

# Inclusive $\eta/\omega$ reconstruction in $\pi^+\pi^-\pi^0$ decay channel using kinematic fitting

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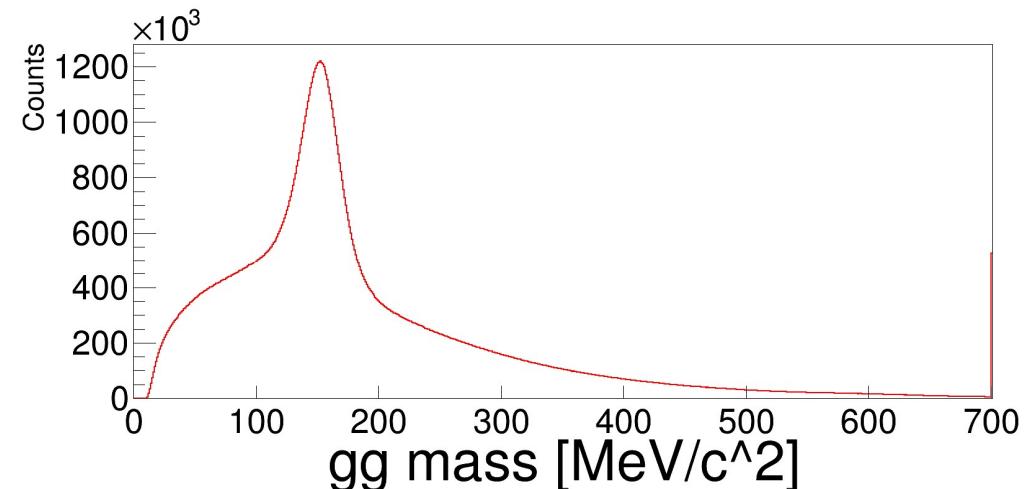
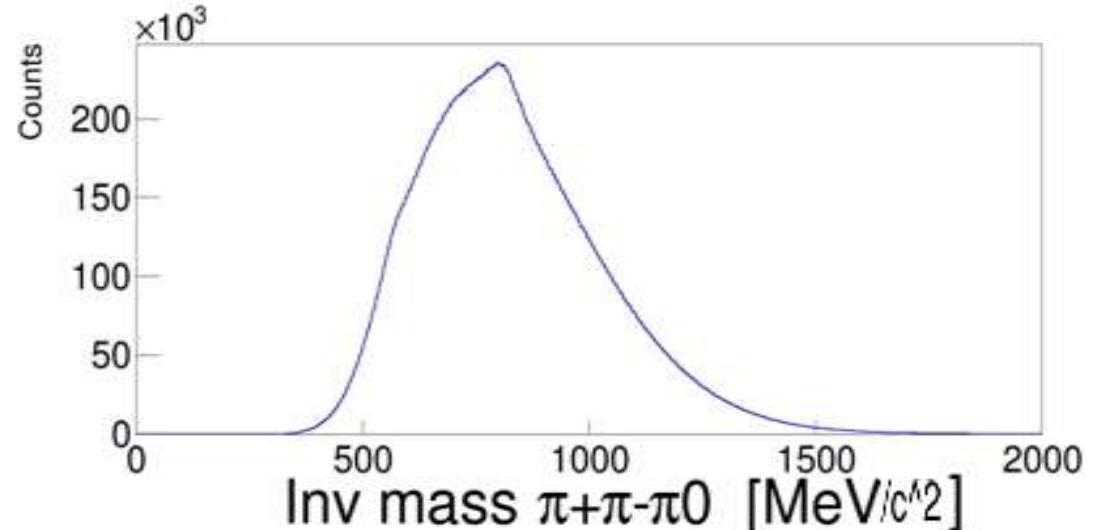
# Plan of presentation



- Motivation of kinematic refit in  $\pi^+\pi^-\pi^0$
- Results of  $\pi^0 \rightarrow \gamma\gamma$  kinematic refit with mass constraint
- $\eta/\omega$  mass distribution and it's improvement
- Amount of measured  $\eta/\omega$
- Outlook

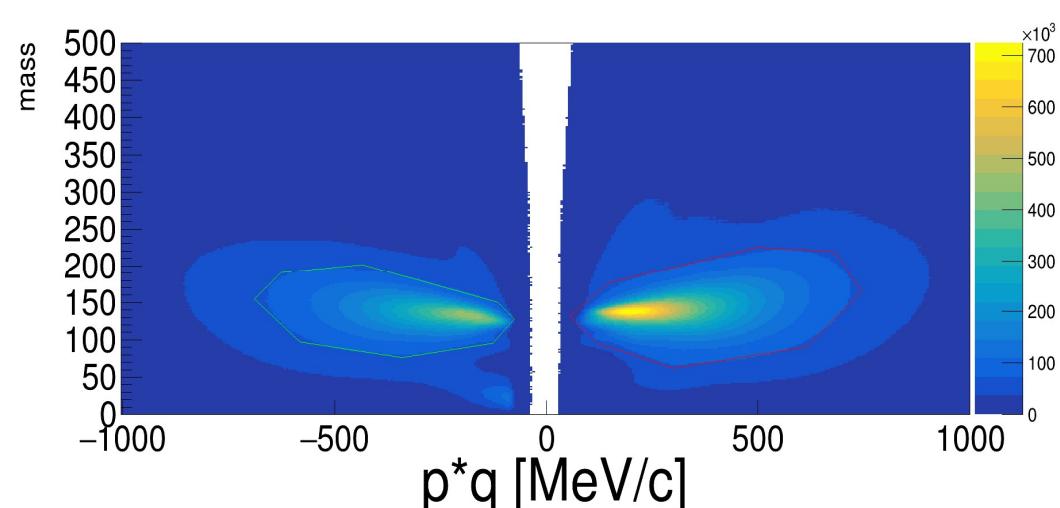
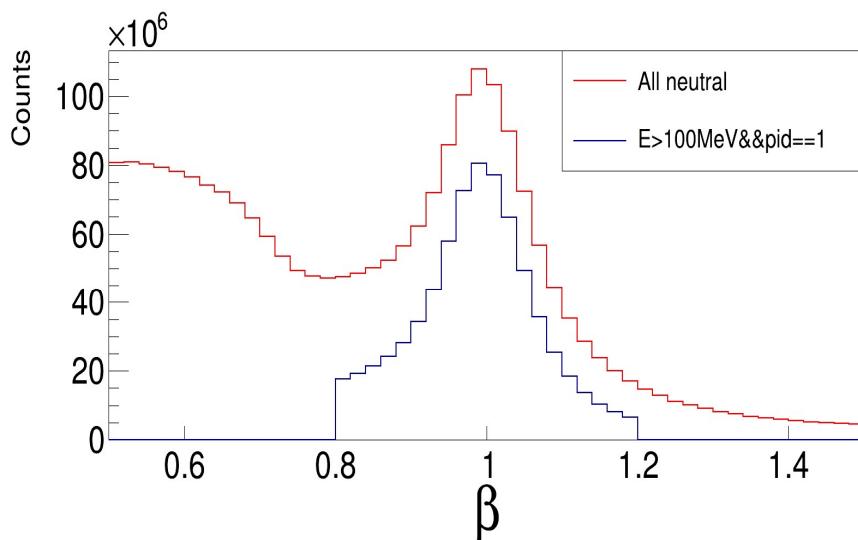
# Motivations

- Improvement of resolutions of channels with neutral mesons decays.
- Ex.  $\eta/\omega \rightarrow \pi^-\pi^+\pi^0 [\rightarrow \gamma\gamma]$   
 $\pi^0 \rightarrow \gamma\gamma$  improvement.
- Kinematic refit cuts out large amount of background.



# Event selection conditions

- Event selection:
  - At least 2 photons with  $E > 100$  MeV and  $0.8 < \beta < 1.2$
  - At least one  $\pi^+$  and at least one  $\pi^-$ . Chosen with graphical cuts on mass-charge\*momentum spectrum
- Simulations: official channel 921  $pp \rightarrow pp\eta (\rightarrow \pi^+\pi^-\pi^0)$  dst (Jochen) 100 000 000 events
- Data 19 days: 36-53 and 60



# Kinematic fit configuration

- Error estimation for photon reconstruction and parametrization :

-photon energy resolution:  $\frac{\sigma_E}{E} = \frac{5.8\%}{\sqrt{E[GeV]}}$  [A. Rost phd thesis]

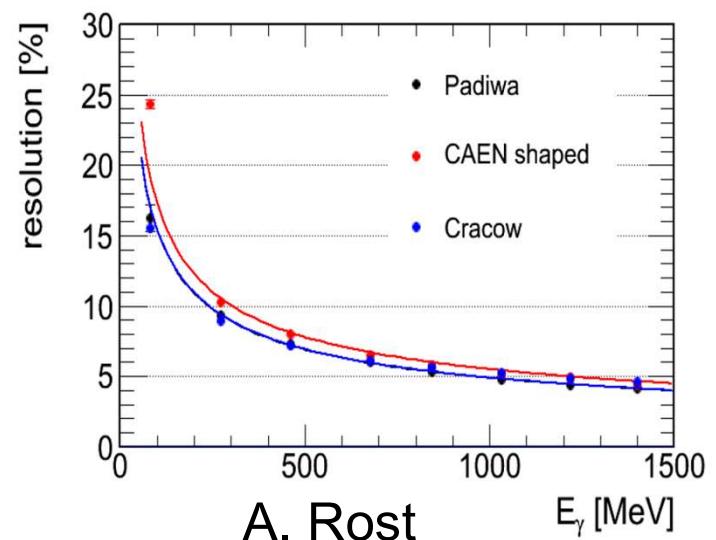
-photon  $\theta$  and  $\phi$  resolution:  $\sigma_\theta = \sigma_\phi = 2.5^\circ$  [EMC geometry]

-vertex constraint (R,Z) not used

- $\gamma\gamma \rightarrow \pi^0$  refit using  $\pi^0$  mass constraint:

-Convergence: max 10 iterations  $\Delta\chi^2 < 1$

-Probability cut  $P > 0.25$



# Results-Simulations-QA plots

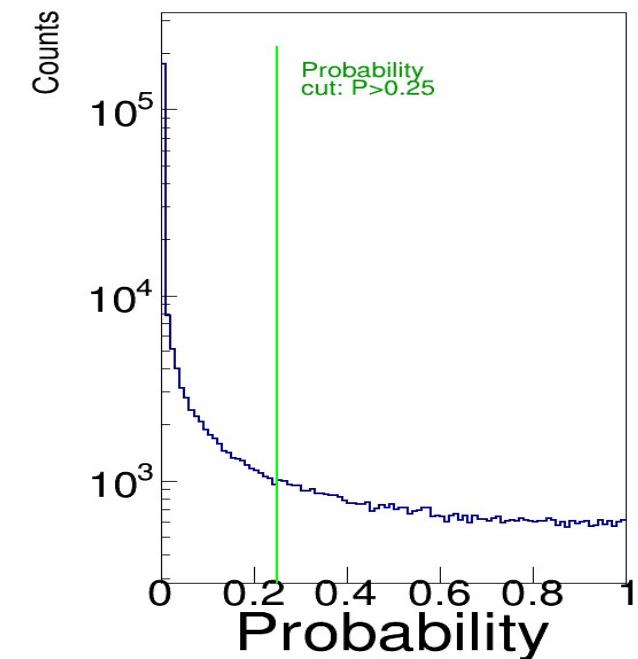
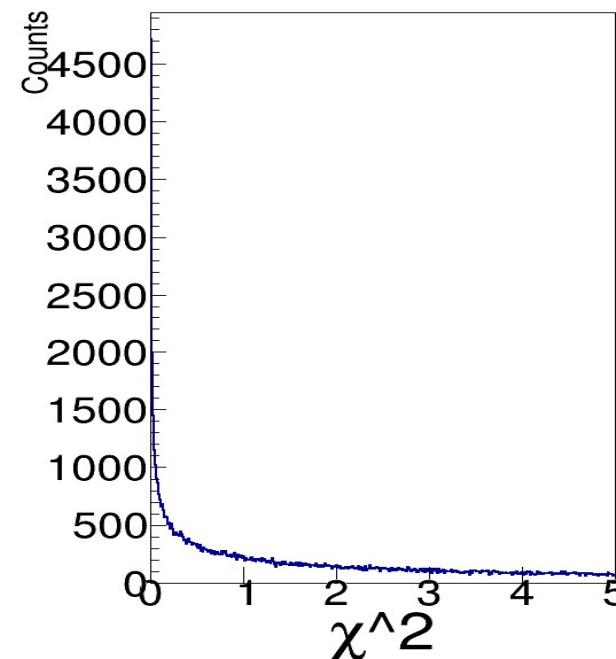
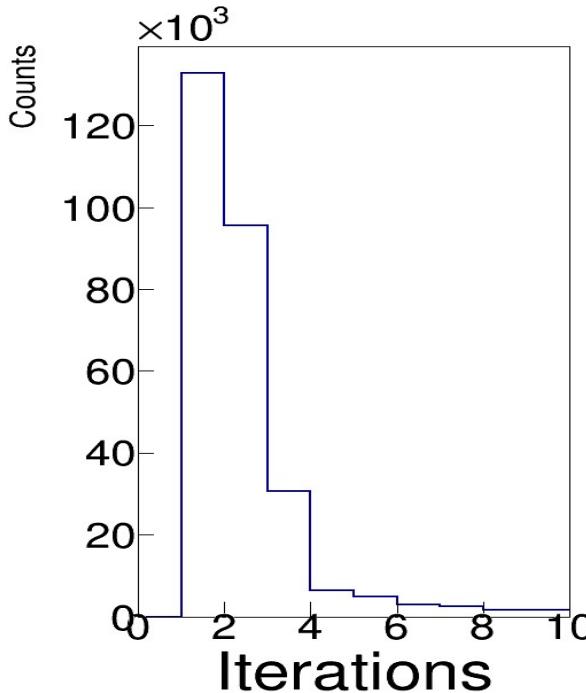
- $\pi^0$  procedure efficiency after cut on probability

$$\epsilon_{\pi_0} = \text{Acc.} * \text{rec. eff.} = \frac{\text{true } \pi_0 \text{ events returned}}{\text{Total events}} = \frac{149202}{100000000} \approx 1.5\%$$

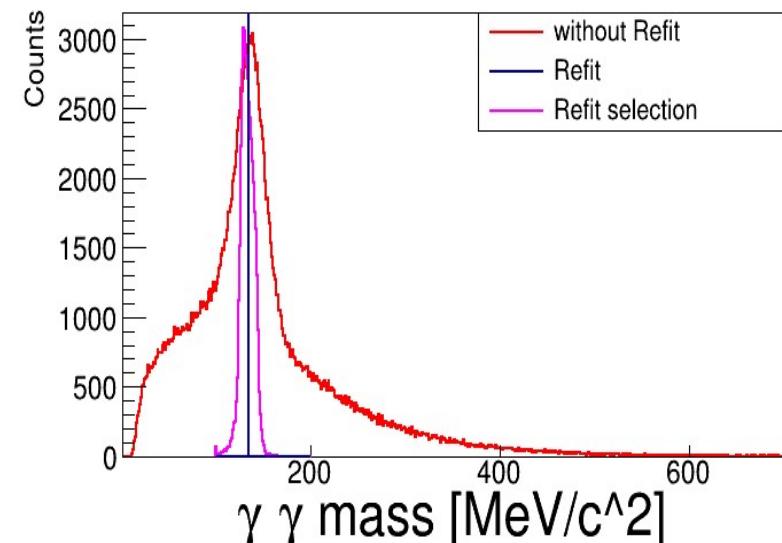
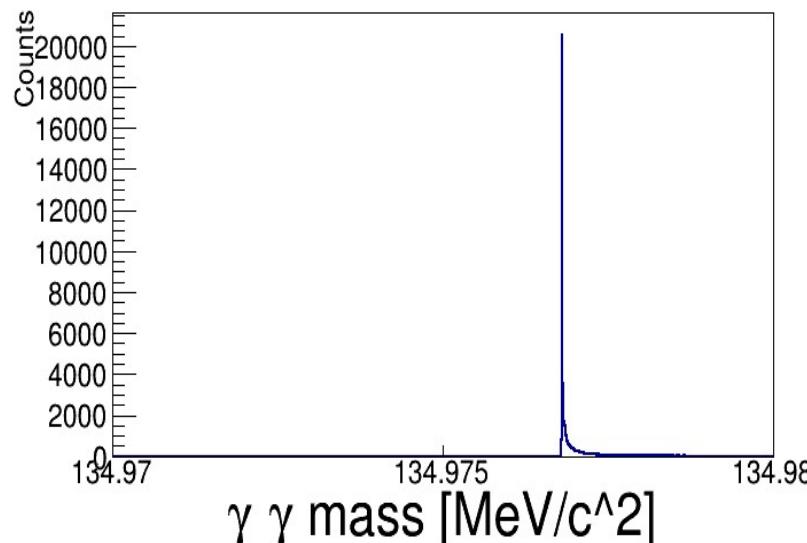
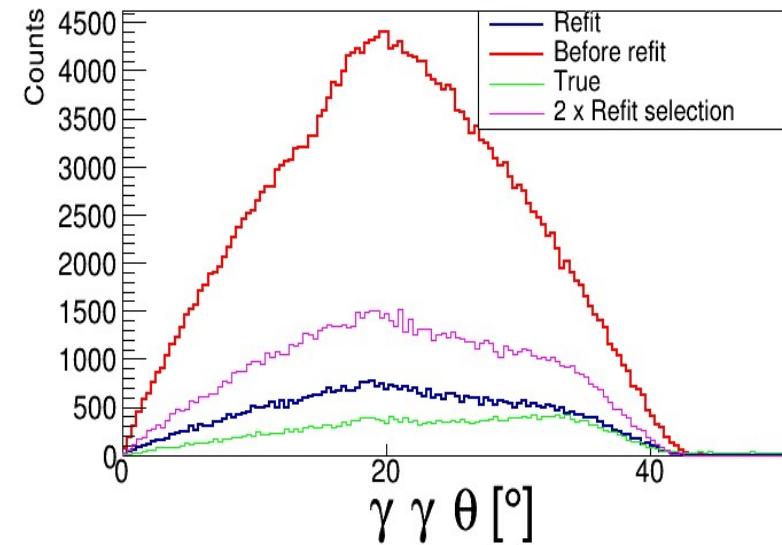
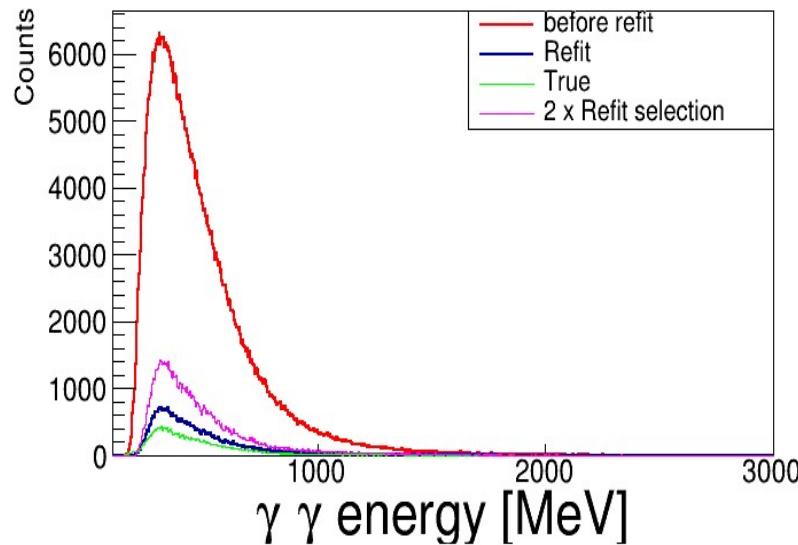
- $\eta$  procedure efficiency:

$$\epsilon_{\eta} = \text{Acc.} * \text{rec. eff.} = \frac{\text{true } \eta \text{ events returned}}{\text{Total events}} = \frac{25629}{10000000} \approx 0.026\%$$

$$\text{Refit efectivnes: } \epsilon_{refit} = \frac{\gamma\gamma \text{ refited}}{\text{total } \gamma\gamma \text{ number}} = \frac{52057}{200998} \approx 26\%$$

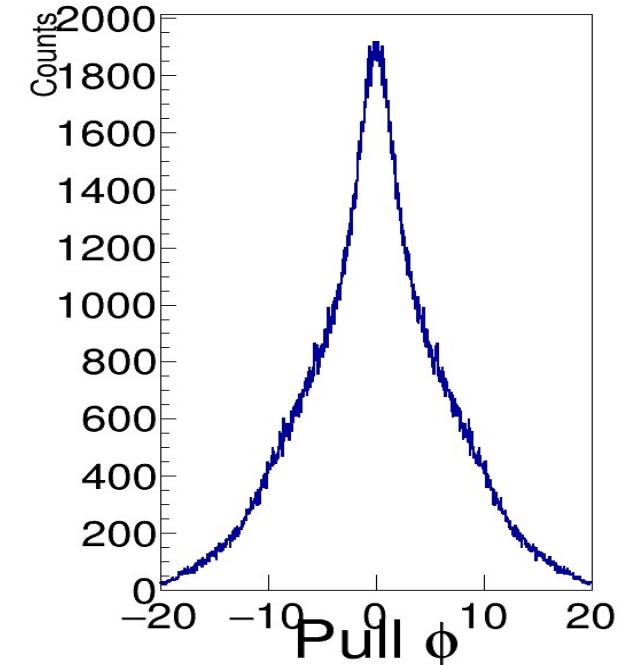
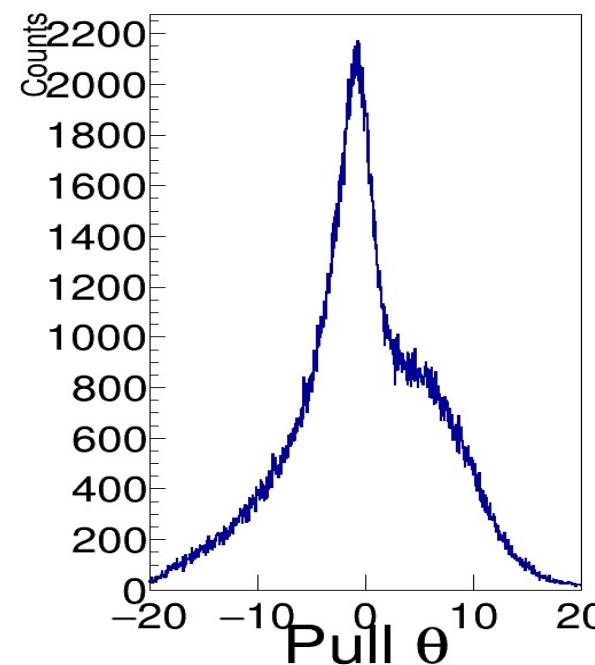
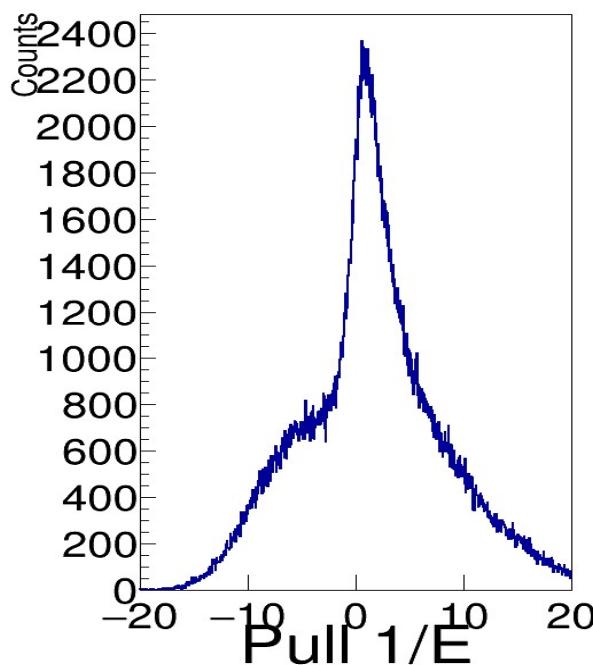


# $\pi^0 \rightarrow \gamma\gamma$ refit results-simulations



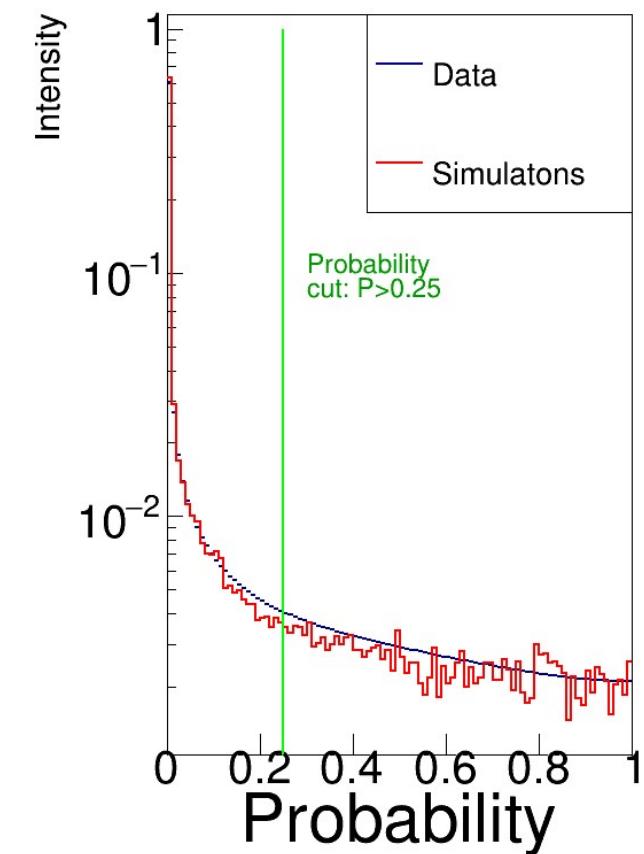
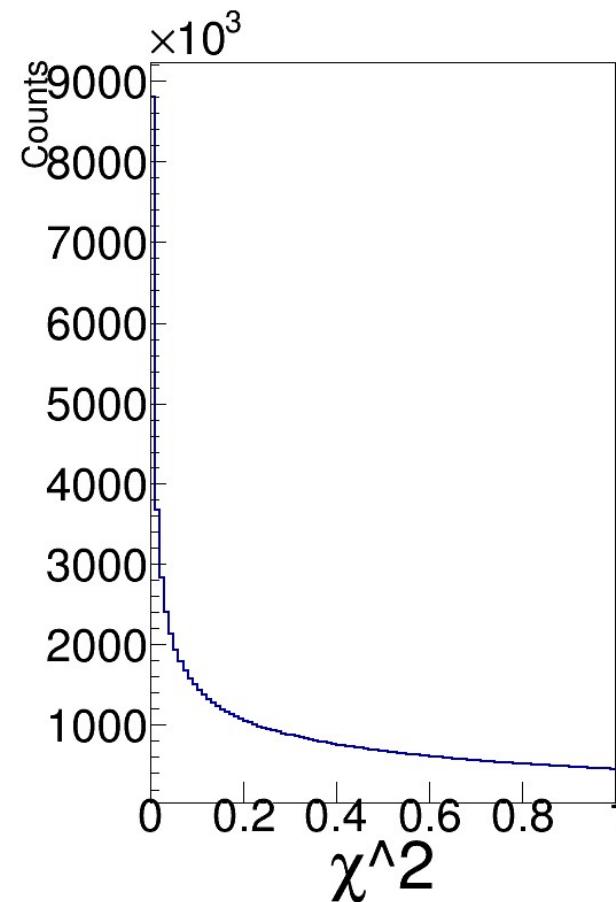
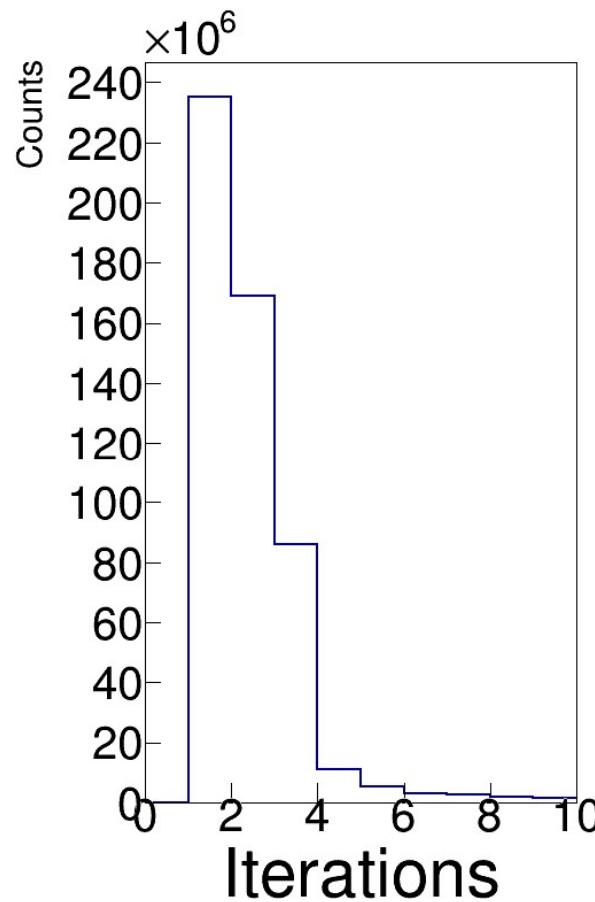
# Pulls-Simulations

$$\bullet \text{ Pull} = \frac{y_{fit} - y_{con}}{\sqrt{\sigma_{con}^2 - \sigma_{fit}^2}}$$



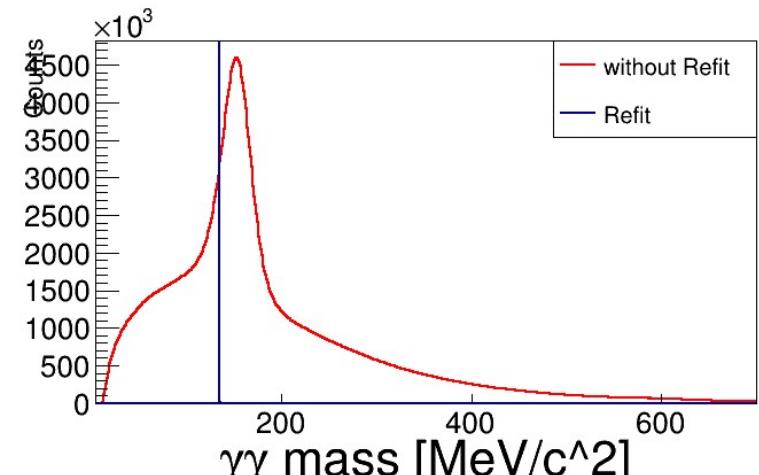
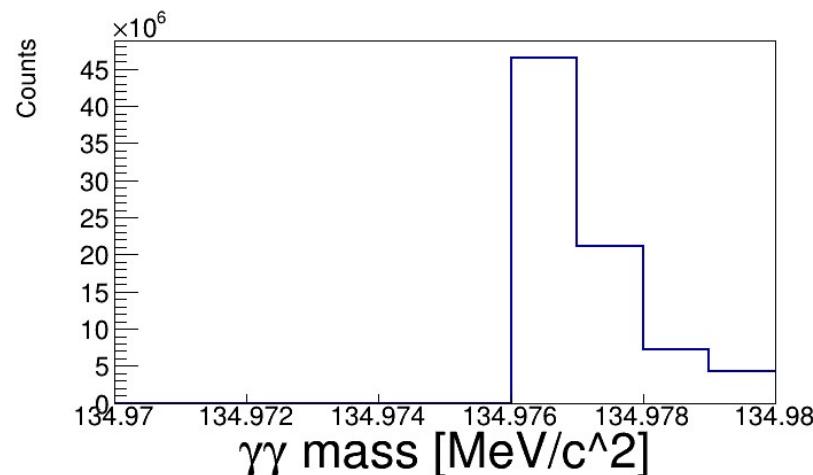
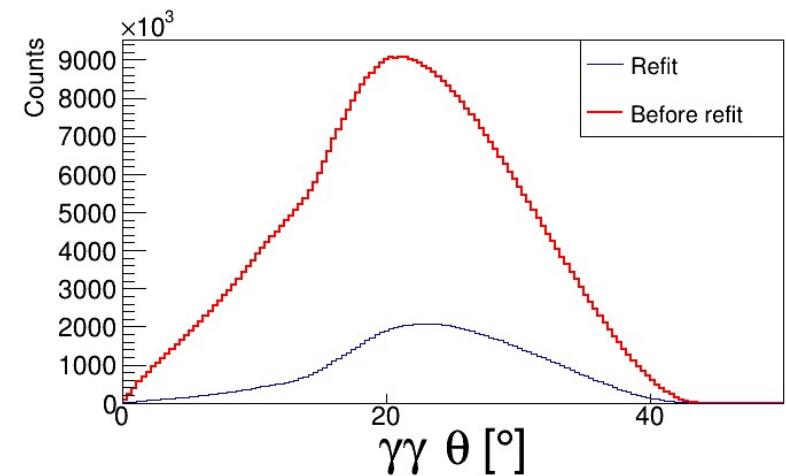
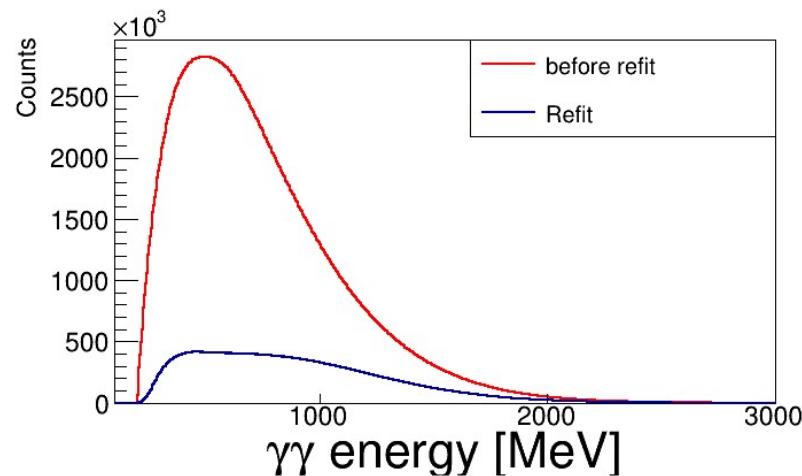
- Visible background tails are cut off by probability conditions.

# Results-data



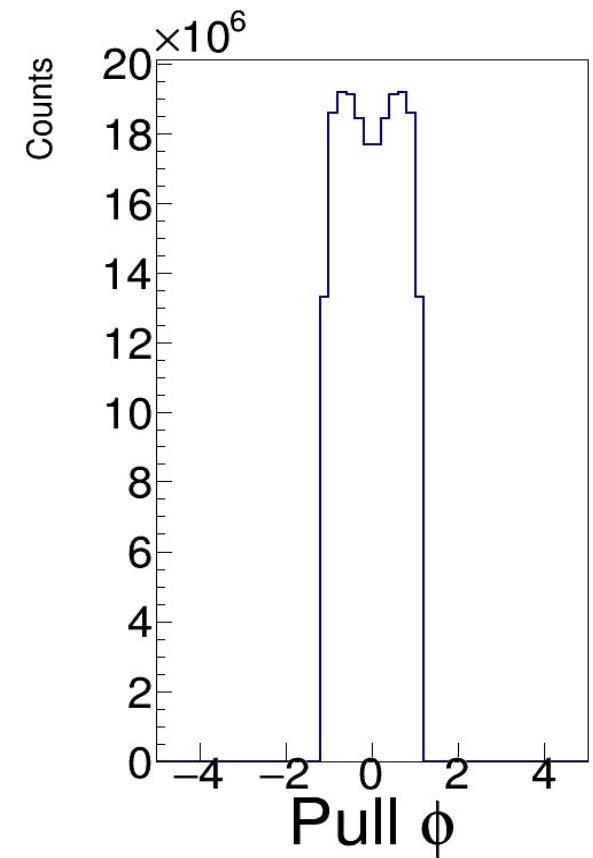
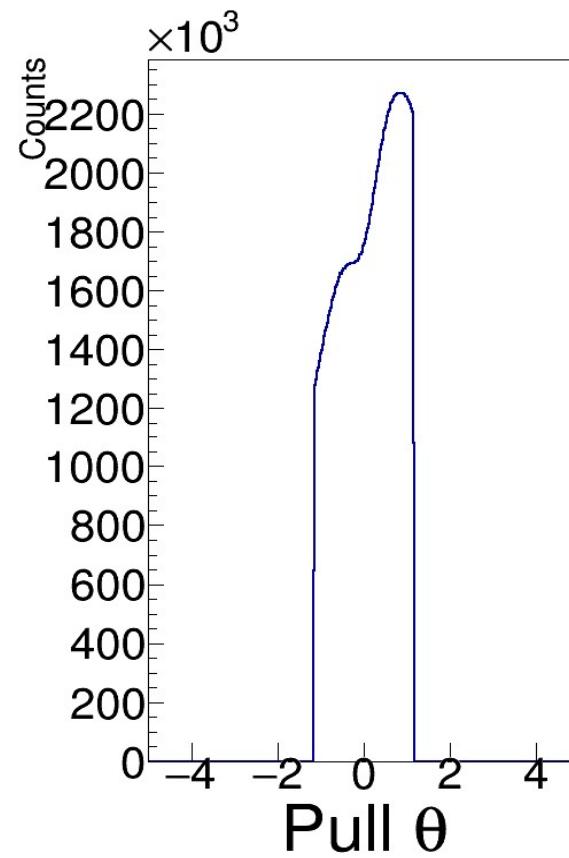
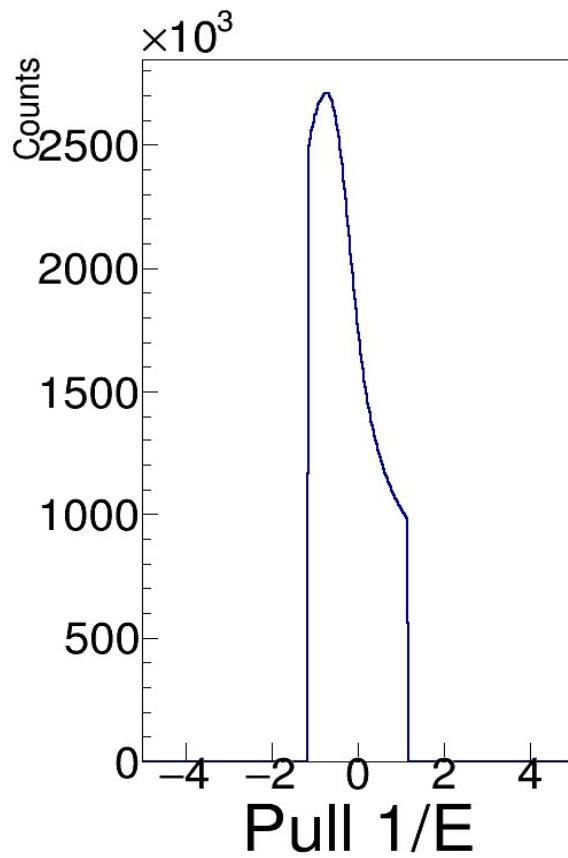
- Simulations agrees with the data

# $\pi^0 \rightarrow \gamma\gamma$ refit results-data



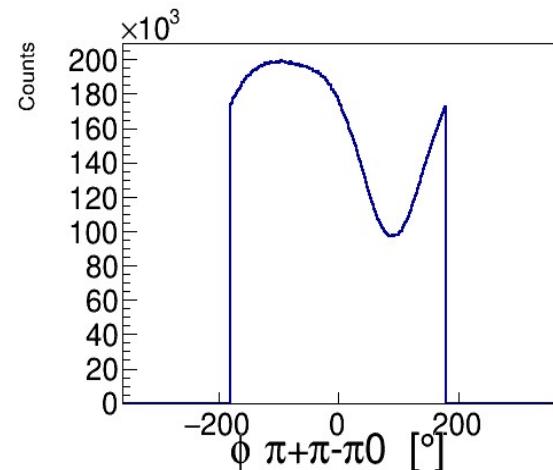
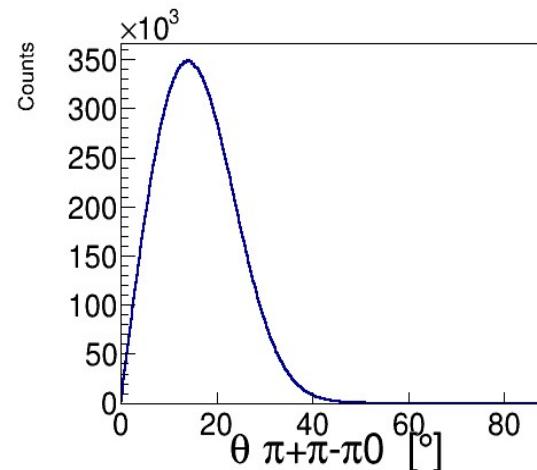
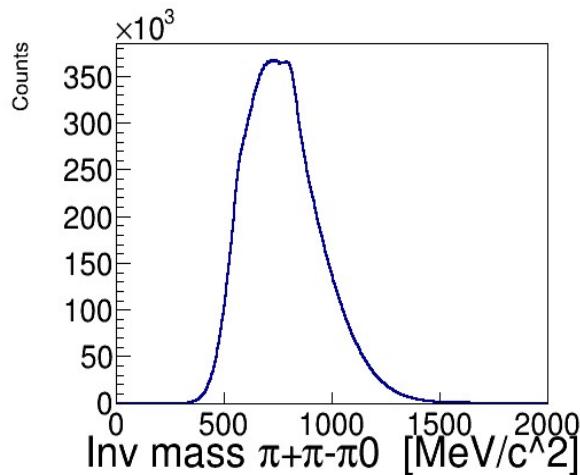
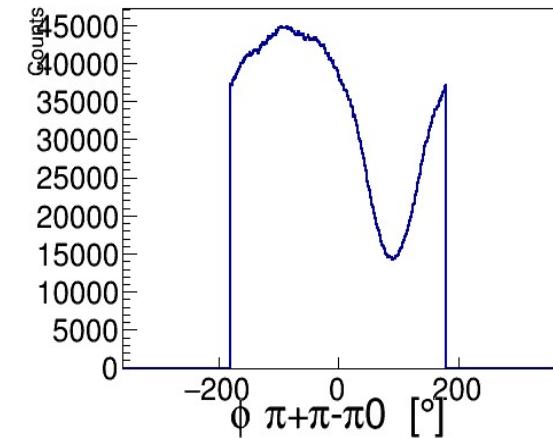
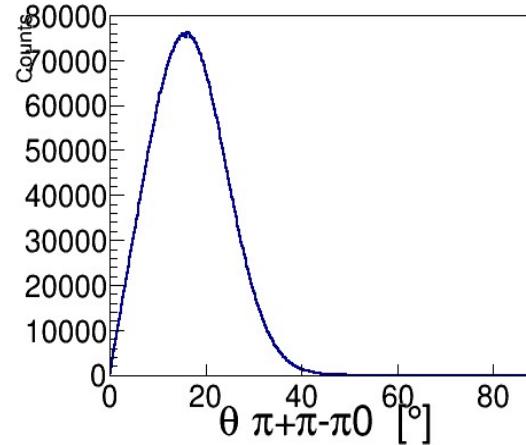
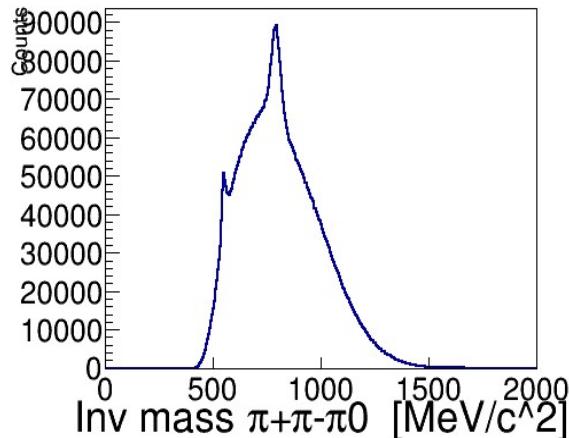
- The  $\pi^0$  mass peak shift will be fixed by the new ECAL calibration (GEN3). This shift influences pull distributions and decreases efficiency of the refit procedure.

# Pull distributions-data



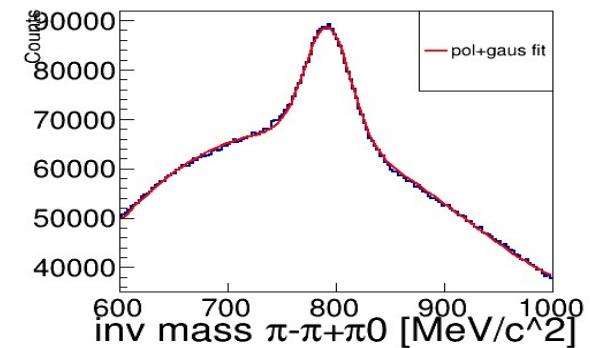
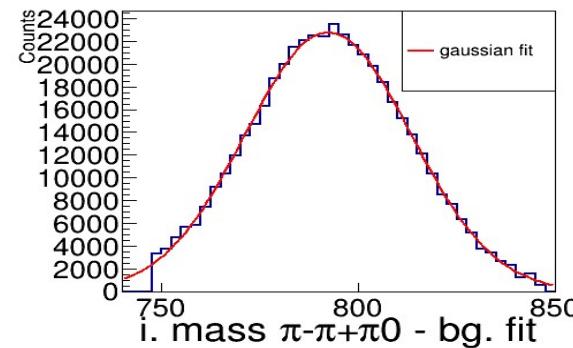
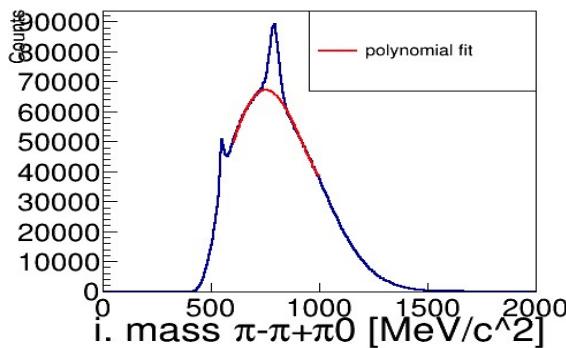
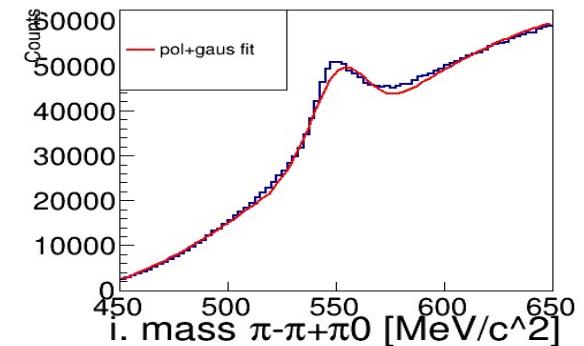
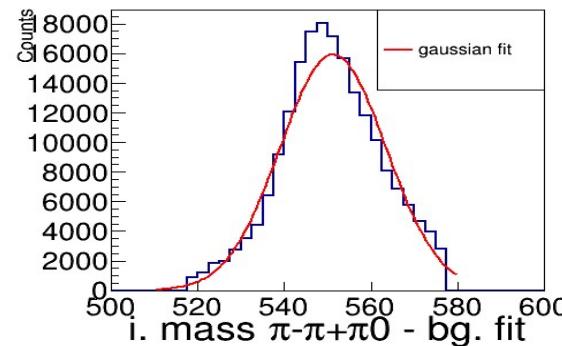
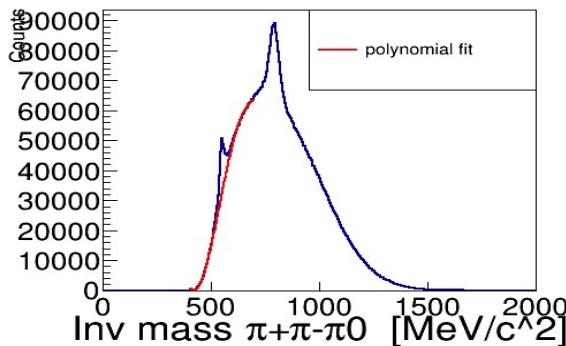
- Pull distribution deformation is caused by not correct ECAL energy calibration.
- Sharp edges of distributions are caused by probability cut.

# $\pi^+ \pi^- \pi^0$ with $\pi^0 \rightarrow \gamma\gamma$ refit



- $\pi^0 \rightarrow \gamma\gamma$  refit greatly makes  $\eta$  and  $\omega$  peaks visible!

# $\eta$ and $\omega$ peak positions and widths



- $\mu_\eta = 550.81(41) \frac{\text{MeV}}{c^2}, \sigma_\eta = 11.81(39) \frac{\text{MeV}}{c^2}$       PDG:  $\mu_\eta = 547.862(17) \frac{\text{MeV}}{c^2}$   
 $\mu_\omega = 792.260(34) \frac{\text{MeV}}{c^2}, \sigma_\omega = 21.075(28) \frac{\text{MeV}}{c^2}$       PDG:  $\mu_\omega = 782.65(12) \frac{\text{MeV}}{c^2}$

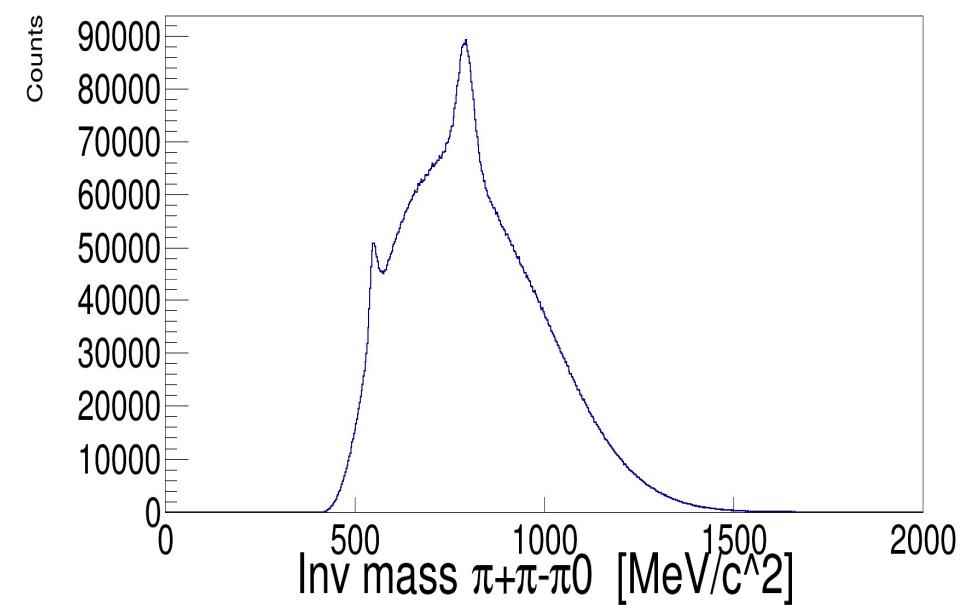
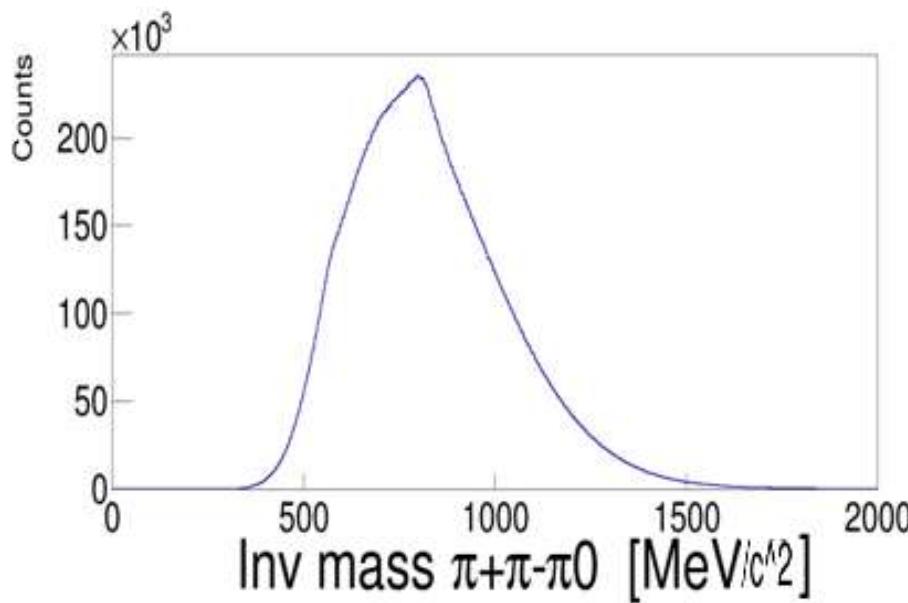
230 259  $\eta$  messons in peak, background 784 799. Signal to bg. ratio 0.29.

536 903  $\omega$  in peak, background 2 594 890. Signal to bg. ratio 0.19.

Results: inconsistency with PDG needs further investigation.

# Summary

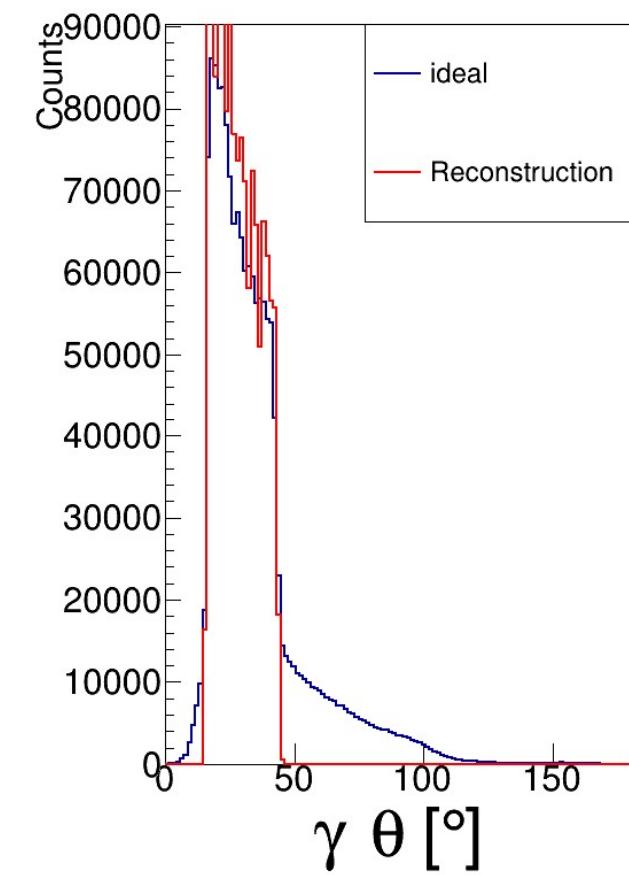
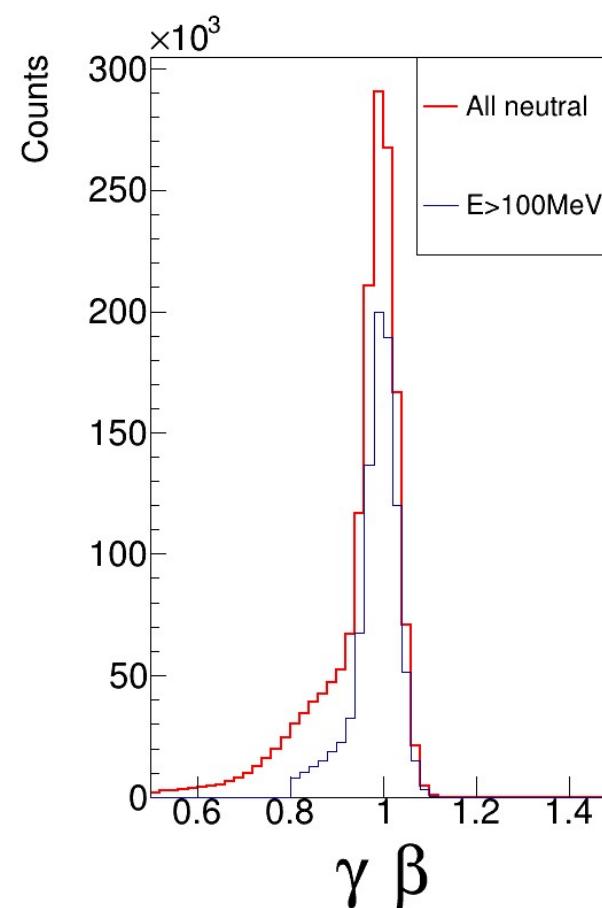
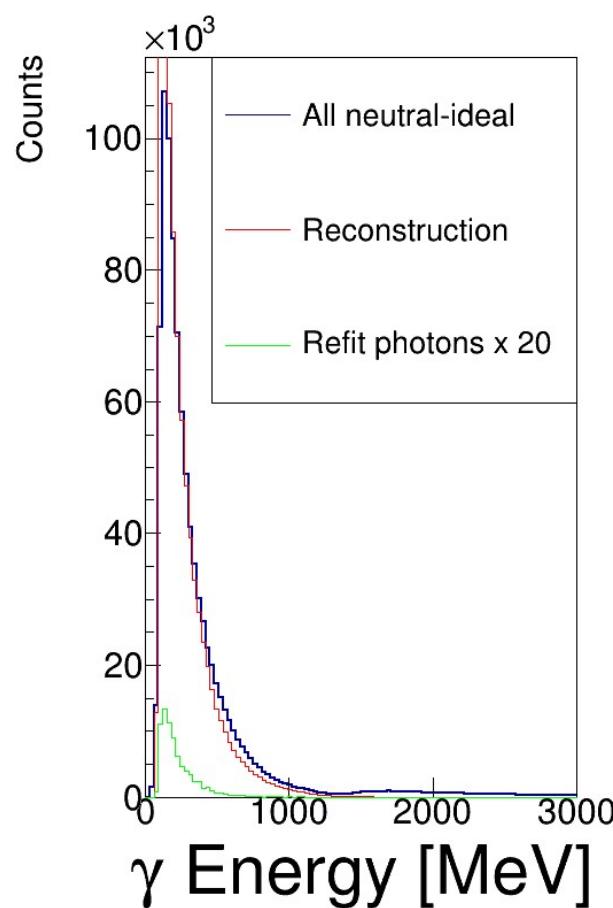
- Estimation of total reconstruction efficiency (including refit) =  $\frac{25\,629}{100\,000\,000} \approx 0.026\%$  and 0.1 % without refit.
- Kinematic refit of  $\pi_0 \rightarrow \gamma\gamma$  greatly increases signal to background ratio of  $\eta$  and  $\omega$ .



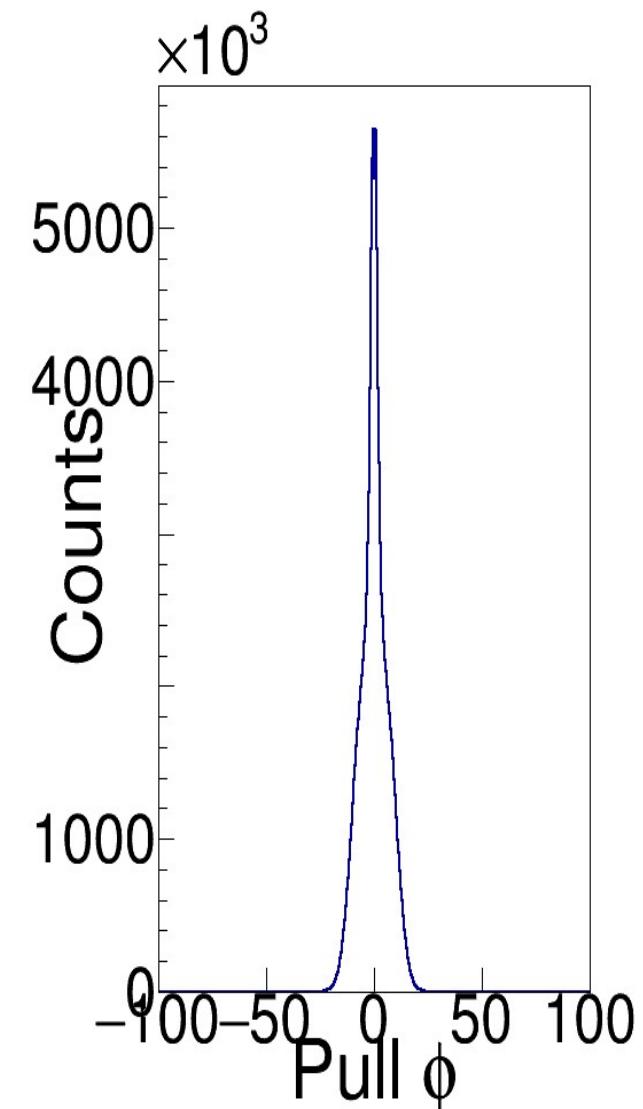
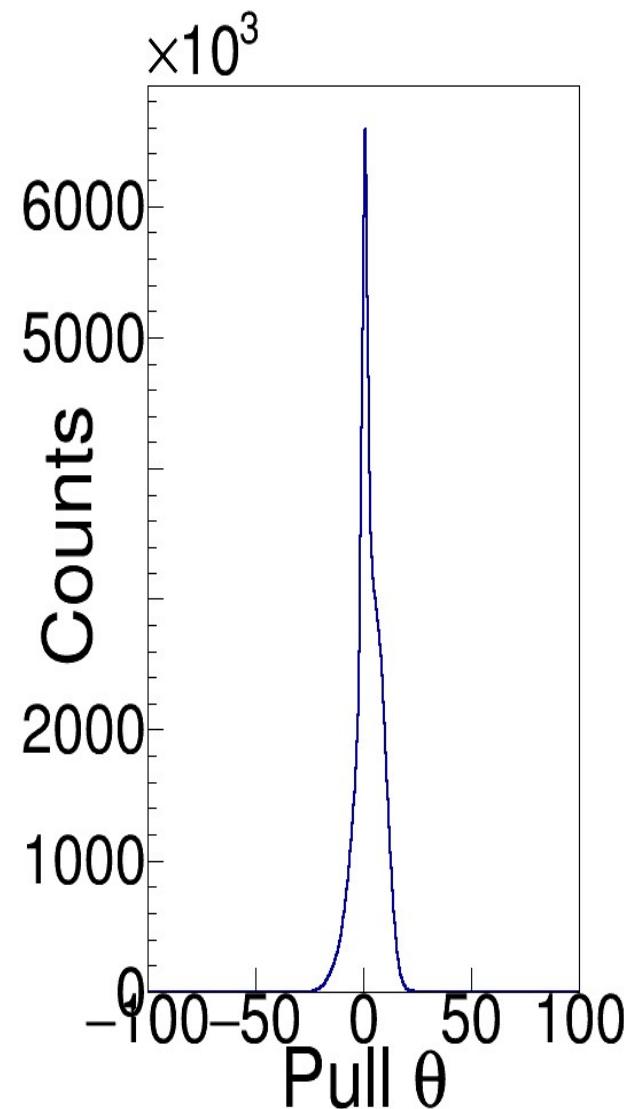
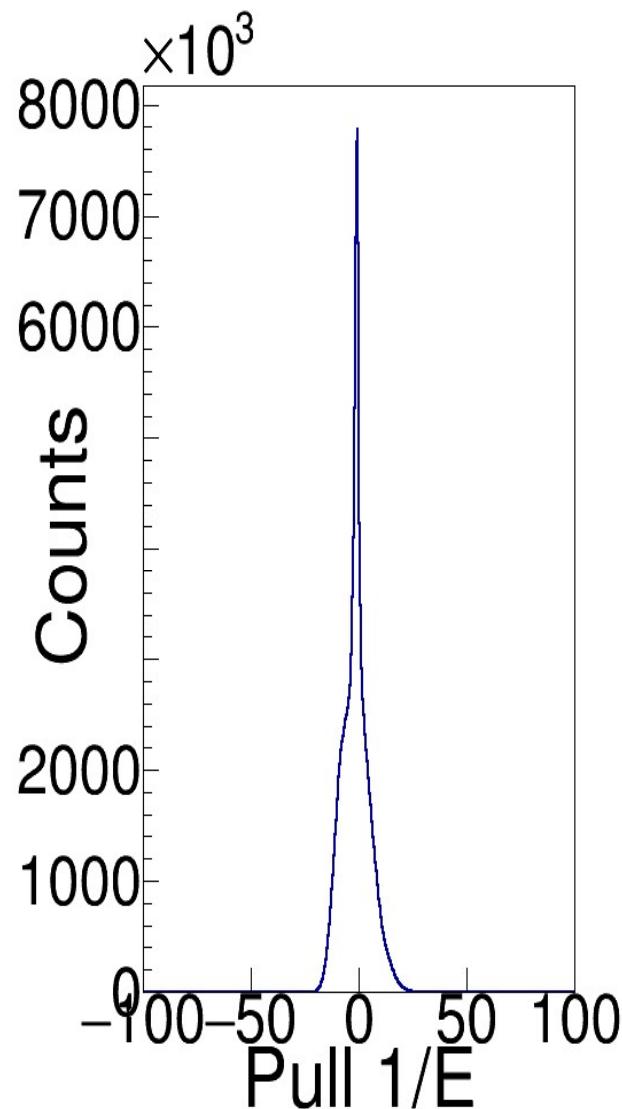
- Data analysis with gen3 ECAL calibration.
- Subtraction of combinatorial background (event mixing) in  $\eta$  and  $\omega$  mass distributions.
- Kinematic refit for  $\eta \rightarrow \gamma\gamma$  channel.
- Reconstruction of  $\eta' \rightarrow \eta \pi^+ \pi^-$  channel using  $\eta \rightarrow \pi^+ \pi^- \pi^0$  or  $\eta \rightarrow \gamma\gamma$ .
- Extraction of inclusive production cross sections for  $\eta$ ,  $\omega$  and  $\eta'$ .

# Back up

# Simulation- $\gamma$ distributions



# Data- pulls no prob cut



- Total  $\eta$  events 10 000 000
- Only 544637 events where all  $\eta$  daughters have been detected in HADES
- 134925 events with true  $\eta$  daughters after pion and photon cuts (2414666 true+background)
- 25614 events with  $\eta$  after refit (31338 true+background)

# $\eta'$ studies

