

**Status on $e^+e^- \rightarrow \gamma Z$ process
Jet Energy Calibration
: Jet Energy Reconstruction Method Study**

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Reconstruction Method

Method 3: Consider ISR and solve the full equation

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

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

Matrix A Inverse

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)

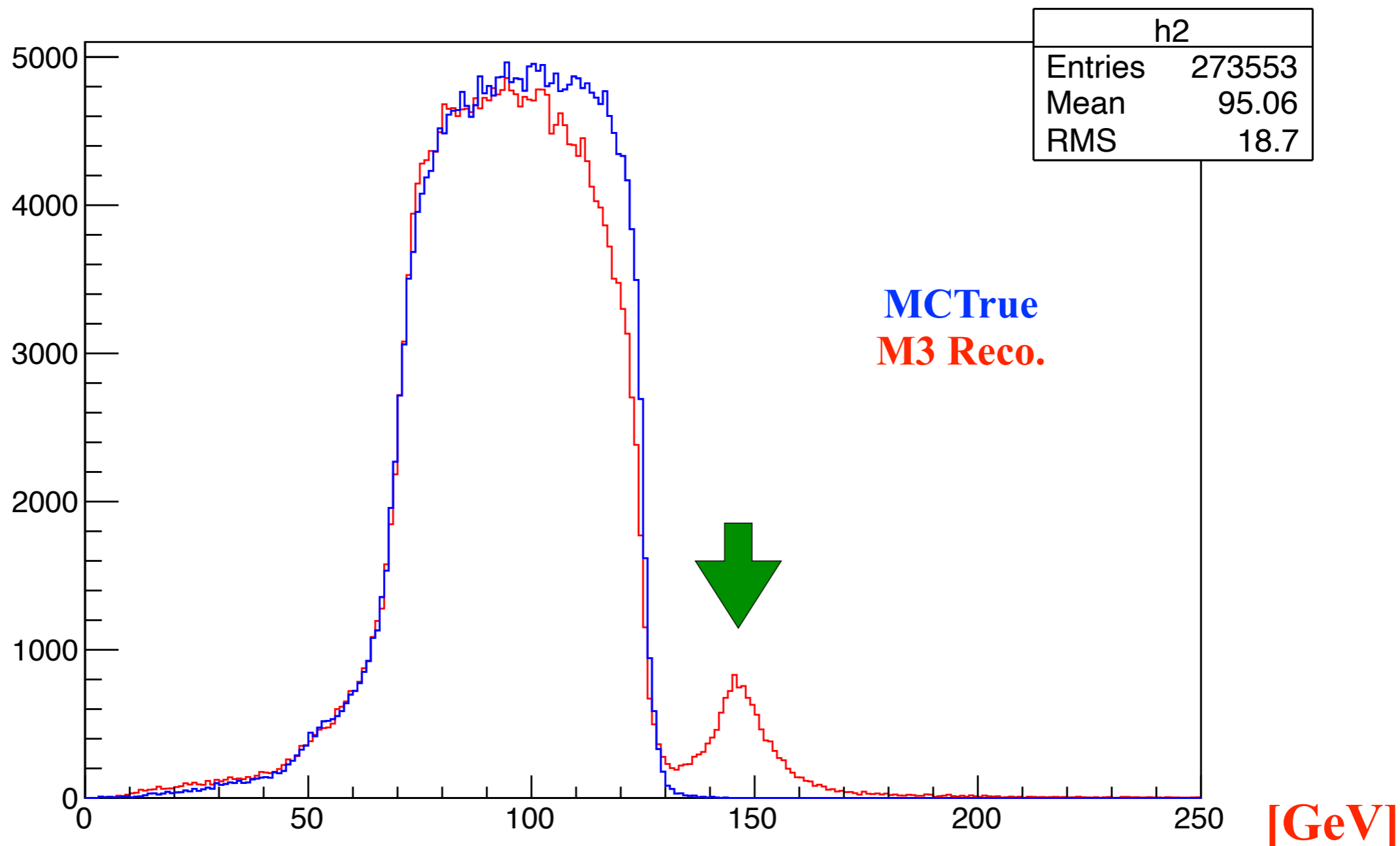
Choose the solution with

- (i) real and positive value with $< E_{CM}/2$
- (ii) solved P_{γ} closest to the measured P_{γ}

Problem: unexpected bump in reconstructed jet energy

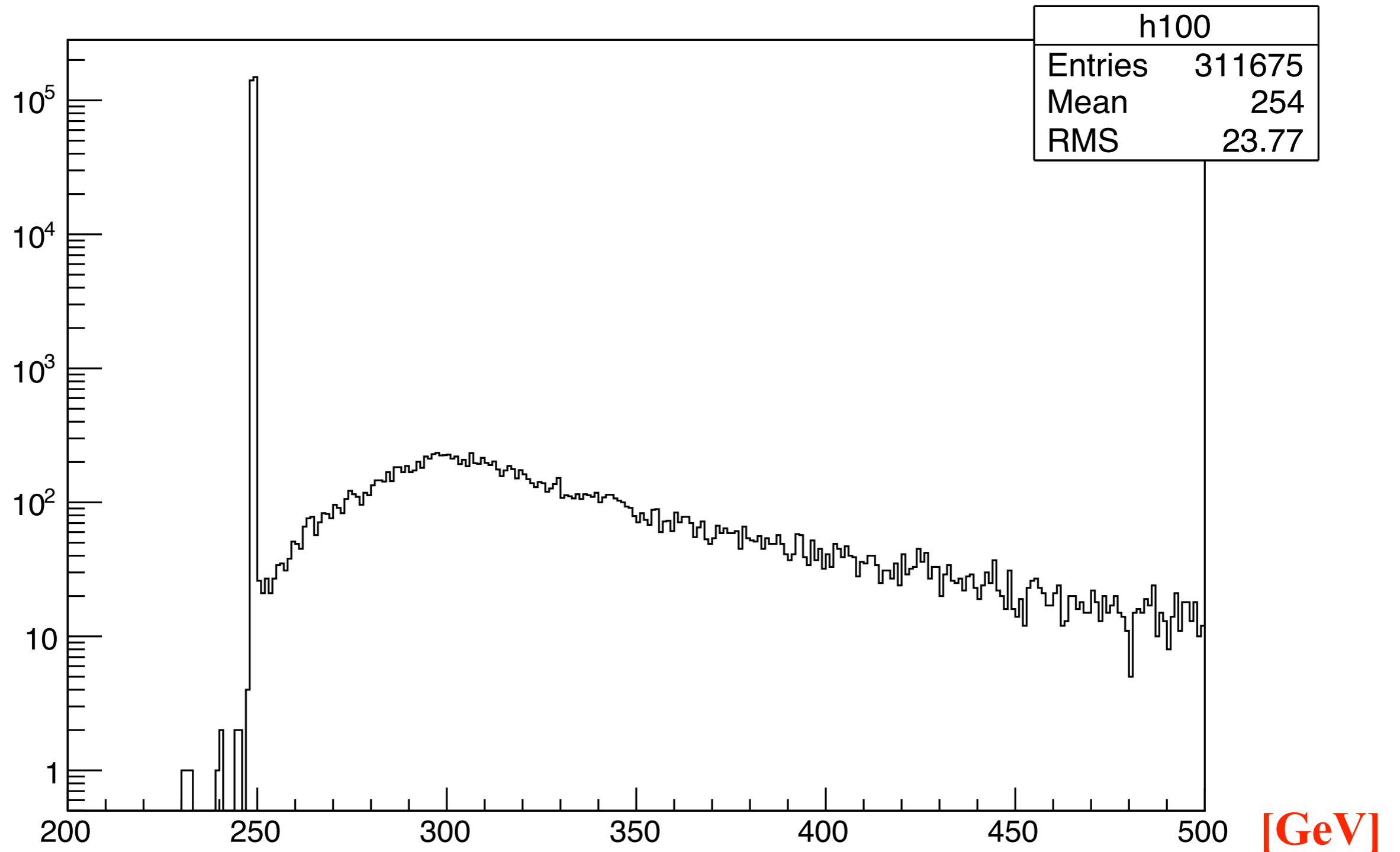
Method 3 Jet1 energy distribution

M3j1E {abs(photonthetaAnl-photonthetaMC)<0.01}



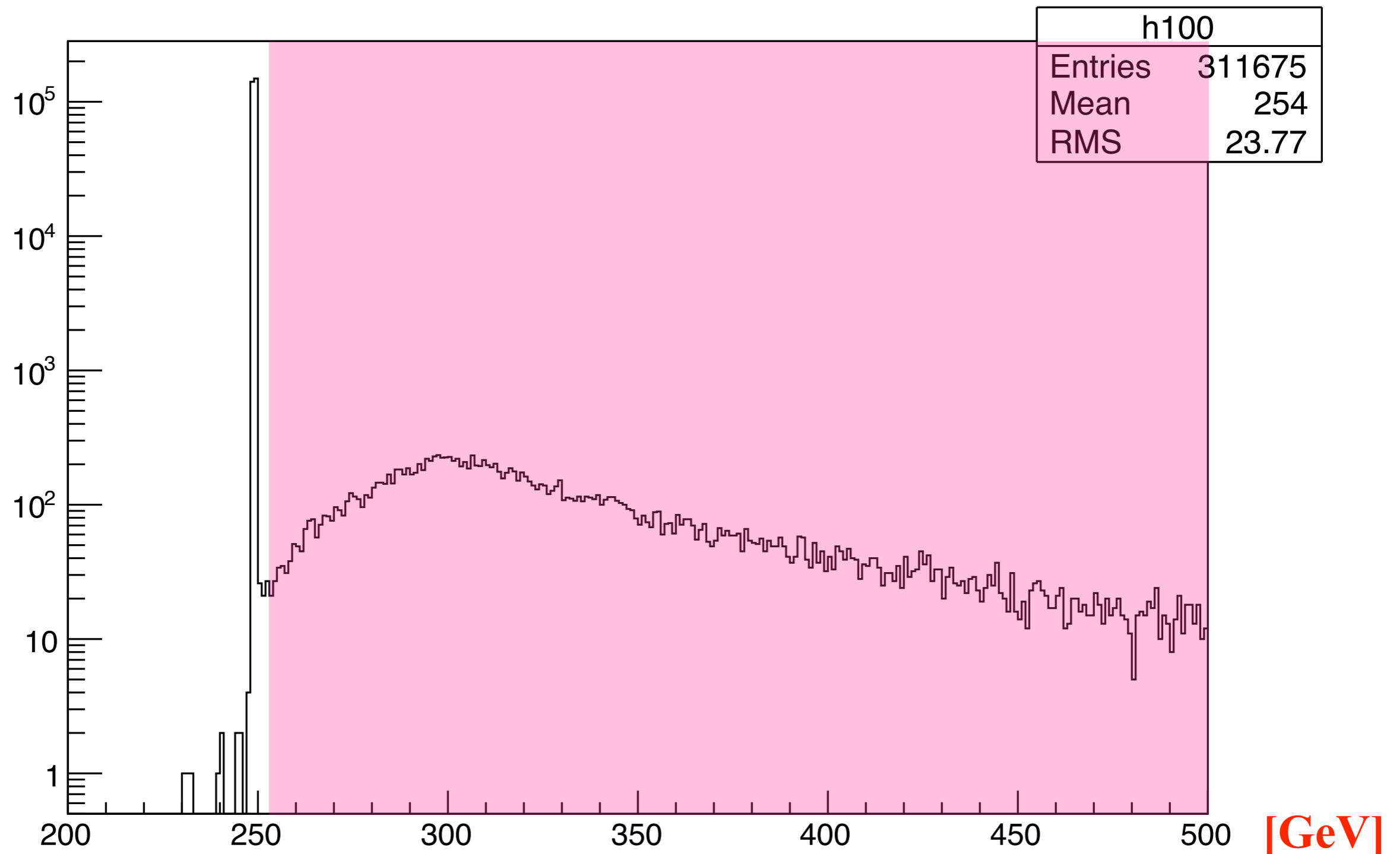
Sum of the Reconstructed Energy

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



Sum of the Reconstructed Energy

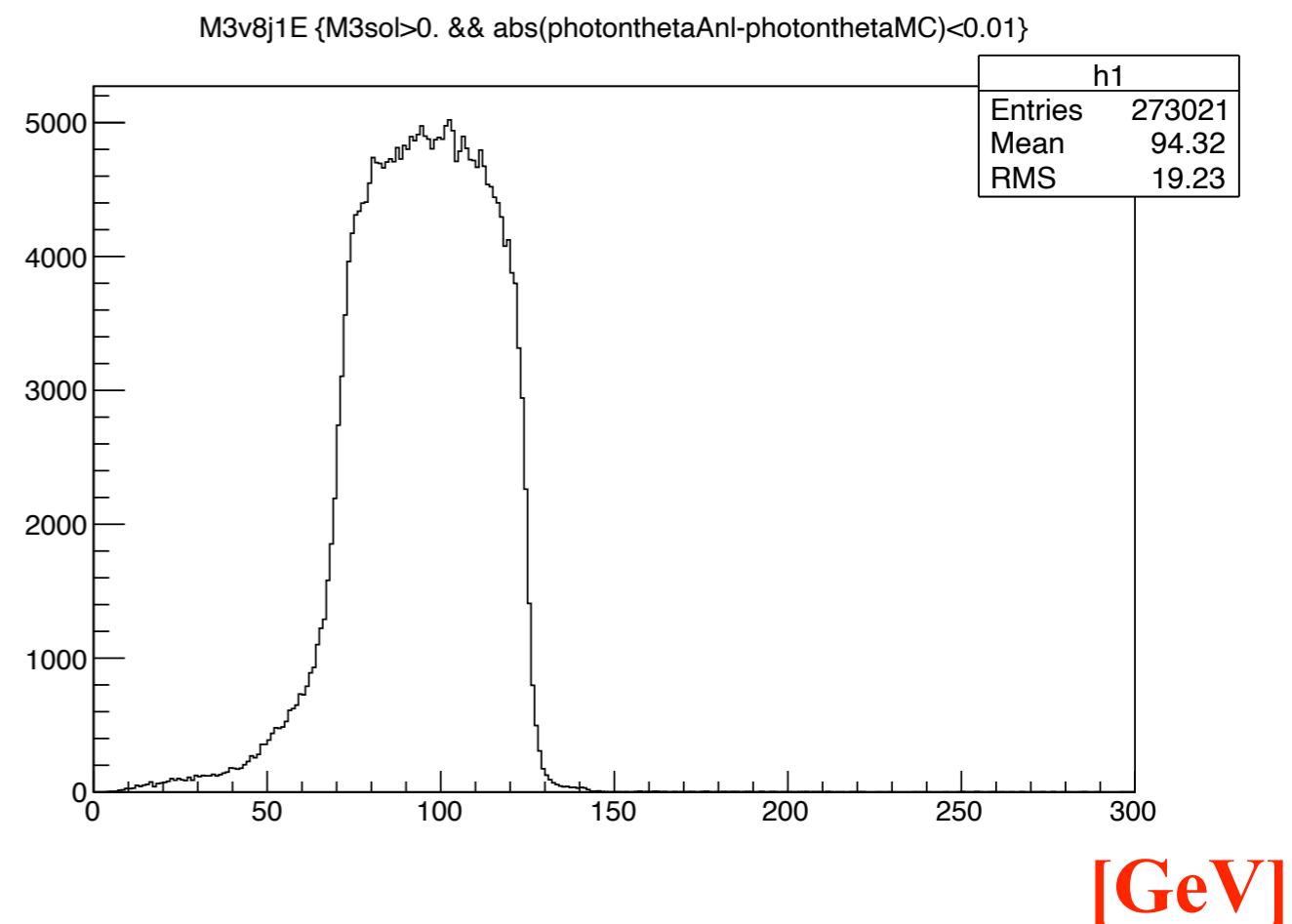
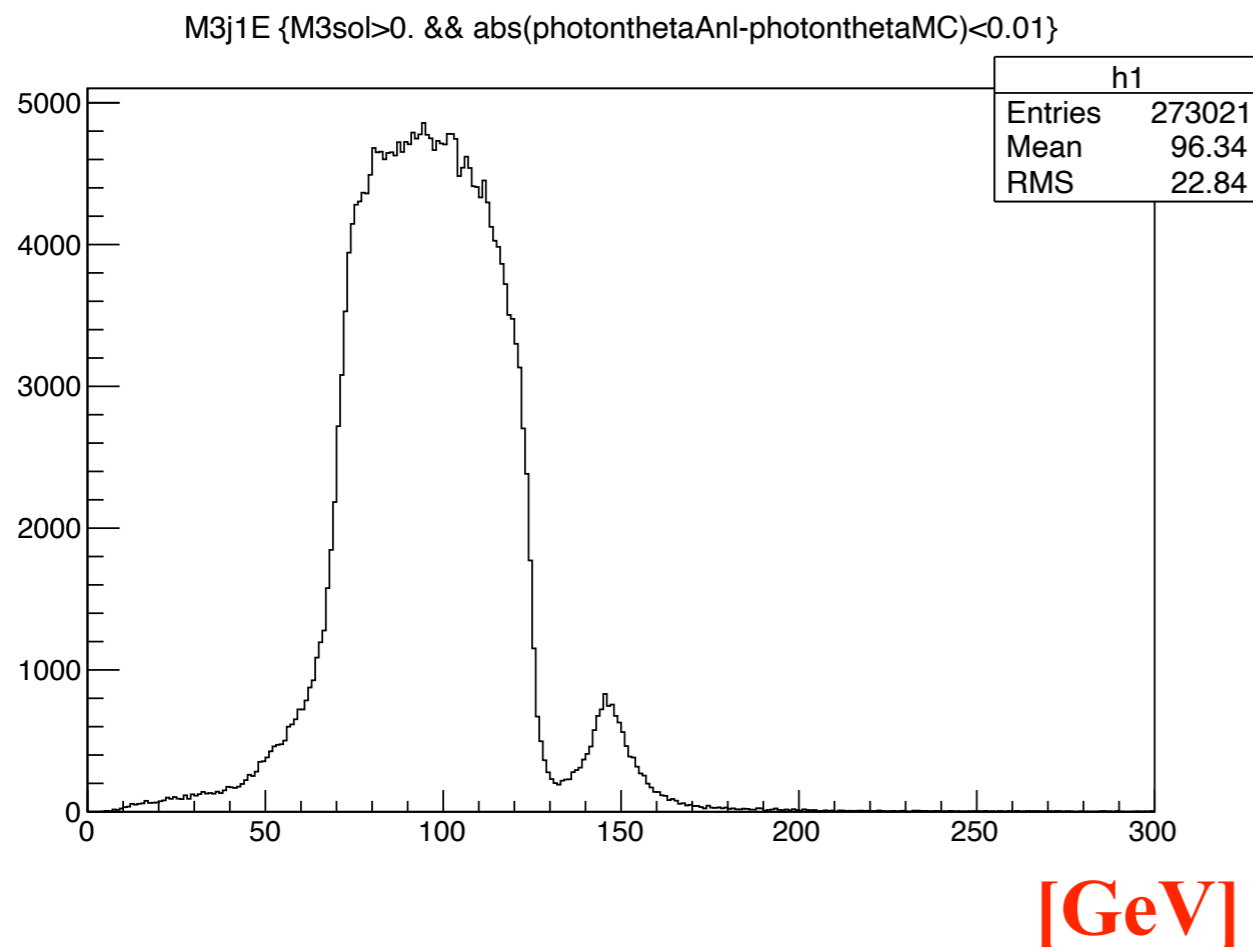
$$\sqrt{P_{J_1}^2 + m_{J_1}^2} + \sqrt{P_{J_2}^2 + m_{J_2}^2} + |P_\gamma| + |P_{ISR}|$$



Problem: unexpected bump in reconstructed jet energy

- When I require the reconstructed $E_{tot} \equiv E_{J1} + E_{J2} + E_{\gamma} + E_{ISR} < 254$ to choose the best answer, the bump disappeared.

Method 3 Jet1 energy distribution



- Why are there cases the reconstructed $E_{tot} \equiv E_{J1} + E_{J2} + E_{\gamma} + E_{ISR} > 250$??

Reconstruction Method

Method 3: Consider ISR and solve the full equation
 Using $(\theta_{J1}, \theta_{J2}, \theta_{\gamma}, \varphi_{J1}, \varphi_{J2}, \varphi_{\gamma}, m_{J1}, m_{J2}) \rightarrow$ Determine $(P_{J1}, P_{J2}, P_{\gamma}, P_{ISR})$

$$\sqrt{P_{J1}^2 + m_{J1}^2} + \sqrt{P_{J2}^2 + m_{J2}^2} + |P_{\gamma}| + |P_{ISR}| = E_{CM} \quad \textcircled{1}$$

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*****
*      Row      * ESum * EISR * EJ1 * EJ2 * E $\gamma$  * E *
*****
*      2 * 366.53696 * 72.535351 * 156.96777 * 58.569181 * 79.066051 *
*      9 * 298.62565 * 9.8457809 * 146.57377 * 25.051876 * 118.63231 *
*     10 * 400.57065 * 1.3064283 * 203.00334 * 75.567307 * 121.25753 *
*     11 * 426.27959 * 50.853665 * 152.64726 * 88.632330 * 135.13139 *
*     12 * 333.03742 * 66.762206 * 141.00941 * 42.028016 * 84.256399 *
*     16 * 282.4159 * 26.559148 * 16.589673 * 128.82622 * 111.20429 *
*     19 * 279.9828 * 54.639210 * 116.56381 * 15.418981 * 94.215952 *
*     27 * 281.90901 * 69.992376 * 136.99227 * 16.916738 * 59.932090 *
*     33 * 382.44162 * 35.440445 * 147.82023 * 66.621390 * 133.36070 *
*     36 * 386.59473 * 54.612970 * 152.68251 * 68.912223 * 111.61674 *
*     50 * 279.53136 * 15.377309 * 127.38918 * 15.142176 * 122.37568 *
*     61 * 297.67282 * 13.505328 * 129.46546 * 24.207362 * 131.23656 *
*     62 * 282.14231 * 47.540821 * 134.59052 * 16.551790 * 84.420444 *
*     66 * 313.20207 * 3.2458796 * 154.15914 * 32.042931 * 124.63790 *
*     68 * 290.91970 * 17.090852 * 141.20568 * 20.714028 * 112.41749 *
*     70 * 1535.683 * 55.852535 * 714.16113 * 643.52186 * 123.50819 *
*     72 * 296.60387 * 10.071965 * 144.07756 * 23.526305 * 119.37677 *
*    142 * 360.68284 * 25.702743 * 145.96058 * 55.722258 * 134.05892 *
*    172 * 339.58430 * 12.741662 * 150.33482 * 45.249473 * 132.17298 *
*    177 * 2495.1260 * 20.447979 * 1122.7955 * 1244.3305 * 108.01703 *

```

$$\sqrt{|P_{j1}|^2 + m_{j1}^2} + \sqrt{|P_{j2}|^2 + m_{j2}^2} + |P_{\delta}| + |P_{ISR}| = 500 \quad \text{--- (8)}$$

$$\begin{aligned} |P_{j1}|^2 + m_{j1}^2 &= \left(500 - \sqrt{|P_{j2}|^2 + m_{j2}^2} - |P_{\delta}| - |P_{ISR}| \right)^2 \\ &= |P_{j2}|^2 + m_{j2}^2 - 2\sqrt{|P_{j2}|^2 + m_{j2}^2} (500 - |P_{\delta}| - |P_{ISR}|) + (500 - |P_{\delta}| - |P_{ISR}|)^2 \end{aligned}$$

$$4(|P_{j2}|^2 + m_{j2}^2)(500 - |P_{\delta}| - |P_{ISR}|)^2 = \left(-|P_{j1}|^2 - m_{j1}^2 + |P_{j2}|^2 + m_{j2}^2 + (500 - |P_{\delta}| - |P_{ISR}|)^2 \right)^2$$

should be required to be positive when solving the equation.

Now trying to implement this.