POTENTIAL ANCILLARY MISSIONS FOR THE MATERIALS TEST STATION

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The neutron flux escaping from the Materials Test Station's (MTS) target and sample assembly may be utilized for other activities on a minimally interfering basis. Possibilities include: 1. Placing feedstock material in fuel and material sample locations, or embedding it within the reflector, to produce neutron-rich isotopes. Placing appropriately sized feedstock in the direct or scattered proton beam to produce neutron-deficient isotopes. The tungsten targets and the lead-bismuth eutectic coolant will contain copious spallation products. A rabbit system may be utilized for short irradiations. 2. Line-of-site paths between the MTS target and experimental vaults would provide neutrons mimicking the natural cosmic-ray spectrum for testing the endurance of electronics. These vaults could be located beneath the 2.4m-thick concrete floor that supports the MTS. Holes bored through the concrete form the site paths. 3. Digital sensors planned for current and next-generation power reactors could be positioned within the MTS components for testing in harsh conditions that simulate current environments or would be expected in LBE-cooled fast reactors. 4. A neutron guide looking at a water moderator in the vicinity of the target assembly would deliver LPSS-like neutrons to demonstrate the performance of experimental apparatus.

THE MATERIALS TEST STATION

The Materials Test Station (MTS) is a facility that will be located within the Los Alamos Neutron Science Center's (LANSCE) Area-A to provide intense neutron fluxes of the proper spectrum to irradiate candidate materials that are required for future reactors. The neutrons are produced when the LANSCE 800 MeV proton beam strikes two tungsten targets. Samples are placed between the targets and on the outsides of the targets and they are wrapped with a tungsten and steel neutron reflector. This package is called the Target Assembly (TA). The dimensions of the TA are 76 cm high by 56 cm wide by 71 cm deep, and it weighs 2 tonnes. Figure 1 shows the neutron flux in the TA.

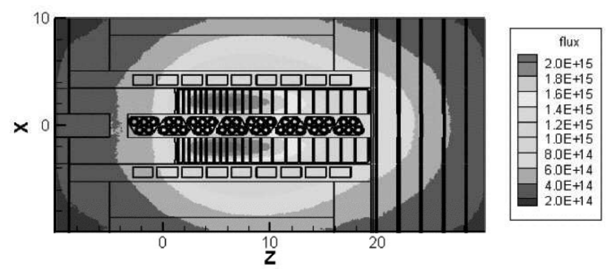

Figure 1. The neutron flux at the mid-plane of the TA in neutrons/cm^2/s for all energies.

The sea of neutrons escaping from the TA is effectively lost for the purposes of the MTS. Discussed are four possible ancillary uses: isotope production, electronics testing, a test bed for digital sensors, and delivering neutron beams of scientific interest.

1. Isotope Production

Work associated with the preparation of the safety documentation for the MTS has produced a compendium of the radionuclide inventory that grows during operation.[1] Several isotopes are created for each element involved. Only the longer lived would be retrievable without using isotope separation techniques. Liquid lead bismuth eutectic (LBE) and heavy water (D_20) are used as coolants and are relatively easy to remove. During TA change-out the LBE can be retrieved for isotope extraction. The D_20 coolant circulates through a pump and heat exchanger in the service cell and it can be tapped on a continuous basis. This raises the possibility of injecting material into the water system and retrieving it from the purification resins. An intriguing thought would be to design the D_20 header within the TA to stop a small capsule without impacting component cooling; the capsule is then retrieved by reversing the water flow during a short interruption of the proton beam.

The targets and sample holder portions of the TA will be replaced annually, the tungsten beam stop will last two or three times longer. The isotopes created during the spallation and neutron absorption in tungsten and the elements of stainless steel are securely confined within these components for eventual retrieval.

Isotope feedstock material may be placed within the neutron flux surrounding the TA by embedding it in the various modules that make up the TA or by placing it with a rabbit system. Calculations show that there is still a strong and potentially useful neutron flux in the shielding that surrounds the vacuum chamber that houses the TA. The averaged flux of neutrons leaving the vacuum chamber is 2×10^{13} n/cm^2/s. (Fig. 2)

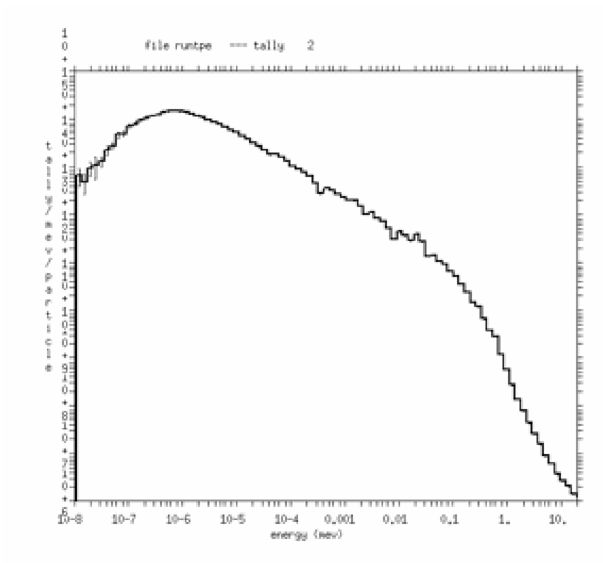

Figure 2. The number of neutrons/MeV/proton, as a function of energy, that pass through the 38 cm-radius wall of the cylindrical vacuum chamber. The beam current is approximately 10^{16} protons/second.

2. Electronics Testing

Ionizing radiation, such as alpha particle and atmospheric neutron radiation, can cause unwanted effects in semiconductor devices, such as flipping the state of memory cells. These radiation-induced effects are known as soft errors and are the most common type of what are known as single-event upsets (SEUs). While these effects can be statistically neglected for large-scale devices, they are important for small-scale objects like memory cells, user memory and registers. With these devices getting smaller and smaller the statistical probability for unwanted errors increases. The Neutron Weapons Research Center (WNR), in cooperation with the semi-conductor industry, has an ongoing research program in this area. However, due to the current limitation for WNR, which is less than 5μA, the possibility was investigated of incorporating a single event upset beamline into the target assembly of the Materials Test Station (MTS).

MTS's anticipated operation at 1.35 mA will produces significantly more neutrons, These neutrons are only usable if the spectrum generated by MTS closely matches the cosmic ray neutron spectrum. The neutron flux from the MTS target has been calculated for a 6 cm by 6 cm beamline that delivers neutrons to a sample area 20 meters away. The chosen direction of the neutron beamline is at an angle of 30^o away from the forward direction of the proton beamline and rotated 45^o downward from the horizontal. The neutron line is extended through the 2.4 m thick concrete floor beneath the MTS facility far enough to allow access from the side of the thick floor. Figure 3 shows the location of two possible experimental rooms. The neutron beam passes at an angle through the room on a plane parallel to the far wall. Removing a concrete shield plug with the building crane provides access to the experimental rooms. A hydraulic elevator lowers personnel and equipment into the room.

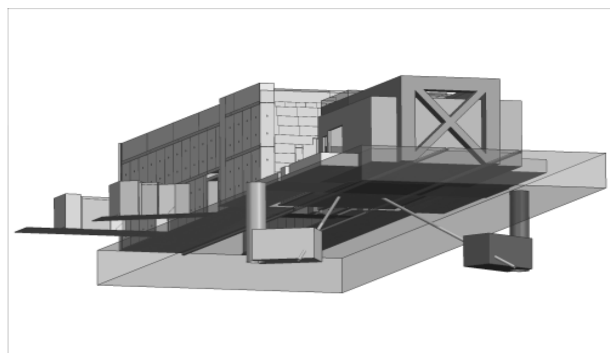

Figure 3. Two neutron flight paths from the TA to experimental halls located beneath the thick floor slab.

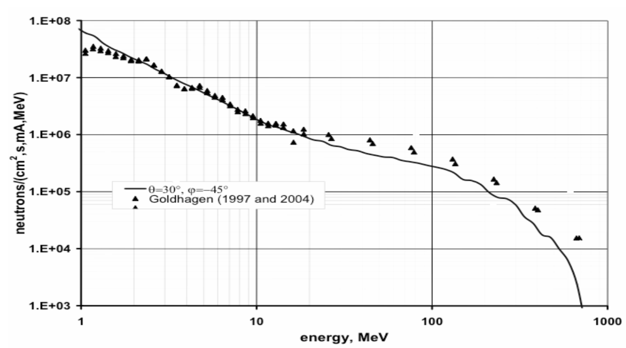

Figure 4. Neutron spectrum calculated for a flight path designed to mimic cosmic rays compared with experimental measurements.

The spectrum for this beam line was calculated and compared to measured data, both of which are presented in Figure 4. This graph shows the close similarity between the measured data and the spectrum predicted for a SEU beamline on MTS. MTS provides a unique opportunity to extent the SEU program, currently operated by WNR, to a much larger scale.

3. Test Bed for Digital Sensors

The design, cost, operation, and maintenance of future power reactors could be significantly enhanced with the use of modern digital sensors in their control systems. Sensors could be placed within the MTS systems to experience prototypical-operating environments.

4. Neutron Beams of Scientific Interest

Two neutron beams of scientific interest are described: NXGENS and ultra-cold neutrons. Both lines require that small neutron capturing and tailoring chambers be placed in intimate contact with the TA. (Fig 5 and 6.) Both lines will utilize rotating disc shutters in their neutron lines. These shutters will fit into the He tank that is proposed to house the shielding that surrounds the TA. (Fig. 7)

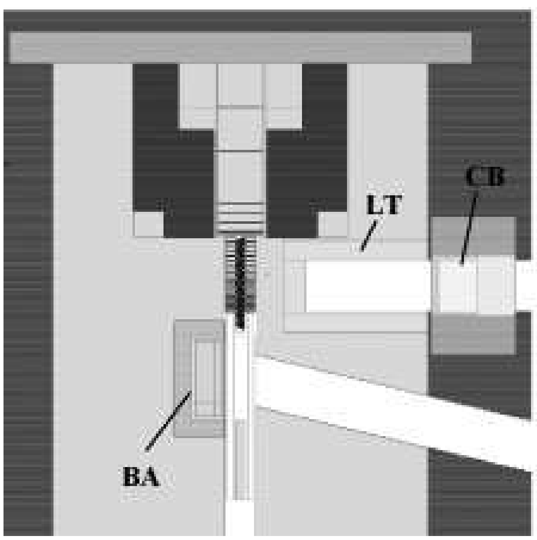

Figure 5. The 90^o line feeds a UCN line and the 75^o line feeds a NXGENS line. Both lines feed to the left for the beam line arrangements shown in Figures 6 and 7.
(BA--Backscattering Moderator, LT--Lead Tunnel, CB--Cold Box)

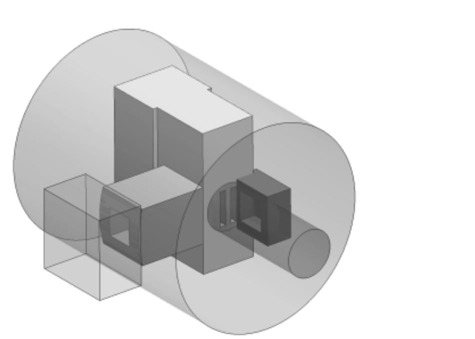

Figure 6. The water filled Be box on the right front of the TA provides neutrons for NXGENS, while the lead tunnel on the left, and the water/parahydrogen/Be box located outside the vacuum chamber, provides neutrons for the UCN line.

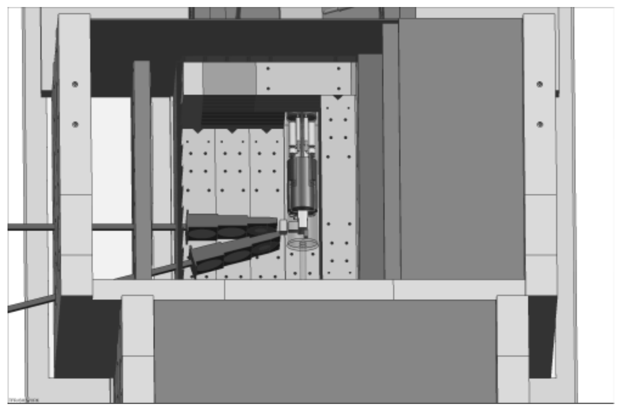

Figure 7. Disc shutters for the neutron beam lines that originate near the TA. The shutters are surrounded with shielding and reside in the He tank housing the MTS target assembly.

4.1 NXGENS

Nuclear reactors and spallation neutron sources have been used for decades for the purpose of neutron scattering. Even though both type of sources produce neutrons in the desired energy regime, both have their advantages and disadvantages due to their forms of operation. Nuclear reactors are continuous sources generating white beams for their scattering instruments. The white beams are on a time-averaged basis much brighter than beams on spallation sources, however white beams to not contain any information about the energy of the incident neutrons unless the beams are monochromized using choppers or monochromators. This of course leads to a loss in time-averaged intensity.

If the proton pulses that strike a spallation target are short, the neutrons are produced at the same time and the more energetic ones will move to the head of the neutron stream that is emitted. The neutron energy can be determined by the time-of-flight between the source and the sample location. This is the basis of short pulse spallation sources (SPSS) such as those at ISIS, SNS, IPNS and LANSCE. This makes an SPSS more efficient than a nuclear reactor.

Depending on the desired experiment one would use either a SPSS or a nuclear reactor.

In the 1990's the concept of a long pulse spallation neutron source (LPSS) was proposed. The idea behind this concept was to combine the advantages of the reactor and the SPSS to open a new dimension for neutron scattering. Several workshops have been held on this subject and extensive simulations have been performed.[2] A long pulse neutron scattering instrument is yet to be built. The Materials Test Station (MTS) provides an ideal opportunity to construct and test such an instrument. Willis[3] has performed a neutronic study on how a long pulse neutron scattering instrument (NXGENS) can be included, in a parasitic mode, in the Materials Test Station. It was concluded in this paper that a 6.5 cm thick water moderator in backscattering geometry, surrounded by 4 cm of beryllium would be the ideal compromise between not interfering with the main mission of MTS and yet maximizing the performance of NXGENS, which is predicted to be 6.6 times higher than the predicted value for the protein crystallography instrument at the Manuel Lujan Jr. Neutron Scattering Center. The layout is presented as the 75-degree beamline in Figures 5, 6, and 7.

4.2 Ultra Cold Neutrons

Over the years ultra cold neutrons (UCN) have become a very important tool to investigate the principles of fundamental physics. Due to the increased demand for ultra cold neutrons, a scoping study has been performed to investigate the possibility of including a UCN test flight path in the concept of the Materials Test Station[4]. This paper points out that the main constraint on the UCN test flight path is the safety concern of placing liquid hydrogen inside the target crypt. Because of this constraint, the envisioned moderator system is placed partly outside and partly inside the target crypt. Inside the crypt, a Pb moderator and a Pb lined tunnel feed the moderator part outside the crypt with epi-thermal and some thermal neutrons. Outside the crypt the epi-thermal neutrons are thermalized by a light water premoderator, which then feeds a para-hydrogen moderator. To further enhance the 8.9 Å flux, which is the critical wavelength for producing UCNs, a hydrogen cooled beryllium reflector filter is placed at the downstream end of the para-hydrogen moderator. As shown by Muhrer and Pitcher[4] this concept is about twice as effective as a comparable system at SNS, operating at 2MW. The layout for this flight path is shown as the 90-degree beamline seen in Figures 5, 6, and 7.

ACKNOWLEDGMENT

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