



Large GEM production at Techtra

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ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

AGREEMENT K156/TT/TS/PH/023L

TECHTRA
TECHNOLOGY TRANSFER AGENCY

The beginning: December 2002

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
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AGREEMENT K 879/ETT/4

LICENSE AGREEMENT FOR USE OF GEM TECHNOLOGY

Licensee: TECHTRA - Technology Transfer Agency



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AGREEMENT K 922/ETT

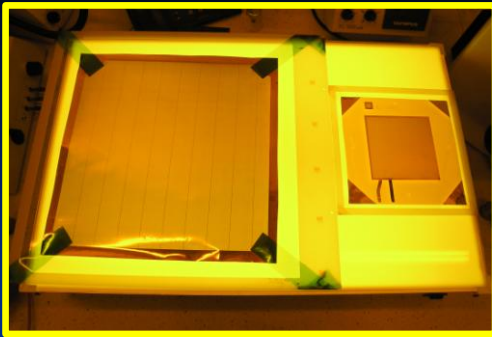
LICENSE AGREEMENT FOR MICROVIA TECHNOLOGY

Licensee: Technology Transfer Agency Techtra Ltd.

GEM manufacturing upon CERN licence:

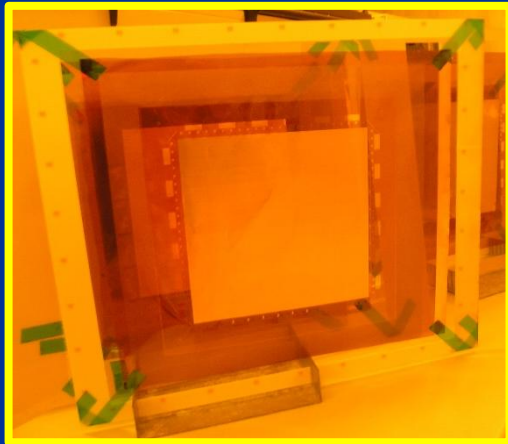
- the same technology
- the same chemistry
- the same quality

RD51, CERN, June 2016



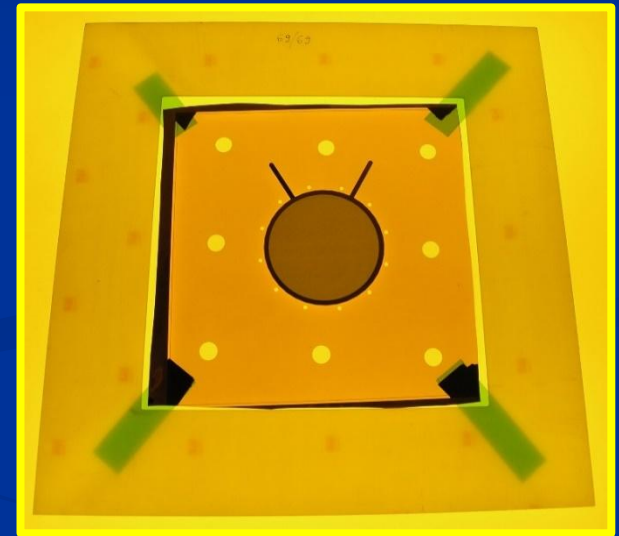
Standard 10x10cm

Since 2010 Techtra has produced over 1000 small GEM foils.

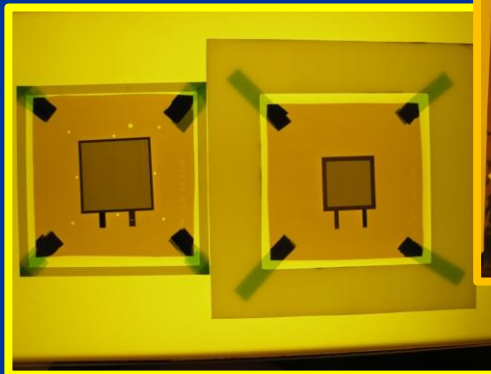


30x30cm „single mask“

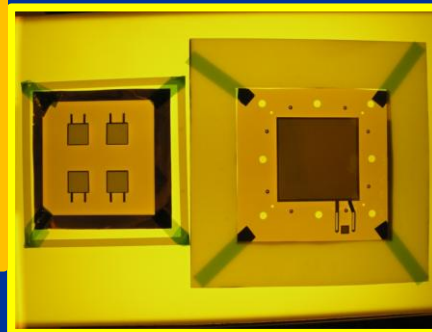
- Different sizes
- Different shapes
- Different pitch
- Different.....



Round \varnothing 5cm



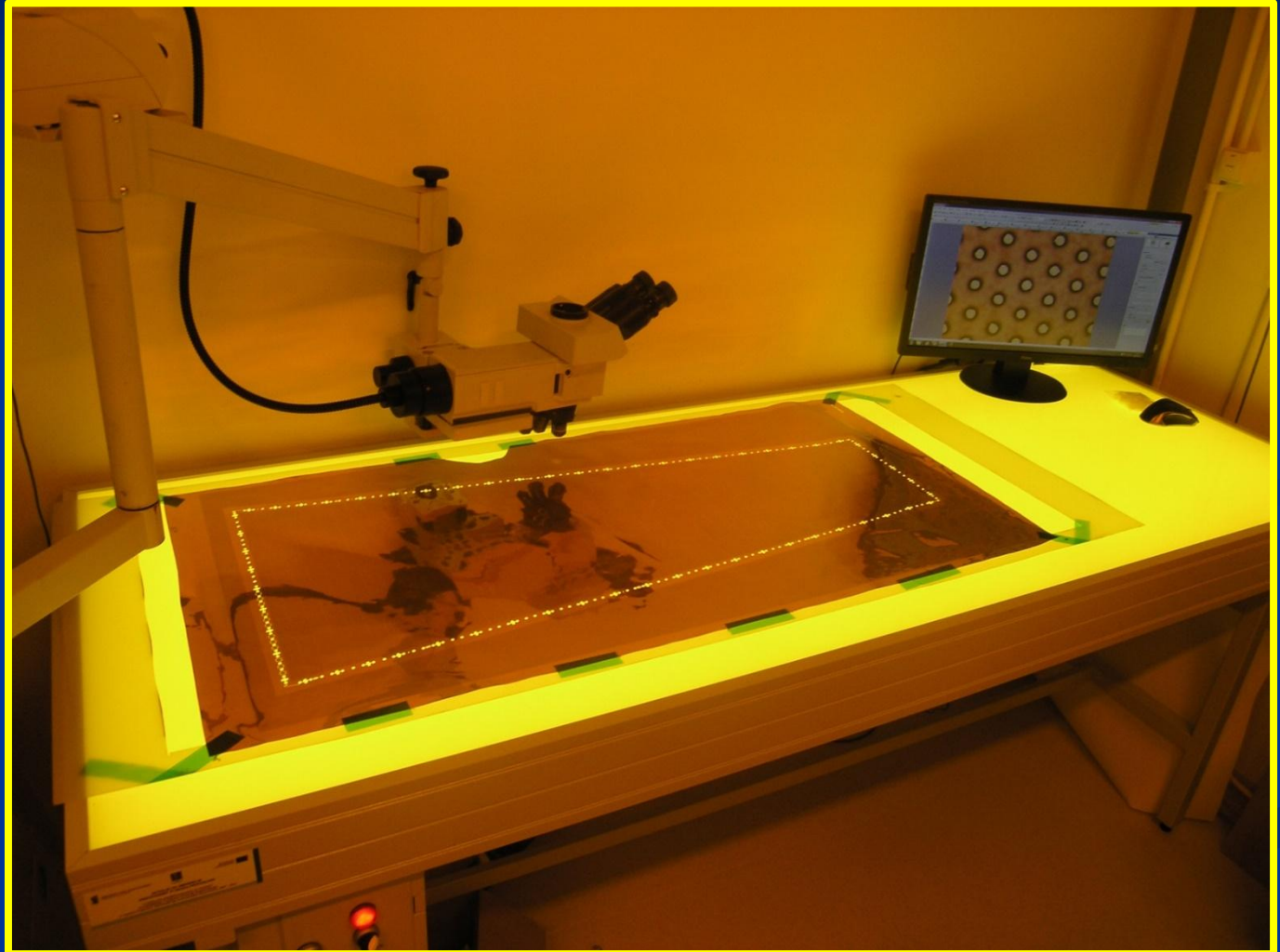
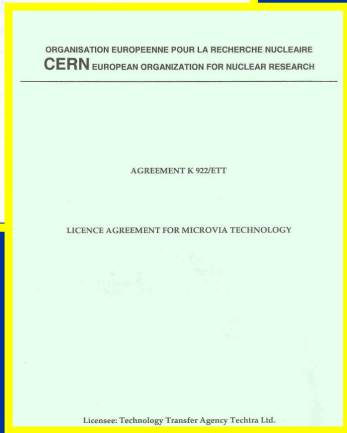
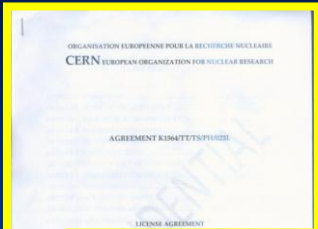
Round \varnothing 12cm



Multi-GEMs Different pitch



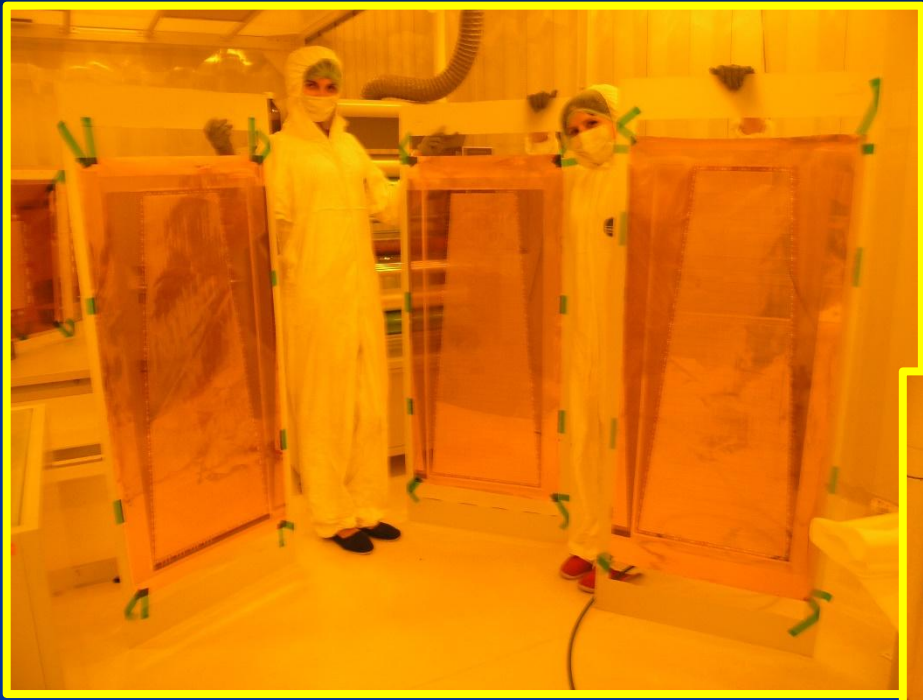
RD51, CERN, June 2016



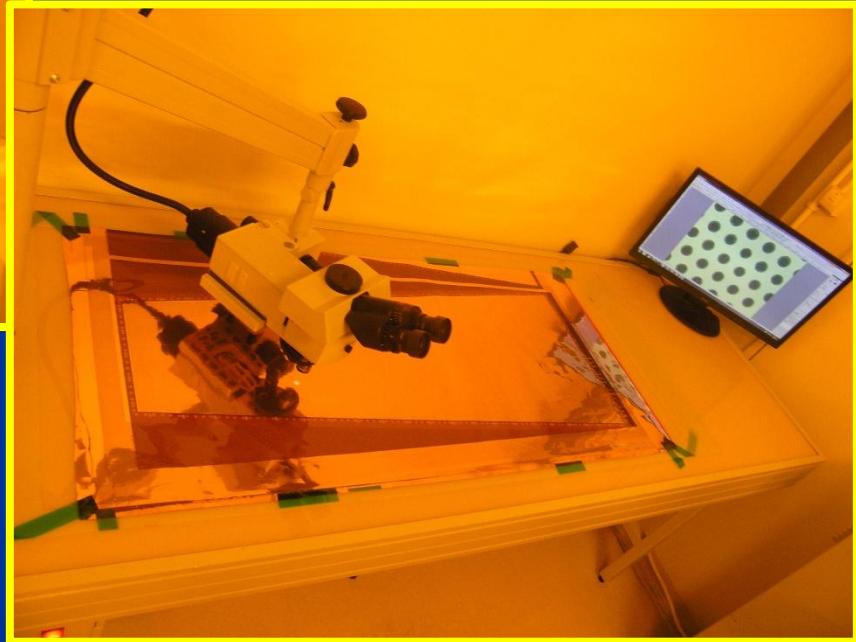
**Micro-Chemical-Vias
technology !**

Prototype of CMS-like GEM (March 2016)

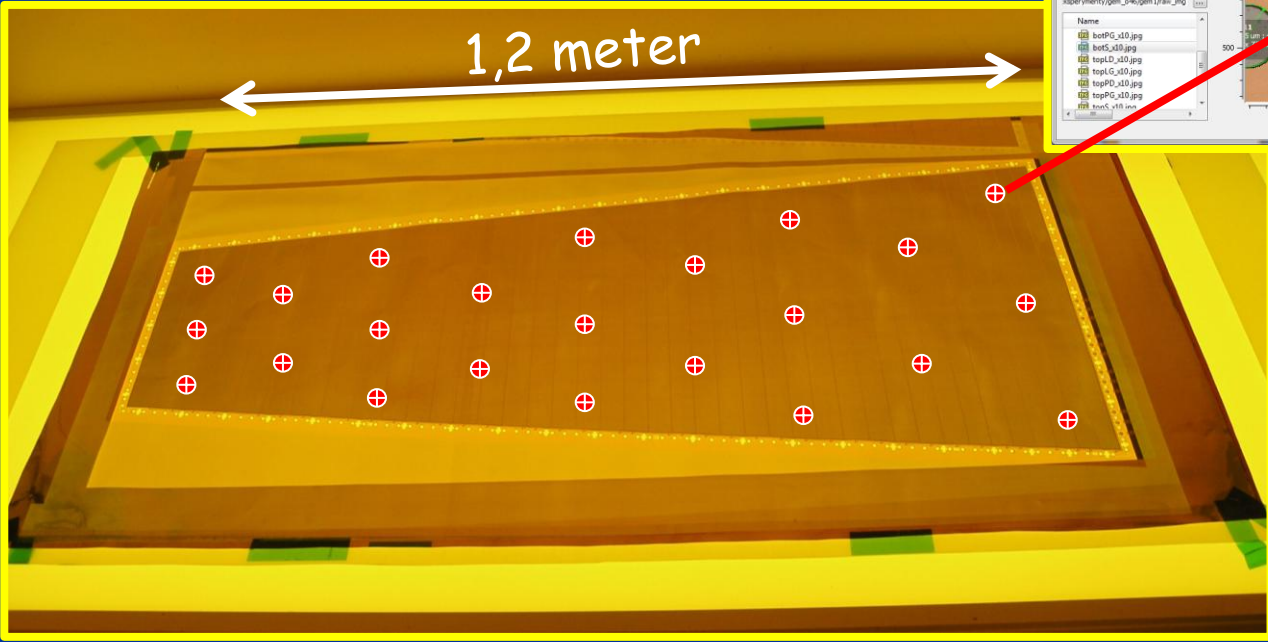
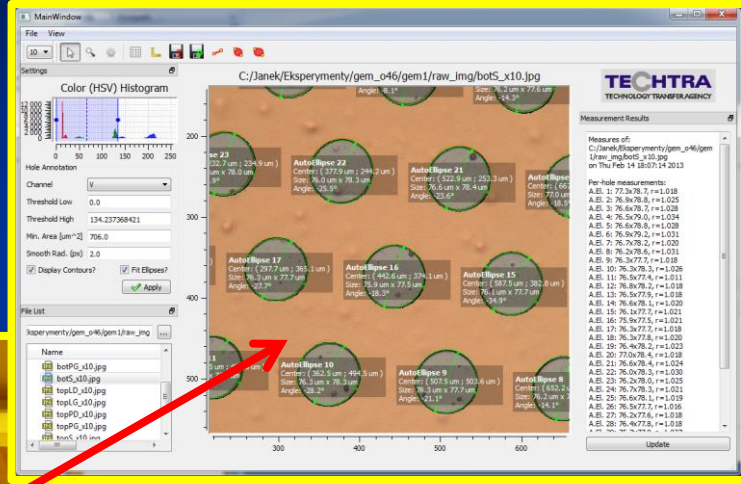
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Serie of 3 GE1/1
GEMs, made by Techtra
in May 2016

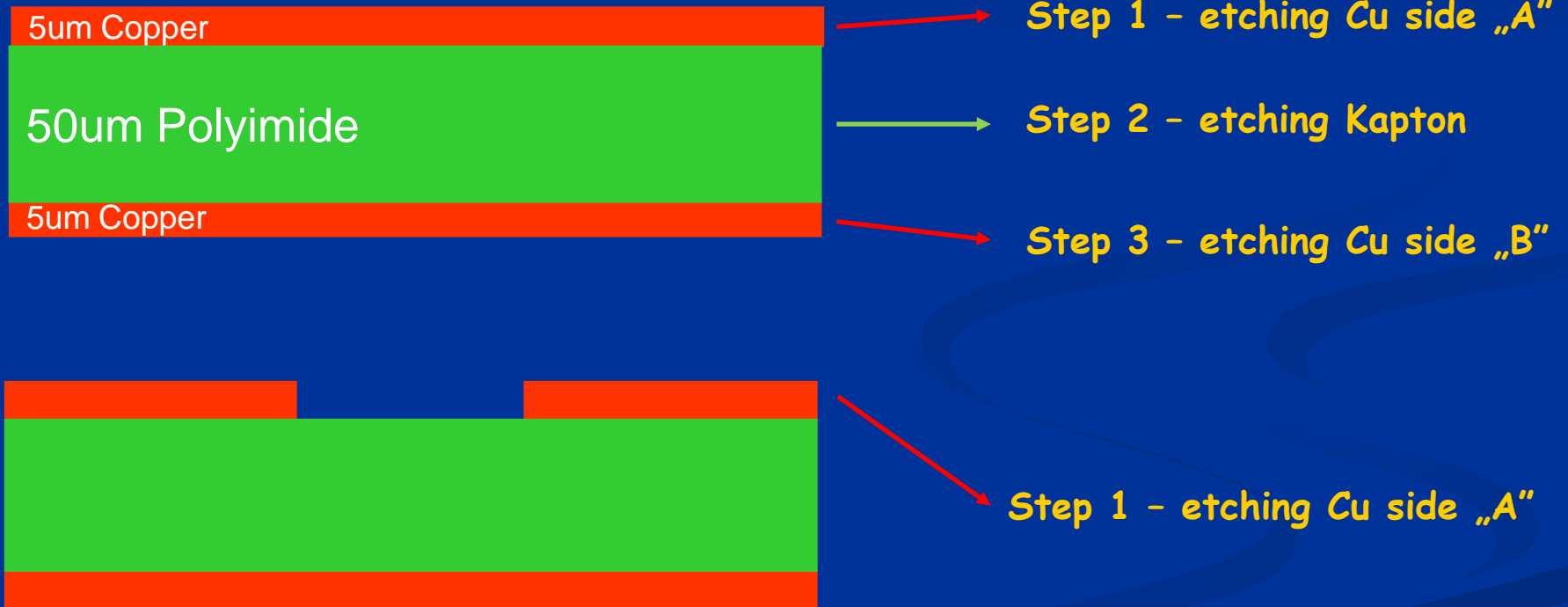


Openings uniformity test:

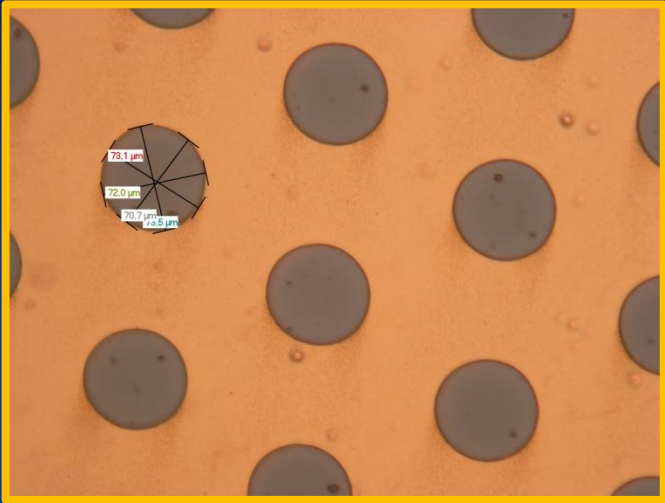
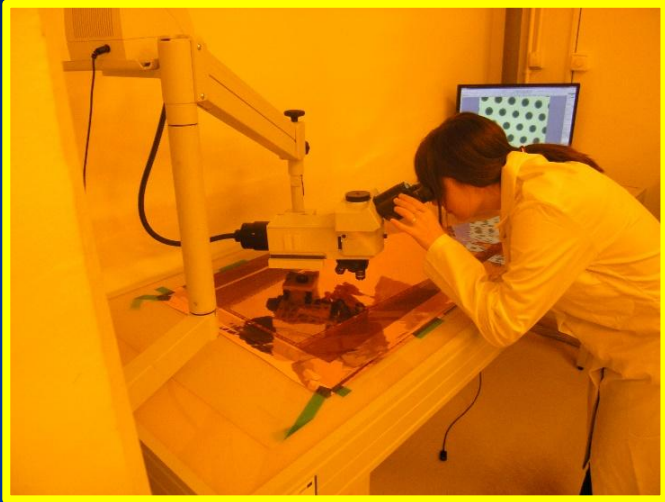


⊕ → Location of measured point. Each GE1/1 gem was measured at 23 points

What to measure in GEMs made with single-mask technique?



Step 1 - etching Cu side „A” - standard procedure. Diameter of $70 \pm 3 \mu\text{m}$



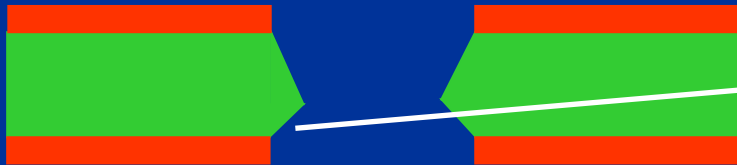
Step 1 - etching Cu side „A”



Step 2 - etching Kapton



Step 3 - etching Cu side „B”



Step 4 - Tuning of the shape

GEM 1 - openings in Kapton

Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	56	51	56	56	55
2	50	53	56	56	56
3	54	48	54	57	54
4	55	45	54	55	55
5	55	49	54	49	55

Median dimension value of GEM 1: 54 µm, std. deviation 3,14 µm

GEM 1 - openings in Cu side „B“

Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	81	68	72	72	76
2	70	70	71	73	73
3	74	65	69	73	76
4	73	66	69	71	71
5	78	65	72	70	76

Median dimension value of GEM 1: 72 µm, std. deviation 4,00 µm

GEM 2 - openings in Kapton

Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	56	52	62	55	54
2	53	58	55	57	
3	57	52	62	57	55
4	56	53	57	59	
5	54	54	64	55	56

Median dimension value of GEM 1: 56 µm, std. deviation 3,14 µm

GEM 2 - openings in Cu side „B“

Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	84	74	76	73	75
2	72	72	71	72	
3	78	72	75	72	74
4	75	72	70	72	
5	80	76	77	74	72

Median dimension value of GEM 1: 74 µm, std. deviation 3,22 µm

GEM 3 - openings in Kapton

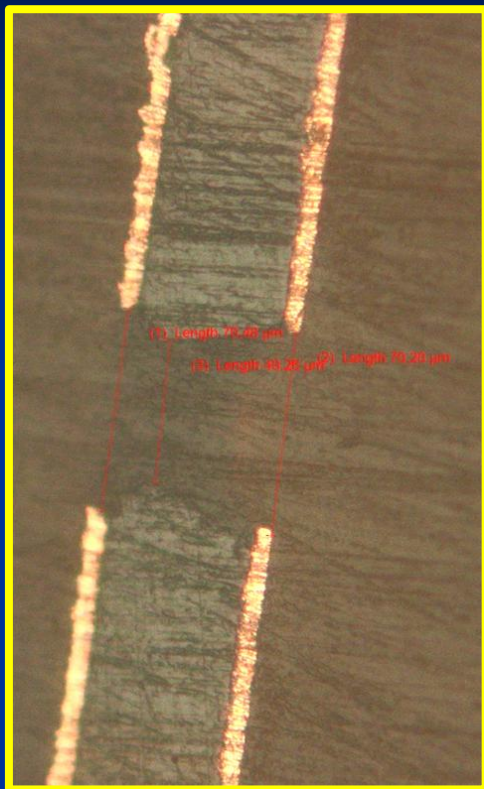
Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	54	48	50	54	51
2	49	53	53	51	
3	54	53	52	52	50
4	55	53	53	53	53
5	55	53	52	50	54

Median dimension value of GEM 1: 53 µm, std. deviation 1,88 µm

GEM 3 - openings in Cu side „B”

Row number	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]	Ø [µm]
1	78	70	74	73	73
2	70	70	71	70	
3	81	70	70	71	72
4	72	72	71	75	
5	79	72	71	71	76

Median dimension value of GEM 1: 72 µm, std. deviation 3,12 µm



Step 4 - Tuning of the shape

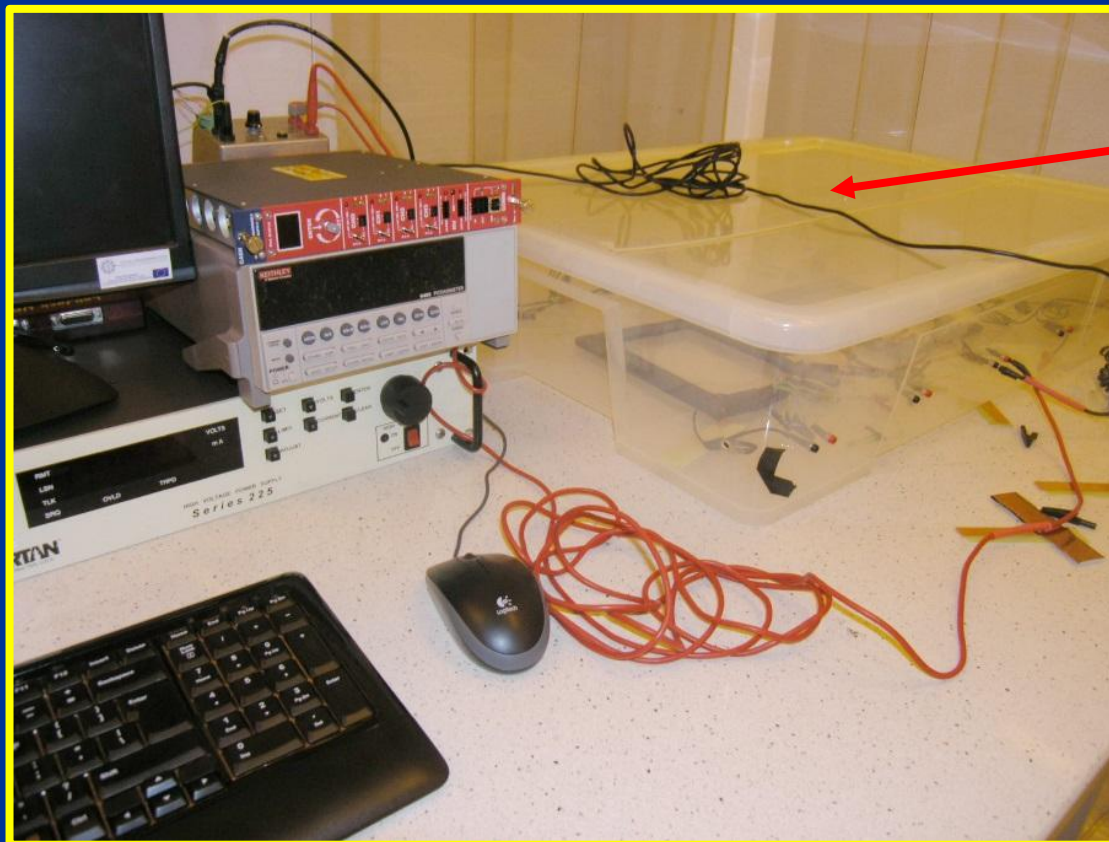
Double conical GEM opening, Techtra

	Cu side „B”		Kapton	
	Median [μm]	Std. dev. [μm]	Median [μm]	Std. dev. [μm]
GEM 1	72	4,00	54	3,14
GEM 2	74	3,22	56	3,14
GEM 3	72	3,12	53	1,88

Remarks

- Side „A” of GEM is uniform
- Side „B” of GEM is not fully uniform:
 - Openings at corners are much greater than others
 - Uniformity may be improved by:
 - Increasing „fake holes” region
 - Increasing numbers of electro-galvanic electrodes

Electrical tests and humidity control



Small test box for different humidity and gas mixture tests

A new test box for 1,5 meter long GEMs is under construction.

HV test stand at cleanroom

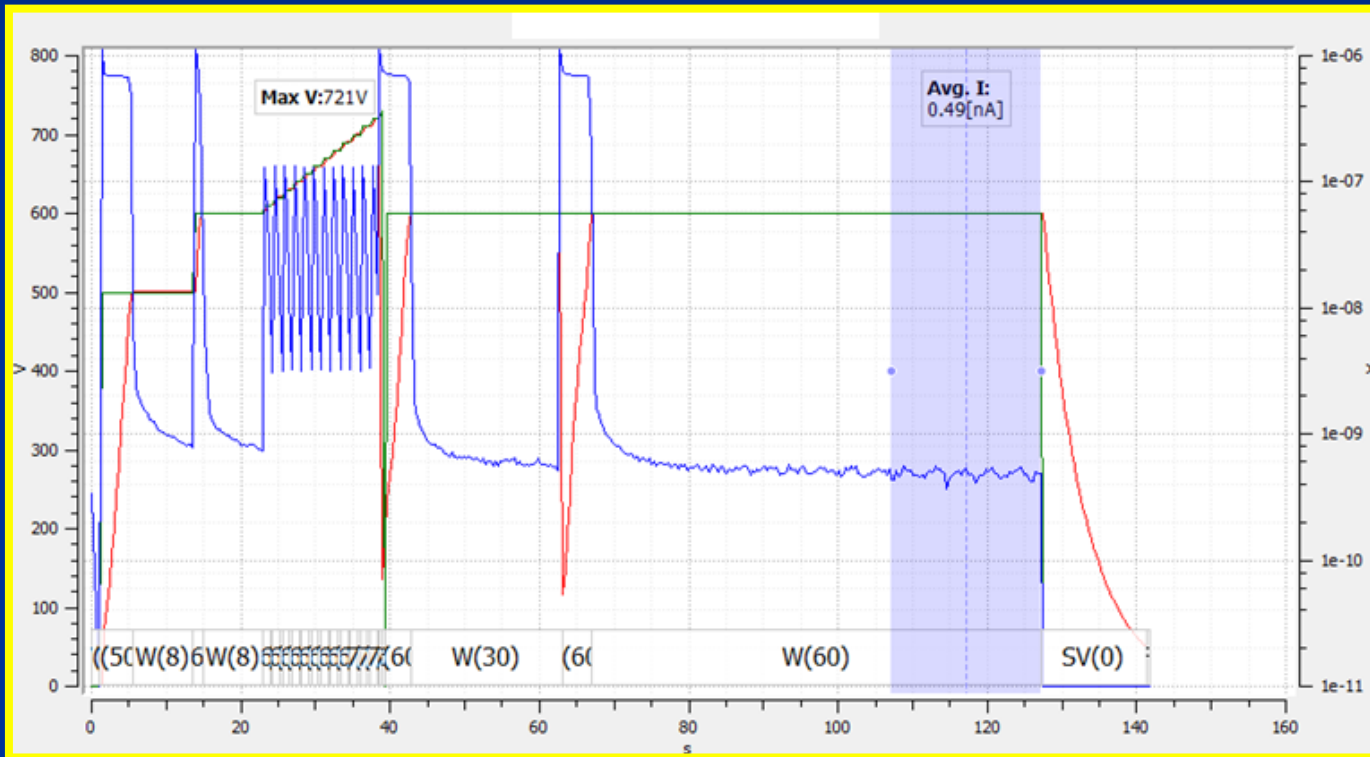


Prototype of CMS-like GEM (March 2016) dark currents

Sector number	Current [nA]	Sector number	Current [nA]	Sector number	Current [nA]	Sector number	Current [nA]
1	2,81	11	5,01	21	1,73	40	2,05
2	2,10	12	1,36	22	4,78	32	9,82
3	16,20	13	1,10	23	2,78	33	2,96
4	5,76	14	3,48	24	4,33	34	3,15
5	1,85	15	20,25	25	3,94	35	1,62
6	1,42	16	15,30	26	1,98	36	5,91
7	5,33	17	3,02	27	3,24	37	25,5
8	2,62	18	3,32	28	4,75	38	5,32
9	3,34	19	2,73	29	1,73	39	2,18
10	4,15	20	1,41	30	3,63	40	1,38

Median currents value of GEM 1: 3,19 μ A @ 600V @ 40% HR
 Standard deviation: 5,31 μ A

Electrical tests



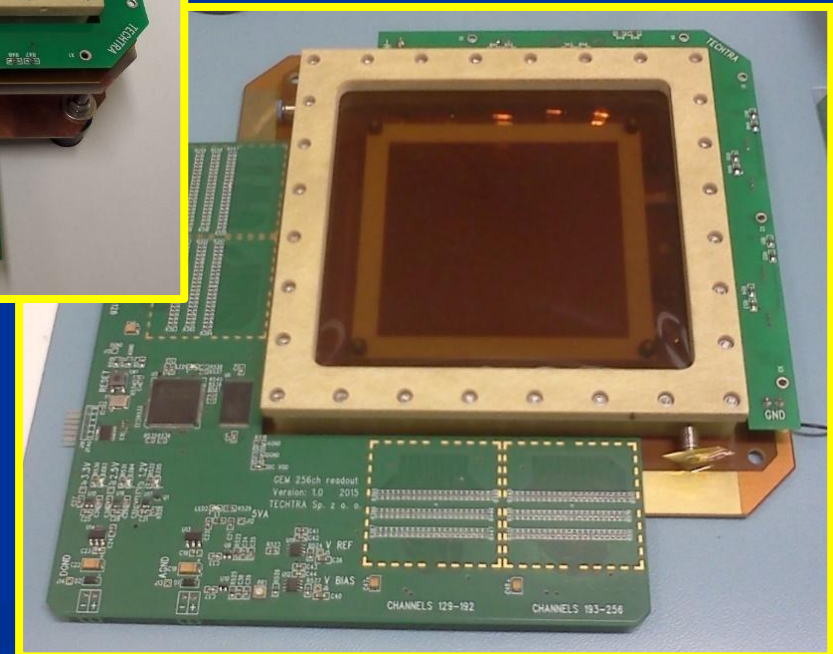
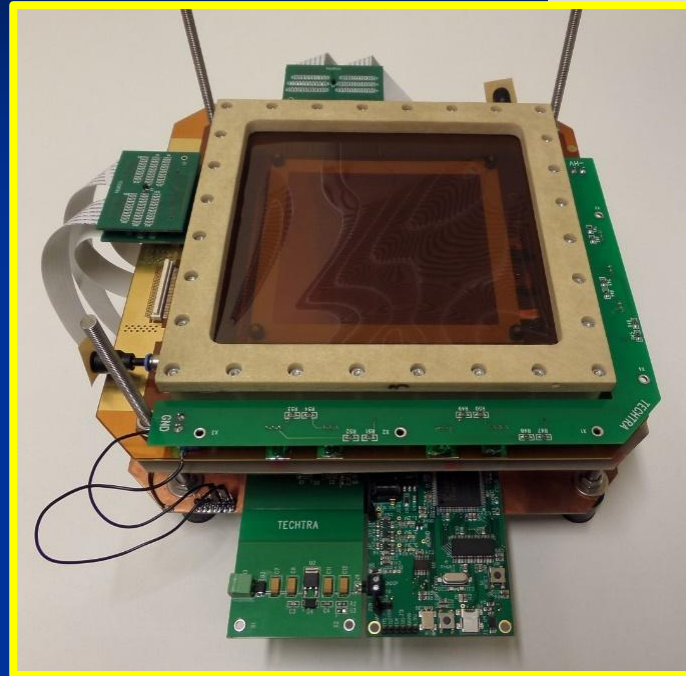
Typical record of
small GEM HV test

HV test for GEM1, GEM2 and GEM3 have not been done because of high humidity - over 60%

GEM detectors sets @ Techtra

Operational prototype

Delivery time:
about one month



Power Supply:

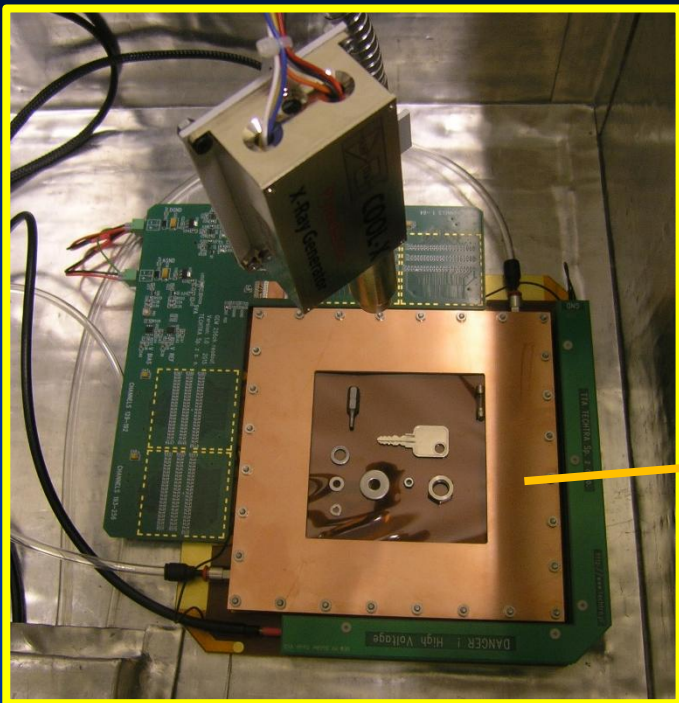
- Analog section: +7 V DC nominal (6,5 V - 9 V)
max current: 200 mA
- Digital section: +7 V DC nominal (6,5 V - 9 V)
max current: 400 mA

High voltage Power Supply and gas:

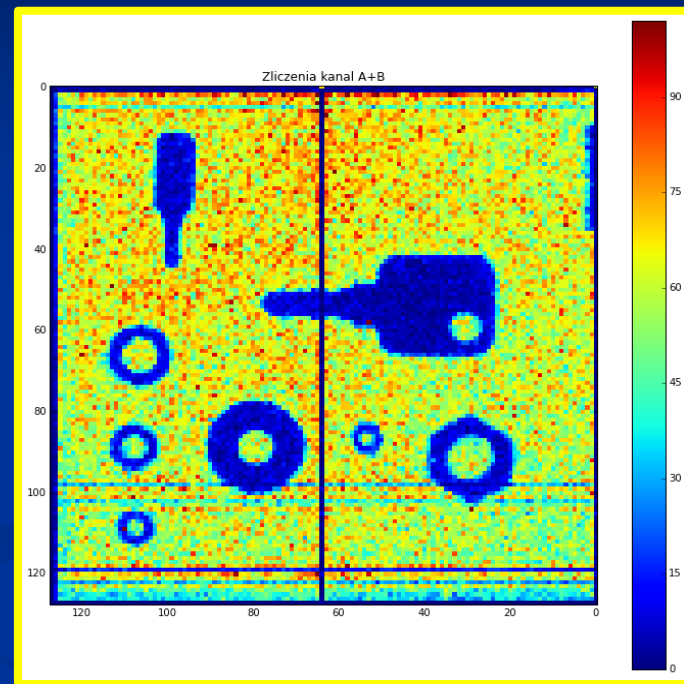
- User defined for proper GEM gain: 2000 V - 3500 V
HV current: 17 μ A @ 3000 V
- Working gas: mixture of Argon and CO₂

Commercially available detector

RD51, CERN, June 2016



GEM detector made by Techtra.



Radiograph made with Cool-X
Amptec miniature X-ray generator

Noise levels when readout board is plugged onto detector:

- Average noise amplitude: 2.8 fC
- Maximum noise amplitude: 5.3 fC
- Average noise [RMS]: 0.8 fC_{RMS}
- Maximum noise [RMS]: 1.2 fC_{RMS}

Charge Bias:

- Regulated by VR1 potentiometer
- Uniformity: < +/- 5%

More info: <http://techtra.pl/en/node/32>

Our Core GEM-team



Conclusions:

1. TECHTRA produces big size GEM foils like GE1/1.
2. Techtra offers complete 10x10cm Plug@Play GEM detectors systems.
3. Techtra has ability to design & produce prototypes or small series of dedicated electronics devices



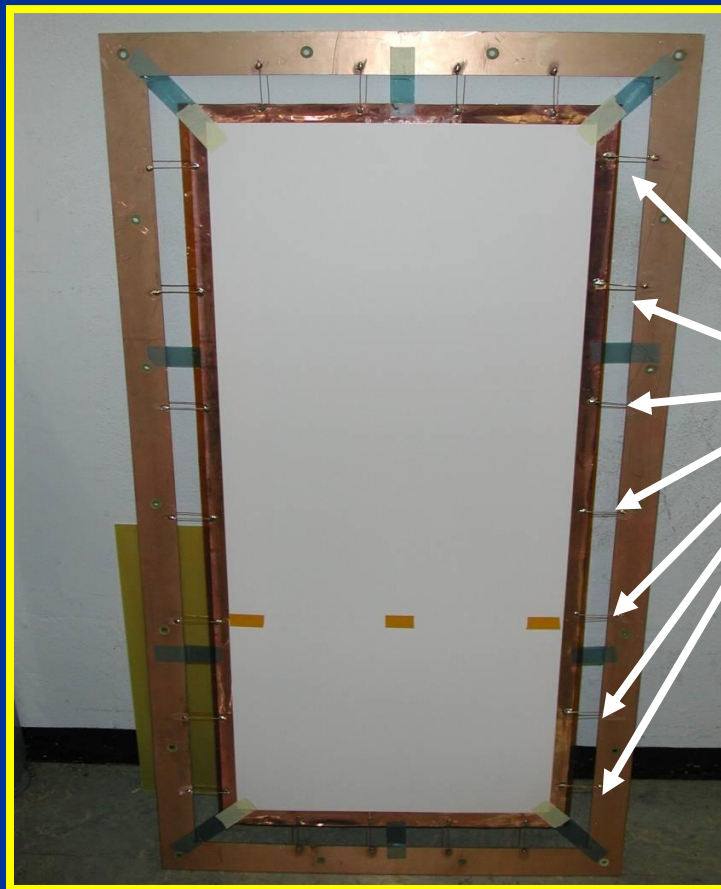
„Dotacje na innowacje”

RD51
collaboration

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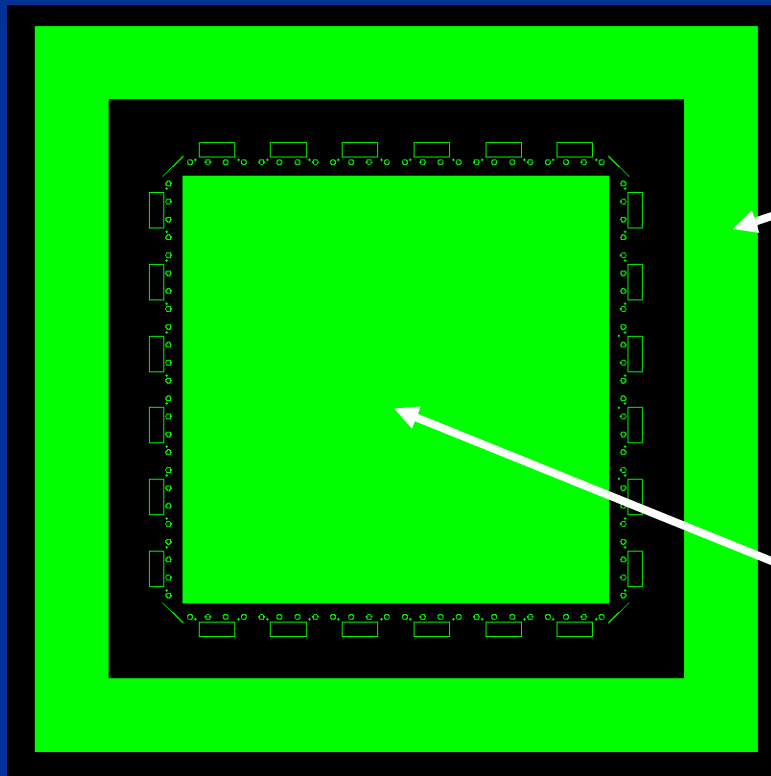
BACKUP:

Improving openings diameter homogeneity:



Multi-electrodes galvanic system

„Fake holes” concept



GEM „fake holes” - to improve openings uniformity during electro-galvanic etching

GEM active area - „true holes”

GEM foil layout.