as simple as possible. Removed radioactive items will be transferred to hot cells, via the casks, where remote handling can be performed efficiently with proper equipment. One of the most important factors involved with this approach is for proper communication between the IPNS personnel and the hot-cell people during the design periods. These communications are essential so that the hot-cell people can become suitably prepared for the anticipated remote handling and possibly post irradiation examination or repair activities.

I. Neutron-Beam Currents as a Function of Proton Energy and Target Diameter in a Pulsed-Spallation Source, J. M. Carpenter and T. G. Worlton, ANL

As is well known, the total number of neutrons produced by spallation increases roughly linearly with proton energy. However, the distribution of neutrons produced in the target becomes more extended as the proton energy increases, since the cascade builds up at small angles from the incident end of the target. The total number of neutrons produced also diminishes as the target diameter is made smaller, since fewer secondary neutron-producing reactions can then take place. Offsetting this is the fact that moderators can be coupled more efficiently to small-diameter sources than to large ones.

Calculations of these effects were done recently at Argonne, using the HETC code to transport high-energy particles, and the VIM code to transport neutrons to low energies. The targets were modeled as NaK-cooled U disks, 1.2 times as long as the proton range, and of variable diameter. An annular void of 1-cm width separated the target from the moderators, which were surrounded with a Be reflector and (except for moderator "C") decoupled by boron layers. The Be reflector radius was kept equal to the target length or 30 cm, whichever was greater. The arrangement is shown in Fig. II-I.1.

Table I shows the resulting epithermal beam current per unit lethargy, evaluated at 1 eV, $EI_p(E)_{1\ eV}$ on a per-proton basis. Results were developed for the average of the four moderators, and for the highest-intensity moderator ("C"). The results for the average moderator are shown in Fig. II-I.2.

As can be seen in Fig. II-I.2, when the proton energy is increased, the beam intensity increases approximately linearly up to nearly 2 GeV, at which energy the anticipated diminishing return is evident. The results also indicate that the beam current diminishes only slightly with increasing target diameters, in the range of diameters studied.

These conclusions apply specifically to the pulsed-source geometry studied, but similar effects would be evident in other arrangements, although the diminishing return on increased proton energy may set in at higher or lower energies.

Of course, the extended length of the source might be exploitable by use of larger moderators, or of a larger number; these possibilities have not been explored.

Table I

NEUTRON YIELDS CALCULATED BY HETC AND VIM

E_p (MeV)	Diam (cm)	n/p	$\left(EI_p(E)_{1\ eV}\right) \times 10^3$	$\left(EI_p(E)_{1\ eV}\right) \times 10^3$ Moderator C
500	6	11.67	4.36	7.07
	8	12.55	3.93	6.09
	10	13.37	3.91	5.77
	12	13.59	3.46	5.50
800	6	22.69	7.94	12.20
	8	24.38	7.77	11.75
	10	26.04	7.60	10.31
	12	28.11	7.58	11.12
1200	6	34.15	11.29	17.02
	8	38.89	11.08	14.63
	10	41.62	11.22	16.52
	12	45.81	10.85	16.06
1800	6	51.16	16.20	23.97
	8	57.49	16.51	24.63
	10	62.37	14.72	20.68
	12	68.06	14.98	21.50

The beam current $EI_p(E)_{1\ eV}$ is in units of n/p·sr.

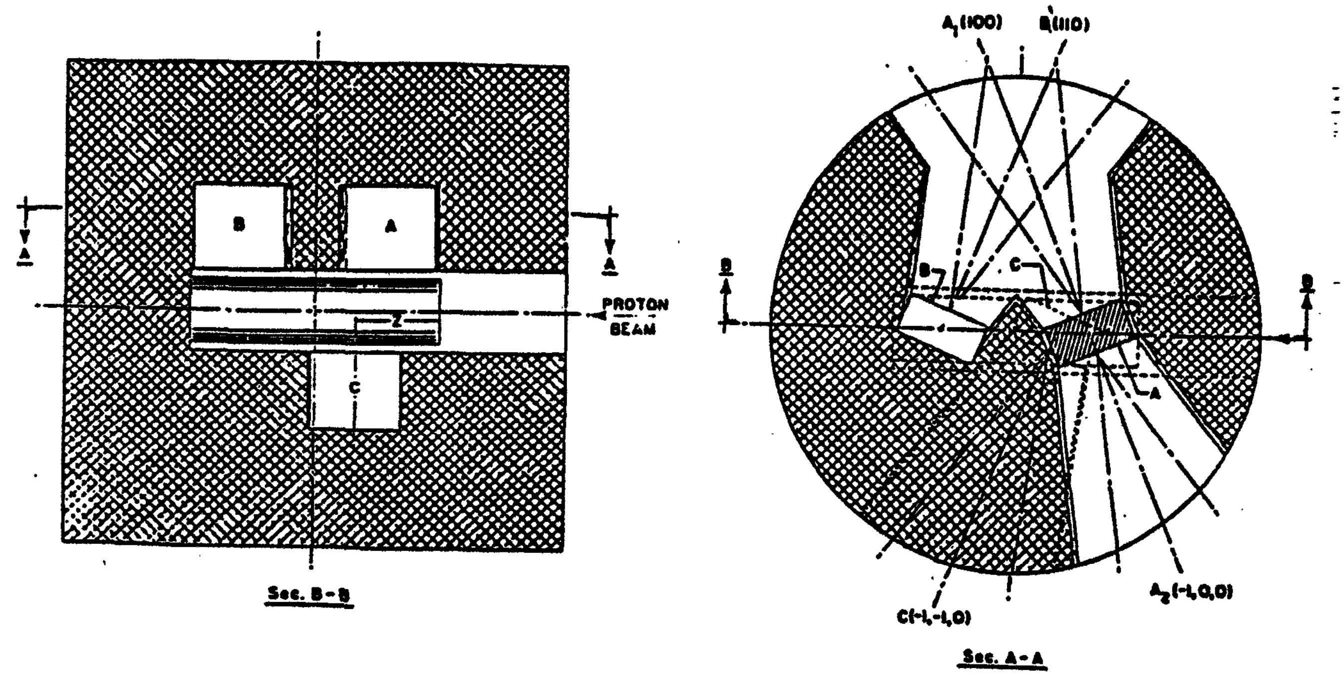

Fig. II-I.1. Arrangement of target, moderators, and reflector for the VIM calculations. The distance, Z, between the front of the target and the centerline of moderator C was determined from the average axial position of the neutrons produced in the HETC calculation. The heavy lines in the figure indicate $^{10}B_4C$ lining of the beam tubes and moderator sides. The cross hatched area is Be reflector. Beam directions from the moderator surface are indicated by lines on either side of the normal to the moderator surface.

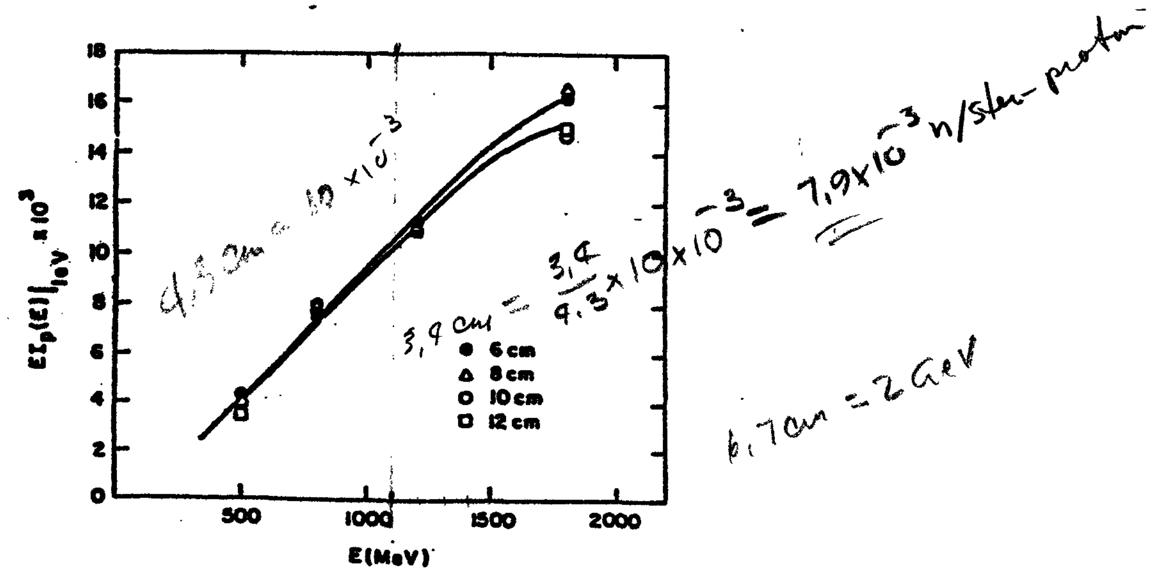

Fig. II-I.2. The energy dependence of the neutron-beam current at 1 eV for the average of the three moderators studied. Results of the HETC and VIM calculations have been corrected for fission below 15 MeV and for neutron leakage in HETC. $EI_p(E)$ is in units of neutrons per proton per steradian.