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#10-163 Reconstruction of Neutron Spectra Using Silicon Carbide Detectors in Monoenergetic Fields with Machine Learning approach

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Recent advancements in machine learning have shown significant
promise in nuclear applications, particularly in optimizing reactor operations, core design, and improving neutron spectroscopy techniques. This study introduces a novel approach that leverages machine learning algorithms to predict neutron spectra based on data obtained from solid-state detectors, with a specific focus on the performance of 4H-Silicon Carbide detectors under various monoenergetic neutron fields. These sensors are considered excellent candidates for fast neutron spectroscopy due to several key properties, such as wide bandgap, high radiation resistance, fast response times and thermal stability.

The experimental measurements were conducted at the Van de Graaff accelerator facility in Prague and at the TOTEM facility in Cadarache. In the first installation, the Silicon Carbide detector was exposed to multiple monoenergetic neutron beams generated via p+T, D+T, and D+D reactions. In the second infrastructure, the detector was subjected to a monoenergetic beam generated by GENIE16 D-T neutron generator. The sensor used in this study has dimensions of 2 mm × 3 mm × 60 µm. These experiments are the result of an international collaboration in the frame of the 'Timepix SiC detector'project under the DANUBE region strategy program. The measurements were post-processed to collect the deposited energy in the detector which is used as input for the machine learning algorithm in order to obtain the reconstruction of neutron spectra. The automated learning spectra prediction is performed considering a training database built with the simulated response of the detector subjected to different synthetic spectra, generated as a combination of different mathematical functions. For the test base, the simulations were performed considering the detector exposed to measured spectra taken from the IAEA Compendium database. Simulations were done using the PHITS code and the machine learning model adopted is Kernel Ridge. Preliminary findings demonstrate that the machine learing-based approach can successfully reconstruct monoenergetic neutron spectra with high accuracy, showcasing its potential for improving fast neutron spectroscopy with semiconductor sensors.

Ongoing research at the IRESNE Institute of CEA Cadarache, precisely in the Department of Nuclear Techniques and Department of Reactor Study, aims to further assess the application of this machine learning technique in complex mixed-field environments, such as reactor pits, to evaluate its feasibility and reliability in real-world nuclear facility conditions. This work underscores the potential of integrating machine learning in nuclear instrumentation and measurement, providing innovative tools for neutron field analysis.

Primary author: BELFIORE, Enrica

Co-authors: Dr BEN MOSBAH, Mehdi (CEA, DES, IRESNE, Nuclear Measurement Laboratory); Dr ANTONI, Rodolphe; LLIDO, Olivier (CEA, DES, IRESNE, DER, Cadarache F-13108, Saint-Paul-Lez-Durance, 13108, France); LYOUSSI, Abdallah (CEA Cadarache); DESTOUCHES, Christophe (CEA, DES, IRESNE, DER, Cadarache F-13108, Saint-Paul-Lez-Durance, 13108, France); SLAVICEK, Tomas (Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, 110 00 Prague, Czech Republic); ŠAGÁTOVÁ, Andrea (Institute of Nuclear and Physical Engineering, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, SK- 841 04 Bratislava, Slovak Republic); GROETZ, Jean-Emmanuel (Laboratoire

Chrono-Environnment, UMR CNRS 6249, Université de Franche-Comté, 16 route de Gray, 25030 Besancon cedex, France)

Presenter: BELFIORE, Enrica

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