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Development of a simple, silicon based, dose equivalent neutron dosimeter for radiation protection purposes through GEANT4 modelling.

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A GEANT4 study into the concept for a simple, silicon-based, electronic fast neutron dosimeter for radiation protection purposes is presented. The circular shaped dosimeter utilised the fluence approach to neutron dosimetry to achieve a dose equivalent response. This approach involved using the neutron dose equivalent conversion coefficients to relate the dosimetry quantity fluence, to the radiation protection quantity dose equivalent. The dose equivalent is key in monitoring personnel exposure as it reflects the biological effect of the radiation.

To measure the neutron fluence, the dosimeter used a polyethylene layer to convert incident neutrons into recoil protons through elastic scattering. The protons were subsequently counted by the silicon detector.

To accommodate the wide range of neutron energies typically present, the detector's sensitive area was split into ring segments that could be readout independently. Each segment was covered with a different thickness of polyethylene, ranging from 0.01 to 1 millimetre. The multiple thickness converter allowed for a range of incident neutron energies to be detected with a high efficiency. The segmented detector allowed weighting factors to be introduced to each segment to adjust the overall detector response to ensure that the number of recoil protons counted per increment of dose equivalent was independent of the neutron energy. With the segmented detector and the weighting factors, calculated based on mono-energetic neutron simulations, the dosimeter showed a significantly reduced energy dependence in the 0.2 to 15 MeV energy range with a real-time, dose equivalent readout.

To address background measurements, particularly from gamma radiation present in neutron fields, one segment of the detector had no converter and so exclusively measured background events. These events were then subtracted from the polyethylene covered segments to estimate the counts from recoil protons. This background subtraction technique was able to provide a good estimate of the recoil proton counts.

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