Princeton School on Science and Global Security

OCTOBER 10–16, 2024

Book of Abstracts

SCIENCE &
GLOBAL SECURITY
PRINCETON UNIVERSITY

PUBLISHED BY THE PROGRAM ON SCIENCE AND GLOBAL SECURITY, PRINCETON UNIVERSITY

TYPESETTING IN LATEX WITH TUFTE DOCUMENT CLASS

First printing, October 2024

The Princeton School on Science and Global Security

The Princeton School on Science and Global Security, launched in 2020, trains next-generation scientists and engineers from around the world in technical perspectives on understanding, reducing, and ending the threat from nuclear weapons. The goal is to provide skills and insights that participants can use in their own research, encourage and inspire them to investigate new ideas to advance global security and a safer and more peaceful world and to foster an international community of such researchers. The School is organized by Princeton University's Program on Science and Global Security (SGS), part of the School of Public and International Affairs.

The meeting includes presentations by invited graduate students, post-doctoral researchers and established researchers on topics such as fissile materials, verification, emerging technologies, and missile defense. It also includes interactive learning experiences and tutorials on nuclear policy.

History

The Princeton School on Science and Global Security traces its origins to the international School on Science and World Affairs organized by the forerunner of the Program on Science and Global Security and the Moscow Institute of Physics and Technology held over eight days in September 1989 outside Moscow. Princeton hosted the second International Summer School on Science and World Affairs in August 1990. The schools focused on nuclear disarmament and global environmental issues. The two schools grew out of discussions between the U.S. physicist Frank von Hippel and the Soviet physicist Roald Sagdeev about the lack of a younger generation of Russian scientists knowledgeable about arms control issues. These discussions also led to the publication of a new international journal, *Science & Global Security,* with an initial editorial board of U.S. and Soviet scientists.

The third Summer School was hosted in Moscow by the newly established Center for Arms Control, Energy, and Environmental Studies at Moscow Institute of Physics and Technology in 1991. The

1992 Summer School was held in Shanghai, hosted by the Center for American Studies (CAS) at Fudan University. It was organized together with the Union of Concerned Scientists (UCS) which took lead responsibility for future meetings. These meetings became known as the International Summer Symposium on Science and World Affairs. Since the first meeting in 1989, these gatherings have hosted over 500 scientists and researchers from over 40 countries.

Program on Science and Global Security

Princeton University's Program on Science and Global Security (SGS), based in the School of Public and International Affairs, conducts scientific, technical and policy research, analysis and outreach to advance national and international policies for a safer and more peaceful world. The Program was founded in 1974 by Harold Feiveson and Frank von Hippel. It is marking its 50th anniversary in 2024.

Throughout its history, SGS has worked on nuclear arms control, nonproliferation, and disarmament to reduce the dangers from nuclear weapons and nuclear power. The control and elimination of fissile materials (the key ingredients for nuclear weapons) is a major part of the SGS agenda. SGS works to understand and reduce the risks from nuclear weapons and the strategies, postures, forces and policies of the nine nuclear armed states. SGS also helps develop confidence-building measures to reduce the risks of crisis, arms racing and nuclear weapons use in the U.S.-NATO-Russian region, South Asia, the Middle East, East Asia, and the Pacific. SGS also works on satellite imagery, VR and robots for treaty monitoring and verification.

SGS does research to support the 2017 United Nations Treaty on the Prohibition of Nuclear Weapons and the goal of the verified and irreversible elimination of all nuclear weapons and weapon programs. SGS is home to *Science & Global Security,* the leading academic peer-reviewed journal for technical arms-control analysis. The journal covers nuclear, biological, chemical, space, and cyber technologies and programs and related security issues. Its goals are to help develop the technical basis for new policy initiatives to reduce the risks from these technologies to international peace and security and to provide a resource for further scholarship and policy analysis.

SGS provides training opportunities for post-doctoral and senior scientists interested in science and security policy. It has helped train technical nuclear arms control and nonproliferation researchers from around the world.

Participants and Abstracts

Jonathan Alfson (he/him)
Bushnell University

Advancing Disarmament Education Within the Physics Curriculum

Abstract. The future of nuclear disarmament and global security will depend on robust networks of experts, including those with physics and engineering specialties, familiar with technical information on nuclear weapons as well as the relevant national and global political and policy context and processes. Physicists have historically been involved in nuclear disarmament and abolition movements since the technology's inception. Despite this history, the discussion of the ethical implications of the technologies created by physicists is not often integrated into formal physics curriculum. This presentation will discuss efforts in the Physicists Coalition for Nuclear Threat Reduction to develop and disseminate educational materials about nuclear technologies and ethics, including synthesizing existing materials for broader use in formal learning environments. The presentation also will give an overview of the Working Group on Disarmament Education based at Cornell University's Judith Reppy Institute for Peace and Conflict Studies. This working group aims to advance understanding of the injustices and inequalities associated with nuclear weapons largely missing from mainstream teaching about nuclear weapons. Both of these educational initiatives contribute to the necessary work of informing future science experts and the general public about the ethics and equity concerns intrinsic to nuclear arsenals.

Biography. Jonathan Alfson is an assistant professor of Physics at Bushnell University in Eugene, Oregon. He completed his PhD at Oregon State University studying physics education. He earned a B.S. in Physics and a B.A. in Mathematics from Arizona State University. Jonathan is currently a Next-Generation Fellow with the Physicists Coalition for Nuclear Threat Reduction. As part of his fellowship project, he is working on curriculum development related to nuclear weapons and nonproliferation.

Joon Baek
Columbia University

Lessons from the Nuclear Weapons Age for Managing AI Development

Abstract. The growing need for a framework for AI governance had led to suggestions for a Manhattan Project approach, with a government-run, large, centralized, technical, crash program to develop and manage AI safely. This presentation will introduce and critique the Manhattan Project approach for AI development and management, arguing that it oversimplifies the complexities of AI regulation, especially the fact that AI development is driven by a diverse array of stakeholders, including private companies and open-source communities. As an alternative, it will examine the successes and shortcomings of nuclear disarmament efforts to identify strategies that might be applicable to AI governance, emphasizing the importance of transparency, international cooperation, and multi-stakeholder engagement. This approach leads to a governance model that includes diverse voices, AI policies that are inclusive, and more likely to be effective in promoting safe, fair, and responsible AI development and management.

Biography. Joon Baek is a software engineer and a master's student studying computer science at Columbia University. He is a member of the OECD Youthwise (OECD's Youth Advisory Board), where he is working on a research project tackling youth perspectives on AI governance. He also runs a youth advocacy and education organization focused on cybersecurity and privacy. He is a member of #Leaders4Tomorrow by the UN Office of Disarmament Affairs and the Data Values Advocate by the Global Partnership for Sustainable Development Data. Joon wants to use technology for social good and hopes to leverage his experience as an engineer, advocate, and a veteran to bring social change.

Alexandra Bodrova (she/her)
Princeton University

Good Robot, Bad Robot: Preventing Dual-Use in AI and Robotics

Abstract. The use of autonomous robotics and artificial intelligence offers a novel approach to addressing key concerns surrounding safety, privacy, and trust issues, including in nuclear facility inspections as part of nuclear nonproliferation, arms control, and disarmament verification efforts. This presentation will introduce a perspective on the convergence of artificial intelligence with robotics such that autonomous systems can be made to operate more freely in real-world settings. A major focus of this presentation is on preventing and mitigating dual-use risks, where robotics technology could be repurposed for harmful applications. As a case study, it will explore how such robots might be put to work in operational and former nuclear facilities to enable reliable, unbiased inspections, while reducing human activities in sensitive environments that also may be hazardous because of radioactive or toxic contamination. The talk will outline algorithms that could allow robots to reject harmful actions or sensitive data processing, and enable an "ethical forgetting" capability for robots to unlearn risky functions and sensitive information. Finally, it will discuss whether a "better angel" algorithm, a watchdog routine ensuring that the robot's actions remain aligned with its intended purpose, can provide an extra layer of security.

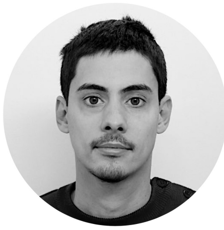
Biography. Alexandra Bodrova is a 4th-year PhD student in Mechanical and Aerospace Engineering at Princeton University, where she is affiliated with the Program on Science and Global Security. Her research explores the safeguarding of robotics and AI against dual-use dilemmas. Her previous research, conducted in Princeton's Intelligent Robot Motion lab, centered on developing generalization algorithms for machine learning as applied to robotics. Originally from Moscow, Russia, she earned her Bachelor of Science in Mechanical and Civil Engineering from the California Institute of Technology (Caltech). Alexandra received the Gordon Y.S. Wu Fellowship and the Henry Ford II Award for academic excellence.

Andrew Fishberg (he/him)
Massachusetts Institute of Technology

Swarm Robot Radiation Detectors in Adverse Environments

Abstract. Robots are capable of navigating a range of challenging environments in search for dangerous radioactive materials. This presentation discusses state-of-the-art multi-agent radiological search, especially in time-sensitive scenarios where GPS may be jammed or unreliable and there are no prior maps. To hasten the search process, the robot swarm must autonomously divide the search region into individual search tasks, intelligently assign them to specific agents, and then execute them in real-time – a process that requires concurrently navigating an unknown environment while constructing a shared inter-agent map. The presentation will outline the algorithmic requirements for distributed simultaneous localization and mapping that is robust to external conditions and contingencies, including being resilient to loss of connectivity between agents, low communication bandwidth between agents, and potential loss of individual agents. It also introduces the use of multiple ultra-wideband sensors to allow relative position and attitude estimation between agents, without external infrastructure.

Biography. Andrew Fishberg is a PhD student at MIT studying robotics, computer science, and AI. His research focuses on the development of multi-agent mapping algorithms in service of nuclear non-proliferation. Prior to his graduate work, Andrew received a CS degree from Harvey Mudd College and worked full-time as an Associate Staff member in MIT Lincoln Laboratory's Advanced Capabilities and Systems Group. Beyond robotics, Andrew has interest in policy, education, and AI/technology ethics.



Valentin Fondement (he/him)
University of Michigan

Exploiting the Whole Potential of Helium-3 Counters for Active Detection of Special Nuclear Materials at Borders

Abstract. Detecting and thus preventing the illicit exchange of special nuclear materials (primarily plutonium and highly enriched uranium) is a critical part of the Non-Proliferation Treaty. Over the years, active neutron interrogation techniques using DT neutron generators have been widely studied in support of border security and custom inspections seeking to monitor potential trafficking of such materials, especially if the material might be shielded. This presentation will explain the challenges of special nuclear materials detection and the utility of active neutron interrogation methods. It will highlight issues with the consistency of neutron output from these generators and the lack of comprehensive monitoring of the behavior of neutron generator tubes throughout their lifetime. It will suggest the value of digitizing the helium-3 pulses to allow improved sensitivity of detection for different elements. Traditional helium-3 counting does not allow discrimination between thermal capture events and fast neutron scattering. A proposed new capability would allow us to estimate separately the fast neutron incident fluence, which weakly varies with the nearby environment, thus providing an online monitoring capability for the DT generator.

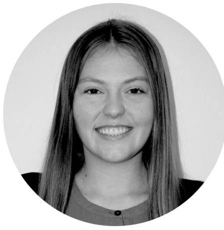
Biography. Valentin Fondement is a Postdoctoral Research Fellow at the University of Michigan. Originally from France, he obtained two master's degrees in 2020: one in physics at the University of Caen, and the other in Electronics and Applied Physics Engineering at the Higher National School of Engineering of Caen. He completed his PhD at the French Atomic Energy Commission (CEA) in Cadarache's research center. During his program, he collaborated with Orano Mining to develop a new logging tool based on active neutron interrogation, to measure simultaneously the uranium content and the hydrogen porosity in mines.

Londrea Garrett (she/her)
University of Michigan

Laser-Based Diagnostics for Nuclear Safeguards on Uranium Enrichment

Abstract. Effective safeguards on uranium enrichment centrifuge facilities are a long-standing challenge for the Nuclear Non-Proliferation Treaty monitoring regime. This presentation will introduce laser-induced breakdown spectroscopy as a diagnostic tool for safeguards and how it has been applied to assay the enrichment of uranium hexafluoride and the development of portable equipment for the monitoring of centrifuge-based uranium enrichment facilities. It will focus on the atomic line pair emitting at 646.49 nm that has been identified as promising for this analysis, and examine its sensitivity to measurement drift, the temporal behavior of both line features and plasma diagnostics, and the extent to which the prominent lines experience self-absorption. Thanks to the many uranium and fluorine emissions visible in this spectral window, modeling can be used to further increase the accuracy of results. It will suggest that these results support extending this research to other isotopic discrimination needs within the safeguards community, such as the identification of plutonium isotopes.

Biography. Londrea Garrett is a PhD candidate in the University of Michigan's Nuclear Engineering and Radiological Sciences Department under Professor Igor Jovanovic. She completed her bachelor's degree in chemical engineering at the University of Rochester. She is a Nuclear Nonproliferation and International Safeguards Graduate Fellow and has been a contributing author on six peer-reviewed publications. Her research focuses on how laser-induced breakdown spectroscopy and related optical spectroscopy techniques can be used for novel nuclear diagnostics, particularly for safeguards applications. After completion of her degree, she hopes to continue performing safeguards work at one of the Department of Energy National Laboratories.

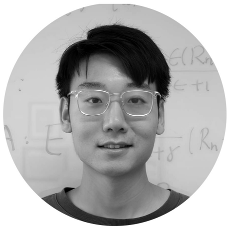


Emily Gunger
University of Florida

Attenuation and Scattering Measurement Device to Characterize Liquid-Based Neutrino Detector Media

Abstract. Large-scale liquid-based neutrino detectors can contain optically transparent mixtures, including water and scintillator, with photons traversing many meters of liquid detection media to be detected by photosensors to register an event. These liquid mixtures' optical properties must be well understood to model detector performance. This presentation will introduce liquid-based neutrino detection and a new horizontal benchtop device that simultaneously measures photon attenuation and scattering lengths for neutrino detector fill materials. The device can be used to determine the optical qualities of any detector liquid, providing real time attenuation and scattering data for operational purification systems. Additionally, it can enhance databases required by machine learning algorithms to predict the performance of new liquids. This approach can be applied to any large format of detector that has a liquid-based detection system that needs to be verified. Such optical transparency measurements are critical to understanding the performance of large-scale neutrino detectors comprised of water, scintillator and mixtures thereof (water-based scintillator). This class of detector is potentially relevant for nonproliferation applications and has demonstrated relevance for fundamental particle physics.

Biography. Emily Gunger is a rising second-year PhD student in Nuclear Engineering at University of Florida. She received my BS in Astronomy and Astrophysics from Embry-Riddle Aeronautical University. She received the MTV Diversity and Excellence Fellowship and the James E. Swander Memorial Scholarship. She is working with the Lawrence Livermore National Laboratory and UK BUTTON (Boulby Underground Technology Testbed Observing Neutrinos) on research into the properties of large-scale liquid neutrino detectors that may be used to non-intrusively monitor nuclear reactors at tens of kilometer standoffs.



Zhenyu He (he/him)
University of California, Berkeley

Using the Hiroshima Fire Plume to Constrain Soot Lofting in Nuclear Winter Models

Abstract. Understanding the potential for nuclear winter is crucial in assessing the catastrophic consequences of nuclear conflict. Models suggest that teragrams of soot from burning cities lofted into the stratosphere could drastically lower global temperatures, leading to widespread famine and suffering far exceeding the immediate casualties of nuclear explosions. However, significant unknowns remain about the scale of fires required to inject such quantities of soot into the stratosphere and the dynamics of extreme convection. This presentation will model the Hiroshima fire plume to understand these dynamics. By replicating the observed plume structure and height, these simulations can help elucidate the conditions under which soot can reach the stratosphere. It also will discuss the challenges posed by the scarcity of observations and the poorly understood dynamics of extreme convection in the atmosphere. Insights from the simulations and a discussion of their implications may underscore the necessity for more comprehensive studies to inform policies aimed at preventing nuclear winter and support the global effort to deter the use of nuclear weapons.

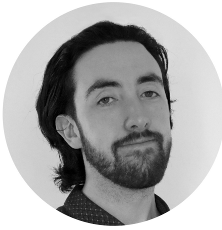
Biography. Zhenyu He am a PhD student in the Earth and Planetary Science Department at UC Berkeley, supervised by Professors David Romps and Inez Fung. My research focuses on atmospheric dynamics, climate change, and nuclear winter. He has conducted extensive studies on the potential for nuclear winter, employing Large Eddy Simulations and 1-D vertical convection models to analyze the dynamics of extreme convection, particularly using the Hiroshima fire plume as a case study. Additionally, he has worked on monitoring greenhouse gas emissions and aerosol retrieval algorithms. He holds a Bachelor's degree from Peking University, where he studied Atmospheric and Oceanic Sciences.

Bernd Hrdy
University of Natural Resources and Life Sciences, Vienna

Nuclear Safety Under Military Attack

Abstract. Nuclear safety depends on stability, continuity and reliability. But it is these conditions based on laws and norms that war threatens to undermine and erodes. Nuclear power plants are designed to withstand multiple internal and external threats, but they are not designed for war scenarios - as the effects of military conflicts are not taken into account. The Russian war in Ukraine has again demonstrated that nuclear power plants can be deliberate or inadvertent targets in armed conflicts This presentation reviews the simulation results of exemplary scenarios for a VVER-1000 reactor at operation that lead to severe accidents at the reactor and were caused by shelling in an armed conflict. In all scenarios, the objective of the attacker is to gain control of the plant, but not to destroy the nuclear power plant, since the results of accidents caused by combat situations at a nuclear power plant are subject to a high degree of variability. The simulation results and the calculated radionuclide releases to the atmosphere prove the obvious – military attacks, even without the intention to destroy the nuclear power plan

Biography. Bernd majored in philosophy and physics in 2005 and in civil engineering / geosciences in 2020. In between, he coordinated projects in democracy building for a German state foundation in Almaty (Kazakhstan) and taught humanities at the American University in Bishkek (Kirghistan). His work and ongoing PhD focuses on nuclear power plants, war, dispersion of radionuclides in the atmosphere and risk maps - specifically on the algorithm behind maps and how to integrate both meteorological and nuclear uncertainties.



Hugh Irving (he/him)
University College Dublin

Casualties from a Nuclear Attack and a Nuclear Weapon Accident at the Clyde Naval Base, Faslane, Scotland

Abstract. The United Kingdom's nuclear forces operate from the Clyde Naval Base in Faslane, Scotland. The base is surrounded by populated areas, with Glasgow, Scotland's largest city, only 40 km away. The base is particularly controversial among local communities due to reports of serious accidents and the site being a likely target in a nuclear attack on the UK. This presentation will introduce the Faslane base and share estimated casualties for a scenario where the base has experienced a nuclear strike. The yield and accuracy of the weapons used are estimated from open source reporting on Russian nuclear weapons. A second case is that of an accidental detonation of one of the UK's own nuclear warheads. Since this would be ground-level and produce a large amount of radioactive fallout, the HYSPLIT atmospheric dispersion code is used assuming randomised historical weather data, to model the fallout effects. The goal is to illustrate the risks posed by this facility to the public and help inform those engaged in disarmament efforts to confront the UK's controversial nuclear weapons renewal plans.

Biography. Hugh Irving is a researcher pursuing a PhD at University College Dublin, Ireland. He has experience in fluid dynamics, computational modeling, applied dynamics and material science. He has contributed to research in wind energy, aerospace engineering, aerosolized infectious disease and more recently nuclear weapons disarmament. Hugh is interested in research impact and is involved in the Effective Altruism research community, which has led him to prioritize working on issues such as renewable energy, infectious disease and nuclear weapons. Hugh holds a BSc in mechanical engineering and an ME in material science and engineering.

J. Thokozile Kabini (she/her)
Princeton University

Radiological Mapping of Former Nuclear Test Sites Using Unmanned Aerial Vehicles

Abstract. France tested seventeen nuclear weapons in Algeria between 1960 and 1966. The tests were comprised of above-ground and underground nuclear explosions. The residual radioactive matter generated by these tests is still measurable over the soil and sand of the Algerian Sahara necessitating long-term environmental monitoring. Traditionally, radiation monitoring of former test sites involves the use of environmental radioactivity techniques which employ ground-based surveys aimed at characterizing radiological species present in the environment. Unmanned Aerial Vehicles (UAV) such as drones mounted with radiation sensing detectors could potentially address important drawbacks of stationary systems. In this presentation, I will discuss the advantages and recent advances in UAV-based surveys including types of drones and sensors that enable precise radiation detection and mapping. I will also discuss their application in radiation monitoring for large-size contaminated areas such as the Algerian test sites and how collected data can be used to assess contamination levels to aid decision-making in remediation efforts.

Biography. Thokozile Kabini is a pre-doctoral fellow at Princeton University's Program on Science and Global Security. She holds a Master's degree in Nuclear Physics from the University of Pretoria in South Africa, where she specialized in nuclear and radiation science. She holds undergraduate degrees in Physical Sciences and in International Relations. In 2012 she joined the South African Nuclear Energy Corporation and in 2014 became a nuclear forensics analyst, with a focus on the analysis of nuclear materials using non-destructive techniques. Thokozile also worked as an analyst at the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) laboratory as part of a team responsible for analyzing radionuclide samples from international monitoring stations.

Manuel Kreutle (he/him)
Forschungszentrum Jülich, Germany

Nuclear Weapons Are Just Waste:
Safeguarding The Back-End of Nuclear Disarmament

Abstract. The challenges of designing long-term safeguards on civilian nuclear waste in underground repositories have some similarities to those of managing the monitored secure storage and disposal of nuclear weapon material recovered during weapon production processes and as part of a disarmament process. This presentation will present a model and software architecture designed for a digital twin of safeguards on civilian nuclear waste and ask how it may be adapted to be useful in a disarmament context. As examples, it will look at the safeguards on the disposal of spent nuclear fuel at the Onkalo repository in Finland, the disposal of highly-active nuclear waste in Germany in the Asse II and Morsleben mines, and the disposal of US defence-related nuclear waste in the Waste Isolation Pilot Plant. It also will discuss the safeguards implications of managing former nuclear weapons material based on the approach taken by the US-Russia Cooperative Threat Reduction program which highly enriched uranium from Soviet nuclear weapons was down-blended into low-enriched uranium for nuclear fuel, and long-term interim storage of nuclear weapons plutonium.

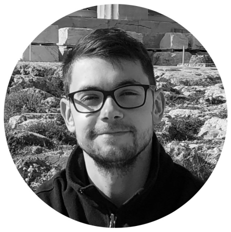
Biography. Manuel Kreutle obtained a Bachelor degree in Physics from University of Heidelberg, Germany, and a Master degree in Physics from University of Hamburg, Germany. During his time in Hamburg, he conducted neutron transport simulations and co-organized international exercises for the purpose of studying nuclear disarmament verification techniques and procedures. In a visit to the Program on Science and Global Security at Princeton University, he investigated the potential of virtual reality (VR) and robotics for remote inspections. In his ongoing doctoral research at Forschungszentrum Jülich, Germany, he explores the intersection between remote monitoring, simulations and VR with the aim of developing a Digital Twin for Safeguards in Nuclear Waste Management.

Ryan Manzuk
Princeton University

Using Satellite Imagery to Detect Long-term Land Use Changes

Abstract. Satellite imagery can provide evidence on the time and place of land use change, for example agriculture, deforestation, and mining, but the temporal range, spatial resolution, and spectral bands of a given satellite program must align with the scope of the land use question being asked. For studies that require multi-decadal histories dating into the previous century, the Landsat mission is the only option for open-source, spatially and temporally continuous images. This presentation will look at crops and growing practices in the Israeli Occupied West Bank, which fits within a single Landsat scene, and show that even though morphological features of vegetation and crops cannot be resolved in Landsat's 30 m pixels, targeted time series analysis of spectral data allows for a reliable method for detecting agricultural land use change. The presentation also will include a brief set of reflections on a recent hyperspectral image of a uranium mine in Pakistan.

Biography. Ryan Manzuk received his PhD in Geosciences at Princeton University in October 2024. His thesis used image analysis and computational methods to investigate the physical properties of ancient environments preserved in rocks, mostly fossil reefs, to investigate feedbacks between the physical environment, climate, and biological evolution. He also works with Situ Studio, Brooklyn, NY, as part of a team combining visual investigations, science, law, and advocacy on issues of human rights, environmental justice, policing, and civil liberties. As a Peace Corps volunteer he spent two years in Guinea working with a small village on sustainable food production practices.

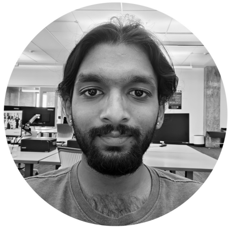


Enrique Miralles-Dolz
Princeton University

Proliferation Risks of Magnetic Confinement Fusion Technology

Abstract. The discussion on the proliferation risks associated with magnetic confinement fusion has primarily focused on two key concerns: the management of tritium inventories and the potential for fissile material breeding. This presentation will introduce magnetic confinement fusion and its proliferation risks and argue that the focus on tritium production and fissile material breeding overshadows a wider spectrum of proliferation risks stemming from spin-off technologies. It will highlight the example of plasma-facing components subject to extreme conditions in fusion reactors that are comparable to those experienced by nuclear weapon re-entry vehicles. Both contexts demand materials capable of withstanding high thermal loads, significant mechanical stresses, erosion, and material degradation. These materials could be tested in fusion reactors, covertly aiding better warhead designs. It also will note how the renewed interest in magnet technology due to its role in fusion reactors can open the possibility of revisiting calutron isotope separation technology and offer ways to overcome the inefficiencies of earlier calutron systems. These examples underscore the need for broader consideration in assessing magnetic confinement fusion proliferation risks.

Biography. Enrique is a postdoctoral researcher at Princeton Plasma Physics Laboratory, working on systems code development for stellarators. He earned his PhD in Nuclear Engineering with a thesis on the incorporation of epistemic uncertainty into the engineering design activities of fusion power plants. His research interests include uncertainty quantification, sensitivity analysis, optimization under uncertainty, and risk analysis. Enrique also holds an MRes in Decision Making, an MSc in Plasma Physics, and a Bachelor's degree in Industrial Engineering.



Pranav Nalamwar
University of Notre Dame

Space Races, Space Junk, and Space Wars

Abstract. If successfully developed and deployed, nuclear-armed hypersonic glide vehicles (HGVs) with intercontinental range will be a new type of offensive nuclear weapon. Existing warhead detection and tracking systems are not designed to track HGVs. The prospect that adversaries may deploy these nuclear-armed, high maneuverability weapons has led the United States to plan space-based sensor systems designed to track intercontinental-range HGVs and to begin testing and deploying them. U.S. deployment of space-based sensor systems designed to track intercontinental-range HGVs would create a very strong incentive for adversaries to deploy weapons designed to disable these systems, such as missiles with kill vehicles that would strike satellites or explode nuclear weapons in Low Earth Orbit (LEO) or Medium Earth Orbit (MEO) during a nuclear attack. The use of kinetic ASATs or nuclear weapons for this purpose would have catastrophic effects for all nations, not just those directly involved in the war. Even testing ASATs designed for this purpose would have serious consequences. This presentation will highlight HGVs, their implications, and the dangers of this new arms race.

Biography. Pranav Nalamwar is a 4th-year Astrophysics and Nuclear Physics PhD student at the University of Notre Dame. His research focuses on nucleosynthesis simulations and globular cluster observations to study where and how heavy elements like gold and platinum form in our universe. He joined the Physicists Coalition for Nuclear Threat Reduction in 2024 as a Next-Generation fellow and is currently studying how the presence of nuclear and anti-satellite weaponry can fuel international conflict and strain tensions amongst various states. He is interested in what actions nations can take to decrease space armaments despite disagreeing parties, much like the tension between the US and Russia during the 2024 UN resolution banning an outer space arms race.

Masashi Nishiguchi (he/him)
Purdue University

The Life and Death of a Nuclear-Powered Spacecraft

Abstract. Nuclear propulsion has been proposed as a possible reliable, long-life span system for space exploration missions to the Moon and Mars since the 1950s and has now resurfaced again. In 2023, NASA signed a contract with the US Defense Advanced Research Projects Agency for a nuclear thermal rocket propulsion system to significantly cut travel time to Mars. However, using nuclear power sources on board spacecraft risks creating nuclear-contaminated debris if there are failures during launch, collisions with space debris or explosions due to malfunctions, attacks by anti-satellites weapons, or containment failure upon uncontrolled reentry to Earth or to another solar system body. This presentation will discuss the idea of space nuclear propulsion and the risk and consequences of accidents leading to dispersion of radioactivity. It will assess the nature and dispersion of nuclear-contaminated fragments from a break-up event, looking at the spread of nuclear particles under the complex gravity field near the Moon and the potential effects on cis-lunar orbits and the lunar surface. It also will assess nuclear-contaminated debris generated in low Earth orbit and the impact for near-Earth satellites and for the Earth.

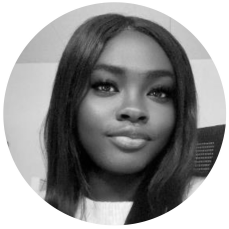
Biography. Masashi Nishiguchi is a PhD student at Purdue University's School of Aeronautics and Astronautics specializing in astrodynamics. His research focuses on the application of event-base camera in the field of space situational awareness, especially detecting and characterizing space debris. Masashi obtained his B.S. in applied mathematics and B.S. in mechanical engineering from University of Mount Union.

Patrick Park
Princeton University

Estimating Potential Tritium and Plutonium Production in North Korea's Experimental Light Water Reactor

Abstract. This talk explores North Korea's 100 MW-th Experimental Light Water Reactor (ELWR) and its potential contributions to the country's nuclear weapons program. Built at the Yongbyon Nuclear Research Center, the ELWR began operations in October 2023 and represents North Korea's first attempts at a light water reactor and domestically-enriched fuel. It examines possible configurations for energy, tritium, or plutonium-production scenarios. Assuming a single-batch core, the ELWR demonstrated an ability to produce about 15 kg of weapons-grade plutonium and 50–80 grams of tritium annually. This tritium can supply four to eight new boosted warheads each year or sustain a maximum arsenal of up to 100–150 weapons. Concurrent production of tritium and weapons-grade plutonium is possible, although trade-offs in the uranium demanded would require re-enrichment of spent fuel to be feasible. These findings underscore the ELWR's significant potential in enhancing North Korea's nuclear capabilities, highlighting the urgent need for international monitoring and awareness of nuclear proliferation attempts.

Biography. Patrick Park is a second-year PhD student in Mechanical Engineering, where I harness visual-thermal satellite imagery and neutronics codes to detect signatures of nuclear proliferation activities in foreign states. Before Princeton, he was a licensed senior operator of a TRIGA research reactor and worked with the Reactor Engineering Group at the NIST Center for Neutron Research. He studied Physics at Reed College, as well as Applied Physics and History at Columbia University.



Priscilla Oforiwaa
International Atomic Energy Agency

Impact of Radiological Release of Radionuclides on Food Safety and Developing Remediation Strategies

Abstract. The testing or use of nuclear weapons releases harmful radionuclides into the environment, contaminating soil, water, and air. This radiological contamination poses significant health risks, as radionuclides can infiltrate the food chain, affecting agriculture, livestock, and aquatic ecosystems. Among the most critical hazards is the contamination of local food sources, as radionuclides absorbed by plants and animals eventually enter the human food chain with long-term exposure through food consumption leading to serious health consequences. This study evaluates the impact of specific radionuclides (Cesium-137, Strontium-89, and Iodine-131) on the food chain using semi-mechanistic methods. It focuses on assessing long-term effects and developing remediation strategies in alignment with the Treaty on the Prohibition of Nuclear Weapons. The study emphasizes the critical need for environmental remediation in contaminated areas, including efforts to decontaminate these environments to prevent further radionuclide transfer into the food chain. It also highlights the importance of international cooperation in monitoring, technological sharing, and the application of best practices and methodologies to decontaminate food supplies and mitigate radionuclide transfer in agricultural land within affected areas.

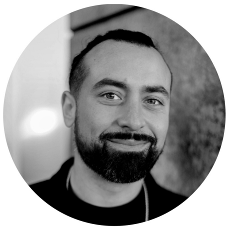
Biography. Priscilla Obeng Oforiwaa is an intern with the International Atomic Energy Agency in Vienna, Austria. She has a BSc degree in Renewable Energy Engineering from Ghana, MSc in Nuclear Science and Engineering Management from Tsinghua University's Department of Engineering Physics in 2019 and completed my Doctoral studies in Nuclear Science and Technology with a focus on Nuclear Security and Safety in August 2023 from the same department. She transitioned into the role as a Postdoc in Nuclear security and Policy, which ended in April 2024.

Faisal Rahman
North Carolina State University

An Analog Switching-based Multiplexing Method to Enable Neutrino Detection for Non-proliferation Applications

Abstract. Detecting neutrinos produced during nuclear reactor operations can be a tool for monitoring reactor operation and discovering undeclared nuclear reactors. Using large volumes of NaI detectors by cascading hundreds of detectors can be an efficient way of detecting low energy neutrinos via coherent elastic neutrino-nucleus scattering (CEνNS), in which a neutrino scatters off a nucleus that behaves as a single particle. However, data acquisition from many detectors using individual analog-to-digital channels can be very expensive. Using a multiplexing method can be a solution to this problem. Nevertheless, in most methods, baseline noise from inactive channels is accumulated on the multiplexed output which degrades low energy signals. This presentation introduces a novel multiplexing method that blocks noise by turning off inactive channels using analog switches. The switching operation is carried out using a signal-driven logic-based algorithm implemented on a field-programmable gate array (FPGA). It will also present a prototype multiplexer, built to demonstrate the multiplexing method, and some data on its performance.

Biography. Faisal Rahman is a PhD candidate in Nuclear Engineering at the North Carolina State University, specializing in radiation detection. His expertise includes gamma detection and characterizing special nuclear materials. His work spans various domains, including development of electronic circuits, and data acquisition (DAQ) systems for non-proliferation and medical imaging applications. Faisal holds a B.Sc. (Hons) in Applied Physics, Electronics and Communication Engineering, and an M.Sc. in Electrical and Electronics Engineering from the University of Dhaka, Bangladesh. Since 2016, he has been a faculty member at the University of Dhaka and is currently on study leave to pursue his PhD.



Shua Sanchez (he/him)
Massachusetts Institute of Technology

Plutonium Pit Aging

Abstract. In a modern two-stage thermonuclear warhead, the plutonium shell (or pit) at the core of the weapon's primary stage must undergo nuclear fission with a large enough yield to drive a fusion reaction in the secondary stage. Changes in plutonium bulk properties over time (an effect called "aging") can potentially degrade the performance of the primary and the yield of the warhead overall. These changes can stem from the spontaneous radioactive decay of plutonium creating lattice defects which may reduce crystallinity (the regular spacings between atoms). Studies over the past two decades have suggested pits remain viable for roughly 80-150 years despite plutonium aging effects. However, the US National Nuclear Security Association has recently pushed for renewed plutonium pit production, motivated in part by a suggestion that current pits may be degrading faster than expected. This presentation will offer a technical analysis of the new claims about the speed of plutonium aging, highlighting possible limitations of the experimental design underlying them. It will suggest a need for more research on whether plutonium pits are aging more quickly or slowly than expected to allow a better informed policy debate on plutonium pit production.

Biography. Shua Sanchez is a postdoctoral fellow in physics at the Massachusetts Institute of Technology, where he studies 2D materials for future energy efficient electronics. During my PhD at the University of Washington, He was an elected leader in my graduate union for five years and led numerous organizing drives and campaigns to improve the lives and working conditions of our members. He also previously worked with the Democratic Party as a campaign organizer across the country.

Shayaan Subzwari
Massachusetts Institute of Technology

Neutron Resonance Transmission Analysis for Arms Control and Safeguards

Abstract. Today, effective arms control and nonproliferation strategies rely on inspection methods that can reliably detect and quantify nuclear weapon-usable materials. Such nonproliferation efforts require the capability to identify and monitor fissile and fertile materials to prevent their diversion for illicit weapons purposes. Additionally, future agreements may include the monitored dismantling of nuclear warheads, verification of which will require confirming that dismantled warhead components presented by states consist of weapon material and are not hoaxes consisting of non-weapon-grade material. This presentation will discuss neutron resonance transmission analysis as a promising technique for these applications by detecting epithermal neutrons passing through materials, providing information about their isotopic composition. It will present recent advances that allow for portable, neutron resonance transmission analysis instruments capable of effectively identifying mid- to high-atomic number targets. It also will note research focused on enhancing this technology for use in high-radiation environments to enable its wider use in safeguarding efforts.

Biography. Shayaan Subzwari is a graduate student at MIT studying nuclear science & engineering as well as technology & policy. He is currently conducting research into technologies for the detection of special nuclear material, with applications for nuclear treaty verification and safeguards. With his undergraduate degrees in physics and global affairs, he has a strong interest in the real-world considerations of nuclear technology and the issues surrounding nuclear weapons.

Stefano Terlizzi
Pennsylvania State University

Nuclear Microreactors and International Safeguards

Abstract. Microreactors (MR) are characterized by compactness, transportability, and nearly autonomous control systems. These features make MRs an attractive technology to supply electricity and process heat to remote areas both for civilian and military applications. For civilian applications, small, modular power units are expected to improve economies of scale and standardization while enhancing safety due to a smaller source term. For military operations, microreactors can help mitigate logistical challenges related to fuel supply. This presentation discusses the challenges of adapting the traditional safeguards regime to nuclear microreactors. It is shown that it is very unlikely that a significant quantity of nuclear material may be diverted from a single MR, due to the use of TRISO particles, the small inventory, and the envisioned operational modes for MRs. However, the potential proliferation of microreactors in remote areas could pose challenges for international inspectors if not addressed through new technological innovations and modifications to the current regime, such as the use of digital twins coupled with remote monitoring for detection of operational anomalies.

Biography. Dr. Stefano Terlizzi is the John J. and Jean M. Brennan Clean Energy Early Career Professor at Pennsylvania State University (PSU). Previously, he was a staff scientist at Idaho National Laboratory (INL), where he led several projects on advanced nuclear reactors, including hydrogen migration in YH- moderated microreactors and developing analysis tools for DOE, NASA, and the NRC. Dr. Terlizzi holds a PhD in nuclear engineering from Georgia Tech and a B.S. and M.S. from the Polytechnic University of Turin. He was also the INL Deslonde De Boisblanc Distinguished Postdoctoral Research Associate and a Georgia Tech Sam Nunn Security Program Fellow.

Raven Witherspoon (she/her)
Princeton University

Modeling Radiological Risks Associated with Fires at Plutonium Pit Production Plants

Abstract. The large-scale production of nuclear weapons during the Cold War has had a significant long-term impact on the environment. In the United States, several sites associated with fissile material production as well as nuclear weapon component manufacturing, such as pit production, have been turned into EPA "superfund" sites, and are still being cleaned-up at a cost of tens of billions of dollars. Beyond routine discharge of radionuclides to the environment, some sites also experienced significant radiological accidents often impacting nearby indigenous, minority, and low-income communities. This paper discusses how advances in atmospheric transport modeling, weather reanalysis, and geographic information service techniques offer new opportunities to revisit the consequences of past accidents through an environmental justice lens. As an example, it presents a new reconstruction of the 1957 plutonium fire that took place at the Colorado Rocky Flats plant. These tools could also be used to assess the potential impact of radiological releases today leveraging even better spatial and temporal resolution weather data and census information.

Biography. Raven Witherspoon is a pre-doctoral fellow in the Program on Science and Global Security. Raven was a Schwarzman Scholar at Tsinghua University, Beijing, receiving a master's degree in global affairs in 2022, and studying Mandarin Chinese as a Blakemore-Freeman Fellow. She holds an undergraduate degree in physics with minors in mathematics, political science, and international social justice studies from Virginia Commonwealth University, where she was a research assistant in the Department of Mechanical and Nuclear Engineering.

School Lecturers & Organizers

Julia Georgiana (she/her)
Princeton University

Julia is the SGS Program Manager, overseeing the day-to-day operations and financial processes of the Program. Since joining Princeton University in 2017, Julia has worked as the Graduate Program Administrator for the Department of Politics and as Study Abroad Coordinator in the Office of International Programs. Previously, Julia worked at various universities, including Rutgers, where she held responsibilities for student affairs and university advancement and donor relations. Julia has an undergraduate degree in Business Management from St. John's University, New York, and a graduate degree in Higher Education Administration from Northeastern University.

Alex Glaser (he/him)
Princeton University

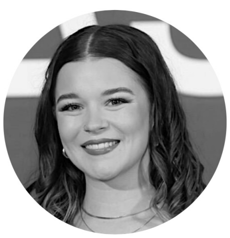
Nuclear Arms Control and Verification

Alexander Glaser is associate professor in the School of Public and International Affairs and in the Department of Mechanical and Aerospace Engineering. Alex has been co-directing the Program on Science and Global Security since 2016. For Princeton's work on nuclear warhead verification, Foreign Policy Magazine selected him as one of the 100 Leading Global Thinkers of 2014. In September 2020, Alex was elected a Fellow of the American Physical Society. Alex holds a PhD in physics from Darmstadt University, Germany.

Robert J. Goldston (he/him)
Princeton University

How to Avert the Coming Arms Race

Rob Goldston is a Professor of Astrophysical Sciences at Princeton University. He was director of the Princeton Plasma Physics Laboratory from 1997 to 2009. He does research on fusion energy and verification technologies for arms control and nonproliferation, serves on the Board of the Council for a Livable World, and writes policy pieces for the Bulletin of the Atomic Scientists.



Mackenzie Knight (she/her)
Federation of American Scientists

Nuclear Arsenals and Modernization Around the World

Mackenzie Knight is a Senior Research Associate for the Nuclear Information Project at the Federation of American Scientists, where she co-authors the Nuclear Notebook—an authoritative open-source estimate of global nuclear forces and trends. She has written and spoken extensively on U.S. nuclear modernization programs like the new Sentinel Intercontinental Ballistic Missile. Mackenzie was previously a Herbert Scoville Jr. Peace Fellow at FAS and received her master's in Nonproliferation and Terrorism Studies from the Middlebury Institute of International Studies.

Moritz Kütt
Institute for Peace Research and Security Policy, Hamburg

Pits and Particles: Weapon Confirmation with Nuclear Physics

Moritz leads the Working Group "Science and Disarmament" at the Institute for Peace Research and Security Policy at the University of Hamburg (IFSH) and is a Visiting Research Scholar with the Program on Science and Global Security. He studied physics and political science, and received his PhD in physics from TU Darmstadt (2016). He researches questions related to the elimination of nuclear weapon programs, with projects on nuclear dangers, escalation, verification and nuclear weapon legacies. His work combines applied nuclear physics with insights from other disciplines. It is his long-term vision to establish a German nuclear disarmament laboratory.

Geralyn McDermott (she/her)
Princeton University

Geralyn McDermott joined the Program on Science and Global Security as Administrative Assistant in 2012. She provides administrative and research support to the Program's faculty, staff, and graduate students. In addition, Geralyn coordinates logistics for domestic and international conferences, arranges travel, and is responsible for expense reporting, and purchasing.

Zia Mian
Princeton University

The Treaty on the Prohibition of Nuclear Weapons

Zia Mian is a physicist and co-director of Princeton University's Program on Science and Global Security. His research interests include issues of nuclear arms control, nonproliferation, and disarmament and international peace and security. He is a co-founder of the Physicists Coalition for Nuclear Threat Reduction. Mian serves on the Board of the Union of Concerned Scientists. In 2022, he was appointed to the UN Secretary-General's Advisory Board on Disarmament Matters. He is the co-chair of the Scientific Advisory Group of the Treaty on the Prohibition of Nuclear Weapons.

Igor Moric
Princeton University

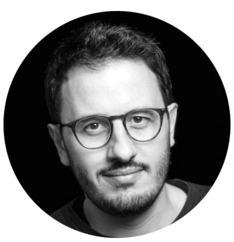
Impact of Overhead Transparency on Nuclear Stability

Igor Moric is a Postdoctoral Research Associate in the Program on Science and Global Security. Previously, he worked as a postdoctoral researcher on the MIMAC and PandaX dark matter detectors at Tsinghua University in Beijing and SJTU in Shanghai, respectively. During his PhD at CNES and Paris Sorbonne he worked on the space atomic clock PHARAO. He has an advanced Master's degree in "Space Systems Engineering" from ISAE-SUPAERO in Toulouse.

Ali Nouri
Princeton University

Working in the White House on AI & National Security

Ali Nouri was a Deputy Assistant to President Biden and Deputy Director of the White House Office of Legislative Affairs. Previously he was an Assistant Secretary in the Department of Energy where he led the Office of Congressional and Intergovernmental Affairs. Before starting his career in Washington, DC, Nouri was a postdoctoral researcher with SGS in 2007–2008. He earned a B.A. in biology from Reed College and a PhD in molecular biology from Princeton University. Ali Nouri is now a lecturer at SPIA.



Sébastien Philippe (he/him)
Princeton University

Modeling the Radiological Impact of Nuclear Explosions

Sébastien Philippe is a Research Scholar with SGS. He works on the reconstruction of fallout from past nuclear weapon tests. Philippe's book Toxique won a 2022 Sigma Award for best data journalism in the world. He received his PhD in Mechanical and Aerospace Engineering from Princeton, was a Stanton Postdoctoral fellow at Harvard, and was a nuclear weapon safety engineer in France. He currently serves on the Scientific Advisory Group of the United Nations Treaty on the Prohibition of Nuclear Weapons.

Pavel Podvig
United Nations Institute for Disarmament Research

Russian Nuclear Weapon Programs and Policies

Pavel Podvig is a member of SGS based in Geneva, where he works as a Senior Researcher at the UN Institute for Disarmament Research (UNIDIR). He started his work on arms control at the Center for Arms Control Studies at the Moscow Institute of Physics and Technology (MIPT). He has a physics degree from MIPT and a PhD in political science from the Moscow Institute of World Economy and International Relations.

Stewart Prager
Princeton University

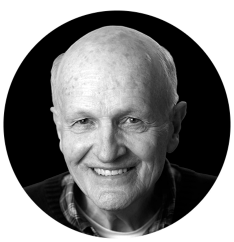
Physicists and Nuclear Weapons Today

Stewart Prager is a professor of astrophysical sciences at Princeton University, and an affiliated faculty member with the Program on Science and Global Security. From 2009–2016, he was director of the Princeton Plasma Physics Laboratory. He was vice-chair of the APS Forum on Physics and Society and is a co-founder of the Physicist Coalition for Nuclear Threat Reduction. He holds a PhD in plasma physics from Columbia University.

Leonor Tomero
JA Green & Company

The U.S. Strategic Posture and the Future of Nuclear Policy

Leonor Tomero is Vice-President for Government Relations at JA Green & Company. In 2021, she served as Deputy Assistant Secretary of Defense for Nuclear and Missile Defense Policy. Prior to this role, she served for over a decade as Counsel and Strategic Forces Subcommittee Staff Lead on the House Armed Services Committee covering strategic forces issues. Leonor holds a BA from Cornell University, an MA in Security Studies from Georgetown University and a JD, cum laude, from American University.



Frank von Hippel
Princeton University

*A Physicist Wanders into Public Policy,
and It Proves Very Interesting*

Frank von Hippel is a senior research physicist and professor of public and international affairs emeritus with the Program on Science & Global Security, which he co-founded in 1974. He received a D.Phil. in theoretical physics in 1962 from the University of Oxford. In 1993–1994, he was assistant director for national security in the White House Office of Science and Technology Policy. Von Hippel's many awards include a MacArthur Prize Fellowship.

Sharon Weiner (she/her)
American University

Ethics, Nuclear Strategy, and Deterrence

Sharon K. Weiner is a visiting researcher at the Program on Science and Global Security from American University where she is an Associate Professor of International Relations in the School of International Service. She is the author of Managing the Military: The Joint Chiefs of Staff and Civil-Military Relations (2022) and Our Own Worst Enemy? (2011). Sharon has worked in Congress, the Pentagon's Joint Staff, and the White House Office of Management and Budget. She holds a PhD in Political Science from MIT.

Lili Xia
Rutgers University

Impacts of Nuclear War on Climate and Food Security

Lili Xia is an Assistant Research Professor in the Department of Environmental Sciences at Rutgers University and serves as the Co-Director of Rutgers Impact Studies of Climate Intervention (RISCI). In recognition of her significant contributions, she was honored with the Global Peach and Health Award in 2022. Dr. Xia is slated to be the chair of the Gordon Research Conference on Climate Engineering in 2026. She earned her PhD in the Atmospheric Sciences Graduate Program at Rutgers University.

Tong Zhao
Carnegie Endowment for International Peace

Chinese Nuclear Policy and Development

Tong Zhao is a Visiting Research Scholar at SGS. He is also a Senior Fellow at the Carnegie Endowment for International Peace. He was a Stanton Nuclear Security Fellow at Harvard's Kennedy School of Government. He is on the Board of the Asia Pacific Leadership Network for Nuclear Non-Proliferation & Disarmament. Tong Zhao holds a PhD in science, technology, and international affairs from Georgia Institute of Technology, as well as an MA in international relations and a BS in physics from Tsinghua University.