University of Würzburg

Performance studies of large resistive Micromegas quadruplets in Test-Beams and High Radiation Environments

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ICHEP2016CHICAGO

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- The first large Micromegas quadruplet prototype

Mechanical accuracy

- Alignment measurements

Basic Performance parameters

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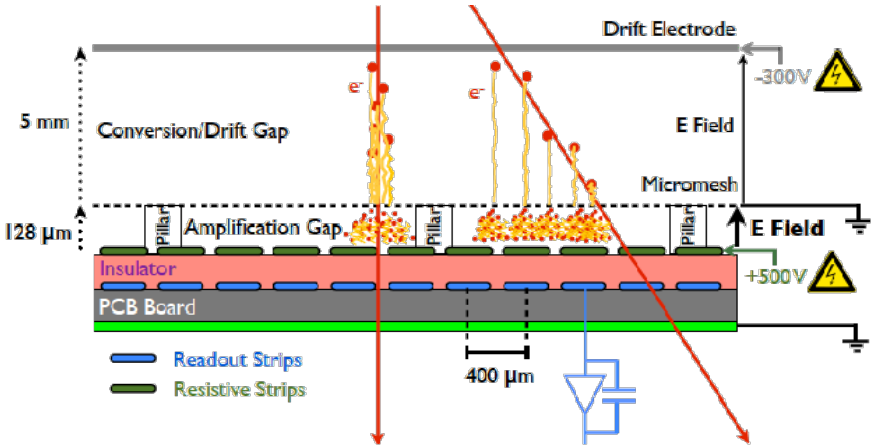
- Gain uniformity after assembly
- Spatial resolution

Design

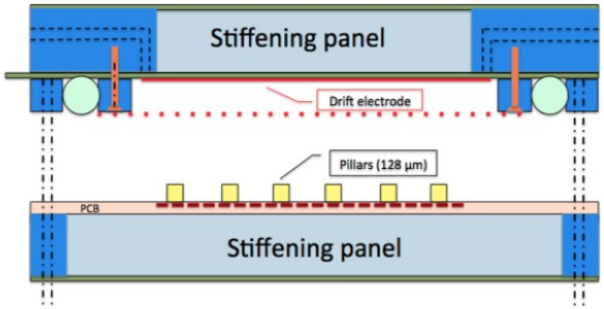
Resistive Micromegas with mechanical floating mesh

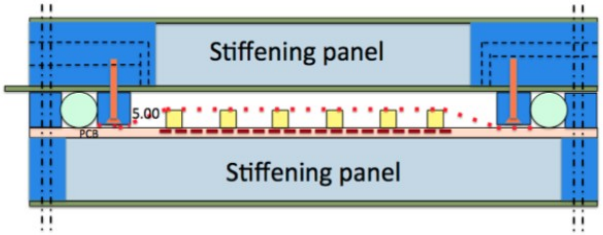
Results from a long R&D phase to develop Micromegas suitable for large experiments



- Readout strips are covered by a 50µm thick Kapton foil carrying resistive strips (0.5-1MΩ/□) to limit spark currents
- Signals are induced via capacitive coupling to the readout strips

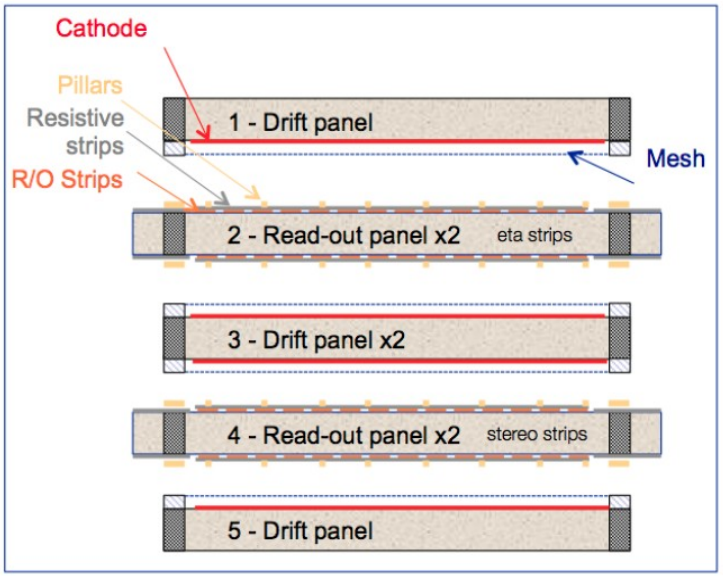
- The mesh is fixed to the drift panel facilitating detector opening and cleaning
- When the detector is closed the mesh is attached to the pillars by electrostatic force





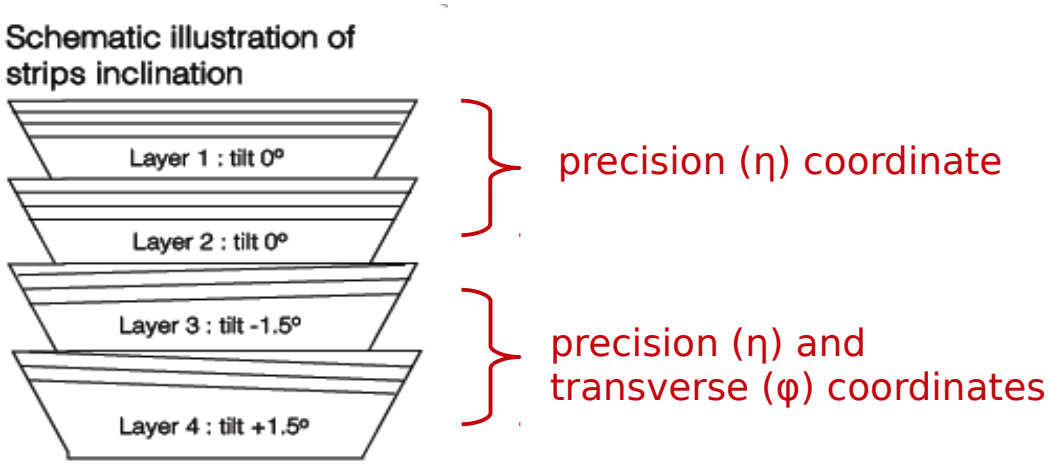
M.Iodice *(5/8/16): Resistive Micromegas for the Muon Spectrometer upgrade of the ATLAS*

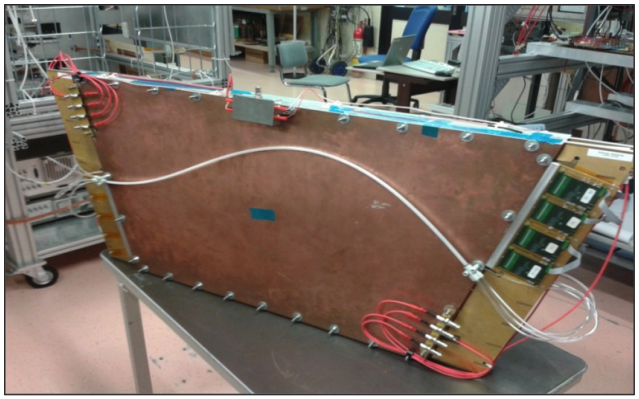
The first large Micromegas quadruplet prototype



- 3 drift panels
- 2 readout panels with identical micromegas structure on both sides (back-to-back)
- 4 gas gaps
- **2 HV sectors per layer**

- 128 µm amplification gap
  - woven stainless steel mesh: 30 µm wires, 50 µm opening
- 5mm drift gap
- 1024 readout channels/layer
  - 315 µm wide strips, 415 µm strip pitch
- Resistive strips sputtered in the Kapton foil

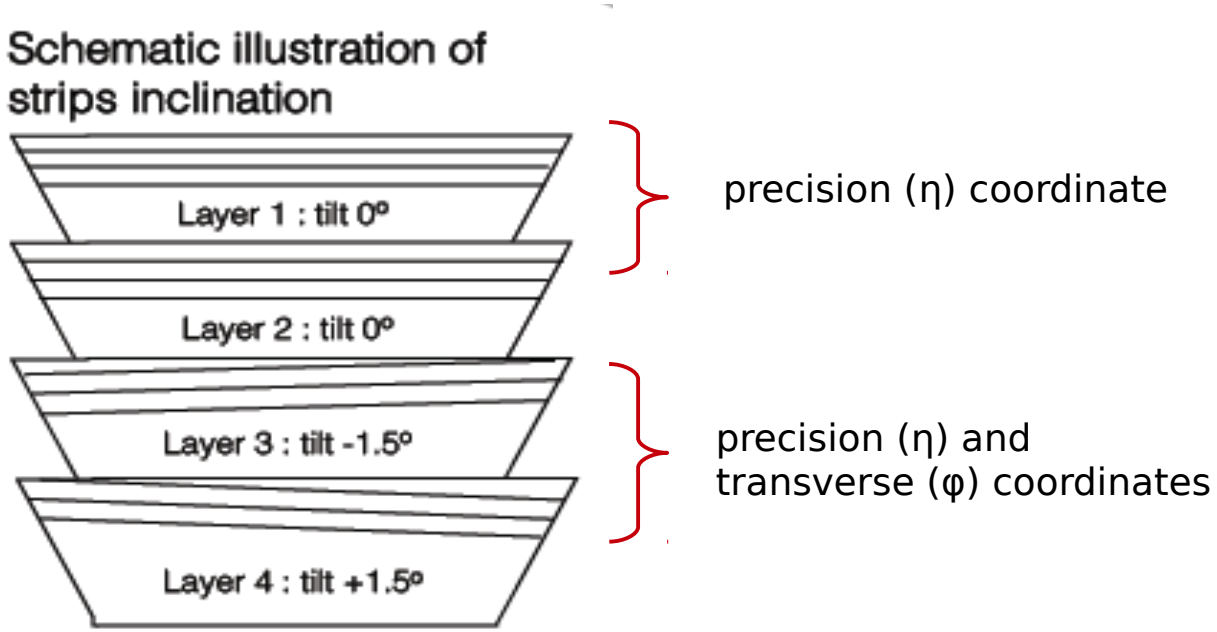




Mechanical Accuracy

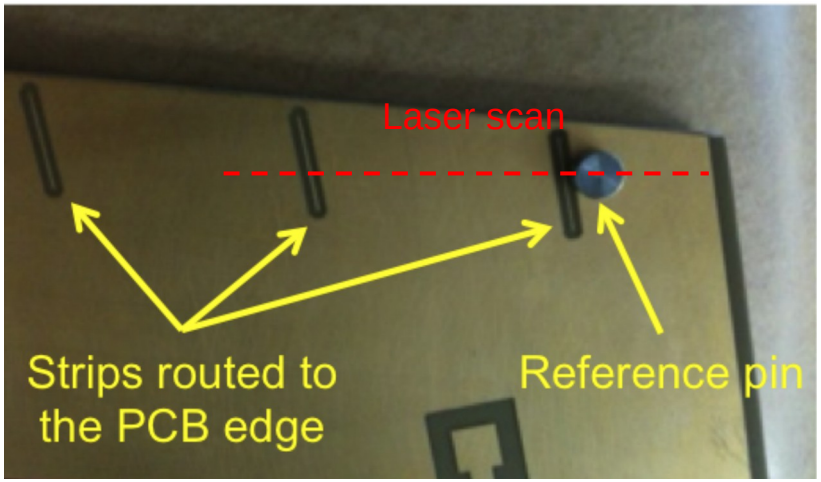
Plane-to-plane alignment

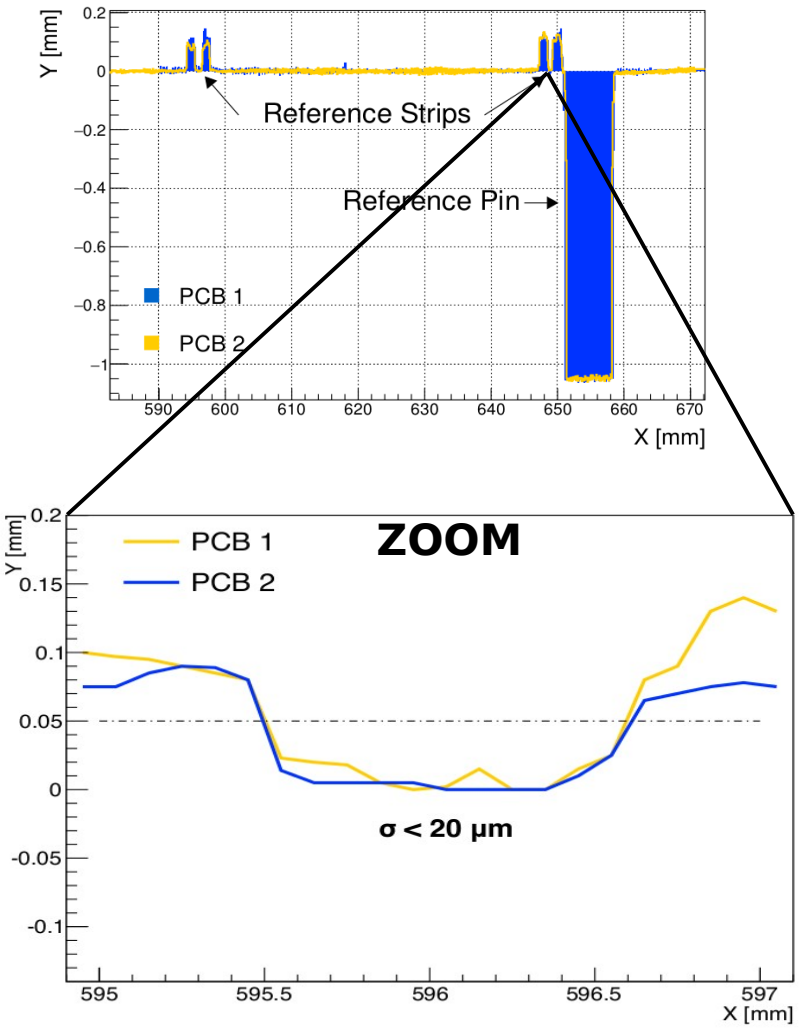
- **A good alignment of the strips is of prime importance**.
- The goal is to know the strip positions to better than **40 μm** on all detection layers.



Plane-to-plane alignment

Mechanical measurement on eta readout panel before assembly (using laser tracker)

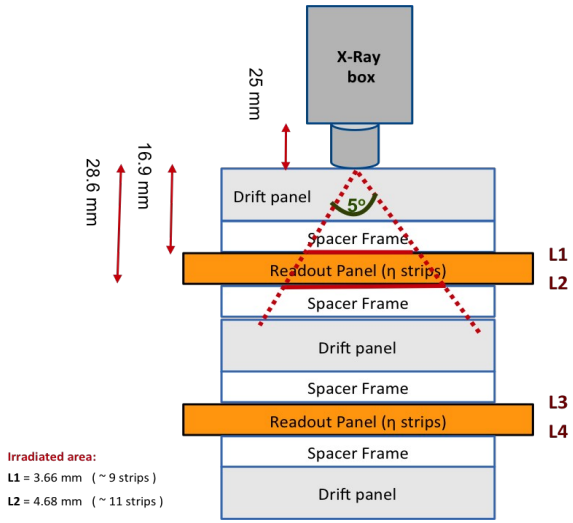




- Position measurement of reference strips on both sides of the η readout panels with respect to a reference pin penetrating the panel.
- The scans of both sides are compared and overlapped at the pin position. The magnification shows the strip-to-strip alignment accuracy better than 20 μm.

Plane-to-plane alignment

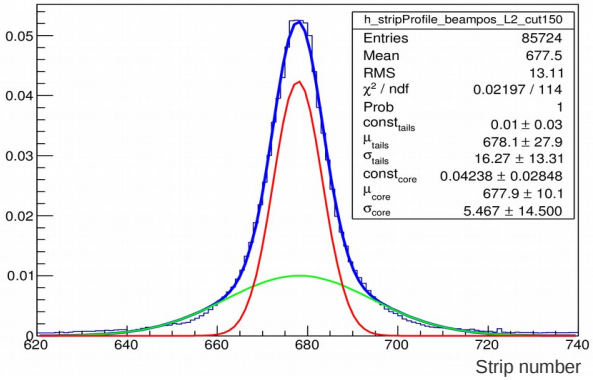
After assembly (using X-rays)



Using an X-Ray (Ag) gun, 2 runs at each position reverting the orientation of the gun to correct for possible inclination of the gun inside the box

- Angle 0°
- Angle 180°

0° 180°



Analysis procedure:

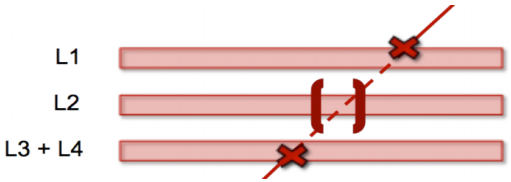
- Fit of the strips profile with double gaussian
- Extraction of the mean value of the core
- Calculation of the mean value between angle 0° and 180°
- Calculation of the difference between the two η layers

			Mean	L1-L2 [strips]	L1-L2 [μm]
Angle 0°	L1	461.41	463.04	0.0465	**19.297**
Angle 180°	L1	464.67			
Angle 0°	L2	460.29	462.99		
Angle 180°	L2	465.7			

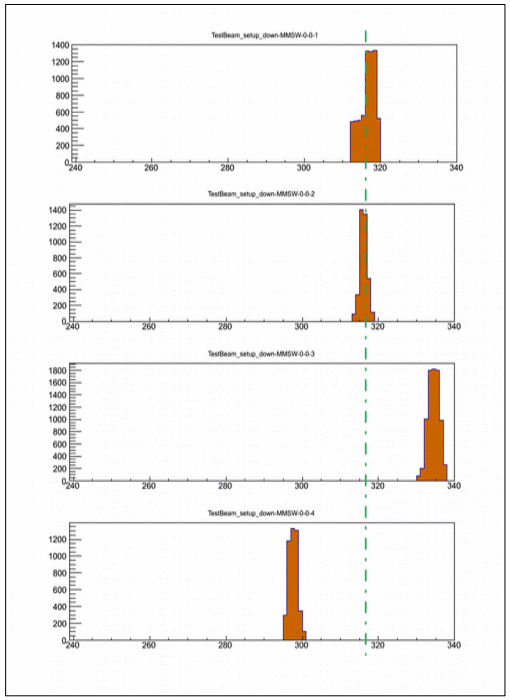
Very good agreement with the mechanical method

Basic performance parameters

Detector Efficiency

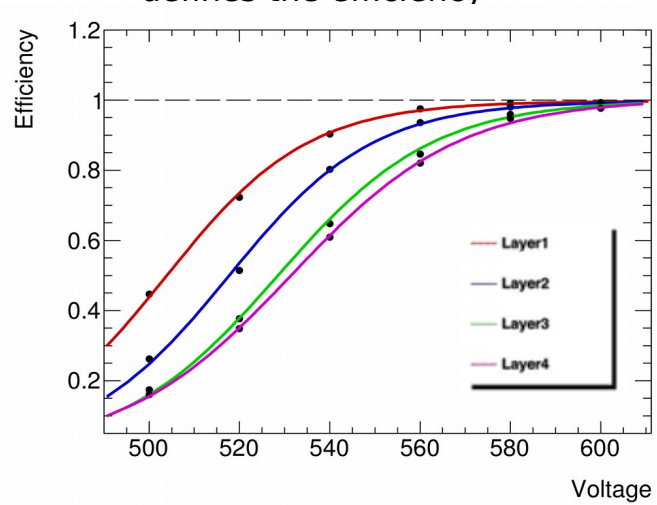


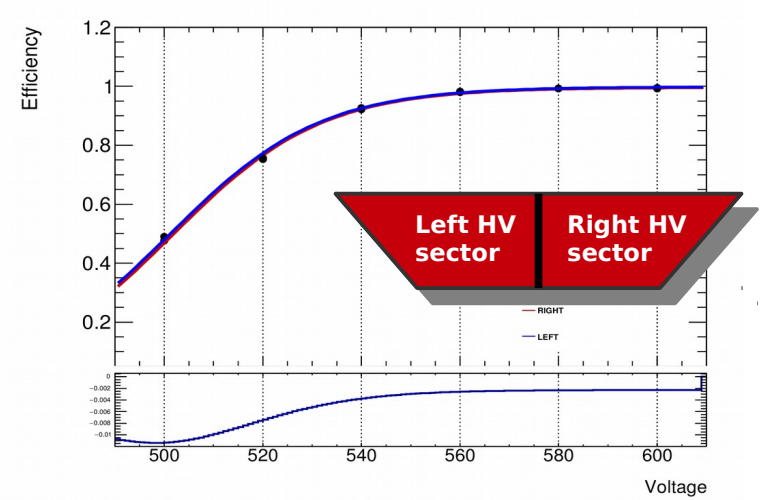
Cosmic event



Efficiency algorithm

- Tracking of the muon using 3 reference layers
- Extrapolation of the expected position on the layer under test
- The presence of a cluster on the layer under test around the expected position defines the efficiency





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.

L1:

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

L2:

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

L3:

χ^2 / ndf	144.7 / 3
0	$0.9999 \pm 5.097e{-05}$
1	528.5 ± 0.1531
2	17.21 ± 0.09755

L4:

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

- *Differences among the layers is due to small variations of the amplification gap*
- *HV sectors within the same layer show the same efficiency*

Clusterization

- Minimum cluster size 2 strips
- 1 missing strip accepted
- Threshold on strip charge

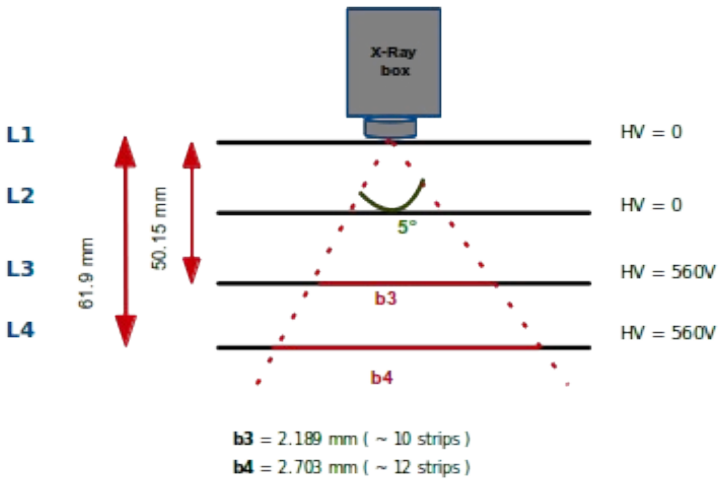
Gain Uniformity after assembly

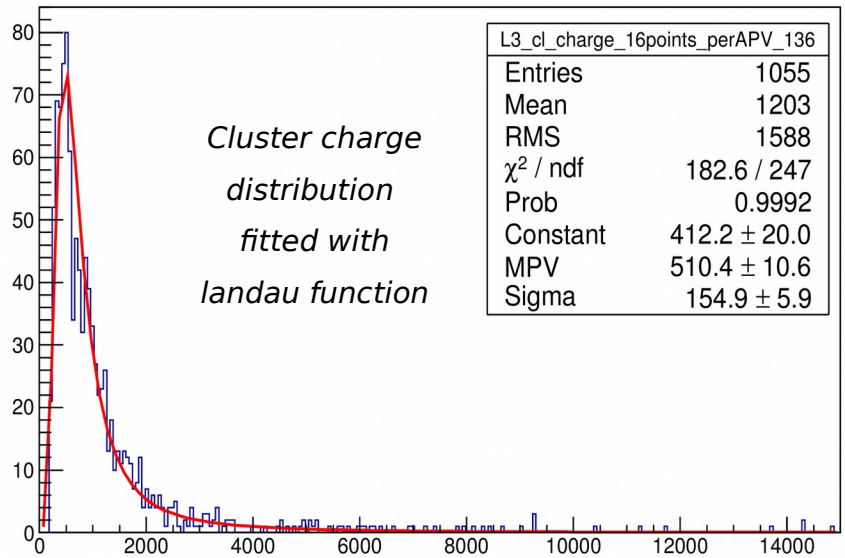
X-Rays

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

Cosmic rays

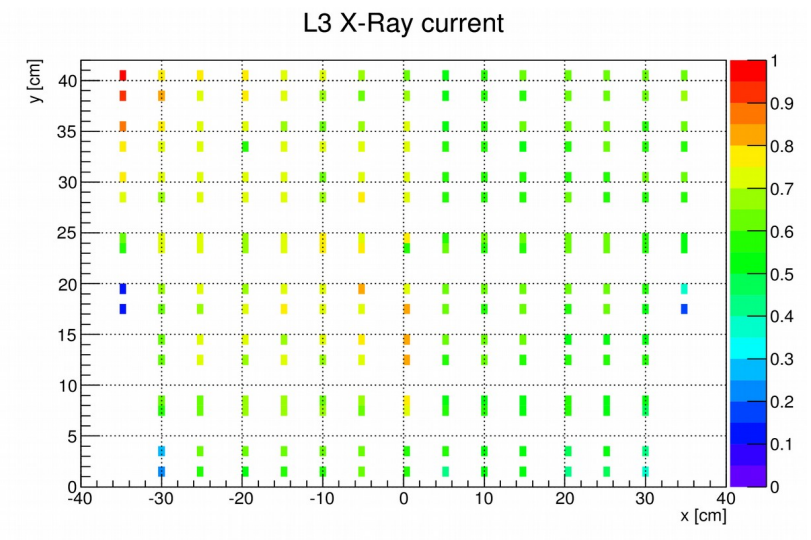
- A window of 20 strips around each area that was irradiated with the X-rays is considered
- For each (x,y) point the cluster charge has fitted with a landau function. The MPV was extracted and plotted to the corresponding position



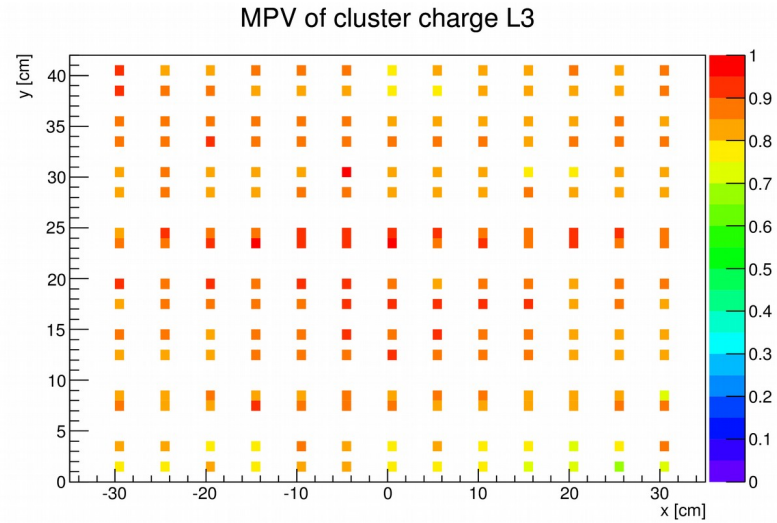


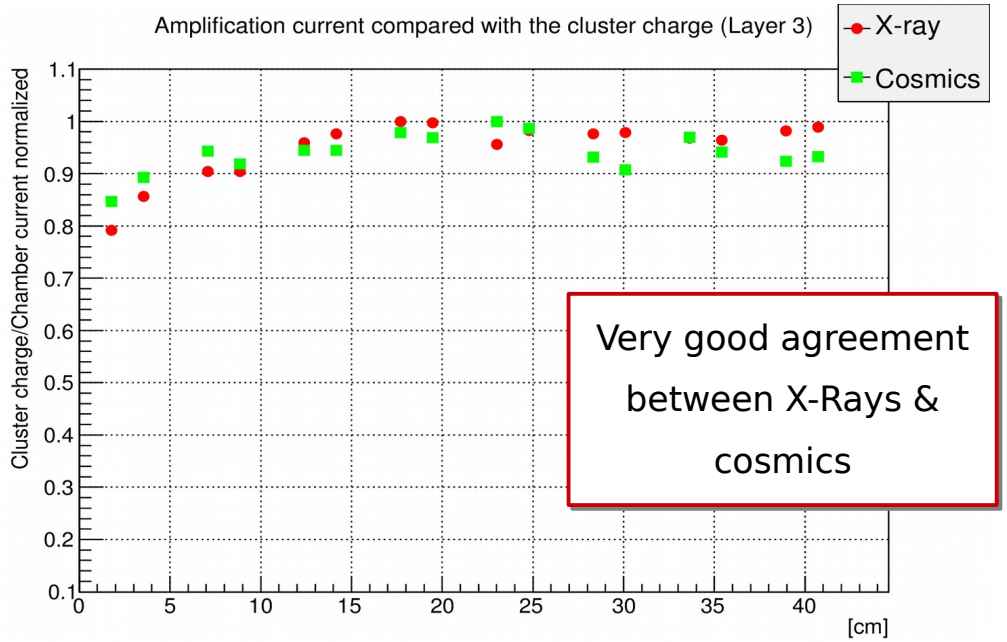
Gain Uniformity after assembly

X-Rays



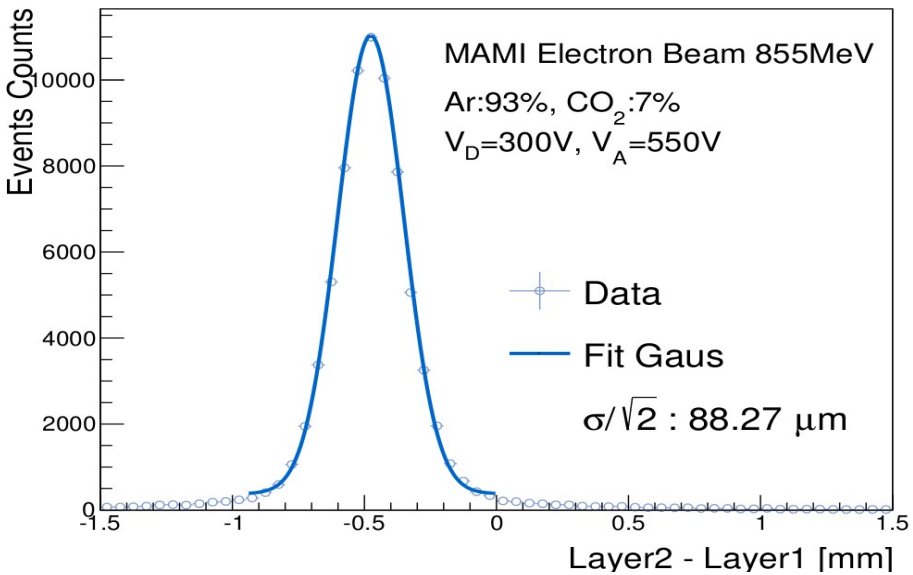
Cosmic rays

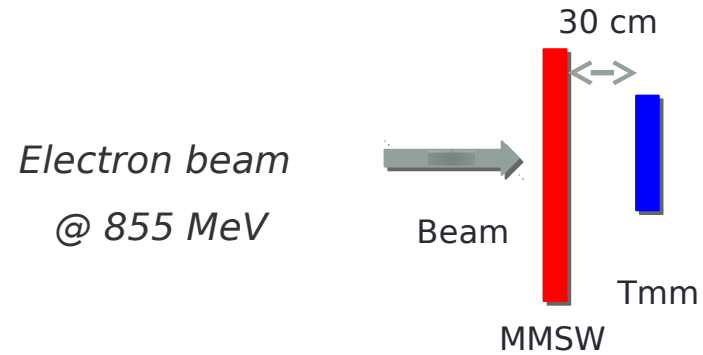


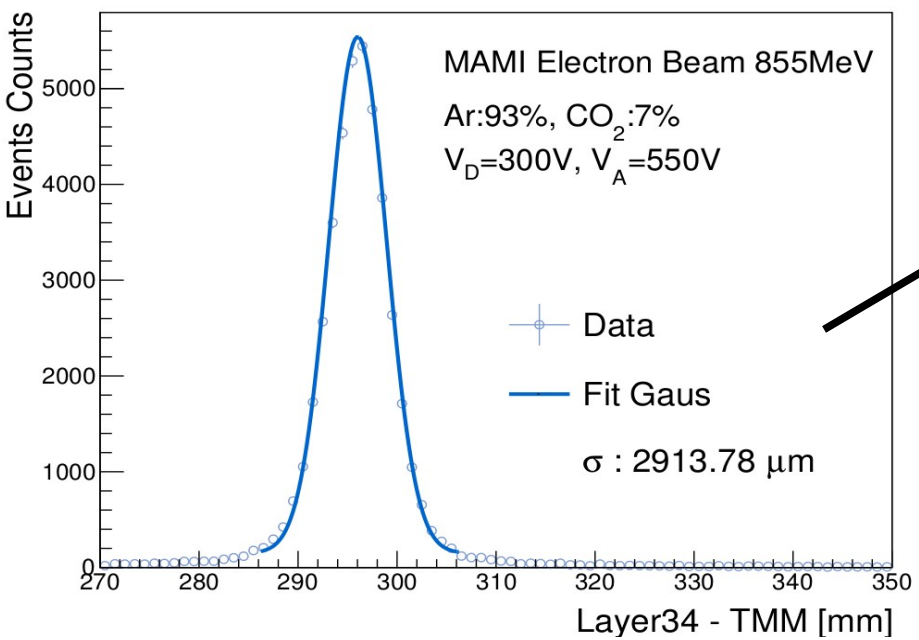


Very good agreement between X-Rays & cosmics

Spatial Resolution@ MAMI Accelerator







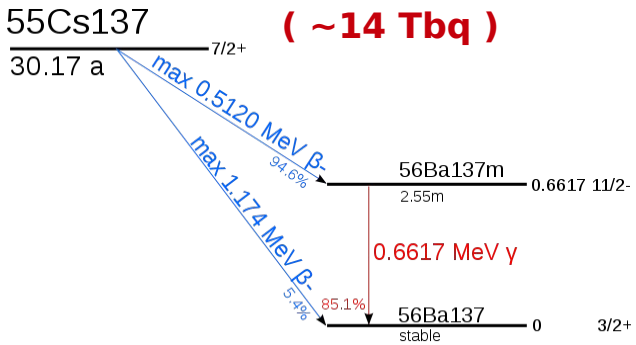
$$\sigma_{Layer\,34-Tmm} = \sqrt{\sigma_1^2+\sigma_2^2+\sigma_{BD}^2+\sigma_{MS}^2} = \sqrt{2.913^2-1.78^2-0.35^2} = 2.28\,mm$$

Resolution of 88 μm for the precision coordinate (η) and 2.28 mm for the transverse (φ) one has been obtained.

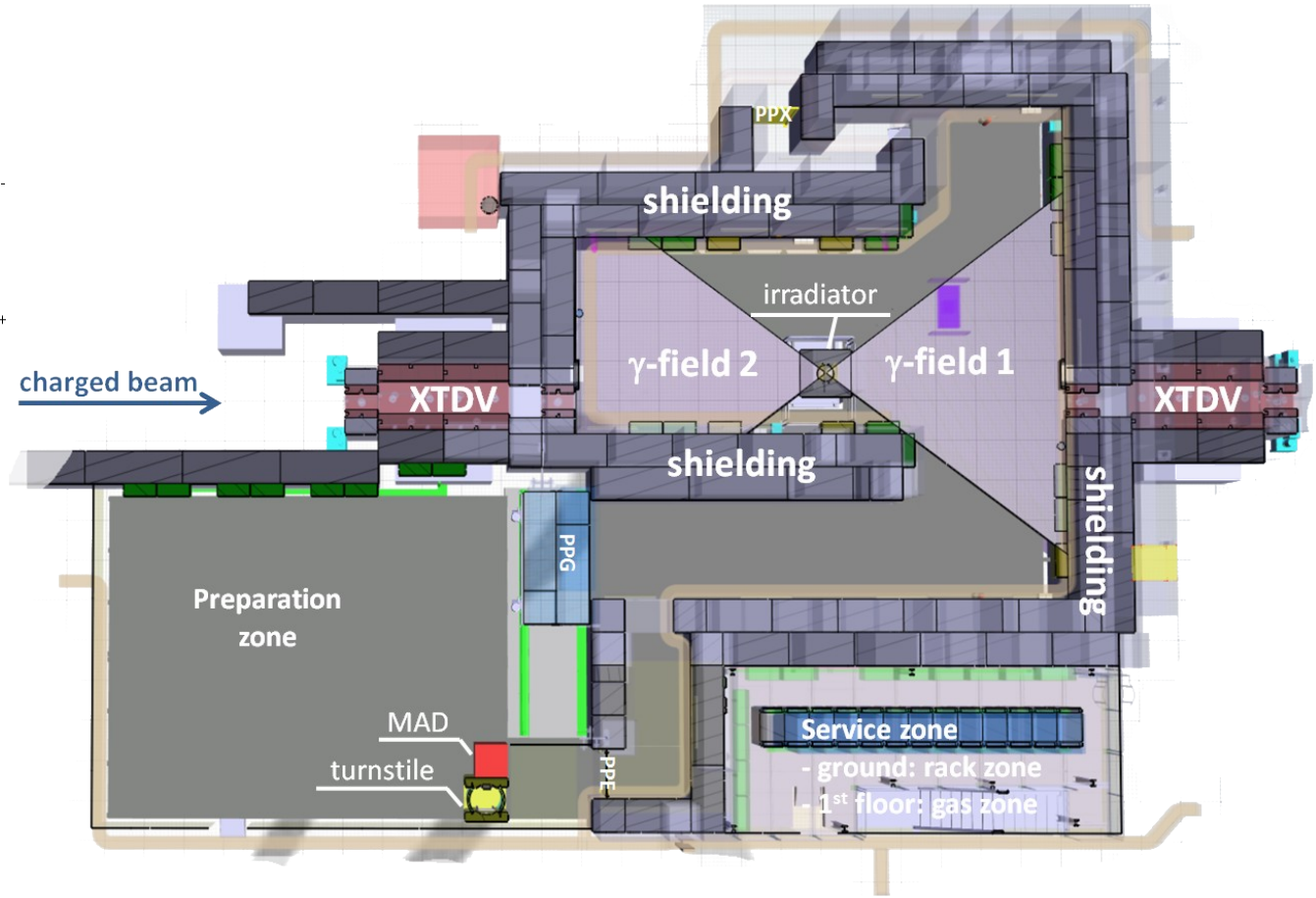
Studies @ CERN Gamma Irradiation Facility (GIF++)

A dedicated irradiation facility with photon energy of ~662 KeV and flux up to 10^8 $cm^{-2}s^{-1}$:

- 55Cs137 **(~14 Tbq)**



- muon 100 GeV

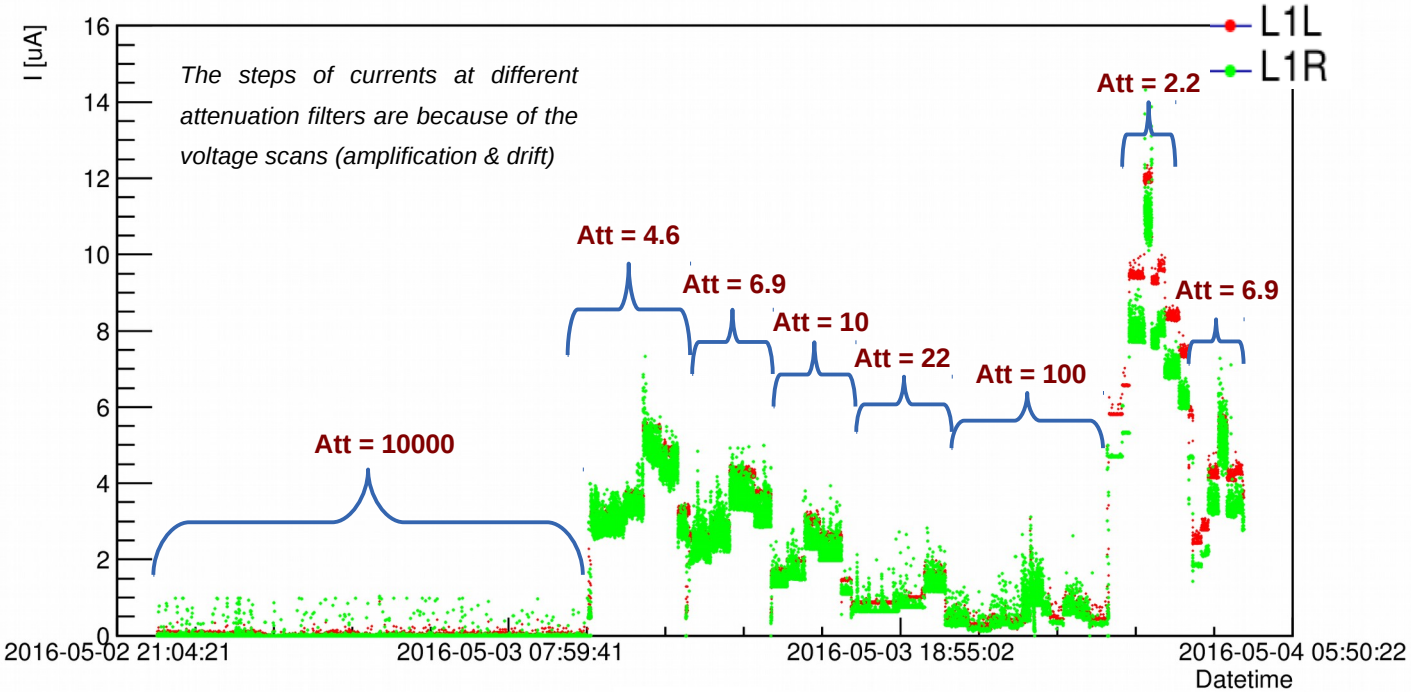


Filter system permits attenuating the photon flux in several steps to reach attenuation factors of several orders of magnitude (~1 - 10^5)

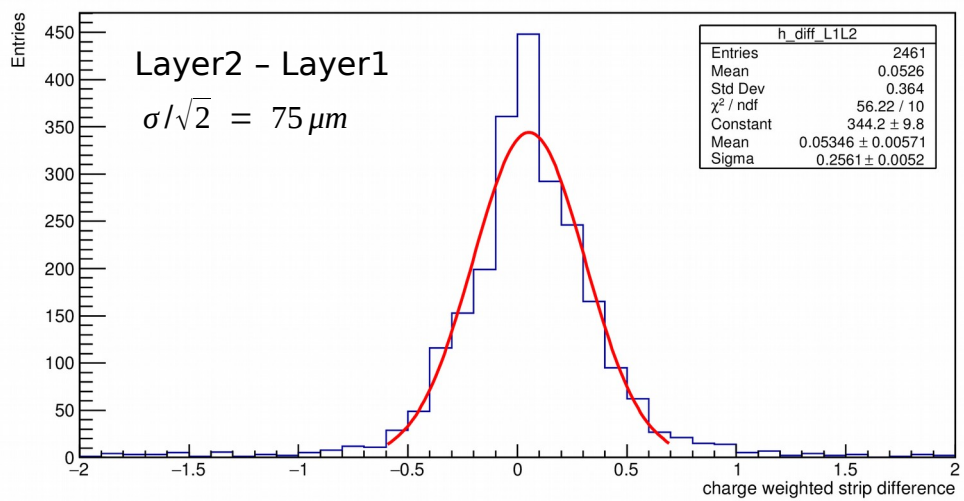
***R.Guida** (5/8/16): GIF++ A new CERN irradiation facility to test large-area particle detectors for HL-LHC*

Studies @ GIF++

- Data with muon beam were taken with source and different attenuation filters:



- Spatial resolution for precision coordinate at muon beam (photon source off):



Poster Session on Monday: *Performance studies under high irradiation of resistive bulk-micromegas chambers at GIF++*

Conclusions

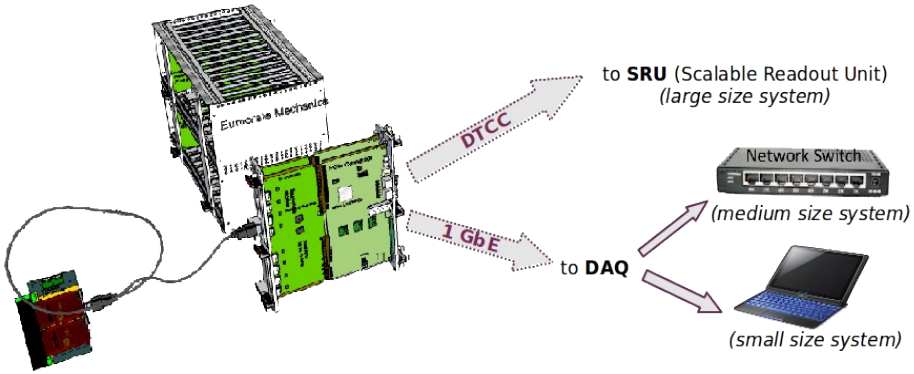
- The construction of the first large four-plane resistive Micromegas detector was achieved serving as prototypes for large experiments
- The alignment of the readout layers was measured during the construction using a laser and after the assembly using X-Rays. Both methods agree on alignment better than 20 μm
- The gain uniformity has been studied with both X-Rays and Cosmic rays providing comparable results
- The intrinsic spatial resolution was determined in an electron and muon beam to be better than 100 μm in the precision coordinate
- Analysis of data with muon beam and photon background is on going
- The detector is currently installed in GIF++ for long term ageing studies

Thank you!!!

BACK-UP

Cosmic set-up

- Cosmic stand composed by two planes of 12 scintillators in the CERN GDD laboratory of the RD51 Collaboration.
- Total area ~2.5 m^2



DAQ based on the SRS

- 32 APVS
- 2 FEC fully equipped
- dedicated DAQ software