



Study of EMC Position Reconstruction

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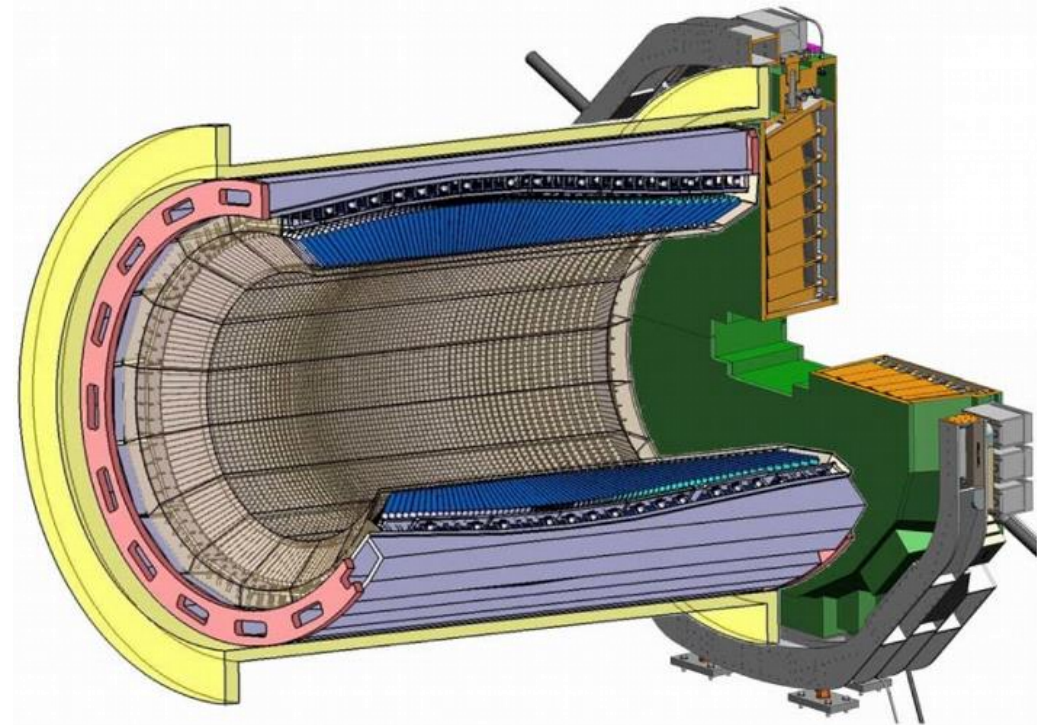
2 Institute of High Energy Physics

Panda Collaboration Meeting

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Introduction

- ✓ \bar{P} ANDA physics
 - Full reconstruction of multi-photon and lepton-pair channels of utmost importance
- ✓ Target Spectrometer
 - Barrel part and two endcaps
 - 15,580 crystals, improved PbWO₄
 - $X_0 = 0.89$ cm, $R_M = 2.00$ cm
 - For barrel EMC, 11200 crystals, the average lateral size of crystal is 21.3mm
- ✓ Forward Spectrometer
 - Shashlik type sampling calorimeter
- ✓ Good energy and spatial resolution for photons
 - $\leq 1\% \oplus \frac{\leq 2\%}{\sqrt{E/GeV}}$ (Target Spectrometer)
 - $\leq 0.5^\circ$ (backward), $\leq 0.3^\circ$ (**barrel**), $\leq 0.1^\circ$ (forward)



- For barrel EMC :
 - $22^\circ < \theta < 140^\circ$
 - $0^\circ < \phi < 360^\circ$

EMC Reconstruction

✓ Reconstruction

- Cluster Finding
 - Start at the crystal exhibiting the largest energy deposit
 - Find the neighbor crystals with energy deposit greater than a certain threshold until no more crystal fulfills the threshold criterion.

• Cluster Splitting

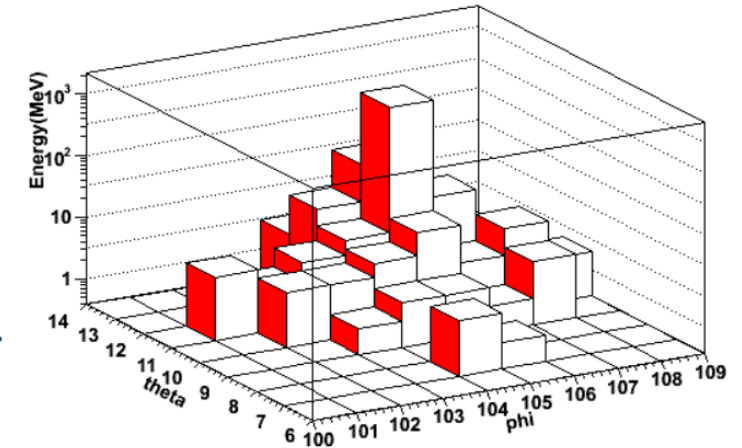
- An energy/position iterative algorithm is used:

$$E_{\text{target}} = E_{\text{seed}} \cdot \exp(-2.5 r/R_M)$$

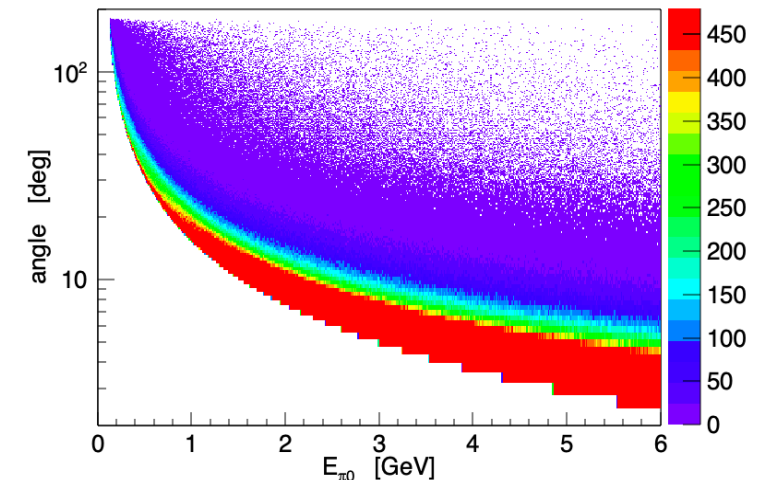
- Estimate energies and positions of the single showers involved as input parameters
- Calculate the fraction of energy for each shower deposited in same crystal

• Cluster position calculation

- The spatial position of a cluster is calculated via a center-of-gravity method



Schematic diagram of 1GeV energy clusters



Angles between the 2γ from π^0

Position Calculation Formula

✓ Shower position calculation:

$$x^{rec} = \frac{\sum_j^N w_j \cdot x_j}{\sum_j^N w_j}, \quad x_j = \theta, \phi$$

where x^{rec} is the reconstruction position of cluster, and x_j is the depth position of the j -th crystal.

• Weighting function: w_j

• Linear:

- $W_j = E_j$

• Lilo:

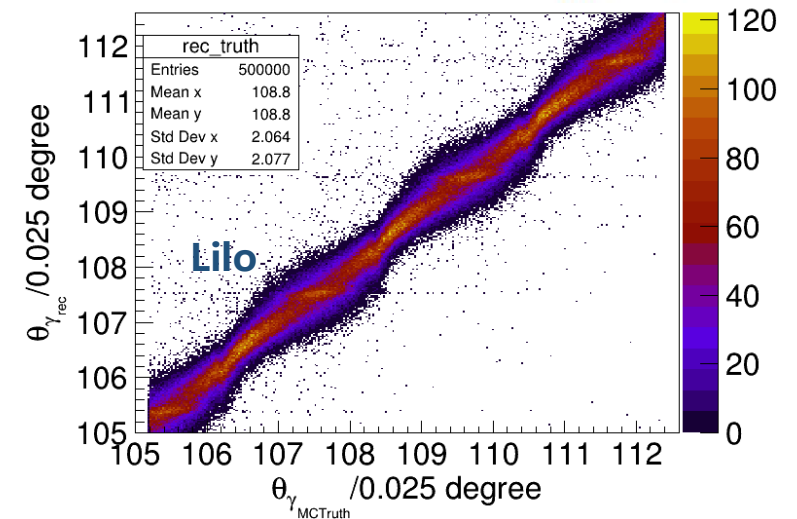
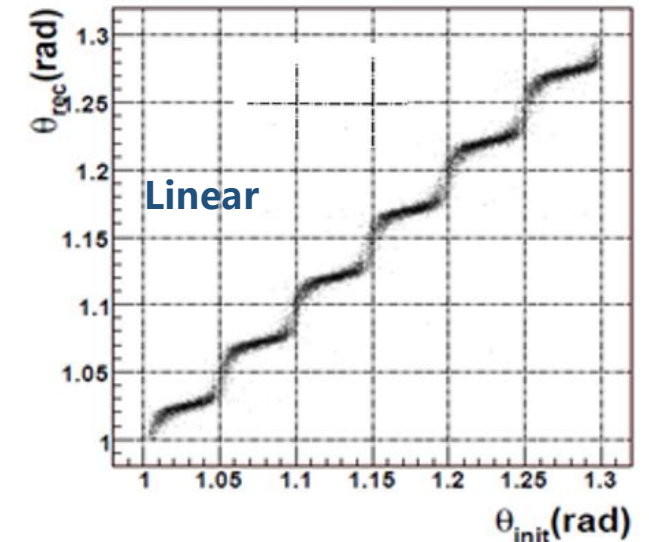
- $W_j = \text{Max}\{0, \text{Offset} + \ln(E_j) - \ln(E_{clus})\}$

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E_{clus}^{1.171}} \cdot E_{clus}^{-0.534}$

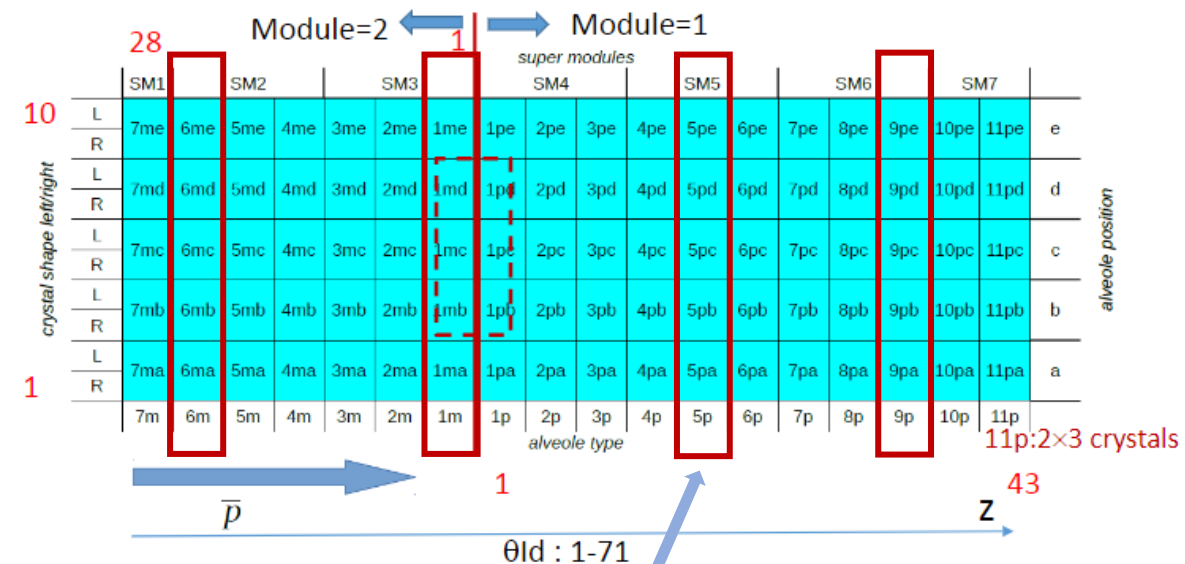
- Raw OffsetParmA=4.071
- Raw OffsetParmB=0.678
- Raw OffsetParmC=1.000

Parameters in PandaRoot
Need to be checked

Technical Design Report for PANDA Electromagnetic Calorimeter



Dataset

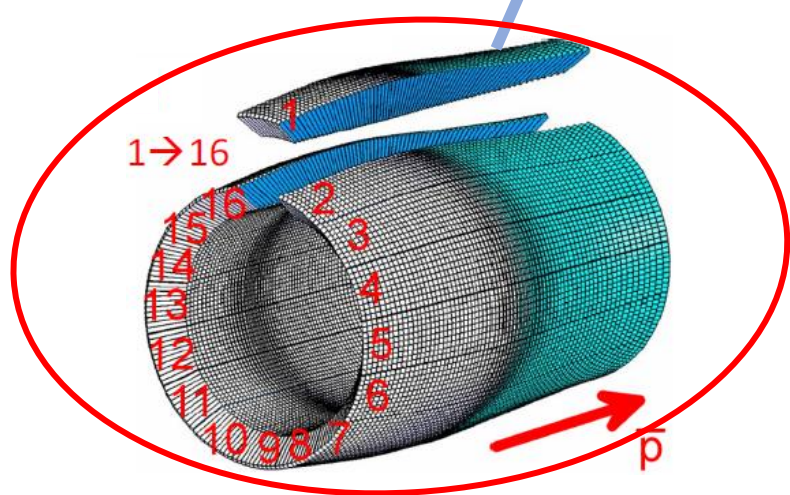


✓ Data sample

- Energy: 0.1~6.0GeV
- Particle: Single Photon
- θ direction: 4 types of submodules

Location	SM2_6m	SM3_1m	SM5_5p	SM6_9p
Range	(128.4°, 134.8°)	(87.6°, 95.6°)	(48.0°, 54.4°)	(28.4°, 31.6°)

- ϕ direction: (0°, 360°)
- Event number: 10000



Barrel EMC Mechanical Structure
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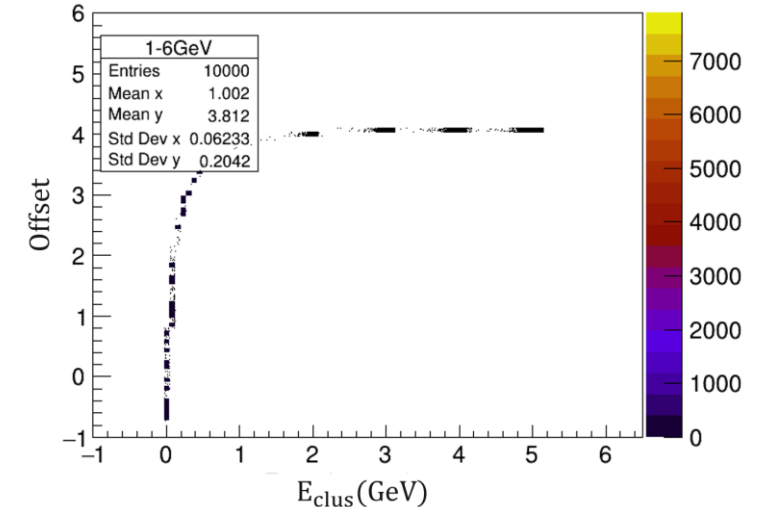
Offset measurements and parameterization

✓ Measure offset by chis-square fit to simulation data:

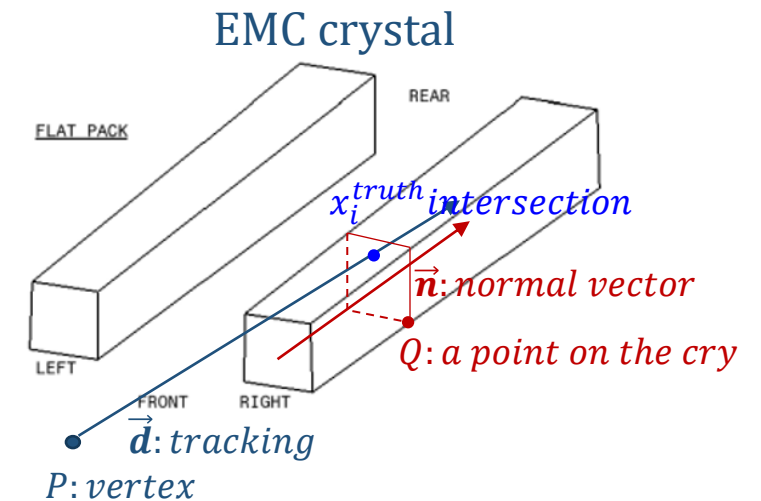
$$\chi^2 = \sum_i^N \frac{(x_i^{rec}(offset) - x_i^{truth})^2}{\sigma_i^2}, x = \theta, \phi$$

where x_i^{rec} and x_i^{truth} are the reconstruction and MCtruth position of the i -th event.

- $x_i^{rec} = \frac{\sum_j^N w_j \cdot x_j}{\sum_j^N w_j}$, $W_j = \text{Max}\{0, \text{Offset} + \ln(E_j) - \ln(E_{clus})\}$
- MCtruth position (x_i^{truth}) is the intersection of tracking and depth plane:
 - $x_i^{truth} = P + t\vec{d}$, $t = \frac{(P-Q) \cdot \vec{n}}{\vec{d} \cdot \vec{n}}$



The offset curve of the raw offset parameters

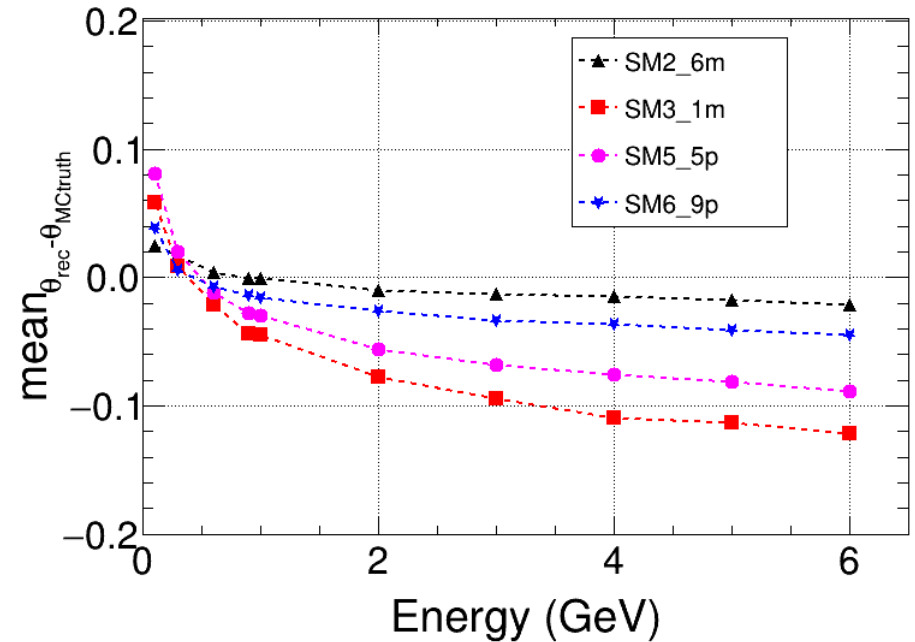


The position calculation schematic of MCtruth

Fit Method

- ✓ Three different chisq fit methods are used
 - Method **A: theta as object**
 - $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$
 - Method **B: phi as object**
 - $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$
 - Method **C: theta as object with mean correction**
 1. Make a correction of the mean shift
 2. $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$
- ✓ The theta and phi distribution of three methods are checked.

- ✓ Mean shift phenomenon at the fitting result

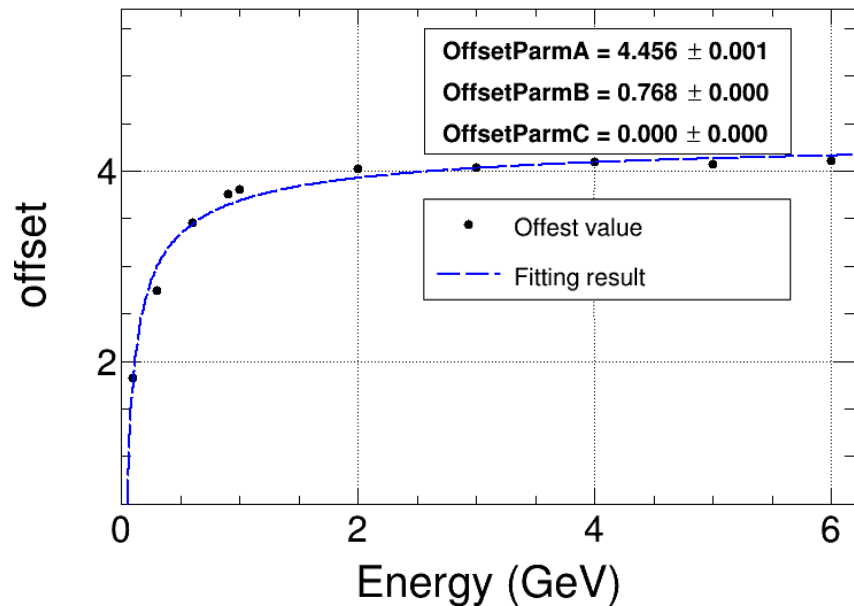


mean $_{\theta_{rec} - \theta_{MCtruth}}$ vs. Energy

Fit Method A: theta as object

✓ Result of Updated Offset Parameters

- $\theta = (128.4, 134.8)$
- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$



Distribution of offset values at different energy points and fitting result

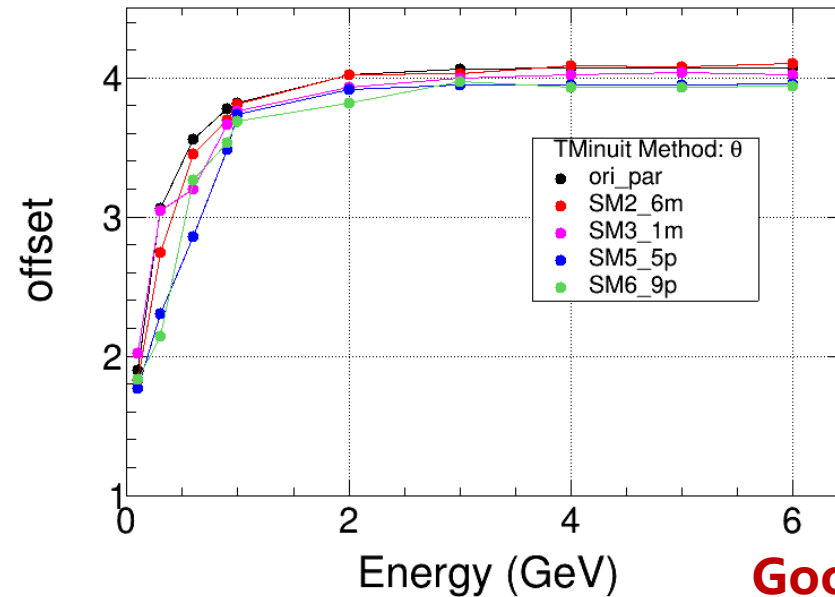
Fitting :

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

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The result of fit the distribution of offset values at different energy points with different data samples.

Original parameter	SM2_6m (128.4, 134.8)	SM3_1m (87.6, 95.6)	SM5_5p (48.0, 54.4)	SM6_9p (28.4, 31.6)
A=4.071	A=4.456	A=4.049	A=3.978	A=4.308
B=0.678	B=0.768	B=0.688	B=0.762	B=0.743
C=1.000	C=0.000	C=0.224	C=0.423	C=0.000



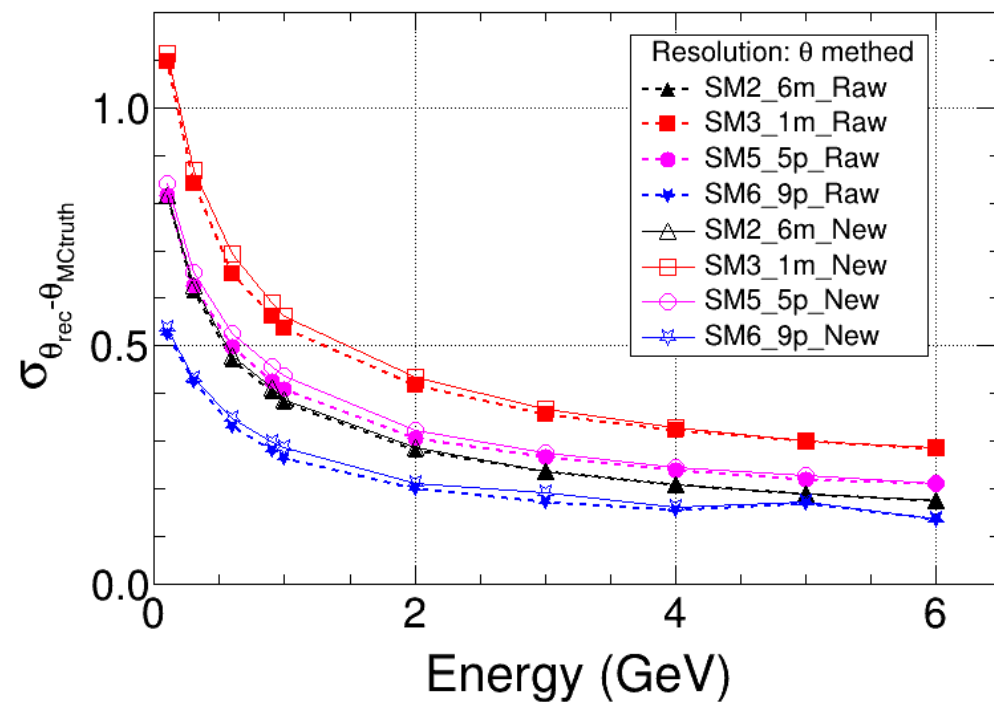
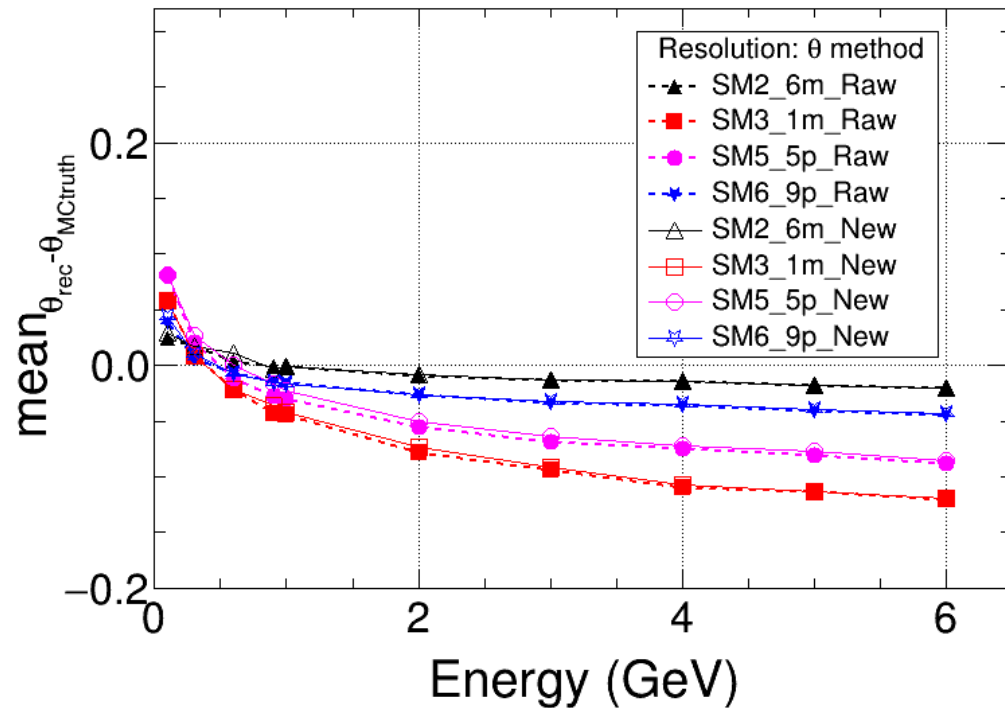
Good consistency

The distribution of offset value at different energy points with different data samples.

Theta check (method A)

✓ Theta distribution

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$
- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).

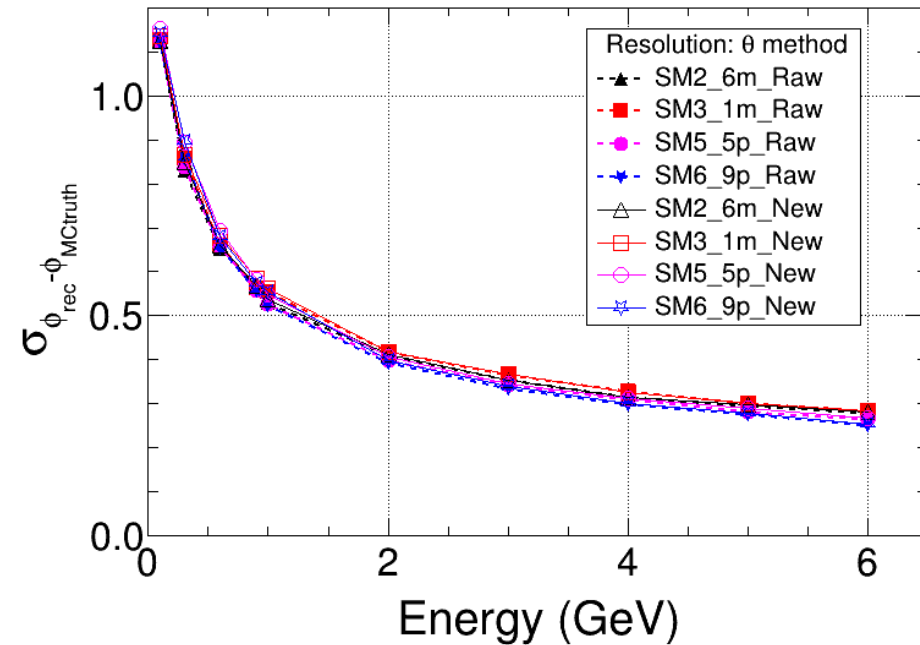
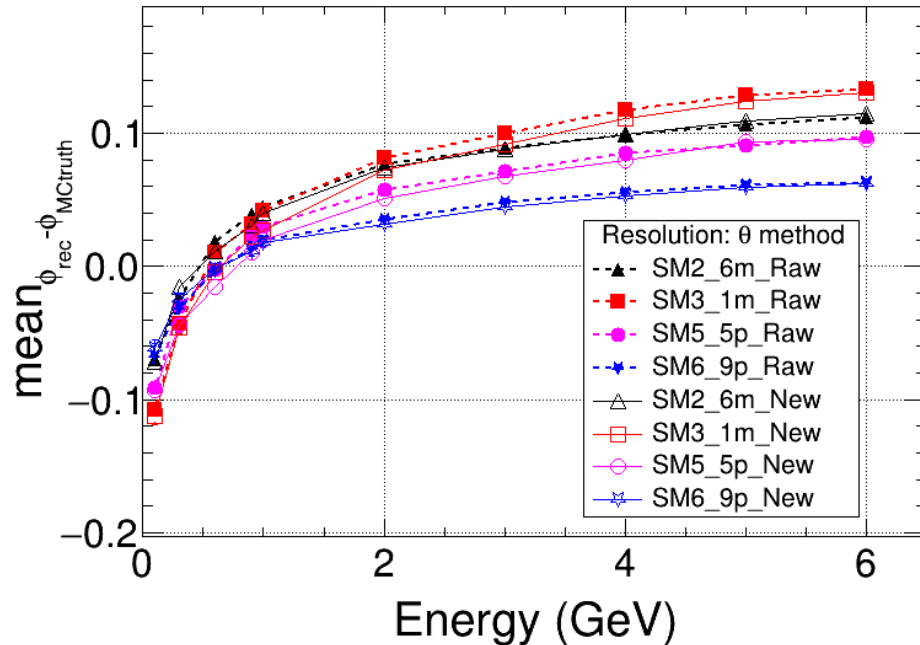


The distribution of origin and updated offset parameter fitting result of $\theta_{rec} - \theta_{MCTruth}$ at different energy points with different data samples.

Phi check (method A)

✓ Phi distribution

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$
- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).



The distribution of origin and updated offset parameter fitting result of $\phi_{rec} - \phi_{MCtruth}$ at different energy points with different data samples.

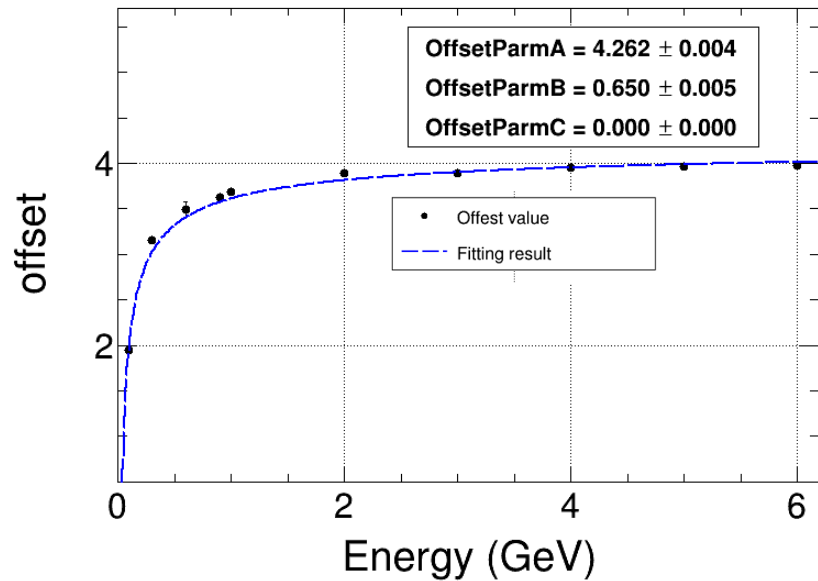
Good consistency among method A and the PandaRoot values

Fit Method B: phi as object

✓ Result of Updated Offset Parameters

- $\theta = (128.4, 134.8)$

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



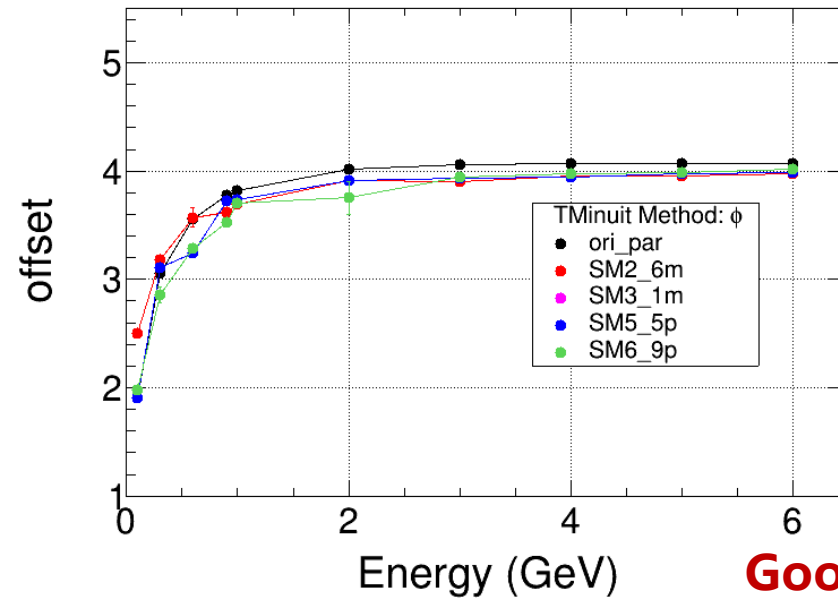
Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · e^{-OffsetParmC·E^{1.171}} · E^{-0.534}

The result of fit the distribution of offset values at different energy points with different data samples.

Original parameter	SM2_6m (128.4, 134.8)	SM3_1m (87.6, 95.6)	SM5_5p (48.0, 54.4)	SM6_9p (28.4, 31.6)
A=4.071	A=4.262	A=4.287	A=4.287	A=4.184
B=0.678	B=0.650	B=0.643	B=0.691	B=0.649
C=1.000	C=0.000	C=0.000	C=0.000	C=0.071



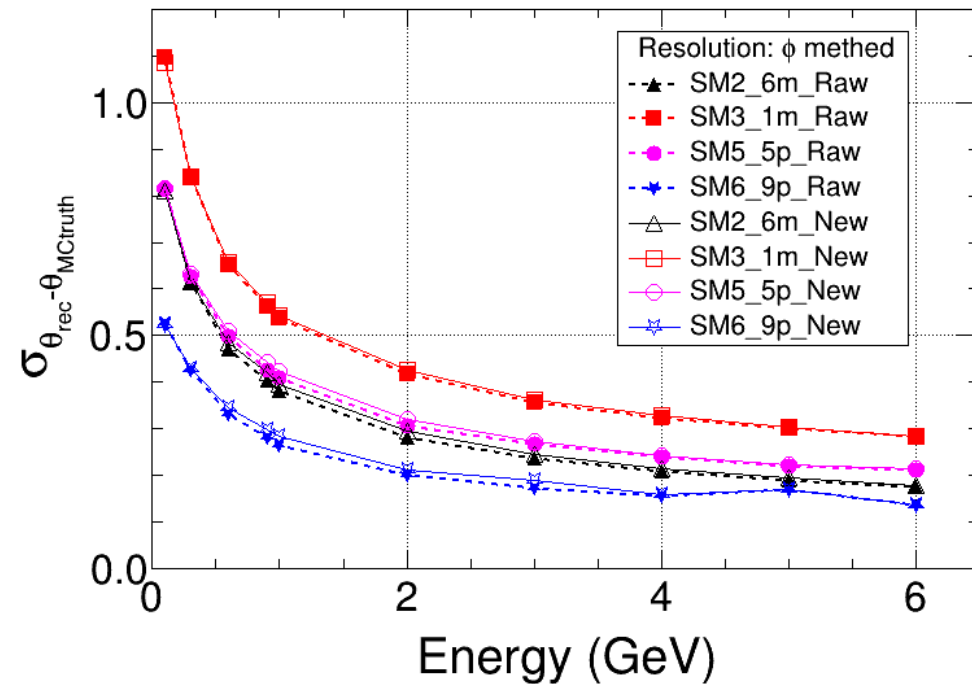
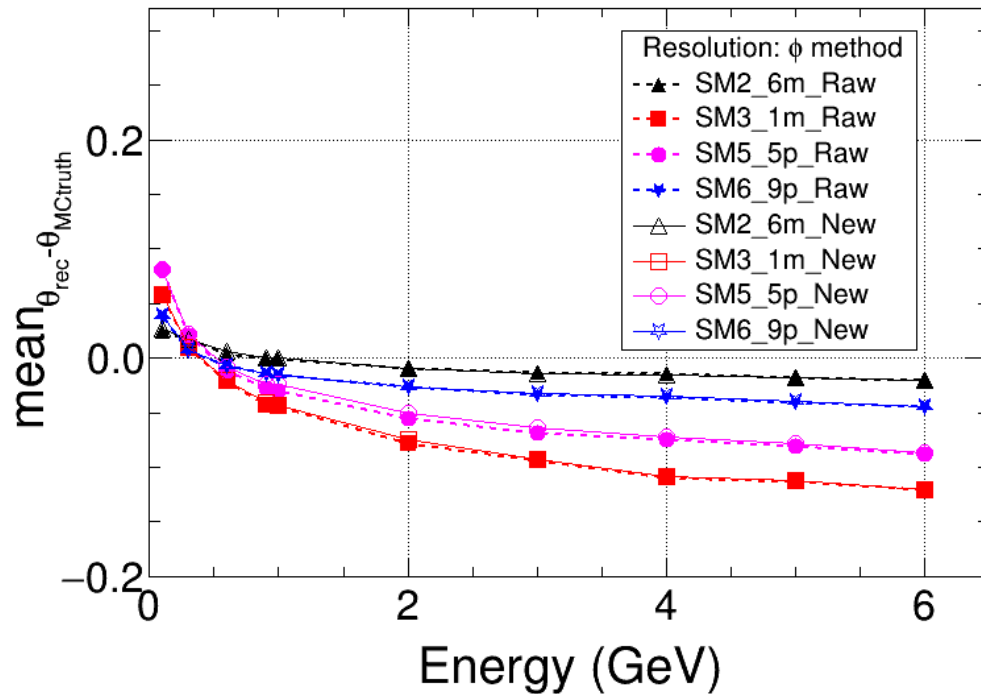
Good consistency

The distribution of offset value at different energy points with different data samples.

Theta check (method B)

✓ Theta distribution

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$
- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).

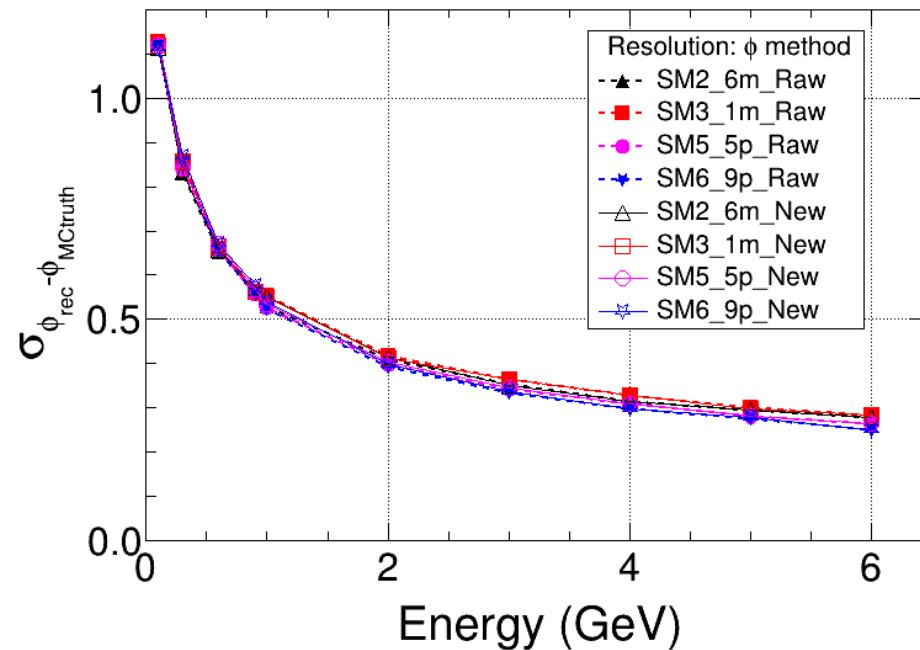
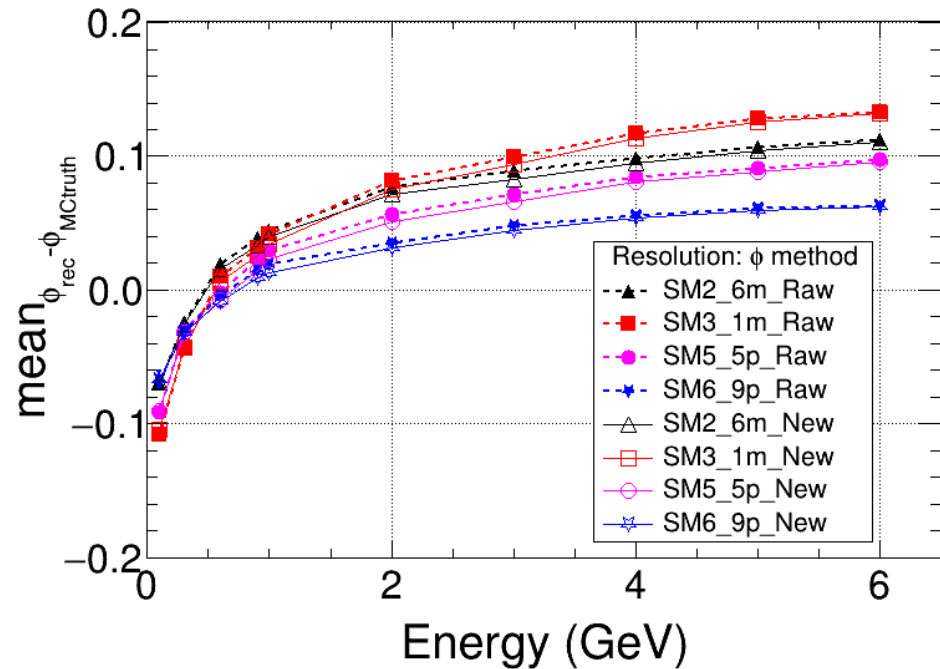


The distribution of origin and updated offset parameter fitting result of $\theta_{rec} - \theta_{MCTruth}$ at different energy points with different data samples.

Phi check (method B)

✓ Phi distribution

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$
- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).



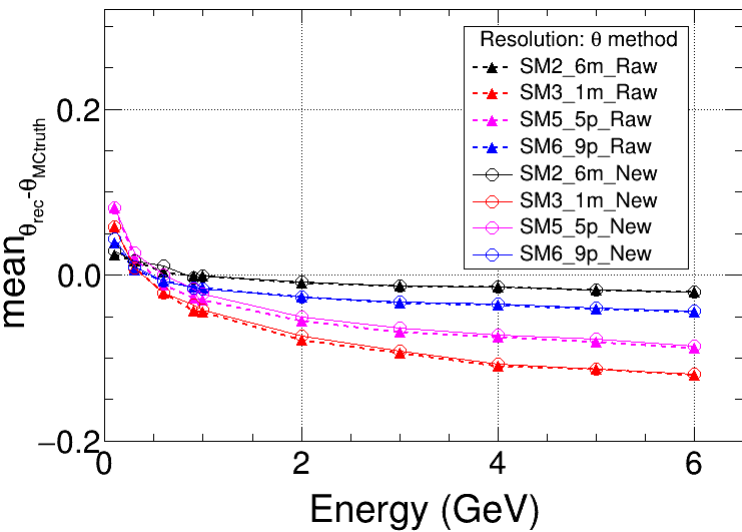
The distribution of origin and updated offset parameter fitting result of $\phi_{rec} - \phi_{MCTruth}$ at different energy points with different data samples.

Good consistency among method B and the PandaRoot values

Fit Method C: theta as object with mean correction

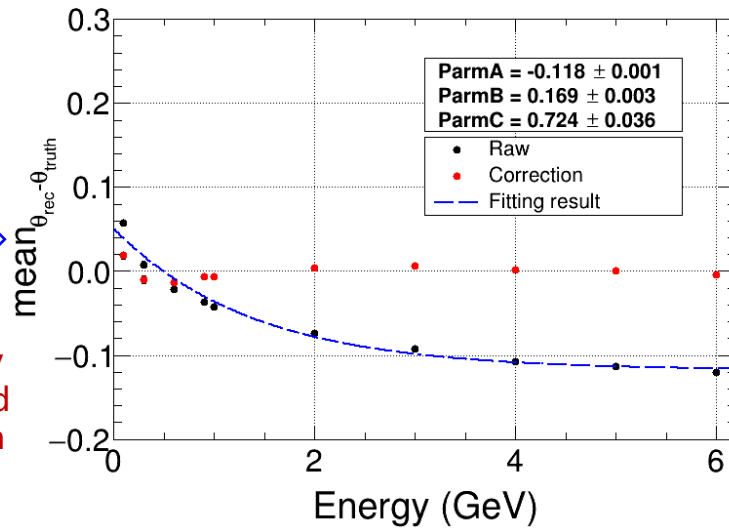
- ✓ Mean shift phenomenon at the fitting result

- $\theta = (87.6, 95.6), \chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$



$mean_{\theta_{rec} - \theta_{MCTruth}}$ vs. Energy

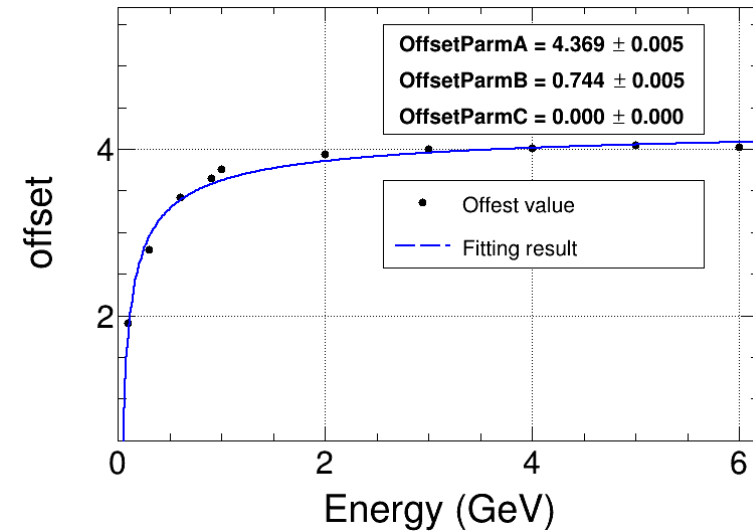
Correcting the mean curve by the constructed fitting function



$mean_{\theta_{rec} - \theta_{MCTruth}}$ vs. Energy

Fitting:

$$\text{Mean} = \text{ParmA} + \text{ParmB} \cdot e^{-E \cdot \text{ParmC}}$$



offset vs. Energy

Fitting:

$$\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$$

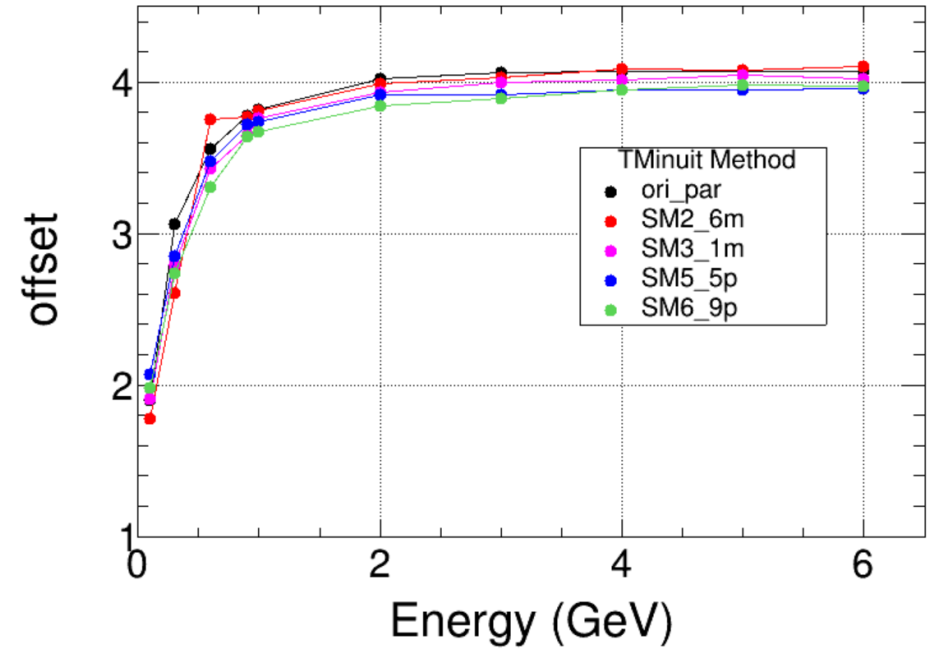
- Chi2 is biased because of the mean shift, so we make a correction

- The shift is removed after the correction

- Re-perform the chisq fit

Fit Method C: theta as object with mean correction

Original parameter	SM2_6m (128.4, 134.8)	SM3_1m (87.6, 95.6)	SM5_5p (48.0, 54.4)	SM6_9p (28.4, 31.6)
A=4.071	A=4.463	A=4.369	A=4.298	A=3.955
B=0.678	B=0.725	B=0.744	B=0.657	B=0.611
C=1.000	C=0.000	C=0.224	C=0.000	C=0.474



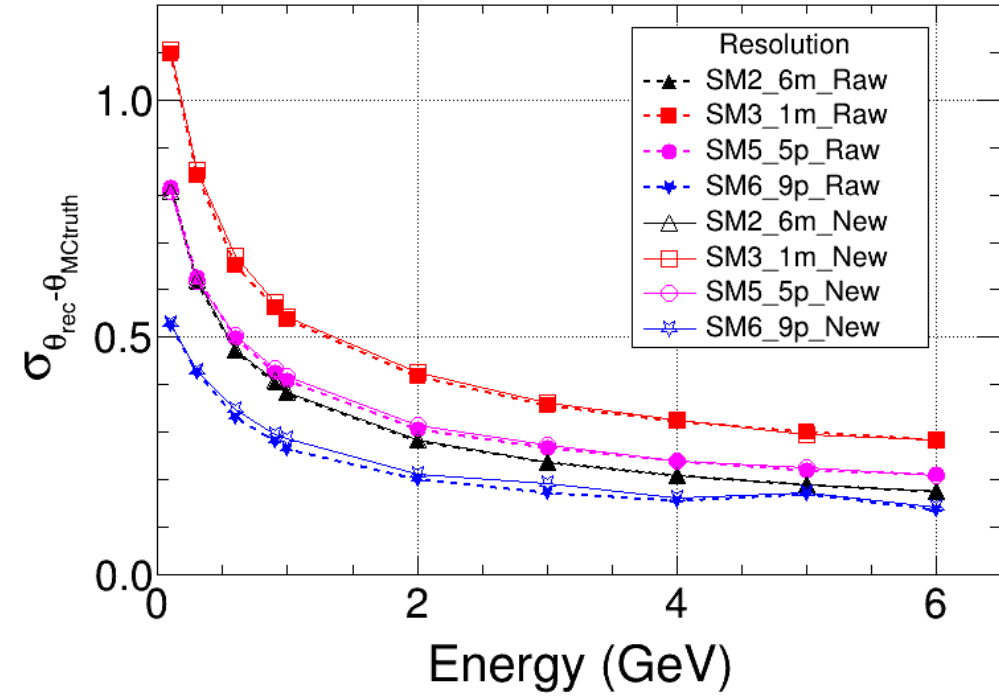
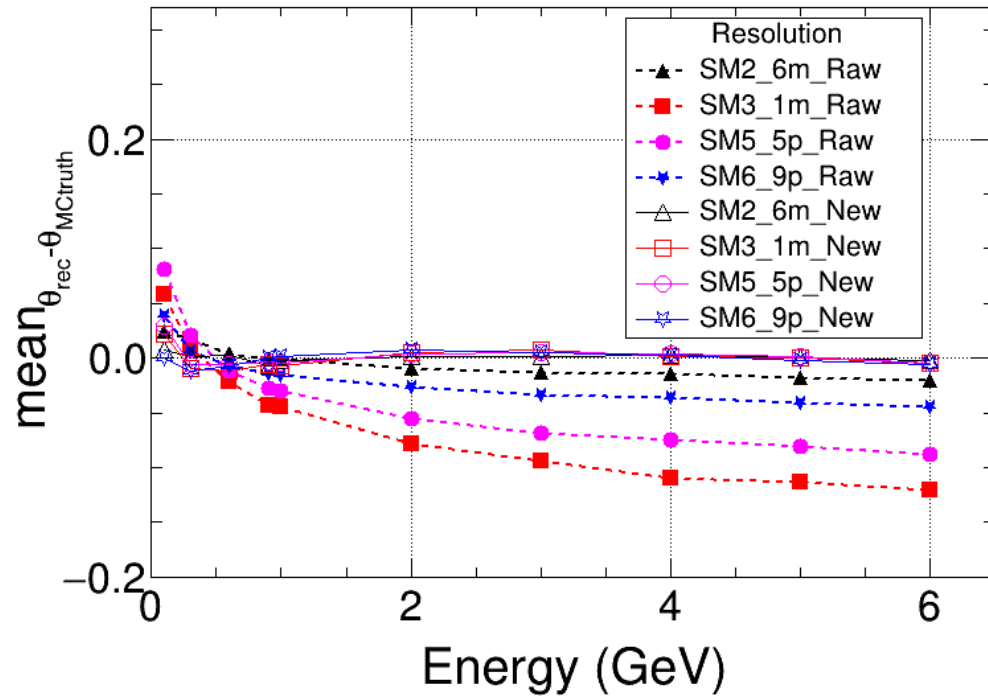
Good consistency

The distribution of offset value at different energy points with different data samples.

Theta check (method C)

✓ Theta distribution

- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).

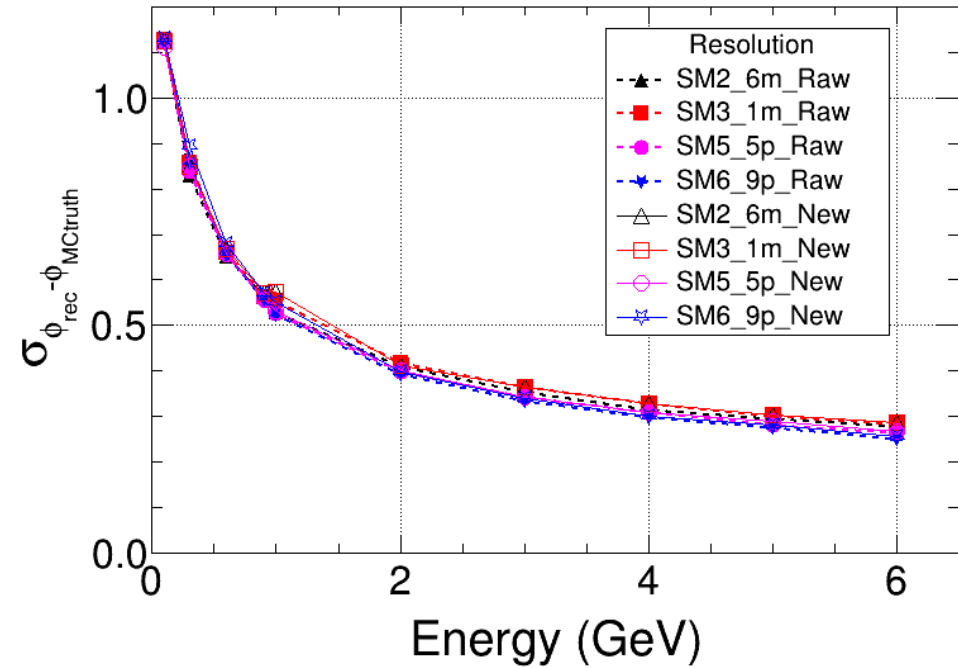
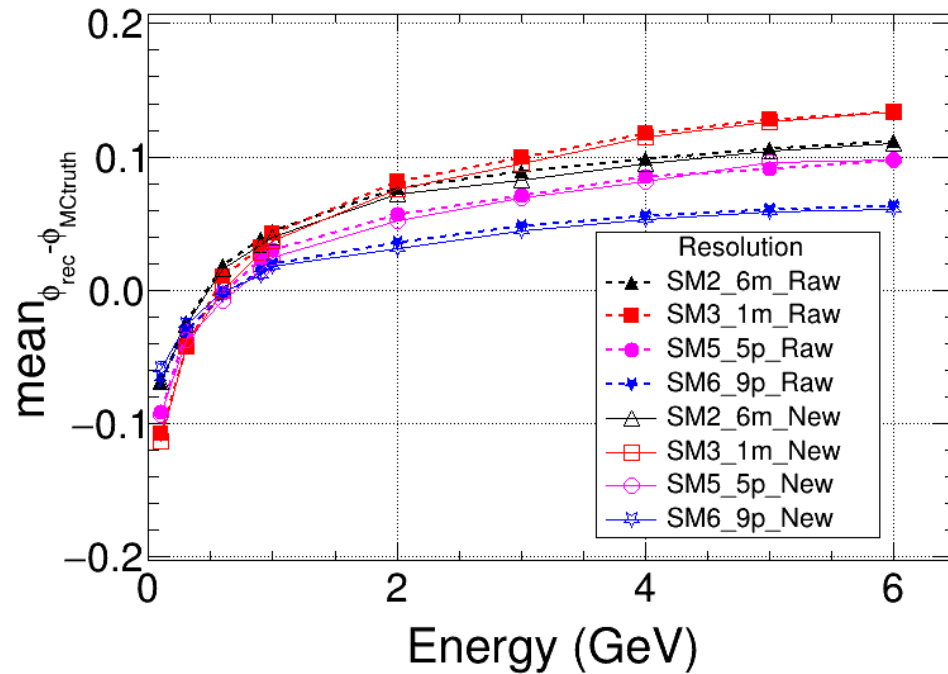


The distribution of origin and updated offset parameter fitting result of $\theta_{rec} - \theta_{MCTruth}$ at different energy points with different data samples.

Phi check (method C)

✓ Phi distribution

- SM2_6m, SM3_1m, SM5_5p, and SM6_9p, in range (128.4°, 134.8°), (87.6°, 95.6°), (48.0°, 54.4°), and (28.4°, 31.6°).



The distribution of origin and updated offset parameter fitting result of $\phi_{rec} - \phi_{MCTruth}$ at different energy points with different data samples.

Good consistency among method C and the PandaRoot values

Summary

- Check and measure the offset in weighting function of EMC position calculation formula
 - use the intersection of tracking and depth plane as mctruth
 - use data sets with different theta' s
- Using 3 different chisq fit methods, preliminary results show good consistency among the 3 methods and the PandaRoot values.
- Will further check the position reconstruction and perform position corrections to improve the position resolution

THANKS!

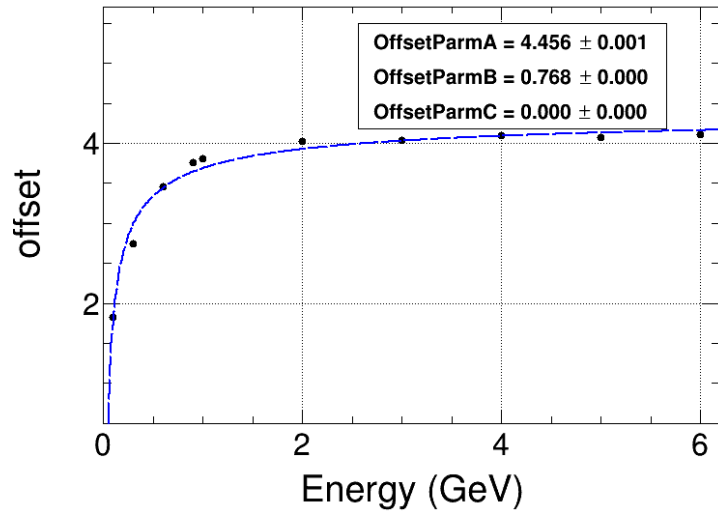
Back up

Update OffsetParm

- Sample:

- $\theta = (128.4, 134.8)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

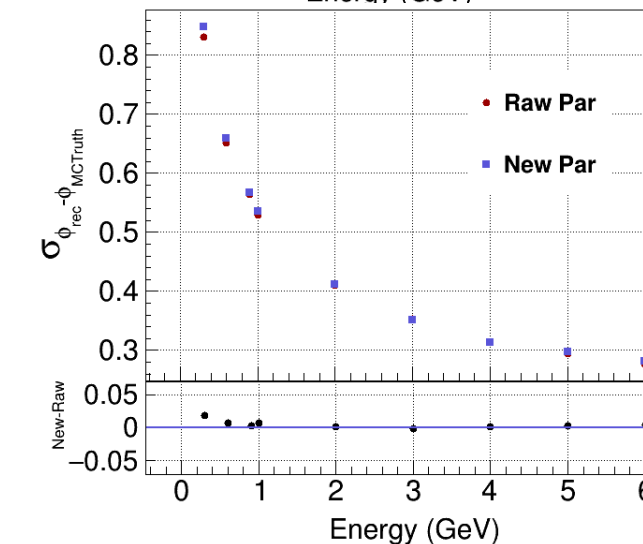
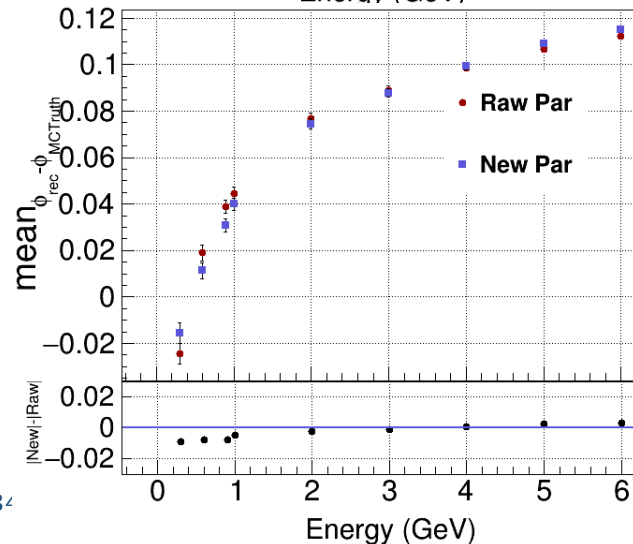
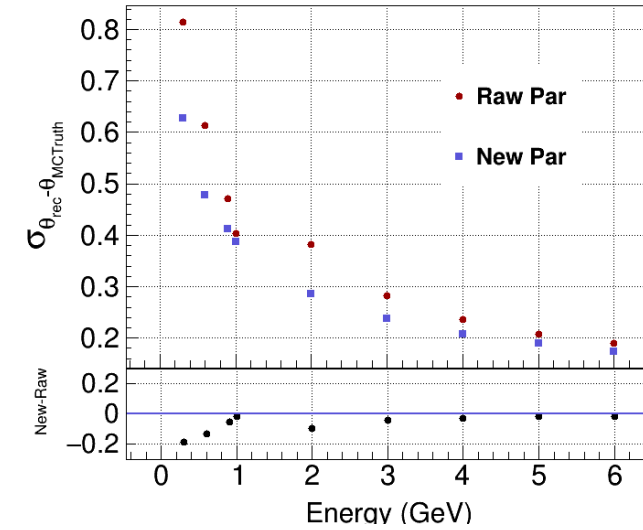
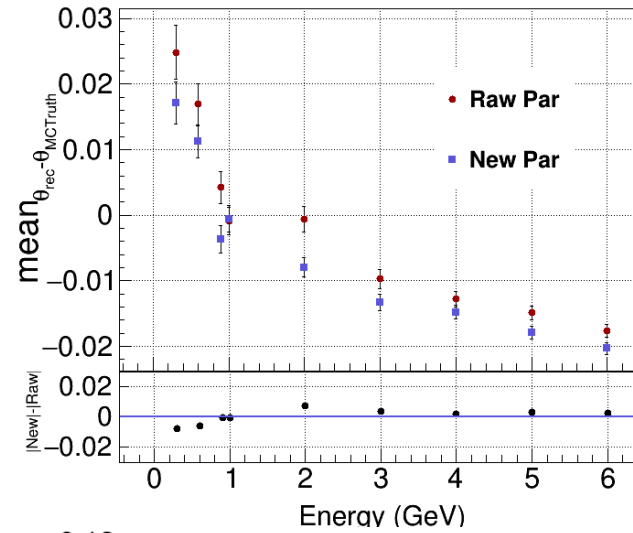


Distribution of offset values at different energy points and fitting result

Fitting :

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$



Update OffsetParm

- Sample:

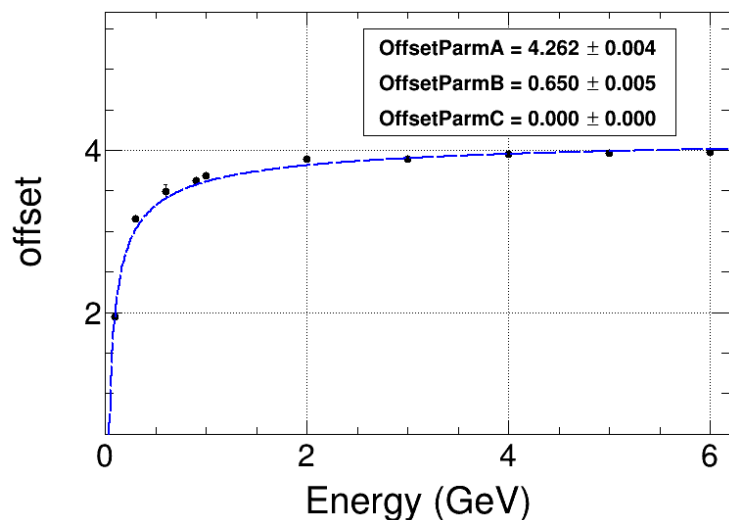
- $\theta = (128.4, 134.8)$

- $\phi = (0, 360)$

- $E = 0.1 - 6\text{GeV}$

- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



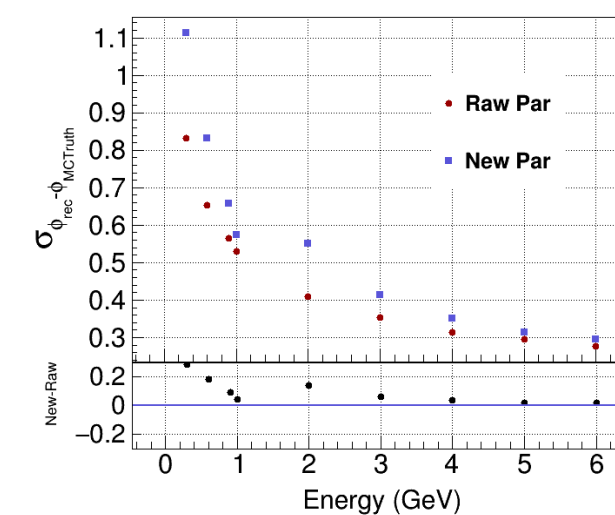
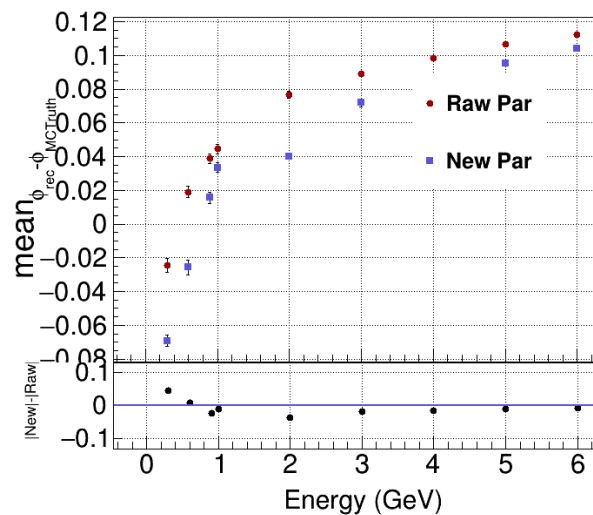
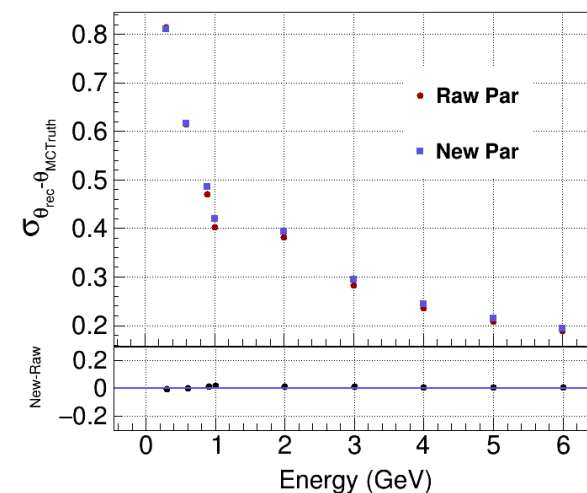
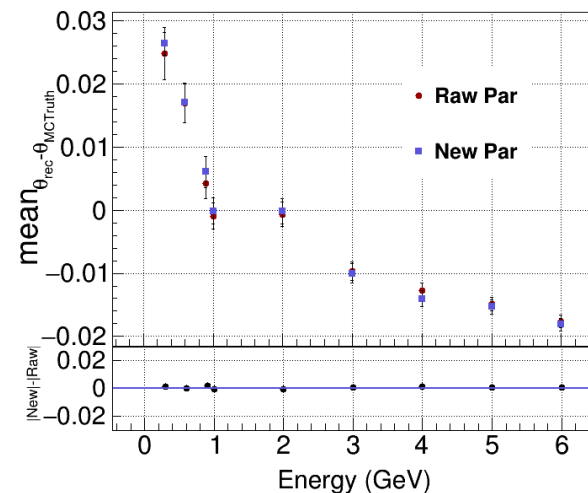
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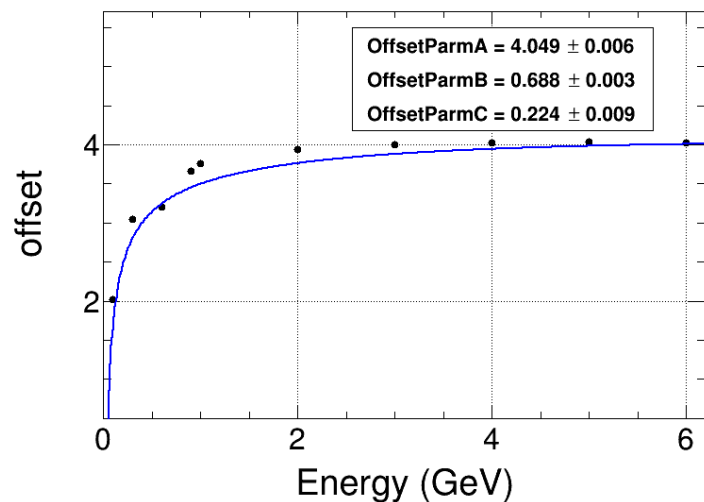
The fitting results of $\theta_{rec} - \theta_{MC\text{Truth}}(\phi_{rec} - \phi_{MC\text{Truth}})$



Update OffsetParm

- Sample:

- $\theta = (87.6, 95.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

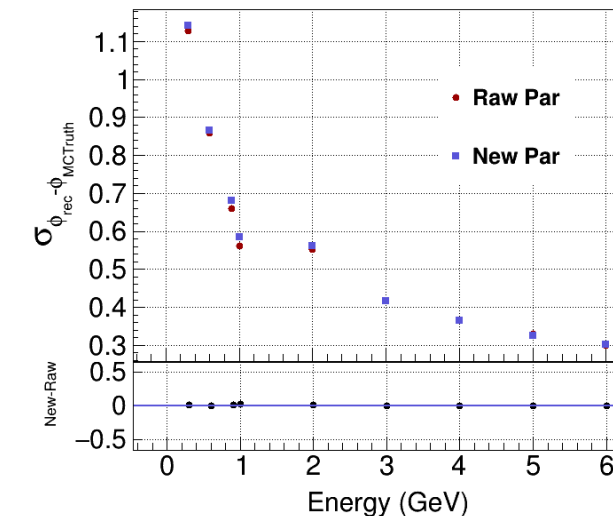
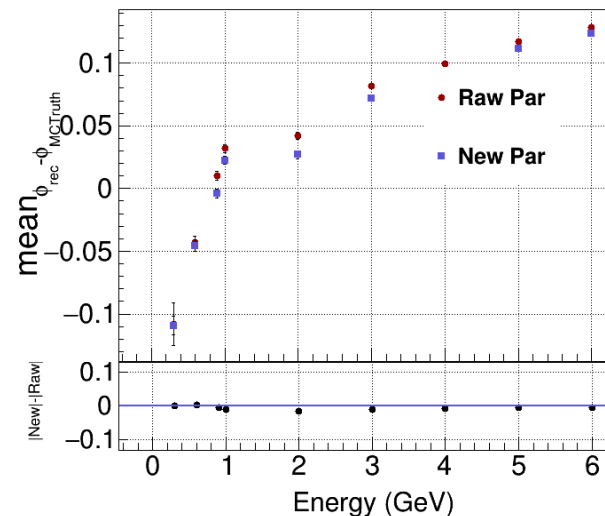
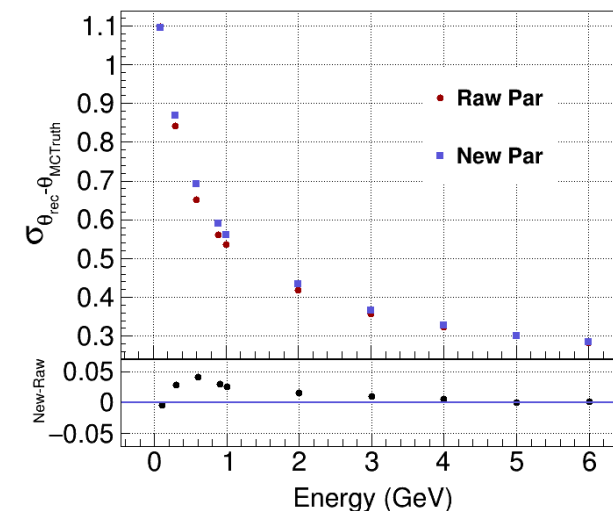
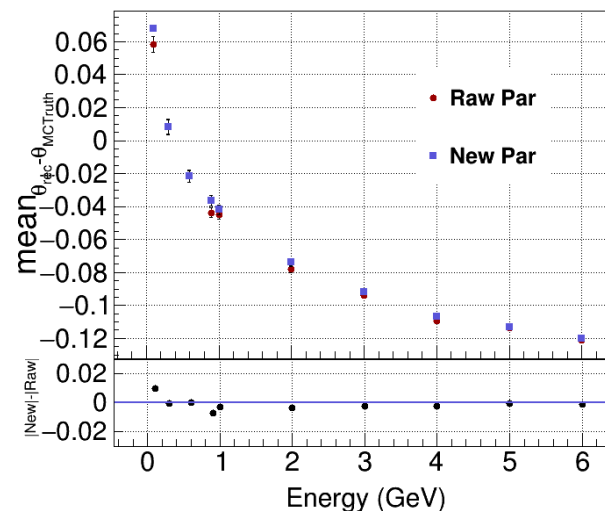


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

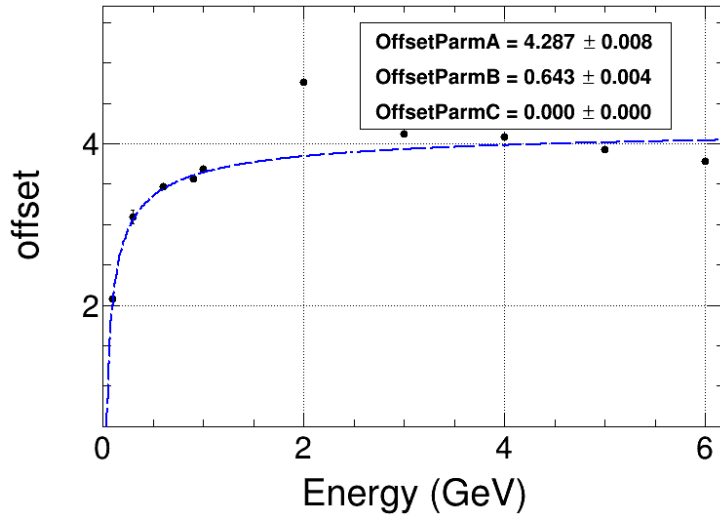
The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$



Update OffsetParm

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- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$

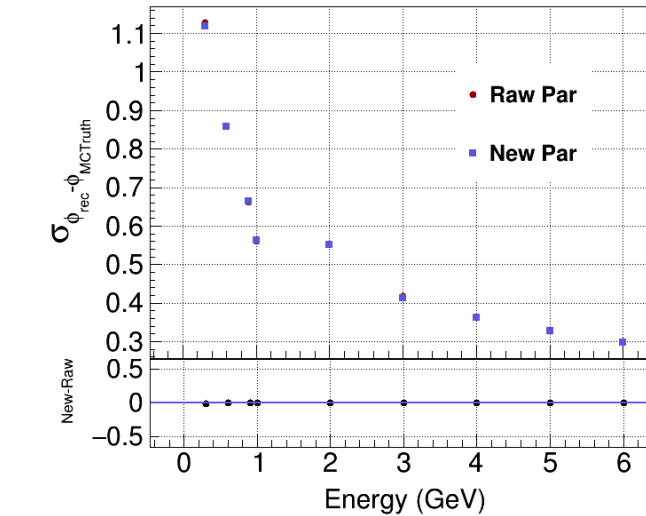
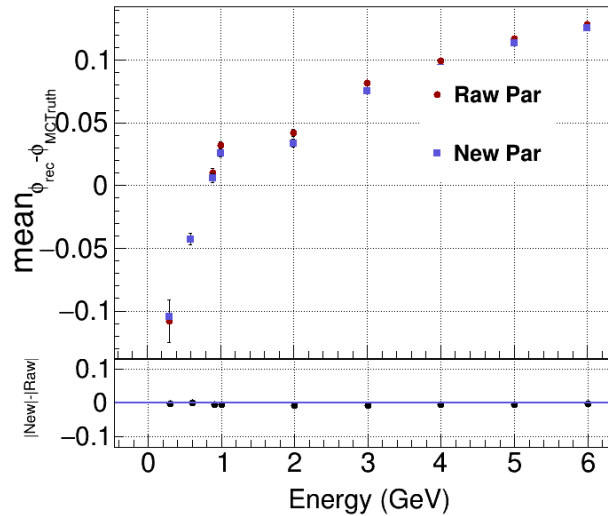
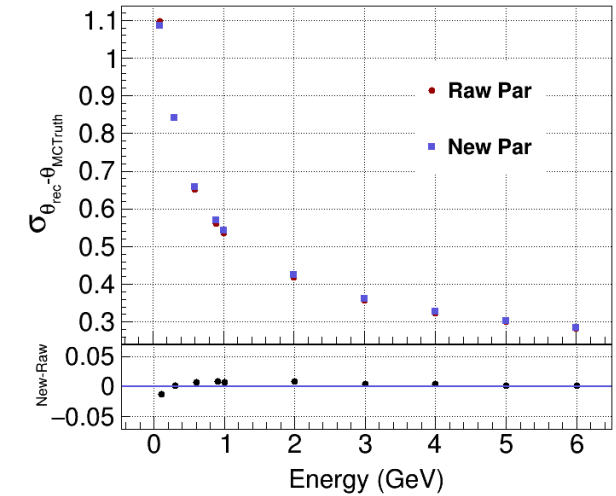
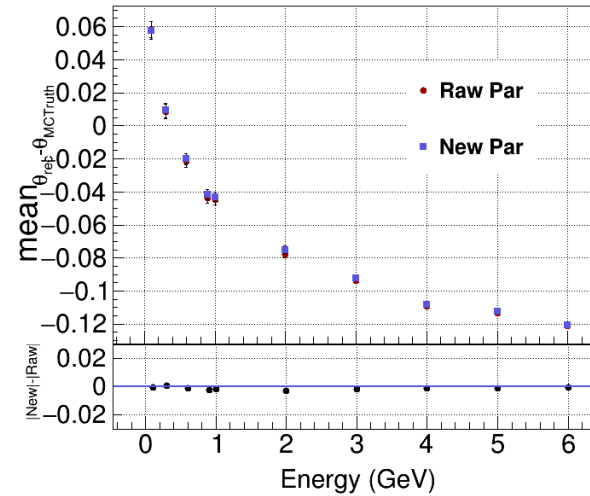


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

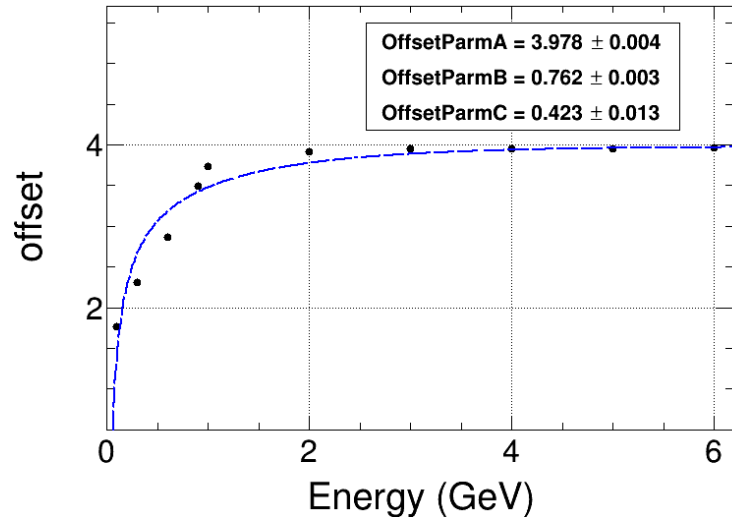
The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$



Update OffsetParm

- Sample:

- $\theta = (48.0, 54.4)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

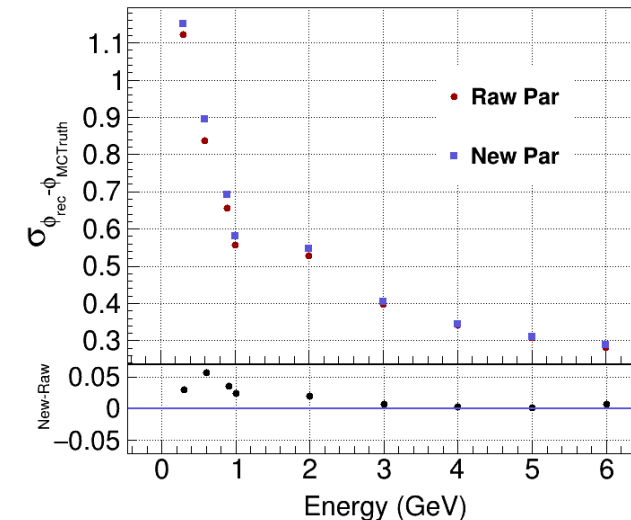
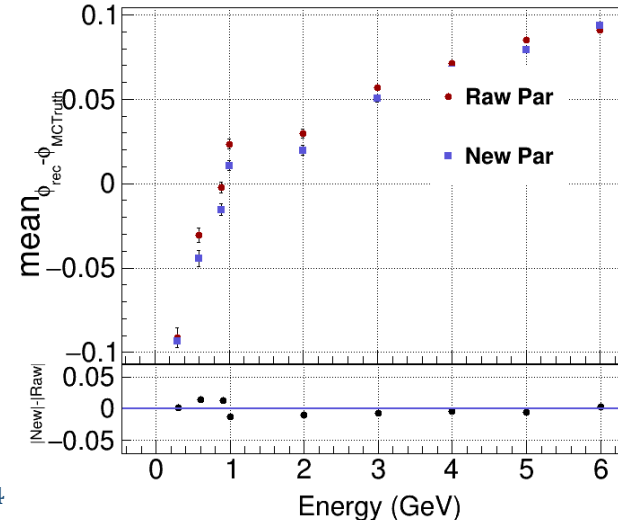
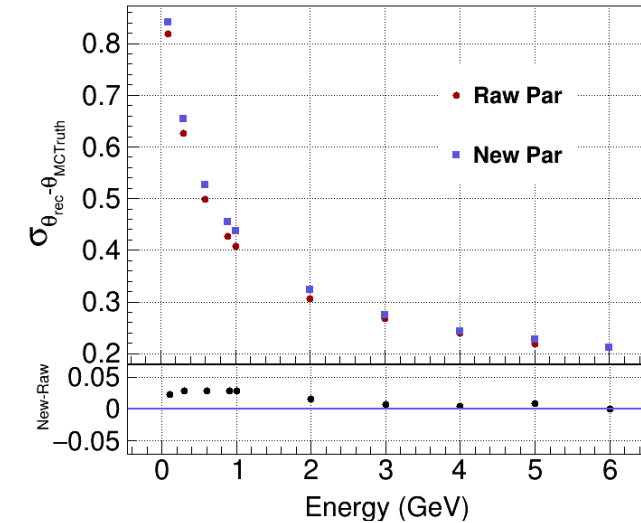
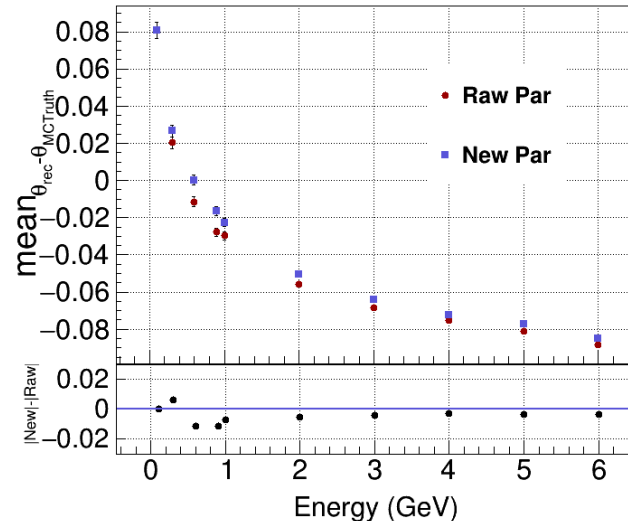


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth}$ ($\phi_{rec} - \phi_{MCTruth}$)

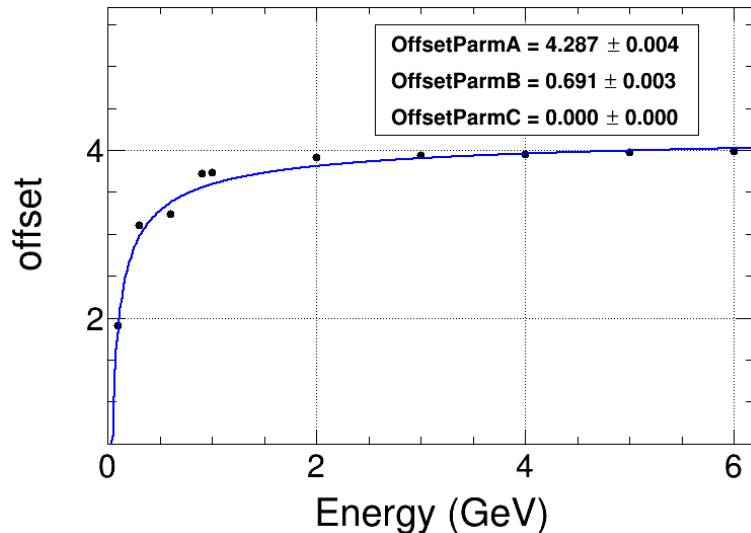


Update OffsetParm

- Sample:

- $\theta = (48.0, 54.4)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$

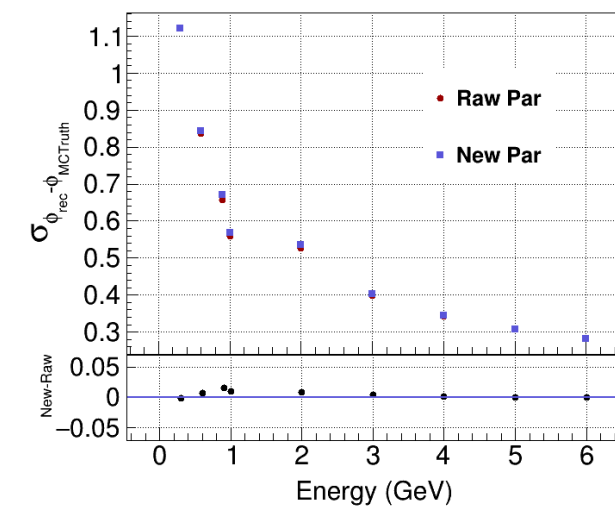
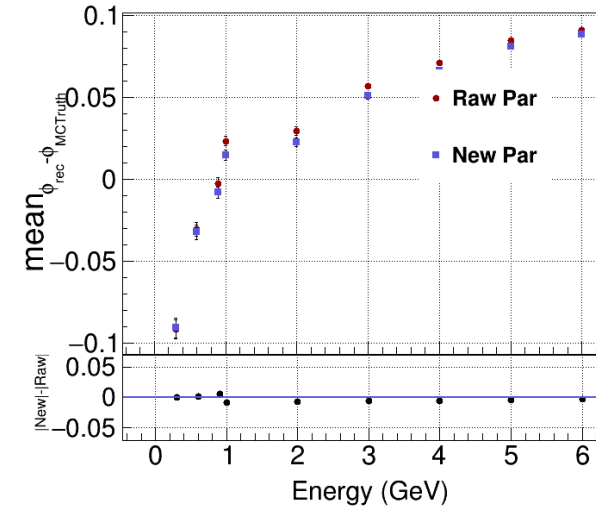
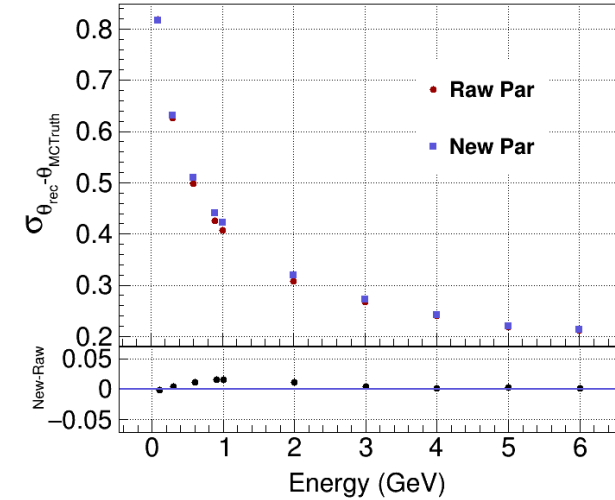
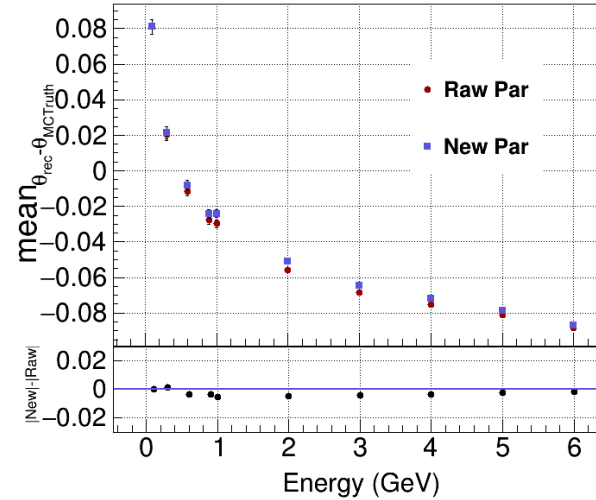


Distribution of offset values at different energy points and fitting result

Fitting :

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$

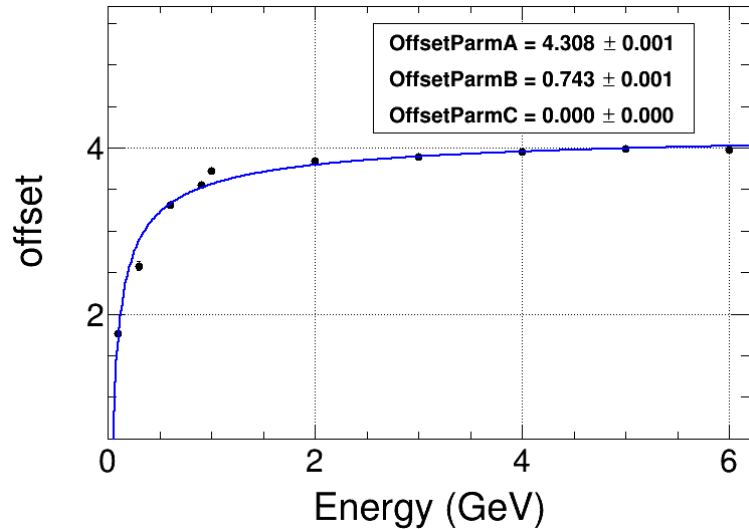


Update OffsetParm

- Sample:

- $\theta = (28.4, 31.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$



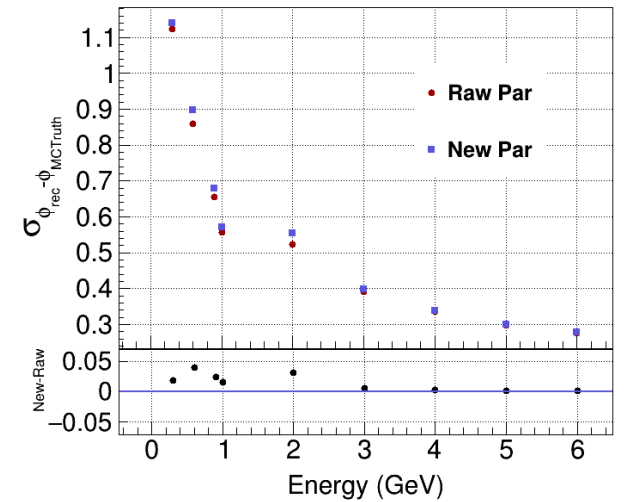
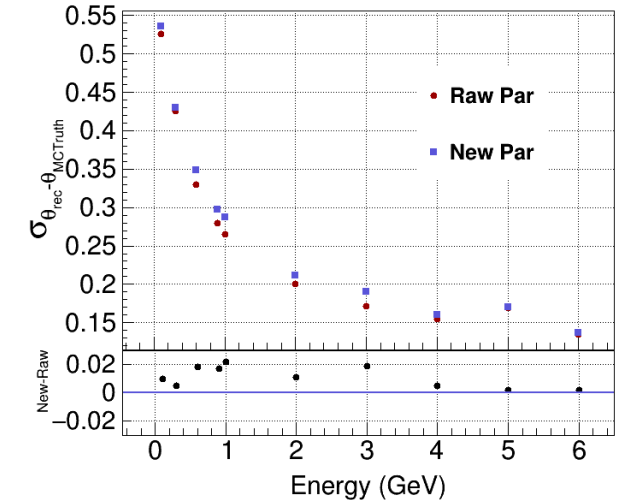
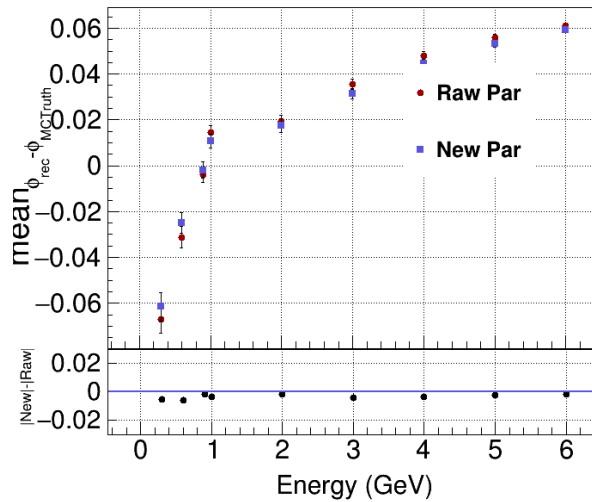
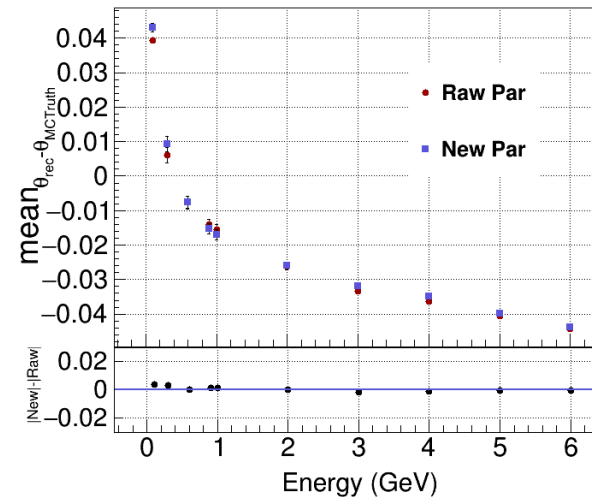
Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

2023/3/9

The fitting results of $\theta_{rec} - \theta_{MCTruth}$ ($\phi_{rec} - \phi_{MCTruth}$)

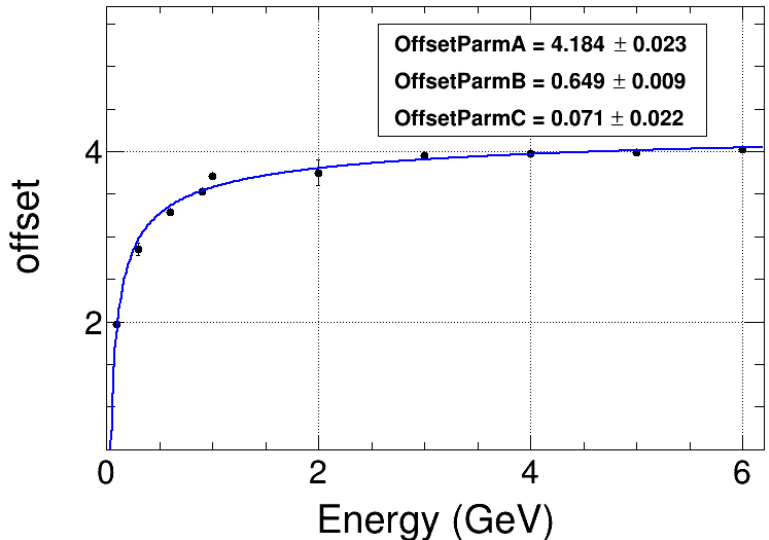


Update OffsetParm

- Sample:

- $\theta = (28.4, 31.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



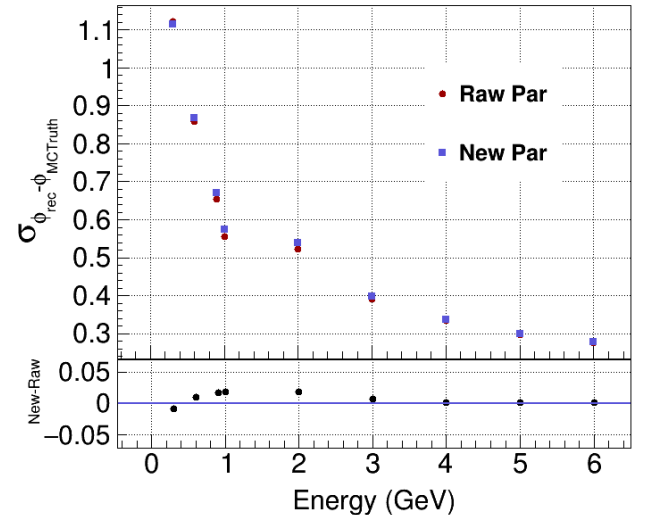
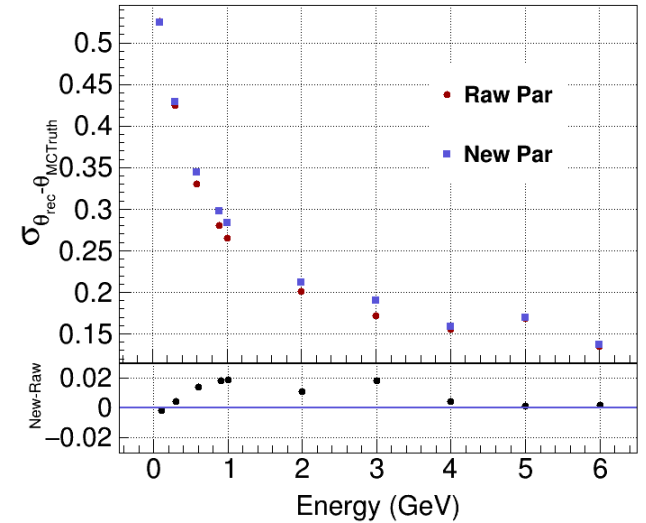
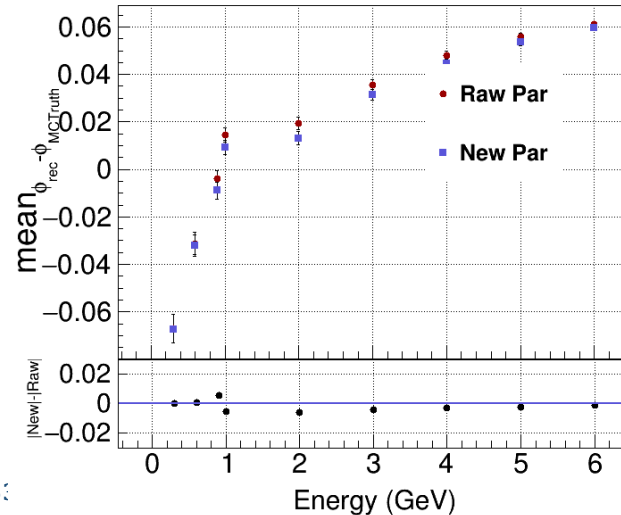
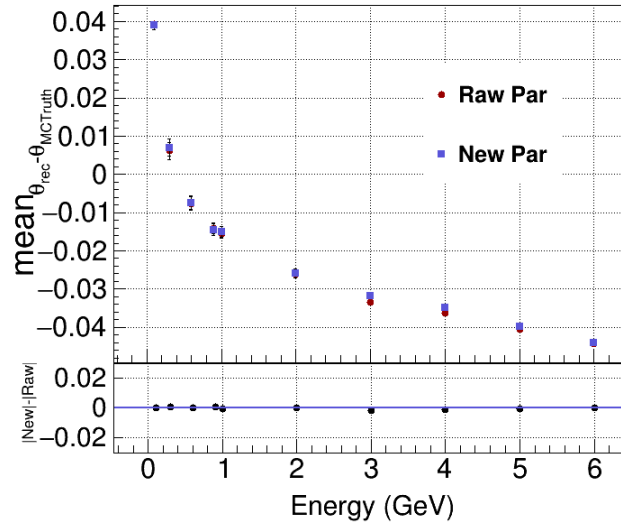
Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.5}$:

2023/3/9

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$

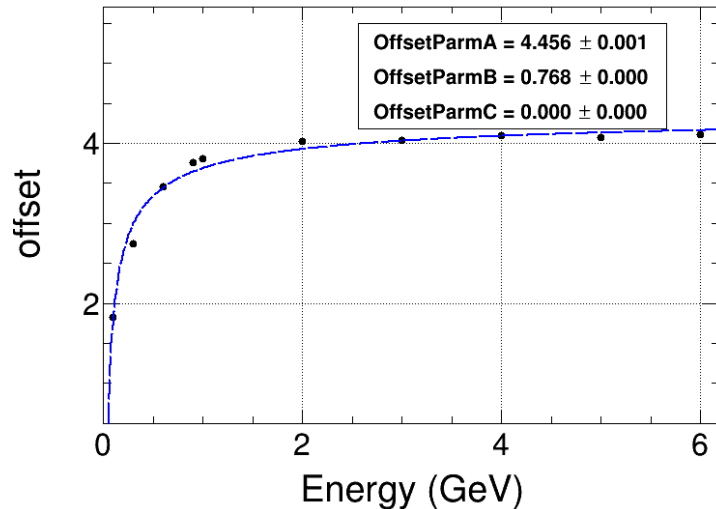


Update OffsetParm

- Sample:

- $\theta = (128.4, 134.8)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

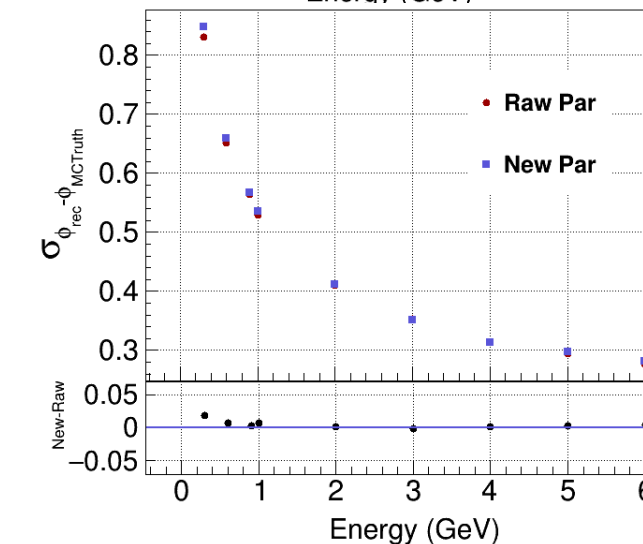
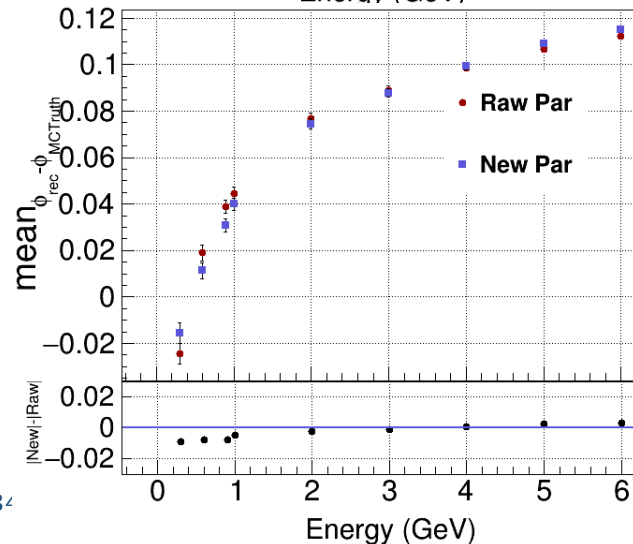
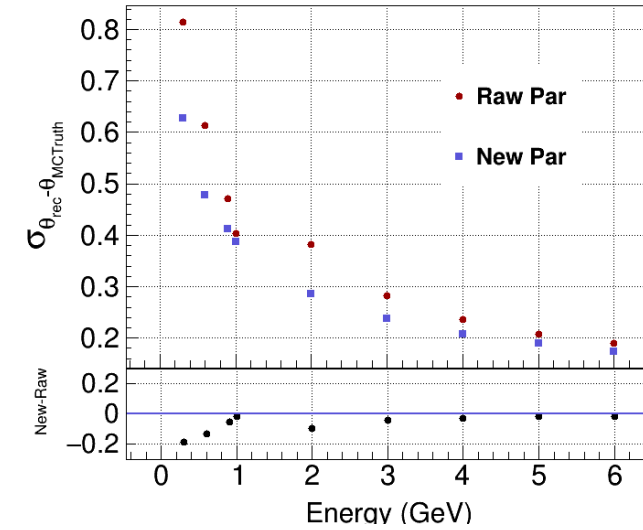
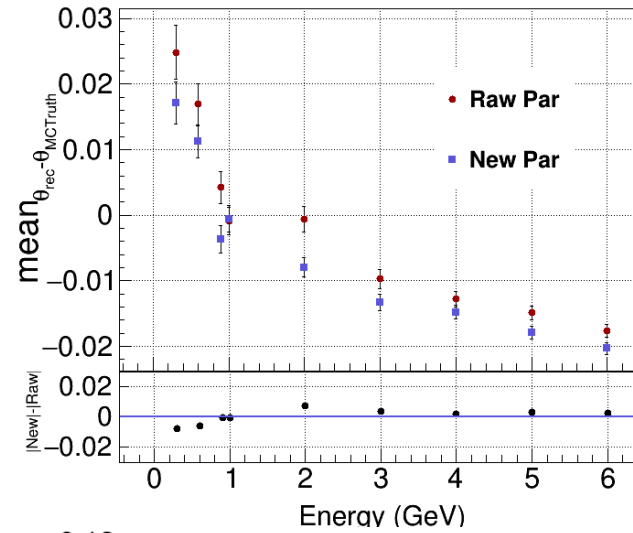


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$

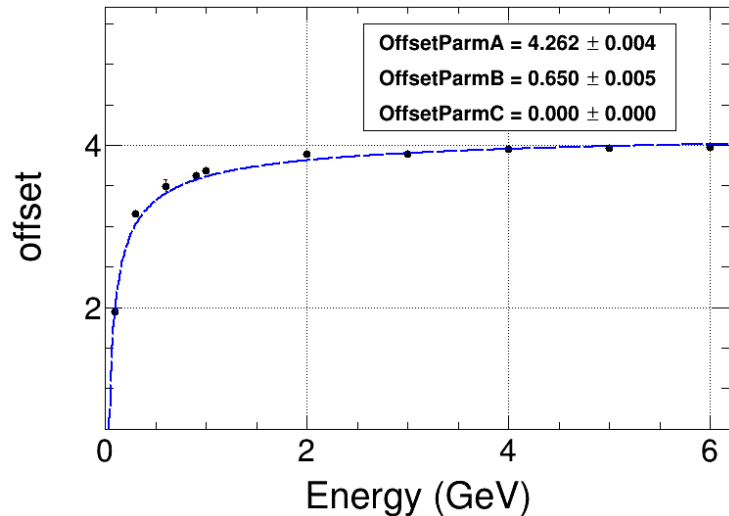


Update OffsetParm

- Sample:

- $\theta = (128.4, 134.8)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



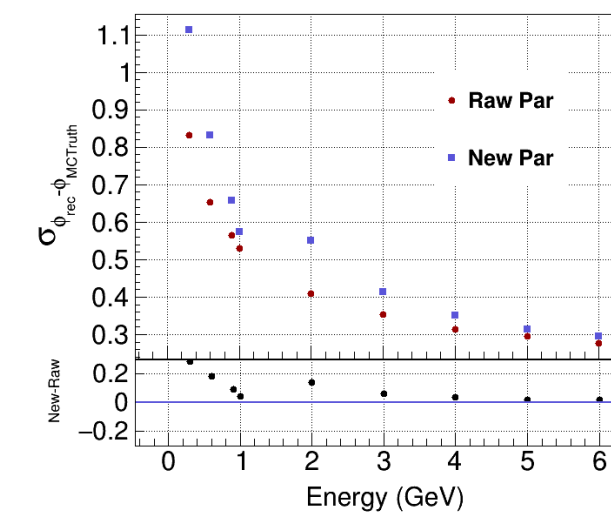
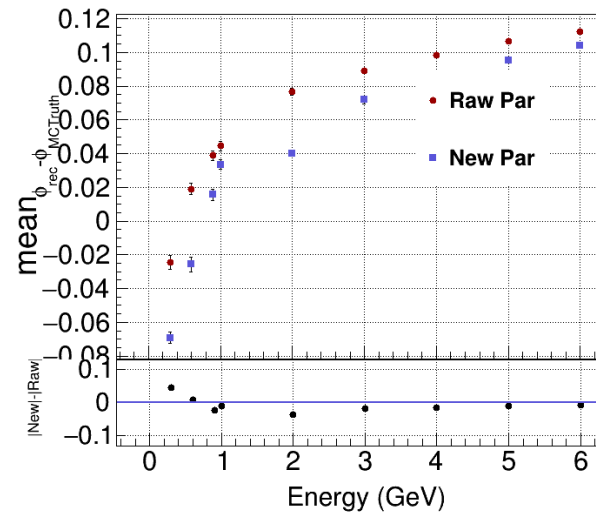
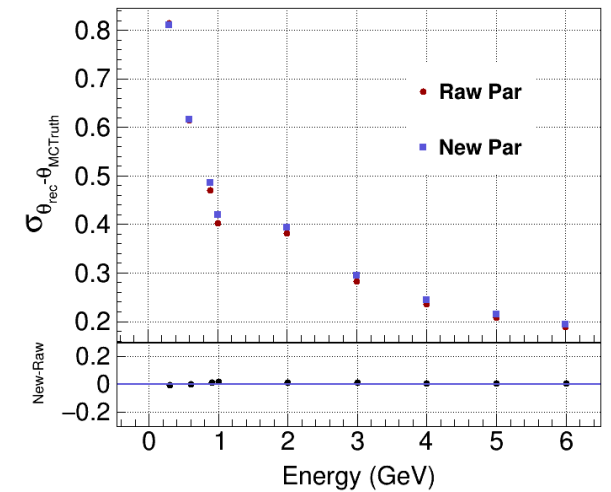
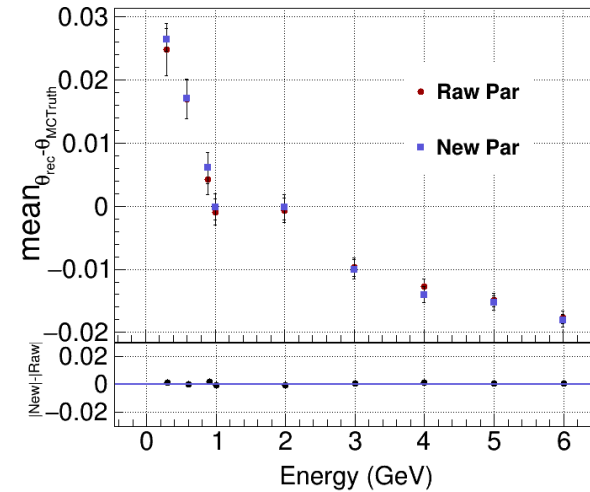
Distribution of offset values at different energy points and fitting result

Fitting :

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

2023/3/9

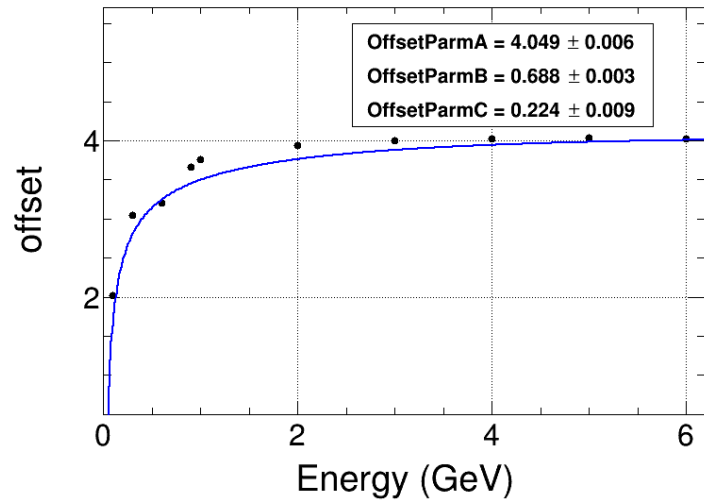
The fitting results of $\theta_{rec} - \theta_{MC\text{Truth}}(\phi_{rec} - \phi_{MC\text{Truth}})$



Update OffsetParm

- Sample:

- $\theta = (87.6, 95.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

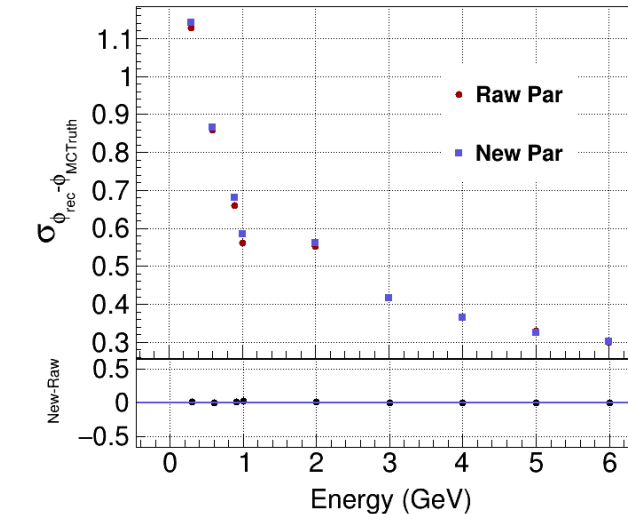
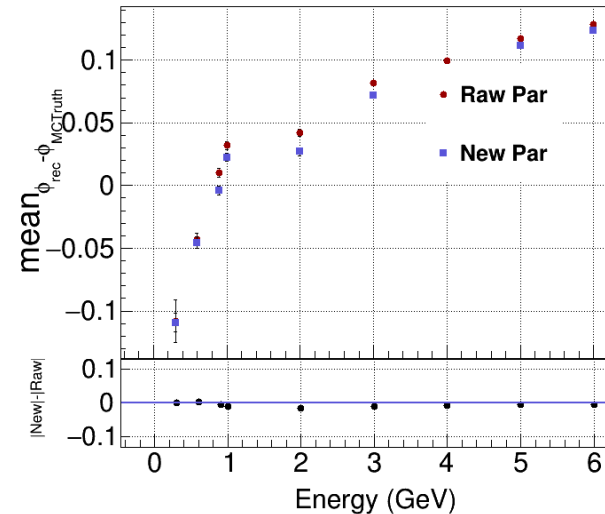
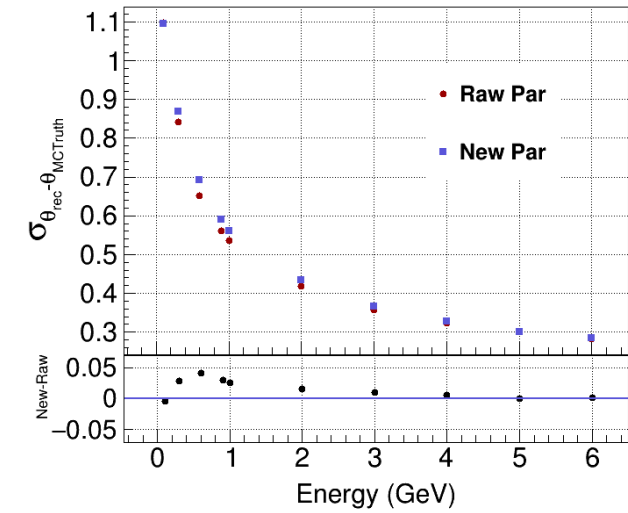
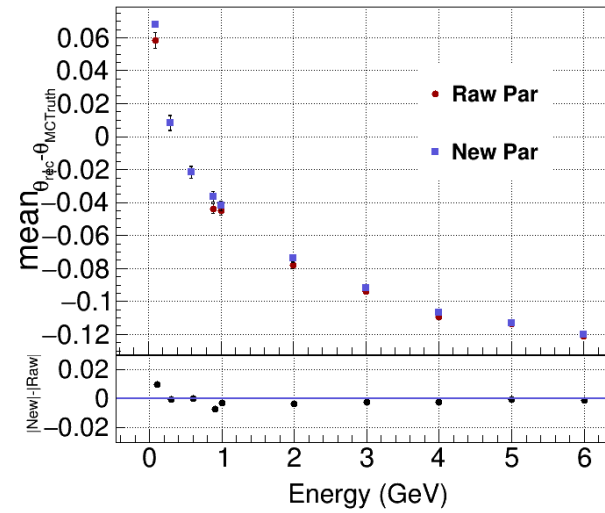


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

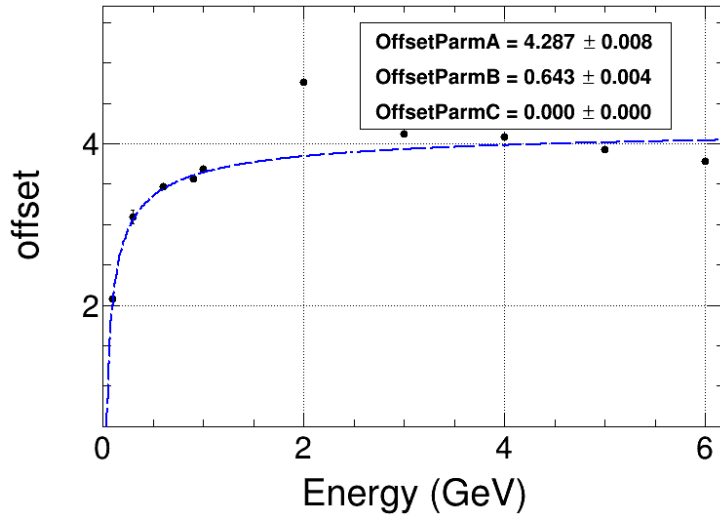
The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$



Update OffsetParm

- Sample:

- $\theta = (87.6, 95.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$

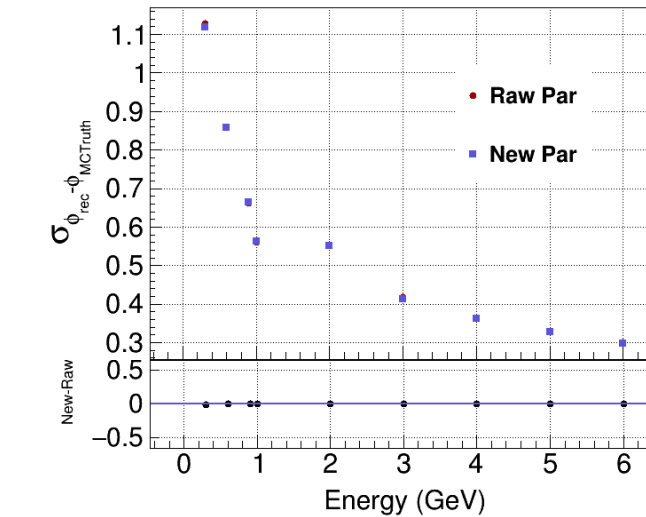
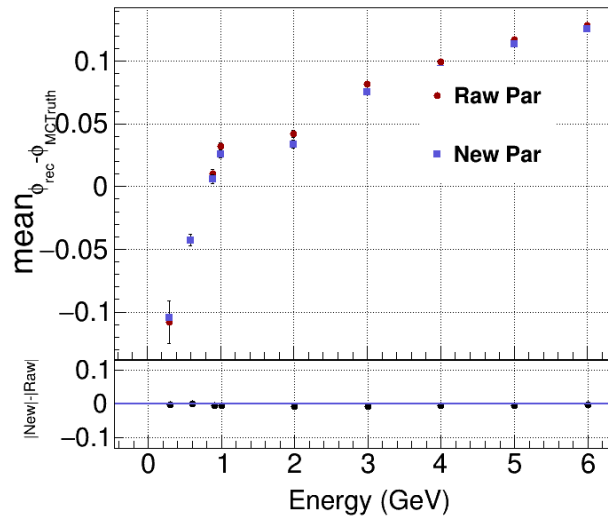
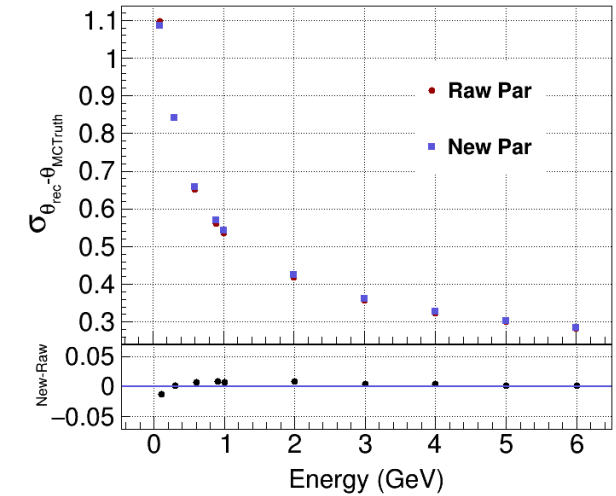
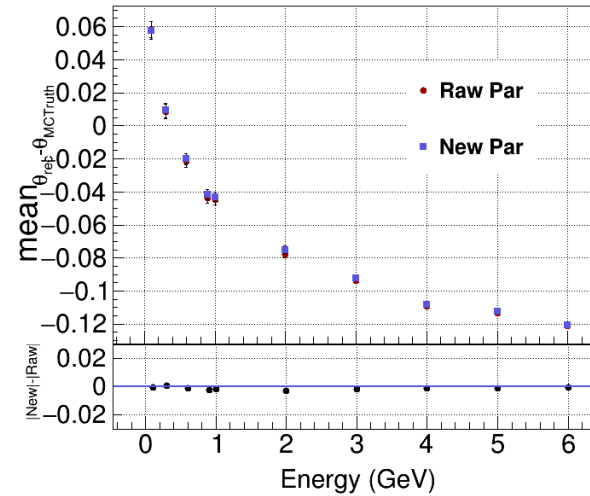


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

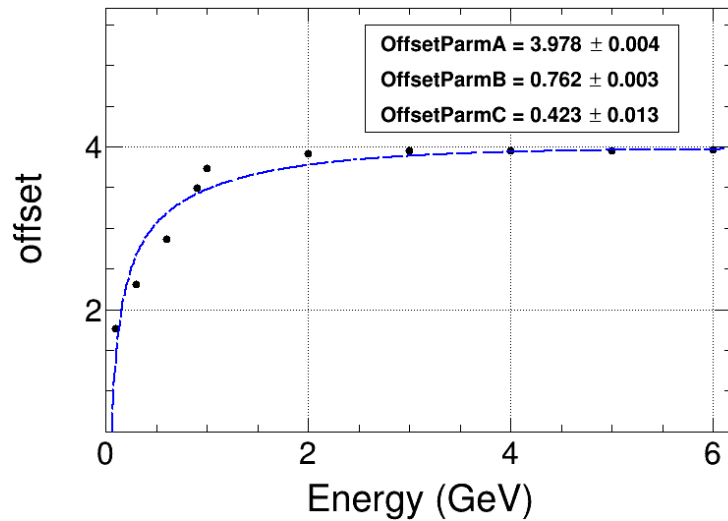
The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$



Update OffsetParm

- Sample:

- $\theta = (48.0, 54.4)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000
- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

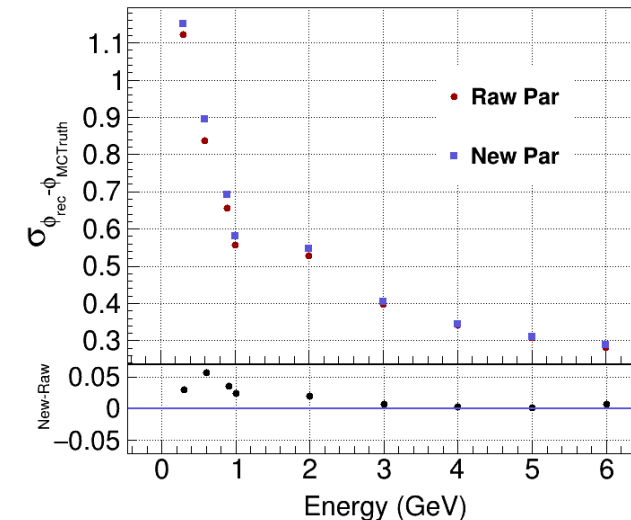
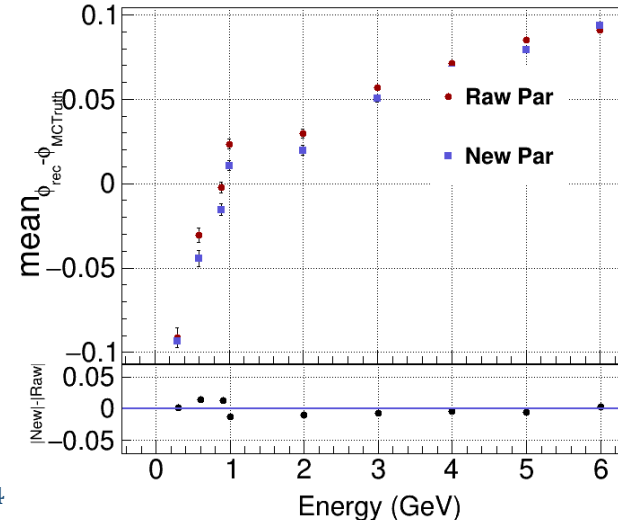
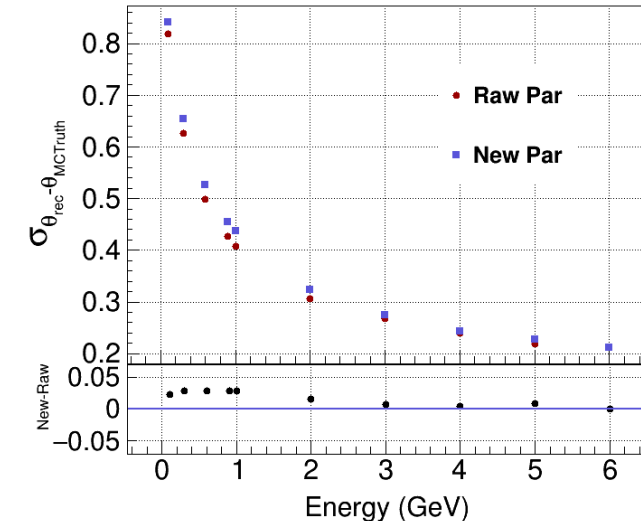
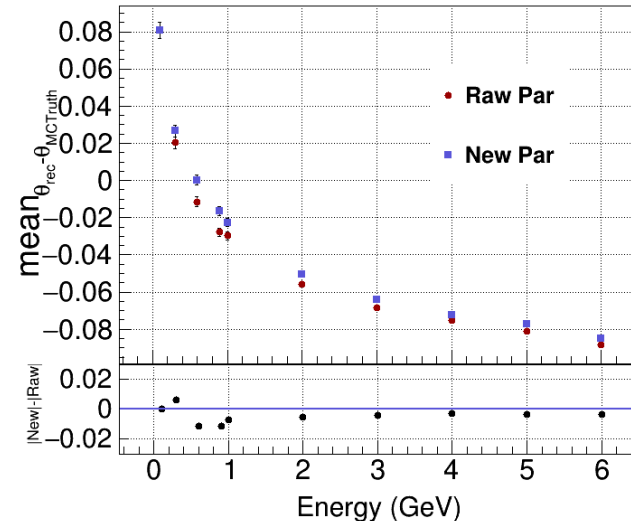


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth}$ ($\phi_{rec} - \phi_{MCTruth}$)



Update OffsetParm

- Sample:

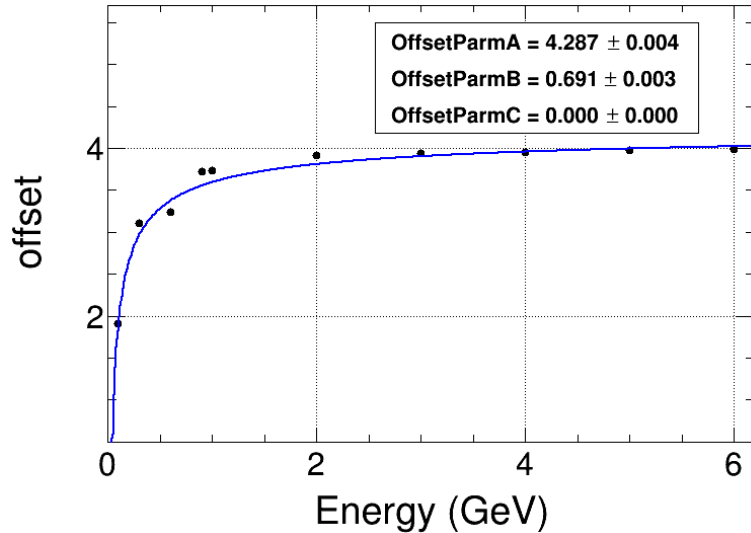
- $\theta = (48.0, 54.4)$

- $\phi = (0, 360)$

- $E = 0.1 - 6\text{GeV}$

- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



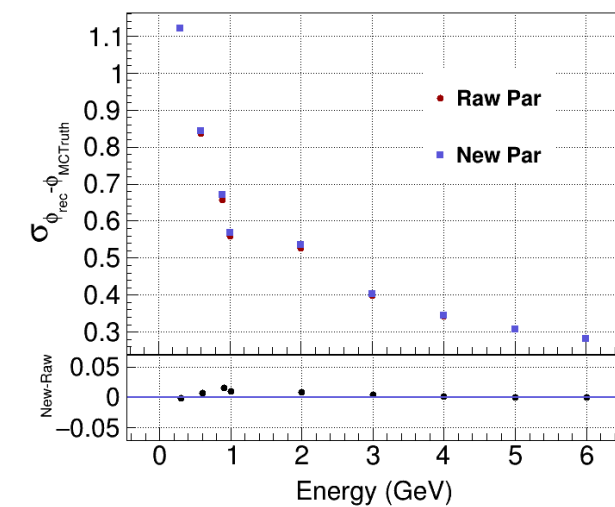
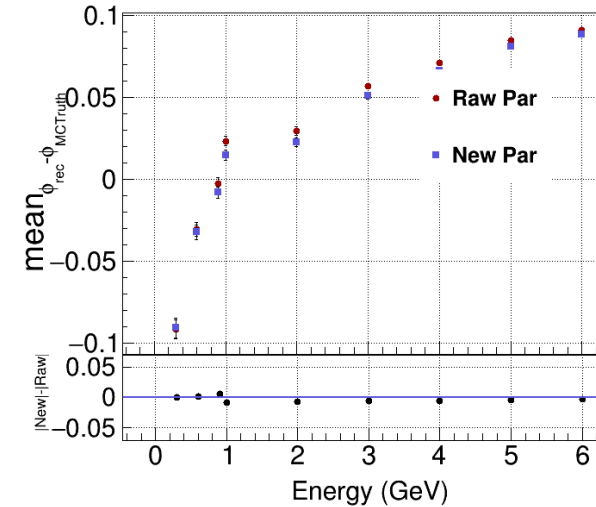
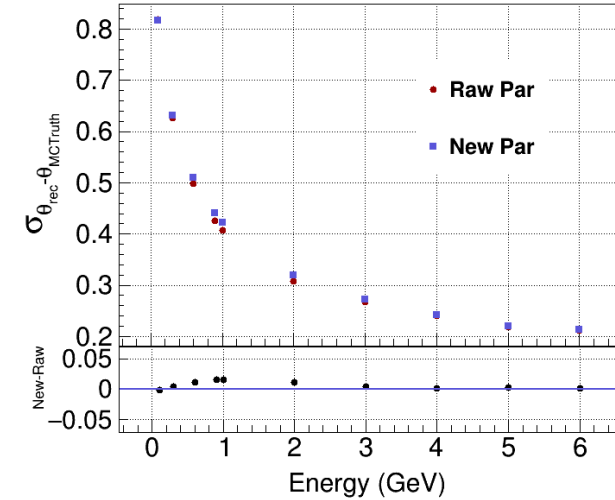
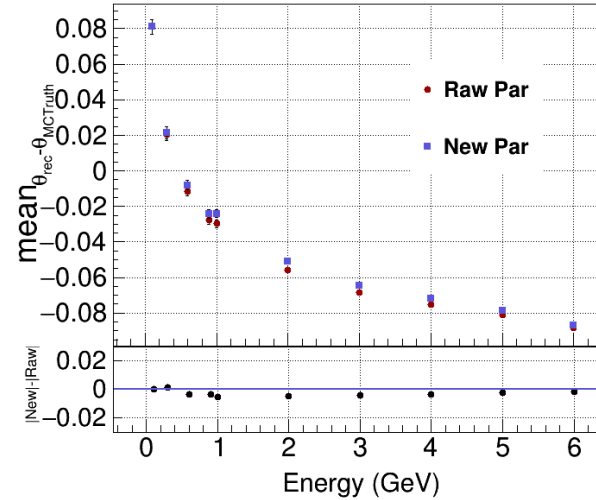
Distribution of offset values at different energy points and fitting result

Fitting :

- $\text{Offset} = \text{OffsetParmA} - \text{OffsetParmB} \cdot e^{-\text{OffsetParmC} \cdot E^{1.171}} \cdot E^{-0.534}$

2023/3/9

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$

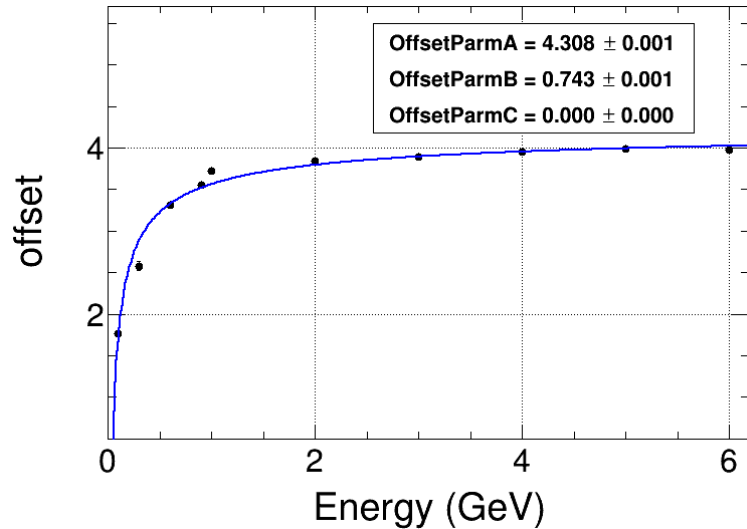


Update OffsetParm

- Sample:

- $\theta = (28.4, 31.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\theta_i^{rec} - \theta_i^{truth})^2}{\sigma_i^2}$

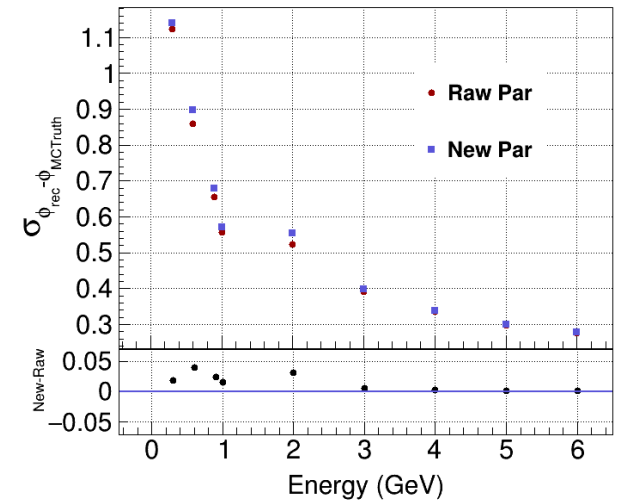
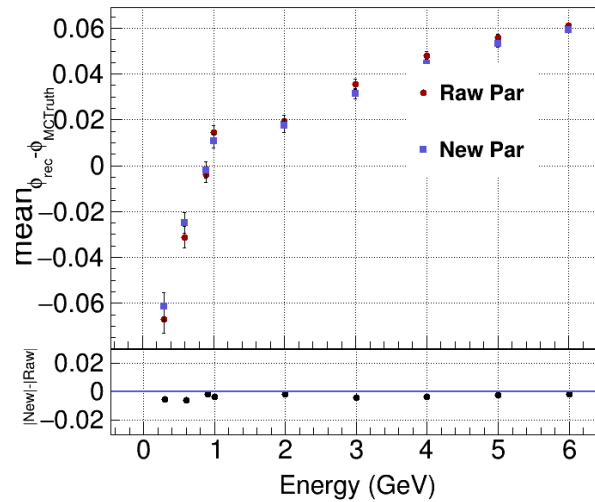
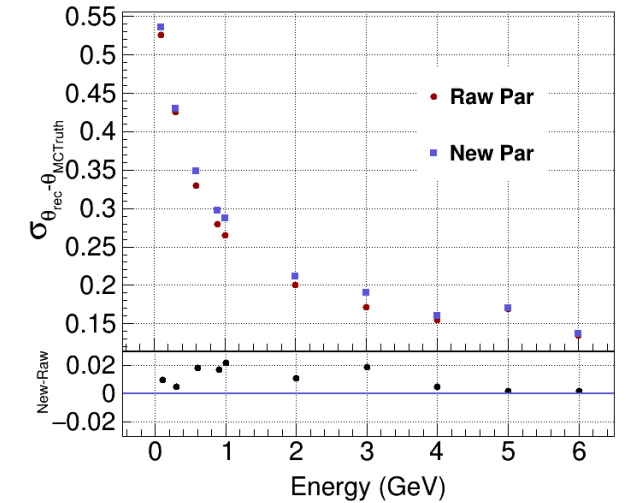
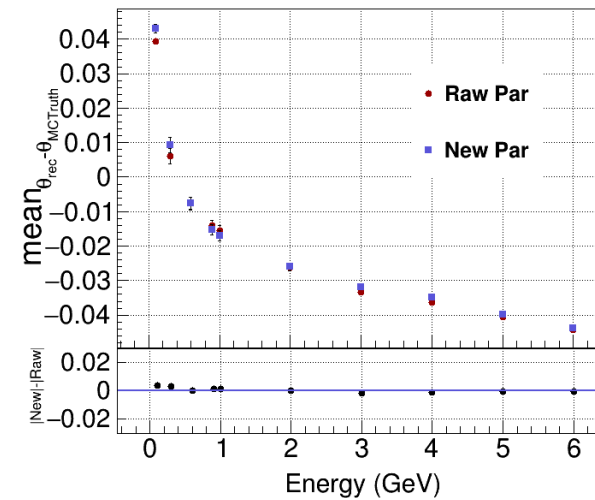


Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.534}$

The fitting results of $\theta_{rec} - \theta_{MCTruth}$ ($\phi_{rec} - \phi_{MCTruth}$)

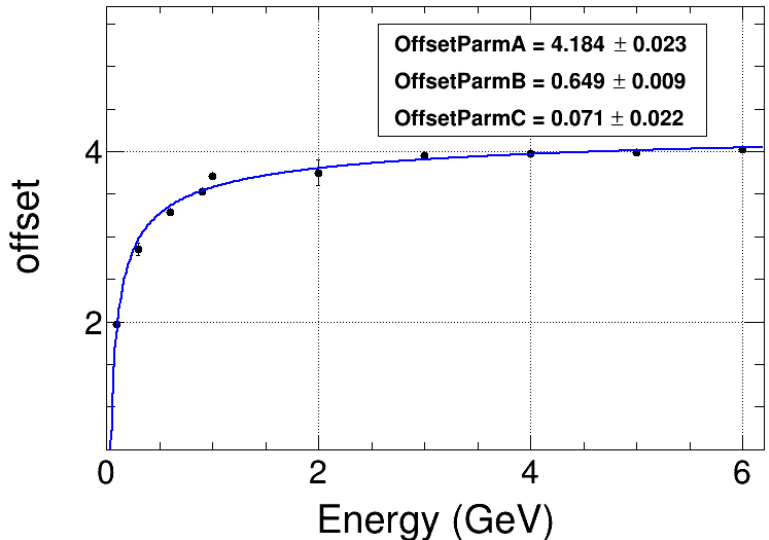


Update OffsetParm

- Sample:

- $\theta = (28.4, 31.6)$
- $\phi = (0, 360)$
- $E = 0.1 - 6\text{GeV}$
- Event = 10000

- $\chi^2 = \sum_i^N \frac{(\phi_i^{rec} - \phi_i^{truth})^2}{\sigma_i^2}$



Distribution of offset values at different energy points and fitting result

Fitting :

- Offset = OffsetParmA - OffsetParmB · $e^{-\text{OffsetParmC} \cdot E^{1.171}}$ · $E^{-0.5}$:

2023/3/9

The fitting results of $\theta_{rec} - \theta_{MCTruth} (\phi_{rec} - \phi_{MCTruth})$

