Upstream Material Effects on EM Resolution

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Discussions with: Carli, Froidevaux, Cranmer Carminati, Wingerter, Aleksa, Lampl, and our group

Combined Test Beam Meeting

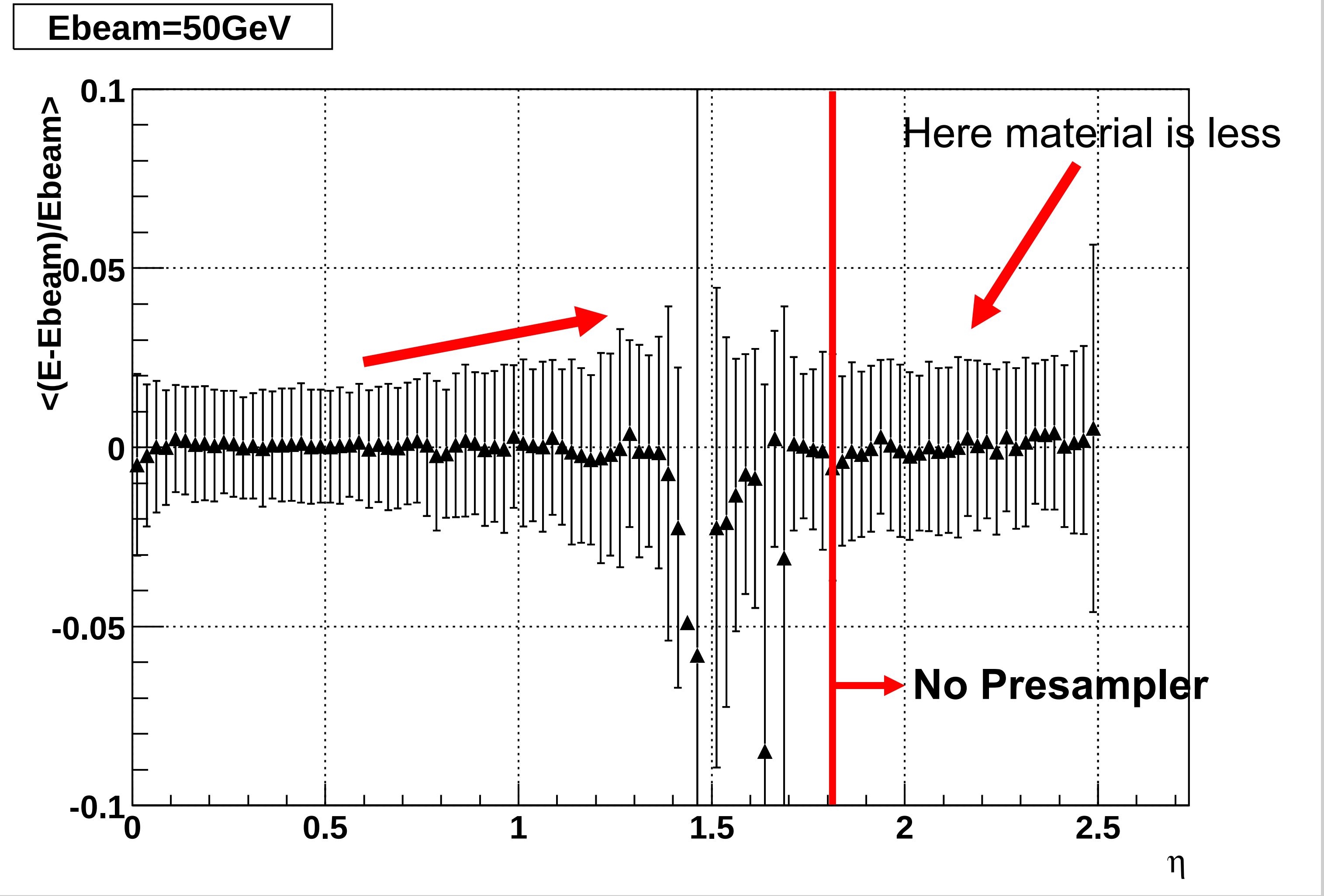
LAr Week 8-Feb-2005

Outline

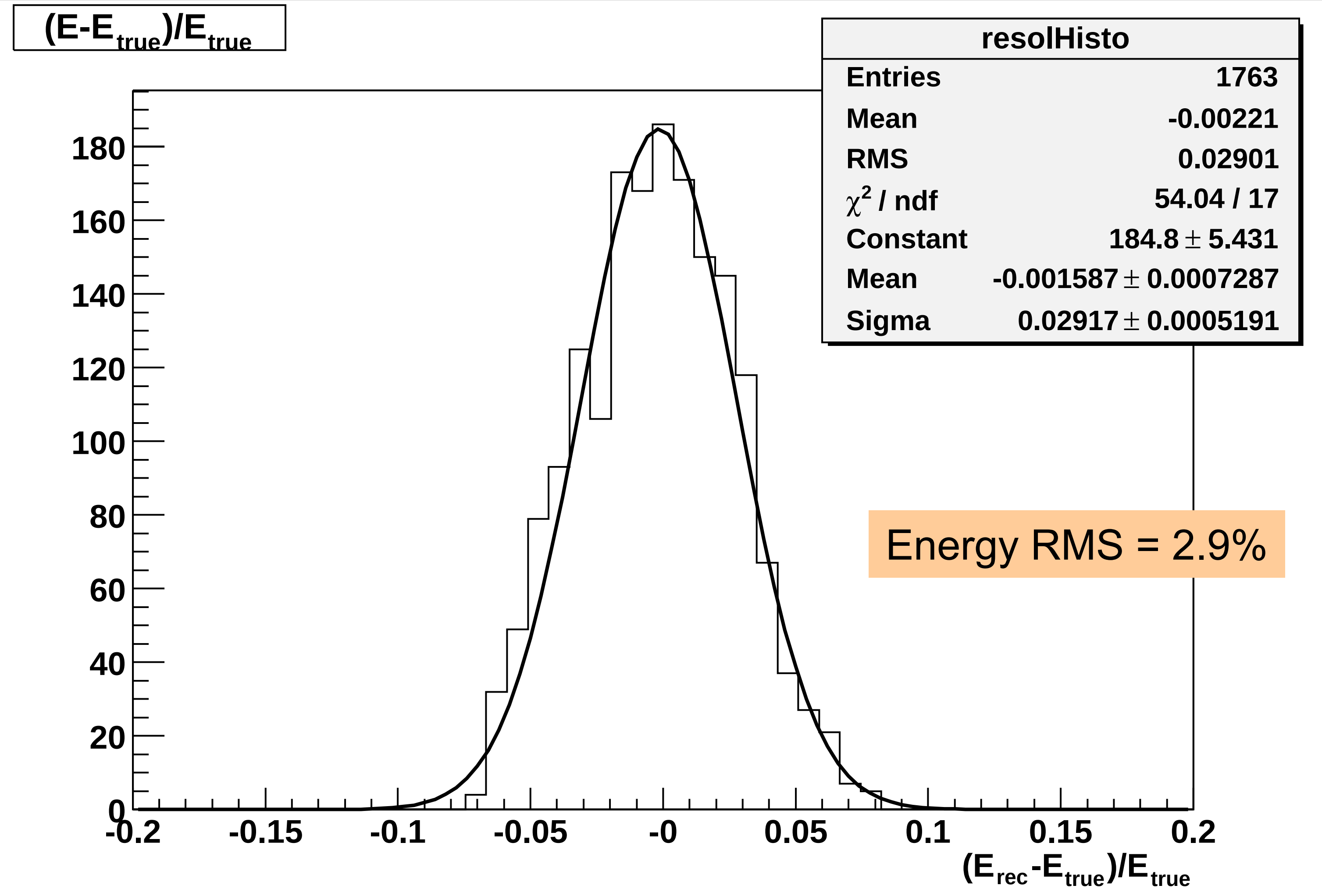
Upstream Material affects resolution->Physics

- 50GeV e^- in ATLAS (~3X0)
- 50GeV e^- in ATLAS with Calibration Hits
- 50GeV e^- in Test Beam Material Scans
  - Will attempt to find sources of loss of resolution
  - CTB04 offers a unique opportunity to test possible corrections
- Shower Depth: key variable for improving resolution.
  - Where we don't have presampler (η>1.8)
  - At the egamma level (cluster-track match)

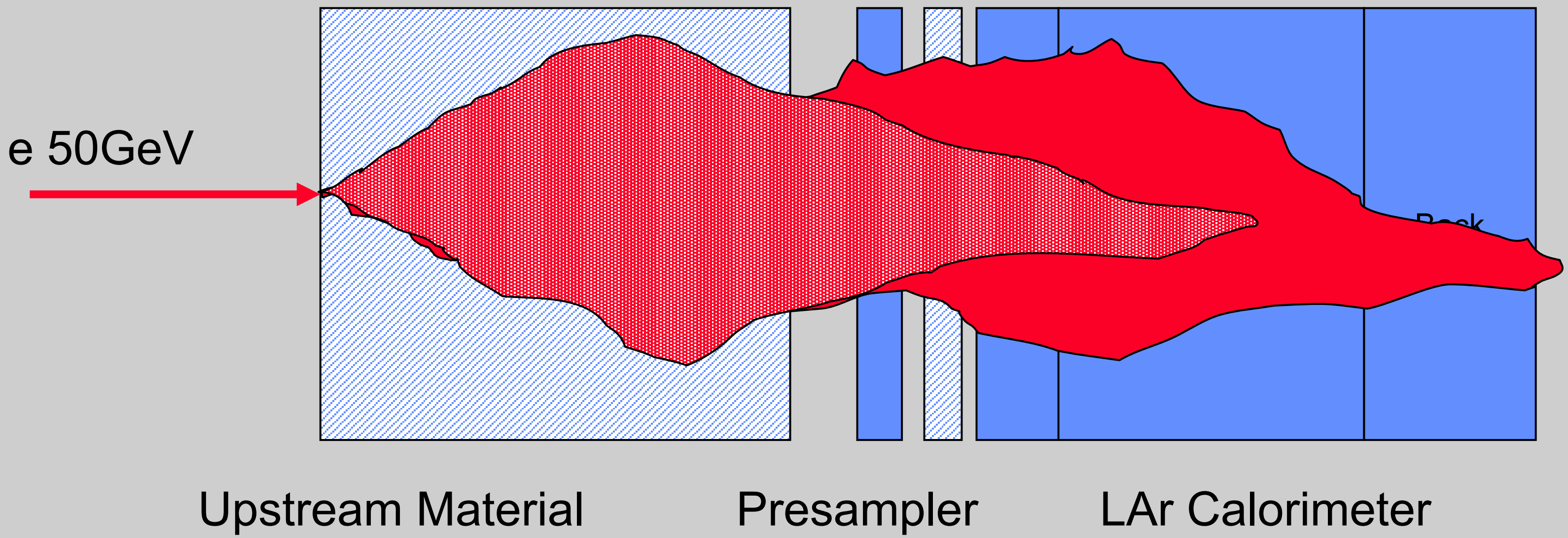
Resolution in ATLAS depends on material



The problem: ATLAS-902
50GeV e$^-$ η=1.3125 (after full calibration)



Longitudinal Fluctuations



Best Performance: Erec independent of Eloss (function of shower depth)

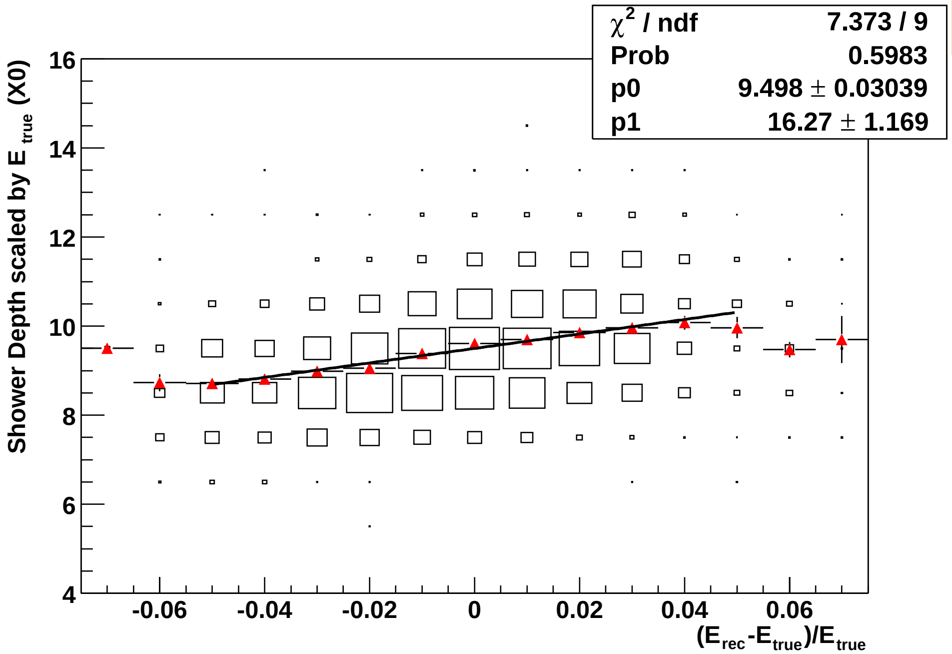
- ATLAS Longitudinal weights calculated using (will change):

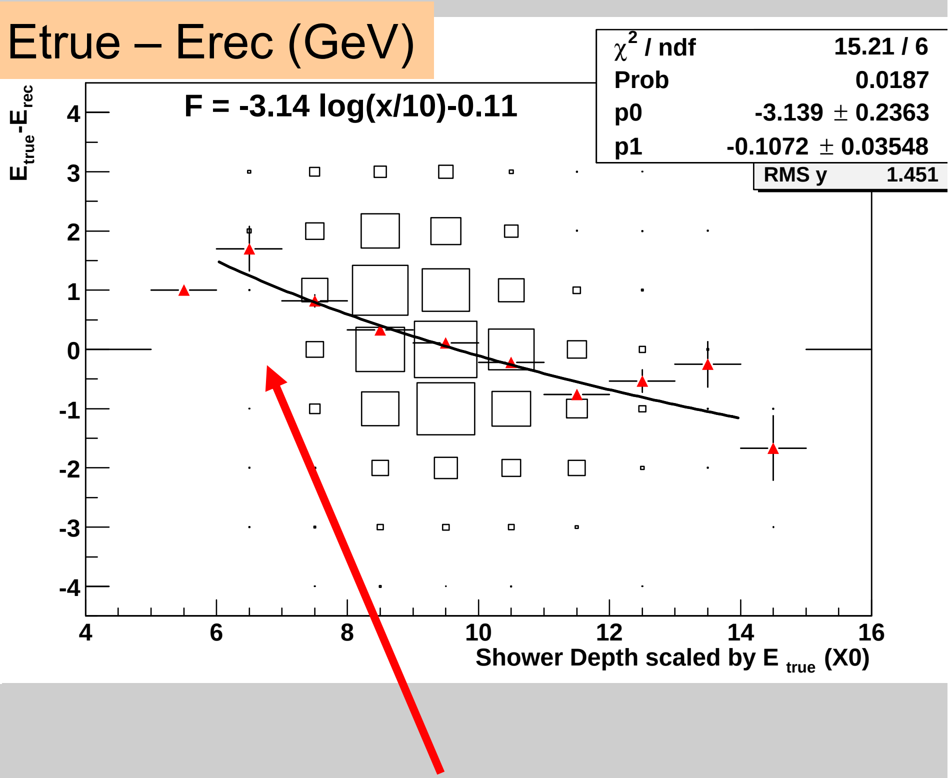
$$E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + W_3 E_3\right)$$

- TB02 Weights:

$$E_{rec} = b + W_0 E_{pres} + \frac{W\sqrt{E_{pres} E_0}}{\sum_{i=1}^{3} E_i} + \lambda \sum_{i=1}^{3} E_i$$

The Problem: Resolution depends on the shower depth (3x7 50GeV e⁻ η=1.3125)





$$d_{true} = \frac{E_{PS}X_0^{PS} + E_1 X_0^1 + E_2 X_0^2}{E_{true}}$$

less energy is reconstructed for early showers

Possible Reasons:

- Presampler principle breaks down at large X0. This means:

$$E_{Loss\ before\ PS} \neq W_0 E_{PS}$$

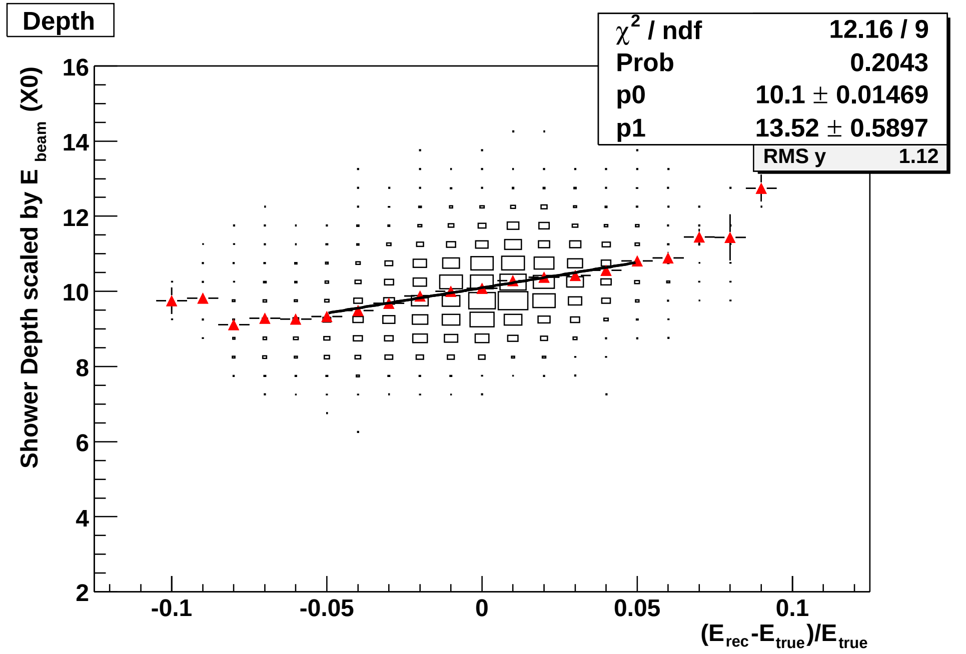
- Calorimeter sampling fraction gets smaller for early showers
- Energy loss which is shower depth dependent.
  - Between PS and Strips
  - Longitudinal Leakage from the back
  - Lateral Losses (out of cone)

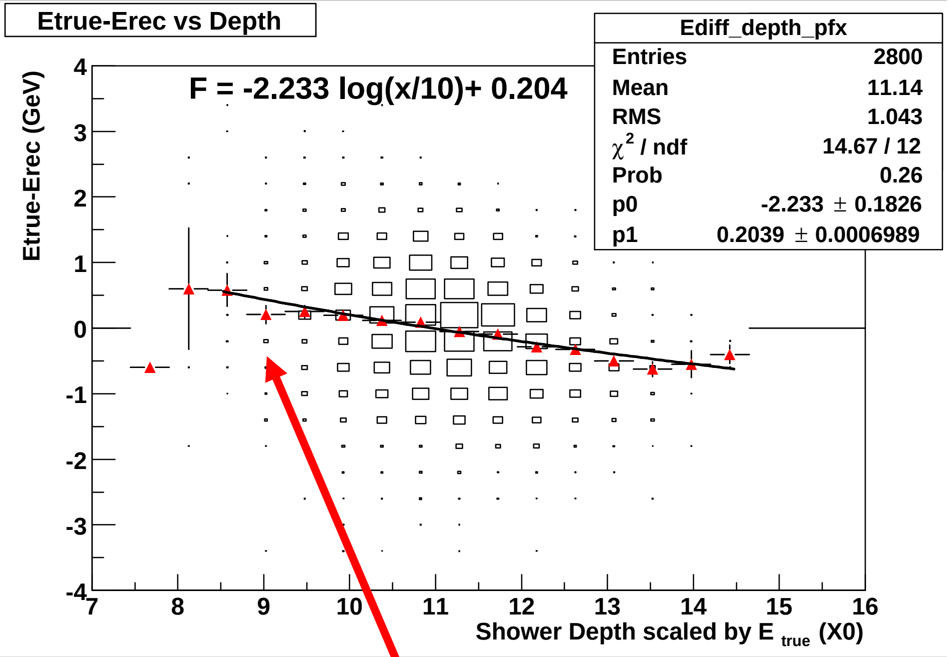
Can we find out why?

- Yes: we now have the ability to produce **calibration hits** in ATHENA
  - Thanks to Seligman, Leltchouk (Nevis), Carminati (Milano)
- I wrote my own calibration hit production for the same η=1.3125 bin with 902 and 50GeV.
- We can get:
  - Energy lost upstream the PS
  - Energy lost between PS and Strips
  - Energy deposited in the Lead Passive layers of the LAr
  - More detailed E deposition
  - EM, Hadronic shower components

Calibration Hits Results

Calibration Hits: less energy reconstructed for earlier showers

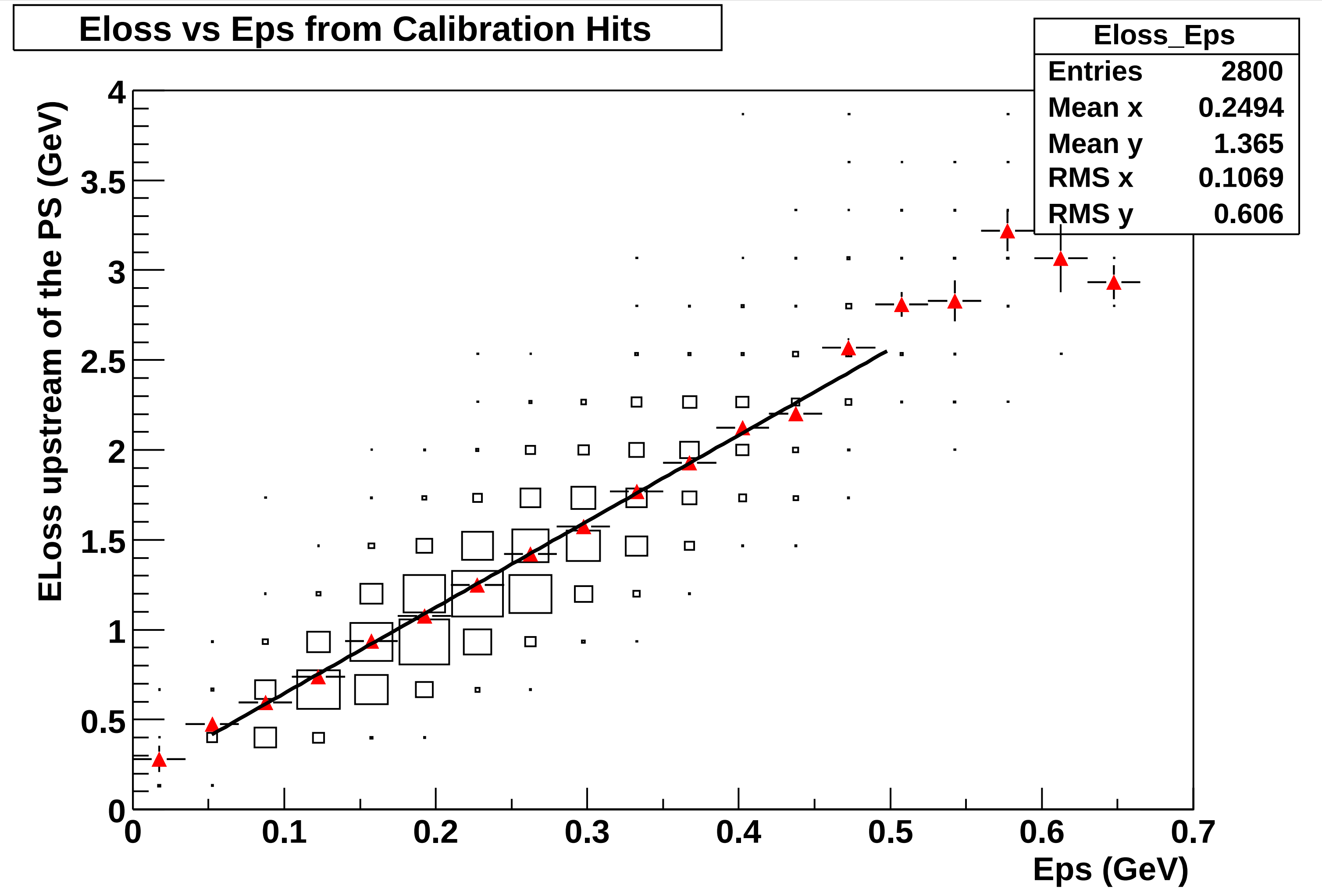




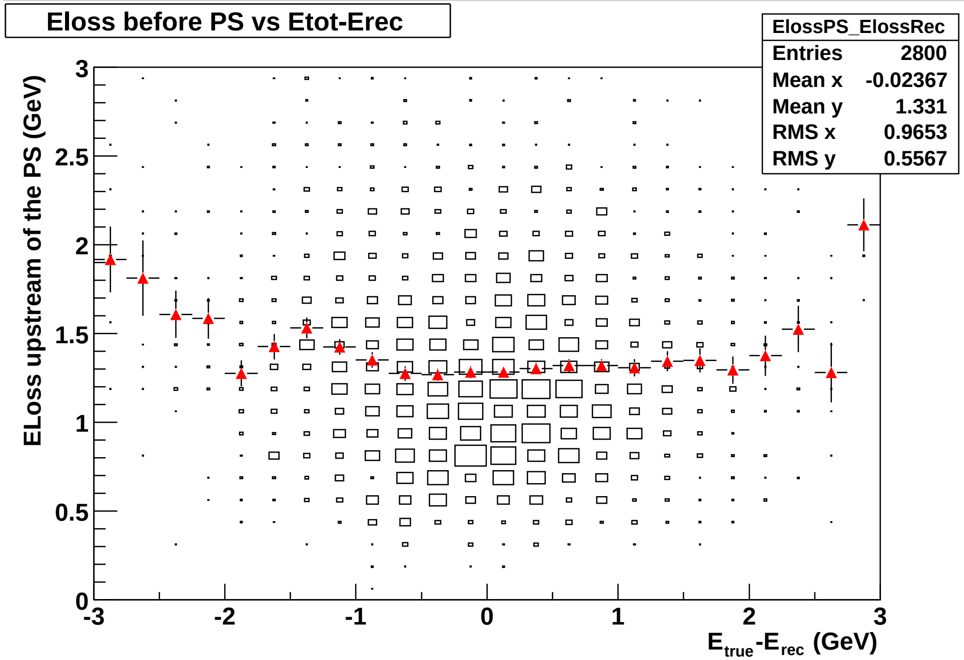
$$d_{true} = \frac{E_{PS} X_0^{PS} + E_1 X_0^1 + E_2 X_0^2}{E_{true}}$$

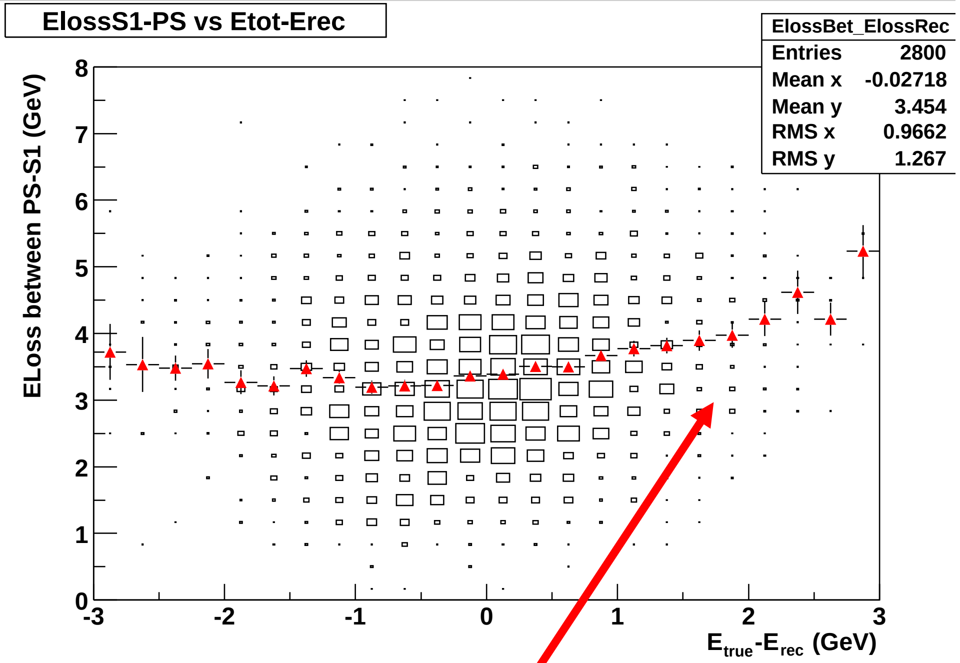
less energy is reconstructed for early showers

Cal-Hits: $E_{loss}=W_0*E_{ps}$ holds! (~3X0)



Cal-Hits: Losses vs Measured Energy



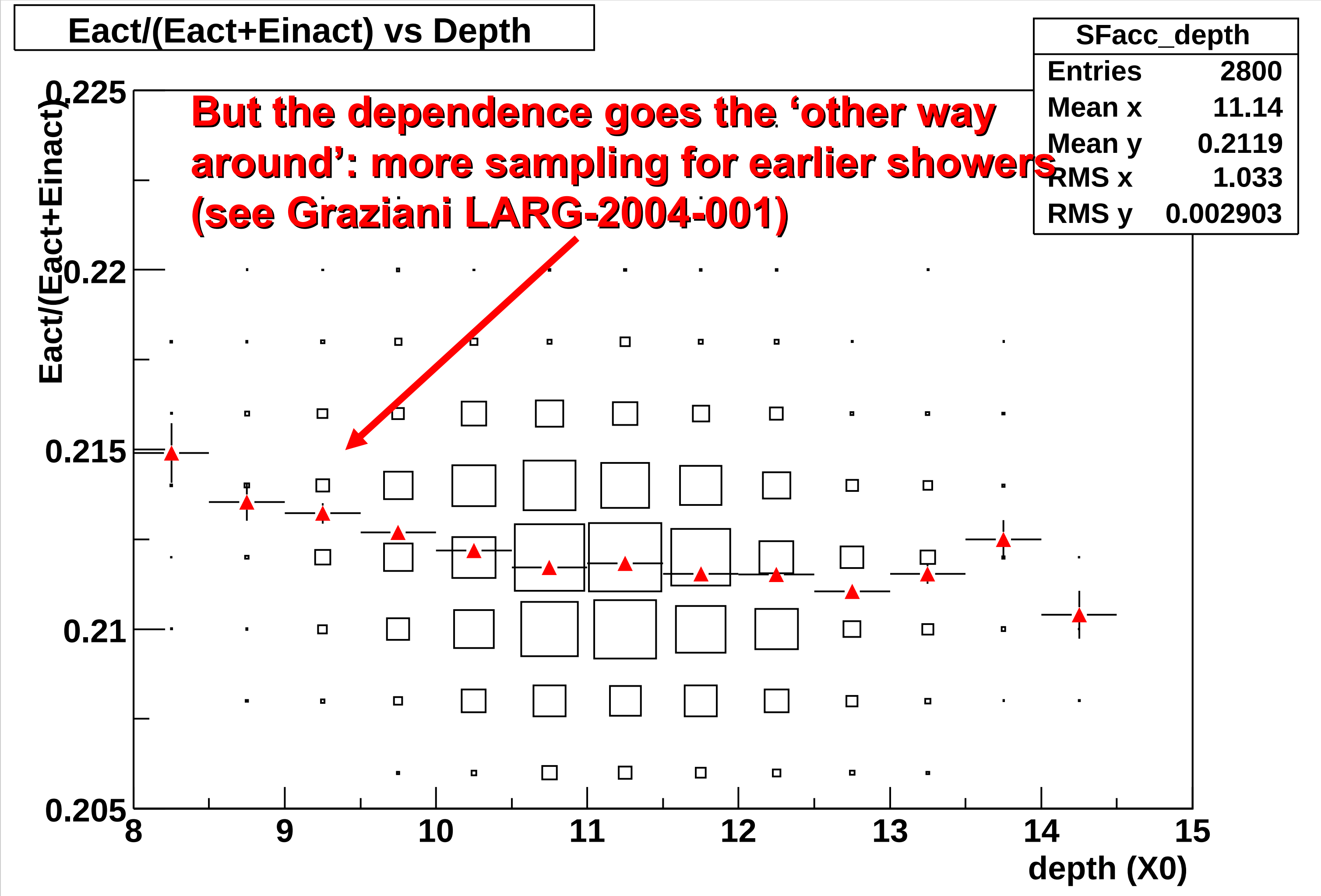


the reconstructed energy does not depend on losses upstream of the Presampler

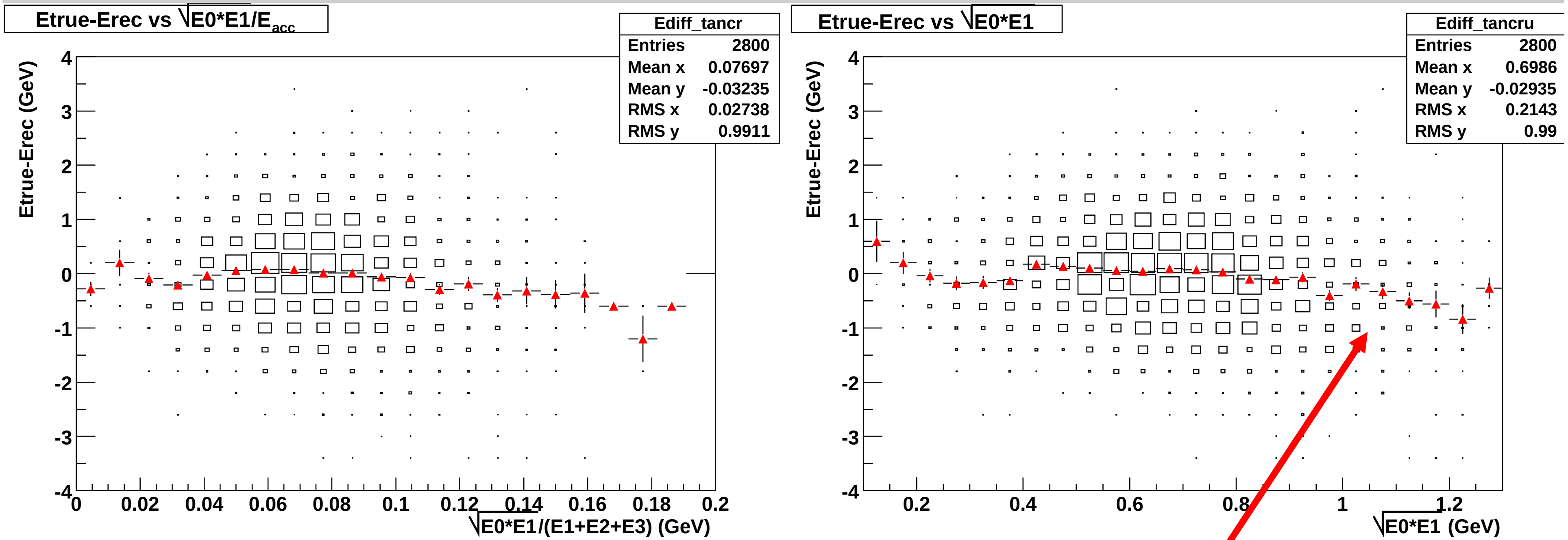
the reconstructed energy depends on the energy loss between strips and Presampler

CAUTION: out-of-cone fluctuations after Clustering is an extra effect (must check)

Cal-Hits: very weak sampling fraction dependence on the depth

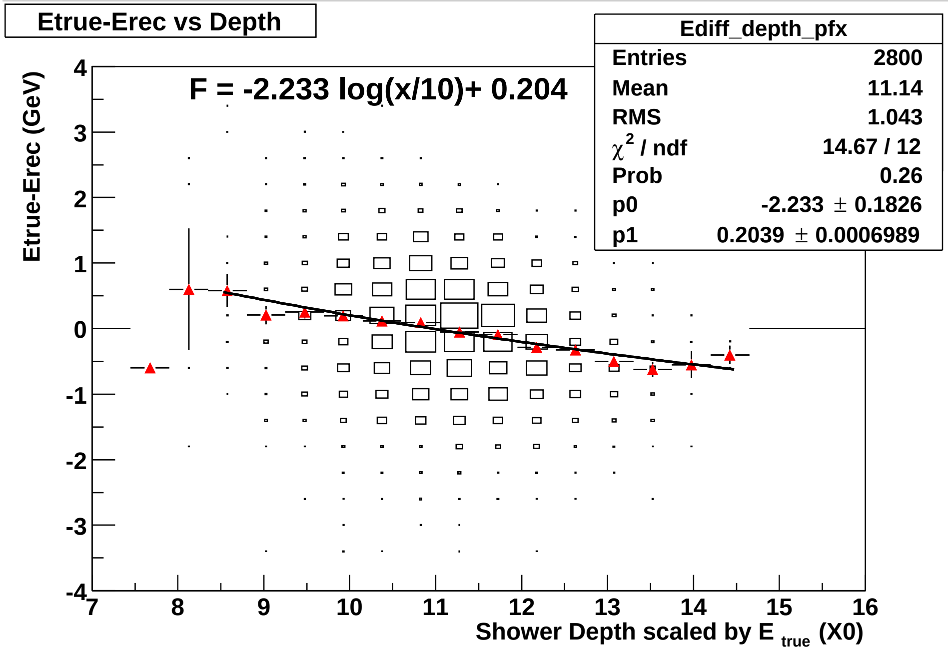


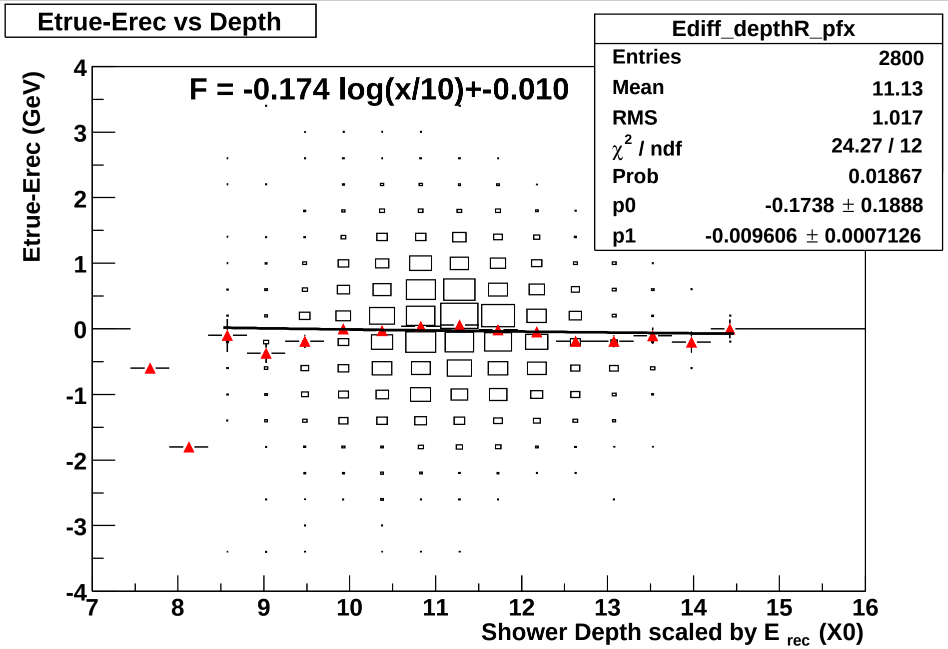
The sqrt(E0*E1) variable?



The sqrt term should help improve the resolution. But very little

Shower Depth: scaled by E_{true} vs E_{rec}

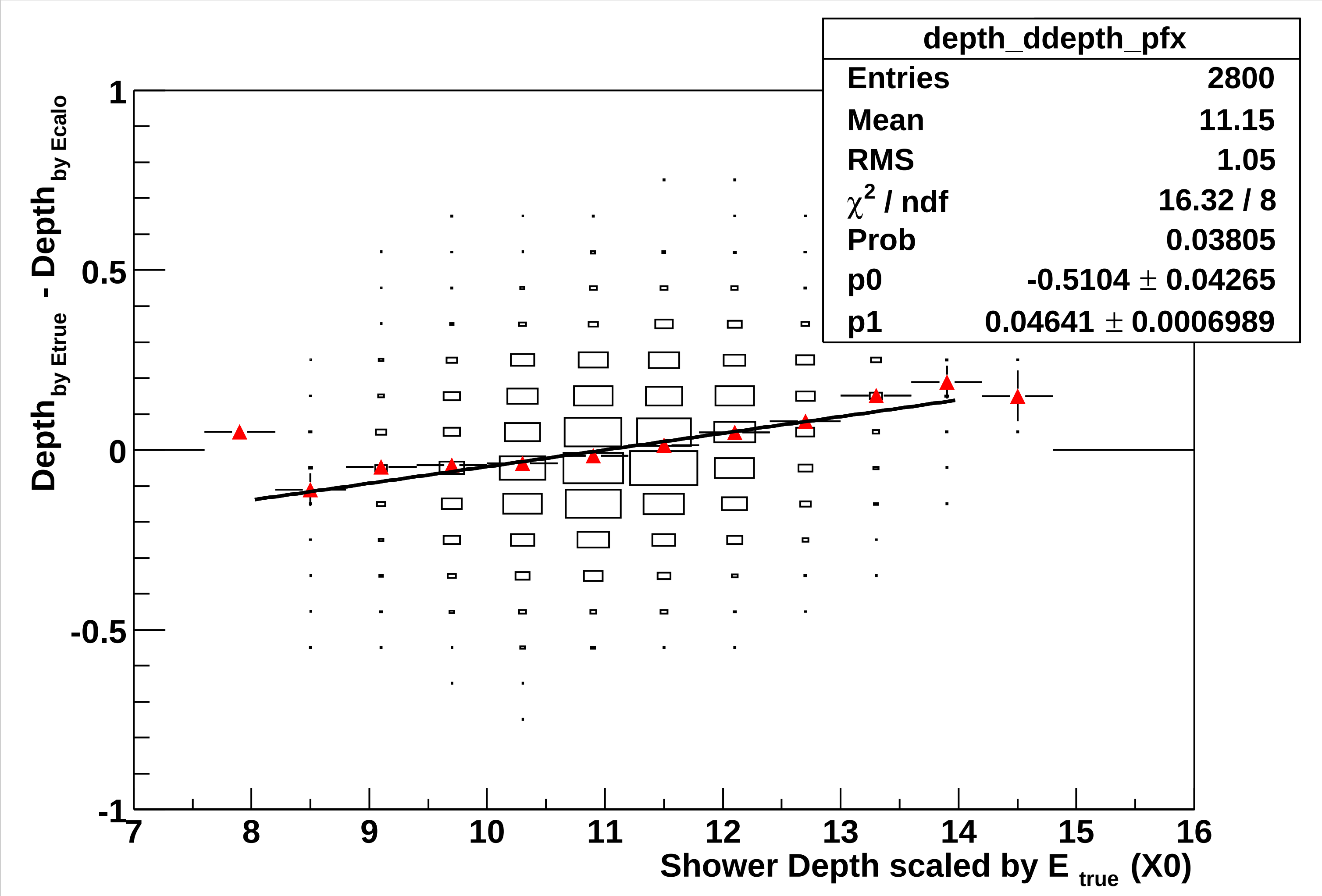




The Shower depth scaled by the measured energy is not as sensitive as the one scaled by the true energy

Why ?

Cal-Hits: Unfortunately the reconstructed depth using the CALO is BIASED!



First Conclusions:

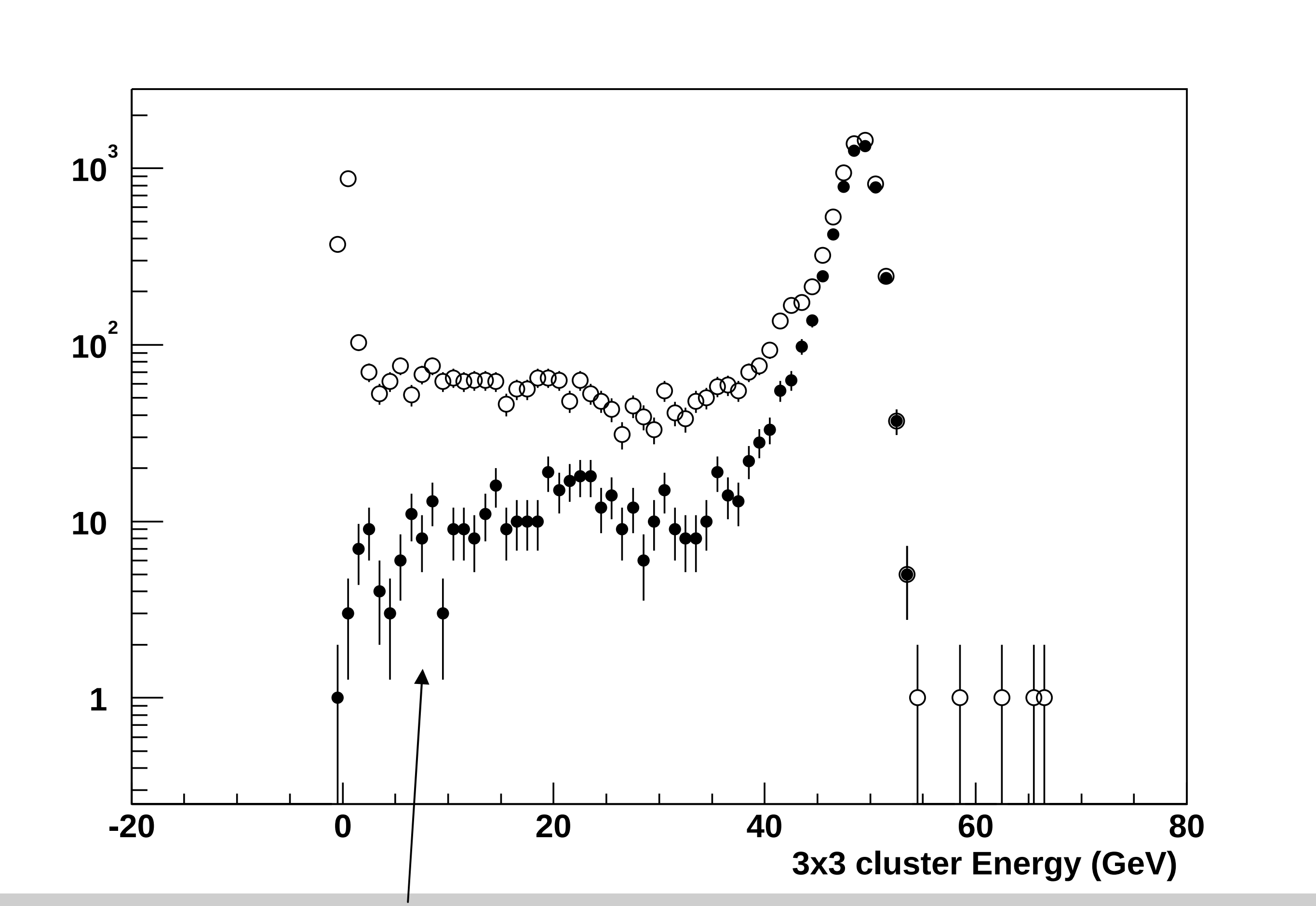
- Reconstructed Energy and Resolution depend on losses between the strips and PS.
  - Less energy reconstructed for earlier showers
  - Clearly visible when we look at "true" shower depth
  - May also be large out-of-cone dependence (didn't check)
  - So, reconstruction depends on longitudinal shower fluctuations which is a very bad feature.
- Small dependence of sampling fraction on longitudinal shower fluctuations
  - It actually goes the opposite way: SF drops with depth
- Presampler works/corrects after 3X0
  - Something already reported by T.Carli

CTB04: 50GeV e^- with $2X_0$ upstream the PS

CTB04: very Preliminary look

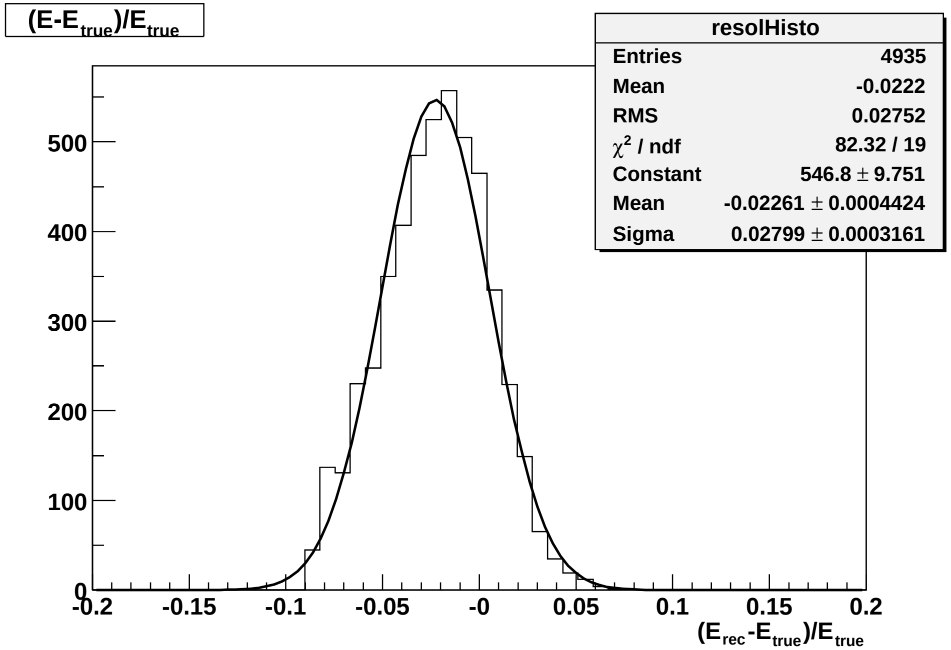
- Runs: 1001042, 1001048 (20,50 GeV electrons)
- Upstream Material:
  - Scintillators+Pixel+TRT -> (0.2+0.11+0.07)X0
  - Al Plates in front of warm vessel: 6-6.5cm
  - Total ~ 2X0 in front of warm vessel
- Pion background: removed with std strip cuts
- Reconstruction: "half-simple"
  - 3x3 EMTB clustering
- Analysis: ESD level in Athena
- Calibrations:
  - Atlas: scale*(W0*Eps + E1 + E2 + W3*E3)
  - TB02-like: scale*(W0*Eps + W3*sqrt(Eps*E1) + Eacc)
  - New including shower depth correction

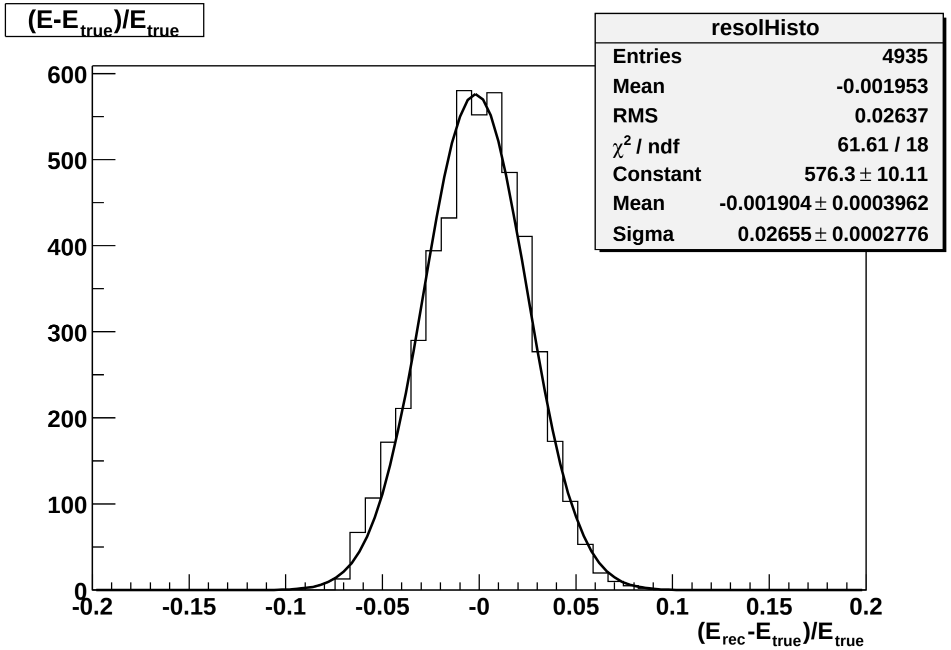
3x3 Spectrum after Prelim. Strips Shower Cuts



$$fracm = \frac{\pm 3strips}{\pm 1strips} - 1 < 0.4$$

CTB04 50GeV e⁻
Material : 6.5cm Al + Pixel + TRT

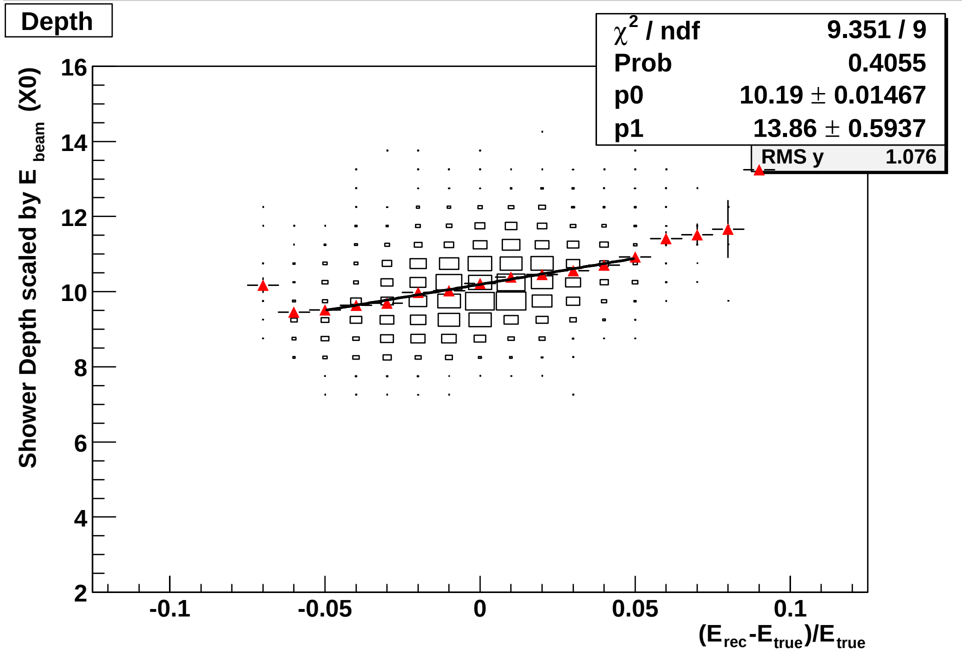


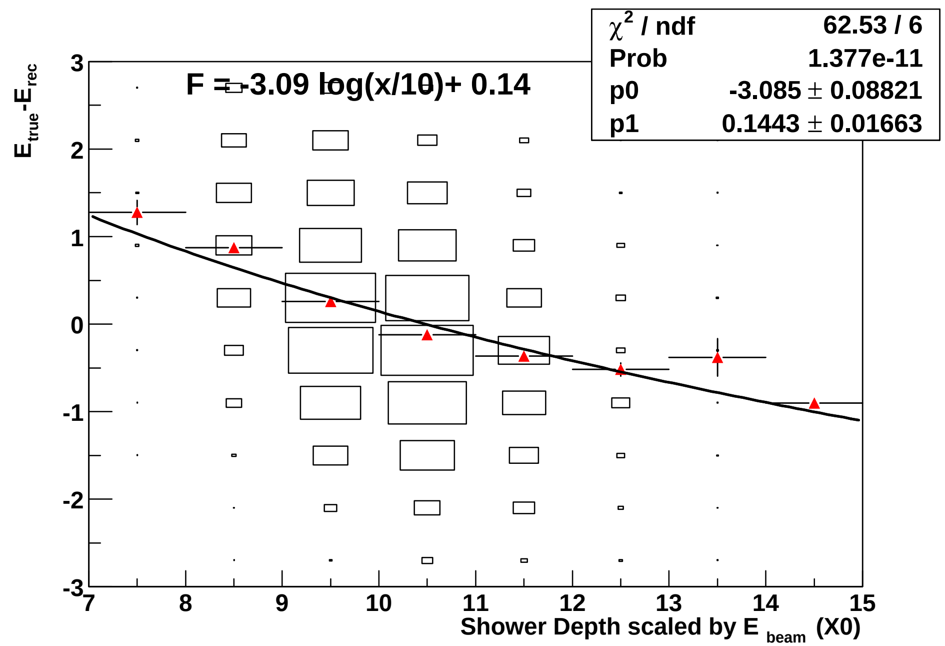


UNCALIBRATED
Erec = Eps + E1 + E2 + E3

CALIBRATED with 20, 50GeV
Erec=scale*(off + W0*Eps + E1 + E2 + E3)

CTB04: Same behaviour as in ATLAS sim





$$d_{true} = \frac{E_{PS} X_0^{PS} + E_1 X_0^1 + E_2 X_0^2}{E_{beam}}$$

Conclusions from CTB?

- Very preliminary look confirms the observation from ATLAS that resolution is lost mostly due to longitudinal shower fluctuations which lead to uncorrected deposits between the strips and the PS
- An additional effect could be out-of-cone losses to have strong shower dependence in the presence of material (not studied)
- As the CTB electronics calibration is coming along, we would like to study these issues hoping to get a correction of this effect.

Backup Plots:
attempt to study potential corrections

Can we correct using the shower depth information?

Correction Based on Shower Depth:

- Obviously we must correct the accordion scale:

$$E_{rec} = \lambda\left[offs + W_0 E_0 + \left(1 + W_2 \log\left(d / \langle d \rangle\right)\right) E_{acc}\right]$$

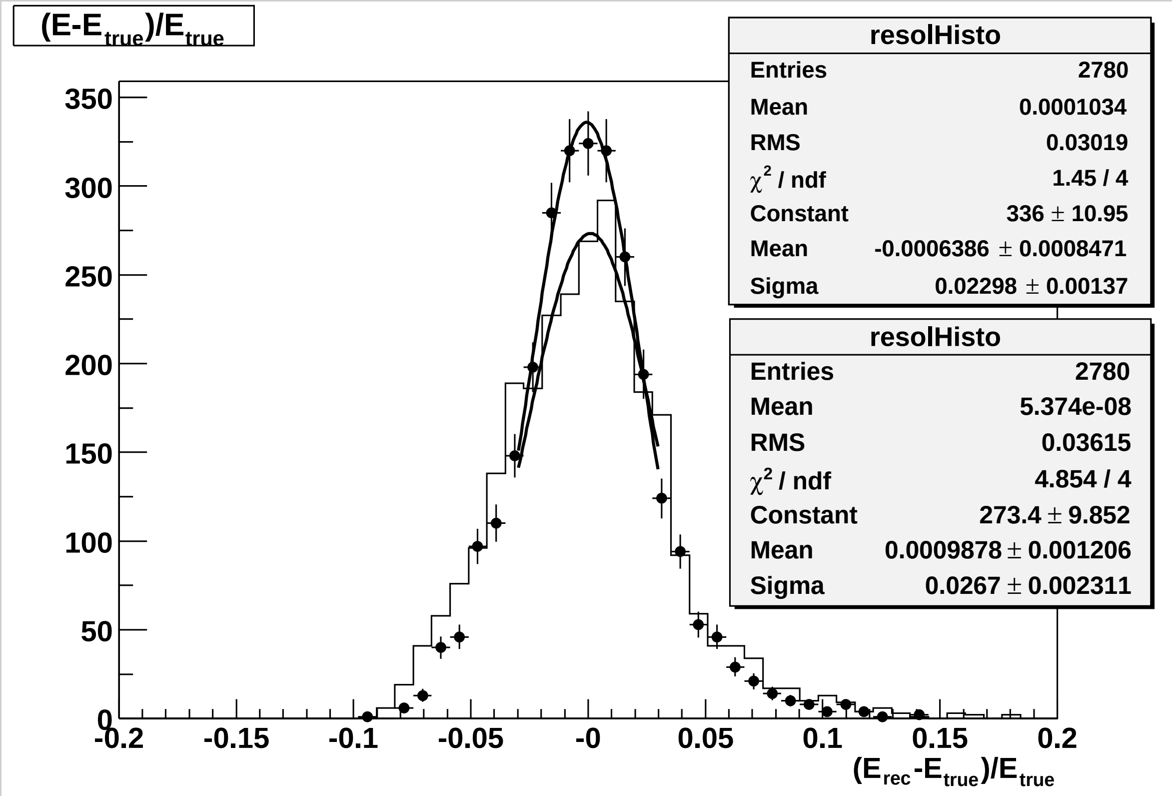
$$d = d_{meas} = \frac{E_{PS} X_0^{PS} + E_1 X_0^1 + E_2 X_0^2}{E_{meas}}$$

$$E_{meas} = E_{ID} \text{ or } E_{Calo}$$

<d> is the mean shower depth (simple parametrization)

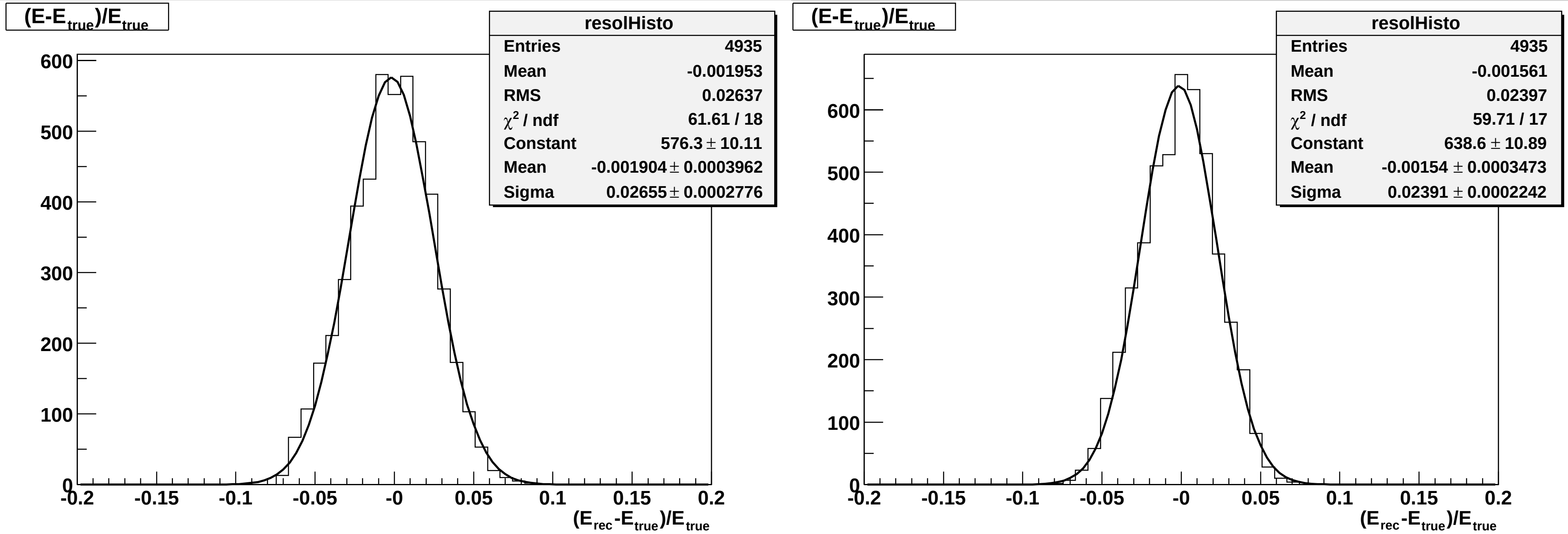
- Below we choose Emeas to be a 4% gaussianly smeared around the Etrue (or Ebeam)
- When Ecalo is used a very small improvement is seen

Correct ATLAS at η=1.3125



20,50 and 100 GeV electrons before and after correction using the “true” Shower Depth with Energy gaussianly smeared by a resolution formula which gives ~4.1% sigma at 100GeV (i.e. much worse than the Inner Detector Resolution).

CTB04: try to do the same



Clear Improvement in RMS. Can we use the data with Inner Detector to study all this?

It is clear that with our ‘best electrons’, where a high quality track is attached to a cluster, it may be possible to perform a correction at the egamma level to improve our resolution.