Tuning of simulation and detector description for electrons and photons: what is relevant to jet/E_T^{miss}?

- **Scale and resolution**
- **Measurement errors**
- **Mapping of material in front of EM calorimeters ($|\eta| < 2.5$)**
- **Inter-calibration: E/p with inclusive e versus Z to ee decays**
- **Certification of loop: MC $\rightarrow$ data $\rightarrow$ adjusted MC $\rightarrow$ etc…**

EM calorimetry: scale, linearity, noise and resolution

For jets and E_T^{miss} what is required?

1. Correct scale for 0.5 to 10-20 GeV (not the usual concern of egamma!):
   ~ 2-3% for 2009-2010 (temperature in TB and pulse shape)?
   Important requirement: E_T^{miss} scale for W to eν

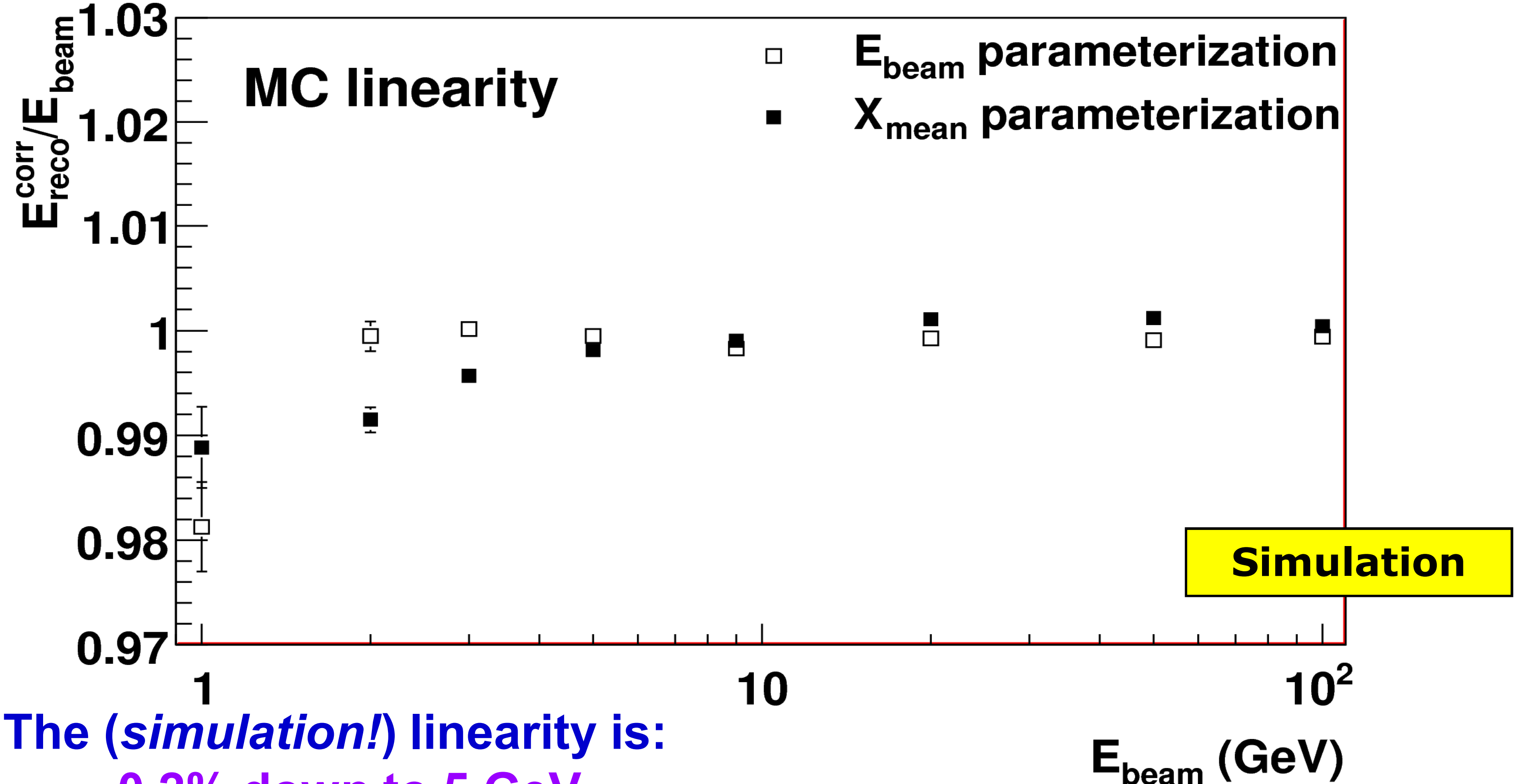
2. Good linearity over same range: ~ 1% for 2009-2010?

3. Stable noise performance (also for E_T^{miss}):
   achieved with cosmics?

4. Reasonably well understood resolution:
   are current expectations from test-beam sufficient?

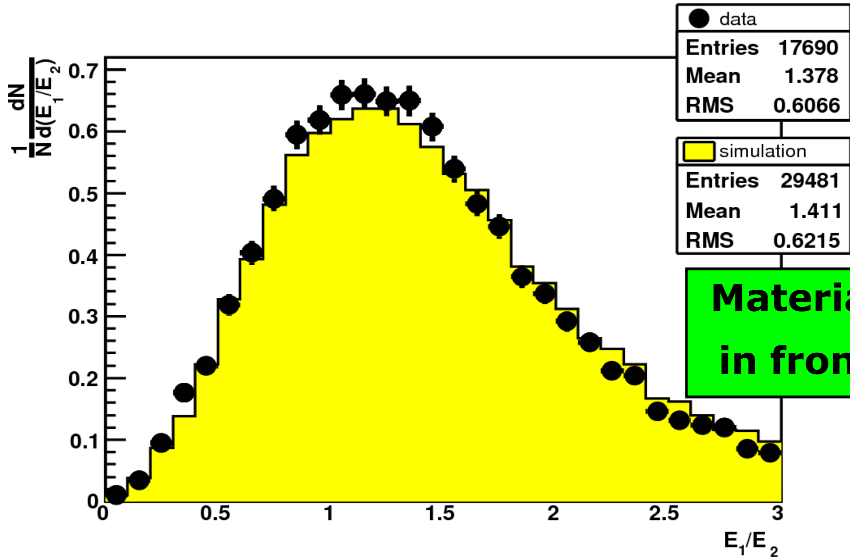
5. No sizable dead areas: OTX problems?

Electrons in TB: linearity (MC, two methods)

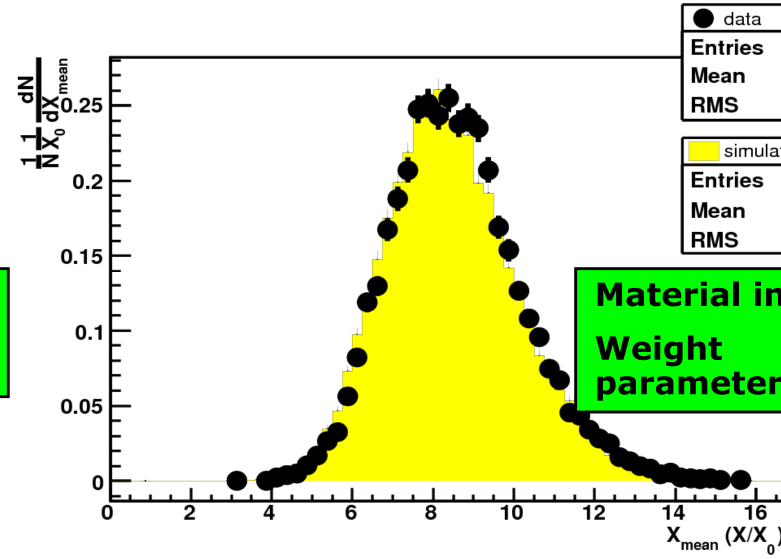


- The (*simulation!*) linearity is:
  - ~0.2% down to 5 GeV
  - ~1% down to 1 GeV
- The E_{beam} parameterised weights behave slightly better at 2 and 4 GeV, while the X_{mean} parameterised weights do better at 1 GeV
- The deviation from linearity is related to *goodness of the parameterisation* of the sampling fraction correction at low energy…

Electrons in TB:
E1/E2, X_{mean}, total energy, lateral profile at 3 GeV

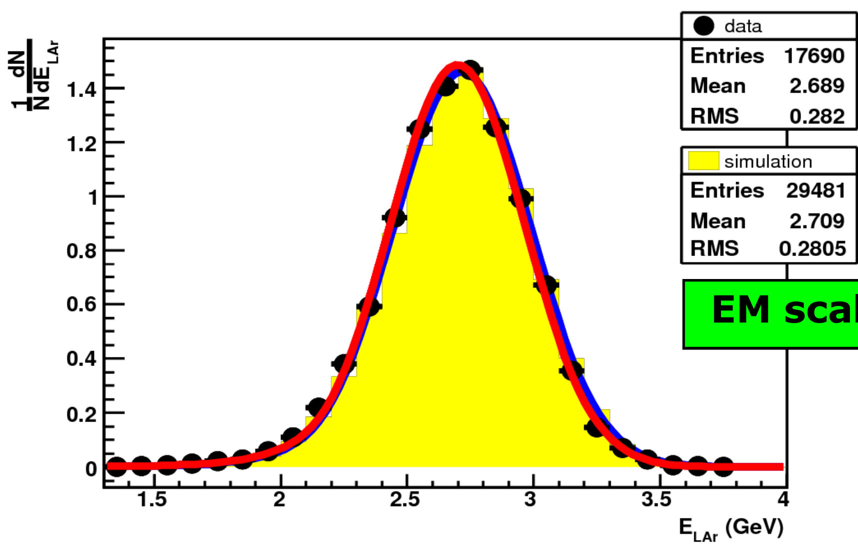


Material in front

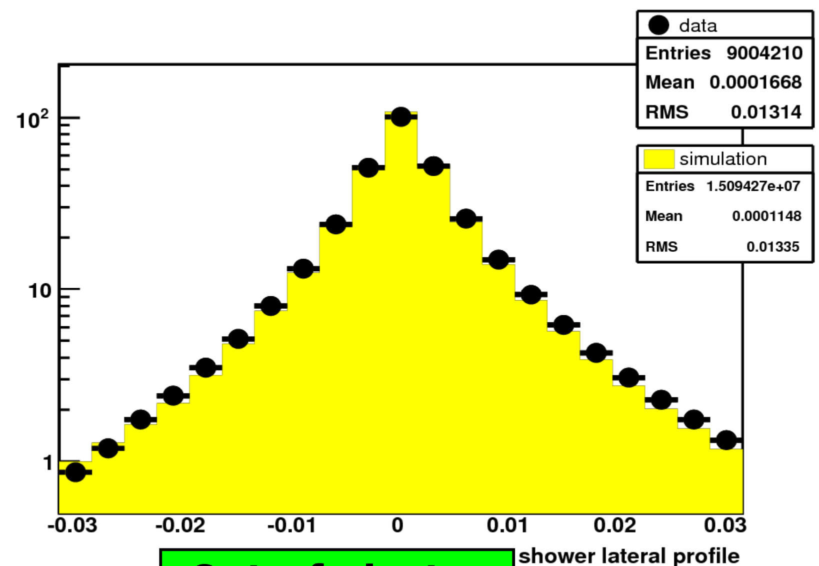


Material in front

Weight parameterisation

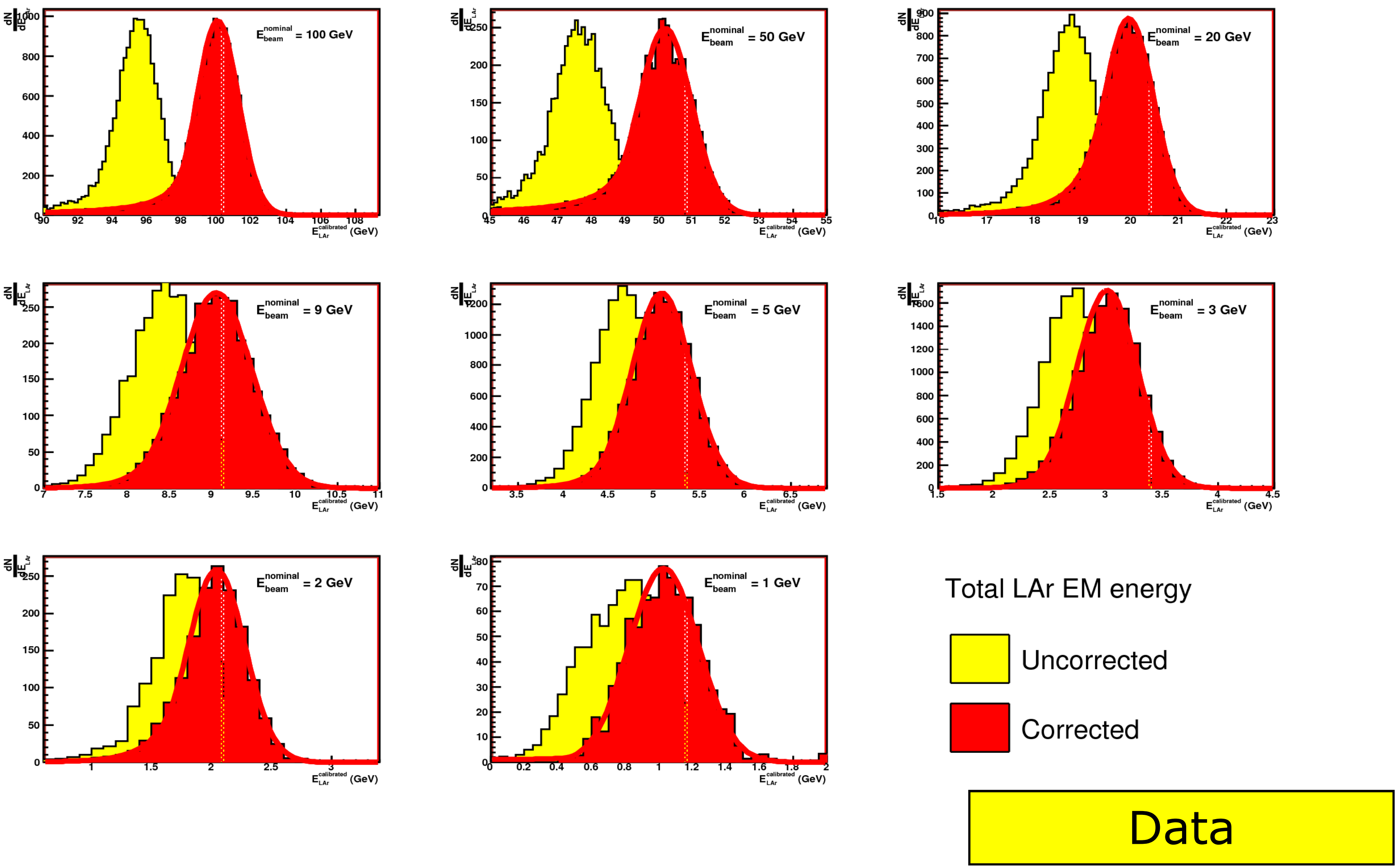


EM scale

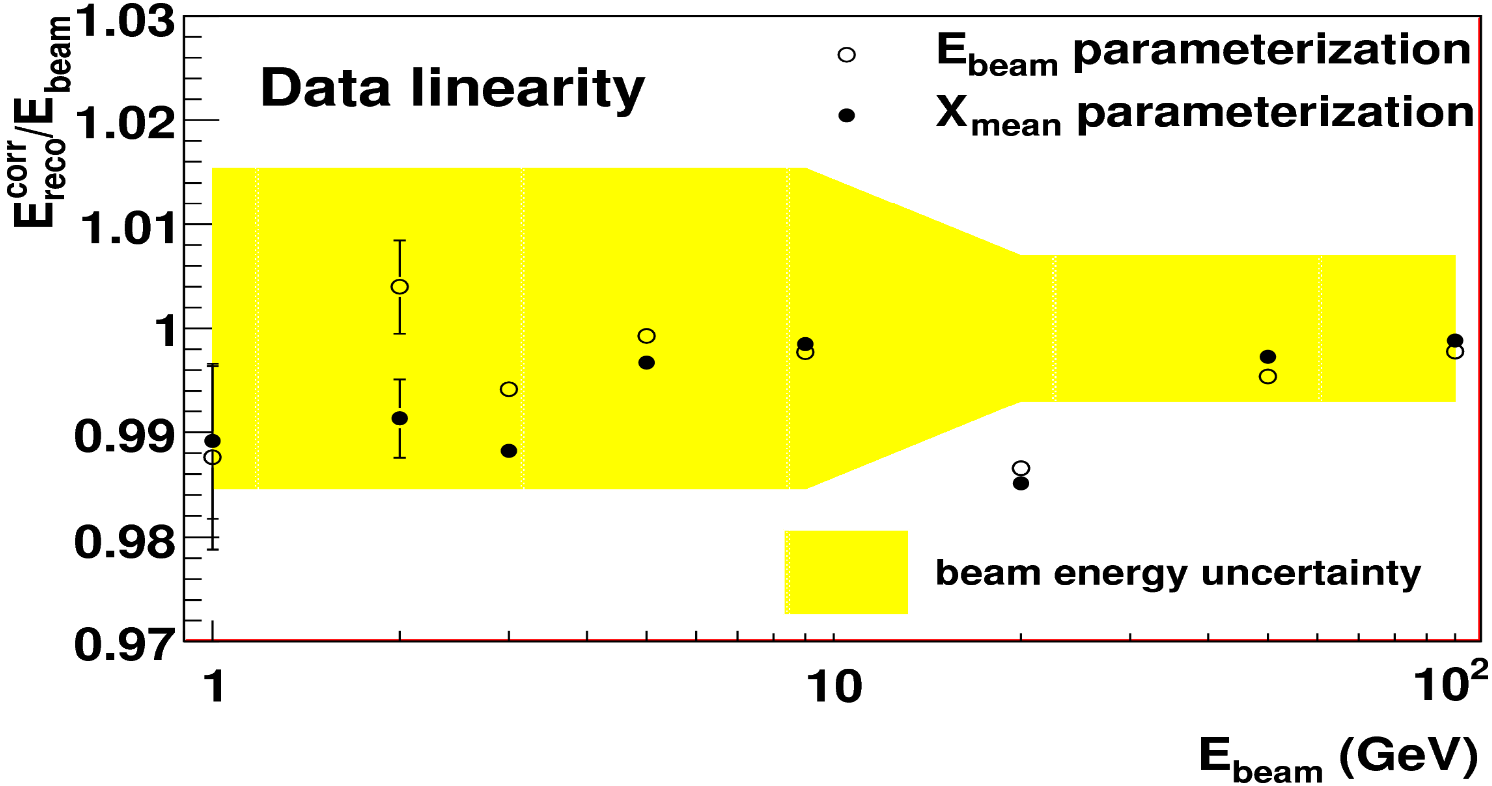


Out-of-cluster corrections

Electrons in TB: total energies (data, X_{mean} weights)



Electrons in TB: linearity (data, both methods) …



The linearity is dominated by the goodness of the Data/MC agreement! The pattern corresponds to the MC linearity "convoluted" with the data/MC ratio

The largest deviation is ~1.5% (at 20 GeV): worse knowledge of the beam energy

For both weight parameterisations, the RMS of the linearity is ~0.4%

Tuning of simulation and detector description for electrons and photons: what is relevant to jet/E_T^{miss}?

- Scale and resolution
- Measurement errors

  http://indico.cern.ch/getFile.py/access?contribId=58&sessionId=3&resId=1&materialId=slides&confId=43390

- Mapping of material in front of EM calorimeters ($|\eta| < 2.5$)
- Inter-calibration: E/p with inclusive e versus Z to ee decays
- Certification of loop: MC $\rightarrow$ data $\rightarrow$ adjusted MC $\rightarrow$ etc…

Measurement errors in egamma (releases 15.2.0 and 15.3.0)

- Modified electron and photon objects include energy momentum covariance matrix

- Allows the user to calculate the invariant mass from electron objects correctly (this will eventually extend to objects of all types, eg Z to $\mu\mu$g decays, W to jj decays, etc.)

- Core code is in 15.2.0 for I4Momentum. What does jet/E_T^{miss} software need to do?
  - for jets, build concrete 3x3 error matrix for jet E, η, ϕ. Code for unconverted photons is a good starting point
  - need also to write methods to convert on the fly this 3x3 error matrix to the generic 4x4 matrix common to all object types and its different representations
  - need to pick up errors from COOL database (first implementation of COOL for InSituPerformance package provided by J. Mitrevski for egamma in 15.3.0)
  - for neutrinos, error matrix should probably be built empirically

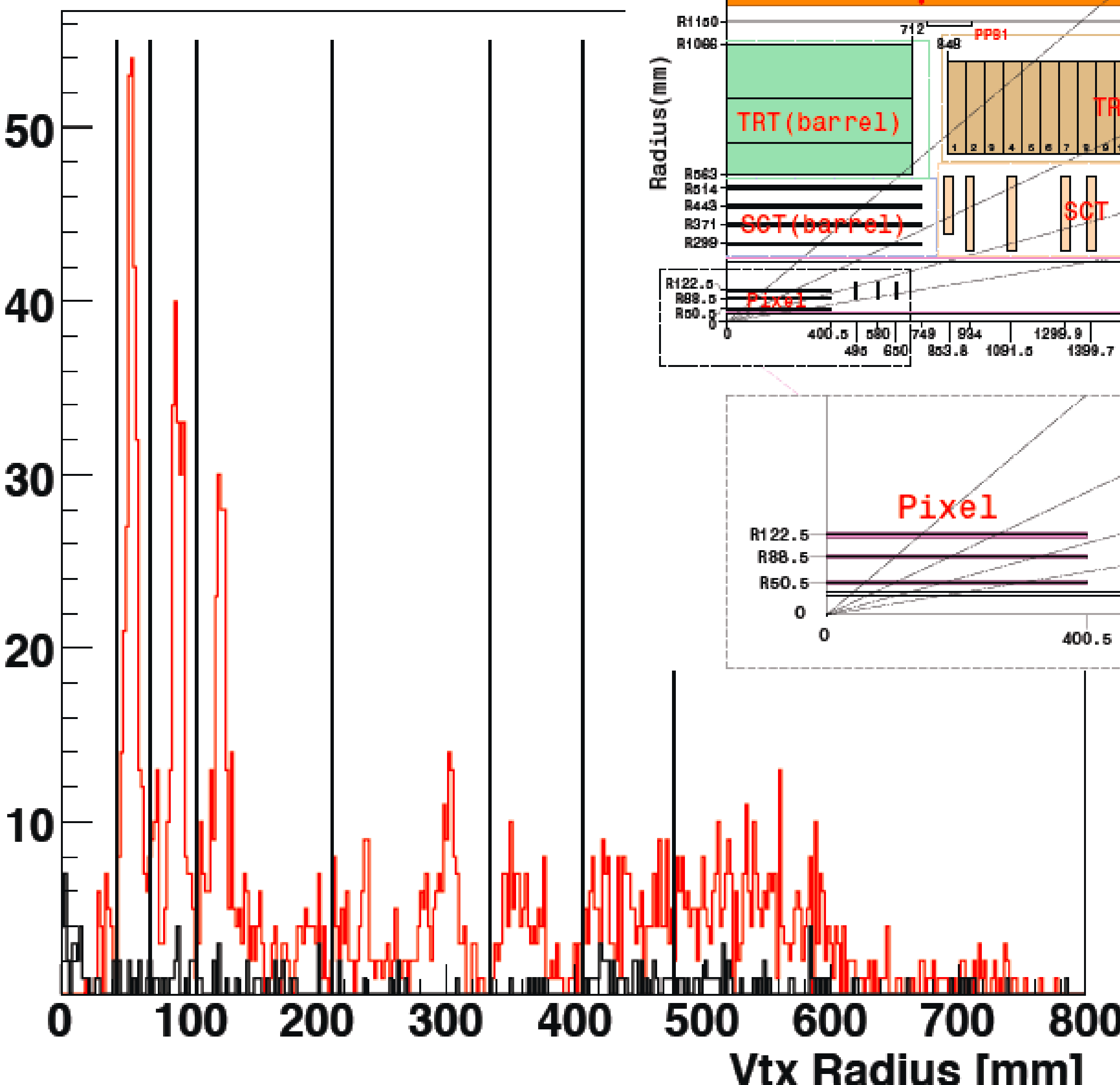
Mapping of material in front of EM calorimeter

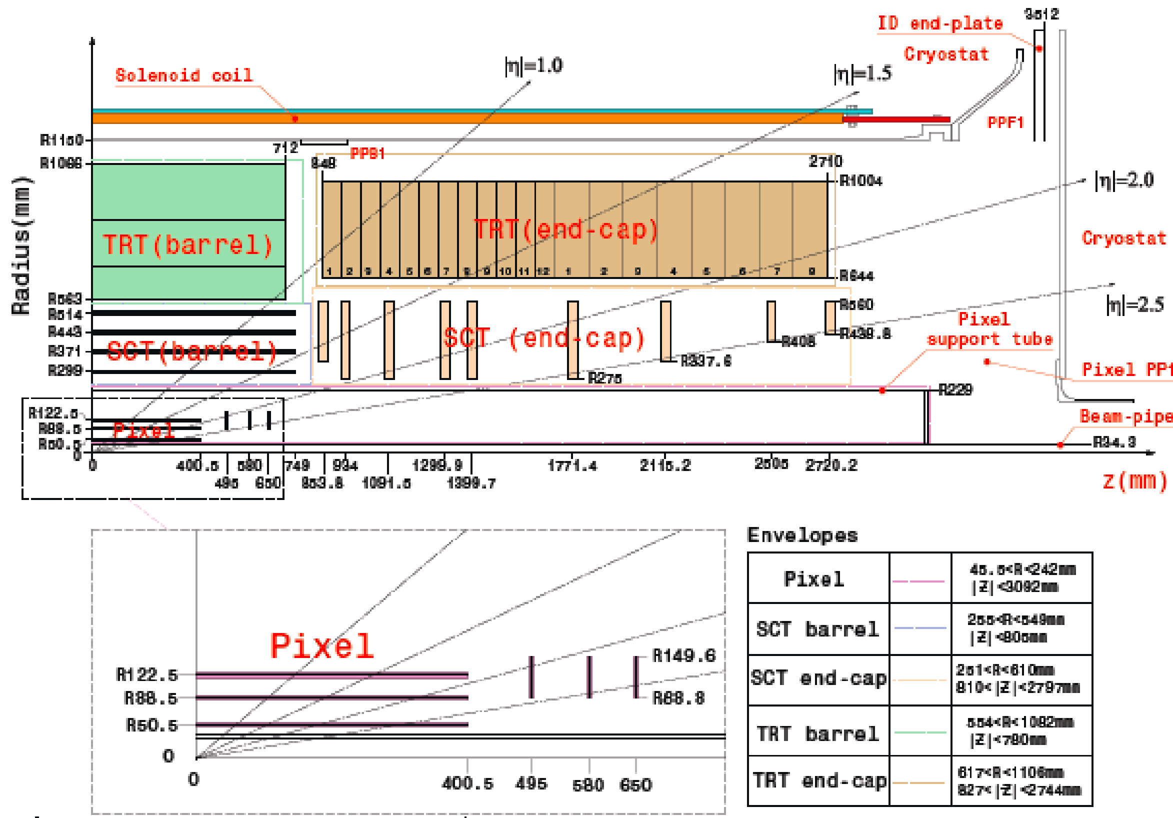
- The importance and duration of this exercise should not be underestimated: the amount of material in the ATLAS (and CMS) trackers is unprecedented in the history of collider experiments

- The work done to itemise and weigh the tracker components and towards the end the tracker macro-assemblies is also unprecedented: we believe we know the weight, X_0 and λ of these macro-assemblies to better than few % of X_0

- The work to do to verify the above to the accuracy required for egamma (in particular for the W mass measurement) of ~ 1% X_0 (at least near the beam line) is colossal and also challenging:
  - photon conversions for material with R < 80 cm: dominant systematics from knowledge of ε versus R
  - shower shapes in EM calorimeter for R > 80 cm: dominant systematics from data/MC agreement (~ 5% X_0)
  - brem recovery tools may also play a role (especially Calobrem)
  - more sophisticated tools (J/ψ mass versus p_T) as cross-checks

Mapping of material in front of EM calorimeter: reconstruct photon conversions in min. bias events





M. Donega

Mapping of material in front of EM calorimeter: fake rate small at low R except very near beam

Dalitz et al.: cut on the radius

	Conversions	Fakes	Fakes/ Conversions
beam pipe	60	64	1.1
B-layer	594	20	0.03
Pixel 1	530	36	0.07
Pixel 2	620	54	0.09
SCT 1	464	18	0.04
SCT 2	244	10	0.04
SCT 3	364	68	0.18
>= SCT 4	812	114	0.14

M. Donega

Mapping of material in front of EM calorimeter

Use 350 k min. bias to reco γ to ee with $p_T > 1$ GeV

Use beam-pipe and Pixel Support Tube to control ε_γ

A few months at 200 Hz will provide all the statistics required

$|\eta|<1.0$ **Truth** **M. Donega** $|\eta|<1.0$ **Reco**

Layer	Nc	x/X0(%)	δx/x
beam pipe	136	0.45	-
b-layer	934	3.12 ± 0.27	9%
extra material	207	0.69 ± 0.07	10%
Pixel 1	911	3.04 ± 0.26	9%
Pixel 2	944	3.16 ± 0.27	9%
PST	145	0.48 ±0.06	11%

Layer	Nc	x/X0(%)	δx/x
beam pipe	11	0.45	-
b-layer	127	5.3 ± 1.6	31%
extra material	16	0.7 ± 0.2	35%
Pixel 1	103	4.3 ± 1.3	31%
Pixel 2	76	3.1 ± 1.0	31%
PST	7	0.29 ± 0.2	66%

In situ calibration for egamma: goals and tools

✓ Note that standard ATLAS simulation does not contain all ingredients describing the detector behaviour, neither for electrons, neither for jets:

a) inter-calibration spread: ~ 1.5% in EM calo, similar in hadronic calorimeters?

b) global constant term: ~ 0.7% in EM calo, much larger in hadronic calorimeters (clear signs seen in E_T^{miss} behaviour for events with very large ΣE_T)

✓ Inter-calibration for EM calorimeters can be performed with E/p (relies on tracker) or Z to ee (without relying on tracker) but not without having understood material in front of EM calorimeter to some degree of accuracy. In this session, we will see how well E/p can be used for hadrons with similar goals.

✓ Global constant term can only be measured with very high E_T objects which is unlikely to happen in 2010 for the EM calorimeter. It may however be possible for jets (?)

Inclusive electron rates expected for 100 pb^{-1}

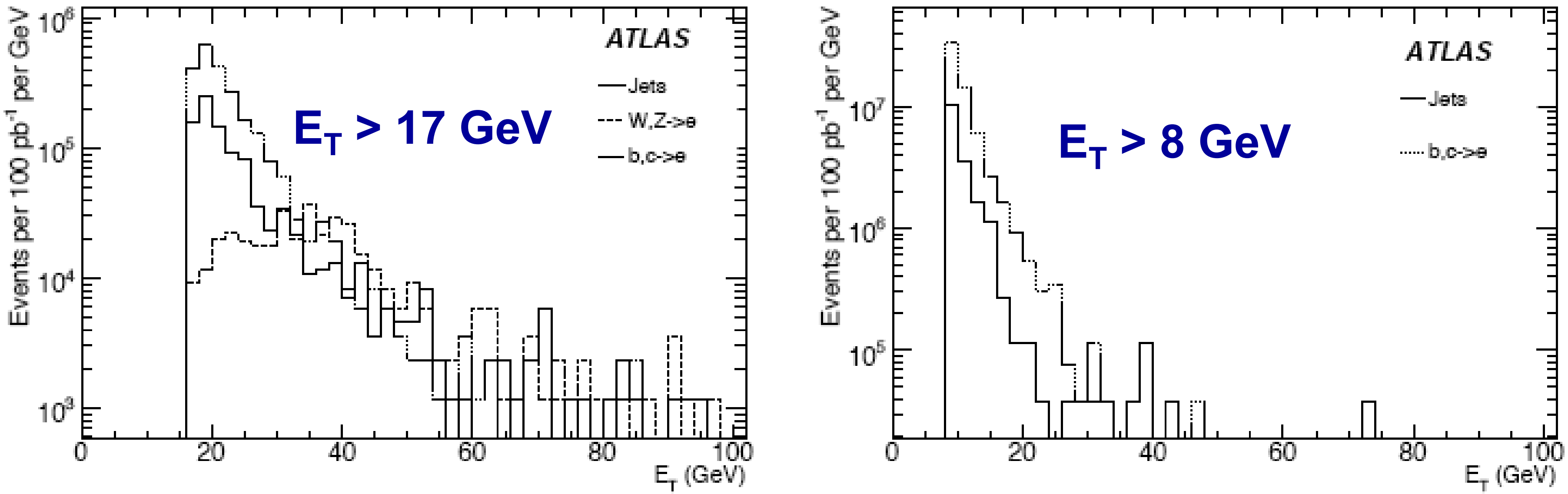


Figure 4: Differential cross-sections as a function of E_T after tight (TRT) cuts, shown separately for the expected components from isolated electrons, non-isolated electrons and residual jet background, for an integrated luminosity of 100 pb^{-1} and for the simulated filtered di-jet sample with E_T above 17 GeV (left) and the simulated minimum-bias sample with E_T above 8 GeV (right).

- ✓ **Expect ~ 10^5 electrons from b,c decay per pb^{-1}**

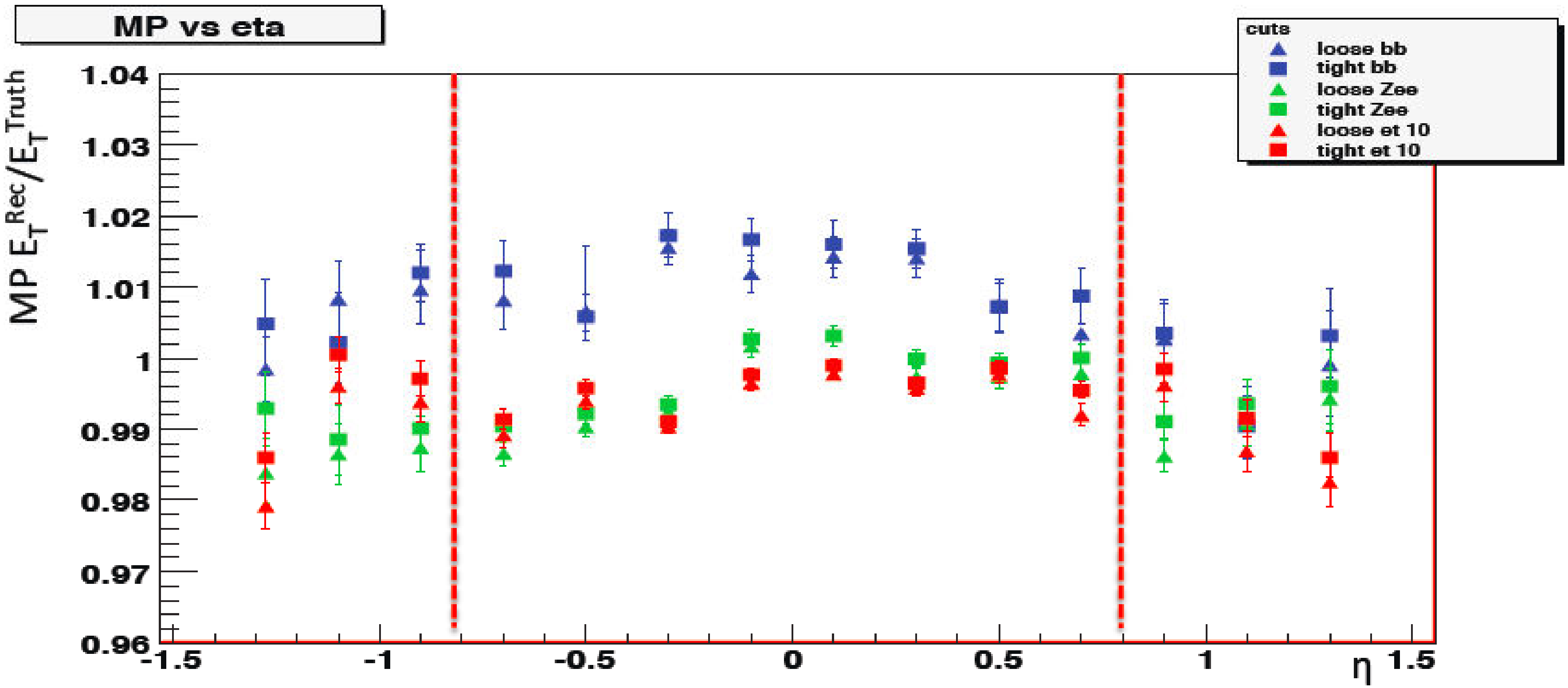
  Note that this method was pioneered by CDF in Run I

  See talk by M. Vincter on Tuesday for more info on E/p

- ✓ **Expect ~ 3000 W to eν and 300 Z to ee decays per pb^{-1}**

Inter-calibration with electrons from b,c to e

bb->e7X pt = 10-20 GeV; Z->ee pt = 10-20 GeV; single electron 10 GeV



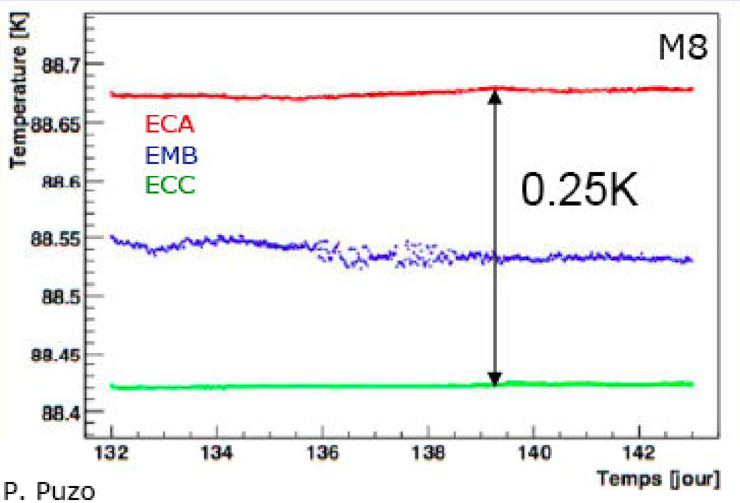
- No significant difference between loose and tight cuts
- MP shifted by about 1% for bb->e7X
- No significant η dependence

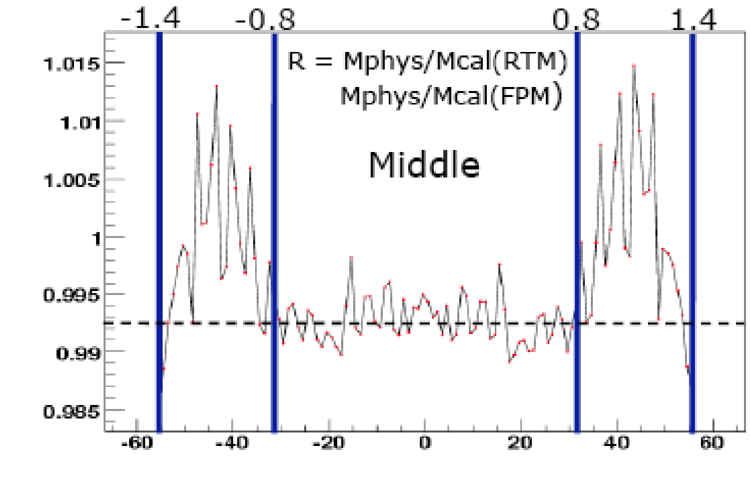
✓ **Expect ~ 200 electrons per cell from b,c decay per 10 pb^{-1} with purity as high as 90% if required (TR helps!)**

What about Z to ee with 10 pb^{-1}?

Simulation

- Simulation of the effect of extra-material
  - Used misal1 data
- Simulation of calorimeter miscalibration
  - $E_{new}=(1+\alpha_{inj})E$
    - Temperature
      - $\eta>1.4$: α_{inj} =+0.25%
      - $\eta<-1.4$: α_{inj} =-0.25%
    - Mphys/Mcal
      - $0.8<|\eta|<1.4$: α_{inj} =-1%



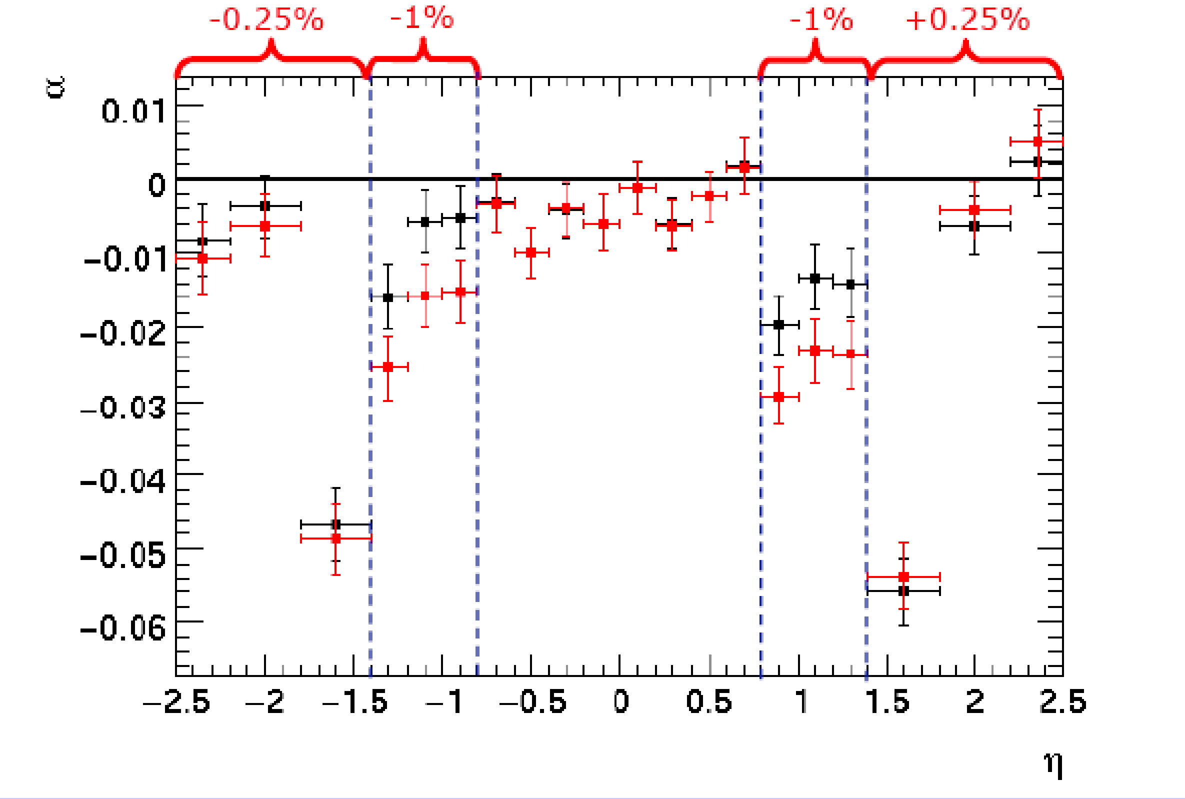


What about Z to ee with 10 pb^{-1}?

Fit results

Misal1

Misal1+simulation calo inhomogeneities



With real data, one cannot disentangle the calorimeter inhomogeities and the effect of extra-material

Outlook

- **For egamma:**
  - **Look more carefully at MC calibration for EMEC inner and Fcal. Need to combine energy range requirements from physics (Z to ee asymmetry) and from jet/E_T^{miss}**
  - **Check EM scale for standard egamma for energies below 10 GeV**

- **For jet/E_T^{miss}:**
  - **Implement measurement errors in EDM (15.4.0?)**
  - **Confirm that a priori knowledge of EM scale at the few percent level is ok for early data**
  - **Confirm whether knowledge of material in front of EM calo at the level of 5-10% X0 is sufficient for early data**
  - **Together with egamma and muons, understand issues related to true versus reco E_T^{miss} in W to lν decays**