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#4-137 Subcritical Neutron and Gamma Noise Measurements at the Seven Percent Critical Experiment (7uPCX)

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As part of a collaborative international effort organized by Lawrence Livermore National Laboratory (LLNL), with key participants from L'Institut de radioprotection et de sûreté nucléaire (IRSN), Los Alamos National Laboratory (LANL), and Sandia National Laboratories (SNL), a series of high-multiplication subcritical neutron and gamma noise measurements were planned and executed. The primary aim of this research was to advance detector technology, assess the validity of gamma noise for subcriticality measurements, and nuclear criticality safety, focusing on collecting list-mode or time-series data from various reactor configurations with multiplication values ranging from 10 to 310. This comprehensive dataset enabled a detailed comparative analysis of multiple detector systems and the results of both neutron and gamma noise measurements.

Sandia National Laboratories' Seven Percent Critical Experiment (7uPCX) was chosen as the optimal facility for these measurements, due to its well-established benchmarks, capabilities, and suitability for this type of research. This zero-power reactor is a light water moderated and reflected array of 6.9% enriched uranium dioxide fuel rods that was designed to investigate the physics of light water nuclear reactor systems at varying fuel-to-moderator ratios

In this study, we specifically explore the use of in-core gamma noise measurements in combination with ex-core neutron noise measurements to assess the subcriticality of the reactor system as well as other kinetic parameters. Four small-volume EJ-309 liquid scintillators were placed within the reactor core, while four portable neutron multiplicity counters, developed by LANL and referred to as MC-15s, were positioned outside the reactor tank. These MC-15 counters consist of 15 He-3 tubes embedded in polyethylene and are equipped with on-board list-mode data acquisition and analysis capabilities, which allowed for detailed real-time data processing.

The results of this experiment show excellent agreement between the two detector systems, despite their differing positions—one in the core and one outside the reactor tank—and the fact that the two systems were measuring different types of particles. This outcome further validates the usage of prompt gammas to infer reactivity, and the reliability of the detection methods employed. Furthermore, the findings show the potential of combining neutron and gamma noise analysis as a powerful tool for subcriticality assessment in nuclear systems.

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