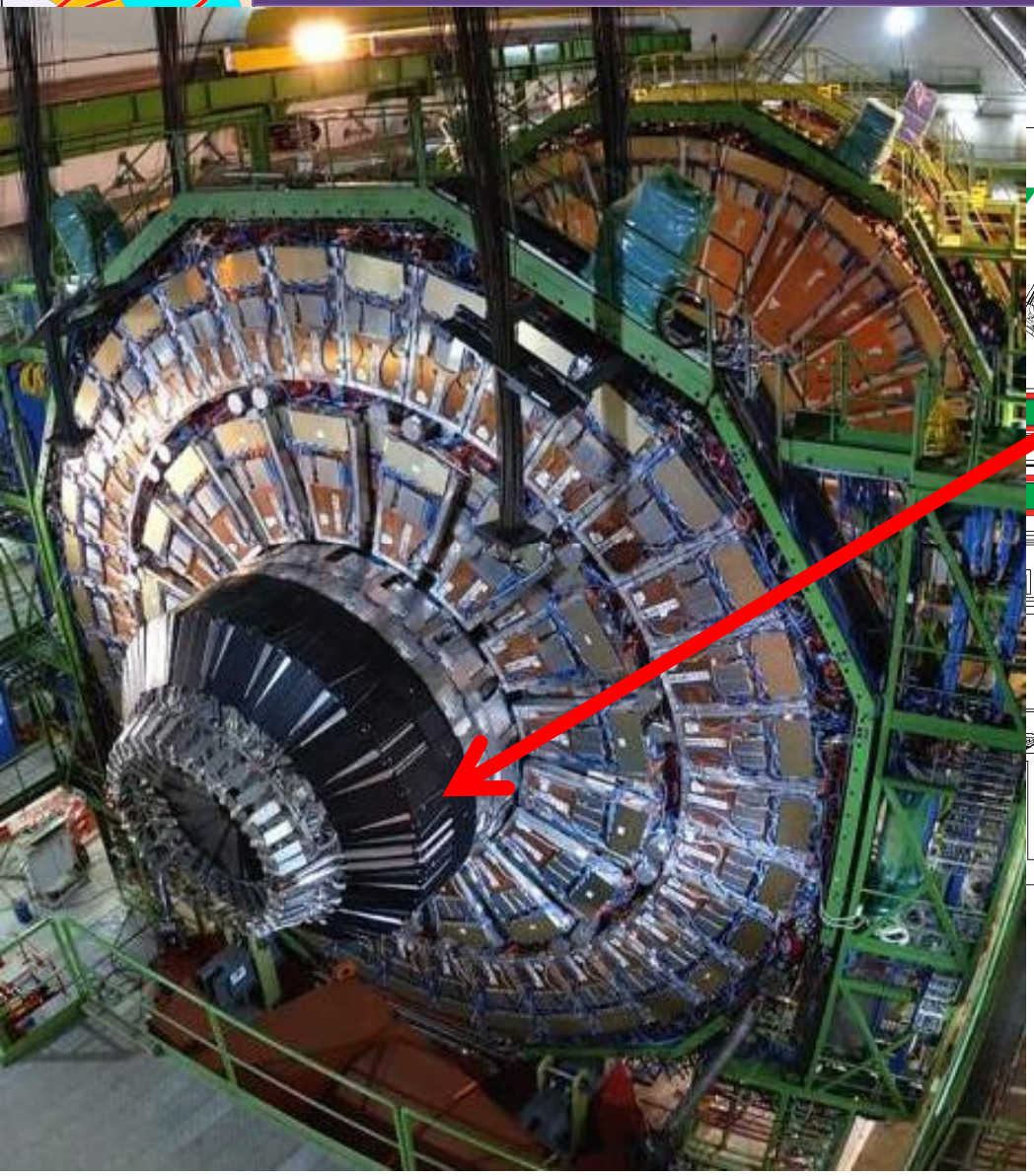
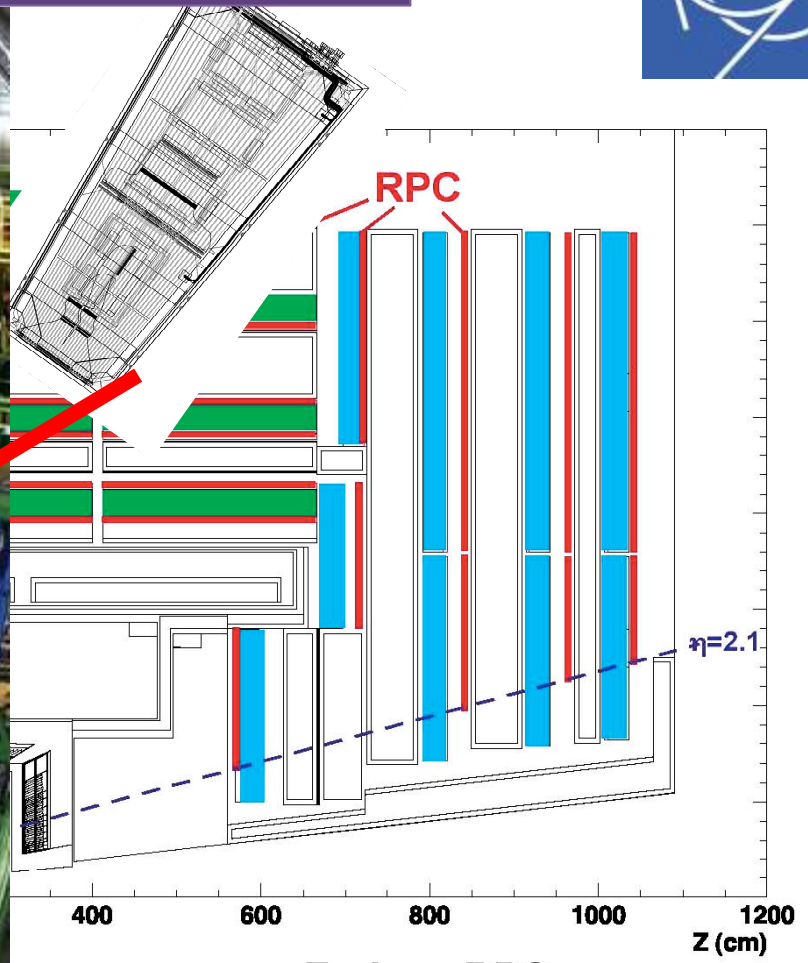
A High Eta Forward Muon Trigger and Tracking detector for CMS

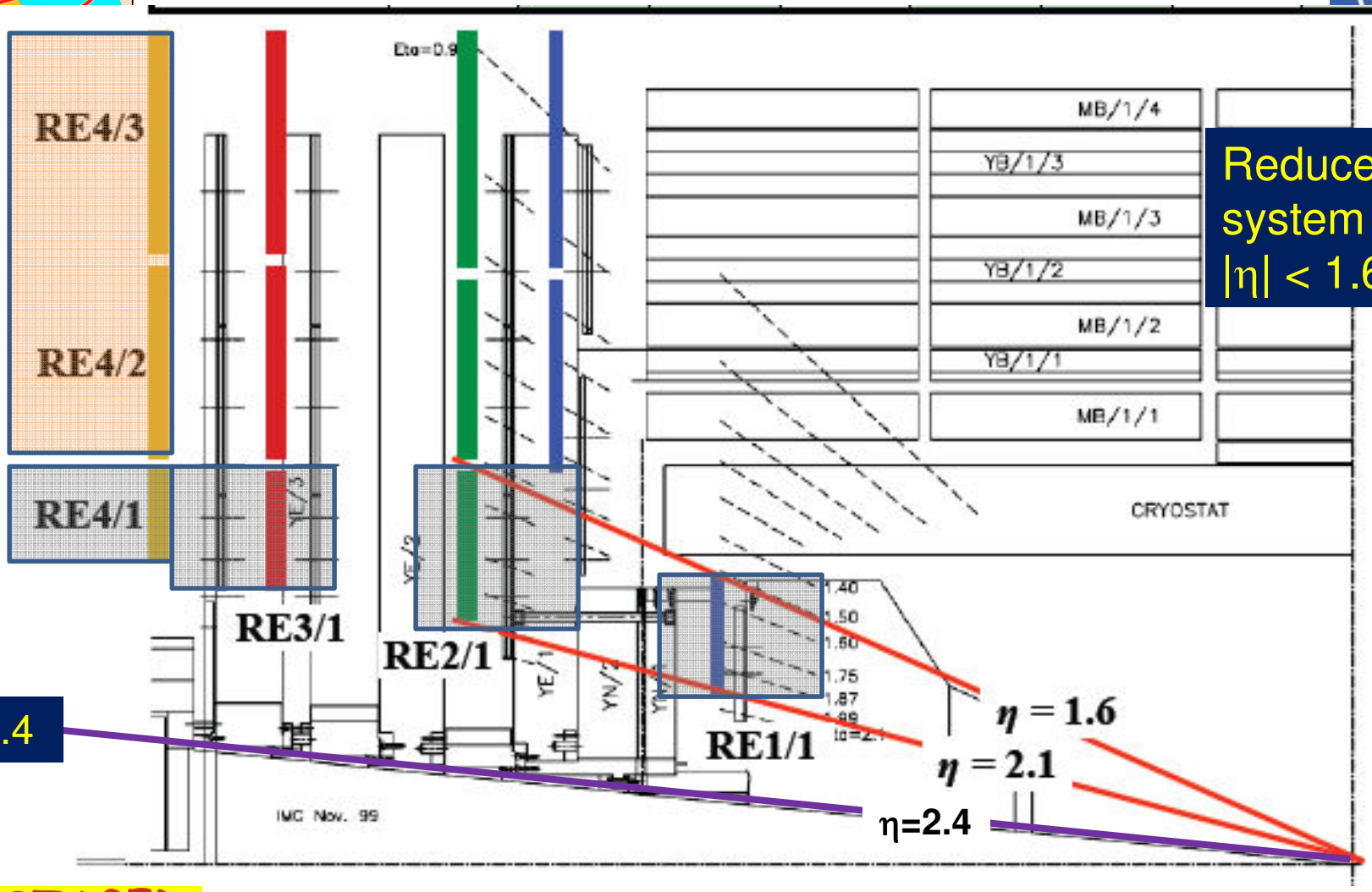




Endcap RPC:

- RE 1,2,3,4 = 1 layers
- 540 trapezoidal chambers
- 80 000 radial strips

Initial RE system –tailored to budget



Reduced RE system
$|\eta| < 1.6$

η 2.4

STAGED

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*

Increase Trigger Efficiency by adding 4th layer RE Upscope: Piet Verwilligen's talk – in Phase I High eta (Upgrade)

Simulations
To be continued..

NIM A 609 2009 (825-829)
A. Sharma and S. Beri (Punjab Univ)

Estimated Particle rates in Forward CMS

RPC Region	Rates Hz/cm^2 LHC (10^{34} cm^2/s)	High Luminosity LHC 2.3 x LHC	(10^{35}cm^2/s) Phase II SLHC ??
RB	30	Few 100	kHz (tbc)
RE 1, 2, 3,4 $\eta < 1.6$	30	Few 100	**kHz (tbc)**
Expected Charge in 10 years	0.05 C/cm^2	0.15 C/cm^2	~ C/cm^2
RE 1,2,3,4 $\eta > 1.6$	**500- kHz**	**Few kHz**	**Few 10s kHz**
Total Expected Charge in 10 years	(0.05-**1**) C/cm^2	few C/cm^2	Few 10s C/cm^2

MPGDs as candidate technology

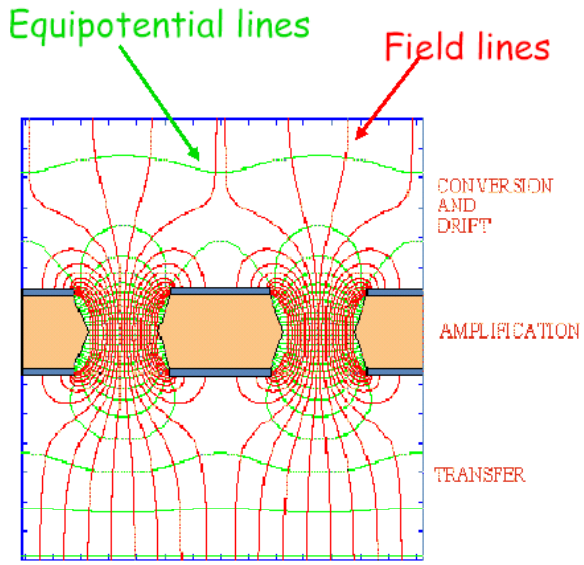
Improve contribution to Muon Trigger Efficiency

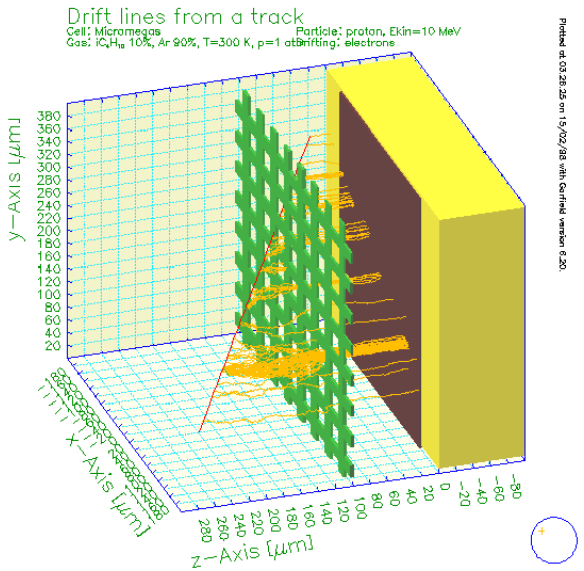
Combine triggering and tracking functions?

Instrument the vacant

(RE i/1) zone in CMS Forward

$1.6 > \eta > 2.4$





A. Sharma et a
Ann Rev.1999

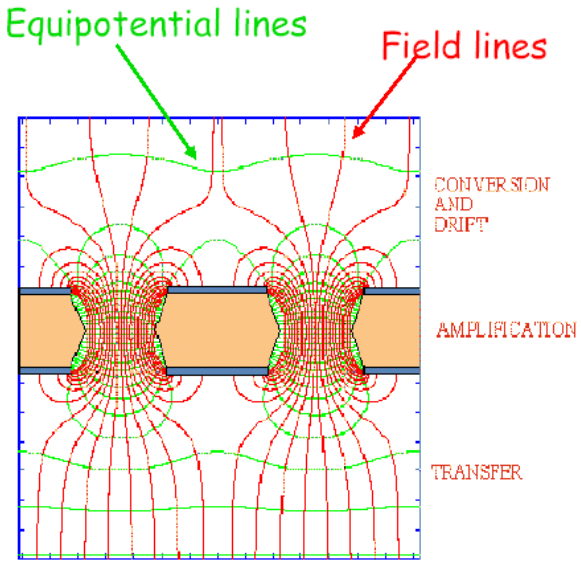
MPGDs as candidate technology

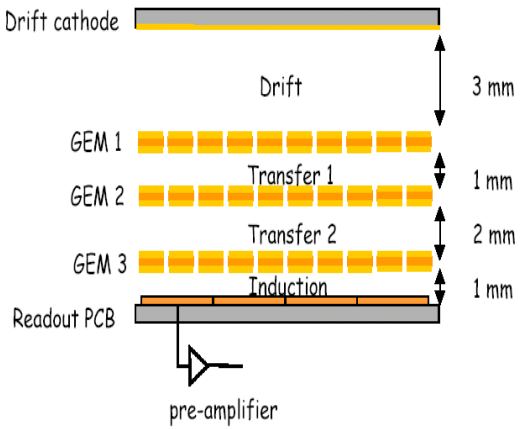
Enhance and optimize the readout ($\eta-\phi$) granularity by improved rate capability

Rate capability – $10^4/mm^2$

- Spatial resolution ~ 100 μm ($\Theta_{track} < 45°$)
- Time resolution ~ 1-3 ns (Gas!)
- Efficiency > 98%
- Rate capability > 5 kHz/cm²

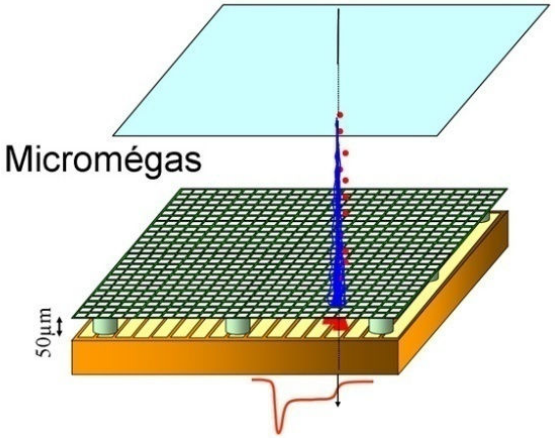
- Argon CO2 (non flammable mixture - big plus)

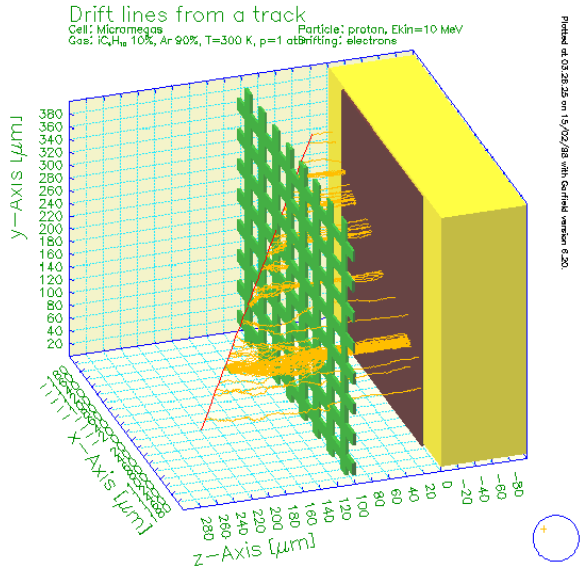




MPGDs as candidate technology

- Potential for going to large areas ~ 1m x 2m with industrial processes (cost effective)
- Long term operation experience in Compass
- Negligible Discharge probability with no consequence
- **Implemented for LHCb first muon station ($4m^2$) ~ 500 kHz/cm^2**
- **Proposed /in prep for ATLAS Muon upgrade ($1000m^2$)**



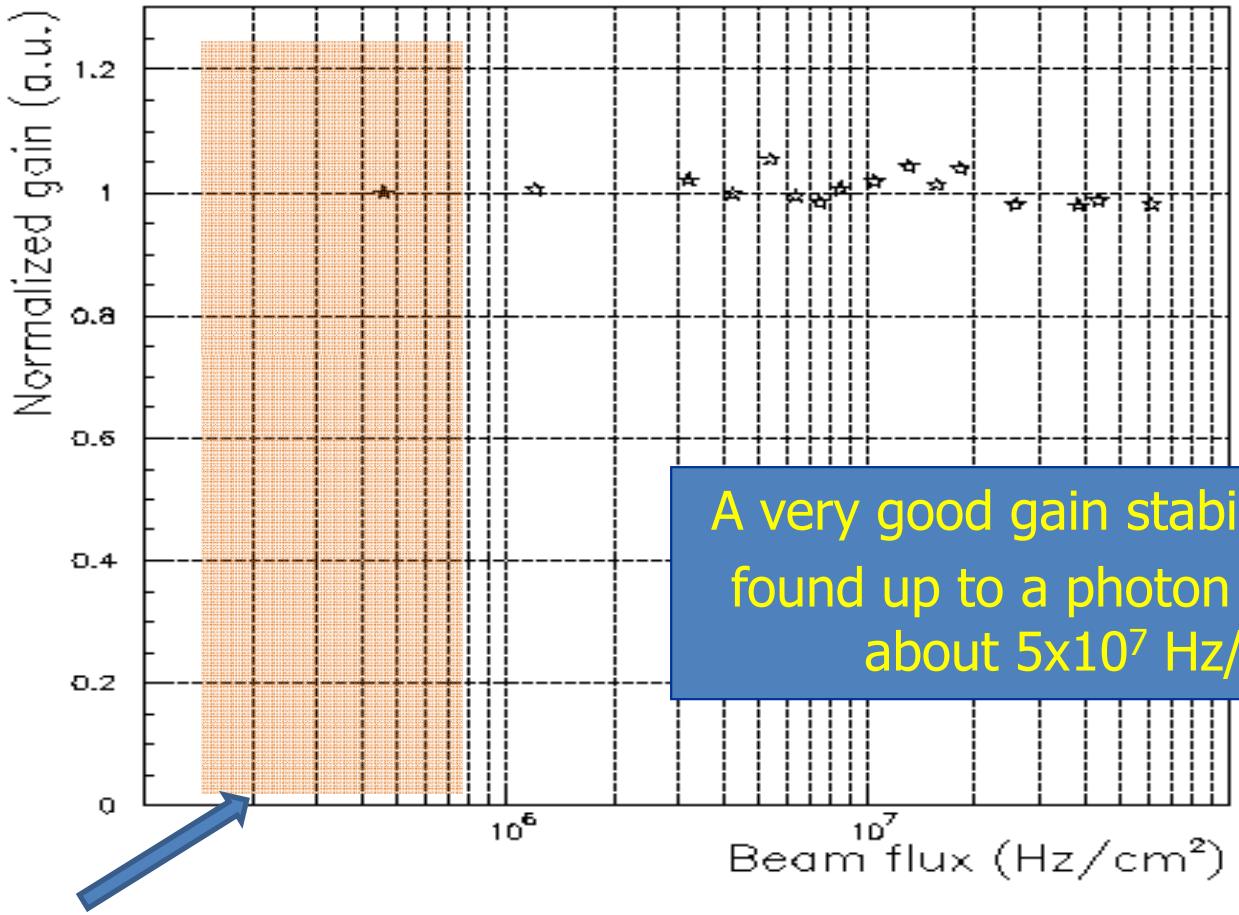


Rate capability

Measured with an X-ray (5.9 keV) tube;

$Ar/CO_2/CF_4$ (60/20/20)

Gain of about $2x10^4$;



A very good gain stability was found up to a photon flux of about $5x10^7$ Hz/cm^2

CMS high η - maximum rate

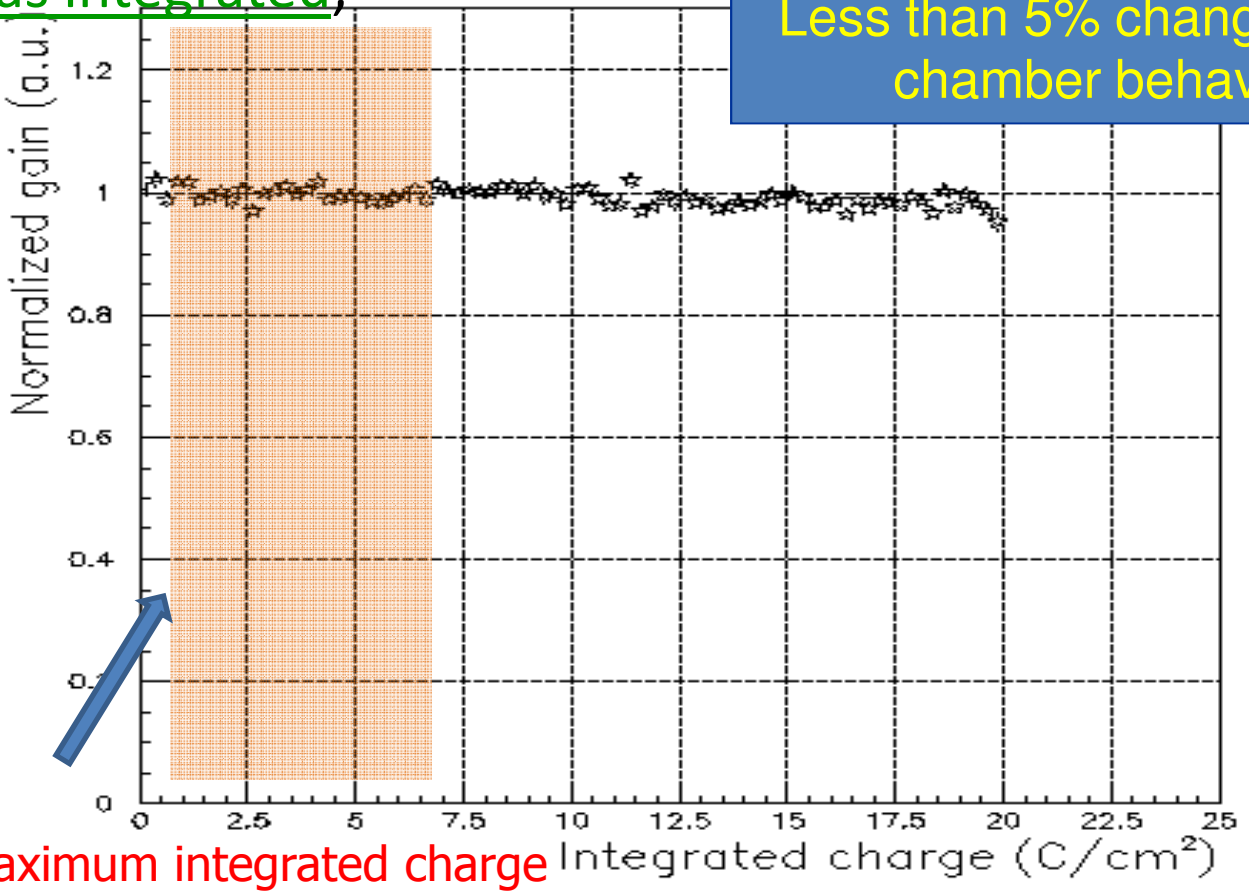
LHCb meas

Triple GEM Ageing test

Gain of 2×10^4

Total integrated charge of 13 C/cm^2 is expected in 10 years of operation in LHCb

50 MHz/cm^2 X-rays, in 10 days a total charge of 20 C/cm^2 was integrated;



CMS high η - maximum integrated charge

LHCb

CMS MPGD
Activities since August 2009

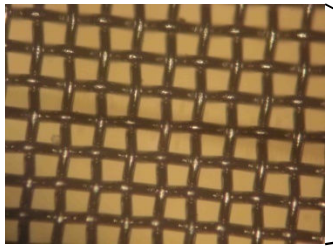
1. Assembly and test of two small MPGD prototypes
   - Micromegas
   - Triple Gem

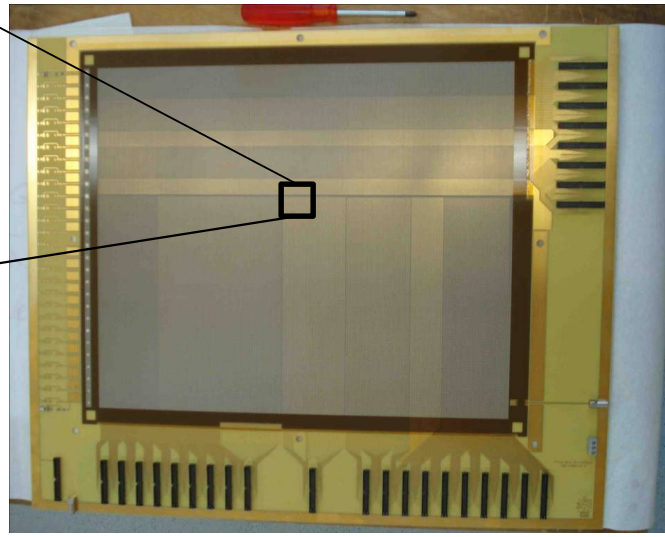
2. Planning for mock up of large prototype
   - Size and envelope limitations
   - Drawings

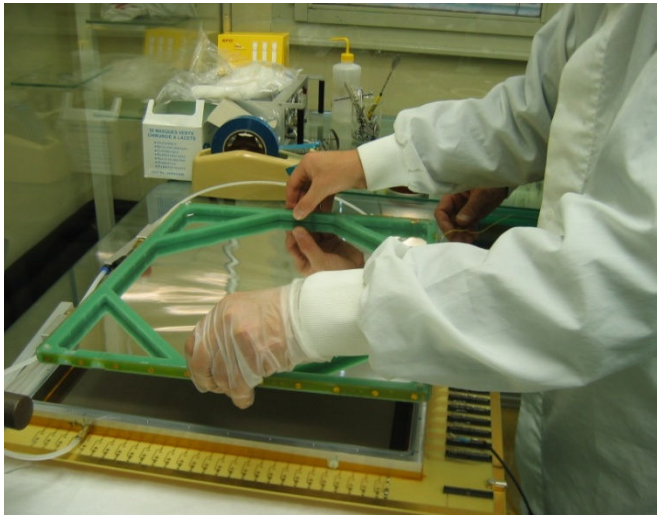
3. Beam test preparation
   - Mechanics and gas lines
   - Readout electronics(?)
   - DAQ

Small proto-CMS-MM-01

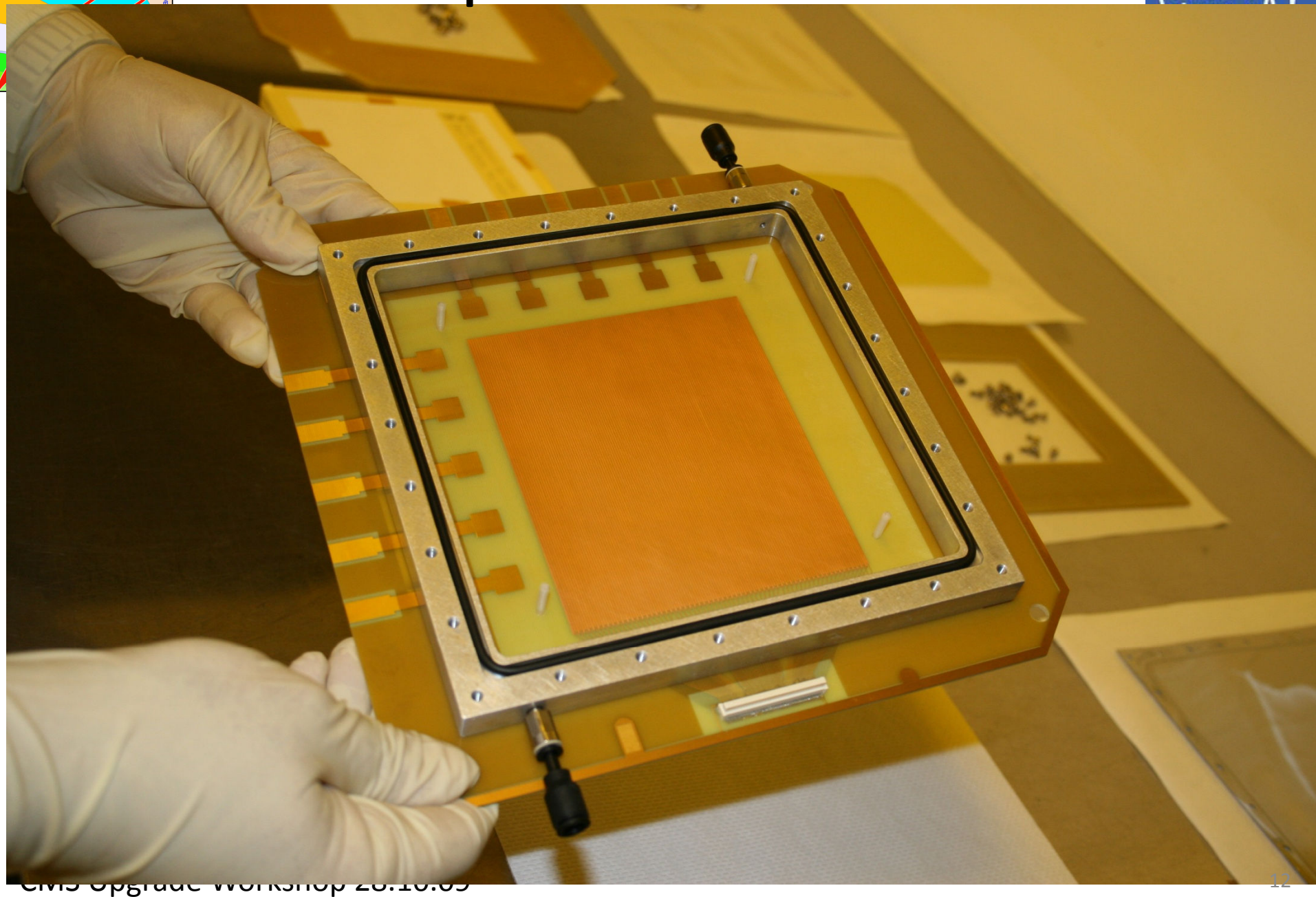
- Standard bulk micromegas fabricated at CERN-TS/DEM
- Homogeneous stainless steel mesh
- Wire diameter ~25 μm
- Amplification gap = 250 μm
- 100mm x 100mm active area
- Strip patterns (128 strips in 100mm ~ 0.700 μm)
- Drift gap: 3 mm

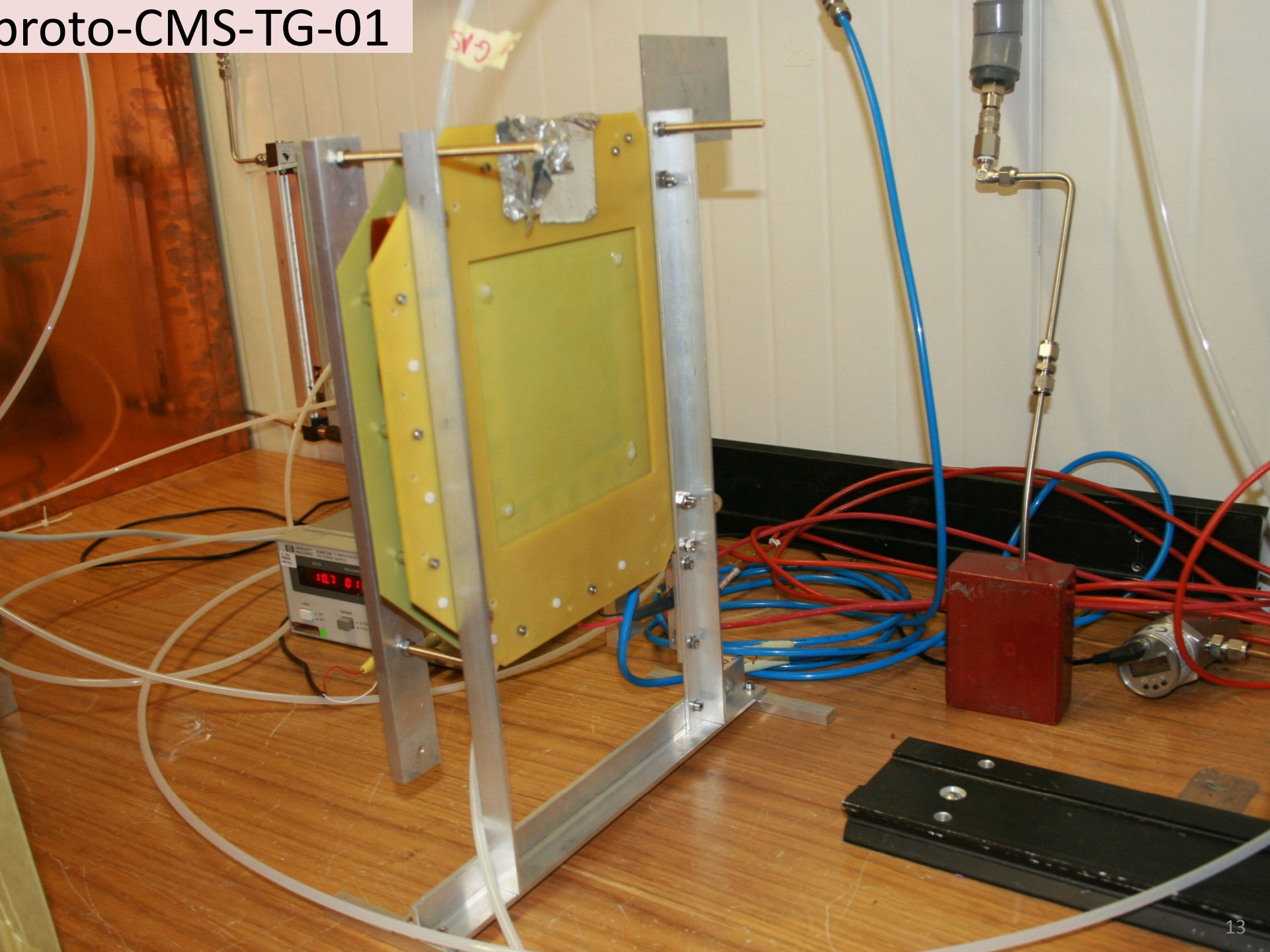




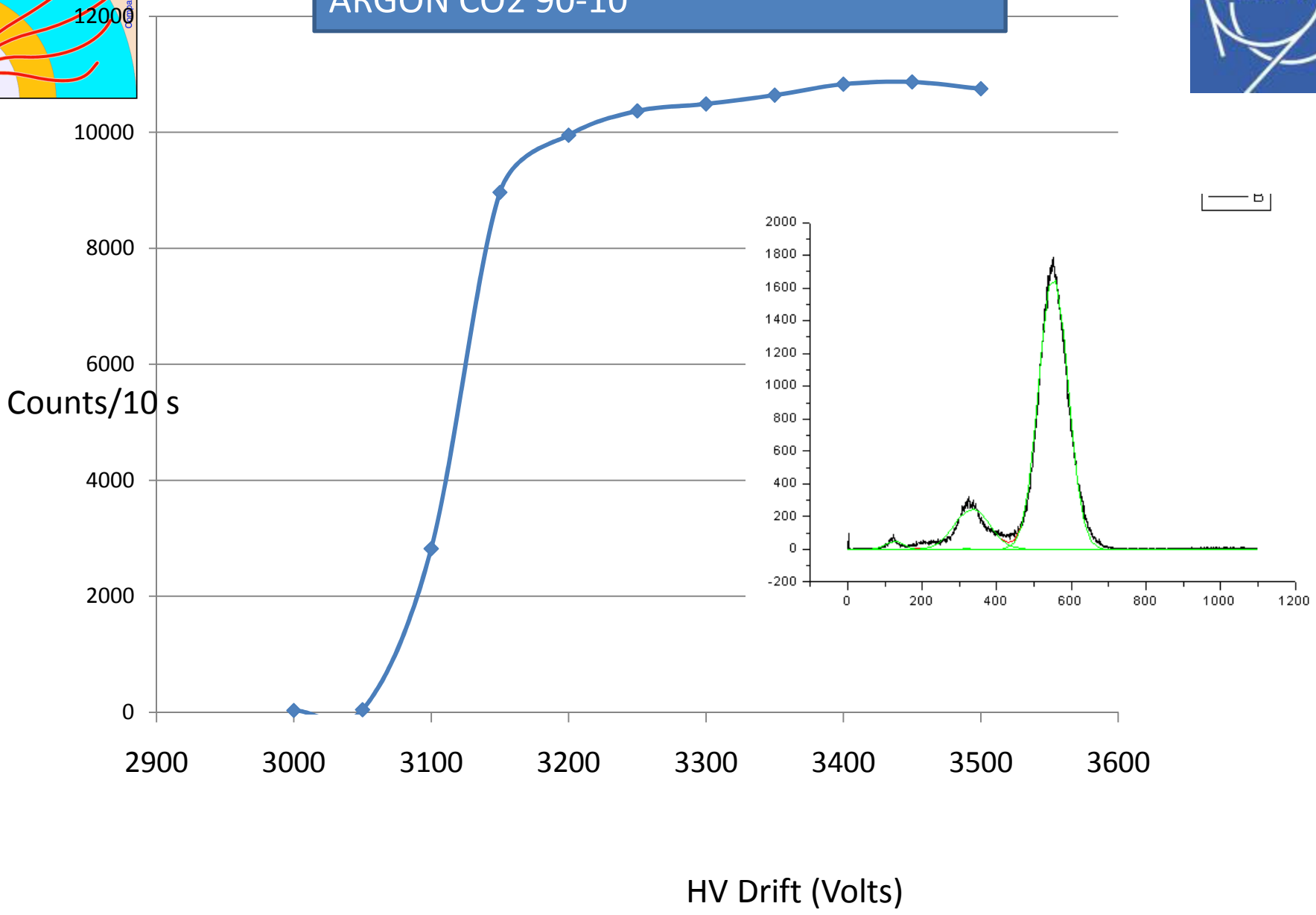


Small proto-CMS-TG-01

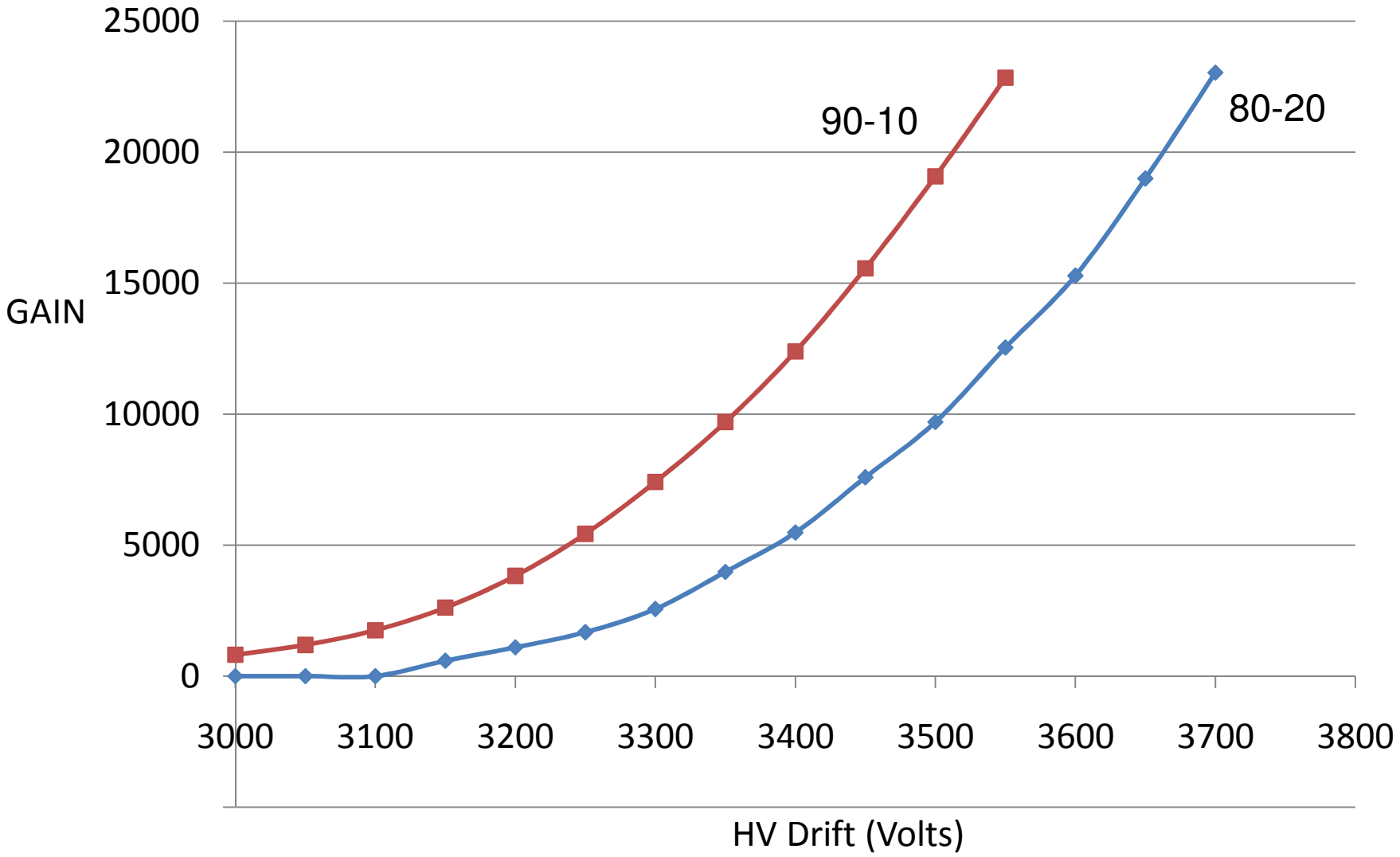



proto-CMS-TG-01

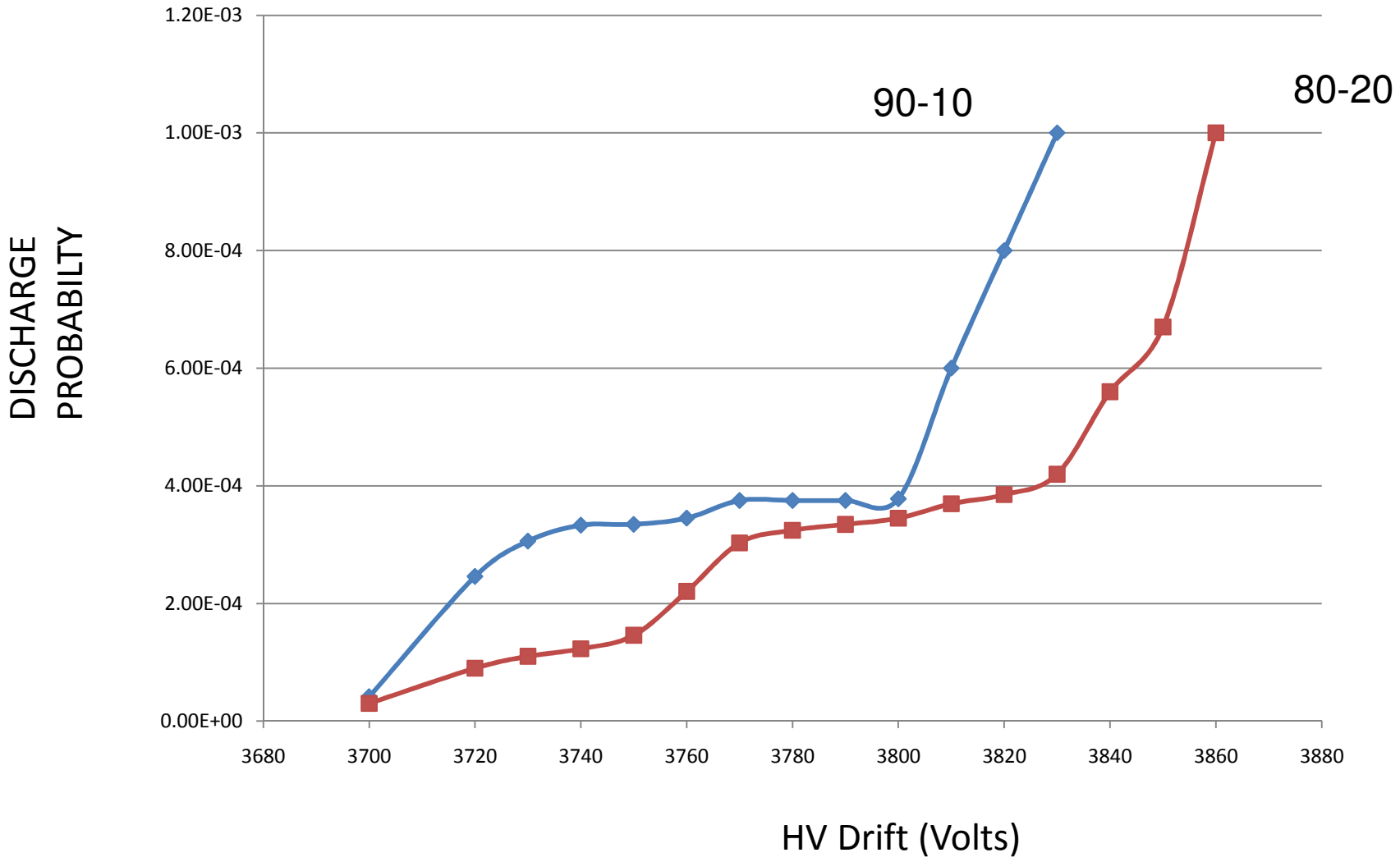
EFFIICIENCY STUDIES WITH TRIPLE GEM ARGON CO2 90-10



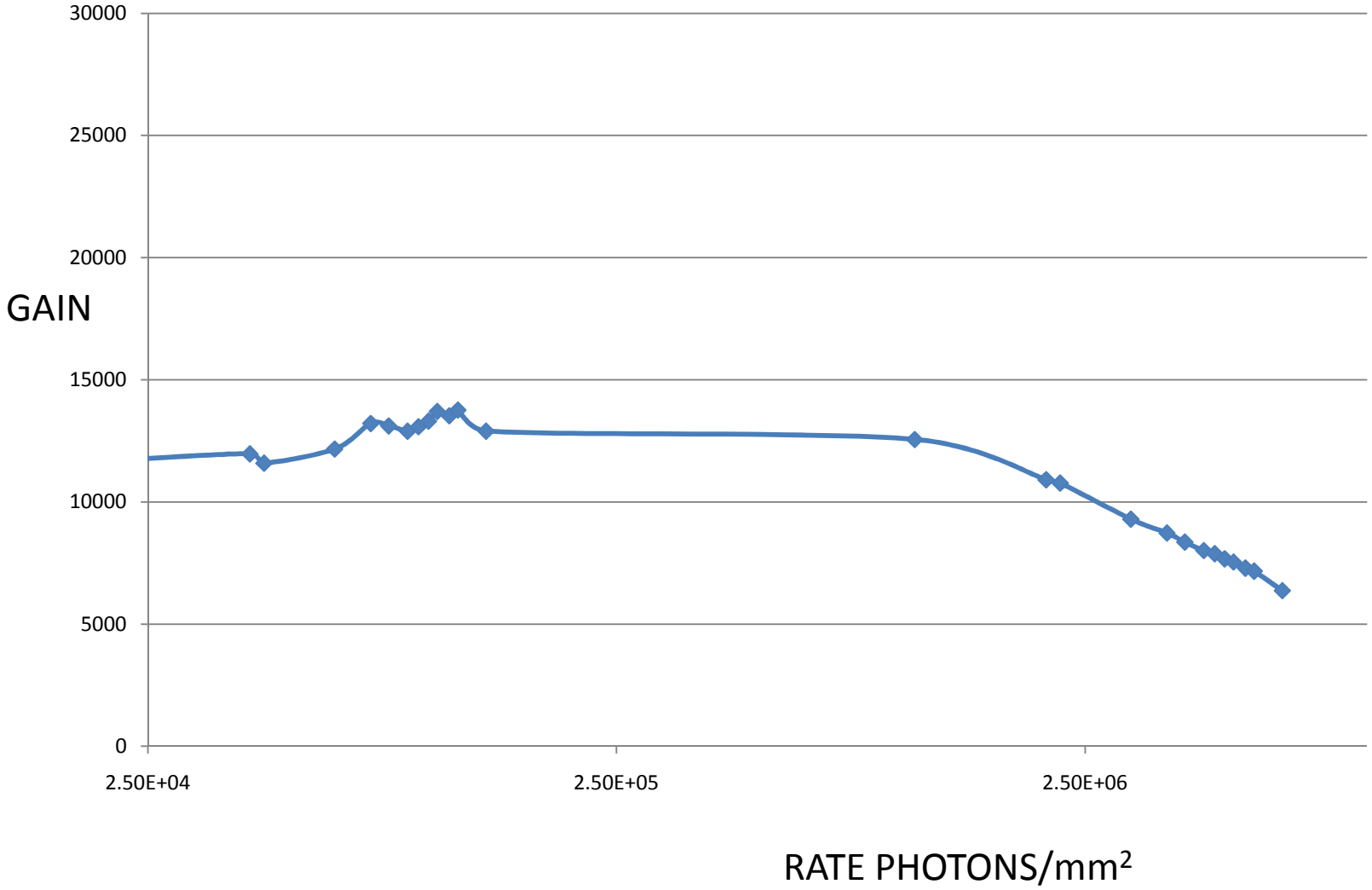
GAIN STUDIES WITH TRIPLE GEM
ARGON CO2
CURRENT WITH Cu X-Rays



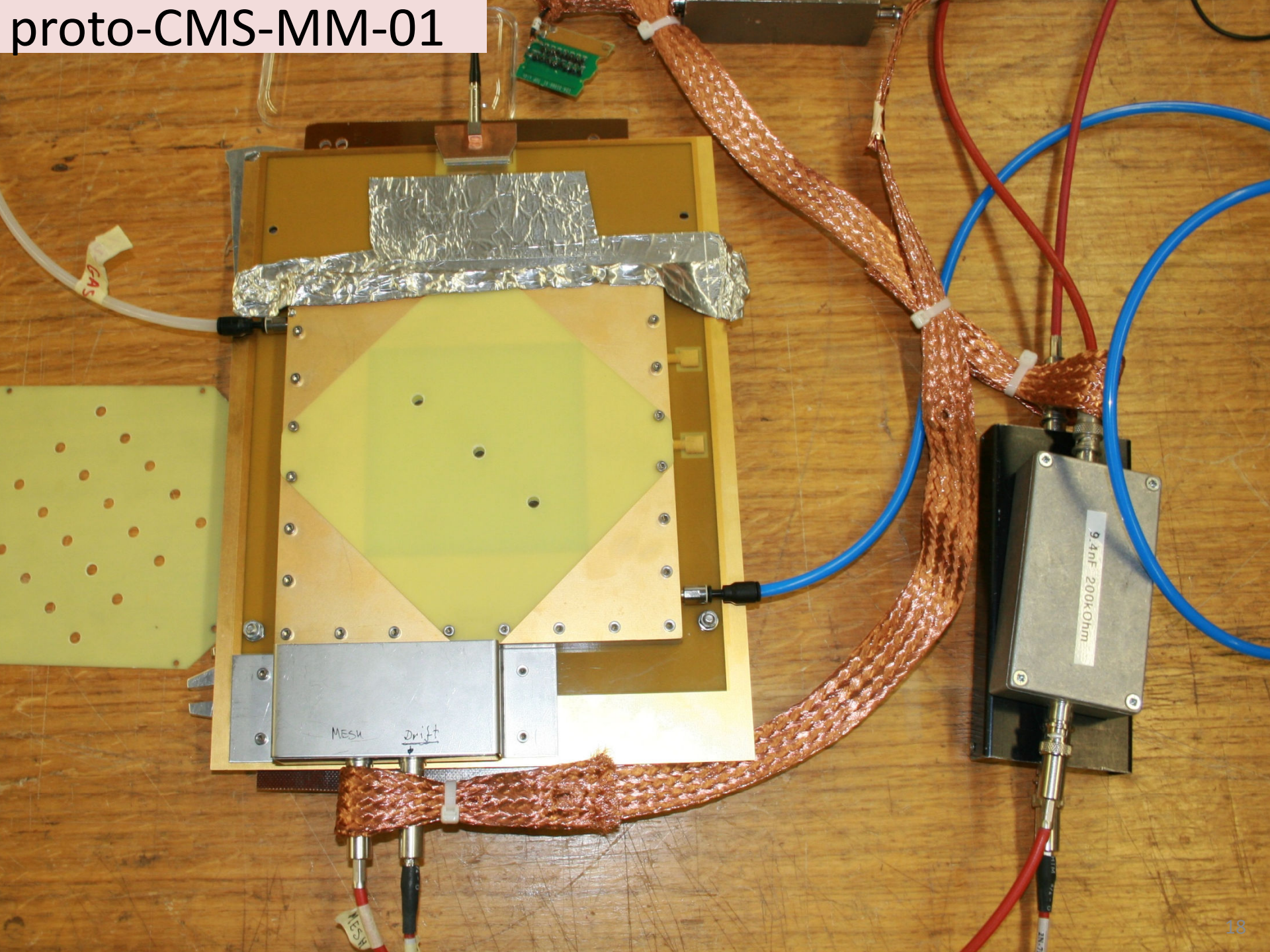
DISCHARGE STUDIES WITH TRIPLE GEM ARGON CO2



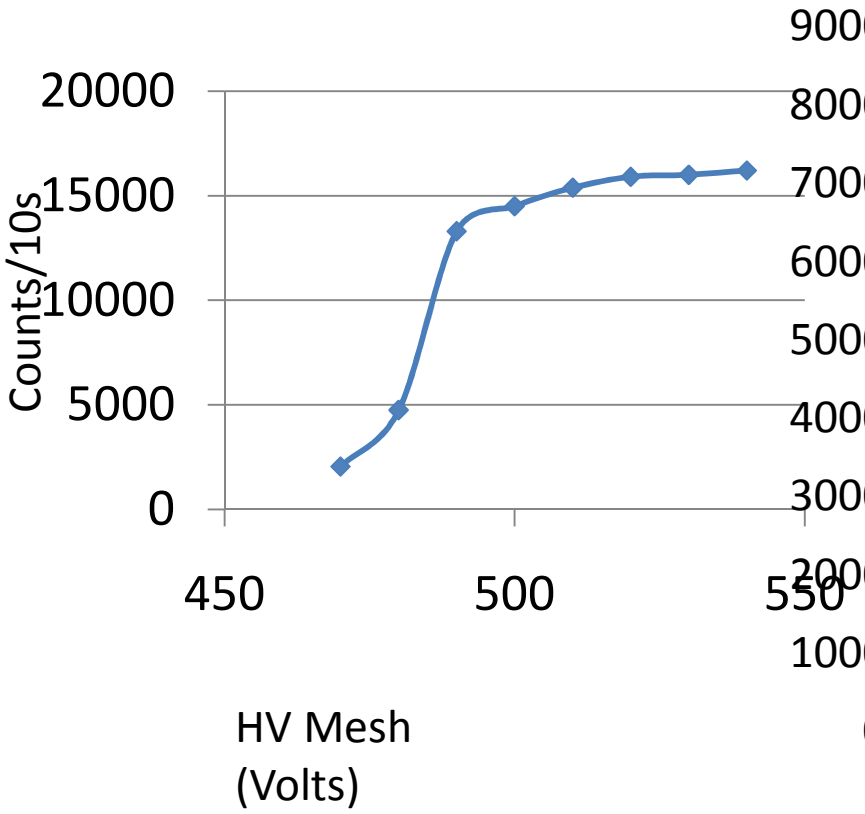
RATE CAPABILITY STUDIES WITH TRIPLE GEM
ARGON CO2 90-10

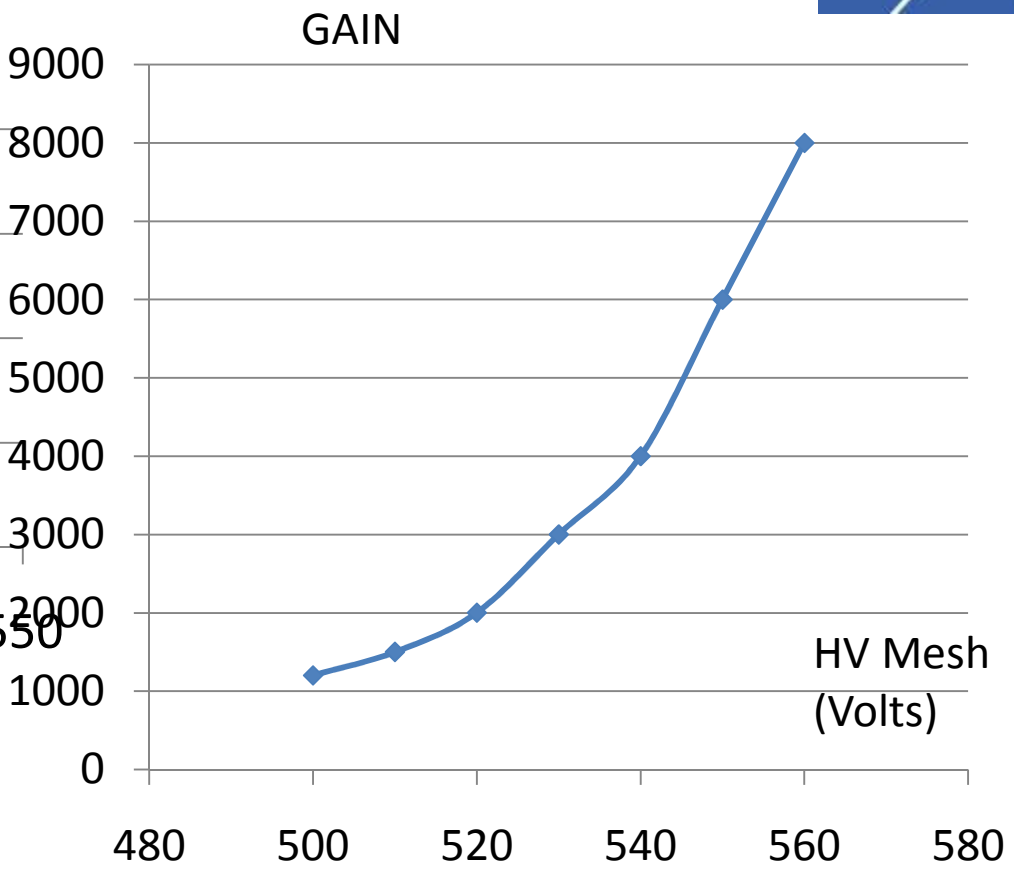


proto-CMS-MM-01



STUDIES WITH CMS-MM-01 ARGON CO2 80-20



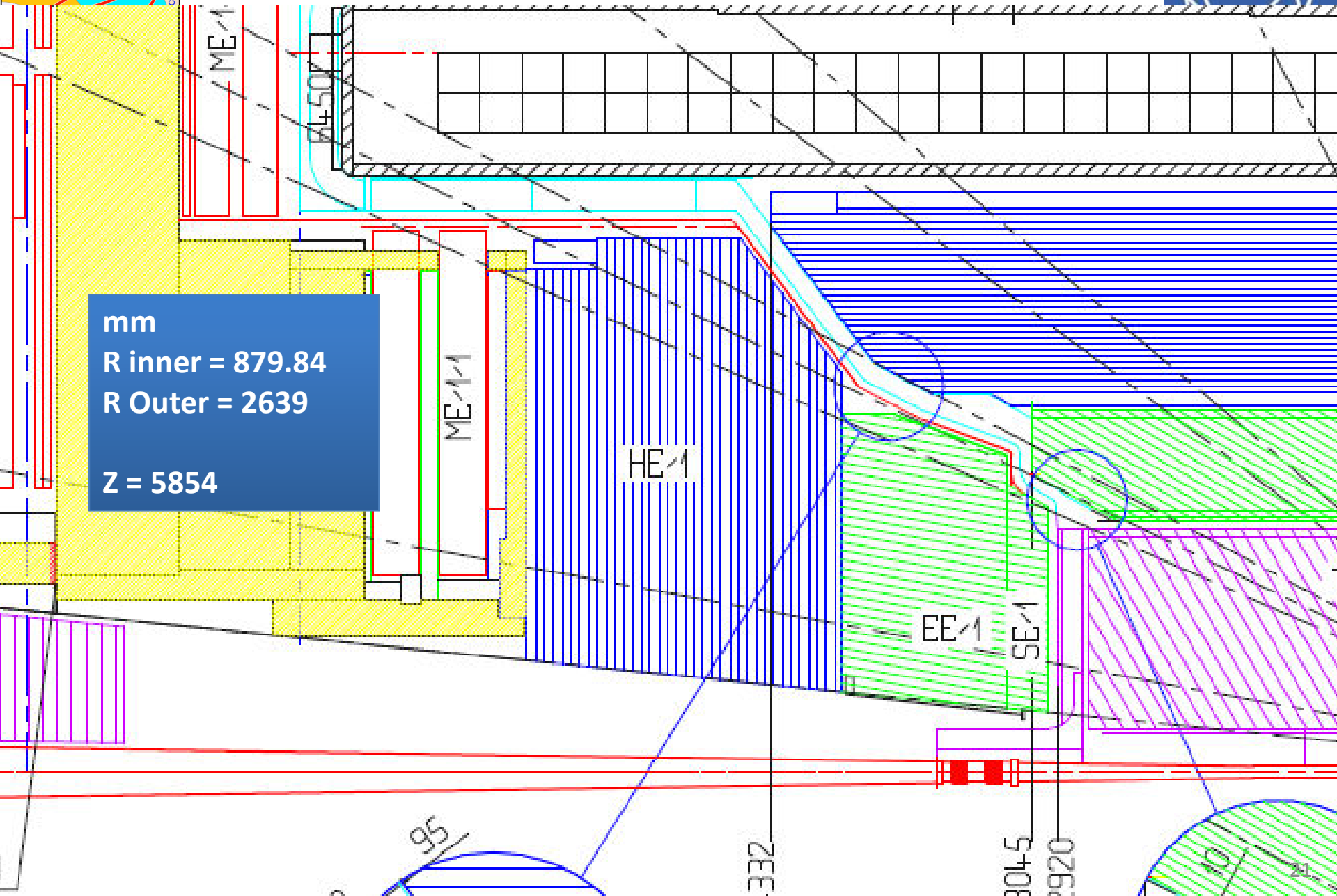


GAIN STUDIES WITH MICROMEGAS
ARGON CO2 80-20
CURRENT WITH Cu X-Rays

PROTOTYPE Plan:

1. Detail mechanical design
2. Definition of the readout electronics and it's mechanical support
3. Services and routing
4. Mockup realization of the detector
5. Production of the prototype

High Eta MPGD Prototype for 1/1 Space



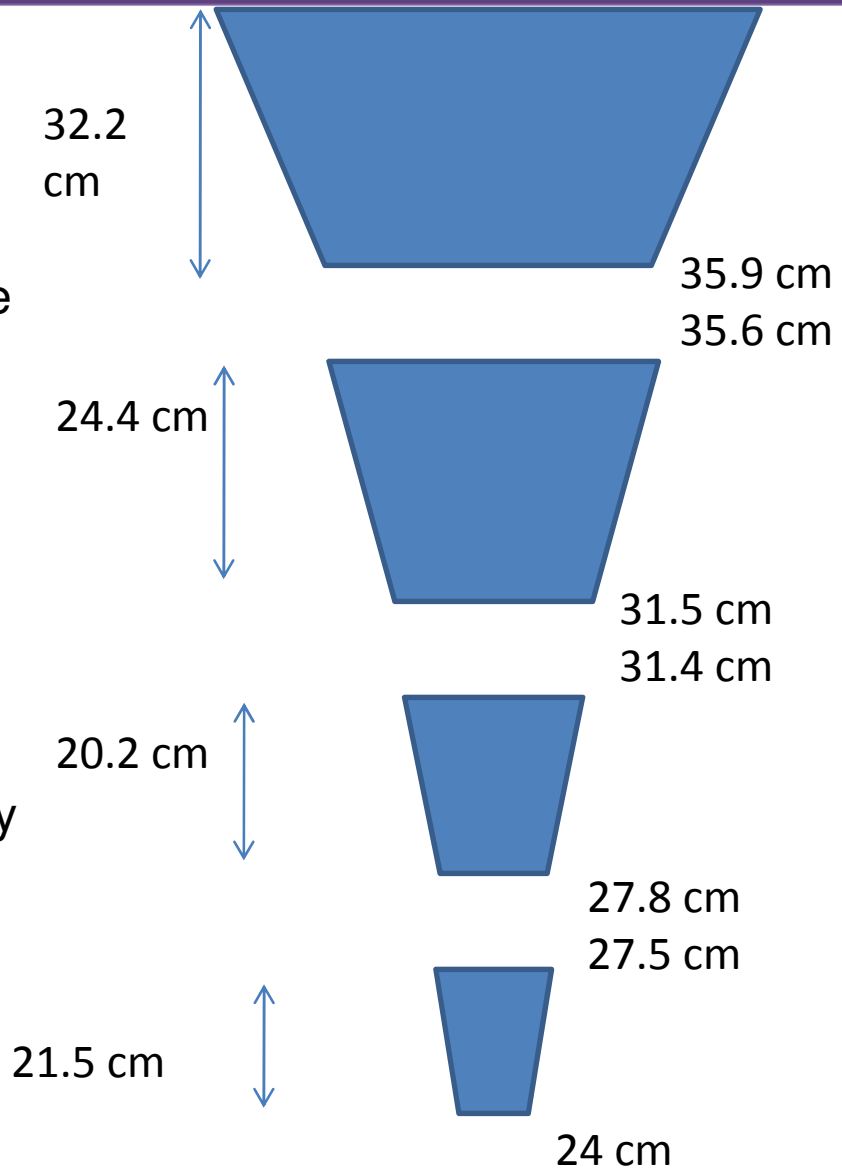
Sensitive Area & Readout Plane Sizes for CMS high η 1/1

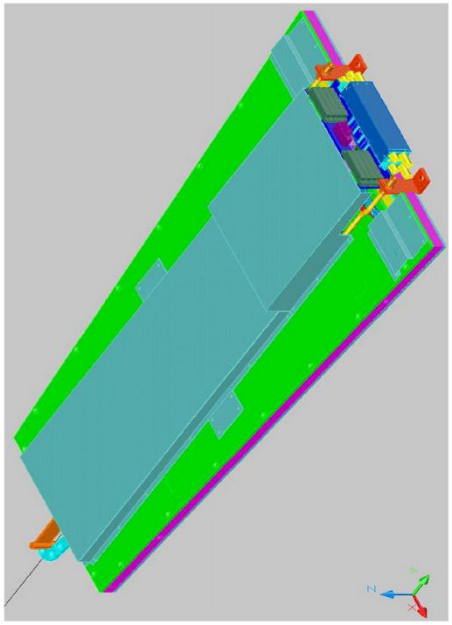
According to present Sensitive area coverage

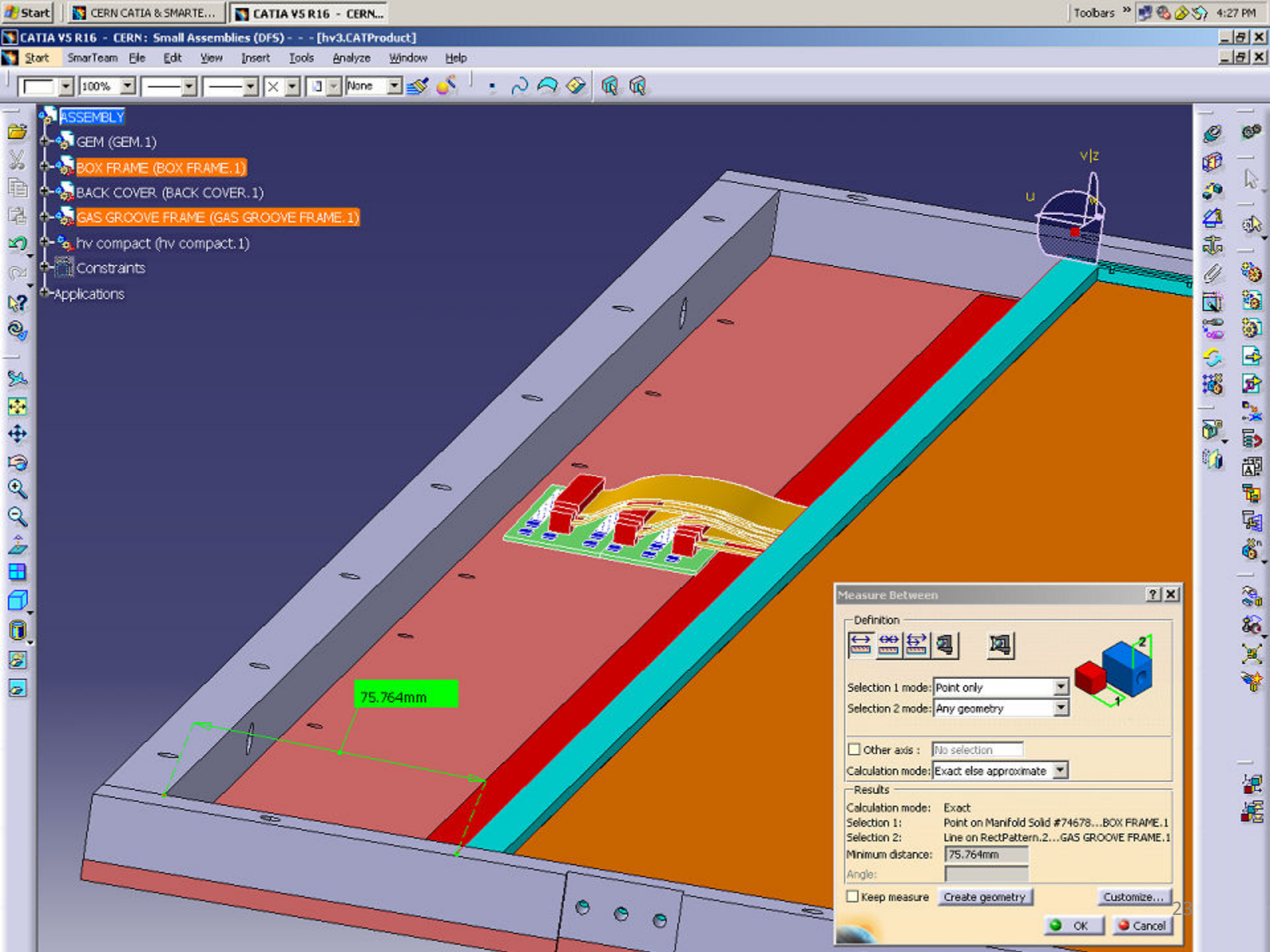
These are routine for Workshop : cm

43x33=1419
36x25=900
32x20=640
28x22=616

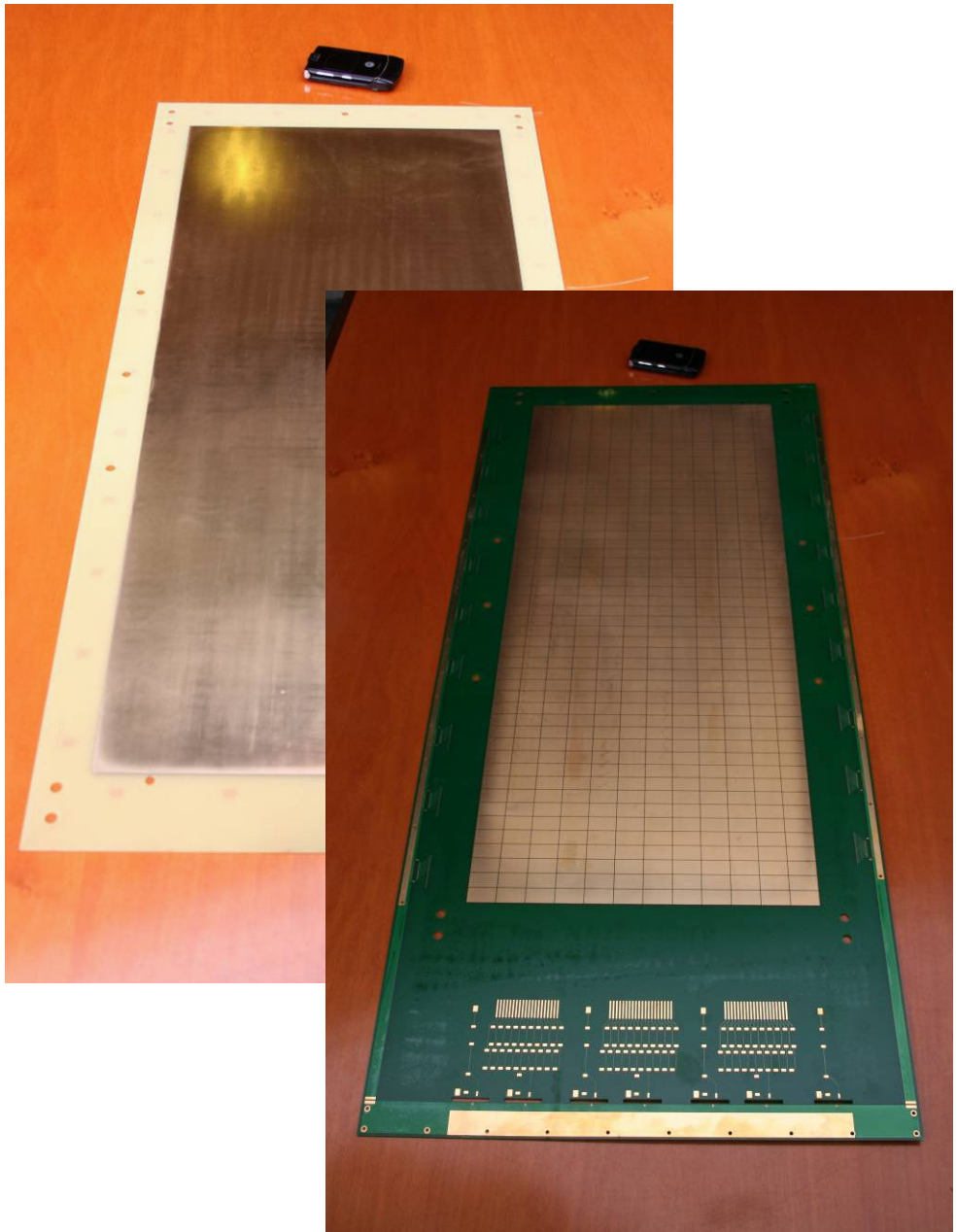
Can extend coverage by 5-7 %
PLUS Extend to eta 2.4



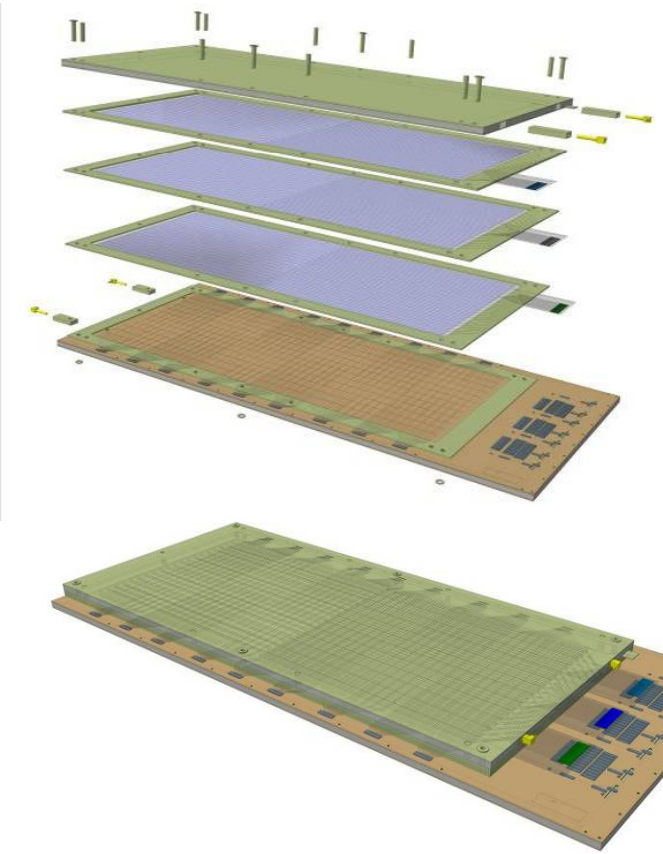



Start
CERN CATIA & SMARTE...
CATIA V5 R16 - CERN...
Toolbars
4:27 PM
CATIA V5 R16 - CERN: Small Assemblies (DFS) - - - [hv3.CATProduct]
Start
SmarTeam
File
Edit
View
Insert
Tools
Analyze
Window
Help
100%
None
ASSEMBLY
GEM (GEM.1)
BOX FRAME (BOX FRAME.1)
BACK COVER (BACK COVER.1)
GAS GROOVE FRAME (GAS GROOVE FRAME.1)
hv compact (hv compact.1)
Constraints
Applications
V|Z
U
75.764mm
Measure Between
Definition
Selection 1 mode:
Point only
Selection 2 mode:
Any geometry
Other axis :
No selection
Calculation mode:
Exact else approximate
Results
Calculation mode:
Exact
Selection 1:
Point on Manifold Solid #74678...BOX FRAME.1
Selection 2:
Line on RectPattern.2...GAS GROOVE FRAME.1
Minimum distance:
75.764mm
Angle:
Keep measure
Create geometry
Customize...
OK
Cancel

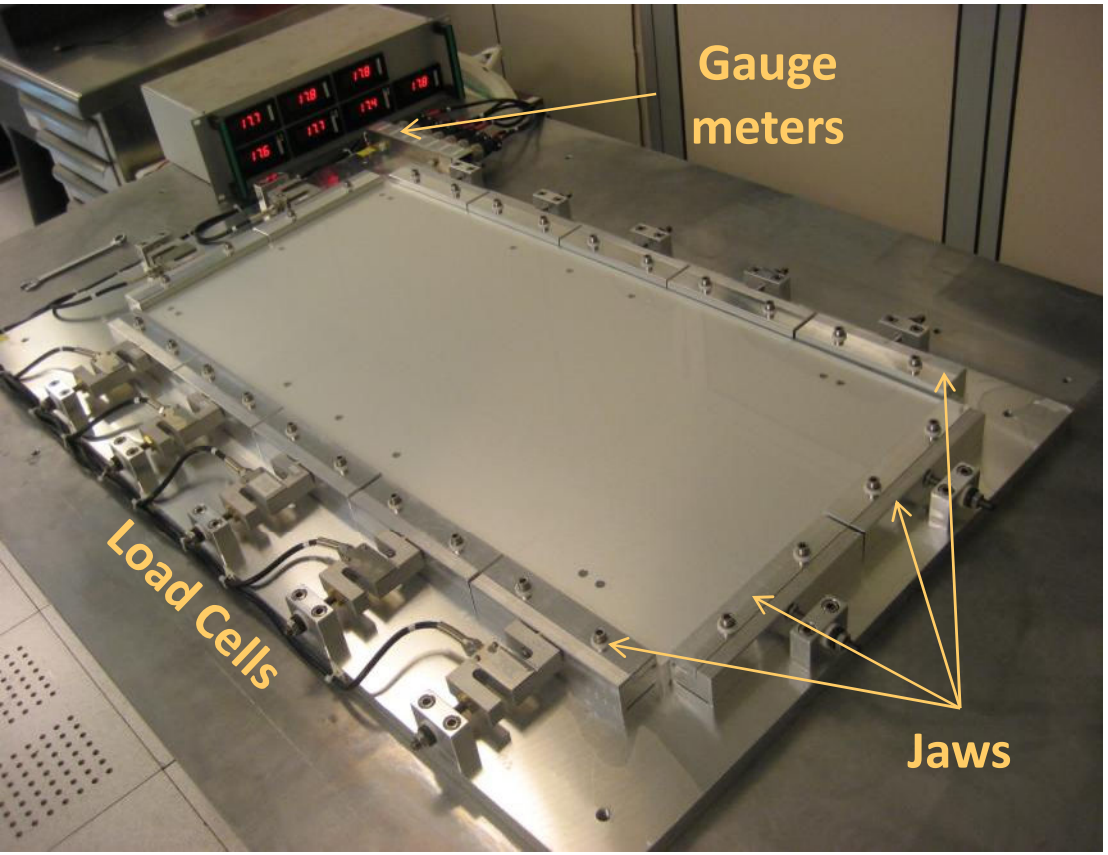
R&D on large GEM: the large prototype



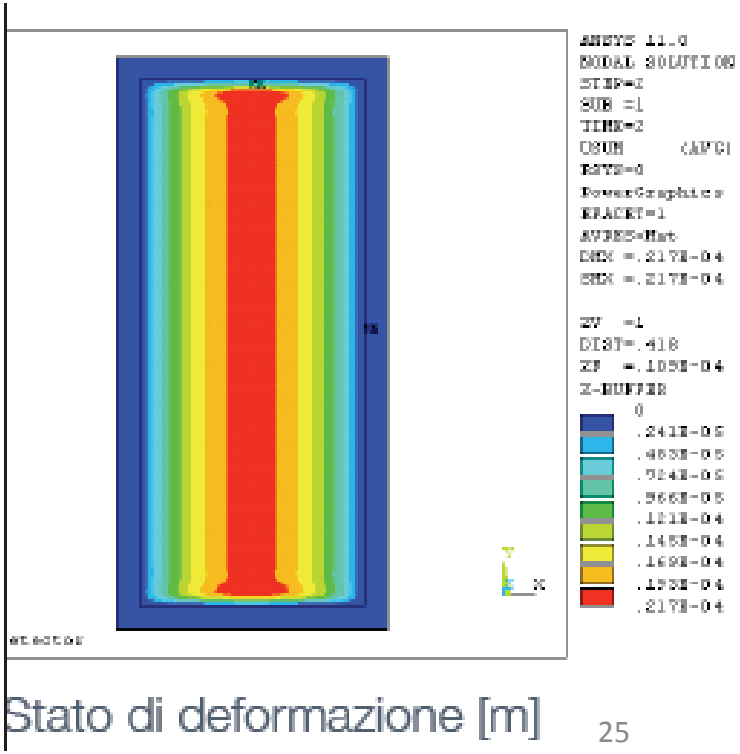
G. Bencivenni – Oct 2009
& RD51
Large area planar GEM (30x70 cm^2 active area



R&D on large GEM: the construction tools



With the usual **1 kg/cm**, finite element simulation indicates a maximum gravitational/electrostatic **sag** of the order of **20 µm**

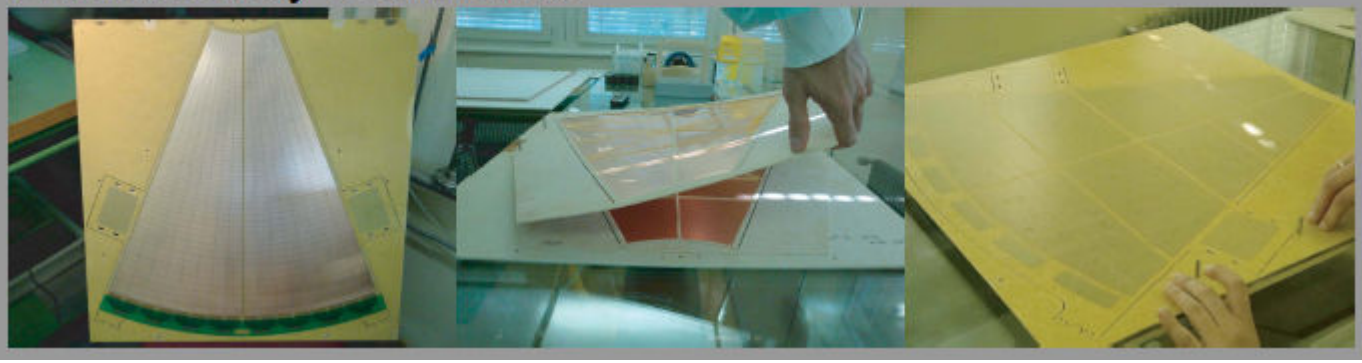


Stato di deformazione [m]

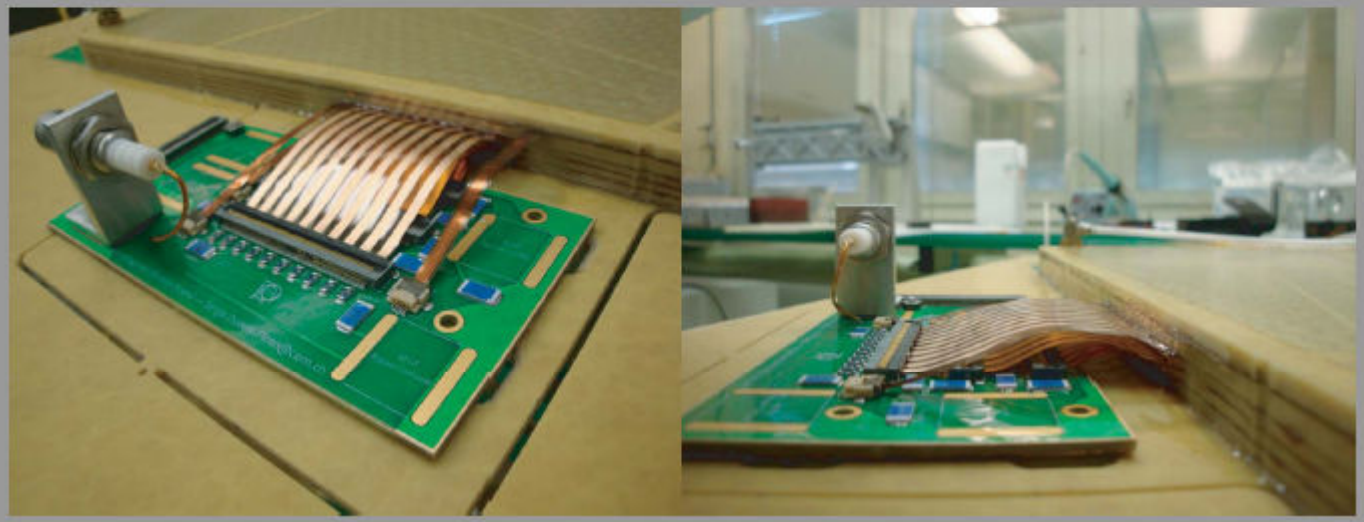
A large **stretching tool** has been designed and built.
The frame gluing will be performed by using the "**vacuum bag**" technique, tested in the construction of the CGEM

Gluing the cathode to the honeycomb frame

Final assembly of all frames

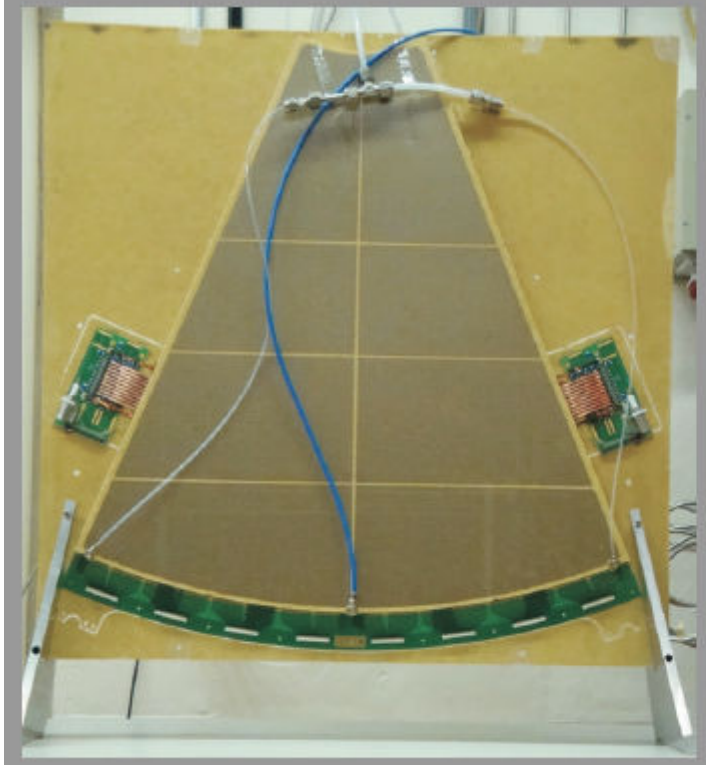


Compact high voltage divider board

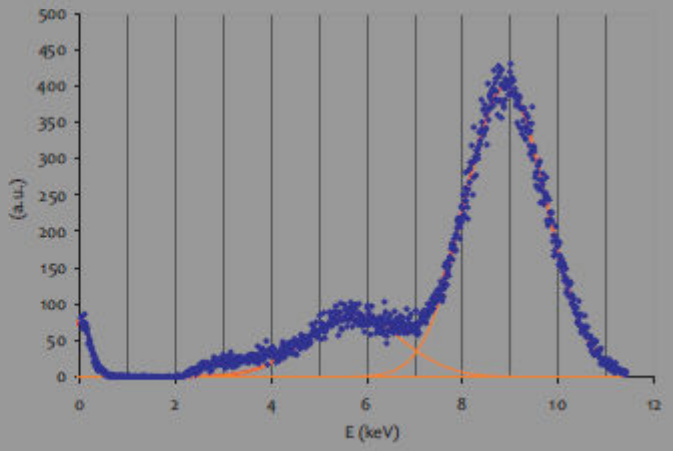


- Based on only SMD components
- Using ZIF sockets to connect to GEM terminals
- Traces that lead to GEM sectors are embedded in frame
- Easy to make, and to replace or debug

FULL SUPPORT FROM RD51 AND COLLABORATORS



- Gas tightness & high voltage stability Ok
- Too late for testbeam by lack of electronics
- $\frac{\sigma_E}{E}$ = 9.5% measured with Cu X-ray (8.9 keV)



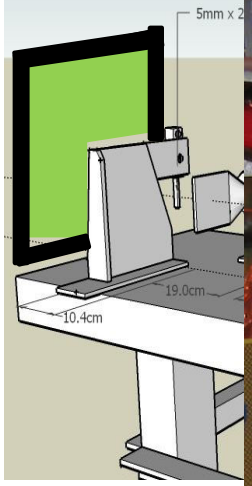
CMS-M-01, CMS-TG-01
Oct. 09 Test Beam Plan

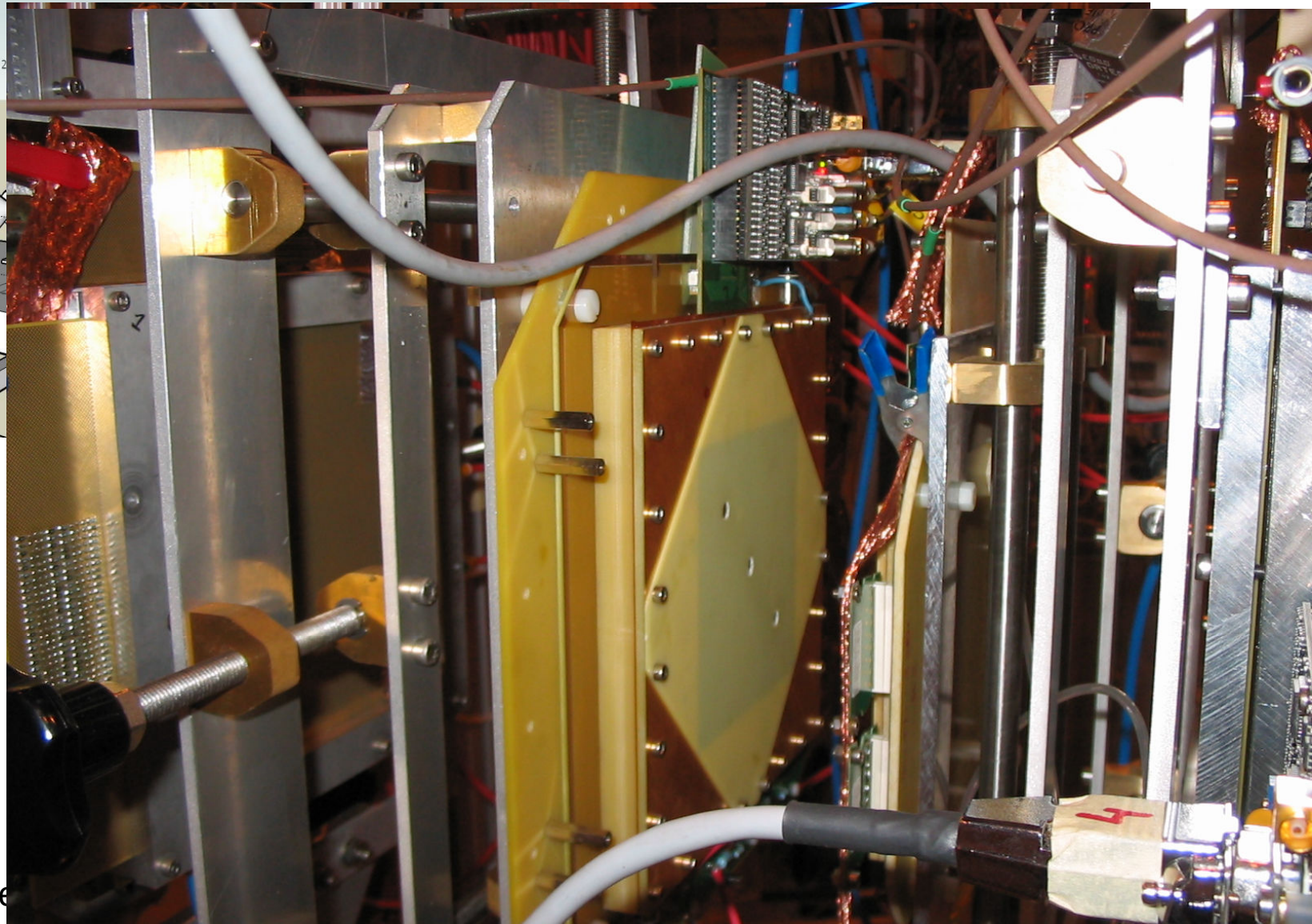
1. Measure Efficiency for perpendicular tracks
1. Measure Efficiency for inclined tracks with tracking
2. Time resolution
3. Tests with Front End electronics for mips
4. Space resolution with present strip size

Next Year

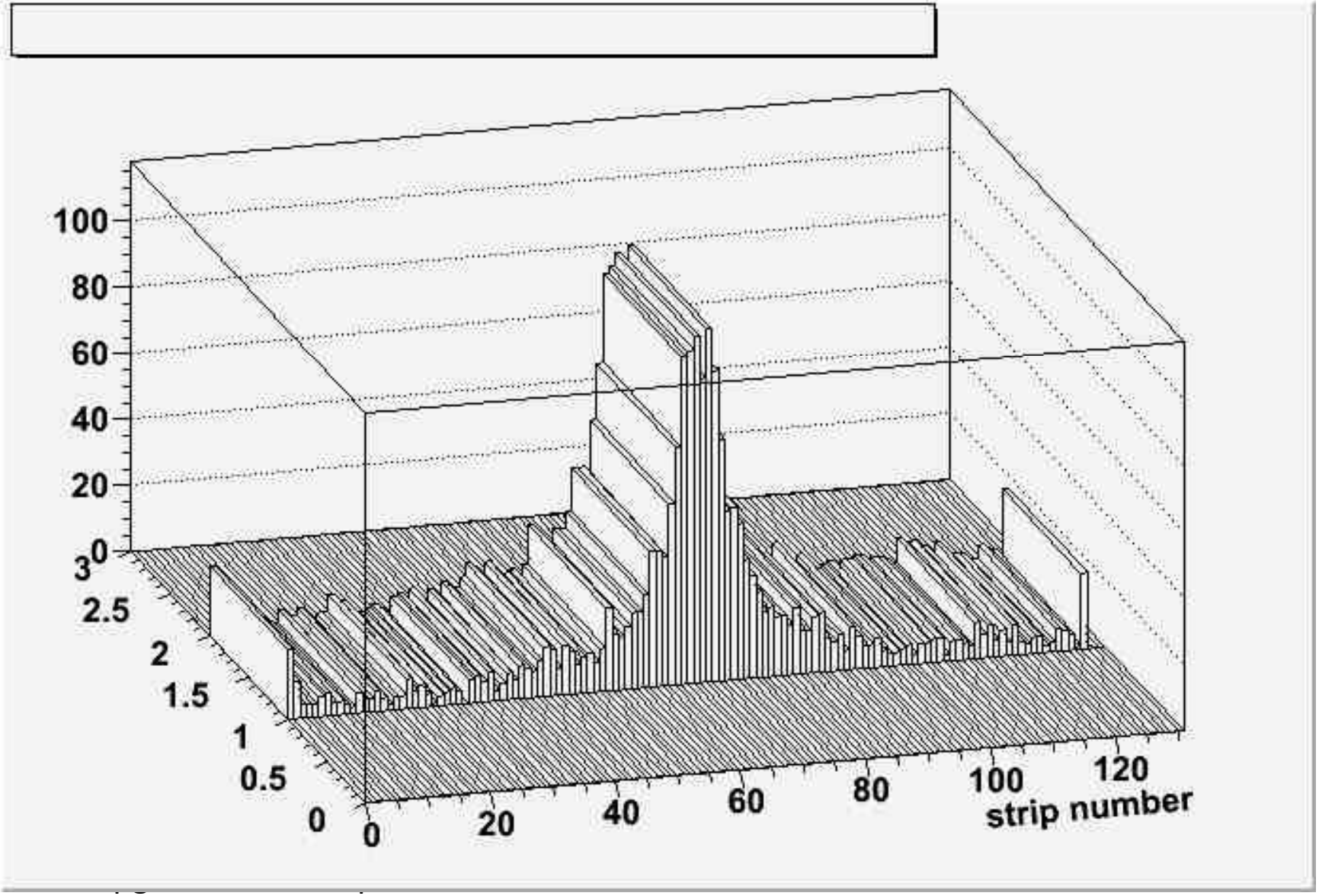
1. Gas Studies
2. Magnetic Field Operation
3. Large Prototype preparation

Test beam at SPS H4 Oct 21-Nov 2





First Results – to be studied in detail



MPGD Meeting 02

This talk is on behalf of collaborators from:
CERN + RD51
LNF Frascati
Sienna
Florida Tech
BHU India

Friday 04 September 2009

Next Meeting 20th November 2009

14:30 Introduction and discussion (20')

14:50 New Physics Potential and Detector Requirements - Albert (de Roeck) (40')

15:30 MPGD Experience and Expression of Interest from Frascati - Stefano Bianco / Benussi / Fabbri (20')

15:50 Current MPGD studies, CSC alignment work within CMS and interest in the high-eta MPGD upgrade from Florida (20') (Slides)

16:10 Current Experience, Expression of interest and (preliminary preparation for Simulations of Trigger Efficiency) - Arun K
Slides ; document)

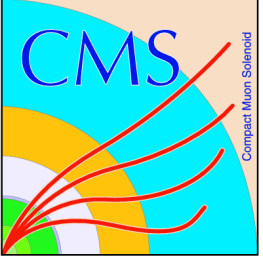
16:30 Update on small prototype tests at CERN - Archana (20')

16:50 Preparation towards large prototype(s) - Andrey / Serguei /Serge (20') (Slides)

17:10 Update on Front End Readout - Nicola Turini (20') (VFAT - Details)

Next Steps..

1. Analyze beam test data
2. Build large size mock up to understand services
3. Build large size prototype to understand performance
4. Calculate rates as a function of eta-phi
5. Background simulations, measurements and calculations
6. Road for muon say 10 GeV, as a function of trigger sectors
7. Stagger / Layer the detector for avoiding fake hits
8. Engineering Design up to eta 2.4
9. **Evaluate the improvement in trigger and tracking efficiency**
10. **Build Two 1/1 size chambers 2010**
11. **Six 1/1 size chambers 2011**
12. **Install six chamber in 2011/2012 shutdown (tba)**



SPARE SLIDES

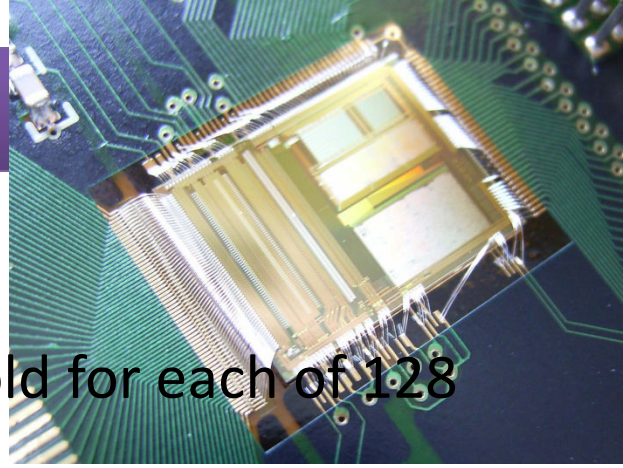
Conclusions

- Single mask technique proved viable and cheap alternative
- Splicing method allows to go beyond limits of base material
- These techniques open the way for large area GEMs

Perspectives

- Connect to fast electronics (VFAT or GP5/7) to study efficiency
- Discharge studies
- Test gain homogeneity
- Charging-up studies of single-, double- and tripleGEM
- Pursue optimization of SMT (steeper holes, smaller rim)

Readout Electronics – VFAT



A digital on/off chip, with an adjustable threshold for each of 128 channels.

Used in all the Totem detectors, the GEMs and the CSCs to simplify the DAQ and trigger design

Quarter micron CMOS technology and measures 9.43mm by 7.58mm.

Trigger function to provide programmable “fast OR” information based on the region of the sensor hit. This can be used for the creation of a trigger.

Tracking function for providing precise spatial hit information for a given triggered event.

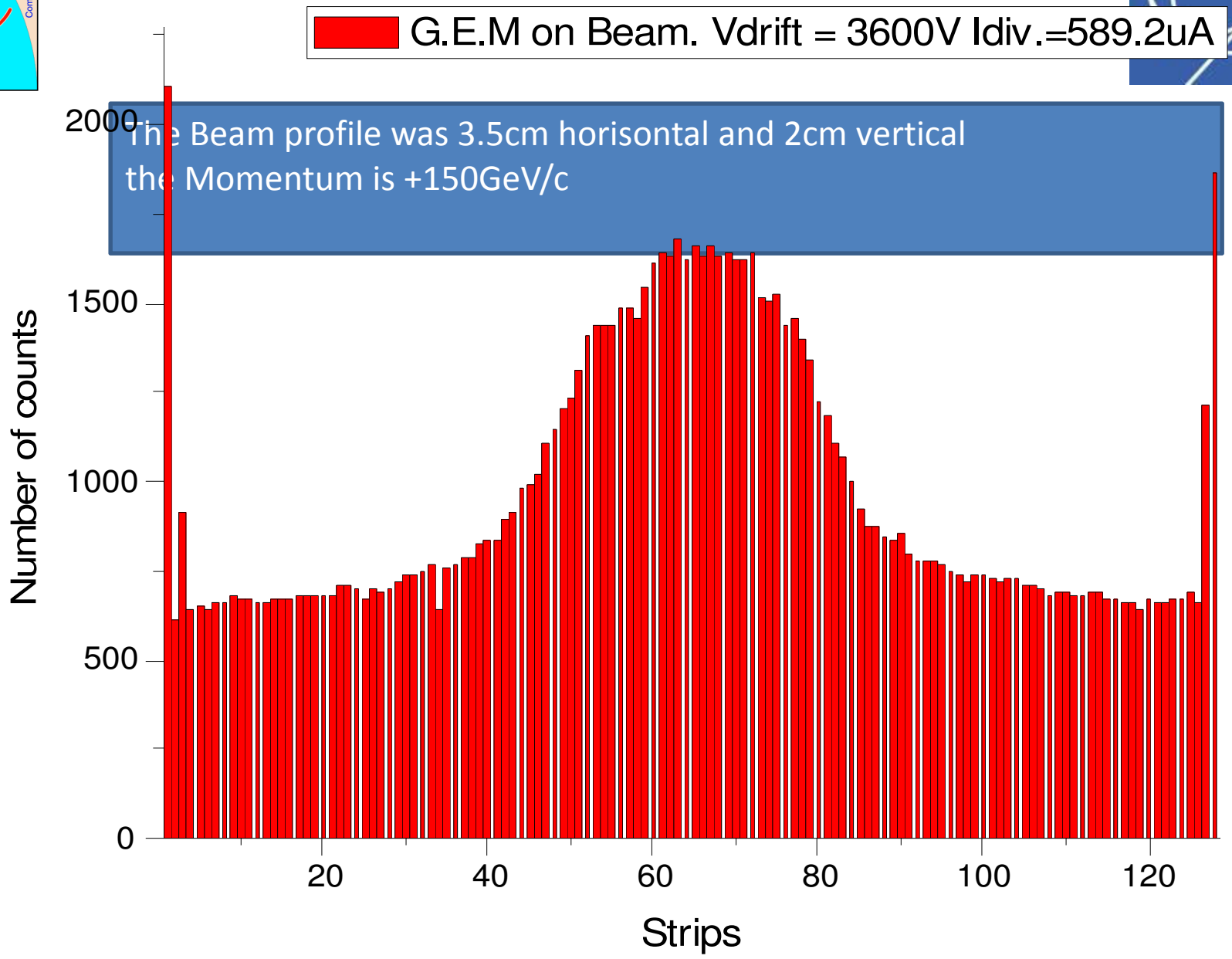
Dose expected at LHC at low eta (0.8– 1.6)

Rate: **30 Hz/cm^2**

Average total charge: **30 pC**

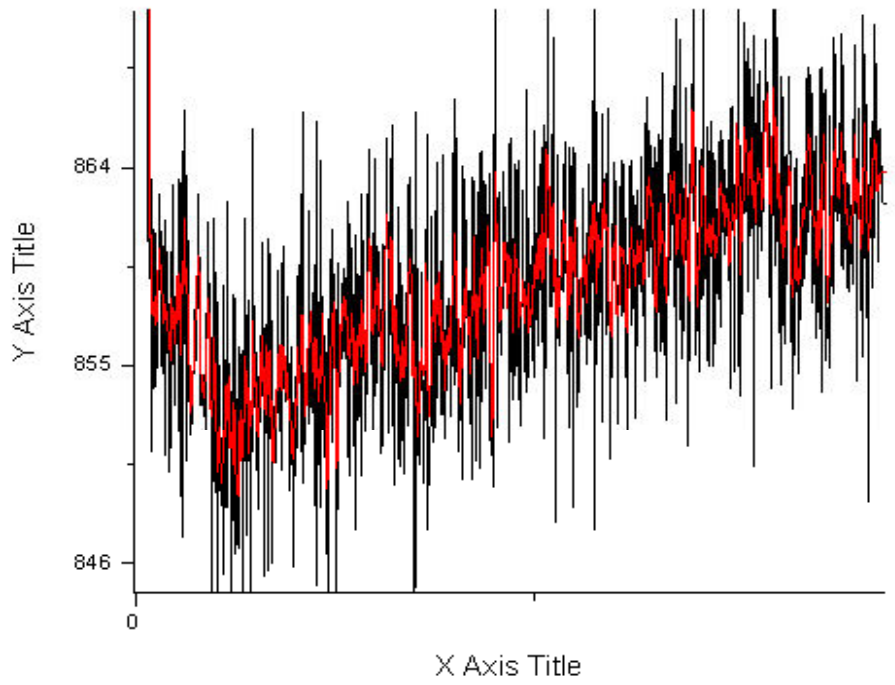
Effective operation time: **5x10^7 s (10 LHC years)**

The total expected charge at **LHC** is **~ 5 10^{-2} C/cm^2**


G.E.M on Beam. Vdrift = 3600V Idiv.=589.2uA
The Beam profile was 3.5cm horisontal and 2cm vertical
the Momentum is +150GeV/c
Number of counts
2000
1500
1000
500
0
20
40
60
80
100
120
Strips

Origin 6.1 - \\cern.ch\dfs\Users\a\archana\Desktop\MPGDs-2009\Archana_SameTime - [Graph3]

File Edit View Graph Data Analysis Tools Format Window Help



LONG TEM STABILITY (0.001%)
CMS-TG-01 OVER 20 hours

D
5 point AA Smoothing of OUTPUTTIMESCA_D

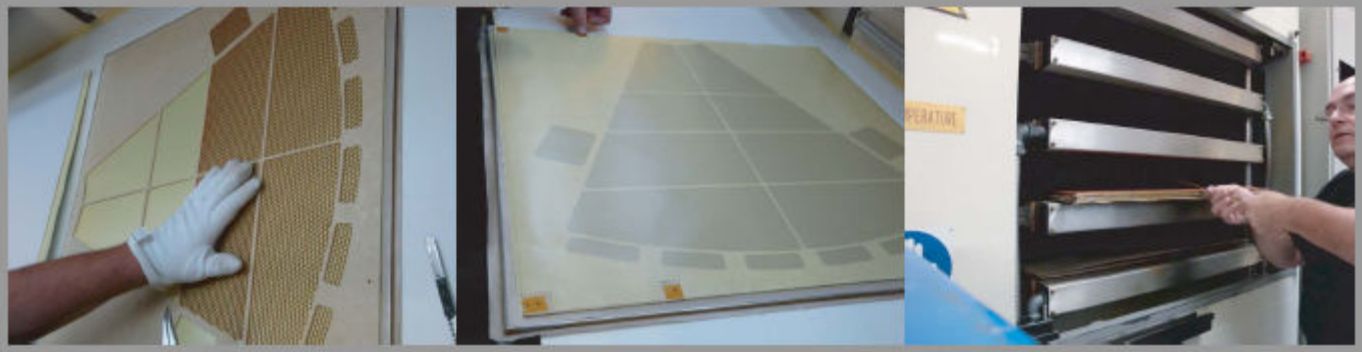
Archana_SameTime

Name	Type	View	Size	Modified	Created	Dependents	Label
Graph1	Graph	Normal	19KB	9/1/2009 09:22	9/1/2009 09:22	0	
Graph2	Graph	Normal	19KB	9/1/2009 09:23	9/1/2009 09:23	0	
Graph3	Graph	Maximized	33KB	9/1/2009 09:25	9/1/2009 09:24	0	
Graph4	Graph	Hidden	20KB	9/1/2009 15:29	9/1/2009 15:29	0	
OUTPUTTIMESCA	Worksheet	Normal	57KB	9/1/2009 09:27	9/1/2009 09:21	3	C:\DOCU...
Smoothed1	Worksheet	Hidden	30KB	9/1/2009 09:25	9/1/2009 09:25	2	5 point A...

R&D at CERN Workshop

Stretching and framing the spliced single mask GEM foils

Making the honeycomb base plane and top cover



Triple GEM Current behavior at Beam