

## Calendar of Events

### THIS WEEK

OCT. 31-NOV. 4

**APS Division of Plasma Physics Conference**  
San Jose, California

TUESDAY, NOV. 1

**New employees tour**  
10 a.m. ♦ LSB Lobby

WEDNESDAY, NOV. 2

**Shredding Event**  
Warehouse Receiving Area #3  
[See page 10 for details.](#)

**NJBIA Innovation Summit**  
8:30 a.m.-2 p.m. ♦ LSB Lobby and MBG Auditorium

NOV. 2-20

**America Recycles Day Clothing Drive**  
Bring clothing to LSB Lobby and Lower Lot entrance

### UPCOMING

WEDNESDAY, NOV. 9

**PPPL Travel Voucher presentation by the Travel Office**  
1 p.m. ♦ MBG Auditorium

**PPPL Colloquium**  
4:15 p.m. ♦ MBG Auditorium  
[History and Derivation of the Schrödinger Equation](#)  
Wolfgang P. Schleich, University of Ulm / Texas A&M University

NOV. 9-10

**PPPL Advisory Council**

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## First results of NSTX-U research operations presented at IAEA Conference in Japan

By John Greenwald

Researchers from PPPL and collaborating institutions presented results from research on the National Spherical Torus Experiment Upgrade (NSTX-U) during October at the 26th International Atomic Energy Agency Conference (IAEA) in Kyoto, Japan. The four-year upgrade doubled the magnetic field strength, plasma current and heating power capability of the predecessor facility and made the NSTX-U the most powerful fusion facility of its kind. Here are first results of the upgrade and related IAEA research presentations.

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## Goldston honored with Nuclear Fusion Award

By John Greenwald

At the 2016 International Atomic Energy Agency (IAEA) Fusion Conference in Kyoto Japan, Rob Goldston received the 2015 Nuclear Fusion Award for his 2012 paper on the heuristic drift model for the power scrape-off width in H-mode tokamaks. The model estimates the width of the layer of hot plasma exhausted from the closed magnetic surfaces of high-performance tokamaks. Such plasmas must be wide enough to avoid delivering a thin and concentrated blow that could damage the walls of the exhaust — or divertor — chamber where the heat is dissipated.

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## Boy Scouts learn about science at PPPL



Carmela Ciummo, of PPPL's Engineering Department, helps Scouts put together solar-powered toy cars during the energy class in PPPL's Science Education Laboratory at the Boy Scouts Science and Technology Fair on Oct. 22. (Photo by Elle Starkman)

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# A day of hands-on experiments for local Boy Scouts

By Jeanne Jackson DeVoe

More than 250 Boy Scouts experimented with chemistry, created and programmed robots, made electromagnets and assembled toy solar-powered cars at a Science & Technology Merit Badge Fair on Saturday, Oct. 22, at PPPL.

The Scouts, from all over New Jersey and Pennsylvania, did hands-on activities in workshops led by PPPL volunteers on topics that included nuclear science, robotics, engineering, inventing, and fire fighting.

“We’re pleased to host this event. This is a great opportunity for the Scouts to talk to and interact with some of the smartest people in the country,” said Terry Brog, interim director of PPPL. “We fully support all of this.”

PPPL has “excellent scientists doing world-class science and engineering. You get to be part of that today,” organizer Robert Sheneman, the head of Environmental Services at PPPL and a Scout leader, told the Scouts. “That’s really cool.”

“It’s fun,” said Adrien Vincent, 12, of West Windsor, New Jersey, who enjoyed putting out fires in the fire safety class and was looking forward to the energy class. “We get to build a car.” Vincent said. He said he came to the event because his favorite subject is science. When he grows up he hopes to be an engineer or maybe a fire investigator.

Volunteer Jessica Guttenfelder said she enjoyed working with Scouts on robotics. “They’re doing great,” Guttenfelder said. Several high school students from the MidKnight Inventors robotics team at West Windsor-Plainsboro South and North high schools also helped out with the robotics class.



Volunteer Laurie Bagley, head of Technology Transfer at PPPL, sits with two of the inventors from her inventions class. (Photo by Elle Starkman)



Terry Brog, PPPL's interim director, addresses the Scouts at the start of the day. (Photo by Elle Starkman)



Jamie Dunnigan, an emergency planning and training coordinator for PPPL's Site Protection, shows a Scout how to extinguish a fire during a fire safety workshop. (Photo by Elle Starkman)

Matthew McKeown, 11, of Levittown, Pennsylvania, said he enjoyed his class on inventions led by Laurie Bagley, head of Technology Transfer. “I like doing science stuff,” he said. “I liked comparing our inventions.”

Scouts took 16 classes throughout the Laboratory with most of PPPL's 30 volunteers leading all-day workshops. Volunteers also gave short talks about fusion energy in the lobby during lunchtime and helped with registration and organizing. “These volunteers gave up their Saturday to provide you with a program unique to the country,” Sheneman told the Scouts, “so be sure to thank them!” 📷

[photos continue on page 3](#)



PPPL's Mark Swanek, a waste management chemist, right, and Scout volunteer Carol Moyer talk to Scouts in the chemistry class in the PEARL Laboratory, which was also taught by Maria Pueyo, a waste management engineer. (Photo by Elle Starkman)

# Boy Scouts STEM Fair

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A Scout contemplates his robot. (Photo by Elle Starkman)



Scouts test how well their robots navigate a maze. (Photo by Elle Starkman)



A Scout creates a design in the programming class, taught by Eliot Feibush. (Photo by Elle Starkman)



Charles Swanson, a graduate student in the Princeton Program in Plasma Physics, helps Scouts make an electromagnet as volunteer Scout Alex Dreyzin looks on in the electricity class in the NSTX-U Control Room. (Photo by Elle Starkman)



The LSB lobby is filled with Scouts at the end of the day. (Photo by Elle Starkman)



Scout leader and event organizer Robert Sheneman, head of the Environmental Services Division, speaks to Scouts in the MBG Auditorium at the start of the event. (Photo by Elle Starkman)

# NSTX-U results presented at IAEA

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The new NSTX-U center stack central magnet that doubles the magnetic field and plasma current, left, and an image of NSTX-U H-mode plasma. (Photo by Elle Starkman/PPPL Office of Communications. Right: NSTX-U Team)

## Physics results of first 10 weeks of operation

The NSTX-U delivered important physics and operational results during its first research campaign under the run coordination leadership of Program Director Jon Menard and Head of Experimental Research Operations Stefan Gerhardt. Principal results and achievements included:

- Quickly surpassing the maximum magnetic field strength and pulse duration of its predecessor prior to the upgrade.
- Achieving high plasma confinement, or H-mode, on just the eighth day of the 10 weeks of experiments. H-mode is a superior regime for fusion performance.
- Reducing plasma instabilities with beams from a second neutral beam injector that was installed to increase the heating of the plasma. This device fired beams at different angles than the first injector which generated the initial instabilities.
- Changing the propagation direction of other instabilities using the second neutral beam injector. This result is consistent with the new beam significantly modifying the distribution of energetic ions. Providing increased flexibility in the distribution of energetic ions was a major scientific motivation for the new beam.
- Advancing development of methods to prevent plasma disruptions and to ramp down plasma when disruptions can no longer be avoided. Such methods will be critical for ITER, the international fusion experiment under construction in France, and for all future tokamaks.
- Identifying and learning to correct conditions called error fields that are common to tokamaks and can hinder the performance of fusion plasmas.
- Commissioning all magnetic diagnostics needed to gauge control of the plasma and demonstrating advanced diagnosis of the surface composition of the reactor walls.

Researchers now look forward to continuing their investigation of key issues needed to develop fusion energy when NSTX-U repairs are completed and the spherical tokamak resumes operation.

## Explaining transition to H-mode

A key challenge to the production of magnetic fusion energy is preventing heat from escaping the core of the superhot plasma held in doughnut-shaped devices called tokamaks. Researchers have long known that a slight increase in heating power can reduce turbulence near the edge of the tokamak, shifting the plasma to an H-mode (high confinement) regime that reduces energy leakage.

But what causes this disappearing turbulence? Researchers at PPPL have found that a popular explanation known as the “predator-prey” model cannot account for the reduction. It posits that the turbulence dumps its energy into a benign spinning of the plasma called “mean poloidal flows” that does not transport heat. For this to happen, the reduction in turbulent energy must roughly equal the increased energy of the mean flows.

To test this theory, the PPPL physicists used a gas puff imaging (GPI) diagnostic that let them directly see turbulent plasma fluctuations in the edge region of PPPL’s NSTX, the laboratory’s flagship fusion facility, which has since been upgraded. By pumping small amounts of neutral gas into the plasma, they caused the neutrals to interact with the plasma and glow. A fast camera recorded the glow and revealed how the turbulence evolved in space and time.

The researchers were also able to infer the velocity of the plasma, enabling evaluation of energy in both the turbulence and the mean flows. This showed that the energy in the mean flows was never more than a few percent of the energy in the turbulence before the shift to H-mode.

With this result, the mystery of the H-mode deepens again. However, by ruling out the predator-prey model, the findings may refocus efforts on other contenders. This could increase the chances of identifying the physics behind the mysterious H-mode, and facilitate the ability to employ it for the success of future fusion reactors.

## PPPL & DIII-D advance understanding of sheared rotation that helps stabilize fusion plasmas

New measurements and simulations of plasma rotation in the DIII-D National Fusion Facility are advancing our understanding and predictive capability for the self-organized “intrinsic rotation” in tokamaks.

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## NSTX-U results presented at IAEA

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It is commonly understood that improved plasma confinement and stability in tokamaks comes through generation of sheared plasma flow, in which one part of the hot gas flows faster than the other. Such flows are typically generated by injection of neutral beam particles that spin the plasma. It has long been assumed that without these beams, there may not be much rotation or shear.

However, the present work shows that simply heating the plasma can cause it to generate a sheared flow. The model shows that heating the core can cause the outer region of the plasma to flow in one direction, while the core flows in the other. Causing this shear is intrinsic torque, a twisting force that produces the rotation.

We have a first quantitative understanding, through simulations of plasma turbulence, of how these processes happen. In these simulations, performed by the GTS code, the turbulence generates a torque that causes the plasma to spin. The plasma flow is generated by the variation of the turbulence with radius, causing the plasma to accelerate from rest and drive differential flow, like the atmospheric jet stream or the bands of Jupiter.

This flow represents the balance between the intrinsic torque driven by the turbulence, and the viscosity of the plasma that keeps the gas from spinning arbitrarily fast. Simulations with GTS are able to predict the plasma rotation, and it agrees very well with the observed rotation in both shape and magnitude.

The key remaining challenge is how to project these processes to ITER, the international tokamak under construction in France, which requires very large simulations that push the limits of present high-performance computing.

### A unique model

Among the key challenges for producing magnetic fusion energy is controlling instabilities known as “edge localized modes” (ELMs). These disturbances at the edge of fusion plasmas can damage components that face the plasma in doughnut-shaped devices called tokamaks that house fusion reactions.

A popular method for coping with this problem uses “resonant magnetic perturbations” (RMPs) to deal with the instabilities. These perturbations, produced by specialized magnetic coils, have mitigated ELMs in tokamaks today. However, researchers are unable to predict how the perturbations will affect ITER, the huge international tokamak under construction in France, for which ELMs could become a major problem.


Now PPPL physicists, together with researchers at the Max Planck Institute for Plasma Physics in Germany, have produced a promising new model for comprehending the processes involved. It departs from conventional theory that has failed to find solutions that can be realized in physical terms.

The older models employed mathematically ill-posed questions, said PPPL physicist Stuart Hudson. Such questions lacked solutions, he said.

The new model takes a novel look at the relationship between the two major forces inside tokamaks — the pressure of the plasma that fuels fusion reactions and the strength of the magnetic field that confines the plasma in place. The inclusion of RMPs transforms the problem into finding states in which the pressure force and the magnetic force are balanced within so-called three-dimensional boundaries.

The model suggests that a mathematical “discontinuous boundary” should be imposed on the problem. This leads to a “discontinuous solution” that can be used to determine the balance between the two forces.

With that solution in hand, the model finds that RMPs will penetrate into the core of the plasma, whereas conventional theory holds that they will be stopped short of the core. At the same time, pressure inside the core will amplify the perturbations, according to the model, and give them greater impact.

These findings could serve as a tool for future operators of ITER. Knowing the depth of RMP penetration, and the fact of its amplification, could lead to much improved modeling of the response of ITER to perturbations used to mitigate the ELMs the giant tokamak will experience. 

## Registration for 2017 Young Women's Conference is open!

Registration for the 2017 Young Women's Conference in STEM, taking place on Thursday, March 23, at Princeton University's Frick Chemistry Building, is now open. If you are interested in bringing your student to the YWC, please [follow the link](#) and register up to three seventh- to tenth-grade students.

If you or anyone you know might be interested in exhibiting at the next YWC, please contact Deedee Ortiz, [dortiz@pppl.gov](mailto:dortiz@pppl.gov), ext. 2785.

## Goldston honored

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IAEA Director General Yukiya Amano presented the award to Goldston, a fusion researcher, Princeton University professor of astrophysical sciences and former director of PPPL.

The editorial board of Nuclear Fusion cited the paper as, "Potentially one of the most important results obtained in recent years in fusion" research. The model "provides a simple yet elegant model for the scrape-off layer power width," the editors said, "and ultimately could have significant impact on the future direction of the field."

At a separate ceremony, Goldston thanked the many members of the edge physics research community who welcomed him and contributed to his understanding of this area of fusion physics, when he decided to focus his research on this area after stepping down from the PPPL directorship in 2009. The community consists of researchers who study the physical properties at the edge of fusion plasmas. [▶](#)



Yukiya Amano, left, presents certificate of the Nuclear Fusion Award to Robert Goldston.

# UNICOR Electronics Recycling

You may bring the following items from home for recycling on Tuesday, Nov. 15.

### Electronic Gadgets:

- Cameras
- Camcorders
- MP3 Players
- Gaming Systems (Handheld & TV Systems)
- Calculators
- Microscopes
- Telescopes
- PDAs

### Household Equipment:

- Televisions
- Cable Boxes
- Telephone Systems
- DVRs
- Copiers/Printers/Faxes

### Computer Equipment:

- Laptops
- Desktop Towers
- Modems
- Keyboards
- Mouses
- Monitors (CRT & LCD)
- Printers
- Computer Wires
- Hard Drives
- DVDs/Tapes
- Circuit Boards Drivers

All items will be collected in front of the Firehouse, from 7:30–10 a.m. Do not bring items to the lobby.

Any questions please contact M. King x3652 or L. Meyer x2599

## PPPL takes part in 2016 National Laboratories Career Day in Atlanta

Atiba Brereton, a mechanical engineer at PPPL, and Arturo Dominguez, senior program leader in Science Education, attended the 2016 National Laboratories Career Day in Atlanta along with representatives from the other 16 DOE national laboratories. The Oct. 20 event was aimed at recruiting high-achieving students at historically black colleges and universities for post-doctorates, internships, and full-time positions.

The career fair was held at Clark Atlanta University (CAU) with events and panel discussions at Spelman and Morehouse colleges, as well as at CAU. Dominguez took part in a panel discussion on “National Lab Faculty Research Opportunities” and gave a talk on PPPL, plasma physics, and fusion energy at Spelman College. In addition to working at the career fair, Brereton spent a day visiting engineering departments at CAU and Morehouse to discuss opportunities at PPPL.

Brereton and Dominguez, along with Andrea Moten, interim head of Human Resources, took part in a National Laboratories Career Day in February at Howard University. 📍



Atiba Brereton and Arturo Dominguez at the National Labs Career Day at Spelman. (Photo by Atiba Brereton)



Dominguez speaks to students at the career fair. (Photo by Atiba Brereton)



Dominguez speaks in a panel discussion on faculty research opportunities with from left to right: Michelle Lee, of Los Alamos National Laboratory, Enrique Cuellar, of SLAC National Accelerator Laboratory, Jeremy Banks, Sandia National Laboratories; Dirk Link, of the National Energy Technology Laboratory’s Research and Innovation Center; and Simona Hunyadi Murph, of Savannah River National Laboratory. (Photo by Atiba Brereton)

## Benefits Fair highlights Open Enrollment



Michael Kozic, left, and Manish Kumar chat with Christine Bensko, of BestDoctors.com at the Open Enrollment 2017 Benefits Fair on Oct. 27 in the LSB Lobby. (Photo by Elle Starkman)

# PPPL America Recycles Day Clothing Drive Challenge for The Trenton Rescue Mission

Please deposit clothing that is clean, gently used, and in usable condition the in collection box Nov. 2-20.

## Drop off locations:

1. LSB Lobby
2. Lab Building (by lower lot entrance)

# It's time to get your flu vaccine!

Influenza is a contagious disease caused by a virus. It can be spread by coughing, sneezing or nasal secretions.

By getting the flu vaccine, you can protect yourself from Influenza and may also avoid spreading this illness to others.

Please call the OMO at extension 3200 to make an appointment.

# Plasma Hutch Sale

## ALL ITEMS 50% OFF!

Start your holiday shopping early at the hutch!

Give your loved ones the gift of PPPL or get yourself something nice!

When: 11/3 & 11/4 from 10:30 a.m.-1 p.m.

Where: LSB Lobby



# Open Enrollment 2017

Annual Benefits Open Enrollment began Oct. 17 and ends Friday, Nov. 11. Nov. 11 is the last day to make any benefit changes.

## Duo Security started Oct. 27

This affects everyone who has a Princeton.edu account, including biweekly employees filling out timesheets. Have questions about Duo? Guidance is available at the Computer Resource Center, Room B153, during the following hours. Please bring your cell phone:

**Thursday, Nov. 3 from 2-4 p.m.**

**Friday, Nov. 4 from 9 a.m.-12 p.m.**

## Recycling Art Contest for America Recycles Day

Create your own art or fashion piece out of recycled products for PPPL's Recycling Art Contest to help celebrate America Recycles Day! The deadline is Nov. 14. Entries will be on display Nov. 14 to 18. Prizes will be awarded to submissions with the most votes on Nov. 18. Winners will receive gift certificates to the Plasma Hutch.



**Questions? Contact Margaret King, ext. 3652, Dana Eckstein, ext. 2588, or Leanna Meyer, ext. 2599.**

# Shred your old business documents!

PPPL will hold shredding events on Nov. 2 & 9 at the warehouse receiving area in the lower parking lot for staff to shred old PPPL business-related records and documents.

Go to <https://goo.gl/Qm2O6o> to submit a work order for your shredding requirements. Record retention and destruction guidelines are available at <http://sportal.pppl.gov/bp/Lists/RecordsSchedule/Allitems.aspx>.

For more information, contact Dean Peterson, [dpeterso@pppl.gov](mailto:dpeterso@pppl.gov), ext. 3998.

**BROCK**

**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 October 31	Tuesday November 1	Wednesday November 2	Thursday November 3	Friday November 4
<b>COMMAND PERFORMANCE Chef's Feature</b>	<b>Eggplant Parmigiano</b> with Pasta	<b>Chicken-Fried Steak</b> with Cajun-Spiced Roasted Potatoes	<b>Teriyaki Roast Pork Loin</b> served with Vegetable Lo Mein and an Egg Roll	<b>Sloppy Joe</b> with Tater Tots	<b>Catfish Po Boy</b> with Fried Okra
Early Riser	<b>Blueberry Pancakes</b>	<b>Roast Vegetable Egg White Omelet</b> with Home Fries	<b>Tater Tot Breakfast Bake</b>	<b>Ham, Egg &amp; Cheese French Toast</b>	<b>Bacon, Spinach &amp; Mozzarella Quesadilla</b> with Cilantro Cream
Country Kettle	<b>Black Bean &amp; Ham</b>	<b>Minestrone</b>	<b>Potato, Cheddar &amp; Bacon</b>	<b>Tuscan White Bean</b>	<b>Onion soup</b>
Grille Special	<b>My Big Fat Greek Turkey Burger</b>	<b>Sausage &amp; Peppers Torpedo</b>	<b>Sweet and Sour Salmon Burger</b> on a Whole Wheat Roll with Lettuce, Tomato and Grilled Scallion	<b>Blackened Chicken</b> with Sauteed Onion & Peppers, Pepperjack Cheese, Tomato & Chipotle Mayonnaise on a Kaiser Roll	<b>Philly-Style Cheesesteak Calzone</b>
Deli Special	<b>Egg Salad Club Sandwich Wrap</b>	<b>Caesar Salad</b> with Tuna, Hearts of Palm, Artichoke, Roasted Peppers & Kalamata Olives	<b>Pizza Steak Sub</b> with Pepperoni, Provolone & Marinara	<b>Italian Tuna Salad</b> with Capers, Olives, Sundried Tomatoes and Basil on Choice of Bread	<b>Cobb Salad Wrap</b> with Turkey, Spinach, Tomato, Blue Cheese, Bacon & Hard-Cooked Egg
Panini	<b>Spicy Crab Salad Wrap</b>	<b>Chicken Breast,</b> Fontina Cheese, Pesto Mayonnaise & Tomato on Ciabatta Bread	<b>Buffalo Chicken Sliders</b> served with Fries	<b>Meatball Parmigiano Sandwich</b>	<b>NY Street Dog— 2 Sabrett Hot Dogs</b> 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**

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.**

Comments: [commteam@pppl.gov](mailto:commteam@pppl.gov) ♦ PPPL WEEKLY is archived on the web at: <http://w3.pppl.gov/communications/weekly/>.