Egamma Performance

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Outline

- Results on the combined testbeam:
  - Liquid Argon Calorimeter standalone results on electron linearity and resolution (presented at CALOR 2008)
  - Converted/Unconverted photon studies (presented at the CTB weekly meeting)
- Calibration strategy for ATLAS
  - Longitudinal weights extraction and estimation with data (could be included in a new in-situ calibration package) (presented at the egamma workshop in June)
  - AOD to AOD recalibration of EM particles
- Electron Identification in ATLAS
  - Rectangular cut optimisation on EM calorimeter variables (could be included in a new package under egamma) (presented at the egamma workshop in June)

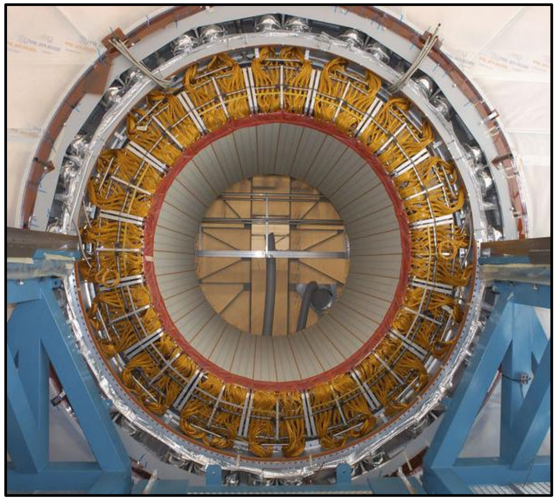
3

LAr Calorimeter Testbeam Results

Electron linearity/resolution

The LAr EM calorimeter & energy reconstruction

The ATLAS half barrel and cryostat



calorimeter module

calorimeter module in cryostat (testbeam)

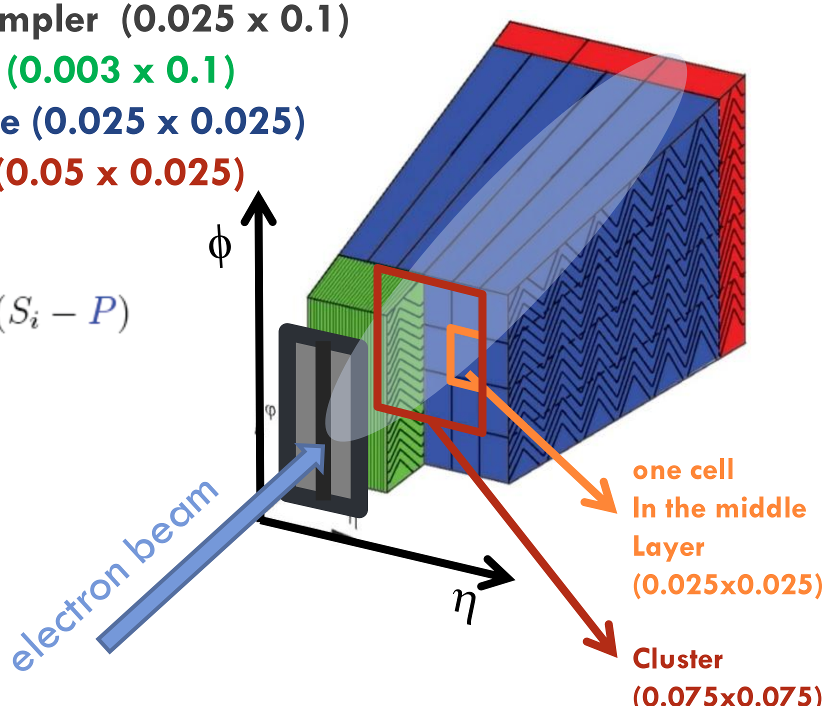
Layers and granularity (Δη x Δφ):

Presampler (0.025 x 0.1)

Strips (0.003 x 0.1)

Middle (0.025 x 0.025)

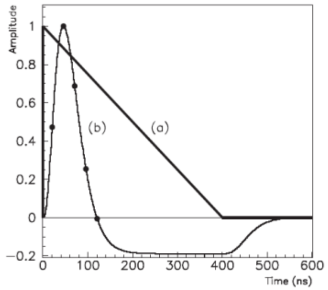
Back (0.05 x 0.025)



- LAr energy reconstruction:
  - Cell energy:

$$E(GeV) = f_{DAC\rightarrow\mu A} \times f_{\mu A\rightarrow GeV} \times \frac{M_{cali}}{M_{phys}} \times g_{ADC\rightarrow DAC} \sum_{i=1}^{n} a_i(S_i - P)$$

  - Electronic calibration constants:
    - p = pedestal
    - a = optimal filtering
    - f,g = ADC → GeV

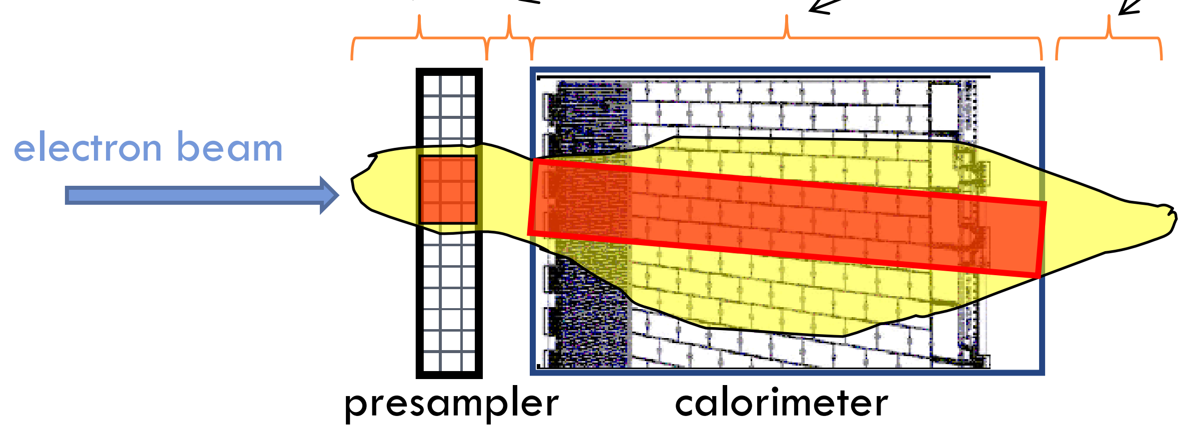


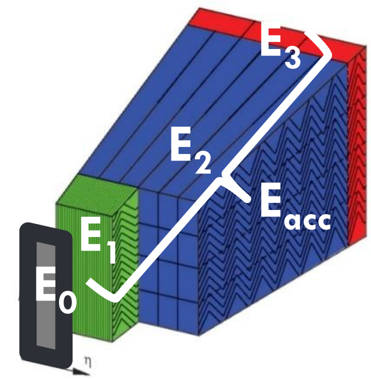
- Cluster: sum of cell energies in 0.075x0.075 over all layers

Electron energy calibration

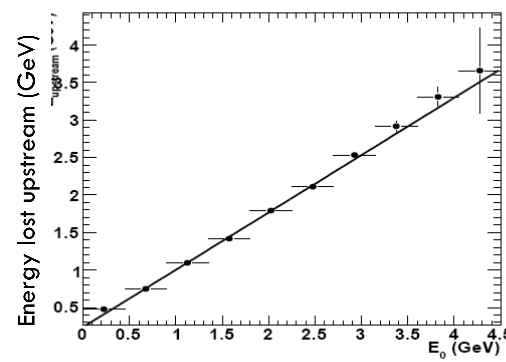
- Energy parameterisation:

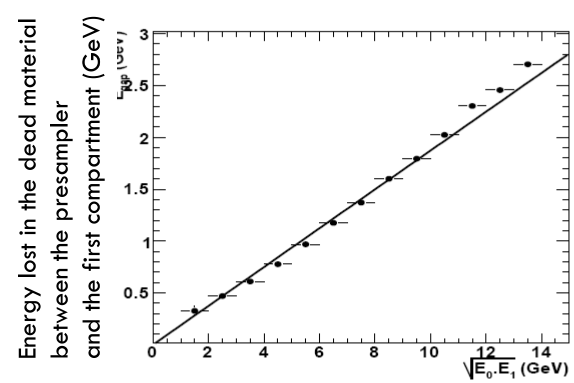
$$E_{electron} = offset + W_0 E_0 + W_{01}\sqrt{E_0 E_1} + \lambda E_{acc} + W_3 E_3$$





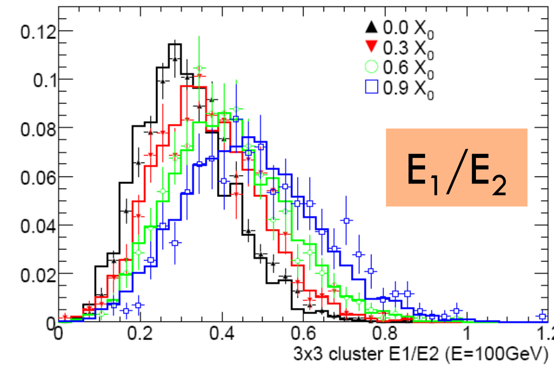
- Offset: energy lost by ionisation in the dead material in front of the calorimeter.
- W_0: correcting for energy lost in front of calorimeter by pre-showering electrons.
- W_{01}: empirical correction for the energy lost in the dead material between the presampler and the first compartment.
- λ: out of cluster correction and sampling fraction
- W_3: correcting for the energy leakage at the back of the calorimeter

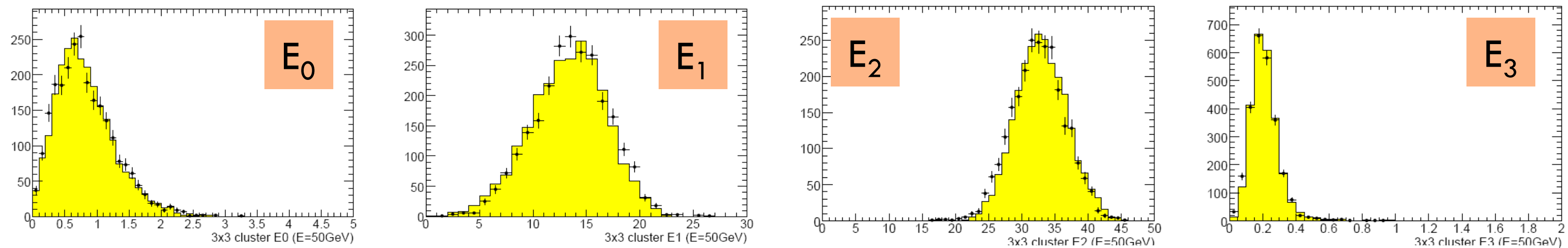




Data/MC comparisons

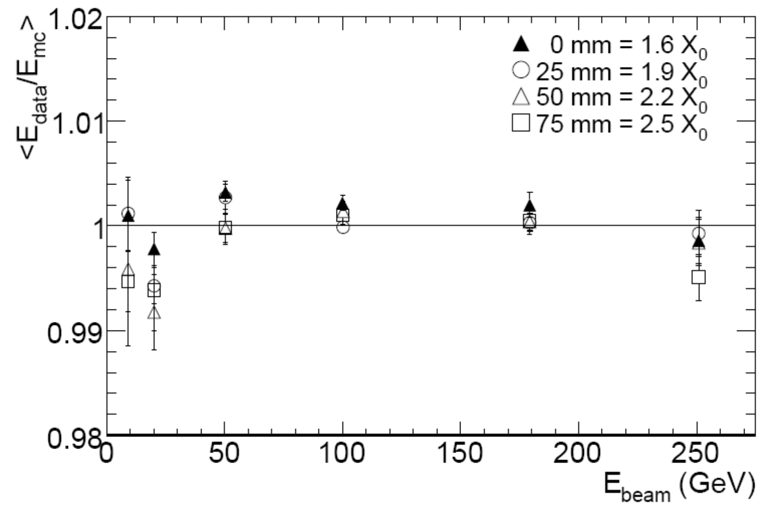
- The energy calibration strategy of the LAr calorimeter relies on the simulation of the experimental set-up and the exact description of the detector response
- A high level of agreement between data and MC is therefore crucial for the performance of the detector.
- In the CTB a big emphasis was given to a careful data-MC comparison.





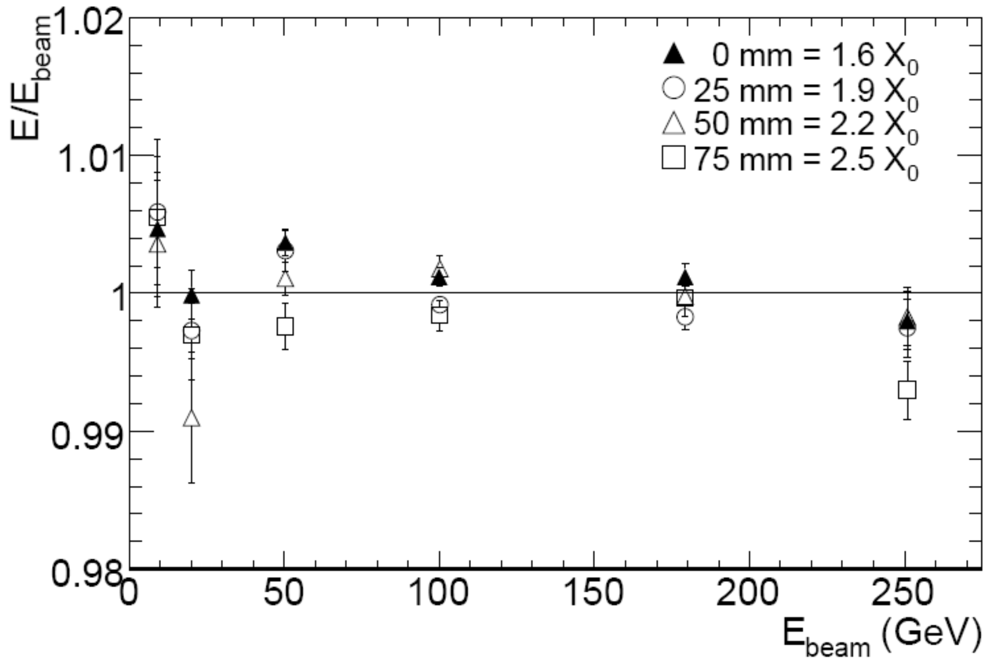
- Percentage mean energy difference between data and MC simulation for all energies and all material configurations

  Considering all systematic errors, the level of agreement between the MC and the data was estimated to be of order 0.4%



Results on energy linearity for electrons (9-250 GeV)

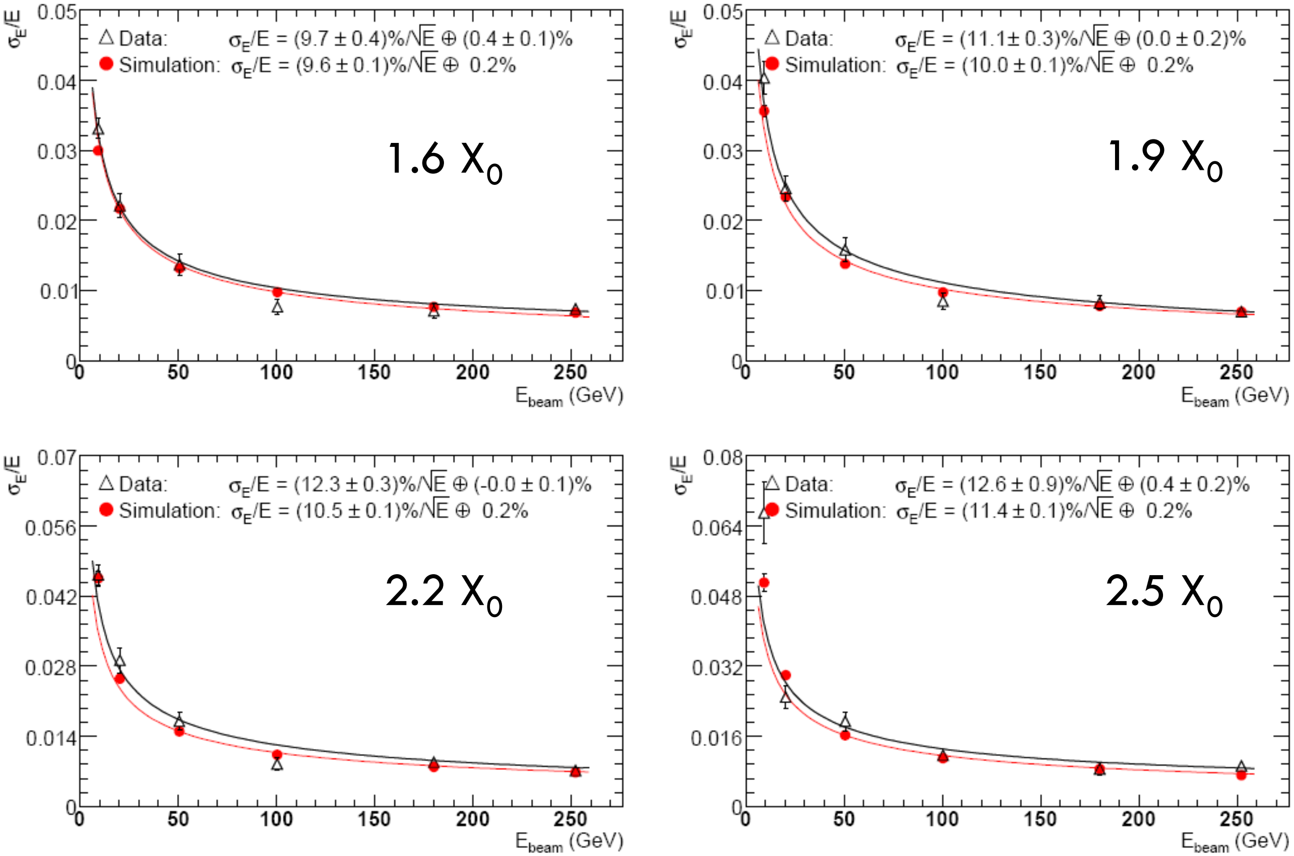
- The energy linearity obtained after application of the longitudinal weights to the cluster sampling energies for 4 different material configurations in front of the calorimeter cryostat: no material, 25, 50 and 75mm of Aluminum.
- These configurations correspond to the amount of material in ATLAS in different eta-regions.
- A 0.5% non-linearity is observed



- Remark: spread of the data-points at the level of 0.2% or less is seen for fixed beam energy. The variations from one energy point to another can be attributed to the systematics of the CTB setup itself. In particular, changes to beam conditions (collimator openings, beam-optics magnetic fields) seem to have large effects in the relative beam energy (systematics of beam line included in the error bars).

Energy resolution results for electrons (9-250 GeV)

- Energy resolution for 4 different material configurations comparing MC and data after the applying longitudinal weights.

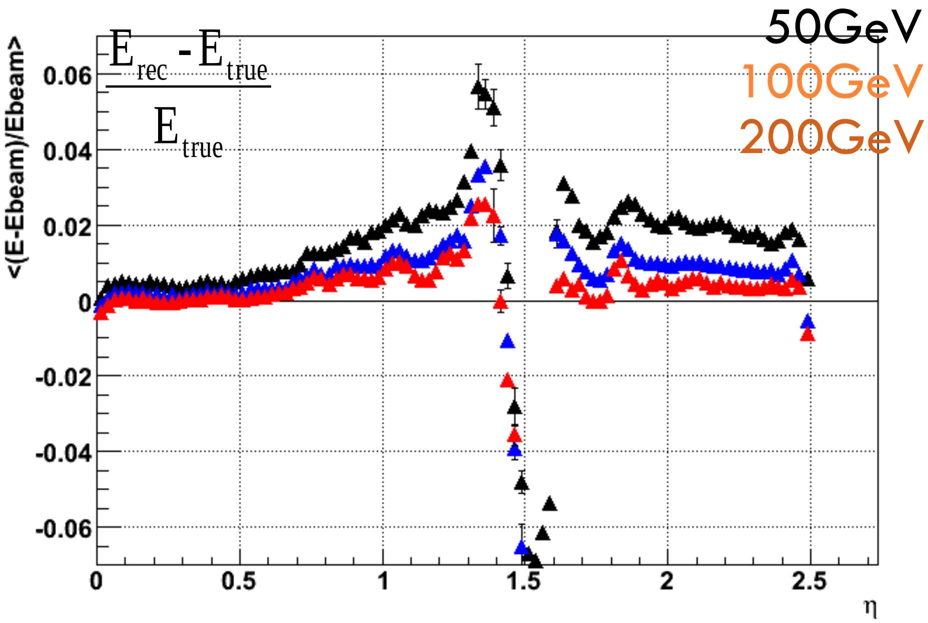


- Remark: The resolution worsens at the approximate rate of $0.5\%/\sqrt{E}$ per $30\% X_0$ increment of the material in front of the calorimeter.

Combined Testbeam Results

Study of converted/unconverted photons

The problem in ATLAS: unconverted photons cannot be calibrated using the same calibration as for electrons



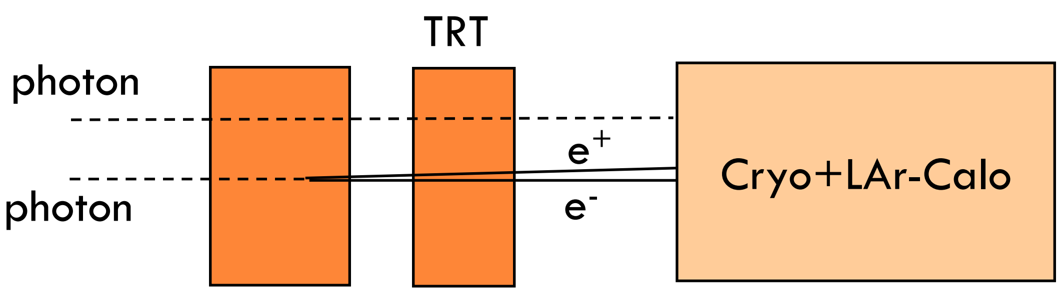
Need for separate calibration for photons

<u>Definition:</u>

Unconverted Photon: a photon which does not convert before the end of TRT.

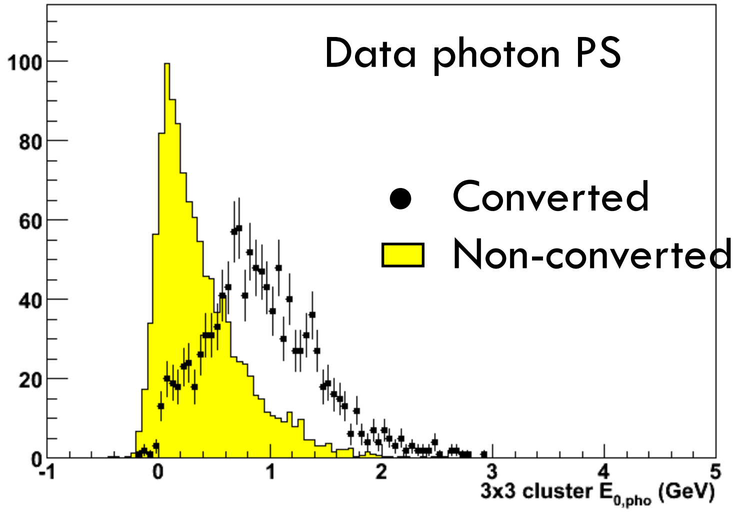
<u>Our goal in CTB:</u>

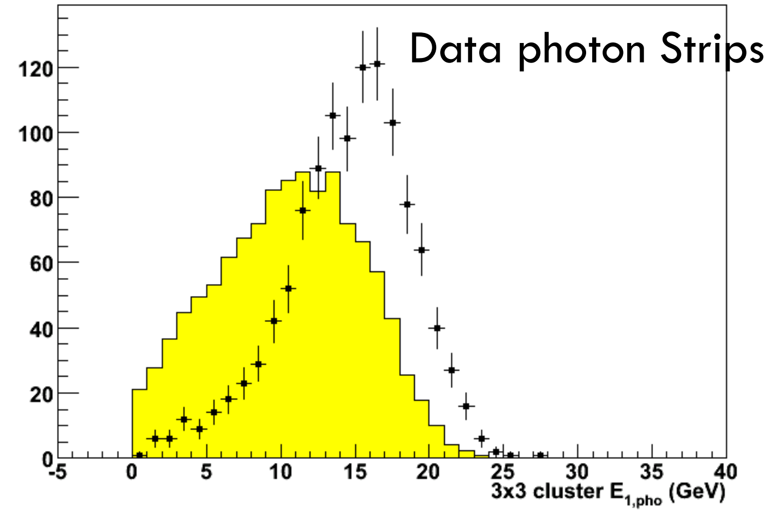
To study the MC description of the Calo response for converted/unconverted photons. This needs to be published.



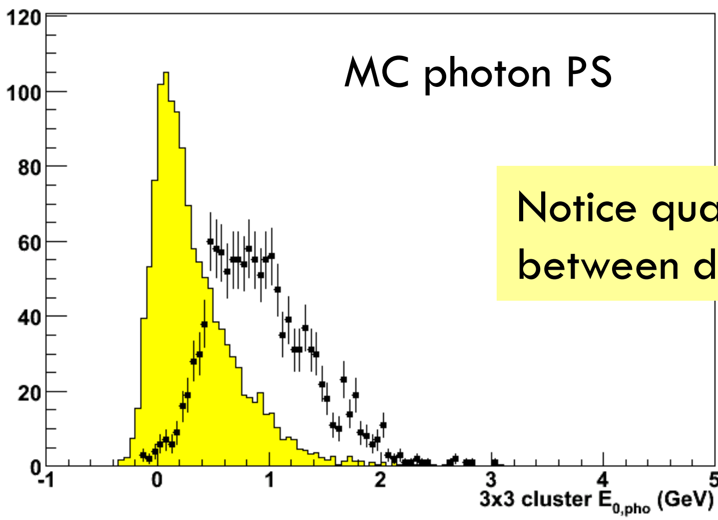
Conversions have different longitudinal profiles

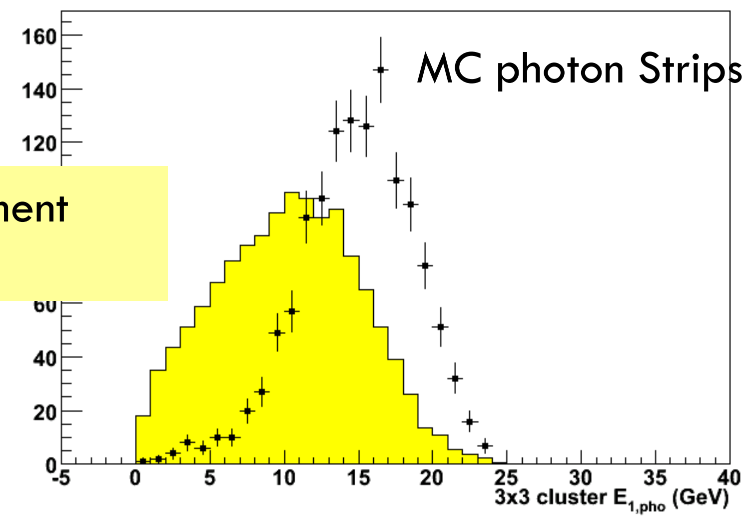
Data using the Scintillator or TRT





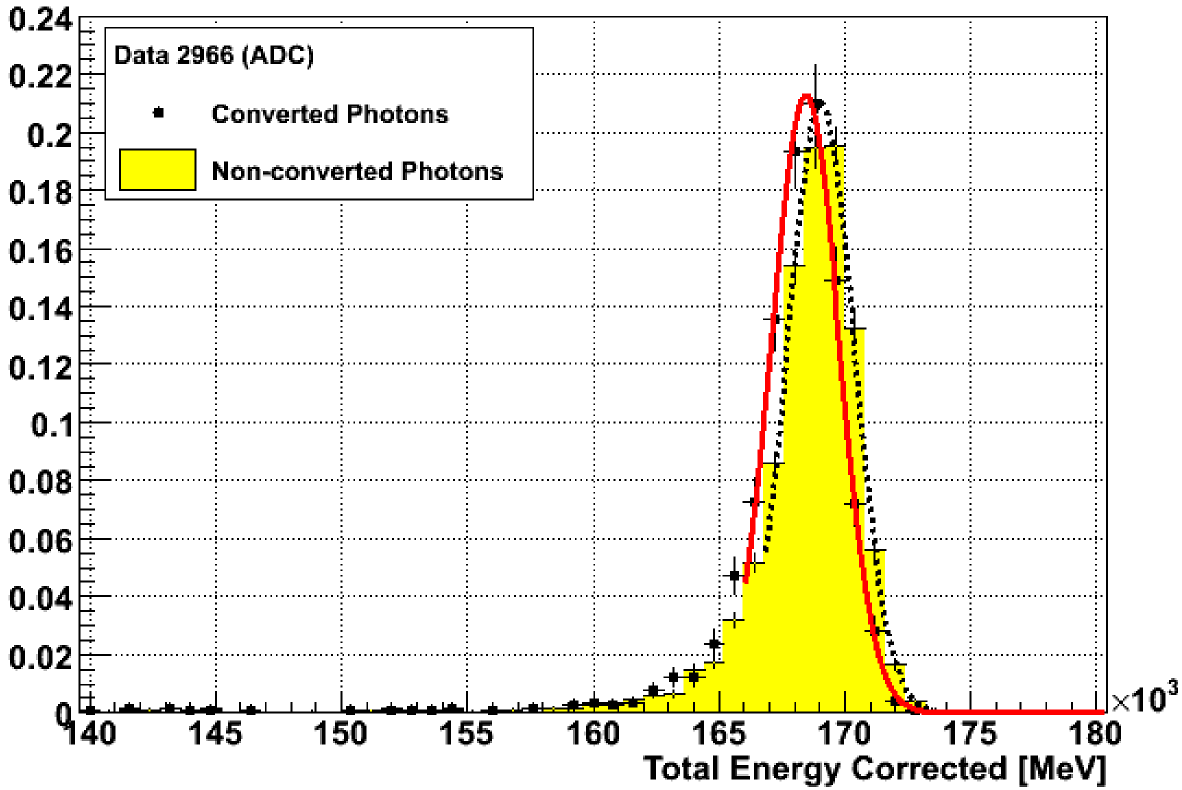
MC using truth





Notice qualitative agreement between data and MC

Energy Scale Shift



fractional increase in the photon energy: $$R = \frac{\Delta M_{Etot}}{\langle M_{\gamma} \rangle}$$

R=1.02 ± 0.12 (stat) %

Extraction Of Longitudinal Weights

from MC and from DATA

Longitudinal Weights Extraction on MC (TDR style)

$$E = \lambda\left(\text{offset} + W_0E_0 + E_1 + E_2 + W_3E_3\right)$$

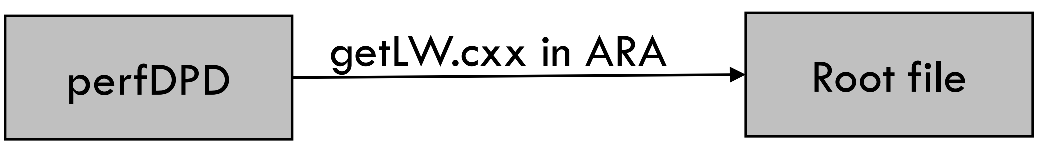
This method is based getting the weights by minimizing the energy resolution.
The only knowledge taken from the MC truth is the initial particle energy.

<u>Step1:</u> Generation of small calibration DPDs

In AODtoDPD:

- We use an athena algorithm to re-cluster from AOD cells.
- We create a new LArEMCaloCluster container and we put in the DPD
- We create a UserData containing some truth info, using the official UserDataSvc

<u>Step2:</u> running MINUIT on the DPDs using AthenaROOTAccess

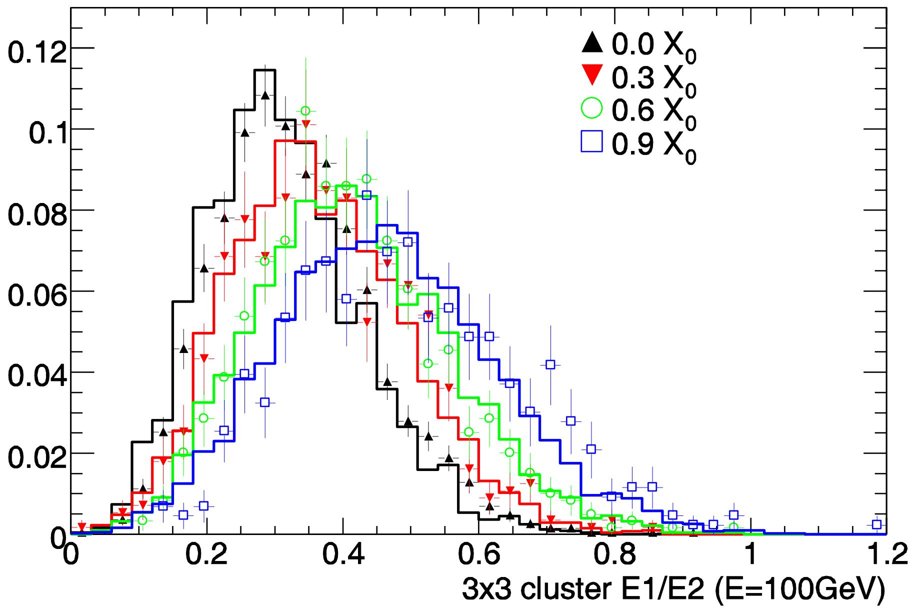


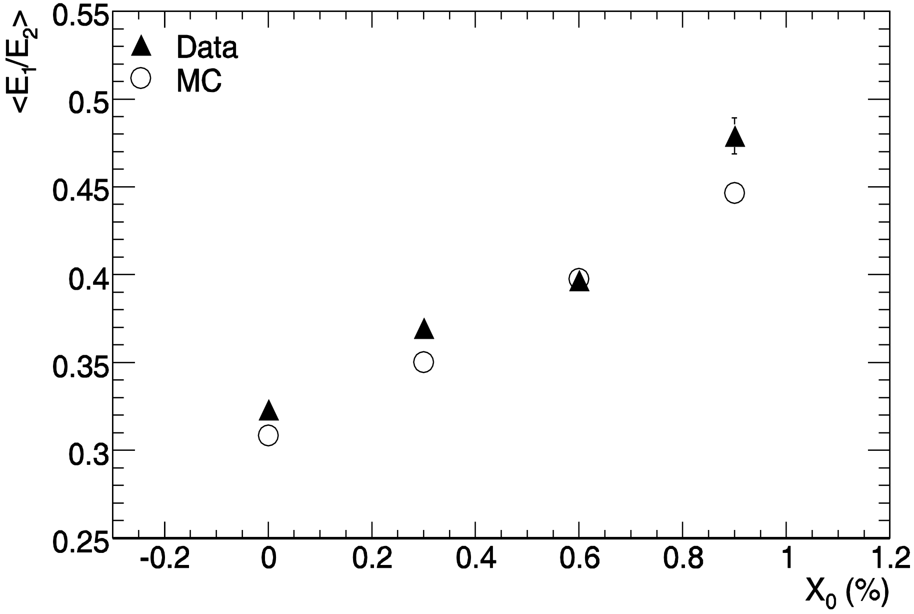
(contains linearity/resolution histos)

This method can be a fast and easy alternative to the now standard calibrations hits method. We are providing these weights for full simulation and atlfast2.

Longitudinal weights from data

Plots from CTB electron draft (Aleksa, Wingerter et al)





For 100GeV electrons here, the E1/E2 (Estrips/Emiddle) is strongly correlated to the material we put in front of the calorimeter.

We expect that this is true for some of the weights (offset and W0)

With high enough statistics, one could achieve a ~0.05X0 discrimation (systematics limit on the E1/E2 due to various effects)

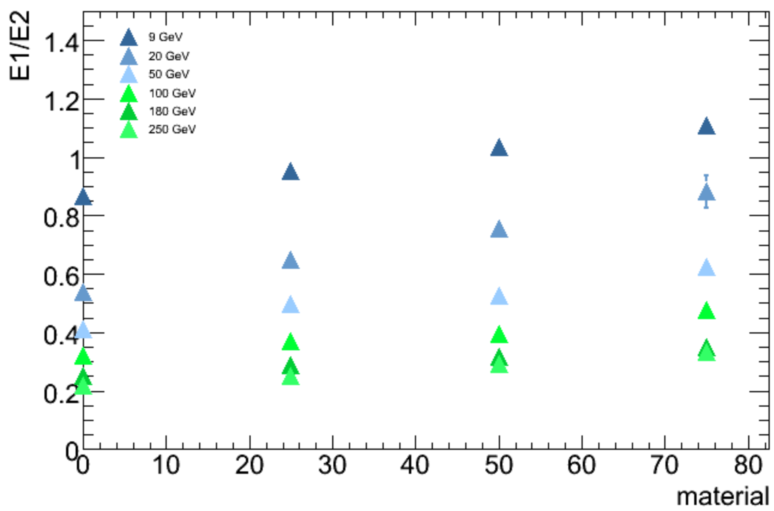
Correction of the weights using data: the idea

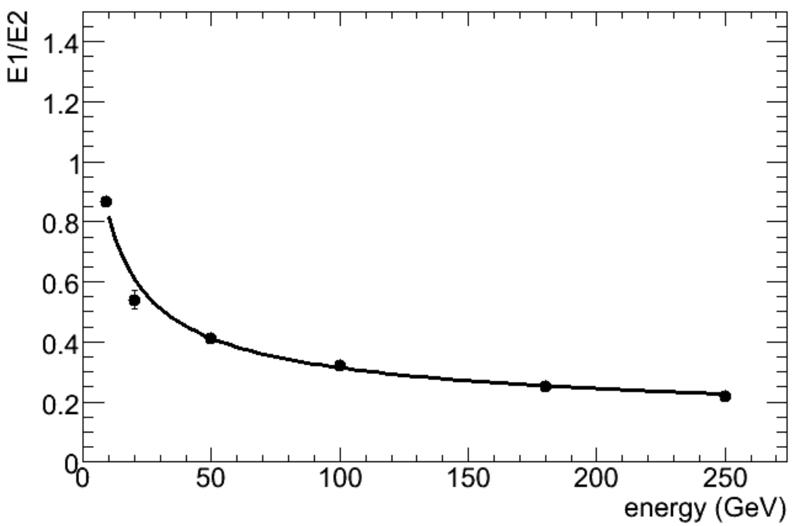
- Here for simplicity we only check the TDR weights because they are energy independent and this helps to collect statistics (iso electrons).
- The idea: Find observables that strongly correlate to the weights.
- Good example: E1/E2 (the ratio of energy in the strips to middle)
- These observables depend on Energy
  - However the TDR weights do not.
  - The calib hit weights do so one needs to bin in Energy

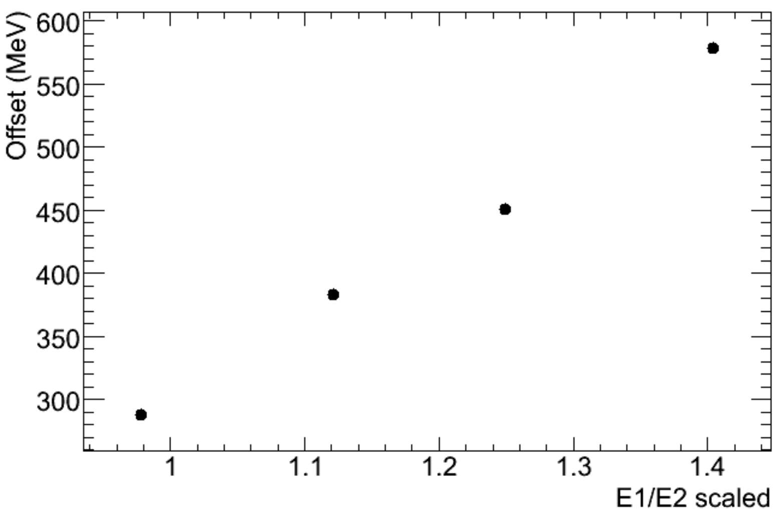
<u>METHOD</u>

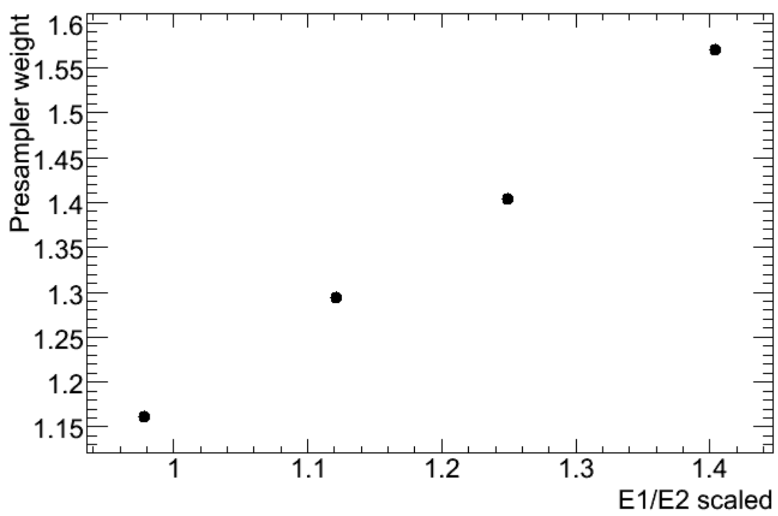
- Build the function E1/E2 vs Energy from MC (call it f(E))
- Unfold the E-dependence: (E1/E2)' = (E1/E2) * 1/f(E)
- Then find the maps (per eta bin) from MC:
  - Offset vs (E1/E2)', W0 vs (E1/E2)' , ...
- Collect data: electrons at certain eta bins (all energies)
- Use the maps to produce: <Offset> , <W0>, ... from the measured E1/E2 from data. These are the new corrected weights

- Fit to determine the energy dependence of E1/E2
- Dependence of weights on scaled E1/E2









We can determine the offset and W0 weights to a few % accuracy from data:

AOD to AOD recalibration of datasets

- We are thinking about a code for AOD to AOD recalibration.
- What we need:
  - Get the new calibration weights
  - Put them in the database or jobOption
  - Read the new weights from the jobOption or Database and apply them to the cluster. This means recluster on the calorimeter cells available in the AOD and apply any sort of cluster correction one needs
- Except from the database part where we need to investigate, all other steps have already been tested and work.

19

IsEM Optimisation

IsEM optimisation

- Produce DPDs containing all necessary variables for electron ID by classifying electrons (from Z, b, γ, fakes)
- The DPD production is done in ATHENA using the UserDataSvc which adds a separate root tree in the AOD file.
- This root tree can then easily be read in TMVA.
- A rectangular cut optimisation is done in TMVA. A set of cuts is produced depending on efficiency/rejection.
- A code using AthenaROOTAccess allows for fast validation of optimized cut (giving electron efficiency, fakes rejection as well as rejection of electrons from b,c,γ...)
- This code can be made available very quickly on CVS if needed (We need people to contribute)

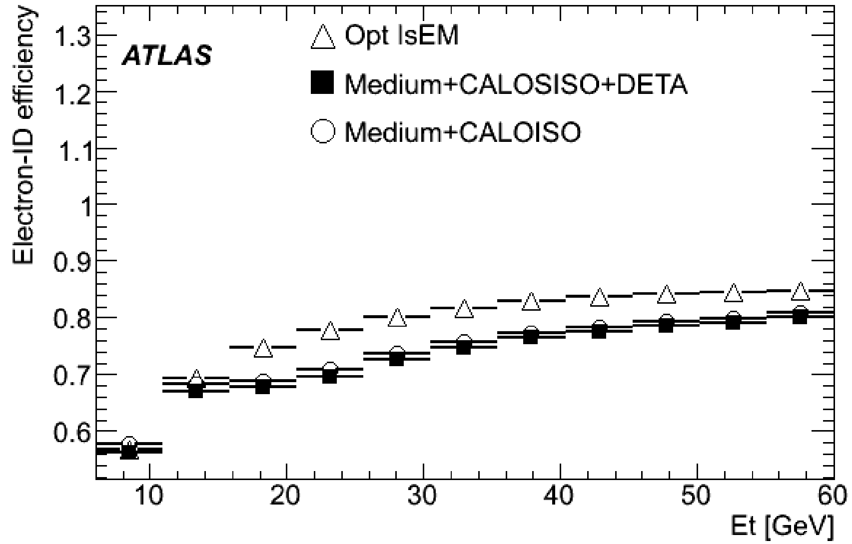
efficiencies/rejections

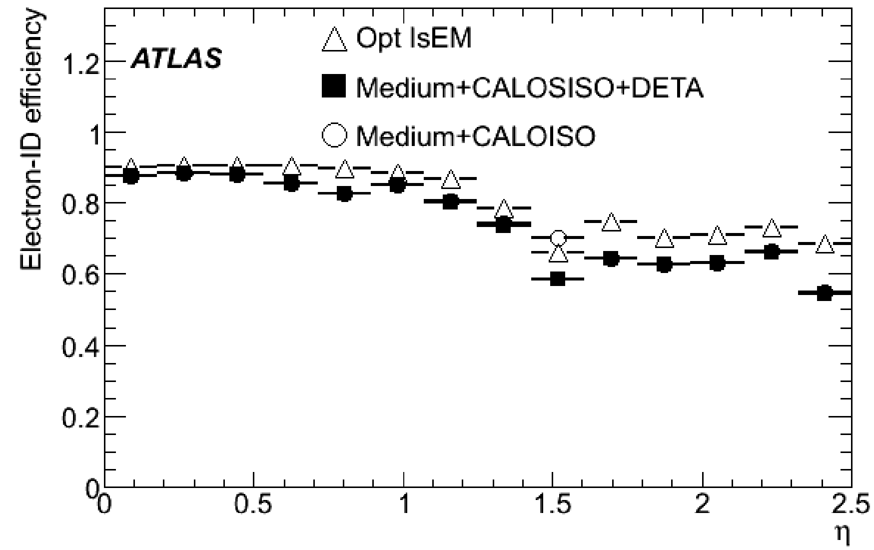
efficiencies	Z→ee > 17 GeV	Z→ee > 8 GeV	H(130) > 17 GeV	H(130) > 8 GeV
Medium+caloiso	76.5 %	75.7 %	78.1 %	75.9 %
Medium+caloiso+deta	75.6 %	74.8 %	77.3 %	75.1 %
Opt IsEM (optimised for eff)	82.0 %	81.0 %	82.7 %	79.3 %
Opt IsEM (optimised for rej)	78.1 %	76.8 %	79.2 %	74.5 %

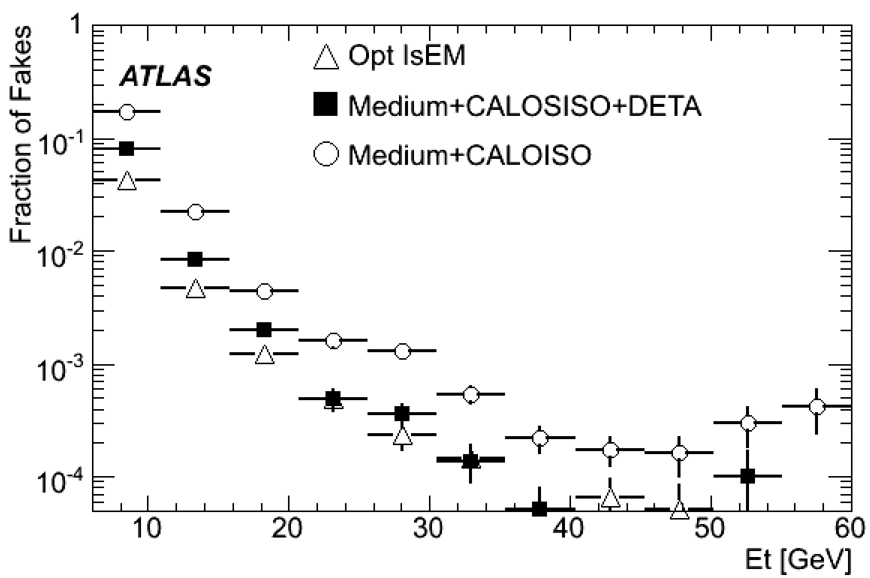
rejections	Dijet (JF17) > 17 GeV	Minimum Bias > 8 GeV	Zee > 17 GeV	Zee > 8 GeV
Medium+caloiso	4028	2256	2502	832
Medium+caloiso+deta	12623	5361	8215	2281
Opt IsEM (optimised for eff)	14060	7050	8728	3801
Opt IsEM (optimised for rej)	28534	18429	17030	8247

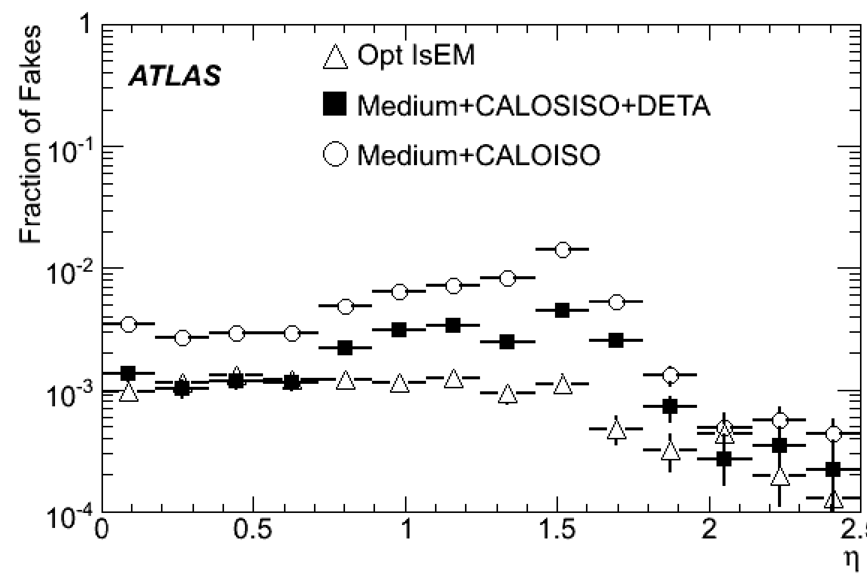
High **efficiency** optimisation

on Z→ee inclusive sample









Conclusion

- We have presented final results on electron linearity and resolution in the combined testbeam. These results are in agreement with the detector performance requirements and earlier testbeams

- We have presented a strategy for Longitudinal weights extraction with data and we are developing a code for recalibration in an AOD to AOD step.

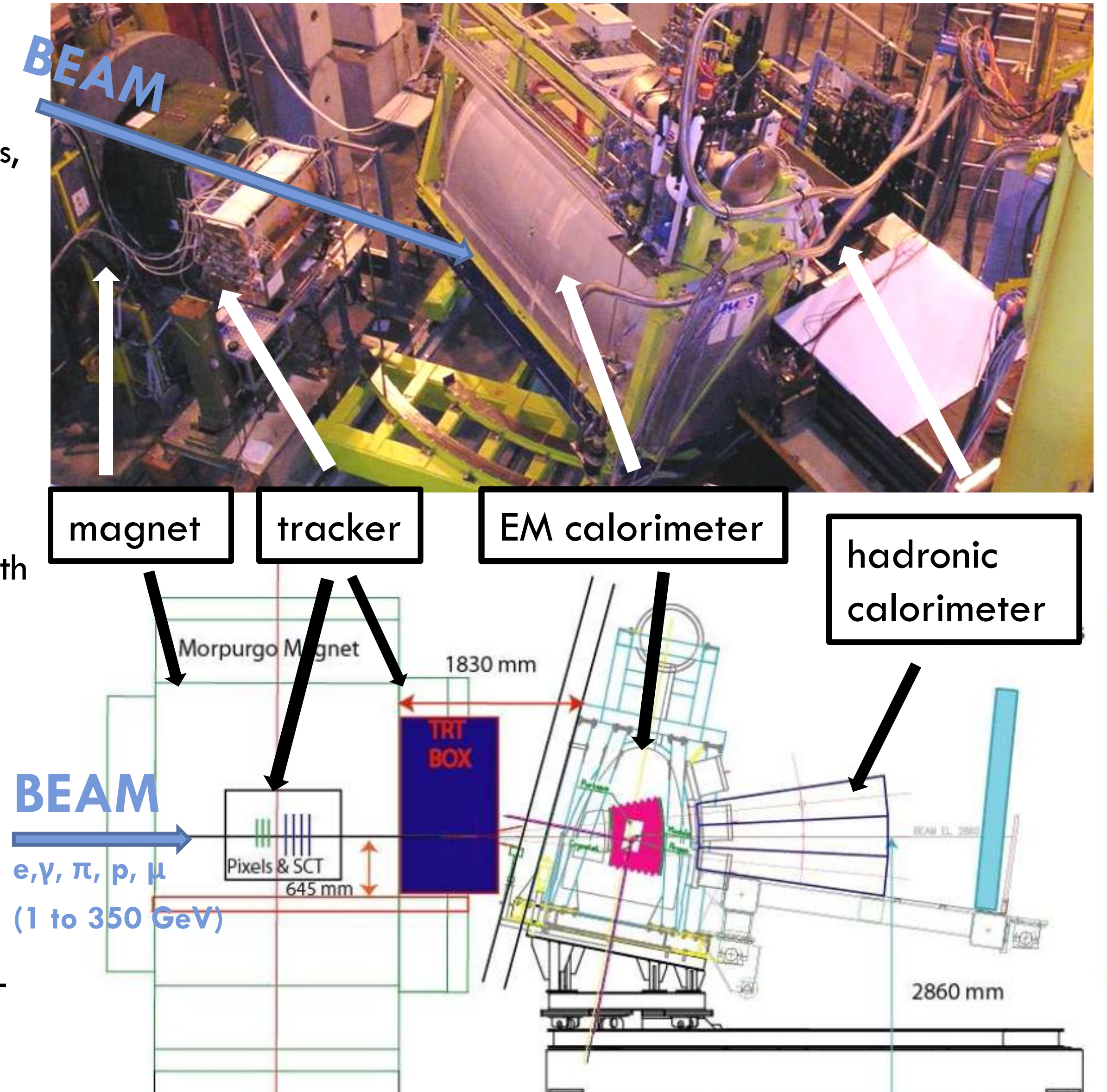
- We have optimized the electron identification and we obtain 5 % better efficiency for a 20 % better rejection compared to the new medium if we optimize for rejection and 3 times the rejection for the same efficiency if we optimize for efficiency.

Backup

The 2004 Combined Testbeam (CTB)

- Full slice of the barrel detector
  - Magnet with horizontal field (1.4 T)
  - Inner detector, tracker (silicium pixels, scilicium strips planes, Transition radiation detector)
  - LAr electromagnetic calorimeter
  - Hadronic calorimeter (Tiles)
  - Muon chambers

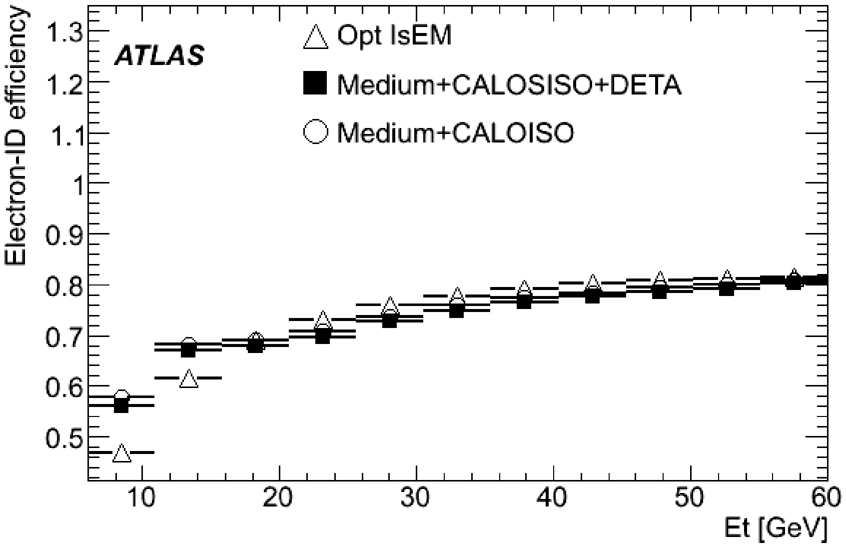
- Main goals of the CTB
  - Test the detector performances with final or close to final electronics equipment, TDAQ infrastructure and reconstruction software.
  - Validate the description of the data by MonteCarlo simulations down to energies of 1GeV to prepare the simulation of ATLAS data.
  - Perform combined studies in a set-up very close to ATLAS (e.g. combined calorimetry, and ID-calorimetry).

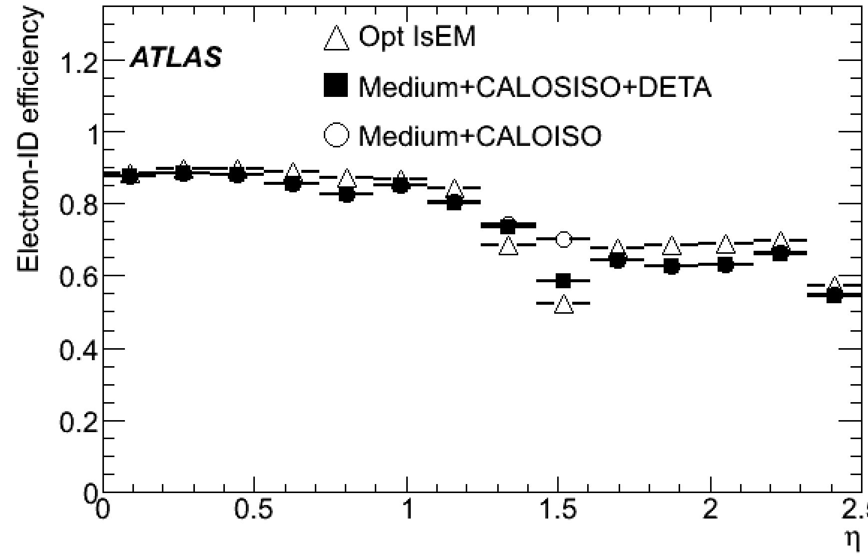


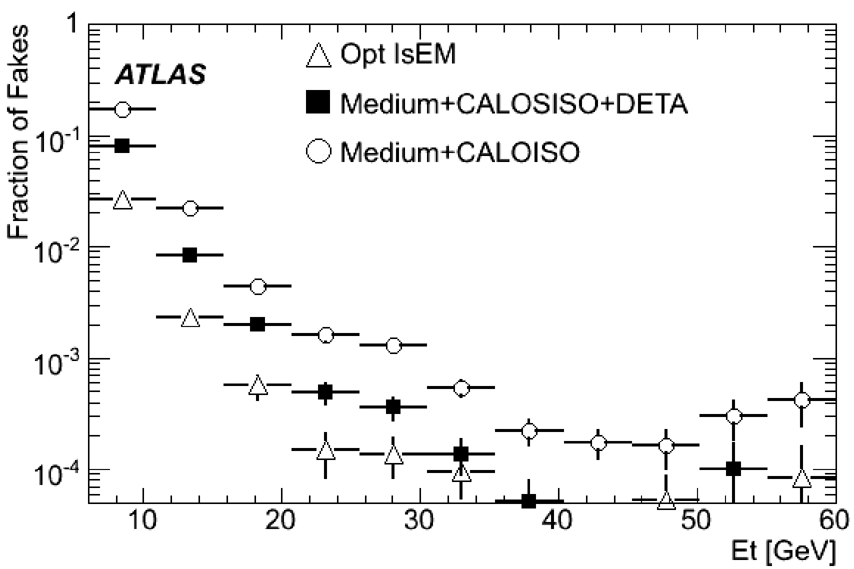
efficiencies/fakes plots

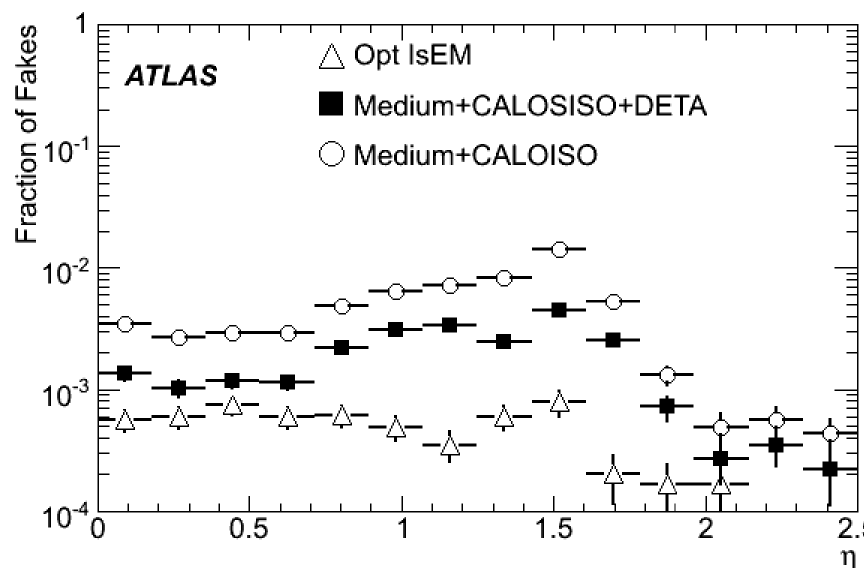
High **rejection** optimisation

on Z→ee inclusive sample





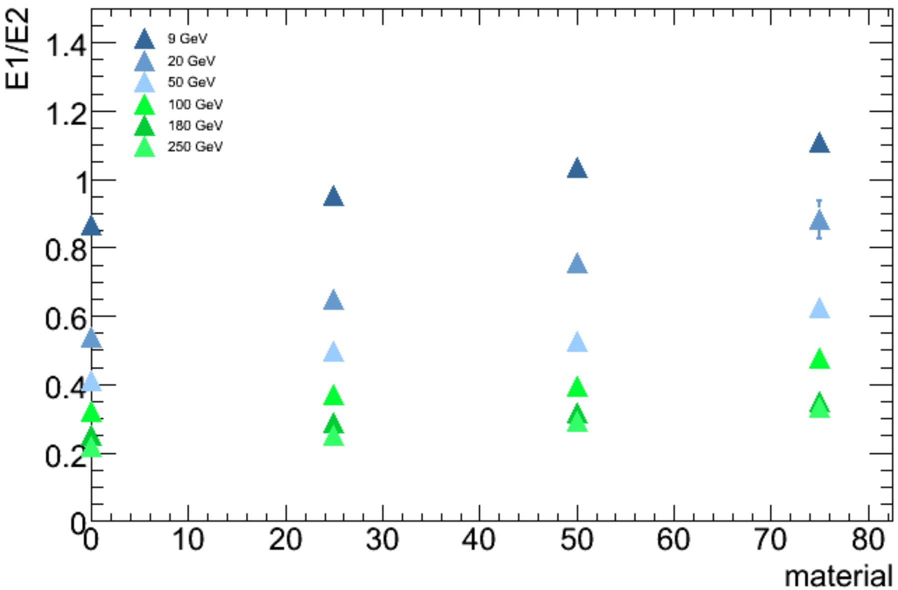


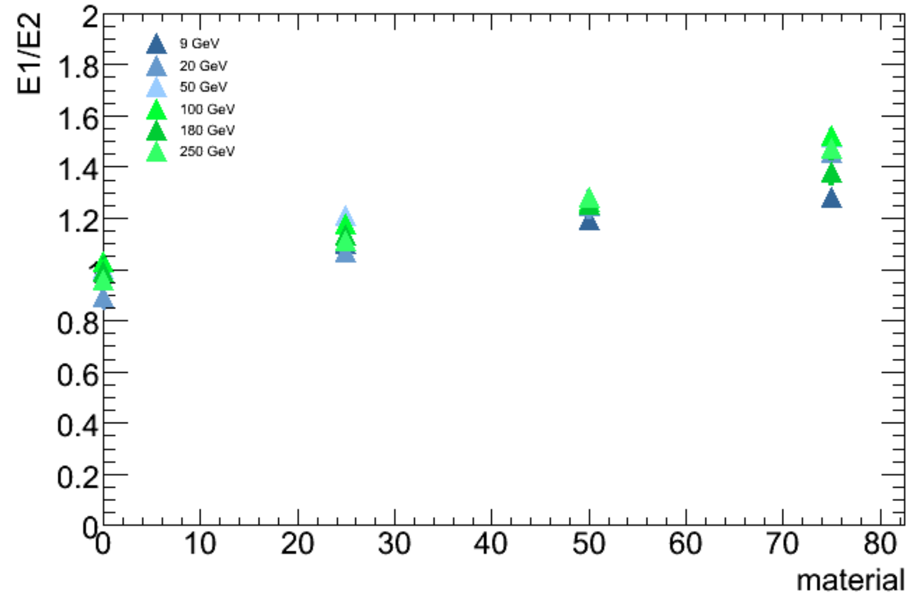


E1/E2 before/after energy unfolding

Energy dependent

Thus there is a unique map from E1/E2 to material/weights for all electron energies

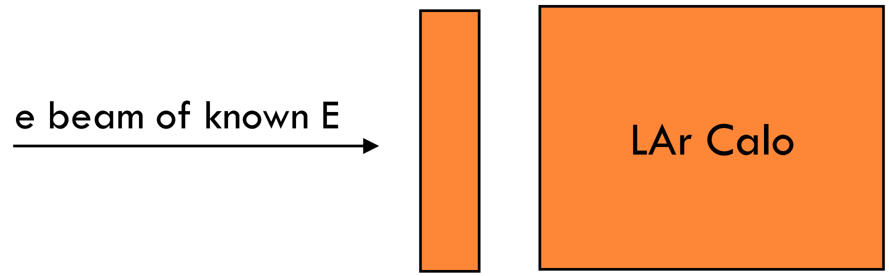




This is how the E1/E2 (mean after fit) changes with material. This procedure can be significantly improved.

Test the method with CTB04 data (prelim)

- Assume the 0mm MC as our baseline
- Extract the E1/E2→Weight maps from MC
- Run on 25mm data for energies 9-250GeV
- Use the E1/E2→Weight from data and extract an average Weight
- Compare it with the “true” Weight from MC.



3 Extra material runs
+25, 50, 75mm of Al

We can determine the offset and W0 weights to a few % accuracy from data: