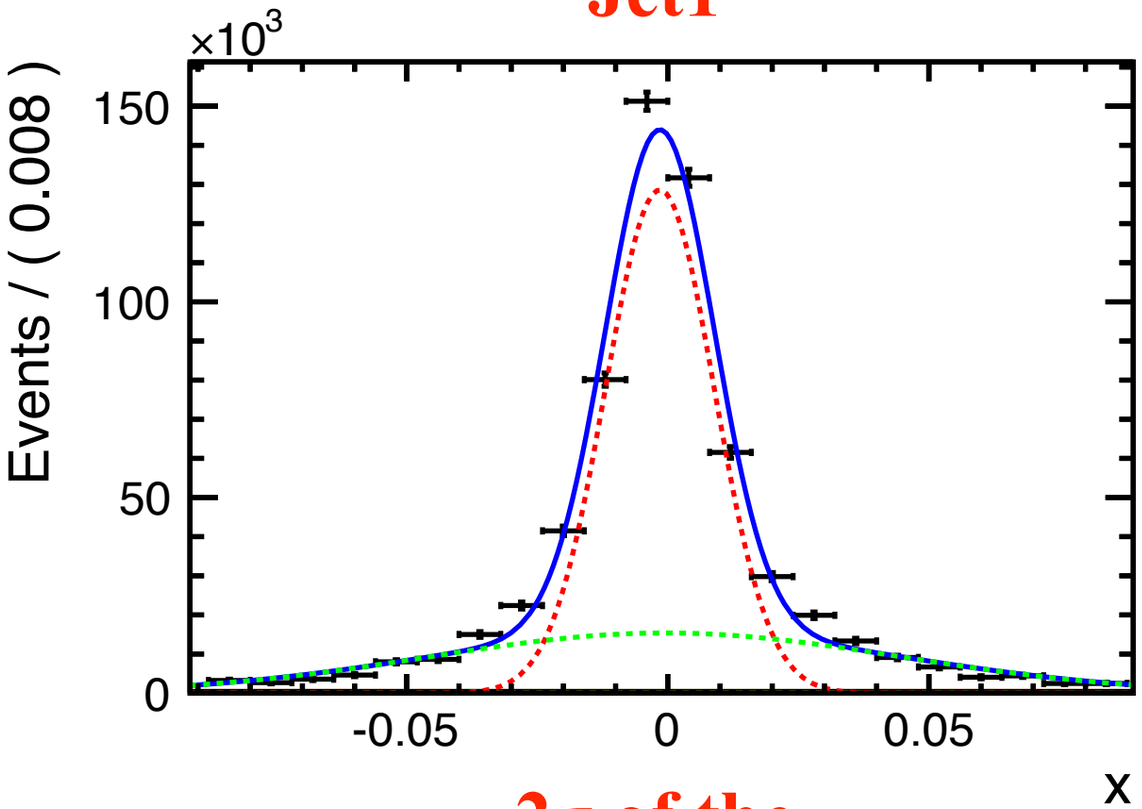
Jet Energy Scale Calibration using $e^+e^- \rightarrow q\bar{q}\gamma$

Takahiro Mizuno
SOKENDAI

Recent Progress

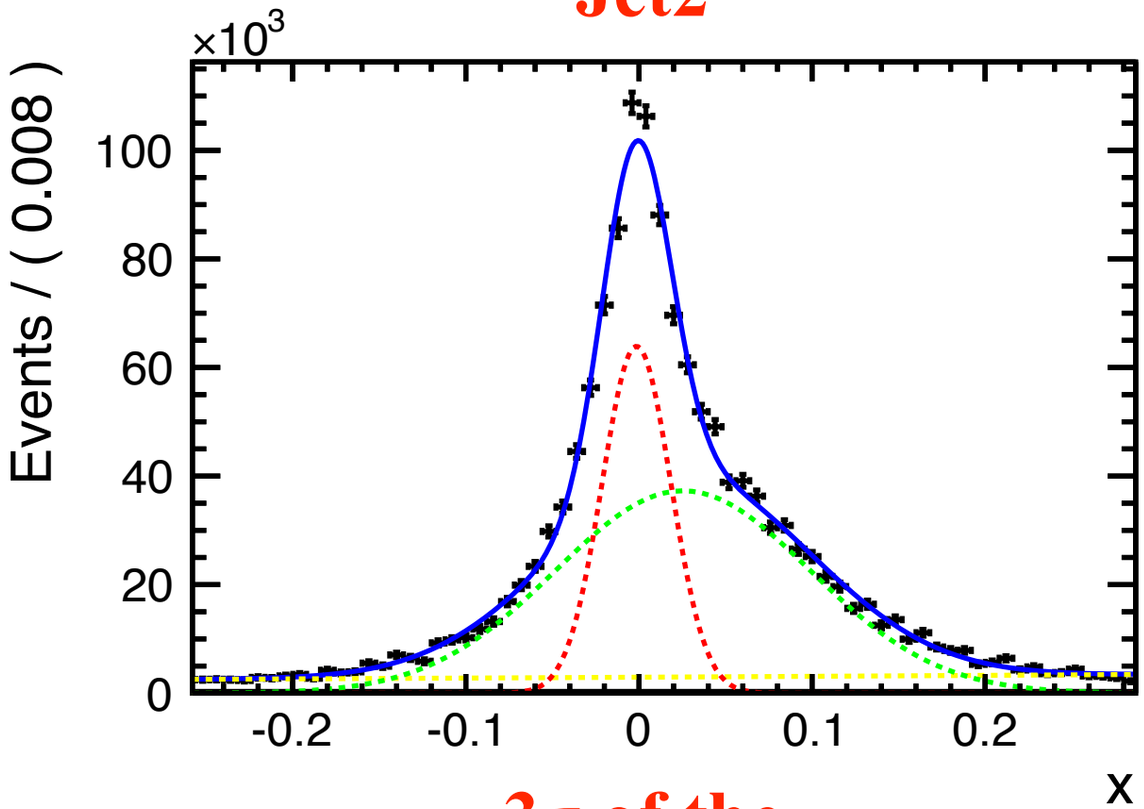
- As some odd fluctuations were seen previously, fitting conditions were slightly changed. Binning of the fitted histograms are set to be finer and fitting range is changed.
- After seeing that, jet1 and jet2 are plotted on the same point.

Jet1



2σ of the base

Jet2



3σ of the base

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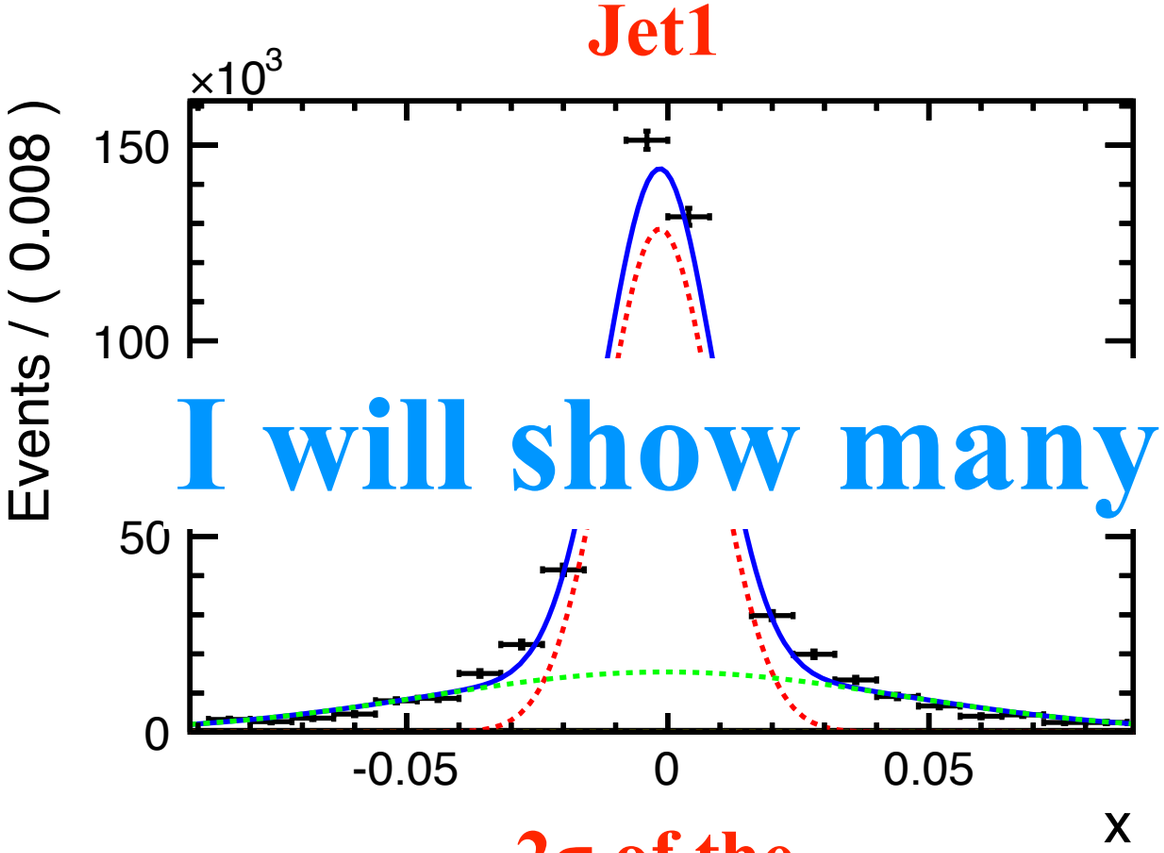
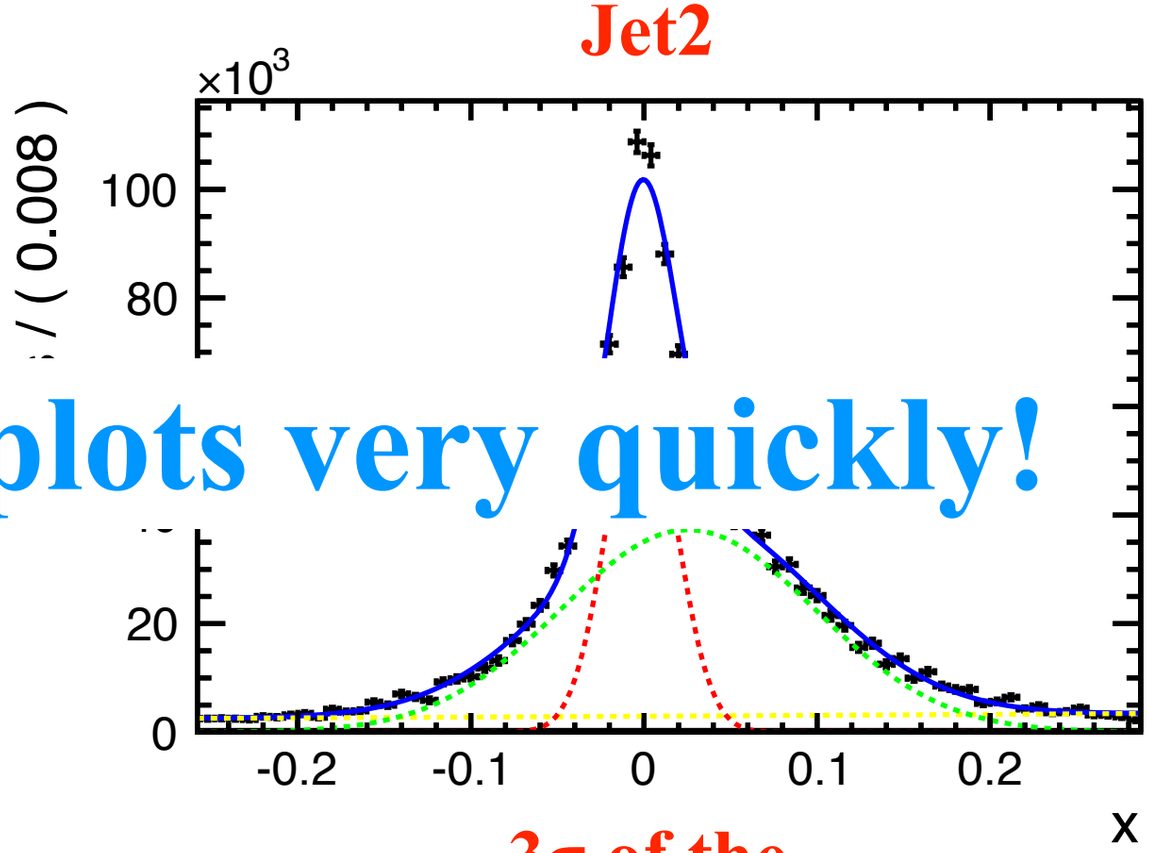


2σ of the base

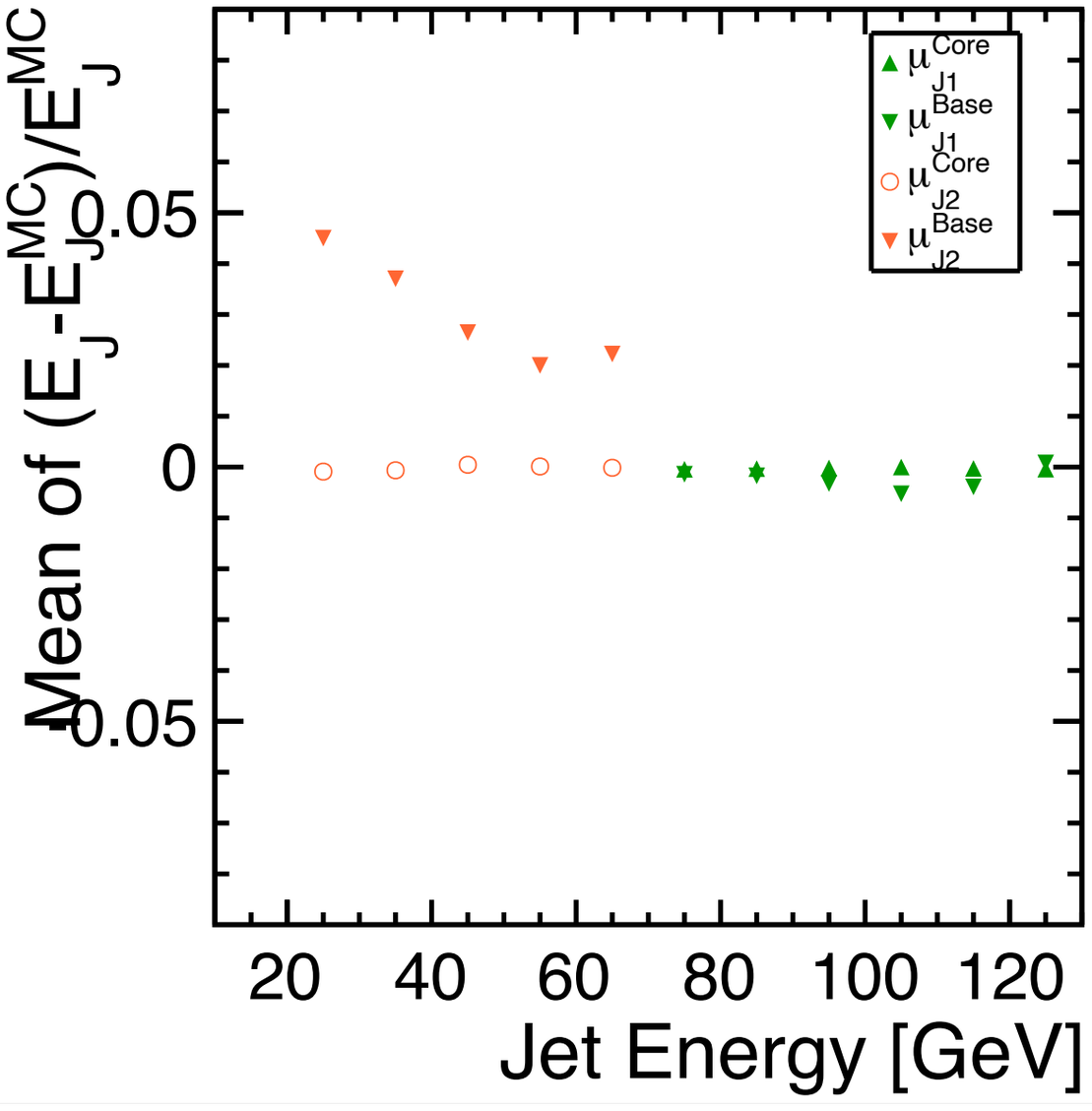


3σ of the base

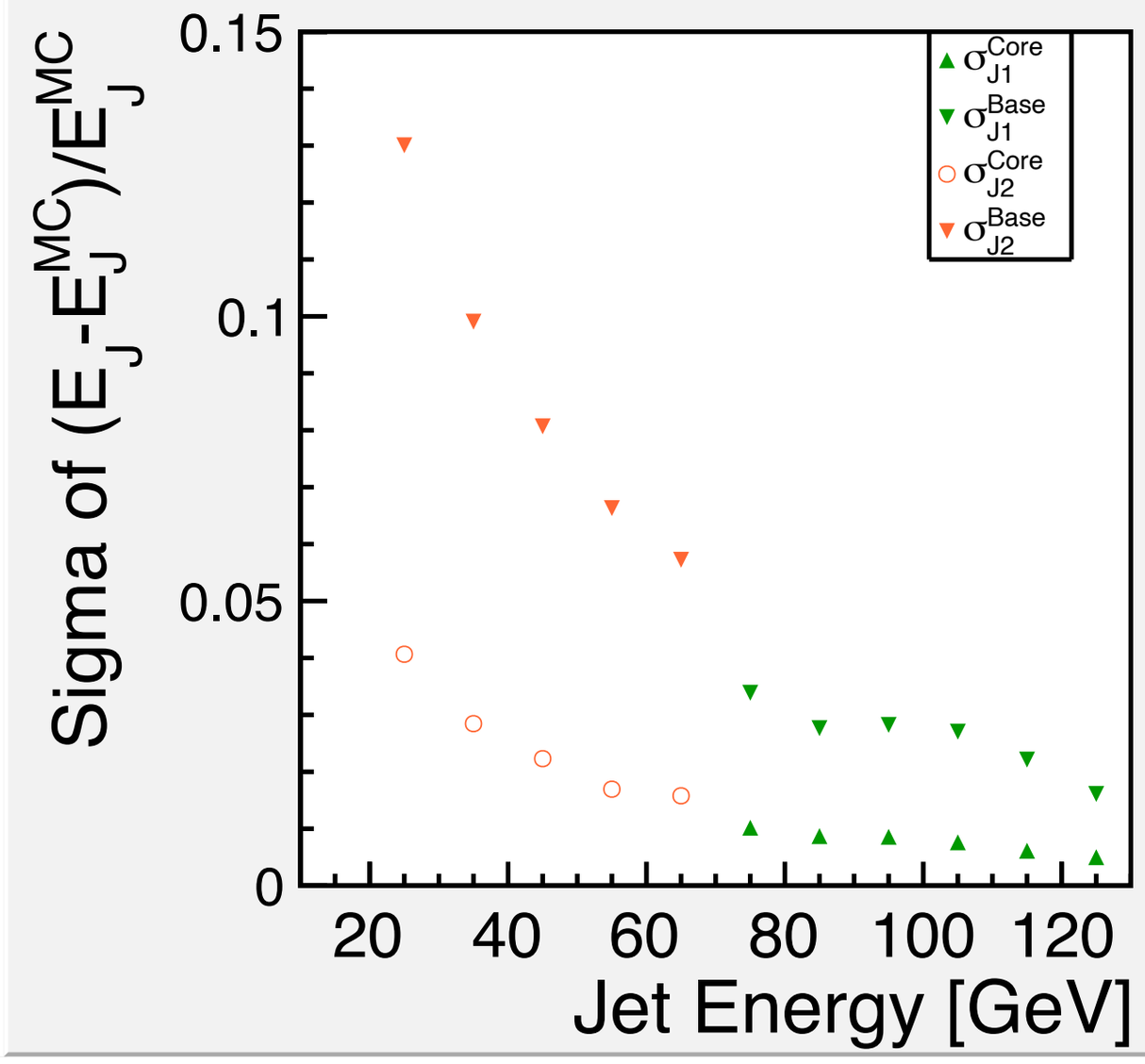
I will show many plots very quickly!

M3 Energy dependence

Mean of the Fitting Gaussian



Sigma of the Fitting Gaussian

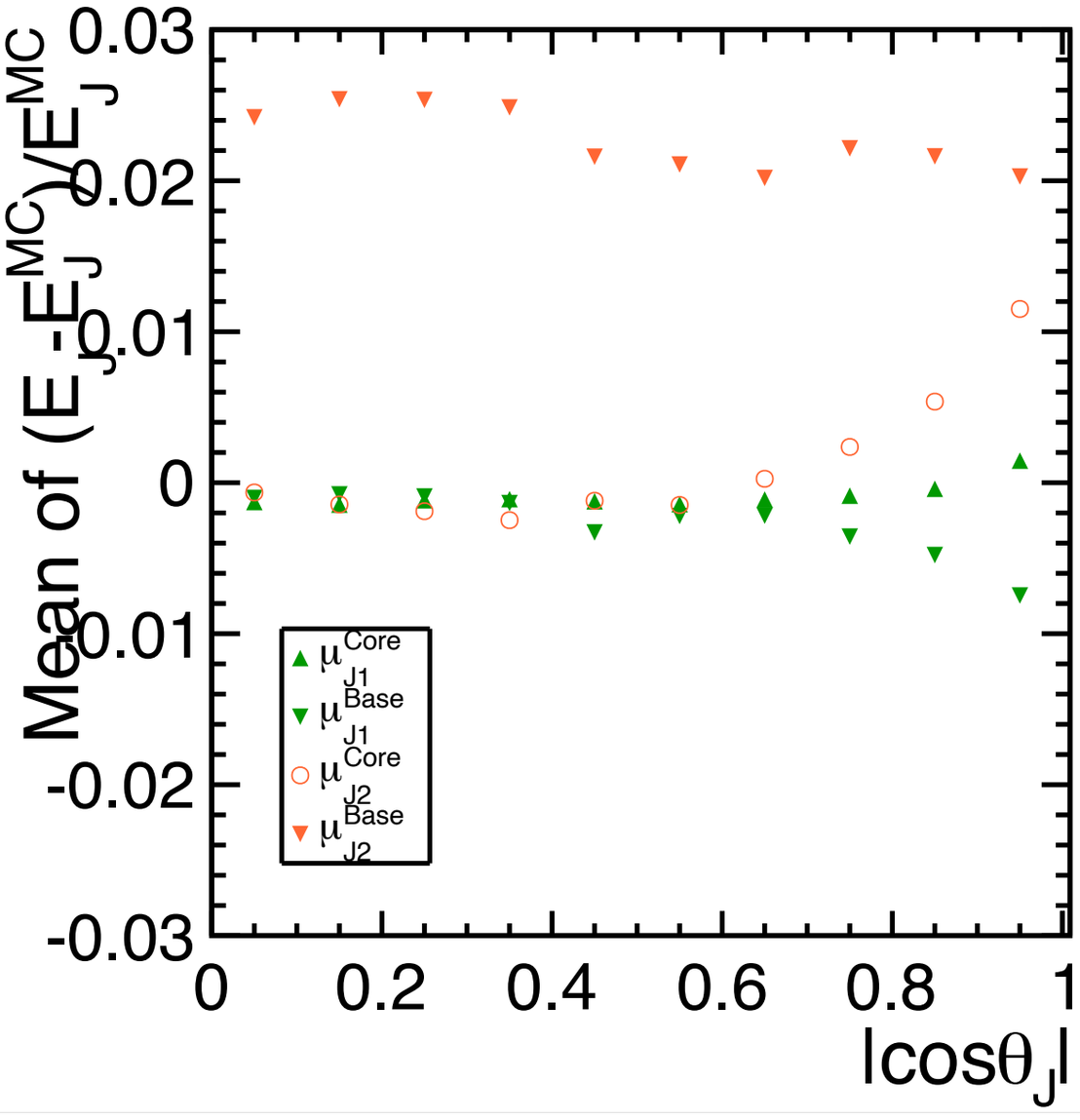


Mean value of the core gaussian is order of 10^{-4} independent on the jet energy.

Sigma value is smaller in the higher energy.

M3 Polar angle dependence

Mean of the Fitting Gaussian



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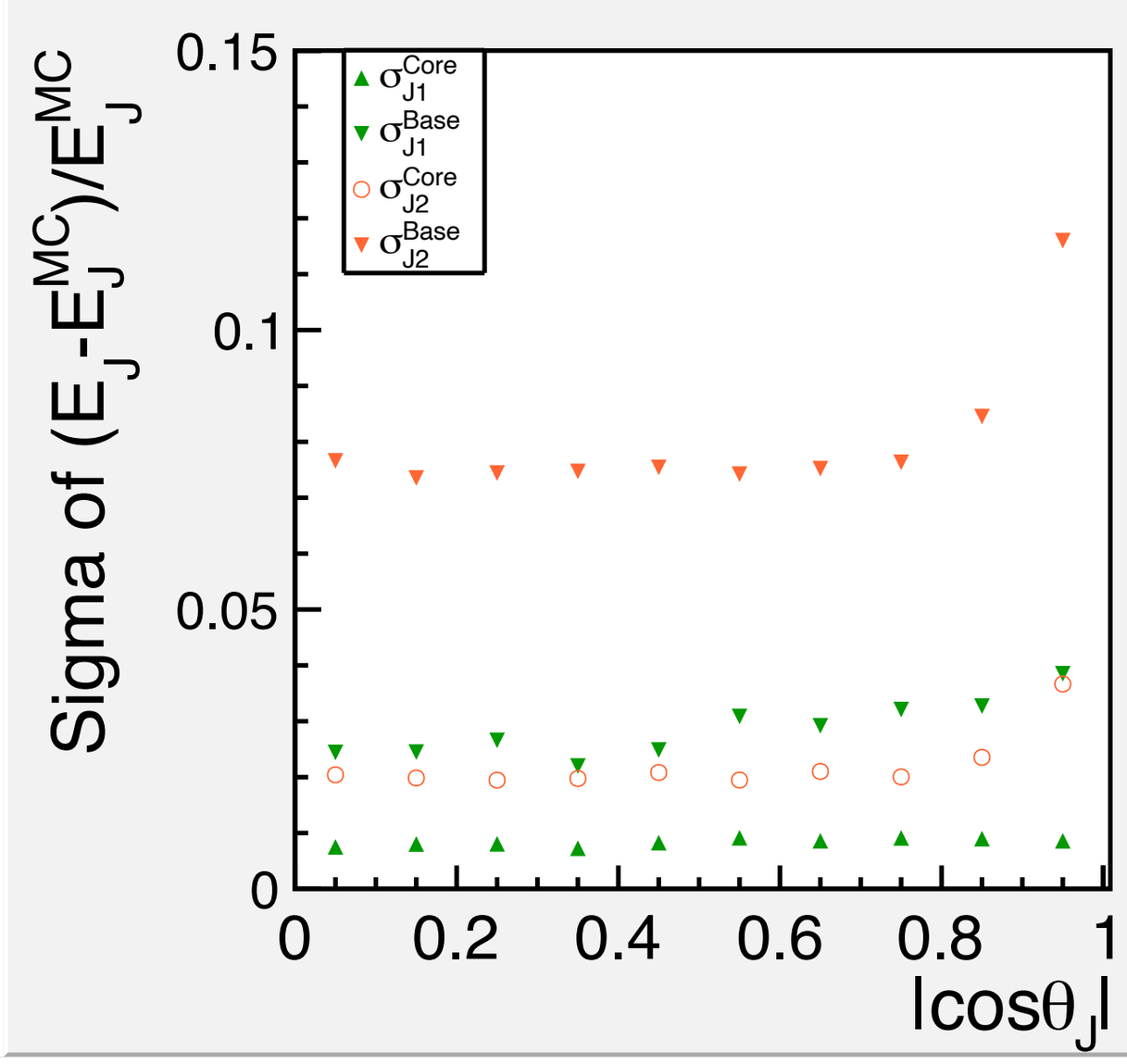

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M3 Flavor dependence

Showing dependence on flavor of the seed of the jet

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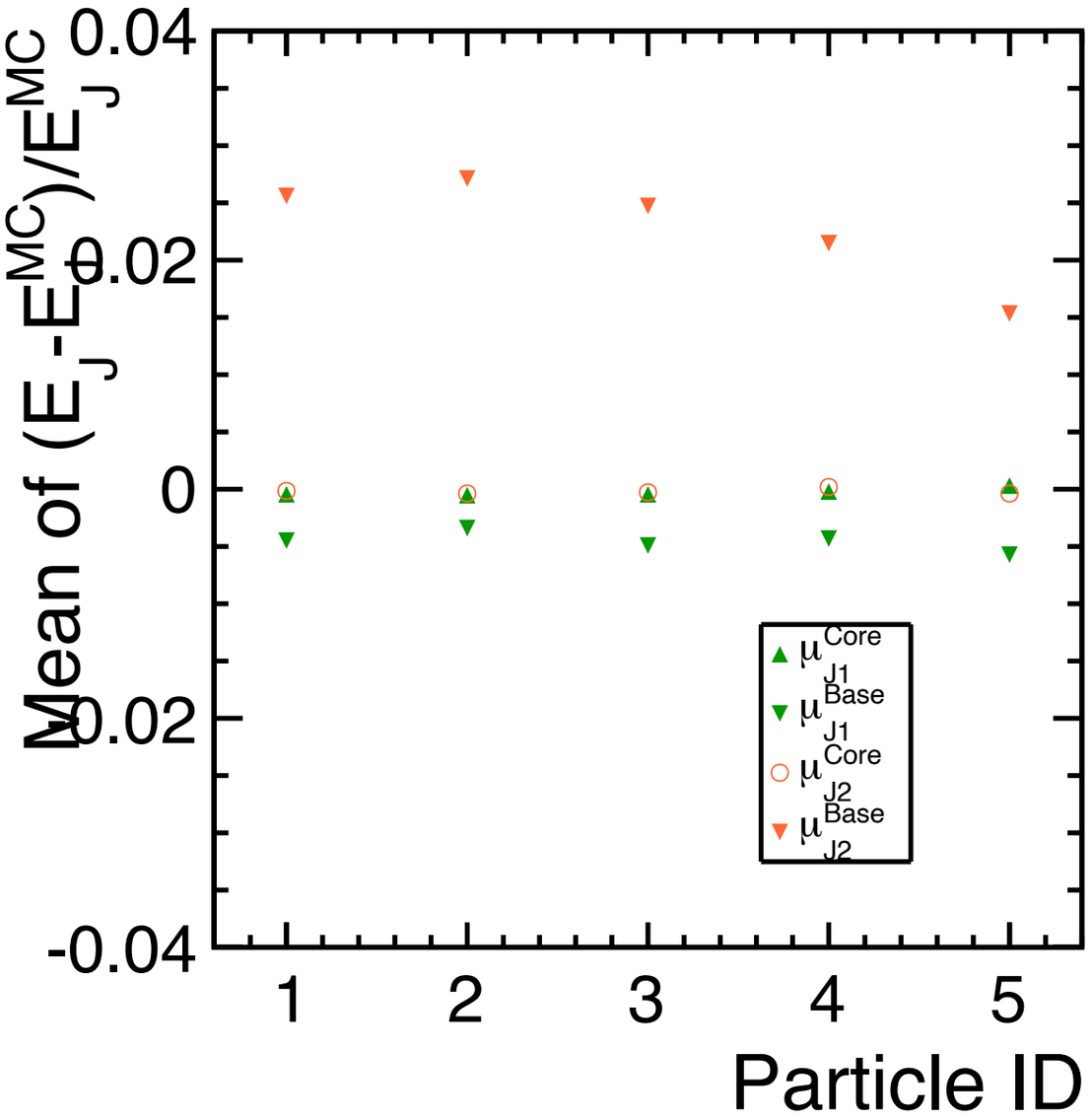

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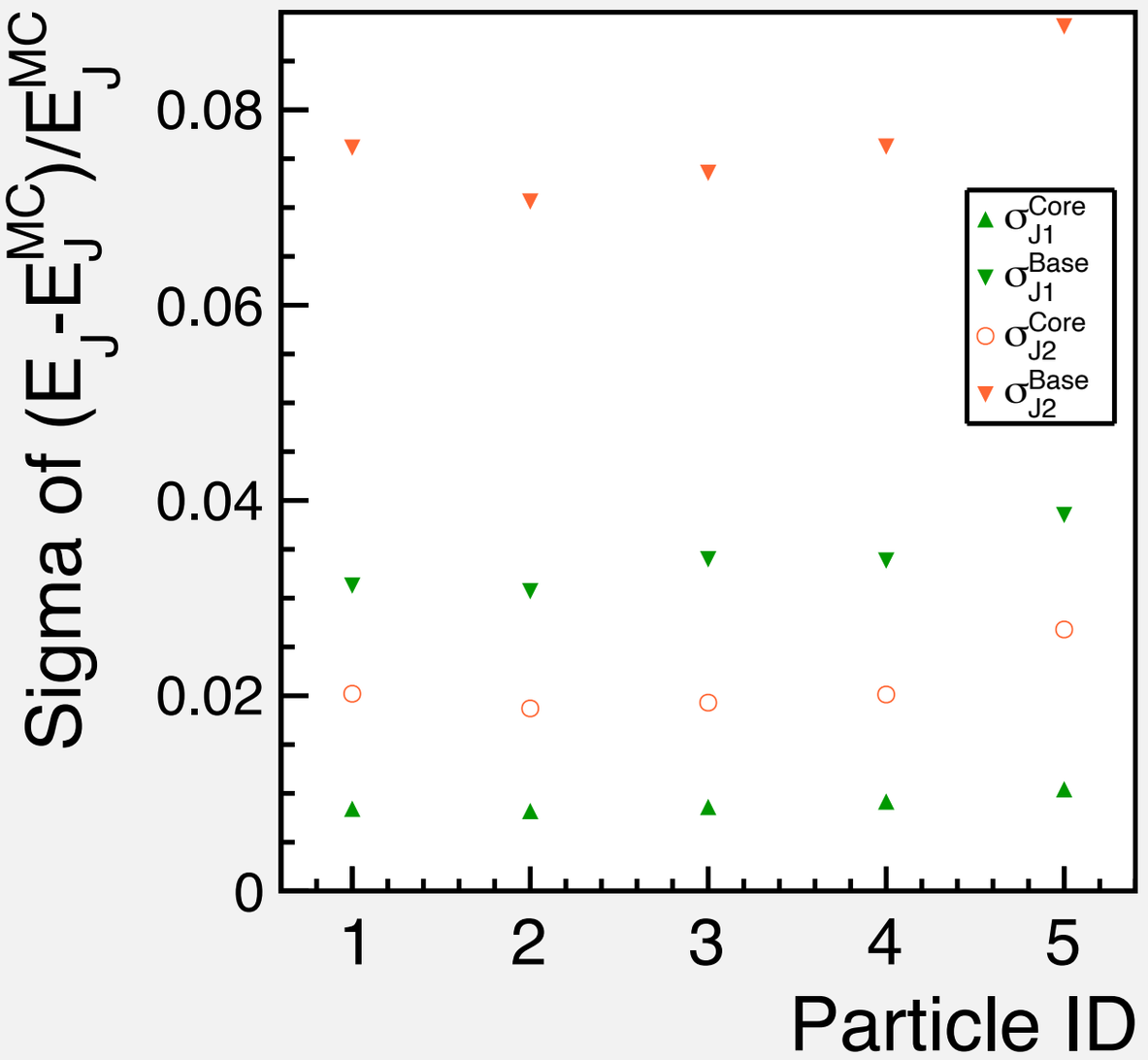

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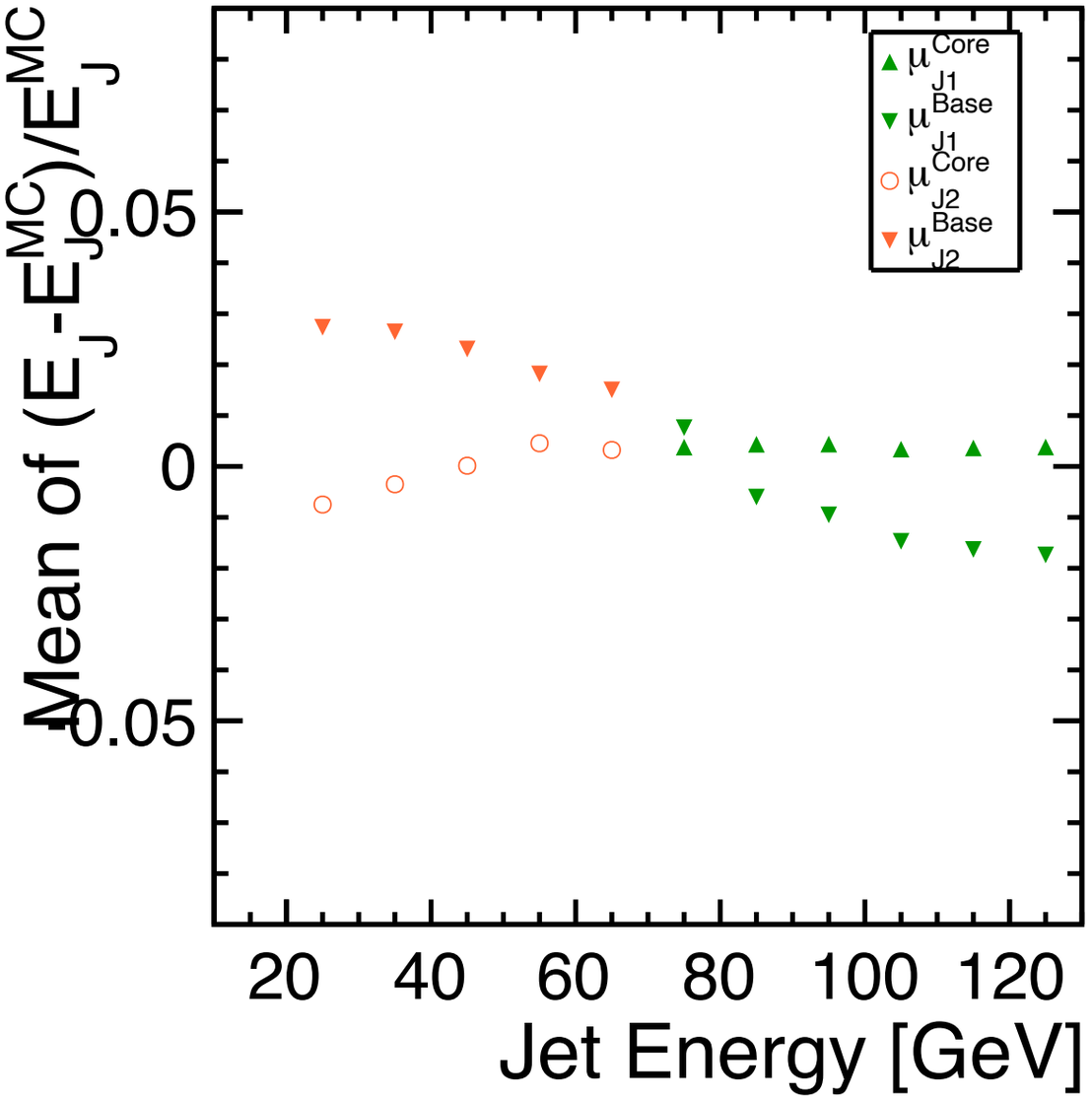
PFO Energy dependence

Mean of the Fitting Gaussian



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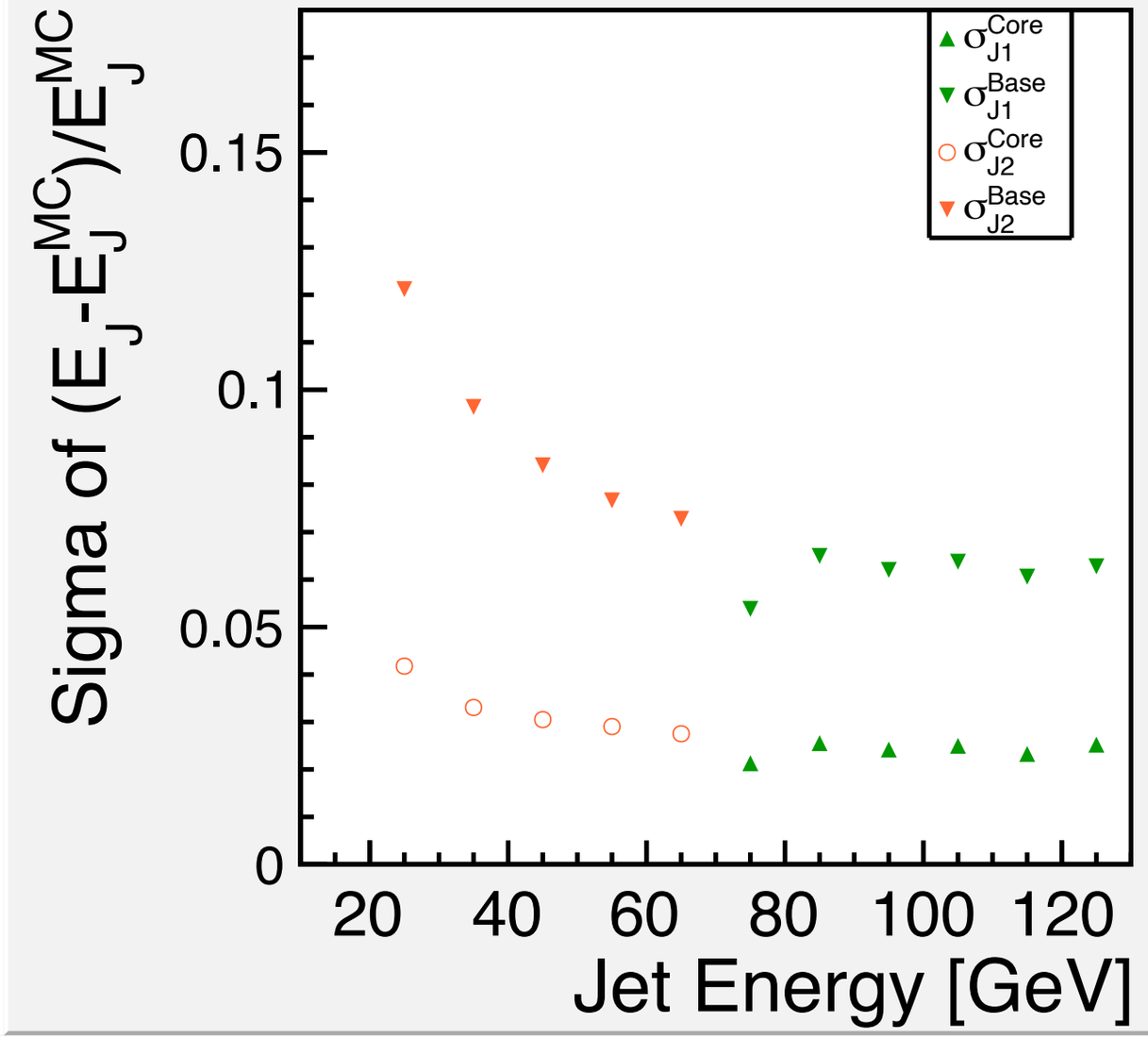

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PFO Polar angle dependence

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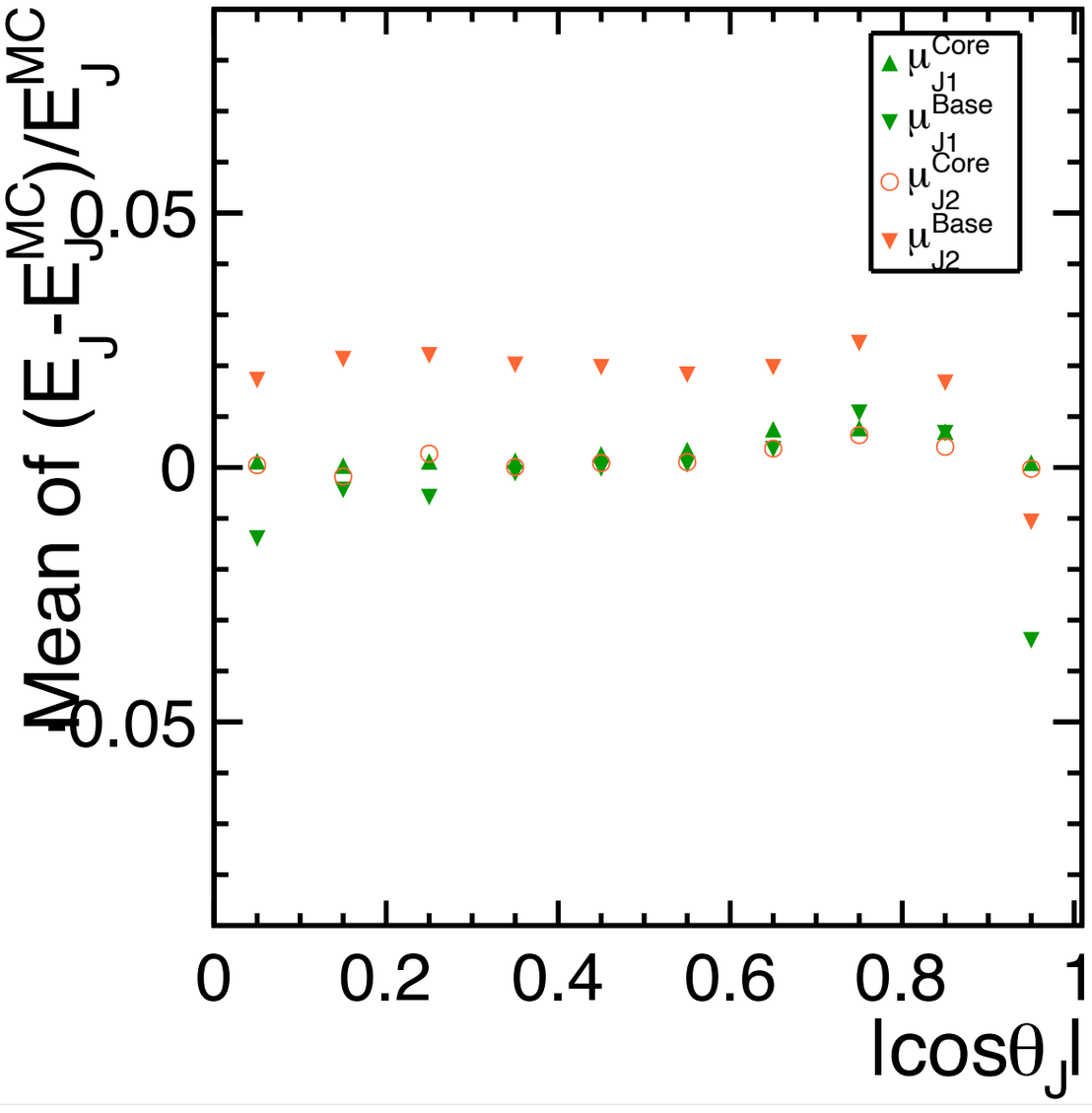

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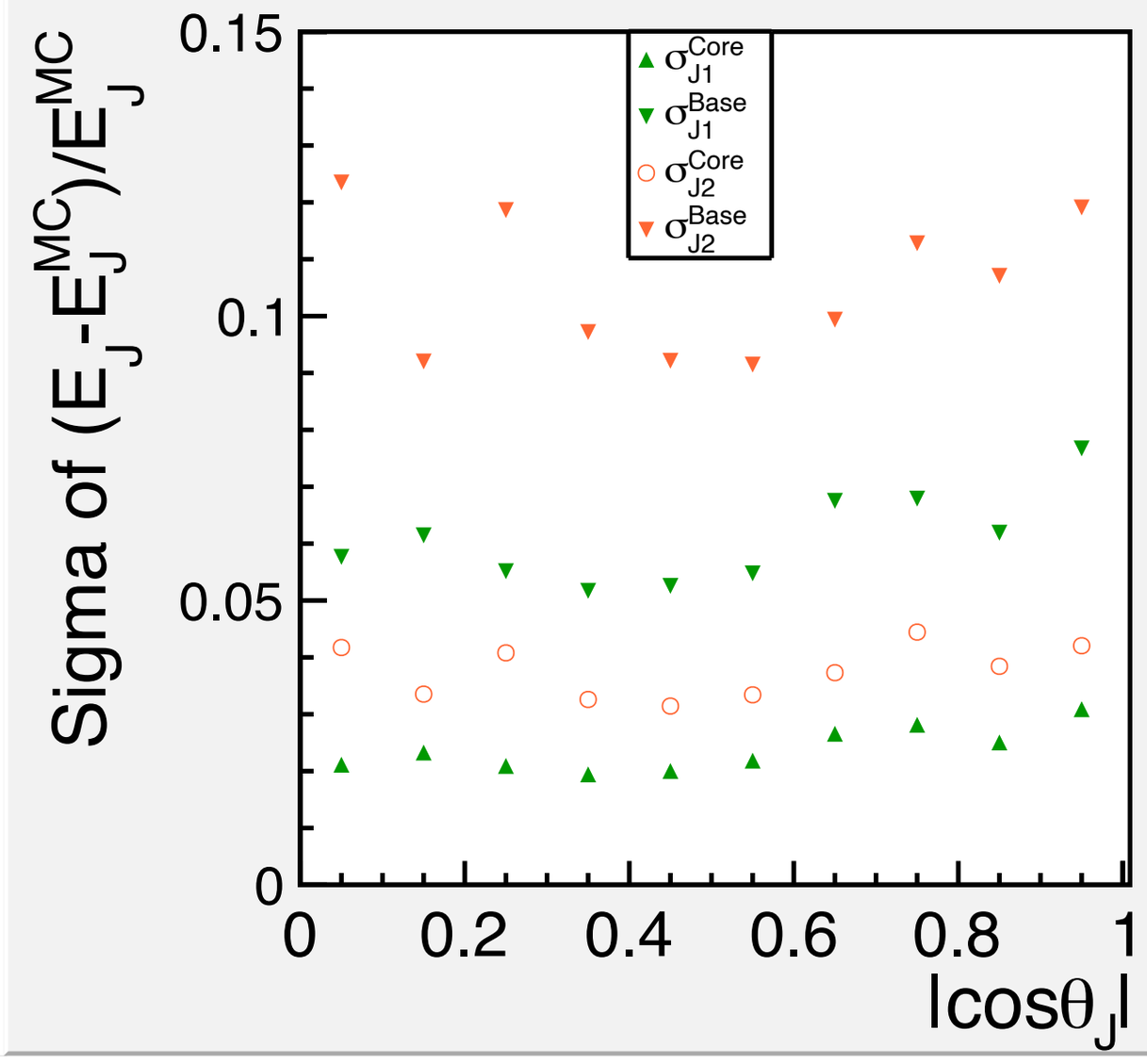

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Showing dependence on flavor of the seed of the jet

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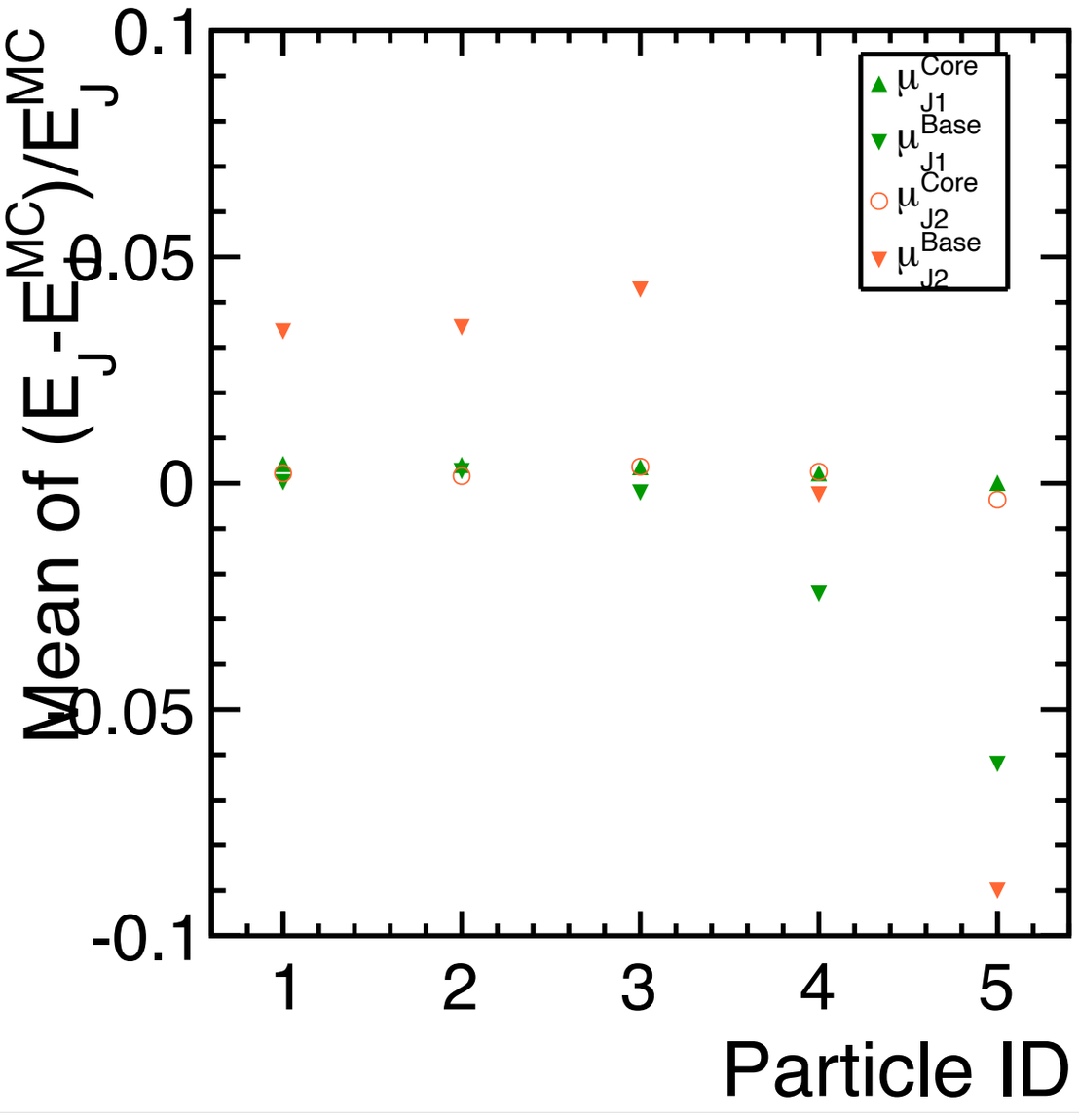

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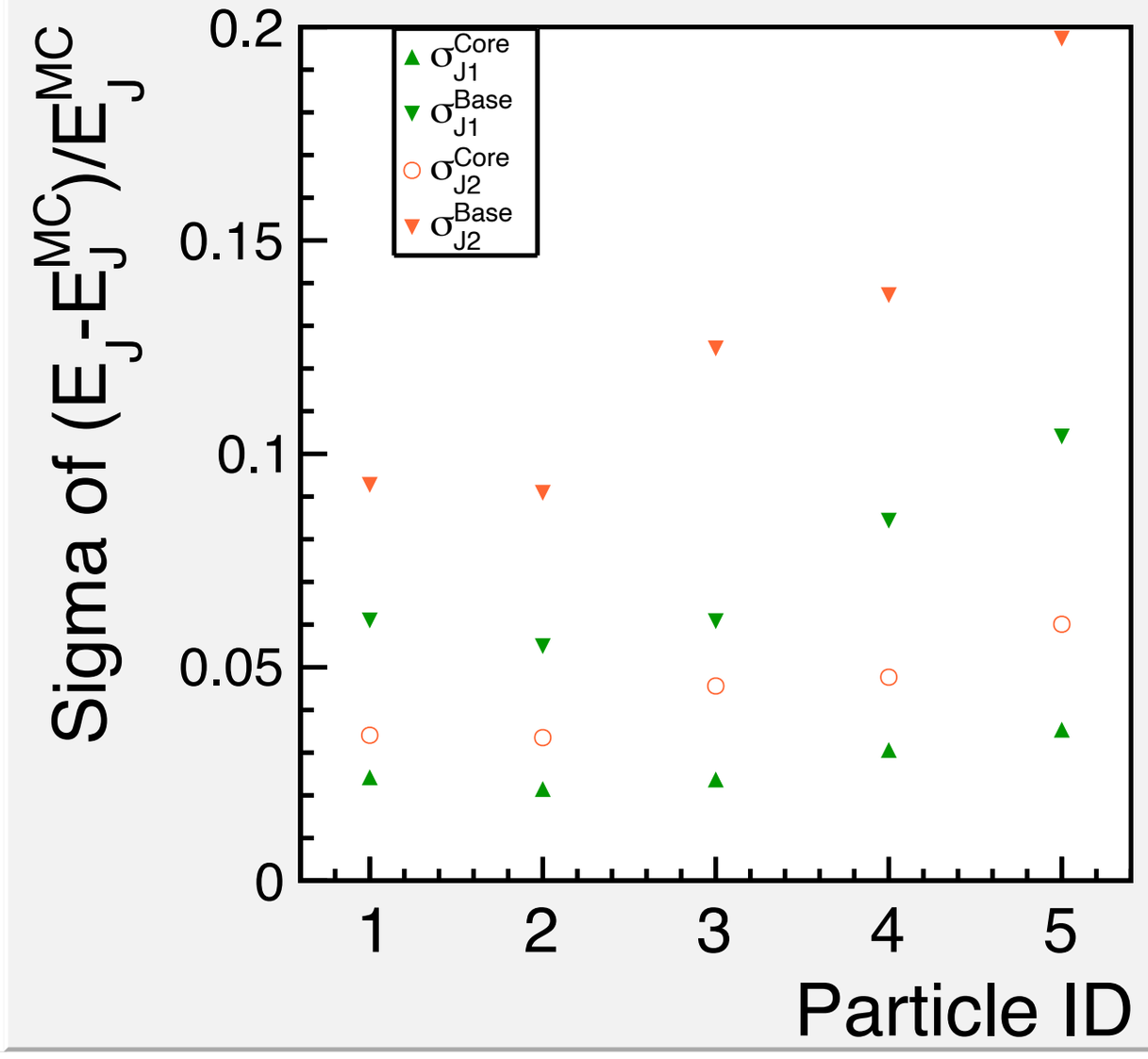

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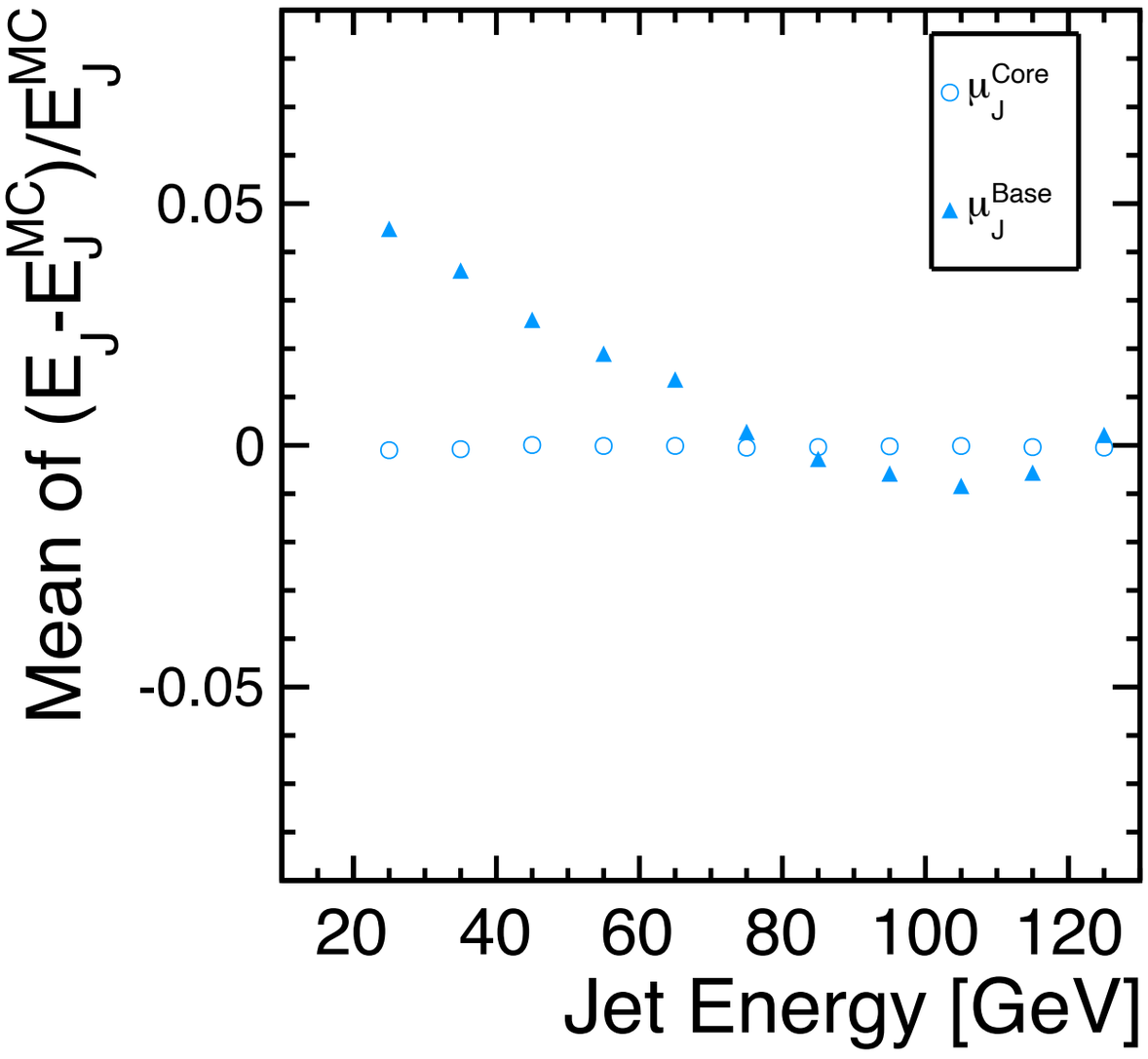

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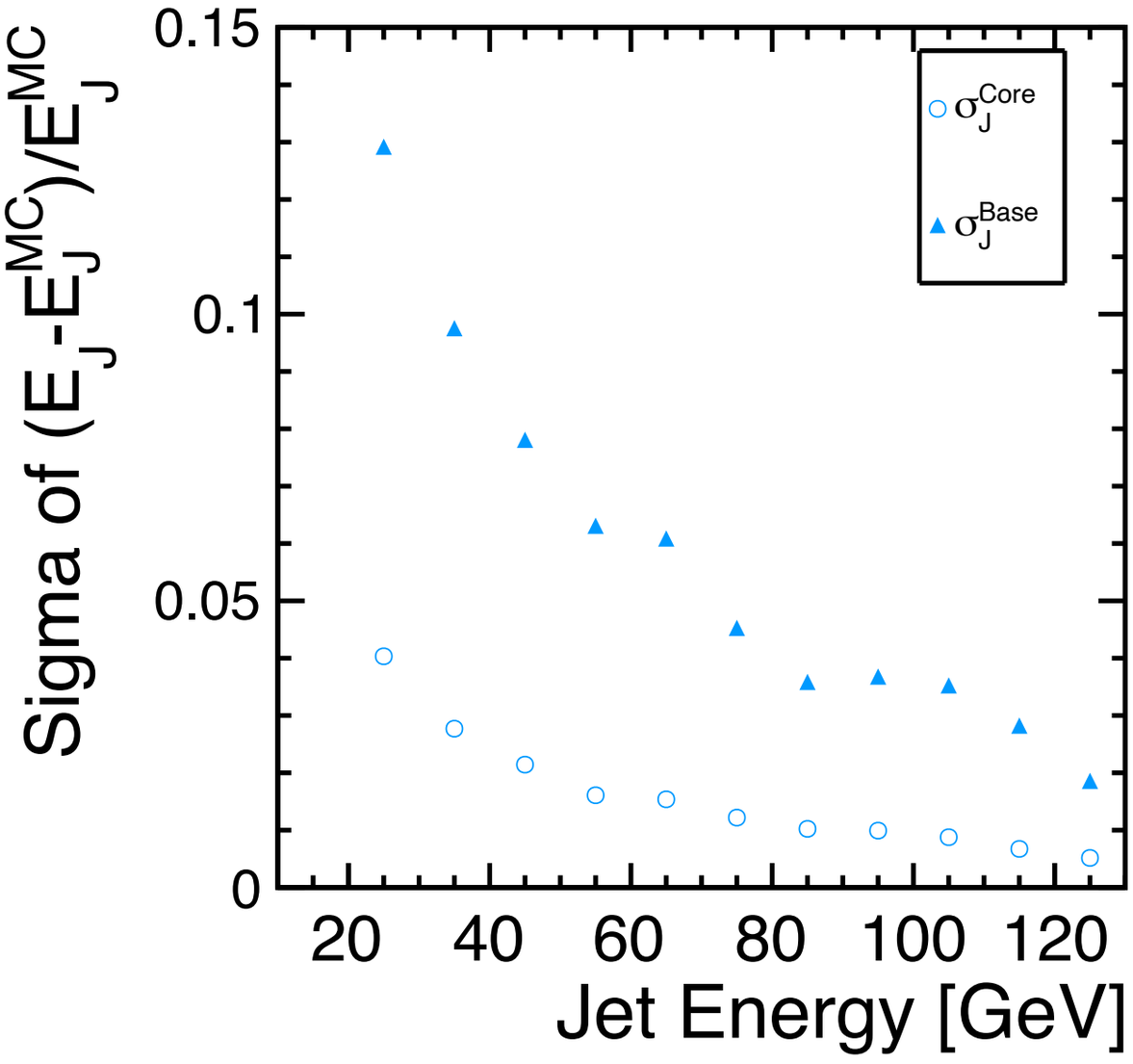

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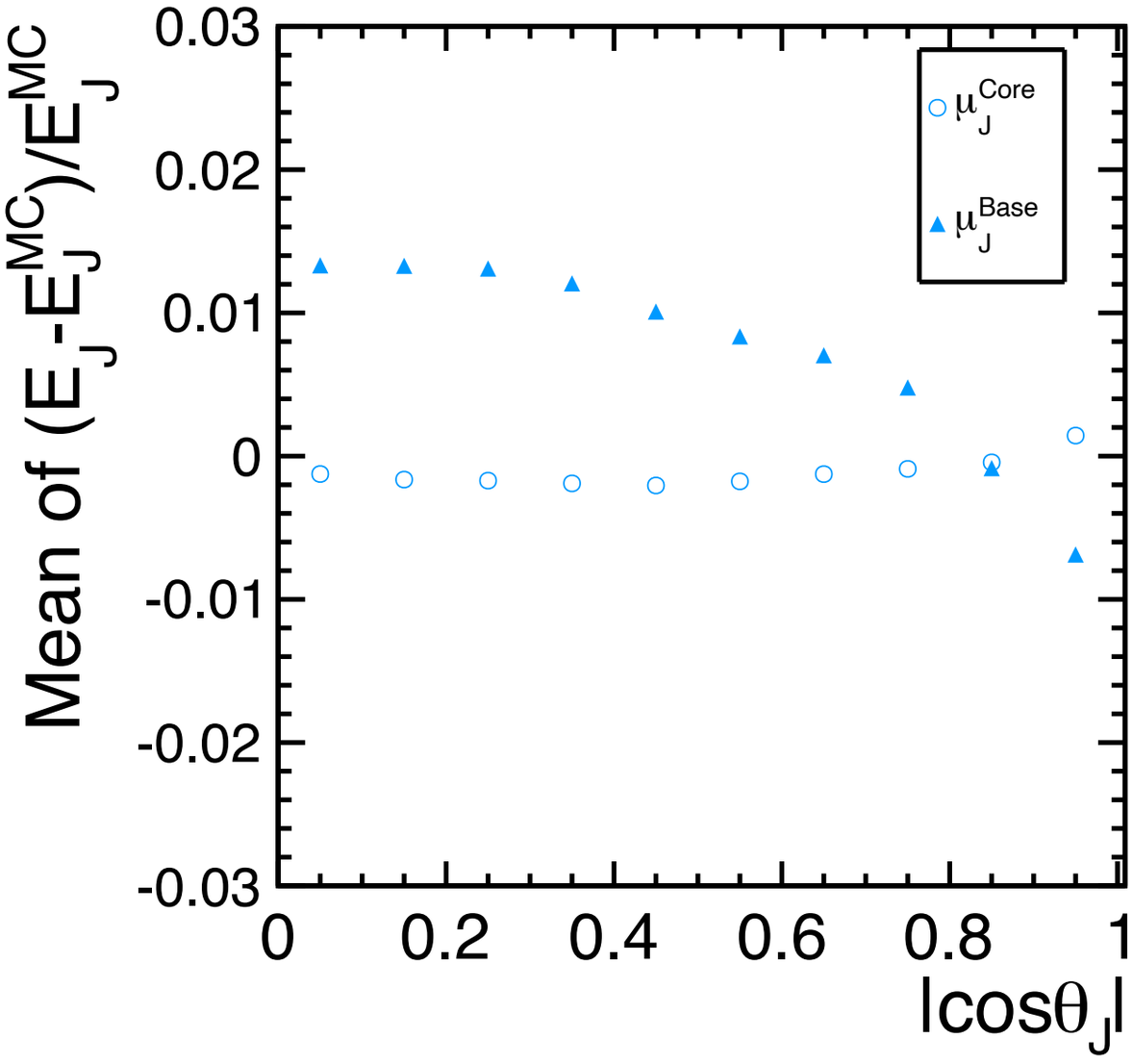

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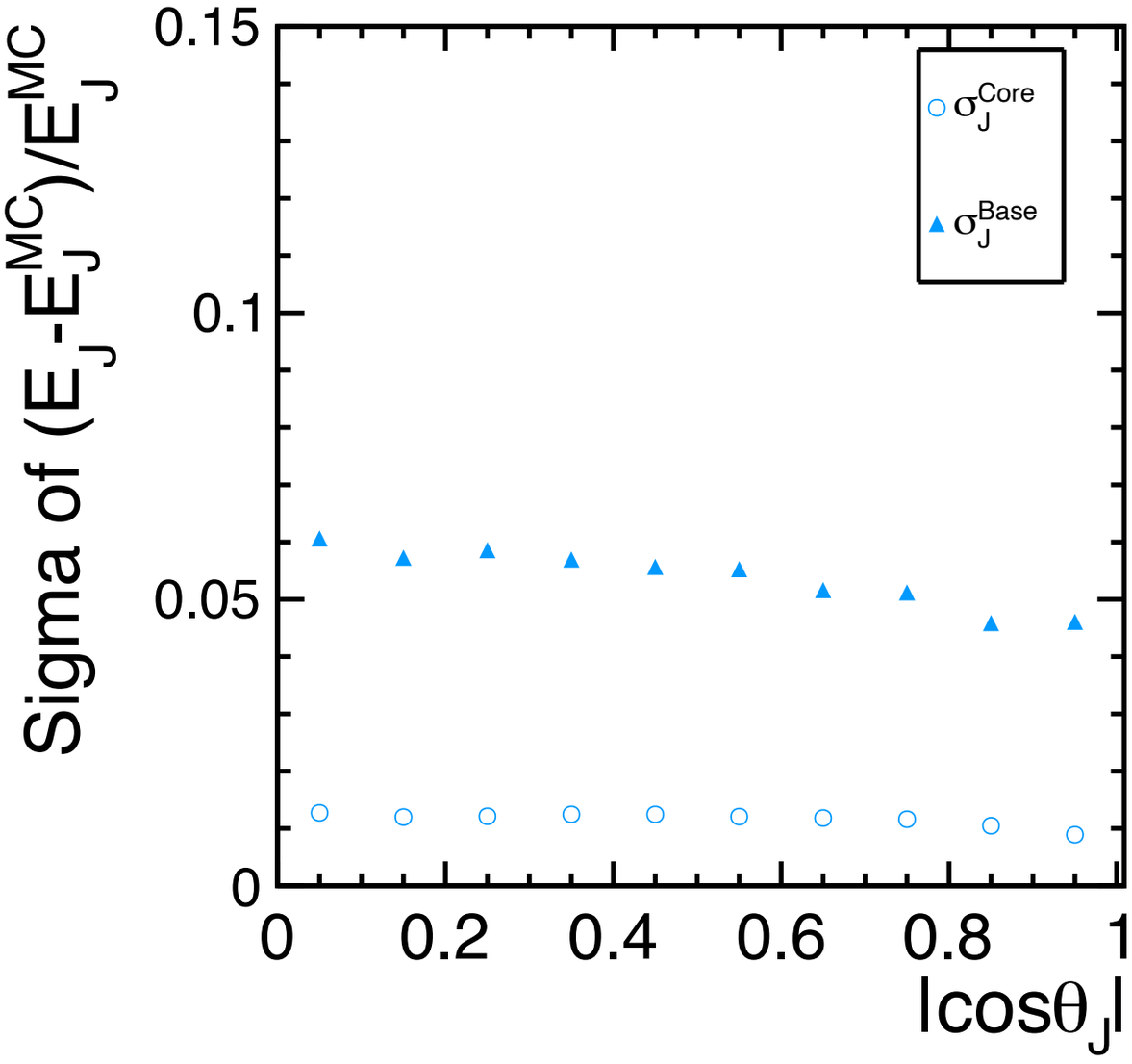

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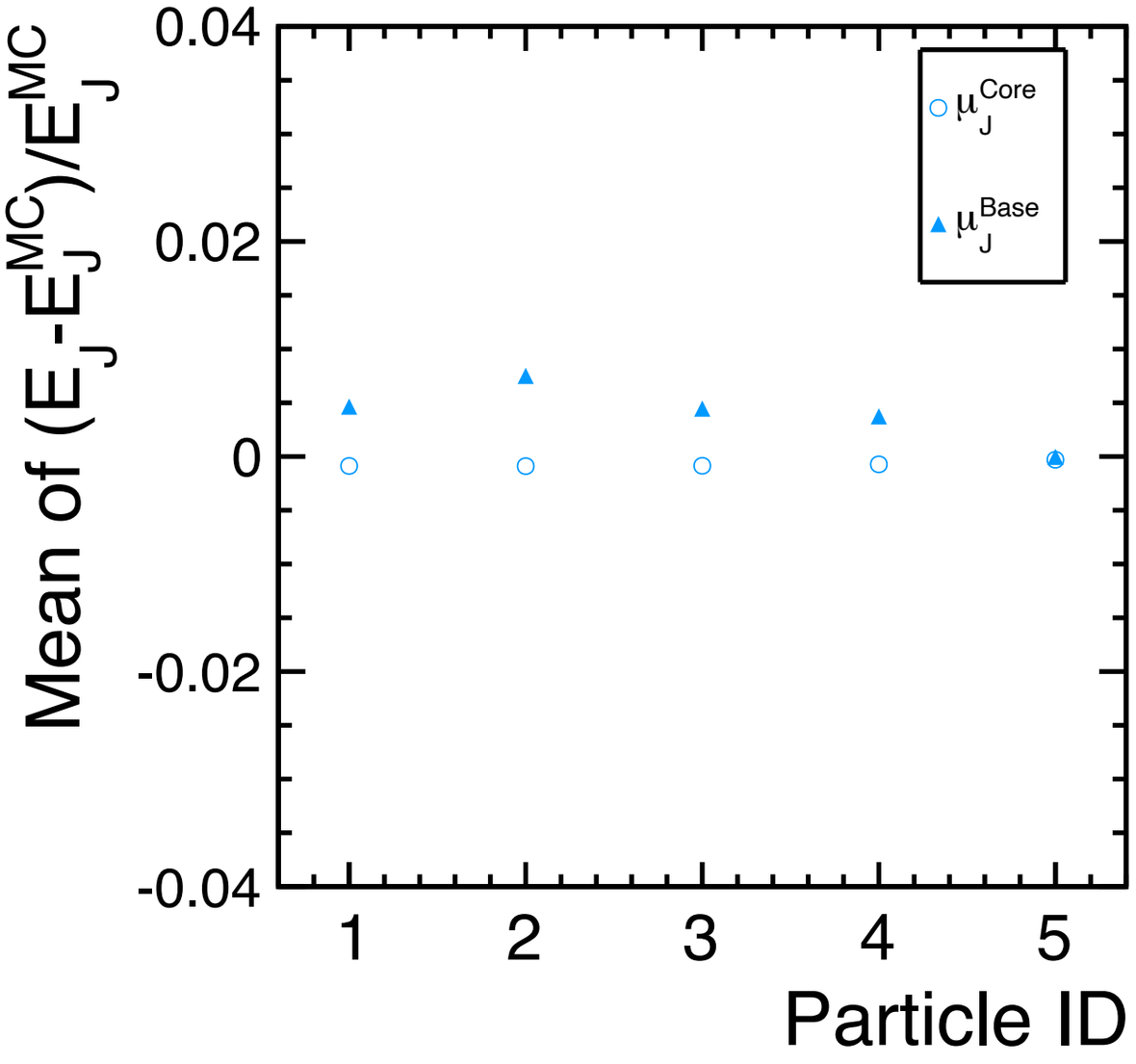

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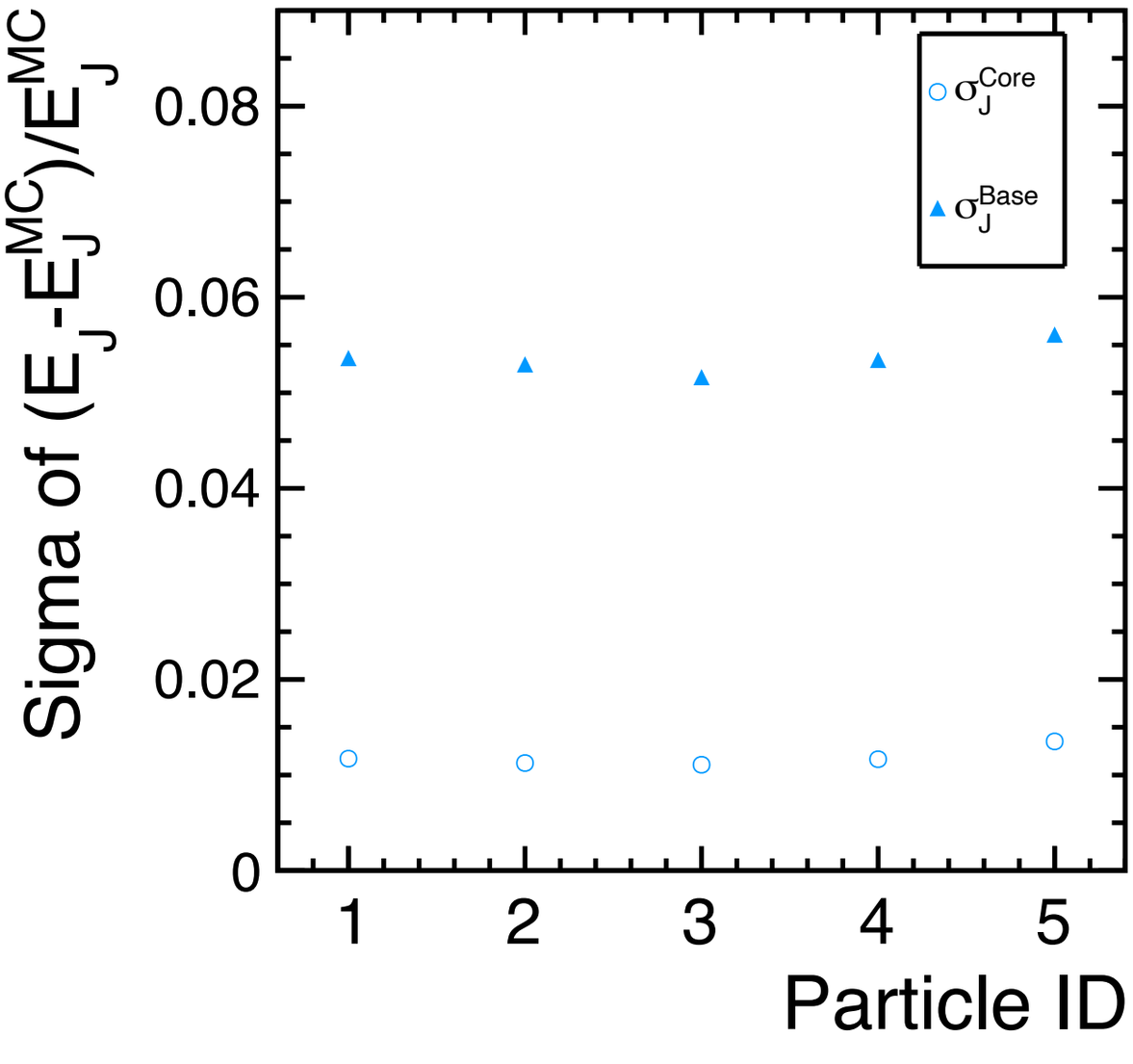

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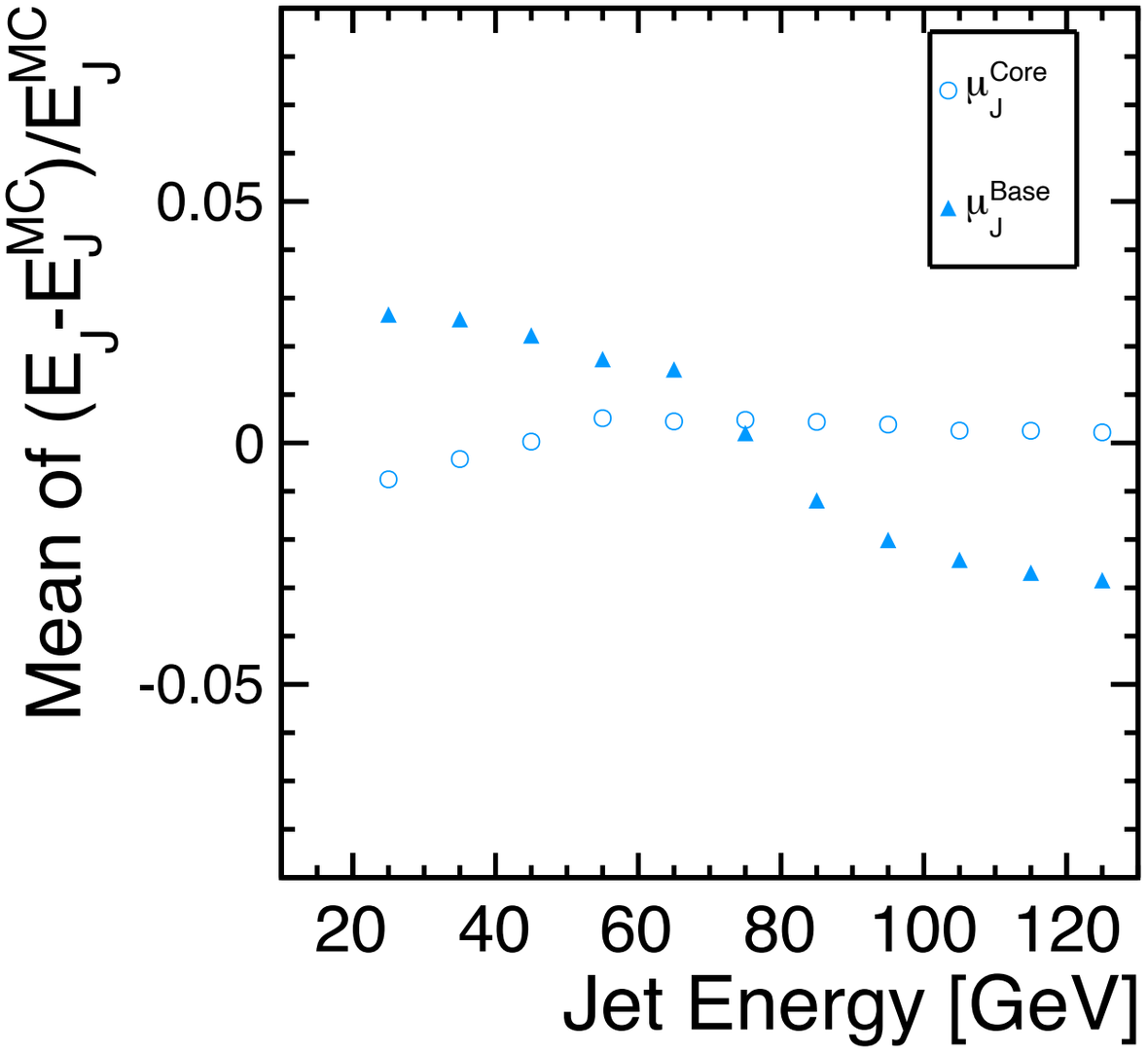

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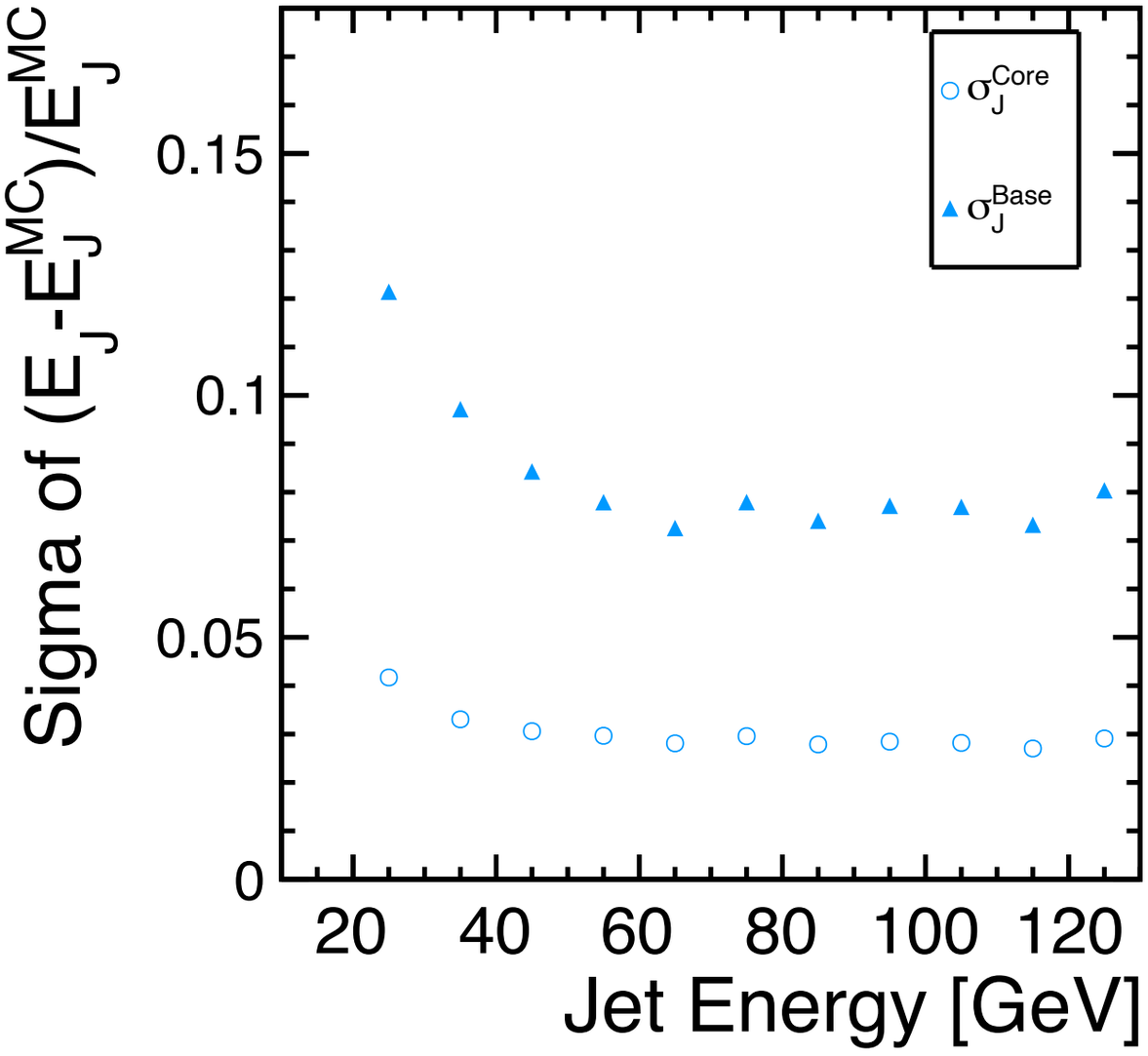

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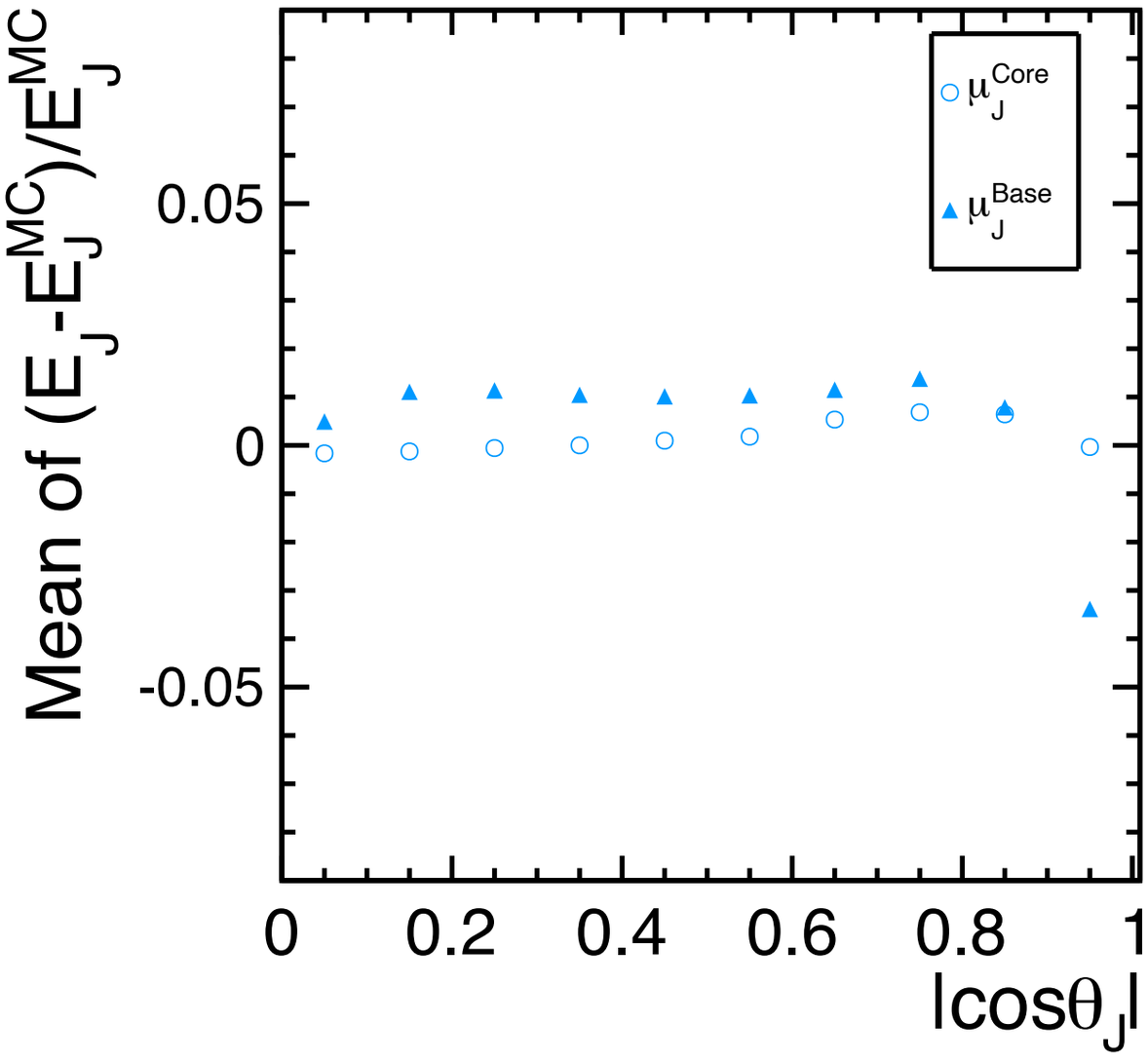

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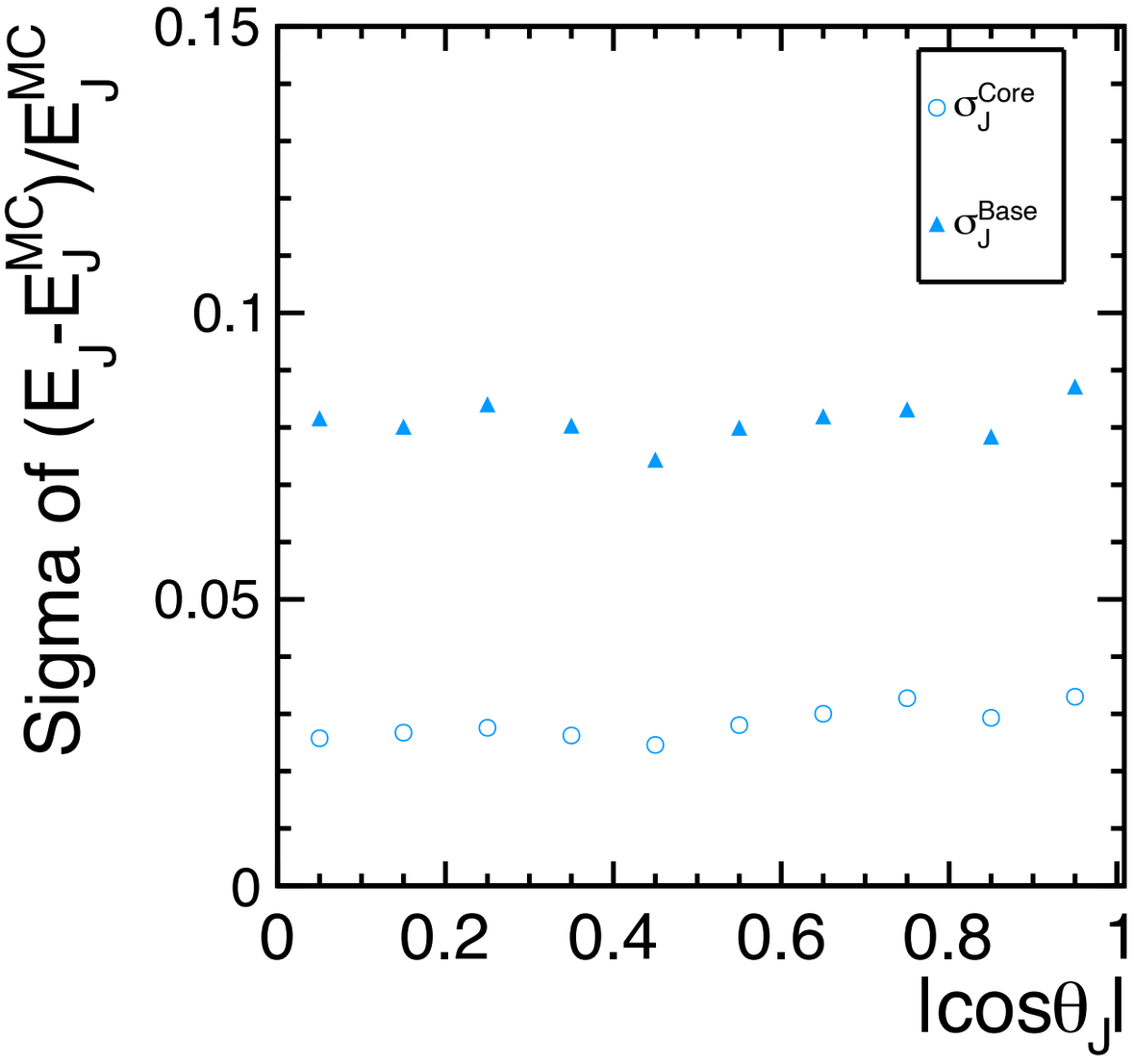

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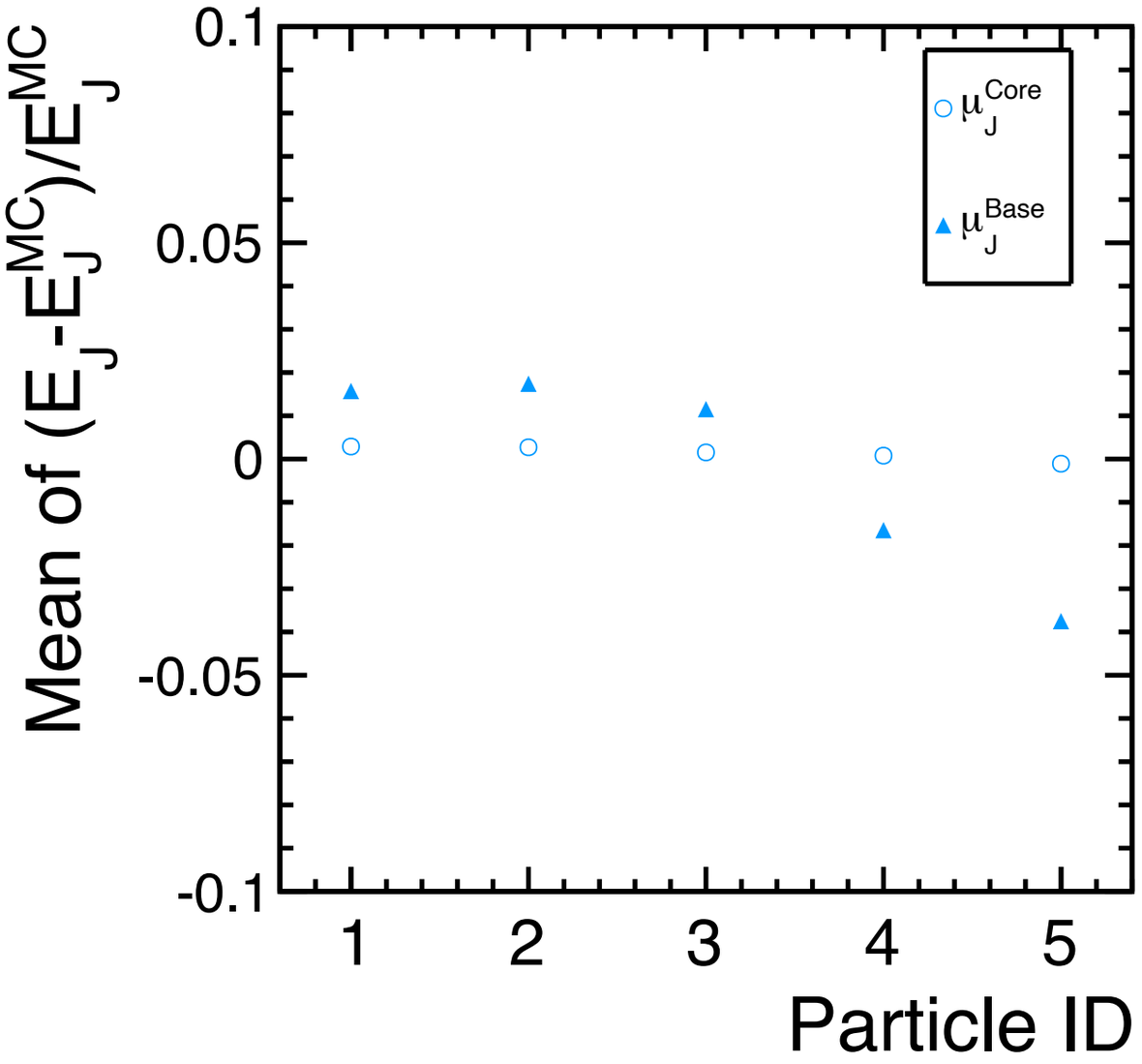

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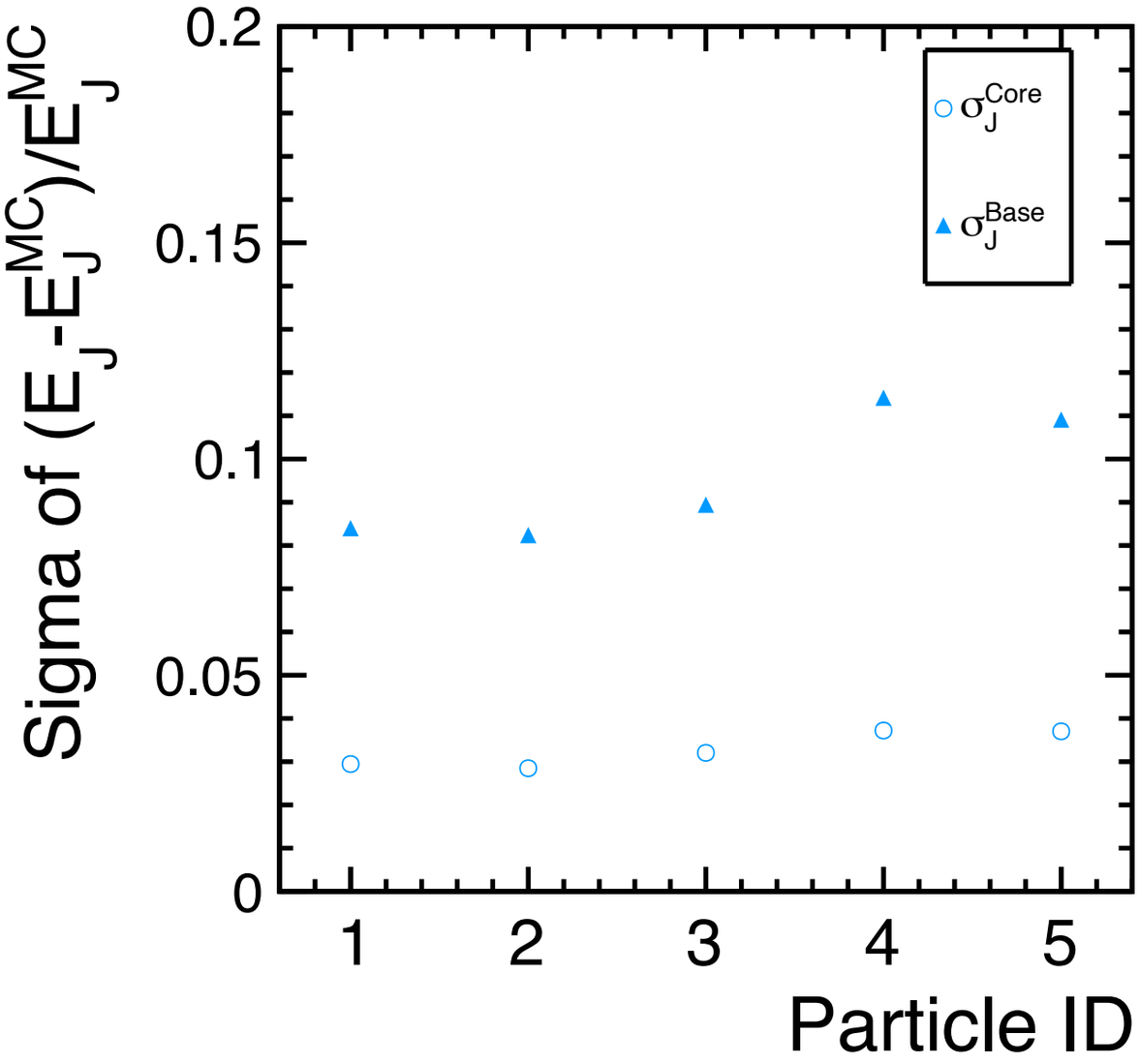
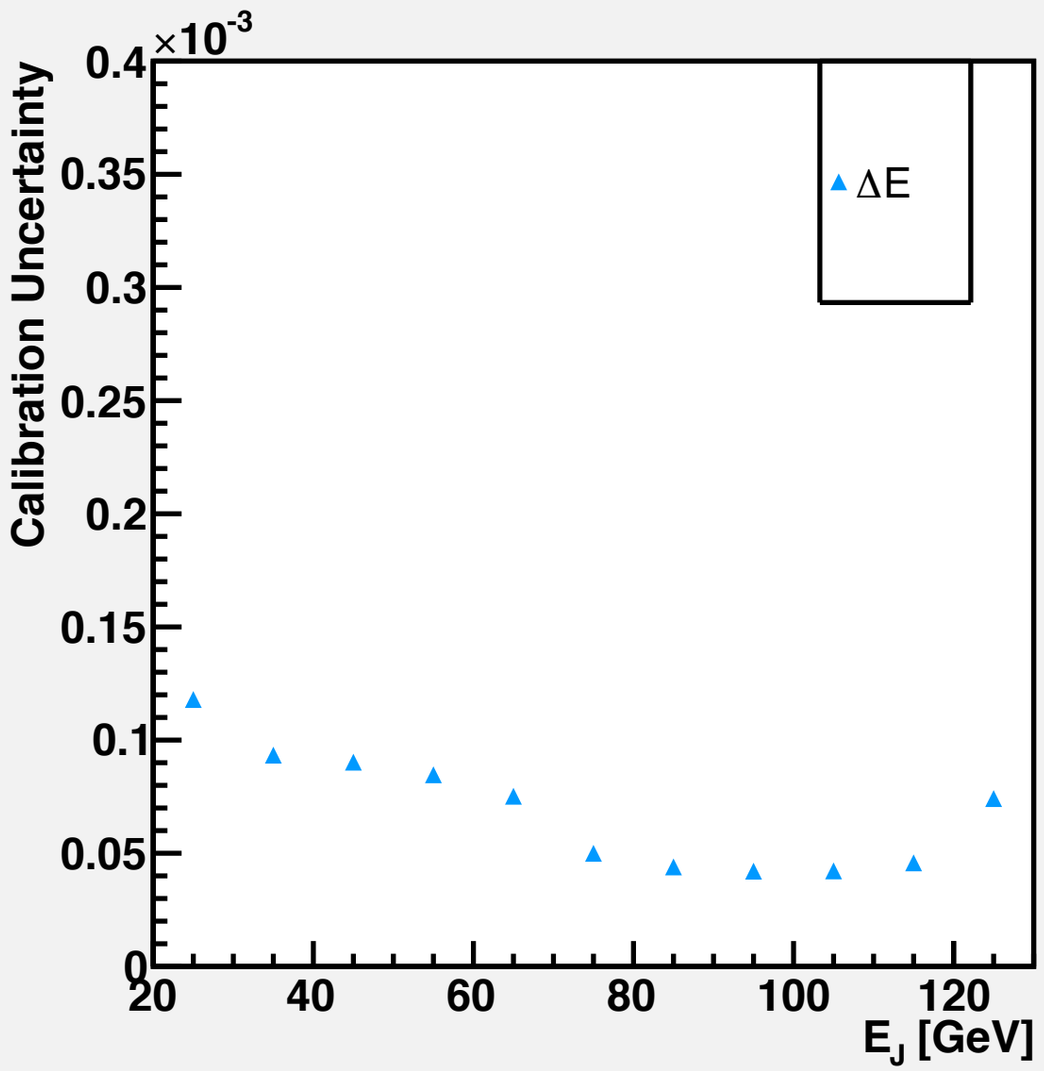


Calibration Uncertainty

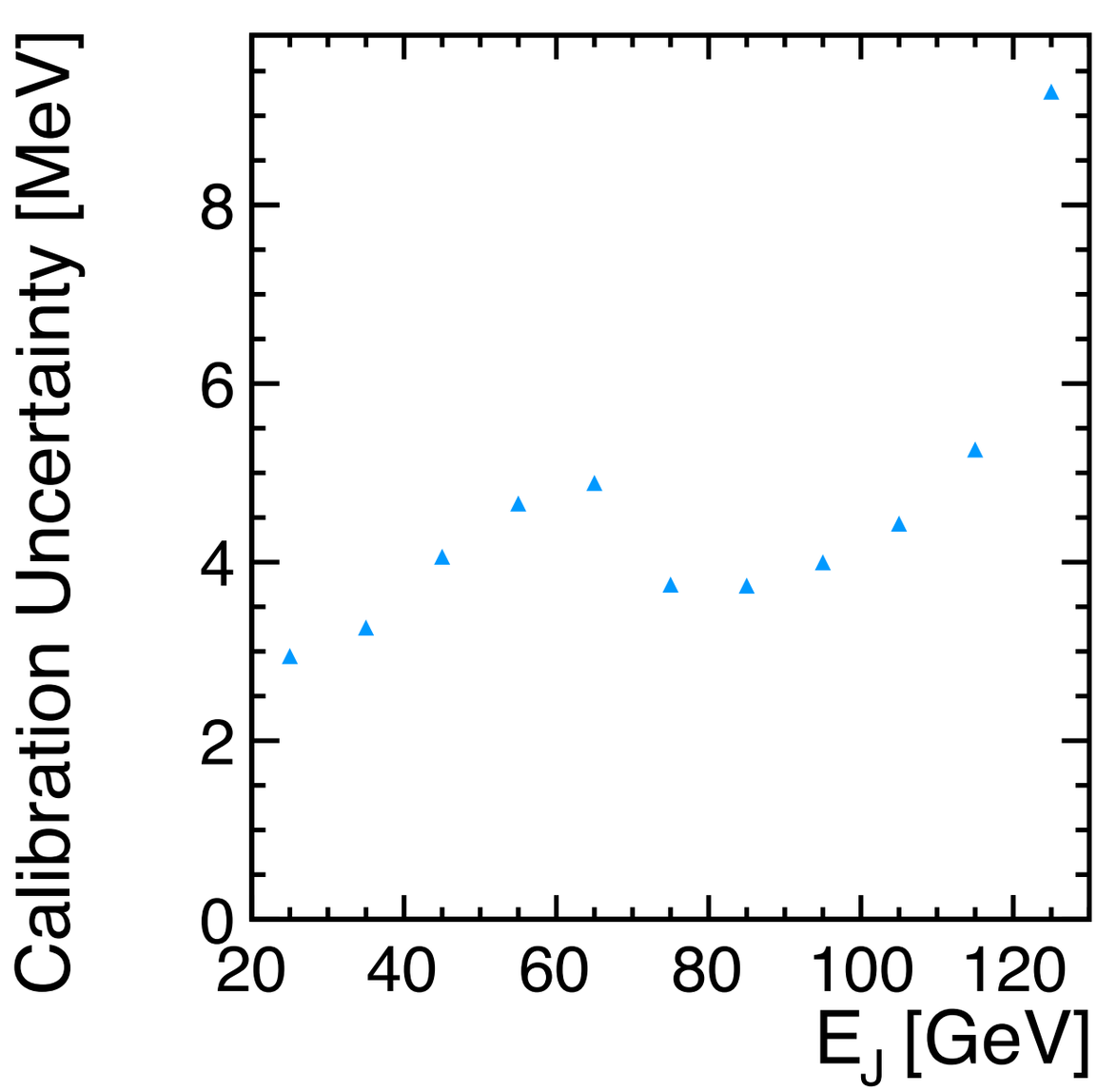
Calibration uncertainty := $\sqrt{(\Delta\mu_{Detector})^2 + (\Delta\mu_{Reconstructed})^2}$

Square root of the squared sum of the error of the mean

Relative uncertainty



Absolute uncertainty



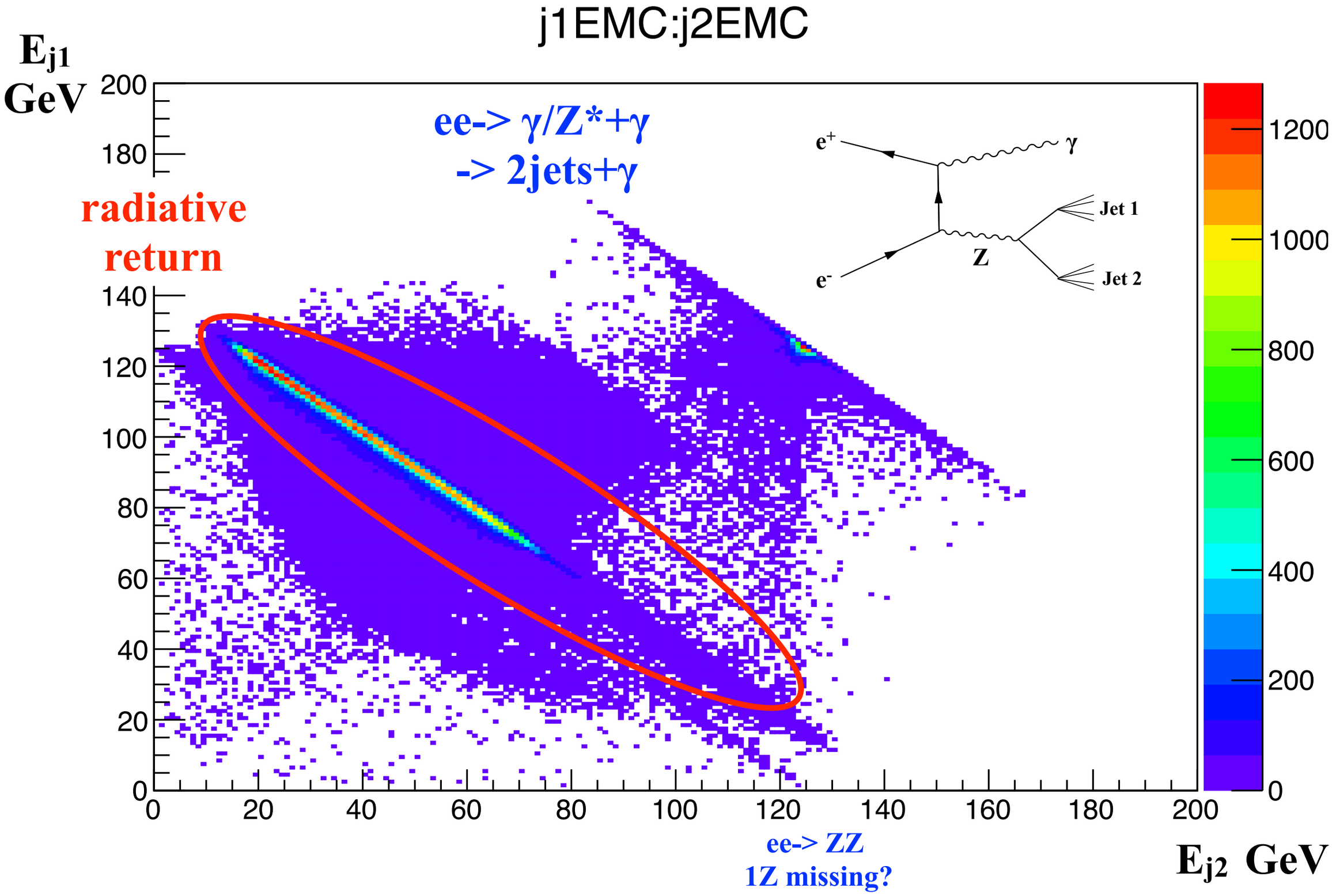
We can calibrate the jet energy scale with about 10^{-4} accuracy, which corresponds to several MeV.

Conclusion & Next Step

- Calibration uncertainty is calculated as a function of energy. It is $<10^{-4}$ accuracy which corresponds to several MeV.
- In the energy dependence plot, horizontal axis (energy) is now from Method3 reconstructed. I will change this into PFO.
- Derive the calibration constant as a function of energy and theta.

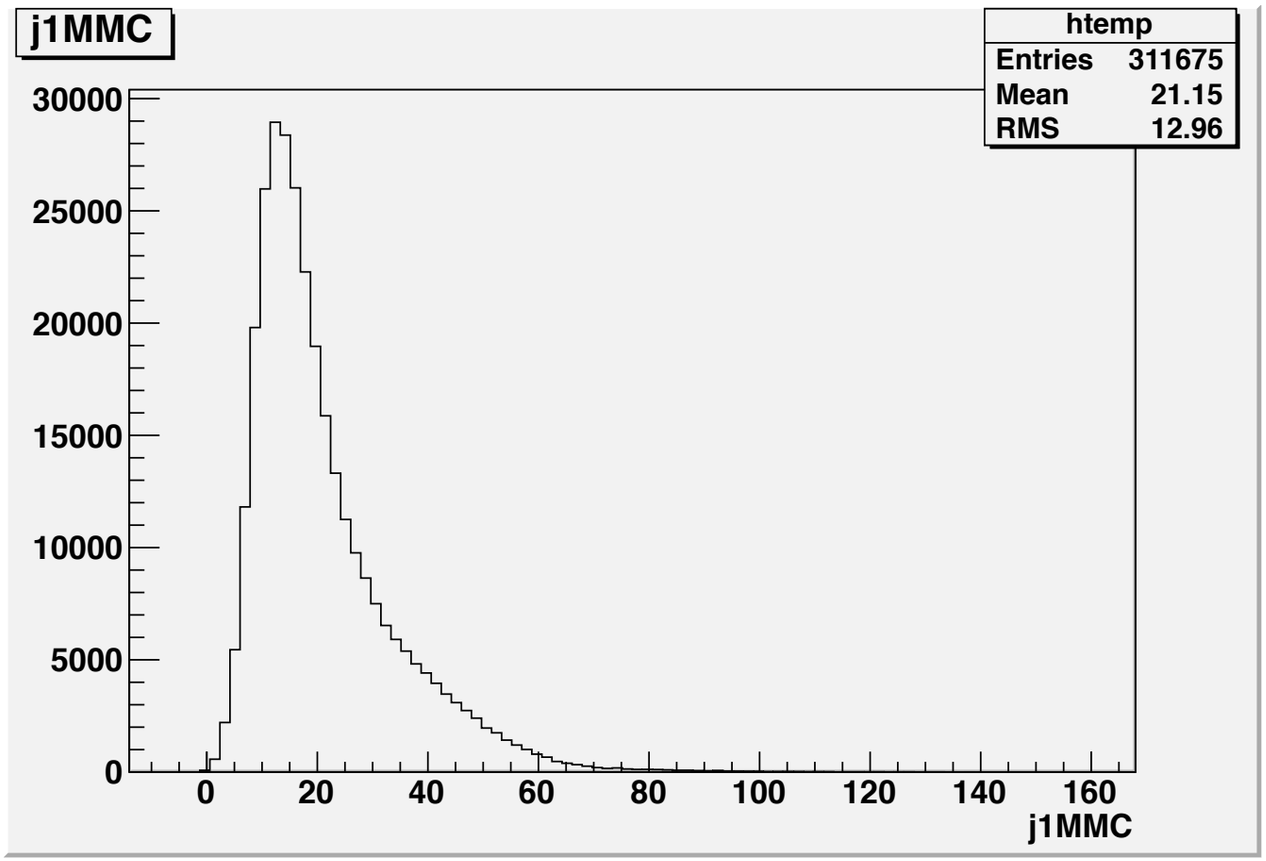
Backup

Jet energy distribution



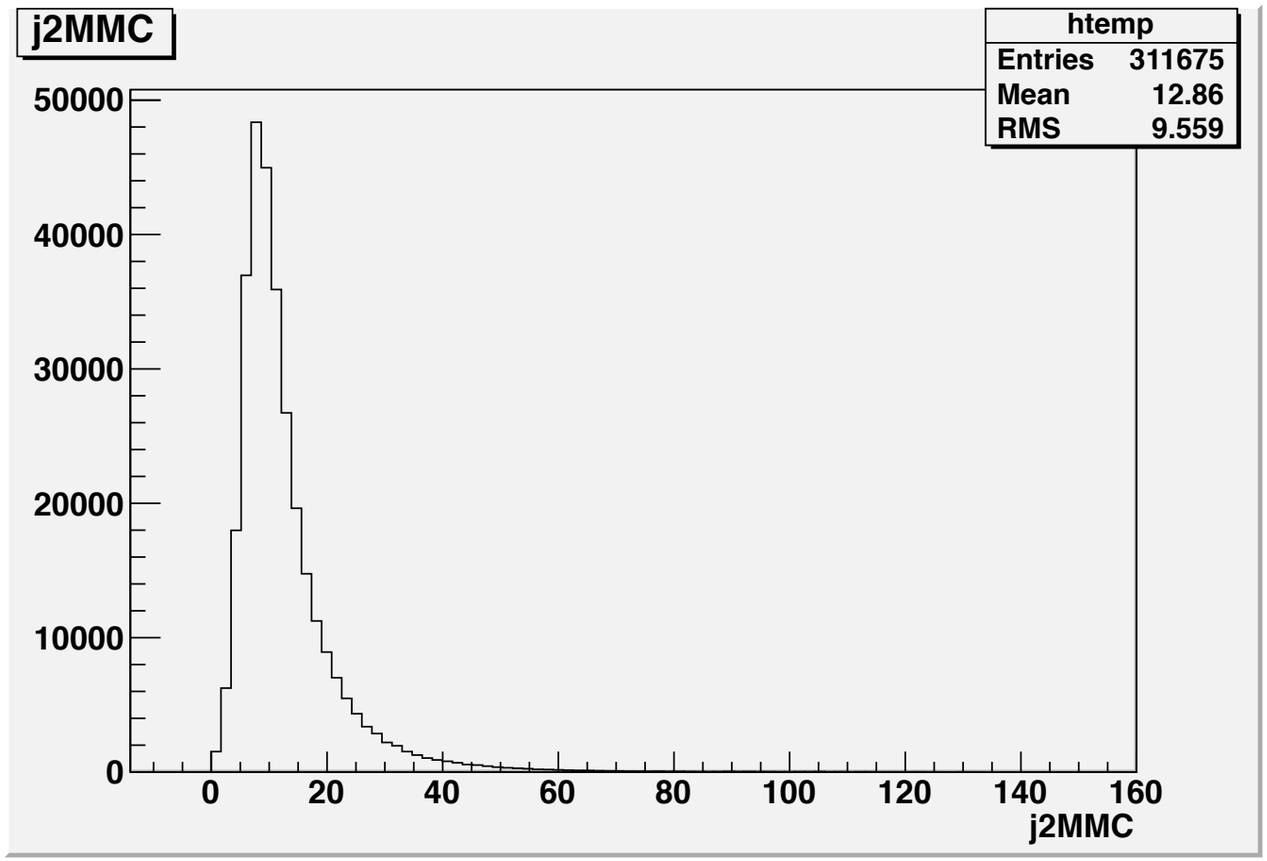
Jet mass distribution

Jet1



M_{Jet1} GeV

Jet2

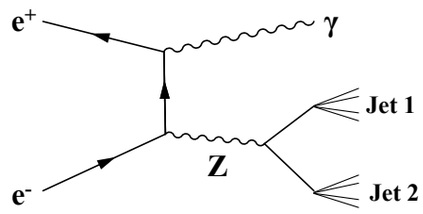


M_{Jet2} GeV

Correct photon selection

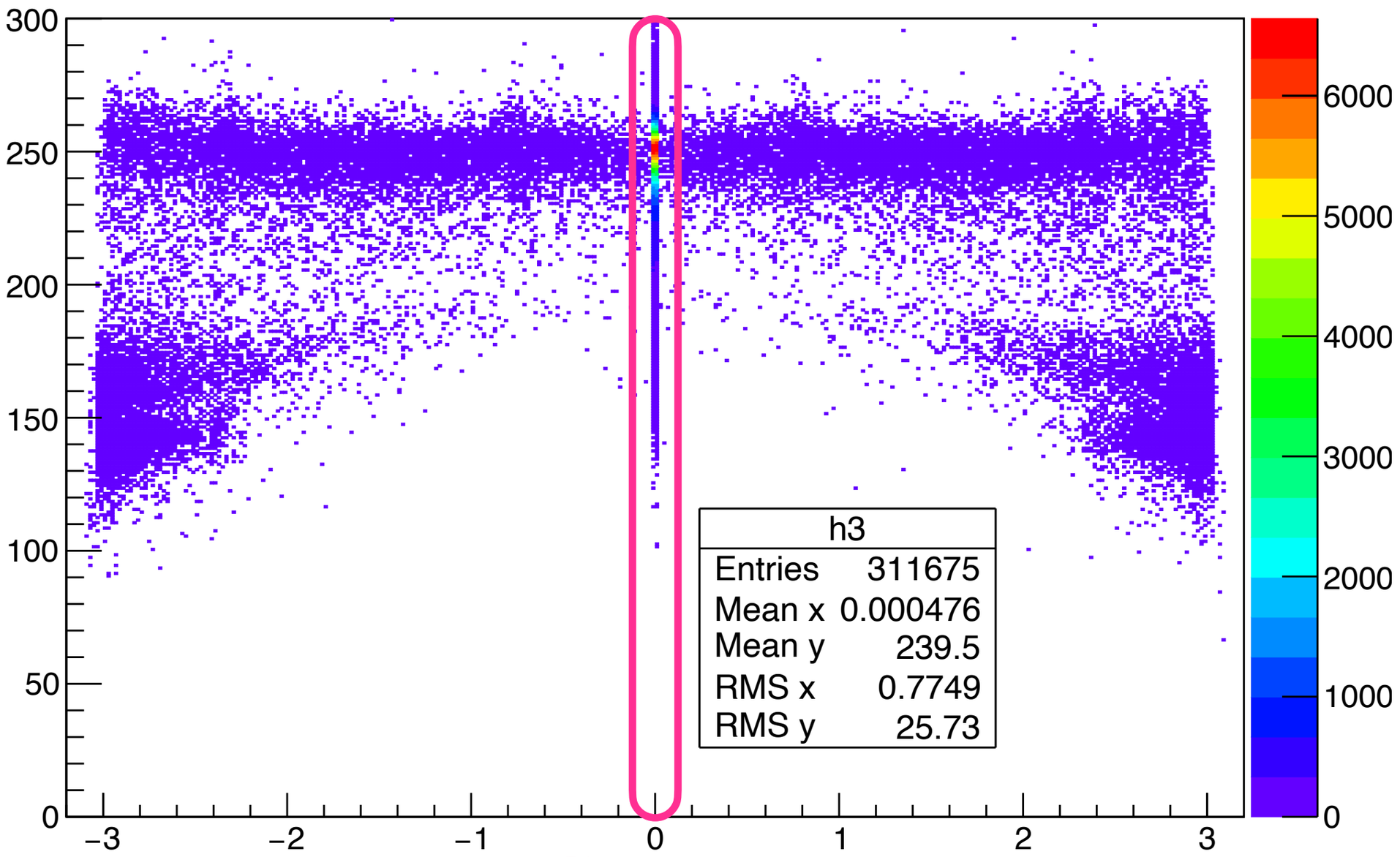
E_{vis} (=E_{j1}+E_{j2}+E_γ) vs. $\Delta\theta_\gamma$ =θ_γ(meas)-θ_γ(MC)

True signal photon: feeble and missing



True signal photon: energetic but missing

Selected photon: from jets



$|\Delta\theta_\gamma|$ <0.01 events: 87.8%

$|\Delta\theta_\gamma|$ >0.01 events: 12.2%

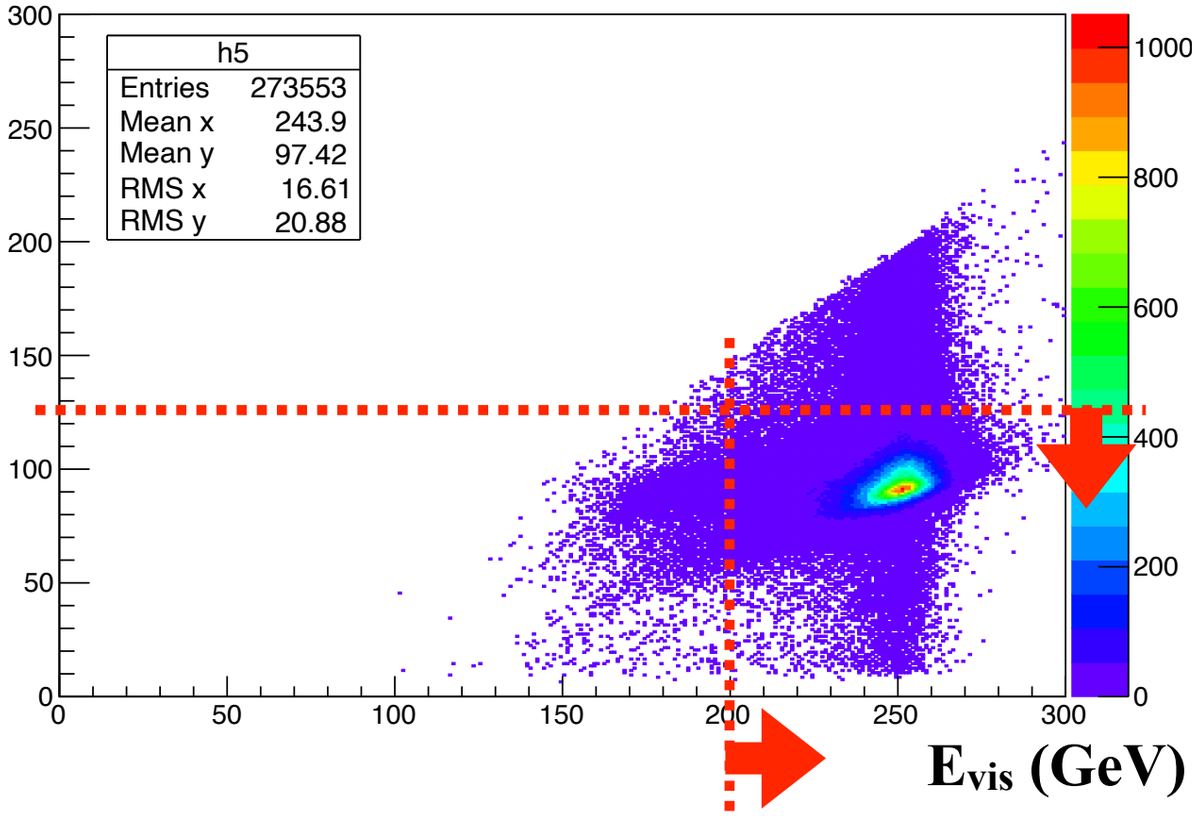
Correct Photon

Correct photon selection cut 1

M_{2j} vs. E_{vis} (=Ej1+Ej2+Eγ)

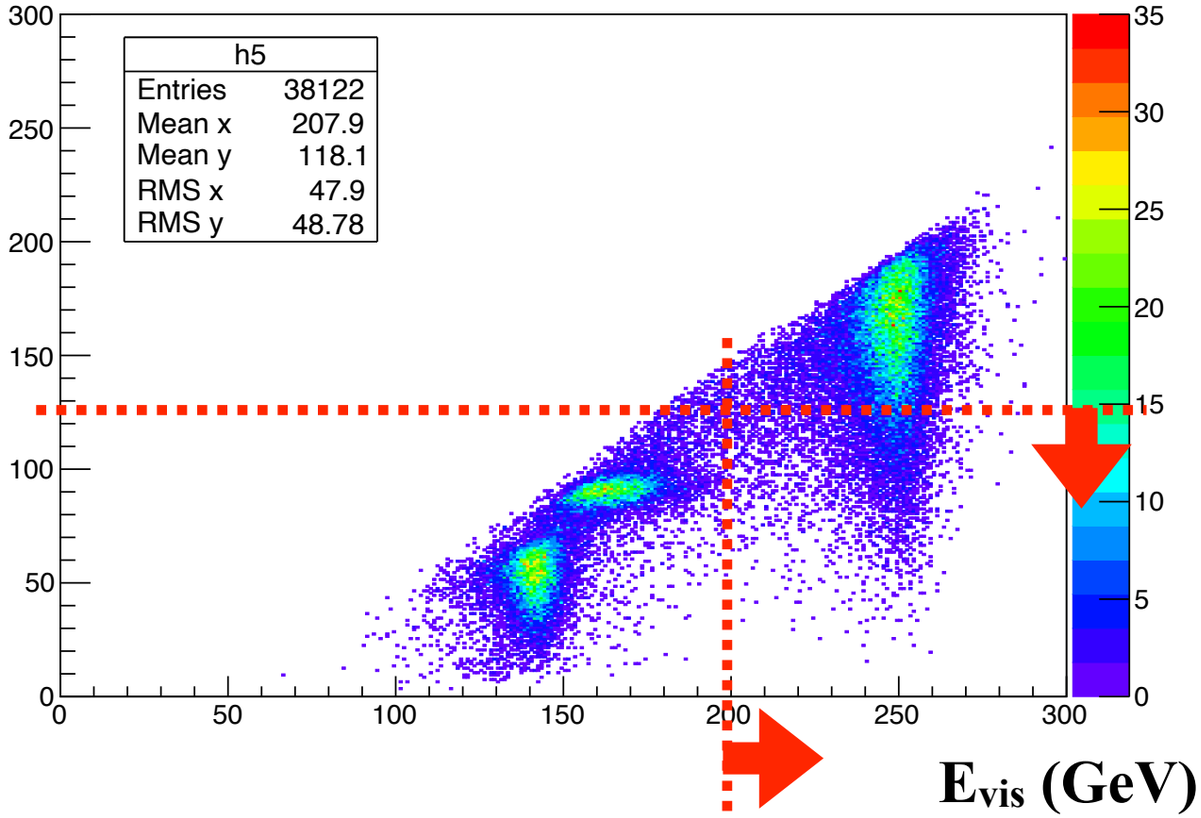
correct photon case

$|\Delta\theta_\gamma| < 0.01$



wrong photon case

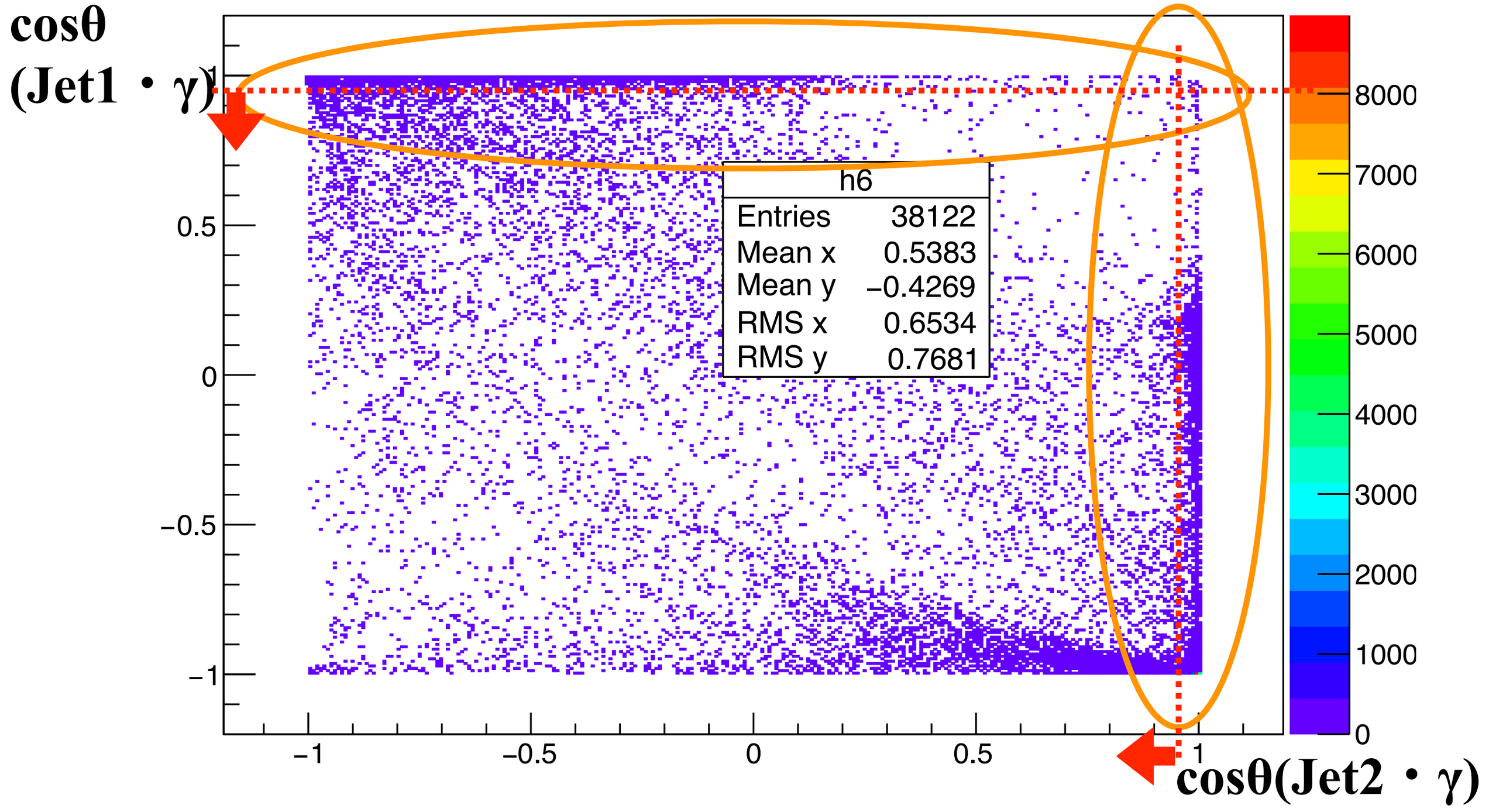
$|\Delta\theta_\gamma| > 0.01$



Cut1: M_{2j} <125 GeV && E_{vis} >200 GeV

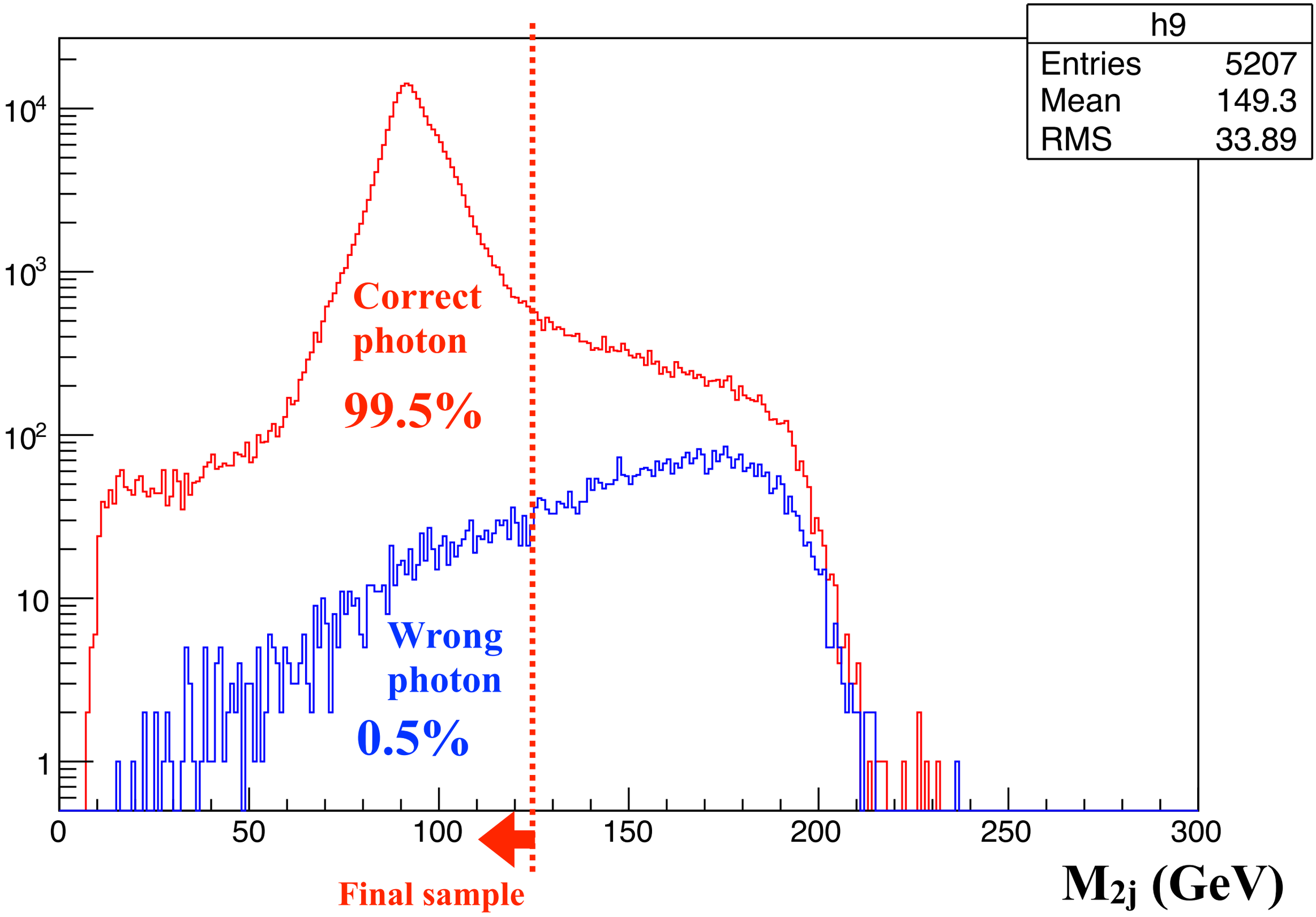
Correct photon selection cut 2

Wrong photons are near jet axes



Cut2: cosθ(Jet1 ・ γ)<0.95 && cosθ(Jet2 ・ γ)<0.95

M_{2j} distribution after all but M_{2j} cut



Source of the bias

Source of the bias is investigated.
-> 2 major source are found.

Inputs and outputs

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})

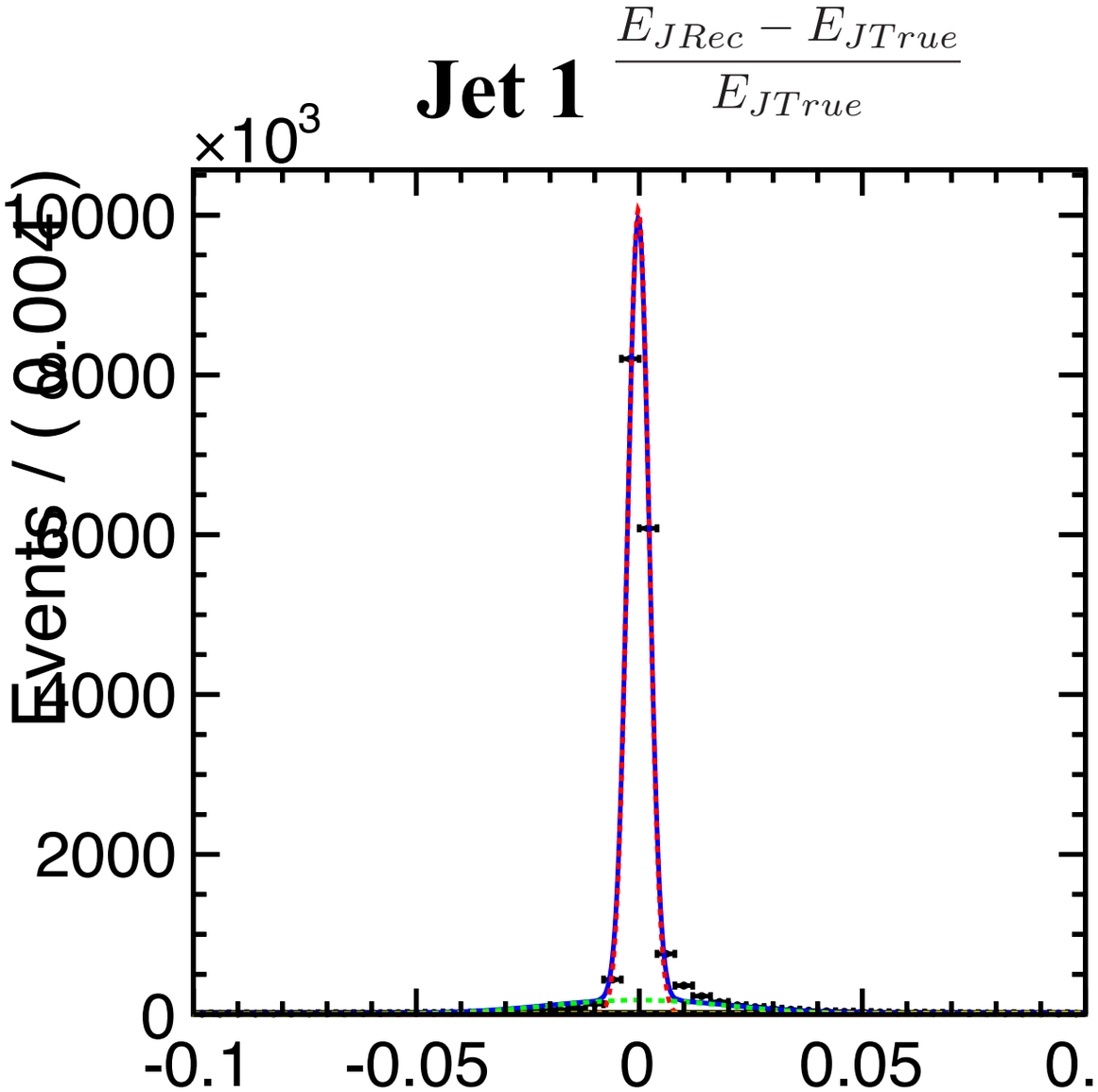
$$\begin{cases} \sqrt{P_{J1}^2+m_{J1}^2}+\sqrt{P_{J2}^2+m_{J2}^2}+|P_\gamma|+|P_{ISR}| = E_{CM} \quad ① \\ \begin{pmatrix} sin\theta_{J1}cos\phi_{J1} & sin\theta_{J2}cos\phi_{J2} & sin\theta_\gamma cos\phi_\gamma \\ sin\theta_{J1}sin\phi_{J1} & sin\theta_{J2}sin\phi_{J2} & sin\theta_\gamma sin\phi_\gamma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

Matrix A — Inverse

(A) Beam energy spread
(B) Error of the jet mass inputs

Source (A): Beam energy spread

When all inputs are all MCtruth,

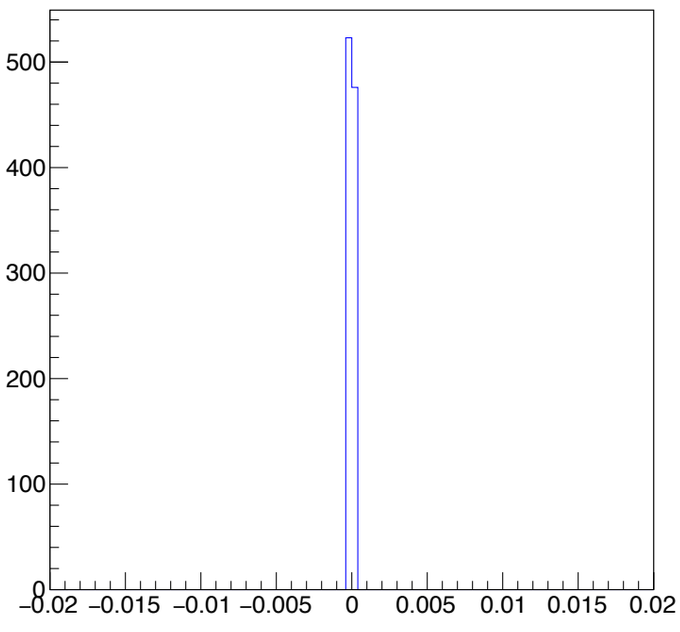


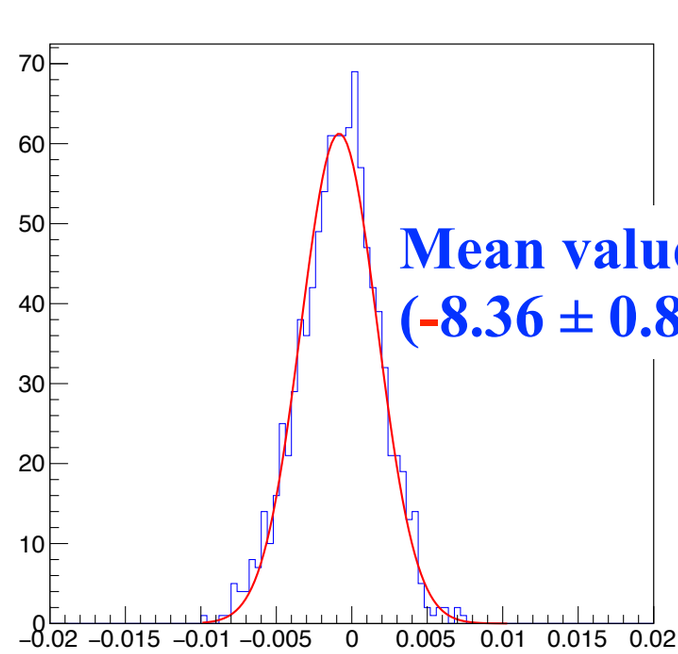
Mean value: (-1.97 ± 0.01) ×10^{-4}

No beam energy smearing

With beam energy smearing (0.3%)

Toy MC Simulation



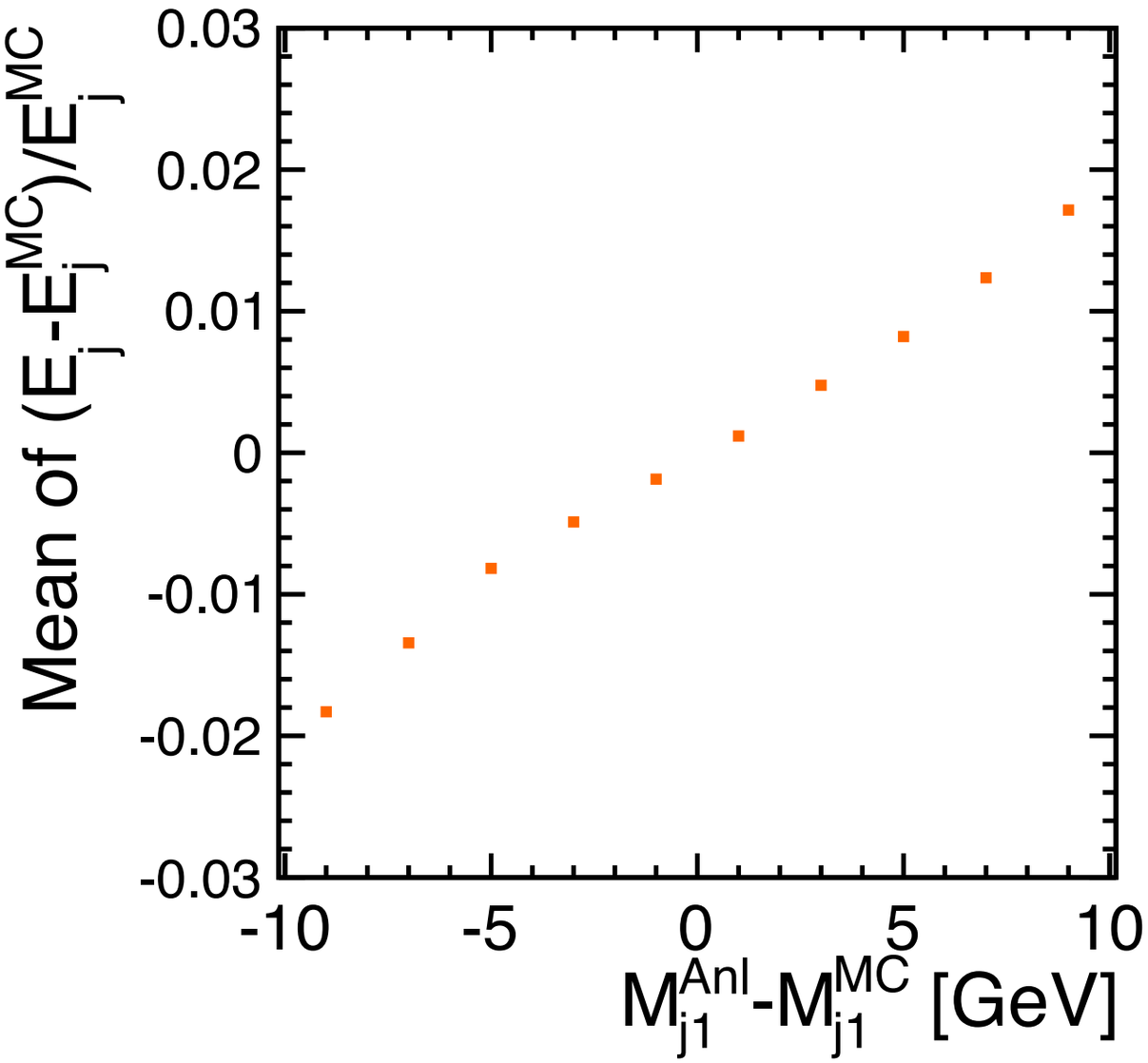


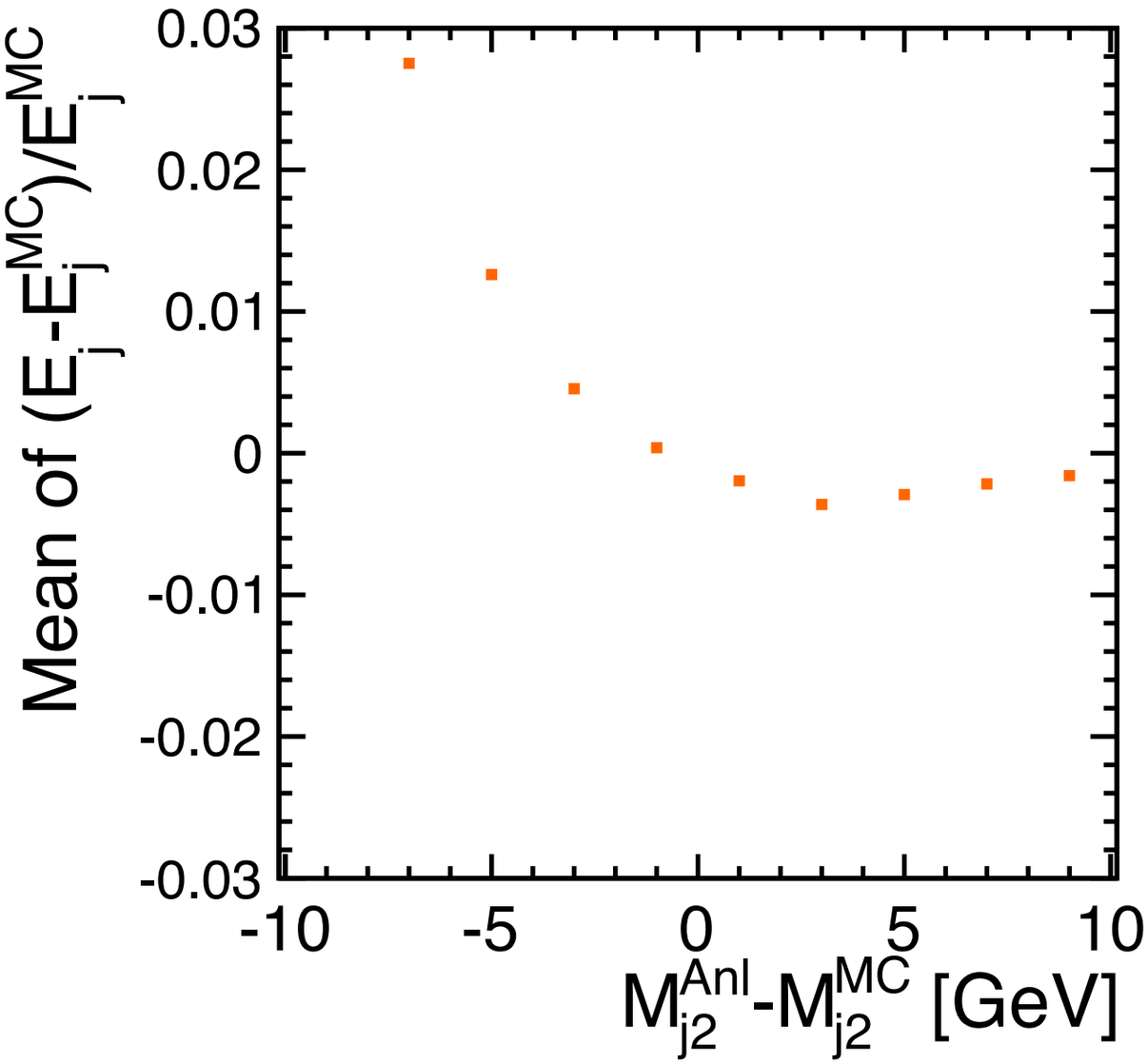
Mean value: (-8.36 ± 0.85) ×10^{-4}

Beam energy spread causes negative bias in jet 1 reconstructed energy.
Positive bias in Jet 2 is also confirmed as well.

Source (B): Error of the jet mass inputs

Mean value of the fitting function for the Jet 1 $\frac{E_{JRec} - E_{JTrue}}{E_{JTrue}}$ as a function of the input jet mass deviation





Large dependence on both jet 1 mass and jet 2 mass input deviations. If $<8 \times 10^{-4}$ accuracy is necessary, compensation to the reconstructed jet energy should be introduced.