The Low Energy Neutron Source (LENS) – A University Based Pulsed Neutron Source For Collaborative Research

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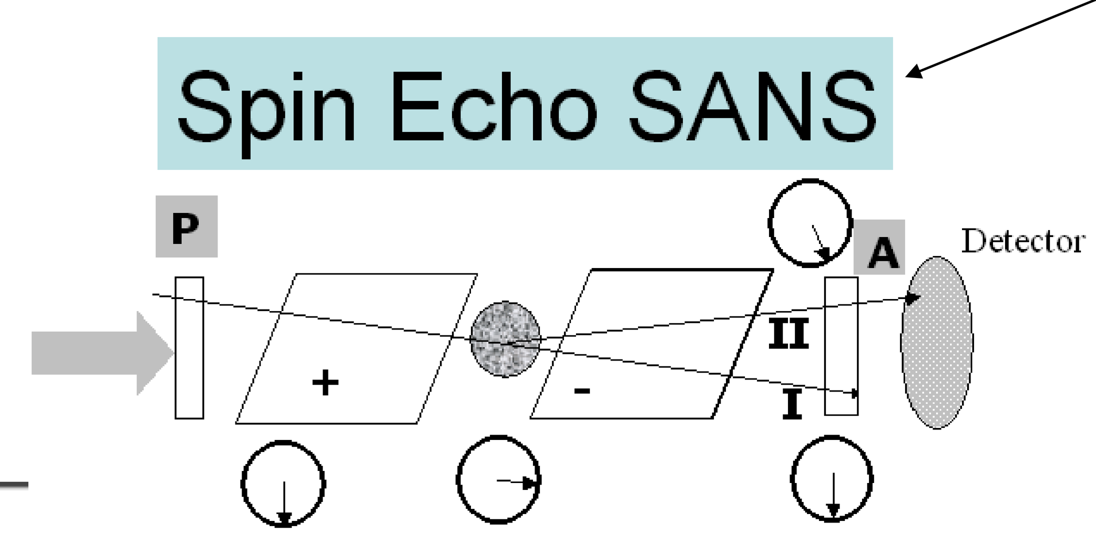
Overview

The Low Energy Neutron Source (LENS) is a university-based pulsed neutron source suitable for materials research using neutrons, educating students in the neutron sciences, and developing novel neutron instrumentation. The neutrons are produces using (p,n) reactions in a beryllium target at a proton energy of 13 MeV or less in two target stations, one devoted to cold neutron production and the other to fast and thermal neutron production. Activities at the facility include large-scale structural studies of materials using Small Angle Neutron Scattering (SANS),Spin-Echo Scattering Angle Measurements (SESAME), and radiography, the development of novel neutron moderator concepts and neutron spin-manipulation equipment, and investigation of neutron radiation effects in electronic components.

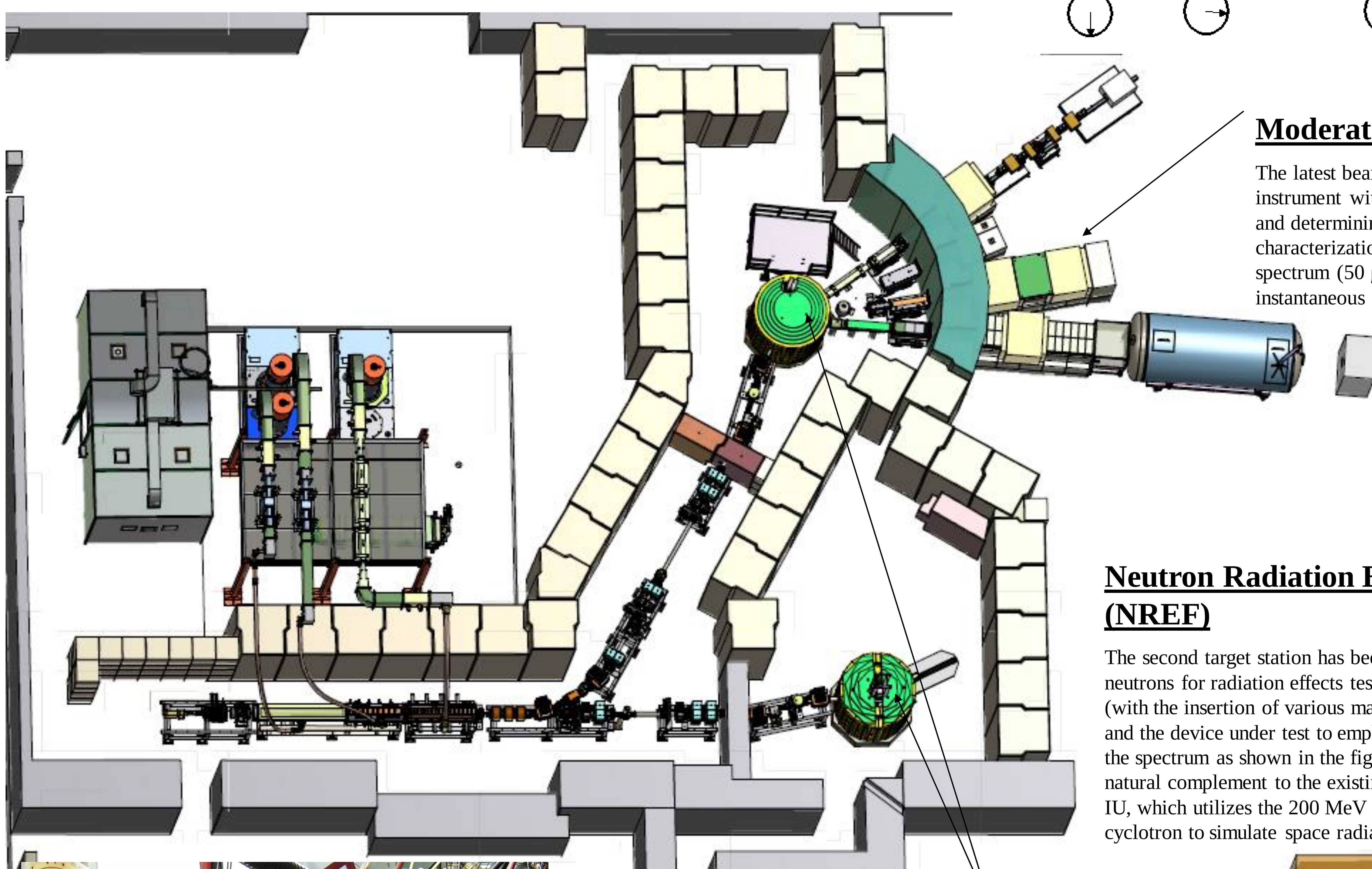


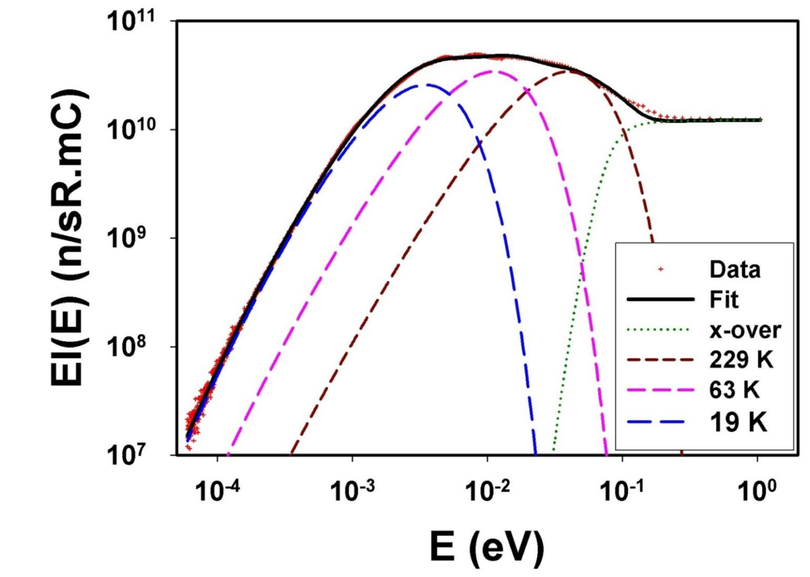
Spin Echo Scattering Angle MEasurement (SESAME):

The first novel instrument to be developed at LENS is one that uses the neutron spin to encode momentum transfer information. In Spin-Echo SANS mode (see figure on the left), a polarized (**P**) neutron beam passes through a magnetic field (+) in which the polarization precesses (as indicated schematically by the clock faces).

For unscattered neutrons (**I**), this precession is reversed in a subsequent field region (-), producing a "spin-echo" condition. Neutrons that scatter in the sample (**II**) will not echo, because the polarization rotation will be different before and after the sample. This technique allows one to probe length scales more than an order of magnitude larger than with the SANS instrument. Variations on this geometry can be used for high resolution diffraction (10-100ppm) or to separate diffuse and specular scattering in reflectometry.

This instrument also provides a polarized neutron beam and neutron optical bench that are being used to develop new spin-manipulation devices for used with polarized neutrons.





Spectrum from the cryogenic methane moderator at LENS exhibiting a spectral component with a temperature of 19K.

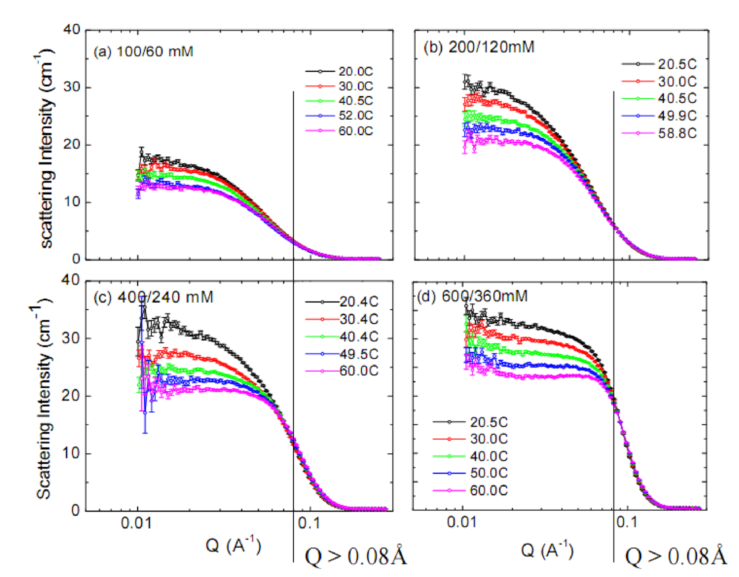
Moderator Imaging Station:

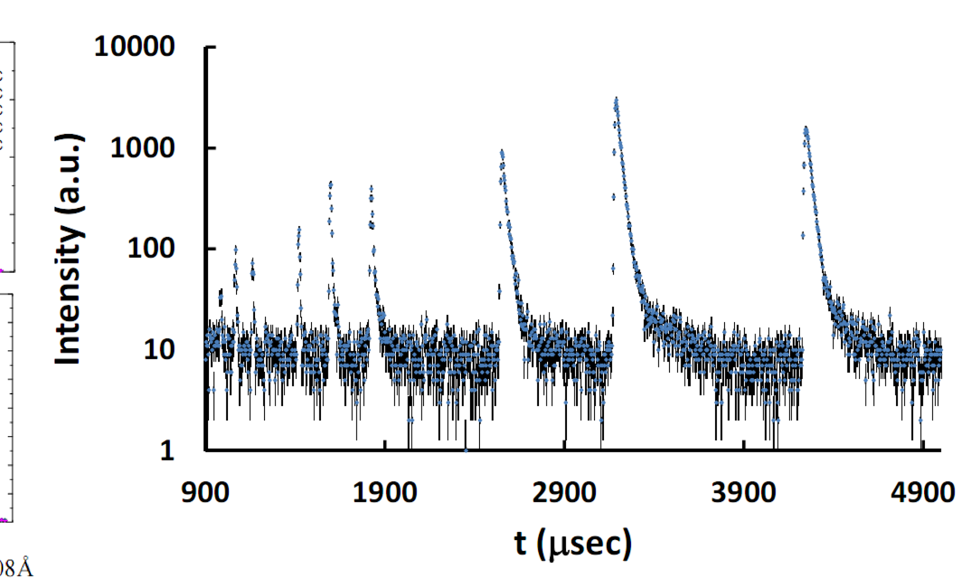
The latest beamline commissioned at LENS is a simple instrument with pin-hole optics for imaging of the moderator and determining its spectrum (very valuable for moderator characterization). This instrument also provides a broad neutron spectrum (50 μeV to several MeV) for testing detectors. Peak instantaneous count rates here can exceed 10^6 n/s.

Small Angle Neutron Scattering:

The SANS instrument at LENS employs a Be filter to limit fast neutron-induced backgrounds and a ^{3}He delay-line style 2D position sensitive detector. It has a variable secondary flight path (1.5 to 4.5m), a primary flight path length of 8.5m, and a Q range of approximately 0.008 A^{-1} to 0.3 A^{-1} . The flux on the sample is roughly 10^4 n/(cm^2.s) at a target power of 4kW. The figure below on the left show SANS data collected from concentrated CTAB/NaSal micelle solutions on this instrument. In fitting to these data with an ellipsoidal model, it appears that the short axis of the ellipsoid remains fixed in length as the temperature changes, but the longer axis changes.

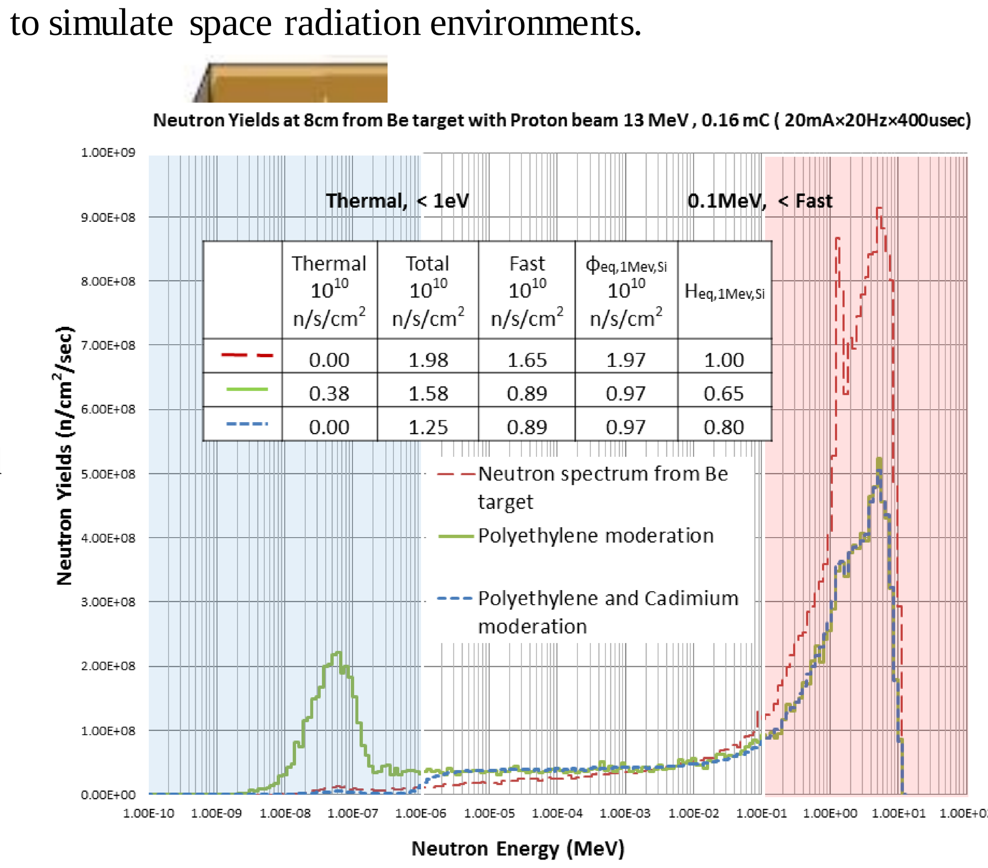
This instrument can also be reconfigured as a time-focused spectrometer for analyzing emission-time distributions from novel neutron moderators. The figure below on the right shows such data for a decoupled water test moderator, showing peaks from the 3rd through 13th order from the Ge (111) family of reflections (energies ranging from 5.6 meV to 950 meV are accessible).

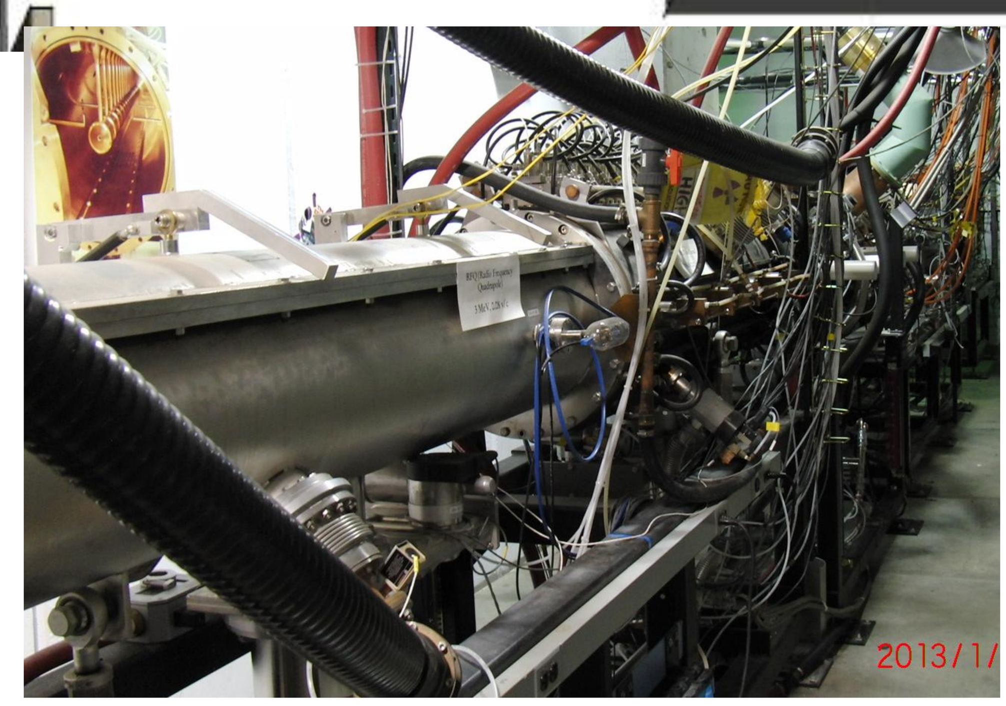




Neutron Radiation Effects Facility (NREF)

The second target station has been optimized to provide neutrons for radiation effects testing on materials and devices (with the insertion of various materials between the target and the device under test to emphasize different regions of the spectrum as shown in the figure below). NREF is a natural complement to the existing RERP user facility here at IU, which utilizes the 200 MeV protons from the IU cyclotron to simulate space radiation environments.



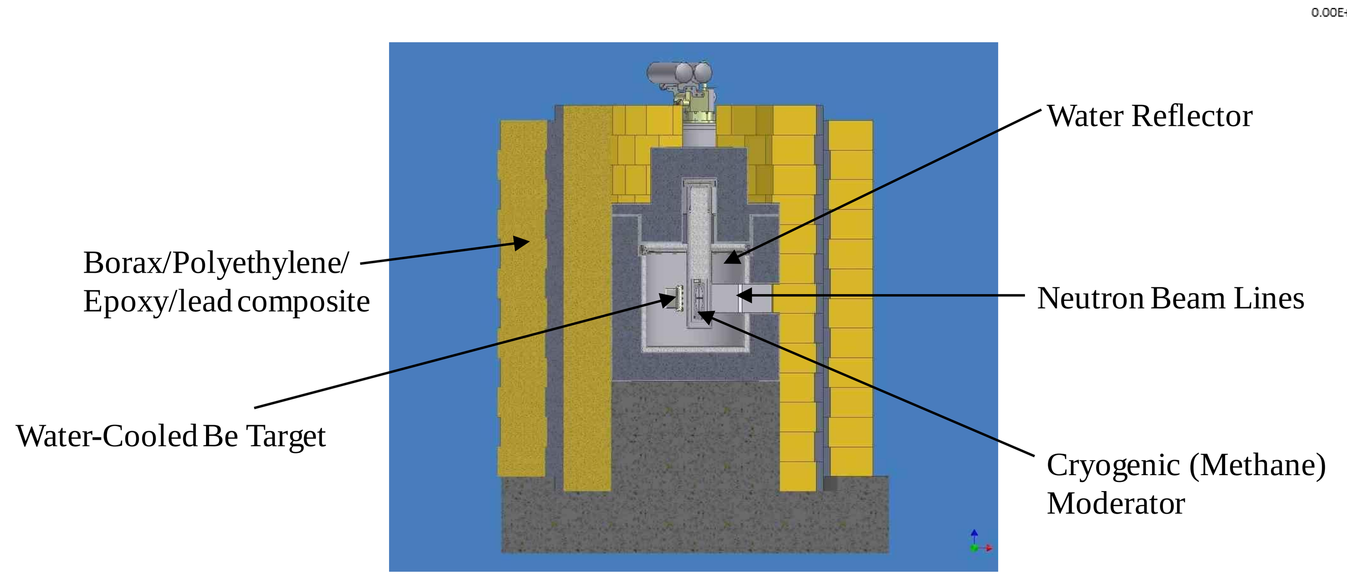


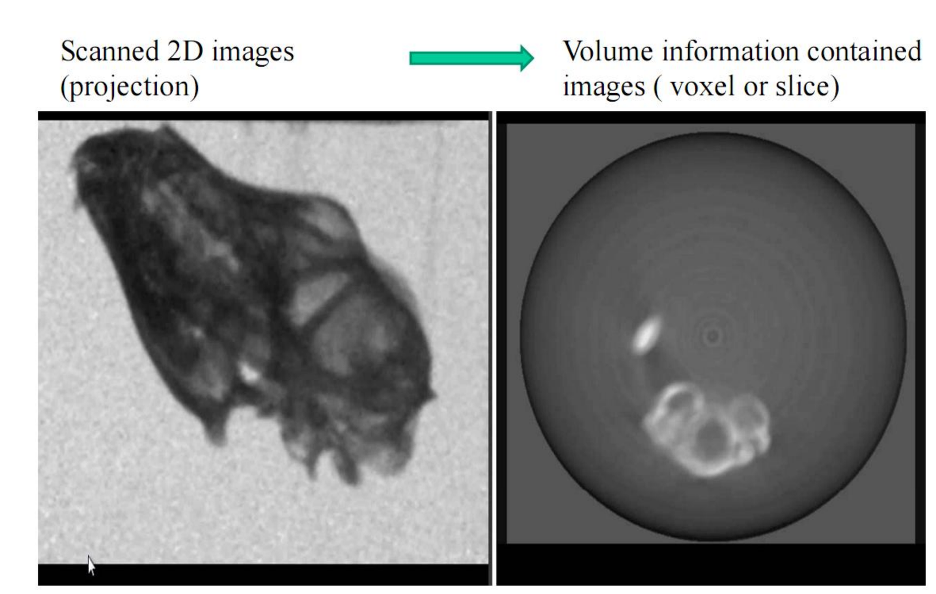
The Target-Moderator-Reflectors (TMR)

The facility utilizes two Target-Moderator-Reflector assemblies, each utilizing a 1 mm thick Be target. One TMRA designed for fast (up to 11 MeV) and thermal neutron production for neutron radiation effect and radiography studies. The other is designed for cold neutron production and utilizes a solid methane moderator at a temperature of 6 K. The design of the cryogenic moderator also facilitates experimental studies of novel moderator designs. Up to 4 different moderator configurations have been tested within a two week period using this capability. The drawing below shows the key elements of the TMR design, and the picture on the right below shows one of the TMR's during its construction.

The Proton Delivery System:

The proton delivery system provides proton beams of 13 MeV energy and up to 25mA peak current with a variable time structure at duty factors up to 1.2% . For structural studies, the facility typically runs with a 600 μsec pulse width and 20 Hz (4kW on target), making it one of very few long-pulse neutron sources in the world today. For moderator or detector studies, the pulse width can be reduced to as little as 10 μsec, and repetition rates ranging from 10 to 40Hz.





Neutron Radiography

The second TMR also supports a research effort in fast and thermal neutron radiography. To date this has been engaged in studies related to cultural heritage and developing tomographic capabilities.

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