

# The lookup tables for EMC - energy and theta corrections and their application

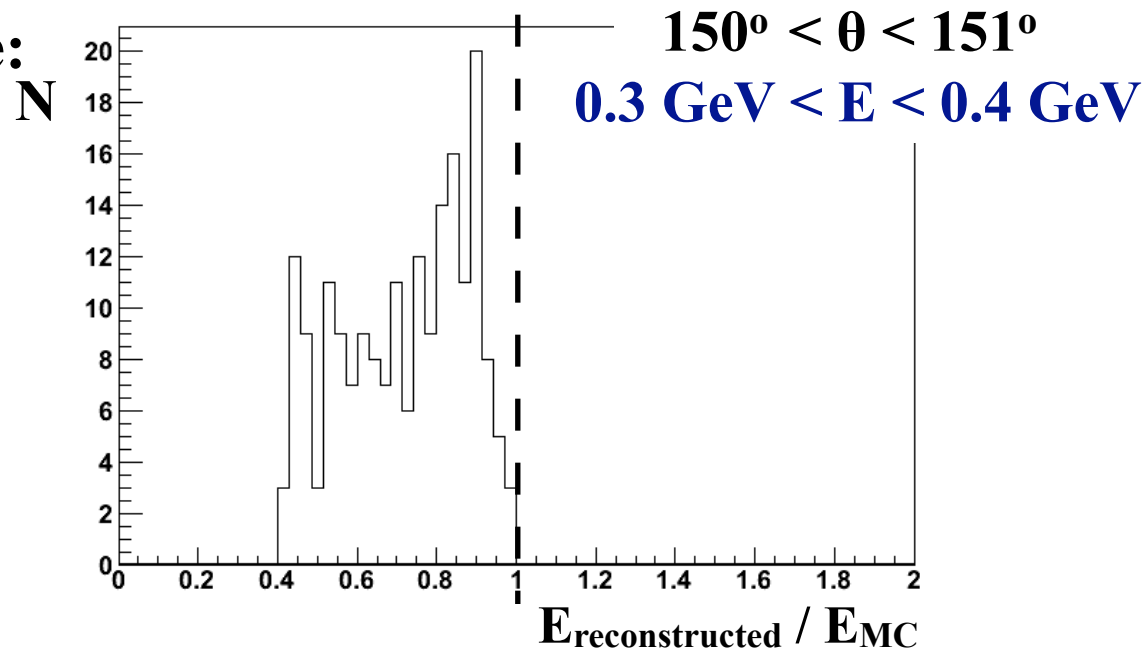
Aleksandra Biegun

PANDA CM, Juelich, 7-11 September 2009



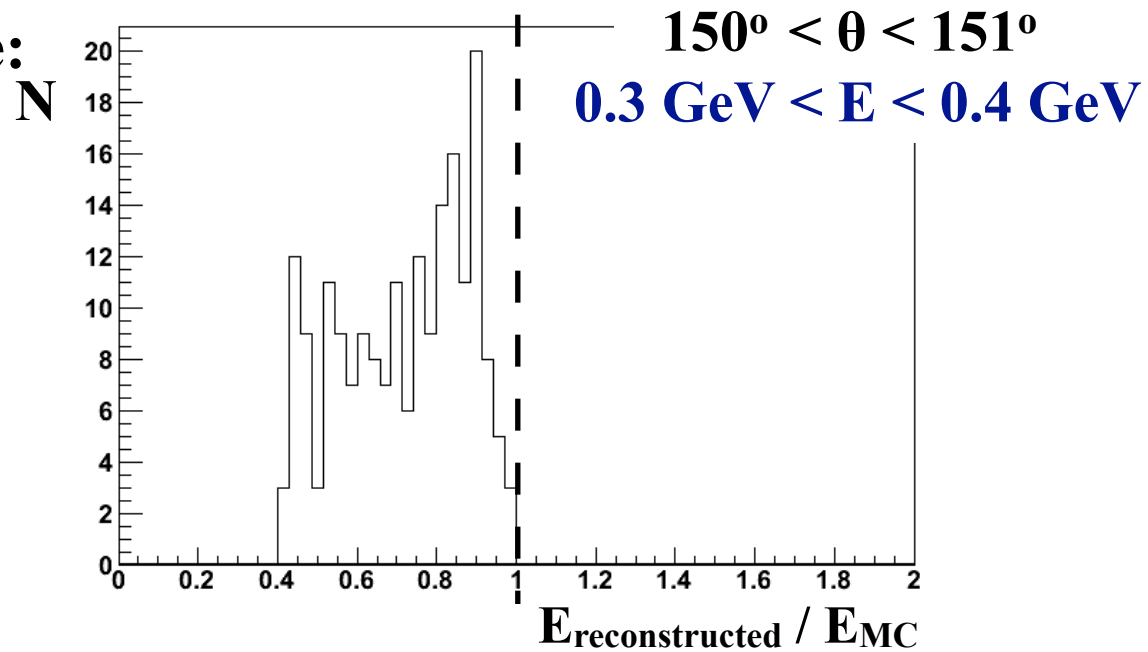
⊙ Presently output from the code:

➔ Shift in energy

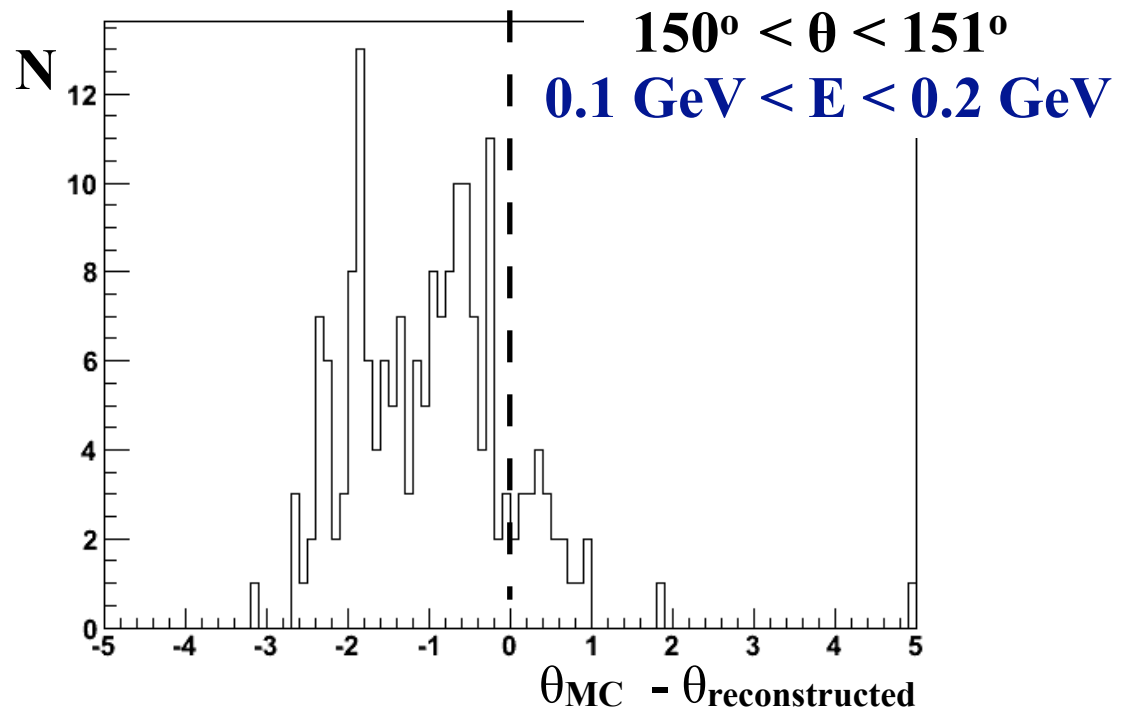


© Presently output from the code:

➔ Shift in **energy**

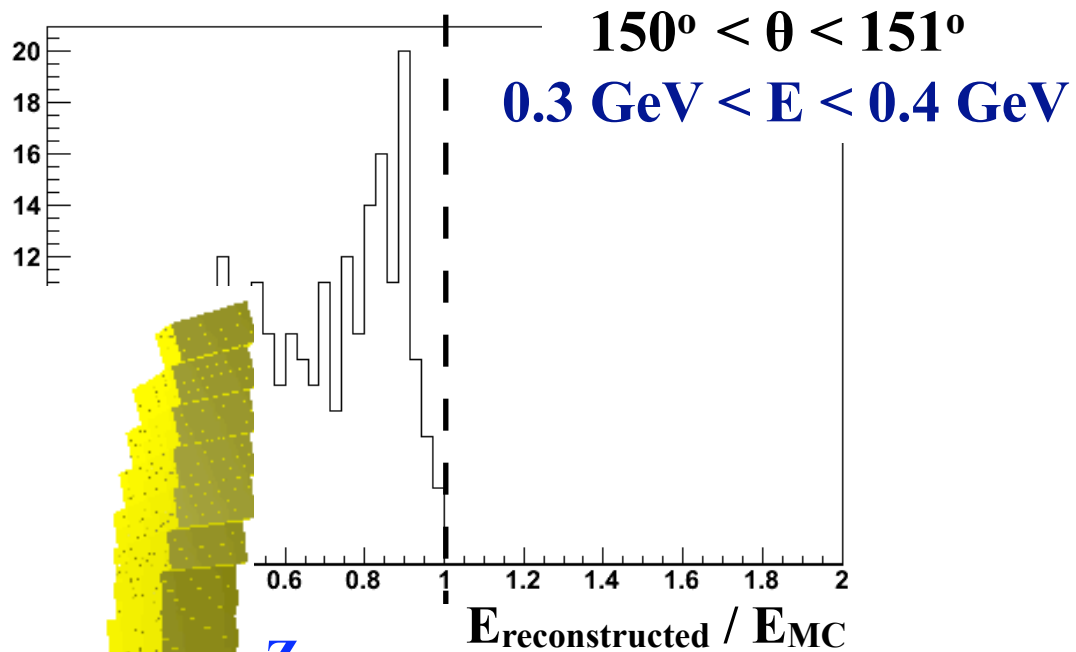


➔ Shift in **theta**

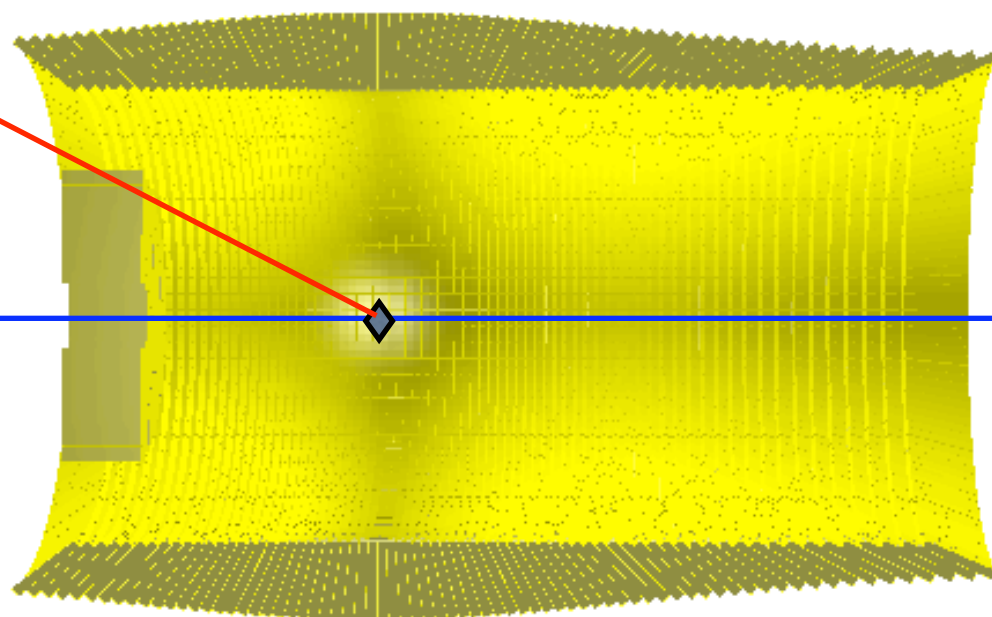
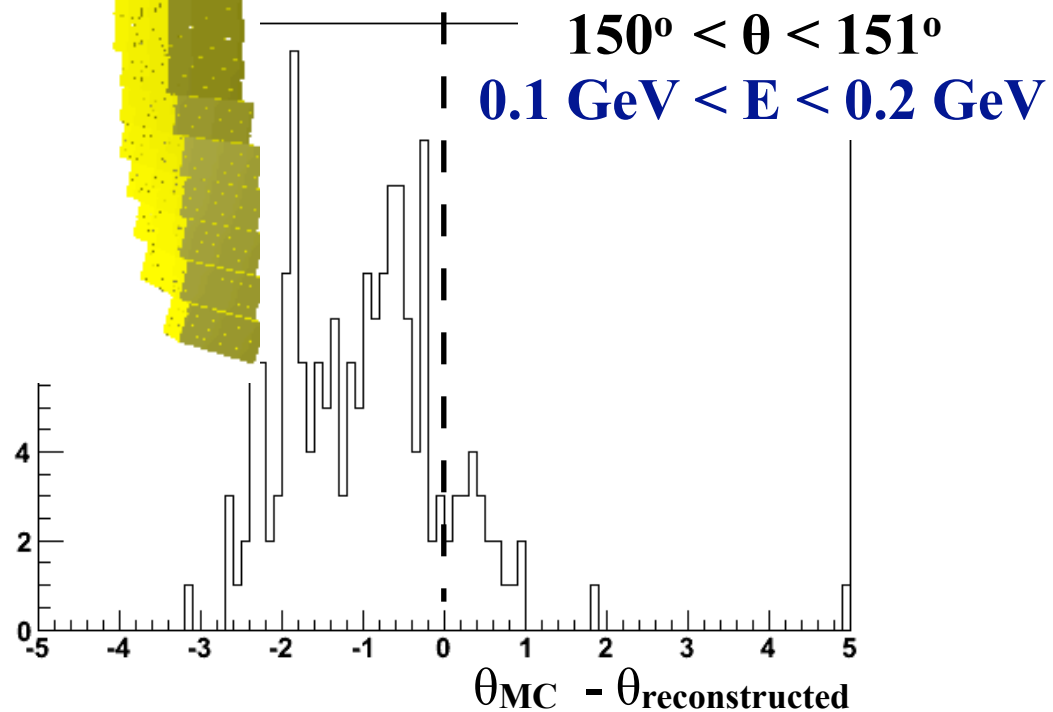


© Presently output from the code:

N



Z



How to correct these?

1<sup>st</sup> step

Photons have been generated:

▶ with the energy: 0 - 10 GeV

▶ angular range:  $\theta \longrightarrow 0^\circ - 172^\circ$

$\phi \longrightarrow 0^\circ - 360^\circ$

2<sup>nd</sup> step⊙ Photon Energy: 0 - 10 GeV

## ● binning:

100 MeV:  $0 \text{ GeV} < E_{\text{photon}} < 1.5 \text{ GeV}$

500 MeV:  $1.5 \text{ GeV} \leq E_{\text{photon}} < 4.0 \text{ GeV}$

1 GeV:  $4.0 \text{ GeV} \leq E_{\text{photon}} < 10.0 \text{ GeV}$

2<sup>nd</sup> step⊙ Photon Energy: 0 - 10 GeV

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1 GeV:  $4.0 \text{ GeV} \leq E_{\text{photon}} < 10.0 \text{ GeV}$

⊙ Polar photon angles  $\theta$ : 0° - 172°

## ● binning:

- Small angles and at the edges - every 1°

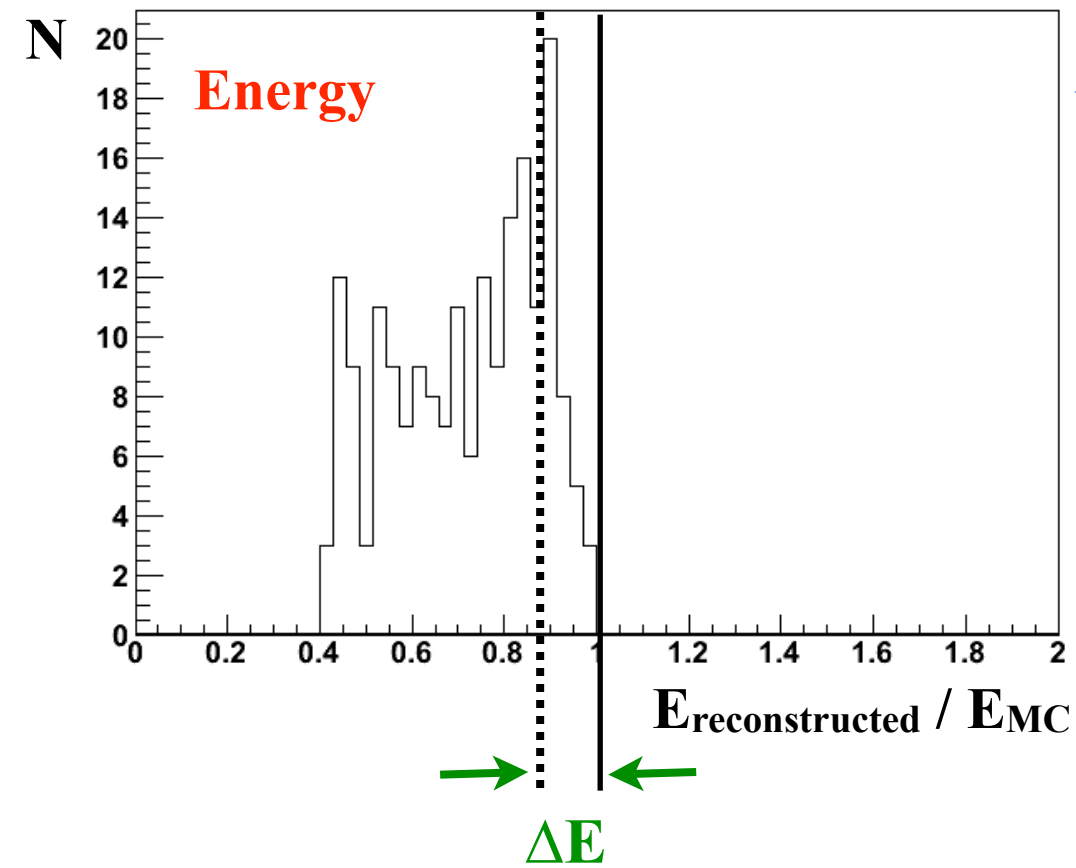
- Barrel - every 5°

- Backward end-cap - every 2°



3<sup>rd</sup> step

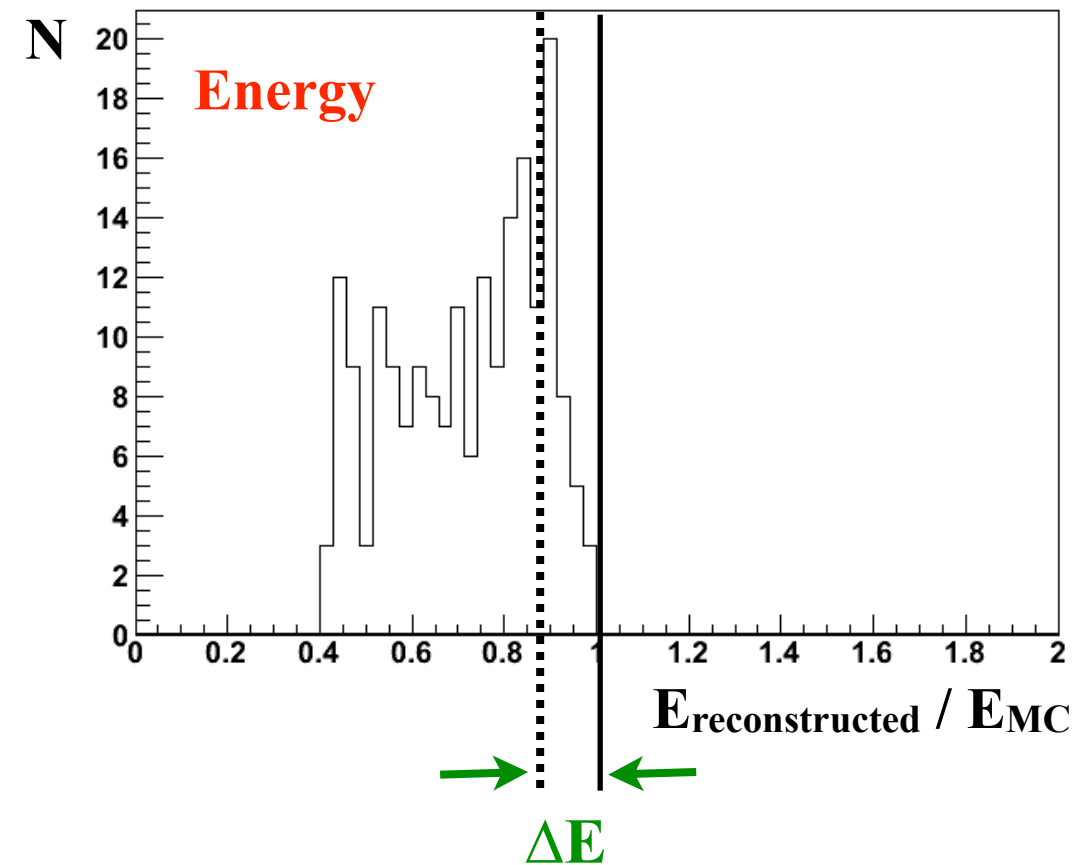
Target EMC



← *GetMean()* for each *energy* &  $\theta$  bin

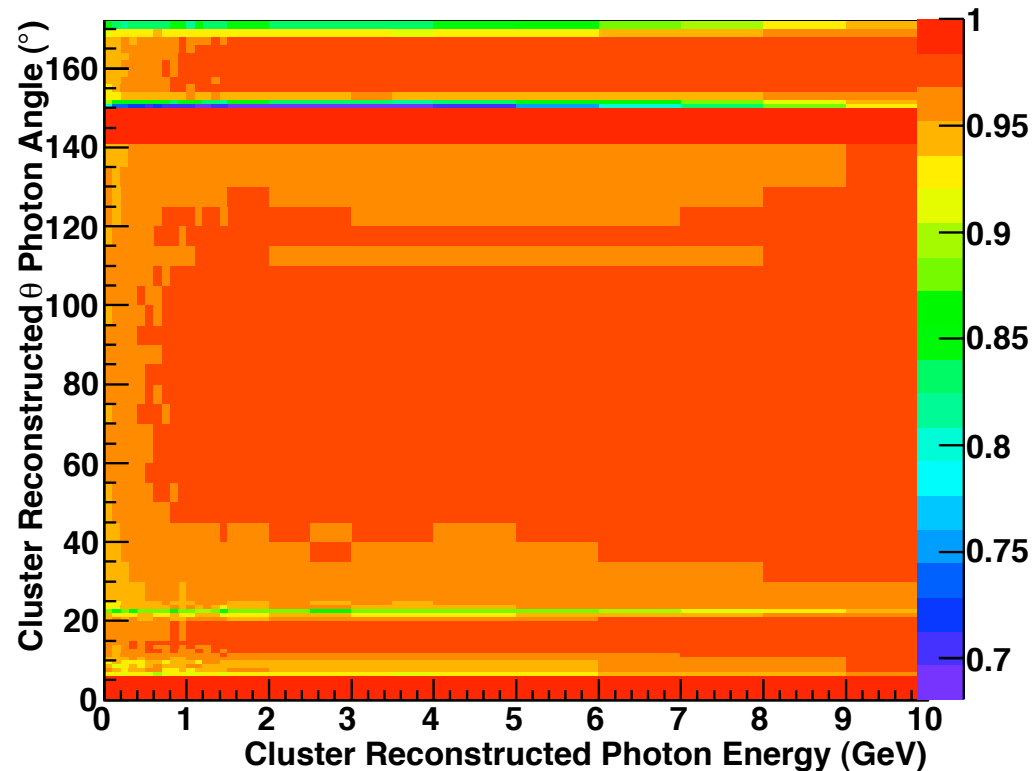
3<sup>rd</sup> step

Target EMC



← *GetMean()* for each *energy* &  $\theta$  bin

*GetMean()* put into a 2D histogram

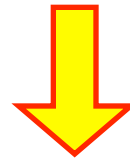


4<sup>th</sup> step

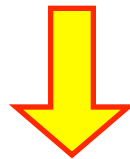
⊙ Interpolation through bins (routine of ROOT) was used

➔ Interpolate the value via bilinear interpolation  
based on the four nearest bin centers

Bilinear interpolation is an extension of linear interpolation for interpolating functions of two variables on a regular grid. The key idea is to perform linear interpolation first in one direction, and then again in the other direction.

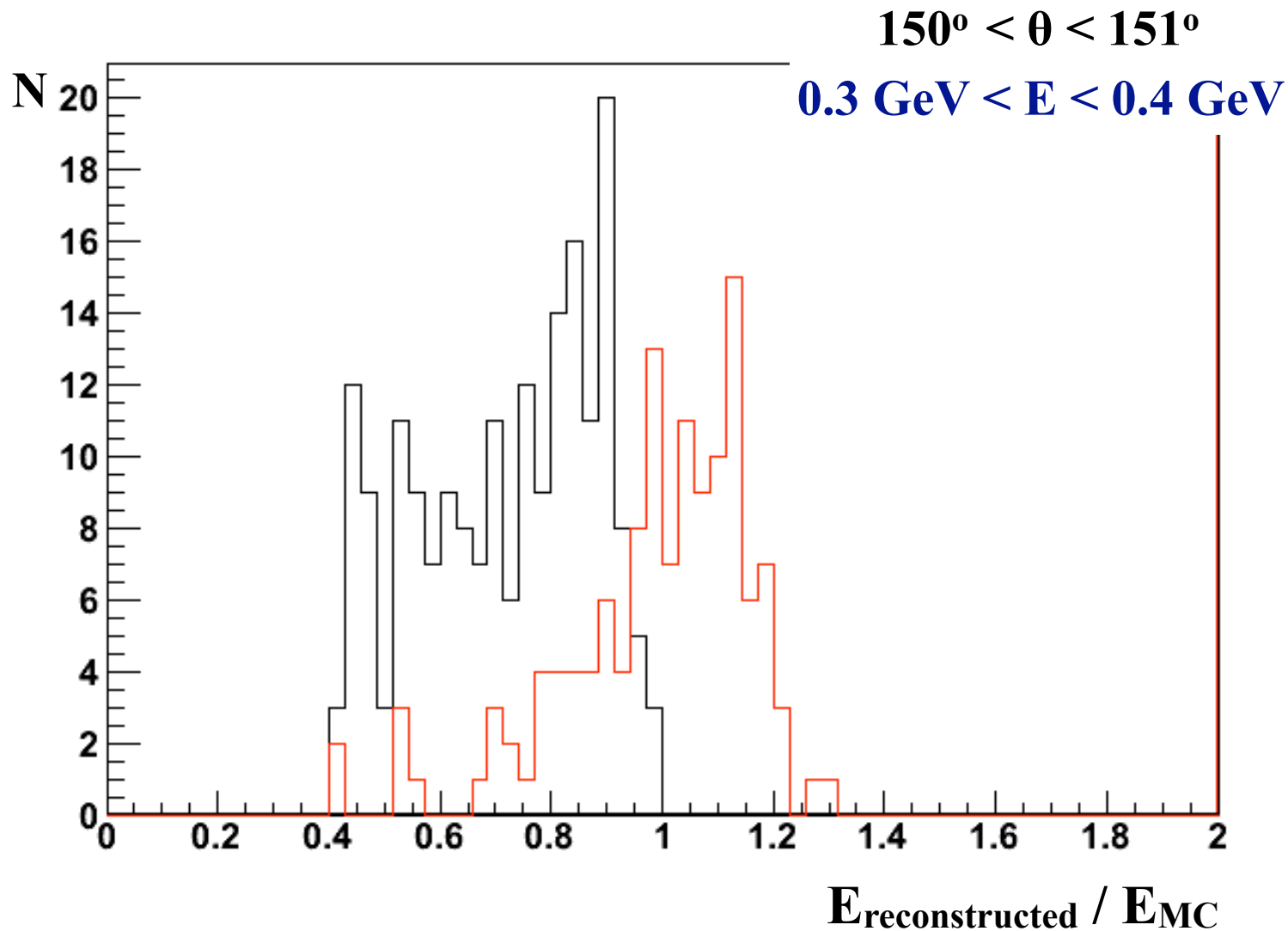


Better value,  $\Delta E'$ , for looking up values is got



Interpolated *GetMean()* put into a 2D histogram

$$E_{\text{corrected}} = E_{\text{reconstructed}} * \Delta E'$$



Before correction

After correction

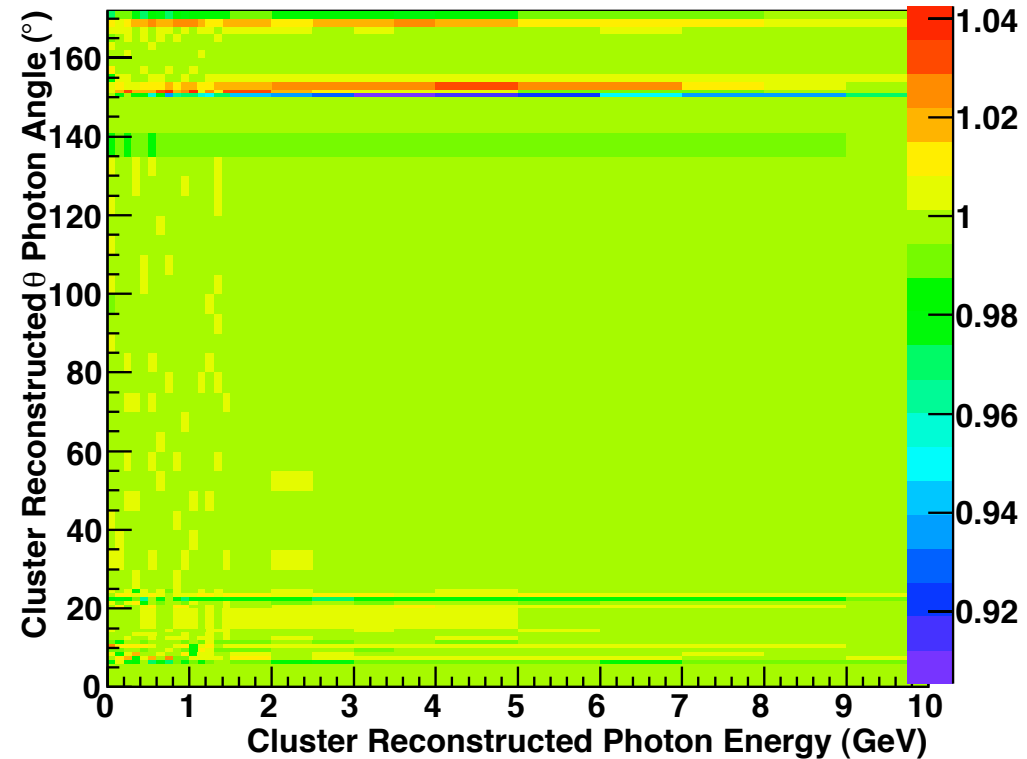
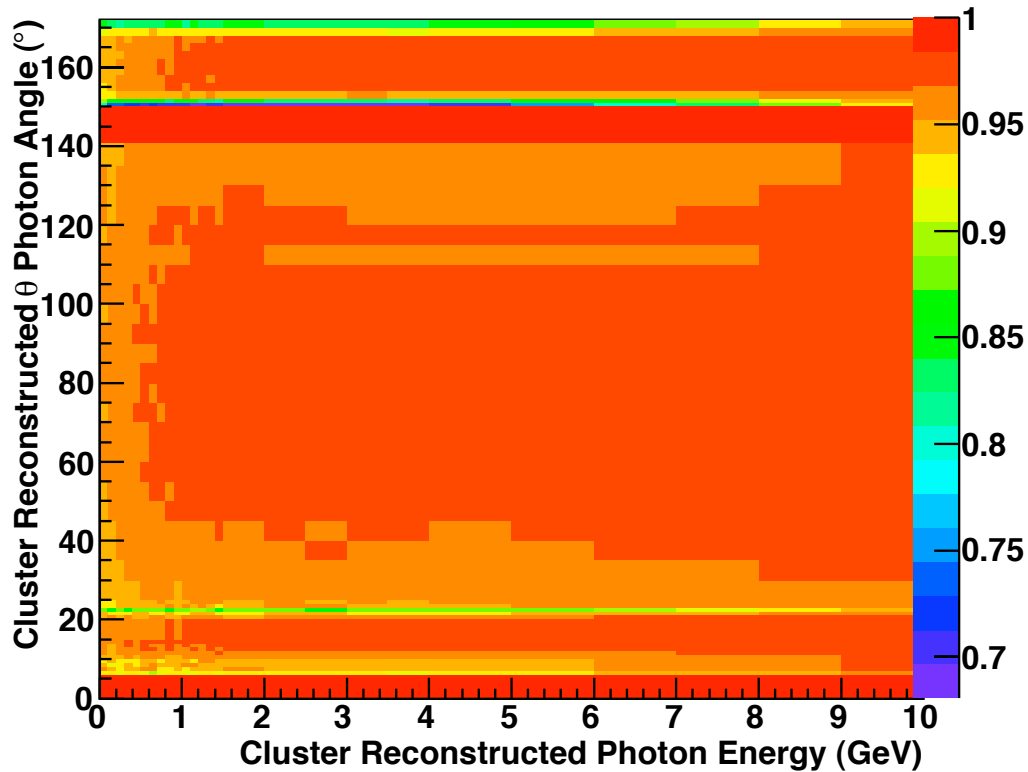
## RESULT

• Before correction

✓ After correction

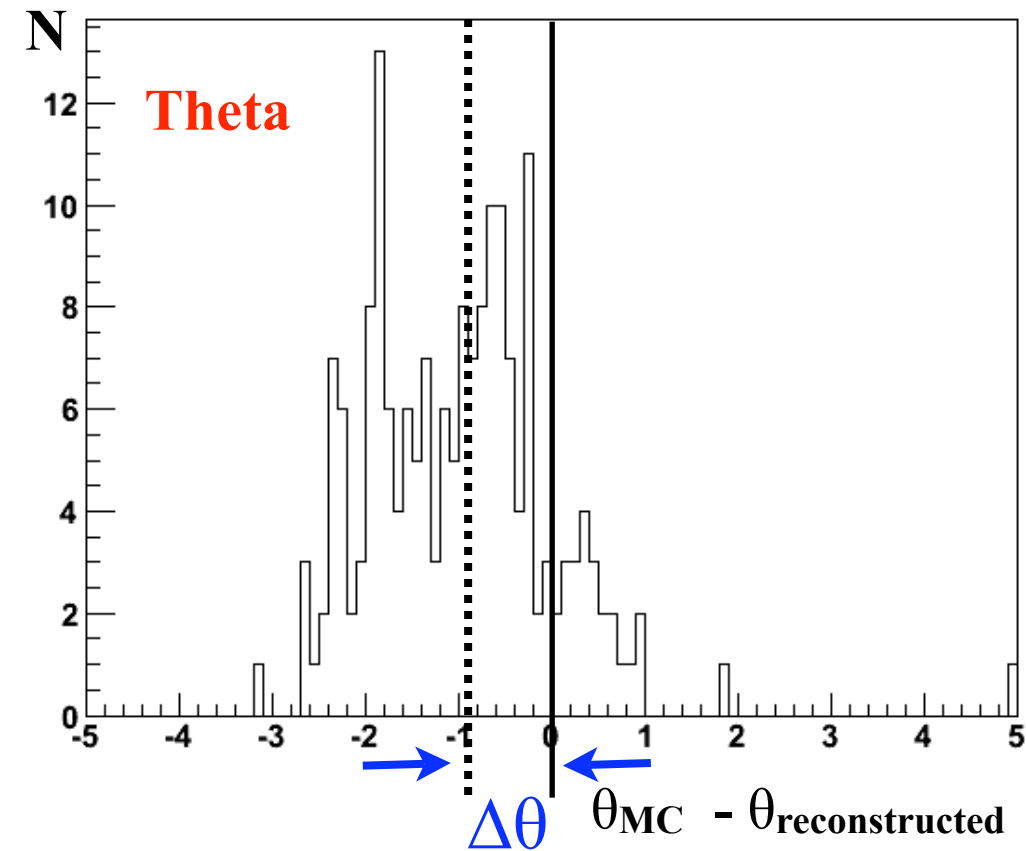
Mean

Mean



5<sup>th</sup> step

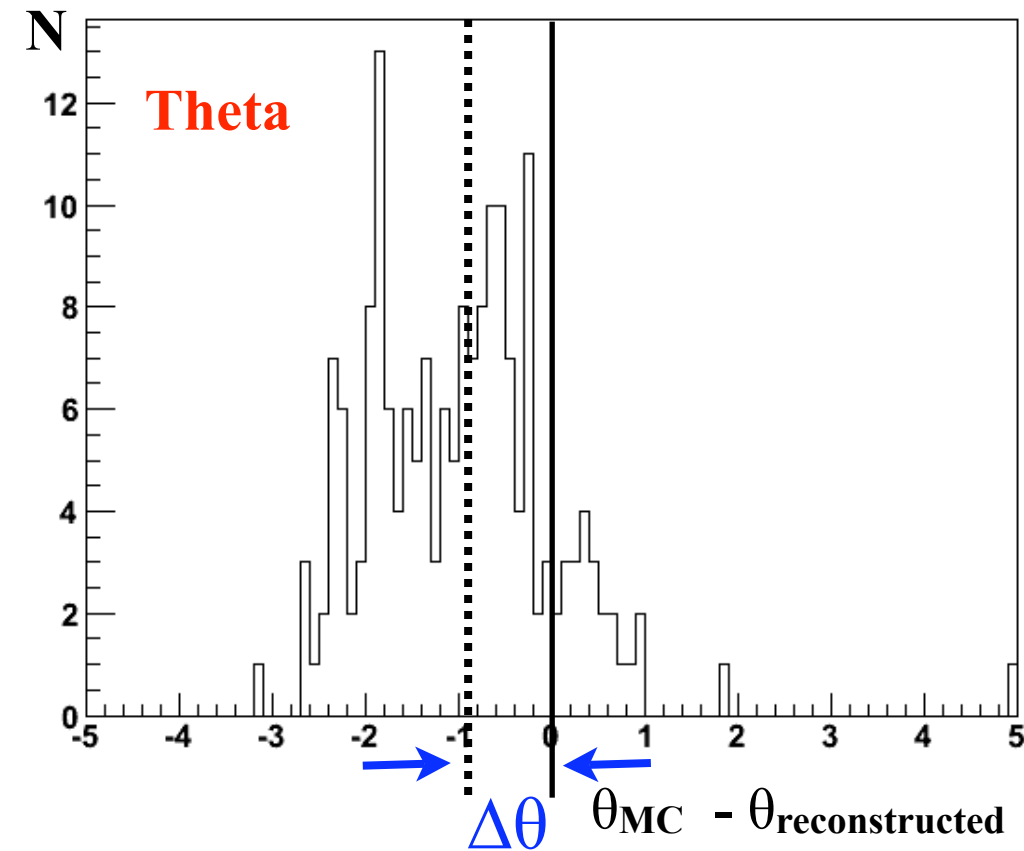
Target EMC



← *GetMean()* for each *energy* & *θ* bin

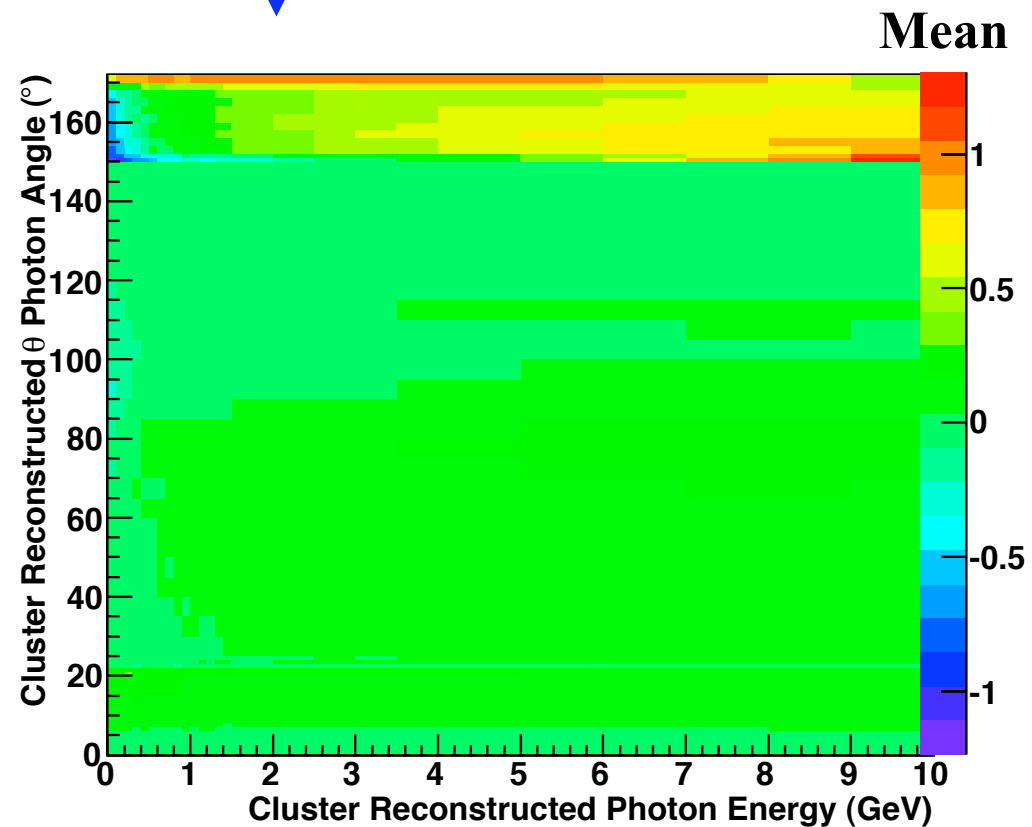
5<sup>th</sup> step

Target EMC

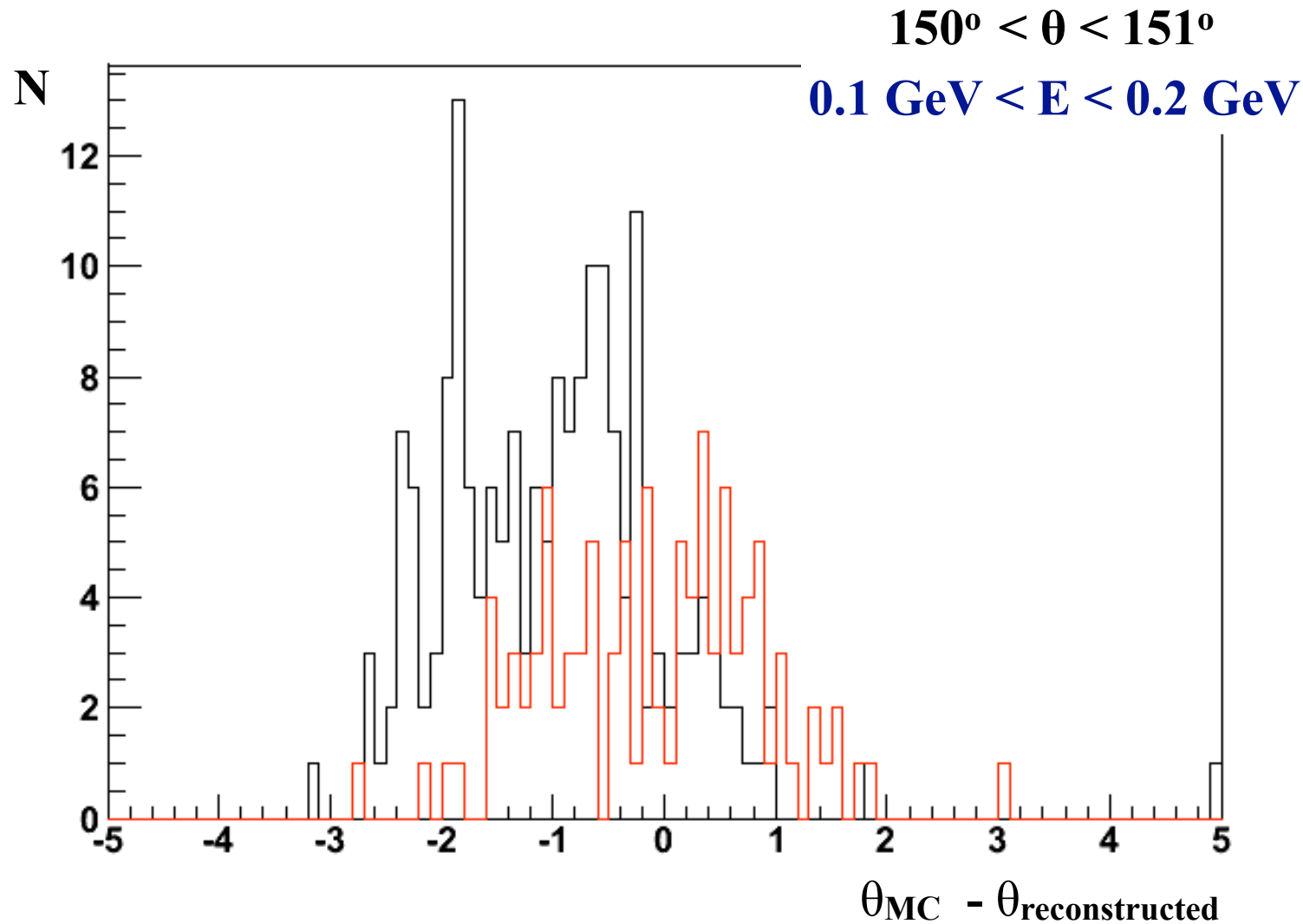


← *GetMean()* for each *energy* &  *$\theta$*  bin

*GetMean()* put into a 2D histogram



$$\bullet \theta_{corrected} = \theta_{reconstructed} + \Delta\theta$$



Before correction

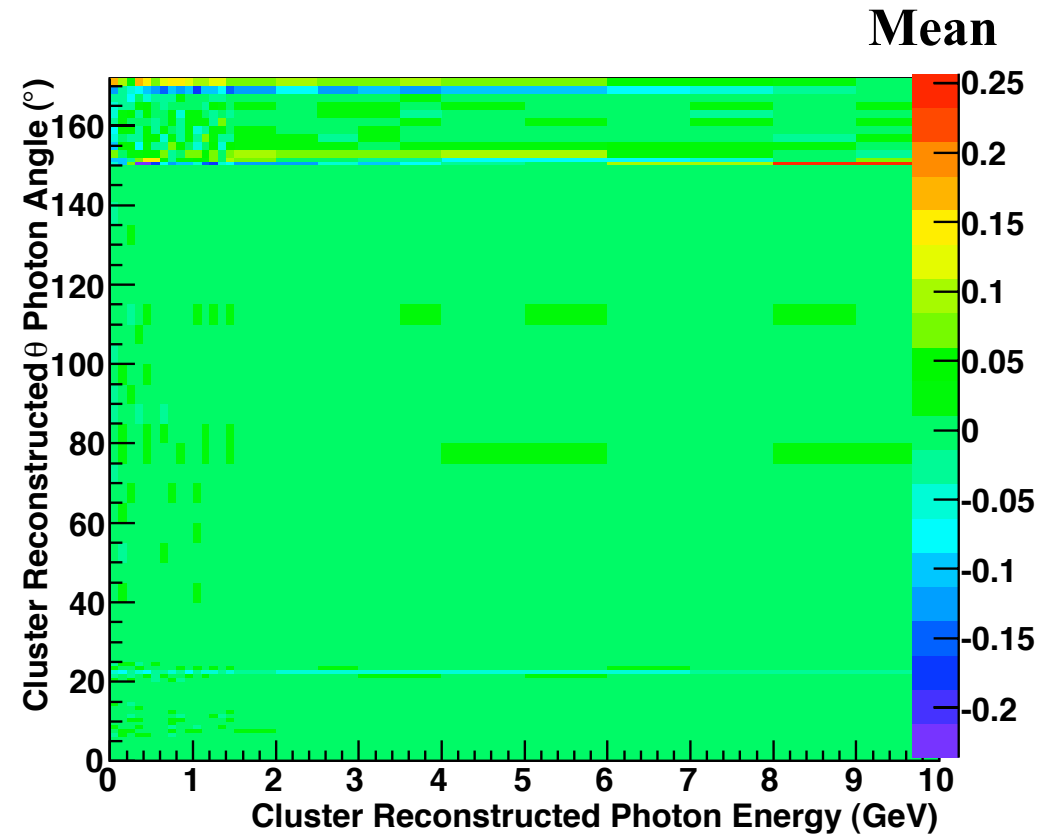
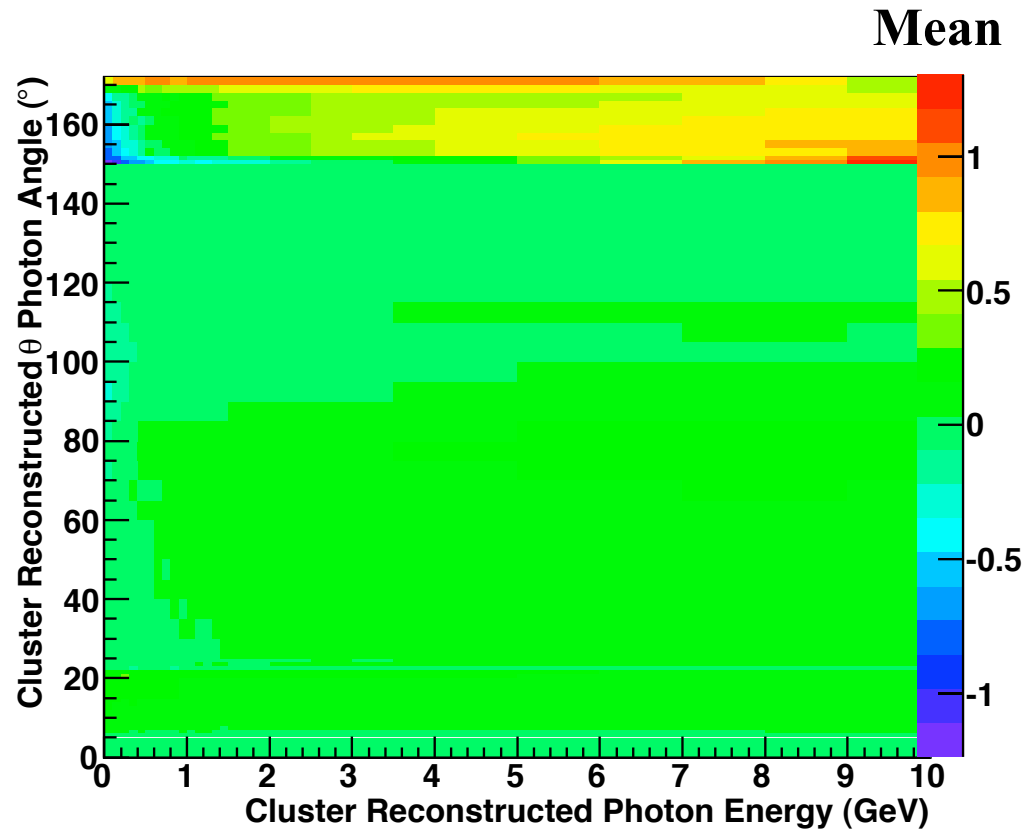
After correction



**RESULT**

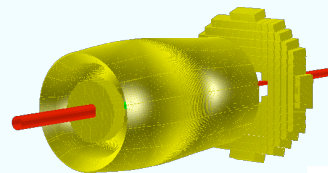
• Before correction

✓ After correction

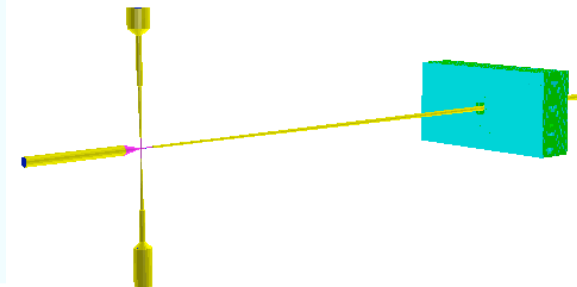



 The **energy** and  $\theta$  corrections have been done for:

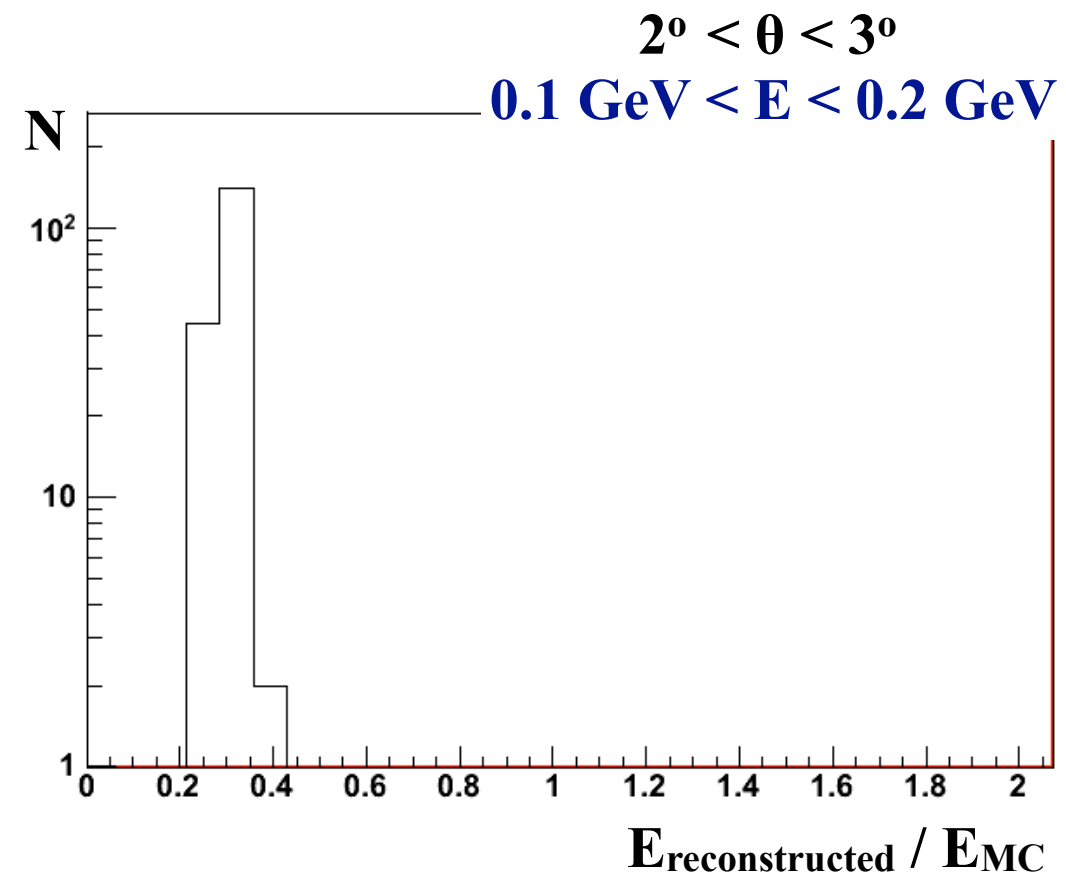
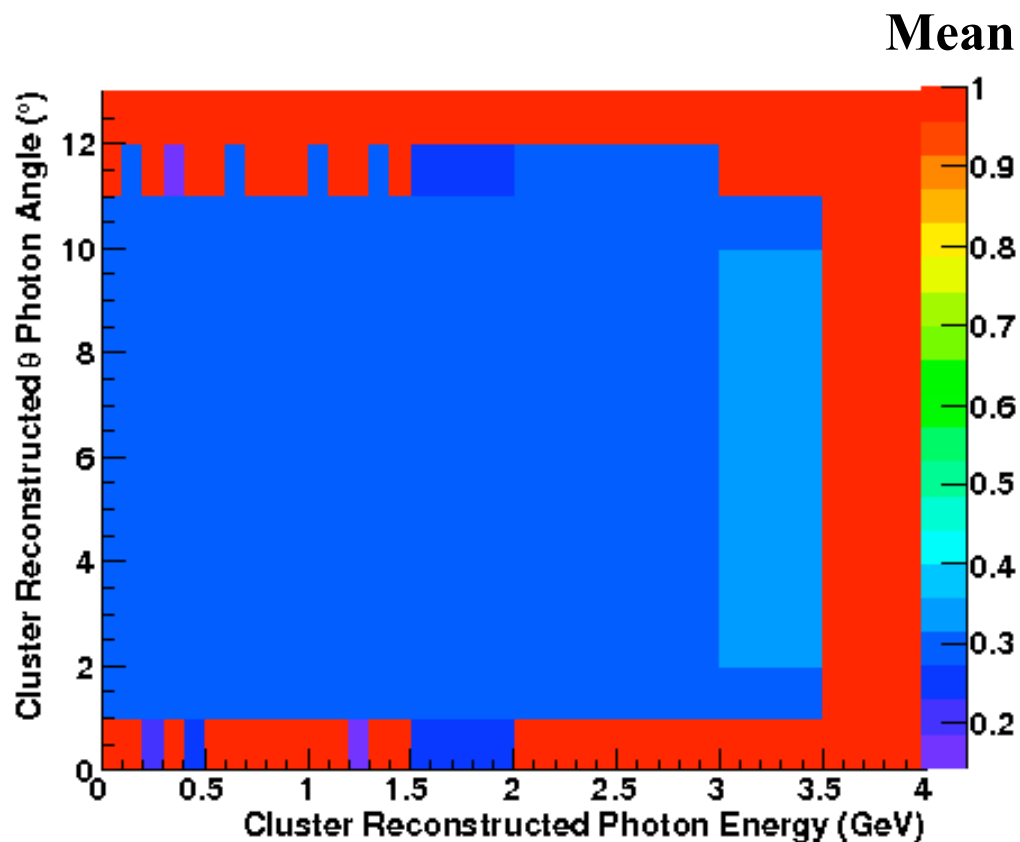

**Target EMC**



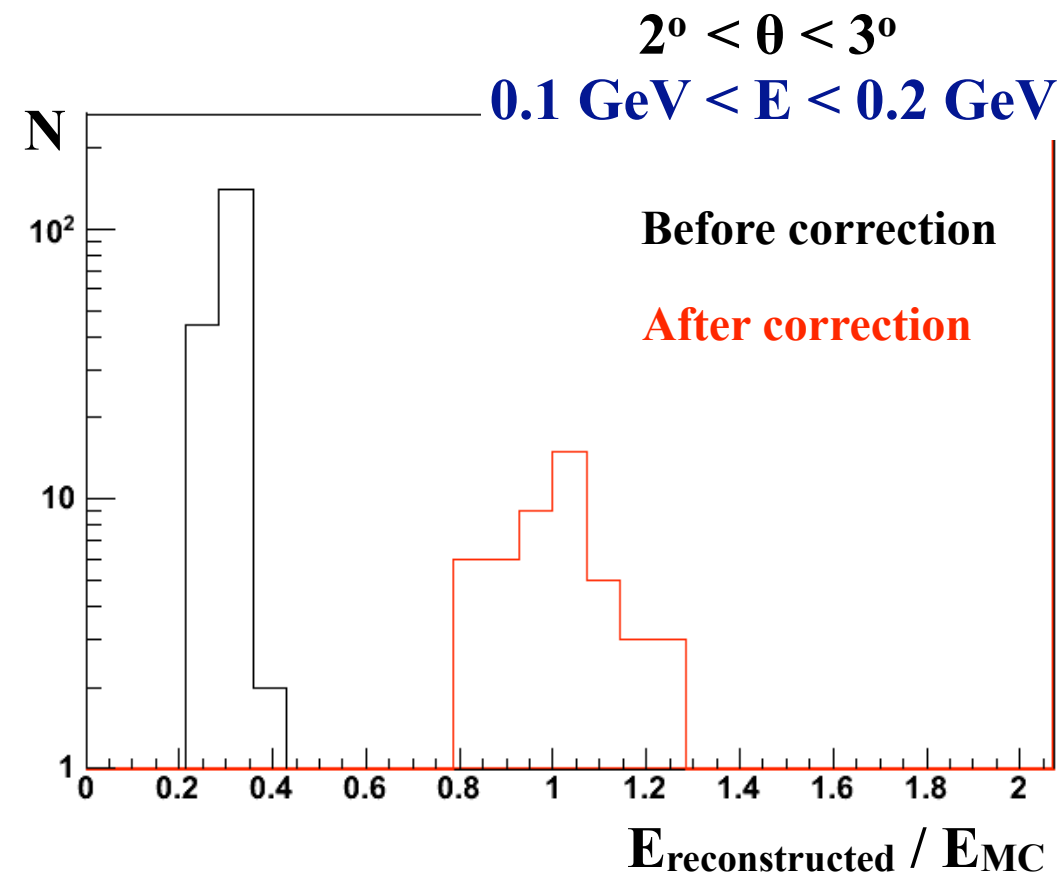
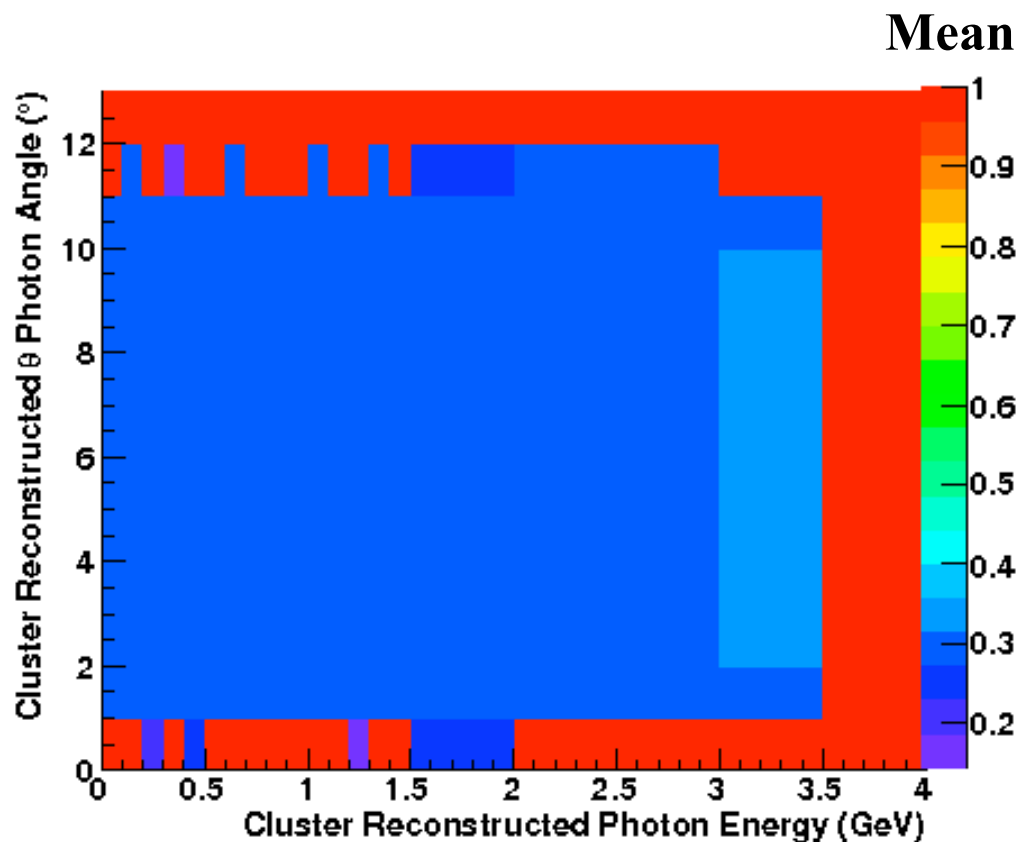

**Shashlyk calorimeter**



- Before correction



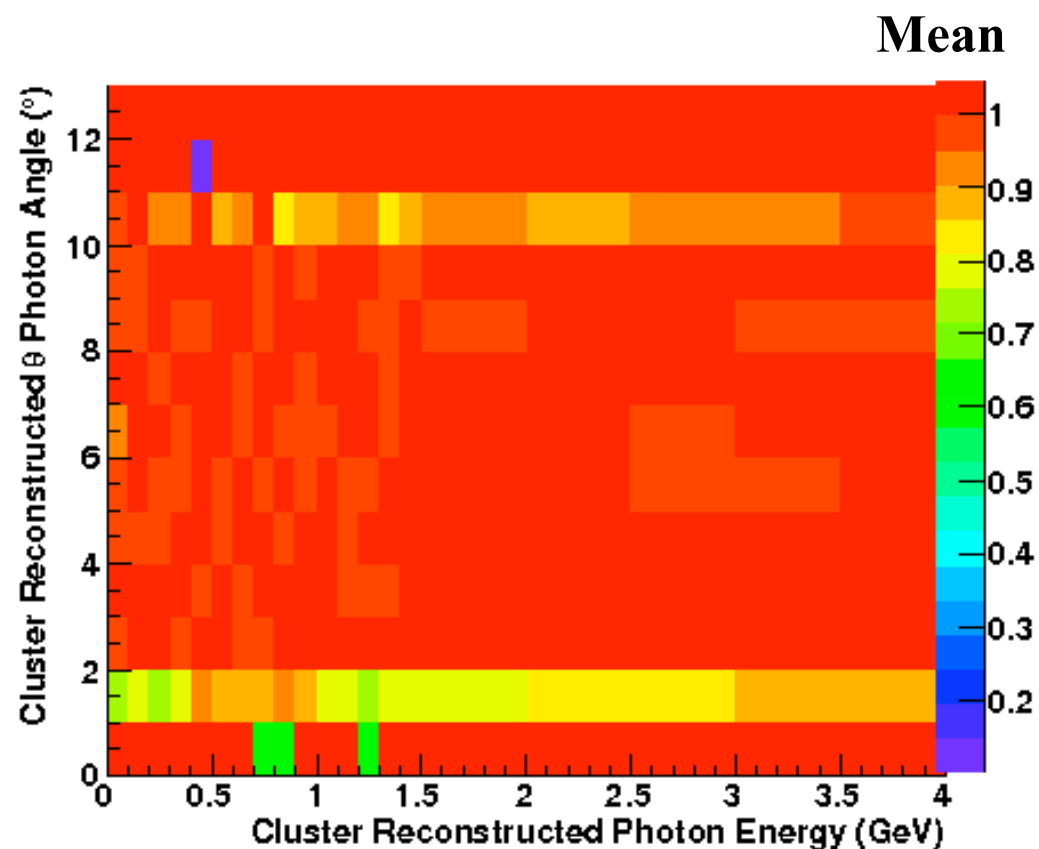
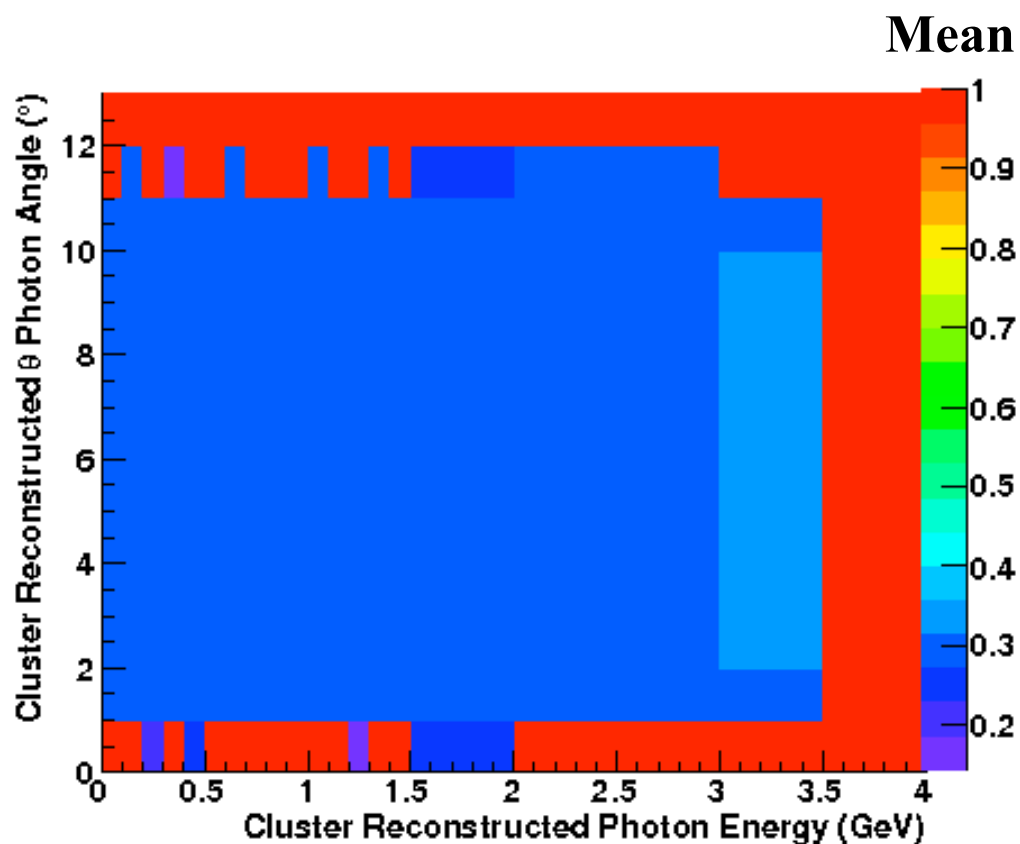
- Before correction



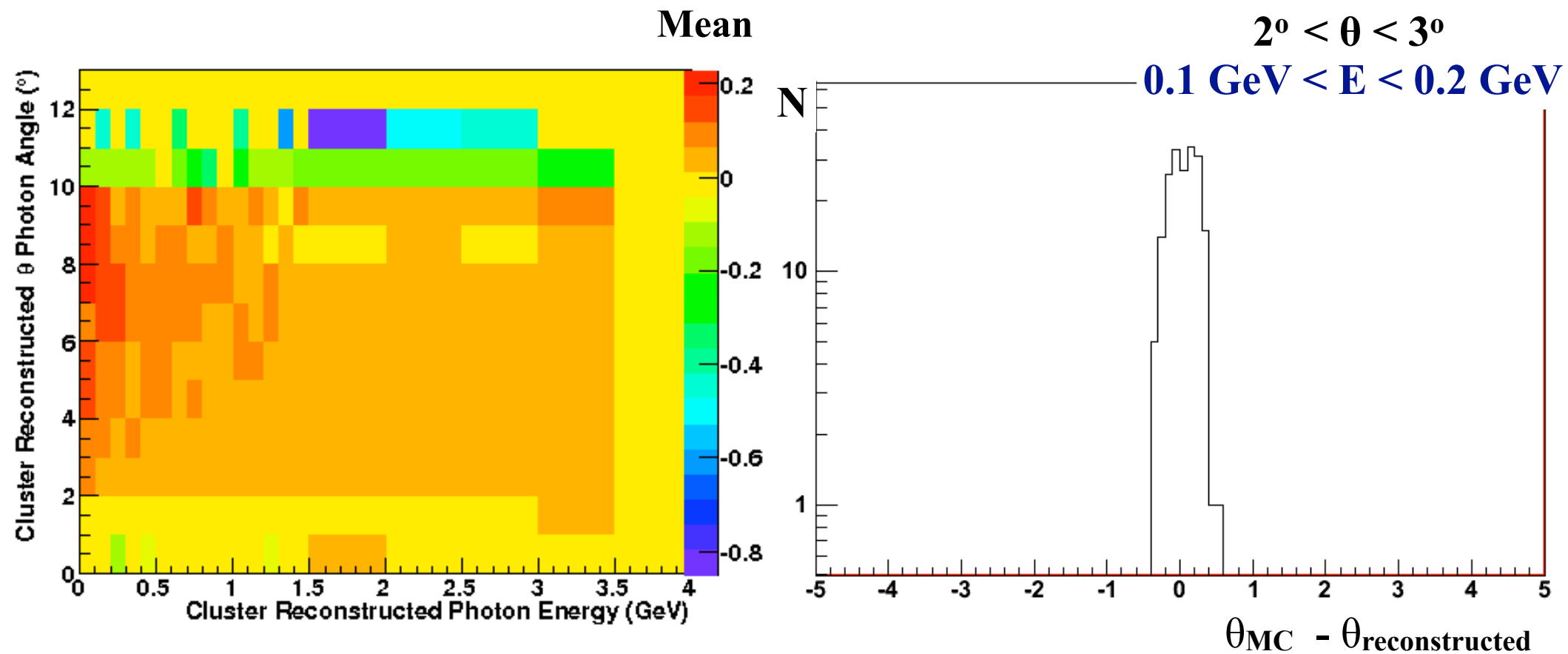
## RESULT

• Before correction

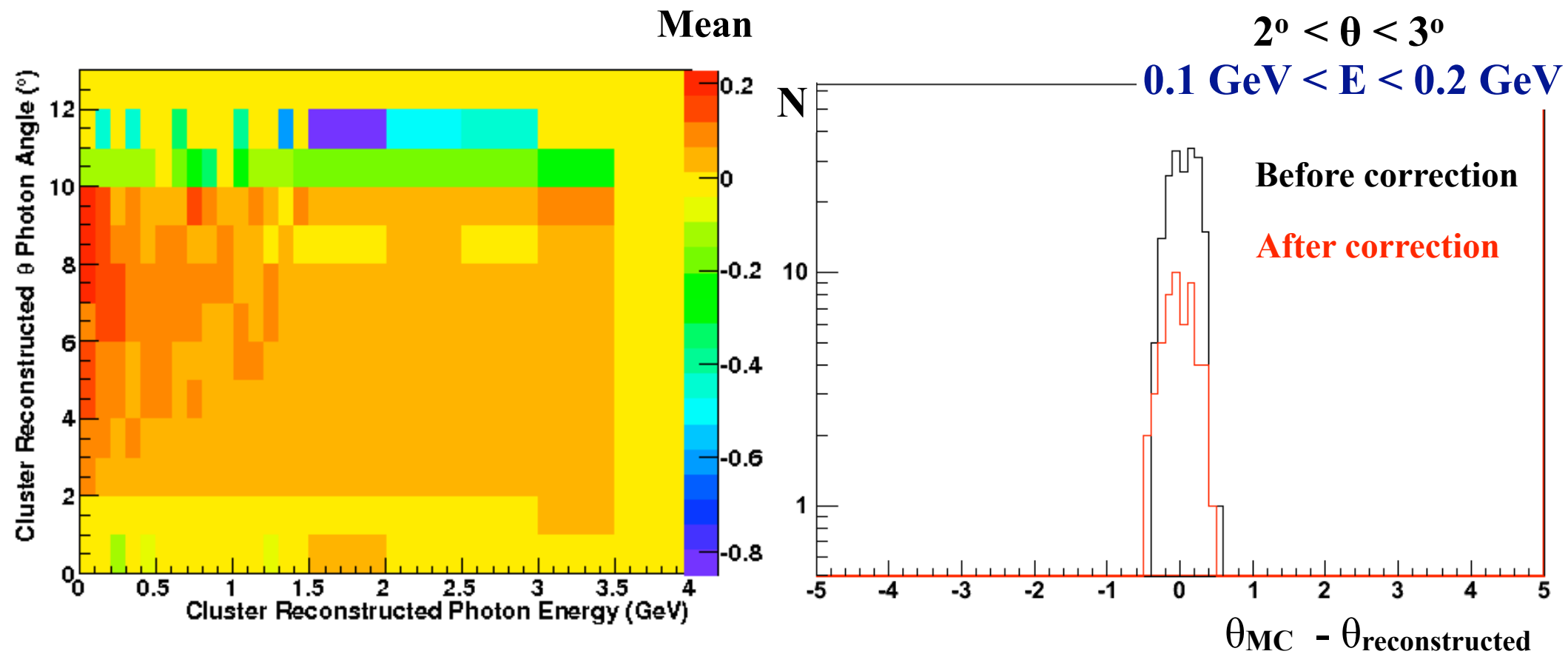
✓ After correction



- Before correction



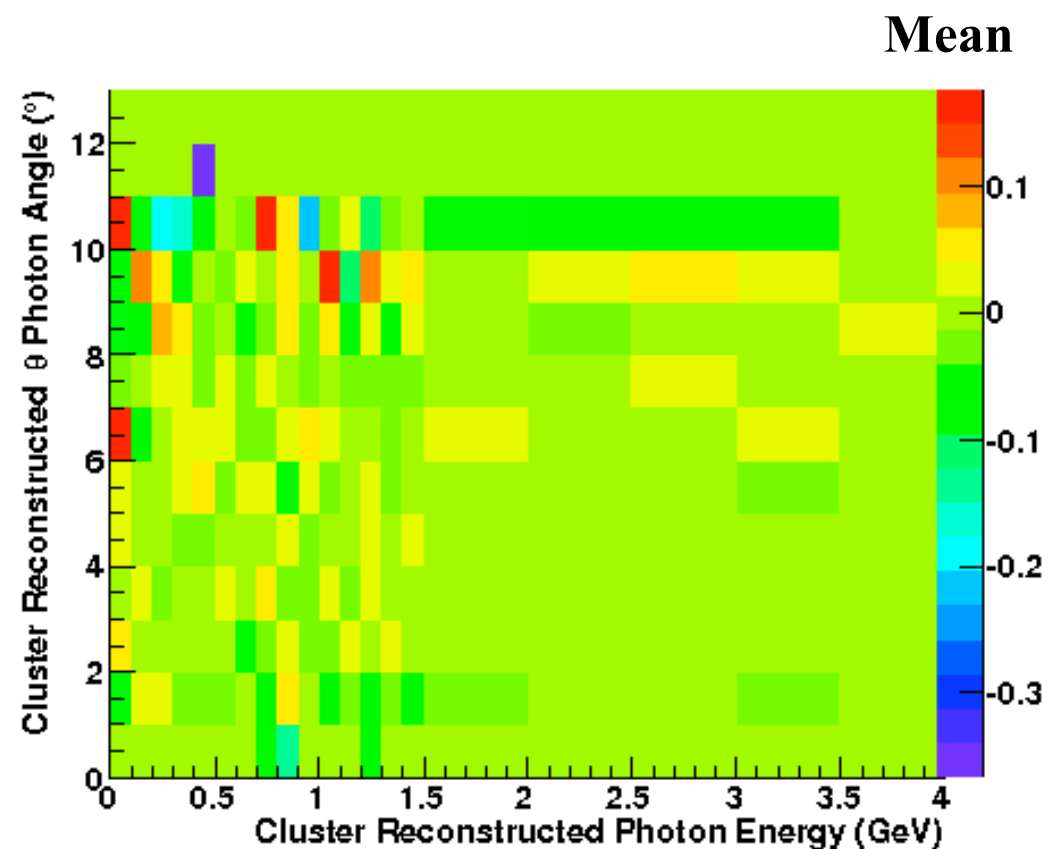
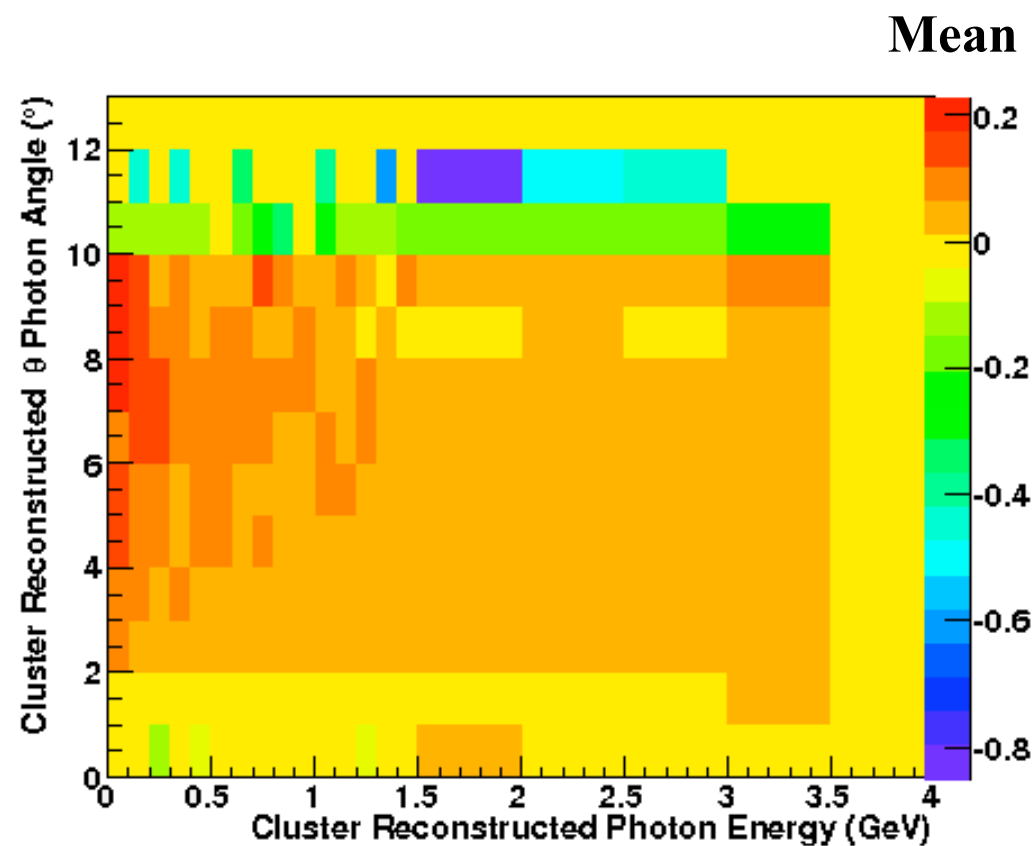
- Before correction



**RESULT**

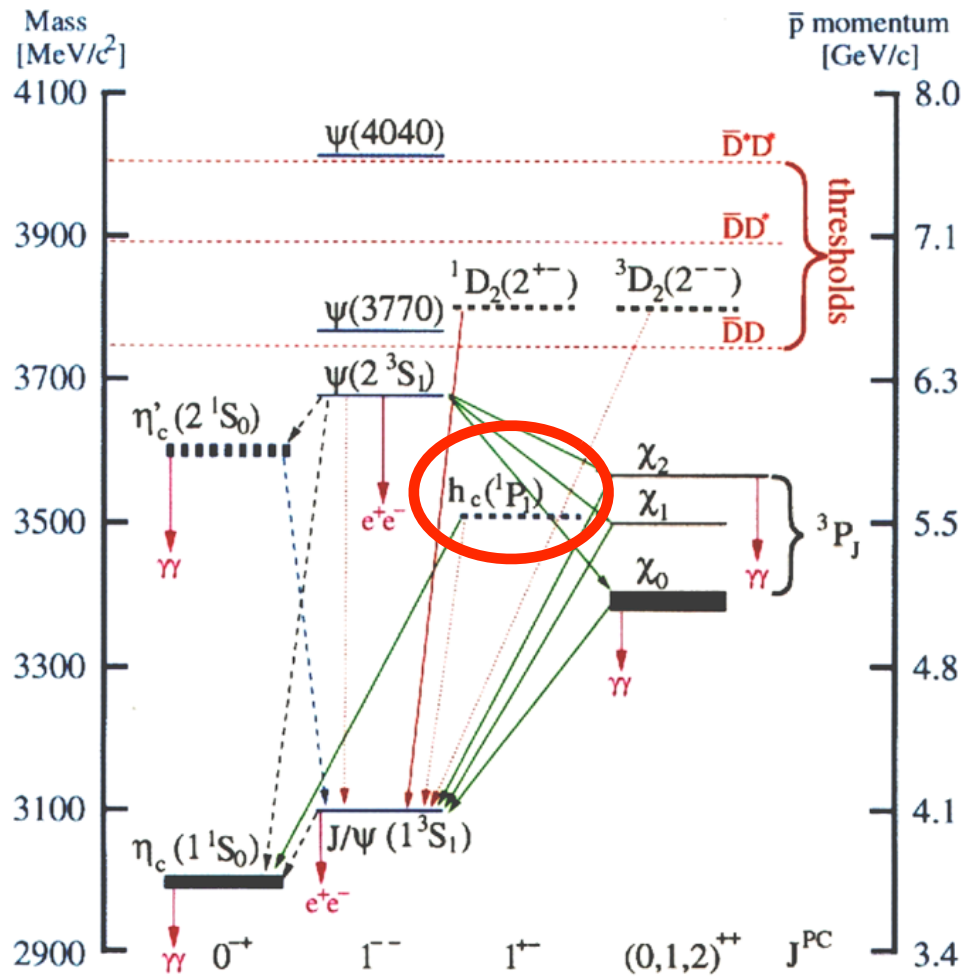
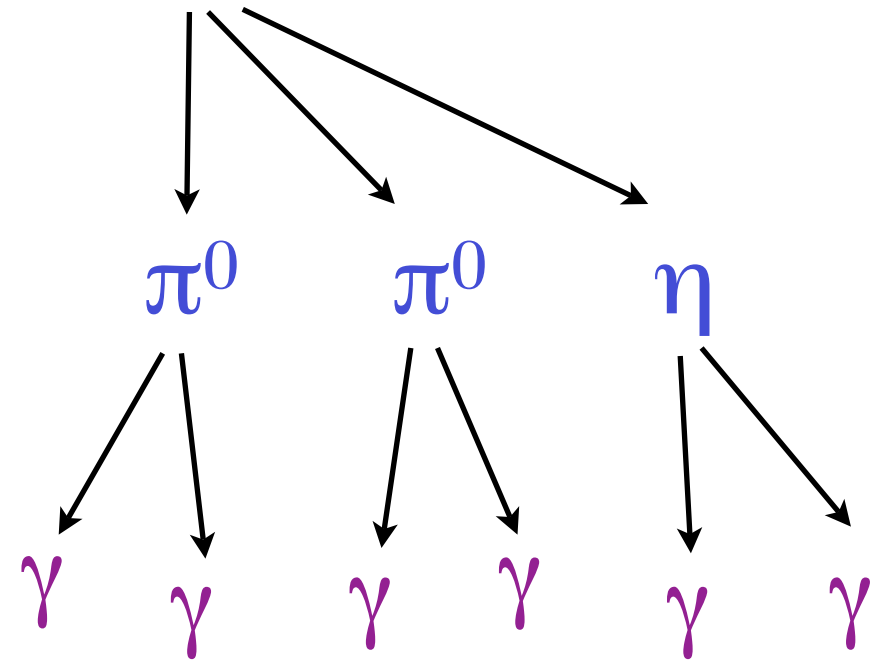
• Before correction

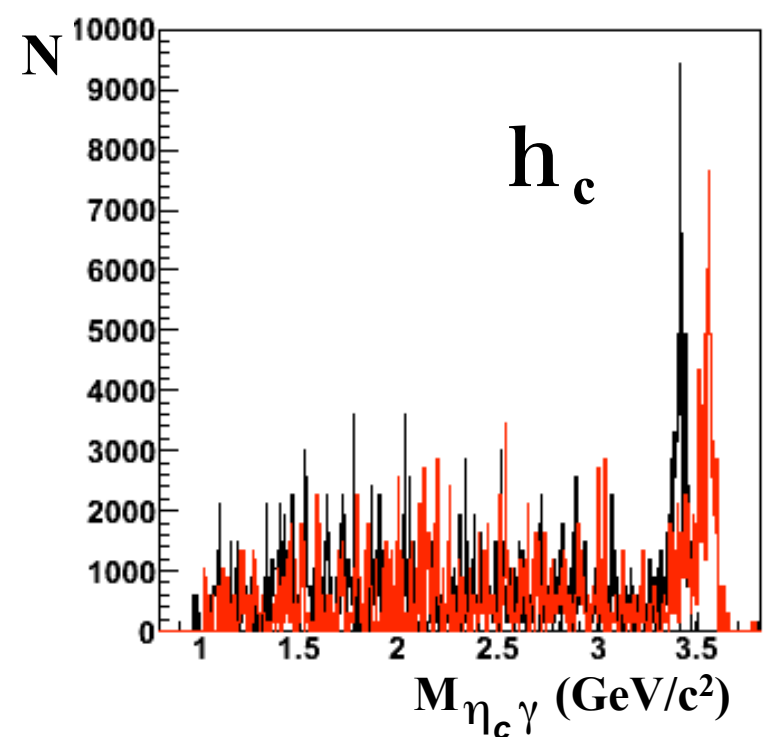
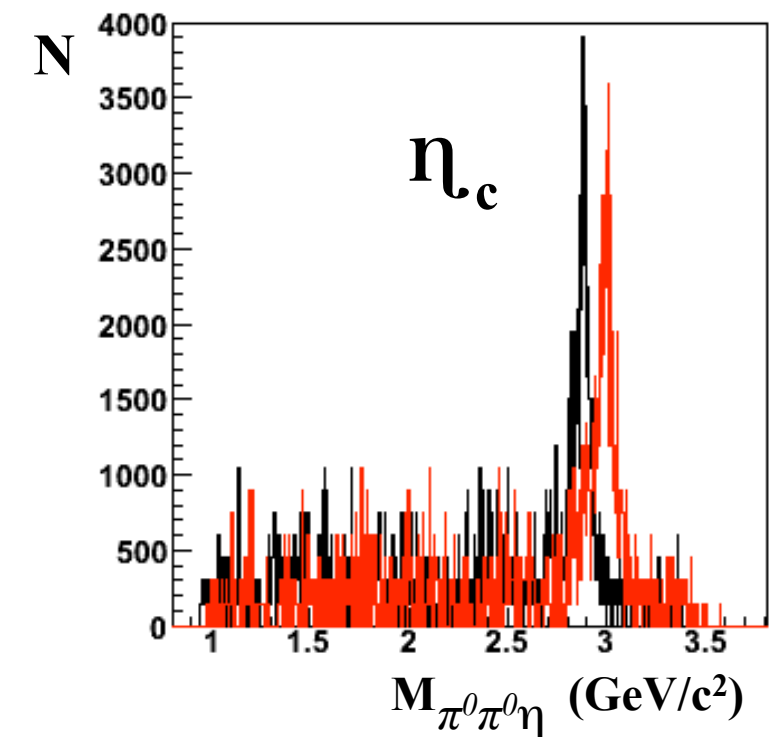
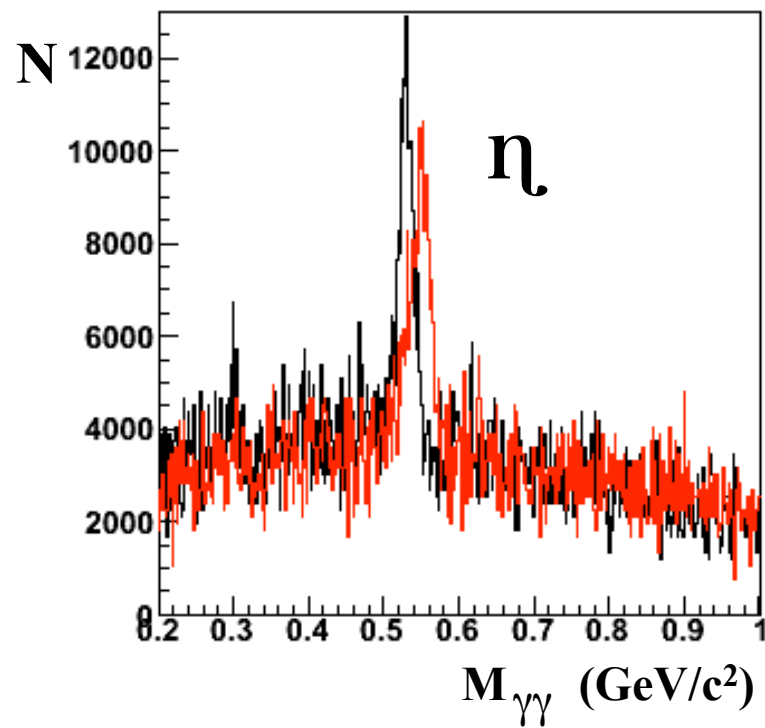
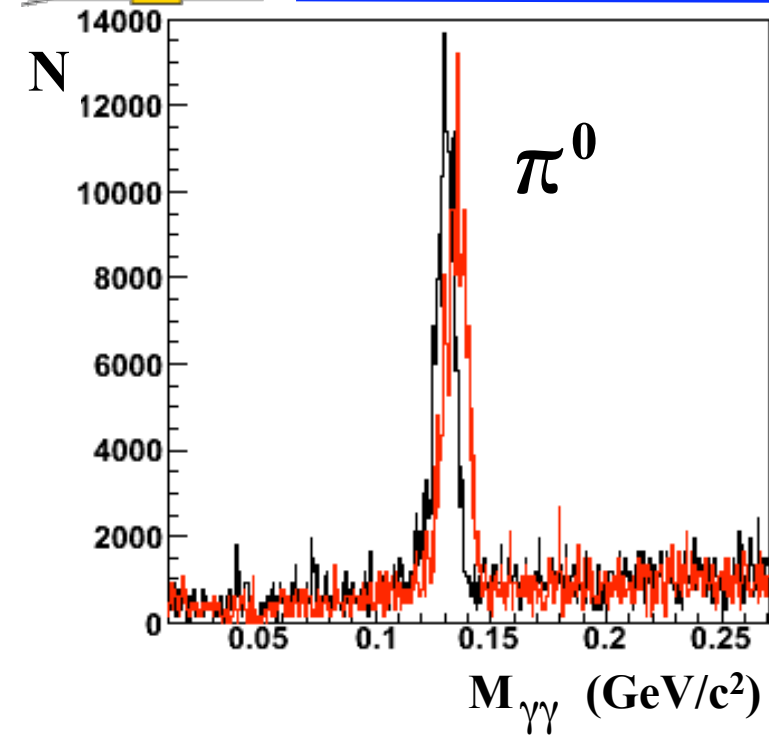
✓ After correction





# Application of the energy and theta corrections

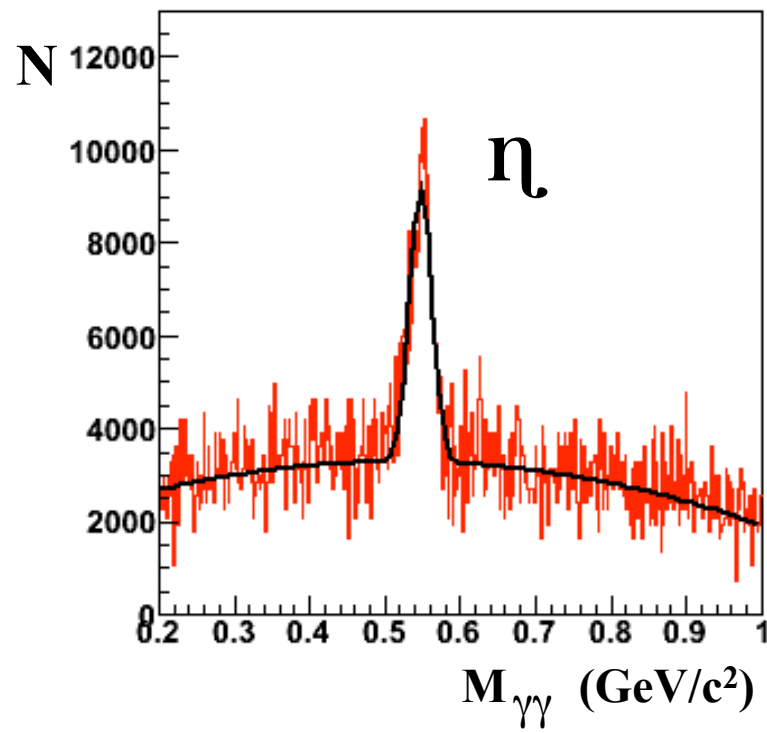
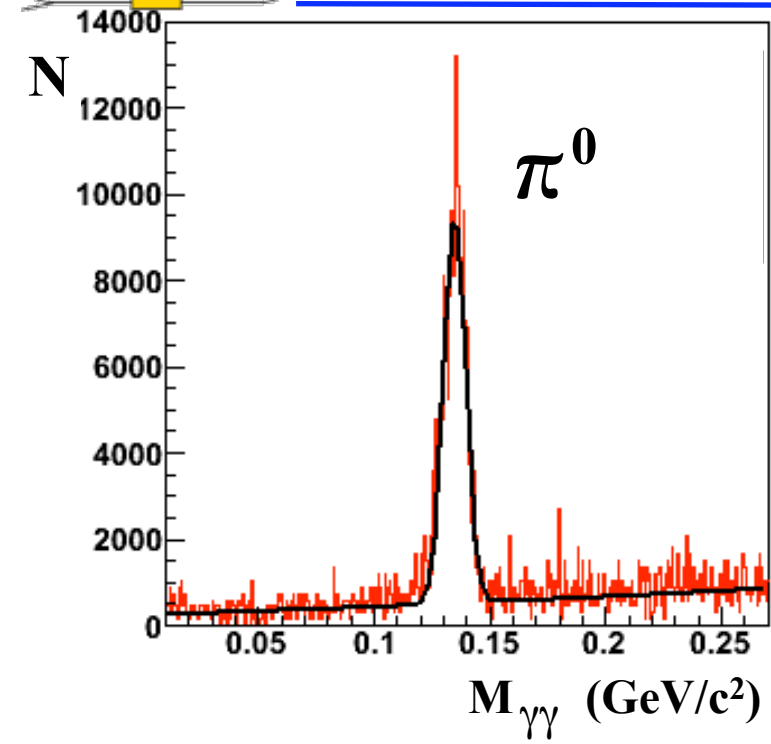




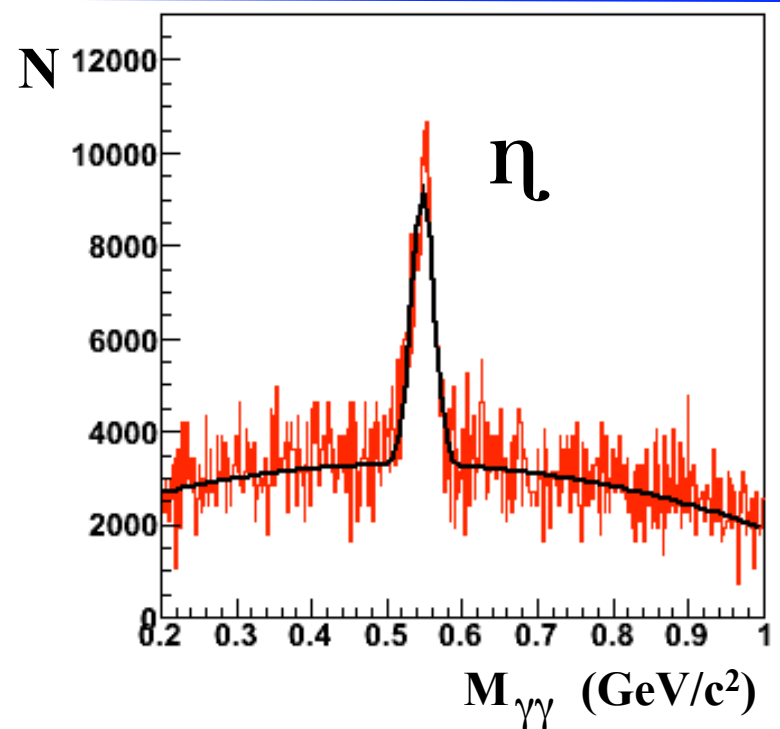
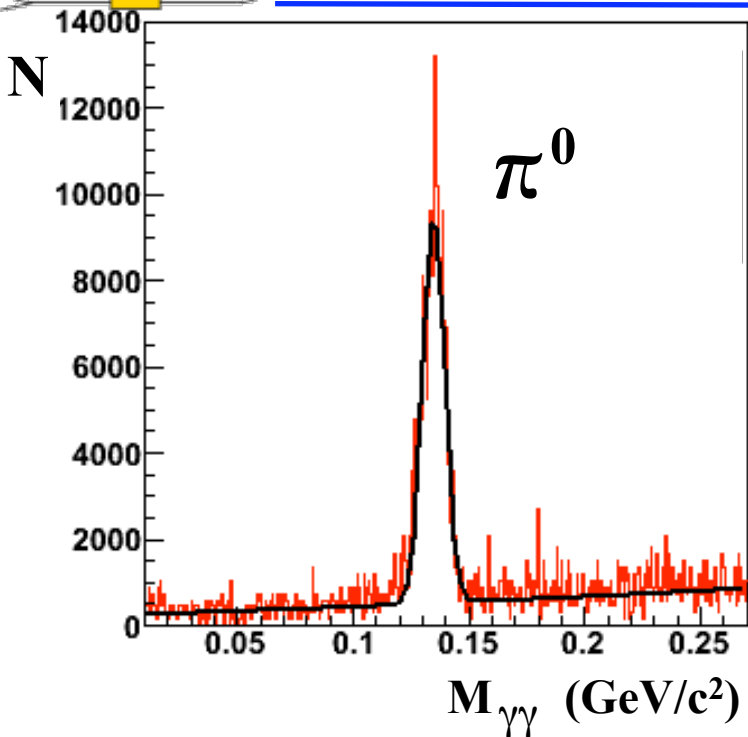
Before correction  
 After correction

- ▶ 150 000 events generated
- ▶ GEANT 4
- ▶ ~ 9 sigma cut

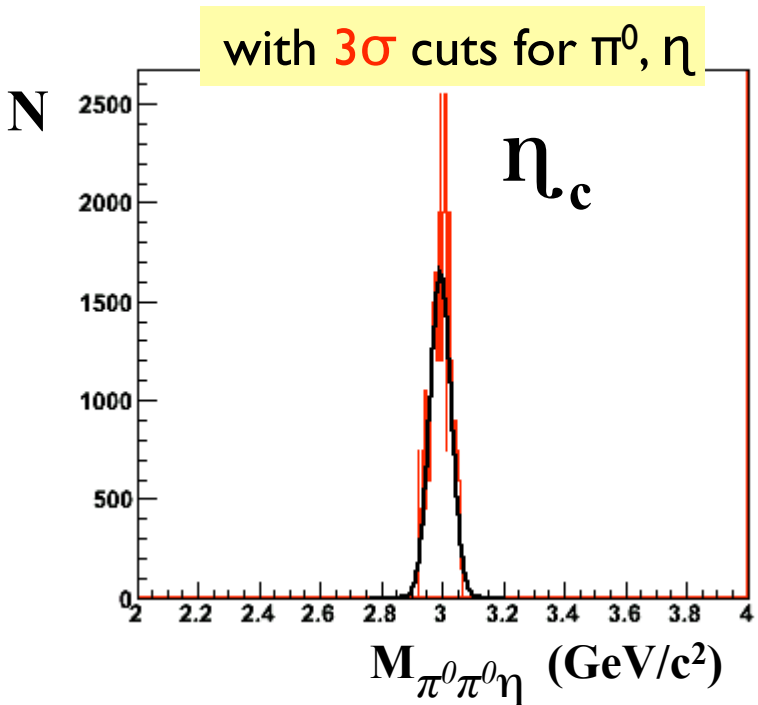
Peaks are shifted to the correct direction!



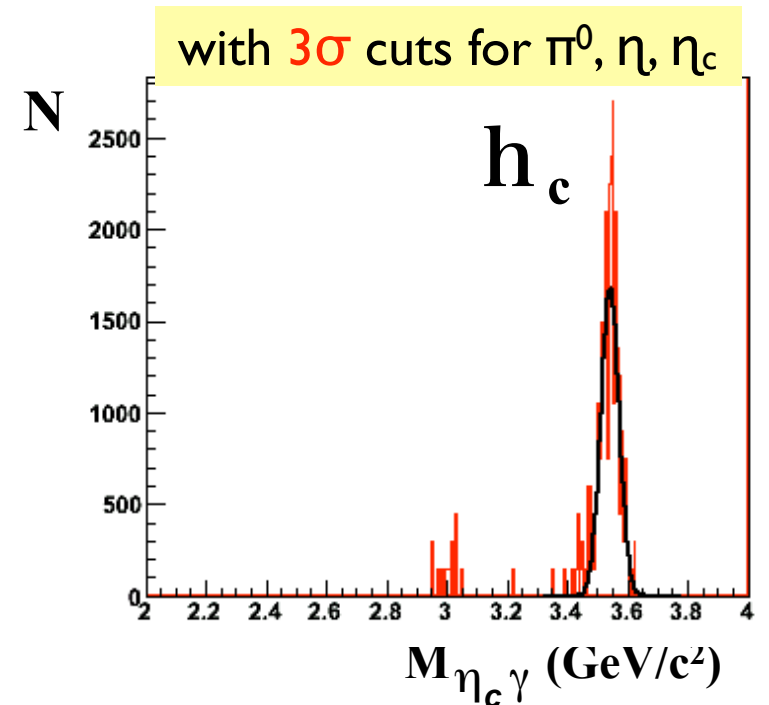
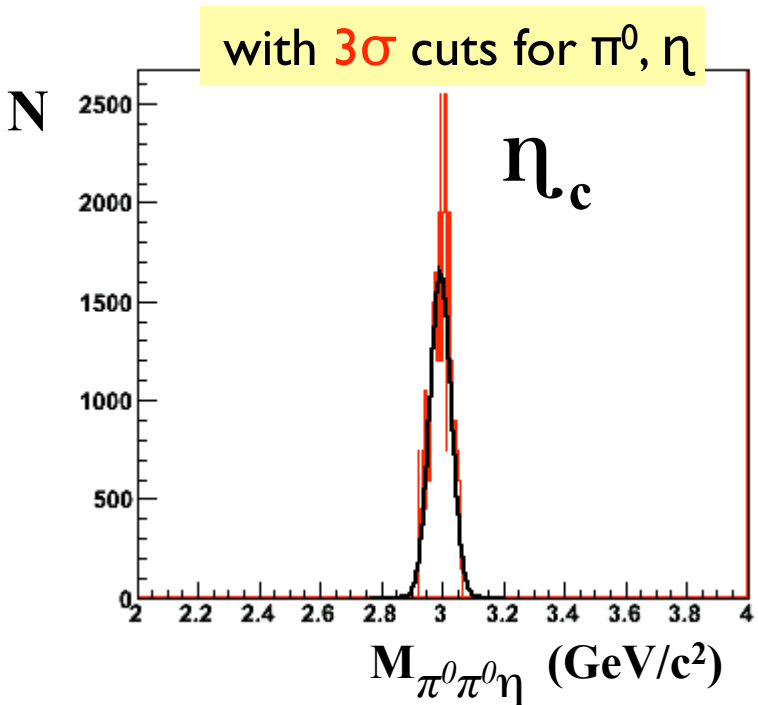
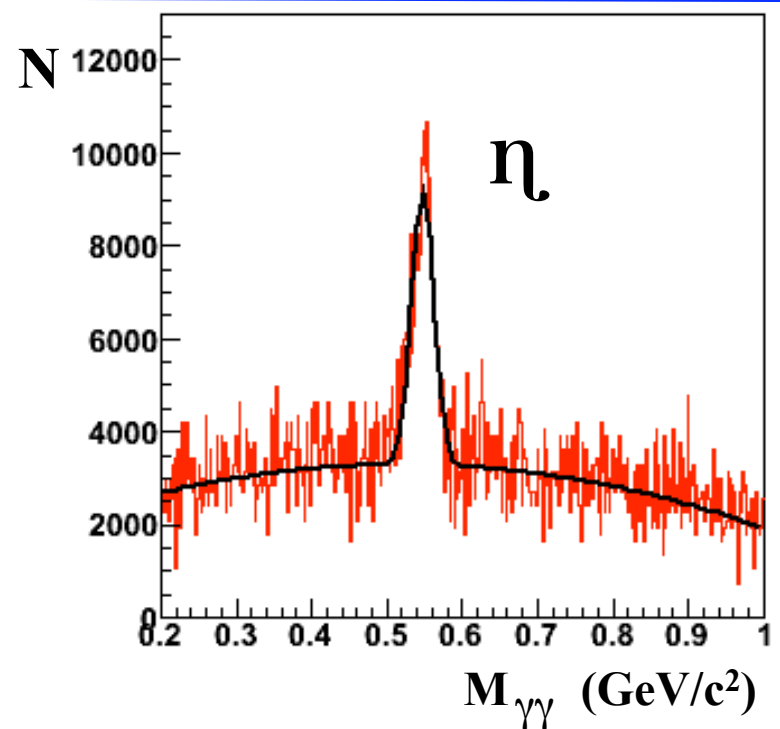
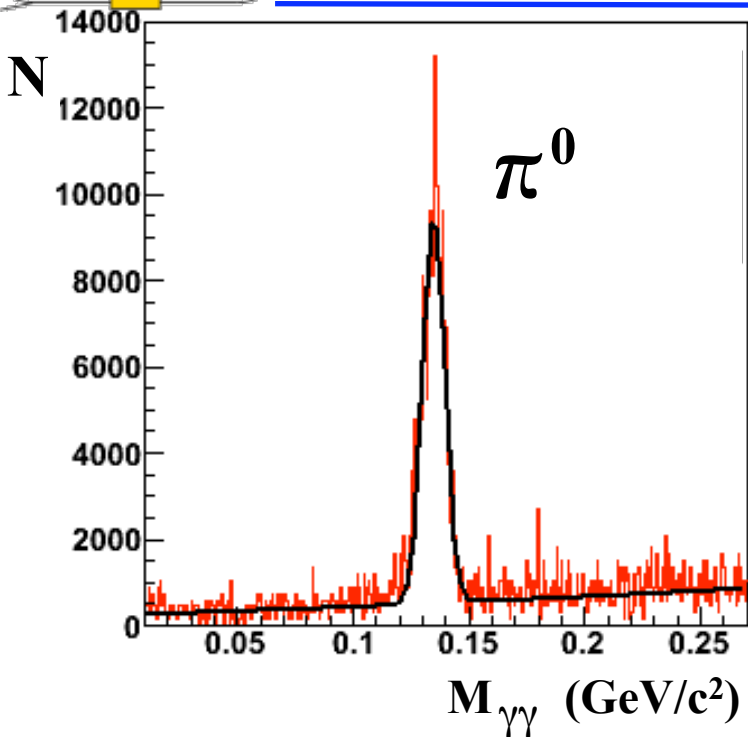
After correction



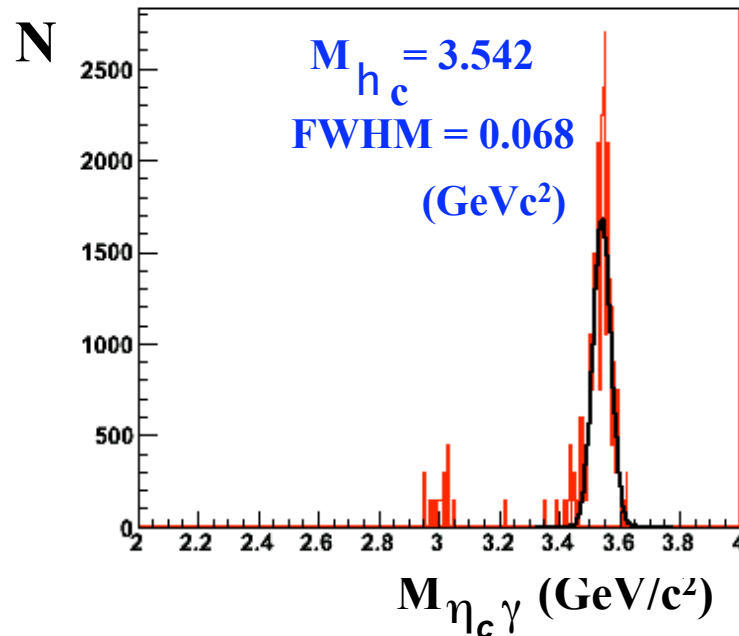
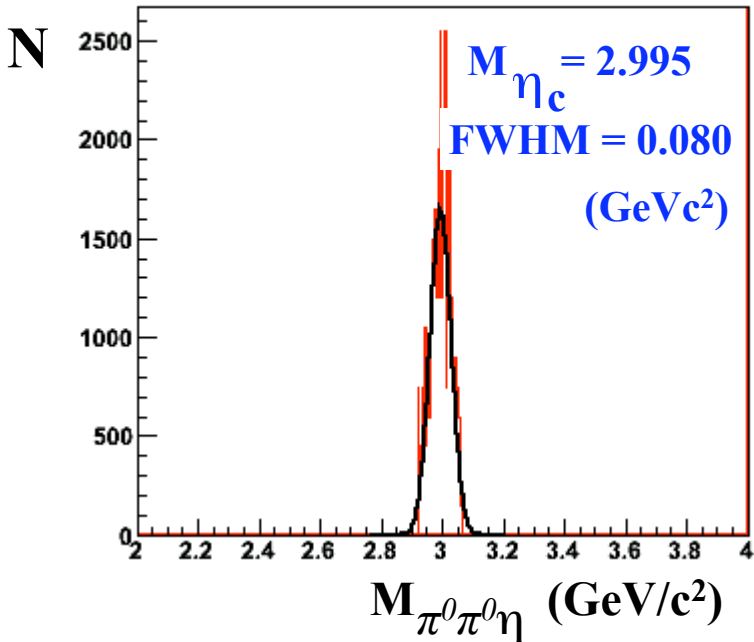
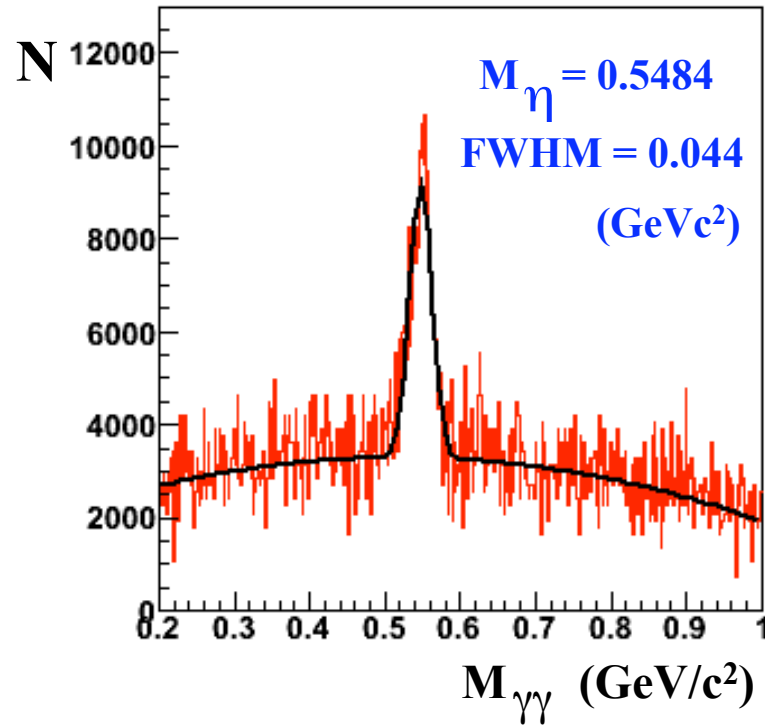
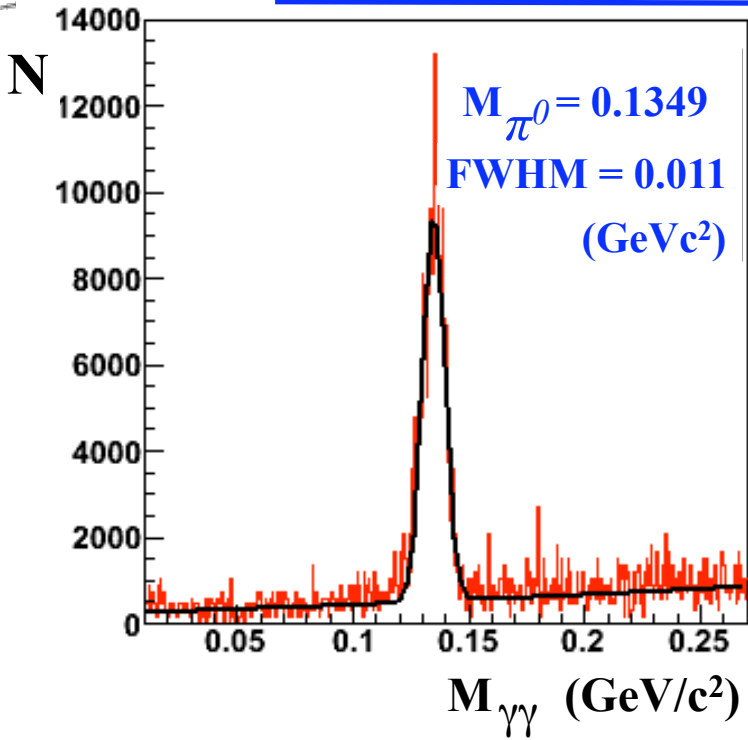
After correction



After correction

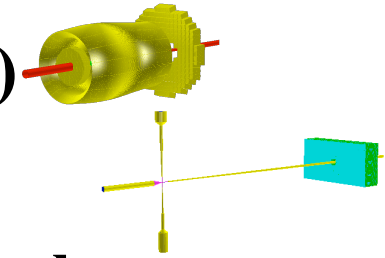


After correction



✓ The energy and theta correction maps have been done

- for full EMC (target EMC & shashlyk, separately)
- using GEANT 4



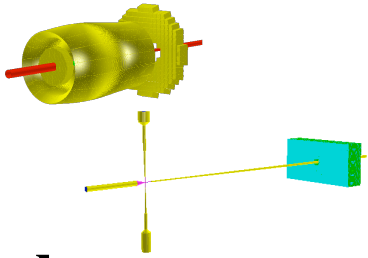
✓ The corrections have been applied in the charmonium  $h_c$  decay

✓ The correction did not change the  $\pi^0$ ,  $\eta$ ,  $\eta_c$ ,  $h_c$  mass resolutions but shifted the masses in the correct direction (!)



✓ The energy and theta correction maps have been done

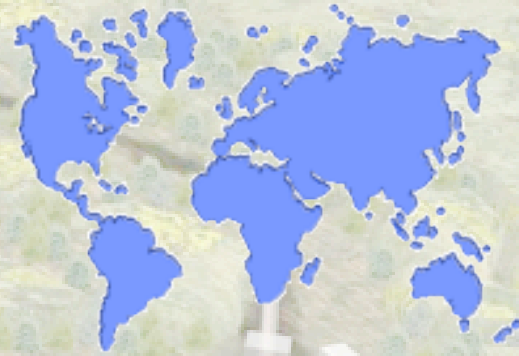
- for full EMC (target EMC & shashlyk, separately)
- using GEANT 4



✓ The corrections have been applied in the charmonium  $h_c$  decay

✓ The correction did not change the  $\pi^0$ ,  $\eta$ ,  $\eta_c$ ,  $h_c$  mass resolutions but shifted the masses in the correct direction (!)

- 
- Shall we put the map into the code?
  - If yes, then:
    - How?
    - For GEANT 3 as well
    - For other versions of Backward end-cap
  - To improve the mass resolution:
    - 1) additional cut for  $E_{\text{photon}}=503\text{MeV}$  and
    - 2) the kinematic fit should be applied



Backup slides



→  $\sigma_p = 33 \text{ nb}$  ( $\bar{p}p \rightarrow h_c \rightarrow \eta_c + \gamma$ )

→  $\text{BR}(\eta_c \rightarrow \pi^0 \pi^0 \eta) = 1.6 \cdot 10^{-2}$

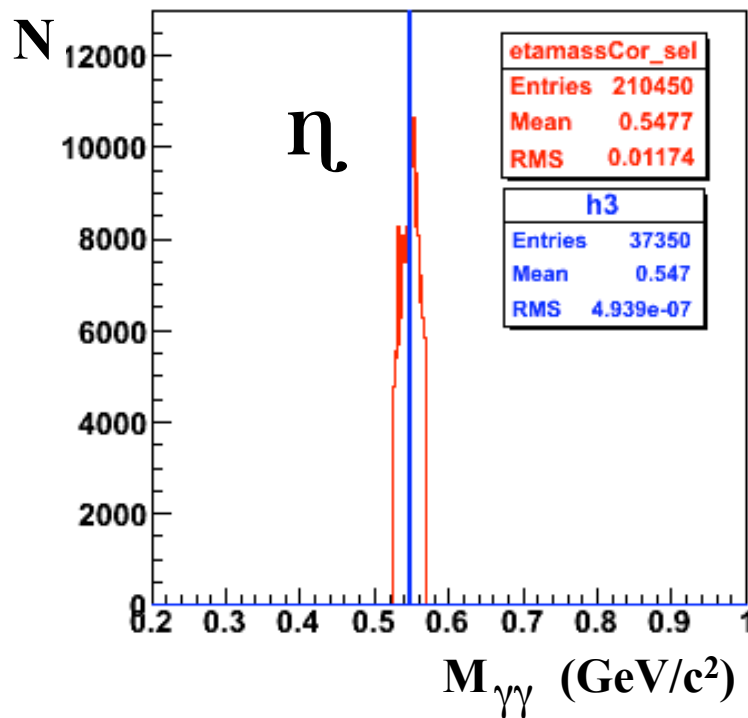
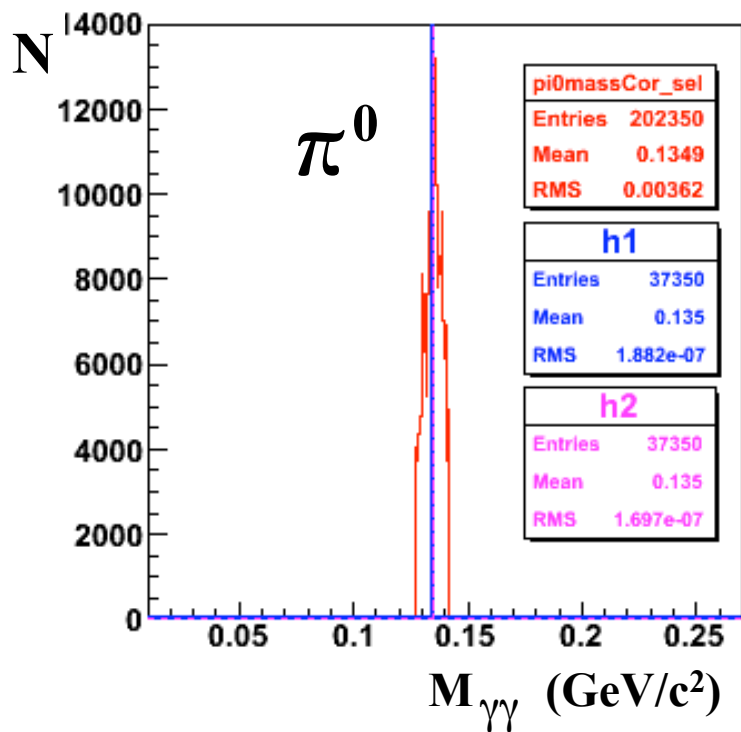
- $\text{BR}(\pi^0 \rightarrow \gamma\gamma) = 0.988$

- $\text{BR}(\eta \rightarrow \gamma\gamma) = 0.394$

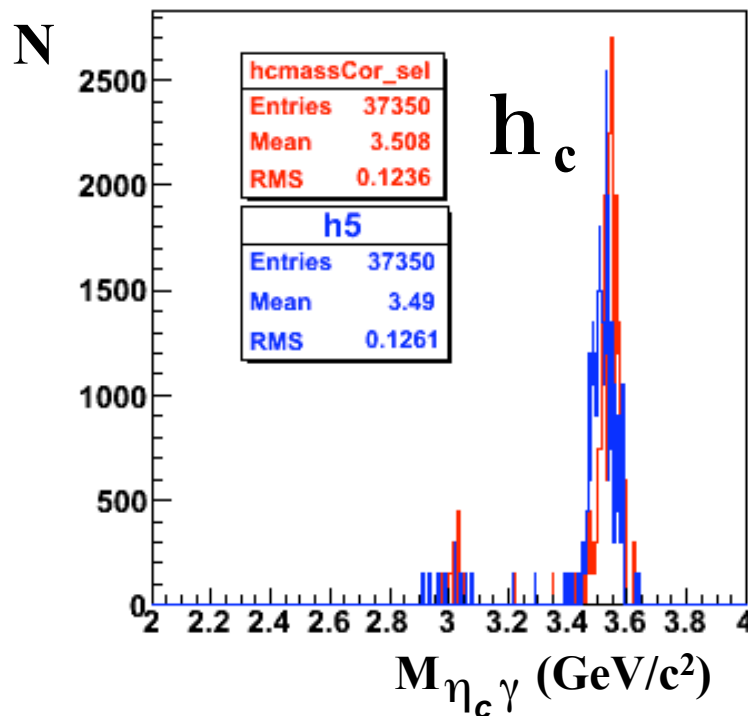
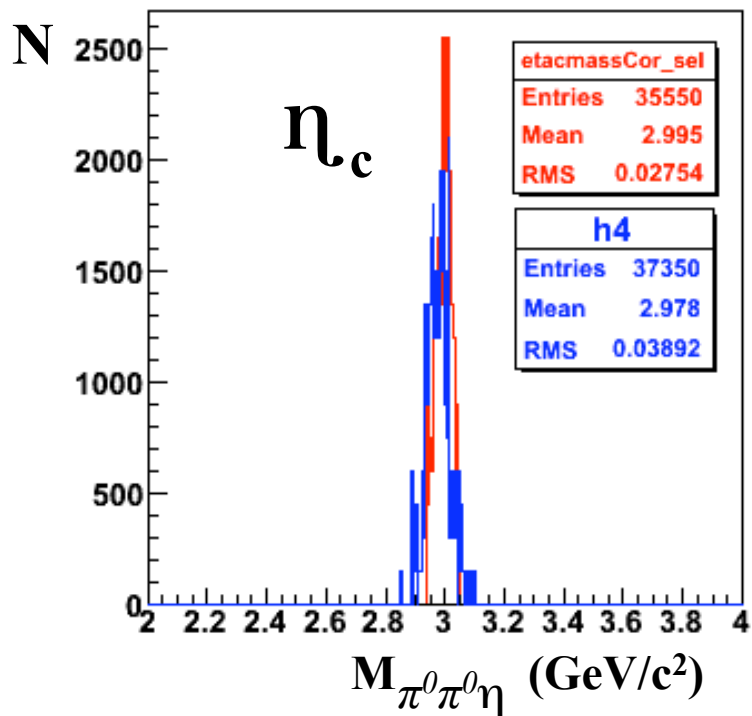
→  $\text{RecoEffi} = 26\%$

Efficiency	26 %
High <b>luminosity</b> mode: $L = 2 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ $\Delta p/p \sim 10^{-4}$	931 events/day
High <b>resolution</b> mode: $L = 10^{31} \text{ cm}^{-2}\text{s}^{-1}$ $\Delta p/p = 4 \cdot 10^{-5}$	93 events/day

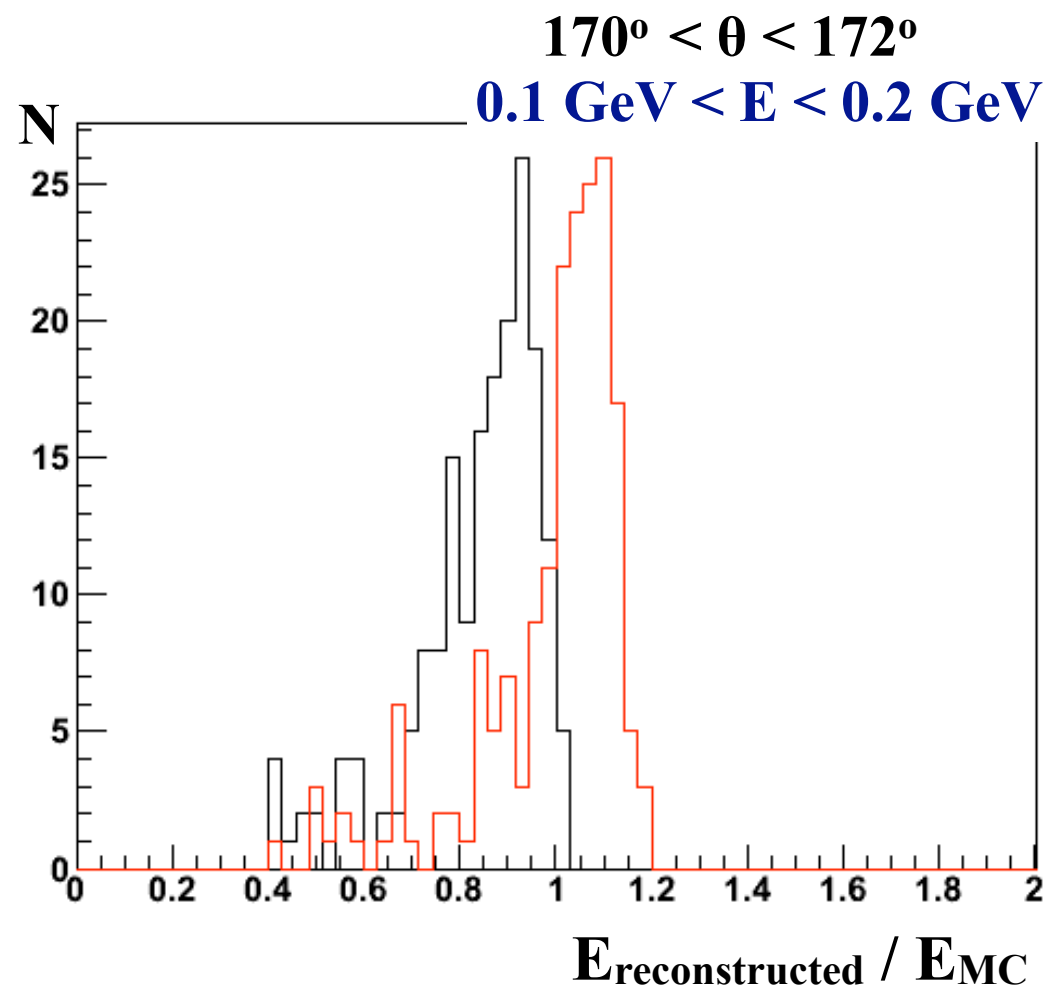
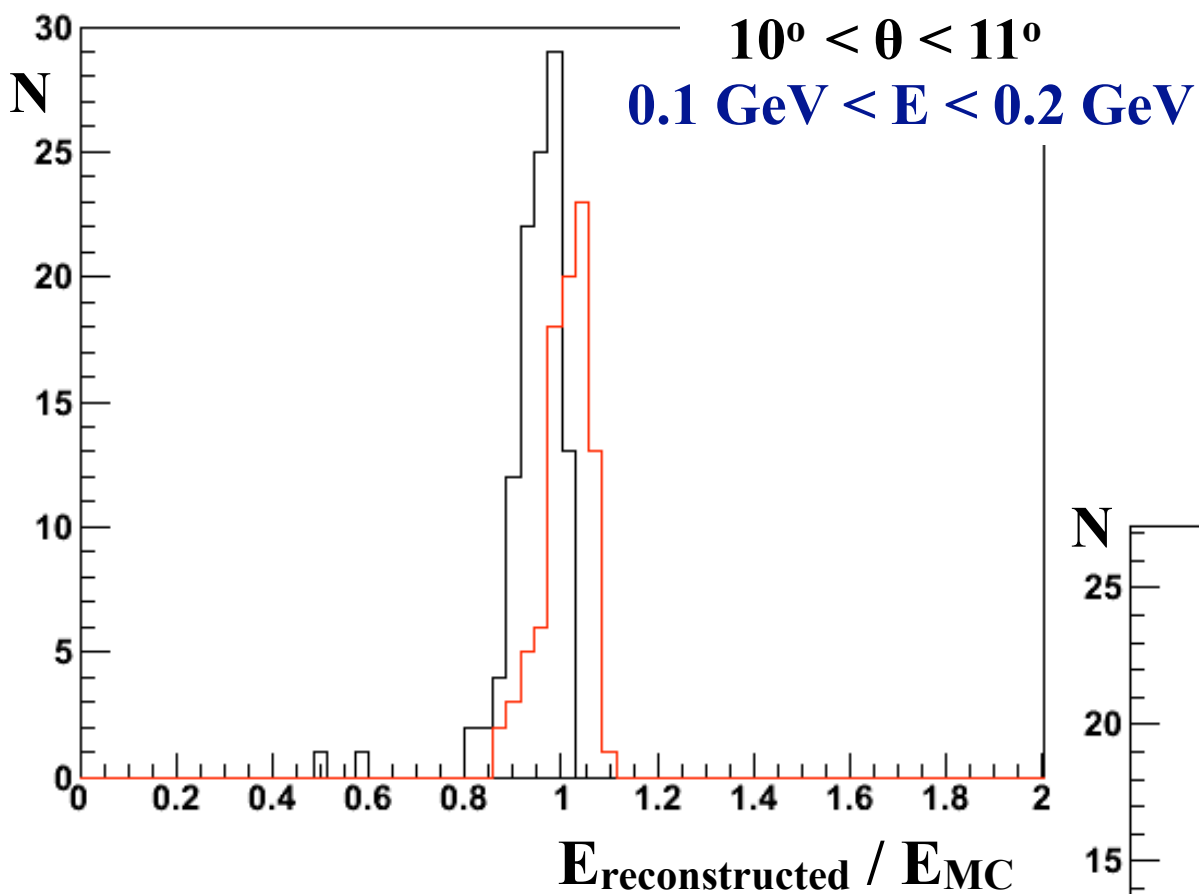
**Shashlyk**

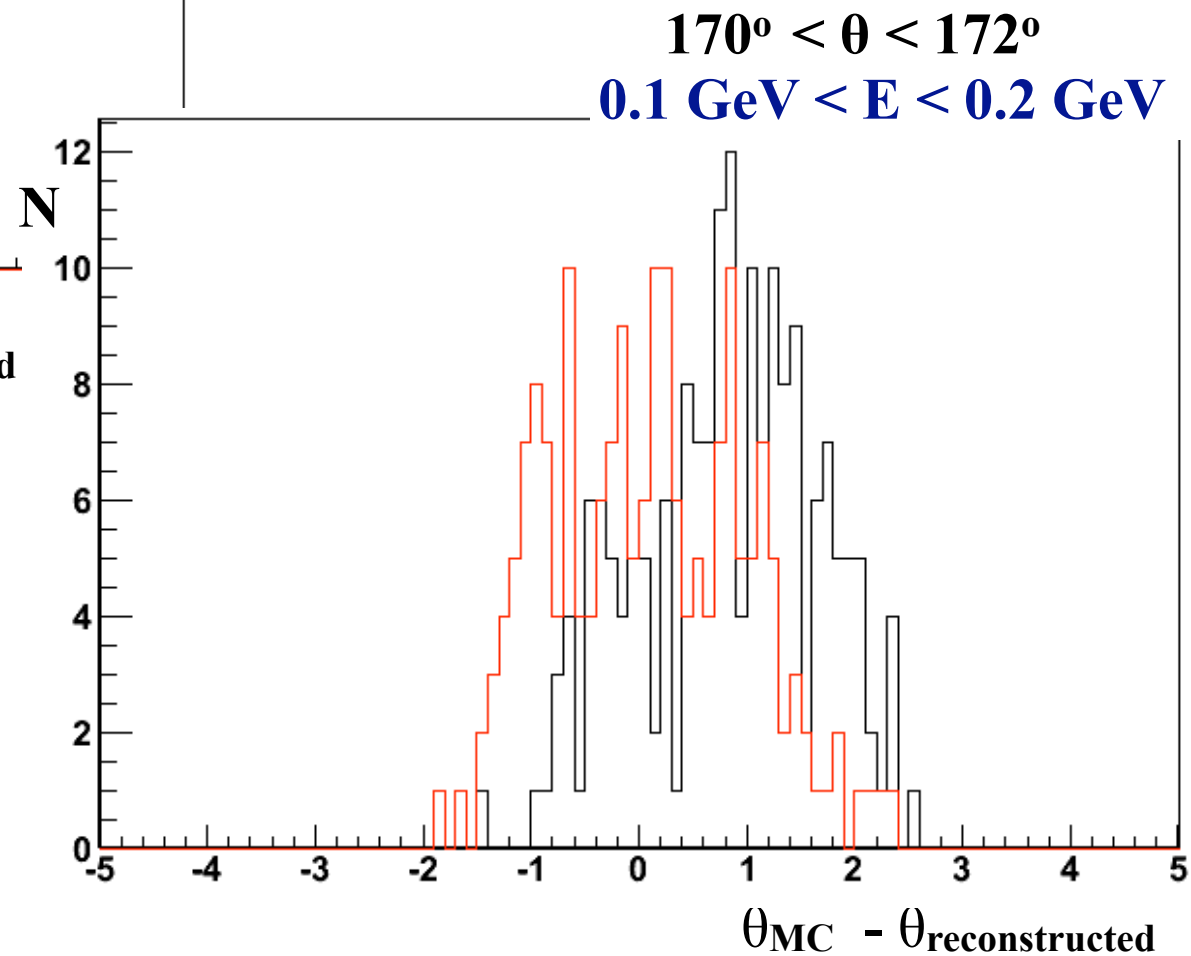
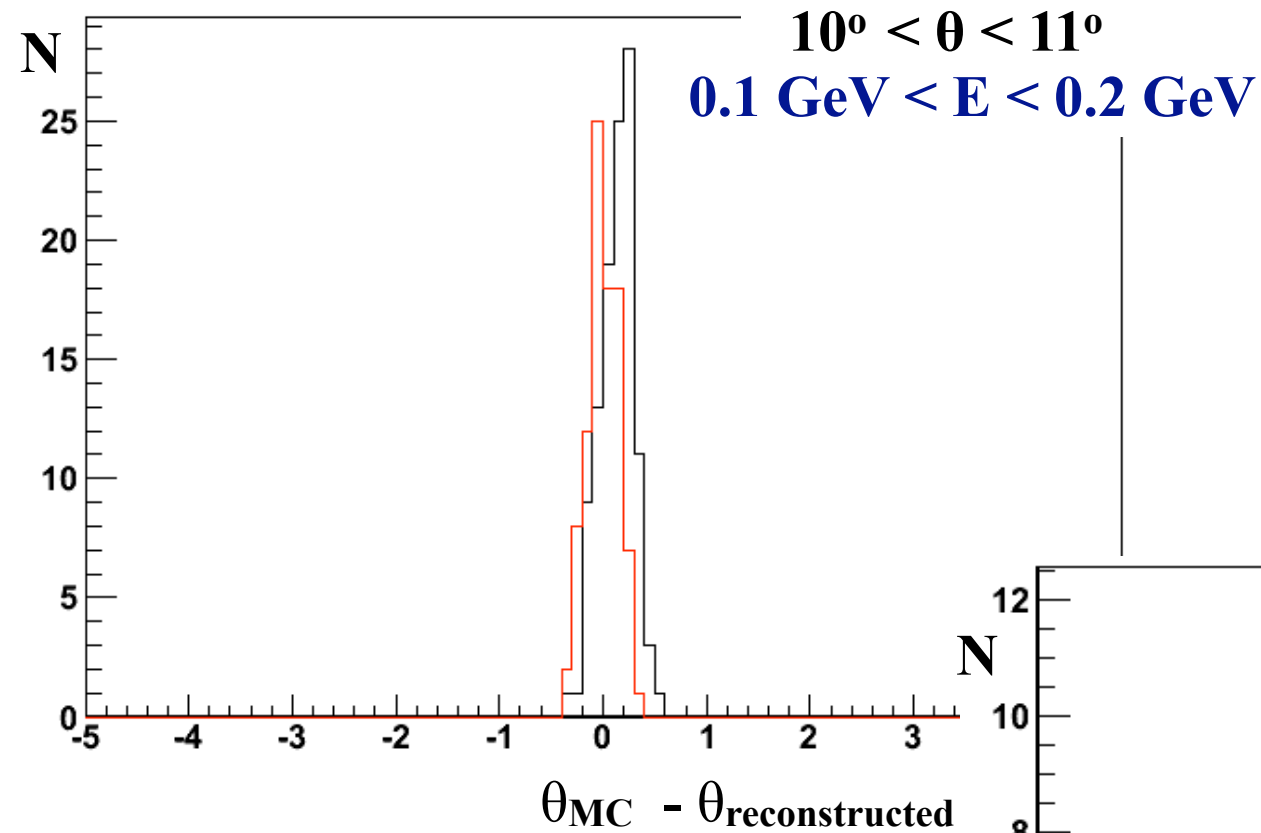


after correction  
with  $\pi^0$  and  $\eta$   
mass scaling



No mass resolution  
improvements  
for  $\eta_c$  and  $h_c$   
with the  $\pi^0$  and  $\eta$   
mass scaling !



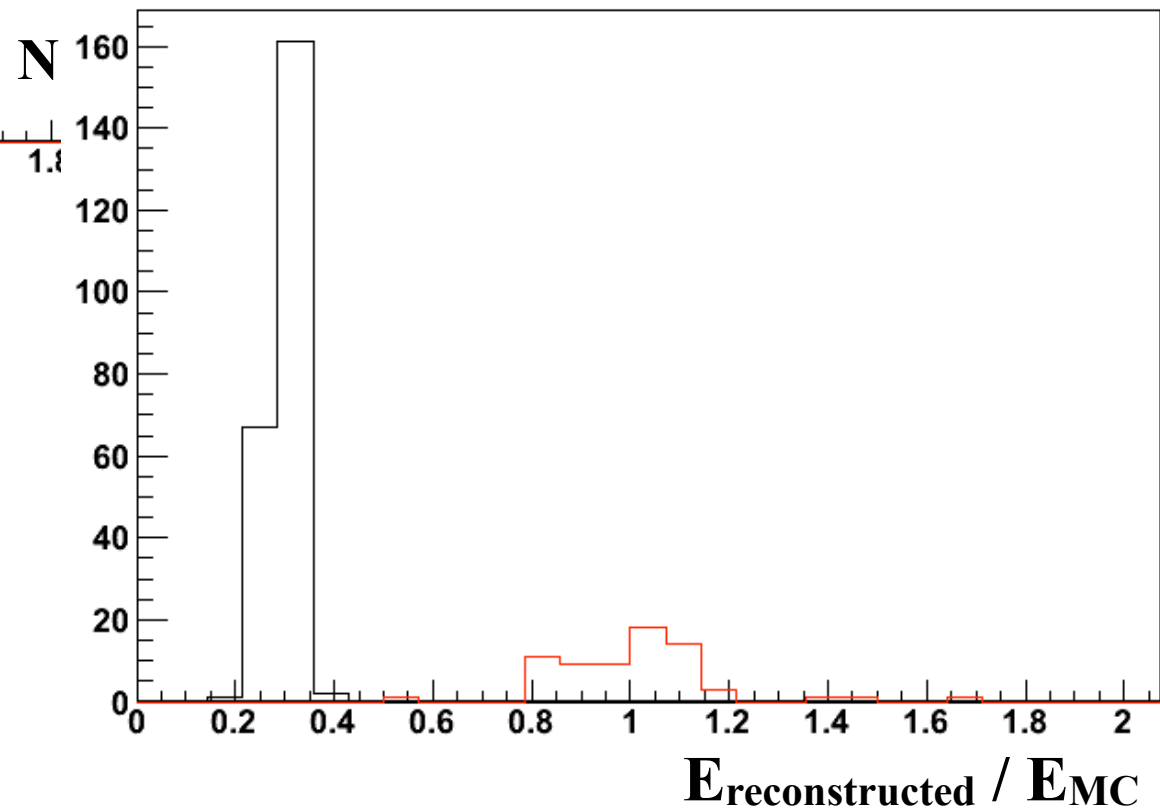
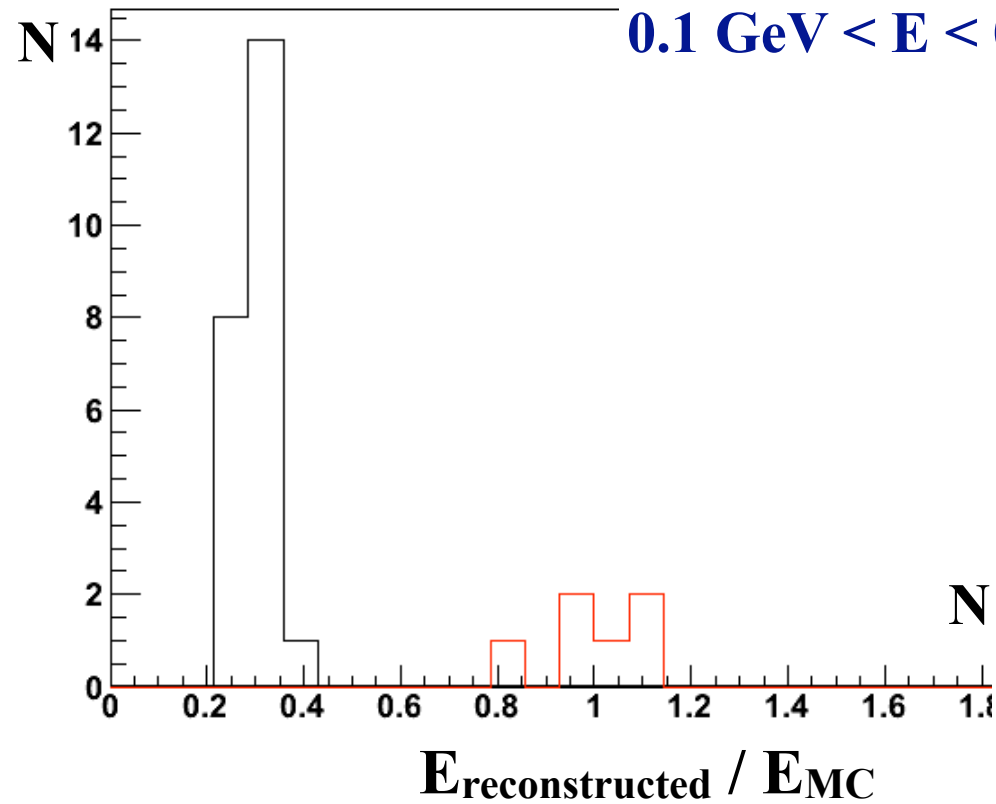


$10^\circ < \theta < 11^\circ$

$0.1 \text{ GeV} < E < 0.2 \text{ GeV}$

**Energy**

before correction  
after correction

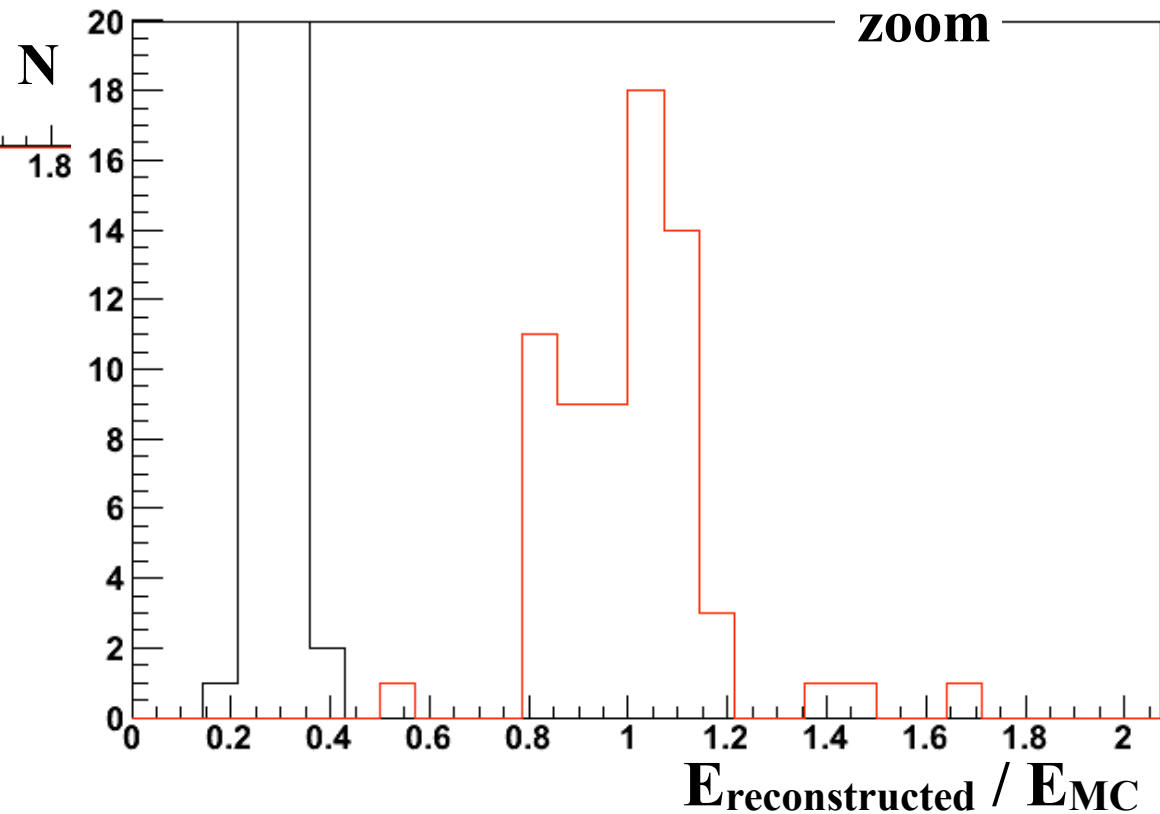
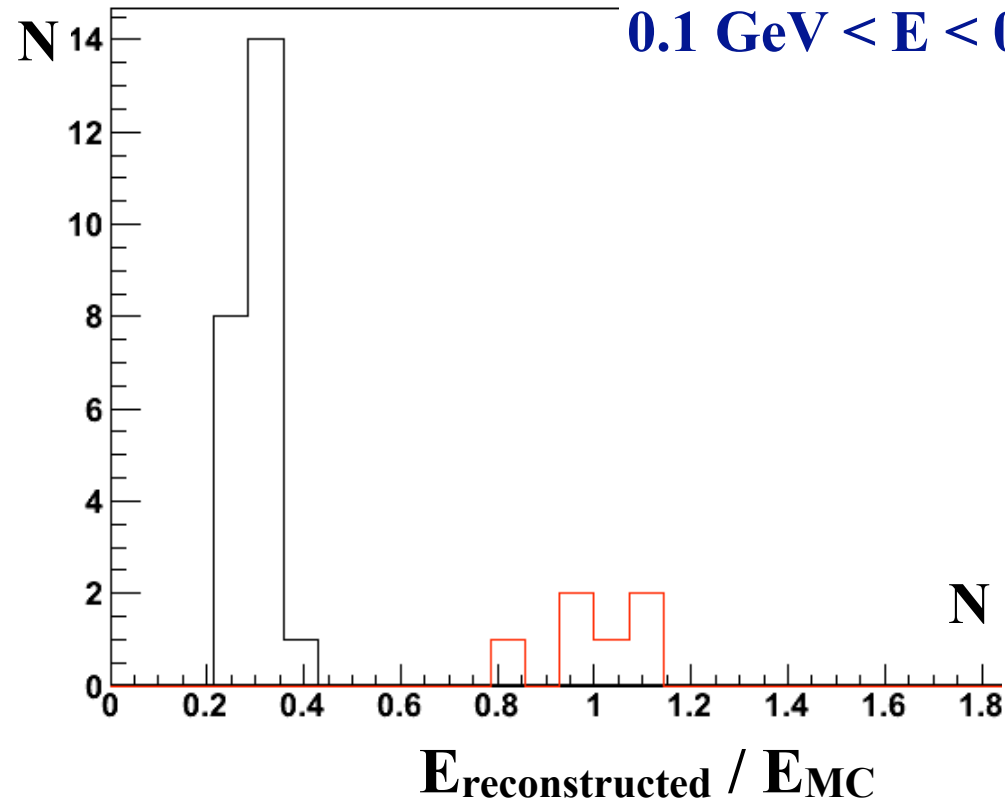


$10^\circ < \theta < 11^\circ$

$0.1 \text{ GeV} < E < 0.2 \text{ GeV}$

Energy

before correction  
after correction



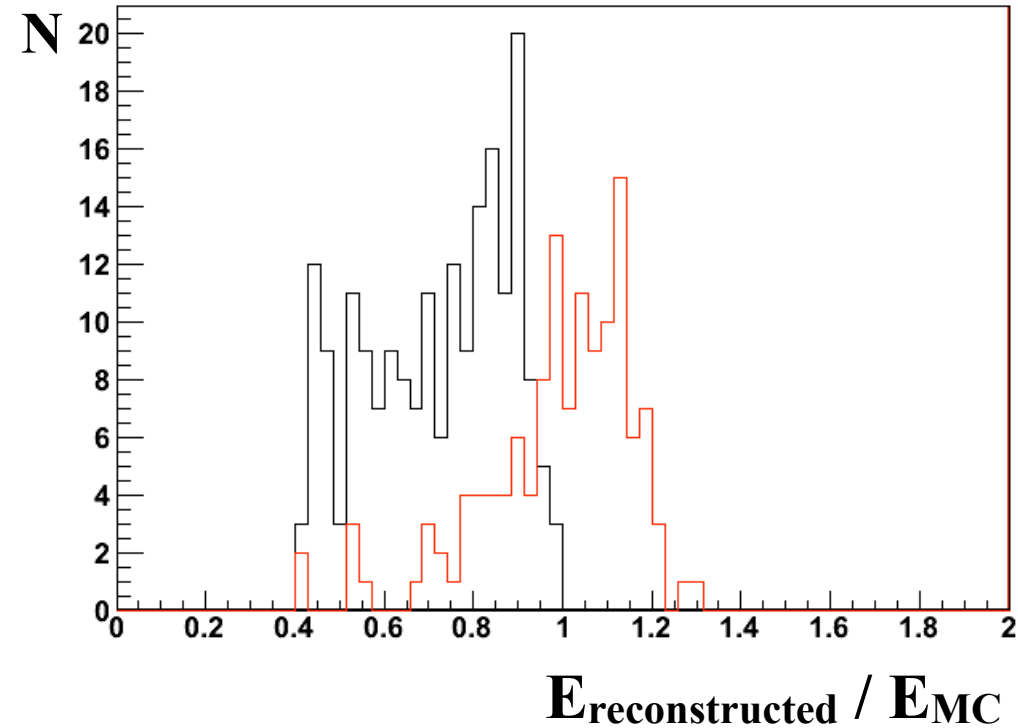
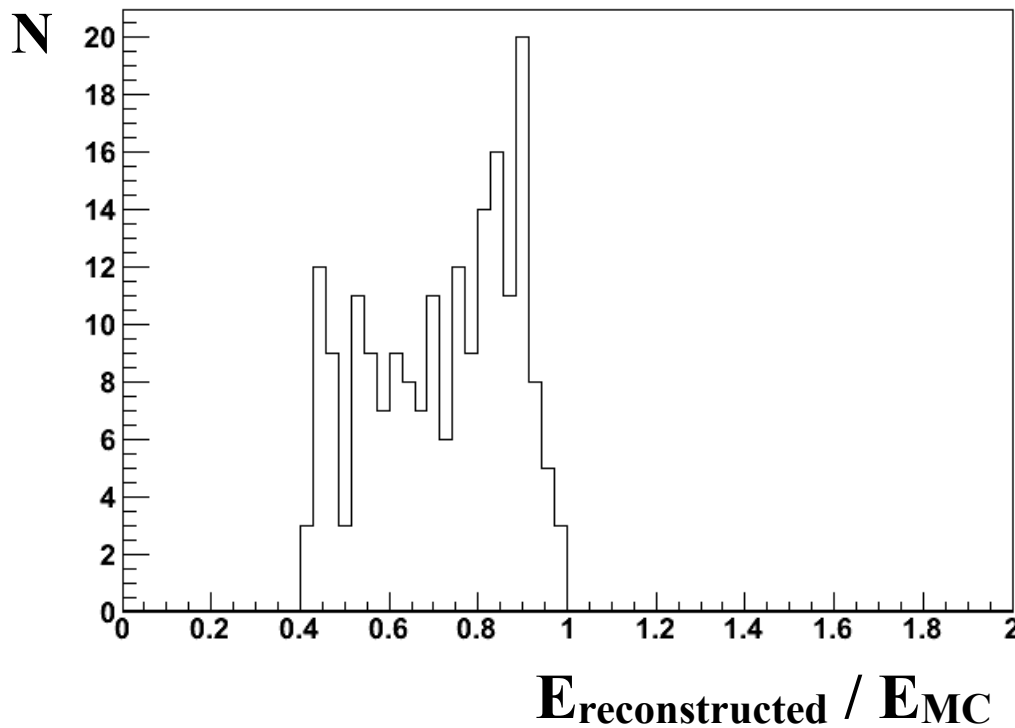


before correction

$150^\circ < \theta < 151^\circ$   
 $0.3 \text{ GeV} < E < 0.4 \text{ GeV}$

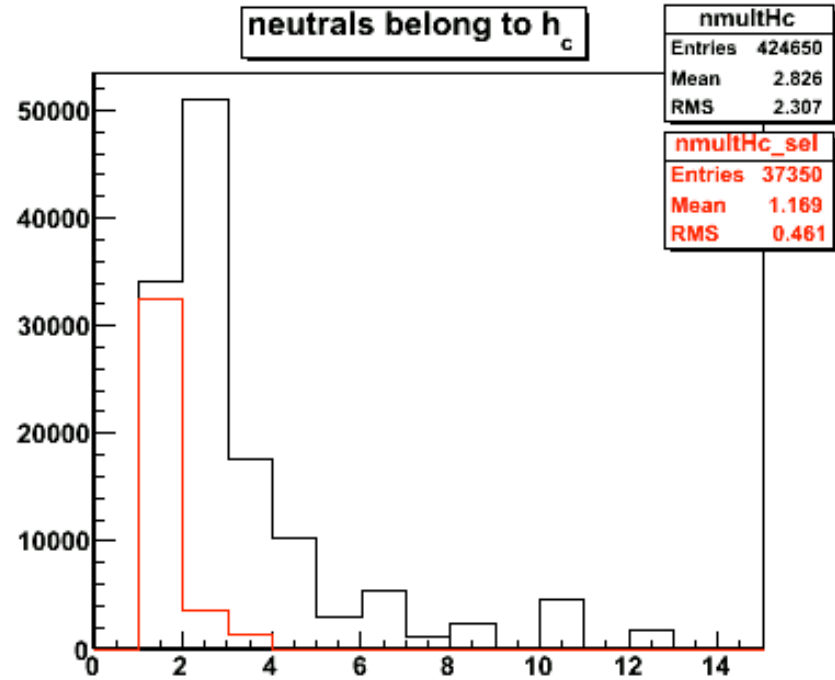
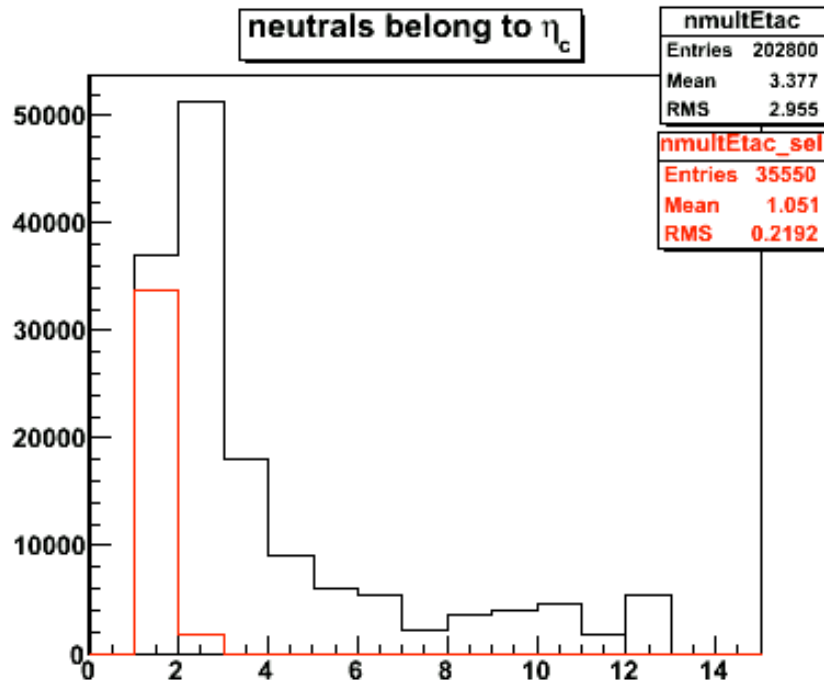
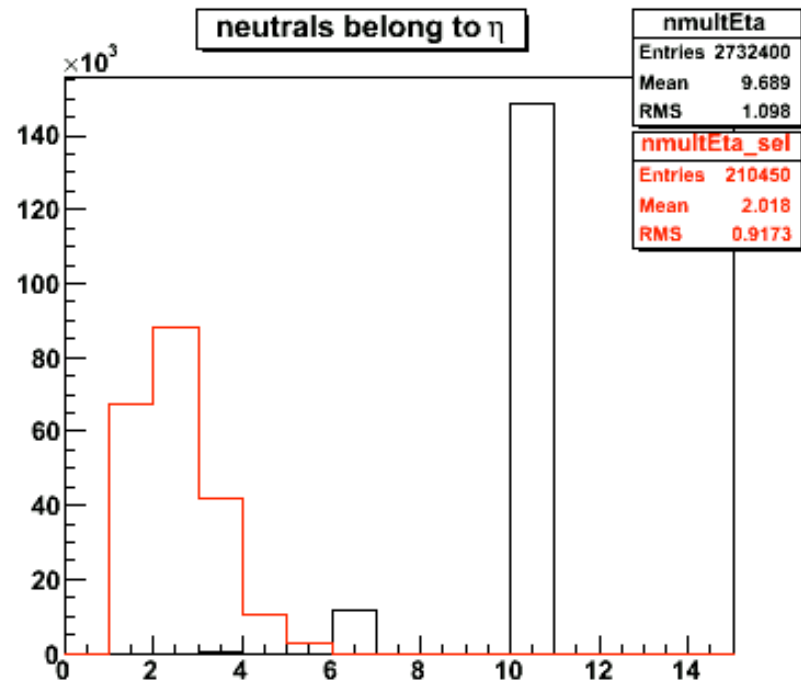
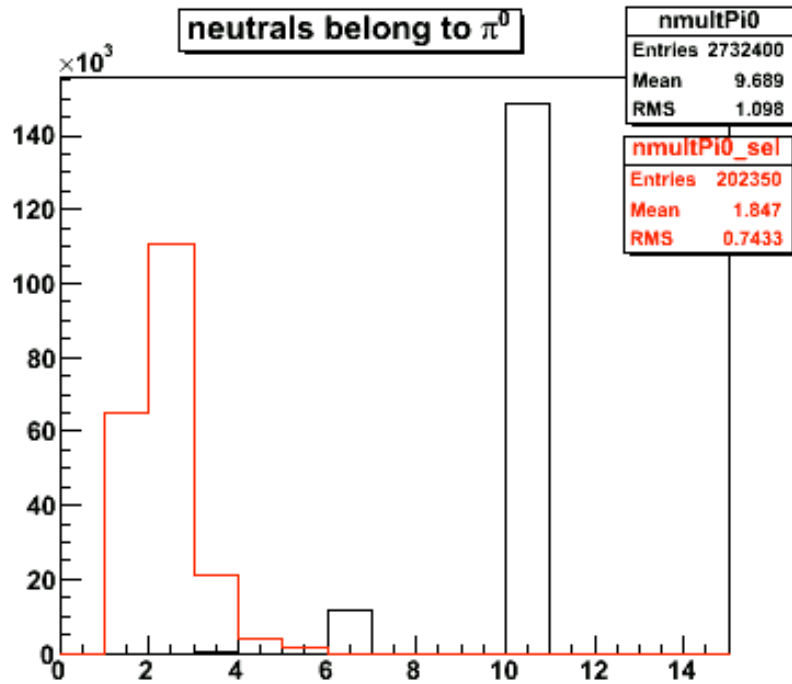
before correction

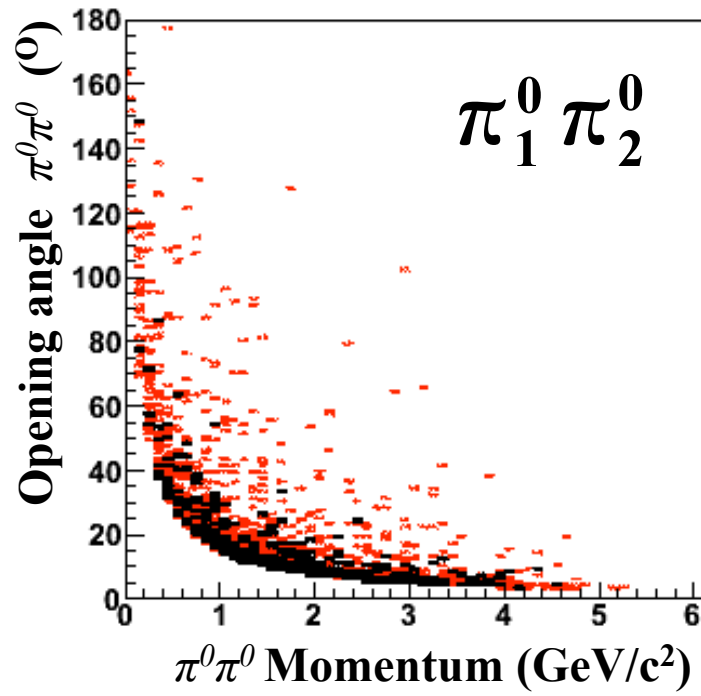
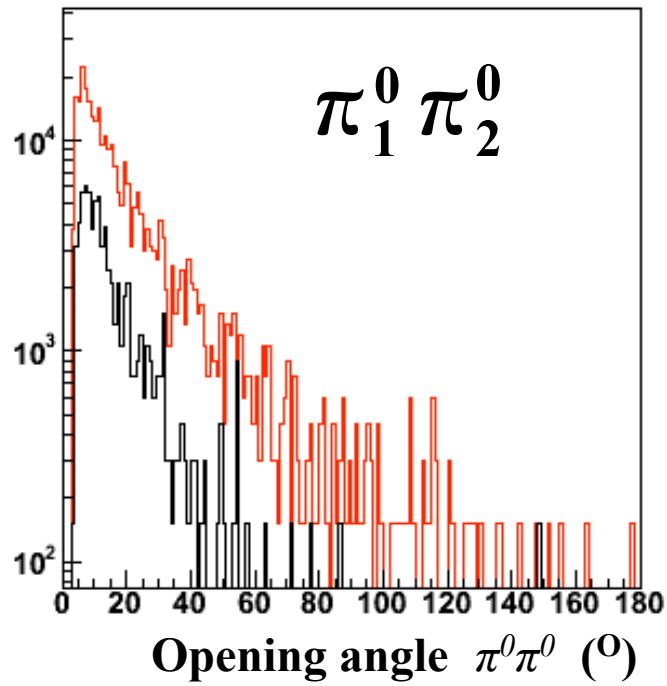
+ after correction



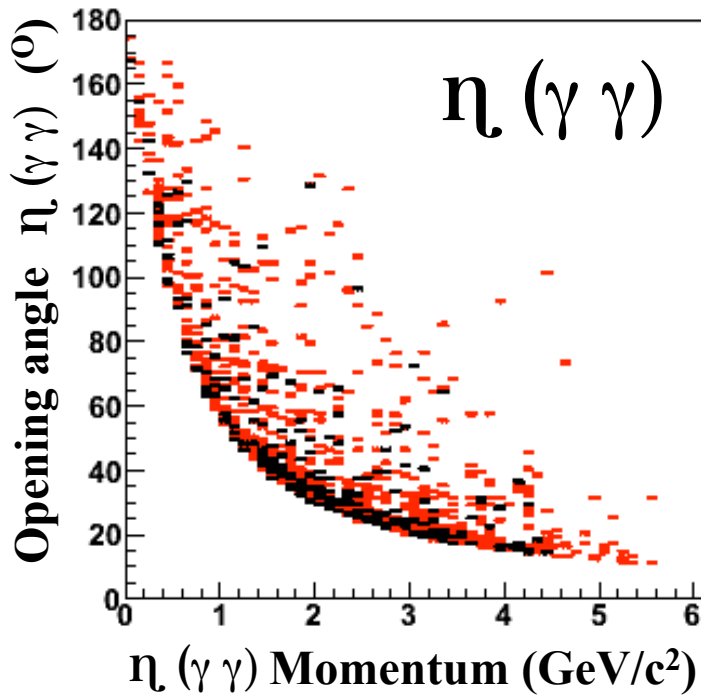
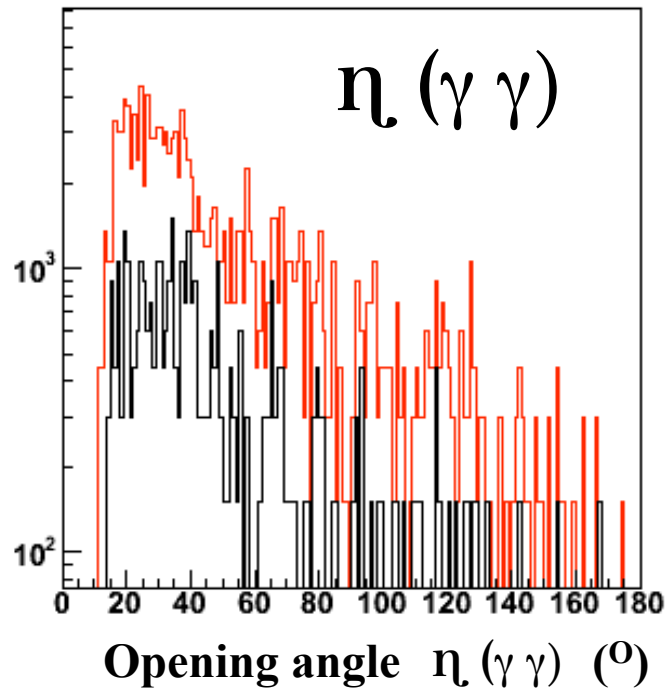
$$\bullet E_{\text{corrected}} = E_{\text{reconstructed}} * \Delta E$$

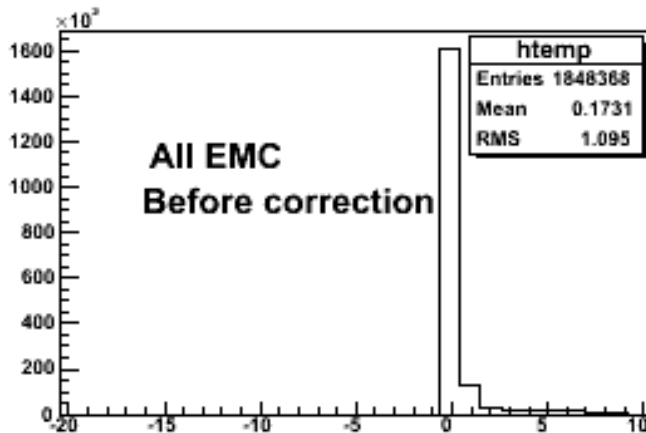
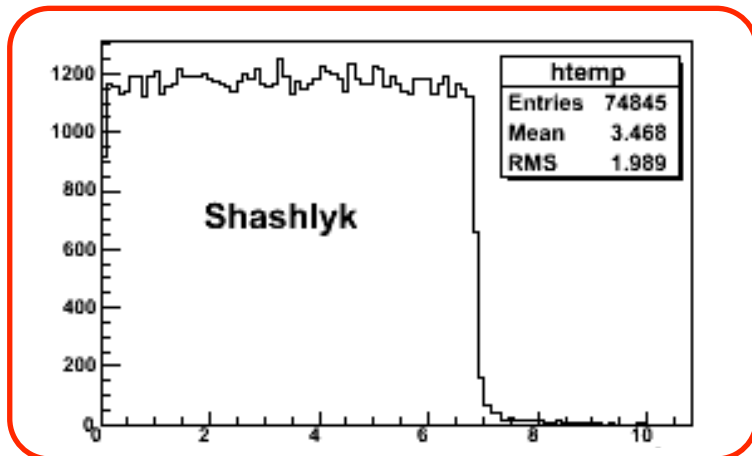
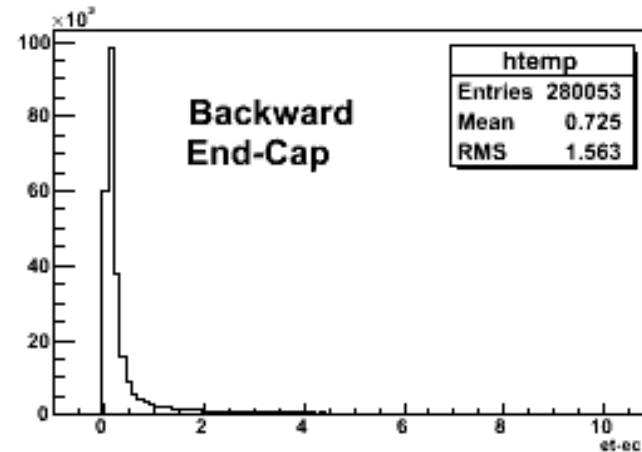
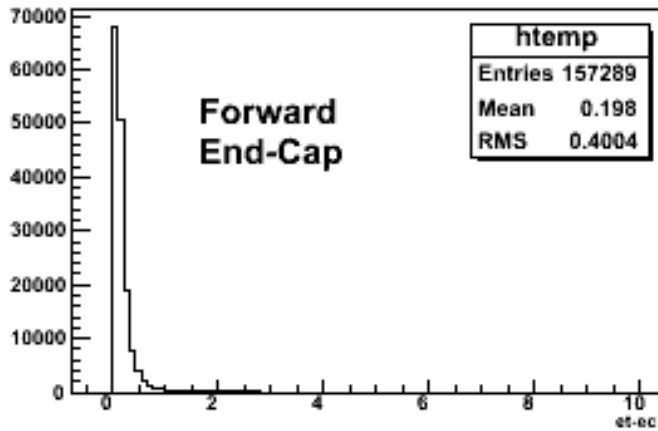
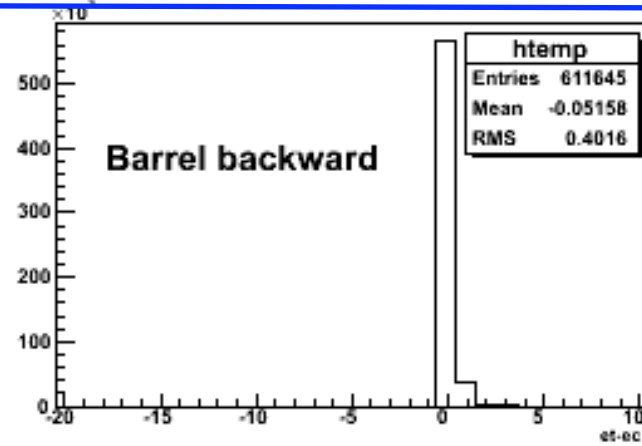
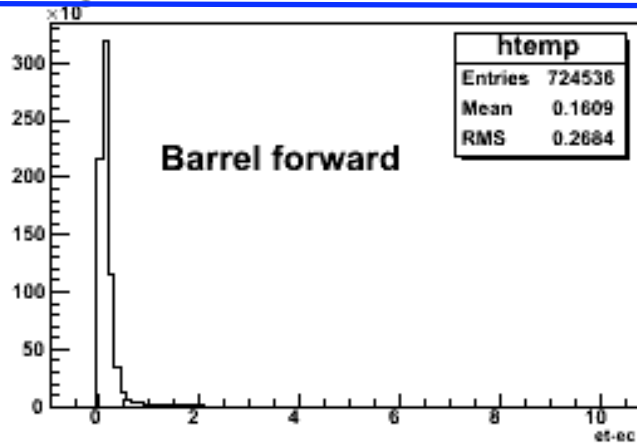
$$\bullet \theta_{\text{corrected}} = \theta_{\text{reconstructed}} + \Delta \theta$$





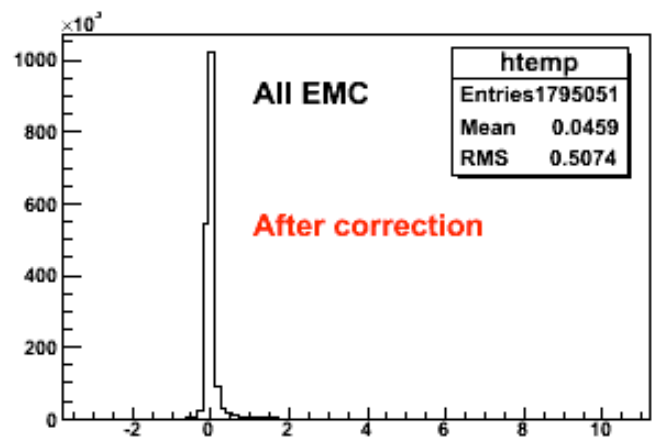
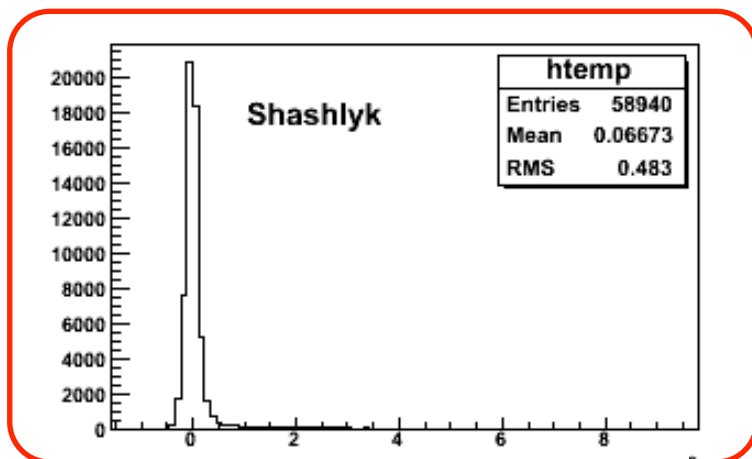
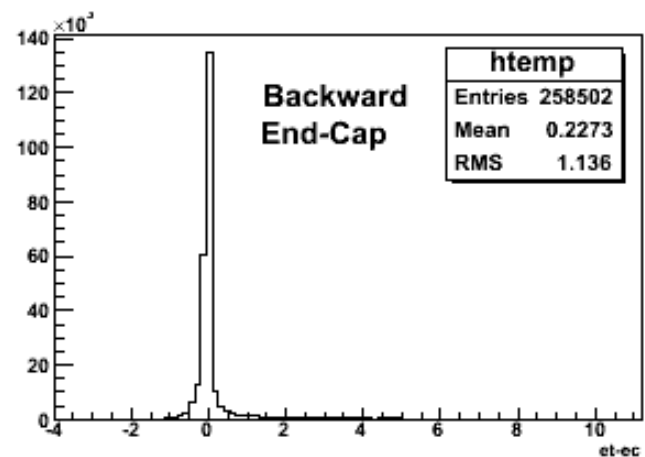
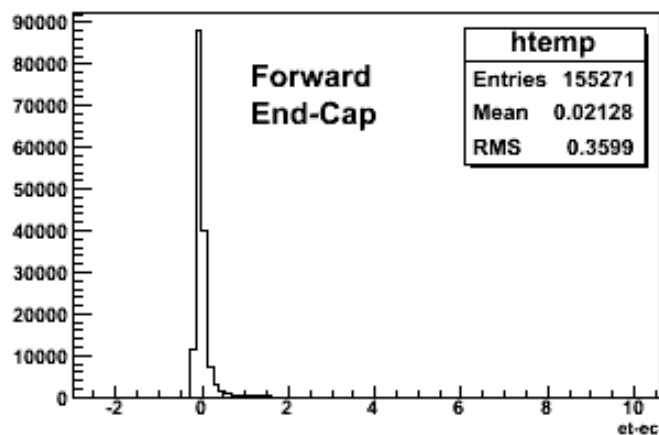
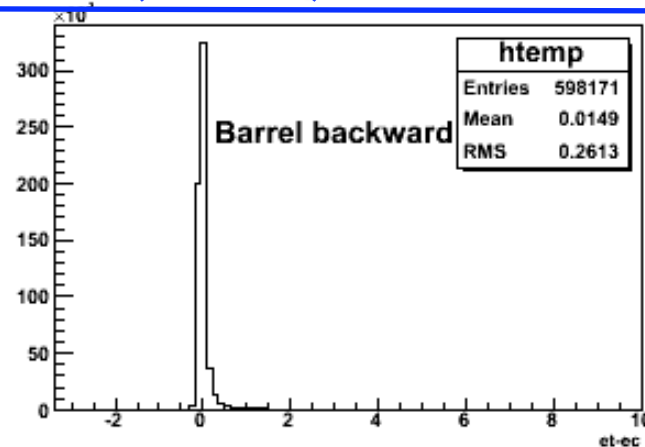
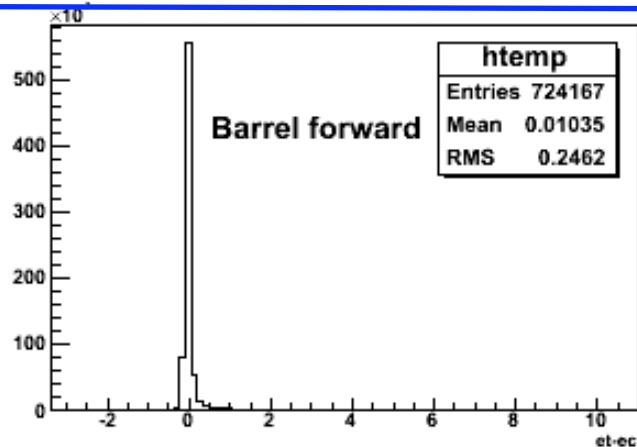
reconstructed  
**Monte Carlo**





EMC -  $E_{reconstructed}$

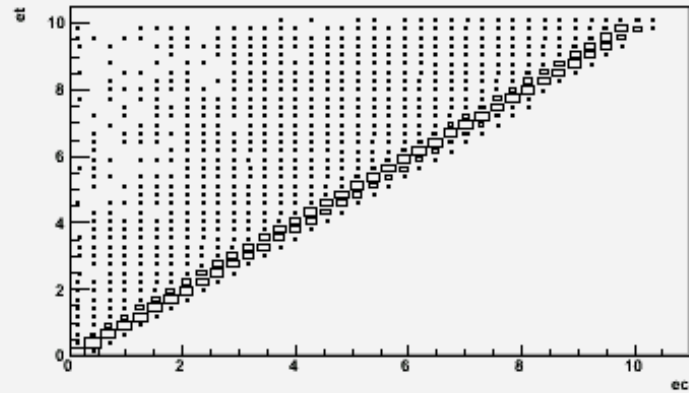
EMC -  $E_{reconstructed}$



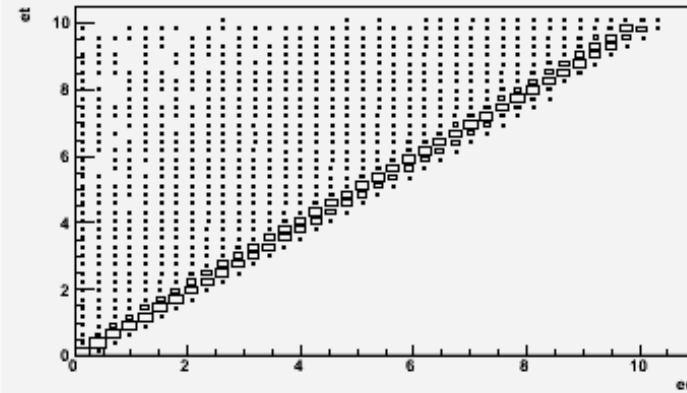
EMC -  $E_{reconstructed}$

EMC -  $E_{reconstructed}$

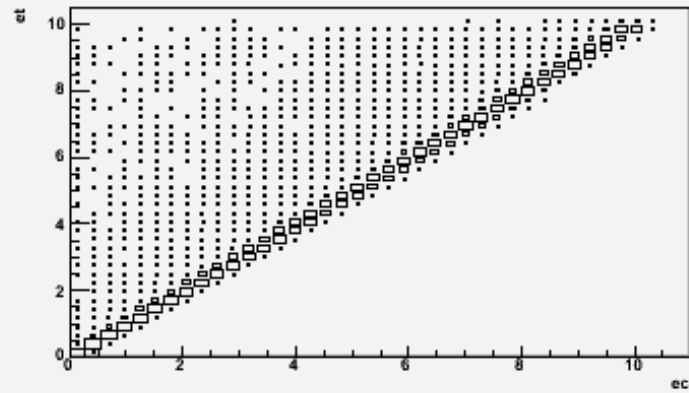
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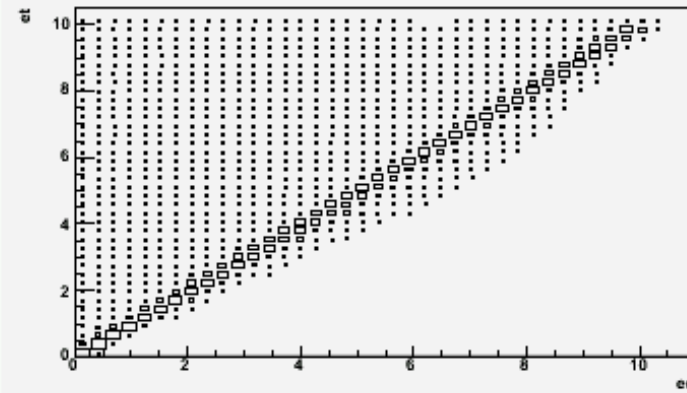
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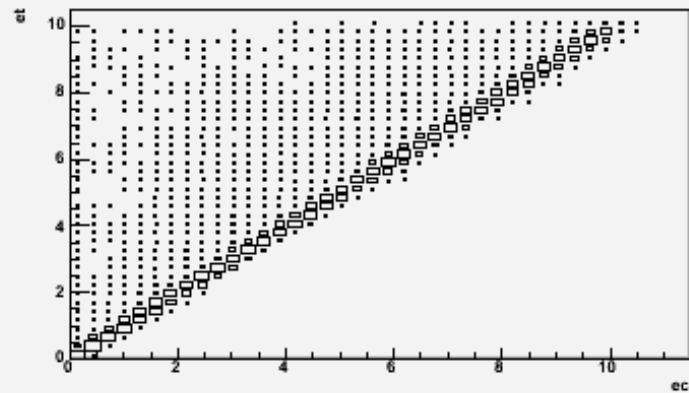
et:ec {module==3}



et:ec {module==4}



et:ec {module==5}



et:ec

