

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

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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 oder 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.

Overview of Invited Talks and Sessions

(Lecture halls HSZ/0002 and HSZ/0004)

Max-von-Laue Lecture

PV XII Wed 20:00–21:00 HSZ/AUDI **Max-von-Laue Lecture: Risikokompetenz – informiert und entspannt mit Risiken umgehen** — ●GERD GIGERENZER

Invited Talks

AGA 1.1	Wed	14:00–14:45	HSZ/0004	Acoustic, Seismic and Magnetic Detection of Banned Activities – 3.5 Decades of Physics-based Peace Research — ●JÜRGEN ALTMANN
AGA 4.1	Thu	14:00–14:45	HSZ/0002	Mass Starvation? Impacts of Nuclear War on Climate Change and Food Security — ●LILI XIA
AGA 5.1	Thu	15:45–16:30	HSZ/0002	Nuclear forensic science – when nuclear scientists and law enforcement meet — ●MARIA WALLENIS
AGA 5.2	Thu	16:30–17:15	HSZ/0002	Applied Physics in the Alva Myrdal Centre for Nuclear Disarmament: Non-Proliferation and Safeguards Activities — ●SOPHIE GRAPE, PETER ANDERSSON, ERIK BRANGER, CECILIA GUSTAVSSON, VAIBHAV MISHRA, DÉBORA MONTANO TROMBETTA, MARKUS PRESTON
AGA 7.1	Fri	13:00–13:45	HSZ/0002	Fireworks or Threat? – Recent Missile Developments in North Korea — ●MARKUS SCHILLER
AGA 7.2	Fri	13:45–14:30	HSZ/0002	The Challenge of Nuclear-Powered Submarines to IAEA Safeguards — ●TARIQ RAUF

Sessions

AGA 1.1–1.1	Wed	14:00–14:45	HSZ/0004	Acoustic, Seismic and Magnetic Measurements
AGA 2.1–2.4	Wed	14:45–16:25	HSZ/0004	New Verification Concepts and Forensics
AGA 3.1–3.2	Wed	16:25–17:05	HSZ/0004	Simulation and Physics Teaching for Security and Disarmament
AGA 4.1–4.3	Thu	14:00–15:25	HSZ/0002	Nuclear Weapons and the Atmosphere
AGA 5.1–5.2	Thu	15:45–17:15	HSZ/0002	Applied Nuclear Physics
AGA 6	Thu	17:30–18:30	HSZ/0002	Members' Assembly
AGA 7.1–7.3	Fri	13:00–14:50	HSZ/0002	Proliferation Challenges

AGA 8.1–8.1 Fri 14:50–15:10 HSZ/0002 **Mathematical Modelling of Conflicts**

Members' Assembly of the Working Group on Physics and Disarmament

Thursday 17:30–18:30 HSZ/0002

1. Wahl der Versammlungsleitung und Protokollführung
2. Bericht der Sprecher
3. Wahl der Sprecher:in
4. Künftiger Arbeitsplan und Aktivitäten

AGA 1: Acoustic, Seismic and Magnetic Measurements

Time: Wednesday 14:00–14:45

Location: HSZ/0004

Invited Talk

AGA 1.1 Wed 14:00 HSZ/0004

Acoustic, Seismic and Magnetic Detection of Banned Activities – 3.5 Decades of Physics-based Peace Research — ●JÜRGEN ALTMANN — Exp. Physik III, TU Dortmund University

Since 1988 we have done experimental research for verification and monitoring for disarmament, peacekeeping and nuclear safeguards, first at Ruhr University Bochum, from 1999 on at TU Dortmund University. The goal is to detect movements of heavy land vehicles and aircraft or other activities that would violate an agreement or are

relevant for peace in other ways. For outside, daylight and weather-independent sensing over short to medium distances (dozens of metres to kilometres) we focused on acoustic, seismic and magnetic signals. Field measurements were done at military training grounds and air bases, at an ambulance-helicopter base and at an exploratory mine for nuclear spent-fuel storage. The theoretical analyses included simulations. The talk will give an overview of the measurements, evaluations and findings. Problems and chances of such physics-based peace research will be discussed, too.

AGA 2: New Verification Concepts and Forensics

Time: Wednesday 14:45–16:25

Location: HSZ/0004

AGA 2.1 Wed 14:45 HSZ/0004

First Steps Towards a Muon Bunker Telescope to Verify the Absence of Nuclear Weapons — ●ALEXANDRA DATZ¹ and MORITZ KÜTT^{1,2} — ¹Institute for Peace Research and Security Policy at the University of Hamburg — ²Program on Science and Security, Princeton University

Measurement approaches to verify the absence (or presence) of fissile materials are currently under intensive investigation. Through such measurements, one can demonstrate the absence of nuclear weapons. Previous measurements relied on particles emitted by the nuclear weapons themselves, photons and neutrons. We propose a new approach, using cosmic-ray-induced muons (muography), and a single detector to find hidden fissile material in potential nuclear weapon deployment sites (e.g. bunkers). Our contribution will present the possible framework for the application of this method to find hidden significant quantities of plutonium or highly-enriched uranium. Additionally, we show simulation results illustrating necessary detector properties and measurement times for a practical application.

AGA 2.2 Wed 15:05 HSZ/0004

Nuclear verification research – an integrated interdisciplinary approach — ●SOPHIE KRETZSCHMAR and MALTE GÖTTSCHE — RWTH Aachen University

Verification is a key element for nuclear arms control. In today's global situation, it faces grave pressure: Increasing geopolitical change, rapid technological developments, and growing mistrust between states pose significant challenges to present and future verification regimes. The BMBF project *VeSPoTec – Verification in a complex and unpredictable world: social, political and technical processes* brings together researchers from physics, political sciences, and sociology to study verification in an interdisciplinary manner. This talk will introduce the project and demonstrate our integrated interdisciplinary approach on an example application case: verifying fissile material declarations using nuclear archaeology. On the technical side, questions remain on how to reduce uncertainties. For practical application, however, equally important questions persist that address a broader perspective: How can confidence be built when uncertainties remain? This talk will present first results on how social, political, and technical factors impact the success or failure of verification and discuss future challenges and potential solutions.

20 min. break

AGA 2.3 Wed 15:45 HSZ/0004

Anti-neutrino detector concepts for safeguarding spent nuclear fuel repositories — ●YAN-JIE SCHNELLBACH^{1,2}, THOMAS RADERMACHER^{1,2}, IRMGARD NIEMEYER³, STEFAN ROTH¹, and MALTE

GÖTTSCHE² — ¹RWTH Aachen University - Nuclear Verification and Disarmament, Aachen, Germany — ²RWTH Aachen University - Physics Institute III B, Aachen, Germany — ³Forschungszentrum Jülich, Jülich, Germany

Spent nuclear fuel (SNF) is an inevitable by-product of nuclear power generation and requires safeguarding, whether in interim storage or deep geological repositories. Anti-neutrino emissions from the ongoing beta decay of fission fragments could provide a complementary monitoring channel, as anti-neutrinos pass through shielding and geology unhindered and can be detected using inverse beta decay (IBD). This study investigates a novel anti-neutrino detection concept using a liquid organic (LOr) time projection chamber (TPC), combining scalability and particle reconstruction of TPCs with the hydrogen target atoms provided by organic compounds. Geant4-based simulations and electron drift modelling are used to study IBD event reconstruction in a container-sized concept detector for interim storage. The concept detector's expected signal rate, sensitivity and directionality are estimated for a representative example repository with varying deployment scenarios. The results are compared to other state-of-the-art anti-neutrino detection technologies proposed for monitoring. This ongoing comparison study will determine the feasibility anti-neutrino detection as complementary safeguards for SNF repositories.

AGA 2.4 Wed 16:05 HSZ/0004

Forensic Measurements for Nuclear Archaeology - A New Approach — ●LUKAS RADEMACHER and MALTE GÖTTSCHE — Nuclear Verification and Disarmament, RWTH Aachen University

Nuclear archaeology is a field of study aiming to reconstruct the production and removal history of weapons-usable fissile materials and thus create estimates of existing stockpiles. A central method of nuclear archaeology is the deduction of a shut-down reactor's lifetime plutonium production using samples taken from within its core. Specific isotopic ratios are measured to assess neutron fluence and thus estimate plutonium production.

We will present a new approach aiming to strengthen the potential of the method by analyzing a larger set of measured isotopic ratios. This allows for the reconstruction of operational histories of the considered reactor in more detail, therefore also improving production estimates. The analysis required for this is however much more complex, so we developed a suitable procedure using mathematical and computational methods that we will present in the form of a first feasibility study.

This new analysis methodology can be used for various applications ranging from crosschecking fissile material declarations for international confidence building, to a combination with specially designed and installed reactor monitor tags to contribute to the verification of the proposed Fissile Material Cutoff Treaty, to reassessing potentially highly uncertain early plutonium production estimates on a purely national basis.

AGA 3: Simulation and Physics Teaching for Security and Disarmament

Time: Wednesday 16:25–17:05

Location: HSZ/0004

AGA 3.1 Wed 16:25 HSZ/0004

OpenMC für Anwendungen in sicherheitspolitischen Fragestellungen — ●OLAF SCHUMANN — Fraunhofer INT, Euskirchen

Strahlungstransportsimulationen sind ein wichtiges Instrument in vielen Gebieten der Kernphysik. Entweder dienen sie der Planung, Auswertung, Verbesserung oder dem tieferen Verständnis von experimentellen Messungen. Manchmal sind Simulationsrechnungen aber auch die einzige Möglichkeit, zu Ergebnissen zu kommen, sei es, weil eine Messung zu aufwendig oder undurchführbar ist, oder weil ein Messobjekt schlicht nicht zur Verfügung steht. Ein häufig genutztes Programm für diese Simulationen ist MCNP, welches umfangreich mit experimentellen Messungen validiert ist und in sehr vielen unterschiedlichen Bereichen eingesetzt wird. Es ist nur nach einer aufwendigen Exportkontrollüberprüfung zugänglich, zudem ist eine Lizenzierung nicht für jeden Anwendungszweck möglich. Hier hat sich in letzter Zeit OpenMC als Alternative etabliert, ein Programm, welches als Open Source Programm frei zur Verfügung steht und keinerlei Einschränkungen bezüglich der Nutzung unterliegt. OpenMC ist ursprünglich für Anwendungen der Reaktorphysik entworfen worden, daher bietet es einen darauf zugeschnittenen Funktionsumfang, der im Vergleich zu Programmen

wie MCNP etwas eingeschränkt ist. Da es als quelloffenes Projekt angelegt ist, können fehlende Funktionen nachgerüstet und zur Aufnahme in die offizielle Version vorgeschlagen werden. Der Vortrag stellt dieses Programm vor und diskutiert Vor- als auch Nachteile gerade für Anwendungen im sicherheitspolitischen Bereich.

AGA 3.2 Wed 16:45 HSZ/0004

Teaching physics for Arms Control, Non-Proliferation and Disarmament — ●GÖTZ NEUNECK — IFSH, Hamburg

Throughout the nuclear age, physicists played an important role to inform the public, advise the scientific community and influence politics. Teaching and education at universities and research groups form the basis for the discussion of future nuclear challenges. In the last decades much scientific-based materials, analytical papers and studies about the risk of nuclear use and non-proliferation dangers were elaborated and published by research groups and individual scientists. The talk intends to identify the most relevant topics, gives short introductions into current activities and literature and develops recommendations for relevant activities at universities and research centers. It gives an overview on active research groups, materials and interactions.

AGA 4: Nuclear Weapons and the Atmosphere

Time: Thursday 14:00–15:25

Location: HSZ/0002

Invited Talk

AGA 4.1 Thu 14:00 HSZ/0002

Mass Starvation? Impacts of Nuclear War on Climate Change and Food Security — ●LILI XIA — Rutgers University

The direct effects of nuclear war would be horrific, with blast, fires, and radiation killing and injuring many people. But in 1983, United States and Soviet Union scientists showed that a nuclear war could also produce a nuclear winter, with catastrophic consequences for global food supplies for people far removed from the conflict. Smoke from fires ignited by nuclear weapons exploded on cities and industrial targets would block out sunlight, causing dark, cold, and dry surface conditions, producing a nuclear winter, with surface temperatures below freezing even in summer for years. Climate change caused by smoke from fires ignited by nuclear weapons would limit the amount of food that could be grown on land or caught at sea. After stored food was consumed there would be mass food shortages in almost all countries. We used one climate model, one crop model, and one fishery model climate to estimate the impacts from six scenarios of stratospheric soot injection, predicting the total food calories available in each nation post-war after stored food was consumed. We estimated that more than 2 billion people could die from nuclear war between India and Pakistan, and more than 5 billion could die from a war between the United States and Russia.

AGA 4.2 Thu 14:45 HSZ/0002

Multi-technological analysis of the January 2022 Hunga Volcano explosive eruption from the perspective of CTBT monitoring — ●JENS OLE ROSS, PATRICK HUPE, ANDREAS STEINBERG, STEFANIE DONNER, PETER GAEBLER, JOHANNA LEHR, CHRISTOPH PILGER, THOMAS PLENEFISCH, and LARS CERANNA — Bundesanstalt für Geowissenschaften und Rohstoffe, BGR, B4.3 Erdbebendienst des Bundes / Kernwaffenteststopp, Hannover

For the detection of potential non-compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT), the International Monitoring System (IMS) with 321 stations is nearly complete.

The huge explosive eruption of the Hunga Volcano (Tonga) on 15th January 2022 and its global observations were record-breaking in many aspects. All IMS infrasound stations measured the atmospheric Lamb

wave and the following infrasound generated by the main eruption, which circumnavigated the globe several times. We also analysed the seismic and hydroacoustic signatures of the event series to characterize source processes and focused on methods for discriminating between earthquakes and explosions as demanded in the CTBT context. Atmospheric Transport Modelling assessed the sensitivity to the eruption for nearby radionuclide stations to estimate the detectability of hypothetical radionuclide releases in a fictitious nuclear explosion scenario.

The results show again the readiness of the CTBT-IMS and strengthen the value of the IMS data for scientific and civilian applications.

AGA 4.3 Thu 15:05 HSZ/0002

Test of a new radioxenon monitoring system for verification of the Comprehensive Nuclear-Test-Ban Treaty - What can be gained from higher sensitivities and shorter sampling periods? — ●SOFIA BRANDER¹, SANDRA BAUR¹, ROMAN KRAIS¹, J. OLE ROSS², and ANDREAS BOLLHÖFER¹ — ¹Federal Office for Radiation Protection, Rosastr. 9, 79098 Freiburg — ²Federal Institute for Geosciences and Natural Resources, GeoZentrum Hannover, Stilleweg 2, 30655 Hannover

For the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) an international monitoring system (IMS) of radioxenon measurement stations has been established. 26 of 40 planned noble gas stations now accommodate systems that automatically collect and analyze a minimum of 1 air sample per day for the nuclides Xe-133, Xe-131m, Xe-133m and Xe-135 in order to detect a possible nuclear weapons test. A new generation of systems, capable of shorter sampling cycles and lower detection limits, is being tested and implemented into the IMS. The German Federal Office for Radiation Protection tested one of these systems, Xenon International, from July 2021 to April 2022 at radionuclide station RN33 on Mount Schauinsland near Freiburg. The obtained activity concentrations are consistent with data from the current operational IMS system SPALAX at RN33, with sensitivities up to one order of magnitude higher for Xe-131m, Xe-133m and Xe-135.

In this talk, I will investigate multiple isotope detections and unusual single detections and explore the benefits of 6h time resolution considering source location capabilities via atmospheric transport modeling.

AGA 5: Applied Nuclear Physics

Time: Thursday 15:45–17:15

Location: HSZ/0002

Invited Talk AGA 5.1 Thu 15:45 HSZ/0002
Nuclear forensic science – when nuclear scientists and law enforcement meet — ●MARIA WALLENIS — European Commission Joint Research Centre Directorate G - Nuclear Safety and Security Nuclear Safeguards and Forensics

Nuclear forensics is a discipline in which JRC Karlsruhe has a pioneering role: JRC was the first institution, which started to perform nuclear forensic analysis "in a routine manner" for seized nuclear materials 30 years ago. Starting as an ad-hoc analysis to respond safeguards and law enforcement authorities - questions on seized nuclear materials - what it is and where it comes from - nuclear forensics has now developed to a grown-up specialty.

Whereas nuclear forensics relies mostly on techniques used commonly in others fields, such as in nuclear safeguards, materials science or geochemistry, it has refined many of the methods and developed characteristic parameters (so-called nuclear forensic signatures) to response to the specifics required due to the criminal investigation.

This presentation will highlight some of the used methods, show newest developments and demonstrate their application by case studies.

Invited Talk AGA 5.2 Thu 16:30 HSZ/0002

Applied Physics in the Alva Myrdal Centre for Nuclear Disarmament: Non-Proliferation and Safeguards Activities — ●SOPHIE GRAPE, PETER ANDERSSON, ERIK BRANGER, CECILIA GUSTAVSSON, VAIBHAV MISHRA, DÉBORA MONTANO TROMBETTA, and MARKUS PRESTON — Uppsala University

In 2020, the Swedish government announced the plans to start up a national competence centre on nuclear disarmament in Sweden. The objective was to highlight the importance of nuclear disarmament and to promote research, teaching and policy support on relevant topics. In mid-2021, the Alva Myrdal Centre (AMC) on nuclear disarmament was formally established at Uppsala University. The AMC combines competences from different disciplines such as peace and conflict research, applied nuclear physics, and international law, and organises the work into six different working groups. One of the working groups, led by the Division of Applied Nuclear Physics at Uppsala University, is focusing on technical aspects. In this division, research on nuclear safeguards has been performed for over 30 years, and competence exists on a number of applied physics applications ranging from nuclear reactions, nuclear power and detection of radionuclides. This presentation gives an overview of a number of different technical research projects that have been pursued within the technical working group under AMC.

AGA 6: Members' Assembly

Time: Thursday 17:30–18:30

Location: HSZ/0002

All members of the Working Group on Physics and Disarmament are invited to participate.

AGA 7: Proliferation Challenges

Time: Friday 13:00–14:50

Location: HSZ/0002

Invited Talk AGA 7.1 Fri 13:00 HSZ/0002
Fireworks or Threat? – Recent Missile Developments in North Korea — ●MARKUS SCHILLER — ST Analytics GmbH, München, Germany

It seems that the North Korean missile program is now advancing at a pace unlike ever seen before. In the third quarter of 2022 alone, North Korea tested more missiles than it had in the first 30 years of its program under its previous leaders Kim Il Sung and Kim Jong Il. This presentation will try to shed some light on what is actually happening in the realm of Kim Jong Un in regard to missile developments and tests, and it will try to derive the underlying strategy by applying technical analyses of the observed activities.

Invited Talk AGA 7.2 Fri 13:45 HSZ/0002
The Challenge of Nuclear-Powered Submarines to IAEA Safeguards — ●TARIQ RAUF — Vienna

The decisions by Australia to import eight nuclear-powered submarines (SSNs) fueled with 97.3% highly-enriched uranium (HEU) from either the US or the UK, and by Brazil to develop its own SSNs fueled with low-enriched uranium (LEU) with technical assistance from France and Germany, have exposed fundamental weaknesses in the nuclear Non-Proliferation Treaty (NPT) and its related IAEA safeguards (verification) system. The NPT only covers "peaceful nuclear activities" while the IAEA safeguards system for NPT non-nuclear-weapon States (NNWS) includes an exemption from verification of "non-proscribed military activities". The IAEA Secretariat and the IAEA Board of Governors seemingly are deeply confused and divided over the safe-

guards implications of these SSN-acquisition programmes. This presentation will describe the problems and suggest possible ways of dealing with them and preserving the 50-year old nuclear non-proliferation regime.

AGA 7.3 Fri 14:30 HSZ/0002
The current Pollution and Contamination of the Biosphere and Humans with radioactive Isotopes through the Proliferation of Uranium used in Modern Weapon Systems - A Summary of critical Research Results — ●FRANK KLIMASCHEWSKI — Uranium Medical Research Institute (UMRI), UK, www.umri.link

Uranium is a heavy metal with superior armour-penetrating properties. It can be found in bullets, tank rounds, precision-guided bombs and missiles, to name but a few. Thousands of metric tonnes of Uranium dust and shrapnel have been released by modern weapon systems during military conflicts in, for example, the following countries: Iraq and Kuwait during Gulf War I and II, Afghanistan during Operation Enduring Freedom, former Yugoslav states Serbia and Kosovo, and very likely Lebanon, Libya, Syria and the Gaza Strip among others. Mass spectrometric analysis of 24-hour urine samples of civilians and veterans returning from such areas shows that they were contaminated by uranic and transuranic isotopes suffering complex health issues and illnesses such as cancers, organ failures and premature deaths. Recent findings by UMRI also indicate health problems among clean-up workers from a military training site in Europe where uranium-containing weapons have been used. More thorough research at other training sites is urgently needed.

AGA 8: Mathematical Modelling of Conflicts

Time: Friday 14:50–15:10

Location: HSZ/0002

AGA 8.1 Fri 14:50 HSZ/0002

Increased Geopolitical Instability as a Consequence of Changed Equilibrium Country Size — ●RICHARD SCHUBERT —
Blücherstr. 55, 10961 Berlin

In the proposed contribution an analogy is established between the equilibrium size of magnetic domains and the historically formed size of countries. The equilibrium size of magnetic domains is given by a minimum of the energy function consisting of different components obeying different scaling laws, e.g. scaling to the cube or the square of the domain size. Thus, different materials have different average domain sizes. The size of the historically formed countries as well depends on a cost/benefit equilibrium, which can also be described by

a kind of energy function. As a consequence of digitization and other changes in technology the parameters of the material countries are made of have changed dramatically leading to a different equilibrium country size. As a consequence, the current geopolitical situation is in a thermodynamic sense highly unstable. In the contribution, it will be shown how the recent developments in the Yellow Sea, Ukraine, and Catalonia could also be interpreted in the framework of this model (ref to 2017). Trying to make suggestions on how to achieve a smooth transition from the old state of the system to a new state closer to equilibrium is, however, outside the scope of the proposed contribution. Part of the ideas are based on the author's long-standing experience in organizing political background discussions http://berlin-3d-art.de/politische_hintergrundgespraech.html