Study of photon detection efficiency

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Introduction (I)

π^0 decay angle

- The angle between the photon and π^0 in laboratory Reference Frame: $\cos(\theta)=\frac{E_2-E_1}{|P_{\pi^0}|}$.

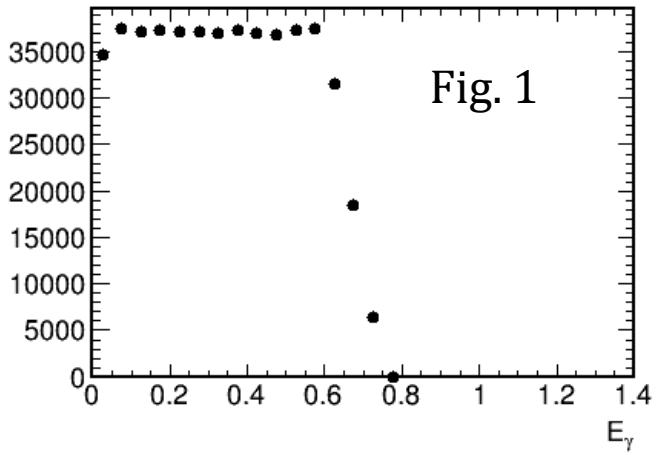
  the relationship between energy of photon E_{low} and $cos\theta$ was $E_{low} = \sqrt{P_{\pi^0}^2 + M_{\pi^0}^2} - P_{\pi^0}\cos(\theta)$

- the $cos\theta$ distribution is uniform if the photon efficiency with different energy are all 100%.
  - according to the $cos\theta$ distribution, efficiency with $cos\theta$ are gotten (Scale to max bin of $cos\theta$ distribution)
  - Efficiency with energy are gotten using the efficiency with $cos\theta$ and the relationship between $cos\theta$ and E_{low}

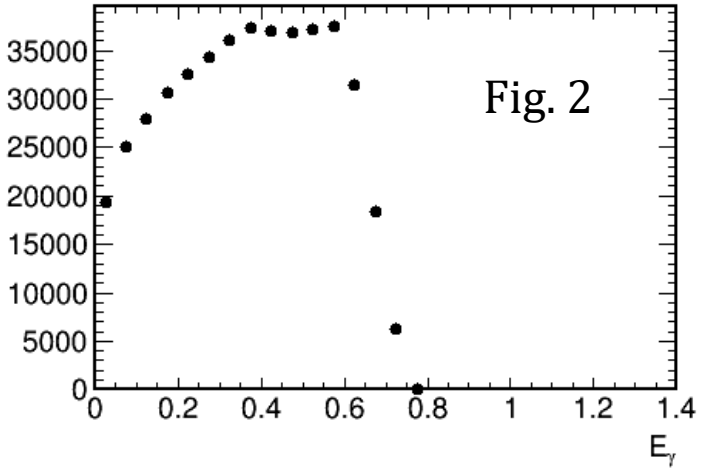
- The difference of efficiency between data and MC was considered as the systematic error.

Introduction (II): validation of this method

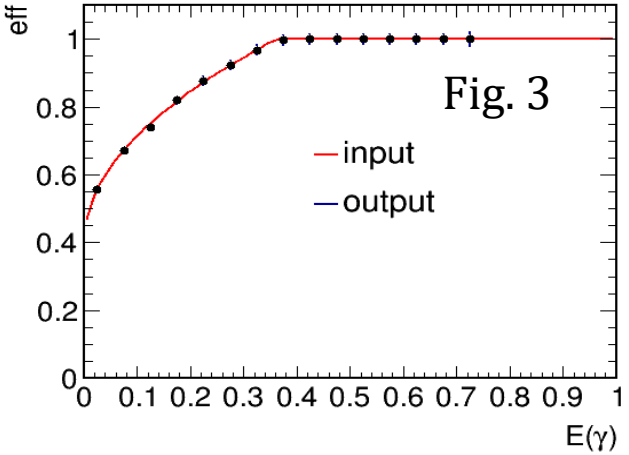
- Generate a π^0 MC sample that energy distribution was shown in Fig.1
- To sample the MC according to an efficiency function $F(E_\gamma)$ → "fake data".
- Using "π^0 decay angle" method to got the photon efficiency as output. The comparison of output and input was shown in Fig.3.



MC sample



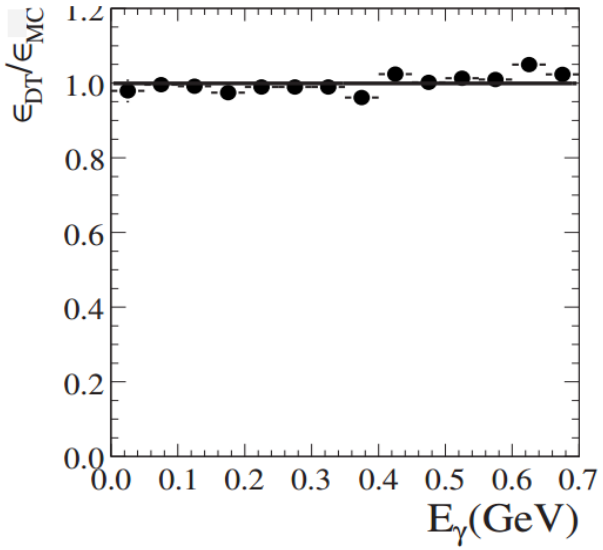
Fake data



$$F(E_\gamma) = \begin{cases} 0.4 + \sqrt{E_\gamma} & ; F(E_\gamma) < 1 \\ 1 & ; F(E_\gamma) \geq 1 \end{cases}$$

Introduction(III): BESIII' result

- BESIII study the photon efficiency using $J/\psi \to \pi^+\pi^-\pi^0$ by the same way
- The difference between data and MC is about 1%



Data set

We using the control sample of $\omega \to \pi^+\pi^-\pi^0$ to study photon efficiency

Path of Data: /cache/halld/RunPeriod-2017-01/analysis/ver08/tree_pi0pippim__B3_T4/merged/*
(run: 30274-31057, REST ver02)

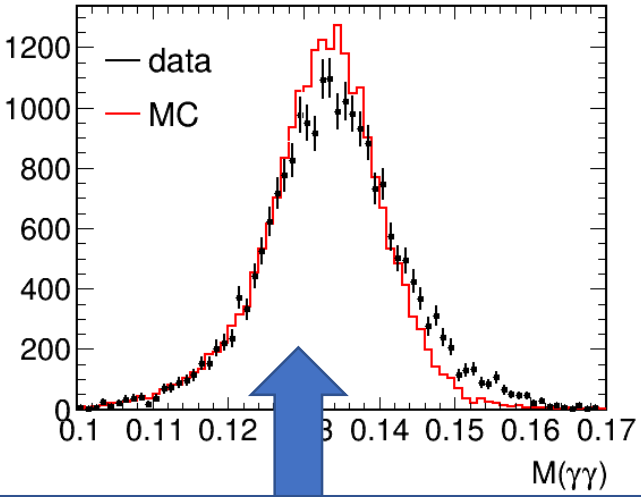
Path of MC: /w/halld-scifs17exp/sim/ver08/gen_omega_3pi/tree_pi0pippim/*
(run: 30496, 30981, 31054, 31023, 30966. REST_2017_01_ver02)

Data are analysis using DSelector with version 3.0
MC are analysis using DSelector with version 2.33

Event selection

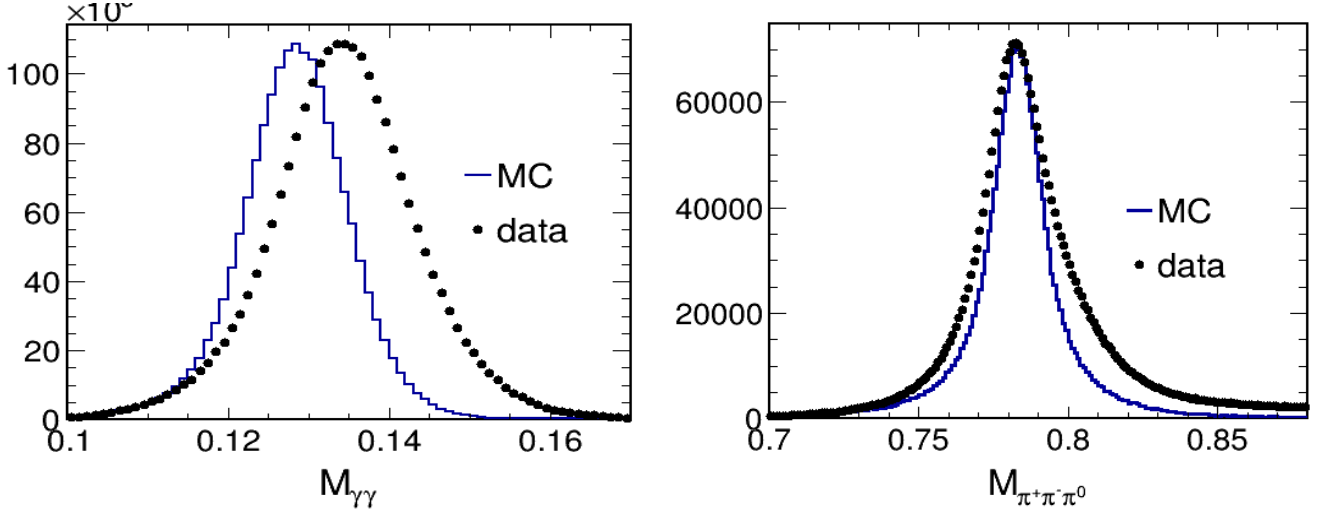
- Kinematic Fit Confidence Level: <0.01
- Missing mass squared: [-0.05, 0.05] GeV
- Measured Missing energy: [-1, 1] GeV
- Measured Missing p_t: < 0.25 GeV
- Photon Beam Energy : [8.4, 9.0] GeV
- π^0 mass : $0.12 < M_{\gamma\gamma} < 0.15$ GeV
- ω mass : $0.76 < M_{\pi^+\pi^-\pi^0} < 0.81$ GeV
- 50 <Vertex Z < 77] cm
- Vertex r < 1 cm

- another MC have no "shift left"



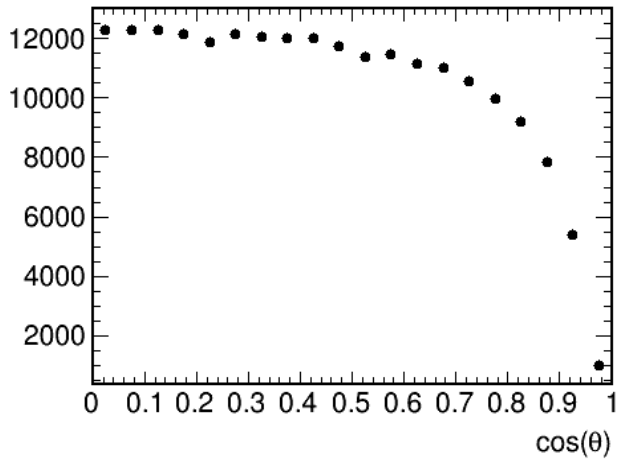
Path of this MC:
/cache/halld/RunPeriod-2017-01/sim/
REST_2017_01_ver02/recon/ver02/gen_omega_3pi/

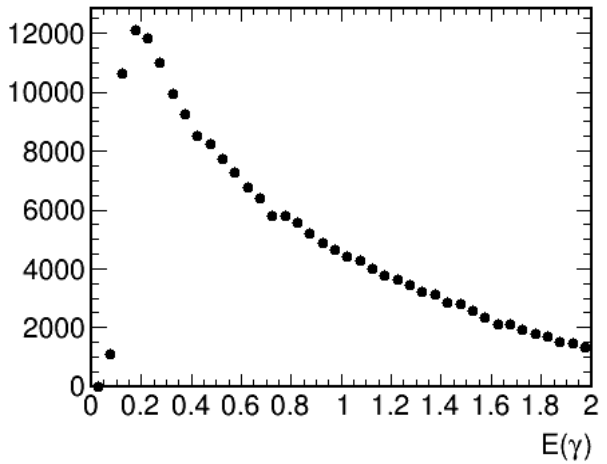
- the mass of π^0 of MC shift left

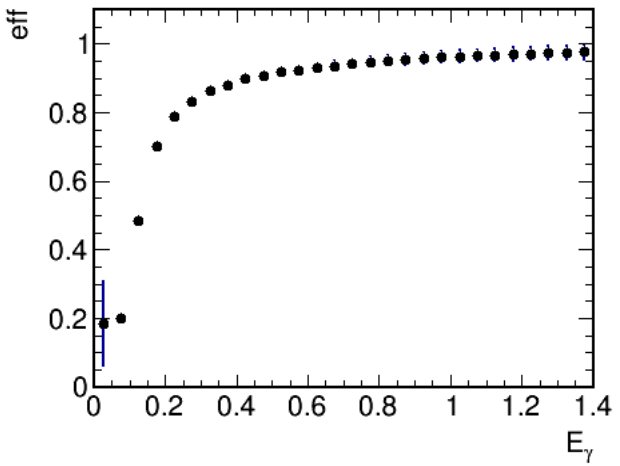


Distribution of $cos\theta$, energy and efficiency with energy

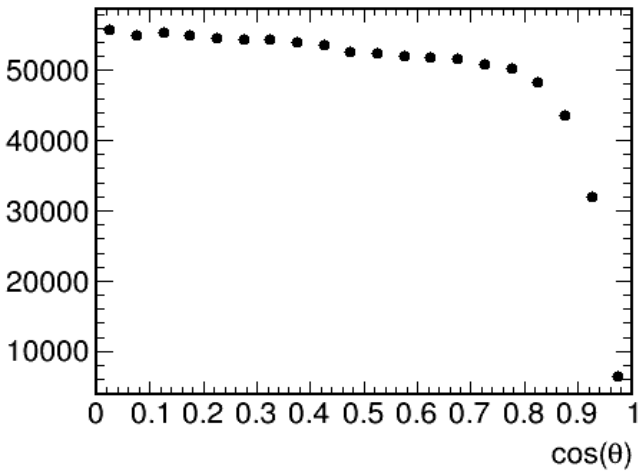
MC

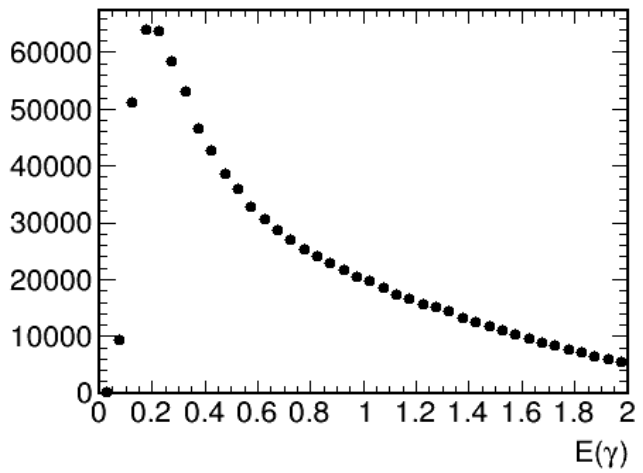


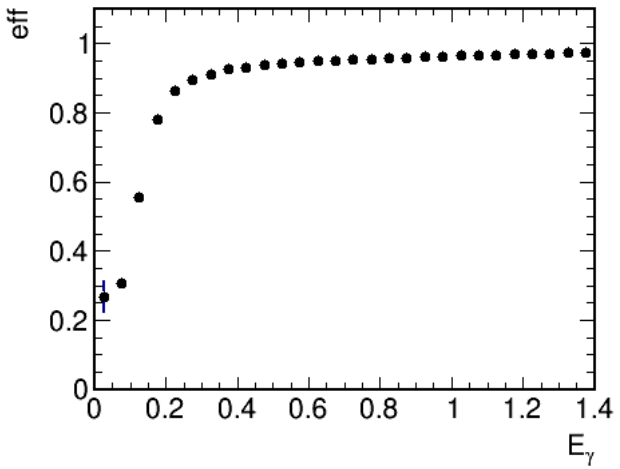




data



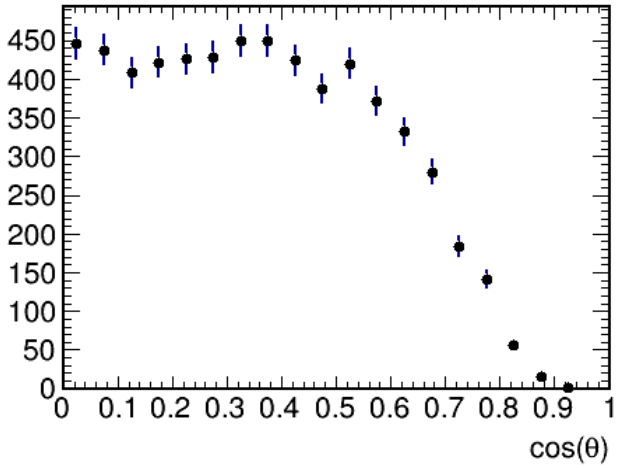


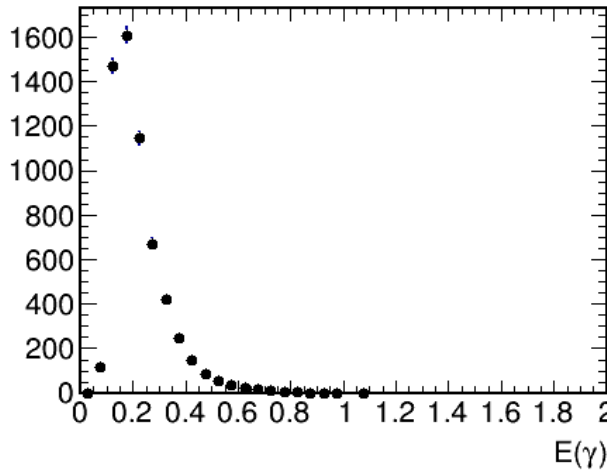


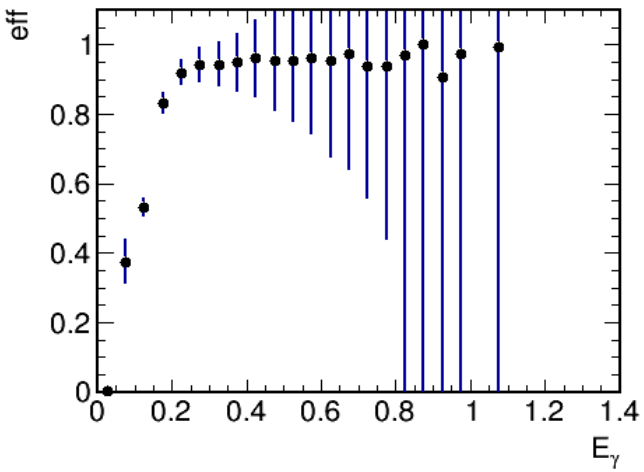
Distribution of $cos\theta$, energy and efficiency with energy

- Two photon are both in barrel

MC







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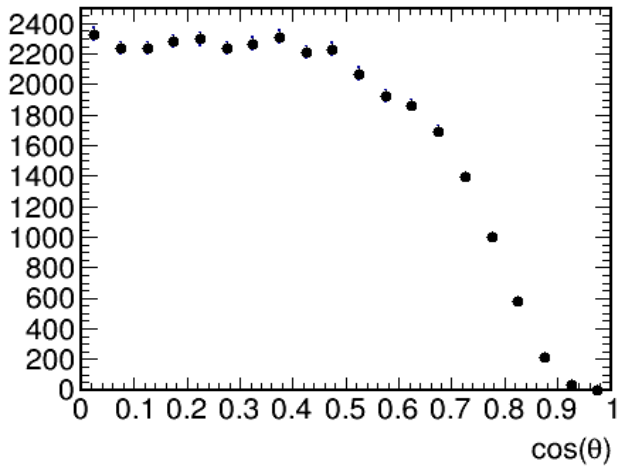
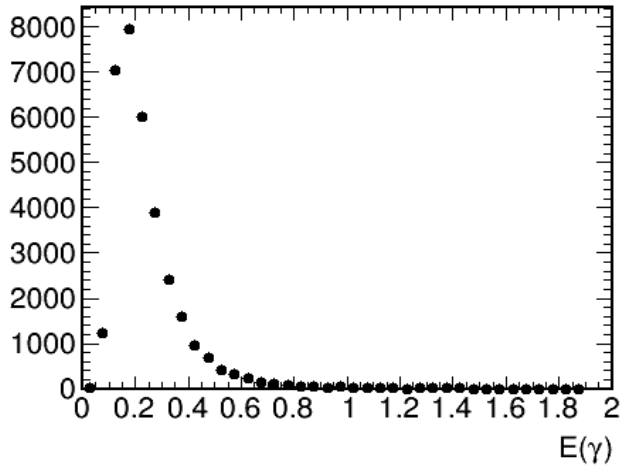
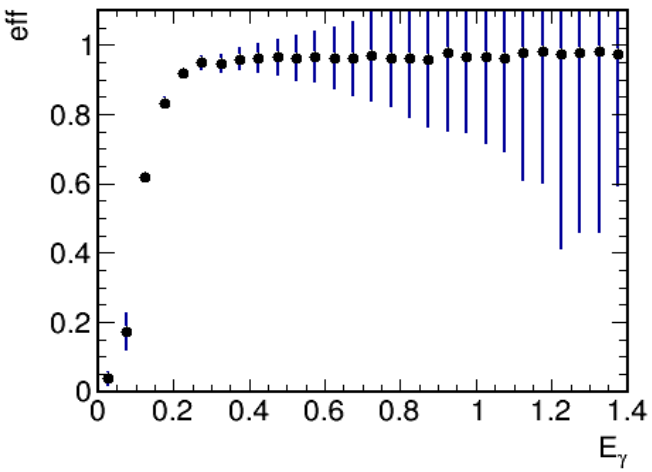


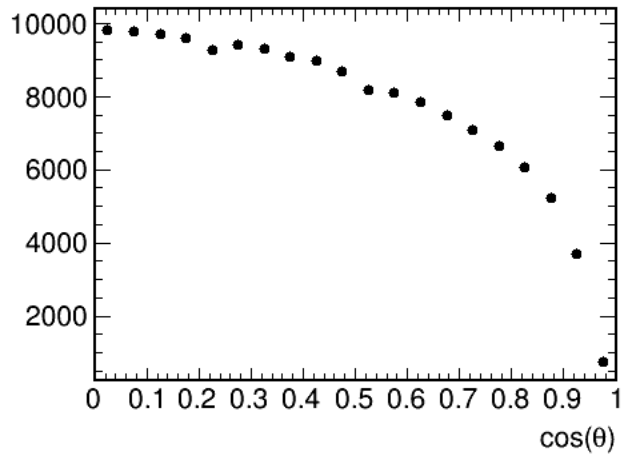


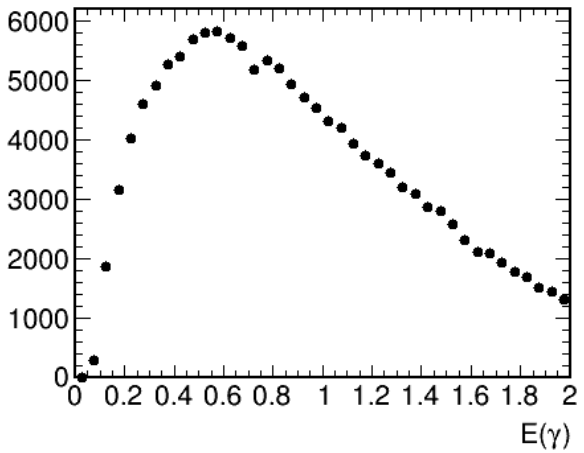


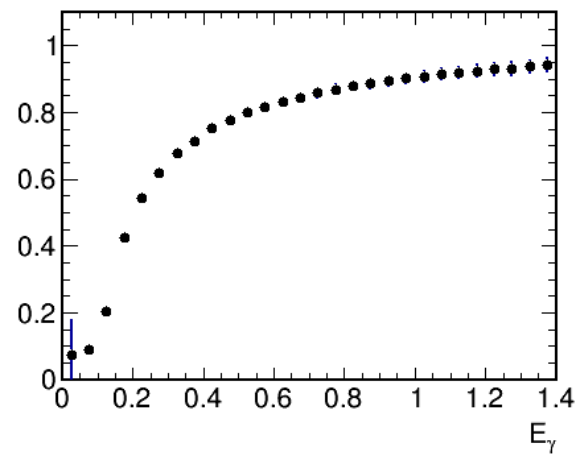
Distribution of $cos\theta$, energy and efficiency with energy

- Two photon are both in Forward

MC







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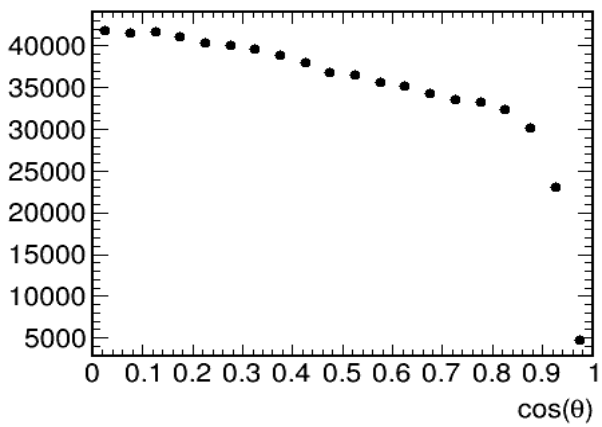
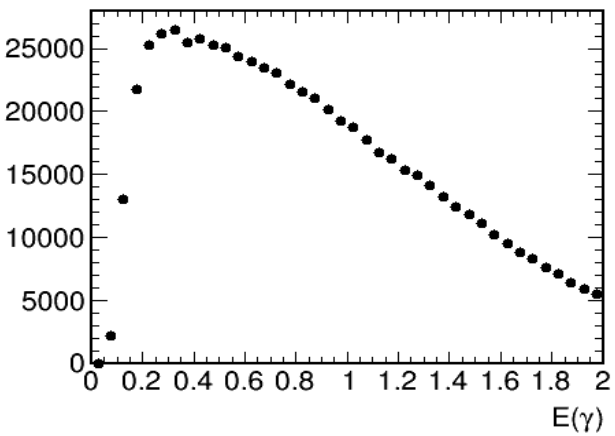
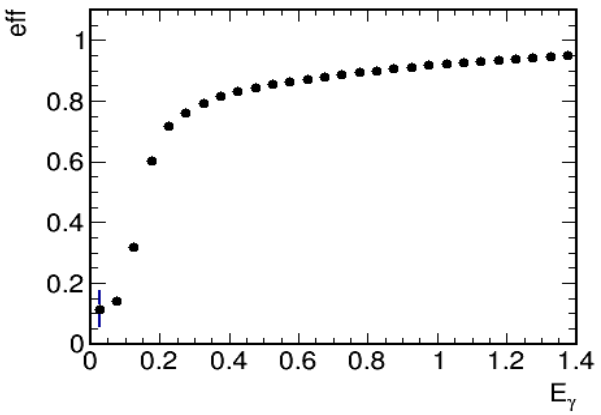


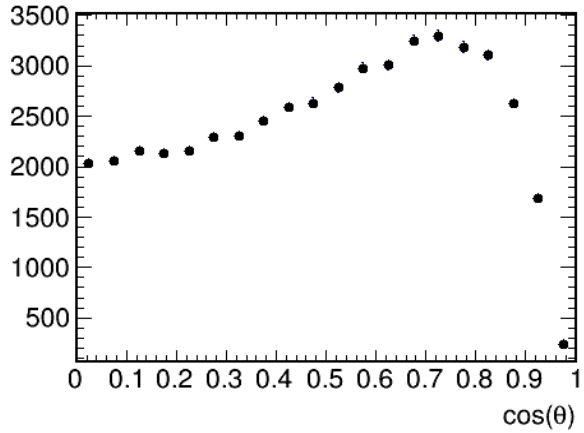


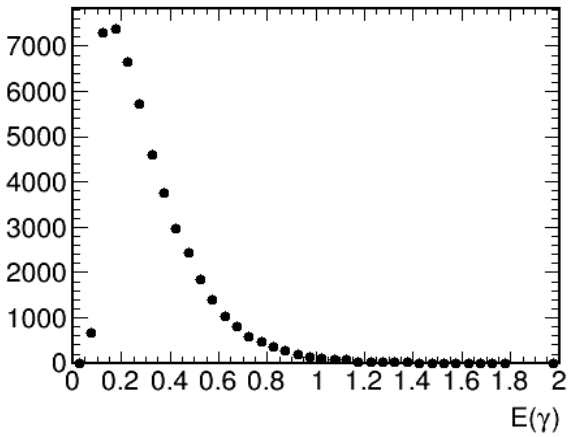


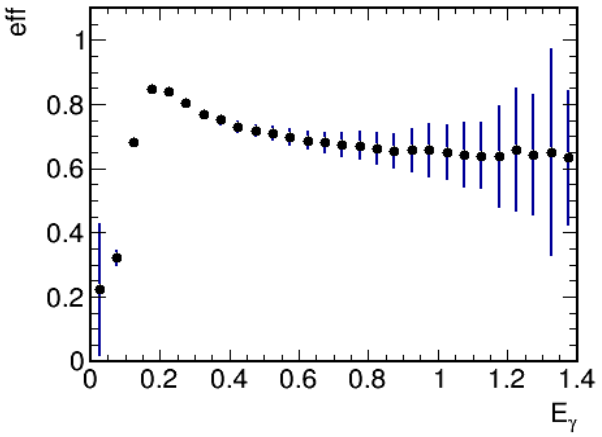
Distribution of $cos\theta$, energy and efficiency with energy

- One in barrel and another in Forward

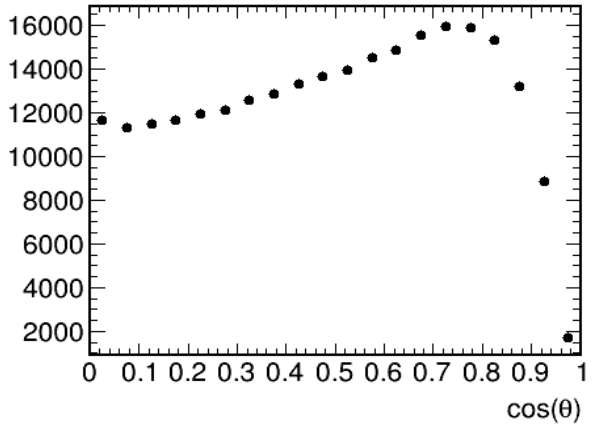
MC

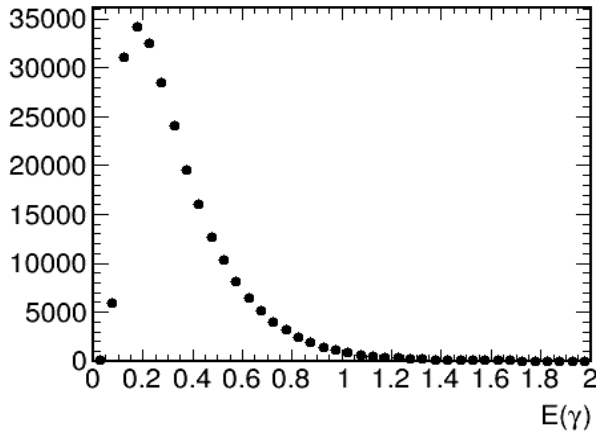


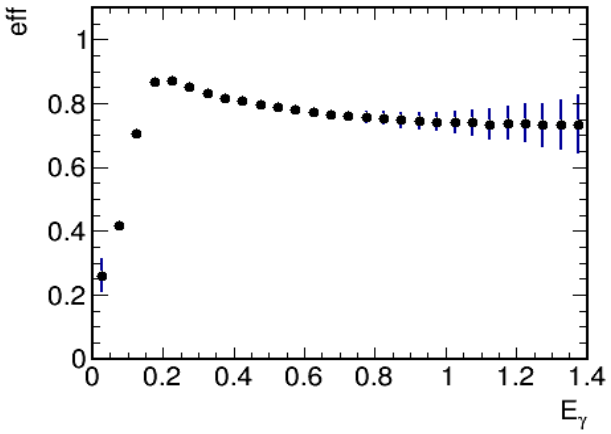




data

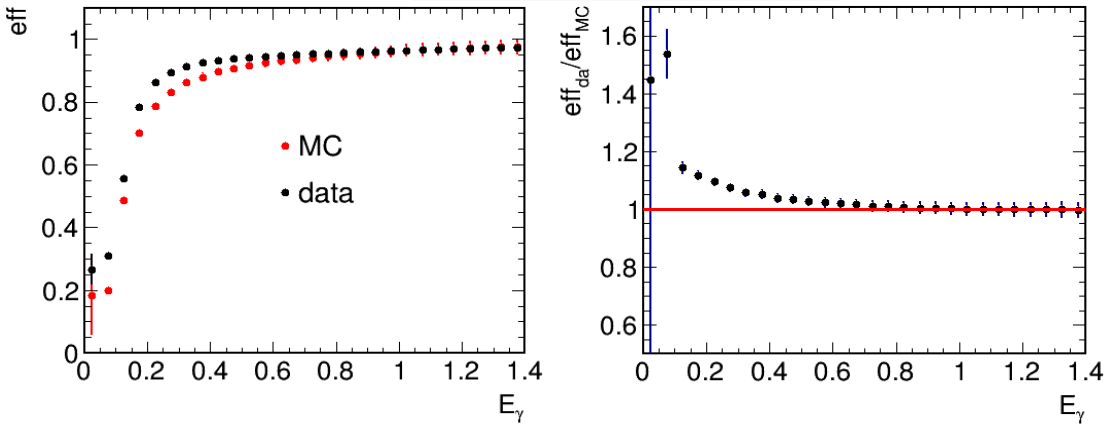




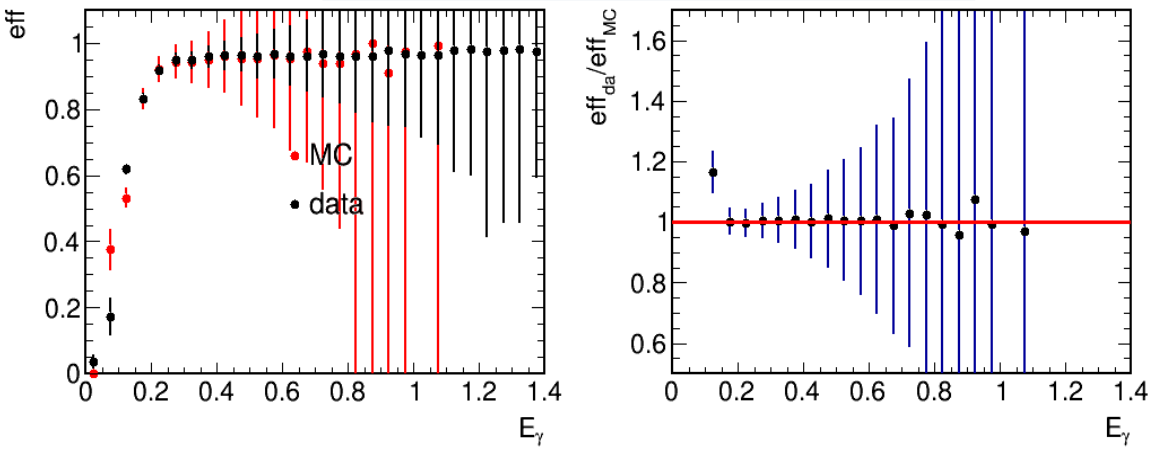


Efficiency and difference of efficiency between data and MC

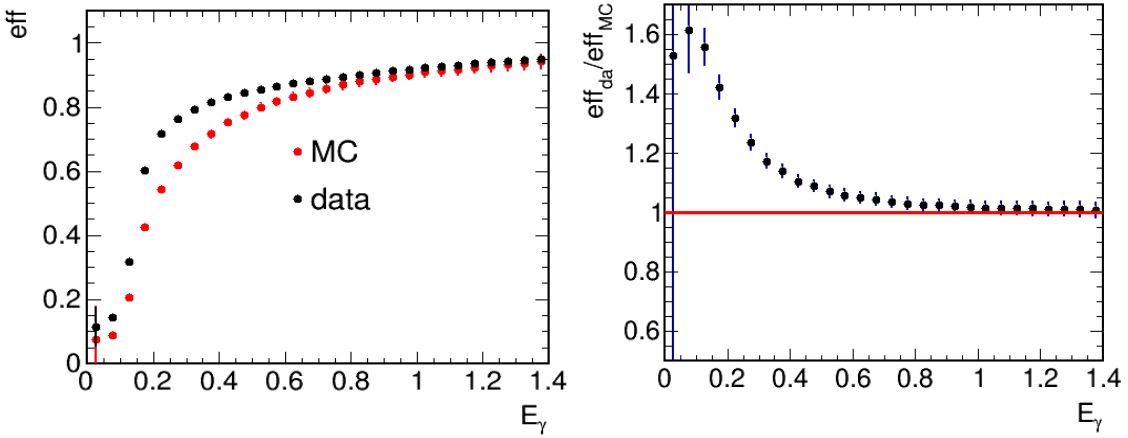
ALL



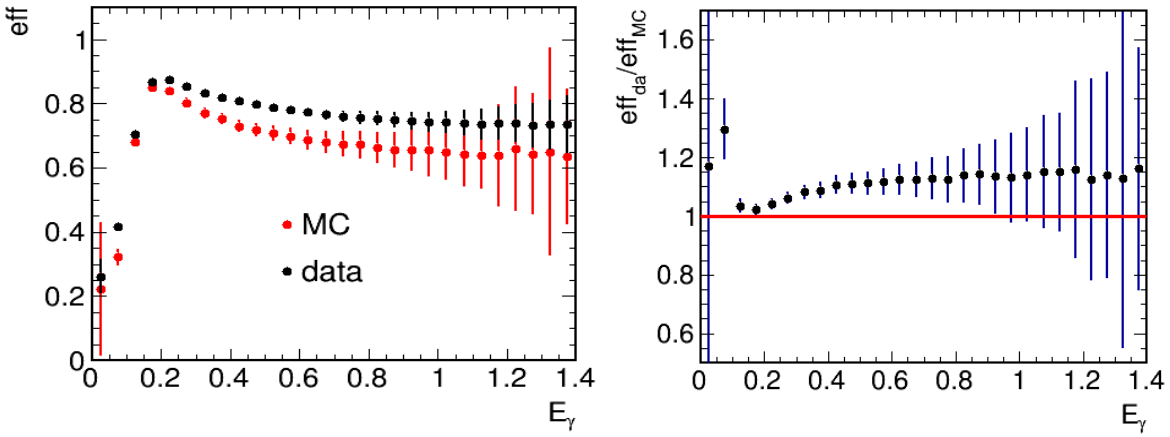
Two photon both in barrel



Two photon both in forward



One in barrel one in forward



Next to do

1. To check why the mass of π^0 of MC move left
   - analysis MC and data with the right version of software

2. Using tag and probe method to measure the efficiency as cross-check

3. Use other channel that have more γ distribution in barrel
   - Like $\gamma p \to \eta\pi^0\pi^0 p$