Calorimeter for ILC

Saturation correction in a gaseous SDHCAL

CALICE collaboration meeting

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On behalf of the **LAPP LC Detector group**

Overview

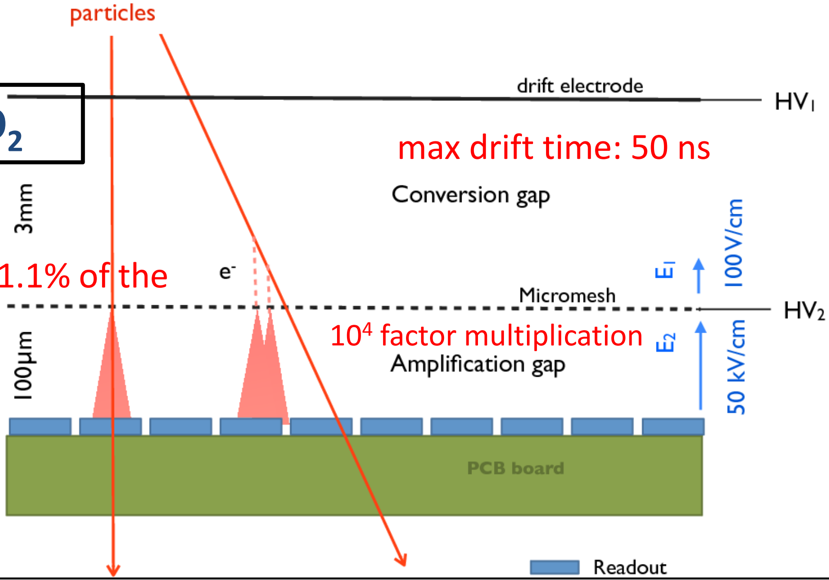
- Introduction
  - R&D: large area Micromegas detectors with integrated electronics
- Simulation and offline analysis
  - Improvement of the linearity and resolution using a second threshold
  - Further improvement with a multi-threshold analysis
  - Application of the methods on the TB data
- Conclusion

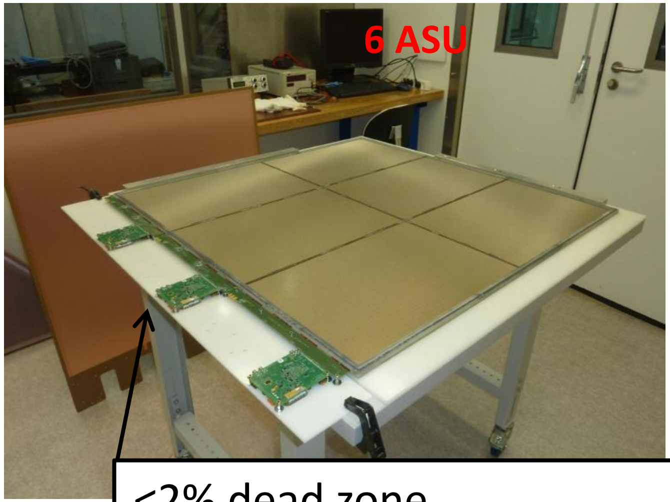
Large area Micromegas detectors

Bulk technology fabrication by the lamination of a steel woven mesh and photo-sensitive layers on a PCB

Ar/CO_2

pillars: 1.1% of the area





<2% dead zone
1 cm thick (incl. 2 mm steel)
9216 pads of 1 cm^2
144 MICROROC ASICs

Advantages of this technology:

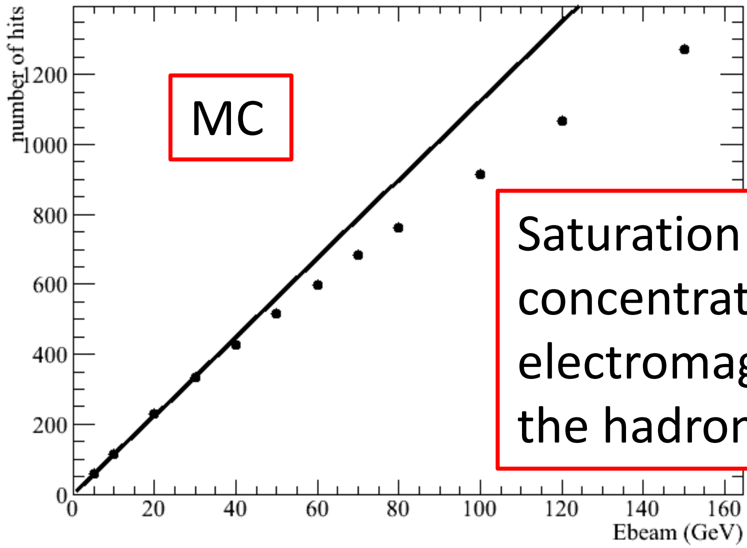
- high rate capability (> tens of MHz/cm^2), radiation hard
- no space charge effect
- low operating voltage 400V -> 500V on Ar/CO_2
- low hit multiplicity (1.05 for 90^o tracks)

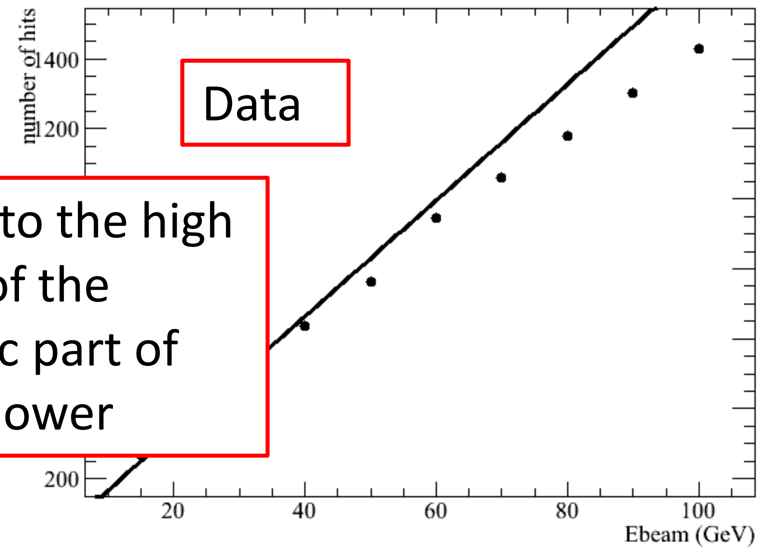
MC and Test Beam data

- Simulated calorimeter using Geant4 (QGSP_BERT physics list)
  - 100 layers of 1x1 m^2 (~10 λ_{int} deep)
  - passive material = 15mm (absorbers) + 4mm (detectors) = 19 mm of steel
  - Active layers: 3 mm of gas with 1x1 cm^2 pads
  - Low threshold:h / cell ~ 0.6 MIP
- Simulated energies: 5,10,20,30,....150 GeV
- 10^4 pions for every energy

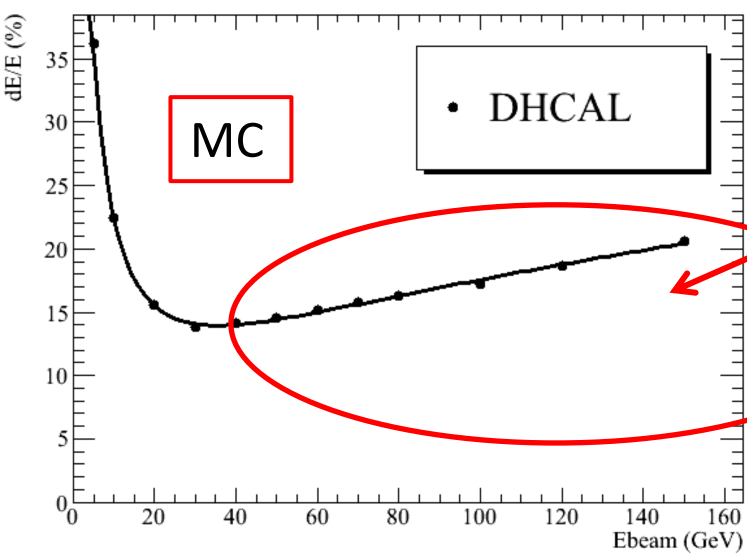
- Test Beam Data: RPC data from Aug. 2012 TB
  - Note: 50 layers
  - TB energy: 10,20... 100 GeV
  - TB data stat: 10-15 k / energy

The problem of saturation





Saturation due to the high concentration of the electromagnetic part of the hadronic shower



Degradation of the resolution (ΔN/N) in higher energies due to this saturation.

For the DHCAL energy reconstruction we fit the upper plot:

N(Ebeam) = A/B.log(1+B.Ebeam)

and then inverse the function to compute Ebeam.

How to correct saturation?

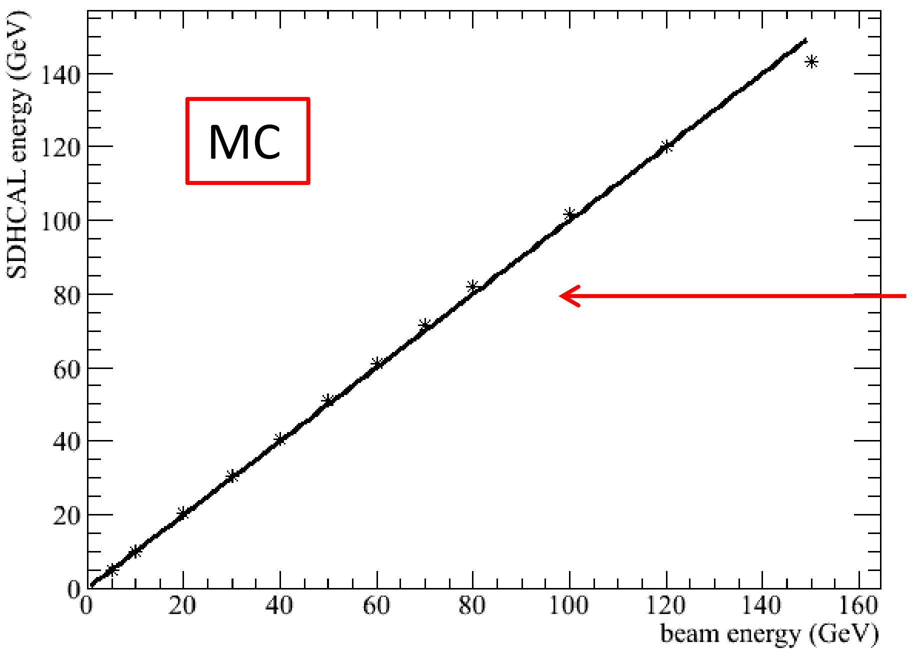
The effects of the saturation can be limited using a second higher threshold.

$$E_{rec}=A\cdot(N_0+B\cdot N_1)$$

The weight of this threshold is computed with a χ^2 minimization using MC.

The term A is computed with the plot of the previous page:

N(Ebeam) = A/B.log(1+B.Ebeam)

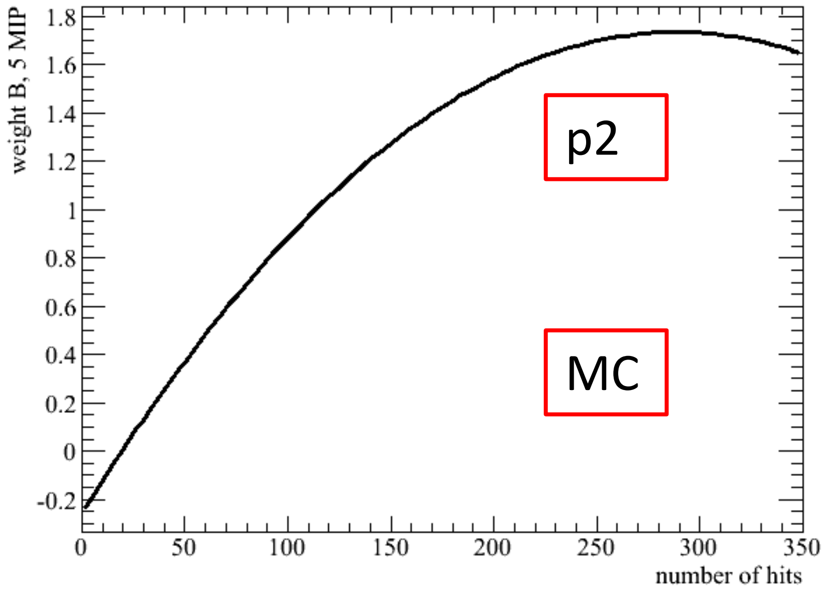


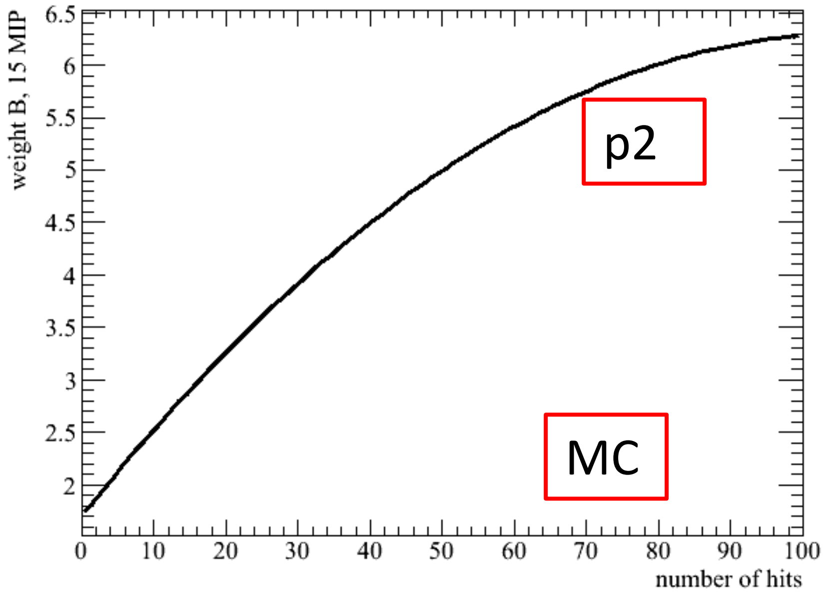
In this example, a second threshold is defined on a 5 MIP energy (verified in every case).

We made sure that using it, the linearity is preserved

We'll now study the effect on the energy resolution

Parametrization of the weights





$$E_{rec}=A\cdot(N_0+B\cdot N_1)$$

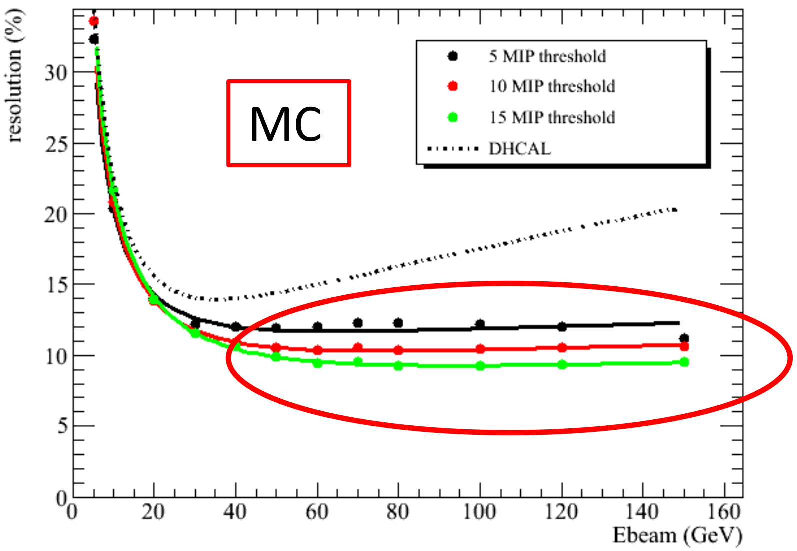
With a global fit we define the optimal value of B as a function of the number of hits of the corresponding threshold.

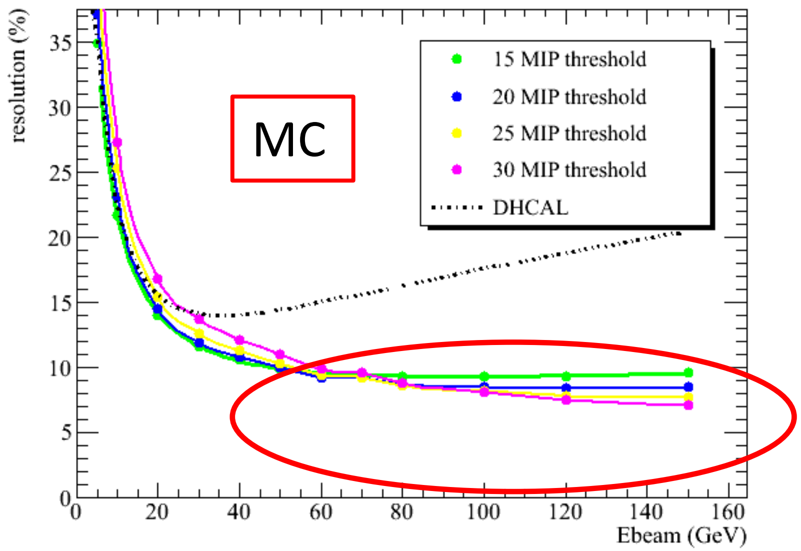
This is done by minimizing E_{rec}- E_{beam}

When reconstructing the energy, we apply the B value that corresponds to the number of cells activating the second threshold in each event.

What's the best value for the second threshold?

We repeat the same exercise with different values of the second threshold, from 5 to 30 MIP.

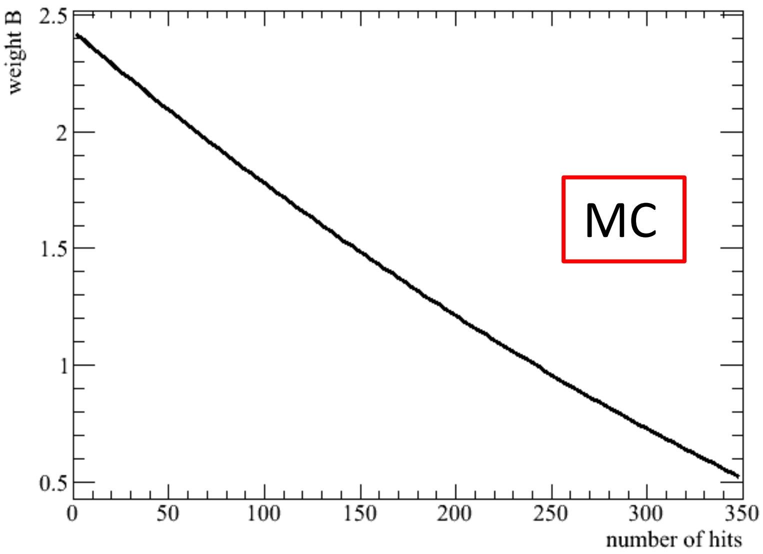




It is clear that a higher threshold is useful until 15 MIP, because with a low second threshold we have again a saturation problem but at higher energy.

After 15 MIP the number of hot cells is too low to give an improvement until ~80 GeV. At even higher energies it becomes useful to chose a higher value for the second threshold

Multi-threshold analysis

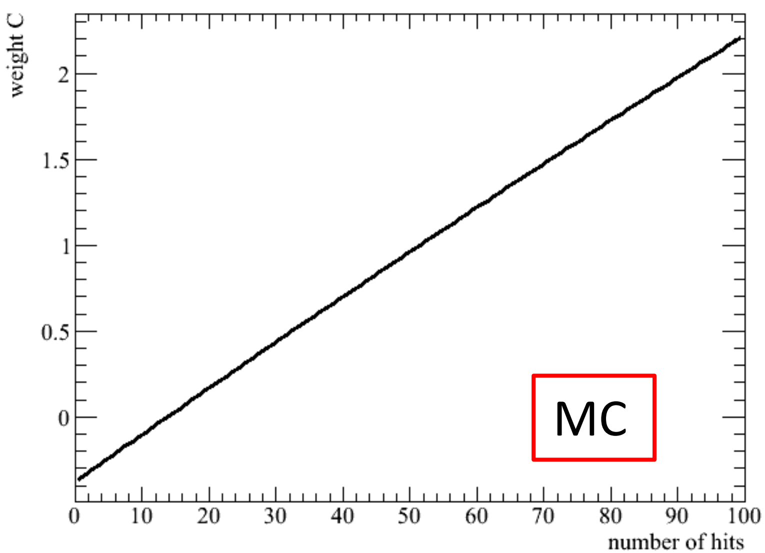


We can achieve even better results when using a combination of three thresholds.

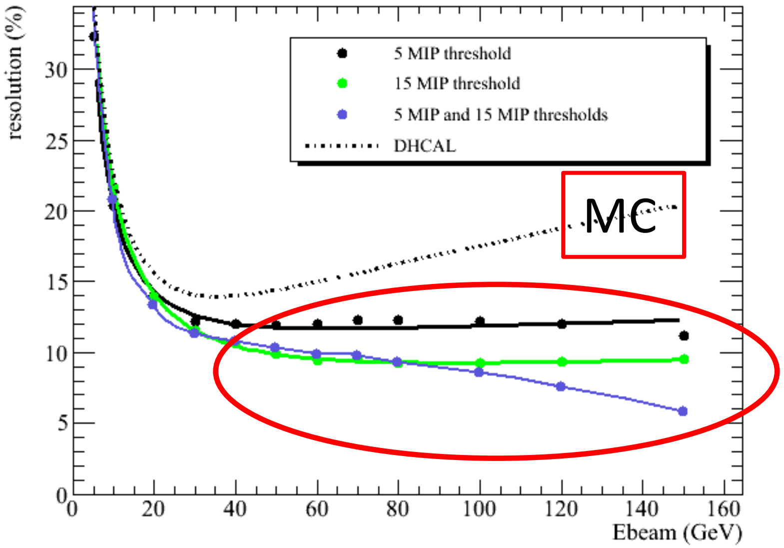
We use both 5 and 15 MIP thresholds.

$$E_{rec}=A\cdot(N_0+B\cdot N_1+C\cdot N_2)$$

The two weights are computed using minuit and a MC optimization.



Multi-threshold analysis



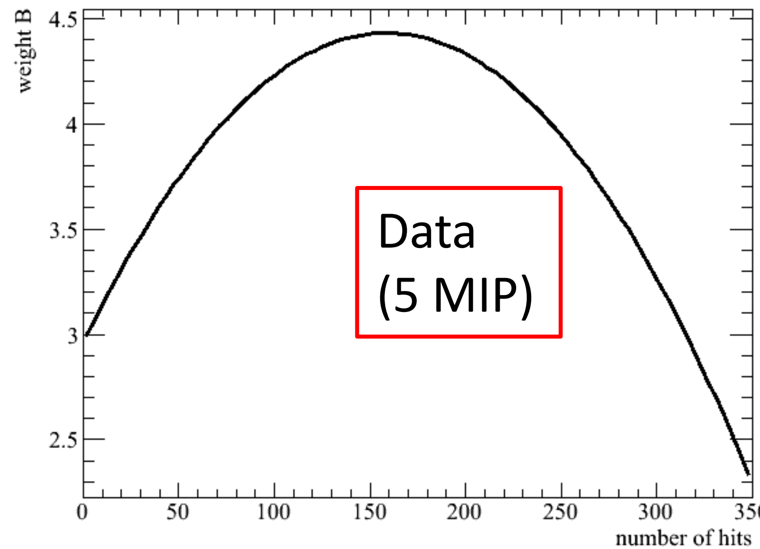
The results are further improved using a third threshold, in the full energy range

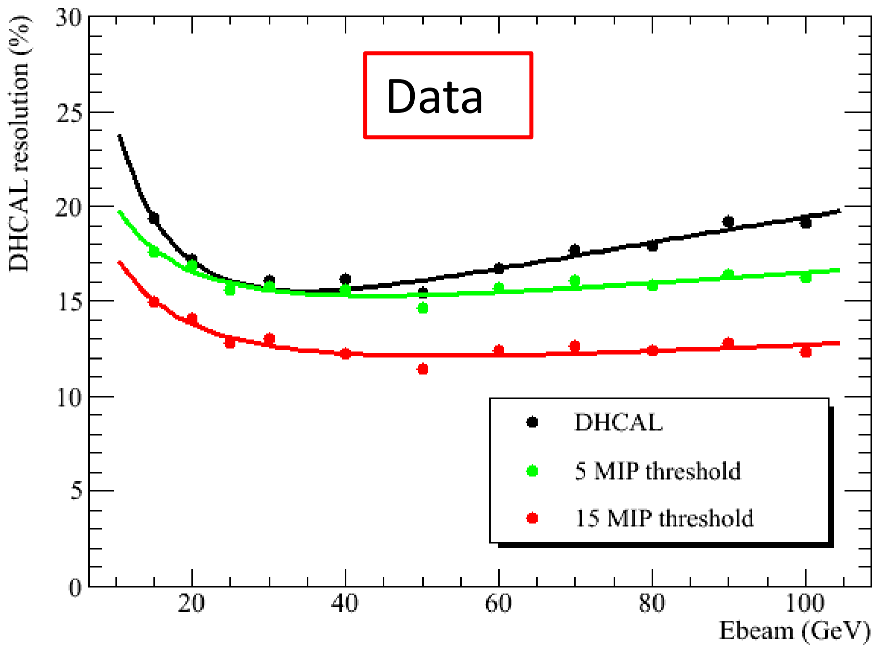
- This could be further improved, using energy dependent characteristics of the hadron shower in a multivariable analysis
- Example: include center of gravity of hits along shower axis in probability distribution
- *Work in progress…*

Validation of the results with data 1/3

We try to parameterize the weight of the second threshold as we did with MC.

The shape is much less logical than in the MC case, to investigate…

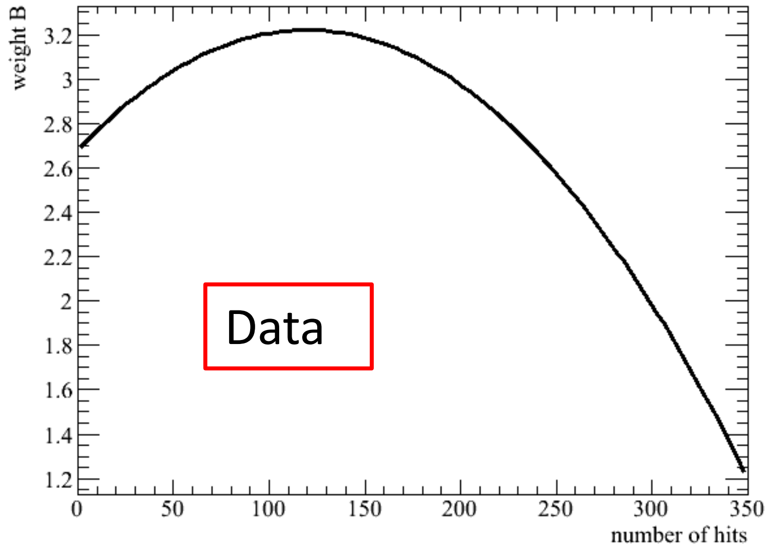


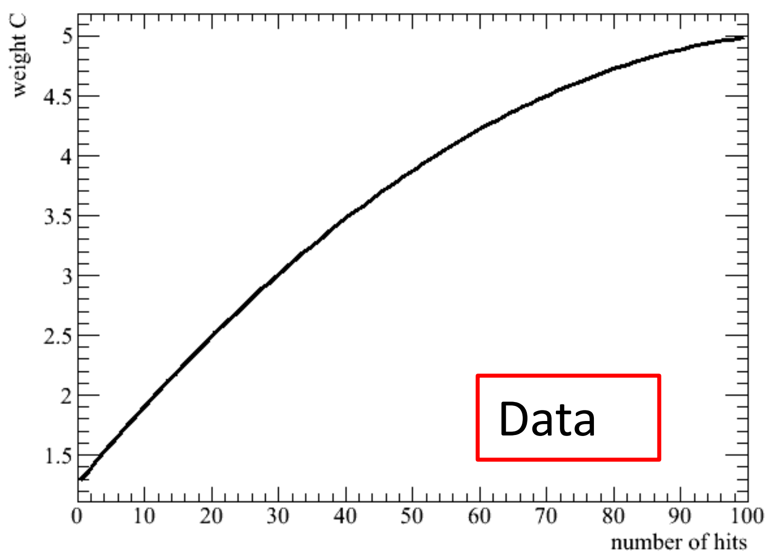


The results validate the same conclusion:

15 MIP is better that 5 MIP for the choice of the second threshold (no data for further investigation).

Validation of the results with data 2/3





We use both 5 and 15 MIP thresholds.

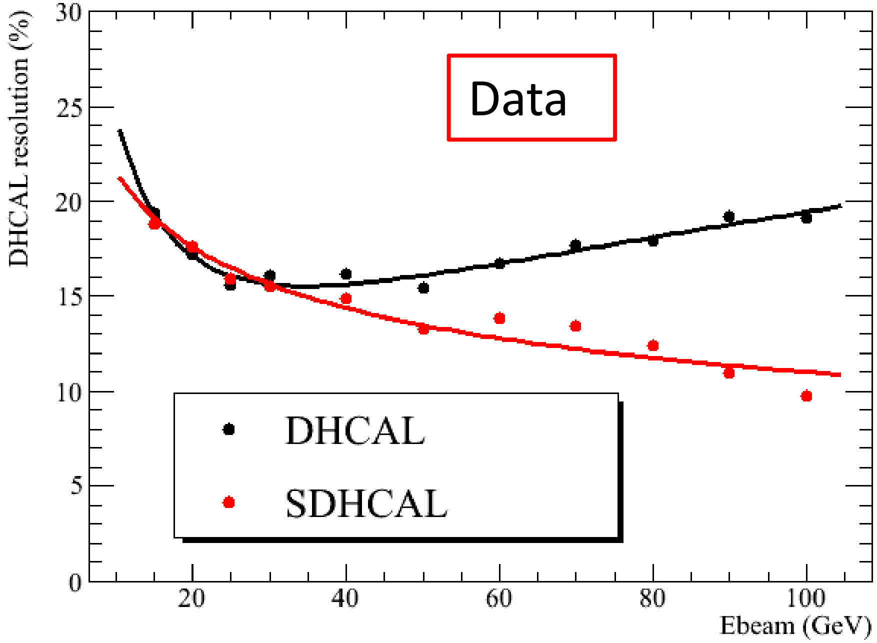
$$E_{rec}=A\cdot(N_0+B\cdot N_1+C\cdot N_2)$$

The two weights are computed using minuit and a Erec=Ebeam optimization.

The results are again not as continuous and logical as with MC.

Validation of the results with data 3/3

Then we use the combination of the two thresholds: 5 MIP and 15 MIP



The results seem to validate the MC results

In the low energies though the results are not optimal

… work in progress, to investigate

Conclusions

- R&D: 1 m^2 Micromegas chambers with a 1 cm^2 segmentation
- MC study of the saturation effects on resolution and linearity
  - Important improvement using an 15 MIP second threshold
  - Optimization of the analysis using three thresholds
- Validation of the study using August 2012 RPC TB data on going
- Future plans: progression on the offline analysis
  - MC: try a multi-variable analysis
  - Data: understand some non trivial effects (maybe new data in 2015?)