PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
August 14, 2017

THIS WEEK

WEDNESDAY, AUG. 16

SULI Poster Session
10 a.m.–1 p.m. ◆ LSB Lobby

FRIDAY, AUG. 18

Public Tour
10 a.m.
Go to http://www.pppl.gov/about/tours to sign up

UPCOMING

SEPT. 5–8

15th Annual IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems
https://nucleus.iaea.org/sites/fusionportal/Pages/15TM-Energetic-Particles.aspx

WEDNESDAY, SEPT. 13

PPPL Inventor Recognition Reception

FRIDAY, SEPT. 15

PPPL Big Bang Bash
11 a.m.
See page 4 for details.

The next issue of the PPPL Weekly will be on August 28.

INSIDE

A first: shock waves created in the lab

By John Greenwald

Throughout the universe, supersonic shock waves propel cosmic rays and supernova particles to velocities near the speed of light. The most high-energy of these astrophysical shocks occur too far outside the solar system to be studied in detail and have long puzzled astrophysicists. Shocks closer to Earth can be detected by spacecraft, but they fly by too quickly to probe a wave's formation.

Opening the door to new understanding

Now a team of scientists has generated the first high-energy shock waves in a laboratory setting, opening the door to new understanding of these mysterious processes. "We have for the first time developed a platform for studying highly energetic shocks with greater flexibility and control than is possible with spacecraft," said Derek Schaeffer, a physicist at PPPL, and lead author of a July paper in *Physical Review Letters* that outlines the experiments.

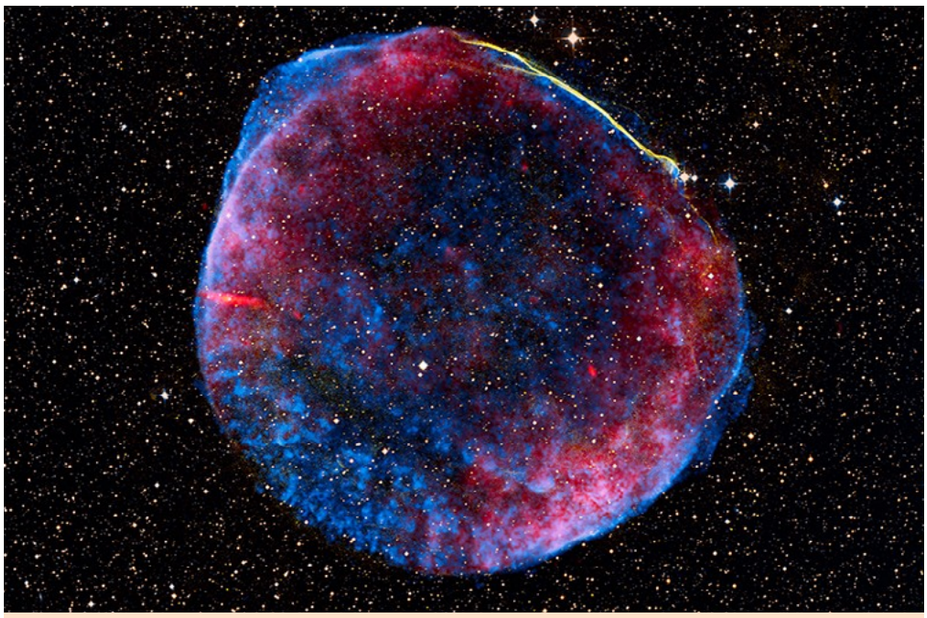

Image of a supernova remnant with shock wave seen as thin blue boundary at the edge. *(Image courtesy of NASA, ESA, Zolt Levay)*

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NSTX-U Recovery Project unveils new designs for magnets and other key components

By Jeanne Jackson DeVoe

The NSTX-U recovery project has developed a new concept for some of its magnets and other changes in its design, all aimed at ensuring that the National Spherical Torus Experiment-Upgrade (NSTX-U) operates reliably once it restarts.

The basic elements of the redesign were scrutinized by external experts and PPPL's NSTX-U Recovery Team during a three-day conceptual design review at PPPL from Aug. 1–3. The reviewers followed the same process as the design verification and validation reviews (DVVRs), with reviewers submitting chits that engineers will investigate before each component has a preliminary and final design review.

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Plasma workshops aimed at diverse faculty and students

By Jeanne Jackson DeVoe

PPPL's Science Education Department held a series of plasma physics workshops this summer for faculty from minority-serving institutions and underserved students led by Arturo Dominguez, senior program leader in Science Education.

In the Workshop in Plasma Physics for Minority Serving Institutions Faculty, July 21–22, Dominguez taught plasma physics theory to five faculty members from historically-black colleges and Hispanic-serving institutions. The teachers also learned how to set up and teach the DC discharge experiment. "The idea is to get them comfortable with plasma physics as a topic they can cover in advanced labs and as a platform to show phenomenon in lower division physics courses and really get their students excited and knowledgeable about it," Dominguez said. "It's an approach to feed our pipeline from under-represented minorities."

The course is similar to the Alpha Immersion course Dominguez has taught for several years. In that course, which he taught again this year from July 18–20, college professors learn how to incorporate plasma physics into their curricula. The workshop is one of several around the country organized by the Advanced Laboratory Physics Association (ALphA) and sponsored by the organization and the National Science Foundation.

Plasma workshop students in the National Spherical Torus Experiment-Upgrade test cell. *(Photo by Raphael Rosen)*

Faculty participating in the workshop on a tour of the National Spherical Torus Experiment-Upgrade test cell with Arturo Dominguez, center. *(Photo by Elle Starkman)*

The programs for professors of minority-serving institutions and for under-represented students are funded by the U.S. Department of Energy Office of Science's Workforce Development for Teachers and Scientists.

The Workshop in Plasma Physics for Undergraduates July 28–29 was especially aimed at underrepresented students. The students spent two days getting an introduction to plasma physics and fusion energy. "The idea for them is to go back to their institutions and maybe be inspired to take classes, to do research related to plasma physics, so that perhaps they will apply to SULI (Science Undergraduate Laboratory Internship) or to graduate school," Dominguez said.

Zoha Nagawe, a rising sophomore from Georgia Tech majoring in physics and biology, was one of the participating students. A first-generation college student whose father is from Afghanistan and whose mother is from Pakistan, Nagawe said she was excited to take the course. "I'm really interested in physics and I find lots of it really cool so when I saw

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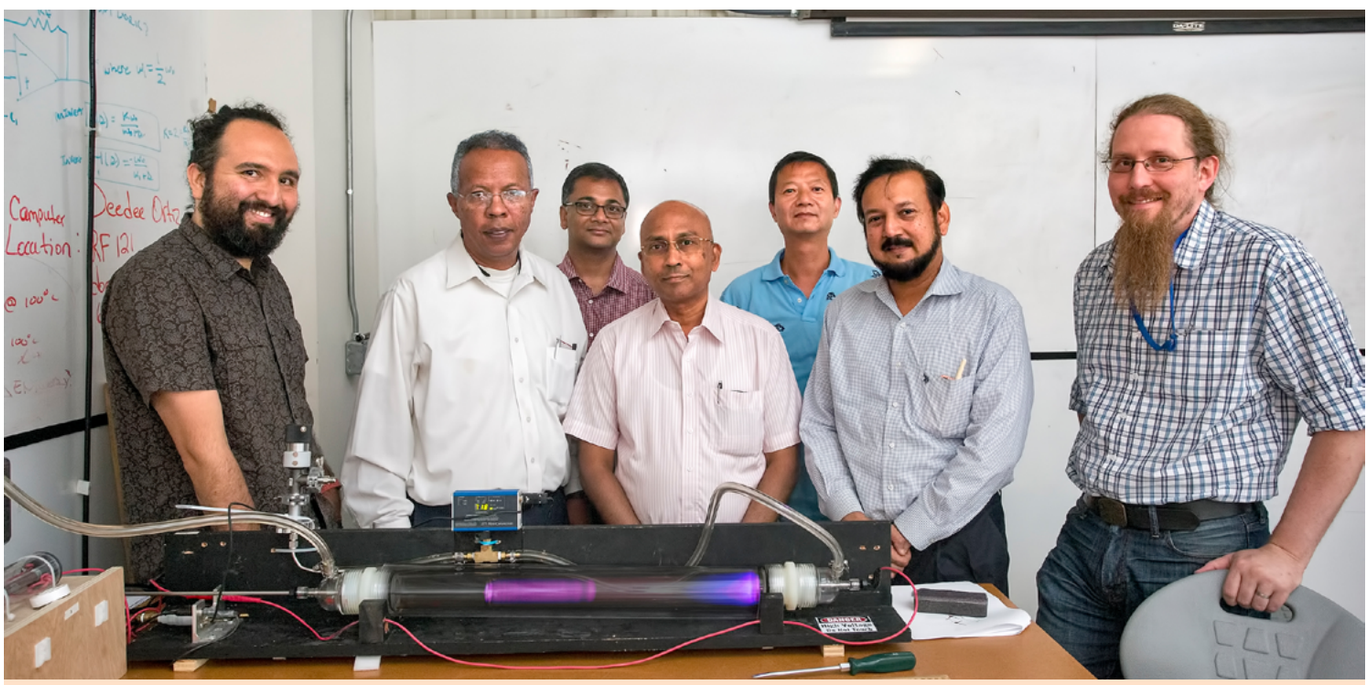

Arturo Dominguez, far left, taught the faculty workshop, assisted by Jeremiah Williams, of Wittenberg University, far right, who also assisted with the Alpha Immersion Workshop. Participants from left are: Dereje Seifu, Department of Physics, School of Computer, Mathematics & Natural Science, Morgan State University, Baltimore; Kausik Das, University of Maryland Eastern Shore; David Devraj Kumar, Professor of Science Education, Director of STEM Education Lab, Florida Atlantic University; Lei Zhang, Associate Professor of Physics, Department of Chemistry, Winston Salem State University; Santanu Banerjee, Tougaloo College, Mississippi. *(Photo by Elle Starkman)*

High-energy shock waves

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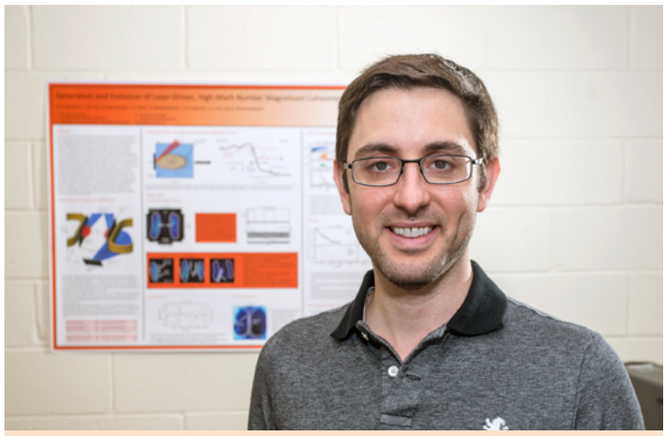
Schaeffer and colleagues conducted their research on the Omega EP laser facility at the University of Rochester Laboratory for Laser Energetics. Collaborating on the project was PPPL physicist Will Fox, who designed the experiment, and researchers from Rochester and the universities of Michigan and New Hampshire. "This lets you understand the evolution of the physical processes going on inside shock waves," Fox said of the platform.

To produce the wave, scientists used a laser to create a high-energy plasma — a form of matter composed of atoms and charged atomic particles — that expanded into a pre-existing magnetized plasma. The interaction created, within a few billionths of a second, a magnetized shock wave that expanded at a rate of more than 1 million miles per hour, congruent with shocks beyond the solar system. The rapid velocity represented a high "magnetosonic Mach number" and the wave was "collisionless," emulating shocks that occur in outer space where particles are too far apart to frequently collide.

Discovery by accident

Discovery of this method of generating shock waves actually came about by accident. The physicists had been studying magnetic reconnection, the process in which the magnetic field lines in plasma converge, separate and energetically reconnect. To investigate the flow of plasma in the experiment, researchers installed a new diagnostic on the Rochester laser facility. To their surprise, the diagnostic revealed a sharp steepening of the density of the plasma, which signaled the formation of a high Mach number shock wave.



Physicist Derek Schaeffer *(Photo by Elle Starkman)*

To simulate the findings, the researchers ran a computer code called "PSC" on the Titan supercomputer, the most powerful U.S. computer, housed at the DOE's Oak Ridge Leadership Computing Facility. The simulation utilized data derived from the experiments and results of the model agreed well with diagnostic images of the shock formation.

Going forward, the laboratory platform will enable new studies of the relationship between collisionless shocks and the acceleration of astrophysical particles. The platform "complements present remote sensing and spacecraft observations," the authors wrote, and "opens the way for controlled laboratory investigations of high-Mach number shocks."

Support for this research came from the DOE Office of Science, the DOE INCITE Leadership Computing program, and the National Nuclear Security Administration, a semi-autonomous agency within the DOE.

Plasma workshops

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Arturo Dominguez, center, with students in the Workshop for Plasma Physics, at Princeton University. *(Photo courtesy of Arturo Dominguez)*

this opportunity to learn more about it, I definitely wanted to apply," she said. "Honestly I'm kind of in awe of all the research and knowledge that's here and I'm really enjoying the networking with other students."

Manas Bharadwalaj, a rising sophomore at Drexel University from Madras, India, who is majoring in astrophysics, was also excited to participate in the program. "I'm very interested in plasma physics," he said. "It's fantastic. Not everyone gets this opportunity. The best part will be seeing the fusion reactor."

Dominguez hopes programs like these, along with the Conference for Undergraduate Women in Physics (CUWiP) Plus workshops for college women held last March, will help create more diversity in SULI and other internship programs and in plasma physics in general. "There's a real need for diversification," Dominguez said, "and we think these targeted approaches are a chance to get our message of plasma science and fusion out to communities that have historically not been reached as much."

The PPPL Big Bang Bash 2017

Friday, Sept. 15
11 a.m.
(rain date Tuesday, Sept. 19)

Enjoy great food, fun games and team-building activities, and the opportunity to network and socialize with friends and colleagues and meet new ones!

The Big Bang Bash includes:

- An Antique & Specialty Vehicle Show
- Cultural Fair
- A United Way community service project
- Dunk Tank and other activities

Bhattacharjee explains solar eclipse that arrives next week to packed audience in the Princeton Public Library

By John Greenwald

A standing-room-only crowd of some 200 people listened intently as PPPL's Amitava Bhattacharjee last week explained the science behind the solar eclipse that will sweep across the United States on Aug. 21. Bhattacharjee, head of the Theory Department at PPPL and a professor of astrophysical sciences at Princeton University, described the dynamics, the path, the consequences and some history of "the extremely spectacular" total eclipse, which will be directly visible to 12.2 million Americans and within a day's drive for most of the country. "You can expect a lot of traffic jams," he told the crowd in the Community Room at the Princeton Public Library.

Bhattacharjee showed visualizations to illustrate the total eclipse path: It will swing along a diagonal from Oregon to South Carolina. He then asked a question: Since the eclipse occurs when the moon is between the sun and the Earth, and the moon rotates around the Earth once a month, why don't we see eclipses once a month?

The answer, he said, is that the orbits of the Earth and moon don't lie in the same plane. Only on rare occasions when the moon's orbit intersects the Earth's orbital plane, at points called "nodes," do eclipses take place.

Moreover, he said, the moon is able to blot out the sun because of a remarkable coincidence. The diameter of the sun is both 400 times greater than the diameter of the moon and 400 times farther from the Earth. The greater distance enables the moon to cast a total shadow over the Earth – in effect, sun and moon appear the same approximate size. It will be essential to wear safety glasses to protect the eyes while watching any part of this event, he said.

Bhattacharjee then described the solar corona, the aura of plasma that surrounds the sun. This aura is normally obliterated by the sun and can be seen only during a total eclipse, which will be visible for about two minutes from any point along its Aug. 21 path. However, NASA spacecraft can study the corona from many different perspectives to gain a great deal of information.

A peculiarity of the corona is that its temperature is between 1 million and 3 million degrees, far hotter than the 10,000 degree surface of the sun. "The reason for this is a major unsolved problem," Bhattacharjee said, as is the fact that the magnetic fields of bodies such as the Earth and sun can last for billions of years.

In discussing the sun's energy, Bhattacharjee described the process of fusion, the merging of light atomic nuclei to release enormous power. "At our laboratory, this process is what we want to carry out — to hold plasma in place to create fusion to produce an enduring solution to the energy problem."

Bhattacharjee concluded his talk with a passage from the diary of novelist Virginia Woolf, who witnessed a total eclipse that lasted just 24 seconds in 1927:

". . .rapidly, very very quickly, all the colours faded; it became darker and darker as at the beginning of a violent storm; the light sank and sank; we kept saying this is the shadow; and we thought now it is over - this is one shadow; when suddenly the light went out. We had fallen. It was extinct. There was no colour. The earth was dead. That was the astonishing moment: and the next when as if a ball had rebounded, the cloud took colour on itself again; and so the light came back."

The audience listens intently to Bhattacharjee's talk. *(Photo by John Greenwald)*

The view from New Jersey

In New Jersey, a partial eclipse will be visible on Aug. 21, with the moon covering a maximum of 73 percent of the sun at the peak of the event. Viewers at PPPL and Princeton University will see the shadow of the moon begin to build at 1:22 p.m. and reach maximum coverage at 2:44 p.m. before ending at 4 p.m. All viewers must wear special glasses to prevent eye damage while watching the event.

For viewers of the total eclipse the shadow will begin to fall over Salem, Oregon, at 12:05 p.m. Eastern Daylight Time (EDT) and will totally blot out the sun at 1:18 p.m. EDT before waning over the state. The shadow will wax and wane over nine more states before leaving Columbia, South Carolina, and heading out to sea at 4:06 p.m. EDT.

NSTX-U design review

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Engineer Michael Kalish discusses the new design for the poloidal field coils on Aug. 3 as external reviewers look on. *(Photo by Elle Starkman)*

External experts will review the final costs and schedule Sept. 6 to 8. PPPL will submit a required final Extent of Condition report, along with an Extent of Cause report on recommended improvements to PPPL's policies, procedures, and systems to the U.S. Department of Energy (DOE) by the end of September.

"This is a really important turning point for the project," Rich Hawryluk, head of the Recovery Team, told the Recovery Team and reviewers. "For the last month we've engaged with issues on NSTX to see what has to be done. Today we hope to go from problem identification to identifying a path forward, and identifying a viable robust solution for these critical issues of the machine."

In addition to the magnets, the conceptual design review also included:

- The upper and lower regions of the vacuum vessel, which Tom Todd, the head of the Extent of Condition (EOC) Committee has dubbed "the polar regions"
- The plasma-facing component (PFC) tiles that have to withstand the plasma exhaust heat
- Improvements to the bakeout system to ensure safe and effective heating of the PFC tiles to drive out water vapor and impurities prior to operation
- The addition of a fiber optic "machine instrumentation system" to benchmark the analysis and track key parameters during operation
- The need to improve radiation shielding in and around the test cell

A focus on reliability

The concept for three new sets of magnets is aimed at remedying issues seen with the PF1-A upper coil, which failed last summer, causing the machine to shut down. That coil and its twin, the PF1-A lower coil, and two sets of similar coils, the PF1-Bs and PF1-Cs, are used to shape the plasma and are nestled next to the lower and upper regions of the center stack. The EOC recommended all three coil pairs be replaced since they were manufactured under the same conditions as the PF1-A upper coil and would likely have the same quality issues.

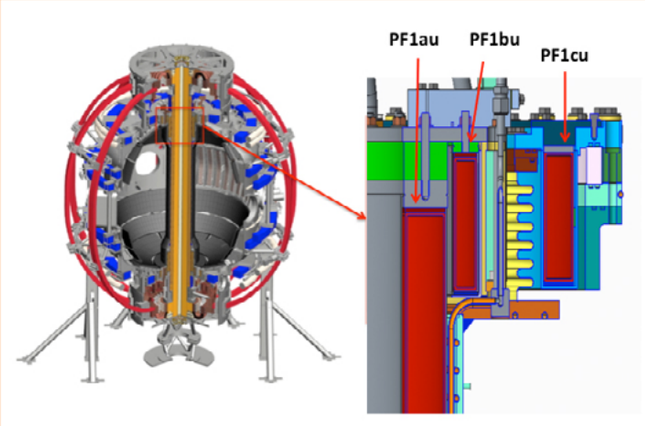
Before building the three sets of magnets, PPPL engineers have added an additional step to ensure they are manufactured reliably. PPPL and two additional vendors will construct three PF1-A prototypes (the PF1-As are being prototyped because they are the most complex of the three coil types). The prototypes will be taken apart and tested extensively to ensure that they meet PPPL's specifications. Proposals from several companies to build the prototypes are now being evaluated.

In addition, PPPL has instituted new quality assurance processes that require a PPPL staff member to be present at all coil fabrication sites to monitor each step of constructing the coils through a complex process that involves winding copper and injecting the coils with a resin at high temperatures called vacuum pressure impregnation. "We plan to have a much higher oversight everywhere coils are built," said Steve Raftopoulos, the responsible engineer for magnets.

New coil designs

The coils were also redesigned with reliability in mind. "The goal here is to make these coils work reliably for the lifetime of NSTX-U," said Michael Kalish, the engineer leading the coil design effort.

The redesign of the PF1-A coils avoids problems encountered with the failed PF1-A coil, which had to be removed from the center stack for a complete forensic analysis. This required the entire center stack to be removed from the vacuum vessel by a crane. Following the recommendations of the EOC, PPPL engineers are redesigning the coils so that they are not wound on metal spools, called mandrels, as they were in the past. This change allows for more thorough electrical testing of the coils before PPPL accepts the coils from the factories, to ensure that defects like those in the failed PF1-A coil are not present in the new coils. PPPL is developing a split-core transformer test method that will improve the sensitivity of turn-to-turn testing.



An illustration shows the location of the PF1-A, B and C coils next to the center stack in the National Spherical Torus Experiment-Upgrade.

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NSTX-U design review

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Eliminating the mandrel will also improve the ability to visually inspect the coils after they are fabricated. The elimination of the mandrel as a permanent feature of the coil has delayed the process but reduces risk. "We've made a lot of progress," said Charles Neumeyer, the Recovery Project Engineering Director. "We are heading in the right direction."

Polar Regions

Marc Sibilia is leading a team that is redesigning the top and bottom regions of the vacuum vessel to accommodate the new coils. The design eliminates many features included in NSTX-U for coaxial helical induction or CHI research. CHI is a non-inductive method of producing a plasma. The EOC deemed some of these features too risky and recommended that most of these features be removed and CHI "indefinitely deferred." One concern was that the design could expose the container surrounding the PF1-C coils to plasma.

Ankita Jariwala gives a presentation Aug. 2 on plasma facing components. *(Photo by Jeanne Jackson DeVoe)*

The new design also aims to solve an issue during the last NSTX-U operations when the vacuum vessel did not reach the required temperatures for a complete bakeout. The bakeout is used to rid the vacuum vessel of impurities by heating it to 350 degrees Celsius. The vessel was never heated to that temperature in the last run due to worries about potential damage to the nearby PF1-B coils, which are close enough to the divertors that they could be damaged by heat. In the redesign, the PF1-B coils will be more heavily insulated and improvements will be made to the helium system that provides heating during bakeout.

Plasma-facing components

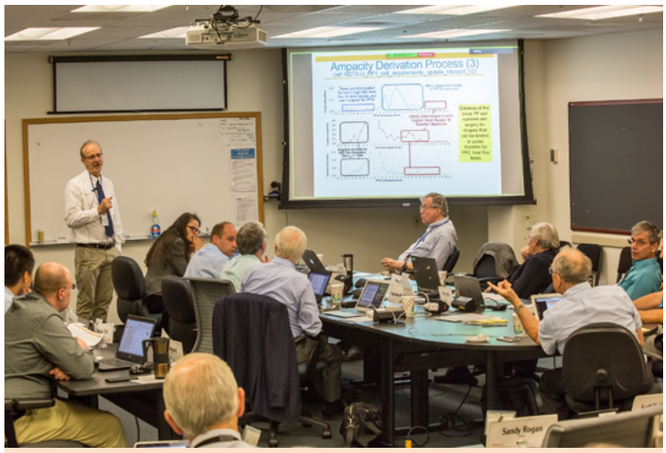
The PFC tiles are challenging components because they must withstand the plasma exhaust heat as well as halo currents that flow during plasma disruptions. The tiles need to be very reliable because they are located inside the NSTX-U vacuum vessel. If a tile failure occurs during operations, the machine has to be shut down and the vacuum vessel vented to atmospheric pressure to allow access for repairs, leading to an outage of several months. A team of engineers led by Doug Loesser is working on solutions to this problem, which could include arrays of smaller pre-attached tiles instead of large tiles that have limited capacity to withstand high heat flux.

Bakeout improvements

A high temperature helium system is used to heat the PFC tiles to 350 degrees Celsius (°C) during bakeout and a pressurized water system is used to hold the vacuum vessel at 150°C. Improvements to this system are being planned by engineer Joe Petrella to ensure safe and reliable performance that reaches the 350°C target baking temperature on all PFC tiles.

Machine instrumentation

State-of-the-art analysis is used to predict electromagnetic, thermal, and structural loading of NSTX-U during operations, providing essential information to the engineers who



Charles Neumeyer, Recovery Project engineering director, gives a presentation on Aug. 3. *(Photo by Elle Starkman)*

design various components on the machine. In order to validate or "benchmark" the predictions of the analysis, the redesign includes an enhanced instrumentation system based on fiber optic technology. The use of fiber optics is very advantageous because the sensors are immune to the effects of magnetic fields and high voltages present on the machine. Based on research by Hans Schneider, the redesign will include a new technology called Fiber-Bragg that best suits the NSTX-U application.

Additional shielding

Tests conducted by George Ascione identified 10 areas outside the vacuum vessel where neutron levels indicated leaks from penetrations or holes in the wall due to various equipment. Plans being developed by Erik Perry call for all the penetration areas to be shielded and for a labyrinth or concrete wall to be built around the southeast wall of the test cell to provide further protection.

Reviewers said they were pleased with the progress of the plans. "It's been quite amazing to see the progress," said Ron Parker, emeritus professor of MIT's Plasma Science and Fusion Center.

The CDR panel was chaired by Valeria Riccardo, PPPL head of engineering. Members of the panel were: Tom Todd, chair of the EOC committee and retired chief technologist at the Culham Centre for Fusion Energy; Rob Bamber, Culham Centre for Fusion Energy; Arnie Kellman, General Atomics; Christian Vorpahl, ITER; Dan Kellman, General Atomics; Bill Beck, MIT's Plasma Science and Fusion Center; Michel Huguet, former head of ITER Magnets; Brian LaBombard, MIT's Plasma Science and Fusion Center; Dennis Youchison, Oak Ridge National Laboratory; Rem Haange, former ITER technical director; Rui Vieira, MIT's Plasma Science and Fusion Center; Martin Cox, Culham Centre for Fusion Energy; Ron Parker, emeritus professor at MIT's Plasma Science and Fusion Center; Larry Dudek, Jerry Levine, and Frank Malinowski, PPPL.

Robert Ellis gives a presentation Aug. 2 on plasma facing components in the outboard divertor. *(Photo by Jeanne Jackson DeVoe)*

PPPL staff, friends and family reel in fish and fun on annual fishing trip

A group of 51 people that included PPPL and Princeton University staff, summer interns, friends and family had a day of fun and fishing aboard the charter boat Suzie Girl on Sunday, Aug. 6, during the annual (unofficial) fishing trip. The group caught numerous black sea bass, fluke, and other fish. Three people won cash prizes: Former PPPL'er Reggie Thomas won $40 for catching the first fish; Tacuma Reese, son of PPPL's Westley Reese, won $40 for catching the most fish with 47 fish; and 7-year-old Xavier Hughes, grandson of PPPL's Charles Hughes, won the grand prize of $80 for catching the biggest fish.

Photos courtesy of Andy Carpe.

Jane Feng and husband Steve Pan.

Xavier Hughes, grandson of Charles Hughes, with his fish, which won the prize for the biggest fish.

Ambica Nandanavanam and her son Abhiram Kakani.

Hans Schneider, left, with Andy Carpe, and summer intern Madeline Griffith.

Mark Karlik Sr. and Mark Karlik Jr.

The fishing group aboard the Suzie Girl before setting out.

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 August 14	Tuesday August 15	Wednesday August 16	Thursday August 17	Friday August 18
COMMAND PERFORMANCE Chef's Feature	**Beef and Bean Burrito** with Yellow Rice	**Buffalo Chicken Mac and Cheese**	**Jerk-Seasoned Pork Chops** with Pineapple Rice and Mango Salsa	**Flatbread Pizza** with Tossed Salad	**Bourbon Chicken** over Rice
Early Riser	**Blueberry Pancakes**	**Fried Bologna and Egg Sandwich**	**Tater Tot Breakfast Bake**	**Ham, Egg & Cheese French Toast**	**Bacon, Spinach & Mozzarella Quesadilla** with Cilantro Cream
Country Kettle	**Cream of Broccoli**	**Spinach and White Bean**	**Chicken Pot Pie**	**Cream of Mushroom**	**Beef and Rice**
Deli Special	**Italian Hero**	**Cobb Salad Wrap**	**Lemon-Rosemary Turkey Sandwich**	**American Hoagie** with Ham, Bologna, and American Cheese	**Italian Tuna Salad Wrap**
Grill Special	**Cheddar Bacon-Wrapped Hot Dog**	**Chorizo Quesadilla**	**Grilled Fish Cake Sandwich**	**Grilled Margherita Sandwich**	**Pepperoni Roll**
Panini	**Sweet and Sour Meatball Sandwich**	**Chicken Breast,** Mozzarella Cheese, Spinach and Tomato Pesto on Ciabatta Bread	**BBQ Pork Rib Sandwich** with Cole Slaw	**Corned Beef Reuben Sliders**	**NY Street Dog—** 2 Sabrett Hot Dogs with Sauerkraut, Red Onions & Mustard served with Fries

	Monday August 21	Tuesday August 22	Wednesday August 23	Thursday August 24	Friday August 25
COMMAND PERFORMANCE Chef's Feature	**Roast Pork** with Barley Wild Rice Pilaf and Vegetable	**Power Bowl**	**Caprese Chicken** with Orzo Pilaf	**Wild Mushroom Turkey Meatloaf** with Mashed Potatoes and Vegetable	**Fish and Chips**
Early Riser	**Bacon, Egg and Cheese English Muffin**	**Mexican Breakfast Burrito**	**Potato, Roasted Pepper & Sundried Tomato Casserole** with 2 Eggs any Style	**Cinnamon-Raisin Pancakes** with Homemade Apple Compote	**French Toast Sticks**
Country Kettle	**Manhattan Clam Chowder**	**Vegetable**	**Chicken Noodle**	**Tomato Soup**	**Chili Bean**
Deli Special	**Spring Chicken Salad Wrap**	**Asiago Roast Beef** with Grilled Onion, Tomato & Horseradish on Pumpernickel	**California BLT** with Avocado	**Turkey Sloppy Joe**	**Spicy Crab Sushi Wrap**
Grill Special	**Grilled Vegetable Quesadilla**	**Chipotle BBQ Pulled Pork Sandwich** with Fries and Slaw	**Burgerlicious Buffalo Turkey Burger**	**Jalapeño Popper Bacon-Wrapped Hot Dog**	**Teriyaki Chicken Cheesesteak**
Panini	**TBD**	**Baja Fried Flounder Hero** with Crunchy Slaw and Pico de Gallo	**Pastrami and Swiss** on Marble Rye	**Chipotle Roast Beef Melt** on Foccacia	**Breaded Chicken Cutlet** with Ham, Swiss Cheese, Lettuce & Honey Mustard on Ciabatta

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/.

The next issue of the PPPL Weekly will be on August 28.