Validation studies of the Micromegas quadruplet prototype for the ATLAS upgrade

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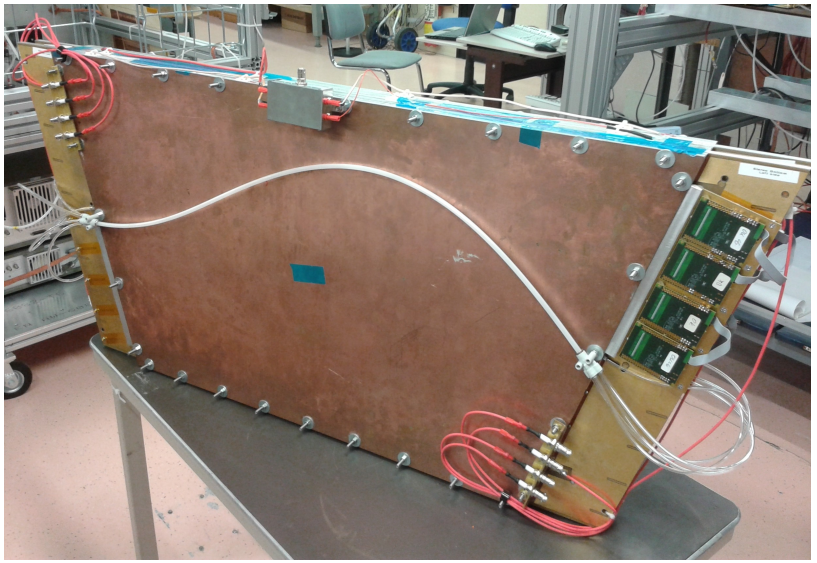
Outline

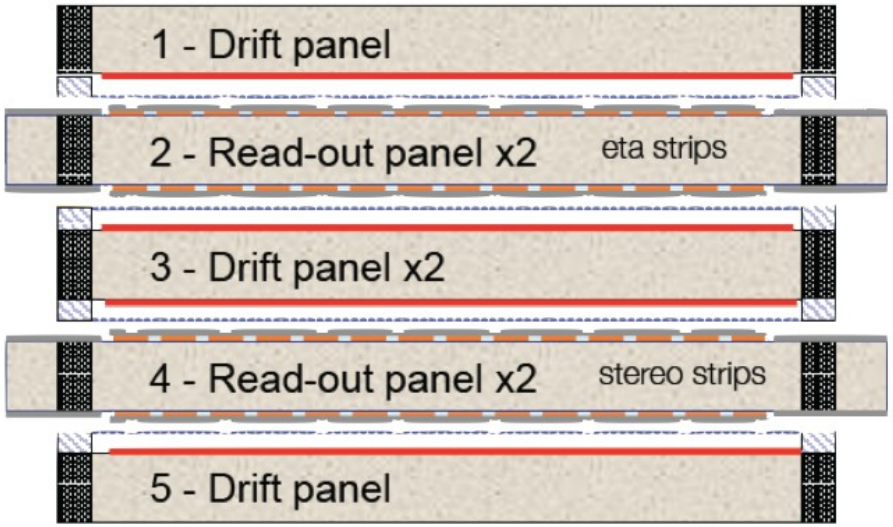
- Introduction
- Efficiency Scan - Stability
- Gain uniformity measured with Cosmics and X-Rays
- Conclusions

MicroMegas Small Wheel (MMSW) prototype

Quadruplet detector with active area ~0.5m^2 per plane, following the general design foreseen for the ATLAS New Small Wheel upgrade project (Common project between CERN, University of Mainz and Kobe)

- 4 readout layers arranged in two doublets back-to-back
  - 2 x horizontal strips
  - 2 x stereo strips inclined by ±1.5°
- 1024 strips per readout layer, strip pitch 415 μm
- Readout strips covered with 50μm thick Kapton foil and sputtered resistive strips with a surface resistivity of 1MΩ/sq

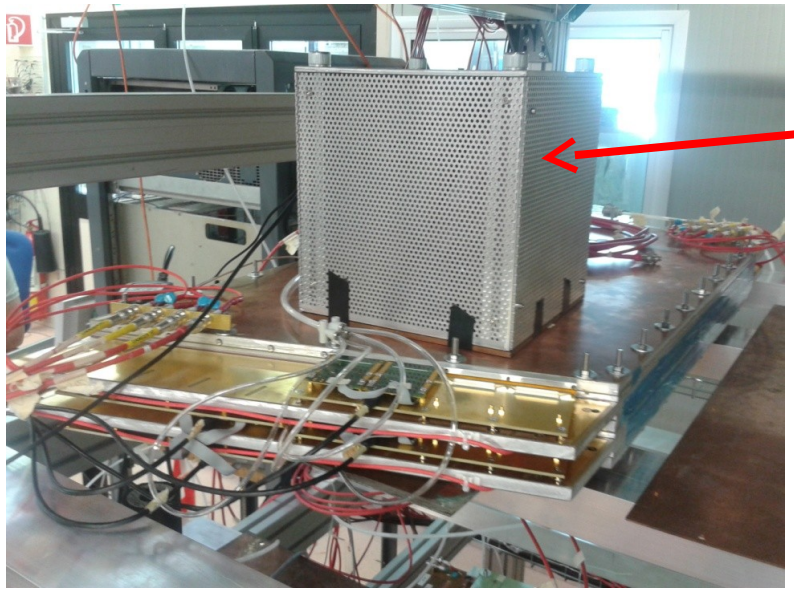




Description of the setup in the GDD lab

Cosmic measurements:

- 12 plastic scintillators per plane, 2m apart, active area ~2.5 x 1.1 m^2 (8 used for data taking)
- Cosmic rate ~18Hz
- SRS system: 2 FECs fully equipped with 32 APVs + mmDAQ



X-Ray measurements:

Mini-X Silver (Ag) gun

- HV up to 50kV

- Beam intensity up to 80μA

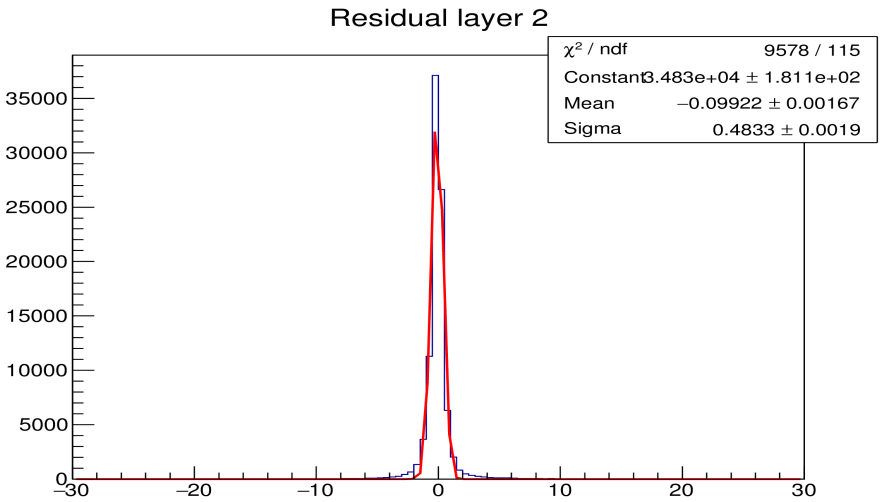
Gas mixture: Ar:CO_2 93:7

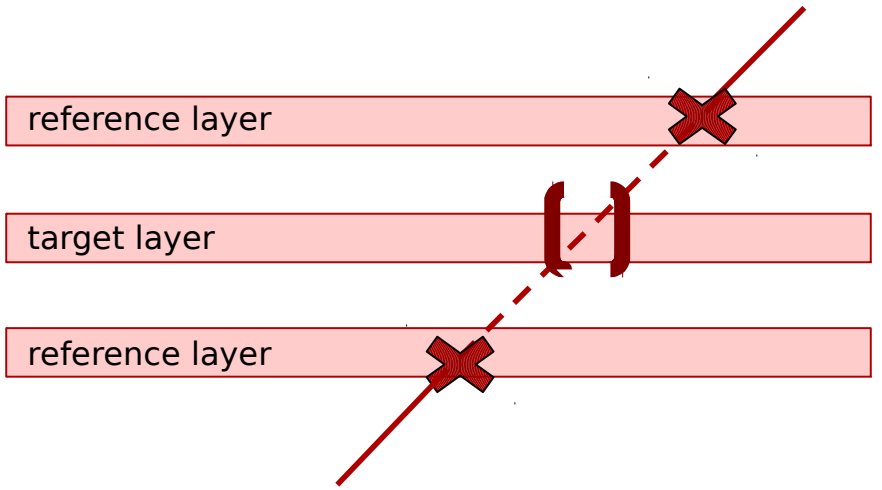
Efficiency Scan

- Cosmic data
- Scan at different Voltages the target layer, from 500V to 600V. All the other layers at 580V (reference layers)
- Reconstruct tracks without using an external tracking system

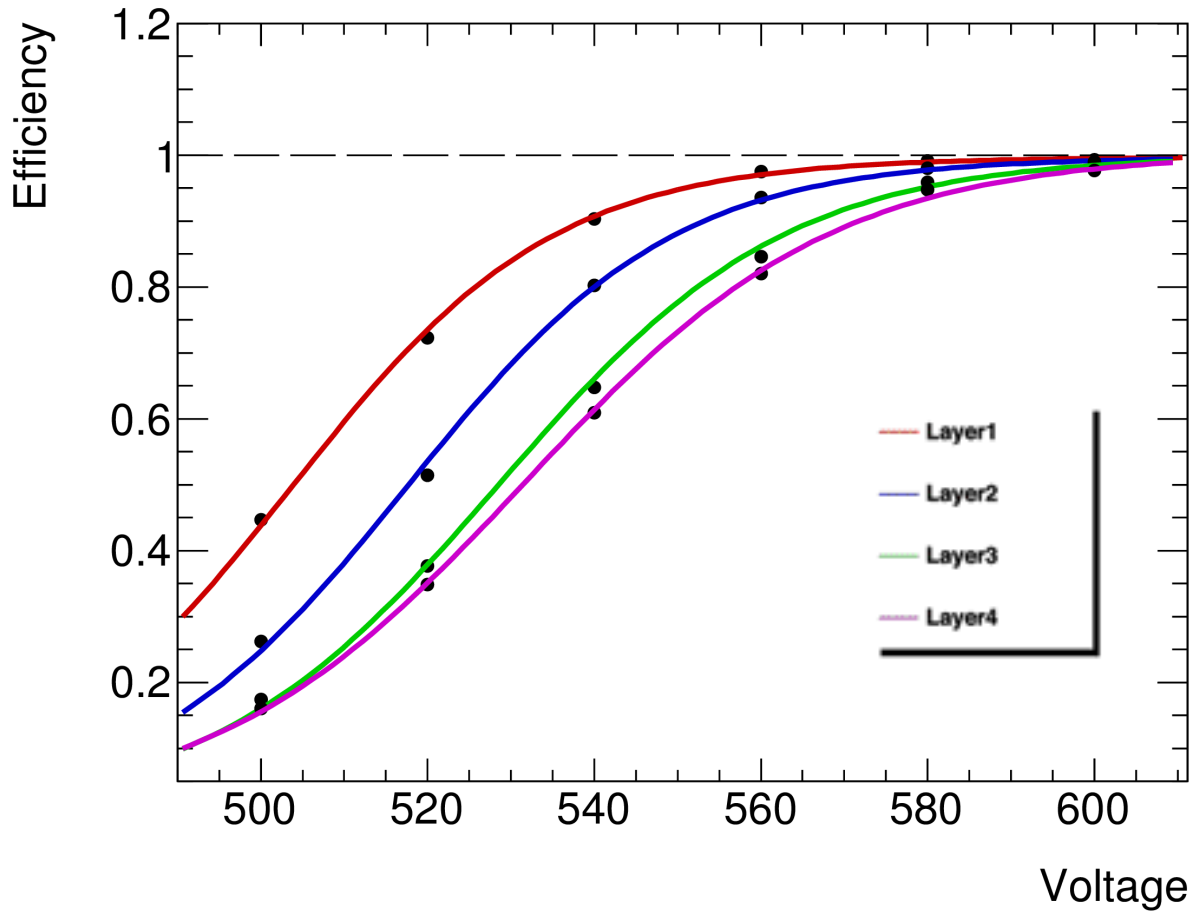
Algorithm

- Reconstruction of tracks in the reference layers.
  - 2 layers needed to reconstruct X coordinate, at least 1 stereo
- Extrapolation or interpolation to the target layer. If cluster is found in this layer in a defined acceptance window, the layer is considered to be efficient.
  - The acceptance window is calculated by the residuals from the expected and the measured positions





Efficiency Scan



Fermi-Dirac function:

$$y = \frac{A}{1+e^{(x-B)/C}}$$

A = the plateau value of the efficiency

B = the flex point

C = how steep is the turn-on curve.

Layer 1

χ^2 / ndf	59.84 / 3
0	0.9972 ± 0.0005592
1	503.8 ± 0.1965
2	15.65 ± 0.1604

Layer 2

χ^2 / ndf	75.75 / 3
0	0.9972 ± 0.0007443
1	517.6 ± 0.1502
2	15.96 ± 0.1296

Layer 3

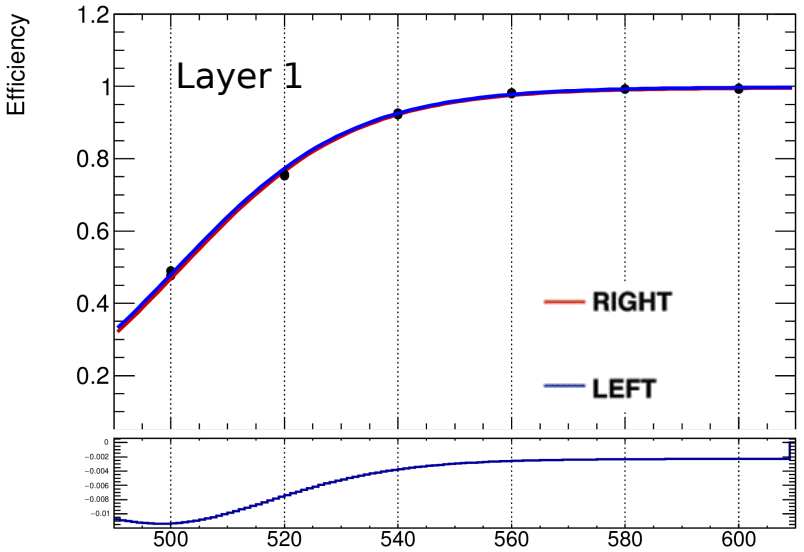
χ^2 / ndf	144.7 / 3
0	0.9999 ± 5.097e−05
1	528.5 ± 0.1531
2	17.21 ± 0.09755

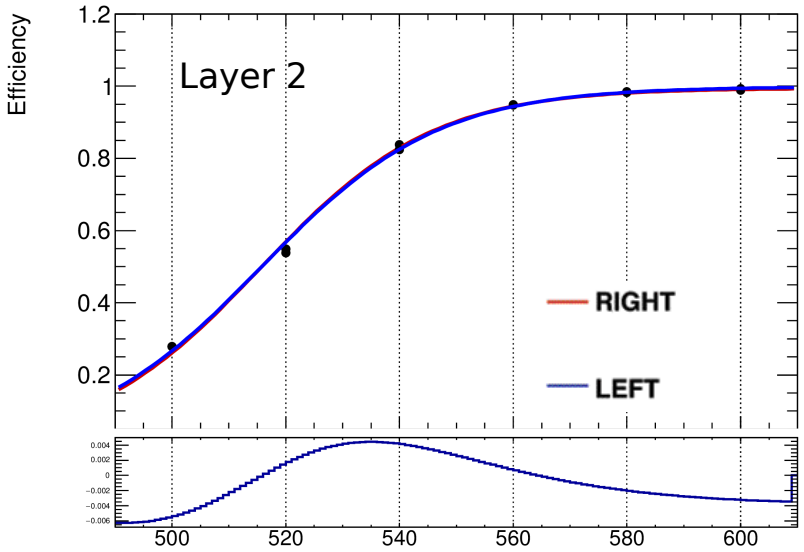
Layer 4

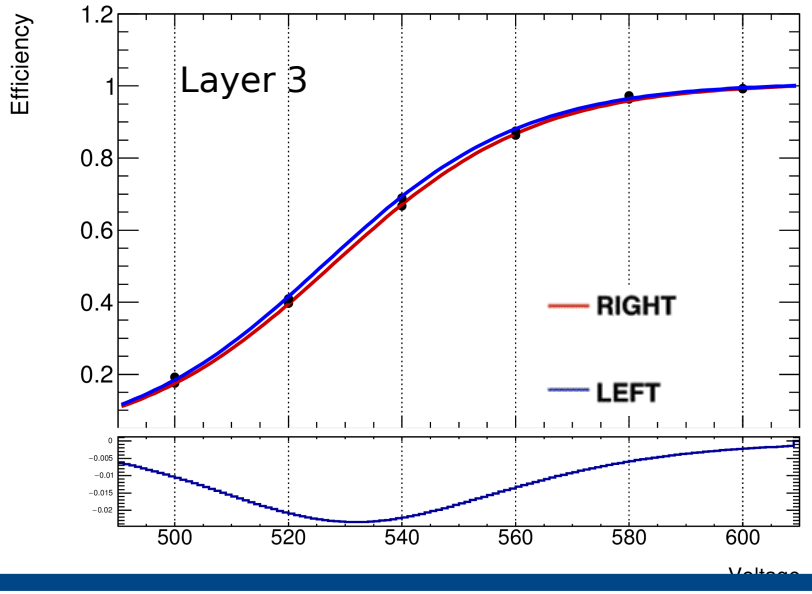
χ^2 / ndf	53.24 / 3
0	0.9999 ± 0.0003154
1	531.3 ± 0.1525
2	18.34 ± 0.1121

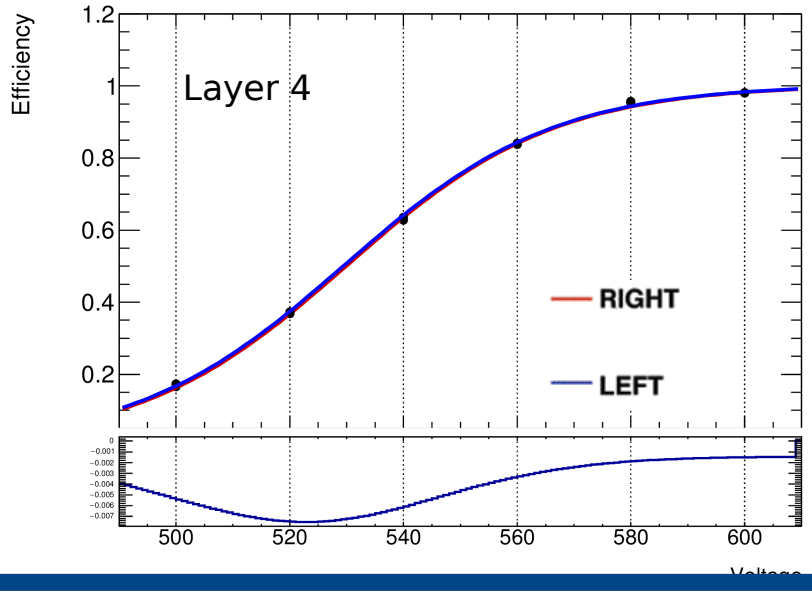
Efficiency Scan per HV sector

- Each readout layer has two independent HV lines (Right and Left)



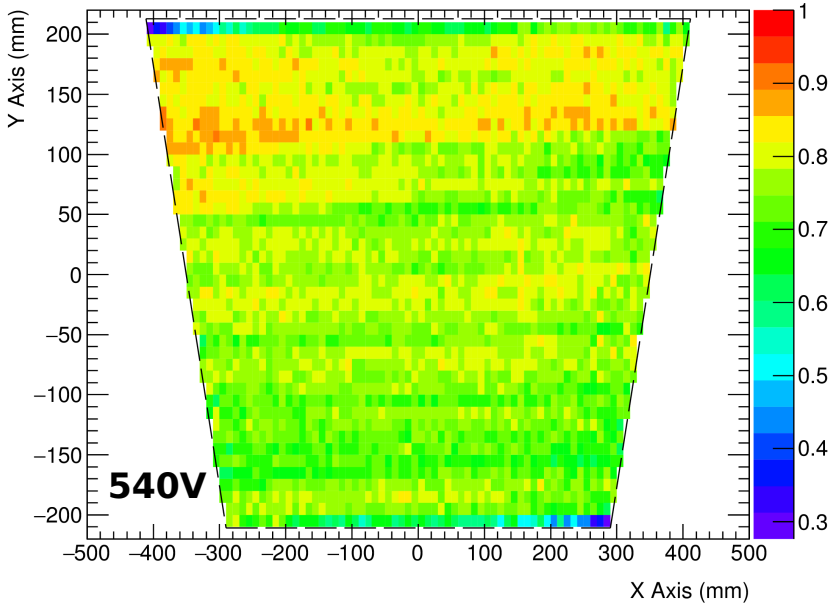


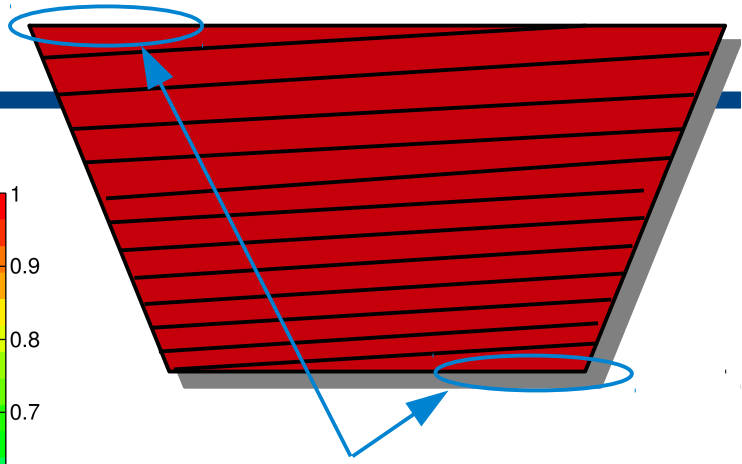




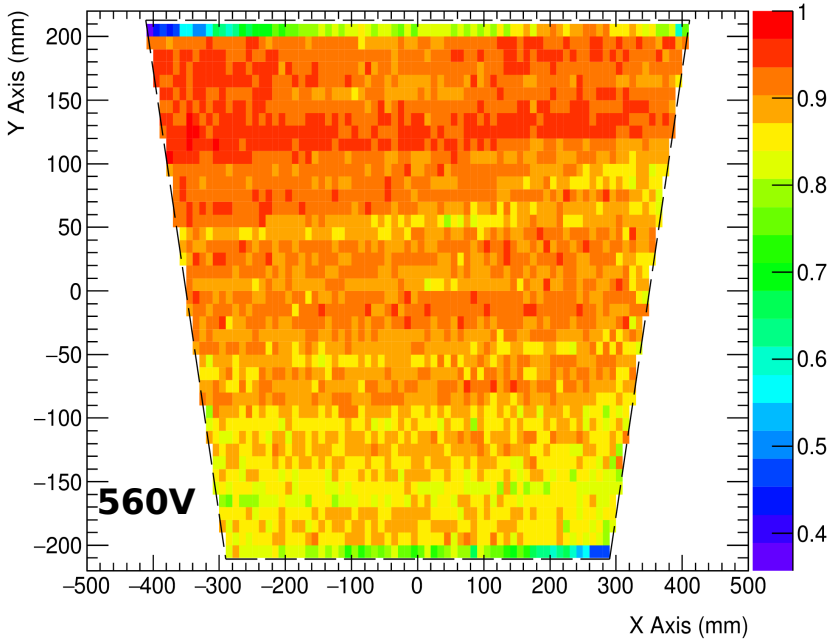
2D Map Efficiency

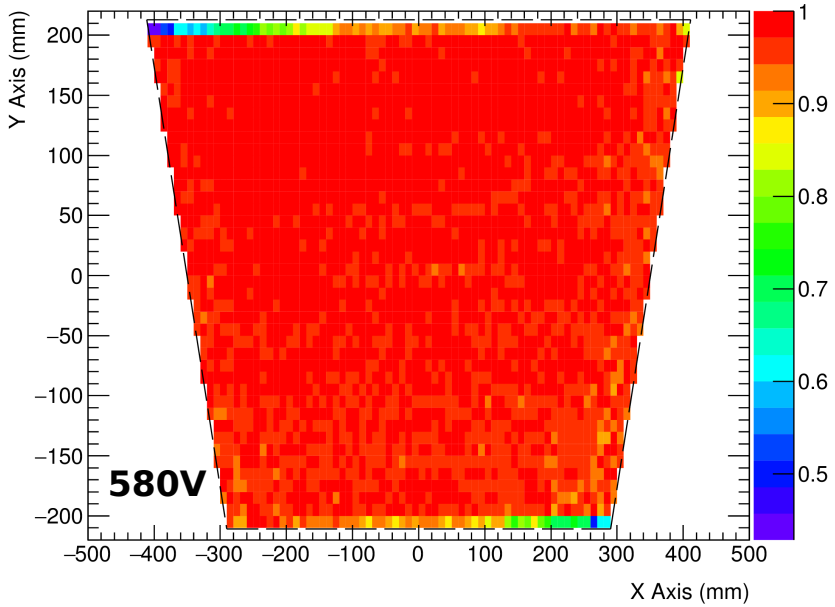
2D efficiency map of Layer 4
in different voltages





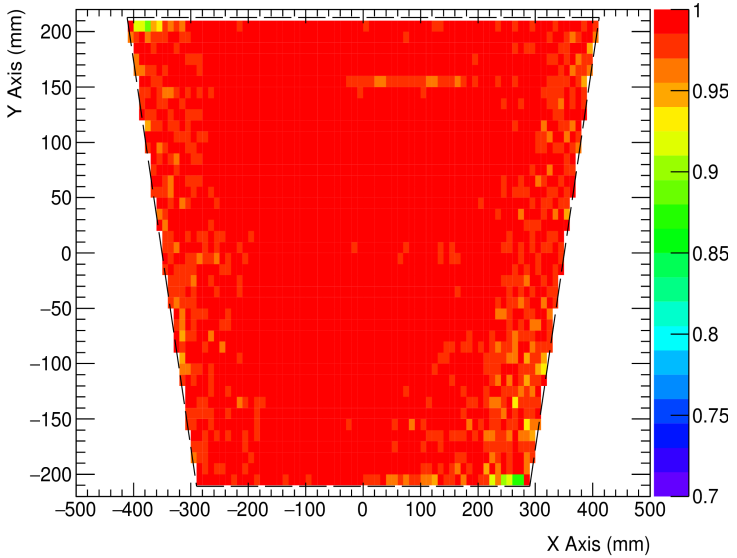
no readout strips in these areas by construction



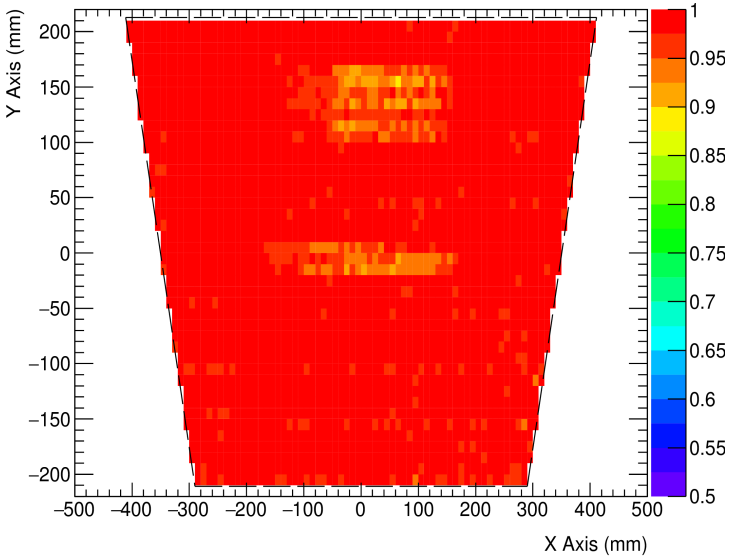


2D Map Efficiency – All Layers at 580V

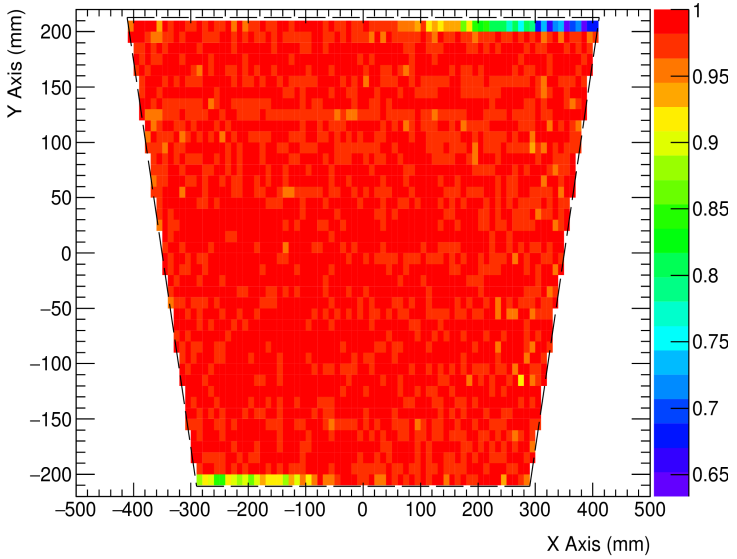
Layer 1



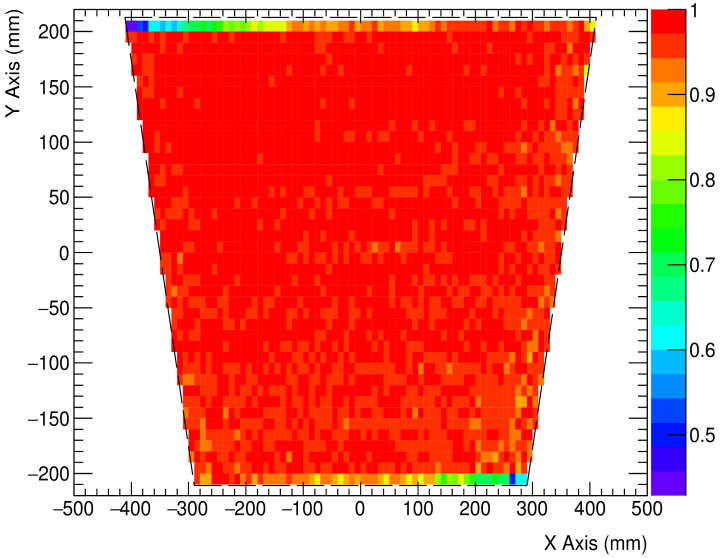
Layer 2



Layer 3

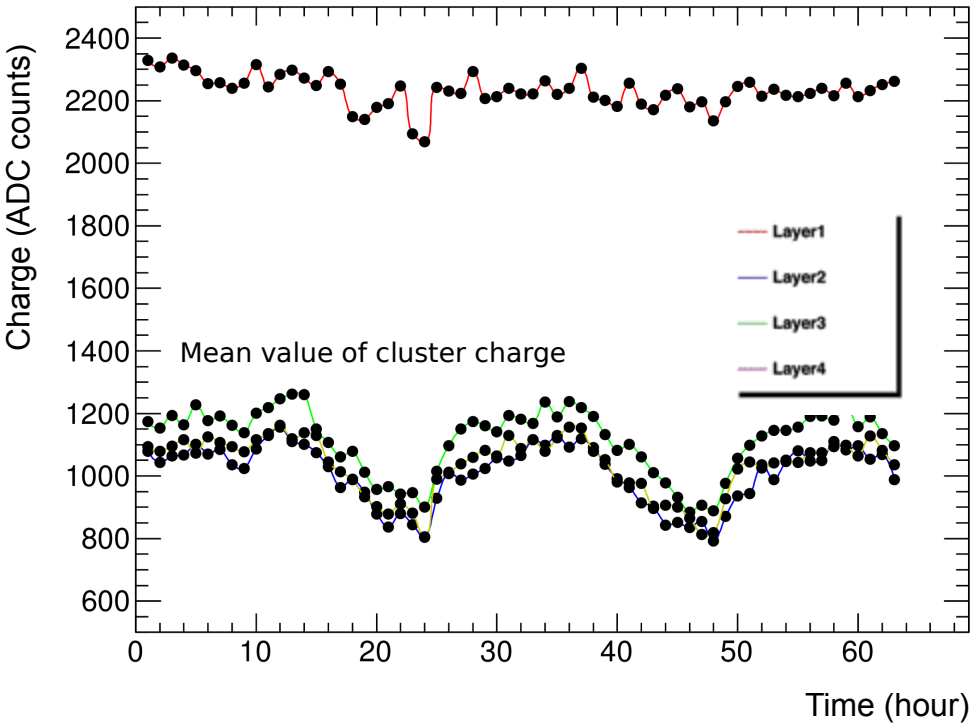


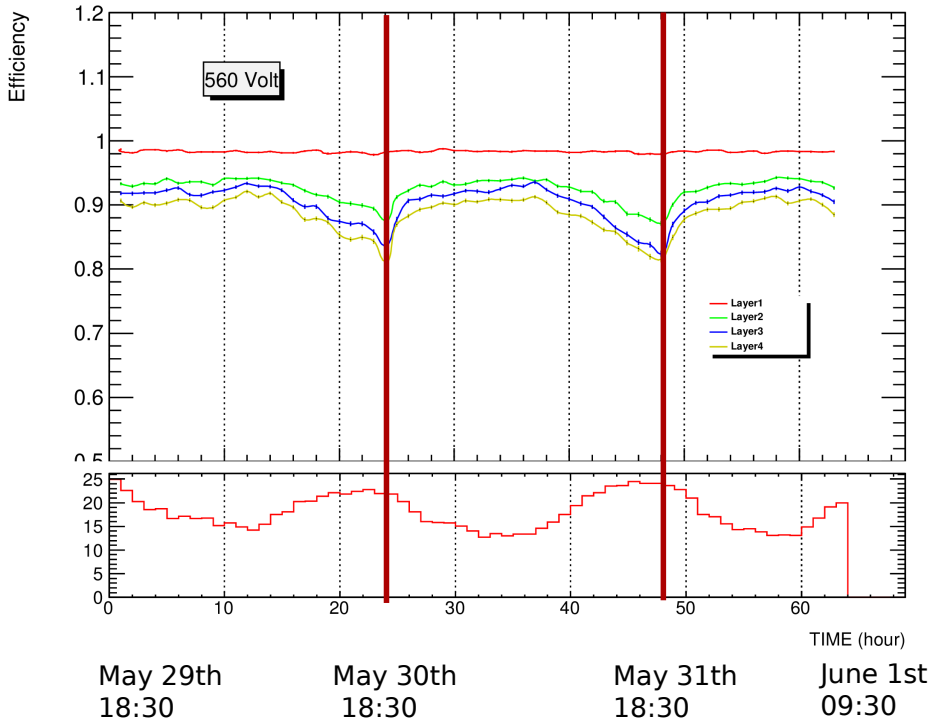
Layer 4



Efficiency Stability – Preliminary results

- For this kind of studies the HV must be less than the "good" working point. → All layers at 560V
  - Layer 1 at 560V is already at the plateau region
- Drop of the efficiency on Saturday and Sunday ~ 18:30
- Cluster charge mean values follow the same trend
- Possible correlation with the outdoor temperature ? (gas bottle located outside the lab)



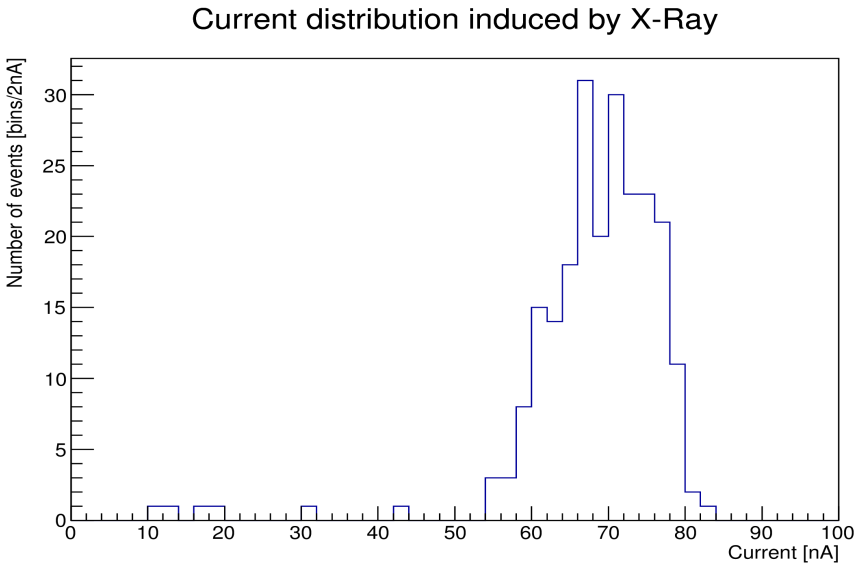


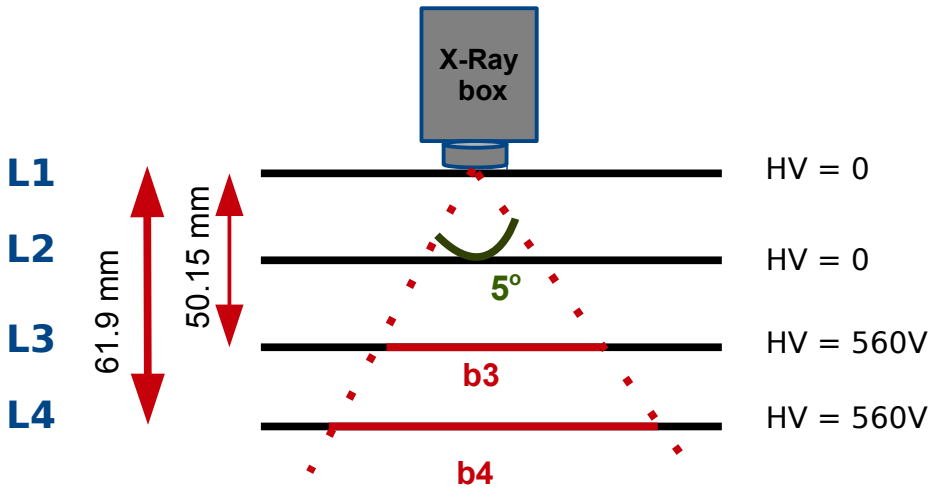
Further studies are foreseen:

- Run with gas supply at constant temperature

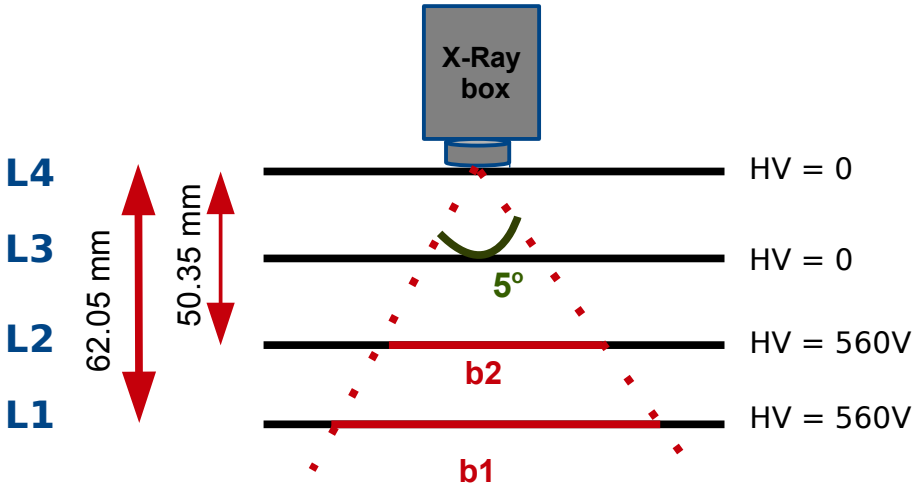
Gain uniformity measurements with X-Rays

- Monitor of the amplification current
- X-Ray settings: HV=50kV, I=50μA, 2mm collimator (cone angle of 5°)
- 228 different points in two set of measurements
- Layers under study set to 560V while upper layers were turned off



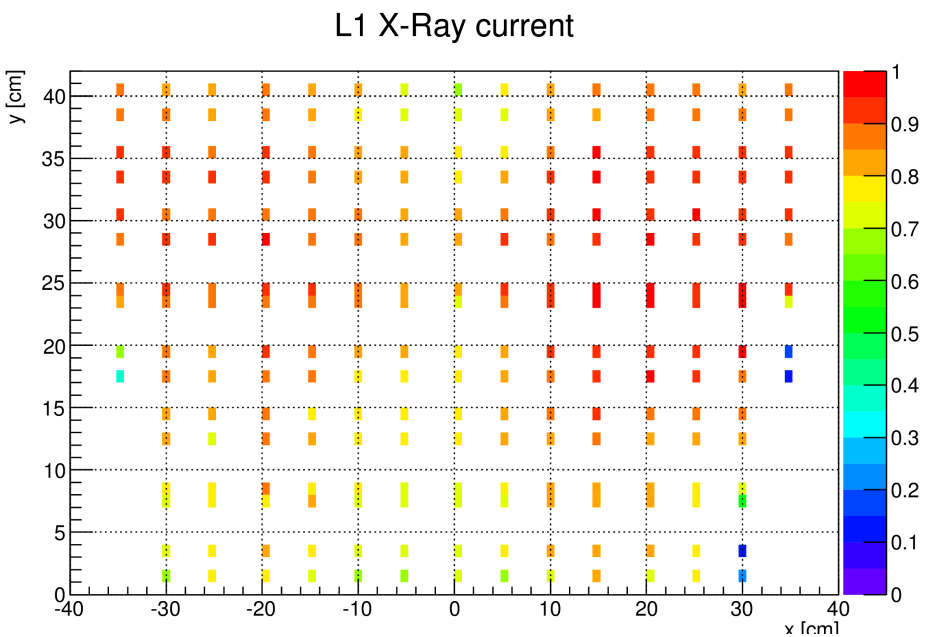


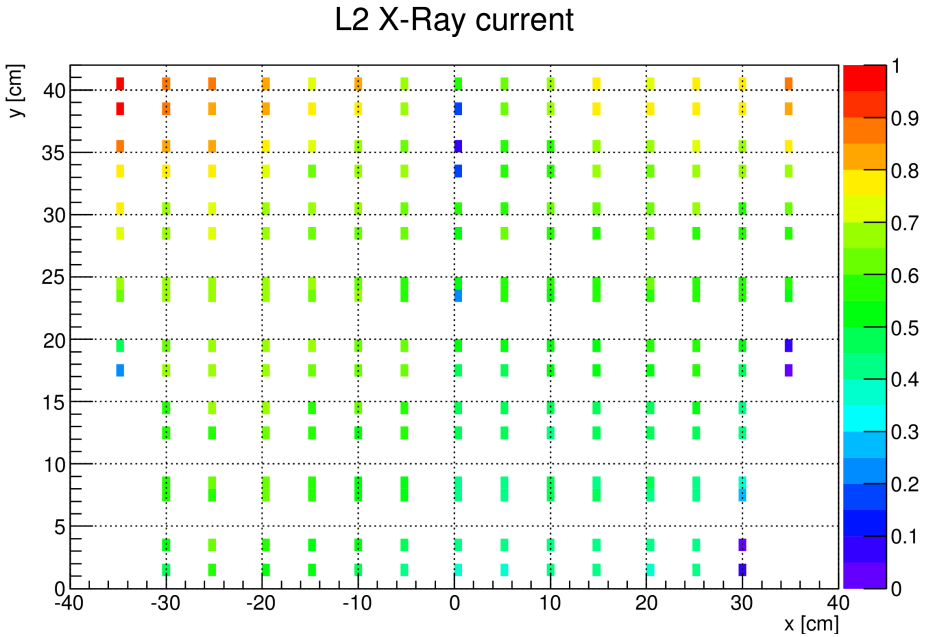
b3 = 2.189 mm (~ 10 strips)
b4 = 2.703 mm (~ 12 strips)

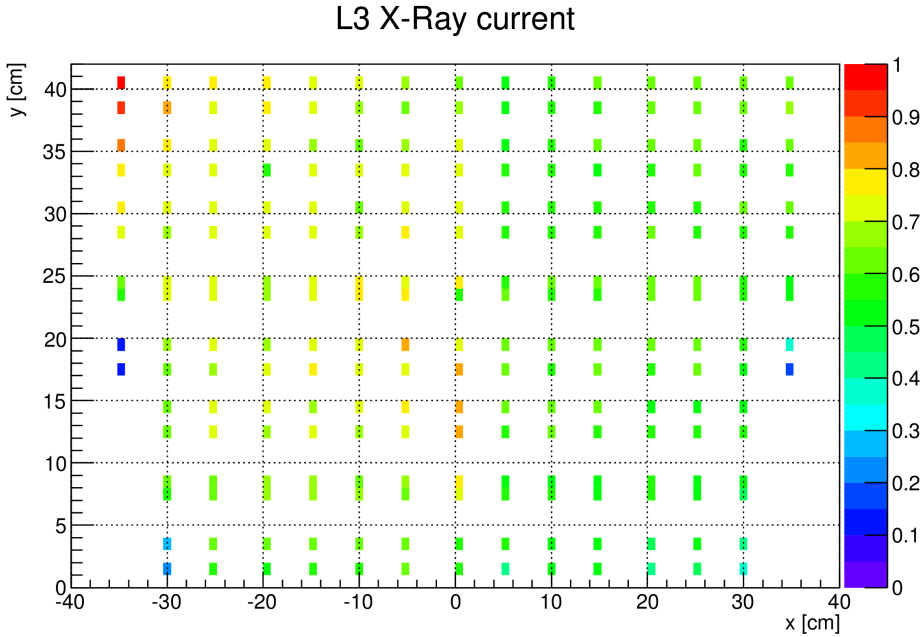


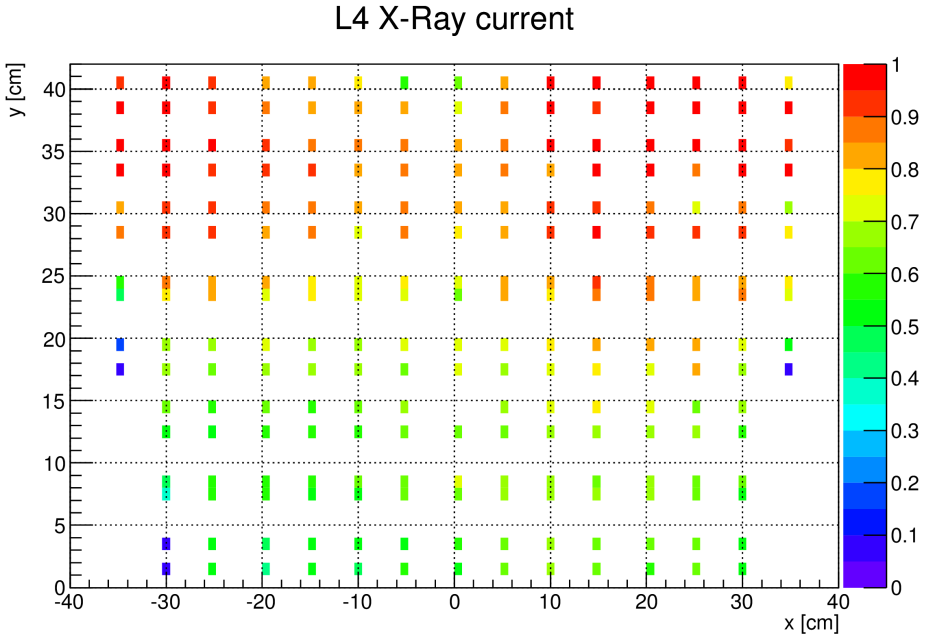
b2 = 2.198 mm (~ 10 strips)
b1 = 2.709 mm (~ 12 strips)

Gain uniformity measured with X-Rays





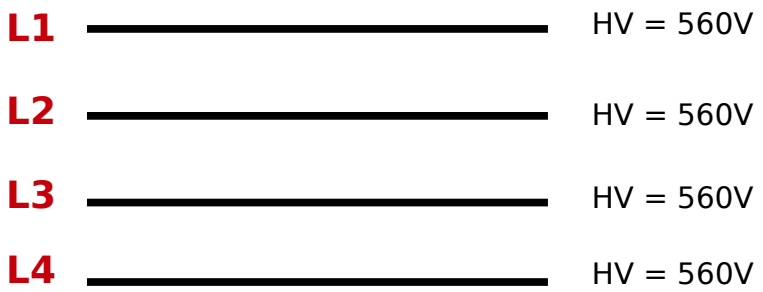


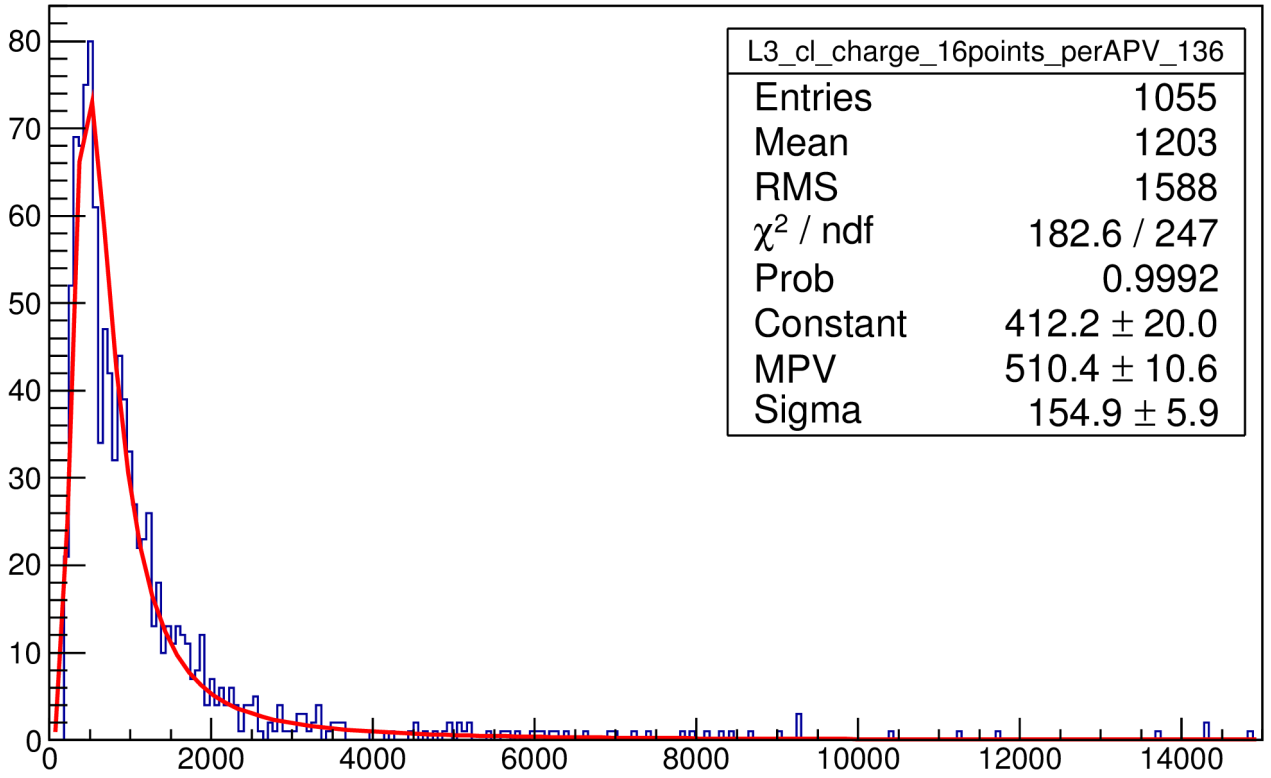


Current normalized to the higher value of each layer in order to be compared with the cosmic data

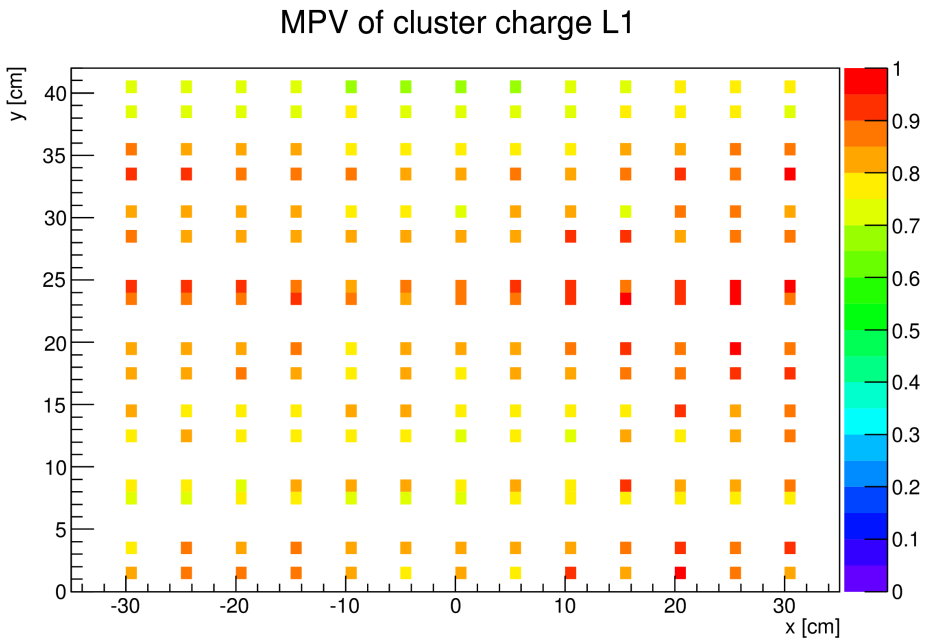
Gain uniformity measured with Cosmics

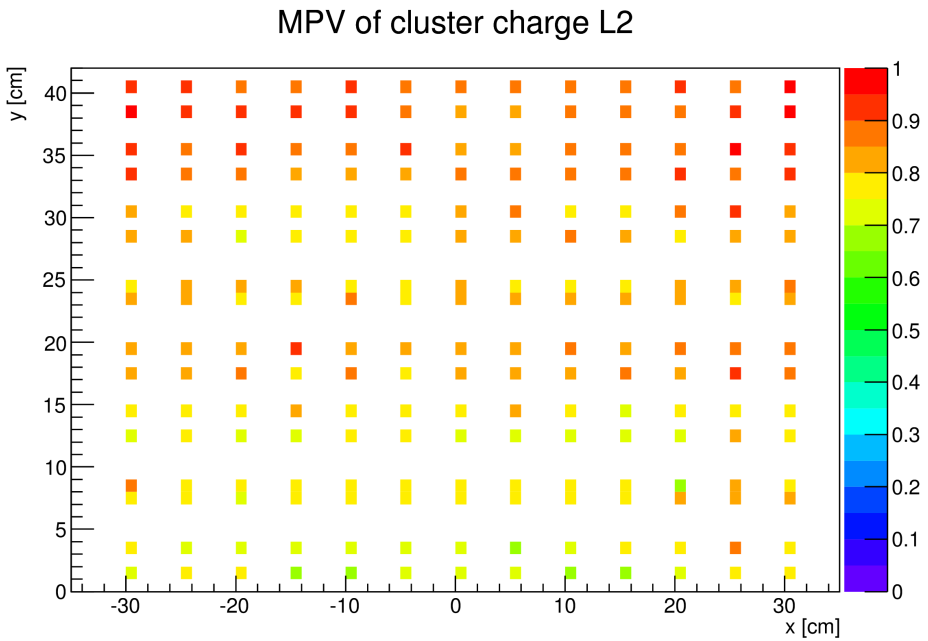
- All layers at 560V, Layer 1 on top
- To produce the same 2D map as with the X-rays a window of 20 strips around each (x,y) point was opened in order to increase the statistics
- For each (x,y) point the cluster charge was collected and fitted with a landau. The MPV was extracted and plotted to the corresponding position.

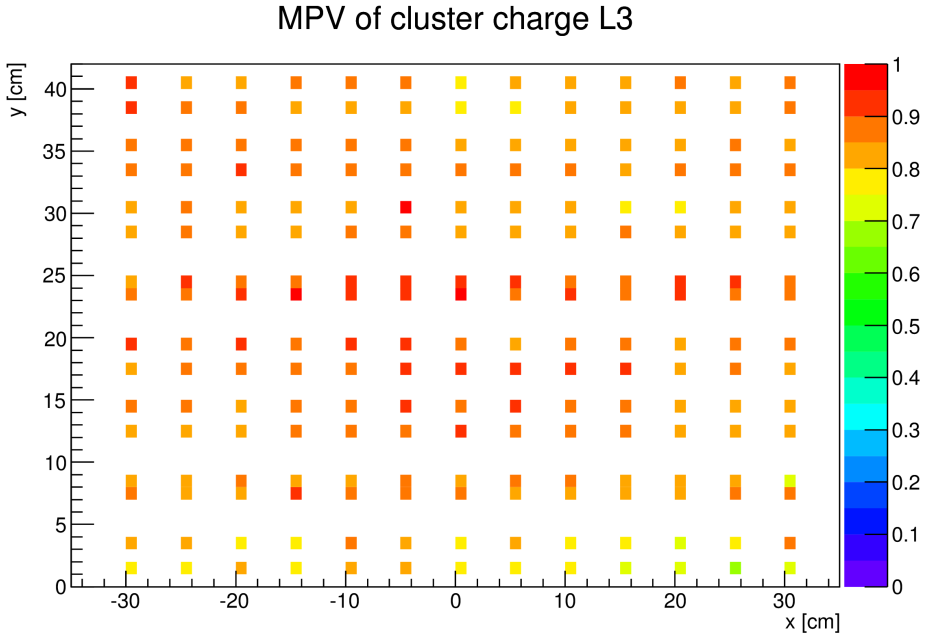


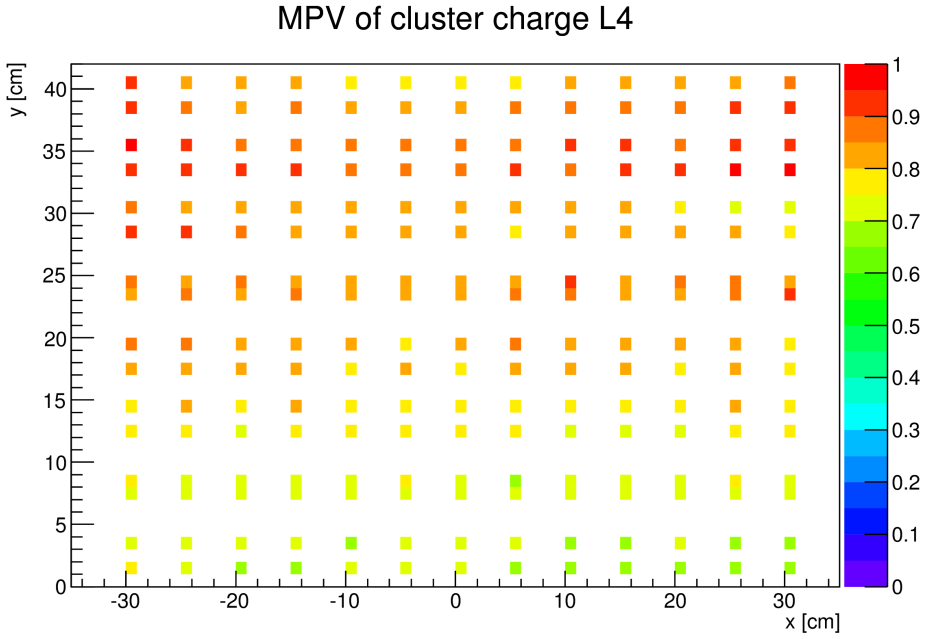


Gain uniformity measured with Cosmics



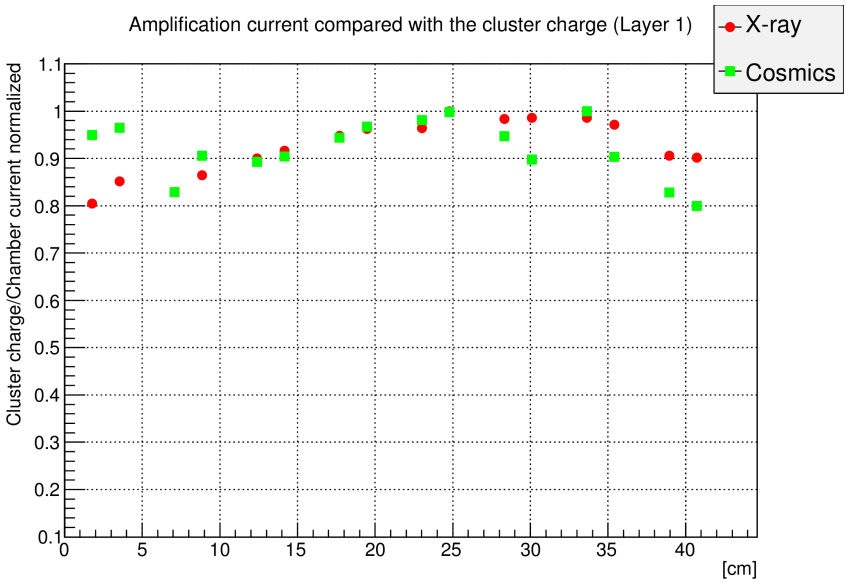


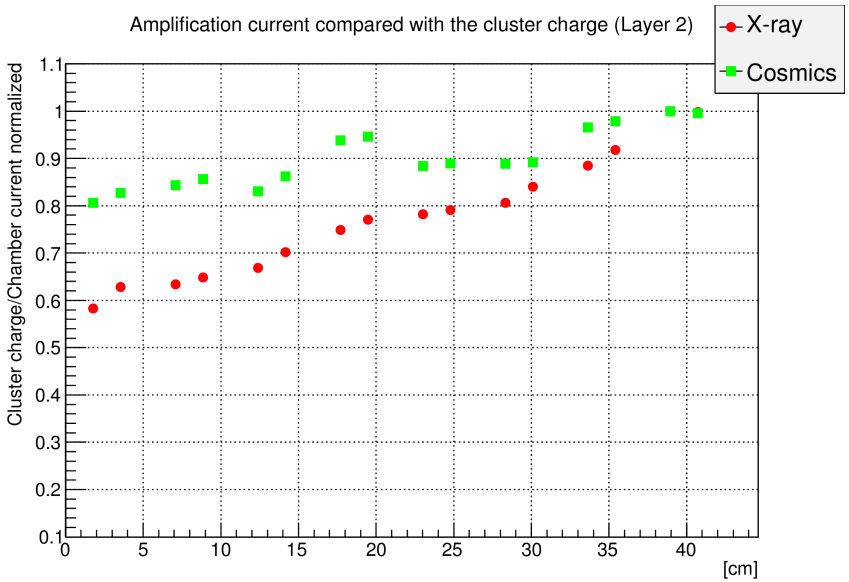


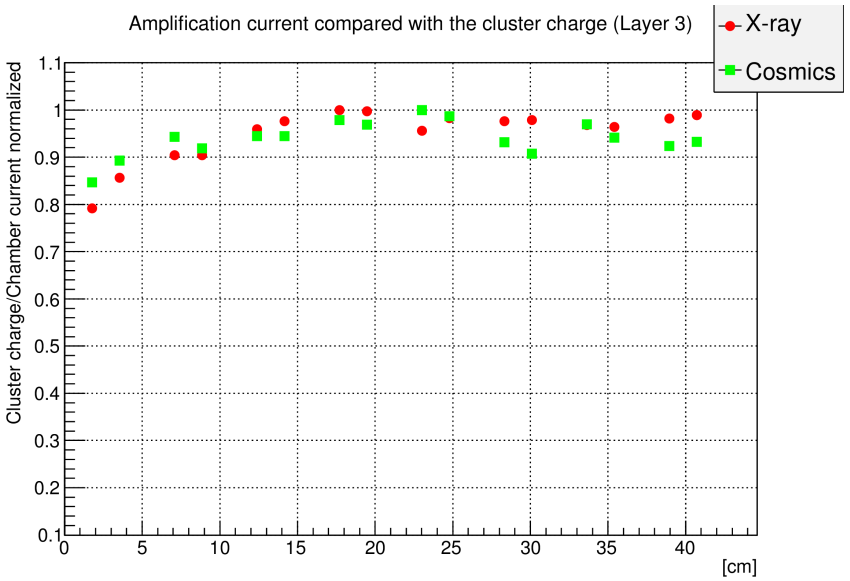


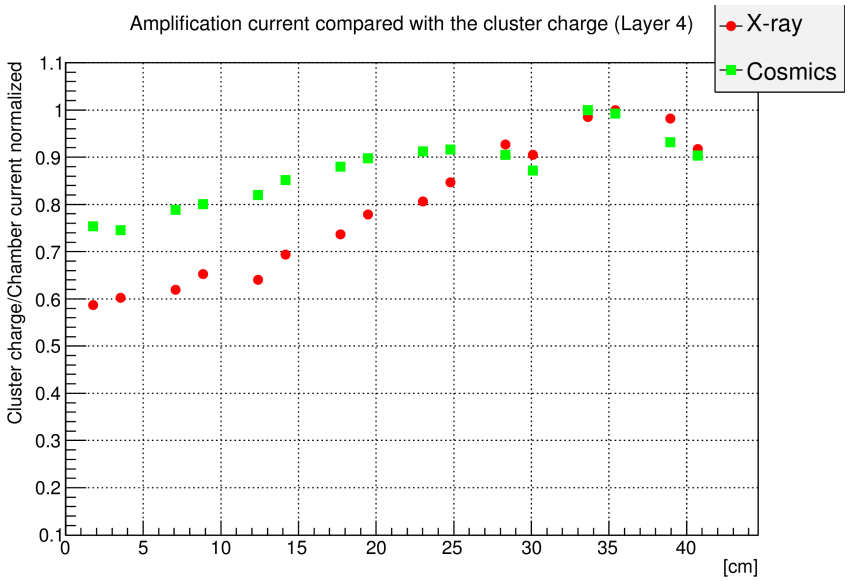
Comparison between X-Ray and Cosmic measurements

- In order to compare the amplification current measured with the X-Rays and the MVP of the cluster charge, the average of each y measurement was taken



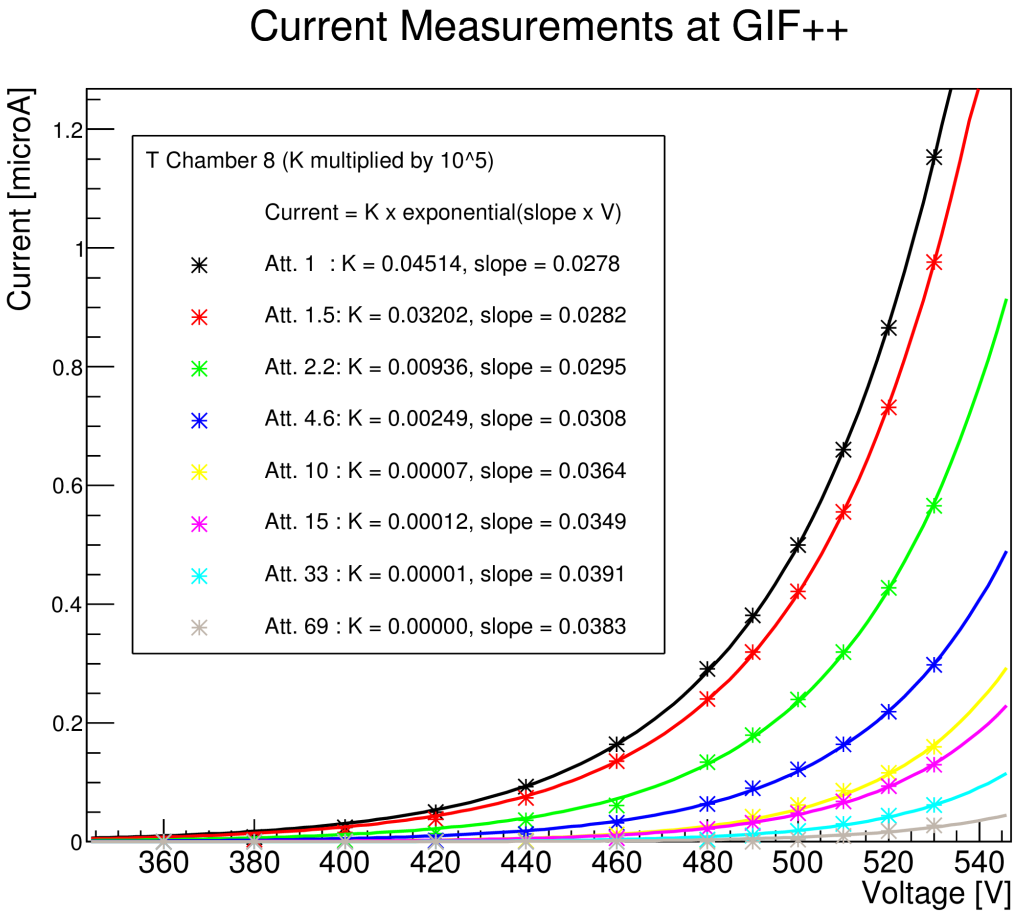






GIF++ plans

- To finalize the qualification of the chamber, long term aging studies are foreseen
- In few weeks the chamber will be installed in GIF++ to study its behavior under high rate irradiation
- The setup is ready and everything is in place
- Since 1 month now, we take data with 2 bulk Micromegas chambers to exercise the validation procedure



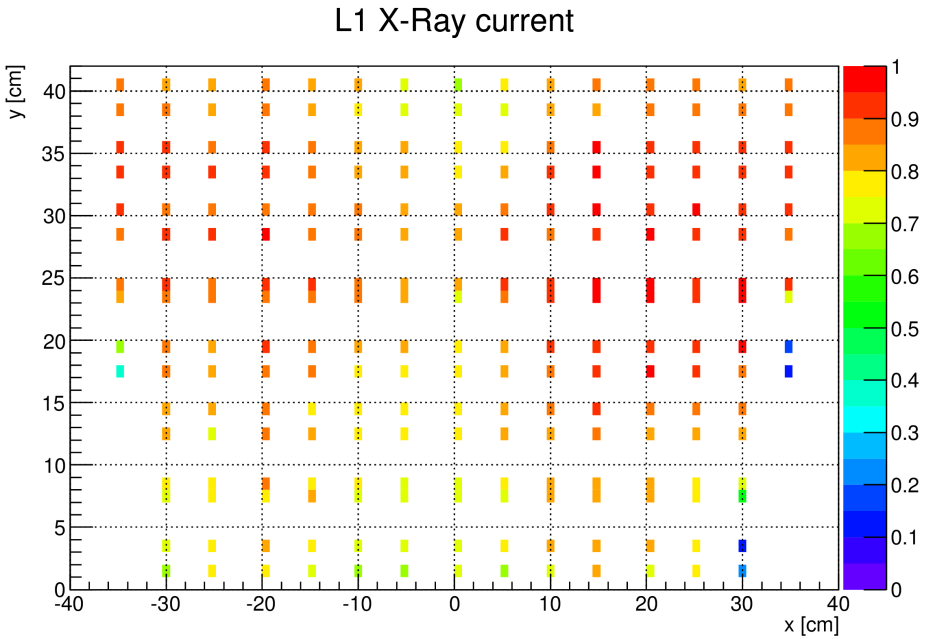
Conclusions

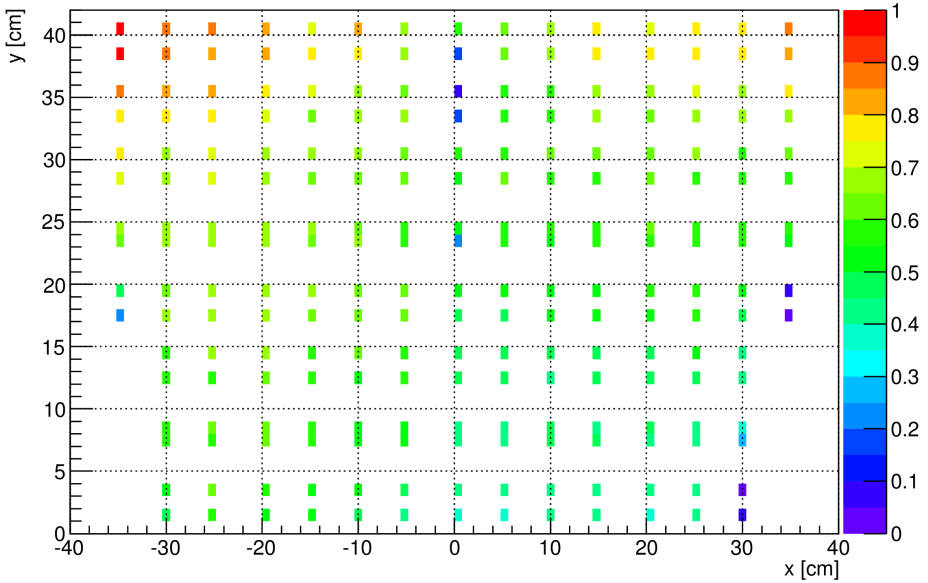
- Systematic studies of the efficiency and the gain homogeneity of the MMSW quadruplet have been performed. All layers show very good efficiency and gain uniformity for our application in ATLAS.
- The comparison of Cosmics and X-Rays are in good agreement.
  - 2 layers have an overall uniformity along the strips of the order of 20%
  - 2 layers show a difference of the order of 40% (still under investigation)
- Next step: long term operation studies are foreseen in GIF++

BACK-UP SLIDES

Gain uniformity for L1 and L2 in different configuration

Layer 1 on bottom, away from the X-Ray gun





Layer 1 on top, close to the X-Ray gun