Triple GEM detectors : measurements of stray neutron.

F.Murtas CERN and LNF-INFN

- GEM as neutron detector
- Burning Plasma Monitor
- Neutron detectors
- Conclusions

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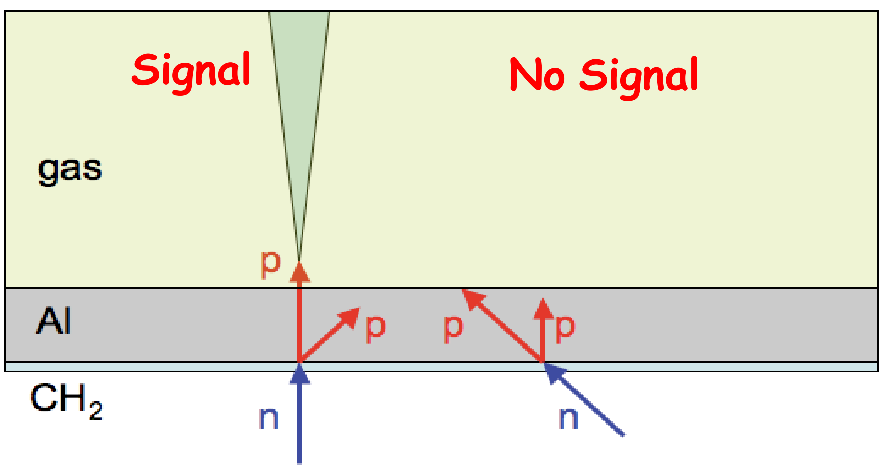
Polietylene Converter Cathode

2.5 MeV Neutrons interact with CH_2, and, due to elastic scattering processes, protons are emitted and enter in the gas volume generating a detectable signal.

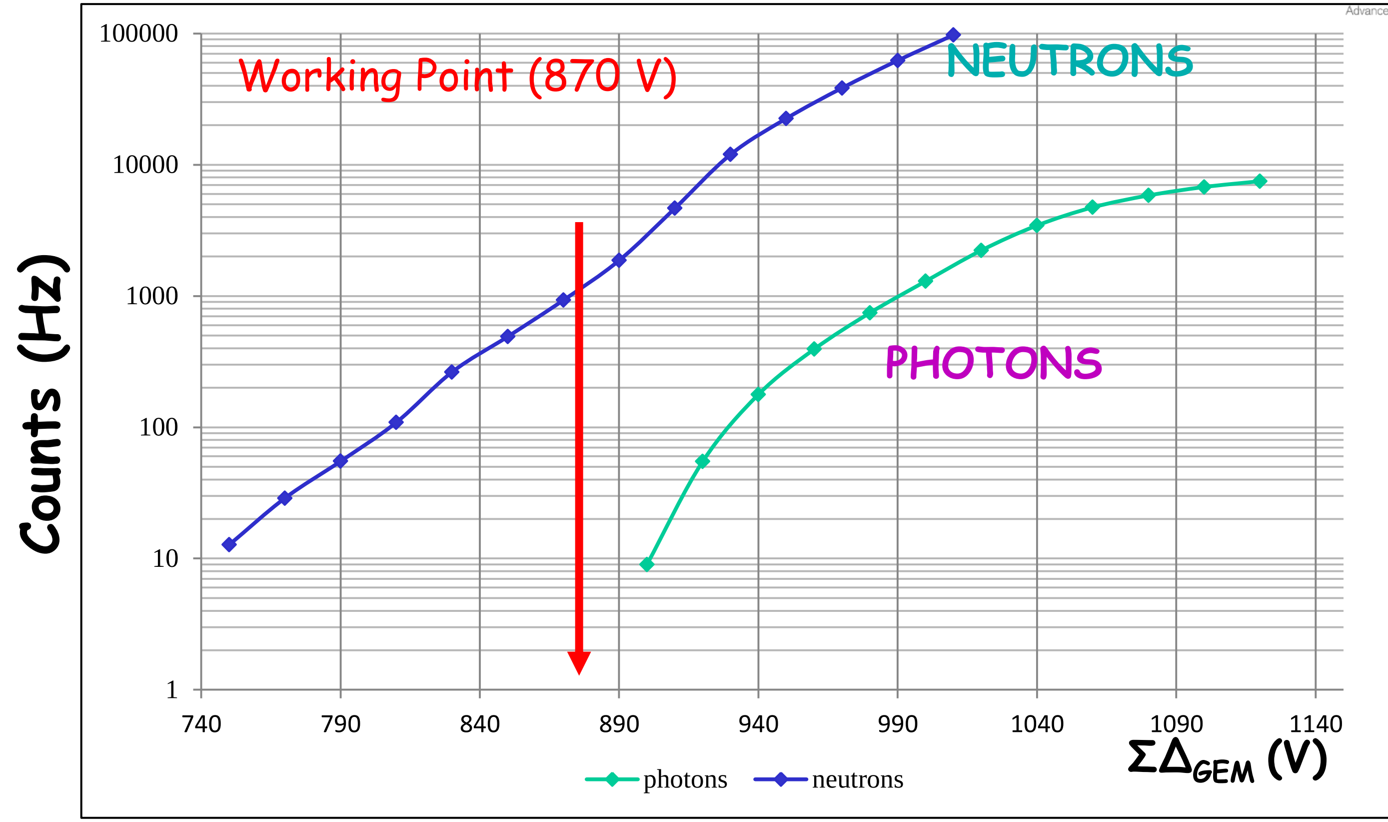
Aluminum thickness ensures the directional capability,

stopping protons that are emitted at a too wide angle.



Optimized CH_2–Al thicknesses (50 μm-50 μm) determined by simulations (MCNPX-GEANT4)

Detector Working Point

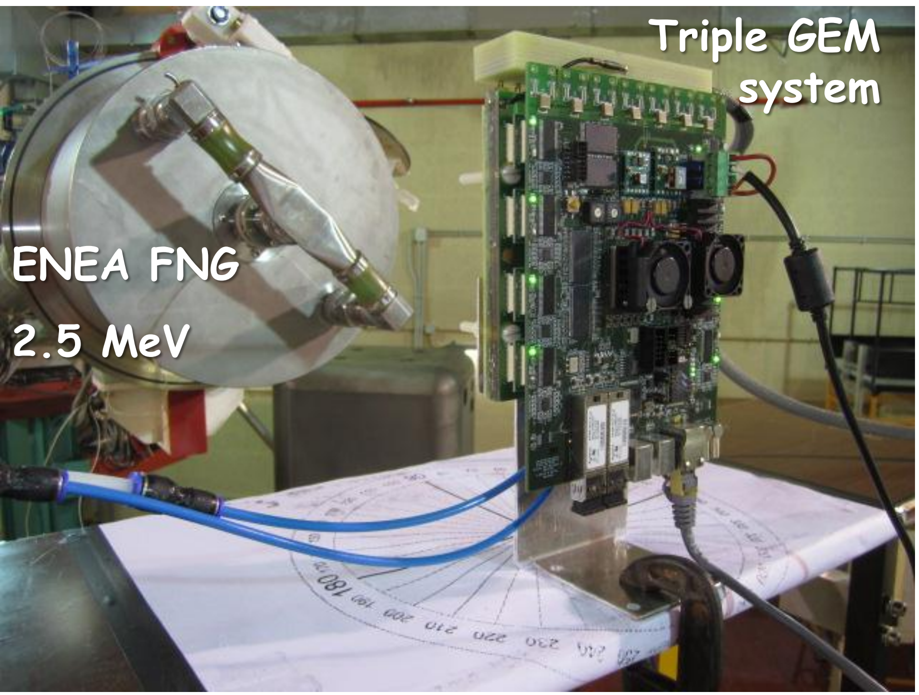


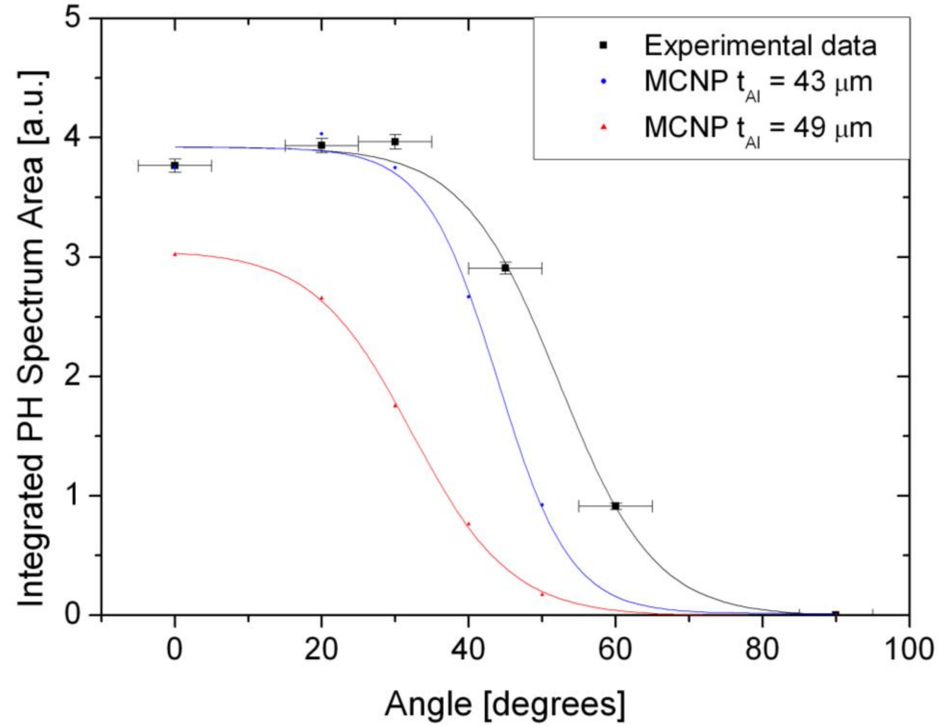
Counting rate Vs chamber gain: up **to 890 V** the chamber is sensitive to fast neutron but not to gamma rays

Test at Frascati Neutron Generator

Measurement of the PH spectrum acquired under 2.5 MeV neutron irradiation at different angles with respect to beam direction and comparison with MCNP.
As expected the integrated PH counts decrease when increasing the angle.

NIO2BEAM prototype



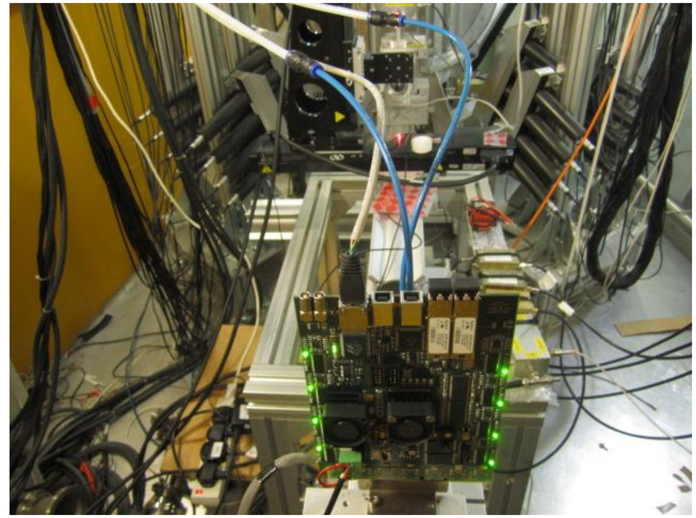


Comparison between measurements and simulations suggests that the Al thickness is less than 43 μm. Measured alluminum thikness is 40 μm.

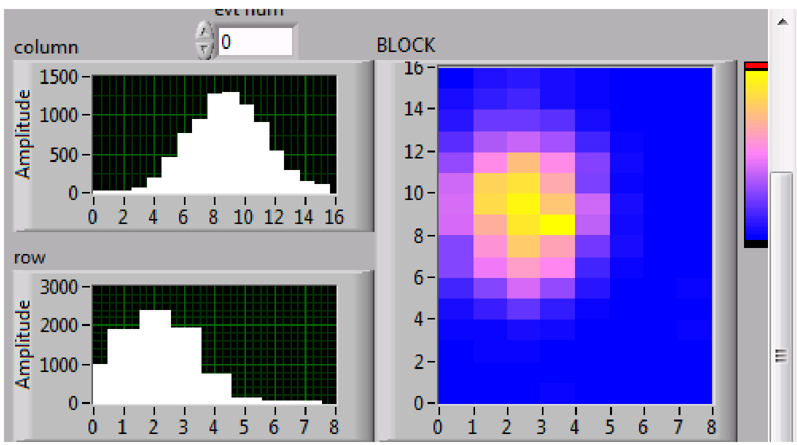
Fast Neutron Monitor (ISIS)

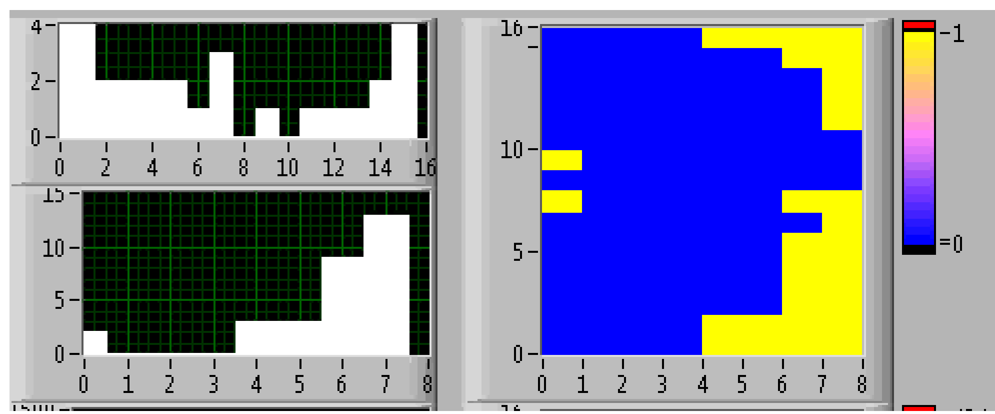
Monitor for a fast neutron beam with energies ranging from a few meV to 800 MeV

Tested at neutron beam of the Vesuvio facility at RAL-ISIS.



NIO2BEAM prototype

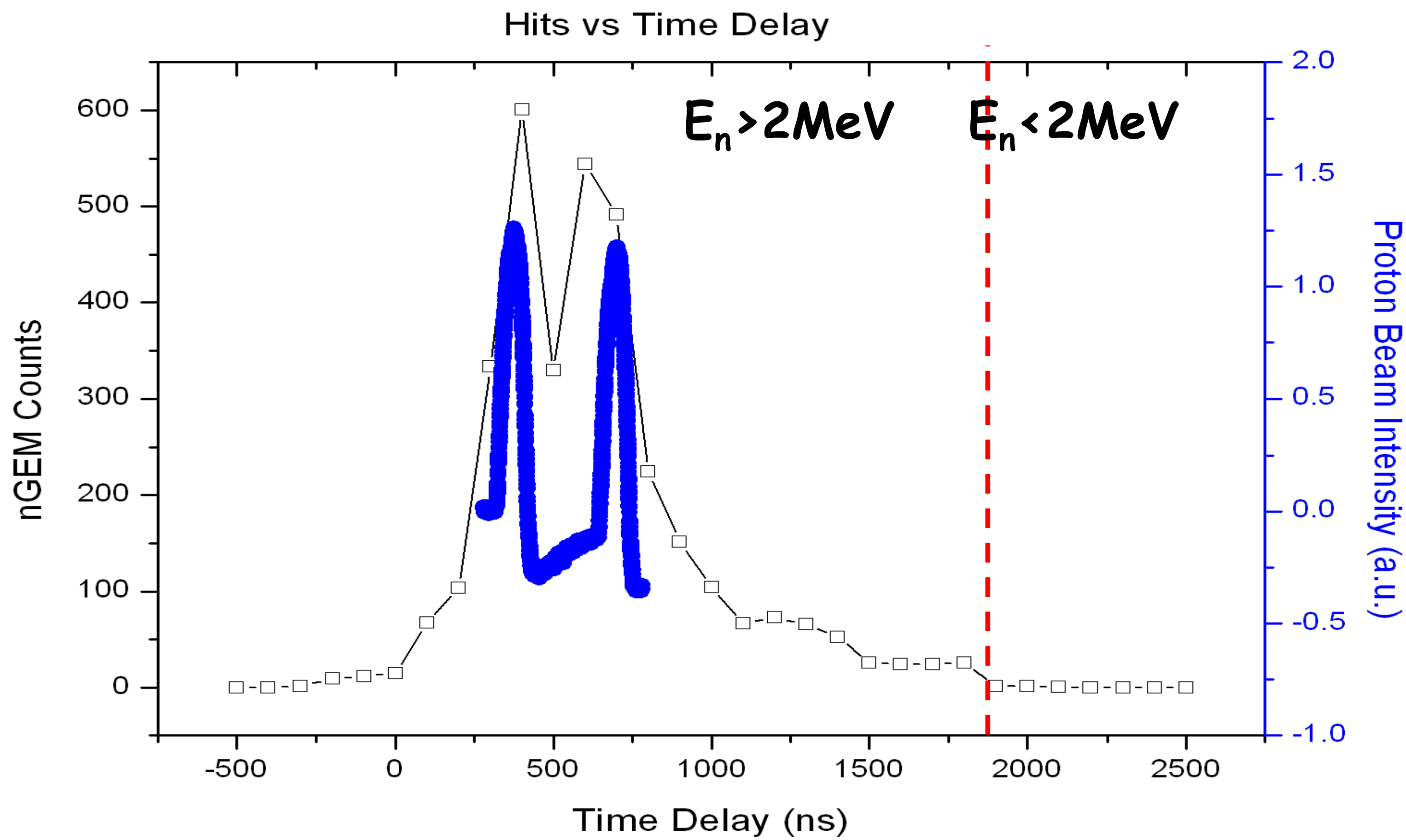




Beam profiles and intensity

Neutron beam monitorig during the shutter opening

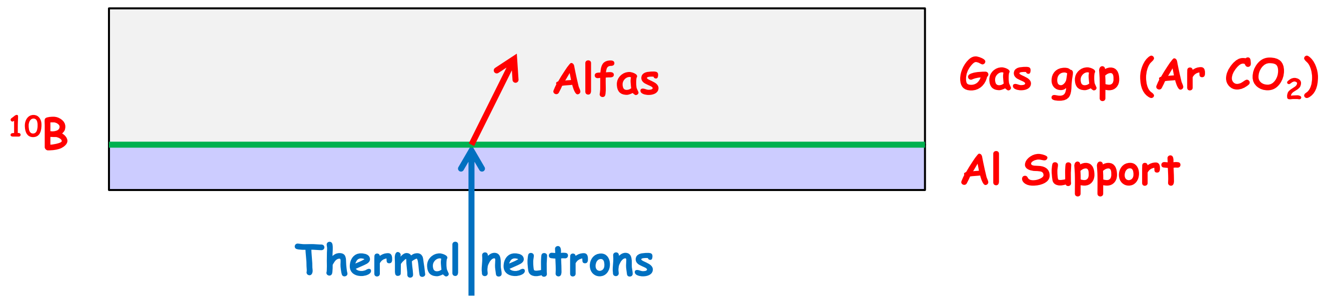
Neutron time line



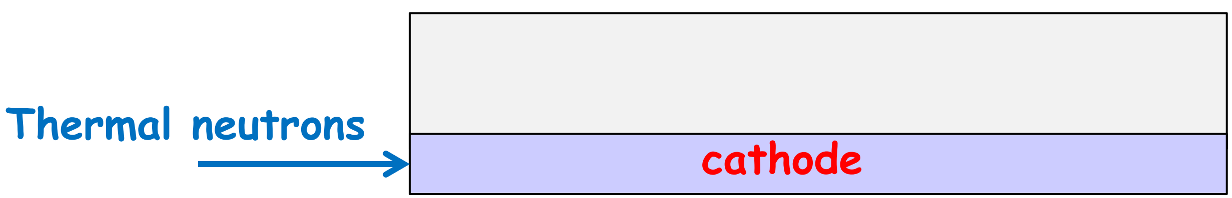
Measurement of the difference between the arrival time of bunch and the T0 using GEM counts during a 100 ns wide gate and comparison with proton beam profile intensity

^{10}B Cathode for thermal neutron

Thermal Neutrons interact with ^{10}B, and alfas are emitted entering in the gas volume generating a detectable signal.



Side-On detector



Actually 4% efficiency ... working to obtain 50%.

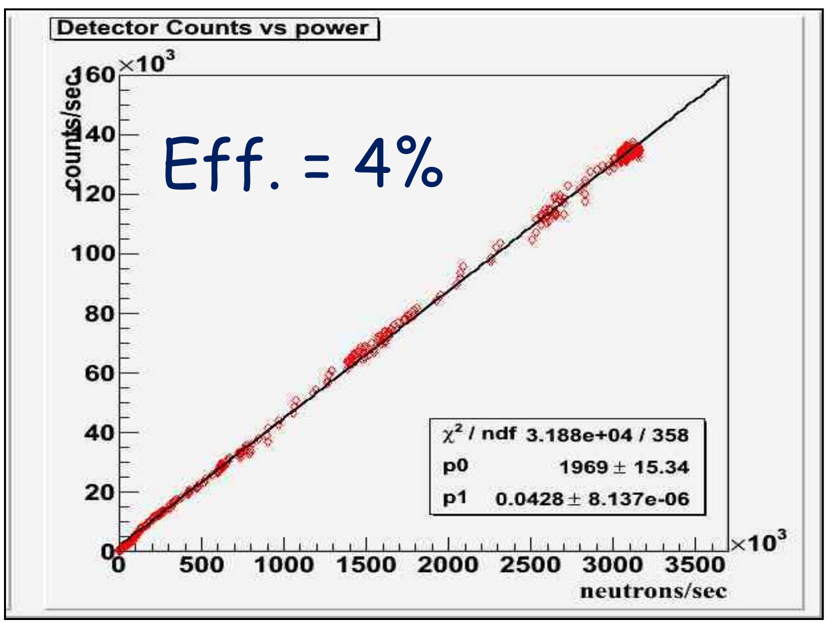
Monitor for fission reactor

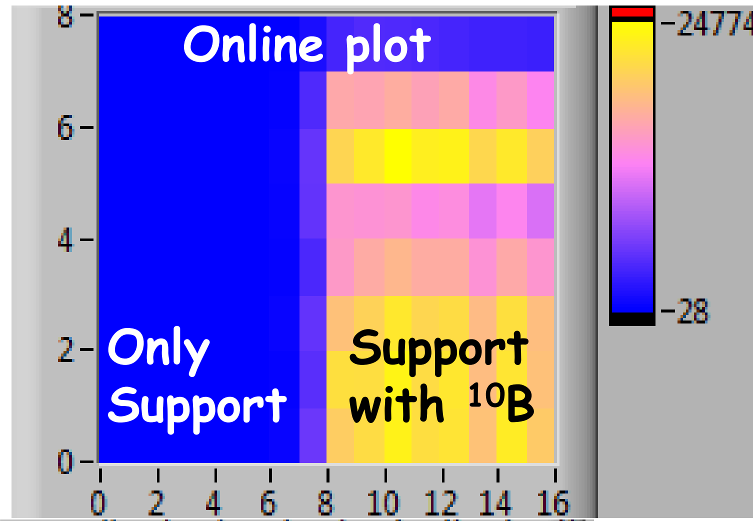
ARDENT
Advanced Radiation Dosimetry European Network Training

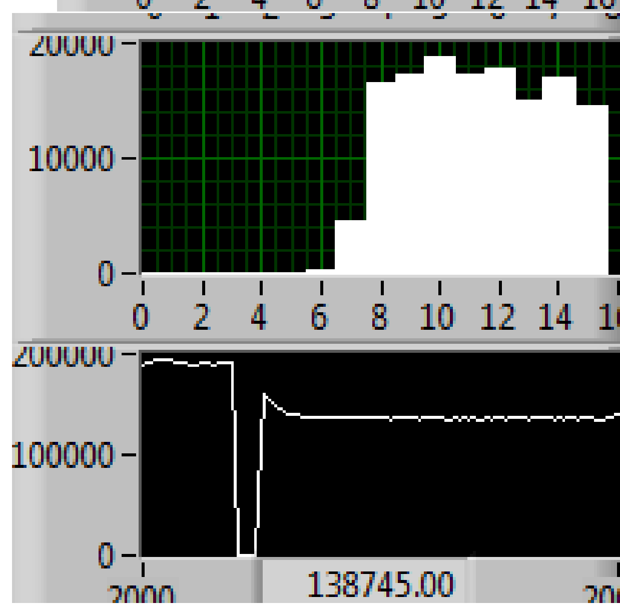
Measurements at Triga (ENEA)
Power of 1 MW

Gamma background free
Without electronic noise

Good linearity up to 1 MW







N-TOF Thermal neutron Beam spot

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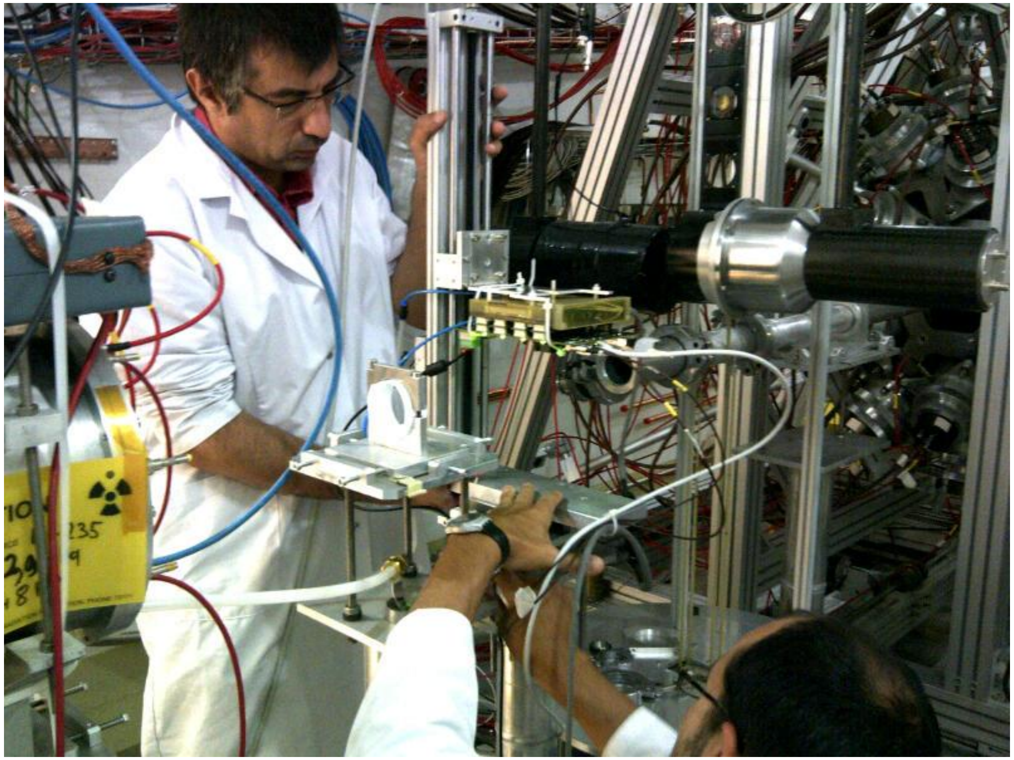

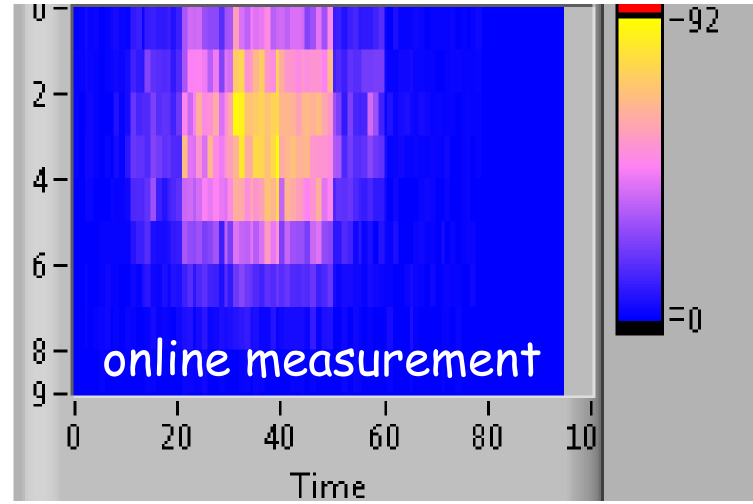

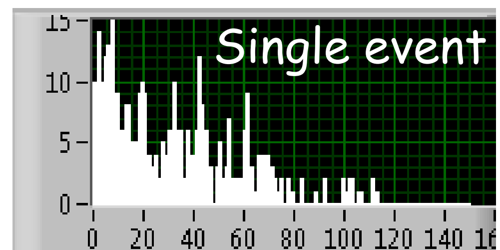

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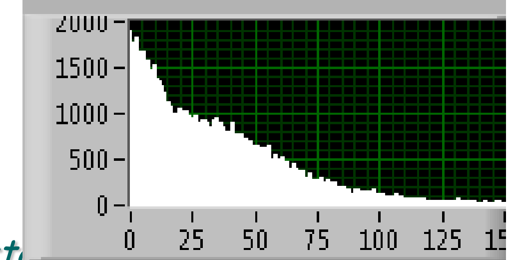
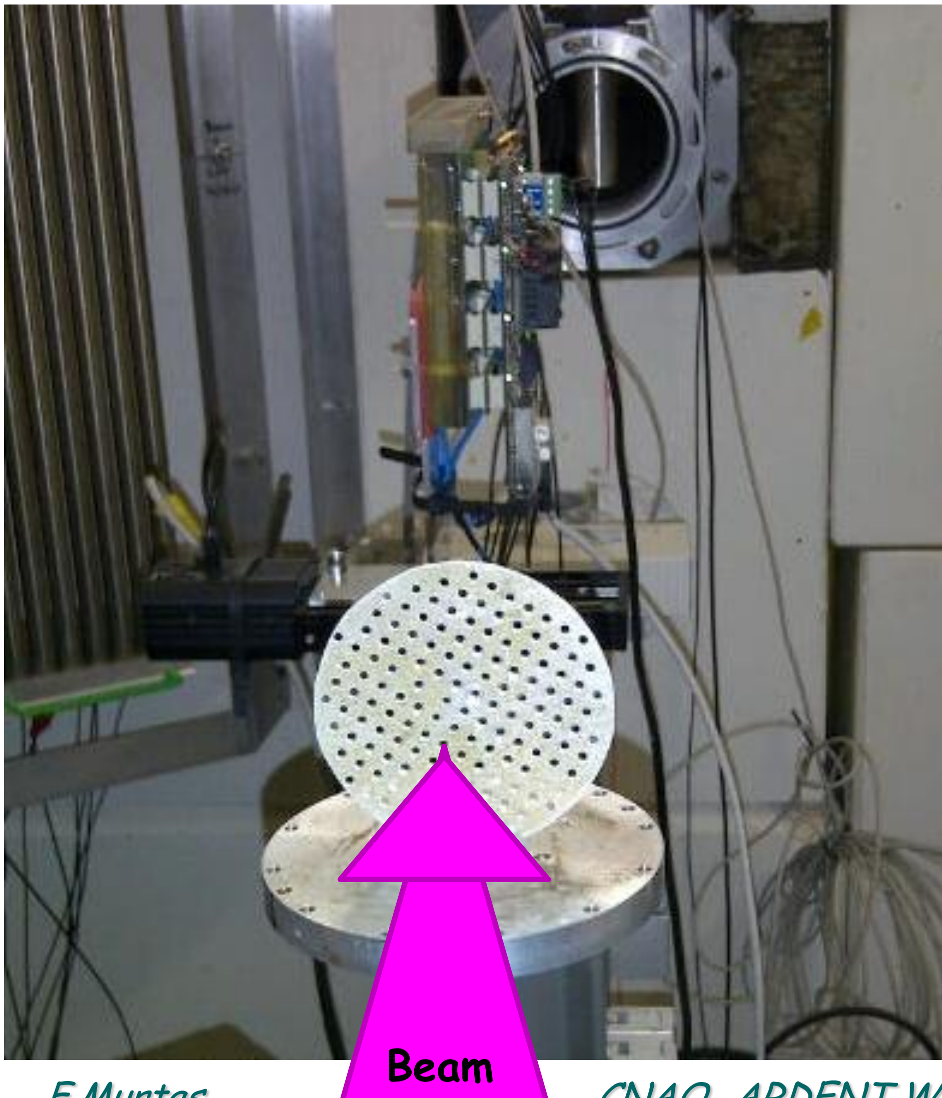
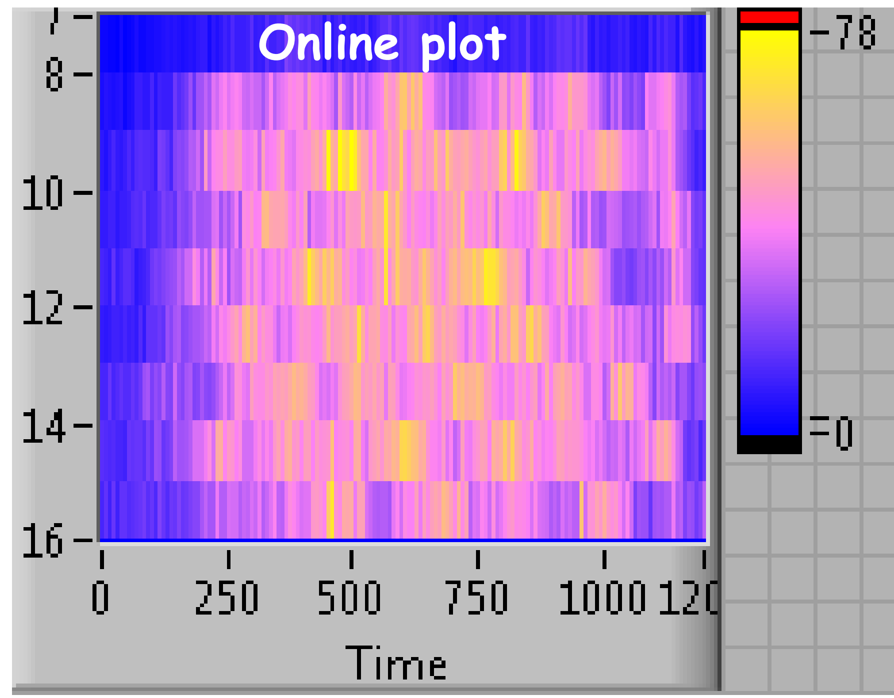


Time spectrum (1ms/bin)

150ms gate

Imaging of Thermal Neutron beam through a cadmium grid (ISIS)



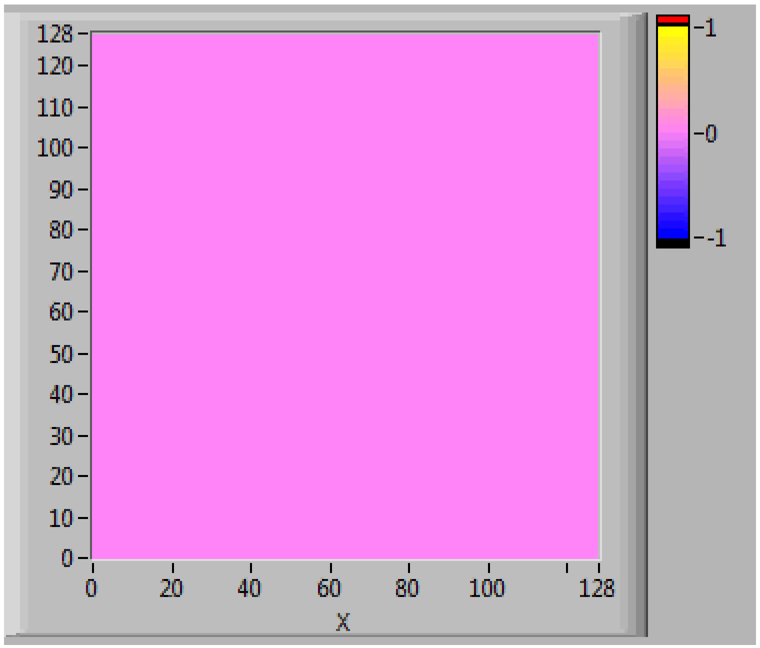


X-Ray Monitor for radioactive waste

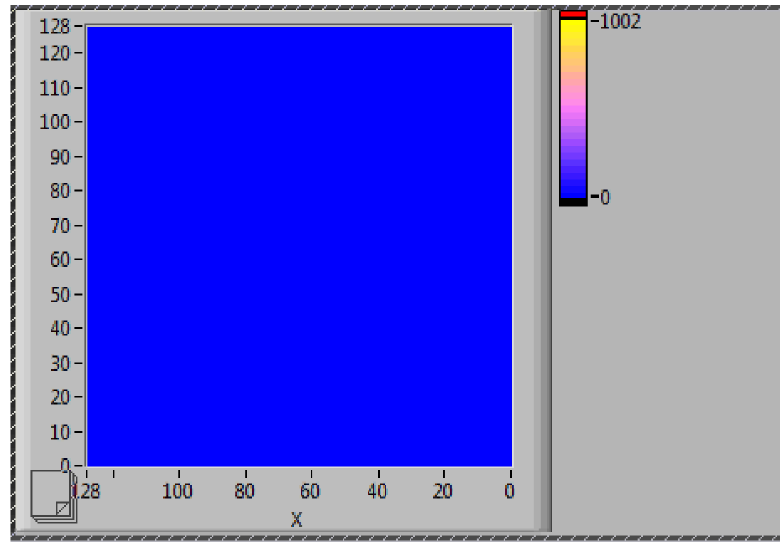
Gamma Monitor for radiotherapy

X-Ray Images

X-Ray beam of 6 KeV

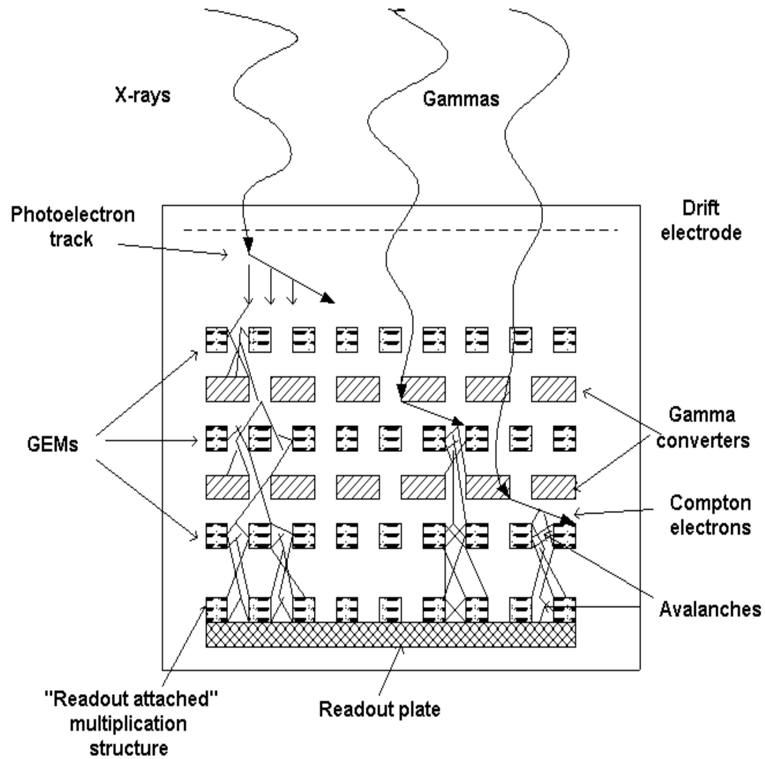


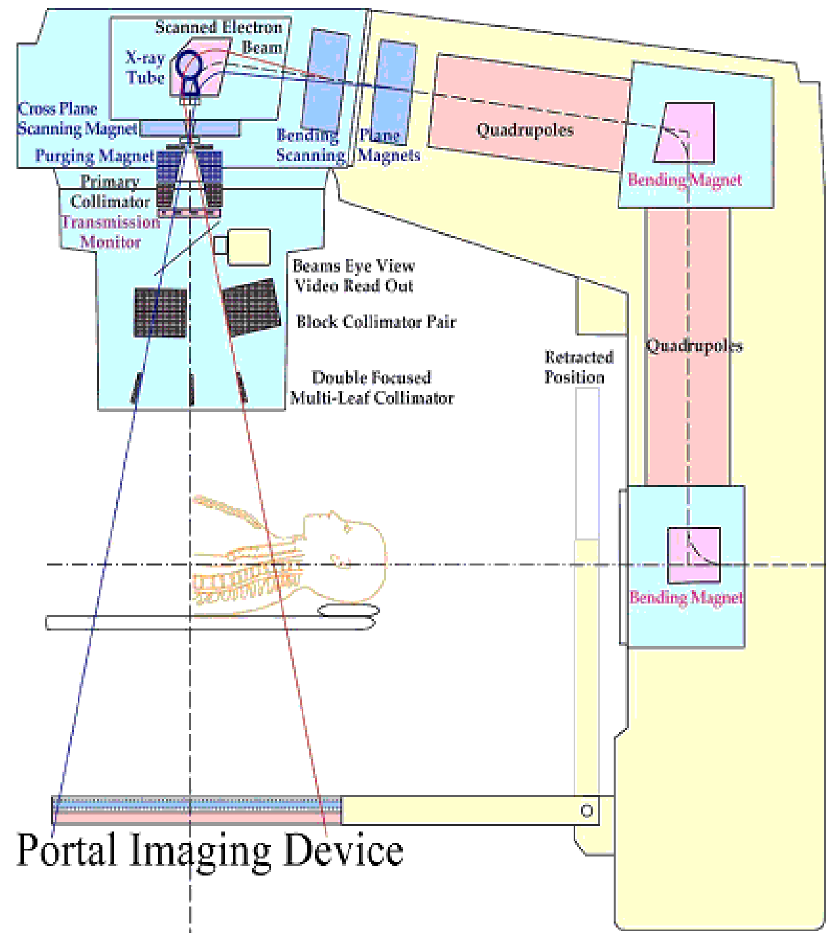
X-Ray 6 KeV
With a mesh of 600 micron holes
Pitch of 2 mm



This detector will be used for imaging of radioactive waste at CERN

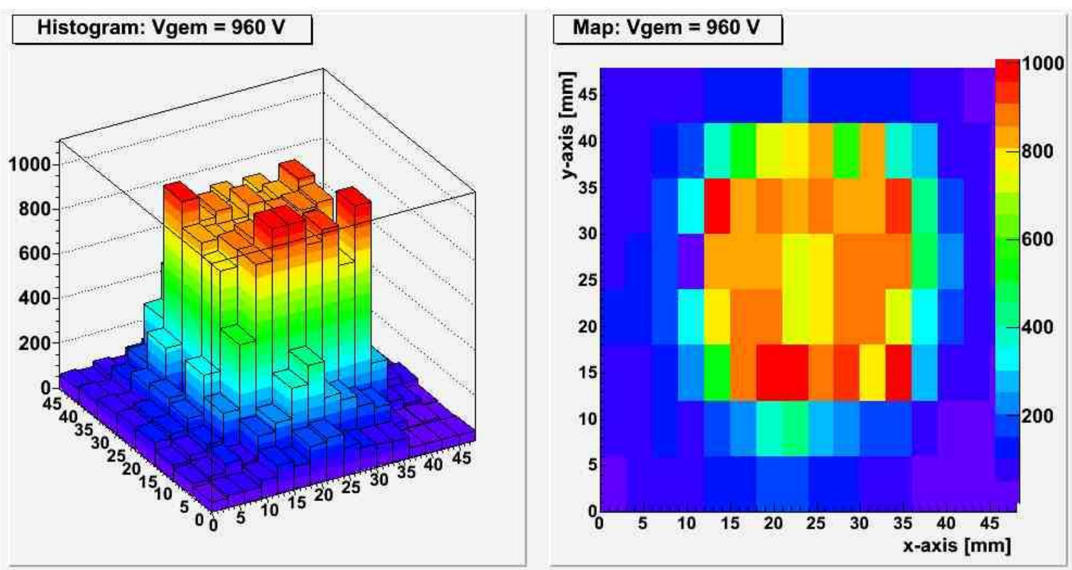
GEM on medical imaging

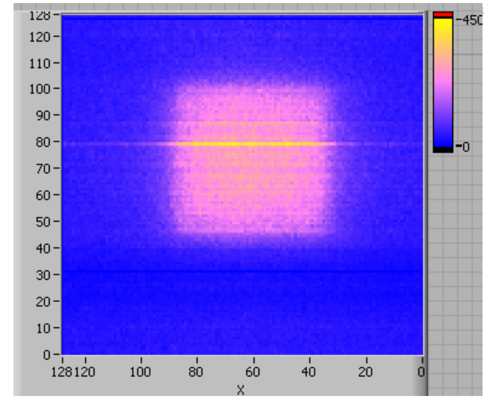


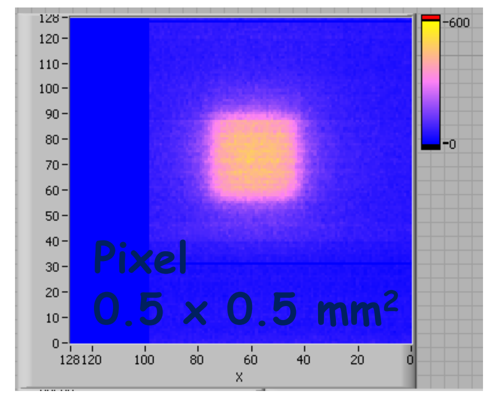


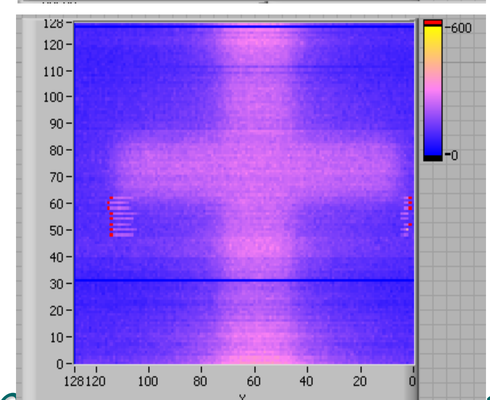
Gamma flux measurements at PTV

Gamma flux of 10^8 Hrz/cm^2 6-1 MeV





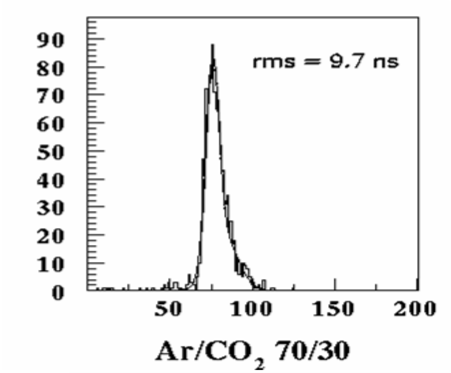


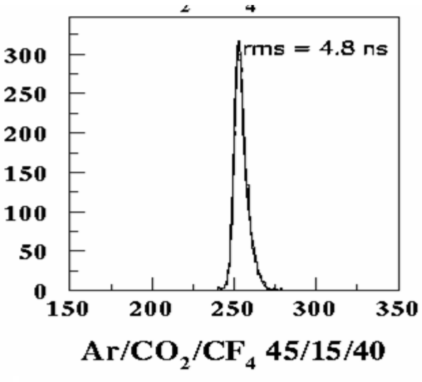


Summary

- ✓ Two GEM neutron monitor has been tested, at ISIS neutron spallation source, nuclear reactor Triga, nTOF at CERN.
- ✓ A fast neutron detector with polietylene
- ✓ Developments are in progress improving directionality and spectroscopy
- ✓ A thermal neutron detector with Boron cathode with 4% efficiency
- ✓ Developments are in progress improving efficiency (40-50%)
- ✓ Tests at Policlinico Tor Vergata (Rome) for Gamma Monitor show good and promising results

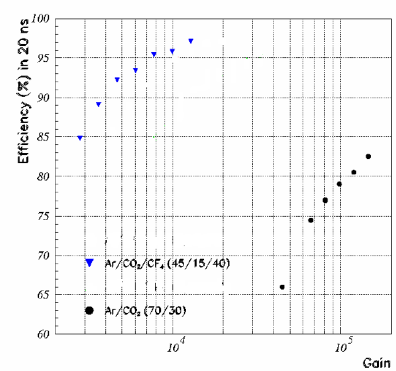
GEM Performances (2002-2006)





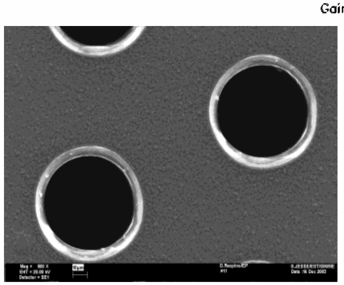
The results of several tests* on 10x10 cm^2 prototype allowed us to select the $Ar/CO_2/CF_4$ with geometry 3/1/2/1 mm

→ better time resolution 4.8 ns in respect of Ar/CO_2



→ higher efficiency at lower gas gain : 96% in 20 ns

Max space resolution O(100 μm)



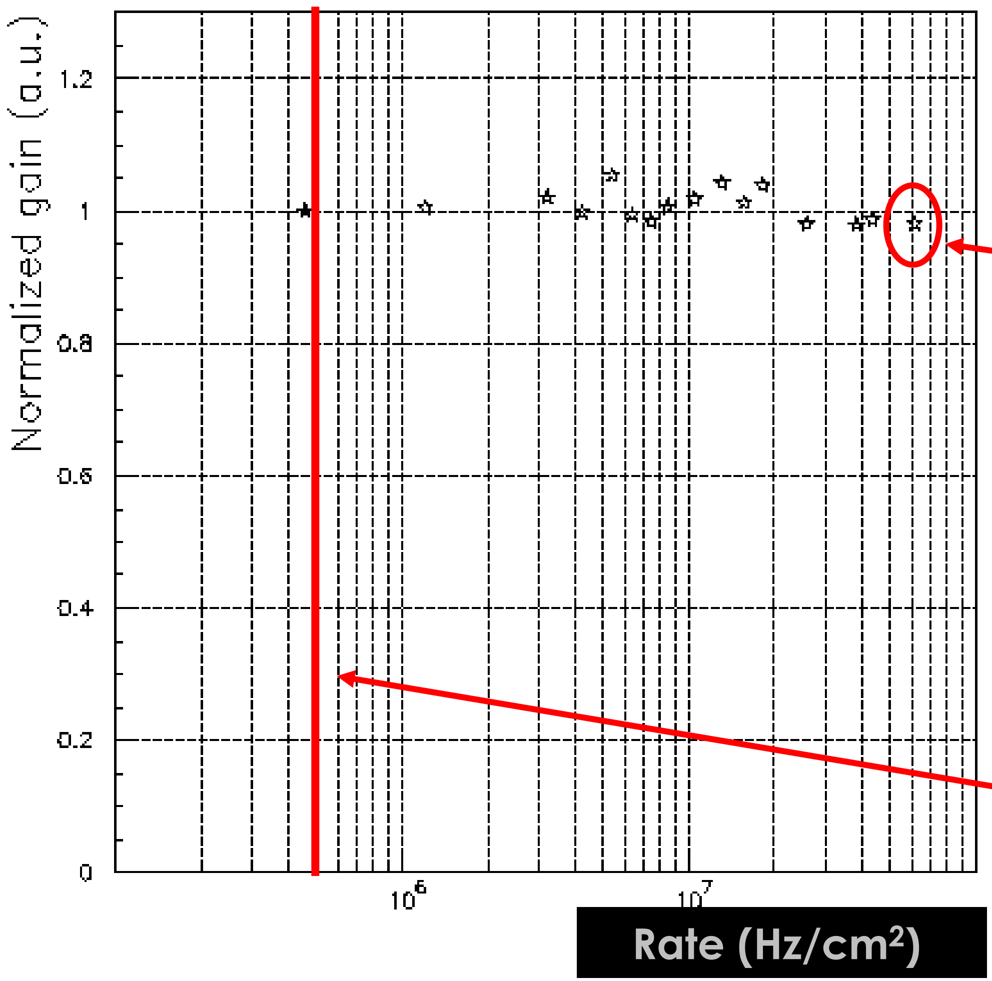
Ageing studies on whole detector area 20x24 cm^2:
25 kCi ^{60}Co source at 10 MHz/cm^2 on 500 cm^2
Integrated charge 2.2 C/cm^2

Detector performance recovered with a 15 V shift on HV

G.Bencivenni et al., NIM A 518 (2004) 106
P. de Simone et al., IEEE Trans. Nucl. Sci. 52 (2005) 2872

Linearity at very high rate

- The rate capability was measured with an X-ray (5.9 keV) tube over a spot of ~ 1 mm^2
- The detector was operated at a gain of ~ $2x10^4$



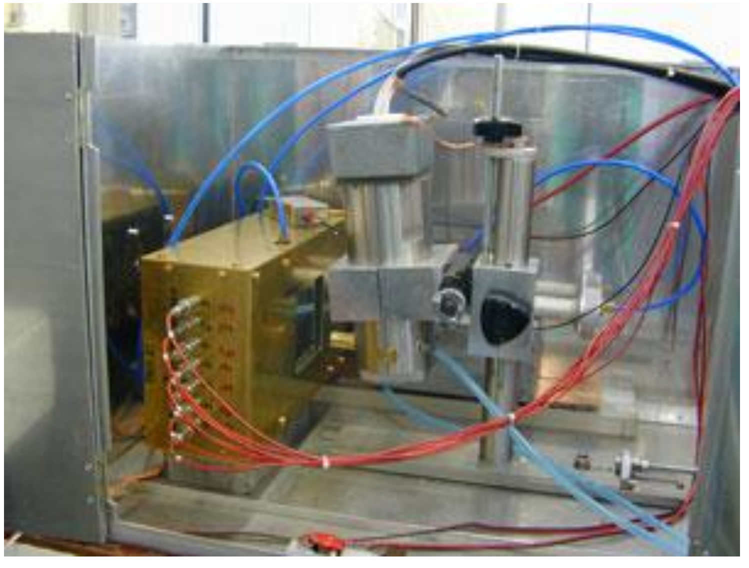
A very good gain stability was found up to a photon counting rate of 50 MHz/cm^2

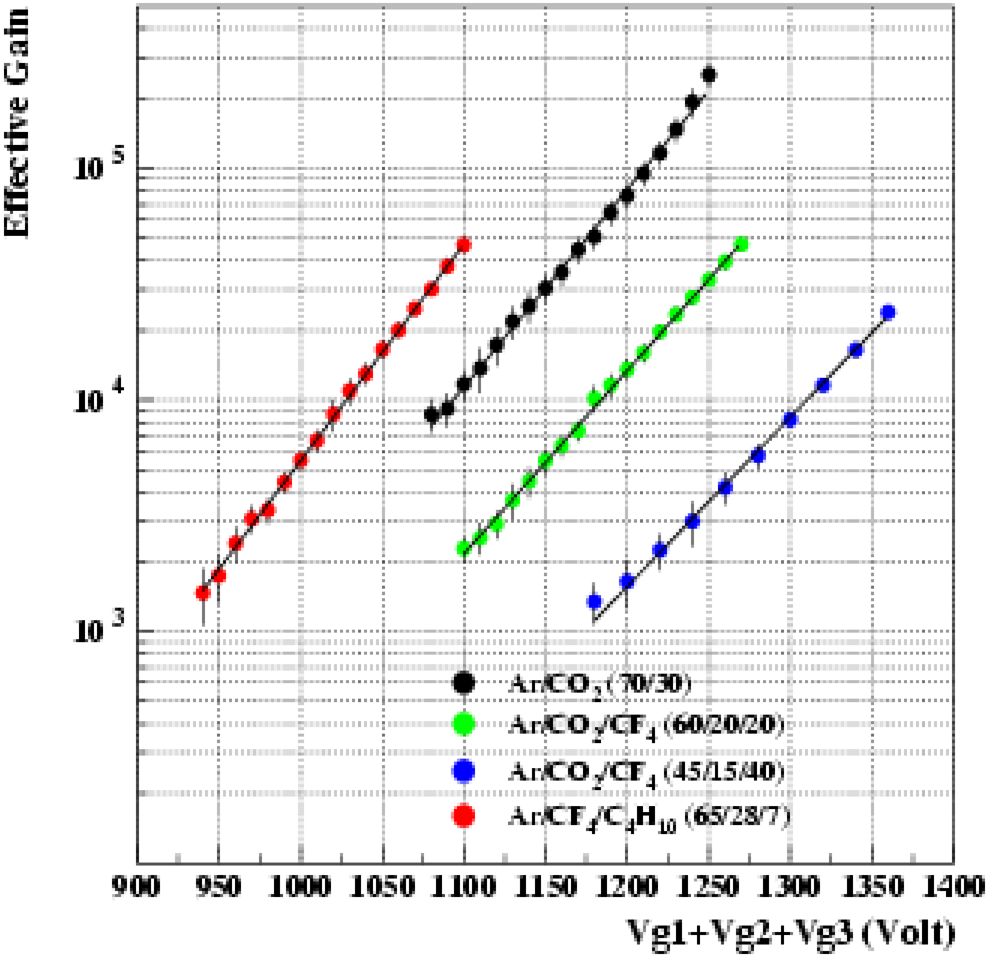
LHCb M1R1 maximum rate (460 kHz /cm^2)

Gas Gain

The effective GAIN G_{eff} of the detector has been measured using a 5.9 keV X-ray tube, measuring the rate R and the current i, induced on pads, by X-rays incident on the GEM detector.

$G_{eff} = i / eNR$





$$G_{eff} = A\, e^{\alpha(Vgem1+Vgem2+Vgem3)}$$

A and α depend on the gas mixture.

Discharge probability

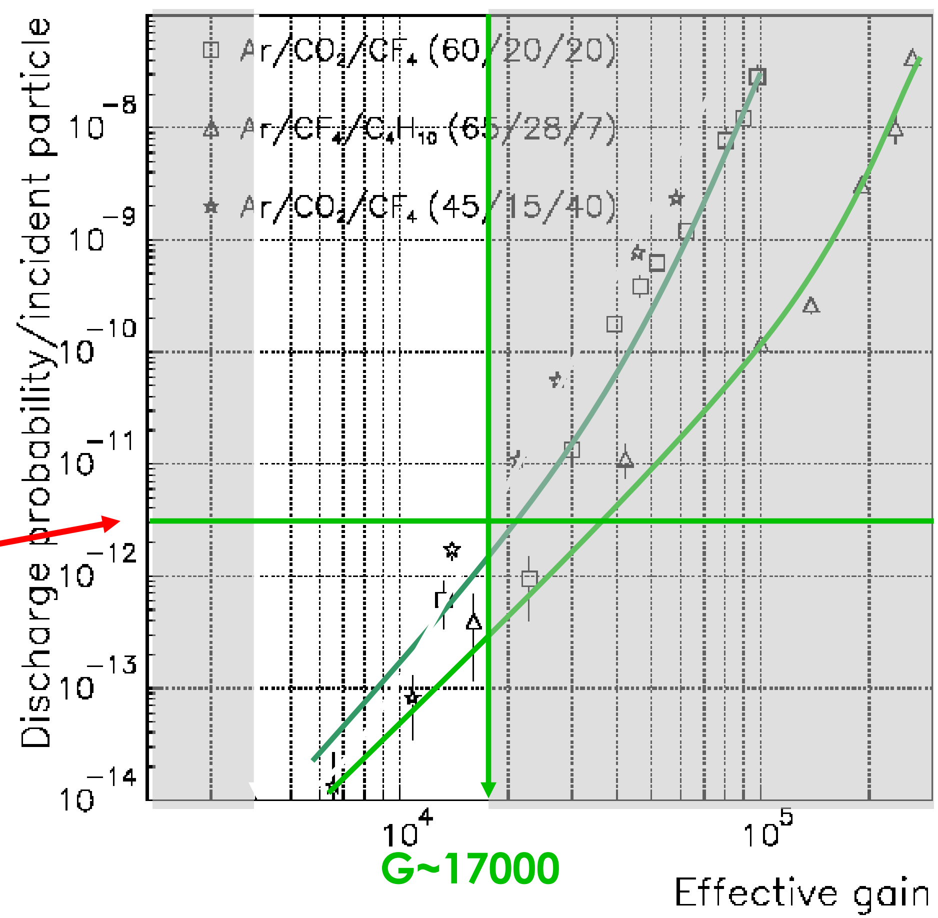
At PSI we exposed three detectors to a particle flux up to 300 MHz.

Each detector integrated, without any damage, about 5000 discharges.

In order to have no more than 5000 discharges in 10 years in M1R1 the discharge probability has to be kept below 2.5 10^{-12} (G < 17000).

This limit is conservative because up to 5000 discharges no damage was observed.

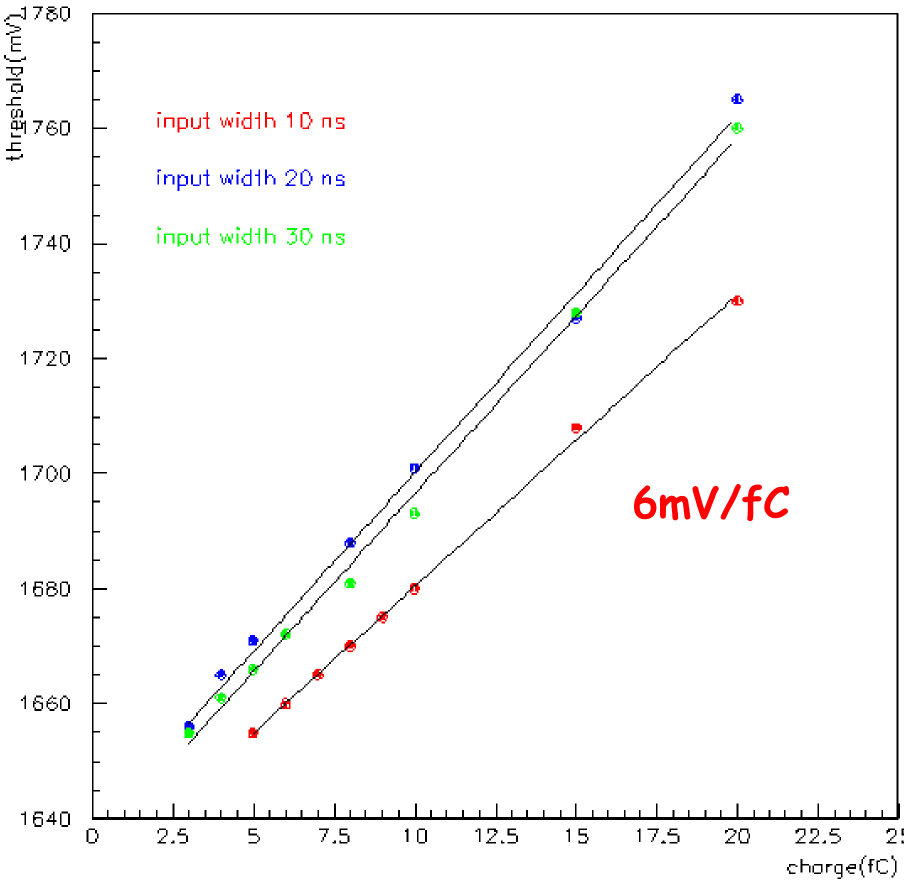
Working region



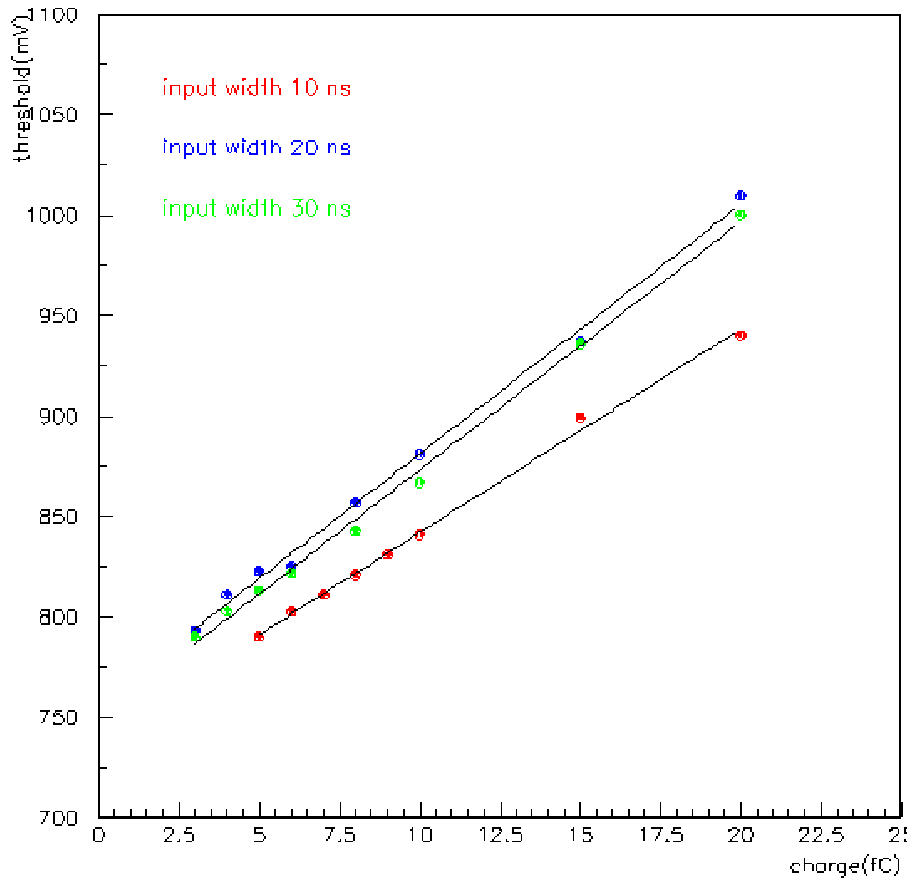
Carioca Card Sensitivity

The sensitivity is measured vs two different thresholds

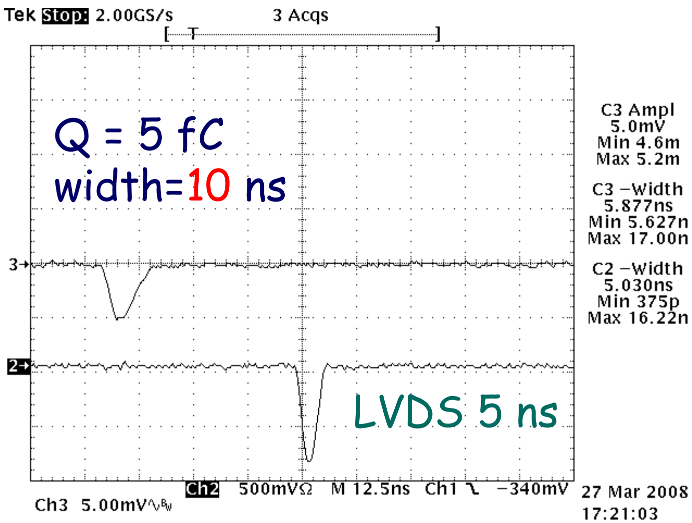
DAC Threshold on power supply

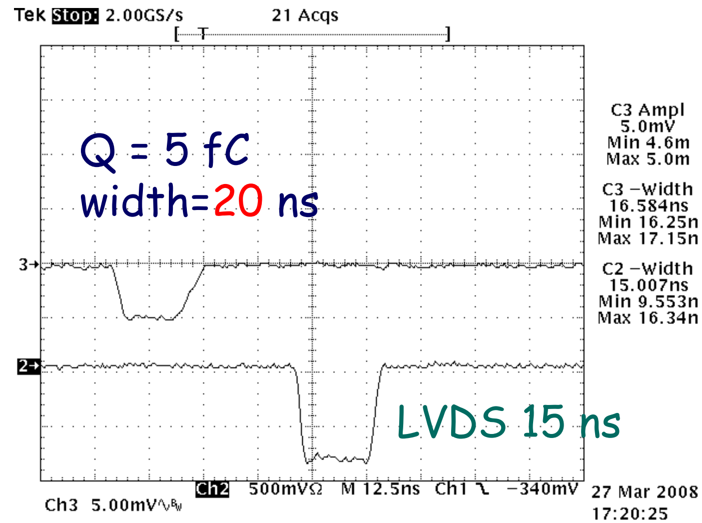


Threshold on Carioca



Carioca Card Sensitivity





The sensitivity has been measured injecting a charge between 5 and 20 fC with different width