Comparison between the CERN-2015 testbeam data and Montecarlo simulation

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A very simple *Montecarlino* has been realized, to check the results obtained with the recent calibration testbeams at CERN (August and September 2015)

The main goal is to test the geometric response

All the different type of used particle beams have been simulated (muons, electrons, pions)

The simulated calorimeter response has been compared with the results of the data analysis (using simple tool)

A good agreement is found (in terms of geometric response)

Montecarlo

Simple code (based on GEANT3) to reproduce the prototype behavior (in terms of geometry and physics)

Detector:

N_x x N_y x N_z active cubes (CsI, ρ = 4.51 g/cm^3)

surrounded by the support structure (PTFE, ρ = 2.20 g/cm^3)

Beam:

aligned along *z*

positionable in *x* and *y*

2D gaussian profile with defined σ_x and σ_y

Physics:

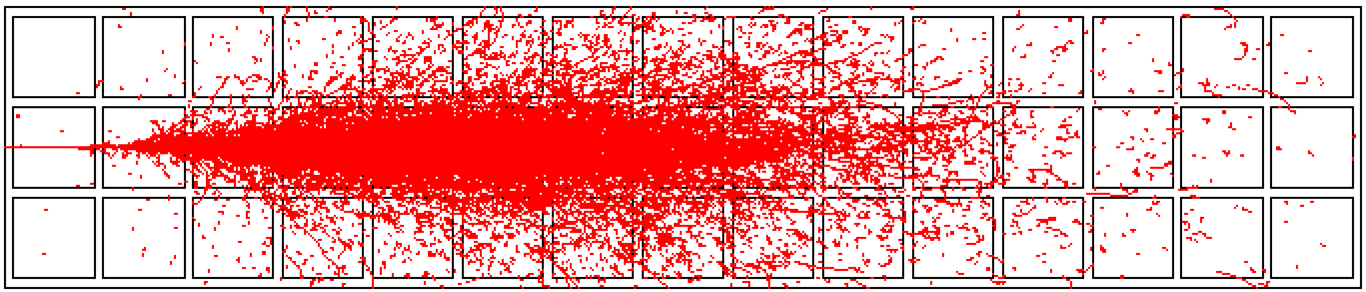
all *electromagnetic* and *hadronic* interactions (GEANT3)

Output:

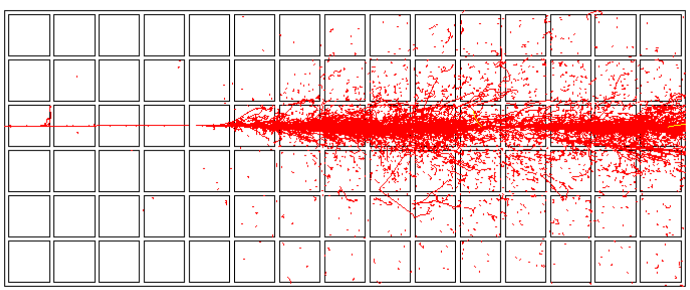
Deposited energy in each cube. No readout simulation

The configuration can be easily changed to reproduce different geometries

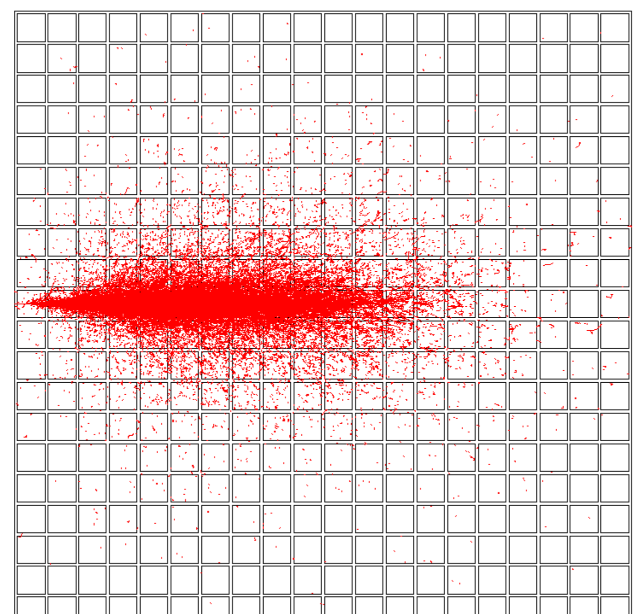
3 x 3 x 15 100 GeV e^-



6 x 6 x 15 100 GeV π^-



20 x 20 x 20 200 GeV e^-



In these pictures only ***charged*** particles internal to the detector are shown

Analysed data

A preliminar analysis has been performed on august testbeam calorimeter data available in Pavia (no tracker data)

Some common *tools* has been used available during the test (i.e. analyze, draw, etc.: thanks to Eugenio and Lorenzo)

Analysed topics:

- muons - absolute calibration / equalization
- electrons - total energy / containment / resolution
- pions - shower position

Muon calibration

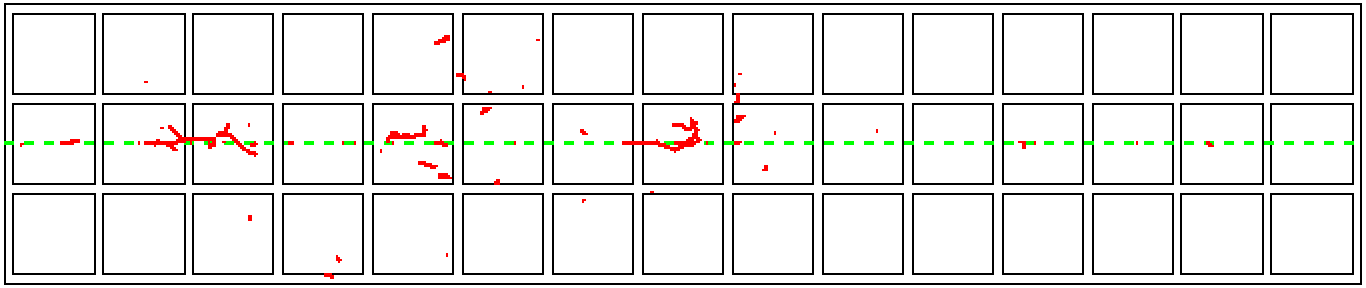
The continuous energy loss by ionization of a m.i.p in CsI is (from PDG)

$$\left(\frac{dE}{dx}\right)_{min} = 1.24\,\frac{MeV}{g\,cm^{-2}} \approx 5.6\,MeV/cm$$

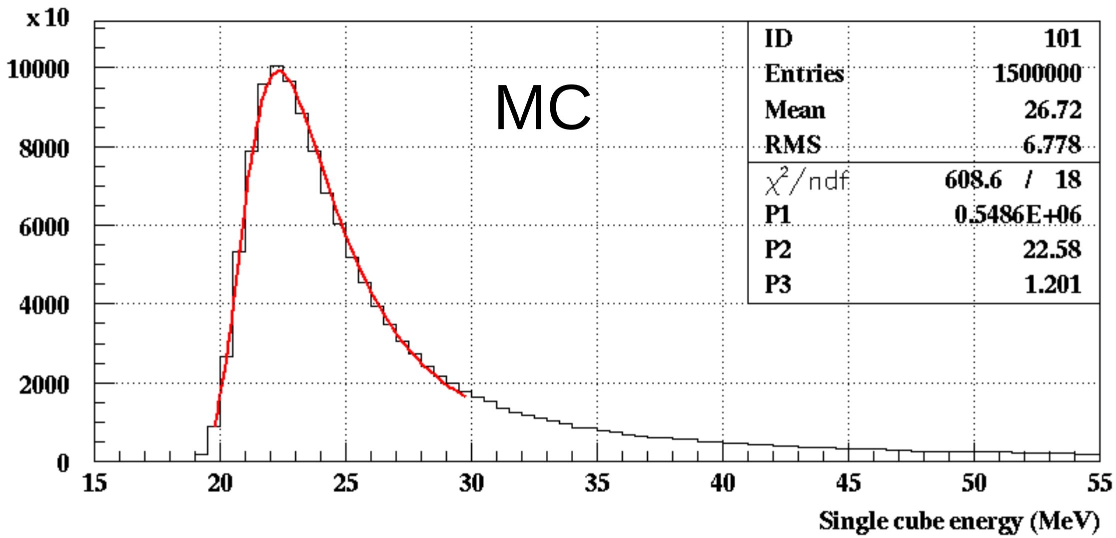
(the minimum is for $\gamma \approx 3.5$)

Then a m.i.p crossing a 3.6 cm side CsI cube should deposit about 20.2 MeV

However, for high energy muons, the effect of the secondary particles has to be taken into account



Muon calibration

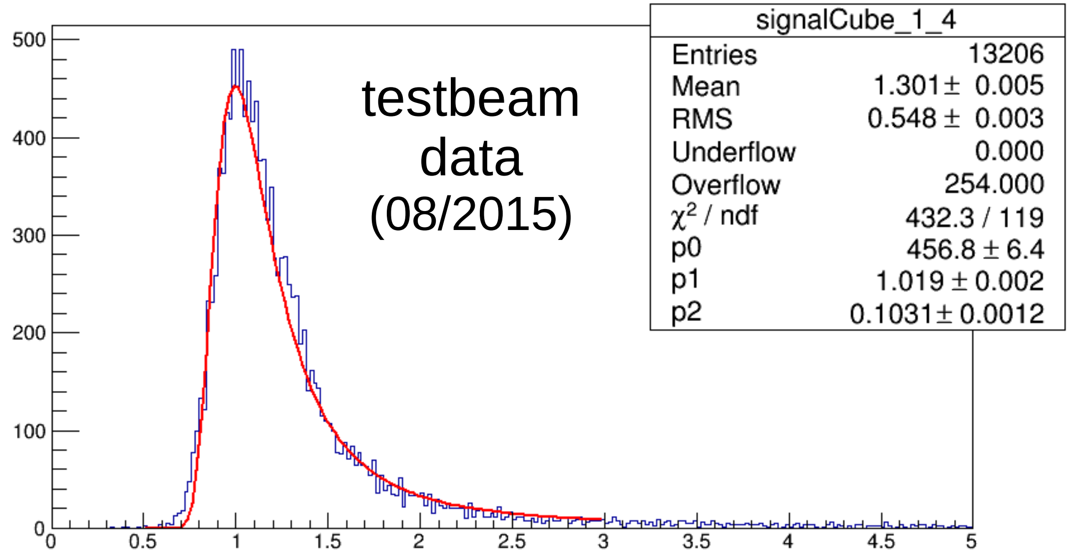


The most probable value of energy released in a single CsI cube is ≈ 22.6 MeV

to be compared with the m.i.p. energy release (PDG) of ≈ 20.2 MeV

(the muon is a m.i.p @ 350 MeV)

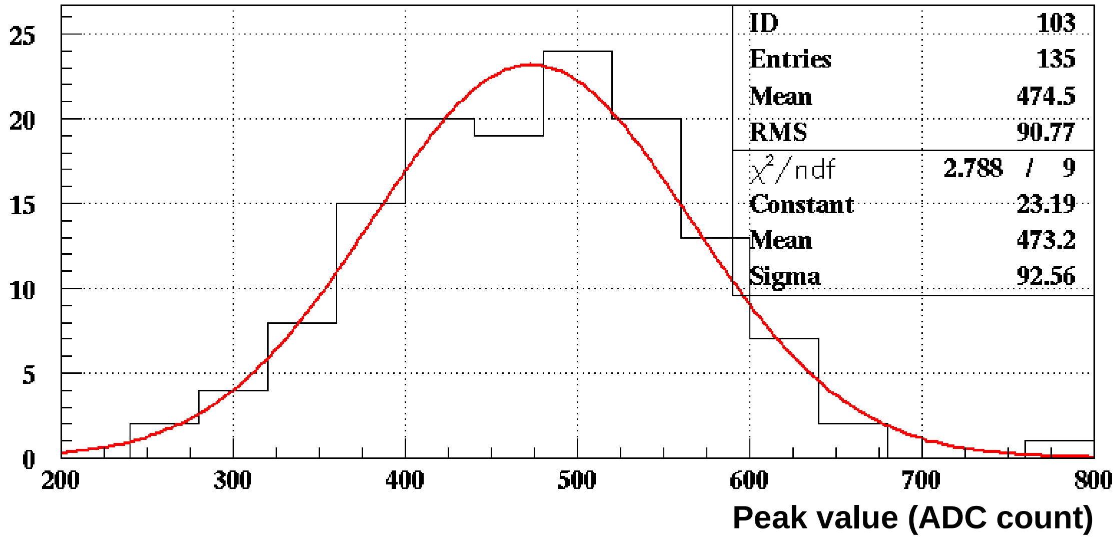
150 GeV muons



The cubes are equalized by mean of *calibration factors*, to reproduce a m.i.p. response

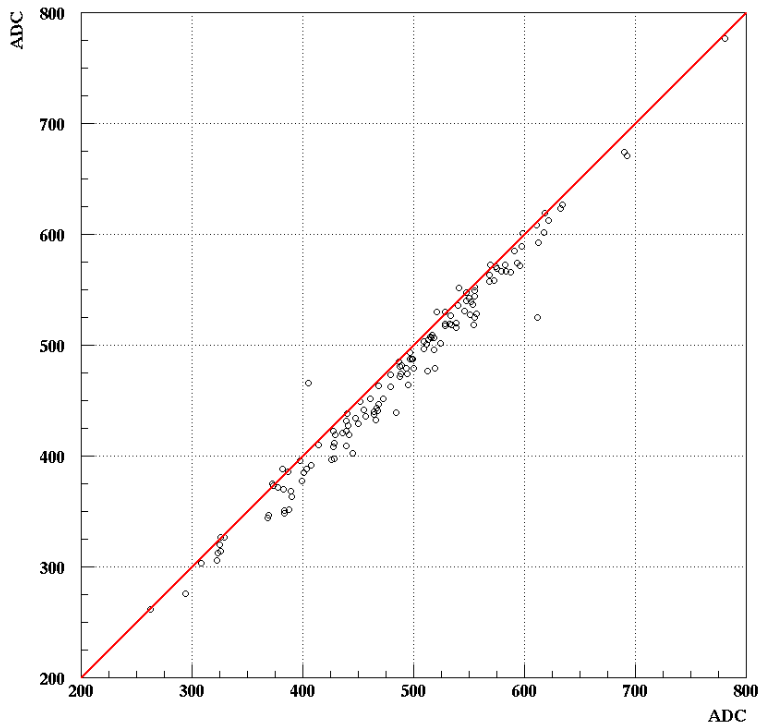
The uniformity of the cube response is about 20 %

Calibration factors



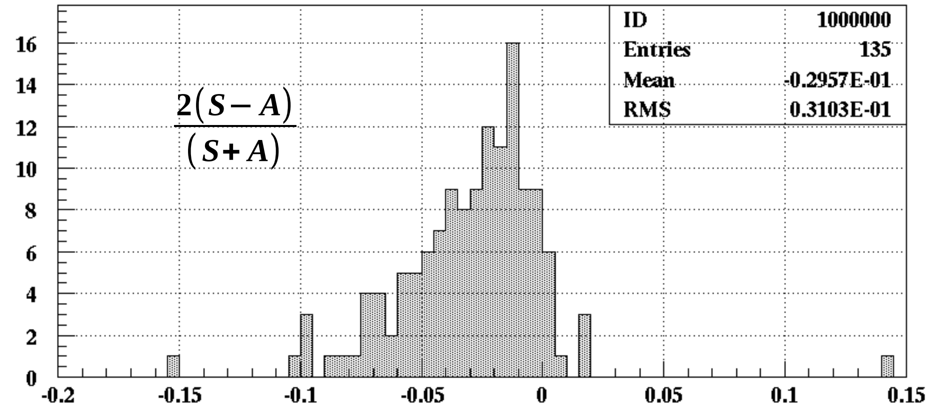
testbeam calibration factor (august 2015)

the uniformity is about 20 %

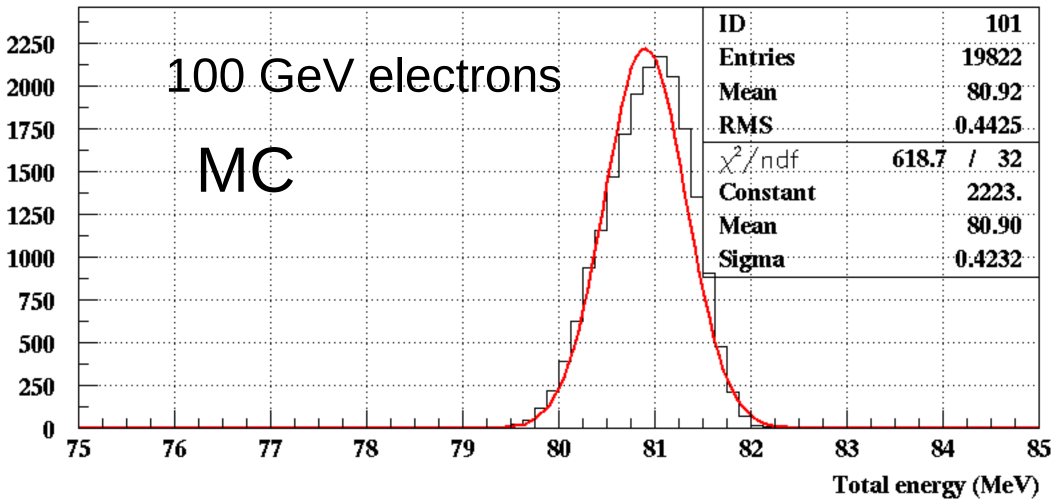


Sep vs. Aug

No relevant difference between the 2 testbeams (august and september)



Energy measurement: electron beam

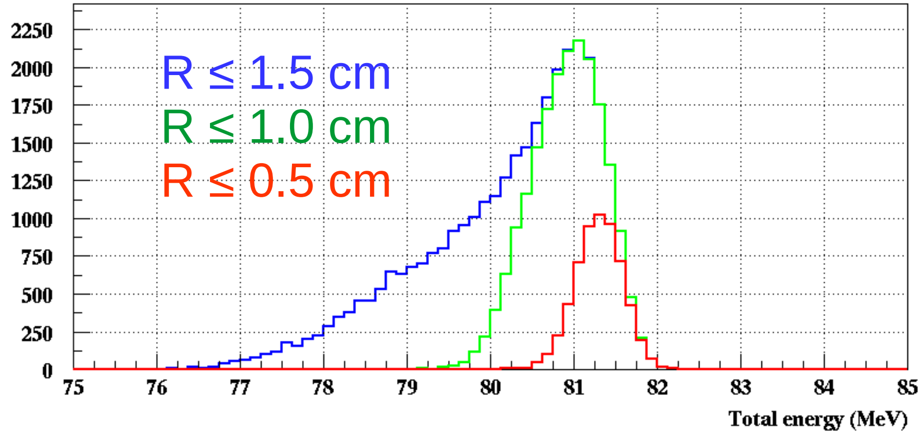


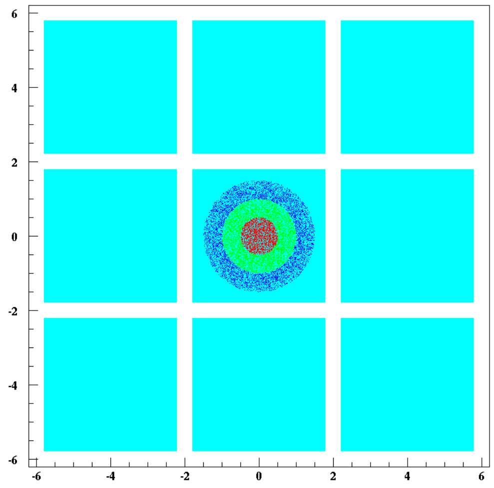
The contained energy is about 81 % for 100 GeV e^-

The (Montecarlo) energy resolution is 0.5 % !

(Too simple simulation !)

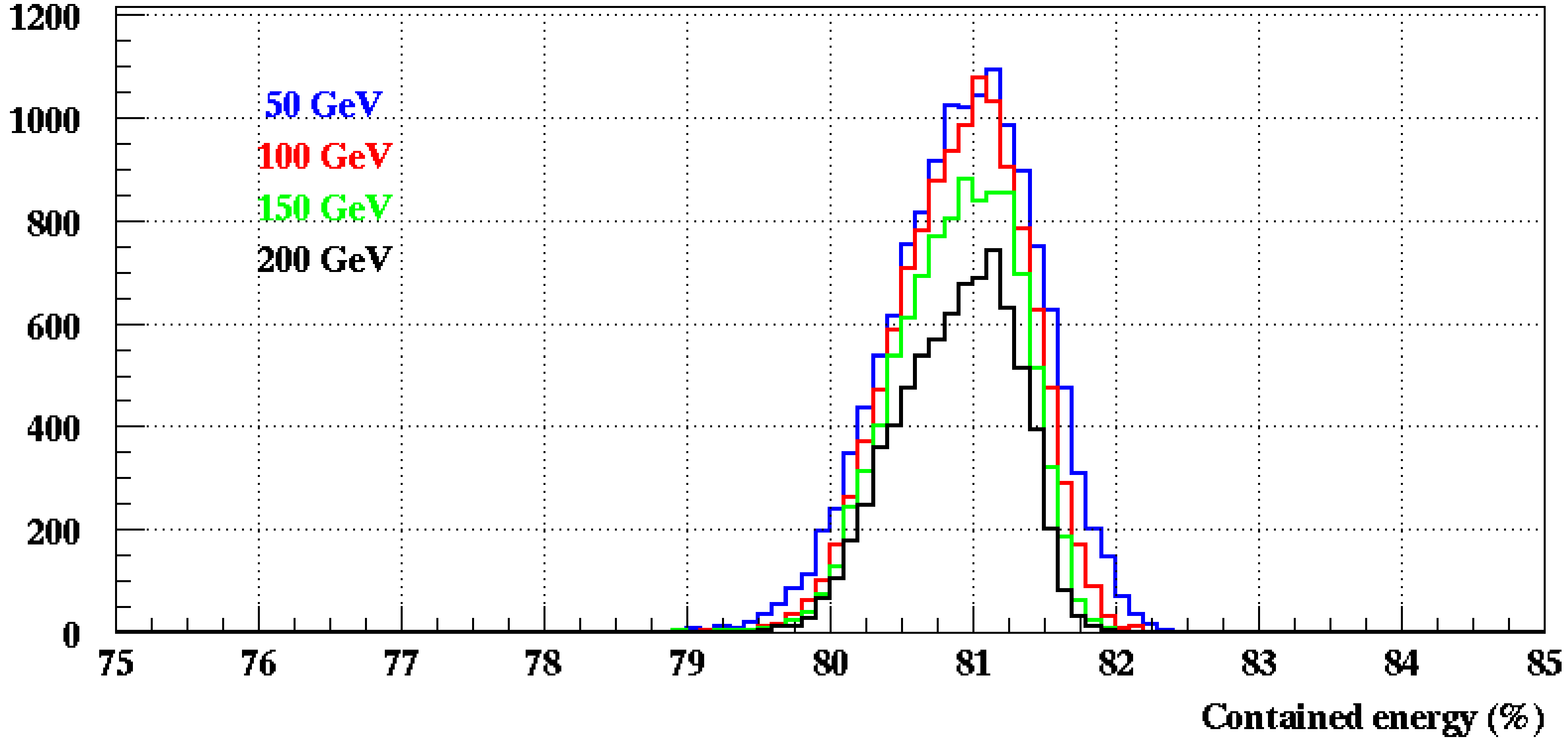
The fraction of contained energy depends on the input position (in particular on the distance R from the axis of the cube)





Energy measurement: electron beam

The contained energy fraction does not depends on beam energy



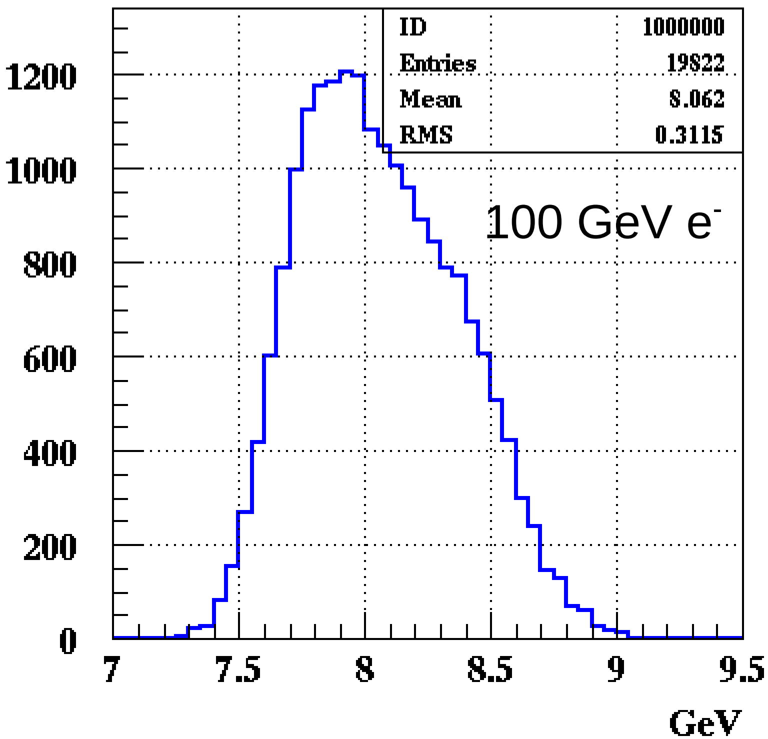
It depends only on the calorimeter geometry

The configuration 3 x 3 x 15 corresponds to about 5.9 x 5.9 x 29.5 $(X_0)^3$

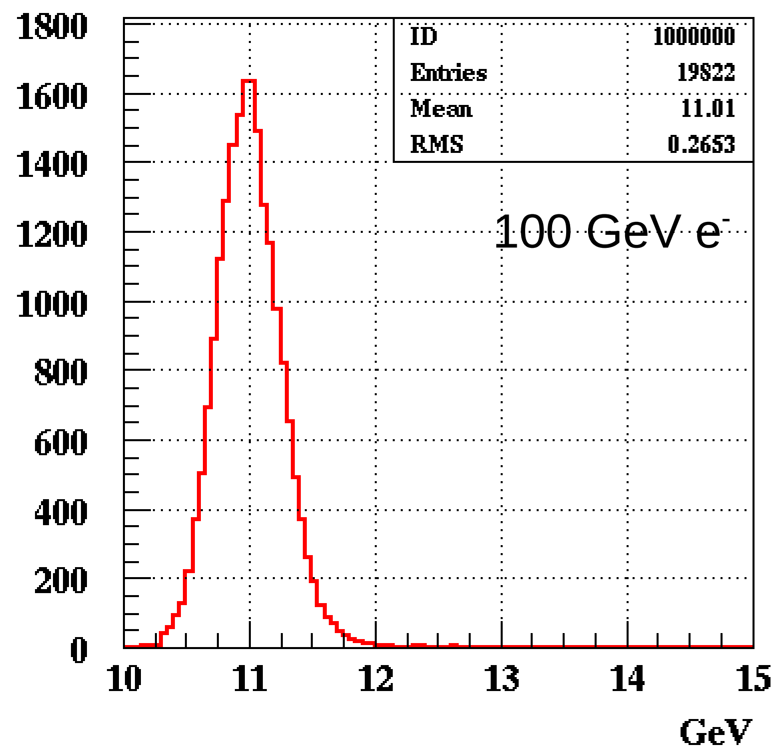
Energy measurement: electron beam

The energy is lost both in the passive medium (PTFE) and outside the calorimeter

Energy lost in the passive medium

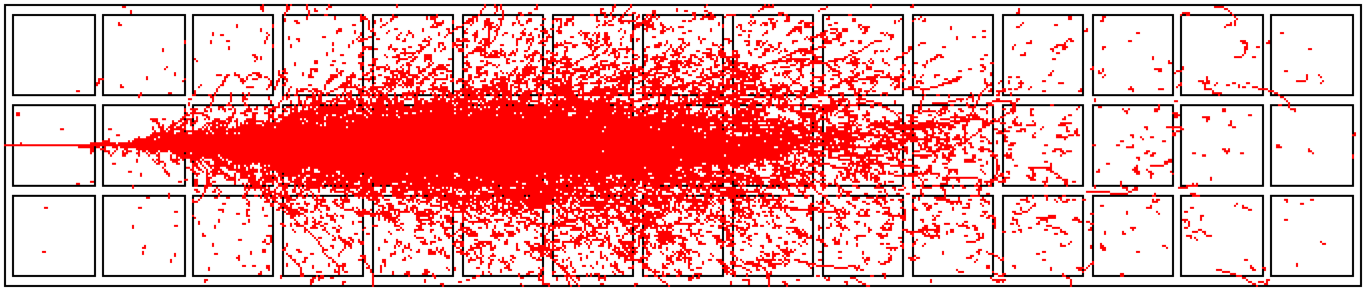


Energy going out of the calorimeter

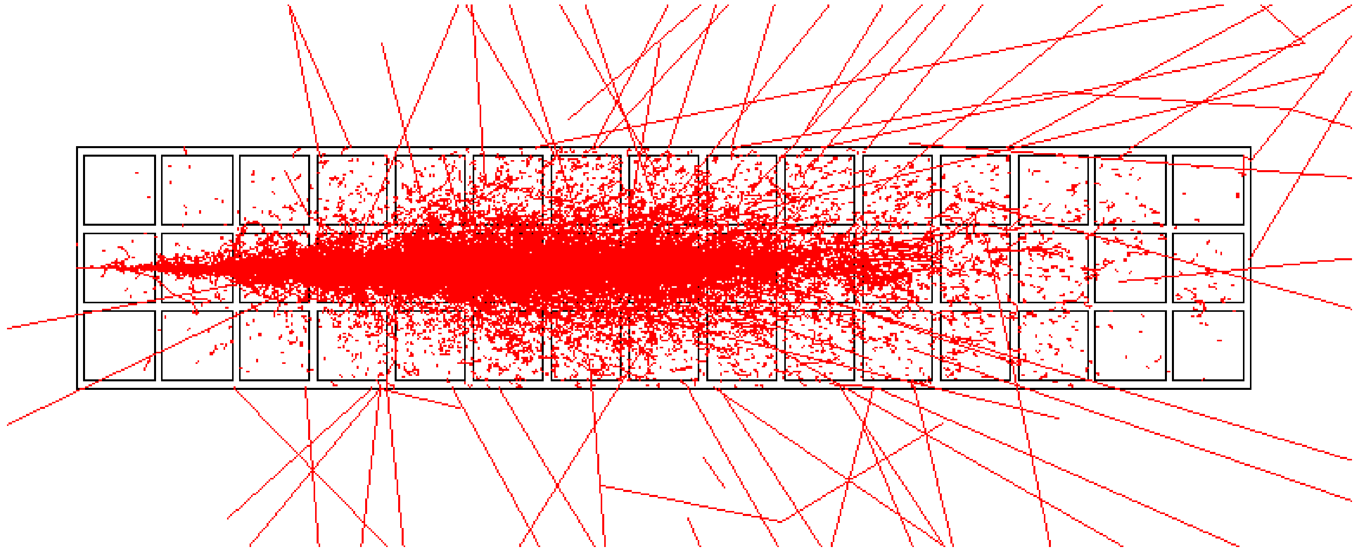


100 GeV electrons (R ≤ 1 cm)

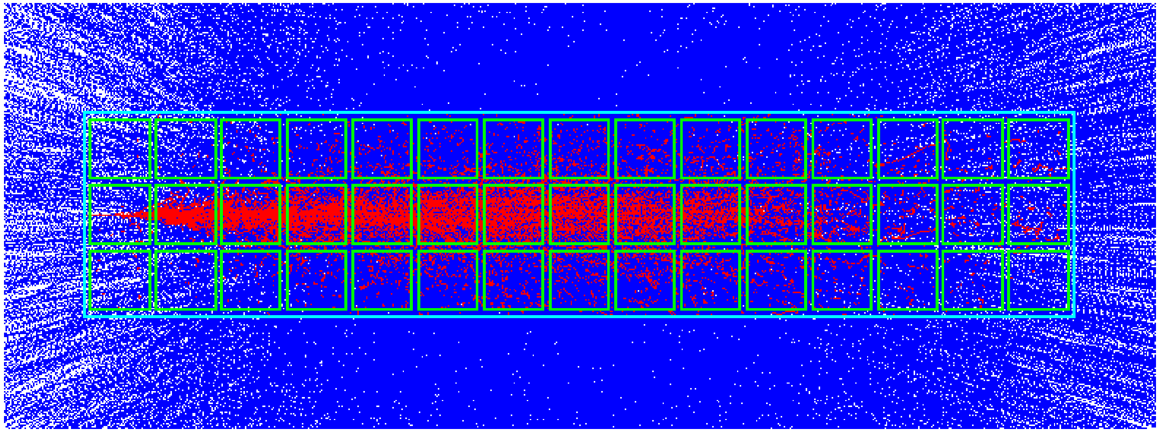
Energy measurement: electron beam



internal charged particles



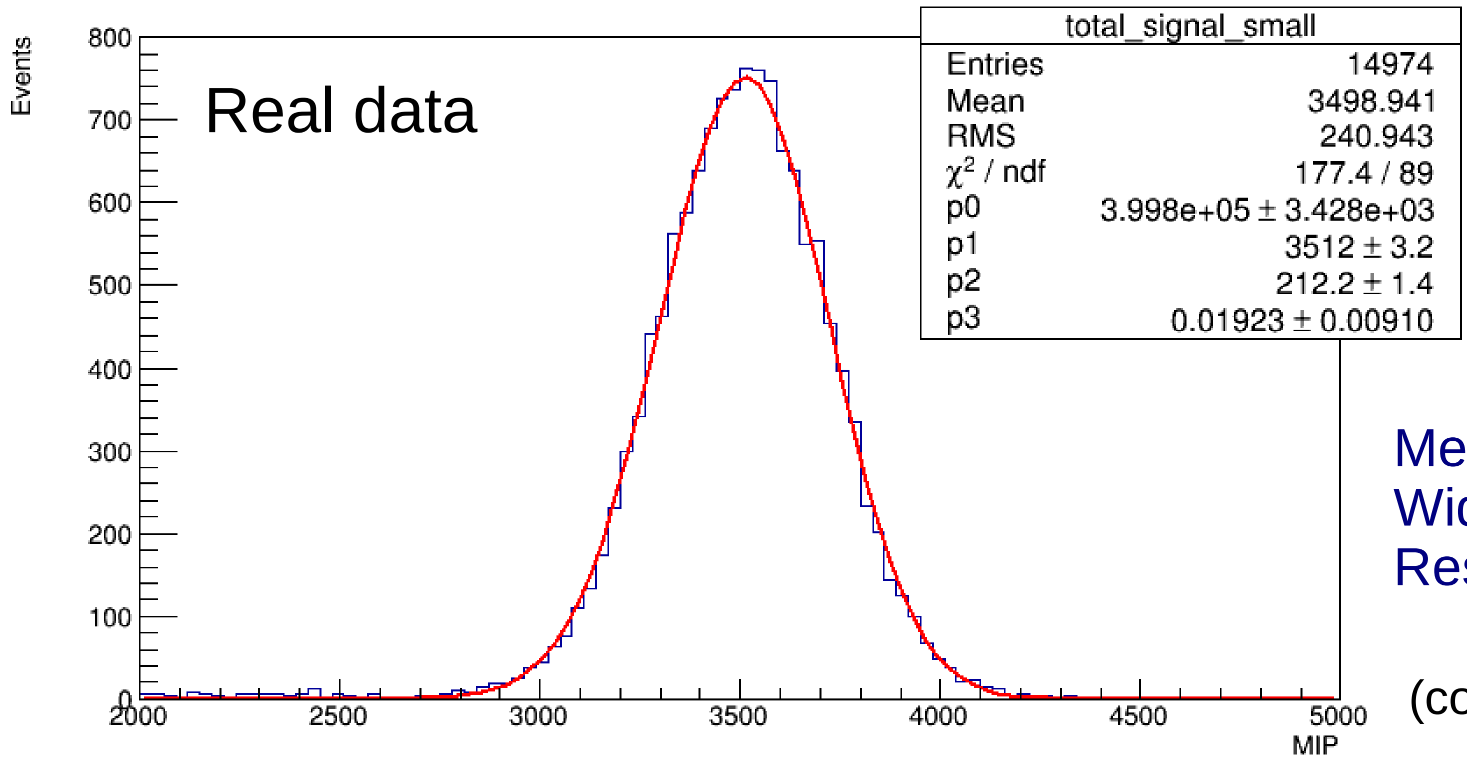
internal and external charged particles



internal charged (red) and external neutral (blue) particles

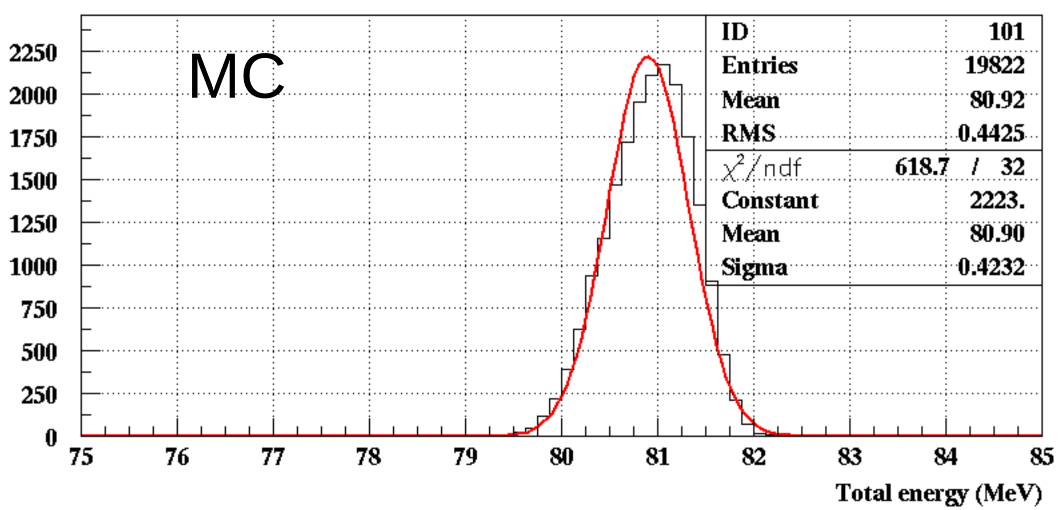
most of the external lost energy is due to the neutral particles (gammas)

Energy measurement: electron beam



Mean energy = 79.4 GeV
Width = 4.8 GeV
Resolution = 6.0 %

(considering 22.6 MeV/muon)



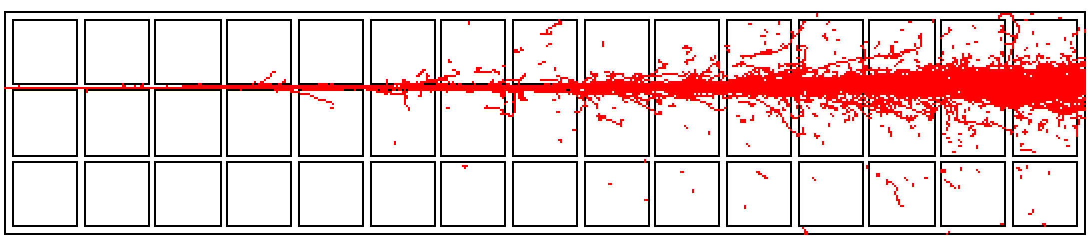
Mean energy = 80.9 GeV
Width = 0.4 GeV
Resolution = 0.5 %

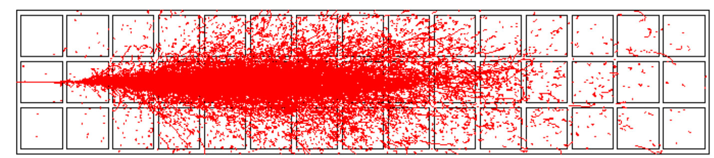
The MC does not simulate noise and efficiency

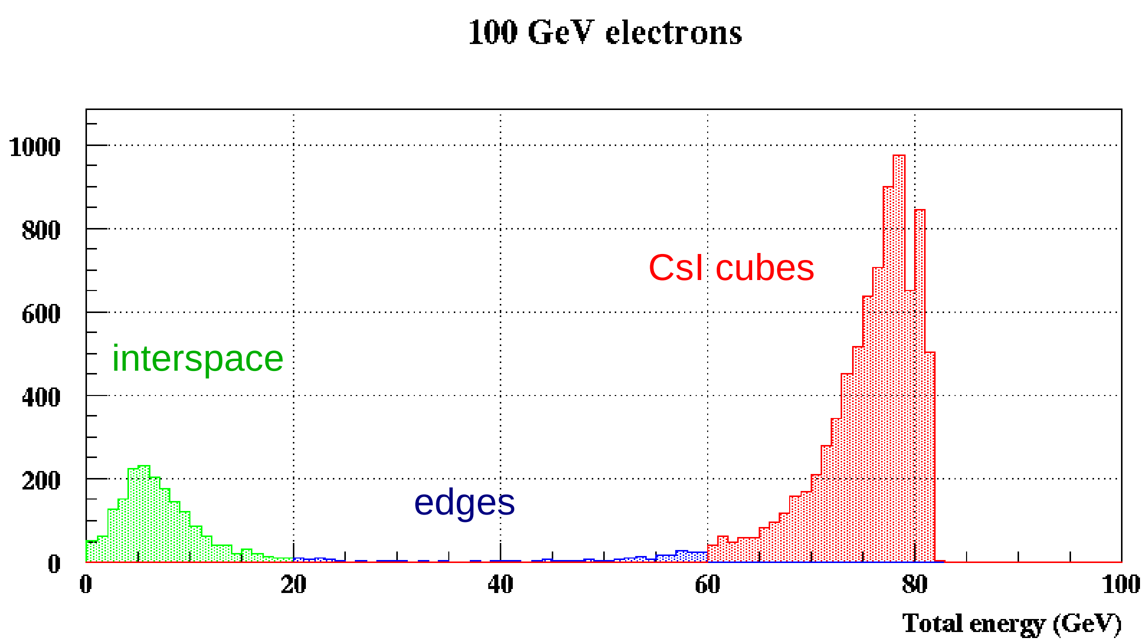
Some *special effect*

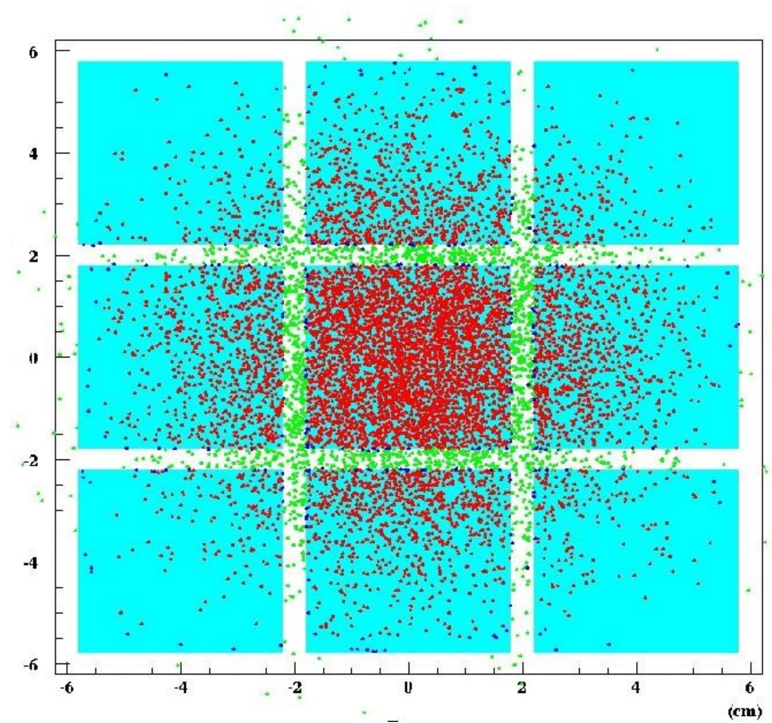
"*channeling*" into the passive material (PTFE)

When a ultra-relativistic particle (exactly oriented along the *z* axis) enter into the passive material (low Z and low density), a big amount of energy is lost, because all the produced secondaries particles are strongly forward-peaked



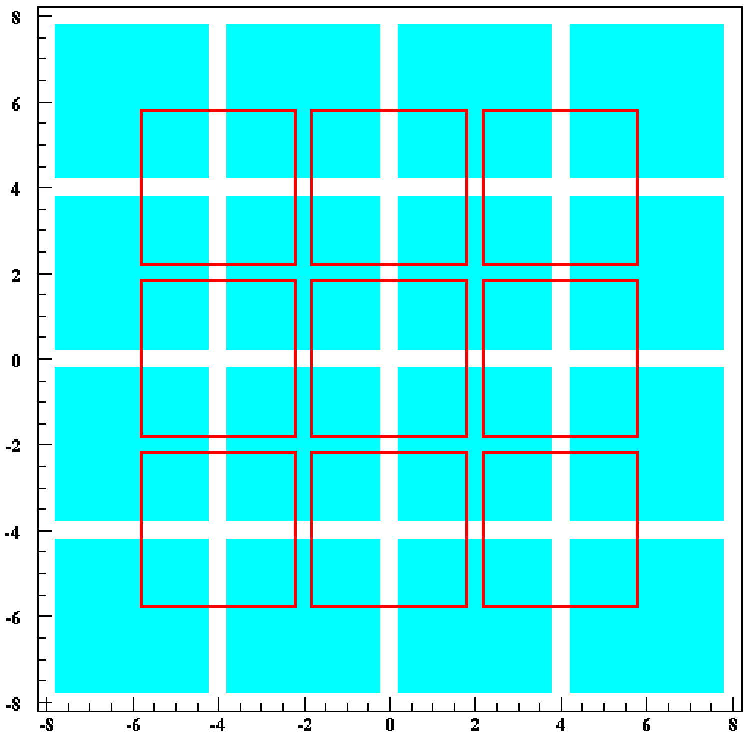






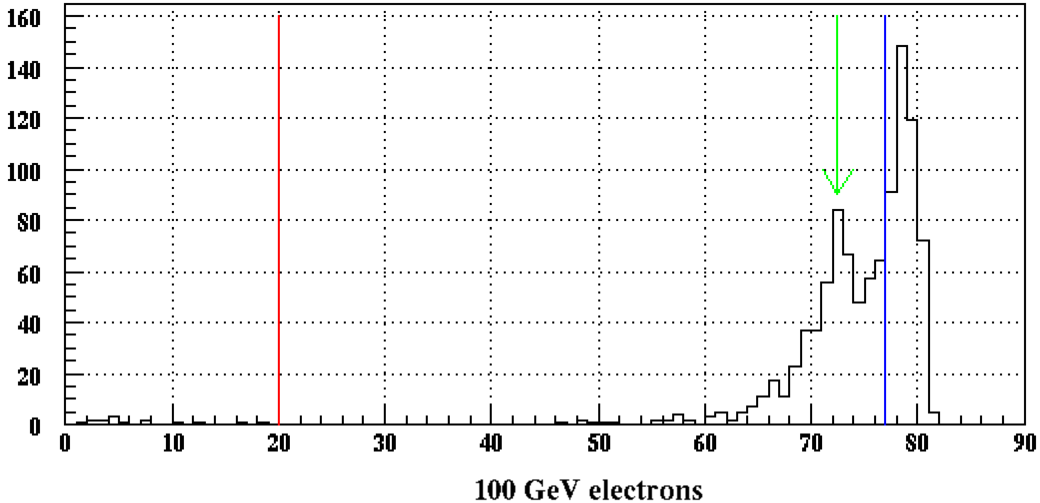
$\sigma_x = \sigma_y = 2$ cm

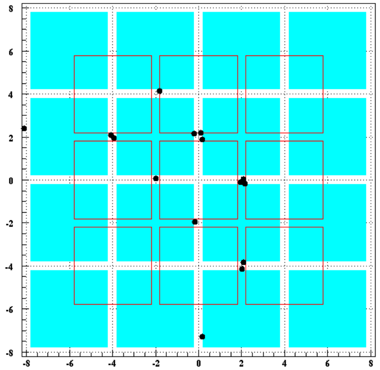
A possible solution...



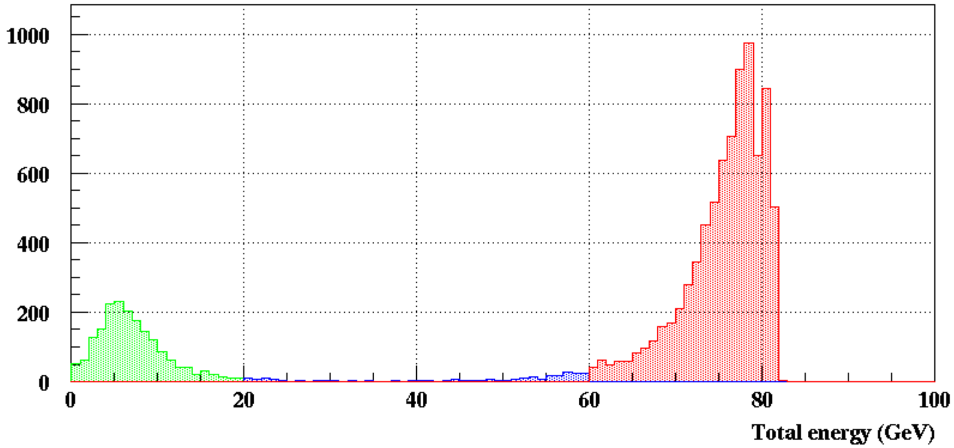
staggered layers

recovers a significant fraction of *lost* energy

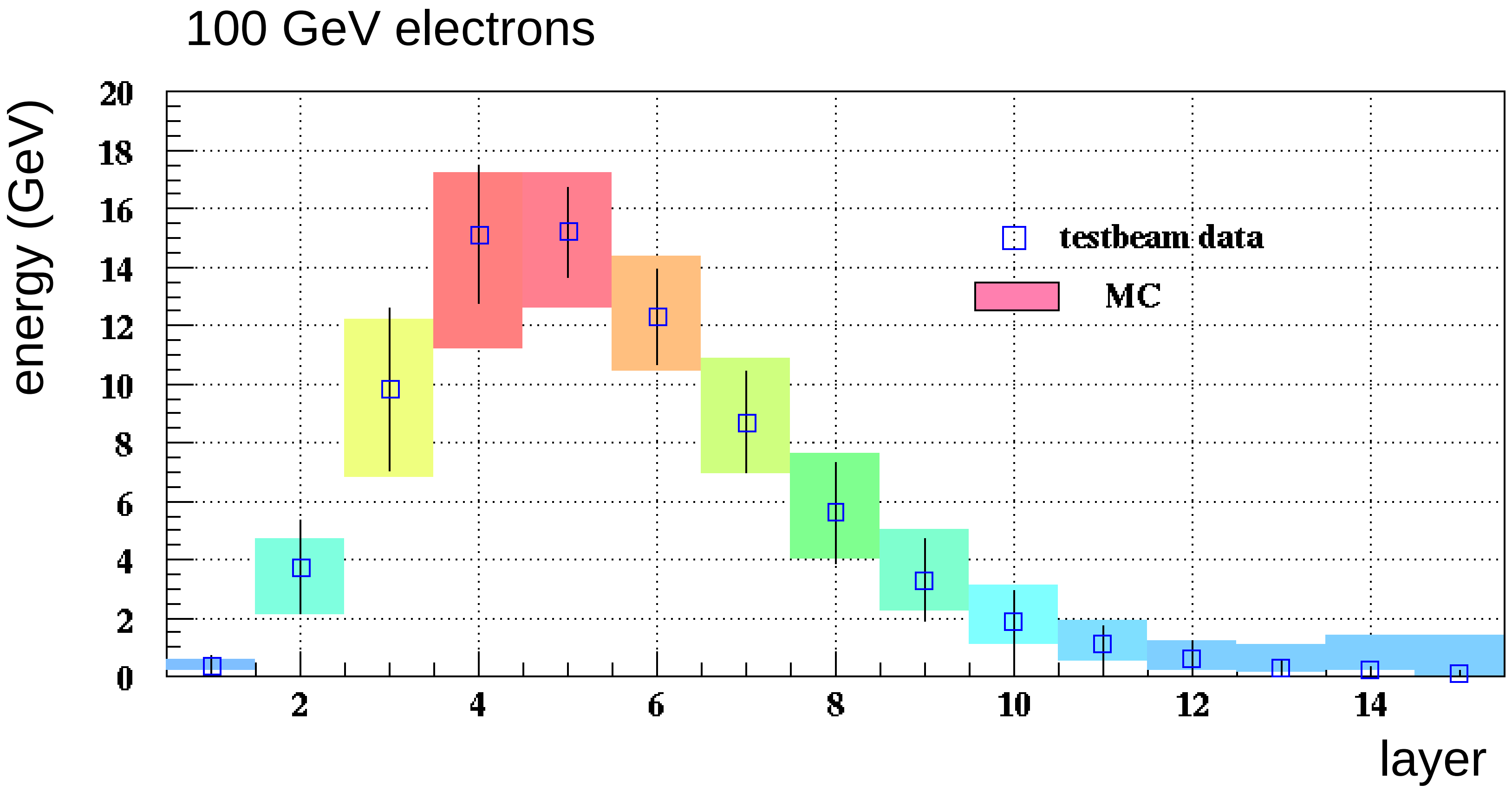




Reduces the probability to have *channeling*

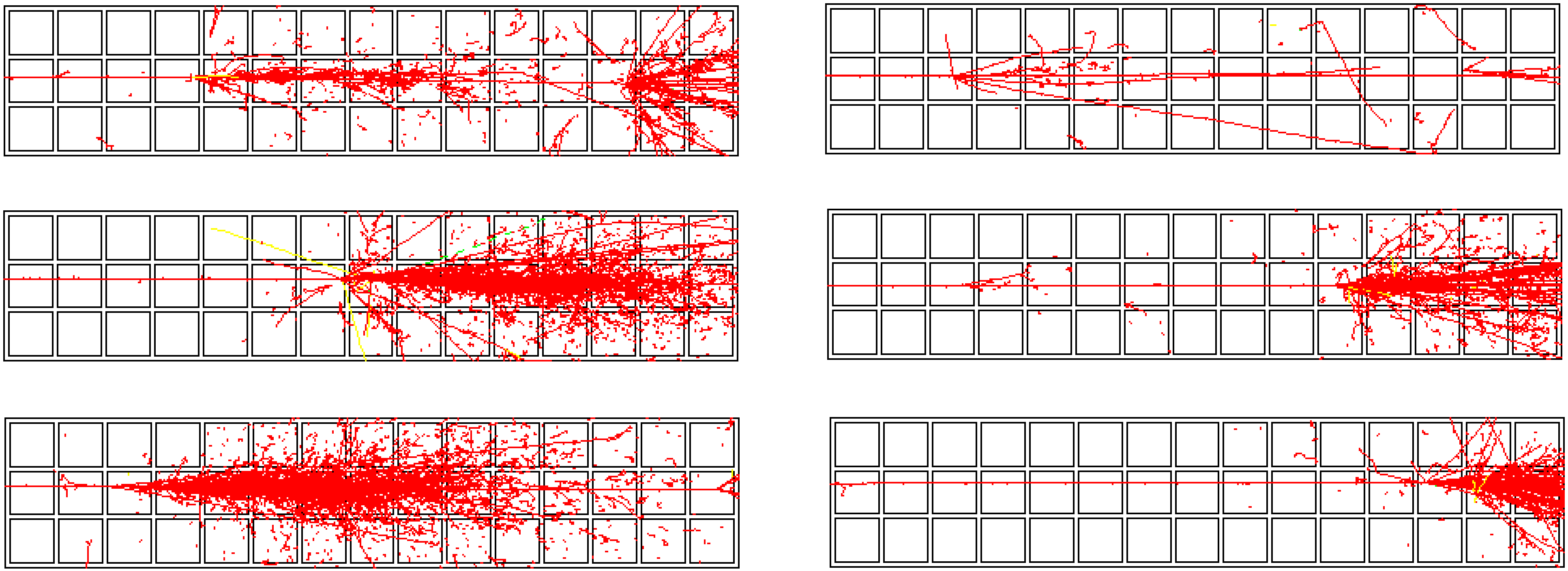


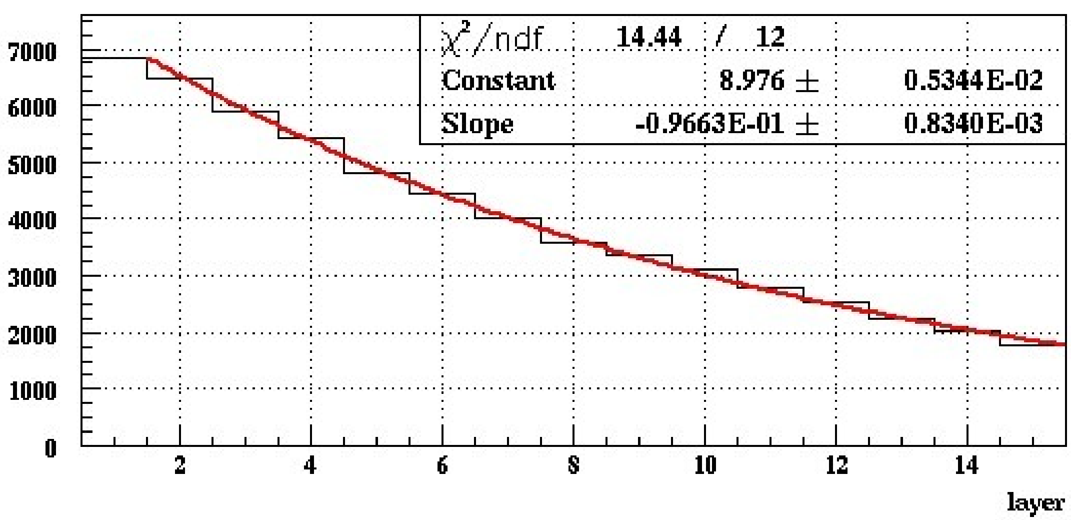
e.m. shower longitudinal profile



Hadronic shower: pions beam

50 GeV π^-





The probability to have a hadronic shower originating in the *i-th* layer is

$$p(i) = P_1 \exp(-i P_2)$$

where $P_2 = \lambda_{layer} / \lambda_{int}$ is the thickness of a layer expressed in interaction length units. For the adopted geometry $P_2 = 0.104$

yet to be analysed...

Conclusions

- A simple Montecarlo has been used to check the results coming from the CERN calibration testbeam
- A good agreement between simulation and data is found
- The detector response due to geometry is understood
- Such results can help to design the future systems

Fine