Uva GEM R&D Update

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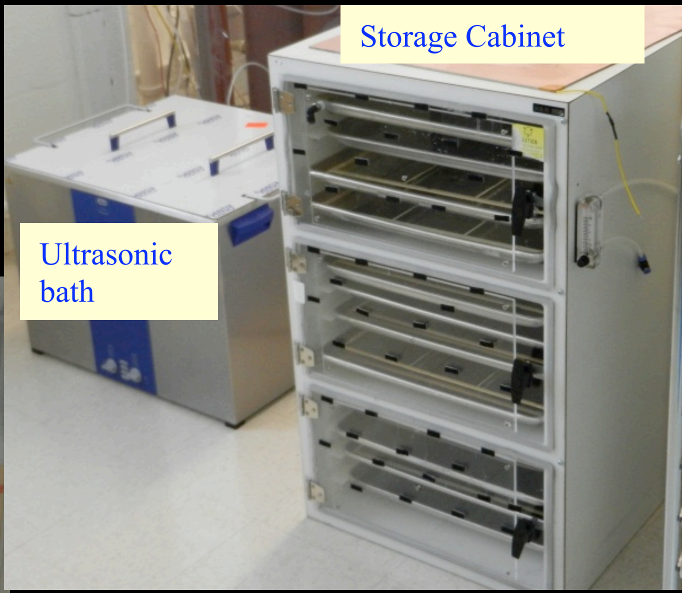
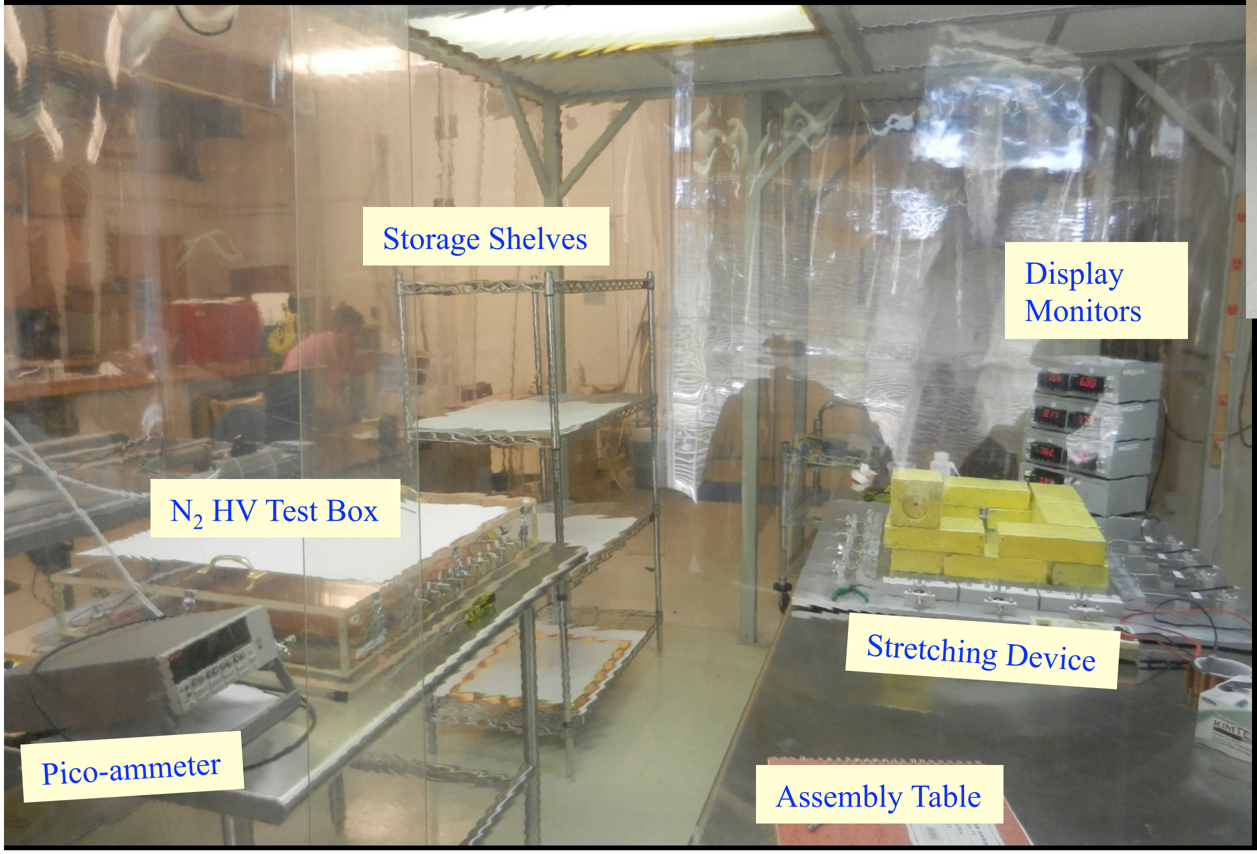
GEM Lab @ UVa

Our Class 1000 Clean Room

- Current Clean Room (3.5 × 3 m^2) Built originally for the BigBite drift chambers construction
- Located in a large (4.5 m x 9 m) semi-clean area.
- Additional clean room (3.5 × 2 m^2) to be installed before Xmas





- Mechanical stretching device
- HV Test N2 Gas box
- Keithley Pico-ammeter 6487 with 500 V source➔ Ohmmeter
- Ultrasonic bath (Elmasonic S900H)

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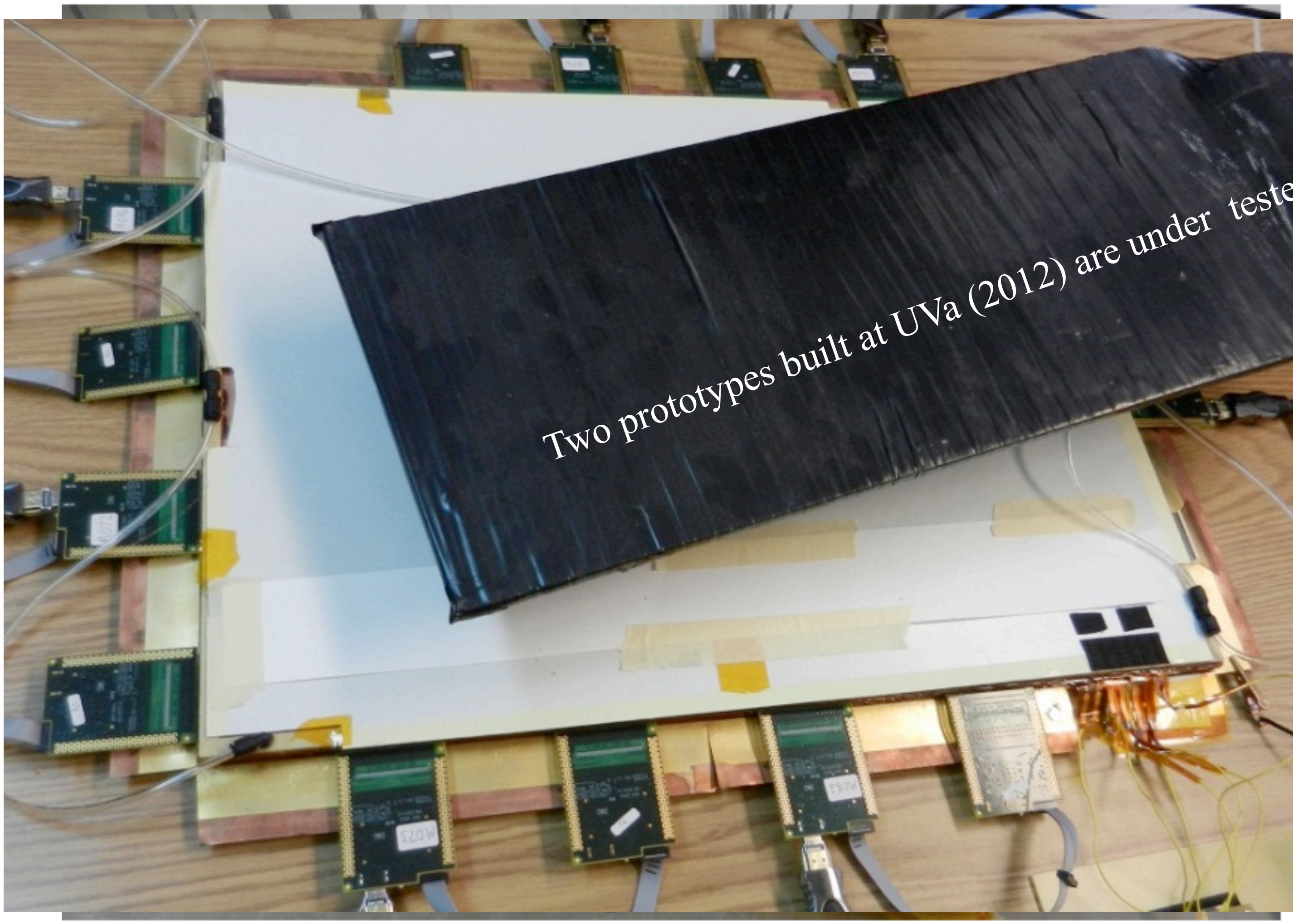
Status

- Construction of the first two SBS prototype GEM chambers (40 cm x 50 cm) is complete.
- It is working well and is under testing now.
- SRS APV readout system and the Italian APV readout system setup at UVa and is working well.
- The next set of SBS chambers will be 50 cm x 50 cm: parts ordered: expected construction in February.
- Install new clean room and upgrade equipment by January 2013.
- The design of the EIC R&D very large prototype chamber is complete – the size of this is similar to the largest SoLID chambers.
- The foils and frames for this chamber ordered; plan to construct in the Spring.
- Need to finalize the readout scheme.

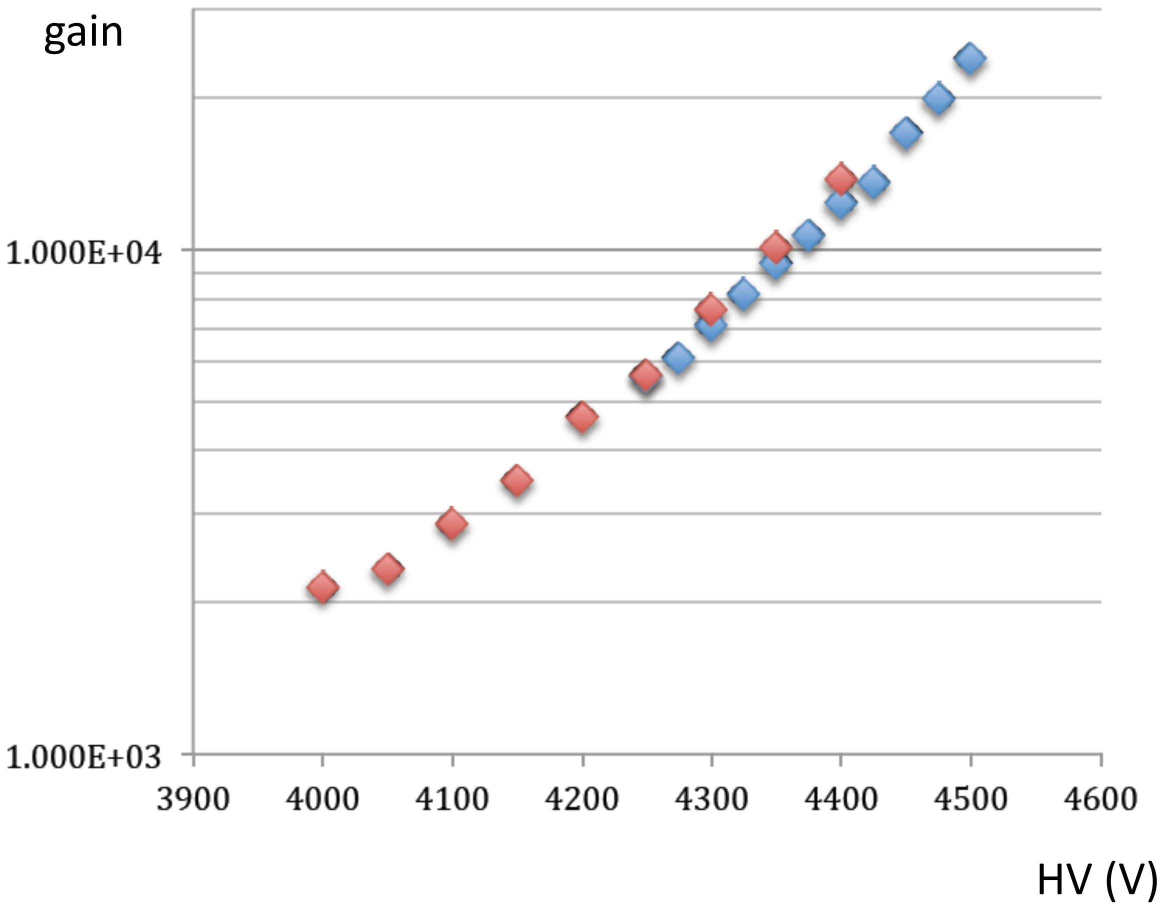
The SBS prototype #1 connected to the Italian APV readout system

9 APV25 FE (5 on X and 4 on Y) cards on the chamber with the back plane, the Panasonic to ZIF connectors and the FE cards grounded directly to the GEM readout ground



MPD VME64x board with the HDMI cables to communicate with the FE cards

SBS GEM module Gain calibraion



- Number of primary electrons in a GEM due to a MIP ~ 20
- Gain of 10^4 -> 2 x 10^5 e-
- ~ 30 - 40 k e- per strip.

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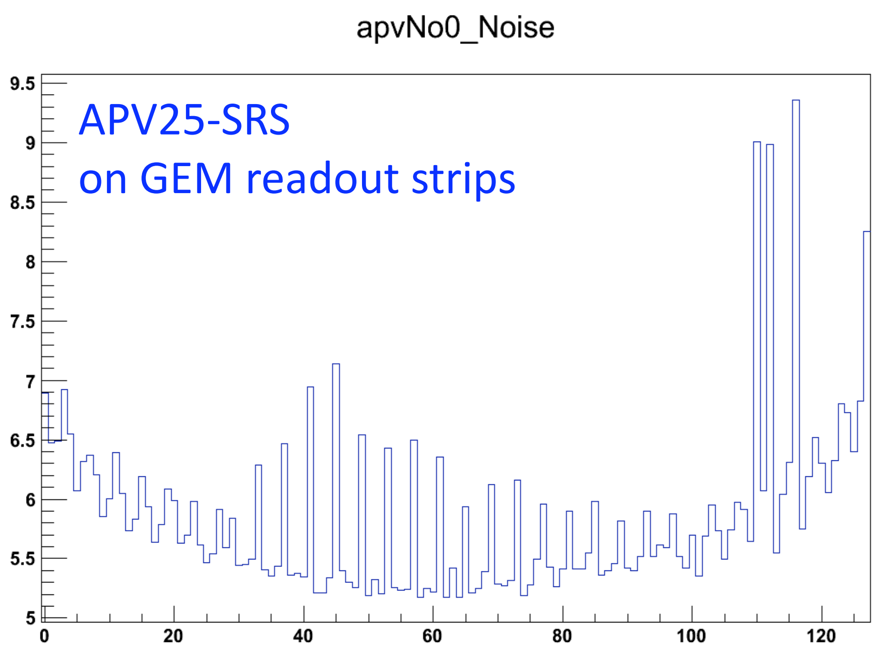
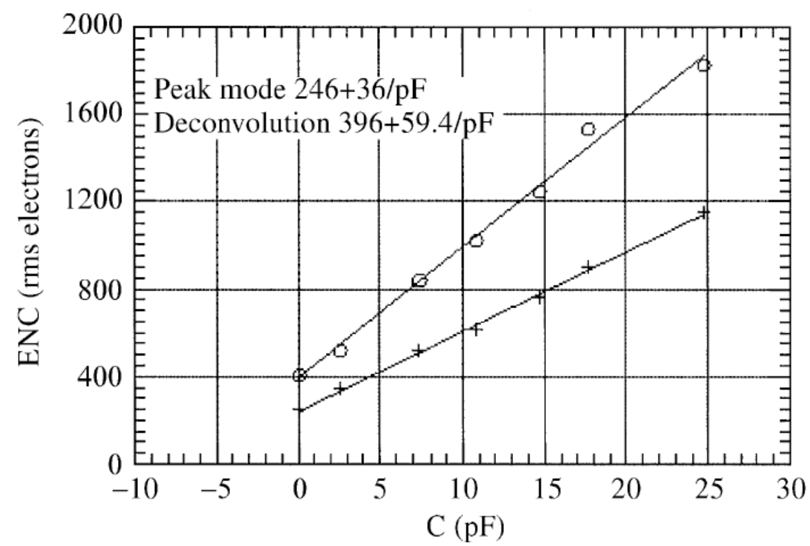
Study of the noise (rms of the apv25 channels)

- Typical rms noise of a given APV cards from a pedestal run SRS
- This rms is obtained after common mode correction of the baseline
  - An average of 6-8 adc counts for apv25-SRS
  - ~ 1200 to 1600 ENC
- a cut at 5 sigma for zero suppression ➔ ~ 6000 e-





Expected pedestal noise level for the APV25 chip:
Capacitance for SBS chambers ~ 40 pF - ~ 1600 e- in peak mode
For SoLID, up to ~ 60 pF – 2400 e-

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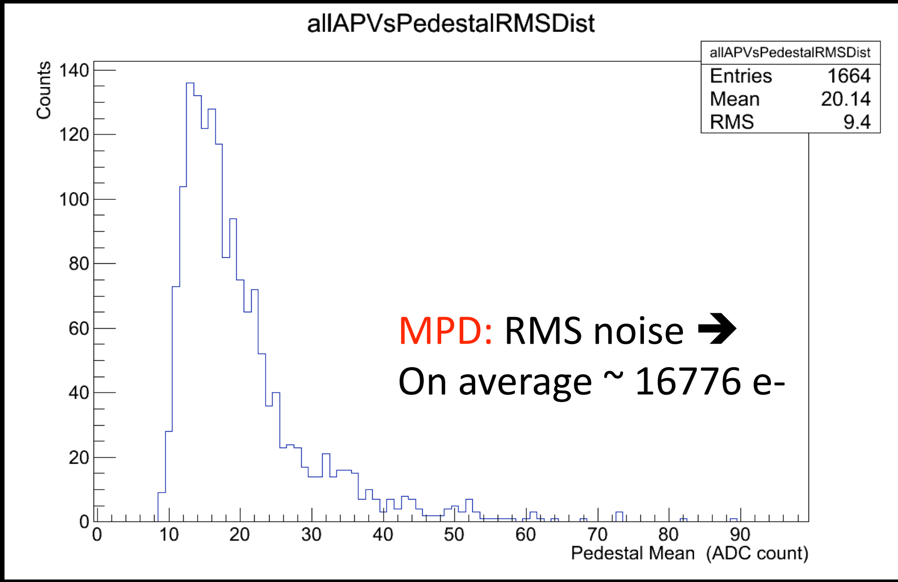
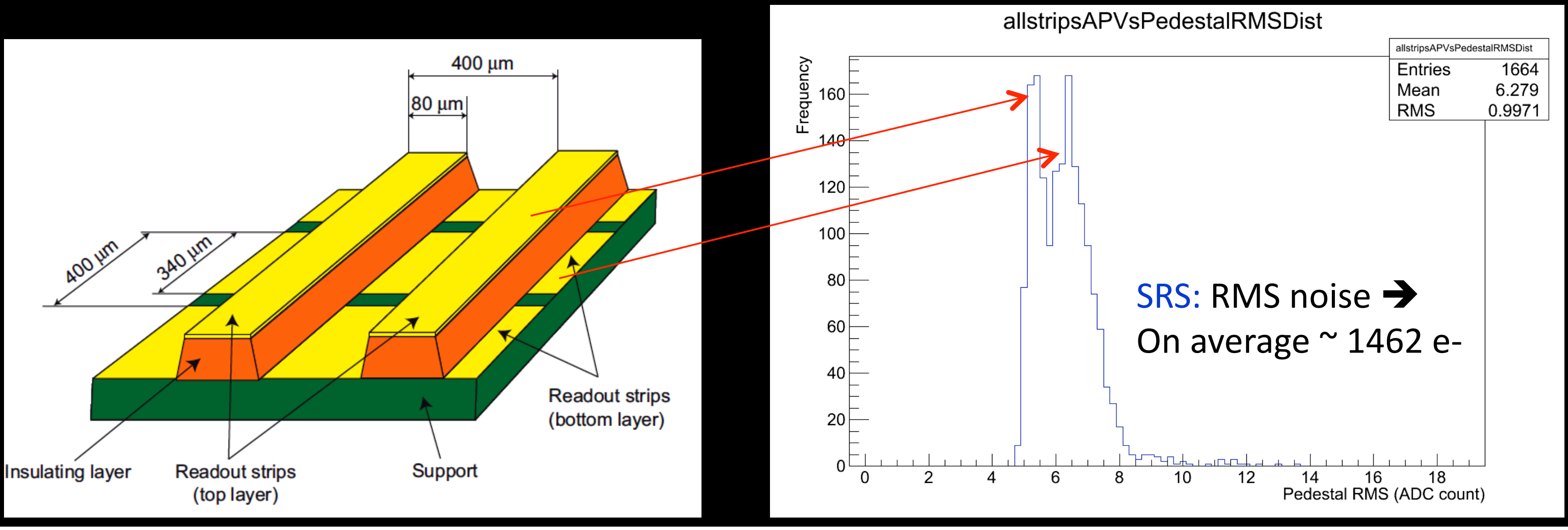
Electronic Noise of the APV25 Systems

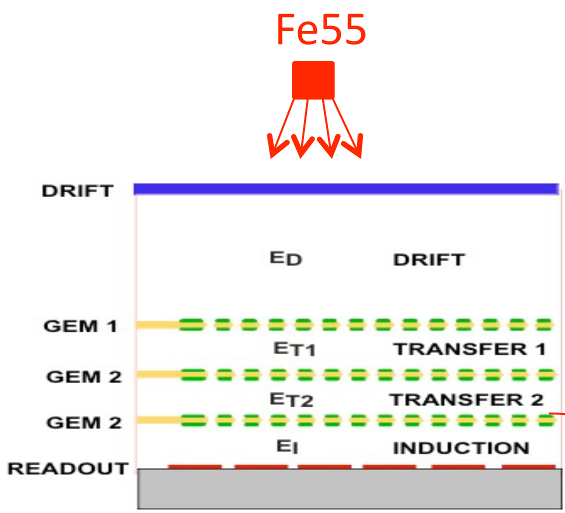
- Noise in ADC counts is 3 × bigger for MPD (~20 ADC channels) than SRS (~7 ADC channels)
- When translated into ENC, it becomes a factor ~10 because MPD has a gain 3 to 4 times higher than SRS
- With the APV25-SRS, the effect of the strip capacitance can be clearly seen

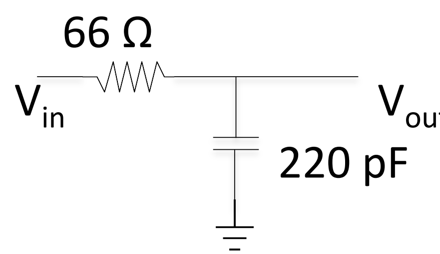


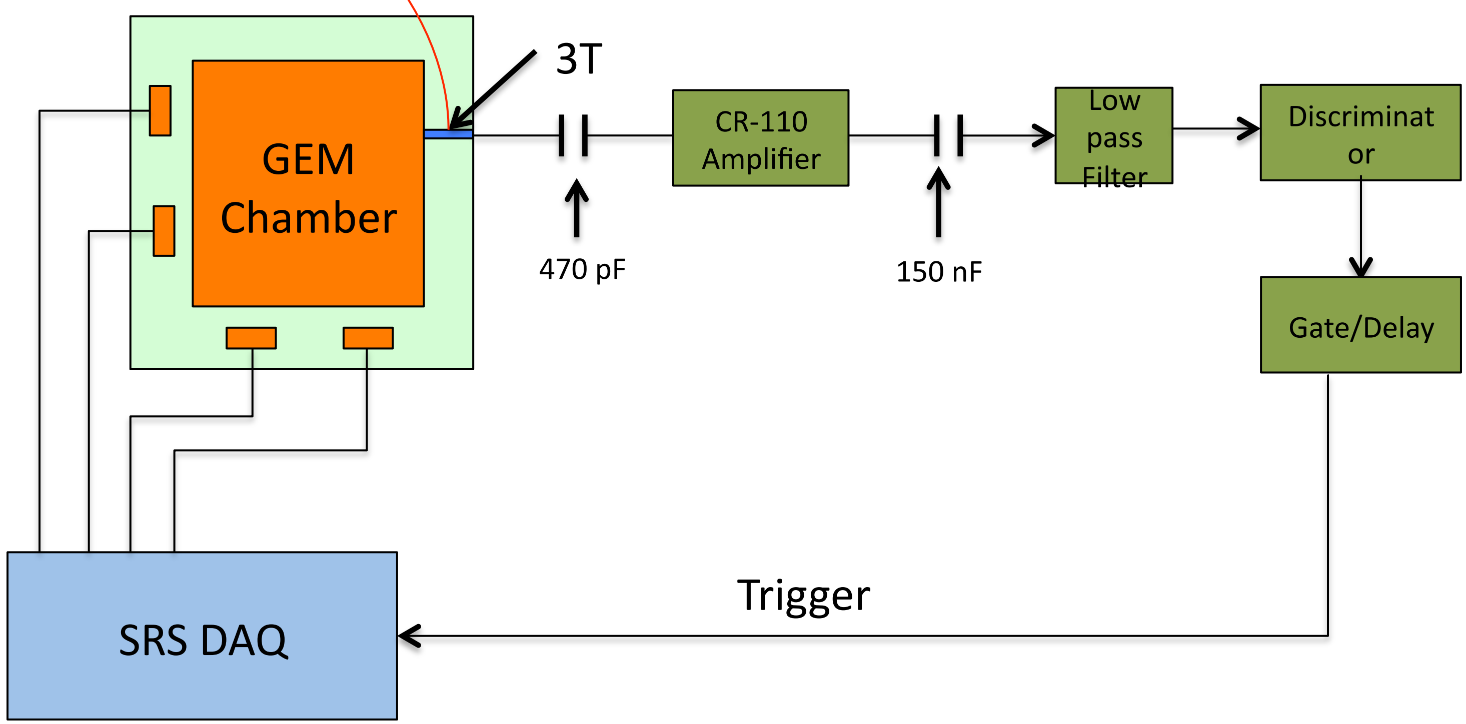


Setup of the Small GEM chamber with ^{55}Fe

- Low pass filter used to reduce high frequency noise.
- The cut off frequency for this low pass filter is 10 MHz.

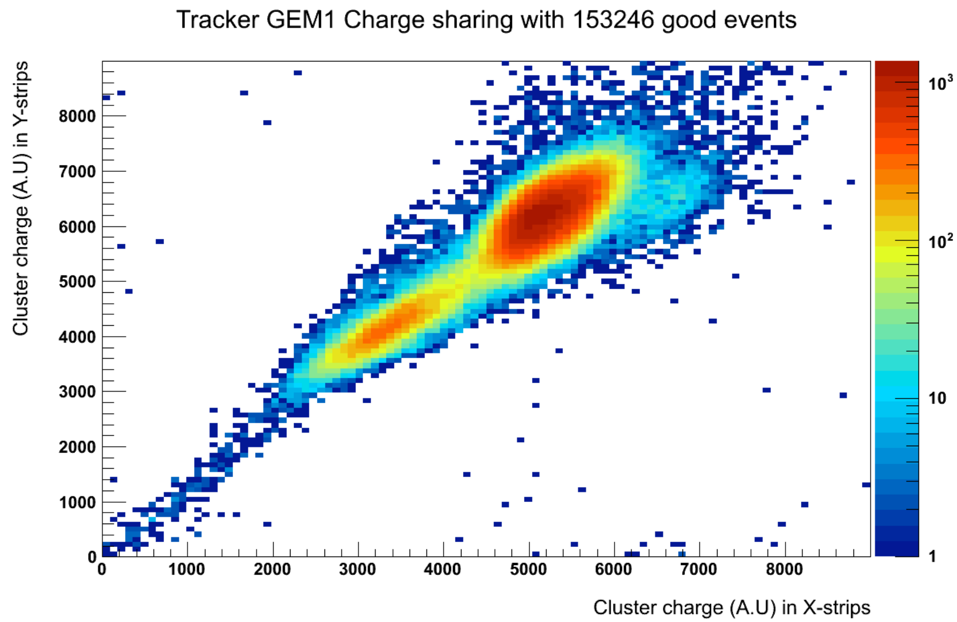


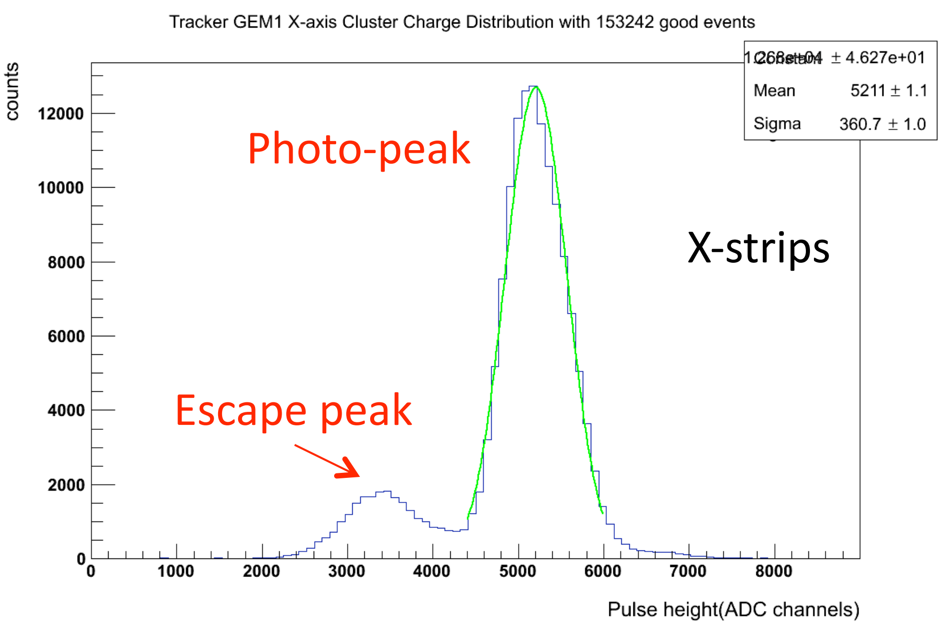


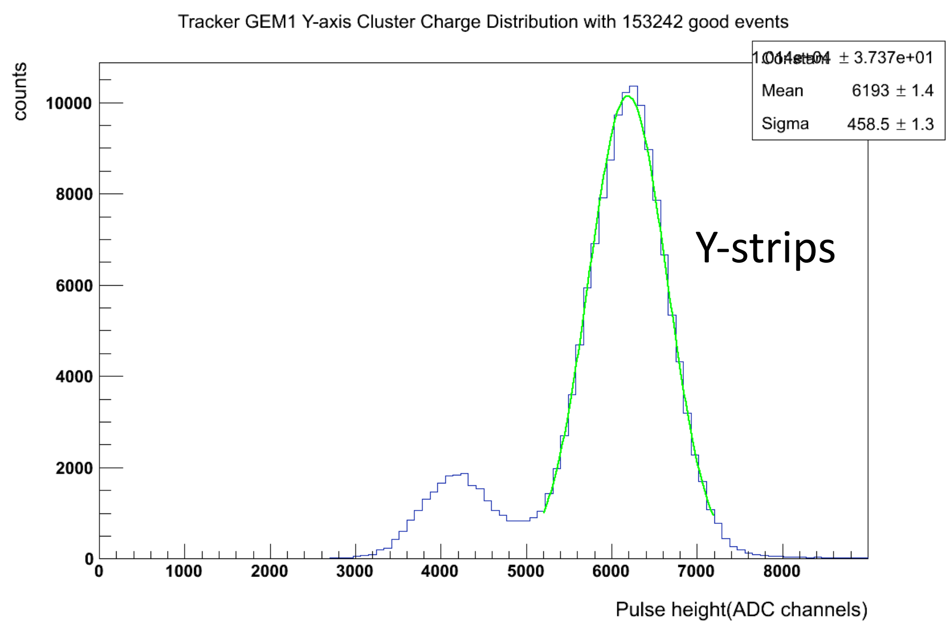


^{55}Fe spectrum

- HV = 4 kV on the voltage divider
- Trigger threshold at 50 mV on GEM foil
- Distribution of strip cluster max ADC counts ➔ the Fe55 spectrum

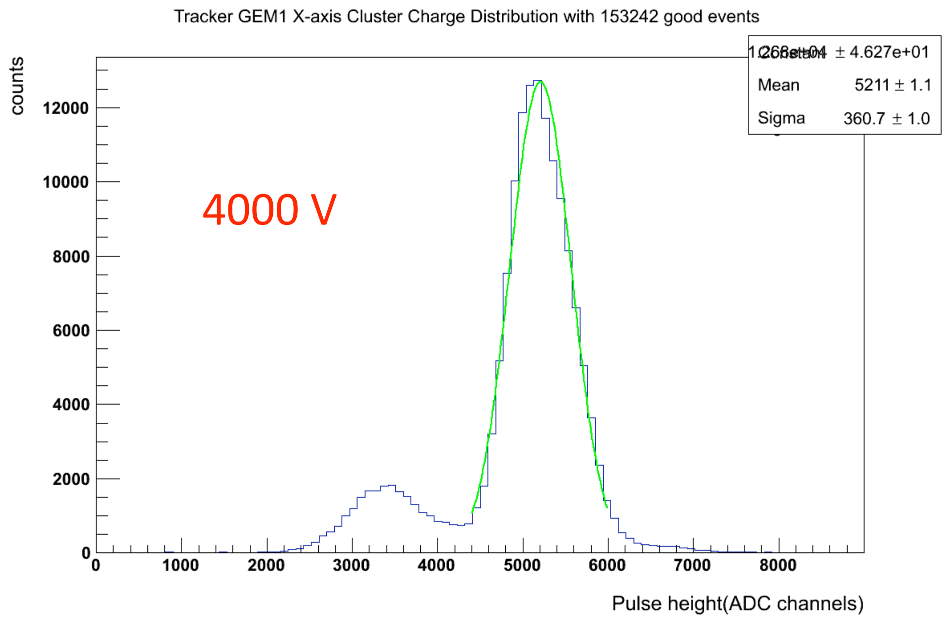


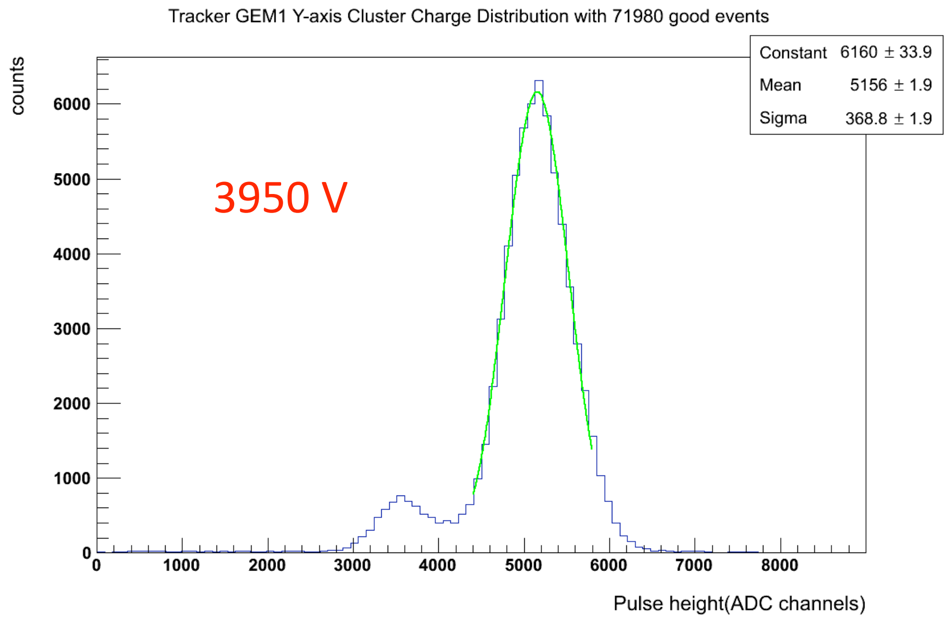


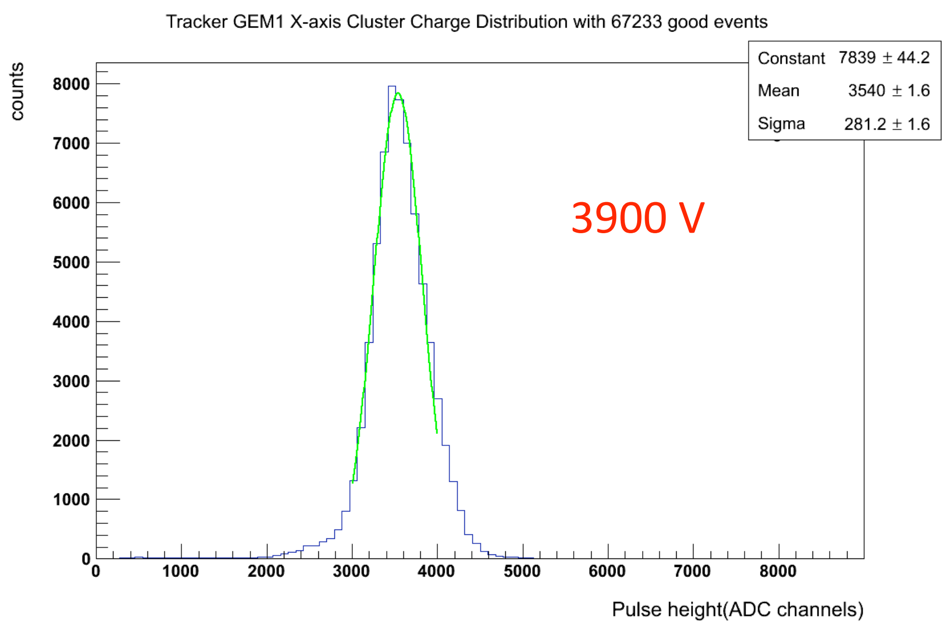


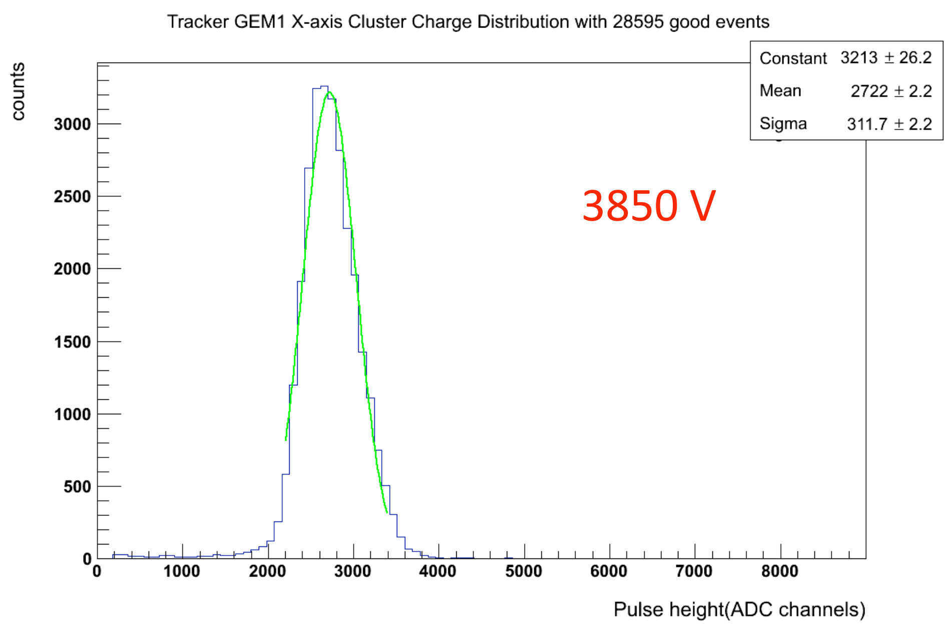
^{55}Fe spectrum vs. HV

X-strips



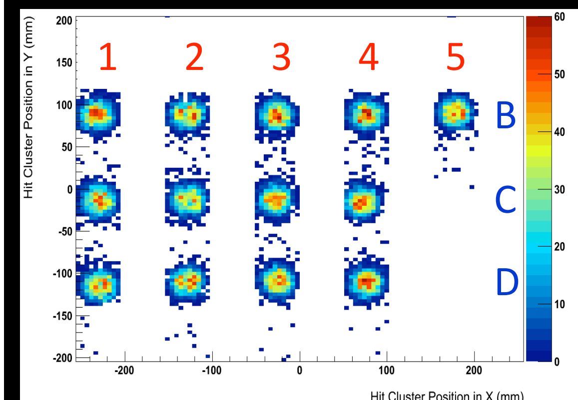


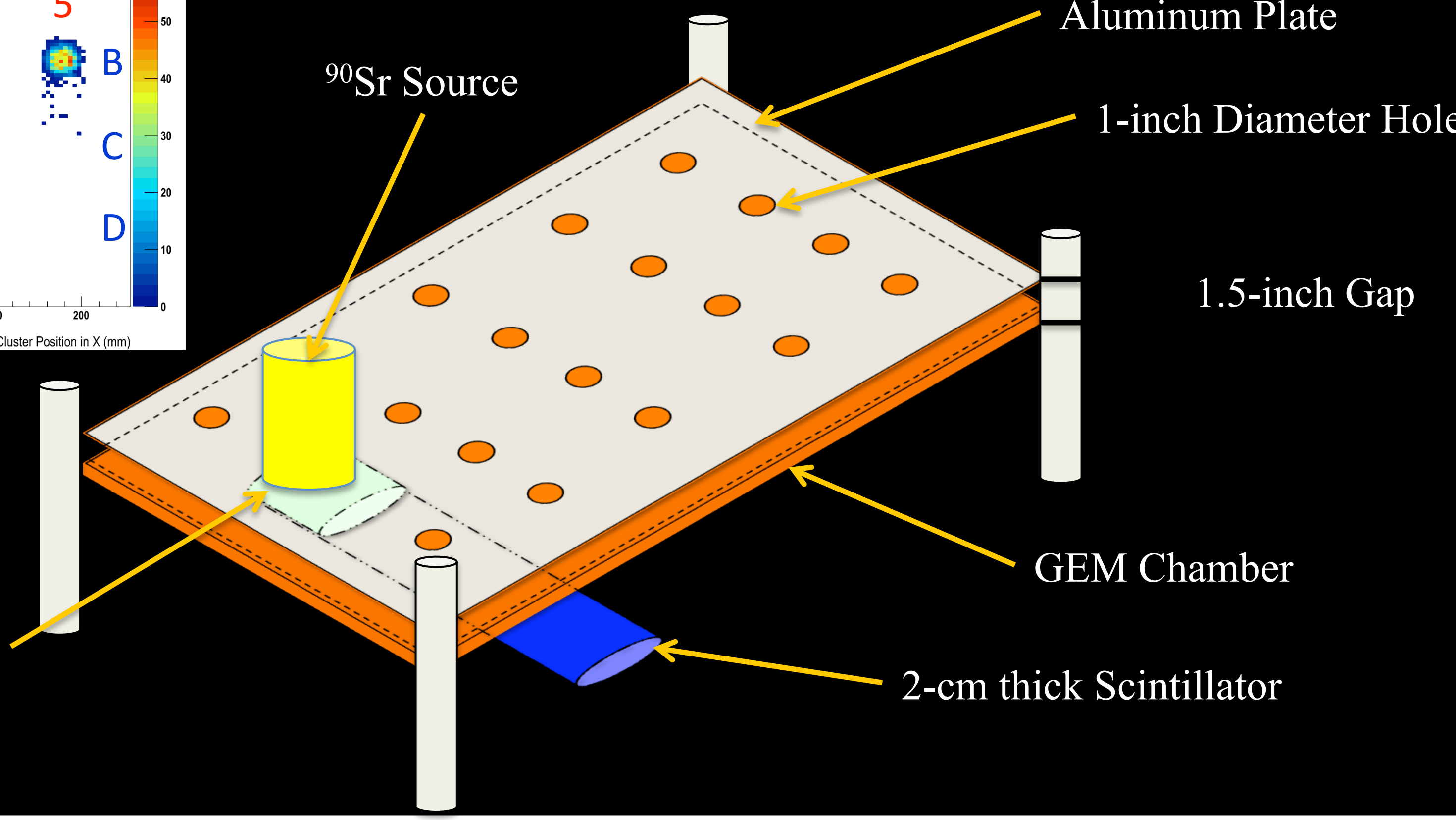




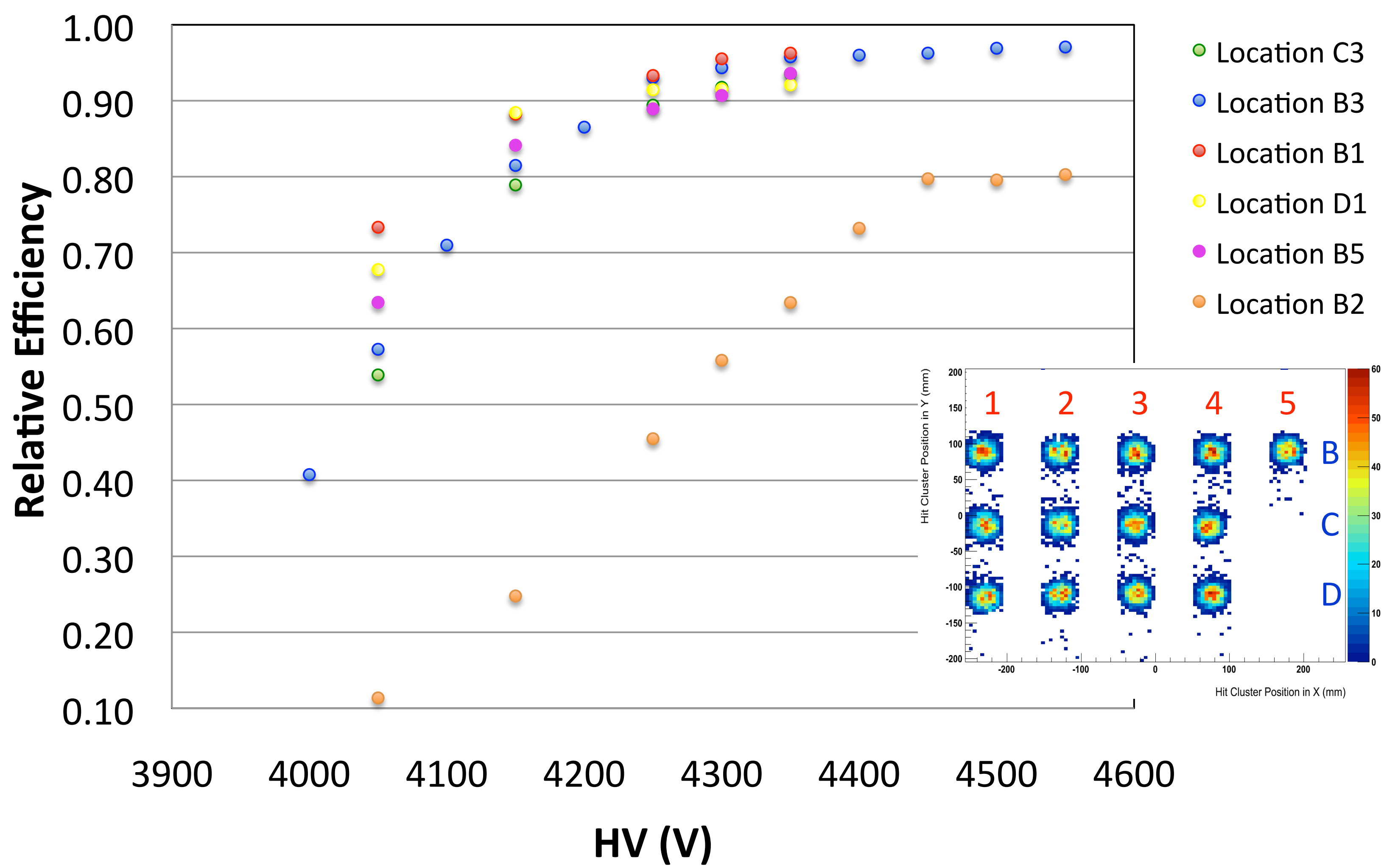
Setup of SBS GEM Test with ^{90}Sr

- The test used ^{90}Sr source located above the 1st prototype SBS GEM chamber at different locations to study efficiencies, ADC spectrums, charge sharing and other important characteristics of the chamber by varying the gas flow rates, and directions
- The threshold of the scintillator was set at 135 mV throughout the test (unless specified by other values)

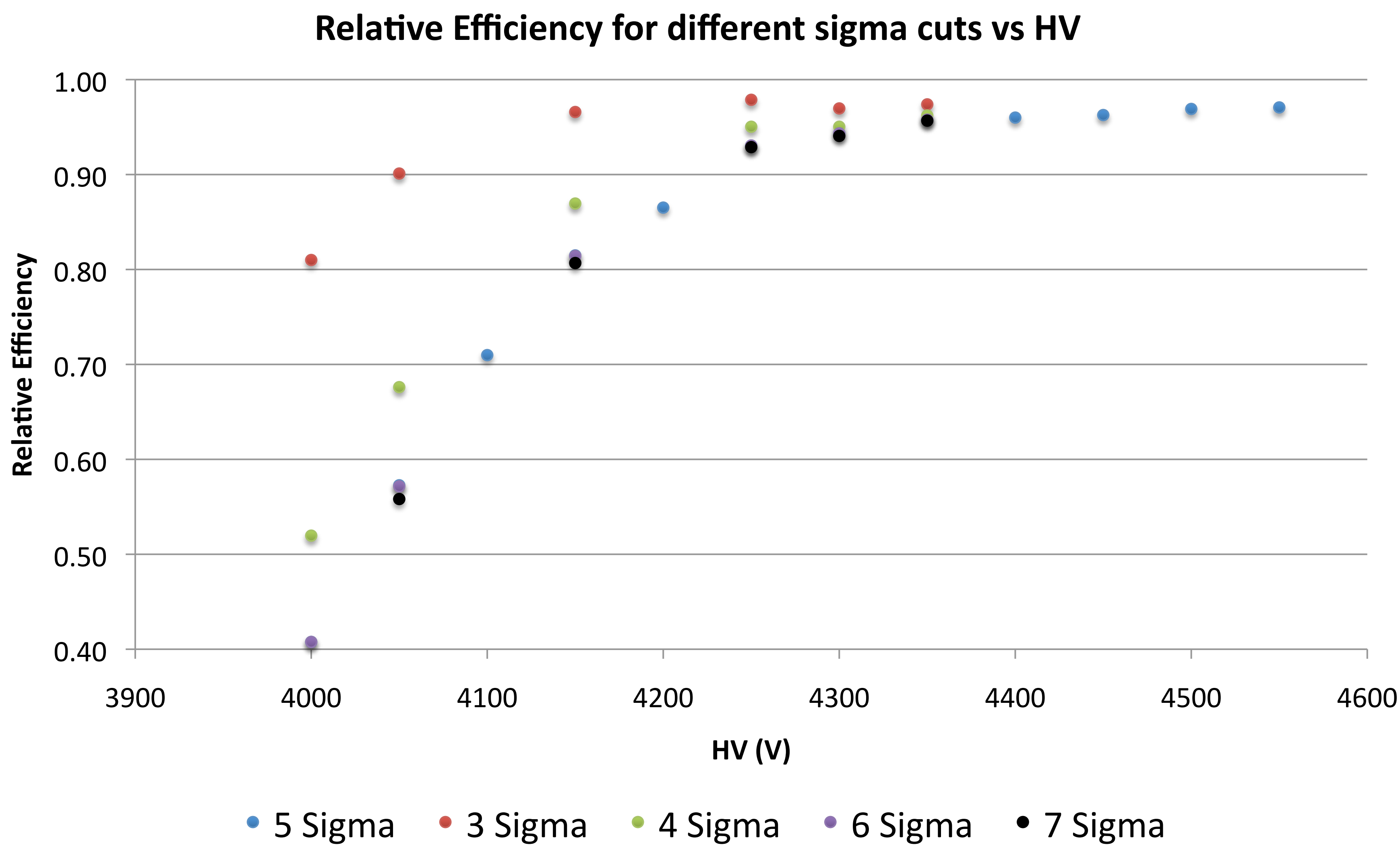




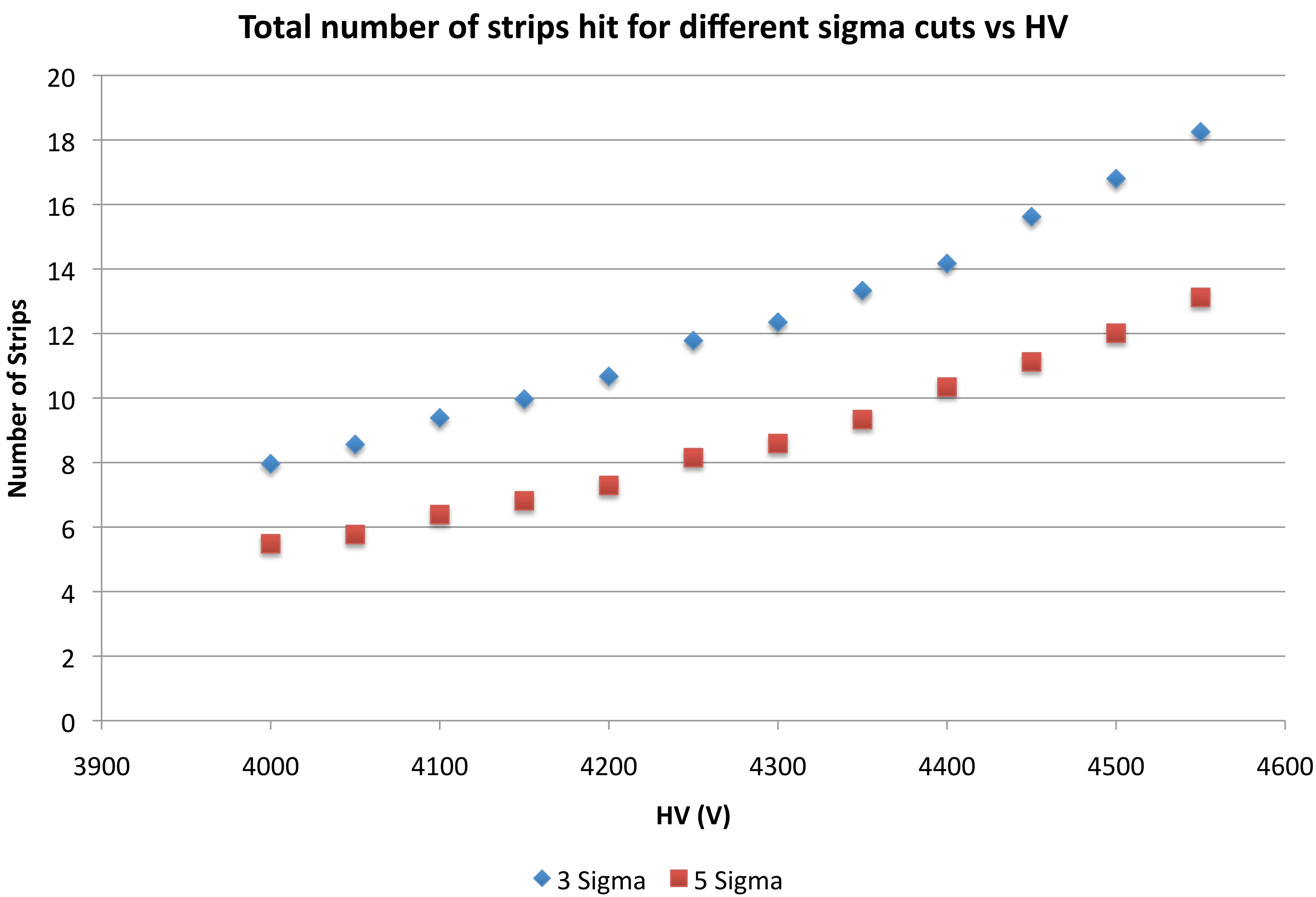
Efficiency vs. HV of the SBS GEM with ^{90}Sr



Test of the SBS GEM chamber with ^{90}Sr



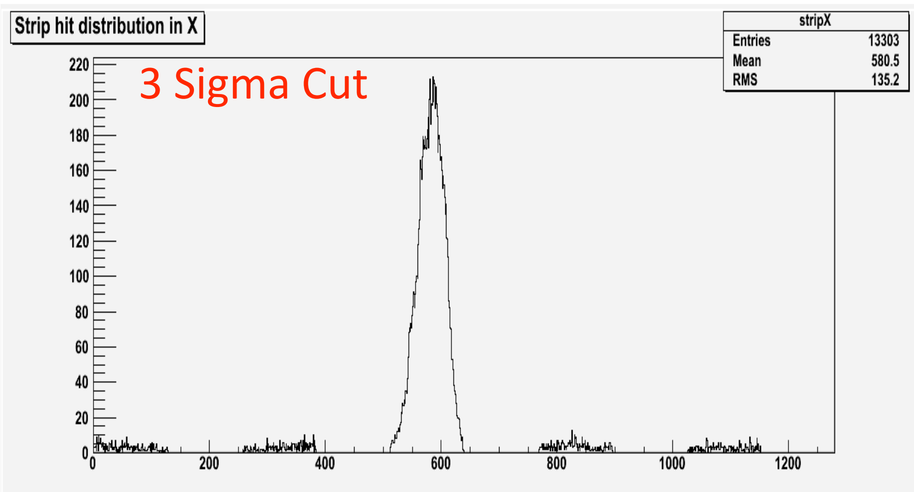
Test of the SBS GEM chamber with ^{90}Sr

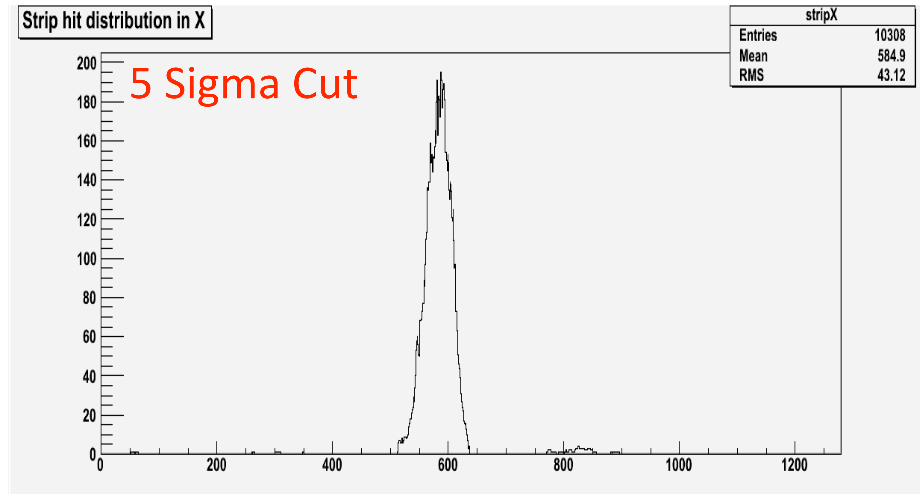


Test of the SBS GEM chamber with ^{90}Sr

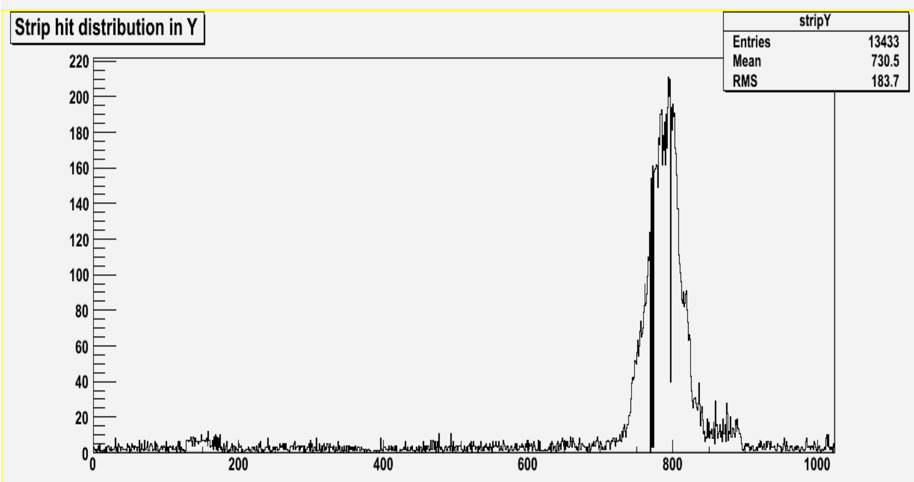
Hit distribution

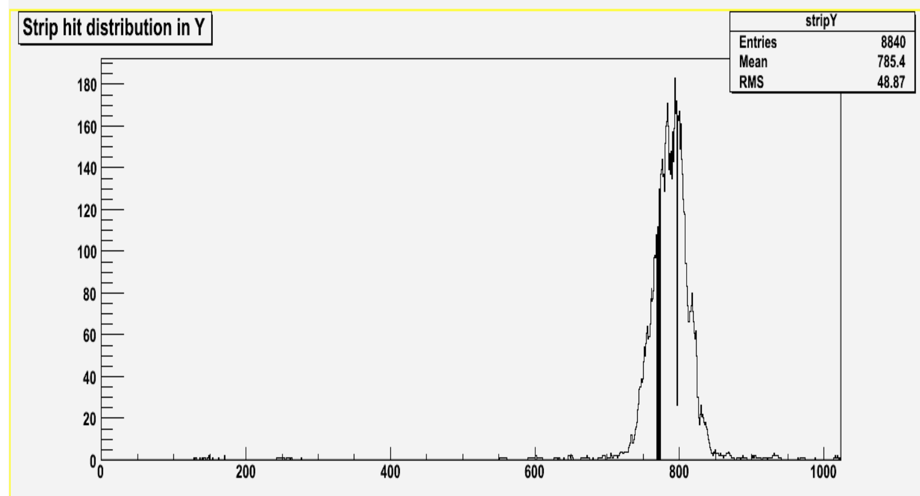
Condition:
1) 200 mL/min < Gas flow rate < 300 mL/min
2) Gas Direction: 1
3) Position: B3
4) HV = 4400 V





X-strips



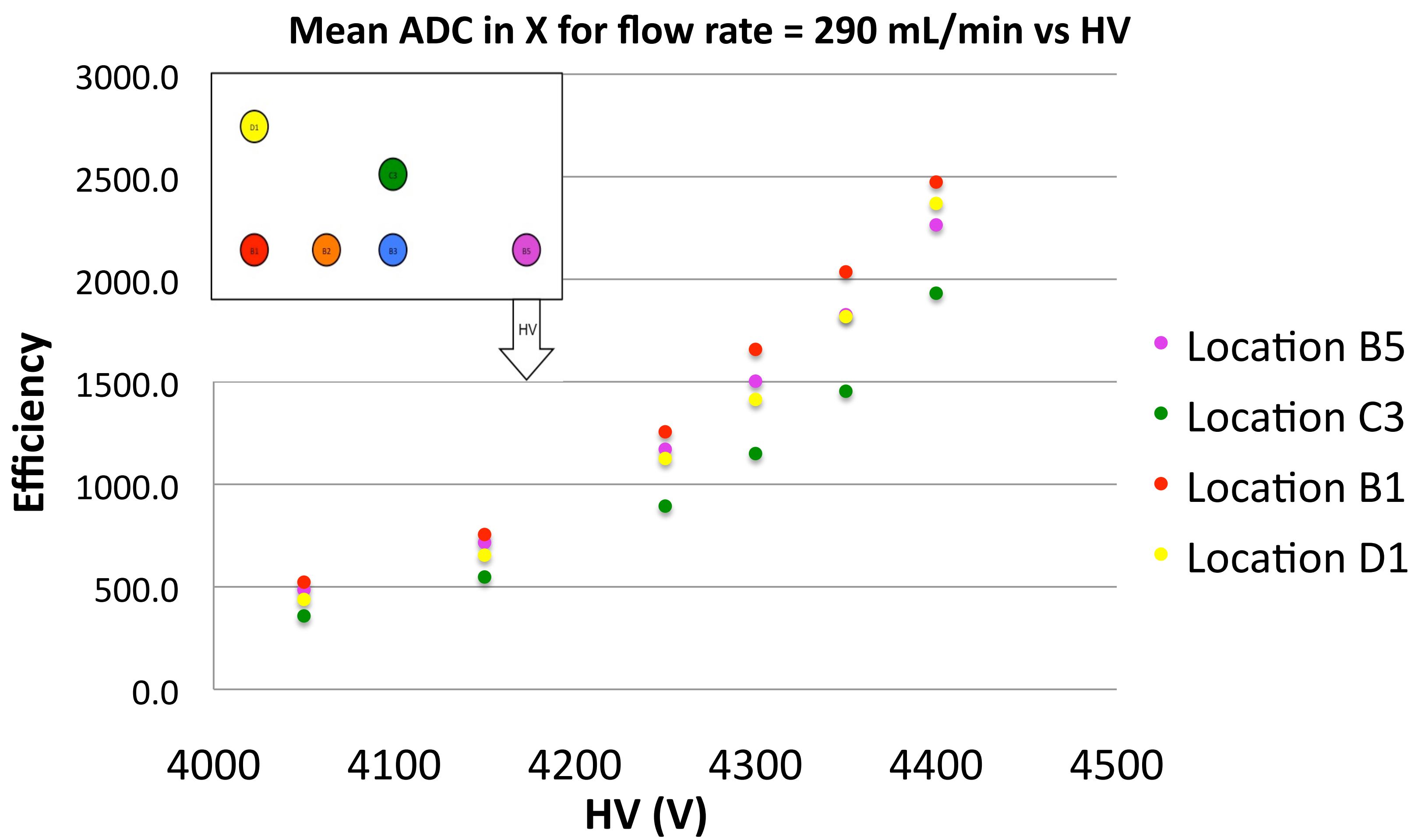


Y-strips

Test of the SBS GEM chamber with ^{90}Sr

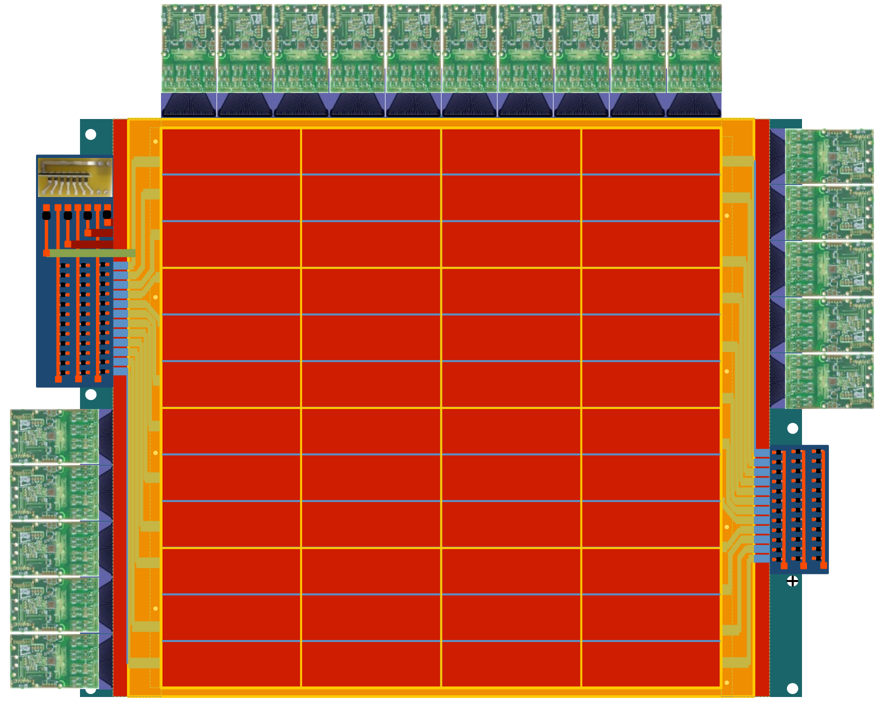
Average ADC in X direction

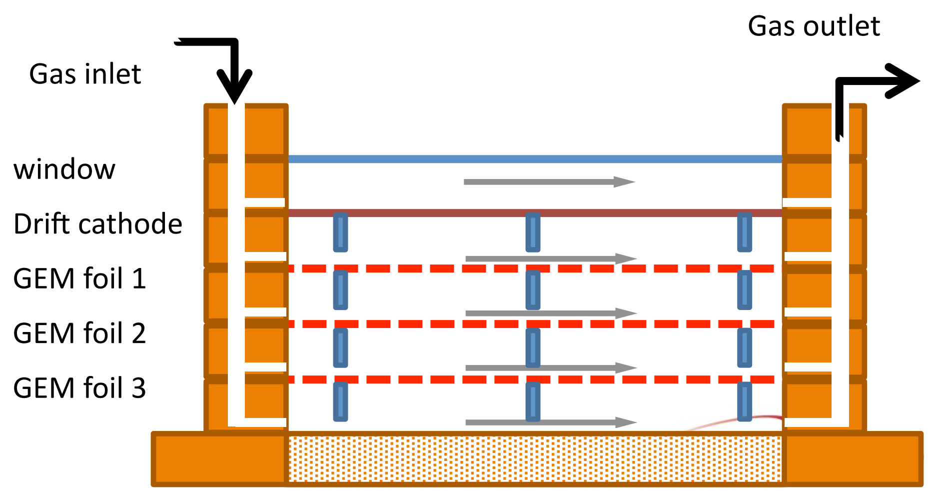
Condition: 1) Gas flow rate = 290 mL/min
2) Gas Direction: 2
3) 5 sigma cut



Proposal for a new design for the SBS GEM polarimeter trackers by Kondo Gnanvo

- **Module of $50x50cm^2$ to replace the $40x50cm^2$**
  - 32 modules to be built instead of 40 for the 8 Polarimeter chambers
- **Wider GEM frames along x-axis**
  - Width of 30 mm instead of 8 mm
  - Better stretching
  - alignment holes away from active area
- **Wider readout support frame along x-axis (74 mm)**
  - Room for strips connectors and GEM HV sectors electrodes
- **No protective resistors on the GEM foils**
  - External resistor boards
- **Gas system same as in Evaristo design**





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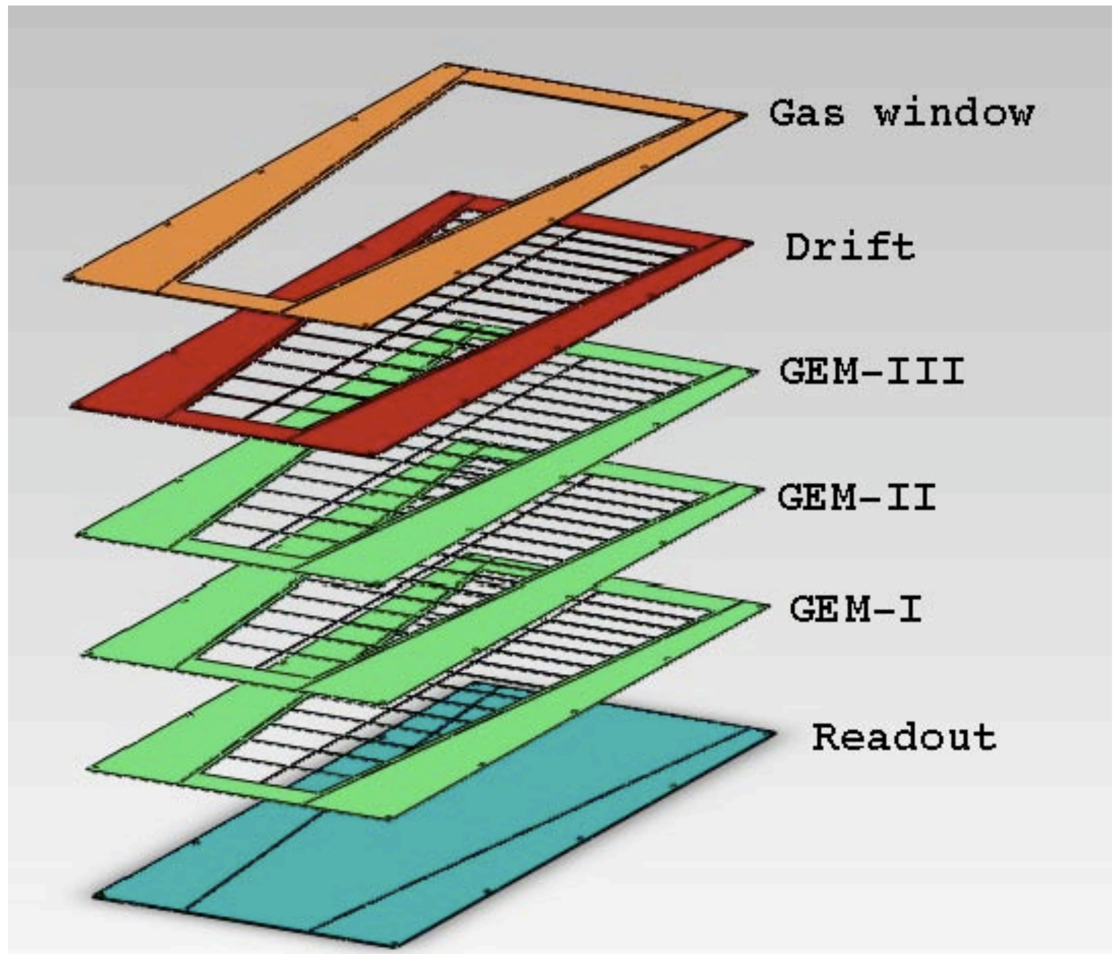
100 cm x (45 cm -22 cm) Prototype

- **Funded by EIC R&D program**
- **Similar to the size of largest SoLID chambers**
- **The design is complete: orders have been placed**



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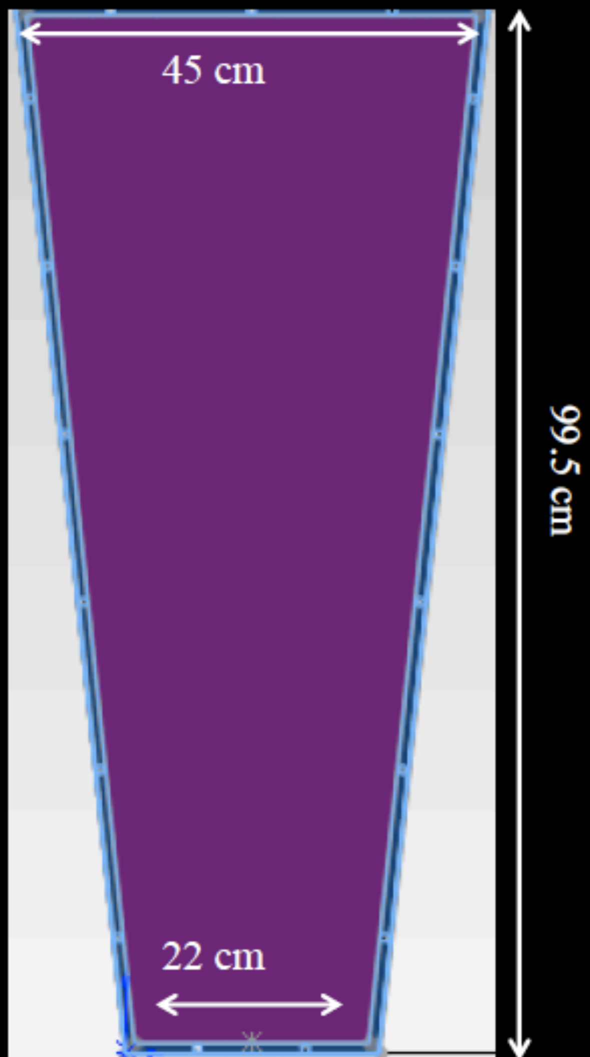
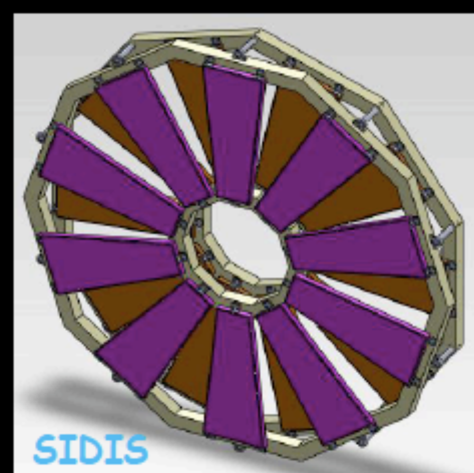
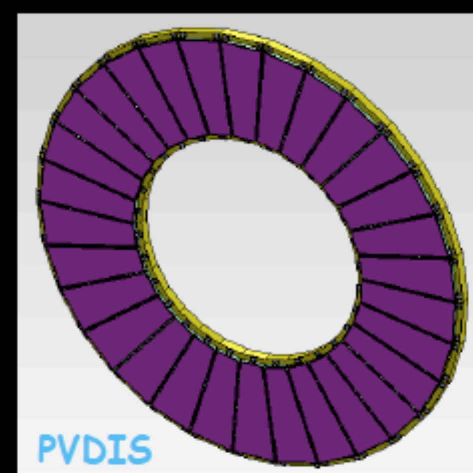
Large Area GEM R&D



Common R&D for various projects:

- EIC R&D funding at UVa for designing and prototyping a large area GEM for Forward Tracker
- Chamber size very similar to largest SoLID GEM and for CMS high Eta Muon Upgrade
- Seth Saher (UVa undergrad. student) is already working on the design

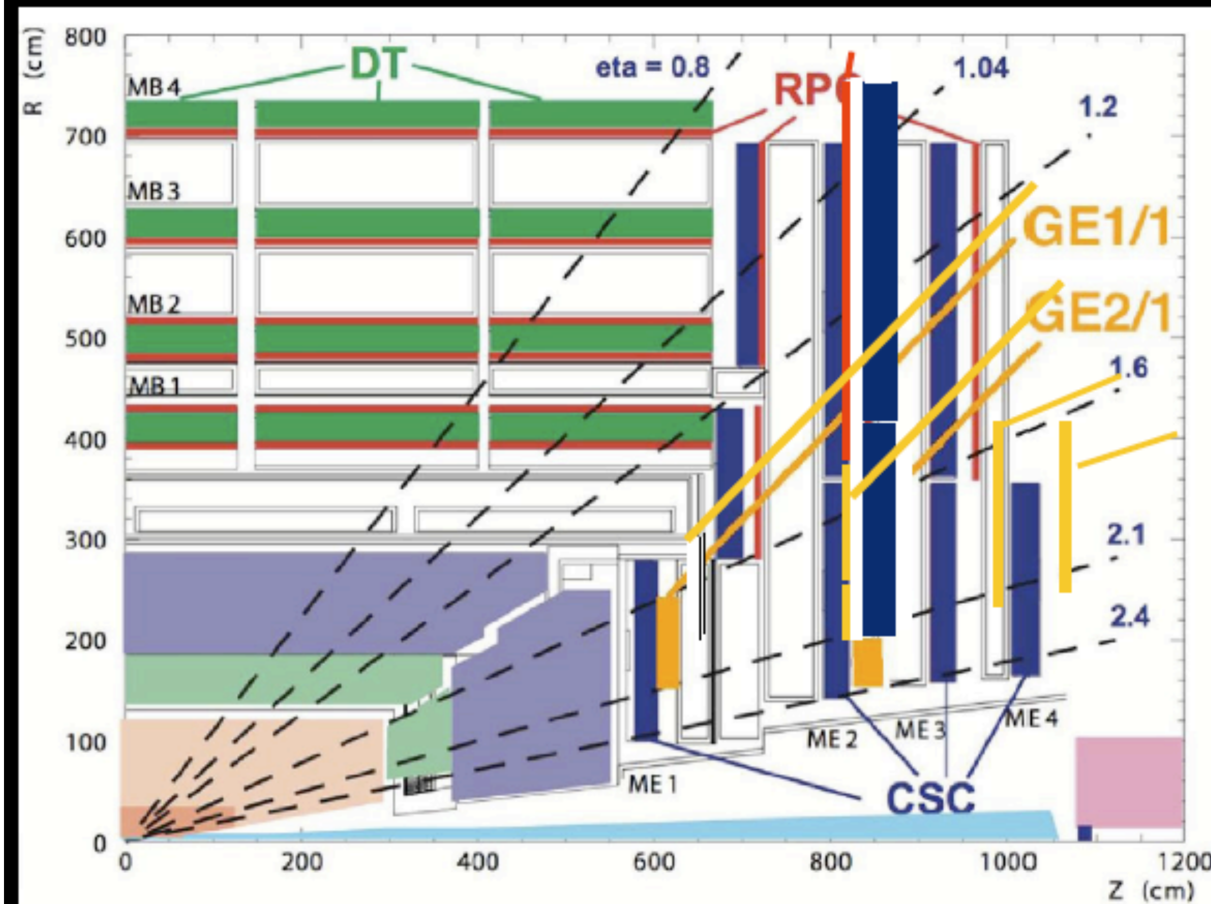




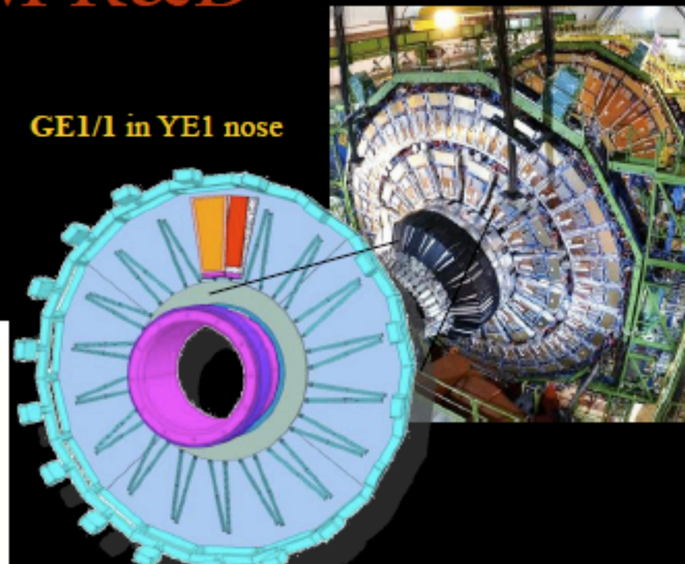
• Several chambers of this size have been built under the CMS upgrade program (see the next slides), but they are 1D readout; our chamber will be 2D readout.

Large area CMS GEM R&D

The currently un-instrumented high-η RPC region of the muon endcaps presents an opportunity for instrumentation with a detector technology that could **sustain the radiation environment long-term** and be suitable for operation at the LHC and its future upgrades into Phase II: **GEM Detectors**



GE1/1 in YE1 nose

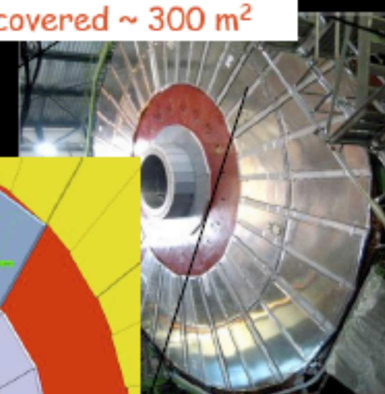


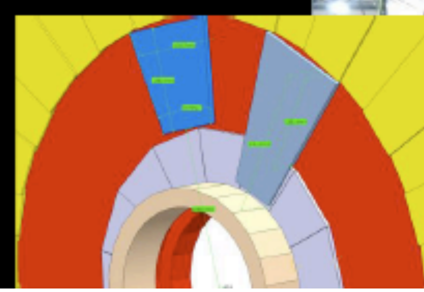
GEM s for triggering and tracking

- Proposal to cover the 1.6 < |η| < 2.4 region with GEMs.
- GEMs for
- 240 GEM chambers

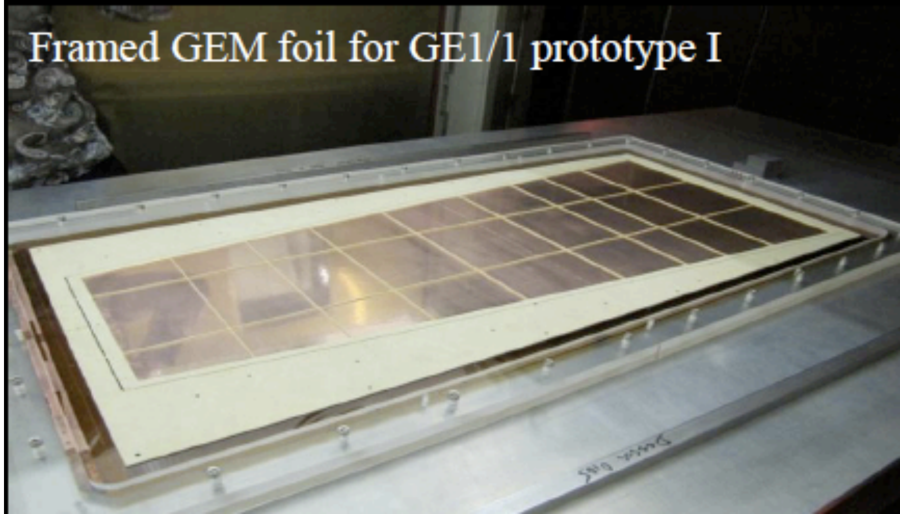
Total active area covered ~ 300 m^2

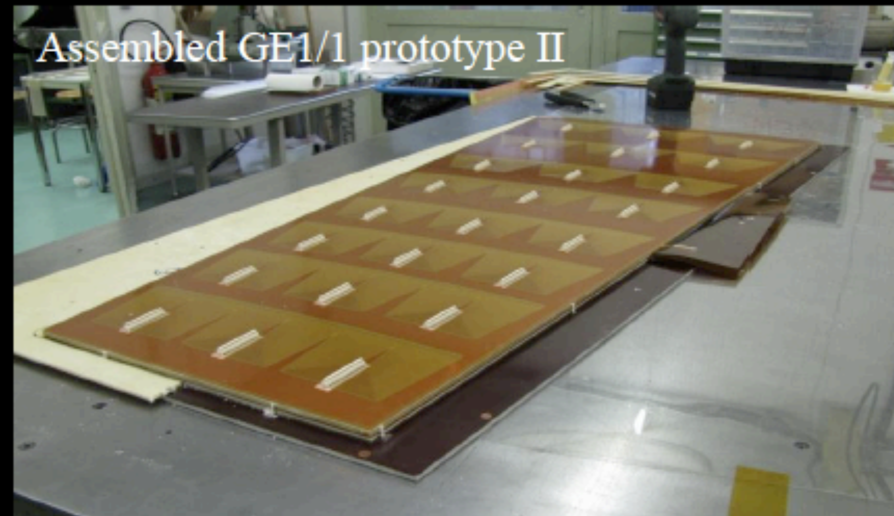
GE2/1 on back of YE1





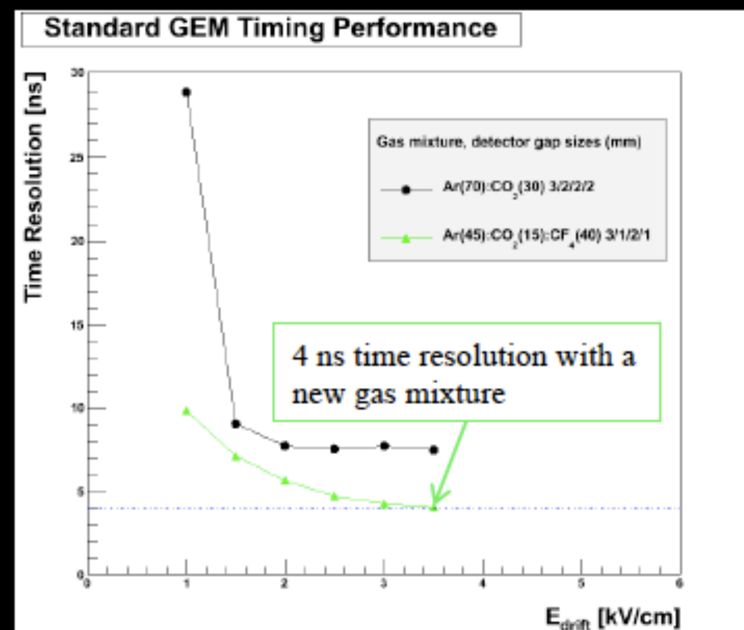
Large area CMS GEM R&D





Extensive R&D by CMS Collaboration over many years:

- New Geometry (3-1-2-1) triple GEM with Ar/CO2/CF4 to achieve 4 ns timing resolution
- Participate in the development with RD51 Collaboration of the single mask technique for large area GEM
- NS2 technique for faster and spacer free GEM assembly
- Contributing in the development of the VFAT/SRS Electronics



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Large GEM R&D Motivations

•Develop techniques to fabricate large area GEM chambers with narrow edges and 2D readout.
• Develop a 2 D readout for large area GEM chambers
• Construct a 100 cm x (25-40) cm GEM chamber with narrow edges and 2D readout

•GEM modules of the size needed for SoLID have been developed as part of CMS GEM R&D; however these were of the "self-stretching" GEM type, which requires the foils stretching components to be part of the GEM chamber edge; this significantly increases the amount of material present in the detector volume.

• An alternate approach to use an external stretcher for the GEM foils and to glue the stretched foils on to narrow frames. The proposed UVa GEM prototype is designed with 8 mm edges, minimizing the amount of material within the detector volume.

• The large area CMS prototype GEM modules had 1D readout; the UVa prototype will have a 2D readout, so that the radial coordinate of the track is available in addition to the azimuthal coordinate

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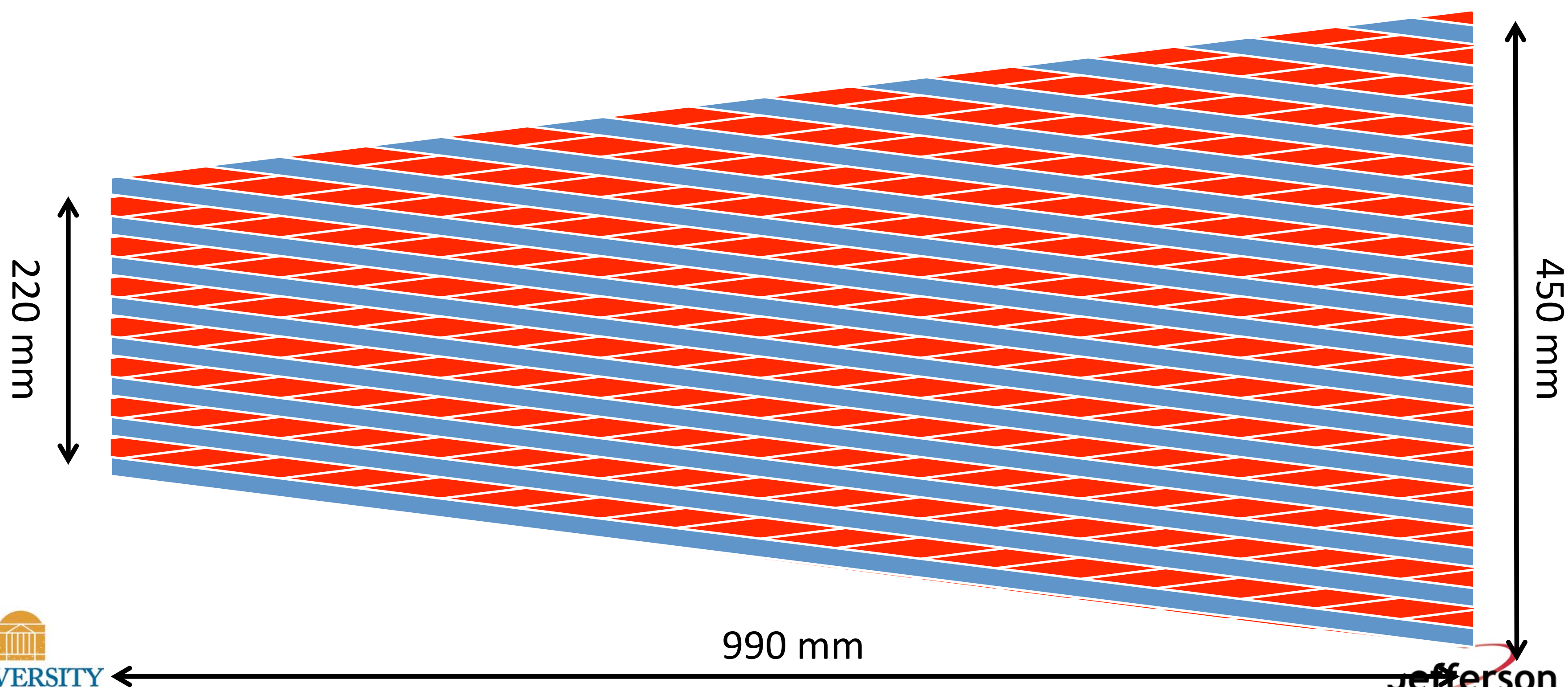
2D stereo angle R/O for EIC & SOLID Large GEM chamber

- Suggested readout scheme:
  - a 2D readout optimized to get high accuracy in the ϕ coordinate, lower but sufficient resolution in the **r** coordinate.
  - each set of stripes parallel to one of the radial sides of the module: strip pitch is 0.6 mm for locations 7 and 8; 0.4 mm for locations 5 and 6.
  - Issues: High capacitance in long readout strips; will SNR be an issue ?



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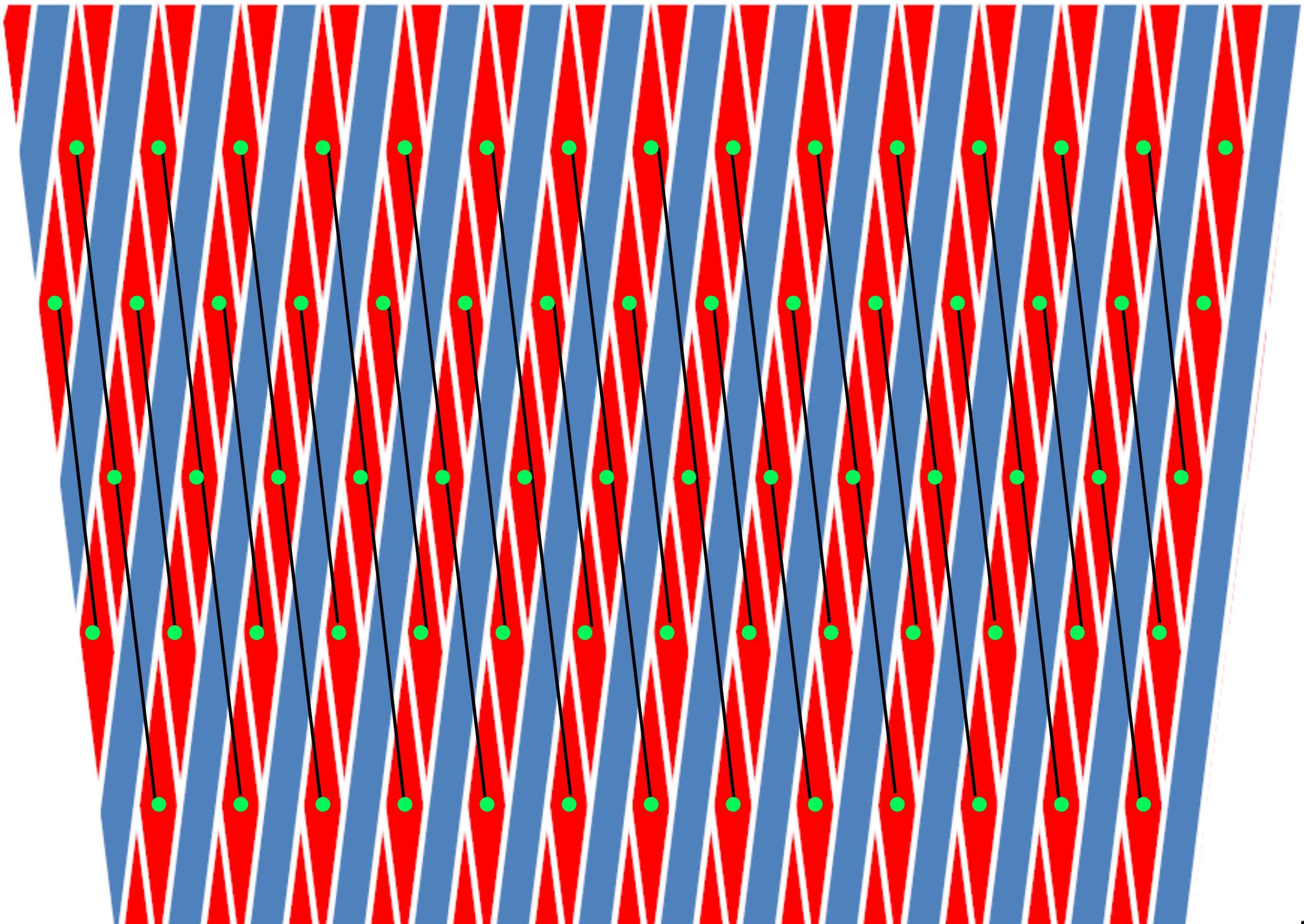
2D stereo angle R/O for EIC & SOLID Large GEM chamber



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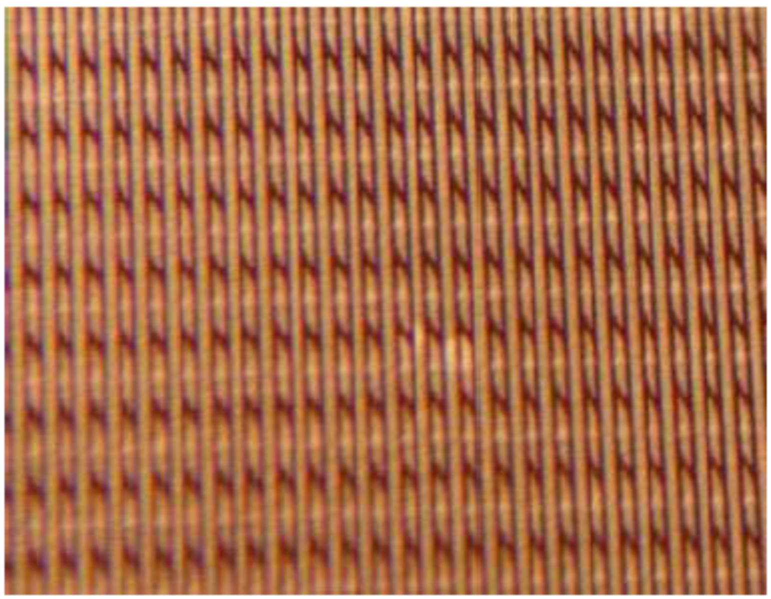
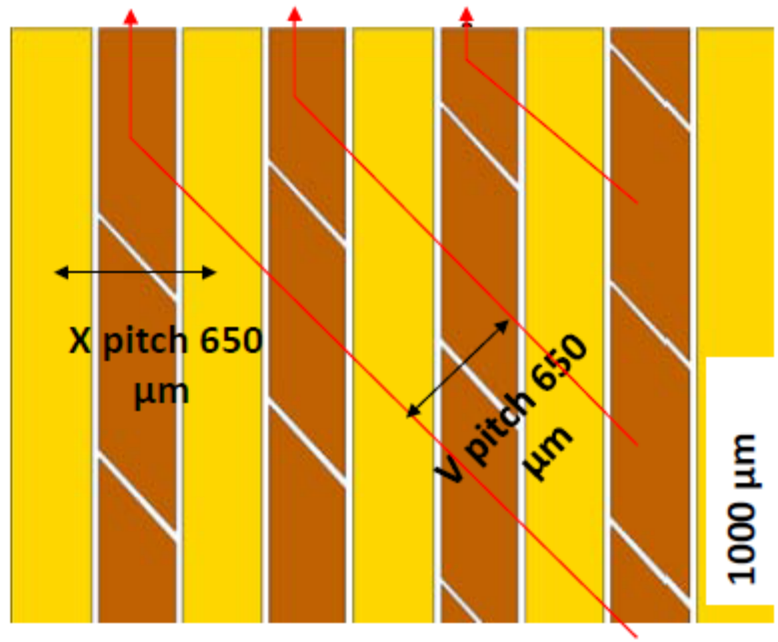
2D XV readout on Kapton foil for KLOE2 @ INFN Frascati

(2) XV readout and magnetic field

A new readout was drawn to fit the cylindrical shape of the IT anodes: a double-layer circuit with an X-V pattern realized with strips (X) and pads (V) etched on the same kapton layer. Pads are connected by vias to form the V-strips.





The new readout, mounted on small planar GEMs, has been tested in magnetic field on a test beam at CERN.

2D XV readout on Kapton foil for KLOE2 @ INFN Frascati

PVDIS GEM configuration

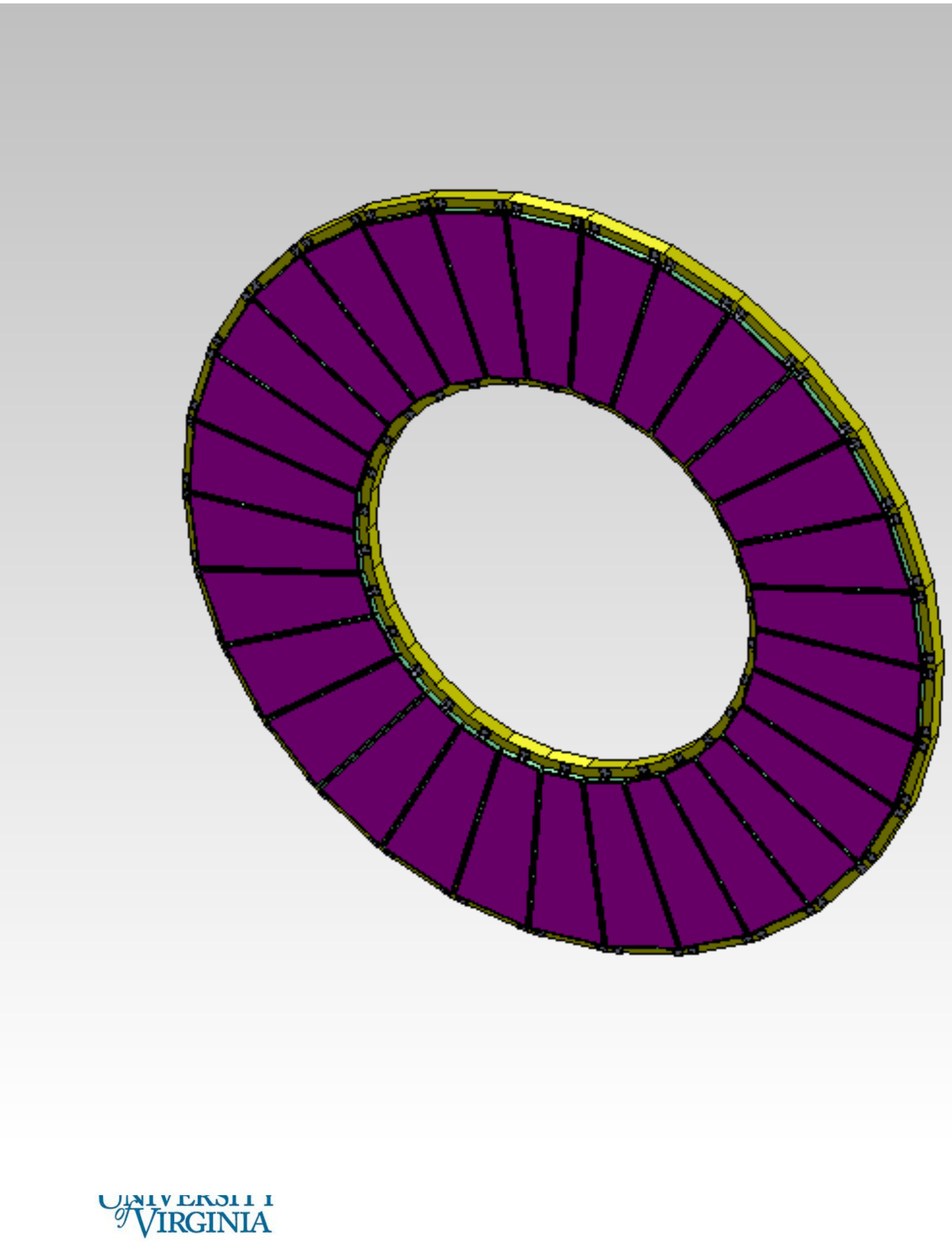
- For this readout scheme readout channel estimation

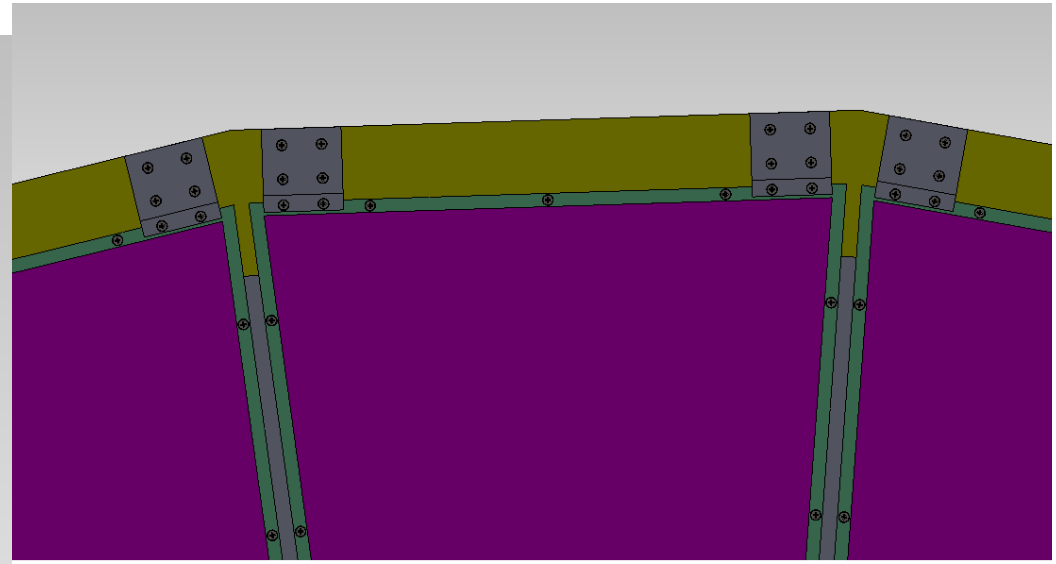
Plane	Z (cm)	R_I (cm)	R_O (cm)	# of channels
5	150	55	115	30 k
6	190	65	140	36 k
7	290	105	200	35 k
8	310	115	215	38 k
total:				140 k

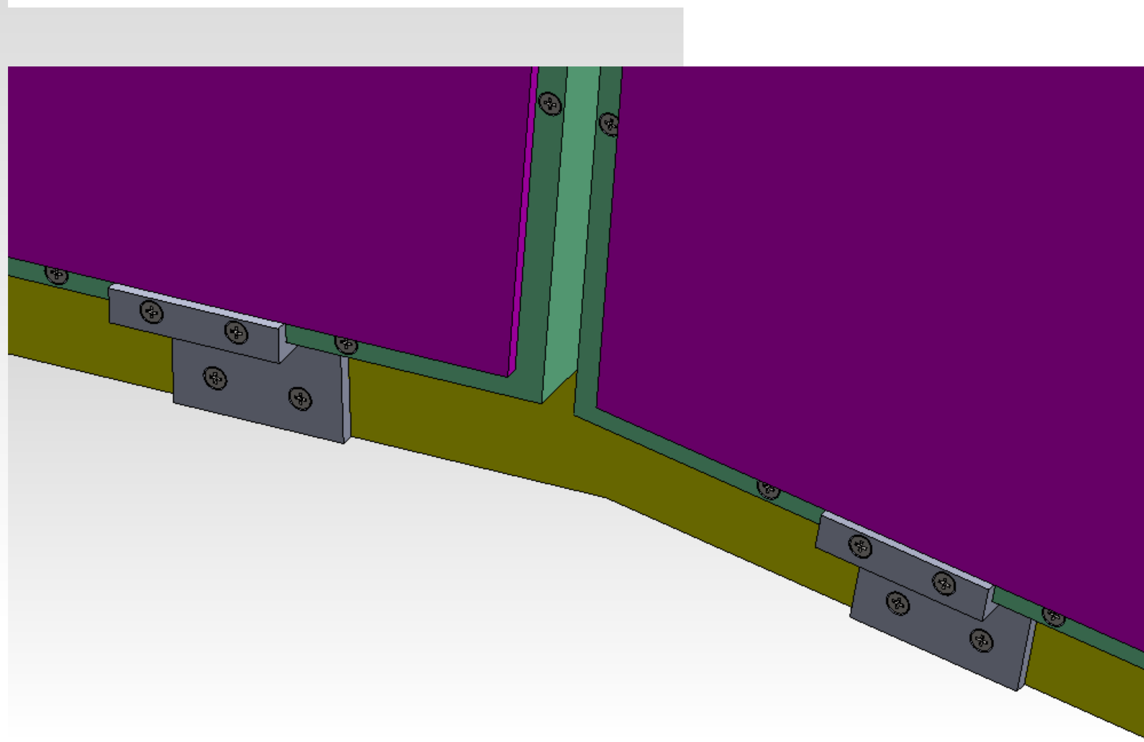
- with 20% spares, we will need about 170 k channels.
- Good news: cost of electronics going down – cost per channel for the RD51 SRS APV-25 based readout is estimated to be ~ $ 2.50 - $ 3.00 + R&D expenses to optimize electronics for SoLID needs.

The total cost of readout electronics can be less than $ 1 M

PVDIS GEM configuration



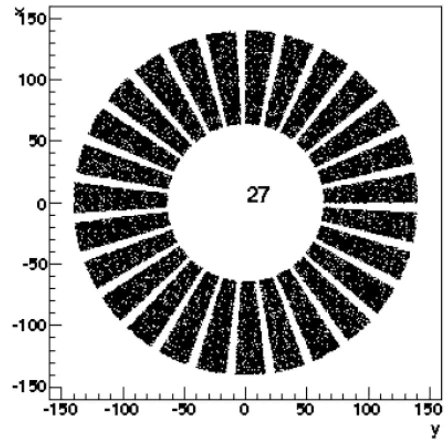




SIDIS GEM configuration

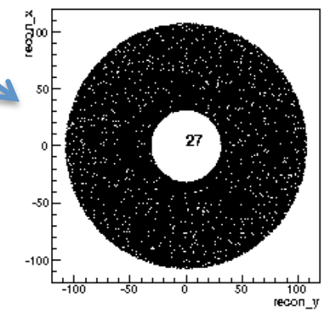
- Six locations instrumented with GEM:
- PVDIS GEM modules can be re-arranged to make all chamber layers for SIDIS. – move the PVDIS modules closer to the axis so that they are next to each other

Plane	Z (cm)	R_I (cm)	R_O (cm)	Active area	# of channels
1	197	46	76	1.1	24 k
2	250	28	93	2.5	30 k
3	290	31	107	3.3	33 k
4	352	39	135	5.2	28 k
5	435	49	95	2.1	20 k
6	592	67	127	3.7	26 k
total:				~18	~ 161 k



PVDIS

SIDIS



- More than enough electronic channels from PVDIS setup.
- The two configurations will work well with no need for new GEM or electronics fabrication.

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SIDIS GEM configuration