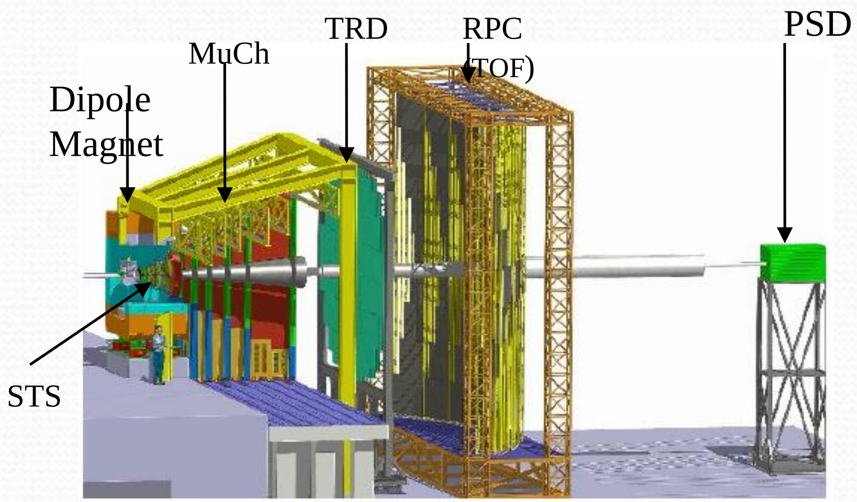
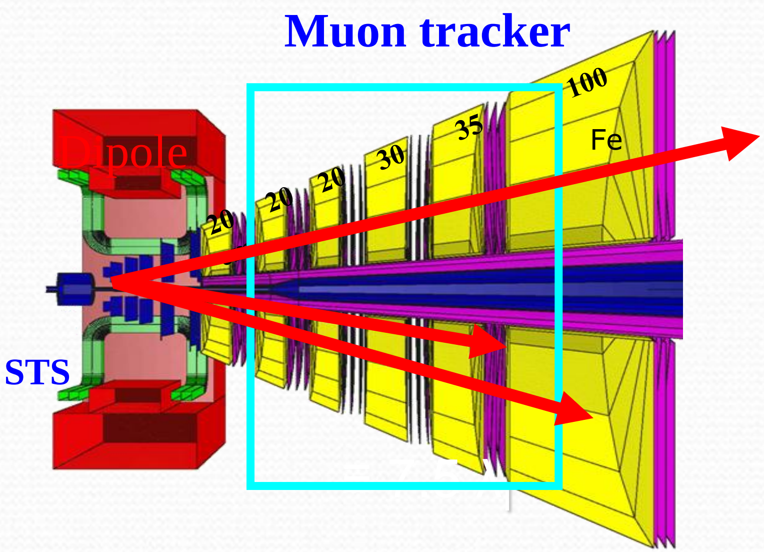
R&D activities on GEM Detector Development for CBM Experiment

Anand Kumar Dubey
VECC, Kolkata

(for CBM India collaboration)

CBM Experiment @ FAIR





Compressed Baryonic Mattter (CBM)
-- a fixed target heavy ion expt. at FAIR
-- energy range 2-45 GeV/u
-- expected to begin in 2017.

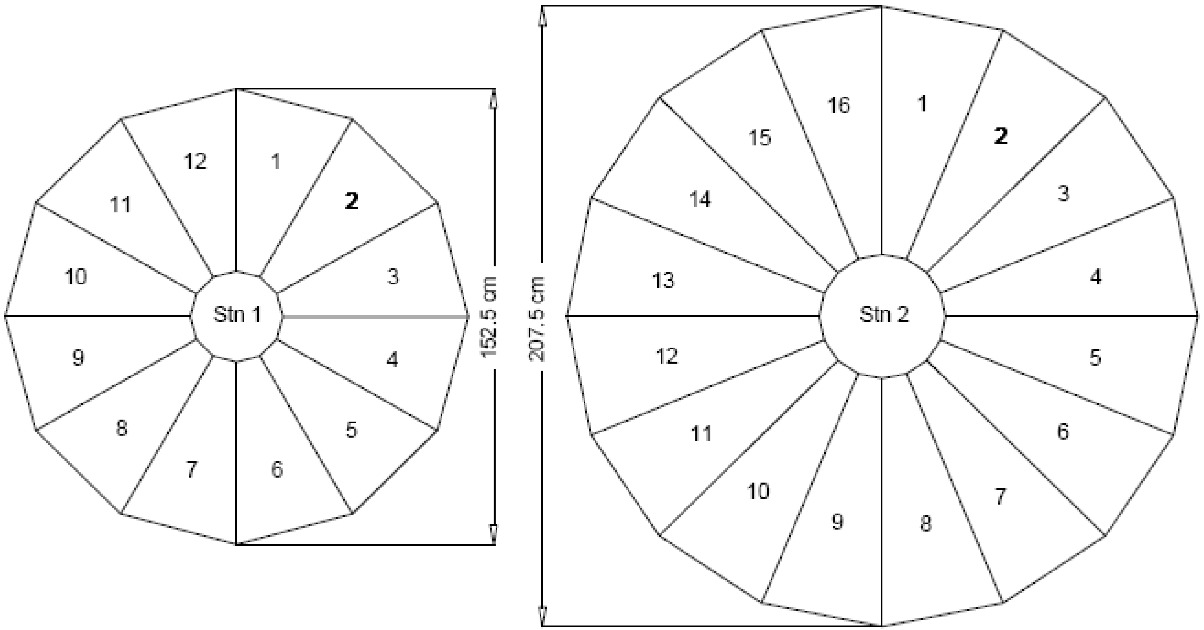
Aim : to detect muon tracks from the collision.

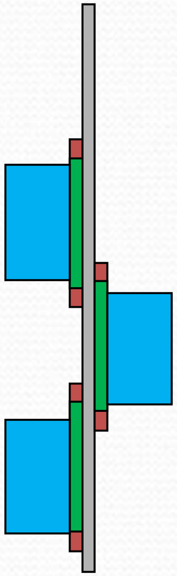
Challenges in Muon Detection @ CBM

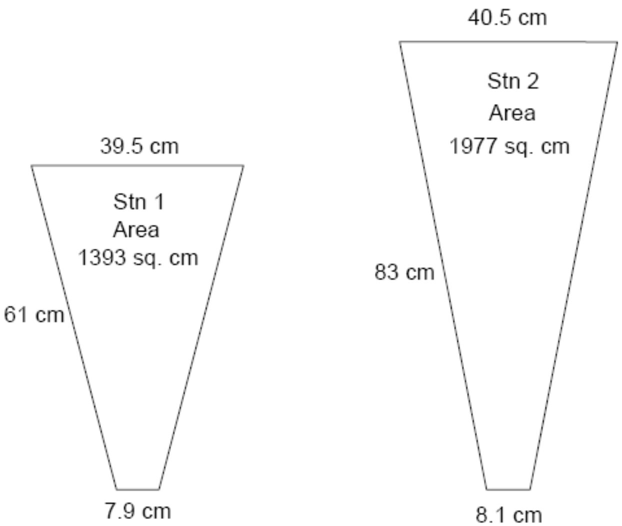
- **high collision rate of ~ 10 MHz**
- **high granularity -- hit rate of 1 MHz/sq.cm**
- **Should be radiation resistant**
- **Large area detector – modular arrangement**
- **Data collected(for ALL CBM detectors) in self triggered mode**

For the first few stations, micropattern detectors--- GEMs, Micromegas.
At VECC, we are pursuing R&D with GEMs for MuCH

Sector layout of GEM chambers



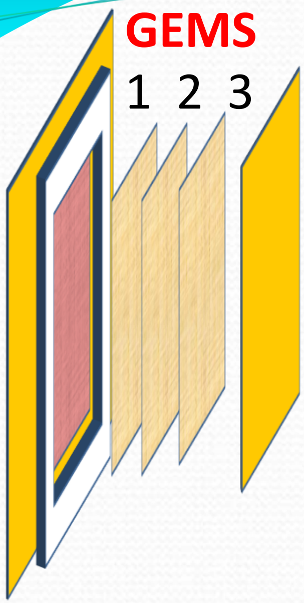




Station #	Layer #	R1 (cm)	R2 (cm)	Area (sq.mt)
1	1	13.25	66.25	1.32
	2	14.25	71.25	1.53
	3	15.25	76.25	1.75
2	1	18.75	93.75	2.65
	2	19.75	98.75	2.94
	3	20.75	103.75	3.24
3	1	24.25	121.25	4.43
	2	25.25	126.25	4.80
	3	26.25	131.25	5.19

Total area = ~28 x 3 = 84 sq. m + spares, For SIS 100 ➔ 42 sq. m. + spares

Results from Lab tests (using conventional ortec electronics)

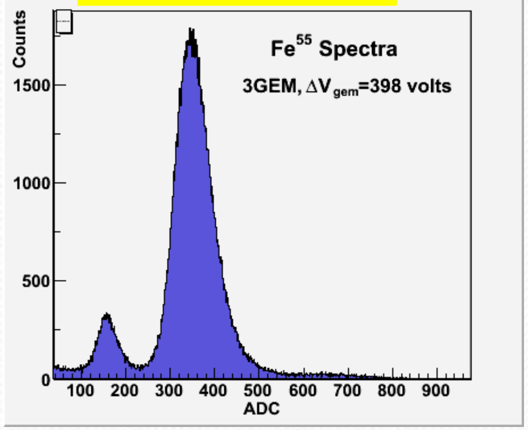


CERN made framed GEMs 10 cm x 10 cm

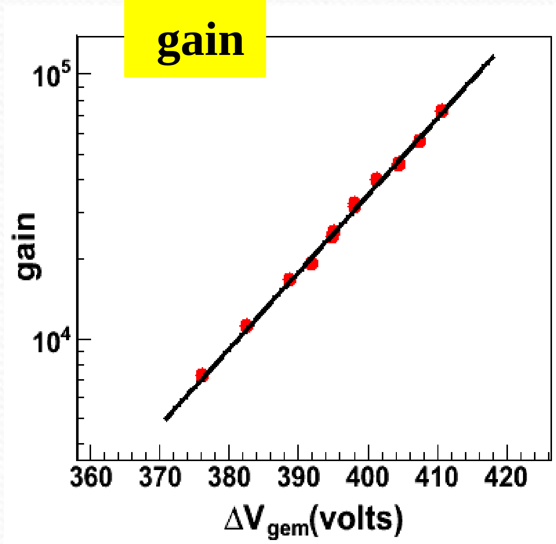
Ar/CO2 – 70/30

Used a Resistive Chain For biasing the GEMs In symmetric configuration

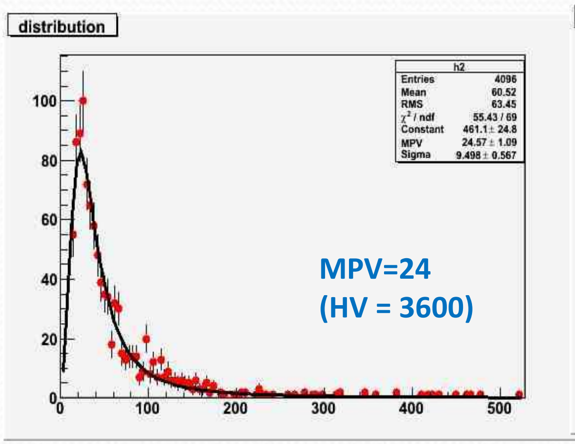
X-ray source

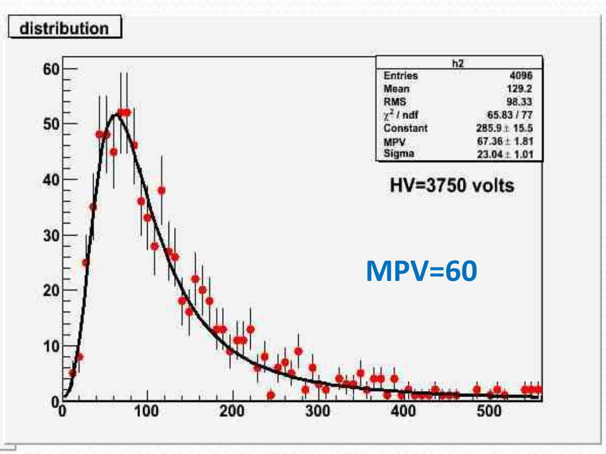


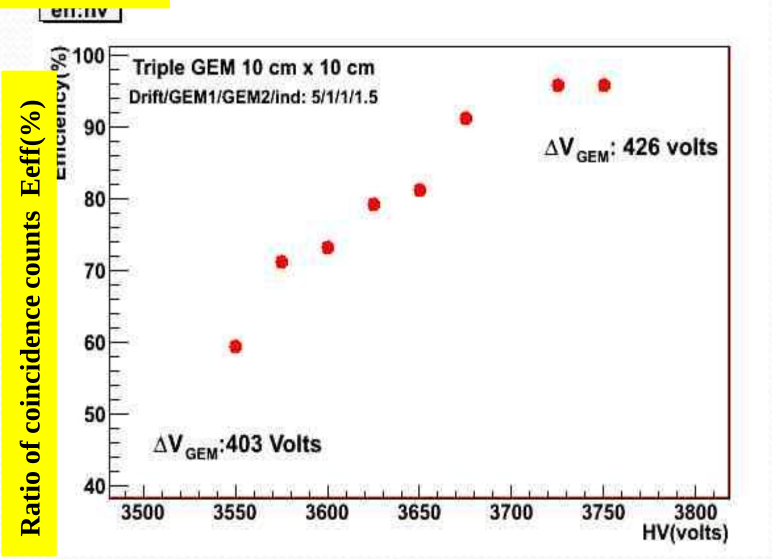
gain



Cosmic muons







Beam test of GEM prototype chambers

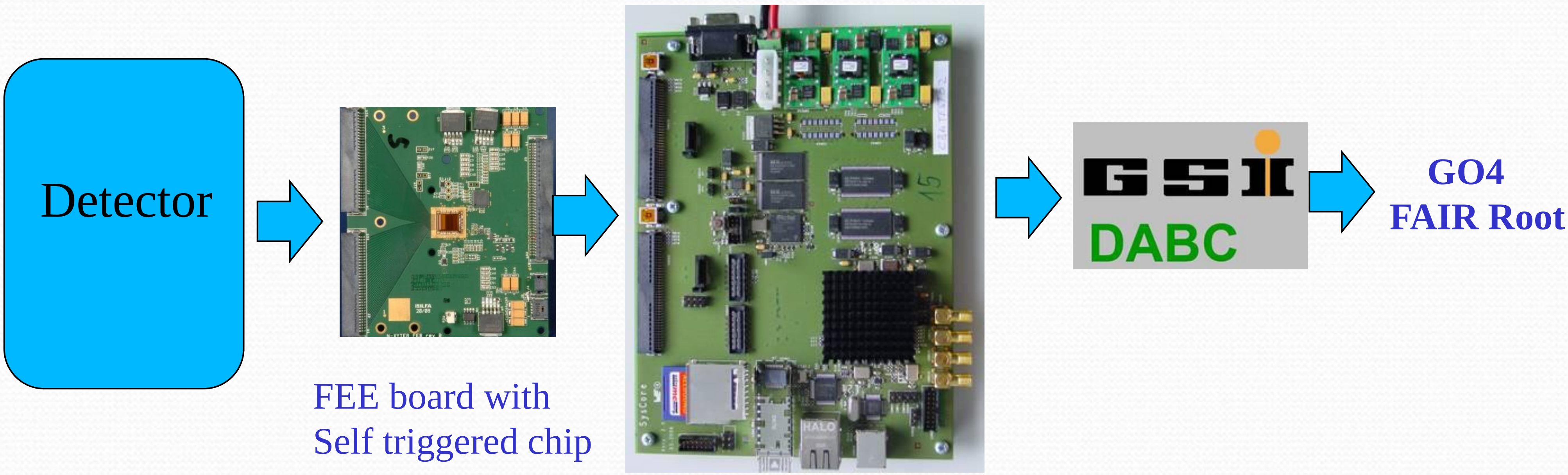
Aim :

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

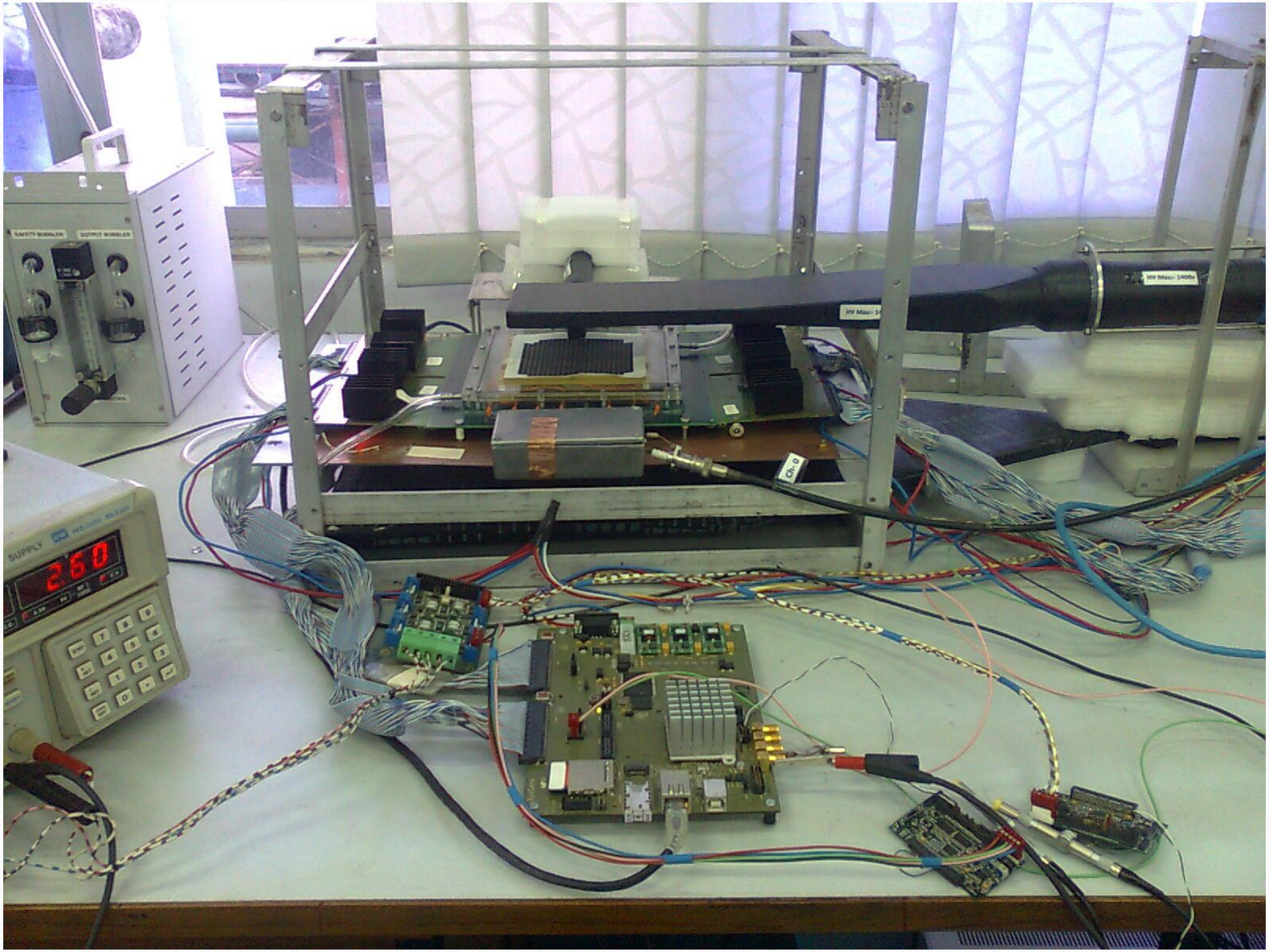
-- testing with actual electronics for CBM : nXYTER

-- nXYTER is a self triggered ASIC – coupled to ROC(ReadOut Controller) and then fed to the DAQ.

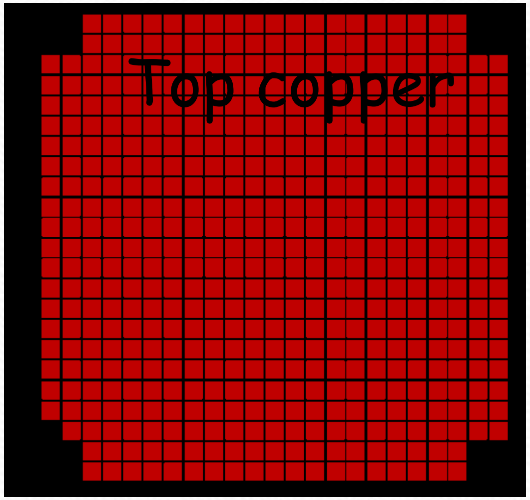
-- testing with the actual CBM DAQ



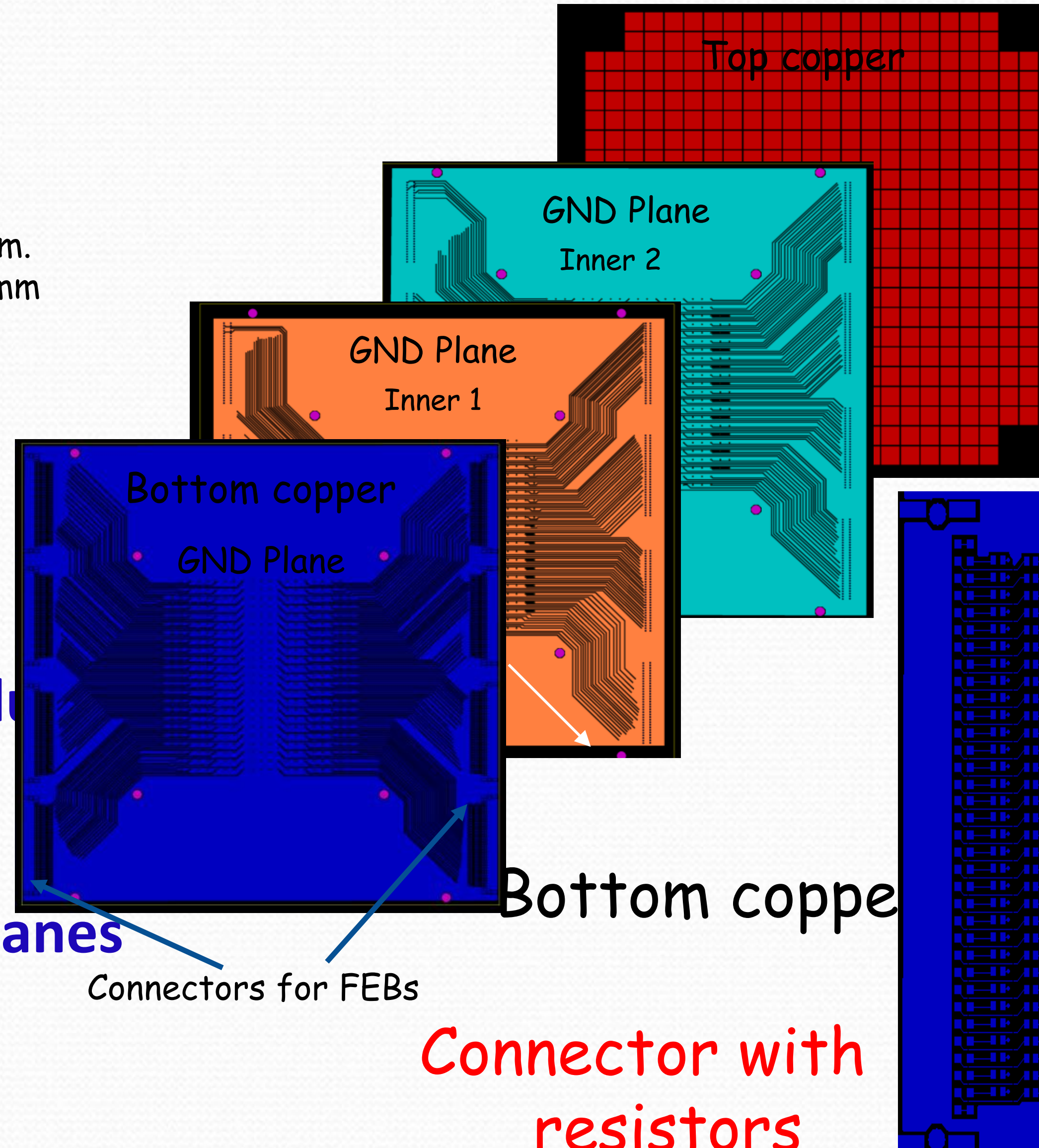
Cosmic Test setup at VECC for testing in a self triggered mode.



Readout PCBS for Test beam 2010



Pad area-
67*73 Sq mm For 3mm.
For 4mm - 88*97 sq mm



Bottom coppe

Connectors for FEBs

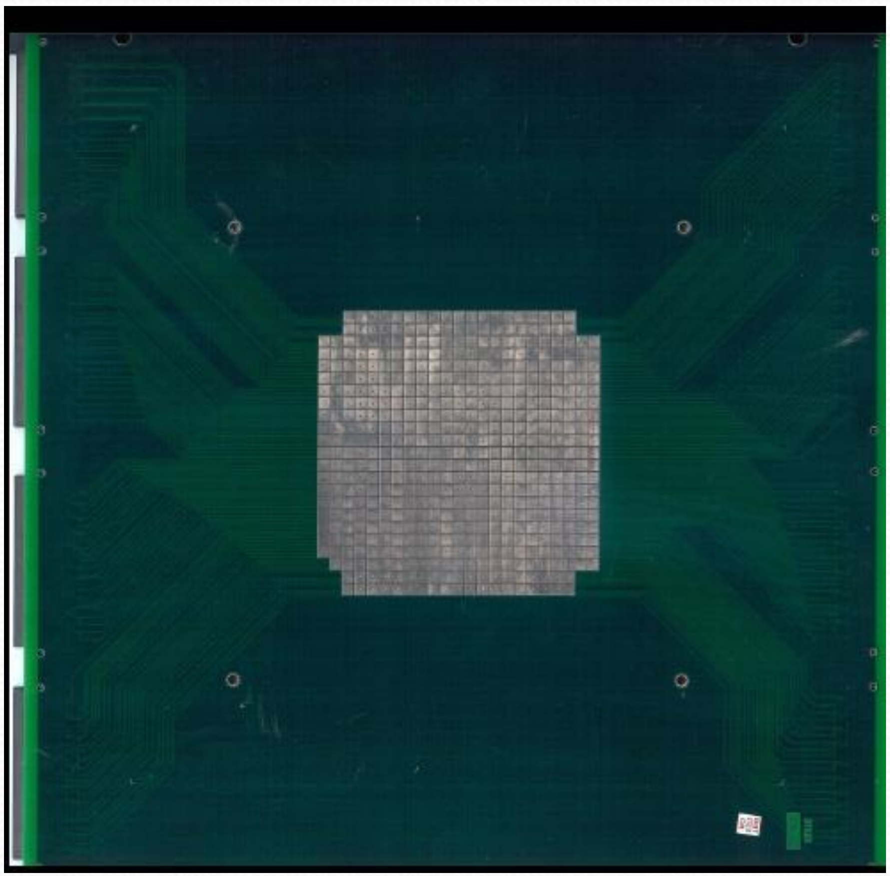
Connector with resistors

❖ Main Features :

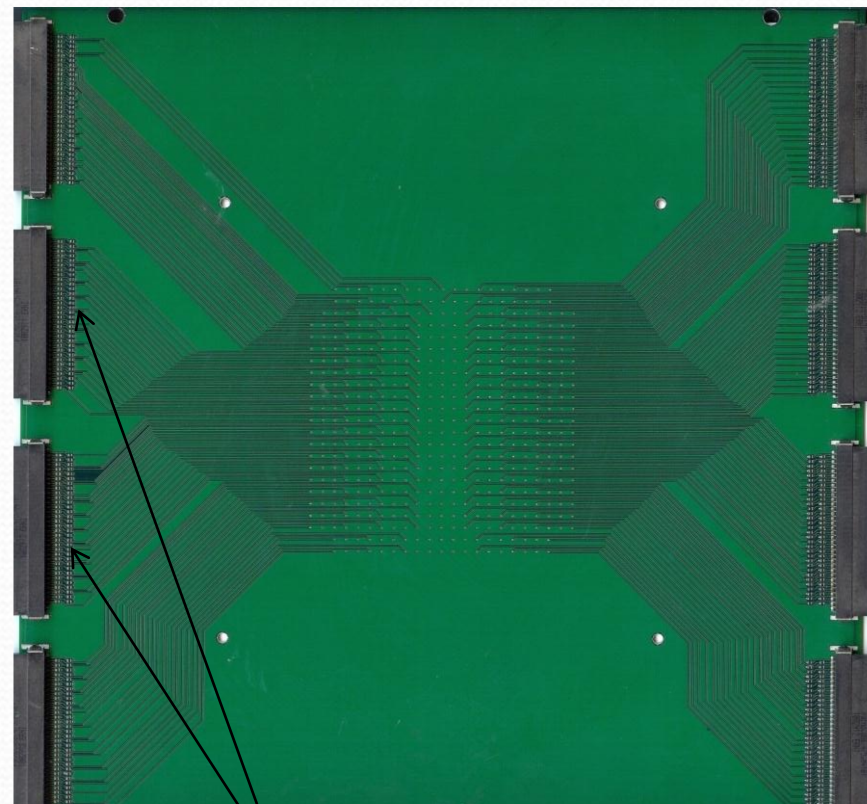
- **Both 3 and 4mm square pad sizes**
- **Not Staggered ('09 test beam modu**
- **Symmetric Square Pads**
- **Multi Layers (4) with GND Planes**
- **Signal Tracks are distributed in 3 planes**
  - **Reduce the cross talk**
  - **Track to Track spacing increases**
- **Blind Vias for gas integrity**
- **Gnd Tracks between Signal Tracks**

Readout Pads for Nov 2011 beamtest

inner side

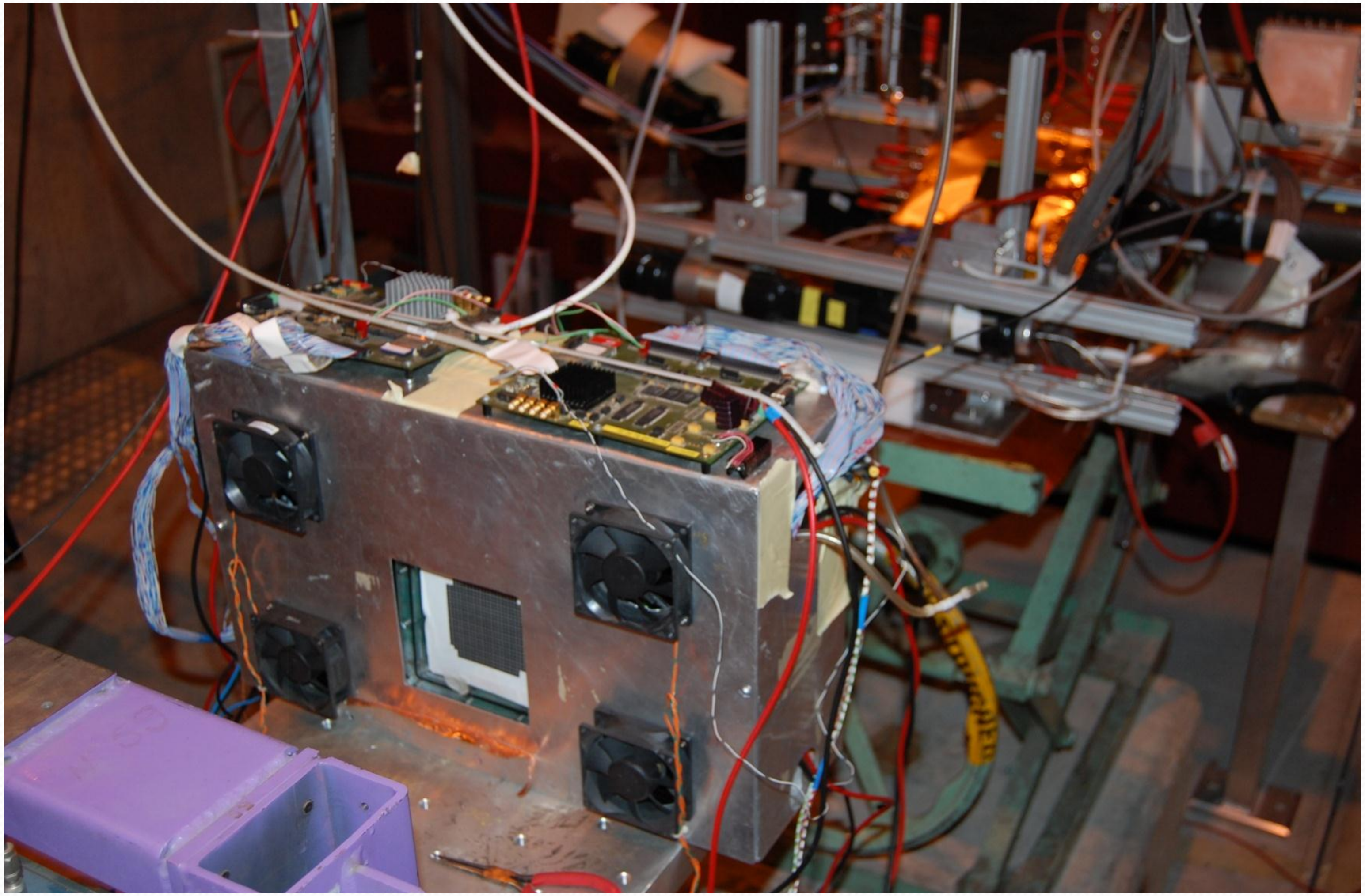


PCB with connectors



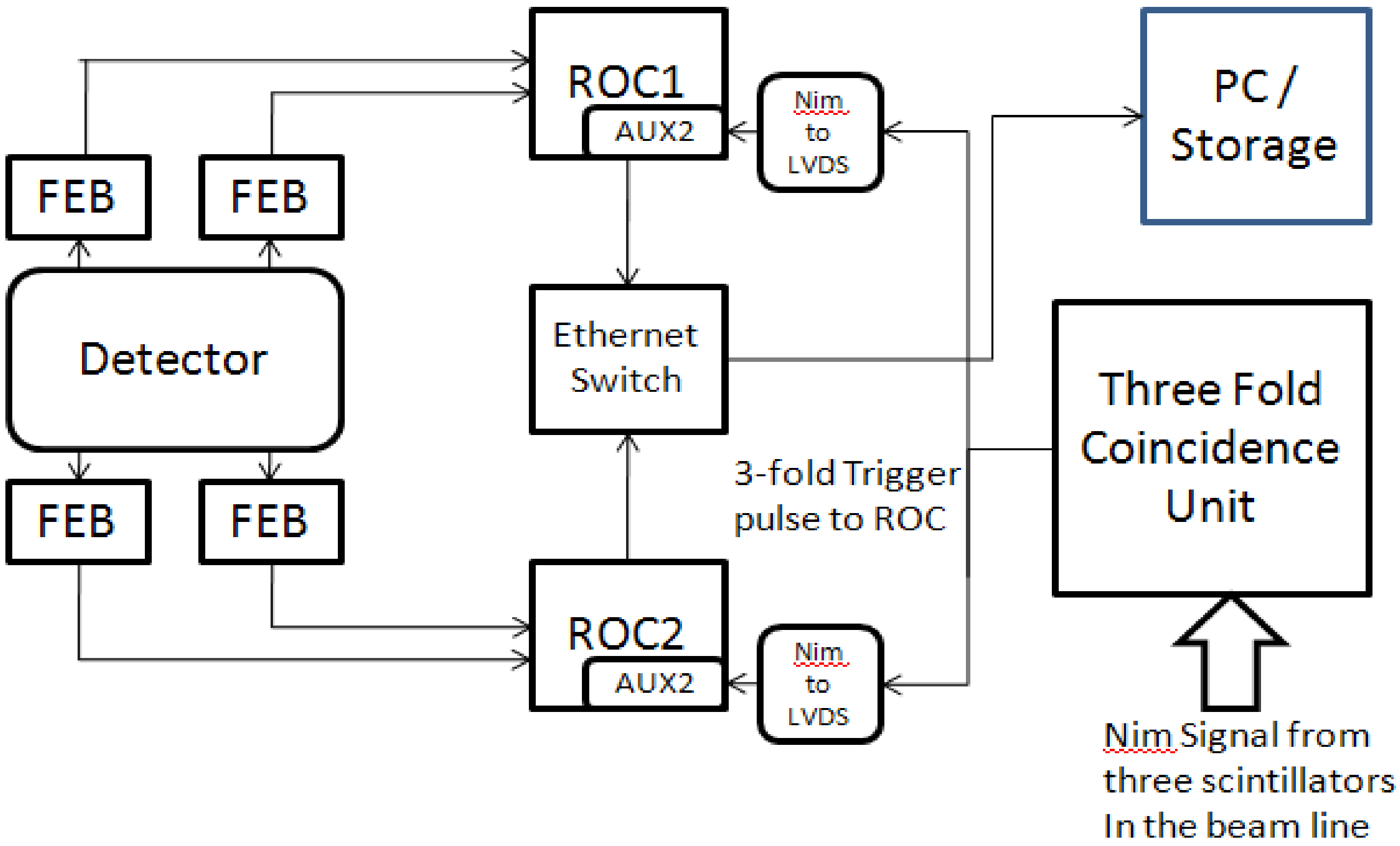
10 ohm Protection resistors at each channel

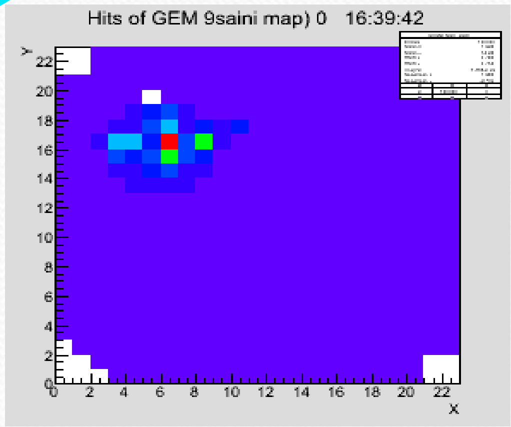
Test Beam Set Up (CERN/ H4 beam line)

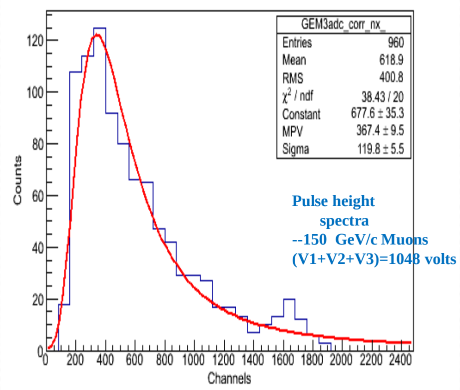


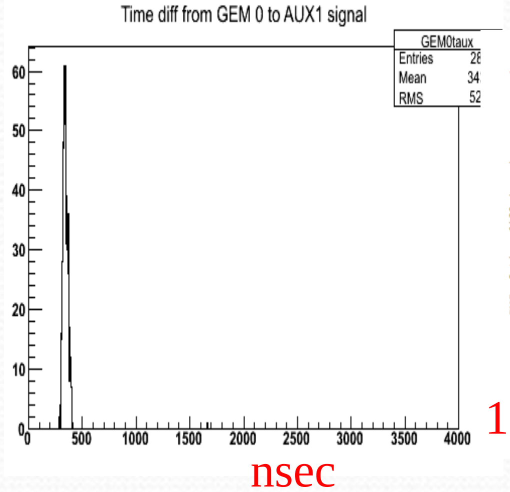
(thanks to Leszek's lab for all the help)

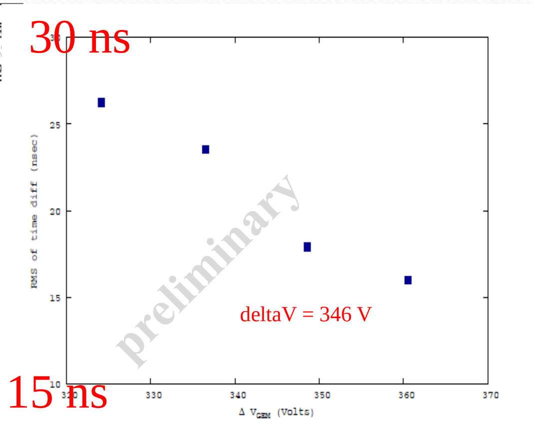
Schematic of the Data Acquistion for tests at CERN-H4 beamline

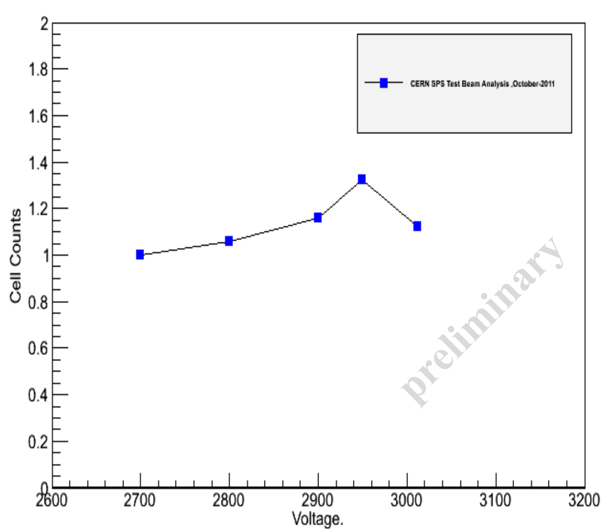


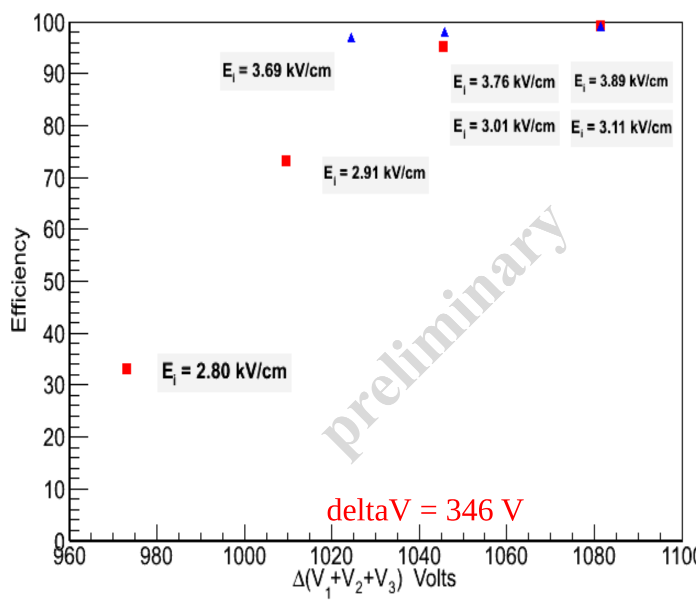


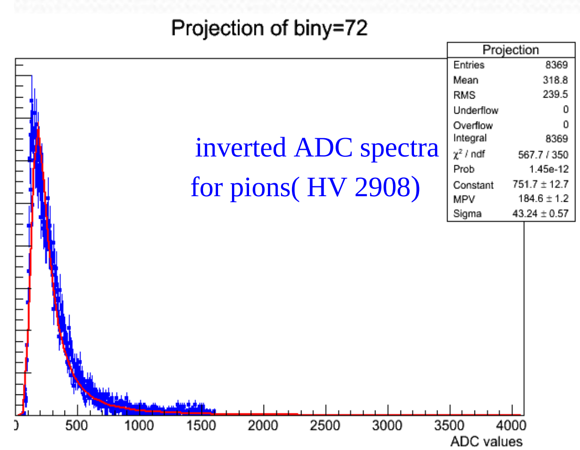








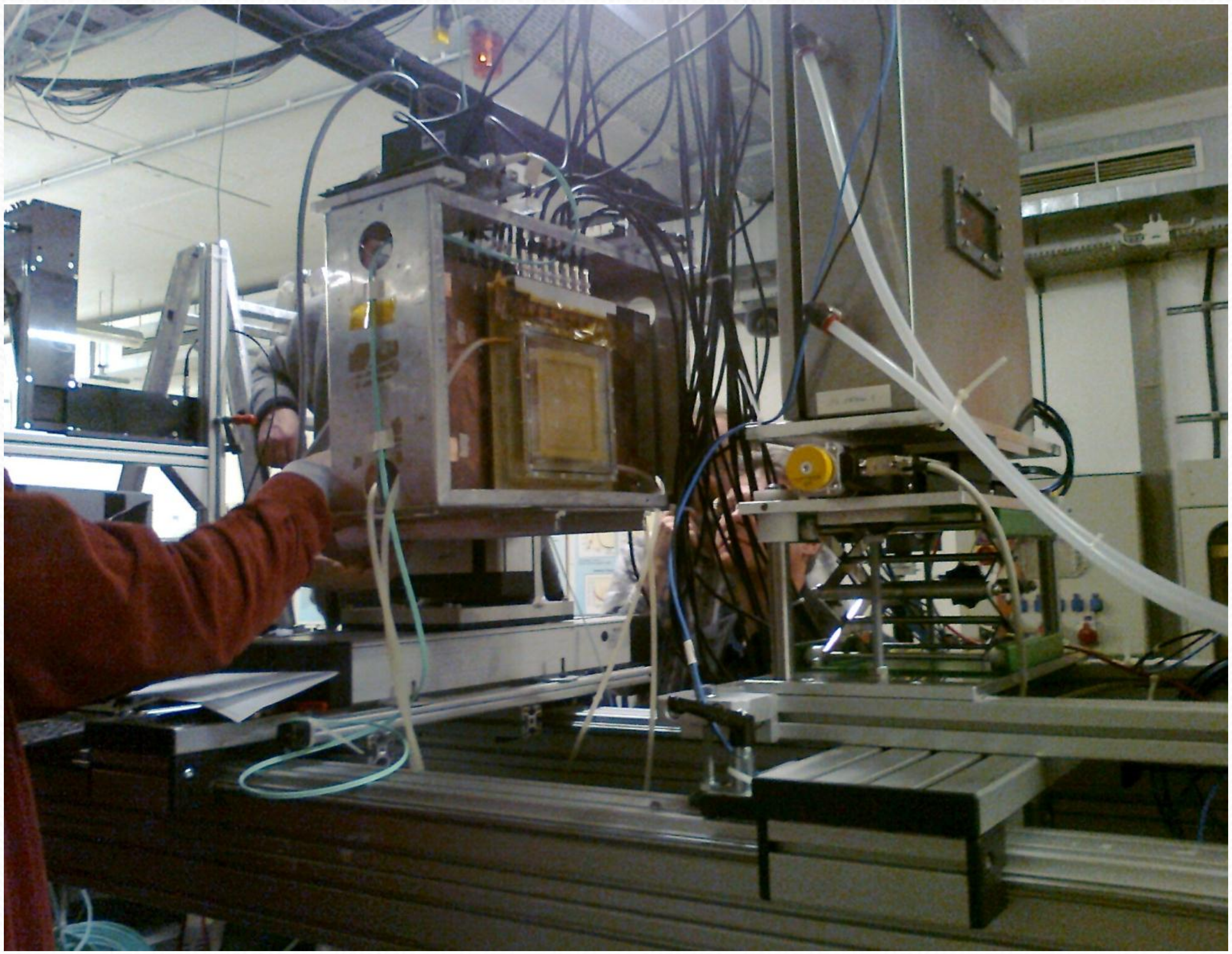




Cluster Size

Efficiency (using muon beam)

Julich Beamtest (Jan-2012)



-- Using Single-mask GEMs

-- First time using 7 individual
HV inputs instead of Res. chain.

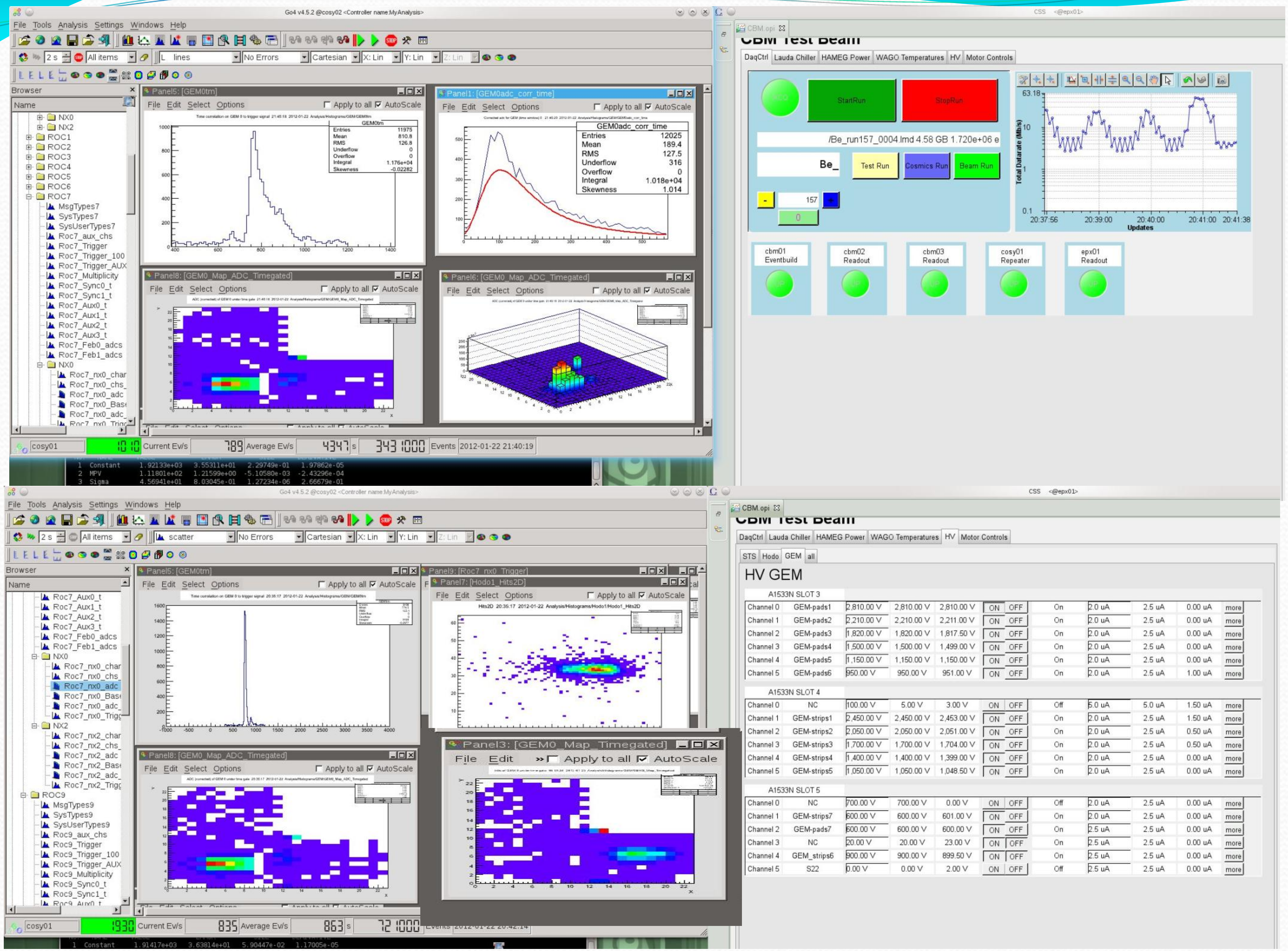
-- to understand the effects
of Drift and Induction
fields

-- data taken at several
combinations of bias voltages

-- Other detectors – STS,
Beam hodoscope

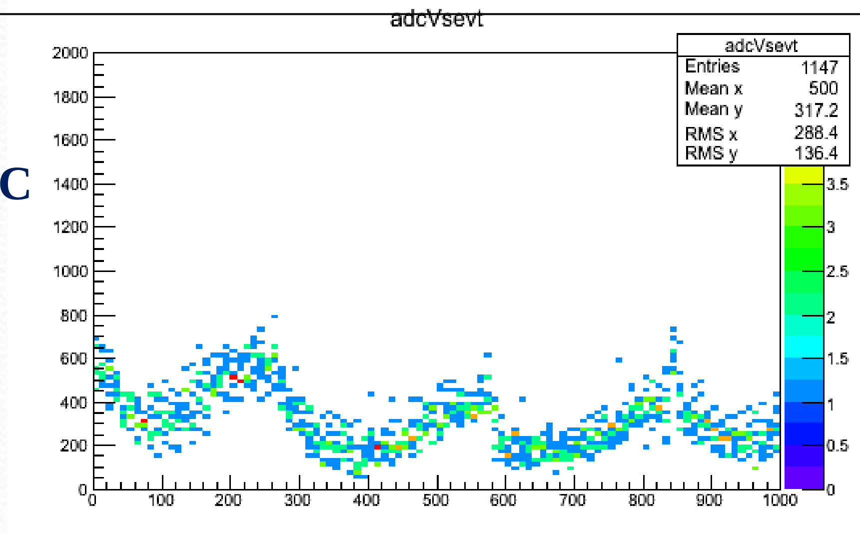
--- Test with high intensity beam
(no discharges seen, no saturation
with slight gain variation)

Julich Beamtest 2012



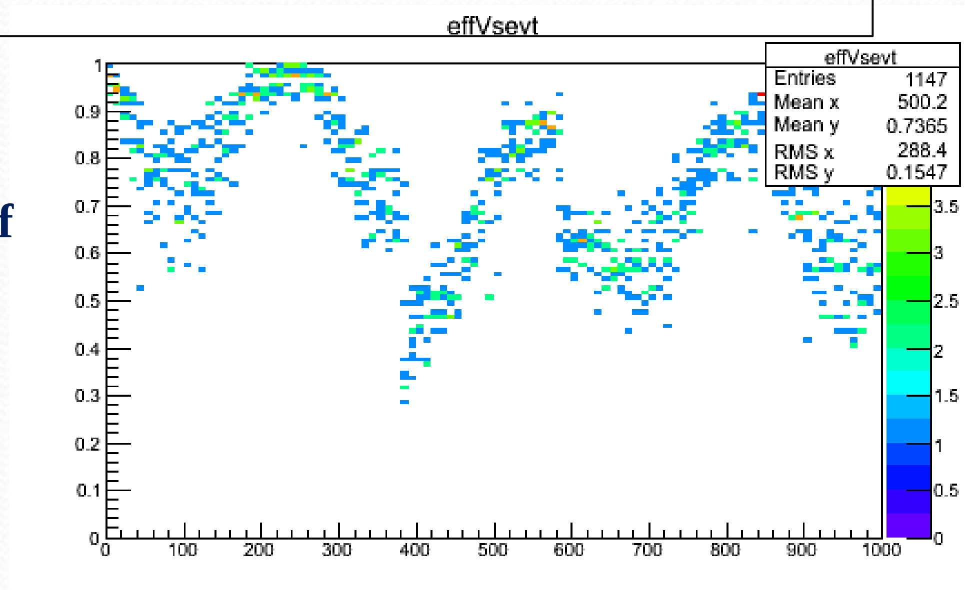
Variation of gain with beam intensity
(Low Intensity (KHz average) Run 215)

ADC



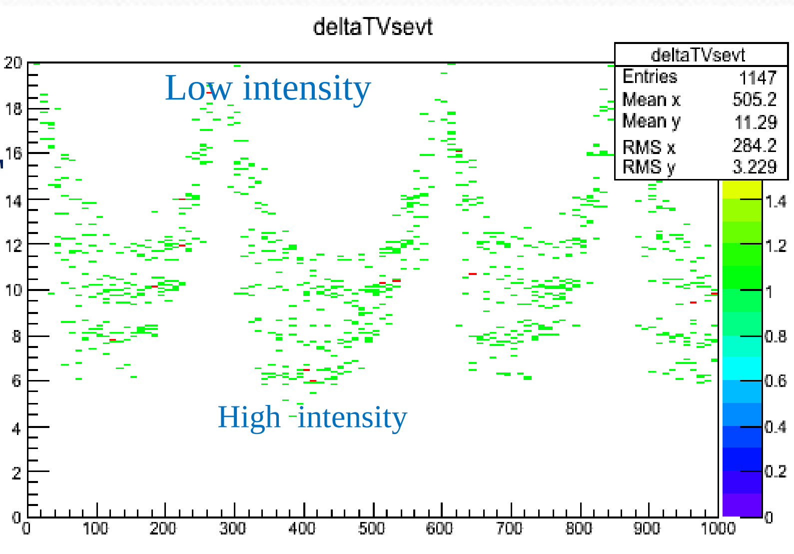
Event No

Eff



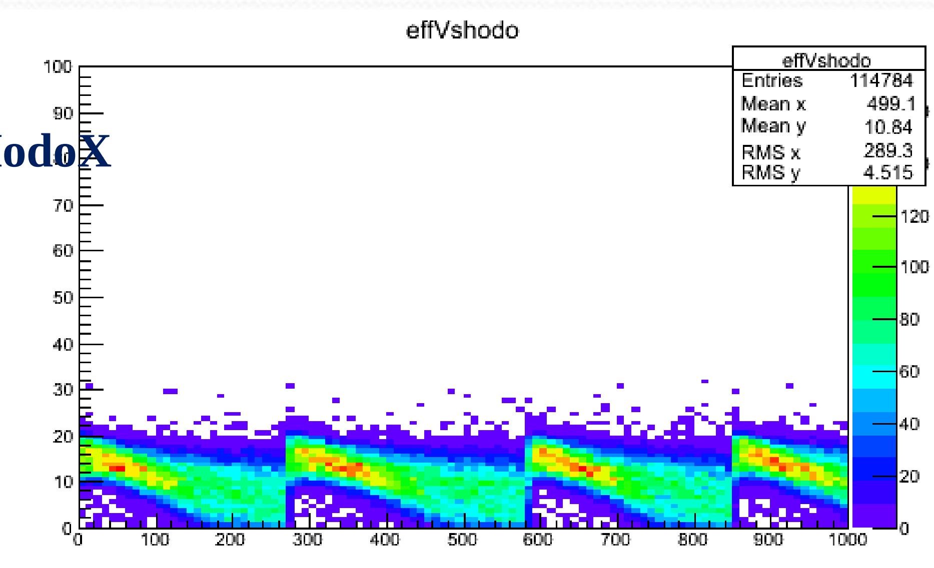
Event No

DeltaT



Event No

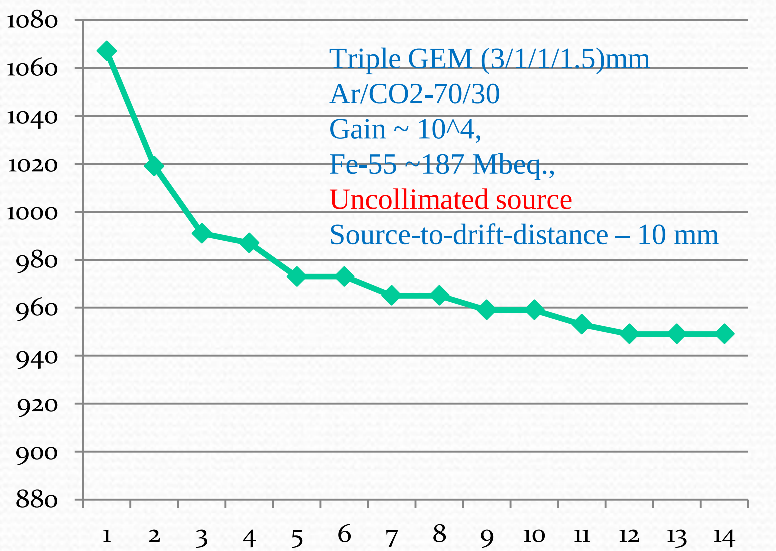
HodoX



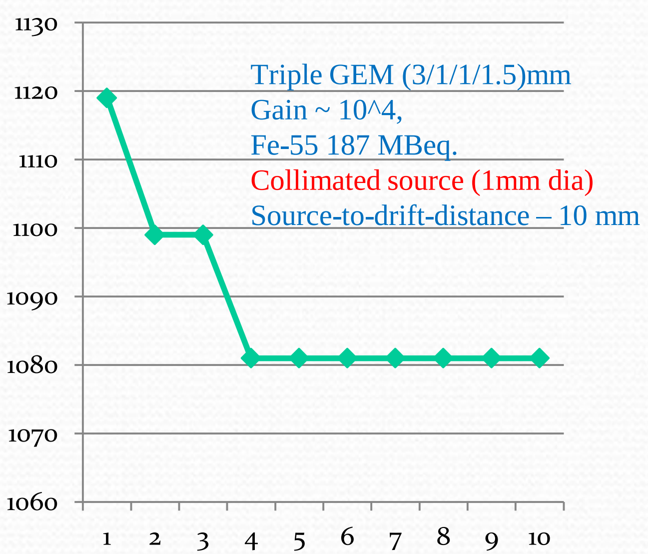
Event No

Gain variation

(with time)

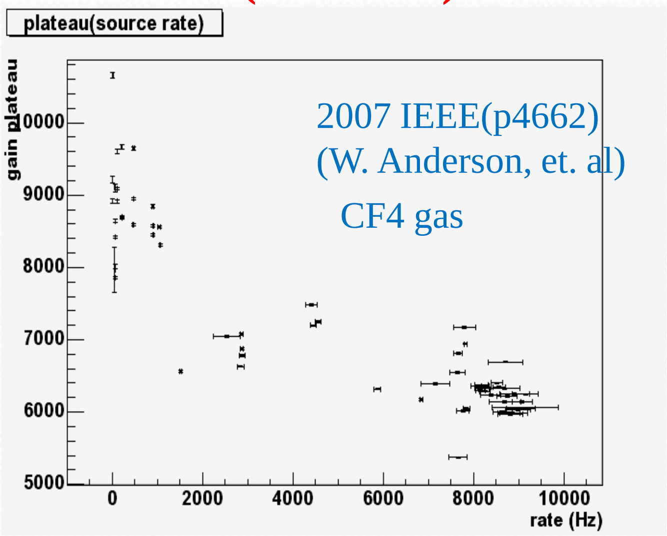


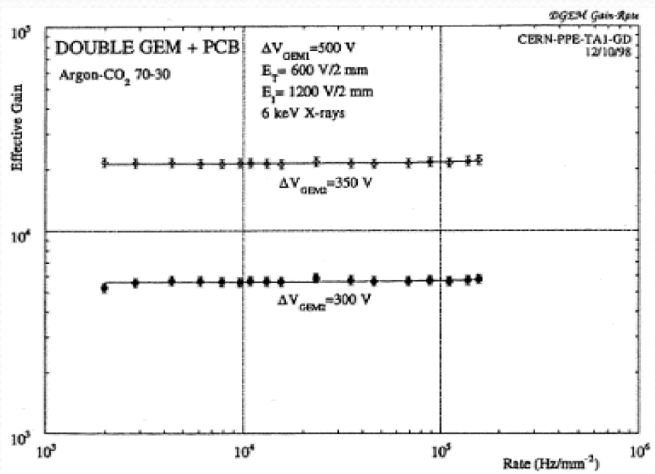
30 sec **420 sec**



120 sec

(with rate)





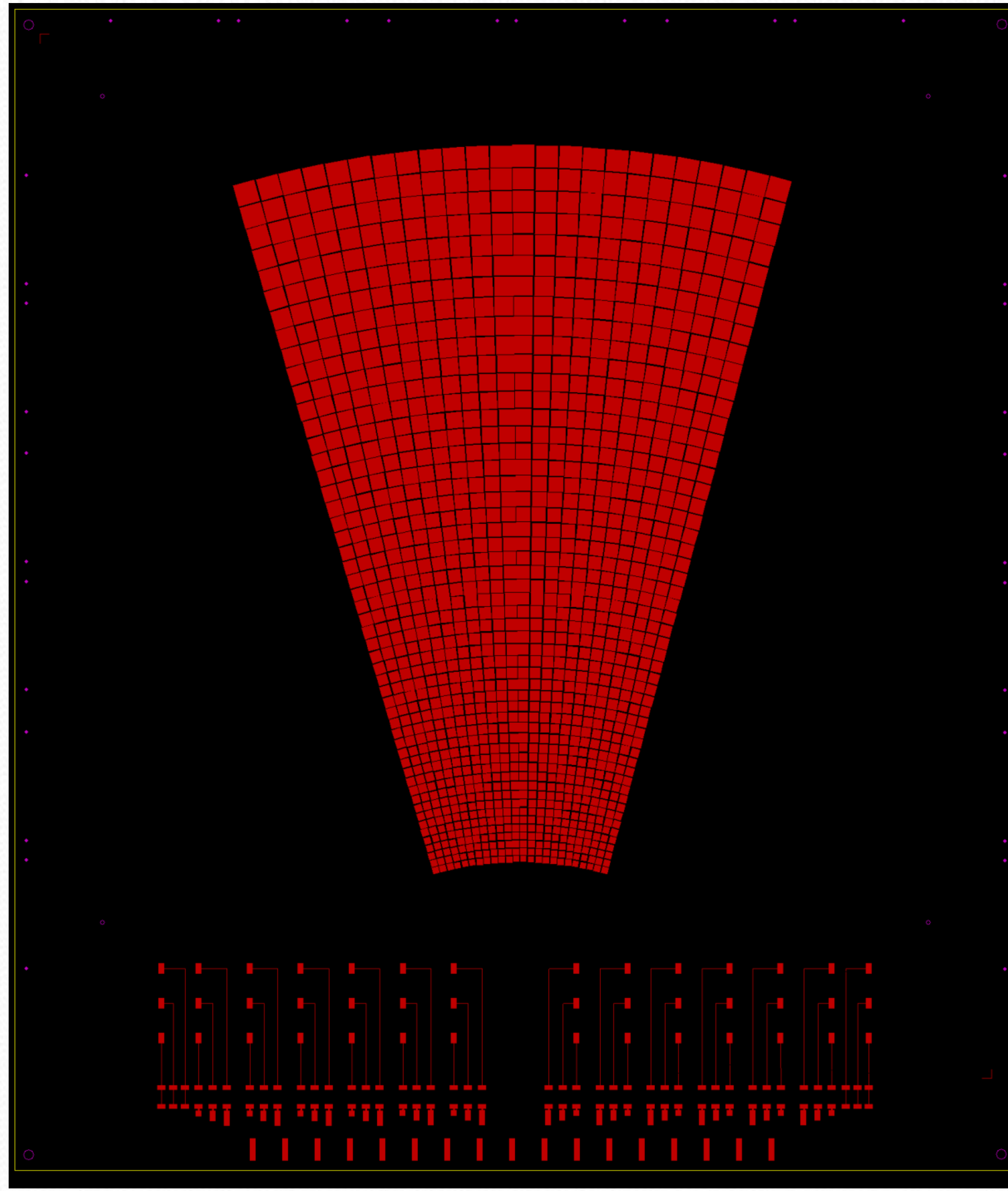
What happens at higher rates ?
Where does the gain stabilize and in how much time ?

Sector PCB, a first attempt

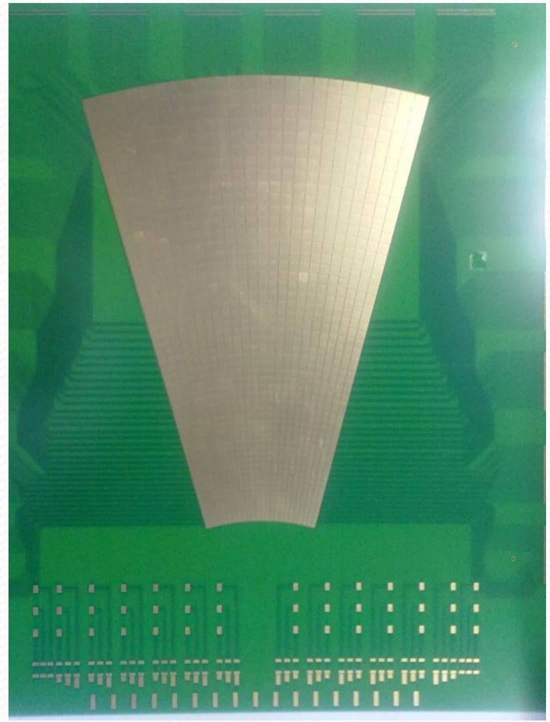
~ 1200 pads

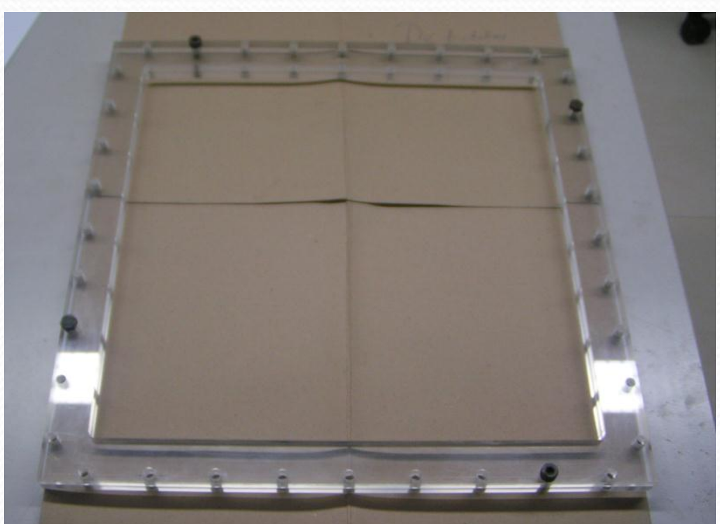
-- in 9 FEBs placed at the three sides of the board

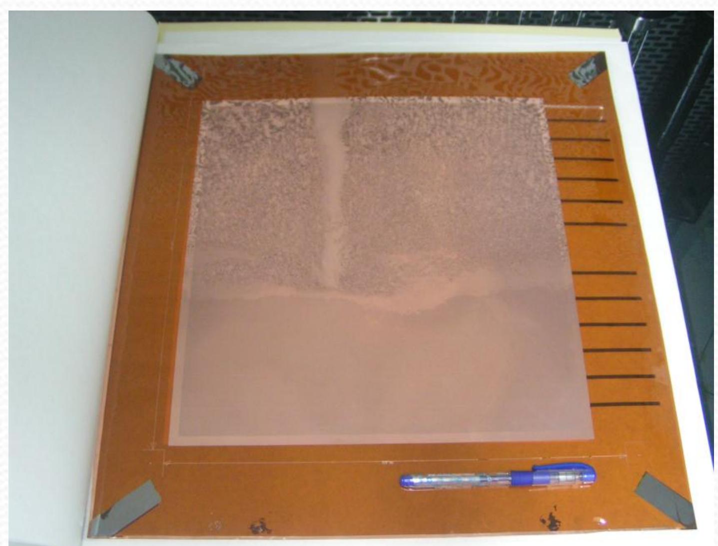
-- 5 ROC’s would be needed

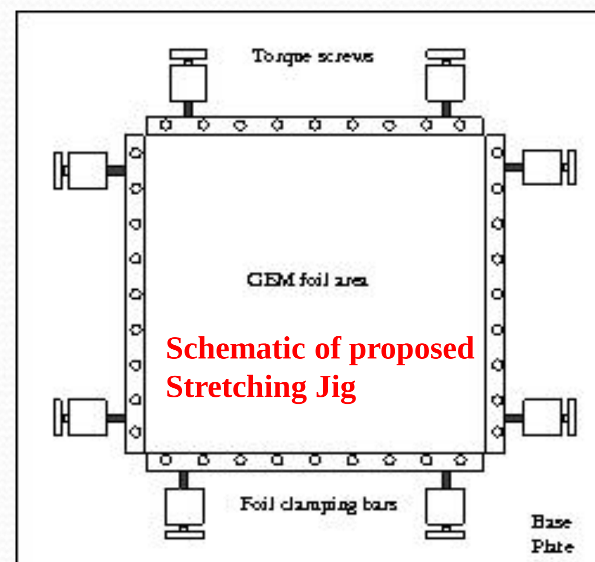


Towards making a large size GEM chamber









Schematic of proposed Stretching Jig

SUMMARY

- We have built and tested several multi GEM prototypes at VECC.

- Have tested their response to MIPs using cosmics – at VECC lab, an efficiency of 95 % achieved using conventional electronics. Prototypes tested with proton, pions, muon beams. Preliminary results suggest an efficiency of ~95 % with muon beams using self trigered readout, more checks underway.
- **Next Steps:**

  -- Testing a large size GEM (30 cm x 30 cm). Solving issues concerning design, stretching/gluing, optimizing jigs, etc.

  -- Radiation test with neutrons at VECC.

  -- Rate capability with single mask GEMs

  -- studying the GEM charging up issue – stability test

- **FEE – has been nXYTER so far, a ASIC similar to nXYTER is under production. full attention on TOTEM and CMS upgrades at LHC – towards use of large size GEMs.**

Thanks For Your Attention

he CBM Collaboration: 55 institutions, 450 members

Croatia:
RBI, Zagreb
Split Univ.

China:
CCNU Wuhan
Tsinghua Univ.
USTC Hefei

Czech Republic:
CAS, Rez
Techn. Univ.Prague

France:
IPHC Strasbourg

Hungaria:
KFKI Budapest
Budapest Univ.

Norway:
Univ. Bergen

India:
Aligarh Muslim Univ.
Panjab Univ.
Rajasthan Univ.
Univ. of Jammu
Univ. of Kashmir
Univ. of Calcutta
B.H. Univ. Varanasi
VECC Kolkata
SAHA Kolkata
IOP Bhubaneswar
IIT Kharagpur
Gauhati Univ.

Korea:
Korea Univ. Seoul
Pusan Nat. Univ.

Germany:
Univ. Heidelberg, P.I.
Univ. Heidelberg, KIP
Univ. Heidelberg, ZITI
Univ. Frankfurt IKF
Univ. Frankfurt, FIAS
Univ. Münster
FZ Dresden
GSI Darmstadt
Univ. Wuppertal

Poland:
Jag. Univ. Krakow
Warsaw Univ.
Silesia Univ. Katowice
AGH Krakow

Portugal:
LIP Coimbra

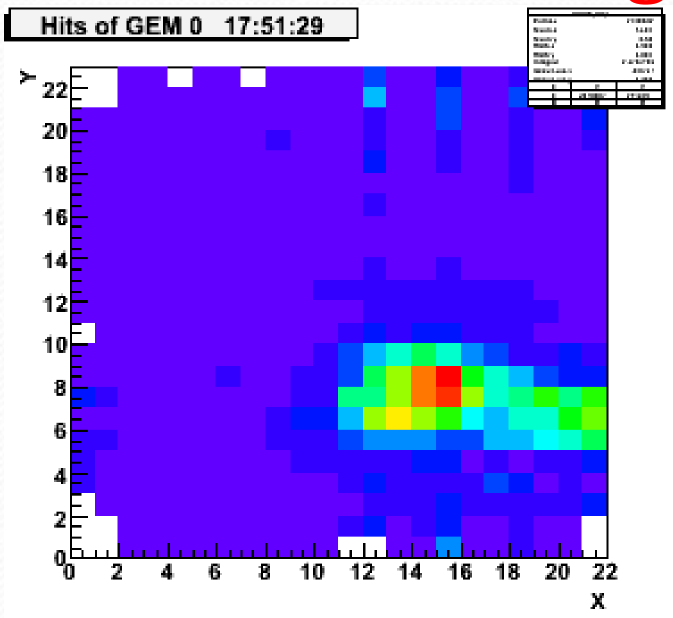
Romania:
NIPNE Bucharest
Univ. Bucharest

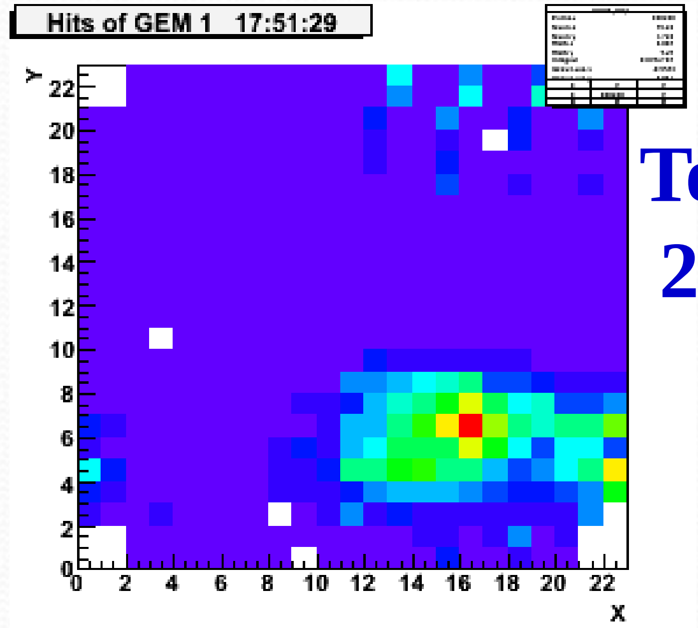
Russia:
IHEP Protvino
INR Troitzk
ITEP Moscow
KRI, St. Petersburg
Kurchatov Inst., Moscow
LHEP, JINR Dubna
LIT, JINR Dubna
MEPHI Moscow
Obninsk State Univ.
PNPI Gatchina
SINP MSU, Moscow
St. Petersburg P. Univ.

Ukraine:
T. Shevchenko Univ. Kiev
Kiev Inst. Nucl. Research

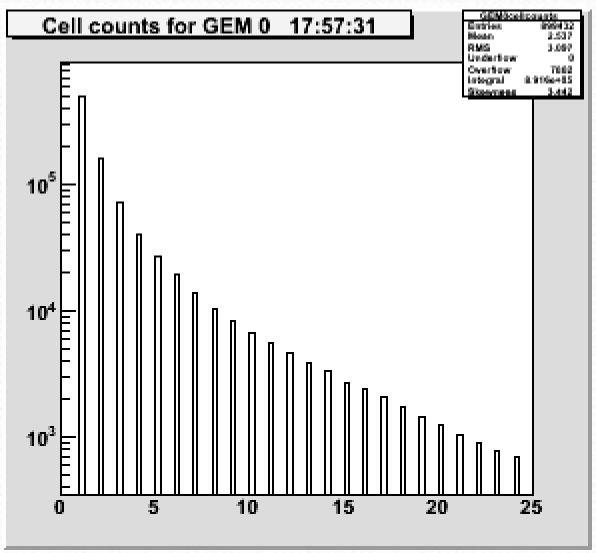
14st CBM Collaboration meeting
5-9 Oct. 2009, Split, Croatia

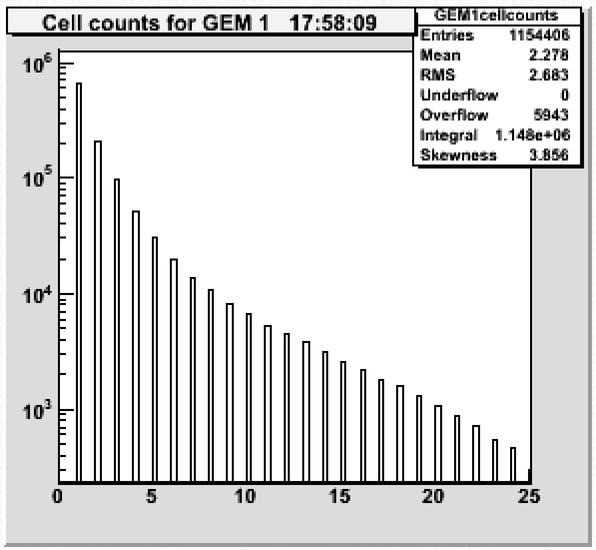
High Intensity Run





Tested from 25 kHz to 350 kHz

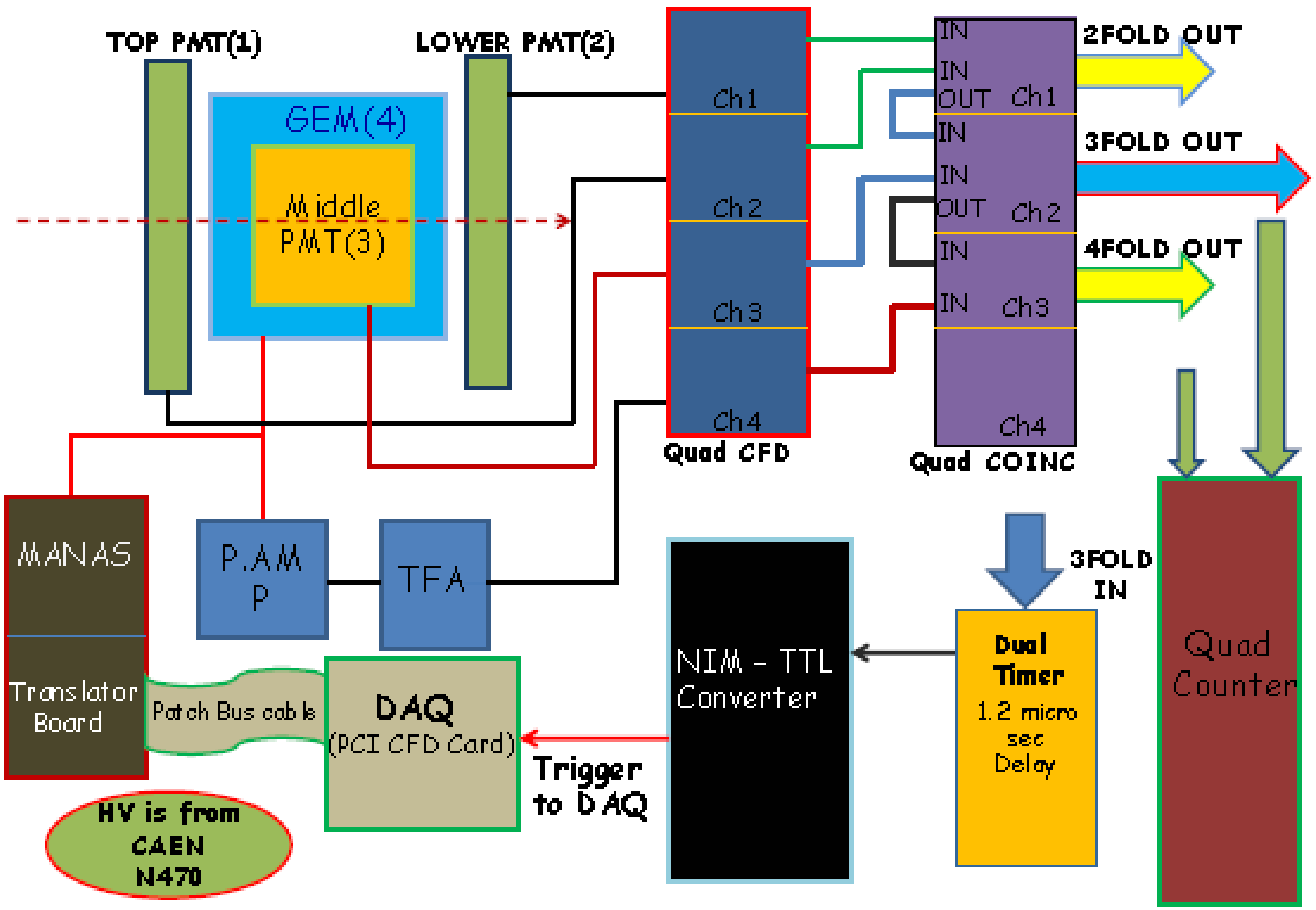




The average cluster size shows no significant change from low to high rates

BACKUPS

Cosmic Setup and test with MANAS

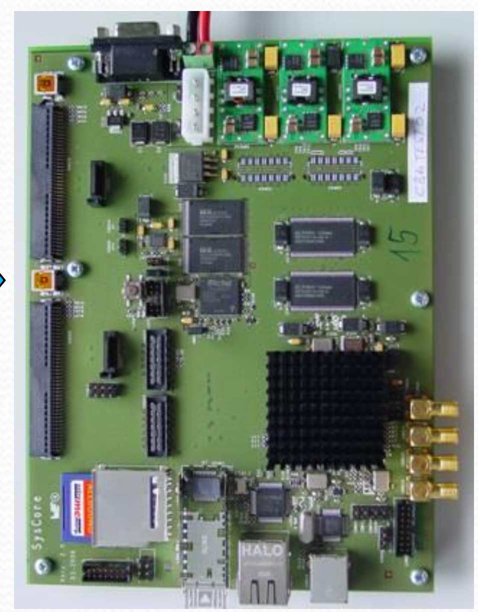


Test of prototypes in Self trigered mode

1. **nXYTER as the front end board**
2. **Readout Controller for …**
3. **CBM DAQ**

Detector

FEE board with
Self triggered chip



Readout Controller
(ROC)

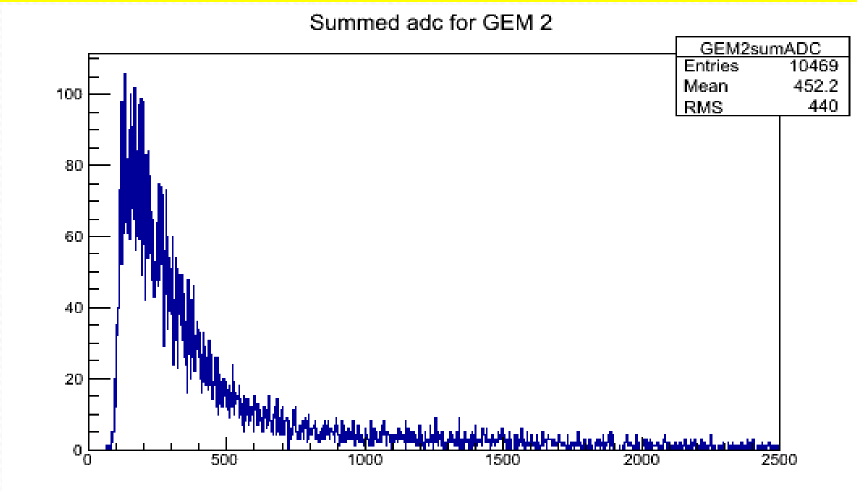
DABC

Data Acquisition
Backbone Core (DABC)

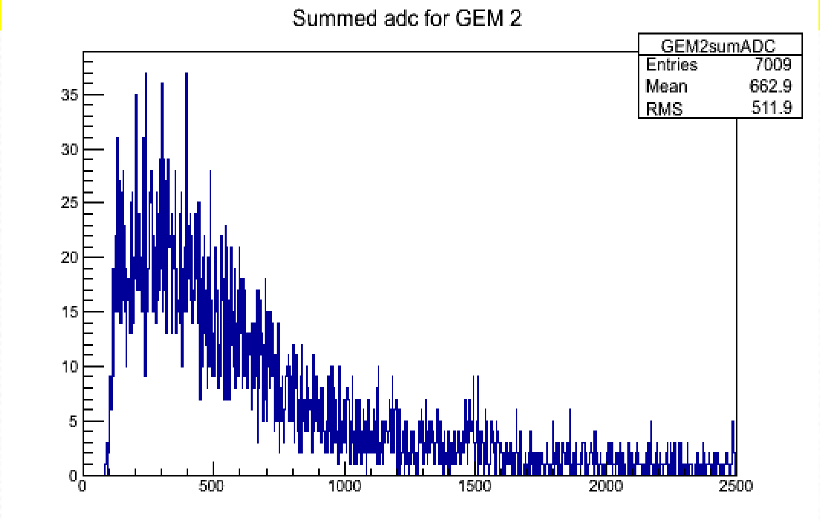
GO4
FAIR Root

This, the transfer of the measured data and the controlling of the functional behavior of the nXYTER and the ADC is done by **ROC** Board

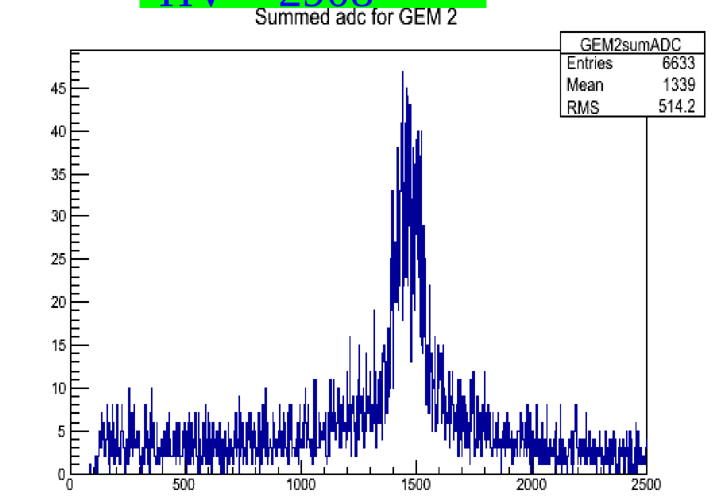
Pions without absorber - 3



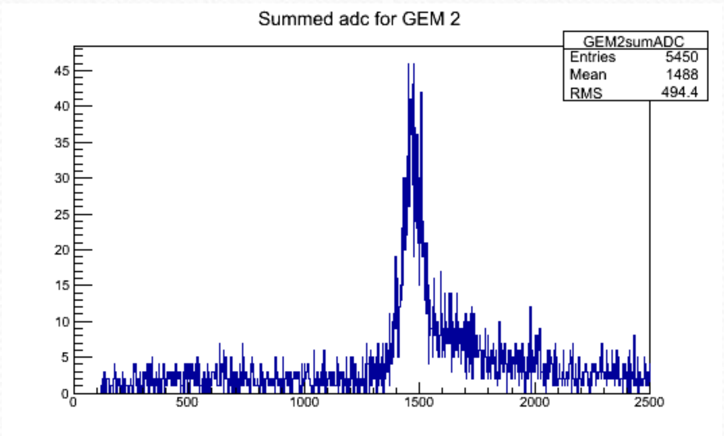
HV = 2908



HV = 3012



HV = 3218



HV = 3322

Huge Saturation in ADC for higher voltages

Specifications of the required ASIC

1. channel/chip: preferred 64
2. channels/system: 1M
3. chips.system: 15K
4. Power limit: needs more calculation as this is basically limited by cooling capability. for a sector of 9000 channels with 50mW (as specified by TRD) power dissipation, we see total load for heat is, 450W. We need to see if we can take away this heat..
5. Noise limit: about 1 fC
7. average I/P cap: ? have to measure it
9. Maximum hit rate/channel: 1.6 MHz
10. Required shaping time: 80nsec
11. min charge/hit: for a gain of 10^4, we can say 10^4 electrons (1.6 fC) is minimum charge
12. Average charge: Based on present simulation we get 30fC
13. Max charge: depends on dynamic range used.
14. Required dynamic range: simulations are on to estimate that.
15. Charge polarity: Negative
16. Type of energy distribution: ?
17. Measured quantity: Energy (ADC)
18. Input signal shape (<10 nsec)