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#04-136 Reactor pulse operation for nuclear instrumentation detector testing –preparation of a dedicated experimental campaign at the JSI TRIGA reactor

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The availability of neutron fields with a high neutron flux, suitable for irradiation testing of nuclear instrumentation detectors (such as fission and ionization chambers and self-powered neutron detectors) relevant for applications in nuclear facilities such as material testing reactors (MTRs), nuclear power reactors and future fusion reactors is becoming increasingly limited. Over the last several years there has been increased interest in the experimental capabilities of the 250 kW Jožef Stefan Institute (JSI) TRIGA research reactor for such applications. This is thanks to extensive experimental and computational efforts in the past to characterize the experimental conditions in the reactor, in large part in collaboration with the Instrumentation, Sensors and Dosimetry Laboratory of the French Atomic and Alternative Energy Commission (CEA) –Cadarache. The maximal achievable neutron flux in the reactor in steady-state operation mode is approximately 2×10^{13} n cm^{-2} s^{-1}, in contrast to the MTR-relevant neutron flux range 10^{14} –10^{15} n cm^{-2} s^{-1}. The JSI TRIGA reactor can also operate in pulse mode, where one of the reactor control rods is ejected from the reactor core, thus introducing a sufficiently large reactivity to achieve prompt supercriticality. This operation mode is made possible by the TRIGA fuel, in the form of a dispersion of uranium and zirconium hydride, which gives rise to a large, prompt and negative temperature coefficient of reactivity. The resulting time dependence of the reactor power is a pulse, the peak power and duration depending on the initial inserted reactivity. In pulse mode, the maximal achievable peak power is approximately 1 GW, corresponding to a peak neutron flux level of the order of 10^{17} n cm^{-2} s^{-1}, for a duration of a few milliseconds.

Pulse operation mode at the JSI TRIGA reactor has been investigated mainly in the academic context, for the validation and improvement of the Fuchs-Hansen model describing the reactor behaviour during reactor pulses and for educational activities, however its application for irradiation experiments was of limited scope. Recognizing the potential of reactor pulse mode for nuclear instrumentation detector testing, in particular the possibility of extending the useful neutron flux range up to MTR-relevant levels, in 2019, a bilateral collaboration project between the CEA and JSI was initiated. The aim of the project is the performance of absolute neutron flux measurements at very high neutron flux levels in reactor pulse operation. The measurements will be made possible by special CEA-developed miniature fission chambers (fissile deposit mass targeted at 50 ng) and by modern, validated, wide dynamic range data acquisition systems, in particular the CEA-developed MONACO system. In addition to the JSI TRIGA nuclear instrumentation, providing information on the peak power and released energy, activation dosimetry will be employed as a reference for the normalization of the recorded detector signals (neutron flux integral) for reactor pulses with differing characteristics. Finally, as an alternative experimental method enabling the measurement of the reactor power dependence during pulse operation, measurements of the intensity of Cherenkov light are proposed and being investigated.

This paper presents the 2019-2020 preparatory activities for an exhaustive experimental campaign to be carried out at the JSI TRIGA reactor jointly by CEA and JSI researchers during the first semester in 2021. A series of test measurements using not fully appropriate fission chambers in reactor pulse operation was performed using a Keithley electrometer and the MONACO fission chamber acquisition system. Activation dosimetry measurements were performed for several thermal and fast neutron sensitive nuclear reactions. Photodiodes and silicon photomultipliers (SIPMs) have been tested in steady state and pulse operation modes. The presented results provide useful and promising experimental indications relevant for the design of the experimental campaign.

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