EM Linearity using calibration constants from Geant4

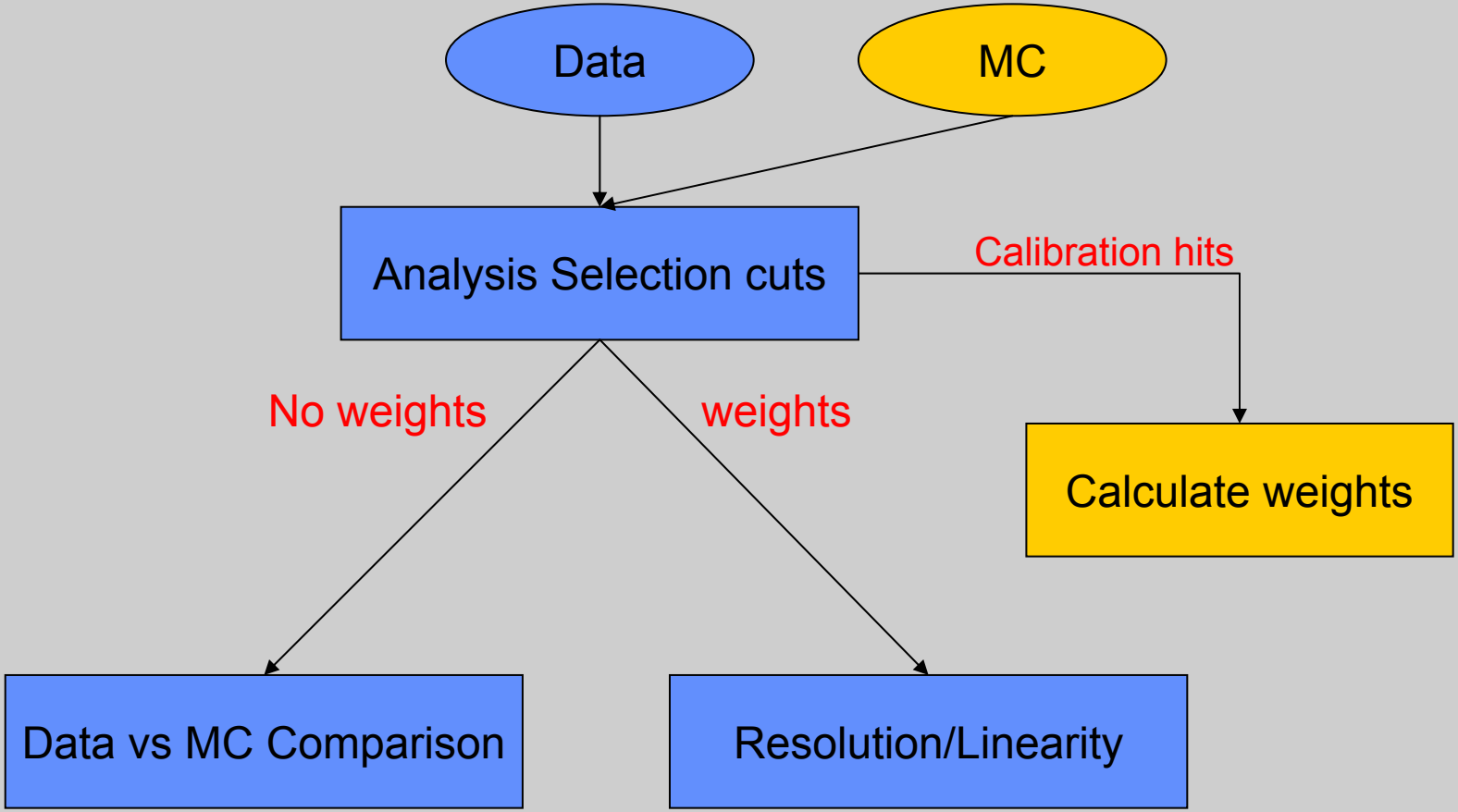
H8 Combined Test Beam meeting

CERN, 13-Dec-2005

ATLAS Calibration: Reminders

- 1. Calibration for Material effects ONLY
  - Choose a parametrization: $E_{rec} = f(w_i, E_0, E_1, E_2, E_3)$
  - Extract weights $w_i(E)$ from G4 Simulation
  - Weights are not extracted per cell but in an eta/phi matrix
    - ATLAS today: 100bins in eta with bin size the middle cell width
  - Weights have energy dependence depending on parametrization
  - Weights may always provide optimum linearity but NOT necessarilly optimum resolution (ATLAS today)
- 2. Calibration in-situ
  - Extract an overall scale per eta/phi region using data (Z->ee)
  - Impossible to do this per cell: typically one uses middle cell bins in eta and “intercalibration” regions in eta/phi (0.2x0.4)

Method


Data
MC
Analysis Selection cuts
Calibration hits
No weights
weights
Calculate weights
Data vs MC Comparison
Resolution/Linearity

Parametrization(s)

Simple Parametrization (almost like ATLAS)

$$E_{rec} = \lambda\left(off + PSsc \cdot E_0 + \frac{1}{SF_{acc}}\left(E_1 + E_2 + E_3\right)\right)$$

Absorbs out-of-cone correction

Sophisticated Parametrization (see egamma Rome-Talk)

$$E_{rec} = \lambda\left(off + PSsc \cdot E_0 + Sf \cdot \sqrt{E_0 \cdot E_1} + \frac{1}{SF_{acc}}\left(E_{acc}\right)\right) + E_{out-cone}$$

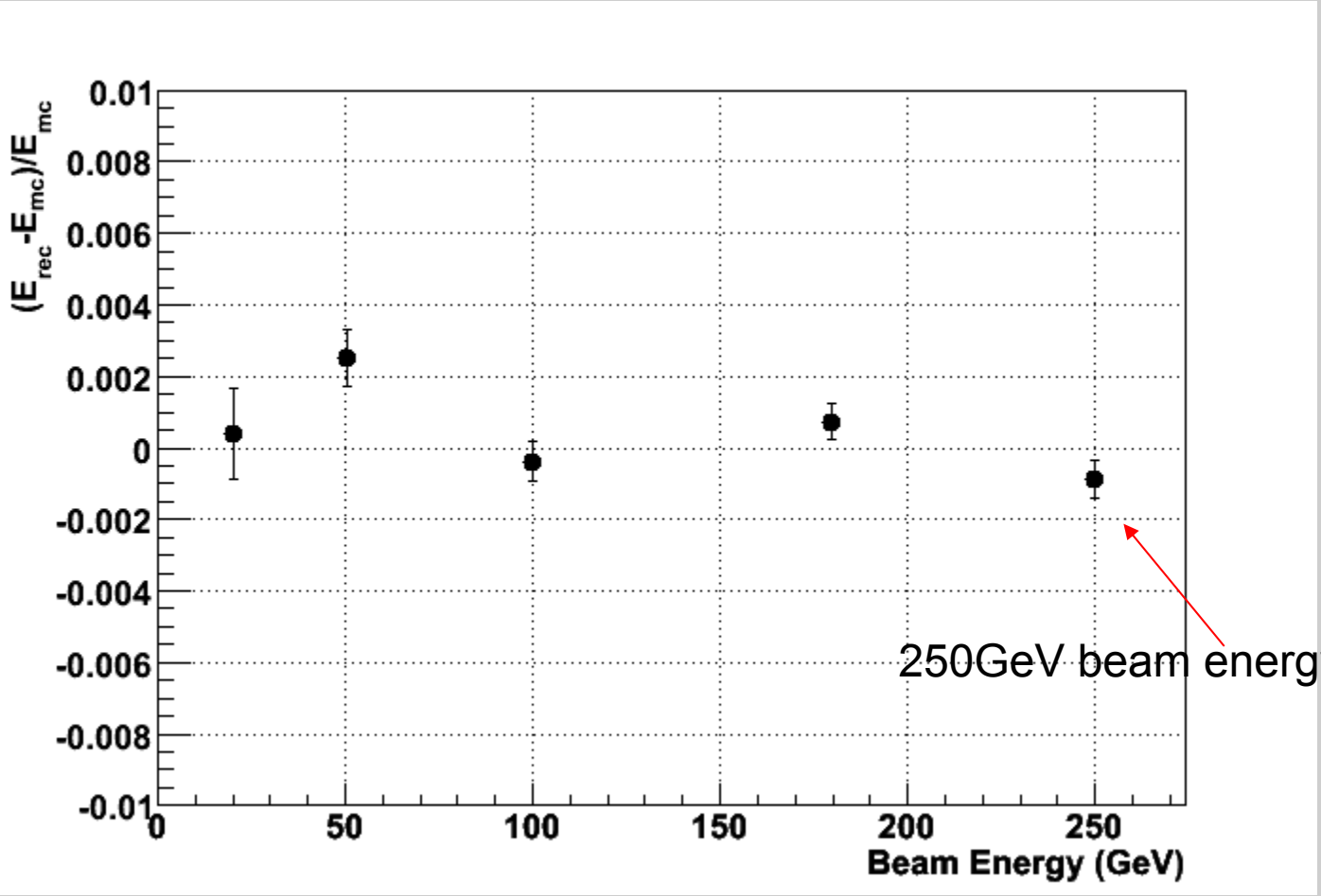
Alas Tancredi

Alas Orsay

Analysis (see http://agenda.cern.ch/fullAgenda.php?ida=a057200)

- Material Scan: 20-50-100-180-250GeV for periods 5-6
- Release 10.5.0, OFC-9
- 3x3 EMTB cluster with ncells>66
- Clock>2ns (except for 100GeV, 3-16ns)
- MC scale factors:
  - Eps_scaled = 0.8*11/13*Eps
  - Etot_scaled = 0.98*Etotal
- Data scale factors:
  - $E_{stips\_corrected} = 0.92*E_{strips}$
- Ecell_tile < 1.5GeV
- MuTag < 500 counts
- MuHalo < 700 counts (for 180GeV, 250GeV runs no effect)
- eta/phi cuts

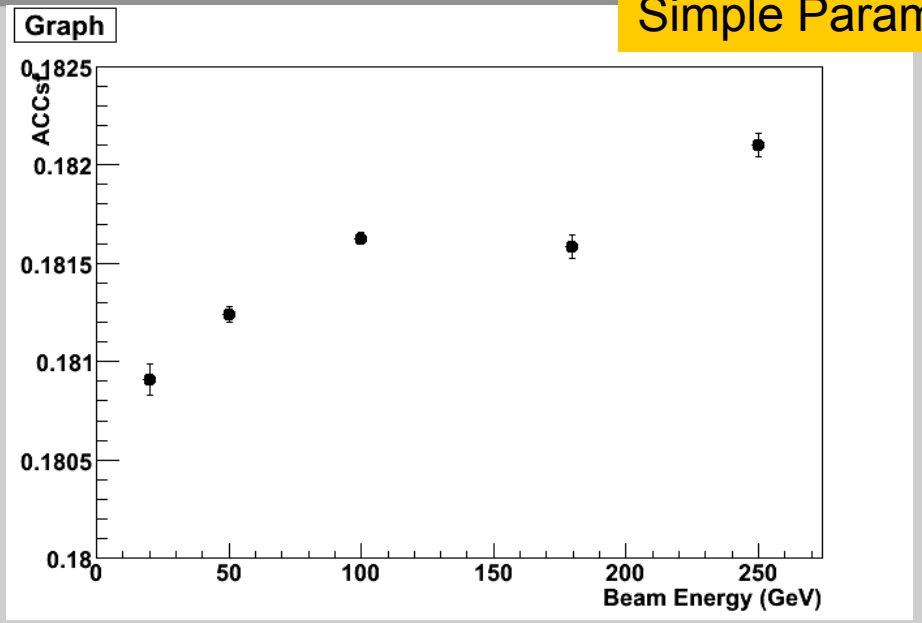
Data vs MC (no weights - 0mm Aluminum case)

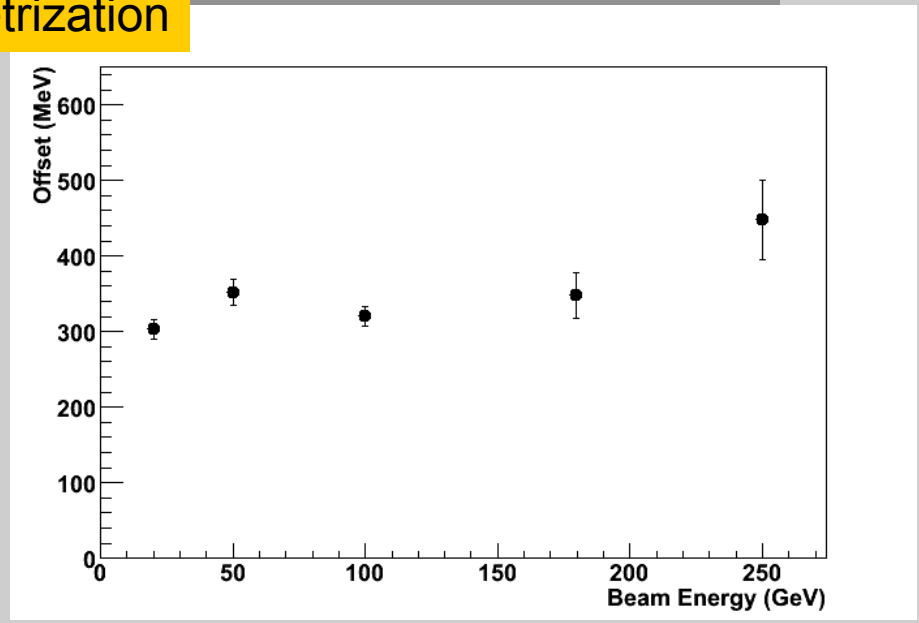


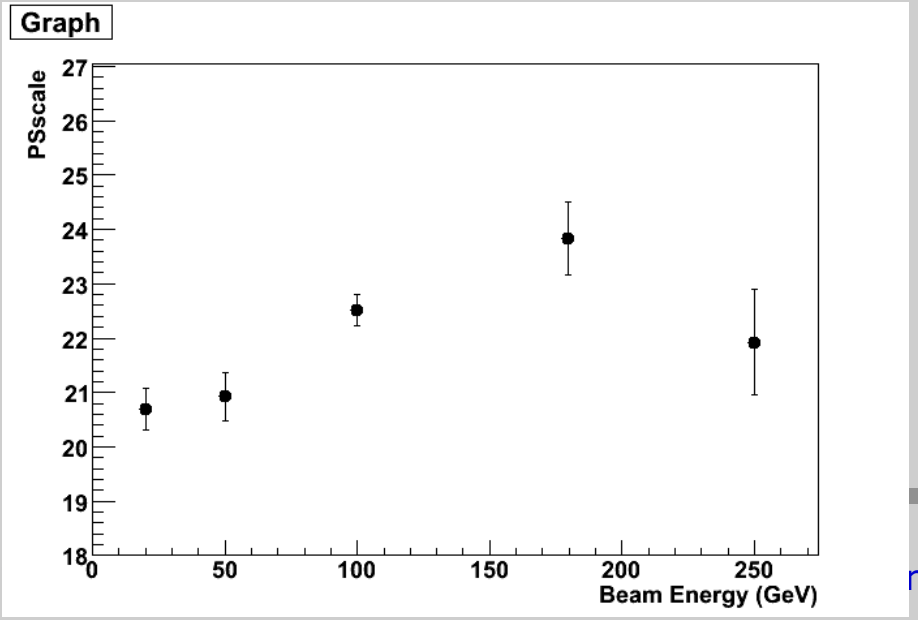
Current Status: Data vs MC agreement to the 0.3% level

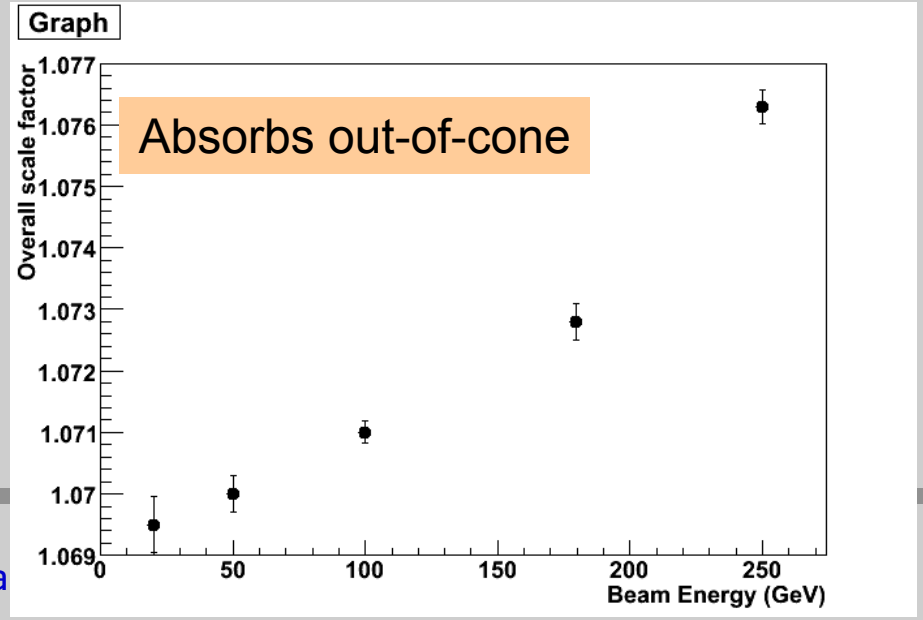
Extracted Weights vs Energy (calib.hits)

Simple Parametrization





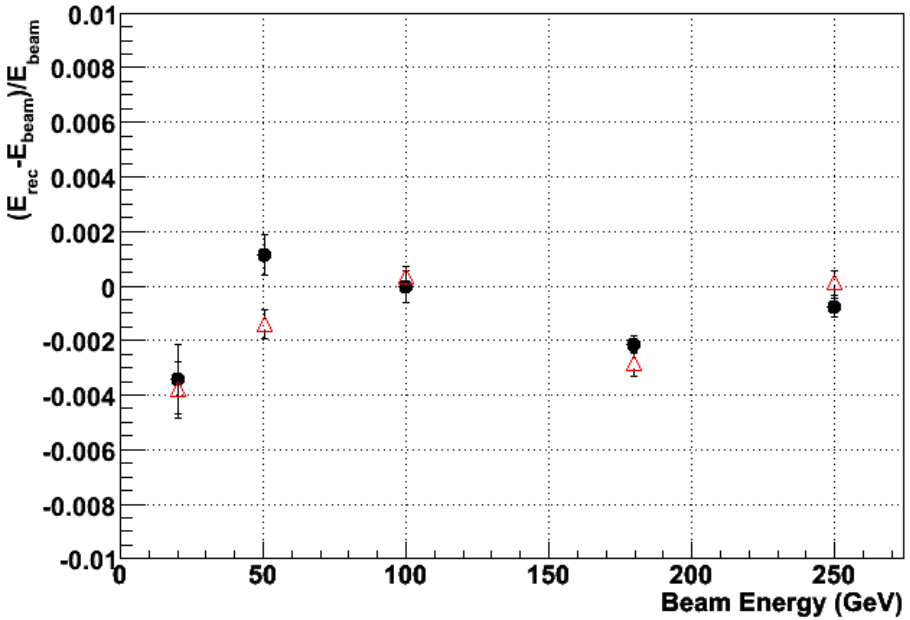




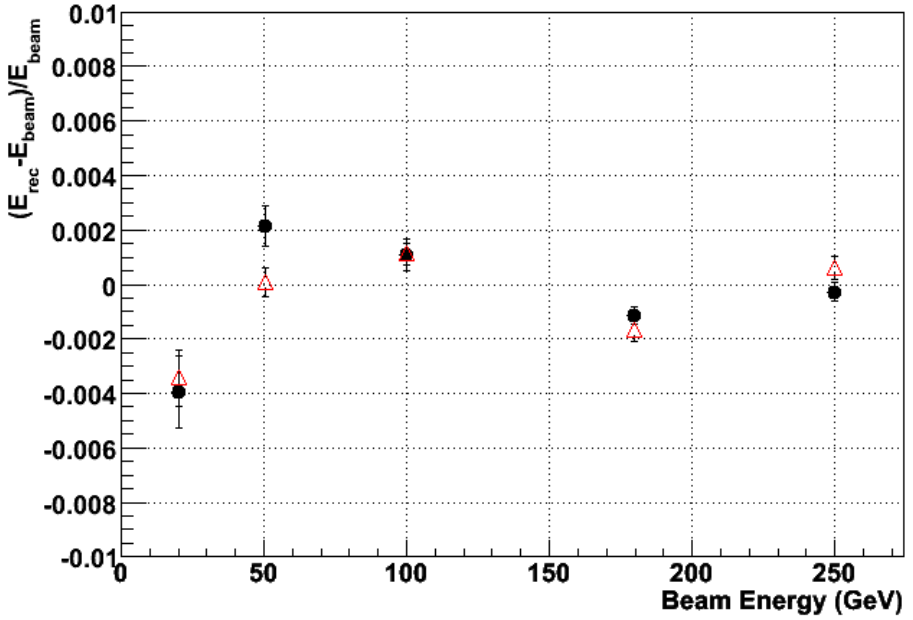
Absorbs out-of-cone

Linearity for Data (black) and MC (red)

Simple Parametrization



Sqrt Parametrization



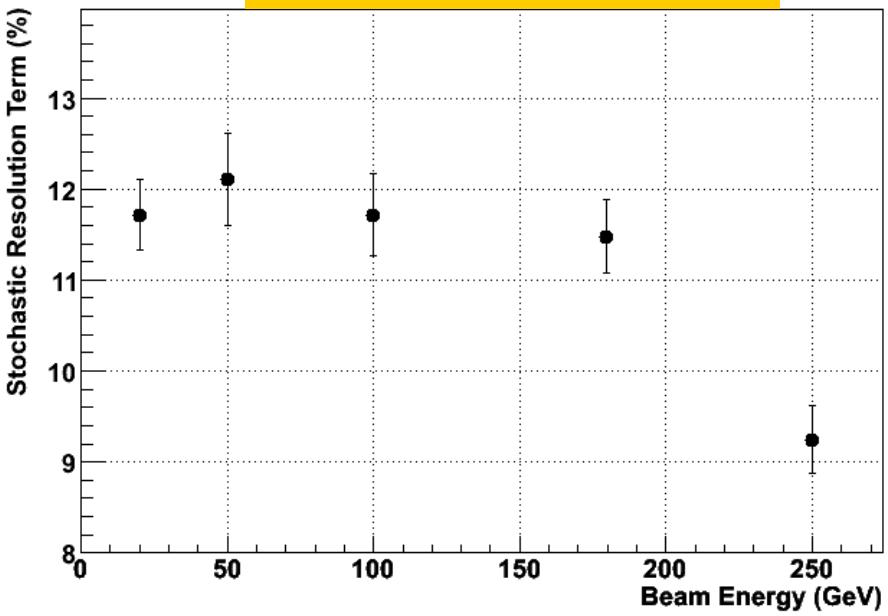
Surprise: MC is non-linear to the 0.4% level. But this maybe due to statistical limitations in the weight extraction with calibration hits. If MC gets linearized I expect also the data to be linear to the 0.2-0.3% level.

Errors in the previous plot

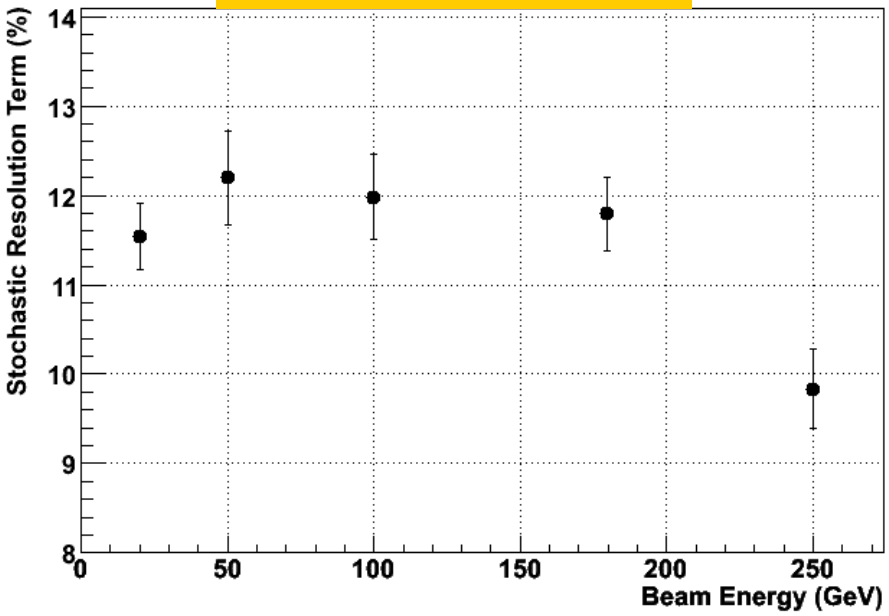
- 15-30MeV for (relative beam energy), under study.
- Errors from the extraction of calibration Hits.
- Errors from the fit of the electron energy distribution (assumed gaussian)
- At low energies MC has significant non-Gaussian tail that shifts the mean by **-0.4%** wrt to the Gaussian mean. For the other energies:
  - 50GeV: 0.1% shift
  - 100GeV: 0.07% shift
  - 180-250GeV: 0.04% shift

Gaussian Resolution (stoch.Term) for data

Simple Parametrization



Sqrt Parametrization



Sqrt parametrization (without out-of-cone depth correction) gives about the same resolution and linearity within errors. This may change dramatically with the increase of the material because the sqrt parametrization seems to have less non-Gaussian tails (better RMS).

Systematic Checks

- Digitization step in MC: tried digitizing calibration hits before clustering them (using the same formula as in LArDigiMaker)
- Clustering: tried EMTB and private 3x3 (small deterioration in linearity).
- Checked biases in Calib. Hits parameter fitting.
- Simple parametrization leads to increased tails at low Energies, so it would be interesting to check with the more sophisticated sqrt parametrization.
- Linearity check with constant weights (alas ATLAS) works fine with a small hit in resolution.

Conclusions

- Trying to calibrate the data by using calibration hits from G4 (maximize information use).
  - Data vs MC must be in agreement first (now 0.3%)
  - Use a simple parametrization for starters
  - Then calibrate the MC (for now 0.4% linear)
  - Apply to data (it's a convolution of the agreements above)
- Several beam systematics on linearity under study:
  - Relative beam energy error (B-current, collimators, Sync.Radiation)
    - B-current: error seems small ~0.05% (Nicolas)
    - Collimators? (Nicolas, Walter +)
    - Synch. Radiation? (Nicolas, Walter +)
  - Systematics from Ramps (Martin, Walter +)
  - Systematics from OFC variation with clk (0.5% in some cases)

Extra slides

ATLAS today: using single electrons

- I extracted the present ATLAS weights using single electrons and doing χ^2 fits per eta bin
  - But, this fit is not really needed if the true energy depositions in ATLAS are known.
  - Energy dependence is unknown (the fit forces <Erec>=Etrue)
- True depositions are given by G4 Calibration Hits
- Our goal:
  - extract longitudinal weights w_i from calibration hits
  - Use this as initial ATLAS calibration for material effects
  - Test different parametrizations for Erec to improve resolution

ATLAS today: Caution

- When someone uses electron samples from Z->ee with photos, or single electrons+pile-up, or all of the above to extract the weights that match to his analysis:
  - The weights correct also for physics effects unknown at present and dependent on the event generators!
  - True electron energy should not be used since this is not possible in practice (use Z mass or E/p instead, but not easy).
  - This is wrong: we want to separate the material dependent effects and not parametrize our MC samples EM response to give good linearity.

2004 Test Beam: validates the method

- Get agreement between Data and MC before corrections
  - Beam line material description in MC must be correct
  - Beam profiles must agree
  - Certain systematics in Data (see Erec vs clk) must be understood
- Start with a parametrization for Erec
- Extract weights for this parametr. using calib. hits
  - Same MC events that are used in data vs MC comparison must be used
  - Modulations: must be extracted/applied AFTER the weights
- Apply the weights to both Data and MC
  - Successful if Linearity is comparable to beam line error (0.05-0.1%?)
  - Successful if Resolution Stochastic Term is nominal (10-11%)