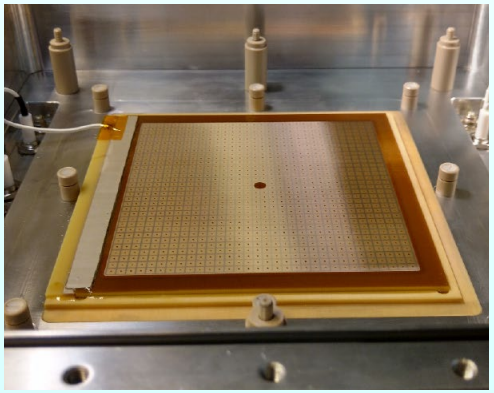
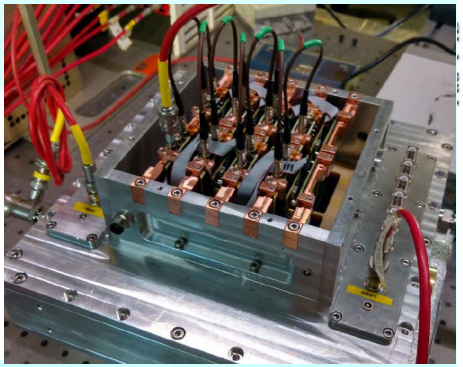
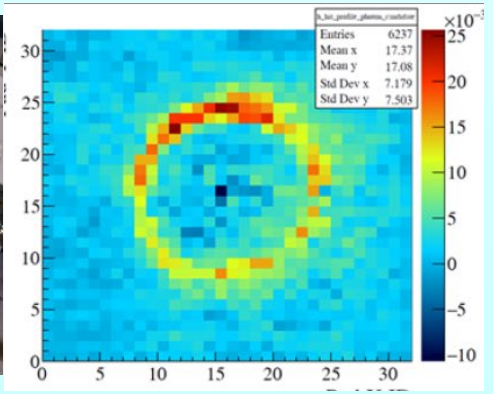
Development of a modular mini-pad gaseous photon detector for RICH applications at the EIC

Fulvio Tessarotto (INFN – Trieste)

COMPASS RICH Hybrid PDs
Mini-pad prototype architecture
THGEMs preparation
Micromegas performance
Test-beam at CERN M4
Encouraging results







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The experience of COMPASS RICH-1

A large gaseous RICH

providing:

hadron PID from 3 to 60 GeV/c

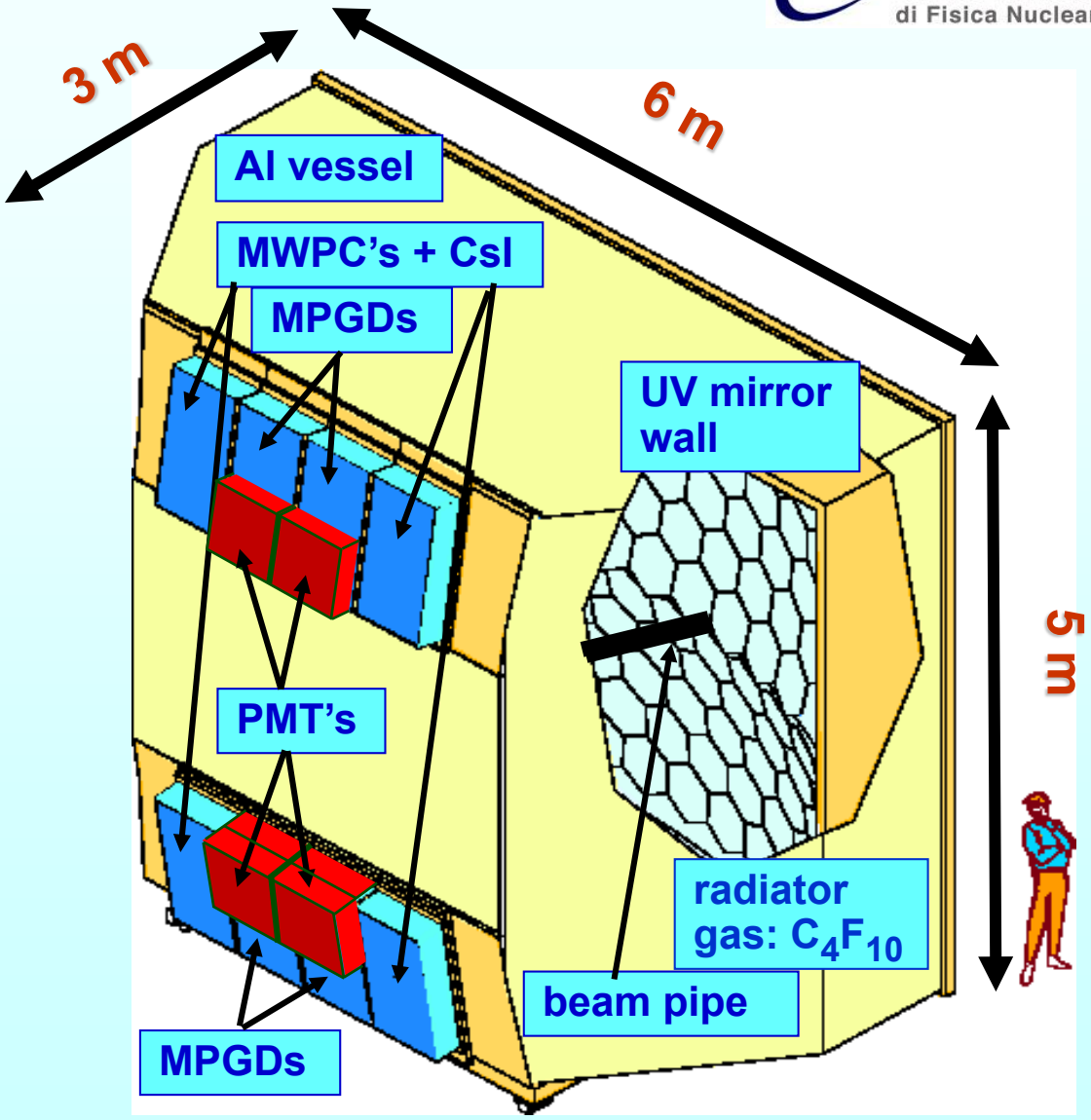
acceptance: H: 500 mrad V: 400 mrad

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 with MWPCs
upgraded in 2006 with MAPMTs,
in 2016 with THGEMs + Micromegas

total investment: ~ 5 M €



The Hybrid MPGD-based PDs

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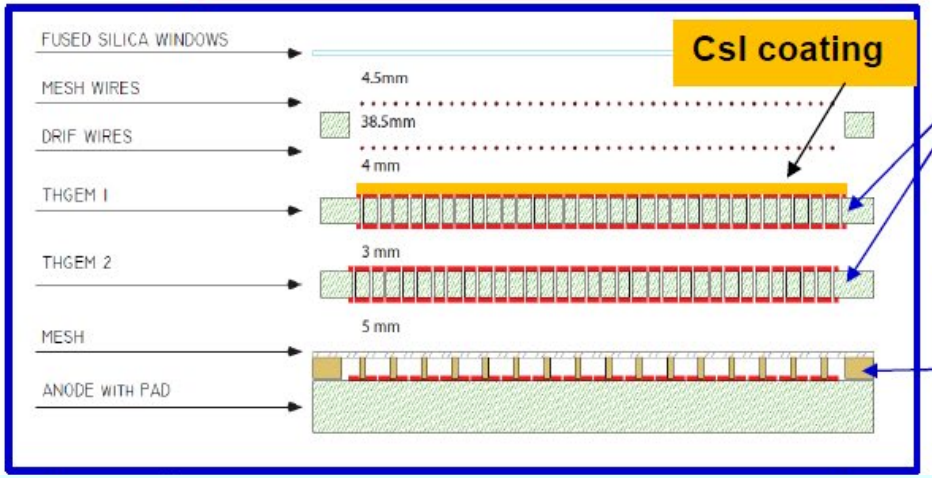
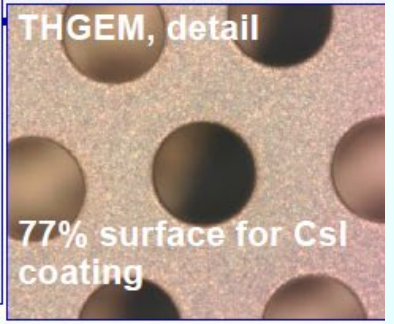
Following a 7-year R&D



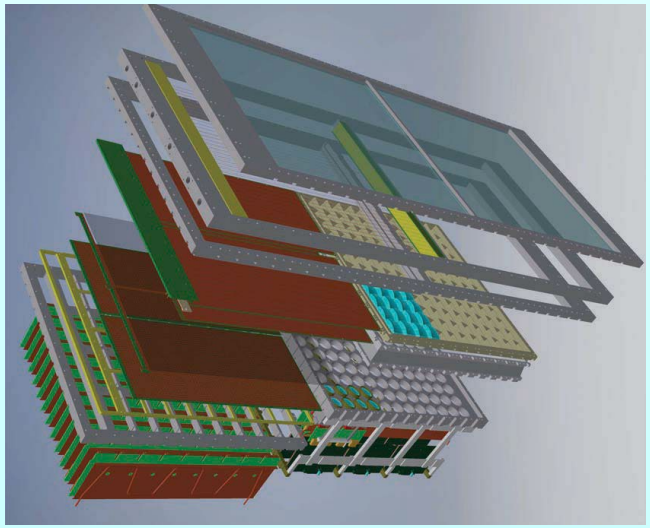
2 layers of staggered THGEMs:

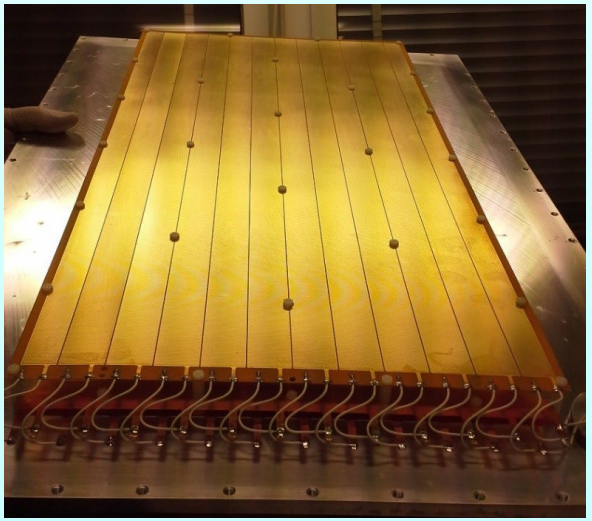
- pre-amplification
- transversally enlarged avalanche

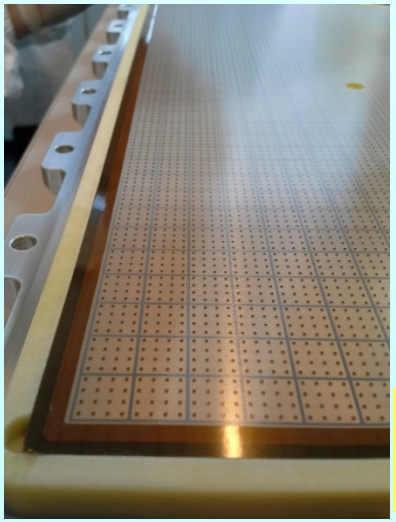


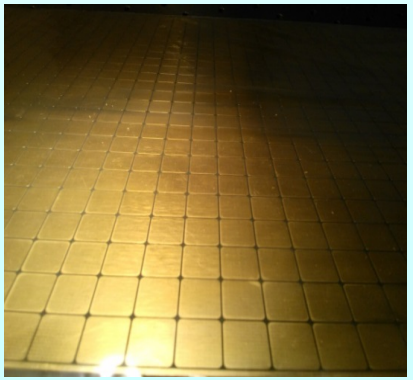
Resistive* MICROMEGAS by *bulk technology

- trapping the ions
- ~100 ns signal formation



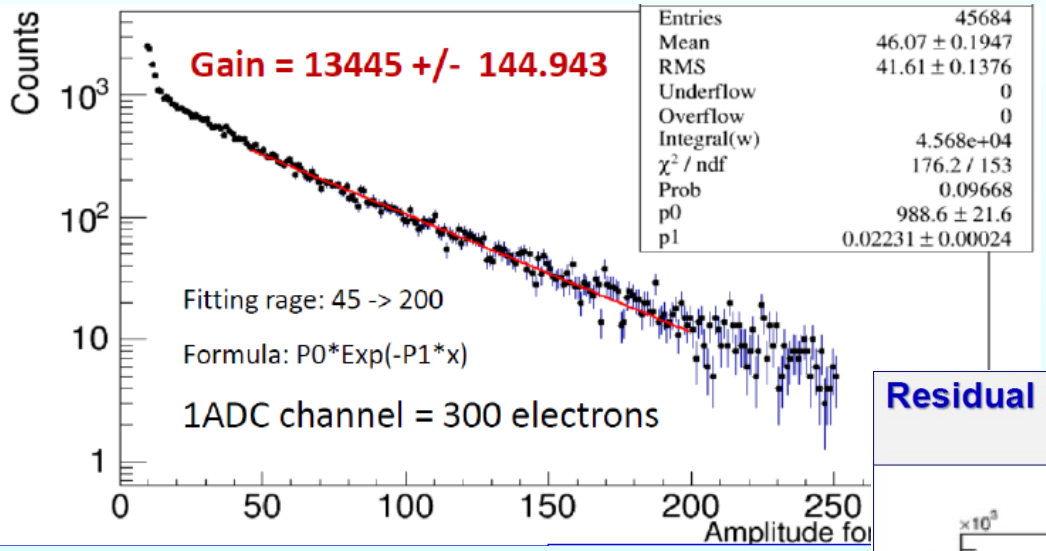




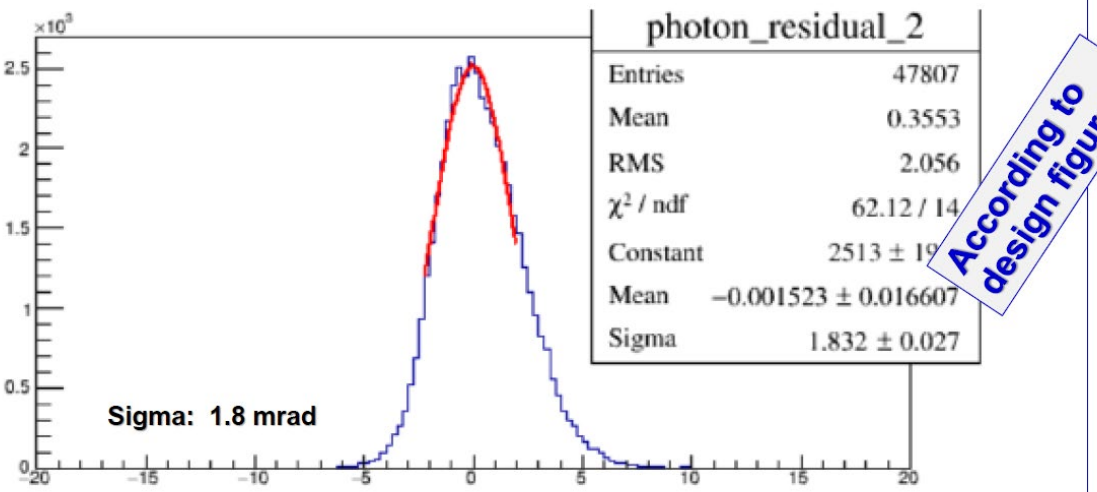


8mm X 8mm pads at positive HV

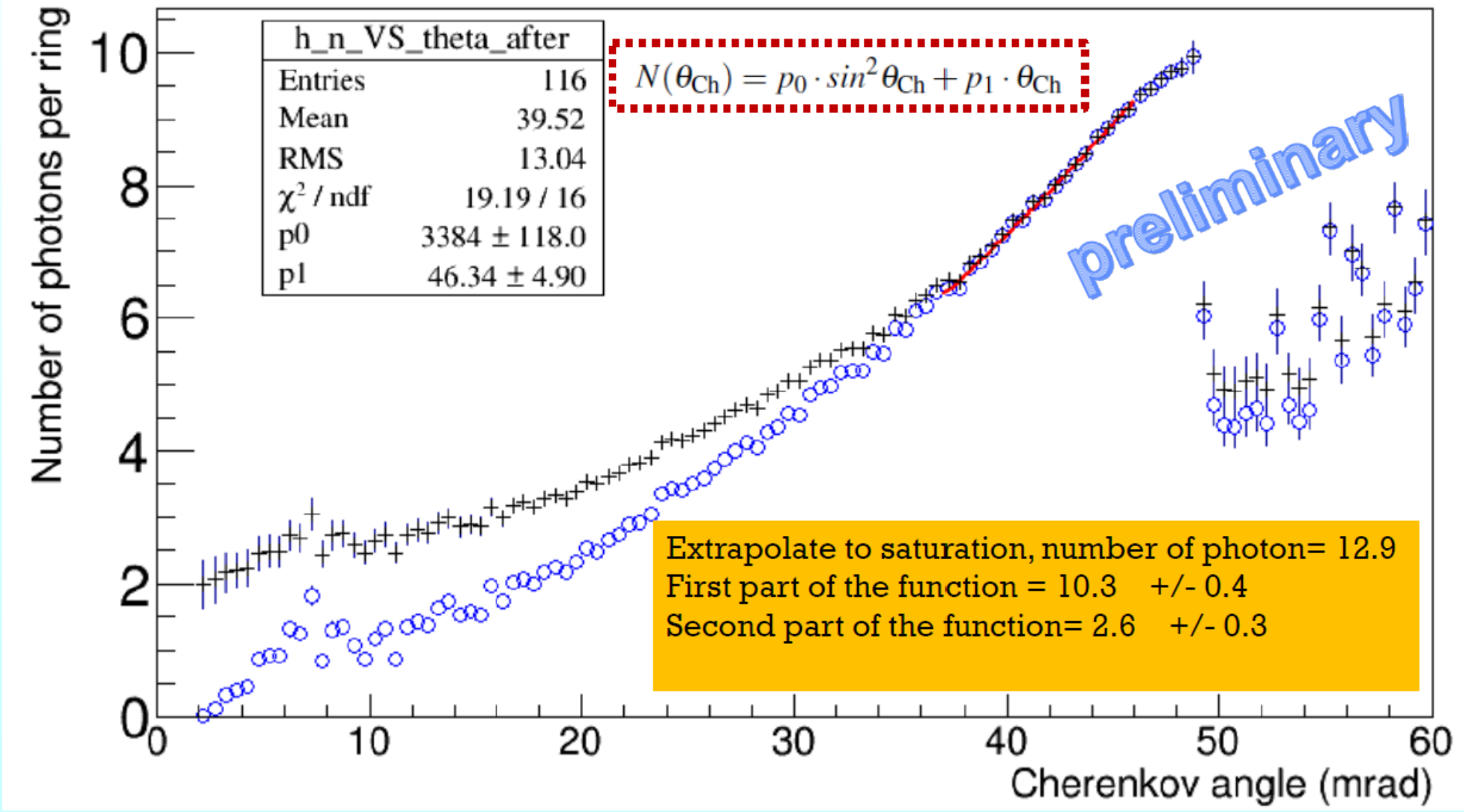
gain and space resolution



Residual distribution for individual photons (preliminary):
$\theta_{calculated} - \theta_{photon}$



Detected photons per ring

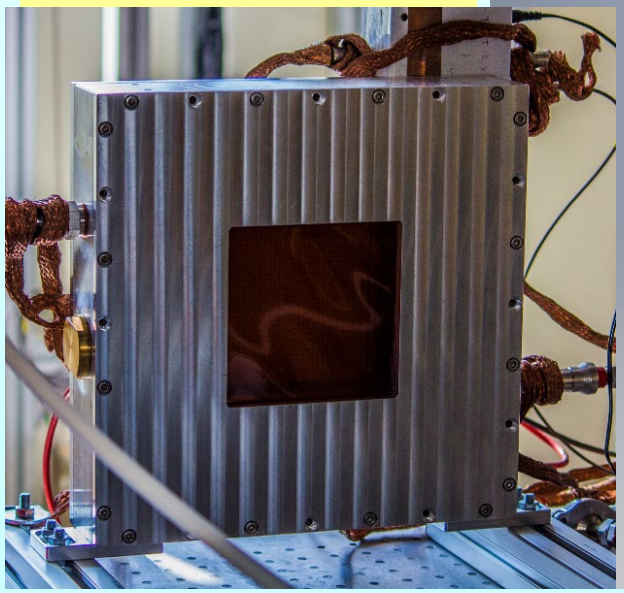


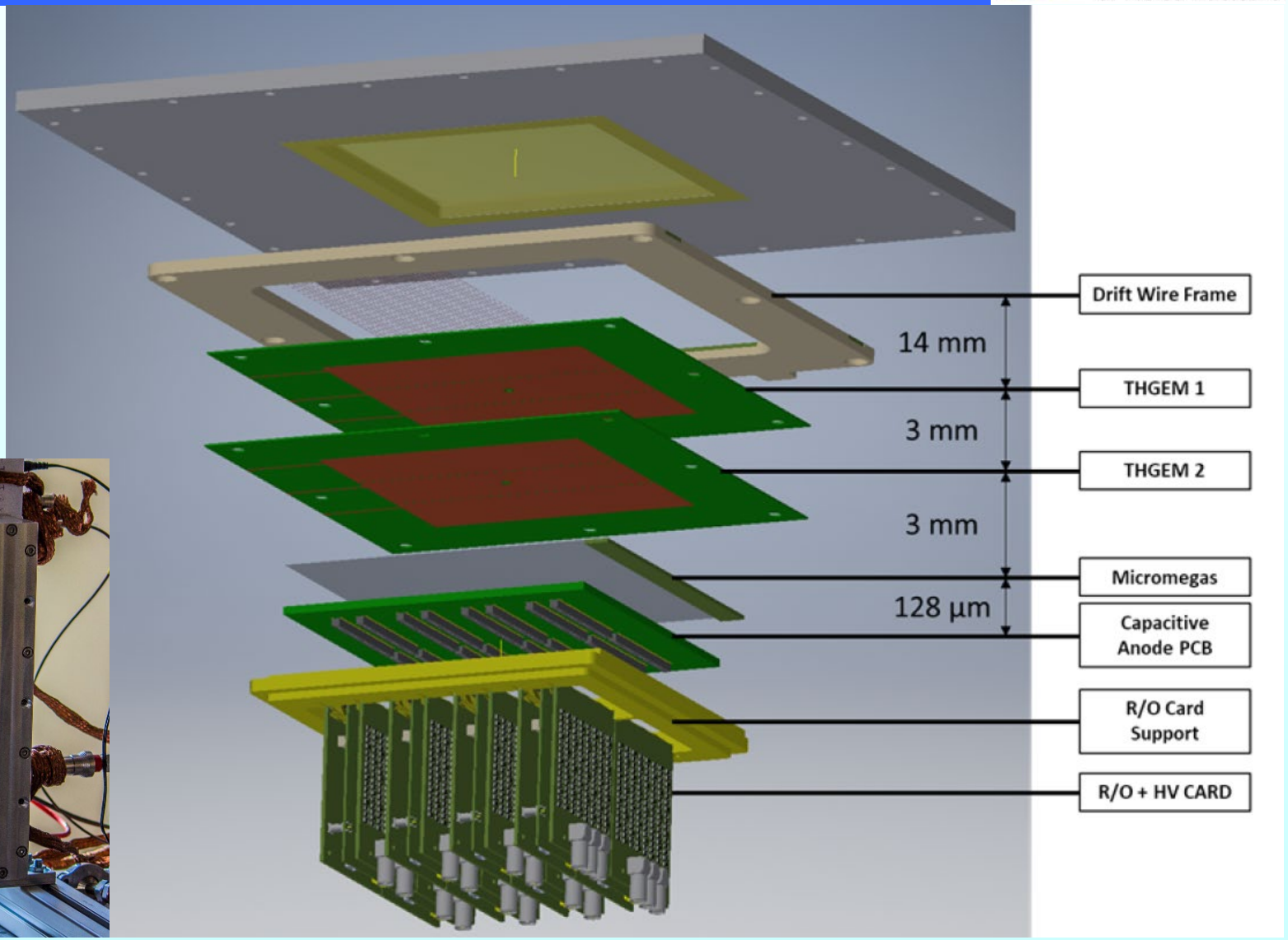
The mini-pad PD architecture

Modular structure: all components and services within the active area

Prototype with 10x10 cm^2 active area.

1024 square pads of 3x3 mm^2 with 0.5 mm inter-pad space





THGEM raw material selection

Our thickness uniformity requirements are stricter than those offered by producers → material selection

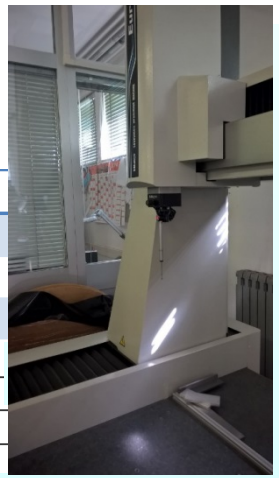
50 foils of 1245 mm x 1092 mm → cut out borders → 800 mm x 800 mm → thickness measurement

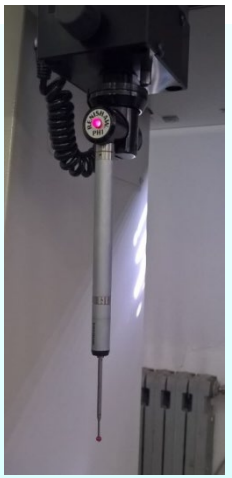
Elite Material Co., Ltd. Technical Data

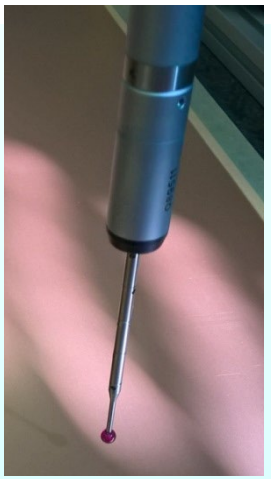
http:\\www.emctw.com

Lead-free , Halogen-free Material

PRODUCT			EM 370-5		
Thickness			0.407 mm		
Copper			35µ / 35µ		
Sheet Size			1 245 x 1 092 mm		
Permittivity (RC 50%)	1 MHz	2.5.5.9	C-24/23/50	–	4.8
	1 GHz			–	4.3
Volume resistivity		2.5.17.1	C-96/35/90	MΩ-cm	$>10^{10}$
Surface resistivity		2.5.17.1	C-96/35/90	MΩ	$>10^{9}$



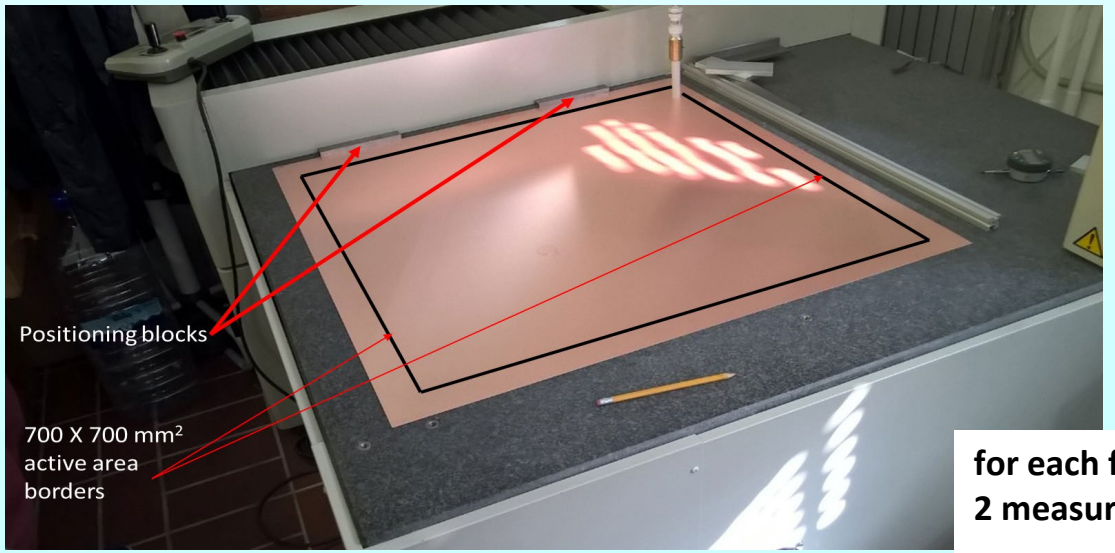




Mitutoyo EURO CA776

coordinate measuring machine with ruby touch probe,

hosted in a thermalized room



underpressure induced flatness

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

THGEM production and treatment

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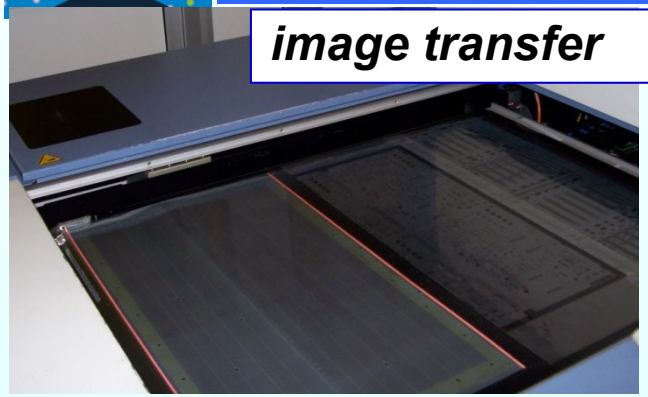
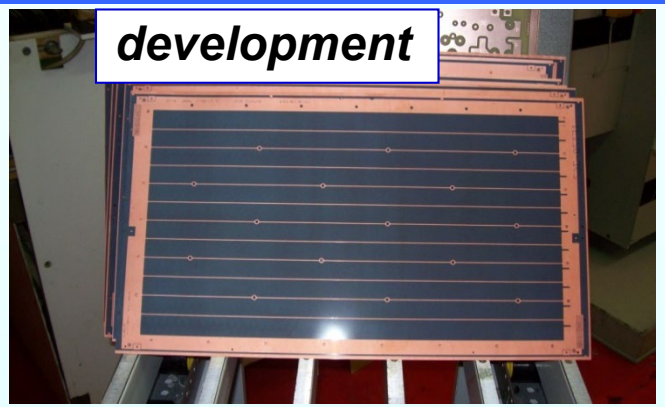
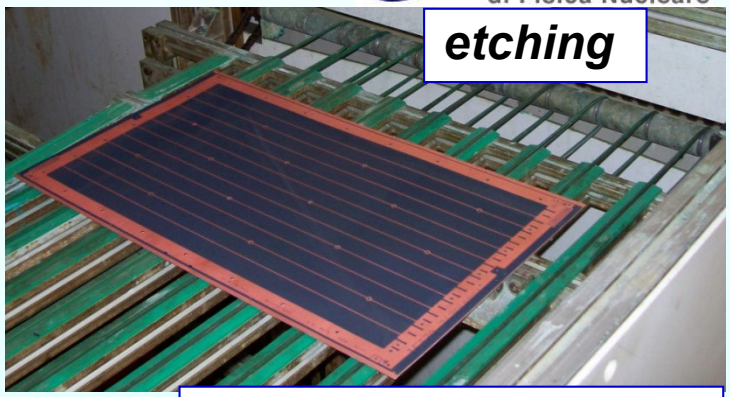
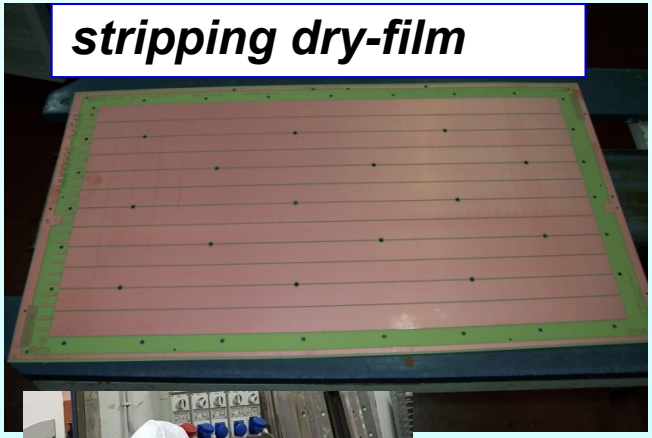
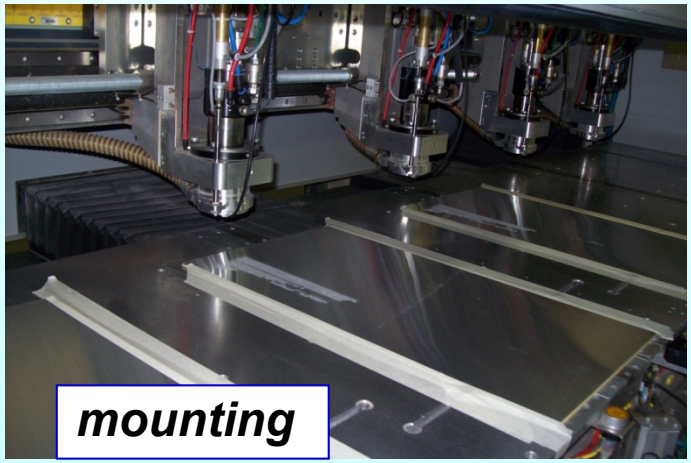
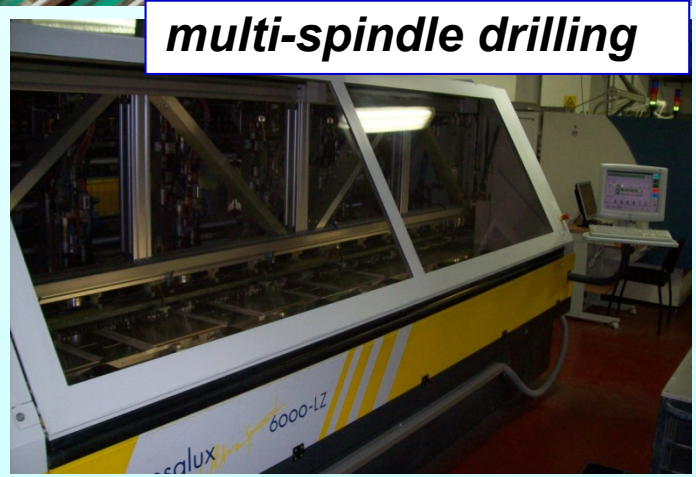




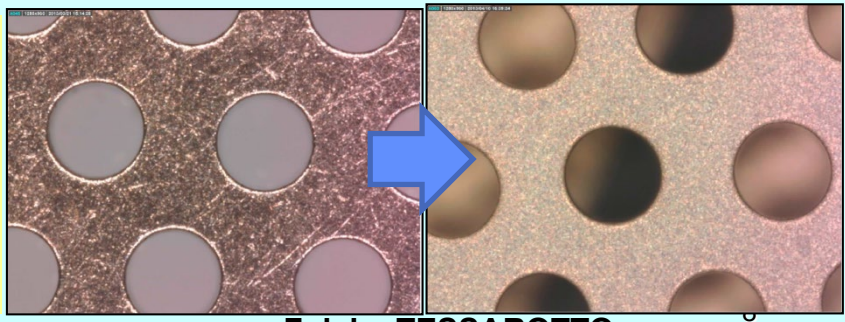




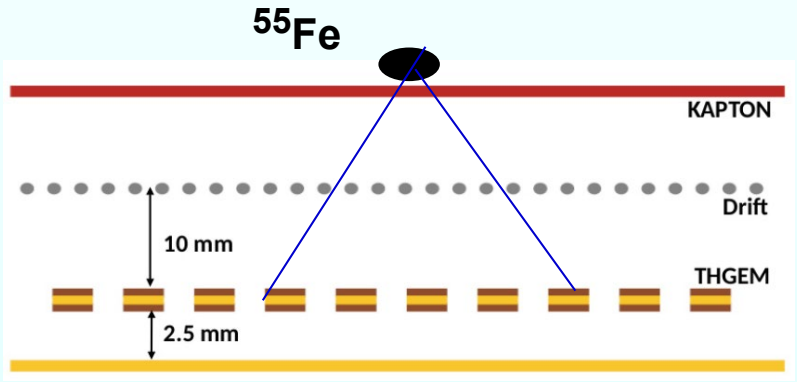




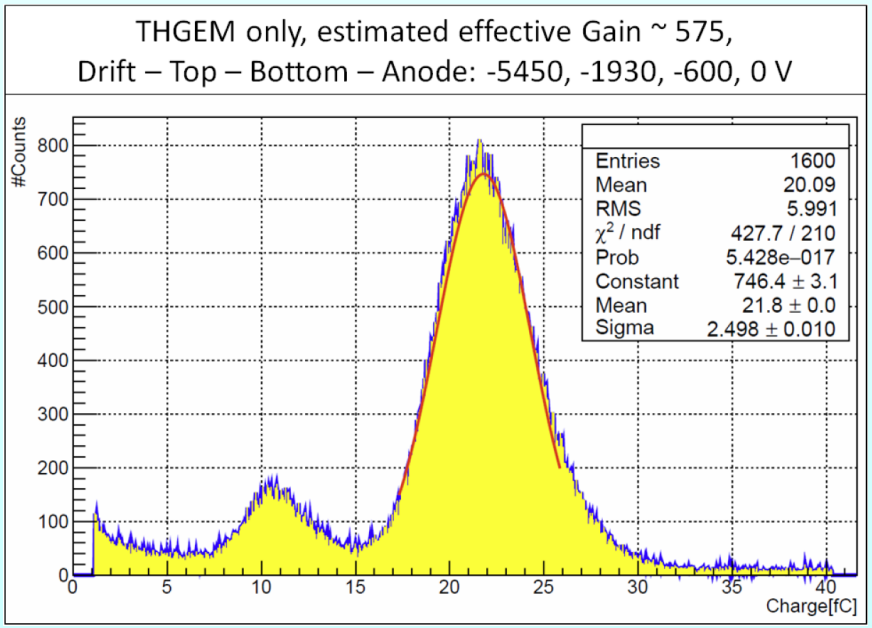
In Trieste a specific cleaning procedure is applied : polish with fine grain pumice powder, pressure water cleaning, ultrasonic bath with Sonica PCB solution (PH11), distilled water rinsing and oven @ 160 ºC

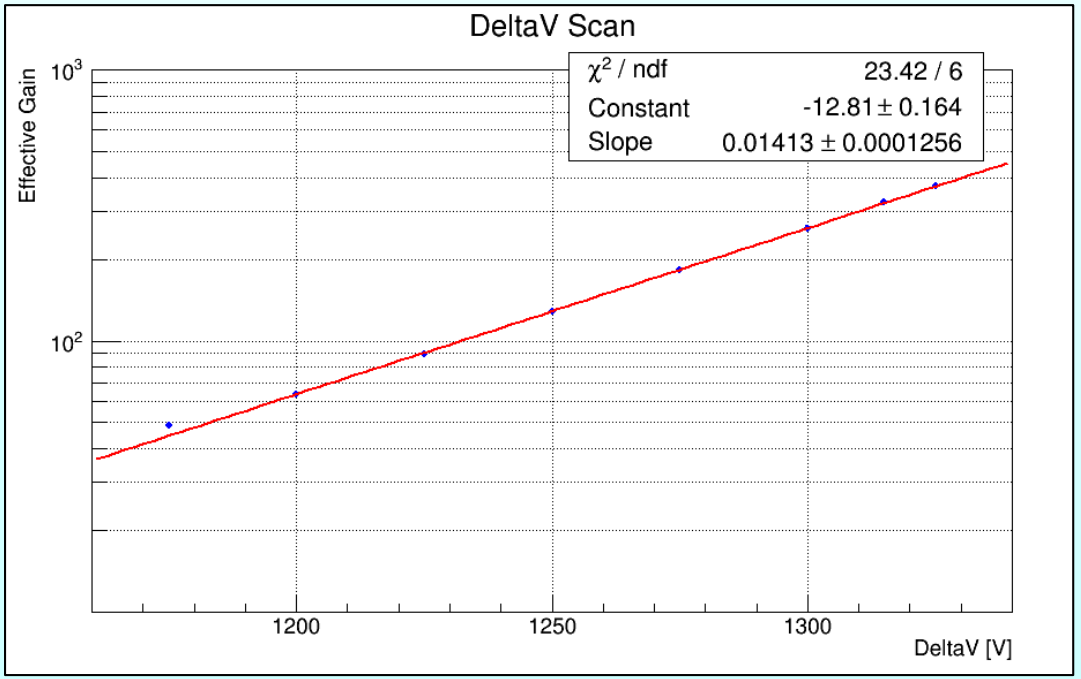


Good THGEM response



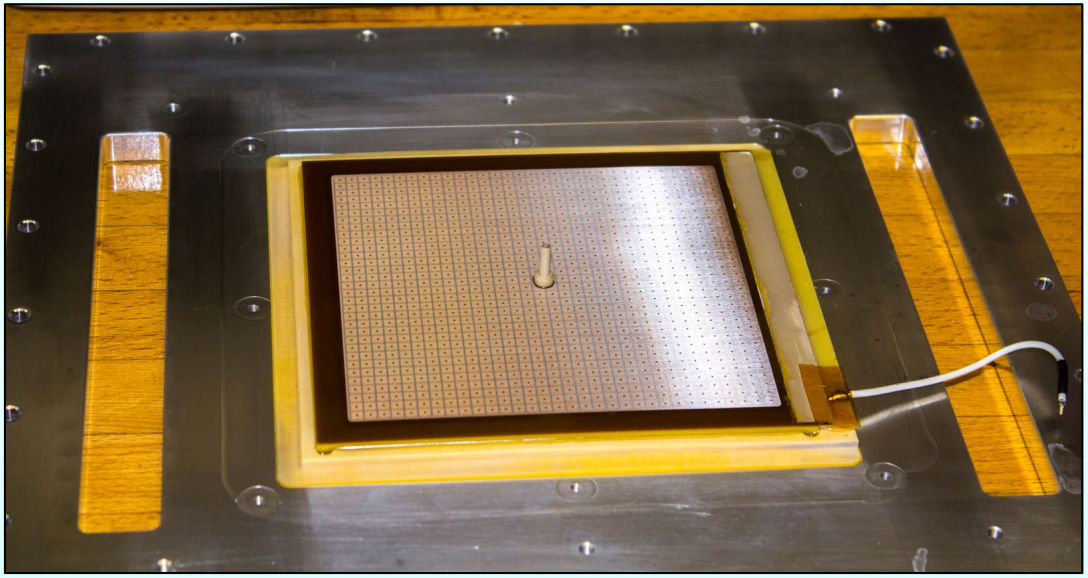
Test performed using Ar:CO2 70:30 gas mixture,
^{55}Fe source, AMPTEK Mini-X, Picoquant PLD 4000B
Ar:CO2 70:30,
CREMAT CR110 + ORTEC + AMPTEK MCA 8000A

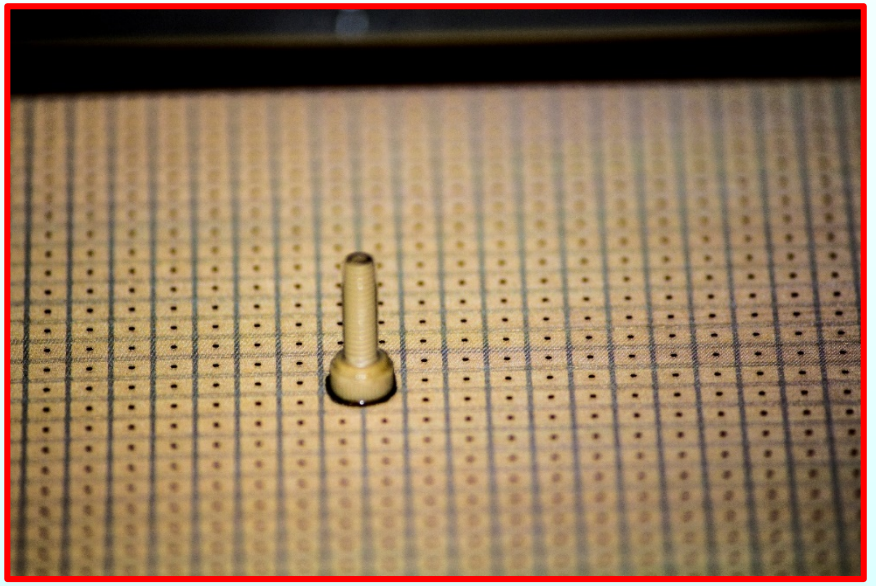




THGEM gain uniformity: ~ 5%

The mini-pad Micromegas



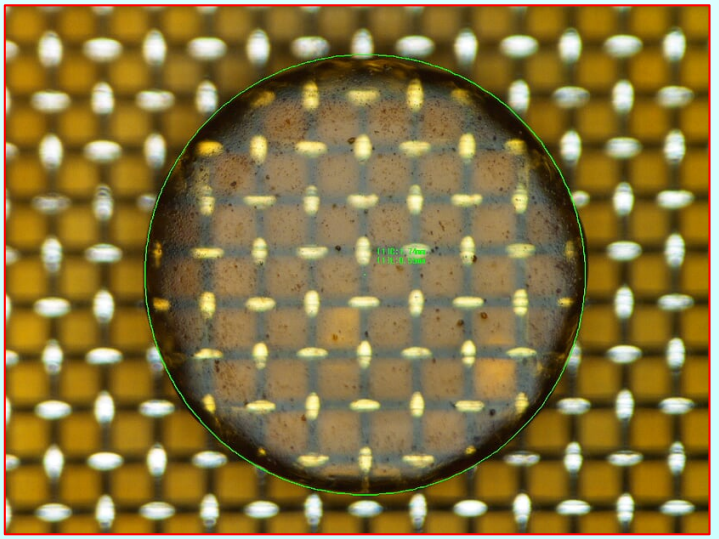


Produced at CERN, standard bulk technology

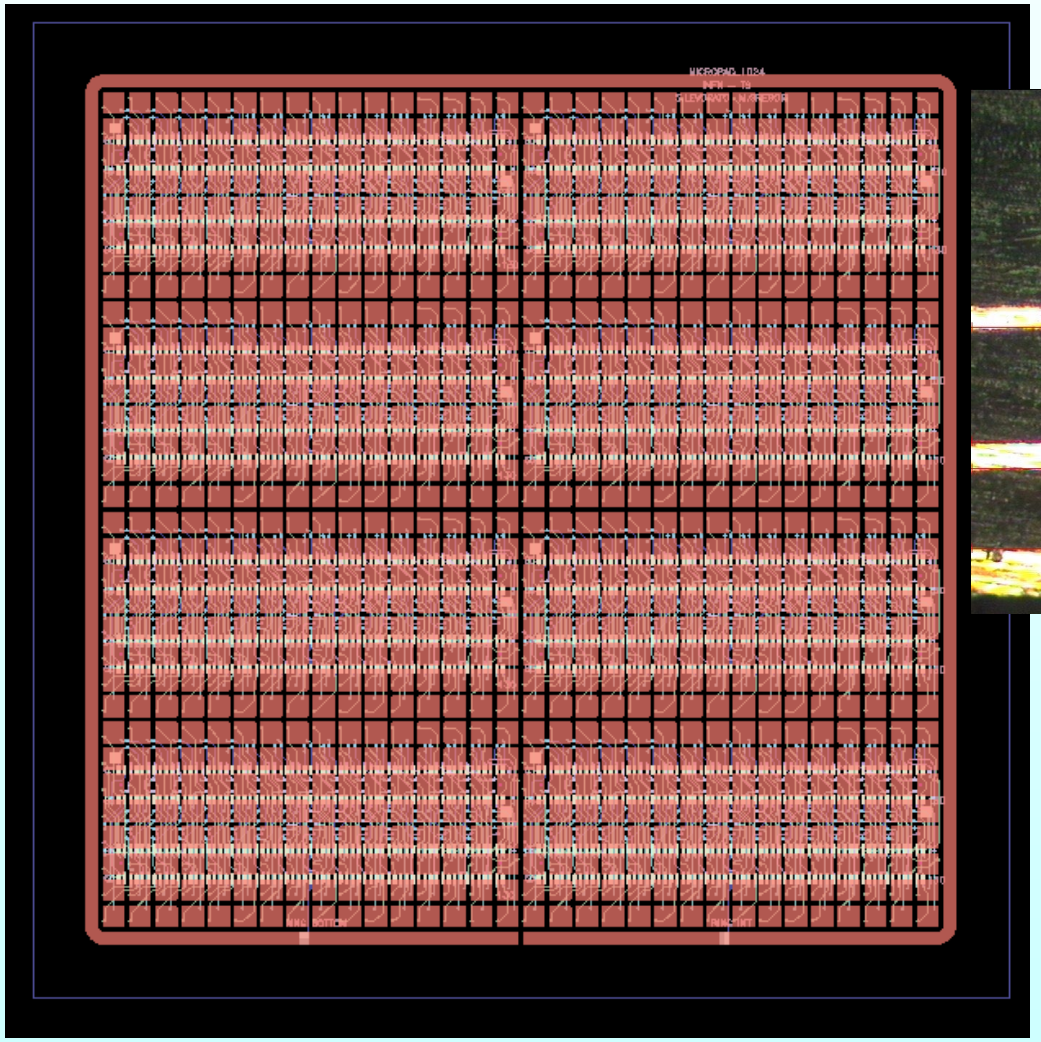
woven stainless steel mesh,18 µm wires, 63 µm pitch

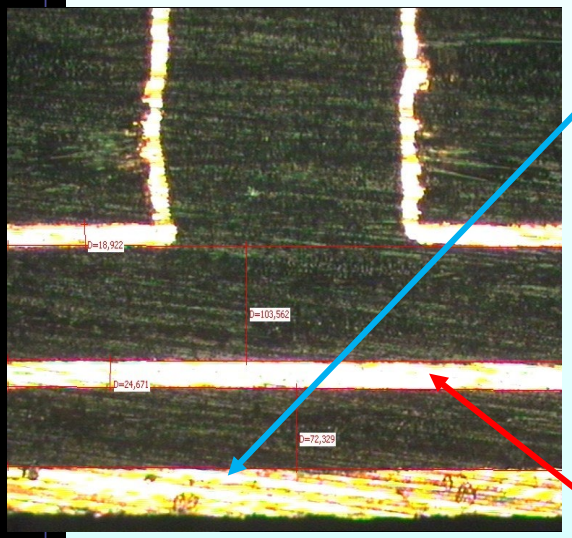
One pillar per pad, 500 µm diameter.

Gap = 128 µm.

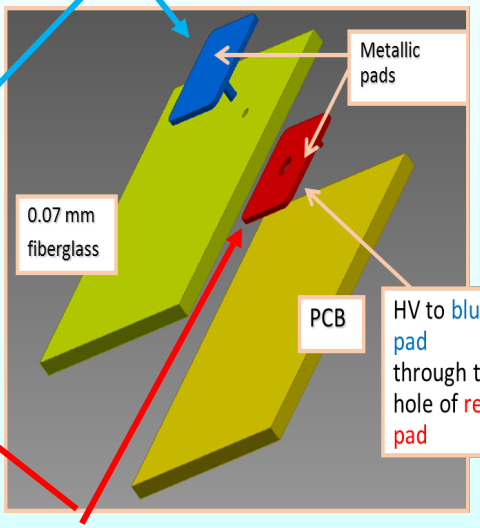


The anode structure

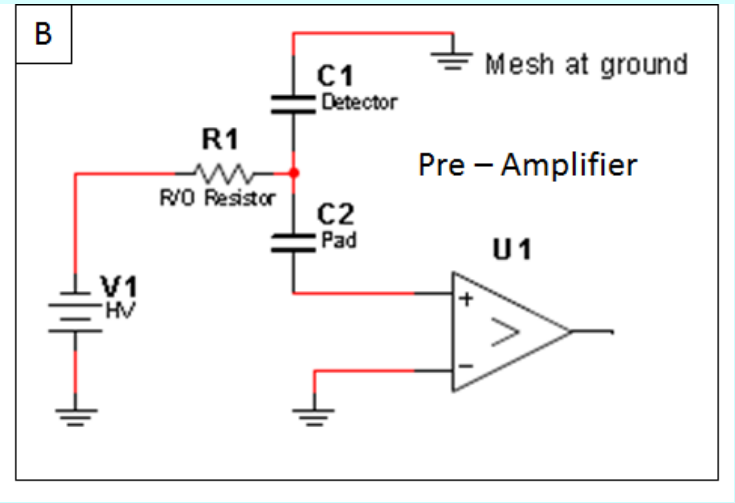




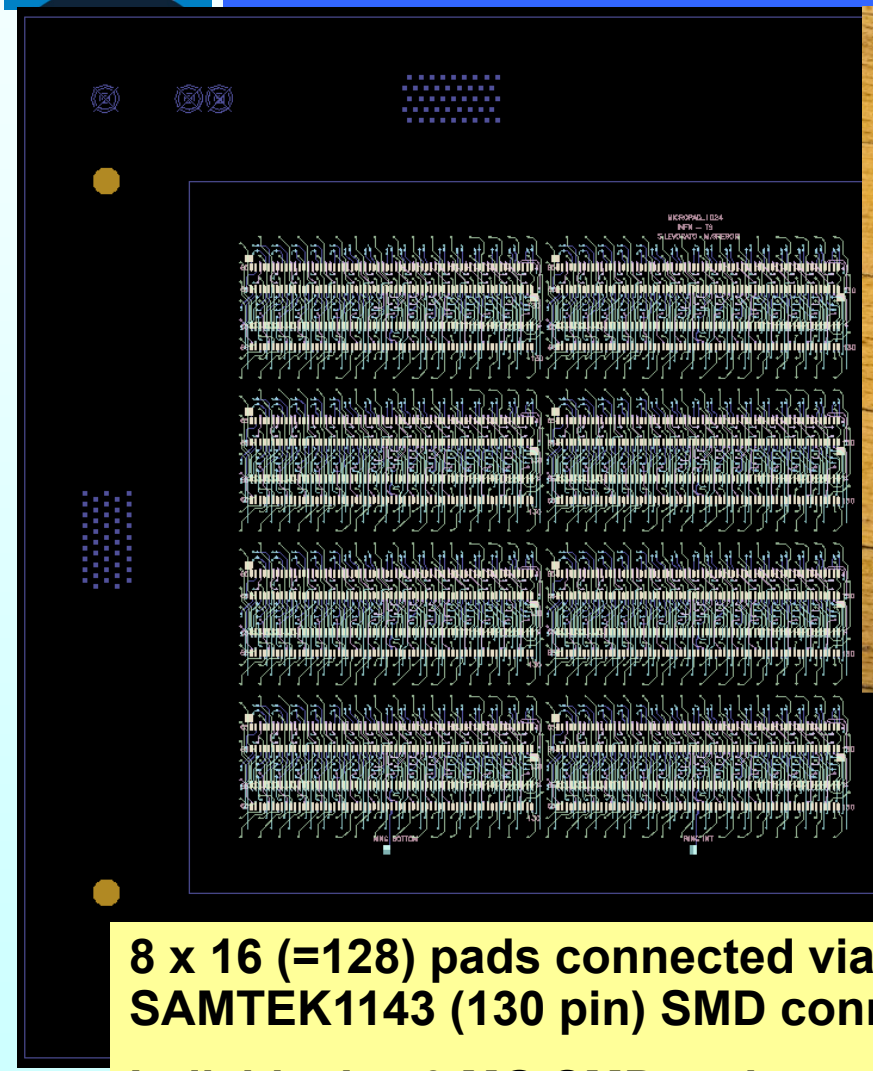
"surface anode" pad

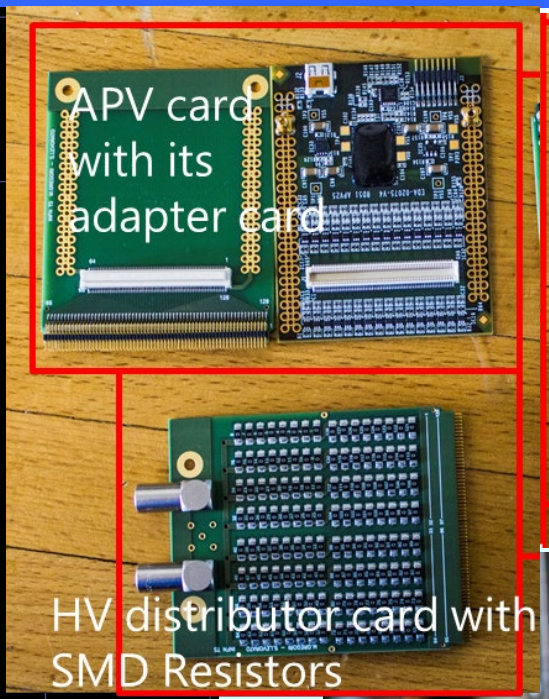


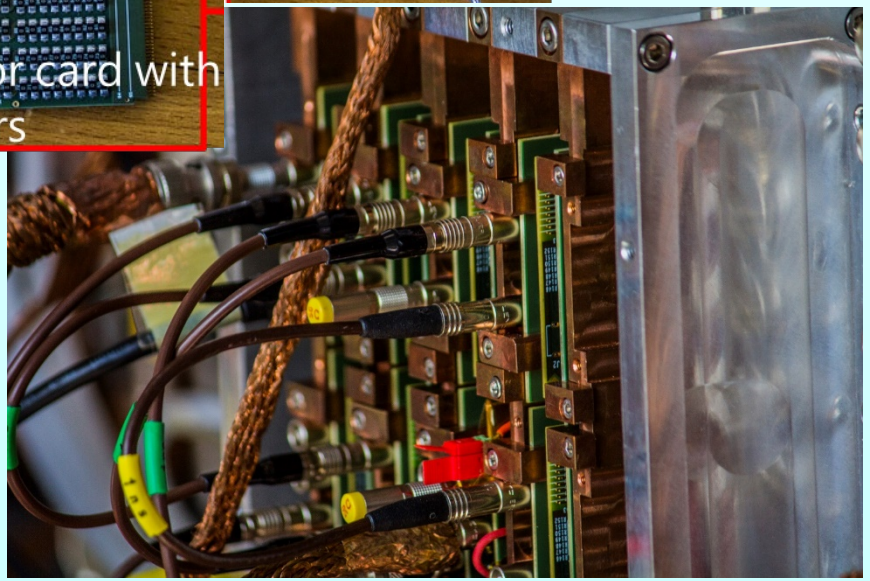
"buried pad"



HV and readout cards



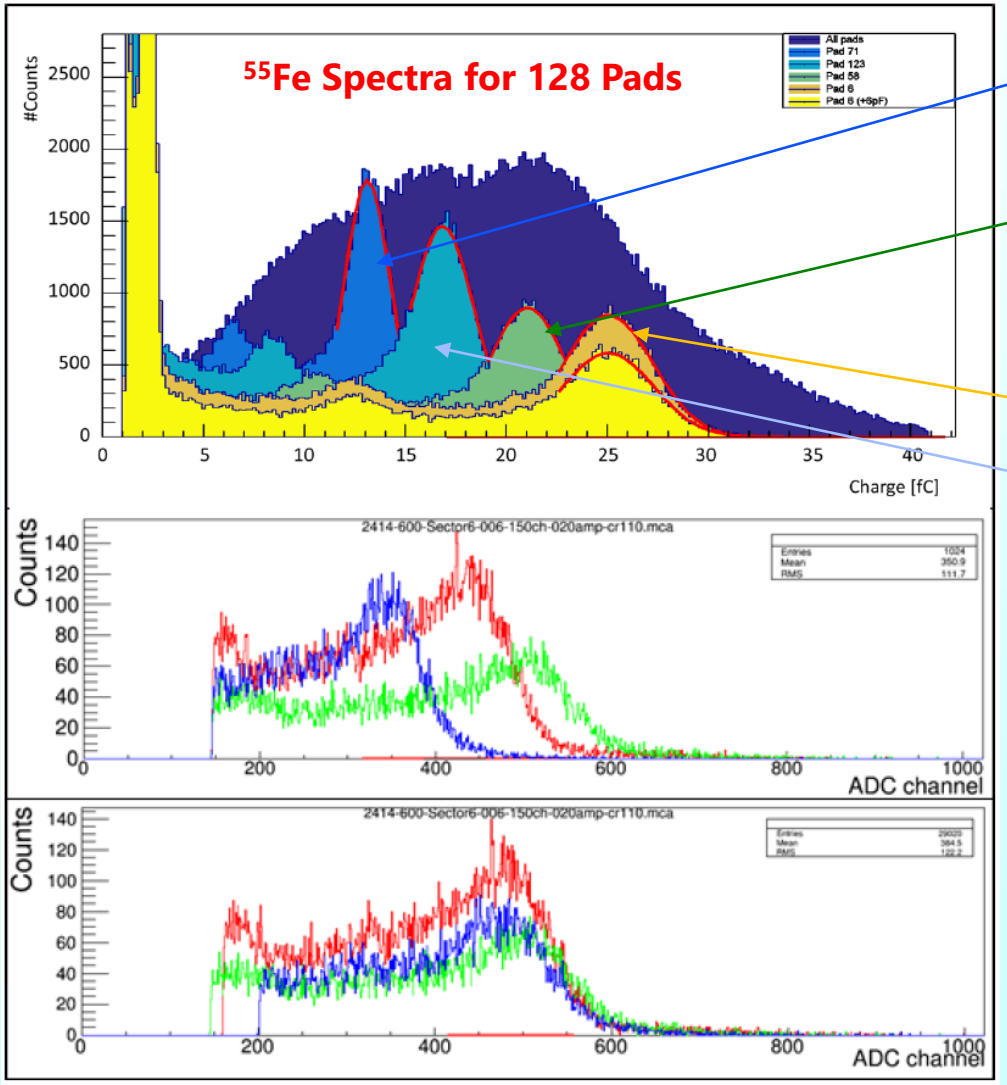




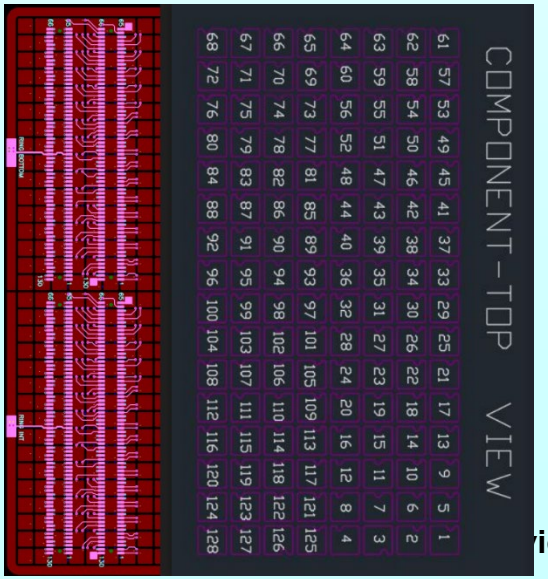
8 x 16 (=128) pads connected via SAMTEK1143 (130 pin) SMD connector

Individual 470 MΩ SMD resistor per pad on HV distribution cards (128/card)

Non uniform response

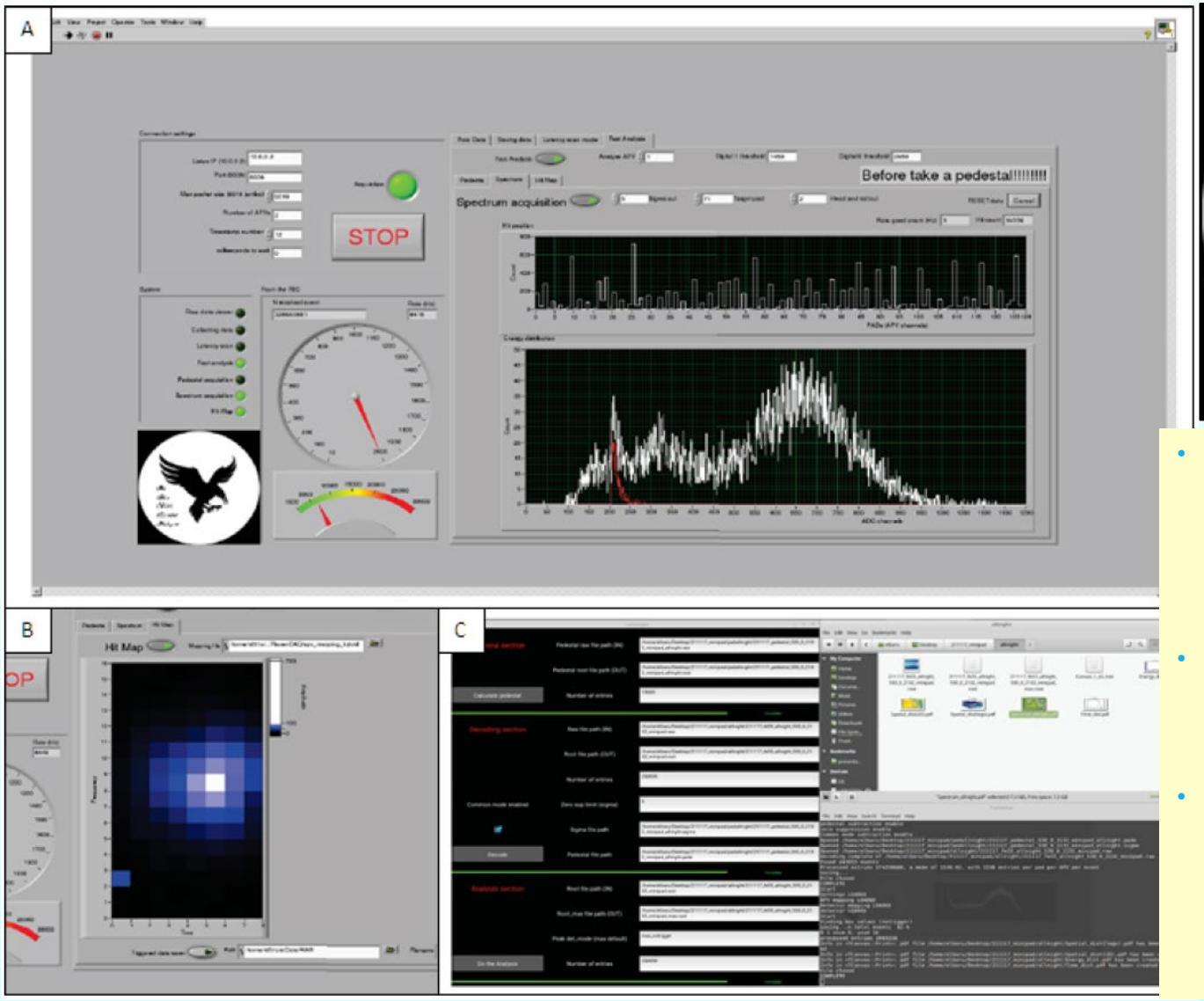


68	67	66	65	64	63	62	61
72	71	70	69	60	59	58	57
76	75	74	73	56	55	54	53
80	79	78	77	52	51	50	49
84	83	82	81	48	47	46	45
88	87	86	85	44	43	42	41
92	91	90	89	40	39	38	37
96	95	94	93	36	35	34	33
100	99	98	97	32	31	30	29
104	103	102	101	28	27	26	25
108	107	106	105	24	23	22	21
112	111	110	109	20	19	18	17
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



Correction factors measured with standard pulse and applied offline to obtain good uniformity

Raven

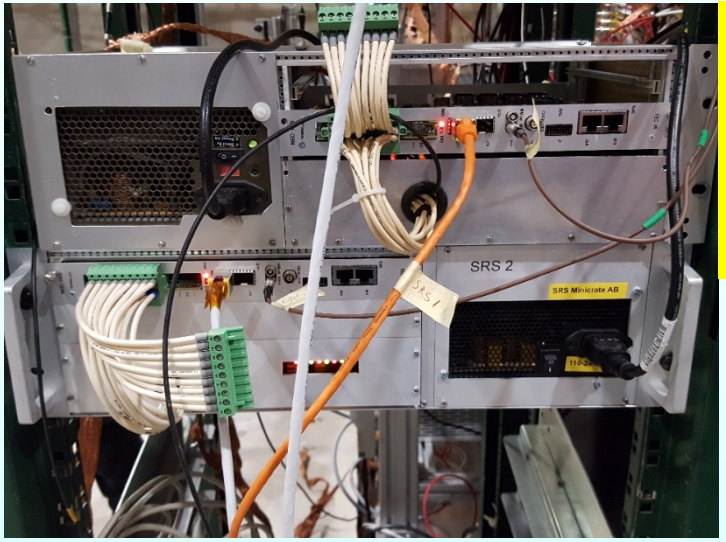


sRs
dAta
eVent
dEcoder
aNalyzer

- For easy use of Scalable Readout System (SRS) we developed a LabVIEW based DAQ and the data decoder + Analysis software including the GUIs for easy access.
- It 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

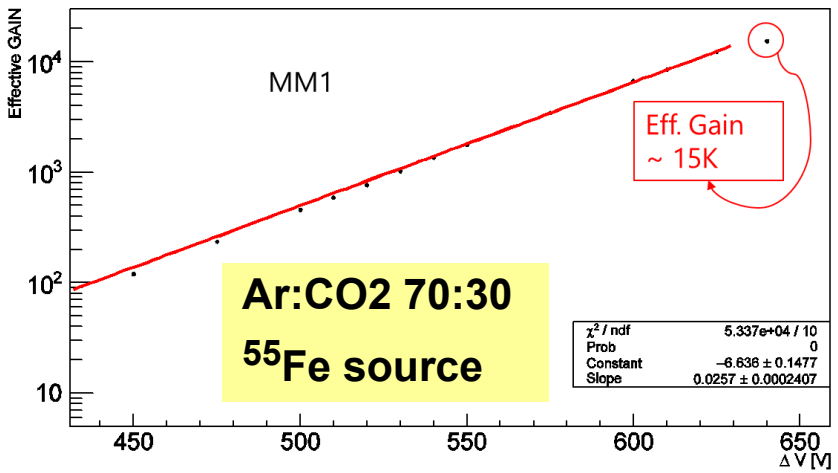
HV and readout

CAEN N1471H



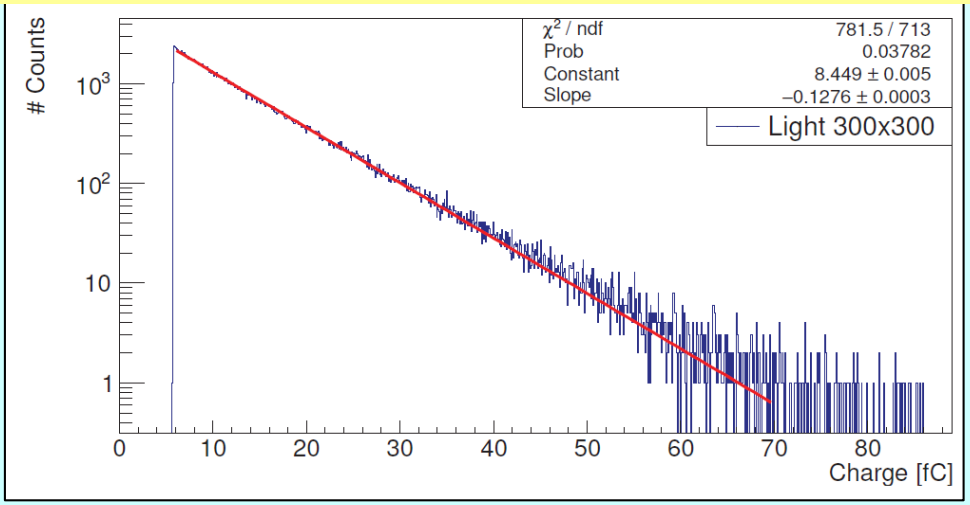
SRS Scalable Readout System

developed in RD51

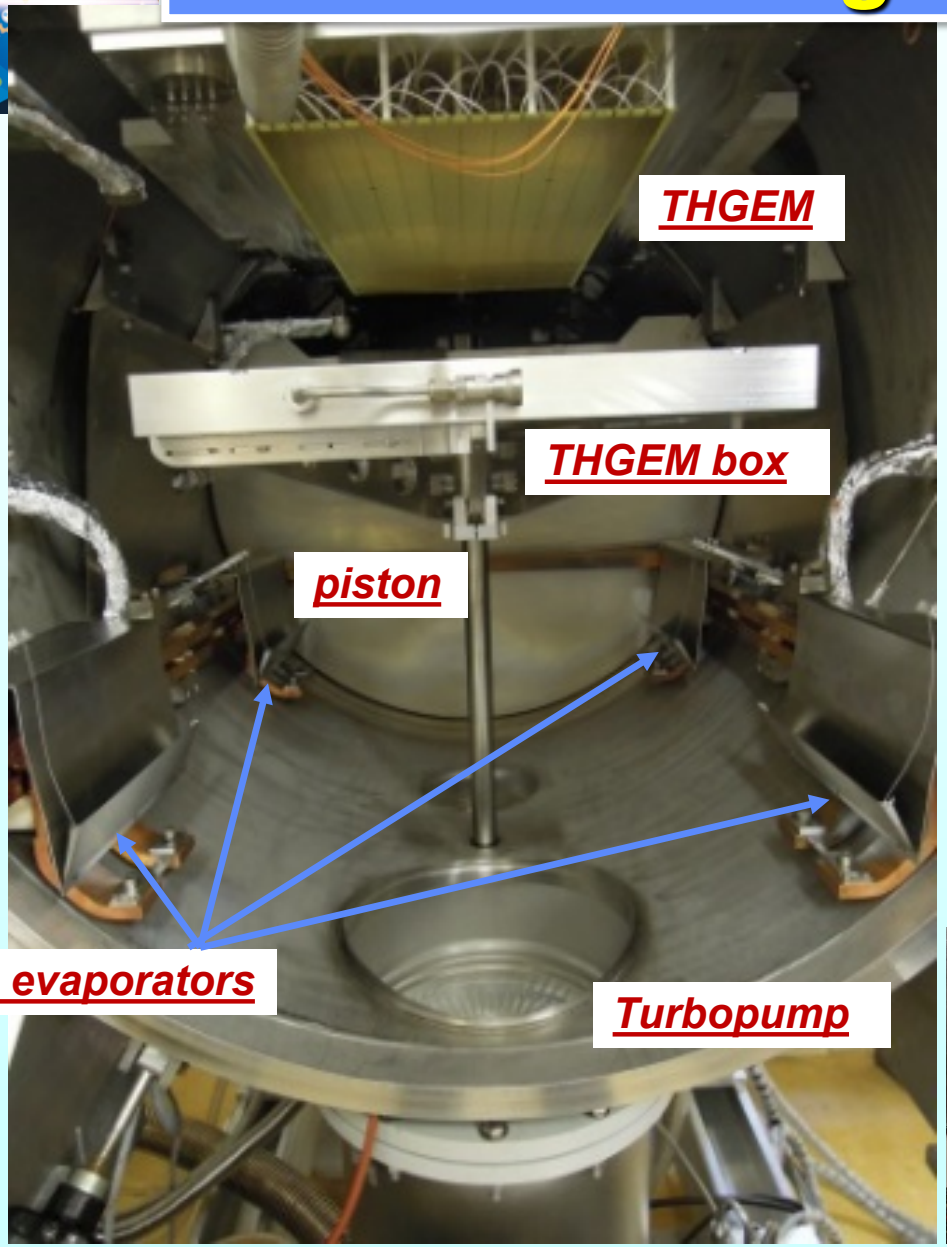


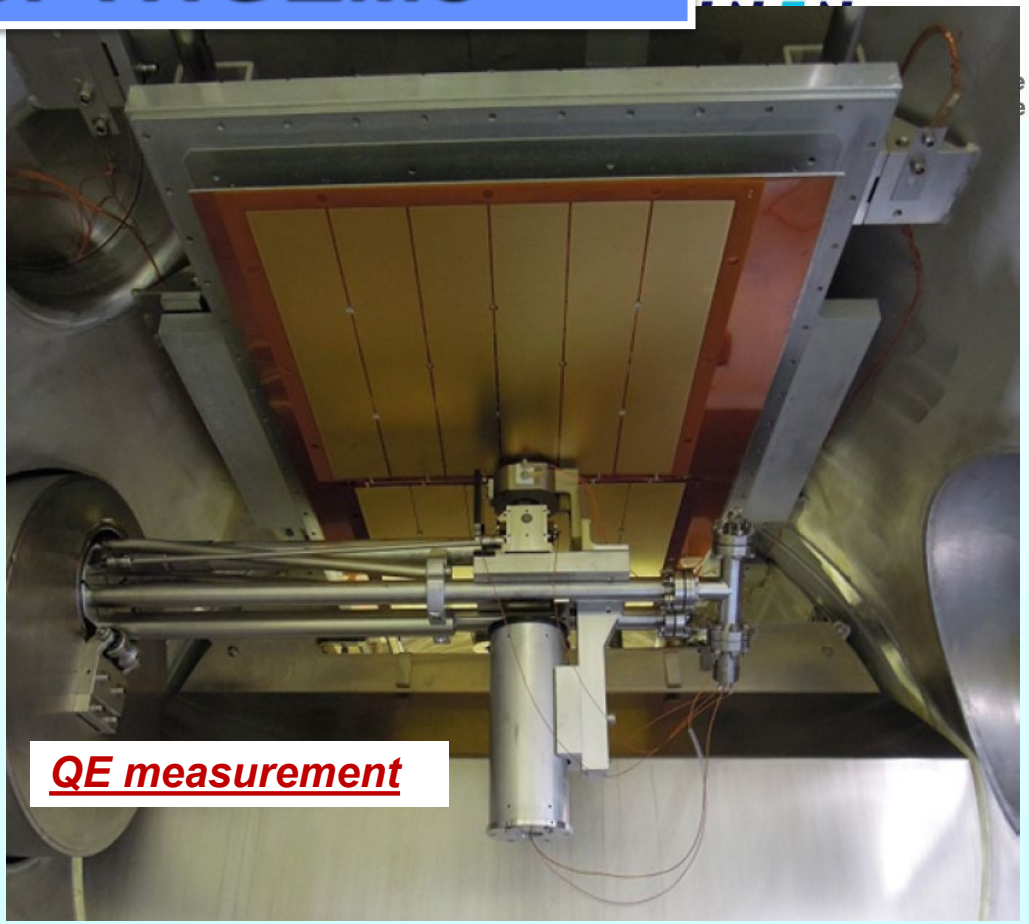
Ar:CH4 50:50

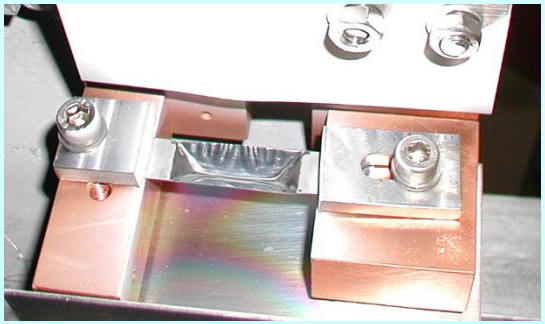
Picoquant PLD 4000B pulsed UV laser source



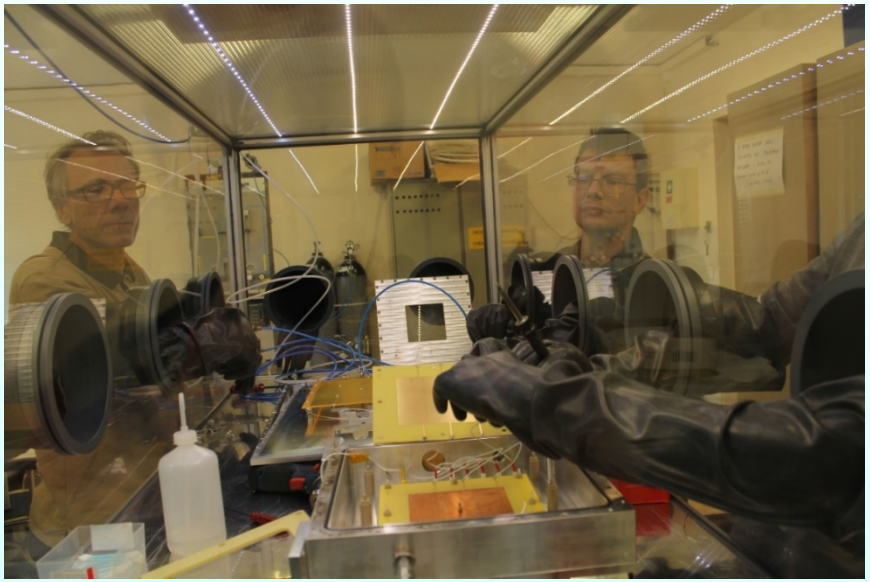
CsI coating of THGEMs

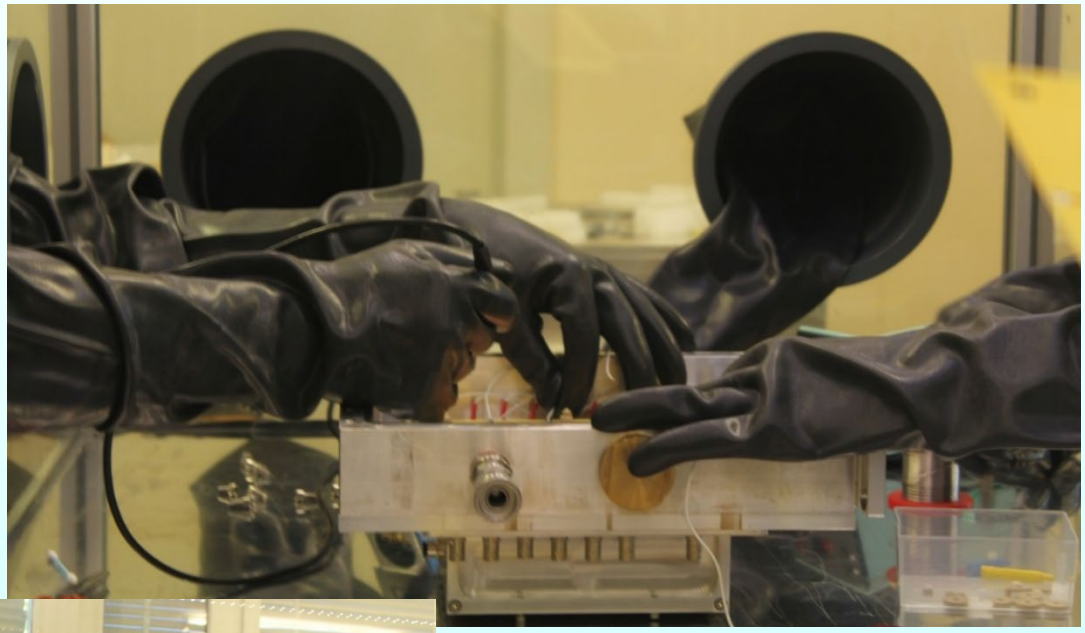


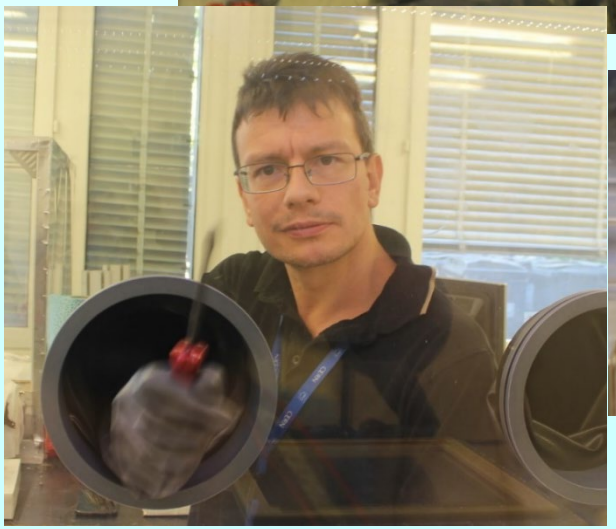


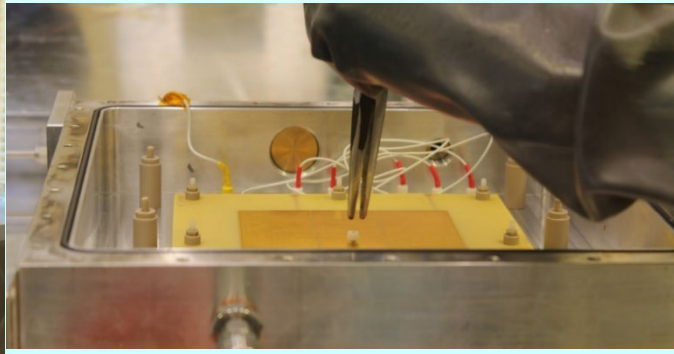


assembling

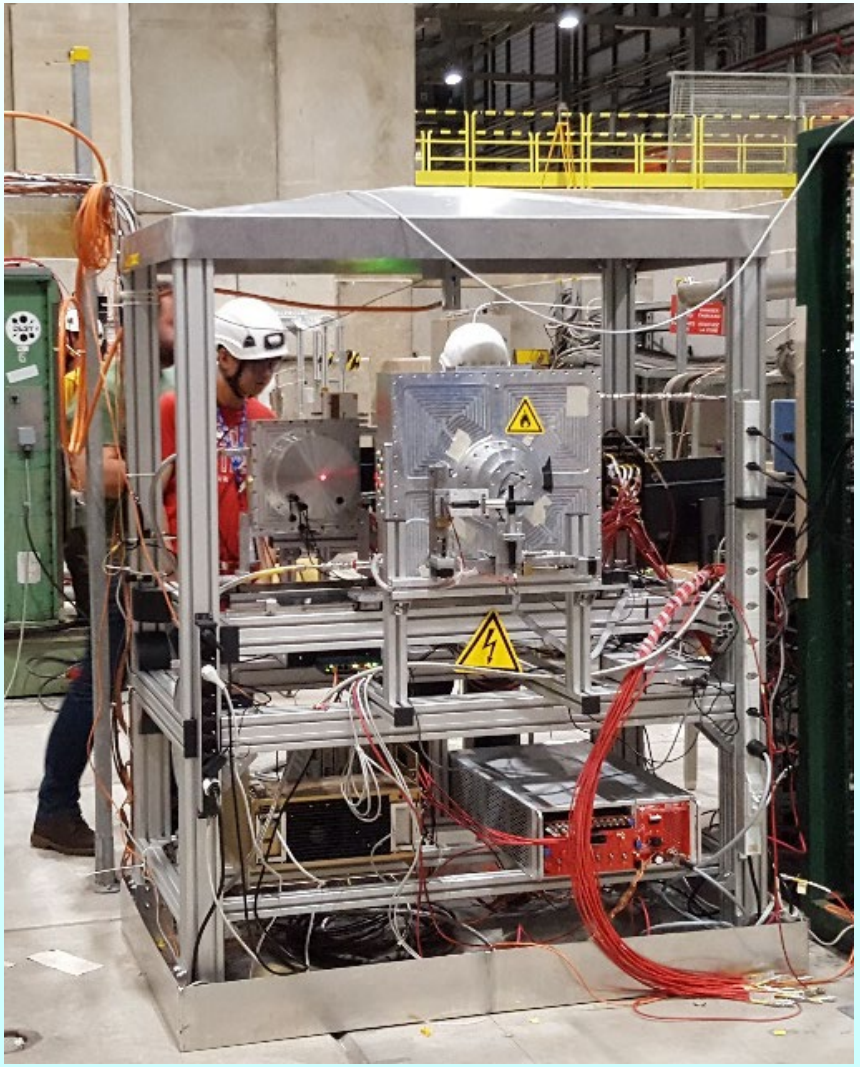




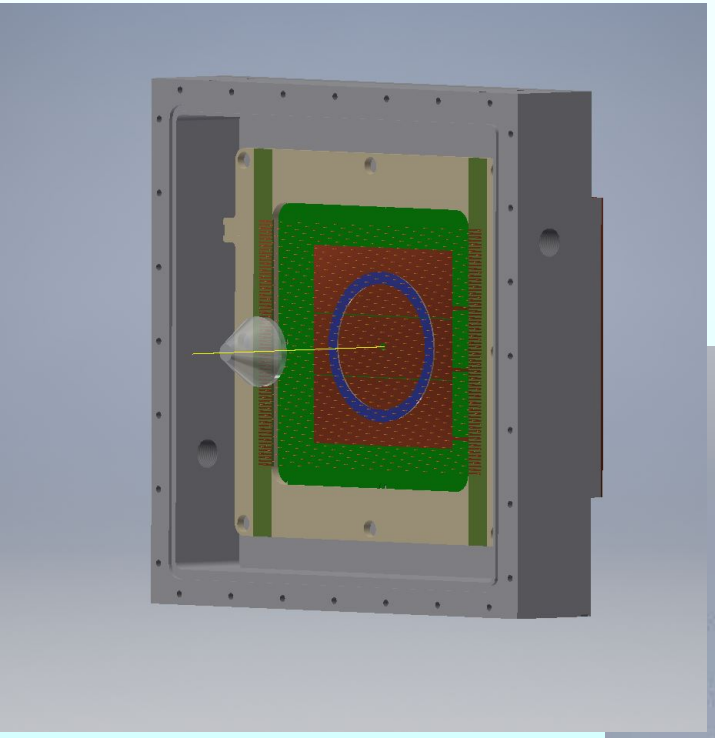


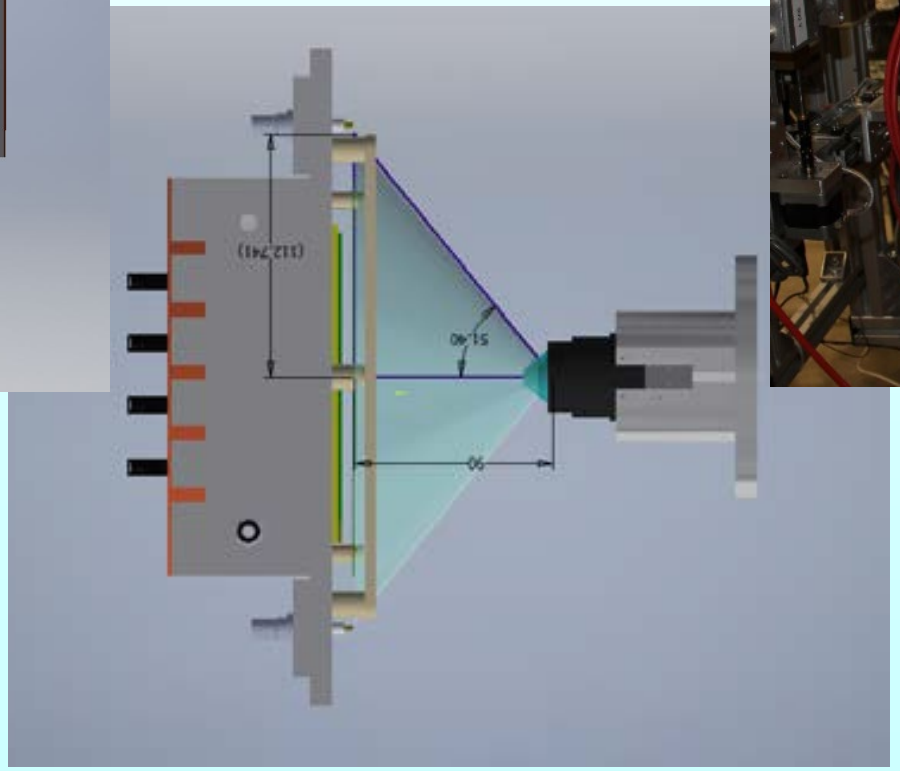


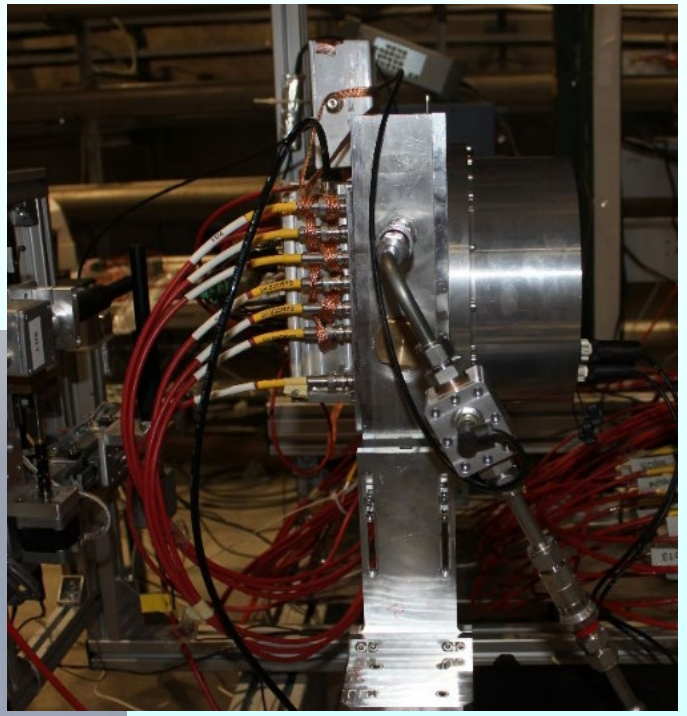
Installation in the RD51 beam area



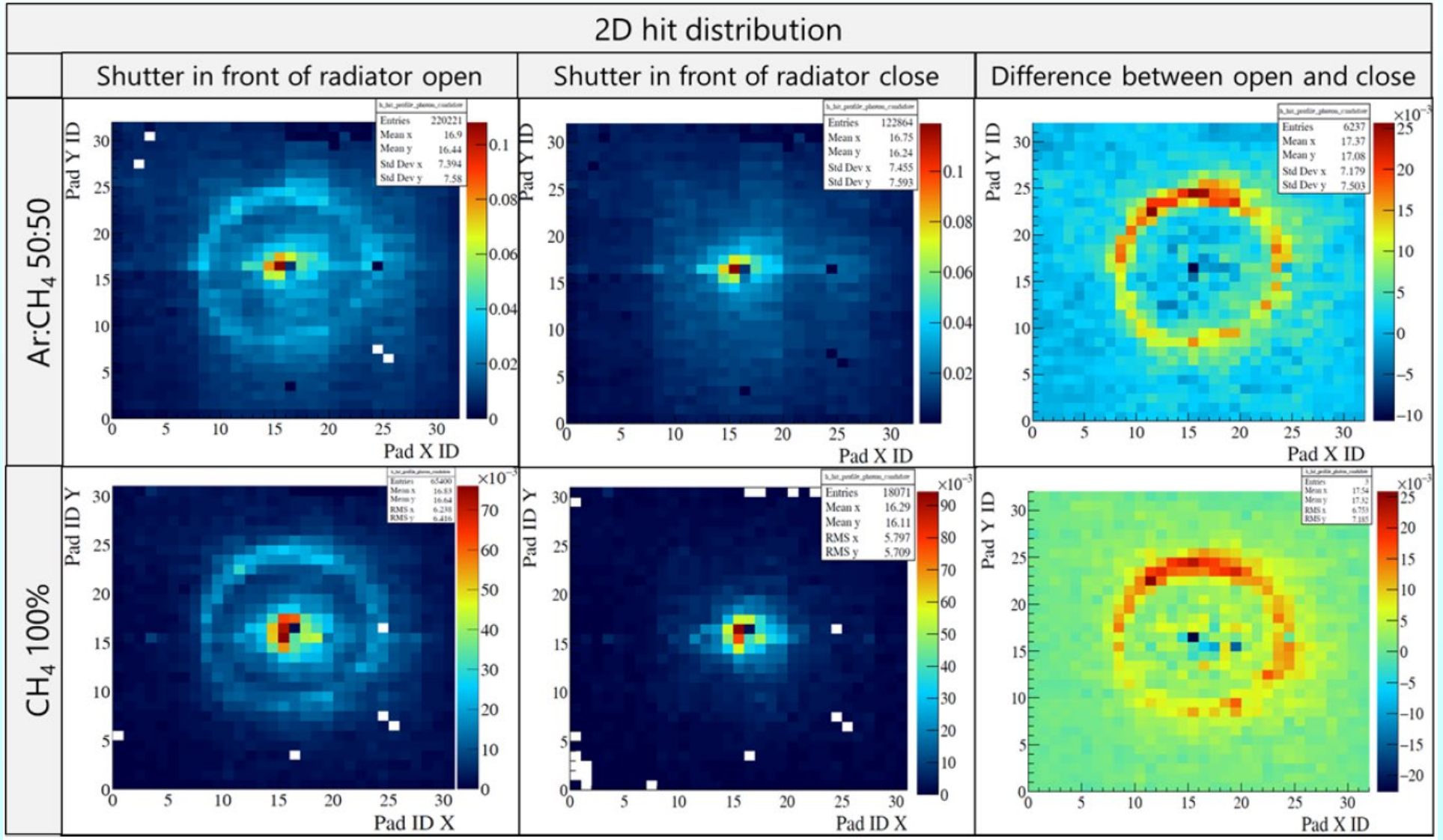
Expected rings







Rings in Ar:CH_4 50:50 and pure CH_4



The team

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Conclusions

A gaseous Photon Detector prototype was built with readout pads of 3 x 3 mm^2

It has the THGEM - Micromegas architecture of the COMPASS RICH hybrid PDs

A non uniformity of response from the pads was investigated and corrected for

A test-beam at the CERN H4 beam line was performed

The first results are encouraging