SCATTER MEASUREMENTS IN A WATER PHANTOM AND ATTENUATION MEASUREMENTS FOR VARIOUS MATERIALS FOR 15 MEV NEUTRON BEAMS

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To perform effective cancer radiotherapy it is necessary to minimize the radiation dose to the patient at points outside of the treatment volume. Two sources of this dose for 15 MeV neutron beams were examined in this thesis: shield (collimator) transmission and patient scatter.

The neutrons were produced via the $^{3}H(d,n)^{4}He$ reaction by bombarding a thick tritium target with 200 keV deuterons. Neutrons at angles between 10^{o} and 25^{o} were used and covered an energy range of 14.5 to 15.0 MeV with an average of approximately 14.8 MeV. Monitoring and "electronic" collimation were accomplished by the associated particle (AP) technique in which a coincidence was required between the detected neutron and its associated alpha before the

neutron event was recorded.

Neutrons were detected in a NE 213 liquid scintillator 2.54cm. in diameter and 2.54cm. high operated with a proton energy bias of 1.5 MeV. Pulse shape discrimination was used to eliminate recording any gamma ray interactions in the scintillator.

Good geometry attenuation measurements were measured as a function of thickness for steel, polyethylene, water, lead and cerrobend (a low melting point bismuth alloy used for beam shaping in cancer radiotherapy). Steel was the best attenuator per length and water the worst. Lead and cerrobend gave nearly the same results. Scattered neutrons from shields of steel and polyethylene were measured as a function of shield detector distance for neutron beams of 20x20cm.^{2} cross sectional area. The ratio of scatter to primary for a steel shield 15cm. from the detector was three times the scatter to primary ratio for a polyethylene shield of the same thickness and distance from the detector.

Patient scatter was determined by measuring neutrons scattered to points outside of collimated neutron beams which were incident on a 30x20x24cm.^{3} water phantom located 125cm. from the neutron source. The electronic collimation eliminated room scatter and collimator scattered neutrons from the measurements. Measurements were performed at depths of 5, 10, 15cm. for field sizes of 7x7cm.^{2}, 13x13cm.^{2}, and 18x18cm.^{2}. Scatter was measured at points up to 8cm. from the edge of the collimated primary beam. For the 13x13cm.^{2} neutron beam the kerma due to neutrons above 1.5 MeV at 10cm. depth in the phantom was calculated at 10 and 14cm. from the beam center as 5.3% and 1.9% of the kerma in the center of the beam at the same depth. The neutron kerma for all energy neutrons at 18cm. from the beam center ($\sim$11cm. from the beam edge) was estimated to be no greater than 1% of the kerma at the center of the beam.

From these experiments it can be concluded that electronically collimated AP neutron beams can only be used as a preliminary means of evaluating materials for radiotherapy shielding because of the large fraction of scattered neutrons which are not measured by this technique that emerge from the shields. Comparing the water phantom measurements to beam profiles measured by other researchers for neutron collimators, it was seen that the neutrons in the penumbra of a 50cm. thick steel/polyethylene collimator would contribute twice as much neutron dose to a point 10cm. outside of a 13x13cm.^{2} neutron beam at 10cm. depth than the patient scatter dose at the same point. A 75cm. thick collimator would reduce neutron the dose from the collimator penumbra to approximately the same level as the patient scatter dose at this point.

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