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ENGREN setup with liquid scintillator array for neutron multiplicity measurements in nuclear fission

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Investigation of prompt fission neutrons (PFN) properties is important due to PFNs carry information on excitation energy of fissile nucleus [1,2]. This information is important for nuclear energy installation development and research in nuclear physics and astrophysics. The ENGREN experimental setup has been developed at the Joint Institute for Nuclear Research (JINR, Dubna, Russia) to study the correlated properties of fission fragments (FF) and PFN. The setup consists of a double-gridded Frisch ionization chamber (IC) with a target mounted on the common cathode of the chamber, combined with 32 PFN detectors arranged in a spherical configuration around the target at a distance of 50 cm. The cathode signal of the chamber provides the time reference for the fission event. The anode signals allow for the measurement of the fission fragment energies. The PFN detectors are based on the EJ-309 liquid scintillator by SCIONIX and enable neutron-gamma discrimination through pulse shape discrimination (PSD) and pulse height (PH) analysis, as well as neutron time-of-flight (ToF) measurements. The detection of multiple prompt fission neutrons (PFN) was estimated using the Monte Carlo method and introduced in [3]. In this work the 32 EJ-309 liquid scintillation detectors used in the ENGREN setup were characterized in terms of their response and gamma-ray detection efficiency. The energy calibration of the liquid scintillators (LS), which is typically challenging due to Compton scattering effects, was performed by comparing the experimental detector response with Monte Carlo-simulated spectra. The response functions and light output resolution were obtained by least-squares minimization of the simulated response functions fitted to experimental data from calibration gamma sources (Cs-137, Na-22, Co-60). Additionally, the neutron/gamma pulse shape discrimination (PSD) capability was evaluated using a PuBe neutron source, and the PSD performance was analyzed as a function of the applied voltage. Preliminary test measurements with a ^{235}U target were conducted at the Intense Resonance Neutron Source (IREN).

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