Beam Test 2012

Update of TASC data analysis

by

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CALET TIM, Pisa June 2015

Outline

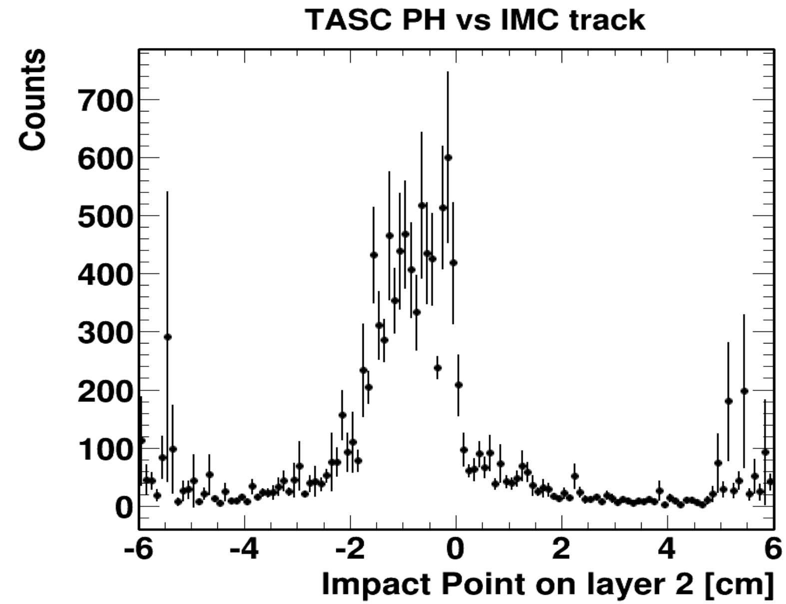
- TASC calibration with muons

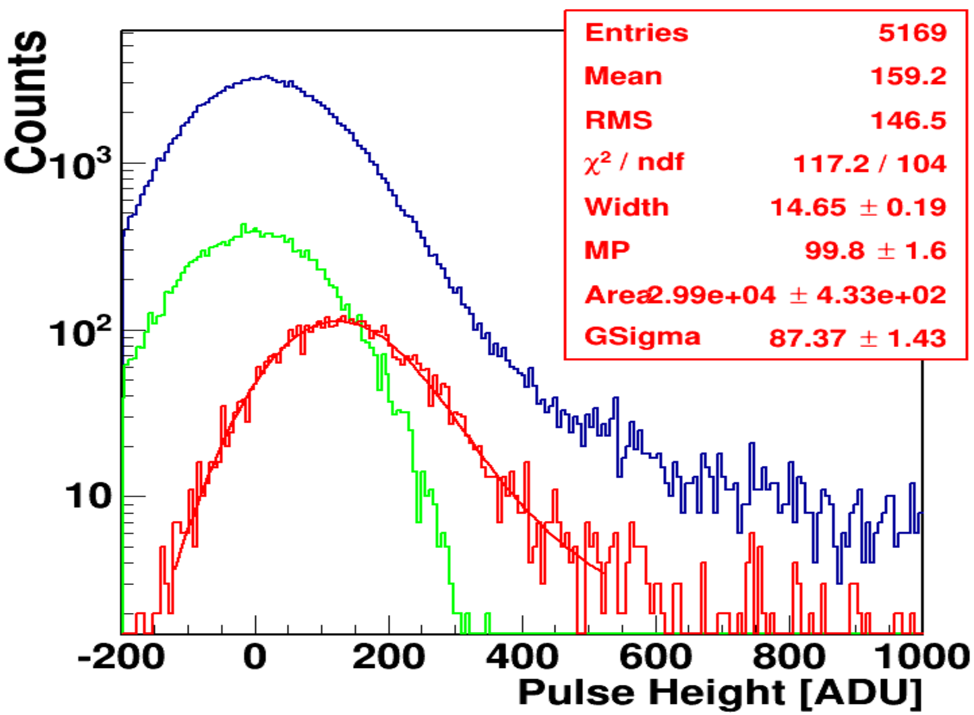
- TASC response with electrons beams at **10, 20, 30, 50, 80, 100, 150, 200, 250 and 290 GeV**:

  total energy deposit
  longitudinal profile
  comparison with Fluka and Epics MC simulations
  energy deposit vs primary particle energy
  energy resolution
  variation of APD gain with temperature
  study of calibration of 250 and 290 GeV electrons as a function of temperature

TASC calibration :
channel calibration with MIPs

- **150 GeV muon beam;**
- **Use IMC tracking to select particles crossing the PWO crystal under study**
- **Selection cuts applied on χ^2 and on fit parameters**

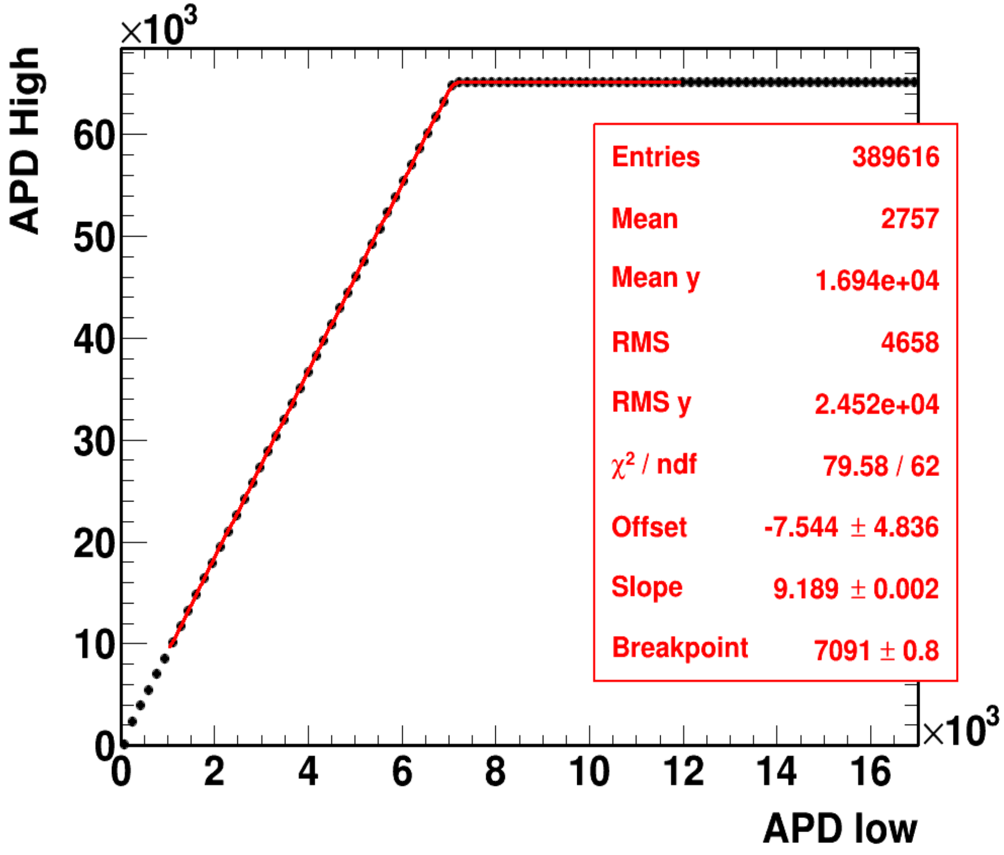




- **Pedestal (green curve) , physics events (blue curve) and MIPs selection (red curve)**
- **Fit with a landau convoluted with a gaussian (langaus)**
- **Fitted MPV used as calibration coefficient**
- **Sigma used to reproduce the channel spread in MC simulation**

TASC calibration - second step:
APD High/Low stitching

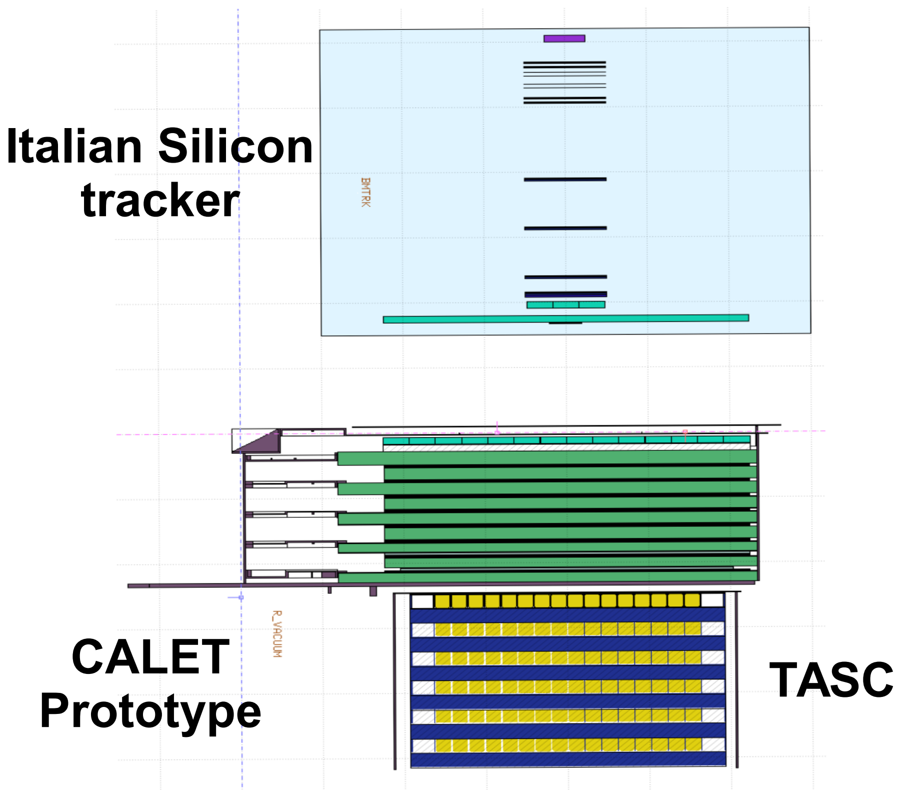
Electron runs



- High gain vs Low gain plot in each channel
- fit to a break line
- Fit parameters used to connect the two signal ranges

MonteCarlo Simulation of Beam Test

Beam Test setup



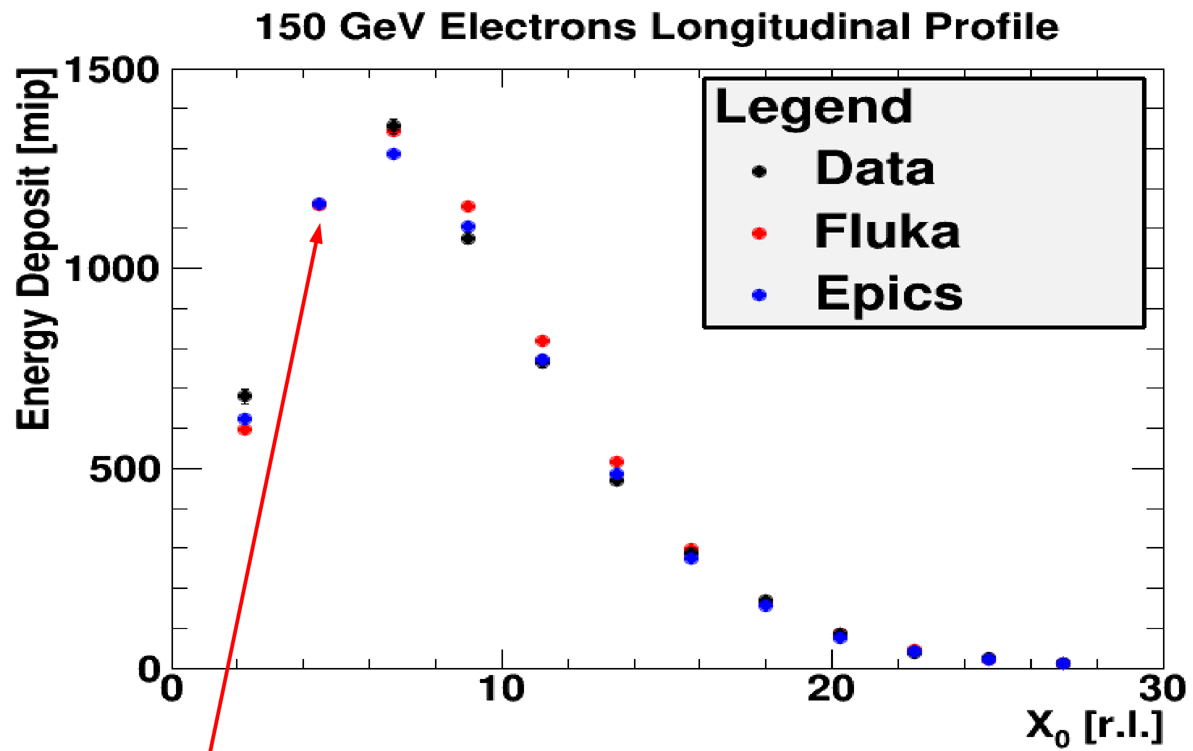
Beam test apparatus simulated with Fluka

The simulated energy deposit is without any fluctuation caused by a detector

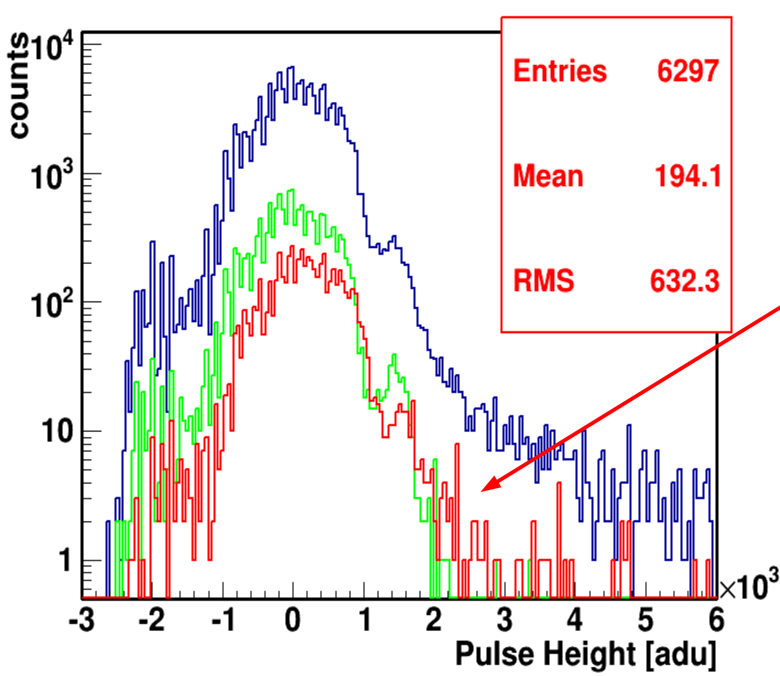
An event-by-event gaussian fluctuation (noise) event-by-event added

The noise of each TASC channel is simulated using the fitted sigma from MIP data

Data vs MC: Mean Longitudinal Profile at 150 GeV



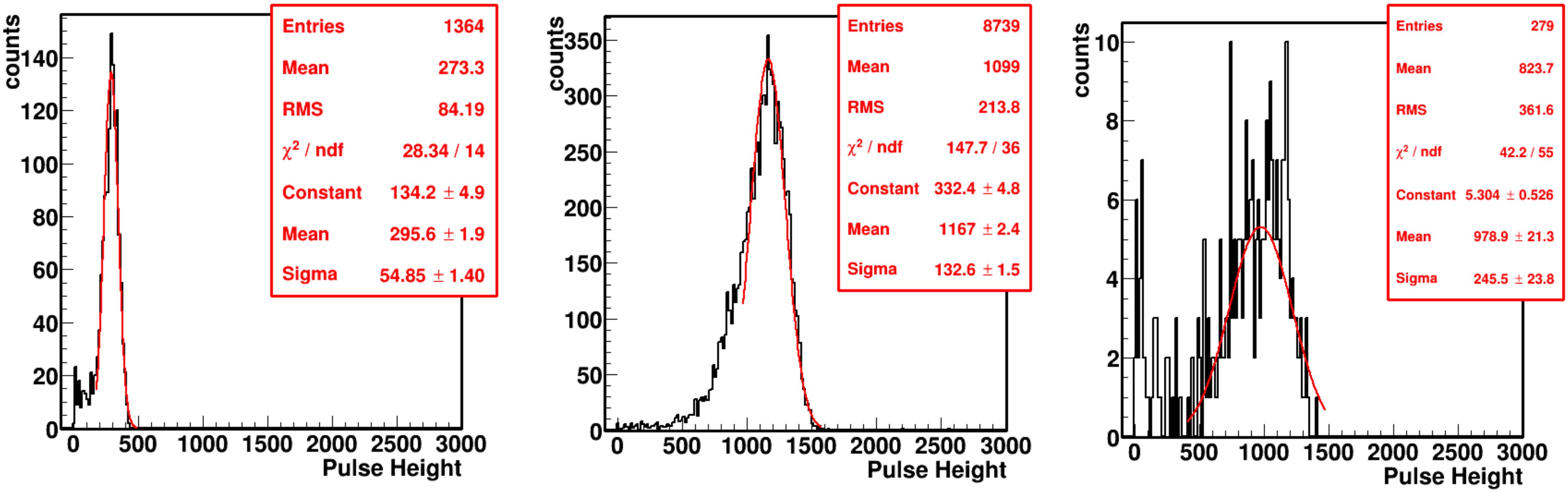
2nd layer central log



2nd layer (readout by BBM3 electronics) cannot be calibrated using MIPs;
not possible to measure the MIP peak values

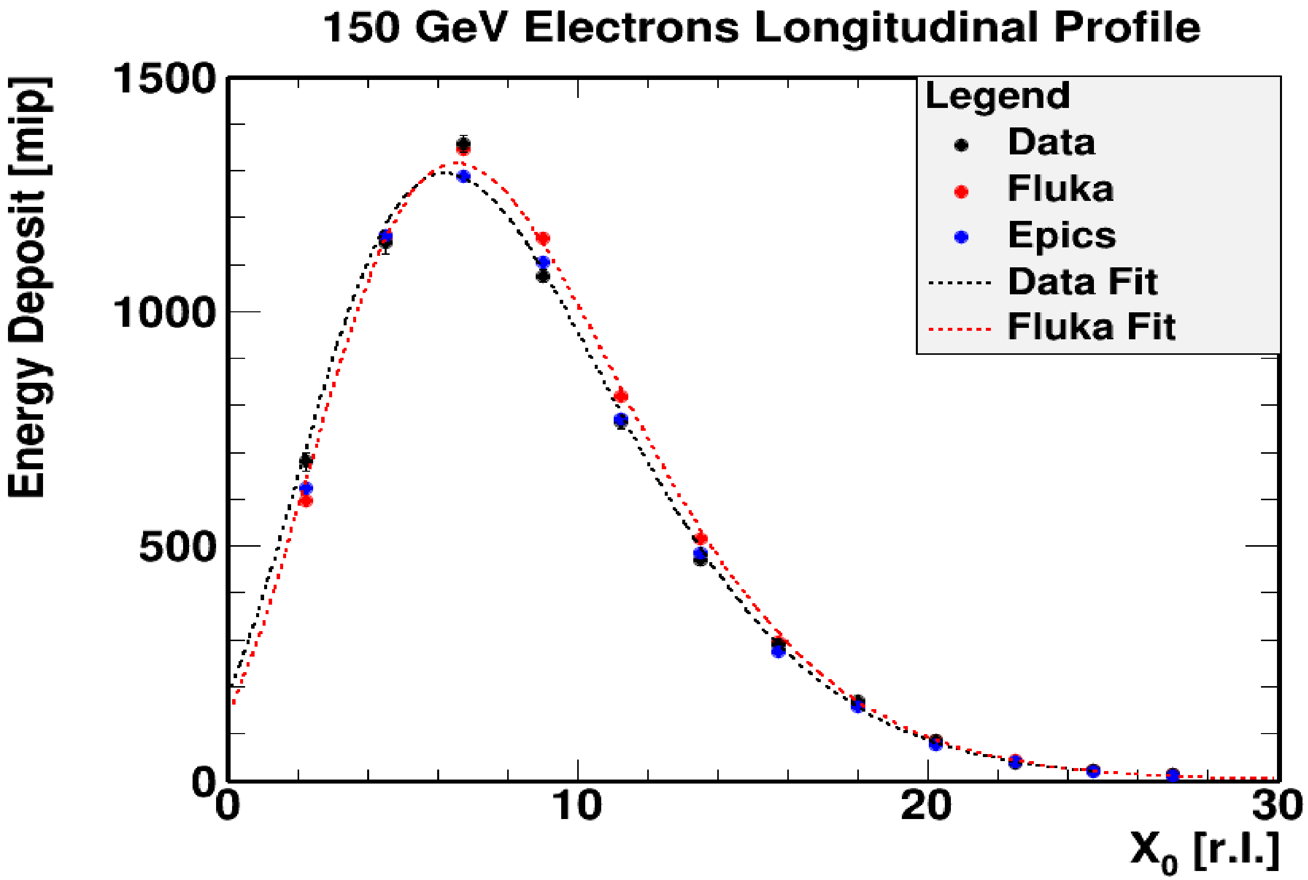
to overcome this problem and calibrate this layer, we applied a two steps procedure

2nd Layer calibration : logs equalization



- **100 GeV electron runs**
- **The beam illuminated all three logs**
- **Each plot is fitted to a gaussian function to obtain the peak value**
- **The peaks have been equalized to the average**

2^{nd} layer calibration: MC rescaling

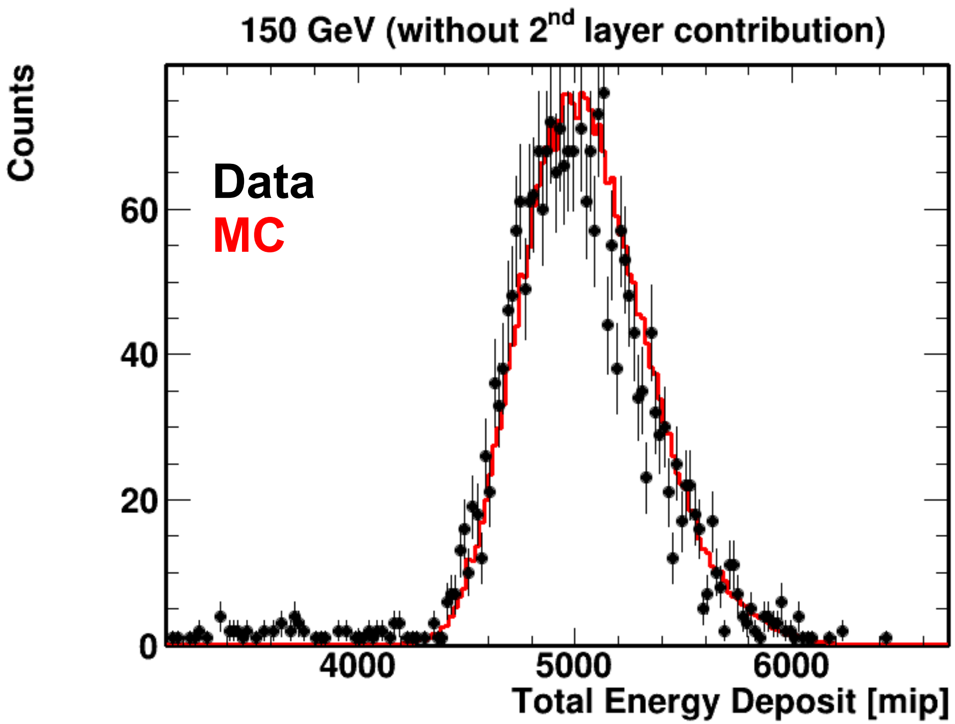


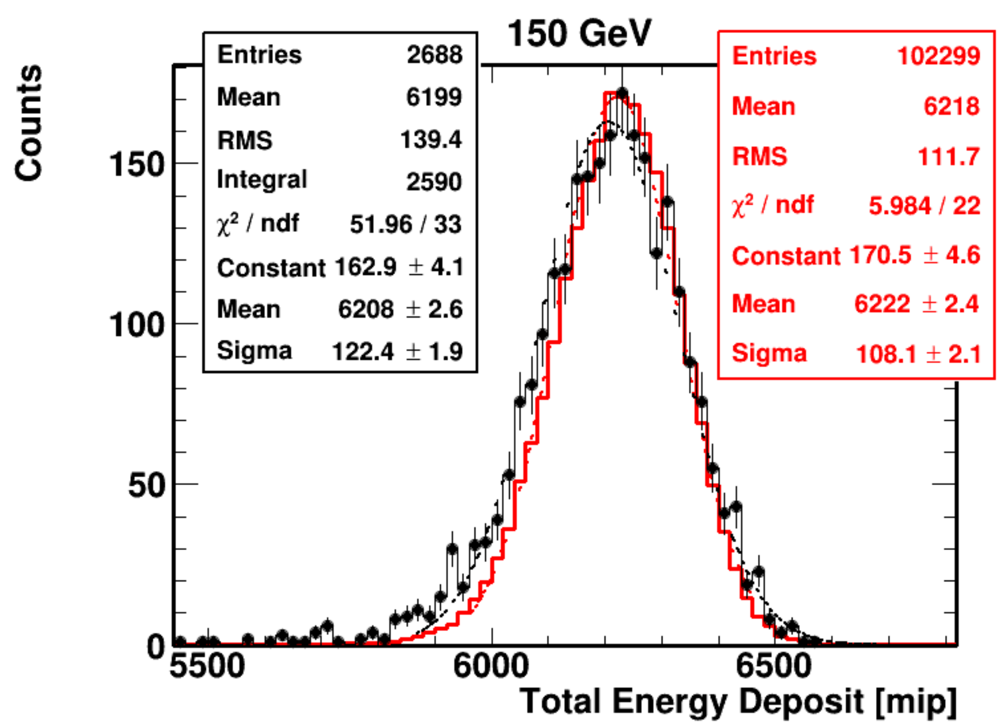
$$\frac{dE}{dt} = \frac{E_0 b}{\Gamma\left(bt_{max}+1\right)}\left(bt\right)^{bt_{max}} e^{-bt}$$

MC average longitudinal profile fitted to a Γ-function;

using the fitted curve a conversion factor (ADC to MIP units) for the 2^{nd} layer is calculated.

150 GeV electrons total energy deposit: Data vs MC



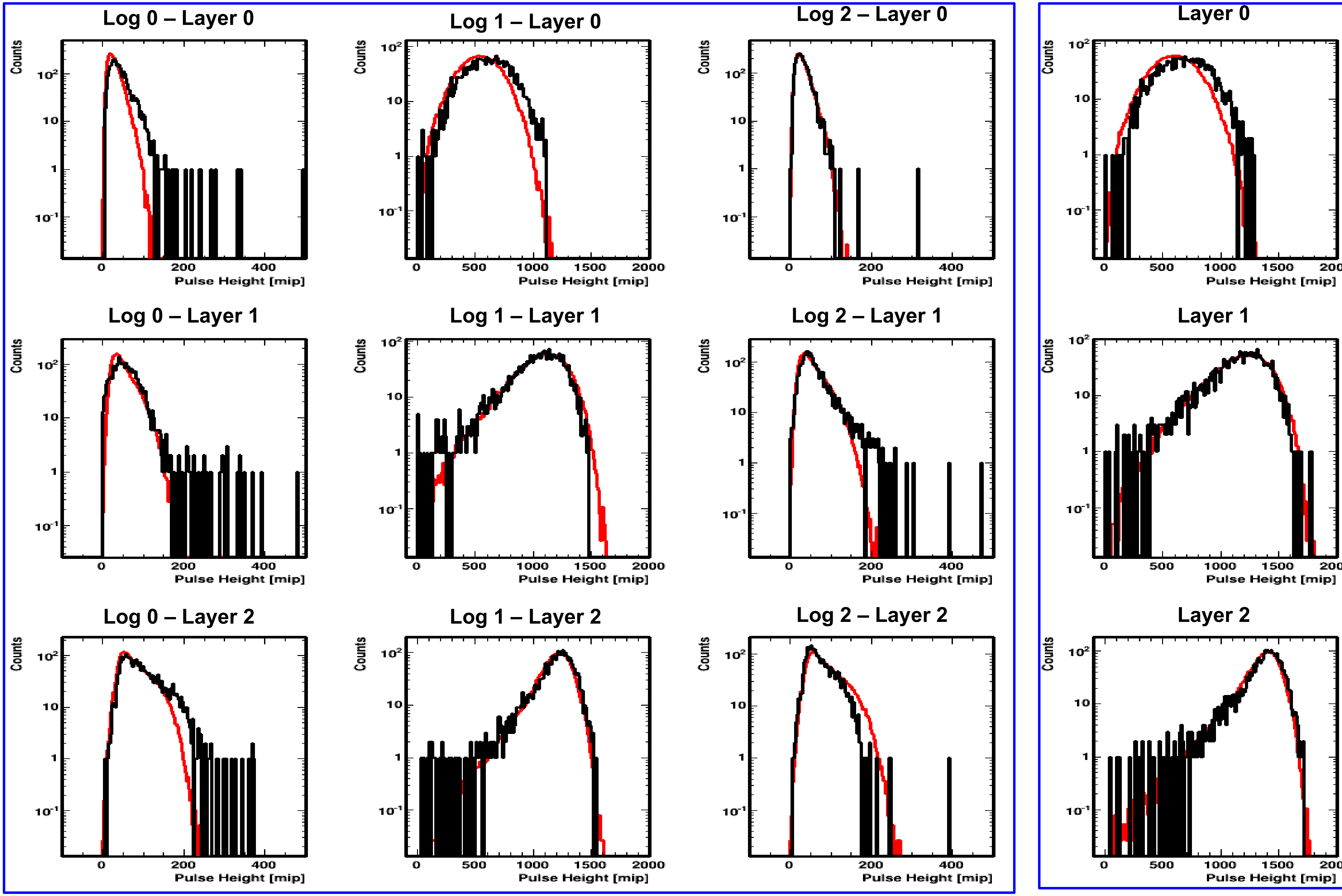


the peaks of two distributions differ less than 1%

the energy resolution of data is ~2% against ~1.7% of MC

that discrepancy probably due to calibration problem in 2nd layer

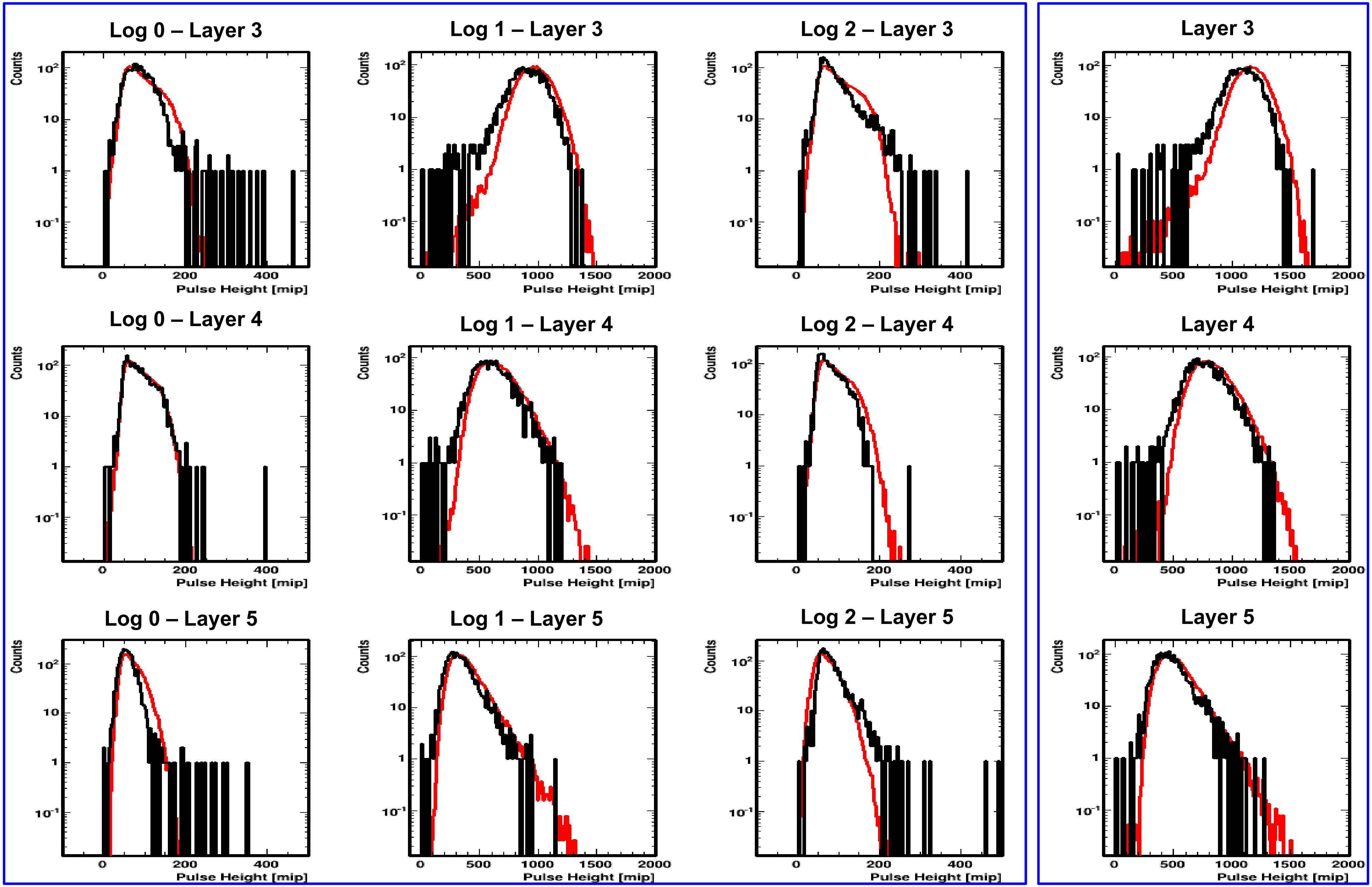
150 GeV Electrons: Data vs MC



Pulse height in each channel

Energy layer deposit

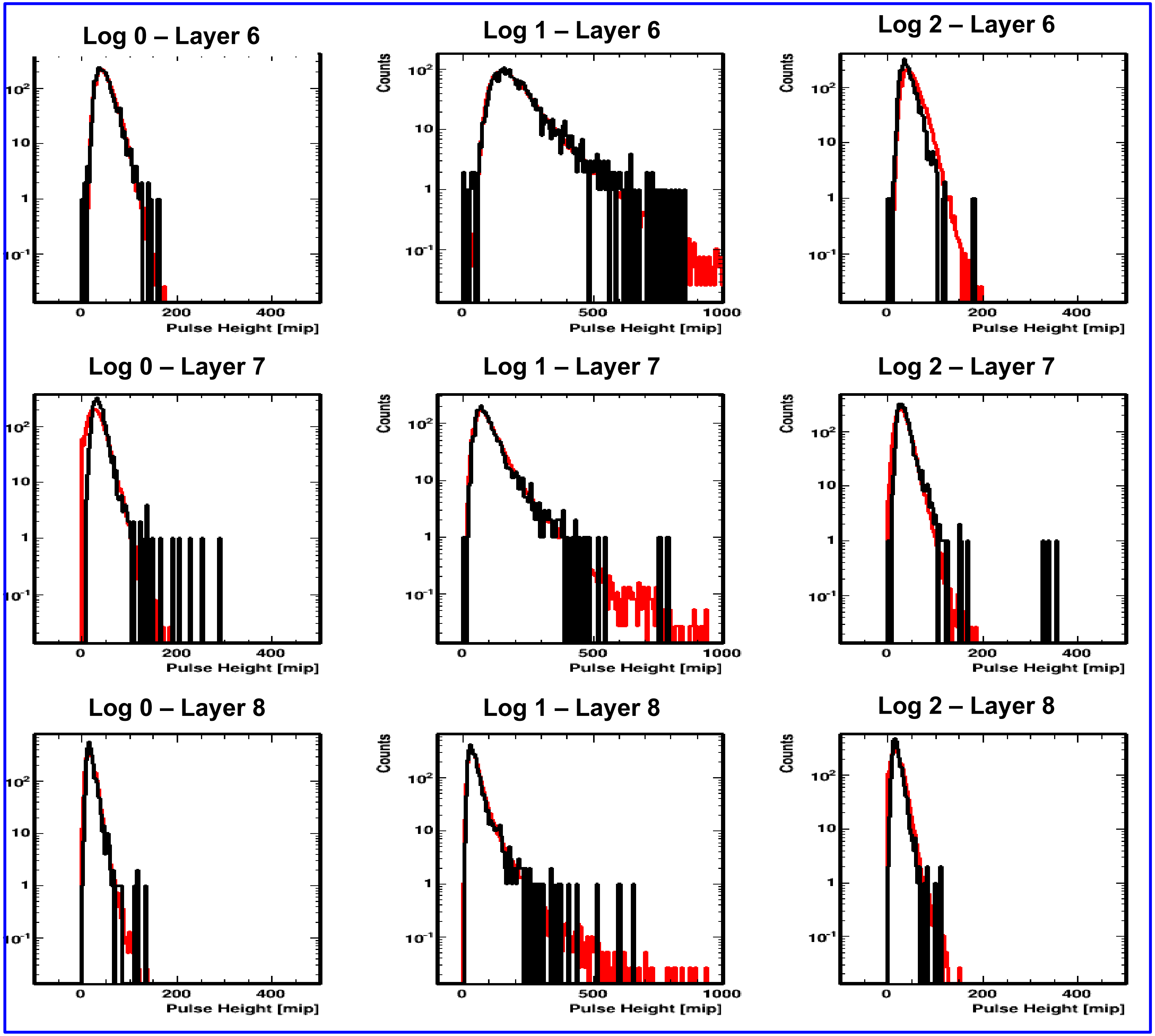
150 GeV Electrons: Data vs MC



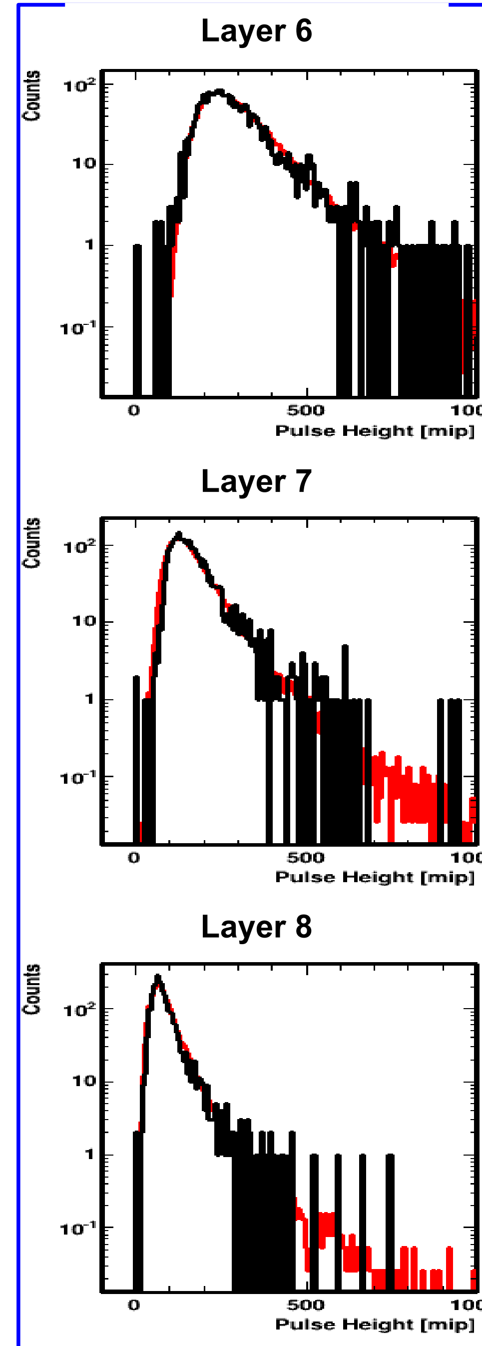
Pulse height in each channel

Energy layer deposit

150 GeV Electrons: Data vs MC

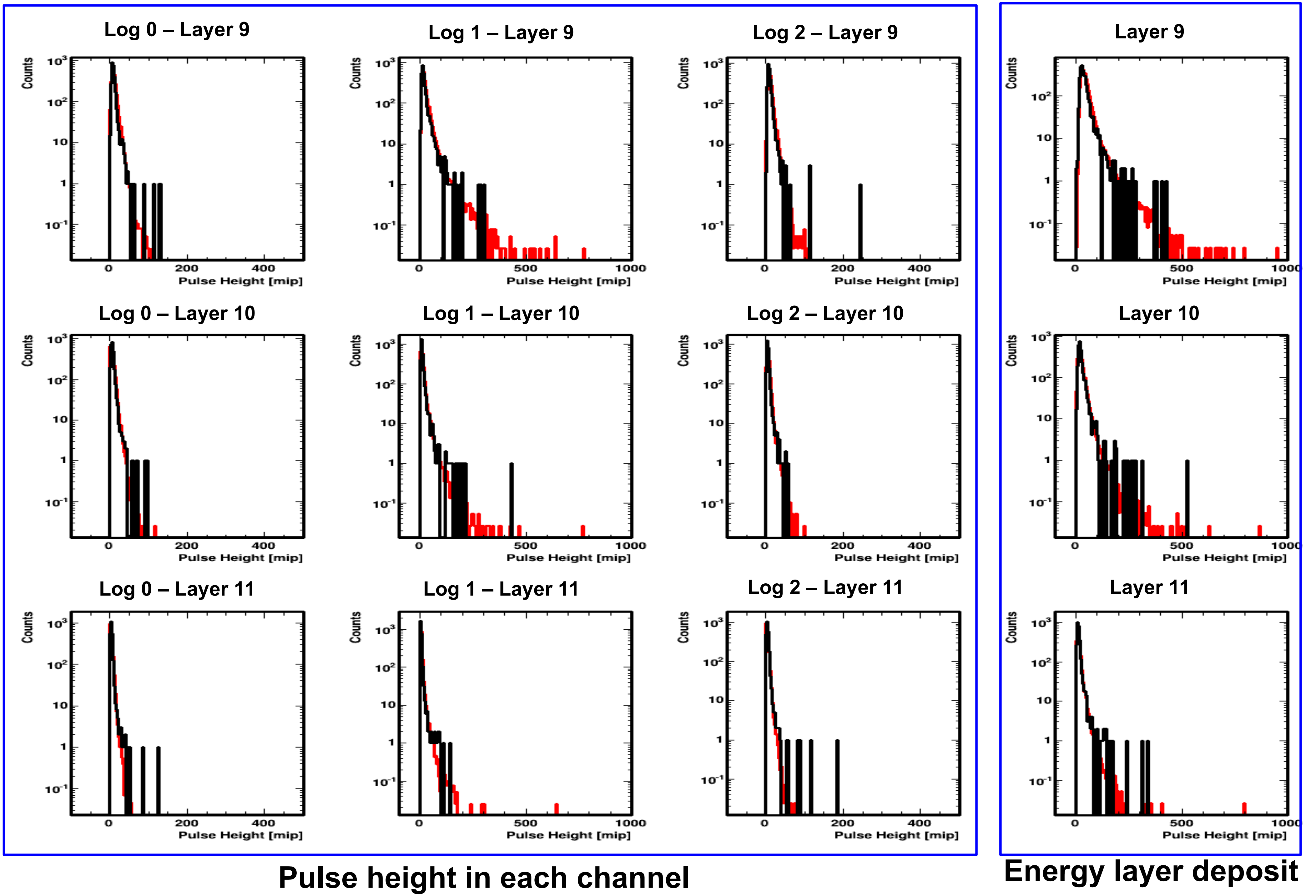


Pulse height in each channel

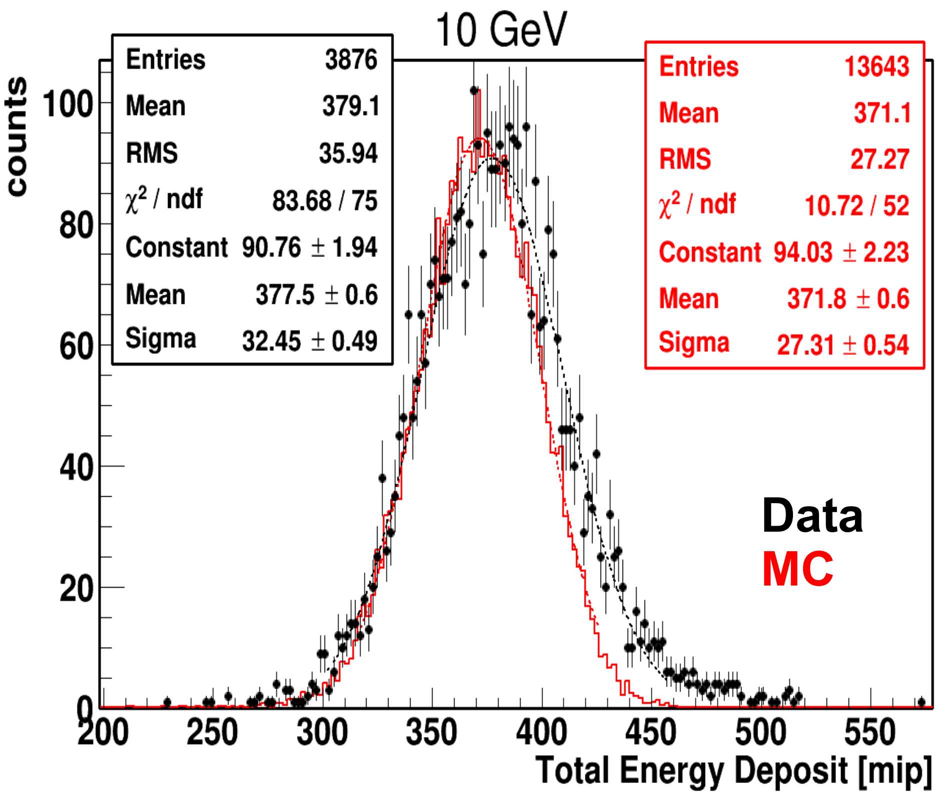


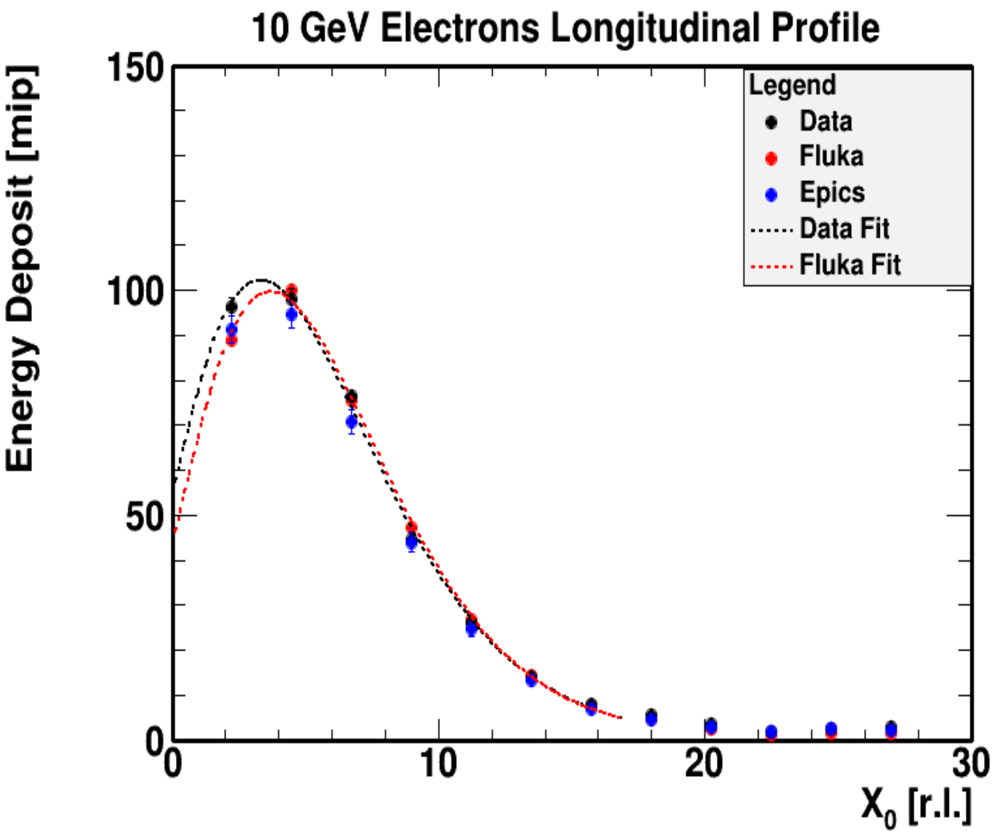
Energy layer deposit

150 GeV Electrons: Data vs MC

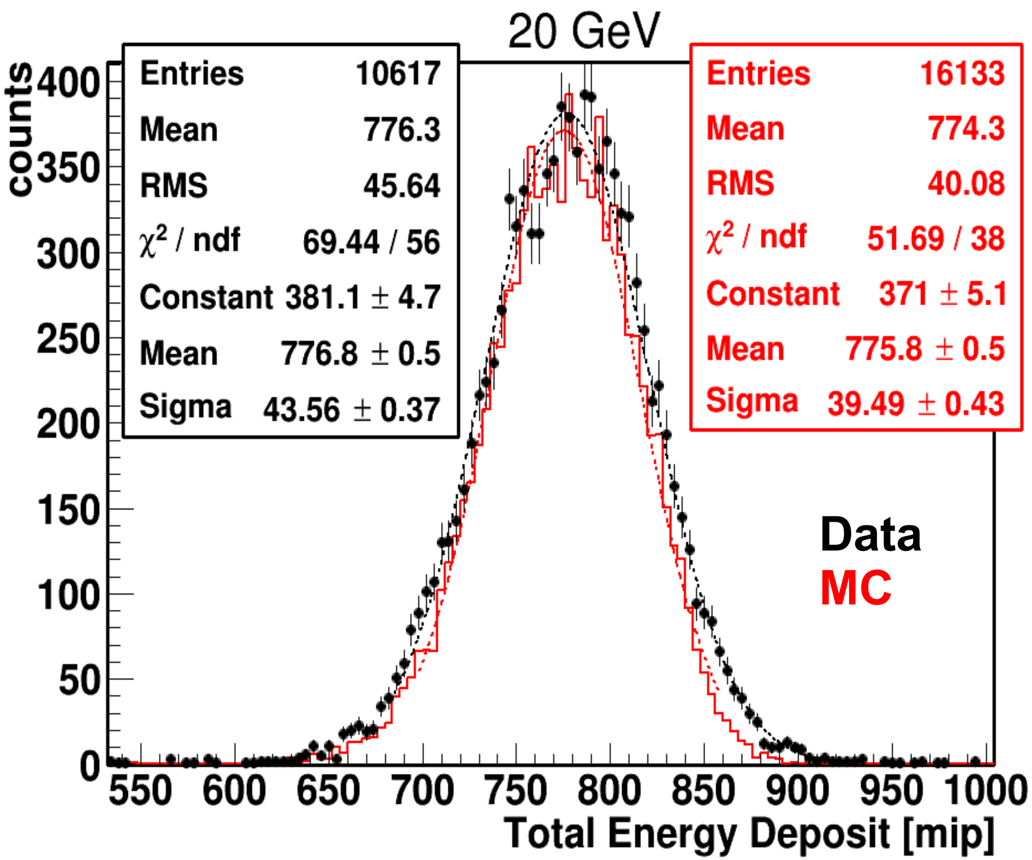


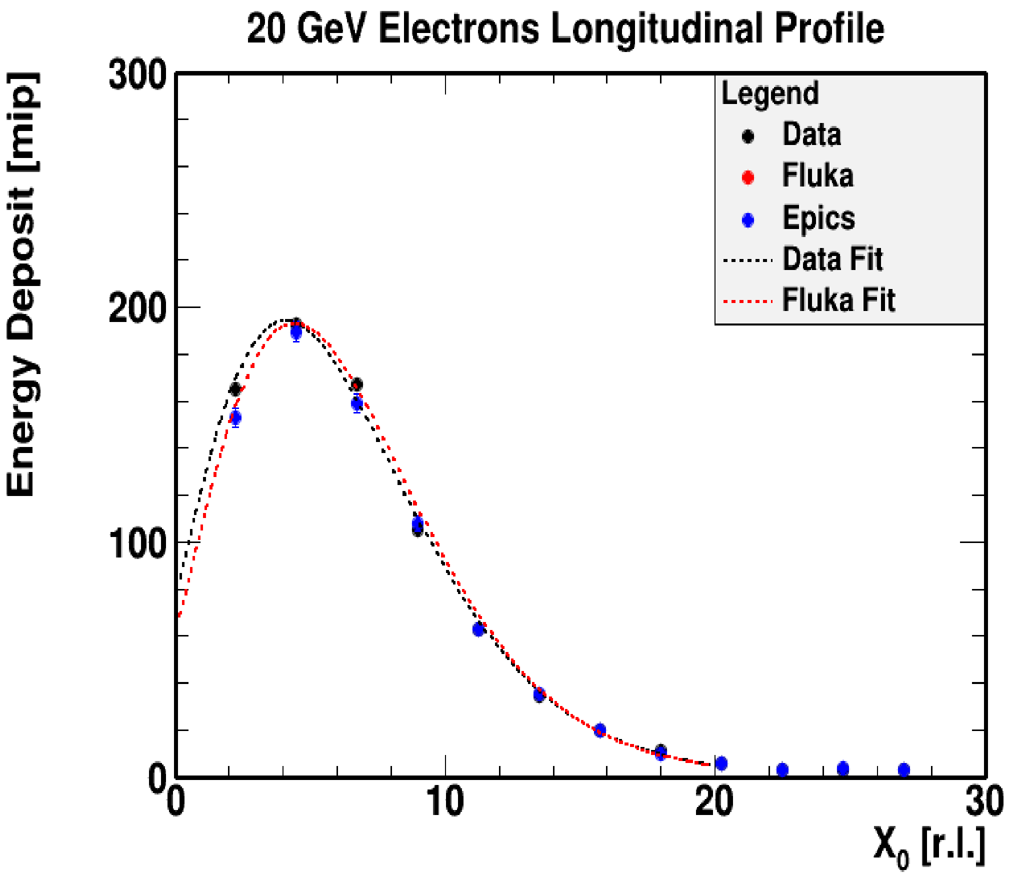
10 GeV Electrons: Data vs MC



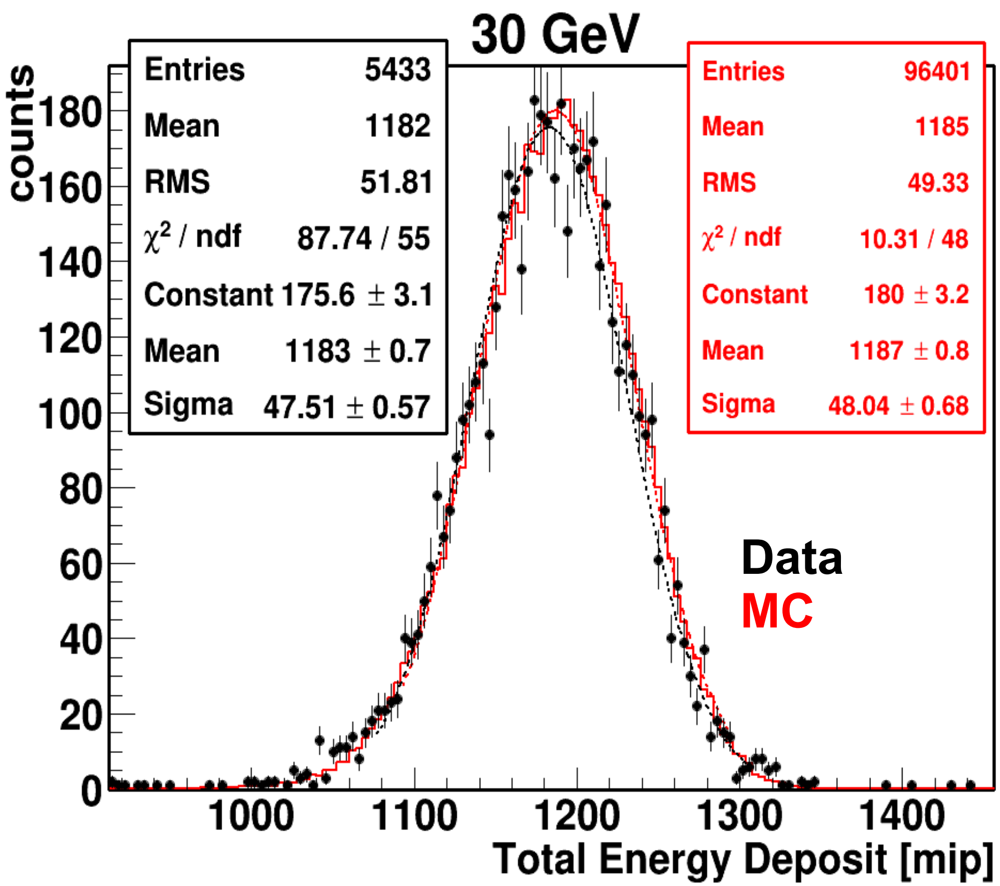


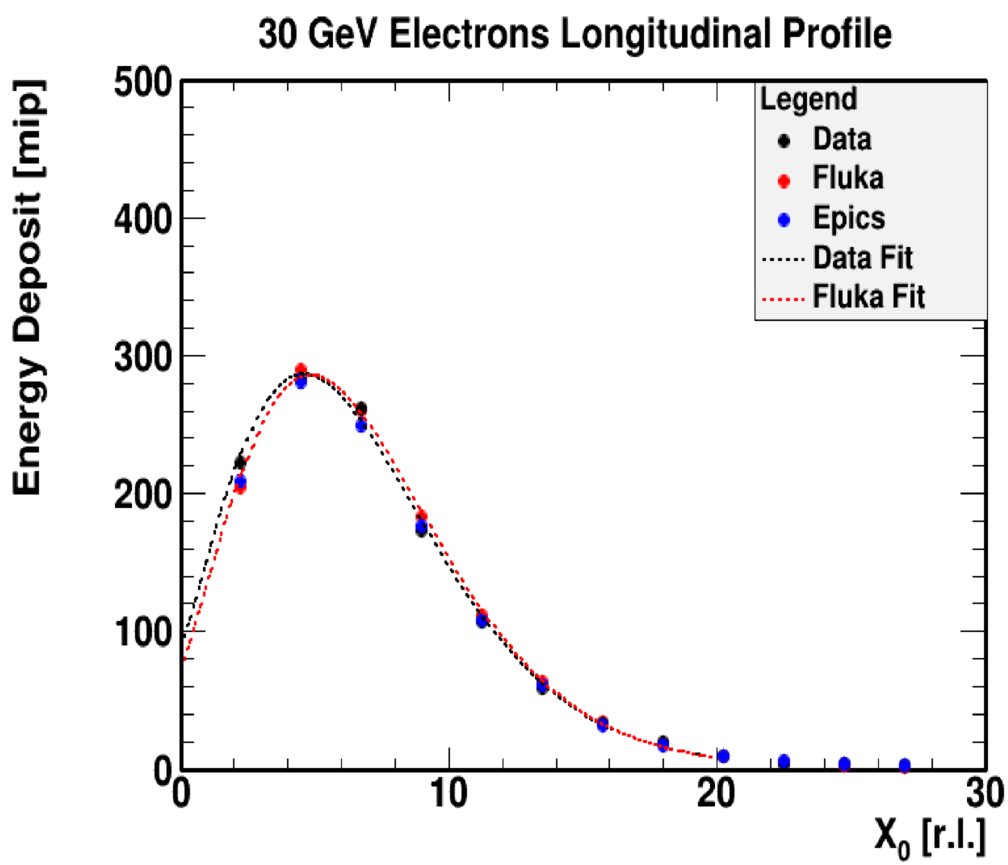
20 GeV Electrons: Data vs MonteCarlo



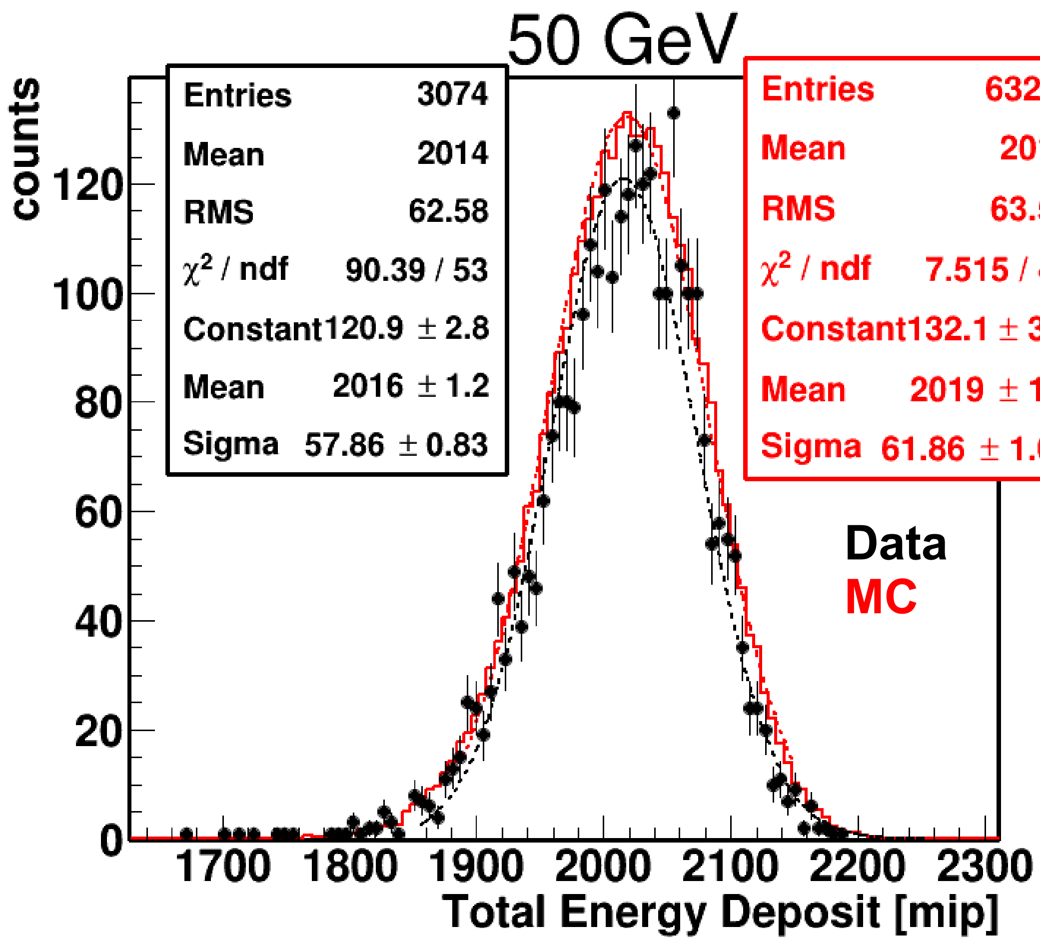


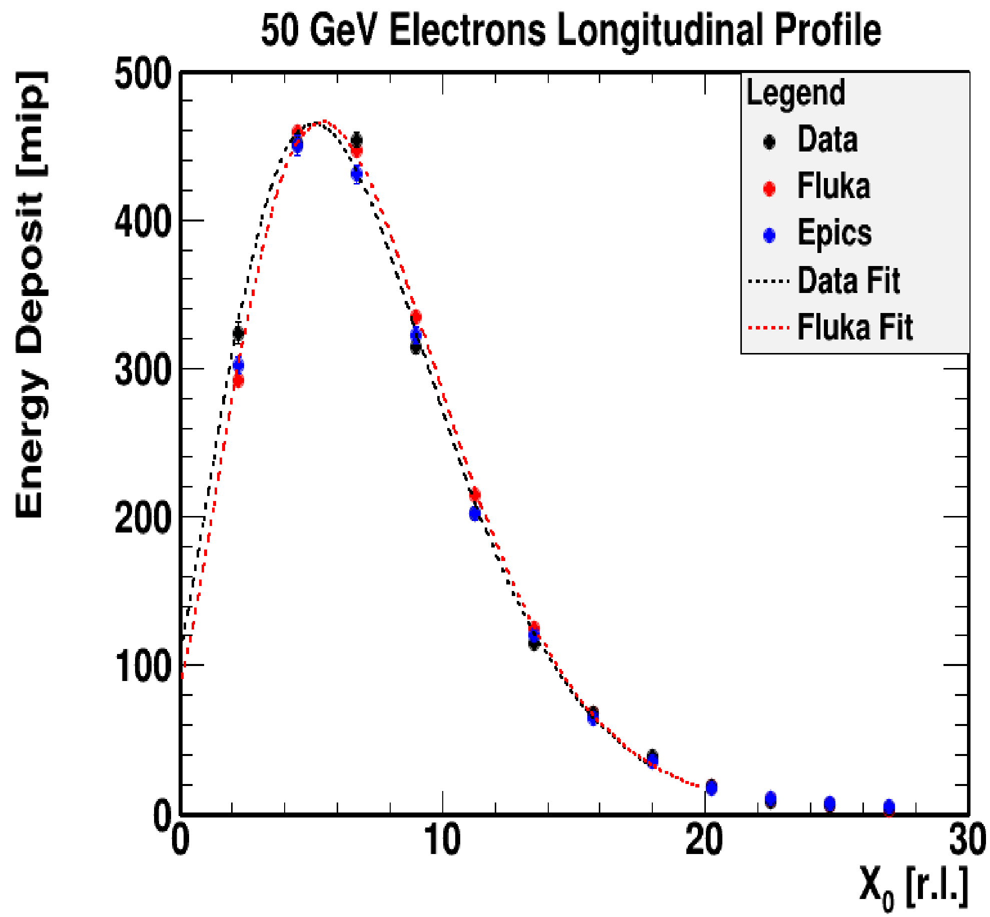
30 GeV Electrons: Data vs MonteCarlo



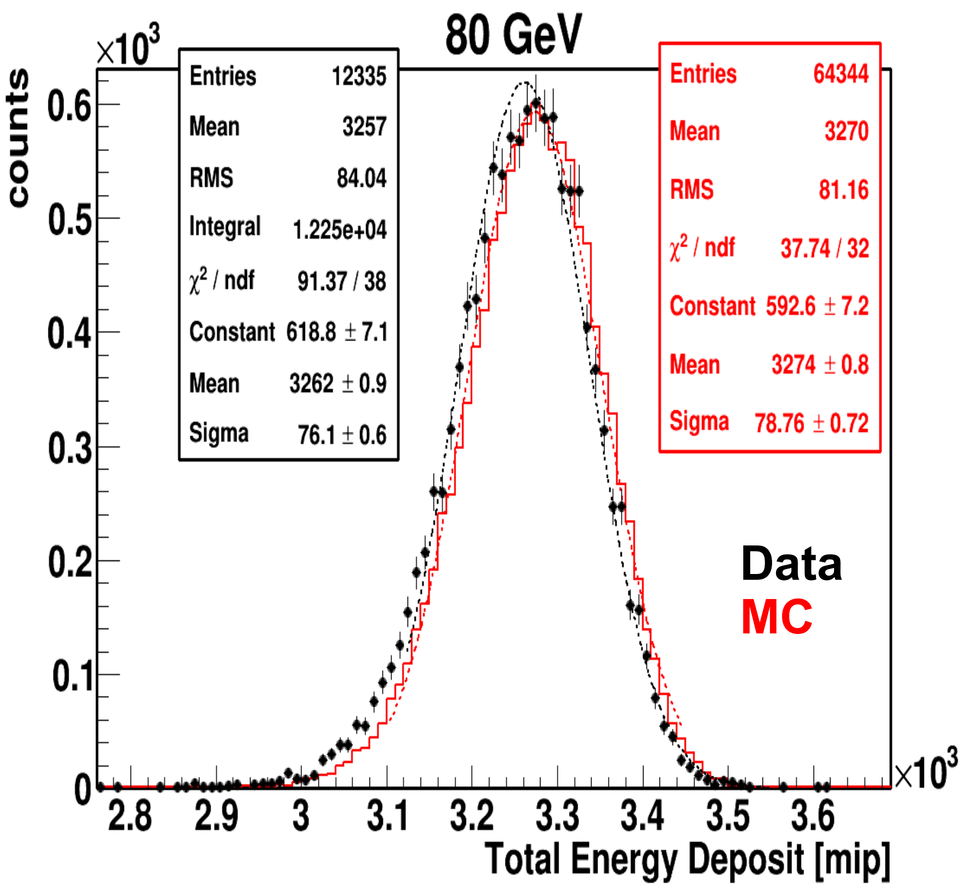


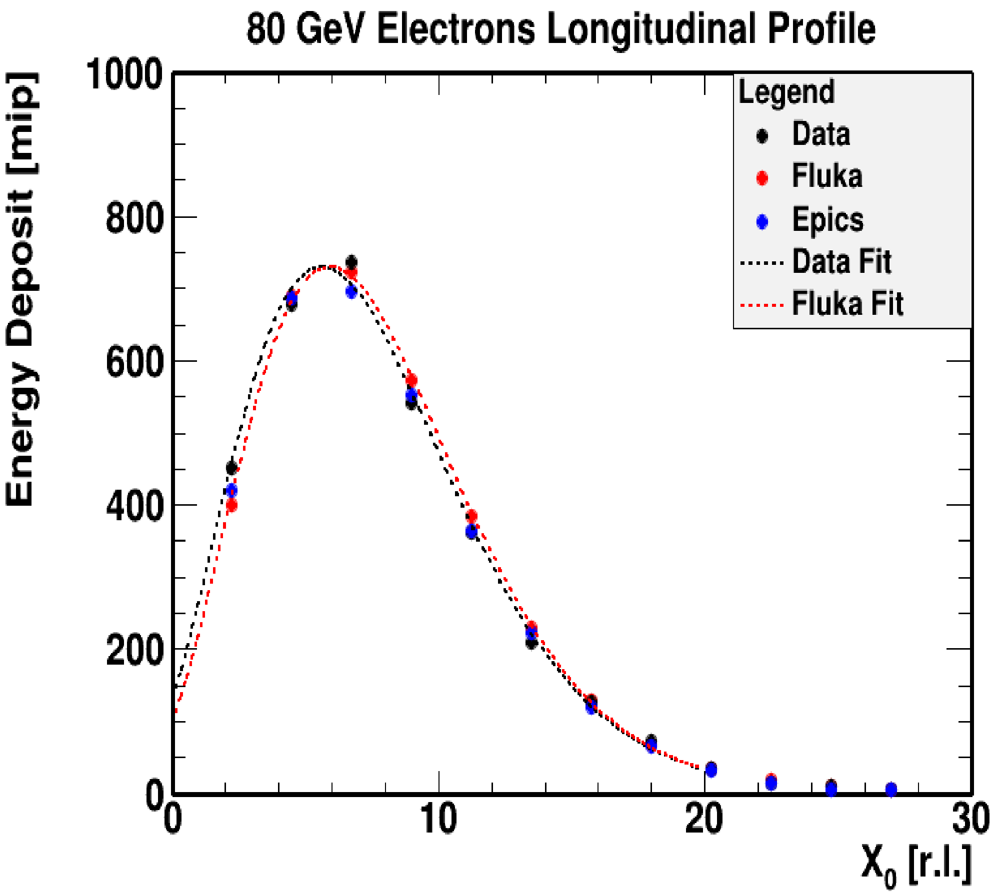
50 GeV Electrons: Data vs MonteCarlo



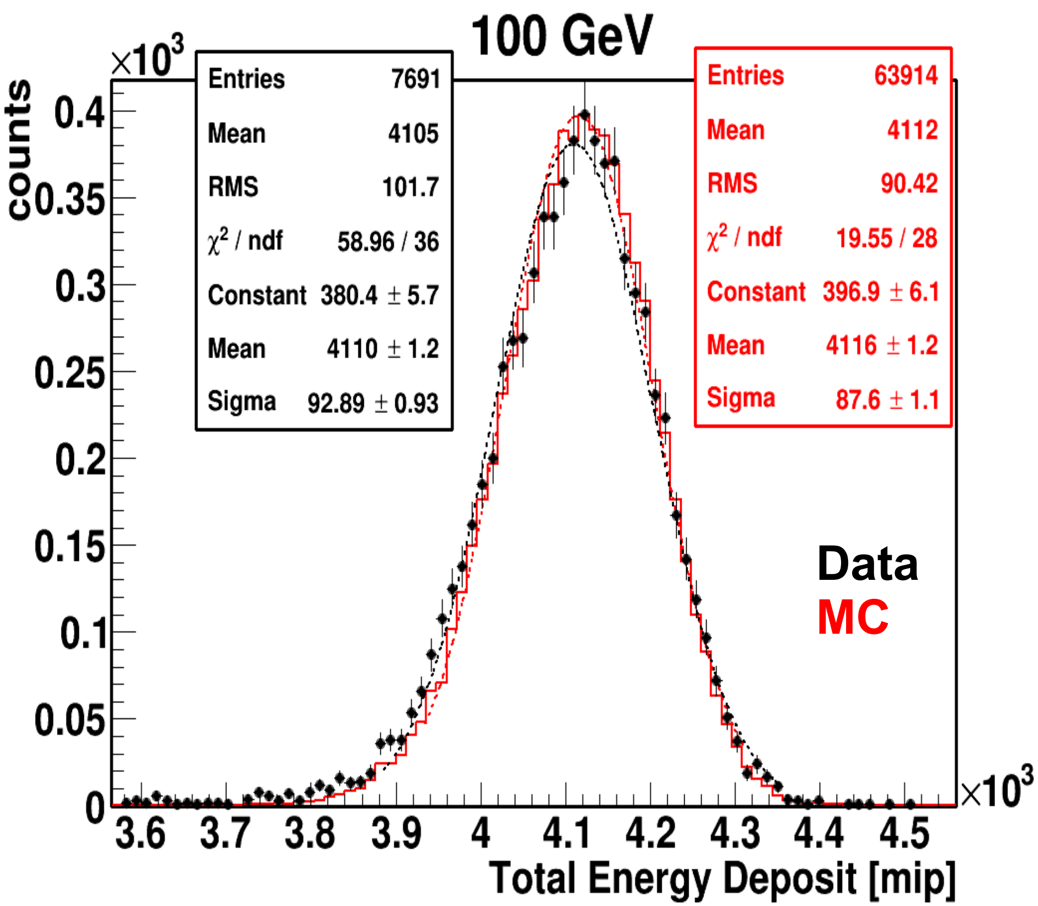


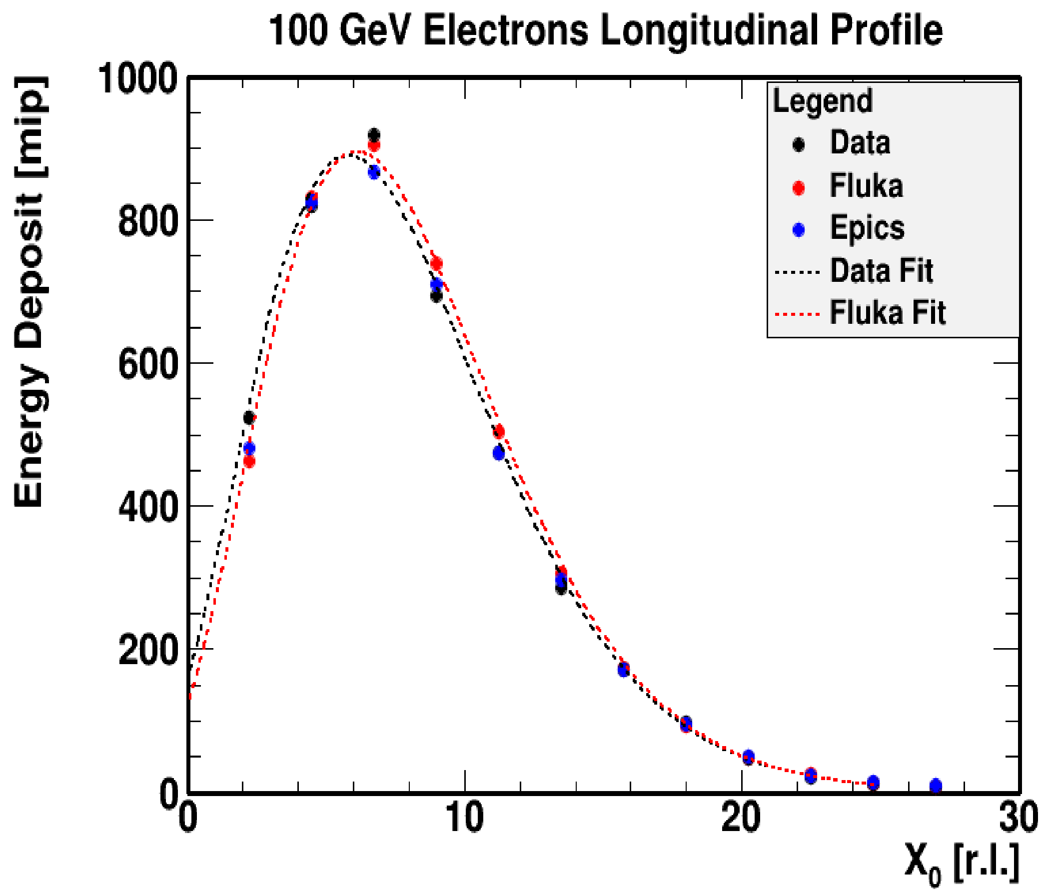
80 GeV Electrons: Data vs MonteCarlo



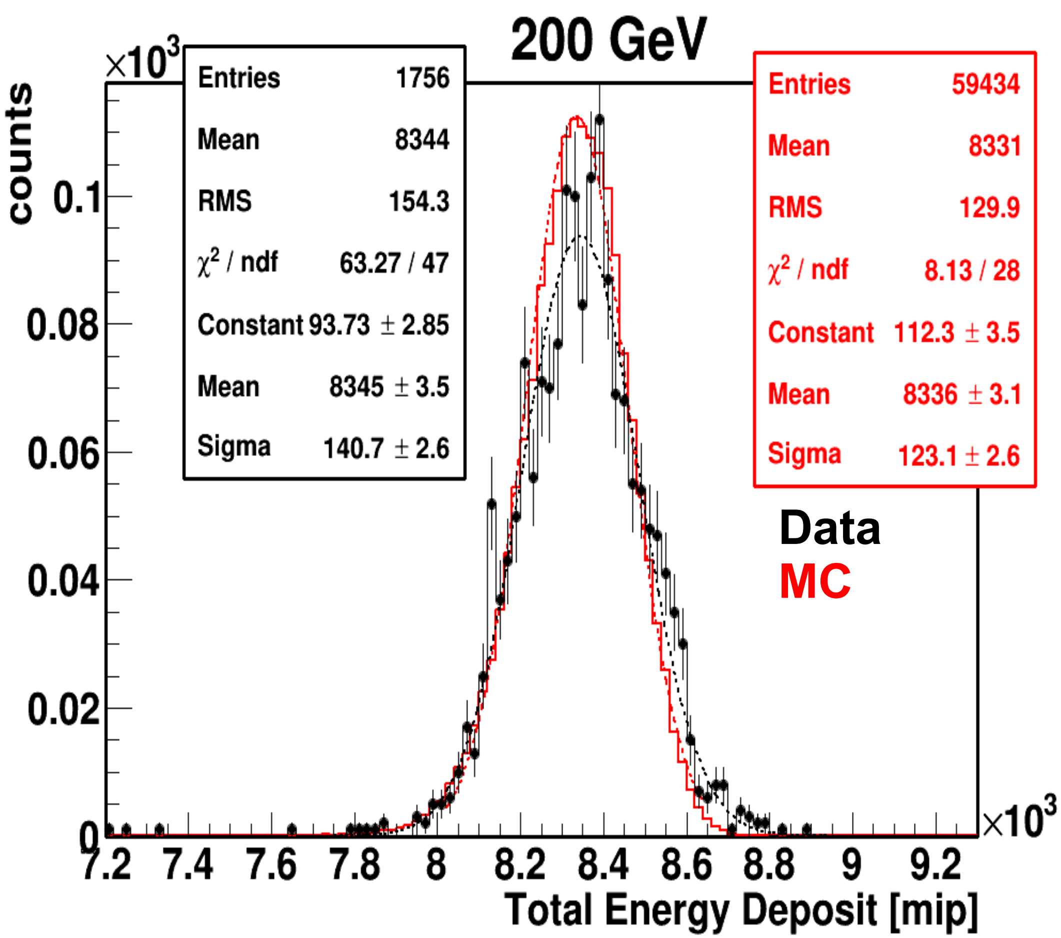


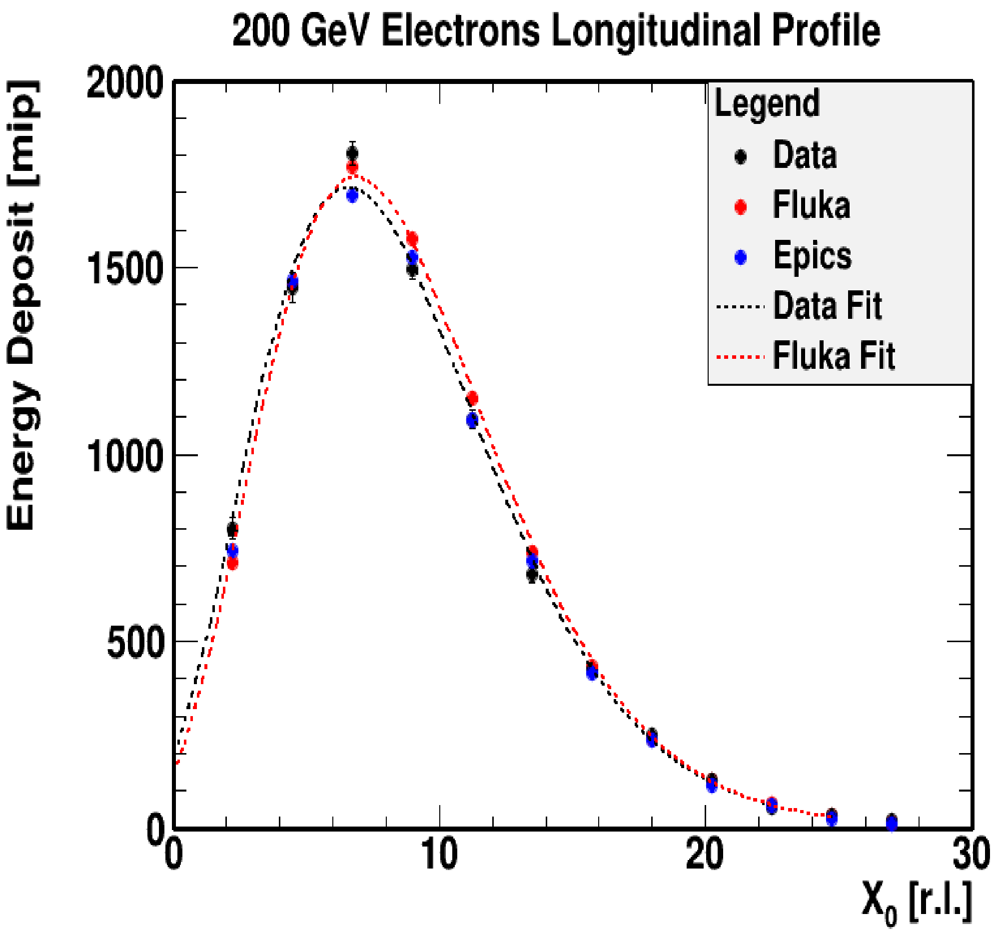
100 GeV Electrons: Data vs MonteCarlo



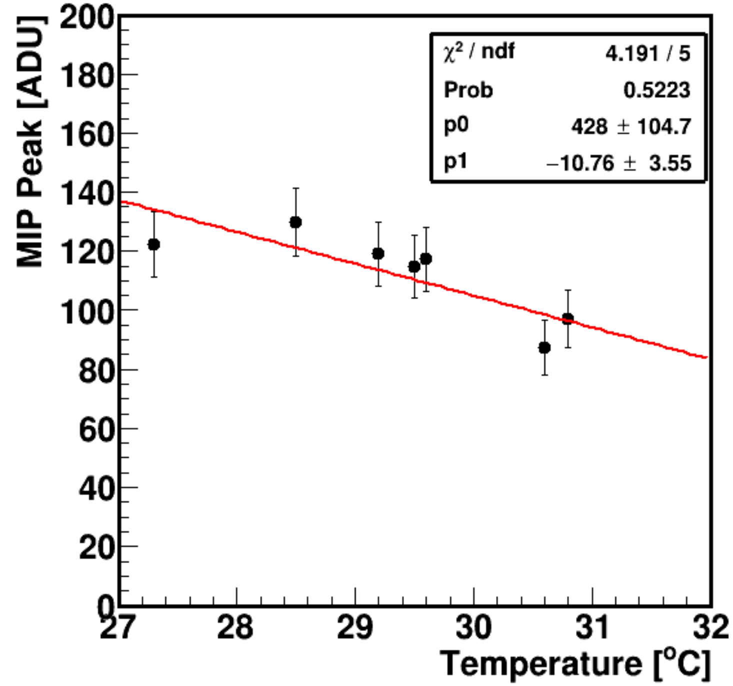


200 GeV Electrons: Data vs MC





250 GeV and 290 GeV electrons runs

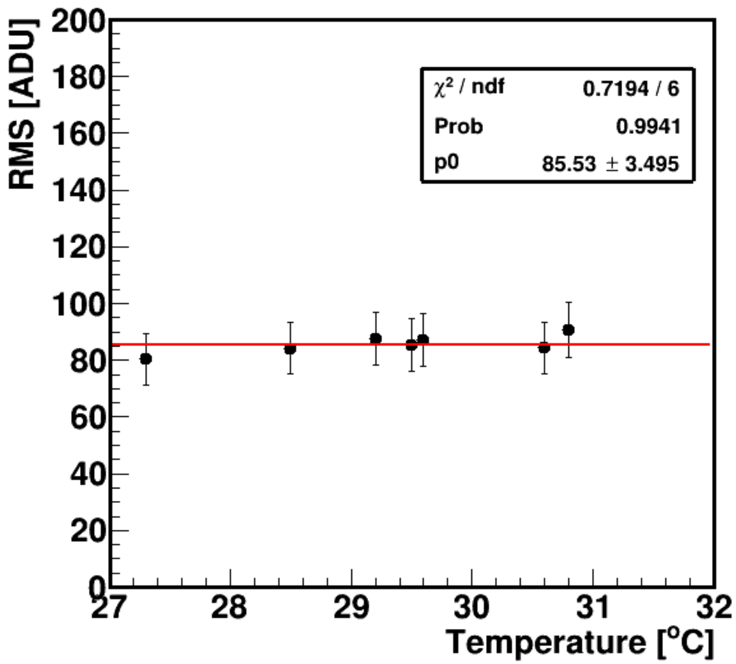


MIP peak position in each channel depends on the temperature (about -10 ADC/°C)

the calibration table cannot be applied to 250 GeV and 290 GeV electrons because taken at different temperature (greater than 1 °C) wrt previous runs

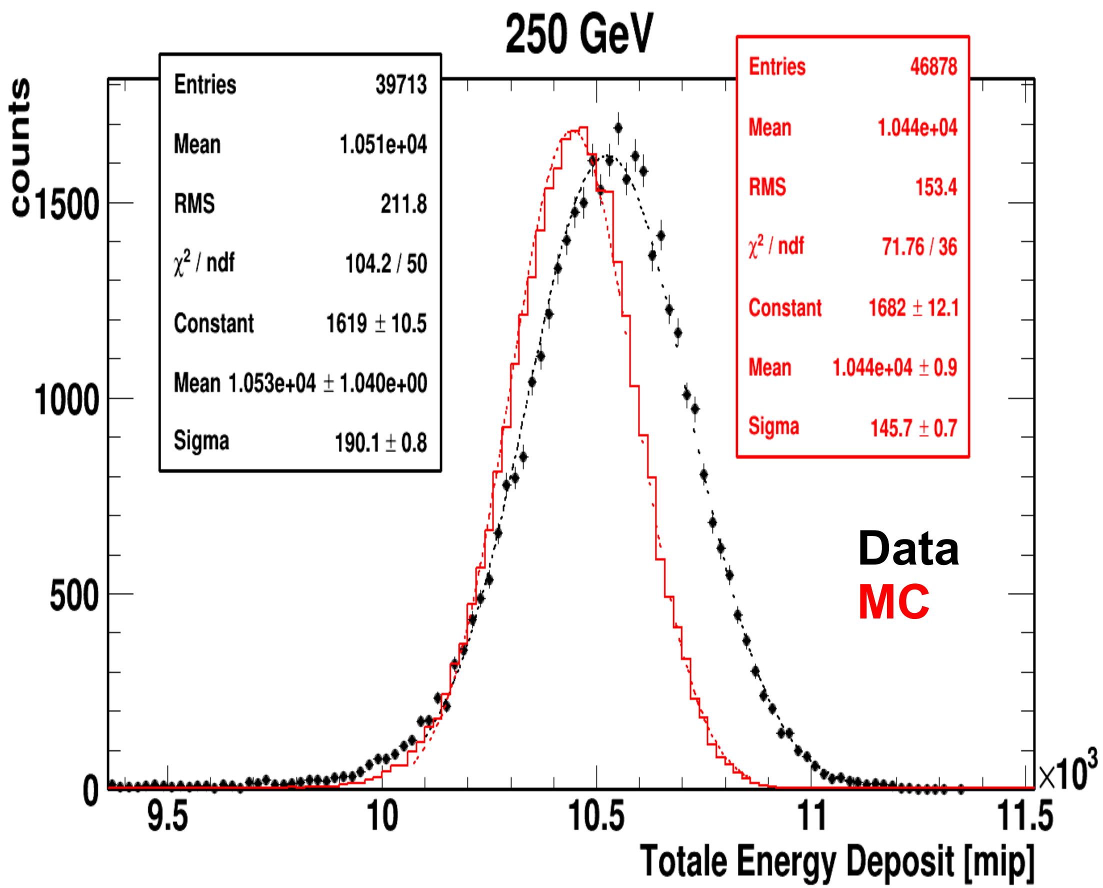
using muon runs at different temperatures, we measure the MIP peak variation with temperature in each channel

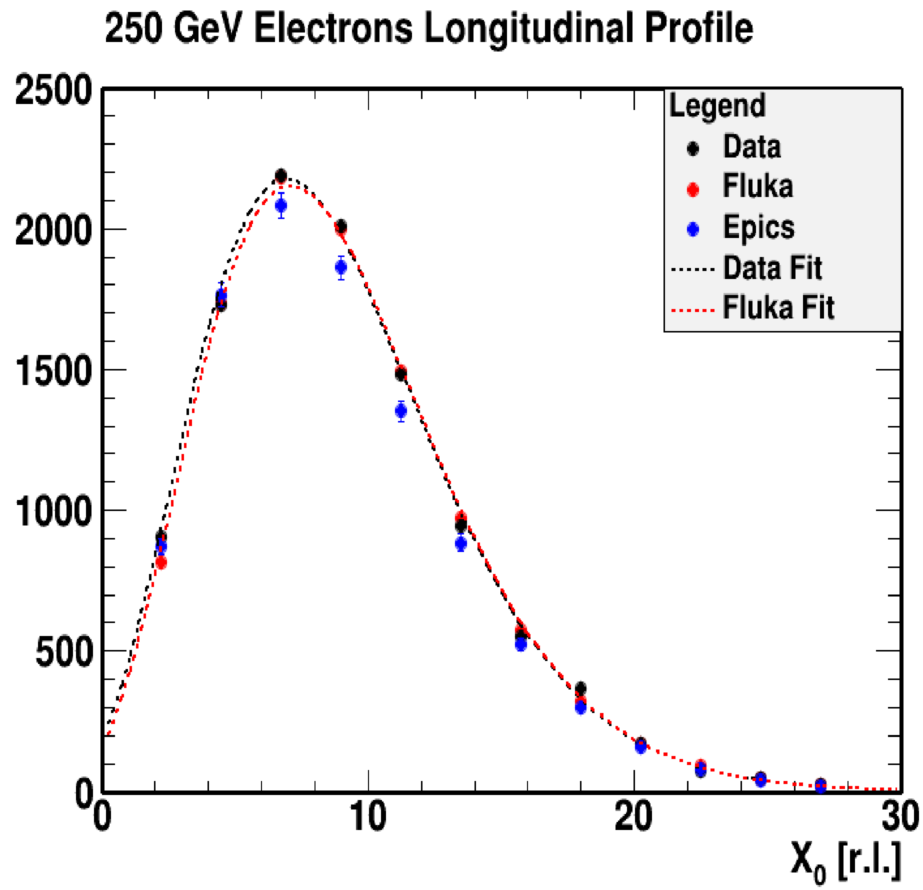
from the fit results, we calculated two calibration tables for 250 and 290 GeV electrons



the RMS of each channel remains stable as the temperature changes;

250 GeV Electrons: Data vs MC

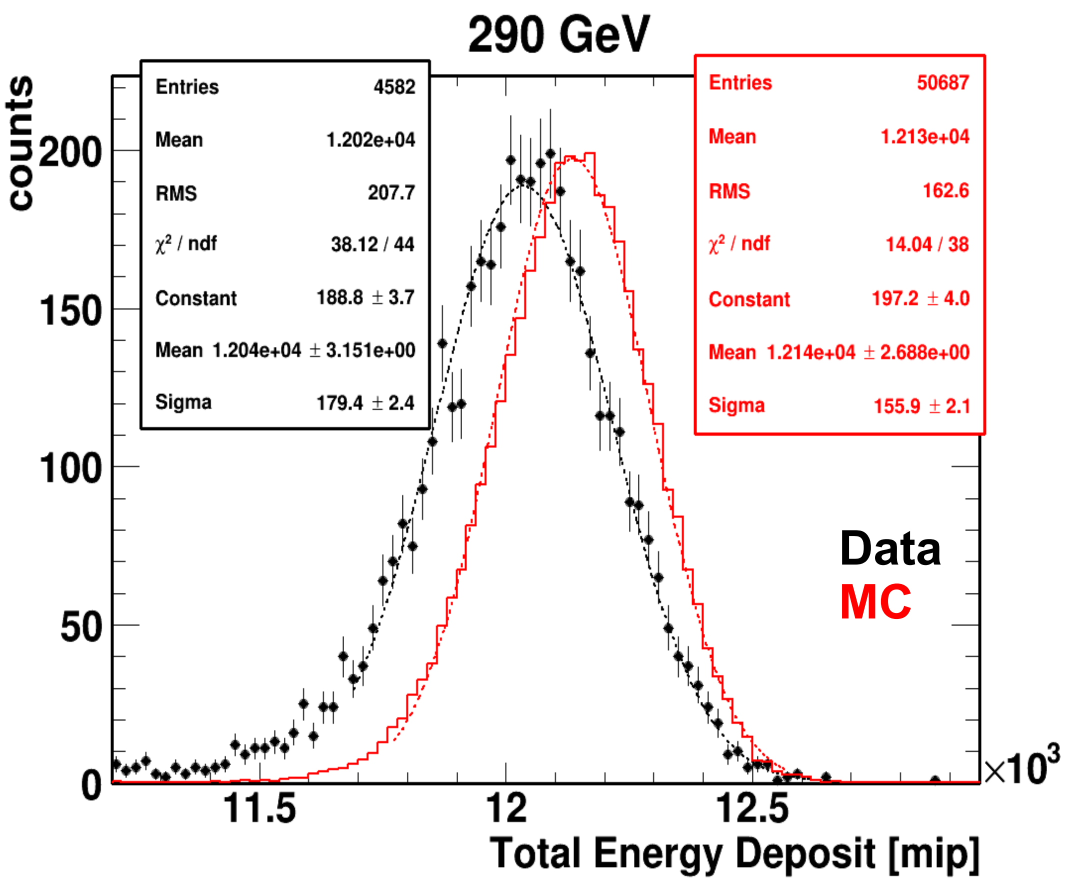


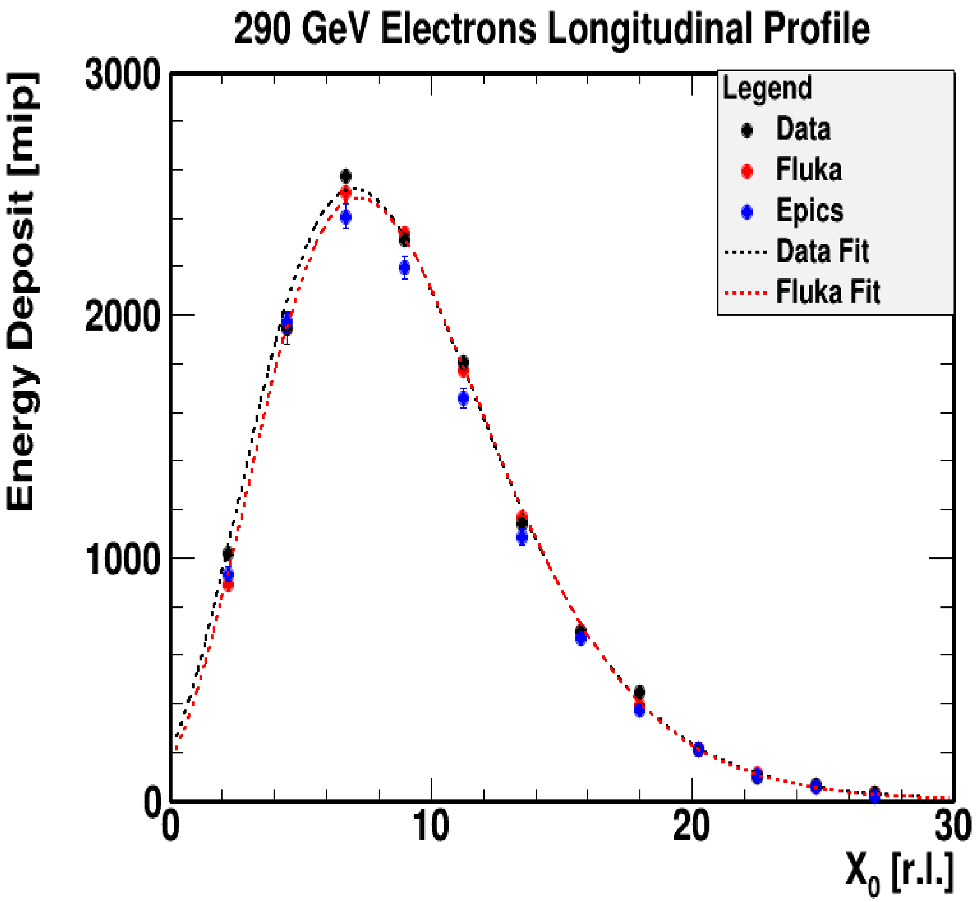


the peaks of two distributions differ by less 1%;

the energy resolution of data is about 1.8% against 1.4% of MC;

290 GeV Electrons: Data vs MC



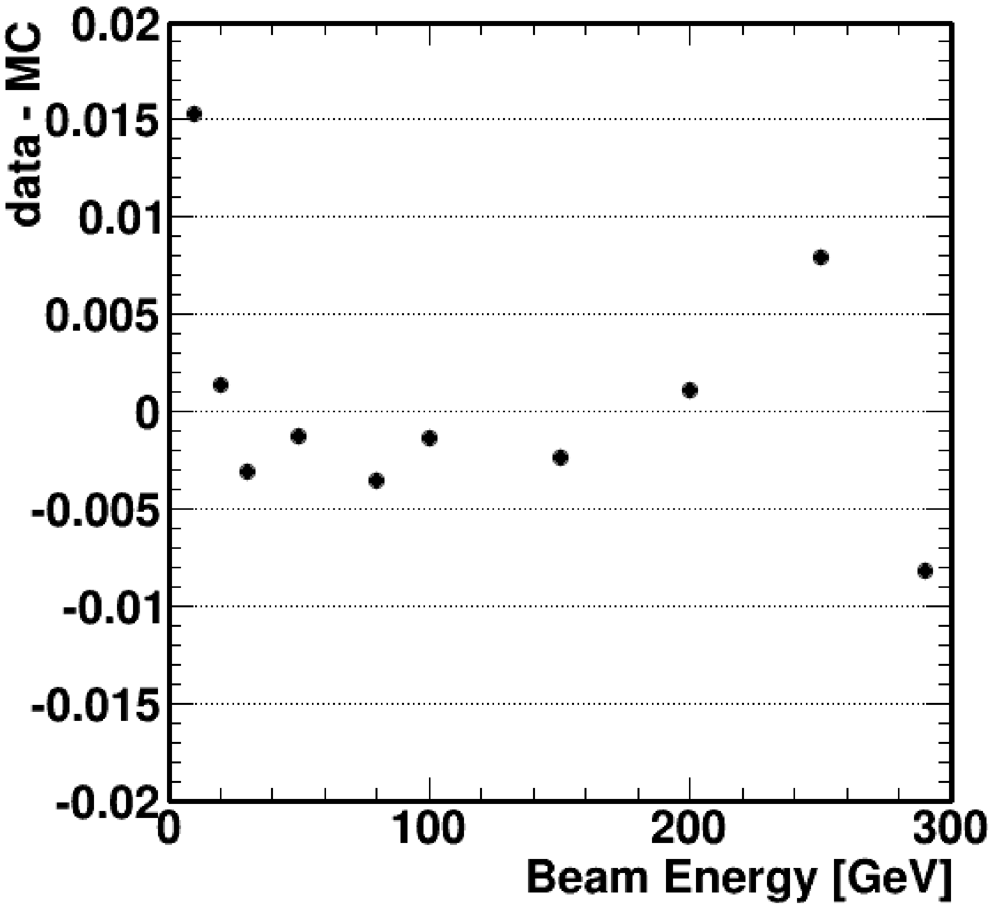


the peaks of two distributions differ by less 1%;

the energy resolution of data is about 1.5% against 1.3% of MC;

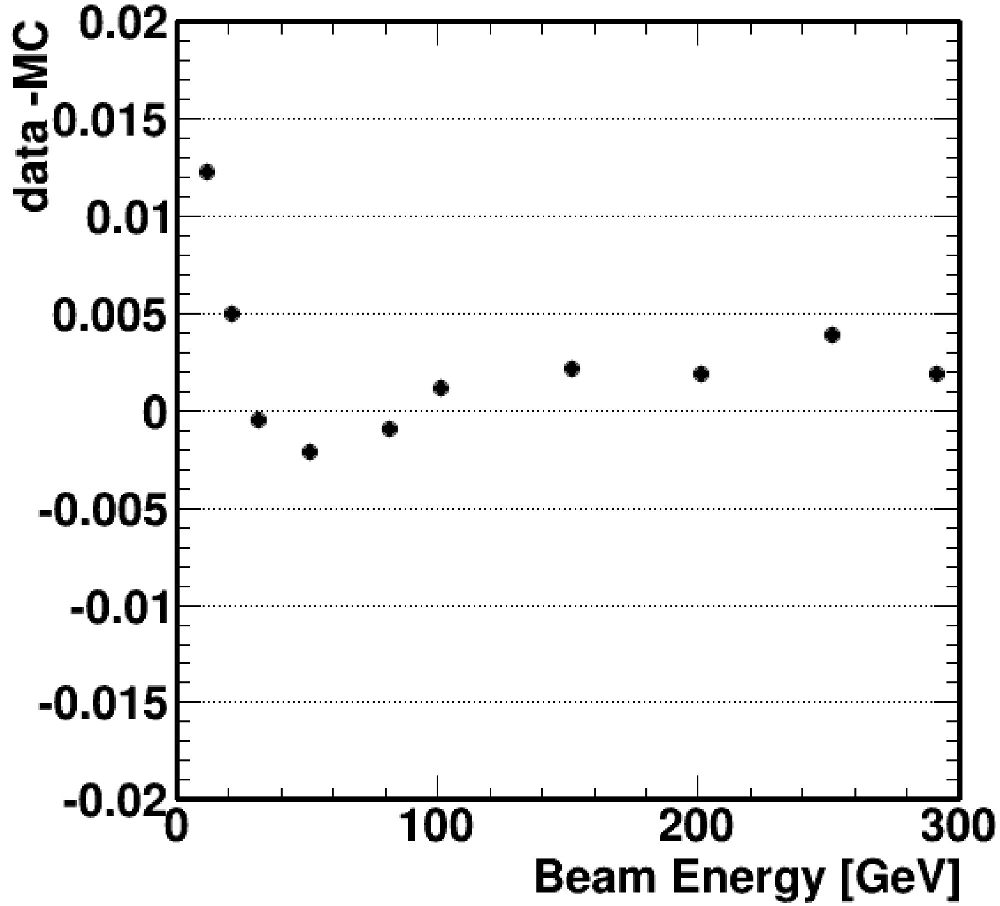
Difference between data e MC

(Data peak – MC peak)/MC peak



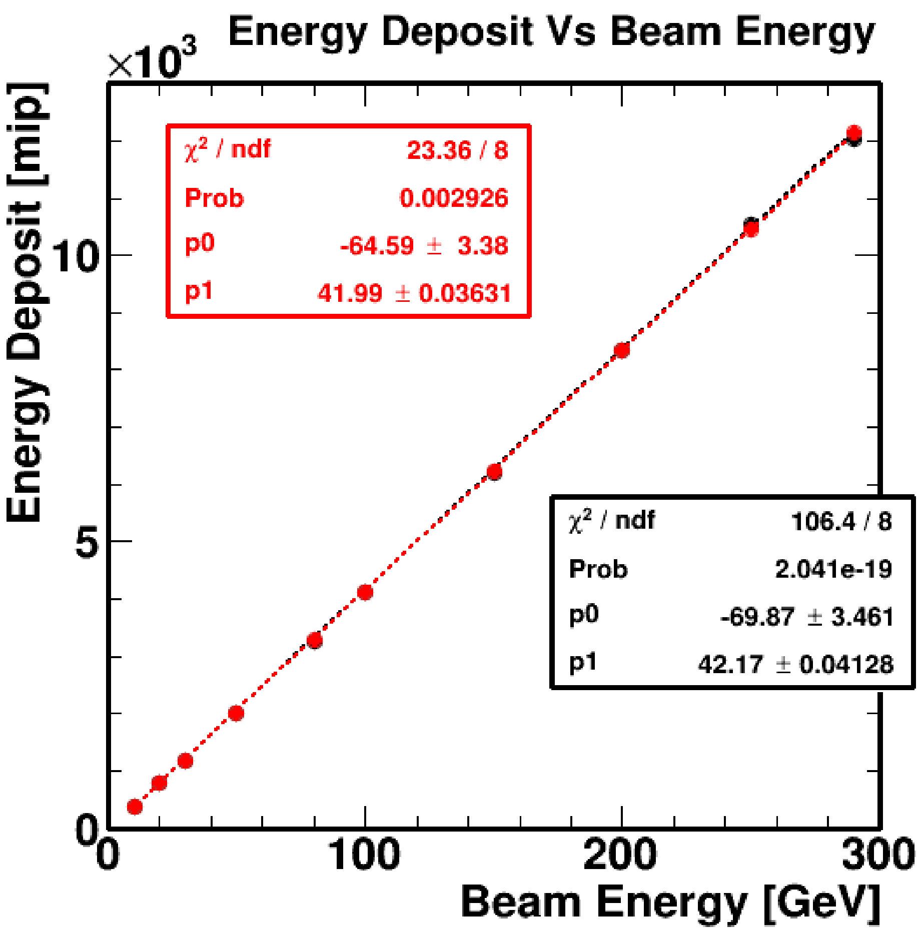
except for 10 GeV electrons, the difference between Data peak and MC peak is always less than 1% (also at 250 and 290 GeV)

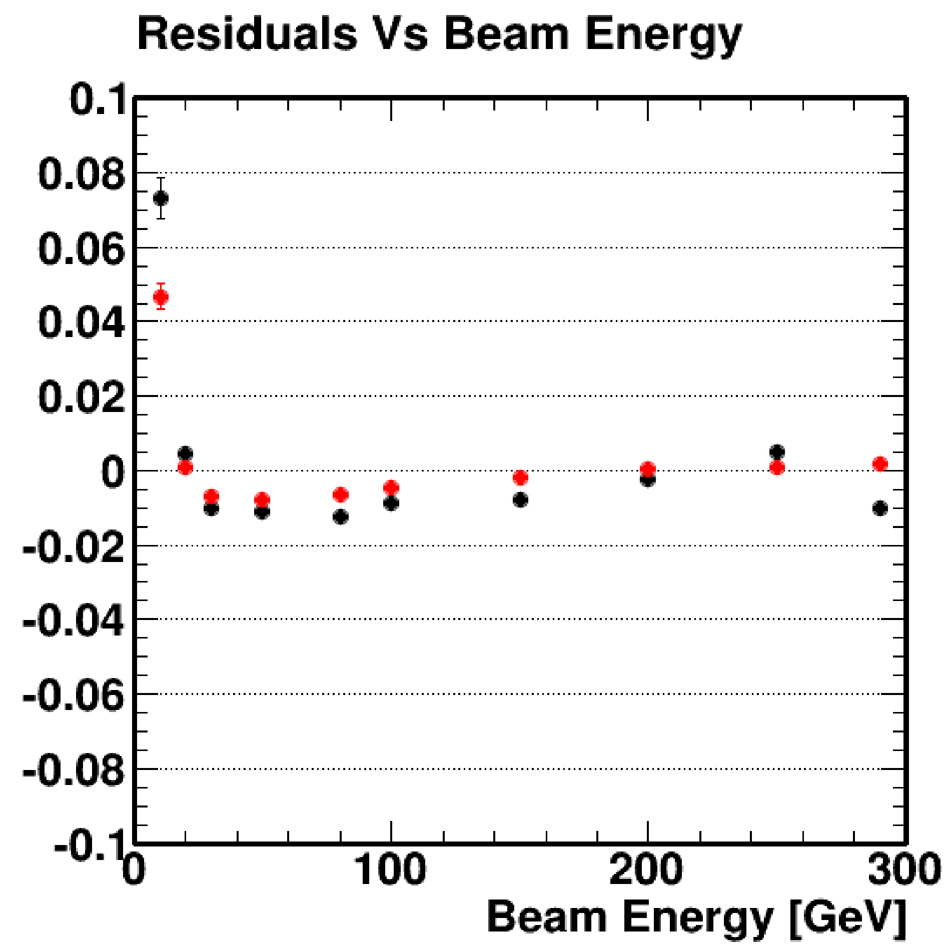
Data resolution – MC resolution



except for 10 GeV electrons, the difference between Data resolution and MC resolution is always less than 0.5%

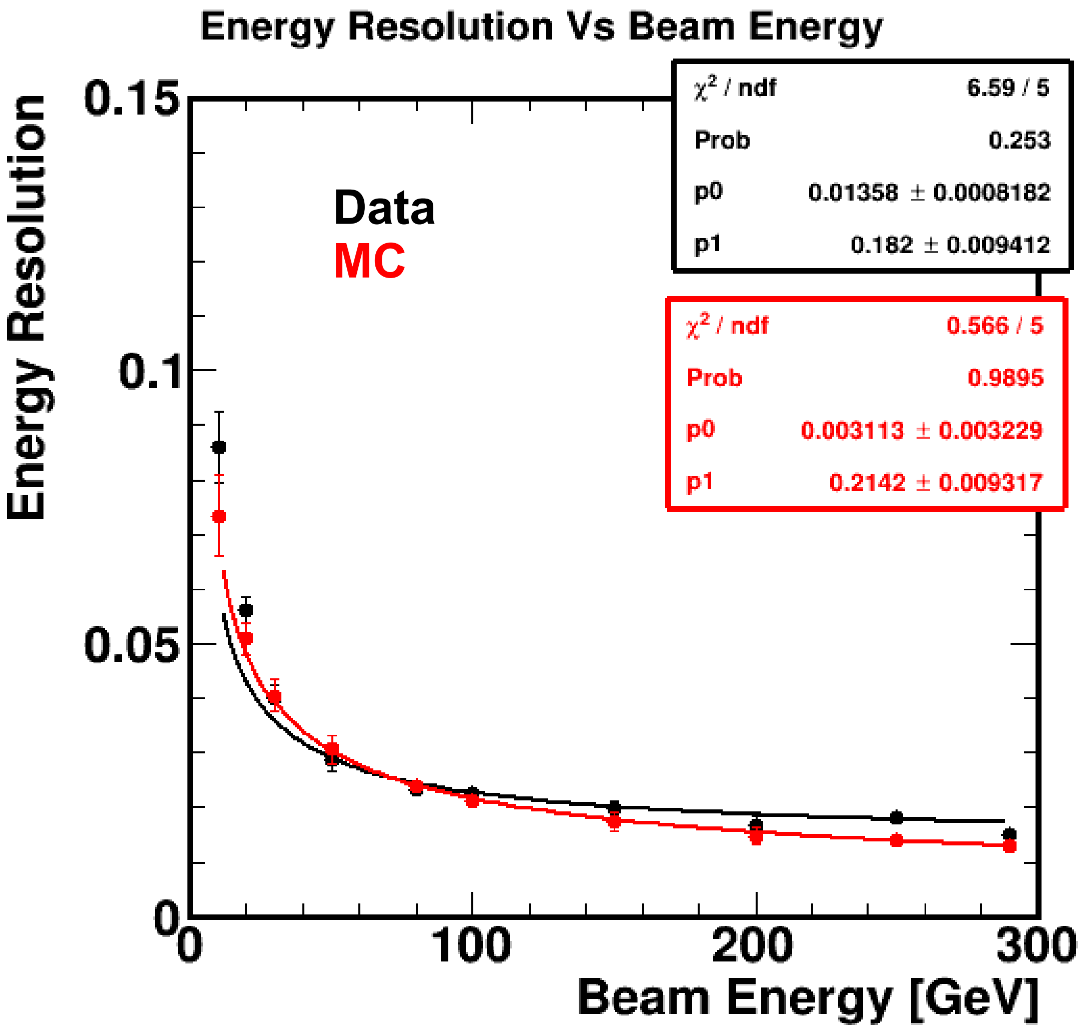
Energy Deposit vs Beam Energy





The TASC response is linear:
except for 10 GeV electrons, the residual value is always less than 2% (also at 250 and 290 GeV)

Energy Resolution vs Beam Energy (1)

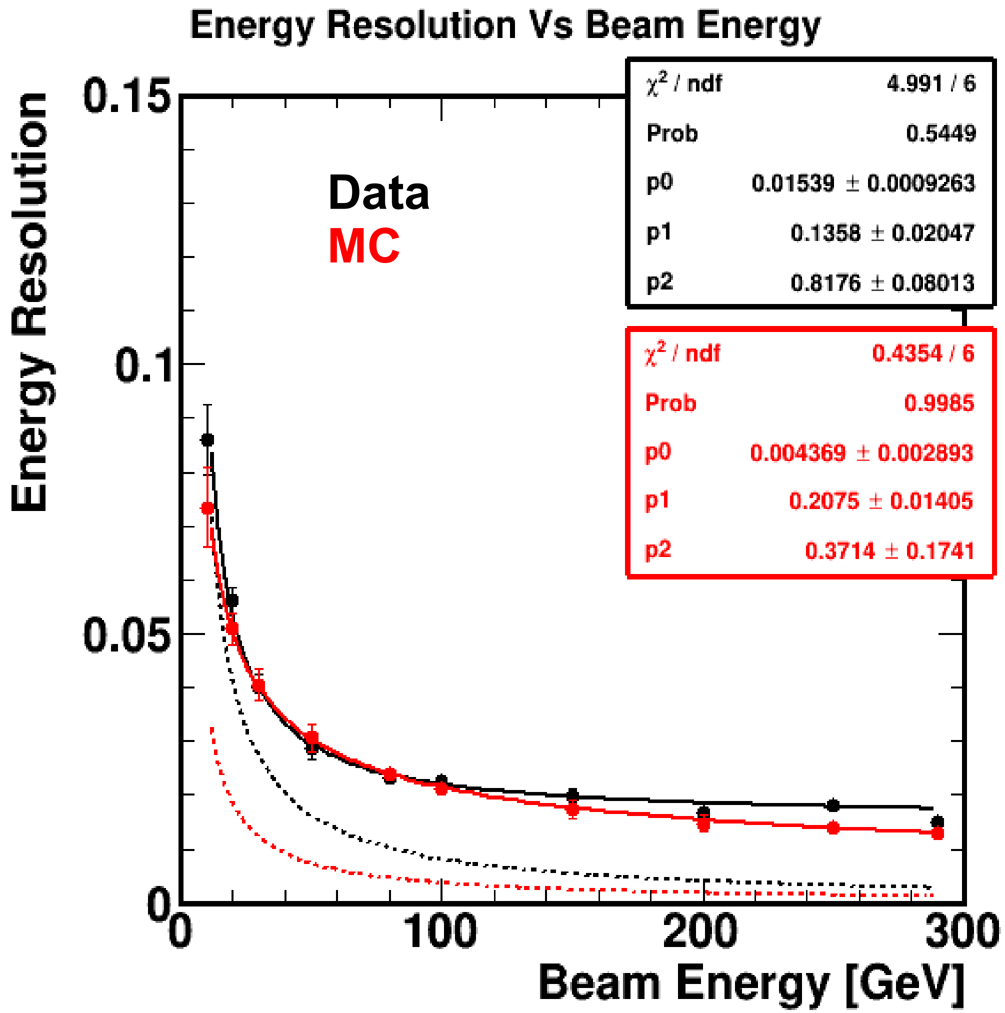


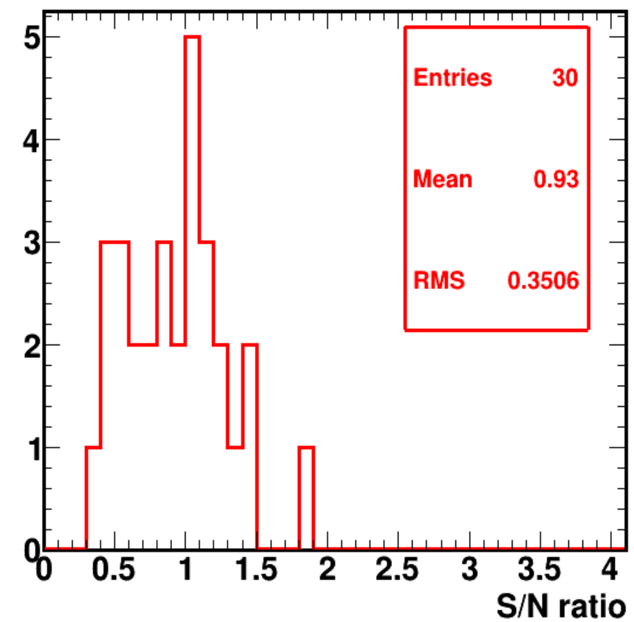
$$f(E) = p_0 \oplus \frac{p_1}{\sqrt{E[GeV]}}$$

The points at 10 and 20 GeV not used to fit the curves

	P_0	P_1
Data	(1.4±0.1)%	(18±1)%
MC	(0.3±0.3)%	(21±1)%

Energy Resolution vs Beam Energy (2)



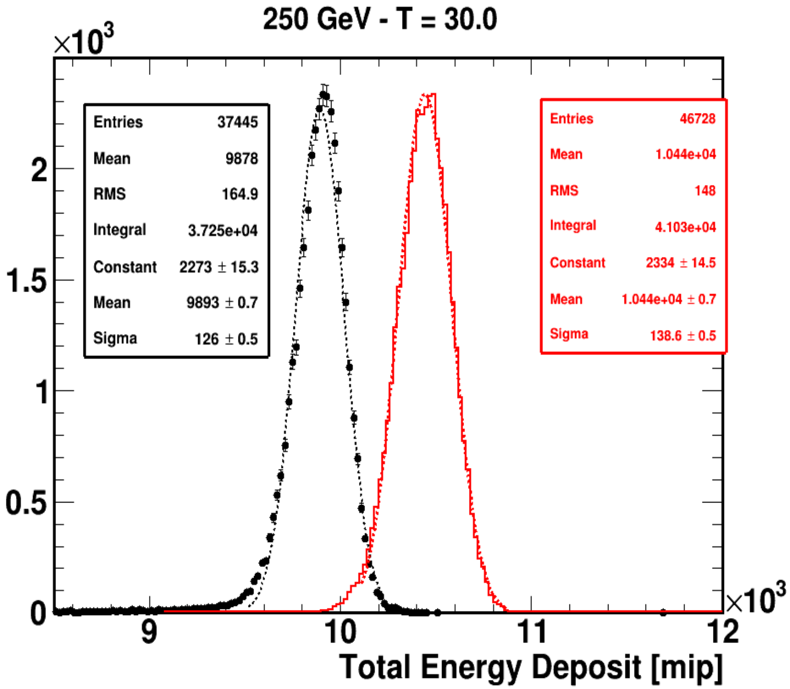


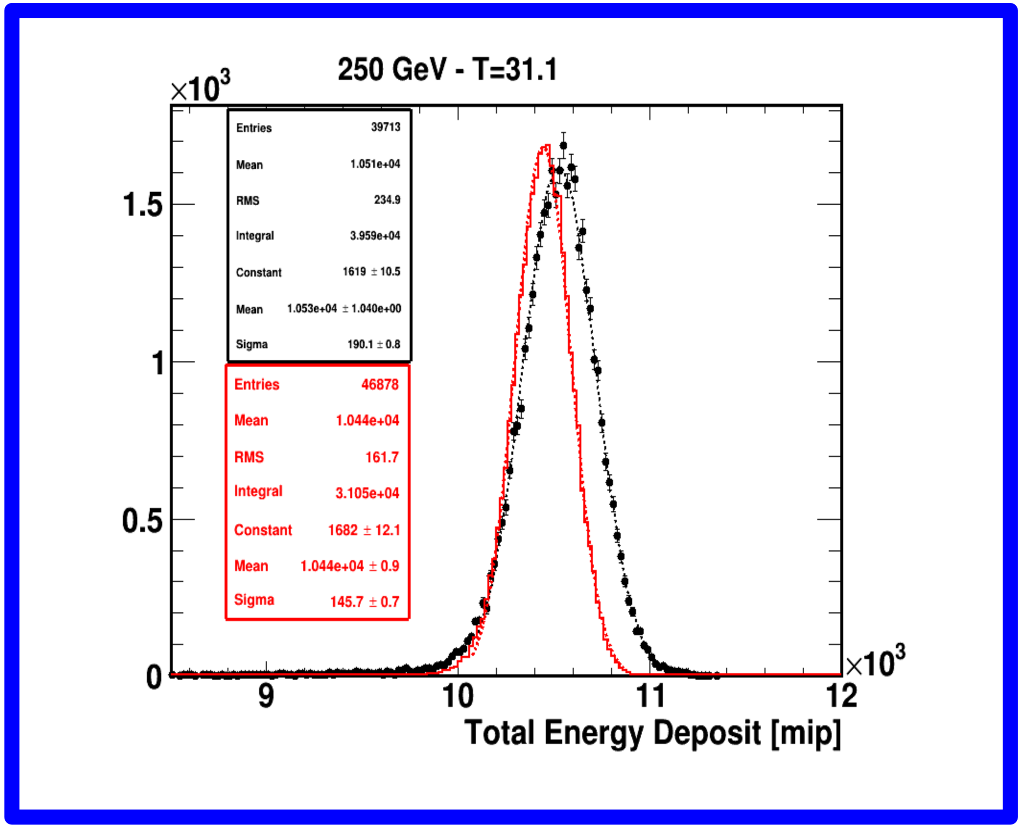
- **low signal to noise ratio**
- **we introduced a term to take into account the instrumental effects at low energies**

$$f(E) = p_0 \oplus \frac{p_1}{\sqrt{E[GeV]}} \oplus \frac{p_2}{E[GeV]}$$

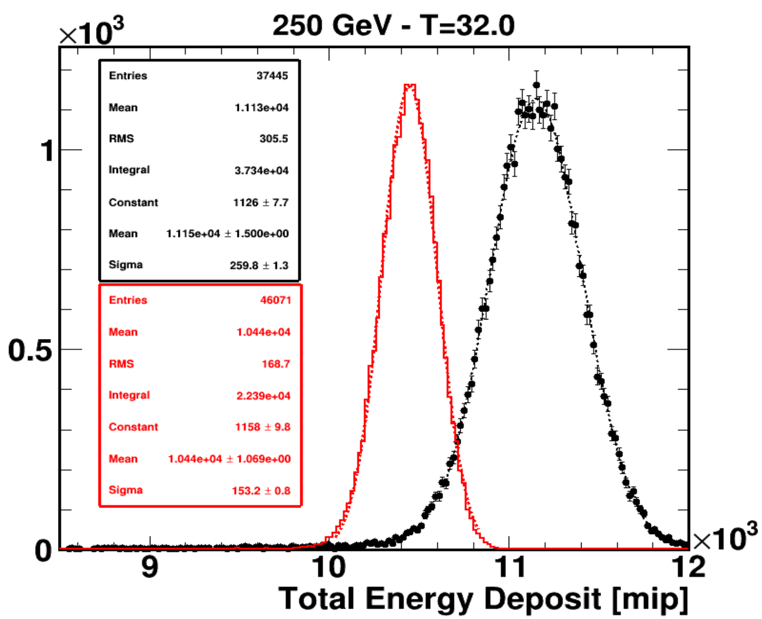
	P_0	P_1	P_2
Data	(1.5±0.1)%	(13±2)%	(81±8)%
MC	(0.4±0.3)%	(21±1)%	(37±17)%

Fine calibration of 250 GeV electrons (1)





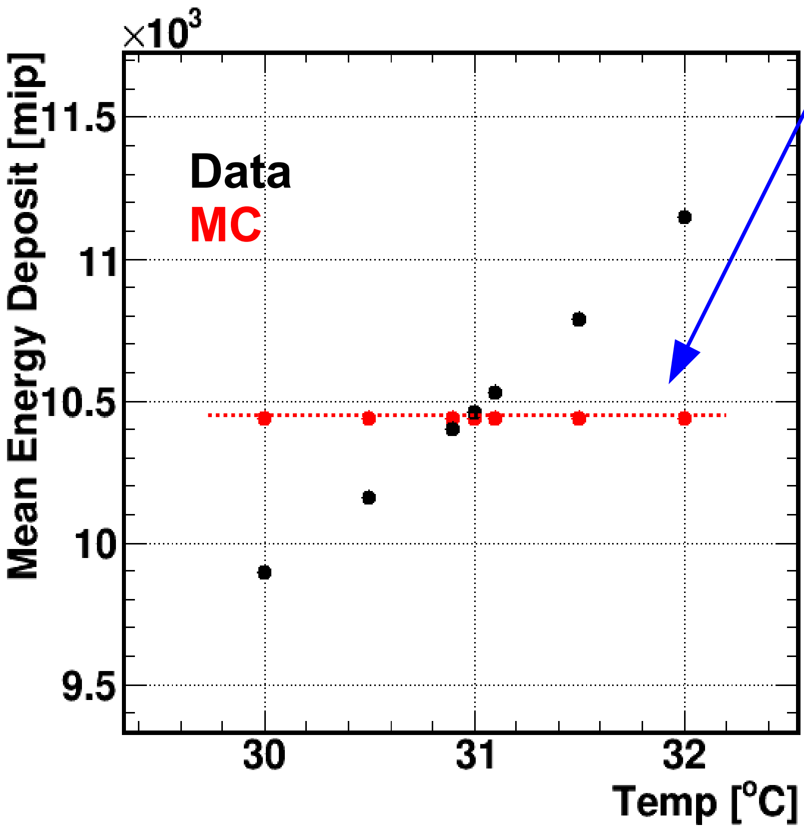
Nominal temperature



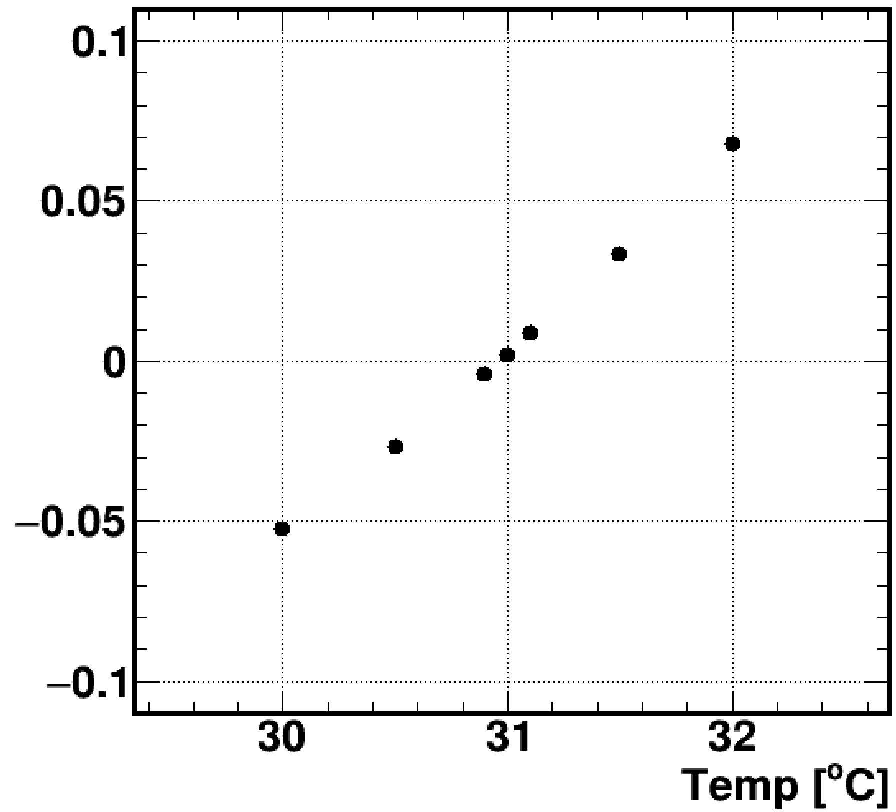
- **Strong variation of calibration table wrt temperature used**

Fine calibration of 250 GeV electrons (2)

the Mean energy deposit
of MC is constant

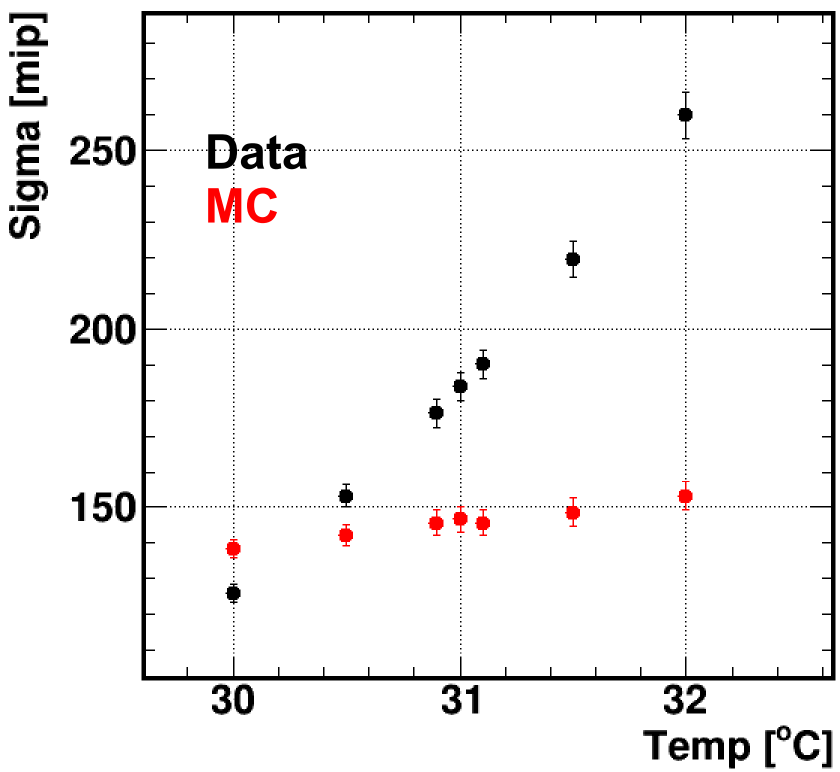


Mean energy deposit as a function of temperature value used to build the calibration card

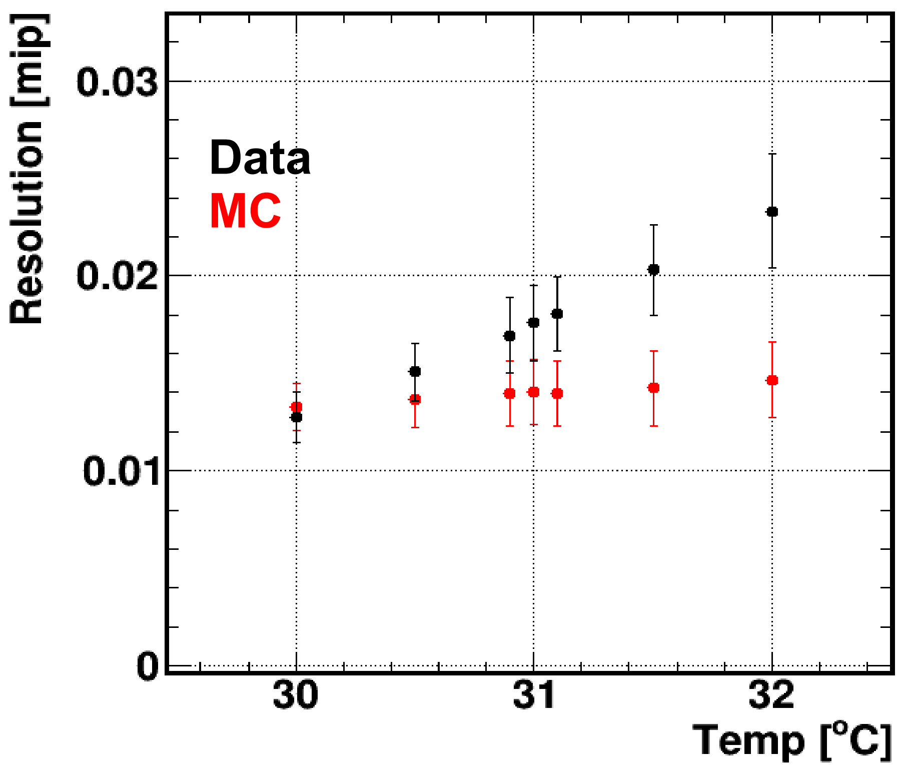


Residuals between data and MC mean value

Fine calibration of 250 GeV electrons (3)

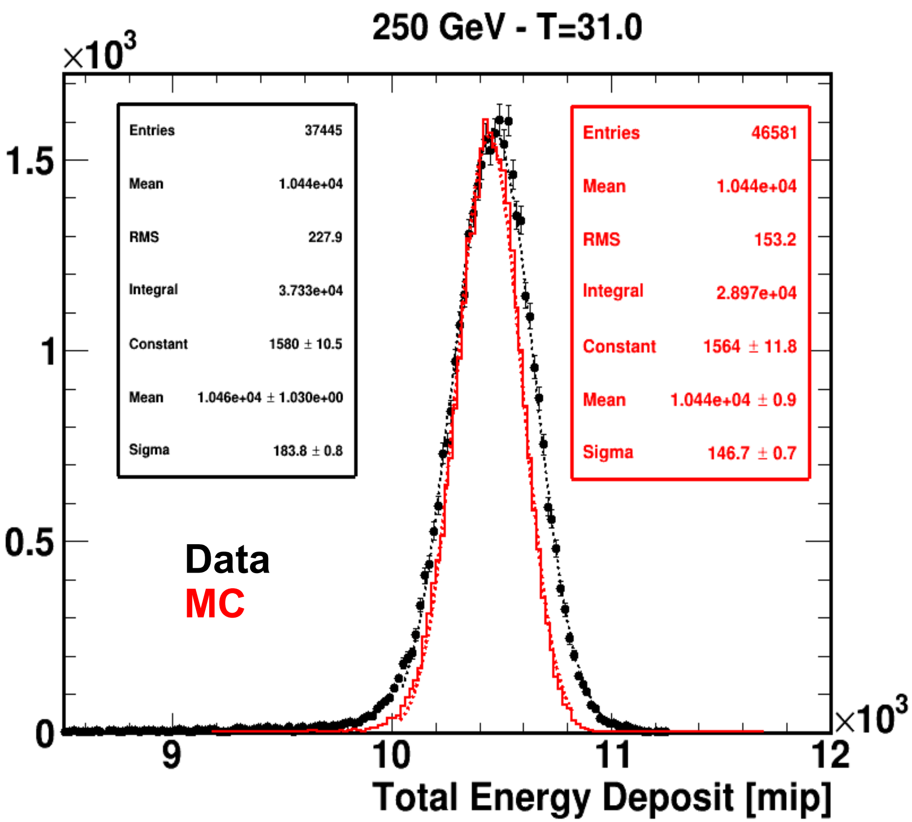


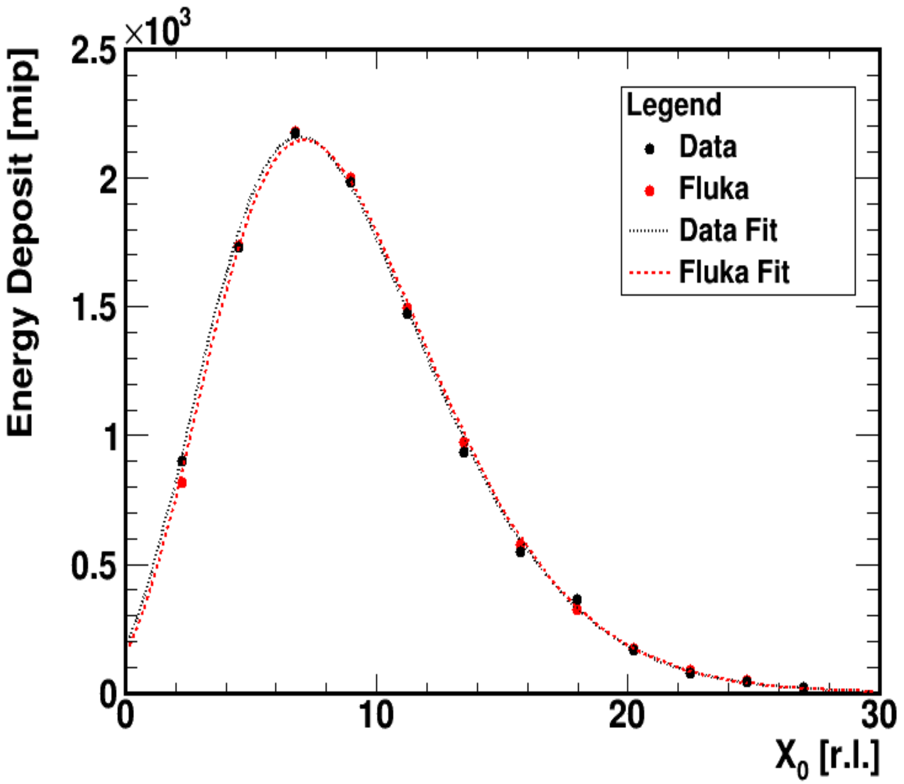
Sigma of energy distribution as a function of temperature value used to build the calibration card



Energy resolution as a function of temperature value used to build the calibration card

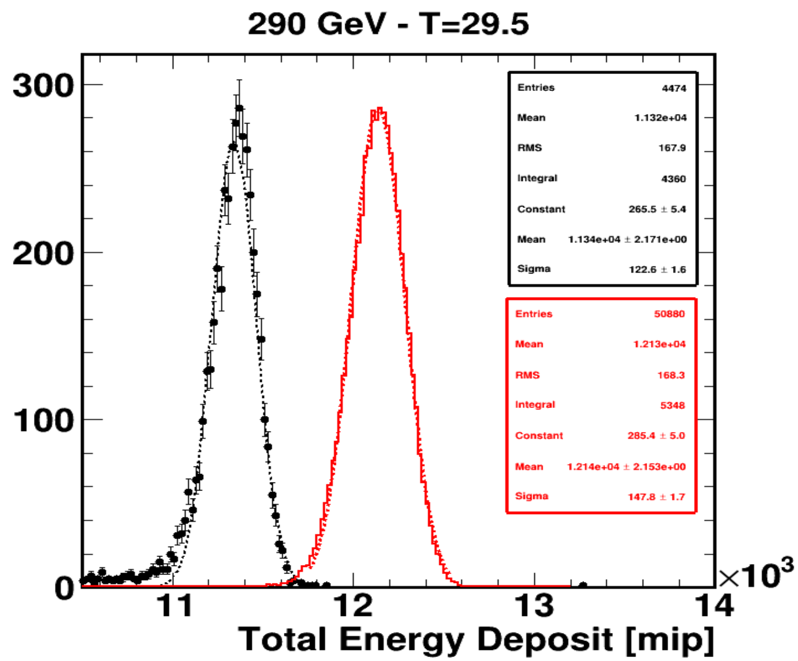
Fine calibration of 250 GeV electrons (4)

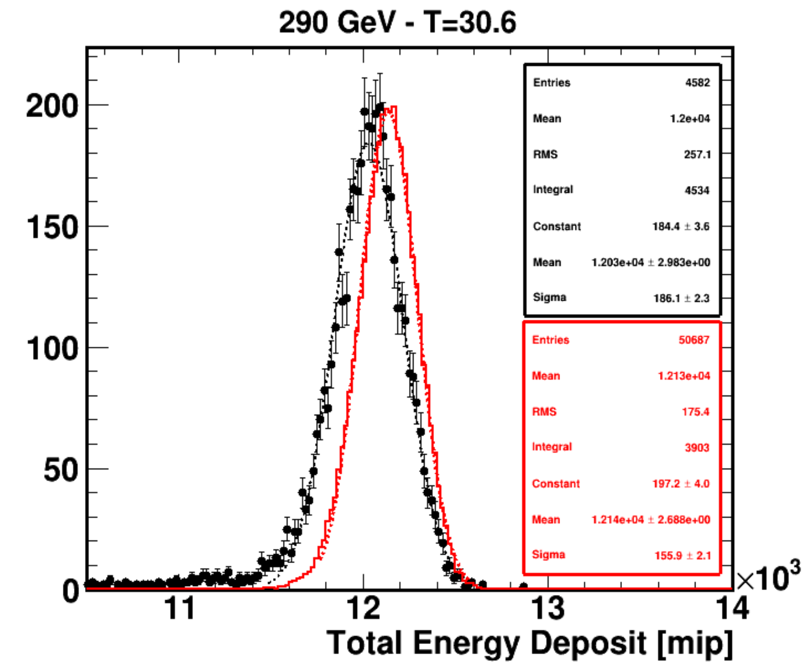




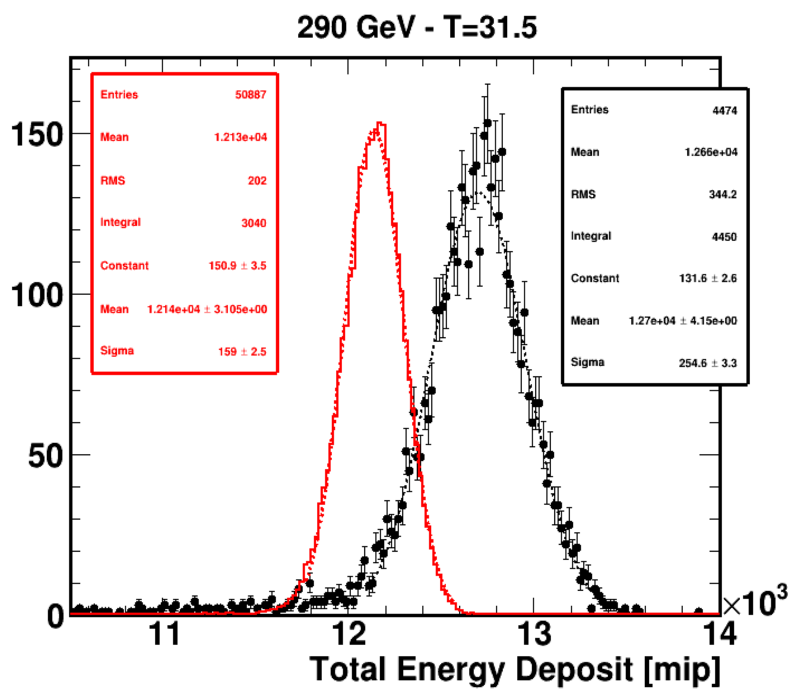
We obtained the best fit between Data e MC using the calibration table built at T = 31.0 °C (the nominal value is 31.1 °C)

Fine calibration of 290 GeV electrons (1)





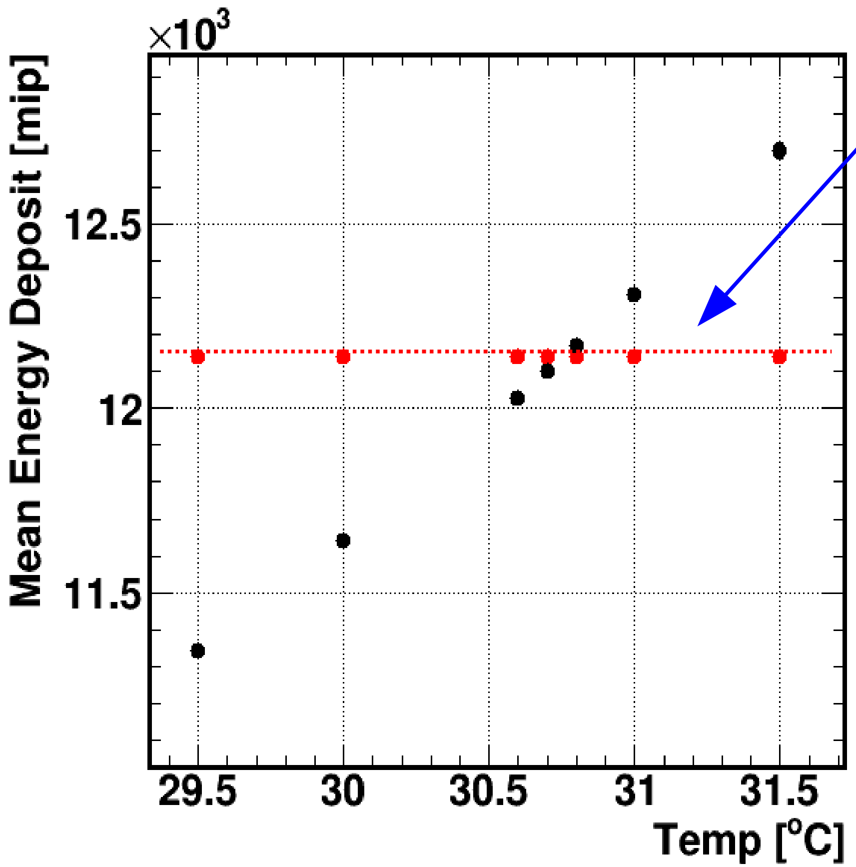
Nominal temperature



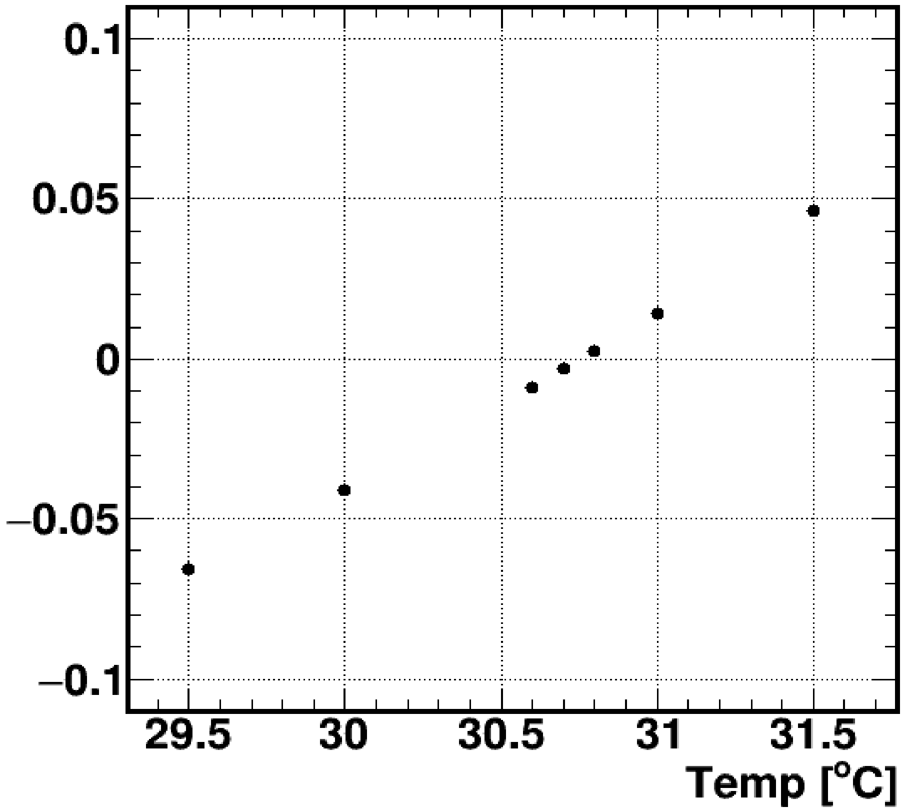
- **As in case of 250 GeV electrons, there is a strong variation of calibration table wrt temperature used**

Fine calibration of 290 GeV electrons (2)

the Mean energy deposit of MC is constant

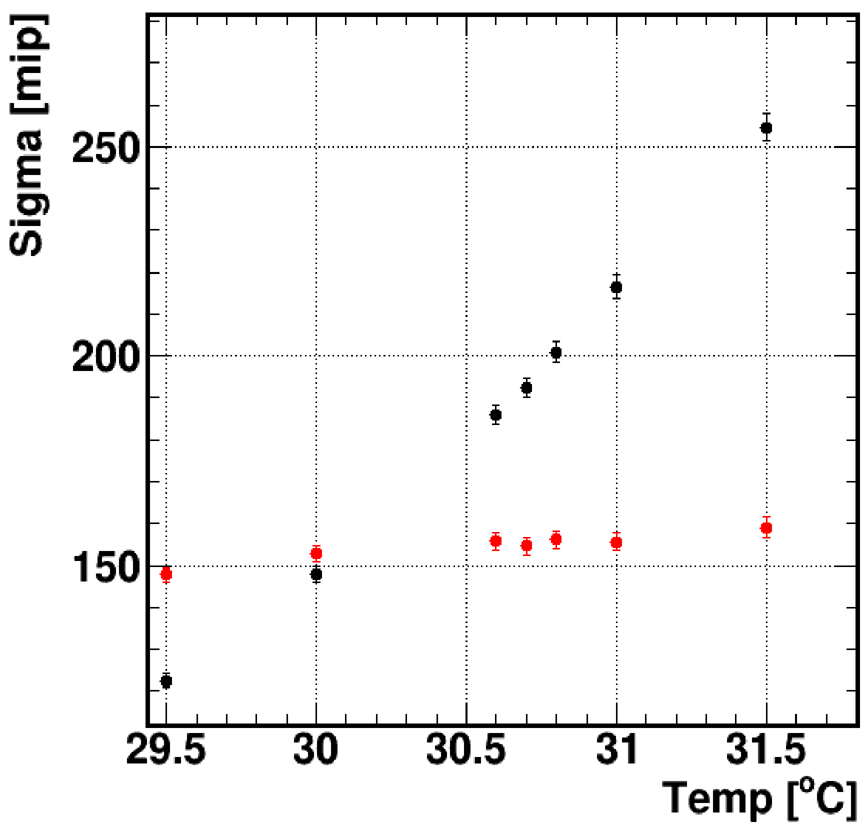


Mean energy deposit as a function of temperature value used to build the calibration card

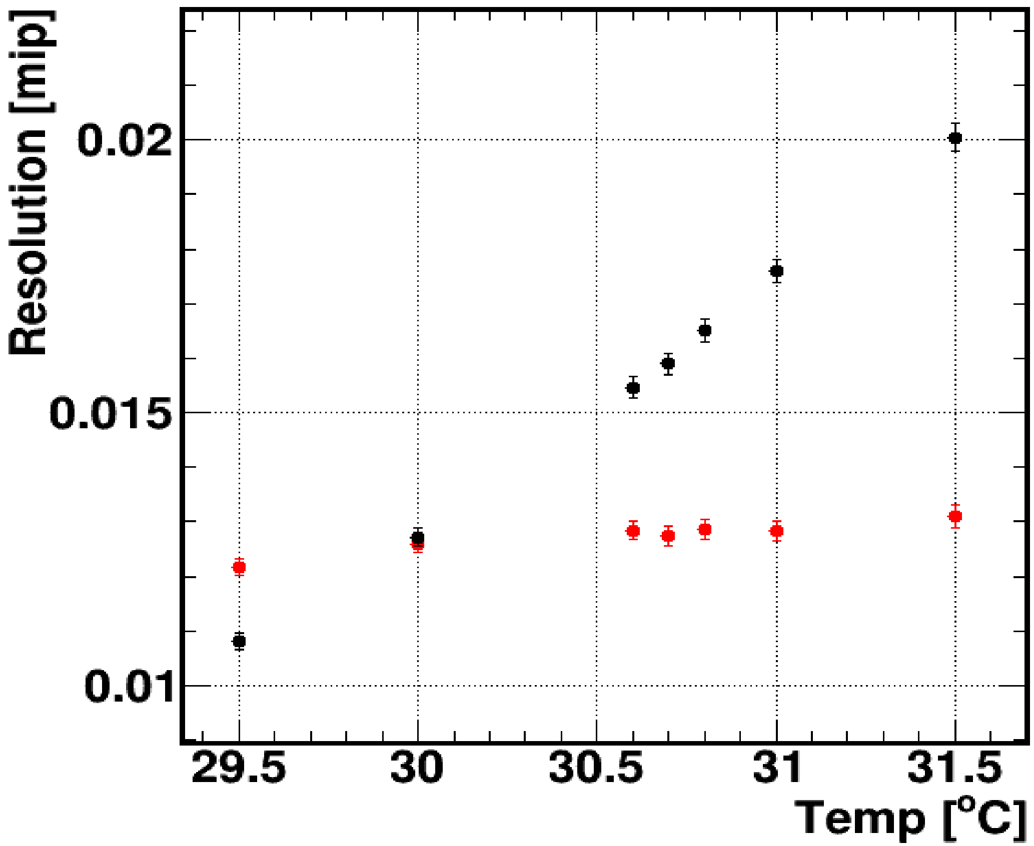


Residuals between data and MC mean value

Fine calibration of 290 GeV electrons (3)

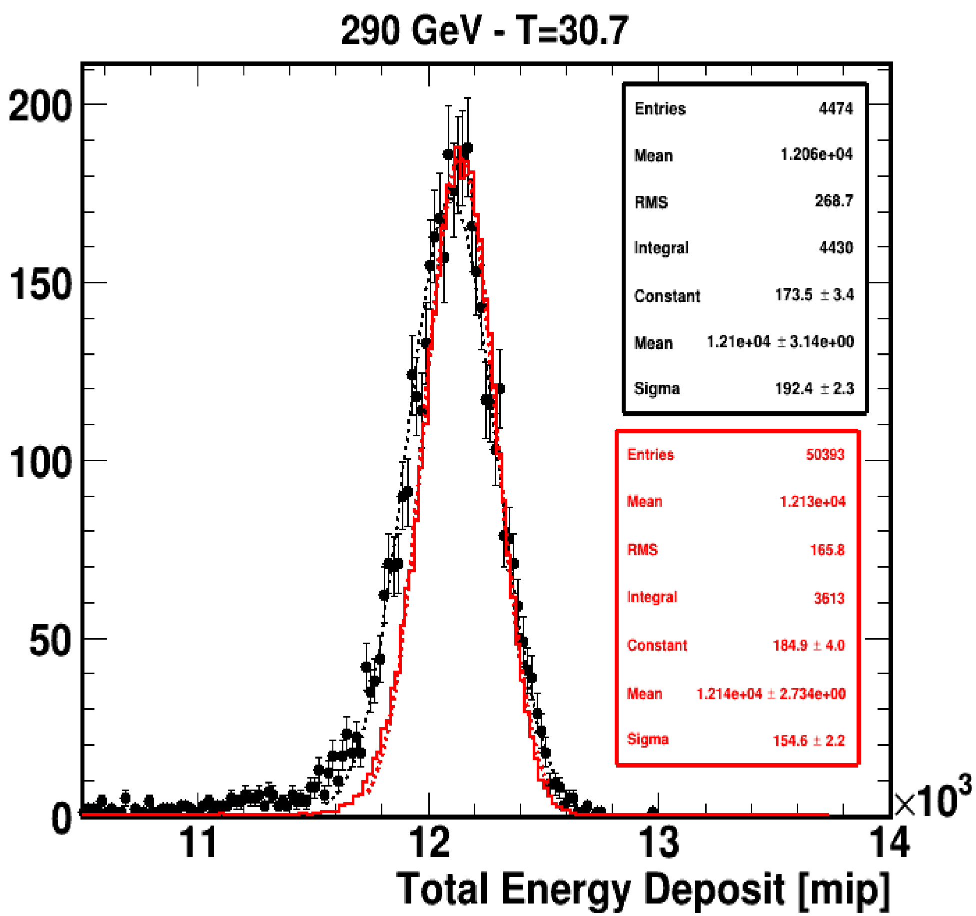


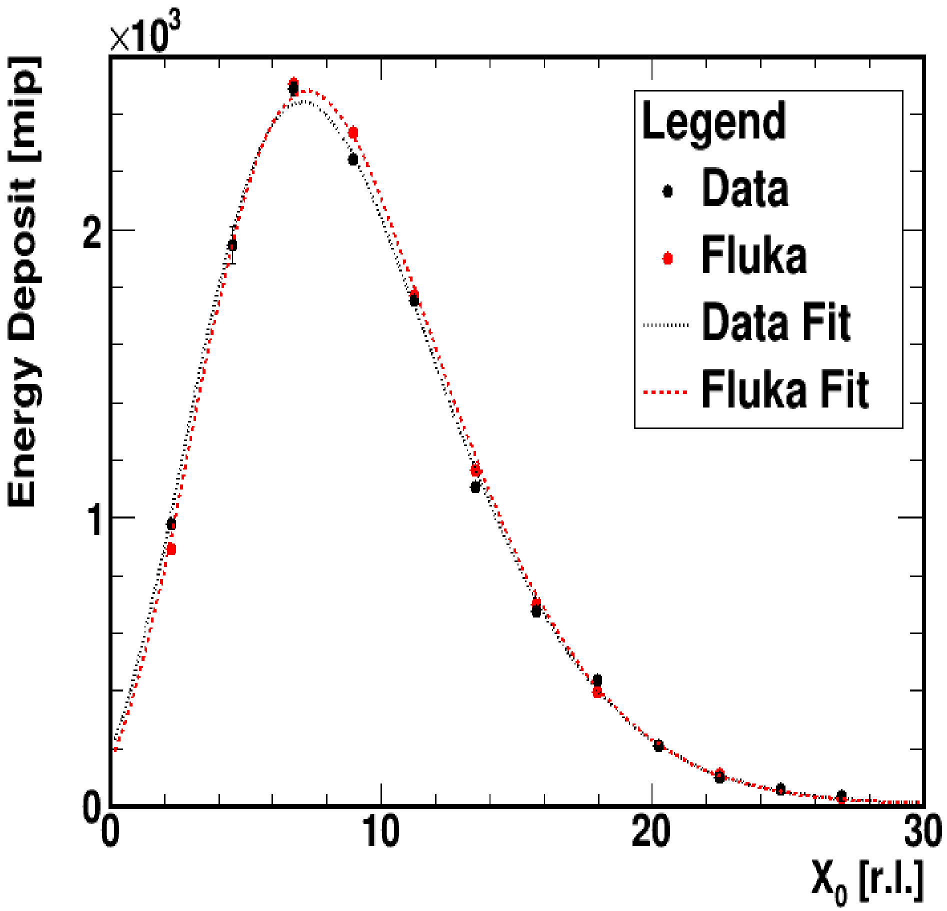
Sigma of energy distribution as a function of temperature value used to build the calibration card



Energy resolution as a function of temperature value used to build the calibration card

Fine calibration of 290 GeV electrons (4)

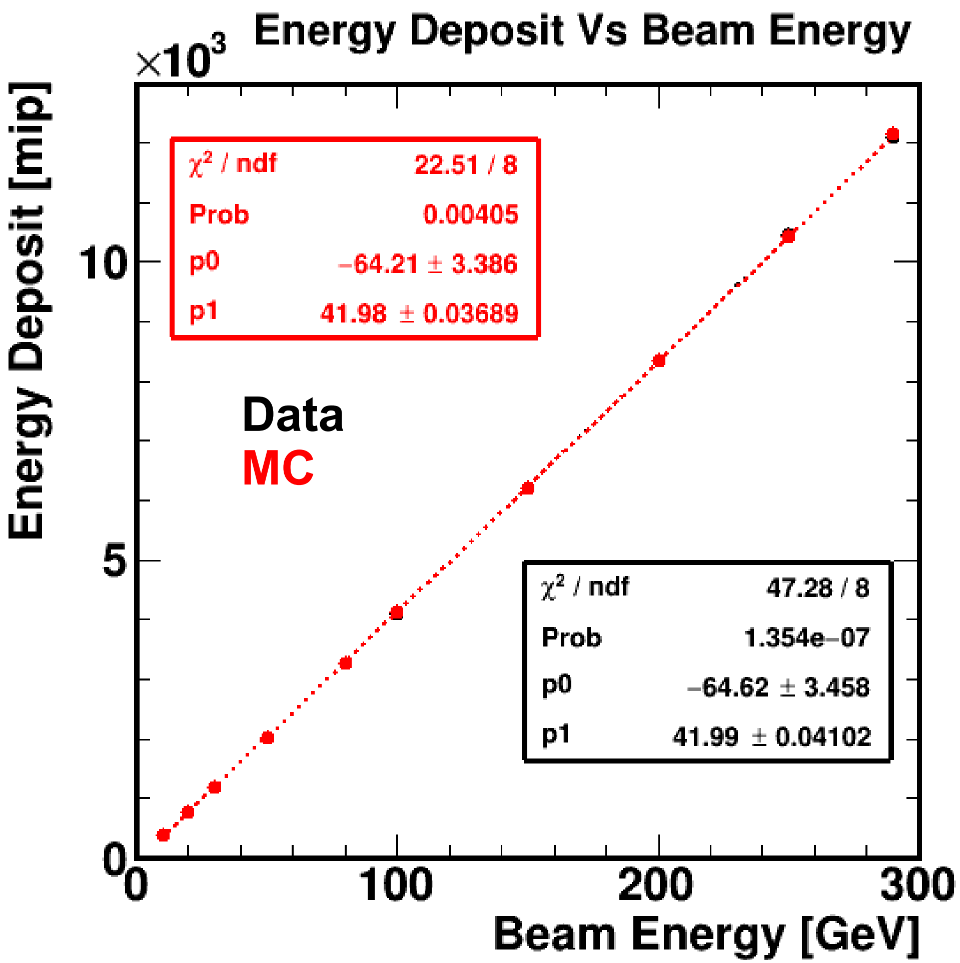


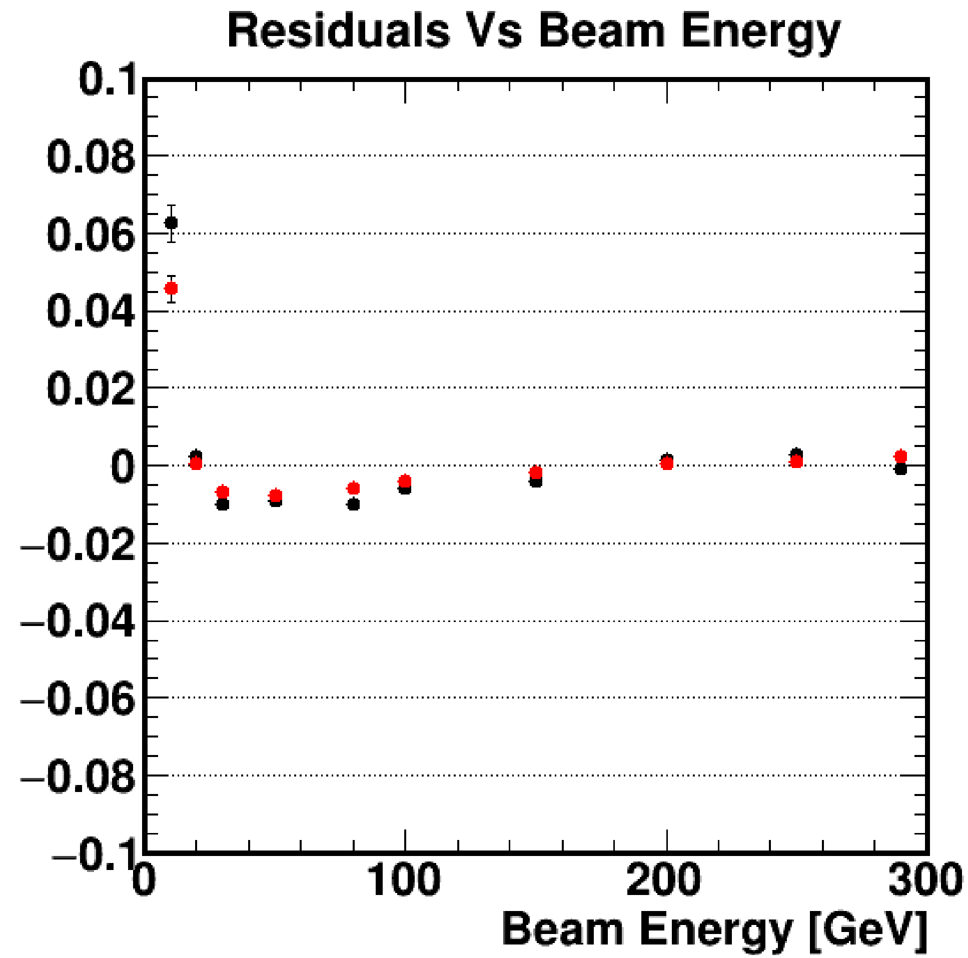


We obtained the best fit between Data e MC using the calibration table built at T = 30.7 °C (the nominal value is 30.6 °C)

Energy Deposit vs Beam Energy

after fine calibration for 250 Gev and 290 Gev electrons

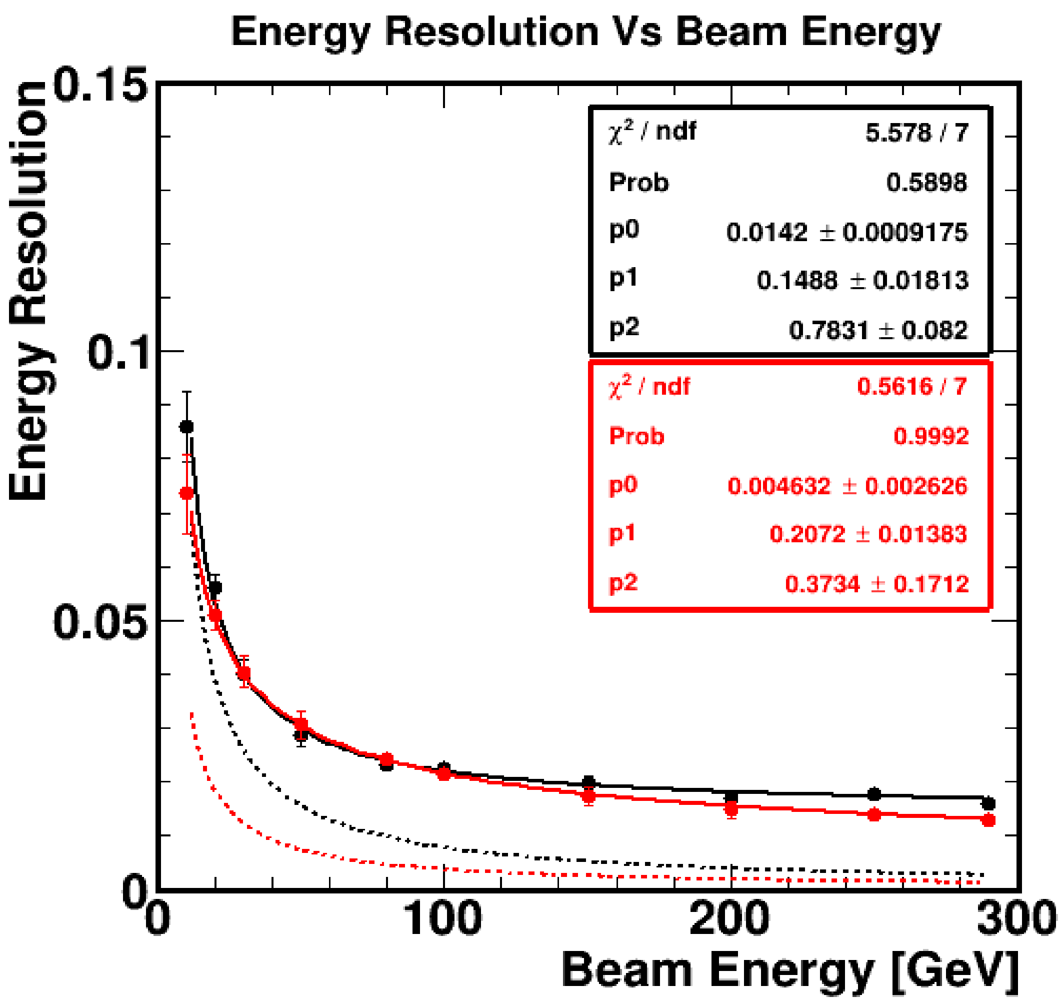




The TASC response is linear:
except for 10 GeV electrons, the residual value is always less than 2% (also at 250 and 290 GeV)

Energy Resolution vs Beam Energy

after fine calibration for 250 Gev and 290 Gev electrons



- low signal to noise ratio
- we introduced a term to take into account the instrumental effects at low energies

	P_0	P_1	P_2
Data	(1.4±0.1)%	(15±2)%	(78±8)%
MC	(0.5±0.3)%	(21±1)%	(37±17)%

$$f(E) = p_0 \oplus \frac{p_1}{\sqrt{E[GeV]}} \oplus \frac{p_2}{E[GeV]}$$

Conclusions & Suggestions

TASC calibration method based on MIP works fine

Good agreement between beam test electron data and FLUKA MC

Good TASC linear behaviour up to 290 GeV

Calibration criticities:

- **possible bias on MIP fitted peaks due to low S/N ratio**
- **a fine monitoring of temperature changes is mandatory**

Appendix: list of files used

- **150 GeV muon beam for calibration:**
  20120928_001904_mu-169
  20120928_022006_mu-172
  20120928_041941_mu-174

- **100 GeV electron beam used to calibrate 2nd layer:**
  20120928_221415_ele100-211
  20120928_233425_ele100-213
  20120929_000357_ele100-215
  20120929_104250_ele100-241

- **150 GeV + 200 GeV electron runs used for stitching:**
  20120929_024721_ele150-222
  20120929_035339_ele150-224
  20120929_045728_ele150-226
  20120929_055351_ele150-228
  20120929_065237_ele150-230
  20120929_145535_ele200-249
  20120929_154957_ele200-251
  20120929_164448_ele200-254
  20120929_175114_ele200-257
  20120929_184809_ele200-259
  20120929_194208_ele200-261
  20120929_203636_ele200-264
  20120929_213939_ele200-266