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A Transient Reactor Physics Experiment with High-Fidelity, 3-D Flux Measurements for Validation and Verification

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Program: NEAMS

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ABSTRACT: ***It is proposed to instrument the University of Wisconsin Nuclear Reactor (UWNR) with novel micro-pocket fission detectors (MPFDs) for measuring 3-D flux distributions. The measured data will be compared to simulation using the PROTEUS tool from the NEAMS toolkit and other tools. The MPFD devices are very small, which leads to a negligible perturbation of the neutron flux, low sensitivity to gamma-ray interference, and the potential for high-resolution measurements. The proposed work will use a 3-D array of MPFDs and standard reactor instrumentation to capture highly-resolved flux and temperature distributions for several steady-state and transient conditions.***

The MPFDs proposed for deployment in the UWNR have been under active development at K-State for several years. Many properties of the basic MPFD design are ideal for large-scale, in-core deployment, including its compact size, radiation hardness, gamma-ray insensitivity, and relatively low cost. A basic MPFD consists of a small insulating structure that contains a miniature, gas-filled pocket. A conductive layer is deposited on opposing sides of the device, and a neutron-reactive material is applied to the conductive layers.

The UWNR is a 1-MW thermal reactor loaded with TRIGA fuel. An array of MPFD strings will be placed in the UWNR. Each string will have at least 5 MPFDs, and at least 5 MPFD strings will be placed radially. Several experiments will be performed with the instrumented reactor. Steady-state fluxes and temperatures will be measured over a full range of reactor power levels. In addition, several transient experiments will be performed, including SCRAMS and pulses of various widths, with particular emphasis on those configurations leading to the largest time-dependent spatial effects.

Computational models of the UWNR experiments will be developed using PROTEUS and auxiliary tools. Because the UWNR was recently converted to LEU, only small changes in the composition must be quantified. The models will be used to validate the methods of PROTEUS and identify any gaps in its features.

Currently, no benchmarks exist that capture the highly-resolved spatial and temporal behavior needed to test similarly high-fidelity methods. Even though the coupled-physics effects observed in TRIGA-fueled reactors are far less complex than those observed in much larger systems (e.g., commercial light-water reactors), it is precisely for this reason that a *full-scale, coupled-physics analysis of a TRIGA-fueled reactor will serve as a crucial step toward similar analysis of more complex systems.*