Neutron Beam Imaging with GEM-based detectors

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INTRODUCTION

Due to the 3He worldwide shortage, new high efficiency thermal neutron detectors shall be developed in order to replace the current 3He detectors for future spallation sources such as ESS (Fig.1).

Very high-rate thermal and fast neutron detectors are needed for ESS and for future fusion experiments as MITICA (full scale prototype) (Fig.2).

GEM (Gas Electron Multiplier) detectors can be adapted to detect fast and thermal neutrons with a proper converter cathode.

GEM detectors could be used both as beam monitors and as diffraction detectors.

TRIPLE GEM TECHNOLOGY

Converter cathode

• Negligible discharge probability
• High rate capability (MHz/mm²)
• Large areas (~1m²)
• Adaptable readout structure
• Different shapes

Imaging with Neutrons

A bi-dimensional VESUVIO (ISIS-RAL) beam profile reconstruction was obtained by exposing the detector to the neutron beam for 2 minutes.

The imaging property of each detector was tested by inserting samples of different material and shape in the beam.

\[ V_{\text{beam}} = \sum_{\text{readout pads}} = 870 \text{V} \]

insensitive to γ-rays; gain=100

The fast neutron beam profile reconstruction was compared to the one obtained by diamond detectors positioned on the same beam line.

The thermal neutron one was compared to the image obtained by cadmium coupled x-rays films.

All the samples were correctly reconstructed and the definition of the reconstruction depends on the type of readout anode.

Fast neutrons

Thermal neutrons

REFERENCES


DETECTORS COMPONENTS

1) Neutron converter cathode

• 400 μm thick Al foil coated with a 1 μm thick B,C film.
• In the nuclear reaction \( n^{(25)B, 0} Li \) (σ(25 MeV) = 3980b) alpha particles (1.47 MeV) and \( ^7 Li \) ions (0.84 MeV) are emitted back to back and the one entering the gas volume generates a detectable signal.
• B,C thickness ensures an efficiency of around 1% (sufficient for high flux beam monitors).

2) GEM foils

• Thin Kapton insulating foil copper-clad on both sides and perforated by a high density, regular matrix of holes.
• Charge amplification structure.
• Localization performed recording the charge detectable signal.
• Protons entering the gas volume generate a detectable signal.
• Al thickness ensures the directionality capability, stopping protons that are emitted at a too wide angle.

3) Electronics

• Padded readout structure
• CAROCA-GEM digital chips
• FPGA Mother-board

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