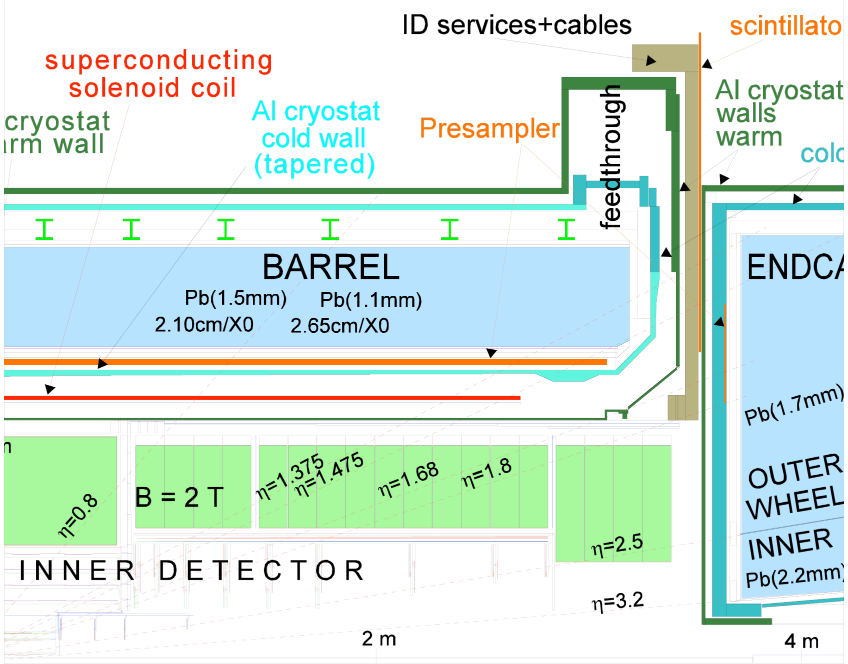
A quick look at electrons in ATLAS and testbeam (from calibration to performance)

Nicolas & Stathes

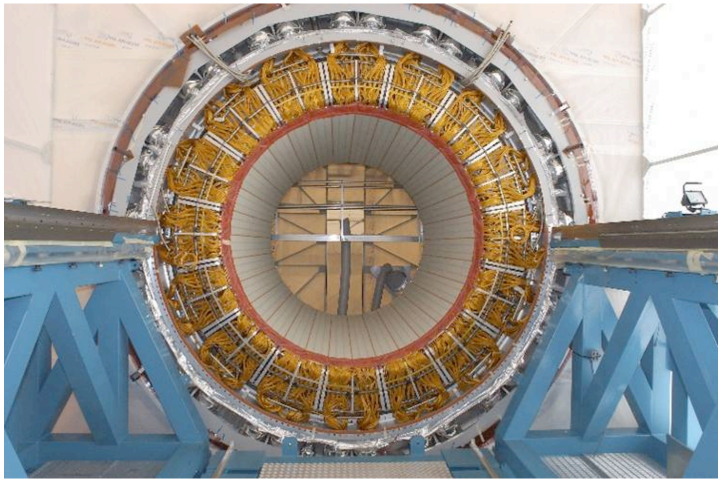
OUTLOOK:

- The electromagnetic calorimeter in ATLAS
- The calibration method in ATLAS using MC simulation
- ATLAS performance on electron reconstruction
- The combined testbeam of 2004
- Electron performance on the combined testbeam
- Ideas for in-situ calibration of the ATLAS calorimeter derived from testbeam experience and backed-up by testbeam data

The EM calorimeter

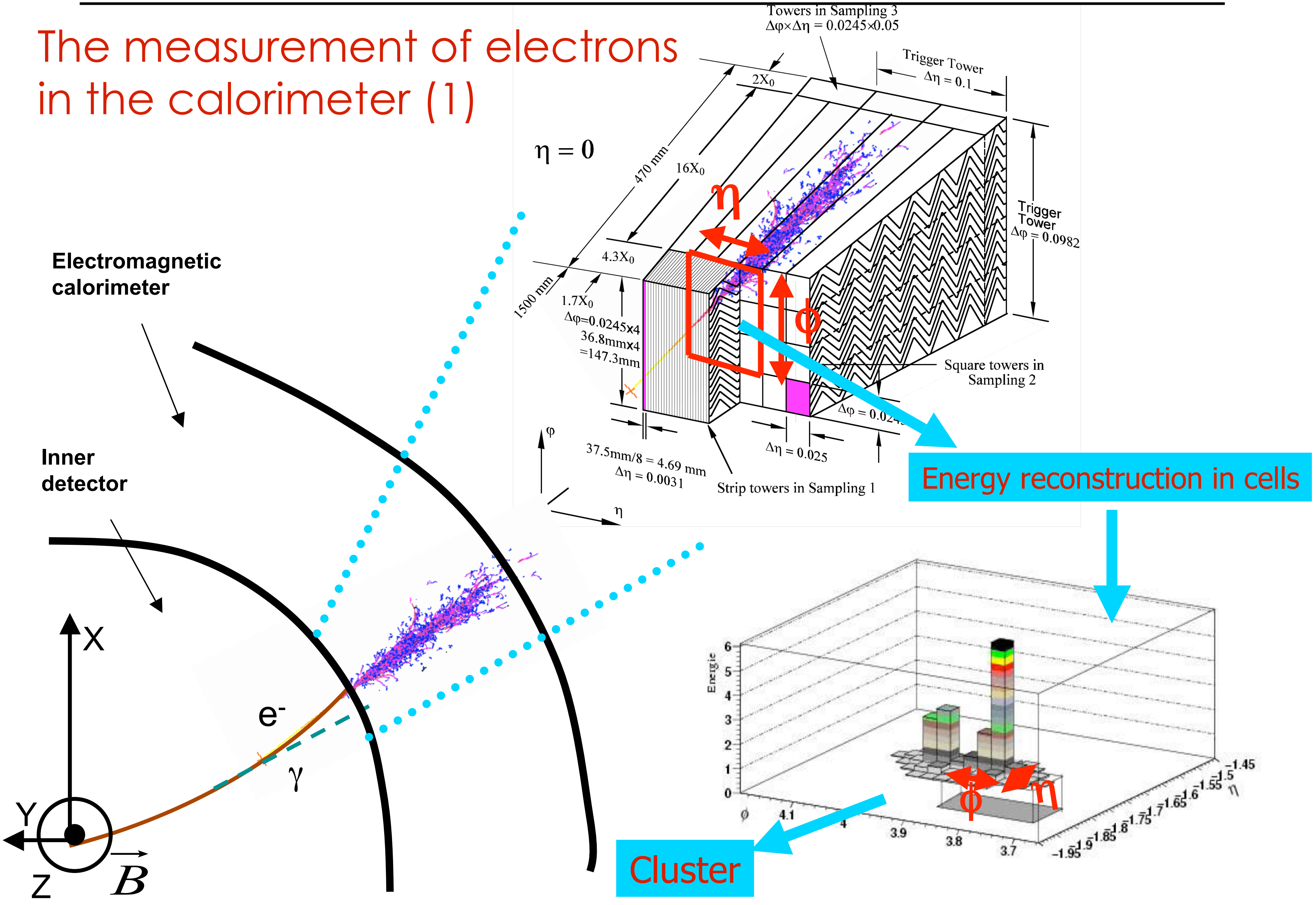


- **Geometry**
  - The EM calorimeter has two end-caps and a barrel part, each divided into modules.
  - Each one of these modules has three compartments in depth.
  - In front of the calorimeter, there is a presampler (for $\eta<1.8$), whose purpose is going to be explained later.



  - The calorimeter is a sampling fraction calorimeter composed of lead plates interspersed with liquid argon gaps. The calorimeter (with exception of the presampler) has an accordeon shape

The measurement of electrons in the calorimeter (1)



Energy reconstruction in cells

Cluster

Reconstruction of electrons in the calorimeter (2) -->clustering algorithm

- We suppose that the cells are already fully calibrated to the EM scale.

- The standard cluster used for electron reconstruction is:
  - a 3x7 in the barrel (corresponding to 3 middle cells in η and 7 middle cells in ϕ, projected over all layers)
  - a 5x5 in the end-cap (5 middle cells in η and 5 middle cells in ϕ)

- The showers are found by moving a 5x5 window in the EM calorimeter, summing the energy of all cells in that window and looking for a maximum. When a maximum is found, the other cluster sizes are built around the center of the initial window.

- The energy of the cluster in the different layers need to be added together to get the total cluster energy.

- But this energy needs calibration… we will see that weights can be applied to the layer energies.

Reconstruction of electrons in the calorimeter (3) --> calibration

- The aim of the calibration is obviously to reconstruct the initial energy of the electron. The response of the calorimeter needs to be the same, wherever the electrons hit. The detector needs to be uniform in position and linear in energy.

- Unfortunately many effects contribute to make the detector non-linear and non-uniform:
  - The dead material in front of the calorimeter
  - The dead material between the presampler and the first compartment
  - The geometry of the detector
  - The energy lost out of the cluster or the leakage out of the back compartment
  - The high voltage fluctuations
  - Temperature

- Using the layer weights we can use the MC and a specific paramterisation of the total energy of the cluster to calibrate the calorimeter.

Reconstruction of electrons in the calorimeter (4)
--> Longitudinal weights

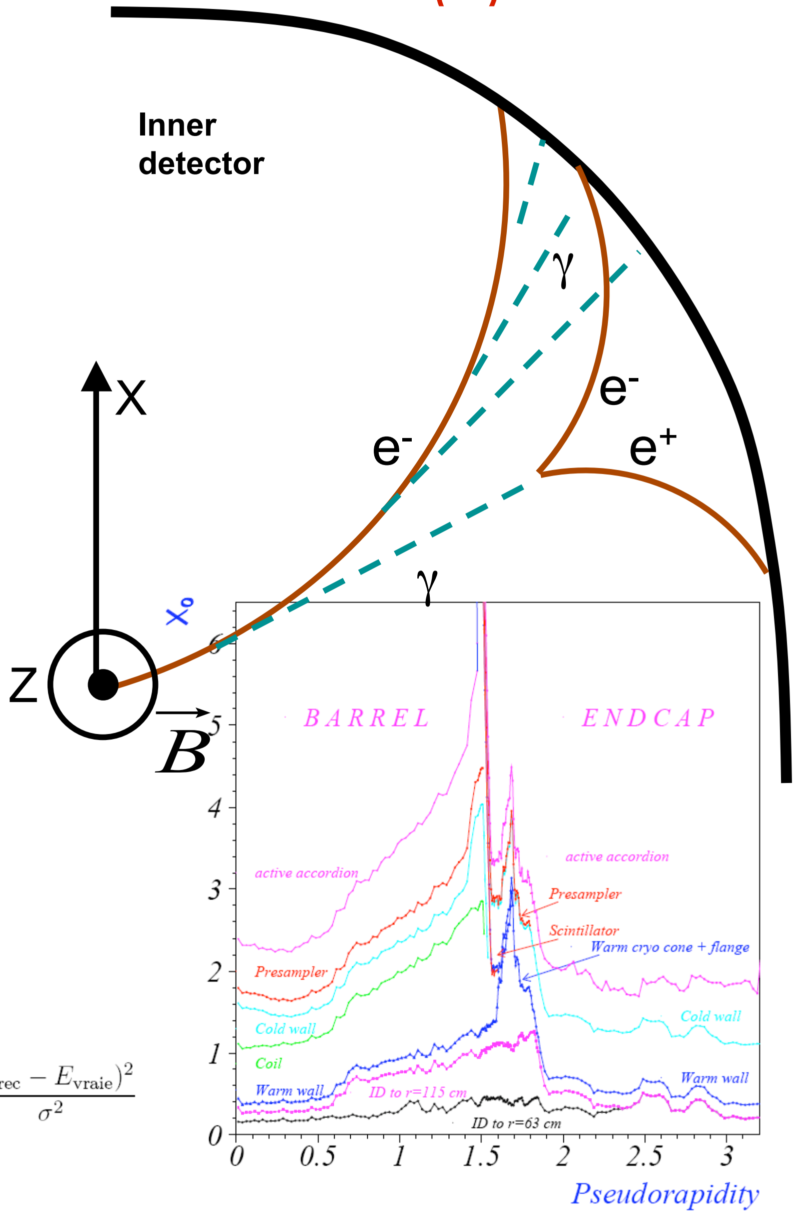
- The standard energy parametrisation used in ATLAS is

$$E_{rec} = \gamma\left(a + bE_{pres} + E_1 + E_2 + eE_3\right)$$

  - The γ parameter is used to compensate for energy lost outside of the cluster.
  - The energy lost in the dead material is recovered by $E_{pres}^{corr} = a + bE_{pres}$

    a : loss by ionisation of the electron going throught the dead material

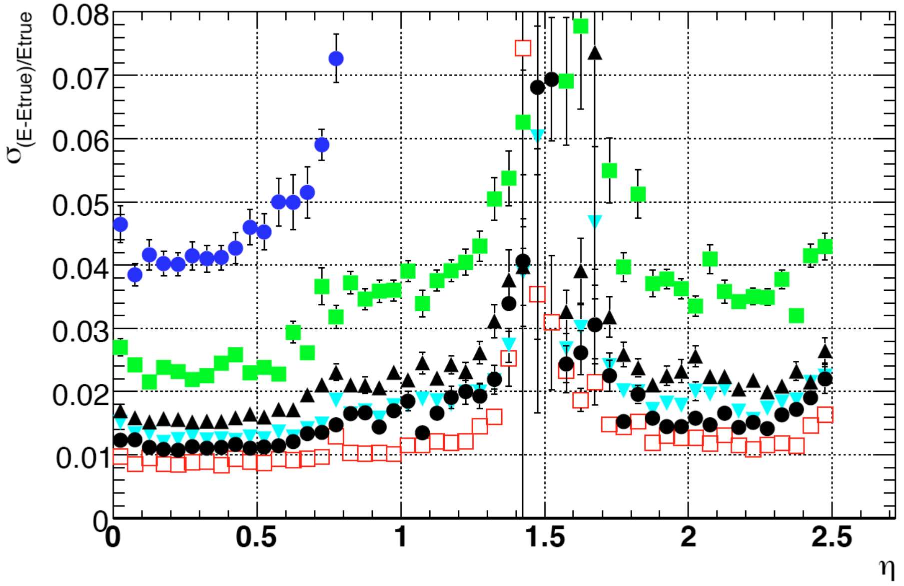
    b : energy loss due to secondary particles
  - Energy leakage: $E_3^{corr} = eE_3$



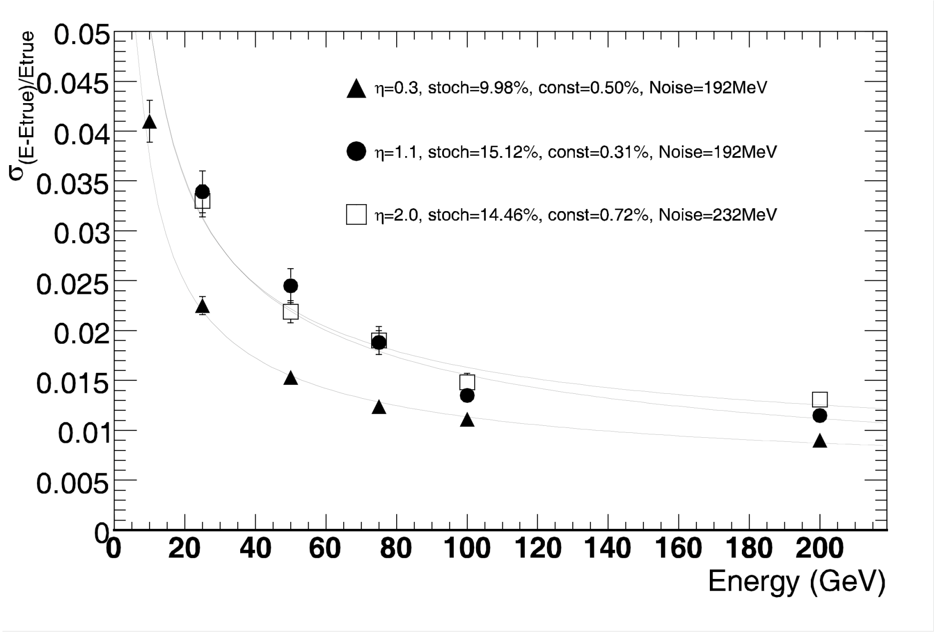
The weights are extracted by minimizing $\chi^2 = \sum_{evts} \frac{(E_{\rm rec} - E_{\rm vraie})^2}{\sigma^2}$
On all energies for each bin of 0.025 in η

Performance of electron reconstruction in ATLAS

- Energy resolution versus η for different electron energies

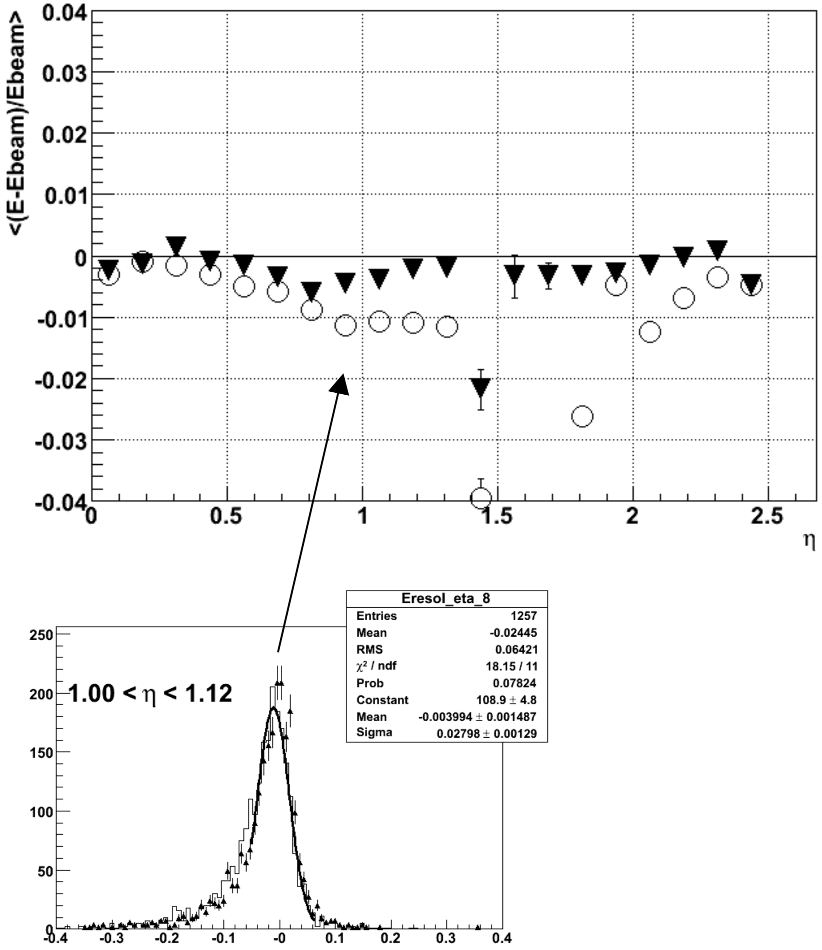


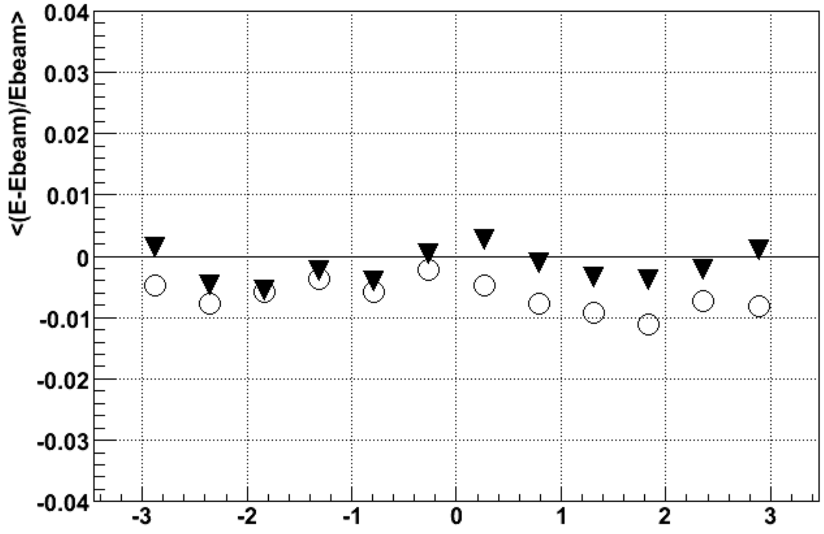
- Energy resolution versus energy for 3 η bins

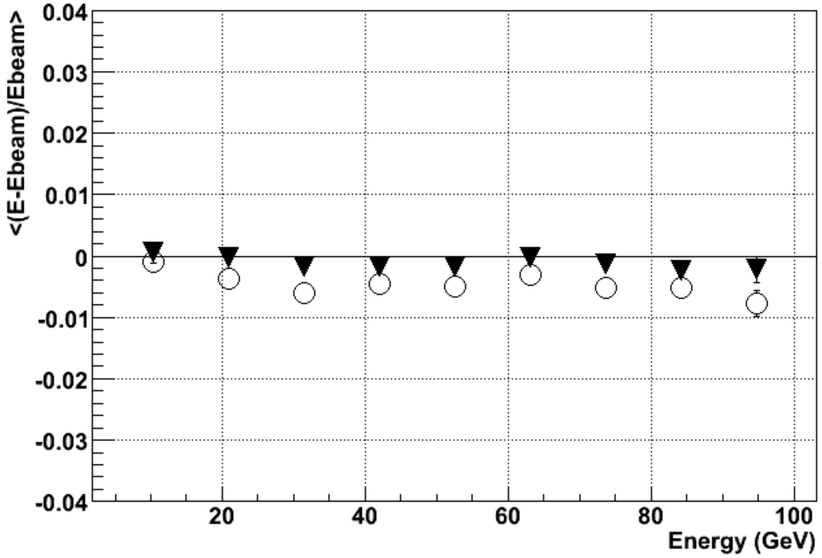


Performance of electron reconstruction in ATLAS (2)

Electron Uniformity/Linearity in H->4e events





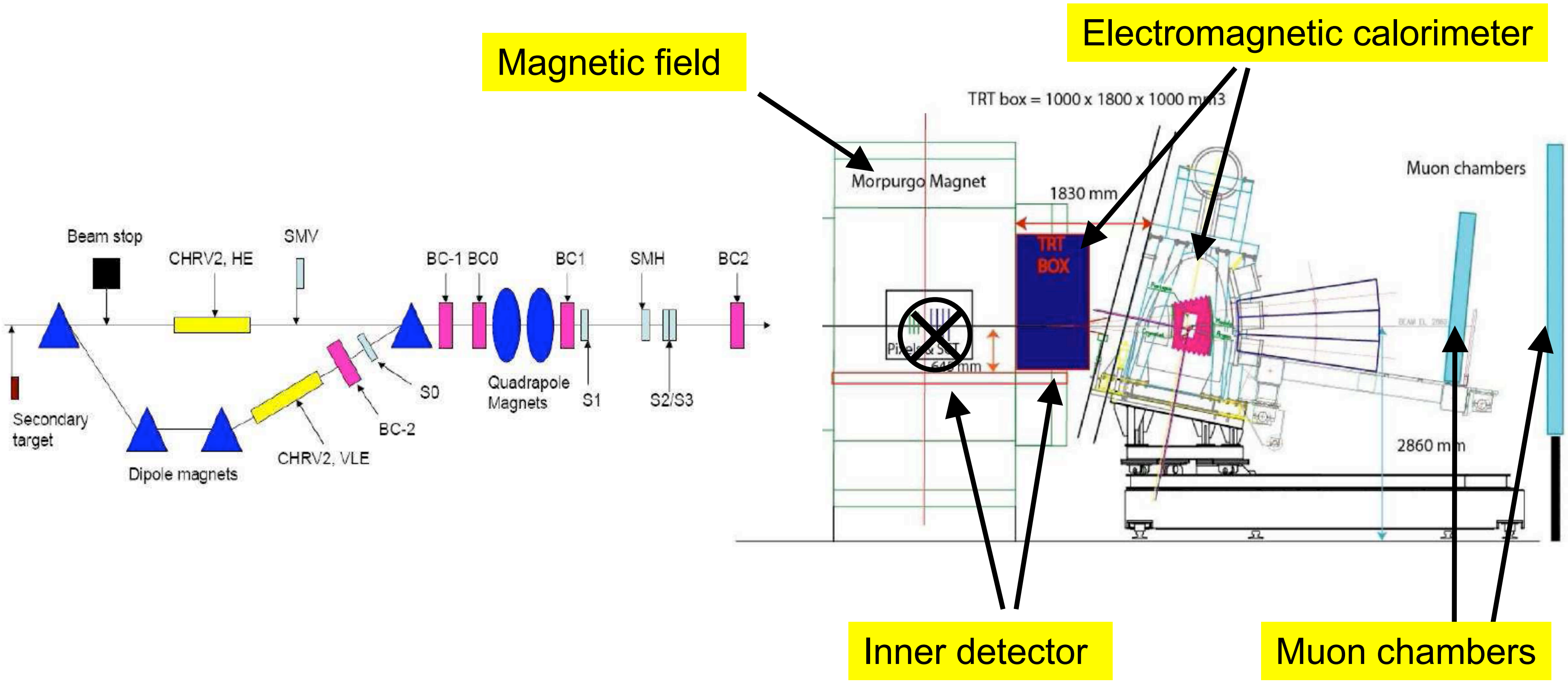


Ideal CSC-01-00-00 H→4l sample

Misaligned CSC-01-02-00 H→4l sample

The combined testbeam of 2004

- Aim: Verifying the performance observed in ATLAS for the electron linearity for different dead material configuration.



Magnetic field

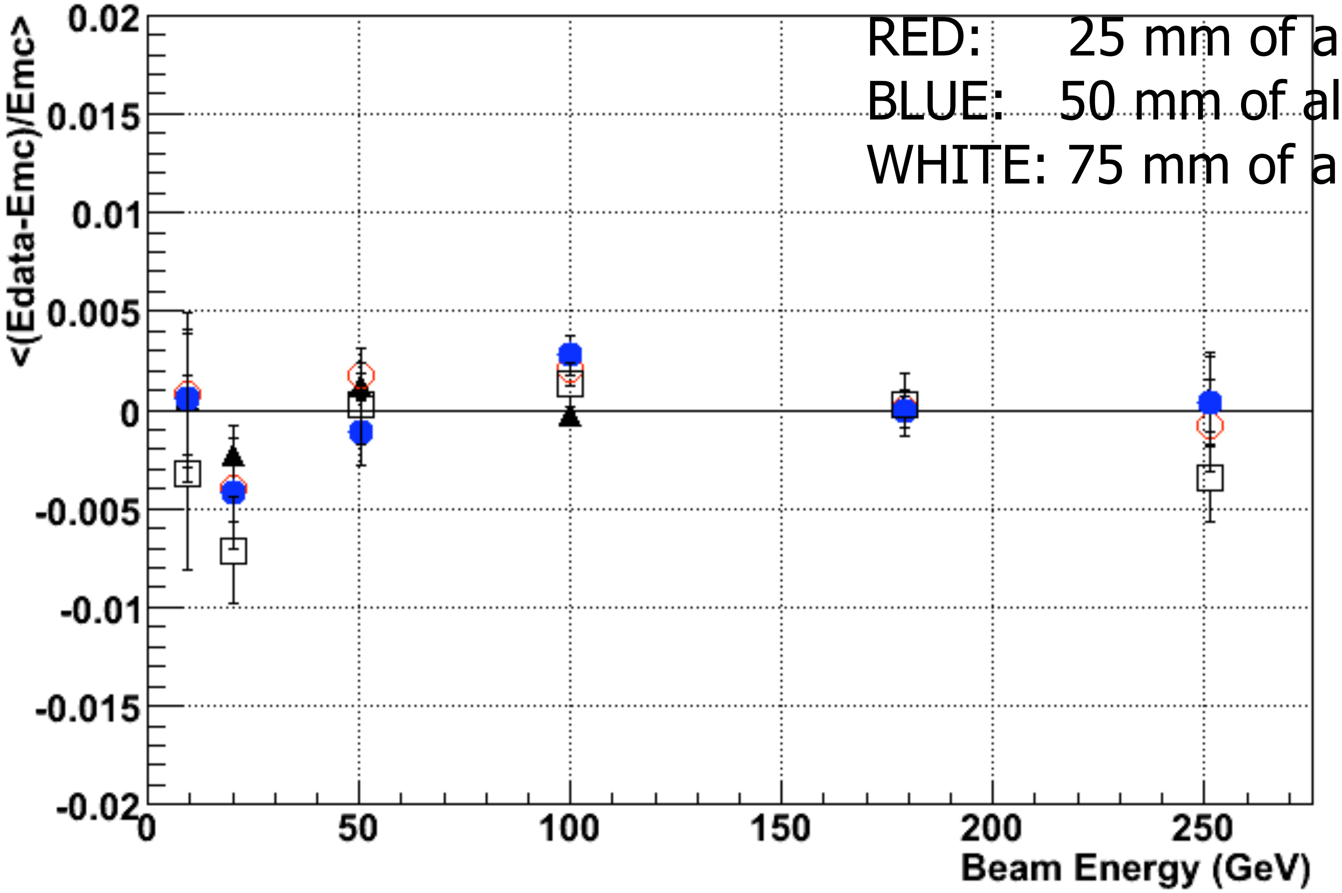
Electromagnetic calorimeter

Inner detector

Muon chambers

MC/DATA comparison for different materials and energies

BLACK: no material
RED: 25 mm of aluminium
BLUE: 50 mm of aluminium
WHITE: 75 mm of aluminium



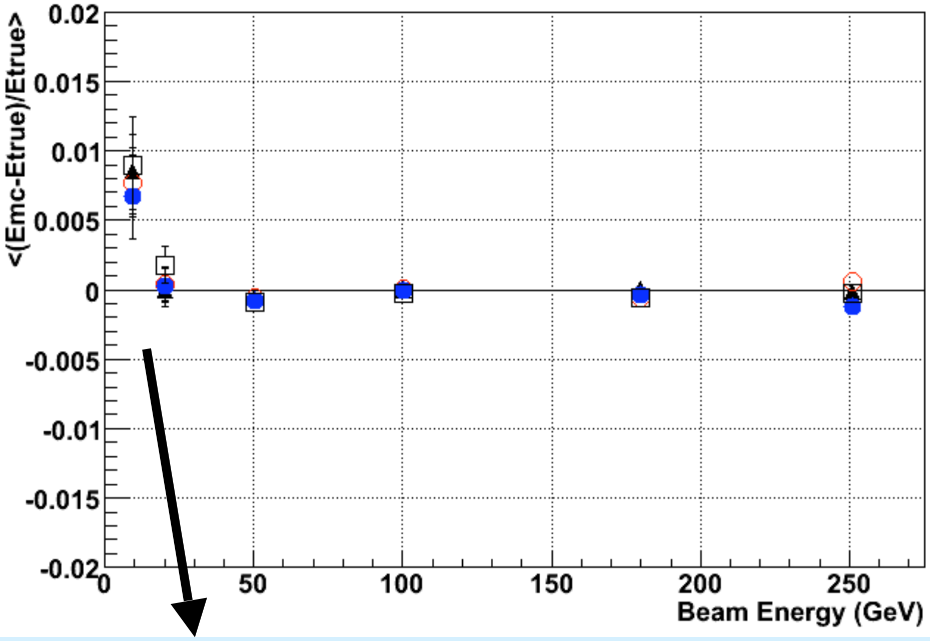
Overall agreement better than 0.5 % (for ‘no material’ runs even 0.2 %)

Layer weights calculation

- This is done « à la ATLAS » as explained before. $E_{rec} = \gamma \left(a + bE_{pres} + E_1 + E_2 + eE_3 \right)$

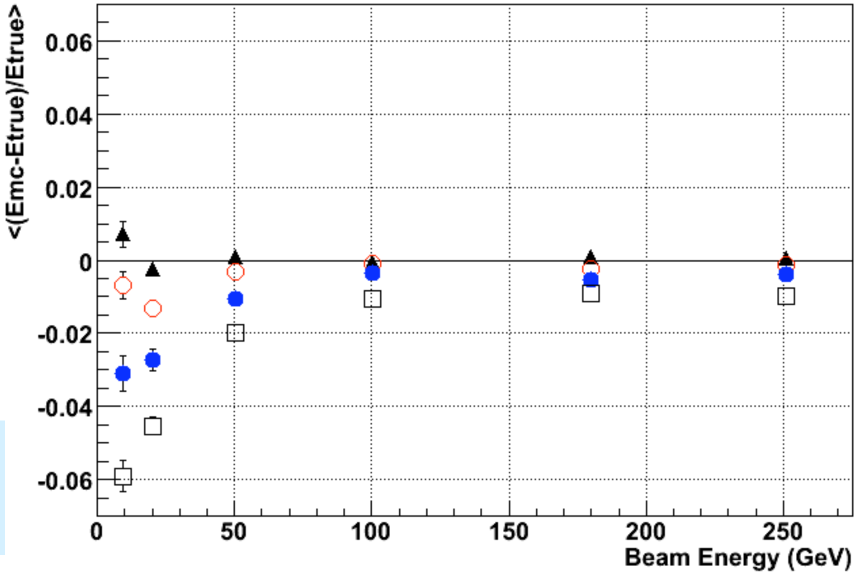
  $\chi^2 = \sum_{evts} \frac{(E_{\text{rec}} - E_{\text{vraie}})^2}{\sigma^2}$ is minimised over all en energies.

- If we are using different optimised set of weights for each material we get:

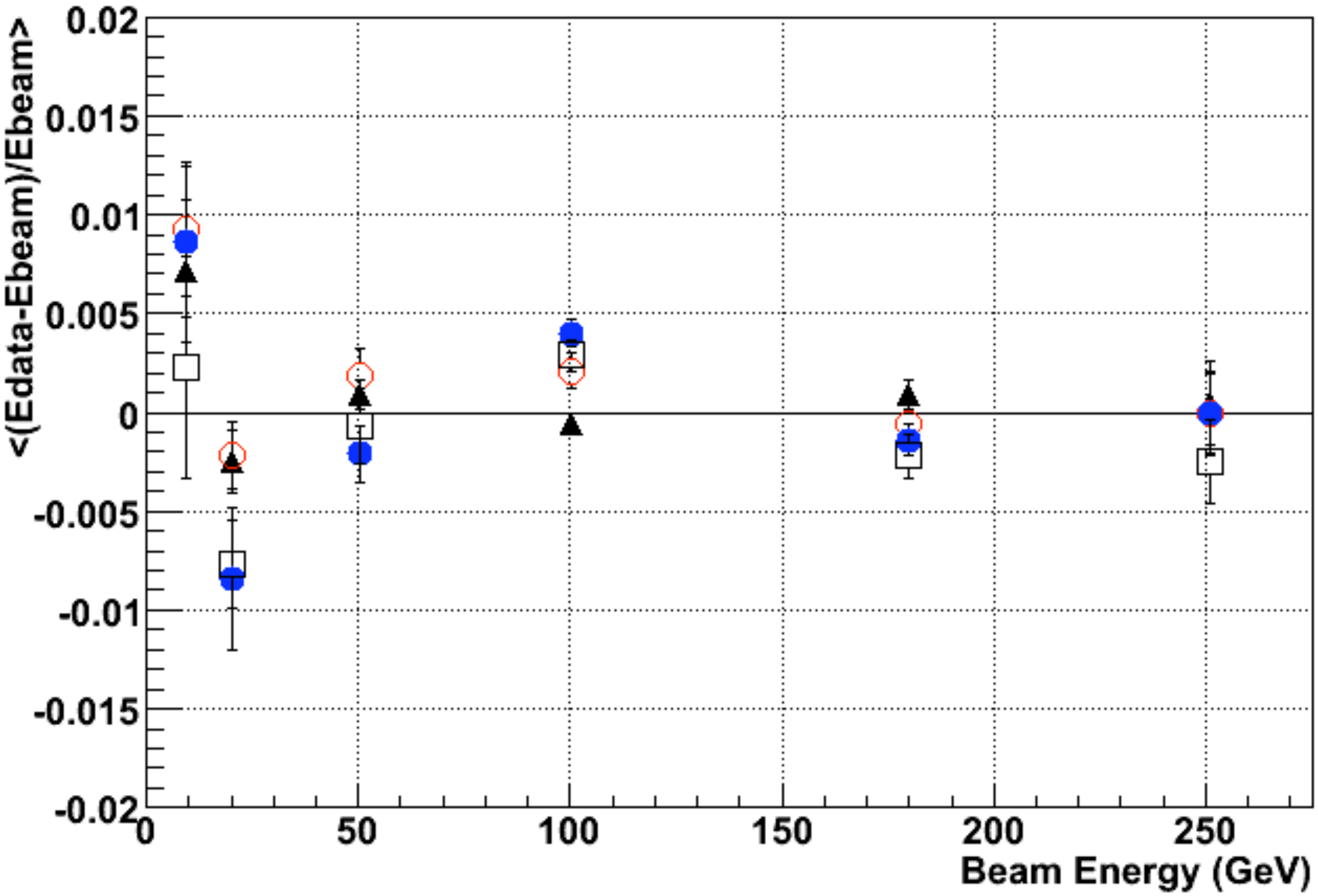


The method is not optimal, the weights should be energy dependent

If on the other hand we use one set of weights for all materials we get:

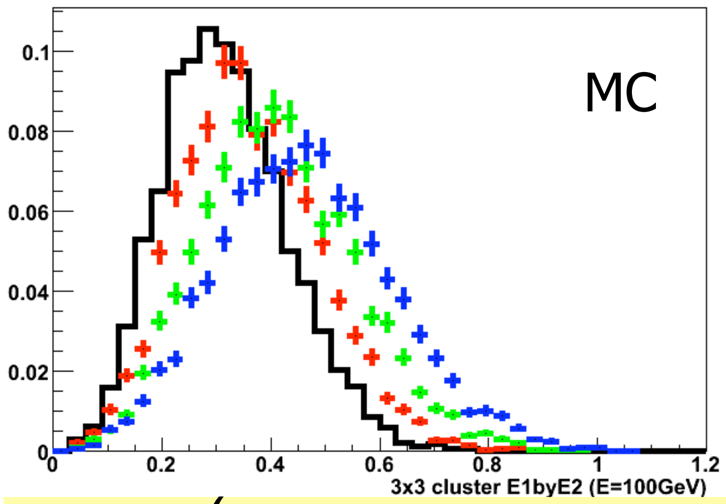


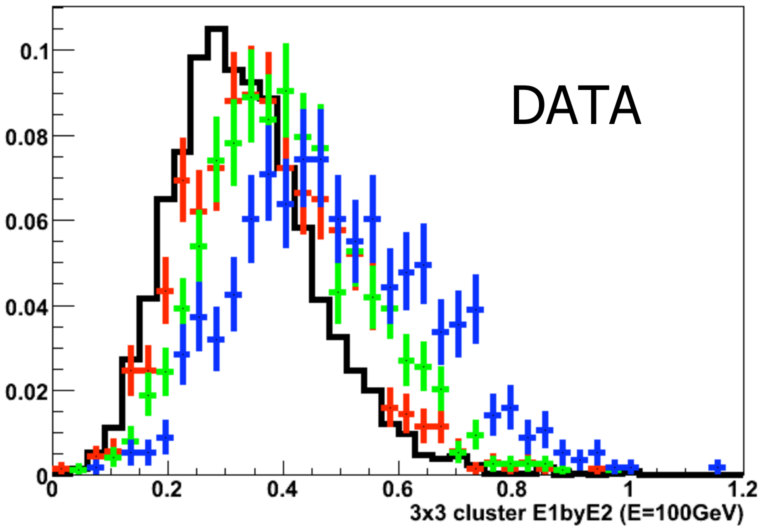
Electron linearity on DATA (weights optimized on MC for each material)



Ideas for In-situ calibration

- Do everything with Z->ee?
- We don't have a precise knowledge of the material distribution in front of the calorimeter. This contributes to non-linearities that we can't simply correct with Zs
- Find observables that are sensible to the material and that we can use in data.
- In testbeam we observed that E1/E2 (energy in first layer/energy in second layer), shifts in position and changes in shape when varying the material

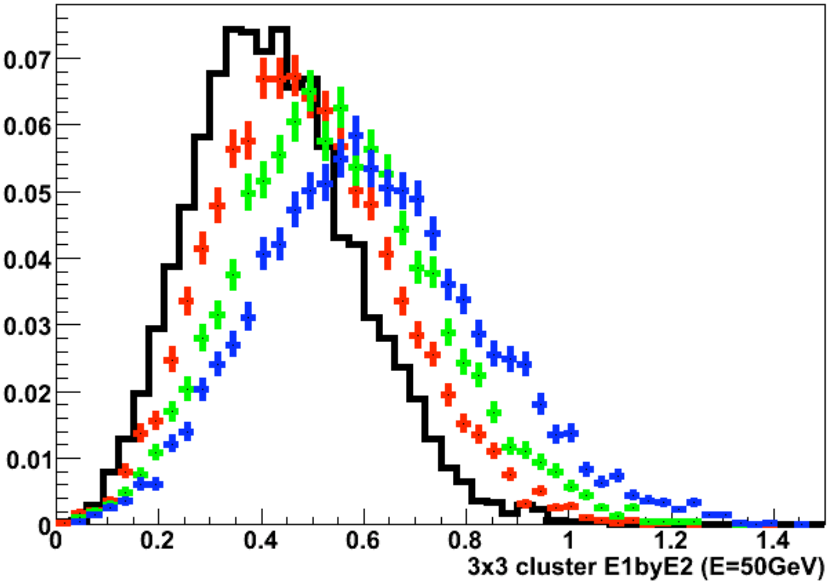


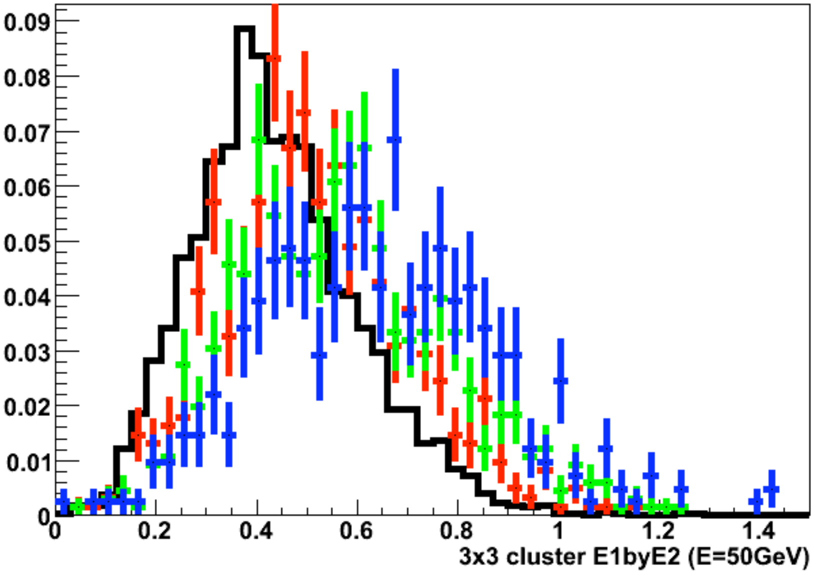


$$E_{rec} = \gamma\left(a + bE_{pres} + E_1 + E_2 + eE_3\right)$$

In ATLAS we can determine the relation between the offset (a) or the b parameter and E1/E2 for a given energy (on MC). On data we can then use this relation to get the offset that we need to apply to correct for non-linearities.

	Mat (mm)	a(MeV)	b
Black:	0	288	1.16
Red:	25	383	1.29
Green:	50	451	1.40
Blue:	75	578	1.57


0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
3x3 cluster E1byE2 (E=50GeV)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
3x3 cluster E1byE2 (E=50GeV)