LANSCE steady-state unperturbed thermal neutron fluxes at 100 μA

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ABSTRACT: The "maximum" unperturbed, steady-state thermal neutron ***flux*** for LANSCE is calculated to be $2x10^{13}$ n/cm^2-s for 100 μA of 800-MeV protons. This LANSCE neutron flux is a comparable entity to a steady-state reactor thermal neutron flux. LANSCE perturbed steady state thermal neutron fluxes have also been calculated. Because LANSCE is a ***pulsed*** neutron source, much higher "***peak***" (in time) neutron fluxes can be generated than at a steady-state reactor source.

Introduction

The intercomparison of pulsed-spallation-neutron-source and reactor-source performance is complex and ultimately has to be based on individual experiment/instrument particulars. Carpenter defined an "effective peak flux" to describe the performance of a pulsed neutron source.[1] Care should be used in quantitatively applying the "effective peak flux" concept to characterize pulsed neutron-source performance. However, for a pulsed spallation source, a "thermal" neutron flux can be calculated which is similar to a steady-state reactor thermal neutron flux. This spallation source neutron ***flux*** is the spatial maximum of the unperturbed steady state thermal neutron ($E < 0.625$ eV) flux inside a moderator.

Approach

The LANSCE spallation neutron source has been described elsewhere.[2] An expanded plan view of the LANSCE target/moderator arrangement is depicted in Fig. 1. Some nomenclature is in order. Liners eliminate neutron "crosstalk" between the moderator surface viewed by a flight path and the reflector/shield. Decouplers neutronically isolate the moderator per se from the reflector/shield. Poisons define an "effective" moderator volume for thermal and cold-neutron production. The neutron energies at which liners, decouplers, and poisons are neutronically effective depend on the material type and thicknesses.

At Los Alamos, we have a powerful Monte Carlo computational capability applicable to spallation-neutron-source-performance computations[3] I used this computational tool to calculate a variety of thermal neutron fluxes for the LANSCE target system. Thermal neutrons are defined to include all neutrons with energies below 0.625 eV. This is how thermal neutron fluxes are being quoted for the Advanced Neutron Source and for the ILL reactor;[4] the ILL is basically the "world standard" to which other neutron producing facilities are compared.

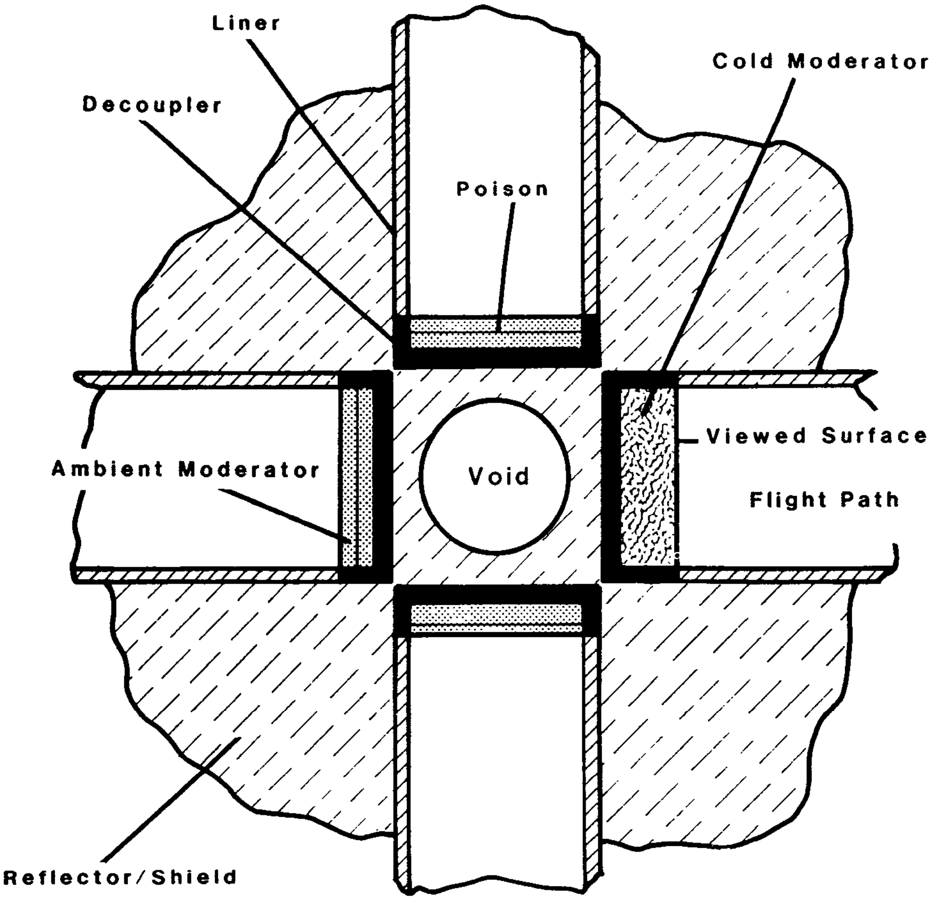

Fig. 1 Expanded plan-view schematic diagram of the LANSCE target/moderator arrangement. The liquid-hydorgen moderator is depicted on the right side.

Simplistically, LANSCE moderator neutron fluxes are ***perturbed*** in two ways: 1) neutronically—with liners, decouplers, or poisons, and 2) spatially—by the intrusion of void spaces through the reflector/shield to extract neutron beams for experiments. I define a ***decoupled*** LANSCE moderator to be one in which poisons, decouplers, or liners are used. Conversely, a ***coupled*** LANSCE moderator is one where no poisons, decouplers, and liners are utilized. A ***coupled/perturbed*** moderator is perturbed by the void space used to extract neutron beams. A ***coupled/unperturbed*** moderator does not have a void space for neutron beam extraction. At present, LANSCE operates with four decoupled/perturbed moderators;[2] the thickness of the Lansce H_2O moderators is a nominal 3.5 cm.

Results

A plot of the average thermal neutron flux at the surface of a LANSCE moderator viewed by an instrument is shown in Fig. 2 as a function of moderator thickness.

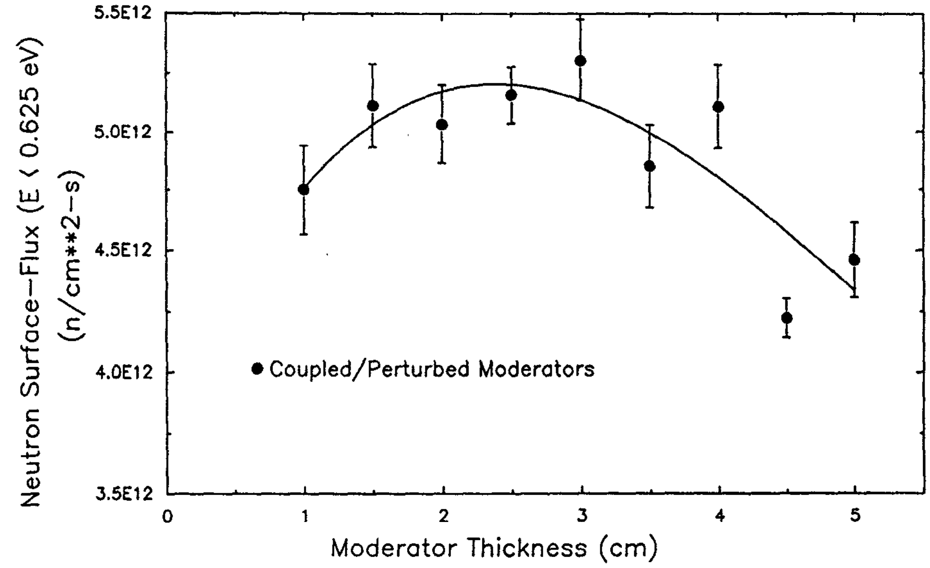

Fig. 2 LANSCE thermal neutron flux at a water moderator surface as viewed by an experiment, for 100 μA of proton current.

These data are for coupled/perturbed 13 by 13 cm H_2O moderators; the neutron flux is averaged over the 13 x 13 cm surface. The fluxes are, therefore, "useful" fluxes in a practical sense because they are averaged over a 169 cm^2 area. A polynomial fit to the data shows a broad peak in the range 1.5 to 3.5 cm.

I calculated the spatial distribution of thermal neutrons inside 2.5- and 3.5-cm-thick coupled moderators, for both perturbed and unperturbed cases. The results are shown in Figs. 3 and 4. For the 3.5-cm-thick moderator, the maximum thermal neutron flux is about $2x10^{13}$ n/cm^2-s. This is to be compared to the ILL value of $1.5x10^{15}$ (see Ref. 4). Even though the surface fluxes (for the moderator surface viewed by an instrument) are similar for the two moderator thicknesses, there may be an advantage for the thicker moderator because of potential gain from the use of "honeycomb" moderators,[5] etc.

The thermal neutron flux from a LANSCE decoupled/perturbed H_2O moderator is compared to that from coupled/perturbed and coupled/unperturbed H_2O moderators in Fig. 5. One can see the gain (of about 6) in going from a decoupled to a coupled moderator. A further gain would be realized by removing the poison from within the decoupled moderator.[2]

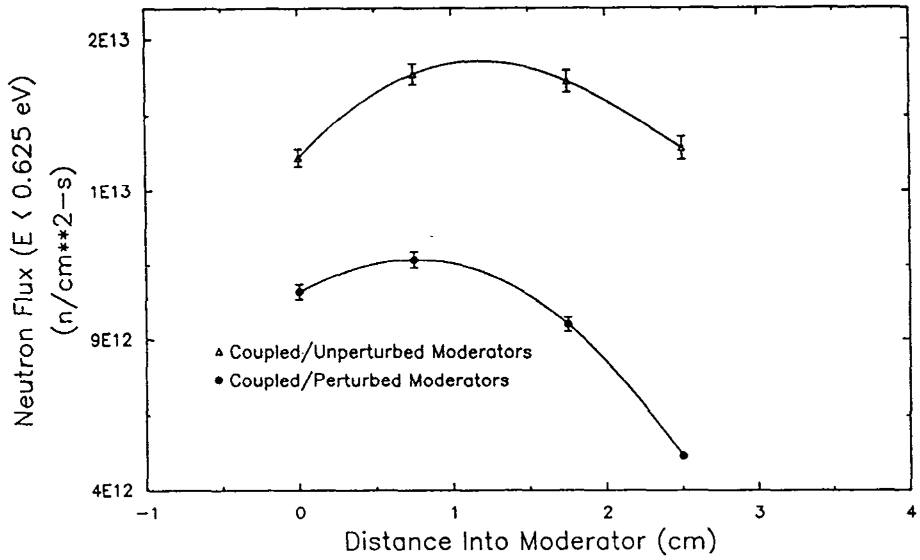

Fig. 3 Spatial distribution of thermal neutron flux for a 2.5-cm-thick LANSCE water moderator, for 100 μA of proton current.

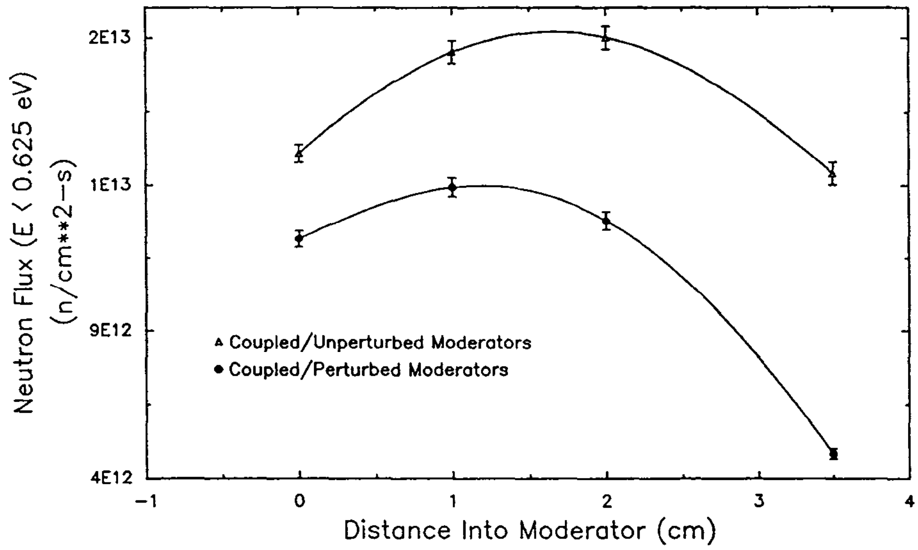

Fig. 4 Spatial distribution of thermal neutron flux for a 3.5-cm-thick LANSCE water moderator, for 100 μA of proton current.

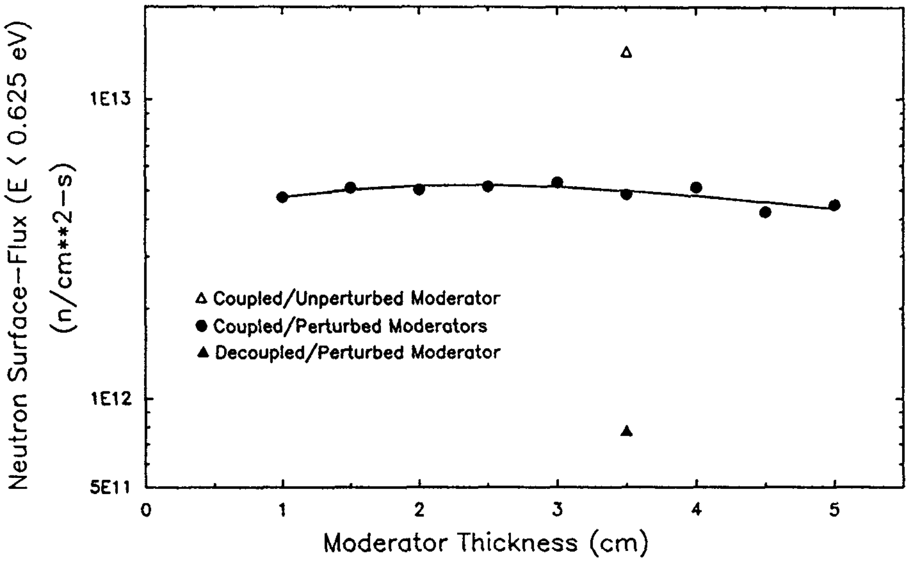

Fig. 5 Thermal neutron flux at the surface of various LANSCE water moderators, for 100 μA of proton current.

Conclusions

Thermal neutron fluxes have been calculated for the LANSCE spallation neutron source. The steady-state thermal neutron flux value of $2x10^{13}$ is similar to a steady-state reactor thermal neutron flux. Because LANSCE is a pulsed-spallation neutron source, much higher peak (in time) thermal neutron fluxes are generated than at a steady-state reactor. Intercomparing the performance of a pulsed neutron source with a steady-state reactor source is complicated and dependent on experiment/instrument particulars.

Because of engineering realities associated with high-power source design, care should be exercised in extrapolating LANSCE thermal neutron flux values for 100 μA of 800-MeV protons to higher proton currents and energies.

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