PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
September 12, 2016

Calendar of Events

THIS WEEK

WEDNESDAY, SEPT. 14

Princeton University classes begin

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Spacetraveler's Manifesto: The Other-Worldly Career of Freeman Dyson
Phil Schewe, University of Maryland

FRIDAY, SEPT. 16

Public Tour
10 a.m.
Email tours@pppl.gov

SATURDAY, SEPT. 17

Community and Staff Day
3:30 p.m. ◆ Princeton University
See page 6 for details.

UPCOMING

WEDNESDAY, SEPT. 21

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Superintelligence, Artificial General Intelligence (AGI), and Existential Risk
Susan Schneider, University of Connecticut

TUESDAY, SEPT. 27

Tour Guide Meeting
9:30–10:30 a.m. ◆ MBG Auditorium
Tour Guide Training
10:30–11:30 a.m. ◆ MBG Auditorium
See page 3 for details.

FRIDAY, OCT. 7

American Red Cross Blood Drive
8 a.m.–1 p.m. ◆ American Red Cross Bloodmobile, Lower End Parking Lot

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Next steps for fusion energy based on spherical tokamak design

By John Greenwald

Among the top puzzles in the development of fusion energy is the best shape for the magnetic facility — or "bottle" — that will provide the next steps in the development of fusion reactors. Leading candidates include spherical tokamaks, compact machines that are shaped like cored apples, compared with the doughnut-like shape of conventional tokamaks. The spherical design produces high-pressure plasmas — essential ingredients for fusion reactions — with relatively low and cost-effective magnetic fields.

A possible next step is a device called a Fusion Nuclear Science Facility (FNSF) that could develop the materials and components for a fusion reactor. Such a device could precede a pilot plant that would demonstrate the ability to produce net energy.

Physicist Jonathan Menard. (Photo by Elle Starkman)

Spherical tokamaks as excellent models

Spherical tokamaks could be excellent models for an FNSF, according to a paper published online in the journal Nuclear Fusion on Aug. 16. The two most advanced spherical tokamaks in the world today are the recently completed National Spherical Torus Experiment-Upgrade (NSTX-U) at PPPL, and the Mega Ampere Spherical Tokamak (MAST), which is being upgraded at the Culham Centre for Fusion Energy in the United Kingdom.

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Intern creates tool for plasma snapshot

By Jeanne Jackson DeVoe

When most of today's college interns were still in kindergarten, Max Wallace was working for more than a decade as a programmer for various companies, founding a hackerspace in Charlotte, North Carolina, and writing code for start-ups in Silicon Valley.

He gave it all up to return to college with the ambitious goal of becoming a physicist and working to make fusion energy a viable source of generating electricity. A student at Laney College in Oakland, California, Wallace was an intern for two summers at PPPL through the Community College Internship (CCI) program. He has used his talents to develop a tool that can give scientists a quick snapshot of individual plasma experiments or "shots" in PPPL's National Spherical Tokamak Experiment-Upgrade (NSTX-U).

Wallace said his experience as an intern at PPPL has been invaluable. "Working on plasma and working on fusion in Princeton at this Lab is beyond anything I could have hoped for," Wallace said. "The world's experts are here and no matter how silly your question is or what your experience is, they will sit down and explain everything to you. I'm really enjoying that."

Wallace's advisor, physicist Ahmed Diallo, said Wallace has a professional attitude that came from his years of experience in the corporate world. "He brings a lot to the table," Diallo said. "I like people who are go-getters and hard workers."

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Wanted: Undergraduate women interested in physics for January conference

By Jeanne Jackson DeVoe

Applications are being accepted for the 2017 Conference for Undergraduate Women in Physics (CUWiP) Mid-Atlantic regional conference Jan. 13–15 at Princeton University, which will focus on workshops aimed at providing tools to encourage women to remain in science, technology, engineering, and mathematics (STEM) fields.

The conference, for some 200 undergraduate students, is sponsored by the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) and Princeton University. It is being organized by PPPL Science Education program leader Shannon Swilley Greco and others. The conference is supported in part by the DOE's Office of Science and the National Science Foundation.

"The primary focus is to give participants the tools they need to remain in STEM," Greco said. "Part of that is to expose them to the opportunities available to them but also to help them combat the effects of gender stereotyping and the feelings of isolation that might come from being a member of an underrepresented group," Greco said. "This is done through practical workshops and intimate discussions as well as networking and providing resources that help to build a support network and a community of women in physics."

With less than a third of physics majors pursuing a career as faculty at colleges and universities, a workshop will discuss physics careers "beyond academia," she said. The conference will expose physics majors to the wide array of choices available to them in STEM fields, not only in academia but also in industry, technology transfer, and science education, among others.

Students can apply for the conference online at cuwip.princeton.edu by the deadline of Oct. 14. The conference also has a Facebook page at https://www.facebook.com/cuwipprinceton. Preference will be given to female undergraduate physics majors from the Mid-Atlantic area and Puerto Rico who have never attended a CUWiP conference before.

The conference is one of nine CUWiP conferences in the U.S. and one in Canada being run simultaneously. The keynote speaker is Nergis Mavalvala, a physics professor at the Massachusetts Institute of Technology, whose remarks will be broadcast live from Massachusetts to all the CUWiP sites. Mavalvala worked on the Laser Interferometric Gravitational Wave Observatory (LIGO) at Caltech, which this year detected cosmic gravitational waves. Her research is focused on developing instruments for gravitational wave detectors.

Conferencegoers at the Princeton conference will come from six states (New Jersey, New York, Pennsylvania, Connecticut, Delaware, and Vermont) and Puerto Rico and will take part in workshops on careers, work-life balance, and diversity. Students pay for transportation (which they are encouraged to get from their departments) and a $45 fee. The costs of the conference, lodging, and meals are covered. Most of the conference will be held at the University. PPPL will host tours of the Laboratory during the afternoon of Friday, Jan. 13.

Conference organizer Shannon Swilley Greco. (Photo by Elle Starkman)

One special feature of the Princeton conference will be a workshop in plasma physics, which Greco has dubbed "CUWiP Plus," for about 20 participants as an extension of the conference. The workshop, funded by the DOE, will help PPPL recruit visiting faculty and recruit students for PPPL's Student Undergraduate Laboratory Internship (SULI), Community College Internship (CCI) and the DOE's Visiting Faculty Program. It is one of three such workshops planned for 2017.

Some of the rotating conference sessions will focus on gender bias and how it may affect women's careers. These include a workshop on LGBT issues called "Out in STEM." Plenary speaker Meg Urry, the Israel Munson Professor of Physics and Astronomy and director of the Center for Astronomy and Astrophysics at Yale University and past president of the American Astronomical Society, is known for her efforts to increase the number of women in physics.

Greco and Lyman Page, the chair of Princeton's Department of Physics, applied to host the conference more than a year ago. Greco was inspired by a conference at Rutgers University in January of 2015 in which she was took part in a panel discussion. She has been planning for the conference ever since.

Princeton University departments contributing to the conference include the Departments of Physics and of Astrophysical Sciences; the Center for Complex Materials; the Office of the Provost and others.

Students can apply online at cuwip.princeton.edu by Oct. 14.

Xaymara Rivera, left, a freshman at Lehigh University, and Willma Arias de la Rosa, a freshman at the University of Pennsylvania, work on a robotic arm for PPPL's Princeton Tritium Observatory for Light, Early Universe Massive Neutrino Yield experiment (PTOLEMY). (Photo by Elle Starkman)

Intern

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A faster, easier tool

Working with Diallo, Wallace developed software that uses an established set of tools to analyze fusion experiments to get a snapshot of various plasma parameters essential to producing energy at any point in the experiment. The visualization tool, which they call "ThomsonViz," uses Multipoint Thomson Scattering, an established method of measuring the temperature, density, and pressure in fusion devices.

The "ThomsonViz" tool can show scientists any of these factors at any point during an experiment or shot just by moving the cursor. It is a faster and easier tool for scientists than many similar programs, Wallace and Diallo said. "Any interested researcher or scientist can quickly review the shot, see if this is something they want to study further and get a fast understanding of the shot behavior," Wallace explained. Diallo said his main role as a mentor will now be "to push to see if other people will use it."

Wallace came to his interest in physics and in academia later in life than many people. He calls himself a "recovering dot-NET programmer" in his LinkedIn profile and says that while he is flattered in recruiters' interest in his .NET skills, "I'm really content chasing fusion reactor design right now." He adds that, "I also don't really have grown-up business clothes anymore."

Wallace hopes to present a poster on the "ThomsonViz" program at the American Physical Society's Division of Plasma Physics conference in San Jose, California, along with one other Community College Intern student and 23 Student Undergraduate Laboratory Internship (SULI) students from PPPL. Both programs are sponsored and managed by the DOE's Office of Science's Office of Workforce Development for Teachers and Scientists.

A programming career after high school

He became a programmer straight after high school. He tells the story of how he got his first job at a real estate company where he had been hired to scan massive numbers of documents. He programmed the scanner to automatically scan the documents and left work to go to the mall. When his boss saw what Wallace had done, he fired him. But the boss then hired him back a few days later to reproduce the code he used to scan all the company's documents. The company became one of the first real estate companies to digitize its documents.

Wallace worked for several different companies in the Charlotte area. In 2010, he founded a hackerspace, where people like himself could get together to learn about various technologies. The hackerspace won fame when it won a Guinness world record by painting a 10,000-square-foot QR code on a building rooftop.

Max Wallace, a Community College intern from Laney College in Oakland, California, shows fellow intern Priya Jaglal a poster on his research during a student poster session at PPPL in August. Wallace developed software to allow scientists to get a quick snapshot of experiments on the National Spherical Torus Experiment-Upgrade (NSTX-U). (Photo by Chris Cane)

Wallace and his wife, Raquel, who is also a programmer, moved to San Francisco four years ago to work in software. Wallace worked for various companies, including a wine company that analyzes consumer drinking habits. His most recent programming job was at a start-up that offered consumer loans. Wallace optimized a code that automatically sent out rejection letters for loans. "When you optimize a code until it is capable of sending 5,000 rejection letters a second you're not helping anybody," Wallace said. "That's not something society needs."

Envisioning a career in fusion energy

He wound up quitting that job and rethinking his career. The turning point came when his mother-in-law asked him, "What would you do if you weren't afraid?" When he pondered that question he thought, "The planet has some genuine problems and I'd like to work on them." That is how he came to further investigate a technology he had always been interested in: fusion energy.

Wallace has become an evangelist for fusion energy. "The ultimate goal is to invent a fusion reactor and save the world," he says.

But he must first get through college and graduate school. Diallo has warned him that becoming a physicist is a long process that can take at least five years once you get admitted to graduate school. "I told him it's a commitment," Diallo said.

Wallace does not seem intimidated by that prospect. He hopes to come back to PPPL one day as a graduate student and he encourages other undergraduates to apply for internships. "The message I would have for anybody who's interested in working as an intern at PPPL is just go ahead and do it. Don't worry if you're not good enough. Don't worry if you're too old. There's a very large scope of work to be done here."

Tour Guide Meeting

Please come to a tour meeting on Sept. 27 from 9:30–10:30 a.m. in the MBG Auditorium. Both experienced and new tour guides are welcome.

After a general meeting, experienced tour guides will be free to leave at 10:30 a.m. New tour guides will stay for a tour training session from 10:30–11:30 a.m.

Spherical tokamak

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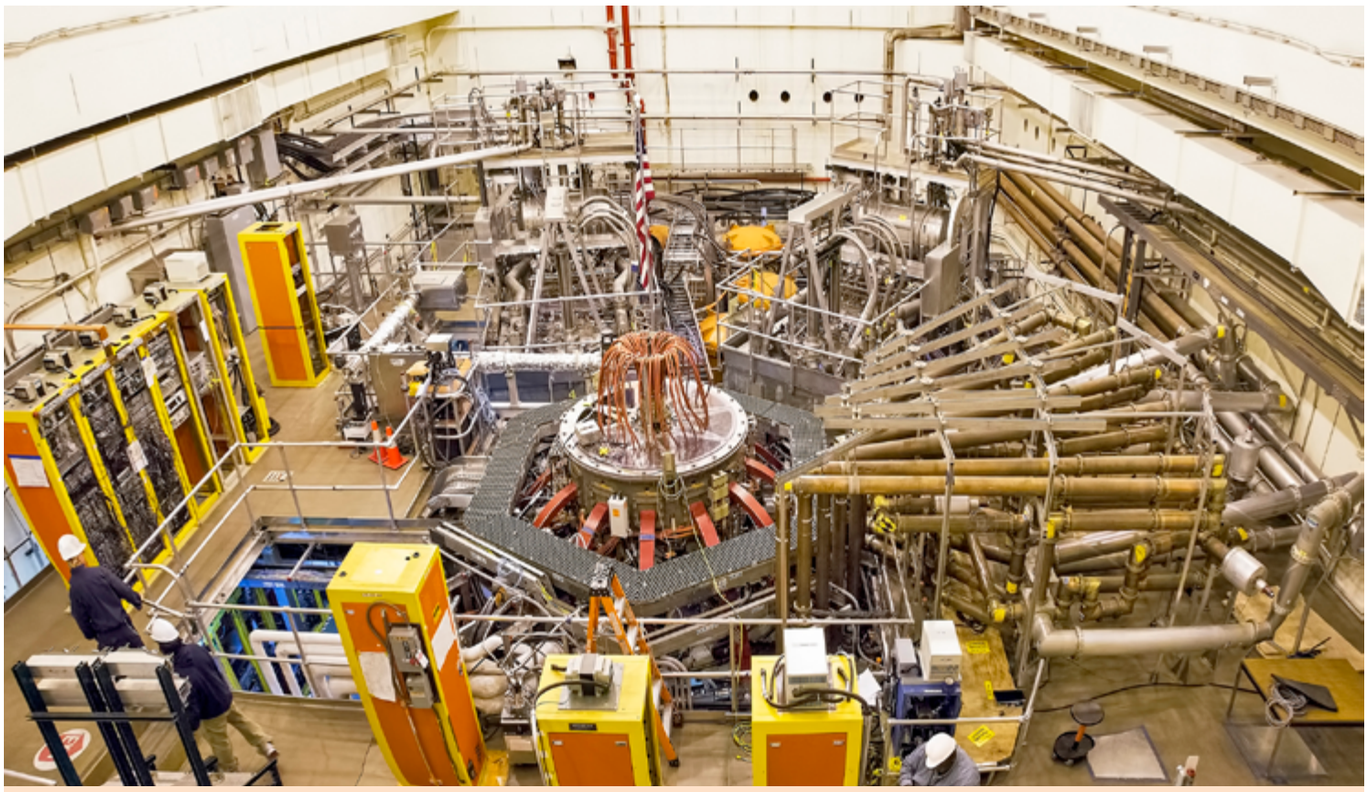

Test cell of the National Spherical Torus Experiment-Upgrade with tokamak in the center. (Photo by Elle Starkman)

"We are opening up new options for future plants," said Jonathan Menard, program director for the NSTX-U and lead author of the paper, which discusses the fitness of both spherical tokamaks as possible models. Support for this work comes from the DOE Office of Science.

The 43-page paper considers the spherical design for a combined next-step bottle: an FNSF that could become a pilot plant and serve as a forerunner for a commercial fusion reactor. Such a facility could provide a pathway leading from ITER, the international tokamak under construction in France to demonstrate the feasibility of fusion power, to a commercial fusion power plant.

A key issue for this bottle is the size of the hole in the center of the tokamak that holds and shapes the plasma. In spherical tokamaks, this hole can be half the size of the hole in conventional tokamaks. These differences, reflected in the shape of the magnetic field that confines the superhot plasma, have a profound effect on how the plasma behaves.

Designs for the Fusion Nuclear Science Facility

First up for a next-step device would be the FNSF. It would test the materials that must face and withstand the neutron bombardment that fusion reactions produce, while also generating a sufficient amount of its own fusion fuel. According to the paper, recent studies have for the first time identified integrated designs that would be up to the task.

These integrated capabilities include:

- A blanket system able to breed tritium, a rare isotope — or form — of hydrogen that fuses with deuterium, another isotope of the atom, to generate the fusion reactions. The spherical design could breed approximately one isotope of tritium for each isotope consumed in the reaction, producing tritium self-sufficiency.
- A lengthy configuration of the magnetic field that vents exhaust heat from the tokamak. This configuration, called a "divertor," would reduce the amount of heat that strikes and could damage the interior wall of the tokamak.
- A vertical maintenance scheme in which the central magnet and the blanket structures that breed tritium can be removed independently from the tokamak for installation, maintenance, and repair. Maintenance of these complex nuclear facilities represents a significant design challenge. Once a tokamak operates with fusion fuel, this maintenance must be done with remote-handling robots; the new paper describes how this can be accomplished.

For pilot plant use, superconducting coils that operate at high temperature would replace the copper coils in the FNSF to reduce power loss. The plant would generate a small amount of net electricity in a facility that would be as compact as possible and could more easily scale to a commercial fusion power station.

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Center stack of the NSTX-U. (Photo by Elle Starkman)

Tour Guides and Tour Hosts Wanted!

We are looking for engineers and physicists who are willing to donate a couple of hours of their time each month to show off the Laboratory to students, clubs, and local people who are interested in science. Our growing tour program is a great way to educate the community about fusion energy and the Lab's mission and to let them know about the cutting-edge research taking place at PPPL.

Please plan to come to our tour meeting. **See page 3 for details.**

Please email Jeanne Jackson DeVoe, jjackson@pppl.gov, to volunteer.

Spherical tokamak

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High-temperature superconductors

High-temperature superconductors could have both positive and negative effects. While they would reduce power loss, they would require additional shielding to protect the magnets from heating and radiation damage. This would make the machine larger and less compact.

Recent advances in high-temperature superconductors could help overcome this problem. The advances enable higher magnetic fields, using much thinner magnets than are presently achievable, leading to reduction in the refrigeration power needed to cool the magnets. Such superconducting magnets open the possibility that all FNSF and associated pilot plants based on the spherical tokamak design could help minimize the mass and cost of the main confinement magnets.

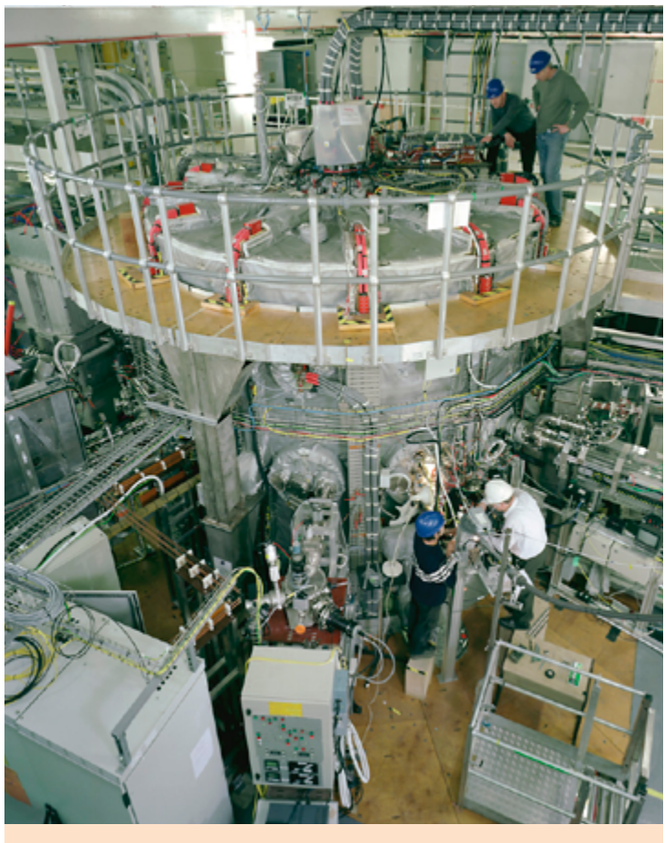
For now, the increased power of the NSTX-U and the soon-to-be-completed MAST facility moves them closer to the capability of a commercial plant that will create safe, clean and virtually limitless energy. "NSTX-U and MAST-U will push the physics frontier, expand our knowledge of high temperature plasmas, and, if successful, lay the scientific foundation for fusion development paths based on more compact designs," said PPPL Director Stewart Prager.

Twice the power and five times the pulse length

The NSTX-U has twice the power and five times the pulse length of its predecessor and will explore how plasma confinement and sustainment are influenced by higher plasma pressure in the spherical geometry. The MAST upgrade will have comparable prowess and will explore a new, state-of-the art method for exhausting plasmas that are hotter than the core of the sun without damaging the machine.

"The main reason we research spherical tokamaks is to find a way to produce fusion at much less cost than conventional tokamaks require," said Ian Chapman, the newly appointed chief executive of the United Kingdom Atomic Energy Authority and leader of the UK's magnetic confinement fusion research programme at the Culham Science Centre.

The ability of these machines to create high plasma performance within their compact geometries demonstrates their fitness as possible models for next-step fusion facilities. The wide range of considerations, calculations and figures detailed in this study strongly support the concept of a combined FNSF and pilot plant based on the spherical design. The NSTX-U and MAST-U devices must now successfully prototype the necessary high-performance scenarios.



Mega Ampere Spherical Tokamak (MAST).
(Photo courtesy of Culham Centre for Fusion Energy.)

Community and Staff Day

Community and Staff Day Sept. 17 features a day of free activities at Princeton University

PPPL proudly participates in this event each year! Community and Staff Day will be held on Sept. 17. Volunteers are needed for the Family Fun Fest from 3:30 to 6:30 p.m. with a table featuring our plasma, light, vacuum and electricity/magnetism demonstrations. If you've never engaged the public with these cool devices, this is a great introduction to the demos and to the rewarding experience of communicating our work to people outside the Lab.

To volunteer, please contact Shannon Swilley Greco (sgreco@pppl.gov). For more info on the event, please see https://community.princeton.edu/events/community-staff-day.

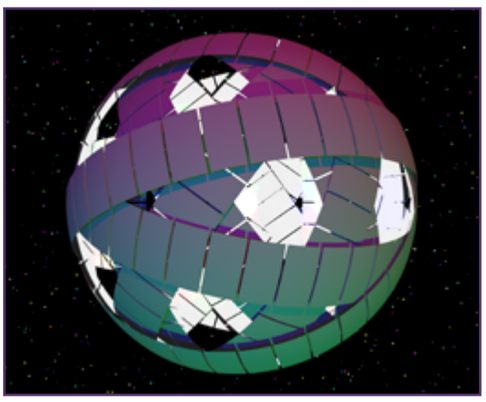
The Community and Staff Day schedule includes:

- Princeton Tigers football game versus Lafayette University. Kickoff is at 5 p.m. Get your free tickets online at www.GoPrincetonTigers.com/tickets or pick them up from Marianne Tyrell, in Engineering 106, Ana Datuin, in Mod 6, room 132, or in the Director's Office or Human Resources, from 10 a.m.–4 p.m.
- Youth Sports Clinic for children ages 5 to 12, 3:30 to 4:30 p.m., Weaver Track
- Family Fun Fest: 3:30 p.m. through halftime – Games and activities from local non-profits and University departments.
- Fireworks after the game.

Call 609-258-5144 for more information.

COLLOQUIUM

Spacetraveler's Manifesto: The Other-Worldly Career of Freeman Dyson



Phil Schewe
University of Maryland

Wednesday, Sept. 14
4:15 p.m., M.B.G Auditorium, Lyman Spitzer Building

American Red Cross Blood Drive

Friday, October 7

8 a.m.–1 p.m.

American Red Cross Bloodmobile
Lower End Parking Lot

The need for blood is constant and your donation is important for maintaining a healthy and reliable blood supply. One pint of donated blood can save up to three lives.

Please give blood. All blood types are needed.

To schedule a donation appointment, please contact the OMO at extension 3200.

Thank you.
American Red Cross
Occupational Medical Office Staff

BROCK

MARK GAZO
Chef Manager

Café at PPPL

BREAKFAST ..... 7 a.m. • 10 a.m.
CONTINENTAL BREAKFAST ..... 10 a.m. • 11:30 a.m.
LUNCH ..... 11:30 a.m. • 1:30 p.m.
SNACK SERVICE ..... until 2:30 p.m.

	Monday September 12	Tuesday September 13	Wednesday September 14	Thursday September 15	Friday September 16
COMMAND PERFORMANCE Chef's Feature	**Chicken Parmesan** served with Pasta	**Baked Ziti** with Garlic Bread	**Fried Chicken** with Cornbread Stuffing & Collard Greens	**Mac & Cheese** served with Stewed Tomatoes	**Fish & Chips**
Early Riser	**Bacon, Egg & Cheese Croissant**	**Banana-Walnut French Toast** with Caramel Sauce	**Mango & Blueberry Pancakes** served with Choice of Breakfast Meat	**Biscuits & Gravy** with Choice of Breakfast Sausage	**2 Eggs, 2 Pancakes,** Choice of Breakfast Meat & Potatoes
Country Kettle	**Creamy Chicken & Mushroom** with Wild Rice	**Tomato Bisque**	**Beef Barley**	**Vegetable Noodle**	**Matzoh Ball Soup**
Grille Special	**Chili Burger** with Crisp Onions & Cheddar Cheese on an Onion Roll with Chipotle Mayo	**Hot Pastrami & Cheddar Cheese** on French Bread	**Fish Taco** with Cabbage, & Pico de Gallo served with Corn Relish & Chipotle Lime Sour Cream	**Turkey, Bacon,** Cheddar, Diced Tomato, Red Onion and BBQ Chipotle Mayo Flatbread	**Roast Vegetable Stromboli**
Deli Special	**Middle Eastern Stacked Veggie Sandwich** with Hummus, Eggplant, Red Onion, Red Pepper Tomato, Mozzarella & Balsamic on Wheat Roll	**Chicken, Avocado,** Pepperjack Cheese & Tomato on Ciabatta Bread	**Turkey Pastrami** on Rye with Coleslaw, Swiss Cheese and Russian Dressing	**Open-Faced Cheesy Seafood Melt** on French Bread	**Chicken, Mozzarella,** Red Onion, Basil, Arugula and Balsamic Tomatoes on French Bread
Panini	**Breaded Pork Cutlet** with Slaw on a Soft Roll	**Fish Cake Sub** with Pepperjack Cheese & Chipotle Cream	**Turkey Meatball Parmesan Torpedo**	**Portobello Mushroom & Fontina Cheese** with Roasted Peppers on Ciabatta	**Foot-long Chili Dog**

MENU SUBJECT TO CHANGE WITHOUT NOTICE

HEART HEALTHY VEGETARIAN OPTION

WEEKLY
Editor: **Jeanne Jackson DeVoe** ◆ Layout and graphic design: **Kyle Palmer** ◆ Photography: **Elle Starkman**
Science Editor: **John Greenwald** ◆ Webmaster: **Chris Cane** ◆ Communications Director: **Larry Bernard**

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DEADLINE for calendar item submissions is noon on WEDNESDAY. Other stories should be submitted no later than noon on TUESDAY.
Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://w3.pppl.gov/communications/weekly/.