UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description for SPRING 2017

Project Title: Fabrication of a neutron radiation and micro-Raman microscopy facility (UNCC_NEUT)

Supporter: UNC Charlotte

Supporter Technical Representative: ASSIGNED

Faculty Mentor: __X__ ASSIGNED _____ TBD (check one)

Single Team __X__ Dual Team _____ (check one)

Personnel (EN/ET): _____ E, _____ Cp, _____ Cv, __2__ M, _____ SE

(Complete if the number of students required is known)

Expected person-hours: (250 per student)

Description of Project:

This represents a new facility housed in the EPIC building that contains a source of high energy neutrons (Adelphi, DD-108) capable of producing very large doses of x-ray and neutron radiation (neutrons of 108 n□s-1 at 2.5 MeV). This can be used for a broad range of studies for materials science, particle physics, and fundamental engineering application. Alongside this generator is a micro-Raman instrument (Horiba, Xplora) that combines confocal imaging and Raman measurement for high resolution surface analysis.

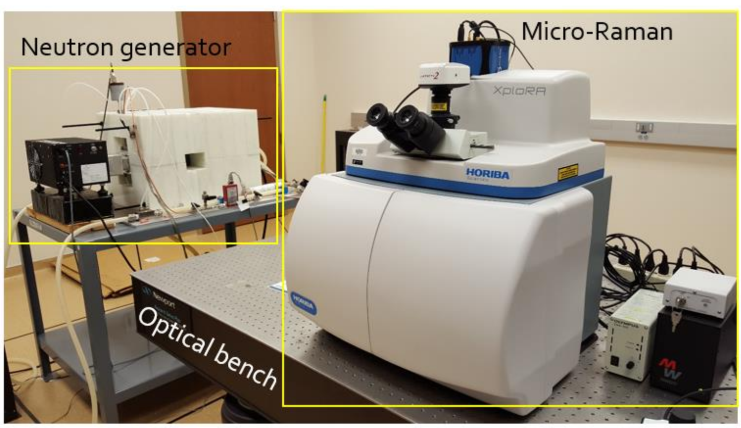

Figure 1: Photograph of the neutron source and micro-Raman instruments

As can be seen in Figure 1, in the current facility the neutron generator does not have required safety enclosure that should consist of three layers of materials with proper thicknesses. A leaded housing is needed to block the X-ray; a high density polyethylene (HDPE) casing to ‘thermalize’ the neutrons. Thermalization slows down the neutrons thereby increasing their cross section so that they can be absorbed by atomic nuclei. This polyethylene housing will thermalize neutrons in many directions after which they can be absorbed with an additional layer of boron infused polyethylene. There is an aperture at the front from which the neutron flux emerges and this is where specimens can be placed for irradiation.

The goal of this facility is to house the neutron source inside a radiation enclosure that absorbs both neutron and x-ray radiation. With suitable shielding operators will be able to conduct experiments in the laboratory during operation (see next section). Shielding will also ensure radiation doses are not harmful for personnel in adjacent rooms.

Initial Project Requirements (e.g. weight, size, etc.):

To serve as a safe system for non-professional users it will be necessary to fabricate an enclosure for the neutron generator. A method for transferring specimens into and out of this enclosure will also need to be constructed. Once completed it will also be possible, with appropriate certified training, allow student users.

Radiation shielding must be sufficient for operators to be in the room during testing. This requires shielding above the minimums often implemented in user facilities that exclude operators (i.e. the current University of Missouri facility). To determine the shielding requirements we have used the Monte Carlo simulation software provided by Oak Ridge National Laboratory to model radiation transmission. Using this software, it has been possible to determine the thickness and types of shielding materials necessary to reduce exposures well below the legal threshold of 25 µSv/hr to less than 4 µSv/hr and typically less than 2 µSv/hr (near to the limit of detection) at distances of 100 cm or more from the enclosure. A solid model and results of the simulation study are shown in Figure 2.

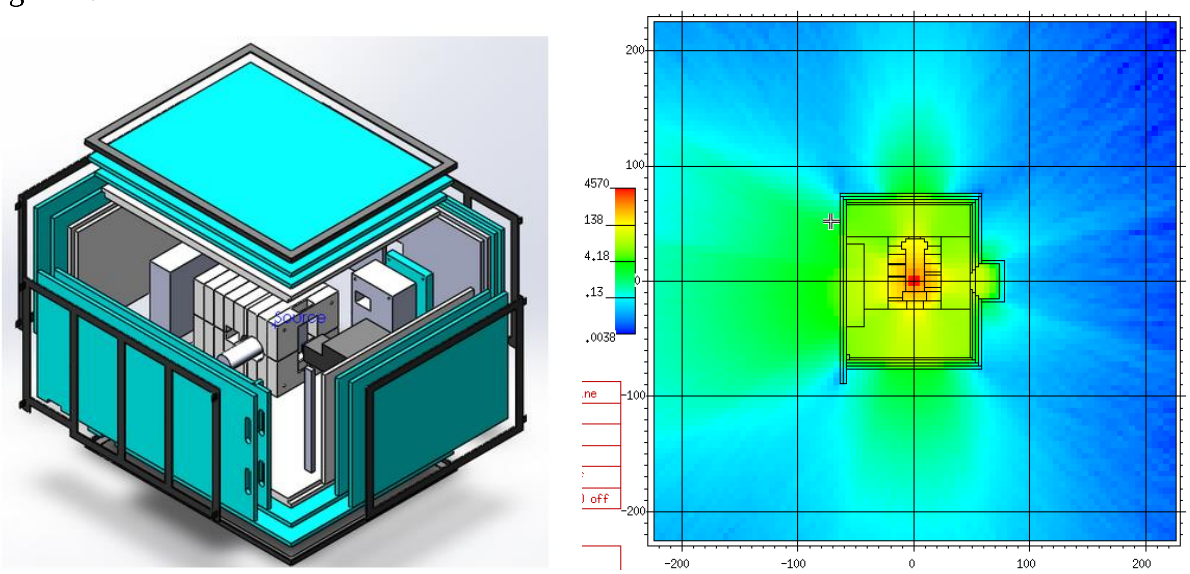

Figure 2: Shielding of neutron source for user operation; exploded view of solid model of shielding design (left) with high density polyethylene HDPE (white), boronated polyethylene BPE (blue), and steel (black), Monte Carlo simulation of radiation outside of the shielded enclosure (right). The green region indicates doses of less than 2 µSv/hr at a distance of 30 cm form the enclosure.

Expected Deliverables/Results:

The enclosure has been designed and major enclosure components manufactured. The goal of the project is to fabricate the facility and create and automate the measurement process. This will require development of hardware interfaces (Labview) for control of pneumatic systems and motors. Upon completion of this it will be necessary to develop standard operating procedures.

List here any specific skills or knowledge needed or suggested (If none please state none):

Students should desirably have mechanical and electric process control (mechatronics) skills.