

CURRENT POSITION Postdoctoral Research Associate  
Massachusetts Institute of Technology  
Plasma Science and Fusion Center  
Cambridge, Massachusetts, 02139 USA

CONTACT INFORMATION *Mail:* MIT PSFC *Phone:* (518) 428-9014  
175 Albany St., NW17-125 *Email:* [hbar@mit.edu](mailto:hbar@mit.edu)  
Cambridge, MA 02139 *Website:* [science.haroldbot.com](http://science.haroldbot.com)

EDUCATION **Massachusetts Institute of Technology**, Cambridge, MA, USA  
[Sc.D.](#), Nuclear Science and Engineering, February 2014  
Thesis advisors, D.G. Whyte, R.C. Lanza, G. Wright  
GPA: 4.5/5.0

S.M., Nuclear Science and Engineering, 2009  
Thesis advisors, D. G. Whyte, B. Lipschultz

**Cornell University**, Ithaca, NY, USA  
B.S., Applied and Engineering Physics, 2006

## RESEARCH INTERESTS

- Accelerator based diagnostic techniques for materials analysis (hardware development, spectroscopy, beam optics and modeling)
- Design of fusion and fission reactors and other energy systems.
- General design, engineering, and integration of scientific equipment

## CURRENT RESEARCH PROJECTS

- Development of accelerator based diagnostic techniques for in-situ analysis of plasma facing components in magnetic fusion devices.
- Development of simulation tools for charged particle beams in complex fields
- Materials studies using ion beam analysis techniques.
- Hardware development for linear accelerators and beam optics.
- Design studies for fusion reactors/experiments
- Design study for ion beam facility for radiation-materials science.

## ENGINEERING EXPERIENCE:

**Prototyping:** accelerator hardware, instrumentation, mechanical design, PCB design

**Electrical Eng.:** analog circuit design, PLC controls, DC/RF/pulsed power systems

**Mechanical Eng.:** structural/thermal analysis, FEA, pneumatics, vacuum systems

**CAD Modeling:** SolidWorks, AutoCAD, QCad, Eagle

**Scientific Computing:** Python, MATLAB, COMSOL

**Neutron Transport Modeling:** MCNP

**Fabrication:** machining, welding, brazing, electrical soldering, carpentry

## TEACHING EXPERIENCE AT MIT

- Graduate Resident Tutor: Mentoring and advising undergraduate students. 2007 - 2013
- Assistant lab instructor: 22.071 - Electronics, Signals, and Circuits: Feb. - March 2011
- Teaching assistant: 22.63 - Eng. Principles for Fusion Reactors: Sept. - Dec. 2012

## RESEARCH EXPERIENCE

- **MIT: Plasma Science and Fusion Center**, Feb. 2014 - present  
**Postdoctoral Research Associate**, Cambridge MA, Supervisor: Dennis Whyte
  - Continued development of accelerator-based in-situ materials diagnostics for the Alcator C-Mod tokamak.
- **MIT: Plasma Science and Fusion Center**, Sept. 2009 - Jan. 2014  
**Doctoral Research**, Cambridge MA, Advisor: Dennis Whyte
  - Developed a novel RFQ accelerator based in-situ materials diagnostic integrated with Alcator C-Mod tokamak. This diagnostic injects a 0.9 MeV deuterium beam into the tokamak vacuum vessel, using the magnetic field coils to steer the beam for targeted ion beam analysis of plasma facing components.
  - Refurbished and upgraded a radio frequency quadrupole (RFQ) accelerator controls to enable remote operation in a radiation test-cell environment with high magnetic fields.
  - Contributed to design studies for compact, steady-state fusion devices and accelerator-based materials test facilities.
- **MIT: Plasma Science and Fusion Center**, Sept. 2006 - Aug. 2009  
**Masters of Science Research**, Cambridge MA, Advisor: Dennis Whyte
  - Reconstructed and refurbished a 1.7MV tandem accelerator and beam lines for ion beam analysis (IBA) of materials.
  - Constructed a beamline for Rutherford backscattering spectroscopy and external

- proton beam induced X-Ray and gamma spectroscopy.
  - Performed a IBA study of net plasma erosion and poloidal transport of tungsten in the Alcator C-Mod divertor.
- **General Atomics: Fusion Diagnostics Division**, June 2006 - Sept. 2006  
**Internship**, San Diego CA, Supervisor: Rejean Boivin
  - Designed and built a test setup for measuring the time response of fast thermocouples used for heat flux measurement on plasma facing components in the DIII-D tokamak.
- **Sandia National Laboratories**, June 2005 - Sept. 2005  
**Internship**, Albuquerque NM, Advisor Dr. John Maenchen
  - Fabricated and assembled components for the upgraded Radiographic Integrated Test Stand (RITS) accelerator.
  - Designed and built a calibration system for B-dot current sensors used in RITS.
- **Cornell Laboratory for Plasma Studies**, Sept. 2004 - April 2006  
**Undergraduate Research**, Ithaca NY, Advisor: Prof. Bruce Kusse
  - Developed an electroplating technique for fabricating modulated-diameter wires for for pulsed plasma experiments with X-ray radiography and Z-pinch applications.
- **Cornell High Energy Synchrotron Source**, Sept. 2003 - Sept 2004  
**Undergraduate Research**, Ithaca NY, Advisor: Dr. Ernest Fontes
  - Fabricated and tested stepper motor control units for x-ray optics.
  - Created a video based x-ray beam imaging system for x-ray optics.
  - Built hardware and instrumentation for various beamline end-station applications.
- **U. Albany Institute for Materials/Albany Nanotech**, June 2003 - Sept. 2003  
**Undergraduate Research**, SUNY Albany, Advisor: Dr James Castracane
  - Characterized and simulated micro-fabricated diffraction gratings.
- **U. Albany Institute for Materials/Albany Nanotech**, June 2001 - August 2002  
**Internship**, Albany NY, Advisor: Dr James Castracane.
  - Designed and built a complete setup for packaging, actuating, testing micro fluidic devices.

## PUBLICATIONS

1. **Barnard, H. S.**, "Development of Accelerator Based Spatially Resolved Ion Beam Analysis Techniques for the Study of Plasma Materials Interactions in Magnetic Fusion Devices." Doctoral Thesis, Massachusetts Institute of Technology, 2014.
2. Hartwig, Z.S., **H. S. Barnard**, R. C. Lanza, B. N. Sorbom, P. W. Stahle, and D. G. Whyte, "An accelerator based diagnostic for plasma-material interactions science on magnetic fusion devices." submitted to *Review of Scientific Instruments* (2013)
3. Olynyk, G. M., Z. S. Hartwig, D. G. Whyte, **H. S. Barnard**, P. T. Bonoli, L. Bromberg, M. L. Garrett, C. B. Haakonsen, R. T. Mumgaard, and Y. A. Podpaly. "Vulcan: A steady-state tokamak for reactor-relevant plasma-material interaction science." *Fusion Engineering and Design* (2012).
4. **Barnard, H. S.**, Z. S. Hartwig, G. M. Olynyk, and J. E. Payne. "Assessing the feasibility of a high-temperature, helium-cooled vacuum vessel and first wall for the Vulcan tokamak conceptual design." *Fusion Engineering and Design* (2012).
5. Whyte, D. G., G. M. Olynyk, **H. S. Barnard**, P. T. Bonoli, L. Bromberg, M. L. Garrett, C. B. Haakonsen, Z. S. Hartwig, R. T. Mumgaard, and Y. A. Podpaly. "Reactor similarity for plasma-material interactions in scaled-down tokamaks as the basis for the Vulcan conceptual design." *Fusion Engineering and Design* (2012).
6. Lipschultz, B., J. W. Coenen, **H. S. Barnard**, N. T. Howard, M. L. Reinke, D. G. Whyte, and G. M. Wright. "Divertor tungsten tile melting and its effect on core plasma performance." *Nuclear Fusion* 52, no. 12 (2012): 123002.
7. Podpaly, Y. A., J. E. Rice, P. Beiersdorfer, M. L. Reinke, J. Clementson, and **H. S. Barnard**. "Tungsten measurement on Alcator C-Mod and EBIT for future fusion reactors" Special Issue on the 10th International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas." *Canadian Journal of Physics* 89, no. 5 (2011): 591-597.
8. **Barnard, H. S.**, B. Lipschultz, and D. G. Whyte. "A study of tungsten migration in the Alcator C-Mod divertor." *Journal of Nuclear Materials* 415, no. 1 (2011): S301-S304.
9. Wright, G. M., **H. S. Barnard**, Z. S. Hartwig, P. W. Stahle, R. M. Sullivan, K. B. Woller, and D. G. Whyte. "Plasma-Surface Interaction Research At The Cambridge Laboratory Of Accelerator Studies Of Surfaces." In *AIP Conference Proceedings*, vol. 1336, p. 626. 2011.
10. **Barnard, H. S.**, "External proton beam analysis of plasma facing materials for magnetic confinement fusion applications." S.M. Thesis, Massachusetts Institute of Technology, 2009.