

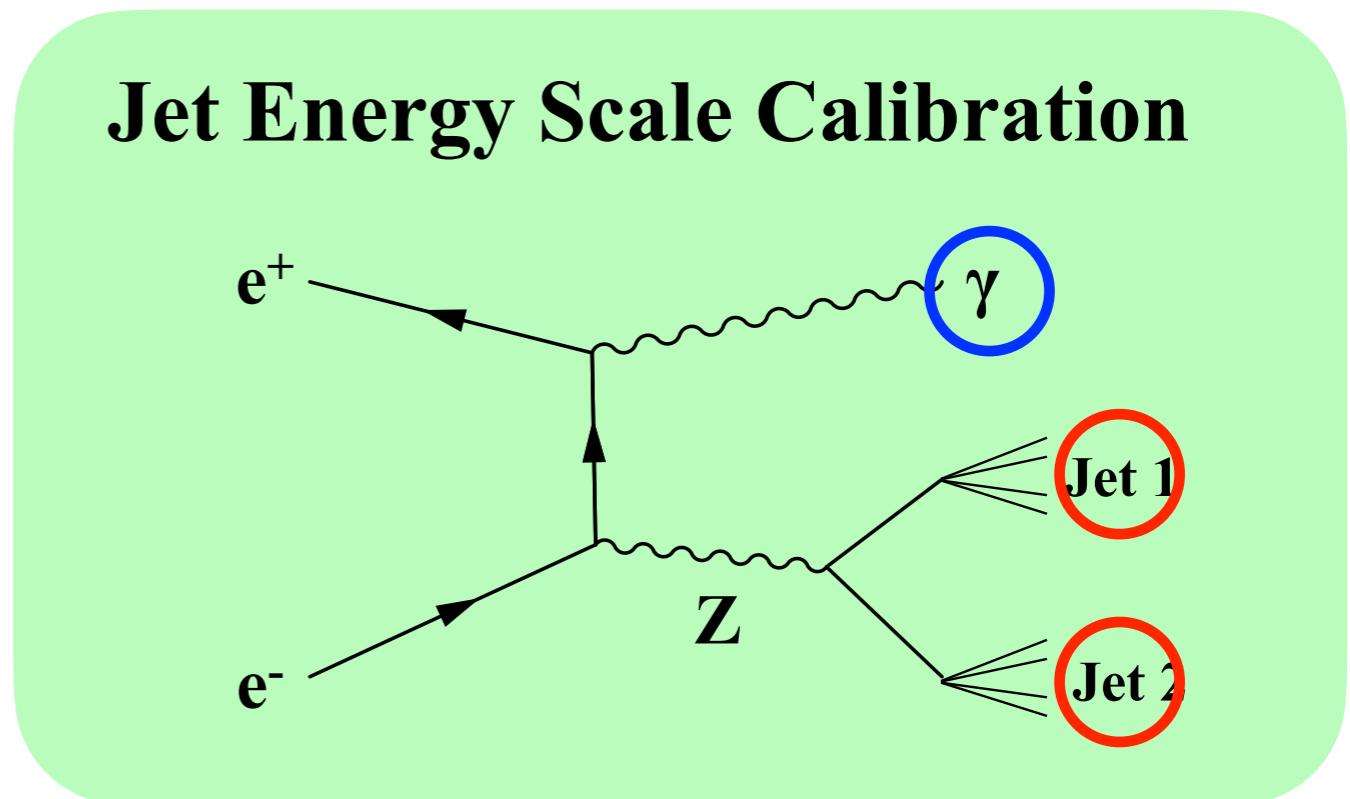
Status on $e^+e^- \rightarrow \gamma Z$ process

Jet Energy Calibration

Takahiro Mizuno

250 GeV DBD analysis

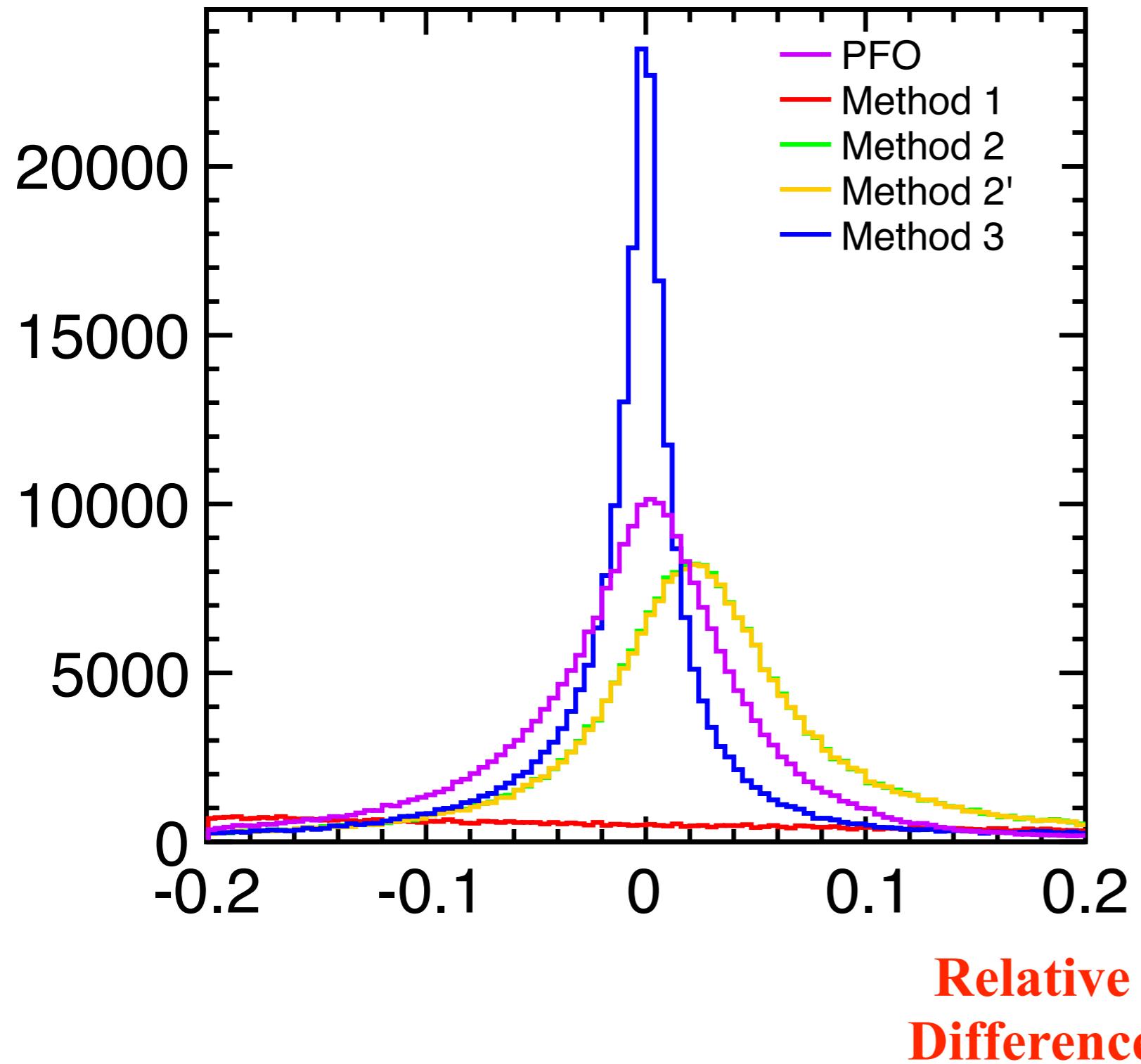
- In order to perform 250 GeV analysis, we decided to use DBD samples instead of current using samples until new sample is validated.
- To make things clear, overlay removal using MCTruth link is implemented.
- Distribution of various observables are checked.
- **The number of samples is increased!**



Method comparison of jet1 E difference

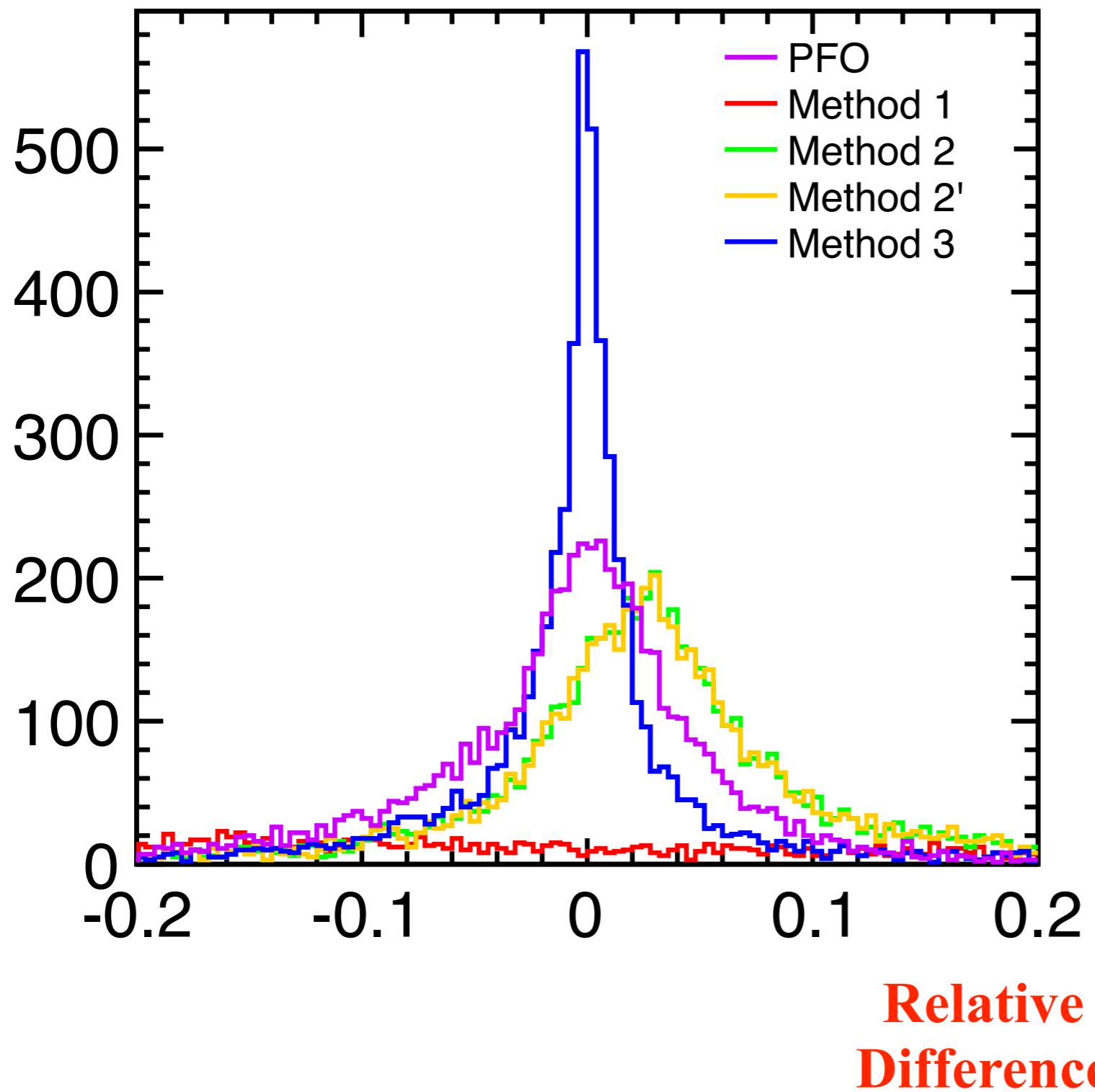
Correct photon selection events

3



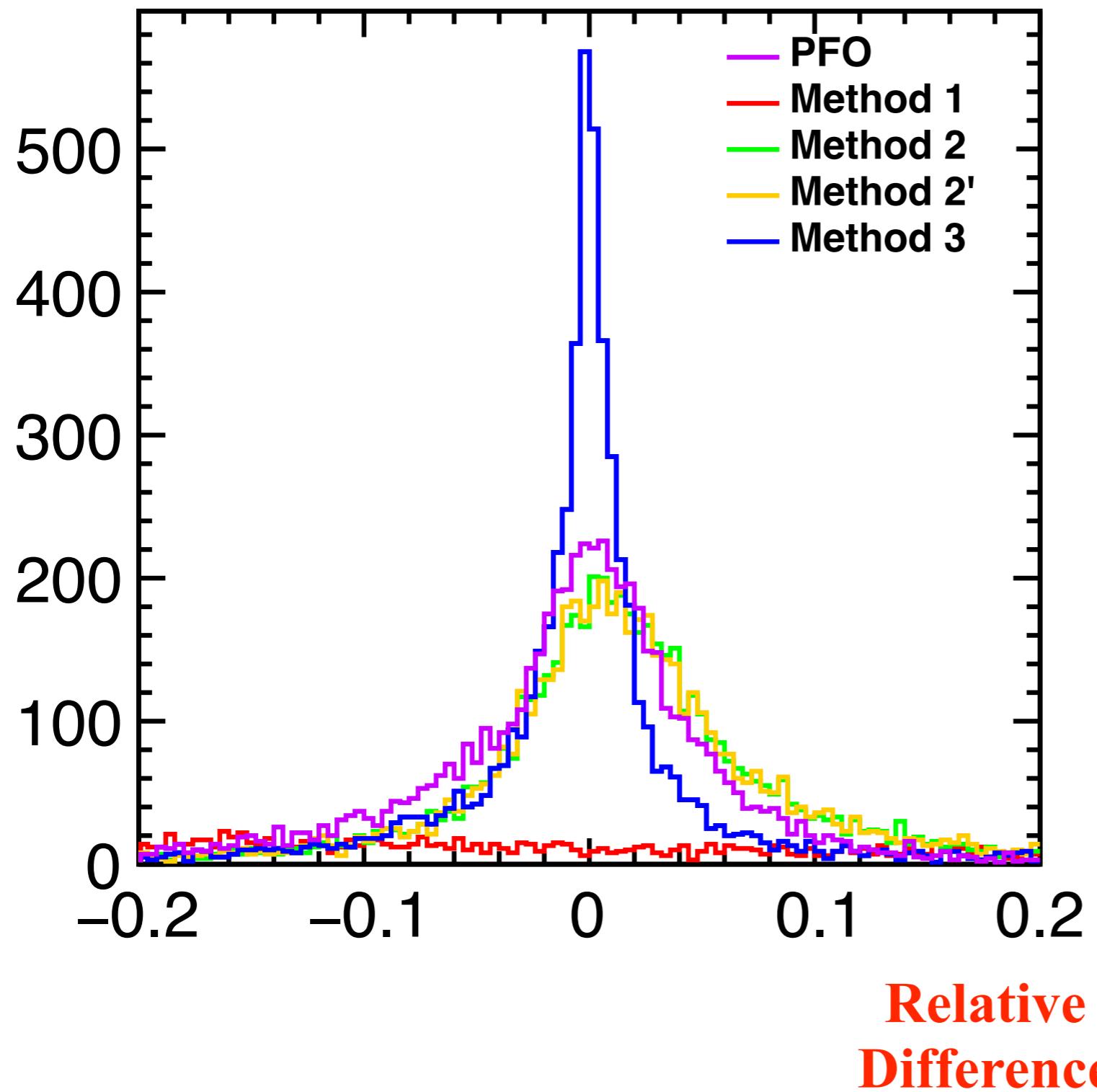
I also checked $\cos(\theta)$ dependence.
Distribution was a little far from Gaussian.

Positive shift issue in M2 & M22



**Method 2 and 2'
have positive shift.**

Positive shift issue in M2 & M22



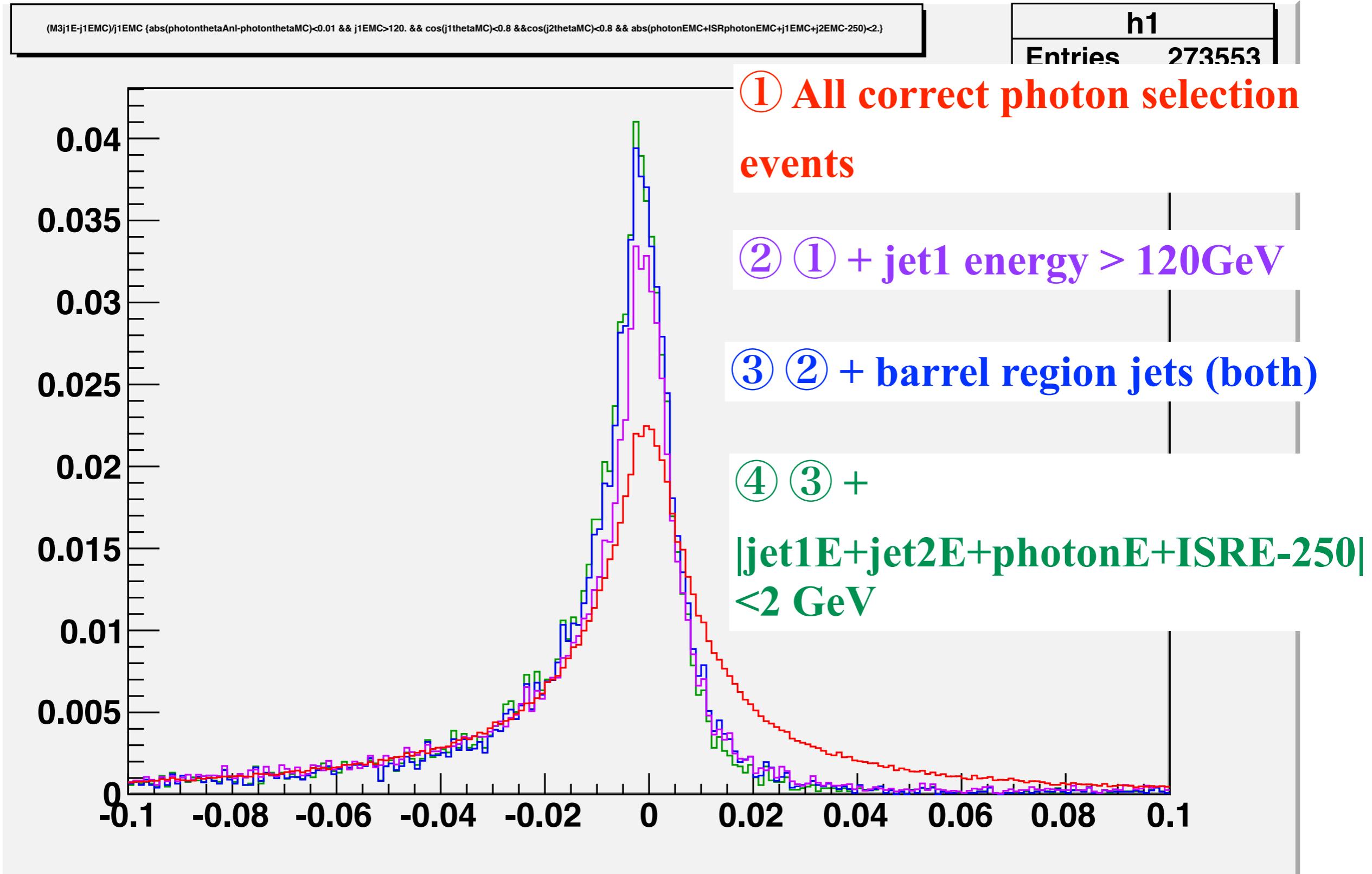
Using “Smeared MCtruth $E\gamma$ ” as input in Method 2 and 2’.

**“ $E\gamma MC + 0.17 * \sqrt{E\gamma MC} * gR$
random->Gaus()**
+ 0.01 * $E\gamma MC * gRandom$ ->Gaus();

The positive shift remained slightly.

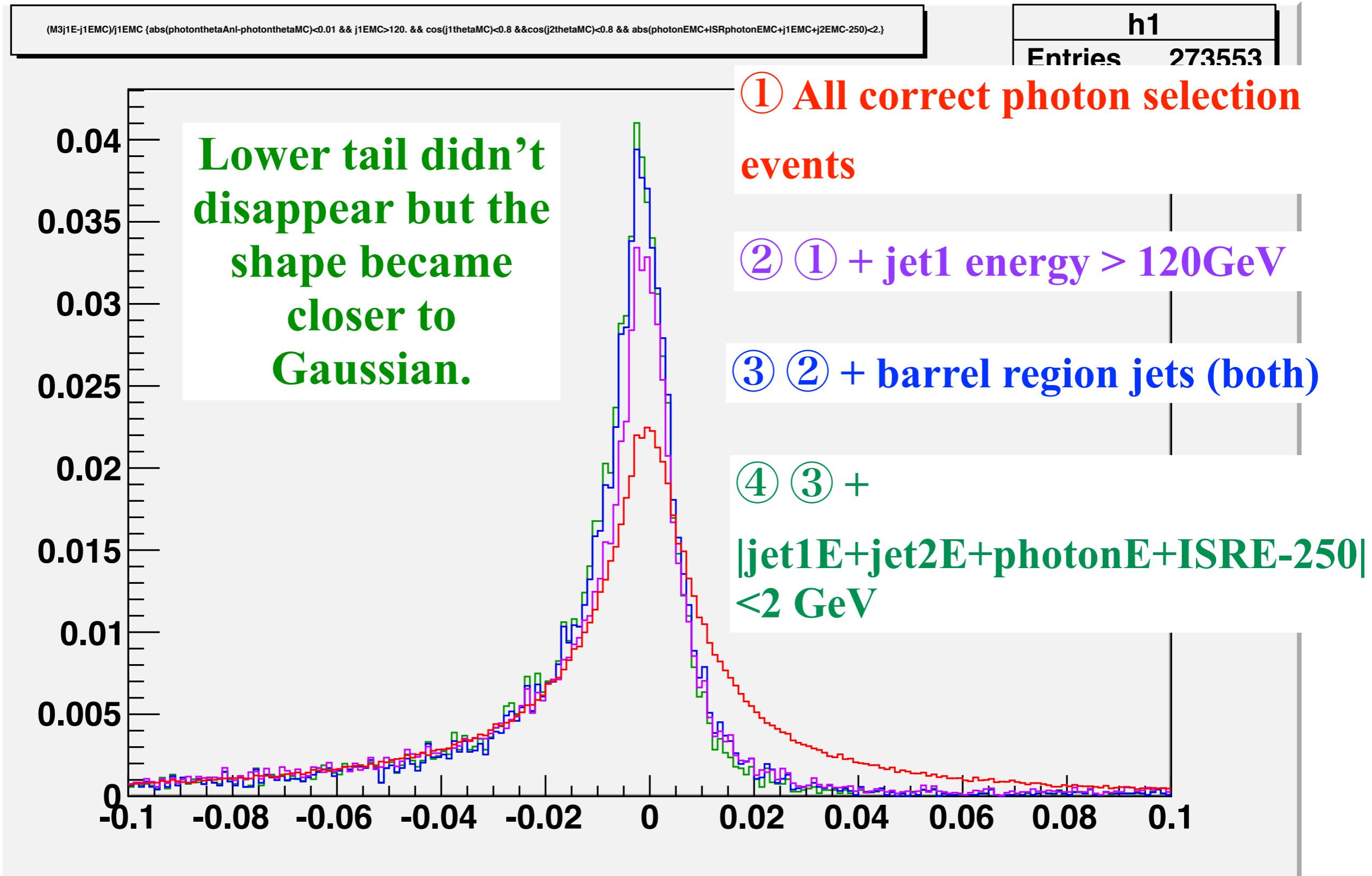
Removing tail

J1 E resolution by Method 3 (Normalized)



Removing tail

J1 E resolution by Method 3 (Normalized)



Backup

Jet Energy Reconstruction Method⁹

Basic ideas: apply momentum conservation

Inputs: measured jet directions and mass and photon directions

Method 1: Use 3-momentum conservation and ignore ISR

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma)$ -> Determine $(P_{J1}, P_{J2}, P_\gamma)$

Method 2': Use transverse momentum conservation and ignore ISR / Use measured P_γ as input

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, P_\gamma)$ -> Determine (P_{J1}, P_{J2})

Method 2: Use 4-momentum conservation and consider ISR / Use measured P_γ as input

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2}, P_\gamma)$ -> Determine $(P_{J1}, P_{J2}, P_{ISR})$

Method 3: Use 4-momentum conservation and consider ISR and solve the full equation

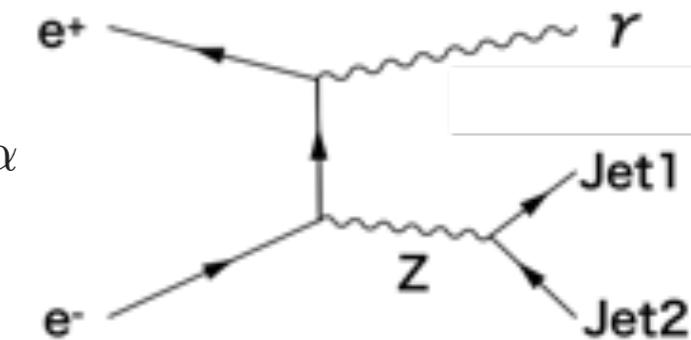
Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2})$ -> Determine $(P_{J1}, P_{J2}, P_\gamma, P_{ISR})$

Reconstruction Method

Based on 4-momentum conservation

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

Beam Crossing Angle $\equiv 2\alpha : \alpha = 7.0 \text{ mrad}$



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 $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2}) \rightarrow$ Determine $(P_{J1}, P_{J2}, P_\gamma)$

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

Matrix A ————— Inverse

Reconstruction Method

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

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2}, P_\gamma) \rightarrow \text{Determine } (P_{J1}, P_{J2})$

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

Method 2: Use measured P_γ as input and Ignore ISR

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2}, P_\gamma) \rightarrow \text{Determine } (P_{J1}, P_{J2}, P_{ISR})$

$$\left\{ \begin{array}{l} \sqrt{P_{J1}^2 + m_{J1}^2} + \sqrt{P_{J2}^2 + m_{J2}^2} + |P_\gamma| + |P_{ISR}| = 500 \quad \textcircled{1} \\ \boxed{\begin{pmatrix} \sin\theta_{J1}\cos\phi_{J1} & \sin\theta_{J2}\cos\phi_{J2} & \sin\alpha \\ \sin\theta_{J1}\sin\phi_{J1} & \sin\theta_{J2}\sin\phi_{J2} & 0 \\ \cos\theta_{J1} & \cos\theta_{J2} & \pm\cos\alpha \end{pmatrix}} \begin{pmatrix} P_{J1} \\ P_{J2} \\ |P_{ISR}| \end{pmatrix} = \begin{pmatrix} 500\sin\alpha - \sin\theta_\gamma\cos\phi_\gamma P_\gamma \\ -\sin\theta_\gamma\sin\phi_\gamma P_\gamma \\ -\cos\theta_\gamma P_\gamma \end{pmatrix} \end{array} \right.$$

Matrix A ————— **Inverse**

2 solutions for each sign of P_{ISR}

\rightarrow choose the best answer which satisfies **①** better

Reconstruction Method

Method 3: Consider ISR and solve the full equation

Using $(\theta_{J1}, \theta_{J2}, \theta_\gamma, \phi_{J1}, \phi_{J2}, \phi_\gamma, m_{J1}, m_{J2})$ -> Determine $(P_{J1}, P_{J2}, P_\gamma, P_{ISR})$

$$\left\{ \begin{array}{l} \sqrt{P_{J1}^2 + m_{J1}^2} + \sqrt{P_{J2}^2 + m_{J2}^2} + |P_\gamma| + |P_{ISR}| = 500 \\ \left(\begin{array}{ccc} \sin\theta_{J1}\cos\phi_{J1} & \sin\theta_{J2}\cos\phi_{J2} & \sin\theta_\gamma\cos\phi_\gamma \\ \sin\theta_{J1}\sin\phi_{J1} & \sin\theta_{J2}\sin\phi_{J2} & \sin\theta_\gamma\sin\phi_\gamma \\ \cos\theta_{J1} & \cos\theta_{J2} & \cos\theta_\gamma \end{array} \right) \left(\begin{array}{c} P_{J1} \\ P_{J2} \\ P_\gamma \end{array} \right) = \left(\begin{array}{c} (500 - |P_{ISR}|)\sin\alpha \\ 0 \\ \pm|P_{ISR}|\cos\alpha \end{array} \right) \end{array} \right.$$

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

→ 8 Possible Solutions!

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