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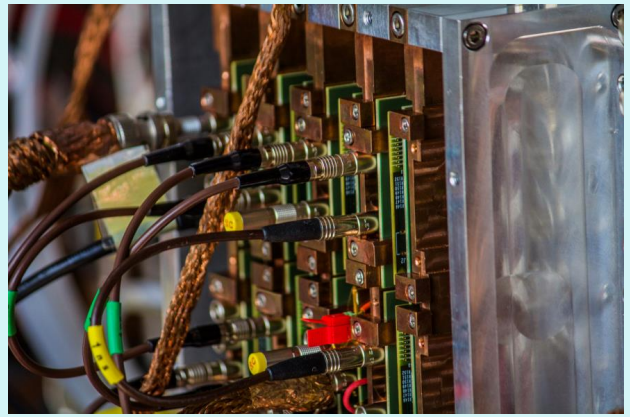
Outline

- Introduction
- Motivation
- R&D and Detector design
- Lab Results
- Conclusions

Optimized MPGD-based photon detectors for PID at the Electron-Ion Collider.



Shuddha Shankar Dasgupta

INFN Sezzione di Trieste

On behalf of

INFN – EIC Group

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Electron-Ion Collider (EIC)

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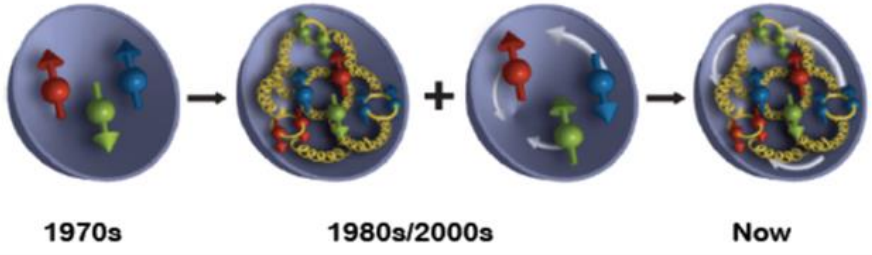
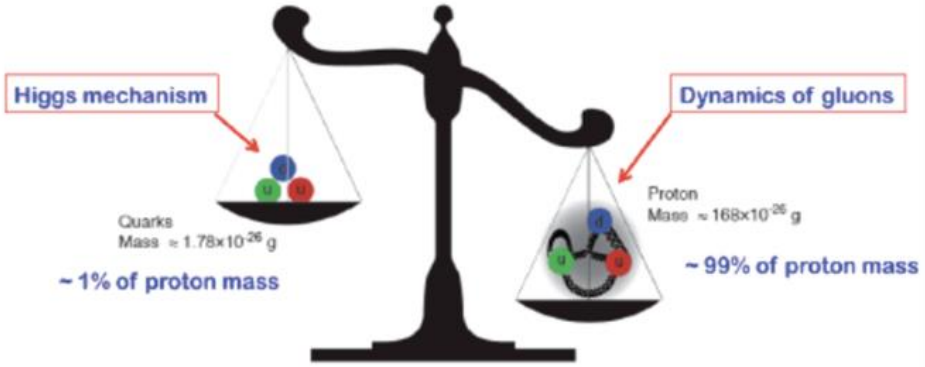
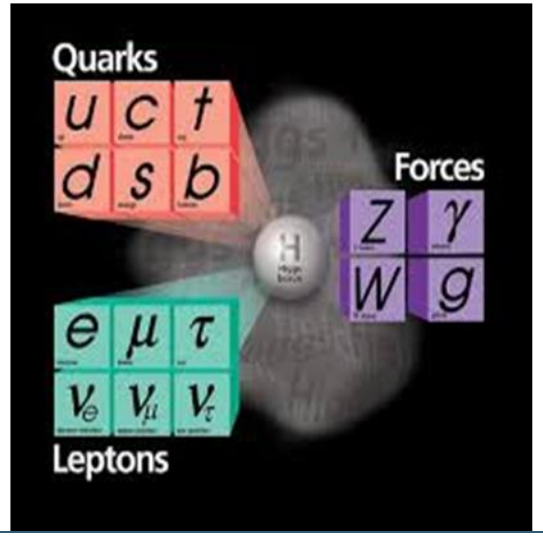
We know very little ...

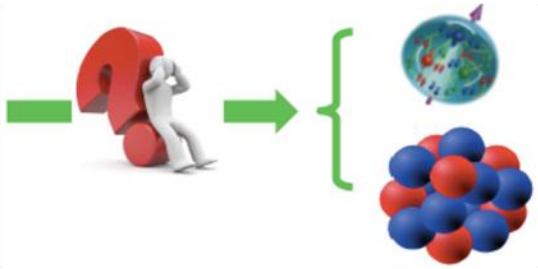


$$\frac{1}{2} = \left[\frac{1}{2}\Delta\Sigma + L_Q\right] + [\Delta g + L_G]$$



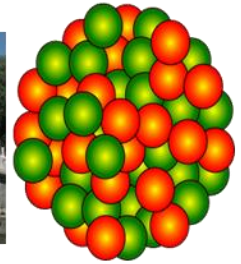
Standard Model: The most successful theory so far ... However ...





Spin structure

Mass structure



What does a proton look like in terms of quarks & gluons?

- **EIC: The next QCD frontier, understanding the glue that binds us all**
- **Collider requirements: High luminosity & energy, variable CM energy, all- A nuclear beams, polarization in e- and light ions**
- **Detector requirements: Hermetic detector, low mass inner tracking, good PID (electron/pion/kaon/proton) in wide range, calorimetry, forward & backwards tracking**

The experience we capitalize from -> COMPASS RICH

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hadron PID from 3 to 60 GeV/c

acceptance: H: 500 mrad V: 400 mrad

trigger rates: up to ~50 KHz

beam rates up to ~10^8 Hz

material in the beam region: 1.2% X_0

material in the acceptance: 22% X_0

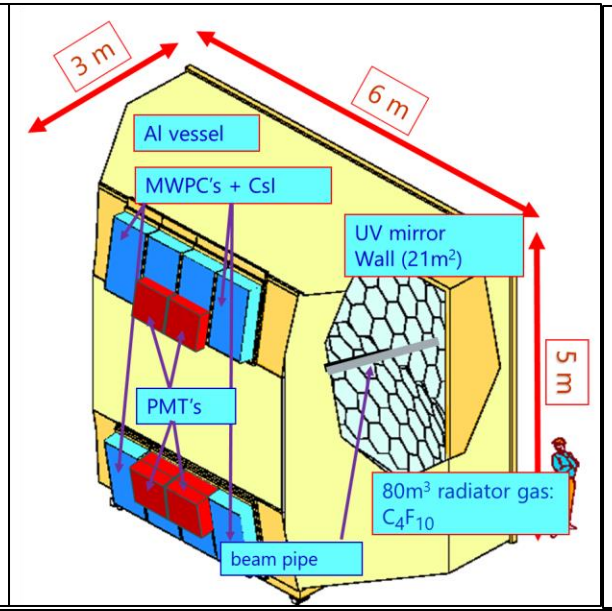
detector designed in 1996

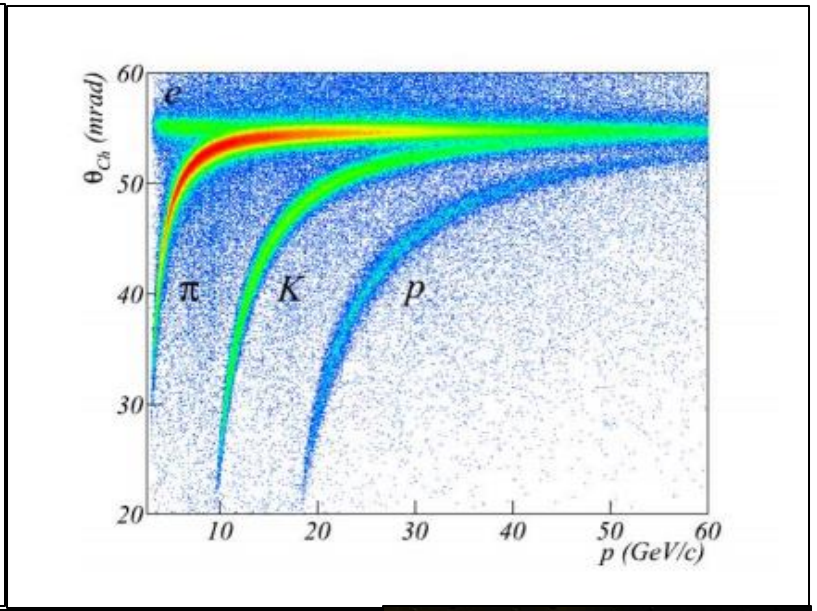
in operation since 2002

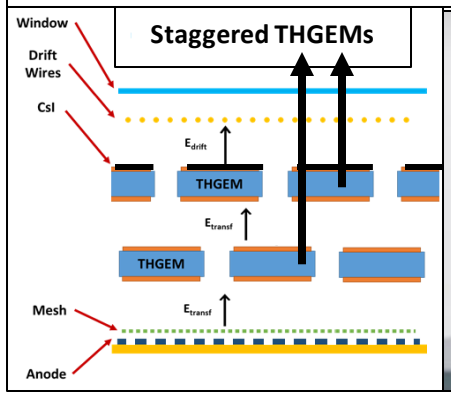
upgraded in 2006

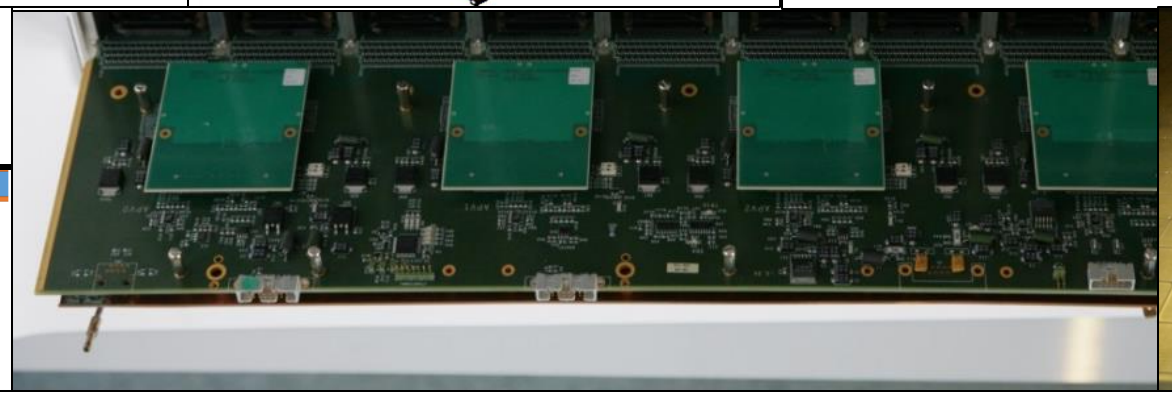
total investment: ~ 5 M €

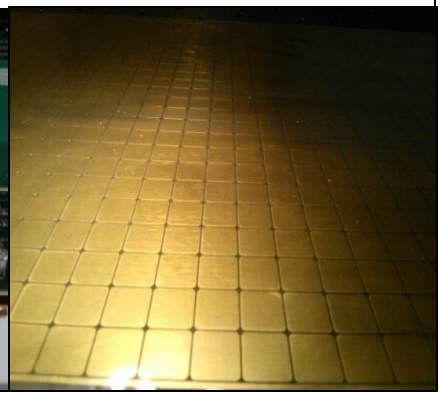
A NEW UPGRADE HAS BEEN DONE IN 2016











The Hybrid PD with MiniPADs

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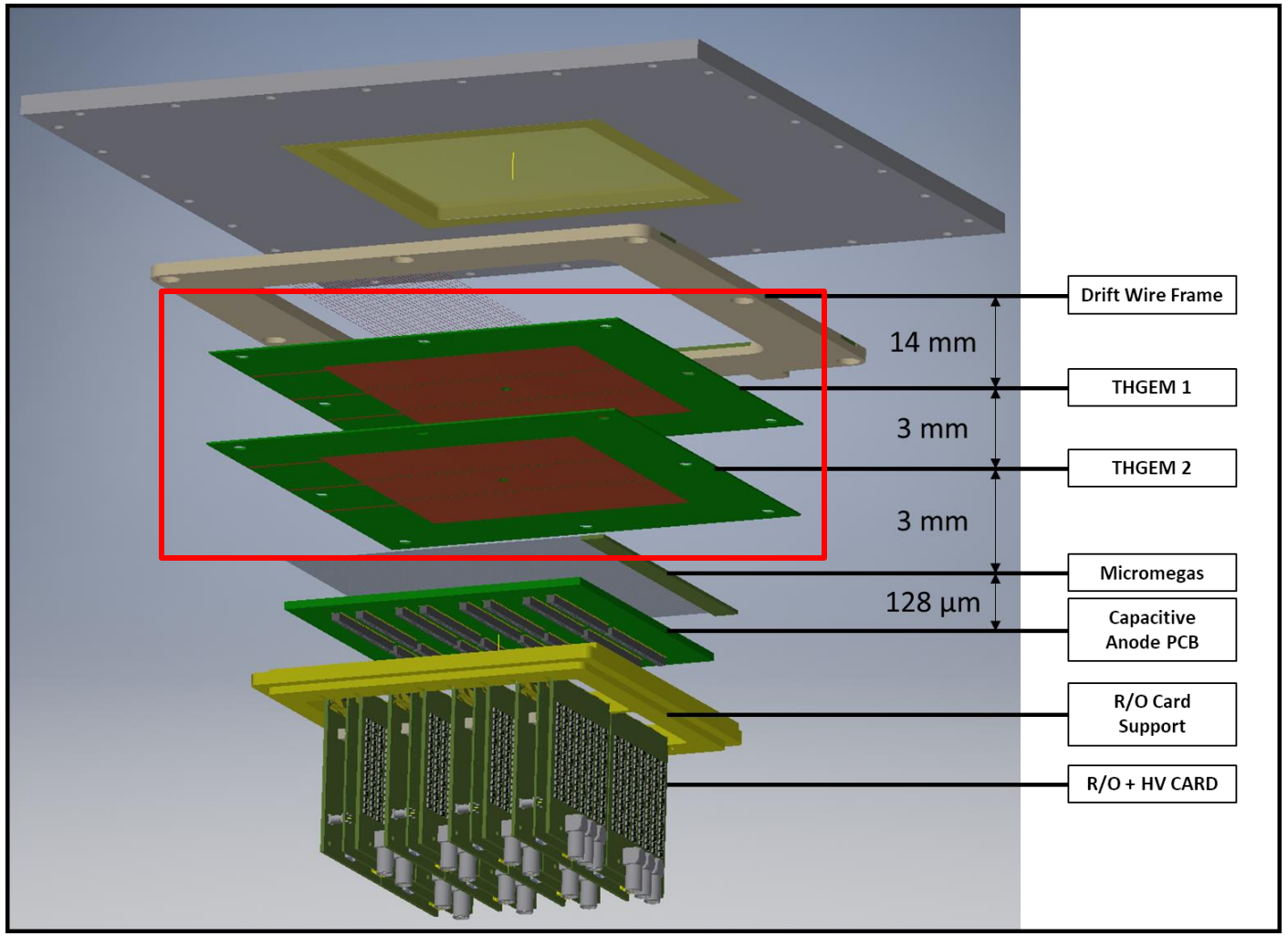
- The requirement for EIC is to have large area Detector of single photons with small pads (3 × 3 mm^2) over several m^2.
- Mosaic architecture with all the components and services installed within the active area has been developed.
- 100 × 100 mm^2 active area hybrid modules with 32 × 32 3 × 3 mm^2 Pads are built for lab tests.
- Each components of the hybrid modules are characterized separately in the lab and then the full module was characterized.
- The R/O is with APV – 25 based Scalable Readout System (SRS).



Pre production quality control

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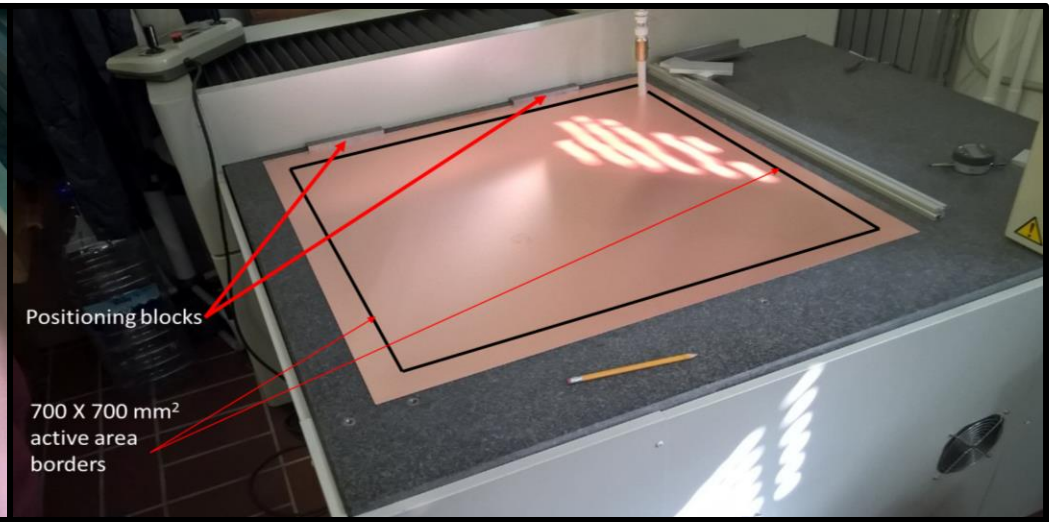
50 foils of 1245 mm x 1092 mm

→ cut out borders

→ 800 mm x 800 mm

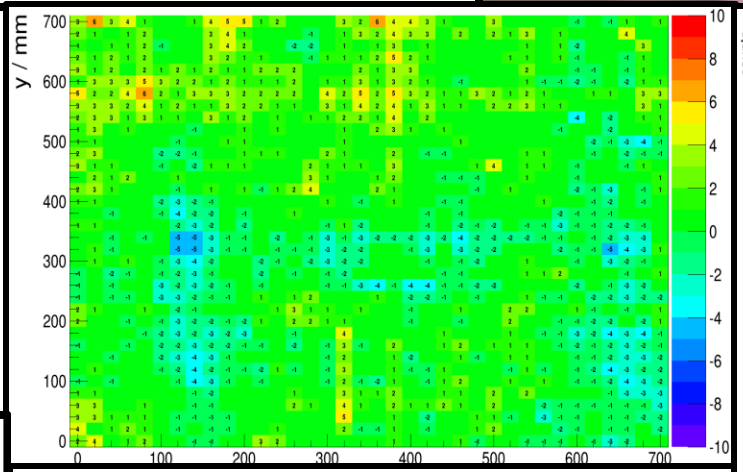
→ thickness measurement



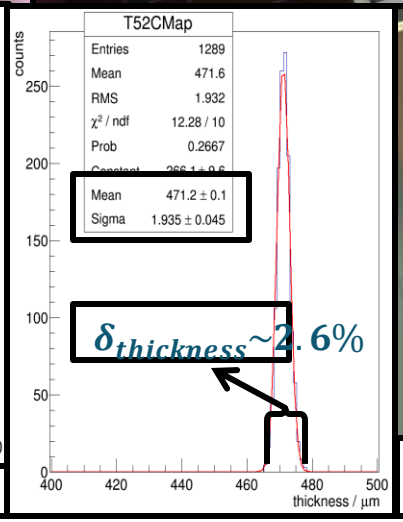
for each foil 36 x 36 points in square pattern are measured
2 measurements (direct and reversed) to allow consistency checks.

- all foils have been labelled and measured → database of local thickness of all THGEMS
- The best region for the Quadrotto have been selected for available Pieces.

$$\delta_{thickness} = \frac{thickness_{max} - thickness_{min}}{thickness_{min}}$$



typical result for a good piece.



under pressure to induced flatness

THGEM post production treatment

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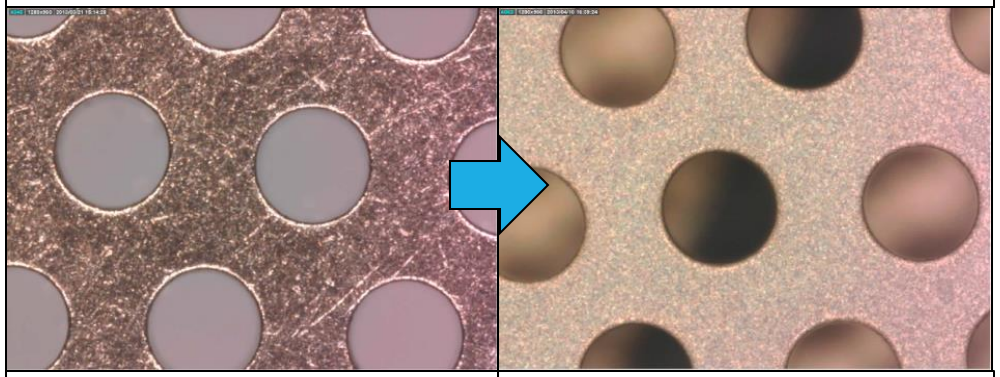
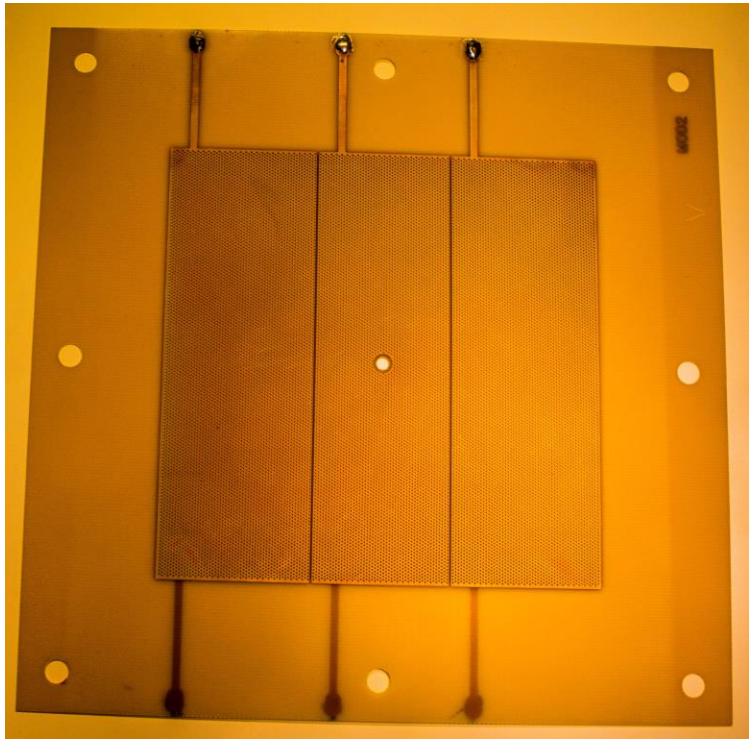
- To drill 15K holes, it takes ~ 3 hrs
- The cost is 1 Euro for 1000 holes…
- We (at ELTOS spa, Italy) produced ~ 8 Pcs.
- Polishing with pumice powder + cleaning in high pressure water and ultrasonic bath with high pH (~11) liquid + drying in oven at 160 ^{0}C also to fully polymerize the glue for 24h



Before treatment	After treatment



THGEM Characterization

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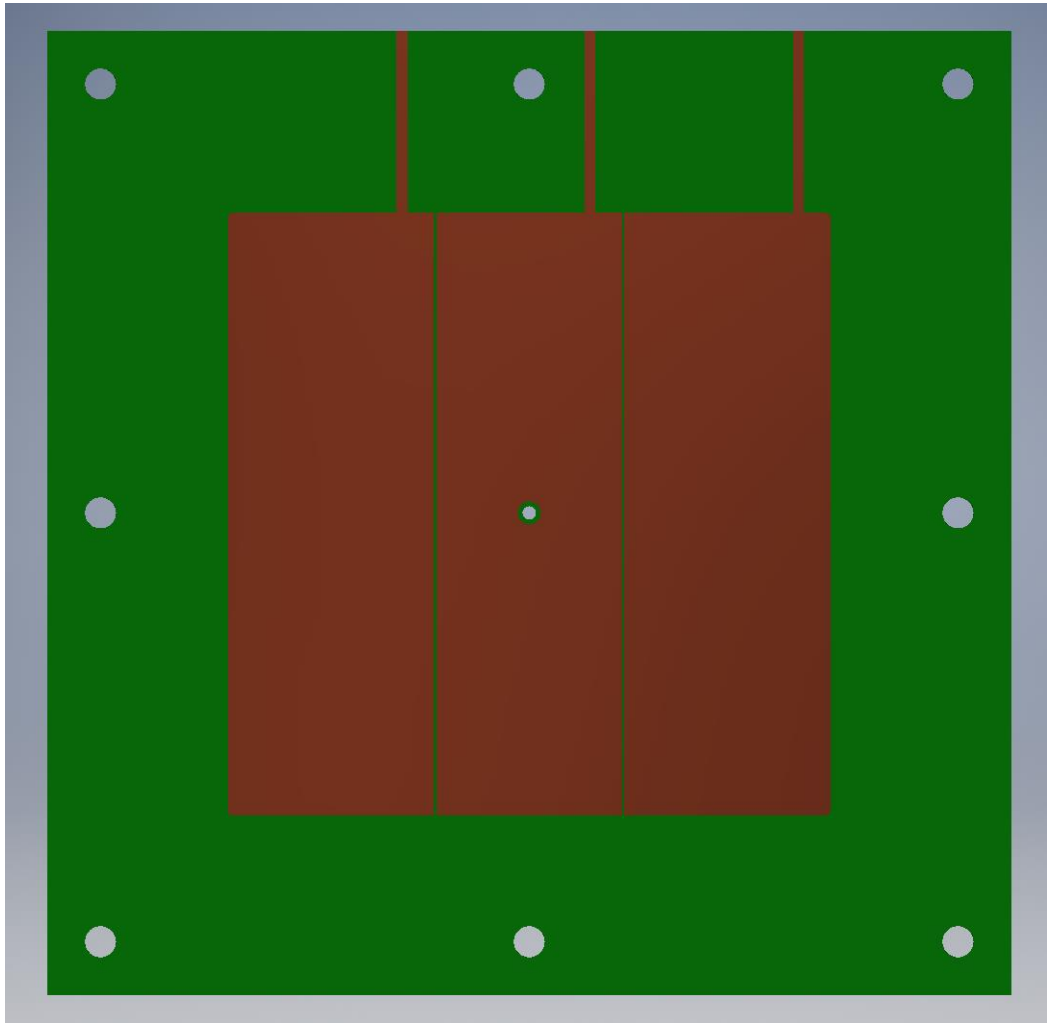

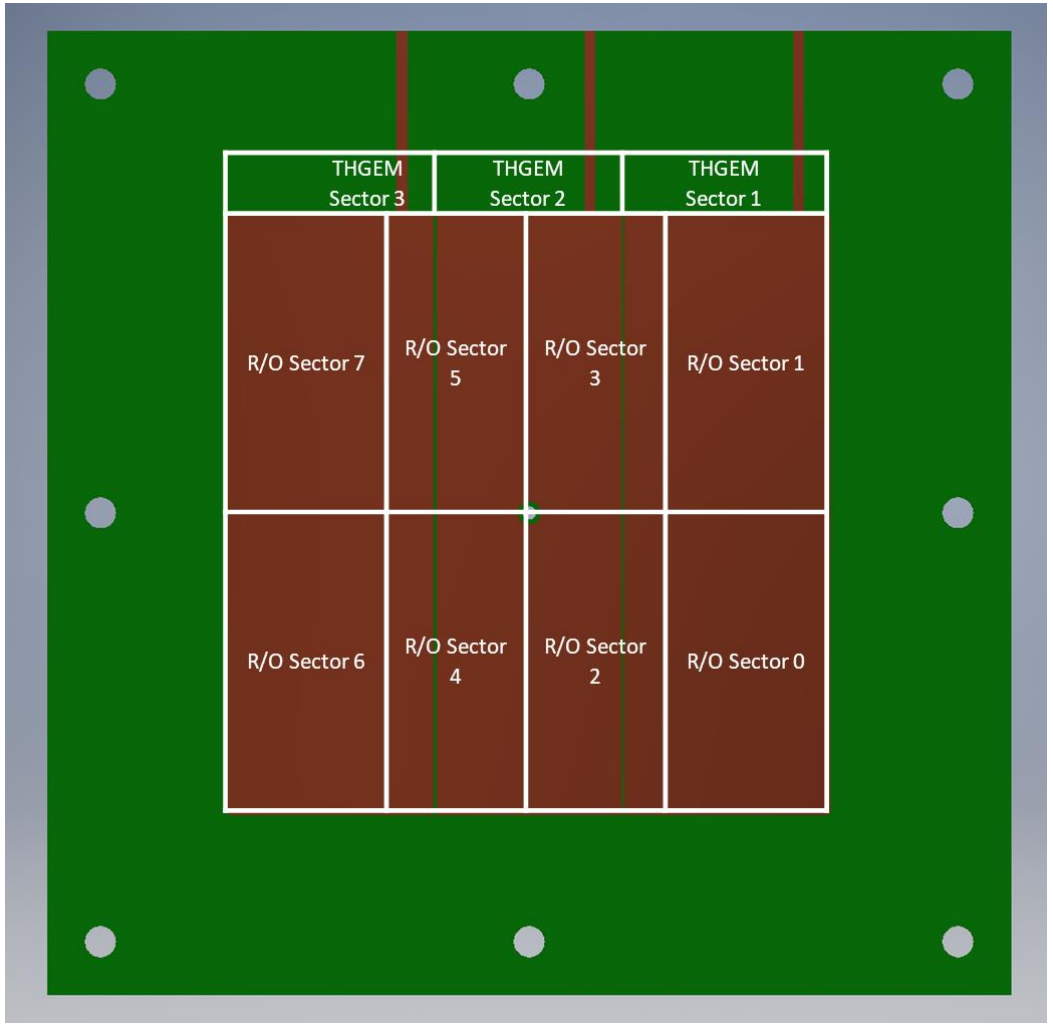

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THGEM Characterization

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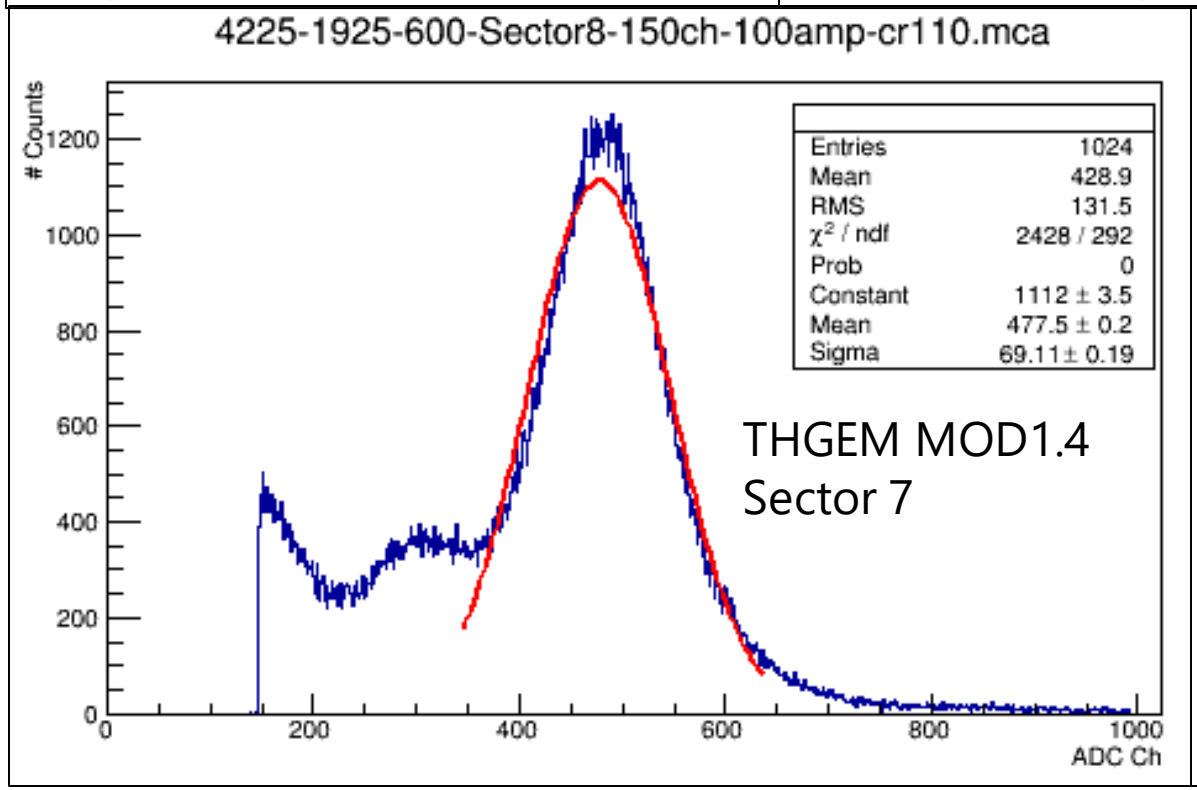
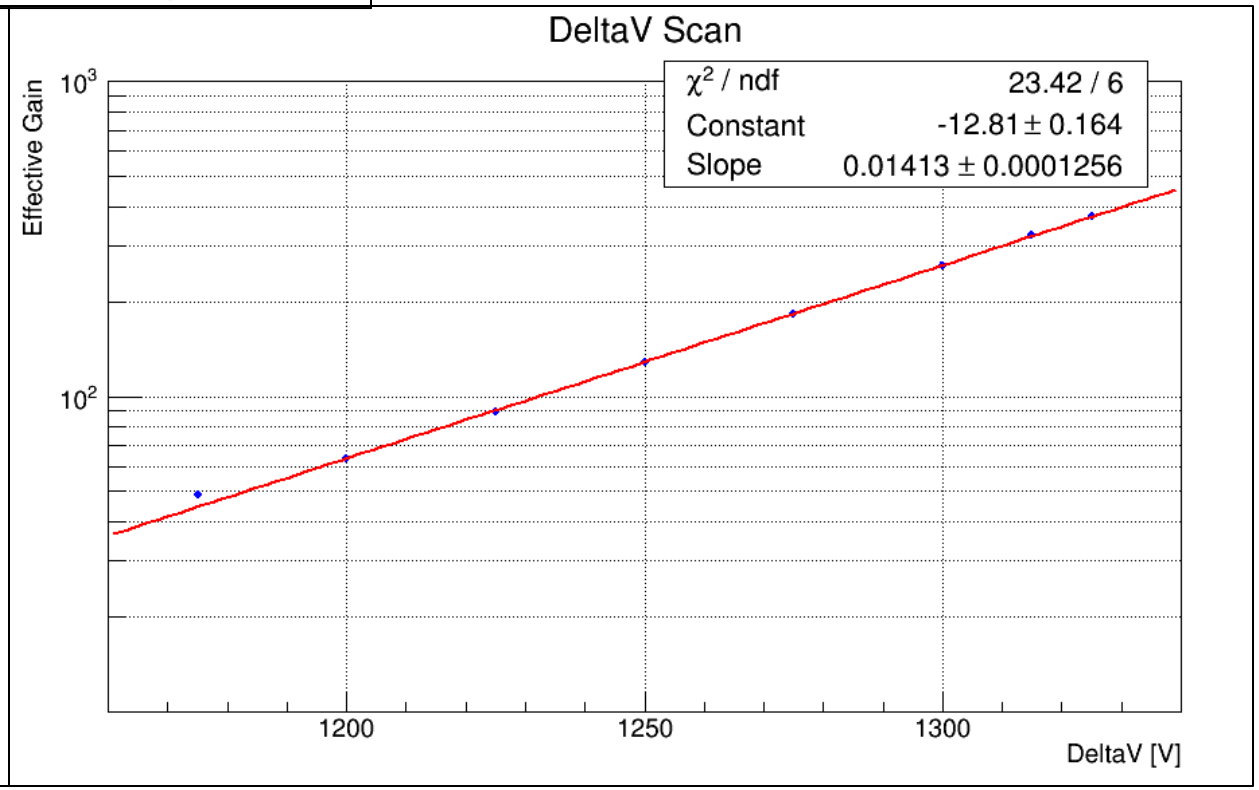
- All THGEMs are characterized using the AMPTEK MINIX X – Ray source
- For characterization 128 PADs (Anode without Micromegas) are used all together.

- CREMAT CSP with AMPTEK MCA 8000A is used as Readout.
- Gas used Ar:CO_2 70:30
- DeltaV scans are performed in few R/O sectors followed by a uniformity scan





THGEM Characterization

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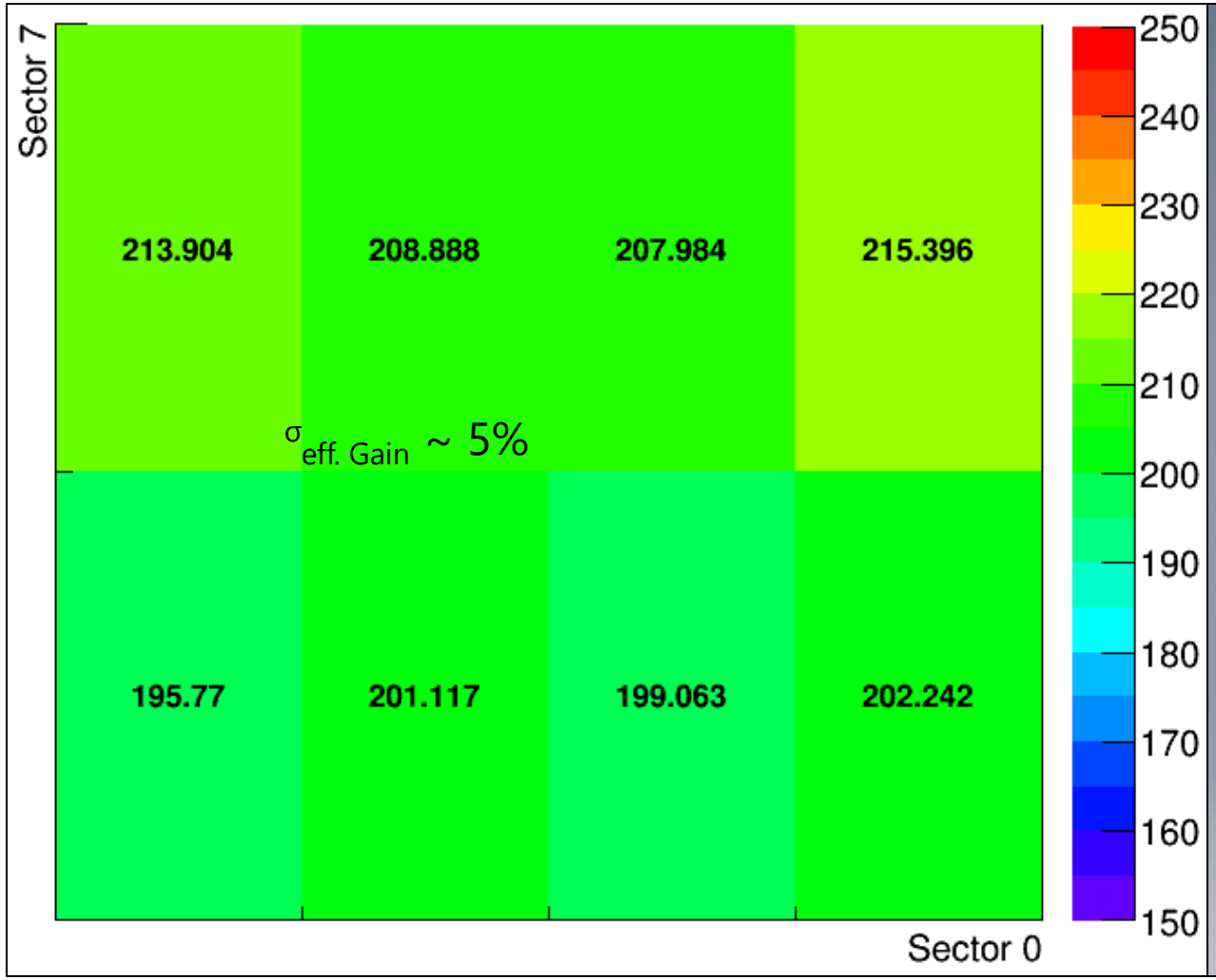
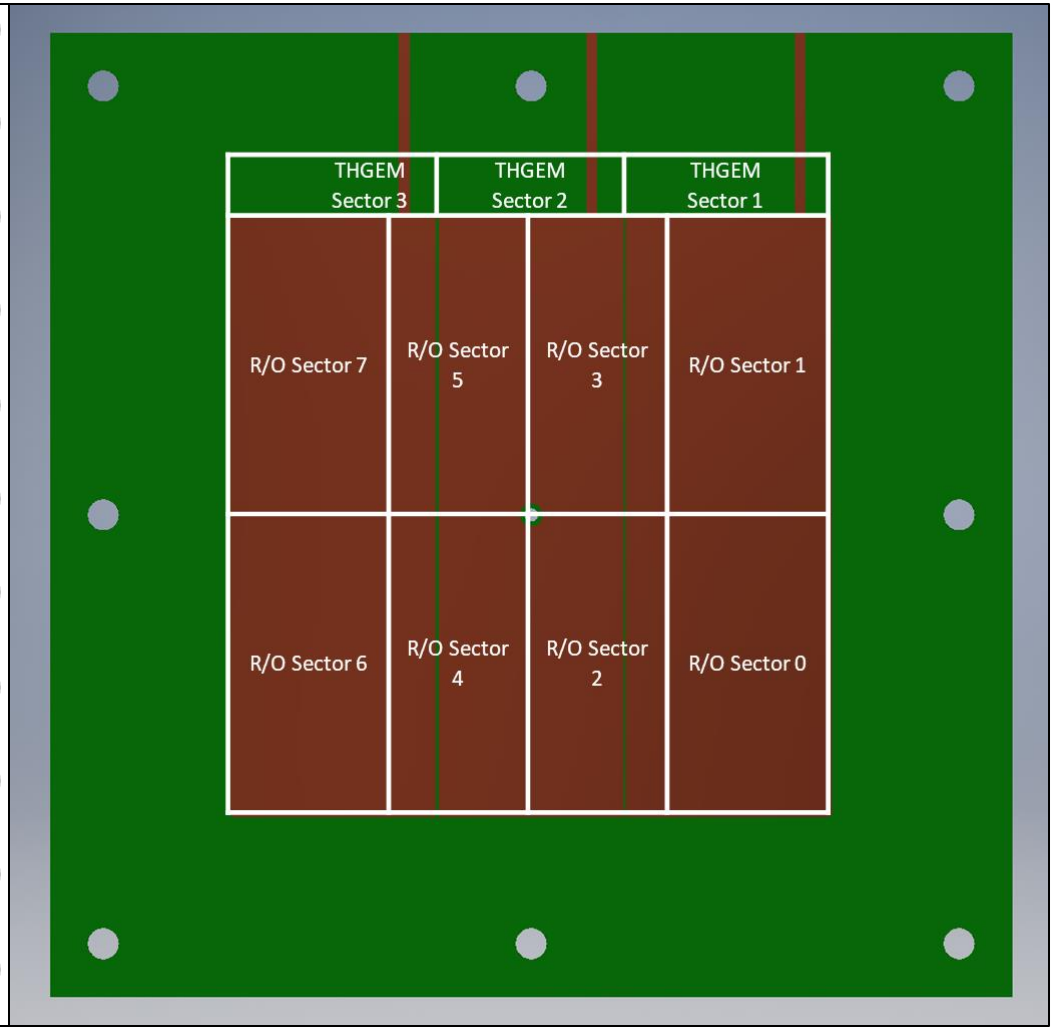
THGEM MOD1.4





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THGEM Characterization

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Final Result

THGEM No.	Gmax	Gmin	Delta	σ	Vmax	V_g/10	Vc	Start date	End Date
1.1	73.61	61.34	0.20	0.09	1290	151	946	5/31/2018	6/1/2018
1.2	329.82	295.41	0.12	0.06	1325	163	906	6/6/2018	6/6/2018
1.3	173.65	150.91	0.15	0.07	1260	161	897	6/4/2018	6/4/2018
1.4	215.40	195.77	0.10	0.05	1315	168	893	6/5/2018	6/6/2018
2.1	185.74	159.51	0.16	0.08	1290	166	906	6/7/2018	6/7/2018
2.2	295.26	237.07	0.25	0.11	1290	142	923	5/23/2018	5/31/2018
2.3	233.13	188.47	0.24	0.11	1275	164	902	6/7/2018	6/7/2018
2.4	191.80	171.91	0.12	0.05	1285	166	903	6/4/2018	6/4/2018

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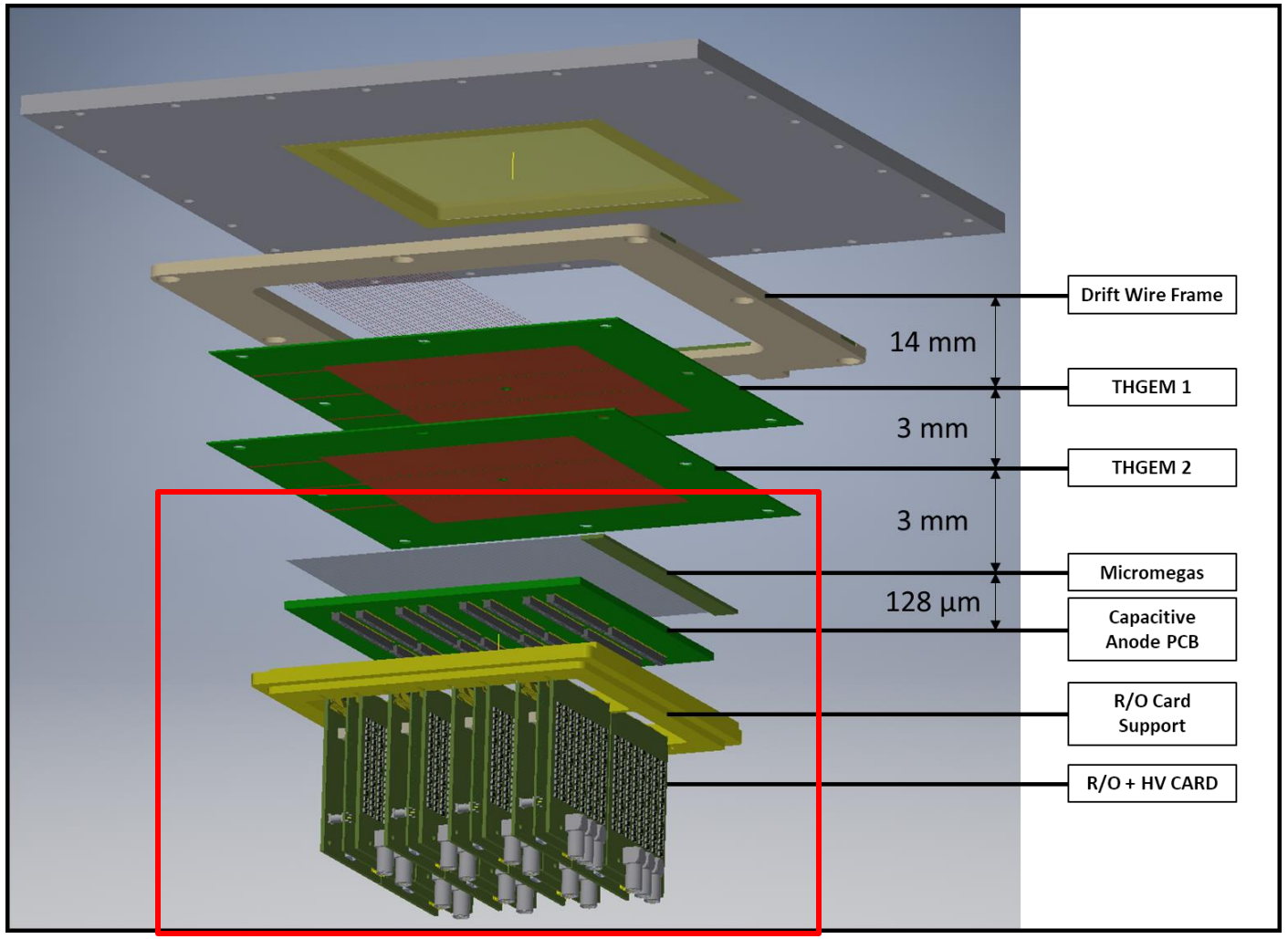

The Bulk Micromegas with MiniPADs

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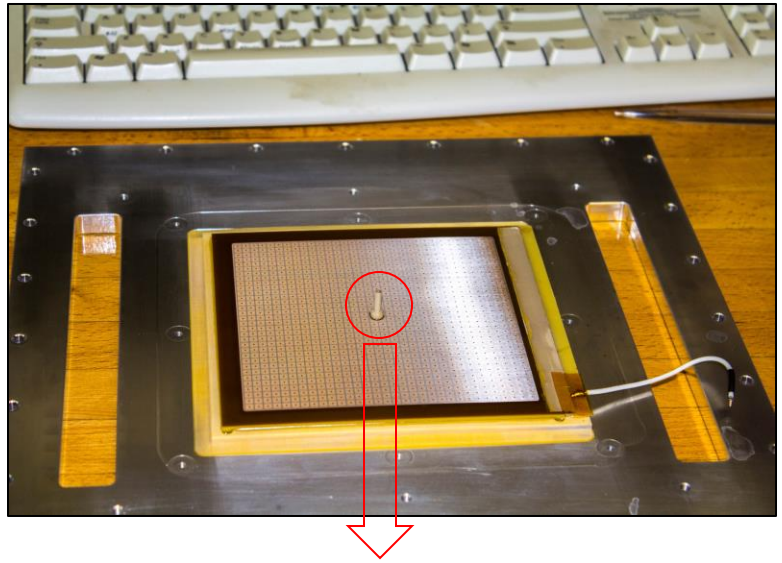
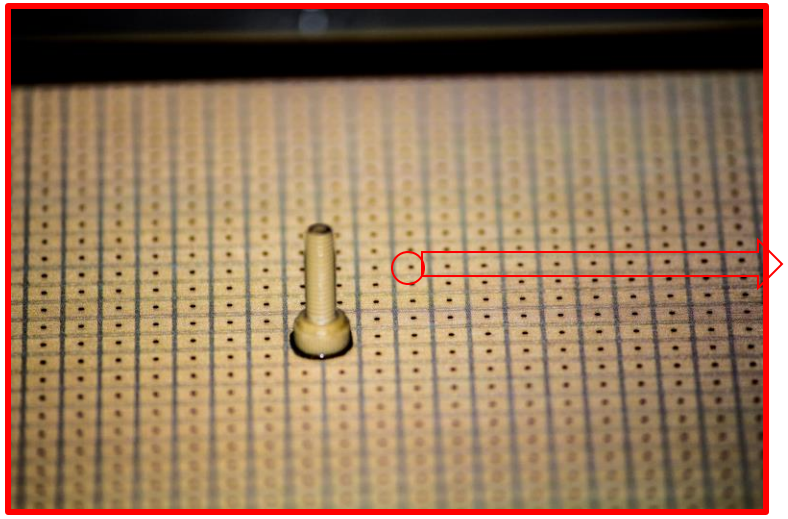
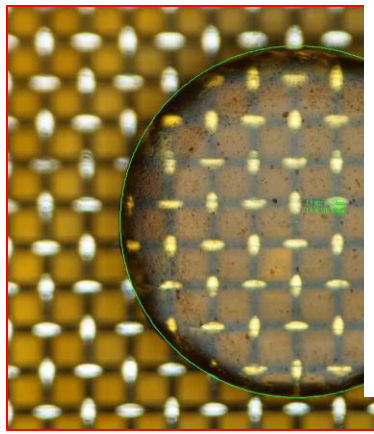
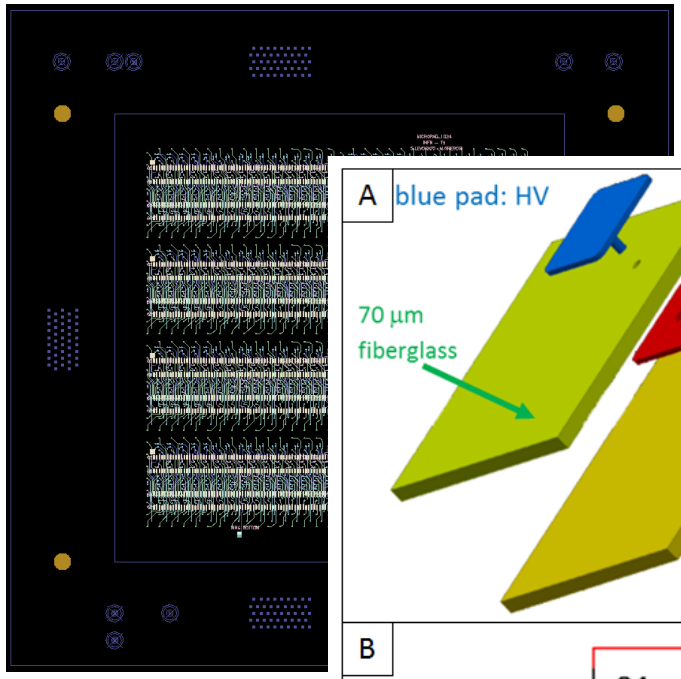
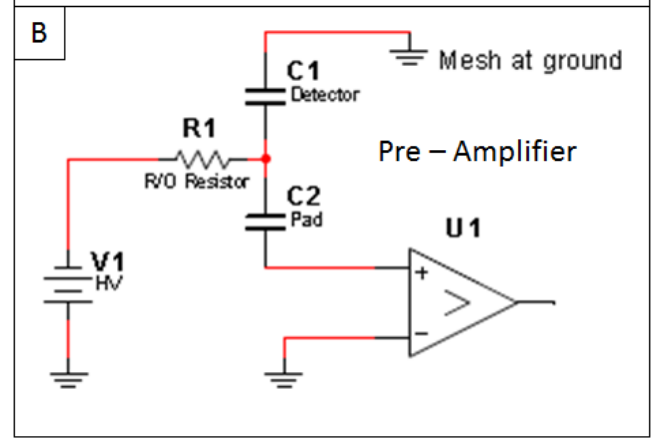
- 2 PCBs are equipped with a bulk Micromegas at CERN and fully characterized at our lab.
- Both for HV and R/O PADs, Each 8 X 16 PADs are connected to the SAMTEK1143 (130 pin) SMD connectors.
- The HV is delivered through a card with 128 SMD 470 MΩ resistors for each 128 pins.
- Both Analogue CREMAT CSP chain with MCA and APV – 25 based SRS systems have been used as Front – End R/O.
- ^{55}Fe or MINIX X – Ray source have been used for characterization.
- Gas Used Ar:CO_2 70:30.











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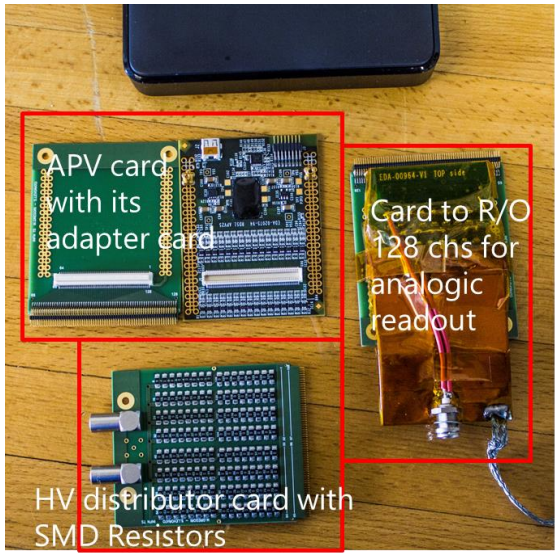

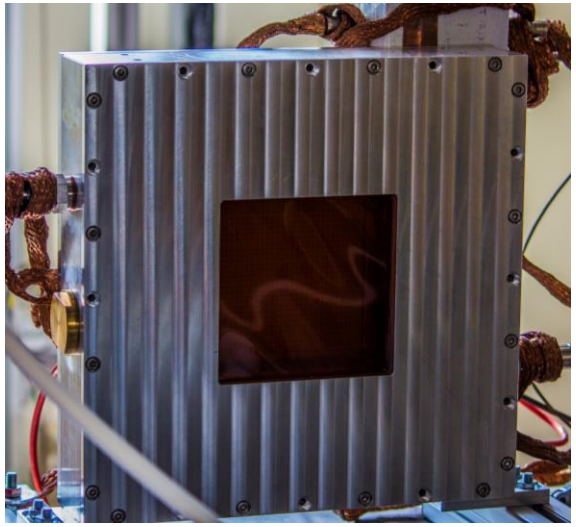

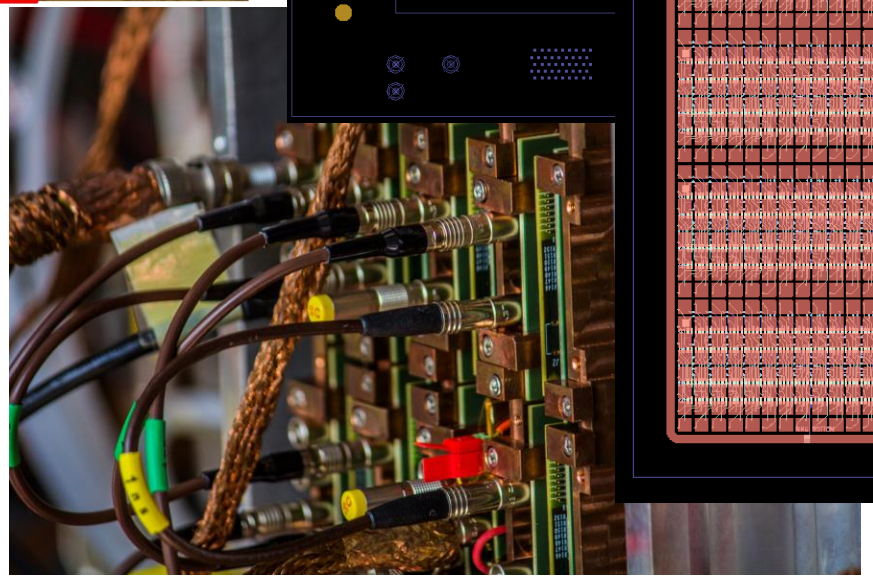

Characterization of the MM

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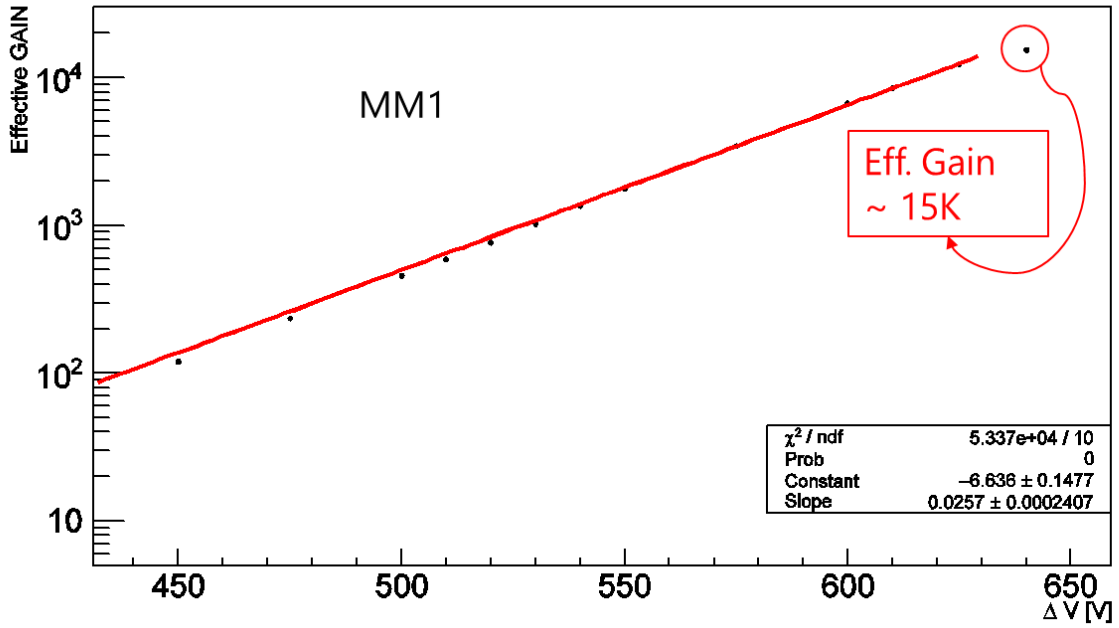

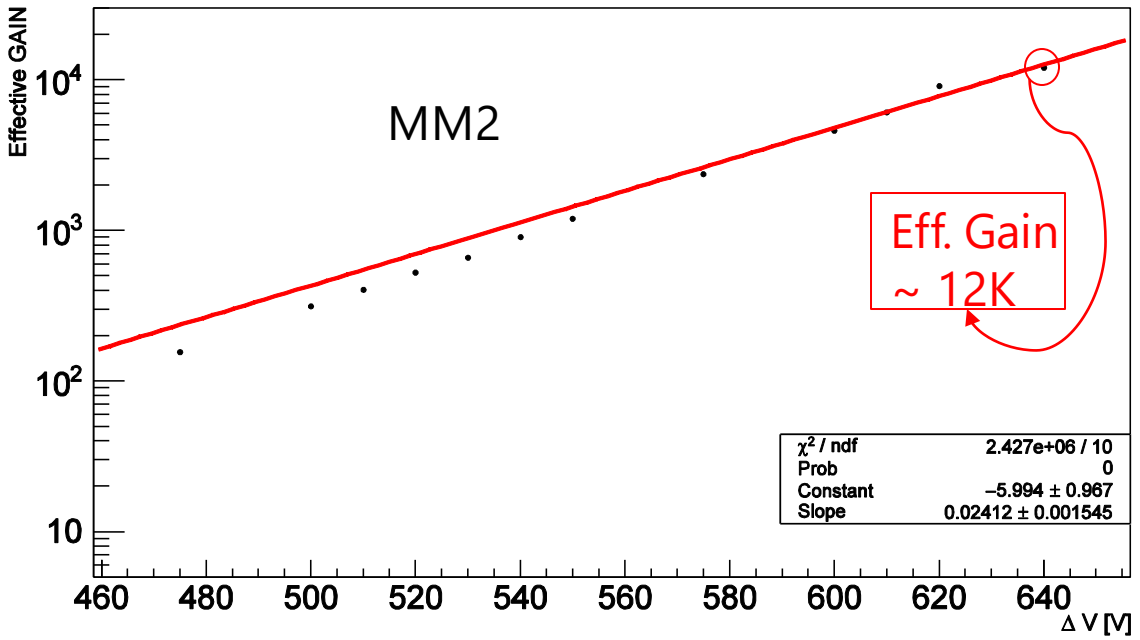

- ^{55}Fe X – Ray source
- CREMAT CSP based Analogue Read – Out With Spectroscopy Amplifier and AMPTEK ADMCA 8000A.
- Gas Used: Ar:CO_2 70:30

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The Bulk Micromegas with MiniPADs

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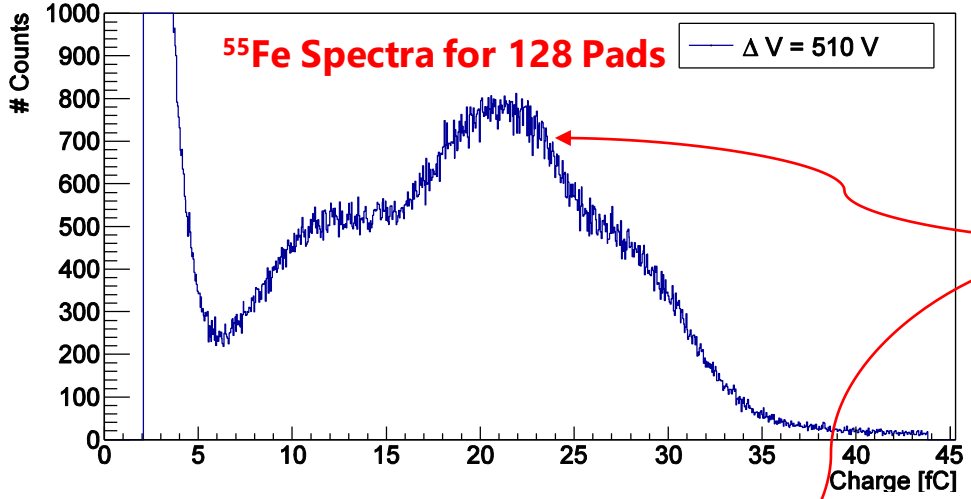
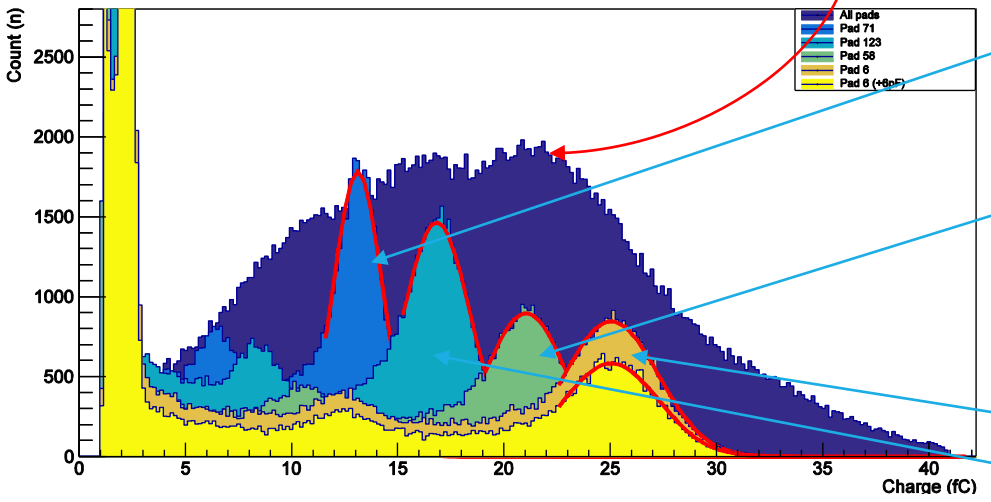
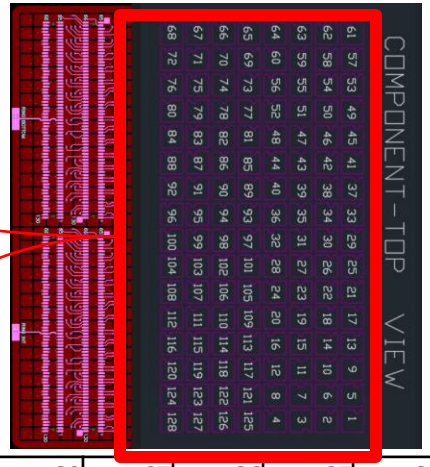
- The first analogue spectra from 128 PADs together were with distorted shape.
- A test of single pad spectrum shows that there is ×2 difference in amplitude between PADs.
- A measurement of the capacitance from these PADs to Micromegas has been measured.
- Corrected off line for the relative capacitance one can correct the differences in Amplitudes.







68	67	66	65	64	63	62	61
72	71	70	69	60	59	58	57
76	75	74	73	56	55	54	53
80	79	78	77	52	51	50	49
84	83	82	81	48	47	46	45
88	87	86	85	44	43	42	41
92	91	90	89	40	39	38	37
96	95	94	93	36	35	34	33
100	99	98	97	32	31	30	29
104	103	102	101	28	27	26	25
108	107	106	105	24	23	22	21
112	111	110	109	20	19	18	17
116	115	114	113	16	15	14	13
120	119	118	117	12	11	10	9
124	123	122	121	8	7	6	5
128	127	126	125	4	3	2	1

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The Bulk Micromegas with MiniPADs

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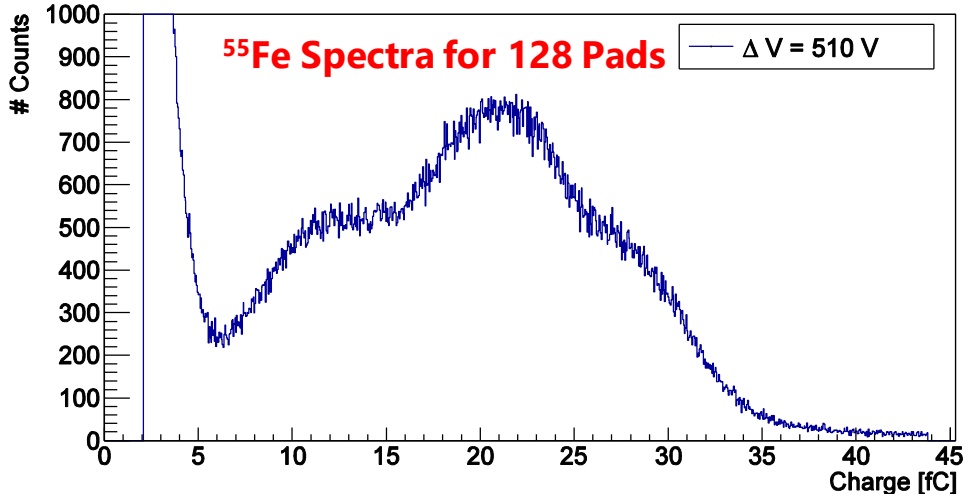
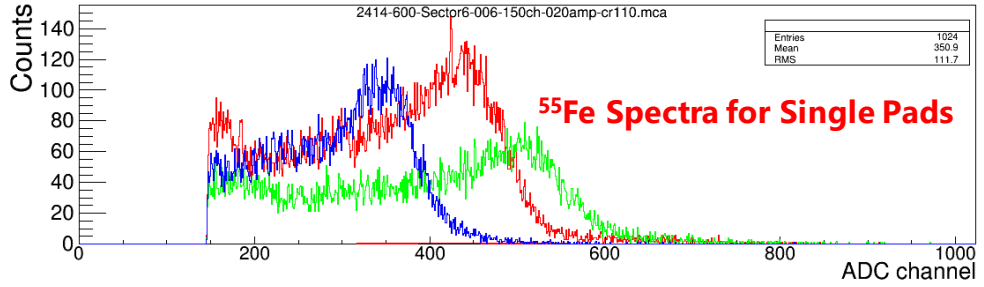
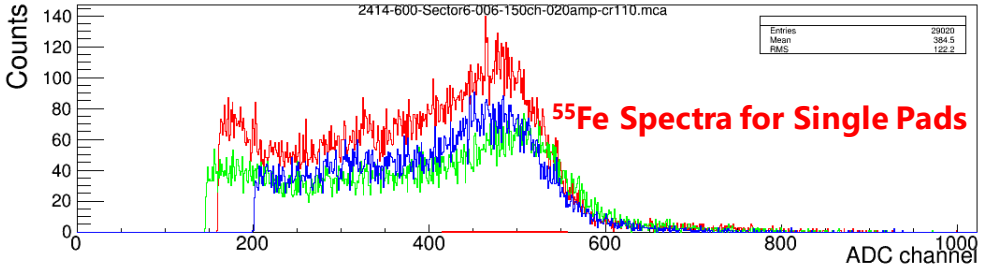
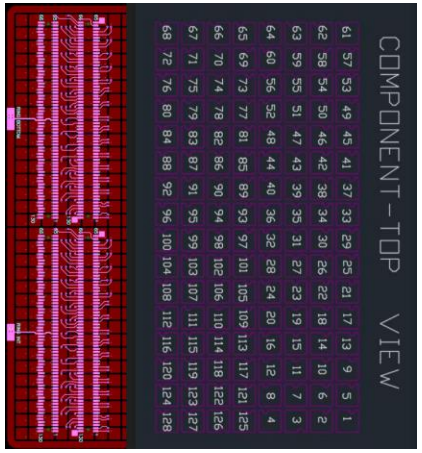
- The first analogue spectra from 128 PADs together were with distorted shape.
- A test of single pad spectrum shows that there is up to "×2" difference in amplitude between PADs.
- A relative measurement of the amplitude was performed by injecting a test pulse through PADs and reading it with standard analogue readout chain.
- Corrected off line for the relative capacitance one can see the amplitudes are in the same place.









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112	111	110	109	20	19	18	17
116	115	114	113	16	15	14	13
120	119	118	117	12	11	10	9
124	123	122	121	8	7	6	5
128	127	126	125	4	3	2	1

Raven DAQ and decoder

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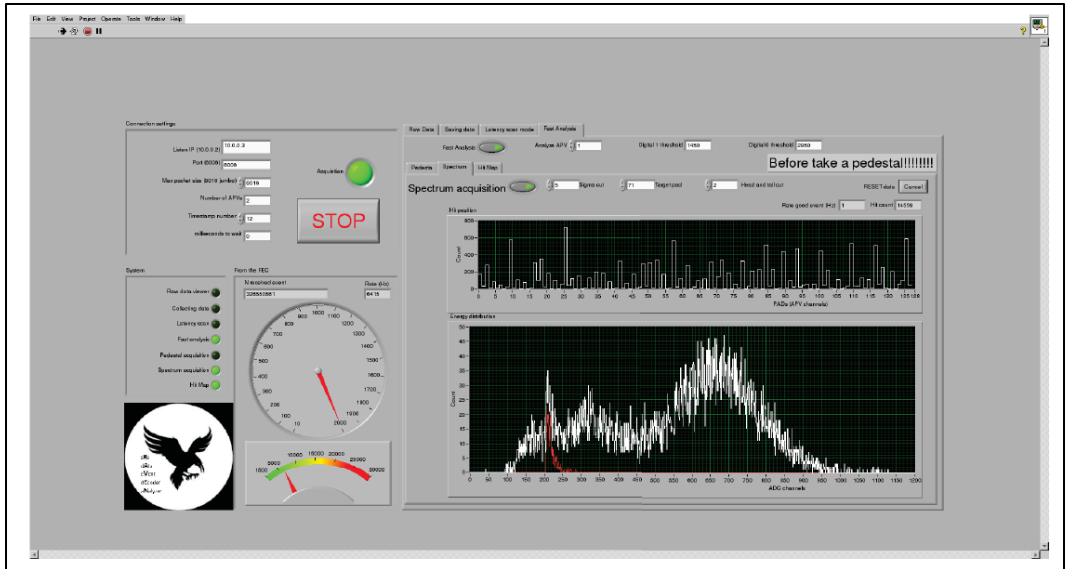
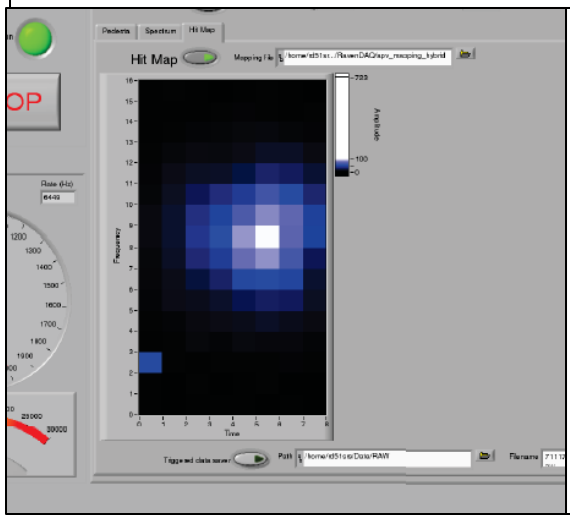
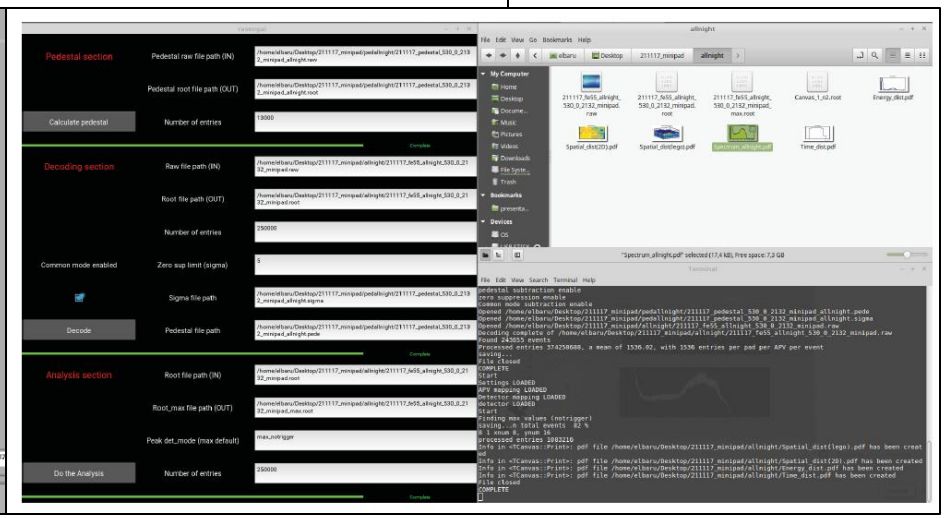
- For easy use of Scalable Readout System (SRS) we developed a LabVIEW based DAQ and the C++ based data decoder + Analysis software including the GUIs for easy access.
- Can handle more than 1k channels, can be extended to several k channels if needed.
- The DAQ can not only take data until ~ 10 kHz (1 APV) but can also do online analysis to show online pedestal subtracted hit maps and Spectra of all the channels







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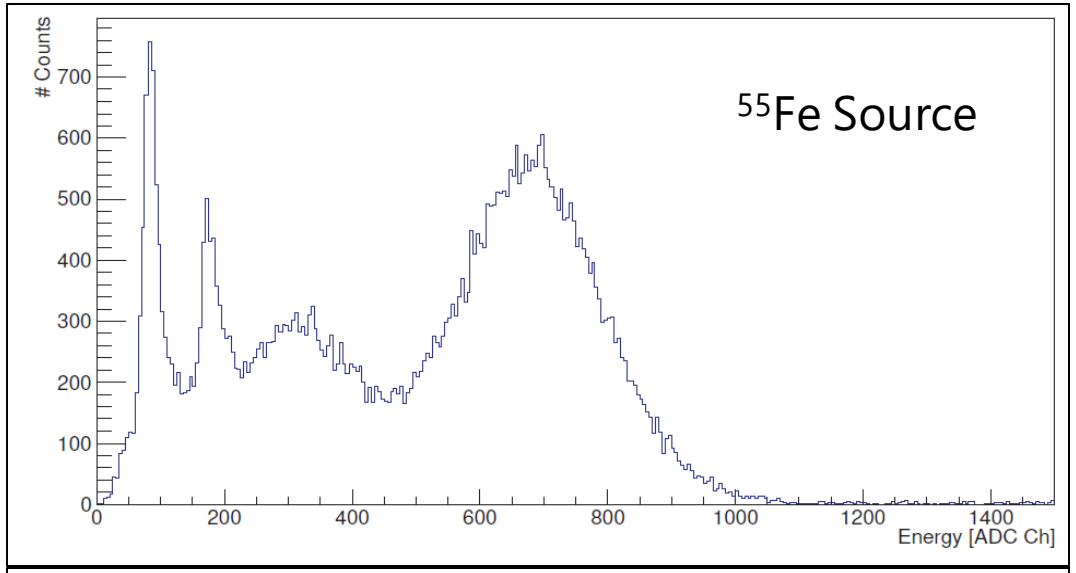

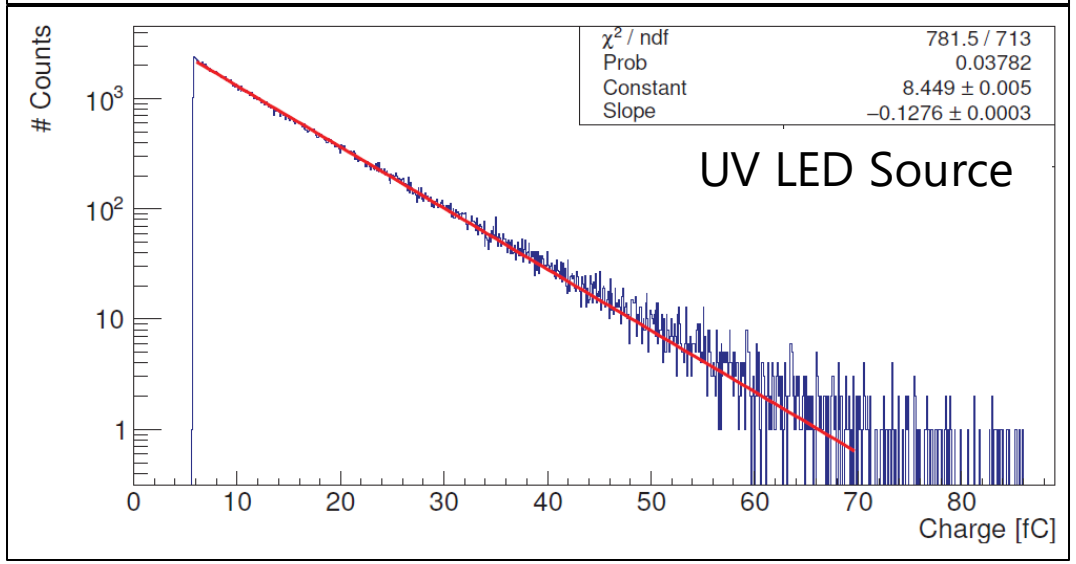

The Hybrid PD with MiniPADs

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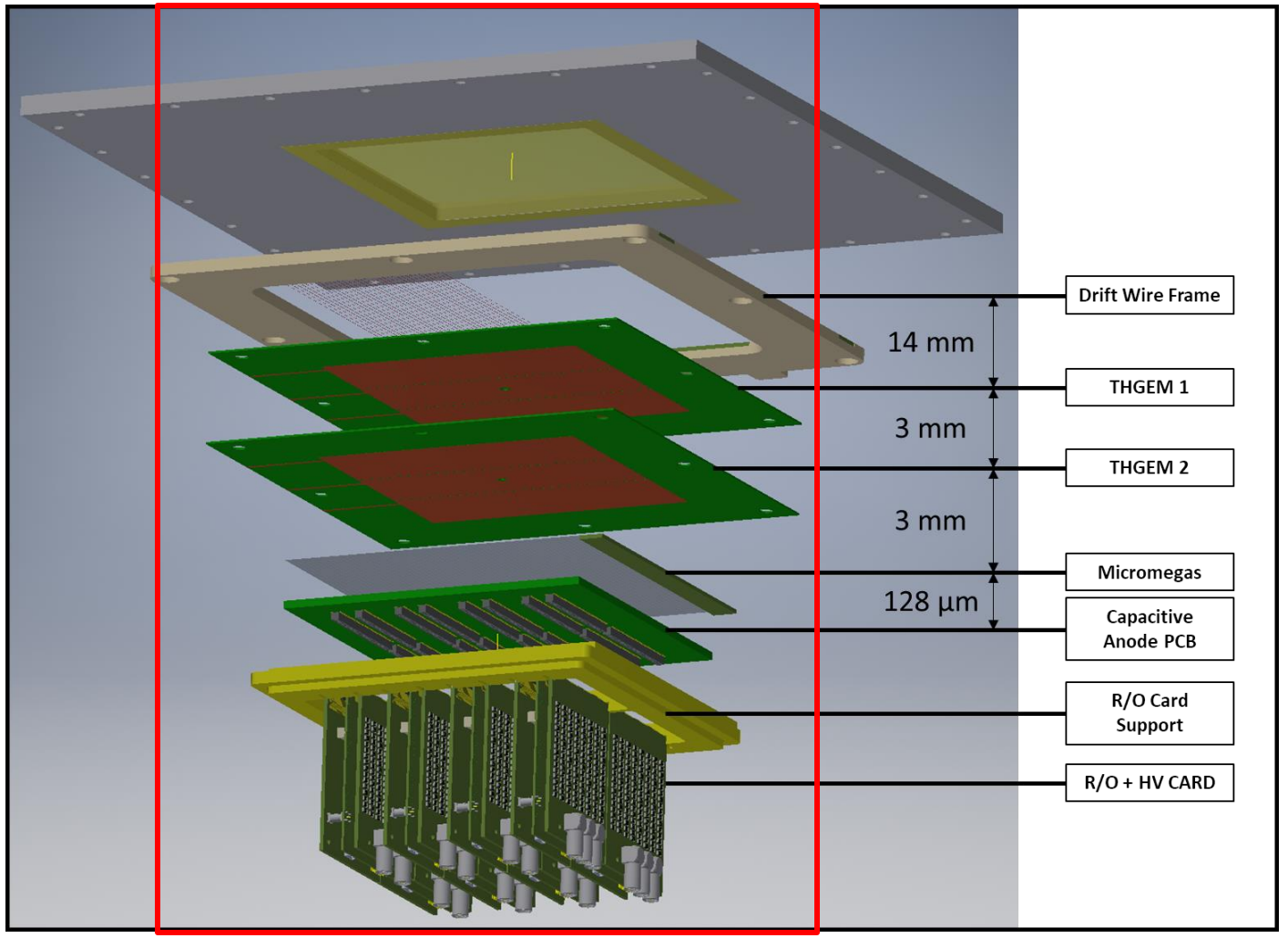
- The requirement for EIC is to have large area Detector of single photons with small pads (3 × 3 mm^2) over several m^2.
- Mosaic architecture with all the components and services installed within the active area has been developed.
- 100 × 100 mm^2 active area hybrid modules with 32 × 32 3 × 3 mm^2 Pads are built for lab tests.
- Each components of the hybrid modules are characterized separately in the lab and then the full module was characterized.
- The R/O is with APV – 25 based Scalable Readout System (SRS).



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The Hybrid with two THGEM

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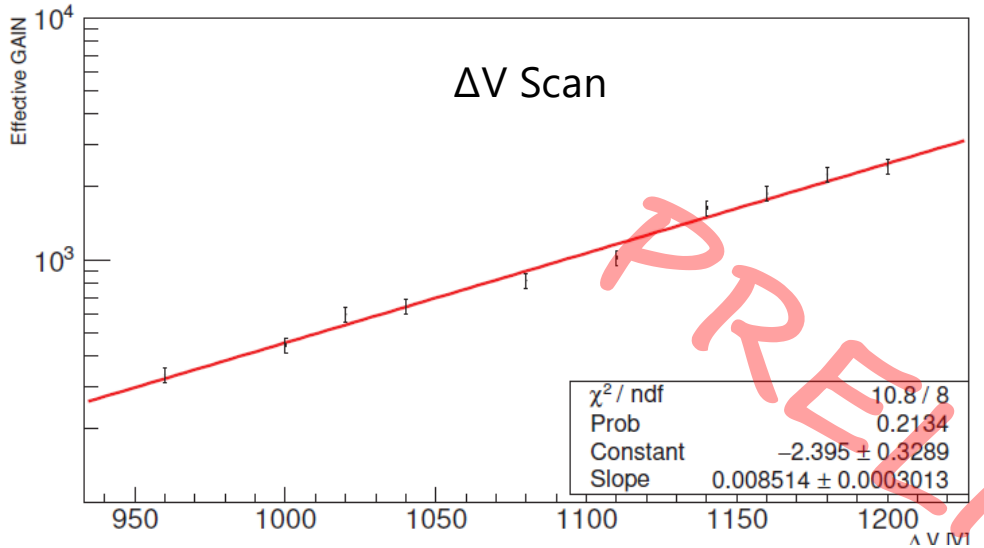
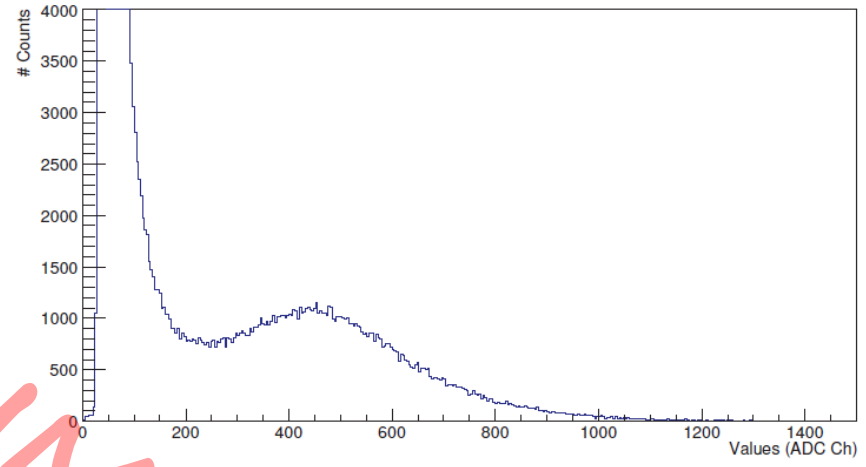
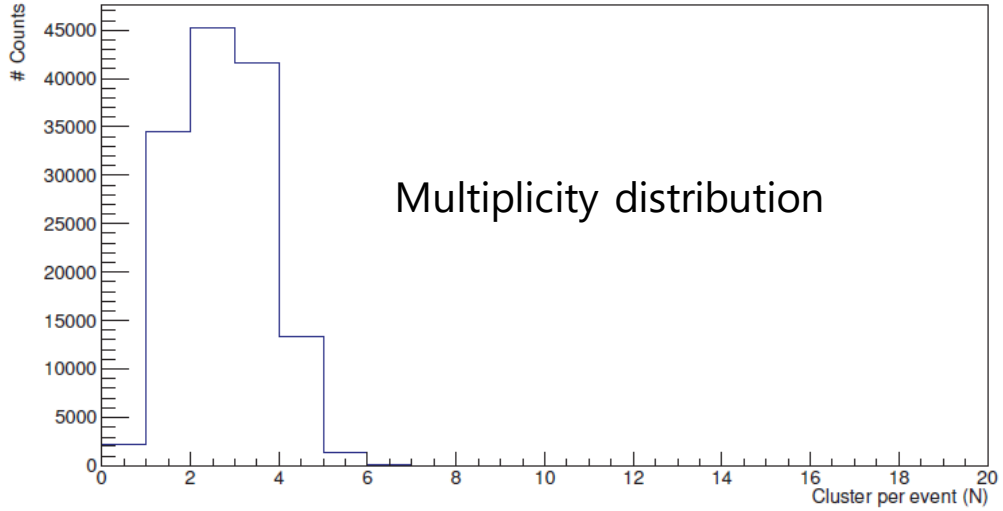
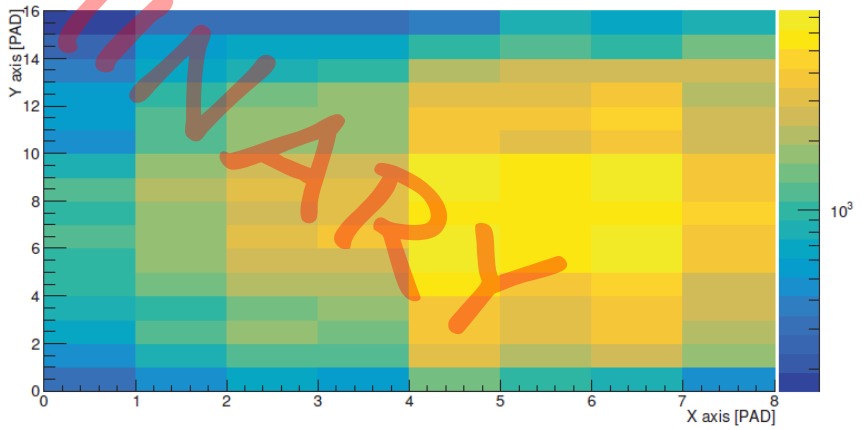
- The ΔV scan was performed with Two THGEMs coupled to one of the Micromegas.
- The first THGEM was kept at 1240 V of ΔV and the Mesh at 640V and the scan was performed by varying the ΔV of the second THGEM.
- The gain was kept between 23 – 12k for the APV dynamic range.
- The Cluster size and the spectra shown is for the gain ~ 12k



Spectra for all chs of 1 APV after clusturing







Hit map for 1 APV after clusturing

Test Beam in October 2018

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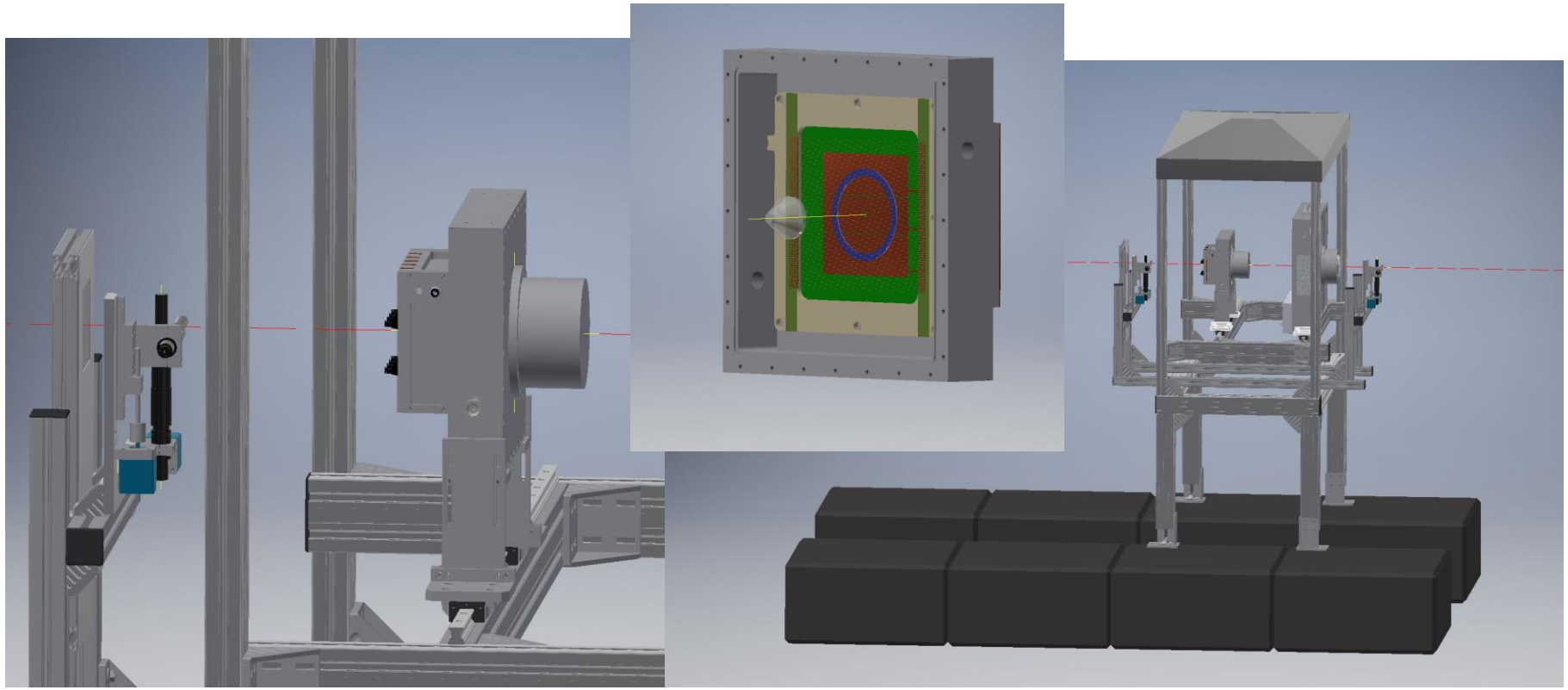
- We are preparing for a test beam to test the first 100 × 100 mm^2 module in μ/π beam in T4 beam line at CERN SPS.
- A quartz radiator will be used to generate the Cerenkov Photons.
- Trigger will be generated from the finger scintillators on the beam
- APV – 25 based SRS system with our Raven DAQ and decoder will be used for data taking and analysis.
- Results will be compared between the old 300 × 300 mm^2 prototype and the new module



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Conclusion

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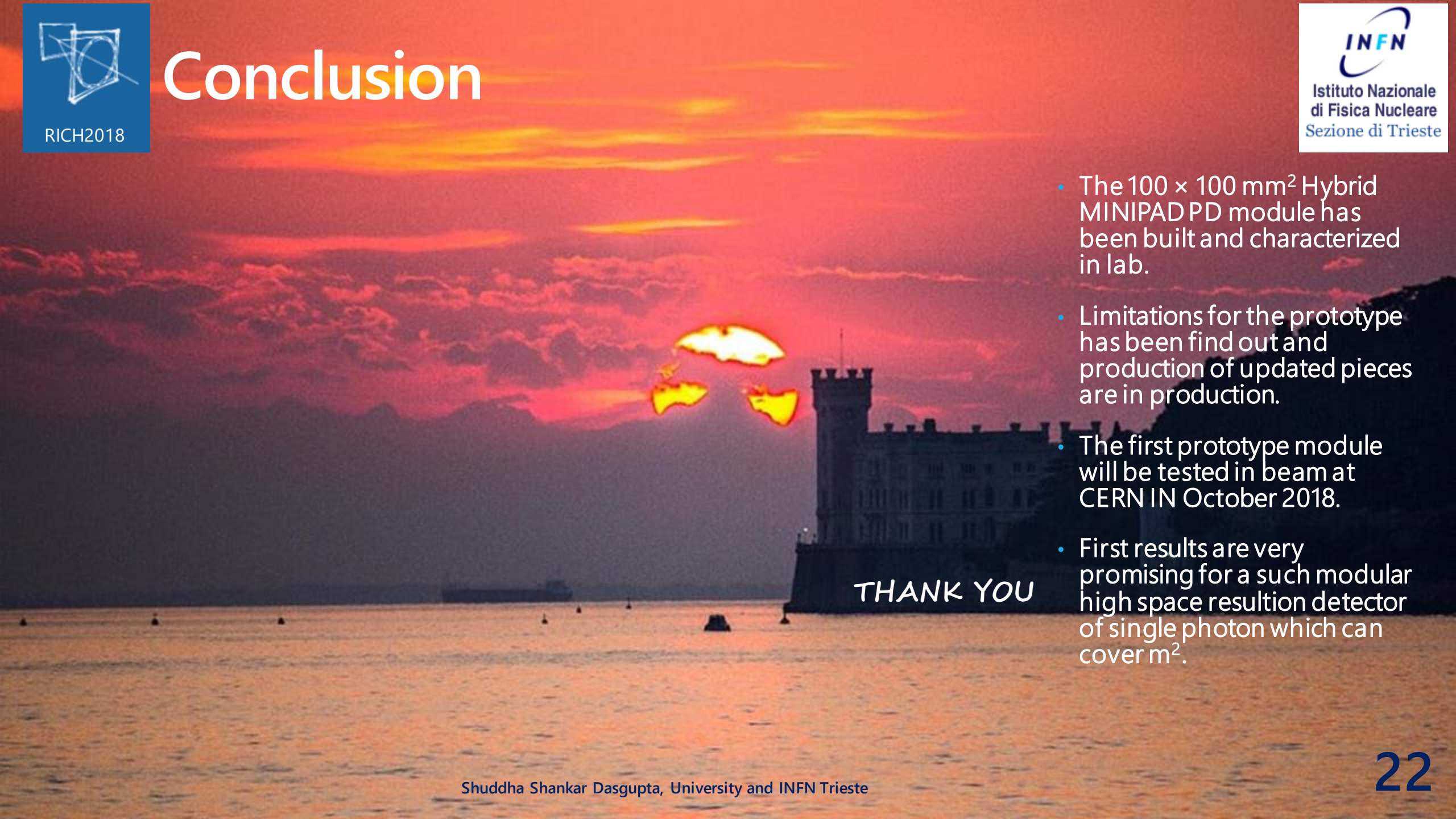
- The 100 × 100 mm^2 Hybrid MINIPAD PD module has been built and characterized in lab.
- Limitations for the prototype has been find out and production of updated pieces are in production.
- The first prototype module will be tested in beam at CERN IN October 2018.
- First results are very promising for a such modular high space resultion detector of single photon which can cover m^2.



Backup: Gain Sharing

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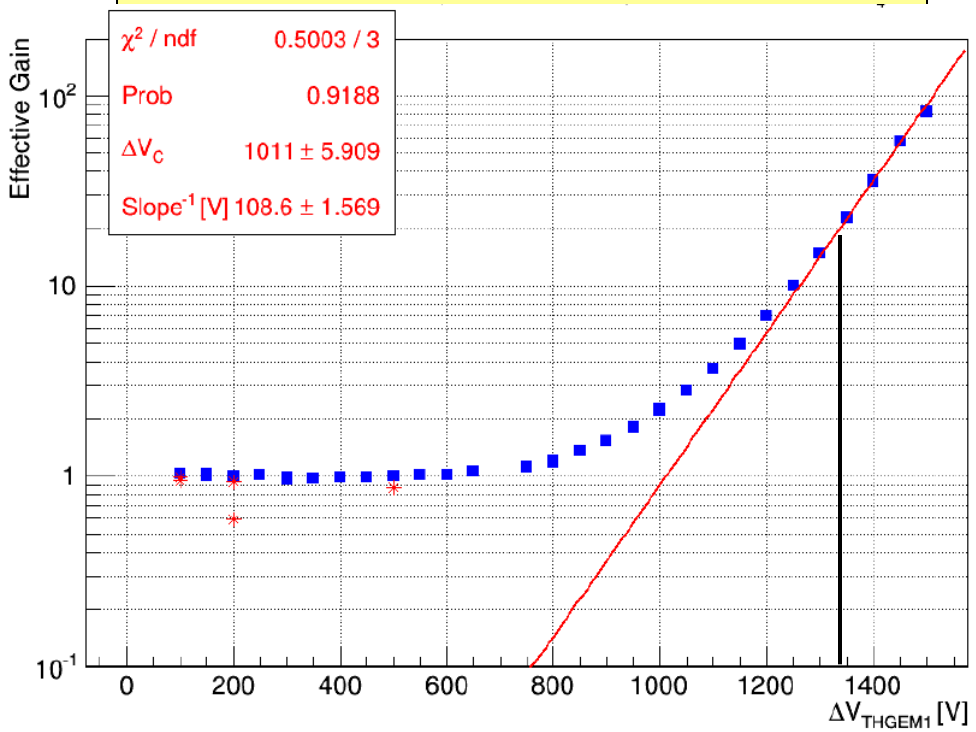
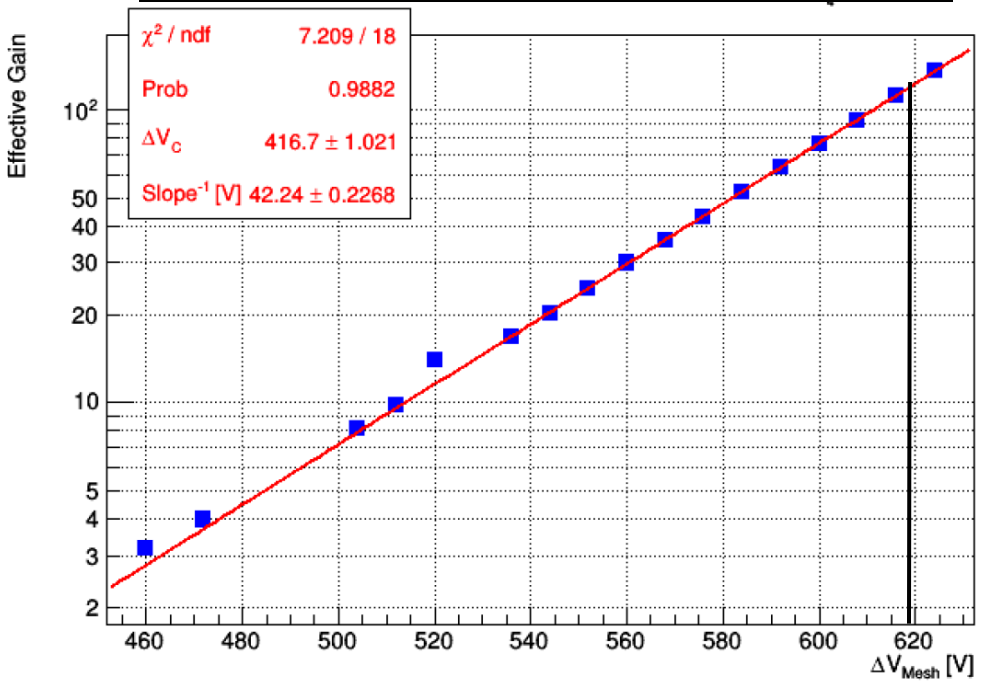
Effective gain*transfer of THGEM1 in Ar/CH4, with THGEM2 and MM at nominal voltages



Effective gain of Mcromegas in Ar/CH4, with THGEM1 and THGEM2 at nominal voltages



Nominal gain: ~30000 with:

THGEM1 gain* transfer1: ~ 20

THGEM2 gain*transfer2 ~ 15

Micromegas gain ~100

BACKUP: IBF

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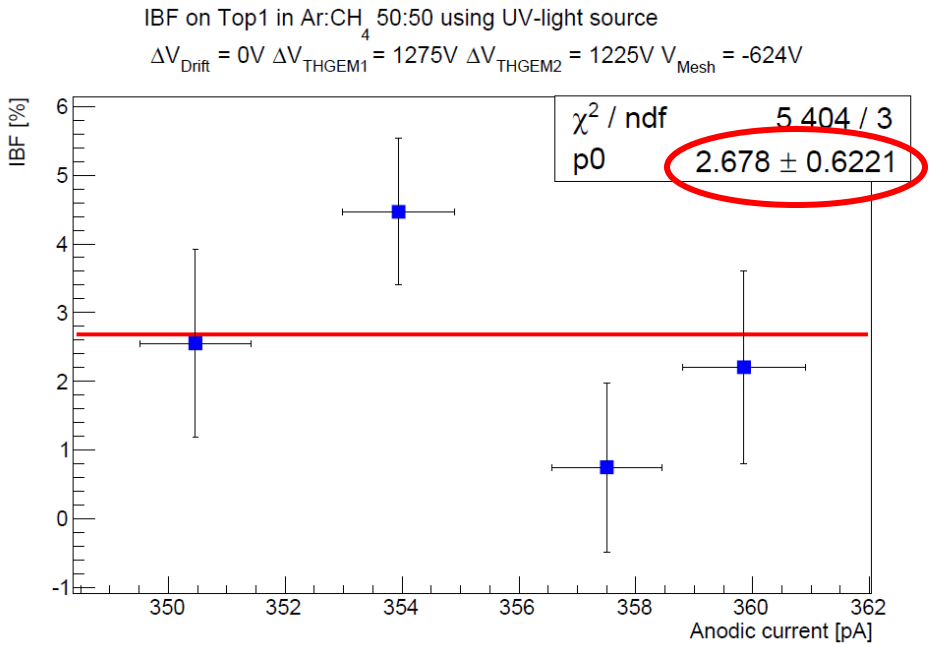

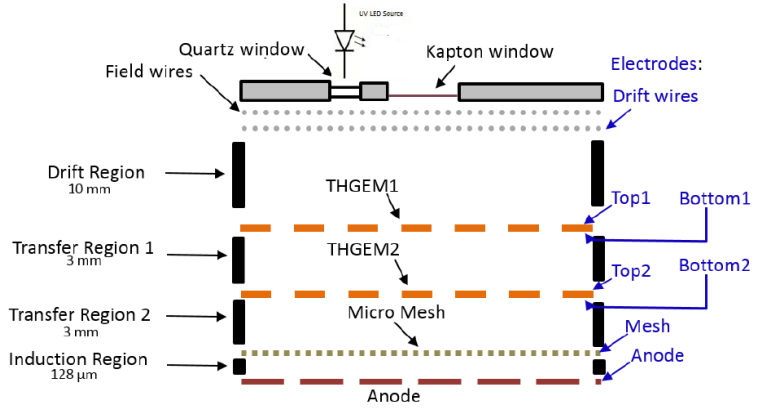

Trieste home-built picoammeters

The result of the direct measurement: 3% nicely matches the expectation

The Bulk Micromegas with MiniPADs

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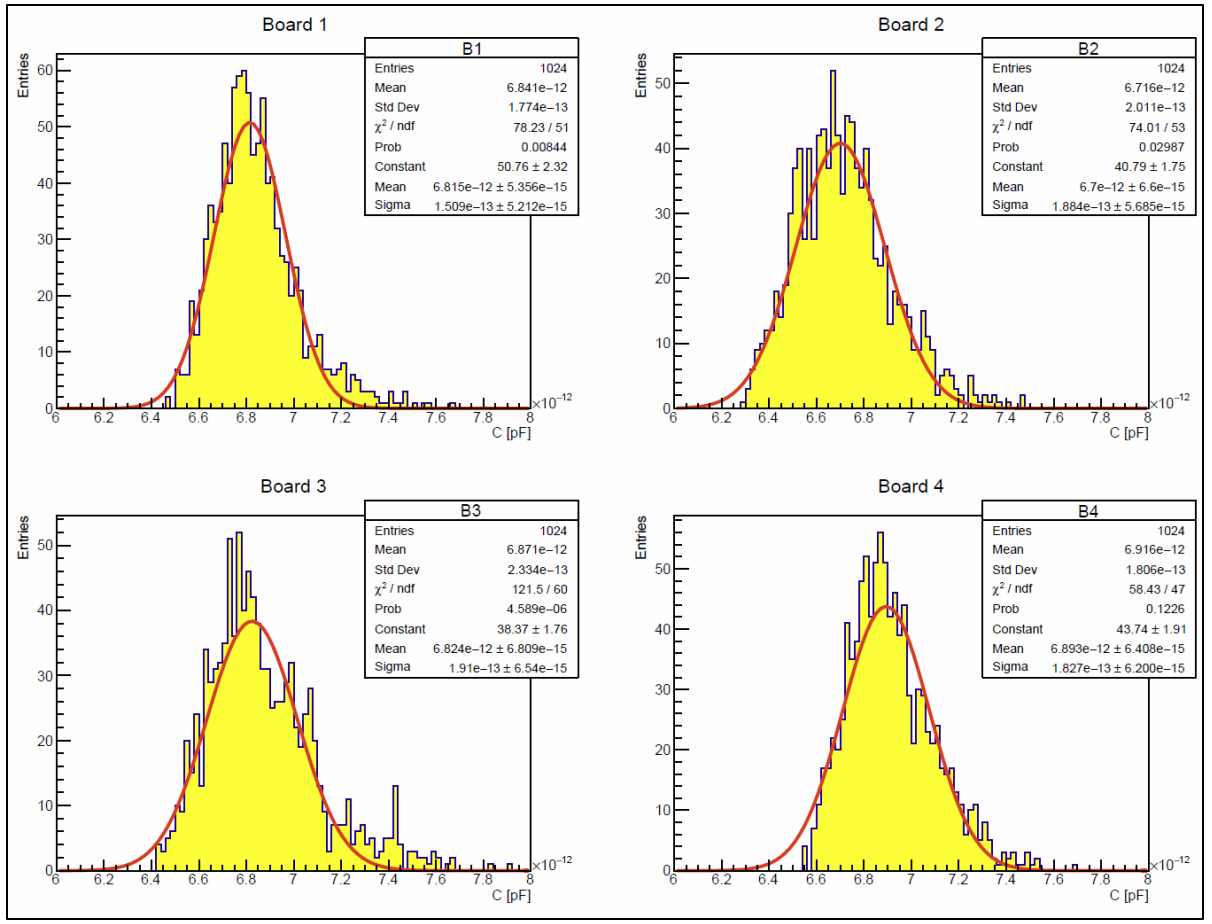
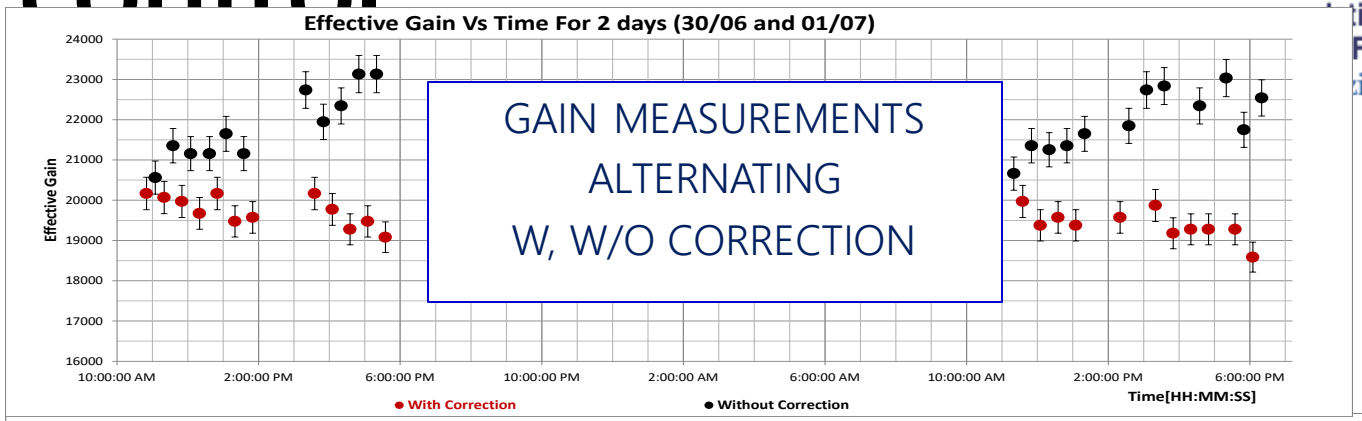
- 4 PCBs have been produced and two of them have been equipped with a bulk Micromegas.
- For each the capacitance between the Readout pads and HV PADs have been measured.
- A variation ~ 3 – 5 % have been noticed.

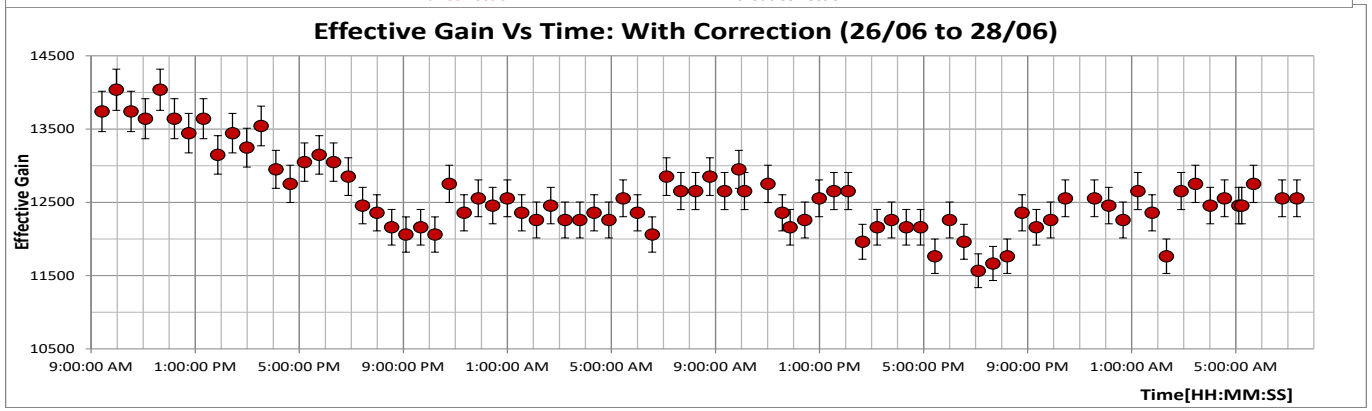


BACKUP: p, T control

p, T sensor at gas input and output

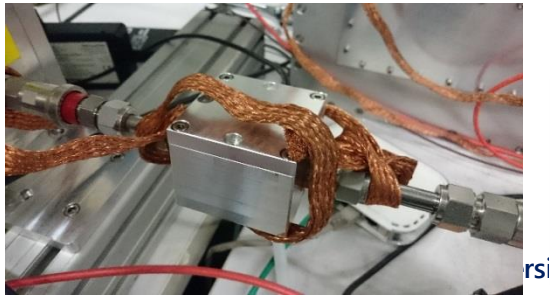


GAIN MEASUREMENTS ALTERNATING W, W/O CORRECTION



applying voltage compensation: gain evolution ~ 40% → ~ 10%

Correction of Voltage $f(P,T)$ LabVIEW based system fully automated + logging



Final co relation coefficient achieved

$$V_{calc} = V_0\left(1 + \alpha\frac{P - P_0}{P_0} - \beta\frac{T - T_0}{T_0}\right)$$