

Working Group on Physics and Disarmament Arbeitsgruppe Physik und Abrüstung (AGA)

Götz Neuneck
IFSH, Universität Hamburg
Beim Schlump 83, D-20144
Hamburg
neuneck@ifsh.de

Matthias Englert
Öko-Institut e.V.
Rheinstr. 95, D-64289 Darmstadt
m.englert@oeko.de

Christian Alwardt
IFSH, Universität Hamburg
Beim Schlump 83, D-20144
Hamburg
alwardt@ifsh.de

Zur Abrüstung, der Verhinderung der Verbreitung von Massenvernichtungsmitteln und der Beurteilung neuer Waffentechnologien sind naturwissenschaftliche Untersuchungen unverzichtbar. Auch bei der Verifikation von Rüstungskontrollabkommen werden neue Techniken und Verfahren benötigt und eingesetzt. Schwerpunkte in diesem Jahr bilden Themen wie die nukleare Abrüstung, Verifikation bzw. die Detektion von Nuklearanlagen und Materialien, Raketenabwehr und Zerstörung von Nuklearsprengköpfen, neue militärrelevante Technologien wie Drohnen. Die Fachsitzung wird von der DPG gemeinsam mit dem Forschungsverbund Naturwissenschaft, Abrüstung und internationale Sicherheit FONAS durchgeführt. Die 1998 gegründete Arbeitsgruppe Physik und Abrüstung ist für die Organisation verantwortlich. Die Sitzung soll international vorrangige Themen behandeln, Hintergrundwissen vermitteln und Ergebnisse neuerer Forschung darstellen.

Übersicht der Hauptvorträge und Fachsitzungen (Hörsaal H-HS XVII)

Hauptvorträge

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AGA 2.1	Wed	14:00–14:45	H-HS XVII	Proliferationsresistenz neuer Reaktorkonzepte — OLAF J. SCHUMANN, ●CHARLOTTE BORNHÖFT, THEO KÖBLE
AGA 3.1	Thu	11:00–11:45	H-HS XVII	International Partnership for Nuclear Disarmament Verification: Current Status and Future Prospects — ●IRMGARD NIEMEYER, GERALD KIRCHNER, GÖTZ NEUNECK
AGA 3.2	Thu	11:45–12:30	H-HS XVII	Nukleare Abrüstungsverifikation in der Praxis: Die Übung NuDiVe — ●SIMON HEBEL, GERALD KIRCHNER
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AGA 4.3	Thu	15:30–16:15	H-HS XVII	The DPRK's SLBMs and SRBMs - A Brief Update on North Korea's Missile Activities — ●MARKUS SCHILLER
AGA 5.1	Thu	16:30–17:15	H-HS XVII	One Size does not Fit All: Greatly Different Mandates for Denuclearizing Nuclear States — ●ROBERT KELLEY
AGA 7.1	Fri	11:00–11:45	H-HS XVII	Robots, Buddy Tags and a MOS 6502: Innovative Tools for Access-Limited Arms Control Verification — ●MORITZ KÜTT, ALEXANDER GLASER, ROBERT J. GOLDSTON

Fachsitzungen

AGA 1.1–1.4	Wed	11:00–13:00	H-HS XVII	New Technologies
AGA 2.1–2.3	Wed	14:00–15:35	H-HS XVII	Fissile Material Production and Nuclear Reactors
AGA 3.1–3.3	Thu	11:00–12:55	H-HS XVII	Nuclear Disarmament Verification
AGA 4.1–4.3	Thu	14:00–16:15	H-HS XVII	North Korea
AGA 5.1–5.3	Thu	16:30–18:05	H-HS XVII	Denuclearization and Verification Technologies
AGA 6	Thu	18:05–19:00	H-HS XVII	Annual General Meeting
AGA 7.1–7.3	Fri	11:00–12:35	H-HS XVII	Verification and Safeguards
AGA 8.1–8.2	Fri	12:35–13:25	H-HS XVII	Non-Nuclear Verification

Mitgliederversammlung Arbeitsgruppe Physik und Abrüstung

Thursday 18:05–19:00 H-HS XVII

- Bericht
- Wahl
- Verschiedenes

AGA 1: New Technologies

Time: Wednesday 11:00–13:00

Location: H-HS XVII

Invited Talk AGA 1.1 Wed 11:00 H-HS XVII
Lethality of Conventional Weapons Detonations Against Strategic Targets — ●RYAN SNYDER — IFSH University of Hamburg

Current debates about arms control and crisis stability lack technically valid assessments about the capabilities of conventional weapons, particularly precision-guided munitions (PGMs), that have become increasingly accurate over the past several years compared with inertially-guided munitions. These accuracy improvements have now enhanced the lethality of such munitions against strategic ballistic missile silos, which will likely add further complications into future nuclear arms control efforts and lower the threshold for nuclear use in a crisis. The technical basis for U.S. PGM lethality against strategic missile silos in Russia and China will be discussed, as well as further opportunities and risks that these weapons present. Additionally, the models will also be used to assess Russian and Chinese strike capabilities against U.S. strategic ballistic missile silos.

AGA 1.2 Wed 11:45 H-HS XVII
Renaissance for Directed Energy Weapons? — ●GÖTZ NEU-NECK — IFSH University of Hamburg

The call to introduce Directed Energy Weapons on the battlefield goes back to Ronald Reagan's Strategic Defense Initiative, but is renewed from time to time. Russia's President Putin introduced a new ground-based combat laser (Peresvet) and U.S. President Trump's Missile Defense Review calls for new laser weapons for defense purposes. The development of high-power lasers for research and industrial purposes has been improved significantly. The talk analyses the current state of the art for laser sources, their dual-use potential and possible solutions for arms control.

AGA 1.3 Wed 12:10 H-HS XVII
Algorithmen und Künstliche Intelligenz als Game-Changer? Moderne Waffensysteme zwischen Erwartung und Wirklichkeit — CHRISTIAN ALWARDT, SYLVIA KÜHNE und ●HENDRIK ERZ — Institut für Friedensforschung und Sicherheitspolitik an der Universität Hamburg

Weltweit rüsten sich Armeen mit softwaregestützten Plattformen wie etwa Schwarmdrohnen oder Robotern aus. Diese Entwicklung wirft die Frage auf, welchen Einfluss neue Technologien auf Waffensysteme und zukünftige Kriegsführung haben und wie diese im Sinne von Rüstungs-

kontrolle reguliert werden können. Das von der Deutschen Stiftung Friedensforschung geförderte Projekt "Algorithmen und Künstliche Intelligenz als Game Changer?" untersucht das bislang kaum adressierte Verhältnis von Erwartungshaltungen an militärische Potentiale und tatsächlich realisierbaren Fähigkeiten, die etwa mit Künstlicher Intelligenz einhergehen.

Es verfolgt - in Abgrenzung zu bislang vorliegenden disziplinär ausgerichteten Betrachtungen - einen methodischen Ansatz, in dem sozialwissenschaftliche Diskursanalyse mit einer technischen Beurteilung derzeitiger softwaretechnologischer Forschung und Entwicklung zusammengeführt werden. Ziel ist eine informierte Einschätzung, was zukünftig im militärischen Bereich erwartet werden kann und was - gemessen an den Erwartungen - der "Science-Fiction" zuzuschreiben ist.

Der Vortrag skizziert den fachübergreifenden Forschungsansatz des Projektes, thematisiert die zugrundeliegenden Fragestellungen und präsentiert erste Ergebnisse.

AGA 1.4 Wed 12:35 H-HS XVII
AI in Decision-Making: Situational Awareness, Early Warning and Command & Control — ●CHRISTIAN ALWARDT — Institut für Friedensforschung und Sicherheitspolitik an der Universität Hamburg

Emerging technologies are a key driver for the development and deployment of modern weapon systems and the ongoing automation of warfare. The foreseeable advances in "Artificial Intelligence" (AI), such as in research and machine learning combined with increased global access to advanced computer technologies might lead to the broader use and proliferation of "game changing" software technologies. In turn, this could fundamentally revolutionize elements of warfare such as situational awareness and decision-making. Such developments would most likely upset future arms dynamics and trigger the worldwide transformation of military forces - the military requirements of quick decision-making and execution would not only increase but also prompt further automation of command and control procedures. As a result, states could be confronted with an "automation race" coupled with increasing risks of misunderstanding and lost situational human control. In a crisis situation, this could lead to regional and strategic instability, as well as to unintended military escalations.

This talk will introduce the increasing importance of algorithms in military decision-making, briefly present exemplary fields of application, discuss the risks and show the difficulties of arriving at arms control agreements.

AGA 2: Fissile Material Production and Nuclear Reactors

Time: Wednesday 14:00–15:35

Location: H-HS XVII

Invited Talk AGA 2.1 Wed 14:00 H-HS XVII
Proliferationsresistenz neuer Reaktorkonzepte — OLAF J. SCHUMANN, ●CHARLOTTE BORNHÖFT und THEO KÖBLE — Fraunhofer INT, Euskirchen

In den letzten Jahren wurden einige neuartige Reaktorkonzepte vorgeschlagen, die zumeist eine verbesserte Sicherheit gegenüber Störfällen und ökonomische Vorteile gegenüber bestehenden Reaktortypen bieten sollen. Zum Teil werden auch Proliferationsaspekte schon bei der Entwicklung berücksichtigt, beispielsweise bei den Arbeiten innerhalb des Gen IV Forums. Allerdings wird immer ein Kompromiss zwischen Sicherheit, ökonomischen Aspekten und der Proliferationsresistenz eingegangen. Für den Betrieb derartiger neuer Reaktorkonzepte ergeben sich teilweise weitreichende Änderungen im nuklearen Brennstoffkreislauf. Beispielhaft zu nennen sind die Nutzung eines schnellen Neutronenspektrums zur Erreichung von hohen Brutzahlen, die Online-Aufbereitung des Brennstoffs am Reaktorstandpunkt oder Konzepte, welche ohne einen Brennstoffwechsel während ihres Lebenszyklusses auskommen sollen. Diese Änderungen erfordern daher Anpassungen an die bestehenden und bewährten Verfahren zur Kernmaterialüberwachung. Im Vortrag werden einige der neue Reaktorkonzepte vorgestellt und der Einfluss auf die Proliferationsresistenz bewertet.

AGA 2.2 Wed 14:45 H-HS XVII

Assessing a state's fissile material production using the nuclear fuel cycle simulator Cyclus — ●MAX SCHALZ, MADALINA WITTEL, and MALTE GÖTTSCHE — RWTH Aachen University, Aachen, Germany

The field of nuclear archaeology aims to reconstruct the fissile material production of a state. While this could apply in a verification context, it is also suited for independent assessments in absence of a formal verification regime using available information on the nuclear programme's history and simulation tools. To this end, we examine the use of Cyclus, a flexible, agent-based nuclear fuel cycle simulator. It provides an easy-to-use framework allowing the simulation of fissile and other material streams throughout numerous different nuclear facilities. By recreating a country's nuclear complex in Cyclus, we determine the maximum production capacity of fissile materials. The results of such simulations could be used to check the consistency of available information, including records that would be provided in a formal verification context. As a case study, the Pakistani uranium enrichment and plutonium production programme is simulated and the results are compared to the available literature.

AGA 2.3 Wed 15:10 H-HS XVII
Reconstructing past reactor operation from isotopic ratios in shut-down facilities — ●LUKAS RADEMACHER, BENJAMIN JUNG,

JAKOB BROCHHAUS, and MALTE GÖTTSCHE — RWTH Aachen

Current stocks of fissile materials are sufficient to increase ten-fold the number of existing nuclear warheads. A comprehensive verification regime monitoring irreversible disarmament requires scientific methods to verify the completeness of fissile material baseline declarations.

We study an approach based on measurements taken in structural materials after reactor shut-down to verify fissile material production histories. Focusing on trace isotopes created by irradiation of structural elements during the active period, the neutron fluence is recon-

structed by analyzing isotopic ratios. The plutonium production can then be inferred from the neutron fluence in conjunction with additional operational reactor parameters.

Sensitivity analysis tools allow us to investigate the impact of different operational parameters on the expected isotope quantities. The goal is to quantify uncertainties of plutonium production estimates stemming from incomplete information of such parameters and to - where possible - develop new methods of gaining additional information about past reactor operations.

AGA 3: Nuclear Disarmament Verification

Time: Thursday 11:00–12:55

Location: H-HS XVII

Invited Talk AGA 3.1 Thu 11:00 H-HS XVII
International Partnership for Nuclear Disarmament Verification: Current Status and Future Prospects — ●IRMGARD NIEMEYER¹, GERALD KIRCHNER², and GÖTZ NEUNECK³ — ¹Forschungszentrum Jülich — ²ZNF Universität Hamburg — ³IFSH Universität Hamburg

The International Partnership for Disarmament Verification (IPNDV) includes technical experts and government representatives of NWS and NNWS to work jointly on procedures and technologies that would allow for effective verification of nuclear disarmament. In Phase I (2016-2017), the Partnership focused on nuclear warhead dismantlement and identified 14 key steps in the nuclear weapons dismantlement lifecycle. Initially, IPNDV considered steps 6 to 10, associated with monitoring the nuclear warhead physical dismantlement process. In Phase II (2018-2019), IPNDV broadened its work to consider wider aspects of nuclear disarmament verification while at the same time deepen the work on specific elements of verification. In moving from paper to practice, IPNDV demonstrated their work and progress through five practical exercises and technology demonstrations: A table top exercise, three technology demonstrations, and the Nuclear Disarmament Verification (NuDiVe) Exercise, co-hosted by Germany and France. In the following phase, IPNDV will build on current working methods and engage in further hands-on activities, including scenario-based discussions, practical exercises and technology demonstrations. The talk will discuss the outcome of IPNDV's first two phases and give an outlook to the next phase.

Invited Talk AGA 3.2 Thu 11:45 H-HS XVII
Nukleare Abrüstungsverifikation in der Praxis: Die Übung NuDiVe — ●SIMON HEBEL und GERALD KIRCHNER — Carl Friedrich von Weizsäcker-Zentrum für Naturwissenschaft und Friedensforschung, Universität Hamburg, Beim Schlump 83, D-20144 Hamburg, Deutschland

Um die technischen und organisatorischen Herausforderungen einer inspezierten Abrüstung nuklearer Sprengköpfe zu untersuchen, sind prak-

tische Übungen unerlässlich. Mit "NuDiVe" ist erstmals eine multilaterale Abrüstungsübung von Frankreich und Deutschland ausgerichtet worden im Rahmen des International Partnership for Nuclear Disarmament Verification (IPNDV). Teilnehmer aus zahlreichen Ländern nahmen die Rollen von Inspektionsteam und Nuklearwaffenstaat ein, um die Demontage eines Sprengkopfes mit allen notwendigen Technologien in Echtzeit zu simulieren. Zwei der Organisatoren berichten von Verlauf und Ergebnissen der Übung.

AGA 3.3 Thu 12:30 H-HS XVII
Moving from Paper to Practice in Nuclear Disarmament Verification: NuDiVe - The Nuclear Disarmament Verification Exercise — JAN GEISEL-BRINCK¹, SIMON HEBEL¹, PHILIP KEGLER², GERALD KIRCHNER¹, MANUEL KREUTLE¹, STEFAN NEUMEIER², and ●IRMGARD NIEMEYER² — ¹Carl Friedrich von Weizsäcker-Zentrum für Naturwissenschaft und Friedensforschung (ZNF), Universität Hamburg — ²Forschungszentrum Jülich GmbH

The Nuclear Disarmament Verification (NuDiVe) Exercise, organised by Germany and France, was held in September 2019 at Forschungszentrum Jülich, as part of the International Partnership for Disarmament Verification (IPNDV). NuDiVe was the first nuclear disarmament verification exercise that was not limited to the organisers, but included participants from 11 countries, taking roles as inspector, host or evaluator. The inspection team applied verification measures immediately prior to and after the notional dismantlement of a fictitious nuclear warhead to gain assurance of the non-diversion of fissile material. The host team, representing the fictional inspected state of "Urania", used managed access arrangements designed to prevent any disclosure of proliferation-sensitive information. Procedures followed were prepared by the organisers, based on inspection concepts and approaches developed by IPNDV. The evaluation team observed the exercise. NuDiVe has shown that multilateral nuclear disarmament verification is possible with the involvement of nuclear weapon states and non-nuclear weapon states. The talk highlights the conceptual design, execution and results of NuDiVe from the organiser's point of view.

AGA 4: North Korea

Time: Thursday 14:00–16:15

Location: H-HS XVII

Invited Talk AGA 4.1 Thu 14:00 H-HS XVII
Denuclearization of the Korean Peninsula — ●TARIQ RAUF — Vienna

Tariq Rauf (former Head of Verification and Security Policy, International Atomic Energy Agency, responsible for the Director General's report on Application of Safeguards in the Democratic People's Republic of Korea). Nuclear weapons were first introduced into the Korean Peninsula in January 1958 by the US through its defence alliance with South Korea. During the inter-Korean war, the US threatened three times to use nuclear weapons against DPRK. There was no DPRK nuclear weapon programme until decades later. South Korea's nuclear weapons research programme was wound up in 1975 with its ratification of the Non-Proliferation Treaty (NPT). In August 2004, the IAEA cited South Korea for previously undeclared nuclear activities involving the reprocessing of nuclear material. Between 9 October 2006 and 3 September 2017, the DPRK carried out six nuclear weapon tests and more than 100 missile tests. Until very recently, annual US-South Korea military exercises had been expanding both in their scope and

numbers of troops, including decapitation strikes, and invasion and occupation of major military and other strategic locations in North Korea. After early mutual threats and insults, DPRK leader Kim Jong Un and US President Donald Trump have held three bilateral summits but as yet no agreement has been possible on denuclearization of the Korean peninsula. This presentation will cover developments regarding the DPRK's nuclear and missile programmes, and assess the prospects and possible measures for achieving the denuclearization of the Korean Peninsula.

Invited Talk AGA 4.2 Thu 14:45 H-HS XVII
Analysis of two controversial putative nuclear tests: North Korea 12 May 2010 and South Indian Ocean 22 September 1979 — ●LARS ERIK DE GEER — Stockholm

In mid-May 2010 CTBT stations at Okinawa, Japan and Ussuriysk, Russia detected very clear radionuclide signals. The nuclides were all daughters of very short-lived xenon isotopes that are abundantly produced in fission. With no other products seen it indicated a very rapid

fission event that forcefully pushed the xenon atoms out through a filtering medium that stopped everything non-noble. Later there were corroborating seismic and infrasound evidence published and by using the famous duck test one could say that if it smelled like a nuclear test, shook like a nuclear test and sounded like a nuclear test then it probably was a nuclear test. Forty years ago there was a similar occasion in South Indian Ocean. A satellite saw a double-humped light flash, hydrophones heard a strong signal and iodine-131 was found in Australian sheep thyroids. Applying the duck test again with the three verbs exchanged to "looked, sounded and tasted" we get the same conclusion: it probably was a nuclear test

Invited Talk AGA 4.3 Thu 15:30 H-HS XVII
The DPRK's SLBMs and SRBMs - A Brief Update on North

Korea's Missile Activities — ●MARKUS SCHILLER — ST Analytics GmbH, München, Germany

After having successfully launched the Hwasong-15 road-mobile ICBM in November 2017, the Democratic People's Republic of Korea (DPRK) apparently adhered to a self-imposed missile launch moratorium for almost 18 months. In May 2019, though, North Korea started to launch missiles again; about two dozen were fired over the summer months of 2019. However, contrary to 2017, these launches were limited to Short Range Ballistic Missiles (SRBMs) and a Submarine-Launched Ballistic Missile (SLBM), and relied on technologies that had nothing in common with the previous ICBM activities.

This presentation will give an update on the observed North Korean missile activities since 2018, including an attempt to distill some possible strategic motives for these activities.

AGA 5: Denuclearization and Verification Technologies

Time: Thursday 16:30–18:05

Location: H-HS XVII

Invited Talk AGA 5.1 Thu 16:30 H-HS XVII
One Size does not Fit All: Greatly Different Mandates for Denuclearizing Nuclear States — ●ROBERT KELLEY — SIPRI Stockholm

The International Atomic Energy Agency (IAEA) has dealt with nuclear materials verification inspections in many states. In only a few cases has the IAEA actually had to deal with extensive programs, nuclear weapons components, and very sensitive nuclear weapon design information. In three significant cases, Iraq (1991-2003), Libya (2004) and South Africa (1993) there were very sensitive nuclear investigations required. All three had widely varying mandates, discoveries and constraints. Future investigations of actual weaponization activities can learn many lessons from these cases. A third, denuclearization active, Project Sapphire in Kazakhstan provided yet another model for extracting dangerous weaponization materials. Hopefully these cases will be studied in preparations for another denuclearization campaign, possibly in the DPRK.

AGA 5.2 Thu 17:15 H-HS XVII
Investigating fissile material in the context of nuclear disarmament verification — ALESSANDRO BORELLA¹, GERALD KIRCHNER², ●MANUEL KREUTLE², RICCARDO ROSSA¹, and KLAAS VAN DER MEER¹ — ¹SCK*CEN, Mol, Belgium — ²Universität Hamburg, Carl-Friedrich-von-Weizsäcker Center for Science and Peace Research, Hamburg, Germany

A key challenge of nuclear disarmament is equipping inspectors with detectors which enable them to determine the presence or absence of fissile material used within nuclear weapons. Promising for this is the analysis of unique gamma and neutron signatures governed by mass and composition of this material.

As part of the work of the International Partnership for Nuclear

Disarmament Verification (IPNDV), we test and compare measurement techniques to be potentially used for the verification of fissile material. At the SCK*CEN in Mol, Belgium, ten measurement teams assessed the performance of various non-destructive passive methods and investigated the influence of the amount and type of fissile material, and the type of shielding material. The process was accompanied by several Monte Carlo based simulations.

In our talk we will present findings from the measurements and the simulations and we will discuss the suitability of these measurement techniques for nuclear disarmament verification.

AGA 5.3 Thu 17:40 H-HS XVII
Untersuchung der Auswirkungen verschiedener Abschirmungen auf die Aussagekraft neutronen- und gammabasierter Verifikationstechniken — ●YANNICK FISCHER, PATRICK SCHUCK, SIMON HEBEL und GERALD KIRCHNER — Universität Hamburg, Carl-Friedrich von Weizsäcker-Zentrum für Naturwissenschaft und Friedensforschung

Eine der größten physikalischen Herausforderungen der nuklearen Abrüstungsverifikation, stellt die Detektion auch kleinster Mengen spaltbaren Materials dar. Im ZNF werden deshalb Simulationen durchgeführt, um die Auswirkungen bewusst gewählter Abschirmungen auf den Neutronenfluss und die Gammaintensität zu untersuchen. Zur Simulation wird das C++-basierte Programm Geant4 verwendet, welches Monte-Carlo-Techniken benutzt, um Photonen- und Partikeltransport zu simulieren. Der Vortrag stellt den Einfluss verschiedener Abschirmungsmaterialien und -geometrien auf die Neutronenflussdichte und deren Energieverteilung dar. Es wird insbesondere untersucht, welche Konfigurationen zu einer effektiven Abschirmung nötig sind, und diskutiert, welche Auswirkungen diese Erkenntnisse auf die Aussagekraft neutronenbasierter Verifikationstechniken haben.

AGA 6: Annual General Meeting

Time: Thursday 18:05–19:00

Location: H-HS XVII

Duration: 55 min.

AGA 7: Verification and Safeguards

Time: Friday 11:00–12:35

Location: H-HS XVII

Invited Talk AGA 7.1 Fri 11:00 H-HS XVII
Robots, Buddy Tags and a MOS 6502: Innovative Tools for Access-Limited Arms Control Verification — ●MORITZ KÜTT¹, ALEXANDER GLASER², and ROBERT J. GOLDSTON² — ¹Institute for Peace Research and Security Policy at the University of Hamburg, Hamburg, Germany — ²Princeton University, Princeton, NJ, USA

Verification approaches for nuclear arms control agreements inevitably encounter restrictions on access to information, items and sites that states-parties deem sensitive for national security purposes. This talk will present three systems which can achieve credible verification re-

sults without the need to lift such restrictions: 1) Robots can inspect sites where inspectors only have limited access. Our neutron-detecting, directionally and spectrally sensitive robot could detect illicit activities in uranium enrichment facilities. 2) Buddy Tags allow to account for treaty-accountable items where identifying tags cannot be directly attached. We demonstrate a prototype with a highly sensitive motion detection system capable of detecting illicit movements with accelerations of 20-30 μ g. 3) Information barriers protect sensitive information acquired during warhead authentication procedures. Based on the MOS6502 processor, we demonstrate a "vintage verification" system.

The template-based, gamma spectroscopy information barrier allows both parties to simultaneously establish trust in the hardware used.

AGA 7.2 Fri 11:45 H-HS XVII

Prospects for Safeguarding Radioactive Waste with Antineutrino Measurements — ●MADALINA WITTEL, ANIKE OHM, and MALTE GÖTTSCHE — Nuclear Verification and Disarmament Group, RWTH Aachen University

The radioactive waste produced in the past decades contains many significant quantities of plutonium, one of the key ingredients for manufacturing nuclear weapons. Thus, it raises an important safeguarding challenge. For the first hundreds of years after discharge, the dominant radioactivity of the waste comes from long-lived beta-decaying elements, in particular ^{90}Sr and ^{137}Cs . In this talk, we discuss the prospects of safeguarding long-term geological nuclear waste repositories by detecting the low-energy antineutrinos emitted via beta-decays by the waste itself. We investigate whether these antineutrino measurements could be carried out with high resolution imaging liquid-argon (LAr) detectors. This emerging technology could detect antineutrinos even below the inverse beta decay kinematic threshold. Furthermore, due to their imaging properties, LAr detectors could also provide directionality information which may be used for background rejection and potentially for indicating if and where a certain amount of nuclear waste has been diverted. In this talk, we present a preliminary feasibility study for employing LAr detectors for safeguarding geological radioactive waste repositories. We consider a realistic repository layout

as a study case and evaluate the detector performance in this context, from first principles. Finally, we address both the challenges and the advantages of employing LAr detectors for safeguards purposes.

AGA 7.3 Fri 12:10 H-HS XVII

Uranium Enrichment, Centrifuges and the Current Situation in Iran — ●MATTHIAS ENGLERT — Öko-Institut e.V. Rheinstr. 95, 64295 Darmstadt

Today highly enriched uranium (HEU) is produced with gas centrifuge technology, a technology which is in the reach of the technical capabilities of most countries worldwide. Problematic developments in nuclear proliferation in the last two decades involved the spread and covert acquisition of centrifuge enrichment capabilities by countries such as Iran. After the discovery of the Iranian nuclear program it was mostly frozen since the Iran Nuclear Deal (JCPOA) in 2015. Due to recent tensions and after the withdrawal from the US in 2018, Iran already restarted certain nuclear activities and announced to increase its activities if European parties (UK, France, Germany) would leave the deal. This talk will give a summary of Iran's fissile material production capabilities based on estimates in the open literature and own calculations. Estimating the separative capacity of gas-centrifuges based on accessible information it is possible to calculate a hypothetical production rate for Highly Enriched Uranium (HEU). The resulting hypothetical production rates depend heavily on the assumption about the enrichment and depletion level, the cascade scheme, on the amount of raw material available and the timescale.

AGA 8: Non-Nuclear Verification

Time: Friday 12:35–13:25

Location: H-HS XVII

AGA 8.1 Fri 12:35 H-HS XVII

Acoustic and Seismic Modelling of Tracked-Vehicle Signals for Monitoring and Verification — ●MATTHIAS PILCH — Technische Universität Dortmund, Experimentelle Physik III, Dortmund, Germany

To better understand the characteristics of acoustic and seismic signals of tracked vehicles measured when passing a sensor line, we numerically model acoustic pressure-pulse and seismic force-pulse responses in air and a layered soil that is similar in its seismic properties to that found at the original measurement site. For tracked vehicles, the strongest sources of acoustic excitation are the exhaust, the intakes and the track mechanism. Seismic excitation is caused by road wheels rolling over track elements, applying vertical force pulses to the ground. Acoustic excitation stems mostly from the engine exhausts and couples into the ground. Acoustic and seismic signals from single pressure pulses are computed by an acoustic-seismic-modelling program with receiver stations at many slant distances. The acoustic-seismic coupling observed in the model generally fits to the expectations. The overall goal is to simulate a pass of a tracked vehicle by superposition of acoustically and seismically produced signals.

AGA 8.2 Fri 13:00 H-HS XVII

Preventive Arms Control for Small and Very Small Aircraft and Missiles — ●MATTHIAS PILCH and JÜRGEN ALTMANN — Technische Universität Dortmund, Experimentelle Physik III, Dortmund, Germany

Small and very small armed uninhabited air vehicles (UAVs) and missiles are actively pursued by militaries worldwide. Despite limited payload, militarily significant damage could be achieved by precision, by hitting sensitive spots, and by attacking in swarms. Principally, UAVs and missiles down to 1 mm size and below could be built in the future. A wide-spread deployment can endanger arms control, destabilise the military situation between adversaries, and provide qualitatively new tools for terrorists. In our project we are preparing lists of small UAVs and missiles currently deployed as well as in research and development, detailing their basic properties; these lists will be made available publicly. They allow statements about the state of technology, scale of research and development efforts and proliferation at present and in the future. In the next phase, the current status and trends will be analysed from a natural-science and technical viewpoint and used to extrapolate developments over a period of 5-10 and 10-20 years. In the final phase options for preventive limitations and their verification will be considered systematically.