

**AREG DANAGOULIAN**

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**Professional Appointments:**

2014 - present 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****Monochromatic sources for cargo inspection****Advisorship and mentoring**

- Current research team
  - a. Jimmy Lee: entered the PhD program in 2015
  - b. Will Koch entered the PhD program in 2018
  - c. Ethan Klein entered the PhD program in 2018
  - d. Peter Lalor entered the PhD program in 2019
  - e. Jacob Bickus entered the MS program in 2019
  - f. Benjamin Sheffer: undergraduate research assistant
  - g. Ruaridh Macdonald, PhD postdoctoral researcher
- Alumni and graduated students (most recent first)
  - a. Jayson Vavrek, PhD.
    - Graduated in May, 2019
    - Currently: postdoctoral researcher at LBNL
  - b. Buck Earl O'Day, PhD
    - graduated in May, 2015.
    - Currently: Assistant Professor at Air Force Institute of Technology
  - c. Ezra Engel, S.M.
  - d. Robert Nelson, S.M.
  - e. Jeremiah Collins, S.M.
  - f. Jake Hecla, S.B.
    - Graduated in May, 2017
    - Currently: PhD program in Berkeley

- g. Jill Rahon, S.M.
  - Graduated in May, 2016
  - Currently: lecturer at West Point Academy
- Mentoring of researchers (current and past)
  - a. Brian Henderson, PhD -- Stanton postdoctoral Fellow
    - Currently: Vice President of Engineering, Lantern UAS Co.
  - b. Zachary Hartwig, PhD -- DOE ORISE postdoctoral fellow
    - Currently: Assistant Professor at MIT
  - c. Bari Osmanov, PhD -- research scientist, worked on the NRF project
    - Currently: research scientist at LANL

## Selected Publications

### \* denotes postdoctoral and student advisees

1. E. M. Engel\*, A. Danagoulian, "A physically cryptographic warhead verification system using neutron induced nuclear resonances," *Nature Communications*, vol. 10 (2019) 1, ([arXiv:1907.06978](https://arxiv.org/abs/1907.06978))
2. 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 ([arXiv:1712.02904](https://arxiv.org/abs/1712.02904))
3. 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, ([arXiv:1802.04225](https://arxiv.org/abs/1802.04225))
4. J. Hecla\*, A. Danagoulian, "Nuclear Disarmament Verification via Resonant Phenomena," *Nature Communications*, vol. 9 (2018) 1, p.1259 ([arXiv:1709.09736](https://arxiv.org/abs/1709.09736))
5. 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*
6. 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
7. A. Danagoulian *et al.*, "Compton Scattering Cross Section on the Proton at High Momentum Transfer", *Physical Review Letters*, Vol. 98, 152001 (2007)
8. 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 journals and proceedings)

9. Ezra M. Engel\*, Ethan A. Klein\*, A. Danagoulian, "Feasibility study of a compact Neutron Resonance Transmission Analysis instrument," *Applied Physics Letters*, in review  
<https://arxiv.org/abs/1909.11120>
10. 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://arxiv.org/abs/1807.02596>
11. 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>, <https://arxiv.org/abs/1909.06920>
12. M. A. Ford, B. E. O'Day\*, J. W. McClory, A. Danagoulian, "Development of a Neutron Spectrometer Utilizing Rubberized Eu:LiCAF Wafers," *Nuclear Instruments and Methods in Physics Research A* (2019) <https://doi.org/10.1016/j.nima.2018.11.144>, in press
13. R.A. Soltz, A. Danagoulian *et al.*, "Fissile material detection using neutron time-correlations from photofission," *AIP Advances* 9, 025011 (2019) [arxiv:1812.03807](https://arxiv.org/abs/1812.03807)
14. 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
15. 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
16. 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
17. 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)
18. 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)
19. 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.
20. 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)
21. 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)

22. 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)
23. 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
24. 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)
25. 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
26. 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)
27. M. Sharma et al., “Neutron Beam Effects on Spin-Exchange-Polarized  $^3\text{He}$ ,” *Physical Review Letters*, Vol 101, 083002 (2008)
28. A. Danagoulian et al., “Real Compton Scattering on Proton at High Momentum Transfers,” *Nuclear Physics A* , Vol. 755, 281 (2005)
29. V.H. Mamyan et al., “Cross Section of Compton Scattering from Proton at High Momentum Transfer,” *Journal of Physics, Izvestia National Academy of Sciences of Armenia* (2005)
30. D.J. Hamilton et al., “Polarization Transfer in Proton Compton Scattering at High Momentum transfer,” *Physical Review Letters* Vol. 94, 242001 (2005)
31. 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)

## 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

## Honors and Awards

- 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 DNDO Mission (issued to the SNAR program, PSI)
- June 2005 - Postdoctoral Fellowship for Foreign Scientists, Ministry of Research, France

## Service

- Journal reviewer:
  - IEEE Transactions of Nuclear Science
  - Nuclear Instrumentations and Methods
  - Science and Global Security
  - Applied Radiation and Isotopes
- 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 DNDO Academic Research Initiative (ARI)
- 2011: proposal review panel for the joint NSF and DNDO Academic Research Initiative (ARI)

## Invited Talks

- 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

### **Languages (fluent)**

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