Ageing studies of resistive-anodes Micromegas for HL-LHC

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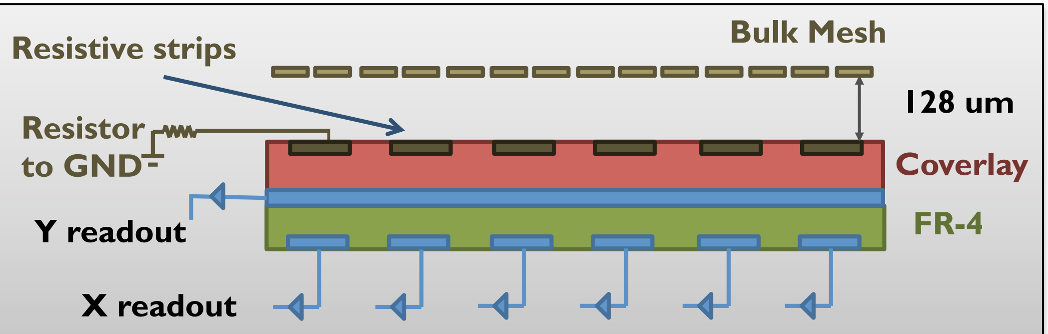
on behalf of MAMMA collaboration

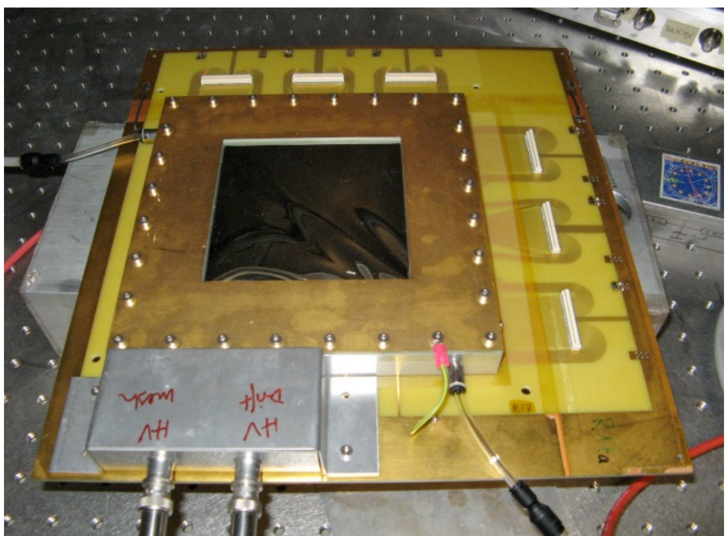
Resistive-anodes prototypes

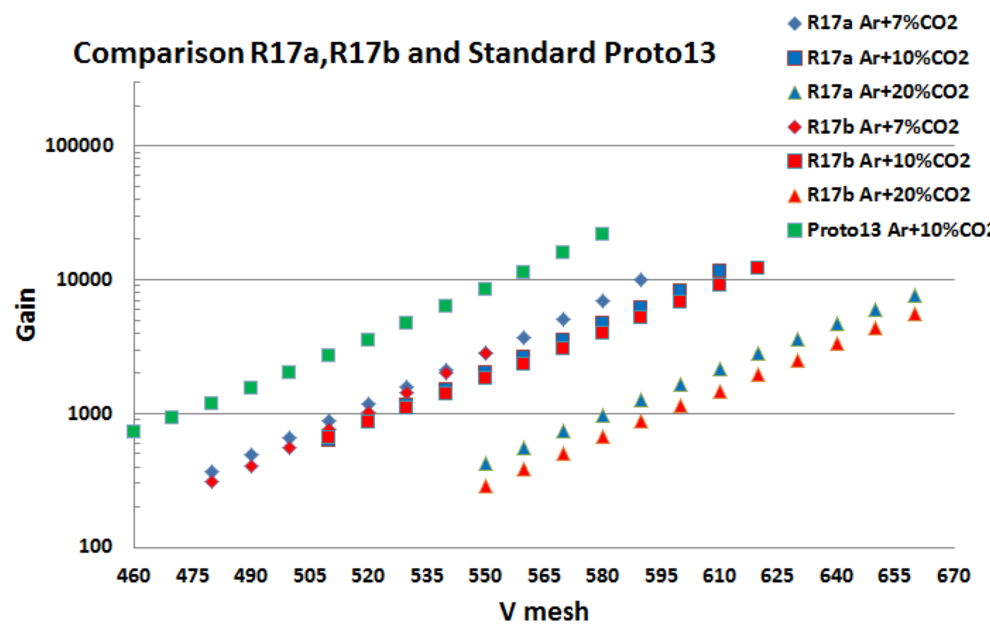


Geometrical properties	
Strip pitch/width for all	250 µm / 150 µm
Top layer (R-strips)	35 µm thickness
Insulator (Coverlay)	60 µm
Y strips (90° to R-strips)	9 µm (Cu)
Insulator (FR-4)	75 µm
X-strips (as R-strips)	9 µm (Cu)

	R17 A	R17 B
R to GND	80-140 MΩ	60-100 MΩ
R along strips	45-50 MΩ/cm	35-40 MΩ/cm

Detectors manufactured @ CERN workshop by R. de Oliveira and lent by J. Wotschack



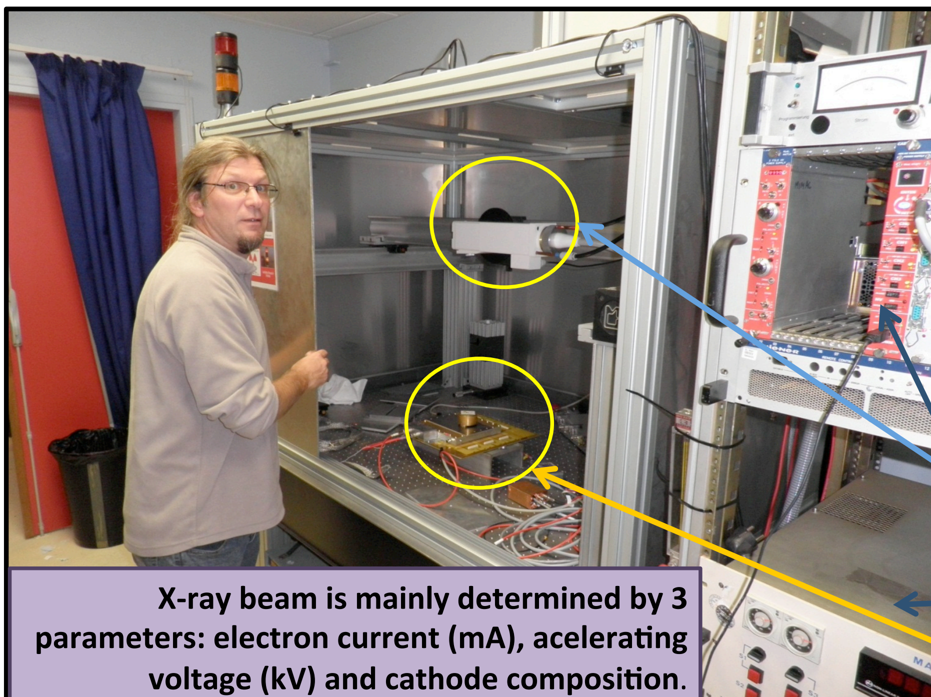


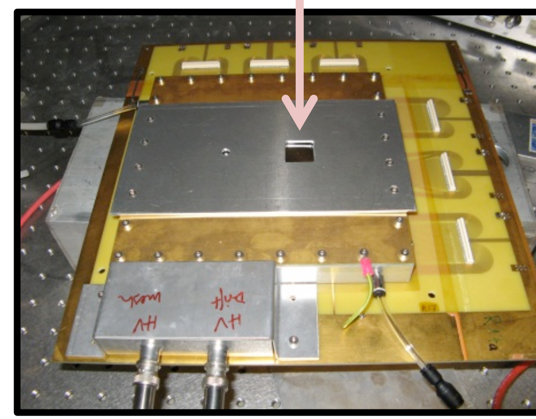
X-rays irradiation setup

X-rays irradiation simulates the total charge accumulated by the detector on a long-time operating period

Operating conditions	
Gas mixture	Ar+10% CO_2
Gas flow	1 renewal per hour (0,5 l/h)
Gain	~ 5000

Detector is exposed only in an area of 4 cm² in order to have a controlled exposed region.





First irradiation period

Equivalent charge generated during 5 years at HL-LHC

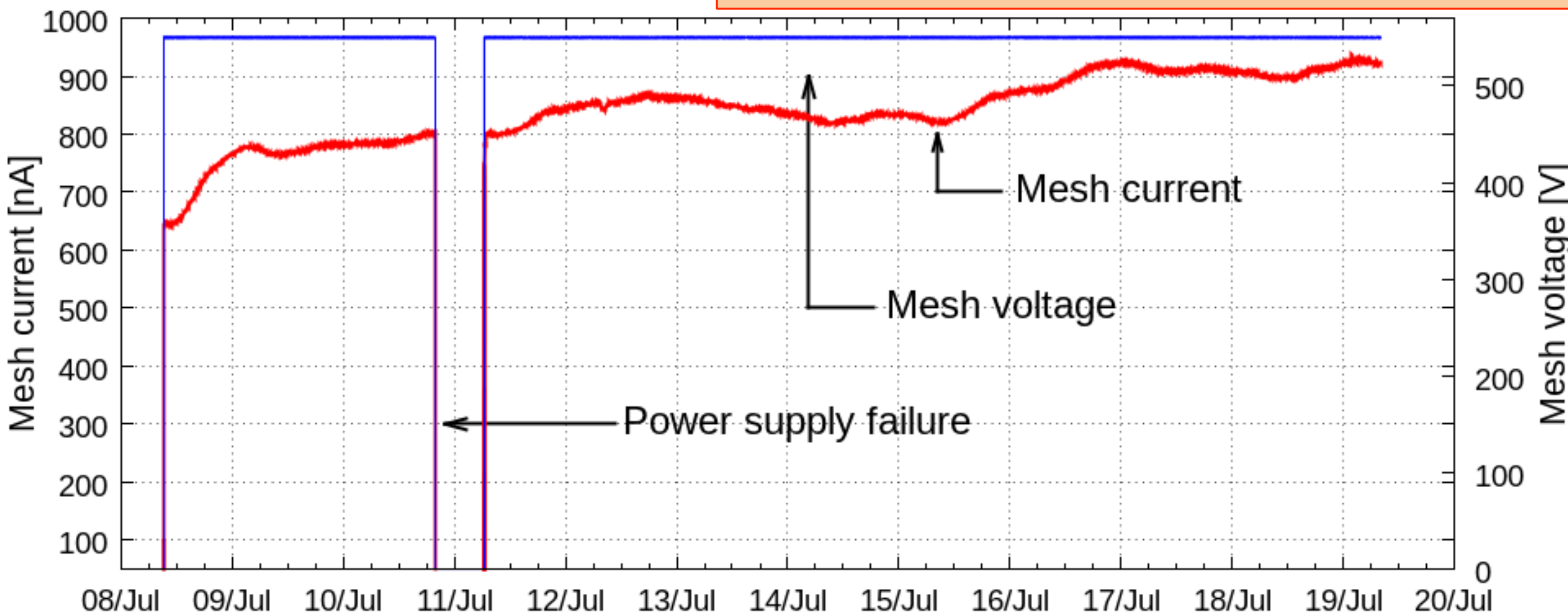
- Maximum expected rate in the region near the beam pipe: 10 kHz/cm^2
- 1000 days of operation (200 days/yr)

- Detector parameters:
  - Ionization potential → W_i (Ar/10% CO_2) = 26,7 eV
  - Gain → 5000
  - MIP energy deposition in 0,5 cm conversion gap → 1250 eV

- Q^{Total} (5 yrs HL-LHC) = 32,5 mC/cm^2

Total exposure time: 11 days and 21 hours
Total charge integrated: 765 mC in 4 cm^2

→ 5 years of HL-LHC with a security factor more than 5

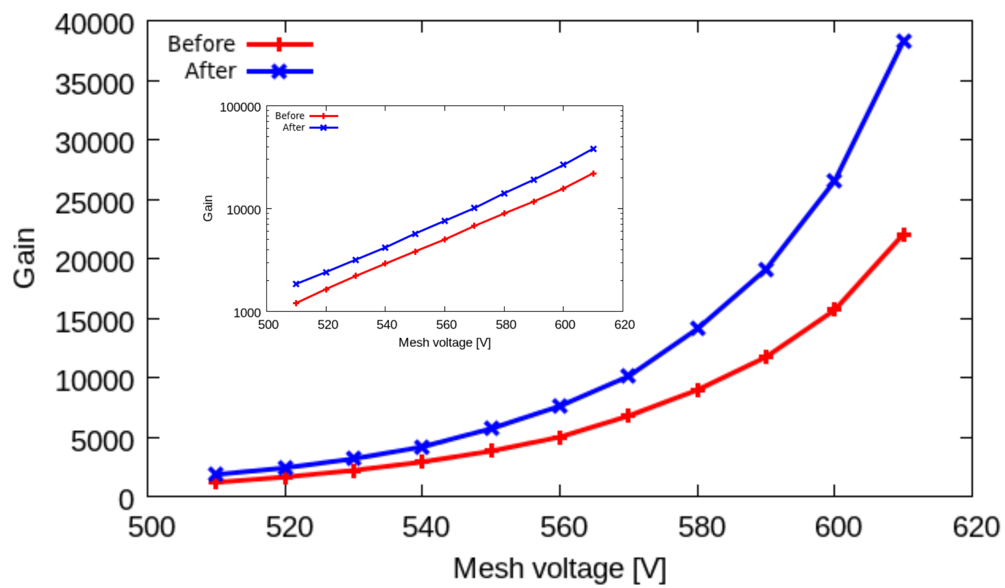


First conclusion

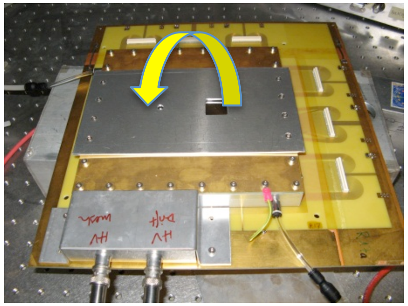
No ageing visible after more than 5 years of HL-LHC
BUT
An increase of almost 50% on the whole period

Possible explanations:

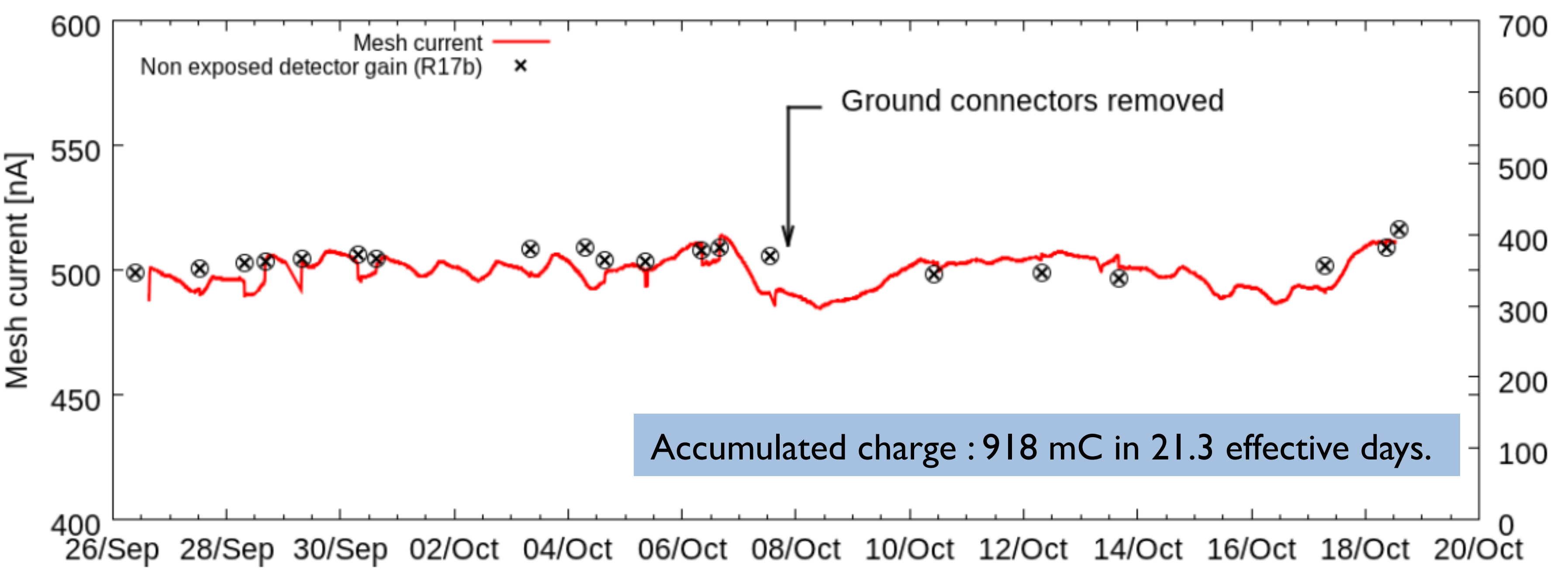
- Curing of the resistive material
- X-strips (copper) were not grounded → charging effect?
- Gas mixture (outgasing, pollution, …) → no reference detector



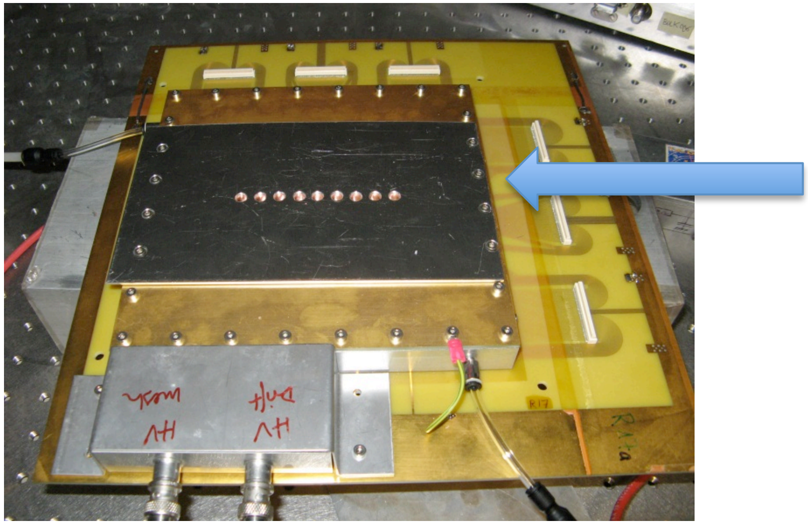
Second irradiation period



- Irradiation in another area of the detector → the mask is just flipped
- Copper X-strips are properly grounded (endcaps)
- Gain of the reference detector (R17) is regularly controled in order to check the gain variations due to (P,T) effect or to gas mixture pollution.



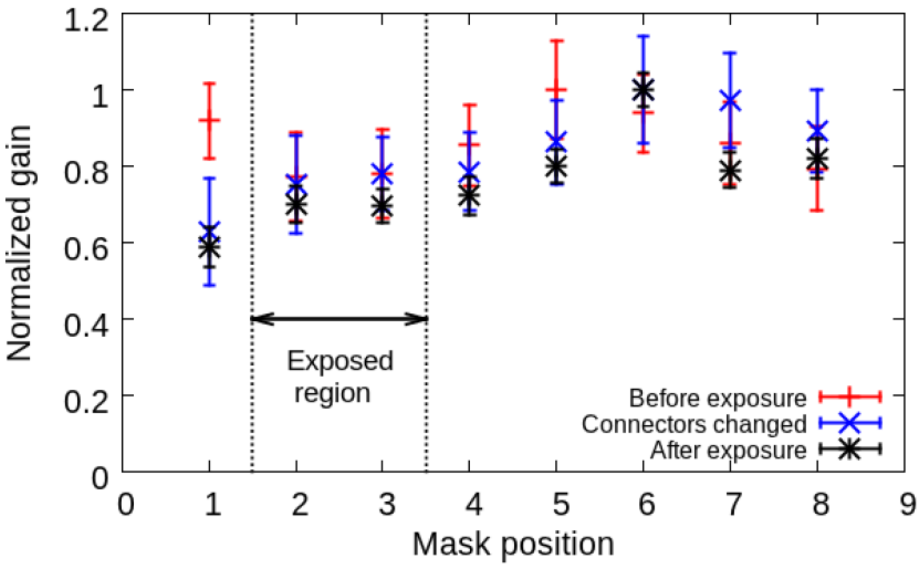
Gain stability check



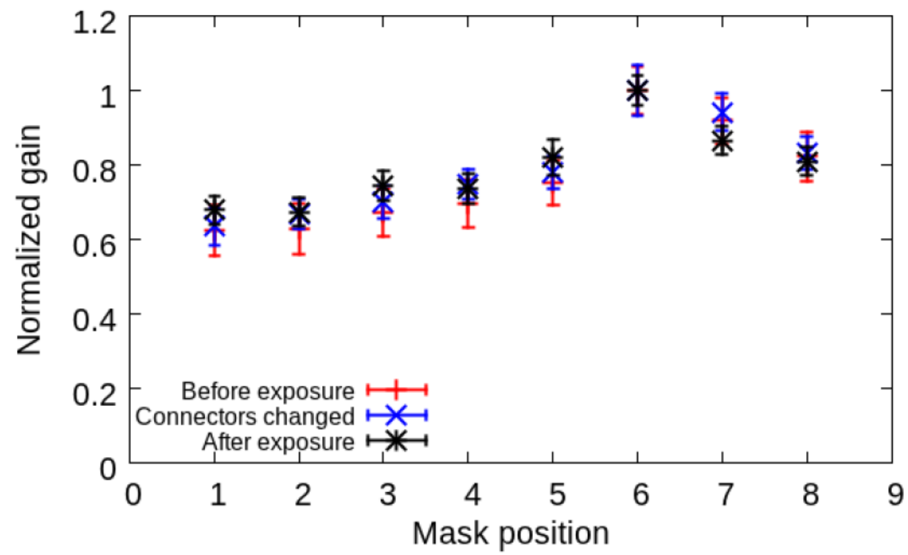
Gain is measured on both detectors before, during and after the irradiation period at several positions.

No gain change in the exposed area

Exposed detector – R17A



Non-exposed detector – R17B

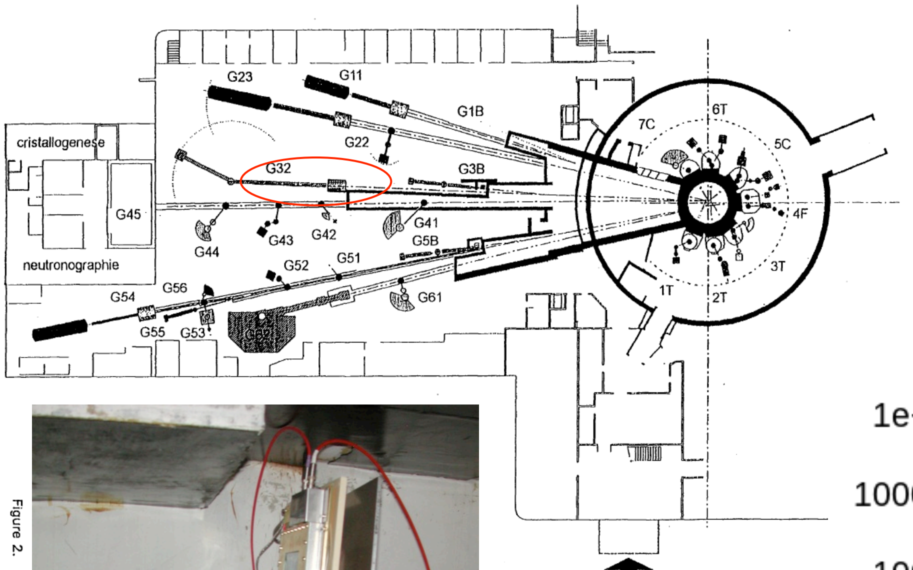


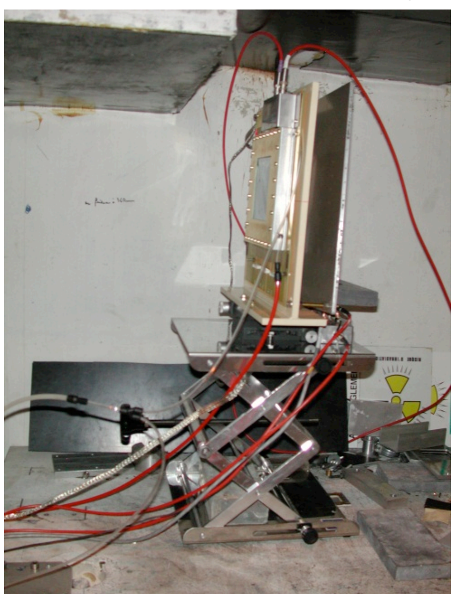
Neutron irradiation

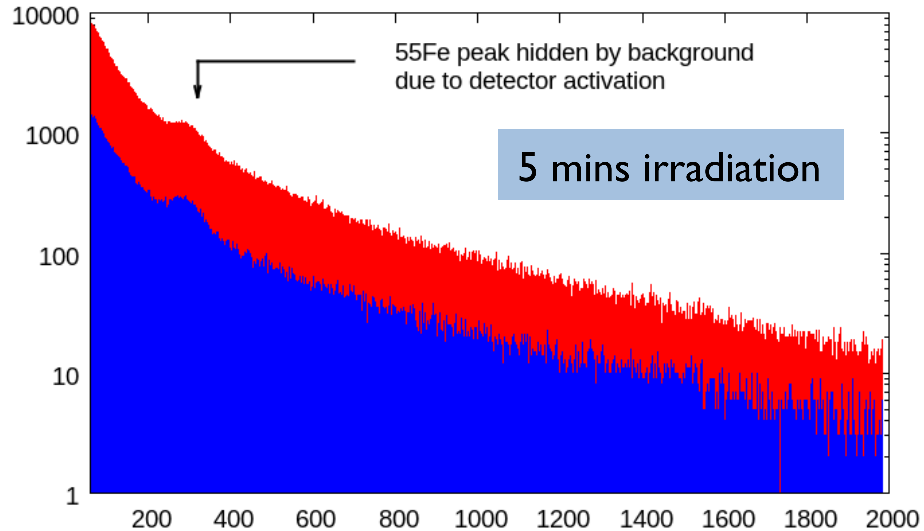
Neutron irradiation near Orphée reactor @ Saclay

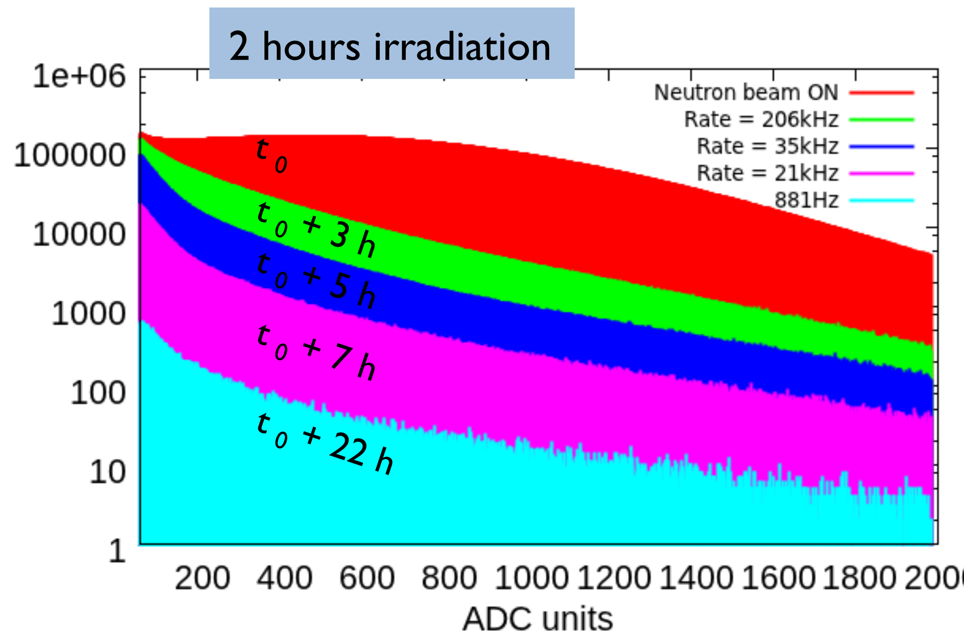
- Neutron flux ~ 8.10^8 n/cm^2/s
- Cold neutrons: 2 to 10 meV

- Same setup: gas, current monitoring, R17A and B, ..





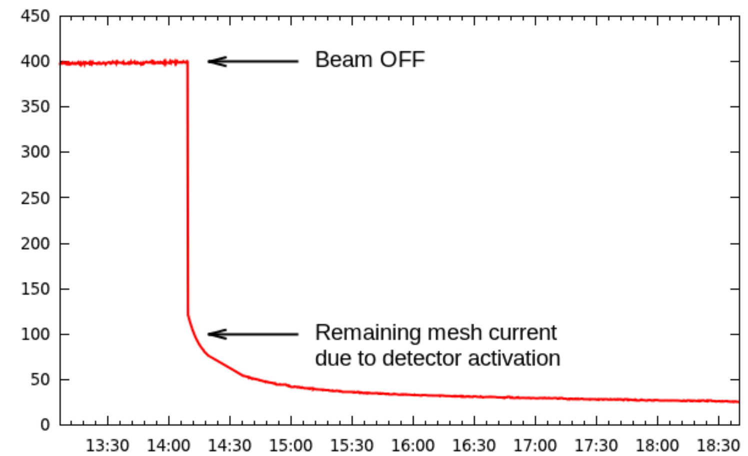


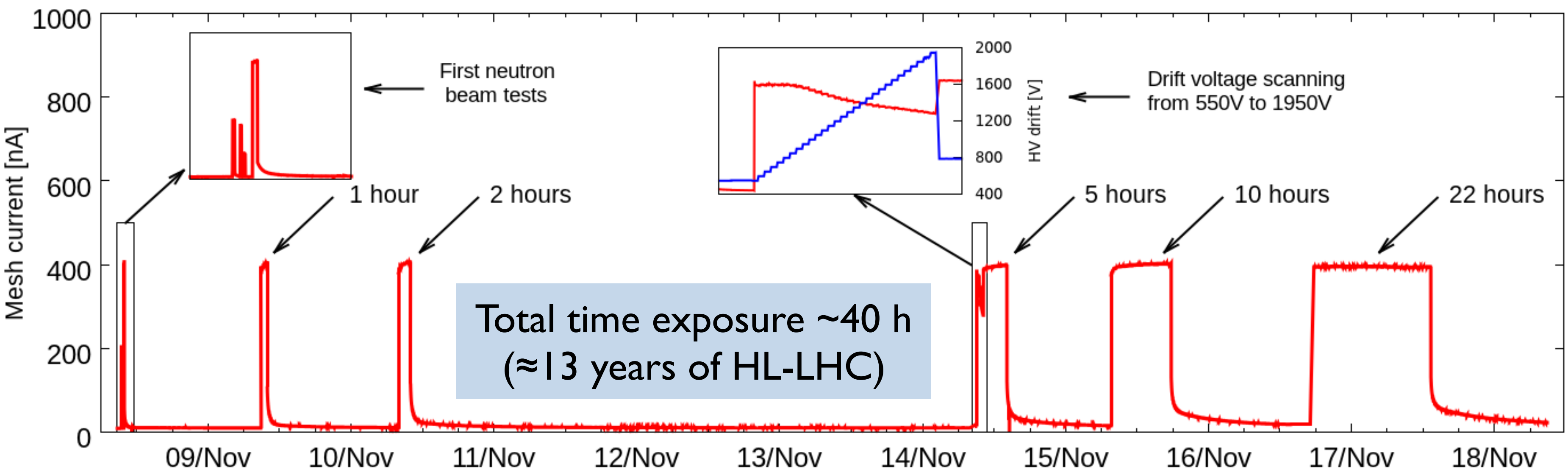


Neutron ageing

- Neutron flux (CSC in ATLAS) → ~3.10^4 n/cm²/s
- 10 years at HL-LHC (200 d/yr) → $17{,}3.10^7$ s
- Security factor → x3
- 5 x lum. Nominale (LHC) → x5 (BdF)
- we will accumulate → 8.10^{13} n/cm²
- One hour at Orphee G3.2 → 3.10^{12} n/cm²

→ or 4/5 monthes of HL-LHC





Total time exposure ~40 h
(≈13 years of HL-LHC)

Conclusion

- <u>Good ageing behaviour:</u>

  - More than 21 days under X-rays irradiation (integrated charge ~ 1 C)
    → 5 years equivalent of HL-LHC with a security factor more than 5
    → No ageing !

  - Neutron irradiation for 40 hours in intense cold neutrons beam
    → current and gain remain stable, no degradation visible
    → More investigations after total desactivation of the detector

- <u>New x-rays irradiation</u> is probably necessary to understand the increasing-current effect

- <u>Neutrons irradiation are still going on</u>:
  - Different configurations with Al and B_4C showing that main activation is coming from the aluminium (material study is necessary for the housing of the future multi-layers)
  - Samples of resistive layers will be also irradiated

- <u>Gamma irradiation</u> near COCASE is under study (500 mGy/h maximum)