PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
January 16, 2017

THIS WEEK

MONDAY, JAN. 16

Martin Luther King Jr. Day
PPPL & Princeton University closed

WEDNESDAY, JAN. 18

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Chaotic Dynamics in the Physical Sciences
Edward Ott, University of Maryland

THURSDAY, JAN. 19

Duo Authentication for email starts

Help Desk open hours for help with Duo Authentication
9–11 a.m. ◆ Resource Room, B153

FRIDAY, JAN. 20

Public Tour
10 a.m.

Help Desk open hours for help with Duo Authentication
1:30–3:30 p.m. ◆ Resource Room, B153

SATURDAY, JAN. 21

Science on Saturday
9:30 a.m. ◆ MBG Auditorium
When Plasmas Meet Surfaces: An Exploration of Physics and Technology at the Plasma-Materials Interface
Angela Capece, The College of New Jersey

UPCOMING

WEDNESDAY, JAN. 25

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Fusion Nuclear Science Facility (FNSF): Its Motivation and Program to Move to Fusion Power Plants
Charles Kessel, PPPL

SATURDAY, JAN. 28

Science on Saturday
9:30 a.m. ◆ MBG Auditorium
The Physics of Cancer
Robert Austin, Princeton University

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New engineering head has two decades of experience on UK fusion experiments

By Jeanne Jackson DeVoe

Valeria Riccardo, PPPL's new head of engineering, is a transplant from the United Kingdom who comes to the position with more than 20 years of experience in project management, fusion design, and analysis on two fusion devices in the United Kingdom that are similar to PPPL's National Spherical Torus Experiment-Upgrade (NSTX-U).


Valeria Riccardo

For the last five years, Riccardo was chief engineer for the Culham Centre for Fusion Energy in Oxfordshire, England, the United Kingdom's national laboratory for fusion research, which operates the Joint European Torus (JET) and the Mega Amp Spherical Tokamak (MAST) facility, two fusion devices called tokamaks. JET shut down operations in November to prepare for fusion experiments using tritium. MAST is undergoing a major upgrade and is expected to restart operation this year as MAST-U, a sister facility to NSTX-U.

"We are fortunate to have Valeria as our new head of engineering," said Terry Brog, interim director of PPPL. "Her engineering experience on the JET and MAST facilities, along with her academic background make her uniquely suited to lead our engineering department."

As head of engineering, Riccardo leads PPPL's largest department, with 240 staff members. She said she welcomes the opportunity to work directly with an engineering staff with a dedicated budget. She came to PPPL, she said, because she was looking for a new challenge and wanted to continue her work in developing fusion energy. "I wanted something different and PPPL is a respected fusion research center," Riccardo said. "I'm still a believer in fusion energy. I would like to contribute to getting a sustainable energy source, so I gave fusion another chance in another place!"

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Feeding the supermassive black hole at the center of our galaxy

By John Greenwald

Scientists at Princeton University and PPPL have developed a rigorous new method for modeling the accretion disk that feeds the supermassive black hole at the center of our Milky Way galaxy. The paper, published online in December in the journal Physical Review Letters, provides a much-needed foundation for simulation of the extraordinary processes involved.

Accretion disks are clouds of plasma that orbit and gradually swirl into massive bodies such as black holes — intense gravitational fields produced by stars that collapse to a tiny fraction of their original size. These collapsed stars are bounded by an "event horizon," from which not even light can escape. As accretion disks flow toward event horizons, they power some of the brightest and most energetic sources of electromagnetic radiation in the universe.

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The following article first appeared on the U.S. Department of Energy's website https://energy.gov. Written by former PPPL Deputy Director for Operations Adam Cohen, currently deputy under secretary for Science and Energy, it highlights a new one-year program to develop the next generation of leaders in energy sciences that includes two PPPL scientists: Michael Jaworski, a research physicist who leads the Materials and Plasma-Facing Components Topical Science Group on the National Spherical Torus Experiment-Upgrade (NSTX-U); and Howard Yuh, a research physicist whose research is focused on NSTX-U and who is also part of a team developing and designing a current profile diagnostic for ITER, the international fusion experiment in Cadarache, France. Biographies from the DOE website are below.

Preparing Today's Leaders for Tomorrow's Scientific and Energy Challenges

By Adam Cohen, Deputy Under Secretary for Science and Energy

The Department of Energy recently launched the inaugural Energy Sciences Leadership Group (ESLG) to develop the next generation of leaders who will tackle our current and emerging scientific and energy challenges. This new one year program is modeled on the Defense Sciences Study Group established 30 years ago. Using the National Laboratory system as the foundation, this program brings participants together to explore the wider ecosystem in which scientific and energy policy is made, innovation happens, and collaboration between academia, government and industry occurs.

The first workshop took place in June in the San Francisco Bay Area and included visits and conversations with leaders at Lawrence Berkeley National Laboratory, Lawrence Livermore, and SLAC as well as Google X, Google, and Nvidia. The second workshop was here in Washington, DC and included meetings with Senior Leadership at DOE, the White House, members of Congress, and with leaders at the Pentagon, NASA, the National Cancer Institute, Department of Transportation, the Overseas Private Investment Corporation, and DC Water.

The inaugural cohort of 14 leaders was nominated by National Laboratory Directors then competitively selected by a Senior Advisory Committee consisting of former National Laboratory Directors. The core of the ESLG experience consists of a series of workshops at National Laboratories (and other associated points of interest) throughout the country and Washington, DC over the course of a year.

The function of these visits is multifaceted. First, they are intended to provide a rich understanding of the diverse science, engineering and analysis that takes place throughout the National Laboratory system. Second, the site visits are an opportunity for participants to meet and engage with a broader community of researchers and leaders whose work is a strong complement to the activities undertaken by the National Laboratories. The program consists of meetings with senior leaders, interactive discussions, conversations and tours with industry, academia, non-governmental organizations, and public sector entities, to help convey the scale, complexity, and interconnected nature of the current energy and scientific challenges. Third, spaced throughout the span of a year, the site visits offer a crucial opportunity for the cohort to come together as a group—including with mentors—to collaboratively develop self-assigned White Papers or "think pieces" that they develop aimed at tackling major scientific, policy or other challenges within DOE mission areas.

A mentor group with deep expertise in energy-related fields and diverse scientific disciplines will provide support and guidance to the cohort as they develop their "think pieces."

Over the course of this year, the ESLG's first cohort will gain exposure to the diverse science, engineering and analysis that takes place throughout the National Laboratory system; develop leadership skills; develop a systems-level understanding of the nation's energy system; meet distinguished leaders from diverse parts of government, the National Laboratories, academia, industry, and non-governmental organizations; and gain first-hand exposure to Federal policymaking and the energy regulatory and policy framework. The year will culminate at the Big Ideas Summit in March 2017 where participants will present their team "think pieces." We are currently selecting the second ESLG cohort who will begin their year at the Big Ideas Summit in March 2017.

Congratulations to the members of the inaugural cohort for their outstanding achievements thus far. We look forward to the many contributions they will undoubtedly make this year and throughout their careers.

The selected participants for the inaugural 2016-2017 ESLG cohort are:

Charles Black, Brookhaven National Laboratory
Johney Green, Jr., National Renewable Energy Laboratory (previously at Oak Ridge National Laboratory)
Nancy Haegel, National Renewable Energy Laboratory
Michael Jaworski, Princeton Plasma Physics Laboratory
Amy Marschilok, Energy Frontier Research Center (EFRC), Stony Brook University
Robert McQueeney, Iowa State University/Ames Laboratory
Lia Merminga, SLAC National Accelerator Laboratory
Timothy Meyer, Fermi National Accelerator Laboratory
Trent Northen, Lawrence Berkeley National Laboratory
Daniel Schwartz, University of Washington
Daniel Sinars, Sandia National Laboratories
Dawn Wellman, Pacific Northwest National Laboratory
Mike Willardson, SLAC National Accelerator Laboratory
Howard Yuh, Nova Photonics/Princeton Plasma Physics Laboratory
Additional information about these cohort participants is available here.

Michael Jaworski


Michael Jaworski

Michael Jaworski is a research physicist at the Princeton Plasma Physics Laboratory. He leads the Materials and Plasma-Facing Components Topical Science Group on the National Spherical Torus Experiment-Upgrade (NSTX-U) project. In this capacity he is leading development of advanced components featuring the use of self-healing materials such as liquid metals as well as conventional, high-temperature refractory metals. Jaworski is also applying these same concepts for materials to problems outside of fusion plasma physics by developing liquid components for advanced power plant systems based on combustion heat sources. Such advanced power plant systems could be critical to improving the efficiency of these energy sources and reducing their carbon intensity.

Jaworski joined the Princeton Plasma Physics Laboratory in 2010 after receiving his Ph.D. from the University of Illinois at Urbana-Champaign. An Illinois native, he holds degrees in mechanical engineering (B. Sc.) and nuclear engineering (M. Sc. and Ph.D.) from the University of Illinois.

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Demolition of the LSB Annex is underway

By Jeanne Jackson DeVoe

Workers have demolished the interior of the Lyman Spitzer Building (LSB) Annex third floor and are moving to the second and then the first floors of the building as work continues on the $26 million Infrastructure and Operational Improvements (IOI) project.

"We've been in the field working for a little over a month and I'm pleased with the progress that we've made so far, especially when you consider the holidays," said Les Hill, the head of the IOI project. "Worker safety has been first rate, the level of Laboratory support for the IOI has been excellent and I'm extremely pleased with our contractor Whiting-Turner. They have been very responsive to our challenges and they have been very responsive to safety concerns."

Piles of sorted debris on the LSB Annex third floor will be carted away and recycled.

The demolition of the second floor of the LSB Annex is still in progress.

One of the two tractors that will dig holes for footers to install columns in the C-Site MG Building.

Workers will install a new electrical and heating and air conditioning system in the building along with new ceilings, walls and partitions. "It's basically an architectural makeover," Hill said.

Materials from the demolition, including metal frames, sheet rock, and insulation, are being sorted into piles. The debris is placed in a chute in the window leading to dumpsters on the ground below. The vast majority of the debris is being recycled, Hill said.

Demolition and excavation in the C-Site MG Building have also commenced. These are the early steps to convert the building into new technical shops. Its renovation will include a new roof, lighting, and a heating and air conditioning system.

The building presently has enormous openings in the first floor that once accommodated motor generators that were removed several years ago. The plan is to build foundations in the basement and install concrete slabs to "fill" these openings and create a large, continuous open floor. The new shop areas will be built on this concrete deck, Hill said. The space will include new office and training areas beneath the mezzanine. The restrooms in the building will also be refurbished.

Workers used the crane in the building to place two pieces of earth moving equipment in the basement to excavate the areas where the foundation footings will be installed. A demolition team is currently demolishing a large enclosed area in the back of the building that once housed power supplies for a previous experiment at PPPL.

(Photos by Elle Starkman)

PPPL moves to Duo authentication starting Jan. 19

PPPL will begin protecting email with Duo two-factor authentication on Jan. 19. PPPL users signing into the Gmail web interface on or after this date will be prompted to complete Duo enrollment. During the first login, users will be guided step by step through the enrollment process. All users with a PPPL email account must complete the process by Jan. 26. The Help Desk will offer open hours in the Resource Room, B153, for additional assistance on Jan. 19 from 9 a.m. to 11 a.m. and on Jan. 20 from 1:30 to 3:30 p.m. For detailed instructions of this process, please go to https://ppplprod.service-now.com/kb_view.do?sysparm_article=KB0010510

Valeria Riccardo

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In her previous position, Riccardo was in charge of analyzing designs for JET and MAST. She said uncertainty over research funding after the United Kingdom's "Brexit" vote to leave the European Union was another factor in her decision to come to PPPL.

The intersection of plasma physics and engineering

Rich Hawryluk, head of PPPL's NSTX-U Recovery Team, met Riccardo when he served on an external review team when JET was assessed for readiness to start its next deuterium - tritium program. Hawryluk said Riccardo's background is perfectly suited to PPPL. "I'm looking forward to working with her in her new role because her work will strongly impact the work on the NSTX-U," he said. "Her early work shows a good understanding of the intersection of plasma physics and engineering and very often the difficult problems in fusion are at the intersection of plasma physics and engineering."

Riccardo said coming to PPPL when the Laboratory is focused on the NSTX-U recovery project gives her the opportunity to learn about PPPL's main experiment. "It makes my introduction easier because it's closer to what I used to do – it's more technical," she said.

Riccardo's interest in physics goes back to when she was at school in Torino, a northern Italian city near the French border. She always wanted to be a physicist but her father insisted she study engineering because he thought she would have more job prospects as an engineer. Riccardo received a master's degree in nuclear engineering from the Politecnico di Torino and a doctorate in mechanical engineering from the Imperial College in London, along with a doctorate in energetics from the Politecnico di Torino.

She was inspired to pursue a degree in nuclear engineering in part because of the energy crisis in Italy, Riccardo said. At one point, fuel was so scarce that government officials banned car travel for vacations on weekends. She picked nuclear engineering despite the fact that job prospects were slim following the 1987 referendum, which banned nuclear power plants and led to the closure of Italy's last four in 1990. So when Riccardo graduated, she got a job at JET as an engineering analyst and moved to England.

Riccardo's first project at JET was to help solve a problem caused by a certain kind of plasma disruption. When the plasma kinked and twisted in a phenomenon known as "asymmetrical vertical displacement events," it caused a huge kick that moved the entire machine sideways by millimeters. Riccardo's dissertation describes how the phenomenon works. Researchers now know how to avoid asymmetric disruptions and reduce the electromechanical and thermal loads of disruption. They achieve this is by injecting large amounts of hydrogen or deuterium mixed with high-Z gases when the plasma is likely to disrupt.

ITER-like Wall project

Before her most recent position, Riccardo was deputy engineering design and manufacture team leader for the ITER-like Wall (ILW) project at JET for six years. She is proud of having translated the physicists' requirements into feasible concepts and working to see them become a reality.

The idea of the project was to use the same materials on the interior of the tokamak as those that will be used on the interior of the giant ITER tokamak, the international fusion experiment being built in Cadarache, France. JET installed beryllium tiles on the interior of the tokamak and covered the divertor with tungsten.

Both beryllium and tungsten are brittle and can easily crack so Riccardo and her team inserted tiny grooves in the tiles that serve as "pre-made cracks so they can breathe," Riccardo explained. "It's operated for five years and nothing has fallen off," she said.

Now Riccardo and her husband, Peter Mandryk, and their three boys, Nicholas, 14; Alexander, 11; and Christopher, 10, are adjusting to life in the United States after moving here just before Christmas. Riccardo said they are enjoying the snow, which is rare in England. They are presently living at a local hotel while they wait for their belongings to arrive from England, before moving to their new house in South Brunswick. In the meanwhile, the boys are enjoying the big breakfasts and practicing basketball (snow permitting) at the hotel. They just began attending their new schools a couple of weeks ago. They will probably continue playing soccer "or as we call it 'football' " in the U.S. and Riccardo's husband may volunteer as a referee. Riccardo also enjoys hiking and hopes to find some good paths in New Jersey.

Riccardo said she welcomes the opportunity to use her skills to help identify and address any potential issues with NSTX-U. At the same time, she will be looking ahead to the future of the department. "I am trying to understand where we are and where we want to go," she said. "Once I get that, I can start thinking about goals for PPPL's Engineering Department."

Application opens for presenters at 2017 Princeton Research Day

Applications are being accepted through Feb. 20 for non-faculty researchers at Princeton University, such as undergraduates, graduate students and postdoctoral researchers, to present at the second annual 2017 Princeton Research Day on May 11. The application is available at https://researchday.princeton.edu.

The link to the Research Day website is available here.
The link to the application is available here.

Supermassive black hole

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Four million times the mass of the sun

The colossal black hole at the center of the Milky Way — called "Sagittarius A*" because it is found in the constellation Sagittarius — has a gravitational mass that is four million times greater than our own sun. Yet the accretion disk plasma that spirals into this mass is "radiatively inefficient," meaning that it emits much less radiation than one would expect.

"So the question is, why is this disk so quiescent?" asks Matthew Kunz, lead author of the paper, assistant professor of astrophysical sciences at Princeton University and a physicist at PPPL. Co-authors include James Stone, Princeton professor of astrophysical sciences, and Eliot Quataert, director of theoretical astrophysics at the University of California, Berkeley.

To develop a method for finding the answer, the researchers considered the nature of the superhot Sagittarius A* accretion disk. Its plasma is so hot and dilute that it is collisionless, meaning that the trajectories of protons and electrons inside the plasma rarely intersect.

Matthew Kunz *(Photo courtesy Princeton Department of Astrophysical Sciences)*

This lack of collisionality distinguishes the Sagittarius A* accretion disk from brighter and more radiative disks that orbit other black holes. The brighter disks are collisional and can be modeled by formulas dating from the 1990s, which treat the plasma as an electrically conducting fluid. But "such models are inappropriate for accretion onto our supermassive black hole," Kunz said, since they cannot describe the process that causes the collisionless Sagittarius A* disk to grow unstable and spiral down.

Tracing collisionless particles

To model the process for the Sagittarius A* disk, the paper replaces the formulas that treat the motion of collisional plasmas as a macroscopic fluid. Instead, the authors use a method that physicists call "kinetic" to systematically trace the paths of individual collisionless particles. This complex approach, conducted using the Pegasus computer code developed at Princeton by Kunz, Stone and Xuening Bai, now a lecturer at Harvard University, produced a set of equations better able to model behavior of the disk that orbits the supermassive black hole.

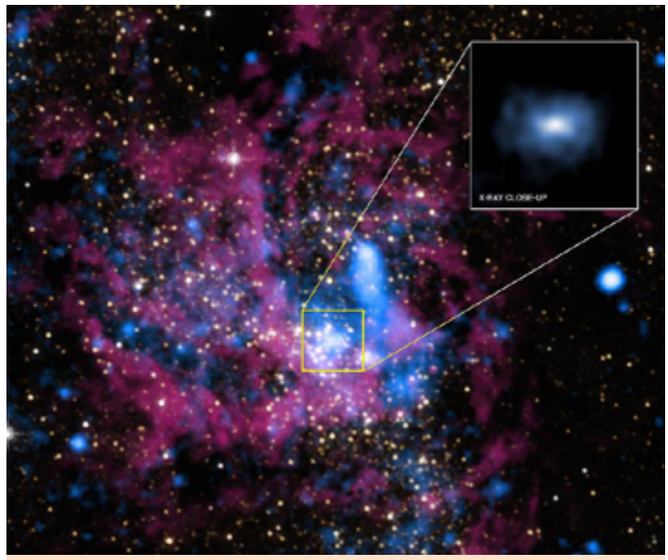


Image and inset of region surrounding Sagittarius A* *(Image courtesy NASA/UMass/D.Wang et al. Inset: NASA/STScI)*

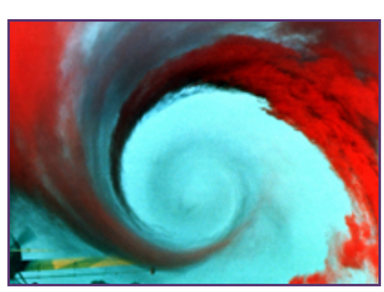
This kinetic approach could help astrophysicists understand what causes the accretion disk region around the Sagittarius A* hole to radiate so little light. Results could also improve understanding of other key issues, such as how magnetized plasmas behave in extreme environments and how magnetic fields can be amplified.

The goal of the new method, said Kunz, "will be to produce more predictive models of the emission from black-hole accretion at the galactic center for comparison with astrophysical observations." Such observations come from instruments such as the Chandra X-ray observatory, an Earth-orbiting satellite that NASA launched in 1999, and the upcoming Event Horizon Telescope, an array of nine Earth-based radio telescopes located in countries around the world.

Research for this paper was funded by the National Science Foundation and grants from the Lyman Spitzer, Jr. Fellowship; a Simons Investigator Award from the Simons Foundation; and the David and Lucille Packard Foundation.

COLLOQUIUM

Chaotic Dynamics in the Physical Sciences



Dr. Edward Ott
University of Maryland

Wednesday, Jan. 18
4:15 p.m., M.B.G Auditorium, Lyman Spitzer Building

DOE Leadership Group

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Jaworski is author or co-author of over 40 peer-reviewed journal articles since 2004. He serves in the US Burning Plasma Organization as deputy leader of the Pedestal and Divertor/Scrape-off Layer Topical Group. He also serves as the NSTX-U machine representative to the International Tokamak Physics Activity Divertor/Scrape-off Layer (ITPA-DSOL) group and is a member of the Princeton Plasma Physics Laboratory Lithium Experts Committee. His favorite quote is by N. Machiavelli: "Make no small plans for they have no power to stir the souls of men!"

Howard Yuh

Howard Yuh is a research physicist working on fusion energy at the Princeton Plasma Physics Lab (PPPL). His physics research is currently focused on the National Spherical Torus Experiment – Upgrade (NSTX-U). He is also part of the team developing and designing a current profile diagnostic for the international ITER tokamak project in Cadarache, France.

Howard Yuh

Yuh's field of expertise is an instrument measuring internal magnetic field angles inside a thermonuclear plasma called the motional Stark effect (MSE) diagnostic, which is currently installed on NSTX-U. Using data from this instrument, one can more accurately calculate the magnetic topology of the plasma and study its effect on plasma confinement, stability, and turbulence. As this measurement is very important for understanding plasma performance, the MSE diagnostic is one of several U.S. in-kind contributions to the ITER tokamak project. To aid in the design of the instrument, Yuh constructed a 3D virtual instrument in software to simulate optical performance, geometry, and measurement sensitivities. Results from these simulations were used to allow the instrument to pass its conceptual design review in 2013, with detailed design work now underway.

More recently, Yuh became a member of a newly formed socio-economic group at PPPL, with the goal of understanding the future roadmap of energy technologies. In particular, the group analyzed risks with large-scale deployment.

Yuh's background is in fusion energy, nuclear engineering, and materials science. Yuh earned a Ph.D. in nuclear engineering at the Massachusetts Institute of Technology and B.S. degrees in material science and engineering as well as nuclear engineering at the University of California, Berkeley

Ronald E. Hatcher
Science on Saturday LECTURE SERIES

Jan. 21	**When Plasmas Meet Surfaces: An Exploration of Physics and Technology at the Plasma-Materials Interface** Angie Capece, TCNJ
Jan. 28	**The Physics of Cancer** **Robert Austin,** Princeton
Feb. 4	**Imperative of Vaccination Nationally and Globally** **Adel Mahmoud,** Princeton

Saturdays at 9:30 a.m., MBG Auditorium

Environmental management system audit

An independent auditor will be auditing PPPL's environmental management system from Jan. 17 to Jan. 20.

Contribute to Princeton University's Business Clothing Drive

Please contribute to Princeton University's annual clothing drive to collect business attire for men and women, benefitting Dress for Success, HomeFront's Suitably Dressed, UIH's Operation Fatherhood, and Isles.

The University is also collecting unwanted stuffed toys for donations to Glad Dogs Nation, which creates safe dog toys from old, unwanted stuffed animals. To learn more about Glad Dogs Nation visit www.gladdogsnation.com

Items can be brought to 350 Alexander St. between 8 and 9 a.m. and 12:30 and 1:30 p.m., weekdays, Jan. 25 through Feb. 1.

Volunteers are needed during collection hours. For more information, or to volunteer to assist with the clothing drive, contact Erin Metro in Community and Regional Affairs at emetro@princeton.edu or 609-258-5144.

BROCK

NICK PETTI
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 January 16	Tuesday January 17	Wednesday January 18	Thursday January 19	Friday January 20
COMMAND PERFORMANCE Chef's Feature	Laboratory closed in honor of Martin Luther King Jr. Day	**Vegetarian Chili** over Rice with Cornbread	**Pork Carnitas Burrito** with Beans	**Beefaroni** with Garlic Breadstick	**Curry Chicken** over Basmati Rice with Naan Bread
Early Riser		**Greek Egg White Omelet** with Spinach, Tomato, Peppers & Feta Cheese	**Hash and Eggs**	**Omelet Florentine** with Spinach, Tomato & Mozzarella	**Breakfast Tacos**
Country Kettle		**Pasta Fagioli**	**Chicken & Quinoa**	**Tomato Lentil**	**Spinach and White Bean with Sausage**
Deli Special		**French Dip** with Swiss Cheese, Caramelized Onion & Horseradish Cream served with Potato Wedges	**Prosciutto, Pesto, Roasted Peppers & Arugula** on Ciabatta	**Tomato & Fresh Mozz** on Ciabatta with Basil, Red Onion & Arugula	**Maple-Roasted Vegetable Wrap**
Grill Special		**Buffalo Chicken Steak Sandwich** with Fries	**Tuna Melt** on Rye served with Onion Rings	**Chicken Zen Sandwich**	**Spinach Salad** with Turkey Bacon, Hard-Cooked Egg, Mushrooms & Raspberry Vinaigrette
Panini		**Swedish Meatball Hoagie**	**Southwest Turkey,** Peppers & Cheddar with Jalapeno Ranch Spread	**Crab Cake** on a Kaiser with Lettuce & Tomato	**Turkey French Dip** with Swiss Cheese

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** ◆ Science Writer: **Raphael Rosen** ◆ Webmaster: **Chris Cane** ◆ Communications Director: **Larry Bernard**

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Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://w3.pppl.gov/communications/weekly/.