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

Takahiro Mizuno

250 GeV DBD analysis

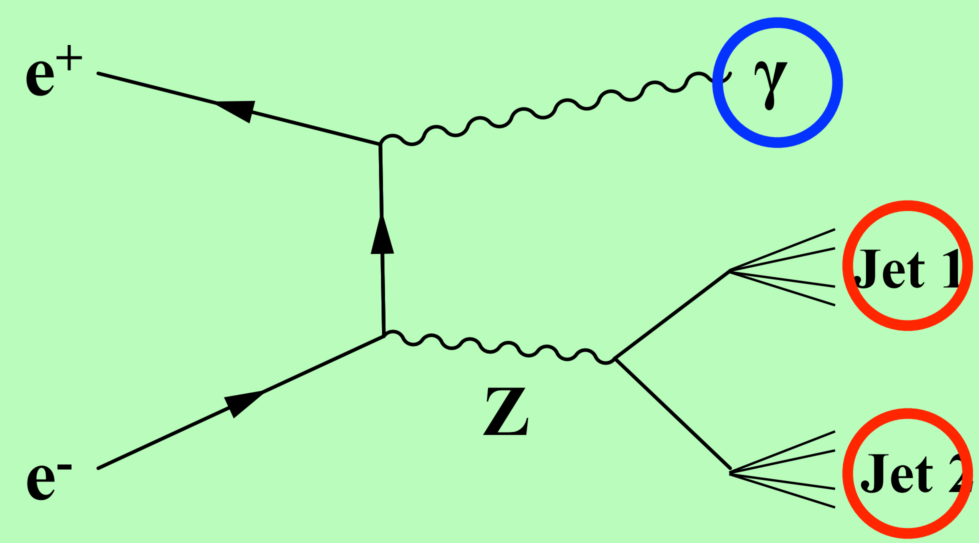
- In order to perform 250 GeV analysis, we decided to use DBD samples instead of current using samples until new sample is validated.

- To make things clear, overlay removal using MCTruth link is implemented.

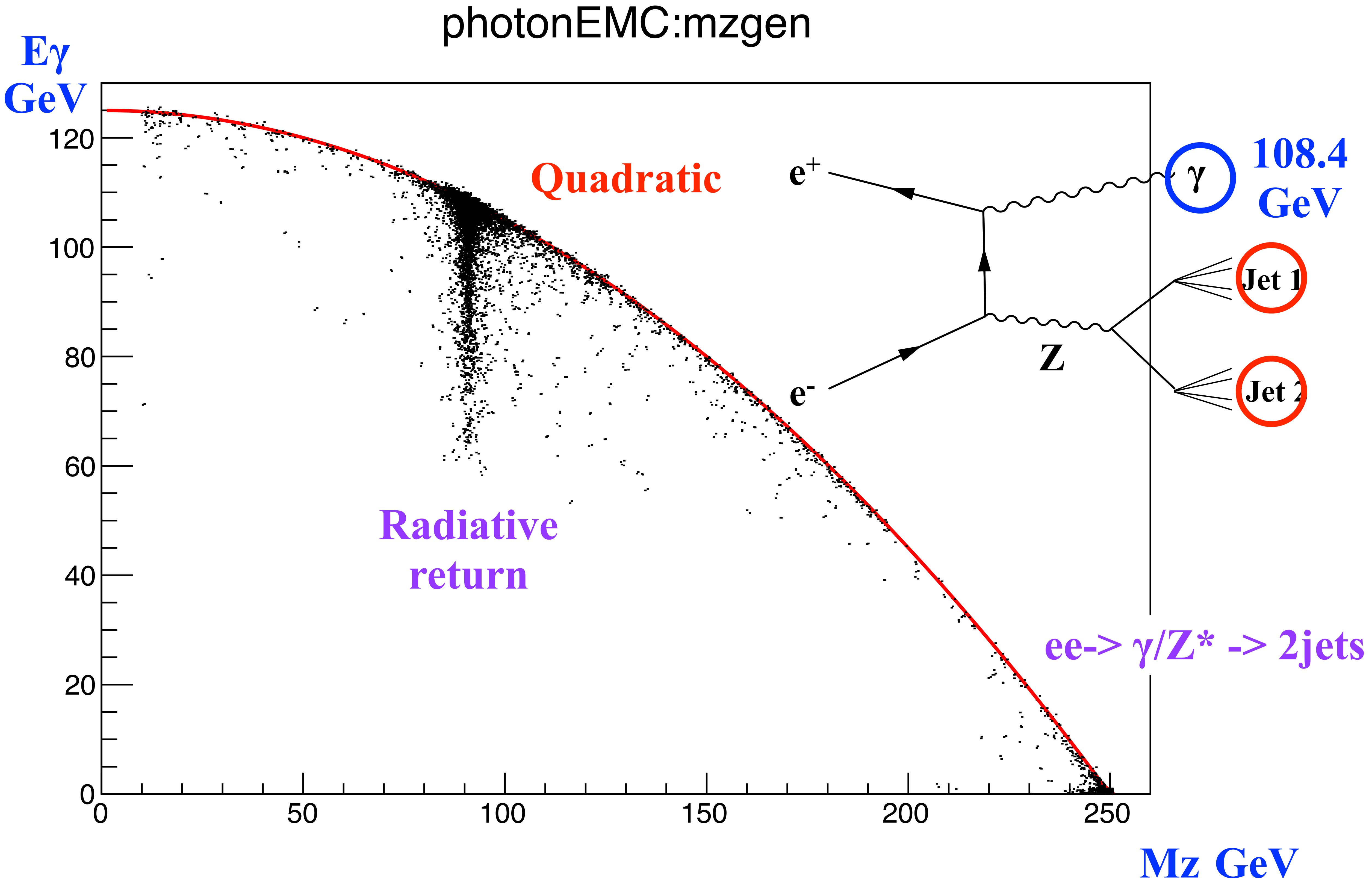
- Distribution of various observables are checked.

- Try to increase the number of samples (not yet done).

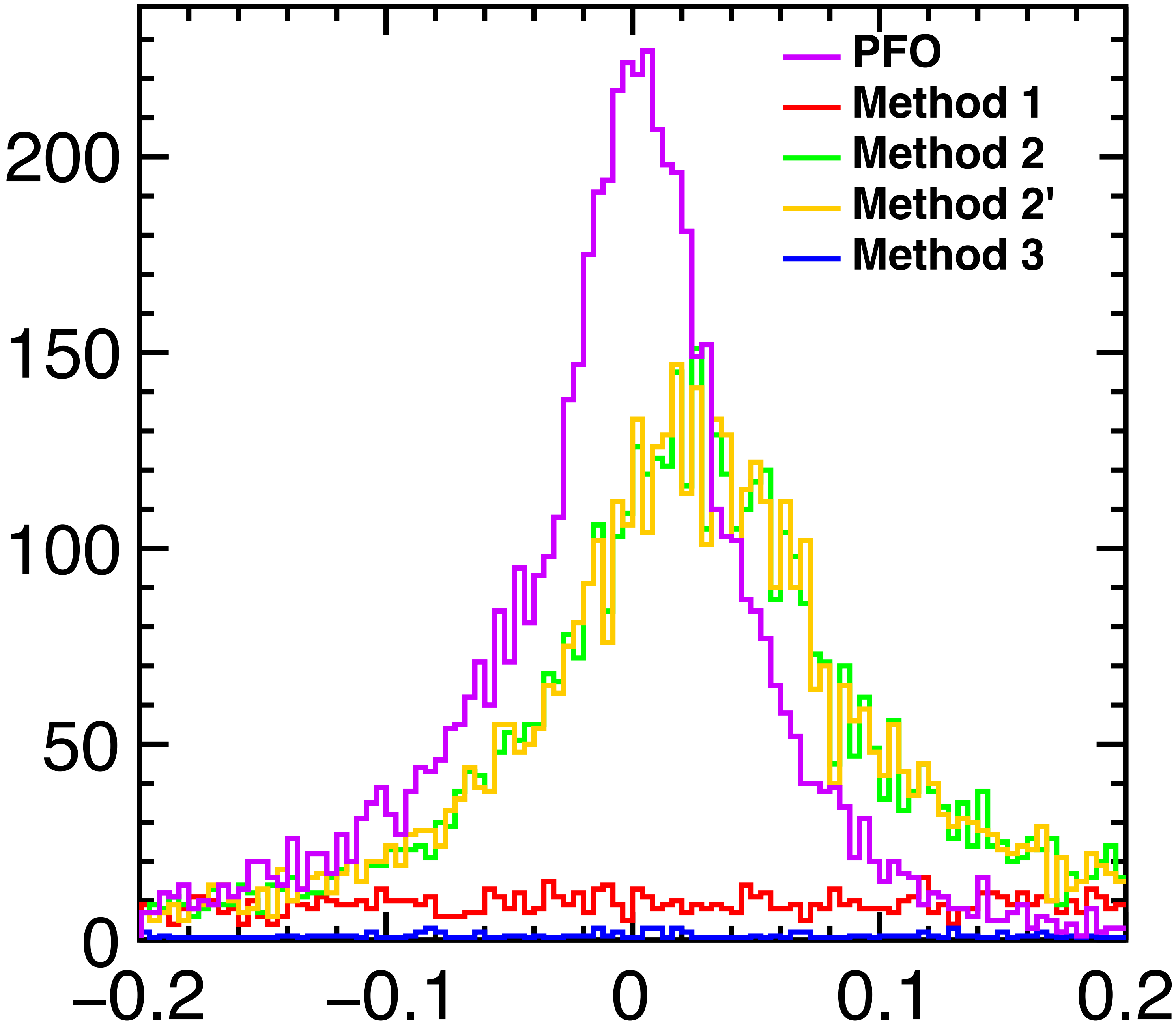
Jet Energy Scale Calibration



Photon energy & Mz distribution



Method comparison of jet1 E difference
Correct photon selection events

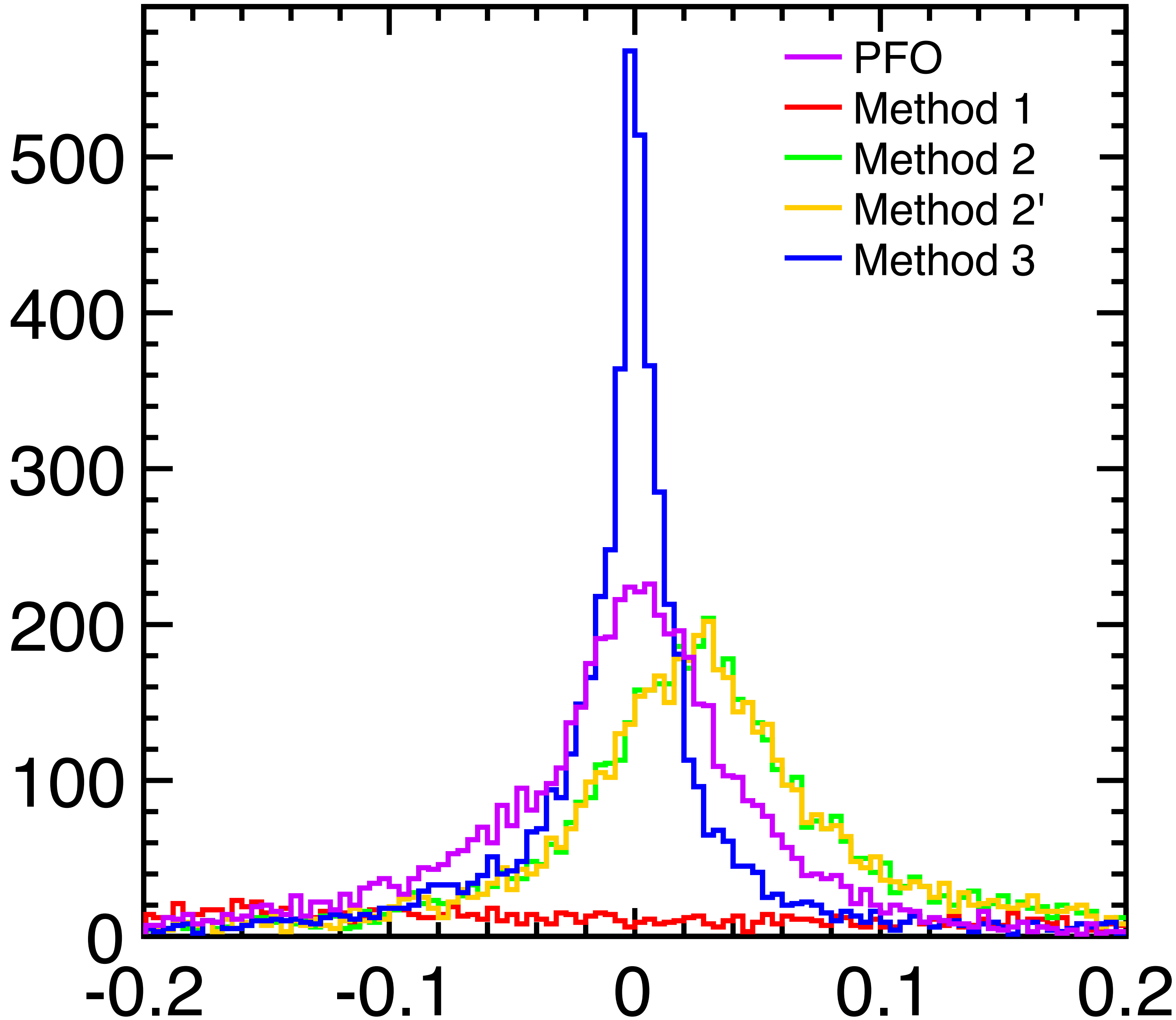


Relative Difference

For some reason, Method 3 is not working.

I am looking into the bug in the Method 3.

Method comparison of jet1 E difference Correct photon selection events



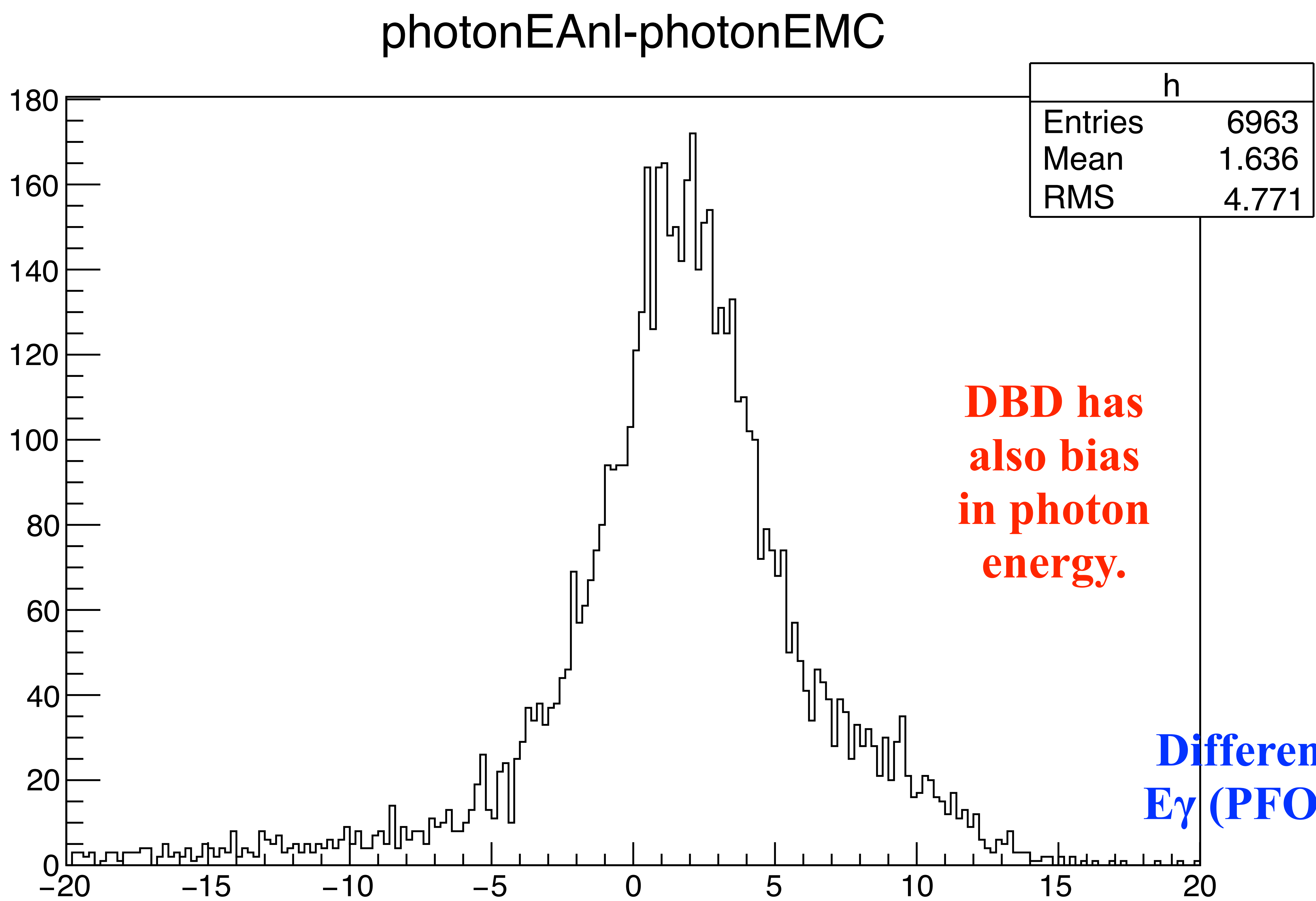
Relative Difference

Bug in the Method 3 is fixed.

The plot tells us that it is the best.

Method 2 and 2' have positive shift.

Photon energy bias in DBD

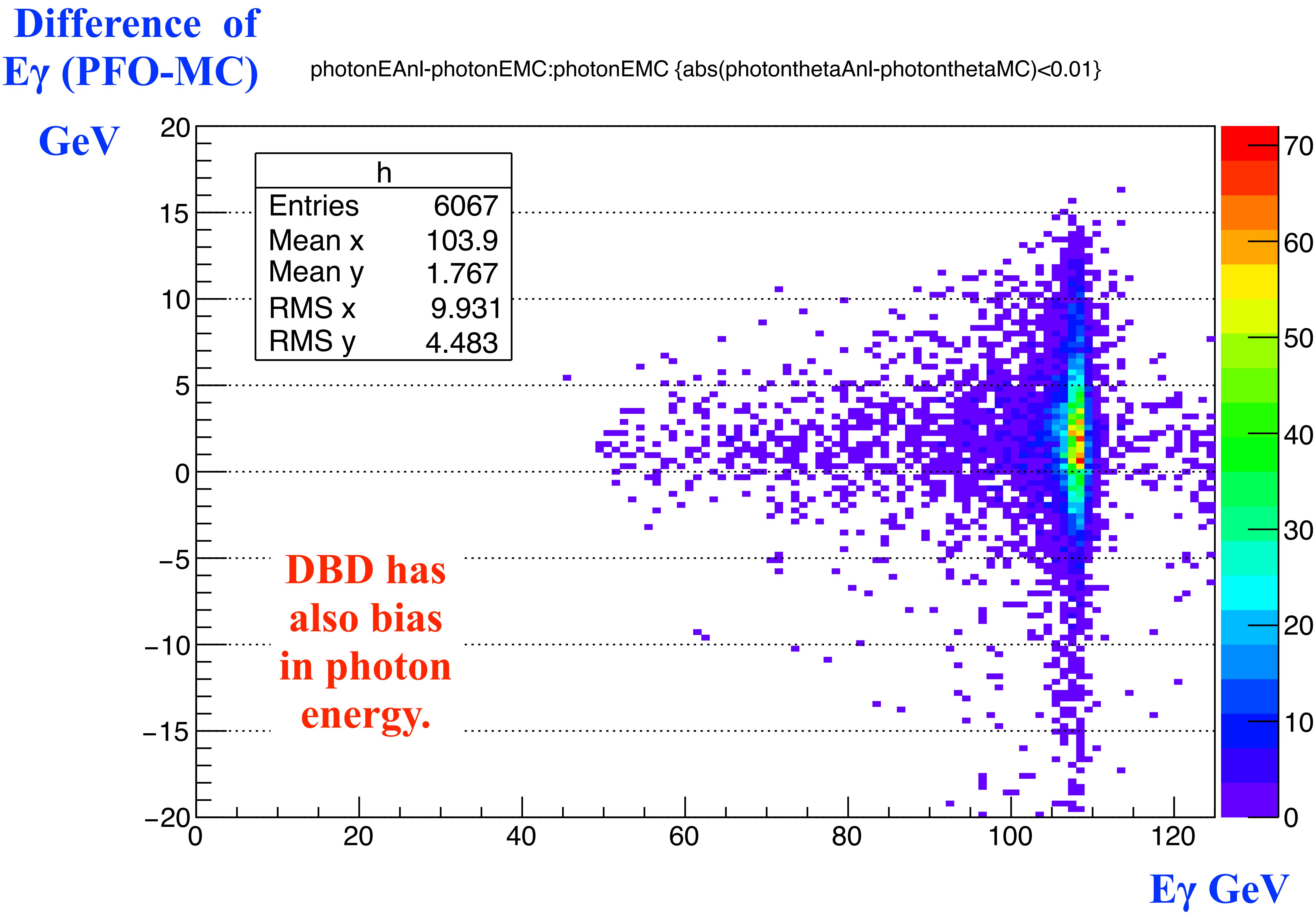


DBD has also bias in photon energy.

Difference of Eγ (PFO-MC)

GeV

Photon energy bias in DBD



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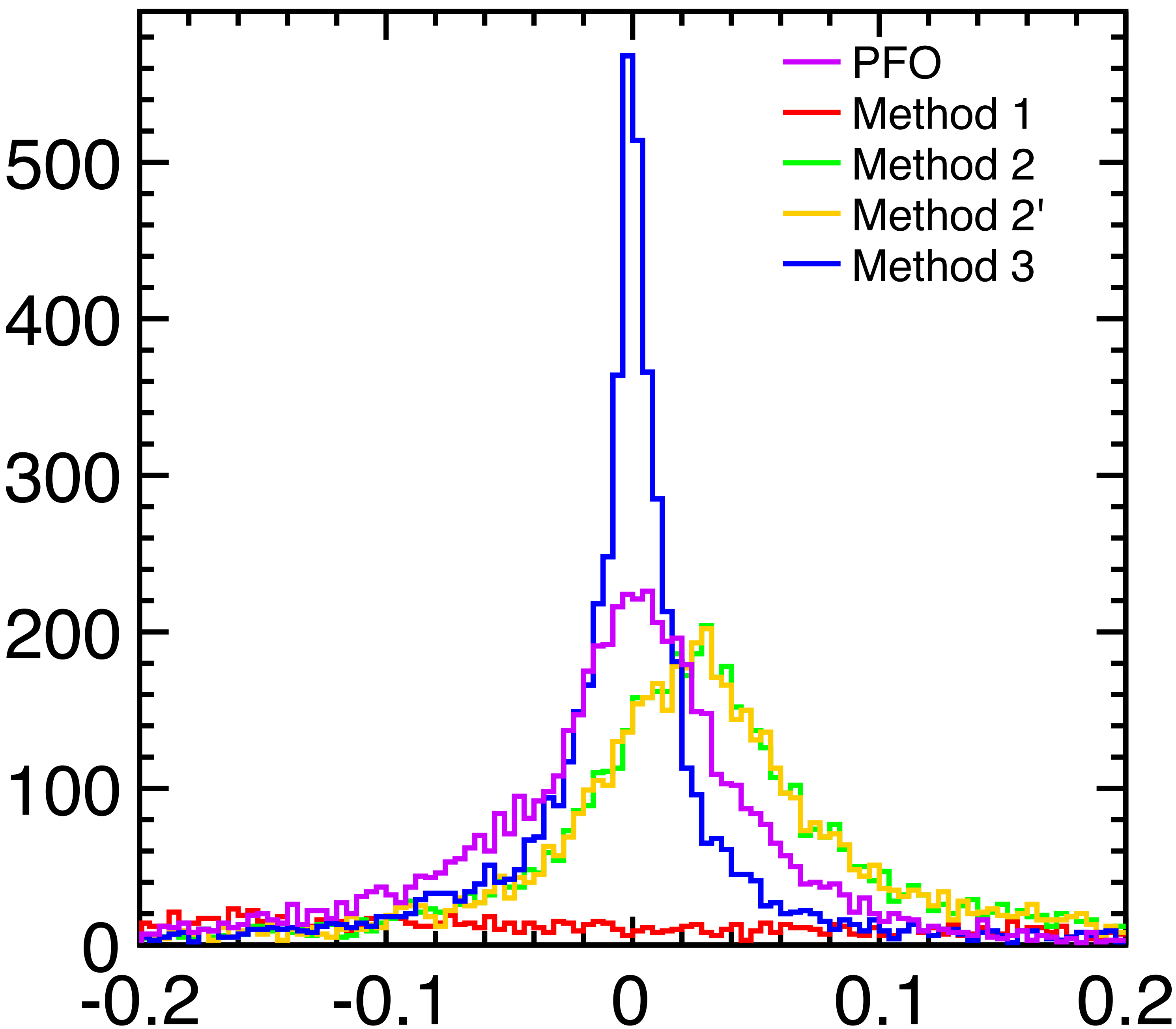
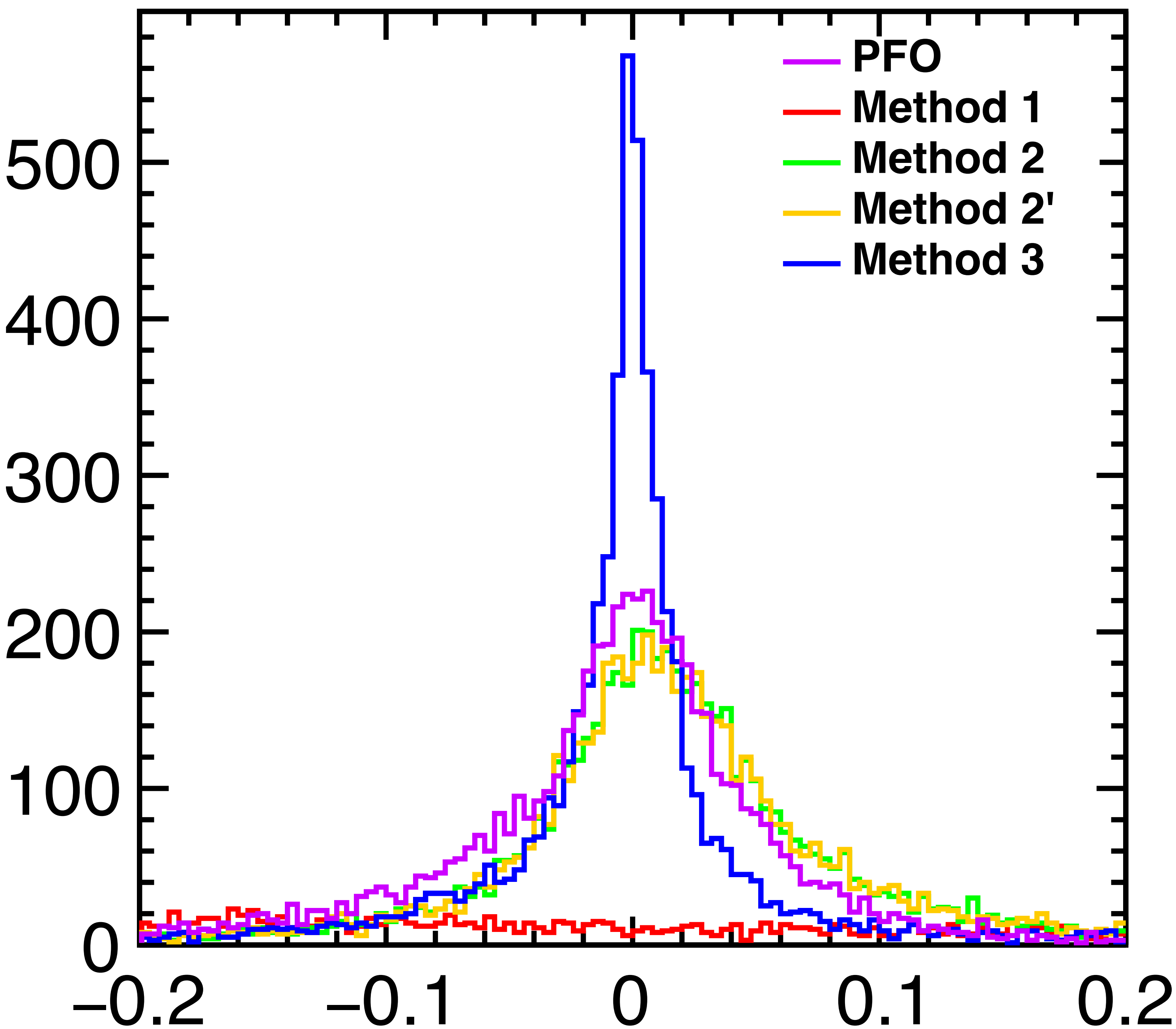


Relative Difference

Method 2 and 2' have positive shift.

Method comparison of jet1 E difference Correct photon selection events



Relative Difference

Using "Smeared MCtruth Eγ" as input in Method 2 and 2'.

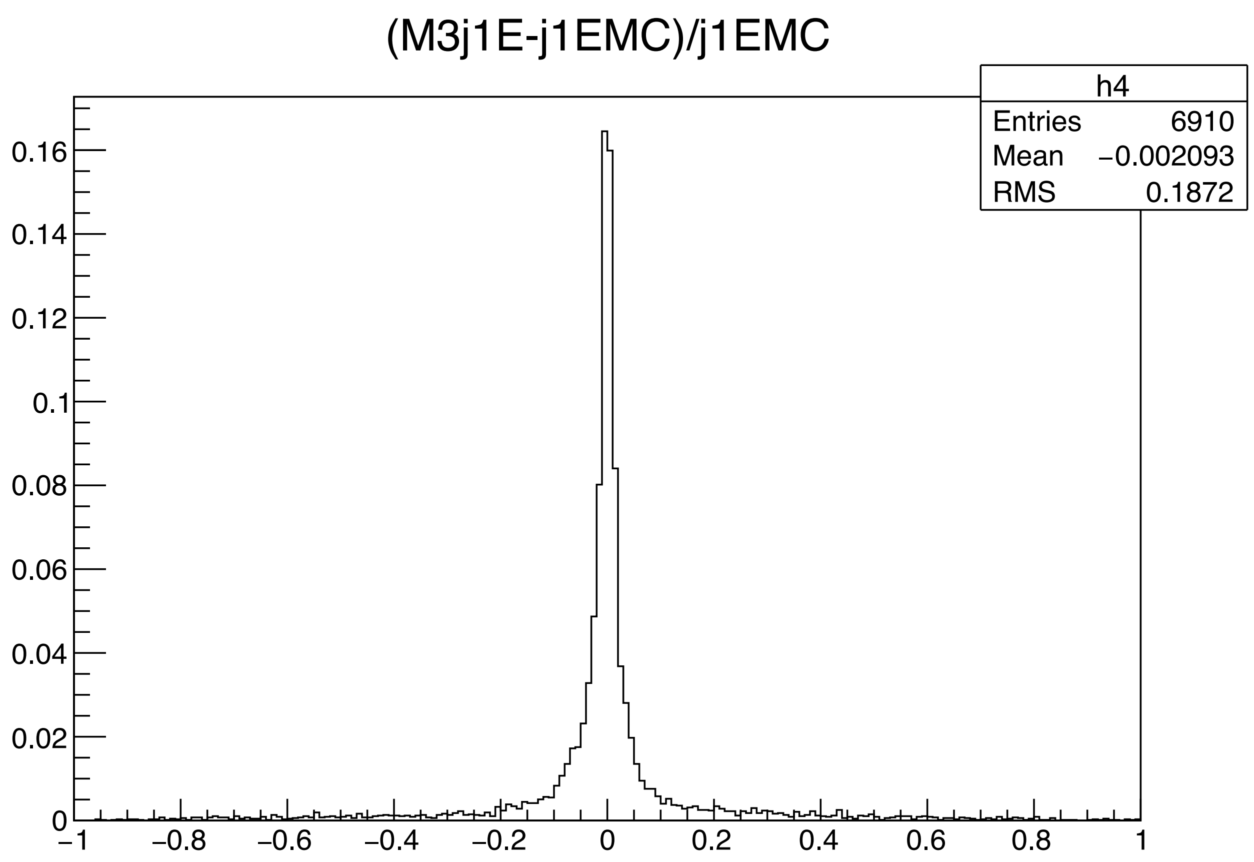
"EγMC+0.17*sqrt(EγMC)*gRandom->Gaus() +0.01*EγMC*gRandom->Gaus();

The positive shift disappeared.

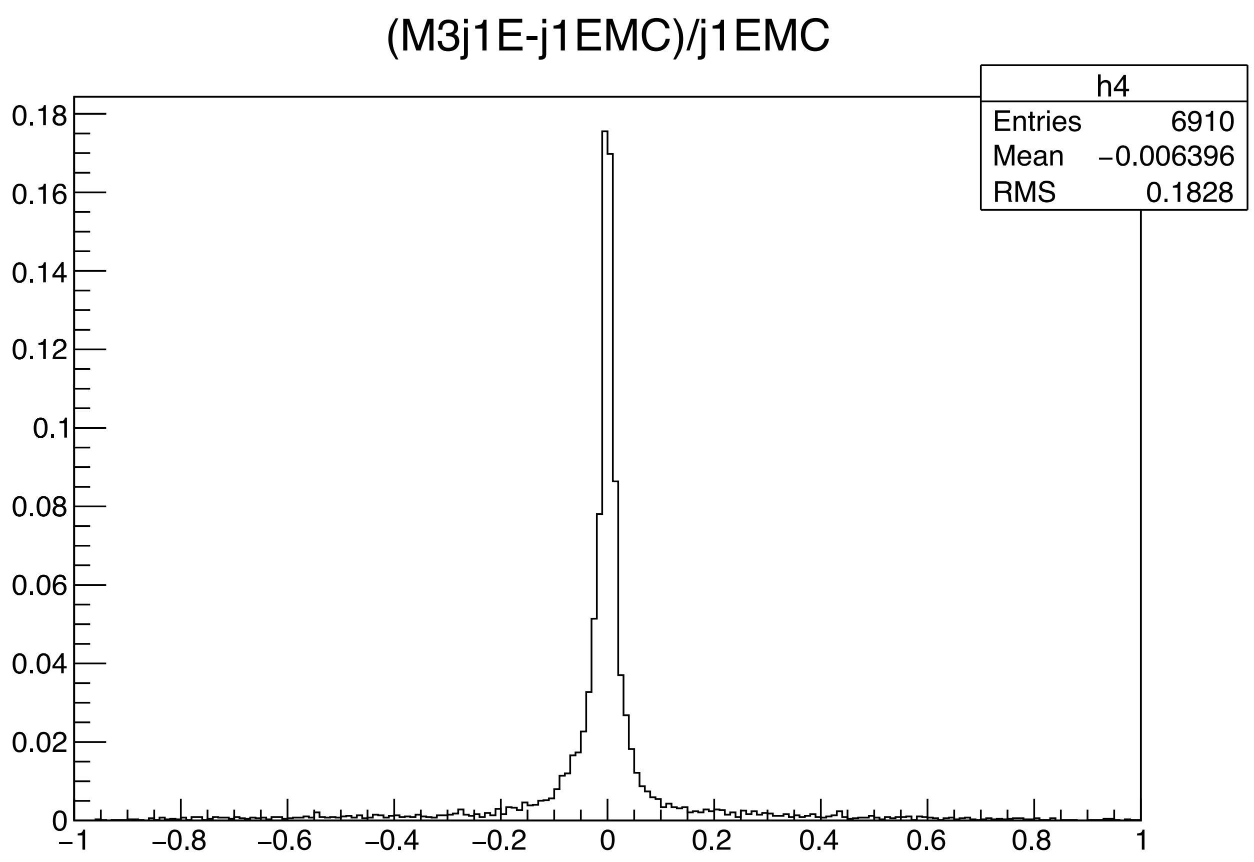
Effects of overlay

J1 E resolution by Method 3

With overlay



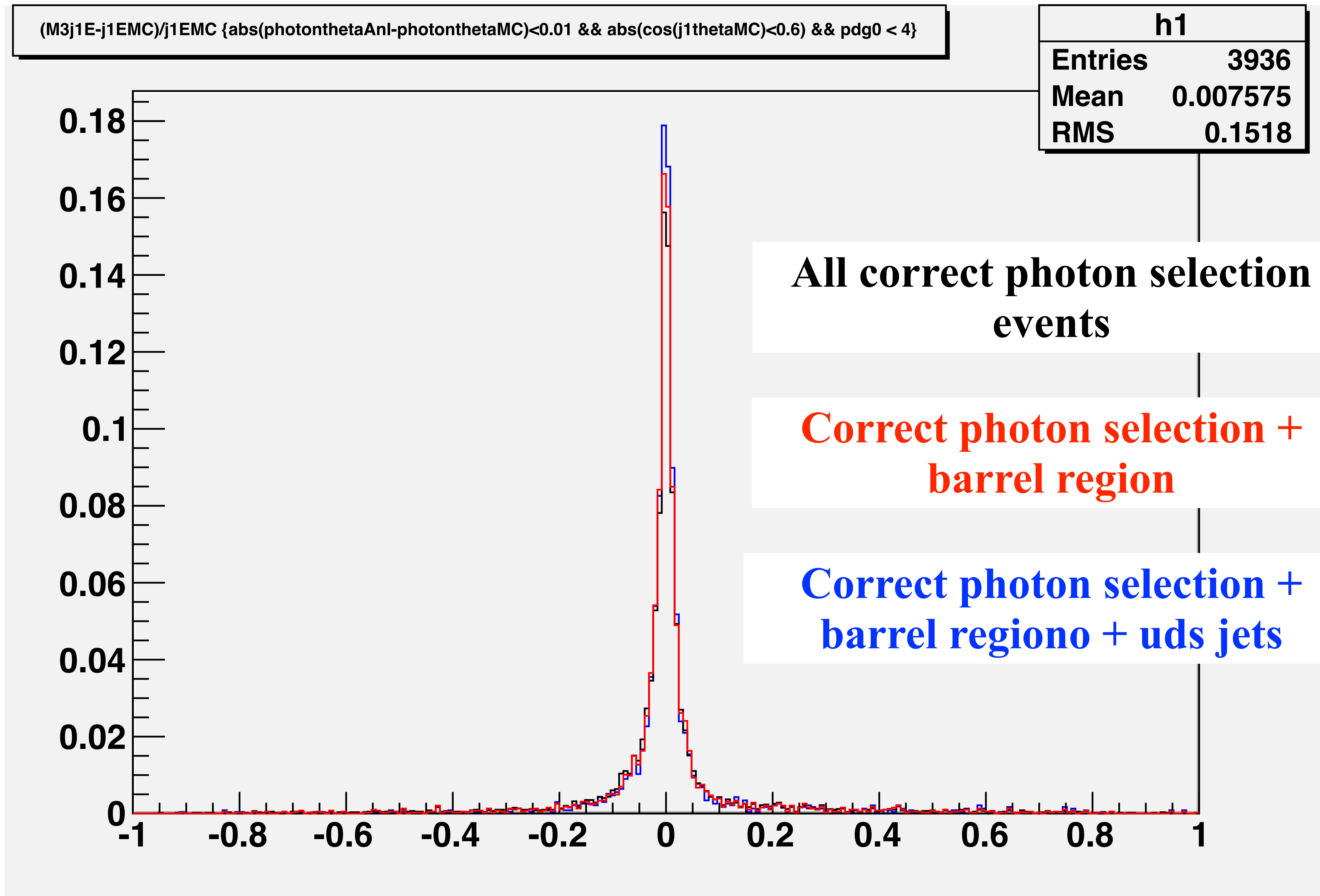
Without overlay



It became slightly better if we remove the overlay.
Especially, positive region tail is mitigated.

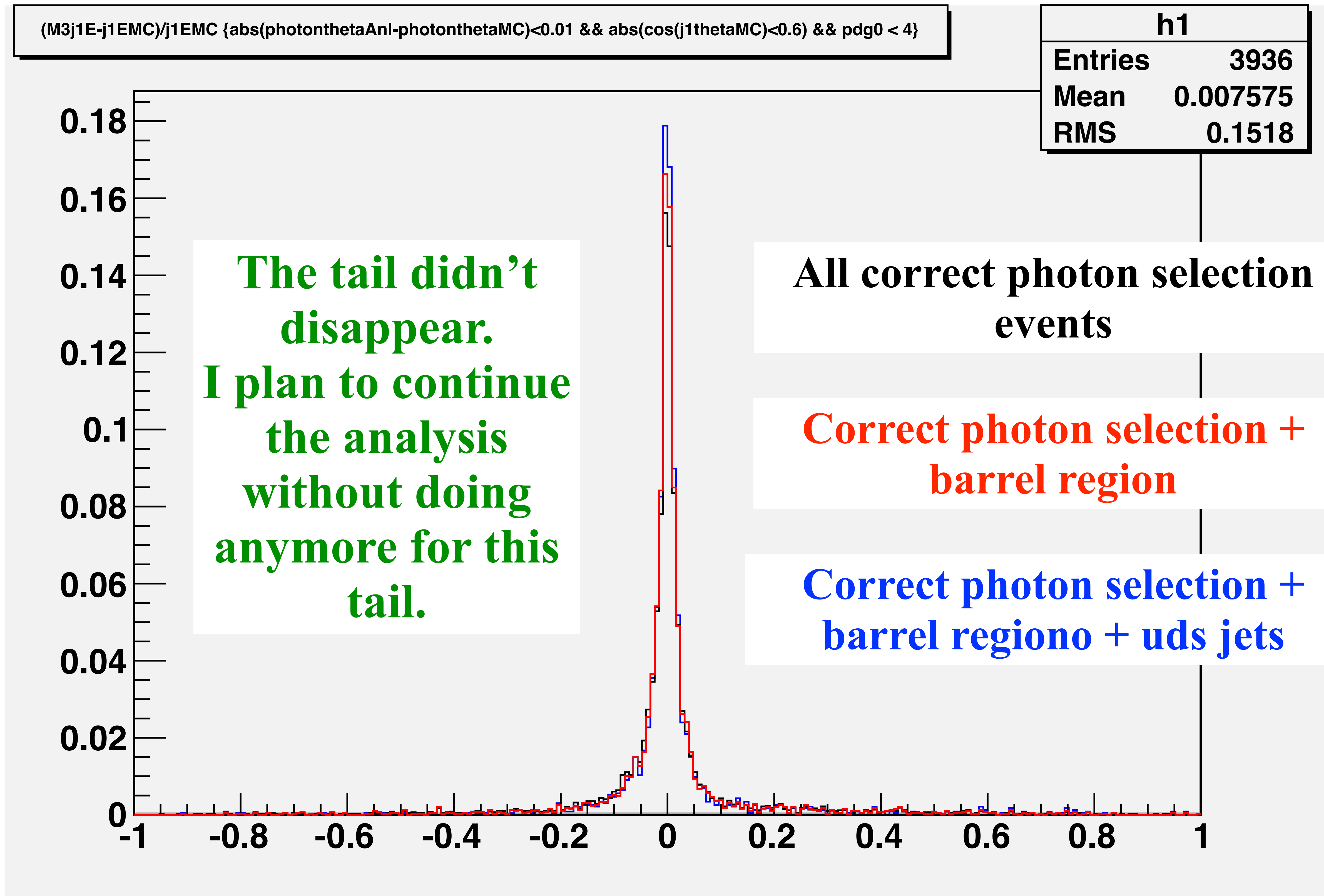
Removing tail

J1 E resolution by Method 3 (Normalized)



Removing tail

J1 E resolution by Method 3 (Normalized)



250 GeV DBD analysis

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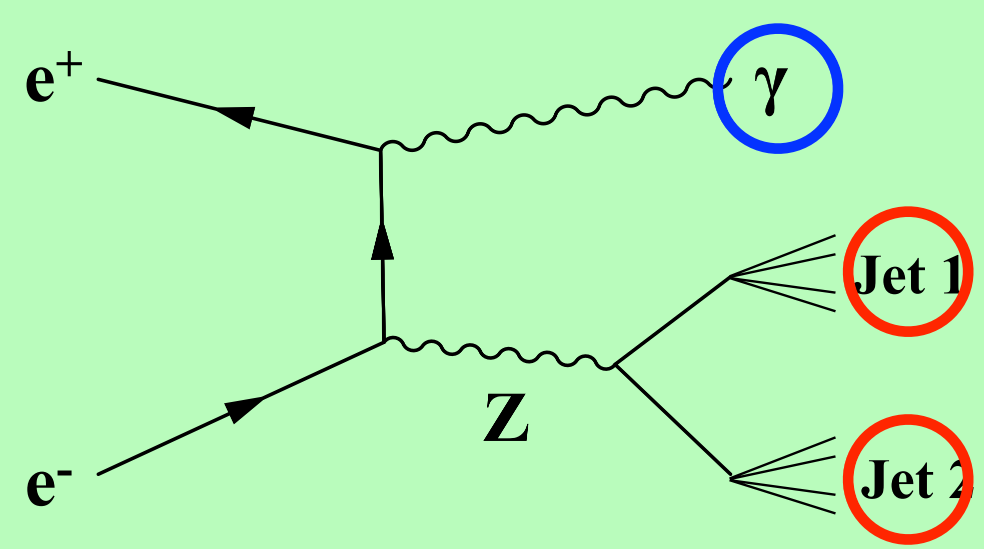
Jet Energy Scale Calibration



Backup

Jet Energy Reconstruction Method

Basic ideas: apply momentum conservation
Inputs: measured jet directions and mass and photon directions

Method 1: Use 3-momentum conservation and ignore ISR
Using $(\theta_{J1},\theta_{J2},\theta_{\gamma},\varphi_{J1},\varphi_{J2},\varphi_{\gamma},)$ -> Determine $(P_{J1},P_{J2},P_{\gamma})$

Method 2': Use transverse momentum conservation and ignore ISR /Use measured P_{γ} as input
Using $(\theta_{J1},\theta_{J2},\theta_{\gamma},\varphi_{J1},\varphi_{J2},\varphi_{\gamma},\mathbf{P_{\gamma}})$ -> Determine (P_{J1},P_{J2})

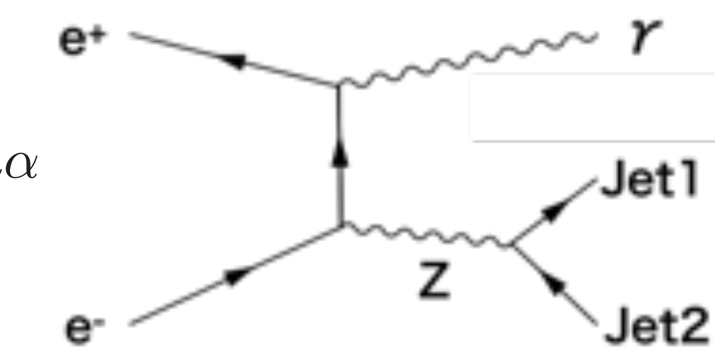
Method 2: Use 4-momentum conservation and consider ISR /Use measured P_{γ} as input
Using $(\theta_{J1},\theta_{J2},\theta_{\gamma},\varphi_{J1},\varphi_{J2},\varphi_{\gamma},m_{J1},m_{J2},\mathbf{P_{\gamma}})$ -> Determine (P_{J1},P_{J2},P_{ISR})

Method 3: Use 4-momentum conservation and consider ISR and solve the full equation
Using $(\theta_{J1},\theta_{J2},\theta_{\gamma},\varphi_{J1},\varphi_{J2},\varphi_{\gamma},m_{J1},m_{J2})$ -> Determine $(P_{J1},P_{J2},P_{\gamma},P_{ISR})$

Reconstruction Method

Based on 4-momentum conservation

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



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

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

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})

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

Method 2: Use measured P_γ as input and Ignore ISR
Using (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})

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

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

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

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