ICANS-XI International Collaboration on Advanced Neutron Sources
KEK, Tsukuba, October 22-26, 1990

Split-Target Neutronics

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ABSTRACT

Monte Carlo simulations show that, for the LANSCE split-target of machineable tungsten, about 60% of the low-energy (<20 MeV) neutron leakage from the target comes from primary (800-MeV) proton interactions. The remaining 40% occurs from secondary high-energy reactions in the split-target. Primary protons are forward directed; secondary high-energy (>20 MeV) particles are also forward directed. Consequently, the neutronic performance of the LANSCE Target-Moderator-Reflector-Shield (TMRS) system is not adversely impacted by employing a split-target. Implementing a split-target allows us to use flux-trap moderators around the void zone between the targets to simultaneously service twelve neutron flight paths.

I. INTRODUCTION

The Los Alamos Target-Moderator-Reflector-Shield (TMRS) system[1] is a neutronically efficient target scheme for a spallation neutron source. I conceived the design in 1984, and we implemented it in 1985. One of the unique features of the device is the use of a split-target (see Fig. 1). This key concept is necessary to employ moderators in "flux-trap" geometry around the void space between the targets (see Fig. 2). This moderator arrangement allows the LANSCE TMRS to simultaneously service twelve neutron flight paths.[1] I ran a series of Monte Carlo simulations of low-energy (<20 MeV) neutron leakage from split-targets of machineable tungsten as a function of the gap-size between the targets. Machineable tungsten used in the LANSCE targets has a density of 18.3 gm/cm^3 and is composed of 97.0 wt % W, 2.1 wt % Ni, and 0.9 wt % Fe. I also studied the effects of upper-target length on low-energy neutron leakage for a gap size of 14 cm. I employed the Los Alamos Monte Carlo Code System[2] in the computations.

II. RESULTS

In all cases, the targets had a diameter of 10 cm. In the target-gap study, the upper-target length was 7 cm and the lower-target length, 23 cm. I varied the target gap from 0 to 25 cm. The computations were done for a point source of 800-MeV protons directed along the target axis. The results are shown in Fig. 3. The data in Fig. 3 are referenced to a 14 cm gap which is the size used in the as-built TMRS at LANSCE. The major reduction (≈7%) in neutron leakage occurs in opening the gap to 14 cm. Very little loss

(≈5%) results in increasing the gap to 25 cm. This minimal loss in neutron leakage allows some hope of increasing the LANSCE target gap to more than 14 cm to reduce high-energy and fast-neutron backgrounds in materials science instruments. However, one must study the effects of target-gap on actual moderator performance for realistic proton-beam profiles. These calculations are currently underway in support of the LANSCE Repair Project.[3]

The essence of the relatively minor perturbations of gap size on split-target neutronic performance depends on how low-energy neutrons are produced by spallation reactions in the split-target (see Fig. 4). In Fig. 4, about 60% of low-energy neutron leakage comes from primary (800-MeV) proton reactions.[4] These incident protons are forward directed; hence, it does not matter if the target is split or solid. Secondary high-energy particles are also forward directed. The net result is that low-energy neutron leakage from a split-target is relatively insensitive (at the <10% level) to the gap size between the targets.

I also studied the effects of upper-target length on bare-target, low-energy neutron leakage for a target gap of 14 cm. For the proton beam conditions stated above, total low-energy neutron leakage is relatively insensitive to the length of the upper target (see Fig. 5). In these studies, the length of the lower target was varied to keep the total target length (upper plus lower targets) to 30 cm.

III. ACKNOWLEDGEMENTS

I appreciate the support of Roger Pynn for this work. I want to thank Tatia Vander Maat for her typing help and Maria DiStravolo for proofreading the text on a very short notice. LANSCE work is supported by the US Department of Energy, Office of Basic Energy Sciences, under contract W-7405-ENG 36 with the University of California.

References

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2. R. E. Prael and H. Lichtenstein, "User Guide to LCS: The LAHET Code System," Los Alamos National Laboratory report LA-UR-89-3014 (September 1989).

3. G. J. Russell, "The LANSCE Repair Project," in these proceedings.

4. G. J. Russell, "Spallation Physics - An Overview," in these proceedings.

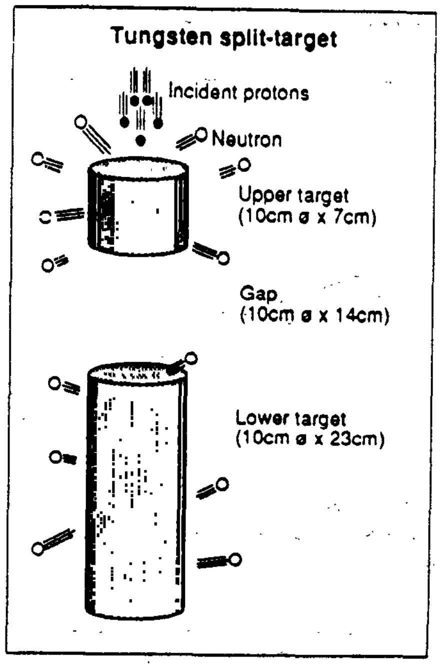

Figure 1. Illustration of the LANSCE split-target

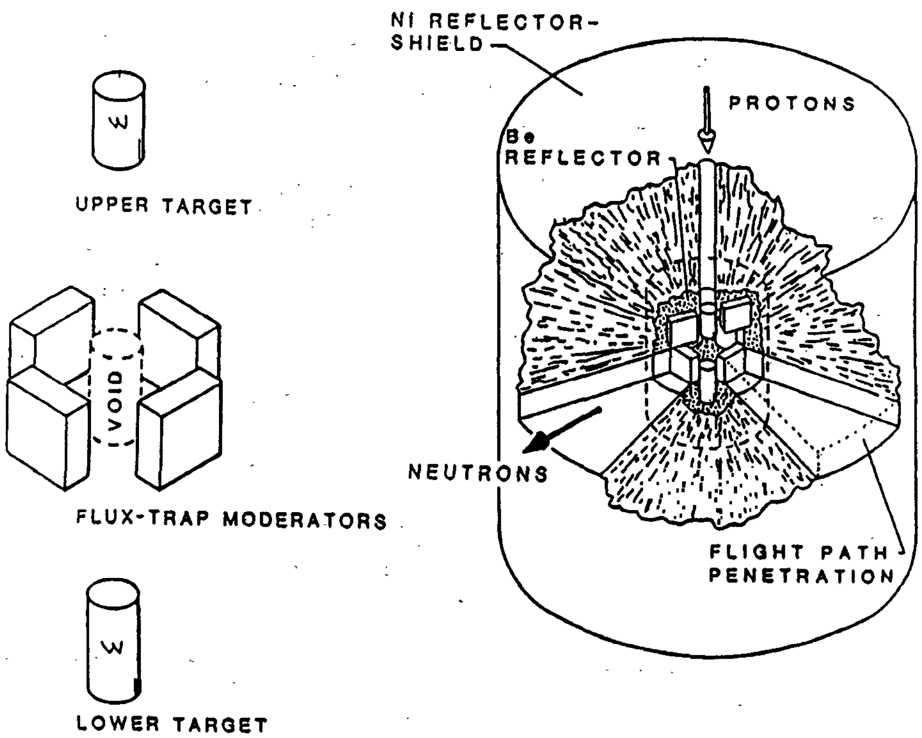

Figure 2. Illustration of the LANSCE Target-Moderator-Reflector-Shield neutron production system.

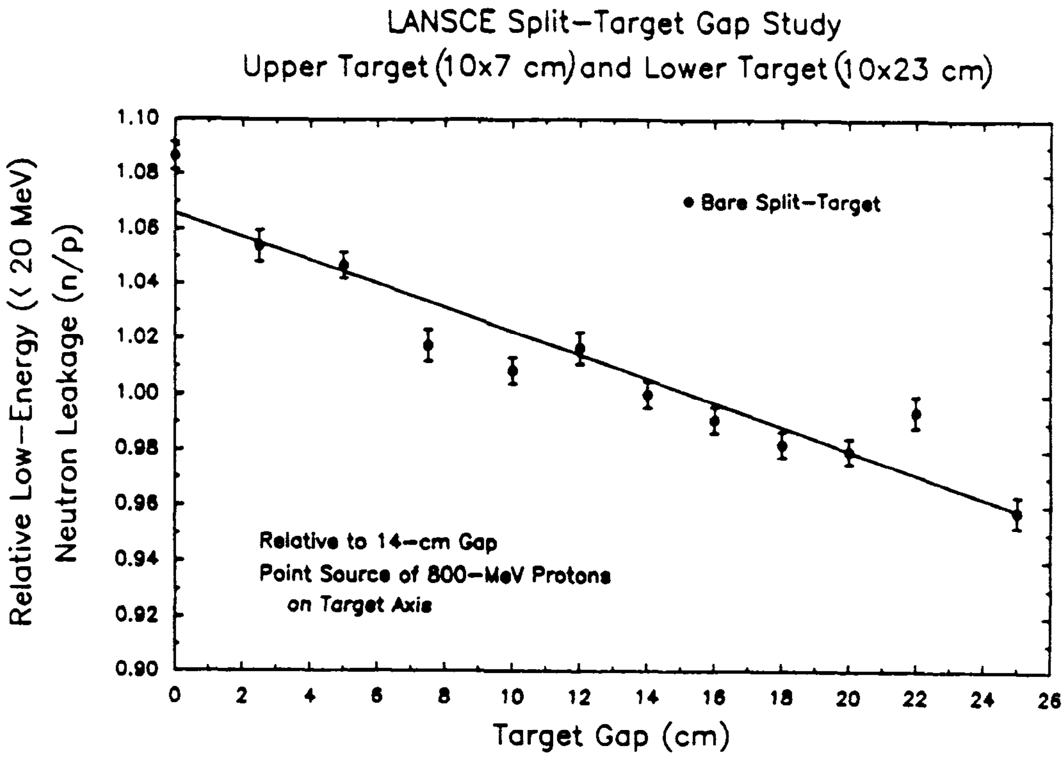

Figure 3. Neutron leakage from the LANSCE split-target. The upper-target length was fixed at 7 cm and the lower-target length was set to 23 cm.

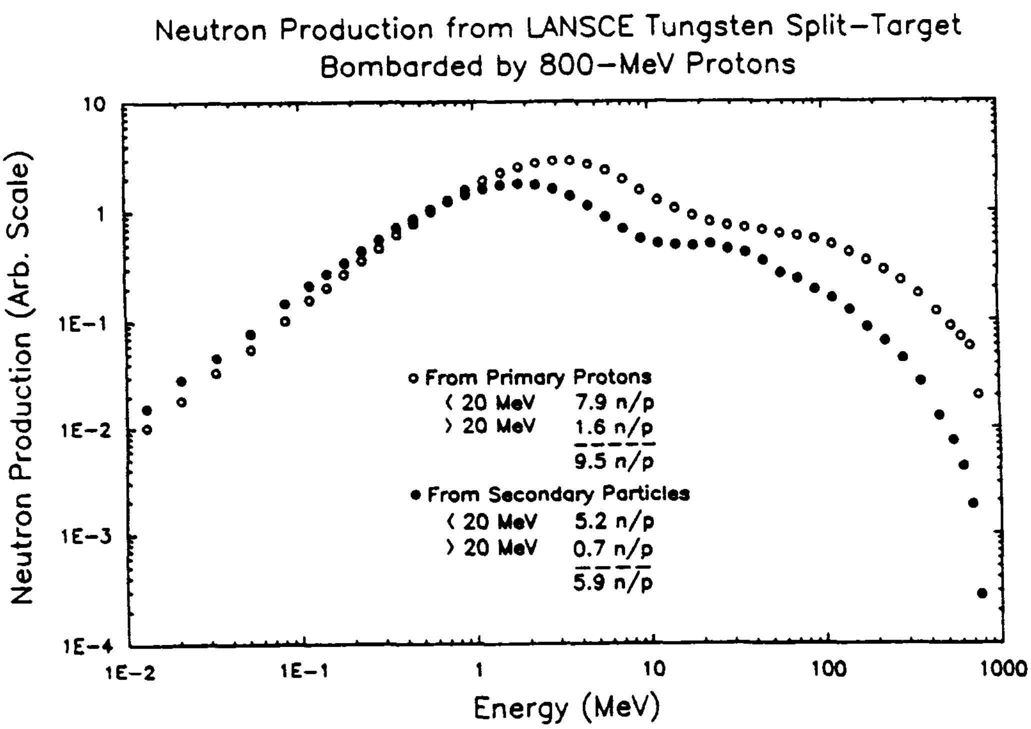

Figure 4. Neutron production from reactions caused by primary proton and secondary particles in LANSCE tungsten-target nuclei.

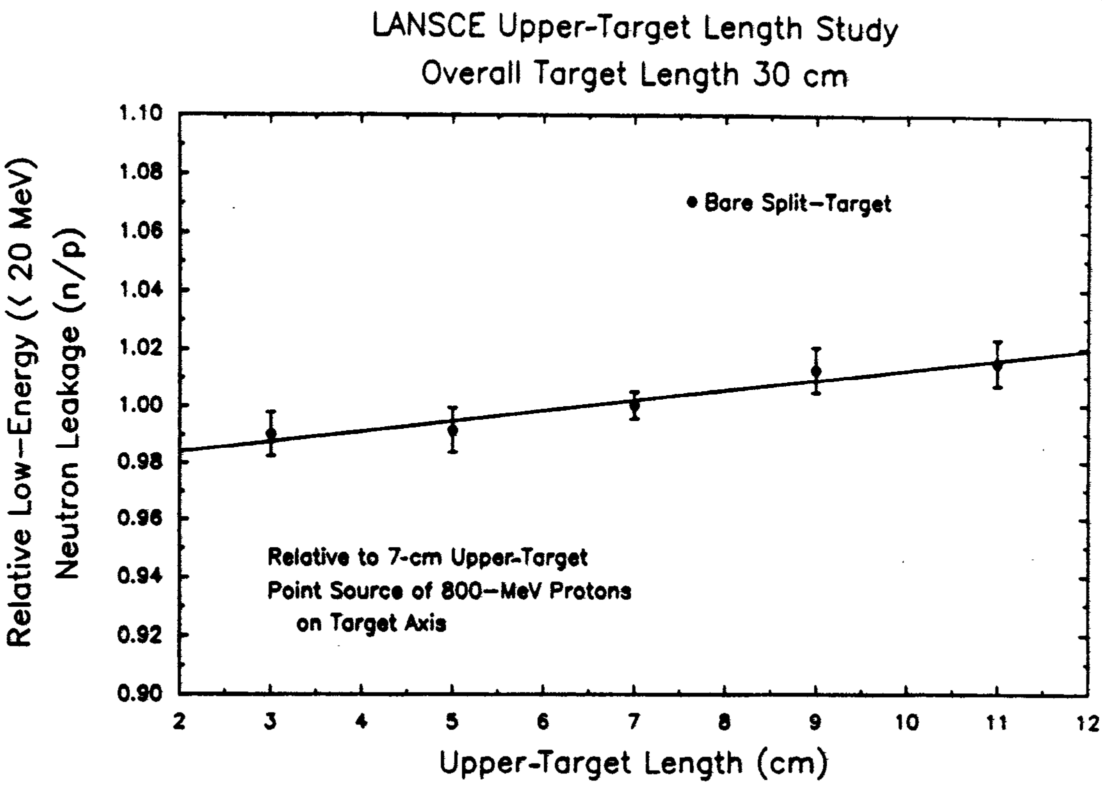

Figure 5. Neutron leakage from the LANSCE split-target. The target gap was fixed at 14.0 cm.