Upstream Material Studies at CTB04

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CTB04 Physics Studies

Official Page: http://www.fisica.uniud.it/%7Ecobal/combined.html

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Studies of Upstream Material Effects on $e^{\pm}/\gamma$ Reconstruction and Calibration in the 2004 ATLAS Combined Test-Beam

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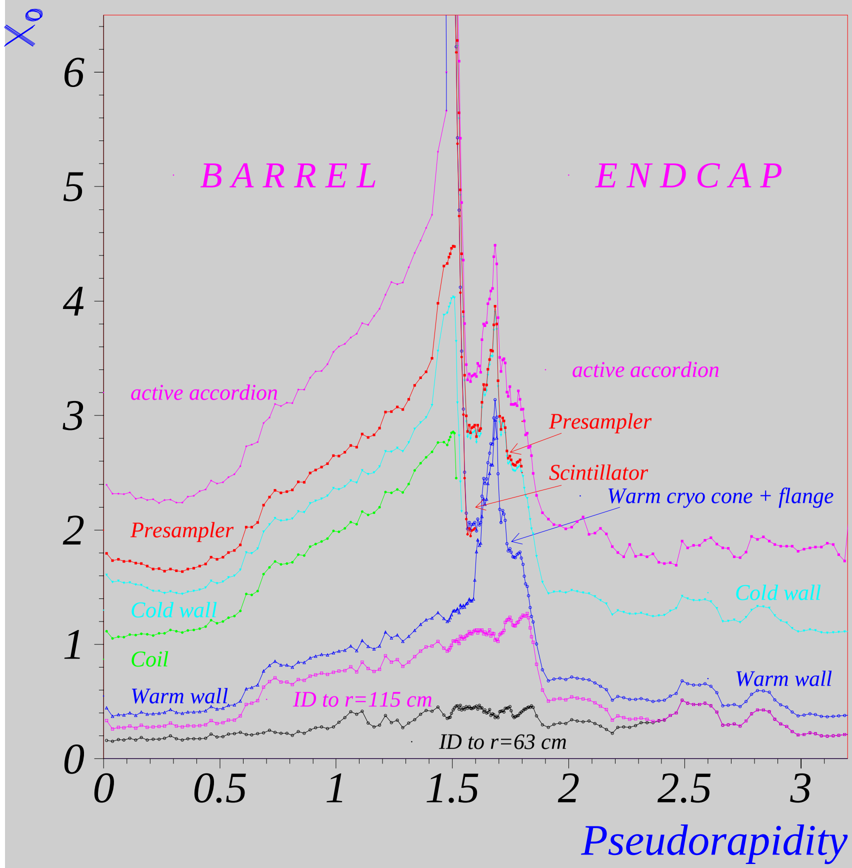
More people: K. Benslama (Columbia), M. Riveline (Weizman), K. Loureiro (UW) (+ more I may forget)

- A small number of people expressed interest for upstream material studies (= doing some real work!)
- TBeam coordinators were contacted (Beniamino) and suggested that some initial MC studies and checks should be done (January/04)
- G4 validation issues came up (Fabiola + Srini)
- A document (not proposal) expressing interest was written and sent to the TB coordinators (Feb/04)
- Since then more people expressed interest and not much has been really done (at least from my part) in terms of studying possible setup's with G4Sim

The Problem: Upstream Material



Photon Lifetime before conversion:

$$N_\gamma = N_{0,\gamma} \cdot e^{-\frac{\Delta x}{\lambda_{INT}}} = N_{0,\gamma} \cdot e^{-\frac{\Delta x}{A/(N_A \sigma_{INT})}}$$

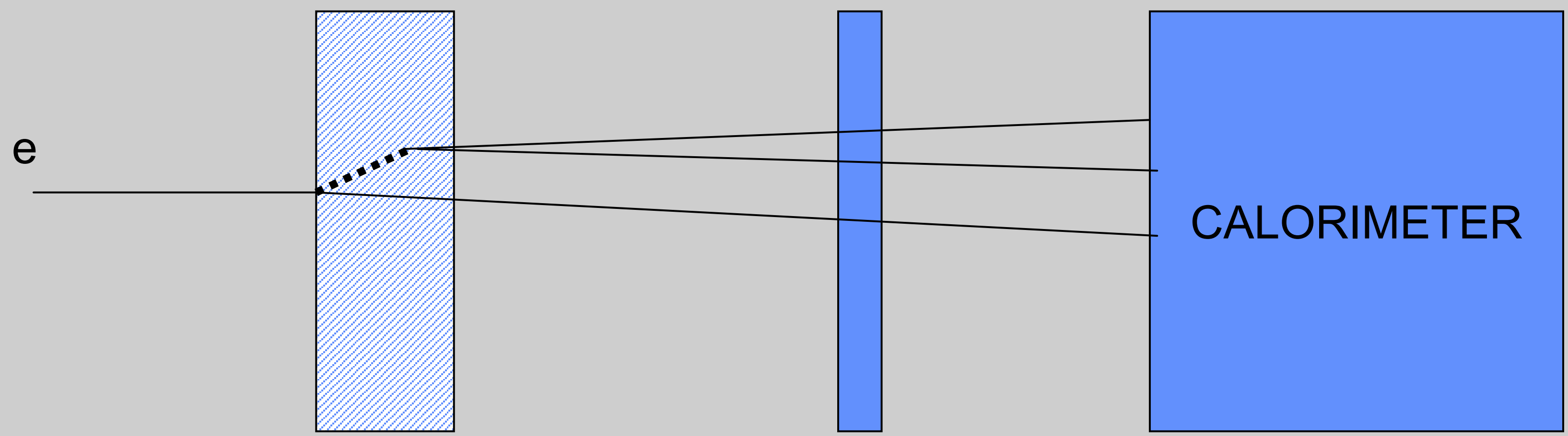
$$= N_{0,\gamma} \cdot e^{-\frac{\Delta x}{9X_0/7}}$$

$$\sigma_{pair} \approx \frac{7}{9} \frac{A}{N_A} \frac{1}{X_0}$$

For 2.2 X0 (central Atlas region):

$$\frac{N_\gamma}{N_{0,\gamma}} = e^{-\frac{2.2X_0}{9X_0/7}} = 0.18$$ Surviving photons!

The Presampler Concept



Upstream Material ΔX_0

$$E_{Lost} \propto \int_0^{\Delta X_0} \left(\frac{dE}{dx}\right)_{MIP} dx$$

Thin Presampler

$$E_{PS} \approx 3 \int_0^{1.0 X_0} \left(\frac{dE}{dx}\right) dx = 3 \cdot \left(\frac{dE}{dx}\right)_{MIP} \cdot \Delta X$$

So, the hope is that for small ΔX_0 and high e Energy (small E_{Lost}/E_{beam}) that:

$$E_{Lost} = \text{Factor} * E_{PS}$$

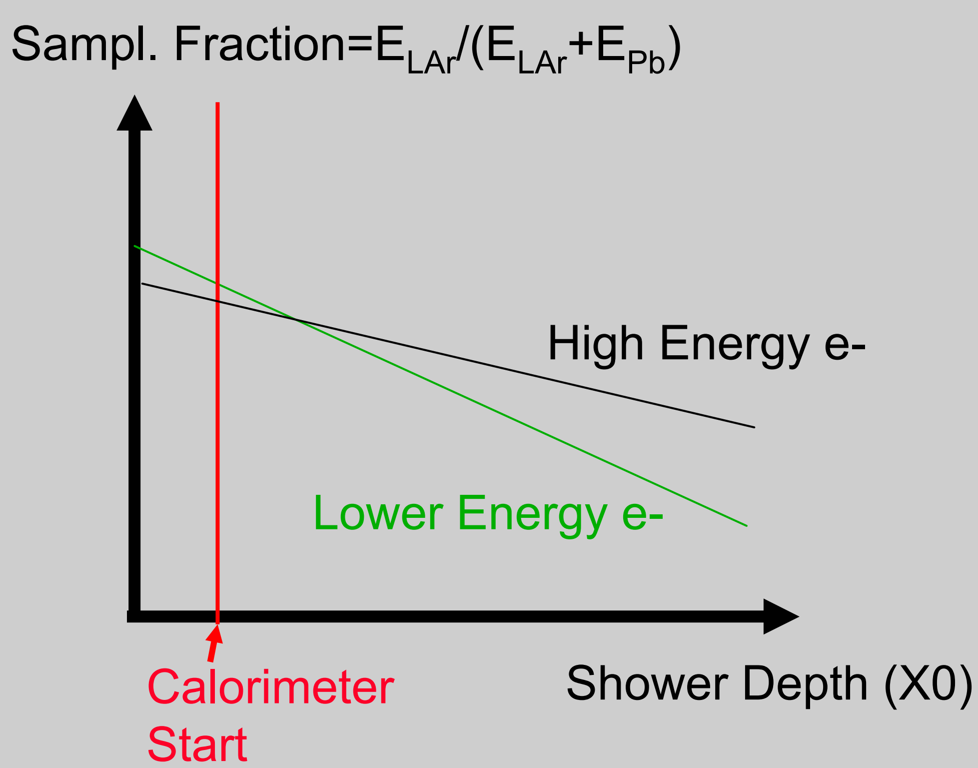
is a good approximation!

The Presampler Concept (2)

- Clearly the approximation is problematic at lower electron energies and larger upstream X_0

- EM shower longitudinal fluctuations may be a problem since now the shower development depends on energy.

Problems due to early showering:



The Sampling Fraction for electrons drops as a function of shower depth.

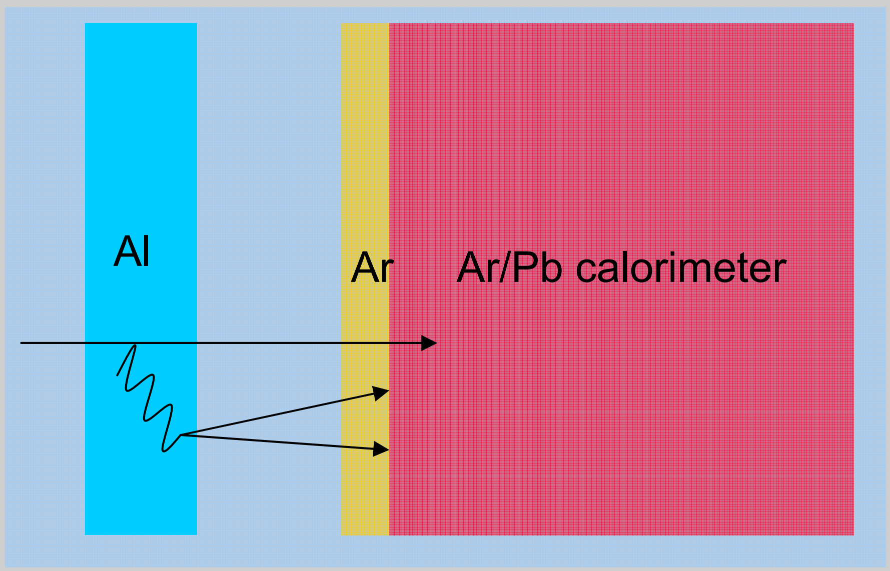
The slope depends on the energy (one can factor out this dependence expressing depth in units of shower maximum: that gives the linearity)

When the shower starts before the calorimeter, this is obviously a problem because the reconstructed energy is:

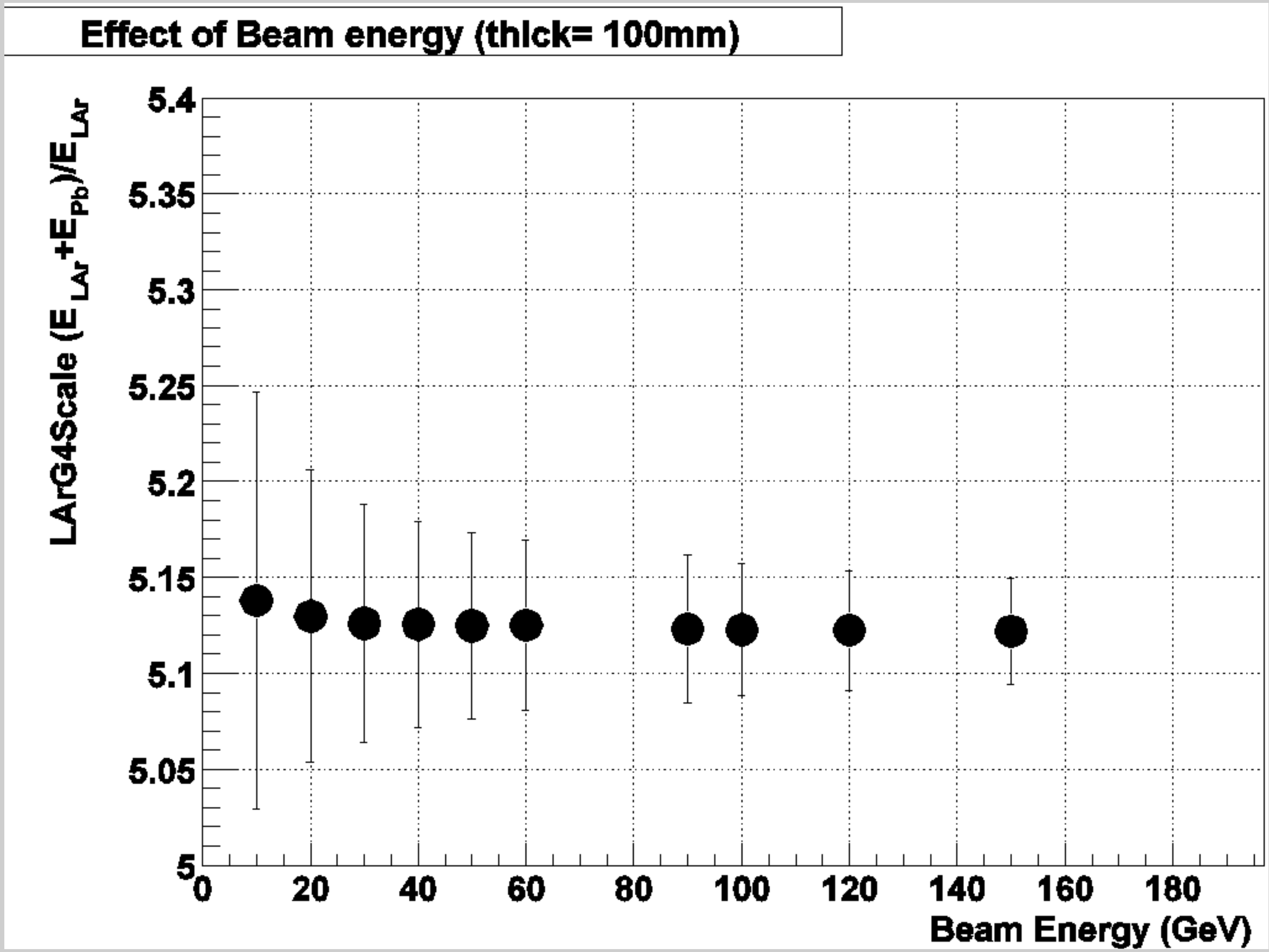
$$E_{rec} = \frac{1}{SF} E_{LAr}$$

and our weight=1/SF is assumed to be energy independent.

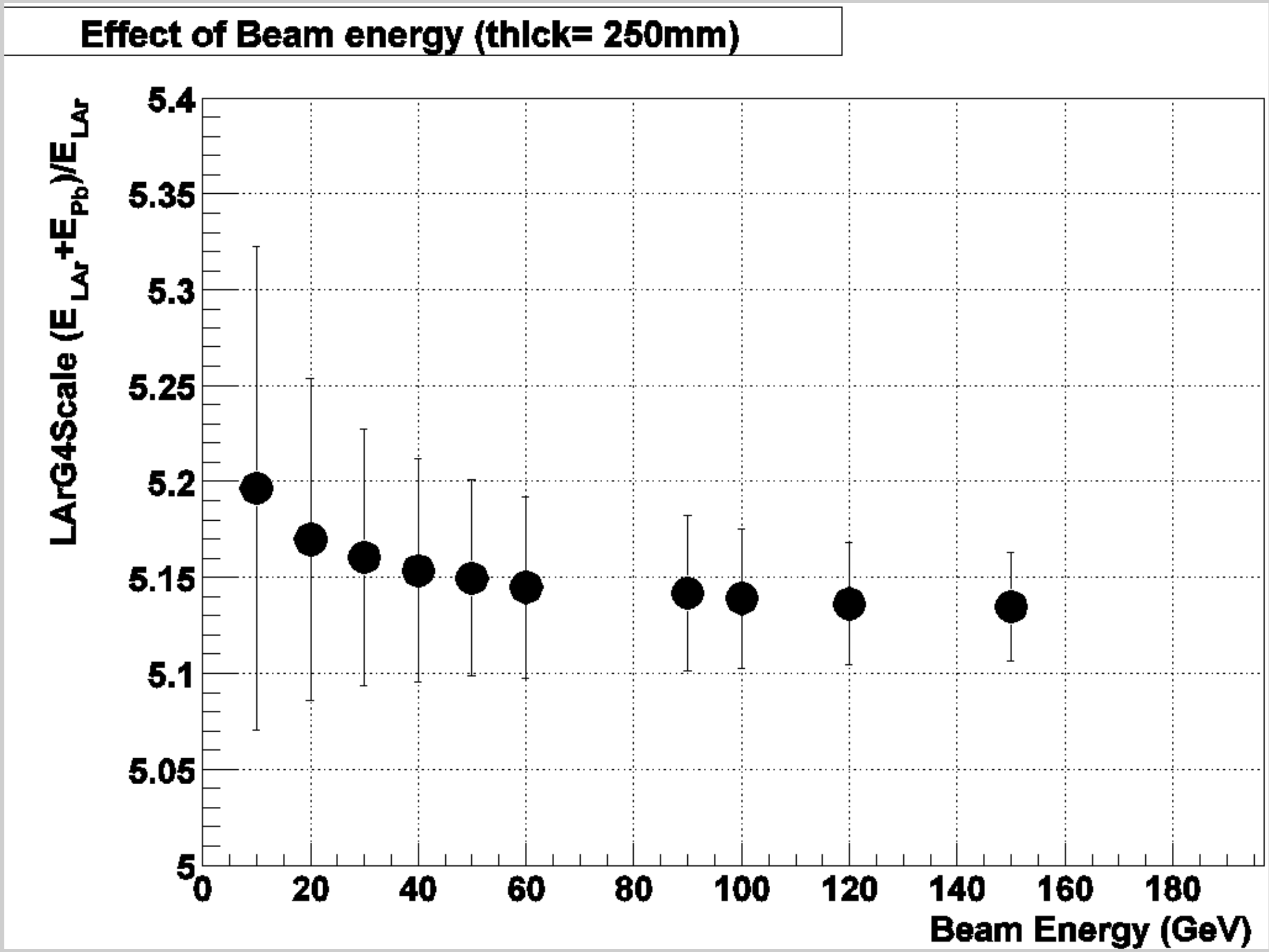
Use a toy Geant4 MC to study these effects (setup by TC)



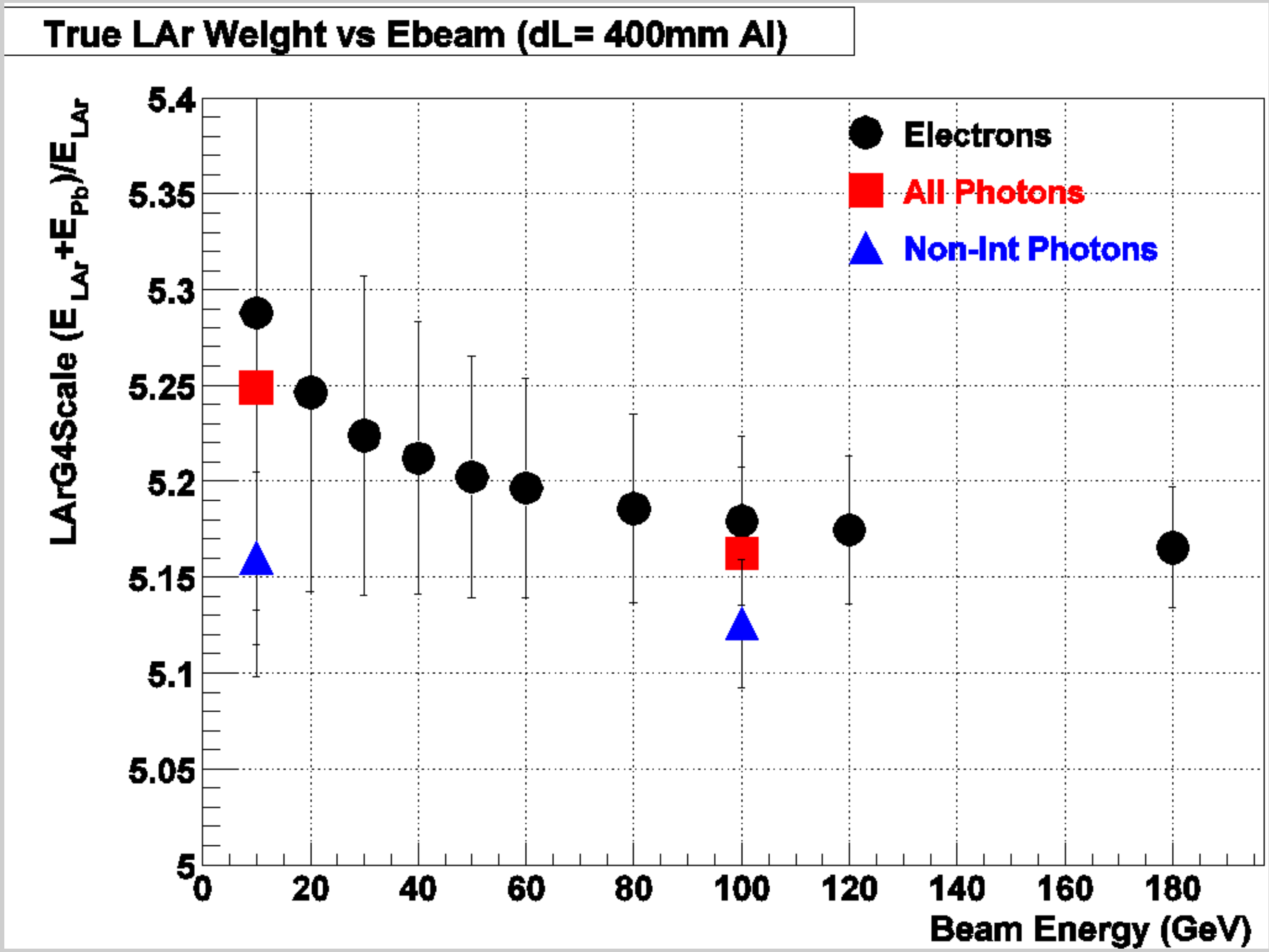
Sampling Fraction: not constant with energy even with ~1X0 in front (i.e. just cryostat)



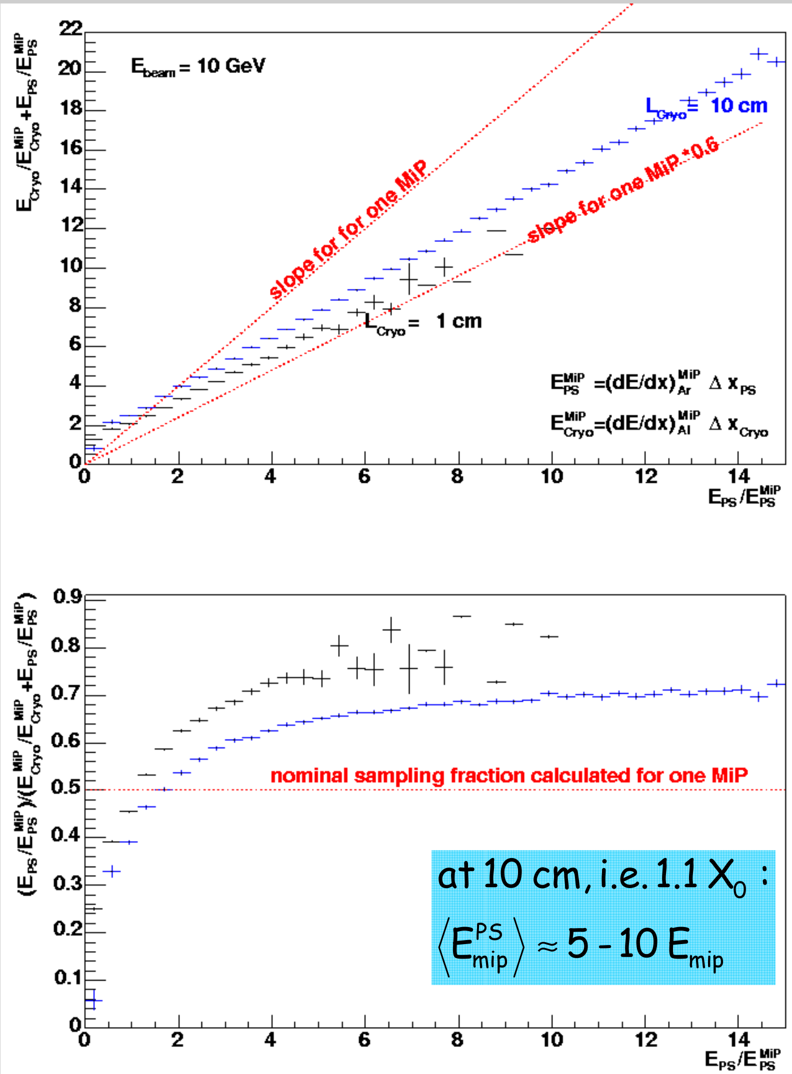
Sampling Fraction: scale and linearity depends on amount of upstream material



Photon vs Electron Response: obvious differences (how do we proceed?)



Use $E_{rec}=W_0E_{PS} + W_{acc}E_{acc}$ to solve the problem



But, it is obvious that there is an offset:

$$E_{cryo} + E_{PS} = a + b\,E_{PS}$$

which is ~1 MIP ~ 40MeV (for 10cm)
In the test beam TC found a much larger offset ~150MeV which he then attributed to material between PS and Strips: **Perrodo ATL-LARG-2001-002**

TC naturally proposed a modified parametrization which optimizes simultaneously both linearity and resolution (see LAr talks):

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

How much energy is this offset?

Material	X0(g/cm^2)	dE/dx (MeV/cm)	ρ (g/cm^3)
Argon	19.55	1.519*ρ	1.396
Pb	6.37	1.123*ρ	11.35
Al	24.01	1.615*ρ	2.7

So, for 25cm of upstream Aluminum (corresponds to the ATLAS central region) one gets for 1 MIP ~ 1.615*2.7*(25cm) = 110MeV

From DC1 a ~200MeV was found from electron fits (see later)

Notice: there are more/new ideas from the Barrel LAr group

- **G. Graziani**
  - For Optimum Resolution: take into account the material between the PS and Strips (1/4 in the PS, 3/4 in the strips SF)
- **T. Carli**
  - Proposed a different PS vs Strips sharing
- **D. Fournier, Kado, Serin**
  - Hybrid EM energy reconstruction scheme (3/04 LAr-week)
- **More?**

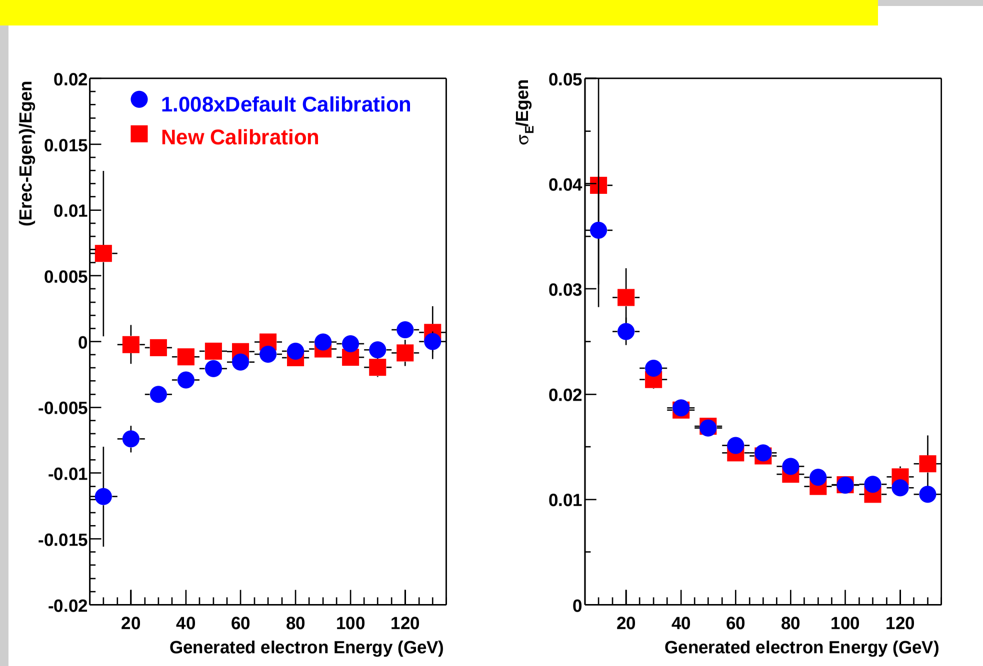
Apply a new Calibration in Athena

New LAr Barrel Calibration

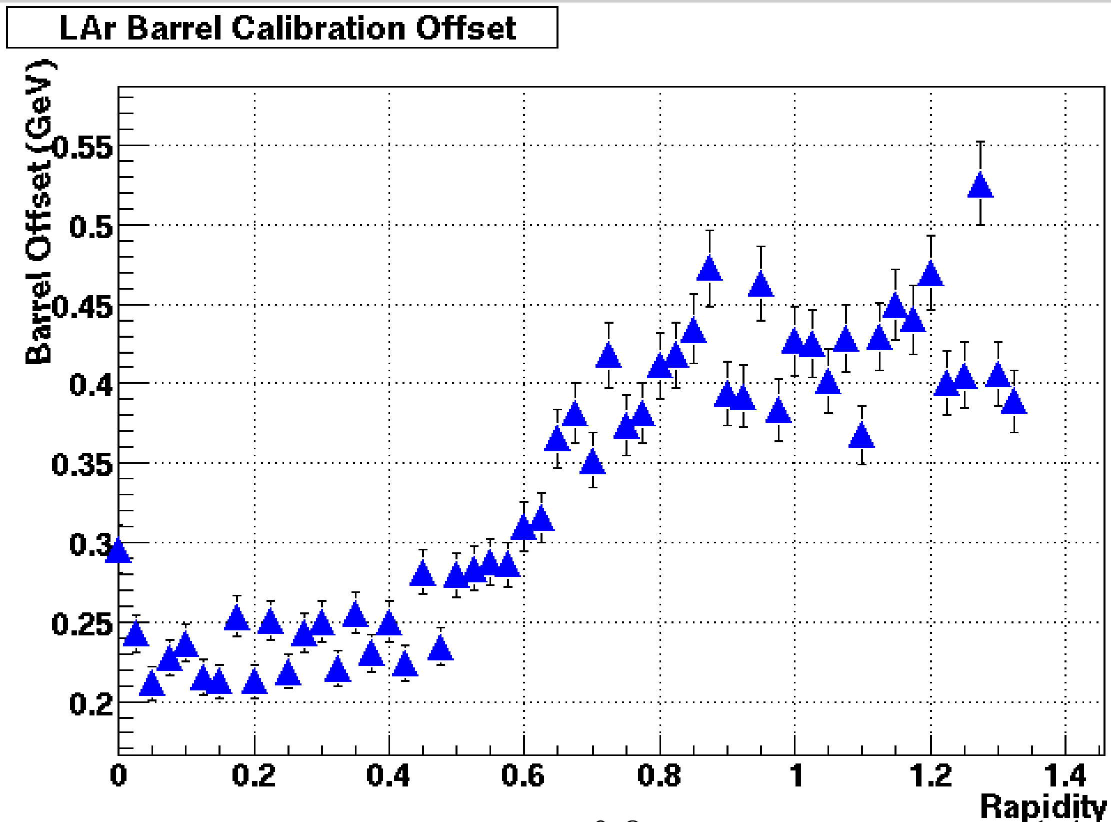
- Uncorrect present calibration in ATHENA. In ATHENA, this is done in cells (**not quite proper strategy**), but we can only uncorrect clusters!
- Use part of the present samples to extract the calibration constants λ, b and W_0:

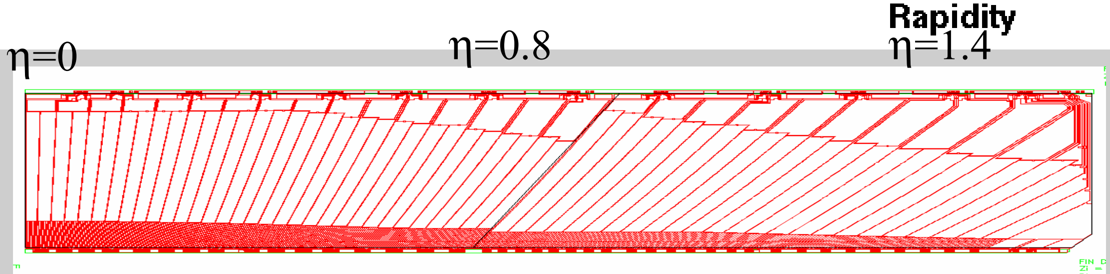
$$E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + W_3 E_3\right)$$

Offset necessary to correct for residual Accordion non-linearity due to upstream material. Correction may have a different form due to the presence of material between PS and Strips (T.Carli) !

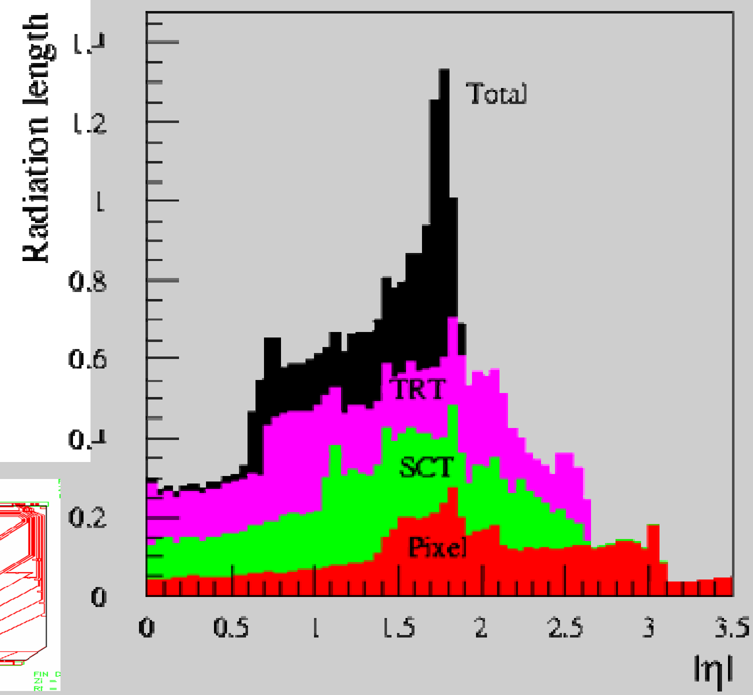


Offset is large and correlated to the upstream material



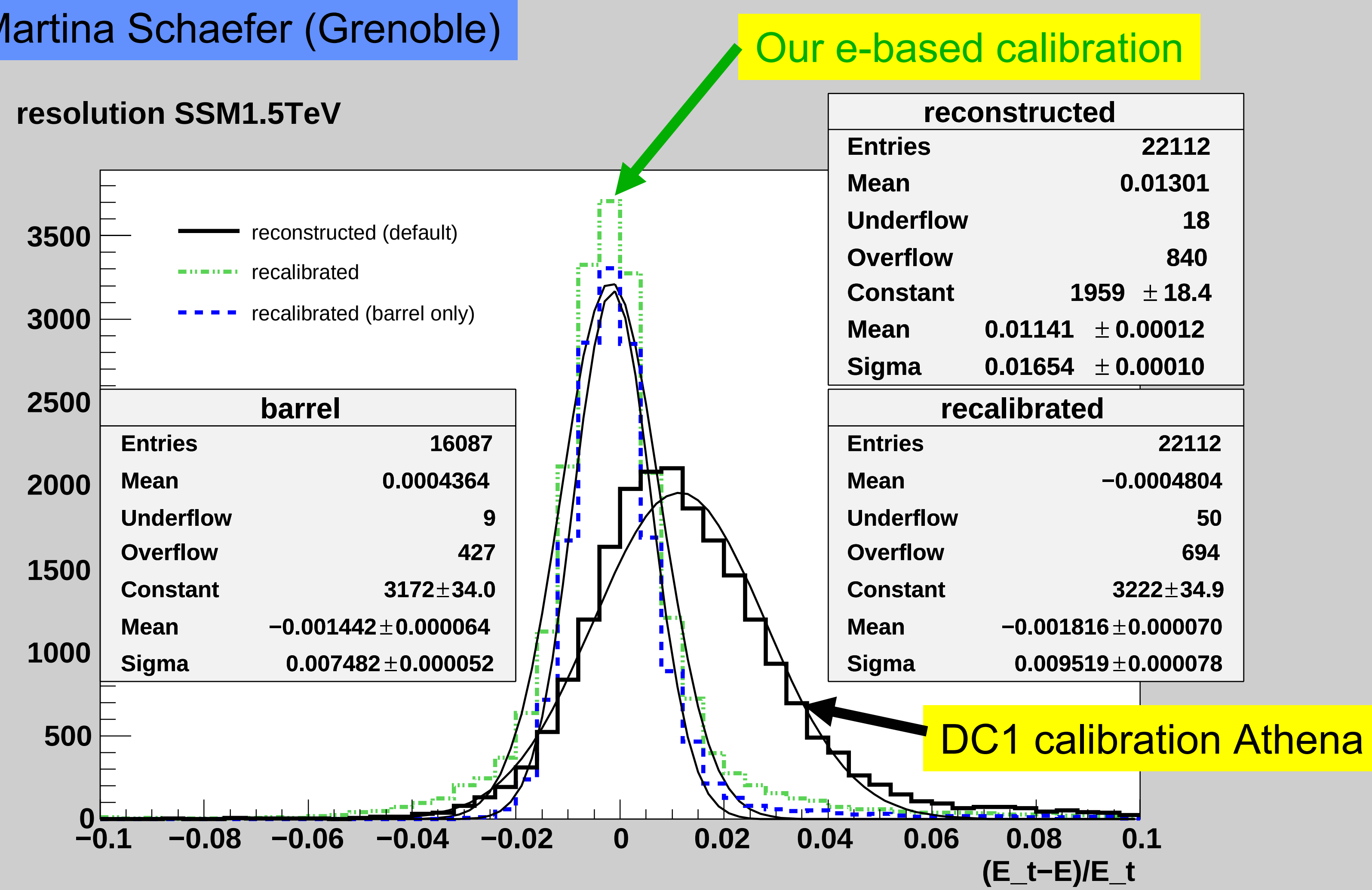


- We calibrate within |η|<1.37
- We use 54 η bins i.e. the granularity of the second sampling (Δη=0.025)



Very high energies: for Z'(1.5TeV)->e^+e^-

plot from Martina Schaefer (Grenoble)

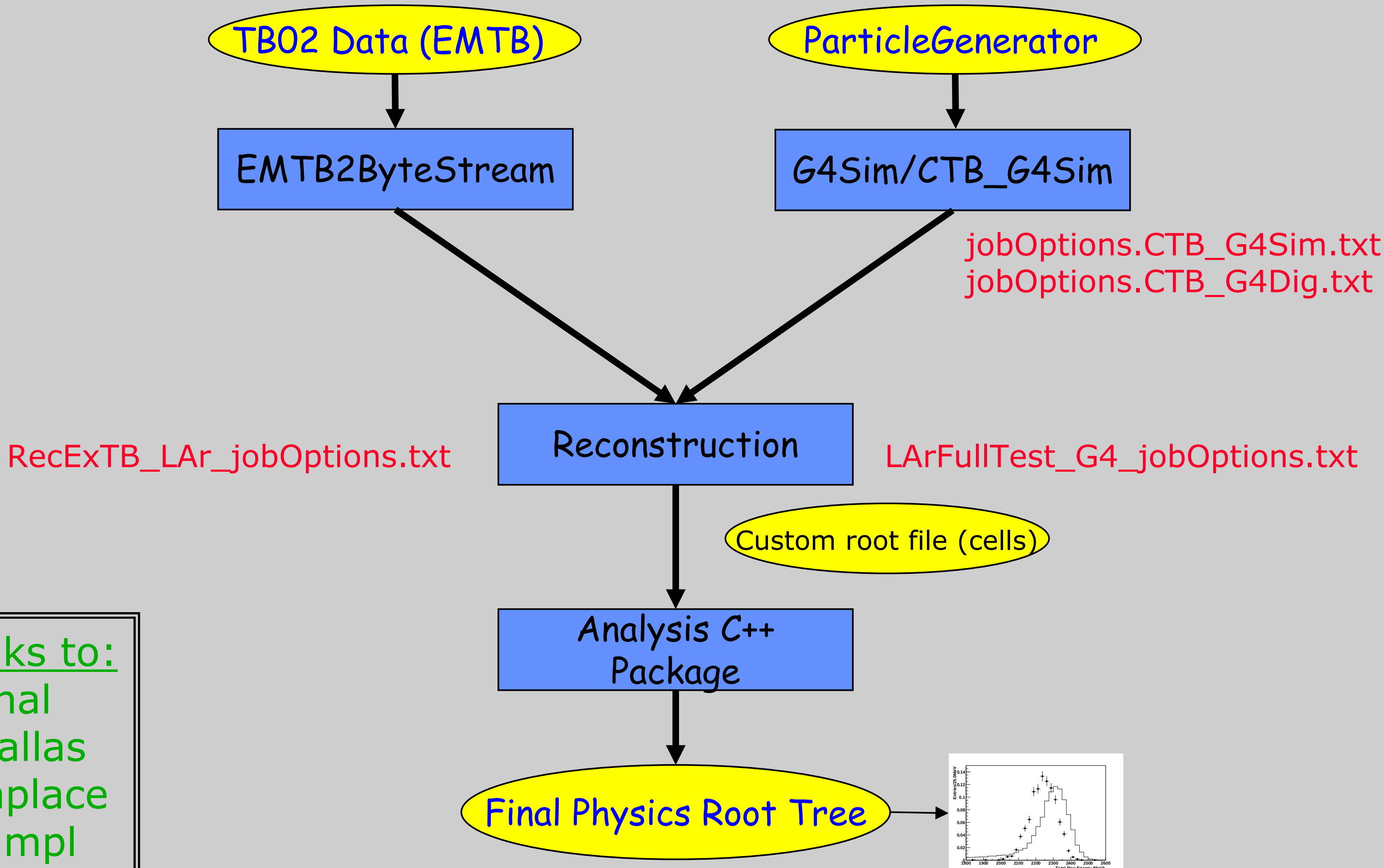


(electron True Energy – Recon Energy) / True Energy

New G4 must be validated

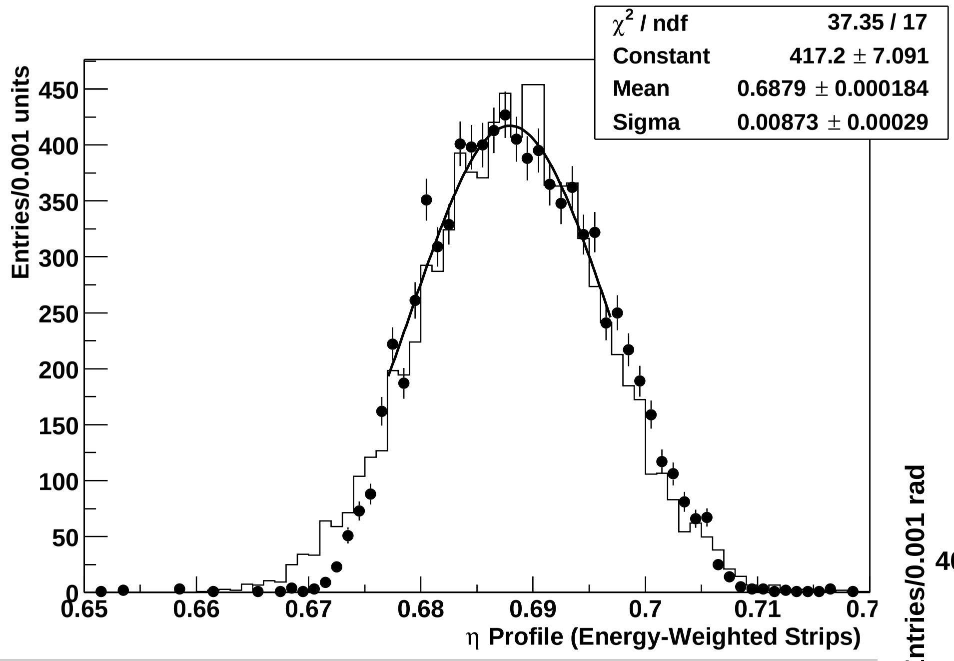
- ✓ We started an effort (SP + TC) with the help of several people to validate the new G4 using TestBeam2002 data
- ✓ We work both inside and outside the Athena framework
  - Gained experience on how to use the CTB04 software
  - First experience: very positive!
- ✓ First results encouraging but a lot of work is needed to control the systematics
- ✓ For more details look at LAr Offline talk (June/04)

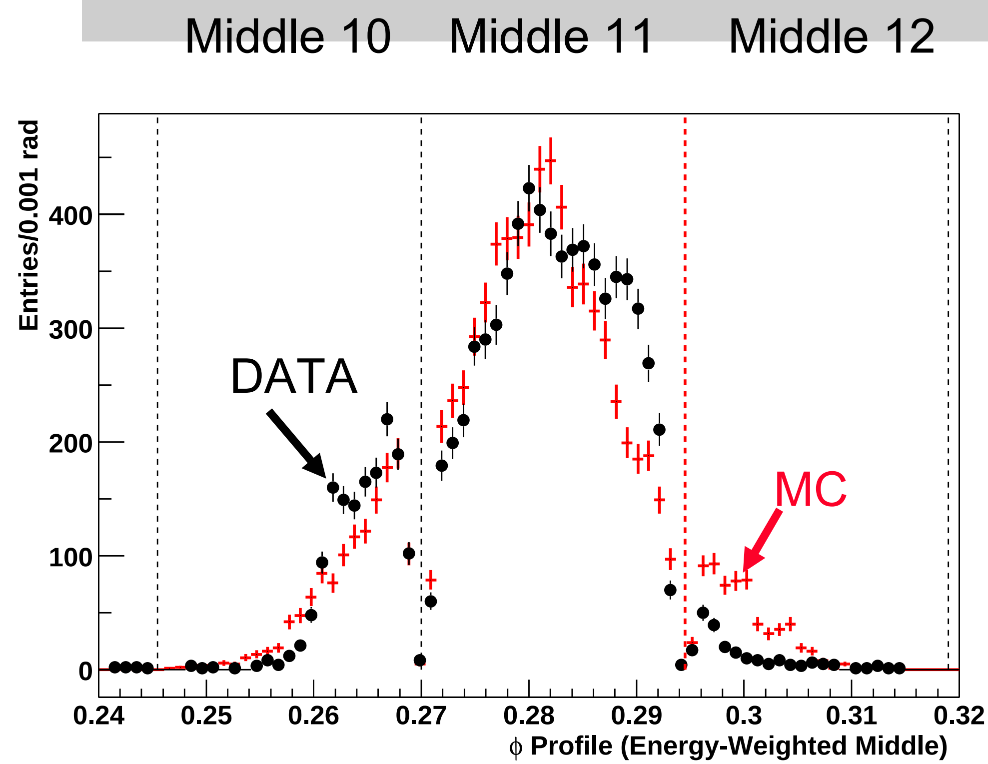
Program Flow (release 8.X.X):



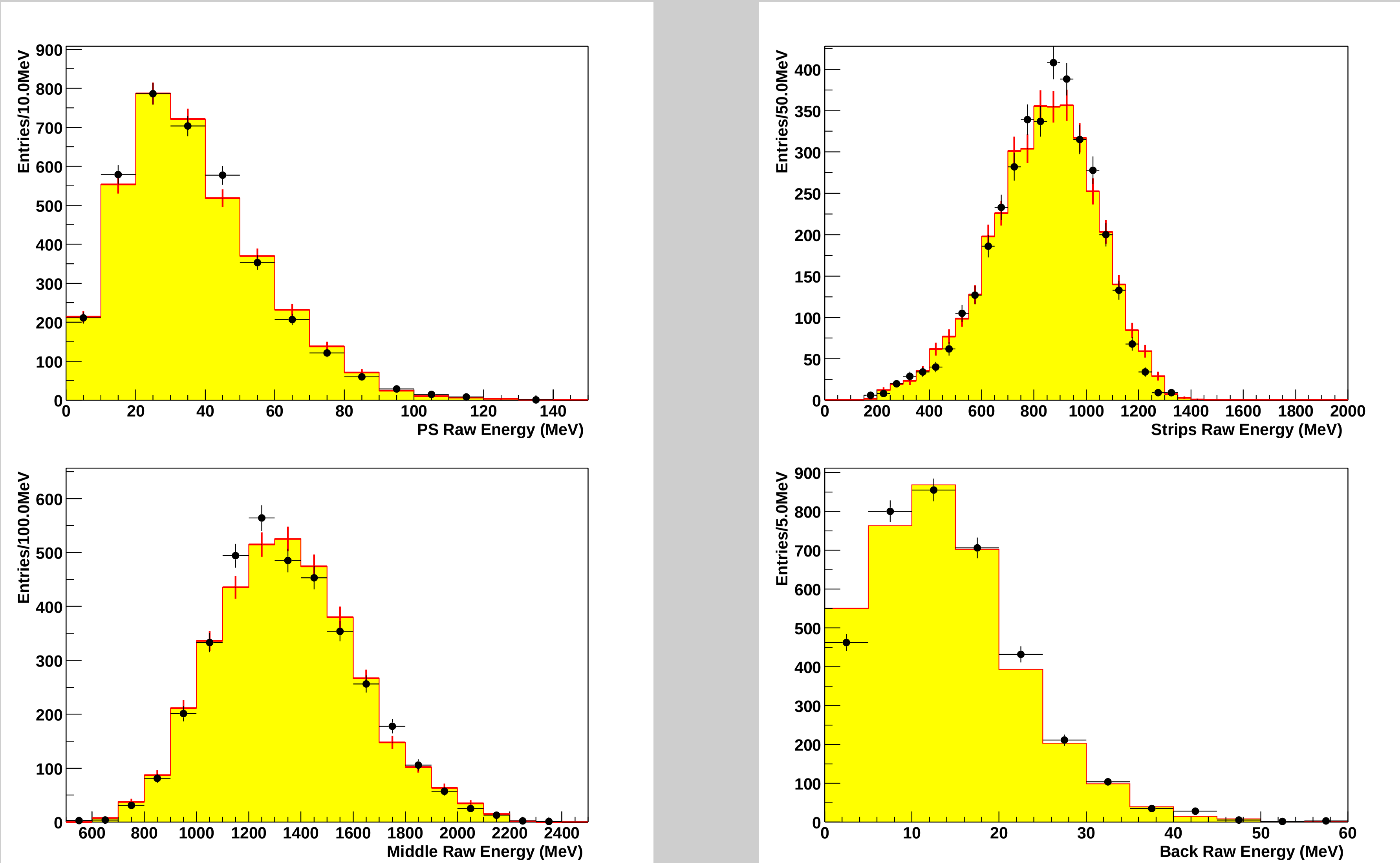
Thanks to:
G. Unal
M. Gallas
S. Laplace
W.Lampl

Beam profile control plots first

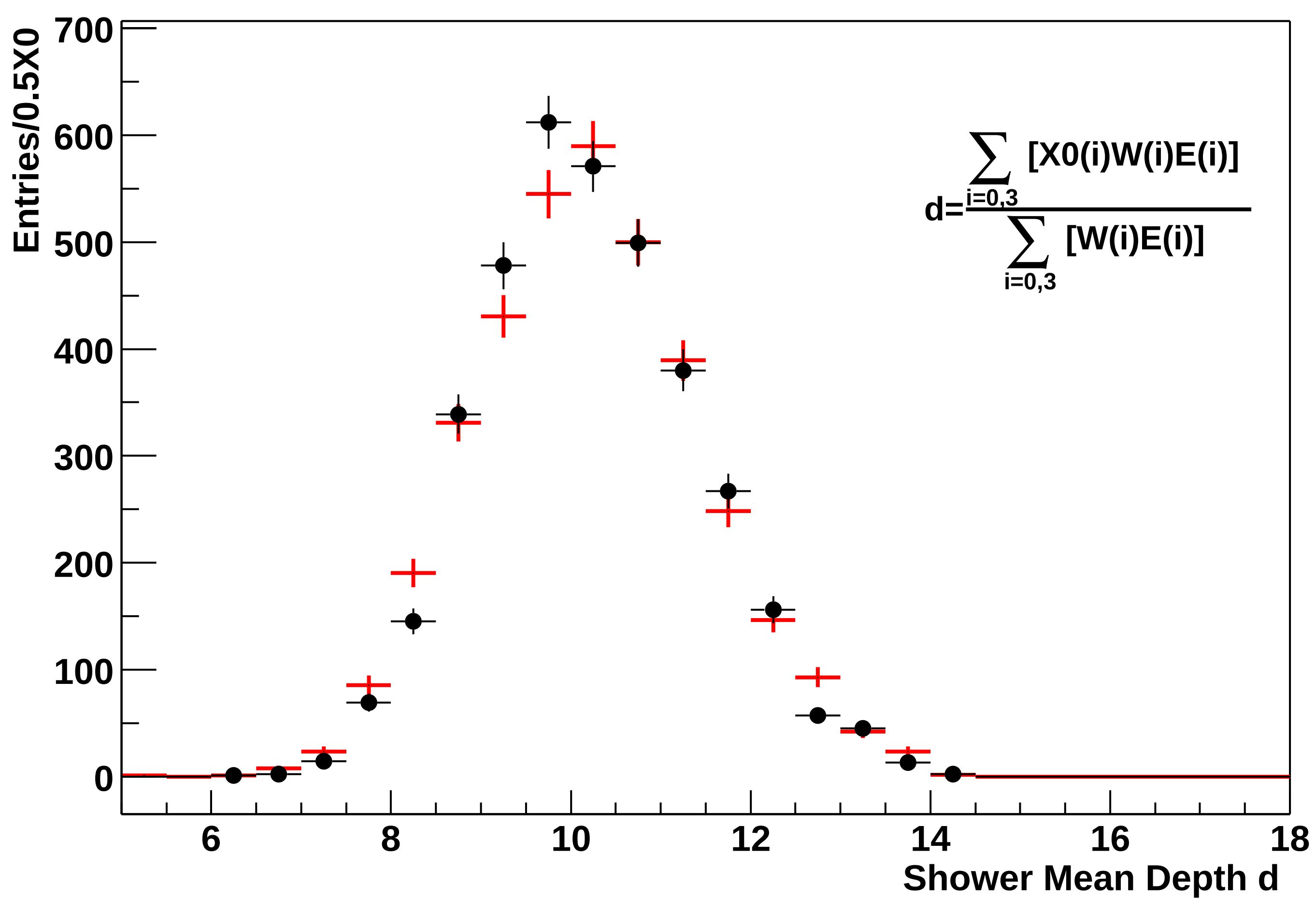




Visible Energy per LAr Sampling 15GeV



Effective Mean Shower Depth 15 GeV



Photons: What kind of weights?

- It is not so obvious: we are dominated by conversions mostly asymmetric, which means that lower energy electrons (say 1-5GeV) may become important (linearity question again)
- First naïve approach:
  - Apply electron weights (with offset) for conversions
    - For example cluster/track match may used as a tag
  - Apply photon weights (no offset) for un-converted photons
    - Example isolated un-matched EM clusters
- But imagine a 20GeV electron versus a 20GeV photon converting to 18GeV+2GeV
  - Does the electron calibration "offset" make sense in this case?

CTB04: important data for e/γ

- ✓ We must study/understand the EMBarrel response for electrons for variable upstream material.
- ✓ Need to take runs with 0,1,2,3,…X0 of upstream material
- ✓ Would also like to take "photon" runs with both e and γ making separate clusters in the Barrel
- ✓ How large is the SFe/SFγ vs upstream material? Will come from MC, but at least we can attempt to check with data

Work Plan

- **Proceed with G4 validation with TB02 data**
- After a proposal of e runs from the coordinators we must run CTB04 simulations to check the proposal + gain experience
- "photon" runs we may want to check the setup with simulation before data taking
- Concerning DC2 (see tomorrow) we plan to apply electron based weights at the cluster level for releases past 9.0.0