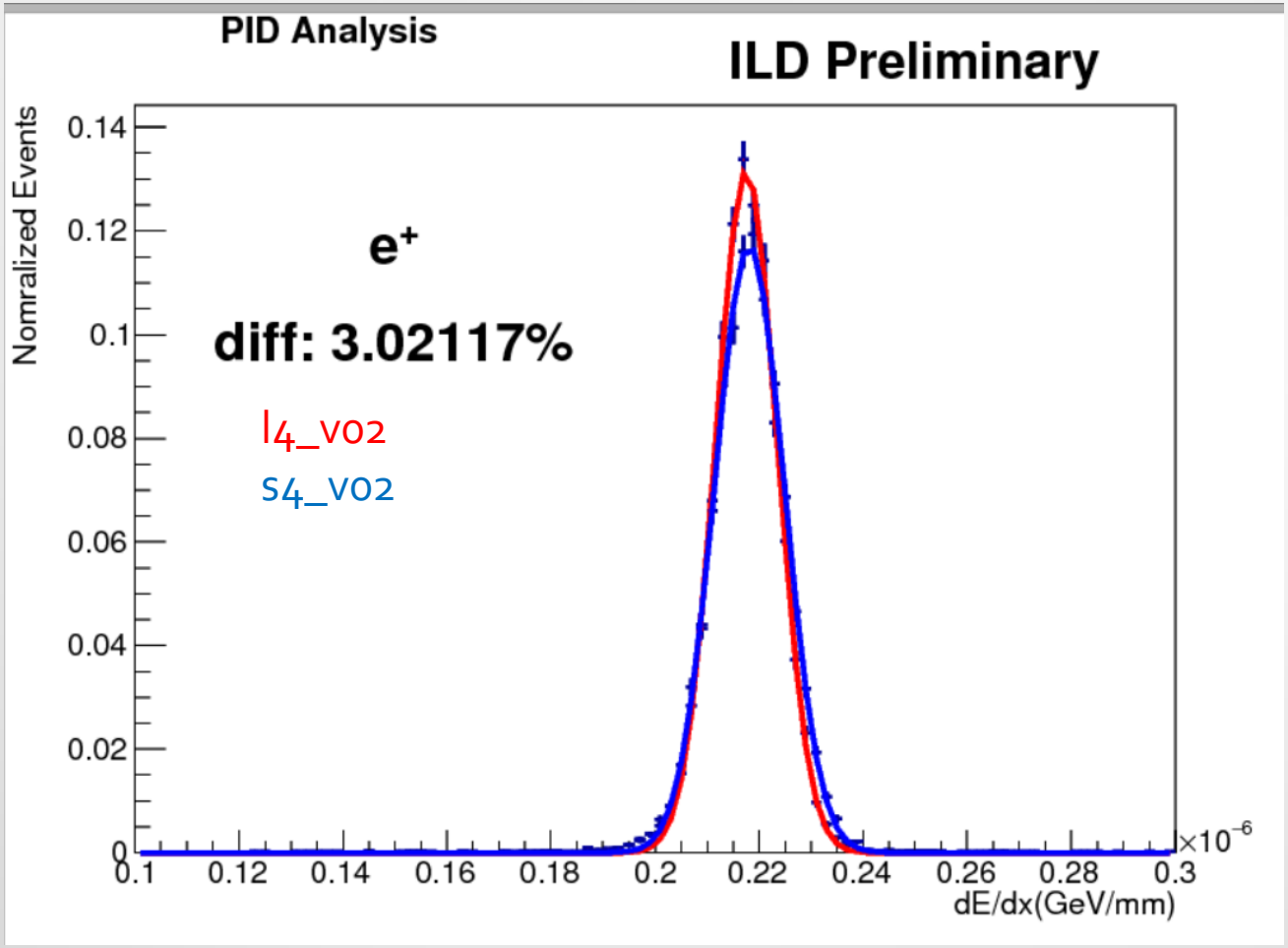




- Fluctuation difference(σ/MEAN): ~3%
  - Natural result
- Fluctuation too small?
  - Do not add any additional smearing now

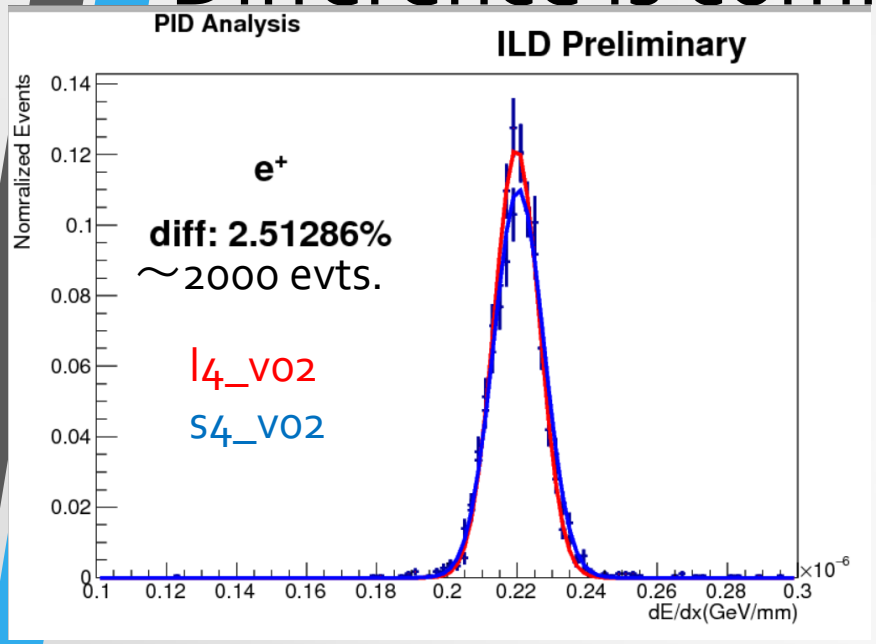
    e.g.) 4.61~4.70% fluctuation for Asian GEM electron beam test result
- Need to check using other MIP particles

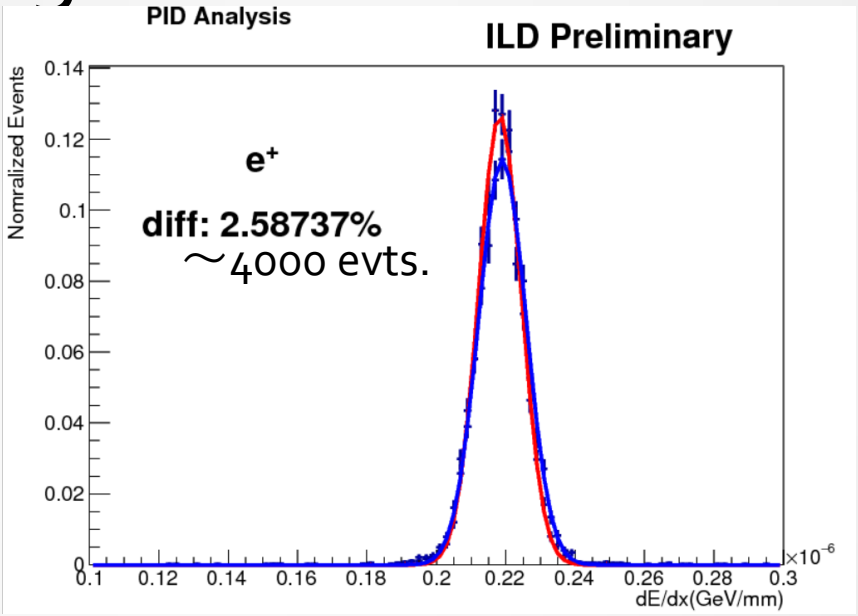
New detector models

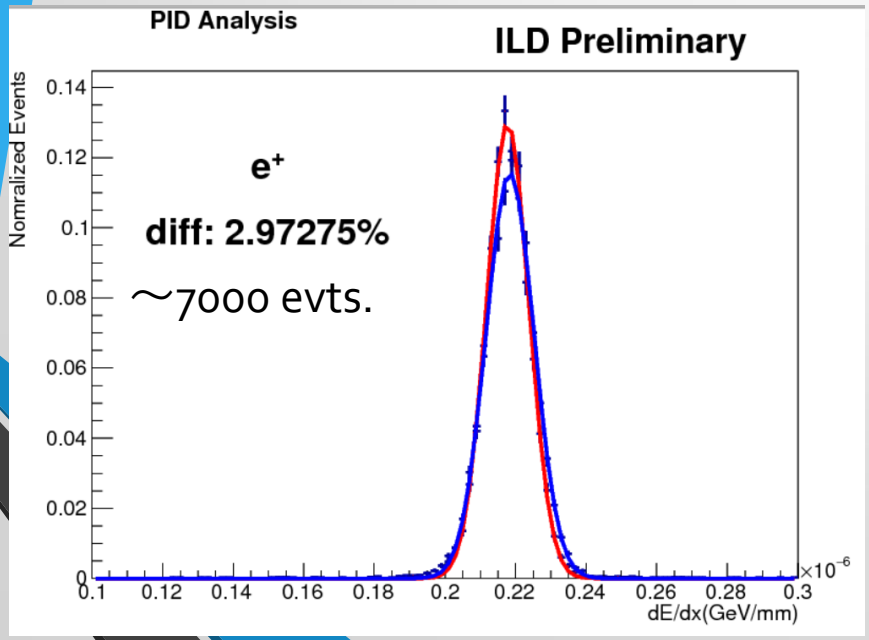


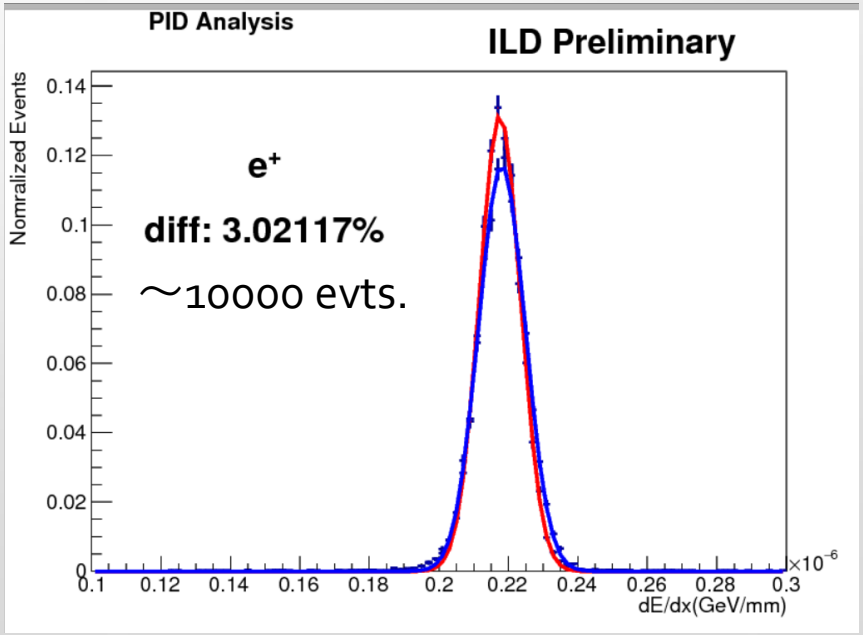
- Fluctuation difference(σ/MEAN): ~3%
  - Natural result

Difference is coming from statistics?







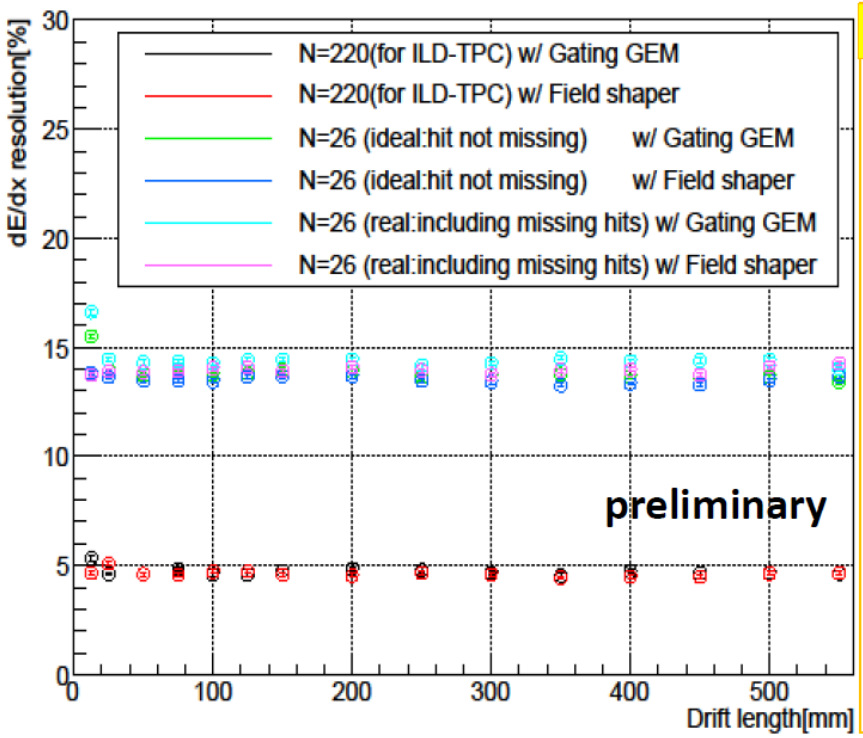


Impose additional smearing

- Impose Gaussian noise on energy deposit at each hit
- l4_v02: 4.60% s4_v02: ???(scaling is enough? 5.34%?)

dE/dx resolution (estimation for ILD-TPC)

13

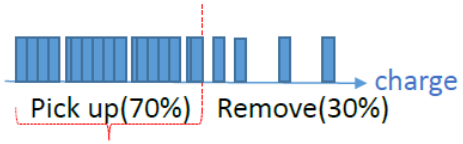


Truncated Mean Method

One event
(charge of 26 measurement points)

× about 8 ⇒ 220 points

Sort by size



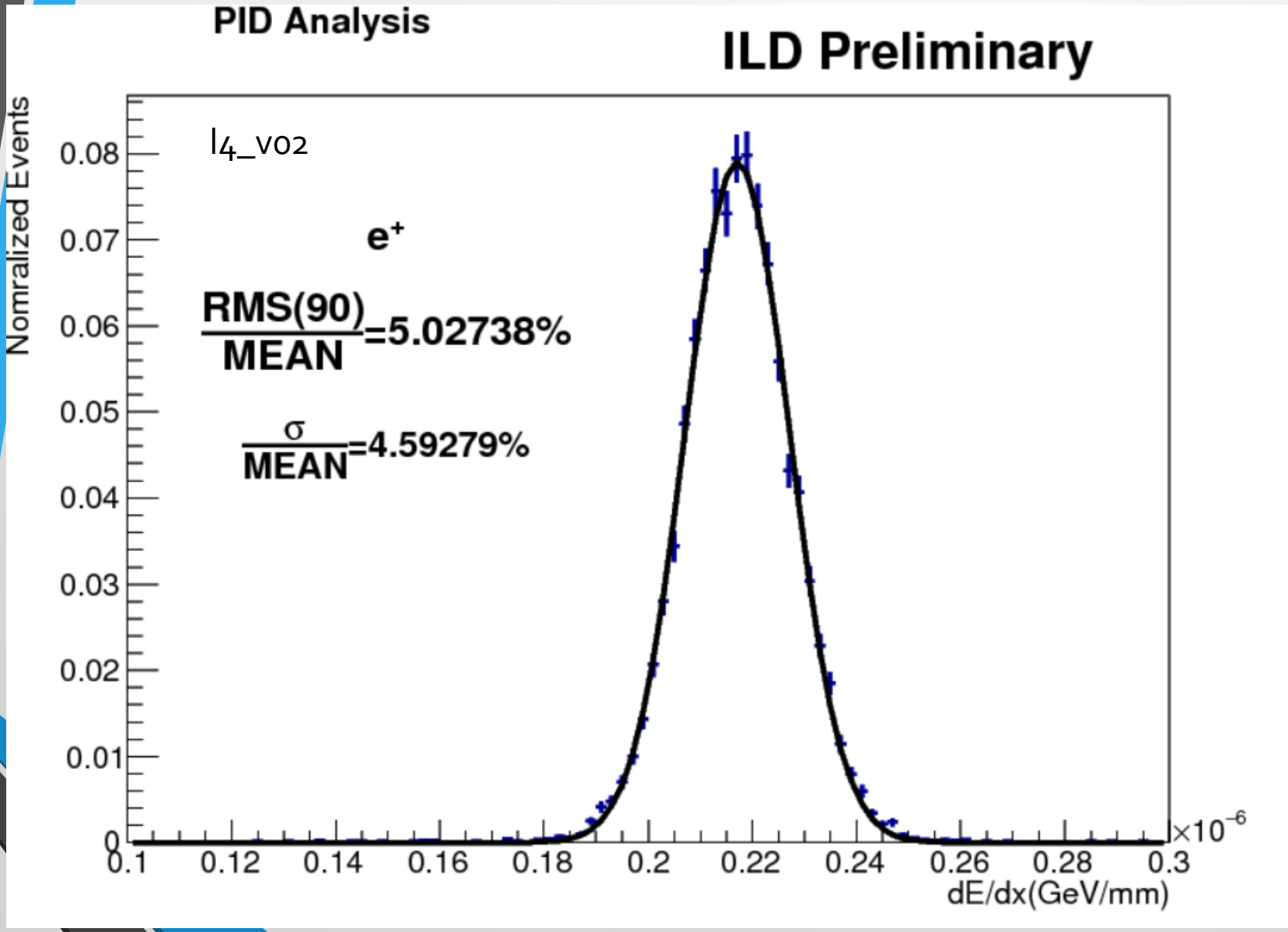
220 × 0.7 =154

Average

$$\bar{Q} = \frac{1}{154}\sum_{i=1}^{154} Qi$$ ···> Plots

- Average of dE/dx resolution with gating GEM is 4.70±0.02%
- Average of dE/dx resolution without gating GEM(with field shaper) is 4.61±0.02%

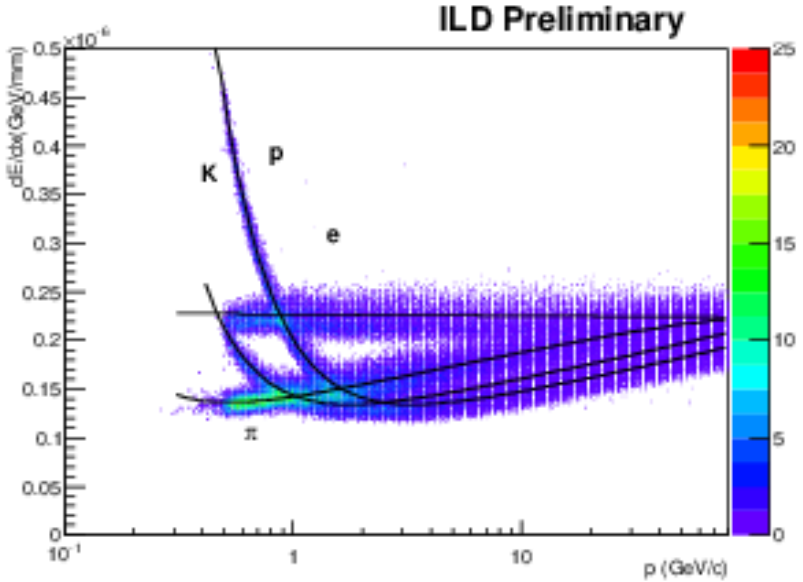
Additional smearing

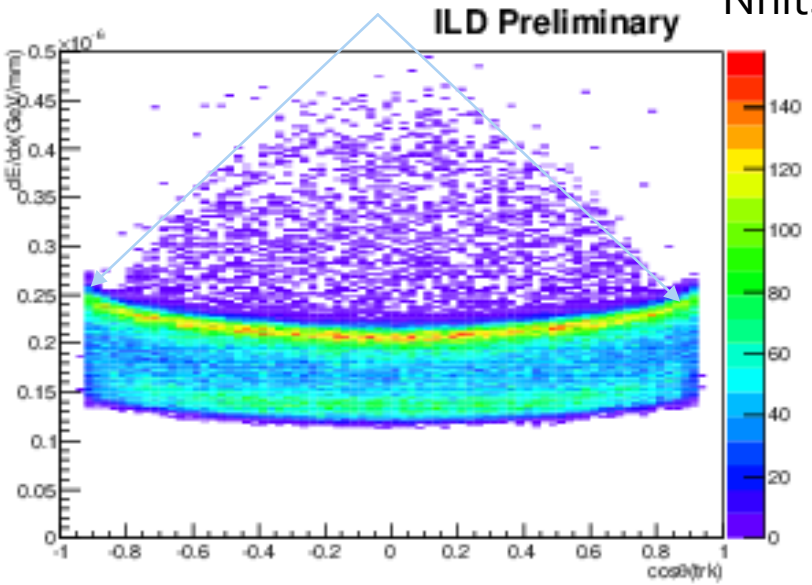


Angular dependence of dE/dx (01_v05)

- There is angular dependence of dE/dx value(before correction)

Nhit>40





- Include angular correction
  - Tried some functions for fitting
  - Best parameterization:

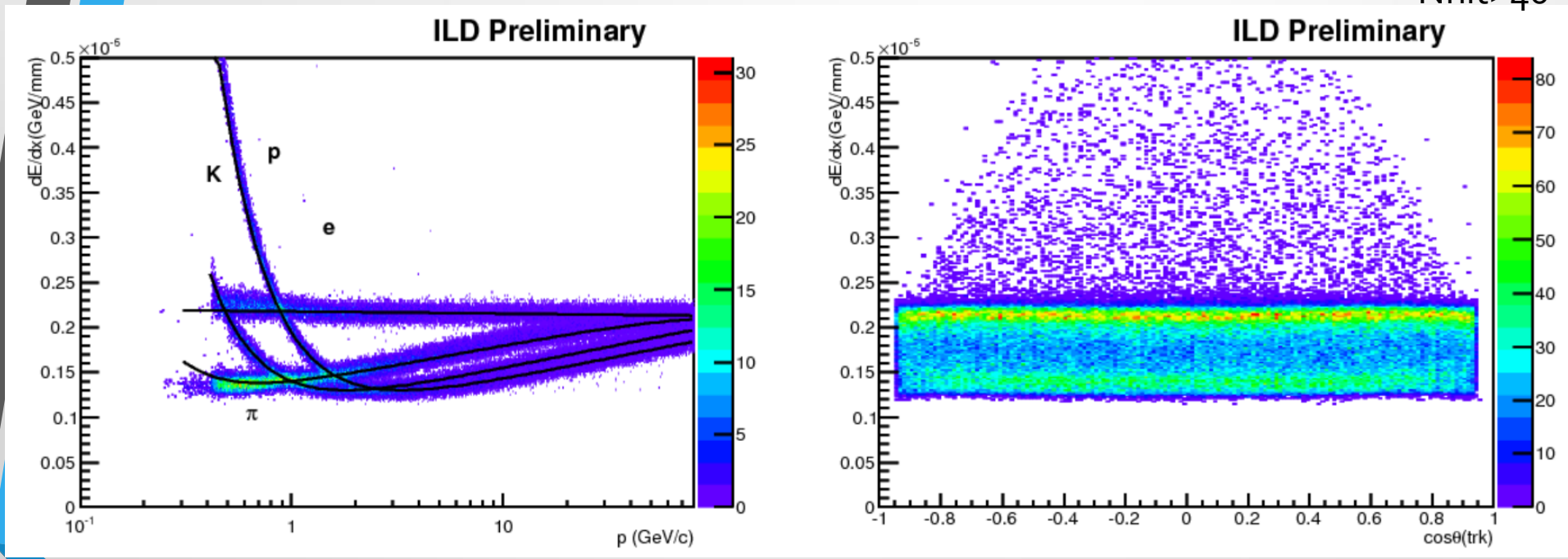
$$\frac{dE}{dx}_{corr} = \frac{dE}{dx} \cdot \min(\theta,\ \pi - \theta)^{0.07}$$

  - This parameterization is best especially very forward region

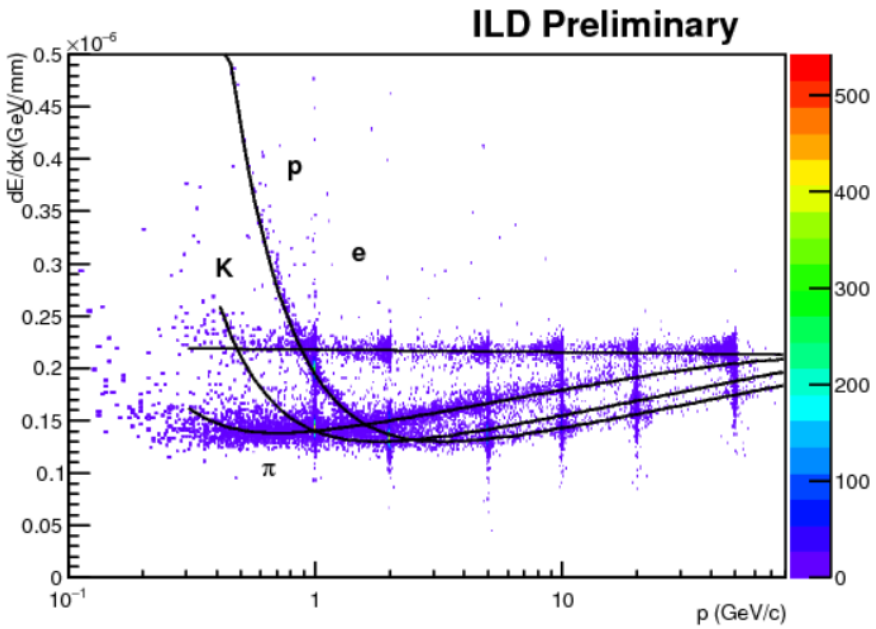
After correction (01_v05)

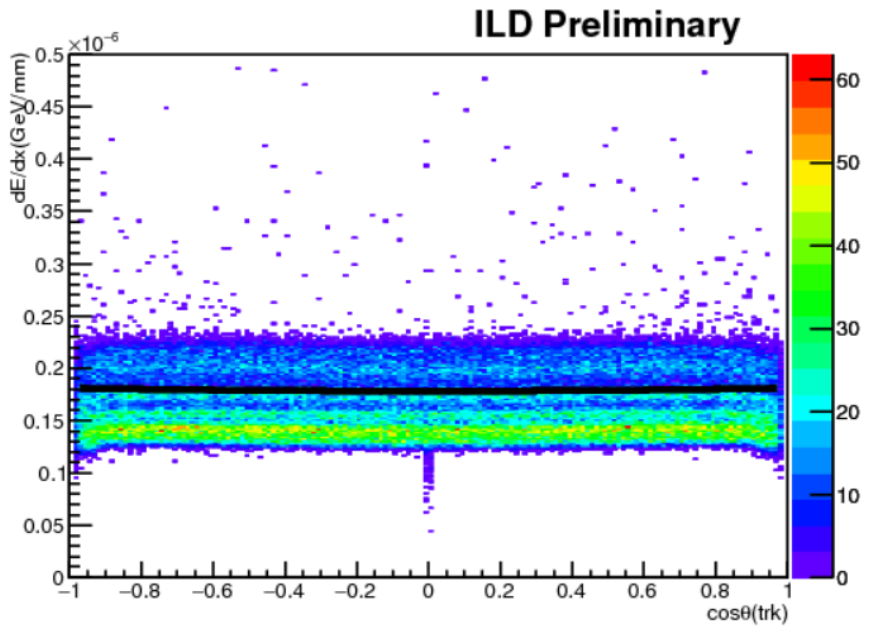
- Very good improvement of dE/dx distribution
  - Forward region very nice!

Nhit>40



New detector model(l4_v02)



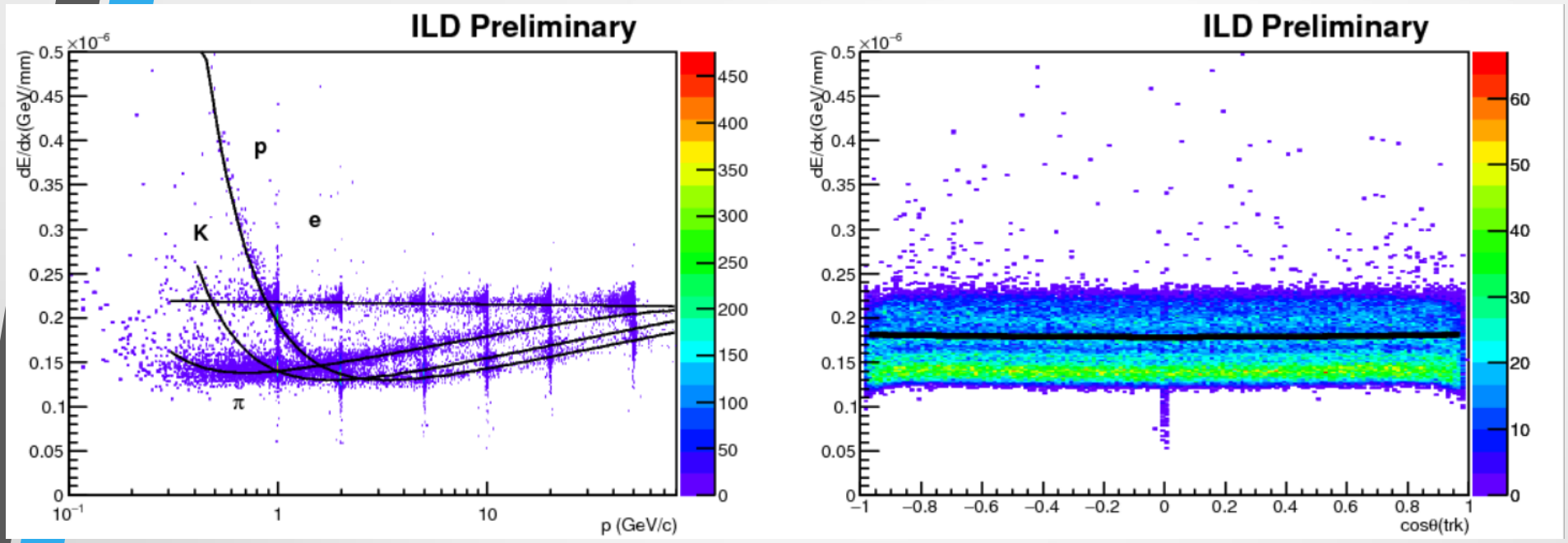


No smearing

- Cannot do full check… but:
  - Bethe-Bloch curve looks OK. Does not change from 01_v05

    → Curve is coming from 01_v05
  - Angle correction is too much in forward region?

New detector model(s4_v02)

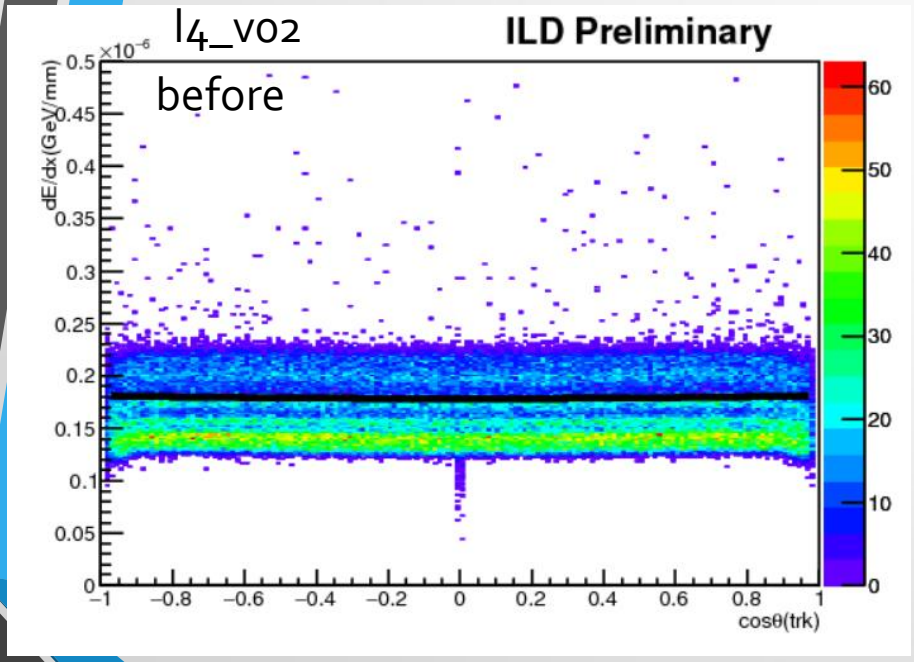


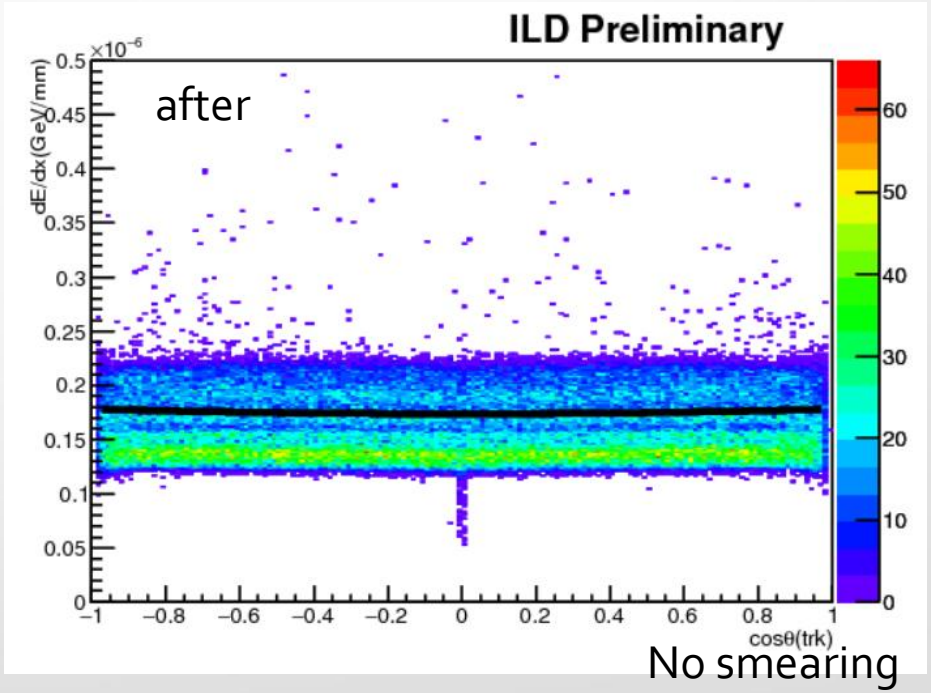
No smearing

- Cannot do full check… but
  - Same tendency as the case of l4_v02

Change angle correction

- Change angle correction
- Fit:$a + b\cos^{2}\theta$
- Looks better





No smearing

Plan

- Introduce some changes to ilcsoft
  - Additional smearing – of course adjustable
  - Angle fit
- Check shower profiles
  - So far, PID looks strange – coming from shower shapes?
- Wait for resolving joint structure issue in Ecal
- After that, ask large samples of single particles
  - All the momentum range(at least, up to 125GeV – up to 250GeV great!)
  - Both charge
- Going to LCFIPlus training and validation with large samples
  - Checking with small samples is ongoing
  - →so far, no problem

backups