AGA 9: Verification III – Antineutrino Detection

Time: Friday 12:00–13:30 Location: HS HISKP

AGA 9.1 Fri 12:00 HS HISKP

nuSENTRY: antineutrino monitoring for future advanced reactors — •Yan-Jie Schnellbach — TU Darmstadt

In recent years, renewed interest in nuclear power as low-carbon source of electricity has lead to significant investment and build ambitions in so-called small modular reactors (SMRs). These reactors are smaller versions of current light water-moderated reactor as well as more exotic concepts. The key feature of modularity aims at mass production of reactor units, which potentially imposes new demands on existing non-proliferation and safeguards regimes. Additionally, advanced reactor concepts introduce ideas such as higher enrichment fuel (high-assay low enriched uranium - HALEU) or bulk fuels (pebble fuel, liquid fuel).

Monitoring reactor operations and concepts via their antineutrino emissions has been demonstrated for large conventional nuclear power plants, with several active R&D projects globally. The nuSENTRY project and group is now investigating the transferability of these technologies to future SMR and naval reactor scenarios. Upcoming detector technologies will be studied to determine their feasibility as antineutrino-based reactor safeguards. Finally, in addition to the antineutrino signal, particle signatures, such as neutron flux or cosmic muon information will also be considered as complementary data stream. Previous work on spent fuel safeguards will be presented and planned investigations into advanced reactor monitoring scenarios will be introduced.

AGA 9.2 Fri 12:30 HS HISKP

Feasibility of Safeguards-oriented Muography with an Antineutrino Detector — •Sarah Friedrich[1], Malte Göttsche[2], Stefan Roth[3], and Yan-Jie Schnellbach[1] — [1]Technische Universität Darmstadt, Darmstadt, Germany — [2]PRIF- Leibniz-Institut für Friedens- und Konfliktforschung, Frankfurt am Main, Germany — [3]RWTH Aachen University, Aachen, Germany

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) requires non-nuclear weapon states to exclusively utilize nuclear materials and technologies for peaceful purposes. It also permits the International Atomic Energy Agency (IAEA) to establish safeguards for the purpose of verifying compliance with the NPT's obligations. In the context of emerging reactor designs, particularly the development of Small Modular Reactors (SMRs), the enhancement of existing safeguards and the examination of novel safeguards are of particular importance. By using the example of a container loaded with spent nuclear fuel, this simulation-based feasibility study demonstrates that the use of cosmic muons makes it possible to obtain information about a container with the muographic application of an antineutrino detector. Moreover, the energy of the muons can be analyzed to ascertain the contents of the container, particularly the materials within, by determining their density. The insights gained from this analysis will be further developed to apply them to the context of SMRs, integrating them with other verification technologies.

AGA 9.3 Fri 13:00 HS HISKP

Drift parameter simulation of TMS TPC prototype for antineutrino detection — •Hannah-Lea Tegtmeyer[1], Malte Göttsche[2], Stefan Roth[1], and Yan-Jie Schnellbach[3] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]Peace Research Institute Frankfurt (PRIF) — [3]TU Darmstadt

Antineutrino detectors can be utilized for non-intrusive verification measures, as they can be deployed externally or atop nuclear facilities with minimal disruption. To improve their utility, the development of portable detectors is critical. Time projection chambers (TPCs) designed to detect neutrinos and antineutrinos typically use liquid argon as a dense detection medium, but its requirement for cryogenic cooling presents logistical challenges. Furthermore, liquid argon is not well-suited for detecting antineutrinos in the energy ranges relevant for spent fuel (<2.2 MeV) or reactor monitoring (<8 MeV). In the alternative drift medium Tetramethylsilane (TMS), which contains protons in the molecule, antineutrinos can react via the inverse beta decay. In addition TMS has more relaxed cooling requirements near room temperature. This research involves simulating the drift parameters of a prototype TPC filled with TMS, aiming to identify the parameter ranges that support reasonable energy resolution and potentially directional sensitivity. The simulations help evaluate whether TMS is a viable alternative to traditional detection media, guiding the optimization of the prototype*s design and performance.