PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
February 12, 2018

THIS WEEK

WEDNESDAY, FEB. 14

Council Café Lunch
12 p.m. ◆ Cafeteria
Hutch Neilson
Head of Advanced Projects and of ITER Fabrication

FRIDAY, FEB. 16

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

SATURDAY, FEB. 17

Science on Saturday
9:30 a.m. ◆ MBG Auditorium
Self-Driving Cars and AI: Transforming our Cities and our Lives
Jeff Schneider,
Carnegie Mellon University

UPCOMING

WEDNESDAY, FEB. 21

Council Café Lunch
12 p.m. ◆ Cafeteria
Jerry Levine
Head of ES&H

Open Forum with Michael Zarnstorff
2 p.m. ◆ B318
See page 2 for details.

FEB. 23–24

N.J. Middle School & High School Science Bowls
See page 4

SATURDAY, FEB. 24

No Science on Saturday
due to Science Bowl

INSIDE

Review of NSTX-U Recovery plans notes progress and outlines challenges

By Jeanne Jackson DeVoe

An assessment team for the U.S. Department of Energy's Office of Science reviewing recovery plans for the National Spherical Torus Experiment-Upgrade (NSTX-U) found that many elements of the plans are on track but challenges remain that must be addressed in order for the project to succeed.

The three-day review by a team of experts drawn from national laboratories and institutions across the country was the first of two reviews focused on PPPL's ability to carry out its plans to respond to issues with its flagship experiment. A second review on the scientific value of the NSTX-U is planned in late March.

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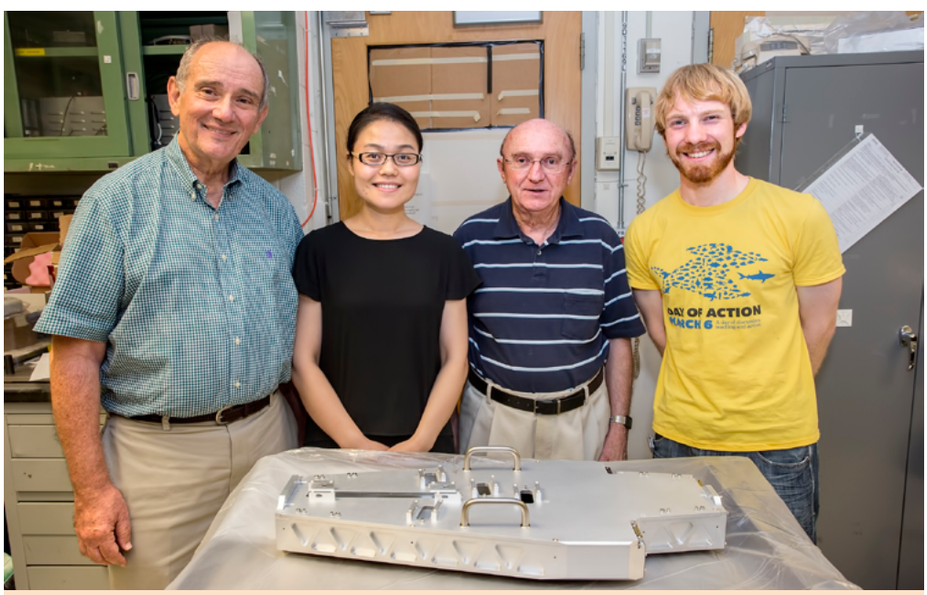
PPPL scientists deliver new high-resolution diagnostic to national laser facility

By Raphael Rosen



The PPPL crew with the instrument before it was delivered to NIF. From left to right: Phil Efthimion, Lan Gao, Ken Hill and graduate student Brian Kraus *(Photo by Elle Starkman)*

Scientists from PPPL have built and delivered a high-resolution X-ray spectrometer for the largest and most powerful laser facility in the world. The diagnostic, installed on the National Ignition Facility (NIF) at the DOE's Lawrence Livermore National Laboratory, will analyze and record data from high-energy density experiments created by firing NIF's 192 lasers at tiny pellets of fuel. Such experiments are relevant to projects that include the U.S. Stockpile Stewardship Program, which maintains the U.S. nuclear deterrent without full-scale testing, and to inertial confinement fusion, an alternative to the magnetic confinement fusion that PPPL studies.

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The mysteries of plasma and solar eruptions earn PPPL graduate an astrophysics prize

By John Greenwald

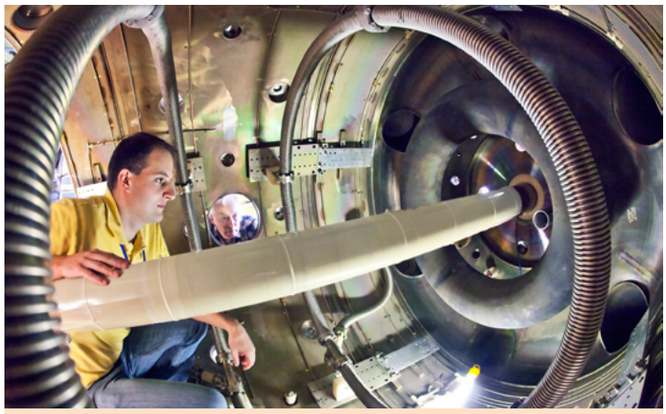
Clayton Myers, a 2015 graduate of the Program in Plasma Physics in the Princeton Department of Astrophysical Sciences who did his research at PPPL, has won the 2018 Dissertation Prize awarded by the Laboratory Astrophysics Division (LAD) of the American Astronomical Society (AAS). Myers, now a physicist at Sandia National Laboratory, received the award for his work on the Magnetic Reconnection Experiment (MRX) at PPPL. The annual prize goes to scientists who have completed their dissertations within three years of the award year.

The MRX device produces laboratory studies of magnetic reconnection, the convergence and violent separation of magnetic field lines in plasma, the state of matter that consists of free electrons and atomic nuclei. Reconnection produces northern lights, solar flares and eruptions, and geomagnetic storms that can snarl cell phone service, black out power grids and disrupt laboratory fusion experiments.

Myers' thesis, titled "Laboratory Study of the Equilibrium and Eruption of Line-Tied Magnetic Flux Ropes in the Solar Corona," gave rise to several first-authored papers that included a *Nature* magazine piece describing a previously unknown mechanism that halts solar eruptions. The award cited his dissertation, "For developing a novel laboratory platform to investigate the magnetohydrodynamic instabilities that drive solar eruptions, and for discovering a new failed eruption regime where the torus instability is halted by a dynamic tension force."

Myers, whose *Nature* paper drew on innovative MRX experiments, said he was honored "to be recognized in an emerging field that lies at the interface between laboratory plasmas and astrophysical events." Advising the dissertation were PPPL physicists Masaaki Yamada and Hantao Ji.

In his thesis, Myers demonstrated the value of laboratory experiments to test, confirm, or challenge state-of-the-art understanding of astronomical observations developed through modeling, and to discover new physics beyond the boundary of current knowledge. Such experiments complement astronomical observations that are limited by the resolution and accessibility of remote-sensing instruments and by the approximations of numerical modeling.



Clayton Myers working on the MRX
(Photo by Elle Starkman)

Myers holds a bachelor's of science degree from Cornell University and worked on diverse projects at PPPL. He conducted magnetic reconnection experiments while earning his doctorate and then moved to the National Spherical Torus Experiment-Upgrade (NSTX-U), joining the team that conducted the first 10 weeks of operation on the upgraded facility. "Every project I have worked on has focused on the interaction between plasmas and magnetic fields," he said. "Fusion and astrophysics are linked by that common thread."

The NSTX-U studies fusion, the fusing of light elements that powers the sun and stars and creates massive amounts of energy. Scientists seek to create fusion on Earth for a virtually inexhaustible supply of power to generate electricity.

At Sandia National Laboratory, Myers works on the Z machine, the world's most powerful pulsed-power facility and X-ray generator, which produces high energy density plasmas that are used to study fusion and the physics of nuclear weapons. This approach to fusion differs from experiments on the NSTX-U, which confines low-density plasma in magnetic fields to produce fusion reactions.

Myers is the seventh Program in Plasma Physics graduate to win a top dissertation award and the first to receive the AAS-LAD prize. Previous winners of the Marshall N. Rosenbluth Outstanding Doctoral Thesis Award, a prize given by the American Physical Society and named for a distinguished physicist at PPPL and General Atomics, were Jonathan Squire, 2017; Jong-Kyu Park, 2010; Yang Ren, 2008; Mark Herrmann, 2000; and Alan Beer, 1996. Also honored was Seth Dorfman, who received the 2013 Fred L. Scarf Award from the American Geophysical Union for outstanding dissertation research that contributes directly to solar planetary sciences including space physics.

Open Forum with Michael Zarnstorff

Wednesday, Feb. 21
2 p.m.
Room B318

Please join the next Open Forum for staff only with Michael Zarnstorff, deputy director for research. Please register here so organizers will know how many people to expect.

NSTX-U Recovery review

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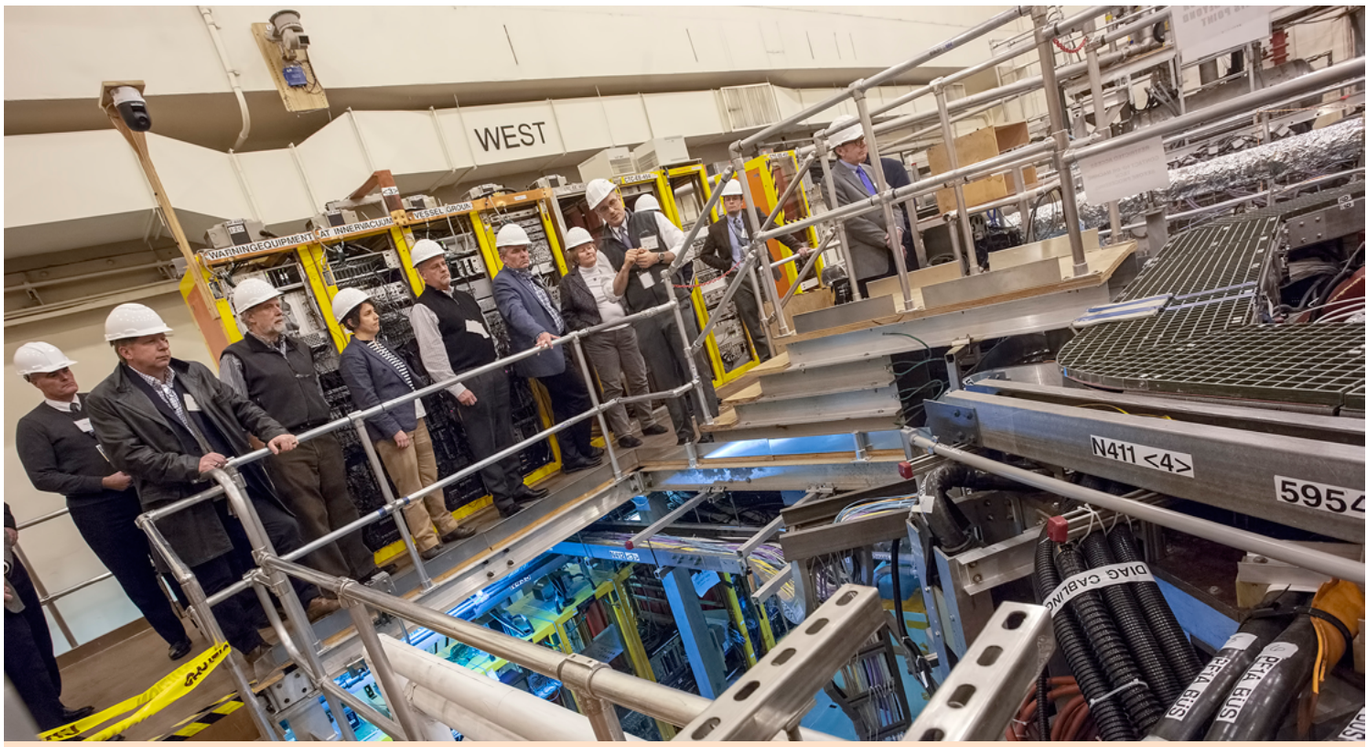

DOE Review Team tours NSTX-U Feb. 6. *(Photo by Elle Starkman)*

"They saw a lot of effort, a lot of progress, a lot of things that were accomplished," Rich Hawryluk, PPPL's interim director, said after the assessment. "But there's a great deal more to be done, not just on NSTX-U but Lab-wide."

Among other issues, the reviewers looked at whether PPPL's cost and schedule plans are realistic and whether the Laboratory has the leadership, management, and staff in place to complete its recovery plan.

PPPL's leadership team and Recovery Project leaders gave presentations during the first day of the review Feb. 6. Dave McComas, Princeton University vice president for PPPL, told the review team that Princeton University has assumed a more active role overseeing PPPL. He noted changes in his office that include the addition of Scott Weidner, assistant vice president for engineering, and Chelle Reno, assistant vice president for operations. McComas also outlined changes in PPPL's management since NSTX-U halted operations in the summer of 2016. "Lab leadership is working very hard to turn the ship around and has done a lot of great work in this area," McComas said. "Still, we need to be vigilant and follow through on all of the improvements."

A deep understanding of the issues

PPPL's Recovery Team has a "deep understanding of the full scope of the issues" on NSTX-U and PPPL has made the necessary changes to enable it to carry out the NSTX-U recovery plans, Hawryluk told the review committee.

Jon Menard, head of the Recovery Project, said the NSTX-U "is an essential user facility in the U.S. fusion program." Research on the device will focus on understanding plasma confinement and sustainment using the new central magnet and second neutral beam injector of NSTX-U. NSTX-U results may lead to more compact next-step fusion devices and will produce research for understanding the physics of a burning plasma such as that in ITER, the international fusion device being constructed in France. Future research would include the use of liquid metals, such as lithium, to coat the walls of the device. This would protect the walls and produce better performance, Menard said.

"Significant improvements" in QA program

The second day was devoted to detailed reviews in subcommittees with additional PPPL presentations. On day three, subcommittee leaders delivered their comments and recommendations.

Reviewers noted "significant improvements" in the Quality Assurance (QA) program, including the adoption of a Quality Assurance Program Description (QAPD) and engineering processes. These steps "should support a successful recovery," said Jay Marx, of Lawrence Berkeley National Laboratory. However, the steps are too recent for reviewers to assess their effect, he said. "The question is whether the needed culture changes take hold throughout the Laboratory."

Confidence in NSTX group

Arnie Kellman of General Atomics' DIII-D National Fusion Facility said the Recovery Team is capable of making the NSTX-U operational. "We have good confidence in the NSTX group to safely and effectively start up the facility," he said at the concluding session.

Kellman said his committee found PPPL's managers and staff "are engaged and committed to completing the project," and stated that management should be receptive to staff feedback. He noted that the 12 design, verification and validation reviews (DVVRs) and two additional extent-of-condition reviews PPPL completed last year on each system of NSTX-U "were critical steps in reestablishing detailed understanding of requirements and functions of all systems."

Reviewers said Hawryluk and PPPL's leadership team, along with McComas and Menard, are clearly committed to making the necessary changes to make the project successful. A new Lab director will need to make a similar commitment, the review team said.

Uncertainty over cost and schedule

Reviewers analyzing the cost and schedule of the Recovery Project, led by Elaine McCluskey of Fermi National Accelerator Laboratory, said PPPL has set an ambitious schedule to complete the Recovery Project by 2020. They questioned whether plans to hold a baseline review in April, as required by DOE, gives the Laboratory enough time. McCluskey noted that cost estimates are currently being updated and it is not clear whether PPPL's cost and schedule plans are detailed enough.

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NSTX-U Recovery review

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Stephen Meador, of the DOE's Office of Project Assessment (OPA), chaired the assessment committee. Other committee members were: Elaine McCluskey, of Fermi National Accelerator Laboratory (FNAL); Jennifer Fortner, of Argonne National Laboratory (ANL); Ethan Merrill, of the DOE's OPA; Jay Marx, of Lawrence Berkeley National Laboratory; Frank Crescenzo, of DOE's Brookhaven National Laboratory Site Office; Norbert Holtkamp, of SLAC National Accelerator Laboratory (SLAC); Hans Vogel, of Oak Ridge National Laboratory (ORNL); Arnie Kellman, of General Atomics; Dan Stout, of Michigan State University; Soren Prestemon, of Lawrence Berkeley National Laboratory; Ruben Fair, of Thomas Jefferson National Accelerator Facility; Richard Boyce, of SLAC; Jim Kerby, of ANL, and Jemila Adetunji, of FNAL (participating remotely).

What are the key elements of the STOP program?

There are 3 key elements to the STOP program: observe work as it is being performed, talk with the worker(s) about what is seen (safe, unsafe, or both), and fill out a STOP card without identifying whom you observed.

Safety first:
Use the STOP program!

Volunteer for the Science Bowl Feb. 23 to 24

Please sign up and volunteer for one or both 2018 NJ Regional Science Bowls on Feb. 23-24!

The Science Bowl needs engineers or physicists to serve as science judges.

The science judge reads along with the moderator and/or takes turns reading questions aloud. The science judge will assist the moderator with pronunciation, and help clarify rules. Science judges may acknowledge a player that buzzes in to answer a question.

Contact Deedee Ortiz, dortiz@pppl.gov, ext. 2785 for more information

NIF X-ray spectrometer

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Final check for the crystal positioning and alignment by Lan Gao before the instrument was shipped to NIF. *(Photo by Elle Starkman)*

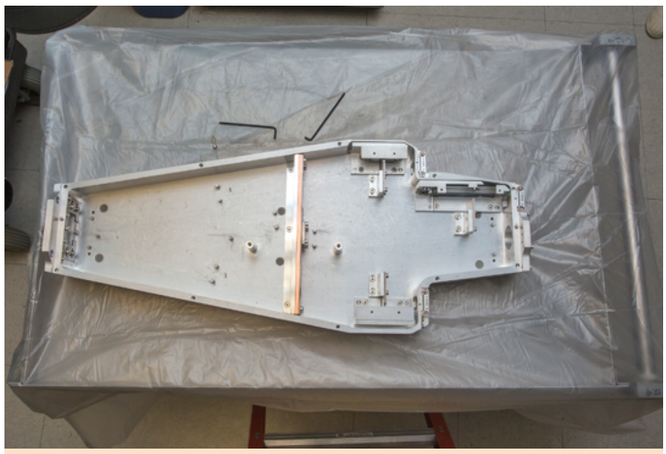
PPPL has used spectrometers for decades to analyze the electromagnetic spectrum of plasma, the hot fourth state of matter in which electrons have separated from atomic nuclei, inside doughnut-shaped fusion devices known as tokamaks. These devices heat the particles and confine them in magnetic fields, causing the nuclei to fuse and produce fusion energy. By contrast, NIF's high-powered lasers cause fusion by heating the exterior of the fuel pellet. As the exterior vaporizes, pressure extends inward towards the pellet's core, crushing hydrogen atoms together until they fuse and release their energy.

NIF tested and confirmed that the spectrometer was operating as expected on Sept. 28. Two more shots were performed in November and January, during which the spectrometer performed well, and two more shots are planned for later this year.

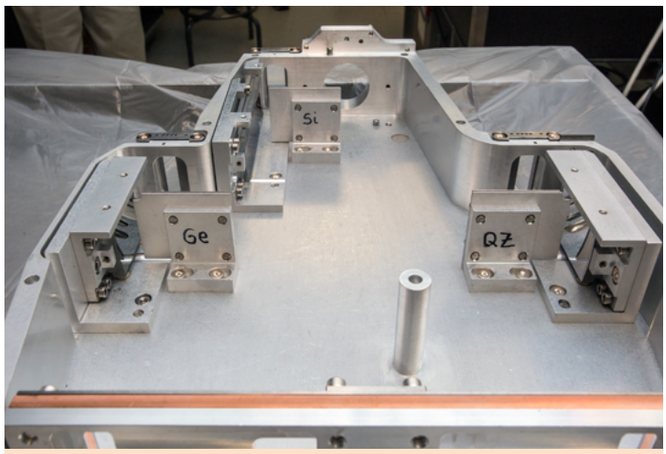
During the experiment, the device accurately measured the electron temperature and density of a fuel capsule during the fusion process. "Measuring these conditions is key to achieving ignition of a self-sustaining fusion process on NIF," said PPPL physicist Lan Gao, who helped design and build the device. "Everything worked out very nicely. The signal level we got was just like what we predicted."

The spectrometer will focus on a small capsule of simulated fuel that includes the element krypton to measure how the density and temperature of the hot electrons in the plasma change over time. "The fusion yield is very sensitive to temperature," said Marilyn Schneider, leader of NIF's Radiation Physics and Spectroscopic Diagnostics Group. "The spectrometer will provide the most sensitive temperature measurements to date. The device's ability to plot temperature against time will also be very helpful."

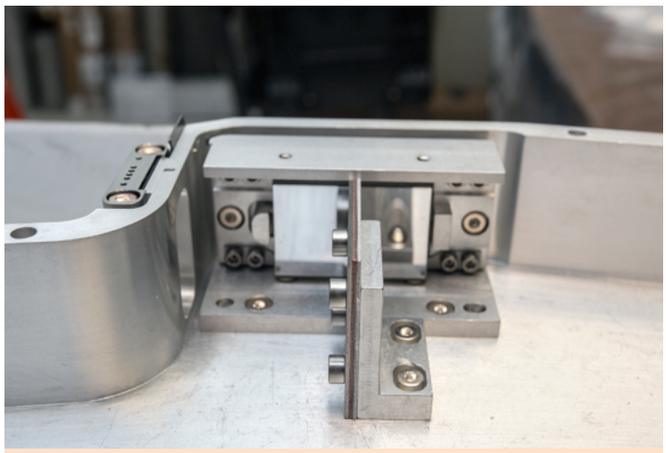
Other PPPL researchers who contributed to this project include Principal Research Physicist Ken Hill; the Head of the Plasma Science & Technology Department Phil Efthimion; and graduate student Brian Kraus.



A cross section of the instrument. The instrument includes three crystal spectrometers: a cylindrical Si111 crystal which provides time-integrated X-ray measurement from Kr Heα to Heβ, a conical Ge220 crystal that provides time-resolved Kr Heβ measurement, and a conical Qz110 crystal that provides time-resolved Kr Heα measurement. *(Photo by Elle Starkman)*



The three spectrometer channels inside the instrument *(Photo by Elle Starkman)*



Zoom-in view of the Qz channel. There is a window next to the crystal assembly for allowing X-rays to propagate through and impinge onto the crystal. In front of the crystal is a shielding piece to block scattered X-rays. *(Photo by Elle Starkman)*

Ronald E. Hatcher

Science on Saturday LECTURE SERIES

Feb. 17	**Self-Driving Cars and AI: Transforming our Cities and our Lives** **Jeff Schneider,** Carnegie Mellon University
Feb. 24	**No Science on Saturday**
Mar. 3	**Looking Ahead A Split Second: How The Brain Learns Predictions In An Unpredictable World** **Sam Wang,** Princeton University
Mar. 10	**Control in the Sciences of Vast Length and Timescales** **Herschel A. Rabitz,** Princeton University **Andrea Woody,** University of Washington

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

Submit your questions for Plasma 101 Lunch & Learn

Please submit your questions about fusion energy, plasma, or any of the research we do here in the box in the LSB lobby.

Sample questions:
What is plasma?
How is what we do different from “nuclear power?”
Why don’t we have fusion energy on the grid yet?

Council Café Lunch

This Week:

Hutch Neilson, Head of Advanced Projects and of ITER Fabrication

Wednesday, Feb. 14
12 p.m., PPPL Café

Feb. 21: Jerry Levine

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 Feb. 12	Tuesday Feb. 13	Wednesday Feb. 14	Thursday Feb. 15	Friday Feb. 16
Early Riser	**Blueberry Pancakes**	**Fried Bologna and Egg Sandwich**	**Tater Tot Breakfast Bake**	**Ham, Egg & Cheese French Toast**	**Biscuits and Sausage Gravy**
Country Kettle	**Chef's Choice**	**Chef's Choice**	**Chef's Choice**	**Chef's Choice**	**Chef's Choice**
Deli Specialty	**Italian Hero**	**Muffaletta**	**Lemon Rosemary Turkey Sandwich**	**American Hoagie** with Ham, Turkey, and American Cheese	**Italian Tuna Salad Wrap**
Grill Specialty	**Taco Cheesesteak**	**Chicken and Sausage Jambalaya**	**Grilled Fish Cake Sandwich**	**Grilled Margherita Sandwich**	**BBQ Turkey Melt**
COMMAND PERFORMANCE **Chef's Feature**	**Beef and Bean Burrito** with Yellow Rice	**Cornmeal Catfish** with Red Beans and Rice and Hush Puppies	**Carved Jerk-Seasoned Pork Loin** with Pineapple Rice and Mango Salsa	**Power Bowl**	**Bourbon Chicken** over Rice
Grilled Panini	**Cheddar Crab Melt**	**Fried Clam Strip Po' Boy**	**Meatball Parmigiana Hero**	**Corned Beef Reuben**	**NY Street Dog—** 2 Sabrett Hot Dogs with Sauerkraut, Red Onions & Mustard served with Fries

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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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/.