Si-W-Ecal treatment for HCAL only analysis and development of event selection processors

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Hcal Meeting DESY

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How to treat the energy loss of a MIP in the Ecal?

Analyses in which hadron starts shower in HCAL.

- Different approaches determine the total energy loss of a MIP in the Ecal
  - Fixed energy deposition calculated by the mean energy deposition in tungsten (Bethe-Bloch)
    Useful if energy deposition distribution of MIP has a large gaussian component
  - Measured energy deposition in silicon cells of Ecal (Sampling fraction and MIP2GeV factor have to be applied)
- Methods differed by a few 100 MeV!

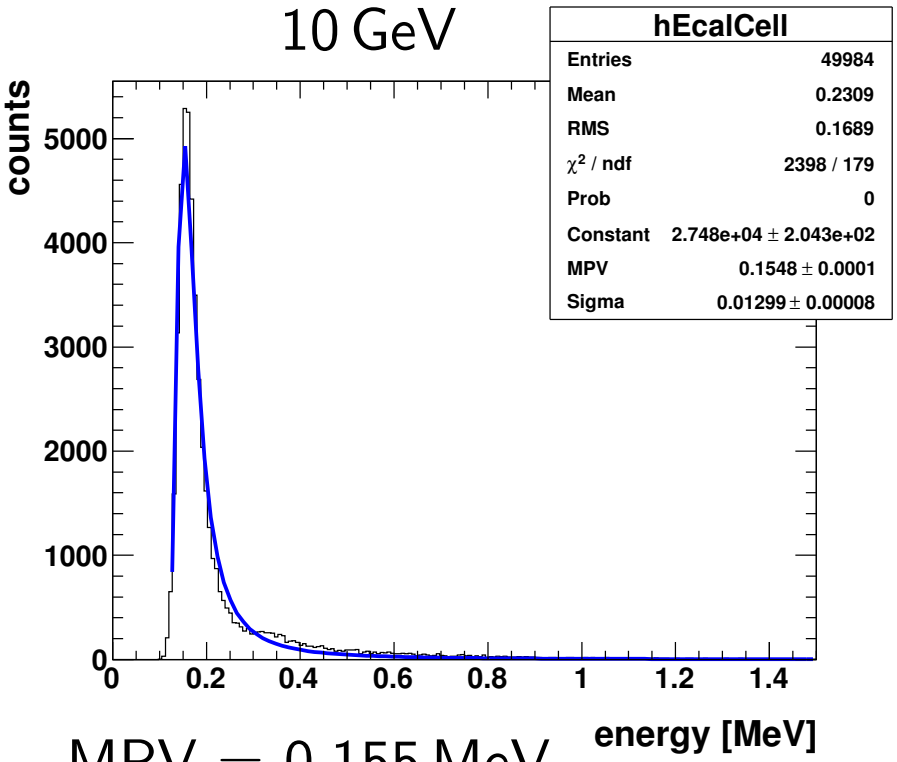
Idea:

- What is the total energy deposit of MIPs in Si-W-Ecal?
- Check which MIP2GeV factor has to be applied
- Check which method is better on average

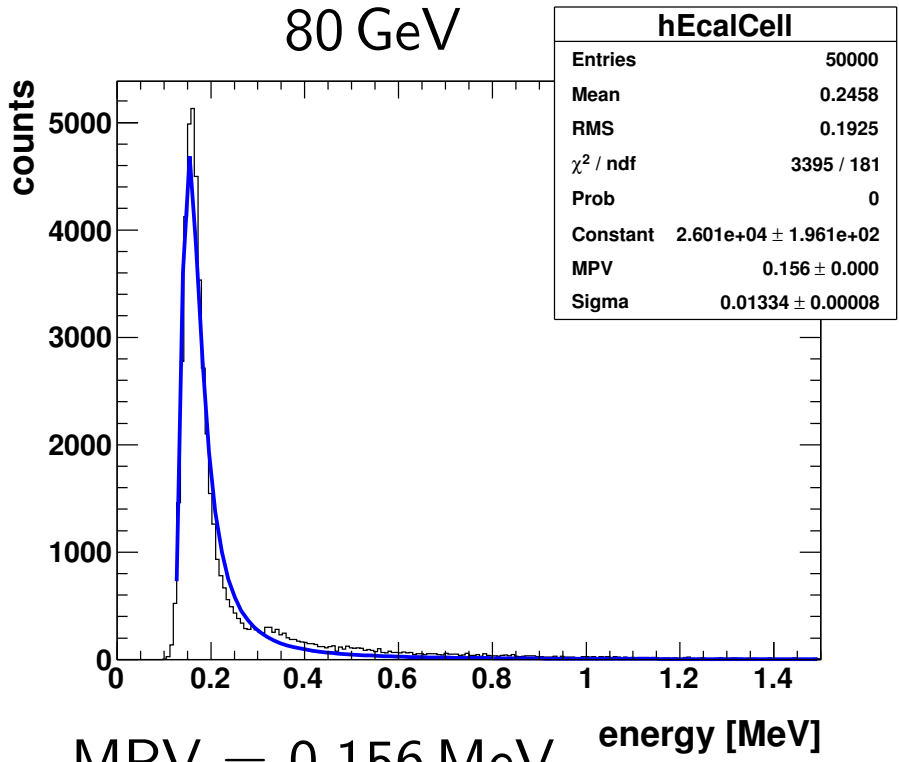
Standalone Geant4 Simulation

- geant4-09-03
- Included Si-W-Ecal with the following materials and geometry:
  - 30 layers of tungsten, PCB, silicon
  - Size of Ecal = Active Area = $18 \times 18\,\mathrm{cm}$
  - Silicon:
    Thickness of $0.525\,\mathrm{mm}$ for each layer
    Size of cells $1 \times 1\,\mathrm{cm}$,
    No gap between cells,
    9720 cells in total
    Type: Z = 14, a = $28.09\,\mathrm{g/mol}$
  - Tungsten:
    Thickness: $10 \times 1.4\,\mathrm{mm}$, $10 \times 2.8\,\mathrm{mm}$, $10 \times 4.2\,\mathrm{mm}$,
    Type: Z=74, a=$183.84\,\mathrm{g/mol}$ - like in Ecal Mokka implementation
  - PCB:
    Thickness of $2.25\,\mathrm{mm}$ for each layer
    choosen as the material for all passive material besides tungsten
  - TimeCut = $150\,\mathrm{ns}$, RangeCut = $0.05\,\mathrm{mm}$, Birks law

How much energy deposit MIPs in the silicon?



MPV = 0.155 MeV

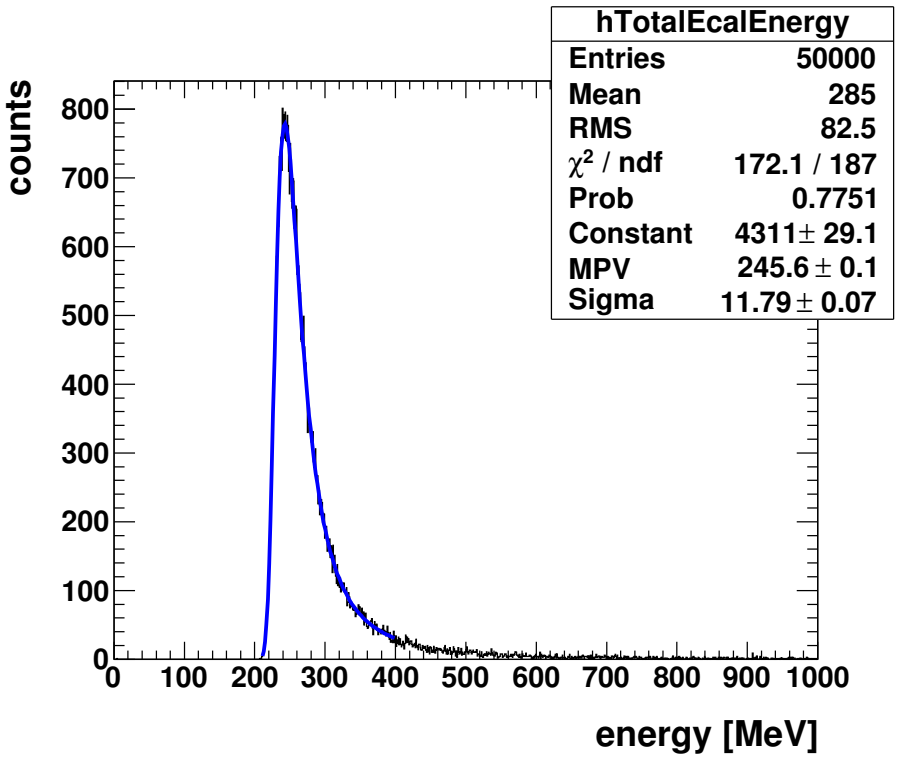


MPV = 0.156 MeV

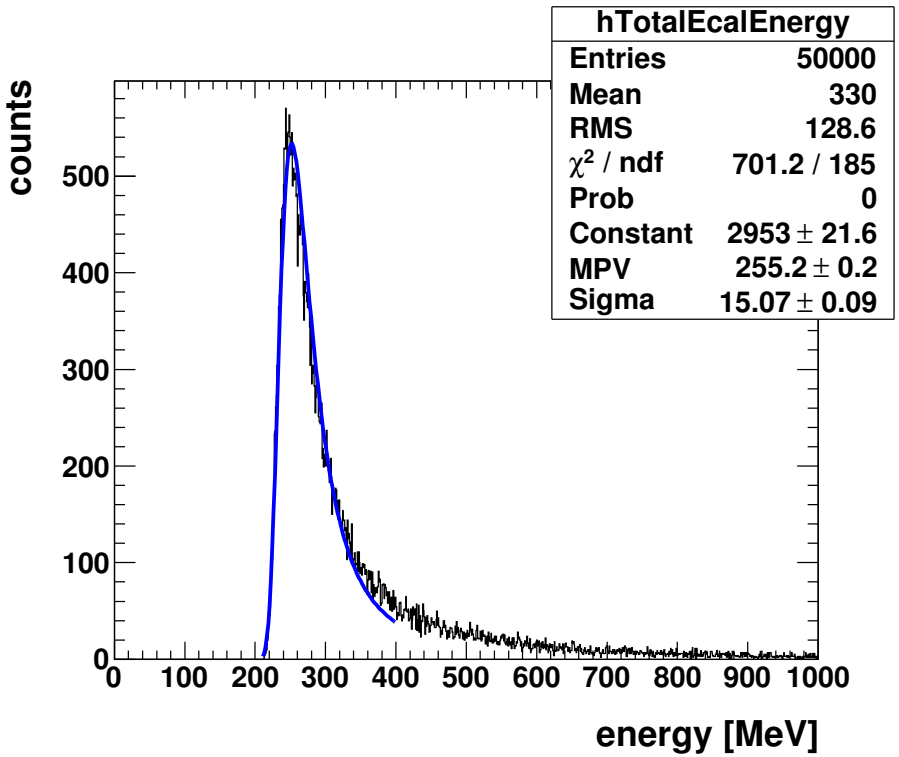
Energy deposition in one silicon cell. MPV changes by less than 1 %
MIP MPV value used in the official digitization: 0.000147 GeV.

What is the total energy deposit of MIPs in the Ecal?

10 GeV



80 GeV



MPV: 246 MeV
Mean: 285 MeV

MPV: 255 MeV
Mean: 330 MeV

Energy deposition in Tungsten, PCB and silicon.

What is the value of the MIP2GeV factor?

It can be extracted from muons runs in simulation. (SF 1:2:3 applied)

- 10 GeV μ^-:

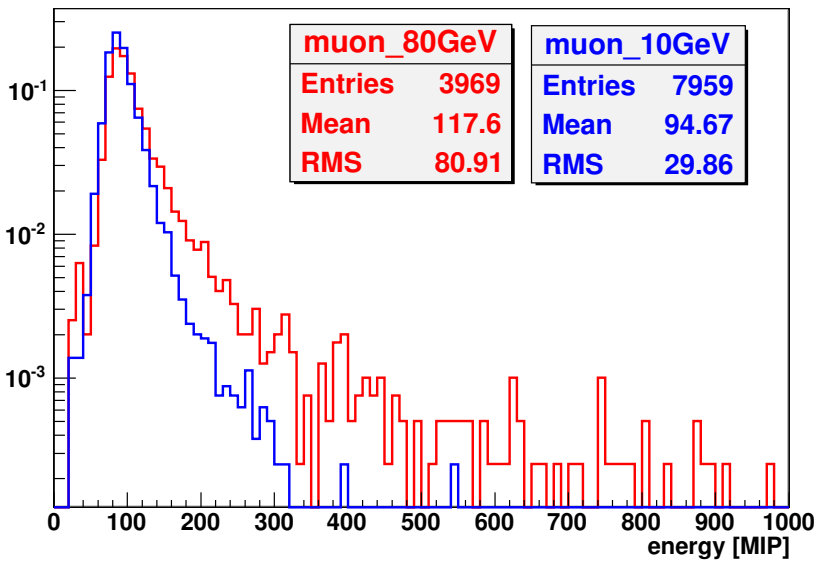
  data: MPV = 85 MIP; Mean = 95 MIP

  sim. total deposited energy: MPV = 246 MeV, Mean = 285 MeV
- 80 GeV μ^-:

  data: MPV = 85 MIP; Mean = 118 MIP

  sim. total deposited energy: MPV = 255 MeV, Mean = 330 MeV

$\Rightarrow$ MIP2GeV factor approx. 0.002953 $\frac{\text{GeV}}{\text{MIP}}$

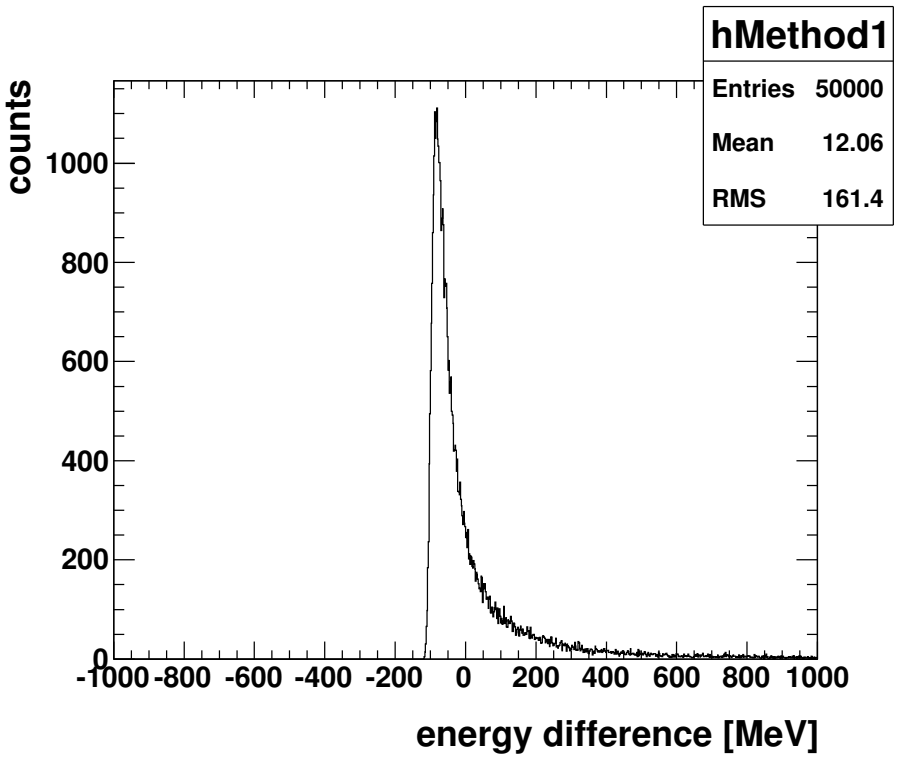


Thanks Marina.

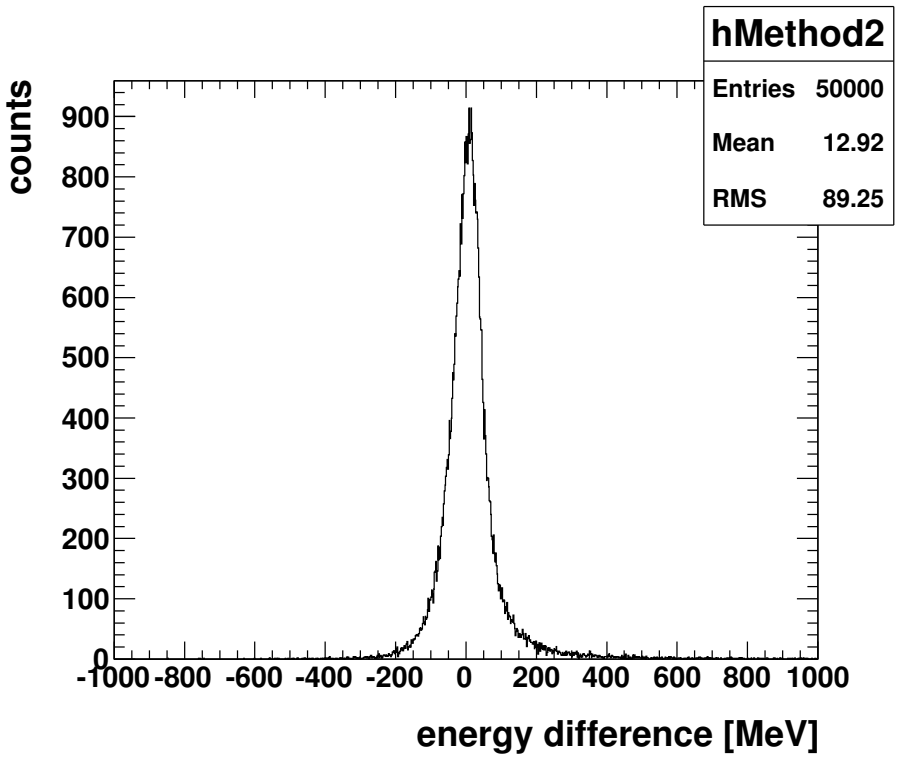
How good is the correlation between the energy deposition in the silicon and total energy deposition?

Difference between the total energy deposition in Ecal and ...

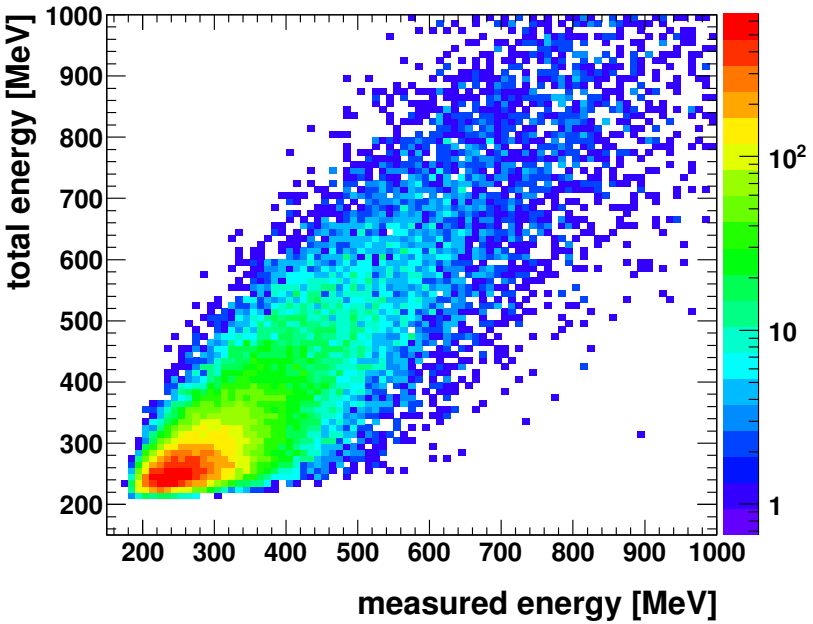
the mean total energy deposition in Ecal

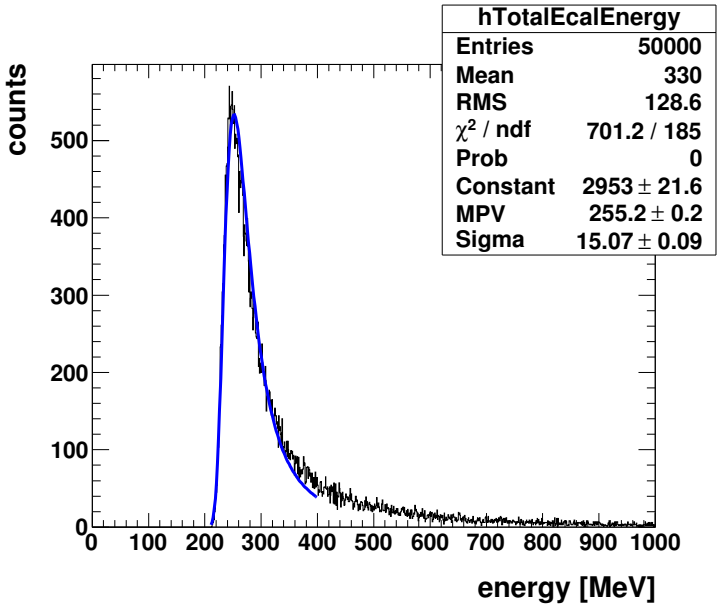


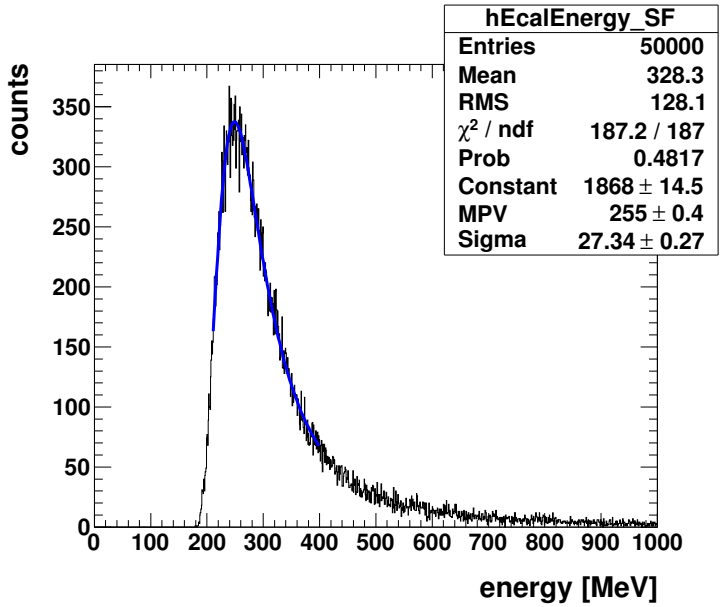
the measured energy deposition in silicon



Method 2: 80 GeV







Conclusion

- Standalone Geant4 Simulation to ananlyse the energy deposition of MIPs in the Silicon-Tungsten-Ecal
- Determination of mean energy deposition in Ecal of 285 GeV/330 GeV for 10 GeV/80 GeV
- Correlation between energy deposition in silicon and total energy deposition sufficient
  $\rightarrow$ Event dependent energy deposition in Ecal should be used
  $\rightarrow$ Sampling fraction and MIP2GeV factor important
- MIP2GeV factor for μ^-: 0.002953 $\frac{\mathrm{GeV}}{\mathrm{MIP}}$

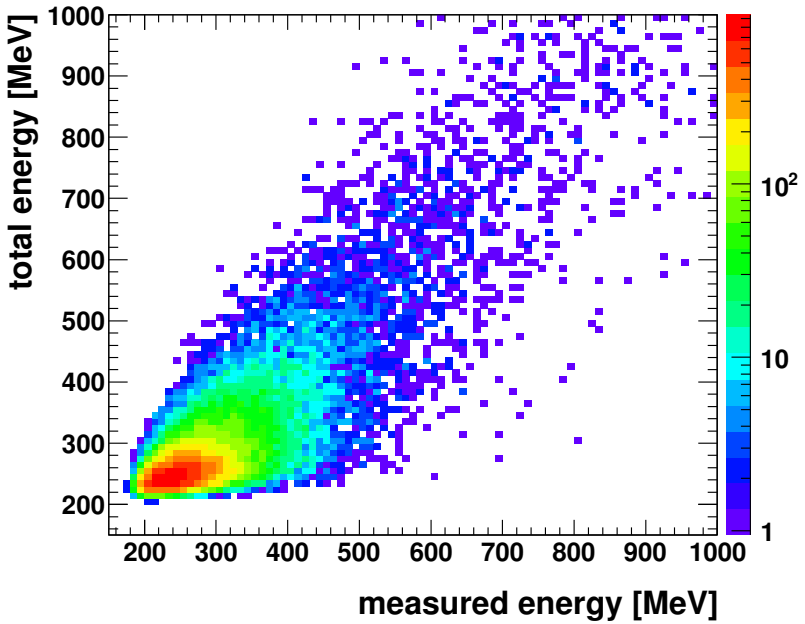
Selection Processors

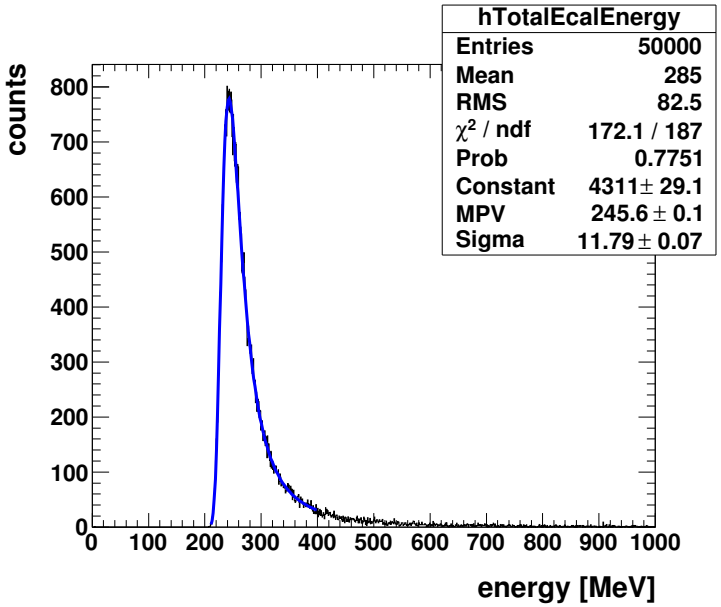
- ExtractBeamParameters: Particle type and beam energy are stored in database
  Processor reads from database for a given run number. Beam paramters are attachted as a LCParameter to each event / or in the run header
- MultiBitGenerator: Official calice software
  Checks if event is a multi particle event. Amplitude of multiparticle detector is compared to a threshold and a multiparticle bit will be attacted as a LCParameter to each event
- EventSelector: Official calice software
  Trigger and Multiparticle selection. Drops all other events
- HCALHadronSelection: Find hadron for given cuts. Creates collection with information about first hadronic interaction.

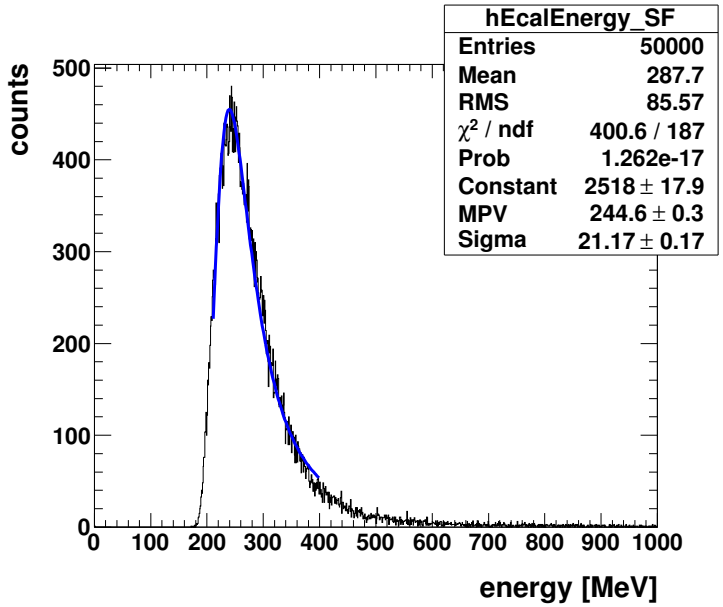
Summary

- Energy of MIPs in Si-W Ecal can be determined with the measured energy in the silicon.
- MIP2GeV factor for muons should be approx. 0.002953 $\frac{\mathrm{GeV}}{\mathrm{MIP}}$
- Official processors should be used for event selection in analyses

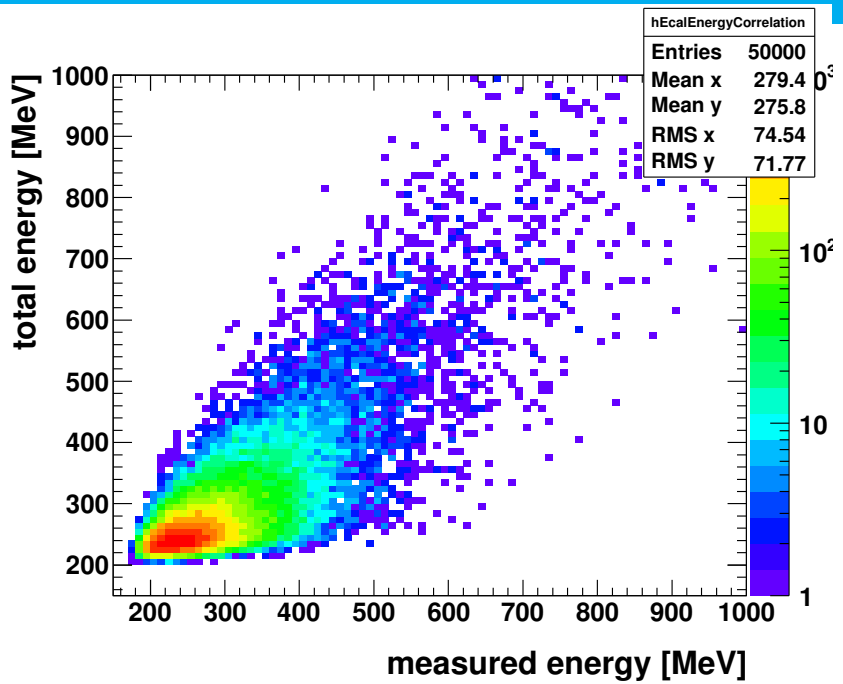
10 GeV

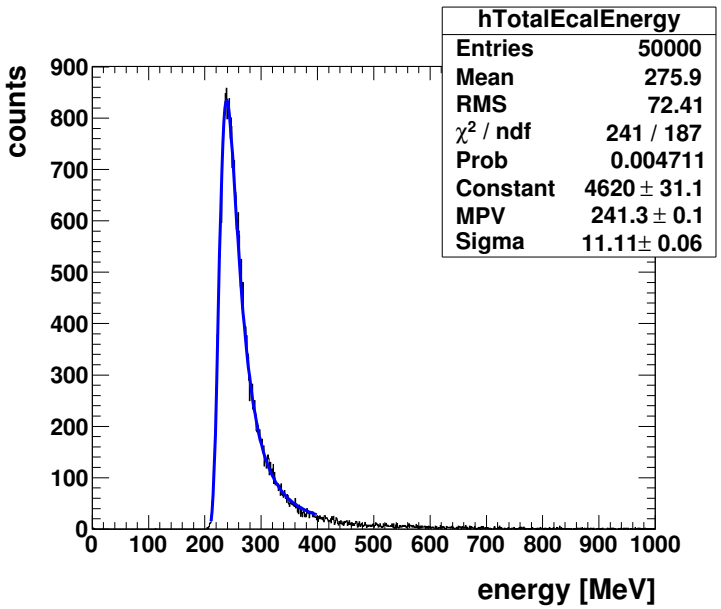

total energy [MeV]
measured energy [MeV]
1000
900
800
700
600
500
400
300
200
200 300 400 500 600 700 800 900 1000
10^2
10
1

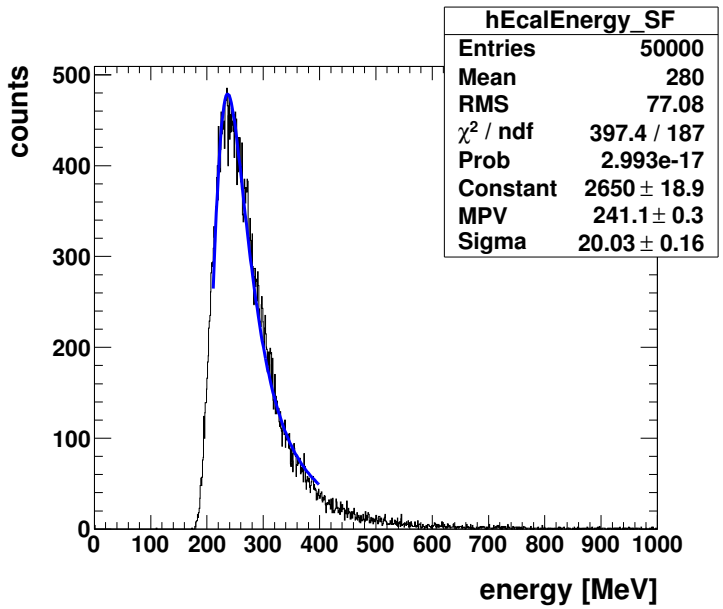

hTotalEcalEnergy
Entries 50000
Mean 285
RMS 82.5
χ^2 / ndf 172.1 / 187
Prob 0.7751
Constant 4311 ± 29.1
MPV 245.6 ± 0.1
Sigma 11.79 ± 0.07
counts
energy [MeV]
0 100 200 300 400 500 600 700 800 900 1000


hEcalEnergy_SF
Entries 50000
Mean 287.7
RMS 85.57
χ^2 / ndf 400.6 / 187
Prob 1.262e-17
Constant 2518 ± 17.9
MPV 244.6 ± 0.3
Sigma 21.17 ± 0.17
counts
energy [MeV]
0 100 200 300 400 500 600 700 800 900 1000

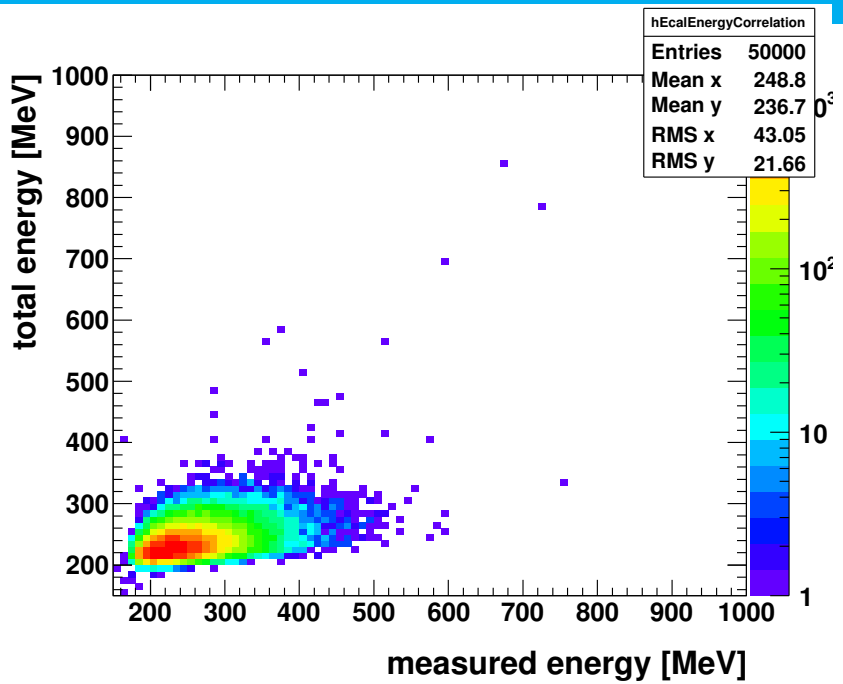
5 GeV

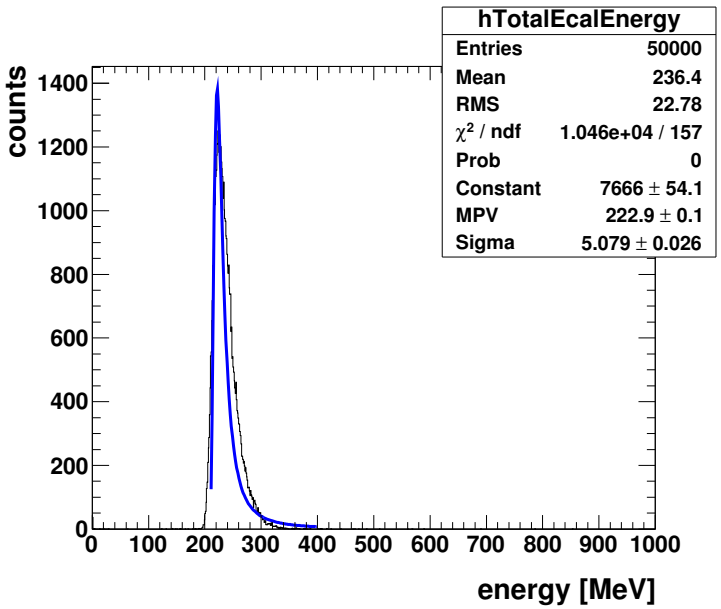

hEcalEnergyCorrelation
Entries 50000
Mean x 279.4
Mean y 275.8
RMS x 74.54
RMS y 71.77
total energy [MeV]
measured energy [MeV]

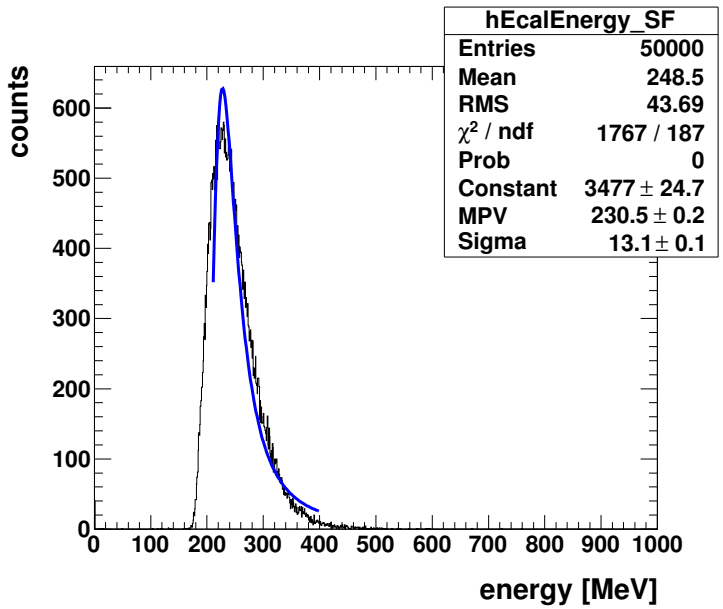

hTotalEcalEnergy
Entries 50000
Mean 275.9
RMS 72.41
χ² / ndf 241 / 187
Prob 0.004711
Constant 4620 ± 31.1
MPV 241.3 ± 0.1
Sigma 11.11± 0.06
counts
energy [MeV]


hEcalEnergy_SF
Entries 50000
Mean 280
RMS 77.08
χ² / ndf 397.4 / 187
Prob 2.993e-17
Constant 2650 ± 18.9
MPV 241.1± 0.3
Sigma 20.03 ± 0.16
counts
energy [MeV]

1 GeV


hEcalEnergyCorrelation
Entries 50000
Mean x 248.8
Mean y 236.7
RMS x 43.05
RMS y 21.66
total energy [MeV]
measured energy [MeV]


hTotalEcalEnergy
Entries 50000
Mean 236.4
RMS 22.78
χ² / ndf 1.046e+04 / 157
Prob 0
Constant 7666 ± 54.1
MPV 222.9 ± 0.1
Sigma 5.079 ± 0.026
counts
energy [MeV]


hEcalEnergy_SF
Entries 50000
Mean 248.5
RMS 43.69
χ² / ndf 1767 / 187
Prob 0
Constant 3477 ± 24.7
MPV 230.5 ± 0.2
Sigma 13.1 ± 0.1
counts
energy [MeV]

Data - MonteCarlo