Gas Electron Multiplier

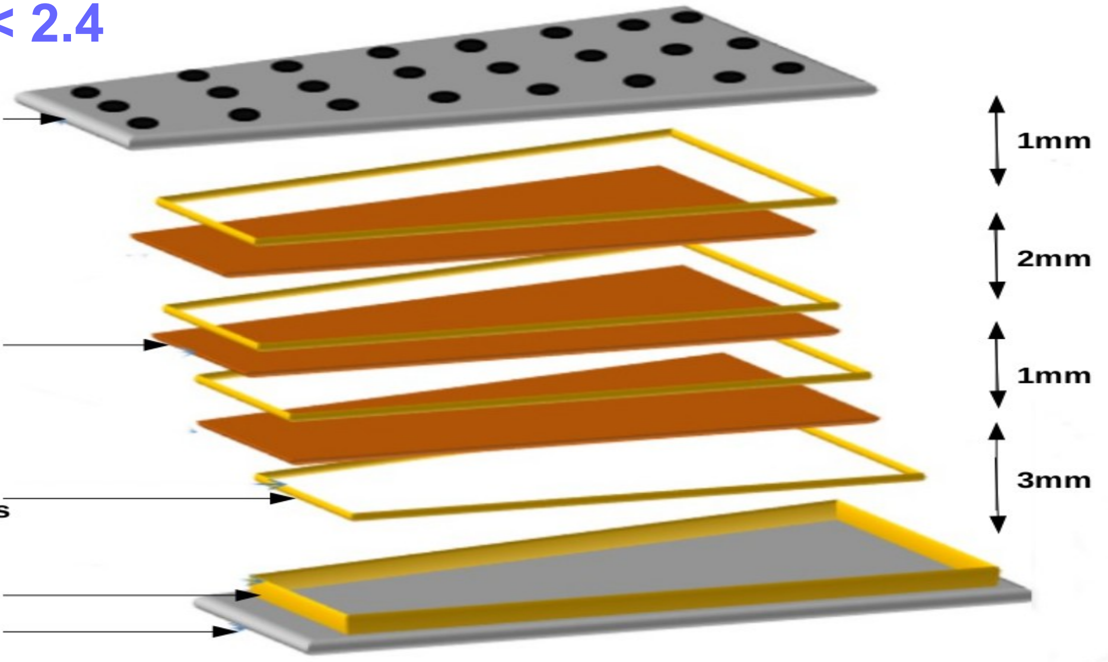
Single Mask GE1/1-V

Trapezoidal Geometery (3/1/2/1)mm

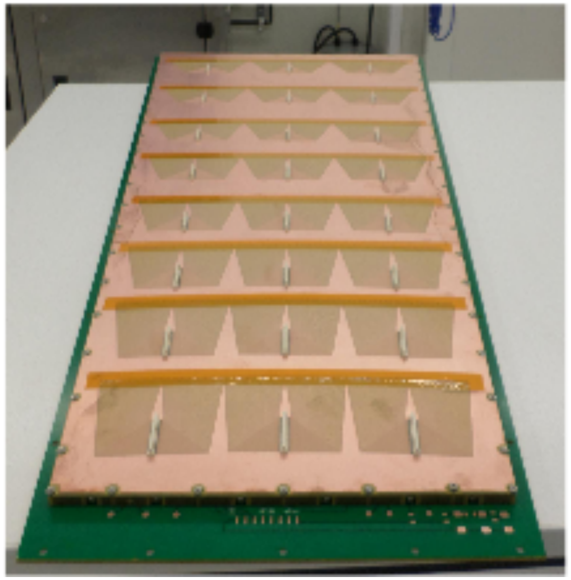
Dimensions: 990mm × (220 – 455)mm

Single readout (0.6 to 1.2mm)

$|1.6 < |\eta| < 2.4$



Design of GE1/1 Prototype



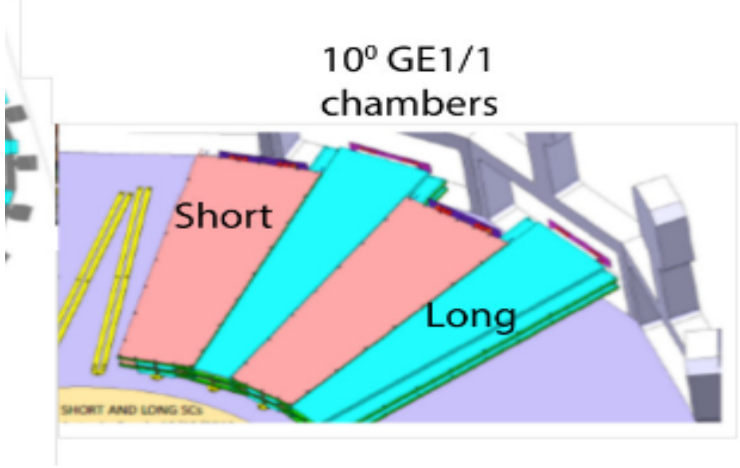
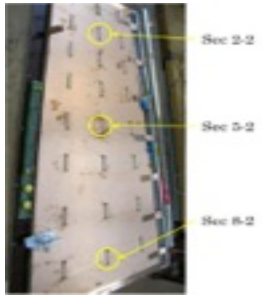


Fig. 41. GEM foil production and test setup at the beam area.

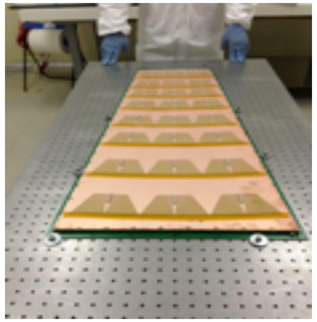
Detector optimization

2010

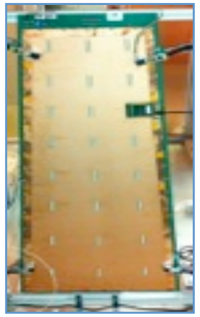


2011

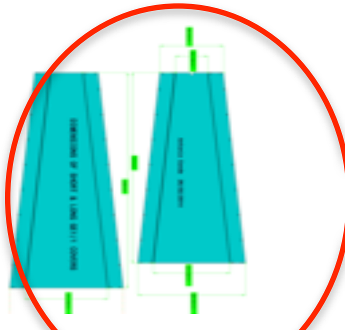
2012



2013



2014



2014/2015

Generation I

The first 1m-class detector ever built but still with spacer ribs and only 8 sectors total

Generation II

First large detector with 24 readout sectors (3x8) and 3/1/2/1 gaps but still with spacers and all glued.

Generation III

The first sans-spacer detector, but with the outer frame still glued to the drift.

Generation IV

First detector with complete mechanical assembly; no more gluing parts together!

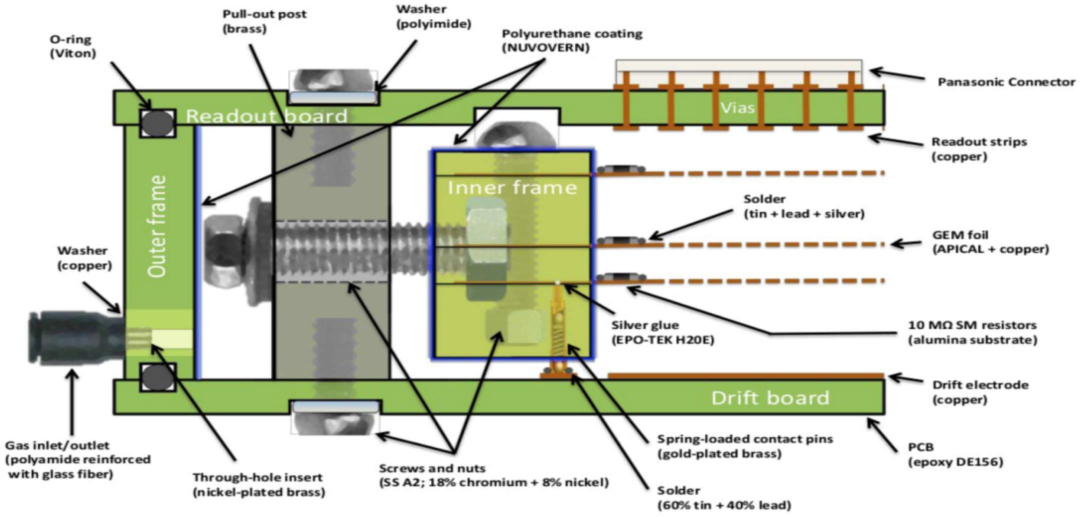
Generation V

Very close to what we will install in CMS. Features re-designed stretching apparatus that is now totally inside gas volume.

Generation VI

Latest detector design; **what we will install in CMS.** Optimized final dimensions for maximum acceptance and final eta segmentation. **Ongoing test beam campaign for DAQ chain stress test.**

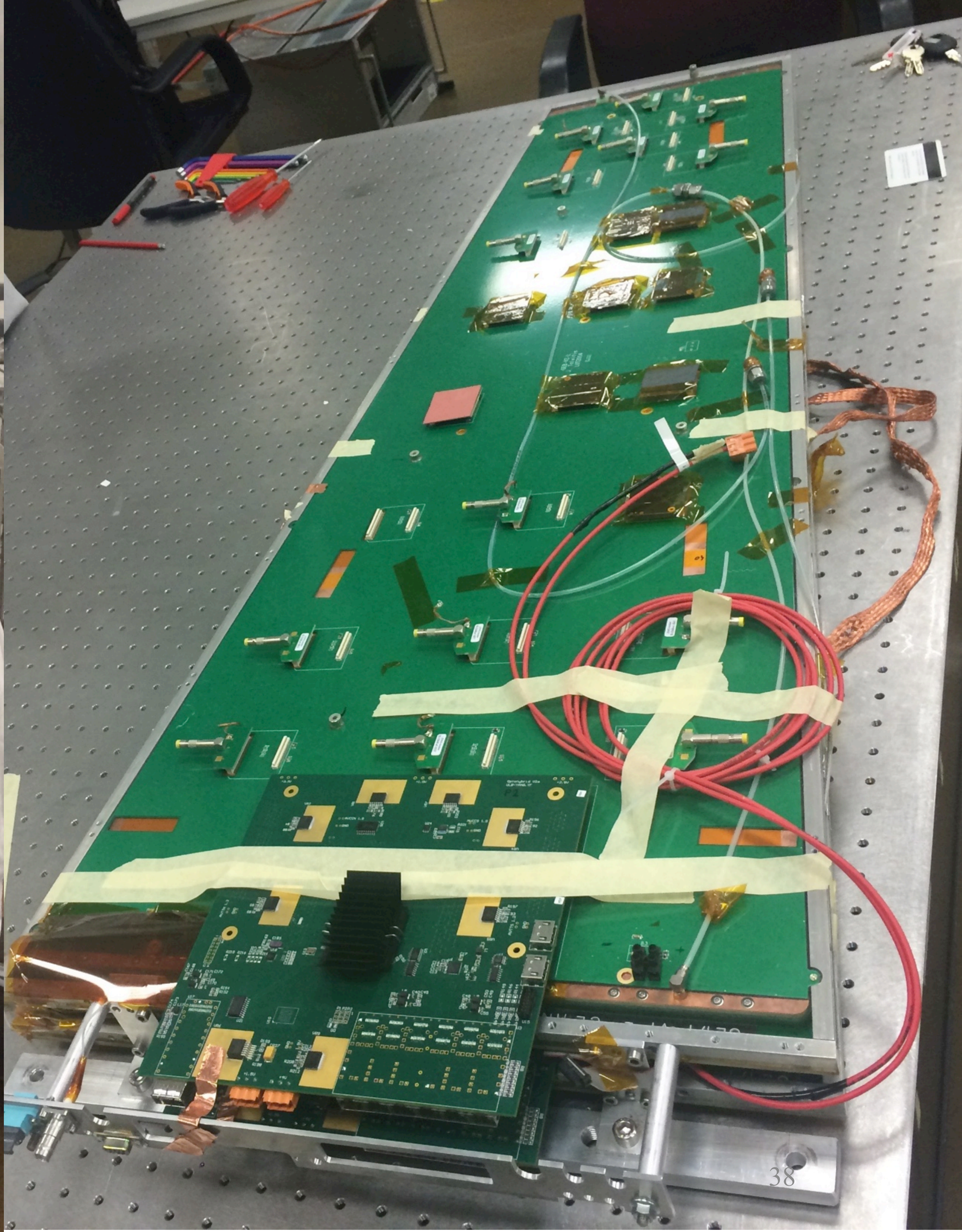
Cross section through inner and outer frames and GEM foils



- GEM foil production uses single mask technology for wet etching
  - Dramatically reduces foil production costs and allows large sizes to be manufactured
- Performance same as that of double mask
- NS2 assembly technique developed
  - Construction time reduced to few hours

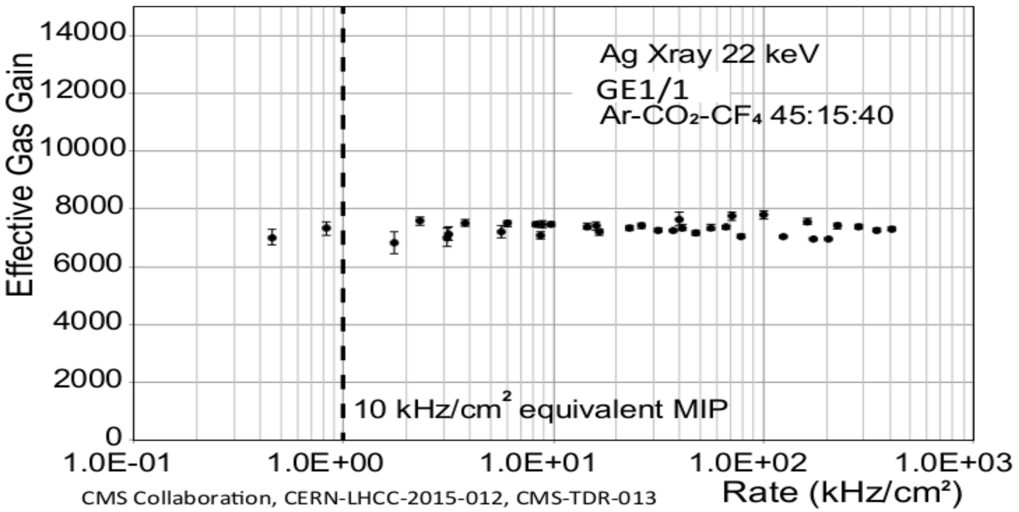
Archana Sharma – Seminar Freiburg
11/11/2015

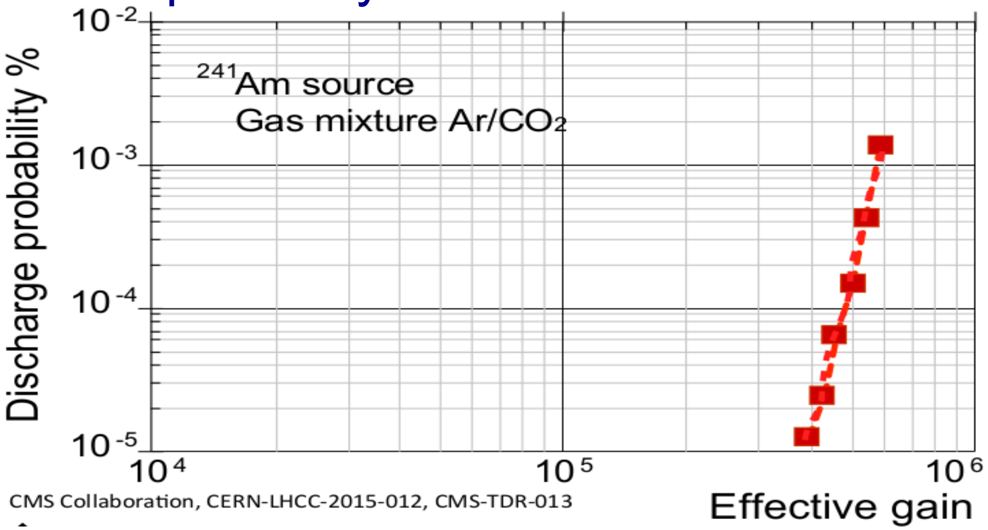
Generation VI - L : CMS GE1/1



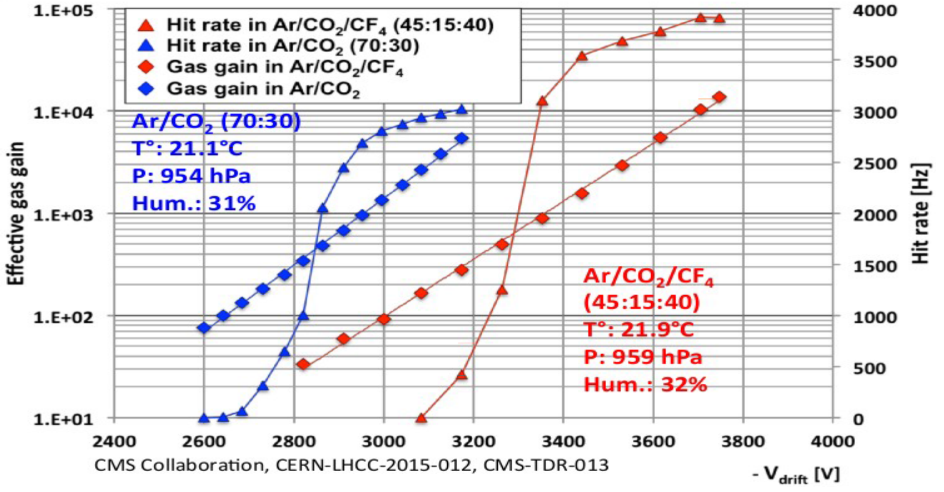
Performance of large prototypes

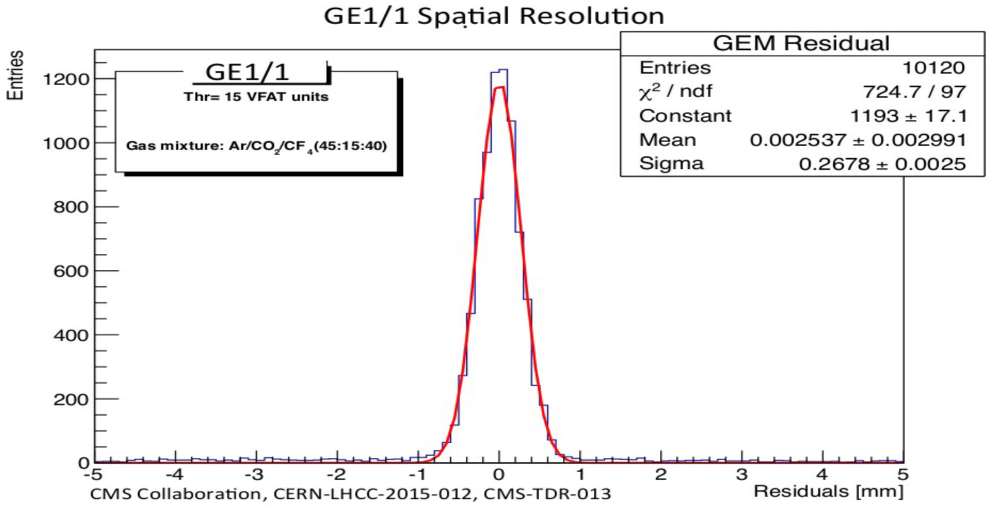
Triple-GEM technology perfectly meets the requirements imposed by the HL-LHC





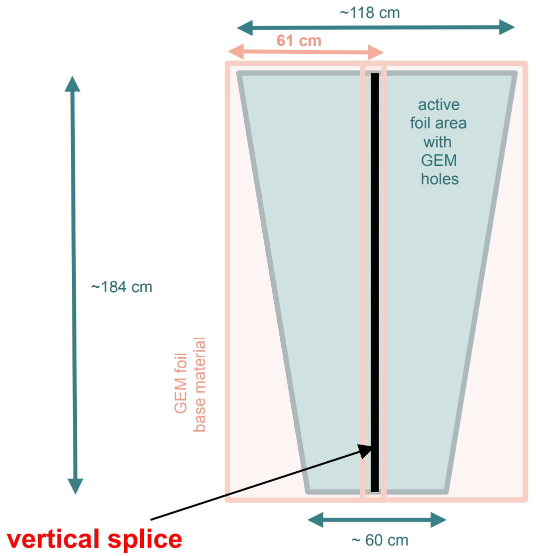
Effective gas gain is constant up to 1e5 kHz/cm^2 with low discharge probability; high spatial resolution





The GE2/1 design

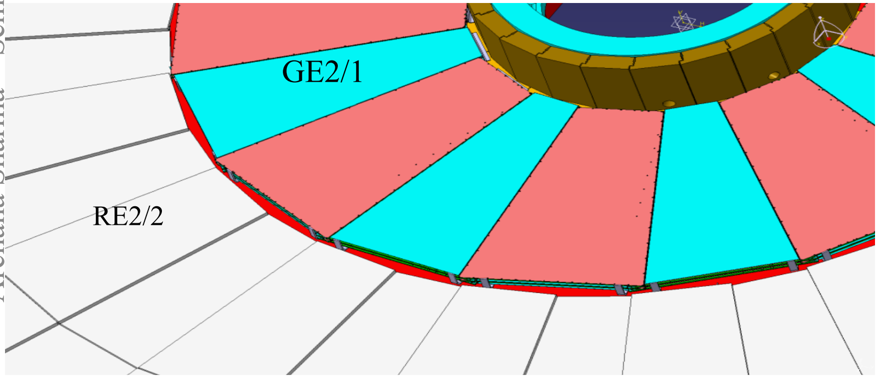
The station GE2/1 consists of 72 triple-GEM chambers arranged in 36 20^0 Super-chamber, covering 1.60<|η|<2.46.



Layout is similar to GE1/1, but covering much larger surface:

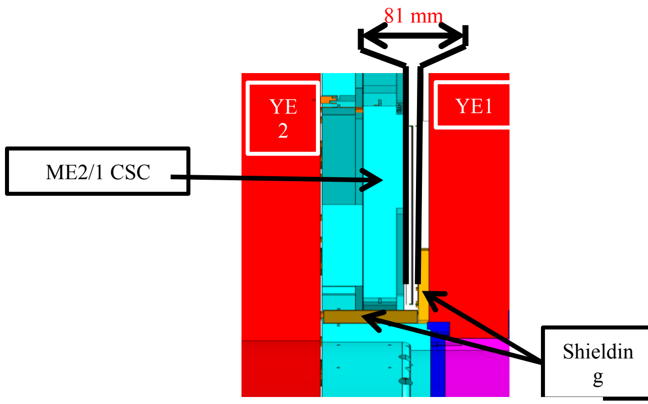
- ✓ largest triple-GEM chamber ever built!

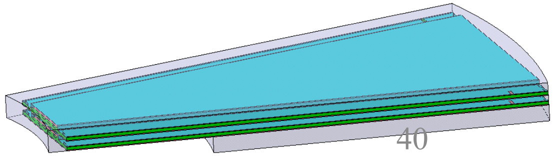
Optimization of engineering design for mass production on-going



Engineering challenges:

- Very thin: only 81 mm width
- need to **splice 2-4 GEM foils** together to build a chamber
- Also considering the 10^0 option





The very forward extension: ME0

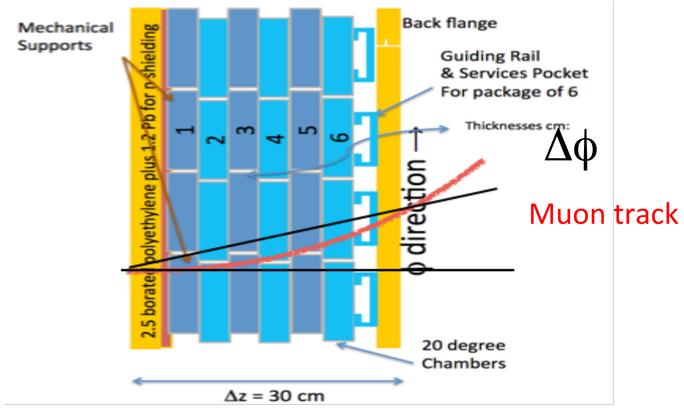
ME0 extends muon coverage behind the new endcap calorimeter to take advantage of the pixel tracking coverage extension for efficient muon ID with low background.

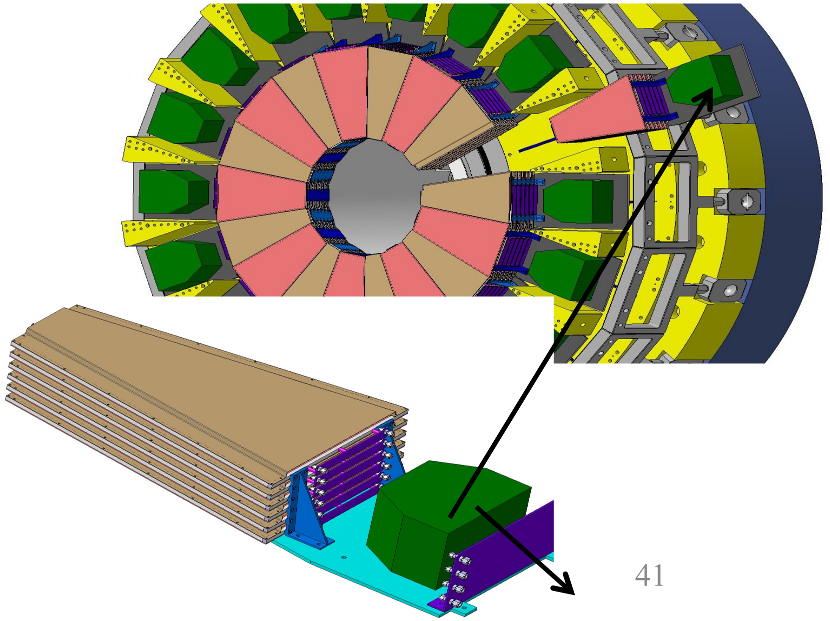
⇒ high granularity and spatial segmentation to allow:

- Pt assignment through Df measurement
- to improve pile-up rejection

⇒ Multi-layered structure:

- improve local muon track reconstruction
- discriminate muon (segment) against neutrons (uncorr hits).
- precision timing
  - ✓ Object reconstruction
  - ✓ Reduce in-time PU and help in vertex association





ME0 baseline layout consists of 216 triple-GEM chambers arranged in 36 20^0 super-module wedge each consist 6 layers of triple GEMs, covering $2<|\eta|<3$

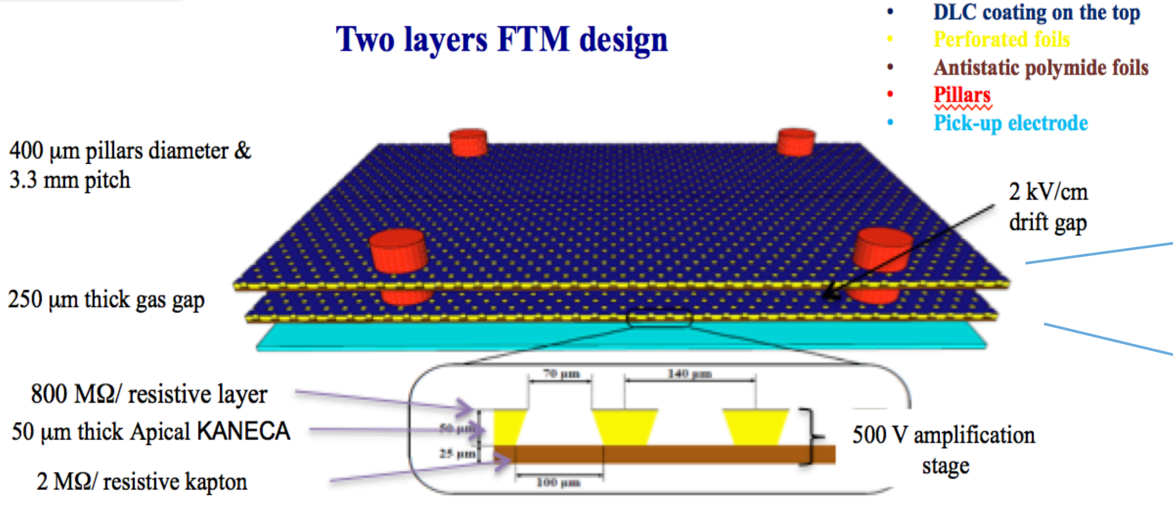
Also R&D on-going on novel MPGD architectures

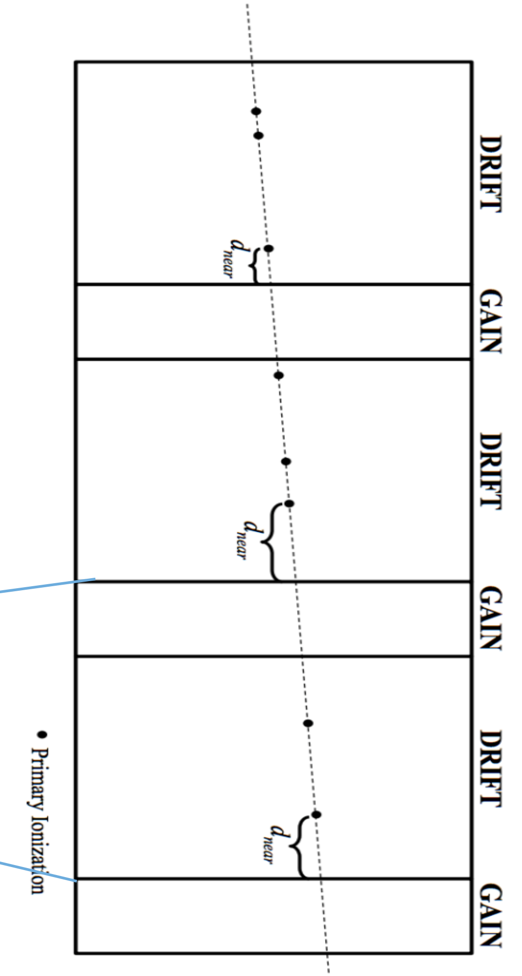
Novelties developments

R&D on Fast Timing Micro-pattern gaseous detector (FTM), Multi-gap of drift and full resistive WELL amplification stages:

- The overall structure is spark free and **transparent** to the signal
  →Signals picked up by the external electrodes;
- **Increase in time resolution** thanks to:
  - Competition of ionization processes in different drift volumes
  - Decrease of the arrival time of the nearest ionization to any multiplication volume
  - Decrease in the fluctuations

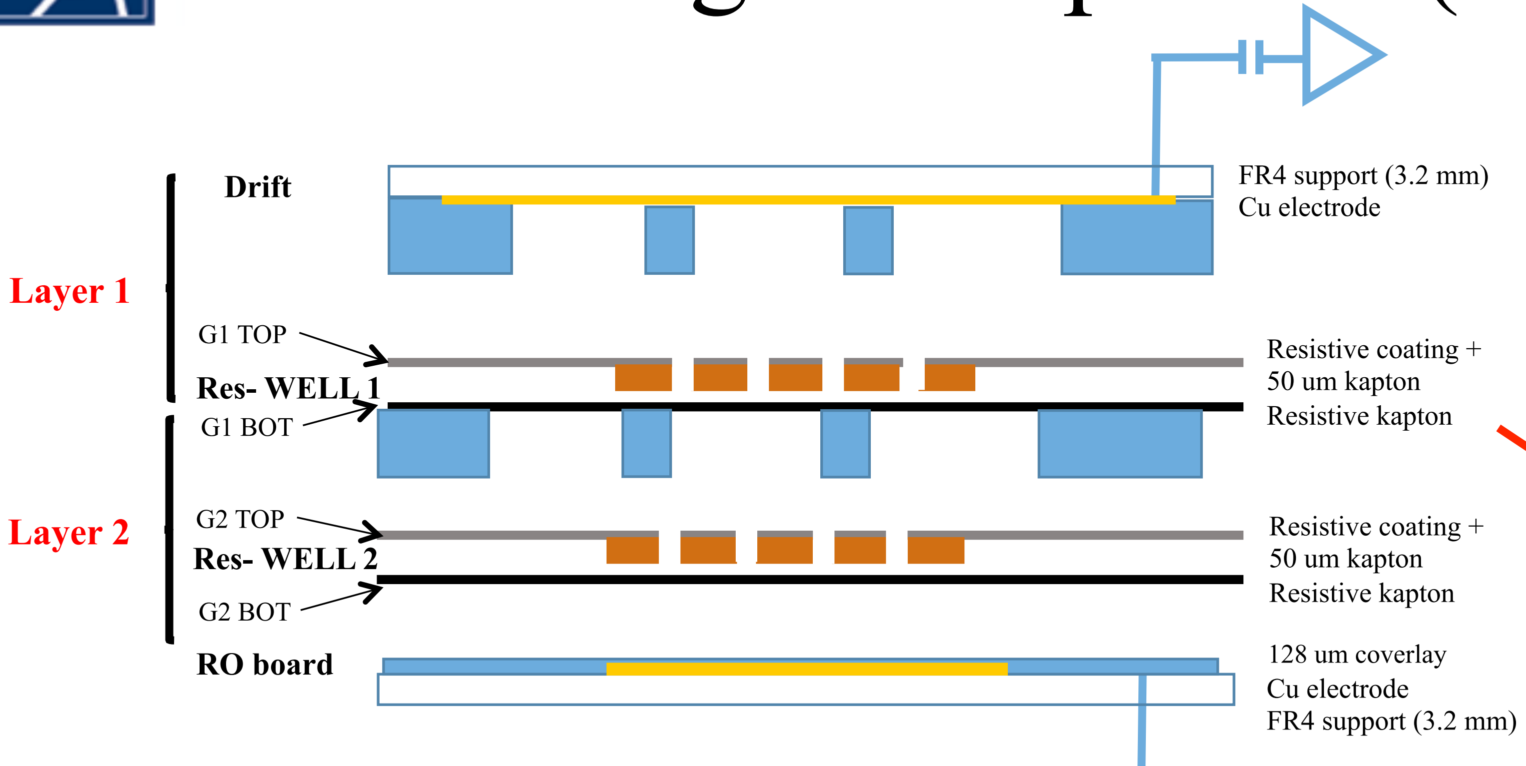
by R. De Olivera, M.Maggi, A.Sharma





Test beam on-going at CERN H4 beam line

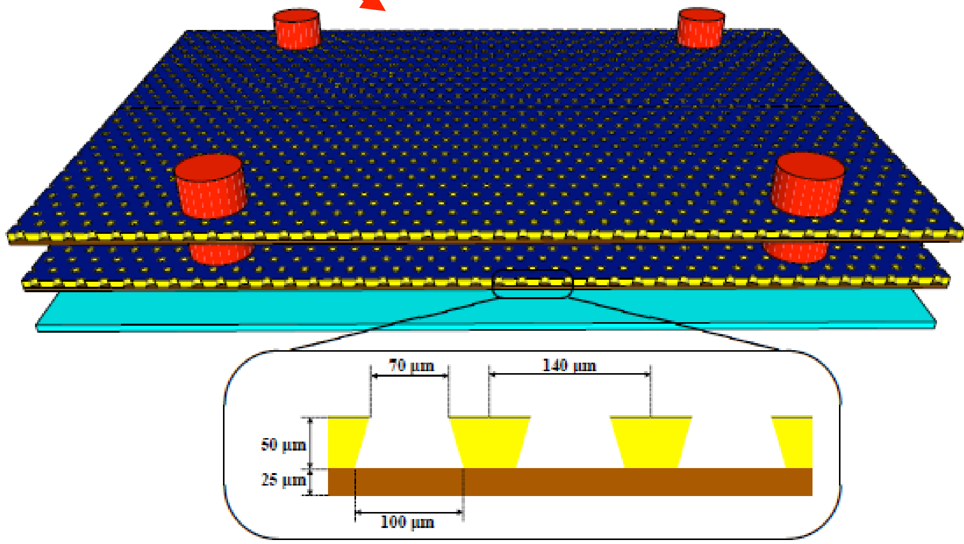
Fast Timing Micropattern (FTM) detector



Two independent drift-amplification stages (Layer 1 & 2 in the picture above)

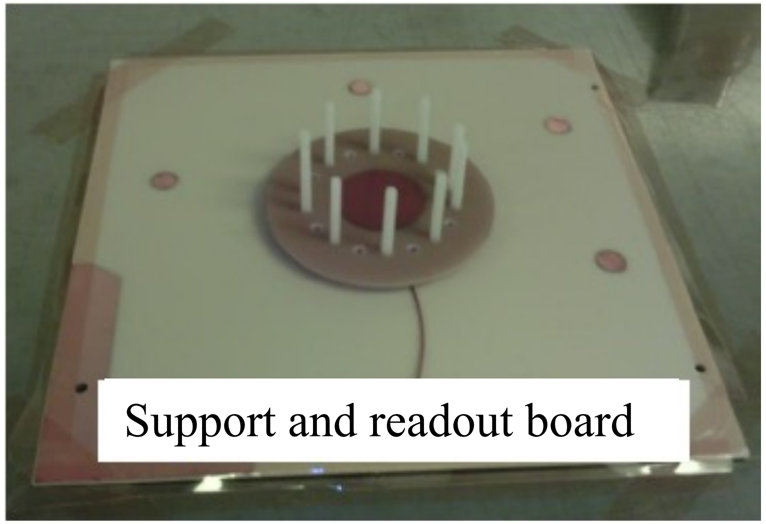
European Patent Application 14200153.6

Reference: arXiv:1503.05330v1

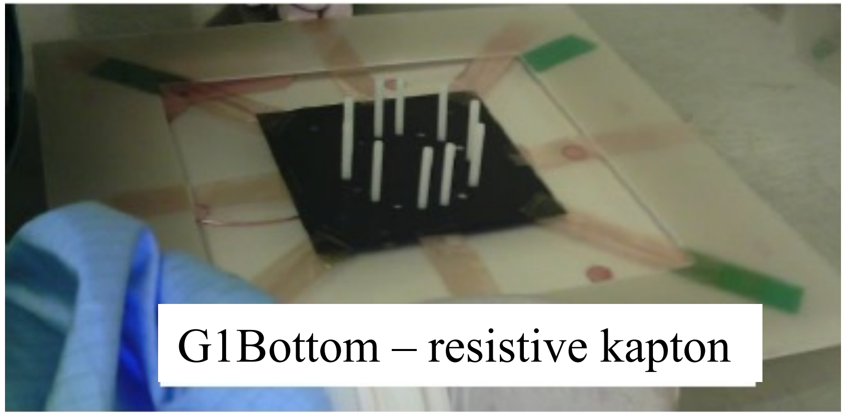


- DLC coating on the top
- Chemical etched foils
- Antistatic polymide foils
- Two layers separated by Pillars
- Pick-up electrode

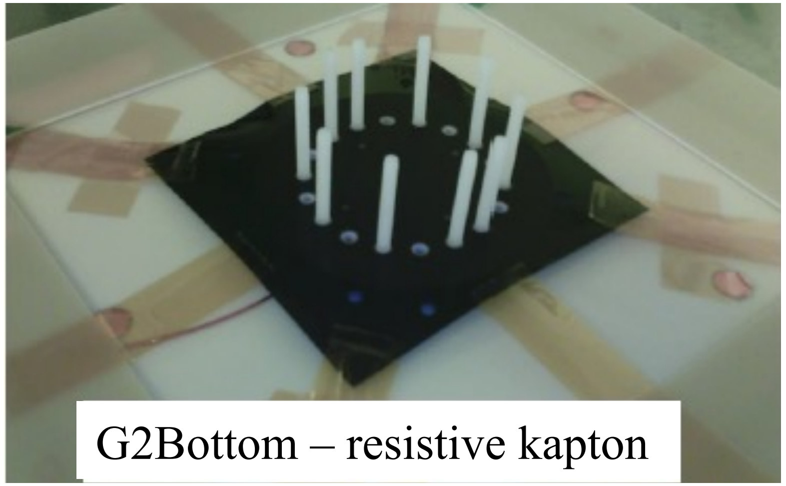
Some pictures of the assembly



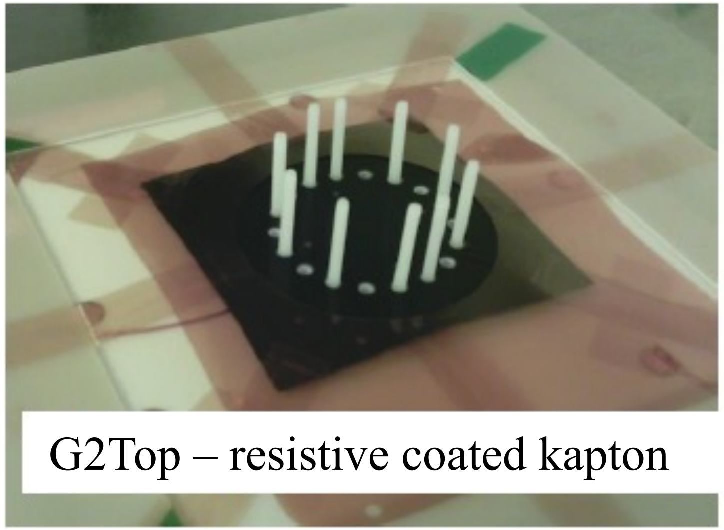
Support and readout board



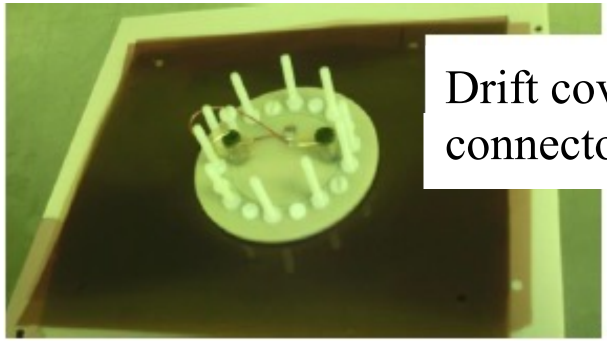
G1Bottom – resistive kapton



G2Bottom – resistive kapton



G2Top – resistive coated kapton



Drift cover and gas connectors

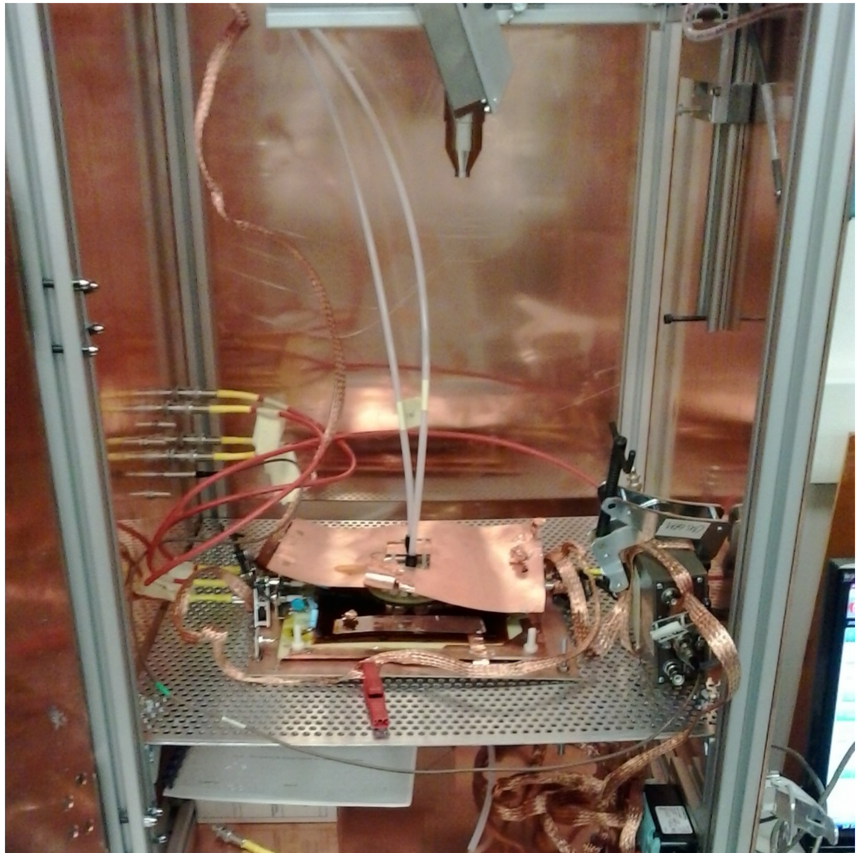
Thanks to Silvia Franchino

Characterization of the detector

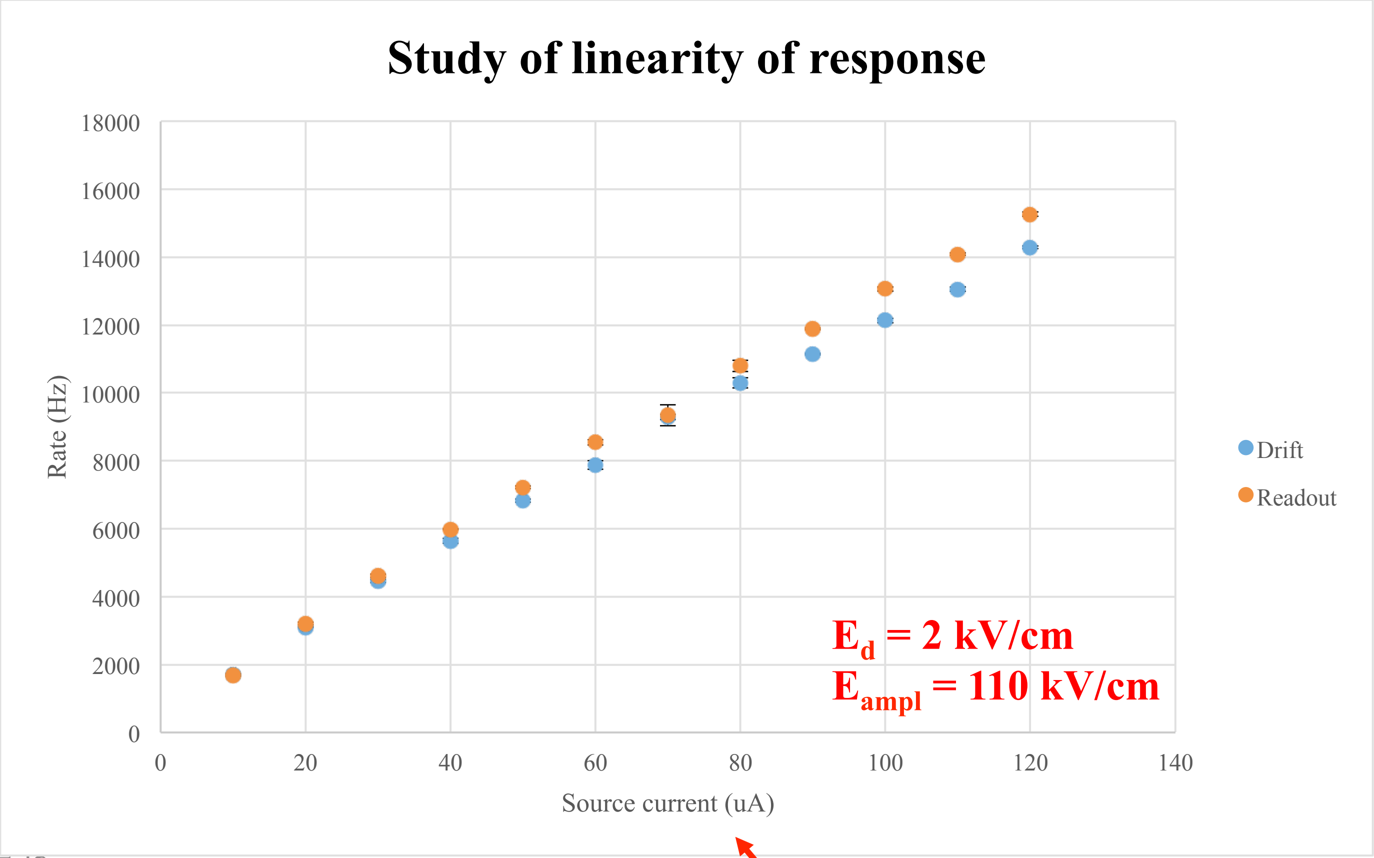
A fully operational testing station has been assembled at the TIF lab at CERN.
The main instrument of this station is a 22 keV X-Ray source (left picture), used for the full characterization of the detector.

The behaviour in different operational conditions has been studied, i.e. different amplification fields, drift fields, incident fluxes, etc..

All the studies have been repeated with two different gas mixtures, Ar/ CO_2 70/30 and Ar/CO_2 97,5/2,5, in order to find the operational conditions.



Some results obtained – Linearity of response



Error bars hidden by the markers.

The aim of this test was to understand if the detector reacts in a **linear way** to the increase of incident particle flux.

This plot, obtained operating just one drift-amplification stage of the detector, shows:

- **Linearity of response** with the incident flux for both data sets, i.e.: signals collected from readout board and drift cathode.
- **Transparency** of the layers → Rates obtained with signals from readout board and drift cathode are comparable

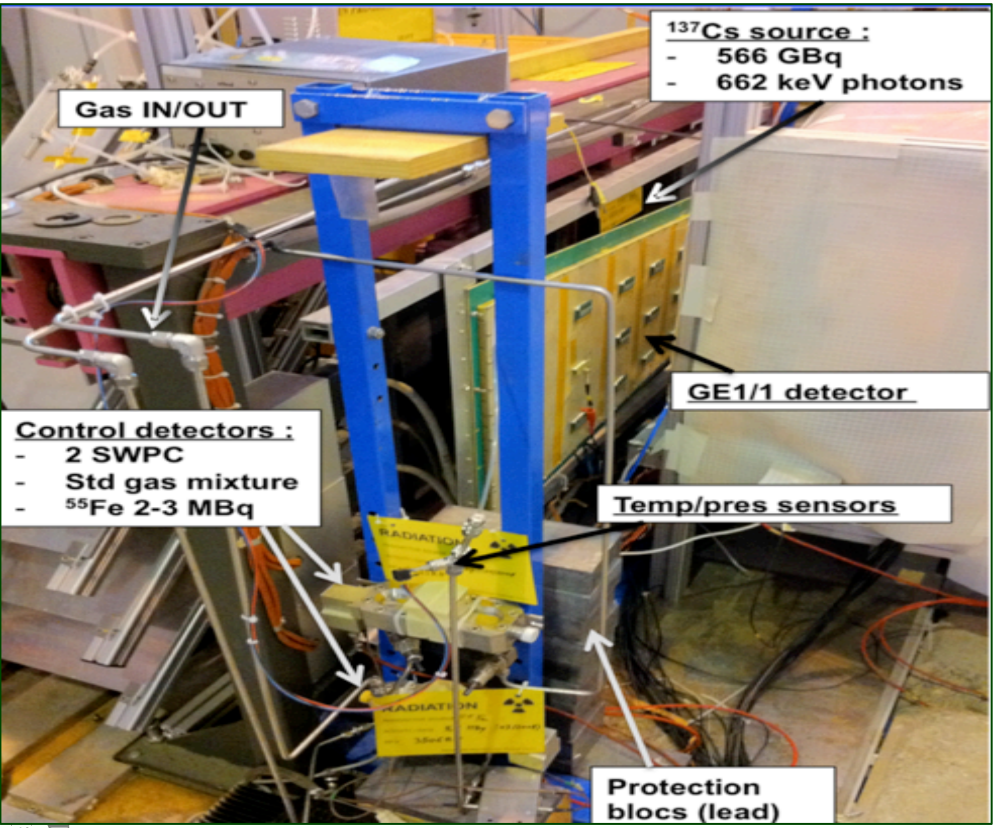
Similar results have been obtained with the other single stage ON and with both the stages ON.

The "source current" is a parameter of the X-Ray source: increasing the current means increase the number of particles emitted

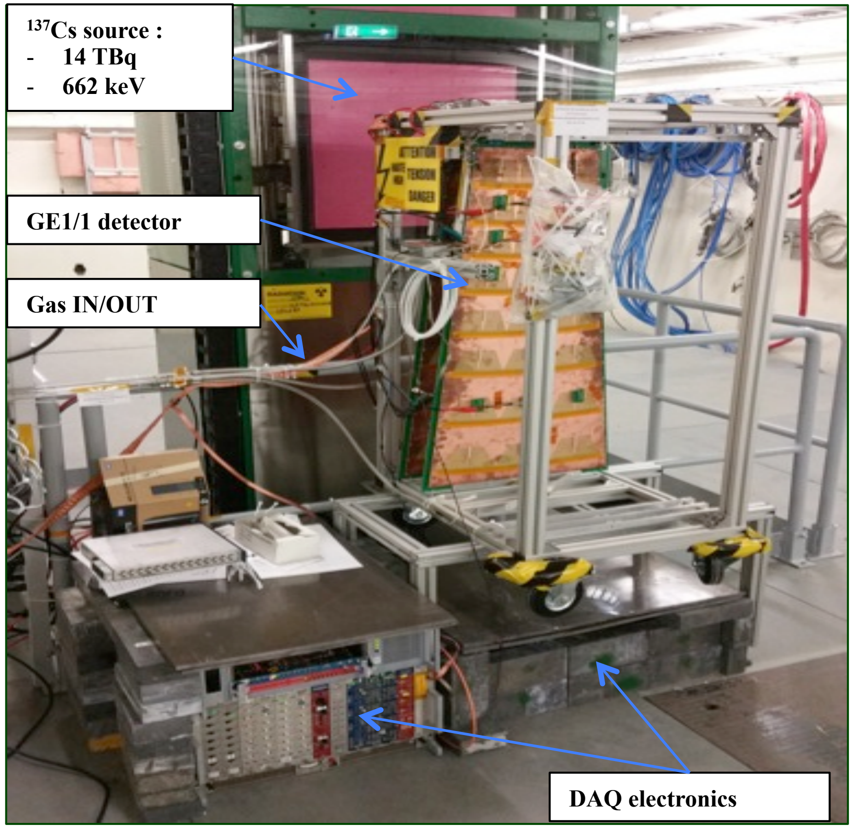
Gas mixture Ar/CO2 70/30
Source: MiniX-Ray Amptek

Gamma Irradiation Facilities

GIF (CERN / Meyrin)



GIF++ (CERN / Prevessin)



Facilities :

***GIF* –**

^{137}Cs – 566 GBq
662 keV photons
DUT : GE1/1-IV
Ar/CO_2/CF_4 (45:15:40)
(@30 cm)

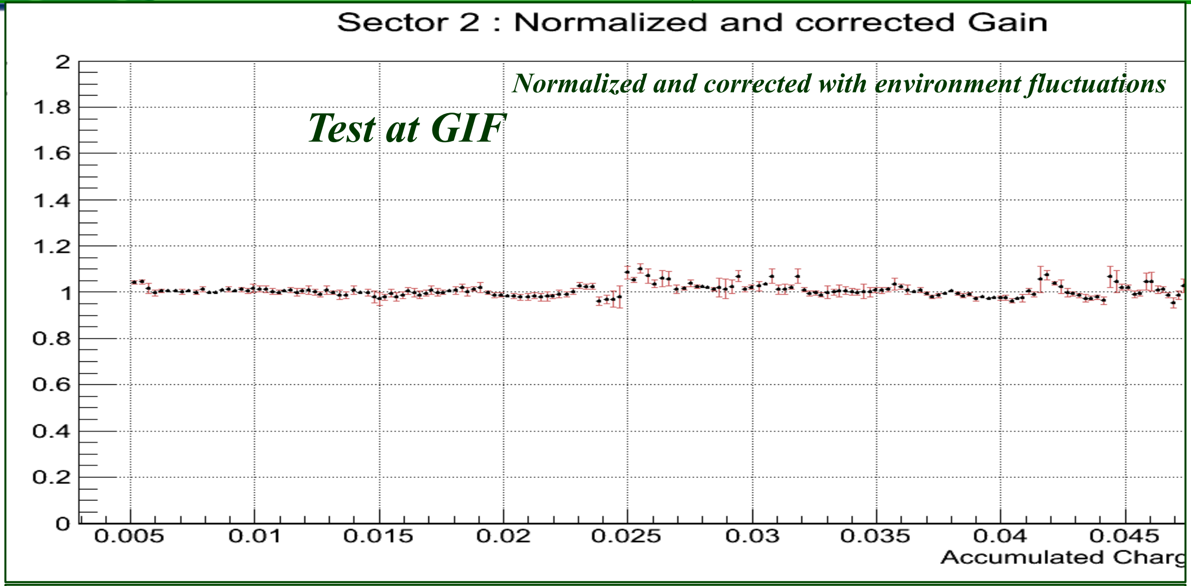
GIF++ –

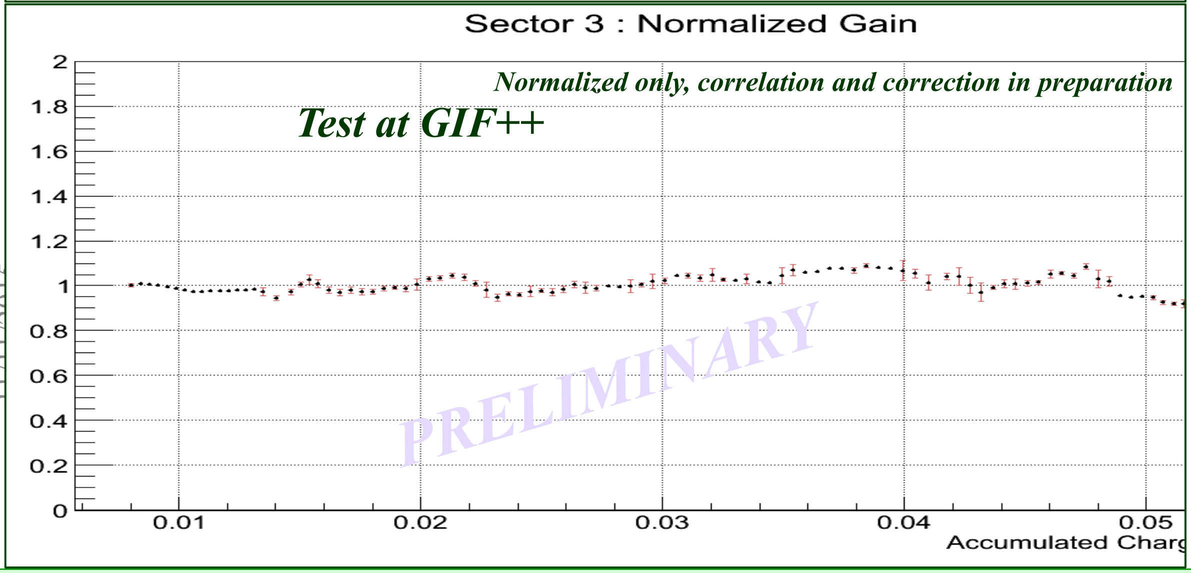
^{137}Cs – 14 TBq
662 keV photons
DUT : GE1/1-IV
Ar/CO_2 (70:30)
(@50 cm)

Aging experiments :

- **Initial study at GIF (7 months) – GE1/1-III → test the setup / extract aging parameter**
- **Aging test at GIF (12 months) // Aging test at GIF++ (6 months) – GE1/1-IVs**

Results





Aging test at GIF :
GE1/1-IV-CERN001 @ gain 2 .10^4
Ar/CO2/CF4 (45:15:40%)
Sector 2 (in front of the source)
12 months of sustained irradiation
Total accumulated charge : 50 mC/cm^2
→ 10 CMS years (HL-LHC)
→ No aging effects observed

Aging test at GIF++ :
GE1/1-IV-CERN002 @ gain 2 .10^4
Ar/CO2 (70:30%)
Sector 3 (in front of the source)
6 months of sustained irradiation
Total accumulated charge : 54 mC/cm^2
→ 11 CMS years (HL-LHC)
→ No aging effects observed

Summary

- Gaseous detectors promise an exciting future at LHC applications
- Moving from few 1000s to 10,000 m^2
- Lot of room for new developments for future (FCC, CLIC, ILC) Projects !

Thank you for your attention