



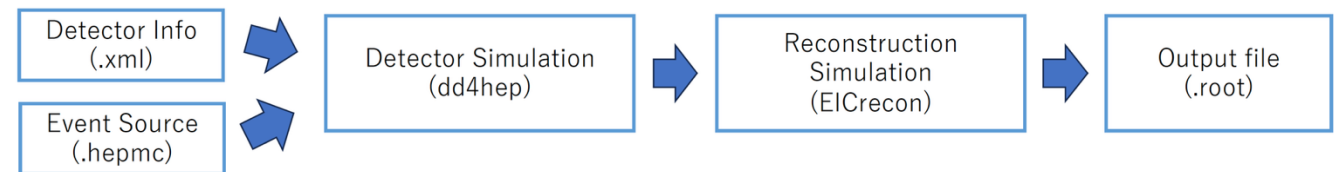
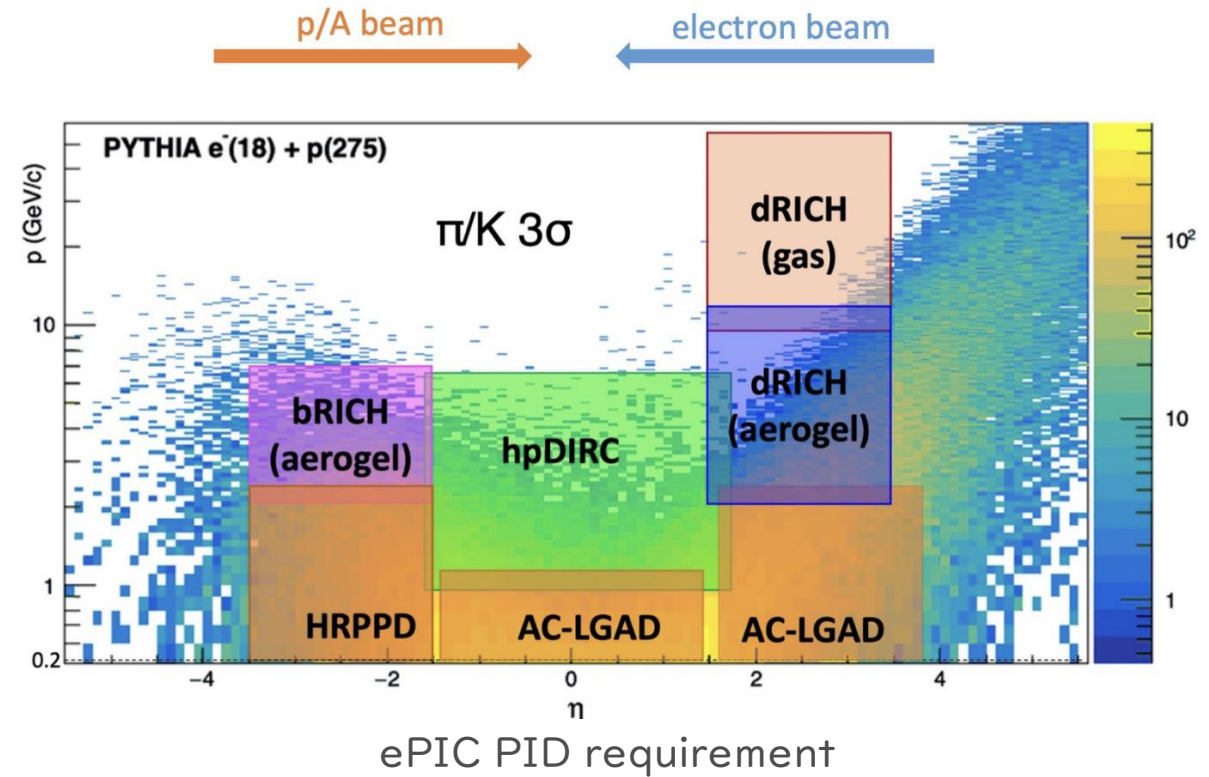
PID performance study using PYTHIA DIS sample

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Note

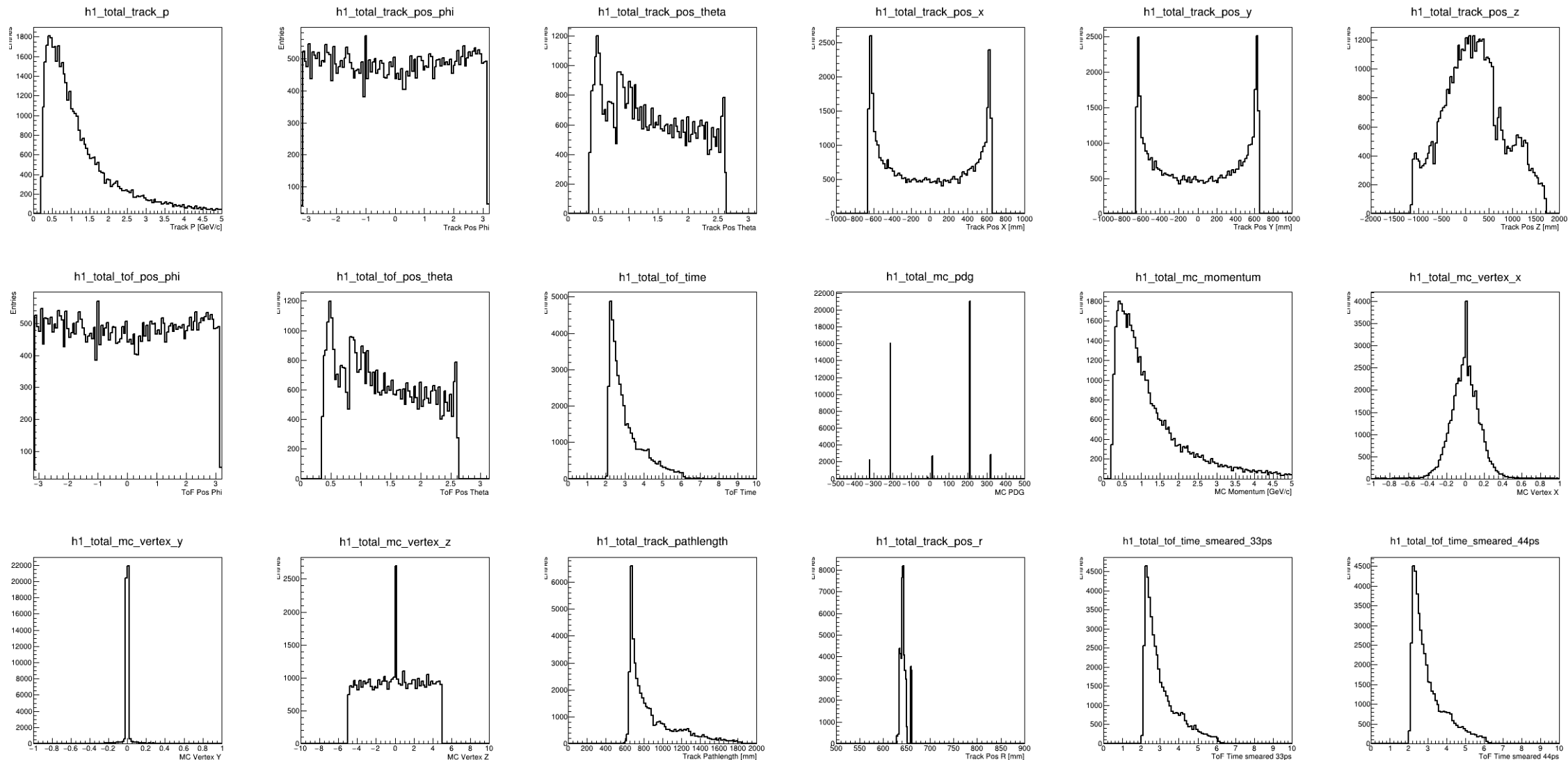
- Generators
 - Pythia NCDIS
 - N_{events} : 200k
 - 18x275 GeV
 - Particle Gun: pi/K/proton
 - N_{events} : 100k for each
 - $0.1 \leq p \leq 5.0$ GeV
 - Eta&Phi: Flat
 - epic ver 25.04.1
- Reconstruction framework
 - EIC Recon Version 1.24.2
- Own developed offline analysis code

- PID performance when considering finite timing resolution will be shown

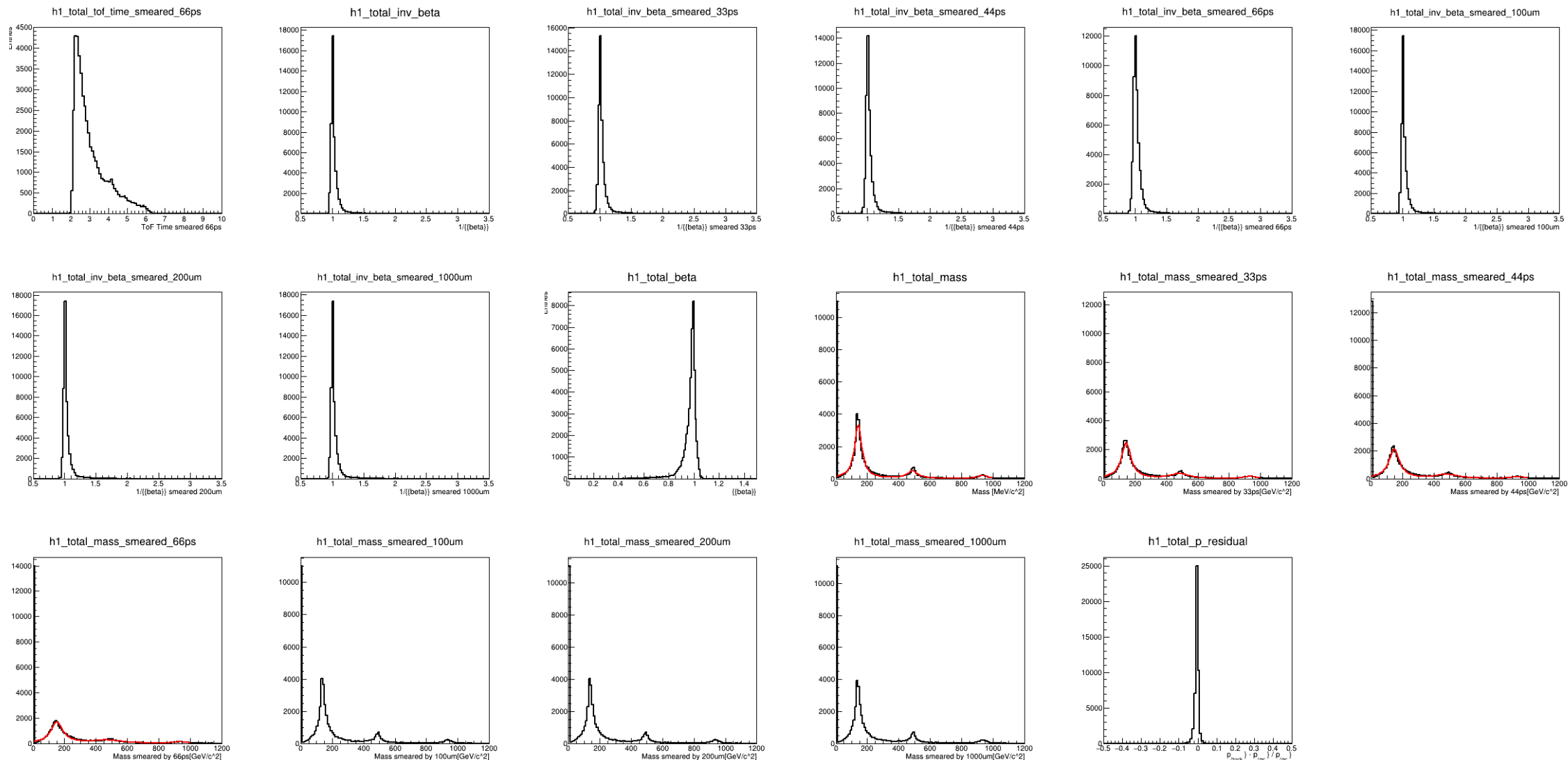


Pythia

Sanity checks 1/2

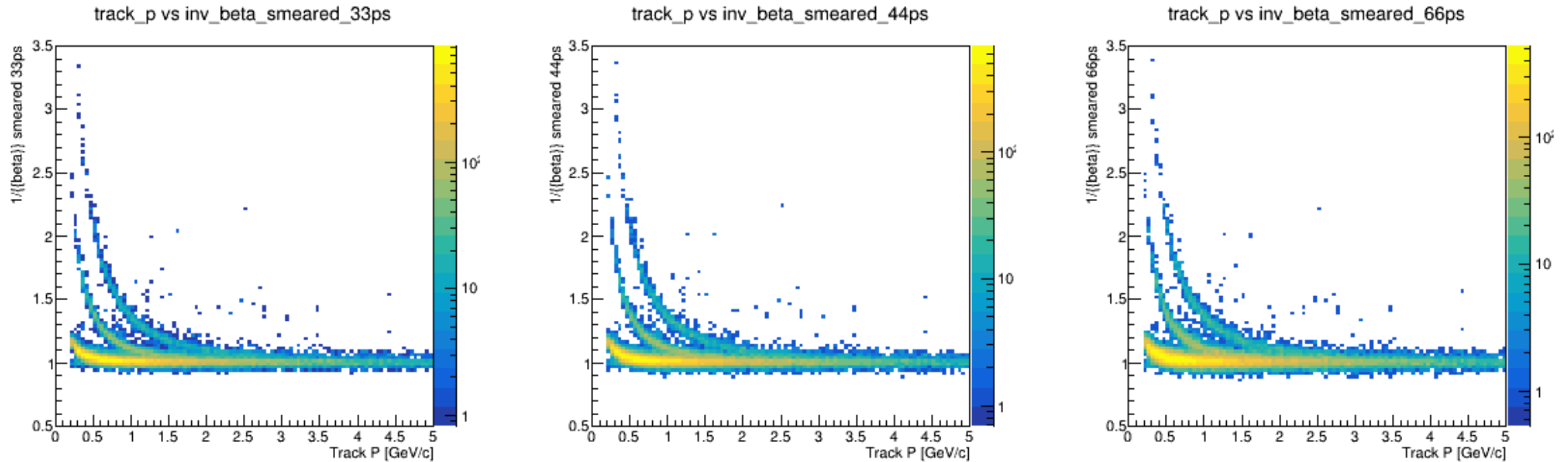


Sanity checks 2/2



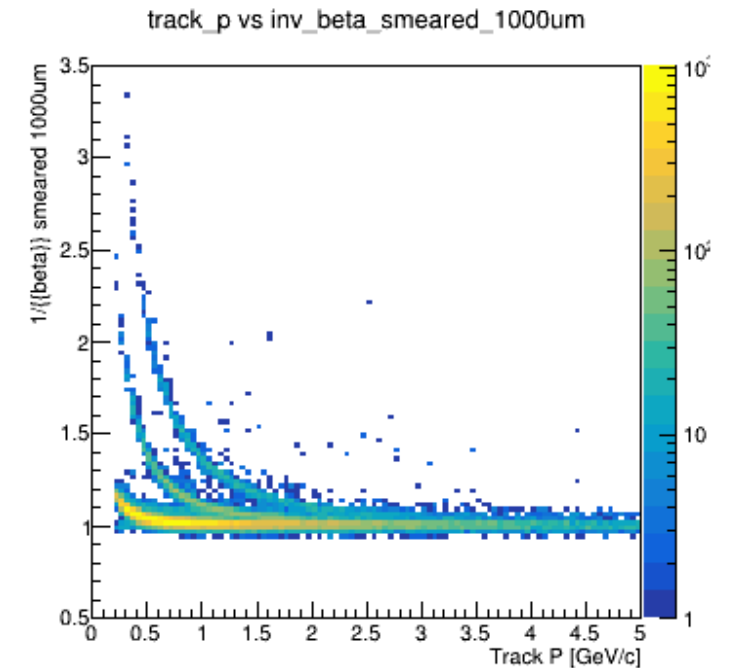
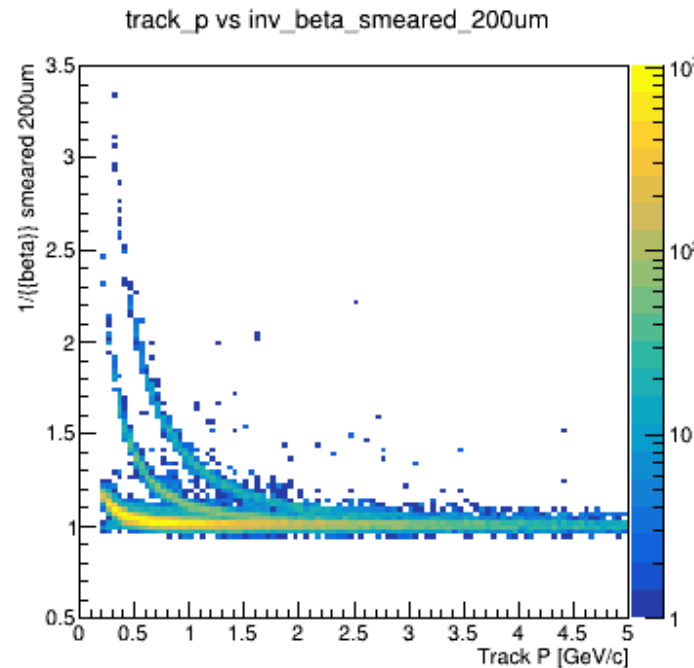
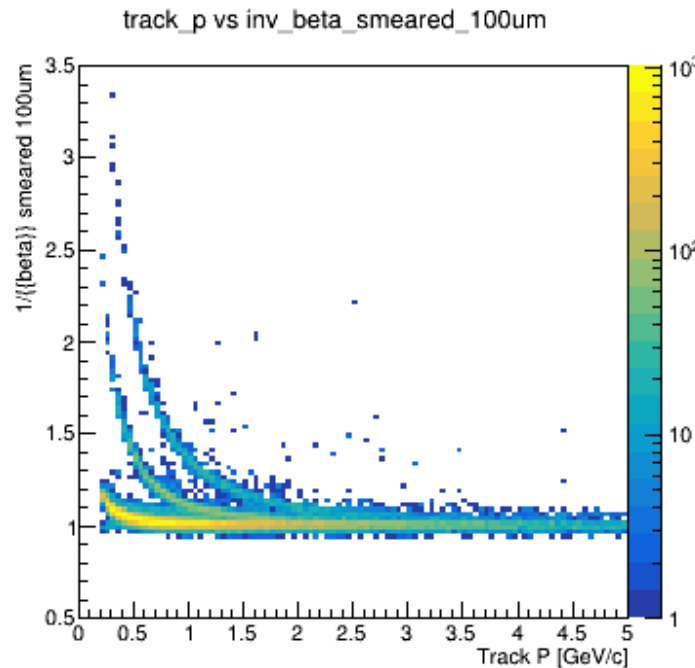
$1/\beta$ vs track momentum + timing smearing

- Timing resolution looks crucial for beta estimation



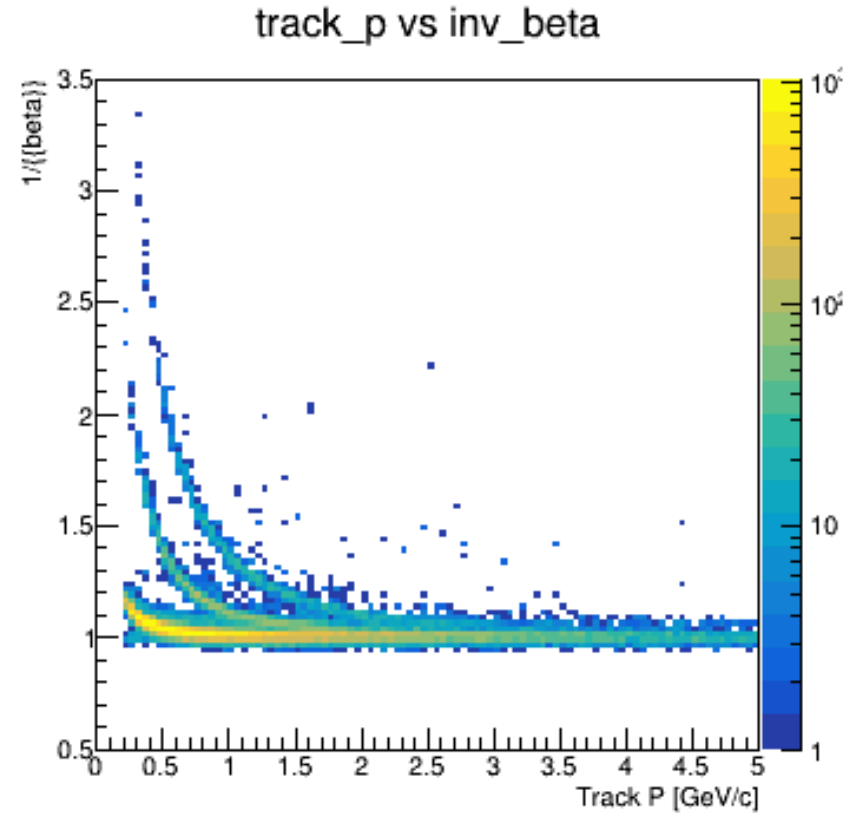
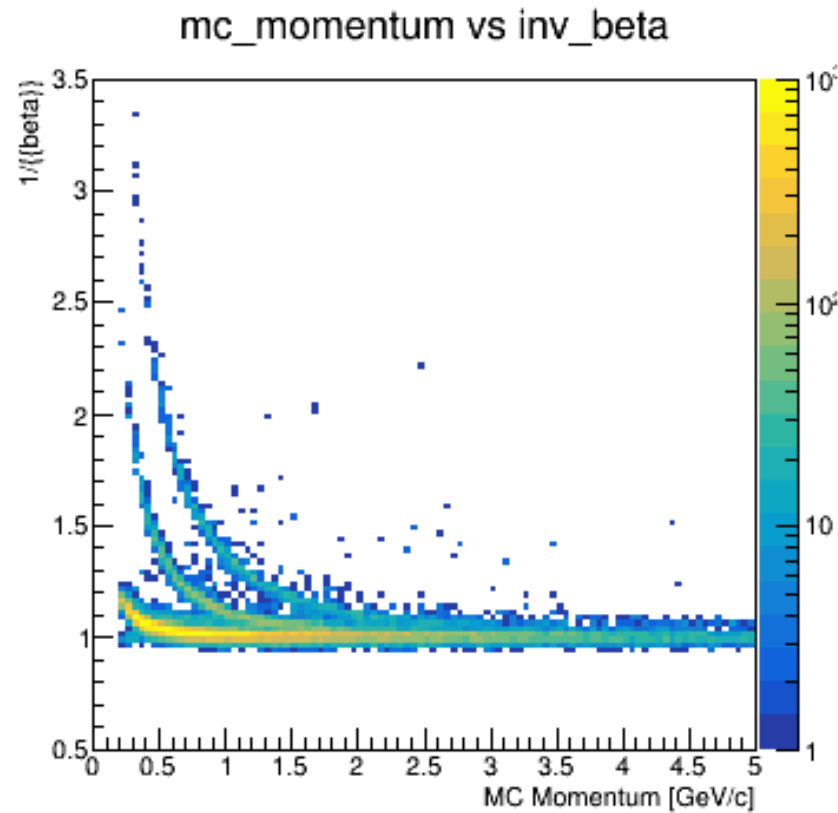
$1/\beta$ vs track momentum + path smearing

- Artificial smearing added: 100, 200, 1000 μm
- No significant impact on beta estimation $\rightarrow$ Path length resolution can be ignored ?



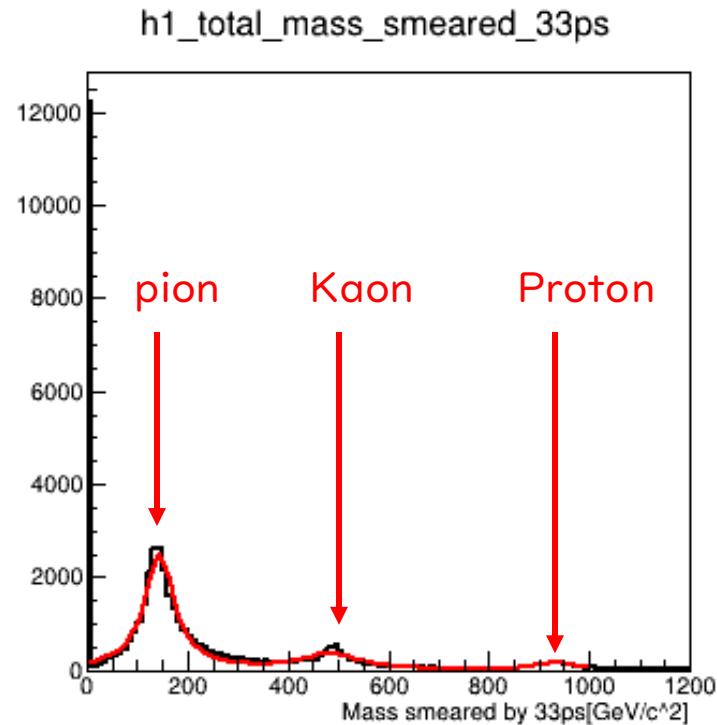
$1/\beta$ vs track momentum or truth momentum

- Track momentum reconstruction looks OK



PID performance evaluation: 3BW fit & FoM

- Obtain each mass peak and its BW width
- Ex) inclusive 3 BWs func fitting
- Introduce Figure of Merit (FoM), to assess the PID performance quantitatively

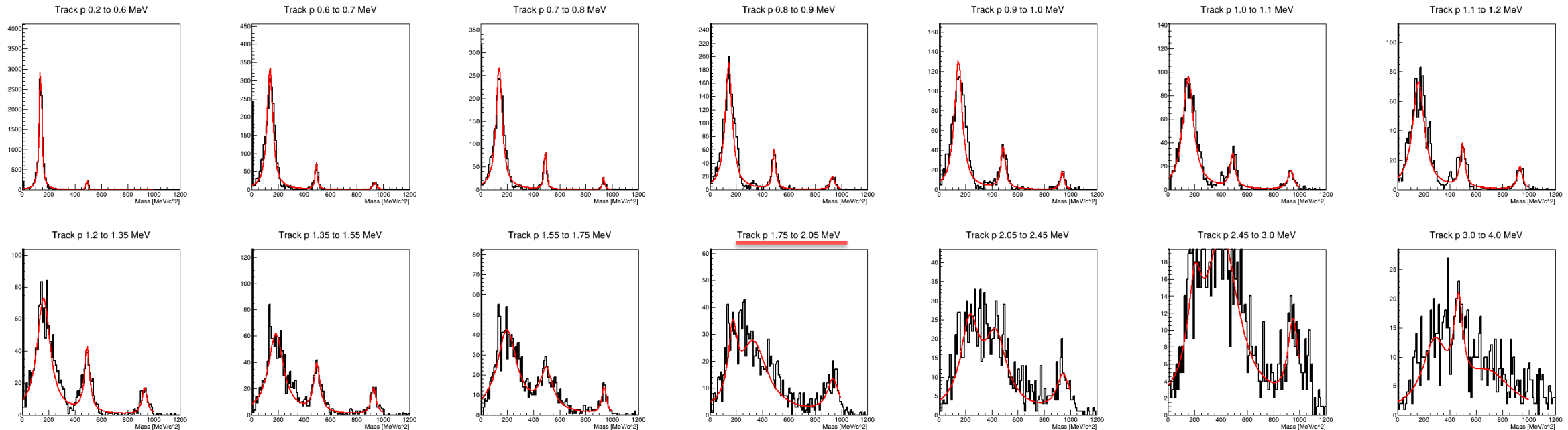


$$\text{FoM} = \frac{|\mu_1 - \mu_2|}{\sqrt{\sigma_1^2 + \sigma_2^2}}$$

- mu: mass peak position
- sigma: BW width (Γ)

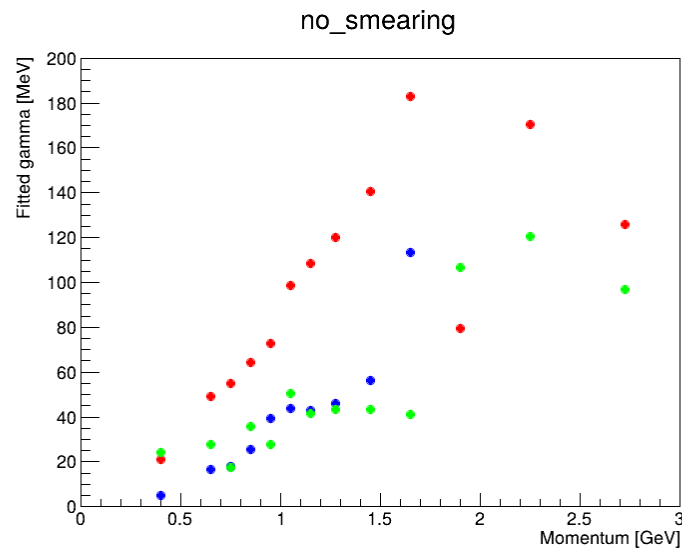
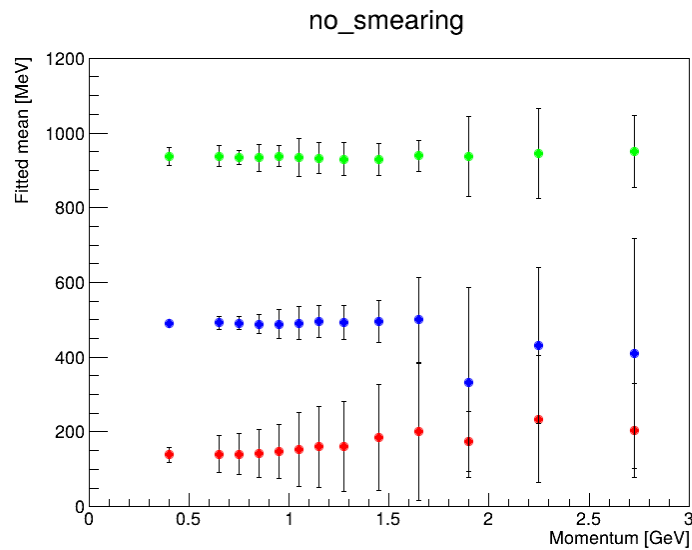
Fitting over each track momentum bin

- Minimum bin interval is chosen such that each bin contain at least 2000 events to stabilize the fitting

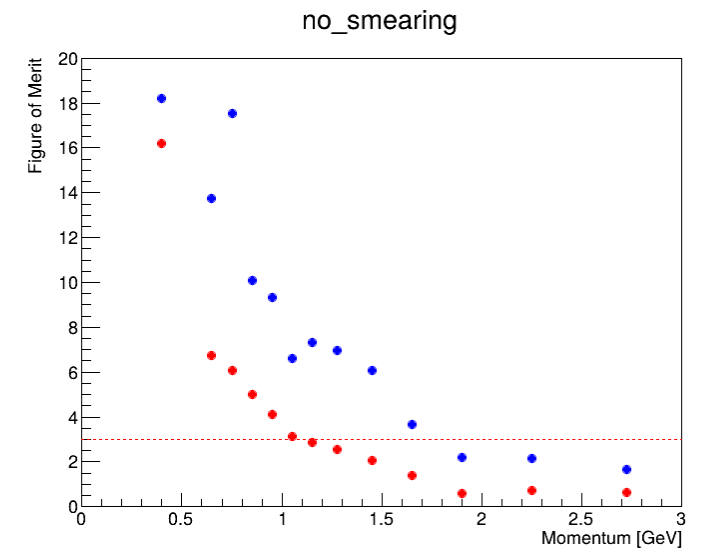


- Fitting worked OK for bins with $p_{\text{track}} < 1.6 \text{ GeV}$ or 1.9 GeV
- Need more statistics for higher p region

Results: I. No smearing

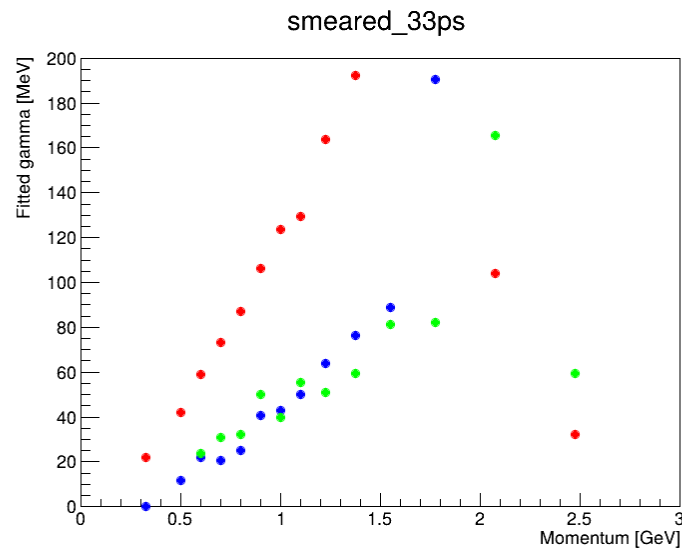
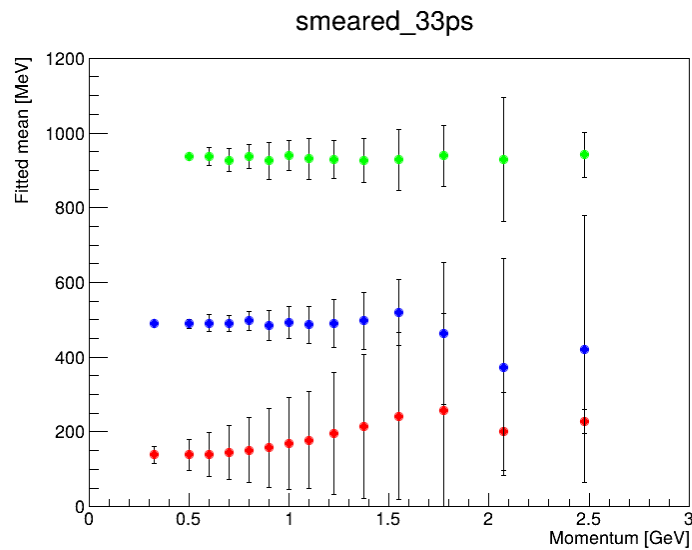


- FoM

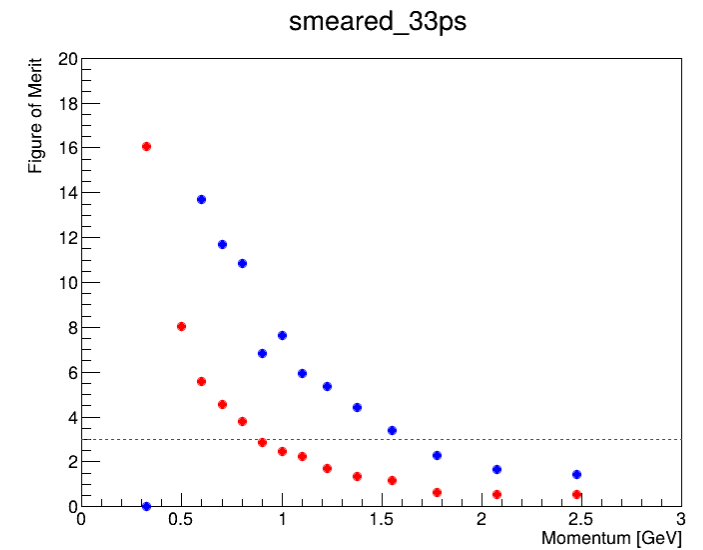


- 3σ separation
 - pi/K 1.15 GeV
 - K/p 1.65 GeV

Results: 2. 33 ps smearing

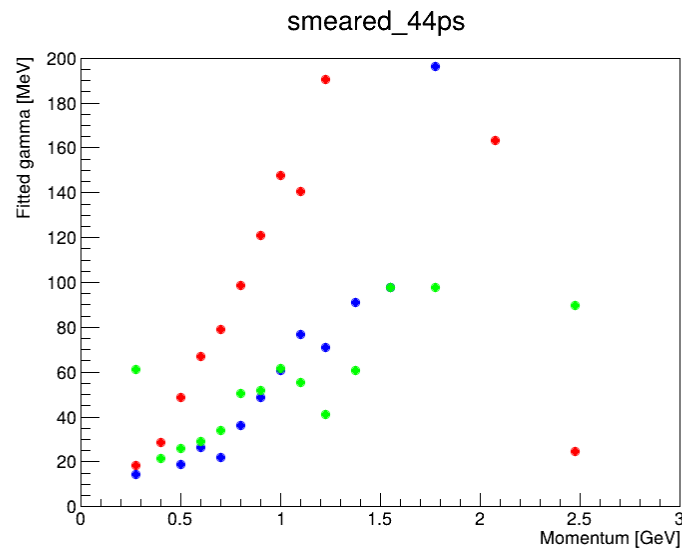
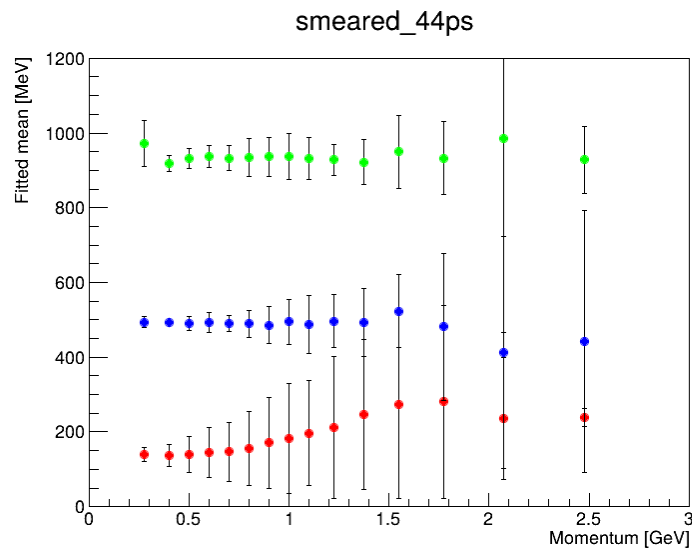


- FoM

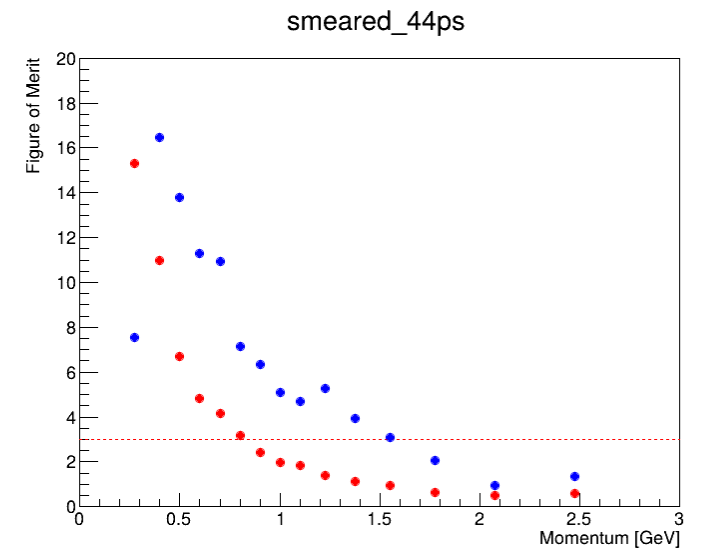


- 3σ separation
 - pi/K 0.9 GeV
 - K/p 1.55 GeV

Results: 3.44 ps smearing

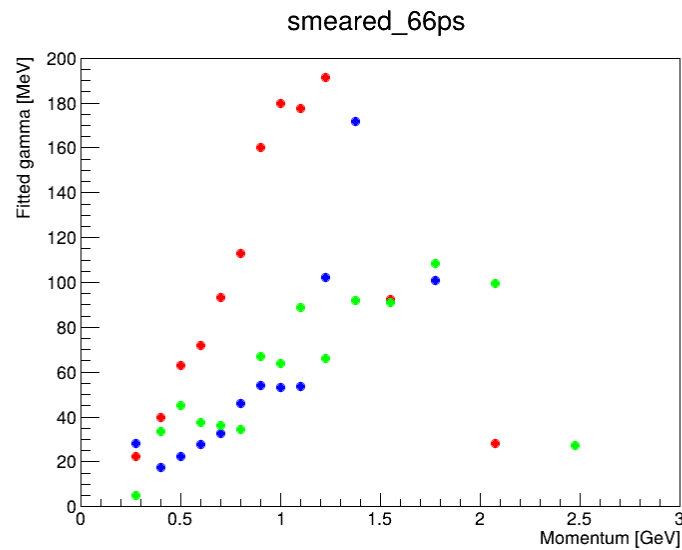
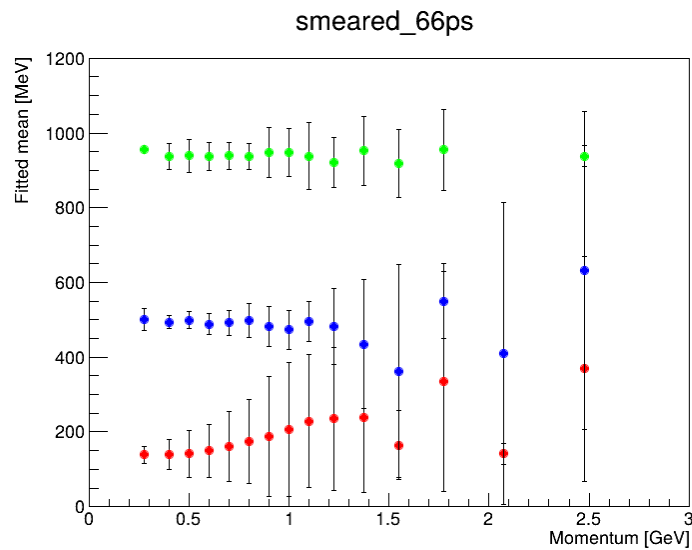


- FoM

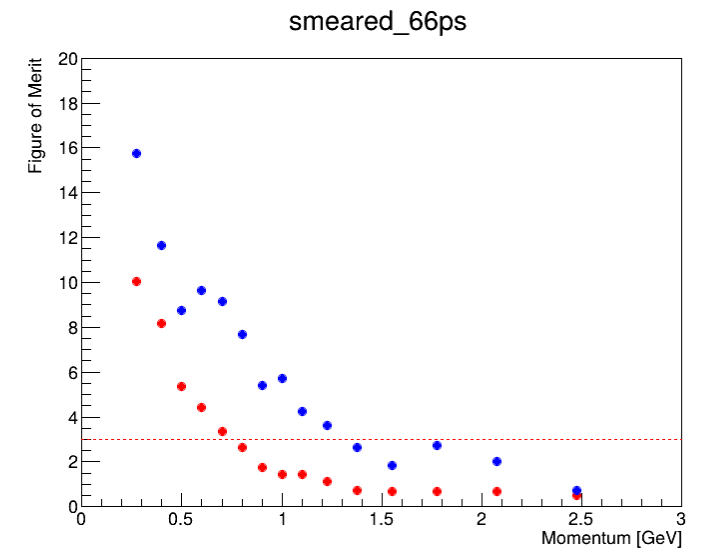


- 3σ separation
 - pi/K 0.8 GeV
 - K/p 1.55 GeV

Results: 4. 66 ps smearing

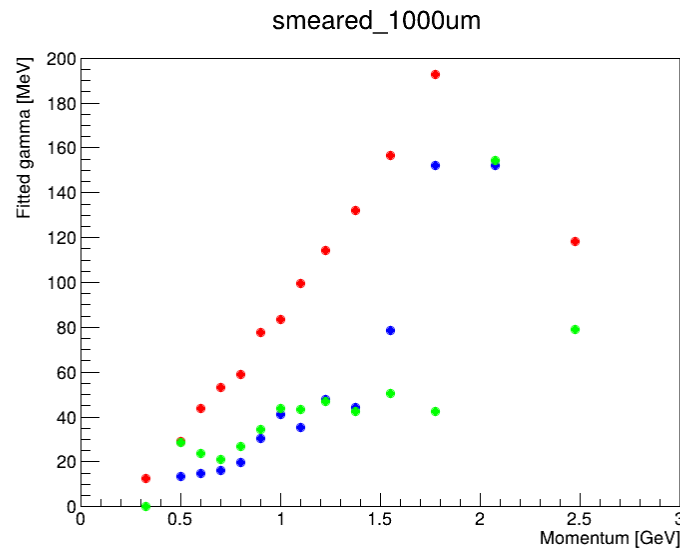
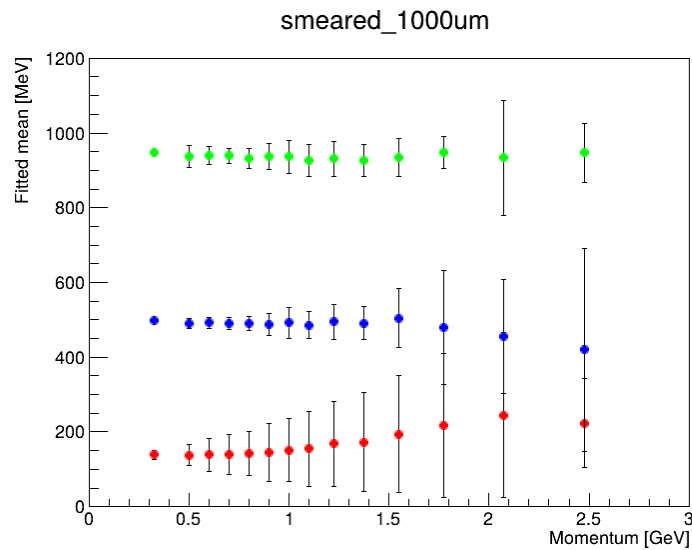


- FoM

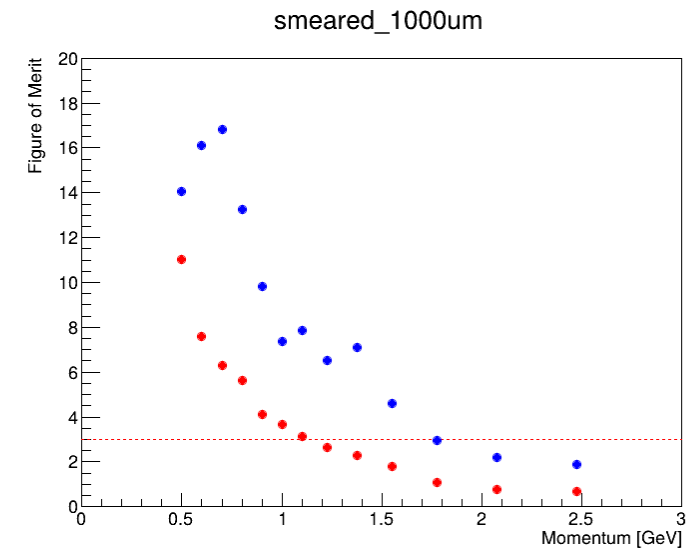


- 3σ separation
 - pi/K 0.75 GeV
 - K/p 1.35 GeV

Results: (5). 1000um smearing for pathlength



- FoM

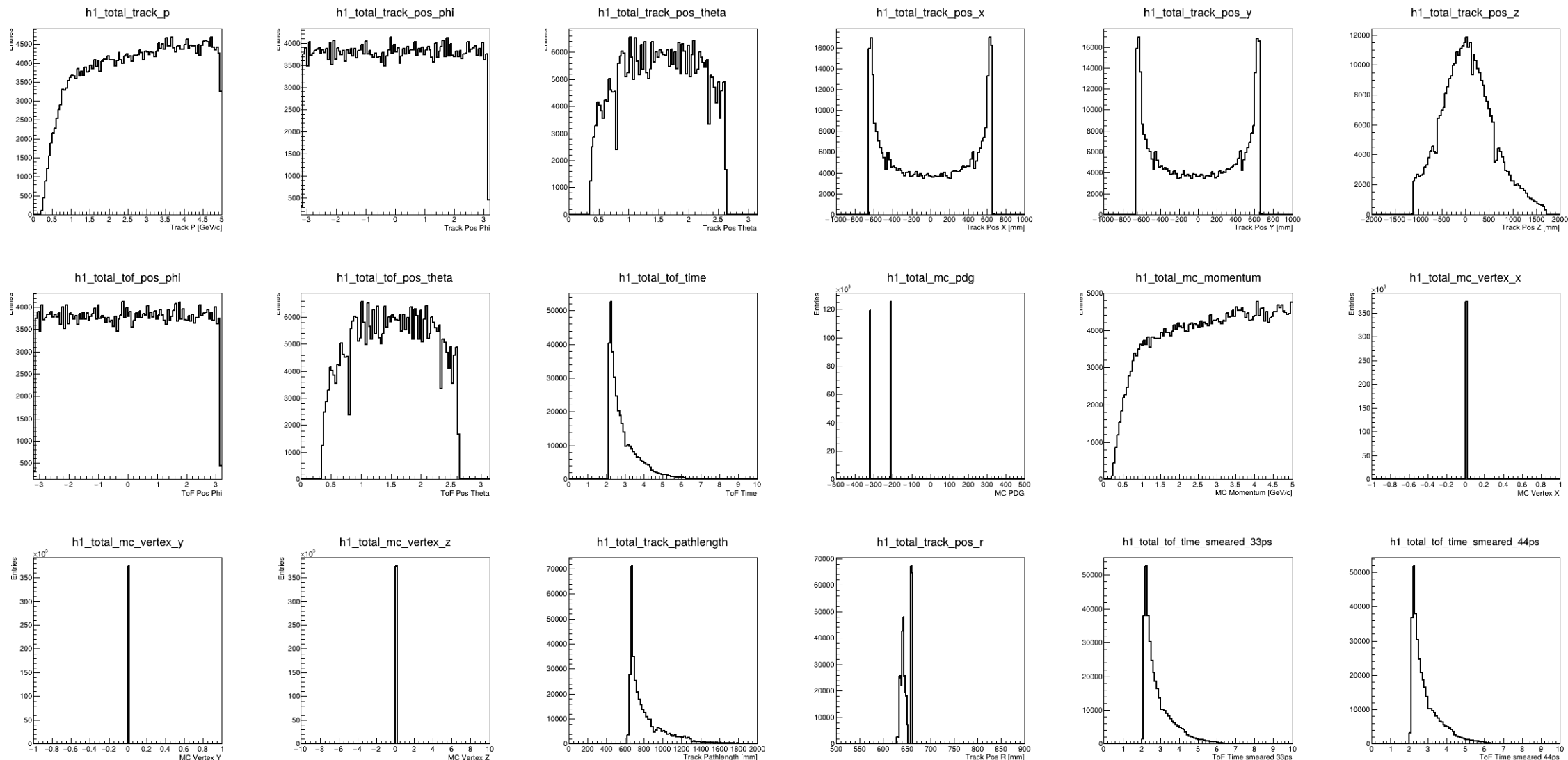


- 3σ separation
 - pi/K 1.15 GeV
 - K/p 1.75 GeV

Single particle gun

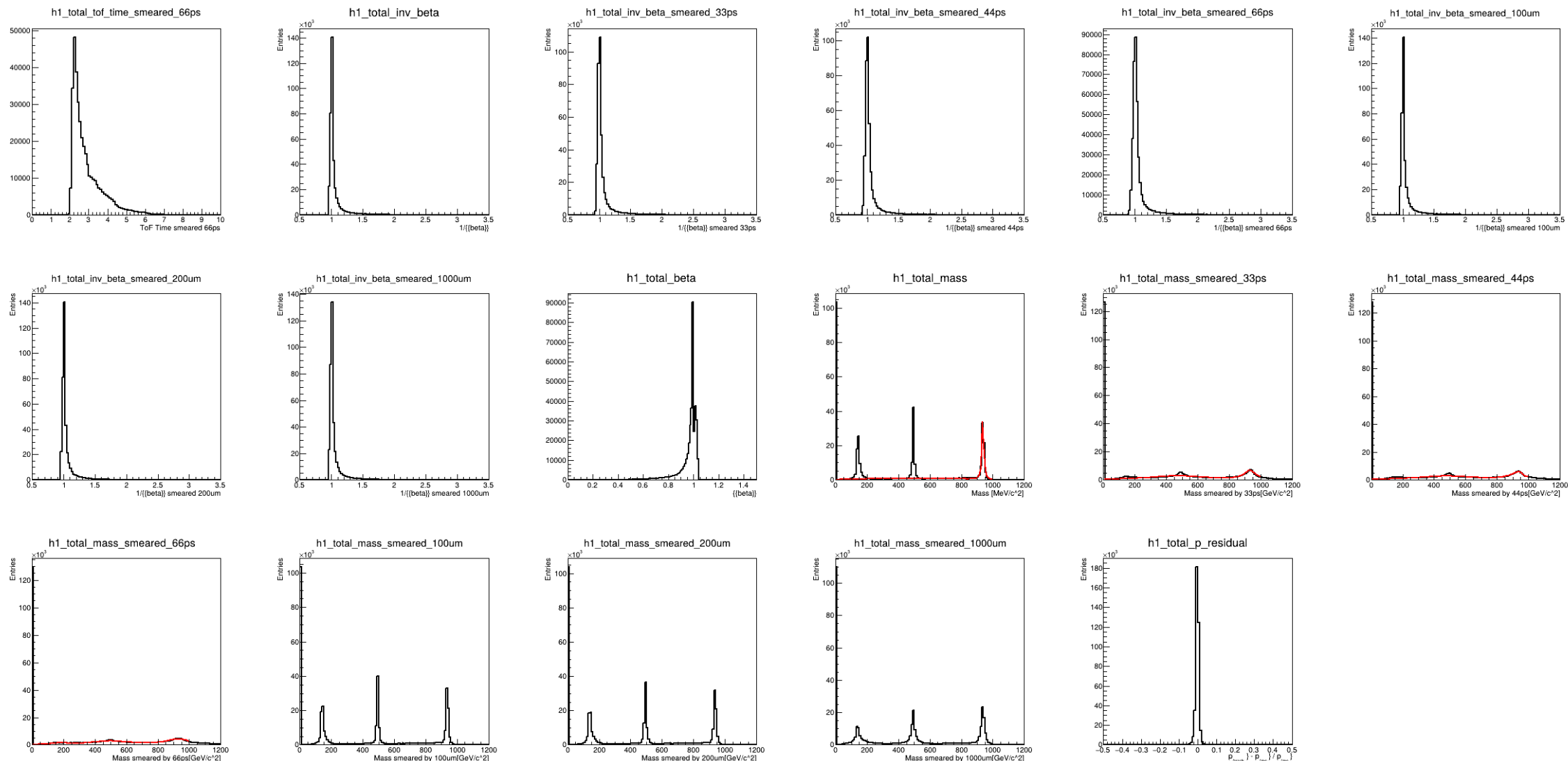
Sanity checks 1/2

Single particle gun



Sanity checks 2/2

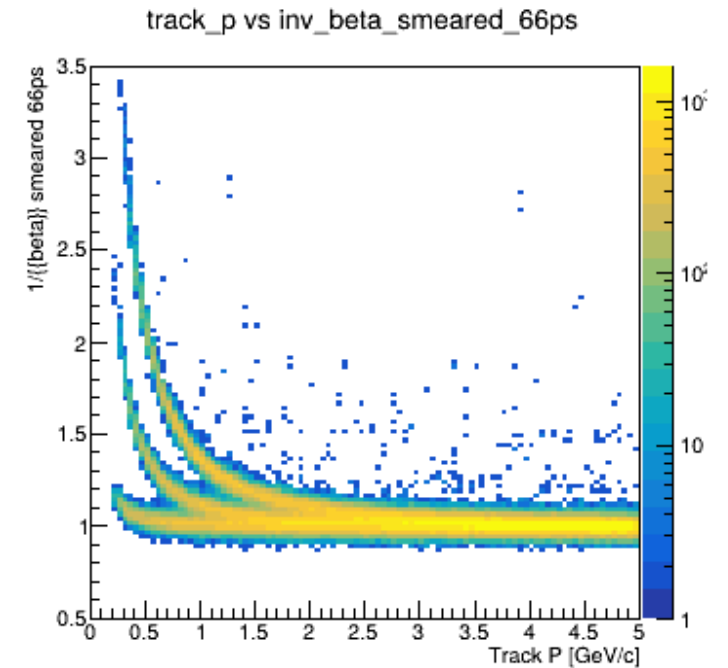
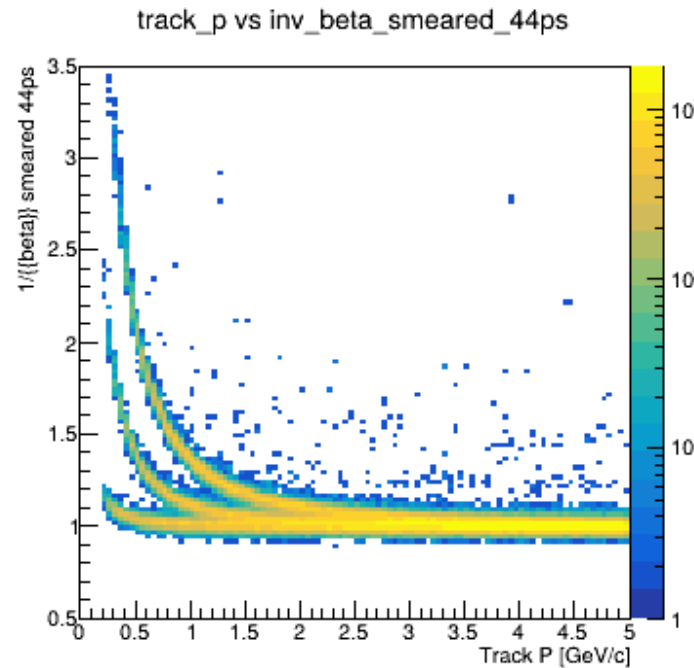
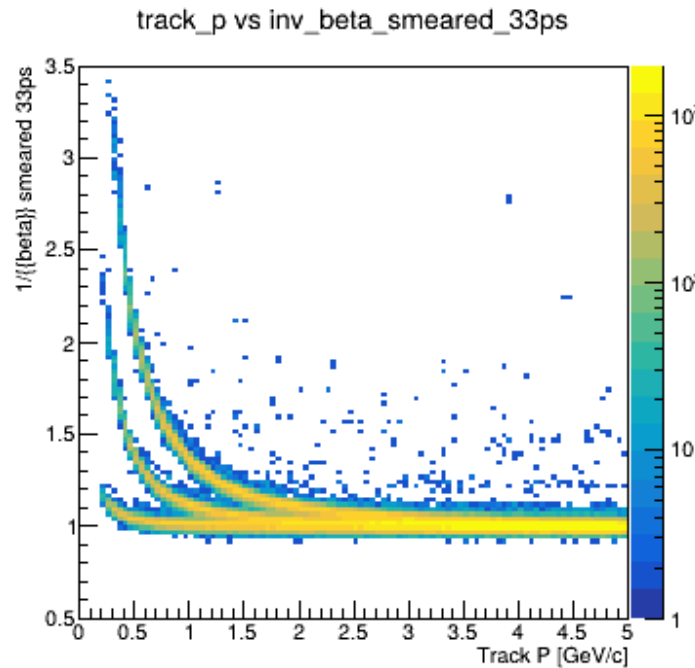
Single particle gun



$1/\beta$ vs track momentum + timing smearing

Single particle gun

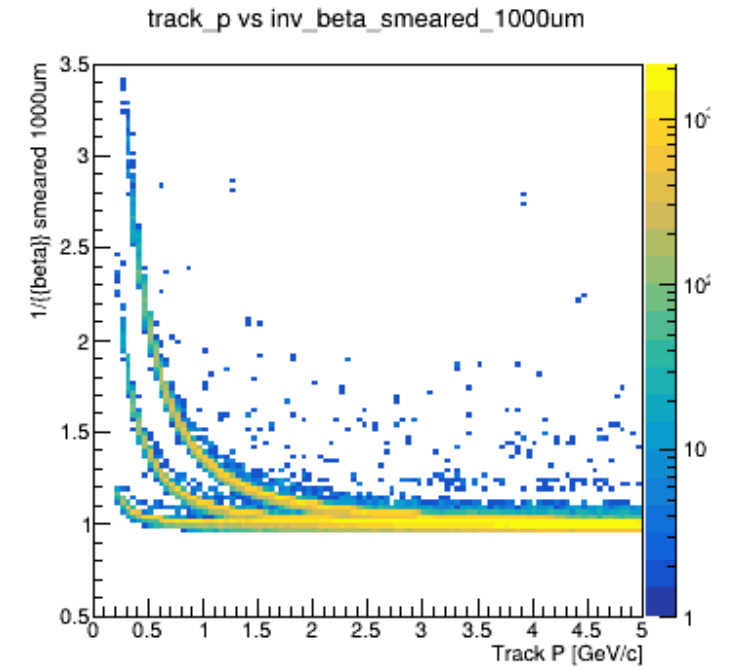
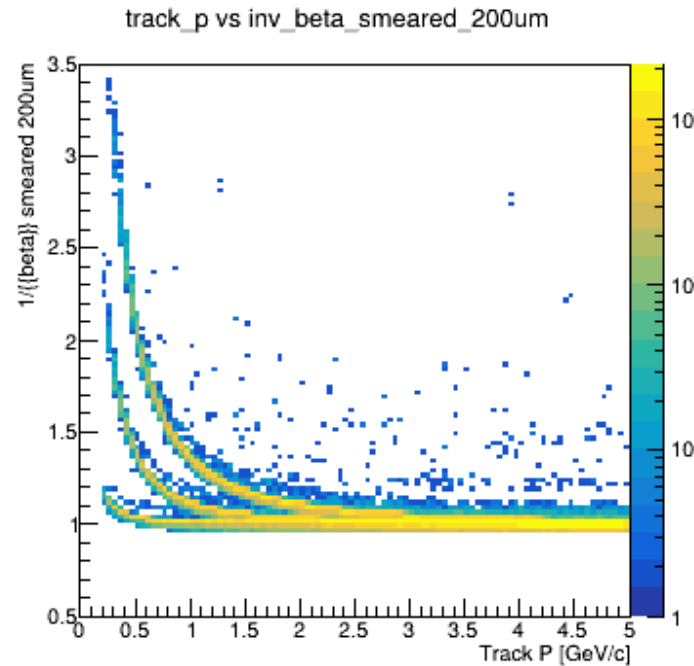
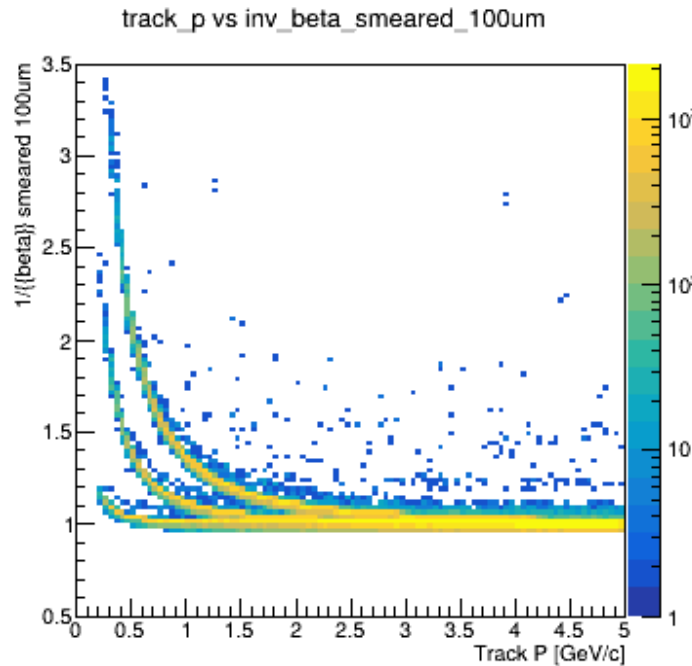
- Timing resolution looks crucial for beta estimation



$1/\beta$ vs track momentum + path smearing

Single particle gun

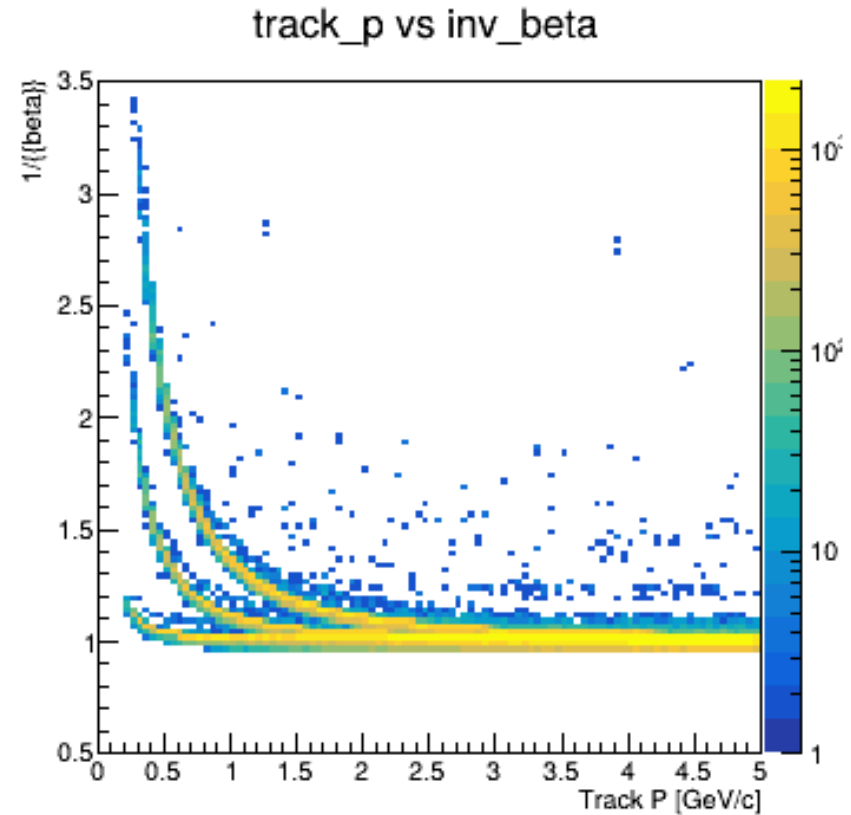
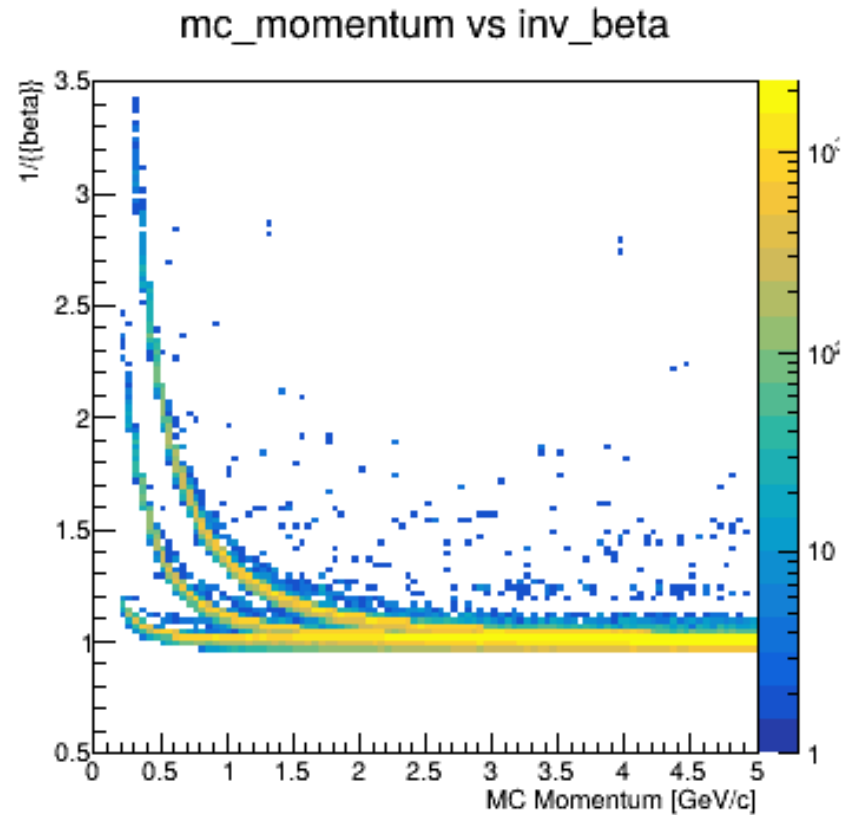
- Artificial smearing added: 100, 200, 1000 μm
- No significant impact on beta estimation $\rightarrow$ Path length resolution can be ignored ?



$1/\beta$ vs track momentum or truth momentum

Single particle gun

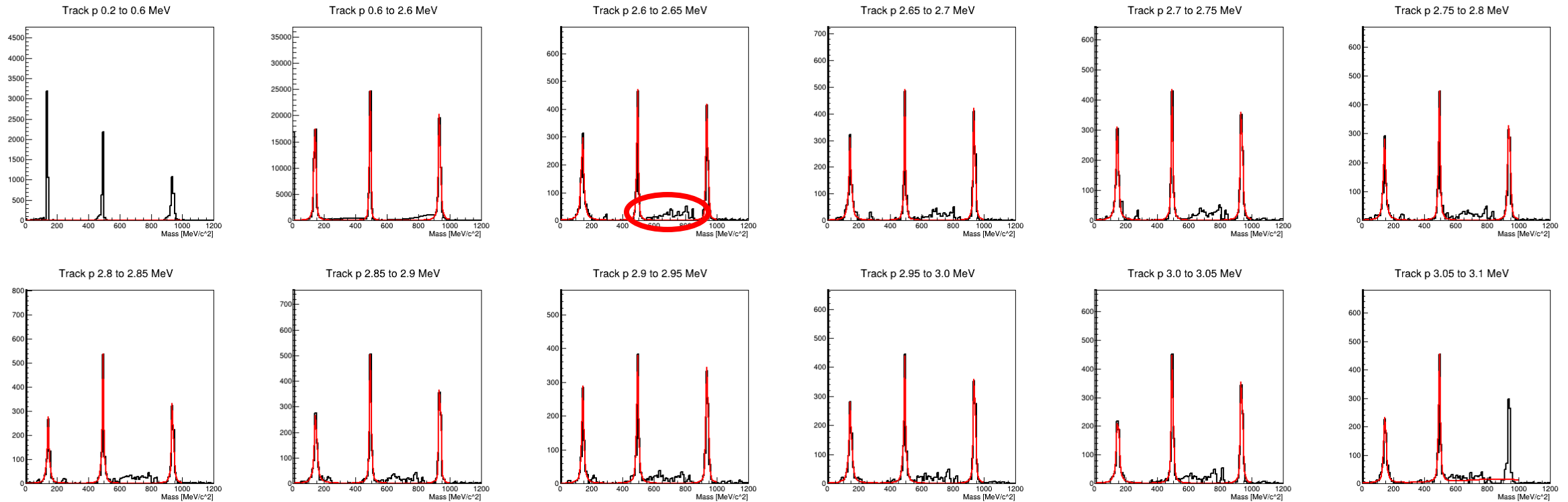
- Track momentum reconstruction looks OK



Fitting over each track momentum bin

Single particle gun

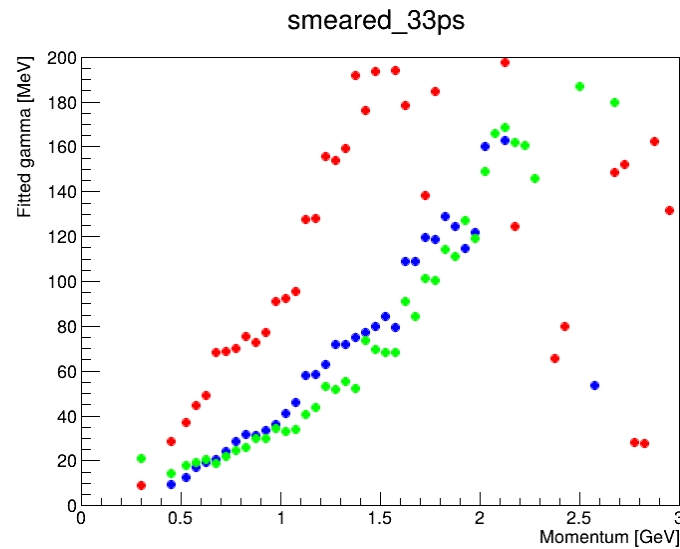
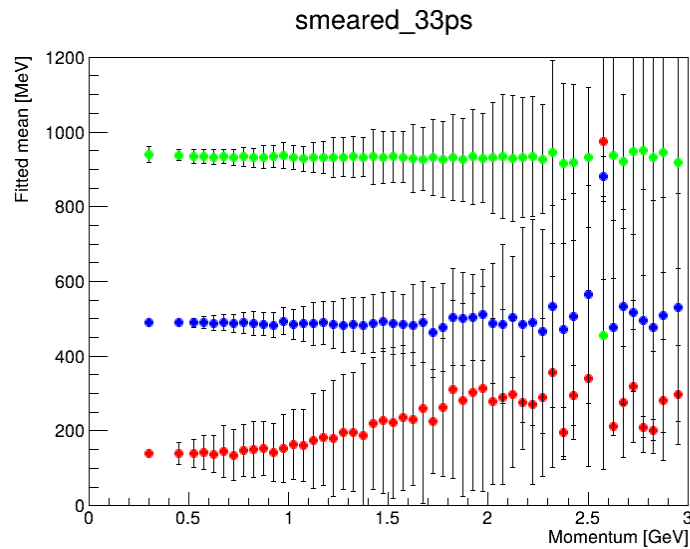
- Minimum bin interval is chosen such that each bin contain at least 2000 events to stabilize the fitting



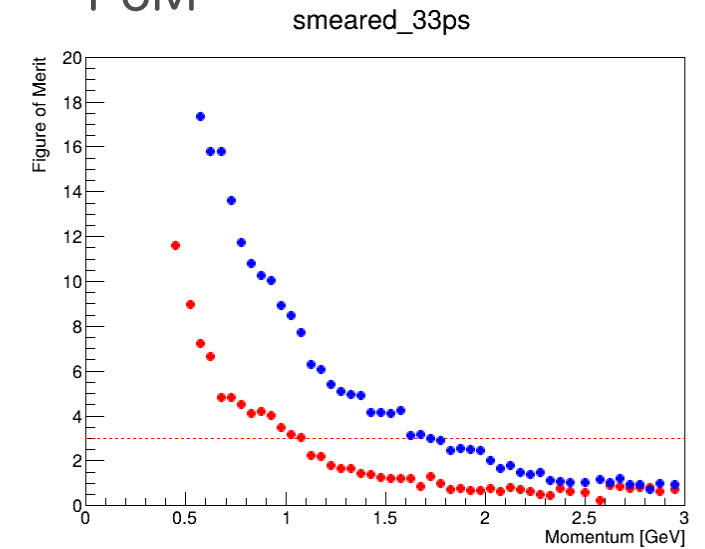
- Fitting worked OK for most bins
- Very sharp w.r.t. Pythia case

Results: 1.33 ps smearing

Single particle gun



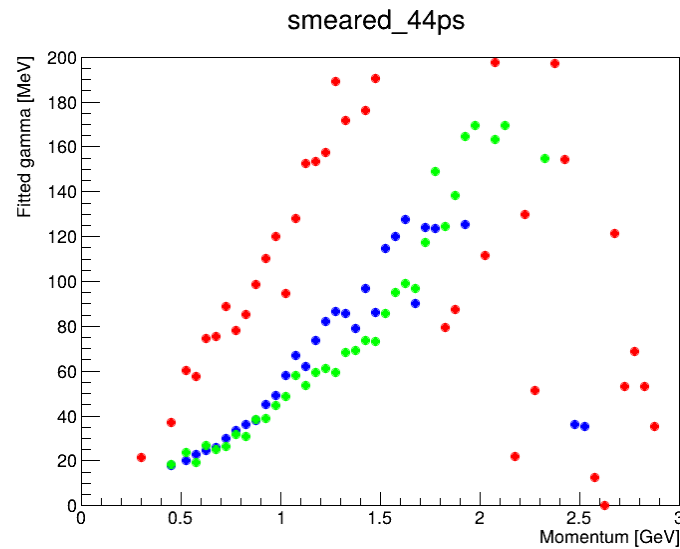
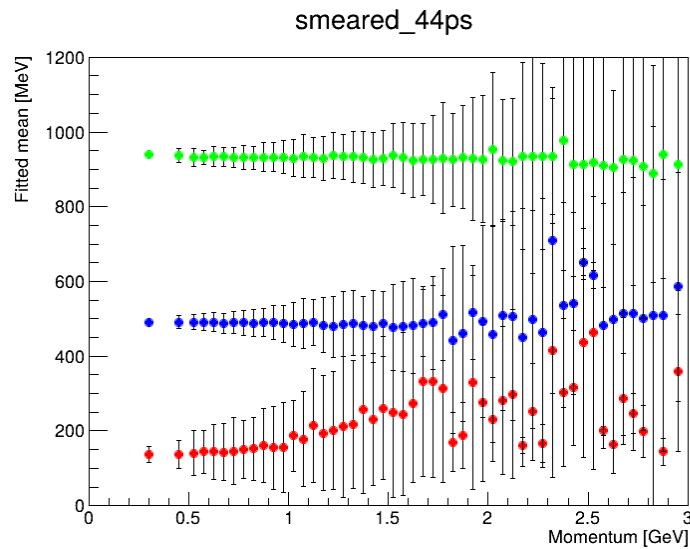
- FoM



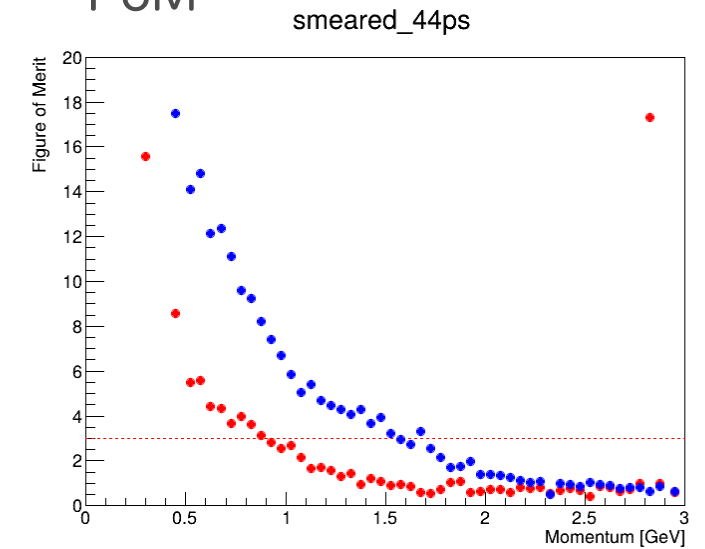
- 3σ separation
 - pi/K 1.05 GeV
 - K/p 1.65 GeV

Results: 2.44 ps smearing

Single particle gun



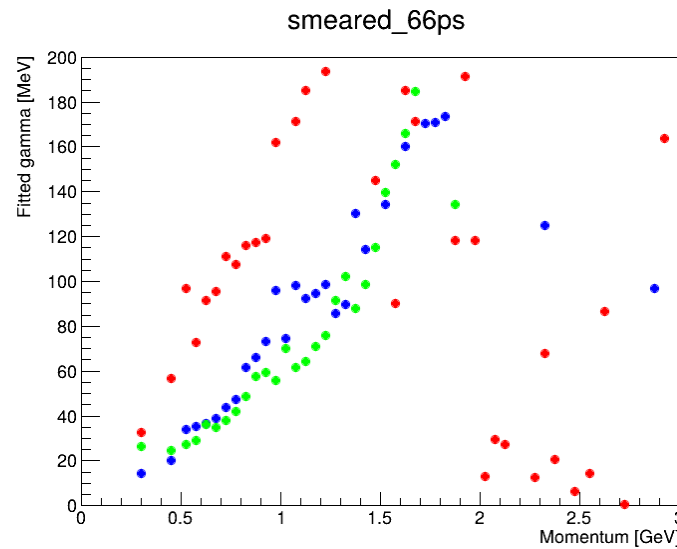
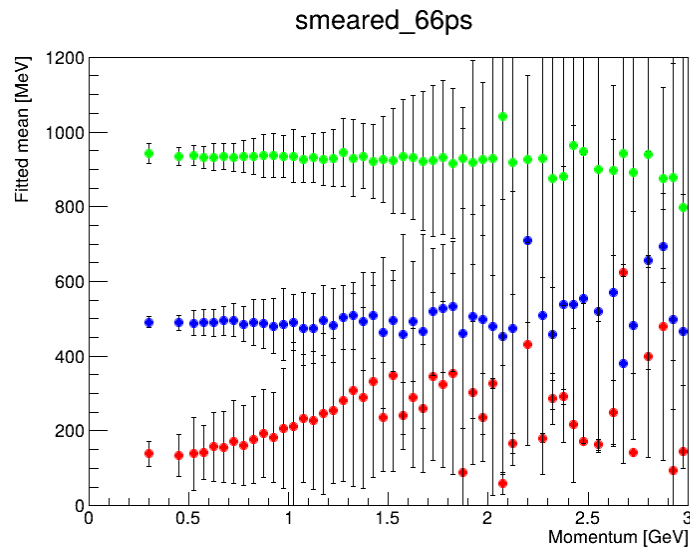
- FoM



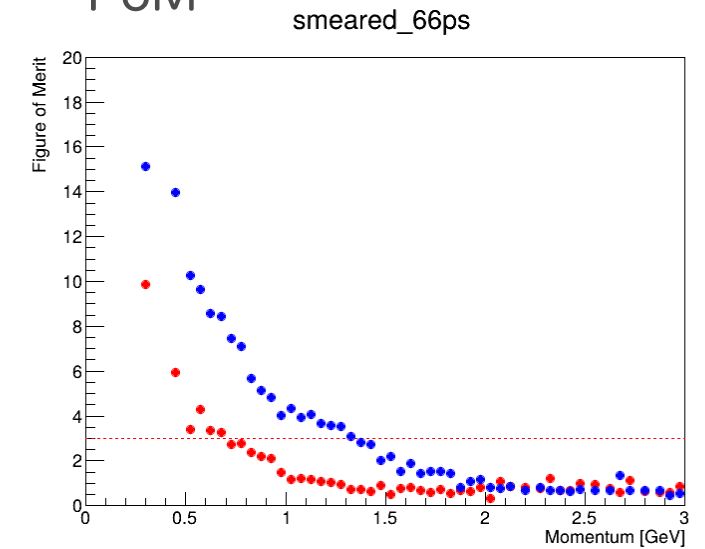
- 3σ separation
 - pi/K 0.9 GeV
 - K/p 1.5 GeV

Results: 3. 66 ps smearing

Single particle gun

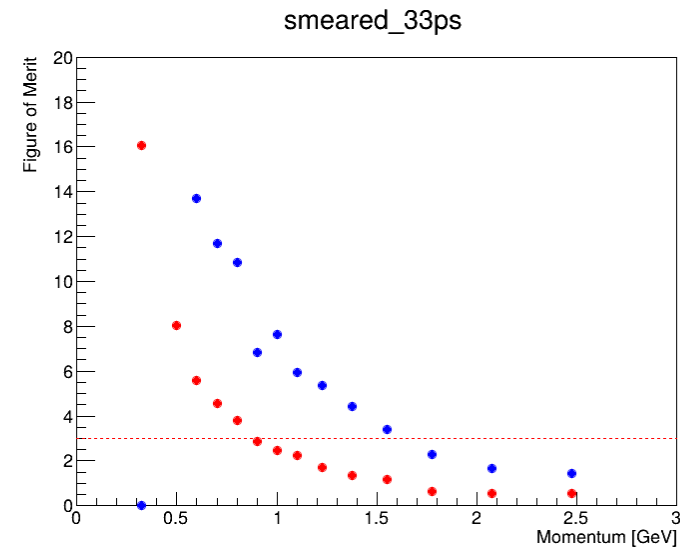
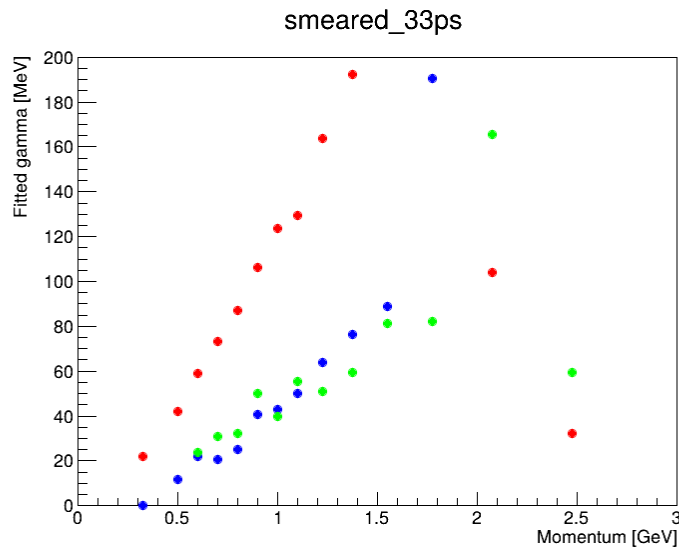
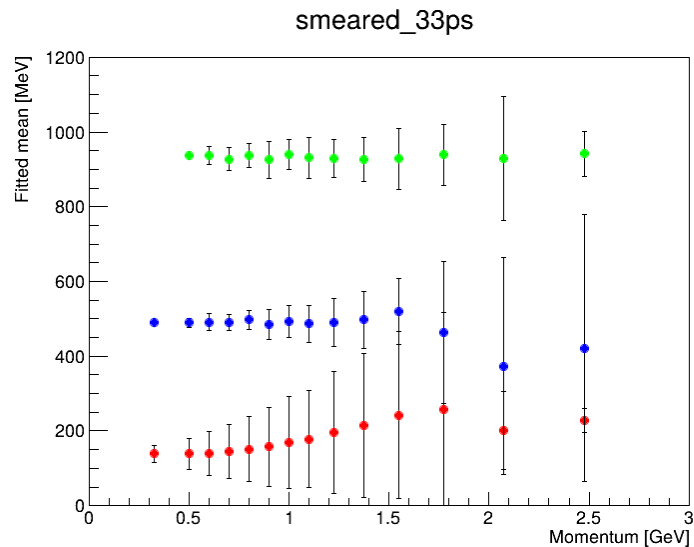


- FoM

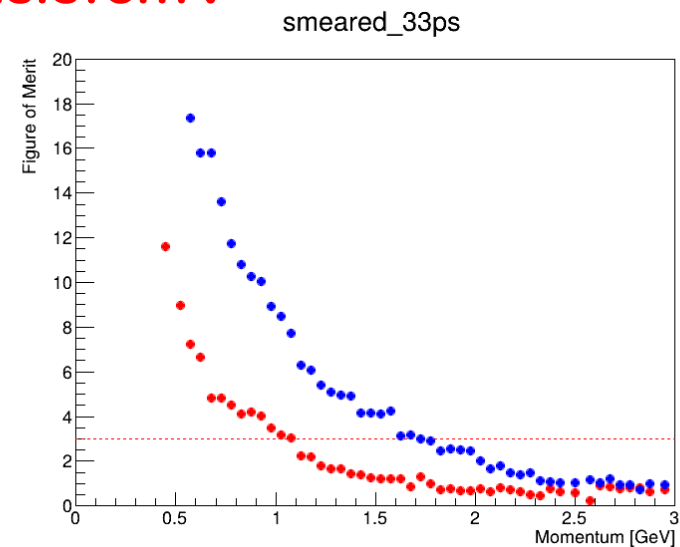
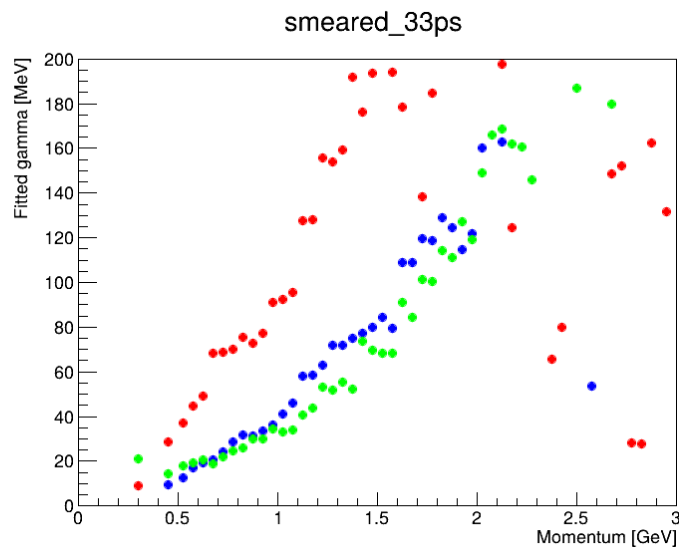
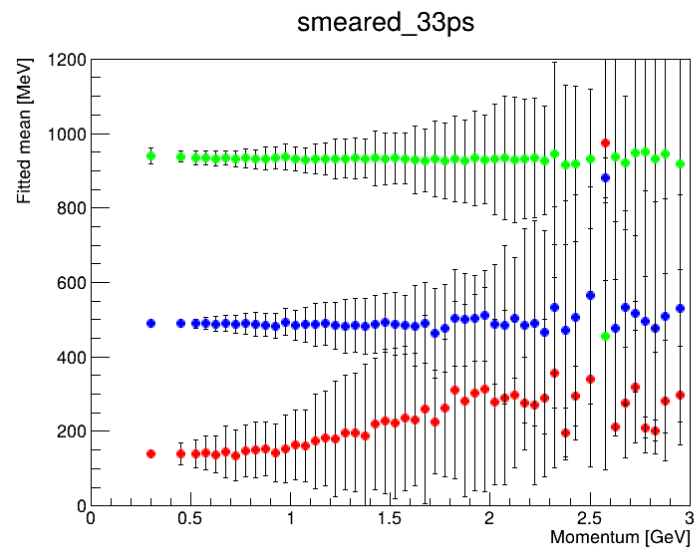


- 3σ separation
 - pi/K 0.7 GeV
 - K/p 1.3 GeV

Results: Ex I. 33 ps smearing Pythia & pGUN



Consistent?



Summary

- PID performance study was performed based on PYTHIA DIS sample and particle gun simulator
- Impact from finite timing and tracking pathlength resolution
 - Ex) 44ps timing resolution
 - 3σ pi/K separation up to 0.8 GeV
 - 3σ K/p separation up to 1.5 GeV
 - Negligible impact from pathlength resolution even considering very large fluctuation
 - 1 mm $\rightarrow$ corresponds a few ps smearing
- NO difference between PHYAS and particle gun
- Todo
 - change mass to squared mass
 - Generate more events