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

- 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 from 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

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Beam Contamination by gammas

Prompt $\gamma$ flash at $\sim$ 600 ns

- Fast neutrons: $\sim$4.7 $\mu$s
- Thermal neutrons: $\sim$63.7 $\mu$s
- "Slow" photons from several processes
- $\gamma$ from neutrons radiative capture in the beam dump

$\Phi (d\gamma/d\text{int}/\text{cm}^2/\text{pulse})$


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

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

Counts (Hz)

Neutrons

Photons

Working point (870V) → gain ~ 300

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How detect fast neutrons

- Neutron converter $60 \, \mu m \, PE + 40 \, \mu m \, Al$
- 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
Delay 2000 ns, HV 870 V, gate 10 ms

- Two different intensity beams arrive to the facility
Measurements: mean efficiency

From proton beam monitor

<table>
<thead>
<tr>
<th>Beam</th>
<th>Count</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam1</td>
<td>49000</td>
<td>±1000</td>
</tr>
<tr>
<td>Beam2</td>
<td>136000</td>
<td>±4000</td>
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</tbody>
</table>

From GEM neutron monitor

<table>
<thead>
<tr>
<th>Beam</th>
<th>Count</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam1</td>
<td>10</td>
<td>±3</td>
</tr>
<tr>
<td>Beam2</td>
<td>26</td>
<td>±5</td>
</tr>
</tbody>
</table>

Mean efficiency 2.0 ± 0.1 e-4
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).

Number of neutrons acquired

Number of neutrons detected

Measurements: energy scan
How to detect thermal neutron

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

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

Eff. = 4%

Online plot top view
Only Support
Support with $^{10}$B

Thermal neutrons
N-TOF thermal neutron Beam spot

With a scan procedure it is possible to make an image of the neutron beam in the thermal region.
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 spot with almost complete rejection of gamma ray
• The mean efficiency of this detector is $2 \times 10^{-4}$
• The efficiency curve vs neutron energy was measured in the range 100 keV- 10 MeV
• With a scan procedure it is possible to obtain the beam imaging for thermal neutrons
• A new prototype for thermal neutrons with 50% efficiency and 9cm window will be ready in 01-2013
• Other GEM detectors was successfully 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\(^2\) \(\sim\) 100 cm\(^2\) of sensitive area
- THERMAL neutrons: 128 pads 3x6 mm\(^2\) \(\sim\) 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 \(\rightarrow\) gate and trigger, out \(\rightarrow\) signals
- HV GEM 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

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Data Acquisition

CARIOCA 1-8

GEM Detector

FPGA

HV-GEM

Neutron_Monitor

Data file

12 V

12 V

Thr, trigger, output

Thr, output

HV

HV

128 pad

gas

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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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