Pbar P -> e+ e- ($\pi^+\pi^-$) analysis with PANDAroot

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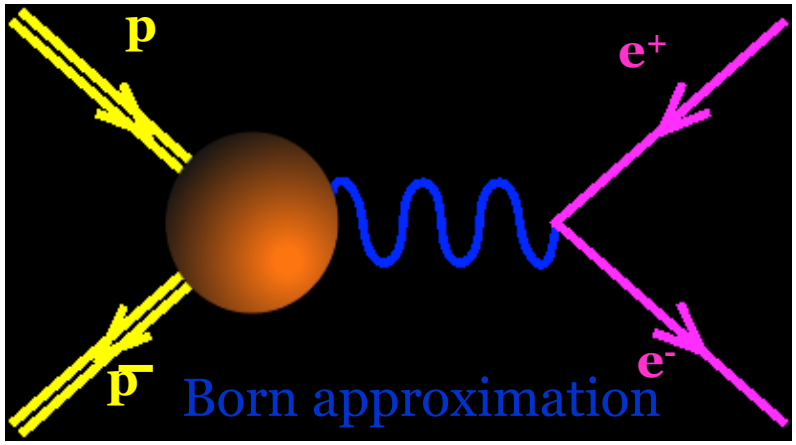
Electromagnetic channels : Time-like proton form factors measurment



Hadronic vertex is parametrized in terms of two electromagnetic FFs

Angular distribution → modulus of $|G_M|$ and $|G_E|$

Main Background : $\bar{p} + p \rightarrow \pi^+ + \pi^-$

$$\frac{\sigma(\pi^+\pi^-)}{\sigma(e^+e^-)} \sim 10^6$$

Rejection factor > 10^{-8} is needed

Outline

e+e- reconstruction efficiency

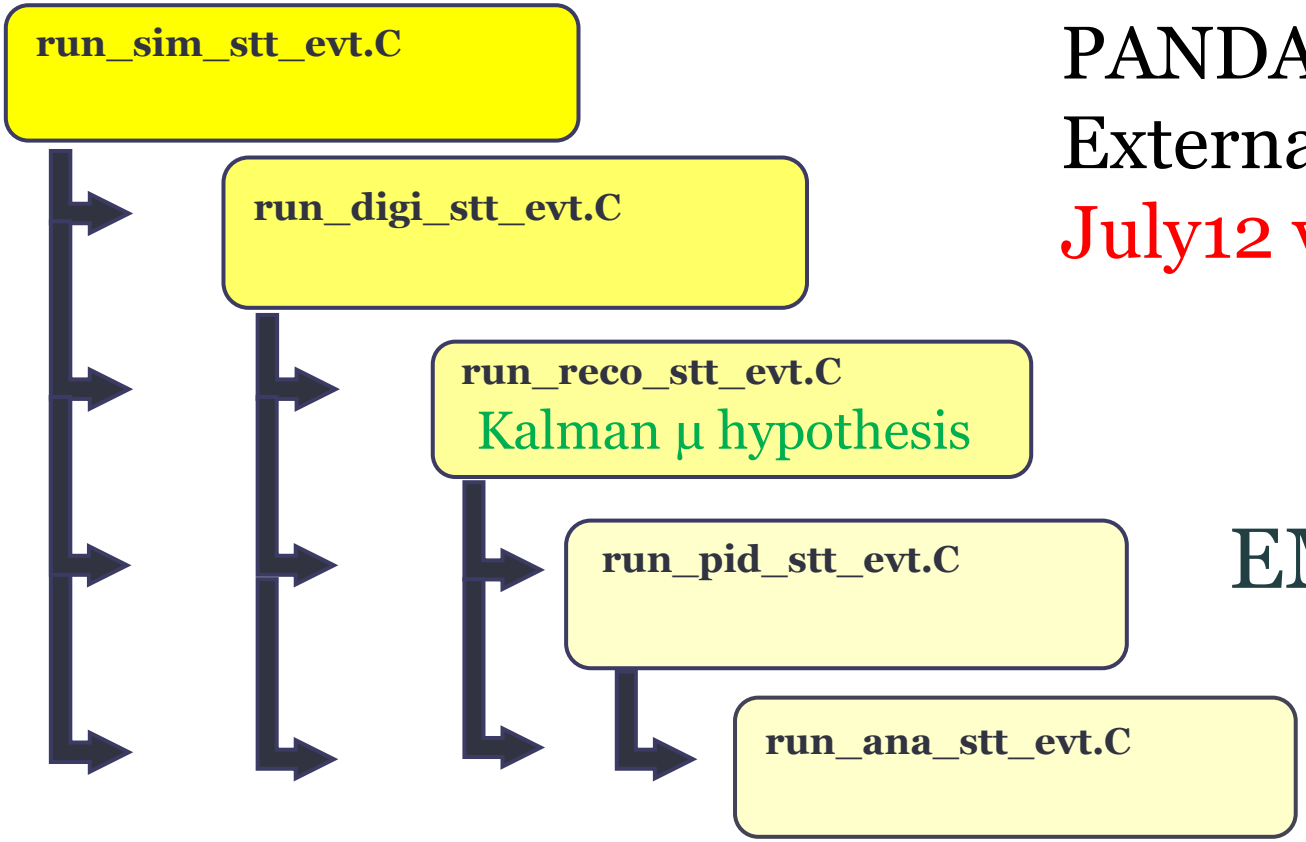
&

$\pi^+\pi^-$ background suppression

Based on :

PID (EMC+STT) analysis and kinematical study

Standard chain of reconstruction



PANDARoot and External packages: July12 version.

EMC & STT only

Simulation done on the grid of the IPNO (D. Marchand and C. Diarra)

Generators:

- $\bar{p}$ + p -> $e^+ + e^-$ (PHSP).
  $\bar{p}$ + p -> $\pi^+ + \pi^-$ (PHSP).

- p= 3.3 GeV/c (s=8.21 $[GeV/c]^2$) ,

- Full range in θ and ϕ angles.

- N(e^+e^-) = 10^6 events.
- N($\pi^+\pi^-$) ~10^7 events.

- No radiative corrections (noPhotos).

Principal points of analysis :

Selected events 1: Reconstructed events which satisfied the conditions:

- One positive and one negative particle per event.
- Best back to back pair was selected in the multi (positive or negative) particle events.

Selected Events 2:

- After Cuts on the PID probabilities (Naive Bayesian Method for EMC & STT) and on kinematics.

Naive Bayesian Method

2 particles hypothesis : electron and pion.

- EMC :

3 variables : E/p, log (Lat), log (Z53)

"Convolution" of probabilities via likelihood factors:

$$\frac{P(e \mid EMC)}{1-P(e \mid EMC)} = \frac{P(e \mid var_1)}{1-P(e \mid var_1)} * \frac{P(e \mid var_2)}{1-P(e \mid var_2)} * \ldots\ldots$$

- STT :

Parametrization of truncated mean dE/dx up to 5 GeV/c.

Ronald Kunne

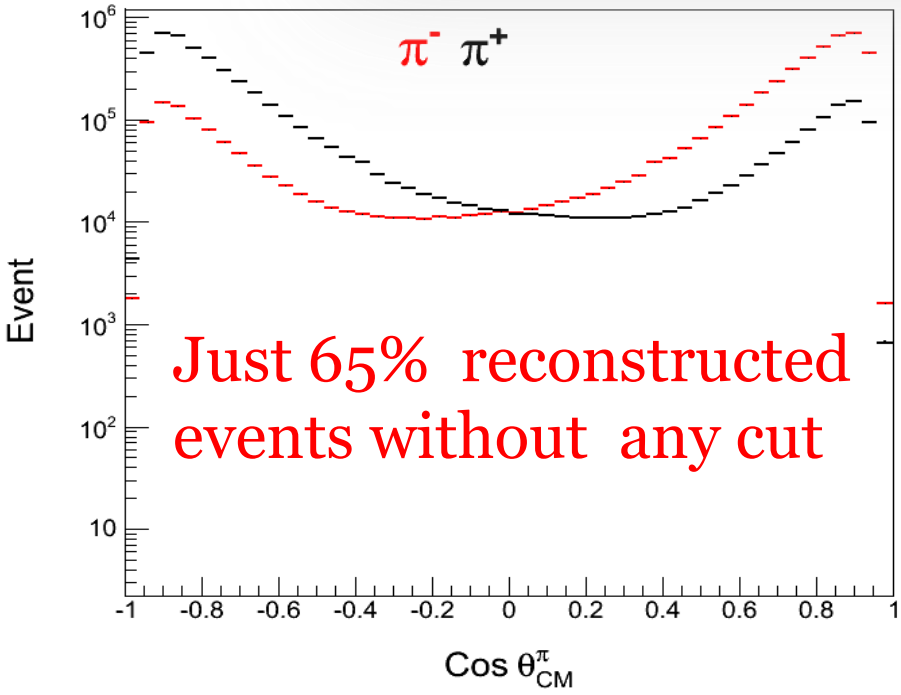
Why PHSP ?

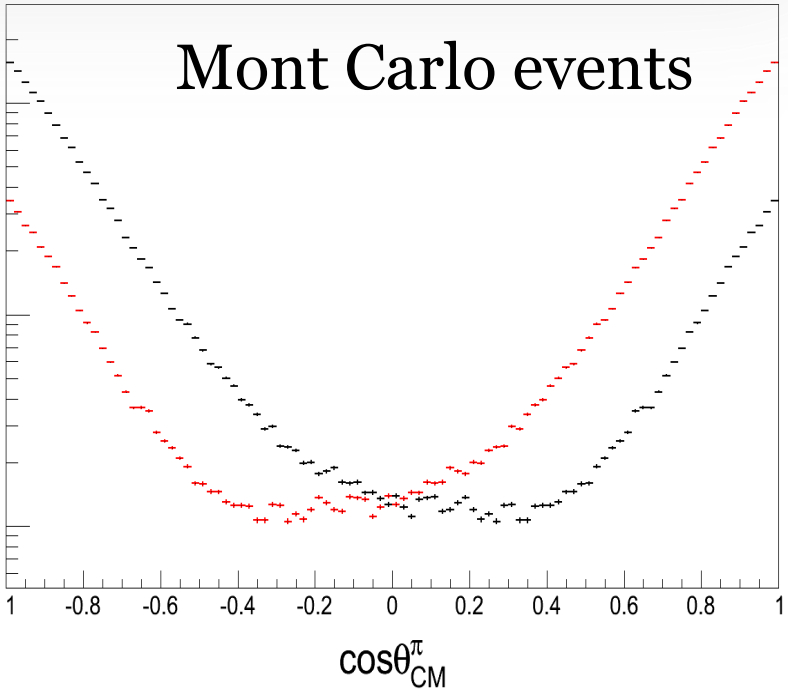
PIONS: PANDARoot Event Generator (Mainz PANDA group)

2.43<p<5.0 GeV: No data are available.

Extrapolation of Regge theory approach from high energy limit.

[J. Van de Wiele and S. Ong, Eur. Phys. J. A46 (2010) 291]

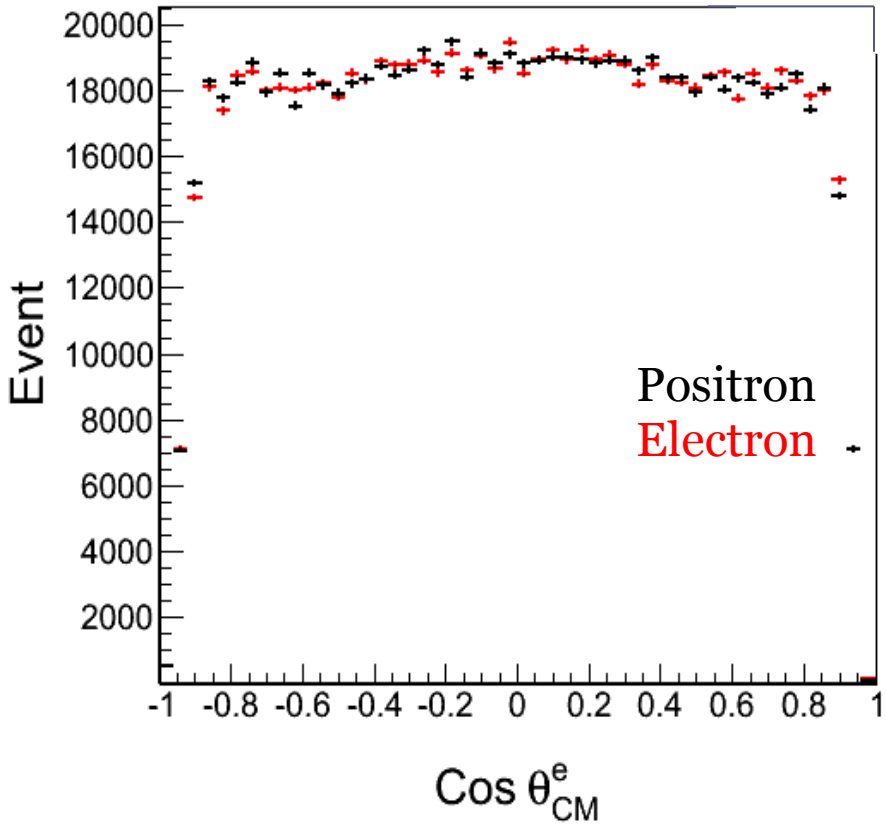




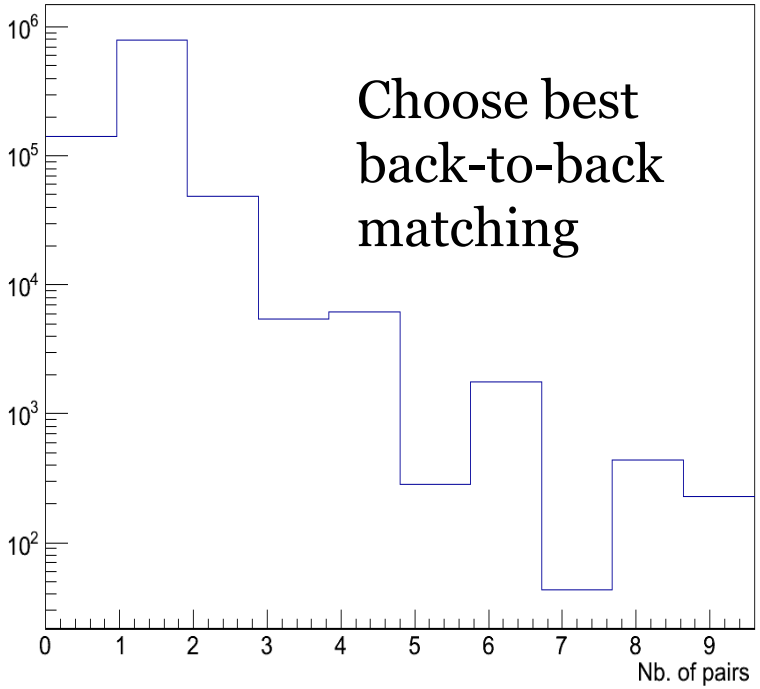
Distribution of pi-/pi+ is very peaked forward/backward :

loosing statistics

Electrons : Reconstructed events

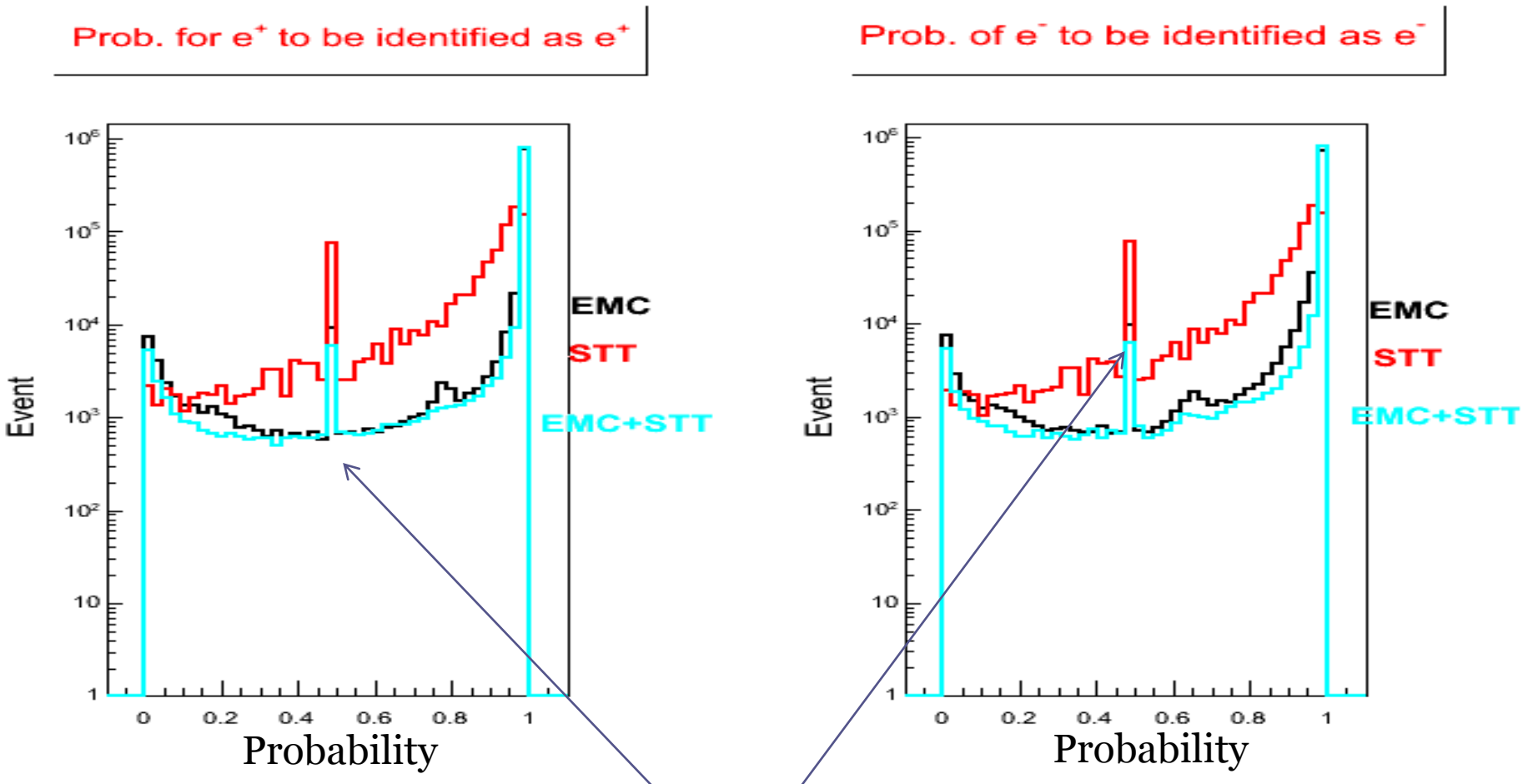


Track pairs per event



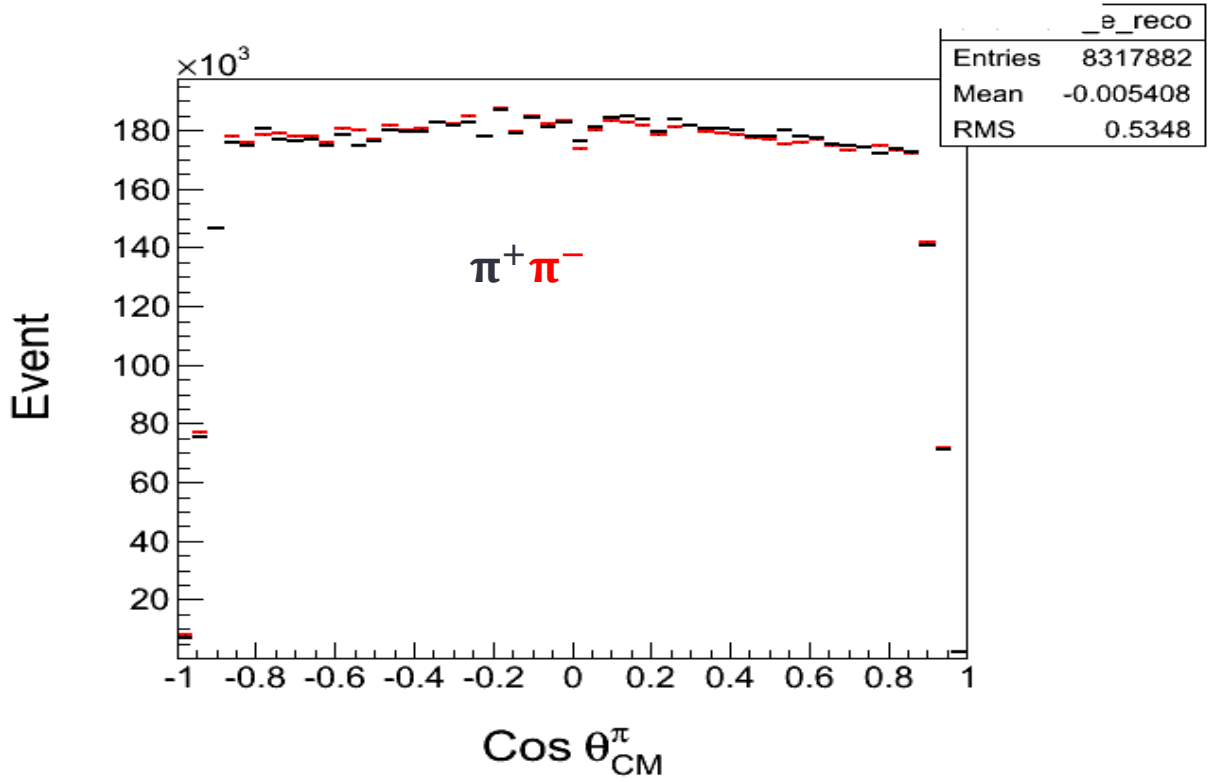
Reconstructed events (86%)

Electron and positron PID using EMC and STT



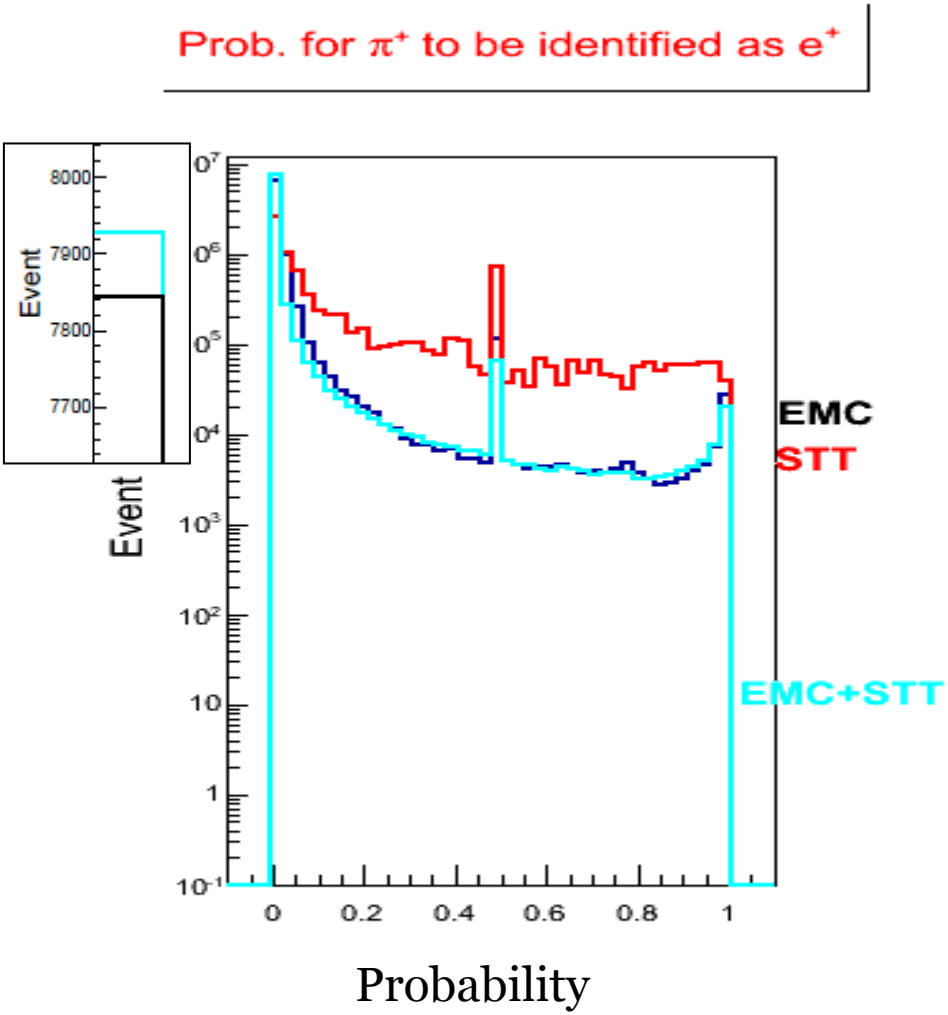
Method does not provide decision, PID distributed equally to both particles

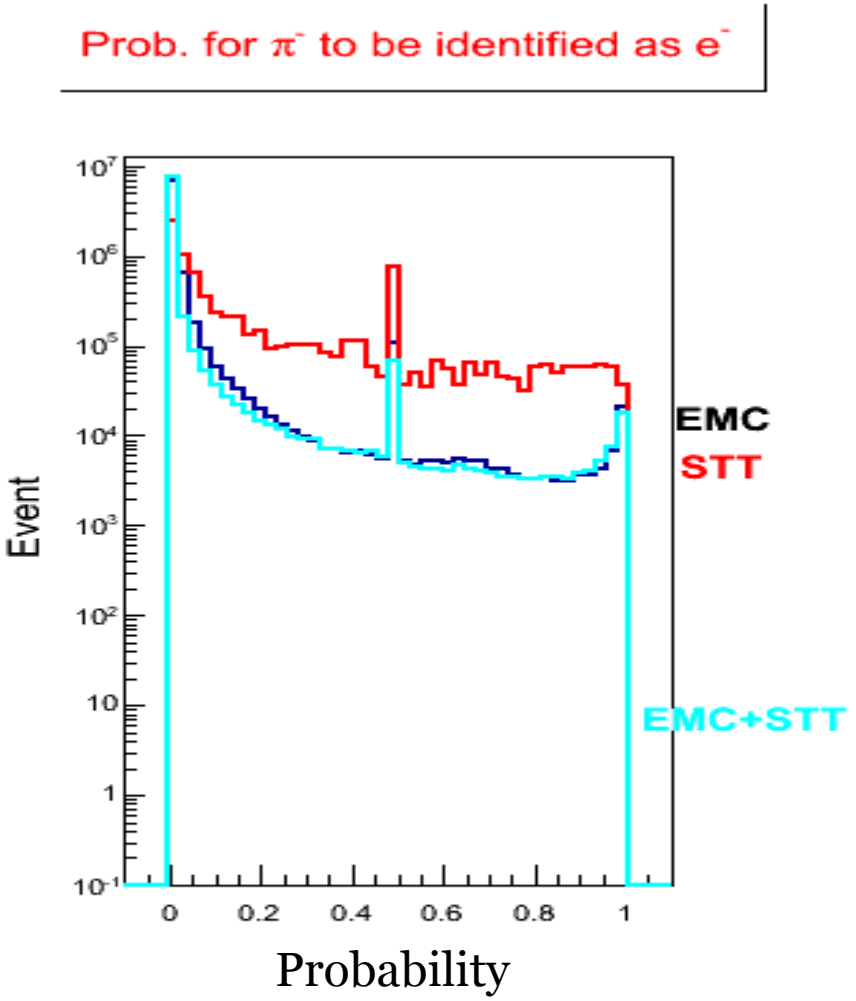
PIONS: Reconstructed events



PHSP: Reconstructed events (84%),

PION PID Using EMC and STT





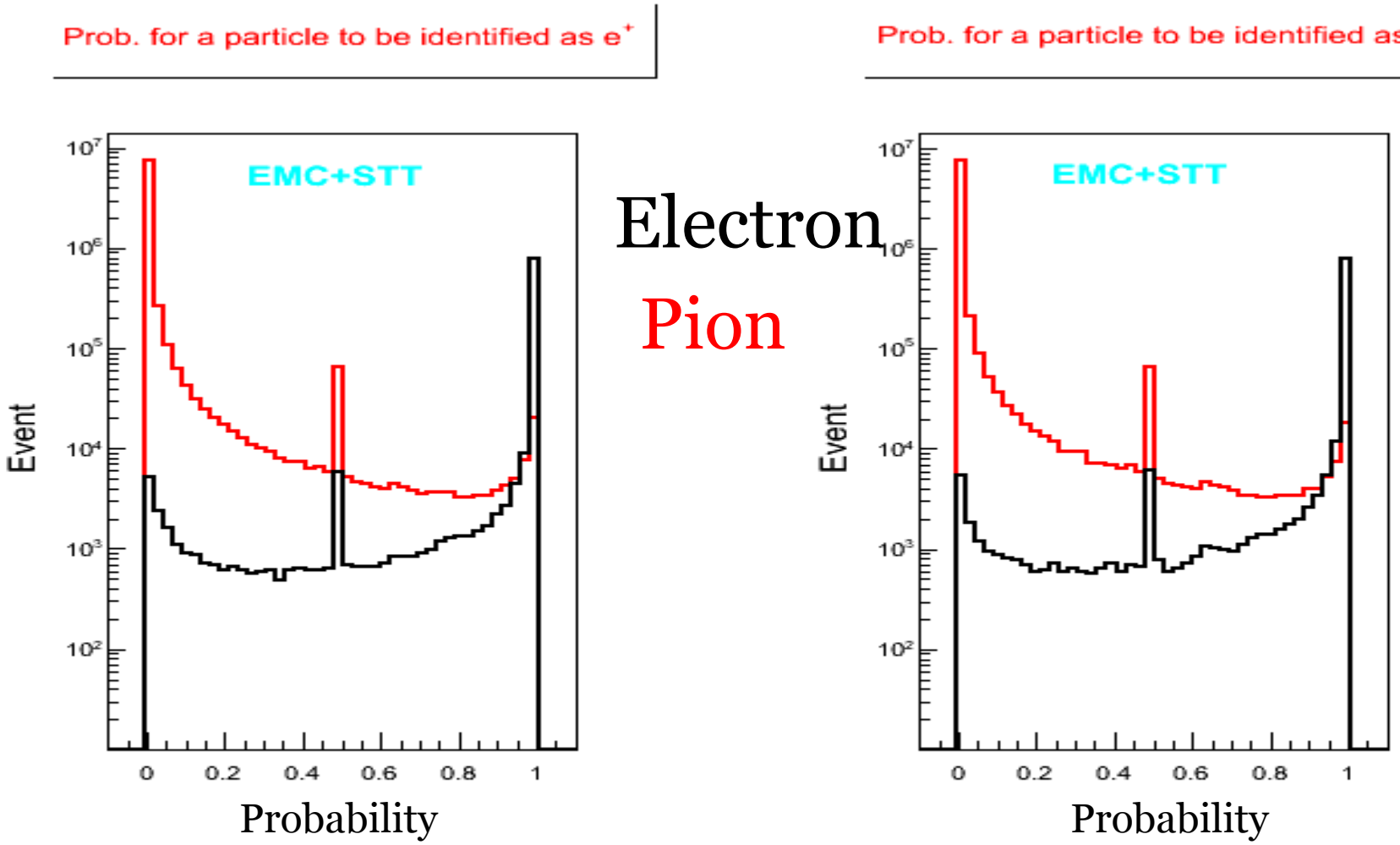
Cuts

- PID > 99%
- Nb. of fired crystals in EMC >5
- $175° < |\boldsymbol{\phi}1 - \boldsymbol{\phi}2| < 185°$
- $179.8° < (\boldsymbol{\theta}1 + \boldsymbol{\theta}2)\ (CM) < 181°$

Bremsstrahlung leaves **θ** and **ϕ** intact

Angle **ϕ** : reduces multi-pion or multi-electron events.
Angle **θ** in CM : Electron/PION separation.

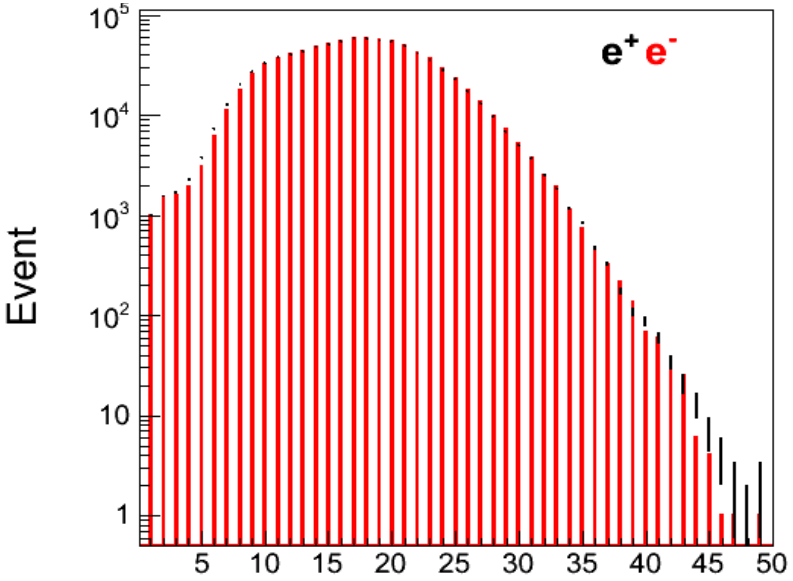
PID Using EMC and STT :



PID > 99% : Signal : 71 ,5%

Background: 37 events [EMC only 87 events]

Cut2: Nb. Of fired Crystals in EMC >5

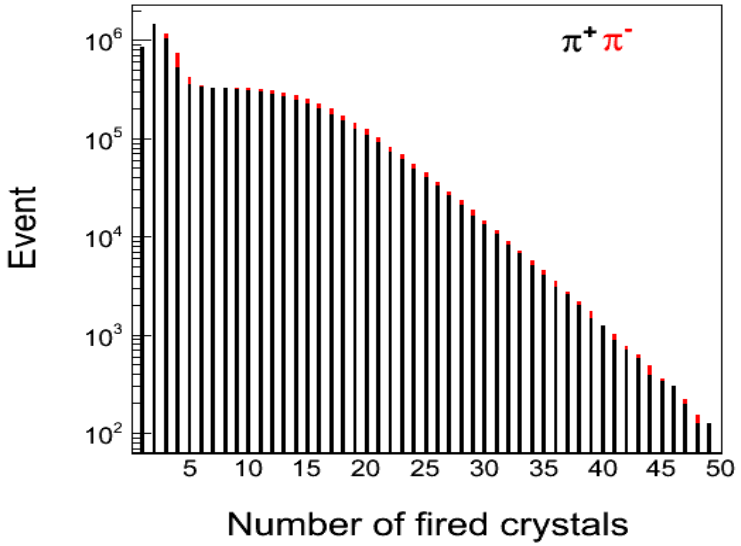


Cut (PID, Nb. Crystals) :

Signal : 71 %

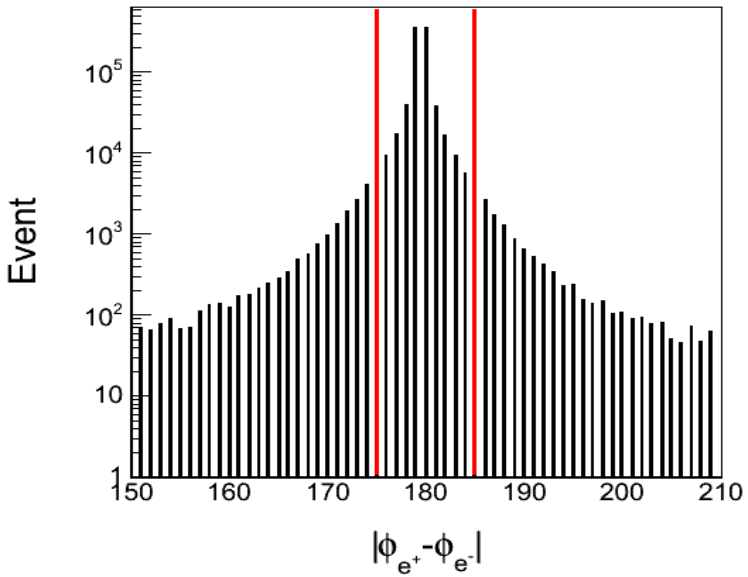
Background: 26 events

This variable can be included in the Bayesian method

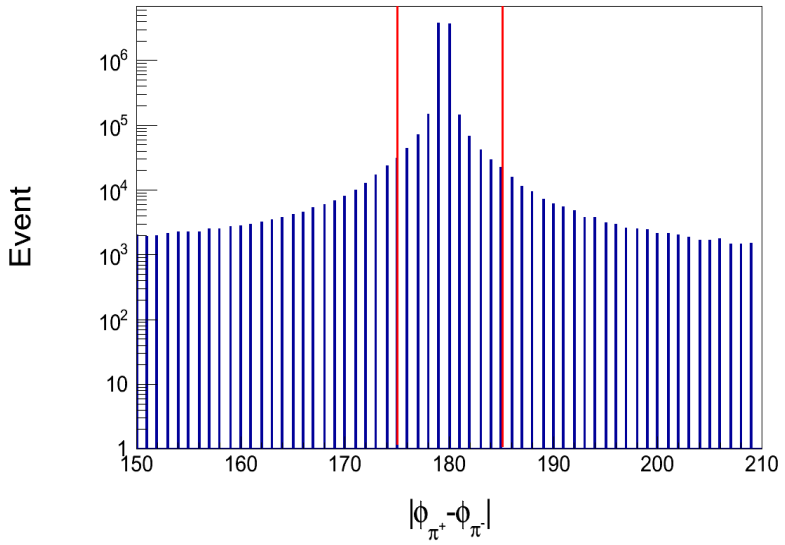


Cut on ϕ distribution

Electrons



PIONS



$$Cut: 175 < |\phi 1 - \phi 2| < 180\ degree$$

Cut (PID, nb. Crystals, ϕ) : Signal : 70%

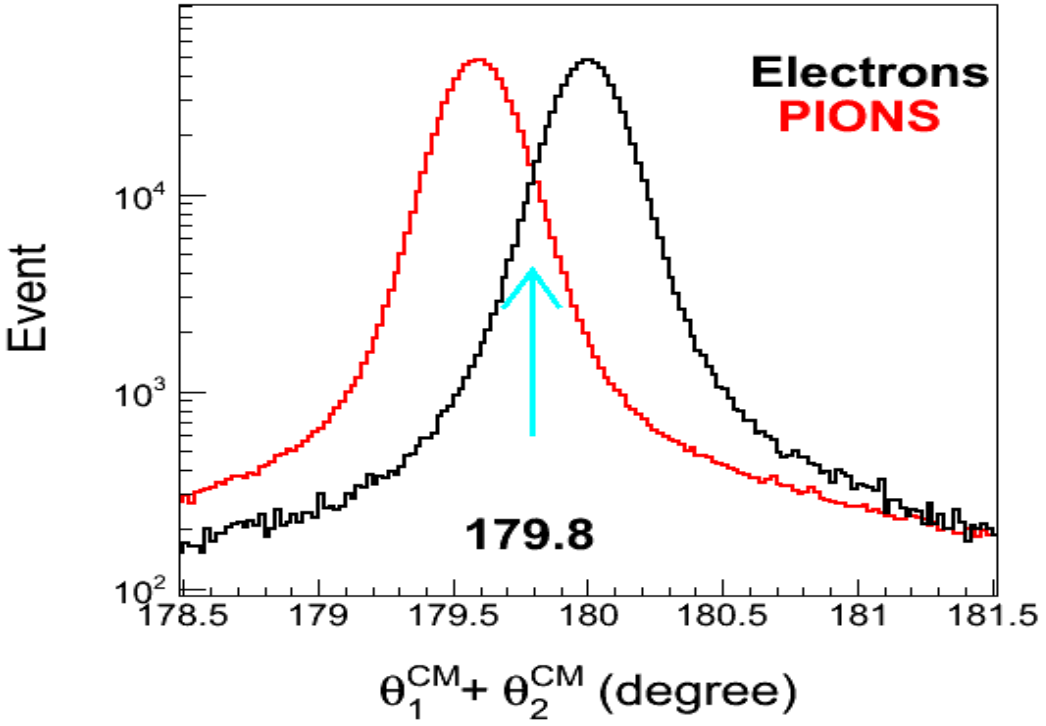
Background: 8 events

Theta Distribution (CM) assuming Electron particle: back-to-back cut (179.8-181 degree)

Electron assumption:

Pion & electron have:

(Px,Py,Pz,$\sqrt{P^2 + (me)^2}$)



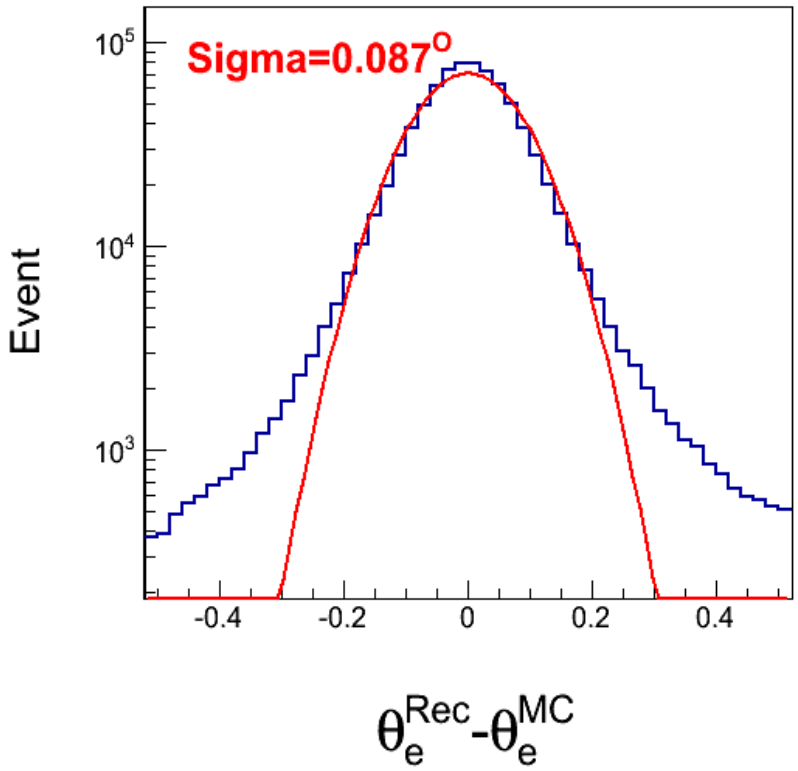
Cut (PID,Nb. Crystals,ϕ,θcm) :

Signal : 61%

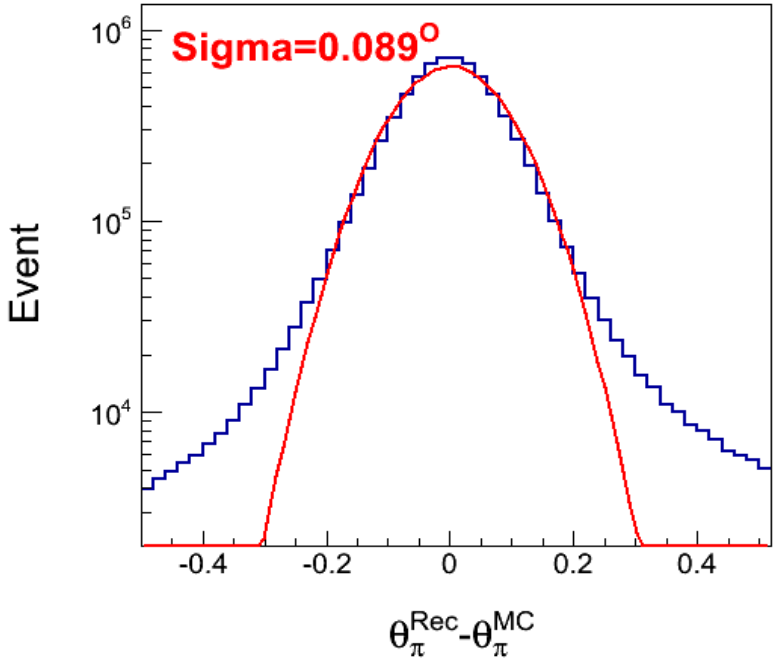
Background: zero pion

Resolution on θ angle:

Electron

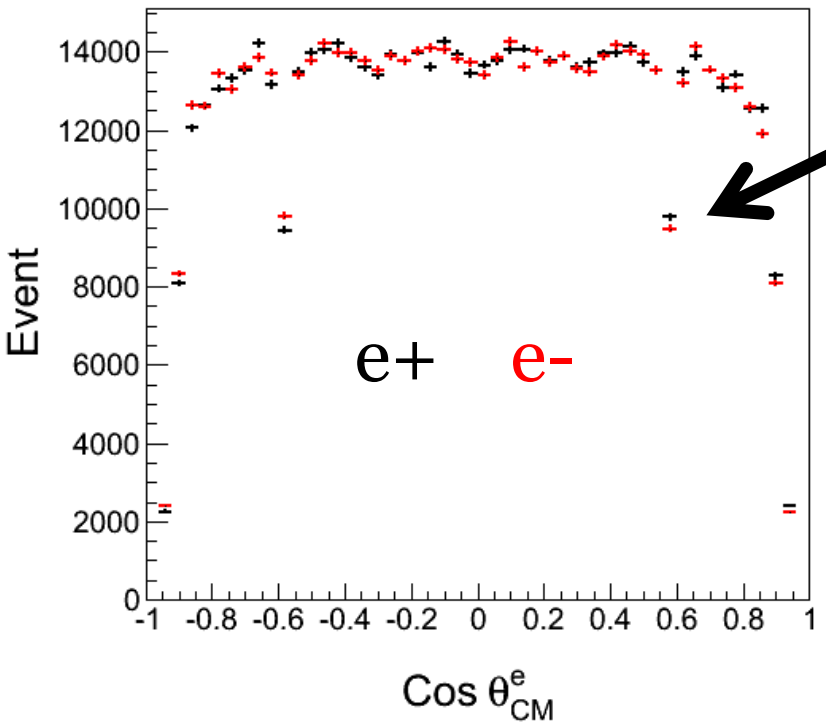


PIONS



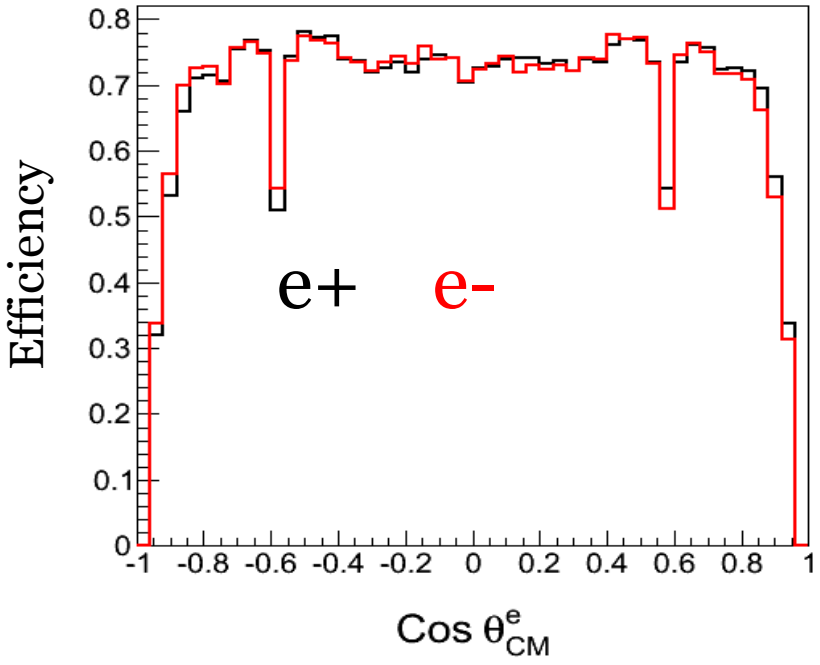
Resolution <0.2°

Angular distribution after all the cuts

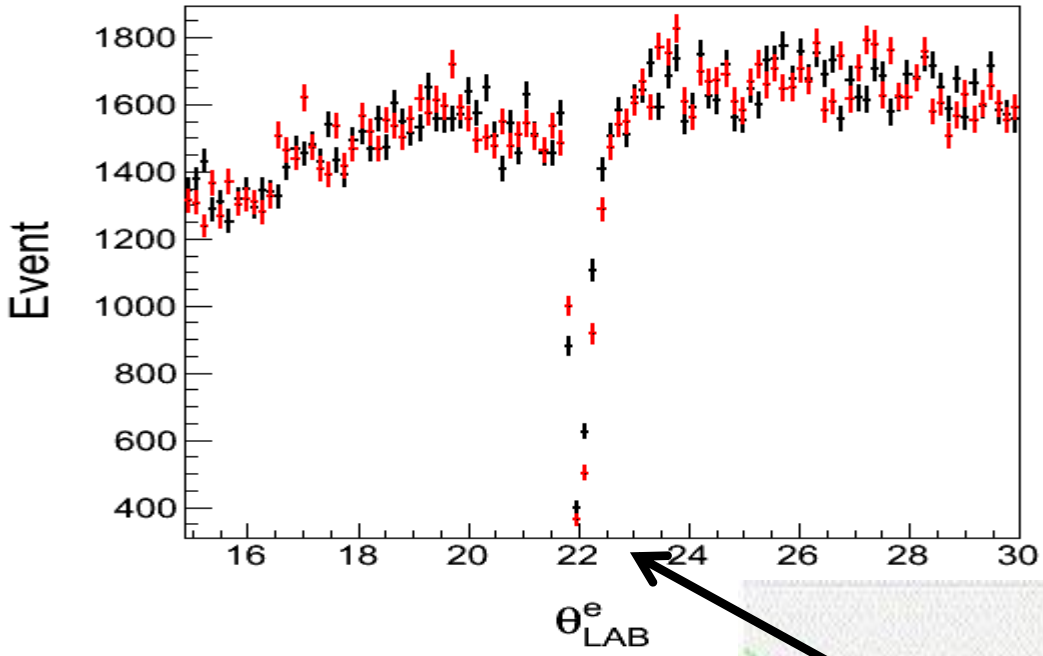


Cosθ(CM)=0.57

Rec.(after cuts)/Rec.(before cuts):

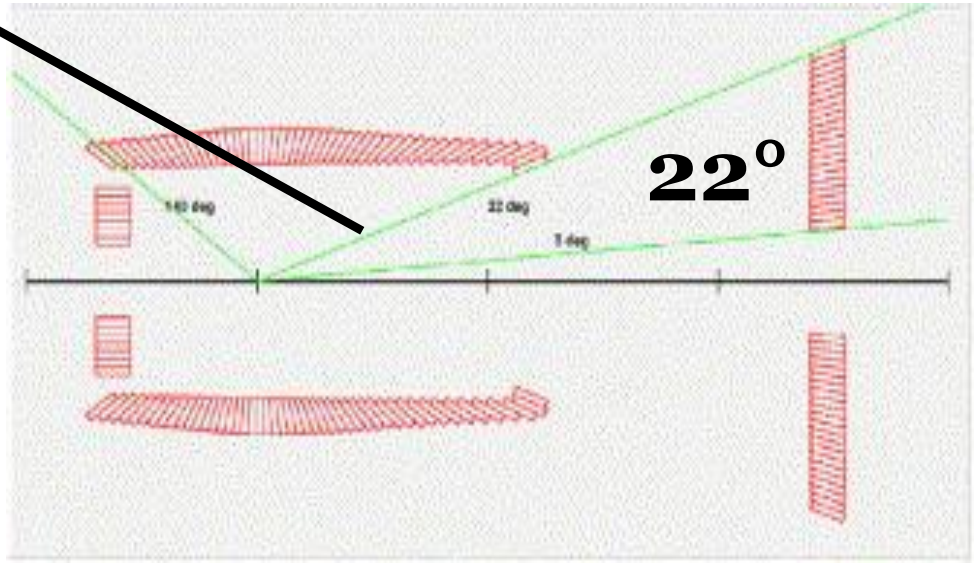


Electrons



Cosθ(CM)=0.57

LAB : 22°



Result

- **N(e^+e^-) = 10^6 events.**
- **N($\pi^+\pi^-$) ~10^7 events.**

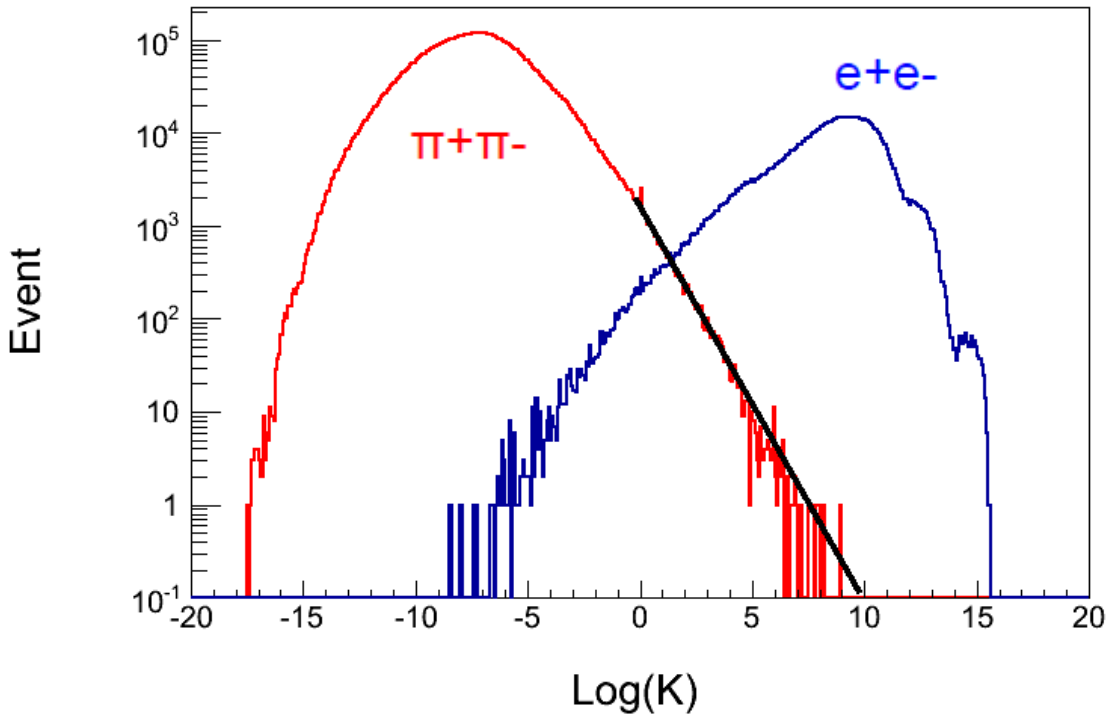
10^{-7} rejection factor of pions

61% signal efficiency

Another way to cut on probabilities:

$$\text{Odds: } K = \prod_{\text{Detectors}} \frac{P}{(1-P)}$$
Tracks

P= (EMC+ STT) probability for the particle to be identified as electron.



By extrapolation :

Rejection factor ~ 10^{-8}

Log(K)=9.7 ;

Signal efficiency: 26%

Conclusion and perspective

- Efficiency 61% for a pion rejection factor ~ 10^{-7}.

- Estimation (PID): Eff. 26 % for ~ 10^{-8} :
(This value can be enhanced using kinematical cuts).

Next steps :

- Simulation with the new version of PANDARoot : Dirc, Disc, EMC, …

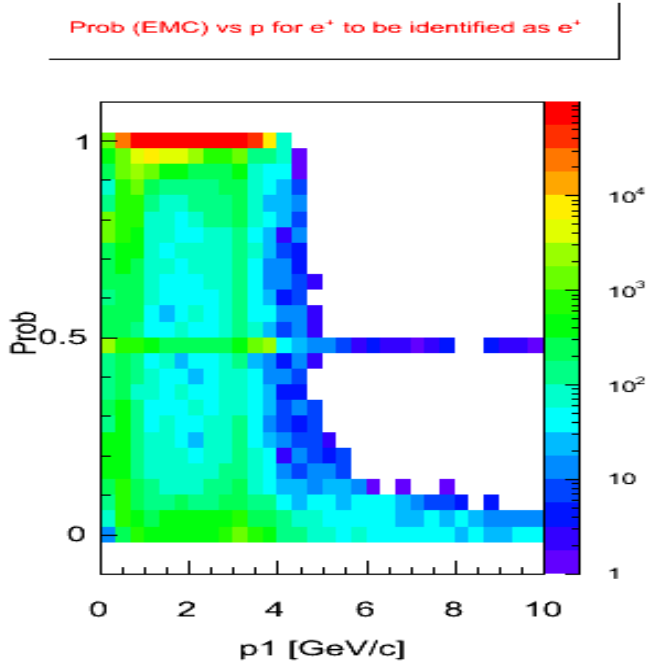
- High Statistics, simulation for different values of «s» :

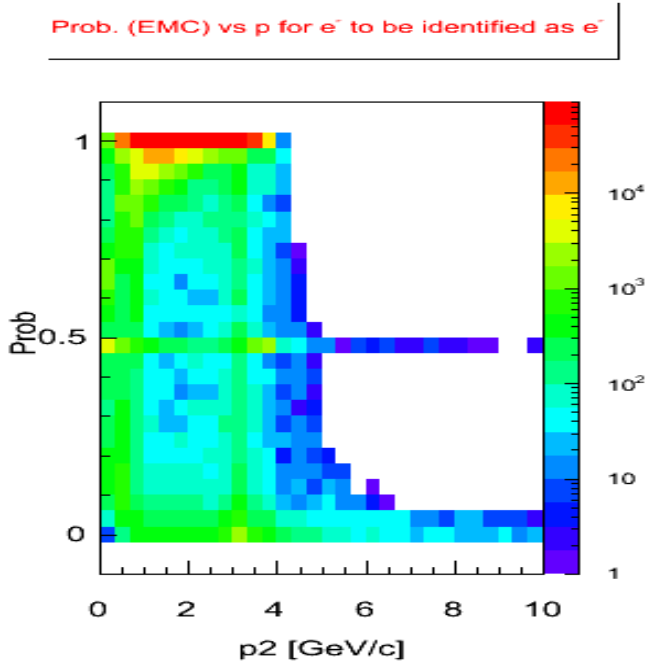
Evaluation of systematic and statistical errors.

Thank you for your attention

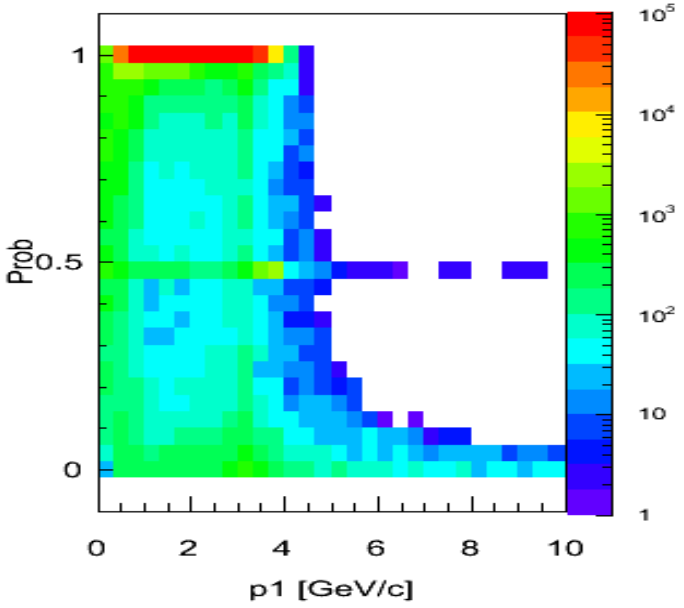
This work was done in collaboration with

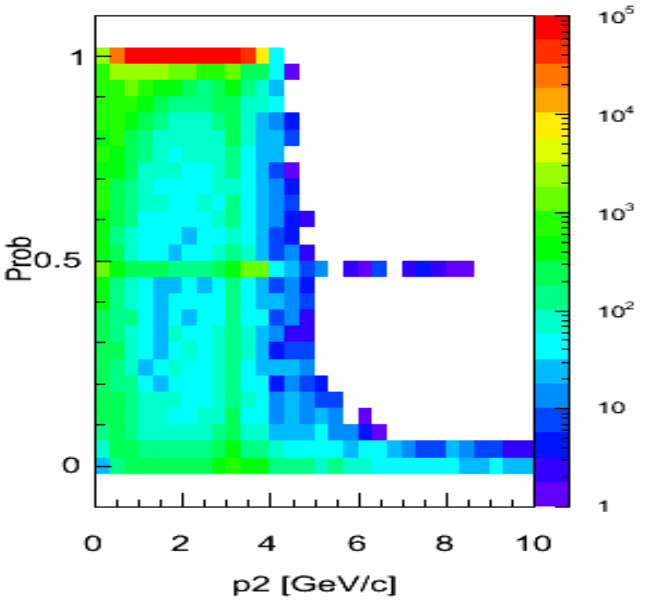
Gosia Gumberidze and PANDA Orsay team.





EMC PID

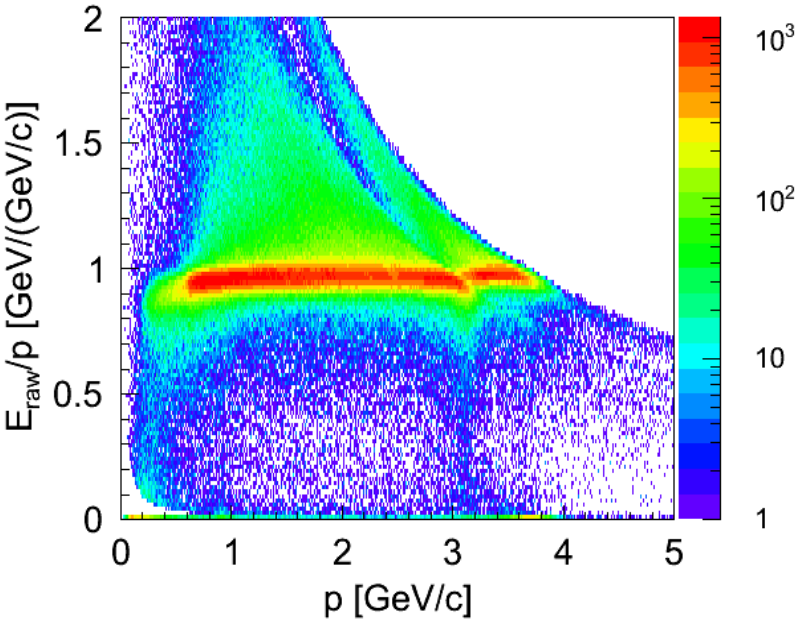




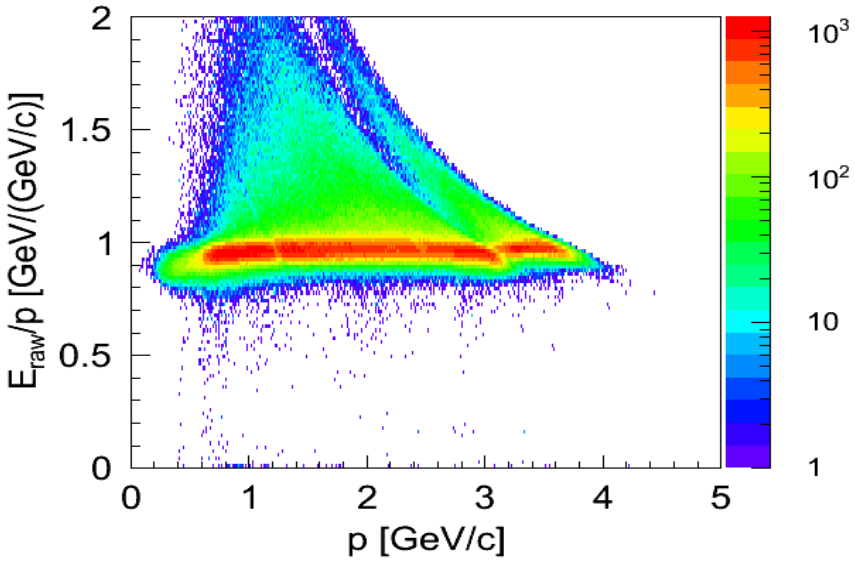
(EMC+STT) PID

Electrons

Before PID cut

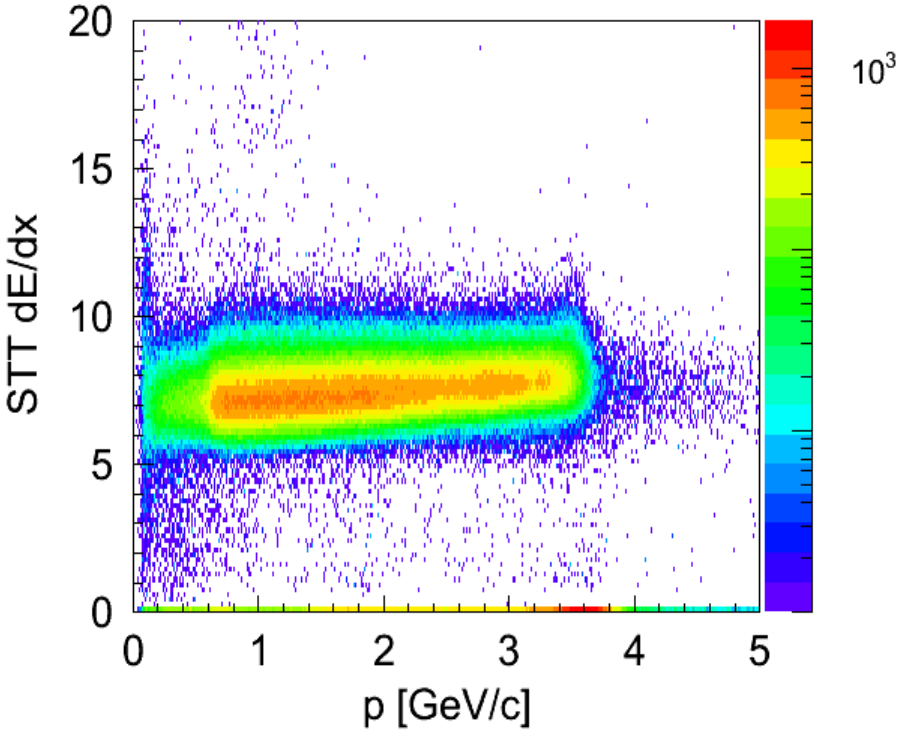


After PID cut

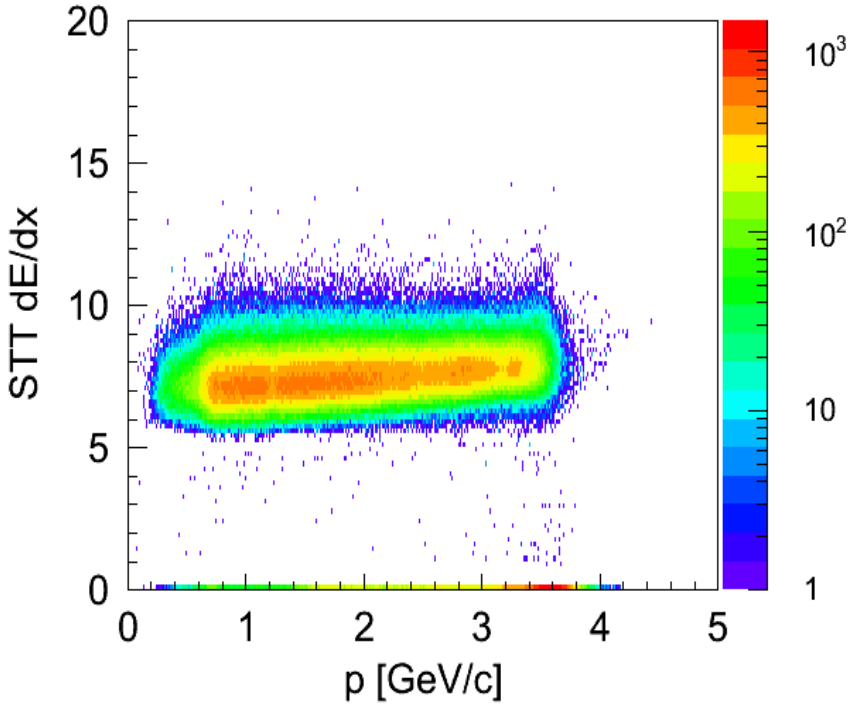


Electrons

Before PID cut

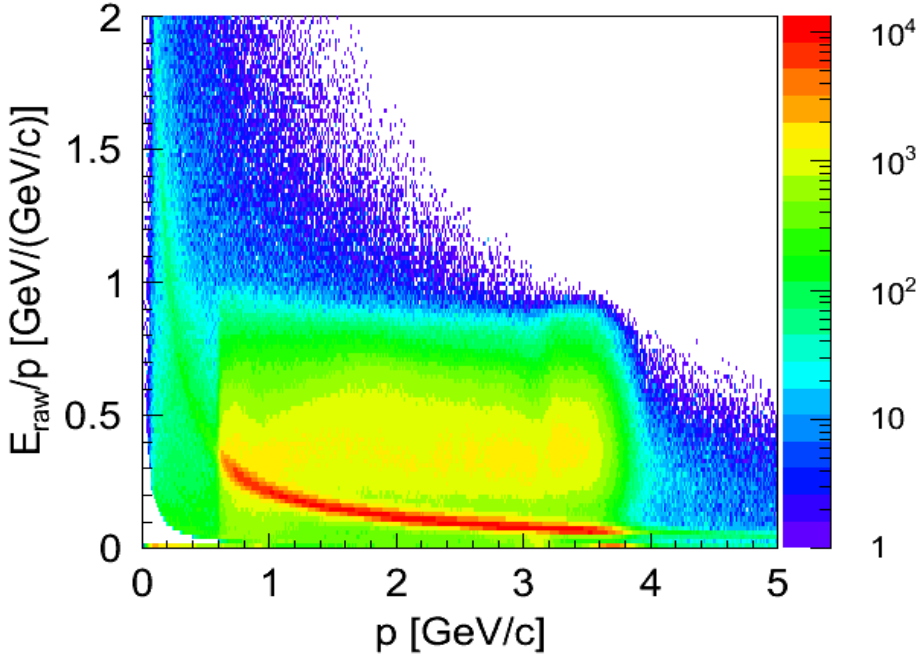


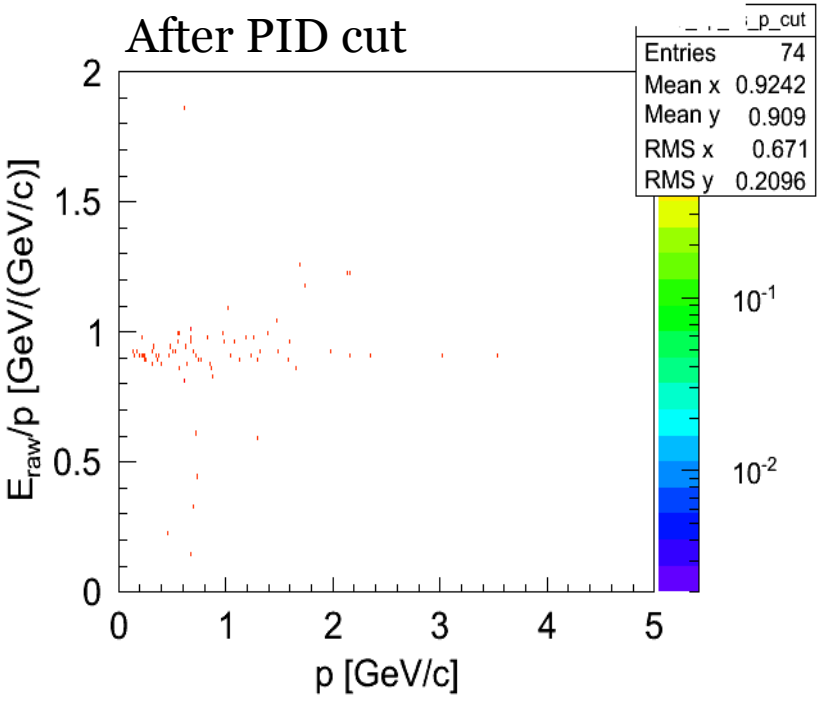
After PID cut



PIONS

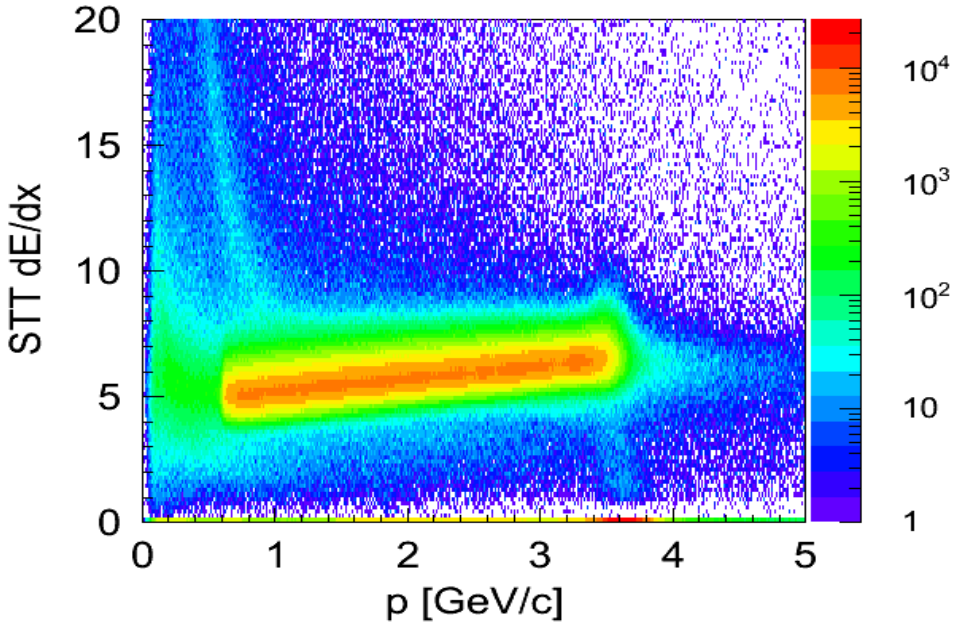
Before PID cut





PIONS

Before PID cut



After PID cut