

# AREG DANAGOULIAN

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## Professional Appointments:

2021 - now Associate Professor (with tenure), Nuclear Science and Engineering, MIT  
2019 - 2021 Associate Professor (without tenure), Nuclear Science and Engineering, MIT  
2014 - 2019 Assistant Professor, Nuclear Science and Engineering, MIT  
2009 - 2014 Senior Scientist, Passport Systems, Inc.  
2006 - 2008 Postdoctoral Research Associate, Los Alamos National Laboratory

## Education/degrees:

2006 UIUC Ph.D. in Experimental Nuclear Physics.  
Thesis title: "Real Compton Scattering on the Proton at 2-6 GeV"  
1999 MIT S.B. in Physics

## Current Research Interests

**Verification of nuclear disarmament treaties via resonant phenomena**

**Conformal detectors using functional fabrics**

## Advisorship and mentoring

- Current research team
  - a. Wenzhao Wei, PhD will start her employment in March, 2023
  - b. Peter Lalor entered the PhD program in 2019
  - c. Jill Rahon entered the PhD program in 2021
  - d. Grigor Tukharyan entered the SM program in 2022
  - e. Shayaan Subzwari entered the SM program in 2023
  - f. Nicole Dombrowski entered the PhD program in 2023
- Alumni and graduated students
  - a. Ethan Klein, PhD
    - Graduated in August, 2023
    - Currently attending MBA at Stanford
  - b. Vik Ohstrom, SM. Graduated in August, 2023
  - c. Peninah Levine, SM. Graduated in May, 2022
  - d. Jefferson Sesler, SM. Graduated in May, 2022
  - e. Justin Knoll, SM. Graduated in May, 2022
  - f. Will Koch, PhD
    - Graduated in May, 2021
    - Currently: lecturer at USMA
  - g. Jimmy Lee, PhD

- Graduated in May, 2020
  - Currently: postdoctoral researcher at MIT
- h. Jayson Vavrek, PhD
  - Graduated in May, 2019
  - Currently: postdoctoral researcher at LBNL
- i. Buck Earl O'Day, PhD
  - graduated in May, 2015.
  - Currently: Assistant Professor at Air Force Institute of Technology
- j. Jacob Bickus, S.M.
- k. Ezra Engel, S.M.
- l. Robert Nelson, S.M.
- m. Jeremiah Collins, S.M.
- n. Jake Hecla, S.B.
  - Graduated in May, 2017
  - Currently: PhD program in Berkeley
- o. Jill Rahon, S.M.
  - Graduated in May, 2016
  - Currently: lecturer at West Point Academy
- p. Jacob Miske, S.B.
- Mentoring of researchers (current and past)
  - a. Farheen Naqvi, PhD. Currently: research faculty at TAMU
  - b. Ruaridh Macdonald, PhD. Currently: postdoctoral researcher at MIT
  - c. Brian Henderson, PhD -- Stanton postdoctoral Fellow. Currently: senior research scientist at MITRE
  - d. Zachary Hartwig, PhD -- DOE ORISE postdoctoral fellow. Currently: Assistant Professor at MIT
  - e. Bari Osmanov, PhD. Currently: research scientist at LANL

## Selected Publications

(asterisk\* denotes research and student advisees)

1. Peter Lalor, Areg Danagoulian, "A semiempirical transparency model for dual energy cargo radiography applications," NIM A, Vol. 1051 (2023) ,<https://doi.org/10.1016/j.nima.2023.168193>
2. Ethan A. Klein\*, Farheen Naqvi\*, Jacob E. Bickus\*, Hin. Y. Lee\*, Robert J. Goldston, Areg Danagoulian, "Neutron Resonance Transmission Analysis with a Compact Deuterium-Tritium Neutron Generator," *Physical Review Applied*, vol. 15 (2021) 054026, <https://doi.org/10.1103/PhysRevApplied.15.054026>, <https://arxiv.org/abs/1911.12276>
3. Hin Y. Lee\*, Brian S. Henderson\*, Roberts G. Nelson\*, Areg Danagoulian, "Multiple Monoenergetic Gamma Radiography (MMGR) with a compact superconducting cyclotron," *Journal of Applied Physics*, vol. 128 (2020) 11; <https://doi.org/10.1063/5.0002201>
4. Ezra. M. Engel\*, Areg Danagoulian, "A physically cryptographic warhead verification system using neutron induced nuclear resonances," *Nature Communications*, vol. 10 (2019) <https://doi.org/10.1038/s41467-019-12386-0>

5. Jayson R Vavrek\*, Brian S Henderson\*, Areg Danagoulian, "Experimental demonstration of an isotope-sensitive warhead verification technique using nuclear resonance fluorescence," *Proceedings of National Academy of Sciences*, vol. 115 (2018) 17 <https://doi.org/10.1073/pnas.1721278115>
6. Brian S. Henderson\*, Hin Y. Lee\*, Thomas D. MacDonald\*, Roberts G. Nelson\*, Areg Danagoulian, "Experimental Demonstration of Multiple Monoenergetic Gamma Radiography for Effective Atomic Number Identification in Cargo Inspection," *Journal of Applied Physics*, vol. 123 (2018) 17 <https://doi.org/10.1063/1.5025805>
7. J. Hecla\*, A. Danagoulian, "Nuclear Disarmament Verification via Resonant Phenomena," *Nature Communications*, vol. 9 (2018) 1, p.1259 <https://doi.org/10.1038/s41467-018-03680-4>
8. R.S. Kemp, A. Danagoulian, R.R. Macdonald, J.R. Vavrek\*, "Physical Cryptographic Verification of Nuclear Warheads," *Proceedings of the National Academy of Sciences*, vol. 113 (2016) 31, *all authors contributed equally to this publication*
9. B.E. O'Day III\*, Z.S. Hartwig\*, R.C. Lanza, A. Danagoulian, "Initial Results from a Multiple Monoenergetic Gamma Radiography System for Nuclear Security," *Nuclear Instruments and Methods in Physics Research, Section A*, vol. 832 (2016) pp. 68–76
10. A. Danagoulian *et al.*, "Compton Scattering Cross Section on the Proton at High Momentum Transfer", *Physical Review Letters* , Vol. 98, 152001 (2007) <https://doi.org/10.1103/PhysRevLett.98.152001>
11. R. Hasty *et al.*, "Strange Magnetism and the Anapole Structure of the Proton," *Science*, Vol. 290 (2000), pp. 2117-2119.

**Publications -- the rest (peer reviewed publications, invited articles, and proceedings)**

12. Peter Lalor, Areg Danagoulian, "Fundamental Limitations of Dual Energy X-Ray Scanners for Cargo Content Atomic Number Discrimination,"(2023) <http://dx.doi.org/10.2139/ssrn.4479725>
13. Peter Lalor, Areg Danagoulian, "Direct atomic number reconstruction of dual energy cargo radiographs using a semiempirical transparency model", submitted to Applied Radiation and Isotopes (2023) <https://arxiv.org/abs/2307.12099>
14. E. Klein, F. Naqvi, A. Danagoulian, "NEUTRON RESONANCE TRANSMISSION ANALYSIS (NRTA) FOR NUCLEAR FUEL CHARACTERIZATION USING A PORTABLE DT NEUTRON GENERATOR," Proceedings of the INMM & ESARDA Joint Virtual Annual Meeting August 23-26 & August 30-September 1 (2021), <https://sti.srs.gov/fulltext/SRNL-STI-2021-00383.pdf>
15. A. Danagoulian, J. N. Miske\* and E. A. Klein\*, "Grasshopper, a Geant4 Front End: Validation and Benchmarking," *2021 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, Piscataway, NJ, USA (2021), pp. 1-7, doi: 10.1109/NSS/MIC44867.2021.9875720
16. S.J. Jepeal, A. Danagoulian, L.A. Kesler, D.A. Korsun, H.Y. Lee\*, N. Schwartz, B.N. Sorbom, E. Velez Lopez, Z.S. Hartwig, "An accelerator facility for intermediate energy proton irradiation and testing of nuclear materials," *NIM B*, vol. 489 (2021) pp. 41-49 <https://doi.org/10.1016/j.nimb.2020.12.020>
17. Areg Danagoulian, "Verification of Arms Control Treaties with Resonance Phenomena," *Nuclear Physics News* v30 (2020) 1, pp 25-30 <https://doi.org/10.1080/10619127.2020.1717271>
18. Ezra M. Engel\*, Ethan A. Klein\*, A. Danagoulian, "Feasibility study of a compact Neutron Resonance Transmission Analysis instrument," *AIP Advances* 10, 015051 (2020) <https://doi.org/10.1063/1.5129961>

19. Michael A. Ford, Buckley E. O'Day\*, John W. McClory, Areg Danagoulian, "Development of a Neutron Spectrometer Utilizing Rubberized Eu:LiCAF Wafers," *Nuclear Instruments and Methods in Physics Research A*, vol. 954 (2020) 161685 <https://doi.org/10.1016/j.nima.2018.11.144>
20. J. Rahon\*, A. Danagoulian, "Hydrogenous content identification in heterogeneous cargoes via multiple monoenergetic neutron radiography," *Nuclear Instrumentation Methods in Physics Research A* 949 (2020) 162860 <https://doi.org/10.1016/j.nima.2019.162860>
21. J.R. Vavrek\*, B.S. Henderson\*, A. Danagoulian, "Validation of Geant4's G4NRF module against nuclear resonance fluorescence data from  $^{238}\text{U}$  and  $^{27}\text{Al}$ ," *Nuclear Instrumentation Methods in Physics Research B* 459 (2019) pp. 188-195 <https://doi.org/10.1016/j.nimb.2019.08.034>
22. R.A. Soltz, A. Danagoulian *et al.*, "Fissile material detection using neutron time-correlations from photofission," *AIP Advances* 9, 025011 (2019) <https://doi.org/10.1063/1.5082174>
23. Ethan Klein\*, Ezra Engel\*, Areg Danagoulian, "Epithermal Neutron Transmission Imaging for Nuclear Security Applications," *Proceedings of the 60th Annual Meeting of the Institute of Nuclear Materials Management* (2019), won the second-place student paper award from INMM's Nonproliferation and Arms Control Division
24. J.R. Vavrek\*, B.S. Henderson\*, A. Danagoulian, "High-accuracy Geant4 simulation and semi-analytical modeling of nuclear resonance fluorescence," *Nuclear Instruments and Methods in Physics Research, Section B* 433 (2018), pp. 34-42 <https://doi.org/10.1016/j.nimb.2018.07.023>
25. M. A. Ford, B. E. O'Day\*, J. W. McClory, M. K. Sharma, A. Danagoulian, "Evaluation of Eu:LiCAF for neutron detection utilizing SiPMs and portable electronics," *Nuclear Instruments and Methods in Physics Research A* 908, (2018) pp. 110-116 <https://doi.org/10.1016/j.nima.2018.08.016>
26. Michael A. Ford, B. E. O'Day\*, Member, John W. McClory, Areg Danagoulian, "Evaluation of LiCAF for Neutron Spectroscopy using SiPMs and Portable Electronics," *Proceedings of Symposium of Radiation Measurements and Applications* (2018)
27. J. R. Vavrek\*, B. S. Henderson\*, A. Danagoulian, "The Radiation Transport Model for Physical Cryptographic Verification of Nuclear Warheads," invited paper, *American Nuclear Society Annual Meeting* (2018)
28. A. Danagoulian, Jayson R. Vavrek\*, *et al.*, "Warhead Verification with Transmission Nuclear Resonance Fluorescence", proceedings of *American Nuclear Science Conference* (2017), invited paper, chosen for "Best Papers of ANTPC" session as part of 8 papers from 130.
29. J. R. Vavrek\*, S. J. Collins\*, A. Danagoulian, B. S. Henderson\*, R. S. Kemp, R. Lanza, and R. Macdonald, "Experimental Progress Towards a Physical Cryptographic Warhead Verification Protocol," *Proceedings of the 58th Annual Institute for Nuclear Materials Management* (2017)
30. B. S. Henderson\*, Areg Danagoulian, John W. Fisher III, Richard C. Lanza, Hin Lee\*, T.D. MacDonald\*, Roberts Nelson\*, Guy Rosman, and Sue Zheng, "Detection of Special Nuclear Materials Using Monoenergetic Gamma-ray Radiography", *Proceedings of the 58th Annual Meeting of the Institute of Nuclear Materials Management* (2017)
31. J.R. Vavrek\*, A. Danagoulian, R.S. Kemp, R.R. Macdonald, "Warhead Verification with NRF," *invited paper, Advances in Nuclear Nonproliferation Technology and Policy Conference*, Santa Fe, NM (2016)
32. J. Rahon\*, A. Danagoulian, T.D. MacDonald\*, Z.S. Hartwig, R. Lanza, "Spectroscopic neutron radiography for a cargo scanning system," *Nuclear Instruments and Methods in Physics Research A* 820, (2016), pp. 141-145
33. D.J. Hamilton, A. Shahinyan *et al.*, "An electromagnetic calorimeter for the JLab real Compton scattering experiment," *Nuclear Instruments and Methods A*, Vol. 643, Issue 1, pp. 17-28 (2011)

34. A. Danagoulian, W. Bertozzi *et al.*, “Prompt neutrons from photofission and its use in homeland security applications,” *2010 IEEE International Conference on Technologies for Homeland Security* (2010), pp. 379 - 384
35. L. Barron-Palos *et al.*, “Measurement of parity-violating neutron capture gamma asymmetries at low-energies,” *Revista Mexicana de Física* 55 (2) 18–22 (2009)
36. M. Sharma *et al.*, “Neutron Beam Effects on Spin-Exchange-Polarized  $^3\text{He}$ ,” *Physical Review Letters*, Vol 101, 083002 (2008)
37. A. Danagoulian *et al.*, “Real Compton Scattering on Proton at High Momentum Transfers,” *Nuclear Physics A* , Vol. 755, 281 (2005)
38. V.H. Mamyán *et al.*, “Cross Section of Compton Scattering from Proton at High Momentum Transfer,” *Journal of Physics, Izvestia National Academy of Sciences of Armenia* (2005)
39. D.J. Hamilton *et al.*, “Polarization Transfer in Proton Compton Scattering at High Momentum transfer,” *Physical Review Letters* Vol. 94, 242001 (2005)
40. T. M. Ito *et al.*, “Parity-Violating Electron Deuteron Scattering and the Proton’s Neutral Weak Axial Vector Form Factor,” *Physical Review Letters* , Vol. 92, 102003 (2004)

## Honors and Awards

- Arms Control Association’s [Arms Control Person\(s\) of the Year award](#), “**For developing an innovative new nuclear disarmament verification process using neutron beams**,” 2020. Other contenders included the French president Emmanuel Macron, multiple US Congress representatives, and the Swedish Ministry of Foreign Affairs.
- American Nuclear Society Radiation Science and Technology Award, “**For technology-critical contributions exploiting nuclear resonance phenomena for warhead verification in nuclear disarmament and nuclear detection techniques in cargo security**,” 2019
- College of Engineering Research Support Committee (RSC) award, MIT, 2019
- Norman C. Rasmussen Career Development Chair in Nuclear Science and Engineering, MIT, 2017
- Teaching with Digital Technology Award Nomination, MIT, 2016
- College of Engineering Research Support Committee (RSC) award, MIT, 2015
- IEEE/NPSS Radiation Instrumentation Early Career Award, 2015, “**For contributions to the field of cargo security and active interrogation, in particular for the development of the Prompt Neutrons from Photofission (PNPF) technique in fissionable material detection.**”
- 2012 Award for Superior Performance in Support of the DHS Domestic Nuclear Detection Office Mission (issued to the SNAR program, PSI)
- June 2005 - Postdoctoral Fellowship for Foreign Scientists, Ministry of Research, France

## Patents

- “Photon Induced Neutron Time Correlations in Special Nuclear Materials,” Passport Systems Inc., Lawrence Livermore National Laboratory. LLNL Record of Invention (ROI) #: IL-12894.
- “Proton Inelastic Reactions for Multiple Monoenergetic Gamma Radiography (MMGR),” U.S. Application No.: 62/814448

## Invited Talks

- December, 2020: “Arms Control Treaty Verification with Nuclear Resonances,” Global Security Technical Webinar Series
- November, 2020: “Arms Control Verification with Nuclear Resonances,” Laboratory of Nuclear Science, MIT
- October, 2020: “Warhead Verification with Nuclear Resonances,” Review of Capabilities for Detection, Verification, and Monitoring of Nuclear Weapons and Fissile Material, National Academy of Sciences (NAS). Invited as one of the two experts (along with Prof. Alex Glaser, Princeton) to brief NAS on warhead verification.
- September, 2020: “Nuclear Physics and Nuclear Disarmament,” Department of Physics, University of Hawaii
- June, 2020: “Nuclear Disarmament Verification with Resonance Phenomena,” Korea Atomic Energy Research Institute
- May, 2020: “Nuclear Disarmament Verification with Resonance Phenomena,” Korea Institute of Nuclear Nonproliferation And Control
- March, 2020: “Innovations in Nuclear Disarmament Verification: Advancing Technology and Approaches,” invited panel participant, International Partnership for Nuclear Disarmament Verification Symposium, Geneva, Switzerland -- cancelled due to COVID-19
- October, 2019: “Cargo Security and Material Science with Superconducting Cyclotrons,” Global Innovation Forum / Transforming Intelligence, Yerevan, Armenia
- July, 2019: “Treaty Verification with Resonance Phenomena,” International Nuclear Physics Conference, Glasgow, Scotland
- April, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Department of Nuclear Engineering, NCSU
- March, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Program on Science and Global Security, Princeton University
- March, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Center for International Security and Cooperation, Stanford University
- February, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Department of Physics, UIUC
- February, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Department of Physics colloquium, Notre Dame University
- January, 2019: “Nuclear Disarmament Verification via Resonant Phenomena,” Physics Division, Los Alamos National Laboratory
- September, 2018: “Nuclear Disarmament Verification via Resonant Phenomena,” Correlations in Partonic and Hadronic Interactions, Yerevan, Armenia
- September, 2018: “Nuclear Disarmament Verification via Resonant Phenomena,” Nuclear Engineering and Radiological Sciences, University of Michigan
- May, 2018: “Nuclear Disarmament Verification via Resonant Phenomena,” Laboratory of Nuclear Science, Department of Physics, MIT
- April, 2018: “Nuclear Disarmament Verification via Resonant Phenomena,” Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, CA

- April, 2018: “Nuclear Disarmament Verification via Resonant Phenomena,” Department of Engineering, UC Berkeley, CA
- October, 2017: “Physical Cryptographic Warhead Verification,” “Best of ANTPC 2016 Papers,” American Nuclear Society, Washington DC.  
Chosen as part of 8 papers from 130.
- March, 2017: “Verification of Warheads Using Physical Cryptography,” College of Engineering, American University of Armenia, Yerevan, Armenia
- January, 2017: “Multiple Monoenergetic Gamma Radiography (MMGR) for Cargo Security,” Department of Physics, University of Massachusetts at Lowell, MA
- November, 2016: “Warhead Verification with Nuclear Resonance Fluorescence (NRF),” Union of Concerned Scientists, monthly webinar
- October, 2016: “Nuclear Security: Detection and Verification of Nuclear Materials,” Department of Nuclear Engineering, Ohio State University, OH
- September, 2016: “Warhead Verification with Nuclear Resonance Fluorescence (NRF),” Advances in Nuclear Nonproliferation Technology and Policy Conference, Santa Fe, NM
- May, 2016: “Nuclear Security: Detection and Verification of Nuclear Materials,” Lawrence Livermore National Laboratory, Physics division seminar
- January, 2016: “Nuclear Security,” Air Force Institute of Technology, physics colloquium
- May, 2015: “Nuclear Security,” MIT-China Low Carbon Program, MIT Energy Initiative (MITEI), MIT
- April, 2015: “Detection of fissionable materials in cargoes using monochromatic photon radiography,” APS Division of Nuclear Physics meeting, Baltimore. APS press conference.
- January, 2015: “Nuclear Detection in Nuclear Security,” Physics Lecture Series, MIT

## Service

- Member of the IEEE RISC Award committee
- Faculty co-director of the MISTI Eurasia program, MIT
- Graduate Admission Committee, NSE, MIT
- Joint U.S./Russia Project on Monitoring and Verification, led by National Academy of Sciences and consisting of world experts on treaty verification, 2020
- Conference Organizer: American Physical Society’s Division of Nuclear Physics Conference, 2021
- Conference Session Chair: IEEE Nuclear Science Symposium, 2019 and 2020
- Journal reviewer:
  - IEEE Transactions of Nuclear Science
  - Nuclear Instrumentations and Methods
  - Science and Global Security
  - Applied Radiation and Isotopes
  - Physical Review Applied
- 2016: NNSA proposal review panel -- University of Illinois at Urbana-Champaign
- 2015-present: committee on radiation safety, MIT
- 2015-present: organized yearly Geant4 week-long tutorial workshop at MIT, 50-60 participants

- 2015: NNSA proposal review panel -- University of Michigan
- 2015: NNSA proposal review panel -- Lawrence Berkeley National Laboratory
- 2014-present: graduate admission committee, Department of Nuclear Science and Engineering, MIT
- 2013: proposal review panel for the joint NSF and DNDI Academic Research Initiative (ARI)
- 2011: proposal review panel for the joint NSF and DNDI Academic Research Initiative (ARI)

### **Languages (fluent)**

Armenian(native), English, Russian, French , Italian