FTOF PID performance

ePIC AC-LGAD TOF DSC Meeting

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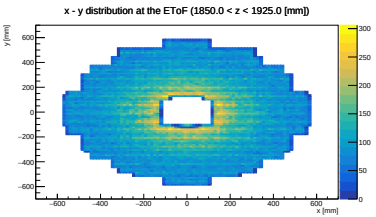
Workflow:

- Simulation: `ddsim`
  - Detector version: `25.08.0`
  - Single Particle Gun
  - Particles: p, K^+, π^+
  - 10^6 event for each particle
  - momentum min: 0.1 GeV
  - momentum max: 5 GeV
  - eta min: 1.5
  - eta max: 4.0
  - distribution: Uniform
  - multiplicity: 1
- Reconstruction: `EICrecon`
  - Version: `v1.29.0`
- Analysis: `ROOT`
  - Offline developed analysis framework

Events Selection:

- Generator Status = 1 (Idiomatic ?)
- Tracks with z-extension of: $1850 \leq z \leq 1925$



Output `TBranchs` used:

- `_CentralTrackSegments_points`
  - `position.x`
  - `position.y`
  - `position.z`
  - `momentum.x`
  - `momentumError.xx`
  - `momentum.y`
  - `momentumError.yy`
  - `momentum.z`
  - `momentumError.zz`
  - `pathlength`
  - `pathlengthError`
  - `theta`
- `TOFEndcapRecHits`
  - `time`
  - `timeError`
- `MCParticles`
  - `PDG`
  - `generatorStatus`

Used Formulas:
The relative speed of the particle is evalued using:

$$\beta c = \frac{\text{pathlength}}{\text{ToF}}$$

Which is then used to determin the particle's mass:

$$m = \frac{p}{\beta c}\sqrt{1-\beta^2}$$

the pseudo-rapidity is determined by:

$$\eta = -\ln\left(\tan\left(\frac{\theta}{2}\right)\right)$$

The figure of merit used to estimate the separation power is defined by:

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

Fit function:
To fit the m^2, a triple Gaussian function is adopted:

$$f(x) = \sum_{i=1}^{3} A_i e^{-\frac{1}{2}\left(\frac{x-\mu_i}{\sigma_i}\right)^2}$$

The fit is done by minimizing the Poisson likelihood:

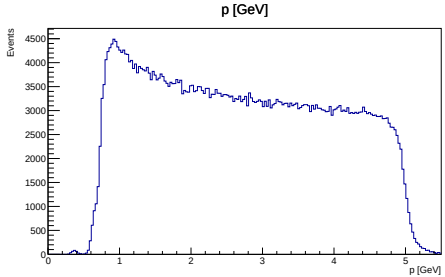
$$-2\ln\mathcal{L} = 2\sum_i \left[\mu_i(\theta) - n_i + n_i \ln\left(\frac{n_i}{\mu_i(\theta)}\right)\right]$$

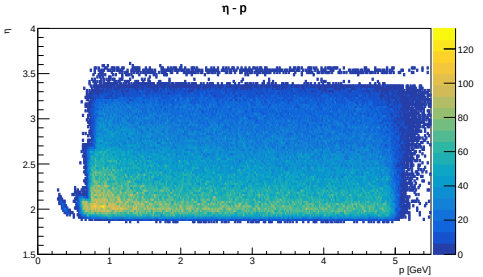
assuming independent Poisson fluctuations in each bin.

Uncertainty propagation:
The uncertainty propagated from each measured observable to the one depending on it is estimated using:

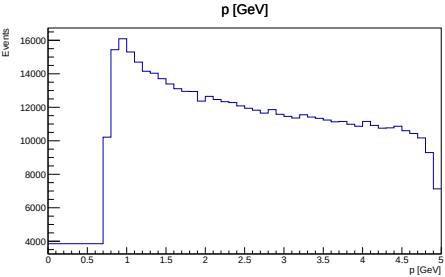
$$\sigma_y = \sqrt{\sum_i \left(\frac{\partial y}{\partial x_i}\sigma_{x_i}\right)^2}$$

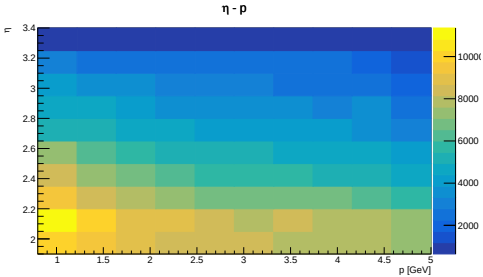
Event distributions with fine binning for reference.



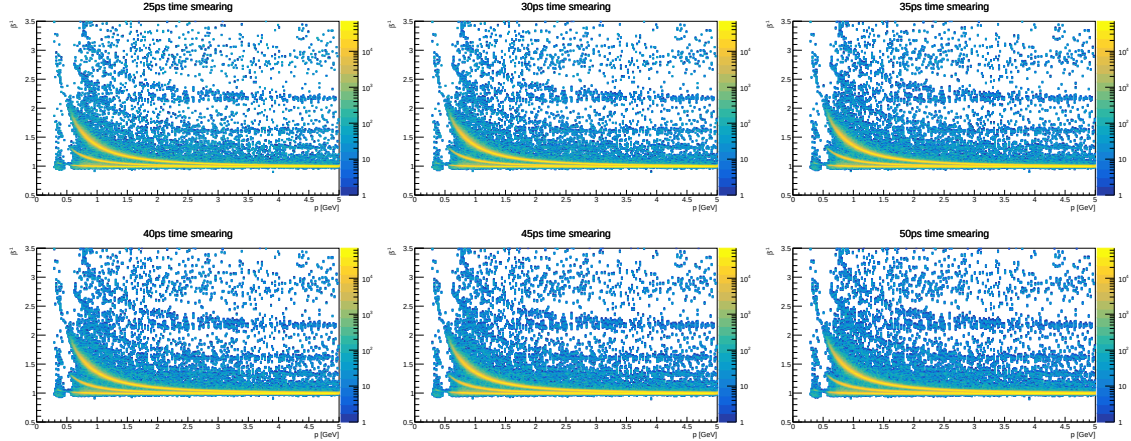


Event distributions with the binning to be used in the fit.

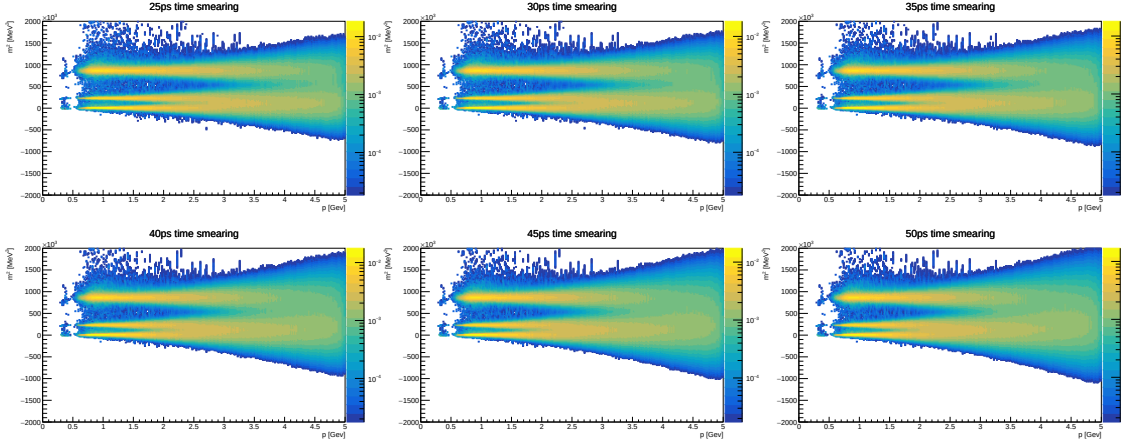




The histograms are filled using $w_p(\beta^{-1}) = \frac{1}{\sigma(\bar{\beta}^{-1})\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\beta^{-1}-\bar{\beta}^{-1}}{\sigma(\bar{\beta}^{-1})}\right)^2}\Big|_p$, where $\sigma(\beta^{-1})$ is evaluated by propagating different time resolutions (25, 30, ..., 50ps).

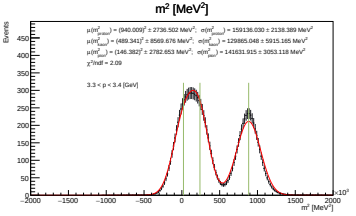


The histograms are filled using $w_p(m^2) = \frac{1}{\sigma(\bar{m}^2)\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{m^2-\bar{m}^2}{\sigma(\bar{m}^2)}\right)^2}\Big|_p$, where $\sigma(m^2)$ is evaluated by propagating different time resolutions (25, 30, ..., 50ps).

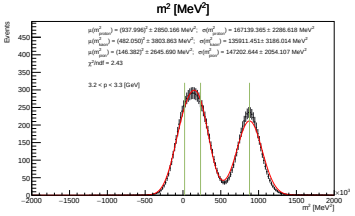


m^2 distributions at 3σ separation p-threshold for p/K^+: inclusive in η

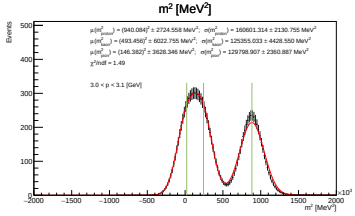
25ps time smearing

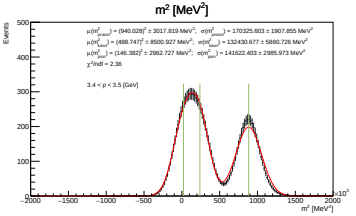


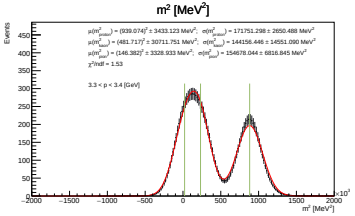
30ps time smearing

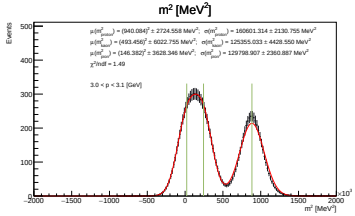


35ps time smearing



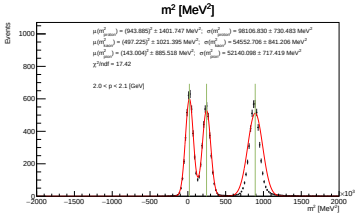




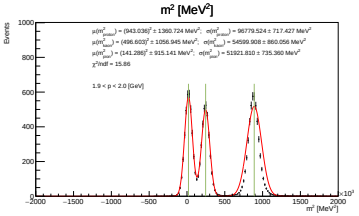


m^2 distributions at 3σ separation p-threshold for K^+/π^+: inclusive in η

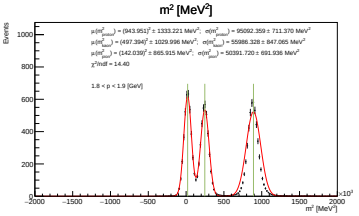
25ps time smearing

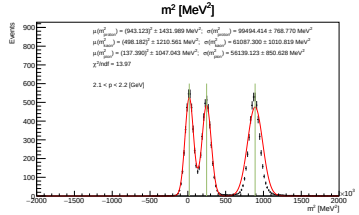


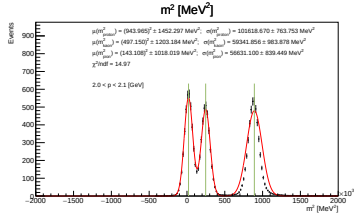
30ps time smearing

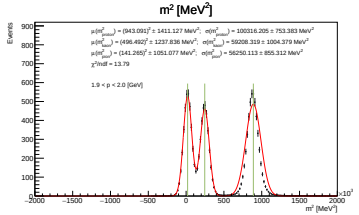


35ps time smearing



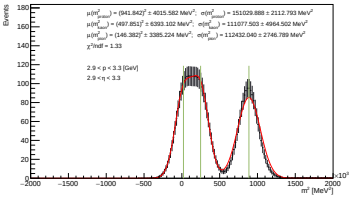




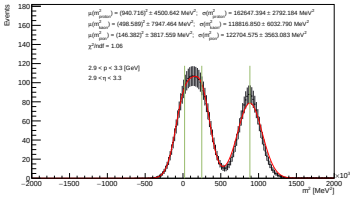


m^2 distributions at 3σ separation p-threshold for p/K^+: $2.65 < \eta < 2.80$

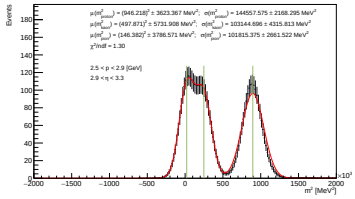
25ps time smearing

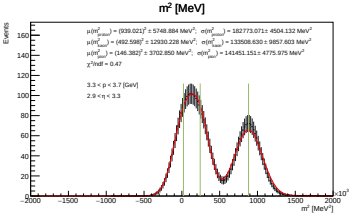


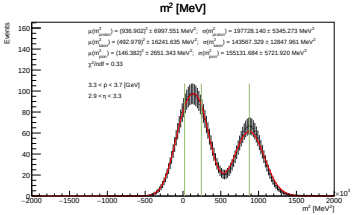
30ps time smearing

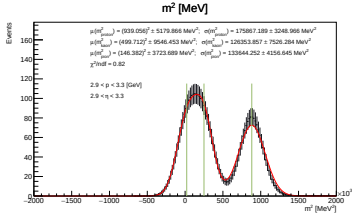


35ps time smearing



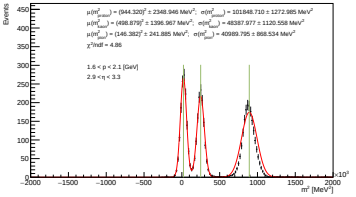




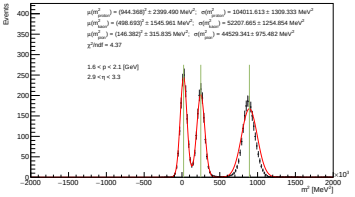


m^2 distributions at 3σ separation p-threshold for K^+/π^+: $2.65 < \eta < 2.80$

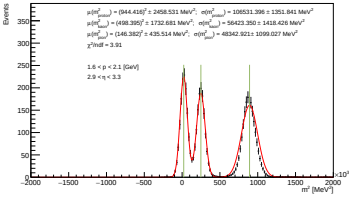
25ps time smearing

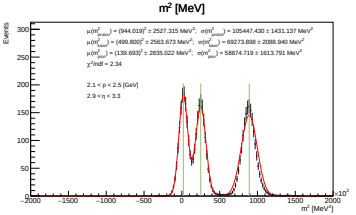


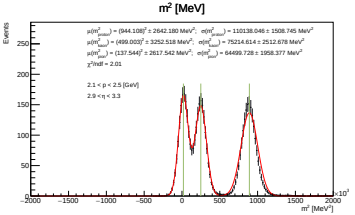
30ps time smearing

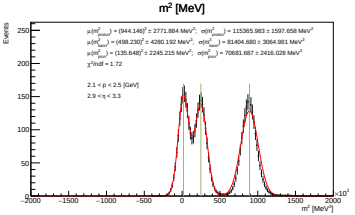


35ps time smearing

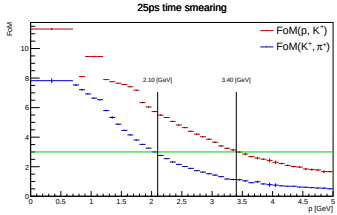


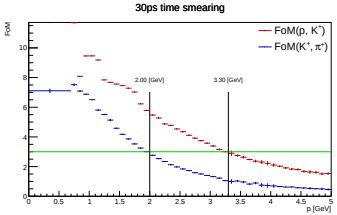


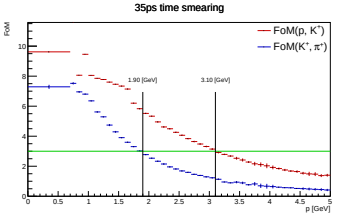


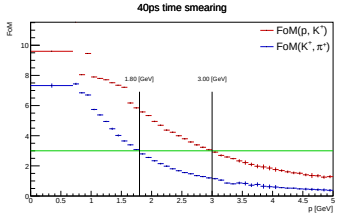


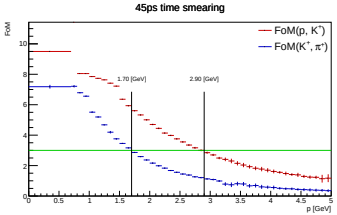
Separation power: inclusive in η

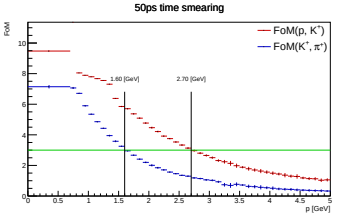




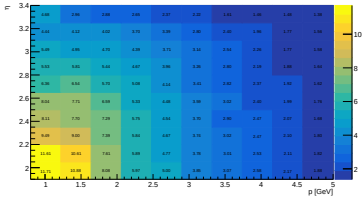


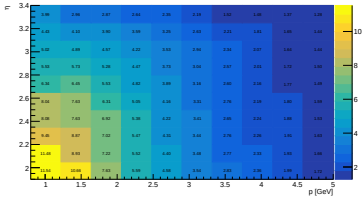


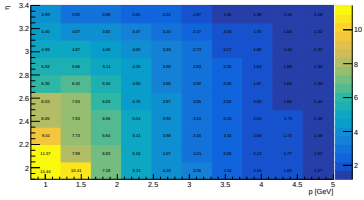


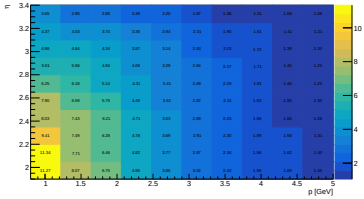


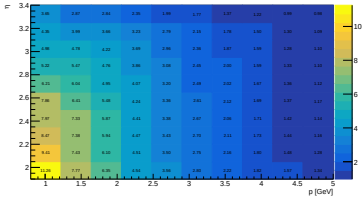
p/K^+ Separation power: per η bins

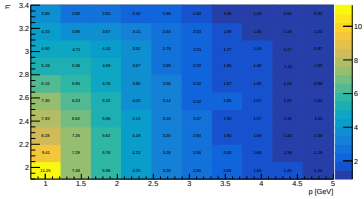




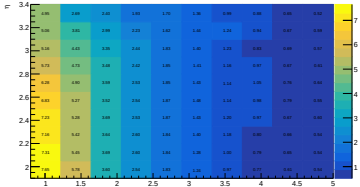


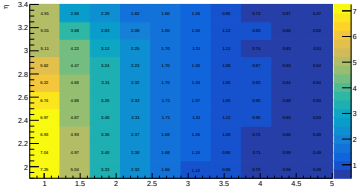


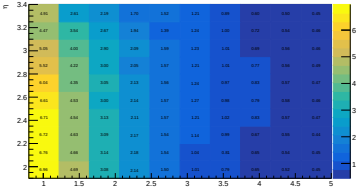


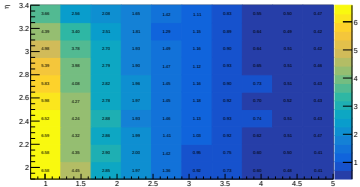


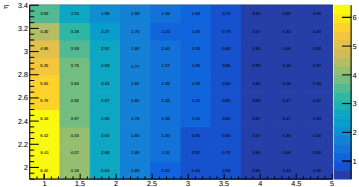
K^+/π^+ Separation power: per η bins

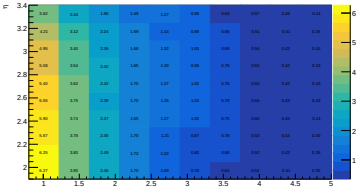






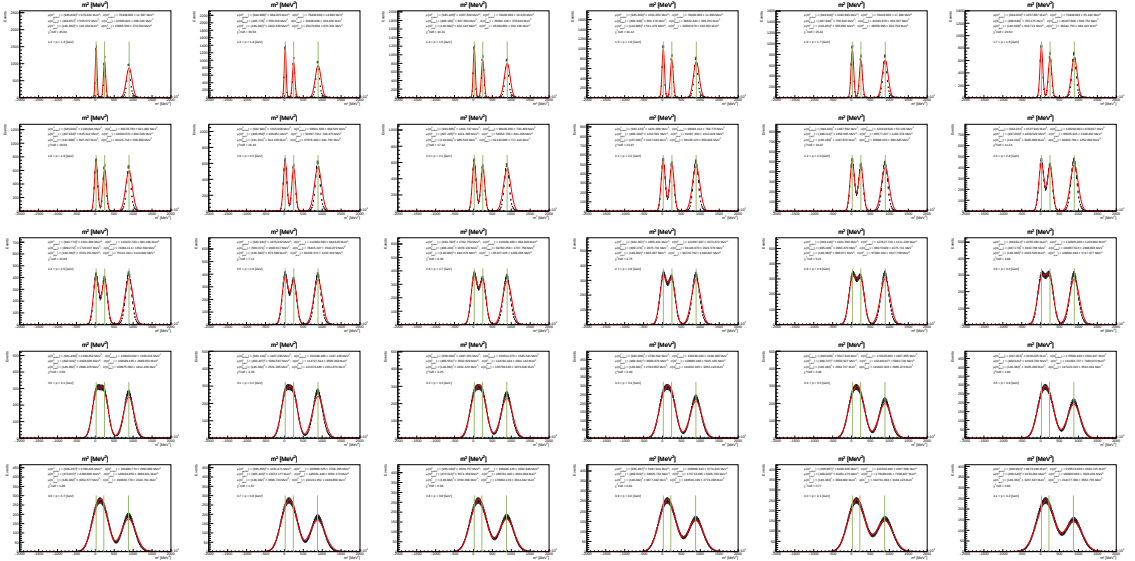




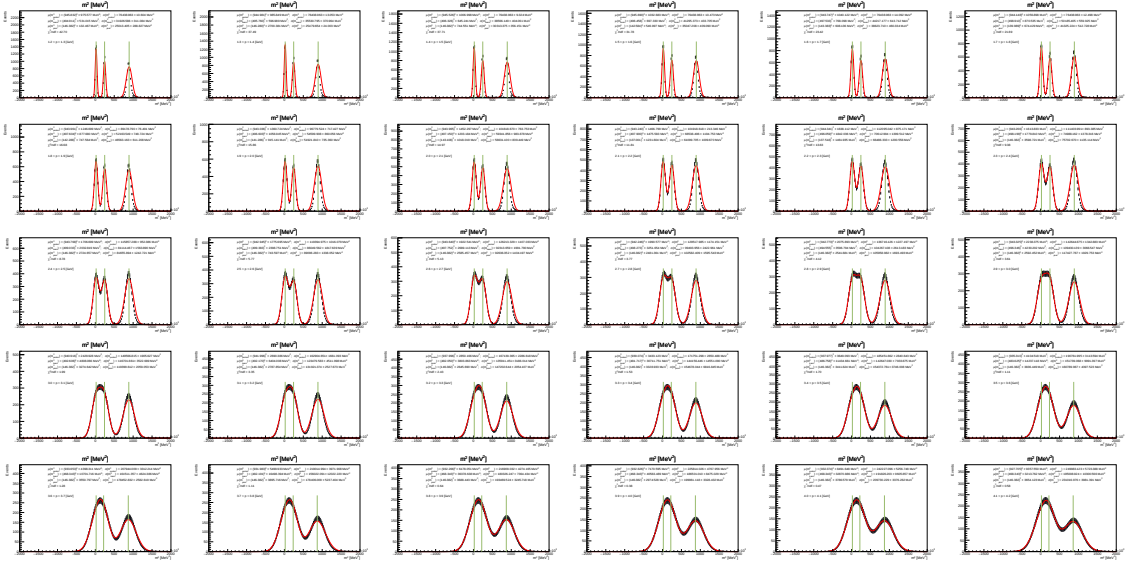


Back Up

m^2 slices: 25ps (inclusive in η)



m^2 slices: 30ps (inclusive in η)



m^2 slices: 35ps (inclusive in η)