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A new GEM based neutron diagnostic concept for high power deuterium beams

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The ITER neutral beam test facility under construction in Padova will host two experimental devices: SPIDER, a 100 kV negative hydrogen/deuterium RF source, and MITICA, a full scale, 1 MeV deuterium beam injector. A number of diagnostics will be deployed in the two facilities to qualify the beams [1]. This paper reports the design of a neutron diagnostic for SPIDER, as a first step towards the application of this diagnostic technique to MITICA, where it would be particularly useful to resolve the horizontal beam intensity profile.
The proposed detection system is called CNESM which stands for Close-contact Neutron Emission Surface Mapping. The CNESM diagnostic is placed right behind the SPIDER beam dump, as close to the neutron emitting surface as possible and aims at providing the map of the neutron emission on the beam dump surface.
The CNESM uses nGEM as neutron detectors [2]. These are Gas Electron Multiplier equipped with a cathode that also serves as neutron-proton converter foil. The cathode is at about 30 mm from the beam dump front surface. It is designed to ensure that most of the detected neutrons at a point of the nGEM surface are emitted from the corresponding 40x22 mm2 beamlet footprint on the dump front surface. The nGEM readout pads (area 20x22 mm2) will record a useful count rate of ≈5 kHz providing a time resolution of better than 1 s. Each nGEM detector maps the neutron emission from a group of 5x16 beamlets: 16 nGEM would be needed to cover the entire beam dump.
The diagnostic was designed on the basis of simulations of the different steps from the deuteron beam interaction with the beam dump to the neutron detection in the nGEM. The deuteron deposition inside the dump was simulated with the TRIM code providing the deposition profiles. Neutron scattering was simulated with the MCNPX code. The scattering contribution is estimated at ≈10% of the neutrons recorded by the nGEM when only neutrons with energy > 2 MeV are detected. The directional response of the nGEM to neutrons reduces the scattering contribution to a much lower level.
The CNESM can be complemented by a number of Fission Diamond Detectors (FDD) [3]. FDDs combine the neutron response of a uranium foil with the radiation hardness of a diamond detector. FDDs can be mounted directly on the beam dump and can operate in vacuum as well as at room pressure.
The main difference between SPIDER and MITICA is the x100 larger neutron fluxes expected. This requires a reassessment including further tests of the radiation hardness of the signal readout electronics. The beam dump geometry with alternating 20 mm diameter swirl tubes means that the detectors can be placed at a distance ≈40 mm from the neutron source compared to ≈30 mm on SPIDER. The effective spatial resolution of the measurement will scale with the achieved source-detector distance.

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[1] G. Gorini et al, RFX_SPIDER_TN_141 Technical Note, 2011
[2] B.Esposito et al, Nucl. Instr. and Meth. A (2009), doi:10.1016/j.nima.2009.06.101
[3] M.Rebai et al, accepted for publication in Nucl. Phys. B (2011)

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