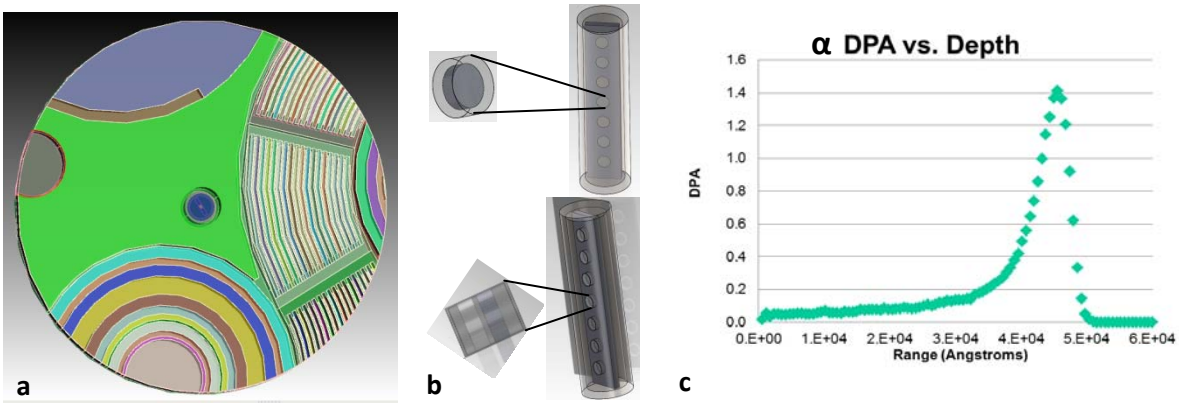
Highlight: Experiment Design of UO_2 Irradiation in the ATR



EFRC researchers Mahima Gupta (Graduate student), Clarissa Yablinsky (Post-Doc.) and Todd Allen (PI) at the University of Wisconsin-Madison and Jian Gan (PI) at Idaho National Lab (INL) propose an experiment that seeks to put several samples of depleted UO_2 in INL's Advanced Test Reactor (ATR) for varying lengths of time to study the effect of neutron irradiation on thermal conductivity of UO_2. The samples will be placed in the B-7 position of the ATR. This position uses the Hydraulic Shuttle Irradiation System (HSIS) that allows a train of 16 capsules to be inserted and removed from the reactor while it is operating. Each titanium capsule in this system is 2.25" long and has an outer diameter of 0.625", with a maximum weight of 27.0 grams. It is intended for the capsules to be in the reactor for a few hours to a few days. The approximate thermal and fast (E > 1 MeV) fluxes in the B-7 location are 2.5×10^{14} and 8.1×10^{13}n/cm^2-s, respectively.

The UO_2 in the capsules is to be surrounded with materials that implant ions into the target, following a reaction with an incoming neutron. The material will undergo a reaction that releases particles with high energy to sufficiently penetrate the UO_2. Two types of reactions are explored for viability. In an (n, alpha) reaction, both an alpha particle and a daughter particle would be incident on the UO_2. In an (n, scatter) reaction, the neutron would elastically scatter with a heavier particle and cause the heavier particle to penetrate the UO_2.

Monte Carlo N-Particle code was used to simulate neutron histories around the capsules and a cross section view of this part of the core is shown in (a). Using the average neutron flux and energy at the B7 position in the ATR, an estimate can be made for the number of ions being implanted into the target as a function of time. This helps us to estimate the duration for which each experimental set up (either scatter or alpha implantation) needs to be in the reactor. Using SolidWorks, models of the capsules were made and were placed in the input code for the B7 position in the ATR (b). (c) shows the Stopping Range of Ions in Matter (SRIM) output for 2.4 MeV α – particles incident on UO_2 target.

Following this experiment design, it is planned to execute these irradiations at the ATR facility in the Idaho National Lab and further study the effect of radiation damage on the thermal conductivity and changes in microstructure of the UO_2. Evolution of stoichiometry at different doses will also be measured.