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Irradiation and characterization of a single hodoscope channel for the SPARC magnetic proton recoil neutron spectrometer with different radioactive sources

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The SPARC tokamak aims to demonstrate a net fusion power gain in tokamaks for the first time (Qfus>1)[1]. A neutron spectrometer based on the magnetic proton recoil technique [2] is being built to measure neutrons with energy between 1 and 20 MeV emitted by fusion reactions. It will infer the total fusion power emitted by the machine, corroborating the demonstration of Qfus>1 through the primary Pfus measurement from other neutron diagnostics [3]. This diagnostic will also provide useful information on ion temperature, D/T ratio, and non/thermal fusion neutrons.

The SPARC NSPC is based on the generation of recoil protons via elastic scattering of collimated neutrons on a foil target and their dispersion via a set of magnets [4][5]. The recoil protons are momentum analysed by the magnets and dispersed onto a hodoscope consisting of an array of ~40 detectors made by a plastic scintillator rod of EJ276D coupled to photomultiplier tubes [6]. The hodoscope is made of three groups of channels whose dimensions are optimized based on the ion optics and the energy of protons.

This work presents the characterization of a single central hodoscope channel using two EJ276D scintillator rods, with dimensions $(8\times5\times100)$ mm³ and $(9\times3.6\times90)$ mm³, respectively. Each was optically coupled to a PMT through a silicone rubber interface and in some cases via a light guide.

The detectors were tested using alpha, neutrons, proton and gamma-ray sources. The first rod was characterized at the Massachusetts Institute of Technology. . The second one was evaluated at ISTP-CNR in Milan, and preliminary results from measurements at the Legnaro National Laboratories (LNL) are also included.

Preliminary results demonstrate the pulse shape discrimination capabilities between gammas and neutrons of the scintillation rods and their performance in detecting protons, confirming the suitability of the scintillator-PMT configuration for high-resolution neutron spectroscopy in SPARC.

[1] A. J. Creely et al.,"Overview of the SPARC tokamak,"J. Plasma Phys. 86,865860502 (2020).

[2] H. Sjöstrand et al. 2006 New MPRu instrument for neutron emission spectroscopy at JET

[3] P. Raj, Rev. Sci. Instrum. 95, 103507 (2024)

[4] S. Mackie, Rev. Sci. Instrum. 95, 119901 (2024)

[5] S. Mackie et al., "Status of the high-resolution magnetic proton recoil neutron spectrometer for SPARC burning plasma diagnosis", this conference

[6] M. Dalla Rosa et al., Rev. Sci. Instrum. 95, 083508 (2024)

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