AGA 6: Nuclear Fuel Cycle and Proliferation

Time: Thursday 16:00–18:00 Location: PTB HS HvHB

Invited Talk AGA 6.1 Thu 16:00 PTB HS HvHB

Proliferation Issues of Future Nuclear Fuel Cycles — •Friederike Friess — Institute of Safety and Risk Sciences, BOKU, Vienna

The current reactor fleet consists almost exclusively of light water reactors. There are some countries that are actively researching other reactor concepts, in particular fast, sodium-cooled reactors. In addition to better fuel utilization, their use should also simplify the disposal of radioactive waste. In order to achieve this, reprocessing of spent fuel rods must be carried out on an industrial scale. This involves the separation of weapons-grade fissile material.

The presentation provides an overview of the activities of various countries on so-called closed fuel cycles and related reactor technology. It focuses on the proliferation risk posed by those technologies and explains why they would thus increase the risk of unauthorized diversion of nuclear material, technology and knowledge.

AGA 6.2 Thu 17:00 PTB HS HvHB

Unusual fissile materials in nuclear weapons — •Matthias Englert[1] and Friederike Friess[2] — [1]Institute for Applied Ecology, Rheinstr. 95, 64283 Darmstadt — [2]Institute of Safety and Risk Sciences, BOKU Vienna

Today's nuclear arsenals typically utilize fissile materials such as uranium - enriched to over 90% in uranium-235 - and plutonium with an isotopic composition exceeding 93% plutonium-239. It has been long established that lower enrichments of uranium or different isotopic variations of plutonium, like reactor-grade plutonium, can still be employed in nuclear weapons. However, their use comes with drawbacks that render them suboptimal for military purposes. All plutonium containing Pu-239 as well as uranium-235 are categorized as 'special fissile material' under the International Atomic Energy Agency (IAEA) safeguards system. Additionally, uranium-233 is considered a special fissile material, produced through neutron capture in a thorium-uranium fuel cycle and subsequently fissioned in a thorium-fueled reactor to generate energy. IAEA defines U-233, uranium enriched beyond 20% U-235, and plutonium with less than 80% Pu-238 as 'direct use' materials, encompassing their compounds such as irradiated reactor fuel (spent fuel) and mixtures like mixed oxide (MOX) fuel. Not as widely recognized are alternative nuclear materials, specifically higher actinoids formed in nuclear reactors through neutron reactions. Neptunium-237, a fissile material reportedly used in a nuclear test explosion, along with isotopes of americium, fall into this category. While these materials are not currently extensively utilized or separated in the nuclear fuel cycle, future plans for alternative reactor designs addressing nuclear waste transmutation could increase the accessibility of these materials and technologies for their separation.

AGA 6.3 Thu 17:30 PTB HS HvHB

Building a Fuel Cycle Simulation Toolkit for Nuclear Verification — •Max Schalz and Malte Göttsche — Nuclear Verification and Disarmament Group, RWTH Aachen University, Aachen, Germany

Nuclear fuel cycle (NFC) codes are regularly used in civilian nuclear programmes, for example to model energy transition scenarios. In contrast to this, NFC simulators have not yet been established in verification or disarmament contexts, despite their many benefits. We present Bicyclus, an open-source Python3 framework aimed at analysing NFCs in such contexts. Bicyclus couples Cyclus, an existing NFC simulator, to a Monte Carlo and a Bayesian inference software. These couplings open up various new applications: The Monte Carlo approach can be used to propagate uncertainties and improve fissile material estimates, while the Bayesian approach is relevant in verification scenarios to reconstruct past NFC operations. We demonstrate both applications in a case study based on a complex, military NFC with HEU and plutonium production, as well as capacities to re-enrich reprocessed, irradiated uranium.