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#10-262 SiC-based detectors for fast neutron measurements in a multi-energy field

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Wide-bandgap semiconductor-based fast neutron detectors, such as silicon carbide (SiC), show promise in meeting the implementation and performance requirements for fusion and fission environments. These requirements include radiation hardness, as well as thermal and mechanical stability. Therefore, controlling the detector's performance based on neutron energy and sensor characteristics is essential for neutron detection and monitoring in mixed radiation environments with high levels of fast and thermal neutron fluxes and gamma emissions at large energy scales.

The diodes under study, made with 4H-SiC polytype, feature a 60µm "p-n"junction that collects electron/hole pairs generated in the space charge region by the interaction of neutron reaction products and gammas in mixed radiation fields. The recorded electric signal can then indicate the energy of the registered reaction products, providing information on the energy of the fast incident neutrons. The use of the sensor in a mono-energetic field has shown in previous work encouraging results for a first estimation of the absolute value of the fast neutron flux. However, qualifying the sensor's response over a wide energy range in a multi-energetic field is complex.

In this work, a solution is proposed using response functions for neutron spectrum unfolding. Due to the limitations of the simulation tool, which relies on nuclear data with large uncertainties for the studied reactions, experimental data were necessary for deconvolution methods using a response matrix. The calibration of these response functions was performed using Time of Flight (ToF) measurements at the Neutron For Science facility of GANIL, which allowed the construction of a response matrix with enough energy channels to meet the requirements of iterative deconvolution methods necessary for neutron spectrum deconvolution.

The presented results are promising across the entire energy range of the neutron spectrum, demonstrating the sensor's ability to estimate neutron flux in a high-energy neutron field with deviations of around 10% over most of the energy spectrum. The experimental campaign has thus demonstrated the sensor's capability to measure neutron flux in a continuous neutron field using an experimental response matrix constructed with Time of Flight (ToF) measurements.

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