Zachary S. Hartwig, Ph.D.

hartwig@psfc.mit.edu +1 314 922 6495 (cell) +1 617 253 5471 (work)
77 Massachusetts Ave, NW17-115, Cambridge MA 02139 http://www.psfc.mit.edu/∼hartwig

Research Interests

Advancing radiation detection, particle transport simulations, and ion beam analysis to solve complex problems in nuclear science and engineering

- Plasma-material interactions in magnetic fusion
- Particle and radiation detectors
- Monte Carlo particle transport simulation
- Ion beam materials analysis
- Digital data acquisition and pulse processing
- Production of fundamental nuclear data
- Conceptual designs for magnetic fusion energy
- Radiation detection for nuclear security

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*, MIT NSE Del Favero Prize in Nuclear Science and Engineering, May 2014.
- *Fellow*, 2013 Kavli Frontiers of Science.
- *Invited talk*, Kavli Frontiers of Science Meeting, November, 2013.
- *Invited talk*, APS Division of Plasma Physics Meeting, Novermber, 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 Initative Global Seed Fund Grant. May 2011.
- *Keynote speaker*, MIT Nuclear Science and Engineering Department (NSE) Research Expo. March 2011.
- *Recipient*, Boston University Alumni Prize for Excellence in Physics. May 2005.

Research Experience

- **Postdoctoral Associate, MIT (2013-present)**: Continuing to develop ion beam analysis techniques and a novel accelerator-based diagnostic for plasma-material interactions in the Alcator C-Mod tokamak. Leading computational conceptual design for magnetic fusion energy devices. Providing particle transport simulation, detector design, and data acquisition expertise to several nuclear security projects.

- **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 analysis tools for digital pulse processing of detector data. Project involved significant team work with Alcator C-Mod personnel and mentoring of younger students.

- **Advisor, Neotron Inc. (2009-2010)**: Played a key role in the development of an innovative lithium-6-based detector for homeland security. The research involved creating high-fidelity models of proposed detector designs using particle transport simulations and working with a team to optimize cost and detection efficiency within the engineering constraints to achieve a final design.

- **Advisor, Cyclotron Group, MIT (2010)**: Predicted the deleterious effects of losing control of an accelerated particle beam in a proposed ultracompact superconducting cyclotron facility. The research involved creating and benchmarking a high-fidelity model of the cyclotron and calculating nuclear heating and radiation damage to the superconducting magnets as a result of various accident scenarios.

- **Research Assistant, Boston University (2004-2006)**: Developed a particle physics simulation for the Muon g-2 Experiment, which searches for physics beyond the Standard Model of particle physics. The simulation is presently used and developed by a world-wide collaboration as the leading computational design tool for the next generation of the experiment that will run at Fermilab National Accelerator Laboratory in 2016. Experimental work on particle detection and data acquisition performed on the MμLAN experiment to measure the lifetime of the muon at Paul Sherrer Institute, Switzerland, 2005.

Zachary S. Hartwig, Ph.D.

hartwig@psfc.mit.edu +1 314 922 6495 (cell) +1 617 253 5471 (work)
77 Massachusetts Ave, NW17-115, Cambridge MA 02139 http://www.psfc.mit.edu/∼hartwig

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 *eg al. Fuel retention measurements in Alcator C-Mod using Accelerator-based In situ Materials Surveillance.* J. Nucl. Mat. **In Press** (2014). doi: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
- 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

The Vulcan Tokamak Conception Design

- 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
- 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
- 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
- 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

Particle detector and particle transport simulations

- 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
- A. Inglis *et al. Glass panel Lithium-6 Detector.* IEEE Conference on Homeland Security (2012). doi:10.1109/THS.2012.6459887

Neutronics studies for a tokamak neutron source

- 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

The MμLAN Experiment (Muon Lifetime Analysis)

- 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
- 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

Reference Publications

A comprehensive physics and mathematics reference for magnetic fusion

- Z.S. Hartwig and Y.A. Podpaly. *The Magnetic Fusion Energy Formulary (Revision February 2014).* Self-published, 2014. Available online at http://www.psfc.mit.edu/research/MFEFormulary

Zachary S. Hartwig, Ph.D.

hartwig@psfc.mit.edu +1 314 922 6495 (cell) +1 617 253 5471 (work)
77 Massachusetts Ave, NW17-115, Cambridge MA 02139 http://www.psfc.mit.edu/∼hartwig

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, soldering, basic machining, detector test platforms

Computer expertise

Programming Languages

- C, C++, Java, Python, Unix shell scripting, GNU make, Matlab, IDL, Open MPI, MPICH2

Particle Transport and Nuclear Physics Codes

- Geant4, MCNP5/X, DAGMC CAD-based neutronics, SRIM/TRIM, EASY, NJOY, TALYS, EMPIRE

Data acquisition, storage and analysis

- ROOT, MDSplus

Computer-Aided Design (CAD) and Analysis

- Solid Edge ST5, CUBIT Tool Suite, COMSOL Multiphysics 4

Productivity Software

- Windows OS, Linux OS (Fedora, RHEL, Ubuntu), Emacs, Subversion, Git, GitHub, LaTeX, LibreOffice, GIMP, Inkscape