WEEKLY

PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research

U.S. DEPARTMENT OF ENERGY

December 18, 2017

THIS WEEK

WEDNESDAY, DEC. 20

Council Café Lunch
12 p.m. ◆ PPPL Cafeteria
Chelle Reno
Princeton University assistant vice president for operations

THURSDAY, DEC. 21

PPPL Holiday Luncheon

FRIDAY, DEC. 22

Laboratory Closed

UPCOMING

MONDAY, DEC. 25

Laboratory Closed

FRIDAY, DEC. 29

Laboratory Closed

MONDAY, JAN. 1

Laboratory Closed

WEDNESDAY, JAN. 3

Council Café Lunch
12 p.m. ◆ PPPL Cafeteria
Hutch Neilson
Head of ITER fabrication

INSIDE

New year to bring a new home for Business Ops staff as LSB Annex renovation wraps up

By Jeanne Jackson DeVoe

PPPL's Procurement and Accounting employees will be moved into brand new offices in the Lyman Spitzer Building (LSB) Annex before most return to work on Jan. 2.

The LSB Annex is one of the centerpieces of the Infrastructure Operational Improvement (IOI) project, along with the C Site-Motor Generator (MG) Building, and it is nearly completed. The wing has new carpeting, ceiling, and heating, ventilation and air conditioning, and new furniture has been installed.

"It's an exciting time just to see these two projects draw to a conclusion," said Les Hill, head of the IOI project.

Artificial intelligence helps accelerate progress toward efficient fusion reactions

By John Greenwald
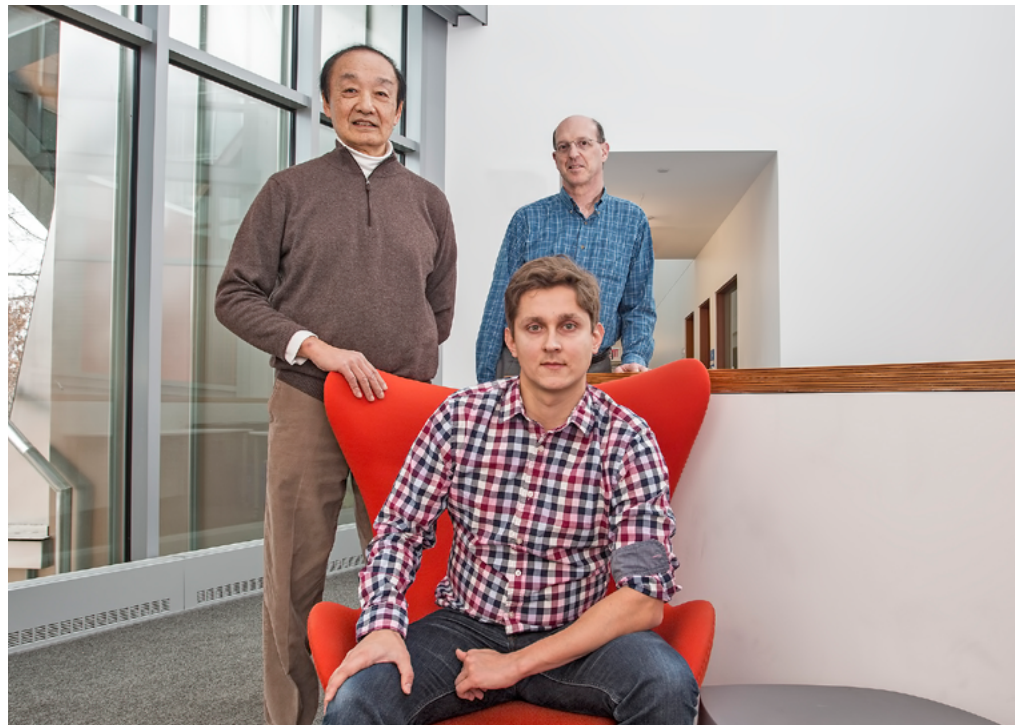
Deep learning developers. Standing: William Tang, left, and Eliot Feibush, with Alexey Svyatkovskiy. *(Photo by Elle Starkman)*

Before scientists can effectively capture and deploy fusion energy, they must learn to predict major disruptions that can halt fusion reactions and damage the walls of doughnut-shaped fusion devices called tokamaks. Timely prediction of disruptions, the sudden loss of control of the hot, charged plasma that fuels the reactions, will be vital to triggering steps to avoid or mitigate such large-scale events.

This issue of the Weekly will be the last issue of the year. The next issue will be on Jan. 8.

Stewart Prager honored with FPA Distinguished Career Award

Stewart Prager, physicist and long-time fusion energy scientist who was director of PPPL from 2009 to 2016, has been honored with a 2017 Distinguished Career Award from Fusion Power Associates (FPA). Prager, a leading contributor to the advancement of plasma physics and fusion science, received the award at the 38th annual meeting of FPA held Dec. 6-7 in Washington, D.C. The association provides students, media and the public with information about the status of fusion development and other applications of plasma science.

Stewart Prager
(Photo by Elle Starkman)

The honor for Prager, a professor of Astrophysical Sciences at Princeton University, cited his "many years of dedication to advancing the prospects for fusion." The citation pointed to his "decades of outstanding career contributions as a scientist, educator, manager, and advisor on all aspects of plasma physics, fusion energy and fusion policy."

Fusion, the power that drives the sun and the stars, is the fusing of light elements that generates massive amounts of energy. Scientists are seeking to replicate fusion on Earth for a virtually inexhaustible supply of power.

Prager was thankful for the FPA award. "Working in fusion has been a remarkable pleasure," he said, "and I am very pleased to receive this recognition from FPA."

Prager joined PPPL as its sixth director in 2009 after 31 years as a professor at the University of Wisconsin-Madison. There he led research on the Madison Symmetric Torus and headed a center that studied plasmas in both the laboratory and the cosmos. Before arriving at Wisconsin he spent two years as a physicist at the predecessor company to General Atomics.

As director of PPPL, Prager enjoyed "the opportunity to help shepherd and steward along new scientific initiatives in fusion and plasma physics, from astrophysics to low temperature plasmas to the National Spherical Torus Experiment upgrade."

Staff explores the Lab on first official employee tour

PPPL held its first official employee tour on Dec. 8. About 20 staff members visited the National Spherical Torus Experiment-Upgrade (NSTX-U) control room, the NSTX-U test cell, the Science Education laboratory, and experiments in the L Wing. The tour guides were Kevin Lamb and Erik Gilson.

Employee tours will be the second Friday of each month from 10 a.m. to noon. Sign up here for the next tour on Friday, Jan. 12 or contact Tours@pppl.gov.
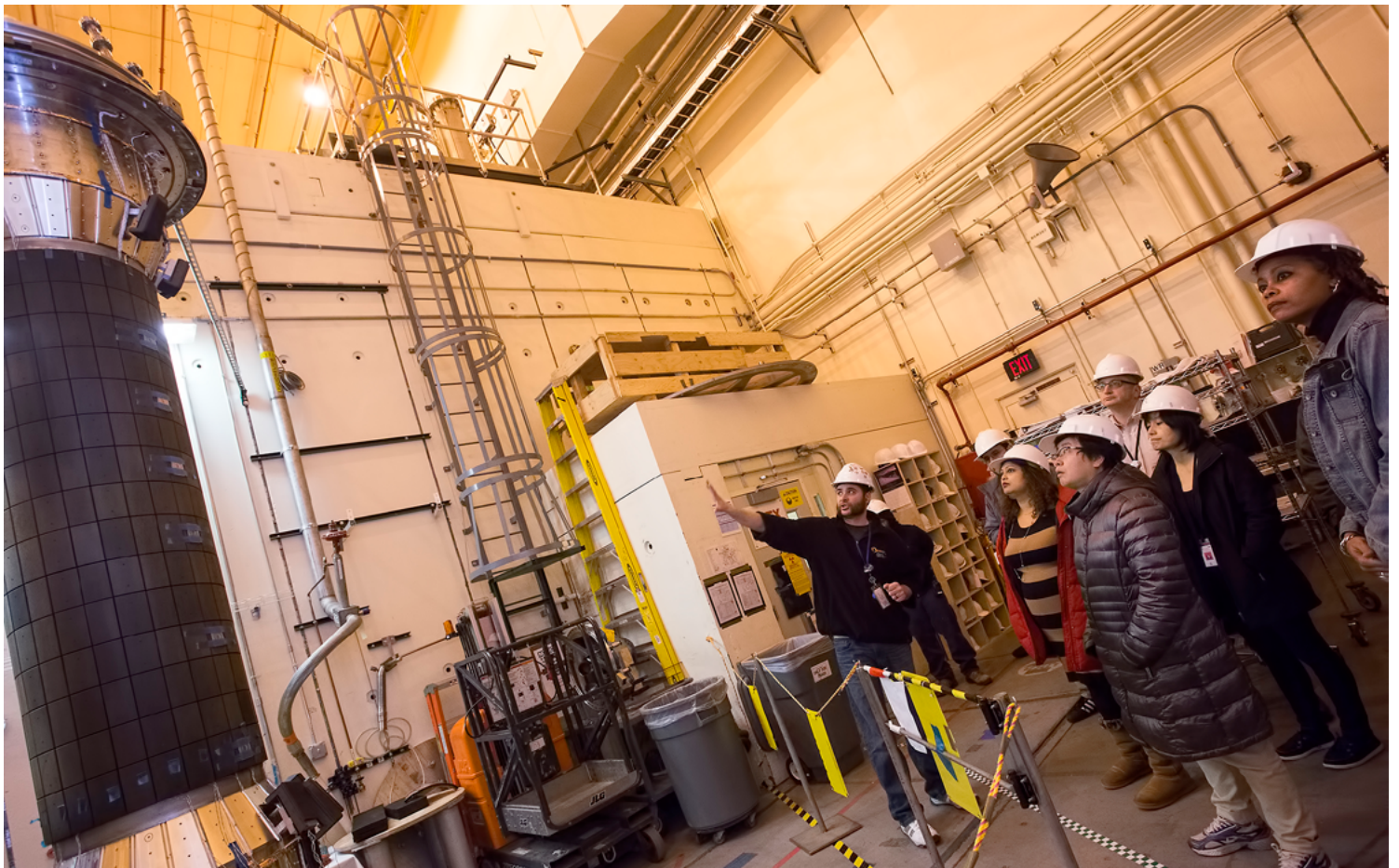
Tour guide Kevin Lamb shows a group of staff members the center stack casing on an employee tour.
(Photo by Elle Starkman)

IOI update

Accounting and Procurement staff will move back into the first floor of the LSB Annex. The second floor will be occupied by Environment, Safety and Health (ES&H) staff, while the third floor will house Quality Assurance and Quality Control staff and some Instrumentation and Controls staff.

Business Operations staff in the C33 modular building, the modular offices next to the lower parking lot that is closest to the LSB Building, have already been told that it's time to get packing. Most of the staff will be moved to their new offices the week of Dec. 25 when many will be on vacation. A third group of staff members in Mod VI, the modular office building housing ES&H, Quality Assurance, and other staff will be moved between Jan. 8 and Jan. 19. The Mod VI building will be demolished shortly after it is vacated.

Once the Accounting and Procurement staff move to permanent digs, Engineering staff still in the Engineering Wing will move into the C33 modular office building in April or May. That will allow renovations of the Engineering Wing that are funded by General Plant Project funds and are not part of the IOI project. The renovations will include a new

Cubicles and filing cabinets in the LSB Annex.
(Photo by Elle Starkman)

drop ceiling, fresh paint, new carpeting, and new furniture from the C33 modular building, said Chris Roames, Facilities strategic planner. That project should be completed by the end of the 2018 calendar year. Most of the Engineering staff would then move back to the Engineering Wing.

Meanwhile, technicians in the Research Equipment Storage Area (RESA) Building are preparing to move their equipment to the C Site-MG Building, which is also nearing completion. The tools will be transported to the new building starting in January, Hill said. Most of the HVAC, interior and fire protection work is complete, including the construction of a training/conference room and an office area. Once the tech shops have moved, workers can begin to convert the RESA Building into storage facility, Hill said.

PPPL is also considering the best use of remaining contingency funds from the IOI project, Hill said. Some of the funds may be used to refurbish and renovate the crane in the C Site-MG Building. The Laboratory is also considering renovating the LSB Annex basement. This work would be aimed at creating a more versatile meeting space that would have updated audiovisual and internet connections.

Offices along the perimeter of a floor in the LSB Annex.
(Photo by Elle Starkman)

Work on the C Site-MG Building is almost complete.
(Photo by Elle Starkman)

The basement of the LSB Annex.
(Photo by Elle Starkman)

Artificial intelligence

Today, researchers at PPPL and Princeton University are employing artificial intelligence to improve predictive capability. Researchers led by William Tang, a PPPL physicist and a lecturer with the rank and title of professor at Princeton University, are developing the code for predictions for ITER, the international experiment under construction in France to demonstrate the practicality of fusion energy.

Form of "deep learning"

The new predictive software, called the Fusion Recurrent Neural Network (FRNN) code, is a form of "deep learning" — a newer and more powerful version of modern machine learning software, an application of artificial intelligence. "Deep learning represents an exciting new avenue toward the prediction of disruptions," Tang said. "This capability can now handle multi-dimensional data."

FRNN is a deep-learning architecture that has proven to be the best way to analyze sequential data with long-range patterns. Members of the PPPL and Princeton University machine-learning team are the first to systematically apply a deep learning approach to the problem of disruption forecasting in tokamak fusion plasmas.

Chief architect of FRNN is Julian Kates-Harbeck, a graduate student at Harvard University and a DOE-Office of Science Computational Science Graduate Fellow. Drawing upon expertise gained while earning a master's degree in computer science at Stanford University, he has led the building of the FRNN software.

More accurate predictions

Using this approach, the team has demonstrated the ability to predict disruptive events more accurately than previous methods have done. By drawing from the huge data base at the Joint European Torus (JET) facility located in the United Kingdom — the largest and most powerful tokamak in operation — the researchers have significantly improved upon predictions of disruptions and reduced the number of false positive alarms. EUROfusion, the European Consortium for the Development of Fusion Energy, manages JET research.

The team now aims to reach the challenging goals that ITER will require. These include producing 95 percent correct predictions when disruptions occur, while providing fewer than 3 percent false alarms when there are no disruptions. "On the test data sets examined, the FRNN has improved the curve for predicting true positives while reducing false positives," said Eliot Feibush, a computational scientist at PPPL, referring to what is called the "Receiver Operating Characteristic" curve that is commonly used to measure machine learning accuracy. "We are working on bringing in more training data to do even better."

Highly demanding

The process is highly demanding. "Training deep neural networks is a computationally intensive task that requires engagement of high-performance computing hardware," said Alexey Svyatkovskiy, a Princeton University big data researcher. "That is why a large part of what we do is developing and distributing new algorithms across many processors to achieve highly efficient parallel computing. Such computing will handle the increasing size of problems drawn from the disruption-relevant data base from JET and other tokamaks."
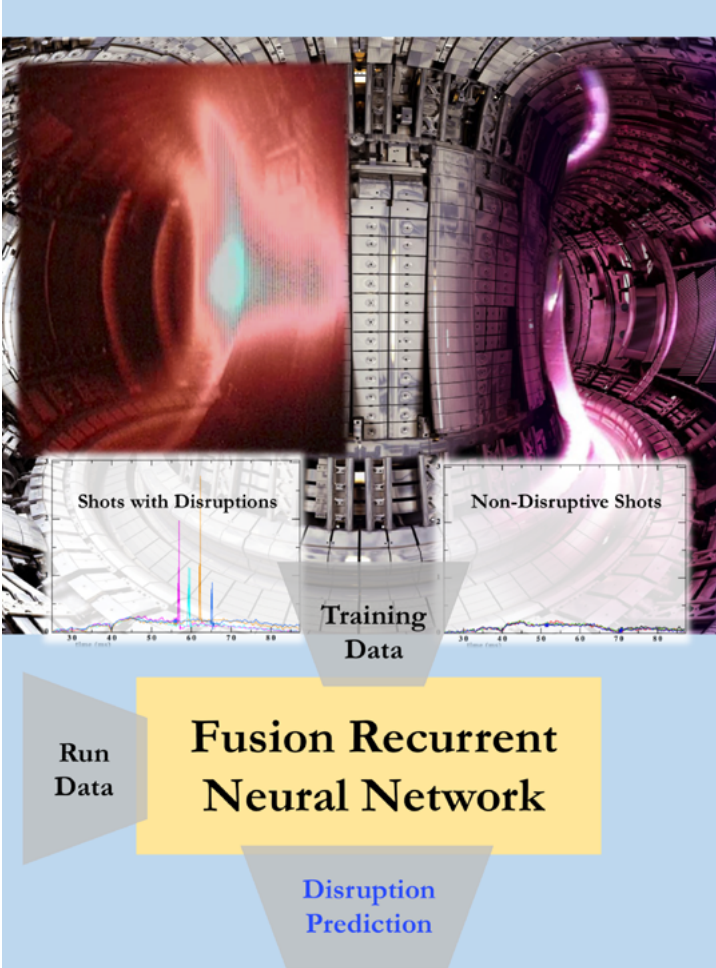
The deep learning code runs on graphic processing units (GPUs) that can compute thousands of copies of a program at once, far more than older central processing units (CPUs). Tests performed on modern GPU clusters, and on world-class machines such as Titan, currently the fastest and most powerful U.S. supercomputer at the Oak Ridge Leadership Computing Facility, a DOE Office of Science User Facility at Oak Ridge National Laboratory, have demonstrated excellent linear scaling. Such scaling reduces the computational run time in direct proportion to the number of GPUs used — a major requirement for efficient parallel processing.

Princeton's Tiger cluster

Princeton University's Tiger cluster of modern GPUs was the first to conduct deep learning tests, using FRNN to demonstrate the improved ability to predict fusion disruptions. The code has since run on Titan and other leading supercomputing GPU clusters in the United States, Europe and Asia, and have continued to show excellent scaling with the number of GPUs engaged.

Going forward, the researchers seek to demonstrate that this powerful predictive software can run on tokamaks around the world and eventually on ITER. Also planned is enhancement of the speed of disruption analysis for the increasing problem sizes associated with the larger data sets prior to the onset of a disruptive event. Support for this project has primarily come to date from the Laboratory Directed Research and Development funds provided by PPPL. ◗


Image of plasma disruption in experiment on JET, left, and disruption-free experiment on JET, right. Training the FRNN neural network to predict disruptions calls for assigning weights to the data flow along the connections between nodes. Data from new experiments is then put through the network, which predicts "disruption" or "non-disruption." The ultimate goal is at least 95 percent correct predictions of disruption events. *(Image and explanation courtesy of Eliot Feibush)*

Plasma 101 gives staff an overview of plasma science and fusion energy

Shannon Swilley Greco, Science Education program leader, hosted PPPL's first Plasma 101 session for staff on Dec. 8 aimed at giving staff a basic understanding of plasma science and fusion energy research at the Laboratory. The group viewed the PhD Comic video and a presentation in the MBG Auditorium and then moved to the Science Education Laboratory, where they took part in plasma demos.

Shannon Swilley Greco gives a presentation on the difference between fusion and fission. *(Photo by Elle Starkman)*
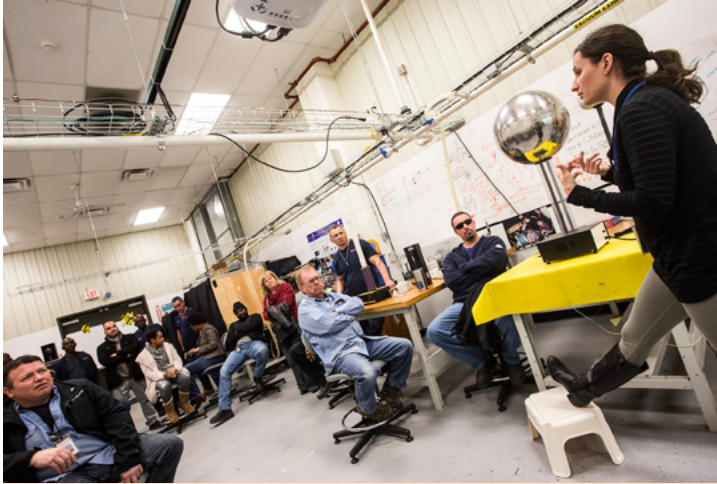
Swilley Greco speaks to staff in the Science Education laboratory. *(Photo by Elle Starkman)*

Margaret Carpe, left, and Fran Cargill have fun with the Van de Graaff generator. *(Photo by Elle Starkman)*

Submit your questions for Plasma 101 Lunch & Learn

Please submit your questions about fusion energy, plasma, or any of the science 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?

A training session for future tour guides

About 20 people attended a tour guide meeting and training session on Dec. 13 for new and current tour guides. The group heard about safety, tour guide training requirements, and training requirements for NSTX-U access. Current tour guides gave an overview of the major sites covered in tours and a brief overview of plasma demonstrations. Presenters were: Jeanne Jackson DeVoe, Tim Stevenson, Kevin Lamb, Brian Kraus, Charles Swanson, Devon Battaglia, Atiba Brereton, and Erik Gilson.

If you are a physicist, engineer, or knowledgeable staff member who would like to become a tour guide or host and were unable to attend the session, please contact tour coordinator Jeanne Jackson DeVoe, jjackson@pppl.gov.

Tour guide Brian Kraus at the training session. *(Photo by Elle Starkman)*

Tour guide Charles Swanson *(Photo by Elle Starkman)*

Atiba Brereton, left, and Kevin Lamb with the Van de Graaff generator. *(Photo by Jeanne Jackson DeVoe)*

Current and future tour guides and hosts attending the session were front row from left: Angela Powell, Chris Smiet, Charles Swanson, Erik Gilson, Brian Kraus; Back row: Jeanne Jackson DeVoe, Michael Cole, David Mikkelsen, Xin Zhang, Seth Davidovits, Shu-Di Yang, Atiba Brereton, Keith Erikson, Prentice Bisbal, David Smith, Evan Yerger, Charles Swanson, Stephen DePasquale, Devon Battaglia, Raphael Rosen, Tim Stevenson, and Kevin Lamb. *(Photo by Elle Starkman)*

A lesson in fusion energy for high school students on a snowy Saturday

About 60 high school students attending a one-day Energy Case Competition at Princeton University through the student-run Princeton University Energy Association learned about fusion energy during a visit to PPPL on Saturday, Dec. 9. The tour was part of the one-day event hosted by the Andlinger Center for Energy and the Environment in which students competed in groups to present clean energy solutions. Other students toured the Andlinger Center at Princeton University and various Princeton laboratories. The students at PPPL toured the Laboratory in two groups of about 30 students each. They visited the NSTX-U Control Room, the Lithium Tokamak Experiment (LTX) hosted by physicist Robert Kaita, and the Magnetic Rotational Experiment (MRI) hosted by Erik Gilson. Other tour guides were: Atiba Brereton, Brian Kraus, Kevin Lamb, and Jacob Schwartz. ⏩
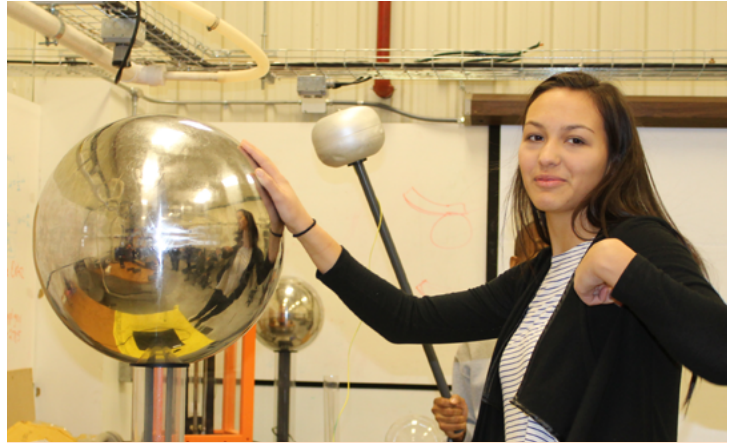
(Photos by Jeanne Jackson DeVoe)

Robert Kaita shows students the Lithium Tokamak Experiment (LTX).

Jacob Schwartz shows students the model stellarator.

A snowy view outside the model stellarator.

A student tries out the Van De Graaff generator.

Brian Kraus demonstrates the AC discharge machine in the Lyman Spitzer Building lobby.

A student touches a plasma ball in the Science Education Laboratory with Atiba Brereton.

Atiba Brereton with students in the LSB lobby.

Kevin Lamb in the NSTX-U Control Room.

Council Café Lunch

This Week:
Chelle Reno
Princeton University assistant vice president for operations

Wednesday, Dec. 20
12 p.m., PPPL Café

Jan. 3: Hutch Neilson

Vote for your favorite as PPPL'ers deck their doors to make them jolly

PPPL'ers brightened up the Lab for the holiday season with a variety of holiday door decorations.

Today, Monday, Dec. 18, is the last day to vote for your favorite!

[Click here to cast your vote.](#)

Make an appointment for your flu shot

Protect yourself from influenza and avoid spreading the illness to others by getting a flu shot.

Please call the OMO at ext. 3200 to schedule an appointment.

Holiday Luncheon

Thursday, Dec. 21

Don't miss this year's holiday event, which is sure to be a great time for all! Join your Laboratory Leadership Council for an afternoon of food, photos and fun! Enjoy a terrific holiday lunch where you can mingle with friends and coworkers and enjoy this year-end celebration together! Event starts at noon on Thursday, Dec. 21 in the LSB lobby!

New For 2017: Photo Booths!

Strike a pose and celebrate the season with two different photo booths where you can create a unique souvenir! Take an awesome team photo with your coworkers or grab your friends and create some smile-worthy memories. Booths will be in the LSB Lobby and in the Cafeteria.

Share A Dessert!

You are invited to bring in a dessert for all to enjoy. Whether it be homemade or store bought, we appreciate the sugar! Please click here to let us know what you plan to contribute.

Thank you in advance for your participation. We look forward to many yummy desserts at the Holiday Luncheon!

BROCK

Café at PPPL

NICK PETTI
Chef Manager

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 Dec. 18	Tuesday Dec. 19	Wednesday Dec. 20	Thursday Dec. 21	Friday Dec. 22
COMMAND PERFORMANCE **Chef's Feature**	**Sloppy Joe** with Tater Tots	**Pasta Puttanesca** with Garlic Bread	**Chicken Gyro** served with Greek Salad	**Holiday Party**	**Happy Holidays!** **Laboratory Closed**
Early Riser	**Biscuit Sandwich**	**Greek Breakfast Wrap**	**Chicken Omelette**		
Country Kettle	**Spring Vegetable**	**Chicken Noodle**	**Tuscan Bean**		
Deli Special	**Liverwurst** with Onion and Stone-ground Mustard	**The Carnegie**—Pastrami, Corned Beef, Swiss, Russian Dressing and Coleslaw on Rye	**Roasted Vegetable Wrap** with Hummus		
Grill Special	**The Plasma**—Chicken, Bacon, and Swiss on French Bread	**Shrimp Quesadilla**	**BBQ Pork Rib Sandwich** with Cheddar and Onion Straws		
Panini	**3-Cheese Panini** with Cheddar, Swiss, Blue Cheese & Tomato on Sourdough	**Spicy Pepperoni Ciabatta**	**Pretzel Melt** with Ham and Swiss		

Dec. 15: Laboratory Closed | **Dec. 26–28:** Chef's Choice | **Dec. 29:** Laboratory Closed

	Monday Jan. 1	Tuesday Jan. 2	Wednesday Jan. 3	Thursday Jan. 4	Friday Jan. 5
COMMAND PERFORMANCE **Chef's Feature**	**Happy New Year!** **Laboratory Closed**	**Kung Pao Meatballs** over Fried Rice with Egg Roll	**Parmesan Herb-Crusted Tilapia** with Roasted Potatoes and Green Beans	**Beef Chili** with Cornbread	**Pasta** with Clam Sauce and Garlic Bread
Early Riser		**Huevos Rancheros**	**Frittata Lorraine**	**Omelette Florentine** with Spinach, Tomato & Mozzarella	**Breakfast Tacos**
Country Kettle		**Beef Barley**	**Chicken and Mushroom**	**Potato**	**Seafood Chowder**
Deli Special		**Greek Tuna Salad** with Pita Chips over Lettuce	**Tomato & Fresh Mozz** on Ciabatta with Roasted Garlic Hummus	**Baked Ham and Swiss Sliders**	**Southwest Turkey,** Peppers & Cheddar with Jalapeno Ranch Spread
Grill Special		**Buffalo Chicken Steak Sandwich** with Fries	**Pizza Burger**	**Blueberry Melt** with Cheddar and Goat Cheese	**Chicken Zen Sandwich**
Panini		**Italian Grinder**	**Crab Cake** on a Kaiser with Lettuce & Tomato	**Knockwurst and Kraut**	**El Diablo**—Hot Ham, Pepperoni, Pepper Jack, Banana Peppers and Chipotle Sauce

MENU SUBJECT TO CHANGE WITHOUT NOTICE

HEART HEALTHY   VEGETARIAN OPTION

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The next issue will be on Jan. 8.