Quality Test of the KLOE-IT GEM foils

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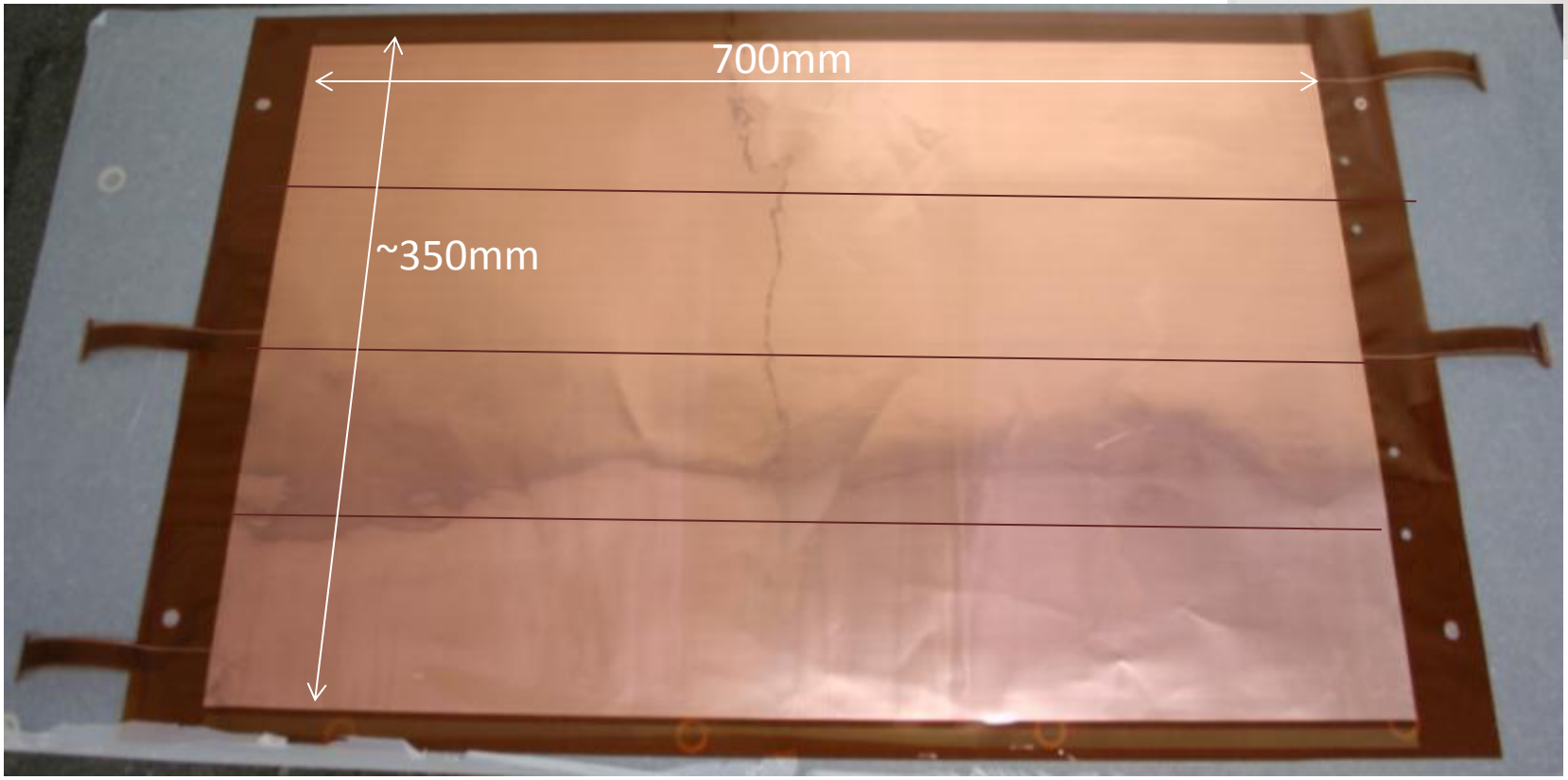
on behalf of the KLOE-IT group

The KLOE IT GEM foil

Detail of the HV connection with the 10+1 vias

N.4 macro-sectors on the bottom side
N.40 micro-sectors (80 cm2) on the top side
All the HV connections are brought to the bottom side through vias, filled with conductive silver glue.



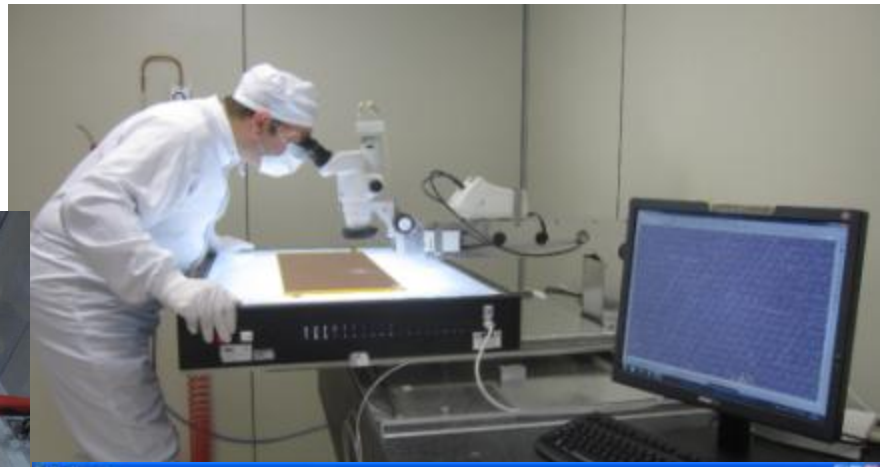
HV test & Visual Inspection

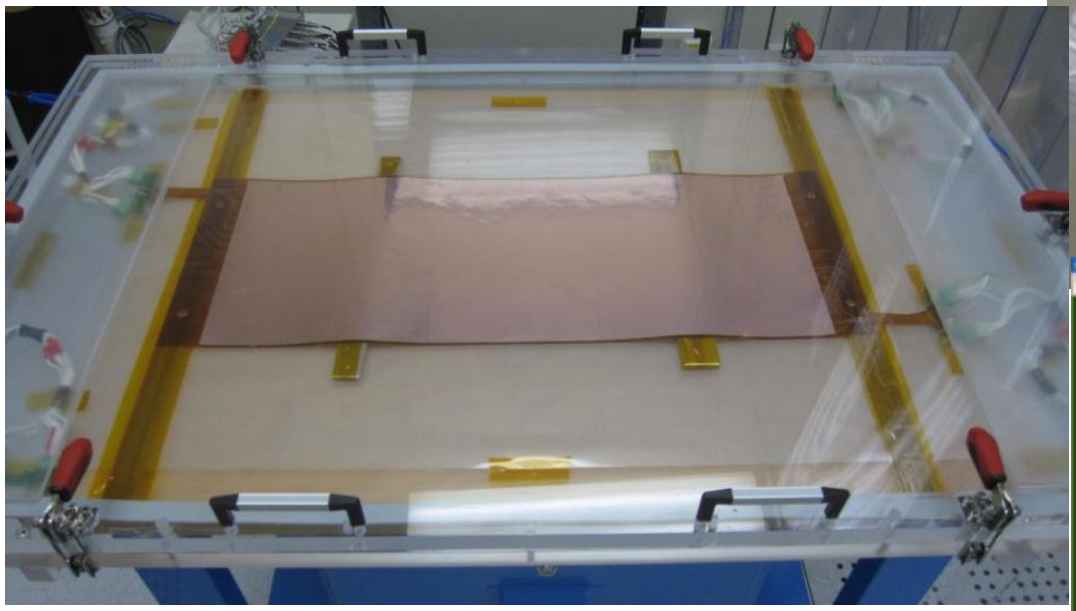
The quality of GEMs is checked with HV in a N_2 flushed box, for humidity reduction (<10% RH).

During the test each sector of the GEM foil is supplied up to 600 V.

Discharge rate and leakage current are monitored.

HV connections are also checked to have R < 2 Ohm





A complete test of a GEM foil takes > 4 hours

Details of GEM test

	Problems	Actions	Outcome	Comments
LAYER 1				
L1G1A			OK	fig. 1a,b
L1G1B			OK	
L1G1C			OK	fig. 2
L1G1D	5 nA @ 600 V	none	BAD	
L1G2A			OK	
L1G2B	short-circuit on 1 sector	none	BAD	
L1G2C			OK	
L1G2D			OK	
L1G3A			OK	
L1G3B			OK	
L1G3C	150 nA @ 450 V and discharge spots	none	BAD	fig. 3
L1G3D			OK	
LAYER 2				
L2G1A			OK	
L2G1B			OK	
L2G1C	cut by blade on two HV tracks	none	BAD	
L2G1D			OK	fig. 4a,b
L2G1E	continous discharge (over-etching)	none	BAD	fig. 5a,b
L2G1F			OK	
L2G2A			OK	
L2G2B	300 nA @ 590 V	back to CERN	OK	
L2G2C	6 nA @ 600 V; over-etching; HR-HV tail;	back to CERN		
	HV tail resistance > 2 Ohm	back to CERN	BAD	
L2G2D			OK	
L2G3A			OK	
L2G3B	80 nA @ 450V;	back to CERN		
	HV tail resistance > 2 Ohm		BAD	
L2G3C	120 nA @ 450 V	back to CERN	OK	
L2G3D	HR-HV tail	back to CERN	OK	

	Problems	Actions	Outcome	Comments
LAYER 3				
L3G1A	over-etching		BAD	
L3G1B			OK	
L3G1C			OK	fig. 6
L3G1D			OK	
L3G2A			OK	
L3G2B	continous discharges	back to CERN		
	HV tail resistance > 2 Ohm		BAD	
L3G2C	5 nA @ 600 V; short-circuit on S18;	back to CERN	OK	
L3G2D			OK	
L3G3A			OK	
L3G3B	1000 nA @ 600 V	none	BAD	
L3G3C			OK	
L3G3D			OK	
LAYER 4				
L4G1A			OK	
L4G1B	3 over-etching; 1 short-circuit	none	BAD	fig. 7a,b,c
L4G1C			OK	
L4G1D			OK	
L4G2A	bad etching quality between microsectors	back to CERN	BAD	fig. 8
L4G2B			OK	
L4G2C			OK	
L4G2D	150 nA @ 600 V	back to CERN	OK	
L4G3A			OK	
L4G3B			OK	
L4G3C			OK	
L4G3D			OK	

Summary

- 50 GEM foil total
- 38 (76%) GEM foils OK
  - 5 of them recovered after Rui's washing
- 12 (24%) GEM foils BAD
  - 8 problems in active area: 3 current leak, 1 short, 3 continuously discharging, 1 rough defined sector edge
  - 4 external problems: 3 high resistance HV vias, 1 damaged HV tails

GEM Zoology

Typical discharge spots

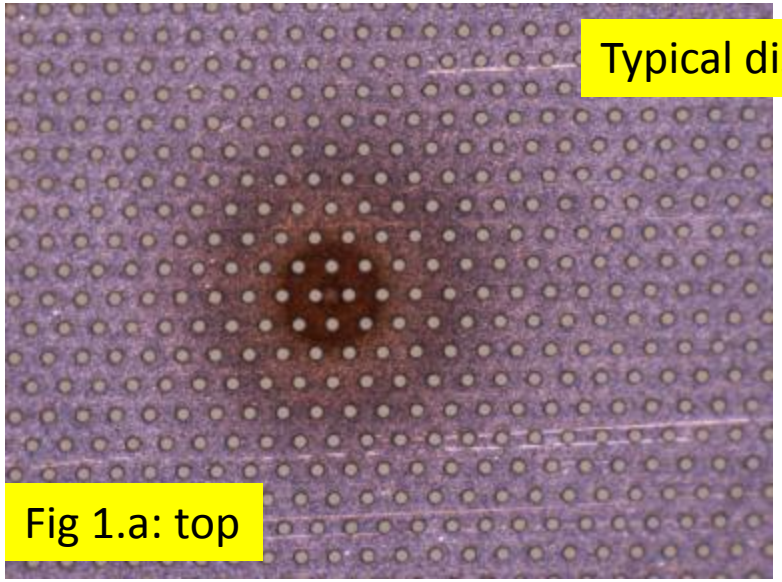


Fig 1.a: top

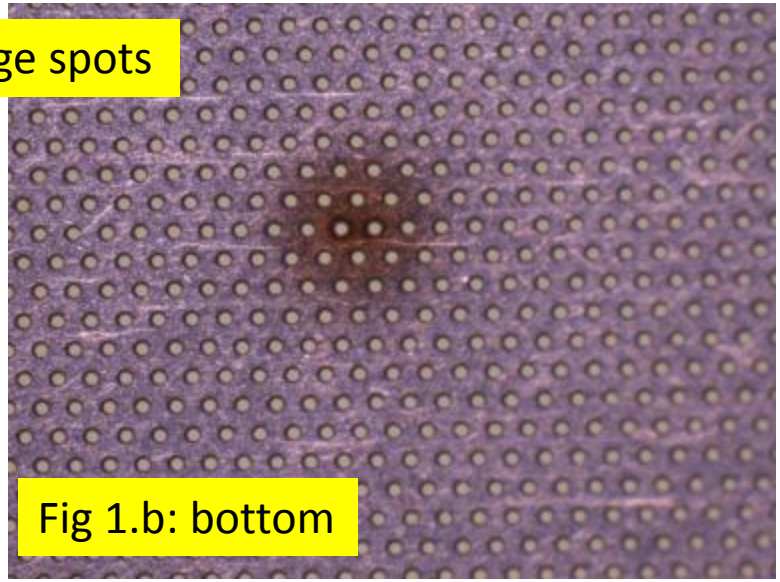


Fig 1.b: bottom

Fig 2: small missing hole

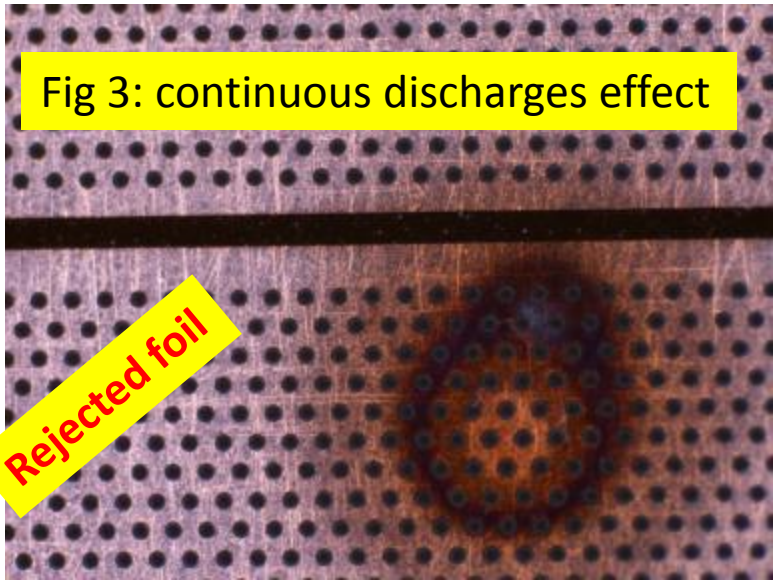
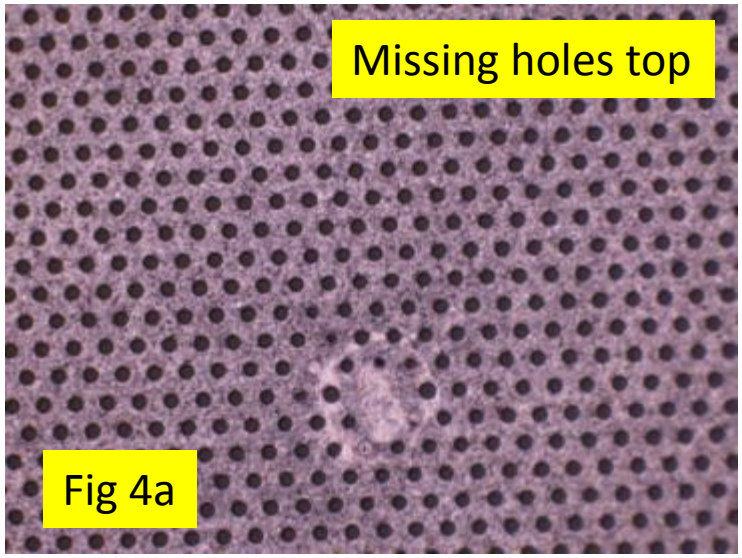
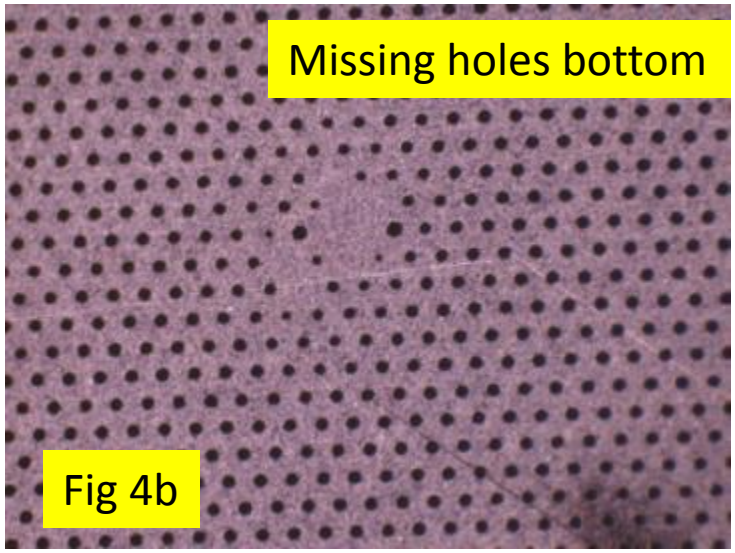
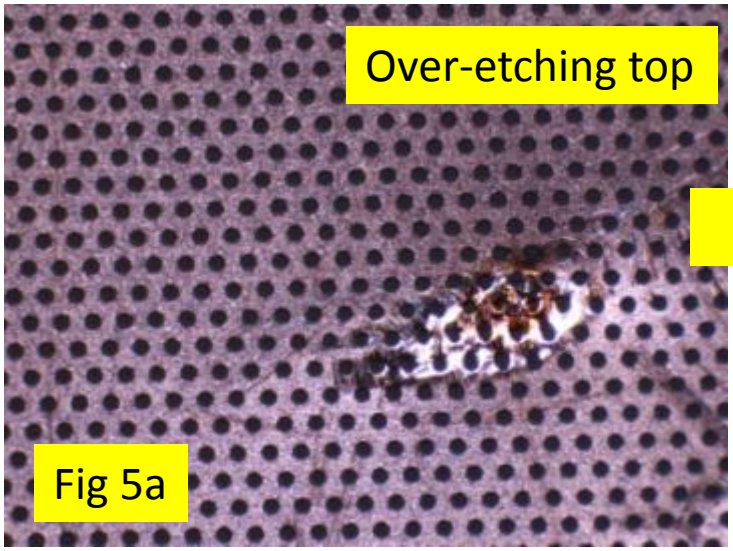


Fig 3: continuous discharges effect

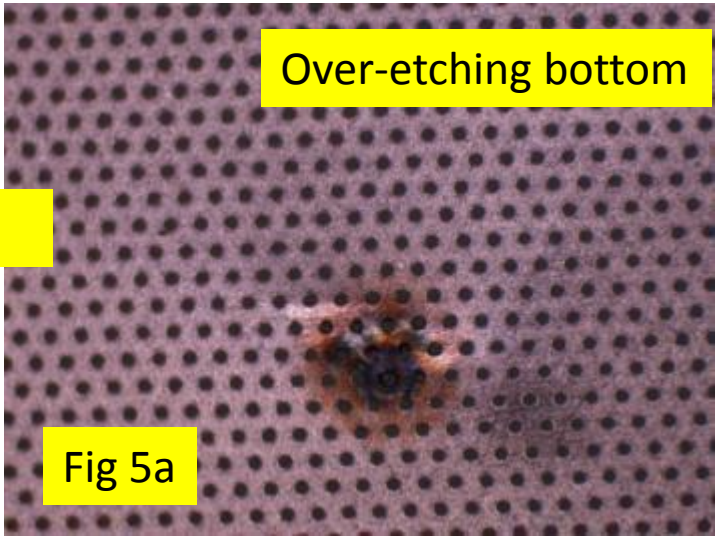
Rejected foil







Rejected foil



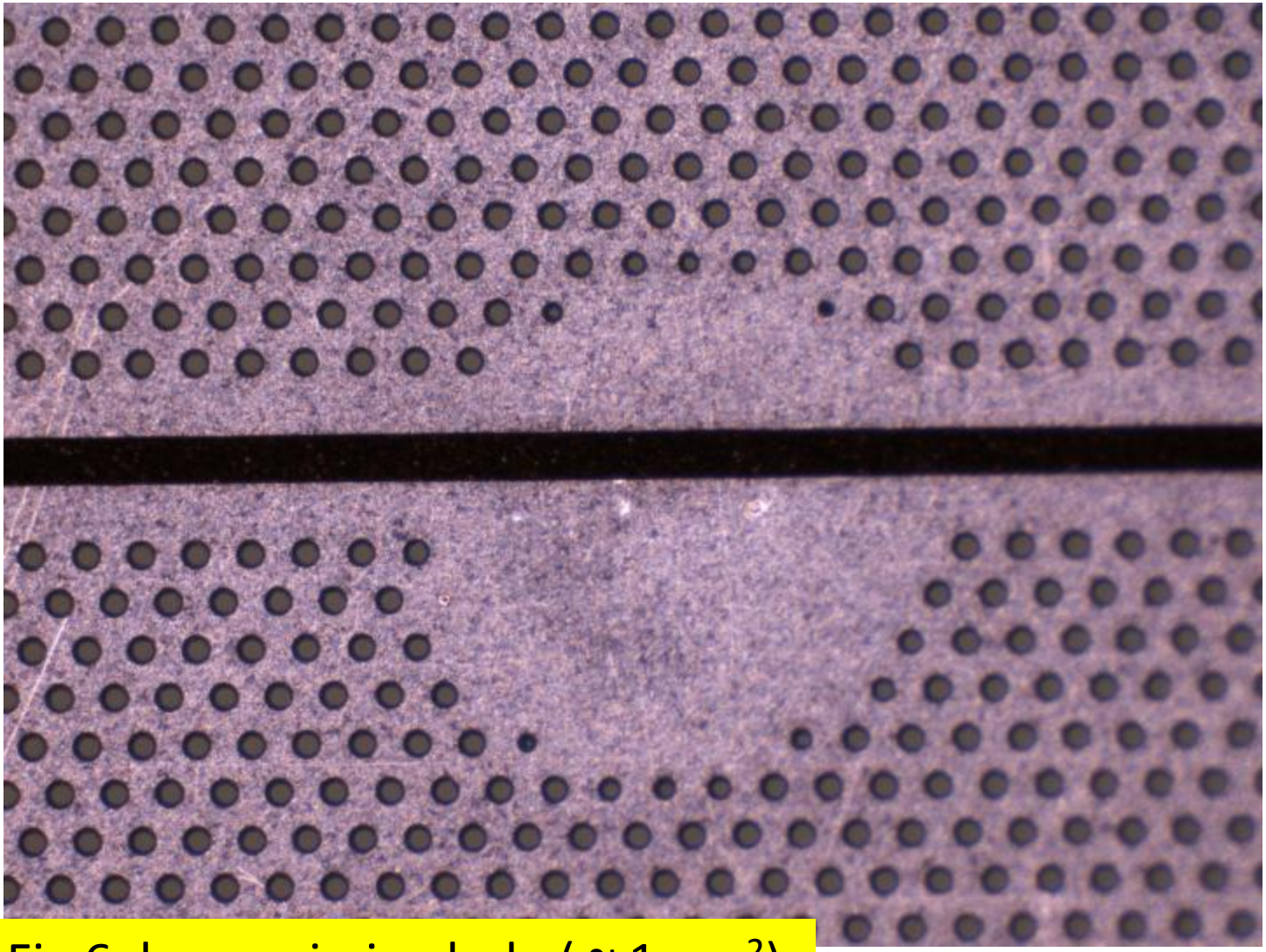


Fig 6: large missing hole (~ 1mm^2)

Typical heavy “over-etching” with residual bottom copper film, leading to continuous discharges (all on the same foil!)

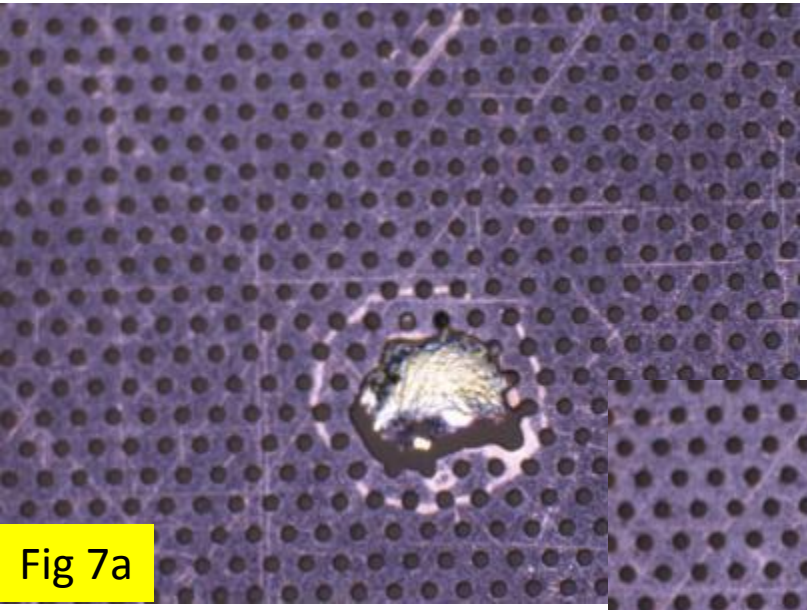


Fig 7a

Rejected foil

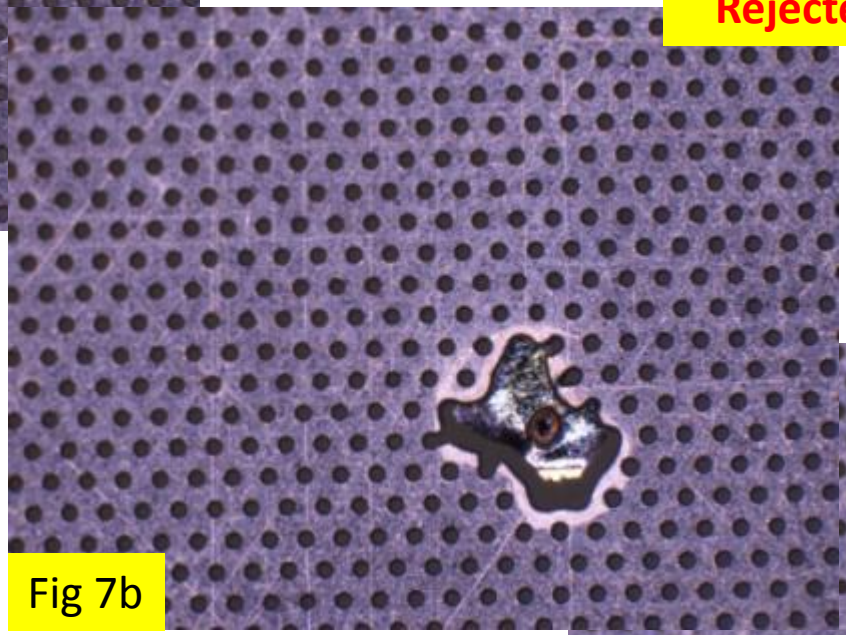


Fig 7b

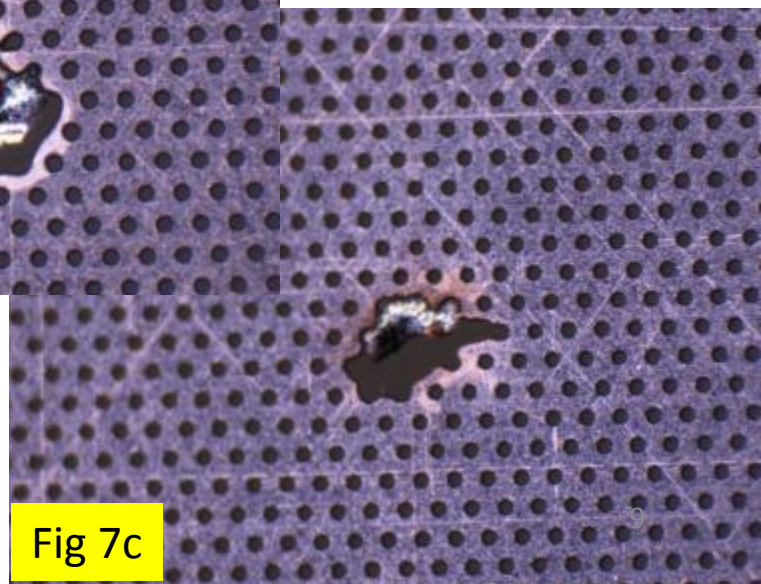
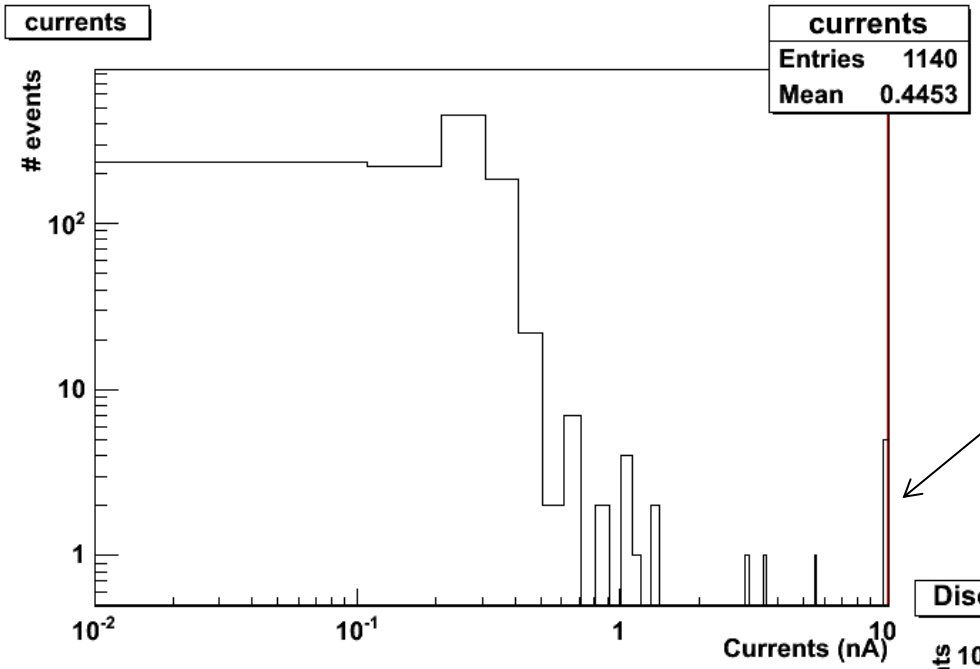


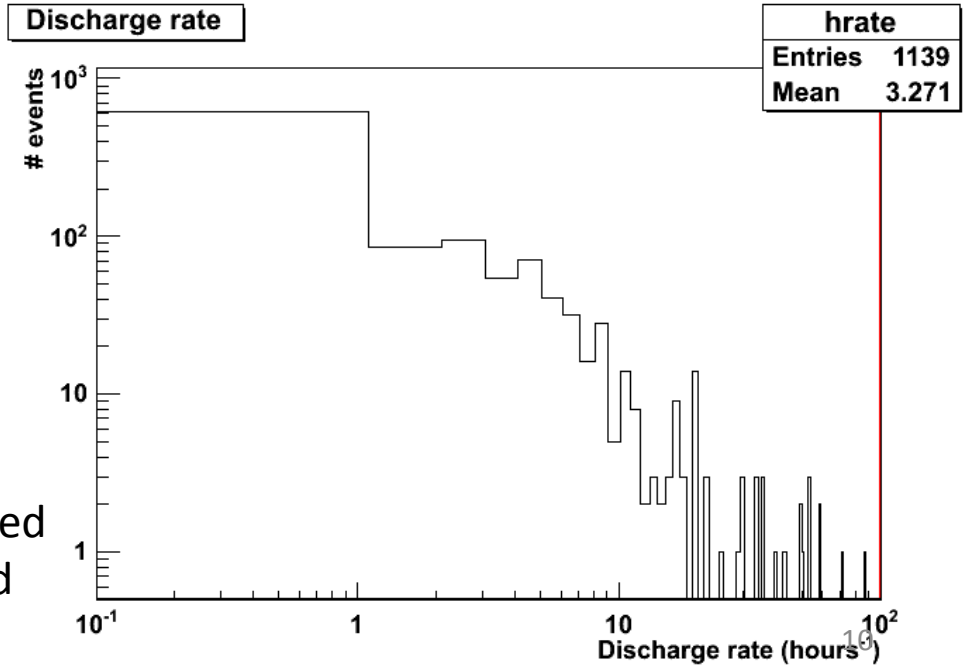
Fig 7c

Current & Discharge rate per sector @ 600 V (in Nitrogen)



Layers 1,2,3

overflow



Discharges counted
in 1 hour period

Conclusions

- The GEM quality test is a high time consuming phase of a GEM detector construction
- The GEM production suffers various problems to be understood & kept under control: the most dangerous is probably the “over-etching” with a residual bottom copper film
- For KLOE the yield was 76% (84% if only active area problems are considered)