Performance test of triple GEM detector at CERN n_TOF facility

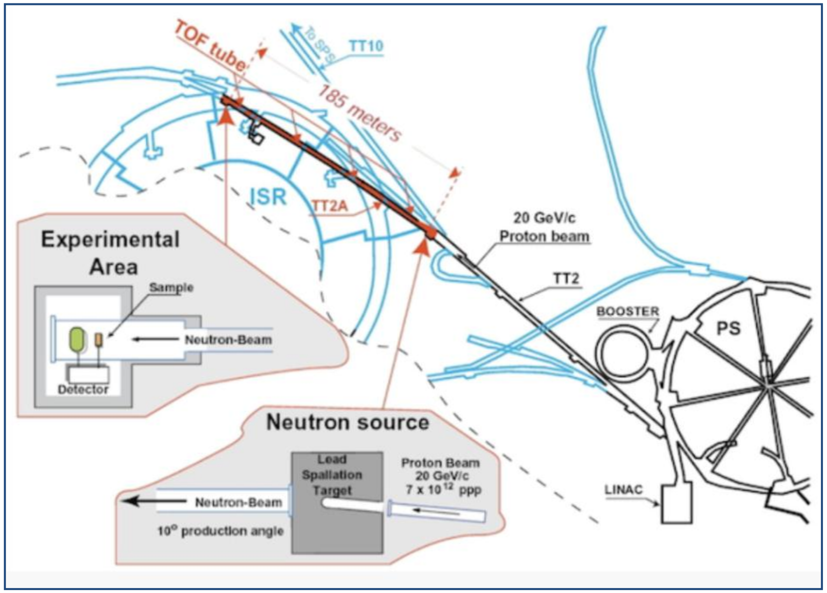
S.Puddu[2,4],

G.Claps[1], G. Croci[3], F. Murtas[1,2], A.Pietropaolo[3], C. Severino[2,4], M. Silari[2]

1) LNF-INFN 2) CERN 3)IFP-CNR 4)LHEP-Bern Universität

- n_TOF neutron facility at CERN
- Triple GEM detector
- Triple GEM detector for fast neutrons
- Conclusion

N-TOF neutron facility @CERN



- Proton **intensity** — *$8x10^{12}$ p/pulse*
- Proton beam **momentum** — *20 GeV/c*
- Proton **pulse width** — *6 ns (rms)*
- high **instantaneous n flux** — *10^5 n/cm^2/pulse*
- wide energy **spectrum** — *25 meV<E_n<1GeV*
- low **repetition** rate — *< 0.25 Hz*
- good energy **resolution** — *DE/E = 10^{-4}*

Neutrons collimated and guided through an evacuated beam pipe to an experimental area at **185 m** from the spallation target.

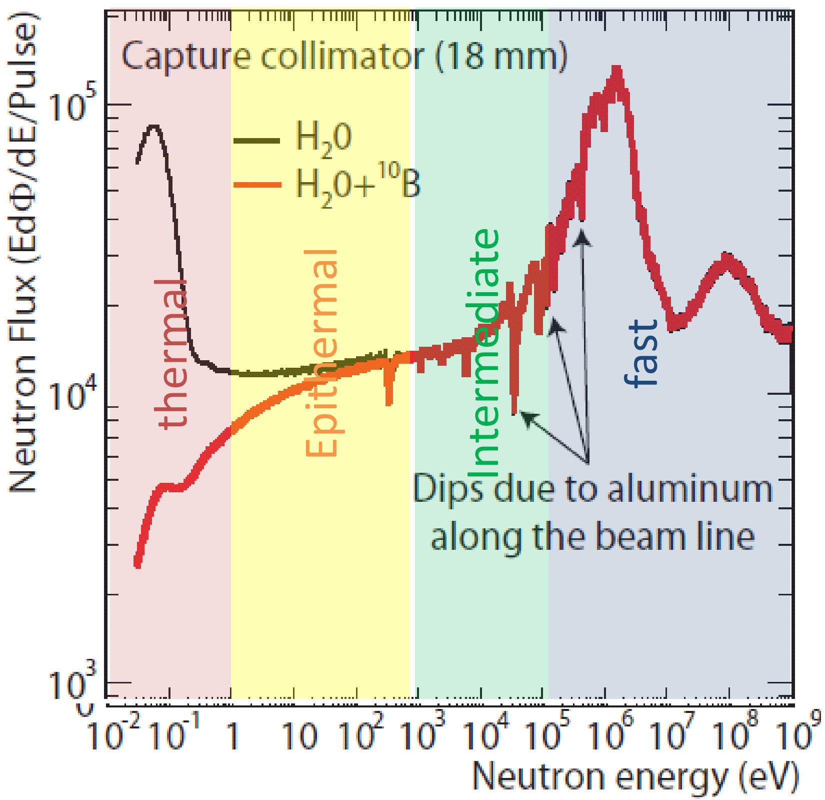
Samples placed in the neutron beam and the reaction products are detected with dedicated detectors.

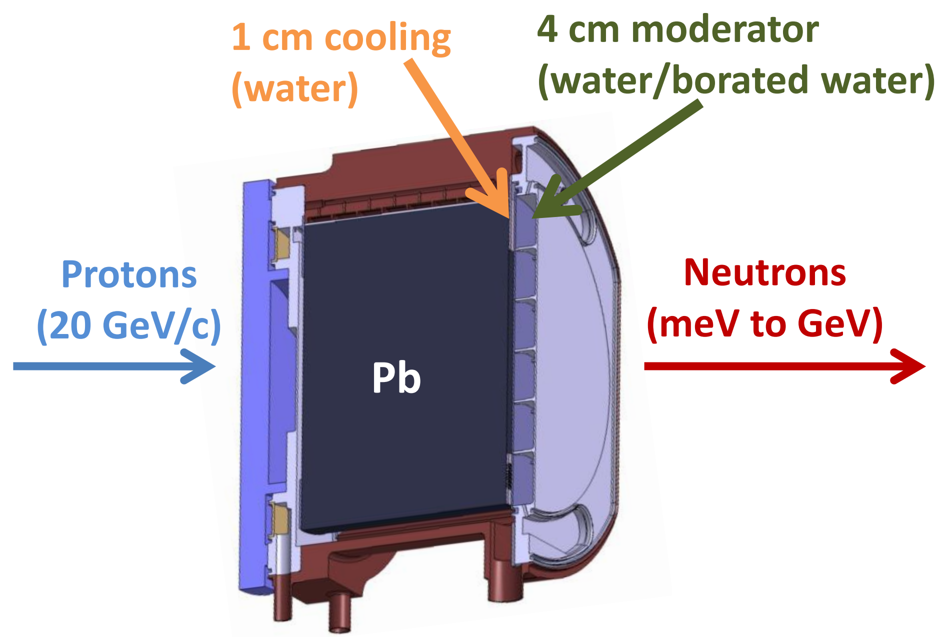
- **large energy range**
- **high number of neutrons in a single pulse.**

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

Neutron spectrum @NTOF

Wide neutron spectrum spanning an energy range from the meV up to the GeV region.

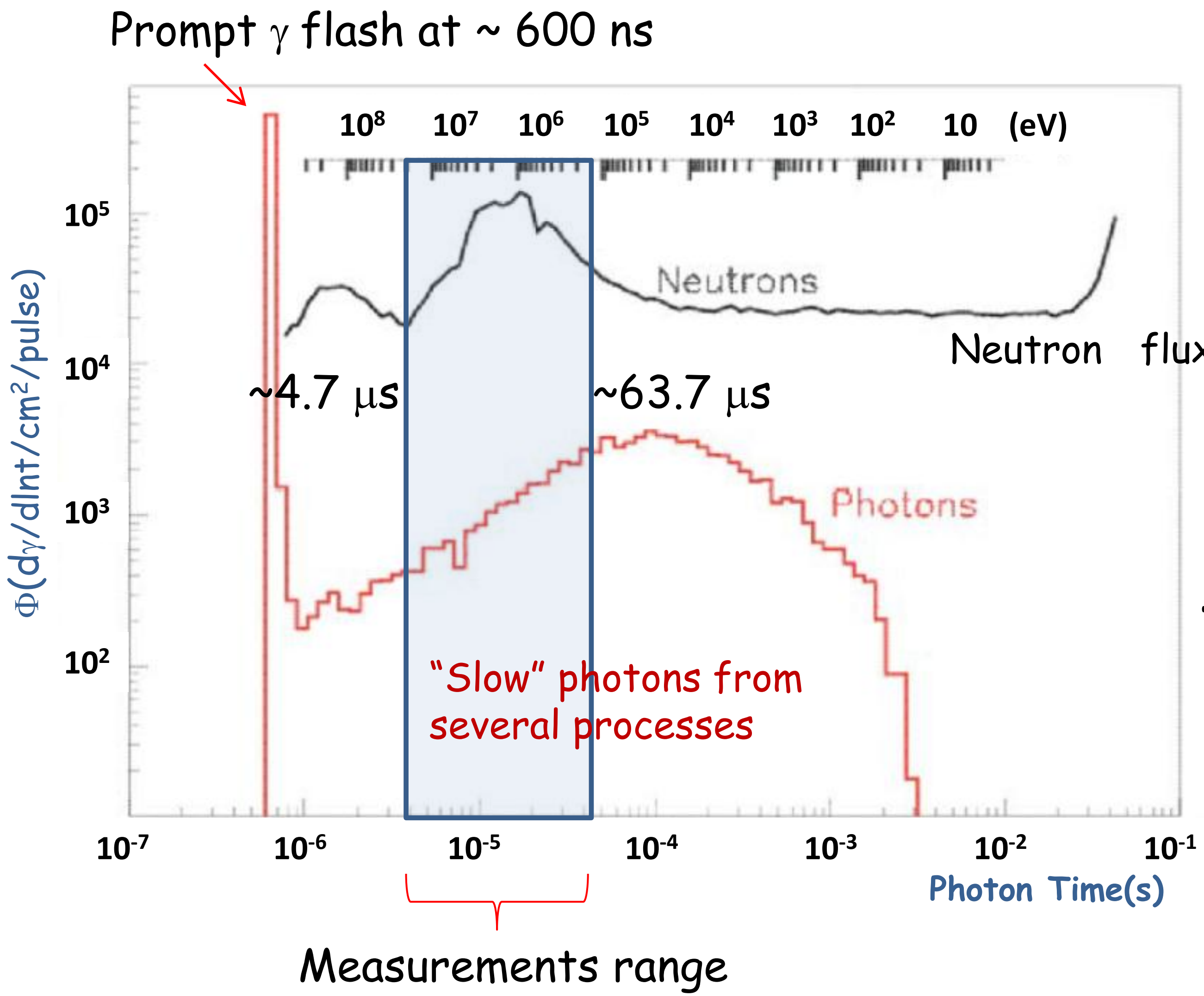




Lead spallation target

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

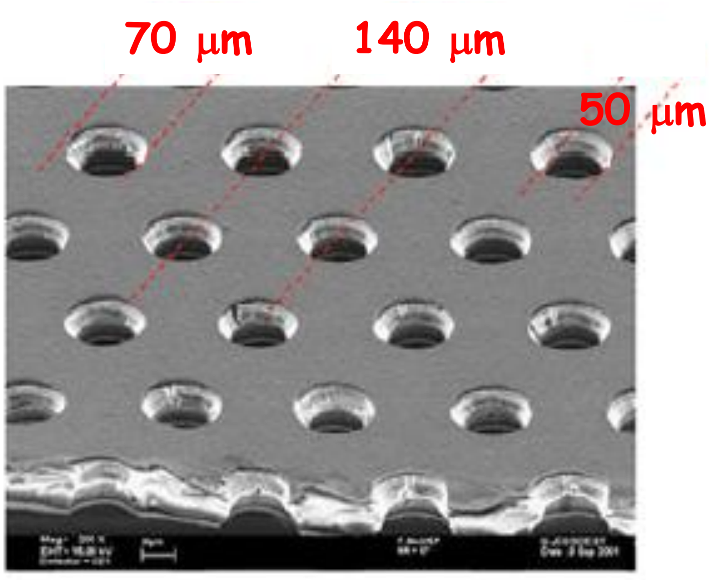
Beam Contamination by gammas

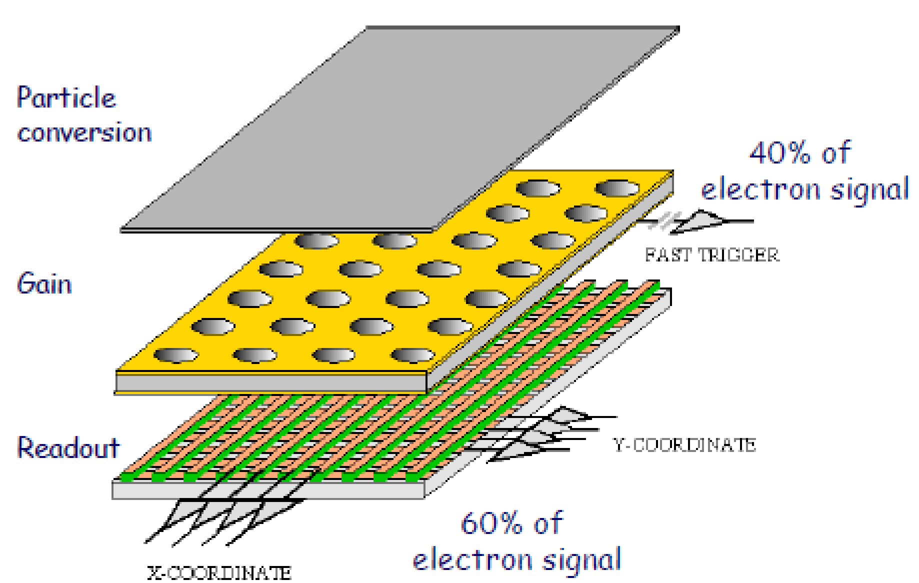


Neutron flux vs energy

+ γ from neutrons radiative capture in the beam dump

Triple GEM detector



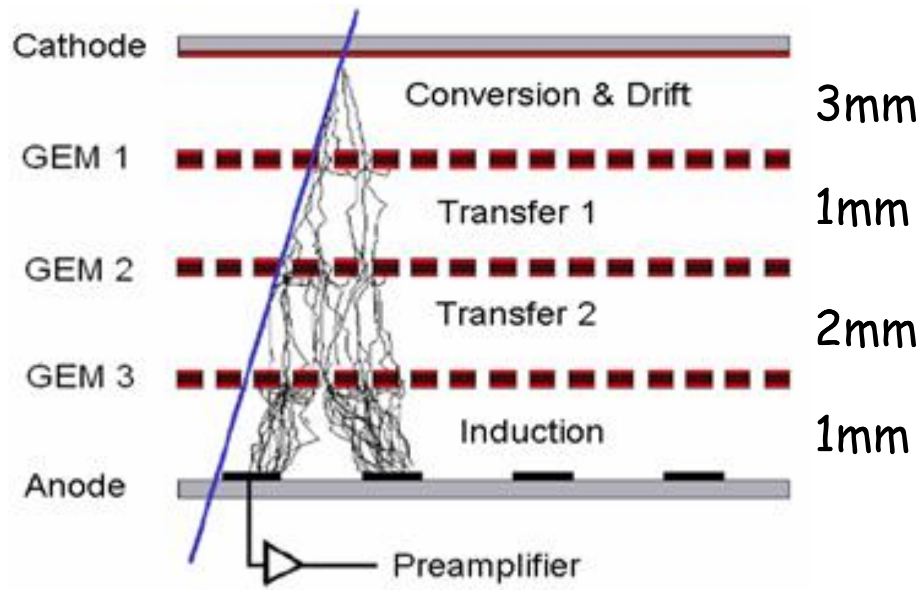


- Particle conversion, charge amplification and signal induction zones are physically separated
- Time resolution depends on geometry and gas: **9.7 ns** for Ar-CO2 (70-30)
- Spatial resolution depends on geometry (up to **200 μm**), however is limited by readout
- Dynamic range: **from 1 to 10^8 particles/cm^2 s**
- Effective gain is given by the formula: $G_{eff} \propto \sum V_{G_i}$

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

Triple GEM detector



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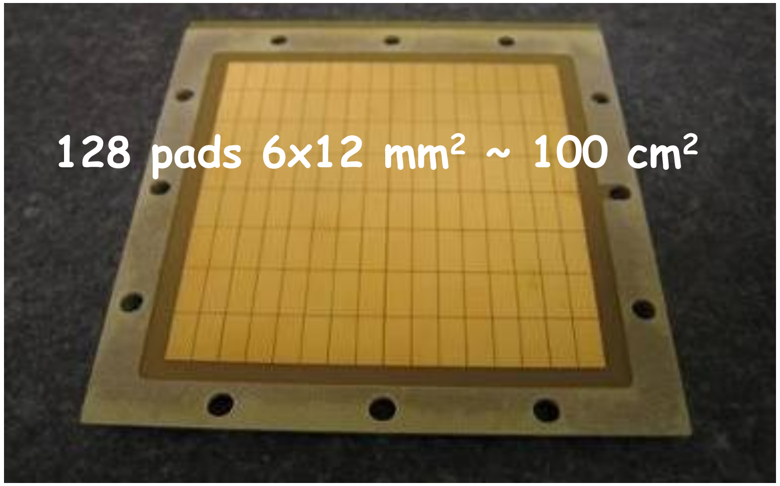
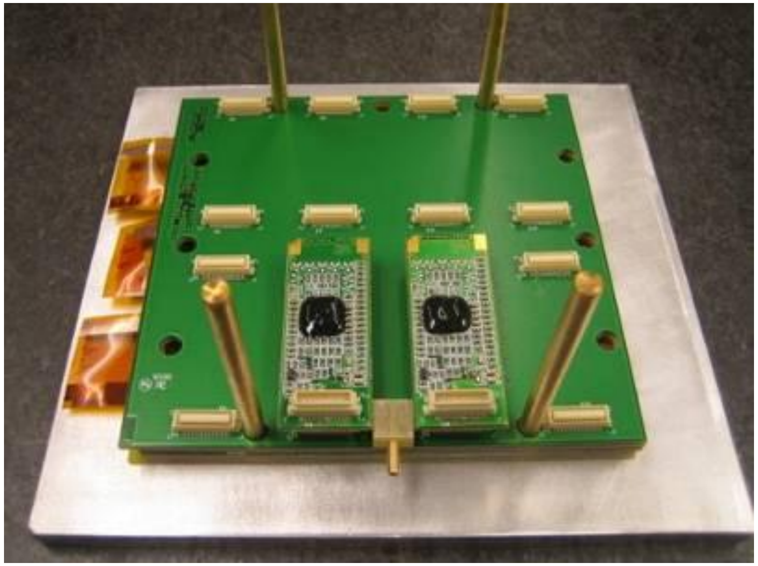
Triple GEM detector: electronics readout





- 128 pads 6x12 mm^2 ~ 100 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

Triple GEM detector: devices

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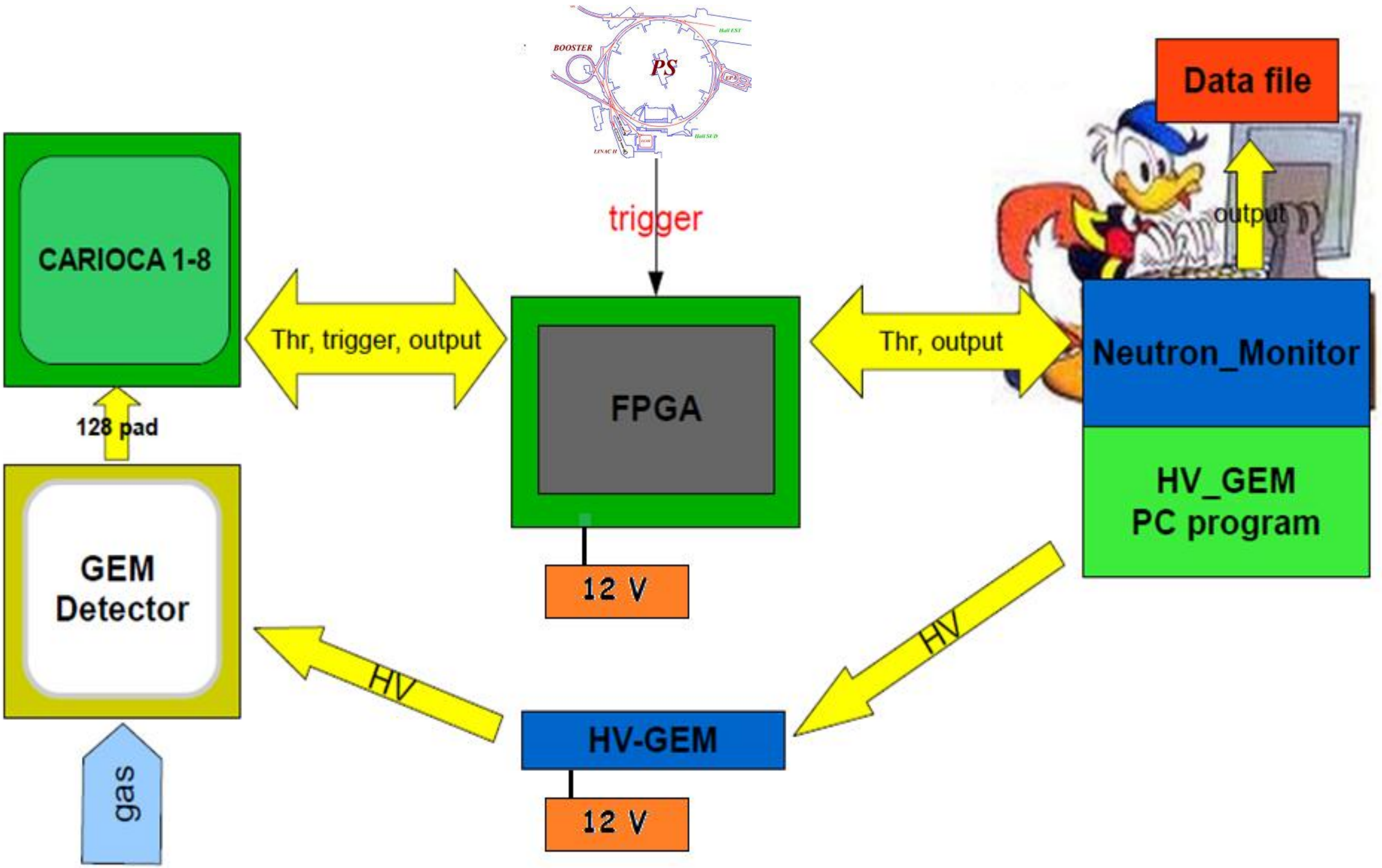
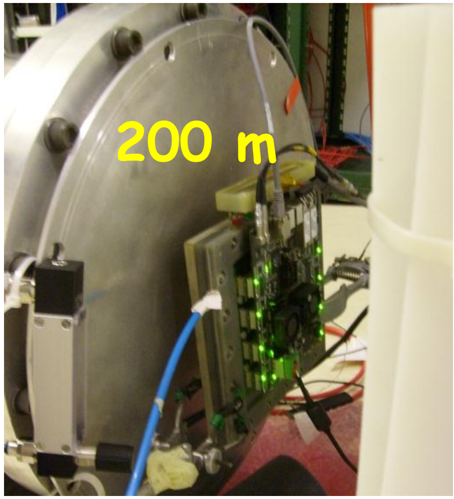
Developed by A.Balla and G. Corradi and Electronic Group LNF-INFN

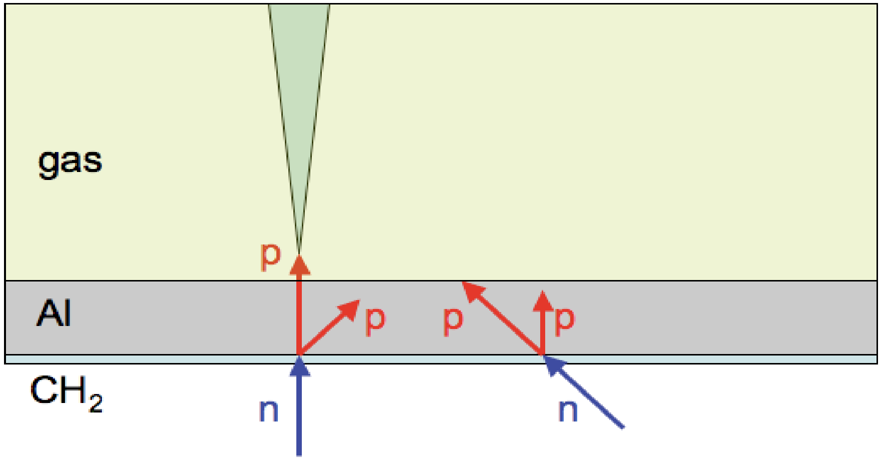
Data Acquisition



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
- Low γ sensitivity: HV at 870V → gain ~ 300

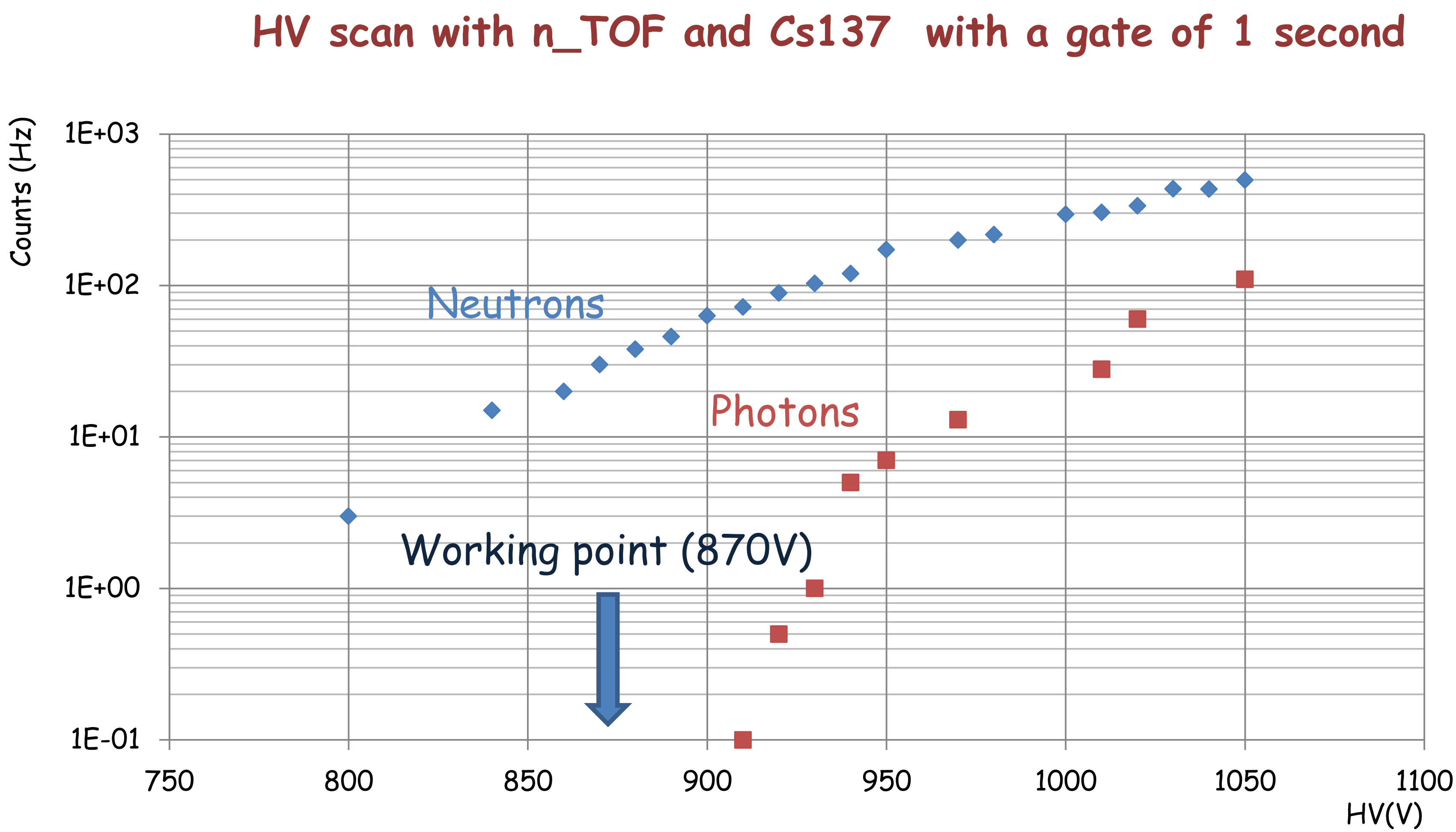




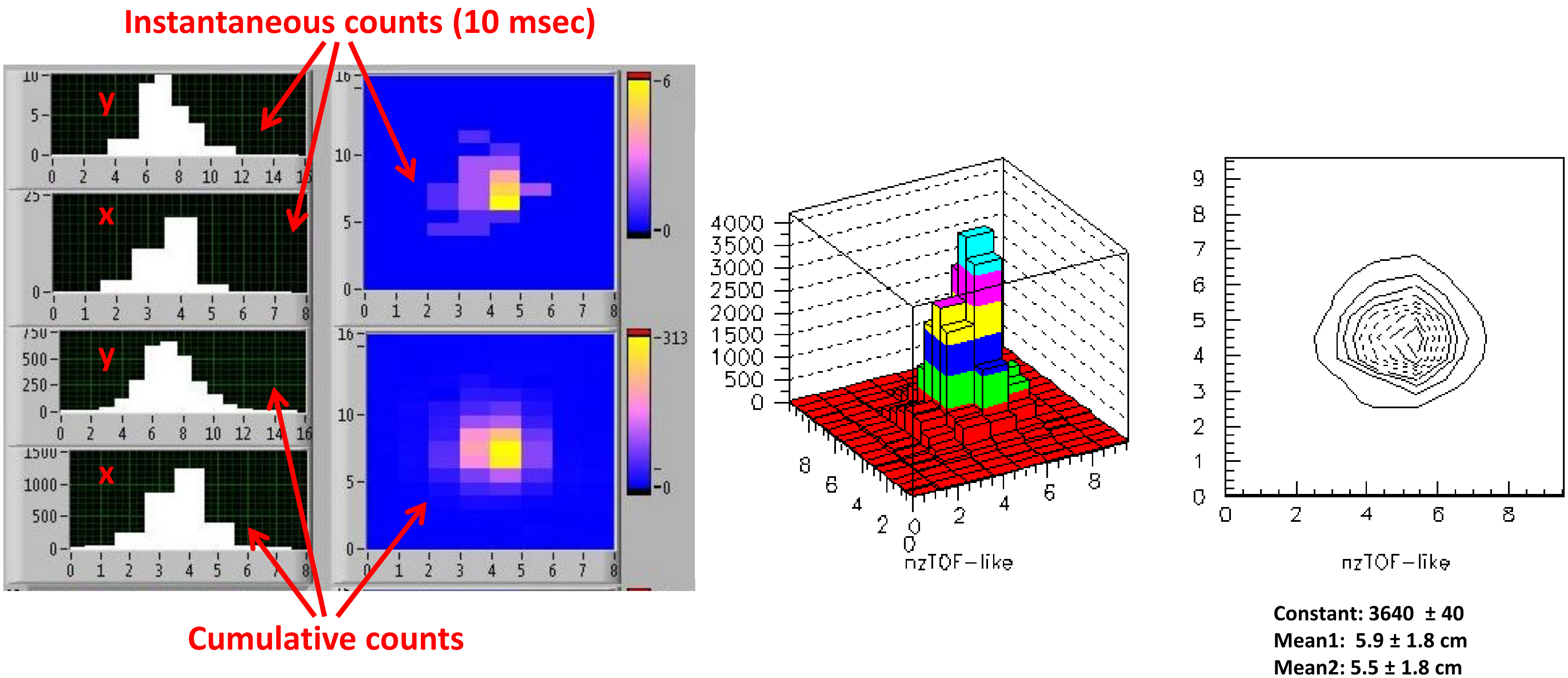
Neutrons interact with CH_2, and, due to elastic scattering processes, protons are emitted and enter in the gas volume generating a detectable signal.

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

Low Sensitivity to Photons



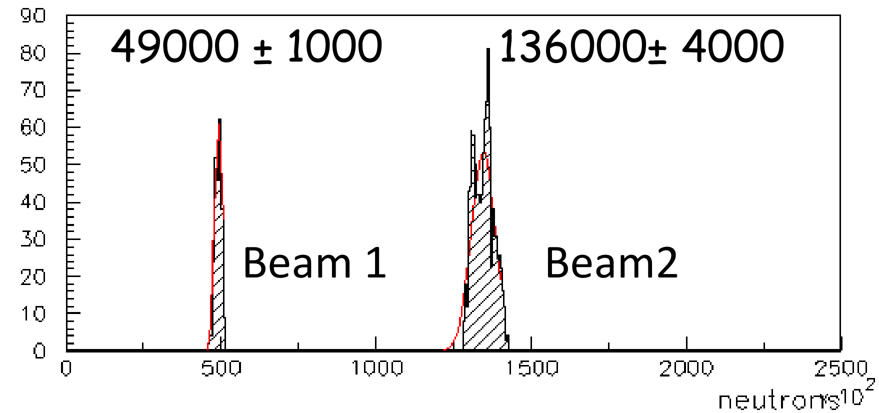
MEASUREMENTS : REAL TIME BEAM PROFILE



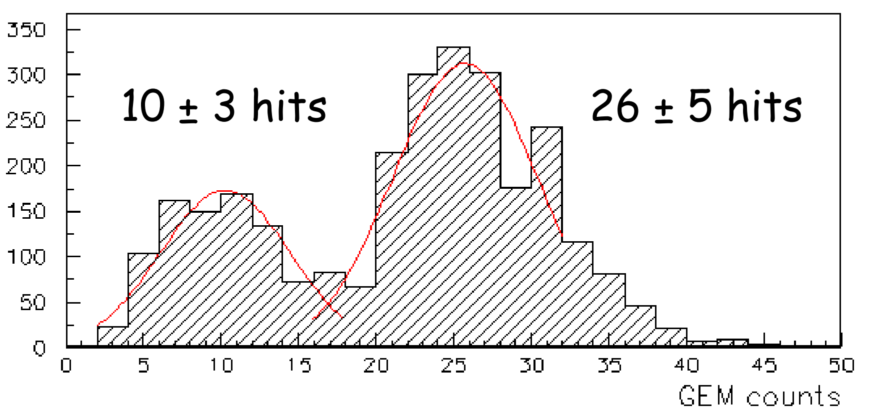
- Delay 2000 ns, HV 870 V, gate 10 ms
- Two different intensity beams arrive to the facility

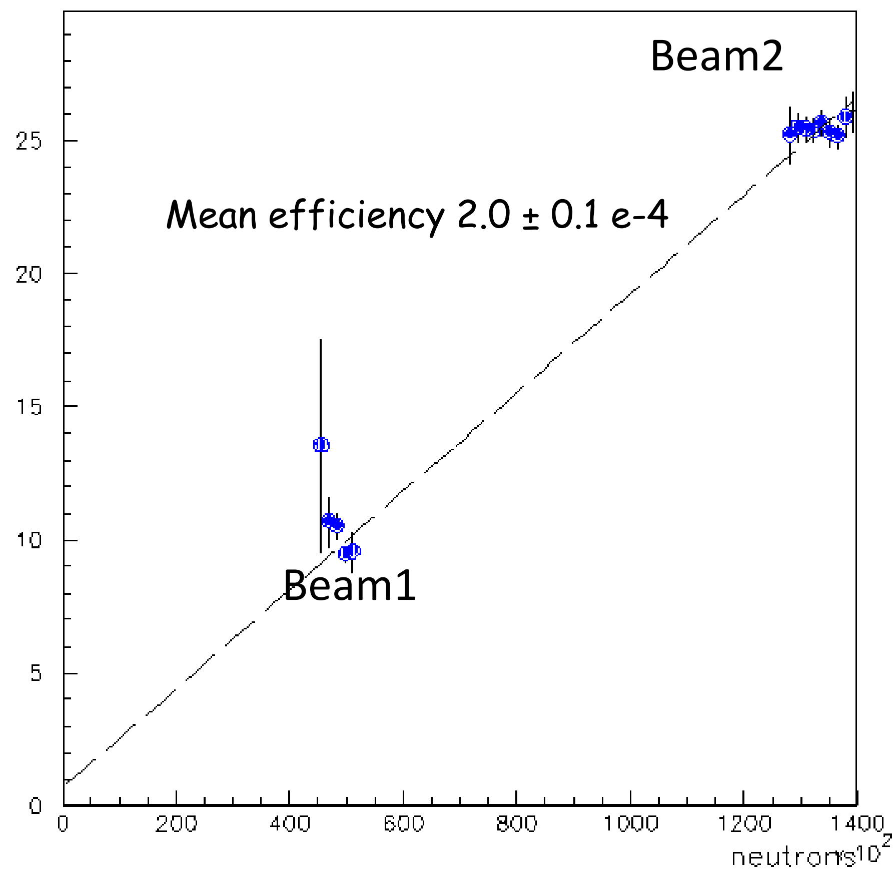
Measurements : mean efficiency

From proton beam monitor



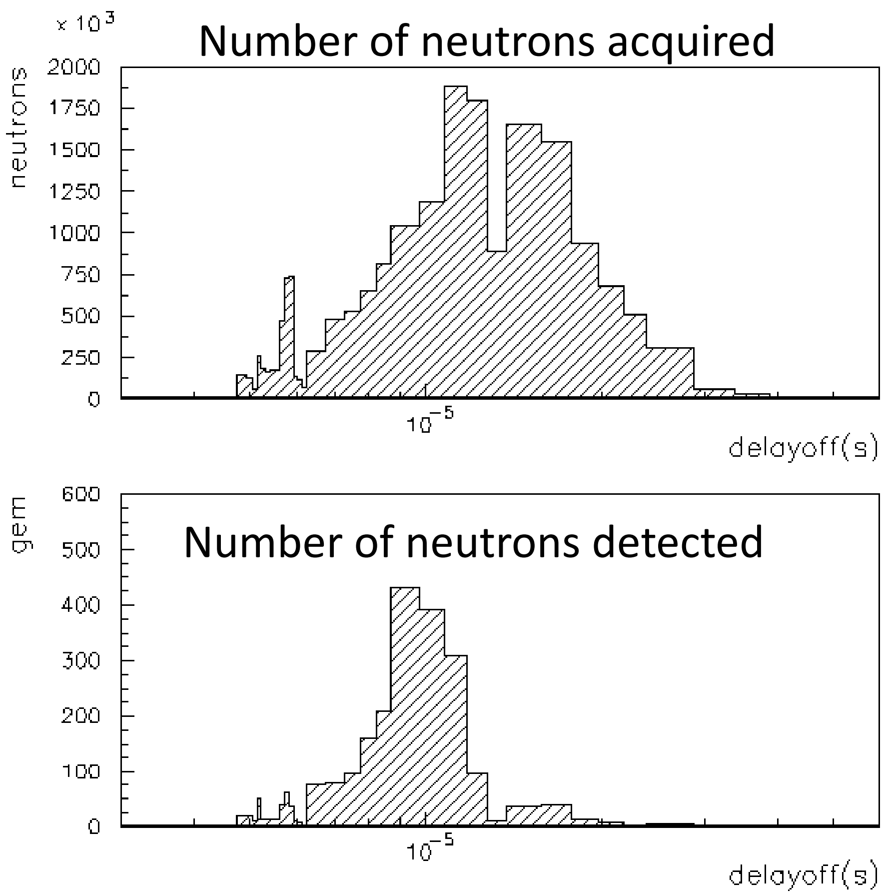
From gem neutron monitor

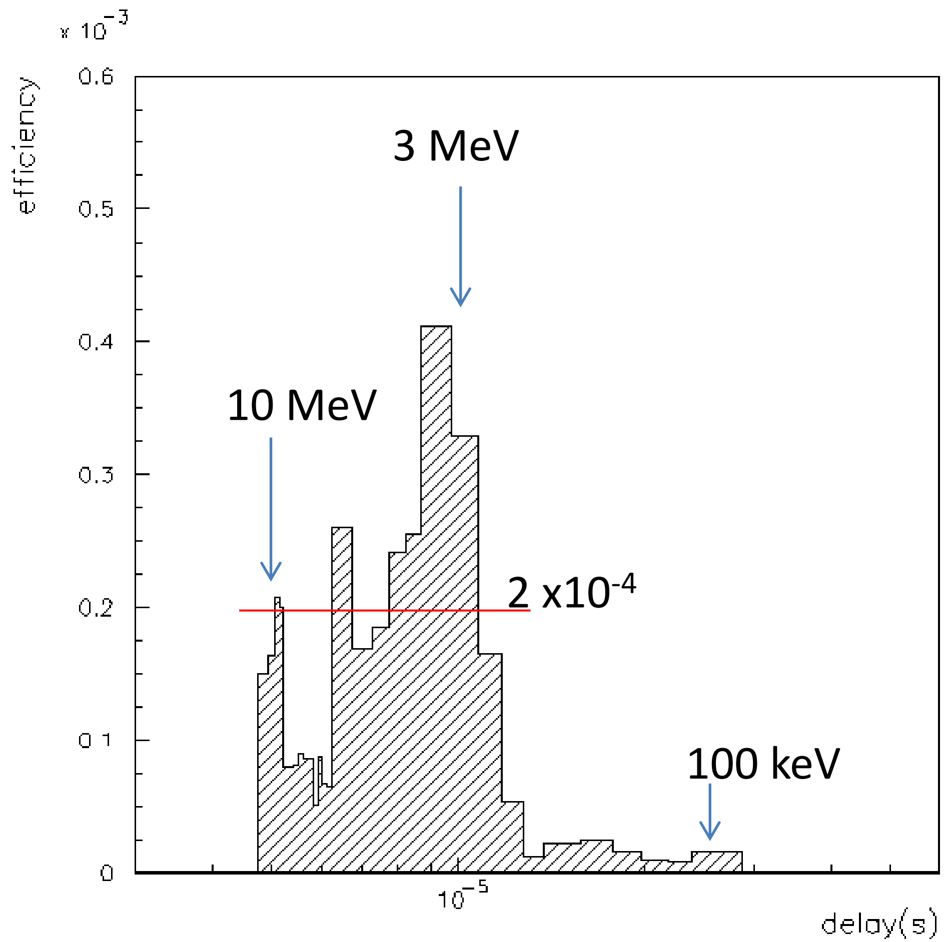




MEASUREMENTS : SCAN IN ENERGY

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) .





CONCLUSIONS

- 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 profile 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
- Other GEM detectors was succesfully tested at ISIS spallation neutron source in UK and the Frascati Tokamak in Italy.