



# Simulation analysis of photon and $\pi^0$ in ECal at the MPD

Xiangrong Zhu Huzhou University

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# Outlook

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## 1. Single photon simulation analysis

- (1) check clustering algorithm
- (2) extract the energy correction function
- (3) check photon flight time

## 2. Single $\pi^0$ simulation analysis

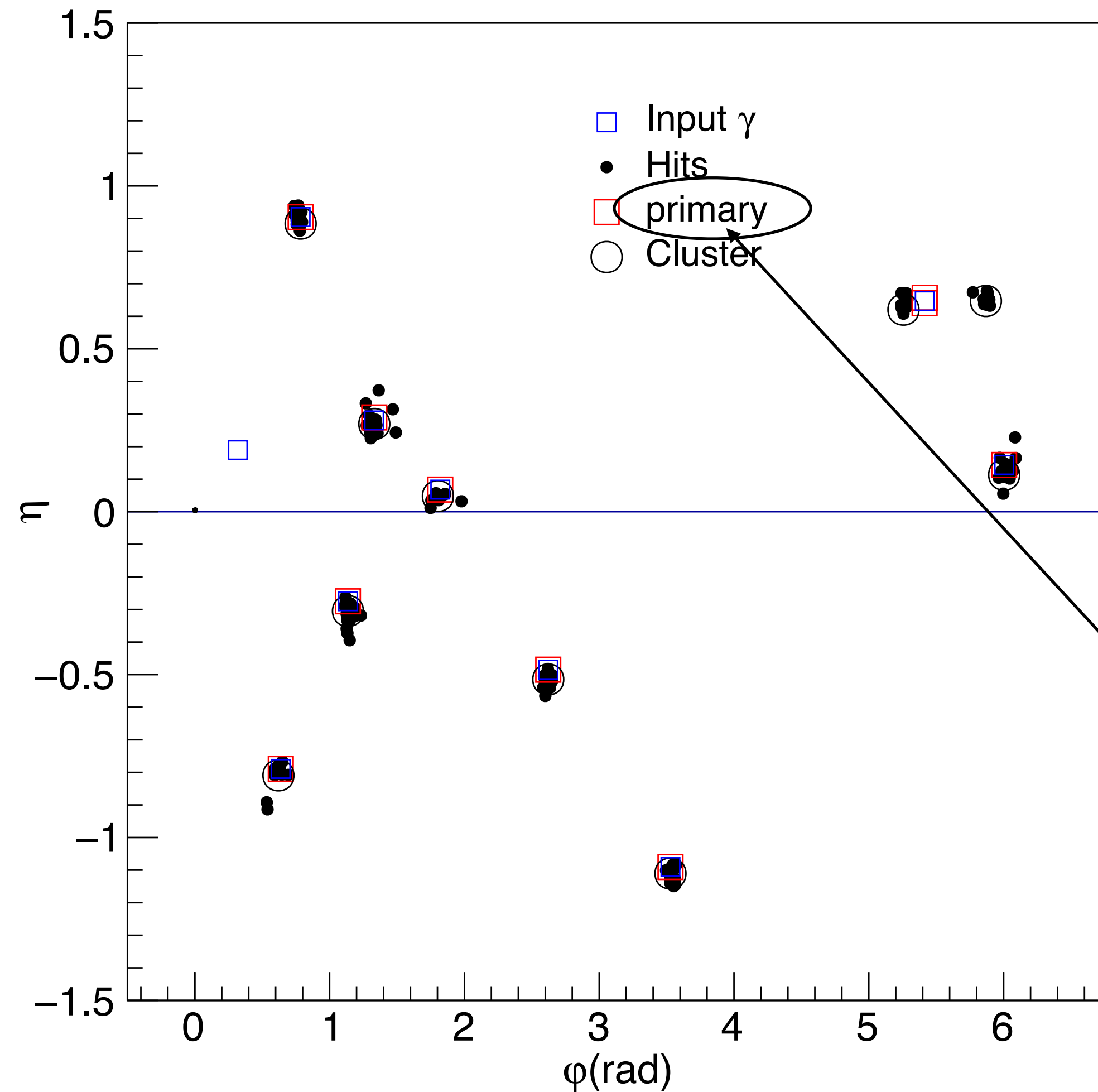
- (1) check merge performance of two photons from a  $\pi^0$
- (2) check the time of the two photons from a  $\pi^0$

## 3. $\pi^+$ , $\pi^-$ and $\pi^0$ simulation analysis

- (1) check the time of hadron cluster
- (2) extract the invariant mass, mass width distribution of  $\pi^0$

# Single photon simulation

input gamma energy: 0.2-5 GeV, 10 gamma per event



## 1. Reconstruction algorithm

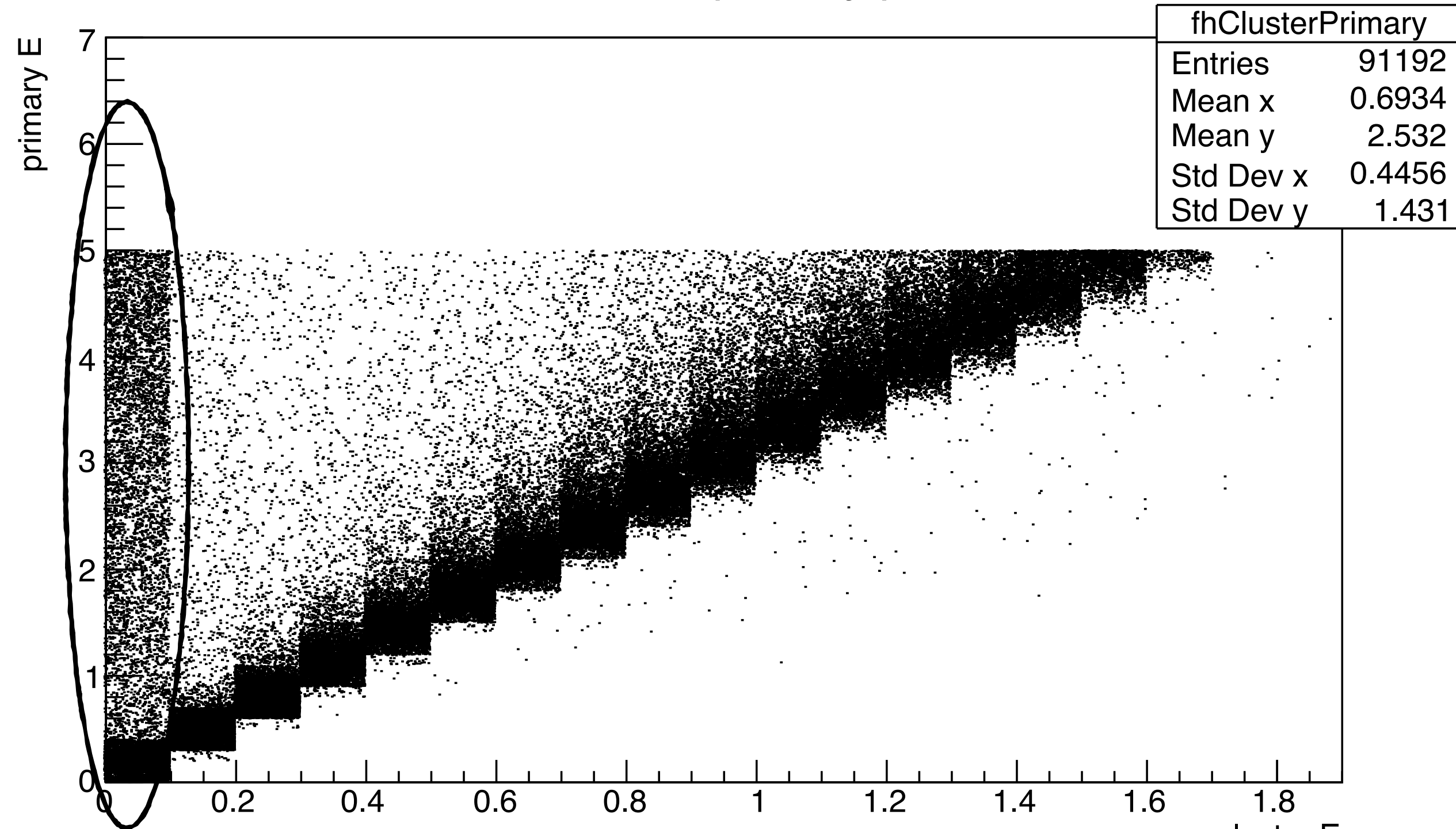
- (1) find seed cell (tower):  $E > 0.01 \text{ GeV}$
- (2) find neighbour cell (tower):  $E > 0.0015 \text{ GeV}$
- (3) find local Maximum N  
if  $N > 1$ , do Unfolding

## 2. Most input gamma are reconstructed

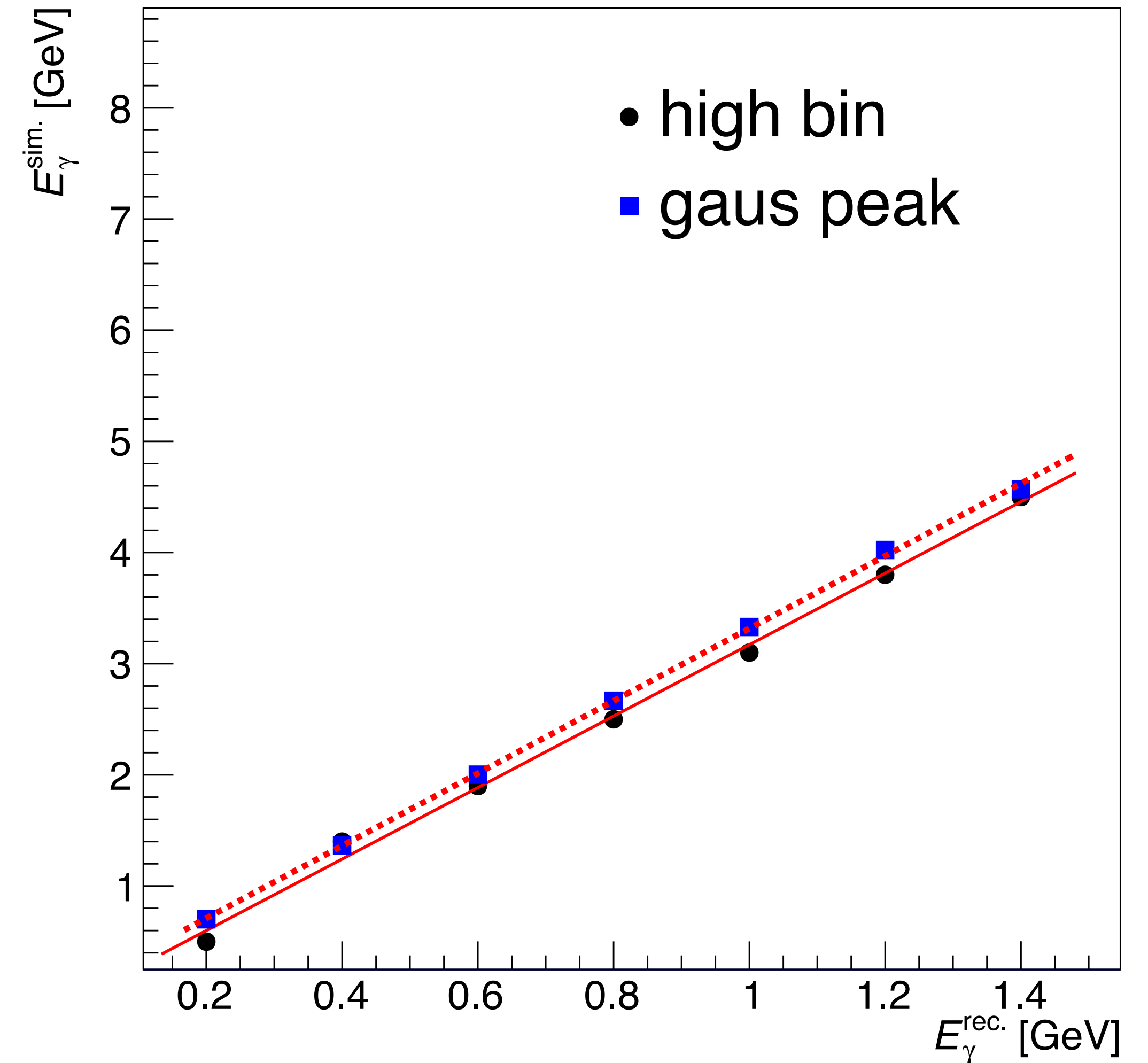
For a given cluster, what is its source

# Single photon simulation

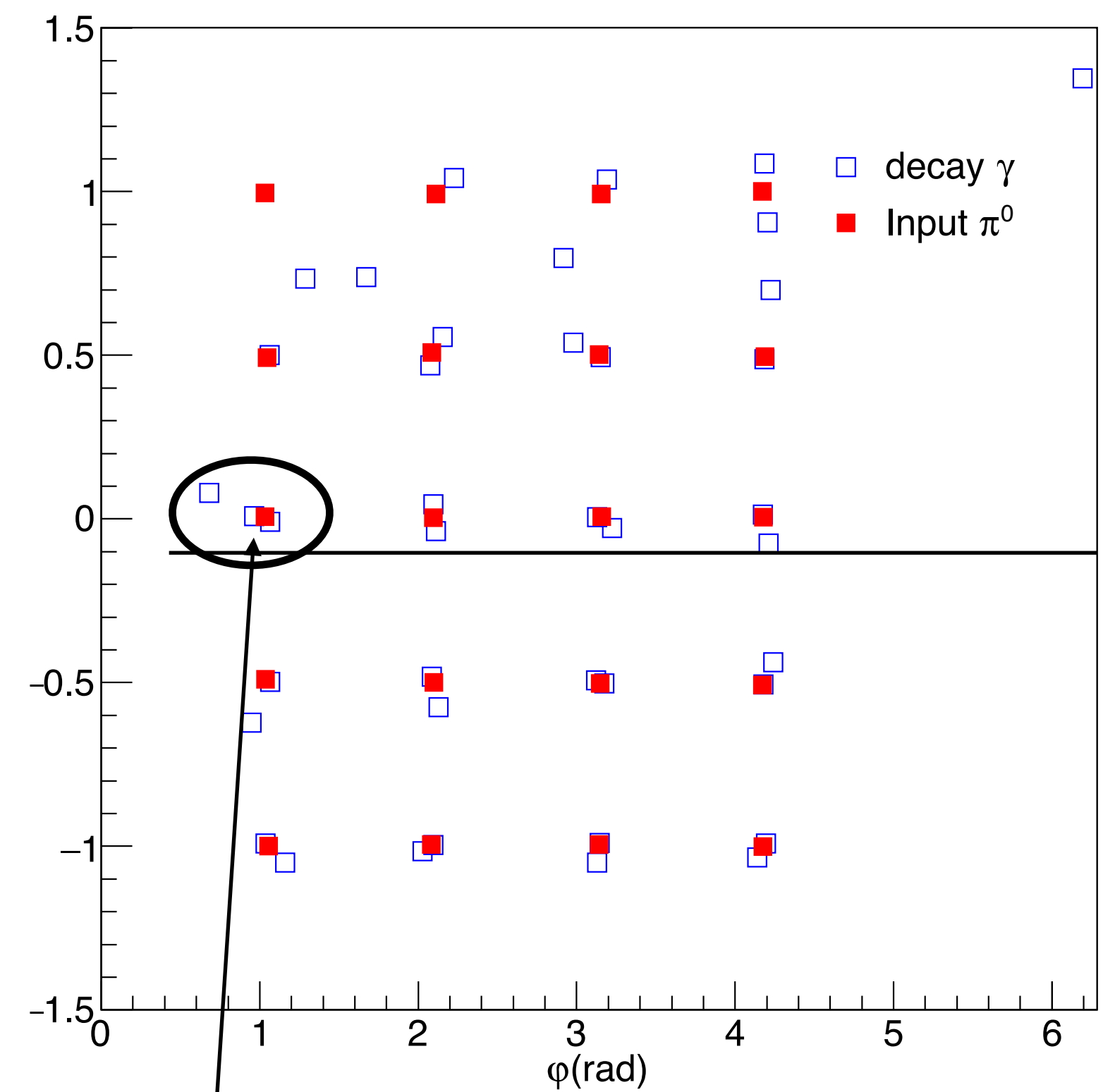
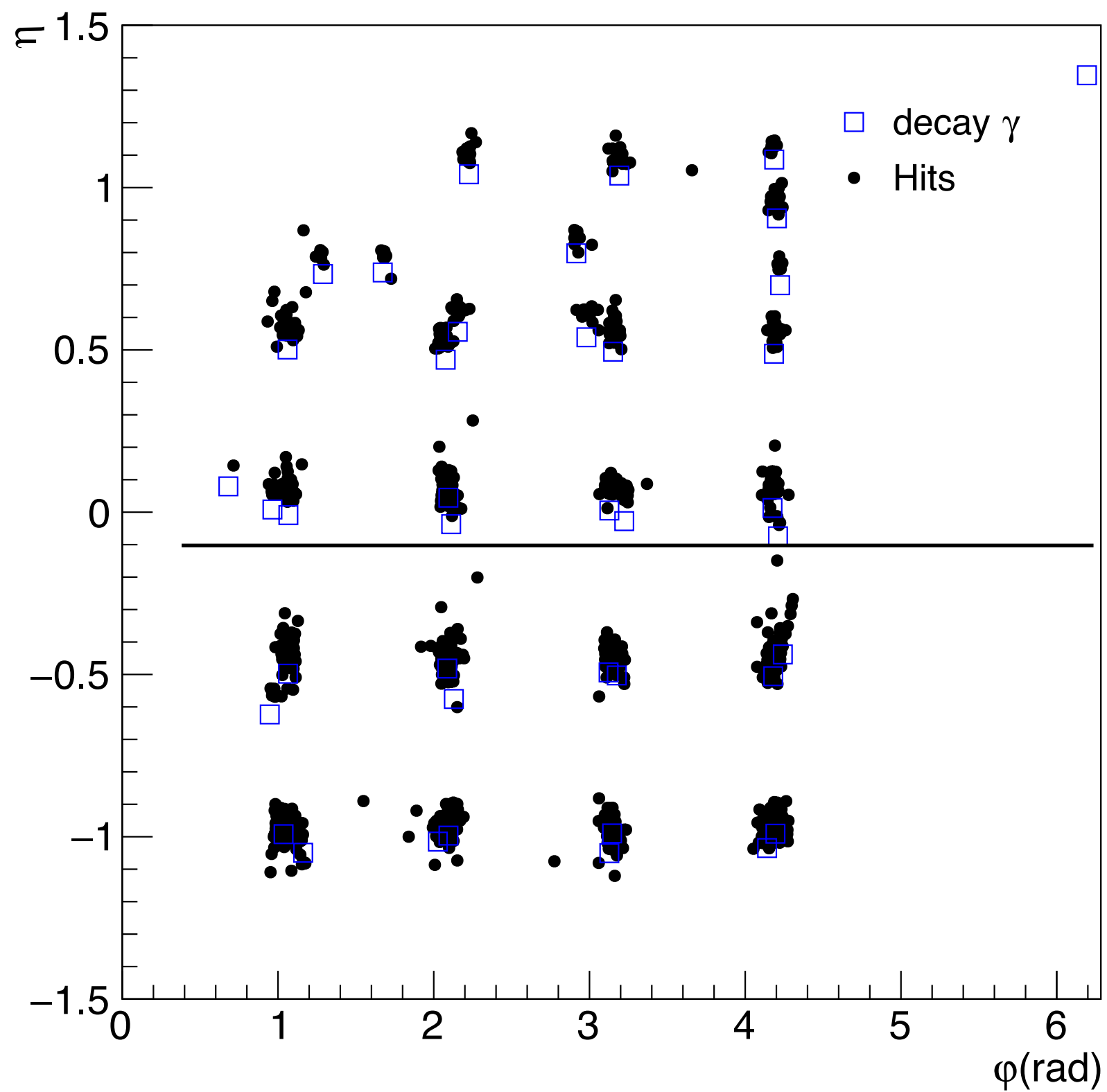
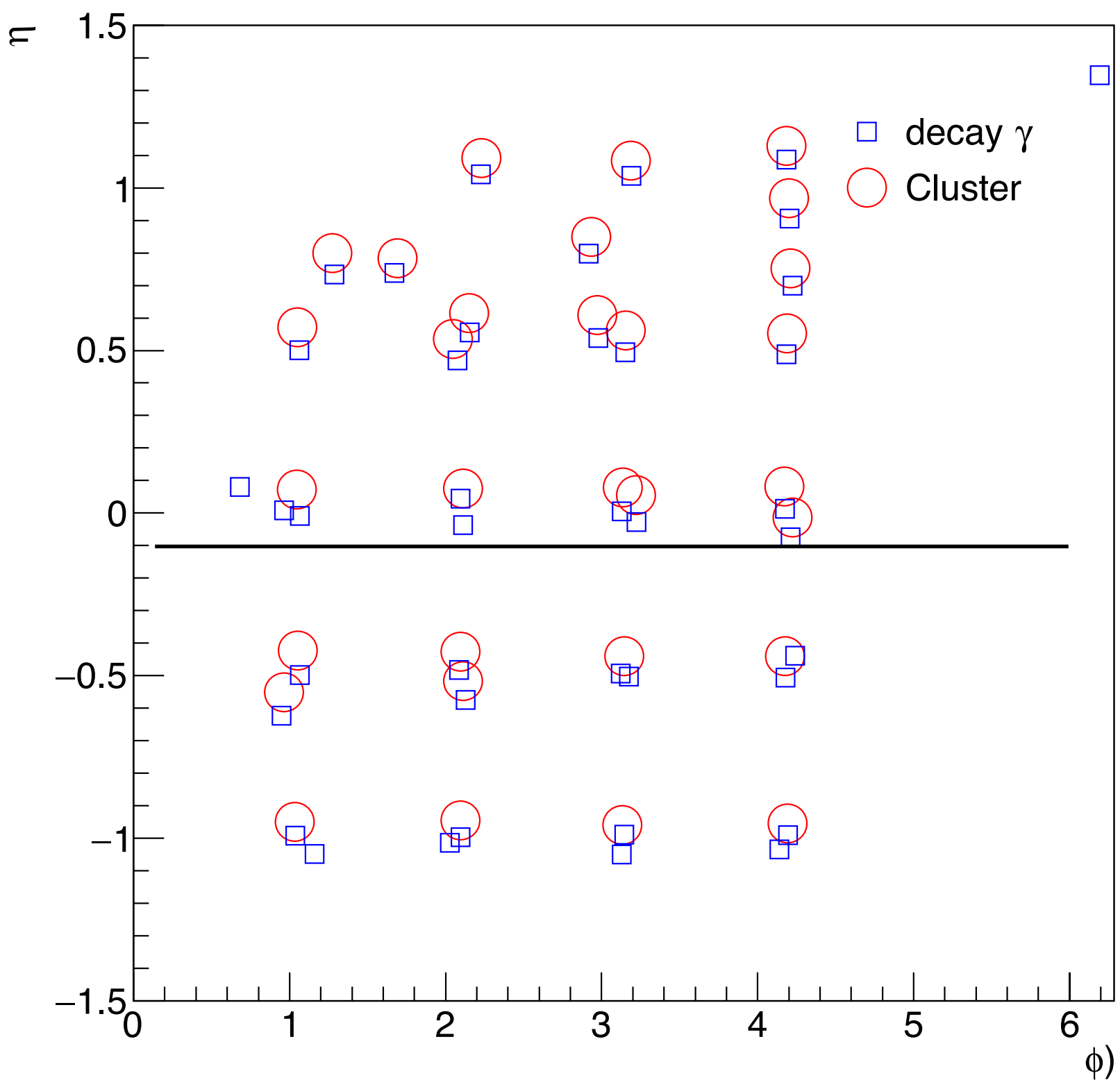
cluster and its primary particle



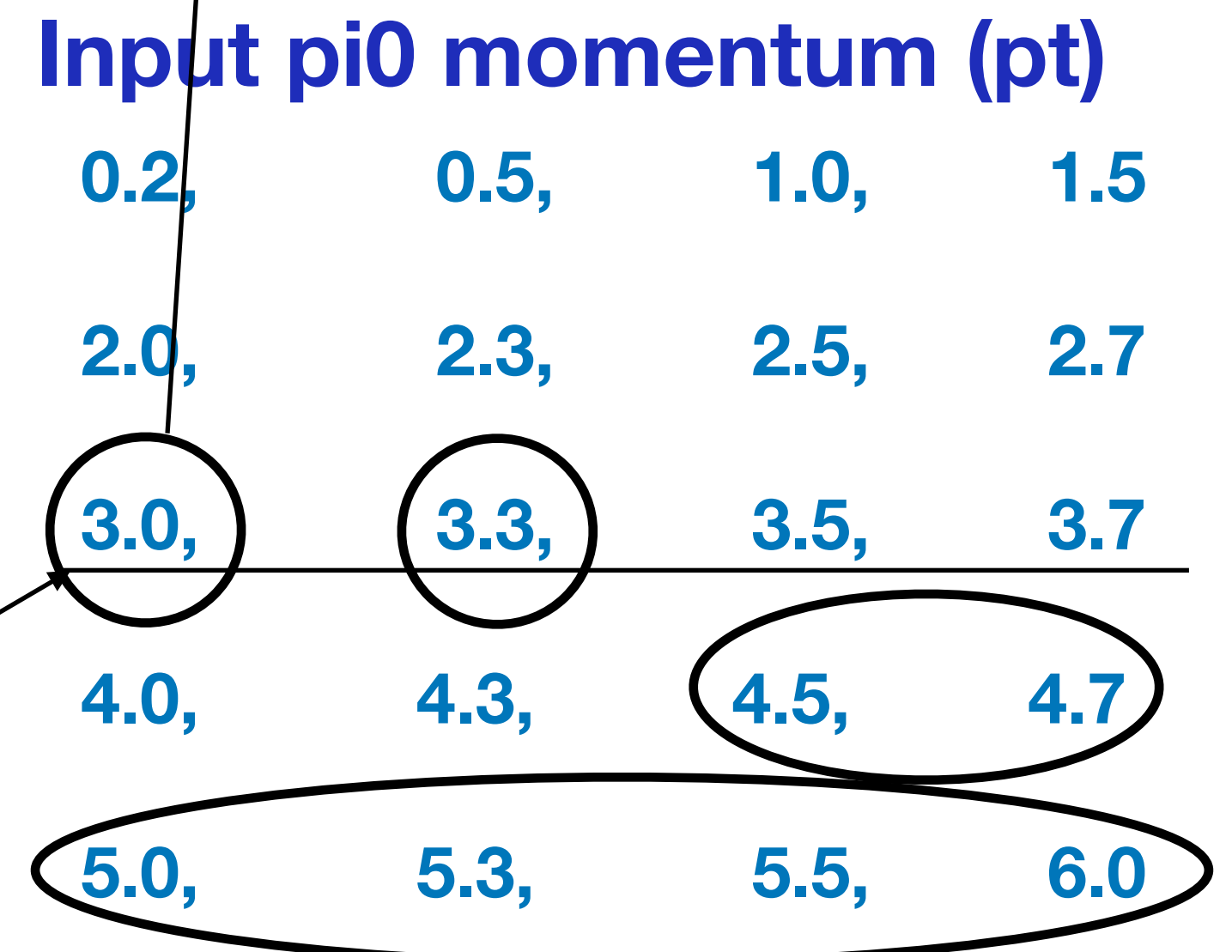
1. low E cluster, but high energy input?
2. extract the energy correction function
  - (1) fit gaus mean (blue point) :  $3.25643 \cdot q + 0.0589221$
  - (2) fit high bin (black point) :  $3.21429 \cdot q - 0.0428571$



# Single pi0 simulation analysis



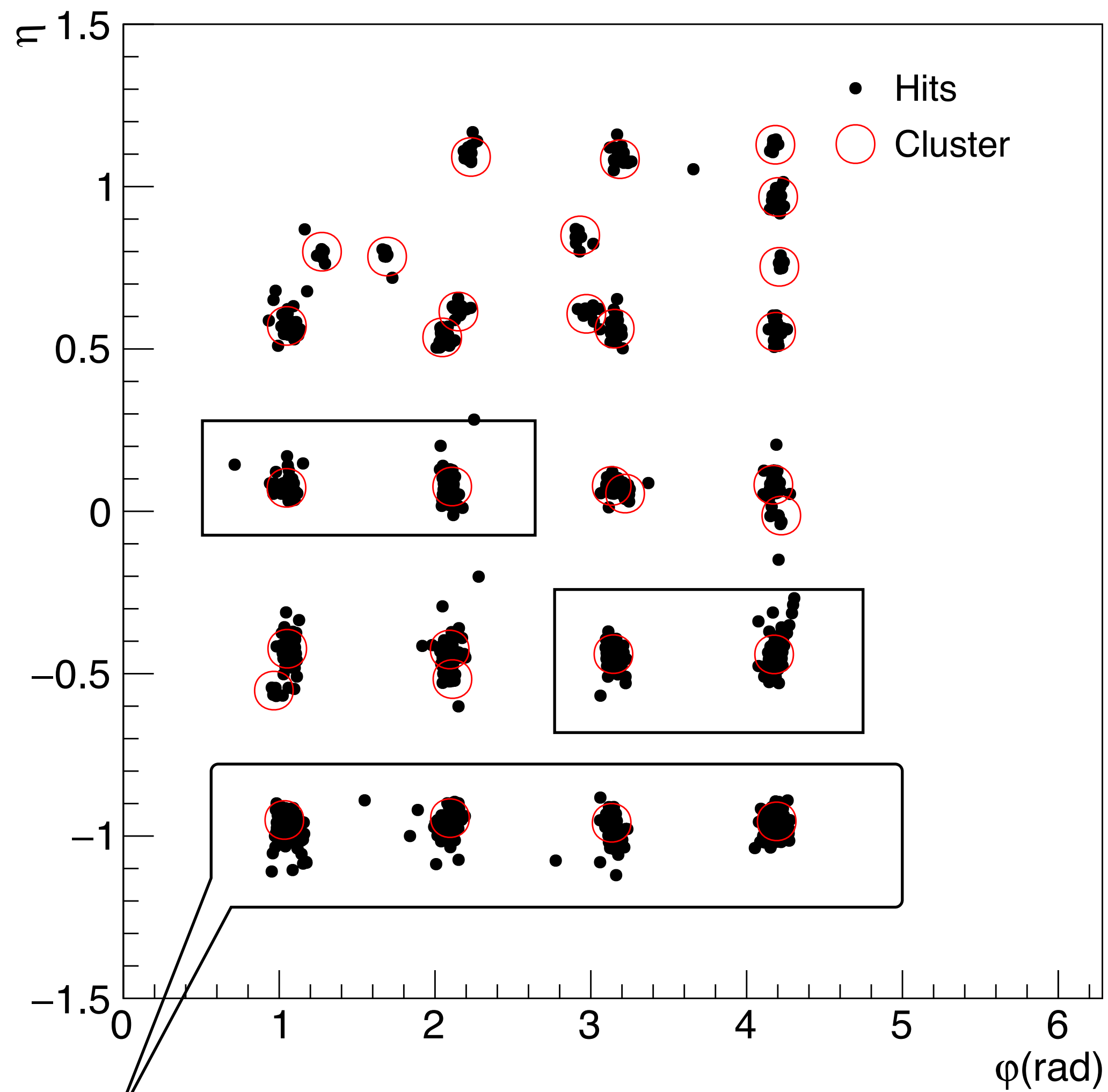
Two clusters from photons of one pi0 starts to merge at  $pt \sim 3.0 \text{ GeV}/c$



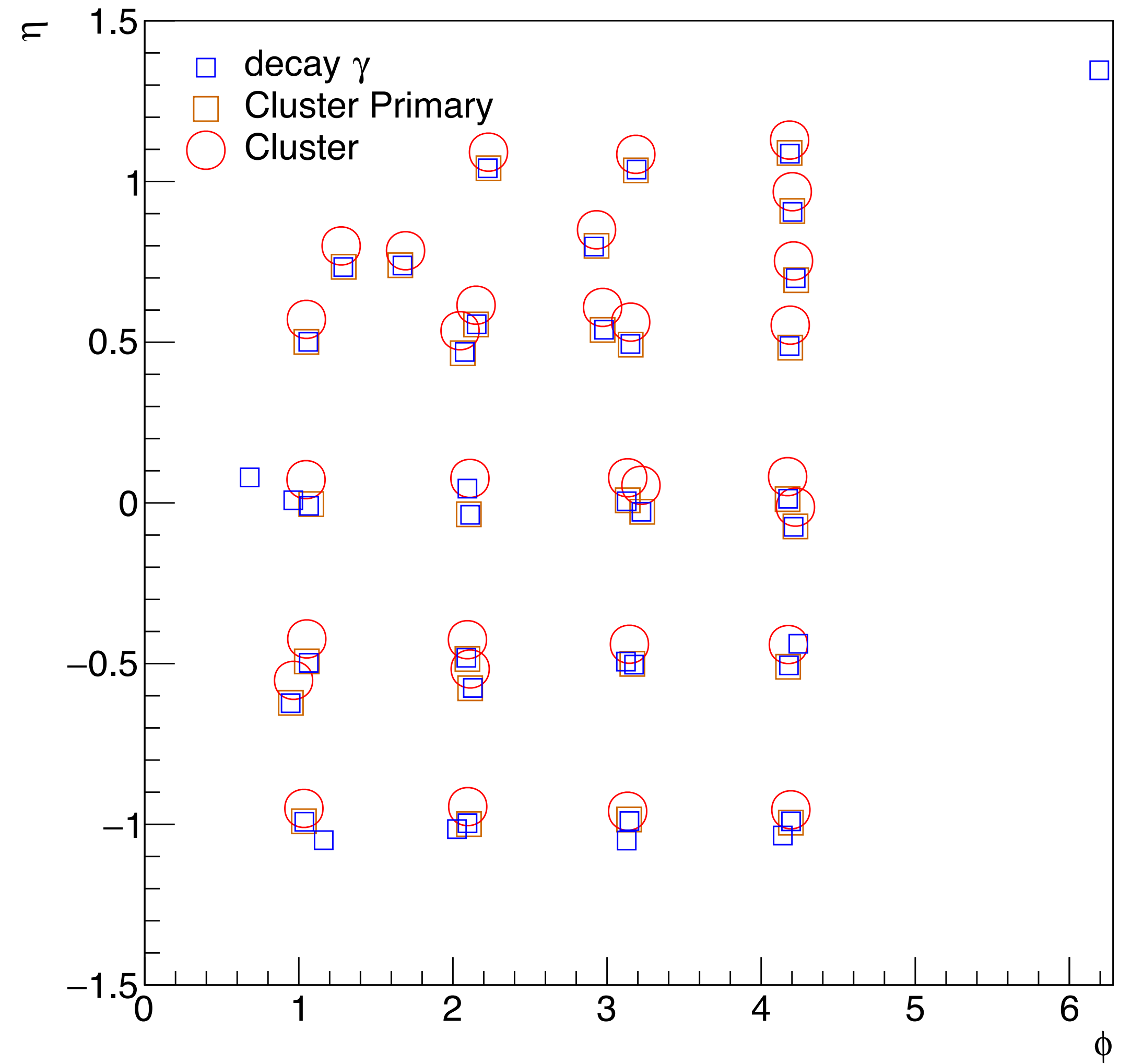
two photons for a pi0 merged

# Single pi0 simulation analysis

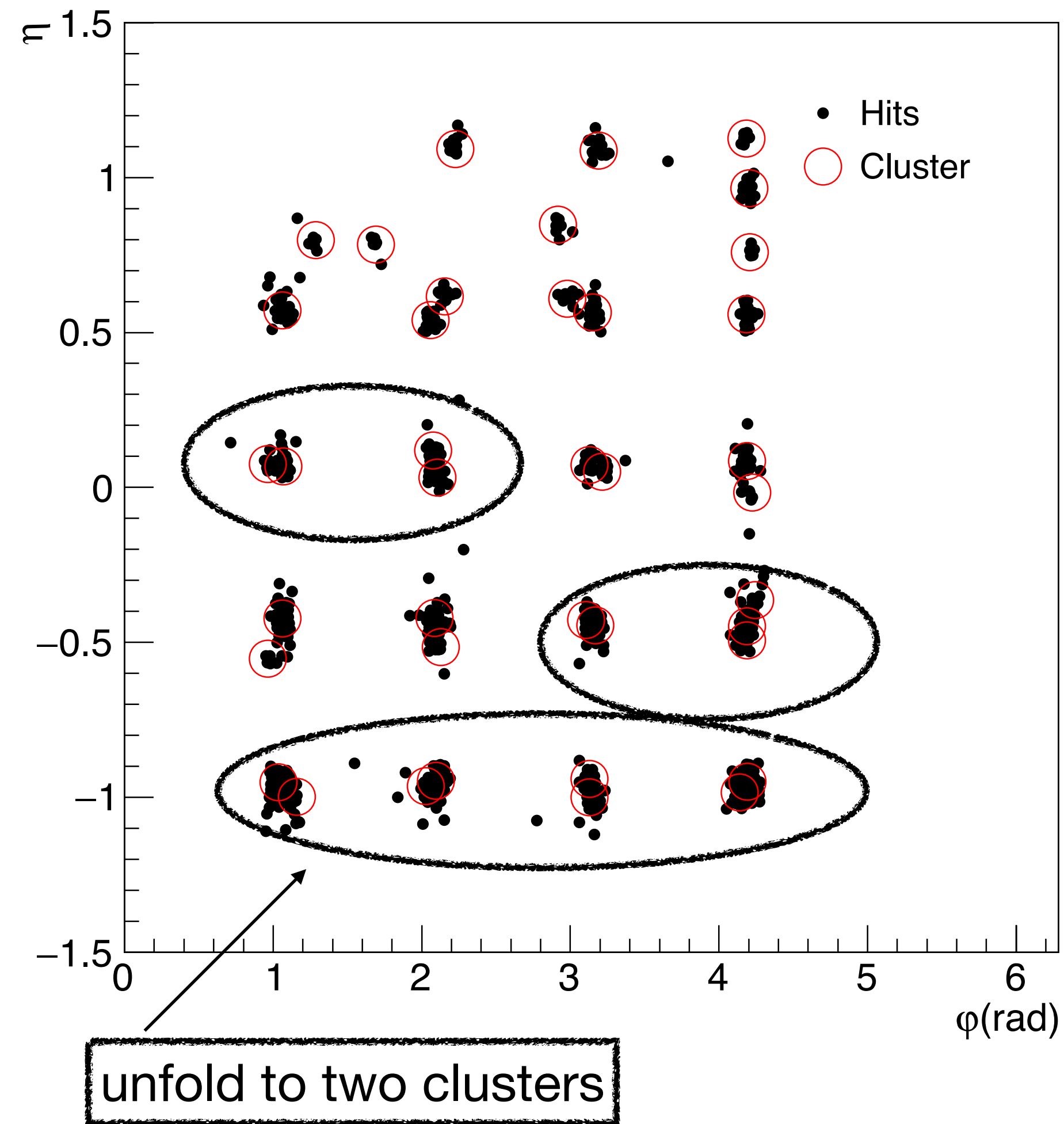
## clustering without unfolding



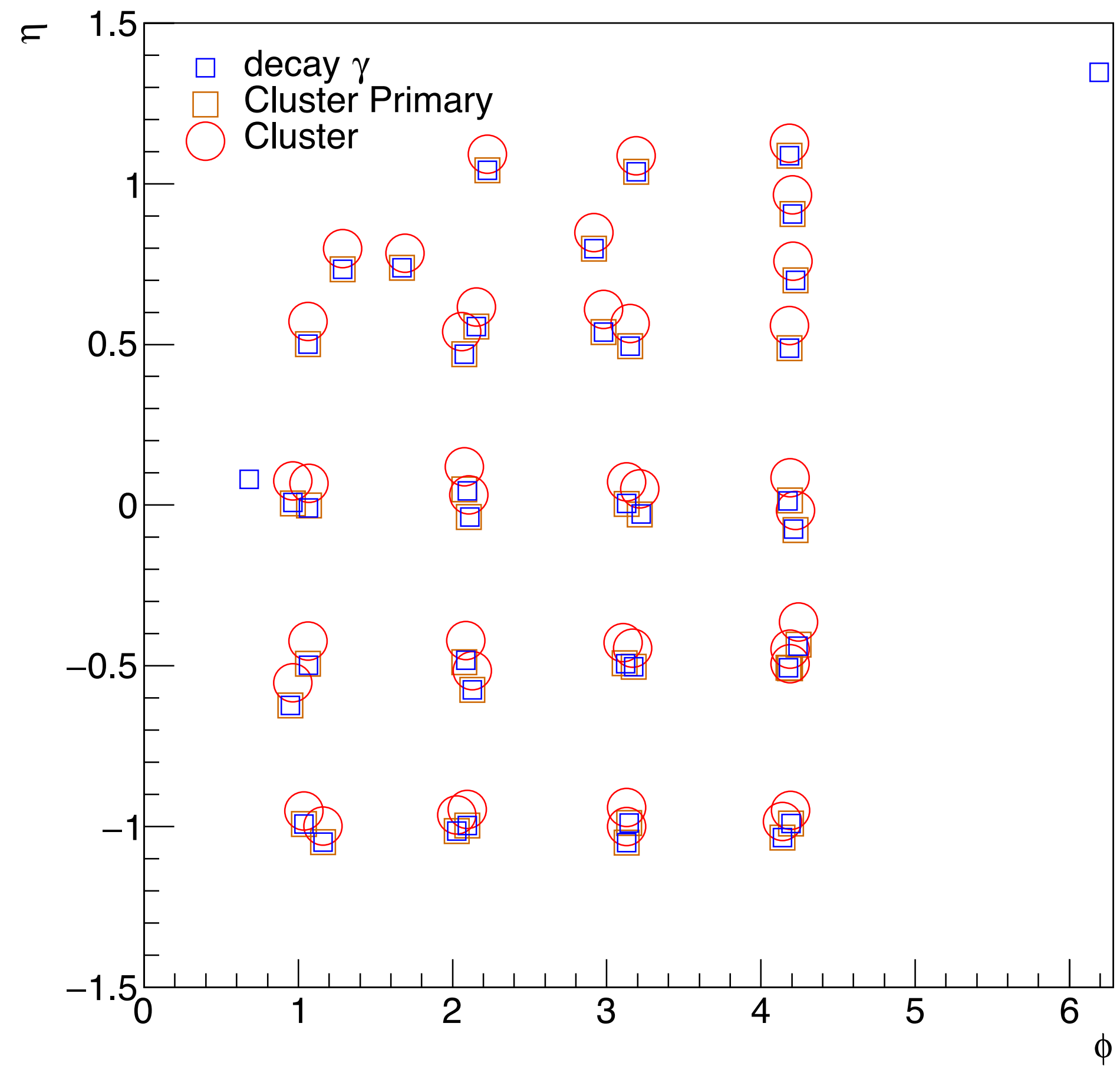
Can not reconstruct two clusters



# Single pi0 simulation analysis

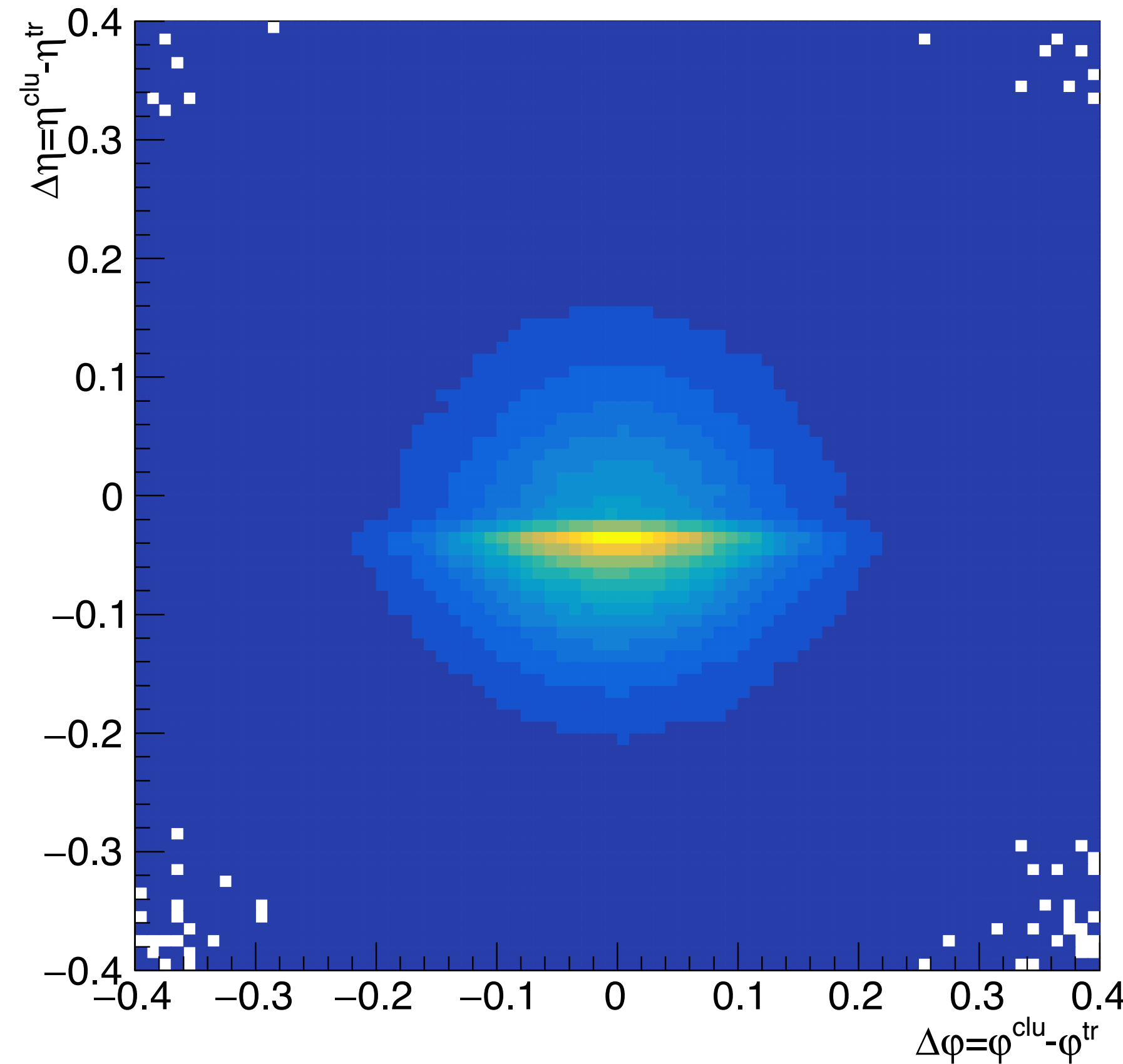


## clustering with unfolding

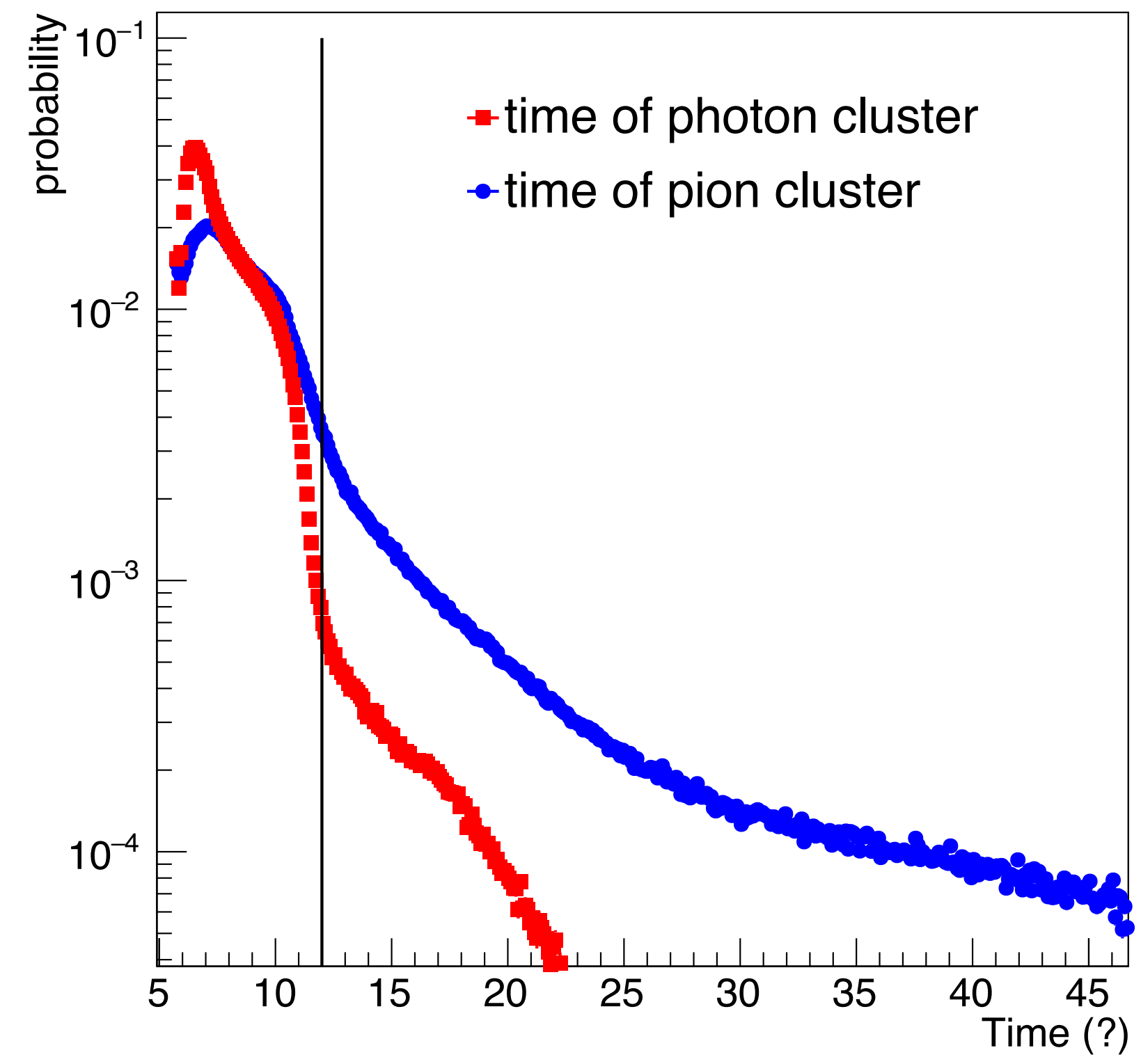


# Extracting photon identification cut

## 1. charged particle vote (CPV)

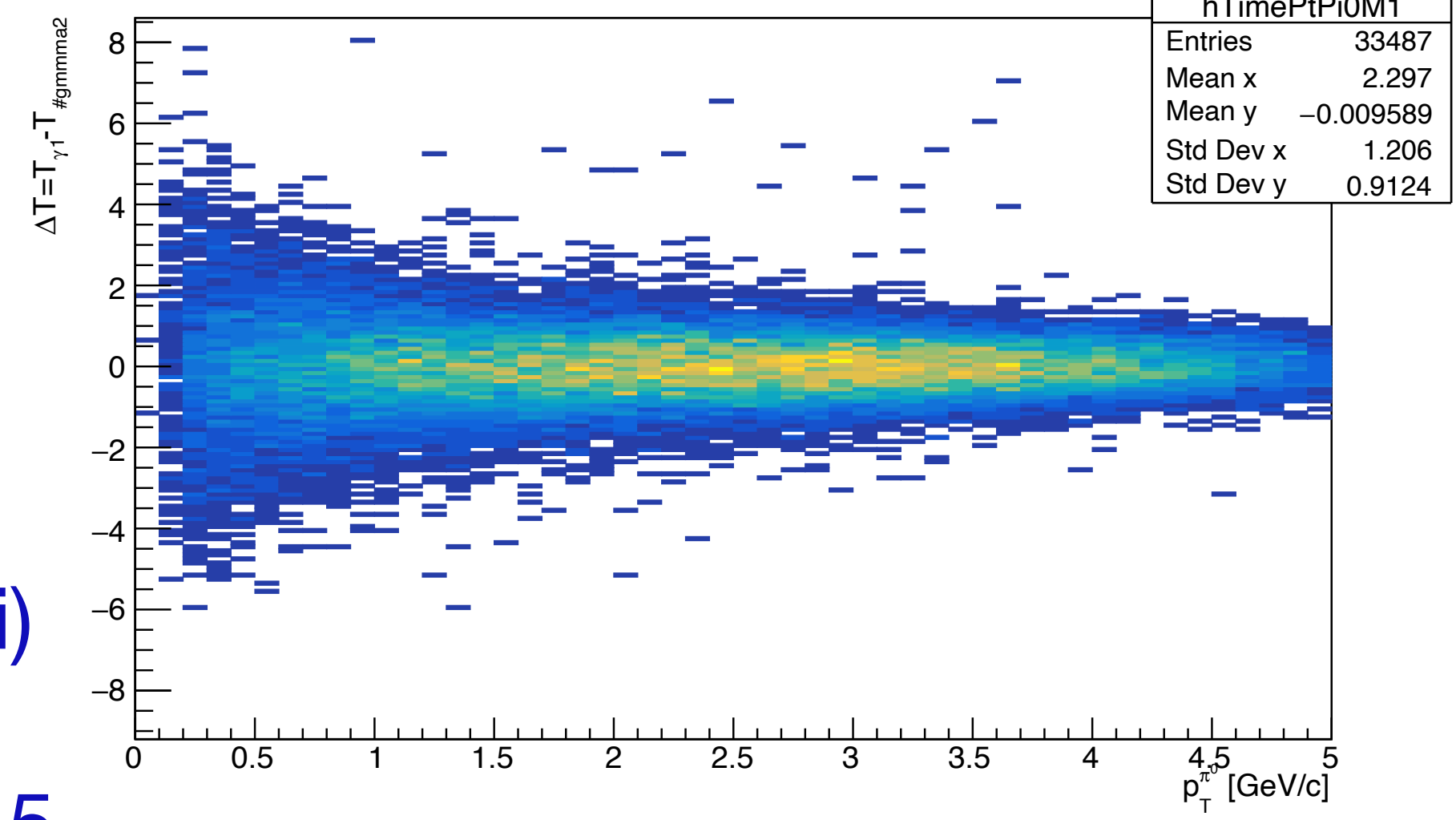


1. calculate distance  $r = \sqrt{\Delta\eta^2 + \Delta\phi^2}$
2. find minimum  $r$  to get this figure
3. hadron cluster :  $|\Delta\eta| < 0.1; |\Delta\phi| < 0.15$



2. cluster time (ns)  
 $T < 12$  for photon

pt vs delta Δ time when  $|mass - 0.135| < 0.03$



In pi0 reconstruction  
 two photons  
 $|\Delta T| < 2$

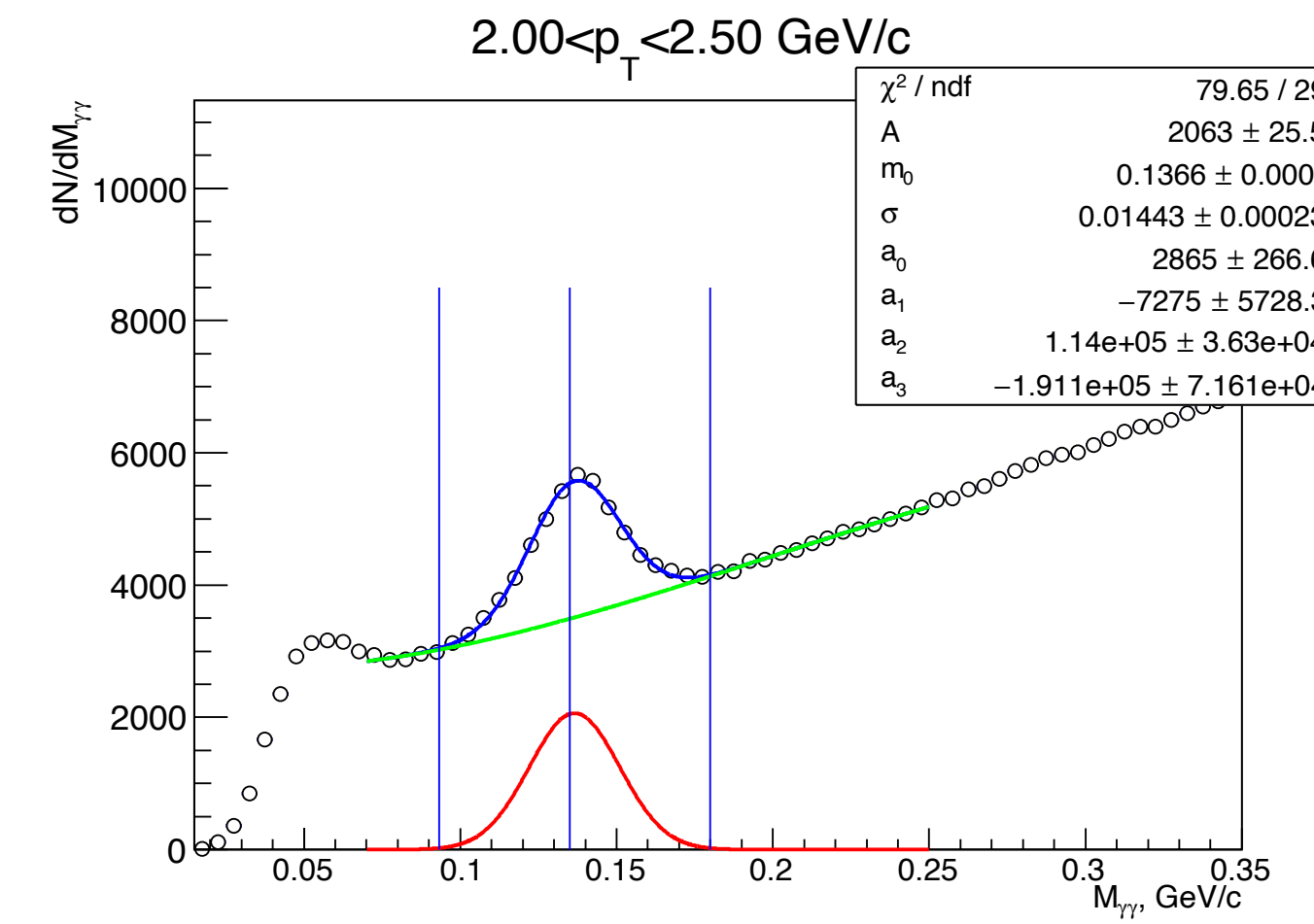
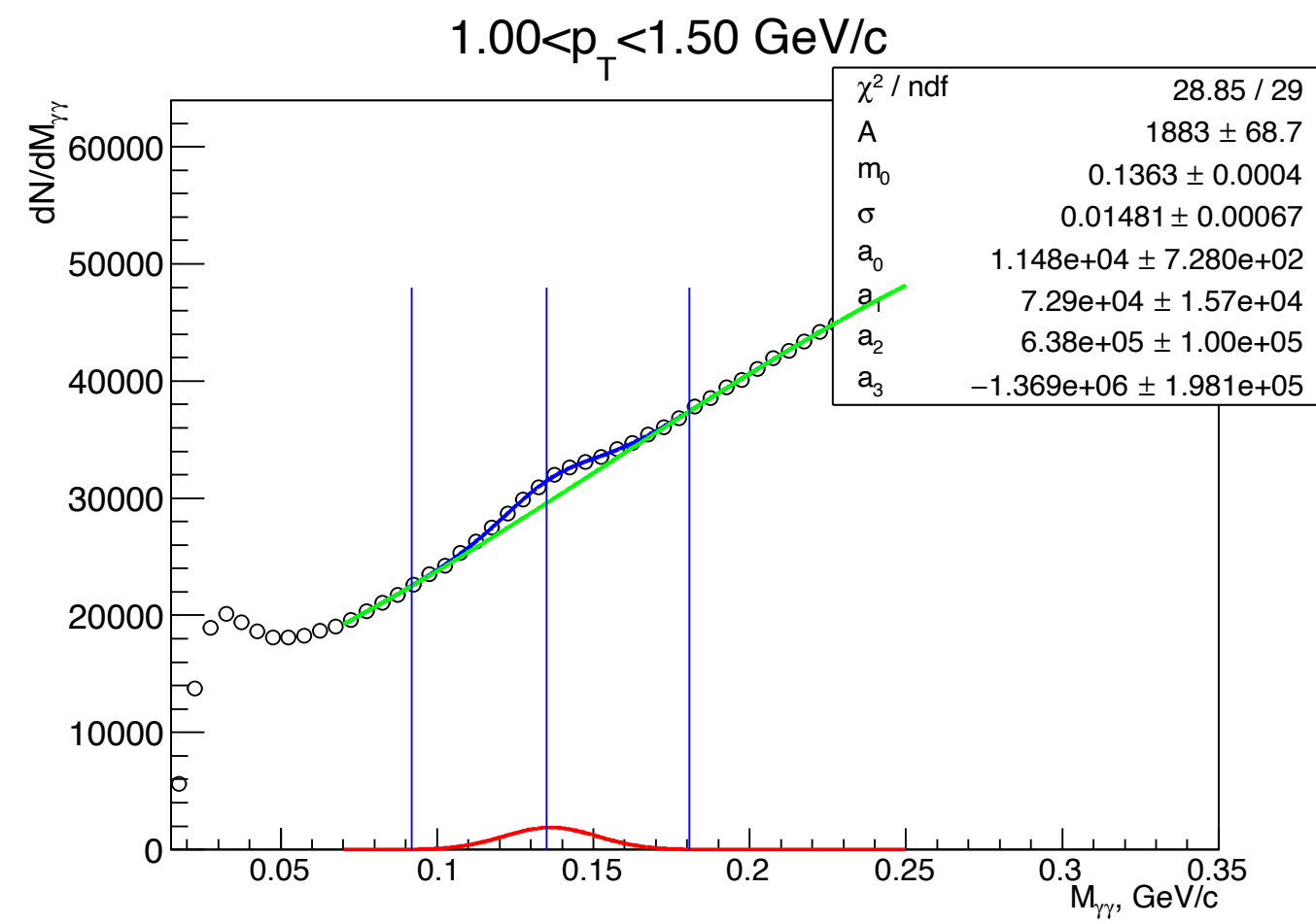


# Calculate the invariant mass of pi0(1)

1. cluster without CPV and time cut
2. fit with gauss+pol3

## Simulation data:

1. 40 pi-, 40 pi+ and 40 pi0 per event
2.  $0.2 < p_T < 5 \text{ GeV/c}$
3.  $-1.2 < \eta < 1.2; 0 < \phi < 2\pi$



pt: 1.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : 2993.91, S/B: 5.84

$N_{\pi^0}$ : 17475.83, StatError: 1014.13, SysError: \*

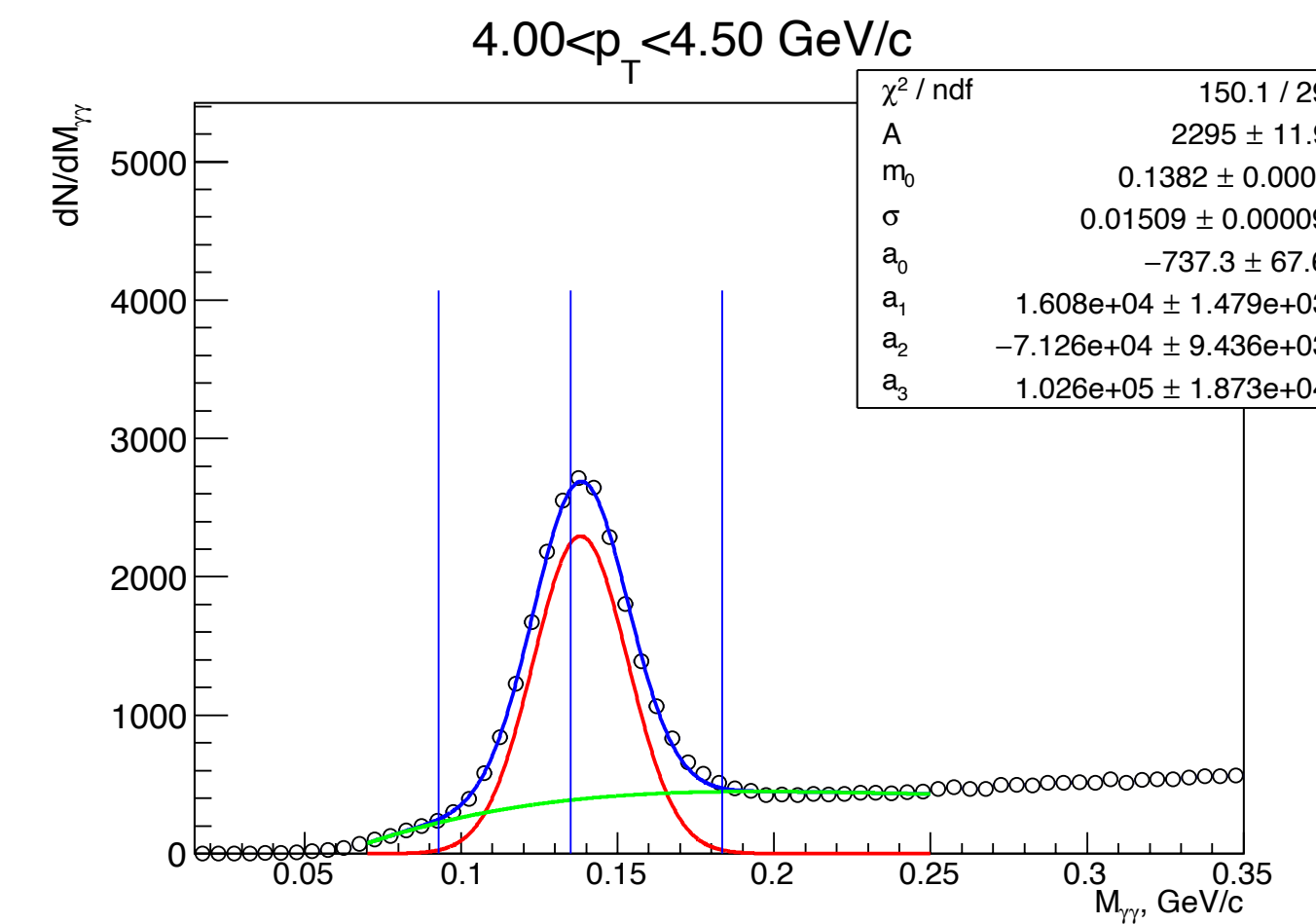
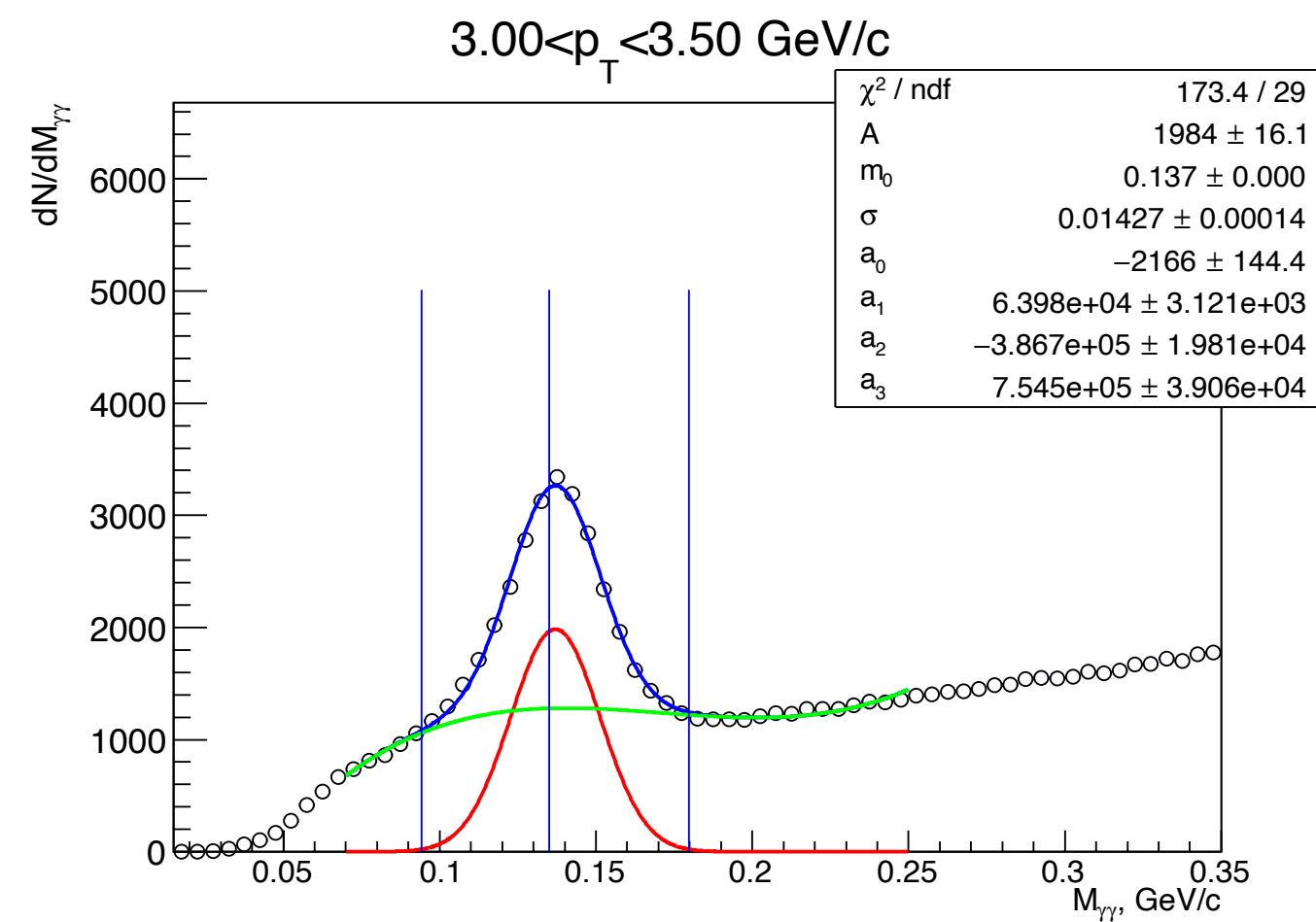
Lines: (left to right,  $+3\sigma$ ): 0.092, 0.135(Pdg), 0.181

pt: 2.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : 352.24, S/B: 52.96

$N_{\pi^0}$ : 18656.02, StatError: 376.43, SysError: \*

Lines: (left to right,  $+3\sigma$ ): 0.093, 0.135(Pdg), 0.180



pt: 3.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : -76.76, S/B: -231.16

$N_{\pi^0}$ : 17743.90, StatError: 230.65, SysError: \*

Lines: (left to right,  $+3\sigma$ ): 0.094, 0.135(Pdg), 0.180

pt: 4.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : 6.79, S/B: 3197.25

$N_{\pi^0}$ : 21700.53, StatError: 170.54, SysError: \*

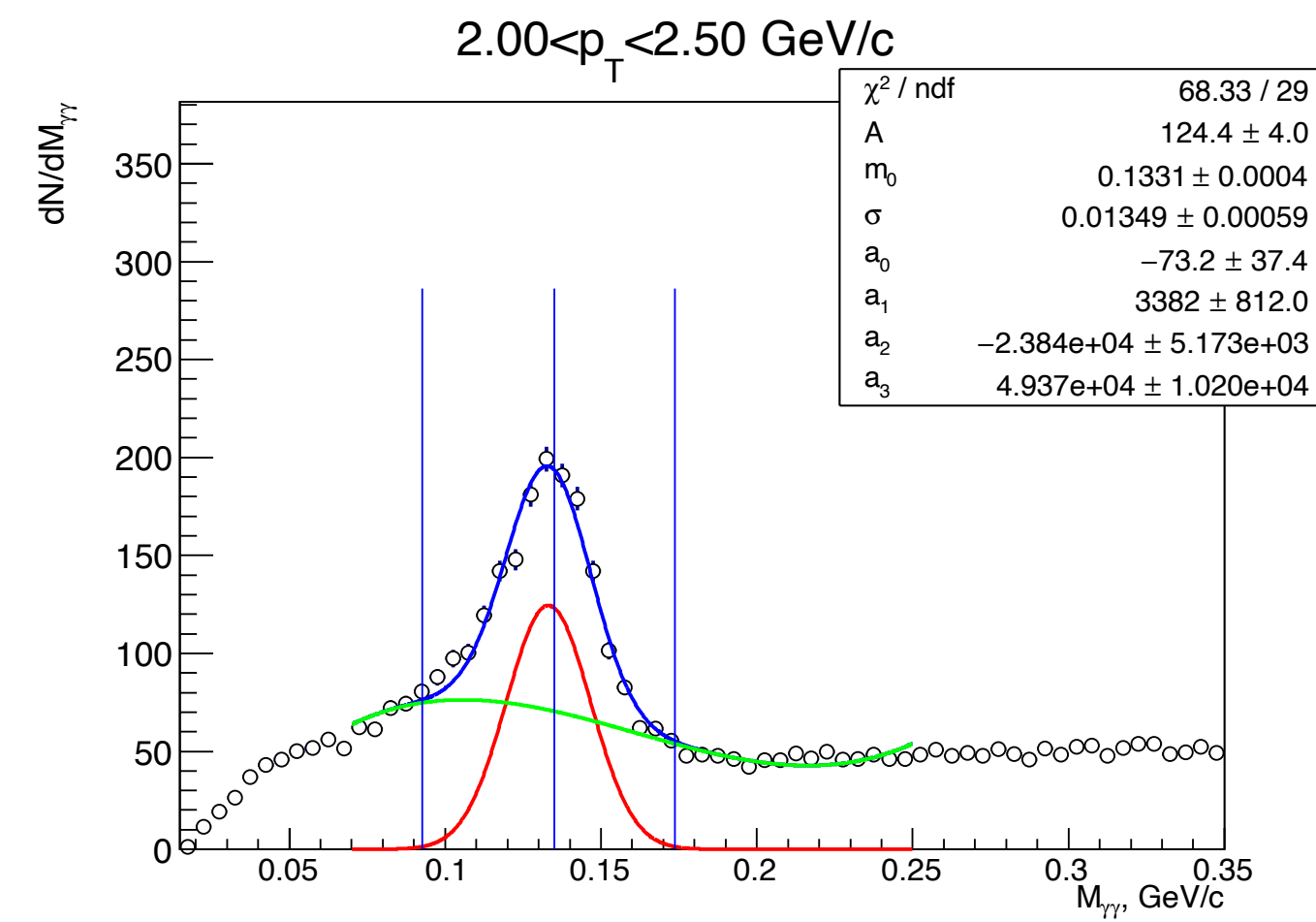
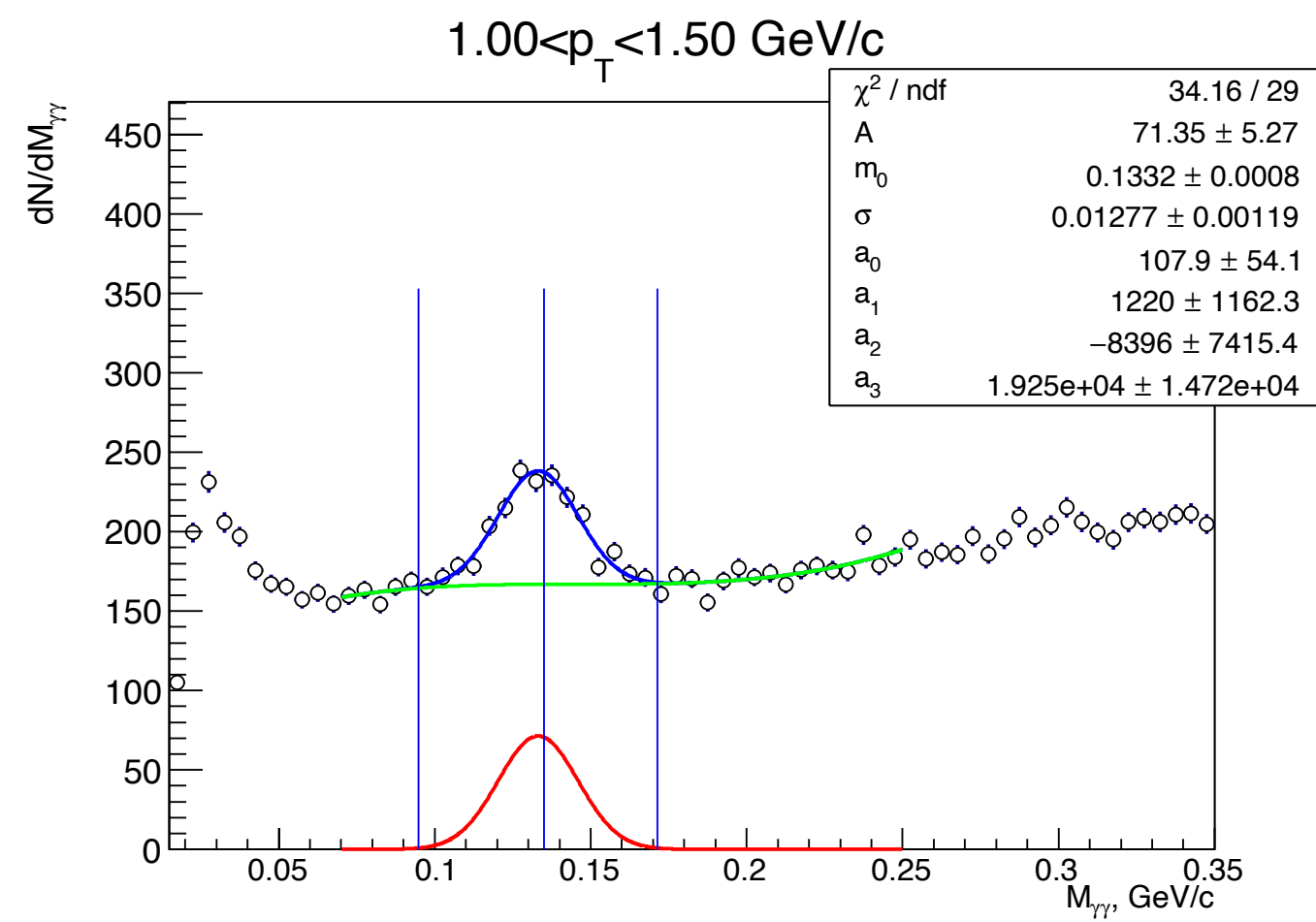
Lines: (left to right,  $+3\sigma$ ): 0.093, 0.135(Pdg), 0.183

# Calculate the invariant mass of pi0 (2)

1. cluster with CPV and time cut
2.  $|\Delta \text{time}| < 2$
3. fit with gauss+pol3

## Simulation data:

1. 40 pi-, 40 pi+ and 40 pi0 per event
2.  $0.2 < p_T < 5 \text{ GeV/c}$
3.  $-1.2 < \eta < 1.2; 0 < \phi < 2\pi$



pt: 1.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : 8.99, S/B: 63.52

$N_{\pi^0}$ : 571.07, StatError: 68.02, SysError: \*

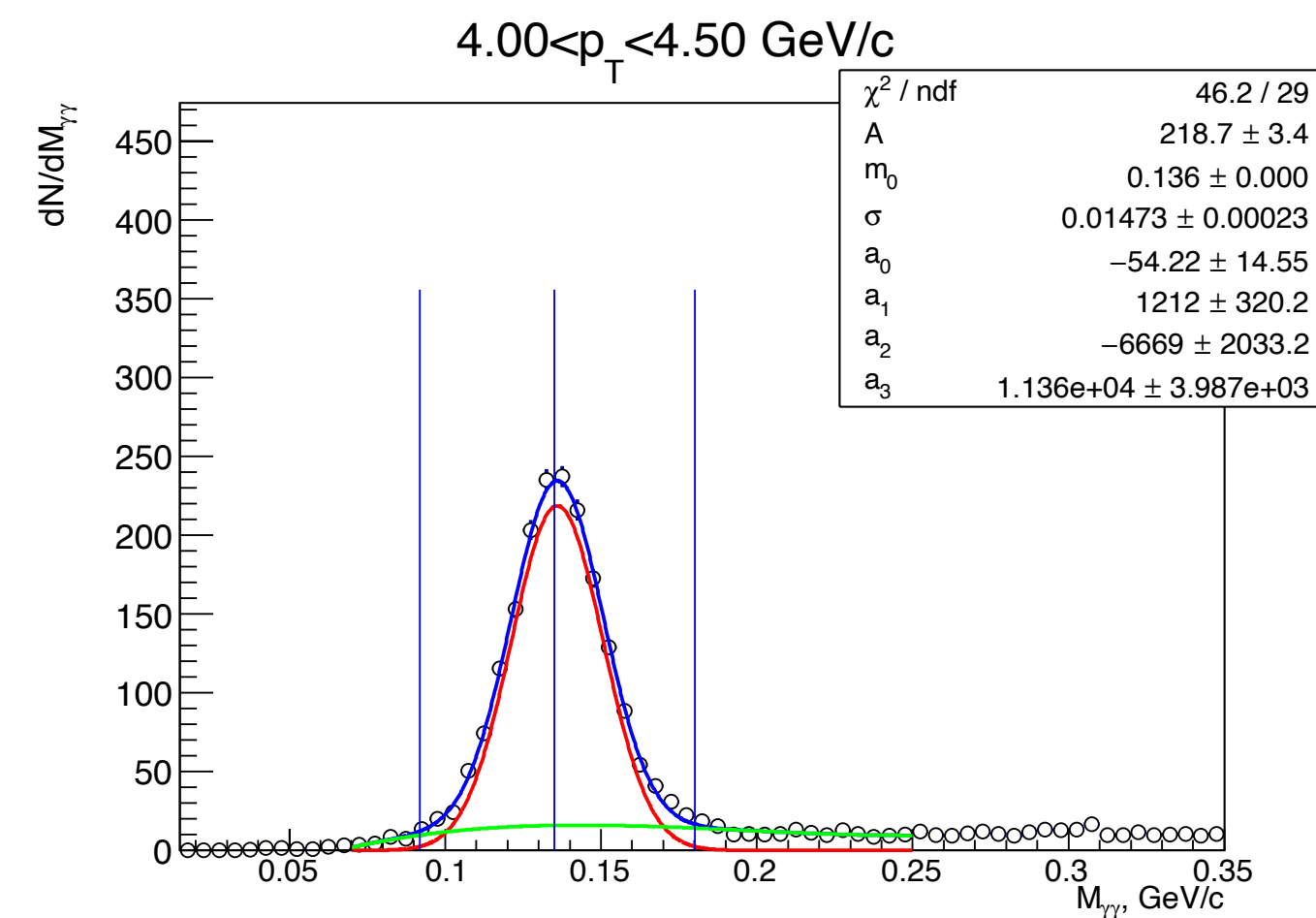
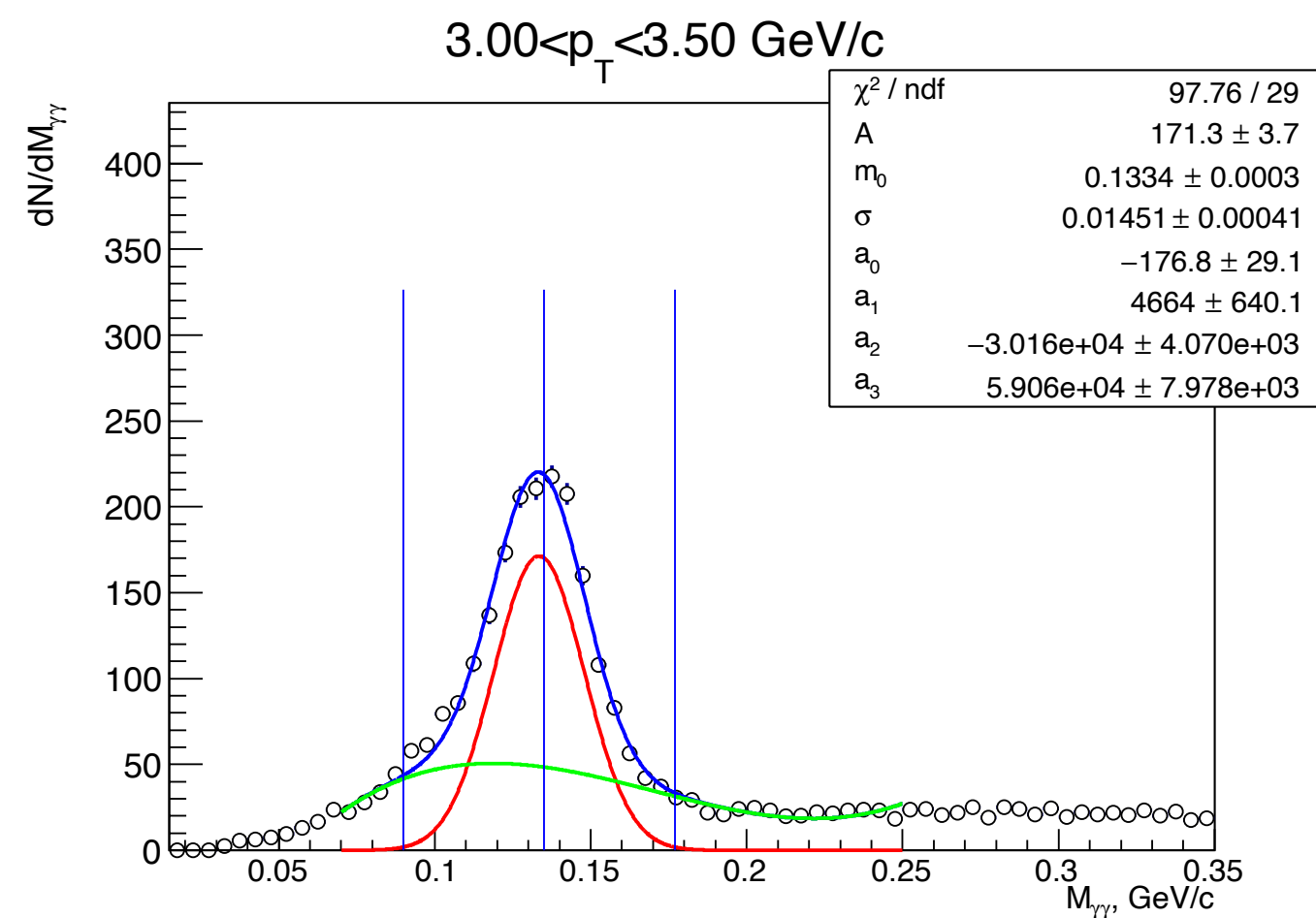
Lines: (left to right,  $\pm 3\sigma$ ): 0.095, 0.135(Pdg), 0.171

pt: 2.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : -4.73, S/B: -222.37

$N_{\pi^0}$ : 1052.08, StatError: 57.39, SysError: \*

Lines: (left to right,  $\pm 3\sigma$ ): 0.093, 0.135(Pdg), 0.174



pt: 3.25, LeftError: 0.25+\*, RightError: 0.25+\*

$N_{\text{background}}$ : -9.62, S/B: -161.90

$N_{\pi^0}$ : 1557.90, StatError: 55.56, SysError: \*

Lines: (left to right,  $\pm 3\sigma$ ): 0.090, 0.135(Pdg), 0.177

pt: 4.25, LeftError: 0.25+\*, RightError: 0.25+\*

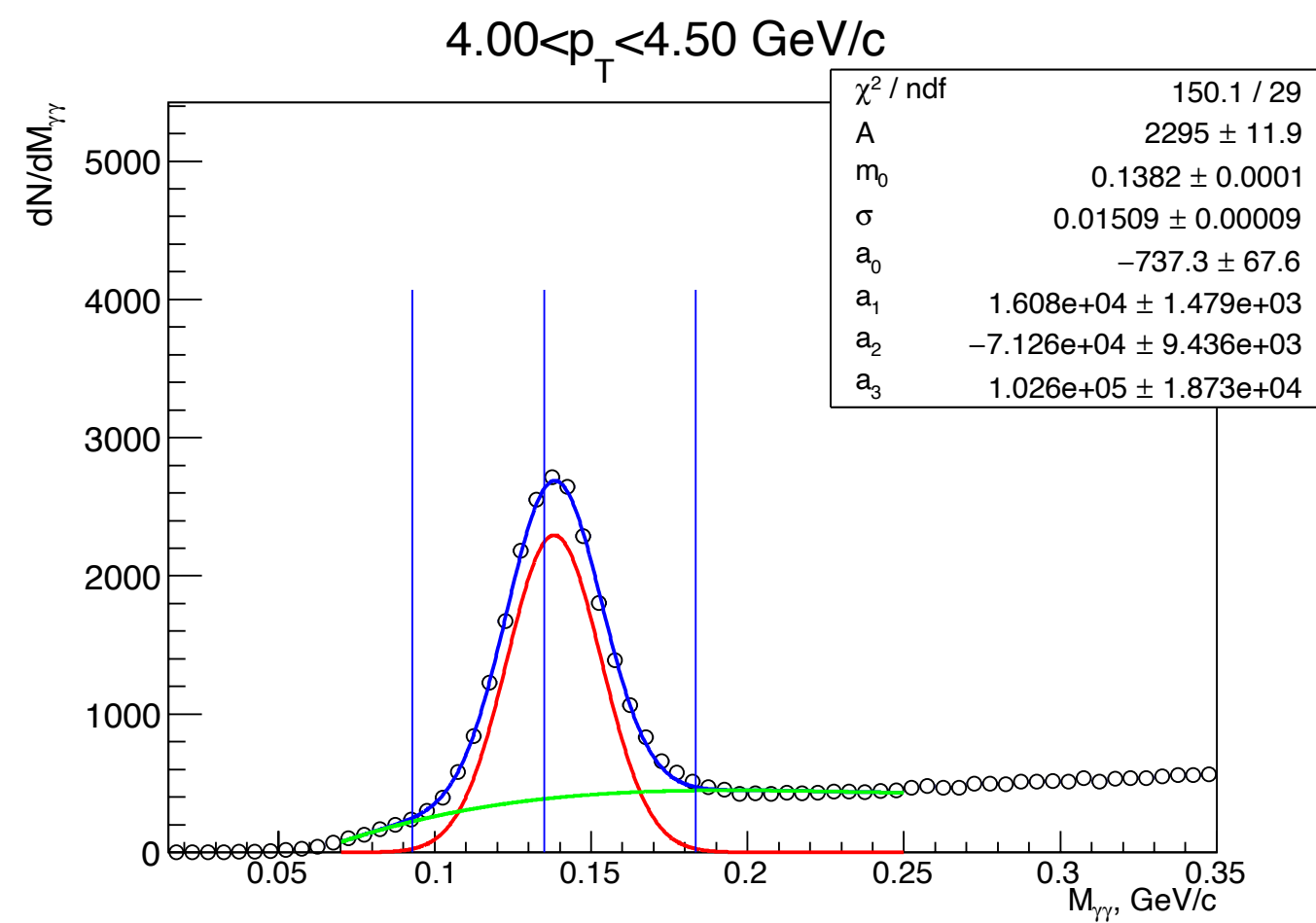
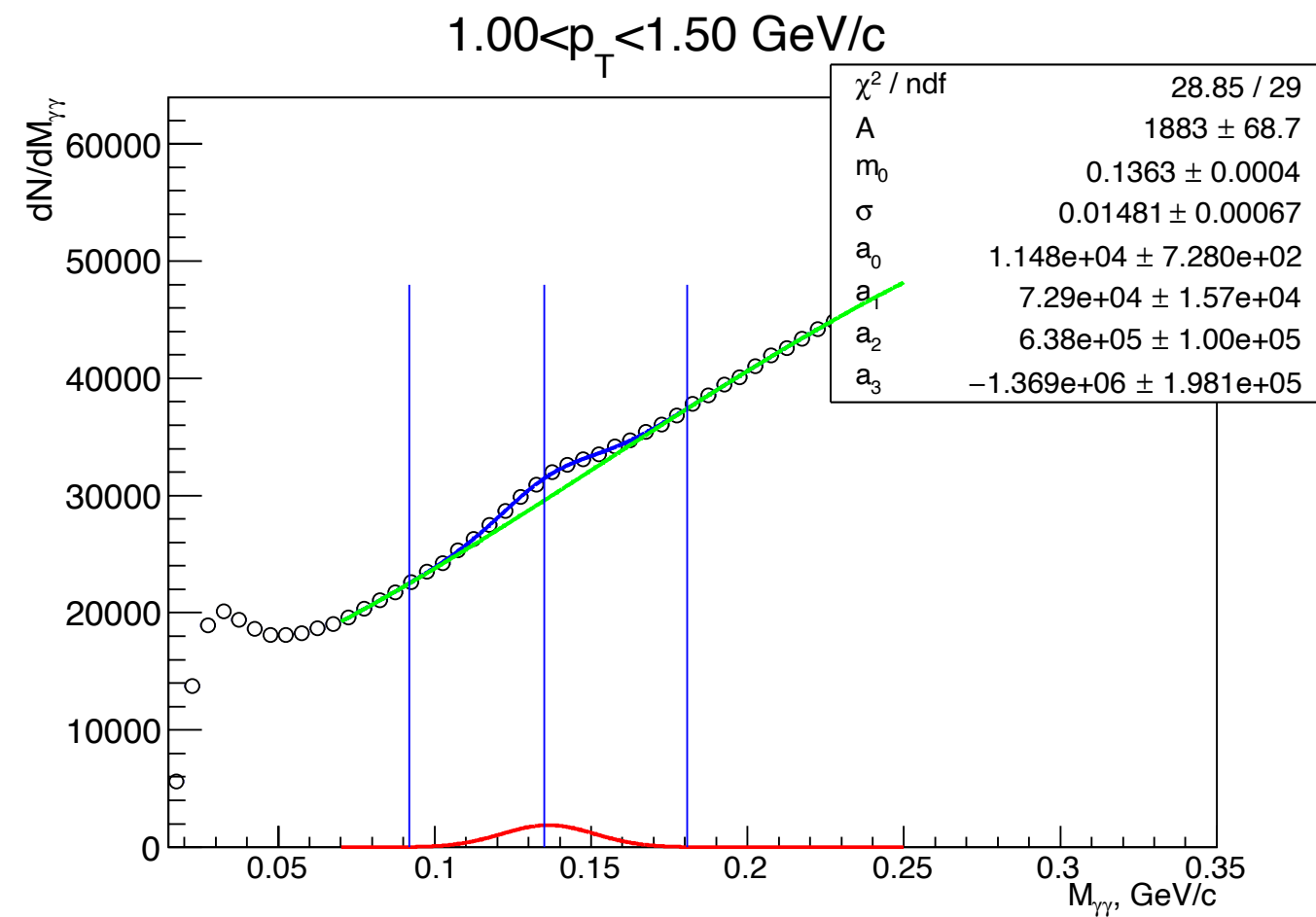
$N_{\text{background}}$ : -1.51, S/B: -1340.09

$N_{\pi^0}$ : 2018.81, StatError: 44.63, SysError: \*

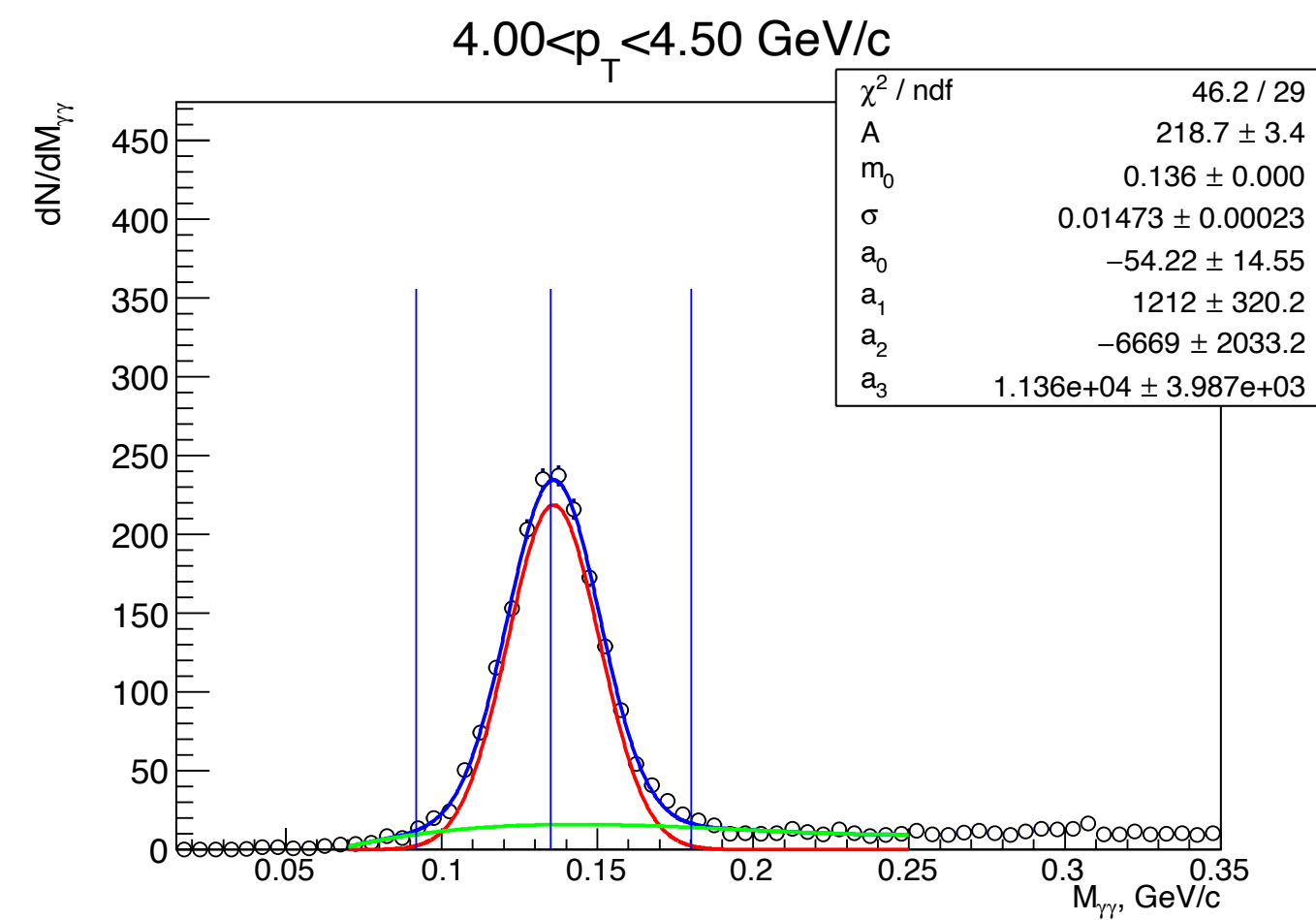
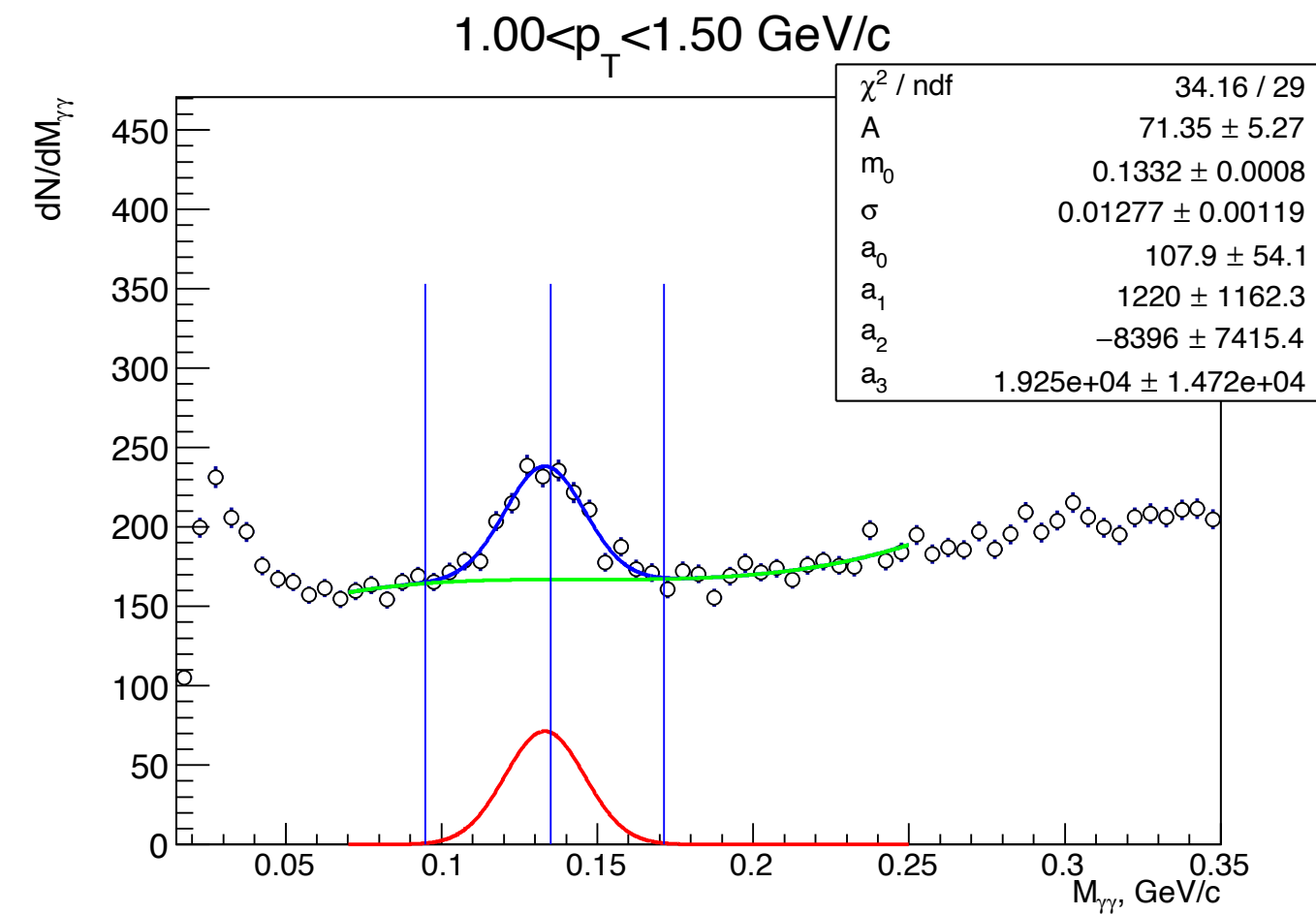
Lines: (left to right,  $\pm 3\sigma$ ): 0.092, 0.135(Pdg), 0.180

# Comparison between W/ and W/o photon PID cuts

## With photon PID cuts



## Without photon PID cuts

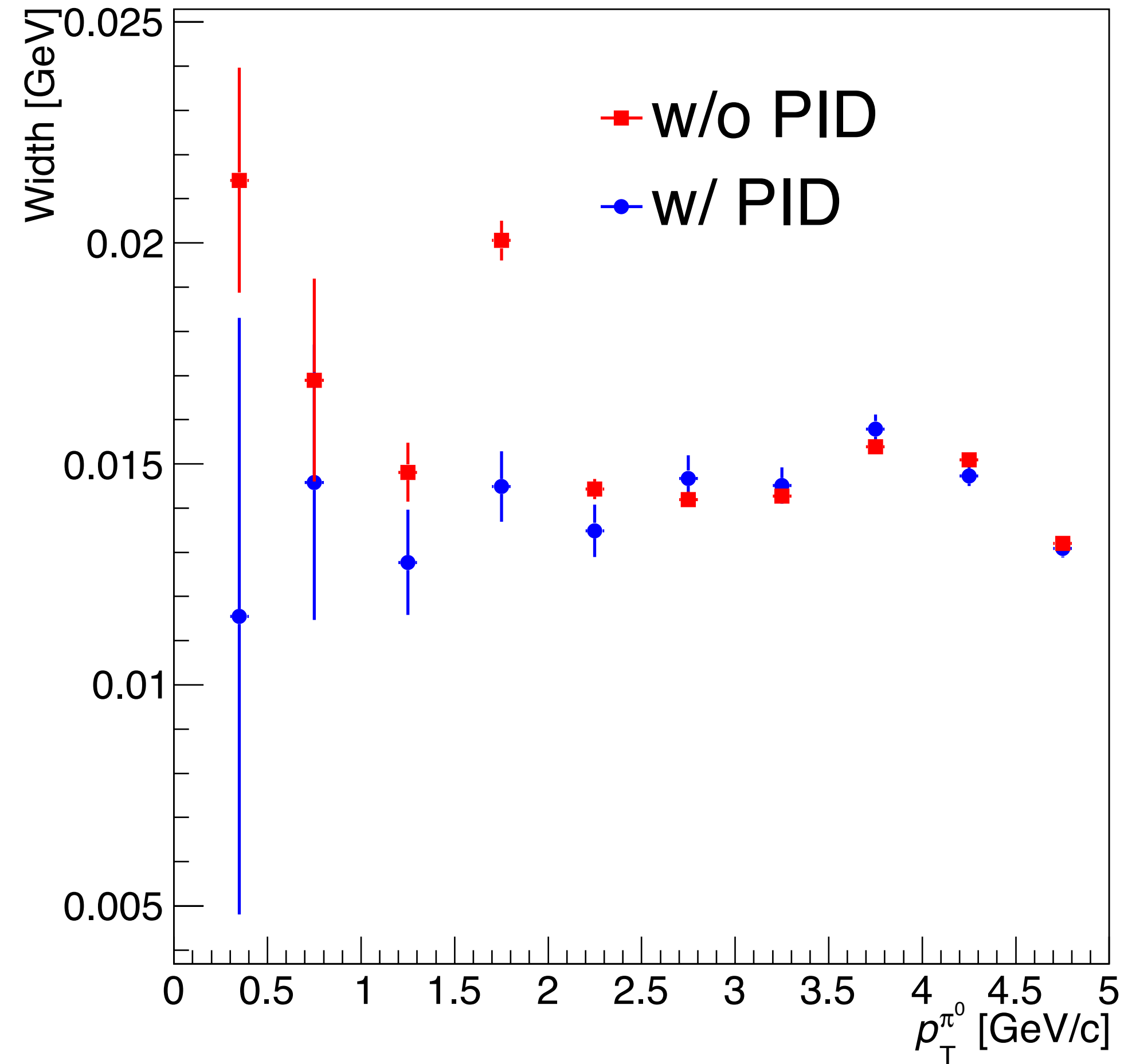
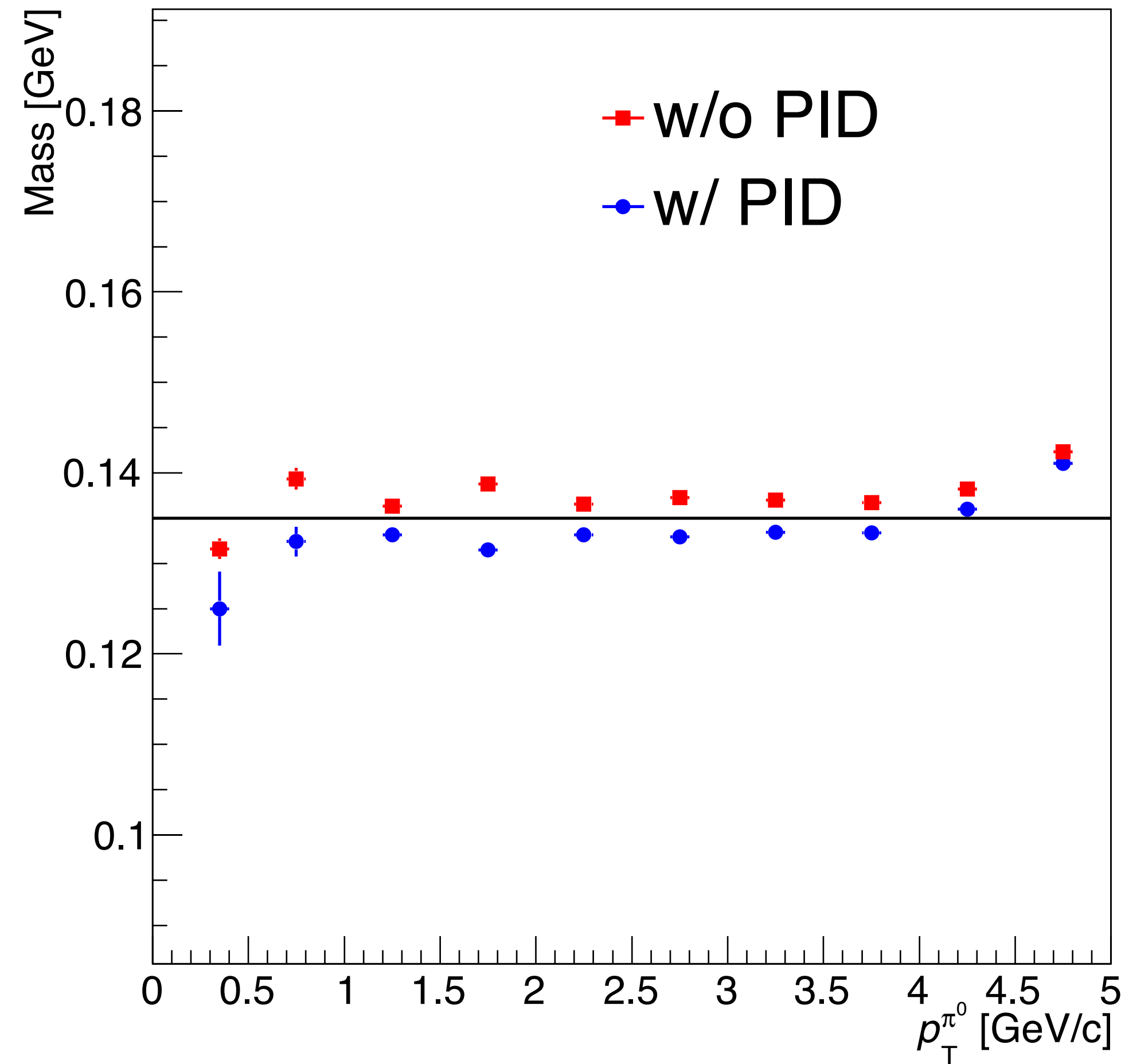


1. PID can powerfully improve the  $\pi^0$  reconstruction at low  $p_T$

2. Hadron cluster are mainly at lower energy

3. the invariant mass and mass width are improved a little at high  $p_T$  with PID

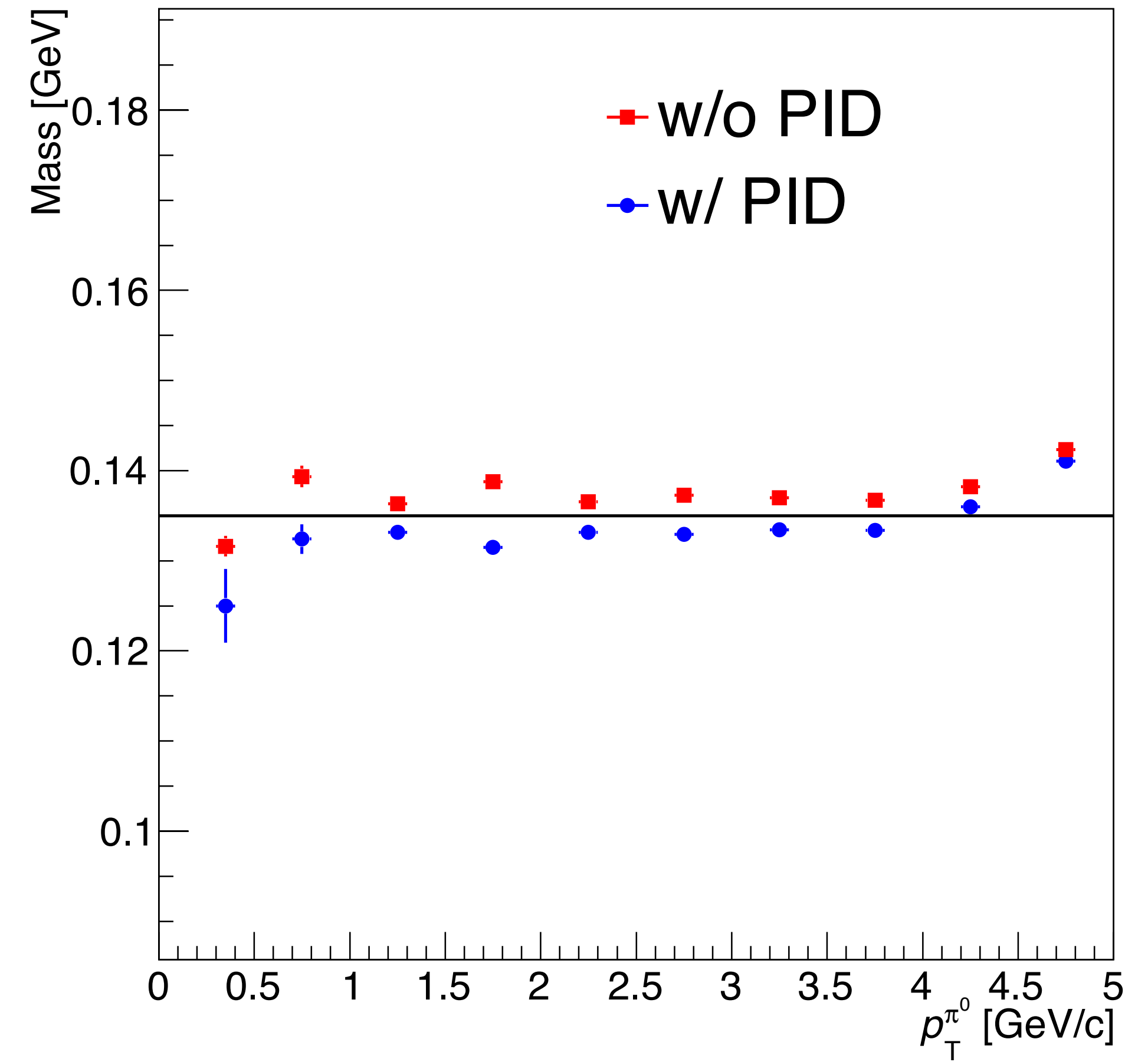
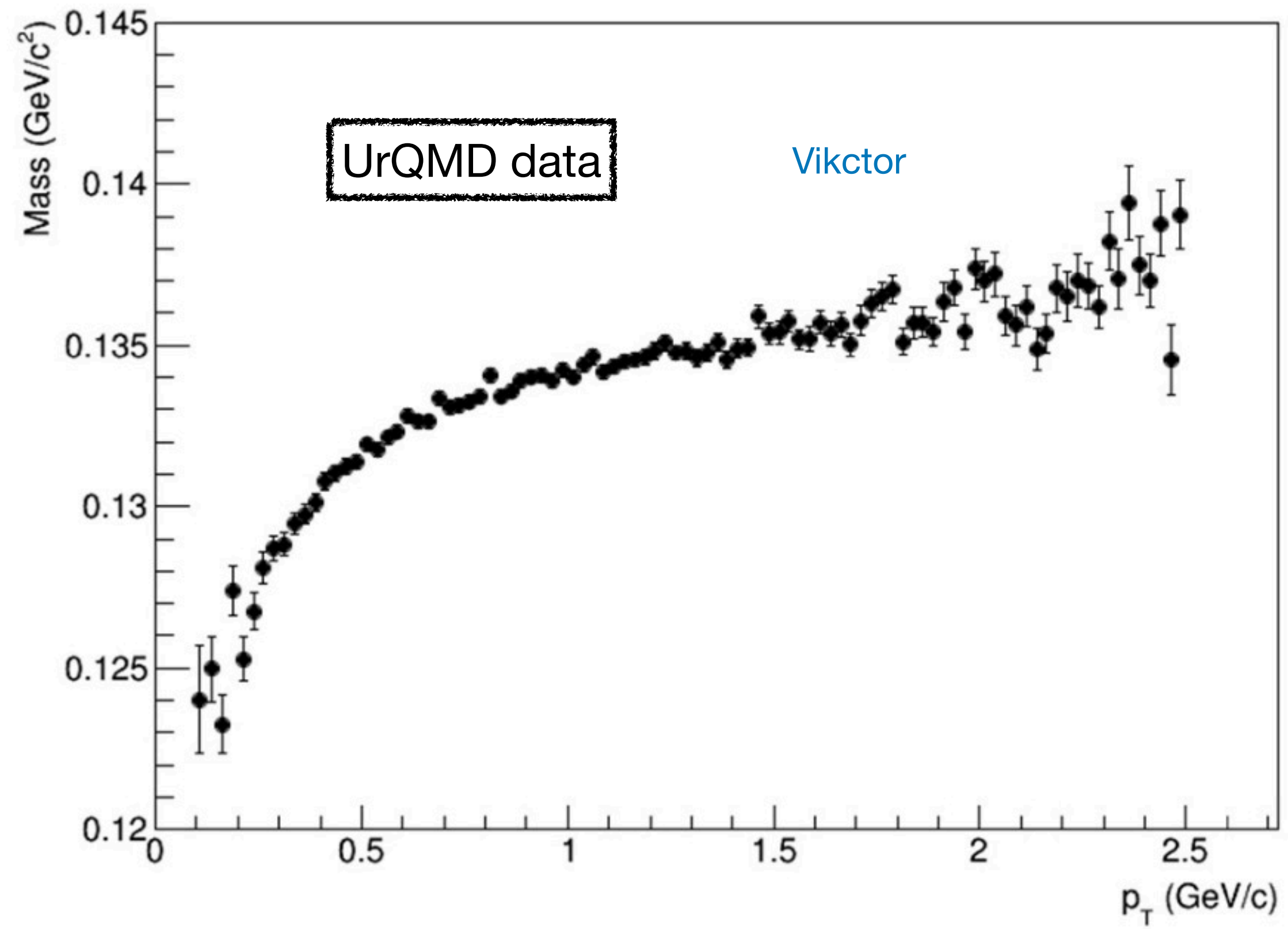
# Invariant mass and mass width



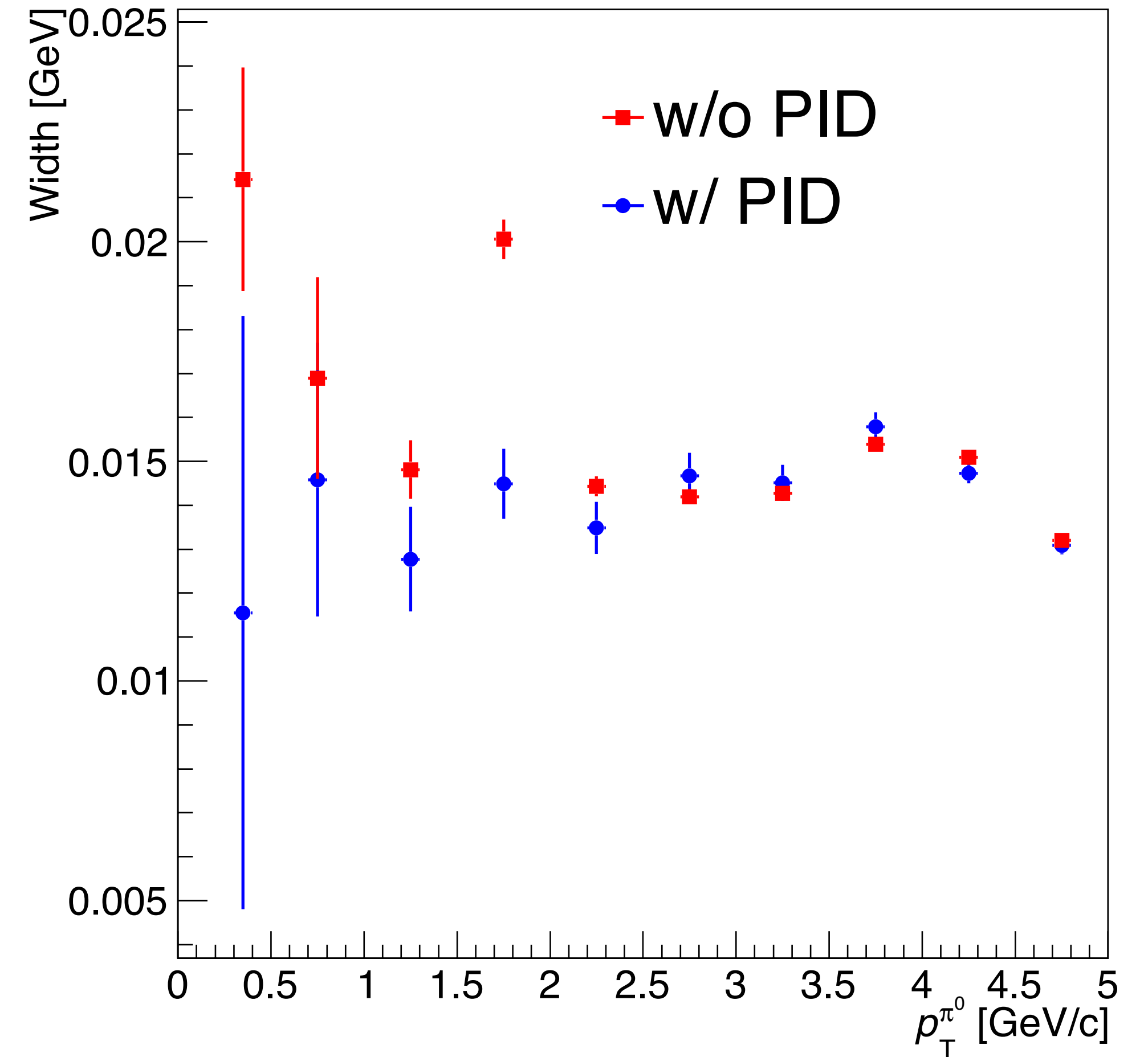
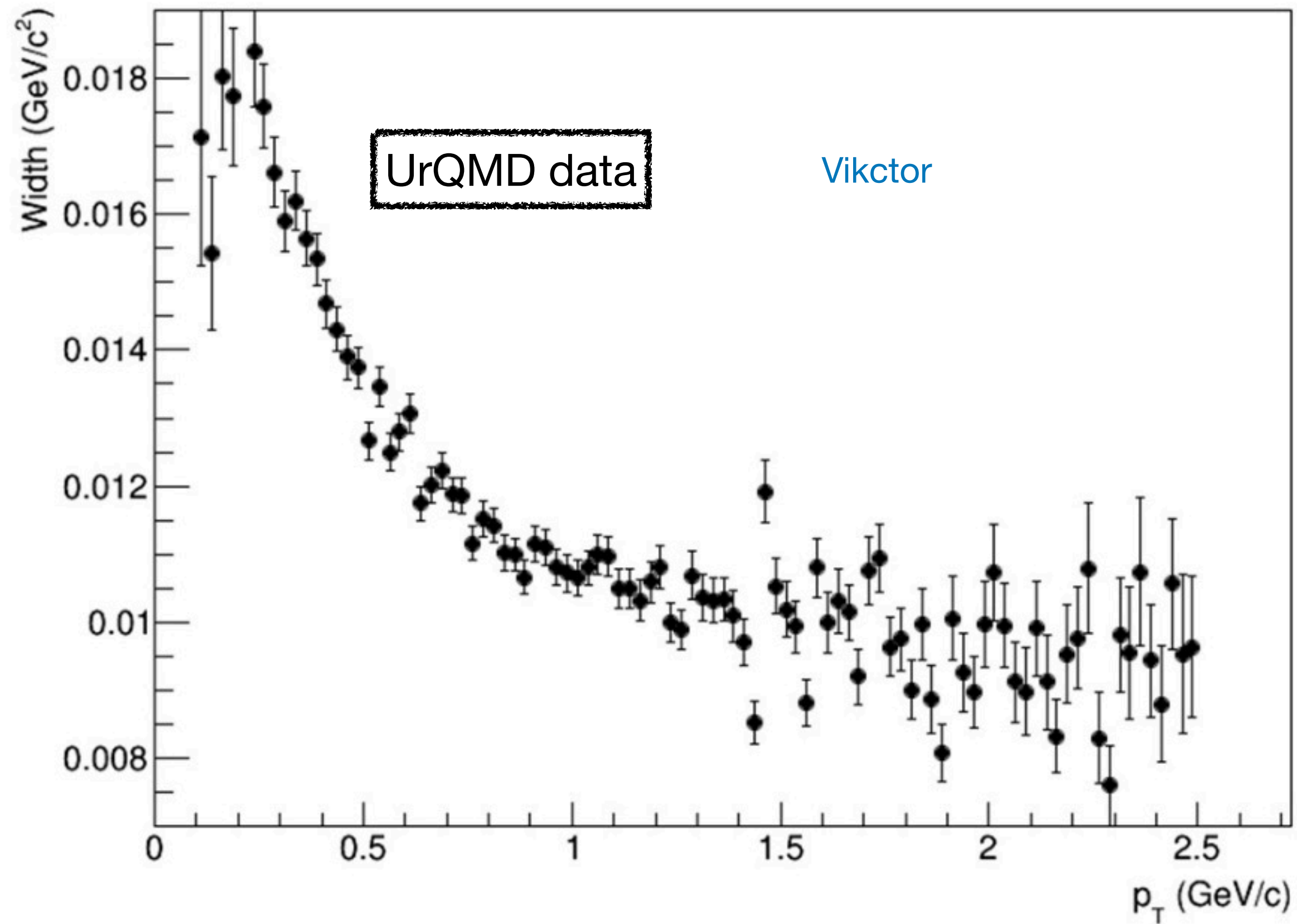
## With CPV and time cut

- (1) the mass becomes lower than the pdf mass
- (2) the mass width is smaller at low  $p_T$

# Comparison with Viktor's results (1)



# Comparison with Viktor's results (2)



smaller at lower  $p_T$  but larger at high  $p_T$

# Summary and outlook

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## Summary

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- (3) check photon flight time

### 2. Single $\pi^0$ simulation analysis

- (1) check merge performance of two photons from a  $\pi^0$
- (2) check the time of the two photons from a  $\pi^0$

### 3. $\pi^+$ , $\pi^-$ and $\pi^0$ simulation analysis

- (1) check the time of hadron cluster
- (2) extract the invariant mass, mass width distribution of  $\pi^0$

## Outlook

1. Simulation with only one photon to check the clustering, energy resolution

2. Analyse UrQMD simulation data for  $\pi^0$  production, and check efficiency, .....

3. Many topics our China-team can try

- (1) neutral meson production,  $\pi^0$ , eta etc.
- (2)  $\pi^0$  flow
- (3)  $\pi^0$ -hadron correlation
- (4) direct photon production and flow
- (5) di-electron production
- (6) .....