Track Propagation in PandaRoot

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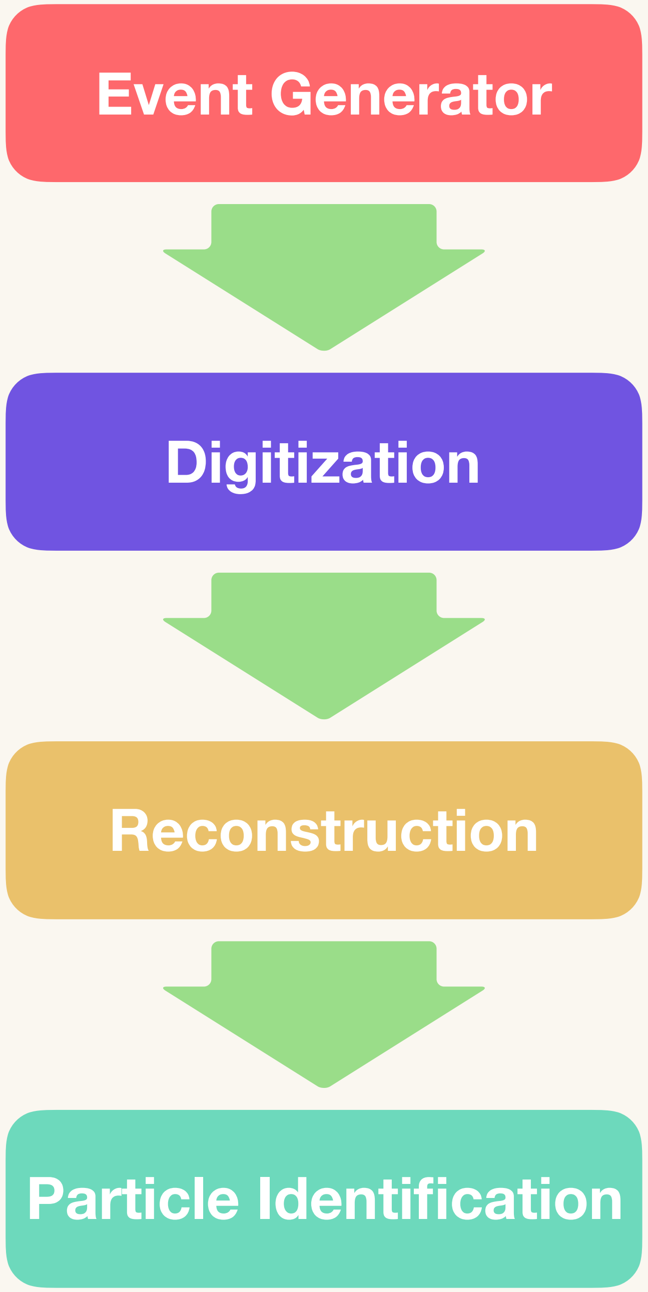
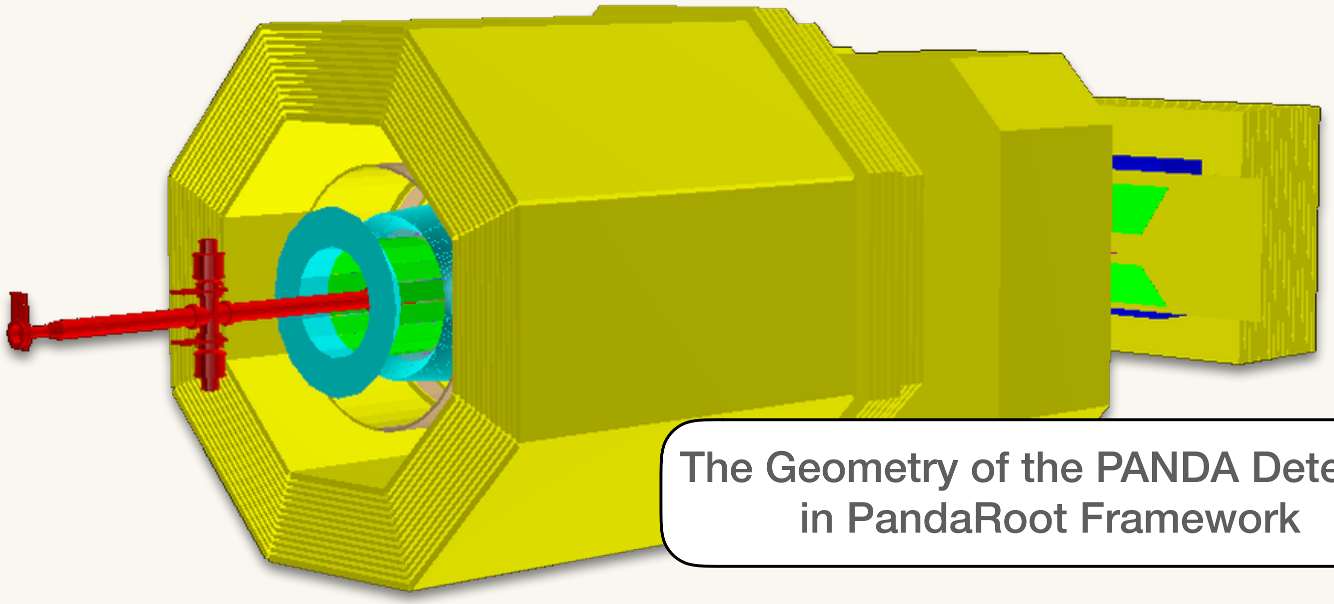
Outline

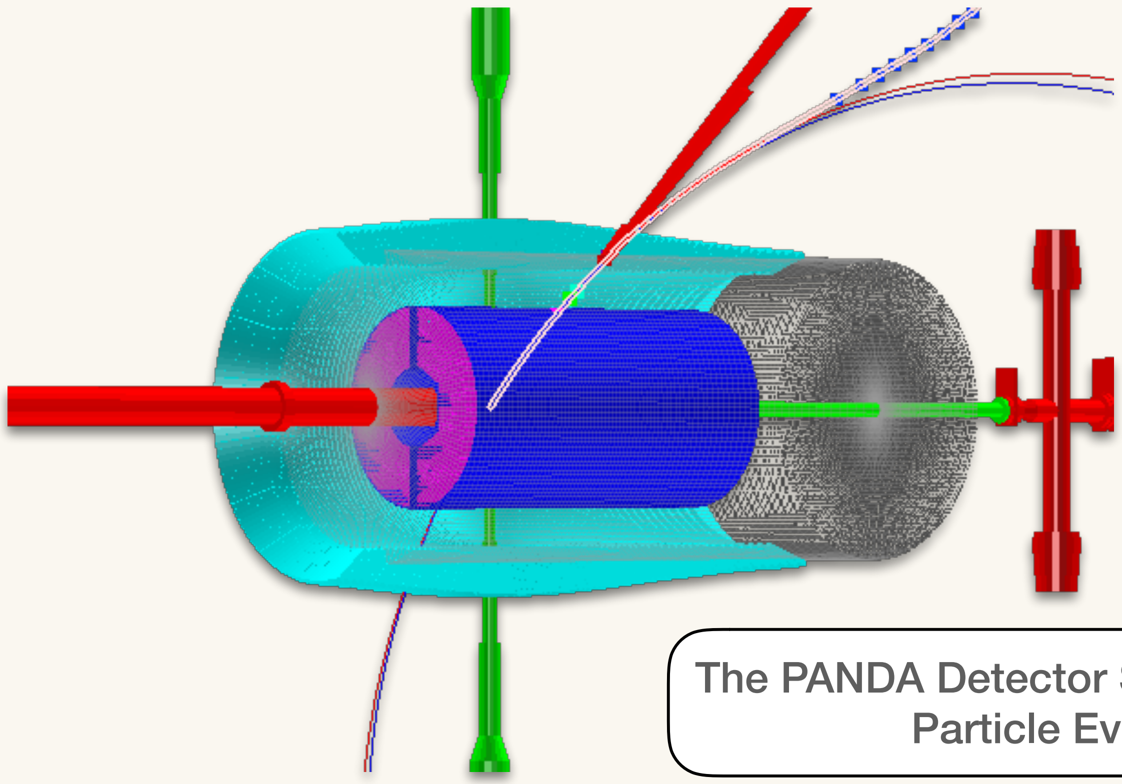
- **Introduction**
  - Reconstruction of Charged Particle Tracks in PandaRoot
  - Classification of EMC clusters
- **Methodology**
  - Verification Matches
  - Calculation of EMC Cut Parameter
  - Non-Constant EMC Cut
- **Results**
- **Conclusion**

PandaRoot, Monte Carlo Simulation





The Geometry of the PANDA Detector in PandaRoot Framework

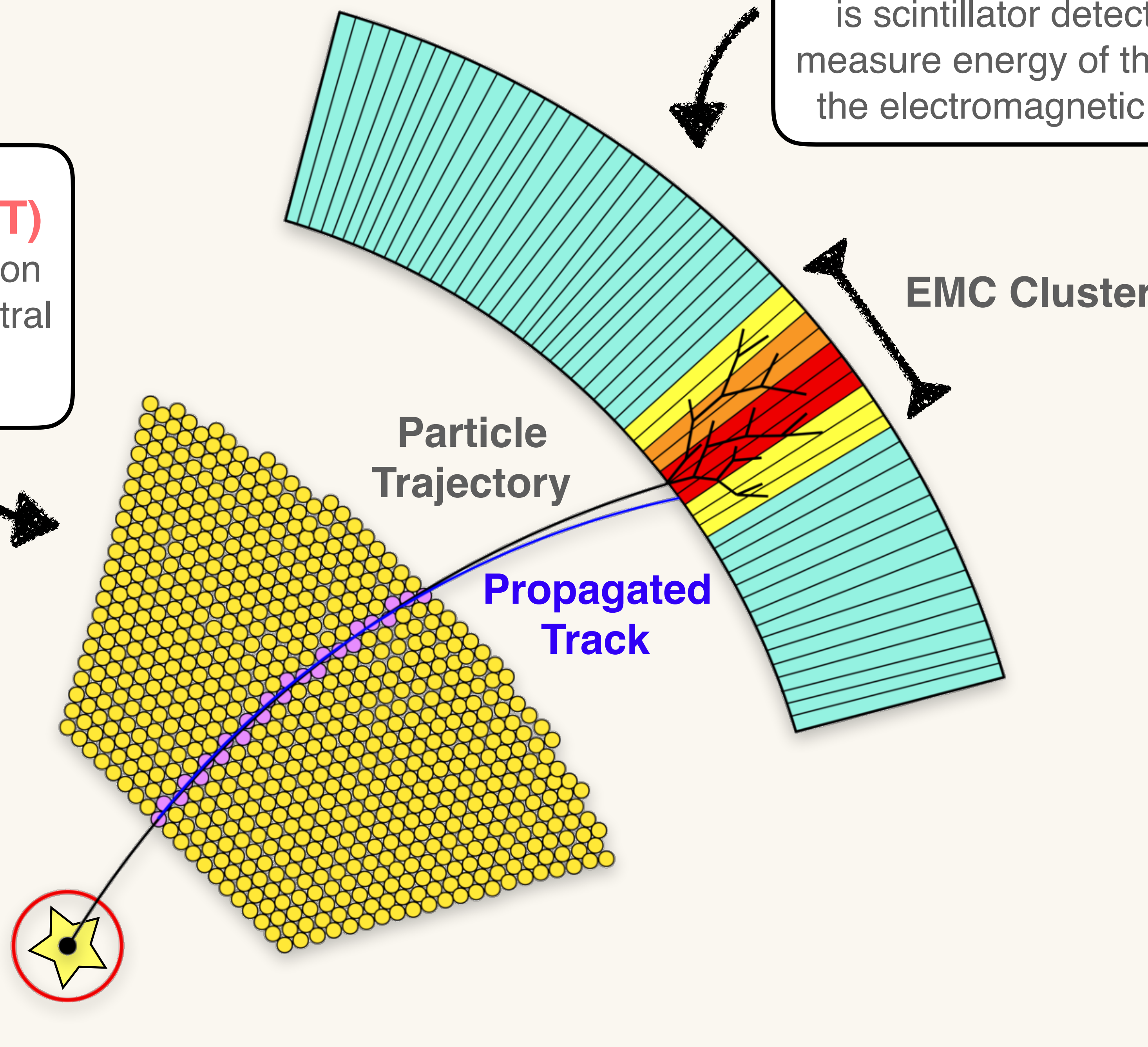


The PANDA Detector Simulation with Particle Events

Reconstruction of Charged Particle Tracks in PandaRoot

Electromagnetic Calorimeter (EMC)
is scintillator detector used to measure energy of the particle via the electromagnetic interaction.

Straw Tube Tracker (STT)
is one type of gaseous ionization chamber, they are used as central tracking system



Propagators

GEANE

Including energy loss,
Coulomb scattering, *B*-field

Linear Propagator

Straight line

$$\vec{x}_{lin}(t) = \vec{x}_e + t\,\vec{v}$$

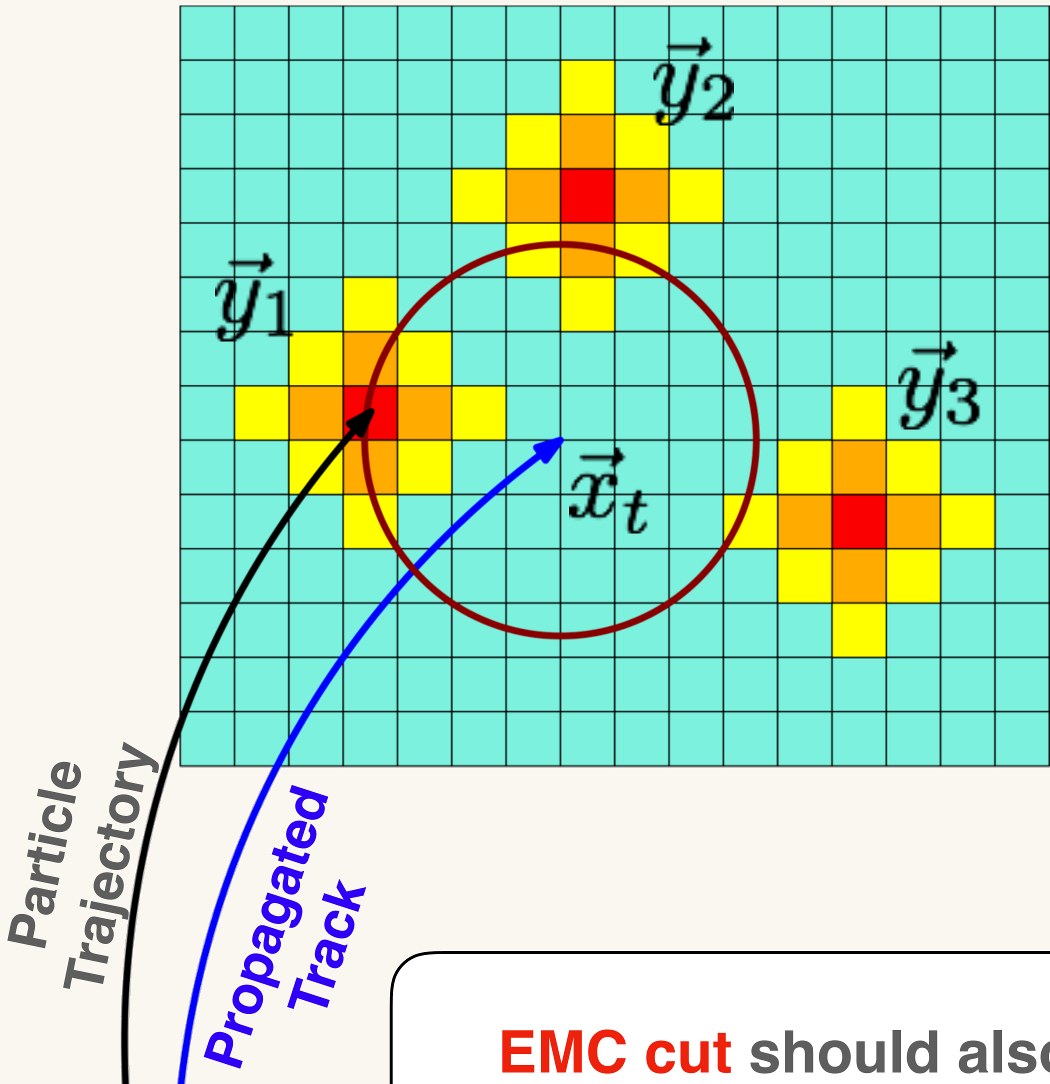
Helix Propagator

Including *B*-field

$$\vec{x}_{hel}(t) = \left(R\cos\omega t, R\sin\omega t, v_z t\right)$$

Classification of EMC Clusters

EMC clusters on EMC Surface



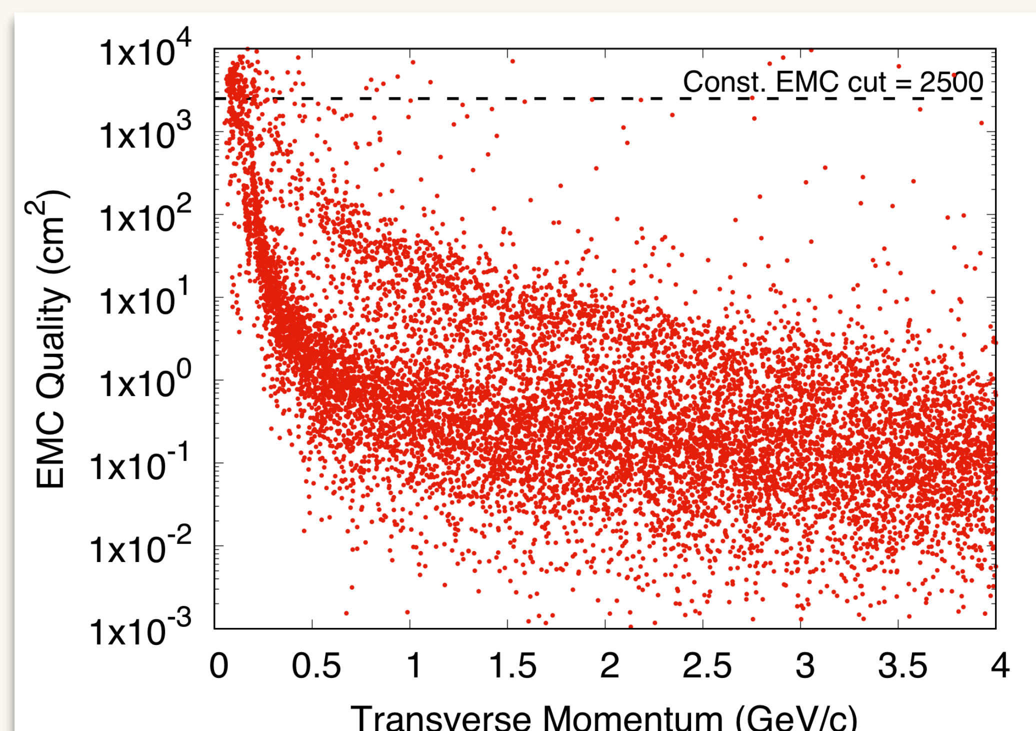
To classify the associated EMC clusters with the propagated point, we consider

- Time when the particle reaches EMC surface.
- The closest cluster to the propagated point, define:

$$\text{EMC Quality} = \min\{(\vec{x}_t - \vec{y}_i)^2\}$$

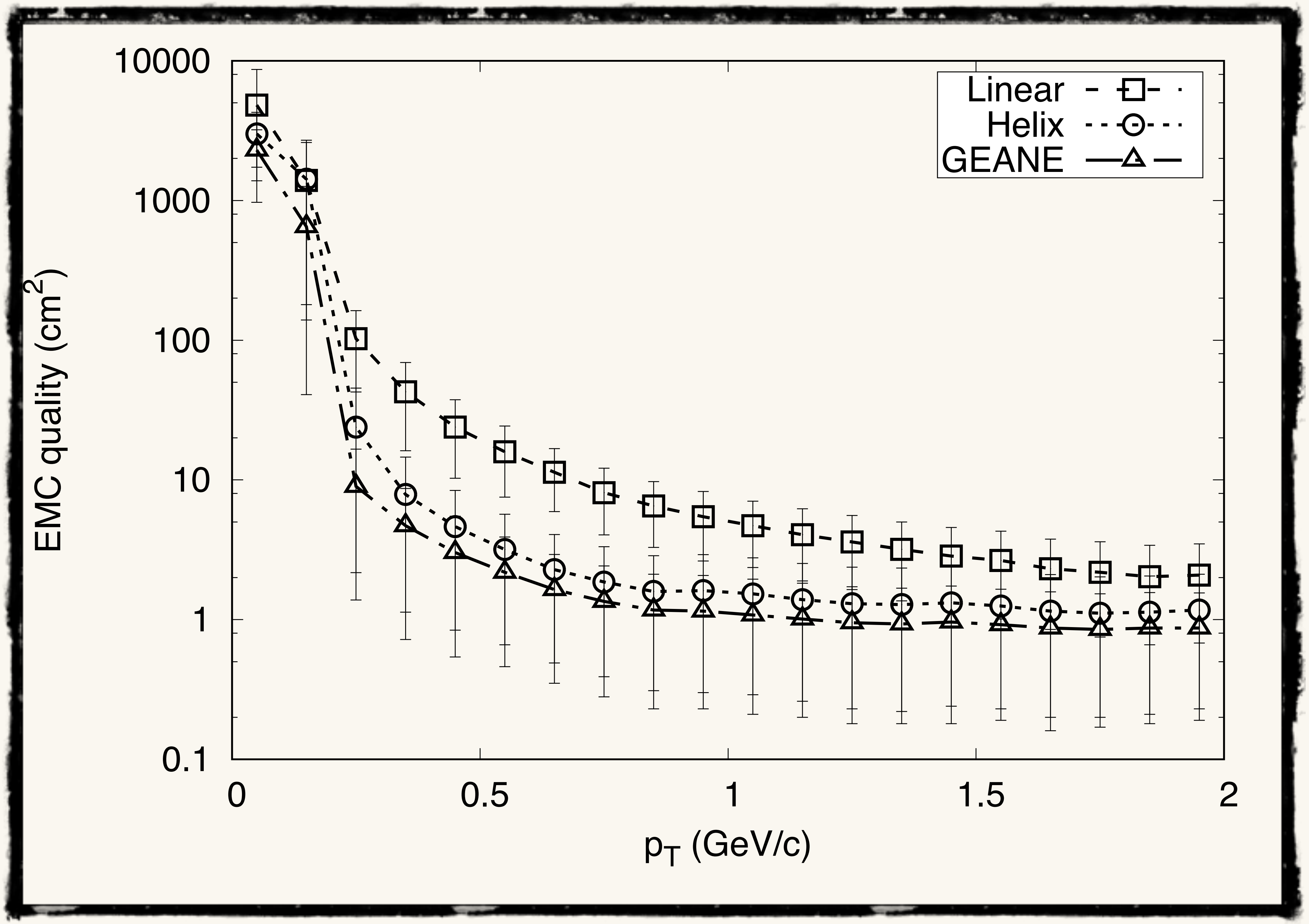
- The distance must below a cut off parameter, which is equal to 2,500 cm^2.

EMC cut should also depend on transverse momentum.

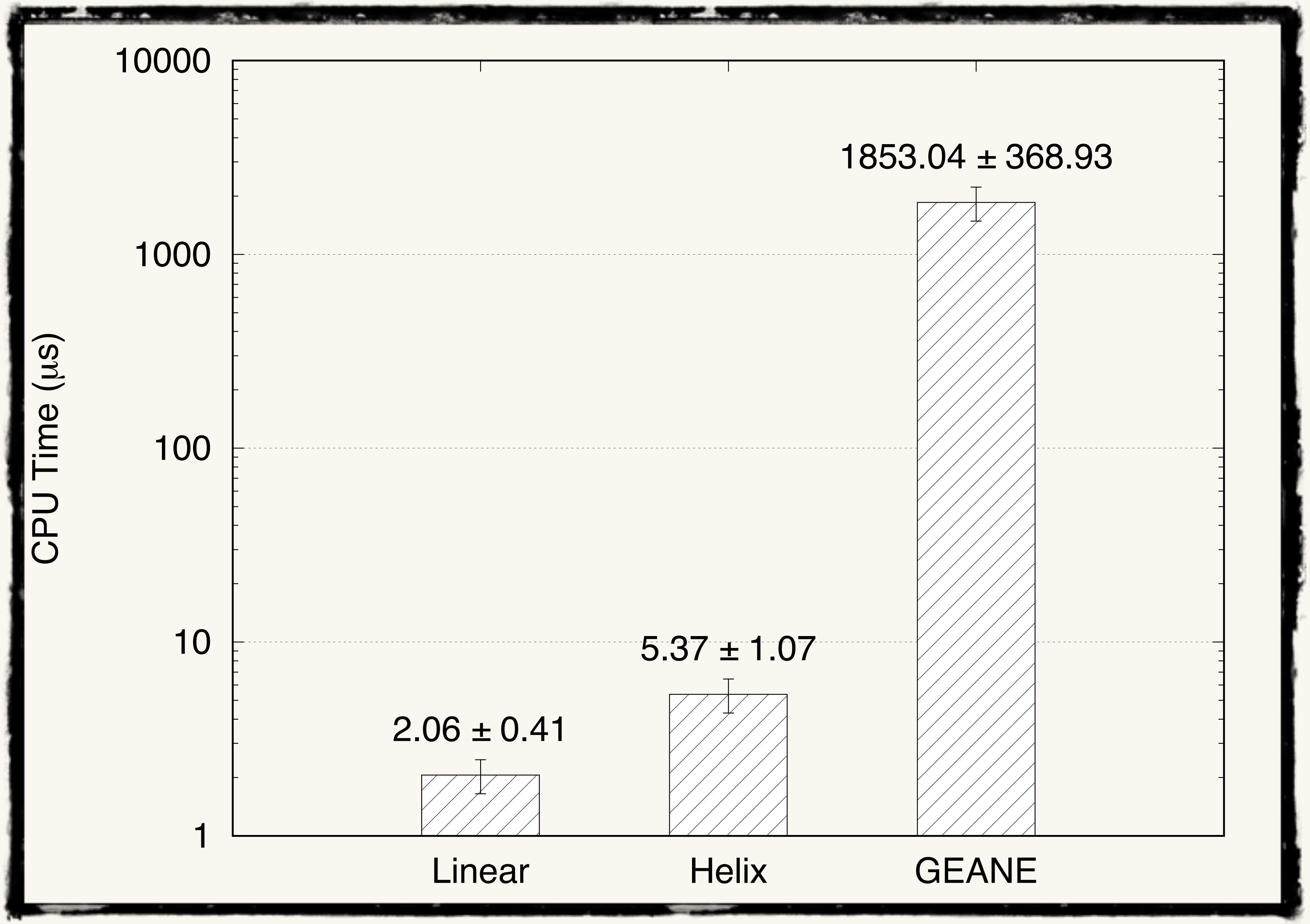


The EMC quality as function of transverse momentum for single-electron events.

Propagators



Propagators - CPU time



Verification Matches

Box Generator
Generate single-particle event.

Monte Carlo Truth Information
ID of signal stored in root files.

Number of Tracks per Event

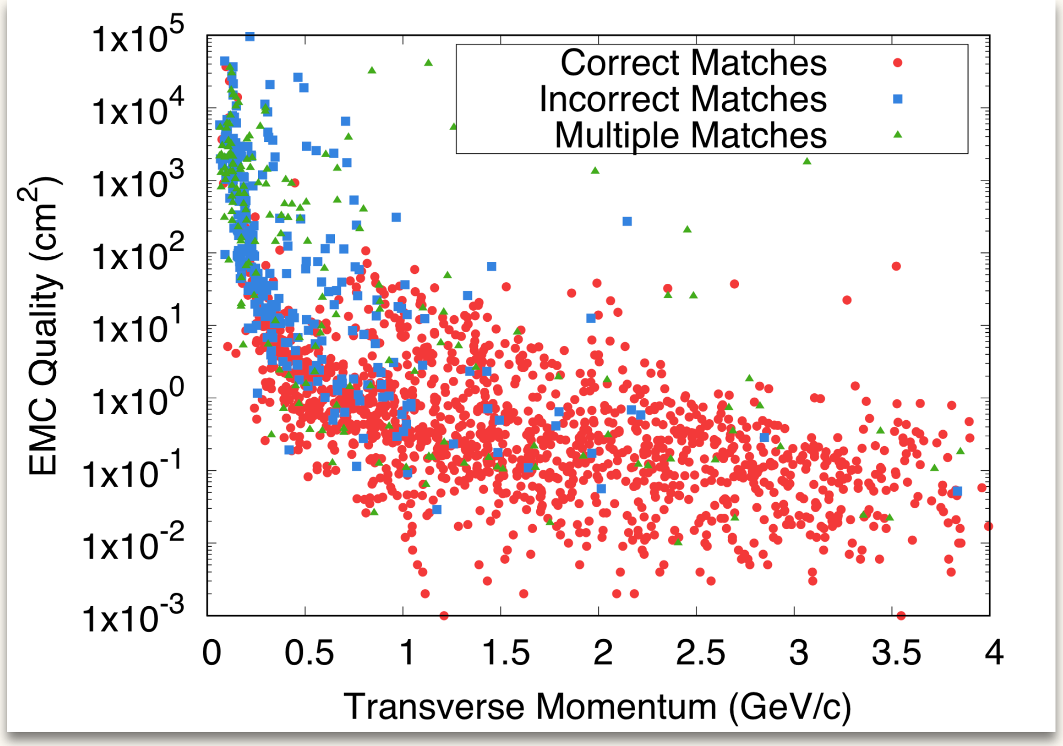
ID of Propagated Track

ID of EMC cluster

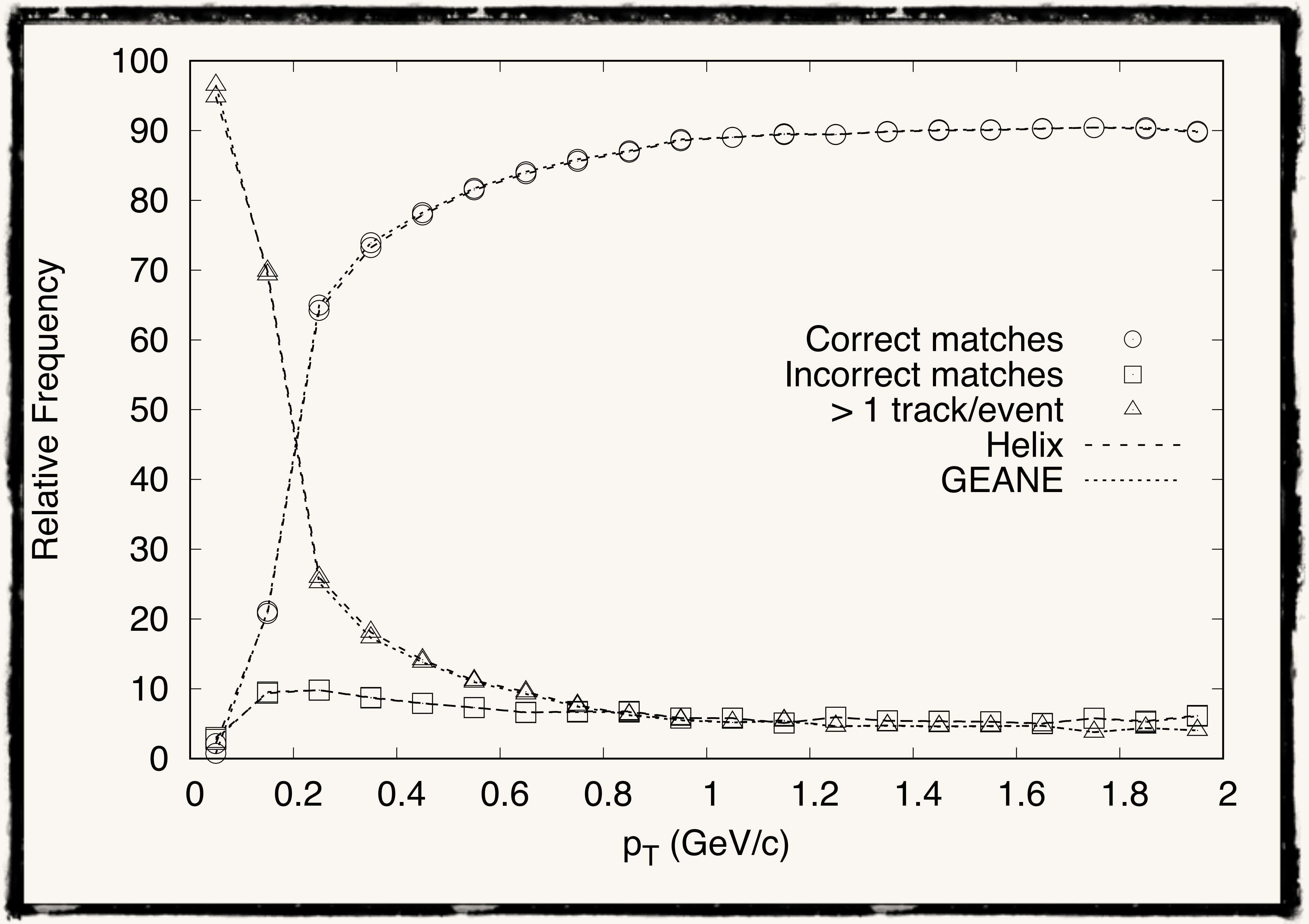
Multiple Match
Events with more than one track

Correct Match
Track and Cluster come from the same MCTrack

Incorrect Match
track and Cluster come from different MCTracks



Verification Matches



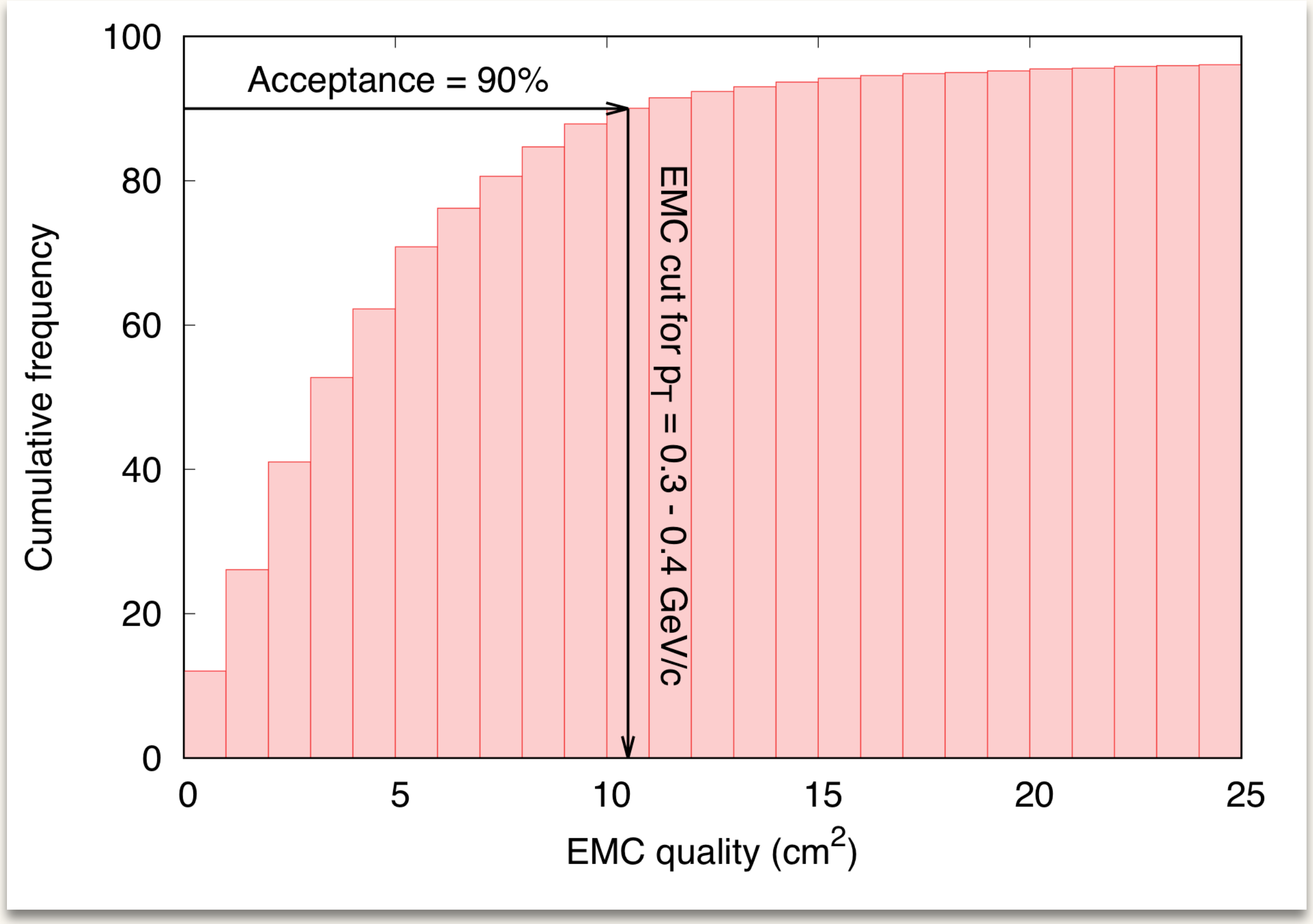
Calculation of EMC Cut Parameters

Acceptance percentage

- The ratio of the number of correct matches with EMC quality less than EMC cut to the total number of correct matches

$$P = \frac{\#\text{correct matches}\{\text{EMC quality} < \text{EMC cut}\}}{\text{Total}\#\text{correct matches}}$$

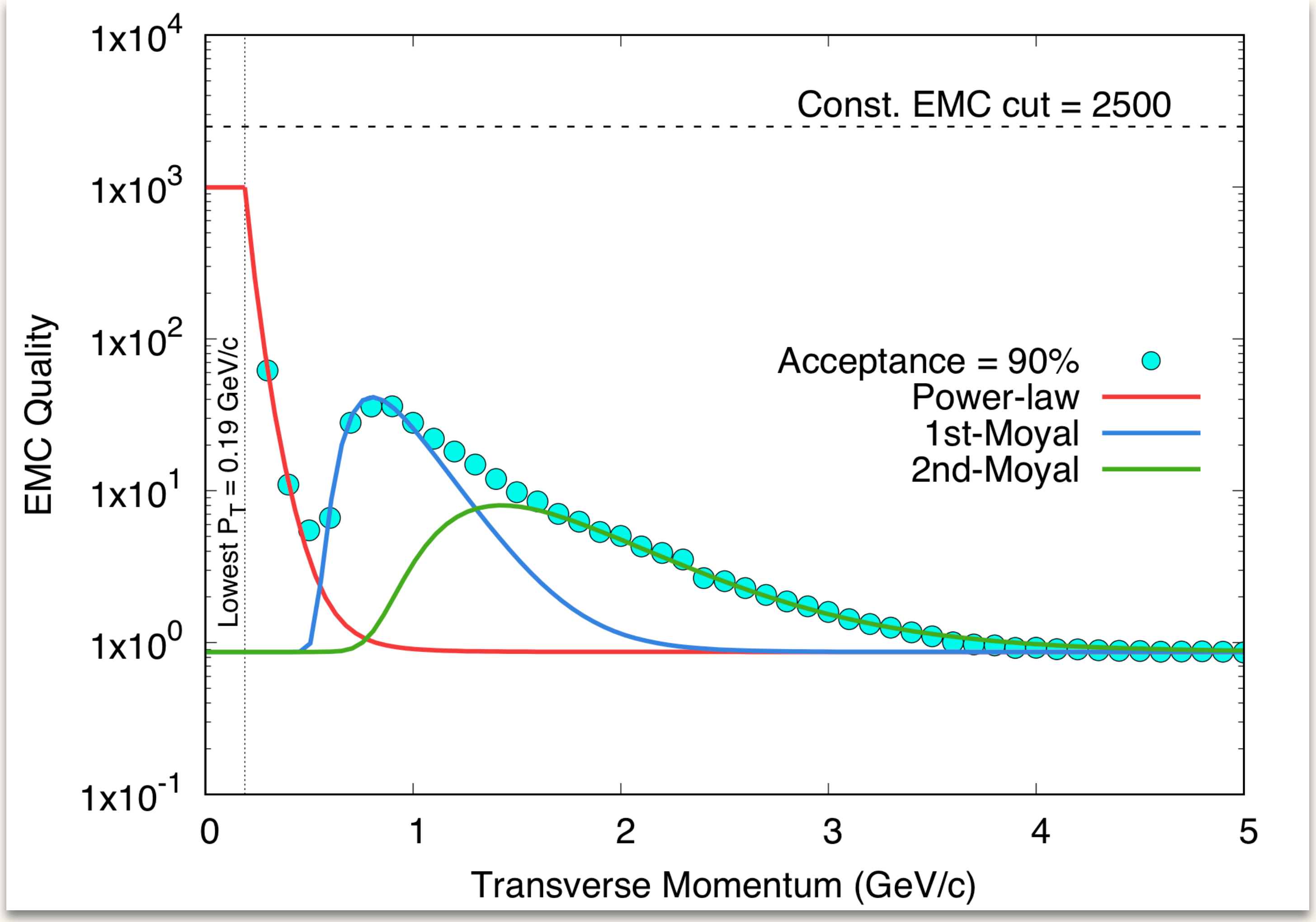
- We use this parameter to calculate the EMC cut by finding the EMC quality that provides cumulative frequency equal to P



The cumulative frequency of EMC quality for single-electron event in transverse momentum range 0.3 - 0.4 GeV/c

Acceptance percentages: 85%, 90%, 95%
Perform this for all 0.1 GeV/c width p_T bins.

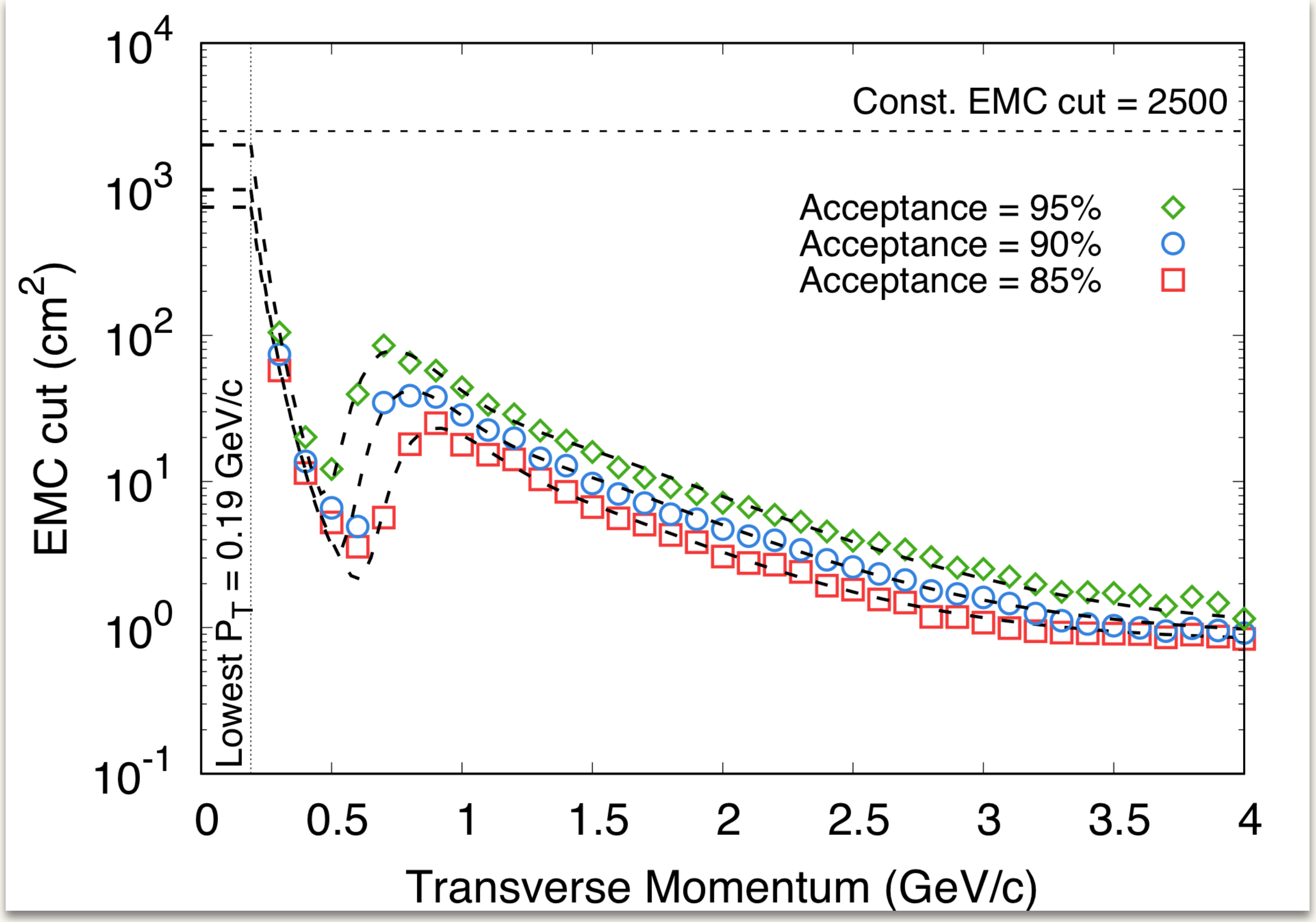
Parametrized EMC Cut



$$c(p_T) = E_0 + (ap_T)^{-k} + \frac{E_{A,1}}{\sqrt{2\pi\sigma_1}} e^{-\frac{1}{2}(x_1 + e^{-x_1})} + \frac{E_{A,2}}{\sqrt{2\pi\sigma_2}} e^{-\frac{1}{2}(x_2 + e^{-x_2})}, \text{where } x_i = \frac{p_T - \mu_i}{\sigma_i}$$

Power-law | **1st-Moyal** | 2nd-Moyal

Parametrized EMC Cut



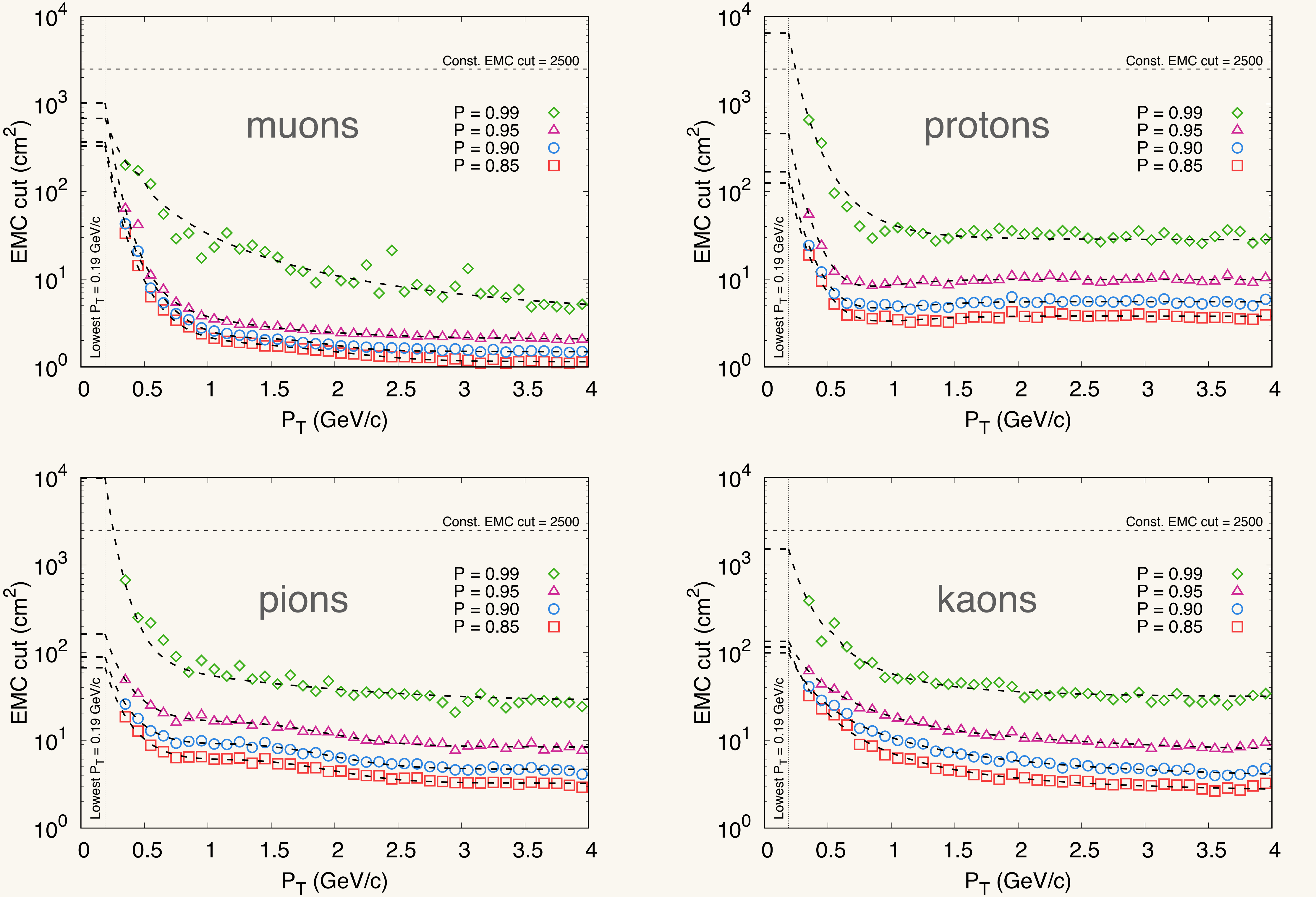
The EMC cut for electrons as function of transverse momentum, for different acceptances

table of fit parameters for electrons

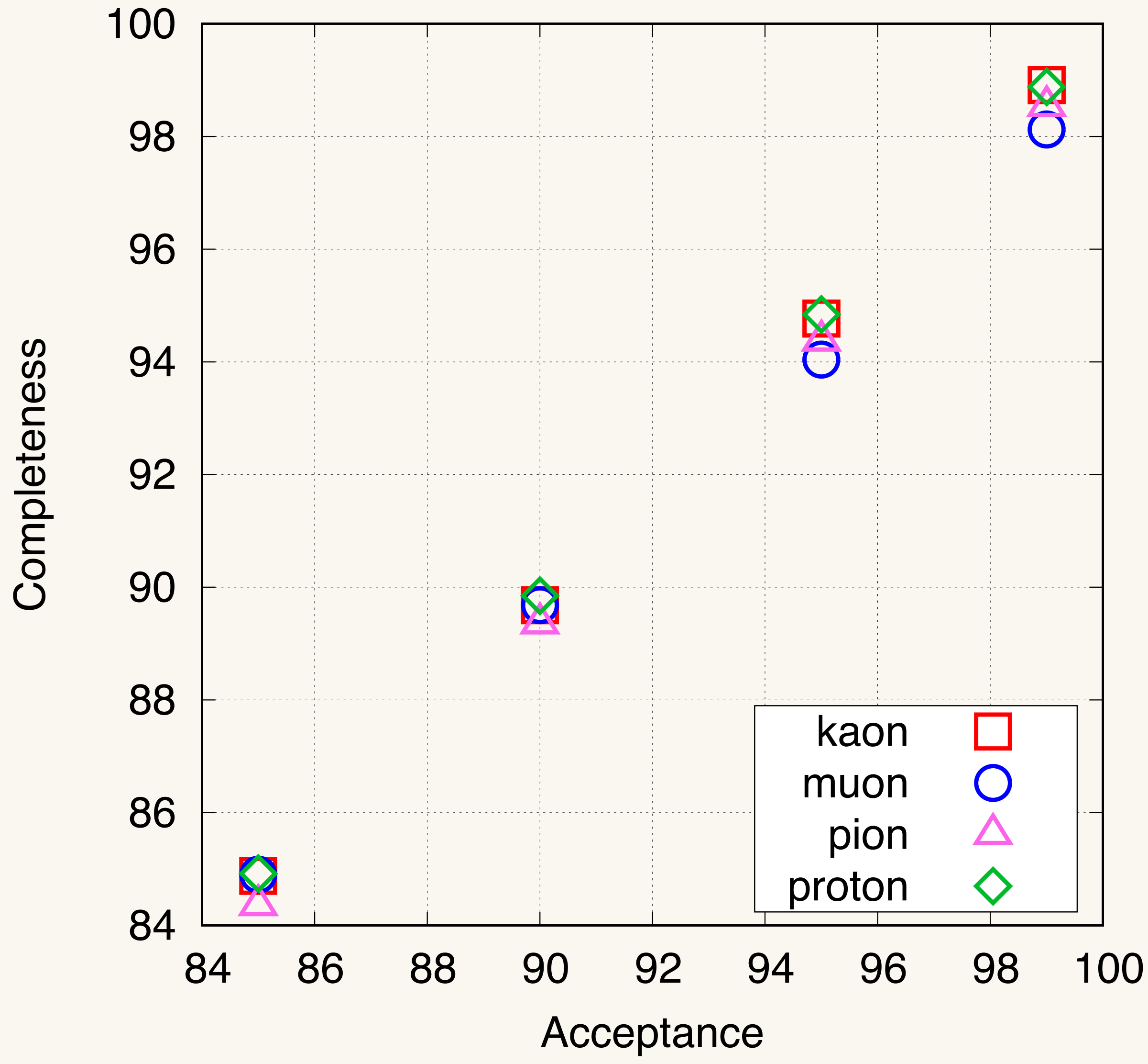
Acceptance	85%	90%	95%
E_0	0.796	0.869	0.954
a	1.634	1.699	1.629
k	5.664	6.104	6.486
$E_{A,1}$	10.820	18.259	34.542
σ_1	0.118	0.109	0.108
μ_1	0.904	0.803	0.734
$E_{A,2}$	3.699	8.121	14.156
σ_2	0.271	0.275	0.285
μ_2	1.543	1.426	1.408
χ^2/ndf	0.357	0.991	9.278

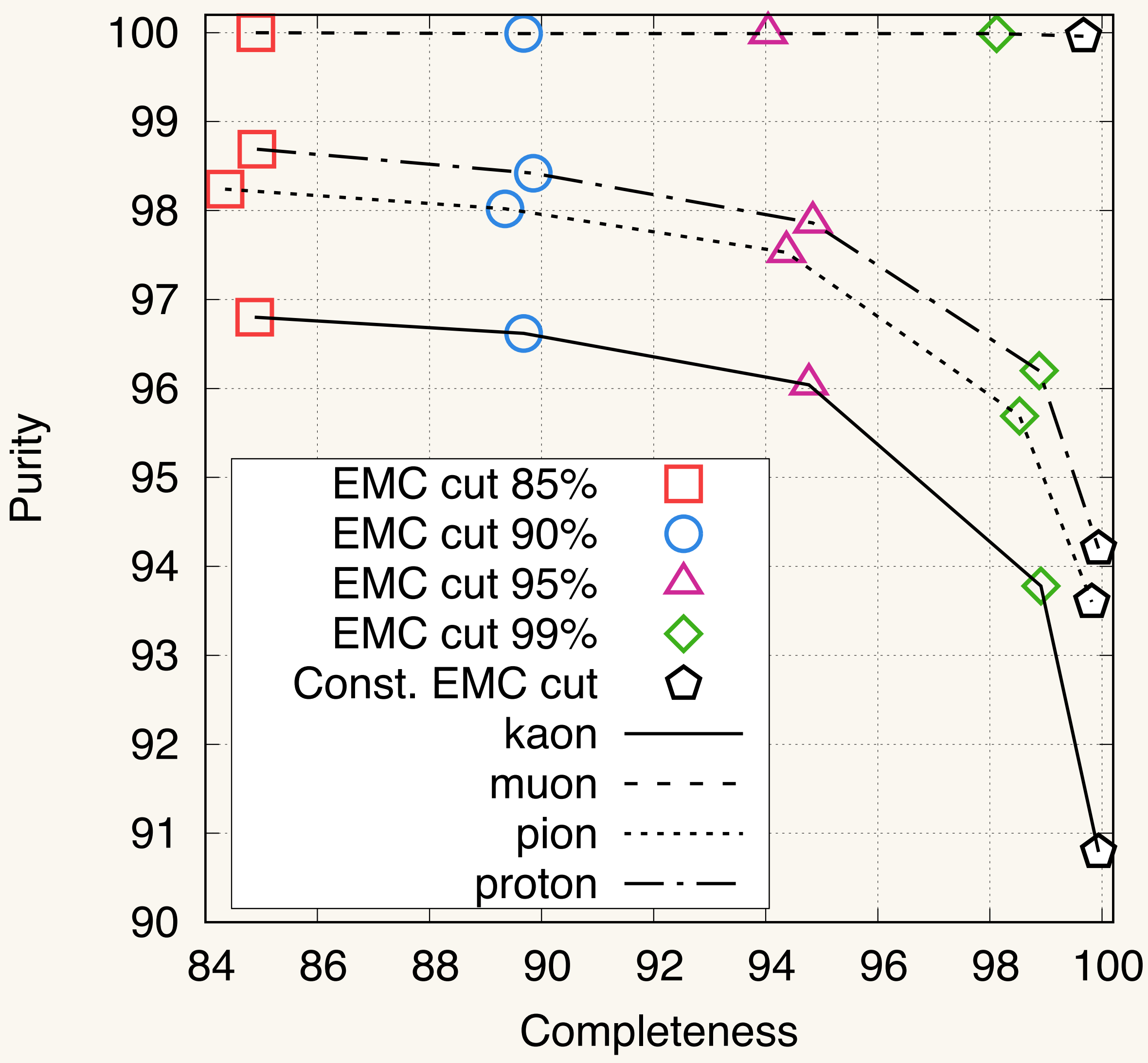
Next step:
Testing function
(During design algorithm)

Parametrized EMC Cut



Parametrized EMC Cut





Issues and Further Work

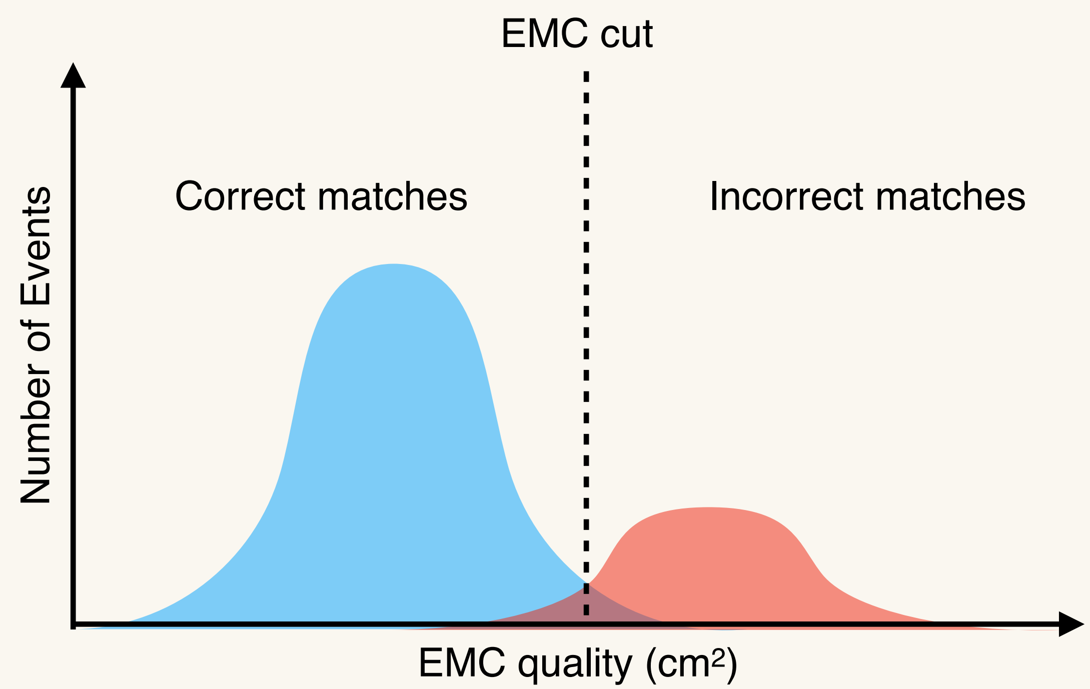
Issues

- Which "**Acceptance**" is the best to classify EMC clusters?
- How do we know the model is **correct**?

Machine Learning

- Binary classification
- EMC quality, p_T, and particle species as input
- Correct and incorrect matches as output

Compare the results from these two



Binary classification of EMC cut.

Conclusion

- Helix propagator gives similar precision as GEANE
- Helix gains ~30% speed in pid
- p_T-dependent EMC cut seems sensible
- Gain in purity up to 5 - 6% compared to constant EMC cut

Thank You …

… and see you in Krabi, March 11-15, 2019!