Semiconductor Detector Study for Detecting Fusion Neutrons with Geant4 Simulations

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Accurate measurements of neutrons in fusion reactors are essential, in order to determine the feasibility and progress of the reaction as well as safety issues. The extreme environmental conditions of such a reactor require resilient diagnostic systems, withstanding high radiation fluxes, temperatures up to 340°C and strong magnetic fields [1]. Semiconductor neutron detectors exhibit promising characteristics for operation in such conditions. Silicon, Diamond and Silicon Carbide are the most studied and anticipated materials for constructing detectors with high efficiency and irradiation resistance. ITER fusion reactor is expected to run D-D plasma measurements in the near future, so the detection of 2.45MeV neutrons with appropriate detectors is of great and immediate importance.

In the present work the study of 2.45MeV neutrons interactions with a silicon, diamond and silicon carbide detector was made, using GEANT4 [2] simulations, in order to compare their response function. An experimental study will follow at the neutron production facility of the TANDEM accelerator of the I.N.P.P. of the NCSR "Demokritos", with detectors provided by CIVIDEC Instrumentation GmbH, so the geometry of the simulations was built accordingly. In order to properly simulate the detector responses, the neutron beam needs to be as realistic as possible. For the experiment the neutrons will be produced via ^{3}H(p,n) reactions in a TiT target producing a quasi-monoenergetic neutron beam of 2.45MeV. Due to the low cross section of the reaction, biasing techniques were implemented in the simulation to increase the counting rate and thus producing a realistic neutron beam. When this beam interacts with the chosen detector material, the statistics continue to be extremely low, so the need arose for further biasing the secondary neutron particles inside each detector. Implementing biasing techniques both in neutron production and detection adds a systematic error to the resulting spectra and a deviation from the unbiased case. Various tests for choosing the suitable biasing factor were performed both in proton and neutron biasing confining the deviation at mostly 15%. The performed tests, the parameters affecting the choice of biasing factor, the main results and future perspectives will be shown and discussed.

References:

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