

## THIS WEEK

FRIDAY, AUG. 4

**Public Tour**  
10 a.m.

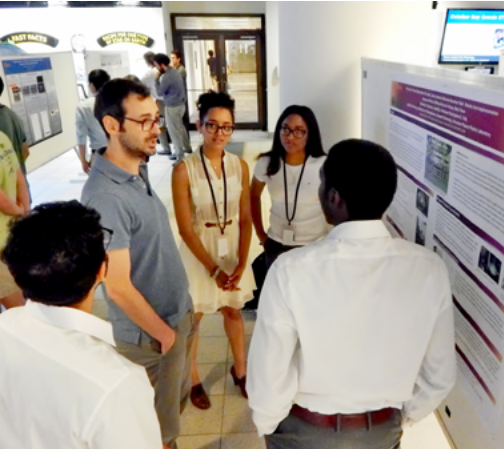
## UPCOMING

FRIDAY, AUG. 11

**Austin Healy Society Tour**  
2 p.m.

WEDNESDAY, AUG. 16

**SULI Poster Session**  
10 a.m.-1 p.m. ♦ LSB Lobby



The next issue of the PPPL Weekly will be on August 14.

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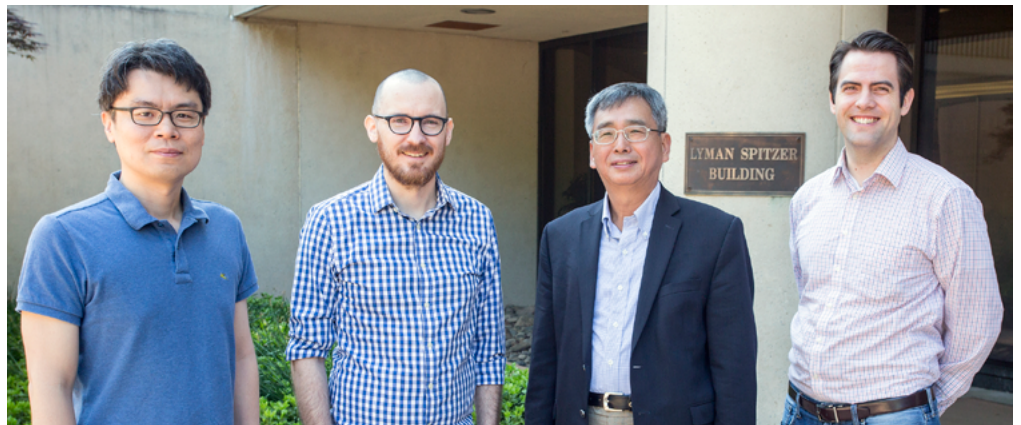
# First basic physics simulation of transition to H-mode at the edge of fusion plasma

By John Greenwald

**P**hysicists at PPPL have simulated the spontaneous transition of turbulence at the edge of a fusion plasma to the high-confinement mode (H-mode) that sustains fusion reactions. The detailed simulation is the first basic physics, or first-principles-based, modeling with few simplifying assumptions.

The research was achieved with the extreme-scale plasma turbulence code XGC developed at PPPL in collaboration with a nationwide team. The findings provide the physics-basis for the successful operation of current and future tokamaks that will produce powerful and economical fusion reactions.

This massively parallel simulation, which reveals the physics behind the transition, utilized most of a supercomputer's power. The XGC code ran for three days and took 90 percent of the capacity of Titan at the Oak Ridge Leadership Computing Facility (OLCF), which is the nation's most powerful supercomputer for open science and capable of performing up to 27 million billion ( $10^{15}$ ) operations per second.



PPPL physicists Seung-Hoe Ku, Robert Hager, Choong-Seock Chang, and Randy Michael Churchill (Photo by Elle Starkman)

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# Environmental Protection Agency recognizes PPPL for reducing waste

By Jeanne Jackson DeVoe

**P**PPL has been recognized by the U.S. Environmental Protection Agency (EPA) for its waste management program, which saved more than \$250,000 by diverting 3,766 tons of waste from landfills.

The agency awarded PPPL the 2016 Federal Green Challenge Regional Award for reducing waste and increasing its combined recycling rate from 84 percent in Fiscal Year 2015 to 97 percent in Fiscal Year 2016. The award is part of the EPA's Sustainable Materials Management program, which challenges federal facilities throughout the country to show annual improvements in their environmental stewardship by reducing waste, purchasing sustainable products, and reducing their carbon footprint.

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# Theory & Simulation Workshop at PPPL advances efforts to develop robust solutions to plasma disruptions

By John Greenwald

The fifth annual PPPL-sponsored workshop on methods to mitigate ITER disruptions discussed recent experiments, theories and simulations that deepened understanding of the processes involved. "Over the five years that the workshops have been held, the international community has come together," said Amitava Bhattacharjee, head of the Theory Department and leader of the July 17-19 sessions in room B318.

The three-day event, attended by some 45 international researchers from PPPL, universities, other national laboratories and ITER, intensified the search for solutions to the problem. "This workshop announced plans for an international task force led by ITER physicists to oversee and coordinate progress year-round," Bhattacharjee said.

energetic electron beams that would seriously damage the plasma-facing components inside the ITER facility.

Discussions at the workshop focused heavily on runaway electrons, the issue considered the most urgent facing ITER. Management "is aware of the impact runaway formation will have on the exploitation of ITER," said Michael Lehnen, scientific coordinator for the stability and control section of the international tokamak, who attended a leadership workshop at ITER headquarters last March

The problem is particularly pressing, he said. "Avoidance or suppression of runaway electrons during disruption mitigation cannot currently be guaranteed," he noted, "because of the present limitation in the physics understanding of runaway electron generation and disruption mitigation processes."

Possible mitigation efforts include injection of shattered pellets inside tokamaks, creating conditions that suppress or dissipate runaway electrons. Among the issues discussed at the workshop was deployment of shattered pellets to mitigate disruptions in the Joint Economic Torus in the United Kingdom, the largest tokamak currently in operation, and other large tokamaks such as DIII-D at General Atomics and ASDEX-U in Germany, and the lessons that such experiments hold for ITER.

Bhattacharjee took heart from the recent event. "I am greatly encouraged by the quality of the world talent focused on this problem," he said, "as is evident from the presentations at the workshop, including the involvement of several young and mid-career colleagues, and am very optimistic that we will find a solution. We must." 📷



Participants in the Theory and Simulation of Disruptions workshop with members of the organizing committee, Valeri Izzo of the University of California, San Diego, Michael Lehnen of ITER and Amitava Bhattacharjee in front row. (Photo by Elle Starkman)

Mitigating disruptions will be crucial for ITER, the international tokamak under construction in France, which is to produce 10 times more power than it consumes. Disruptions, or the sudden quenching of current and heat during fusion reactions, could release powerful wall currents and highly

## A tour for visitors from the Bangladeshi Rural Electric Society



Several people from the Bangladeshi Rural Electric Society toured PPPL on July 17 with tour guide Ray Camp. (Photo by Raphael Rosen)



## Doctoral graduate Jonathan Squire wins 2017 best dissertation award


The American Physical Society has named Jonathan Squire winner of the 2017 Marshall N. Rosenbluth Outstanding Doctoral Thesis Award. Squires, a 2015 graduate of the Program in Plasma Physics in the Princeton Department of Astrophysical Sciences, was honored for his thesis on turbulent plasmas in astrophysics. The selection committee cited the work, “For fundamental contributions to dynamo theory, particularly the analytical and computational elucidation of the magnetic shear current effect.”

Now a postdoctoral fellow in the theoretical astrophysical group at Caltech, Squire said he was “absolutely thrilled and honored to receive this award. PPPL was a wonderful place to do



Jonathan Squire

a PhD and I feel very lucky to have had such opportunities, especially the invaluable support of my advisor, Amitava Bhattacharjee, and other PPPL faculty members.”

A native of New Zealand, Squire received an Honorary Fellowship from the Princeton Graduate School while putting together the thesis. He came to PPPL on an International Fulbright Science & Technology Award and is the fifth PPPL graduate to win the Rosenbluth honor, named for a distinguished plasma physicist at General Atomics and PPPL. Previous winners and the year of their awards: Jong-Kyu Park, 2010; Yang Ren, 2008; Mark Herrmann, 2000; Michael Alan Beer, 1996. 

## EPA award

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“This award recognizes PPPL’s sustained commitment to improving its environmental performance,” said Terry Brog, interim director of PPPL. “As a national laboratory in the energy sector, our Lab and its people value environmental stewardship. We constantly look at what we buy, what we recycle, and how we dispose of waste, which has become a fundamental part of how we operate. We are pleased that the EPA recognizes our efforts. It is testament that we are doing the right thing.”

### Third environmental award this year

It was the third award the Laboratory has received from national agencies this year for its sustainable programs. Earlier this year, PPPL received a gold Green Buy Award from the U.S. Department of Energy (DOE) for its green buying program in fiscal year 2016, the fourth such award PPPL has received in the past six years. The Laboratory also received a U.S. EPA Region 2 Food Recovery Challenge Award for fiscal year 2015 for the Laboratory’s composting program.

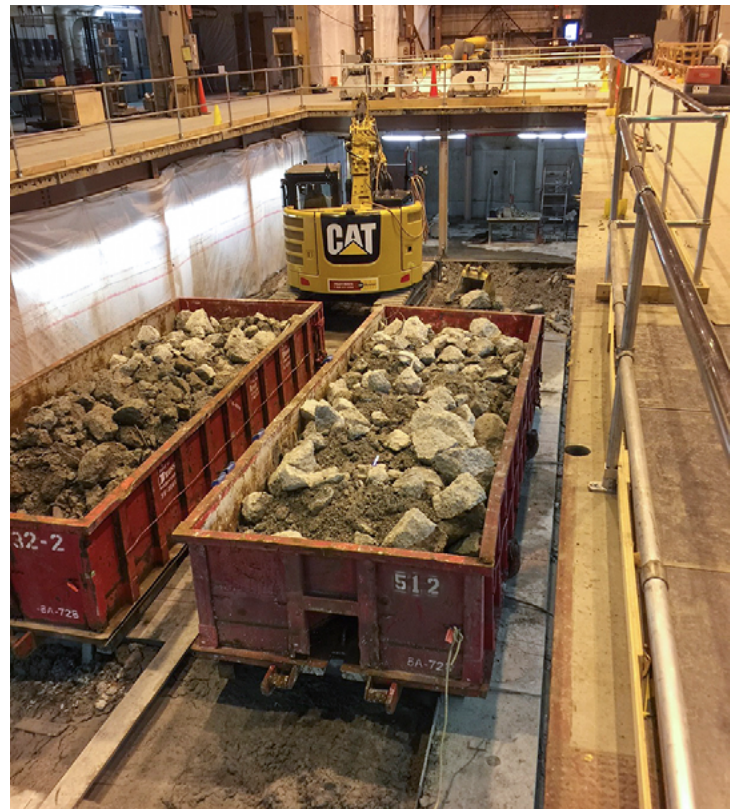
PPPL’s environmental programs include an active recycling and composting program, a program to buy green office and cleaning products, and to reduce its carbon footprint wherever possible by using biofuels in campus vehicles.

PPPL has received numerous awards for its environmental programs over the last several years. The Lyman Spitzer Building, the lab’s main administration building, was granted U.S.-LEED Gold certification in 2011. In 2012, the laboratory received a DOE Federal Sustainability award for reducing its greenhouse gases and was named an EPA Waste-Wise Federal Partner of the Year. In 2013, the Laboratory received the New Jersey Stewardship award.

### Almost all construction debris recycled

The Infrastructure and Operational Improvements (IOI) project can take much of the credit for the Laboratory’s exceptional recycling rate in FY 2016. The project recycled 98 percent of all the construction debris from the project, amounting to 3,765 tons of recycling with just 114 tons of debris discarded. The debris was 92 percent concrete removed from the C-Site MG Building’s basement and included clean wood, scrap metal, wires and cables, asphalt, fill dirt, and gravel. Also included was equipment stored in dozens of trailers on the campus, which are being cleaned out as part of the IOI project.


“I’m pleased that we’ve been able to put together a solid program with some fairly strong recycling goals and are able to meet those goals,” said Les Hill, head of the IOI project. “I’m amazed at how much we’re able to recycle.”



Tons of concrete removed from the C-Site Motor Generator Building basement were recycled in fiscal year 2016. (Photo by Erik Perry)

“Getting an EPA Green Challenge Award is great for the Lab,” said Leanna Sullivan, an environmental scientist at PPPL. “It’s good for us and we can inspire other people to do the same thing.”

Margaret Kevin-King, buildings and grounds supervisor, credits the janitorial staff for their continual efforts to remove unwanted items from the recycling and composting stream, such as plastics and silverware. Kevin-King has been active in trying to make the Laboratory more sustainable for the past 20 years and she said sustainable practices have become a way of life at the Laboratory.

“The people who participate in the program aren’t doing it because it’s a DOE mandate; they’re not doing it for recognition. It’s habitual,” Kevin-King said. “They not only practice it here, they practice it at home. My hope is that this recognition will encourage more people to participate, knowing that this is good for the Lab, it’s good for the DOE, and it’s good for our future.” 



# Edge turbulence

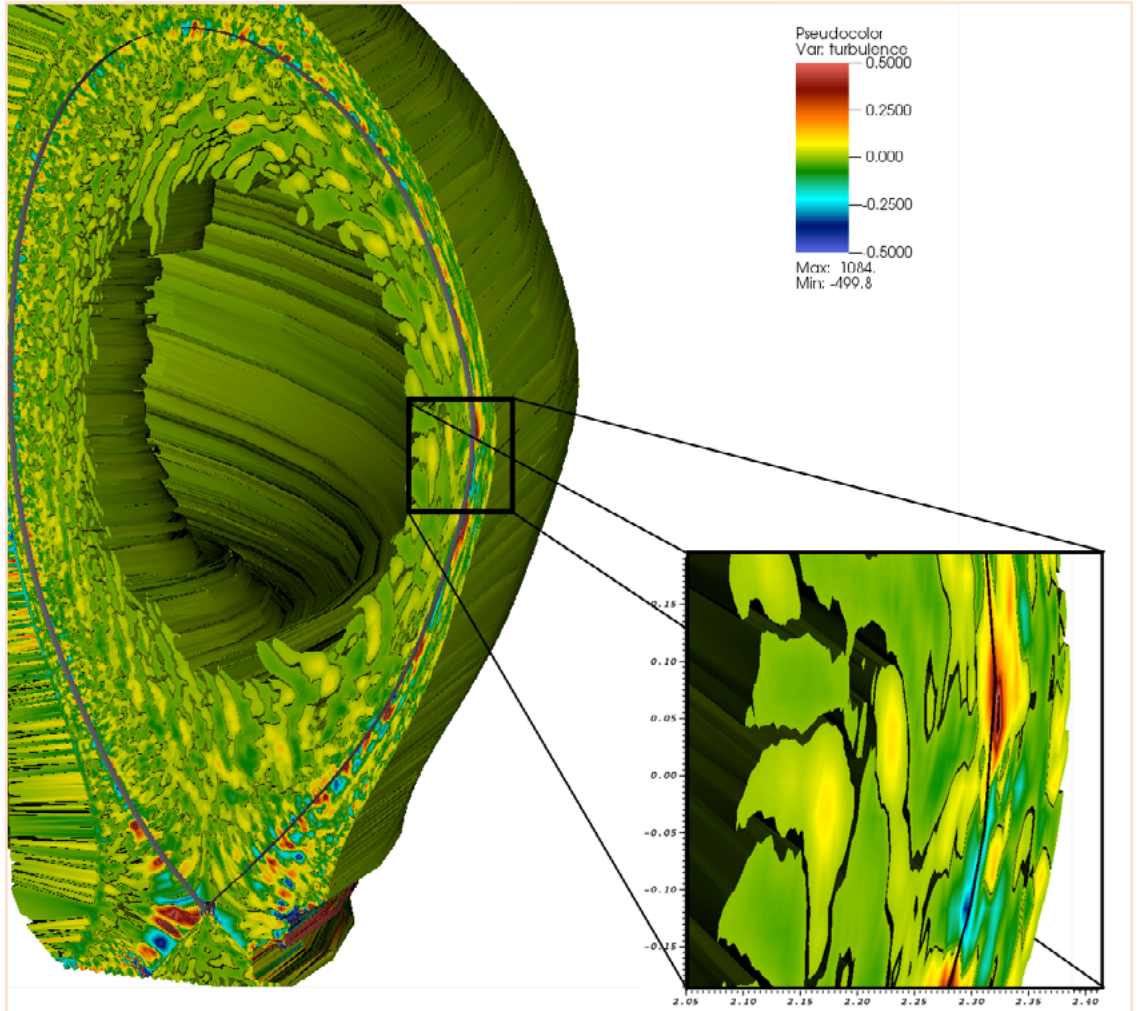
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“After 35 years, the fundamental physics of the bifurcation of turbulence into H-mode has now been simulated, thanks to the rapid development of the computational hardware and software capability,” said C.S. Chang, first author of the April Physical Review Letters paper [118, 175001 (2017)] that reported the findings. Co-authors included a team from PPPL, the University of California, San Diego, and the MIT Plasma Science and Fusion Center. Seung-Ho Ku of PPPL performed the simulation.

As an example of the use of the model, the core of the plasma inside the seven-story ITER tokamak, the international fusion experiment under construction in France, will have to be more than 10 times hotter than the core of the sun, whose temperature is 15 million degrees Celsius. Yet the edge of the plasma, located about two meters away, will be 1,000 times cooler, with most of the temperature dropping over a radial slope whose width is only a few percent of the total plasma size.

In 1982, German researchers discovered that the edge of the plasma can spontaneously bifurcate into a high pedestal with a steep gradient, or transport barrier, that produces the H-mode confinement and maintains the heat of the plasma core. This bifurcation takes place when the heating power of the tokamak is raised above a critical level.

Creation of the transport barrier occurs almost instantaneously. The buildup results from suppression of the edge



Cross-section of an XGC1-simulated tokamak plasma showing different amplitudes of density fluctuation caused by edge turbulence. Inset box: Vertical shearing of eddies of turbulence caused by different plasma flow speeds, related to the breaking of eddies and suppression of turbulence in the figure below. (Courtesy David Pugmire, Oak Ridge National Laboratory.)

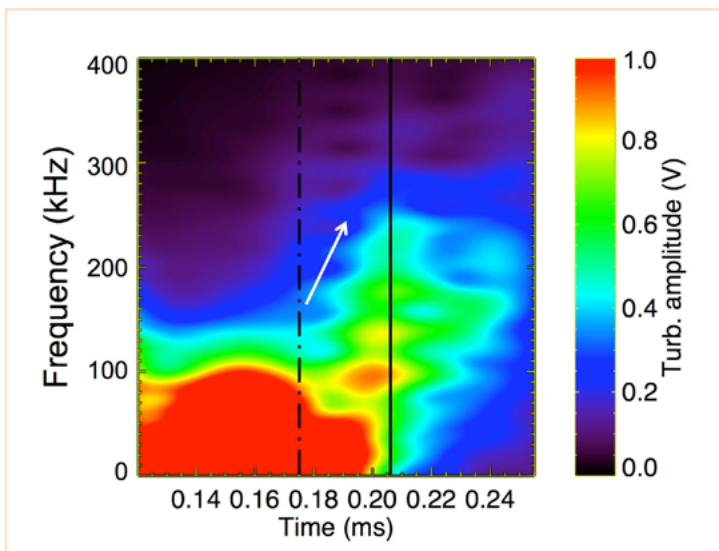
turbulence, which drops from high to low amplitude in less than a tenth of a millisecond. The puzzle baffling physicists for more than three decades is what causes this transition to happen.

Researchers have long held two conflicting stories, based on reduced models and various degrees of simplifying assumptions, which arise from the complexity of the plasma edge and the lack of computing power. One school proposes that the transformation comes from a turbulence-generated sheared flow of edge plasma generated by a process called “Reynolds stress.” Opposing this view is a school that attributes the bifurcation to a non-turbulent sheared flow.

The PPPL extreme-scale code indicates that both stories are partly correct. The simulation reveals that the bifurcation results from the synergistic relationship between the Reynolds stress-generated sheared flow and the non-turbulent-generated sheared flow, which is technically known as the “X-point orbit loss-driven” and “neoclassical” flow. In short, says the paper, “the experimental argument based upon the orbit loss mechanism ... and the conventional Reynolds stress argument work together.”

For ITER and other next-generation machines, the bifurcation to H-mode could require an increase in heating power if the non-turbulent-driven sheared flow proves weaker than today’s tokamaks require. The reverse also holds true: if the non-turbulent-driven sheared flow should prove to be stronger than currently anticipated for ITER, less heating power may be needed to achieve the crucial transformation to H-mode.

The OLCF is a DOE Office of Science User Facility at Oak Ridge National Laboratory. 



Contour plot of spontaneous suppression of high-amplitude, low frequency turbulence in red, with arrow indicating direction of time and increase in frequency. Suppression starts around 0.175 milliseconds and completes around 0.2 milliseconds. (Courtesy Robert Hager and Seung-Ho Ku)

## Panel on transformative capabilities for advancing fusion energy

The subcommittee on “Transformative Enabling Capabilities” of the Fusion Energy Sciences Advisory Committee (FESAC) met July 19-21 in the MBG Auditorium. Members of the panel, chaired by PPPL physicist Rajesh Maingi with Arnold Lumsdaine of Oak Ridge National Laboratory as vice-chair, discussed the most promising capabilities for the U.S. to pursue to promote the efficient

advance toward fusion energy. Panelists came from national laboratories and universities across the country. Topics ranged from high-temperature superconductors to exascale computer programs and self-healing materials. The meeting was the third held this year, with previous sessions in Chicago and Rockville, Maryland. A final report is due to DOE in October. 📄



FESAC subcommittee attendees in front of the Lyman Spitzer Building. (Photo by Elle Starkman)

## 2017 Fishing Trip Aboard the 80' Suzie Girl

**Date:** Sunday August 6th, 2017

**Departure:** 7:30 a.m. SHARP!!!

**Location:** Belmar Marina Hwy. 35, Belmar, NJ 07719

**Cost:** \$80 Per person ALL INCLUSIVE

Cost includes everything Rods, bait, fish cleaning, food, beverages.

All you need to do is show up! If the trip is rescheduled due to bad weather there are NO REFUNDS.

Contact Andy Carpe, ext. 2118, [acarpe@pppl.gov](mailto:acarpe@pppl.gov), Bob Tucker Jr., ext. 3190, [rltucker@pppl.gov](mailto:rltucker@pppl.gov), or Andy Konca, ext. 2537, [akonca@pppl.gov](mailto:akonca@pppl.gov)





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 July 31	Tuesday August 1	Wednesday August 2	Thursday August 3	Friday August 4
<b>COMMAND PERFORMANCE Chef's Feature</b>	<b>Chicken-Fried Steak Melt</b> with Mashed Potatoes and Corn	<b>Sticky Wings</b> with Cornbread	<b>Chicken Gyro</b> served with Greek Salad	<b>Pineapple Chicken Kabob</b> served over White Rice	<b>Four-Cheese Baked Macaroni and Cheese</b> with Stewed Tomatoes.
Early Riser	<b>Banana-Walnut Pancakes</b>	<b>Greek Breakfast Wrap</b>	<b>Chicken Omelette</b>	<b>French Toast Sticks</b>	<b>2 Eggs</b> , Choice of Breakfast Meat & Tater Tots
Country Kettle	<b>Spring Vegetable</b>	<b>Chilled Blueberry Mint</b>	<b>Tuscan Bean</b>	<b>Split Pea</b>	<b>New England Clam Chowder</b>
Deli Special	<b>Liverwurst</b> with Onion and Stone-ground Mustard	<b>BLJT (Bacon, Lettuce and Jersey Tomato)</b>	<b>Curried Ham Salad Ciabatta</b>	<b>Asparagus Wrap</b> with Sundried Tomatoes, Roasted Peppers & Mozzarella Cheese	<b>Italian Chopped Antipasti Wrap</b>
Grill Special	<b>Fried Mortadella Sandwich</b>	<b>Patty Melt</b>	<b>Italian Hot Dog</b>	<b>BBQ Beef Grilled Cheese</b>	<b>Crab, Asparagus &amp; Roasted Pepper Quesadilla</b>
Panini	<b>3-Cheese Panini</b> with Cheddar, Swiss, Bleu Cheese & Tomato on Sourdough	<b>Spicy Pepperoni Ciabatta</b>	<b>Sausage Torpedo</b> with Peppers & Onion	<b>Falafel Wrap</b>	<b>Tuna Melt English Muffin</b> with Fries

	Monday August 7	Tuesday August 8	Wednesday August 9	Thursday August 10	Friday August 11
<b>COMMAND PERFORMANCE Chef's Feature</b>	<b>Chicken Cacciatore</b>	<b>Lung Pao Meatballs</b> over Fried Rice with Egg Roll	<b>Fill Your Box BBQ Lunch</b> — BBQ Chicken, Hot Dogs, Burgers, Beans, Corn, Potato Salad and Iced Tea	<b>Super Salad</b>	<b>Linguine with Clam sauce</b> and Garlic Bread.
Early Riser	<b>Belgian Waffle Sticks</b>	<b>Huevos Rancheros</b>	<b>Frittata Lorraine</b>	<b>Omelette Florentine</b> with Spinach, Tomato & Mozzarella	<b>Breakfast Tacos</b>
Country Kettle	<b>Chipotle Chicken</b>	<b>Pasta Fagioli</b>	<b>Turkey Wild Rice</b>	<b>Tomato Lentil</b>	<b>Chicken Tortilla</b>
Deli Special	<b>Smoked Turkey Baguette</b>	<b>Greek Tuna Salad</b> with Pita Chips over Lettuce		<b>Tomato &amp; Fresh Mozz</b> on Ciabatta with Roasted Garlic Hummus	<b>Southwest Turkey</b> , Peppers & Cheddar with Jalapeño Ranch Spread
Grill Special	<b>Italian Grilled Cheese</b>	<b>Buffalo Chicken Steak Sandwich</b> with Fries		<b>Chicken Zen Sandwich</b>	<b>Chicken Fajita</b> served with Rice and Beans
Panini	<b>Buffalo Shrimp Wrap</b>	<b>Italian Beef</b> with Spinach and Provolone		<b>Crab Cake</b> on a Kaiser with Lettuce & Tomato	<b>Baja Chicken Panini</b> with Pepperjack, Pico de Gallo, and Jalapeño Ranch

MENU SUBJECT TO CHANGE WITHOUT NOTICE

HEART HEALTHY

VEGETARIAN OPTION

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The PPPL WEEKLY is published by the [PPPL Office of Communications](#) on Mondays throughout most of the year and biweekly during the summer, except for holidays. **DEADLINE for calendar item submissions is noon on WEDNESDAY. Other stories should be submitted no later than noon on TUESDAY.**

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