Characterisation of the first prototype of large Micromegas chamber “LM2 Module-0” for the upgrade of the ATLAS Muon System

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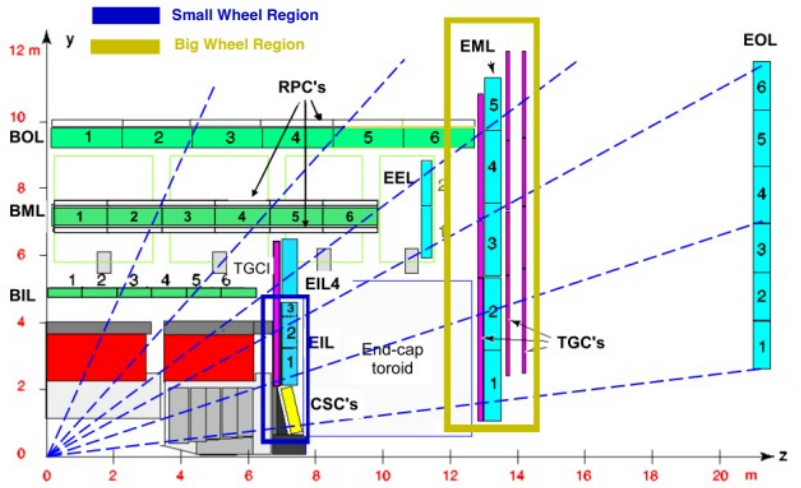
Introduction

LHC Upgrade Phase II: increase of collision intensity → increase of background rate

Small wheels:

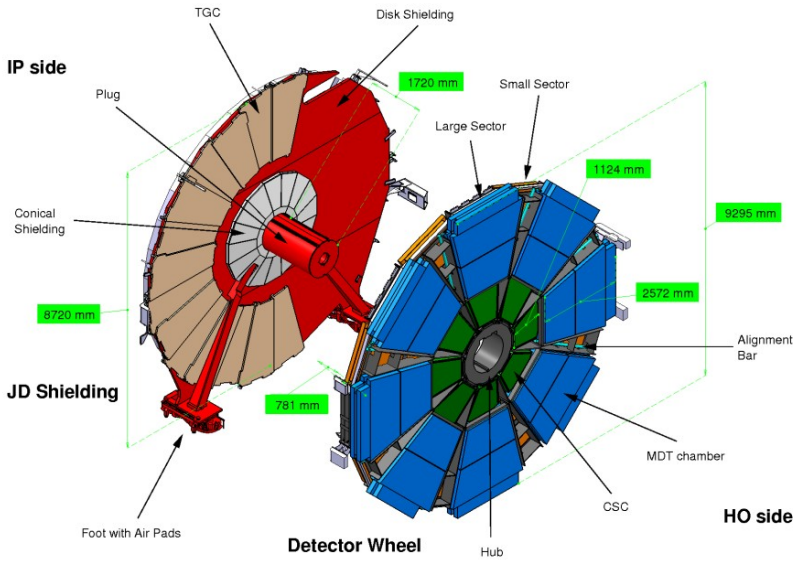
- Trigger + precision muon tracking
- 1280m^2 active area

Increase of maximum hit rate in small wheels region up to 15 kHz/cm^2

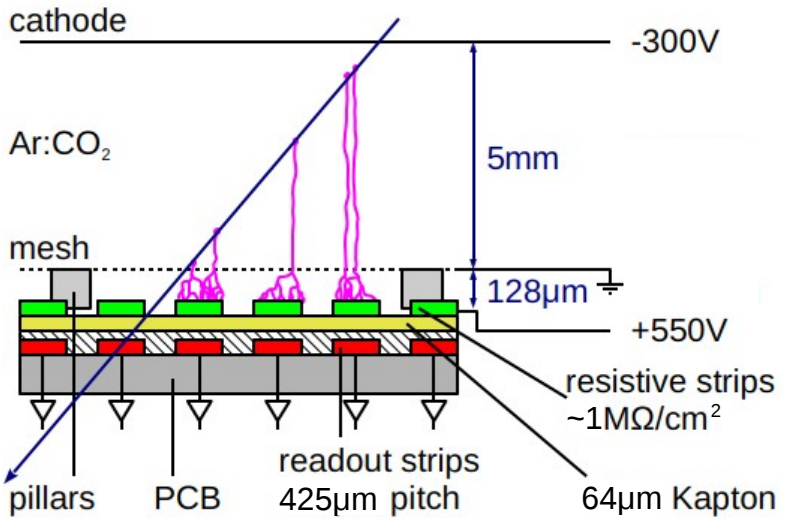


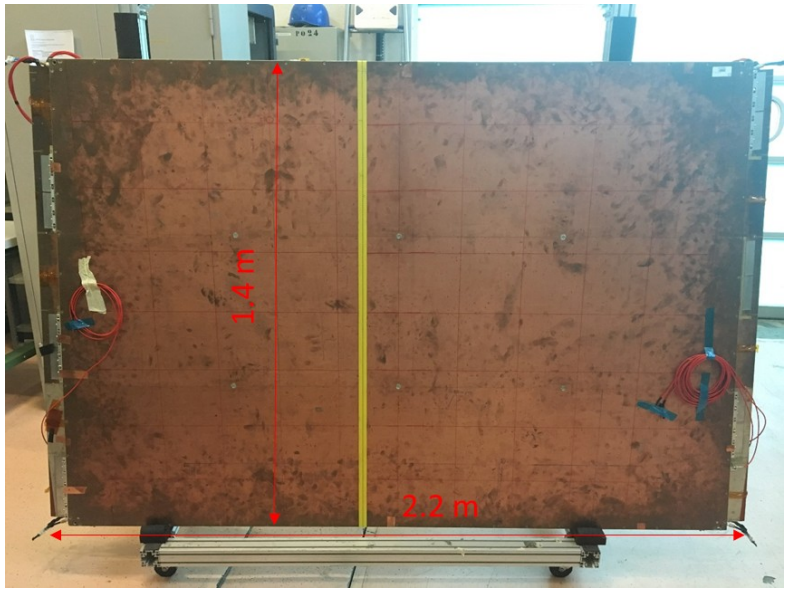
Resistive strip Micromegas:

- micro-pattern gaseous detector → reduced rate per readout channel
- spatial resolution below 100μm for inclined tracks
- high gain: ~10^4
- spark protection



Prototype description

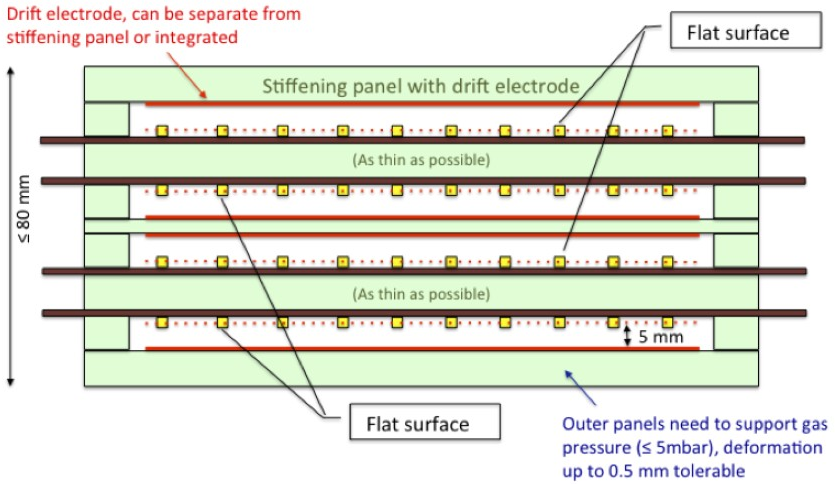




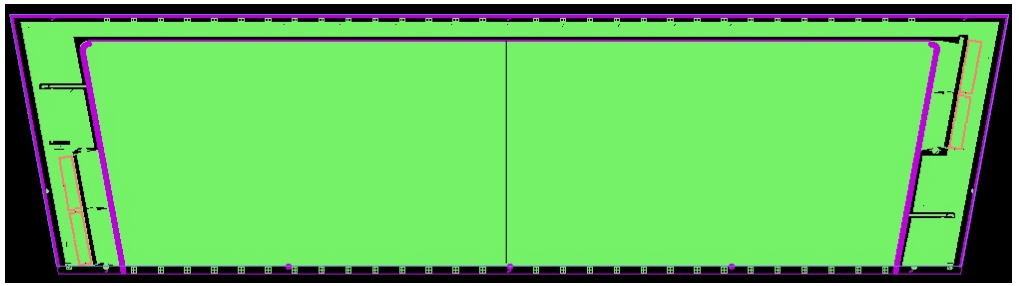
First full-size pre-series chamber – LM2 Module-0

The goal: development of production procedure

- 4 layers: two with horizontal strips, two with ±1.5^0 inclined strips
- 3 anode readout PCB per layer, 2 independent HV regions per PCB
- resistive anode strips creating amplification field
- 1024 readout copper strips per PCB with 425µm pitch
- micro-mesh and cathode compose drift pannel
- gas mixture: Ar/CO_2 (93%/7%)



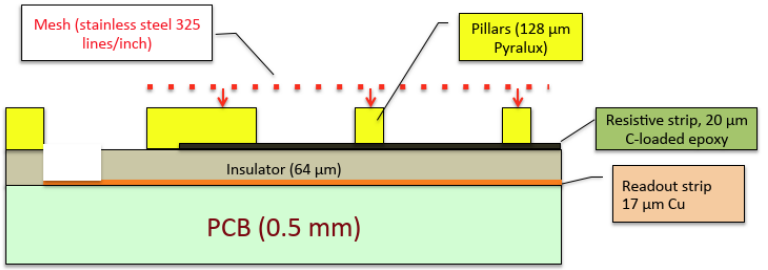
Anode printed circuit board



Left HV sector Right HV sector

MM Readout PCB

3 PCBs per layer: PCB 6, 7, 8.



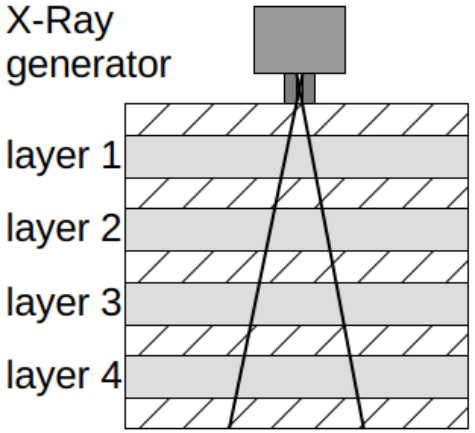
- Pillars – Pyralux structure, supporting mesh and form amplification gap
- Resistive strips – HV distribution
- Kapton foil – insulator between resistive and copper strips
- Copper strips – readout structure
- Textolite base matherial

The PCBs have defects on the active area:

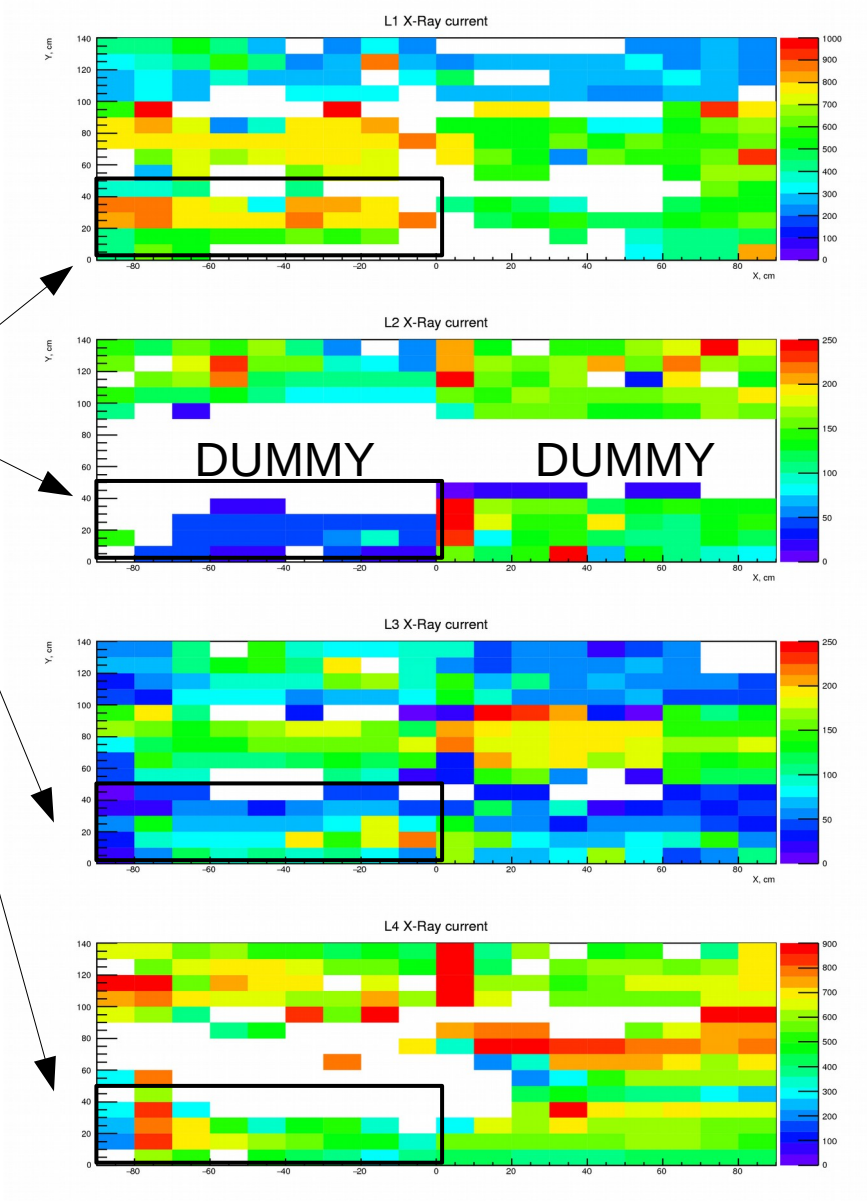
- Missing pillars
- Bumps (height of a few tens microns)
- Scratches
- Damaged edges
- etc...

One was passivated the regions with deffects

Gas-gain mapping with x-rays



This sector is used for all the rest measurements



- Colimated x-ray tube with 5° opening angle
- Silver transmission target
- Tube settings: 50kV, 80μA
- Measure amplification current in 2280 points

Relative gas-gain map has been produced for each layer:

- Measured inhomogeneity ~25%

Efficiency mapping

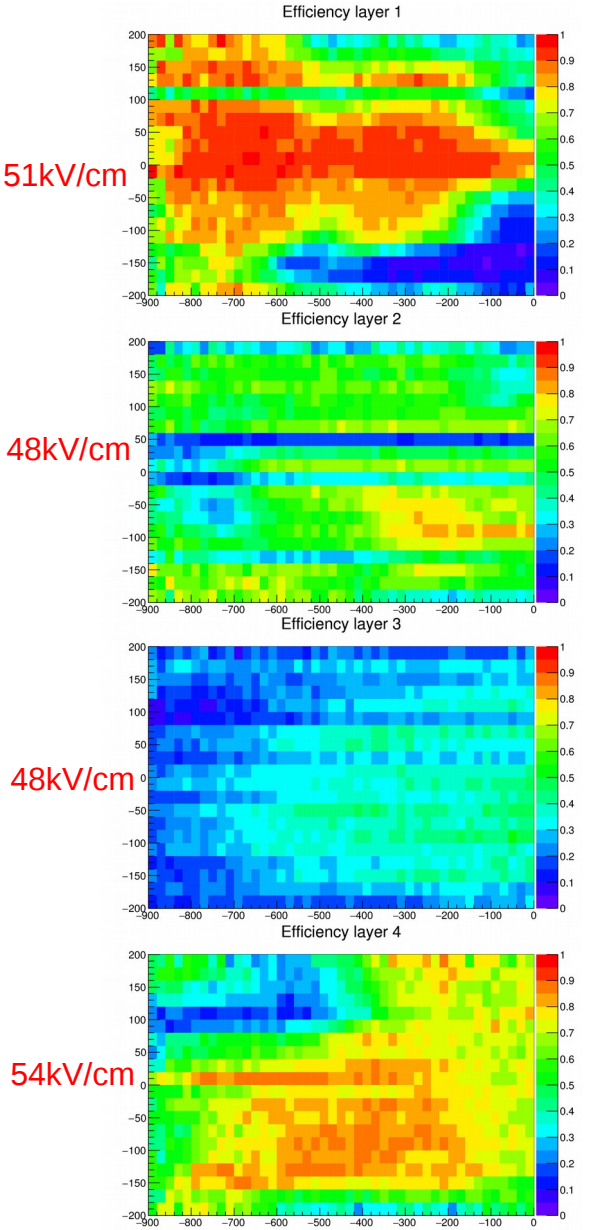
2D distribution of cosmic muons:

- efficiency map for each layer with respect to other 3 layers
- efficient if matching hit in fourth layer within 15mm
- Edrift = 0.6kV/cm

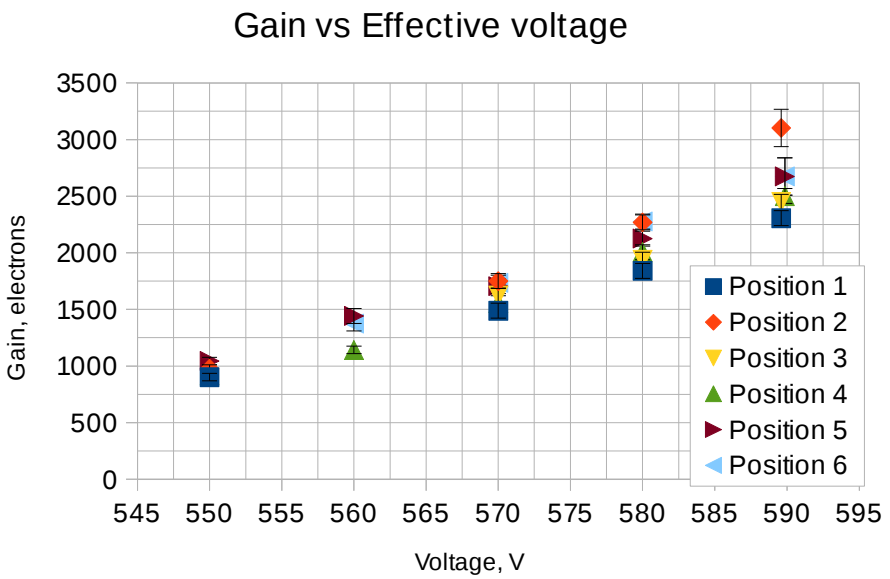
Results:

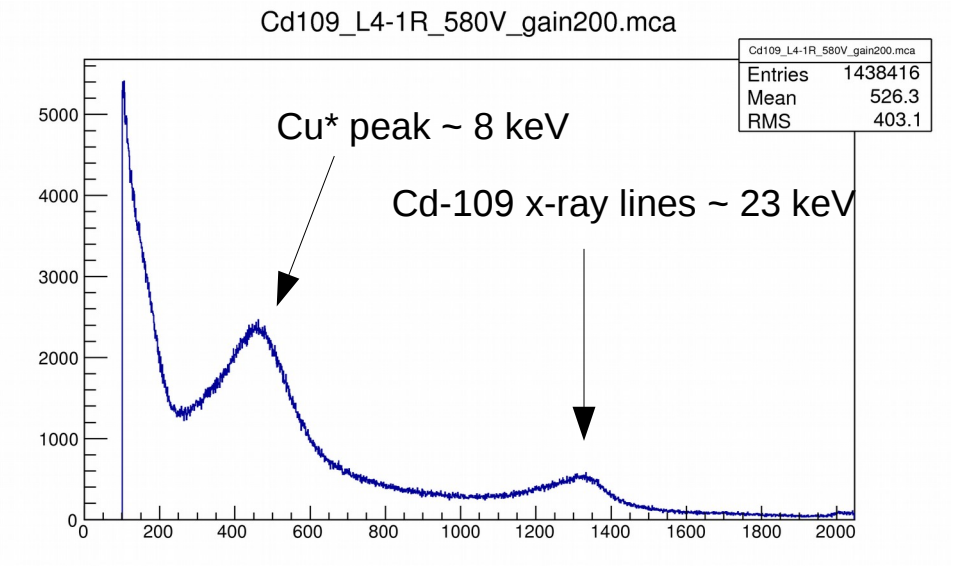
- Corresponds to x-ray map and reparations map
- Efficiency ~90% for layer 1 and 4
- Efficiency ~60% for layer 2 and 3 – low amplification field

Efficiency map PCB6 left HV region



Gas-gain measurements



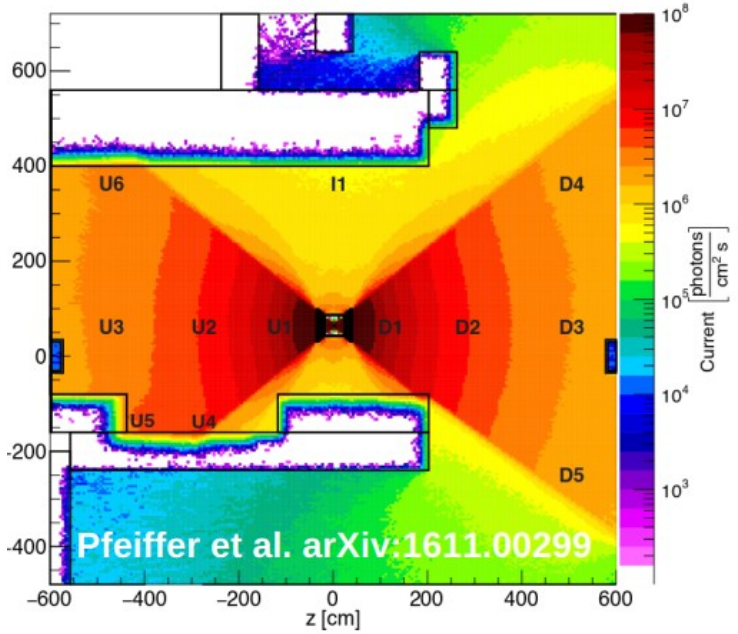


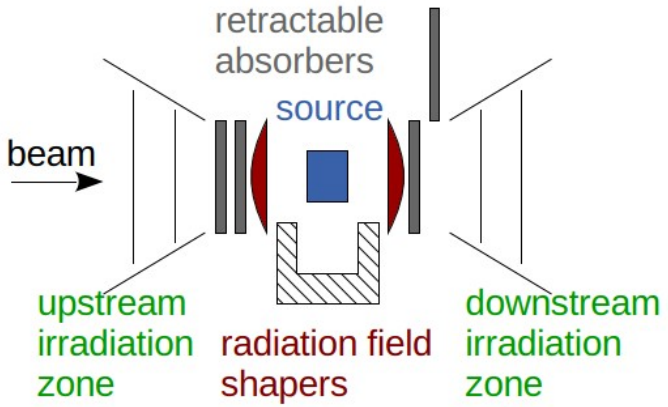
Gain measurements performed with Cd-109 x-ray souce

- Calibrated preamplifier scale
- 6 positions at Layer 4
- Amplifcaton scan at each position
- E_drift = 0.6kV/cm

- Exponential increase as expected
- Gain ~ 2.5×10^3 at 53kV/cm

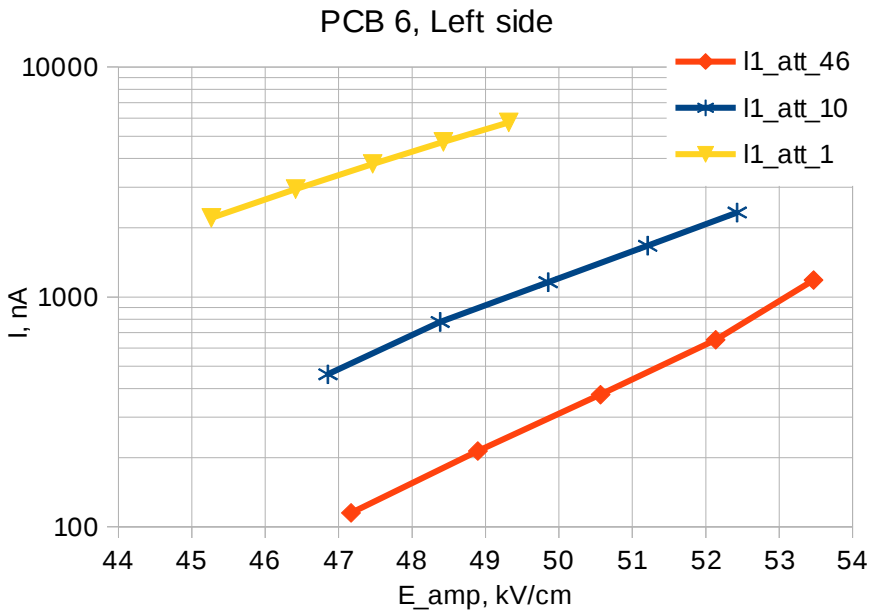
GIF++ facility





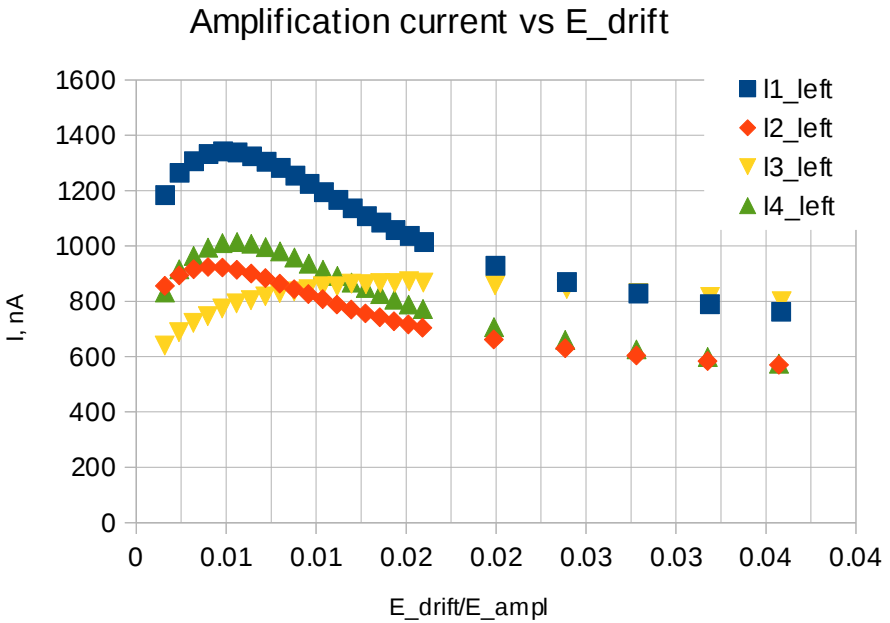
- 13 TBq ^{137}Cs source, SPS North Area
- 662keV γ-radiation + continuum (Compton scattering)
- field shaper: constant photon current in plane
- retractable absorbers → adjust photon flux
- Hit rate ~ $3 \cdot 10^7$ at full source at the chamber position
- high-energy muon beam: ~100GeV, 10^4 per spill

Amplification & drift voltage scan



- HV scan at attenuation factors 1, 10, 46
- E_drift = 0.6kV/cm

→exponential behaviour is observed for any source rate



- Source at attenuation factor 10
- E_ampl ~ 50 kV/cm

- →Low E_drift: electron attachment
- →High E_drift: low electron mesh transparency
- →Difference between Layers 1,2,4 and Layer 3 – to be understood

Muon beam

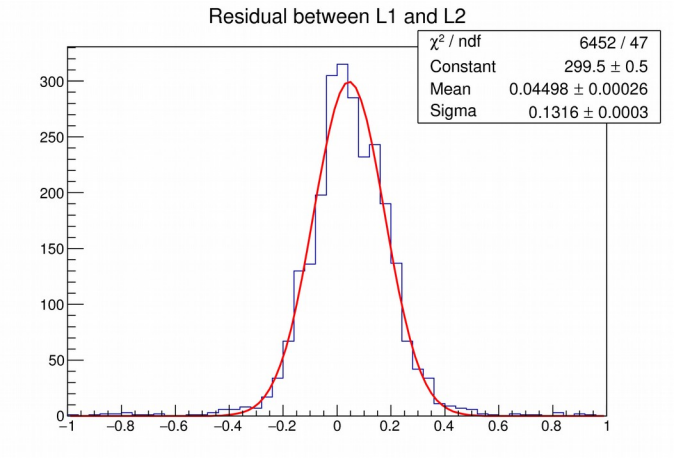
Amplificaton scan at 4 layers performed

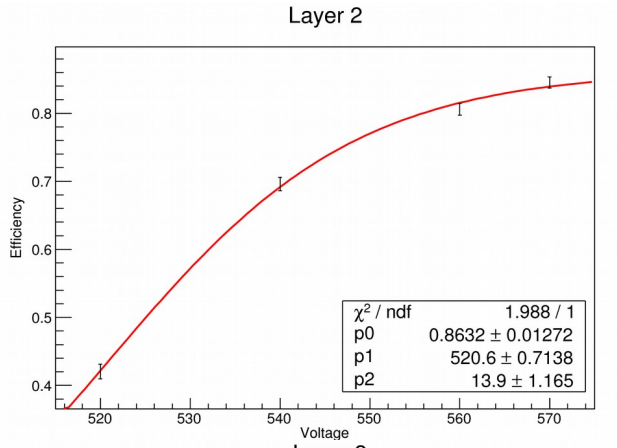
E_drift = 0.6kV/cm

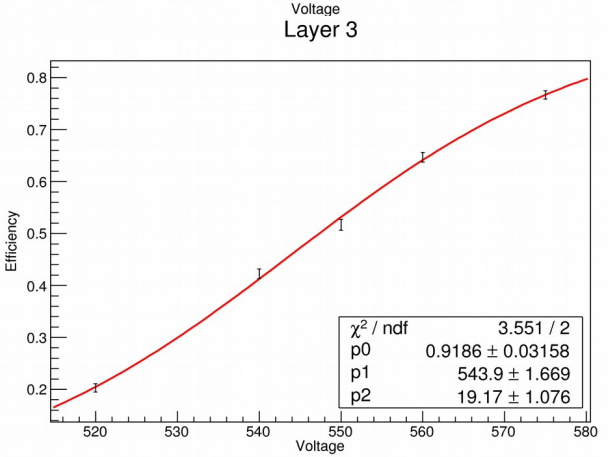
- Layer 1 – working point at 580V (53kV/cm)
- Layer 2 – can't reach working point
- Layer 3 – full efficiency expected at >600V, leeds to low E_drift/E_ampl ratio
- Layer 4 – working point at 600V (54kV/cm)

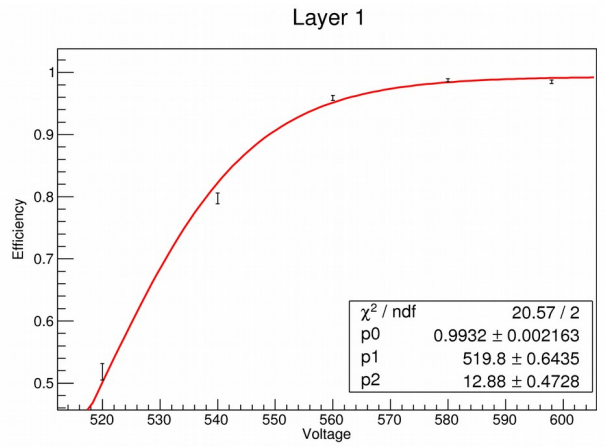
Spatial resolution estimated from residual between hits at Layer 1 and 2

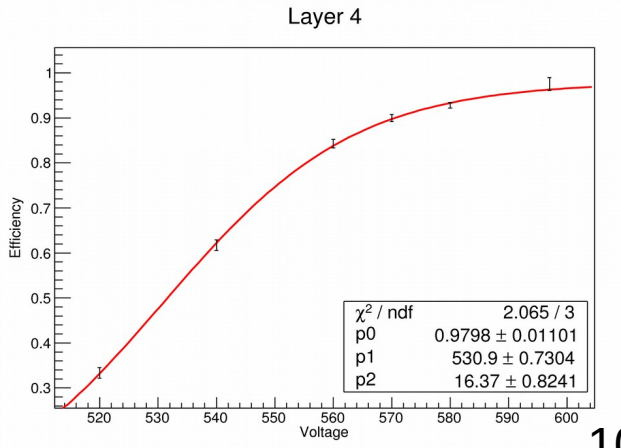
- σ ~ Sigma/Sqrt(2) ~ 93μm



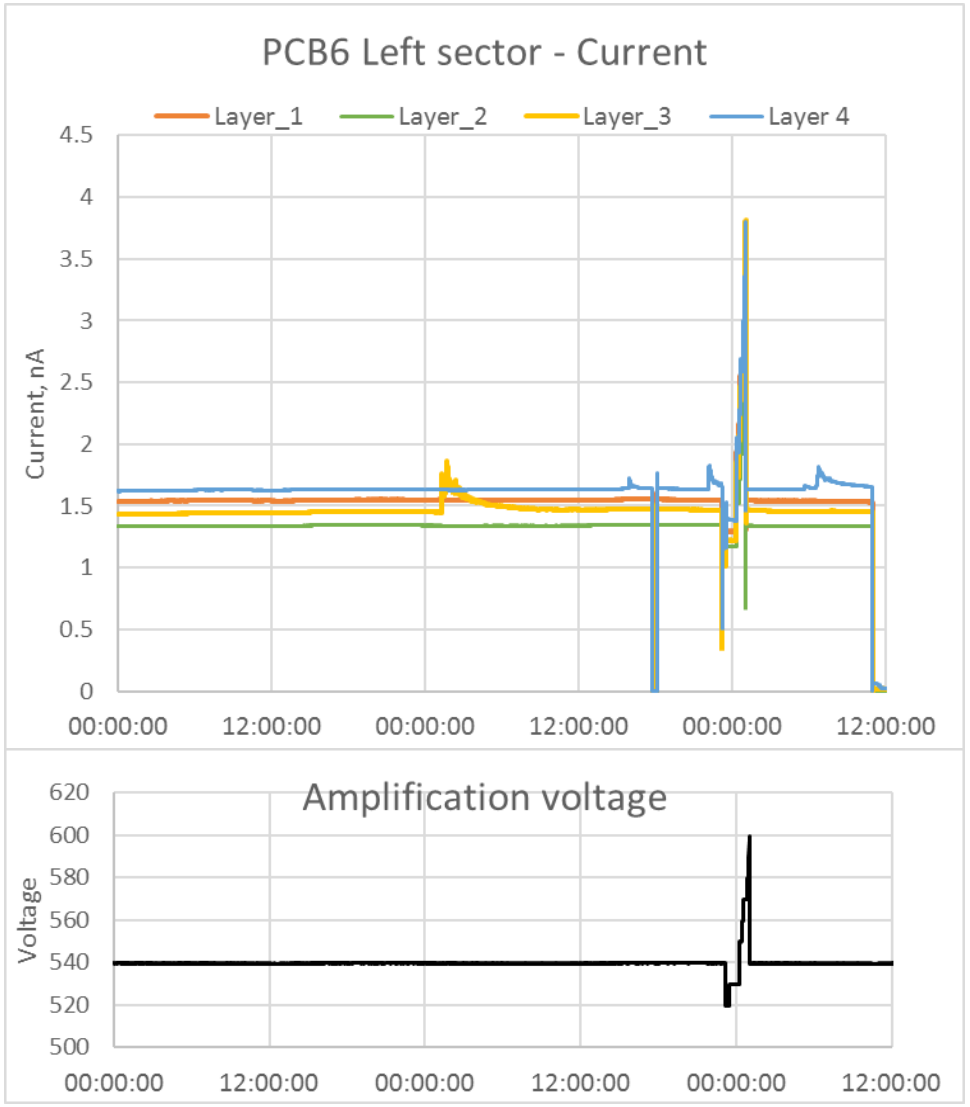




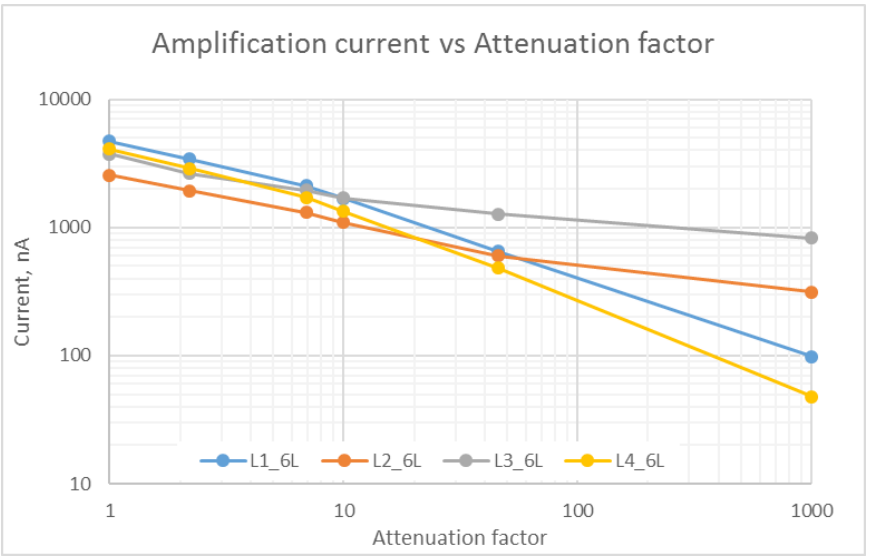




Long-term irradiaton



- 16 sectors under constant HV
- Monitoring current
- Scan for different source attenuation factor
- Operation at constant HV and attenuation factor (a few days in total)
- → no gain degradation observed



Summary

First prototype of pre-series resistive strip Micromegas module constructed and tested

- Tests with x-ray shows inhogeneity of relative gas-gain map ~25% for regions without reparations
- Efficiency map has been produced with cosmics is being corelated to relative gas-gain map and reparations layout
- Single electron gain is estimated with Cd-109 x-ray source at Layer 4 to be ~2.5×10^3

Tests in GIF++

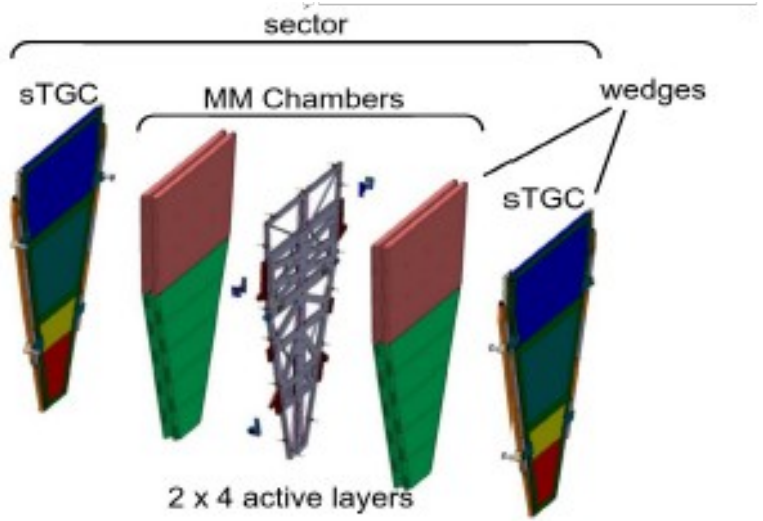
- Amplification and drift scans show expected behaviour
- Working point of each layer is estimated from muon beam
- Spatial resolution measured to be ~93μm

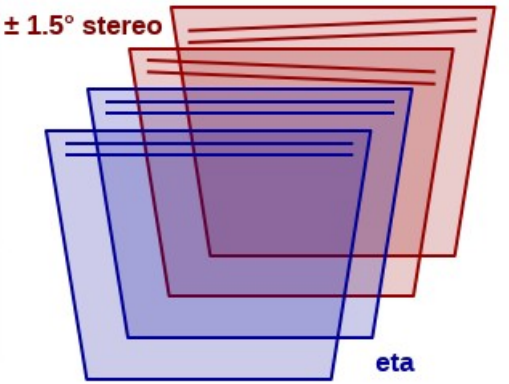
Outlook

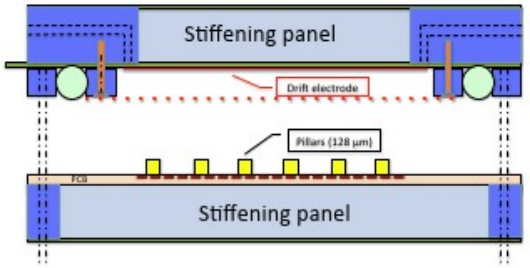
- Open the chamber to study the problem with Layer 3
- Continuation of aging tests in GIF++

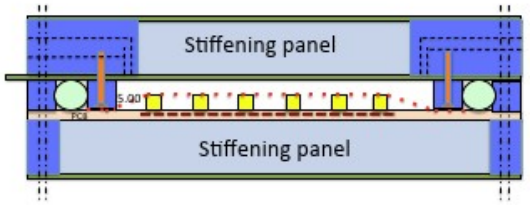
Back-up slides

PCB detales


sector
sTGC
MM Chambers
wedges
sTGC
2 x 4 active layers


± 1.5° stereo
eta

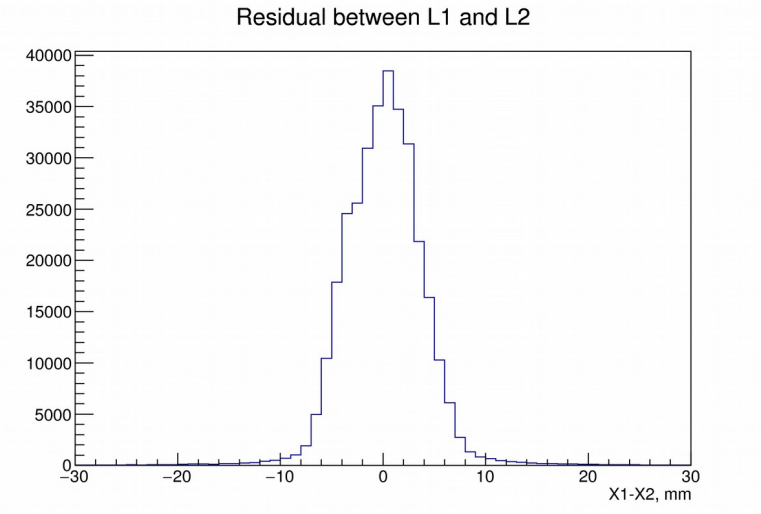

Stiffening panel
Drift electrode
Pillars (128 µm)
Stiffening panel

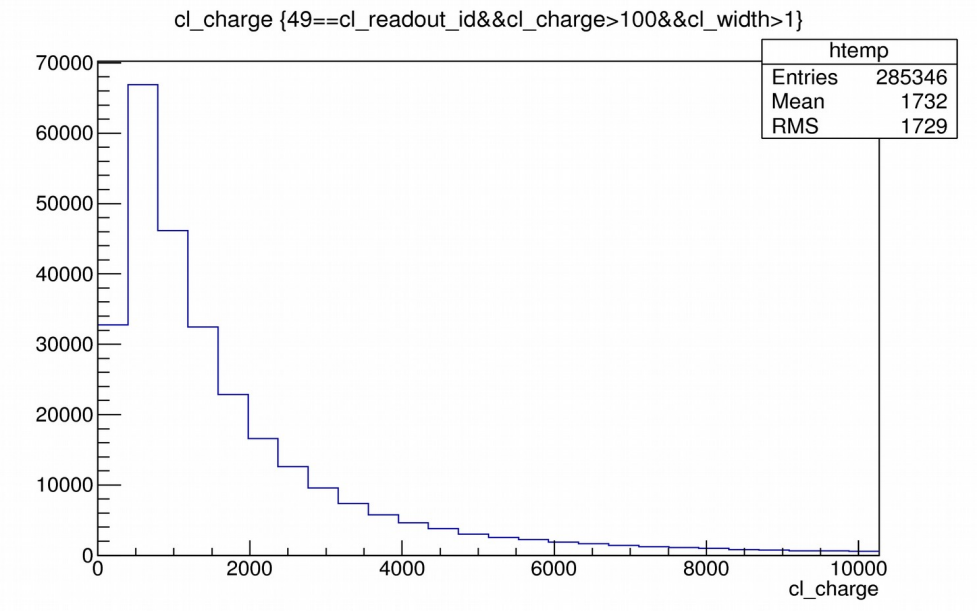

Stiffening panel
Stiffening panel

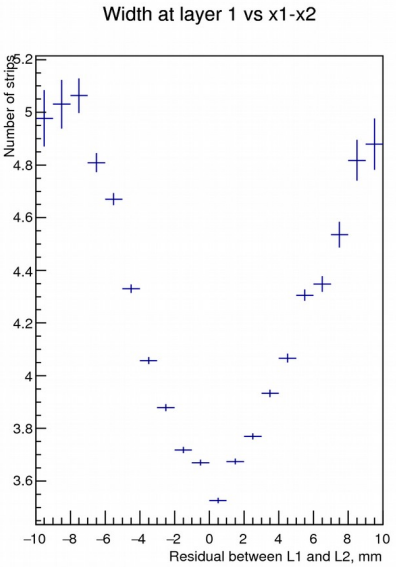
GIF++ Source attenuation factor

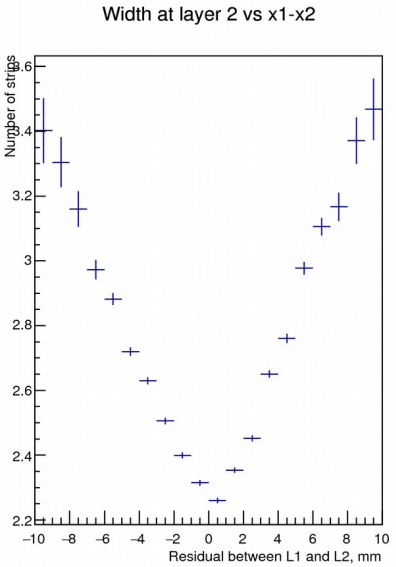
nominal attenuation	observed attenuation	observed photon current [$cm^{-2}s^{-1}$]	measured hit rate small chamber [$cm^{-2}s^{-1}$]	measured sensitivity small chamber
4.6	4.5	$9.8x10^{6}$	$34x10^{3}$	$3.5x10^{-3}$
10	**8.8**	**$5.0x10^{6}$**	**$18x10^{3}$**	**$3.6x10^{-3}$**
46	(29)	($1.5x10^{6}$)	$5.3x10^{3}$	assuming $3.6x10^{-3}$

Cosmics stand









Claster charge map

Claster charge map PCB6-left