Reduction of the Neutron Albedo Flux in the Vertex Detector Region of a Generic SSC Detector

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Radiation damage will be a large problem for SSC detector designers. Estimated dose and neutron fluence levels anticipated in generic SSC detectors are of sufficient intensity that most active detector materials will undergo radiation damage resulting in reduced performance or failure.[1] Many methods are being considered to reduce the radiation levels in these detectors. This report discusses a method whereby the fast neutron albedo flux (100 keV $< E_N <$ 20 MeV) in the vertex detector region interior to the calorimeter can be reduced by factors of 2-10 by the inclusion of small amounts of polyethylene.

The generic detector design considered in these calculations is shown in Fig. 1. The detector is taken to be spherical with a central void region of radius 2.0 m minus the thickness of the polyethylene which will be placed interior to the calorimeter. The detector starts at a radius of 2.0 m and is comprised of uranium and plastic (50% volume U, 50% volume $CH_{1.2}$). The thickness of the detector is sufficient to contain a high energy cascade, i.e., on the order of 1000 gm/cm^2.

The neutron albedo source[1] was obtained from the CALOR[2] code system using HETC[3] and MORSE.[4] A plot of this source distribution is given in Fig. 2.

The source distribution shown in Fig. 2 was used as an inwardly directed isotropic flux boundary condition at 2.0 m (see Fig. 1) in the ANISN[5] code to obtain the neutron flux in the system. The cross section library used with ANISN was DLC31.[6]

The relative energy-dependent neutron fluxes obtained from these calculations are shown in Fig. 3 as a function of polyethylene thickness. The normalization factor in ANISN was set to 1.0, i.e. the data have been normalized to a neutron current of ($0 \leq E_N$

$\leq$ 20 MeV) of 1.0 n crossing inwardly on the 2.0 m boundary. The rapid suppression of the fluxes as a function of the polyethylene thickness is evident.

The integral neutron damage (100 keV $\leq E_N \leq$ 20 MeV) flux and the integral neutron flux times a damage cross section[7] for silicon is shown in Fig. 4 as a function of polyethylene thickness. The integral neutron flux assuming the source is comprised entirely of 1 MeV neutrons is also shown. Again, the rapid suppression of the damage is evident. These data have been normalized to 1 for zero thickness of polyethylene. Approximately 10 cm of polyethylene will reduce the damage due to fast neutrons by an order of magnitude. Assuming the neutrons are all 1 MeV overestimates the effectiveness of the polyethylene. A typical fluence of neutrons in the central cavity has been calculated to be 2×10^{12} n/cm^2/yr.[1] This level of radiation can be expected to produce the onset of device degradation and failure. However, by utilizing the polyethylene to reduce this fluence by a factor of 10, most detector materials located in this area can be expected to operate safely for many years.

References

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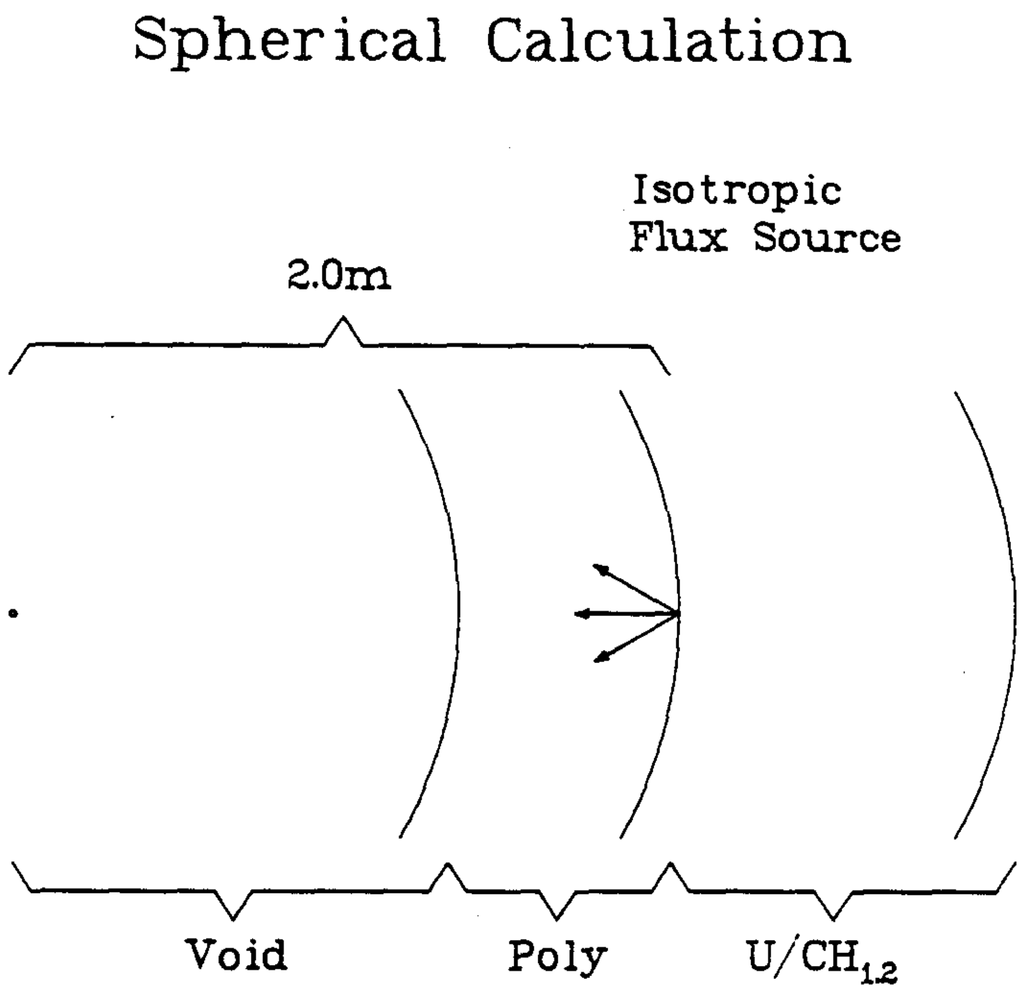
Fig. 1. Geometry of the generic SSC detector.

Fig. 2. Neutron albedo spectrum used in the ANISN calculation as a flux boundary condition at 2.0 meters.

Fig. 3. Reduction in the neutron flux due to various thicknesses of polyethylene.

Fig. 4. Relative reduction in the damage as measured by the integral flux and integral flux times a damage function. Also shown is the integral flux, assuming the source is comprised entirely of 1 MeV neutrons.



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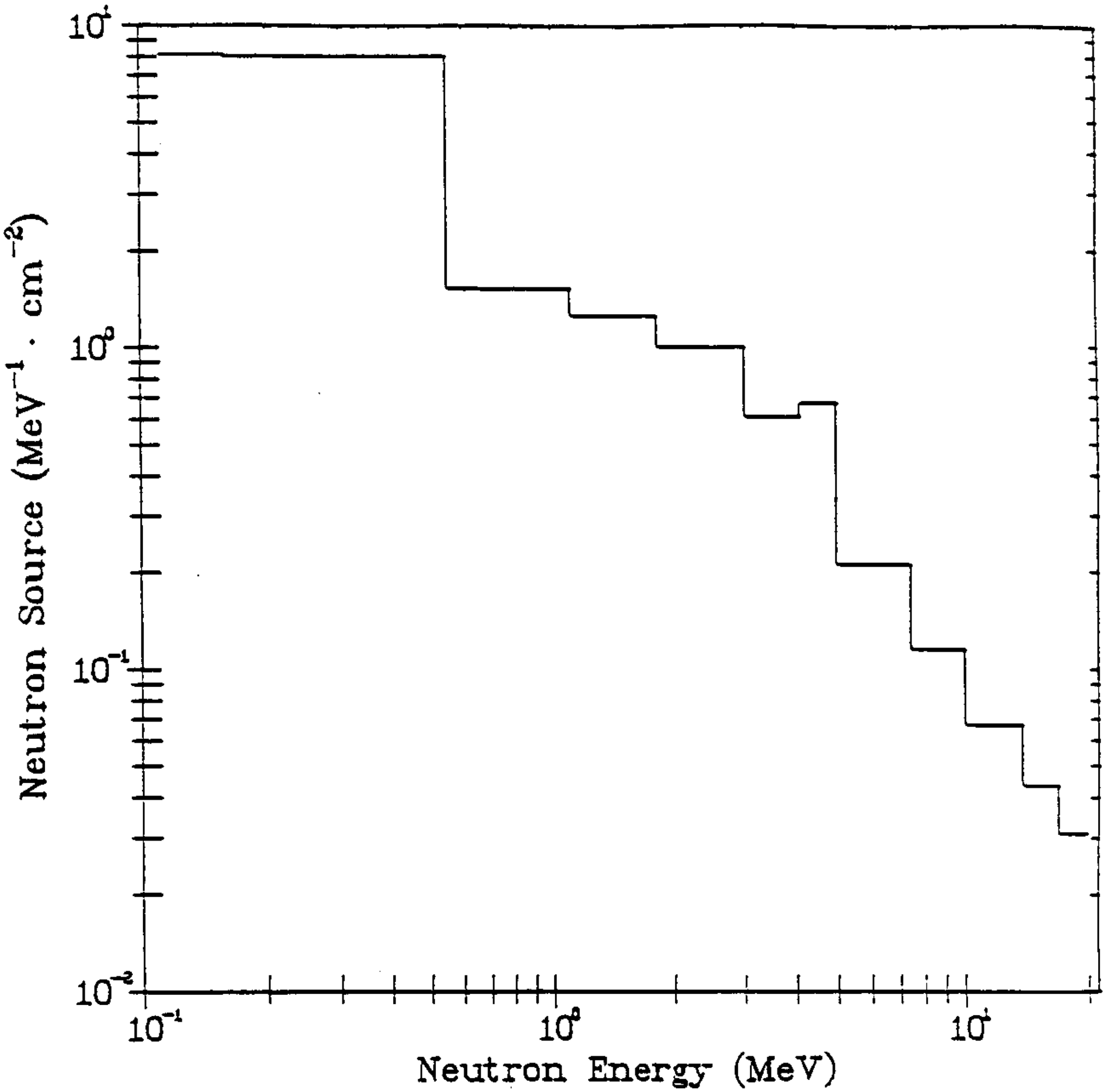

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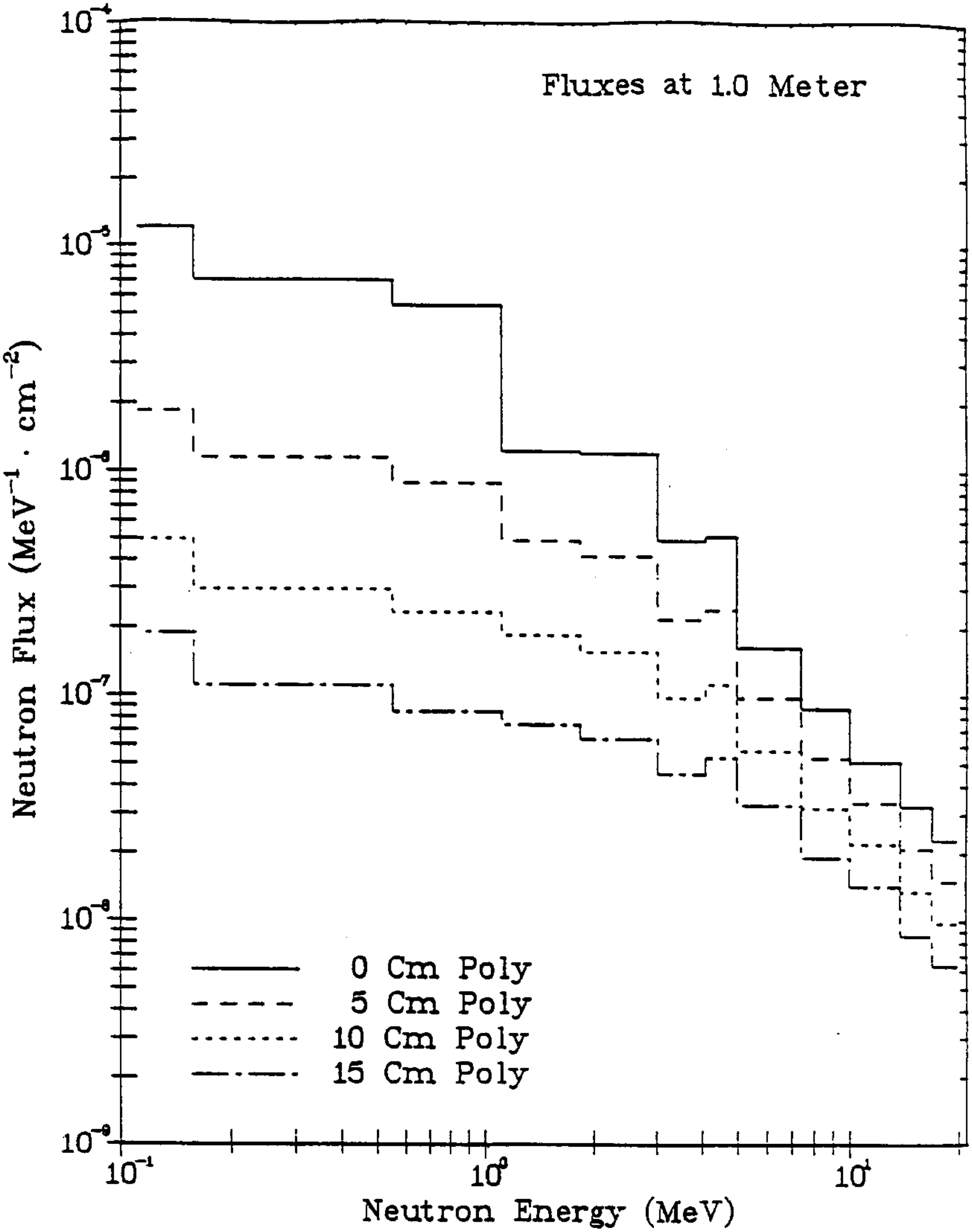
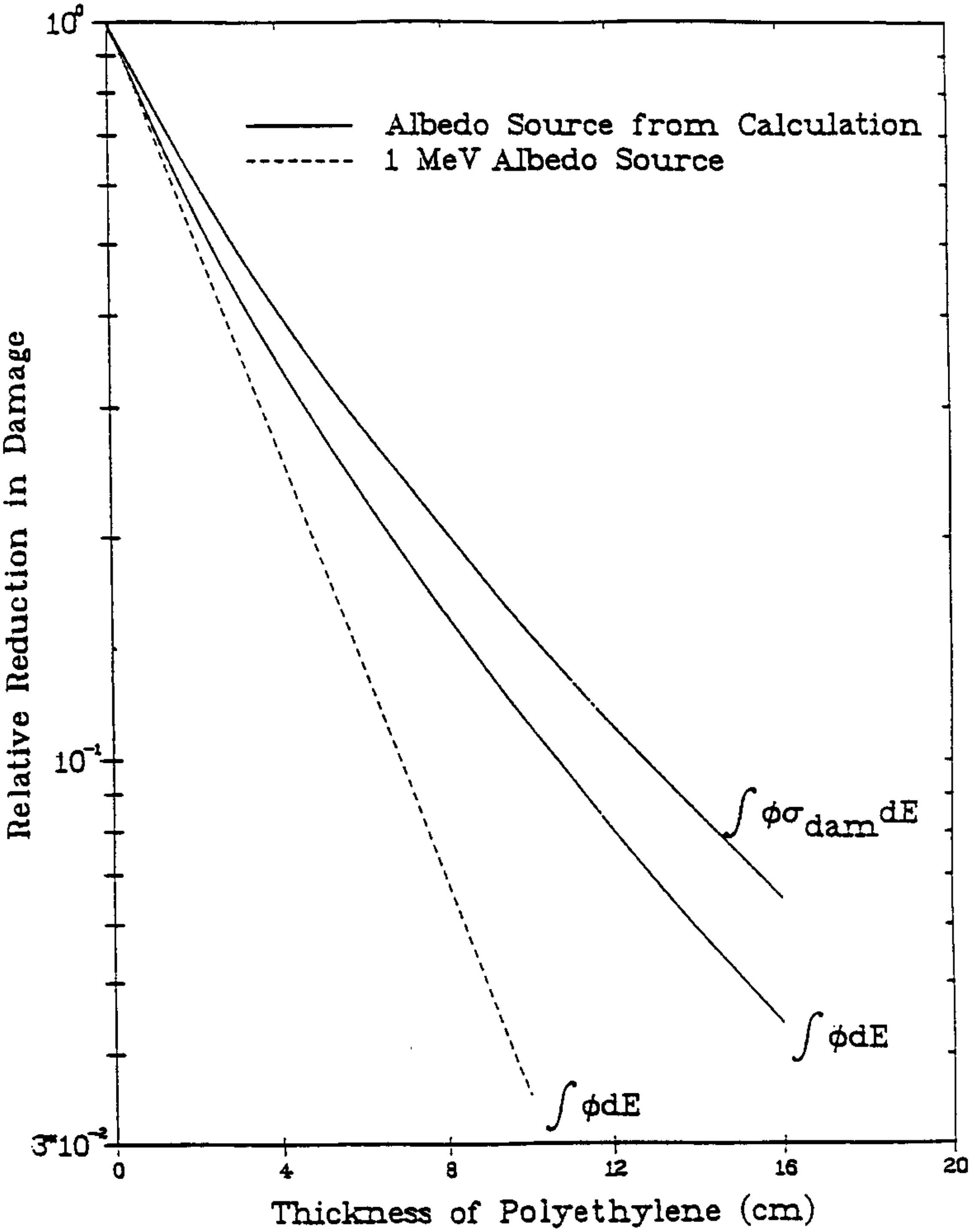


Fig. 3. Reduction in the neutron flux due to various thicknesses of polyethylene.



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