ISIS@MACH ITALIA

Science and Technology Facilities Council
ISIS Neutron and Muon Source

Experiment Proposal

Experiment number GP2023007

Principal investigator (*)	Professor Gabriele Croci, University of Milano - Bicocca, ITALY
Co-investigator	Dr Andrea Muraro, CNR, ITALY
Co-investigator	Dr Enrico Perelli Cippo, Consiglio Nazionale delle Ricerche, ITALY
Co-investigator	Dr Marica Rebai, CNR, ITALY
Co-investigator	Miss Stephanie Cancelli, Università degli Studi Milano-Bicocca, ITALY
Co-investigator	Professor Giuseppe Gorini, Milano-Bicocca University, ITALY
Co-investigator	
Co-investigator	
Co-investigator	
Experiment title	Measurement of B4C thickness of converting layers of a new Multi-layer Boron-coated GEM detector to be used at the ISIS-VESUVIO beam-line
MRF Instrument	**SEM ZEISS SIGMA**
Access Route	Direct Access
Science Areas	Chemistry, Materials, Physics
Sponsored Grant	None
Grant Title	-
Start Date	-
Similar Submission?	-
Industrial Links	-
Non-Technical Abstract	Charcterization of the thickness of B4C converting layers in order to estimate detection efficiency and compare values with measured one. Determination of chemical composition of B4C converting layers
Publications	-

Days requested: 4
Previous GP Number: -
DOI: -
Sponsor: -
Grant Number: -
Finish Date: -

ISIS neutron and muon source

IM@IT E-platform: No

Instruments	**Days Requested:**
Access Route	**Previous RB Number:**
Science Areas	**DOI:**
Sponsored Grant	**Sponsor:**
Grant Title	**Grant Number:**
Start Date	**Finish Date:**
Similar Submission?	
Industrial Links	

Sample record sheet

Principal contact Professor Gabriele Croci, University of Milano - Bicocca, ITALY
MRF Instrument **SEM ZEISS SIGMA** **Days Requested:** 4
Special requirements:

SAMPLE

Material	B4C Coated GEM foils (B4C, Cu, Kapton)	-	-
Formula	B4C (B is B10), Cu (Nat), C22H10N205	-	-
Forms	Solid		
Volume	0,5 cc		
Weight	10 g		
Container or substrate	To be defined with instrument scientist	-	-
Storage Requirements	-	-	-

SAMPLE ENVIROMENT

Temperature Range	273 - 293 K	-	-
Pressure Range	999 - 1020 mbar	-	-
Magnetic field range	0 - 0 T	-	-
Standard equipment	None	-	-
Special equipment	No	-	-

SAFETY

Prep lab needed	No	-	-
Sample Prep Hazards	No	-	-
Special equip. reqs	No	-	-
Sensitivity to air	No	-	-
Sensitivity to vapour	No	-	-
Experiment Hazards	No	-	-
Equipment Hazards	-	-	-
Biological hazards	No	-	-
Radioactive Hazards	No	-	-
Additional Hazards	-	-	-
Additional Details	-	-	-
Sample will be	Returned to user by instrument scientist (when inactive)	-	-

Measurement of B4C thickness of converting layers of a new Multi-layer Boron-coated GEM detector to be used at the ISIS-VESUVIO beam-line.

Background and Context

The constant 3He shortage has requested the development of new gas detectors optimised for slow neutrons. For this reason, for ten years Gas Electron Multiplier (GEM) detectors have been custom designed for thermal and epithermal neutrons.

GEM detectors have been coupled with a 10B4C coated cathode in order to have the neutron conversion via the reaction $n+^{10}B \rightarrow \alpha+^{7}Li$. The charged particles ionize the gas mixture inside the GEM and electrons move inside the holes of the GEM foils creating electron avalanches. Electrons are eventually collected by a padded anode and, with a custom digital electronic readout [1] capable of sustain Millions of counts per seconds (Mcps), the full information is preserved.

Recent works have shown that GEM detectors realised with this configuration can reach a detection efficiency around 1% at 25 meV with a 10^-5 n/gamma discrimination capability. [2]

Despite the good results of these devices, improved detectors are always required for future spallation sources, such as the European Spallation Source (ESS), where a neutron flux in the order of 10^9 n/(cm^2*s) at sample positions is expected. Moreover, a class of samples (like e.g. biological samples, materials for energy storage, catalytic chambers) that may change their structure, composition or characteristics in rapid ways with time need detectors able to collect data very quickly. New GEM detectors shall combine these two features: high detection efficiency and capability to sustain high count rates.

For this reason, a new dedicated GEM detector has been developed as an upgraded version to the one installed in 2019 on the VESUVIO spectrometer. The innovation is the presence of a boron coating on both sides of the GEM (BGEM) foils. Staking six BGEM foils a detection efficiency of 20% at 25 meV neutron energy is reached. The detector will be used the VESUVIO beamline to test the detector as a transmission monitor with thermal and epithermal neutrons. The detector will be placed in a transmission position between the VESUVIO tank and the GS20 scintillator monitor, temporarily replacing the nGEM detector already available at the instrument.

Proposed Experiment

The B4C coating procedure on the GEM layers have been performed at the ESS coating lab at low temperature (<100°C) since the GEM structure (mainly Kapton) cannot stand higher temperatures. The nominal thickness declared by ESS people (about 1 micron on each GEM electrode) have been estimated from standard high temperature deposition algorithm. We have noticed a small discrepancy in detection efficiency values between results obtained by preliminary neutron test and what is expected by simulation and this may be related either to thickness or to chemical composition of converting layer that may be contaminated by other elements rather than B4C. Therefore we propose to perform experiment with SEM microscope and with other techniques in order to determine the B4C thickness and at least identify the presence of possible contaminants.

Justification of requested beam time

We think that taking into sample preparation in order to adapt it to the SIGMA ZEISS SEM microscope and successive sets of measurements we need a total of two working days (about 20 hours). We would like also to ask access to Xeuss 3 HR to complete quantitative analysis. More precise time definition will be agreed with the instruments scientist if we can get in contact with them.

Summary of previous experimental proposals or characterization

There is an on-going ISIS proposal that foresee to test the detector on Vesuvio in 2023. We did not perform any SEM characterization of GEM foils before.

Publications

[1] S. Cancelli *et al* 2022 *JINST* **17** C08028

[2] S. Cancelli *et al* 2021 *JINST* **16** P06003

[3] Romanelli, Giovanni et al. "Thermal neutron cross sections of amino acids from average contributions of functional groups." *Journal of physics. Condensed matter: An Institute of Physics journal* vol. 33,28 10.1088/1361-648X/abfc13. 31 May. 2021, doi:10.1088/1361-648X/abfc13