Triple GEM detector at CERN n_TOF facility

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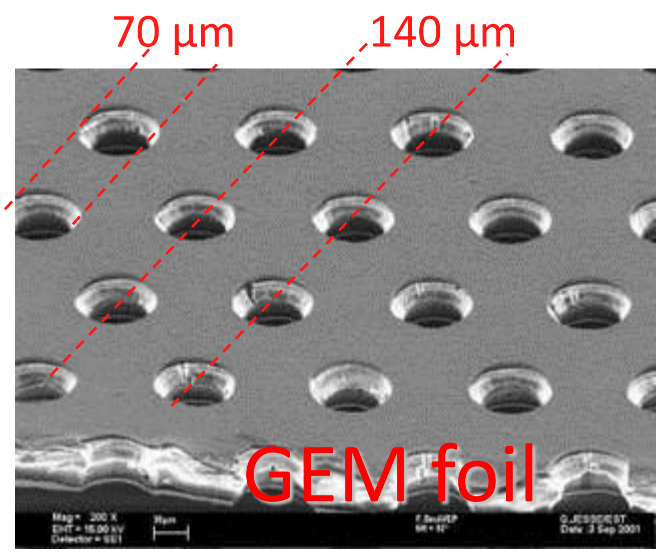
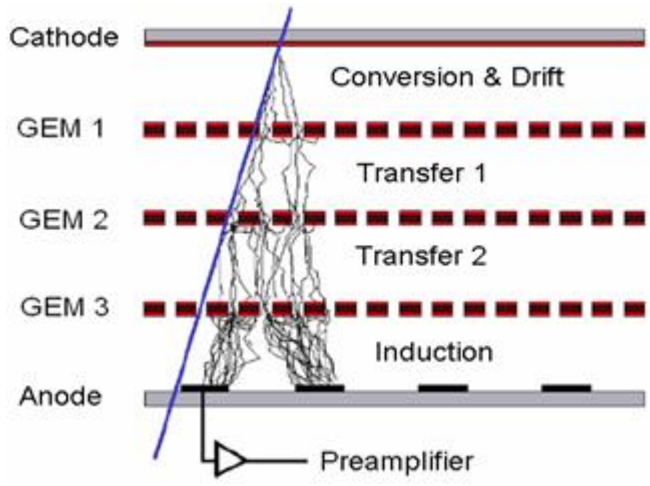
- Triple GEM detector
- Triple GEM detector for fast neutrons
- Triple GEM detector for thermal neutrons
- Conclusion

A triple GEM Chamber

A Gas Electron Multiplier is made by 50 μm thick kapton foil, with copper cladded on each side and perforated by an high surface-density of bi-conical channels;

Several triple GEM chambers have been built in Frascati in the LHCb Muon Chamber framework



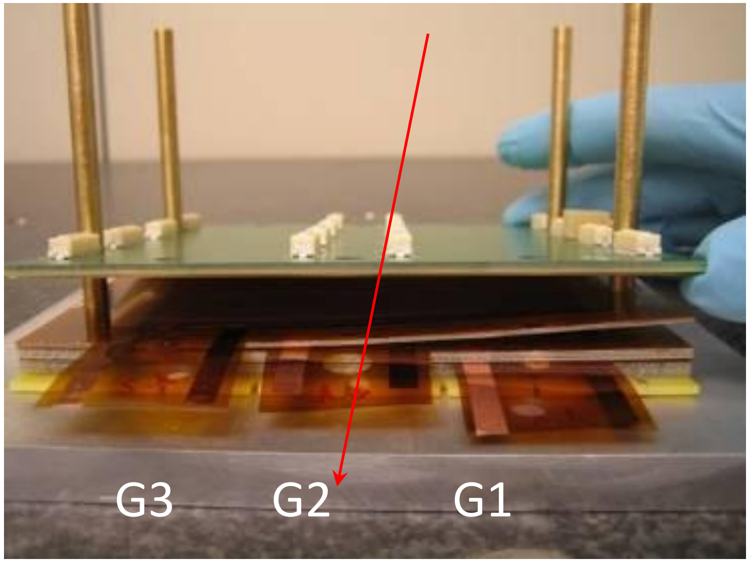


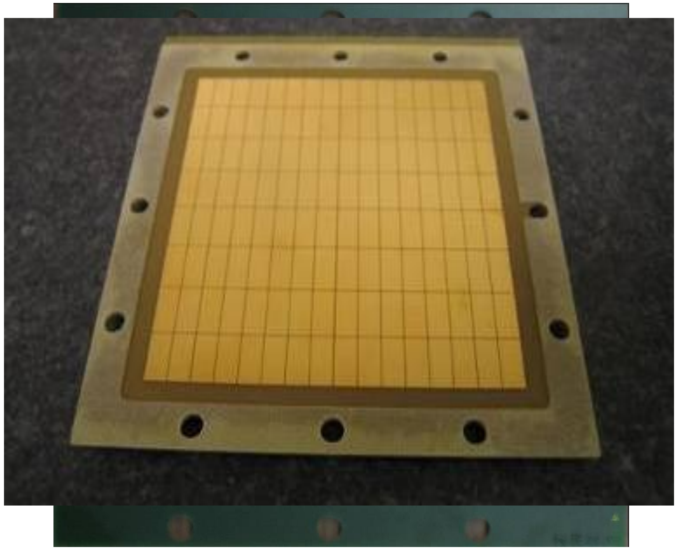
F. Sauli NIM A386 531

M. Alfonsi et al., The triple-Gem detector for the M1R1 muon station at LHCb, N14-182, 2005 IEEE-NSS

A Standard Triple GEM construction

The detectors described in this talk are built starting form the standard 10x10cm^2 : only one GEM foil has been modified to have central electrodes.





The GEM are stretched and a G10 frame is glued on top

- FAST neutrons: 128 pads **6x12 mm^2 ~ 100 cm^2** of sensitive area
- THERMAL neutrons: 128 pads **3x6 mm^2 ~ 25 cm^2** of sensitive area

Beam Contamination by gammas

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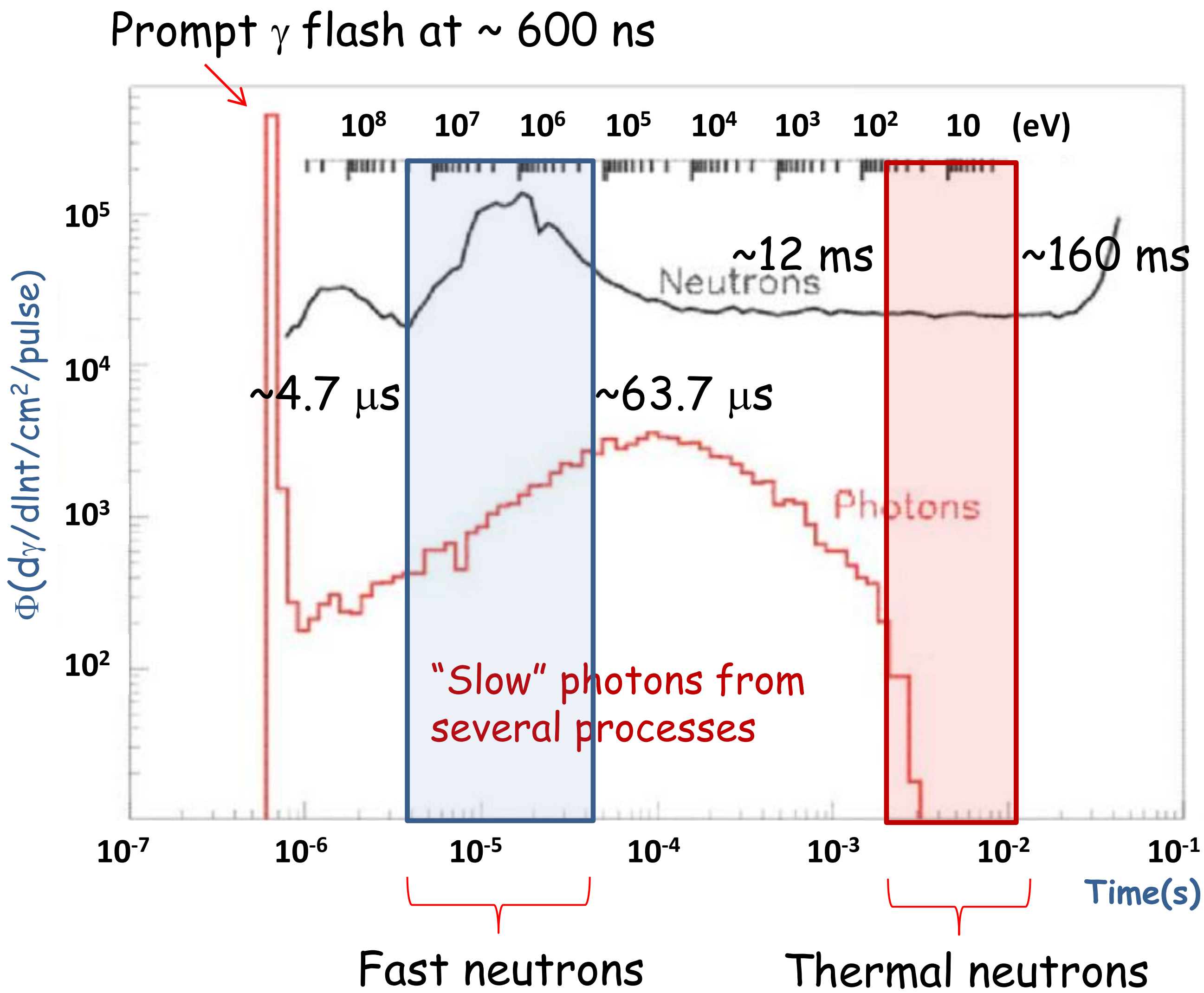


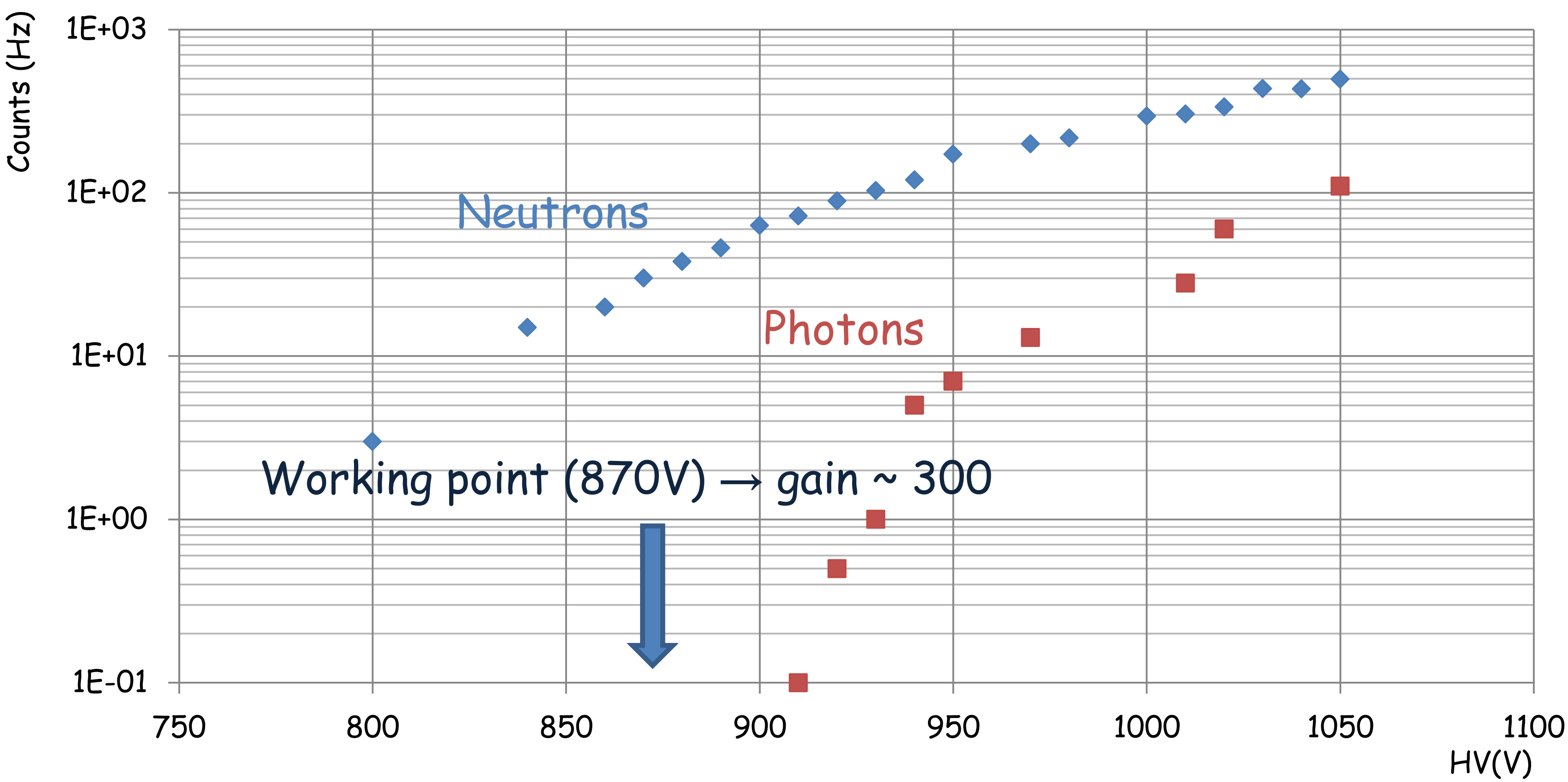
E. Chiaveri et al, CERN n_TOF facility performance report, CERN-SL-2002-053 ECT (2002)

C. Guerrero Sanchez, The neutron beam and the associated physics program of the CERN n_Tof facility, ATS seminar

+ γ from neutrons radiative capture in the beam dump

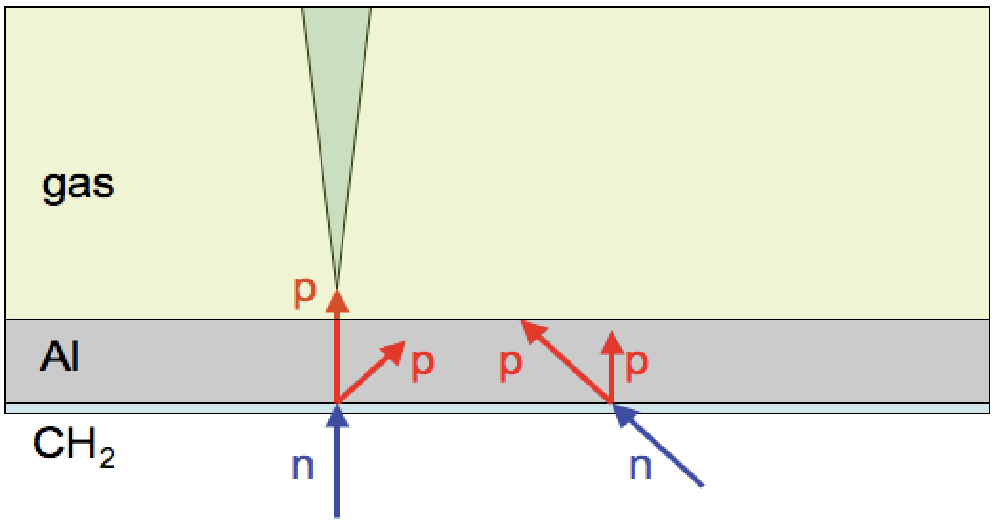
Low Sensitivity to Photons

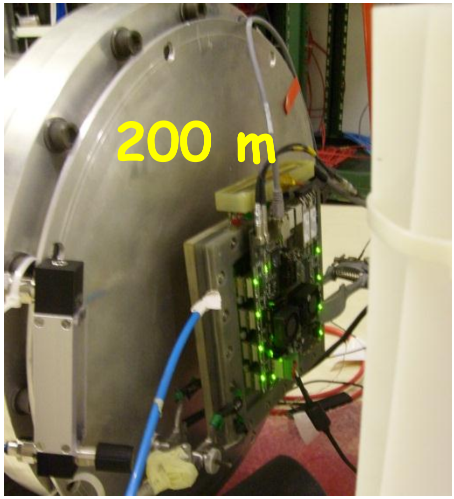
HV scan with n_TOF and Cs137 with a gate of 1 second



How detect fast neutrons

- Neutron converter 60 μm PE + 40 μm Al
- Gas mixture Ar-CO_2 70%-30%
- Measurements near to the beam dump



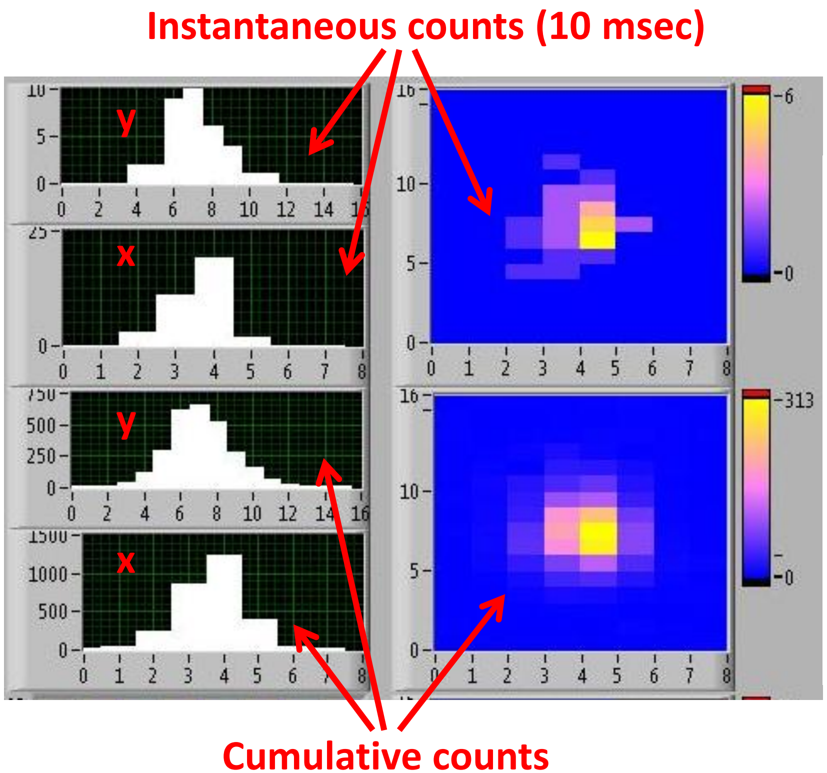


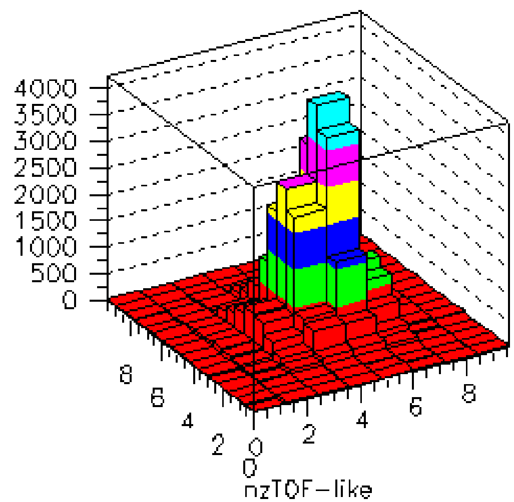
Neutrons interact with CH_2, and, due to elastic scattering processes, protons are emitted and enter in the gas volume generating a detectable signal.

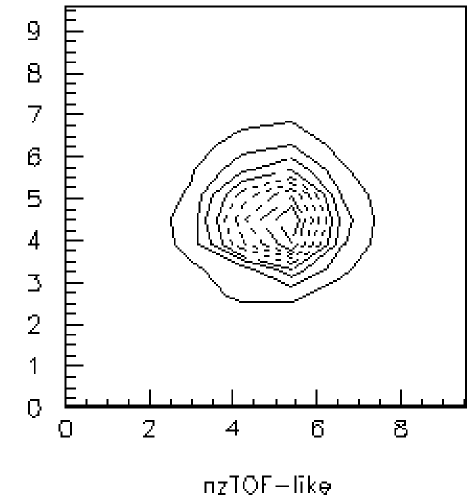
Aluminium thickness ensures the directional capability, stopping protons that are emitted at a too wide angle.

S. Puddu et al., ieee record N21-4

Measurements : beam imaging





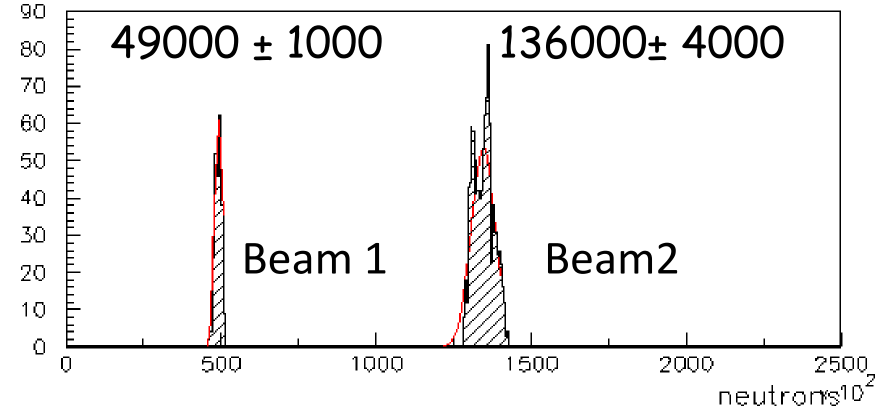


Constant: 3640 ± 40
Mean1: 5.9 ± 1.8 cm
Mean2: 5.5 ± 1.8 cm

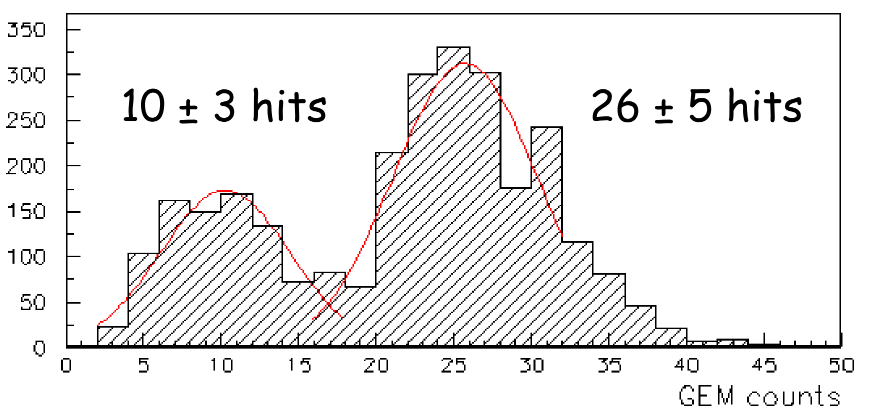
- Delay 2000 ns, HV 870 V, gate 10 ms
- Two different intensity beams arrive to the facility

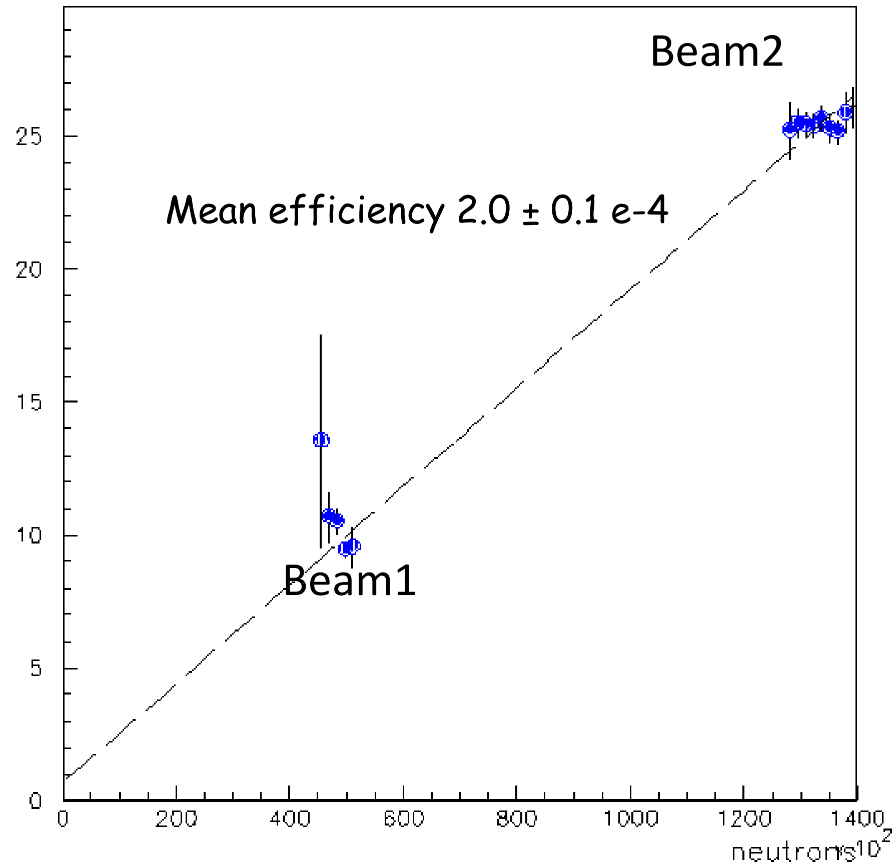
Measurements : mean efficiency

From proton beam monitor



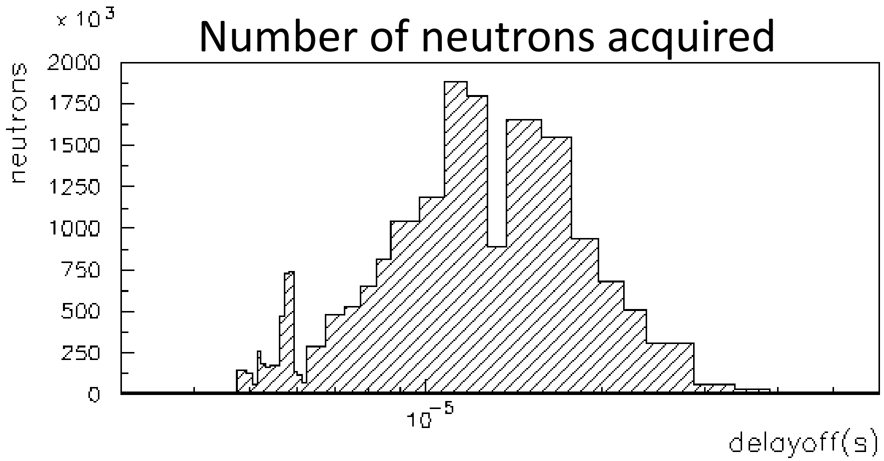
From GEM neutron monitor

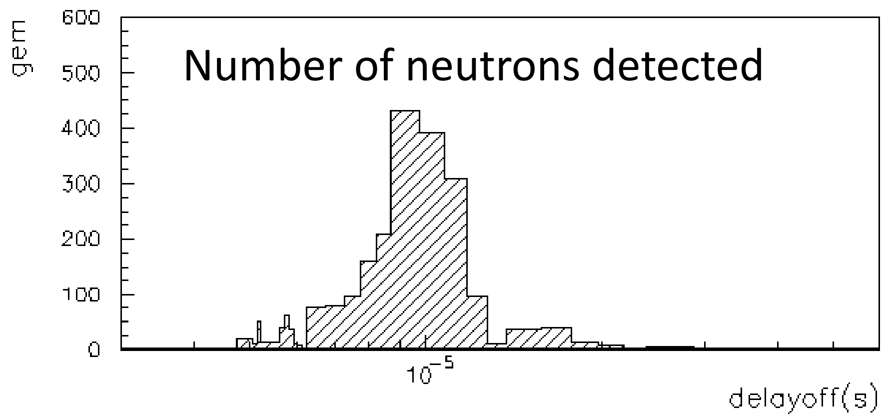


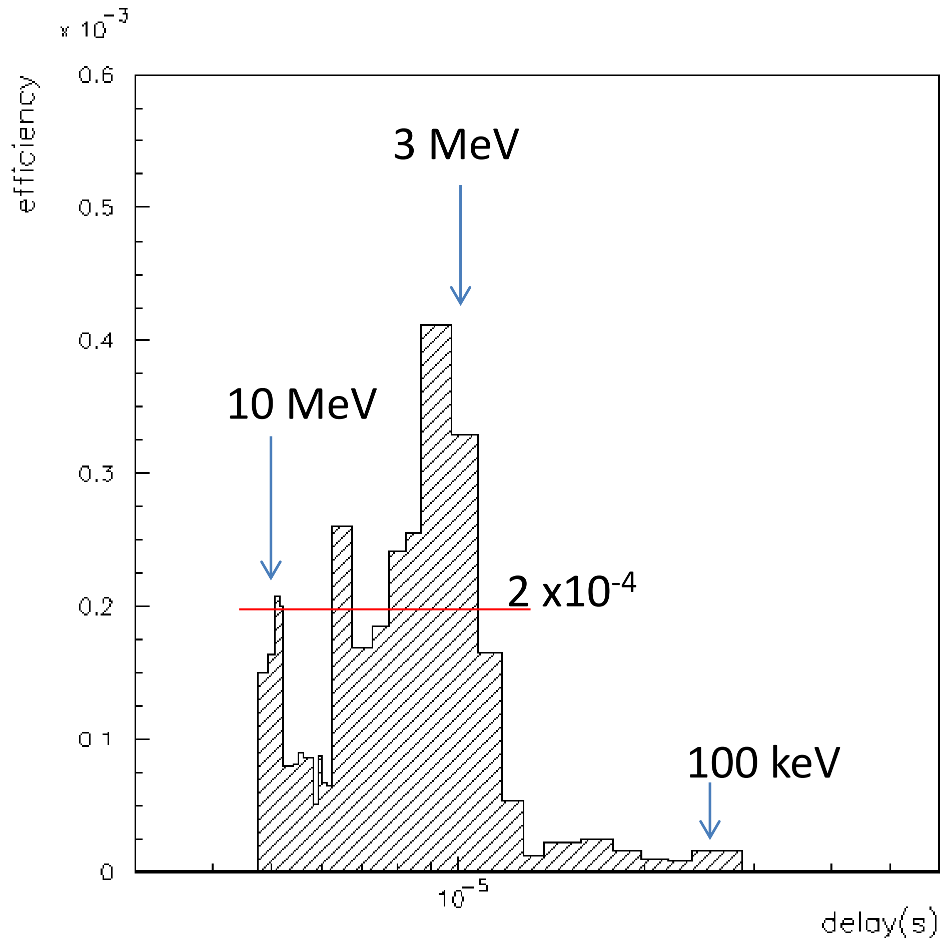


Measurements : energy scan

The FPGA can detect neutrons vs a delay in time allowing to make a time (i.e. Neutron energy) scan that allows the efficiency vs energy to be measured (uncertainty ~0.1 ÷1%, ~20% at 10 MeV) .

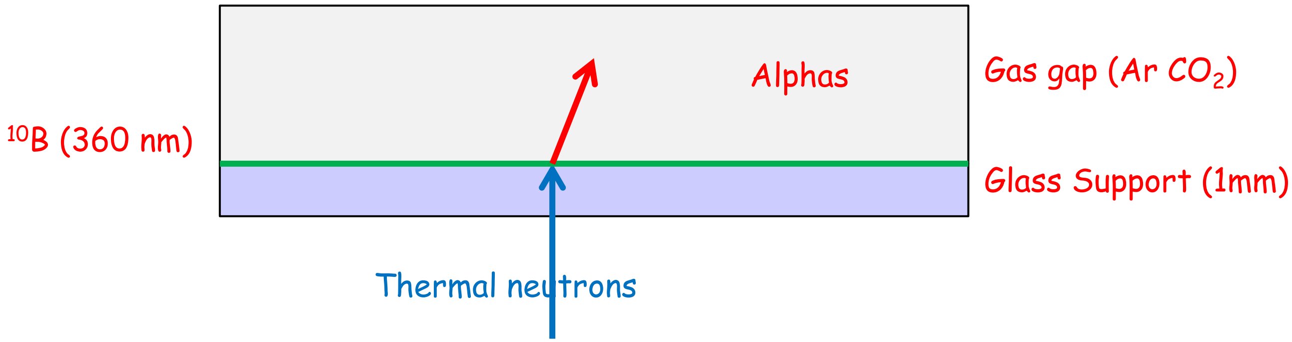




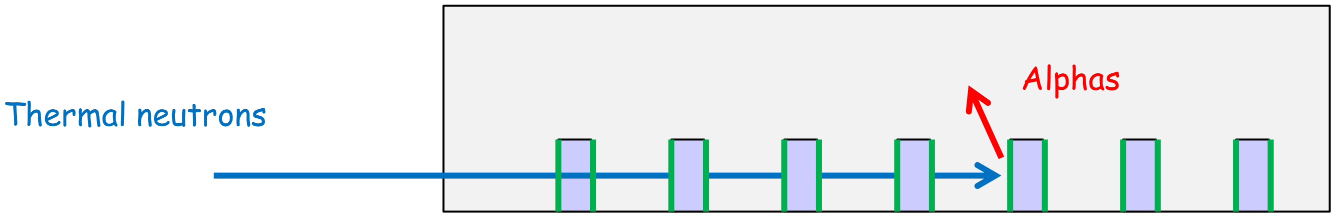


How to detect thermal neutron

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



Side-On detector



Higher efficiency ~ 5%

F. Murtas et al., ieee workshop record He-2-5

Monitor for fission reactor

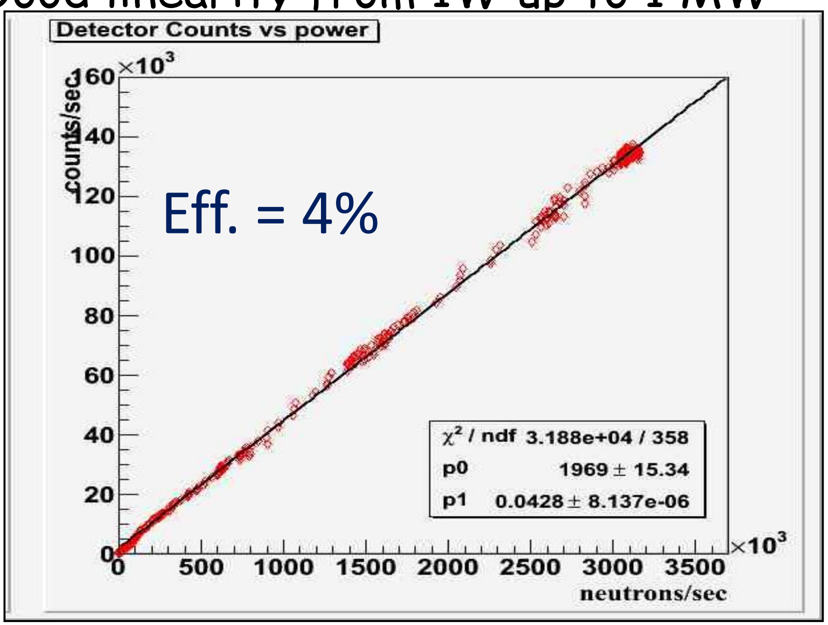
Measurements at Triga (ENEA)

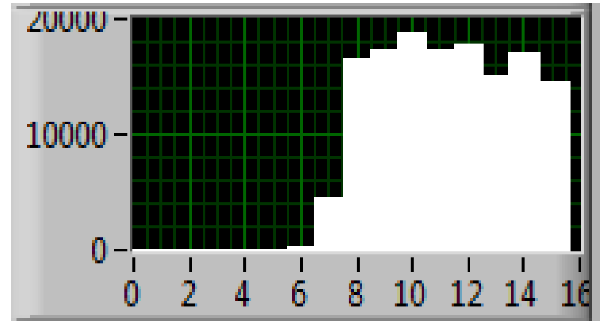
Power of 1 MW

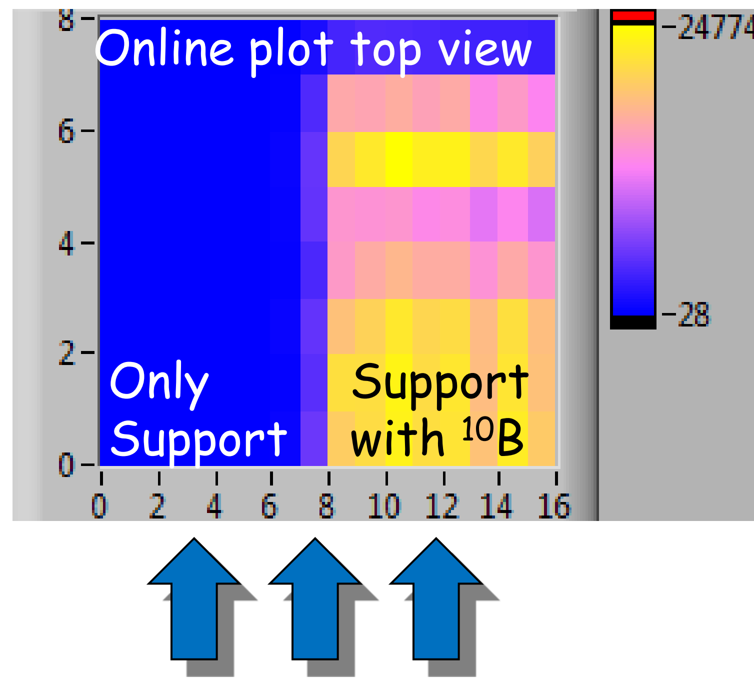
Gamma background free

Without electronic noise

Good linearity from 1W up to 1 MW







Thermal neutrons

N-TOF thermal neutron Beam spot

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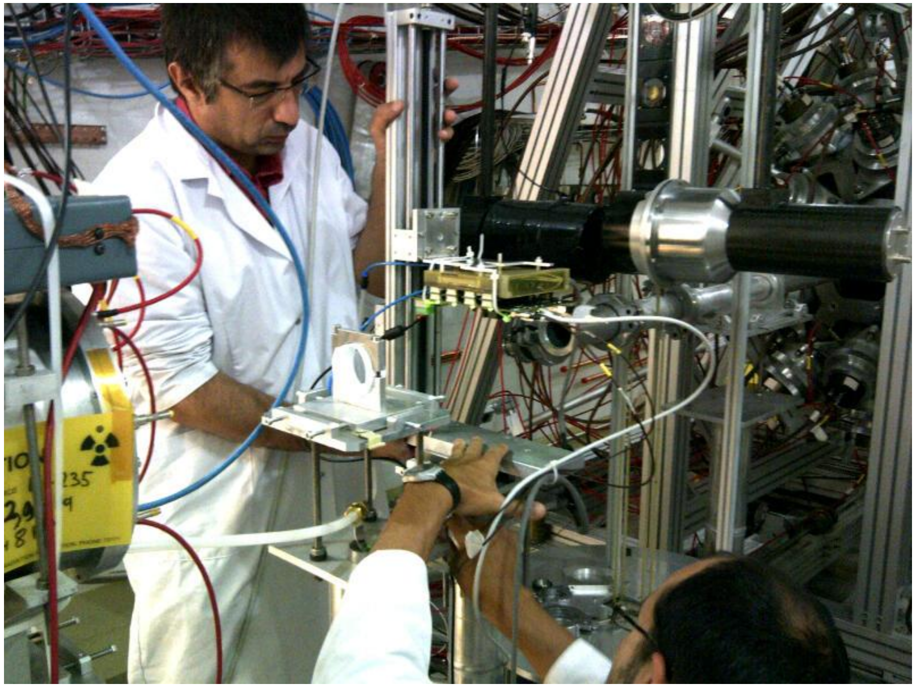
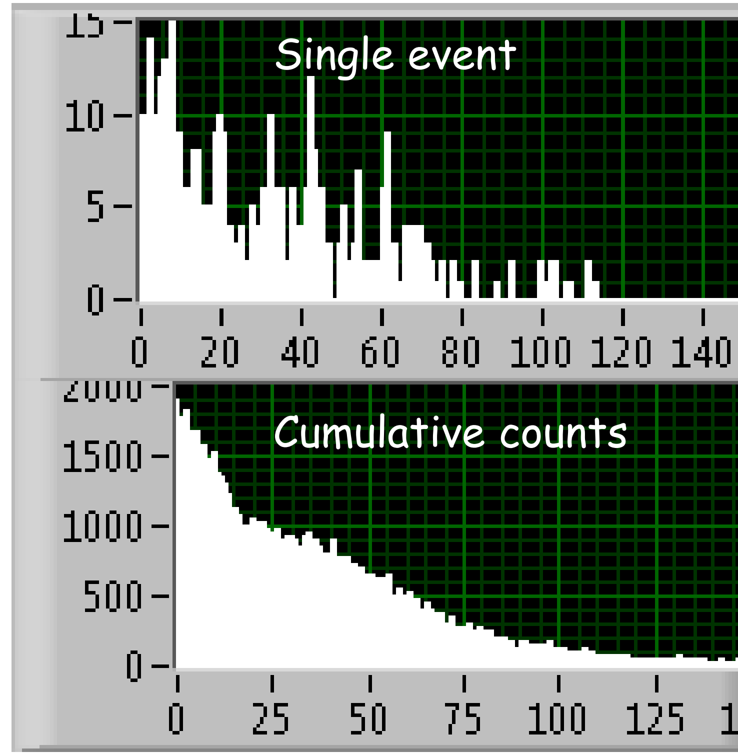
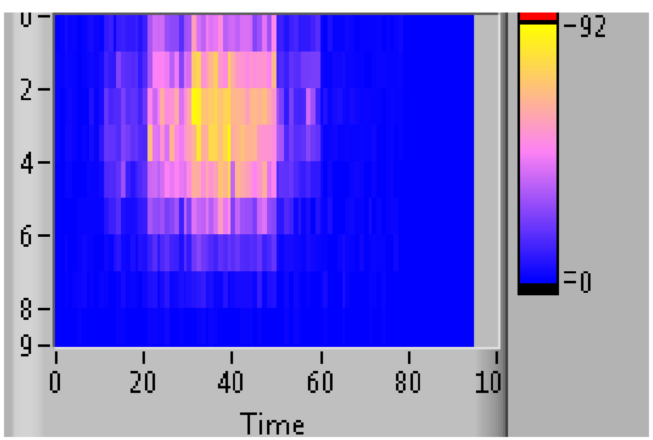


online measurement



Time spectrum (1ms/bin) 150ms gate



With a scan procedure it is possible to make an image of the neutron beam in the thermal region

CONCLUSIONS

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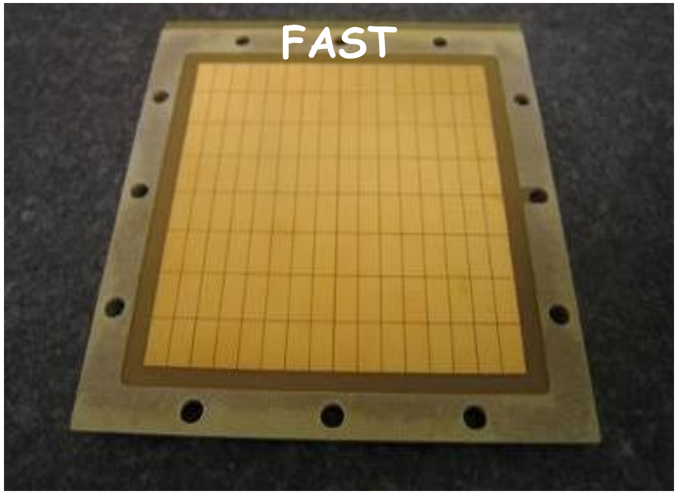
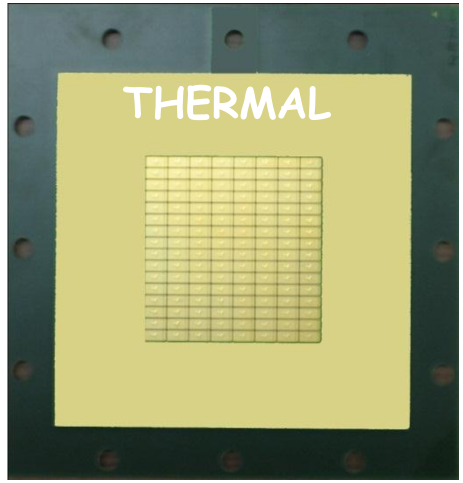
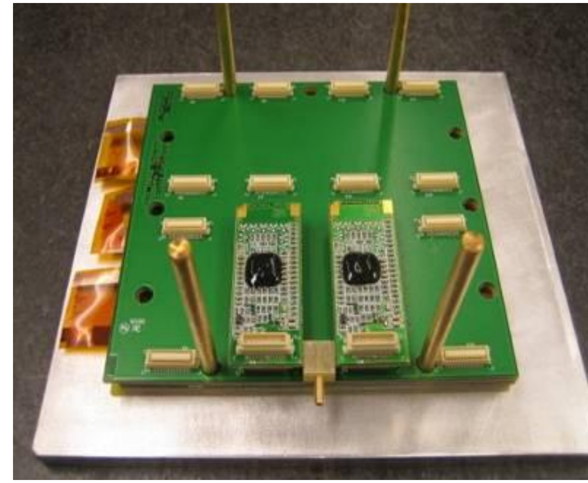
- A triple GEM for fast neutrons has been tested at beam dump in n_TOF facility at CERN
- The GEM detector system is able to measure in **real time** the neutron beam spot with almost **complete rejection** of gamma ray
- The mean efficiency of this detector is **$2\ 10^{-4}$**
- The efficiency curve vs neutron energy was measured in the range 100 keV- 10 MeV
- With a scan procedure it is possible to obtein the **beam imaging** for **thermal neutrons**
- A new prototipe for thermal neutrons with **50%** efficiency and **9cm** window will be ready in 01-2013
- Other GEM detectors was succesfully tested at ISIS spallation neutron source in UK and the Frascati Tokamak in Italy.

Triple GEM detector: electronics readout





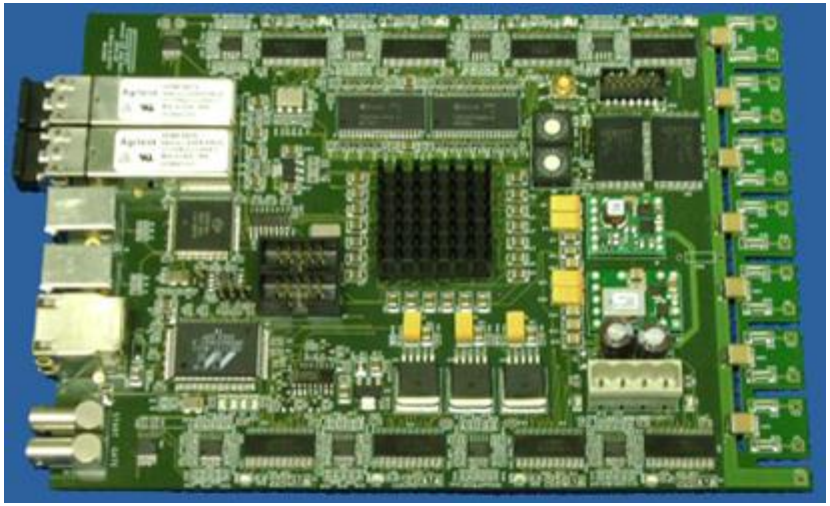


- FAST neutrons: 128 pads 6x12 mm^2 ~ 100 cm^2 of sensitive area
- THERMAL neutrons: 128 pads 3x6 mm^2 ~ 25 cm^2 of sensitive area
- 8 chip CARIOCA to set the threshold on 16 channels and reshape the signal
- FPGA-based DAQ: 128 scaler and TDC channels, in → gate and trigger, out → signals
- HVGEM power supply with 7 independent channels and nano-ammeter

Developed by G. Corradi D. Tagnani Electronic Group LNF-INFN

Developed by A.Balla and G. Corradi and Electronic Group LNF-INFN

Triple GEM detector: electronics readout



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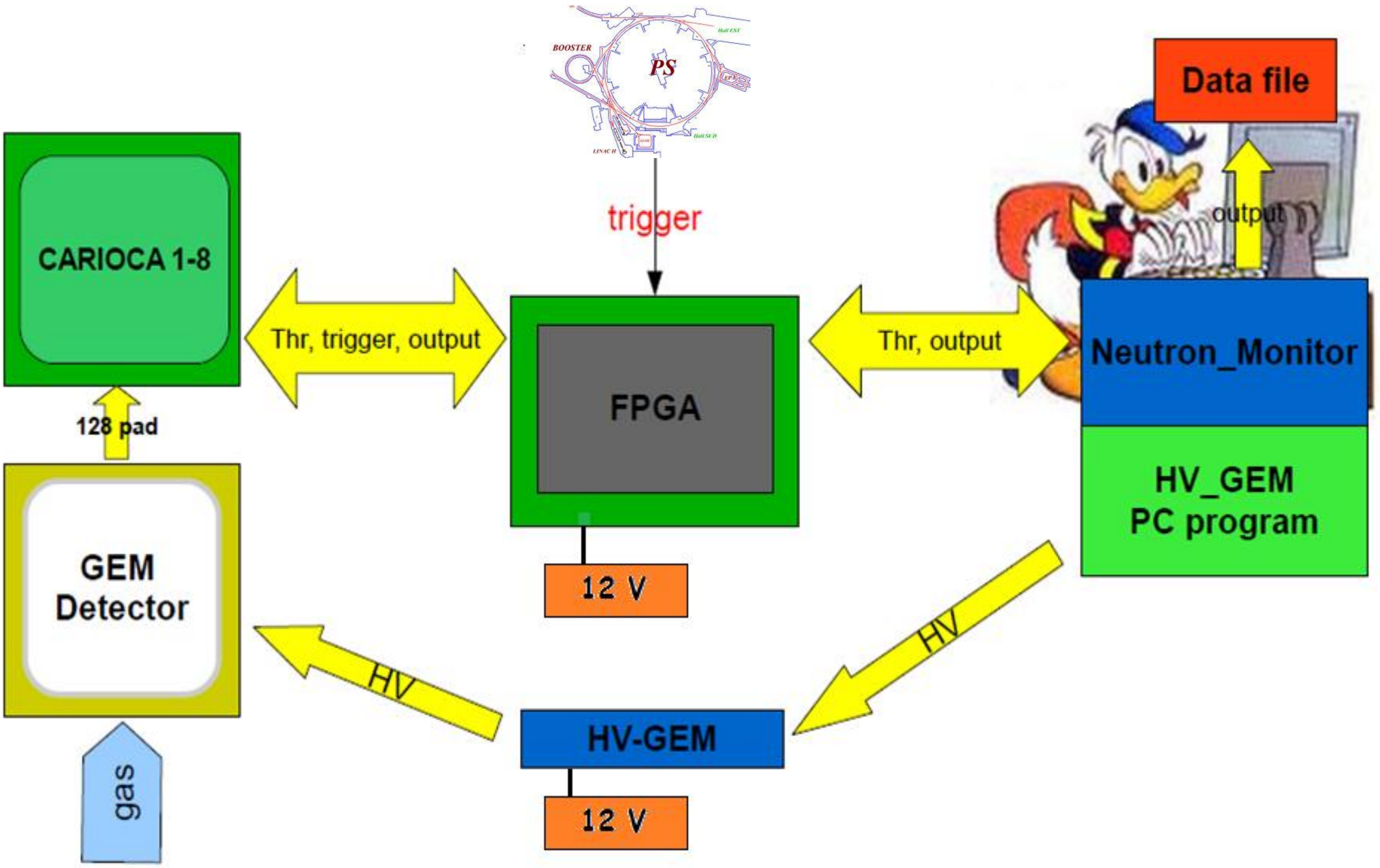
Data Acquisition



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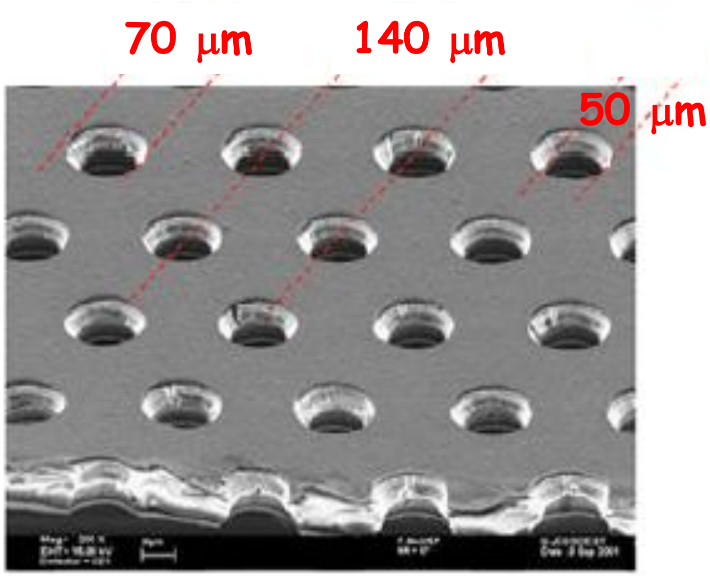

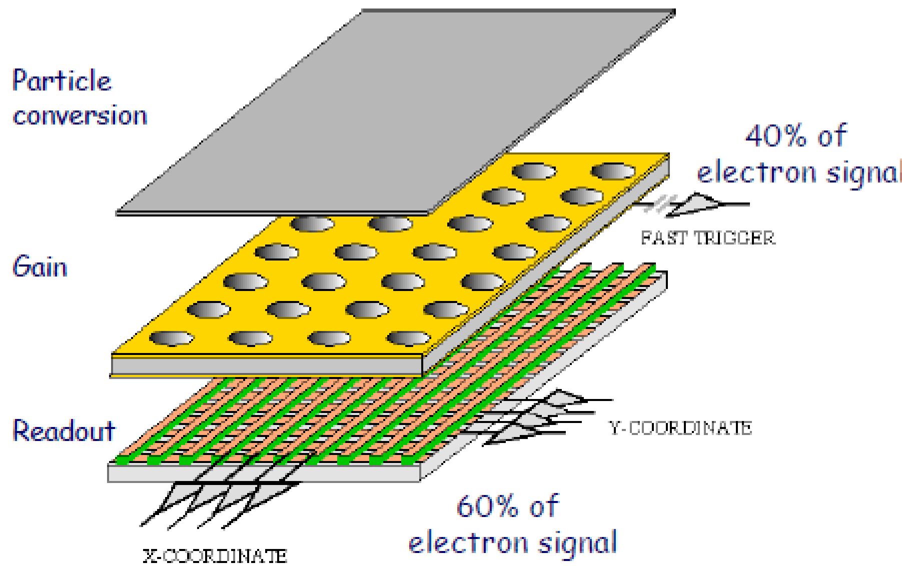

- Particle conversion, charge amplification and signal induction zones are physically separated
- Time resolution depends on geometry and gas: **9.7 ns** for Ar-CO_2 (70-30)
- Spatial resolution depends on geometry (up to **200 μm**), however is limited by readout
- Dynamic range: **from 1 to 10^8 particles/cm^2 s**
- Effective gain is given by the formula: $G_{eff} \propto \sum V_{G_i}$

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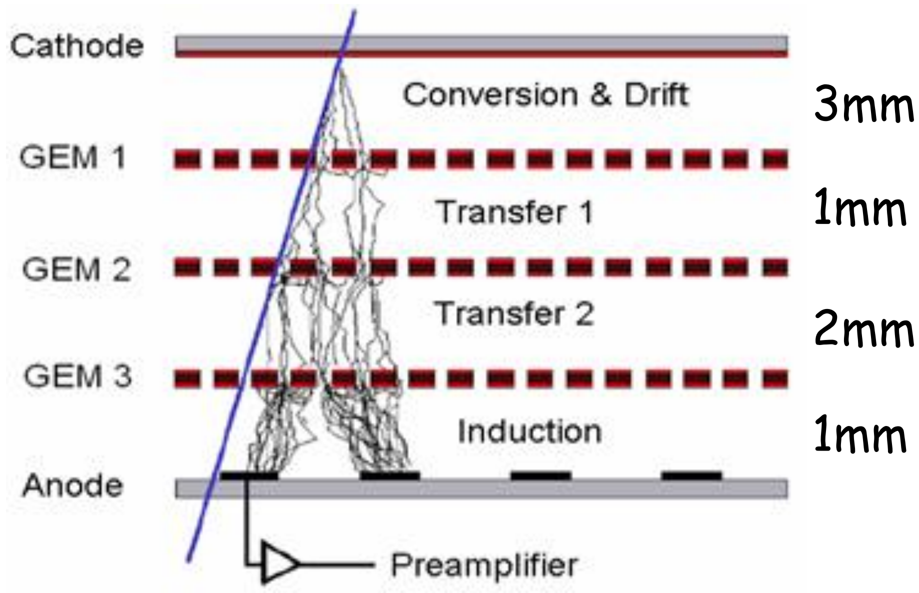
M. Alfonsi et al., The triple-Gem detector for the M1R1 muon station at LHCb, N14-182, 2005 IEEE-NSS

Triple GEM detector



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