Shower centroid reconstruction

- Reminder (M.Presilla, CERN workshop, 11/02) :

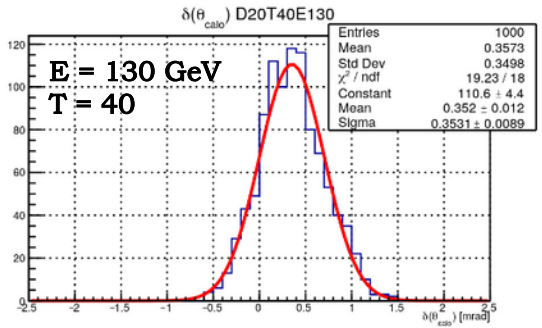
- Shower centroid evaluated in 5x5 cluster with

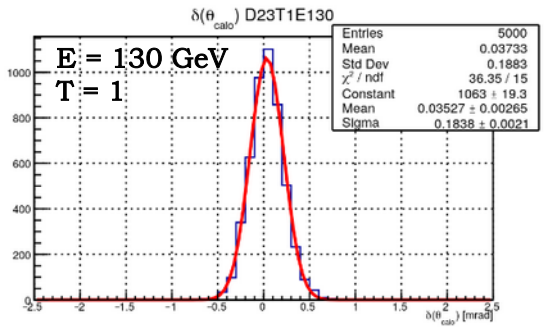
$$x = \frac{\sum_i w_i x_i}{\sum_i w_i}, \quad w_i = \max\left\{0, \left[W_0 + \ln\left(\frac{E_i}{E_T}\right)\right]\right\}, \quad W_0 = 4.0, \quad E_T = \sum E_i$$

Awes et.al.. *"A simple method of shower localization and identification in laterally segmented calorimeters"*
https://doi.org/10.1016/0168-9002(92)90858-2

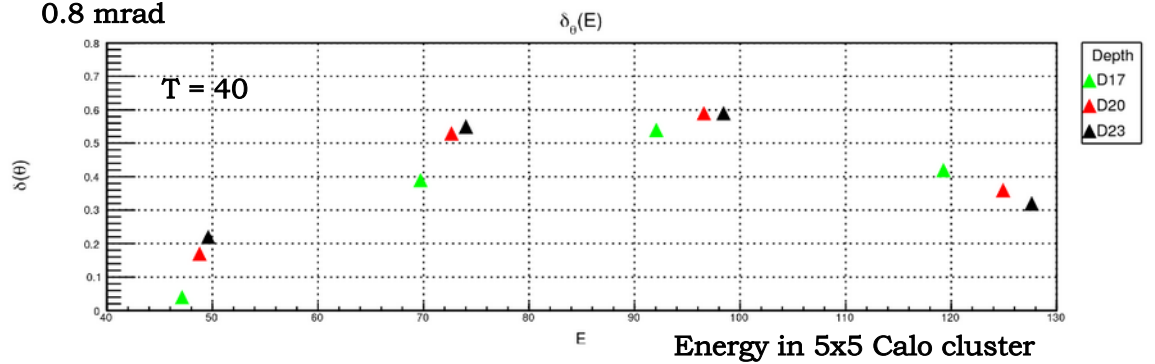
The problem

- Sizable bias in $\delta\theta = \theta_{CAL} - \theta_{e,true}$
- Much more pronounced for hits in last layer, closer to CALO



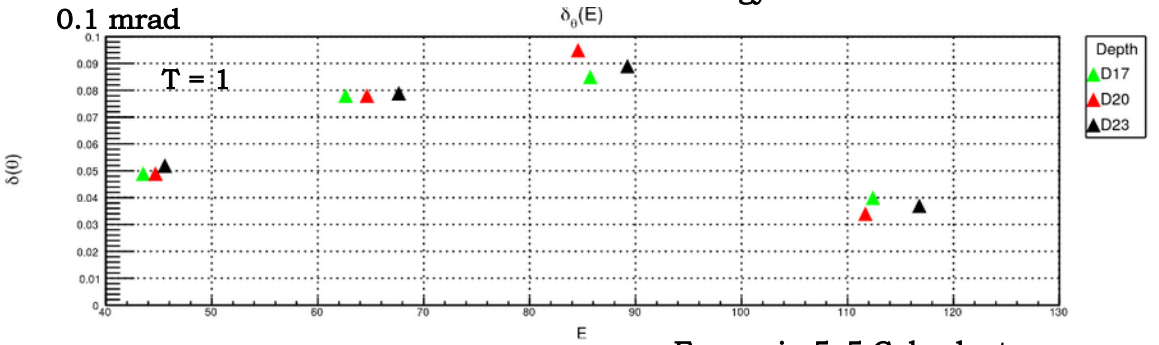


0.8 mrad



Energy in 5x5 Calo cluster

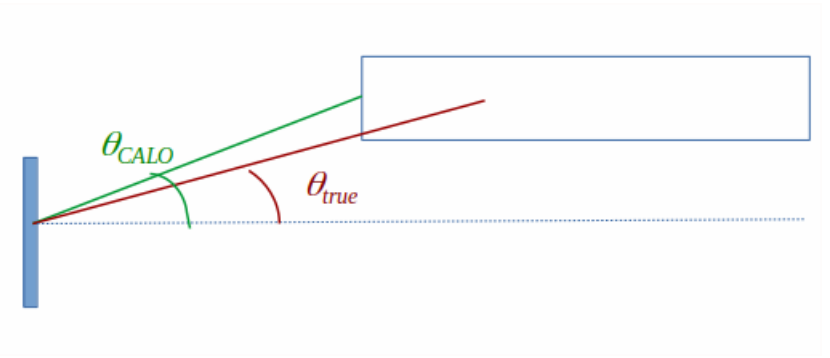
0.1 mrad



Energy in 5x5 Calo cluster

Interpretation

- Impact angle is measured form the ratio of shower *r* and *z* wrt target position: $\theta_{CALO} = atan(r_{CALO} / z_{CALO})$
  - r_{CALO} from algo as above
  - z_{CALO} fixed at CALO entry point
  - source of bias



Bias Correction

- Compare:

$$z_{CALO} = r\ cotg\ \theta_{CALO} \quad wrt \quad z_{true} = r\ cotg\ \theta_{true}$$

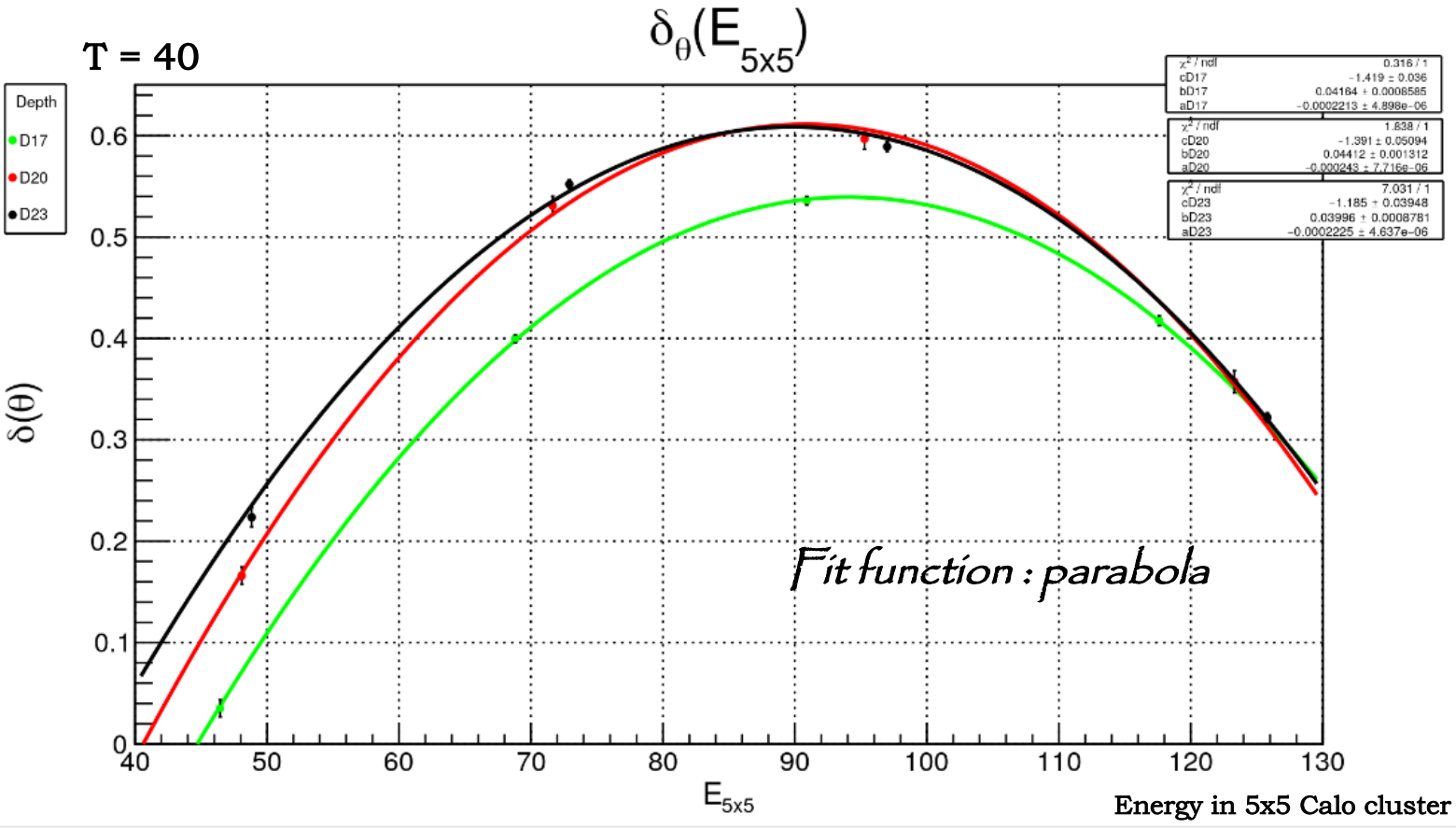
- Who knows z_{true}?
  - in principle ~ log($E_{cluster}$)
  - in fact need to account for leakage

- In fact, parameterize

$$z_{true} = z_{CALO} + \Delta z$$

$$\Delta z = r\ cotg_{true} - r\ cotg\ \theta_{CALO} \simeq r\ \delta\theta(E)/\sin^2\theta_{CALO}$$

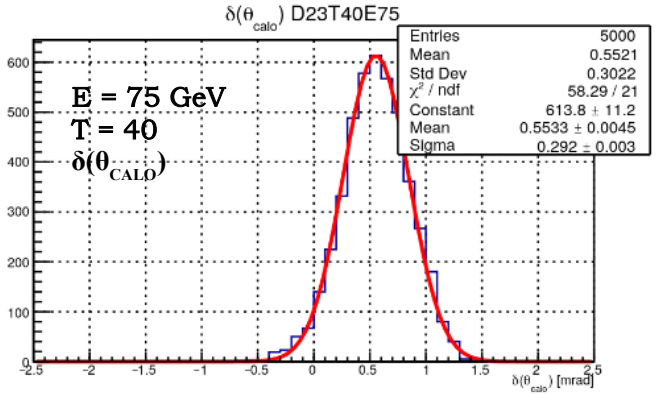
An example

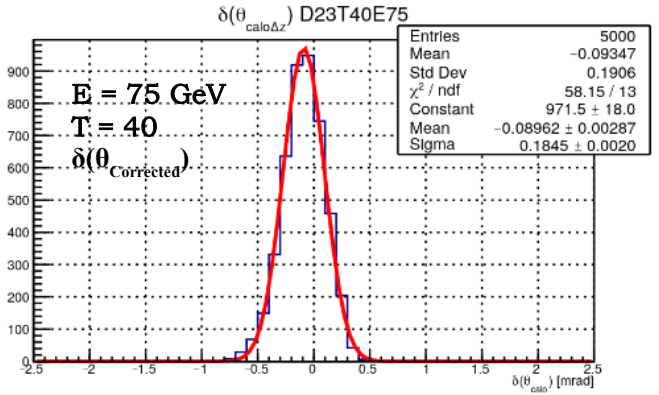

$\delta_\theta(E_{5x5})$
T = 40
Depth
D17
D20
D23
χ^2 / ndf 0.316 / 1
cD17 −1.419 ± 0.036
bD17 0.04164 ± 0.0006585
aD17 −0.0002213 ± 4.898e−06
χ^2 / ndf 1.838 / 1
cD20 −1.391 ± 0.05094
bD20 0.04412 ± 0.001312
aD20 −0.000243 ± 7.716e−06
χ^2 / ndf 7.031 / 1
cD23 −1.185 ± 0.03948
bD23 0.03996 ± 0.0008781
aD23 −0.0002225 ± 4.637e−06
Fit function : parabola
δ(θ)
E_{5x5}
Energy in 5x5 Calo cluster

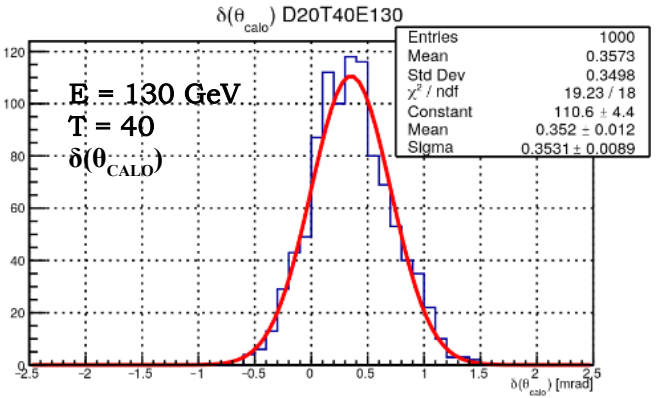
Algo

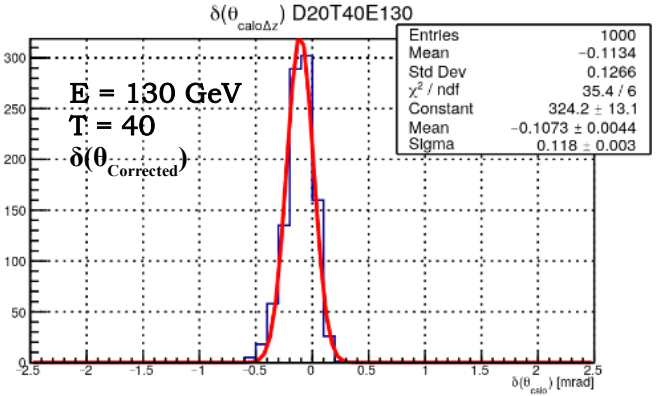
- Compute $\theta_{CALO} = atan\ (r/z_{calo})$
- Compute $z_{True} = z_{CALO} + \delta\ (\theta_{CALO}, E_{cluster})$
- Compute $\theta_{True} = atan\ (r/z_{True})$
- If algo is correct :
  - $\delta\ ' = 0$ *(trivial)*
  - $\sigma(\delta\ ')$ somewhat improved

Results (T40)


δ(θcalo) D23T40E75
E = 75 GeV
T = 40
δ(θCALO)
Entries 5000
Mean 0.5521
Std Dev 0.3022
χ² / ndf 58.29 / 21
Constant 613.8 ± 11.2
Mean 0.5533 ± 0.0045
Sigma 0.292 ± 0.003
δ(θcalo) [mrad]

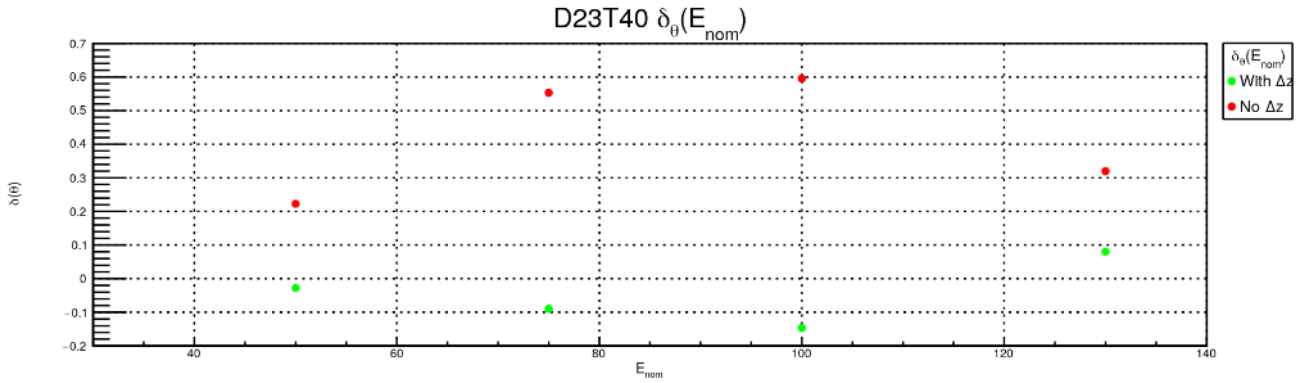

δ(θcaloΔz) D23T40E75
E = 75 GeV
T = 40
δ(θCorrected)
Entries 5000
Mean −0.09347
Std Dev 0.1906
χ² / ndf 58.15 / 13
Constant 971.5 ± 18.0
Mean −0.08962 ± 0.00287
Sigma 0.1845 ± 0.0020
δ(θcalo) [mrad]


δ(θcalo) D20T40E130
E = 130 GeV
T = 40
δ(θCALO)
Entries 1000
Mean 0.3573
Std Dev 0.3498
χ² / ndf 19.23 / 18
Constant 110.6 ± 4.4
Mean 0.352 ± 0.012
Sigma 0.3531 ± 0.0089
δ(θcalo) [mrad]

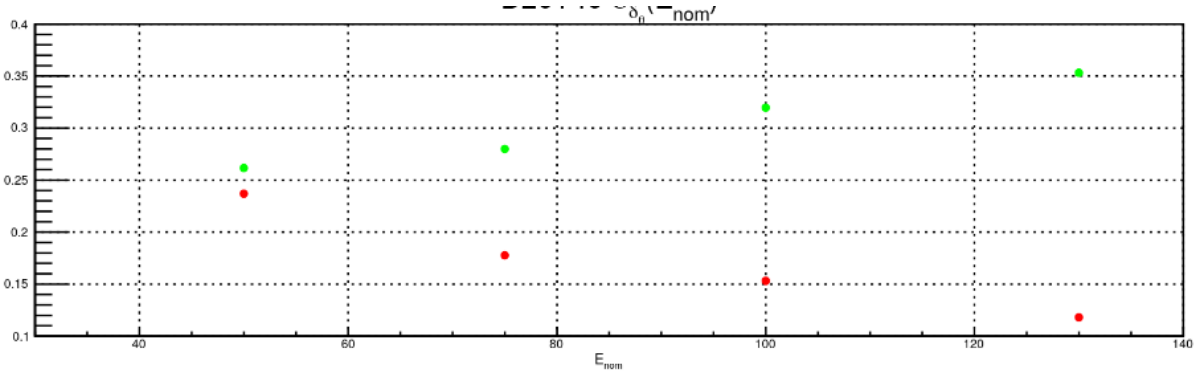

δ(θcaloΔz) D20T40E130
E = 130 GeV
T = 40
δ(θCorrected)
Entries 1000
Mean −0.1134
Std Dev 0.1266
χ² / ndf 35.4 / 6
Constant 324.2 ± 13.1
Mean −0.1073 ± 0.0044
Sigma 0.118 ± 0.003
δ(θcalo) [mrad]

Results (T40)

$\delta(\theta)$



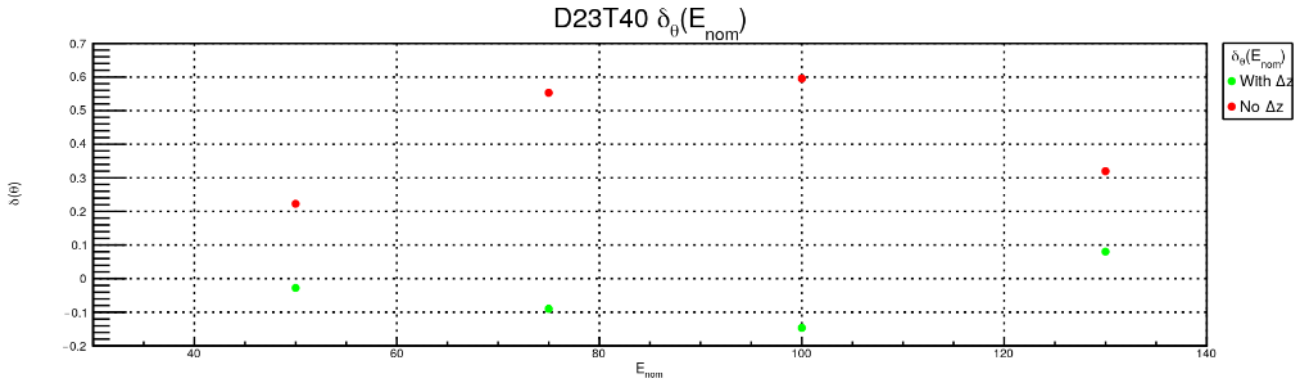
$\sigma_{\delta(\theta)}$



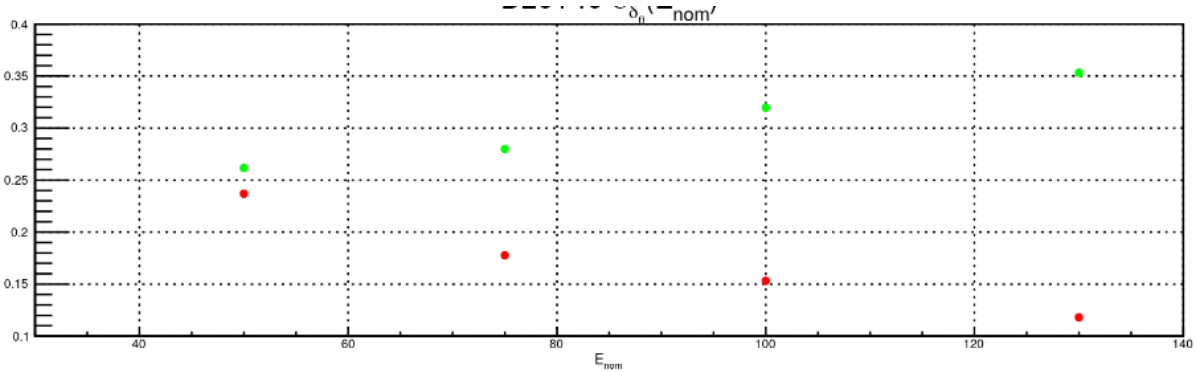
True Energy

Results (T40)

$\delta(\theta)$



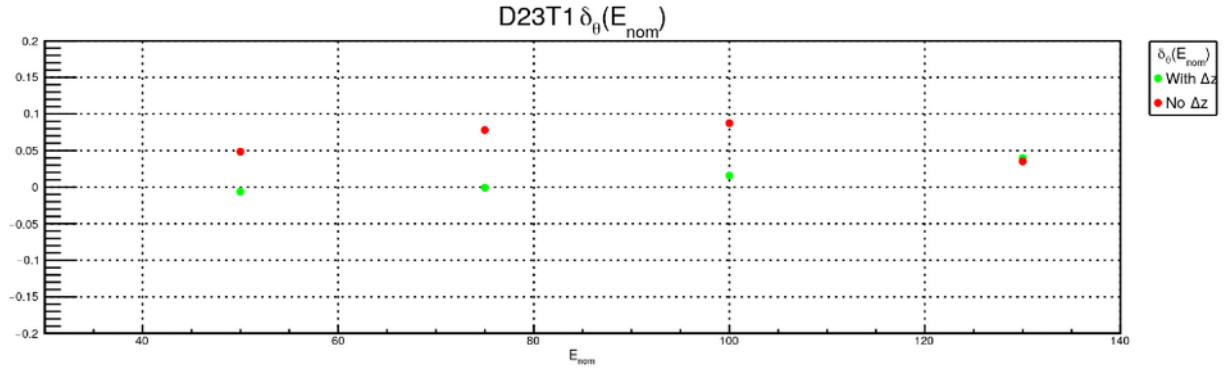
$\sigma_{\delta(\theta)}$



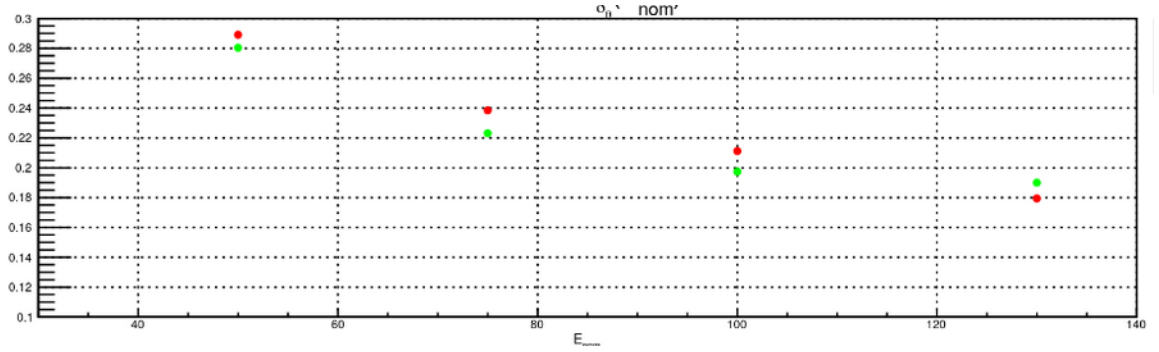
True Energy

Results (T1)

$\delta(\theta)$



$\sigma_{\delta(\theta)}$



True Energy