# Study of a non-constant EMC cut Parameter of Electron and Positron Tracks with Clusters in the Calorimeter of the PANDA Experiment

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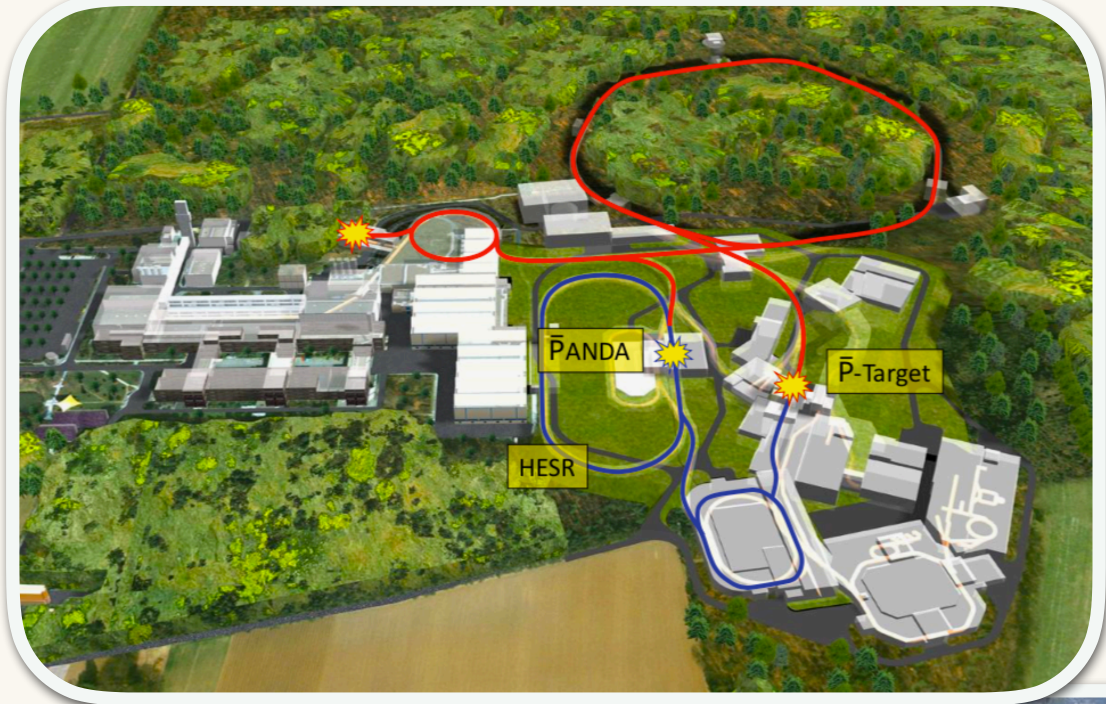
# PANDA Experiment

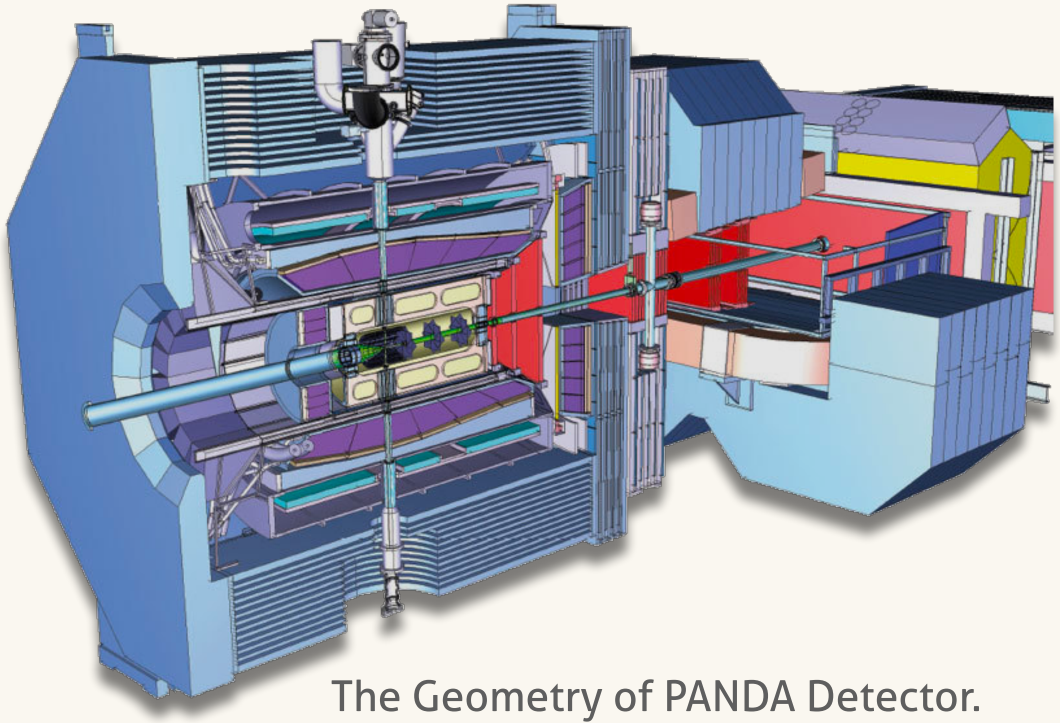


GSI Helmholtz Centre for Heavy Ion Research

Facility for Antiproton and Ion Research

antiProton ANnihilation at DArmstadt

The construction site of PANDA experiment, taken on September 3, 2017 (photo: Till Middelhauve for FAIR)



The Geometry of PANDA Detector.
Retrieved from https://panda.gsi.de/oldwww/framework/detector.php

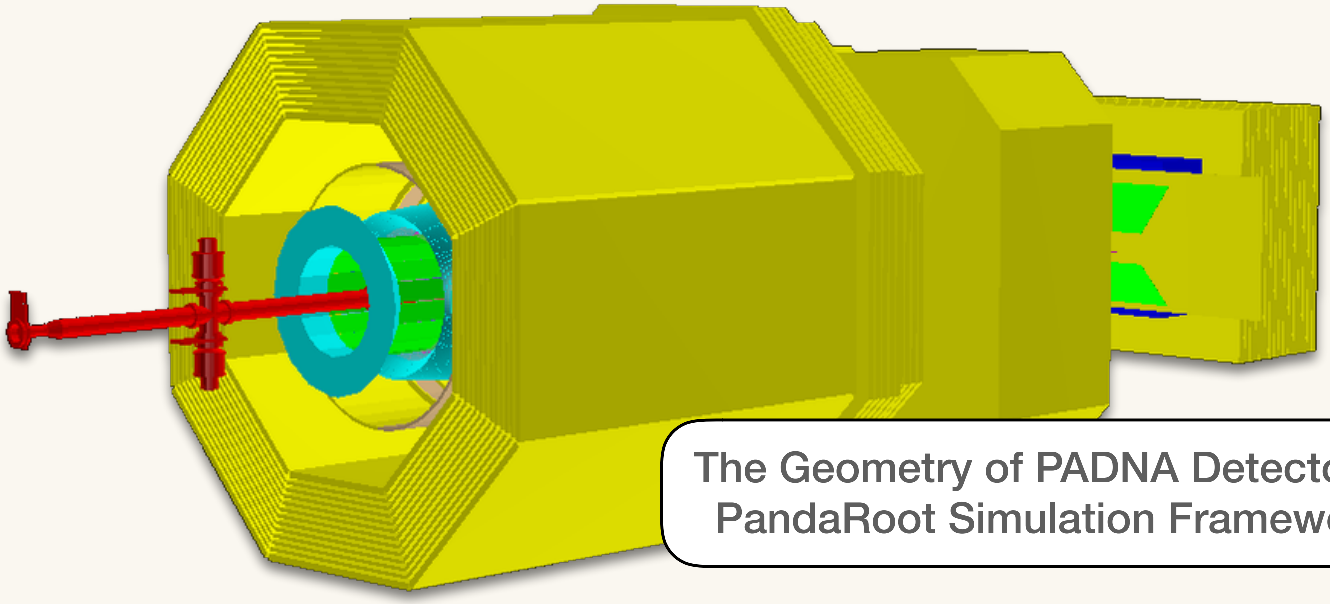
# PandaRoot, Monte Carlo Simulation

**Event Generator**

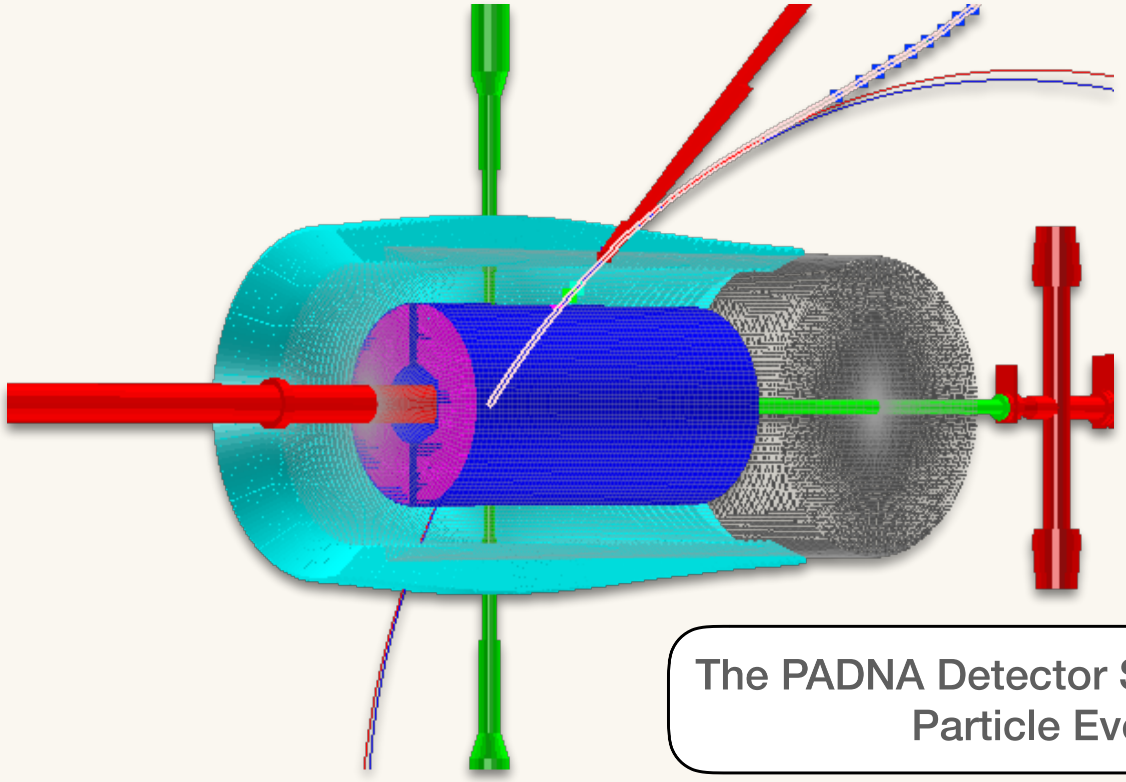
**Digitization**

**Reconstruction**

**Particle Identification**



The Geometry of PADNA Detector in PandaRoot Simulation Framework

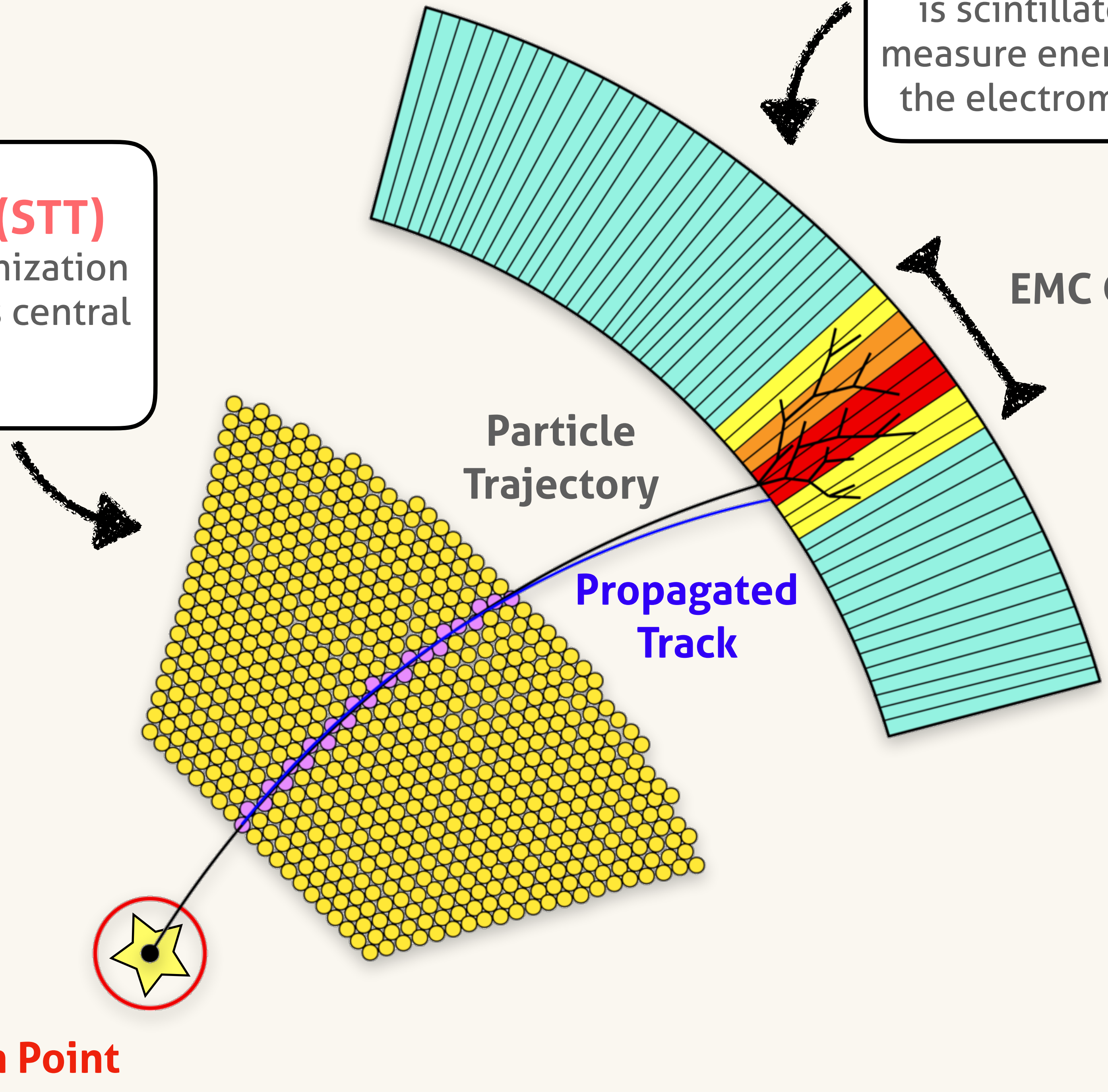


The PADNA Detector Simulation with Particle Events

# Reconstruction of Charged Particle Tracks in PandaRoot

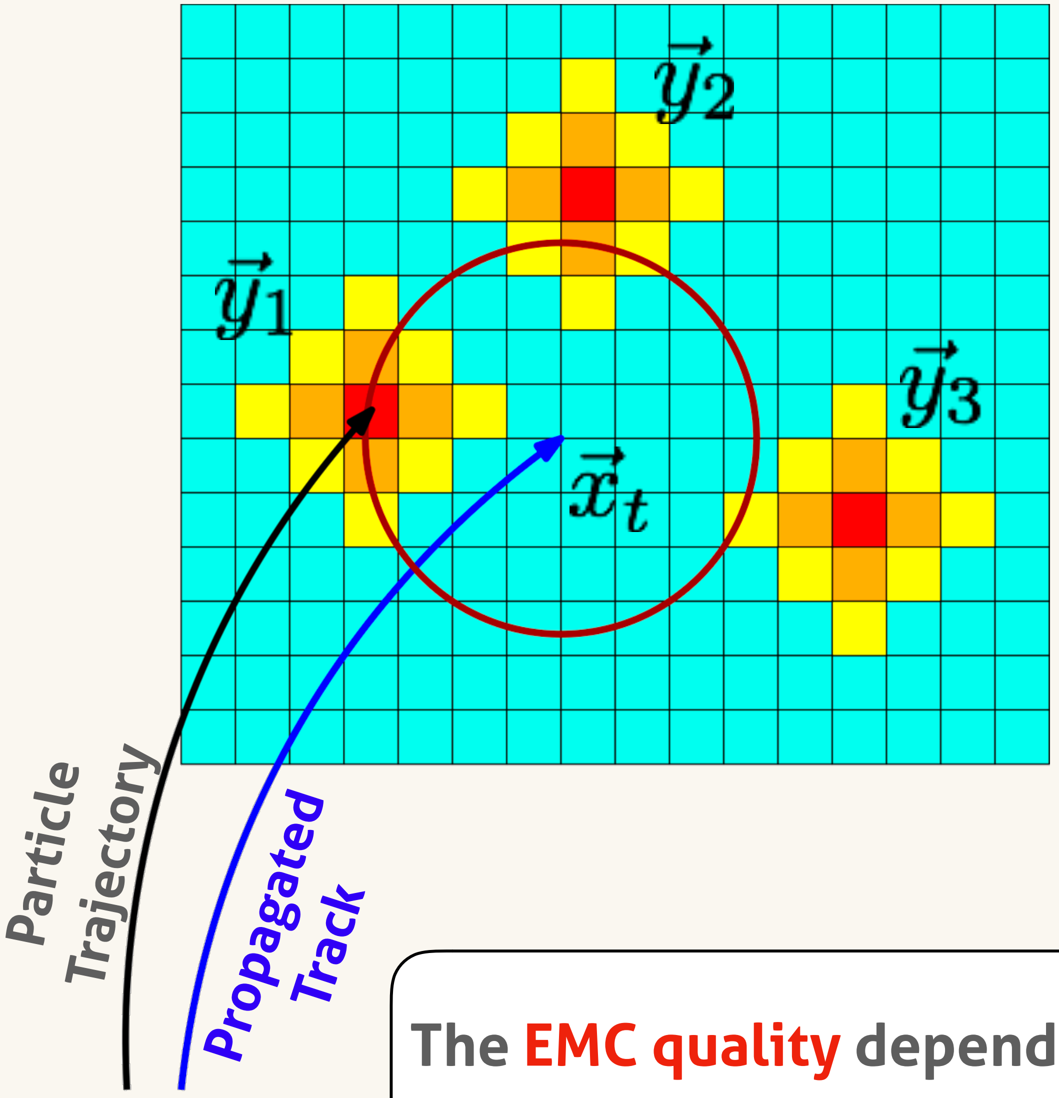
**Electromagnetic Calorimeter (EMC)**
is scintillator detector used to measure energy of the particle via the electromagnetic interaction.

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



# Classification of EMC Clusters

**Three EMC clusters on EMC Surface**

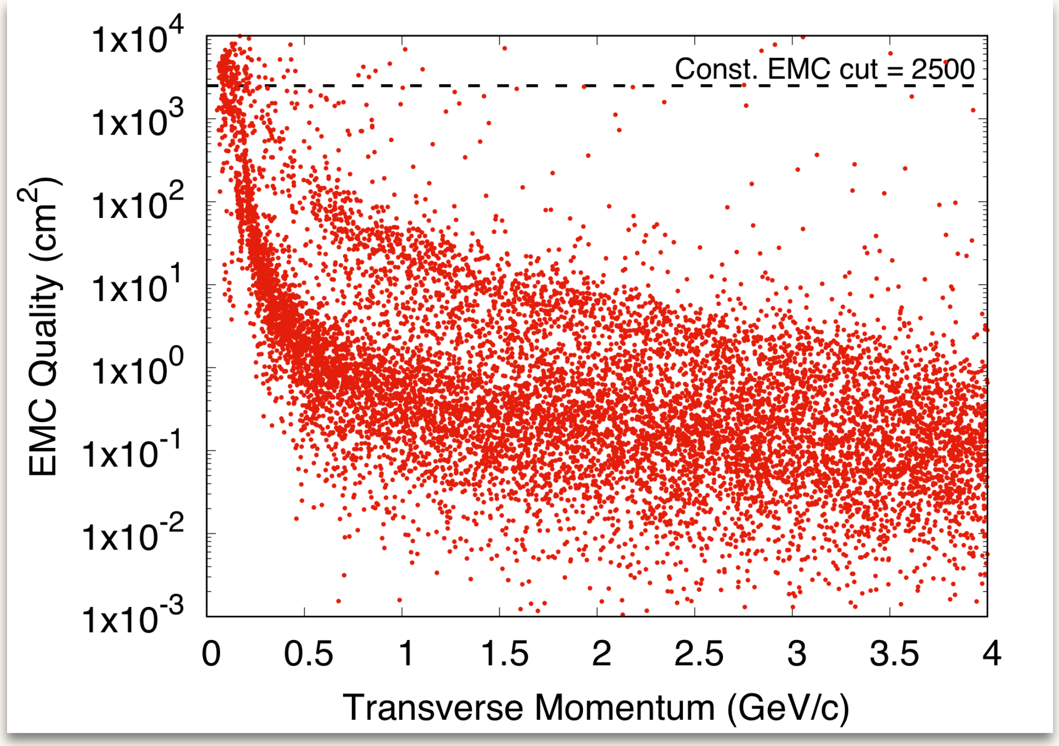


To classify the associated EMC clusters with the propagated point, we consider

- Time when the particle reach EMC surface.
- The closest cluster to the propagated point, which the shortest distance is defined by

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

- The distance must below a cut off parameter, which is equal to 2,500 cm².



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

**The EMC quality depends on transverse momentum. EMC cut should also depend!**

# Verification Matches

**Box Generator**
Generate single-particle event.

**Monte Carlo Truth Information**
ID of signal that stores in root files.

**Number of Track Per Event**

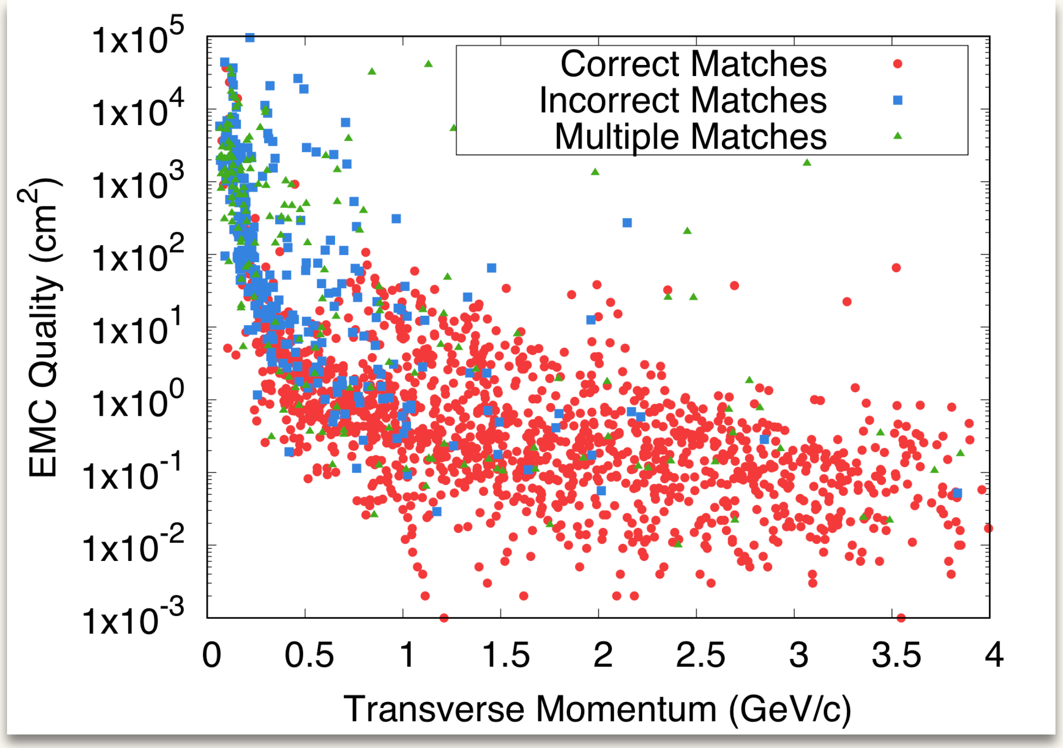
**ID of Propagated Track**

**ID of EMC cluster**

**Multiple Match**
More than one track in these events.

**Correct Match**
Track and Cluster come from the same MCTrack.

**Incorrect Match**
track and Cluster come from the different MCTrack.



The EMC quality where we distinguish between correct matches, incorrect matches, and multiple matches

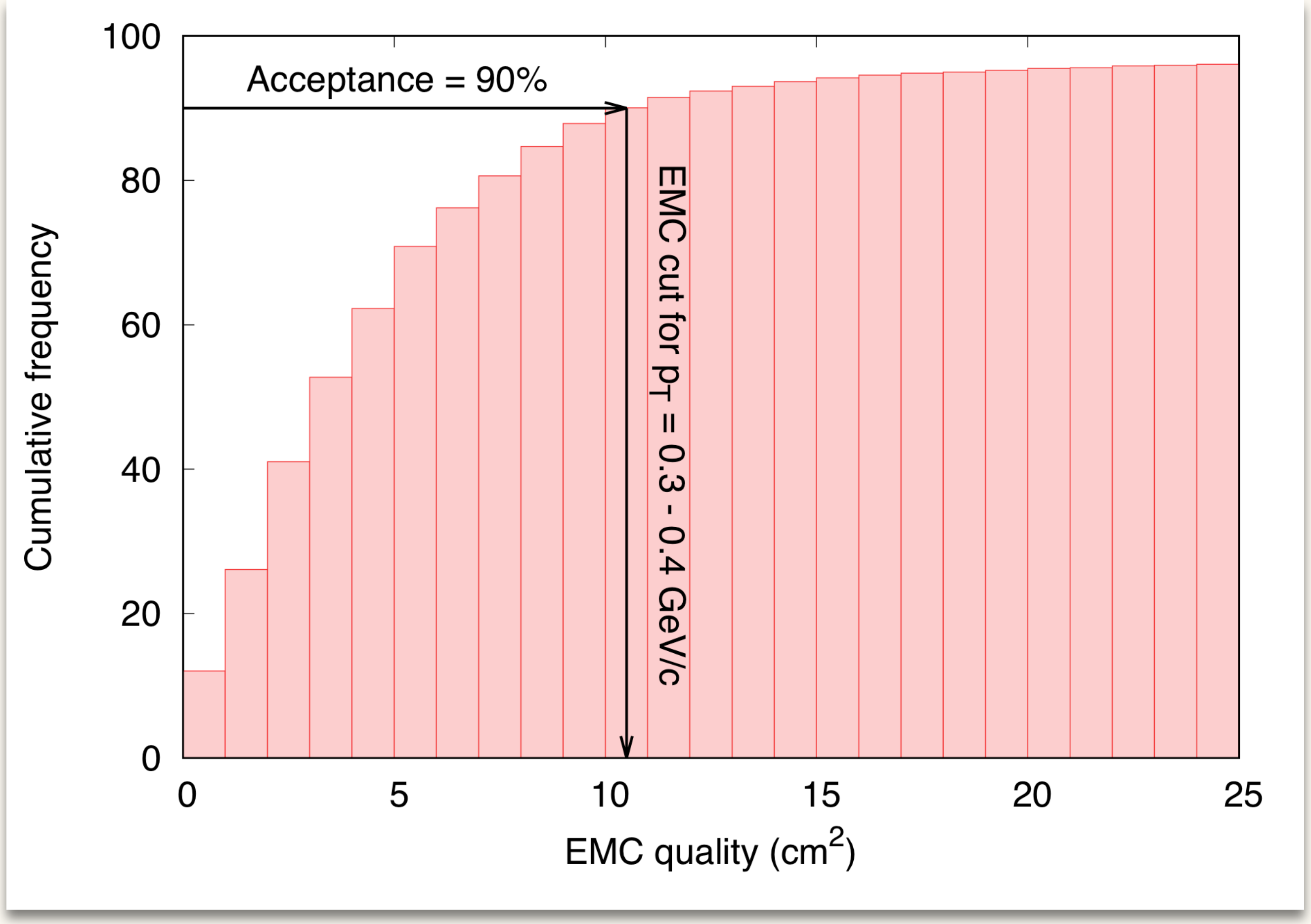
# Calculation of EMC Cut Parameters

## Acceptance percentage

- The ratio of number correct matches that has EMC quality less than EMC cut to the total number of correct matches.

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

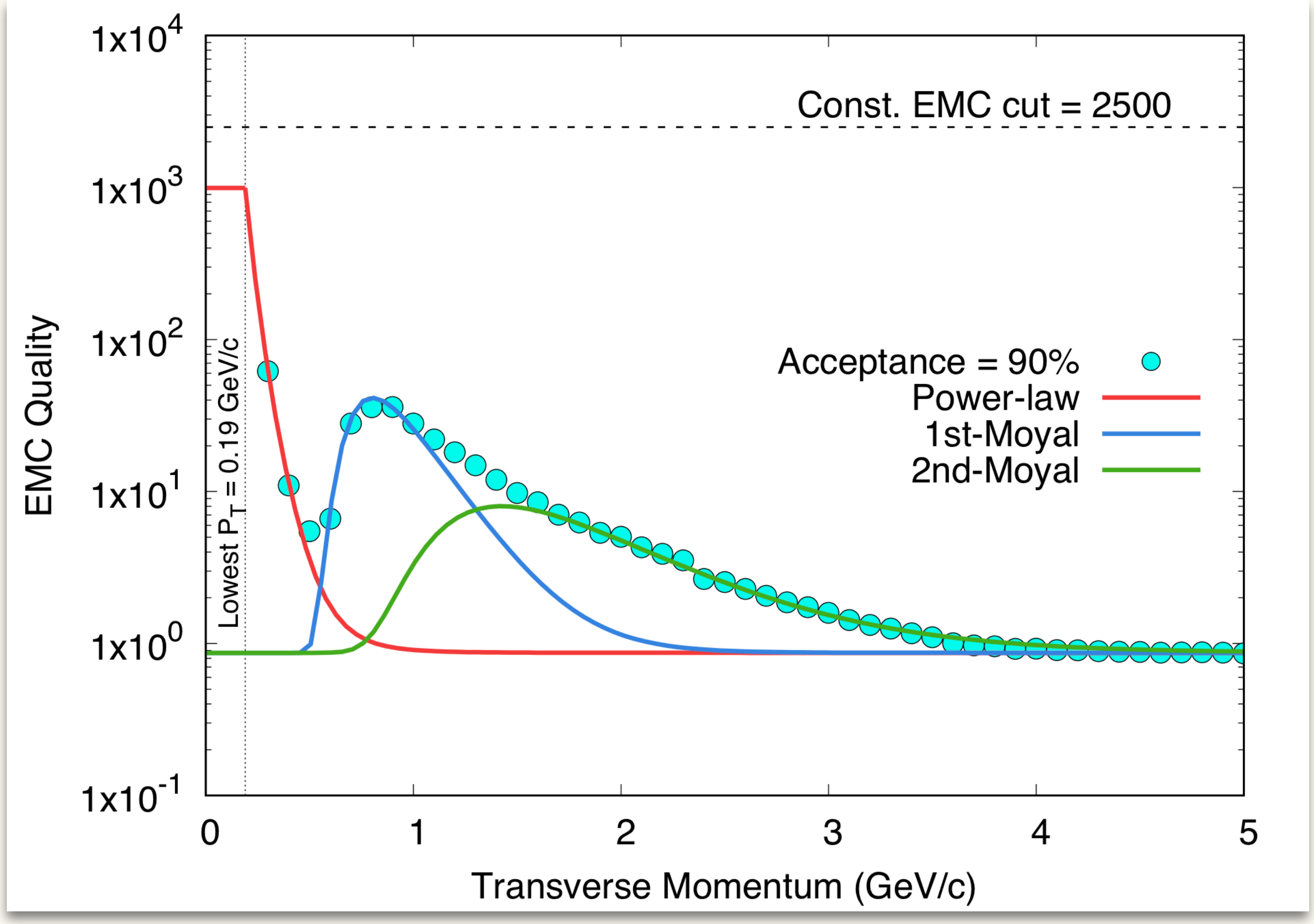
- We use this parameter to calculate the EMC cut by find the EMC quality that provides cumulative frequency reach acceptance percentage.



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

The acceptance percentages in this work are 85%, 90%, and 95% respectively. And we do this for all 0.1 GeV/c momentum bin.

# Non-Constant EMC Cut



- the first peak is power-law distribution because at low momentum, particle might not reach the EMC surface, that mean the distance between will be infinite value.
- For the skewed peak, it might be Landau distribution because this distribution use to describe the energy loss of charged particle traveling in matter, but we use approximate form, known as the Moyal function.

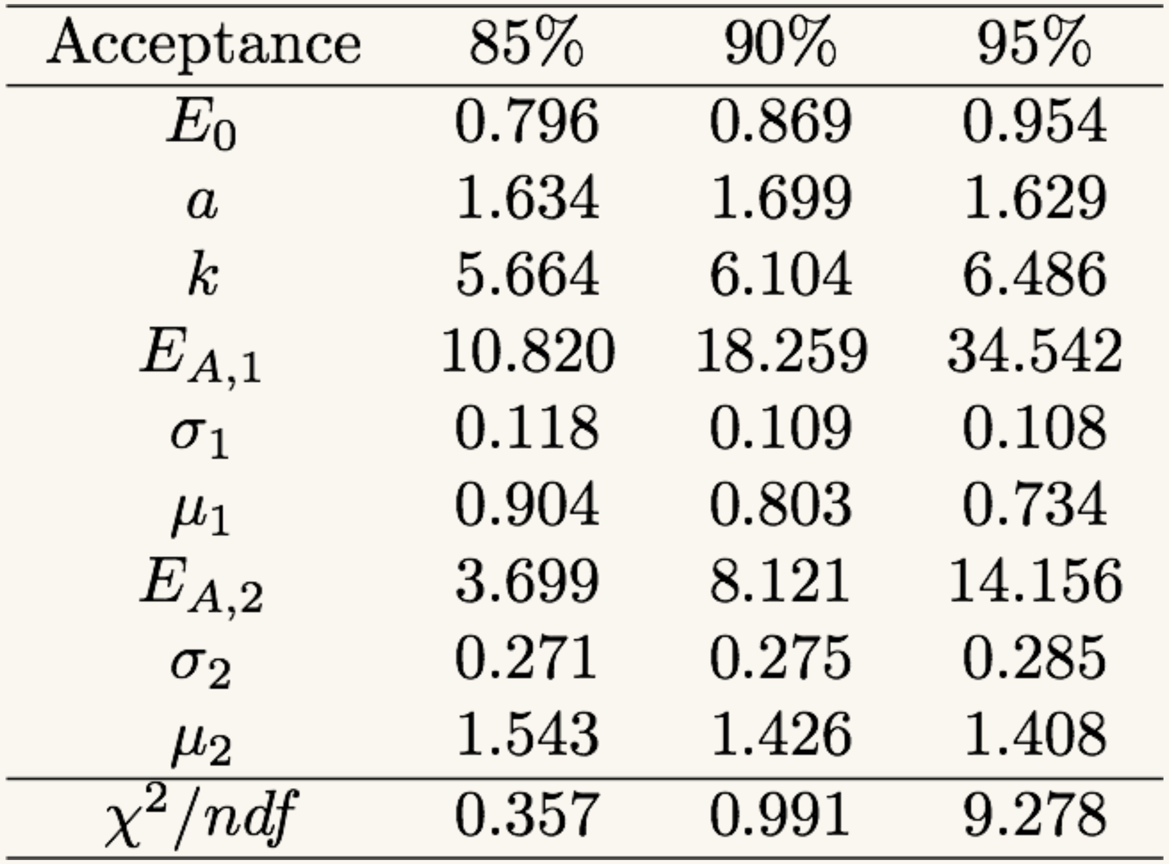
$$c(p_T) = E_0 + (ap_T)^{-k} + \frac{E_{A,1}}{\sqrt{2\pi}\sigma_1} e^{-\frac{1}{2}(x_1+e^{-x_1})} + \frac{E_{A,2}}{\sqrt{2\pi}\sigma_2} e^{-\frac{1}{2}(x_2+e^{-x_2})} , \text{where } x_i = \frac{p_T - \mu_i}{\sigma_i}$$

**Power-law**

**1st-Moyal**

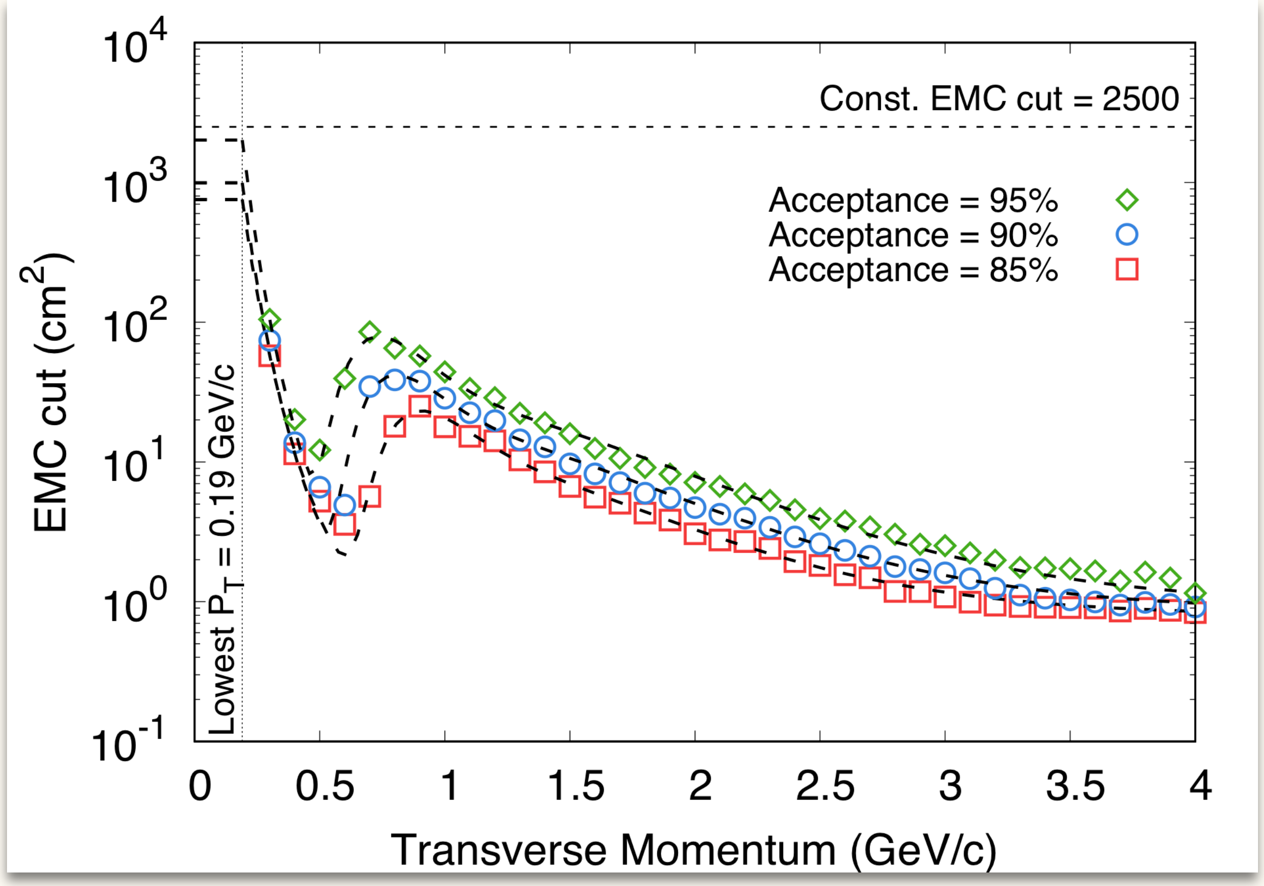
**2nd-Moyal**

# The EMC Cut Equations



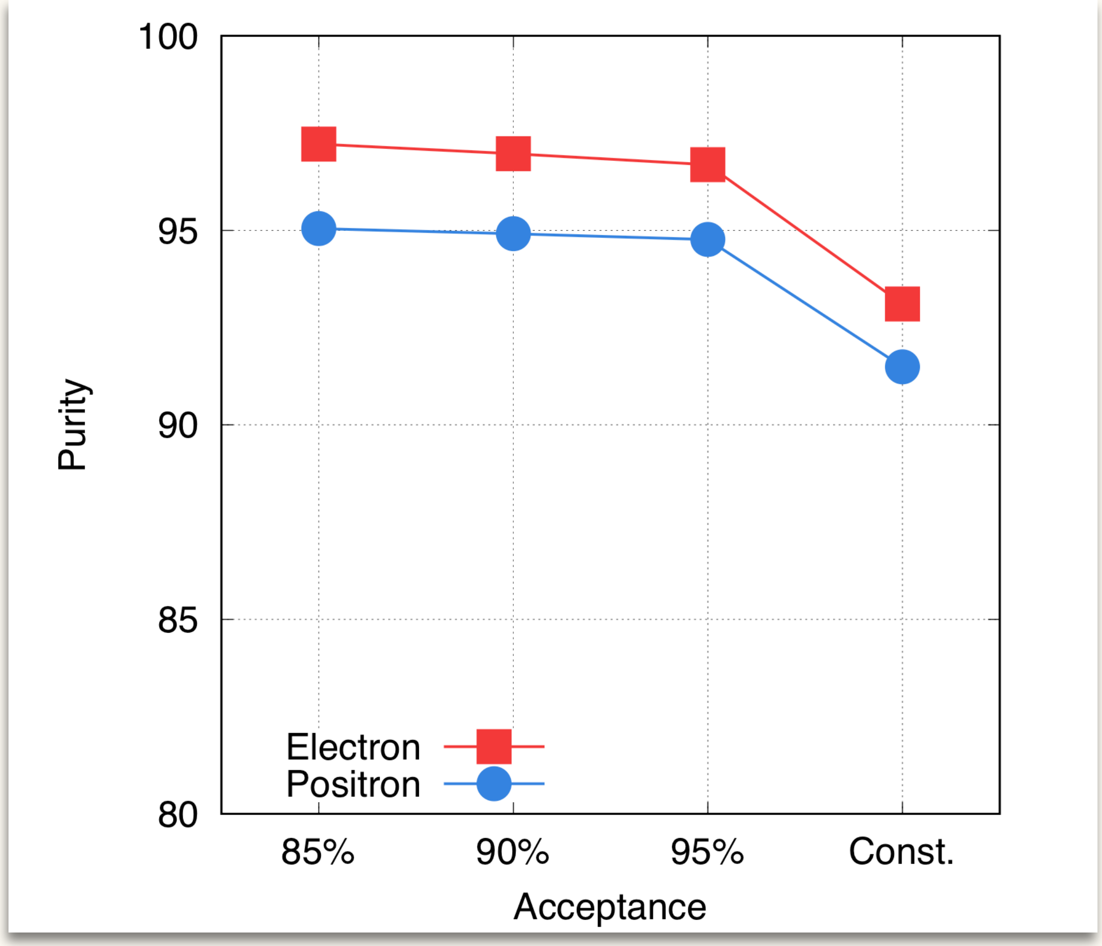
| Acceptance | 85% | 90% | 95% |
|---|---|---|---|
| $E_0$ | 0.796 | 0.869 | 0.954 |
| $a$ | 1.634 | 1.699 | 1.629 |
| $k$ | 5.664 | 6.104 | 6.486 |
| $E_{A,1}$ | 10.820 | 18.259 | 34.542 |
| $\sigma_1$ | 0.118 | 0.109 | 0.108 |
| $\mu_1$ | 0.904 | 0.803 | 0.734 |
| $E_{A,2}$ | 3.699 | 8.121 | 14.156 |
| $\sigma_2$ | 0.271 | 0.275 | 0.285 |
| $\mu_2$ | 1.543 | 1.426 | 1.408 |
| $\chi^2/ndf$ | 0.357 | 0.991 | 9.278 |

The table of fit parameter for electron and acceptance

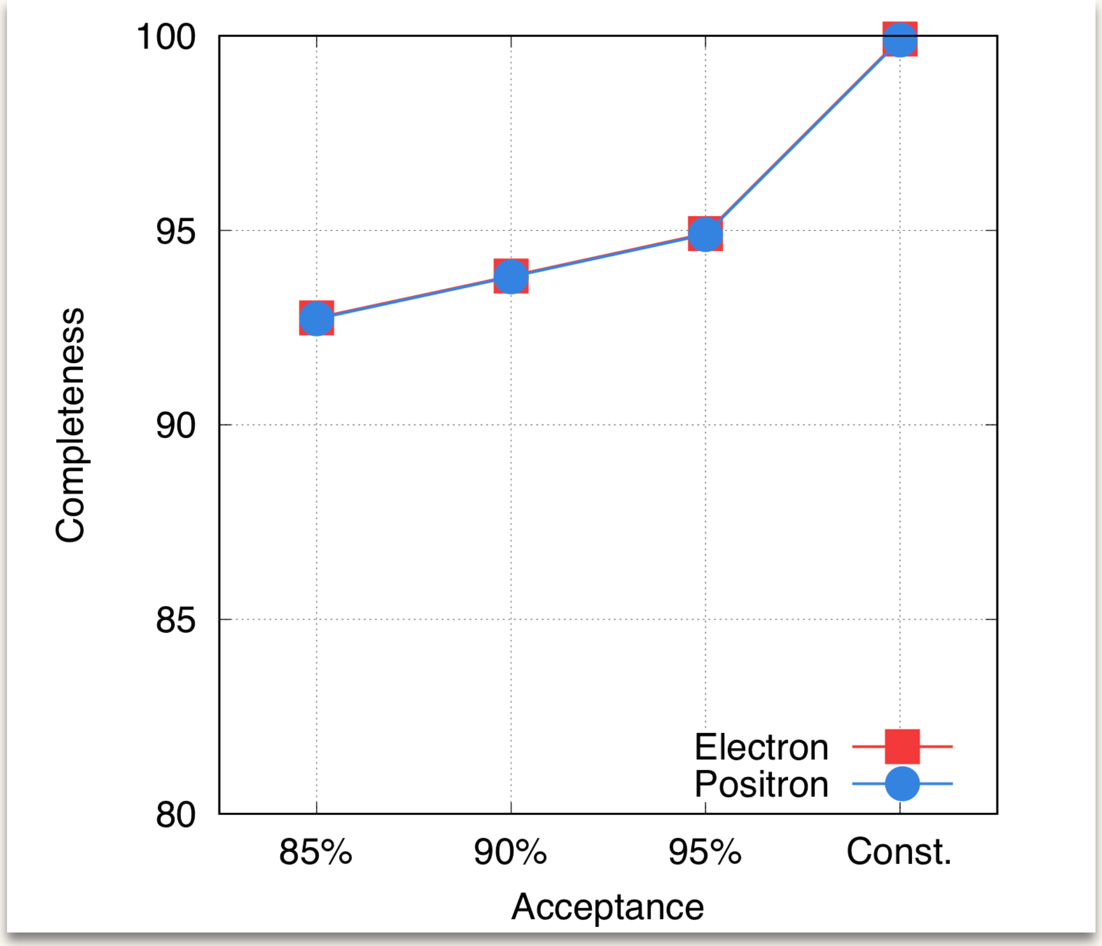


The EMC cut for electron as function of transverse momentum, for different acceptance

# Testing The EMC Cut



Purity vs. Acceptance



Completeness vs. Acceptance

$$\text{Purity} = \frac{\text{Number of correct matches}}{\text{Total number of matches}} \;,\; \text{Completeness} = \frac{\text{Number of correct matches}}{\text{Possible correct matches}}$$

# Conclusion

- In this work, we developed the EMC cut for PandaRoot simulation framework to classify EMC cluster and propagated track.
- By varying the cut parameter as a function of transverse momentum which is defined by power-law and double-Moyal functions.
- Our simulations show that the purity of both particles species can be increase by 3-4% compared to the default value.
- Next we are aiming to do, is we will try to understand the physical meaning of each parameter in the equation and try apply the machine learning to this project.

# Thanks For Your Attention