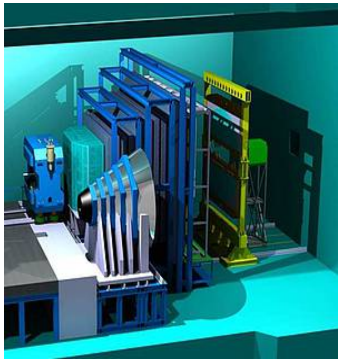

# Large Area GEM Chambers for Muon Tracking in CBM Experiment at FAIR

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VECC
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(CBM Collaboration)

# Plan of Talk:

1. Brief discussion of CBM Experiment.

2. GEM Chamber fabrication and testing

    a) Small Size GEM Chambers

    b) Real Size Prototype Chambers

3. Test Results
    -- validating the design criteria
        -- rate capability and high efficency
    -- Gain stability with time

4. Outlook and Summary

# The Compressed Baryonic Matter Experiment (CBM)@FAIR

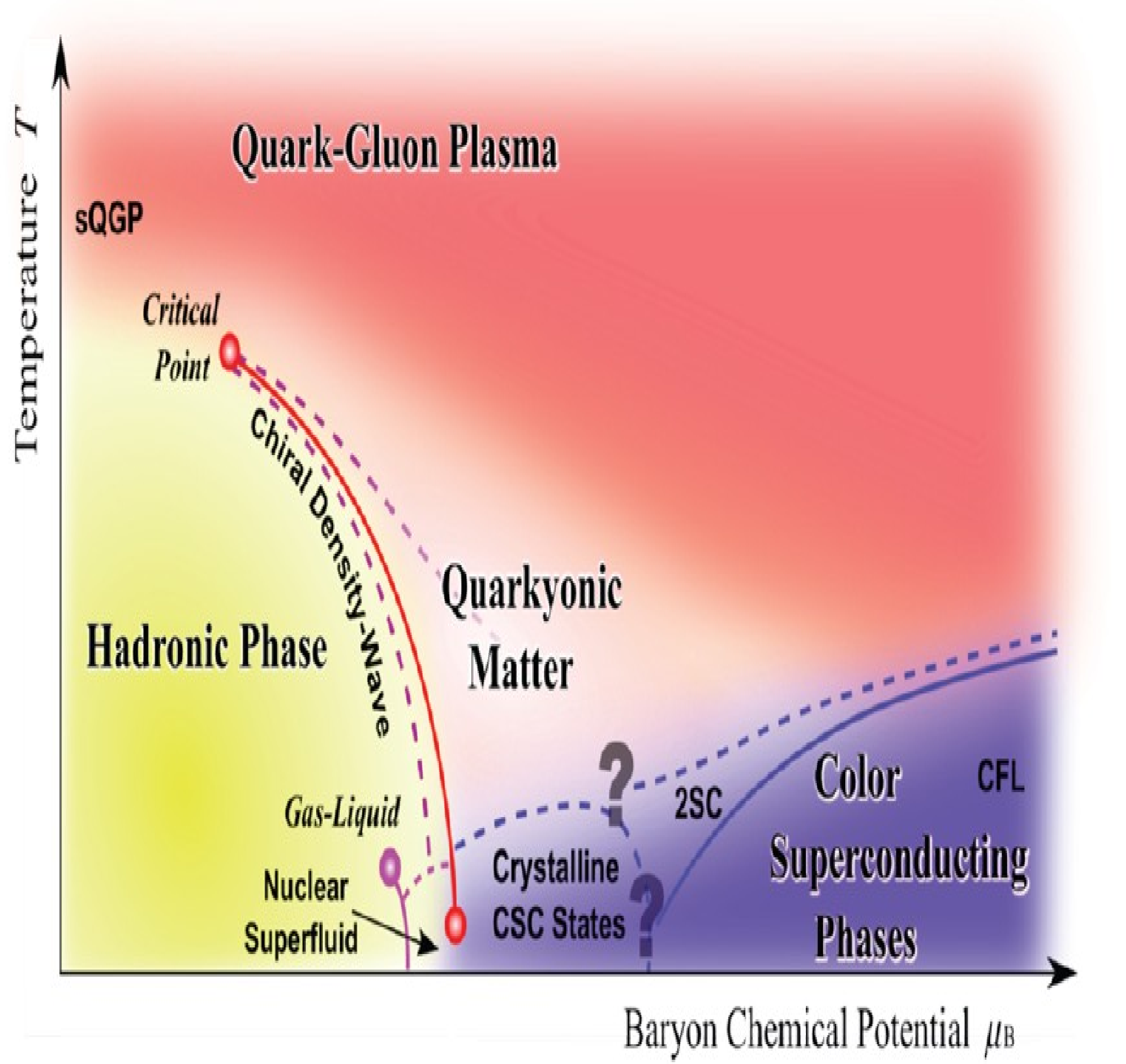
- Fix target heavy ion experiment
- Energy range 2-45 AGeV

## CBM physics program

- Equation of state at high baryonic density
- Deconfinement phase transition
- Chiral symetry restoration

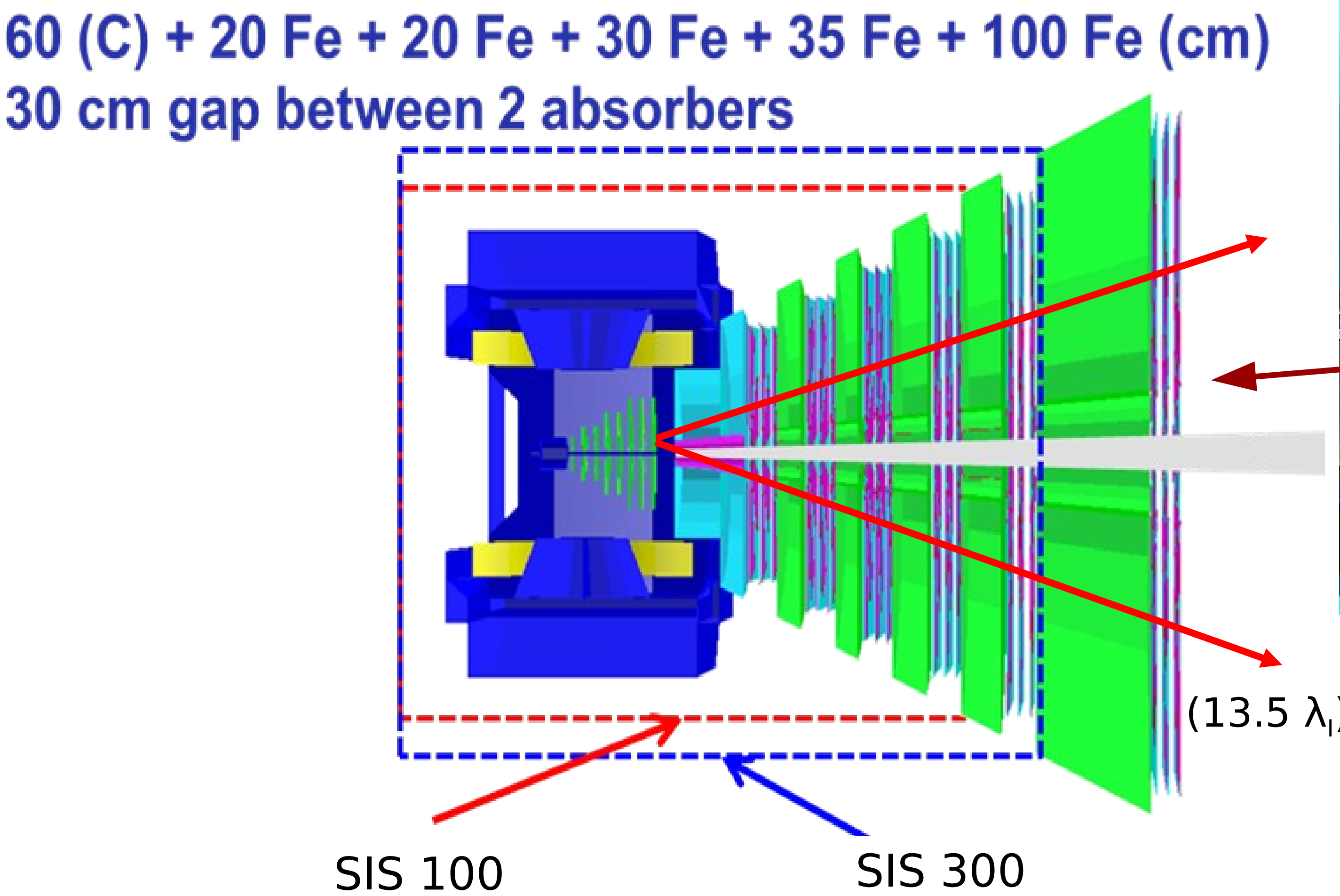
## Diagnostic probes

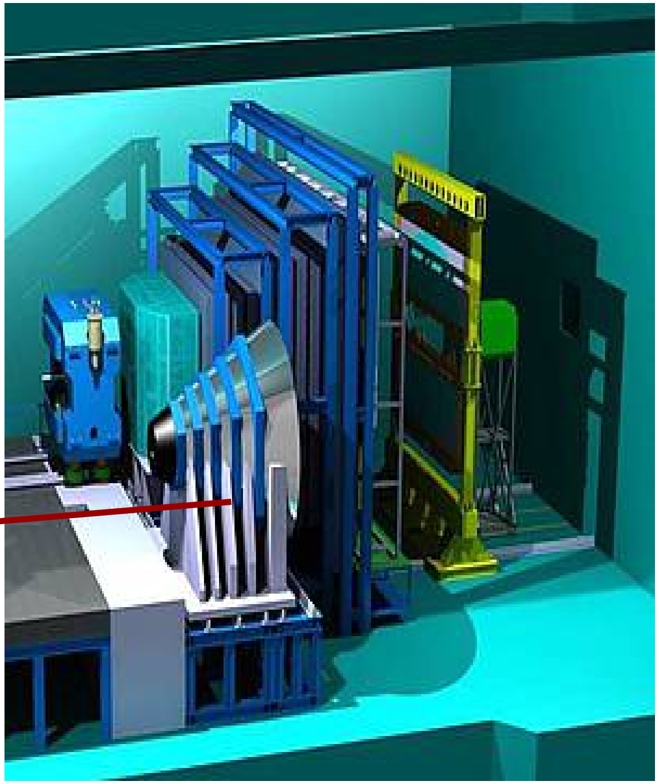
- Open charm, charmonia
- Low-mass vector mesons
- Multistage hyperons
- Flow, fluctuations and correlations



# Muon Chamber (MUCH) system

**Aim: to detect dimuon signals from low mass vector mesons and J/y**



# The Dileptons

- Dilepton pairs emitted in energetic heavy-ion collisions provide valuable information on the evolution and on the properties of the hot and dense fireball.

- Comparison of charmonium yields measured in proton-nucleus and nucleus-nucleus collisions has led to the observation of an anomalous dissociation of charmonium in central collisions of heavy nuclei which was explained by color screening in the quark-gluon phase.

- Till today, this observation still has remained one of the most convincing experimental facts hinting towards the existence of partonic degrees of freedom in the fireball at top SPS energies.

- The dilepton measurements at the CERN-SPS have been performed mainly at 158 A GeV, except for one spectrum taken in Pb+ Au at 40 A GeV by the CERES collaboration where even an increased excess yield has been observed

- A systematic beam energy scan in order to search for the onset of in-medium mass modifications of vector mesons or for partonic contributions to the dilepton yield has not been performed yet.

- **With the dilepton measurements in heavy-ion collisions at FAIR energies the CBM collaboration will open a new era of dilepton experiments in the energy range between 2 and 40 A GeV where the highest net- baryon densities can be created in the laboratory,**

- **no dileptons have been measured in heavy ion collisions at these energies.**
-
- The CBM collaboration will systematically measure both dielectrons and dimuons in p+p, p+A and A+A collisions as function of beam energy and size of the collision system.

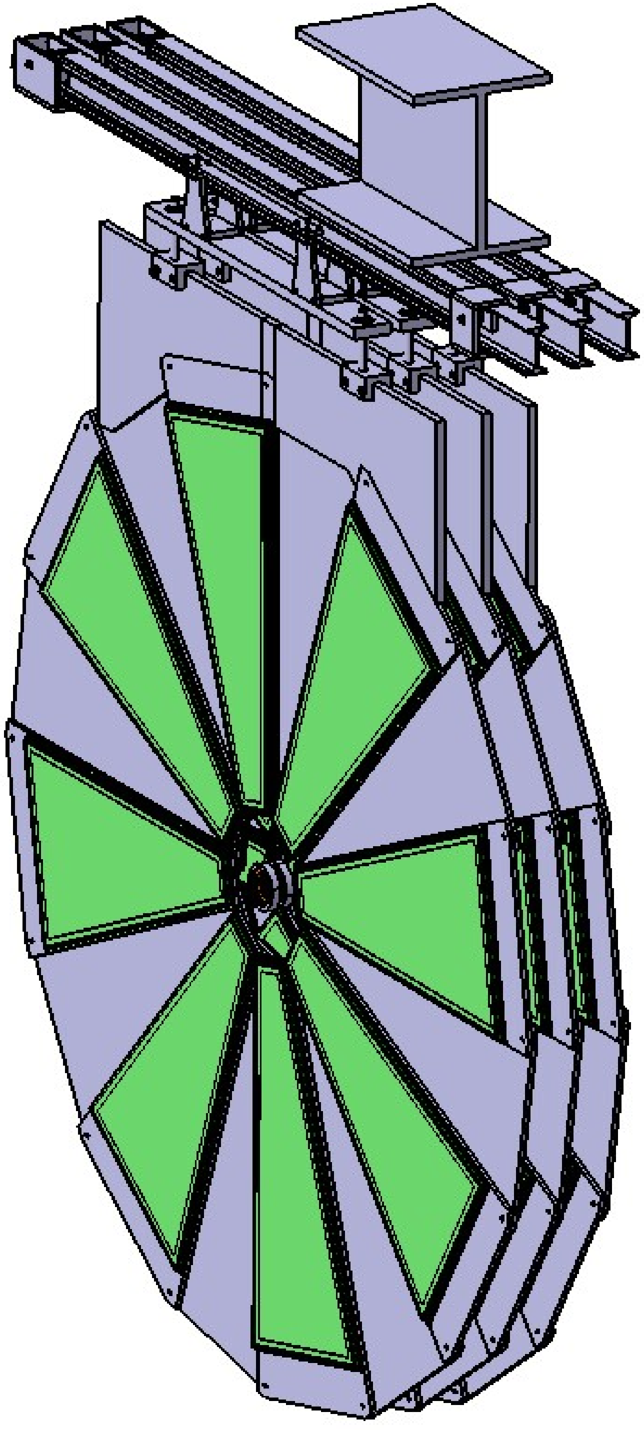
- **The dielectron and dimuon high-precision data will complement each other, and will provide a complete picture on dilepton radiation off dense baryonic matter. Also gamma conversion contamination is largely suppressed in case of dimuons.**

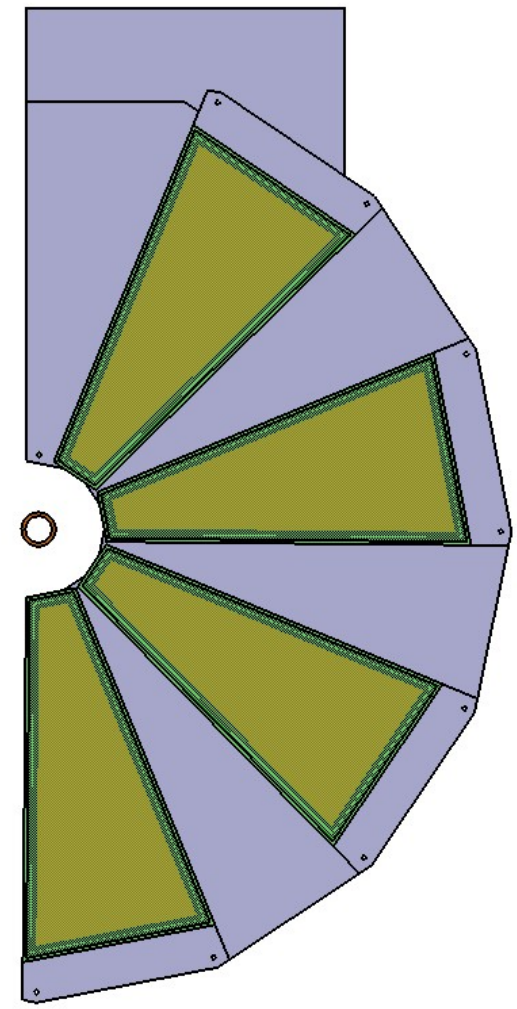
# Challenges in Muon detection

## Main issues:

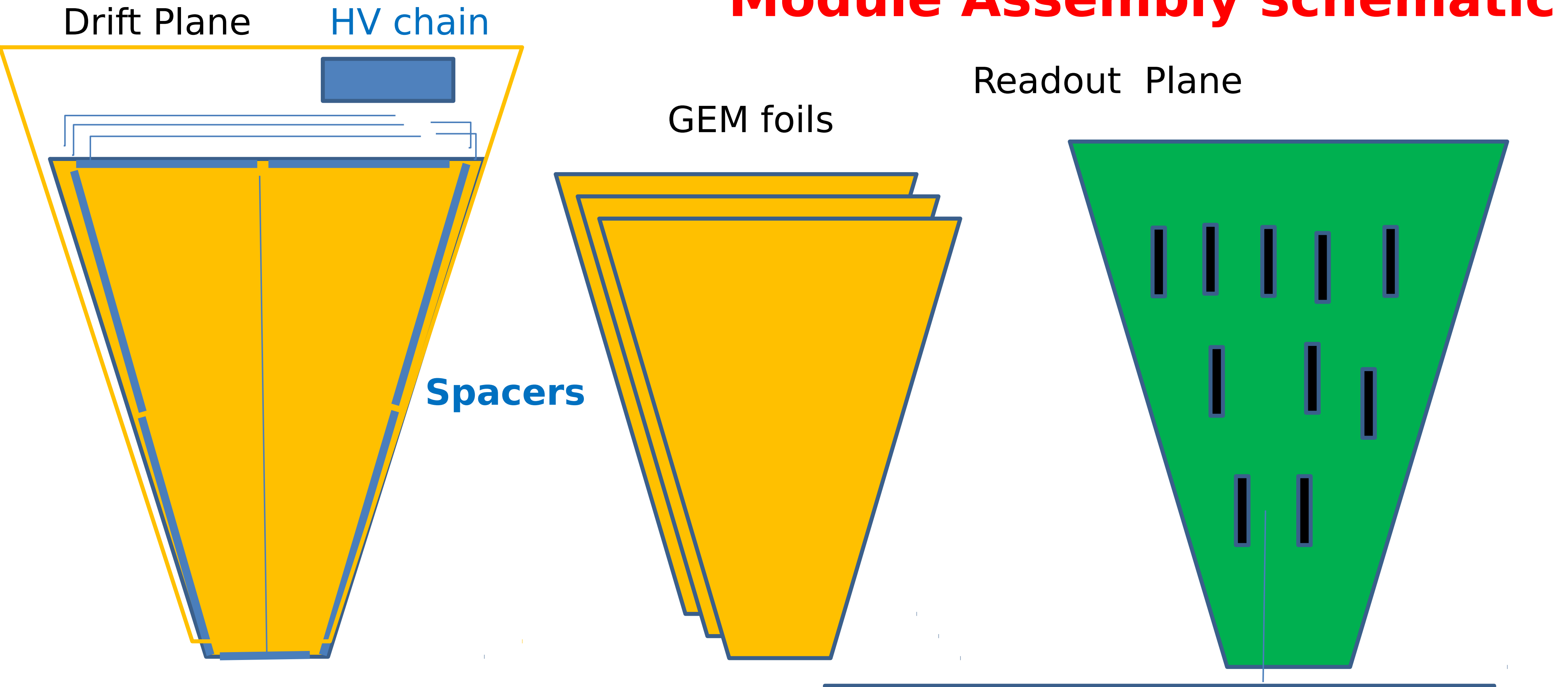
- High collision rates ~ 10 MHz
- The first plane(s) have a high density of tracks
  High granularity in the inner region ~ average hit rate is about **0.4 hit/cm²/event**
- Should be radiation resistant –
  high neutron dose  ~$10^{13}$ n.eq./sq.cm/year
- Large area detector – with modular arrangement
- Data to be readout in a self triggered mode
  -- a must for all CBM detectors.
  -- and event reconstructed offline by grouping
  the timestamps of the detector hits.

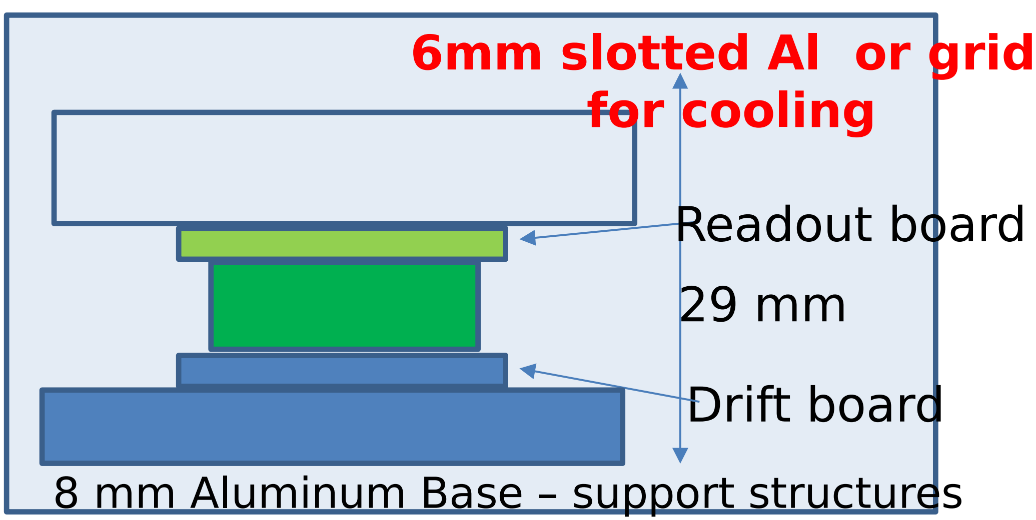
# Mounting Scheme

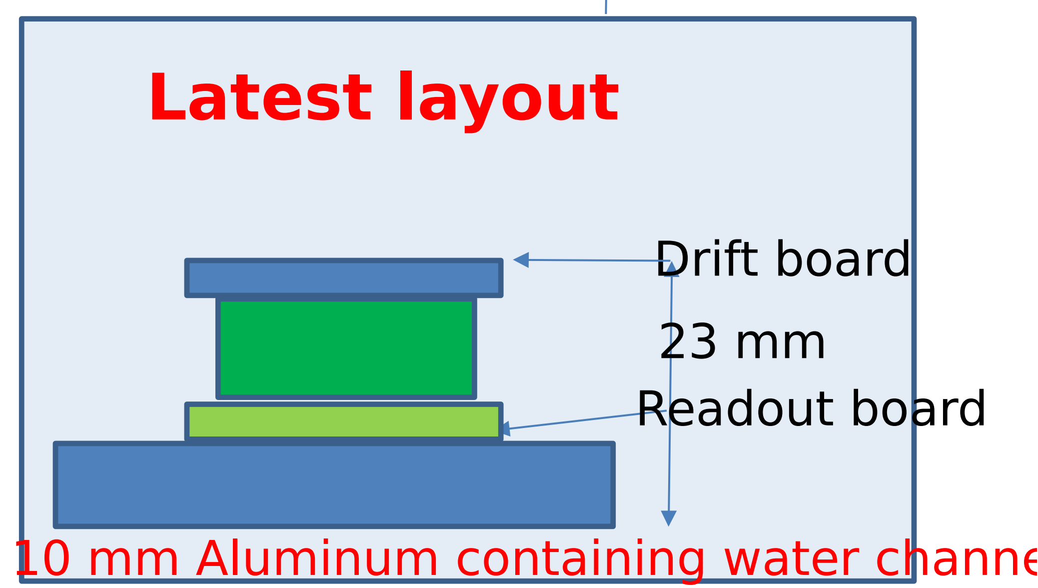




# Module Assembly schematic



# Building trapezoidal shaped triple GEM modules

**--- Trapezoidal shaped as per realisitic dimemntion**
**--- We have built two such real size prototype GEM chambers.**

**--- First one assembled at RD51 lab CERN**
**--- Second one built at VECC.**
**--- The chambers were tested with Fe55 Source as well as particle beam at COSY.**

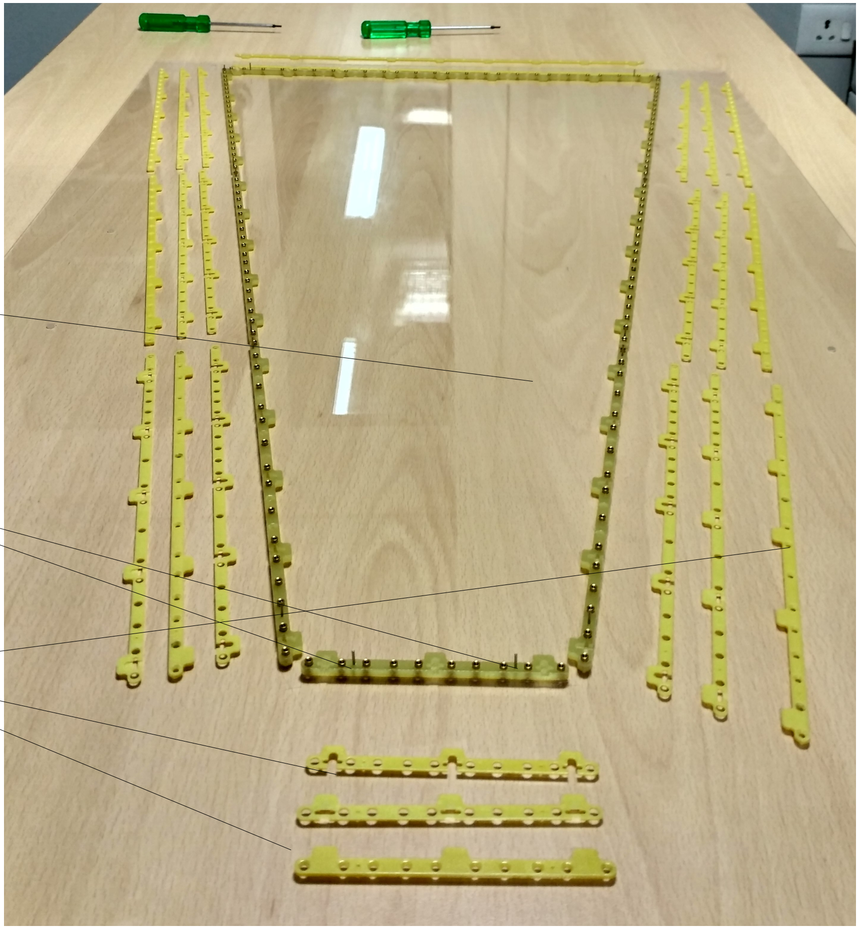
**Fabrication**

- Gem Foil
- Readout PCB
- Drift PCB
- Inner Frame
- Edge Frame

# Real Size fabrication at VECC

## Using “NS2” technique

## This procedure is followed by CMS collaboration as well



Base

Alignment pins

Spacers

**This shows the base where we put GEM foils and spacers one by one.**

**Gap configuration 3 mm / 1 mm / 1 mm / 1.5 mm**

# Real Size fabrication at VECC

**A.** Dimension of chamber of active area:

1. Inner side : 100.25 mm ( max = 153 mm)
2. Outer side : 382 mm ( max = 492 mm)
3. length : 708 mm ( max = 844 mm)

**B.** Dimension of readout pads:

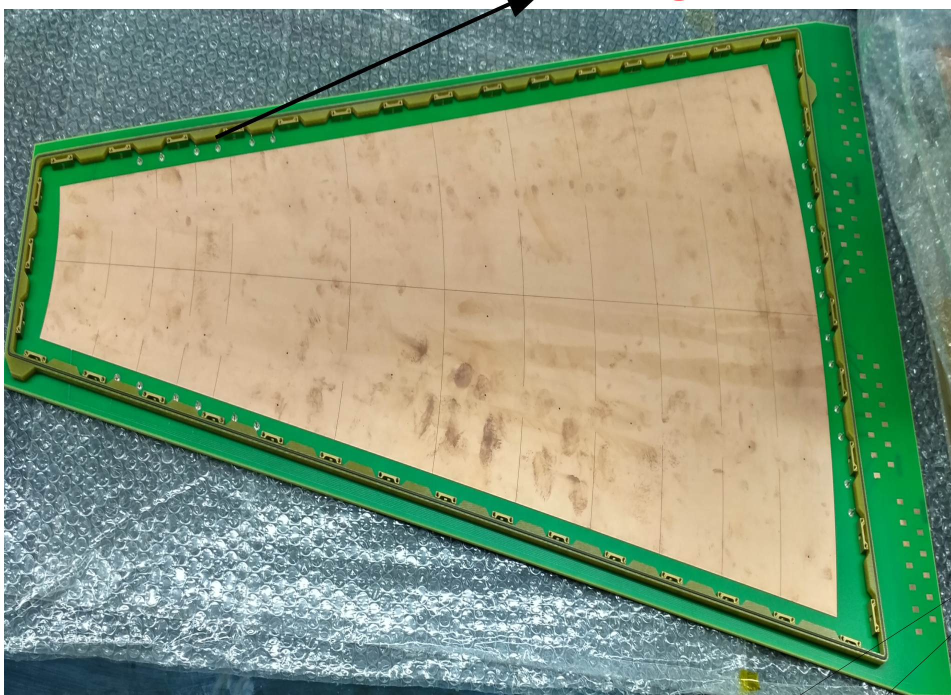
1817 pads with projective geometry

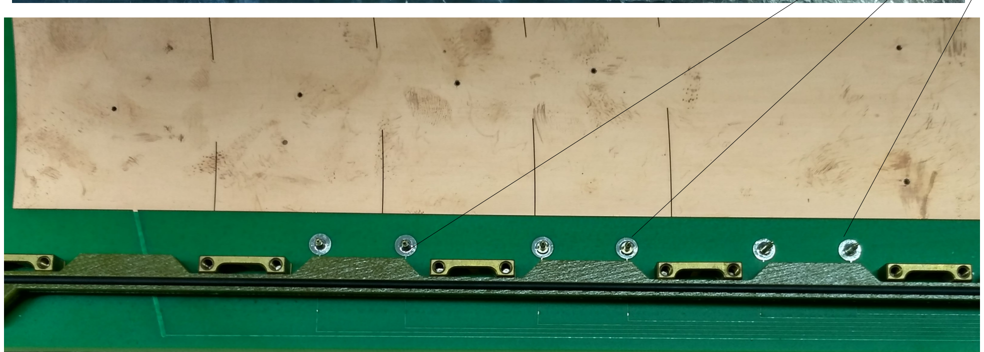
Pad size varies from 4.36 mm to 17.56 mm

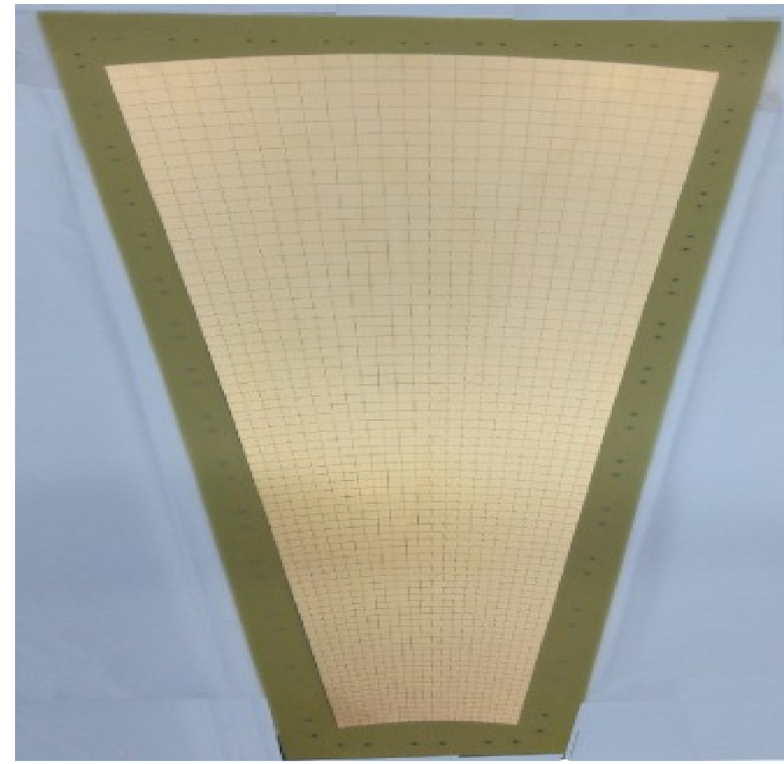
Drift PCB

O-ring

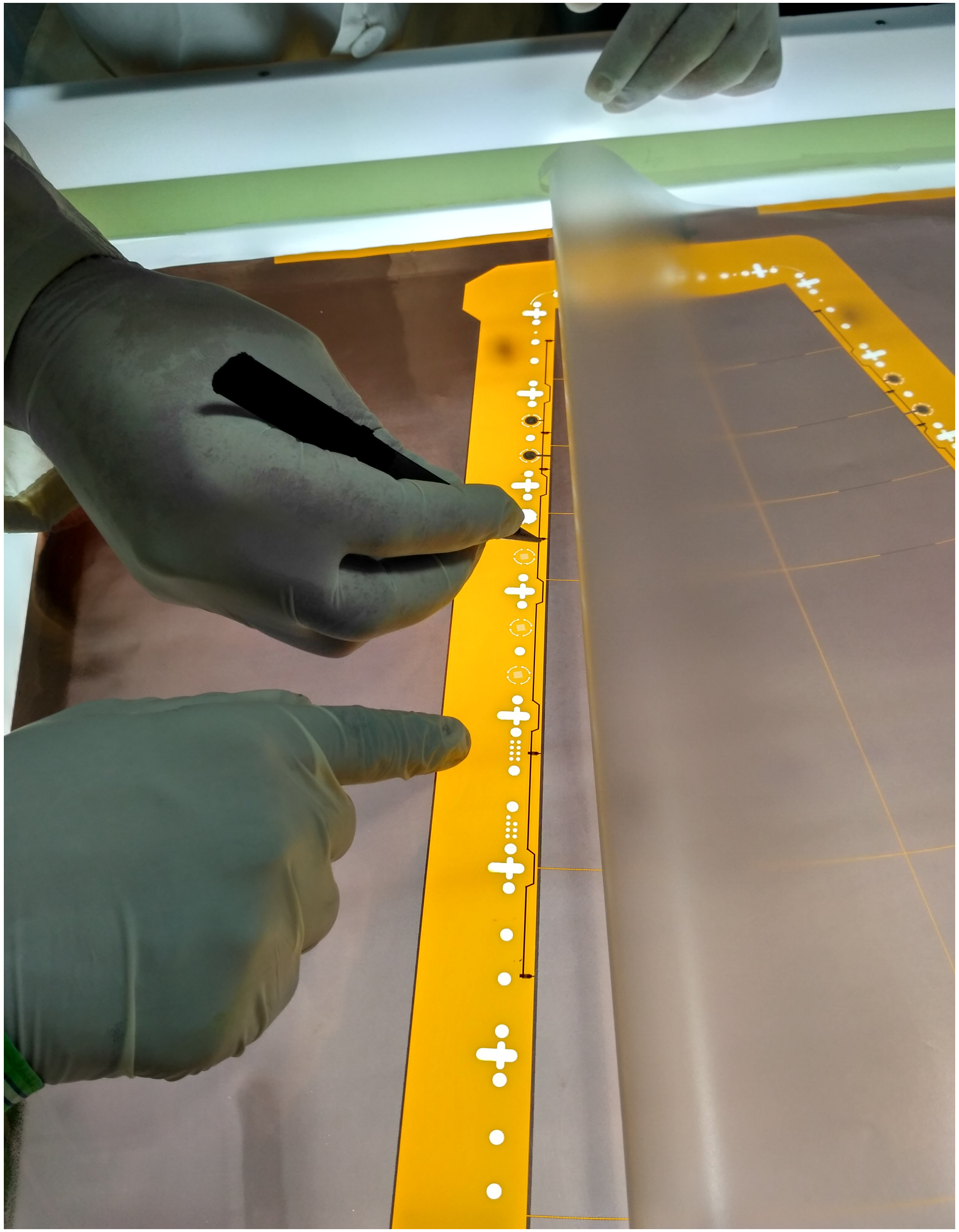
Spring contacts drift PCB

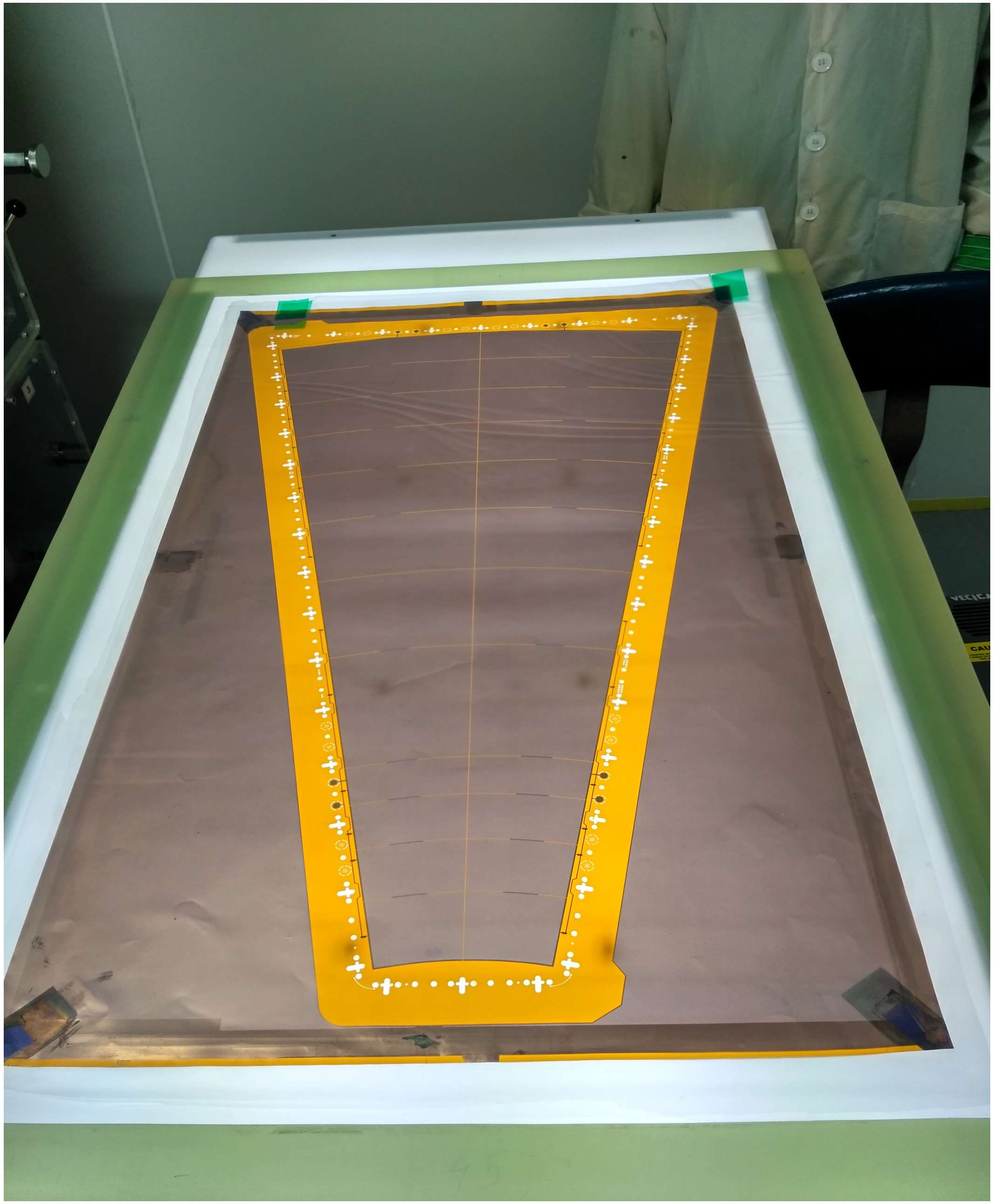


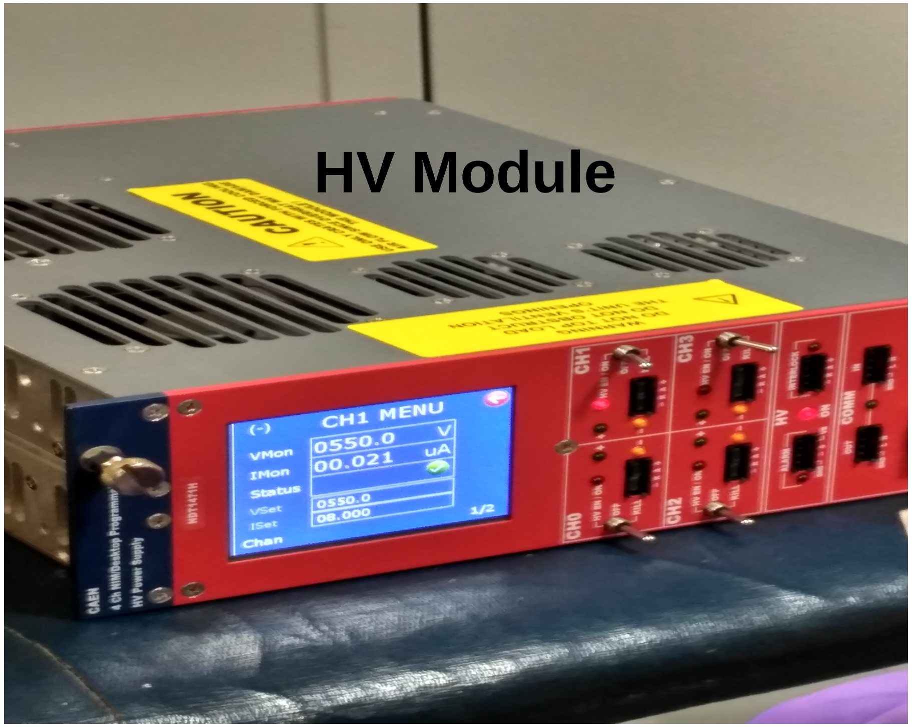




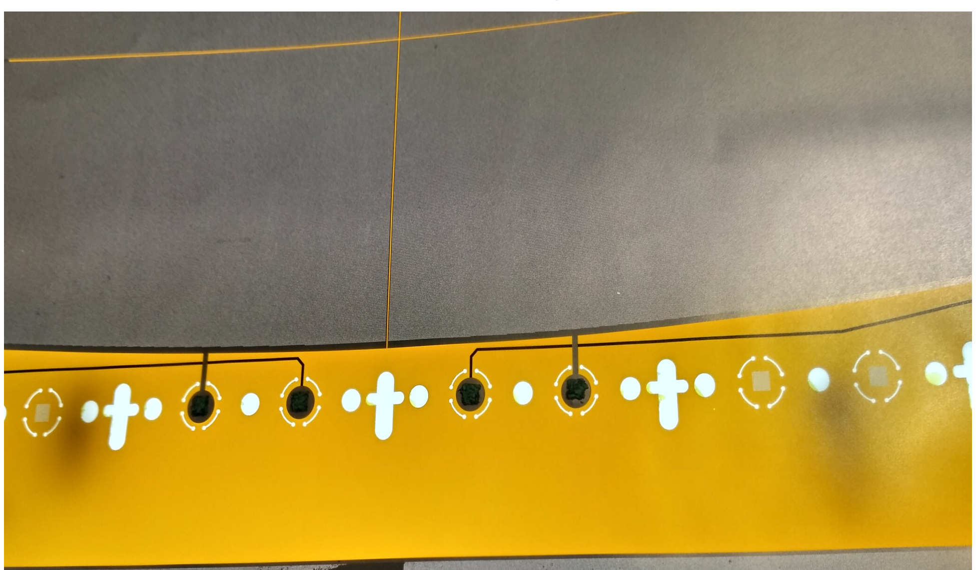
# Inspecting GEM foil on a transluminiscent box



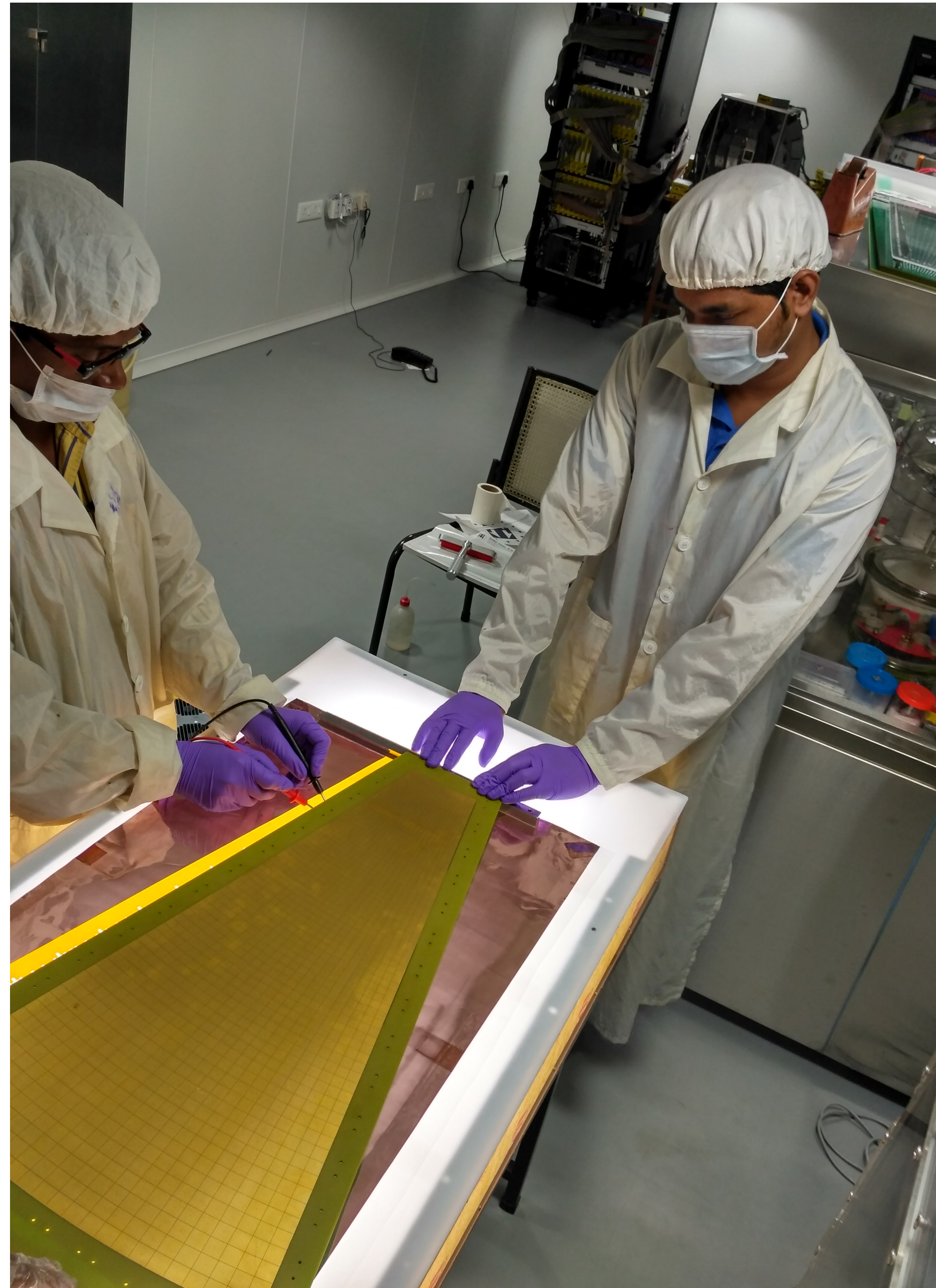


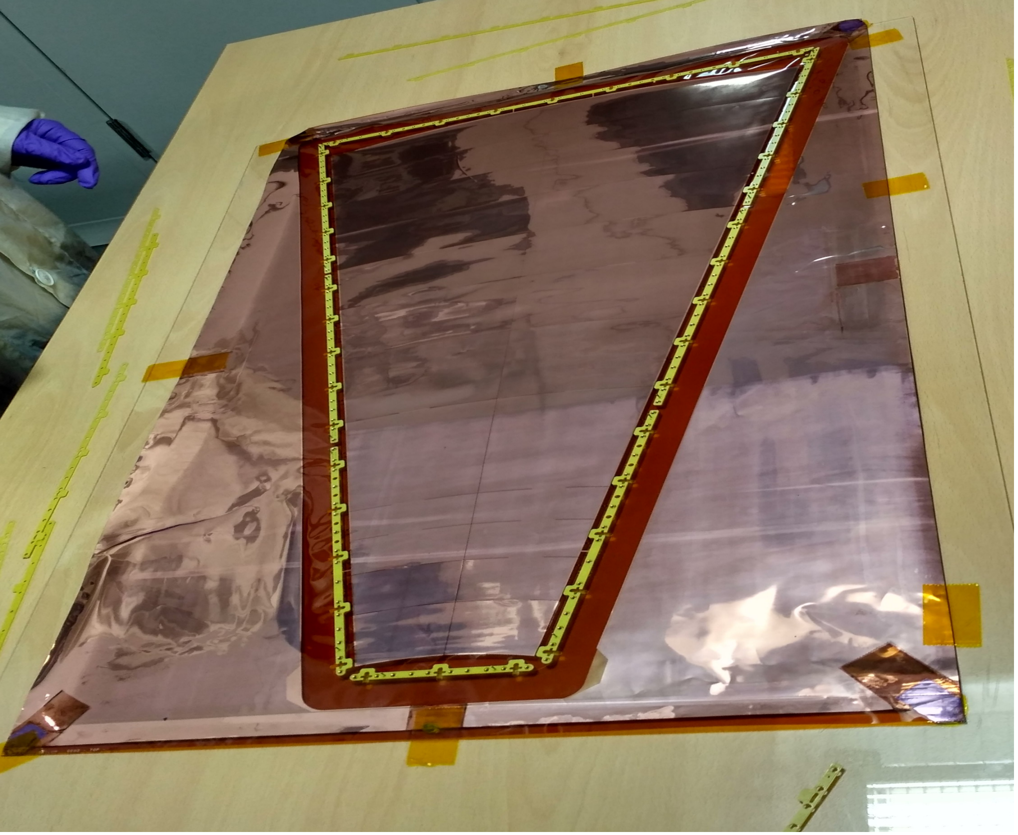
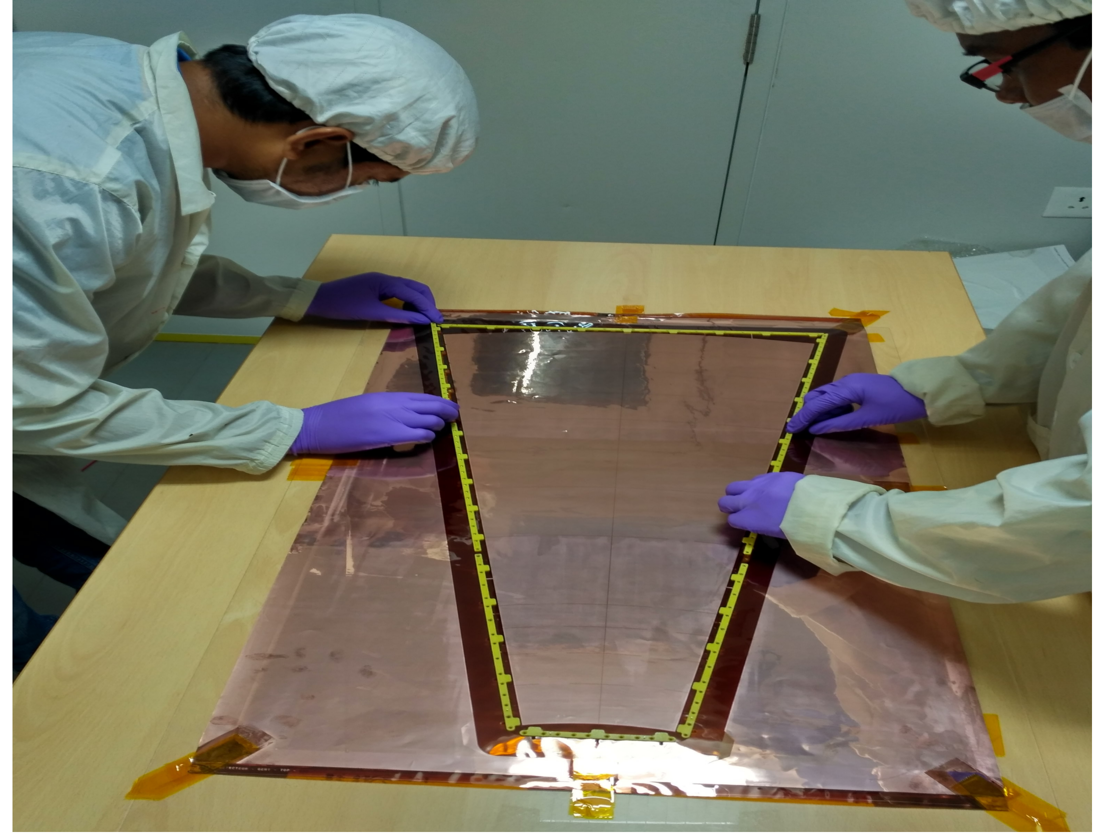
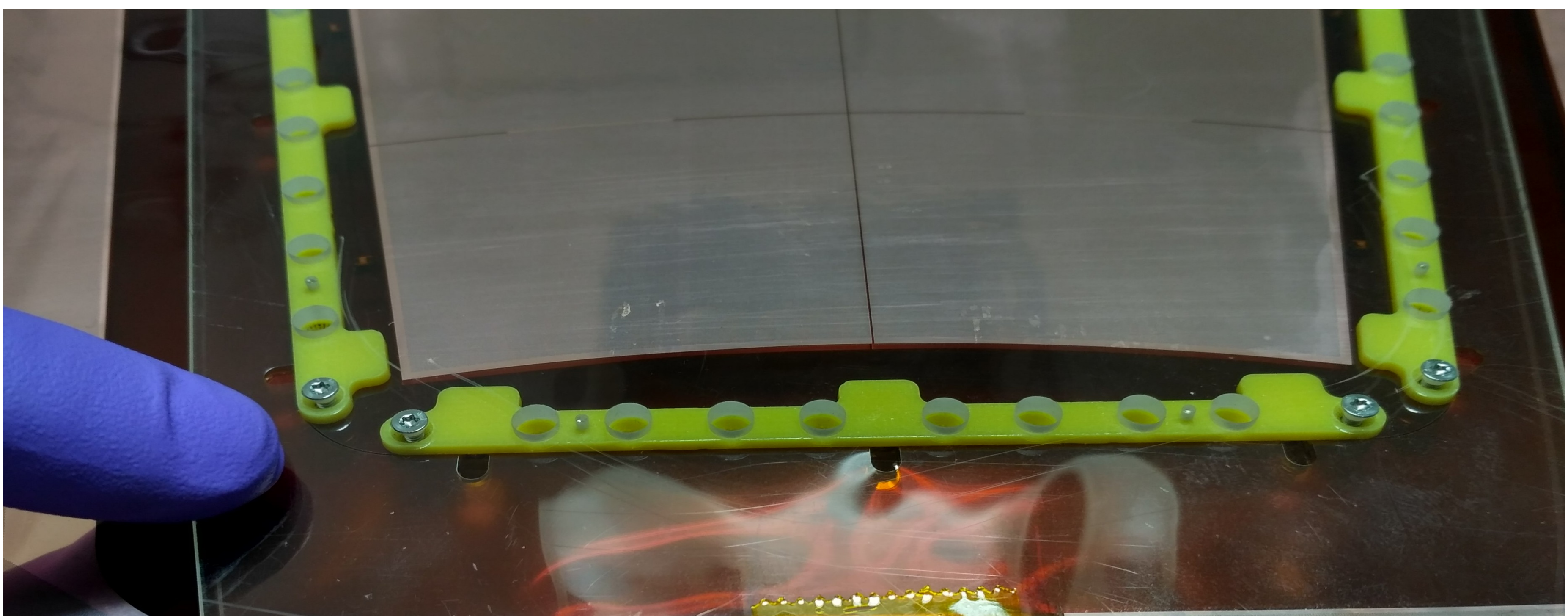



**Each GEM foil is divided in 4 zones and top of each zone is divided in 6 segments through 1 Mohm resistance. Bottom side has no segmentation.**



## leakage test of foil



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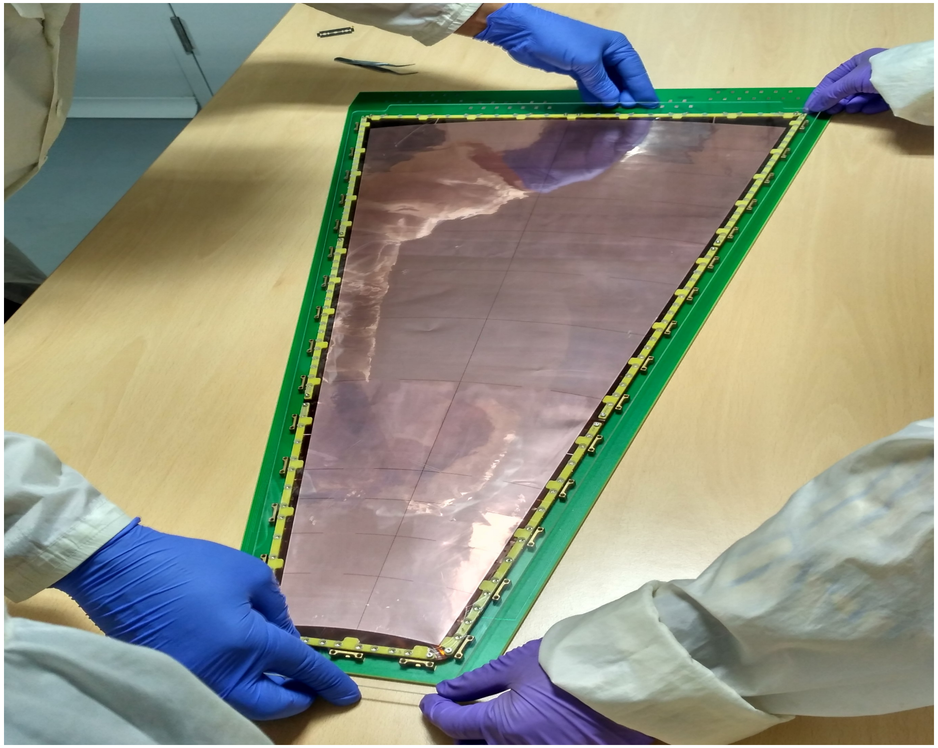
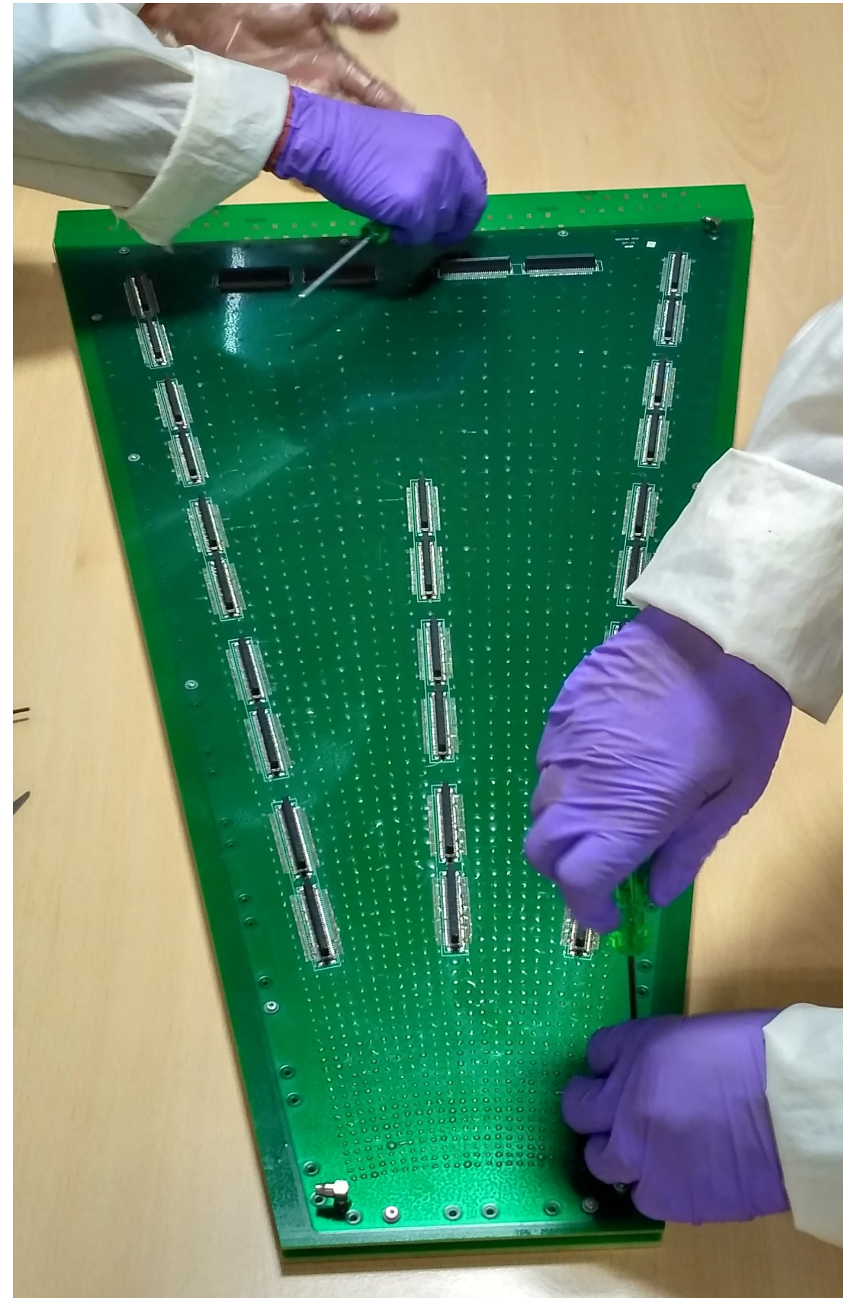
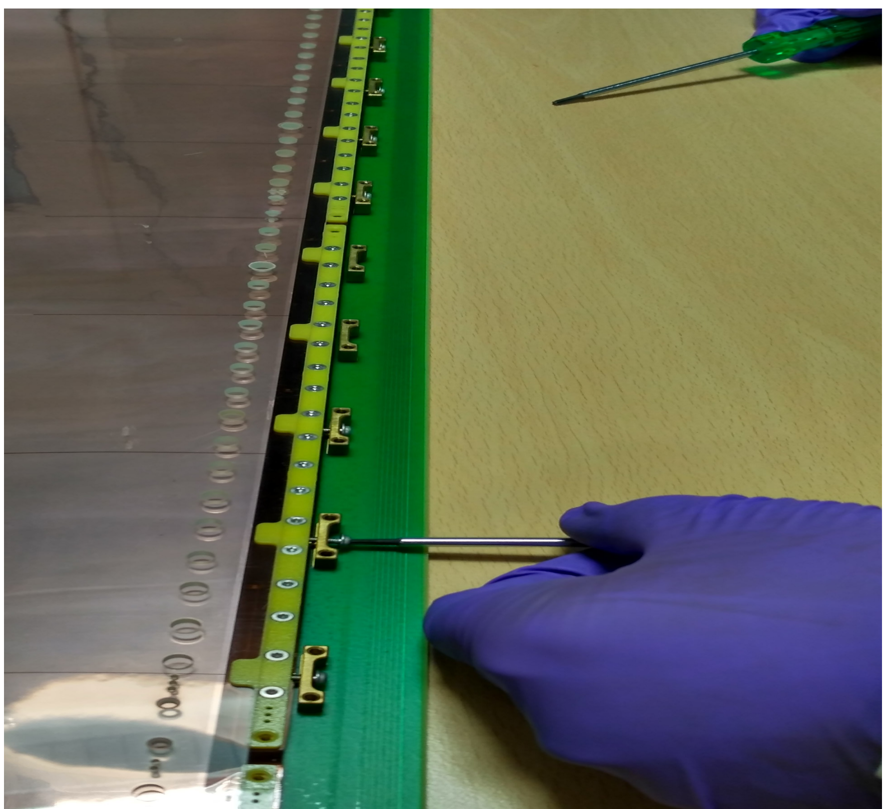






# Beam test of GEM prototype

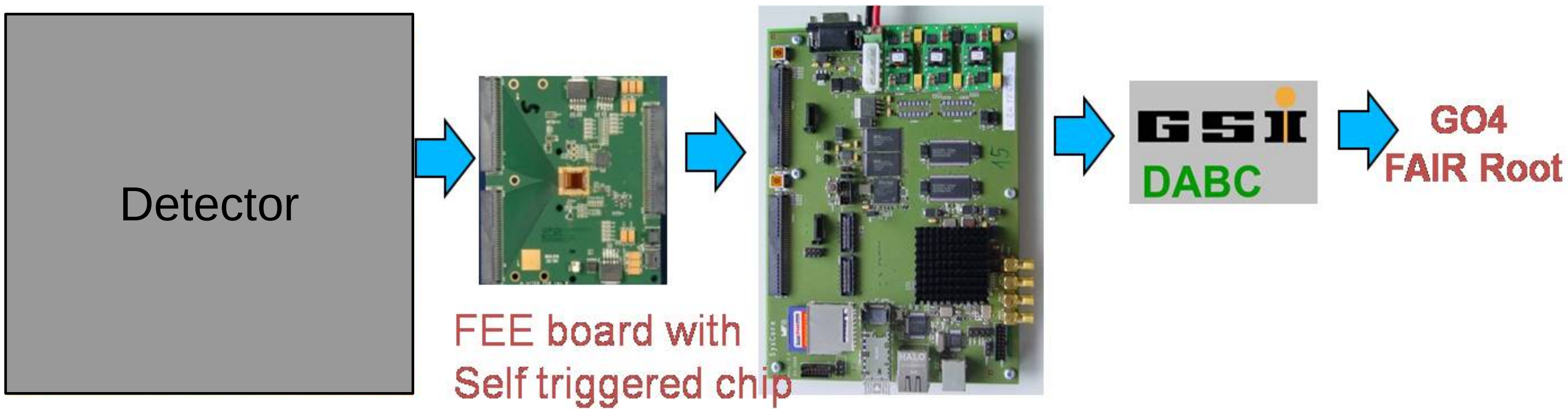
**Aim :**

-- to test the response of the detector to charged particles. mainly in
terms of efficiency, cluster size, gain uniformity, rate handling capability

-- testing with actual electronics for CBM : nXYTER

nXYTER is a 32 MHz, 128 channel self triggered ASIC first developed by DETNEE collaboration for neutron measurements.

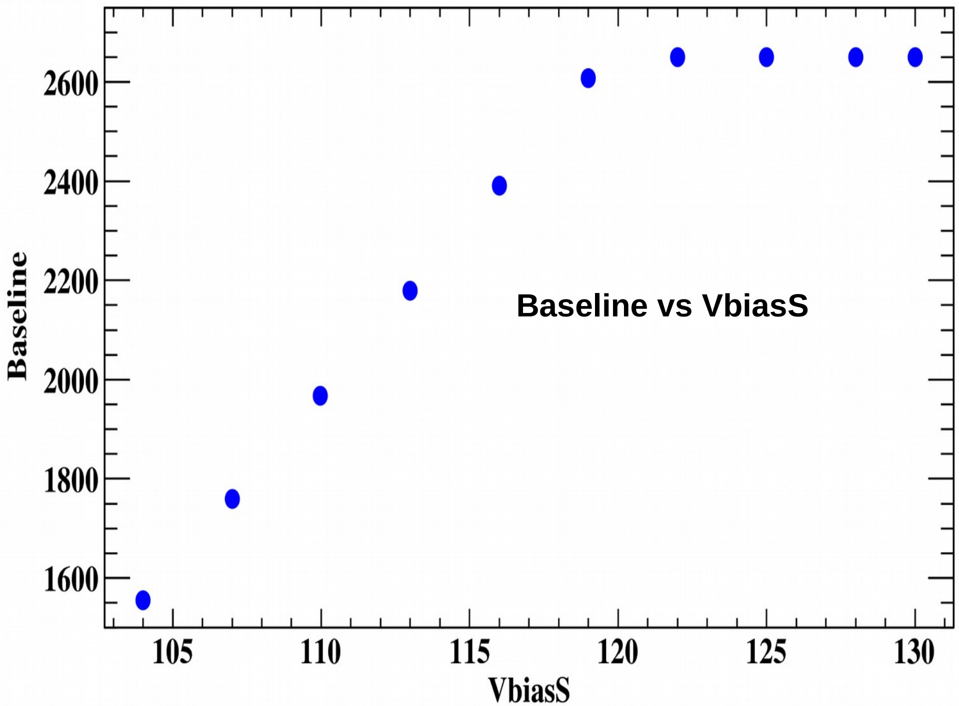
– coupled to ROC(ReadOut Controller)
and then fed to the DAQ.

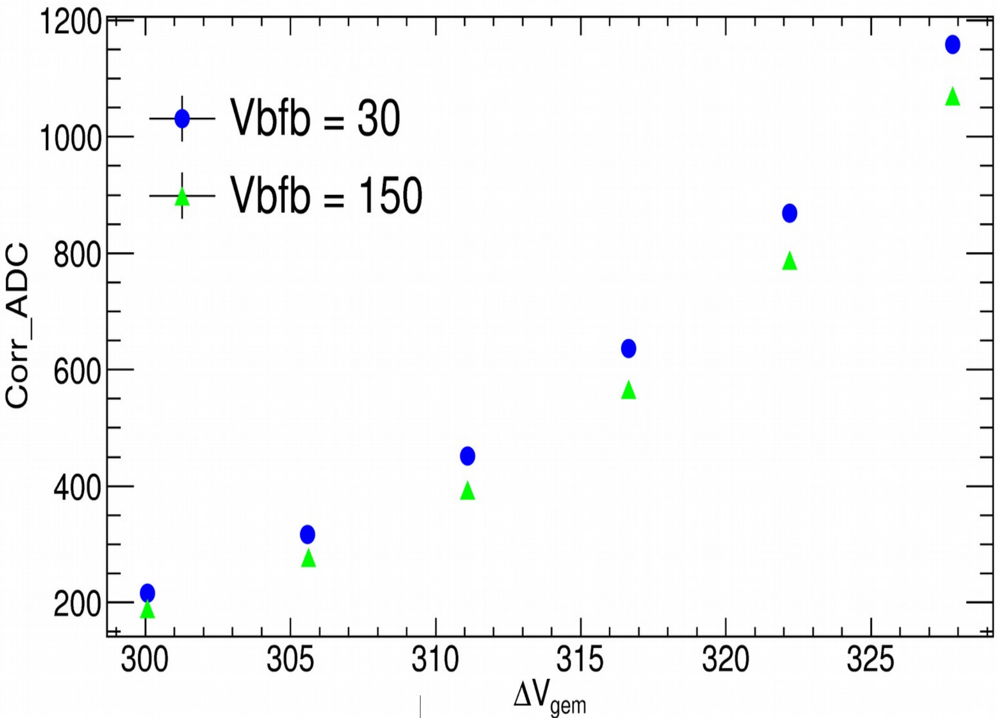


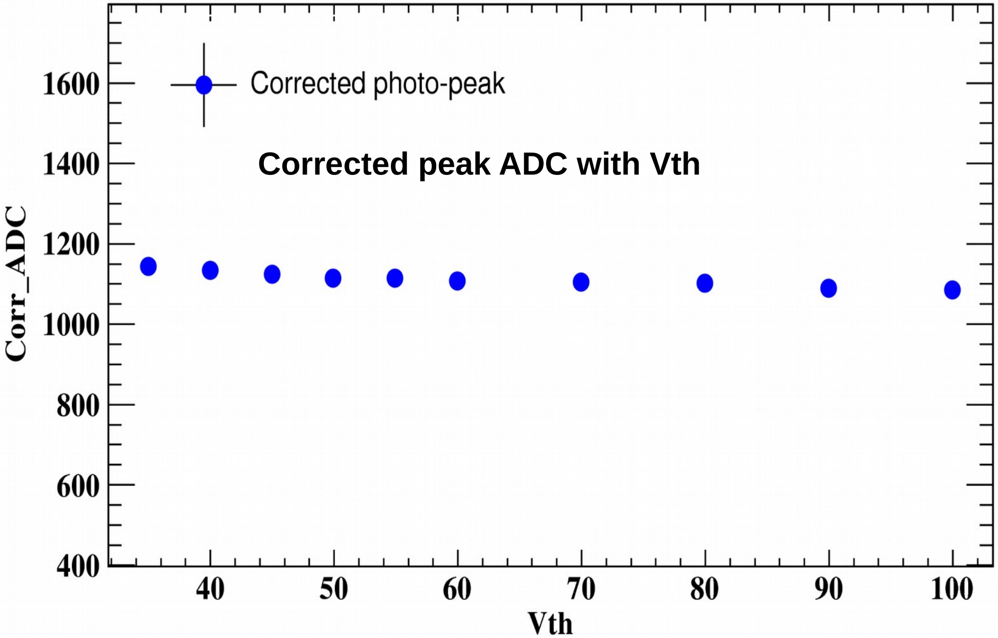

Schematic of the detector test

The nXYTER ADC spectra is inverted as compared to conventional picture, this has to be subtracted from a baseline value channel by channel

# Test of setting parameters of n-XYTER




Variation of baseline corrected peak ADC channel with GEM voltage at two different **Vbfb.**

**Vth:** is the threshold voltage for the comparators i.e. it defines the pulse strength that is neccessary to trigger the comparator

**VbiasS:** is the bias voltage for the first stage of slow shaper of n-XYTER and sets the baseline

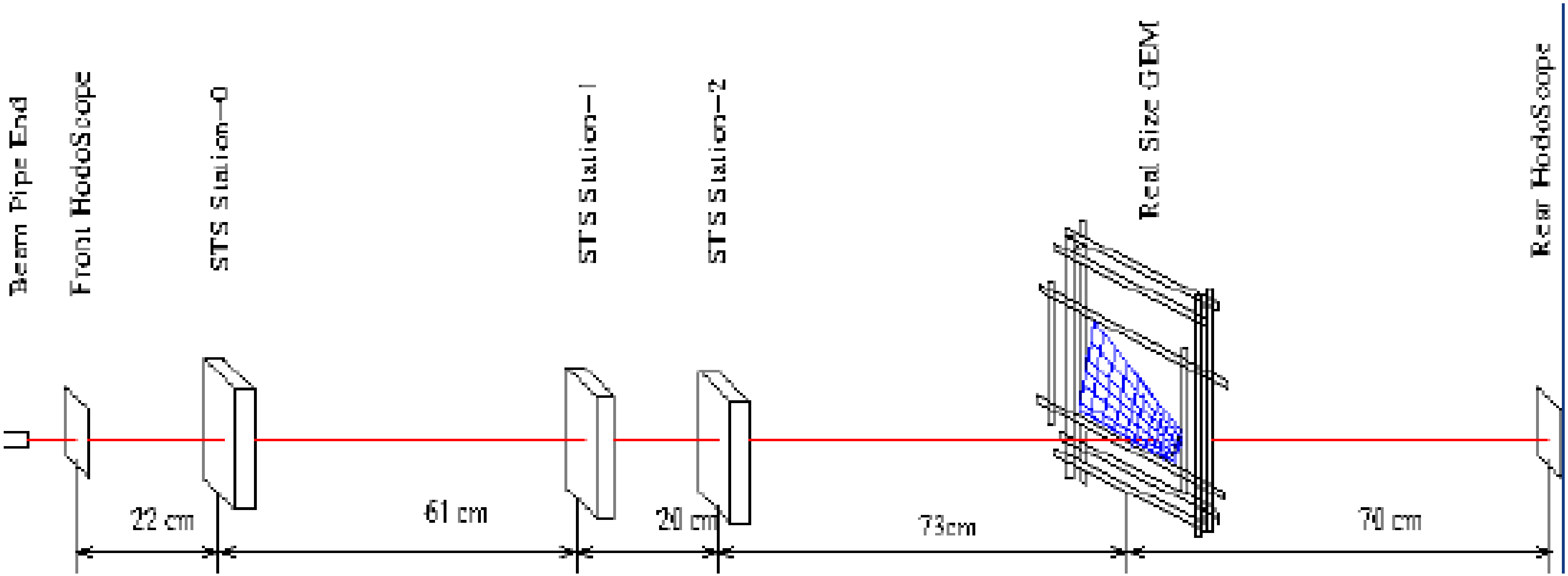
**Vbfb:** sets the discharge time for preamplifier by controlling the resistance of the transistor used in preamplifier of n-XYTER

# Test results of First real size prototype GEM Chamber with proton beam at COSY

**Beam Used – Proton Beam of momentum 2.36 GeV/c**

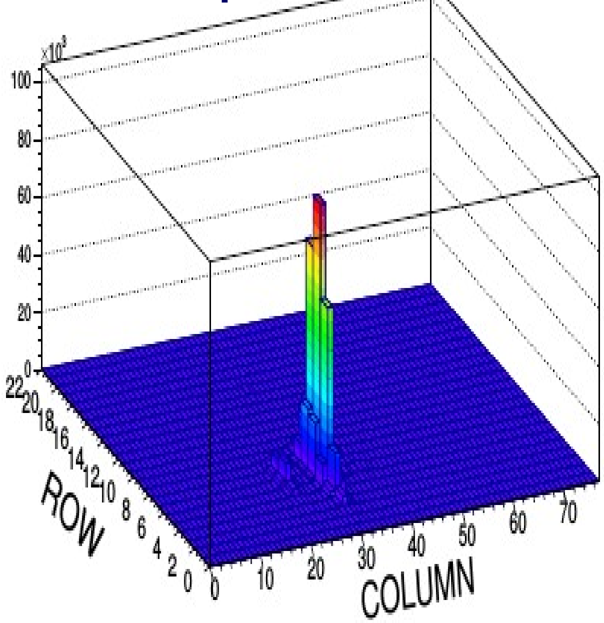
**Gas mixture – Ar:$CO_2$ in 70:30 ratio by mass**

**Electronics – nXYTER based readout system**

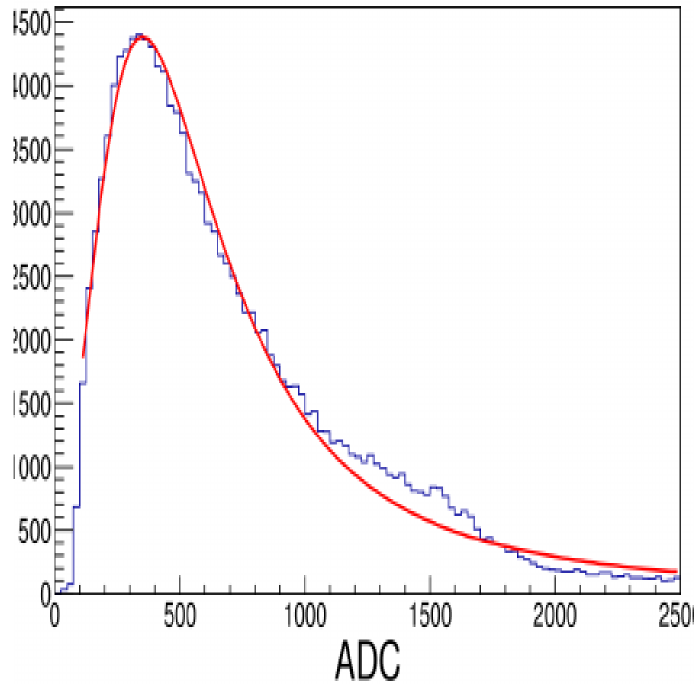



**Test Setup at COSY test beam**

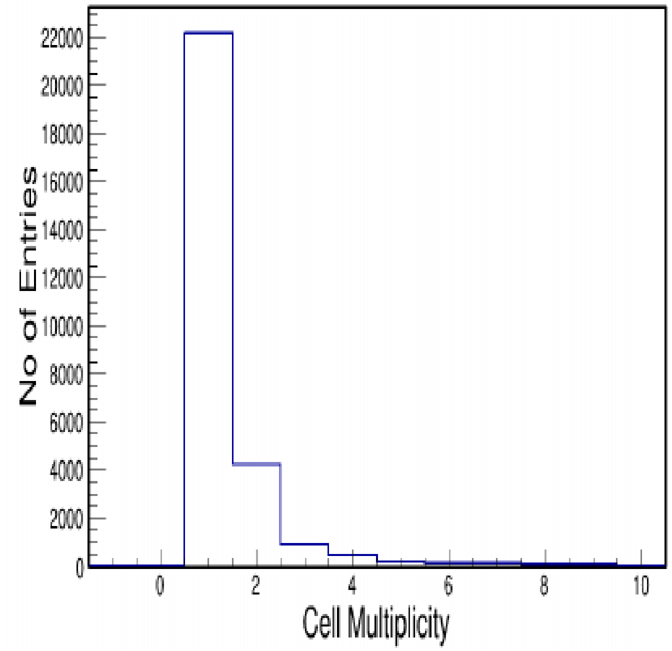
**Beam Spot**



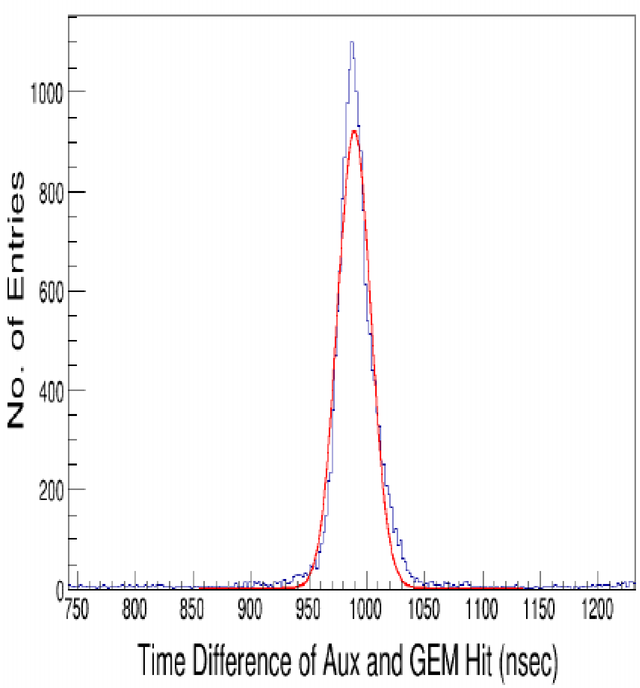

**ADC distribution**



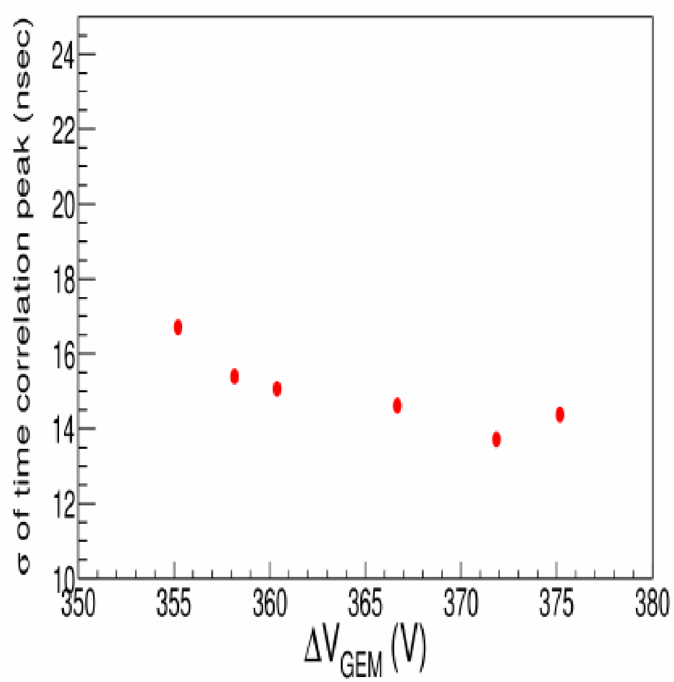

**Cell Multiplicity**



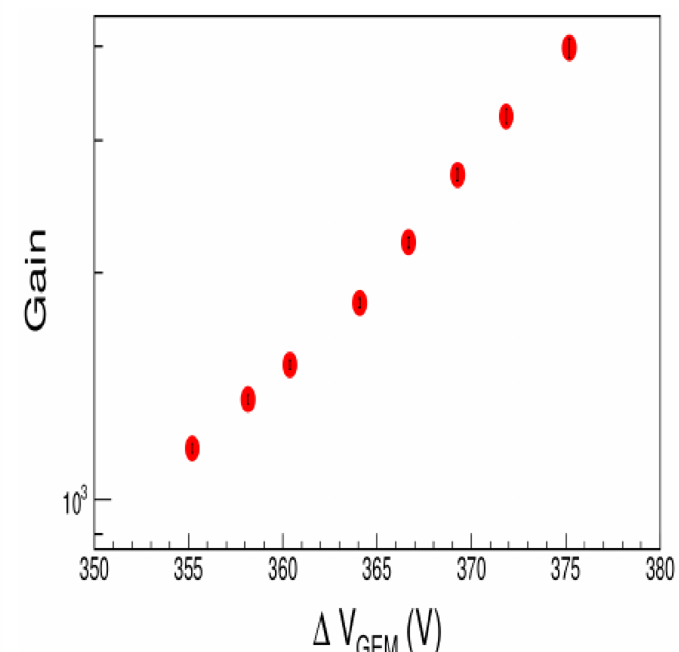

**Time correlation**




**Time Resolution**




**Gain Curve**

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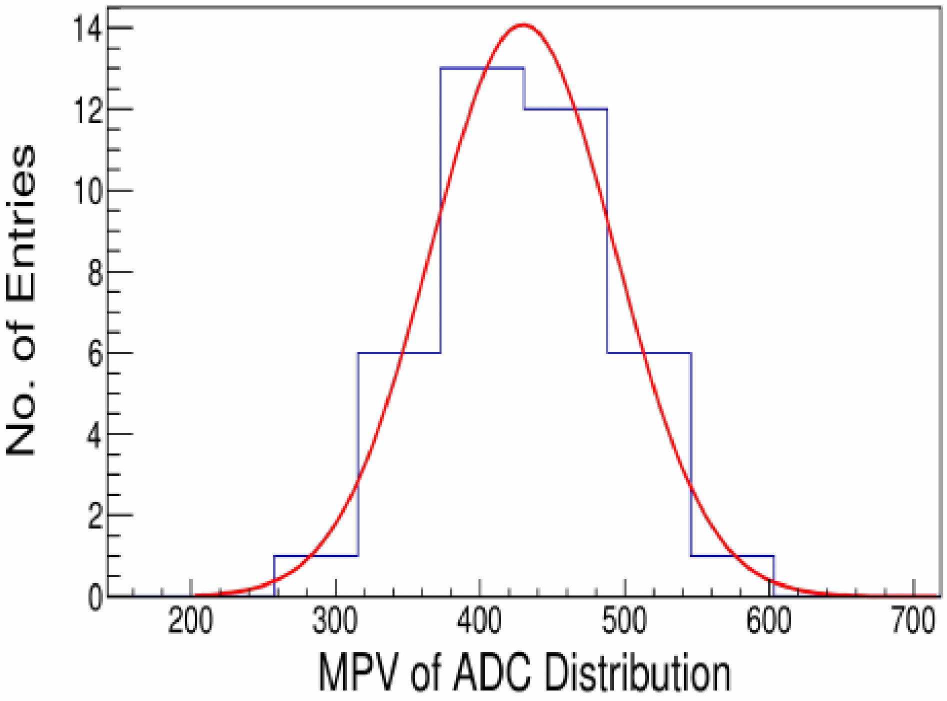
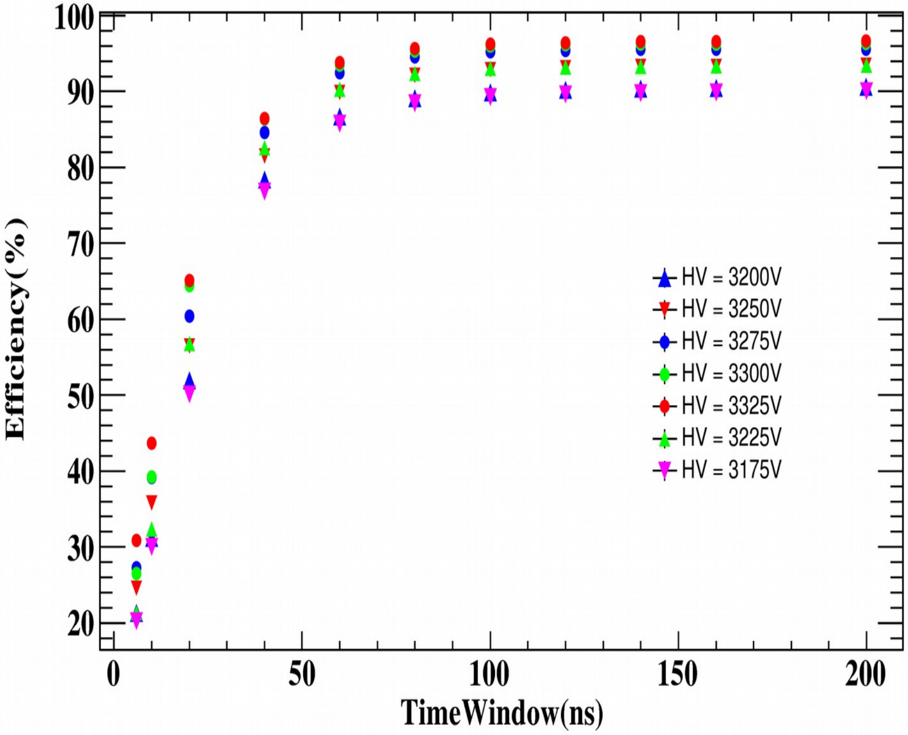
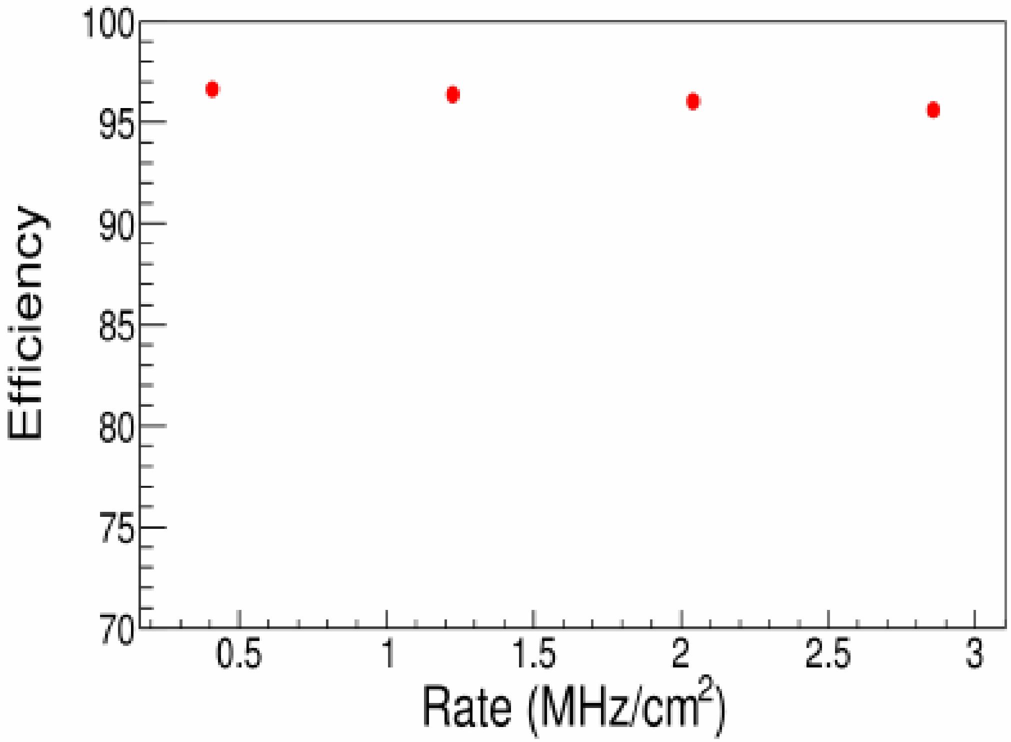


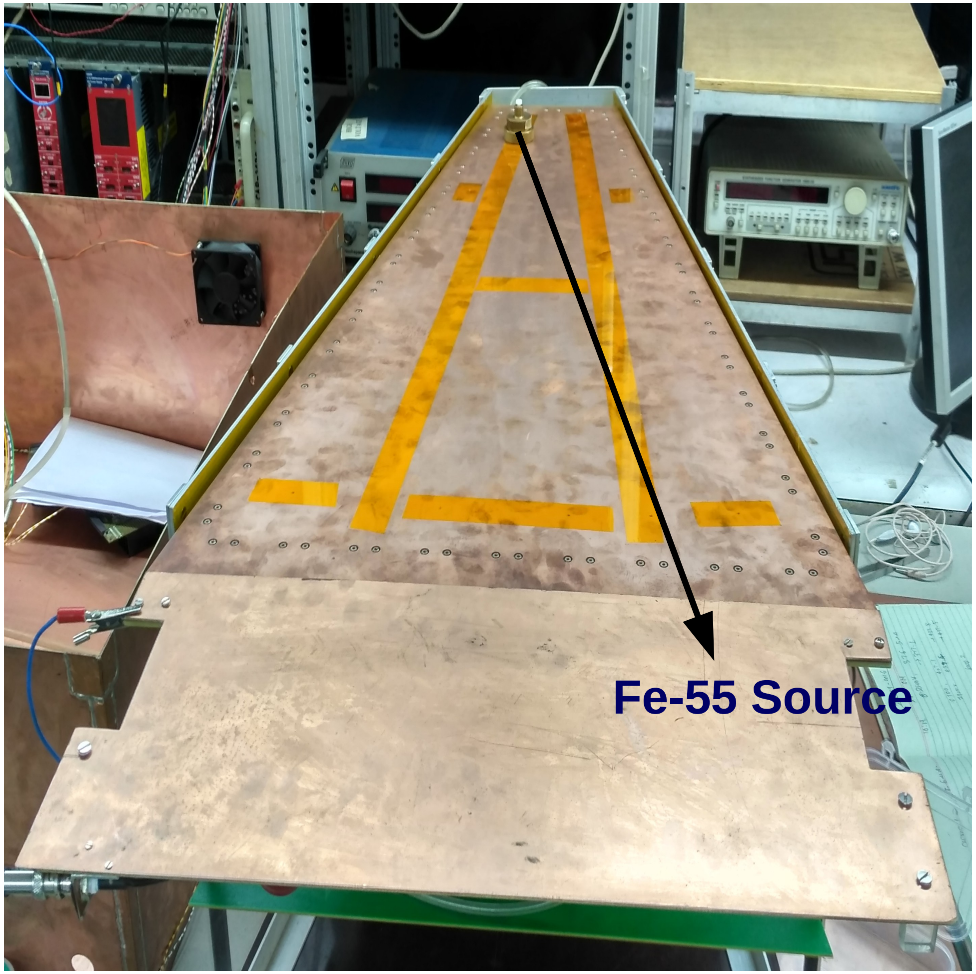




**Gain uniformity**

**Efficiency vs Time window**

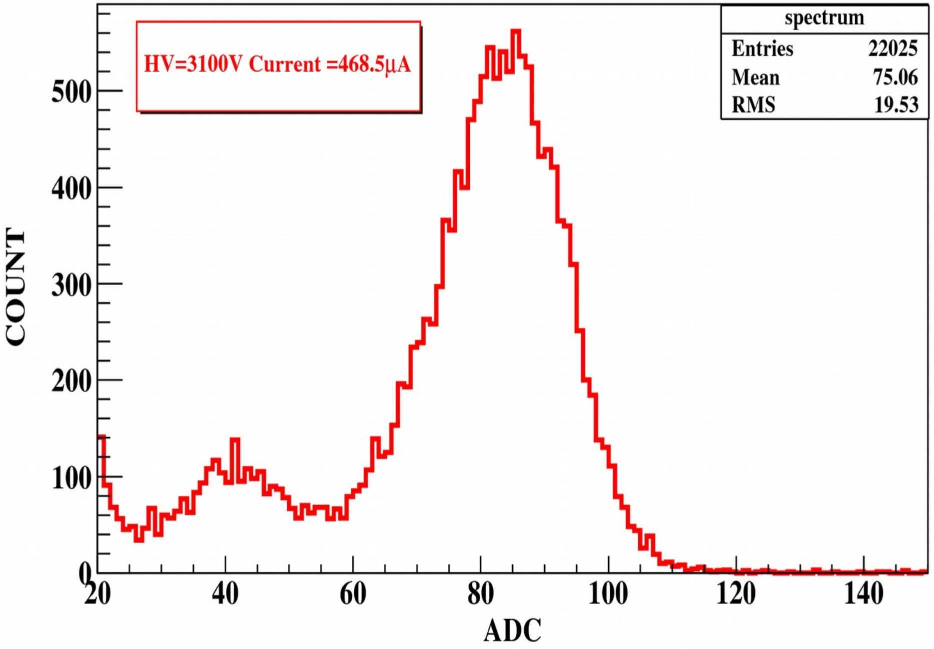
**Efficiency vs rate**

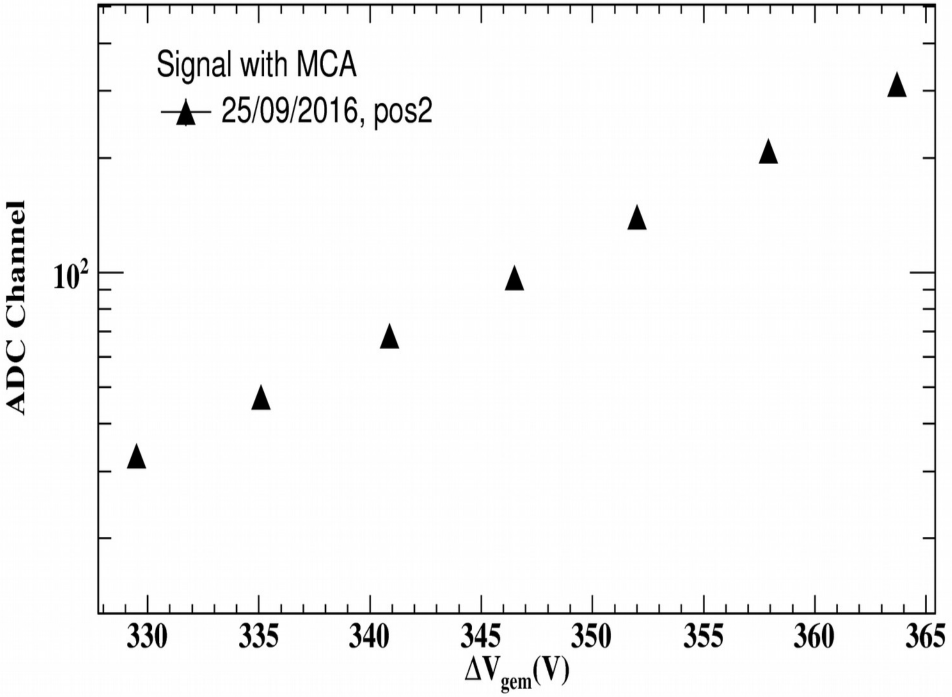
# Testing of chamber (Built at VECC) with Fe-55 source at VECC



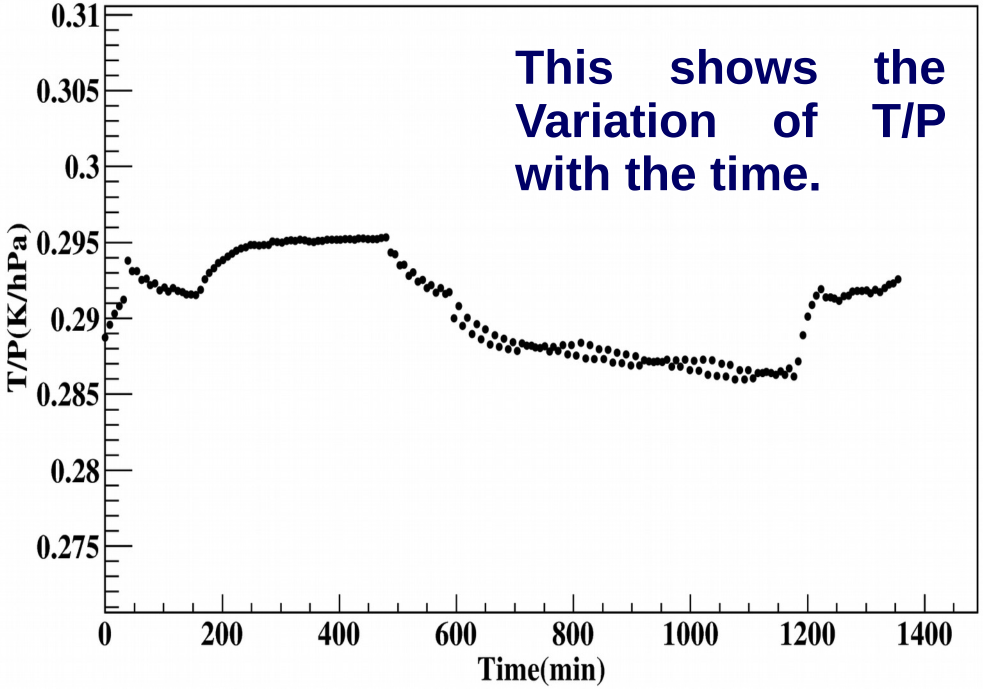

Experimental Setup in Lab

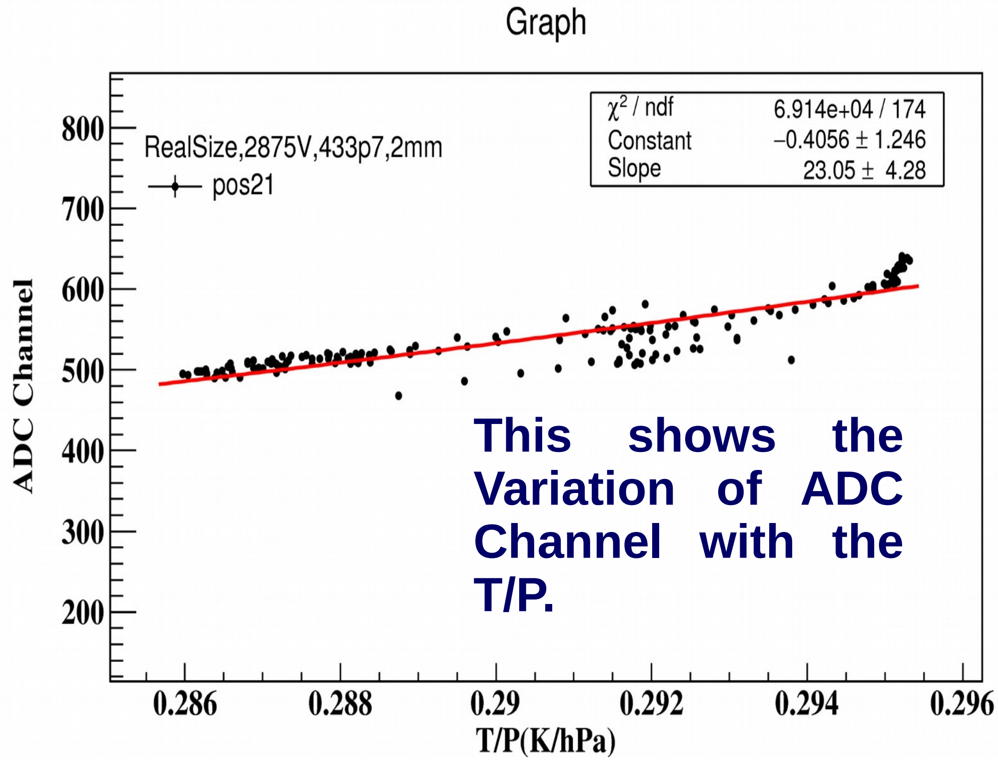
## Pulse height spectra of Fe-55 source

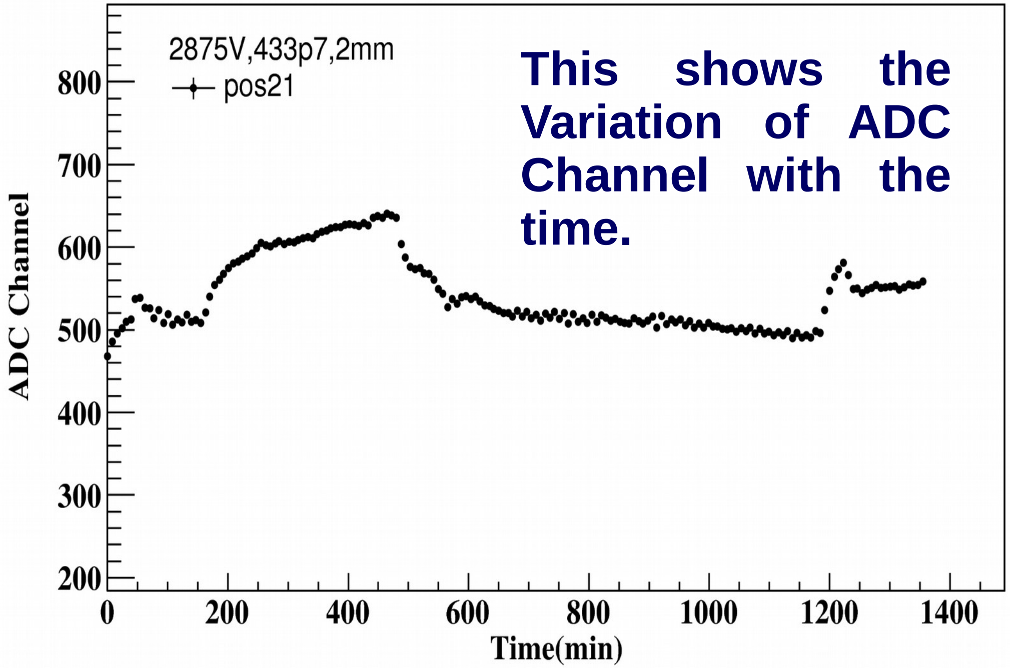


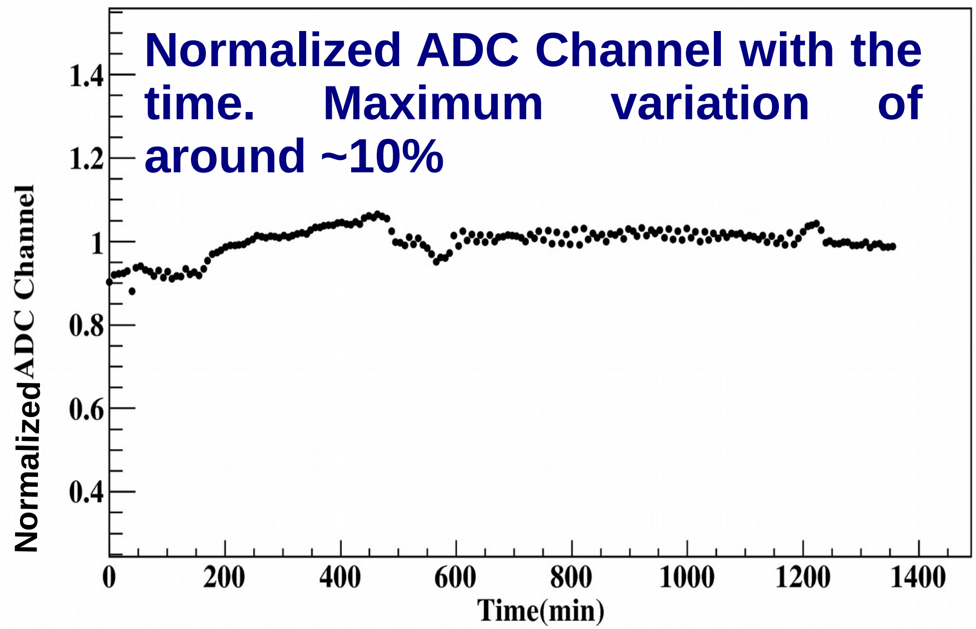



# Gain Dependence on envoirnmental parameters (T/P) for real size GEM



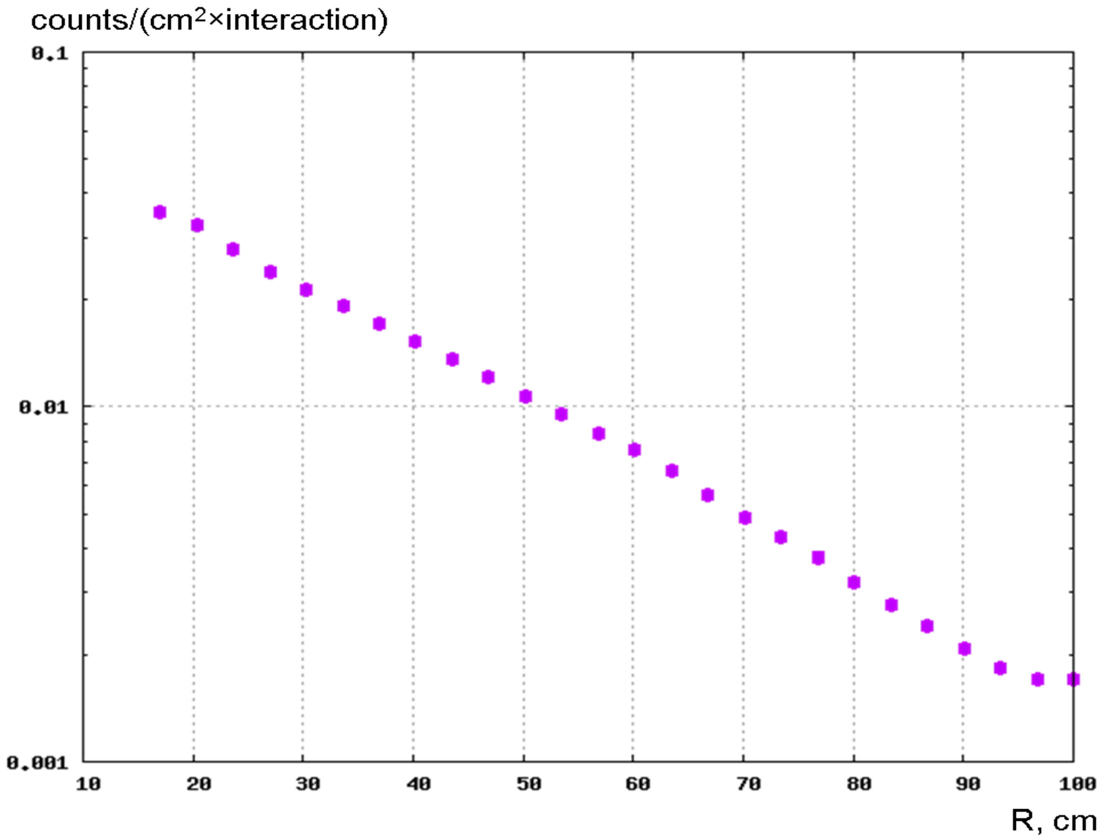



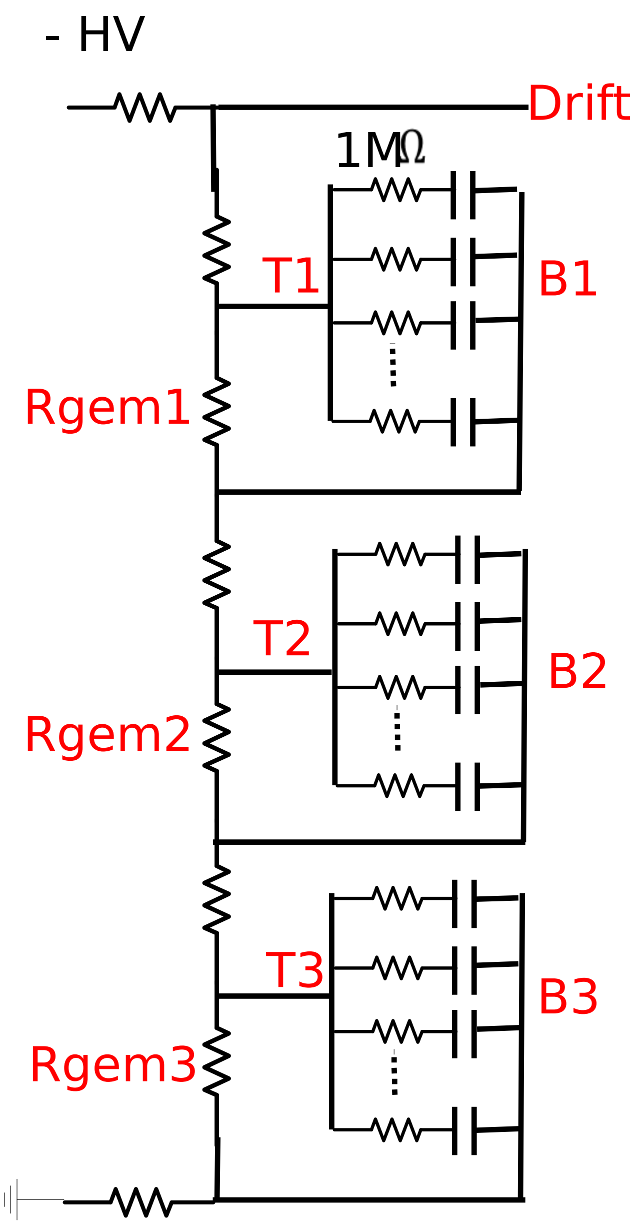



# Pulse current calculation

Branch current = 700 μA

Particle rate : 147 kHz/cm$^2$
Area of detector = 1800 cm2
Particle rate on full detector area = 1800 x 147 = 2.648 x $10^8$ particle/sec
Pulse current = 2.648 x $10^8$ x 30 primaries x 4 x $10^3$ x 1.6 x $10^{19}$
= 5.08 μA ( for 24 segments)
For 1 segment ~0.20 μA => drops accros each resister ~ 0.20 V
If we use the two resistive chain drop will be half.



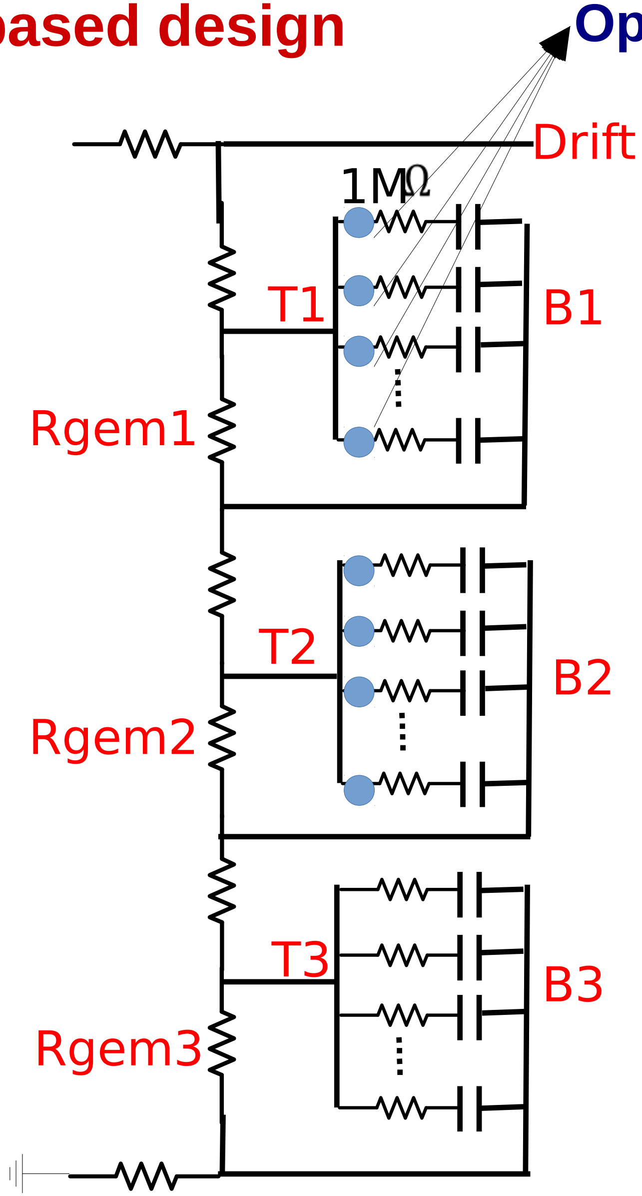
## Short segments

Typical Delta_V GEM = 400 V => Shorted current = 400 V / 1 Mohm = 400 μA => This will leads to the drop in gain

=> high protection resistance => robust against short, leads to gain drop

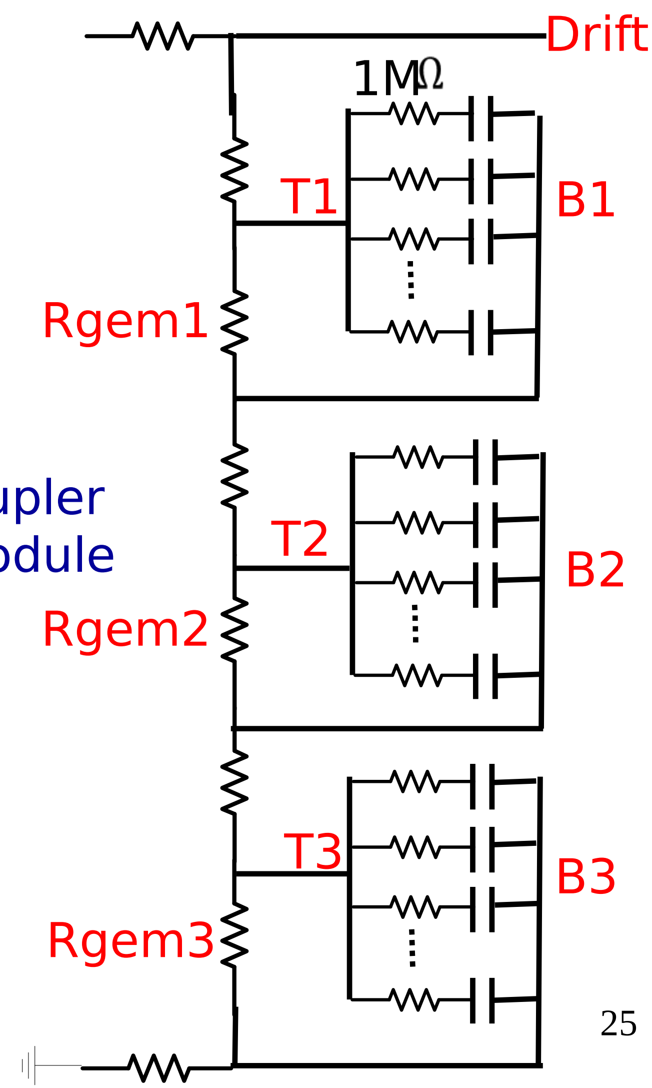
## Optocoupler based design

**Optocoupler switches**



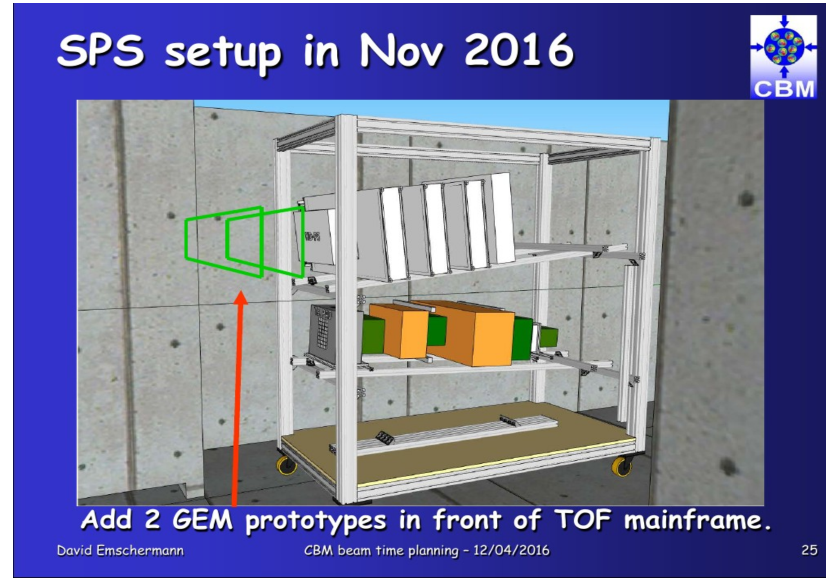

24 segments

Þ 72 optocoupler switches/ module



# Outlook

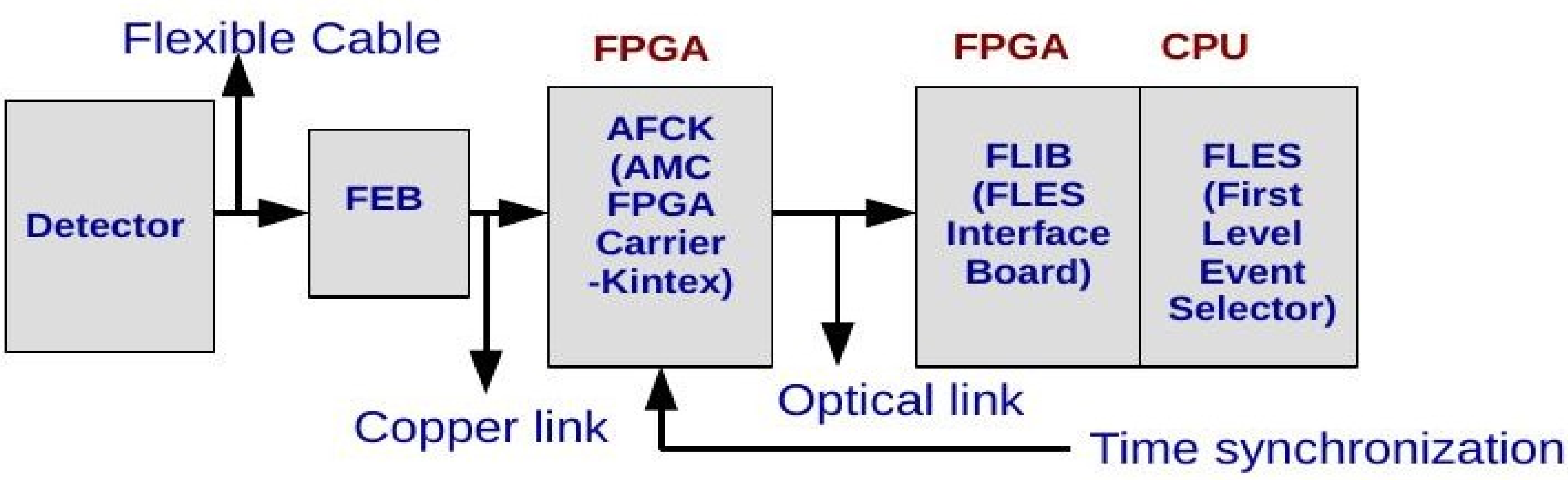
## SPS beam test in November 2016
## ( MUCH + TOF ) With actual DAQ




**Beam** : Lead
**Target** : Lead of thickness 1 or 2 mm
**Beam energies** : 13AGeV, 30AGeV, 150AGeV

**Goal**
**-- particle tracks incident over a large area,**
**-- tracking**

## DAQ:



# Summary:

- Dimuon measurement is the core of the CBM physics program
- A novel segmented absorber with detector triplets designed for MUCH
- SIS100 layout R&D completed, can be extended to SIS300 chambers
- Prototype tests validate the design criteria.
- First Real size Prototype using “ns2” stretching assembled and tested successfully with proton beams and using self triggered nXYTER electronics.
- We have built tested two real size prototypes
- Prototypes test with NEW DAQ will be tested soon in Nov2016 SPS test beam