EXPERIMENTAL EVALUATION OF THE SCATTER OF 14.8 MEV NEUTRONS FROM A STEEL COLLIMATOR

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A 52.5 cm. long steel collimator for 15 MeV neutron therapy beams has been evaluated in terms of the distribution of the collimator scattered neutrons in the field and penumbra, the distribution in the collimator of the neutron scattering sites, and the energy of the neutrons scattered to one position in the penumbra. The benefit in terms of reduced penumbra and increased beam energy to be gained by reducing the scatter with a second taper on the source end of the collimator was determined.

The neutrons were produced by a 200 keV accelerator using the $^{3}H(d,n)^{4}He$ reaction. In order to record only those neutrons which had been scattered from the collimator walls, the associated particle technique was employed to obtain an electronically collimated beam of neutrons. In this manner, unscattered neutrons from the source, room scattered neutrons and shield transmitted neutrons could be eliminated from the measurement.

The associated particle technique requires a coincidence between each detected neutron and its associated alpha particle. The alpha particles were detected by a Si surface barrier

detector located approximately 6 cm. from the tritiated target. This detector was preceded by an adjustable, square collimator which determined the position and size of the associated particle (AP) neutron beam. The neutrons were detected by a NE-213 liquid scintillator followed by an n-γ discrimination circuit. Coincidences were determined by a time to amplitude converter and a single channel analyzer.

Only one side of a two-piece, one-dimensional collimator was irradiated with the AP neutron beam. This permitted the distinction between neutrons transmitted through the side of the collimator into the penumbra and those scattered into the opposite penumbra. The following measurements were made.

1) The flux of neutrons scattered from a single side of the collimator was determined as a function of position in the field and penumbra and as a function of the area of the collimator face being irradiated. A series of calculations was performed to calculate the collimator scatter for a two-dimensional collimator. These calculations indicate that the scatter from a steel collimator with a source-collimator distance of 12.7 cm. and a collimator-detector distance of 60 cm. to be about 7% of the direct flux at the center of a 20 x 20 cm. field and to be proportional to the circumference of the field. Outside of the field this scatter decreased to 1.8% of the direct flux at 9 cm. from the field's edge.

2) The flux of neutrons transmitted through the edge of

the collimator was determined as a function of position in the penumbra. This flux decreased to .5% of the direct flux at 4 cm. from the field's edge.

3) The energy of the neutrons scattered 2 cm. into the penumbra was determined by a time of flight analysis. More than 85% of these neutrons had energies greater than 12 MeV.

4) The collimator blocks used for the above measurements were replaced with fourteen 3.8 cm. thick steel slabs. The flux of scattered neutrons was then determined for different length collimators. This measurement gave the distribution of the scattering sites in the collimator. For the source-collimator-detector configuration used, 50% of the scattered flux originates in the 1/3 of the collimator nearest the source.

It is concluded that the addition of a second taper to the collimator will probably be determined by engineering and design criteria and not by medical or biological criteria since little increase in the average neutron energy and only a 20-30% reduction in the penumbra can be obtained in this manner.