Monte Carlo study of a Micromegas ECAL

Max & Jean, October 3rd 2012

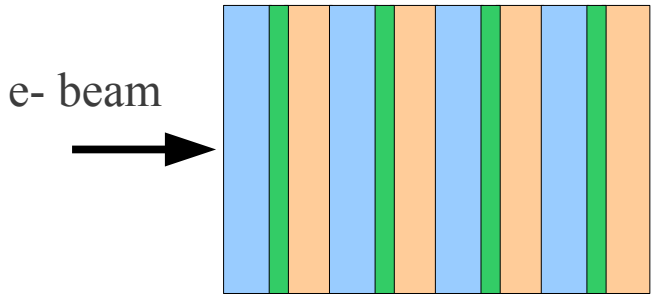
Simulation study

Geometry

Active: 2.5 mm Ar
Passive: 2.5 mm W + 1 mm of PCB
(PCB = epoxy + glass fiber + 10% Cu)

40 layers (40 x 0.6 = 24 cm)

Transverse area 40 x 40 cm^2



Readouts

Analogue: deposited energy

Digital:

- pad of 1 x 1 cm2;
- pad of 0.5 x 0.5 cm2;
- pad of 0.25 x 0.25 cm2;

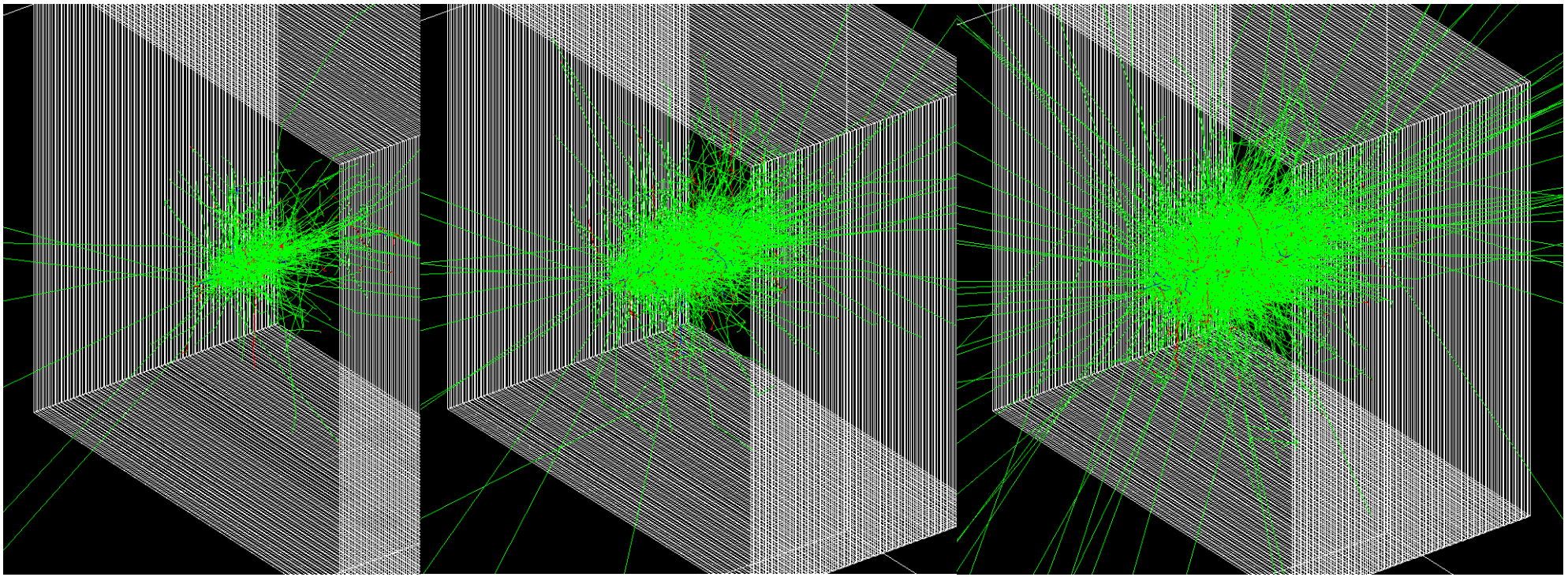
Data sets: 1000 events

Energy range
5-50 GeV, every 5 GeV

Magnetic field (perp. beam dir.)
0-5 Tesla, evergy 1 T

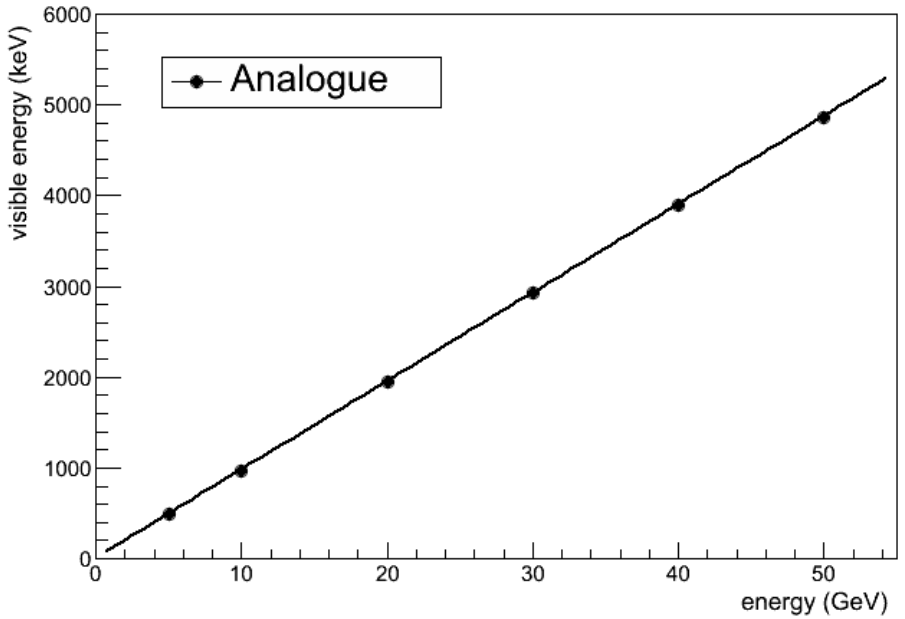
Energy cut = 15 eV
(ionisation potential of the gas)

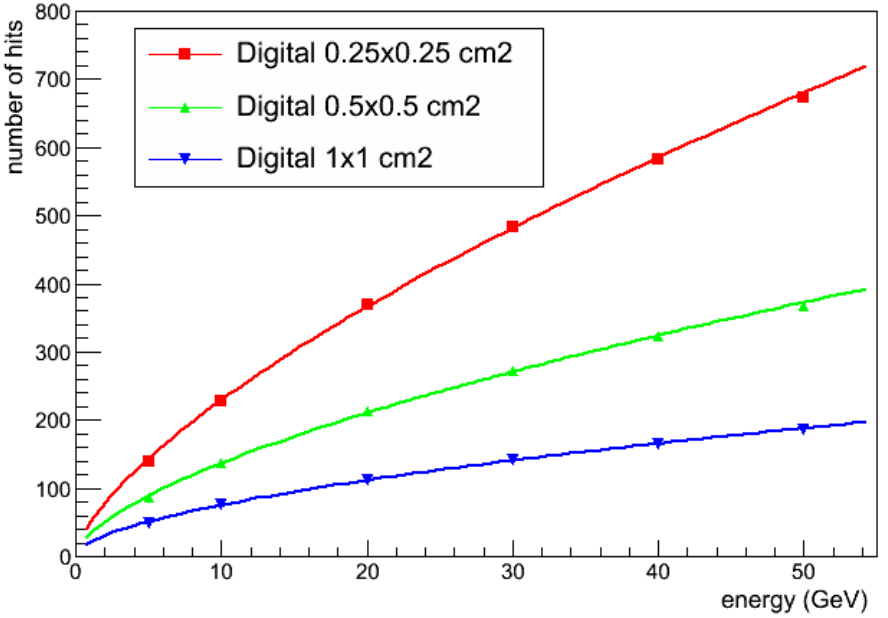
(MC) Event display



5 GeV 20 GeV 50 GeV

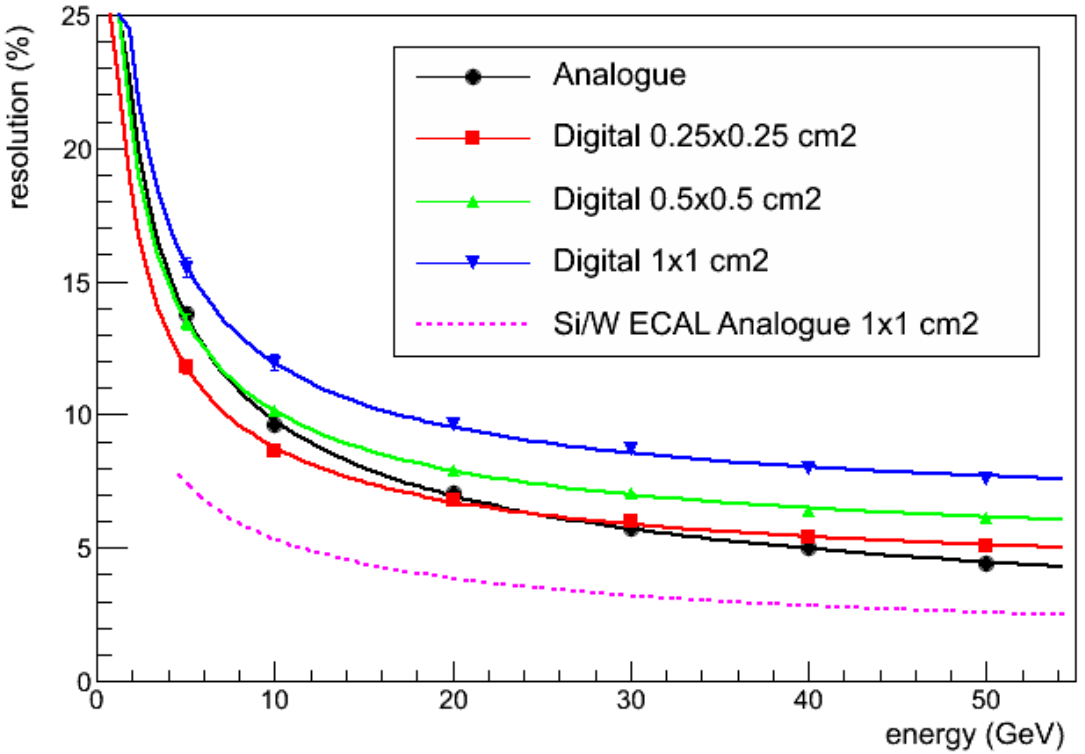
Response





Analogue readout shows best linearity
Pure digital non-linear → should improve with more than 1 threshold

Energy resolution



Energy :
a = 30.7064 +/- 0.548093
b = 1.04639 +/- 0.536468

Nb of Hits (0.25x0.25 cm2) :
a = 25.1382 +/- 0.550677
b = 3.67789 +/- 0.15581

Nb of Hits (0.5x0.5 cm2) :
a = 28.4607 +/- 0.654921
b = 4.67272 +/- 0.172049

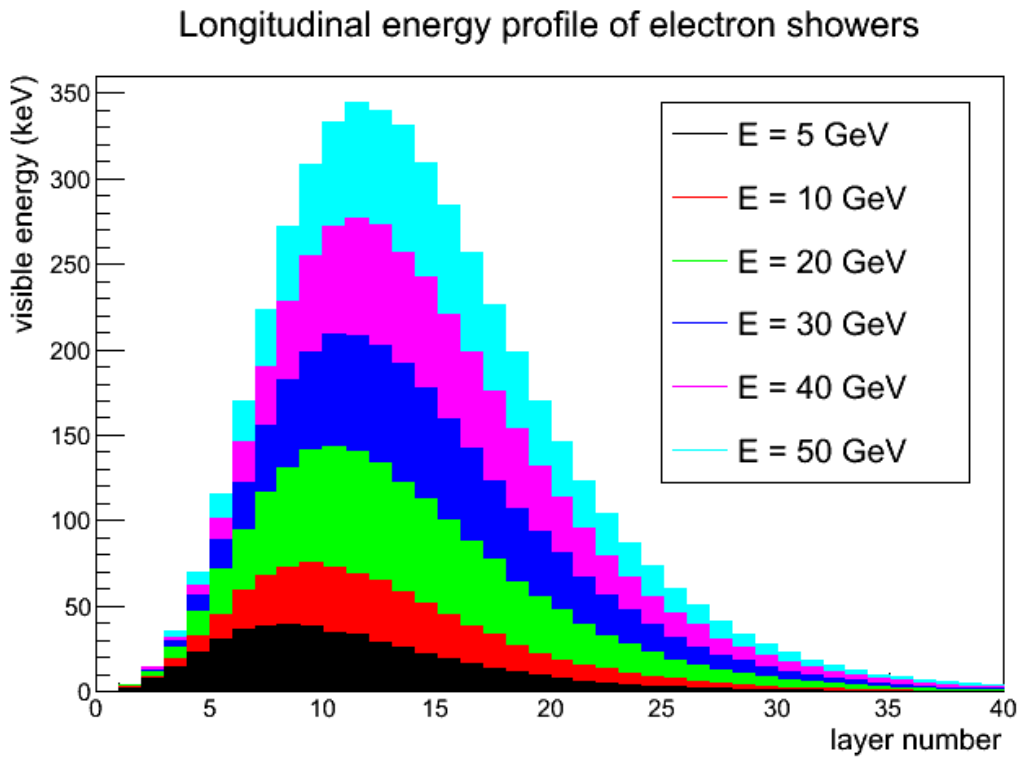
Nb of Hits (1x1 cm2) :
a = 32.2012 +/- 0.801101
b = 6.20984 +/- 0.191099

Analogue readout provides lowest constant term, comparable to Si/W ECAL
With a digital readout, the resolution improves with smaller pads

The stochastic term in the gas geometry is much larger than in the Si geometry
This is expected because the sampling is different

Si/W ECAL test beam yields: a = 16.5 % and b = 1.14

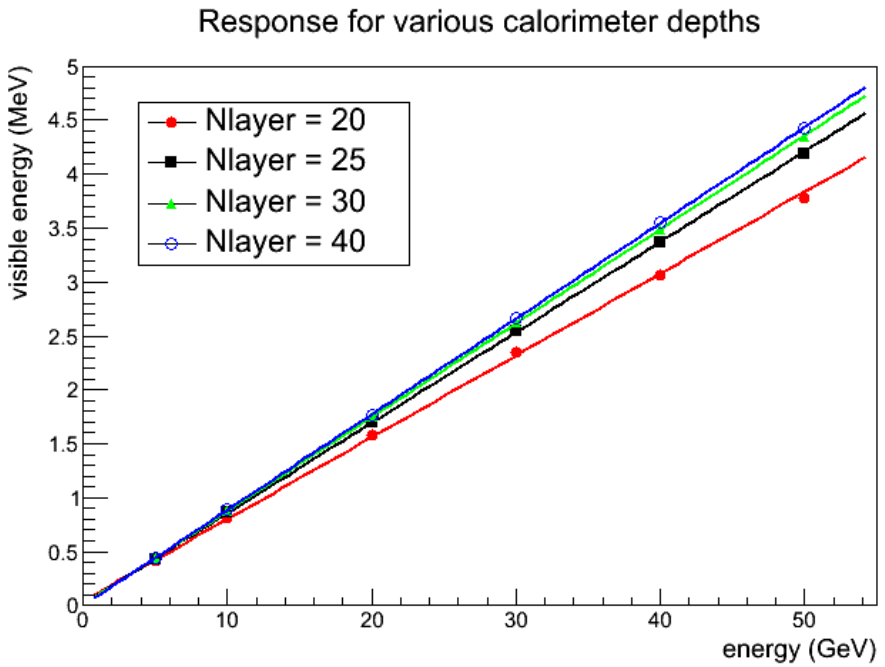
Longitudinal profile

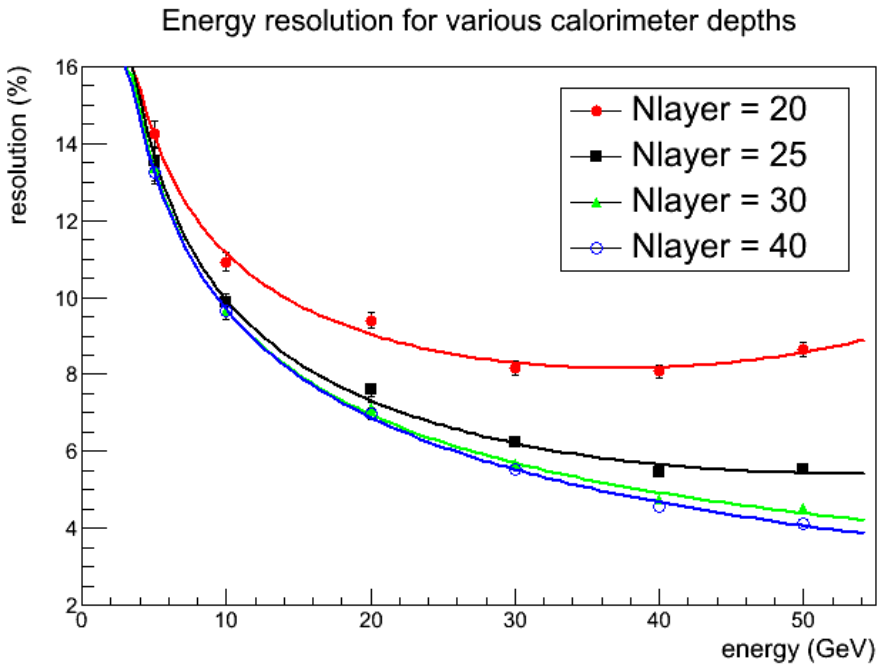


With 40 layers, negligible leakage up to 50 GeV
(higher energies to be simulated)

But 40 layers makes a thick ECAL (24 cm)
→ effect of smaller number of planes on response?

Number of layers

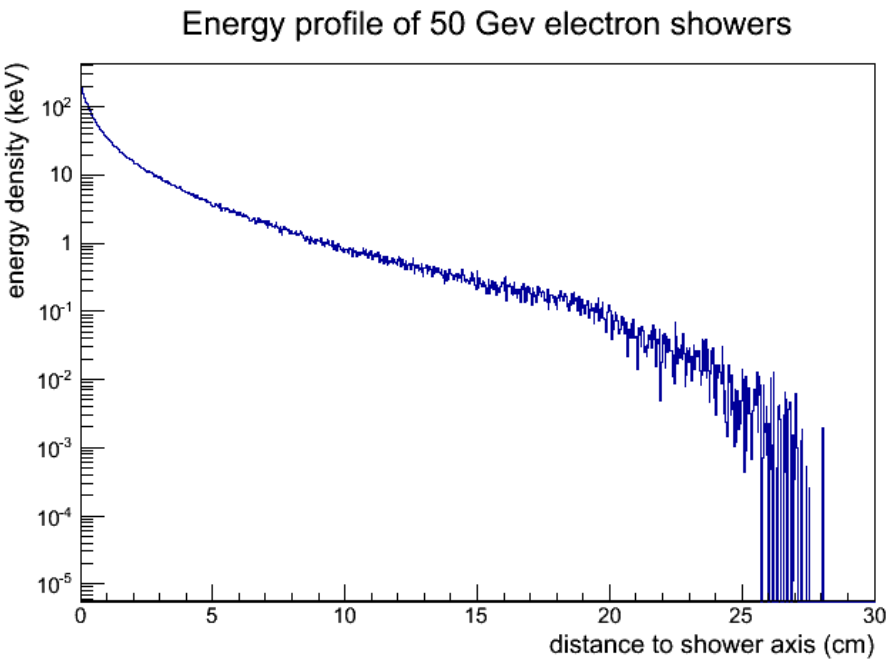


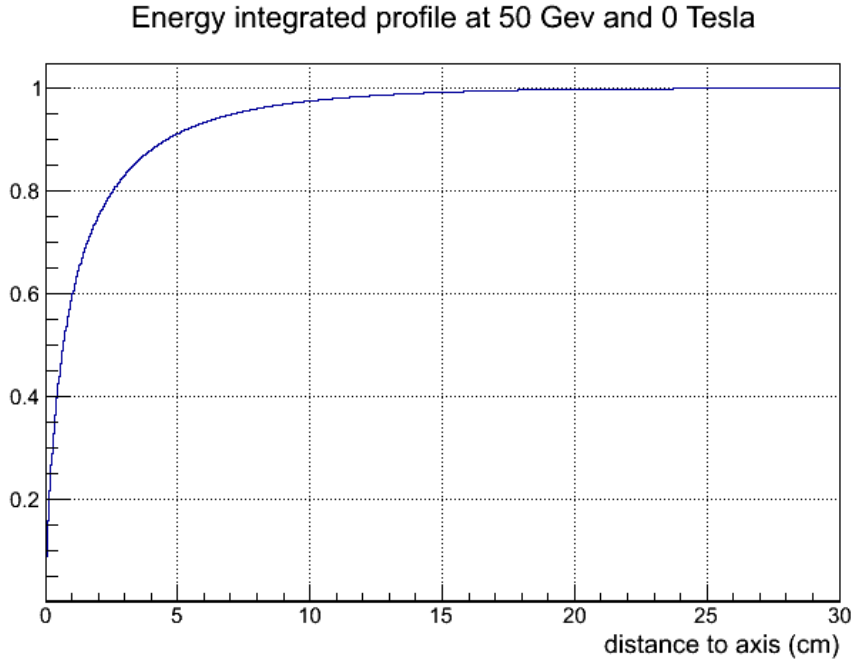


Less signal and more fluctuations due to increased leakage.

Above 30 layers, the resolution is almost independent on the number of layer up to 50 GeV.
(Reminder: leakage correction may be applied)

Radial distribution





From right plot, the Moliere radius (90%) is 4.5 cm.
Quite larger than in W only (0.8 cm)
But can be reduced by increasing the offline threshold.

Possible R&D in 2013

Design : Re-use actual PCB design as much as possible → ASU

With a radius of 8 cm, the lateral energy containment is 98%
→ ASU of 16x16 cm2

Baseline cell size for ECAL is 5 mm
→ 16x16x4 = 1024 channels → 16 ASIC → How many chips are left from 2012?

Space constrains on PCB:
16 ASIC over 256 cm2 → 4x4 cm2 / ASIC → Reduce package size
Any room left for passive protections? → resistive layer?

Open questions:
Where to get the W? → start to collaborate with CERN/CLIC group?
What gap size? 3? 2? 1?

Prototypes and tests

Limited funds → at least 2 ASUs
Linearity from longitudinal profiles @ DESY (electron beam up to 5 GeV)
Effect of the gas mixture (Z) on linearity (He, Ne, Ar)
Digital and analogue readout