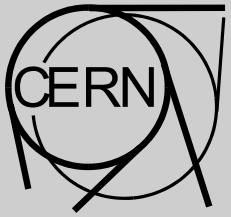



# Higgs -> 4 leptons

## muons: boosting efficiency with the ID
## electrons: LAr Intercalibration effects

B.Mellado, S.Paganis, W.Quayle, Sau Lan Wu
Univ. of Wisconsin

Higgs WG, CERN, Nov-3-04

# muons: boosting the Higgs efficiency

# Muons: efficiencies for 8.7.0

- MuCB: 90% (official Validation 8.7.0)
- MuCB: 90% (our analysis)
- Higgs->4μCB : 65.68% (our analysis)

But:

- Higgs->3μCB +1μ(InDet) : **95.27%**

$(0.9)^4+4*(0.9^3*0.1*\varepsilon)=0.9477$ … expected

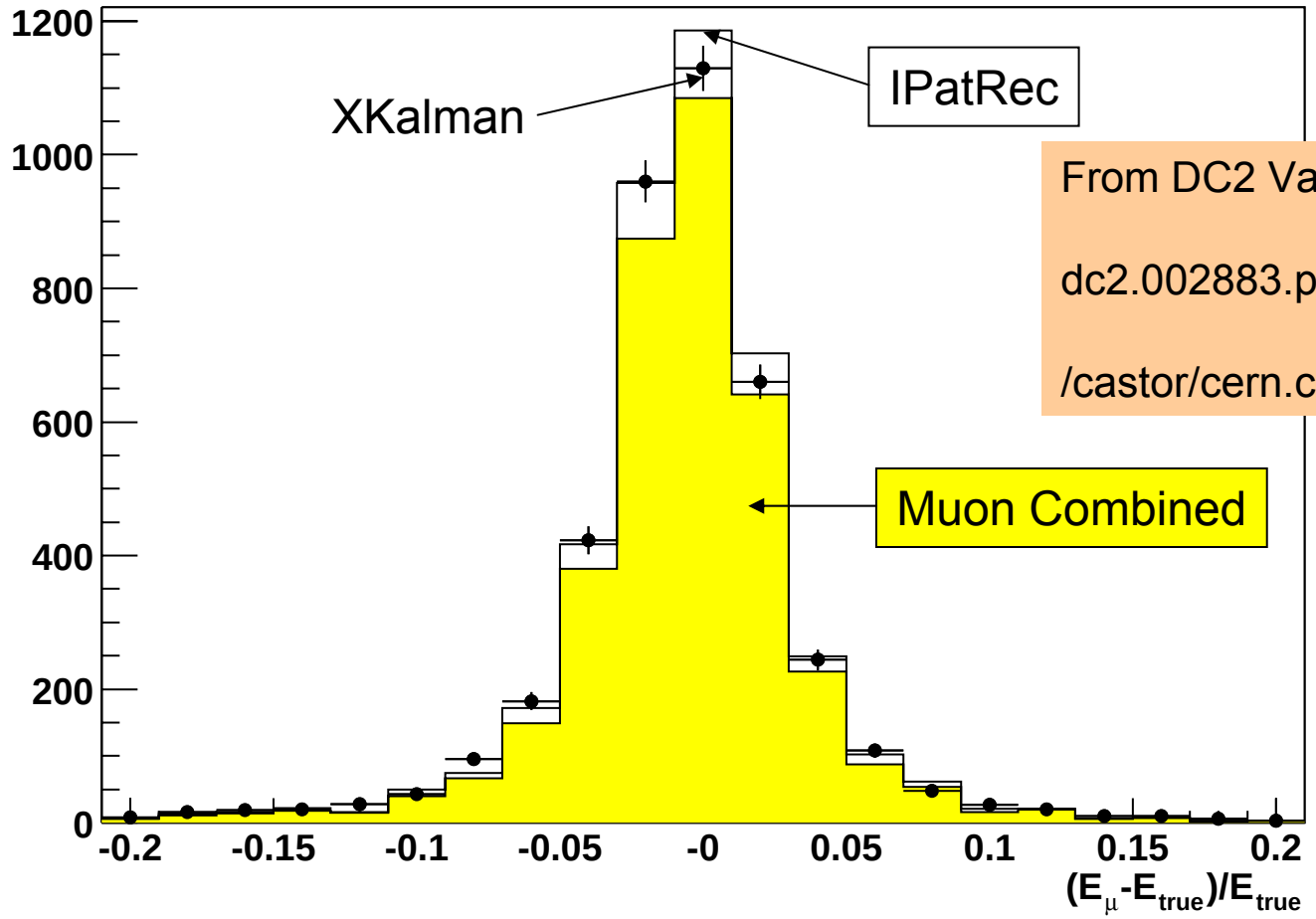
So :

Can we recover the 4th muon using the ID?

Can we keep the background low?

(see past talks by Quayle,Paganis)

# Muons: Resolution (8.7.0)




From DC2 Validation Samples

dc2.002883.pyt_z_mumu.g4recon870

/castor/cern.ch/atlas/project/dc2/preprod/

# Muons: reasons for efficiency losses

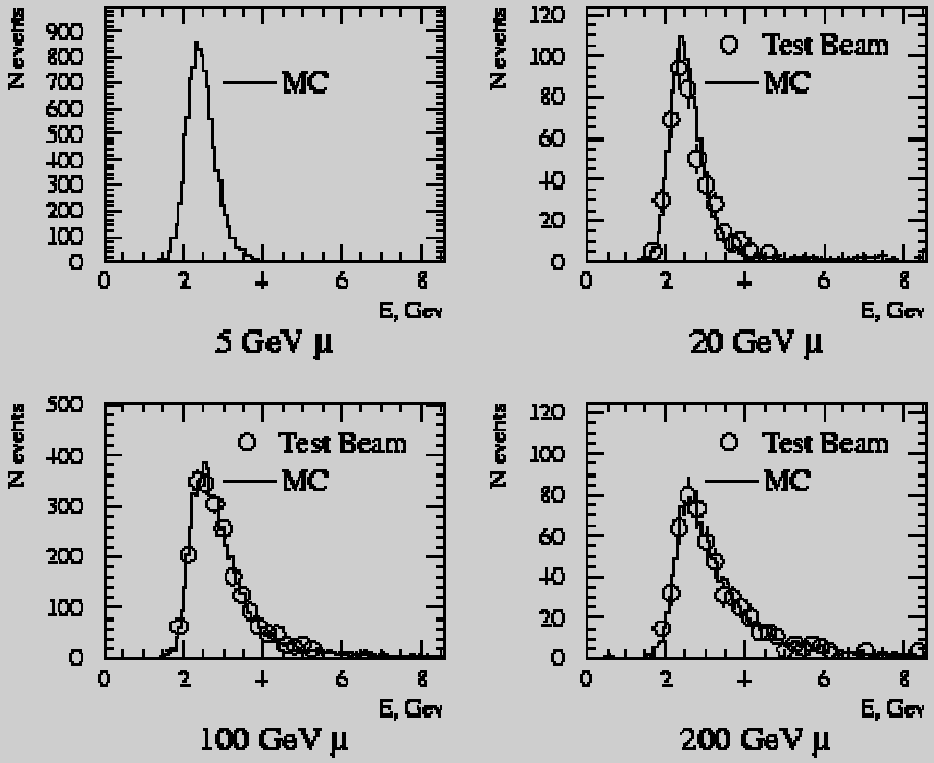
- Software/Reconstruction (being solved)
  - Example: forward shielding
  - Tuning of reconstruction
- Geometrical Acceptance
  - Example: hole in the mid-rapidity
- Energy loss in the CALO
  - Expect to be significant at low muon energies (<20GeV)
- Other?

# Muons: energy loss in the CALO

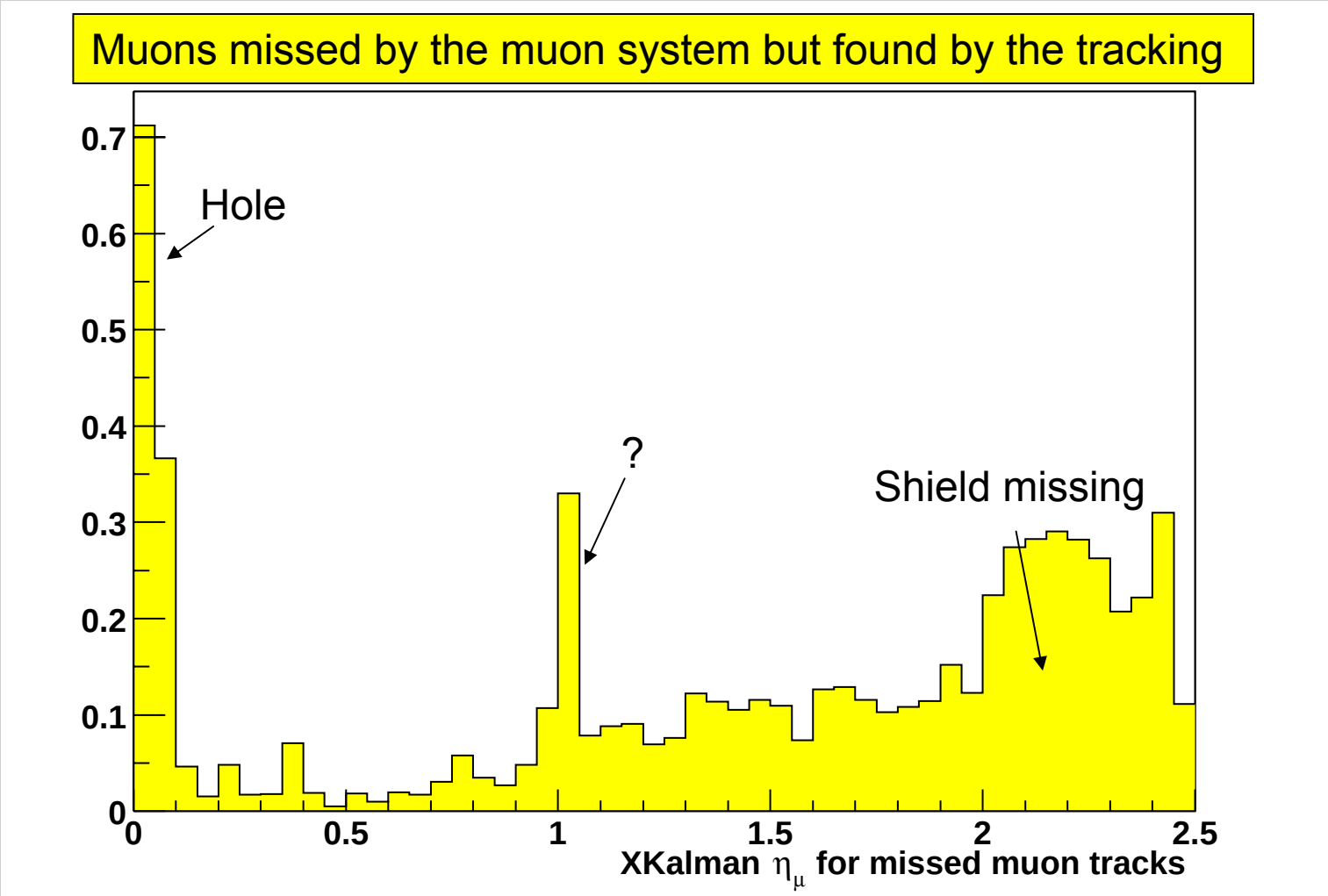
- Results from TILECAL-95-068, Henriques, Karapetian, Solodkov

**For low energies a large fraction of the muon energy is deposited In the calorimeter.**

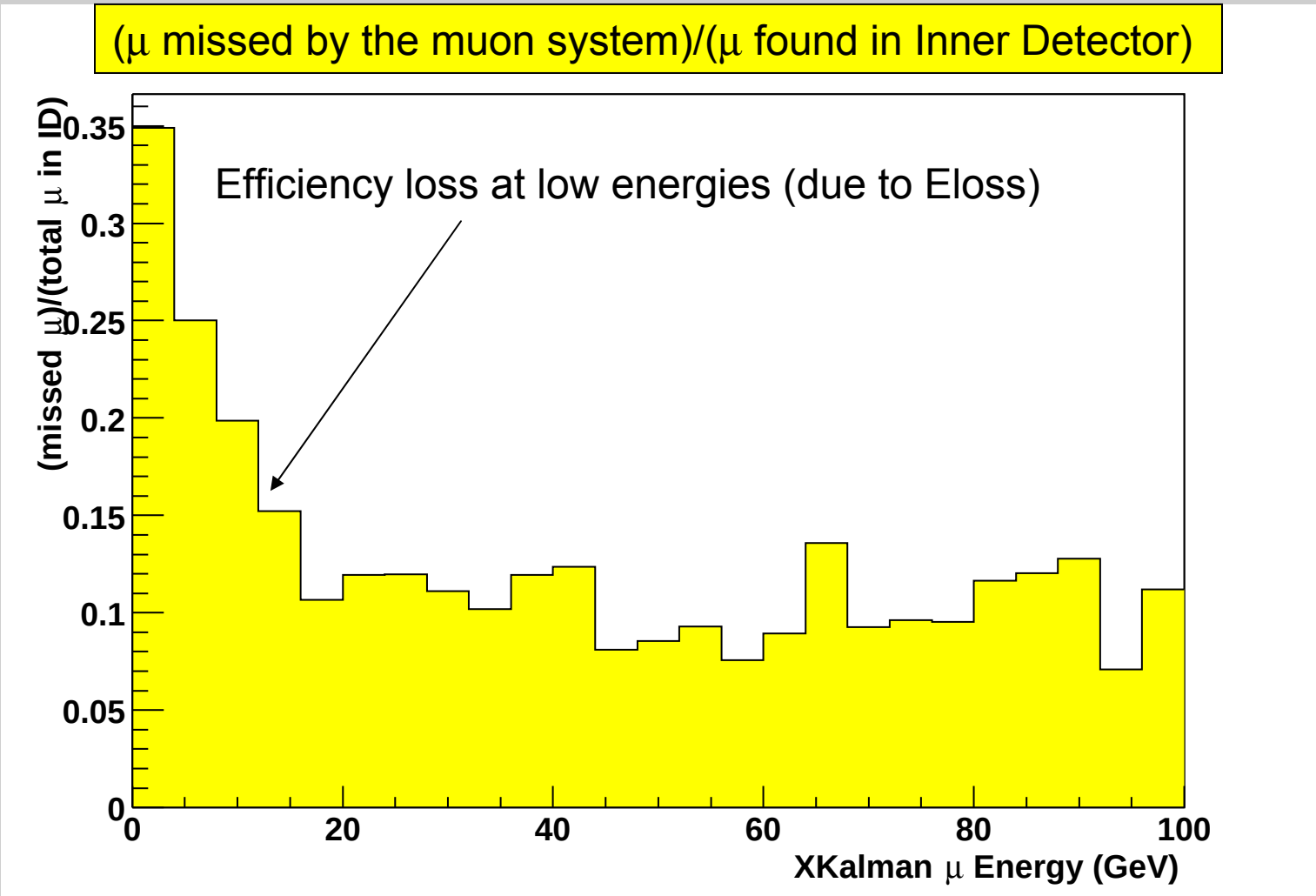
**Expect MuonChamber – InnerDet combination to take a hit at lower energies.**



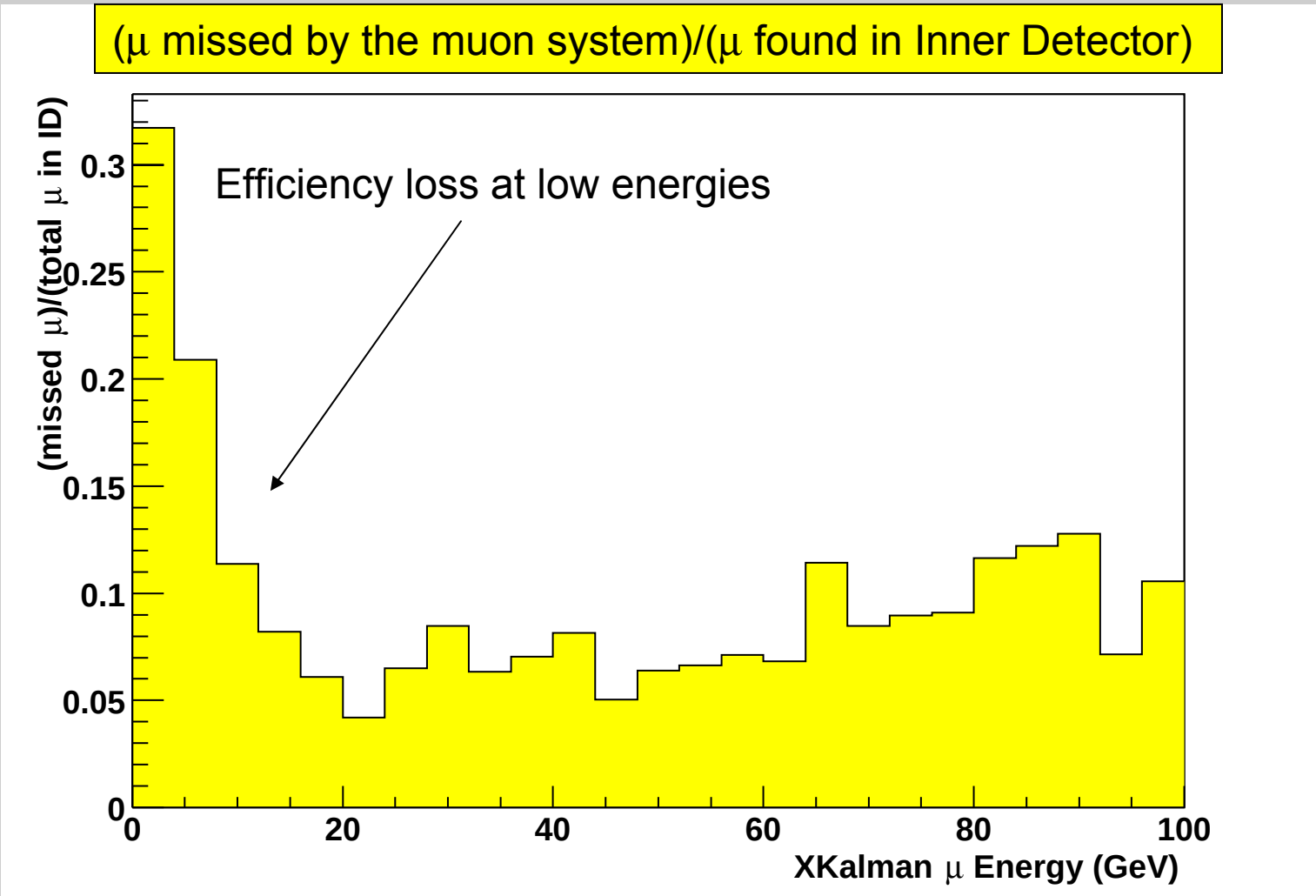
# Where is the muon lost? (versus η)



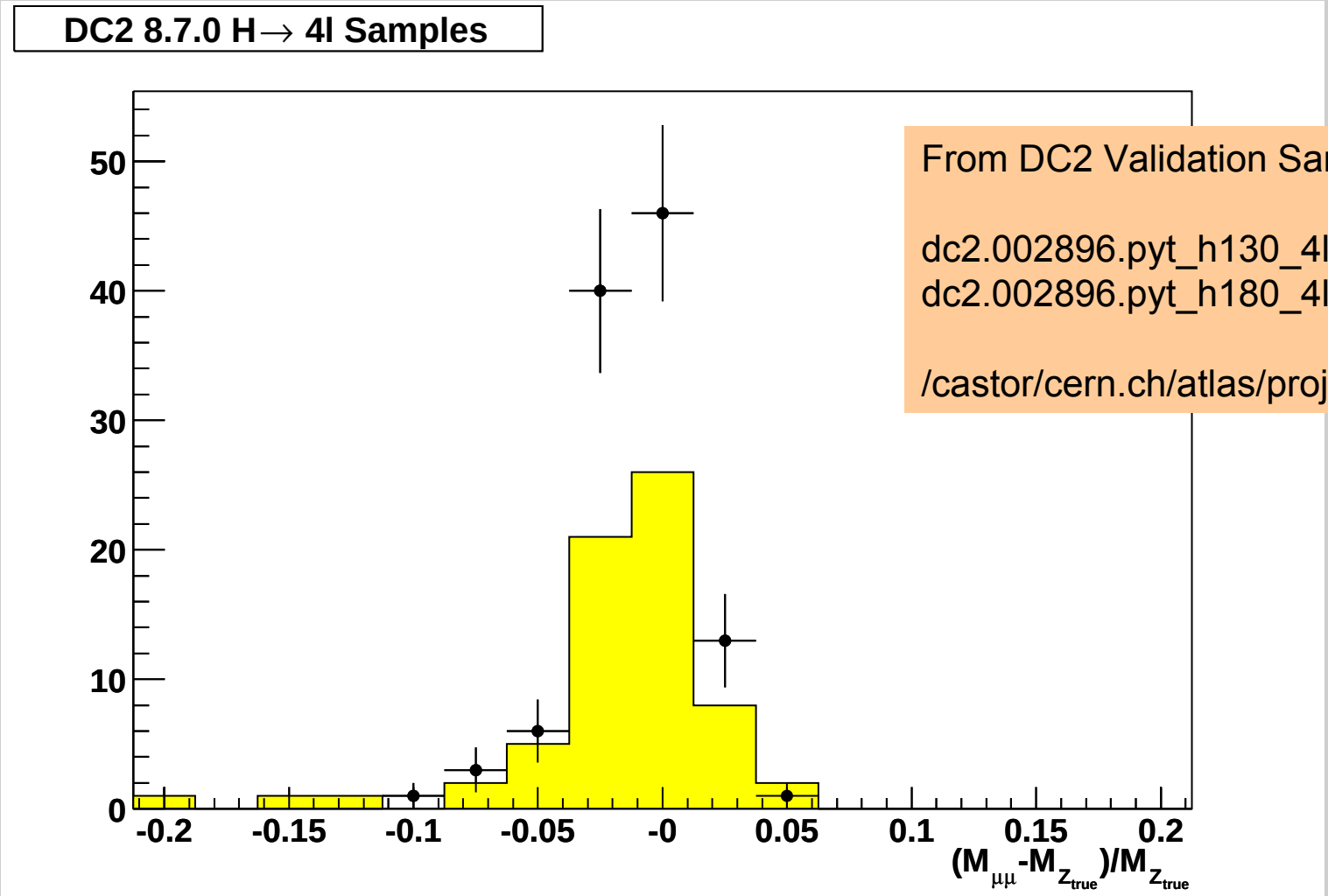
# Where is the muon lost? (vs energy)



# Where is the muon lost? (|η|>0.1)



# Higgs->ZZ->4μ gain in efficiency using the ID




From DC2 Validation Samples

dc2.002896.pyt_h130_4l
dc2.002896.pyt_h180_4l

/castor/cern.ch/atlas/project/dc2/

# Higgs->4muon : Boosting efficiency

- Requiring 4μ in the Muon System gives an efficiency ~65%
- Requiring 3μ in the MS + 1track: ε = 95%
- To search for 4$^{th}$ μ in the Inner Detector:
  - Not easy: background from fakes may kill any signal
  - But: one has to remember that in the H->4l analyses we require very tight isolation criteria (ID+CALO)
  - Moreover: Understanding of the CALO response may help kill big portion of the background: muons suffer a const energy loss in the calorimeter.
  - Calo noise issues? Test Beam input?

# electrons: InterCalibration Effects

# electrons: LAr InterCalibration

- Studies and corrections for upstream material effects on e, Z' and Higgs have been presented in Freiburg and previous talks (Paganis HWG Sep-1-04)

- But CAUTION:
  - ATLAS Simulation doesn't take into account variations in EM calorimeter response due to mechanical, electronics, HV, LAr Purity and Temperature, and other effects.
  - ATLAS Requirement: 0.3% uniformity in 448 regions of the EM Calo.
  - This gives a 0.7% constant term (in energy resolution).

# The problem

- One way is to InterCalibrate with cosmics
  - L. Serin, Commissioning with muons, LAr Week Sep-2003
  - But Problems:
    - High statistics, long time to accumulate
    - Energy deposition in LAr ~0.2-0.3GeV with large fluctuations due to the Lead (Tile: iron is much better)
  - Also, we need to monitor IC during data taking
- In-Situ, people propose Z->ee (F.Djama+TDR)
  - But, to extract LAr weights (LW) which correct for upstream material effects also need electrons.
  - The two problems (LW+IC) are coupled !
  - For PDF uncertainties, see M.Boonekamp StdModel meeting (June 2004) and in this Physics Plennary.

# Some first thoughts on this:

More at the e/gamma meeting (Nov-4-2004)

- We would like to study realistic in-situ calibration methods for the EMC. Before we even move to pp->Z+X or W+X, it is important to understand the problems at the electron level. This allows us to decouple effects that come from the Z itself (lineshape, PDFs, inBrem)

- F.Djama (ATL-LARG-2004-008) showed that uniformity at the 0.3% is possible with Z->ee, based on recovery of weights $\alpha$ (one weight per $\Delta\eta \times \Delta\phi = 0.2 \times 0.4$ region for a total of 448 regions)

# Combined Method

- Expect the intercalibration weights $\alpha$ to be absorbed in the overall scale:

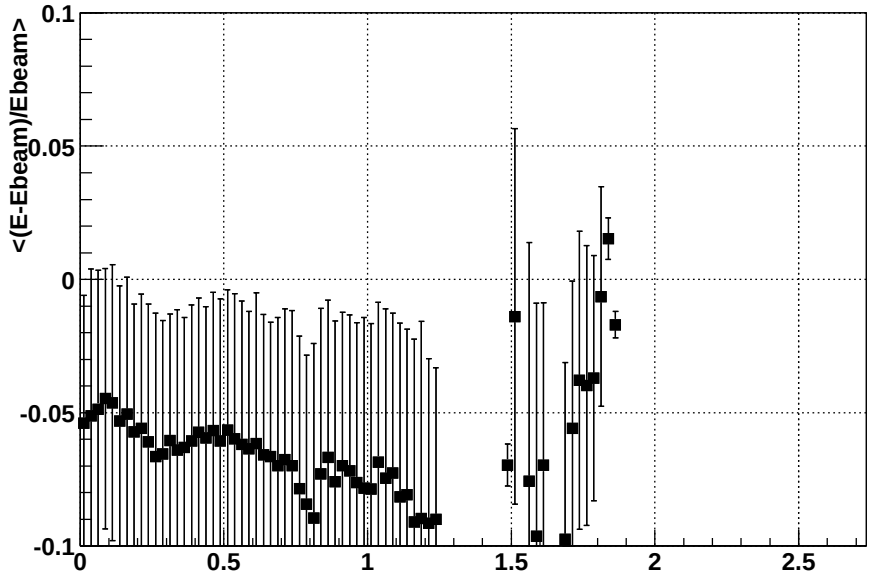
$$E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + W_3 E_3\right)$$

- To do this we can extend the long. weights to be $\phi$ dependent.

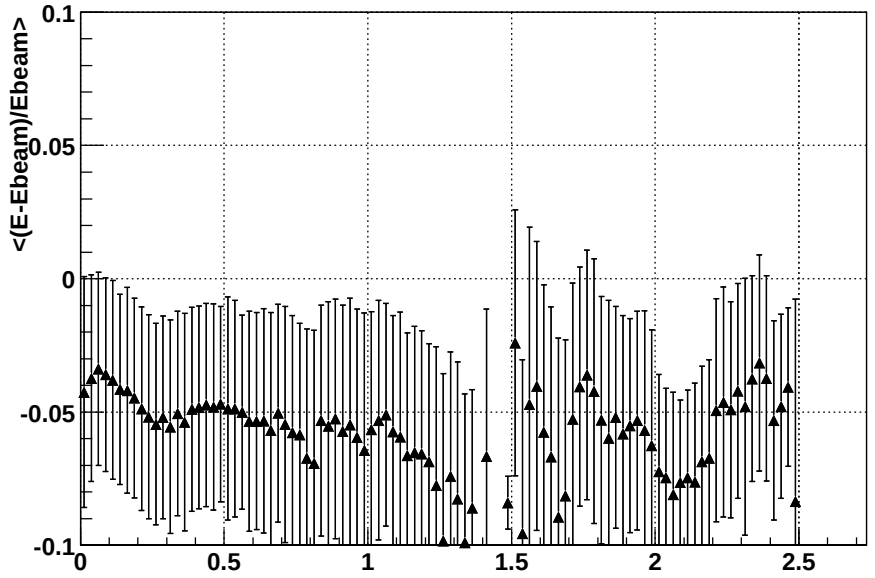
- In the following we apply a ±5% miscalibration in ($\Delta\eta \times \Delta\phi = 0.2 \times 0.4$) regions of the calorimeter and recalculate the weights in ~800 $\eta,\phi$ bins.

# electrons: Miscalibrated Calorimeter

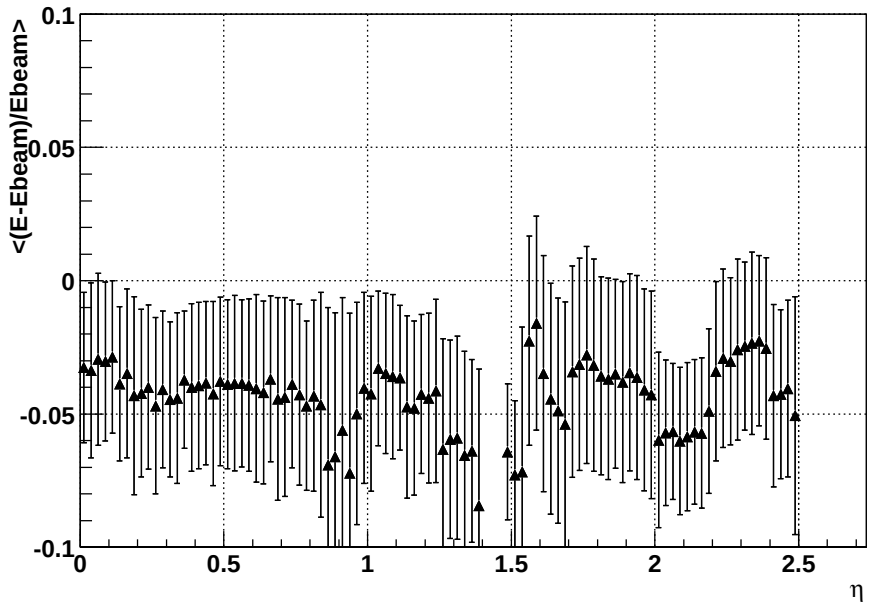
Ebeam=10GeV, misInterCalibrated



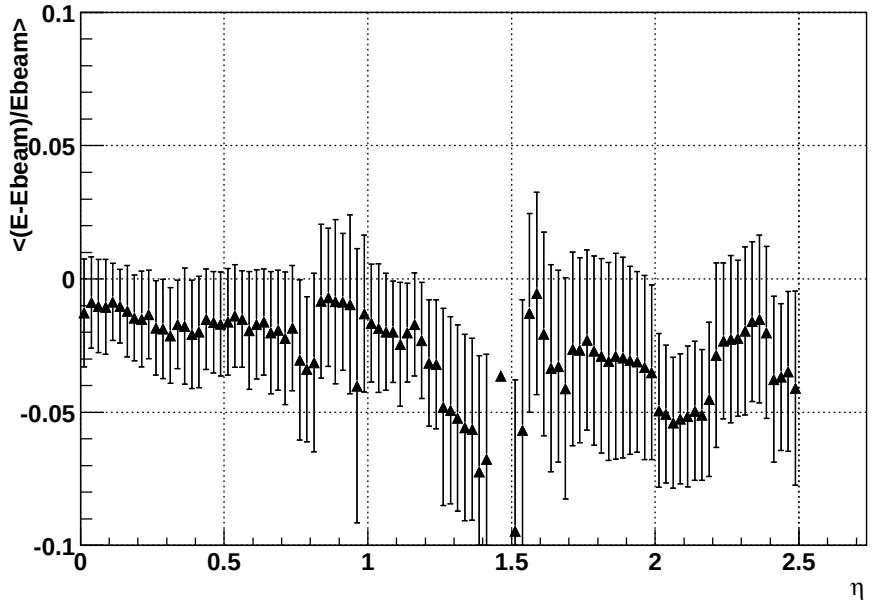

Ebeam=20GeV, misInterCalibrated




Ebeam=50GeV, misInterCalibrated

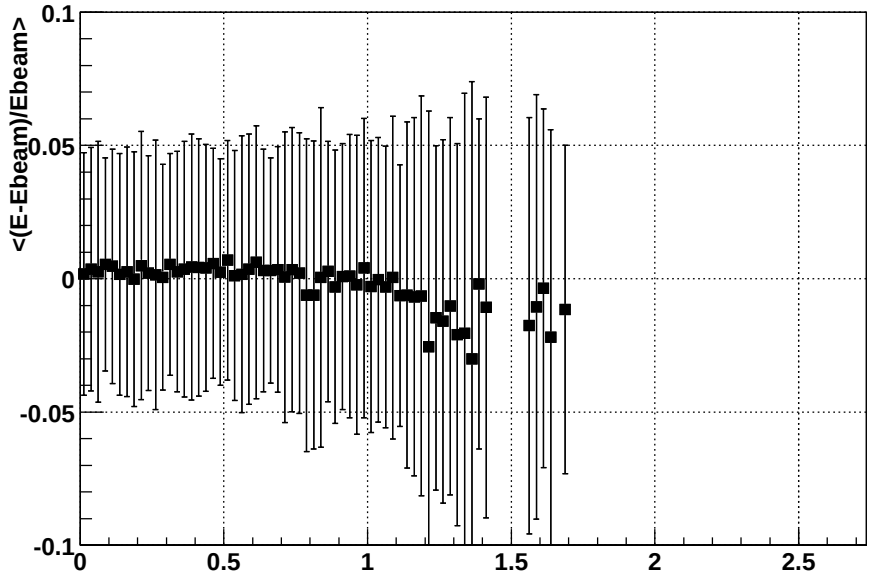



Ebeam=100GeV, misInterCalibrated

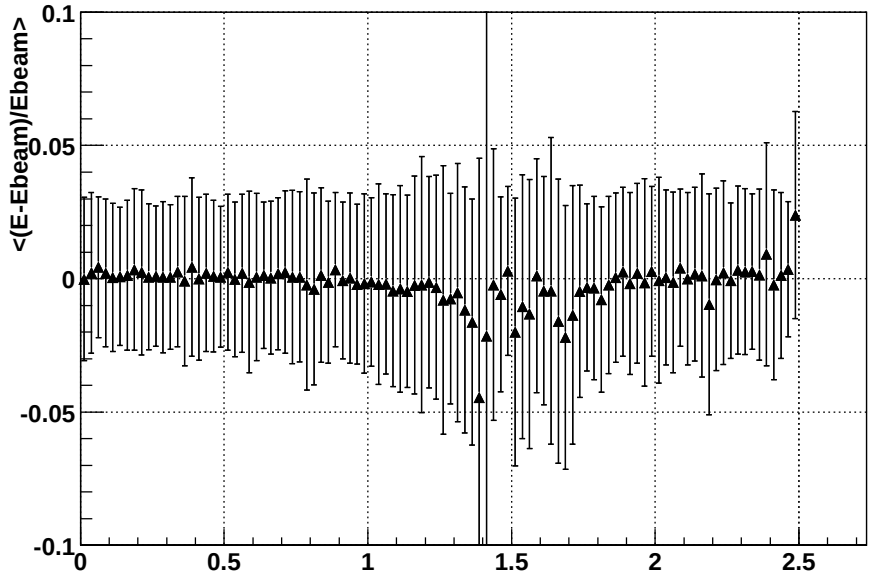


# electrons: Response after combined method

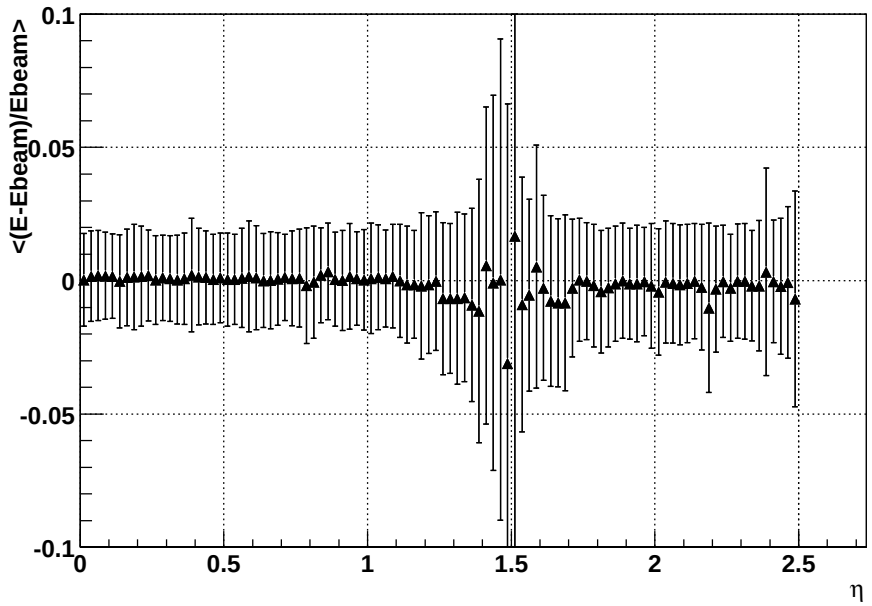
Ebeam=10GeV, InterCalibration



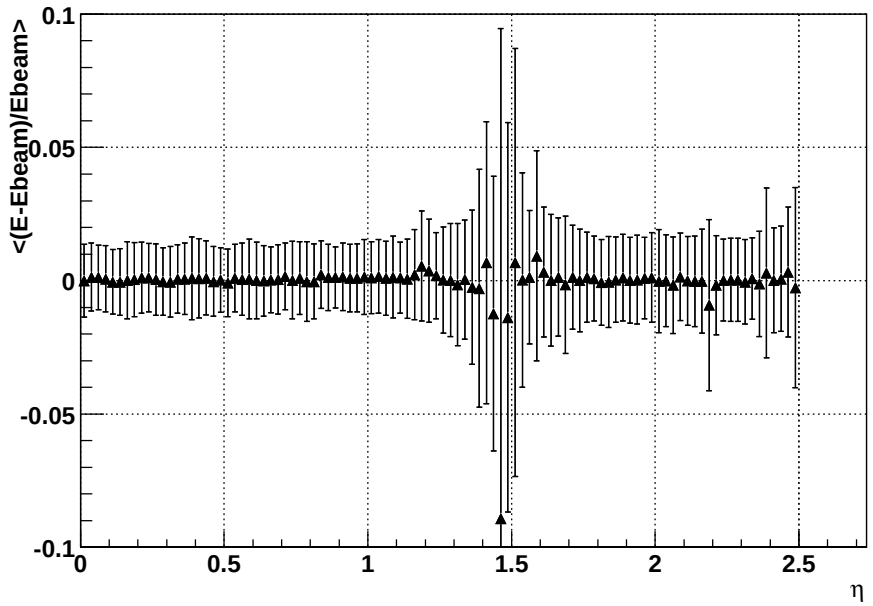

Ebeam=20GeV, InterCalibration



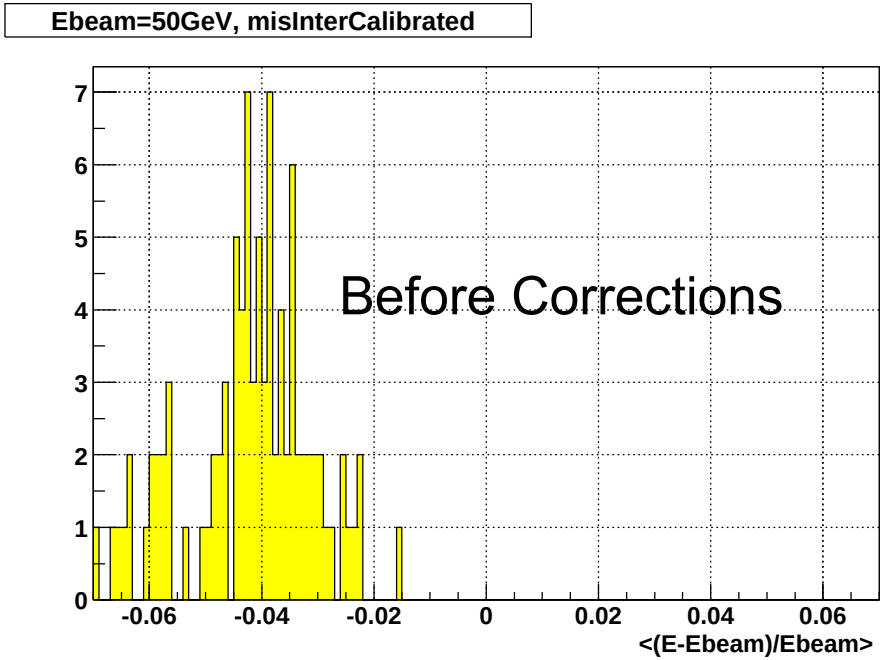

Ebeam=50GeV, InterCalibration

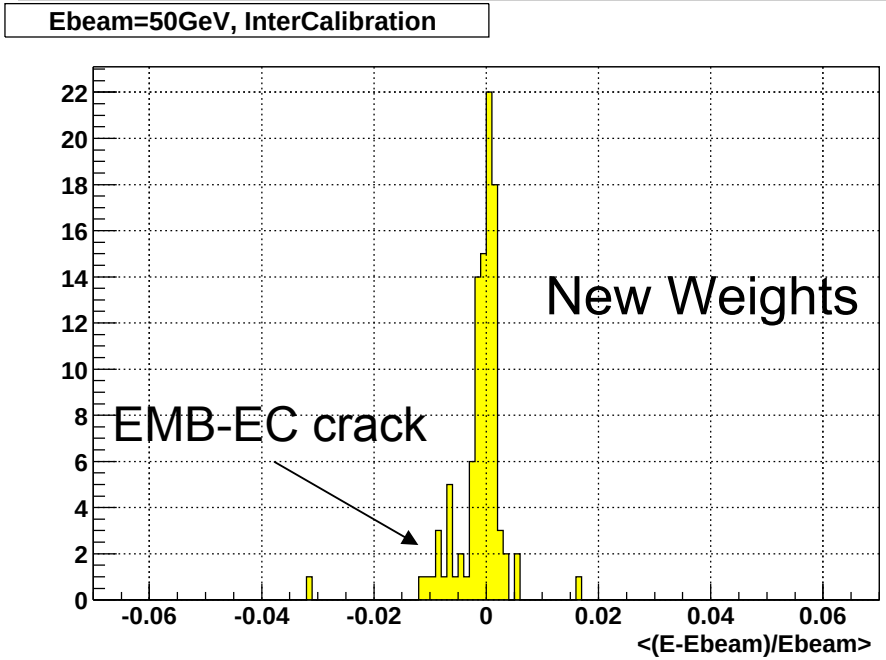



Ebeam=100GeV, InterCalibration



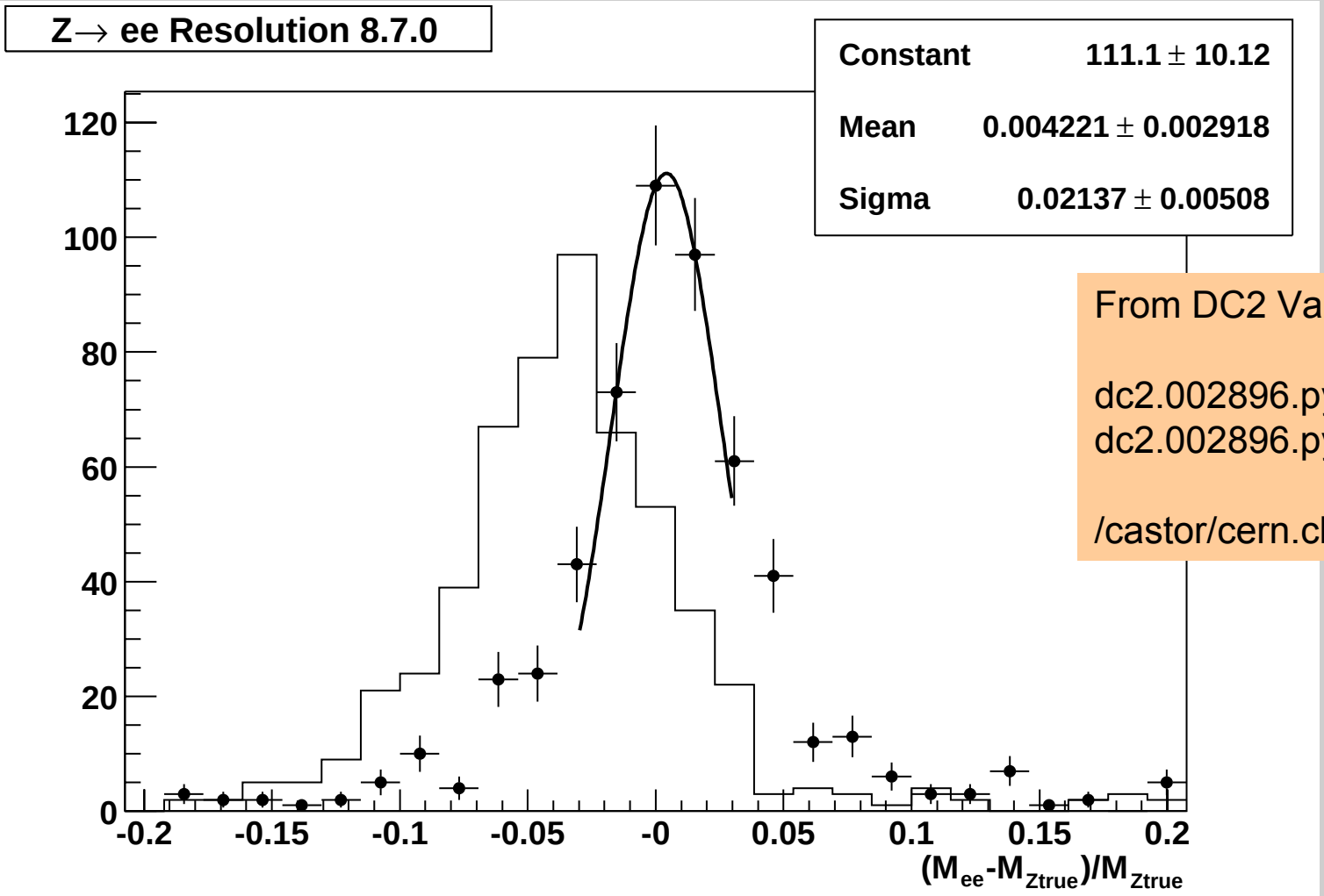
# Look at 50GeV: uniformity




A better than 0.2% Uniformity is found
(crack region excluded)

# Effect on the Z from Higgs->ZZ

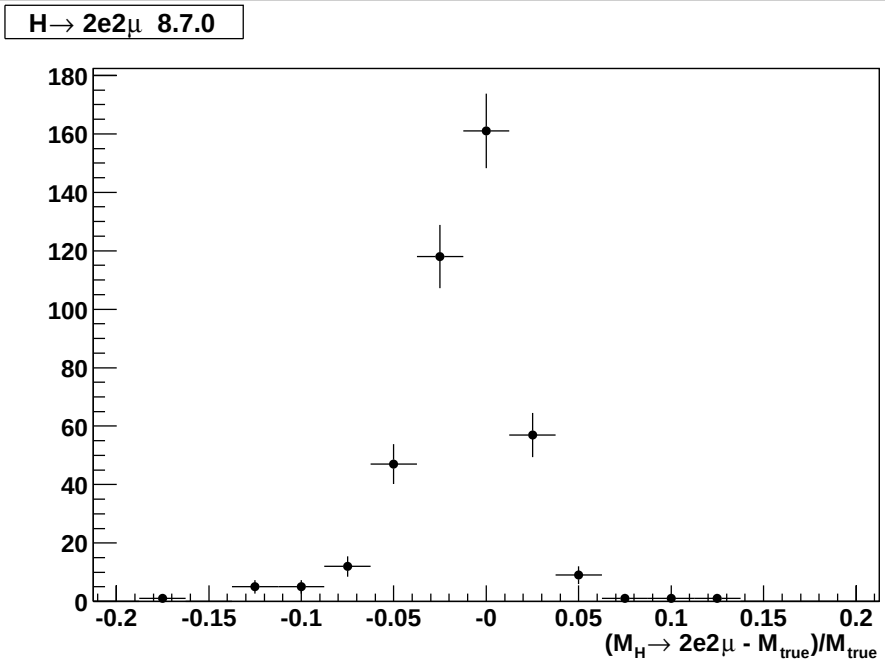


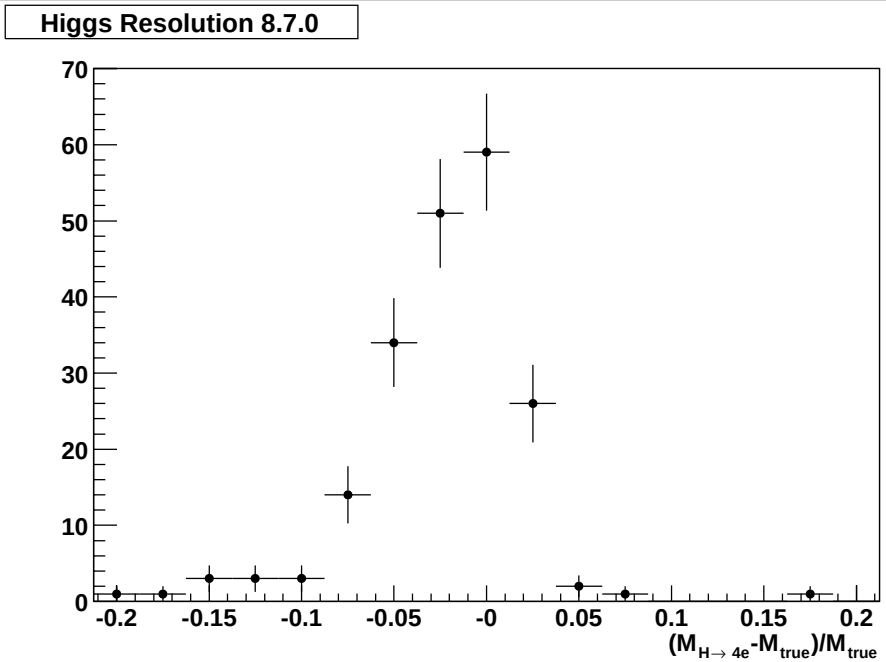

From DC2 Validation Samples

dc2.002896.pyt_h130_4l
dc2.002896.pyt_h180_4l

/castor/cern.ch/atlas/project/dc2/

# Effect on the Higgs->2e2μ,4e Inv. mass




First Higgs->4l official DC2 samples with long. Weights

Masses are centered (corrections do their job)
Resolution hard to compare: 5x5 + realistic noise

# Summary

- Higgs->4μ has just a 65% efficiency

  Higgs->3μ+1track has a ~95% efficiency
  - when 3μ are found in the Spectrom., the 4th muon is always at the ID.
  - We had a first look at this 4th muon/track. The stringent lepton isolation in H->4lepton and the use of calorimetry may allow us to identify this 4th μ/track. Background studies are crucial.

- First look at InterCalibration effects on the Higgs->2e2μ,4e and their correction using electrons
  - The new EMC weights give the correct Higgs and Z mass scales.
  - Weights must be recalculated for new versions and all clusterings.
  - A 0.2% uniformity and simultaneous correction of upstream material effects is possible BUT pp->Z+X events could give a worse result.

# Supporting ViewGraphs