EM Resolution Studies

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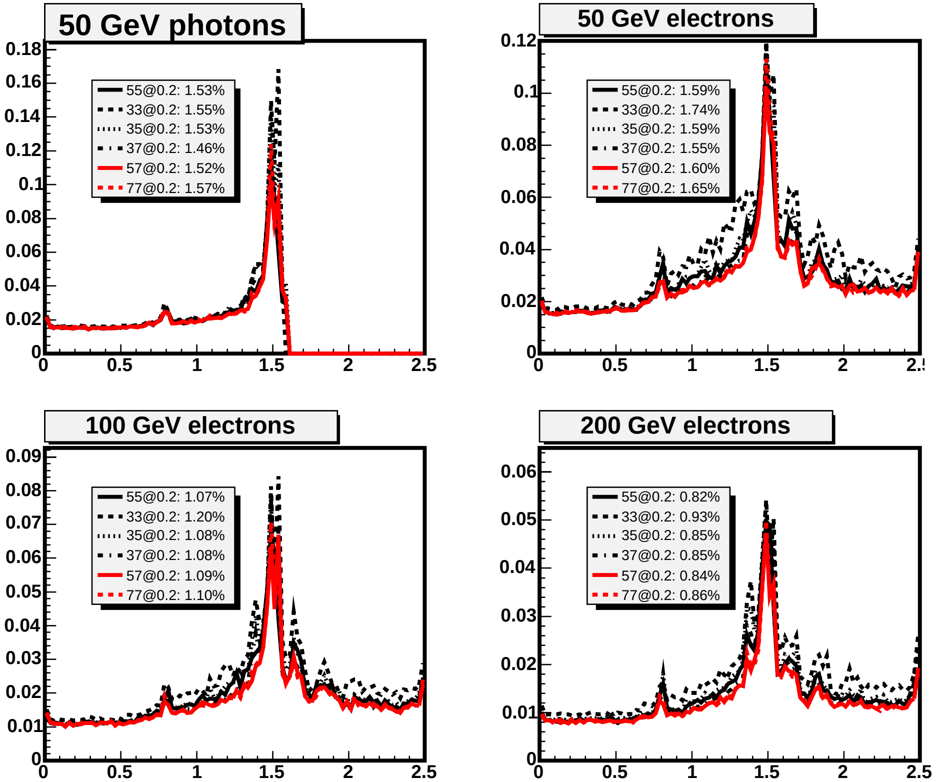
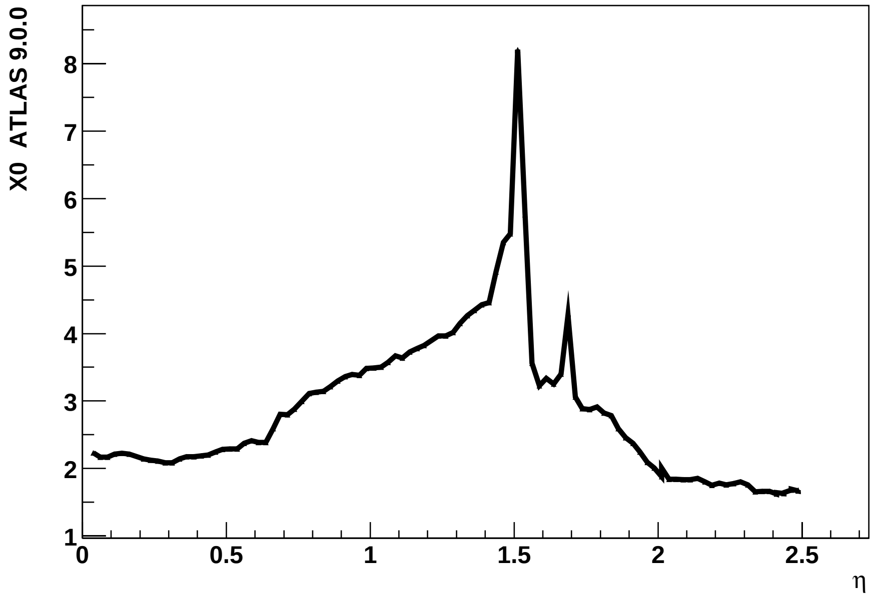
Introduction

- Continue work that started last year (Slovakia Workshop), to understand in detail the origin of loss of resolution at high eta
- Motivate/Study corrections which recover the nominal resolution (TDR/TBeams)
  - Study corrections with MC
  - Test corrections in the combined TestBeam (material scans)
- Our goal here is to identify the dominant effects and NOT to propose a correction:
  - Possible corrections will be discussed/proposed by a group of people from the LAr+egamma communities.

Resolution vs upstream material

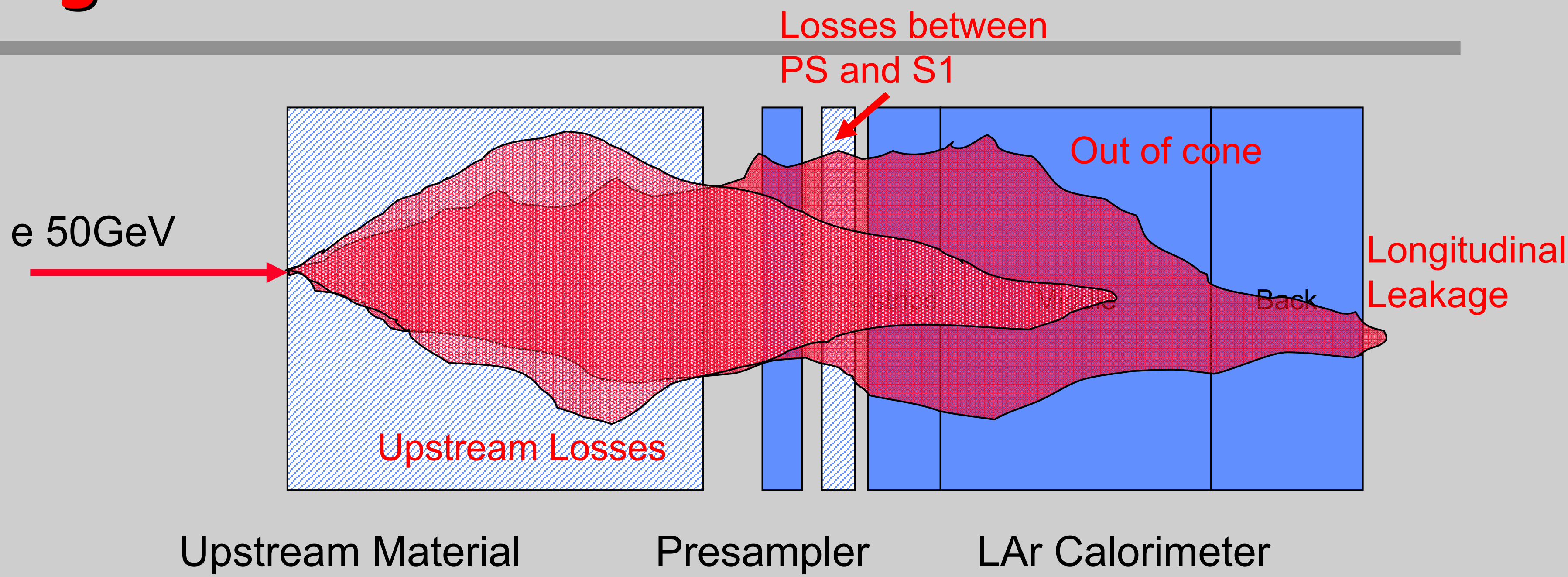




X0 map of material in front of strips (SP)

From Scott Snyder's Resolution studies
Confirmed by L.Flores and G.Unal with 10.0.1

Longitudinal Fluctuations



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

- **ATLAS Longitudinal weights calculated today using:**

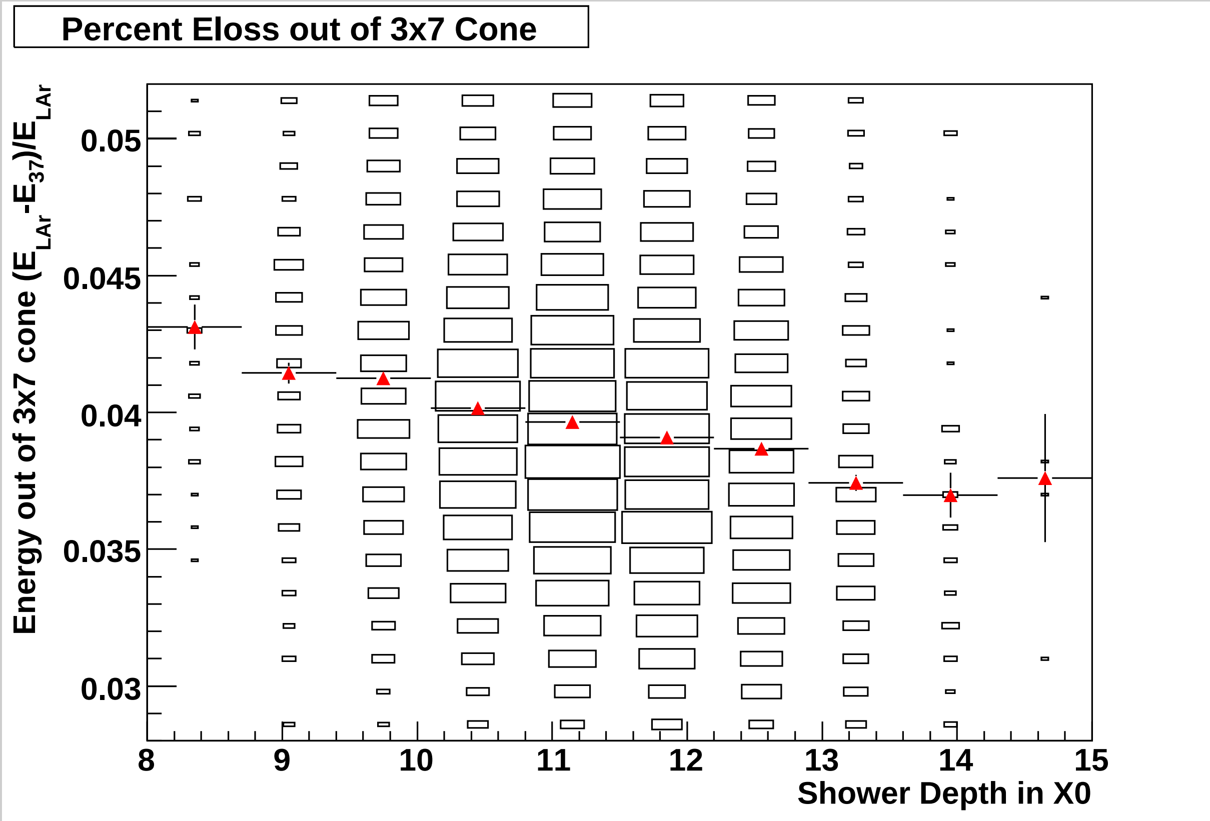
$$E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + W_3 E_3\right)$$

(b:) TDR + offset (coming from TBeam Analysis)

Simulation 10.0.2:

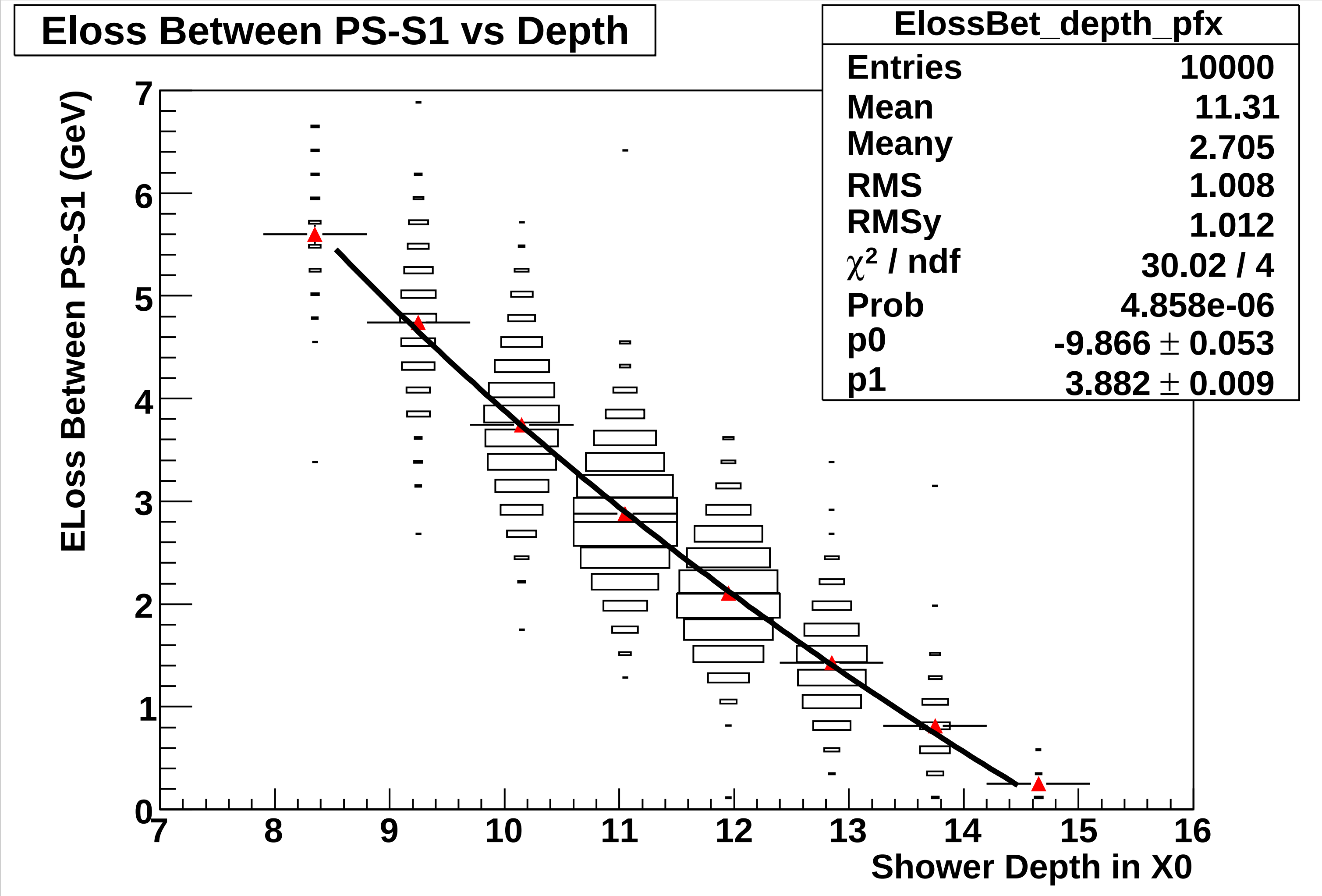
- **Full Simulation:**
  - 20, 50, 100GeV electrons, photons
  - Eta = 1.2125 (~3X0 in front of Strips)
  - Phi = Flat or Fixed
  - Use shower dE/dx information anywhere (calibration hits)
- **Calibration Hits:**
  - Energy in LAr = 'active energy'
  - Energy in Passive material (i.e. Lead) = 'inactive energy'
  - Energy in Cryostat, cables etc = 'dead energy'

Out-of-cone fluctuations depend on shower depth (50GeV electrons, eta=1.2125):

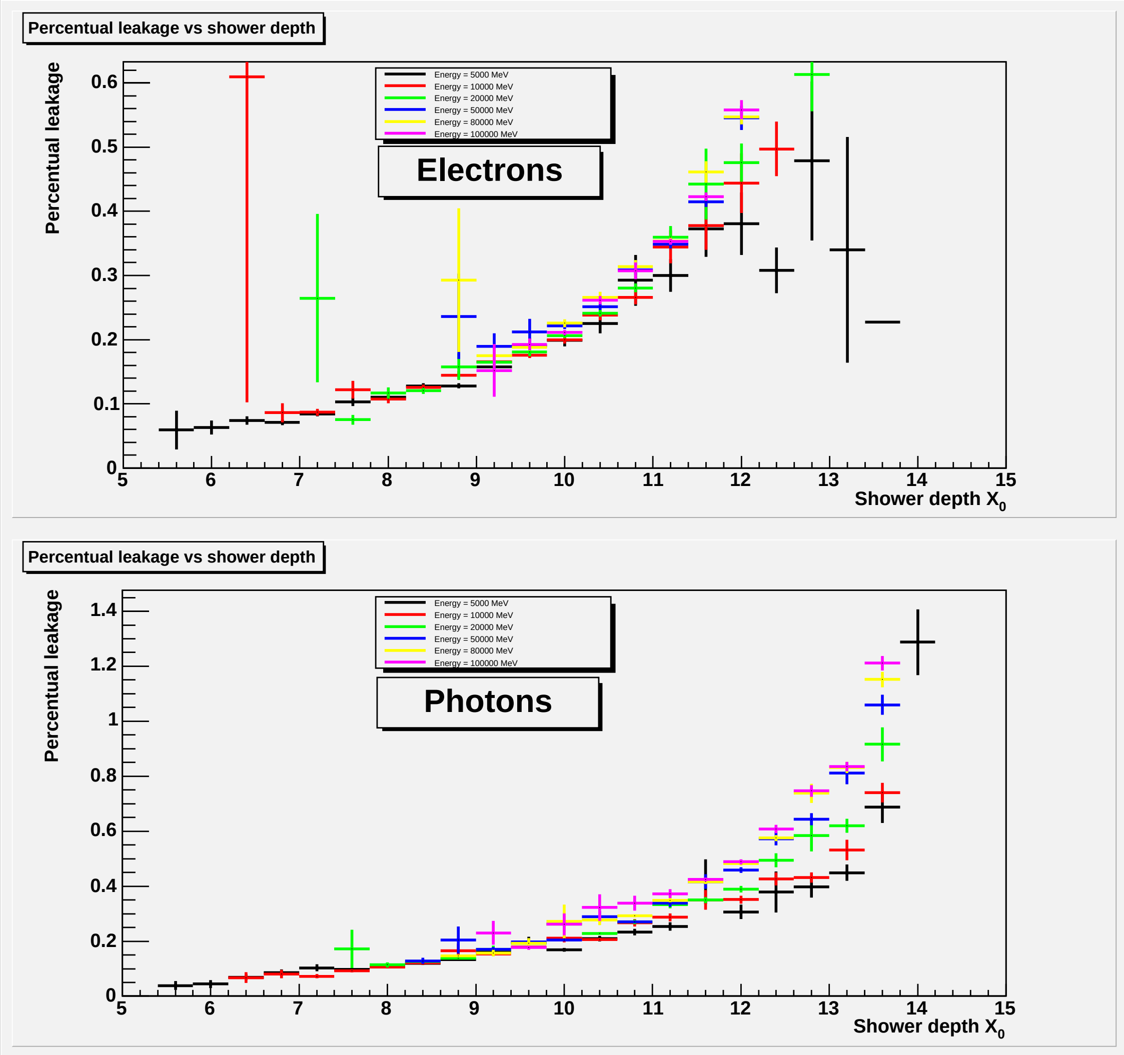


We confirm L.Carminati's findings

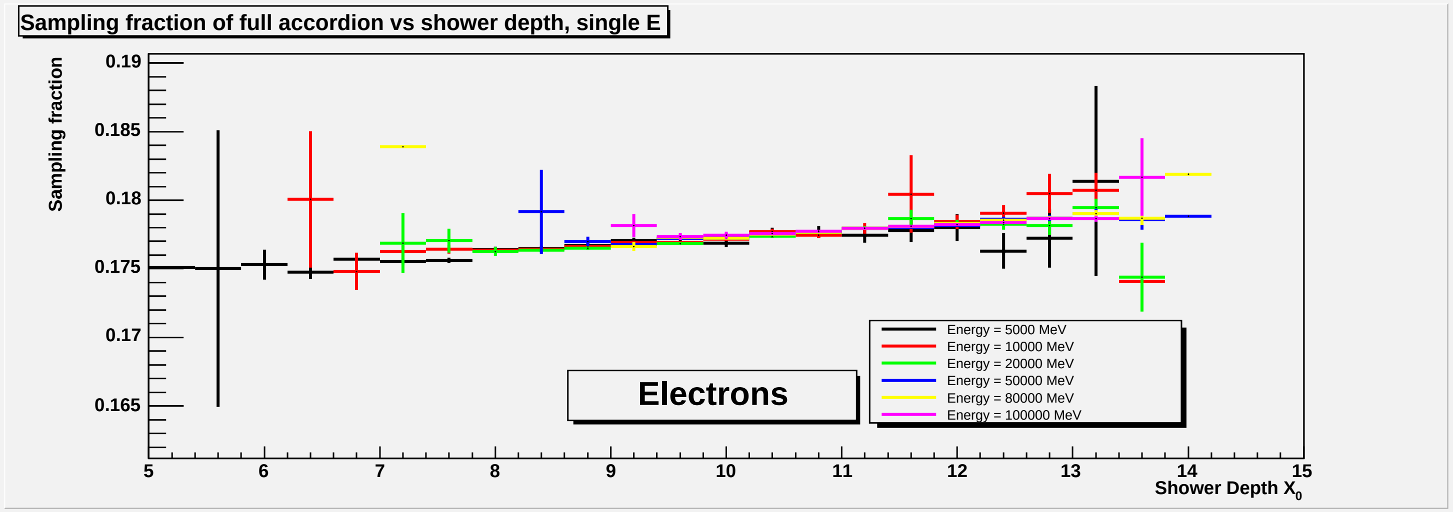
Loss between Strips and PS also depends on depth (50GeV electrons, eta=1.2125): :

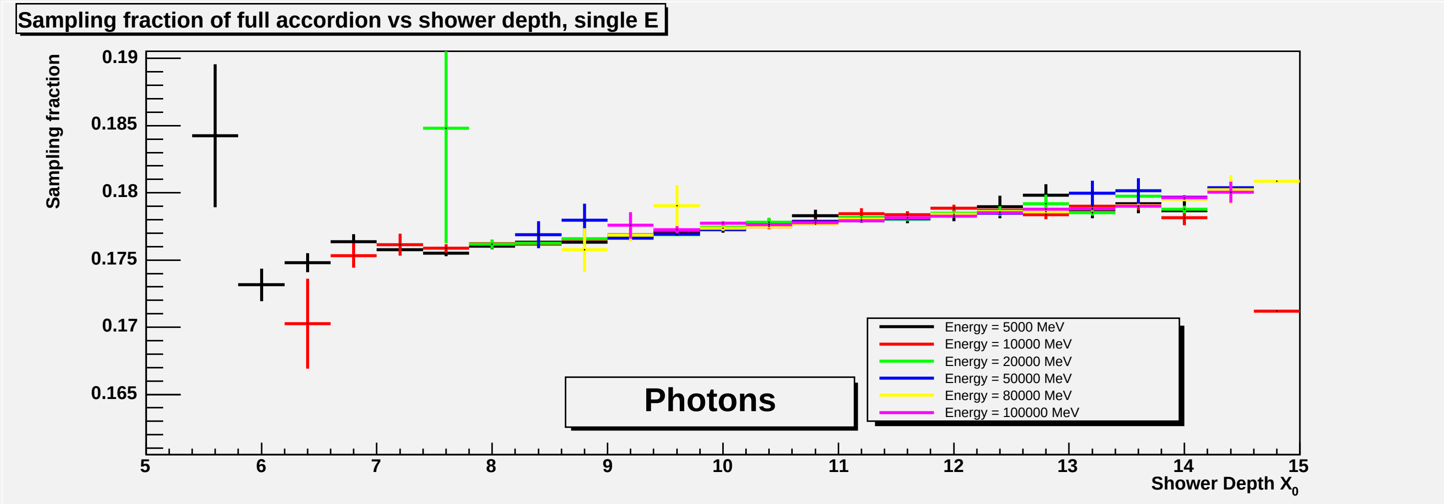


Longitudinal leakage vs depth

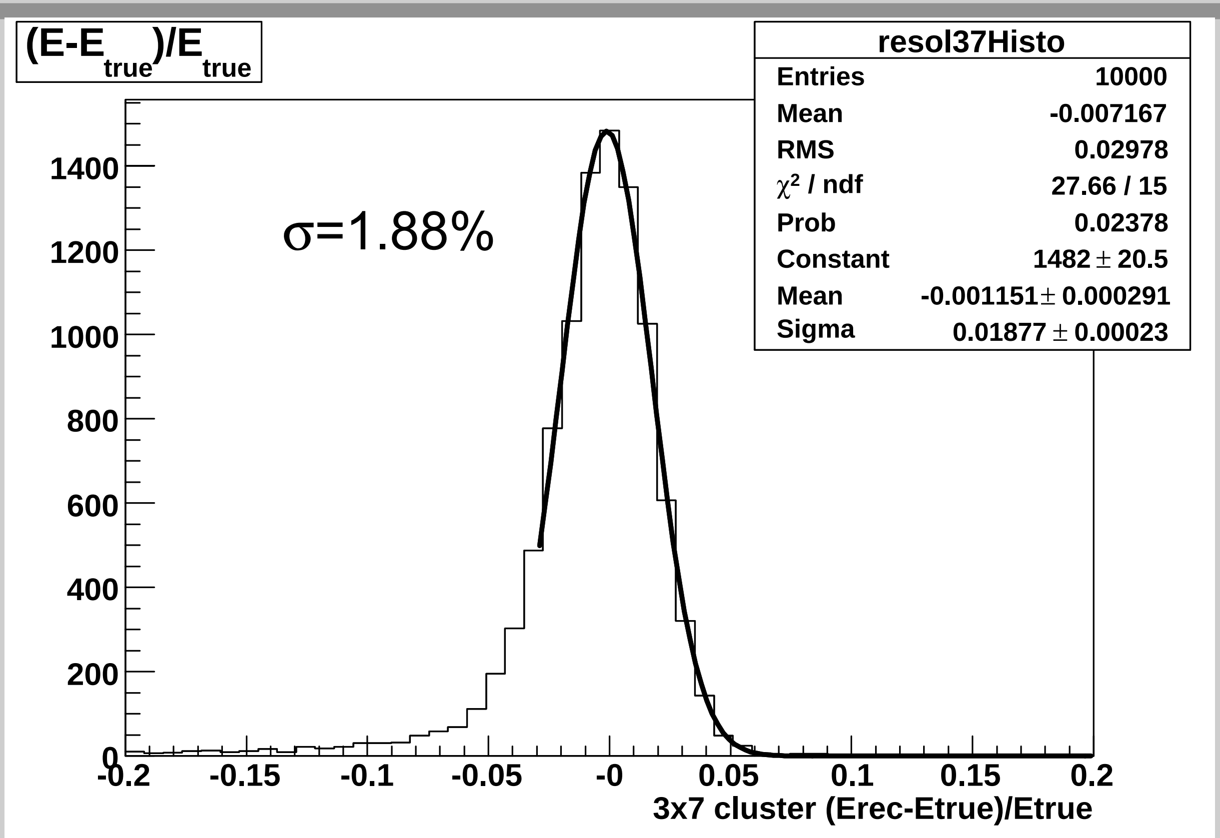


Accordion Sampling Fraction vs depth





3x7 EM Energy alas ATLAS 50GeV e



$$E_{rec} = \lambda\left(b + W_0 E_{pres} + \frac{1}{SF_{acc}}\left(E_1 + E_2 + E_3\right)\right)$$

Caution: the PS weight and offset include downstream losses

$$E_{rec} = \lambda\left(b + W_0 E_{PS} + \frac{1}{SF_{acc}}\left(E_1 + E_2 + E_3\right)\right)$$

$$W_0 = \frac{E_{loss}^{upstreamPS} + E_{loss}^{betweenPS-S1} + E_{PS}^{act} + E_{PS}^{passive}}{E_{PS}^{act}} = \frac{E_{loss}^{beforeS1}}{E_{PS}^{act}}$$

We obtain W0 and b by fitting Eps versus Eloss:
by doing that we obtain weights very similar to the ones in ATLAS

What we should be doing instead is:

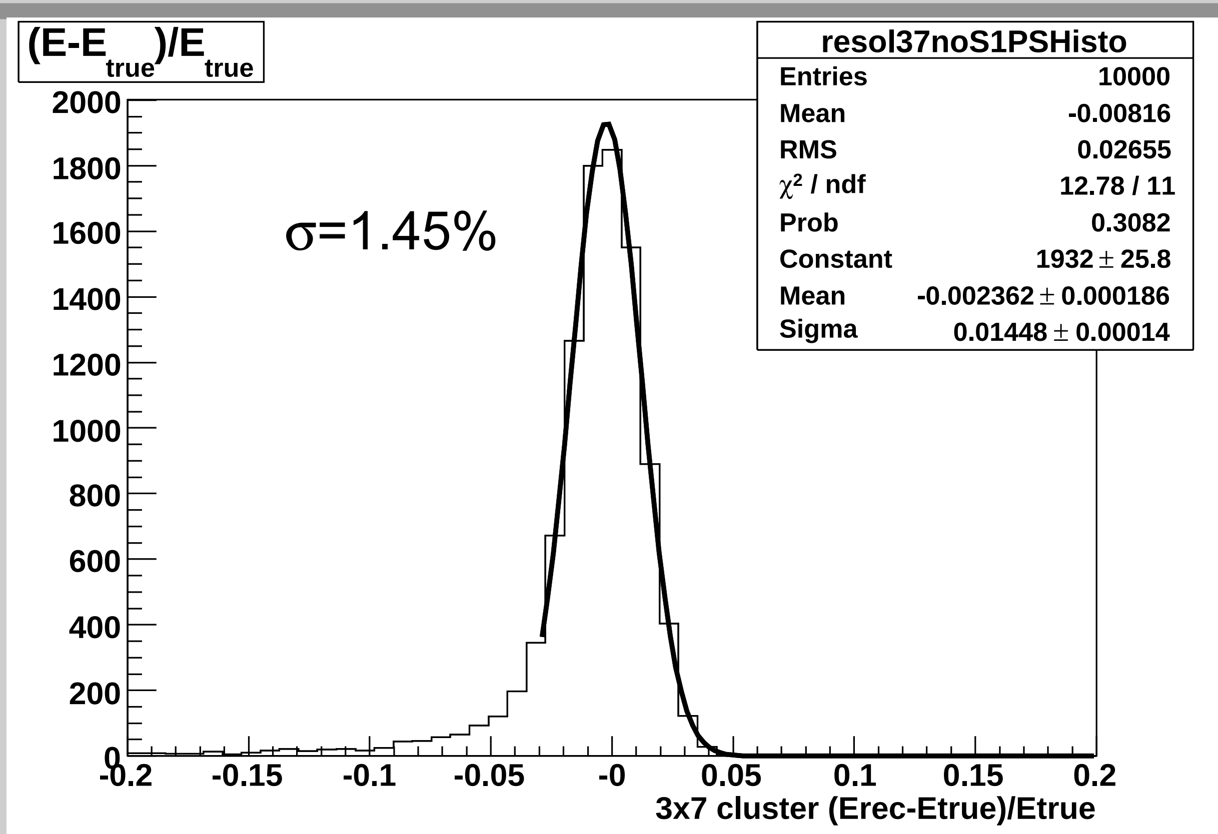
$$E_{rec} = \lambda\left(\underbrace{b + \left\langle \frac{E_{Loss}^{uptoPS}}{E_{PS}^{act}} \right\rangle E_{PS} + \left\langle \frac{E_{PS}^{act} + E_{PS}^{pas}}{E_{PS}^{act}} \right\rangle E_{PS}}_{\text{Presampler Linearity valid up to 3-4X0}} + E_{Loss}^{PS-S1} + \left\langle \frac{1}{SF_{acc}} \right\rangle (E_{acc}) \right)$$

Or even better, to correct for "out-of-cone" energy fluctuations:

$$E_{rec} = E_{outcone} + b + \left\langle \frac{E_{Loss}^{uptoPS}}{E_{PS}^{act}} \right\rangle E_{PS} + \left\langle \frac{E_{PS}^{act} + E_{PS}^{pas}}{E_{PS}^{act}} \right\rangle E_{PS} + E_{Loss}^{PS-S1} + \left\langle \frac{1}{SF_{acc}} \right\rangle (E_{acc})$$

Smaller additional corrections: Longitudinal Losses + SF correction

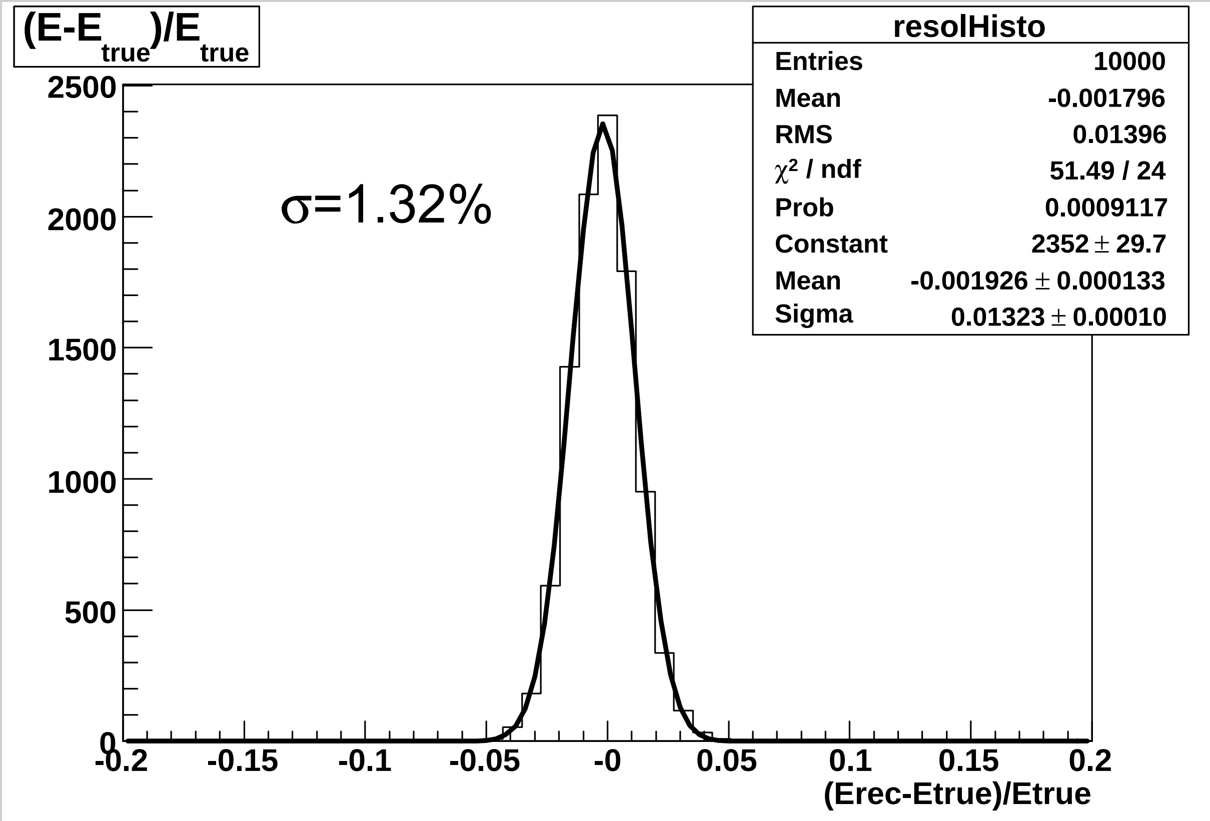
Now use the true Eloss between the S1 and PS



$$E_{rec} = \lambda\left(b + \left\langle \frac{E_{Loss}^{uptoPS}}{E_{PS}^{act}} \right\rangle E_{PS} + \left\langle \frac{E_{PS}^{act} + E_{PS}^{pas}}{E_{PS}^{act}} \right\rangle E_{PS} + E_{Loss}^{PS-S1} + \left\langle \frac{1}{SF_{acc}} \right\rangle (E_{acc}) \right)$$

True Eloss

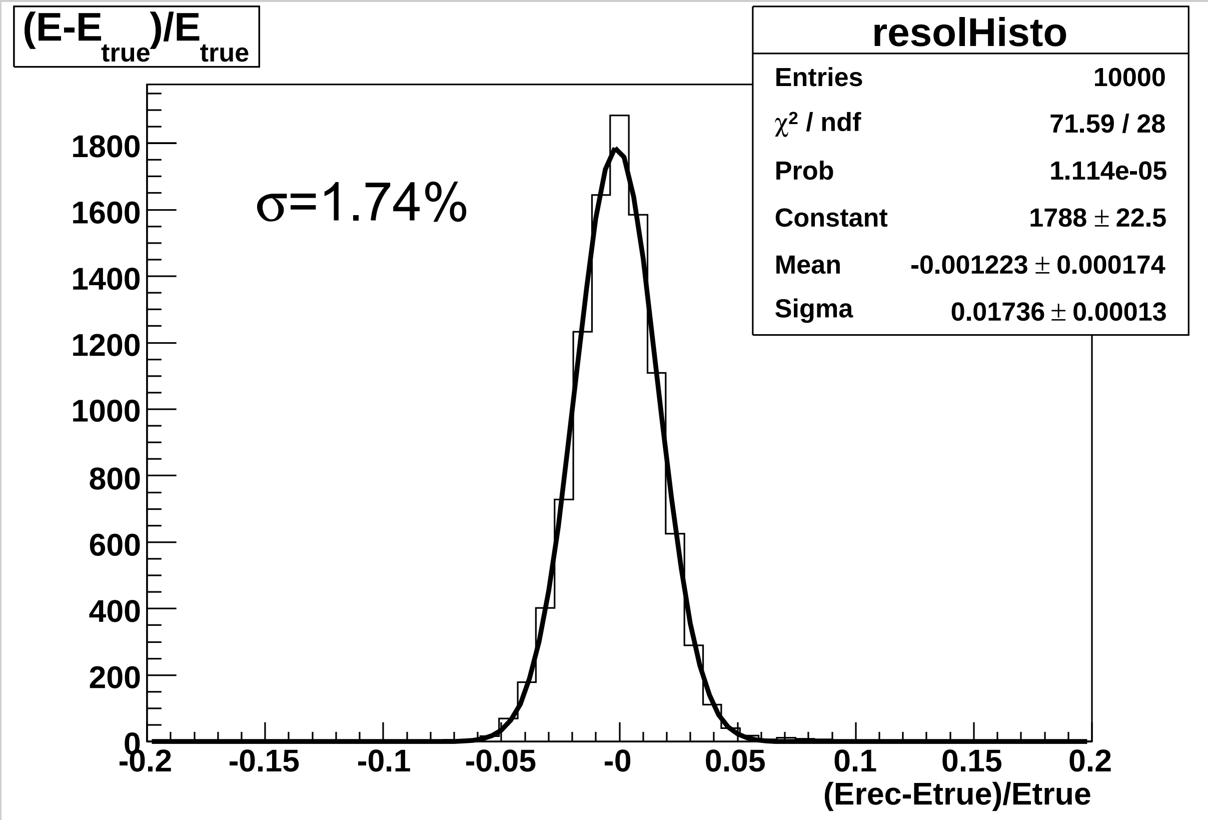
Now use all cells to remove out-of-cone effects



$$E_{rec} = b + \left\langle \frac{E_{Loss}^{uptoPS}}{E_{PS}^{act}} \right\rangle E_{PS} + \left\langle \frac{E_{PS}^{act} + E_{PS}^{pas}}{E_{PS}^{act}} \right\rangle E_{PS} + E_{Loss}^{PS-S1} + \left\langle \frac{1}{SF_{acc}} \right\rangle (E_{acc})$$

True Eloss

Now use all cells and ATLAS calibration



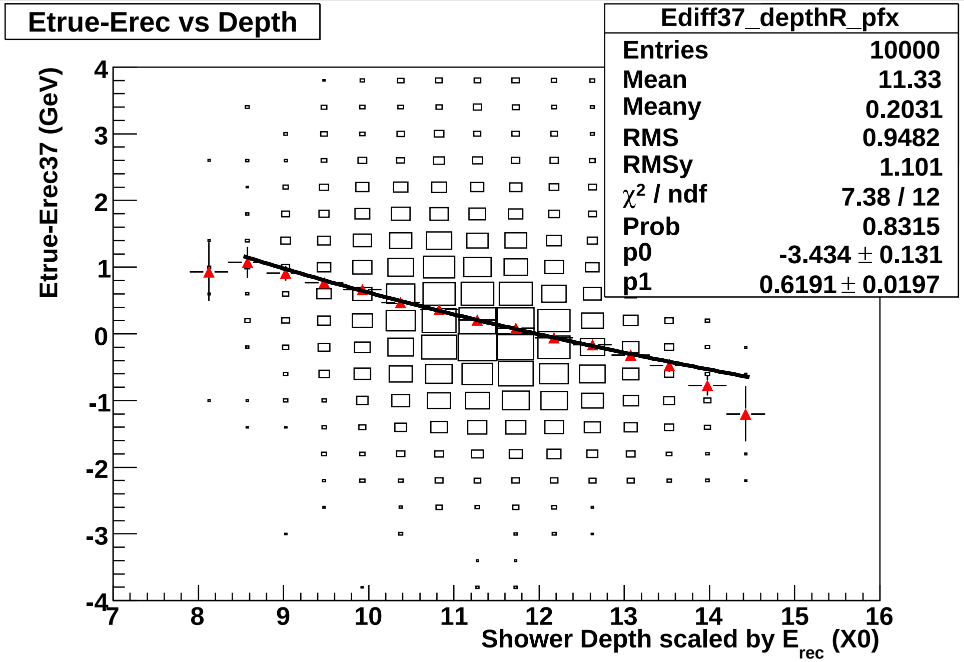
$$E_{rec} = b + W_0 E_{pres} + \frac{1}{SF_{acc}} \left(E_1 + E_2 + E_3 \right)$$

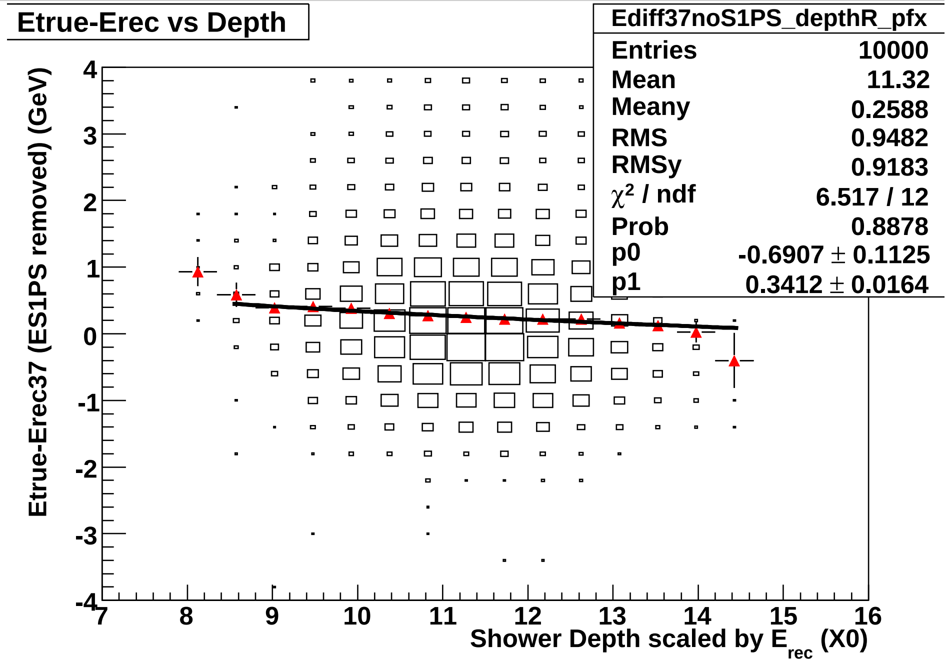
Summary of EM Resolution Loss at eta=1.2125

Electron Energy	20GeV	50GeV
3x7 EM Resolution	2.88%	1.88%
3x7 EM Resolution no losses between PS and S1	2.23%	1.45%
Approx. Optimum EM Resolution (*)	2.12%	1.32% → ~9.5%/sqrt(E)
Loss due to Eloss between S1 and PS	-23%	-23%
Loss due to out-of-cone fluctuations	-5%	-9%

(*) Only dE/dx, i.e. no noise, no pile-up, no charge effects etc.

Resolution vs Depth for 3x7 clusters
(50GeV electrons, eta=1.2125)

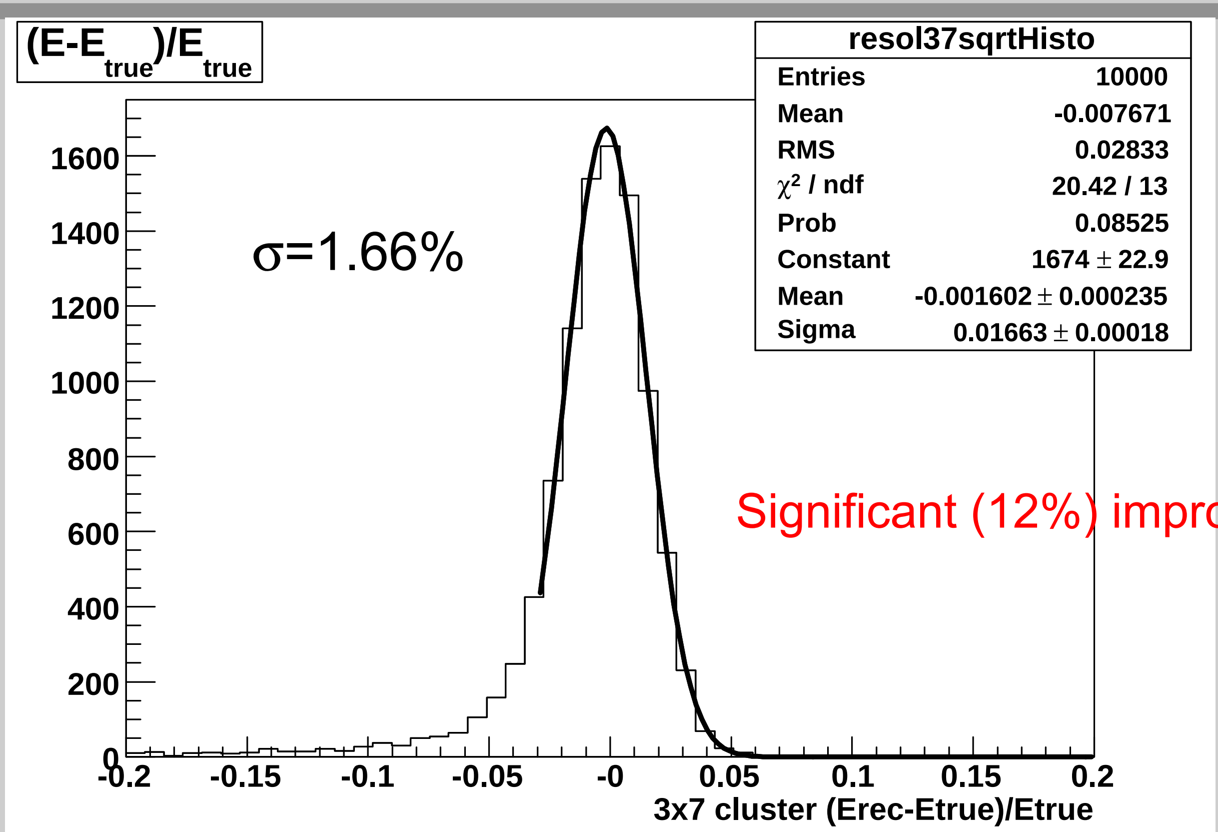




Strong correlation between resolution and shower depth when we reconstruct using the present ATLAS parametrization

Weak correlation between resolution and shower depth when we remove the effects of Elosses between Strips and PS

Eloss between S1-PS from TestBeam sqrt parametrization (T.Carli)

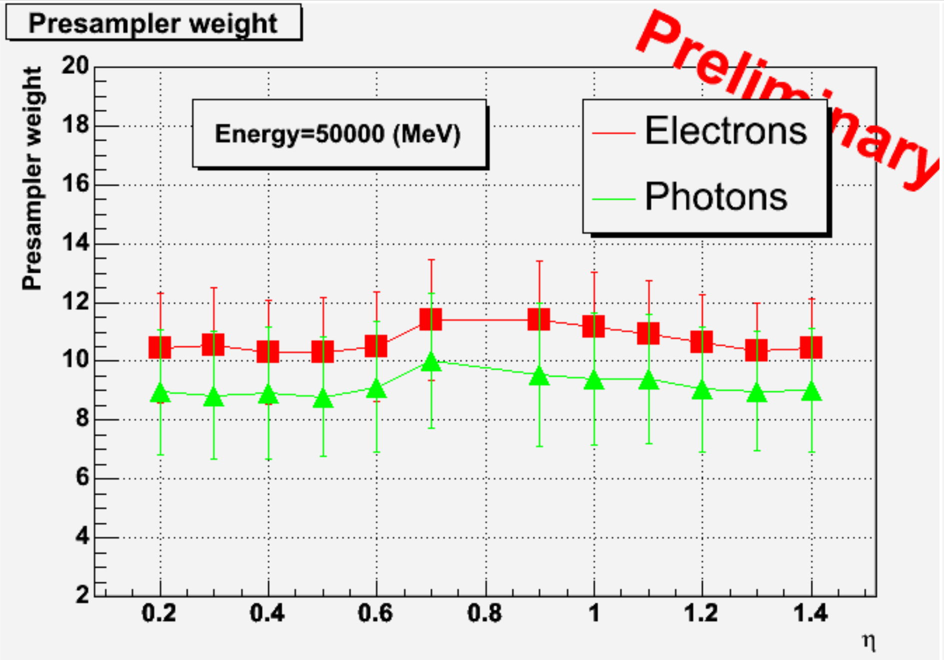


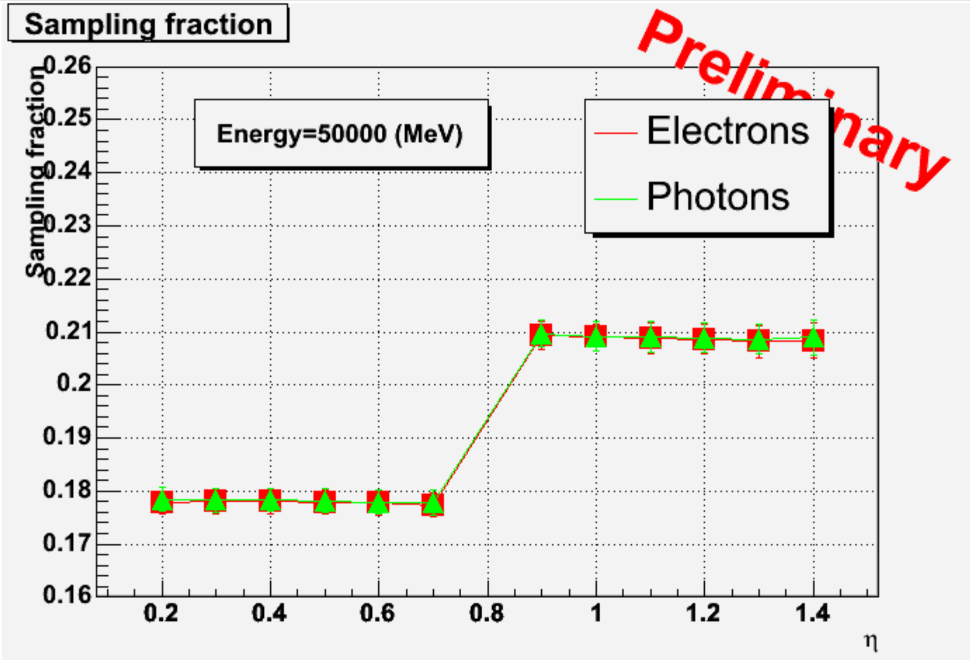
Significant (12%) improvement!

$$E_{rec} = \lambda\left(b + \left\langle \frac{E_{Loss}^{uptoPS}}{E_{PS}^{act}} \right\rangle E_{PS} + \left\langle \frac{E_{PS}^{act} + E_{PS}^{pas}}{E_{PS}^{act}} \right\rangle E_{PS} + E_{Loss}^{PS-S1} + \left\langle \frac{1}{SF_{acc}} \right\rangle (E_{acc})\right)$$

Eloss from TBeam parametrization $c + W_s \frac{\sqrt{E_{PS} E_{S1}}}{E_{acc}}$

Photons (L.Carminati @Slovakia)





Presampler Weight W0 is 10% less for photons.
The accordion SF is the same for electrons and photons.

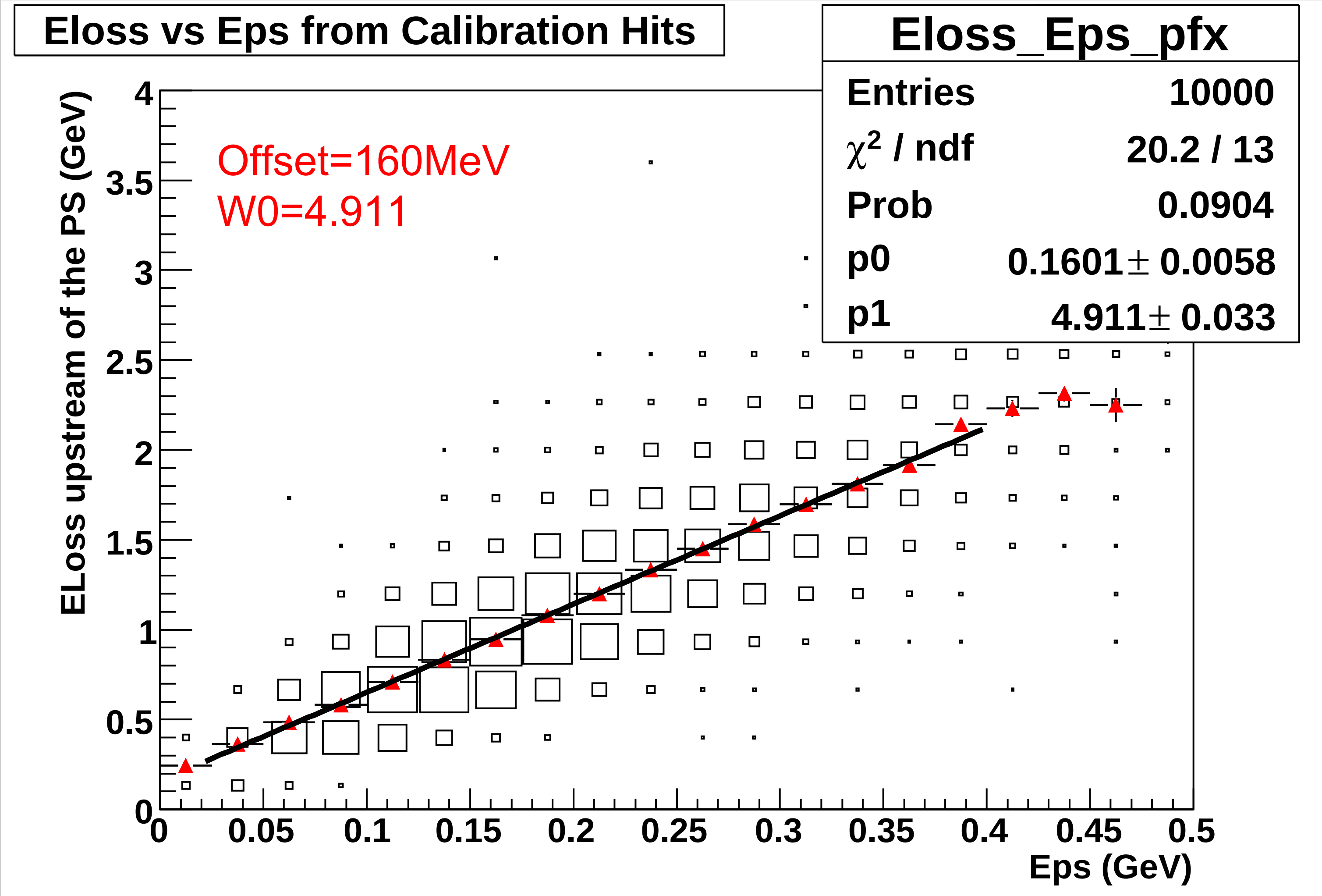
This explains why the photons in ATLAS today are overcorrected by about ~1% (we use electron calibration).

Summary

- EM energy resolution deteriorates at high eta due to the presence of upstream material which significantly increases fluctuations of energy losses.
- At eta=1.2 we found for electrons
  - ~23% resolution loss due to fluct. of Eloss between PS-S1
  - ~9% resolution loss due to fluct. of Eloss out-of-cone
- Fluctuations correlate with (a definition of) the shower depth.
- Test-beam material scans very important for testing potential corrections.

Supporting Viewgraphs

Presampler Linearity at eta=1.2125



Sqrt correction from TBeam 02