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FAST NEUTRON DOSE EQUIVALENT RATES IN HEAVY ION TARGET AREAS

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Abstract

At heavy ion accelerators, personnel access to areas near the target is sometimes important for successful performance of experiments. Radiation levels determine the amount of time that can be spent in these areas without exceeding maximum permissible exposures. Inasmuch as the fast neutrons contribute the major part of the Rem dose rates in these areas, knowledge of the fast neutron levels is important for planning permissive entry to target areas. We have measured fast neutron dose rates near thick medium mass targets bombarded with beams of C, N, O, and Ne ions. Beam energies ranged from 3 to 16 MeV/amu. Dose rates (mrem/h) 1 meter from the target 90 degrees from the beam direction range from ∿ 0.05 at 3 MeV/amu to ∿ 50 at 16 MeV/amu. These data should be helpful in planning permissive entry to heavy ion target areas.

The radiations from accelerator beams interacting with targets and associated target station components such as collimators and beam stops usually require shielding to protect personnel working nearby. Typically, the most penetrating radiations, and consequently the most difficult to shield, are the neutrons. Yields and energies of these determine the shielding requirements. In earlier work[1-3], we measured half-value thicknesses of concrete for neutrons from a range of light ions on a variety of thick targets. For these data, radiation levels without shielding were measured and the work reported in reference 3 included measurements at two energies for ^{12}C ions. In the present work, fast neutron levels were measured for targets bombarded with a variety of heavy ion beams at a wide range of beam energy. These data are useful in developing policies to allow personnel to enter radiation zones around target stations at heavy ion accelerators.

For thick targets, i.e. those that stop the beam, the neutron yield is given by $\int_0^R I(E)\sigma(E)dx$ where I is the beam intensity, R the range of the beam particles in the target material, and σ the cross section for neutron production. For low-energy, heavy ions, the ranges are small and the neutron yields are low compared to those of targets bombarded with light ions of comparable energy. In many such cases, the neutron radiation levels are low enough so that access by personnel to areas near the targets is feasible providing that a suitable surveillance system employing active radiation detectors is in use. For example, a permissive entry system with accumulated dose monitoring has been used routinely for a number of years at the heavy ion target areas of the ORNL EN Tandem Van de Graaff accelerator. Here the beam energies for heavy ions are less than 4 MeV/amu.

At accelerators with higher beam energies, access to target areas is sometimes needed for successful performance of experiments. For example, the new heavy ion time-of-flight system[4] at the Oak Ridge Isochronous Cyclotron uses "state-of-the-art" eletronics to achieve one meter flight time resolution of 0.15 ns. To achieve this, cable lengths for the time signals must be short and the electronic modules located near the target. Fine tuning of the timing signals requires personnel access to the system with a beam on the target. During the initial "shake down" data runs with the time-of-flight system access of the experimenters to the target area was arranged with continuous surveillance by health physics radiation survey personnel.

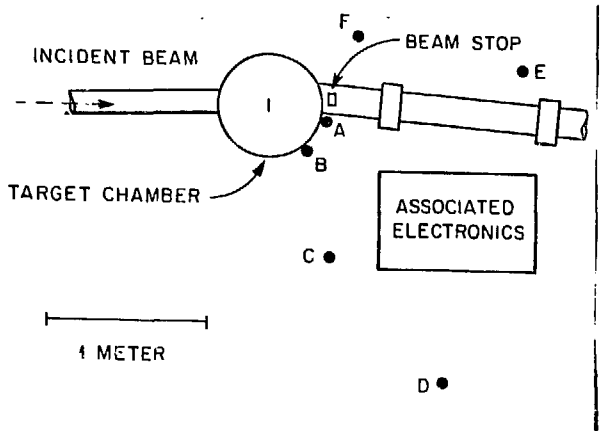

Figure 1. Experimental layout of heavy ion time-of-flight target station at ORIC. The approximate locations are indicated for the fast neutron dose rate readings listed in Table I.

Table I

Fast neutron equivalent dose rates in mrem/hr from 147.6 MeV ^{14}N ions on a stainless steel beam stop. The experimental area is shown in Figure 1. The dose rates in parenthesis are for βγ.

Location	Beam Intensity in Nanoamperers 4	10	30
A	100 - 130	550 - 600	1700 (150)
B	70	200 - 210	750 (35)
C	15 - 17	40 - 45	115
D	4 - 7	8 - 10	25 - 30
E	8 - 10	20 - 25	65 - 70
F	18 - 20	65 - 70	180 - 190 (20)

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