Status on e^+e^- -> γZ process
Jet Energy Calibration

Takahiro Mizuno

New Progress

1. Method Comparison with all eLpR samples in IDR-L

2. Event which signal photon goes into the beam-pipe

3. Angle dependence of Method 3 energy resolution

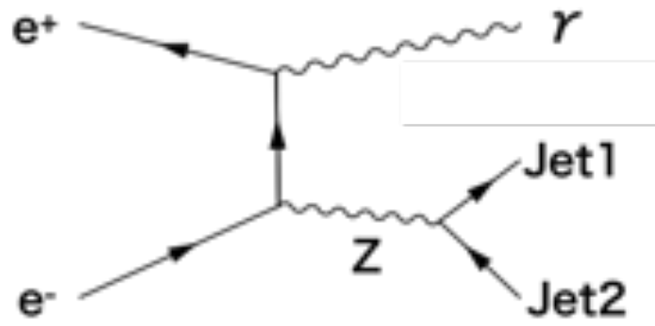
4. Beamstrahlung effect

Reconstruction Method

Based on 4-momentum conservation

$$\begin{cases} \sqrt{P_{J1}^2+m_{J1}^2}+\sqrt{P_{J2}^2+m_{J2}^2}+|P_\gamma|+|P_{ISR}|=500 \\ P_{J1}sin\theta_{J1}cos\phi_{J1}+P_{J2}sin\theta_{J2}cos\phi_{J2}+P_\gamma sin\theta_\gamma cos\phi_\gamma+|P_{ISR}|sin\alpha=500sin\alpha \\ P_{J1}sin\theta_{J1}sin\phi_{J1}+P_{J2}sin\theta_{J2}sin\phi_{J2}+P_\gamma sin\theta_\gamma sin\phi_\gamma=0 \\ P_{J1}cos\theta_{J1}+P_{J2}cos\theta_{J2}+P_\gamma cos\theta_\gamma\pm|P_{ISR}|cos\alpha=0 \end{cases}$$

Beam Crossing Angle ≡2α : α = 7.0 mrad



Direction Angle
θ: polar angle
ϕ: azimuthal angle

- ISR photon = **additional** unseen photon
- Several reconstruction methods (Method **1**, **2'**, **2**,and **3**) are considered.

Method 1: Ignore ISR

Using (θ_{J1},θ_{J2},θ_γ,φ_{J1},φ_{J2},φ_γ,m_{J1},m_{J2}) -> Determine (P_{J1},P_{J2},P_γ)

$$\begin{cases} \sqrt{P_{J1}^2+m_{J1}^2}+\sqrt{P_{J2}^2+m_{J2}^2}+|P_\gamma|=500 \\ \begin{pmatrix} sin\theta_{J1}cos\phi_{J1} & sin\theta_{J2}cos\phi_{J2} & sin\theta_\gamma cos\phi_\gamma \\ sin\theta_{J1}sin\phi_{J1} & sin\theta_{J2}sin\phi_{J2} & sin\theta_\gamma sin\phi_\gamma \\ cos\theta_{J1} & cos\theta_{J2} & cos\theta_\gamma \end{pmatrix} \begin{pmatrix} P_{J1} \\ P_{J2} \\ P_\gamma \end{pmatrix} = \begin{pmatrix} 500sin\alpha \\ 0 \\ 0 \end{pmatrix} \end{cases}$$

Matrix A — Inverse

Reconstruction Method

Method 2': Use measured P_γ as input and Ignore ISR

Using (θ_{J1},θ_{J2},θ_γ,φ_{J1},φ_{J2},φ_γ,m_{J1},m_{J2},P_γ) -> Determine (P_{J1},P_{J2})

$$\begin{cases} \begin{pmatrix} sin\theta_{J1}cos\phi_{J1} & sin\theta_{J2}cos\phi_{J2} \\ sin\theta_{J1}sin\phi_{J1} & sin\theta_{J2}sin\phi_{J2} \end{pmatrix} \begin{pmatrix} P_{J1} \\ P_{J2} \end{pmatrix} = \begin{pmatrix} 500sin\alpha - sin\theta_\gamma cos\phi_\gamma P_\gamma \\ -sin\theta_\gamma sin\phi_\gamma P_\gamma \end{pmatrix} \end{cases}$$

Method 2: Use measured P_γ as input and Ignore ISR

Using (θ_{J1},θ_{J2},θ_γ,φ_{J1},φ_{J2},φ_γ,m_{J1},m_{J2},P_γ) -> Determine (P_{J1},P_{J2},P_{ISR})

$$\begin{cases} \sqrt{P_{J1}^2+m_{J1}^2}+\sqrt{P_{J2}^2+m_{J2}^2}+|P_\gamma|+|P_{ISR}| = 500 \quad ① \\ \begin{pmatrix} sin\theta_{J1}cos\phi_{J1} & sin\theta_{J2}cos\phi_{J2} & sin\alpha \\ sin\theta_{J1}sin\phi_{J1} & sin\theta_{J2}sin\phi_{J2} & 0 \\ cos\theta_{J1} & cos\theta_{J2} & \pm cos\alpha \end{pmatrix} \begin{pmatrix} P_{J1} \\ P_{J2} \\ |P_{ISR}| \end{pmatrix} = \begin{pmatrix} 500sin\alpha - sin\theta_\gamma cos\phi_\gamma P_\gamma \\ -sin\theta_\gamma sin\phi_\gamma P_\gamma \\ -cos\theta_\gamma P_\gamma \end{pmatrix} \end{cases}$$

Matrix A

Inverse

2 solutions for each sign of P_{ISR}

-> choose the best answer which satisfies ① better

Reconstruction Method

Method 3: Consider ISR and solve the full equation

Using (θ_{J1},θ_{J2},θ_γ,φ_{J1},φ_{J2},φ_γ,m_{J1},m_{J2}) -> Determine (P_{J1},P_{J2},P_γ,P_{ISR})

$$\begin{cases} \sqrt{P_{J1}^2+m_{J1}^2}+\sqrt{P_{J2}^2+m_{J2}^2}+|P_\gamma|+|P_{ISR}| = 500 \quad ① \\ \begin{pmatrix} sin\theta_{J1}cos\phi_{J1} & sin\theta_{J2}cos\phi_{J2} & sin\theta_\gamma cos\phi_\gamma \\ sin\theta_{J1}sin\phi_{J1} & sin\theta_{J2}sin\phi_{J2} & sin\theta_\gamma sin\phi_\gamma \\ cos\theta_{J1} & cos\theta_{J2} & cos\theta_\gamma \end{pmatrix} \begin{pmatrix} P_{J1} \\ P_{J2} \\ P_\gamma \end{pmatrix} = \begin{pmatrix} (500-|P_{ISR}|)sin\alpha \\ 0 \\ \pm|P_{ISR}|cos\alpha \end{pmatrix} \end{cases}$$

Matrix A

Inverse

The first equation ① becomes a quartic equation of $|P_{ISR}|$.

-> 8 Possible Solutions!

(2 direction options of ISR × 4 solutions for each quartic equation)

Choose the solution with (i) real and positive value
(ii) solved P_γ closest to the measured P_γ

New Progress

1. Method Comparison with all eLpR samples in IDR-L

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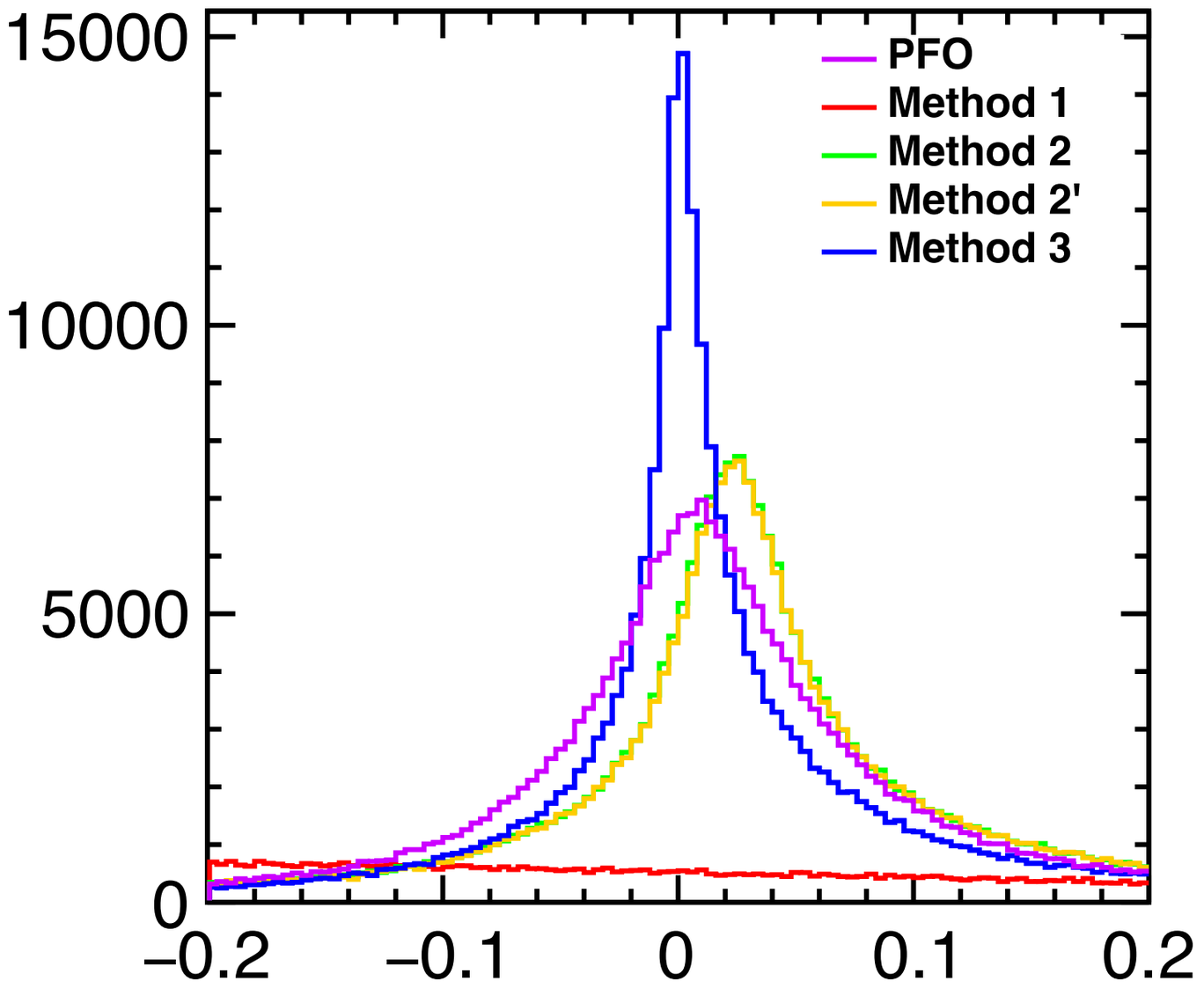
1. Method Comparison with all eLpR samples in IDR-L

With a cut "|photonthetaAnl–photonthetaMC|<0.01"
In order to exclude the events with wrong photon selection



Relative difference of jet1 energy $\frac{E_{JRec} - E_{JTrue}}{E_{JTrue}}$

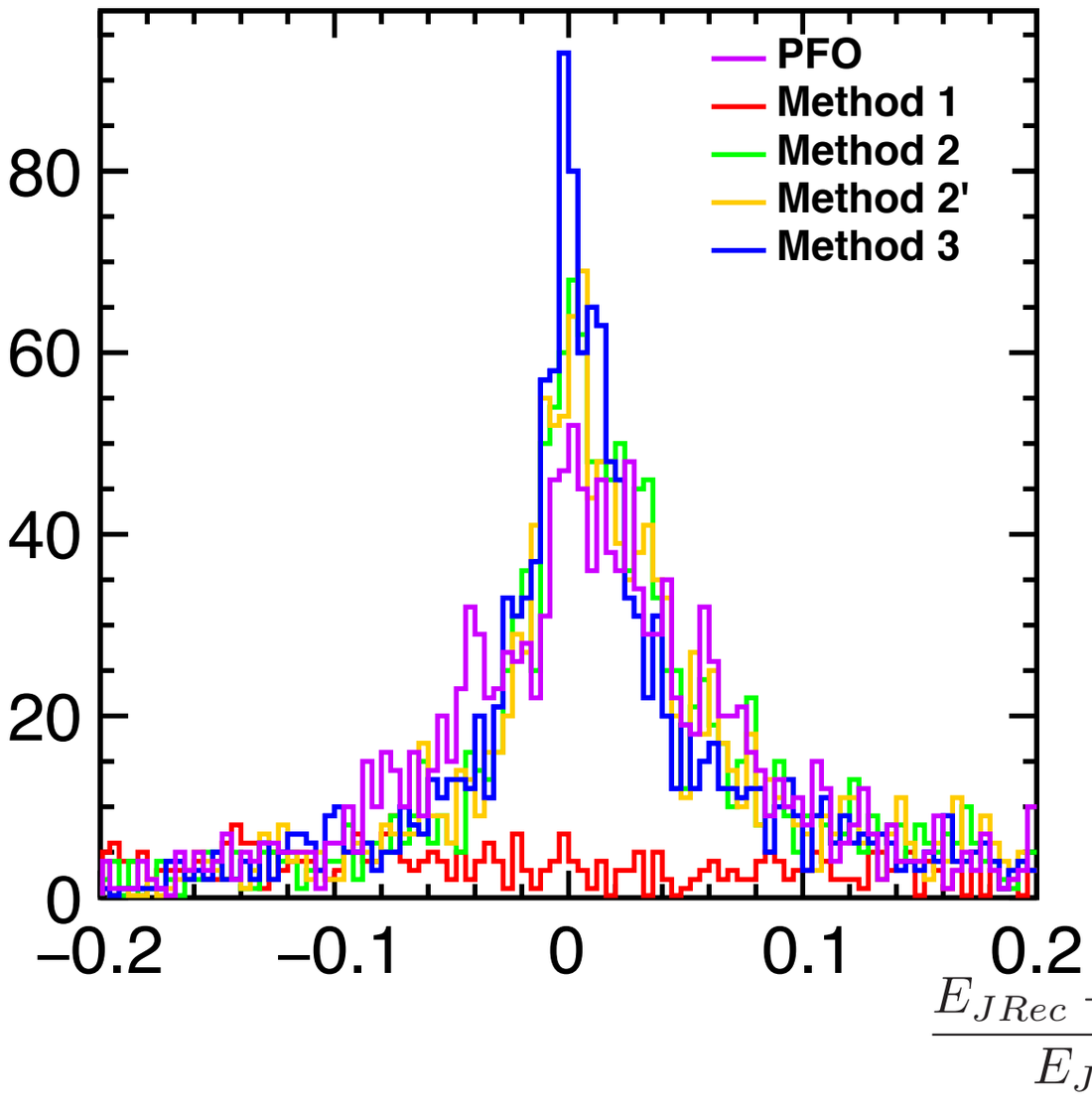
- **Method 3 is the best.**
- **Method 2 & 2' have bias, due to the photon energy bias.**

$$\frac{E_{JRec} - E_{JTrue}}{E_{JTrue}}$$

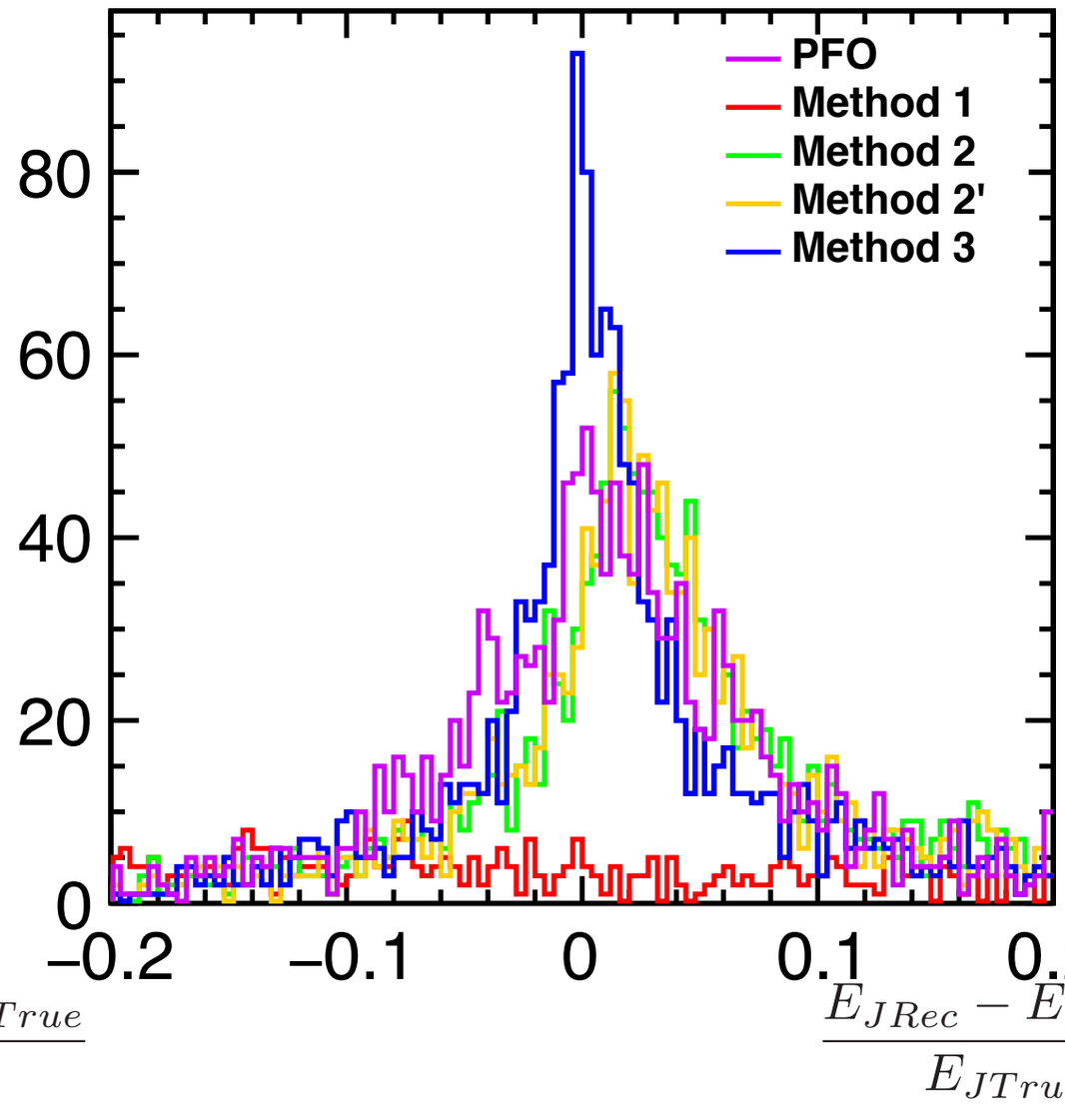
When using smeared MC photon energy
"photonEMC+0.17*sqrt(photonEMC)*gRandom->Gaus();"
as inputs so as to avoid the photon energy bias in PFO,

IDR-S (not full)
|θγAnl−θγMC|<0.01

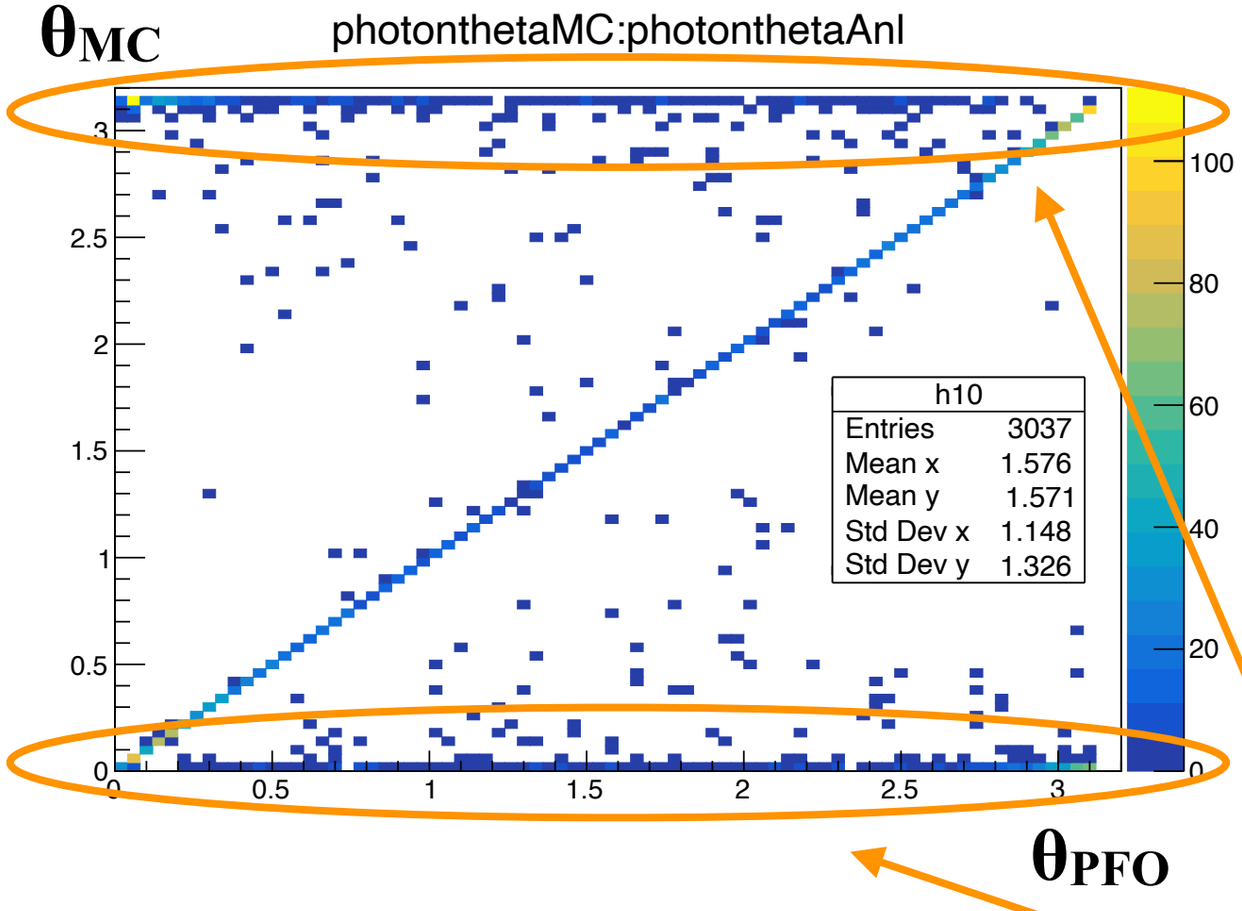
Using smeared MC photon energy

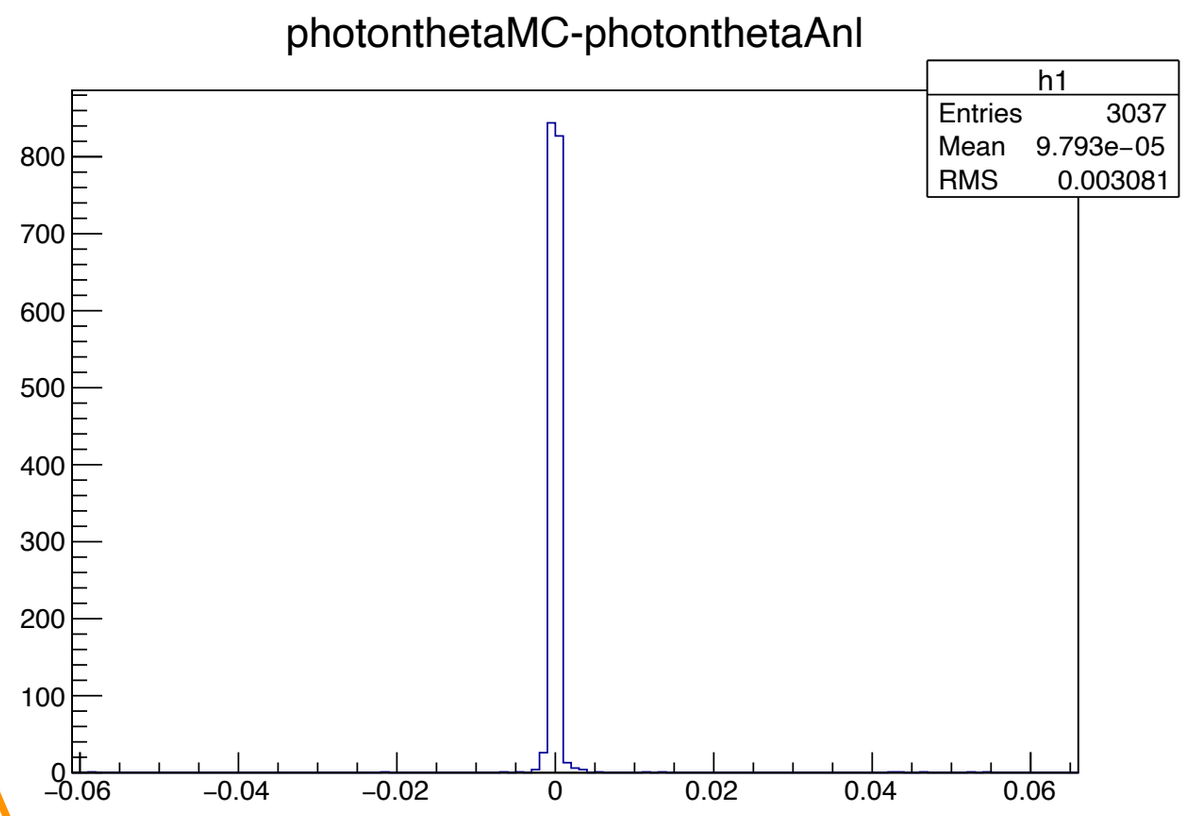


Using PFO photon energy



2. Event which signal photon goes into the beam-pipe



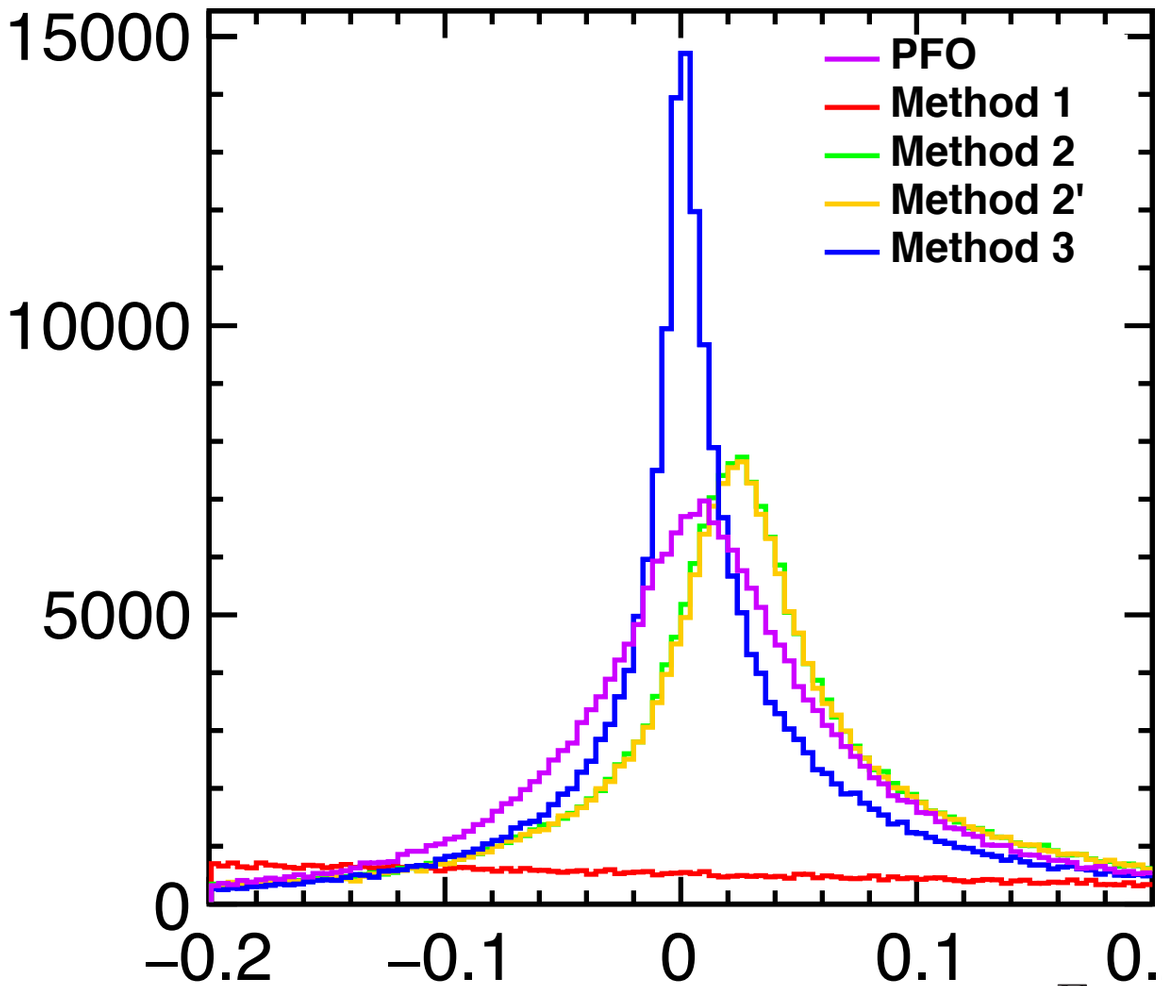


Photon goes into the beam-pipe and wrong photon is chosen

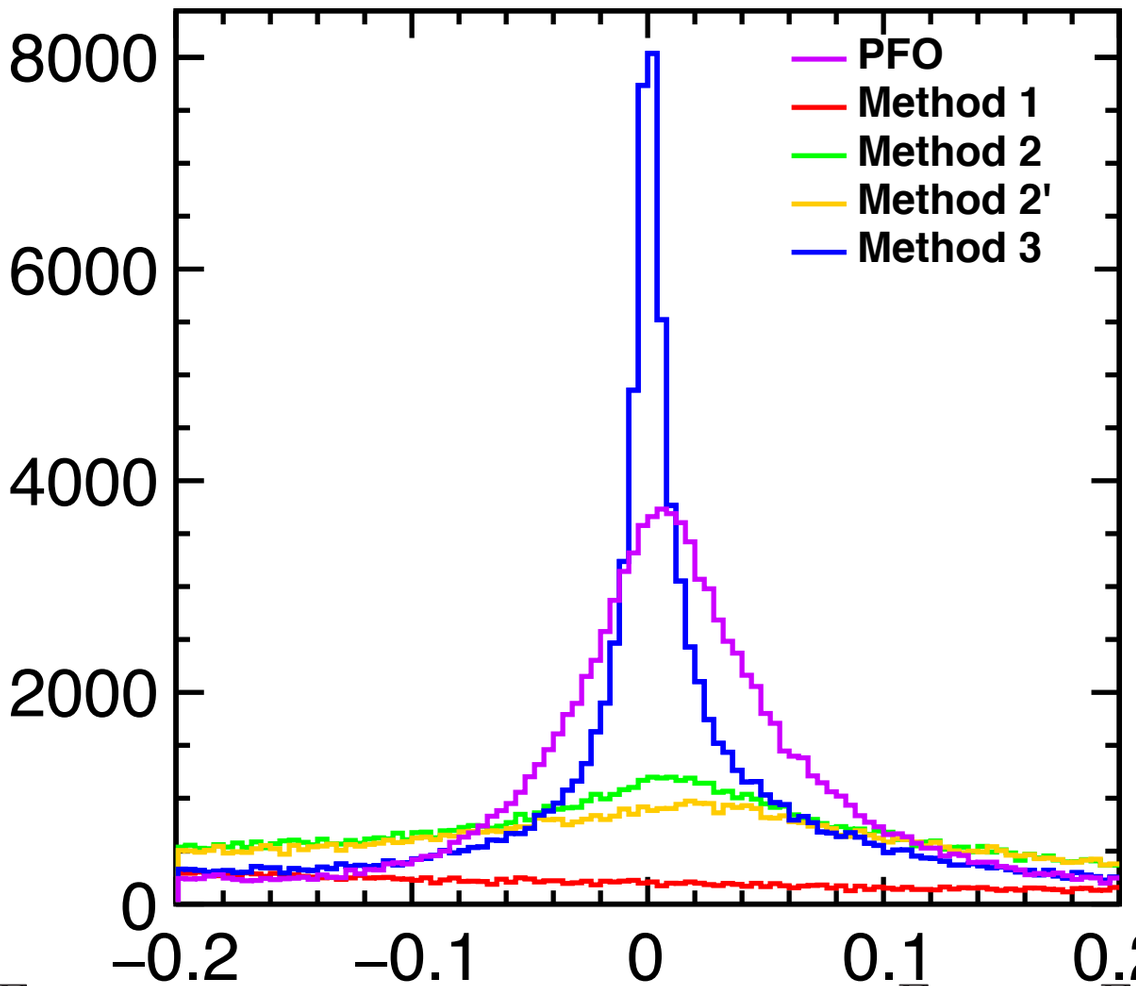
Cut “|photonthetaMC-photonthetaAnl| < 0.01” is appropriate.

2. Event which signal photon goes into the beam-pipe

|θγAnl−θγMC|<0.01
262705 events



|θγAnl−θγMC|>0.01
179205 events



Method 3 still works very well even in the wrong photon case!

Reconstruction Method

Method 3: Consider ISR and solve the full equation

Using (θ_{J1},θ_{J2},θ_γ,φ_{J1},φ_{J2},φ_γ,m_{J1},m_{J2}) -> Determine (P_{J1},P_{J2},P_γ,P_{ISR})

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Matrix A

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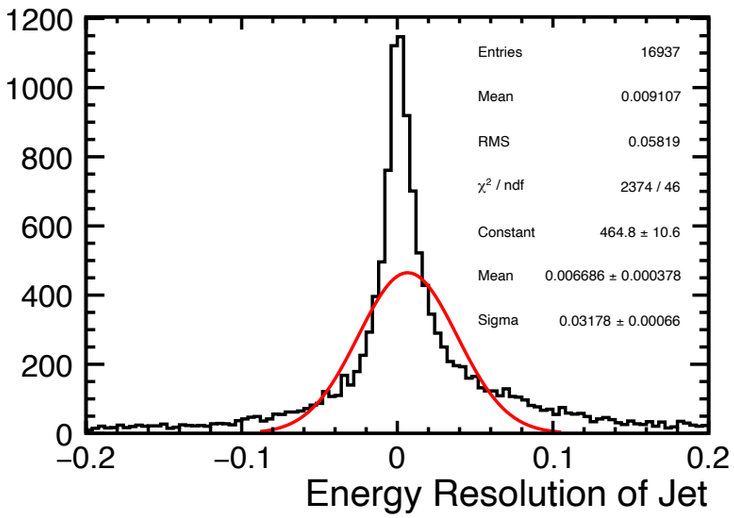
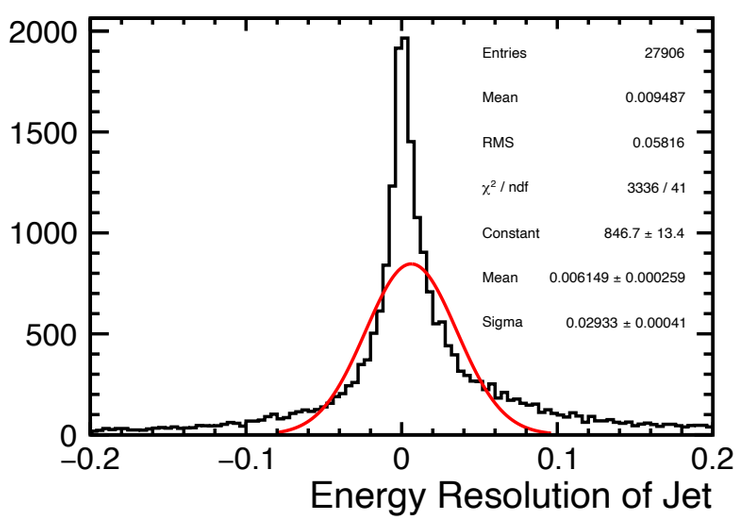
3. Angle dependence of Method 3 energy resolution

Fitted $\frac{E_{JRec} - E_{JTrue}}{E_{JTrue}}$ **with Gaussian**

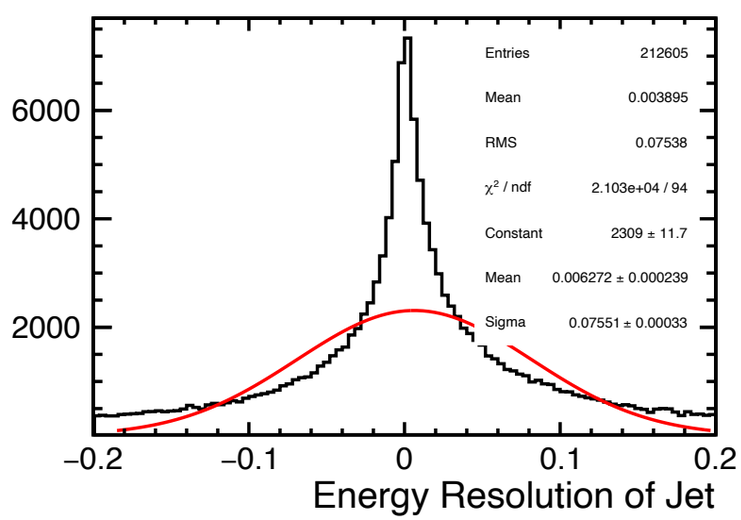
`0.2<|cosθJet|<0.3`



`0.6<|cosθJet|<0.7`



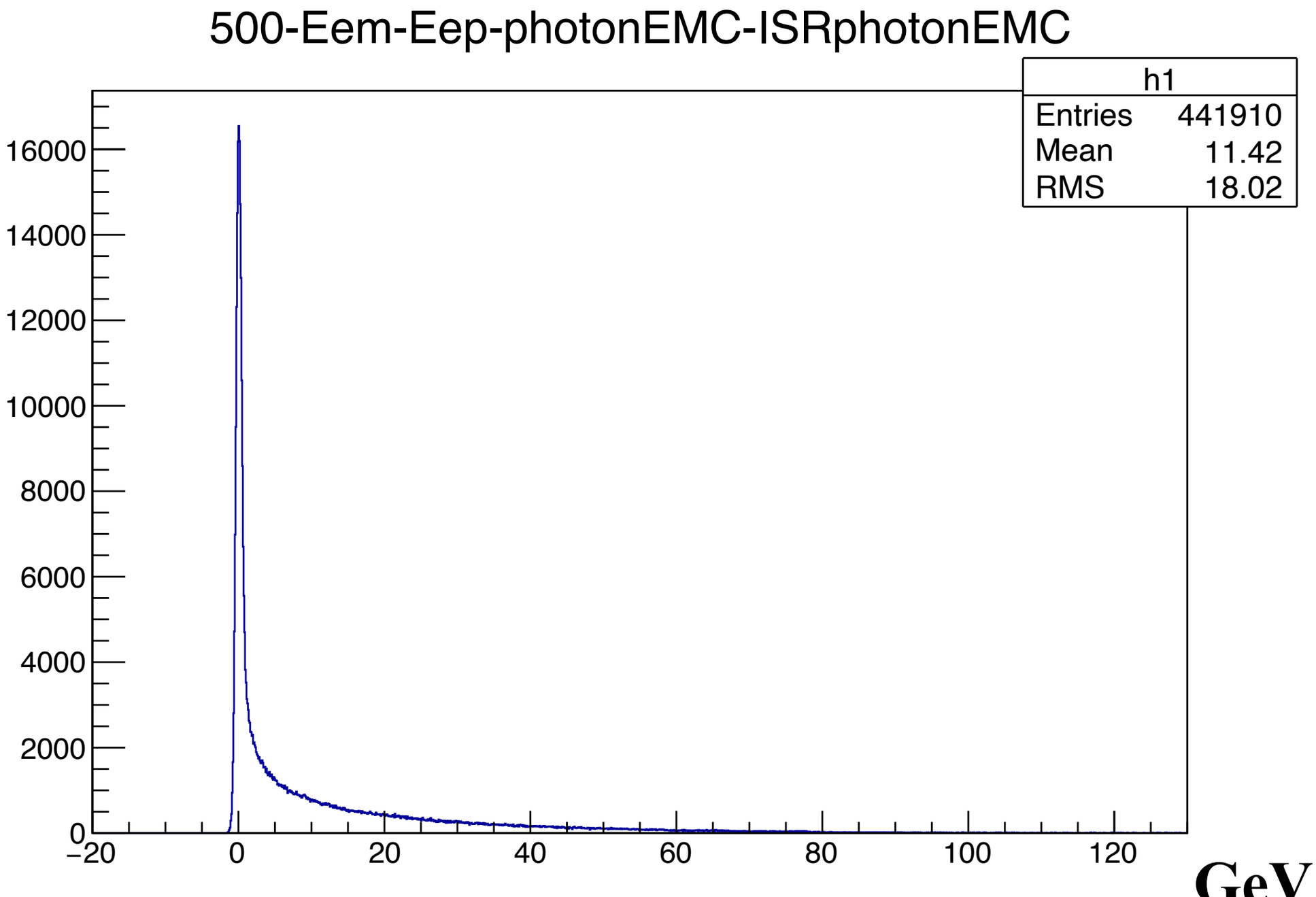
`0.9<|cosθJet|<1.0`



Some theta dependence found, but Gaussian Fitting failed.

-> Need to focus on narrower phase space!

4. Beamstrahlung effect



This is total beamstrahlung energy

-> but I need to assign one beamstrahlung to each beam in the toy MC simulation