ICANS-VI

INTERNATIONAL COLLABORATION ON ADVANCED NEUTRON SOURCES

June 28 - July 2, 1982

SUMMARY OF DISCUSSION SESSION ON BEAMLINE SHIELDING CONSIDERATIONS FOR SPALLATION NEUTRON SOURCES

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This was the first ICANS meeting where we specifically discussed problems associated with shielding beamlines at spallation neutron sources. These problems are difficult to tackle both computationally and experimentally. What makes the problem unique to spallation neutron sources is the possibility of high-energy (up to several hundred MeV) neutrons and charged particles contaminating the thermal neutron beams extracted from these sources. The high-energy neutrons and charged particles can themselves cause biological or instrument background problems or produce neutron and γ-ray progeny (by interacting with collimation systems, instrument components, and beam stops) which must be shielded against.

A typical beamline shield is illustrated in Fig. 1; questions relating to beamline shielding should be considered as a unit. Items needing attention are:

Interior to Bulk Shield

- energy of the proton beam
- target and moderator neutronic coupling
- angle (relative to the proton beam) at which neutron beams are extracted
- moderator field-of-view
- collimator design

Exterior to Bulk Shield

- collimator design
- lateral beamline shielding
- instrument shielding
- beam stop design .

Our discussions identified the following:

- There is a general concern about beamline shielding both from laboratories with operational spallation neutron sources as well as those laboratories planning and constructing spallation sources.
- Shields perform two distinct functions: a) biological shielding, and b) instrument background reduction.
- There is a clear need to establish reliable computational techniques and perform clean benchmark shielding measurements.

Neutron beams from a spallation source are characterized by a high-energy neutron contaminant. Gunter Bauer (KFA) recapped the results of measurements presented at ICANS V, and Tim Broome (RAL) gave the results of HETC calculations; both reports confirmed the likely presence of a high-energy (> 50 MeV) neutron contaminant.

Two other calculations were described:

1) Gary Russell (LANL) reported the results of 'idealized-geometry' Monte Carlo calculations. These computations (using HETC + MCNP) studied lateral shielding by simulating the high-energy beam contaminant with 100-MeV neutrons and allowing this beam to hit an iron cylinder giving the source term for the shield calculations. The beamline shield was comprised of layers of borated polyethylene, iron, regular polyethylene, and concrete. The neutron and γ doses outside the shield were calculated for various combinations of these materials. The calculations demonstrated that Monte Carlo techniques could be effectively used for simple flight path geometries to study fundamental systematics of beamline shielding problems.

2) Tim Broome (RAL) presented simple attenuation calculations; Tim used the Moyer method to determine the shield depth required to satisfy biological radiation protection requirements. These calculations gave the shield depth required assuming a point source description of the moderator flux and a parallel beam tube.

Other calculational techniques were discussed and a concensus emerged that the combination most likely to succeed would be two dimensional discrete ordinates codes with source terms calculated by Monte Carlo. The hope was expressed that calculations of simple geometries might be possible in the near future which could lead to the development of techniques to perform full collimator design calculations. One major limitation with the present codes is the inadequency of existing high-energy (> 20 MeV) neutron cross section libraries. At KFA, some theoretical effort will be expended to create an improved high-energy library. At the WNR, new (p,n) cross-section experiments will be performed in the near future. The physics models in the high-energy codes need improving, but the effort available for this is limited. As a preliminary to establishing a closer contact between ICANS members on the subject of codes, a simple HETC benchmark calculation will be circulated for interlaboratory code comparison.

Operating experience (at WNR, IPNS and KENS) with beamline shielding has shown that systems have evolved which perform satisfactorily at relatively low proton currents of 2-8 μA and at proton energies of 500-800 MeV. However, the shielding arrangements at these facilities are essentially ad hoc or empirical in nature. More work on beamline shielding needs to be done before beamlines can be adequately shielded at higher proton currents. Jack Carpenter (ANL) reported on background problems encountered at KENS during experimental studies of resonance detector systems. These problems stemmed mainly from a halo around the beam which was only eliminated with a substantial amount of lead shielding; the results suggested that the backgrounds were probably due to high- (rather than low-) energy neutrons.

A limited (but important) experimental program at the WNR was described which, together with the knowledge gained from existing flight path shielding, should help better understand beamline shielding problems. At the WNR, lateral beamline shielding questions will be investigated both experimentally and calculationally. A clear need for good benchmark experiments for code validation was identified, but the definition and execution of such experiments will require a great deal more thought. In particular, the measurement of the neutron beam spectrum requires a calibrated high-energy neutron detection system.

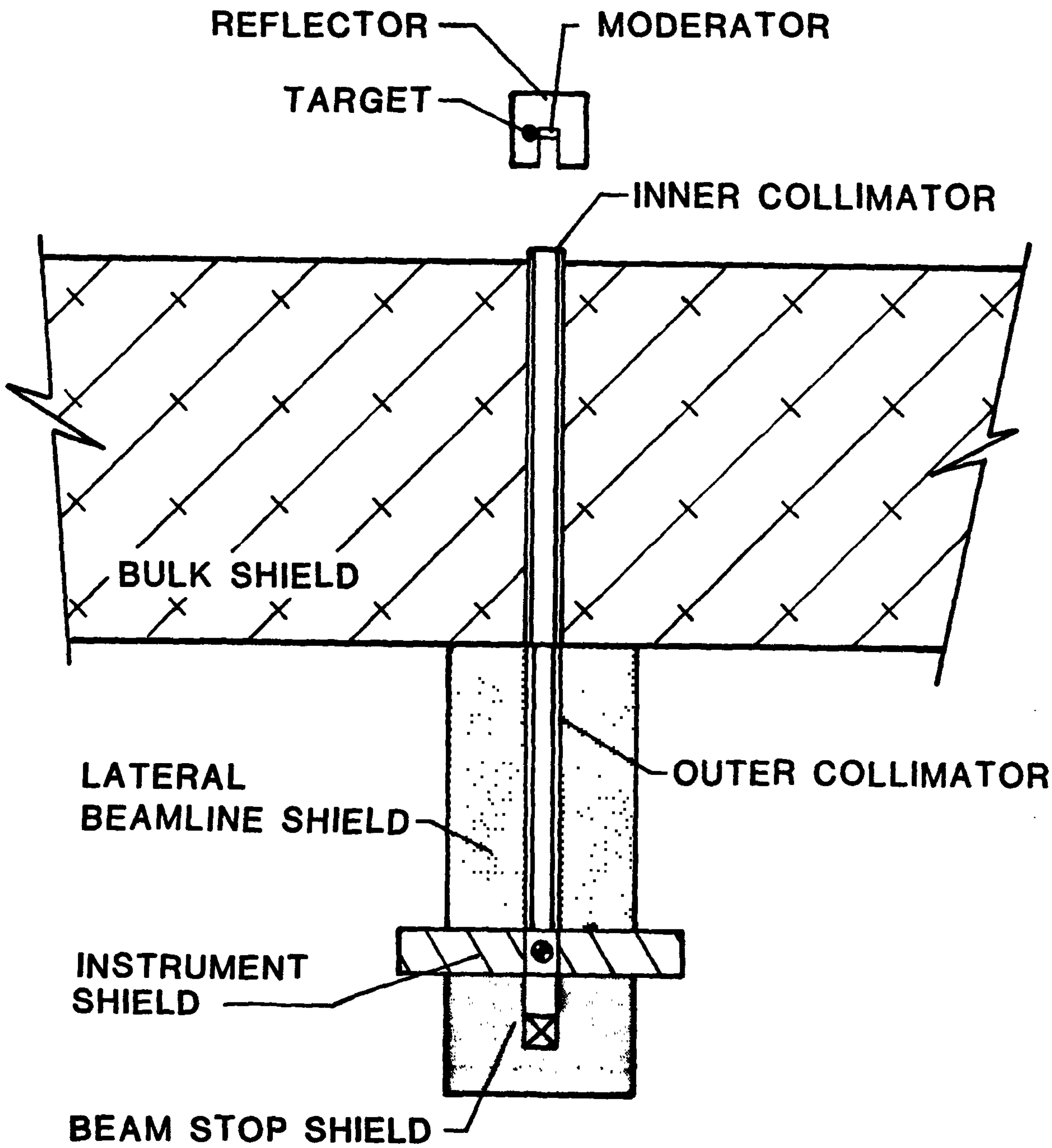

Fig. 1. Illustration of a typical beamline shield.