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#6-194 Directional Detection and Fissile Material Identification: Results from tests campaign at STUK and SCK-CEN with the nFacet 3D detector

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Robust and timely detection, localisation and identification of a radioactive source are critical to applications in security, verification treaty and decommissioning. These measurements are usually done with different instruments. Here, we present results from a detector system relevant to security, non-proliferation or decommissioning activities. Nfacet 3D is a segmented dual-scintillator detector sensitive to gamma-rays and neutrons. It's a directional detector system composed of 64 polyvinyl toluene (PVT) voxels arranged in a 4 × 4 × 4 lattice, each voxel is equipped with a 6LiF:ZnS(Ag) phosphor screen to capture neutrons. The two types of sensitive material enable a simultaneous detection of neutrons and gammas through Pulse Shape Discrimination (PSD) of the scintillation signals. The segmentation of the detector enables the reconstruction of the direction of the gamma-ray and neutron fields as well as count rates and energy deposited that depends on the energy of the incoming radiation, which in turns provide basic information for identifying and localising the source of radiation. We will present results on those measurements and the achieved directional resolution, bias and distance. The directionality and range of the system have been assessed at the STUK facility, Finland in September 2024. We characterised the response of the system for a range of angles and distances with various well-calibrated gammas and neutrons sources. During this measurement campaign, we were also able to test the capability of the system to sense the presence of a neutron source at large distance of tens of meters in an open field. We have also tested the ability of the system to localise the position of a source without prior knowledge of its true position using iterative placement of the detector. The detection range is at least 50 meters, making use of the skyshine effect to detect the source at greater distance than 30 meters. We achieve an angular resolution of 10 degrees at 50 meters with 1,500 neutron counts. The system is also capable to reconstruct the direction of origin of gamma-ray radiations within the detection range, then we assessed the angular resolution and the bias of the system with a Co-60 and a Cs-137 source at fixed distance. We achieve a resolution of less than a degree with 450,000 counts at 20 meters. The source identification capabilities of the system have been assessed during the BeCamp2 measurement campaign, a technical exercise in the context of Verification Treaty measurements, done at the SCK CEN laboratory, Belgium in September 2023. The objective where to determine the potential of different technology to identify undisclosed fissile nuclear material and shielding objects based on reference templates. Using key features of the fissile matter, we were able to distinguish between Uranium-based and Plutonium samples. The detection of U235 was done indirectly with high-energy gamma-rays spectra. The Plutonium was identified using both fast and thermal neutrons in combination with gamma-ray spectra.

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