N. Comments on the Choice of a Slab or Wing Geometry for a Pulsed Spallation Neutron Source, W. Kley, ISPRA

It is known that in steady-state heavy water reactors, the thermal neutron flux is identical in radial or tangential beam tubes if the end of the beam tubes are positioned approximately at the same radial distance from the core, but the signal to background ratio is 100 times better in the tangential beam. Therefore, one does not have to pay a penalty in terms of thermal neutron flux. However, in pulsed-neutron sources this is not the case. Yoshikazu Ishikawa and Noboru Watanabe[1] have measured the thermal neutron conversion efficiency, defined by $n_{th}/sr \cdot n_f$, where n_f is the neutron source intensity, for a number of moderator/reflector systems. The results are summarized in Table I; the data were obtained using an Am-Be neutron source.

The data in Table I have been enumerated for the case where the center of the Am-Be source has been centered at a distance of 2 cm from the moderator surface (as indicated in Fig. II-N.1).

We see that there is a penalty of about a factor of two by choosing a totally reflected wing geometry. It can be expected that the penalty may be even a factor of three or four if a totally reflected slab geometry is used as indicated in Fig. II-N.2.

The question of whether or not this penalty has to be accepted depends actually not only on the signal (thermal neutron flux) but also on the signal to background ratio S/B for the two cases. In order to compare the two cases one has to use a figure of merit.[2]

$$M = \frac{T_2}{T_1} = \left(\frac{S_1}{B_1}\right)\left(\frac{B_2}{S_2}\right)\left(\frac{S_1}{S_2}\right)\frac{\left[\frac{S_2}{B_2} + 2 + 2\sqrt{\frac{S_2}{B_2} + 1}\right]}{\left[\frac{S_1}{B_1} + 2 + 2\sqrt{\frac{S_1}{B_1} + 1}\right]}$$

where T_2 and T_1 are the corresponding measuring times for the two cases in order to obtain the same statistical accuracy. Since we are dealing with

a pulsed neutron source we can suppose that after about 100-200 μs the very fast neutrons have died away and that the S/B ratio will be very similar for the two cases. If this can be proven experimentally, then the choice for a slab geometry is obvious. In any case we can install and phase background rotors that guarantee the equality of the S/B-ratio for the two cases.

References

1. Y. Ishikawa and N. Watanabe, "KEK Neutron Source and Neutron Scattering Research Facility," KEK-78-19, A/I (November 1978).

2. W. Kley, "Design Criteria for Moderators and Beam Tubes for Spallation Neutron Sources," EUR-62-2e (November 1978).

TABLE I

COMPARISON OF NEUTRONICS FOR DIFFERENT TARGET/MODERATOR GEOMETRIES

Unreflected slab-geometry	10 x 10 x 5 cm^3 A = 100 cm^2	15 x 15 x 5 cm^3 A = 225 cm^2	25 x 25 x 5 cm^3 A = 625 cm^2
Thermal neutron conversion efficiency ($n_{th}/sr \cdot n_f$)	1.5×10^{-3}	3.5×10^{-3}	6.2×10^{-3}
Reflected wing-geometry	3.5×10^{-3}		

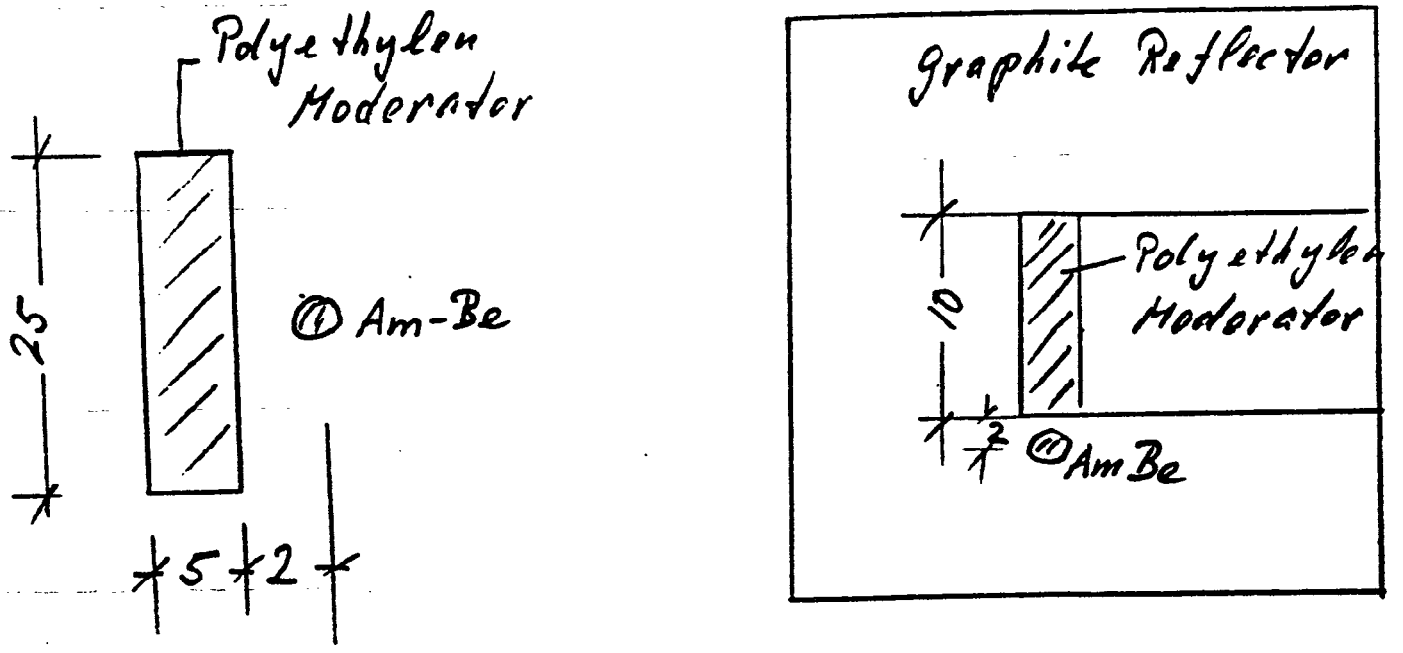

Fig. II-N.1. Slab and reflected-wing geometry. The dimensions are in cm.

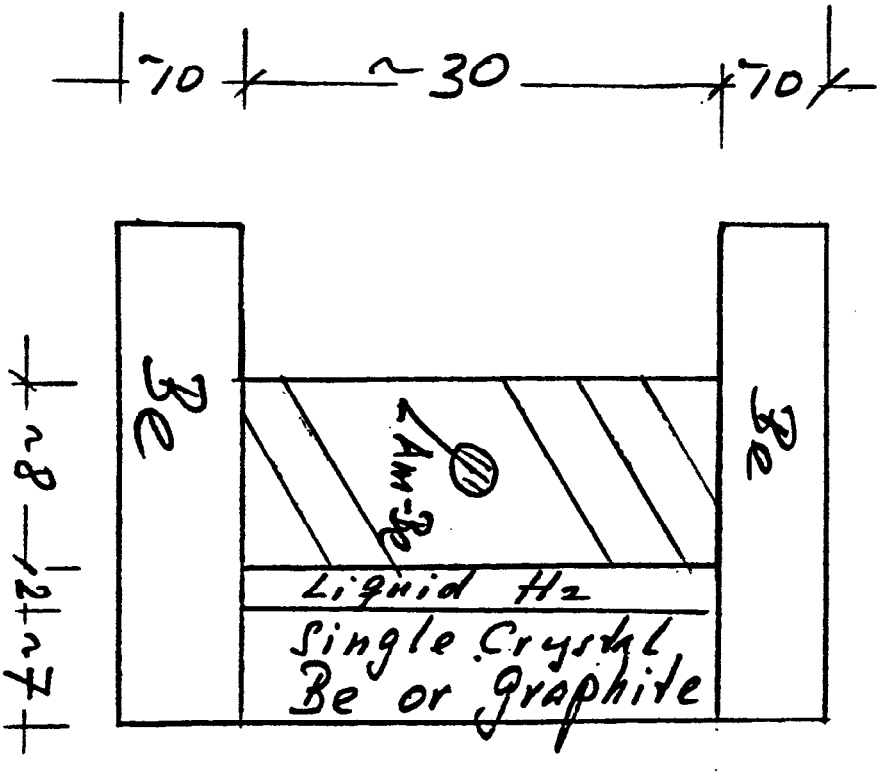

Fig. II-N.2. Reflected-slab geometry. The dimensions are in cm.