

Zachary S. Hartwig, Ph.D.

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RESEARCH INTERESTS

Development and application of radiation detectors, radiation sources, and particle transport simulation to solve complex problems in nuclear science and engineering

- Radiation and particle detector development
- Satellite-born detectors and energy sources
- Accelerator-based nuclear and material science
- Fusion energy nuclear science and device design
- Monte Carlo particle transport simulations
- Digital data acquisition and analysis systems
- Active and passive detection in nuclear security
- Fusion plasma-material interaction science

EDUCATION

Ph.D. in Nuclear Science, MIT. February 2014.

- Concentration: Fusion nuclear science
- GPA: 4.7 / 5.0
- Thesis: *An accelerator-based in-situ diagnostic for plasma-material interactions science on magnetic fusion devices*

B.A. in Physics, Boston University. May 2005.

- Concentration: Experimental particle physics
- GPA: 3.7 / 4.0
- Degree awarded *summa cum laude*
- Recipient of Alumni Award in Physics
- Dean's List all 8 semesters

NOTABLE

ACHIEVEMENTS

- *Recipient*, U.S. Department of Energy ORISE Postdoctoral Fellowship, Jan 2015.
- *Recipient*, MIT NSE Del Favero Prize in Nuclear Science and Engineering, May 2014.
- *Fellow*, 2013 Kavli Frontiers of Science.
- *Invited speaker*, Kavli Frontiers of Science Meeting, November, 2013.
- *USA Cycling National Champion*, Collegiate Track Division II Team Omnium. September 2012.
- *Recipient*, MIT NSE Special Award, Excellence in Science Communication and Policy. May 2012.
- *Recipient*, MIT Plasma Science and Fusion Center Award, Science Education and Outreach. July 2012.
- *Recipient*, MIT International Science and Technology Initiative Global Seed Fund Grant. May 2011.
- *Recipient*, Boston University Alumni Prize for Excellence in Physics. May 2005.

RESEARCH

EXPERIENCE

- **Postdoctoral associate/fellow, MIT (2013-present)**: Initiated and lead a number of diverse research efforts. Lead data acquisition, analysis, and computation efforts for two nuclear security projects (Low-dose monoenergetic gamma radiography system; Zero knowledge warhead verification system). Conducted on-going efforts to bring an ultracompact superconducting cyclotron to MIT for nuclear security and materials research. Proposed and lead a collaboration with MIT Aeronautics and Astronautics Engineering department on novel low-cost satellite-based particle spectrometers and dosimeters. Established a new accelerator science and detector development laboratory with collaborators. Co-founded a design group at MIT Plasma Science and Fusion Center to pursue a new approach to fusion energy with private funding and advanced technology. Continued development of the AIMS diagnostic for plasma-material interaction science on the Alcator C-Mod tokamak.
- **Advisor, Tokamak Energy U.K. (2013-2014)**: Advised a private company on Monte Carlo neutronics simulations for magnetic fusion applications. The work involved training team members on advanced fusion neutronics and improving existing in-house simulation capabilities.
- **Ph.D student, MIT (2007-2013)**: Designed and demonstrated an innovative accelerator-based materials diagnostic for magnetic fusion devices. The research involved creating advanced particle transport simulations, applying radiation detection in a challenging environment, implementing a custom digital data acquisition system, and creating data analysis tools.
- **Advisor, Neutron Inc. (2009-2010)**: Collaborated on development of an innovative lithium-6-based detector for homeland security. The research involved using particle transport simulations to optimize the design and cost of the final detector.
- **Advisor, Cyclotron Group, MIT (2010)**: Predicted the impact of nuclear heating on superconducting magnets in a proposed ultracompact superconducting cyclotron during various operational scenarios using particle transport simulations.
- **Research Assistant, Boston University (2004-2006)**: Developed a particle physics simulation for the Muon g-2 Experiment, previously at Brookhaven National Lab and now at Fermi National Lab. The simulation is presently used as a leading computational design tool for the next generation of the experiment. Performed experimental work on particle detection and data acquisition for the M μ LAN muon lifetime experiment at Paul Scherrer Institute, Switzerland, 2005.

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DOCTORAL DISSERTATION

MIT Department of Nuclear Science and Engineering Ph.D. Dissertation

- Z.S. Hartwig (2013). *An In-situ Accelerator-based Diagnostic for Plasma-Material Interactions on Magnetic Fusion Devices*. Doctoral Dissertation, MIT, Cambridge MA, USA.
[Available for download here](#)

RESEARCH PUBLICATIONS

Accelerator-based In-situ Materials Surveillance (AIMS)

- Z.S. Hartwig *et al.* *Fuel retention measurements in Alcator C-Mod using Accelerator-based In situ Materials Surveillance*. J. Nucl. Mat. **263** (2015) 73. [doi:10.1016/j.jnucmat.2014.09.056](https://doi.org/10.1016/j.jnucmat.2014.09.056)
- Z.S. Hartwig *et al.* *An in-situ accelerator-based diagnostic for plasma-material interactions on magnetic fusion devices*. Rev. Sci. Instr. **84** (2013) 123503. [doi:10.1064/1.4832420](https://doi.org/10.1064/1.4832420)
- Z.S. Hartwig and D.G. Whyte. *Simulated plasma-facing component measurements for an in-situ surface diagnostic on Alcator C-Mod*. Rev. Sci. Instr. **81** (2010) 10E106. [doi:10.1063/1.4832420](https://doi.org/10.1063/1.4832420)

Magnetic fusion energy design and engineering

- Z.S. Hartwig *et al.* *An initial study of demountable, high-temperature superconducting magnets for the Vulcan tokamak conceptual design*. Fus. Eng. Design **87** (2012) 201. [doi:10.1016/j.fusengdes.2011.10.002](https://doi.org/10.1016/j.fusengdes.2011.10.002)
- G.M. Olynyk, Z.S. Hartwig, *et al.* *Vulcan: a steady-state tokamak for reactor-relevant plasma-material interaction science*. Fus. Eng. Design **87** (2012) 224. [doi:10.1016/j.fusengdes.2011.12.009](https://doi.org/10.1016/j.fusengdes.2011.12.009)
- G.M. Olynyk, Z.S. Hartwig, *et al.* *Assessing the feasibility of a high-temperature, helium-cooled vacuum vessel and first wall for the Vulcan tokamak conceptual design*. Fus. Eng. Design **87** (2012) 248. [doi:10.1016/j.fusengdes.2011.12.018](https://doi.org/10.1016/j.fusengdes.2011.12.018)
- D.G. Whyte *et al.* *Reactor similarity for plasma-material interactions in scaled-down tokamaks as the basis for the Vulcan conceptual design*. Fus. Eng. Design **87** (2012) 234. [doi:10.1016/j.fusengdes.2011.12.011](https://doi.org/10.1016/j.fusengdes.2011.12.011)
- Z.S. Hartwig and M. Zucchetti. *Neutronics studies for a compact, high-field tokamak neutron source*. Fus. Sci. Tech. **60** (2011) 725. [Available online at http://www.ans.org/pubs/journals/fst/a_12471](http://www.ans.org/pubs/journals/fst/a_12471)

Particle and radiation detector design, simulation, and data acquisition

- Z.S. Hartwig. *The ADAQ framework: An integrated toolkit for data acquisition and analysis with real and simulated radiation detectors*. Nucl. Instr. and Meth. A *In Press*, 2016.
- Z.S. Hartwig and P. Gumplinger. *Simulating response functions and pulse shape discrimination for organic scintillation detectors with Geant4*. Nucl. Instr. and Meth. A **737** (2014) 155. [doi:10.1016/j.nima.2013.11.027](https://doi.org/10.1016/j.nima.2013.11.027)
- A. Inglis *et al.* *Glass panel Lithium-6 Detector*. IEEE Conference on Homeland Security (2012). [doi:10.1109/THS.2012.6459887](https://doi.org/10.1109/THS.2012.6459887)

Experimental particle physics (The Muon Lifetime Analysis (M μ LAN) experiment)

- D.M. Webber *et al.* *Measurement of the positive muon lifetime and determination of the Fermi constant to part-per-million precision*. Phys. Rev. Lett. **106** (2011) 041803. [doi:10.1103/PhysRevLett.106.041803](https://doi.org/10.1103/PhysRevLett.106.041803)
- V. Tishchenko *et al.* *Detailed report of the MuLan measurement of the positive muon lifetime and determination of the Fermi constant*. Phys. Rev. D. **87** (2013) 052003. [doi:10.1103/PhysRevD.87.052003](https://doi.org/10.1103/PhysRevD.87.052003)

REFERENCE PUBLICATIONS

A comprehensive physics and mathematics reference for magnetic fusion

- Z.S. Hartwig and Y.A. Podpaly. *The Magnetic Fusion Energy Formulary*. Self-published, 2016. [Available online at http://www-internal.psfc.mit.edu/research/MFEFormulary](http://www-internal.psfc.mit.edu/research/MFEFormulary).

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TEACHING EXPERIENCE

- **UROP advisor:** Florent Sainct (2009), Jake Jurewicz (2011), Gabriel Ledoux (2012, 2013)
- **Undergraduate thesis mentor:** Lauren Chilton, MIT Class of 2012.
- **Teaching assistant:** 22.63: Engineering Principles for Fusion Reactors (Prof. D. Whyte). Spring 2012.
- **Teaching assistant:** 22.105 : Electromagnetic Interactions (Prof. D. Whyte). Fall 2010.
- **Private tutor:** High school physics for several Boston University Academy Students. 2005-2006.

LEADERSHIP EXPERIENCE

- **Organizer:** U.S. fusion student advocacy trip to 30 Congressional offices in Washington DC. June 2012.
- **Mediator:** Conflict resolution, MIT Resistance for Easing Friction and Stress Program. January 2010.

HARDWARE EXPERTISE

Detector Data Acquisition

- CAEN S.p.A. data acquisition systems, Tektronix digital oscilloscopes

Particle Detector Construction

- Scintillator crystals, photomultiplier tubes, silicon avalanche photodiodes, silicon photomultiplier, signal preamplifiers, microcontrollers, soldering, basic machining, vacuum hardware, detector test platforms

COMPUTER EXPERTISE

Programming Languages

- C, C++, Python, IPython/IPython notebooks, Open MPI, Unix shell scripting, GNU make, Matlab, IDL, HTML

Particle Transport and Nuclear Physics Codes

- Geant4, MCNP6/5/X, DAGMC CAD-based neutronics, SRIM/TRIM, EASY, NJOY, TALYS, EMPIRE

Data acquisition, storage and analysis

- ROOT, MDSplus
- Lead developer of the ADAQ framework

Computer-Aided Design (CAD) and Analysis

- Solid Edge ST5, CUBIT Tool Suite, COMSOL Multiphysics

Cloud Computing

- Amazon Web Services (EC2 Cloud Compute Framework)

Productivity Software

- Windows OS, Linux OS (Fedora, RHEL, Ubuntu), Emacs, Subversion, Git, GitHub, L^AT_EX, GIMP, Inkscape