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

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# Recent Progress

## Jet energy calibration using 250 GeV DBD sample

**1** Consideration of cut to exclude the wrong photon choice events

**2** Establishment of the new jet energy reconstruction method "Method 4A" & "Method 4B"

# 1 Consideration of cut to exclude the wrong photon choice events

**Full simulation to reconstruct the jet energies -> It turned out that signal photon selection is failed in (38122 events) / 311675.**

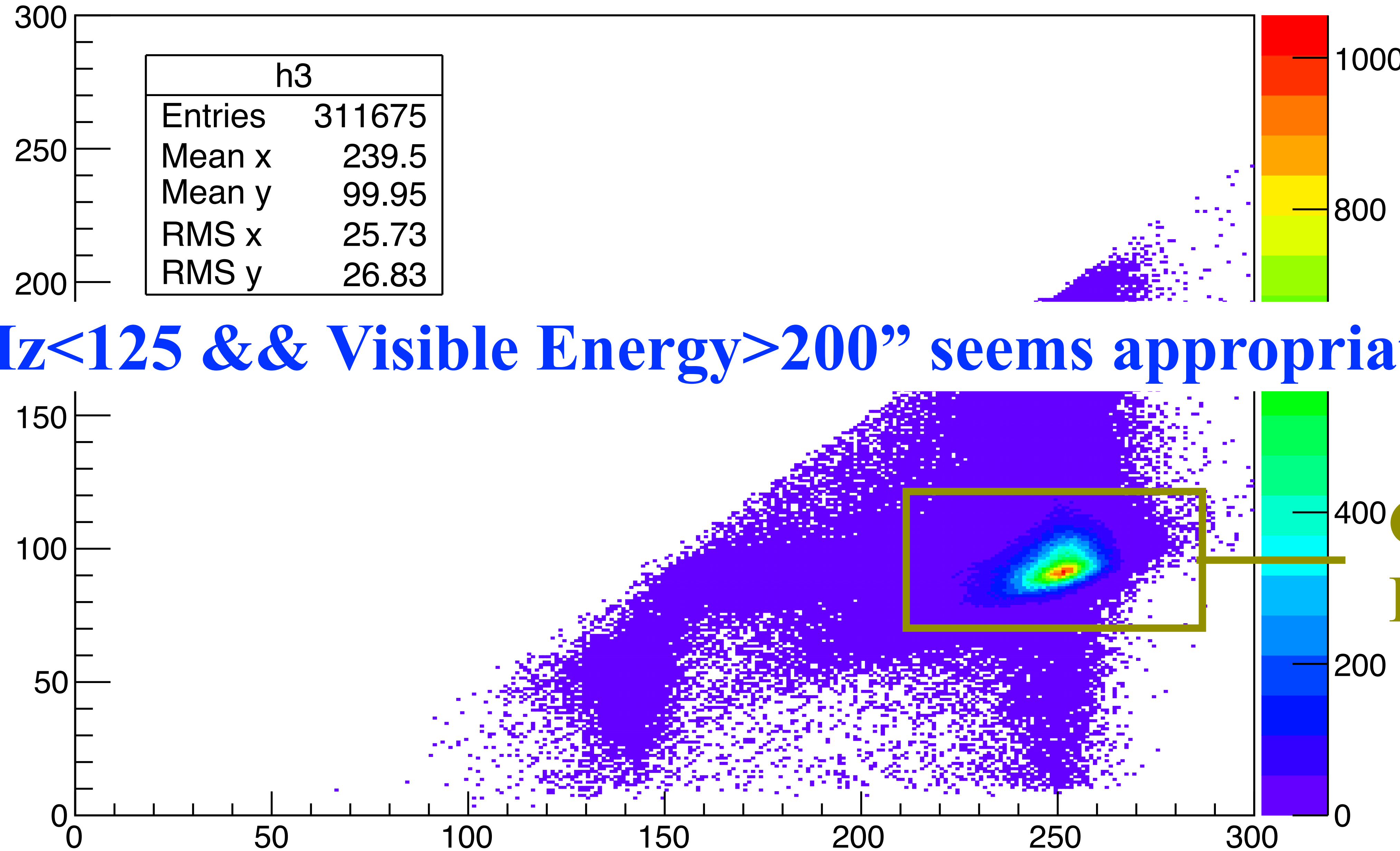
**We need to consider the cut to exclude the wrong photon choice events**
**Not noly "MCcut" but also "Realistic cut"**

# 1. Previous Result

## Mz vs. Visible Energy (=Ej1+Ej2+Eγ)

mz:(j1EAnl+j2EAnl+photonEAnl)

Mz (GeV)




**“Mz<125 && Visible Energy>200” seems appropriate.**

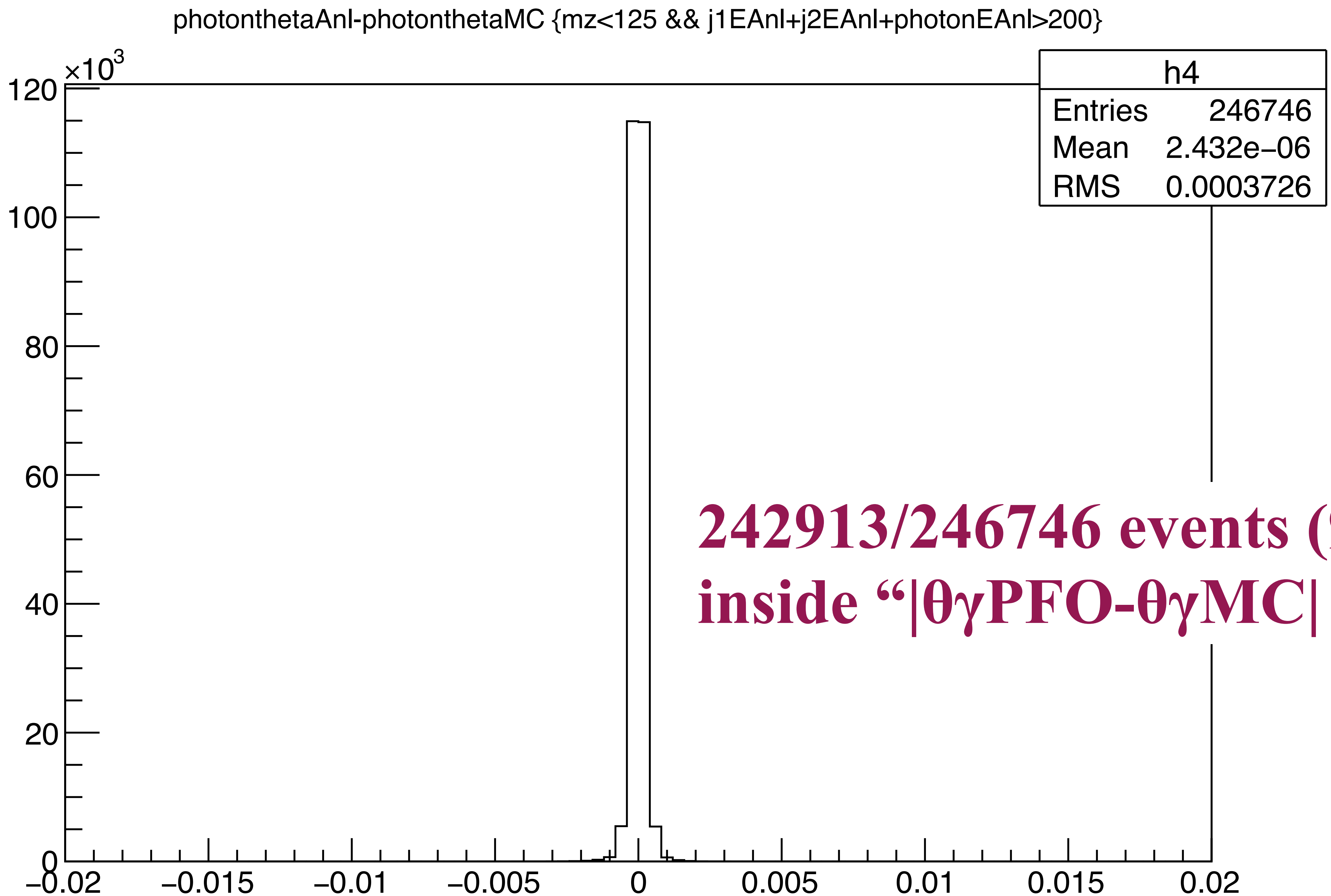
Correct Photon

Visible Energy (GeV)

# 1. Previous Result

## “Mz<125 && Visible Energy>200”

## θ difference (rad)



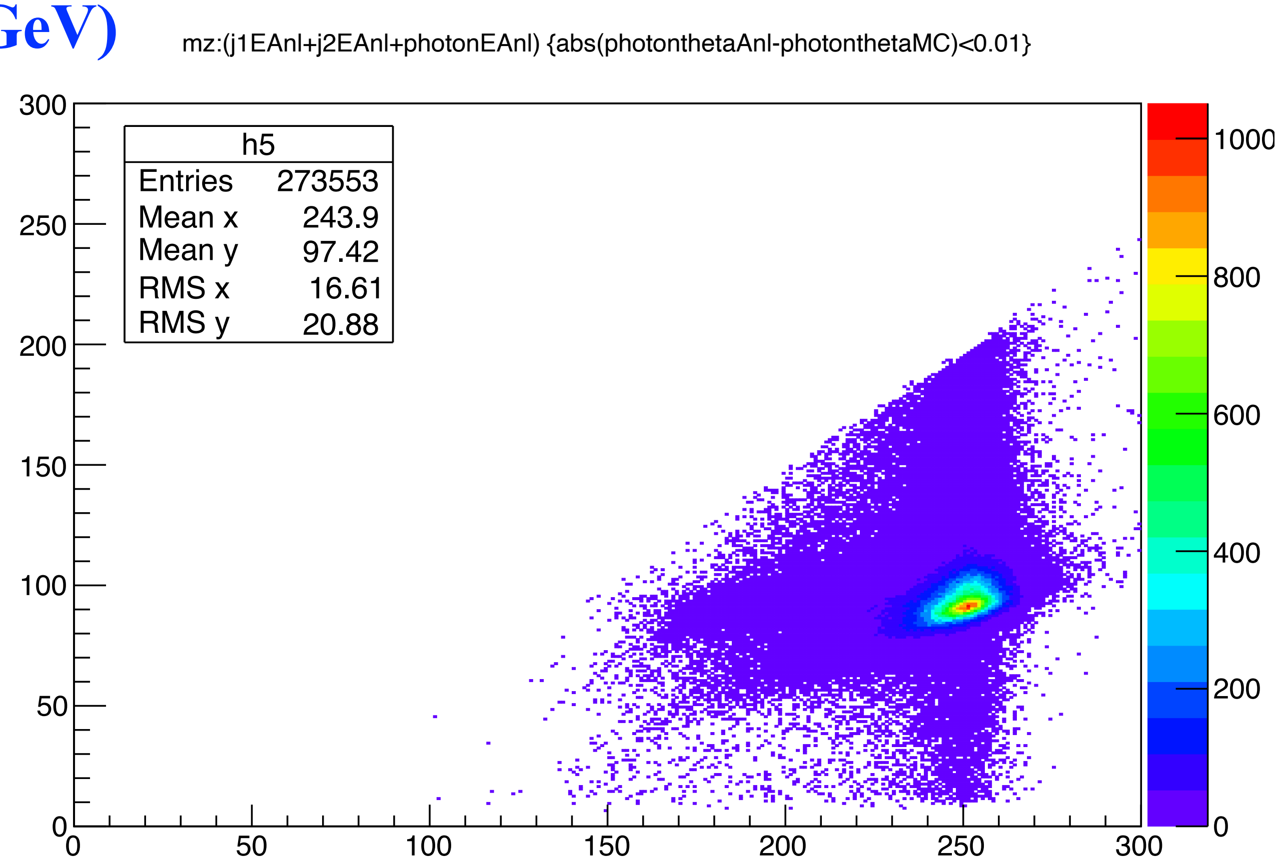

**242913/246746 events (98.4%) inside “|θγPFO-θγMC| <0.01”**

# 1. Realistic Cut

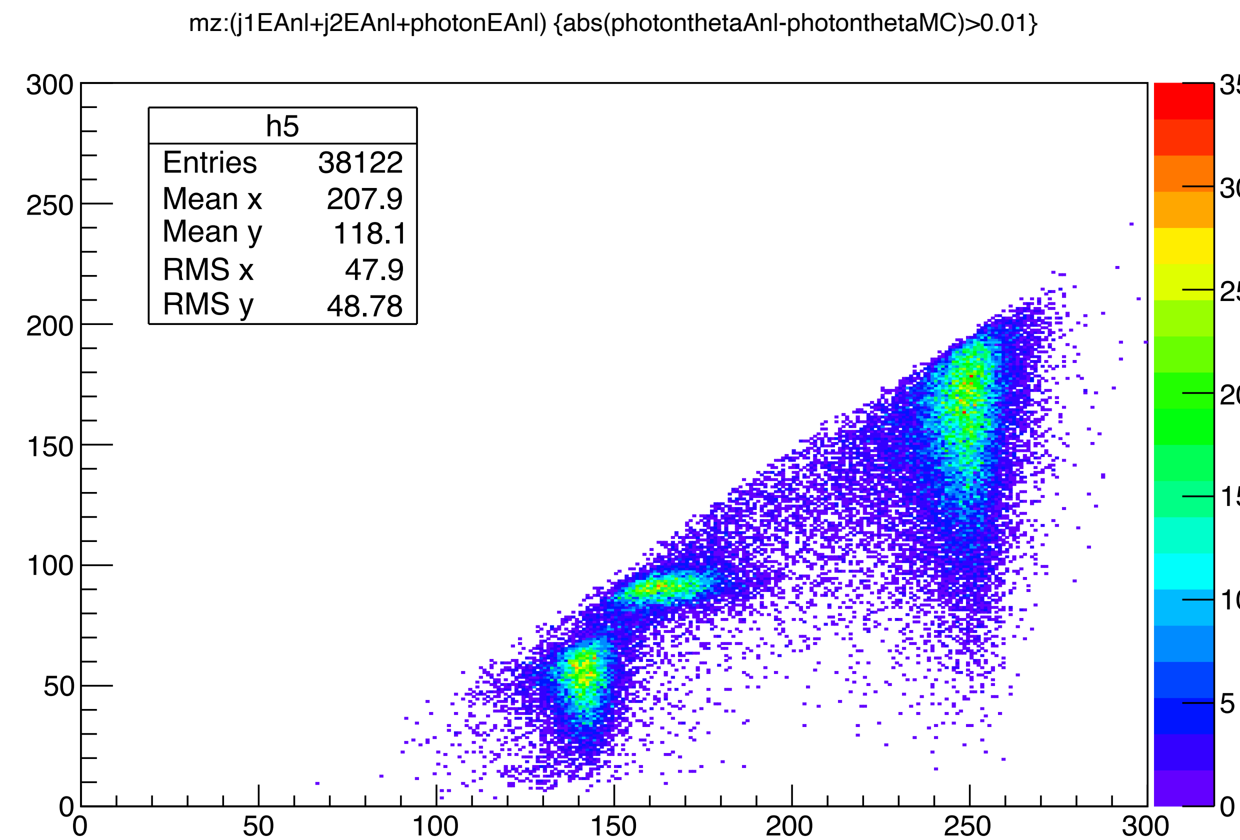
## Mz vs. Visible Energy (=Ej1+Ej2+Eγ)

Mz (GeV)

**correct photon case**




**wrong photon case**

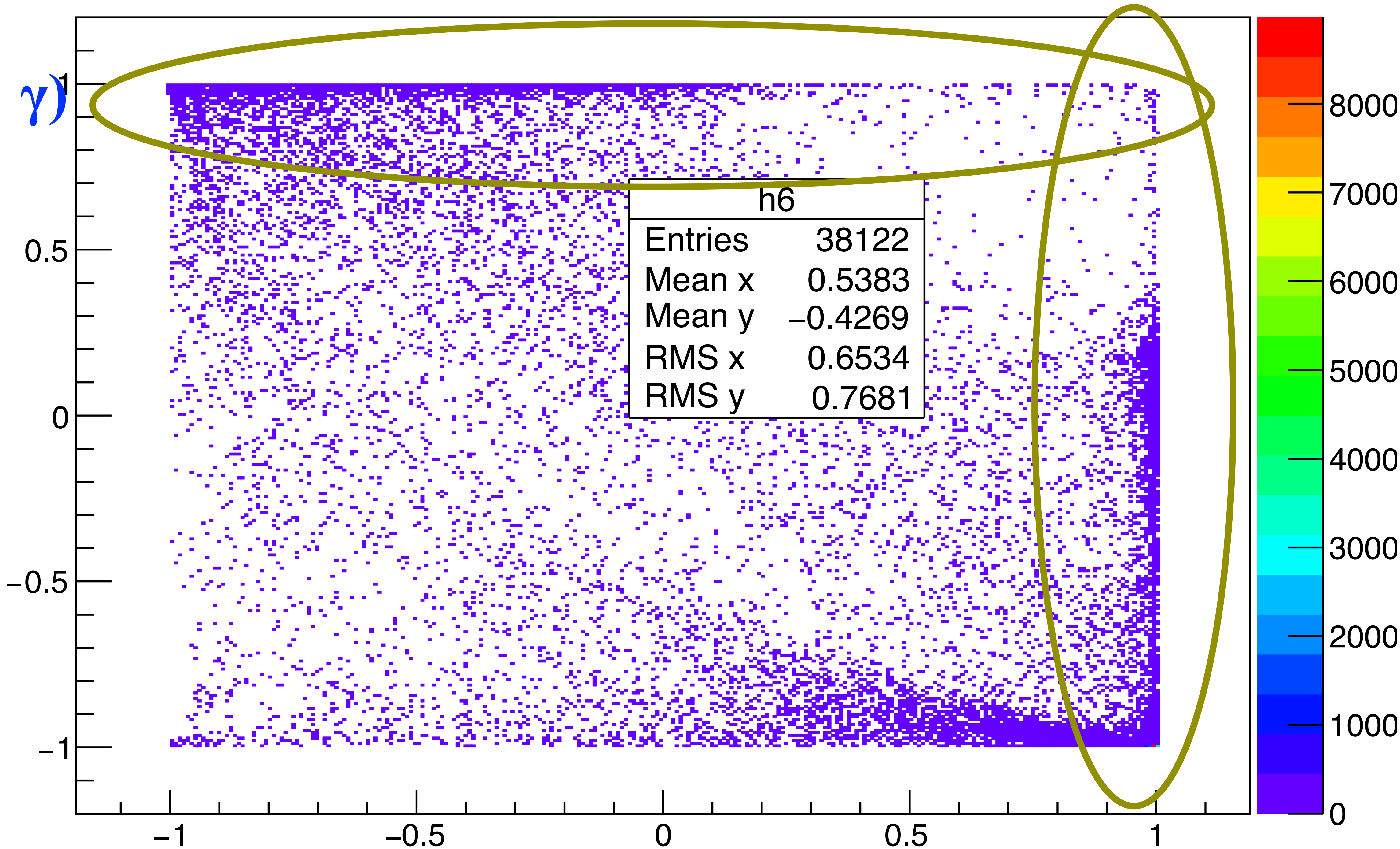



Visible Energy (GeV)

**It seems useless to add lower bound cut "Mz>aa" in addition to cut "Mz<125 && Visible Energy>200".**

# 1. Realistic Cut

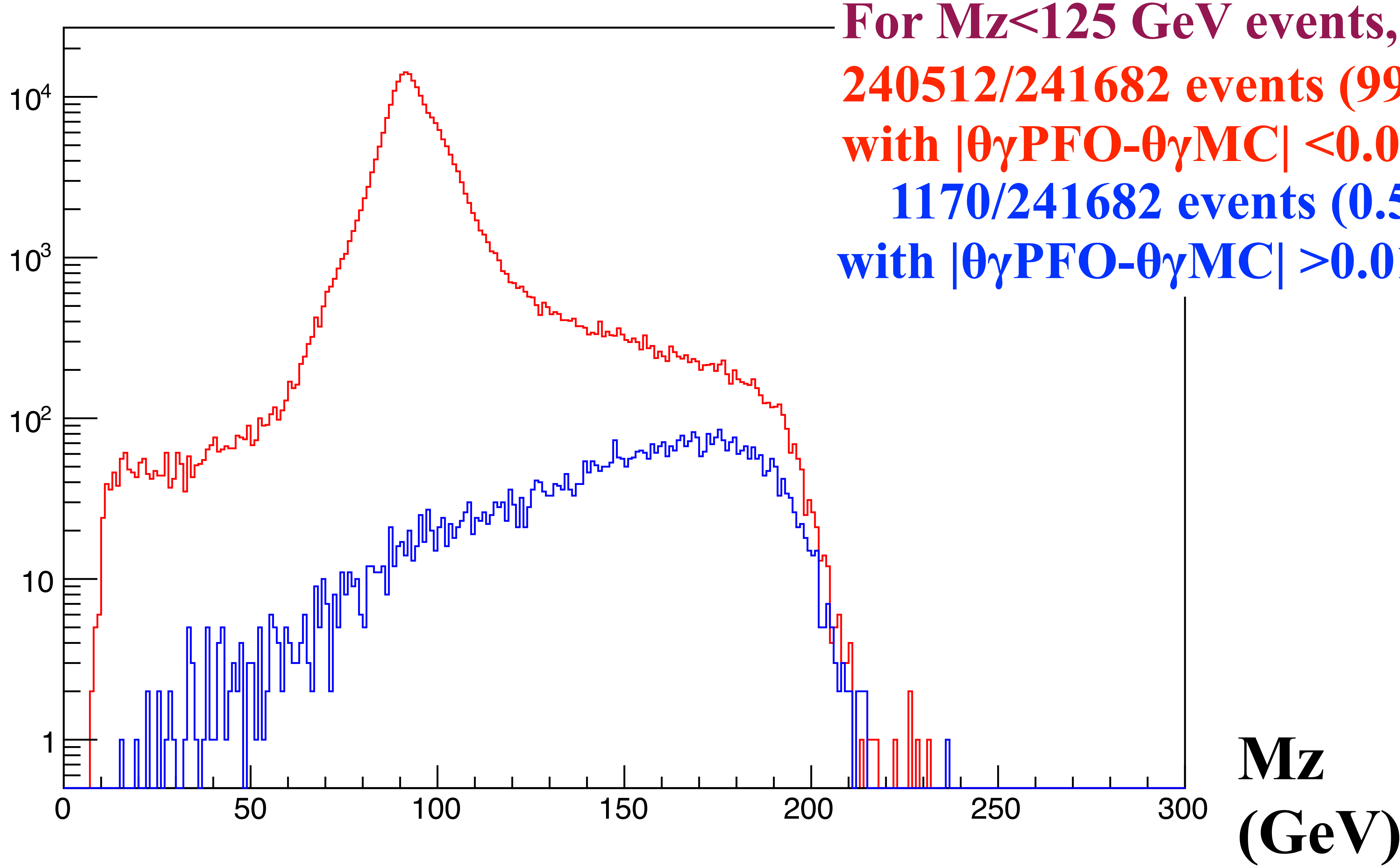
**Normalized inner product of measured jet and measured photon for wrong photon selection events**



# 1. Realistic Cut

**Mz for “Visible Energy>200 && cosθ(Jet1,2・γ)<0.95” events**

**“|θγPFO-θγMC| <0.01” and “|θγPFO-θγMC| <0.01” events**




**For Mz<125 GeV events,**
**240512/241682 events (99.5%) with |θγPFO-θγMC| <0.01**
**1170/241682 events (0.5%) with |θγPFO-θγMC| >0.01**

# 1. Realistic Cut

**Cut "Mz<125 && Visible Energy>200": 242913/246746 are correct.**

**Cut "Mz<125 && Visible Energy>200 && cosθ(Jet1 • γ)<0.95 && cosθ(Jet2 • γ)<0.95": 240512/241682 are correct.**

| | MC Level Cut | Realistic Cut |
|---|---|---|
| In all case | "Method 3 has answer"<br>"\|θγPFO-θγMC\| <0.01" | "Method 3 has answer"<br>"Mz<125 && Visible Energy>200"<br>**"cosθ(Jet1 • γ)<0.95"**<br>**"cosθ(Jet2 • γ)<0.95"** |
| To narrow the phase space | "$\theta_{J1}$MC<…"<br>"$E_{J1}$MC<…"<br>… | "$\theta_{J1}$Measured<…"<br>"$E_{J1}$Measured<…"<br>… |

# 2 Establishment of the new jet energy reconstruction method “Method 4A” & “Method 4B”

**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 ($P_{J1},P_{J2},P_{\gamma},P_{ISR}$)

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

Matrix A

Inverse

**Had to solve two quartic equations and choose the best answer!**
**-> Are there any easier expression?**

# 2 Establishment of the new jet energy reconstruction method "Method 4A" & "Method 4B"

**Jet mass "m" can be expressed as "P/γβ" (P: momentum of the jet)**
**-> Irrational equation ① is reduced to be a linear equation!**

$$\sqrt{P_{J1}^2 + m_{J1}^2} + \sqrt{P_{J2}^2 + m_{J2}^2} + P_\gamma + |P_{ISR}| = E_{CM}$$

$$\Rightarrow |P_{J1}|\sqrt{1 + \frac{1}{(\gamma\beta)_{J1}^2}} + |P_{J2}|\sqrt{1 + \frac{1}{(\gamma\beta)_{J2}^2}} + P_\gamma + |P_{ISR}| = E_{CM}$$

**-> Use measured γβ as inputs**

**Method 4: Consider ISR and solve the full equation**
Using ($\theta_{J1}, \theta_{J2}, \theta_\gamma, \varphi_{J1}, \varphi_{J2}, \varphi_\gamma$, $\boldsymbol{\gamma\beta_{J1}}, \boldsymbol{\gamma\beta_{J2}}$) -> Determine ($P_{J1}, P_{J2}, P_\gamma, P_{ISR}$)

**Method 4A: Represent the equation with $P_{ISR}$**

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

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

**Choose the solution with solved $P_\gamma$ closest to the measured $P_\gamma$**

**Method 4B: Represent the equation with $P_\gamma$**

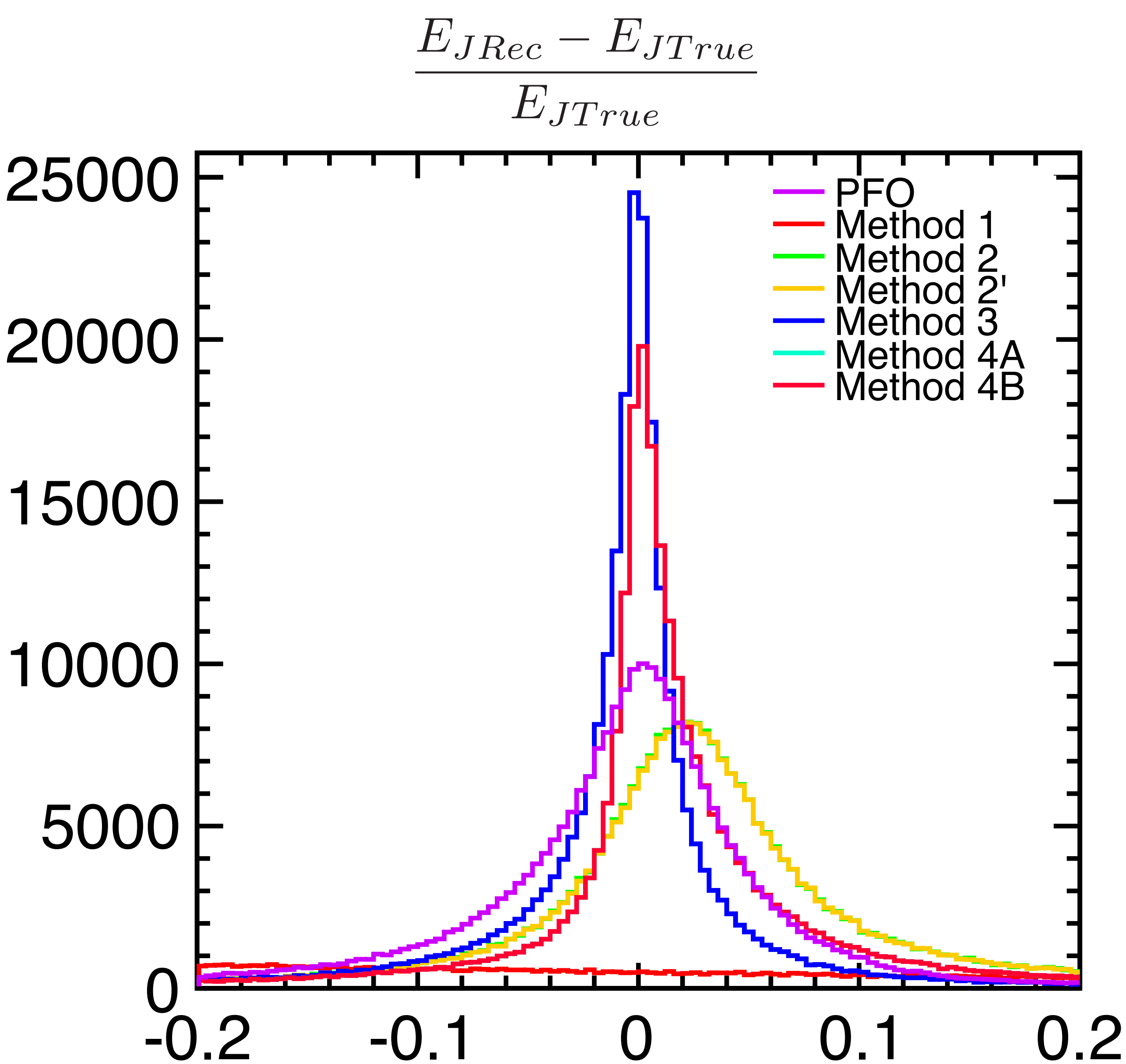
Using ($\theta_{J1},\theta_{J2},\theta_\gamma,\varphi_{J1},\varphi_{J2},\varphi_\gamma,\gamma\beta_{J1},\gamma\beta_{J2}$) -> Determine ($P_{J1},P_{J2},P_\gamma,P_{ISR}$)

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

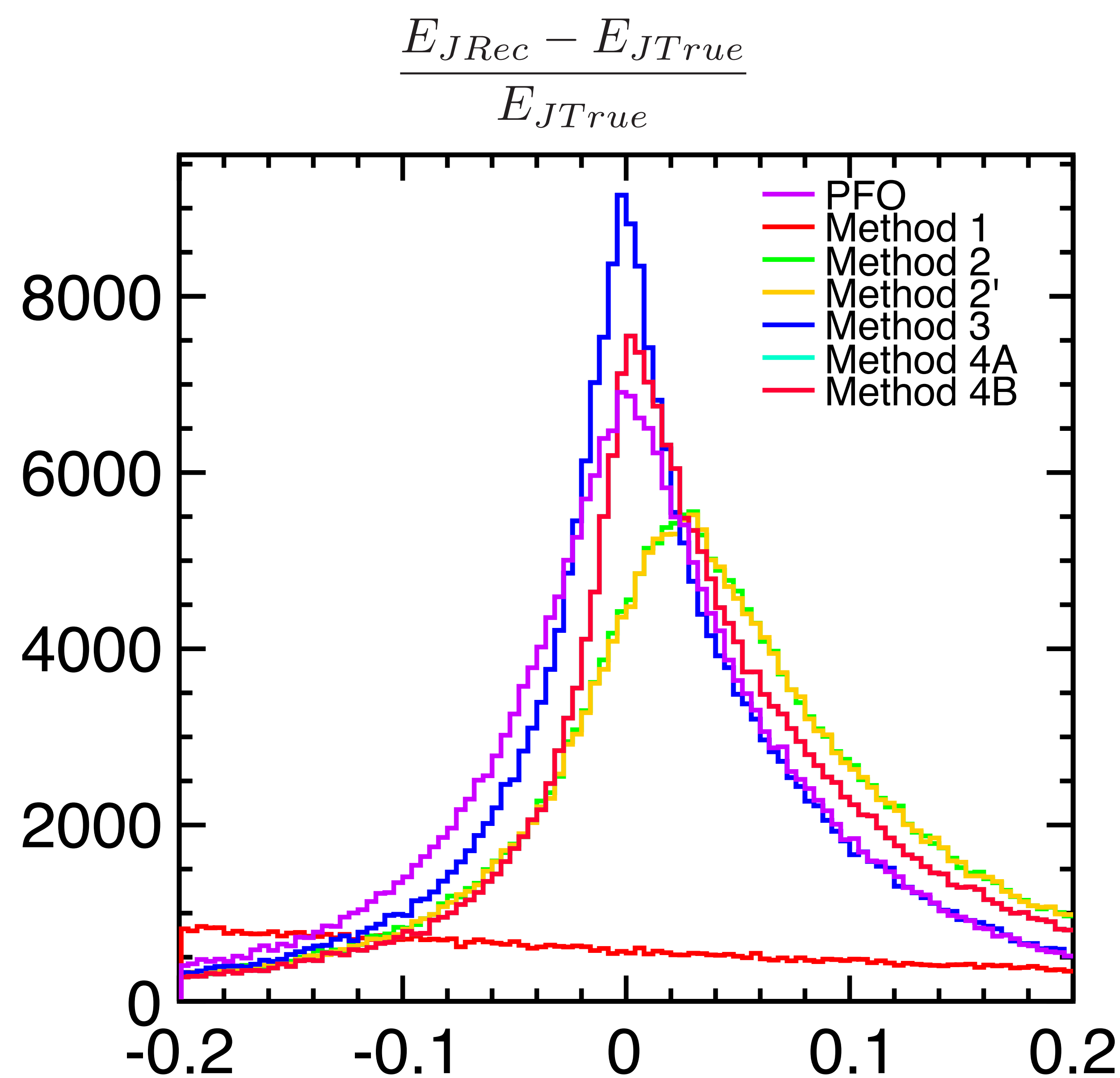
**Choose the solution with solved $P_\gamma$ closest to the measured $P_\gamma$**

# Method Comparison Result

**Jet 1**




**Jet 2**




**Method 4A and 4B are exactly same (because equations are very simple and only sign ambiguity exists).**

**Method 3 is the best judging from peak height and symmetry.**

# Conclusion

- **New realistic cut "Mz<125 && Visible Energy>200 && cosθ(Jet1・γ) <0.95 && cosθ(Jet2・γ) <0.95" seems to be better than previous one.**
  **In this cut, 99.5% of events are correct photon selection case while 98.4% for the previous cut.**

- **Method 4A and 4B using measured γβ as inputs are established so as to avoid the irrational equation in Method 3.**
  **However, Method 3 is the best judging from peak height and symmetry.**

- **I would like to get a final conclusion for the JES calibration before the JPS meeting.**


Thank you for your attention!