GTOCC

Low Energy Resolution of AO Design

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Low Energy Study of AO

- Goal :

Evaluate the Low energy resolution of the AO configuration using a Low energy correction method based on correlations between the lost energy in the tracker and the number of hits.

- Outline :
  - The method
  - A word of caution
  - Why it works
  - Performance plots
  - Conclusions

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Low Energy Study of AO

- Starting point :

  A non negligible fraction of Energy is lost

  in the TKR Below a few 100 MeV

- Use Correlation btw E_Lost and TKR Nhits :
- Definitions :

$$\mathring{A}_0 = \mathring{A}^{cal}_{seen} + \mathring{A}_{leak}$$

$$\mathring{A}_{leak} = \boldsymbol{a} * \acute{I}_{hits} + \hat{a}$$

- Generate MC runs @ various E, θ

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- Fit coefficients as a function of MC Truth

  Energy, Π, Vertex

$$\begin{cases} a = a\left(E_0, q, vertex\right) \\ b = b\left(E_0, q, vertex\right) \end{cases}$$

1st Source of error : model to fit, errors of fit, ...

- For real events E_True is unknown : so one has to use :

$$\begin{cases} a = a\left(E^{cal}_{seen}, q, vertex\right) \\ b = b\left(E^{cal}_{seen}, q, vertex\right) \end{cases}$$

2st Source of error : dispersion of Ι & ϑ

wrong E, wrong Π

- Then use an iterative method :

$$E_1 = Å^{cal}_{seen} + a\left(Å^{cal}_{seen}, q, vertex\right) * Í_{hits} + b\left(Å^{cal}_{seen}, q, vertex\right)$$

$$\ldots$$

$$E_n = Å^{cal}_{seen} + a\left(Å_{n-1}, q, vertex\right) * Í_{hits} + b\left(Å_{n-1}, q, vertex\right)$$

Low Energy Study of AO

- Caution !
- If one uses MC Truth $E = Å^{cal}_{seen} + a\left(E_0, q, vertex\right) * Í_{hits} + b\left(E_0, q, vertex\right)$

One gets very optimistic results !!!

And this is what has been done for the AO performance @ 100 MeV, 0°

(The best way to see that is to look into the code : is there any iteration?!)

Now why does the correct method work ?

$$s^2_E = \frac{s^2_{Å^{cal}_{seen}} + a^2 * s^2_{Í\,hits} + 2 * a * r_{Å^{cal}_{seen}, Í\,hits} * s_{Å^{cal}_{seen}} * s_{Í\,hits}}{\left(1 - \left(a' * Í\,hits + b'\right)\right)^2}$$

It works if $a * r_{Å^{cal}_{seen}, Í\,hits}$ gives a negative contribution to s^2_E

Low Energy Study of AO

• The following results have been obtained using a full simulation of the AO configuration, using an updated model of the calorimeter which includes noise and individual log threshold effects :

- Log end threshold = 2 MeV;
- Noise level = 0.4 MeV

• Note : the energy resolution has been derived using a gaussian fit as : $\Delta E / \text{Å} = s / \langle E \rangle$

• When the reconstructed <E> is biased such as being higher than E_mc_truth, the resolution is defined as : $\Delta E / \text{Å} = s / E\_mc\_truth$

• The bias in reconstructed mean energy reflects the imperfections of the parameterisation as a function of (E, theta)

So there is room for further improvement.

Low Energy Resolution Results

Performance illustration

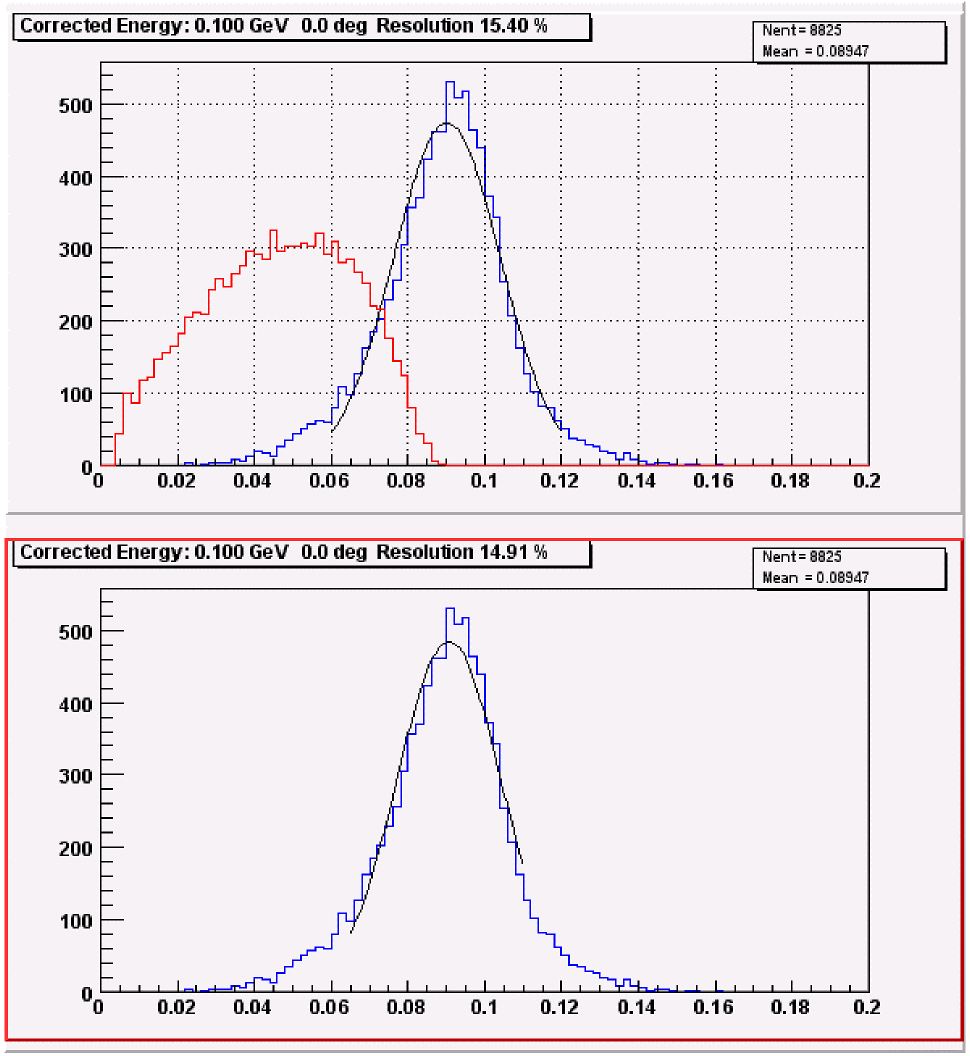
100 MeV Run @ 0° zenith

Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 15 %



Low Energy Resolution Results

Performance illustration

100 MeV Run @ 0° zenith

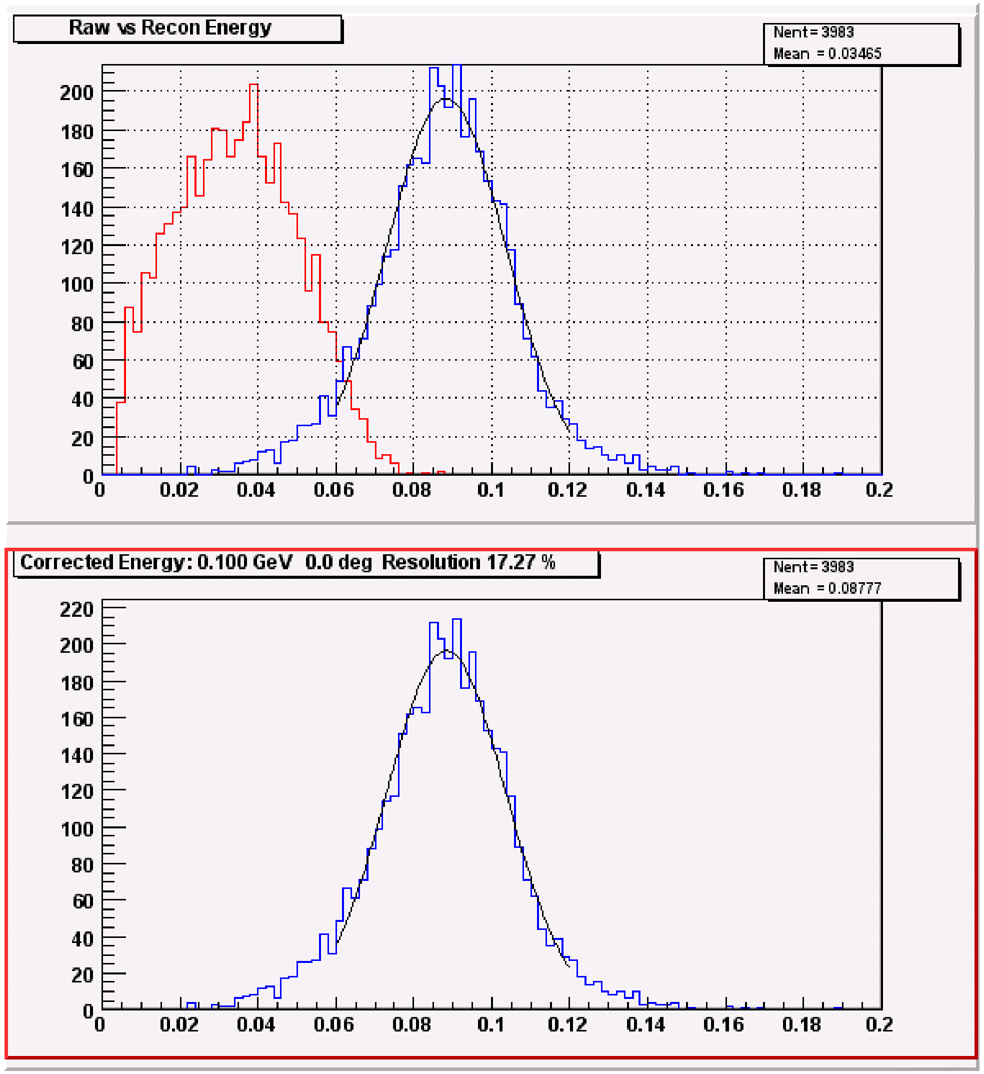
Full AO SIM

Front Converted Events

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 17 %



Low Energy Resolution Results

Performance illustration

100 MeV Run @ 37° zenith

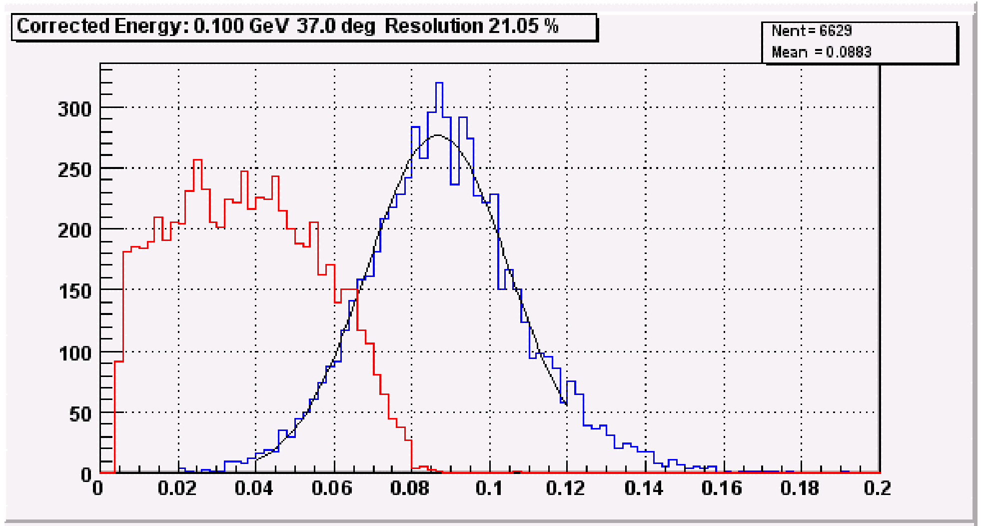
Full AO SIM

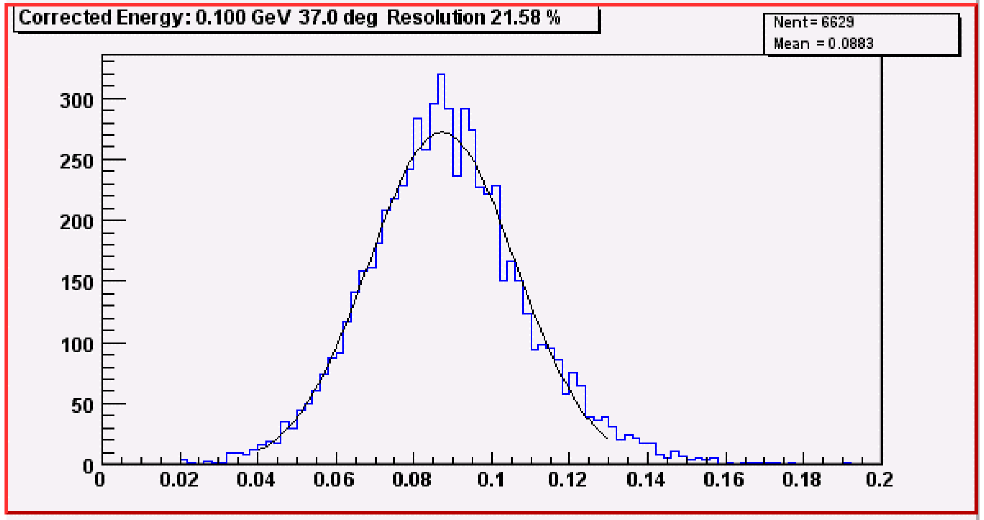
Front + Back

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 22 %





Low Energy Resolution Results

Performance illustration

100 MeV Run @ 60° zenith

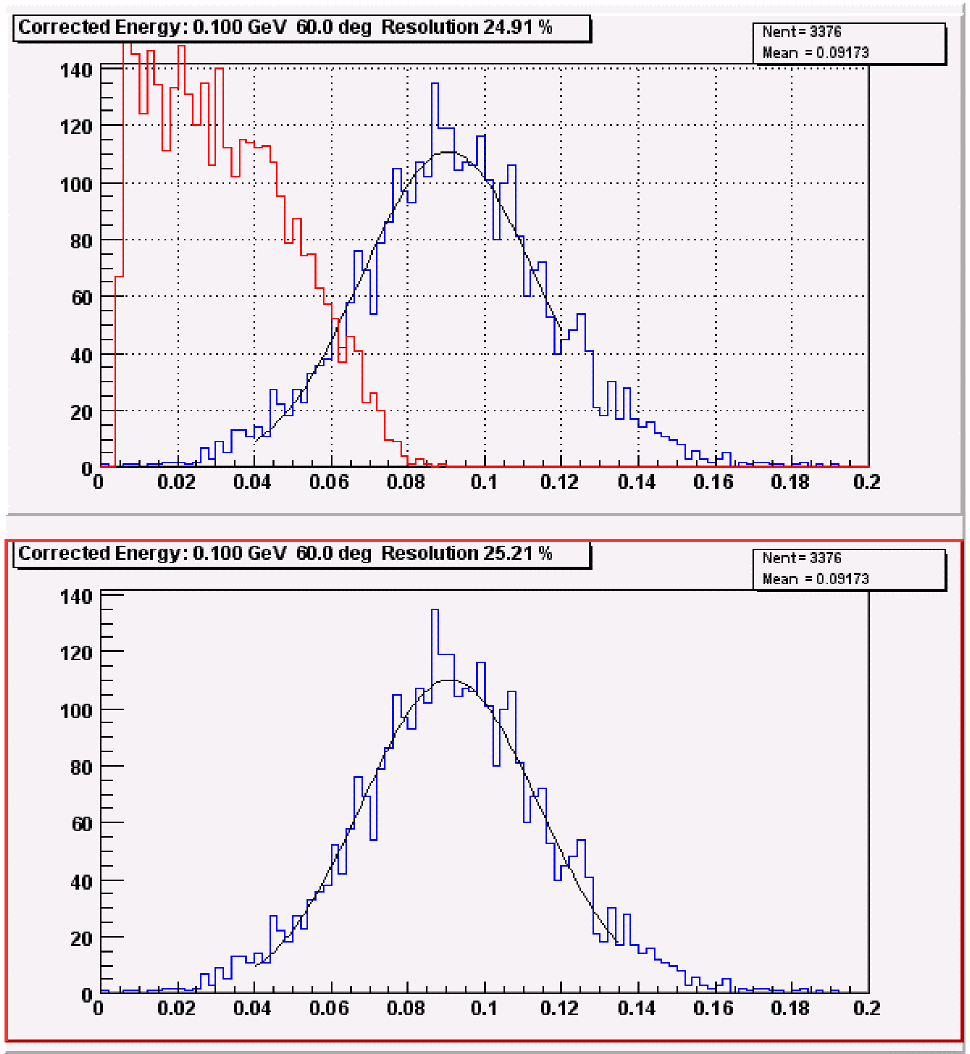
Full AO SIM

Front + Back

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 25 %



Low Energy Resolution Results

Performance illustration

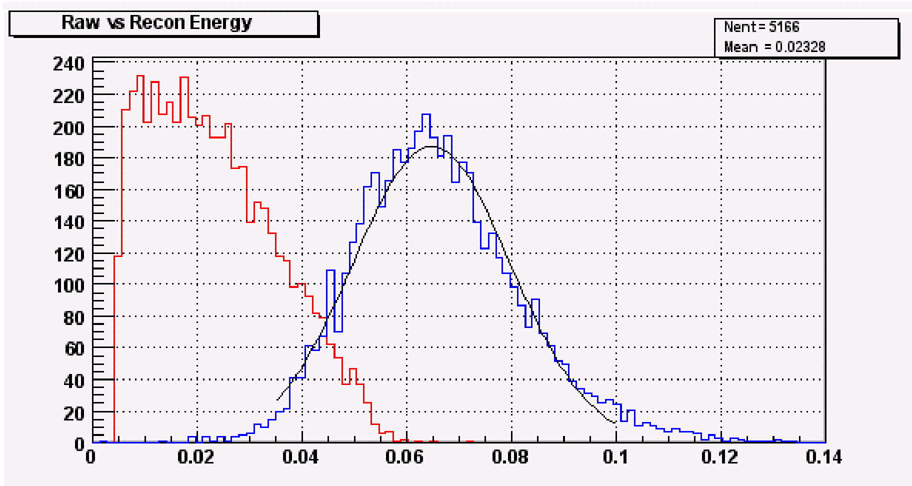
70 MeV Run @ 37° zenith

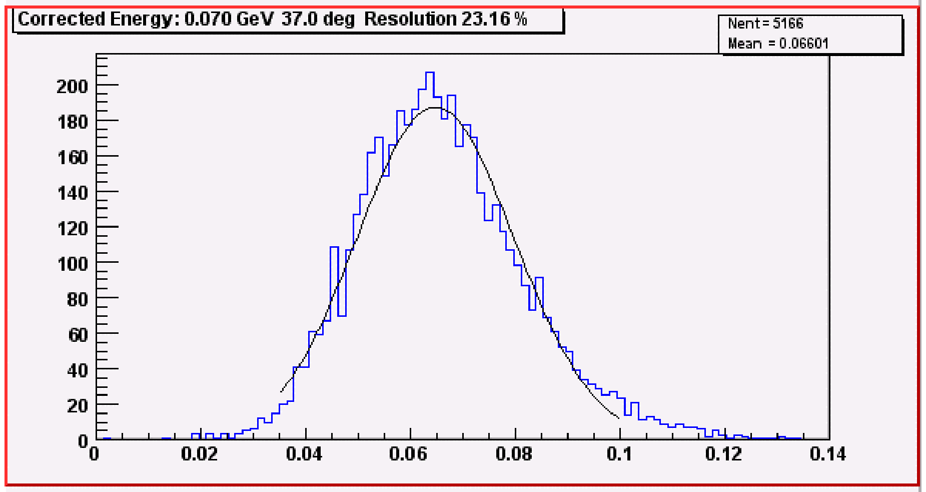
Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 23 %





Low Energy Resolution Results

Performance illustration

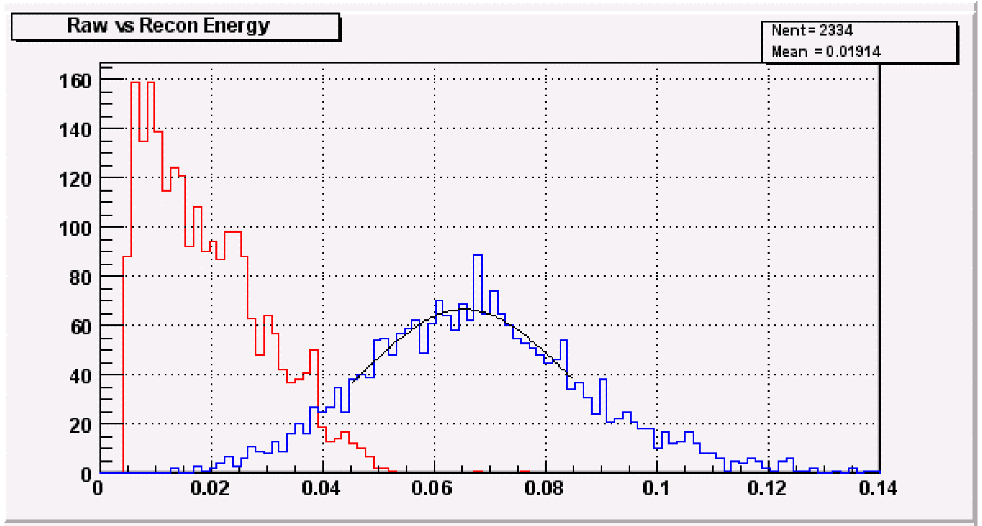
70 MeV Run @ 45° zenith

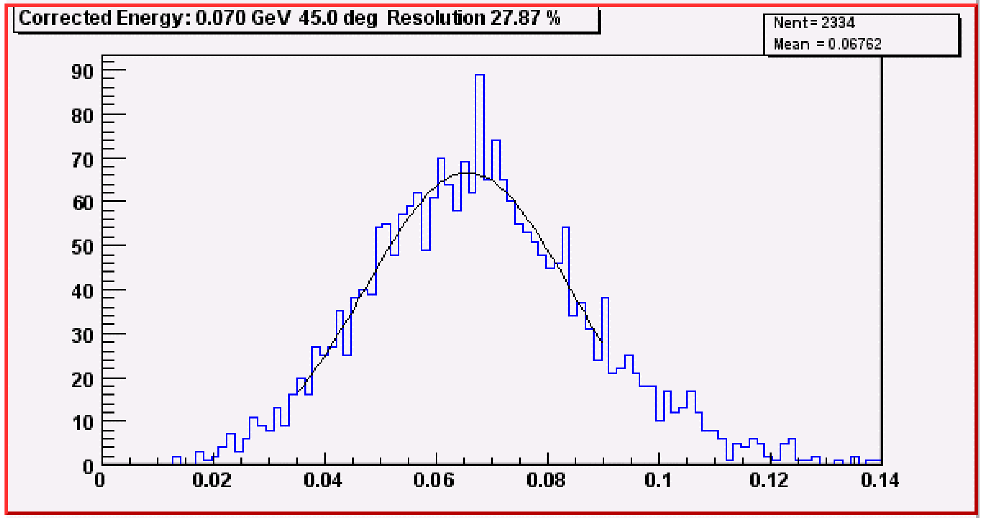
Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 28 %





Low Energy Resolution Results

Performance illustration

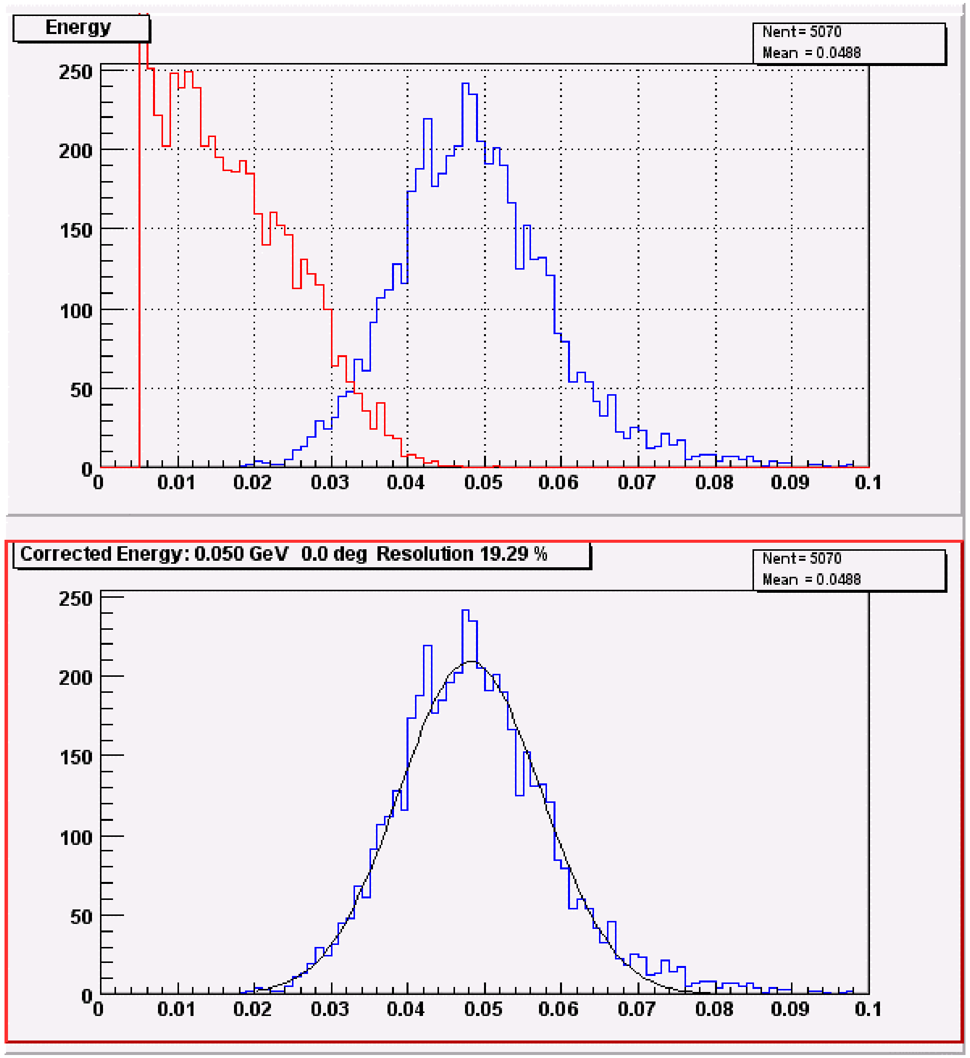
50 MeV Run @ 0° zenith

Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 19 %



Low Energy Resolution Results

Performance illustration

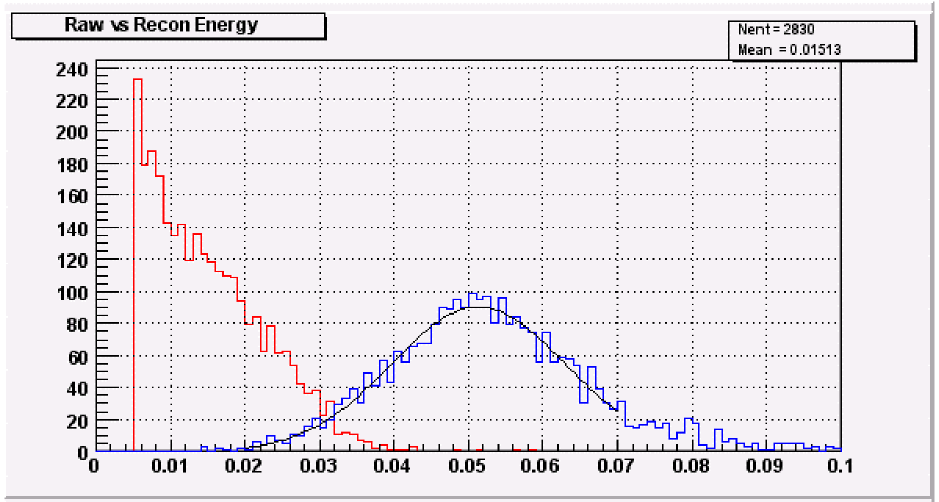
50 MeV Run @ 45° zenith

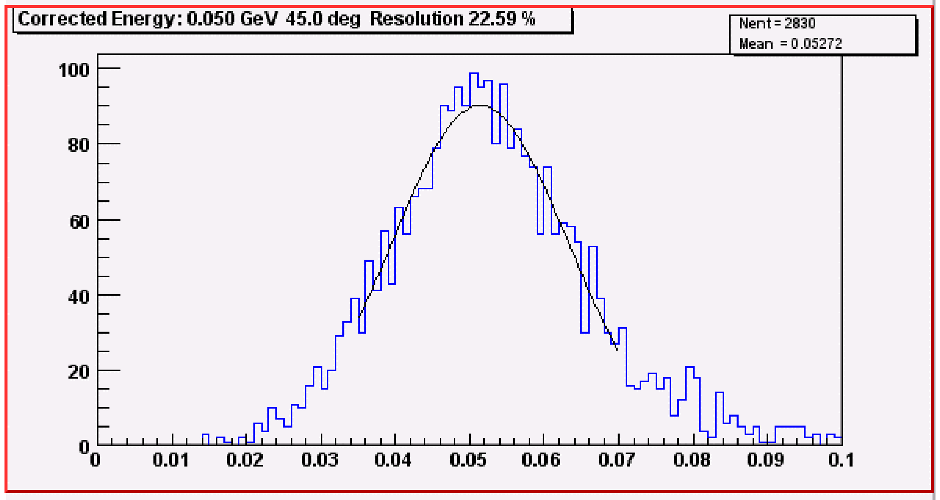
Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 23 %





Low Energy Resolution Results

Performance illustration

50 MeV Run @ 60° zenith

Full AO SIM

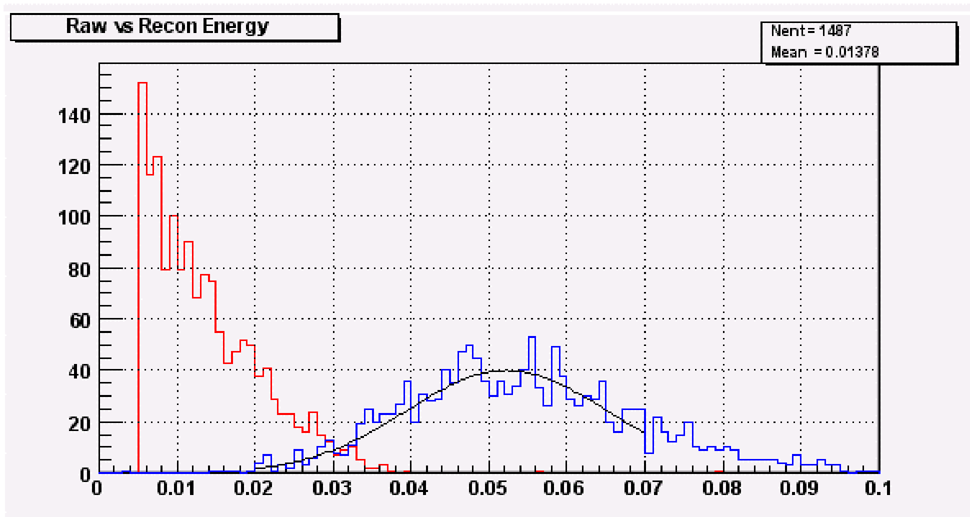
Raw Energy in Red

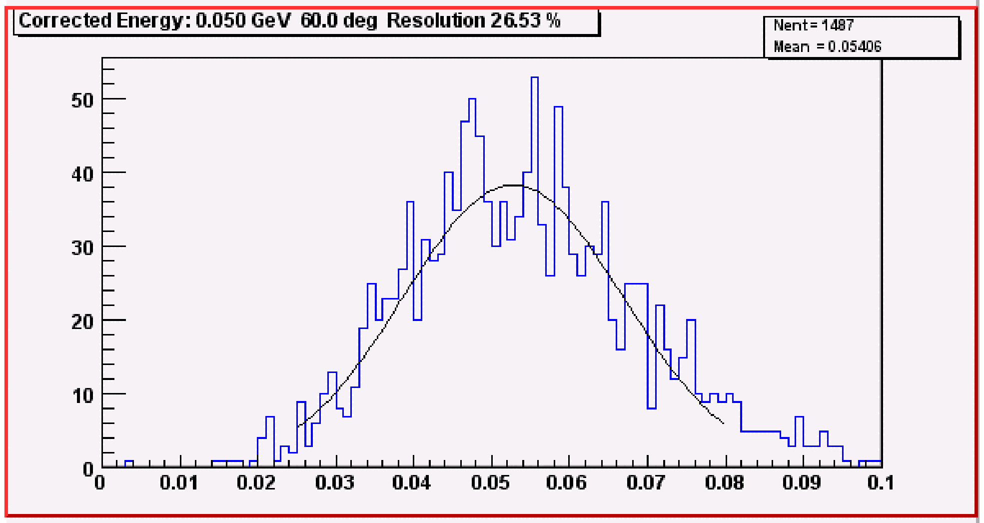
Recon Energy in Blue

Resolution :

$\Delta E / \text{Å} = s / \langle E \rangle$ ~ 27 %

$\Delta E / \text{Å} = s / E\_mc\_truth$ ~ 28 %





Low Energy Resolution Results

Performance illustration

30 MeV Run @ 37° zenith

Full AO SIM

Front + Back

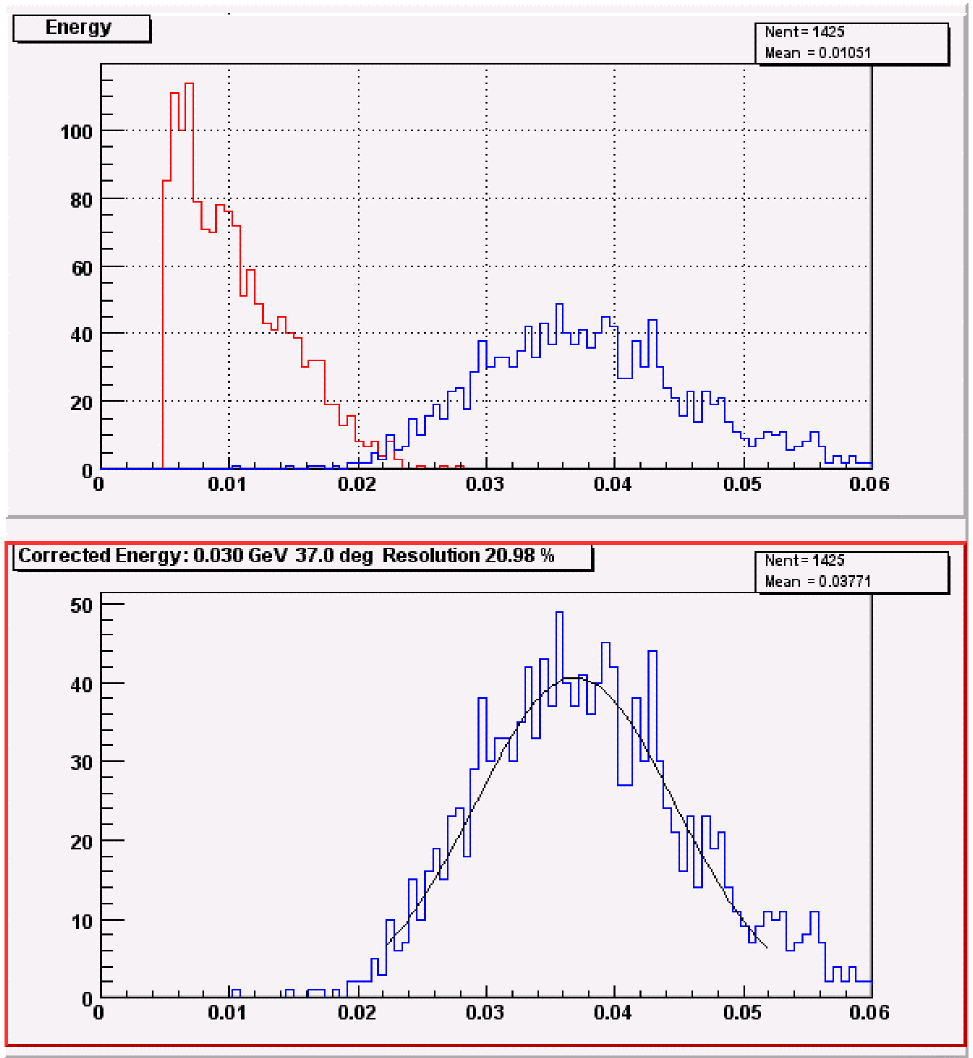
Raw Energy in Red

Recon Energy in Blue

Resolution :

$\Delta E / Å = s / \langle E \rangle$ ~ 21 %

$\Delta E / Å = s / E\_mc\_truth$ ~ 25 %



Low Energy Resolution Results

Performance illustration

30 MeV Run @ 37° zenith

Full AO SIM

Front Converted Events

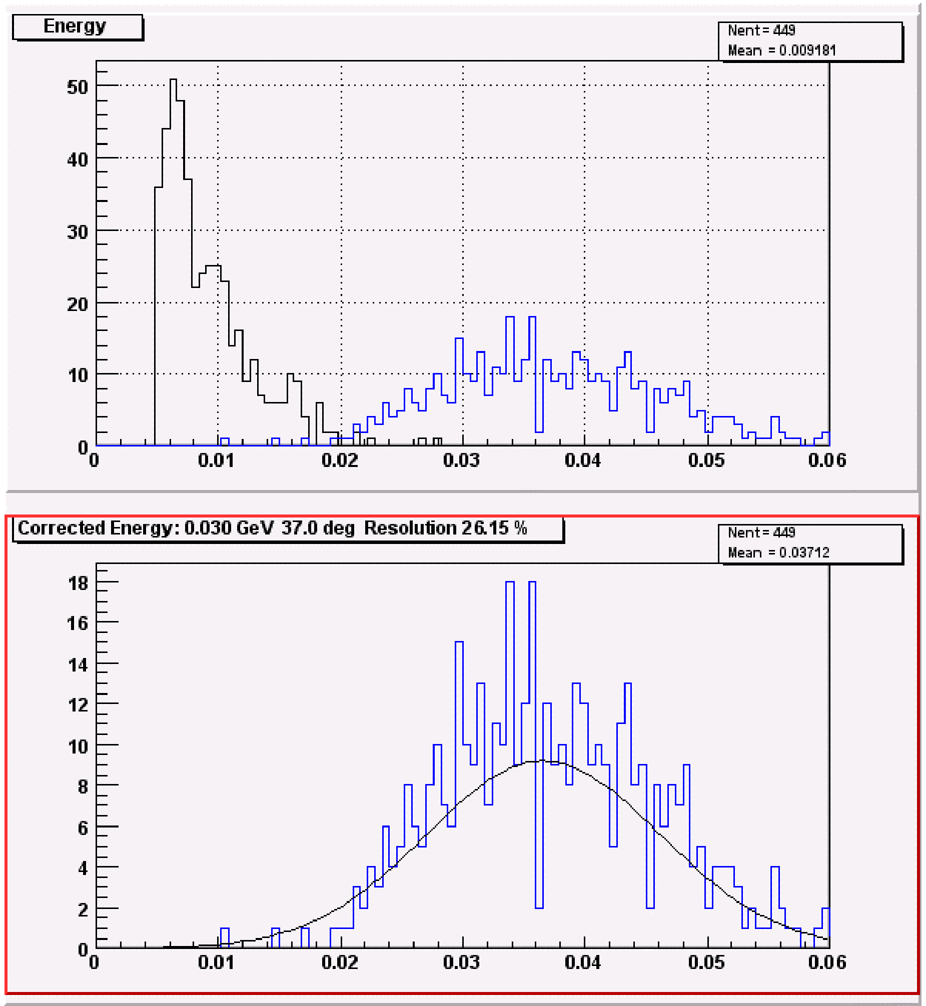
Raw Energy in Red

Recon Energy in Blue

Resolution :

$\Delta E / Å = s / \langle E \rangle$ ~ 26 %

$\Delta E / Å = s / E\_mc\_truth$ ~ 32 %

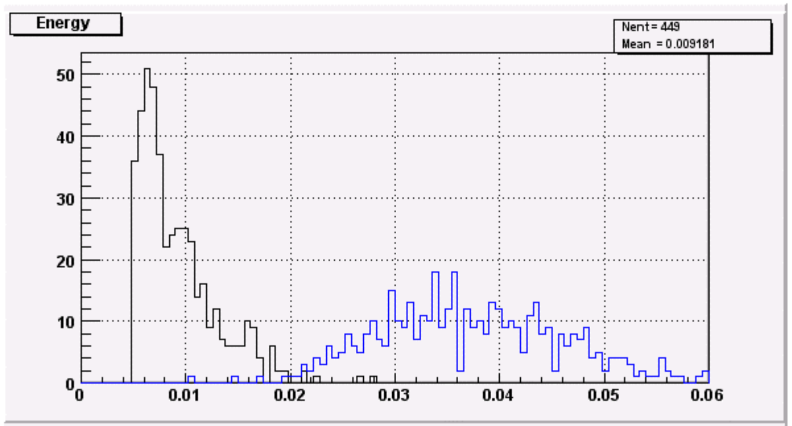


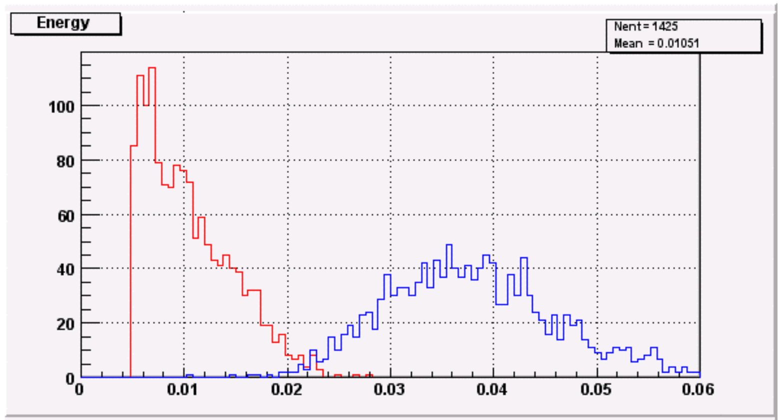
Low Energy Resolution Results

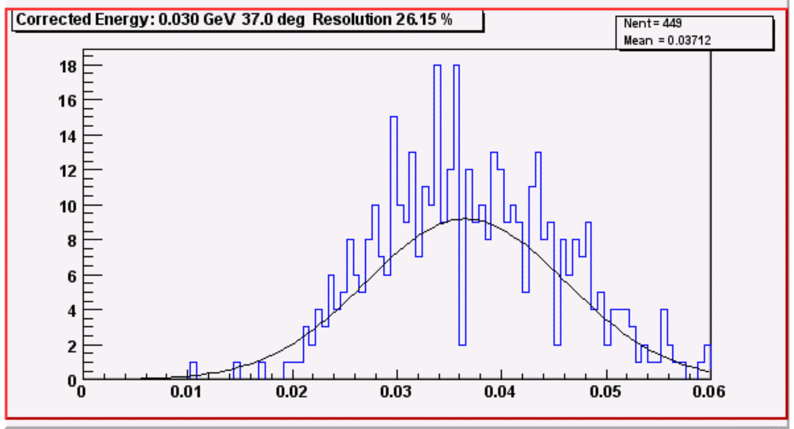
30 MeV Run @ 37° zenith Front Converted Events vs Front + Back

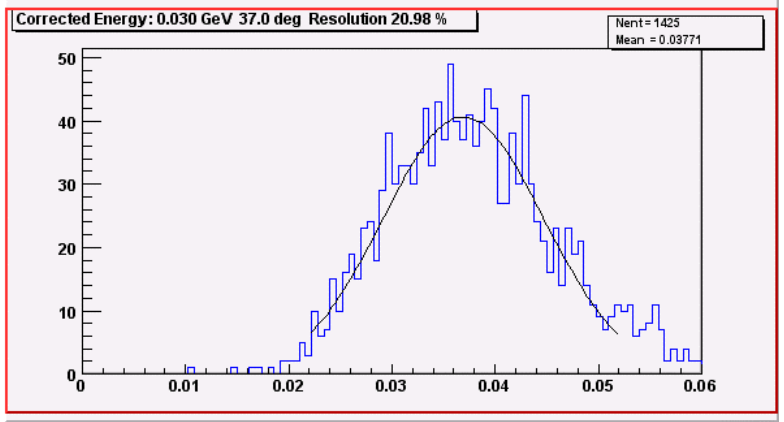
Resolution : ~ 32 %

Resolution : ~ 25 %









Low Energy Resolution Results

Performance illustration

30 MeV Run @ 60° zenith

Full AO SIM

Front Converted Events

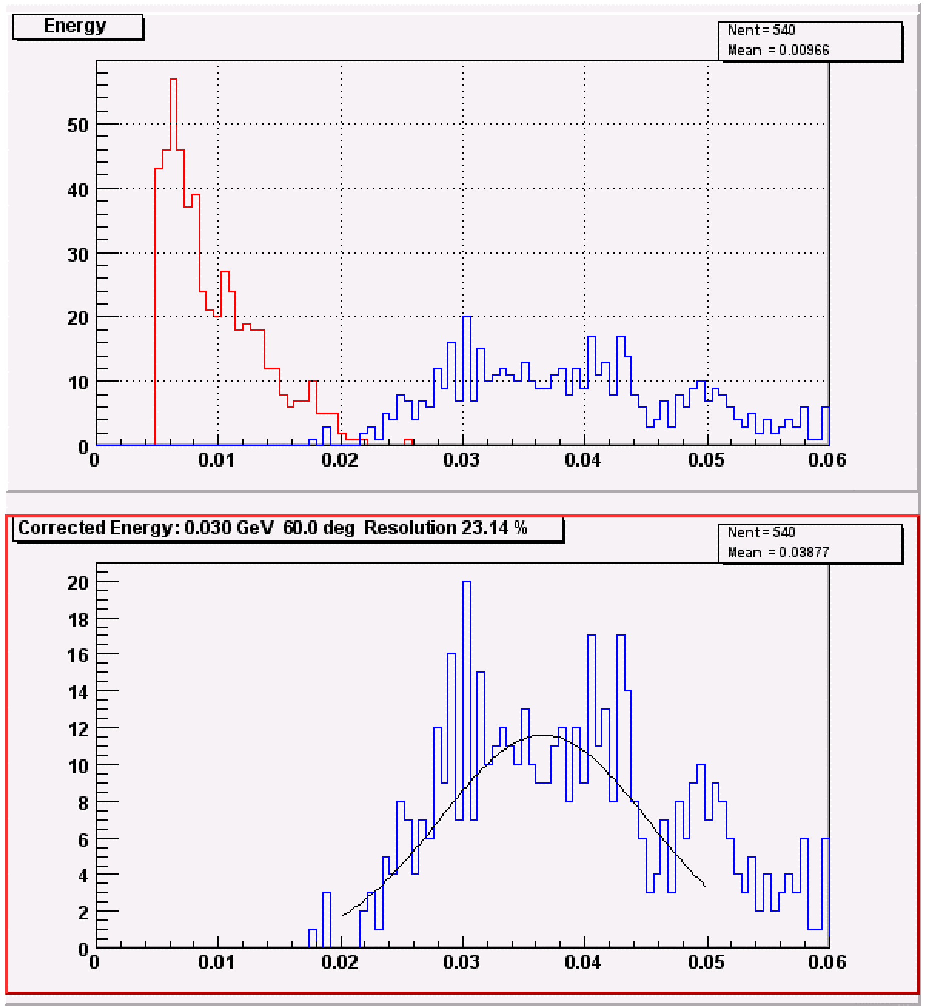
Raw Energy in Red

Recon Energy in Blue

Resolution :

$\Delta E / Å = s / \langle E \rangle$ ~ 23 % but tails

$\Delta E / Å = s / E\_mc\_truth$ ~ 28 %



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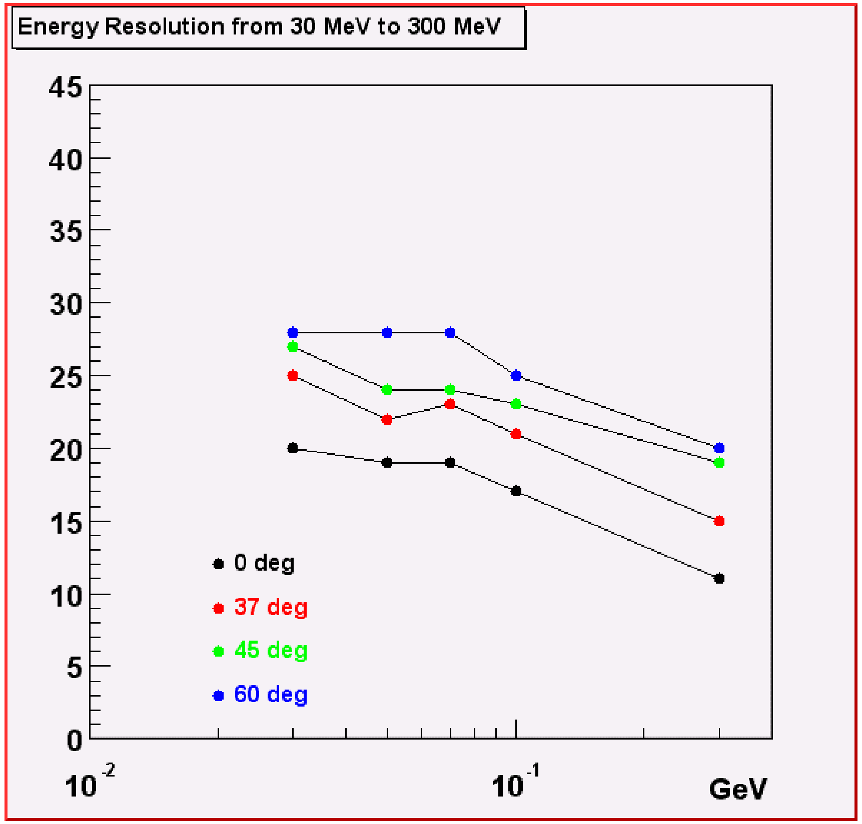
Summary Plot

- Summary plot :
- Resolution is almost constant below 100 MeV between ~20 to ~30 %

- It improves with decreasing zenith angle



•The overall results show that the Energy Resolution is not an issue for the AO (SuperGlast) configuration

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Conclusions

- An iterative low energy correction method has been developed as a function of energy and angle.
- Full simulations of the AO instrument have been made with an updated model of the CALORIMETER, including noise, active diodes and zero suppression effects.
- The application of the energy correction method to simulated data shows basically that the energy resolution is not an issue for the AO configuration : resolution varies from ~15% to ~30% depending on energy and zenith angle, from 30 MeV to 100 MeV, from 60° to 0° zenith angle.
- The Front+Back sections of the TKR together with the first layers of the CAL constitute a non homogeneous sampling calorimeter with a resolution of order 25% around few tens of MeV....
- (The derived energy resolution for the AO response has been too optimistic for 100 MeV normal incidence and too pessimistic below that energy because of use of an incorrect method...).