PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
February 8, 2016

Calendar of Events

WEDNESDAY, FEB. 10

Video of Budget Request Presentation
1 p.m. ◆ MBG Auditorium
Ed Synakowski, Associate Director, Office of Fusion Energy Sciences

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Assessing First Wall Materials at the Atomic Scale and Energy Writ Large at Princeton
Professor Emily Carter, Princeton University

SATURDAY, FEB. 13

Ronald E. Hatcher Science on Saturday Lecture Series
9:30 a.m. ◆ MBG Auditorium
Music and 3D Audio
Professor Edgar Choueiri, Princeton University

UPCOMING

FEB. 19–FEB. 20

New Jersey Regional Science Bowl

SATURDAY, FEB. 20

No Science on Saturday

INSIDE

PPPL, Princeton University physicists join German Chancellor Angela Merkel at Wendelstein 7-X celebration

By Jeanne Jackson DeVoe

PPPL physicists collaborating on the Wendelstein 7-X (W7-X) stellarator fusion energy device in Greifswald, Germany were on hand for the Feb. 3 celebration when German Chancellor Angela Merkel pushed a button to produce a hydrogen-fueled superhot gas called a plasma. The occasion officially recognized a device that is the largest and most advanced fusion experiment of its kind in the world.

The W7-X is a stellarator, a device that uses twisted magnetic coils to confine the plasma that fuels fusion reactions in a three-dimensional and steady-state magnetic field. It is a departure from the more common fusion device used in fusion experiments, a donut-shaped device called a "tokamak," such as that used at PPPL.

A.J. Stewart Smith, Princeton University vice president for the Princeton Plasma Physics Laboratory, and German Chancellor Angela Merkel shake hands in the Wendelstein 7-X control room at the celebration of the first hydrogen plasma. (Photo courtesy of the Max Planck Institute for Plasma Physics).

continued on page 2

Von Hippel, at PPPL, calls for international control of nuclear enrichment

By Jeanne Jackson DeVoe

The world's nuclear enrichment programs should be under international control to prevent the development of nuclear weapons after the new arms deal with Iran expires in 10 to 15 years, said Frank von Hippel, a senior Princeton University research physicist and a former security advisor during the Clinton Administration.

"We have 10 to 15 years to strengthen the non-proliferation machine," von Hippel said, speaking at the Ronald E. Hatcher Science on Saturday public lecture Jan. 30 at PPPL.

continued on page 5

Wendelstein 7-X celebration

continued from page 1

"It was a day of building excitement and it was a very happy mood because everything is working really well on the experiment," said Hutch Neilson, head of advanced projects at PPPL and the coordinator of the U.S. collaboration. "It was kind of amazing when the chancellor walked into the control room her eyes lit up."

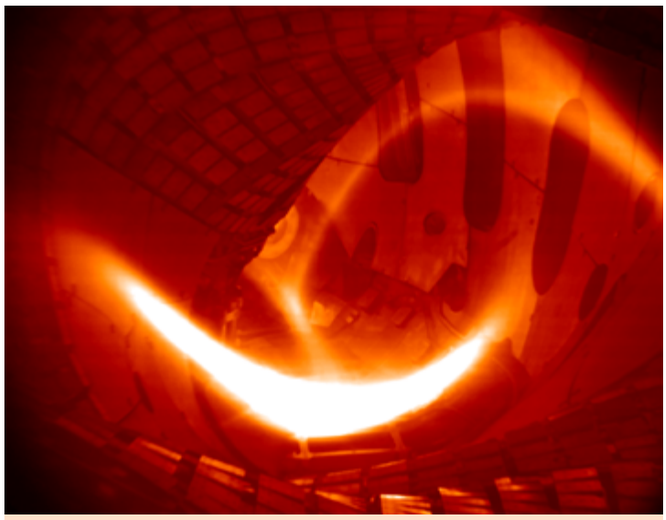
Scientists and dignitaries from around the world watched as Merkel pushed the button to create a hydrogen plasma that lasted a quarter of a second. But that was long enough to begin heating the plasma to 80 million degrees Centigrade. By 2020, the W7-X is designed to produce a plasma that lasts up to 30 minutes and would demonstrate that stellarators could be a model for the fusion power plants of the future.

Merkel acknowledged that there are "huge scientific challenges" and costs associated with developing fusion energy but she said the possibility of developing fusion energy as a source of generating electric energy is worth the investment. "Rising energy demands and the vision of an almost inexhaustible energy source are convincing arguments for investing in fusion," Merkel said.

Neilson and Princeton University Vice President for PPPL A.J. Stewart Smith were among the select group of scientists in the W7-X control room. PPPL physicists Samuel Lazerson and Novimir Pablant also attended the event along with other U.S. collaborators.

"Major progress for the understanding of plasma"

Greeting Merkel on behalf of the U.S. delegation, Smith said the W7-X is a significant achievement that will lead to "major progress for the understanding of plasma." "The W7-X is a major step for fusion research. Princeton and the whole U.S. team are absolutely thrilled," Smith said to Merkel in German. "We are so pleased to be involved in this exceptional event."



A photo of the hydrogen plasma inside the W7-X. (Photo courtesy of the Max Planck Institute for Plasma Physics).

"I am very impressed by the professional way the IPP team was able to successfully build a complex, demanding machine," Smith said after the event. "The success of W7-X shows the daunting challenge of meeting the very tight tolerances needed in stellarators has been solved."

PPPL physicists and other staff members watched the live stream of the event from the Melvin B. Gottleib auditorium at PPPL and applauded when the live stream concluded at the end of Smith's remarks.

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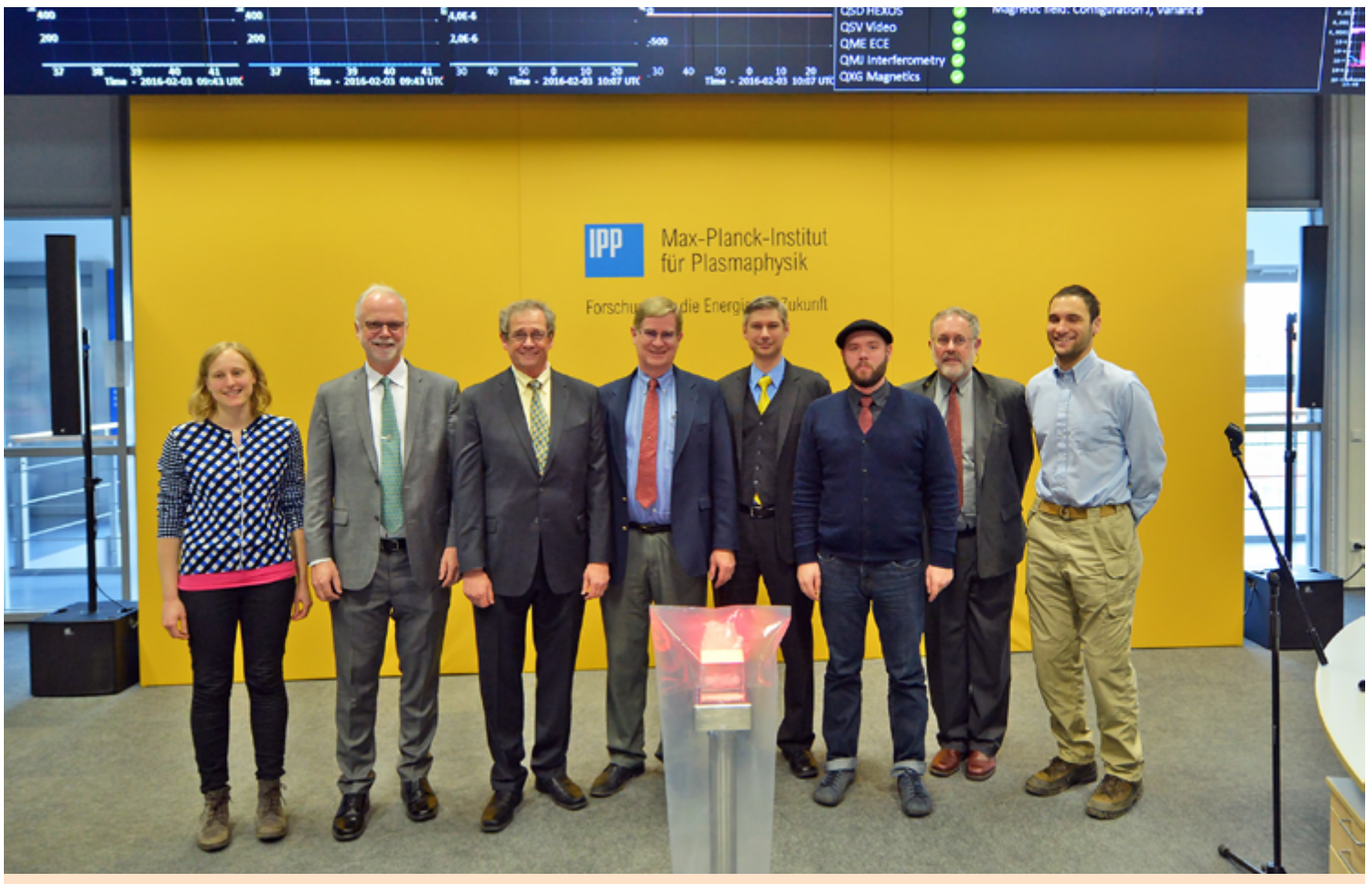


American collaborators at the W7-X event. From left to right: Laurie Stephey, the University of Wisconsin; Ed Synakowski, the associate director for Fusion Energy Sciences in the U.S. Department of Energy's Office of Science; Hutch Neilson, PPPL; Glen Wurden, Los Alamos National Laboratory; Sam Lazerson, PPPL; Novimir Pablant, PPPL; Jeff Harris, Oak Ridge National Laboratory; and Peter Traverso, Auburn University. (Photo courtesy of Glen Wurden, LANL)

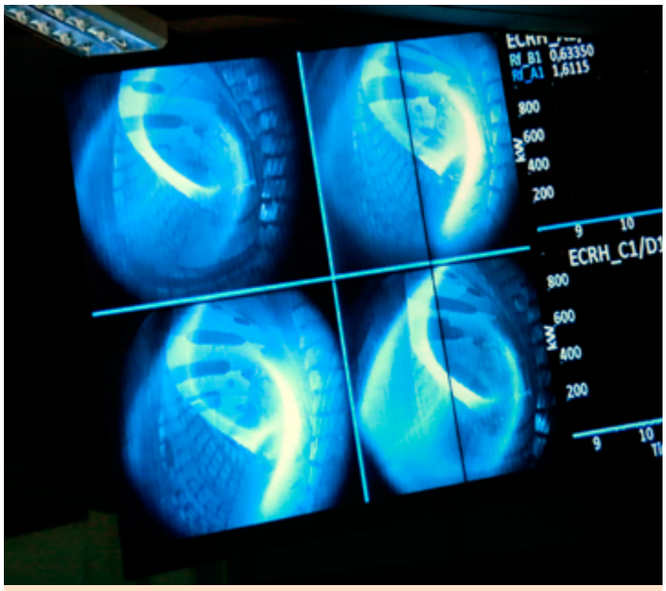
Wendelstein 7-X celebration

continued from page 2

Hutch Neilson, head of advanced projects at PPPL and the coordinator of the U.S. collaboration at the W7-X, greeting Chancellor Merkel in the video of the event.

The hydrogen plasma is "a step on the path to making the device perform as planned," said David Gates, a PPPL physicist and stellarator physics leader, who was on hand at the W7-X for the first test plasma in December and watched the first hydrogen plasma at PPPL. "From a plasma physicist's point of view, this next phase of research is an important milestone."

PPPL leads the U.S. collaboration with W7-X scientists, which is funded by $4 million annually from the Department of Energy's Office of Fusion Energy Sciences. PPPL scientists and technicians built some key components of the machine, which took some 20 years and €1 billion to build. Collaborators include researchers from Los Alamos and Oak Ridge National Laboratories, as well as researchers and students from MIT, the University of Wisconsin, Auburn University, and Xantho Technologies, LLC.



The W7-X plasma as seen in PPPL's MBG auditorium. (Photo by Elle Starkman/PPPL Office of Communications).

PPPL'ers watch the live stream in the PPPL auditorium. (Photo by Elle Starkman/PPPL Office of Communications).

"Exceeding expectations"

Neilson said the experiment is already getting good results. "We're getting data and physics results from it exceeding expectations for what everybody thought would be accomplished during this start-up period."

PPPL researchers designed and delivered the five massive 2,400-pound trim coils that fine-tune the shape of plasma in fusion experiments. Physicists also designed and built an X-ray spectrometer for measuring the plasma temperature. A current project is the design and construction of divertor scraper units that intercept heat from the plasma to protect divertor targets from damage. Pablant used the X-ray spectrometer to make the first plasma temperature measurements on W7-X.

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PPPL engineers complete the design of Wendelstein 7-X scraper unit

By Raphael Rosen

Engineers at PPPL have finished designing a novel component for the Wendelstein 7-X (W7-X) stellarator, which recently opened at the Max Planck Institute of Plasma Physics (IPP) in Greifswald, Germany. Known as a "test divertor unit (TDU) scraper element," the component intercepts some of the heat flowing towards the divertor — a part of the machine that collects heat and particles as they escape from the plasma before they hit the stellarator wall or degrade the plasma's performance. Stellarators are fusion facilities that confine plasma in twisty magnetic fields, compared with the symmetrical fields that tokamaks use.

Two of the components are being built and are scheduled to be delivered to IPP in September 2016, with the complete unit to be installed and ready to operate in late 2017. Once installed, the scraper will let physicists explore a wide variety of ways to arrange the stellarator's magnetic fields and vary the currents and pressures of the plasma. This project was supported by the DOE Office of Science (Office of Fusion Energy Sciences).

Engineers realized the need for the scraper element when they noticed that as the plasma exited the vessel, it sometimes struck parts of the divertor that weren't intended to handle high heat loads. "This problem had to be solved to avoid damage to the stellarator equipment," said Hutch Neilson, head of PPPL's advanced projects department and coordinator of PPPL's collaborations with W7-X.

The resulting design, begun by scientists at Oak Ridge National Laboratory (ORNL) and completed by researchers at PPPL, ensures that the heat from fusion reactions will hit the scraper before reaching the divertor. "The scraper element is an additional divertor plate that intercepts the heat earlier," said Sam Lazerson, a stellarator computational physicist at PPPL who will be stationed at W7-X until February 2016.

Engineers plan the scraper together with diagnostic devices to measure the heat flow more precisely. And they will use computer models to "check our understanding of how the exhaust power flows from the plasma to the stellarator's first wall," said Neilson.

Designing the scraper element meant overcoming several obstacles. The primary physics-related challenge involved finding the best shape for the scraper's plasma-facing surface. This process called for modeling the "edge plasma heat flows in the complicated 3D magnetic field in both the edge and divertor regions," said Neilson.

Engineers also had to consider that the scraper would not be actively cooled. This was a problem since the temperature of the scraper would rise more quickly than that of its supporting structure during W7-X operations. "The design relied on sophisticated thermal-mechanical analyses by our Engineering Analysis Branch," said Neilson. The analysis ensured that "all materials will stay below their temperature limits and that stresses caused by thermal expansion will be low enough to avoid component damage."

A panel of researchers from PPPL, ORNL, and IPP approved the design on November 11, 2015, after a series of reviews. According to a committee report, "discussions between the PPPL cognizant engineer, Douglas Loesser, and IPP staff, resulted in a simplified design that will significantly reduce design, fabrication, and assembly costs."

Wendelstein 7-X celebration

continued from page 3

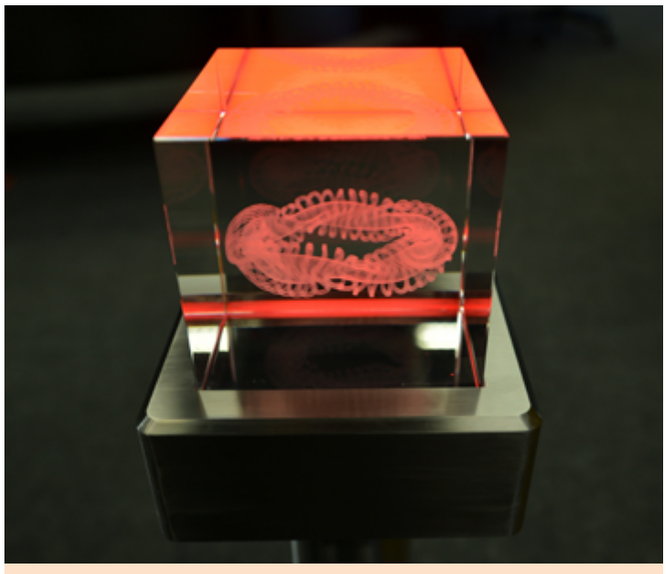
PPPL researchers have also collaborated on research at the W7-X. Lazerson has been at the W7-X since March of 2015 and performed one of the first experiments on the machine when he mapped the structure of the magnetic field and proved that the main magnet system, and the trim coils that PPPL designed and had built in the U.S., were working as intended. He presented his research at the APS Division of Plasma Physics Conference in November.

"I was really proud of the American contingent for the work they've done," Neilson said the evening of the event. "We've made ourselves as indispensable as it's possible to be. We're not on the periphery. We're doing things that matter."

Two approaches to the same problem

Neilson said stellarators and tokamaks are simply two different approaches to the same difficult challenge of developing fusion as an energy source. He added that the W7-X is putting more attention on the potential of stellarators.

"The arrival of W7-X on the scene sort of creates a buzz about stellarators," Neilson said. "I think in the U.S., the arrival of such an advanced machine, which is competitive with anything that's out there in terms of capabilities, is just bound to shift the conversation about stellarators."



A close-up of the crystal block with an image of the W7-X on a pedestal that served as a button for starting the W7-X plasma. (Photo by Glen Wurden, LANL)

PPPL has taken a different approach to stellarators with its quasi-axisymmetric stellarator or QUASAR, which was not completed. With W7-X now operating, it could also lead the U.S. to reconsider stellarators, Neilson said. "For 10 years, the focus is going to be on W7-X itself," he said, "but it does create an atmosphere in which it's reasonable to ask, 'What about us?' "

Science on Saturday: Frank von Hippel

continued from page 1

Frank von Hippel discusses the Iran nuclear deal at the Jan. 30 Ronald E. Hatcher Science on Saturday lecture.

Von Hippel said security analysts at the Program on Science and Global Security at Princeton University, which he founded, had some input into the deal. But their idea of establishing multinational oversight was rejected. "I think it was probably too complex to be negotiated in the time frame that the deal was negotiated," he said.

Von Hippel was one of 29 top scientists around the country to sign a letter endorsing the Iran deal, saying that it "will advance the cause of peace and security in the Middle East and can serve as a guidepost for future non-proliferation agreements."

"I do think that it was actually remarkable and the pressure cooker in which this happened was remarkable," von Hippel said during his lecture.

Difficulties go back to 1953

Iran's difficulties with the United States go back to 1953 when the CIA helped depose Iran's democratically elected government, von Hippel said. Decades later in 1979, Iranians overthrew the shah and took over the U.S. Embassy in Tehran, taking 66 American diplomats and citizens hostage. The U.S. government imposed sanctions that year and added more sanctions in subsequent years. The sanctions were lifted last month after International Atomic Energy Agency (IAEA) inspectors verified Iran was complying with the terms of the nuclear deal.

The deal was aimed at preventing Iran from creating an atomic bomb using either uranium or plutonium. Uranium mined from the earth contains only 0.7 percent (seven-tenths of 1 percent) U-235, the isotope used to fuel nuclear reactors and make bombs. Therefore, it must be enriched using centrifuges, von Hippel said. Bomb-grade uranium is enriched to above 90 percent and most power reactors use uranium that is enriched up to 5 percent. Iran was processing a higher-grade uranium of up to 20 percent. "My own view is they never decided to make a weapon but they wanted a nuclear weapons option," von Hippel told the crowd.

Atomic bombs can also be created with plutonium, which is made when uranium is irradiated in a nuclear reactor. It would take about 8 kilograms of plutonium to create a powerful nuclear weapon, a process that would take about 200 days, von Hippel said.

Evidence that Iran was enriching uranium emerged in 2002, when a satellite shot images of the Natanz Uranium Enrichment Plant, von Hippel said. The evidence led IAEA officials to demand Iran stop producing uranium, but Iran went on to build two more nuclear facilities. Von Hippel showed satellite images of the Arak reactor taken in 2005 and the Fordow underground enrichment facility taken in 2009. Fordow was designed for 2,7000 centrifuges and produced 20 percent uranium.

Iran's nuclear program and U.S. sanctions continued until two years ago. Despite President Barack Obama's declaration that he was willing to negotiate with Iran after he was elected in 2008, there was little progress in a nuclear deal until 2013, von Hippel said. That's when Iran elected President Hassan Rouhani and negotiations for a deal began, von Hippel said.

Reducing centrifuges

The agreement calls for the Fordow plant, which is buried deep underground, to be transformed into a scientific research center. The Natanz plant will continue operating but the number of centrifuges will be reduced from 10,000 to 5,000 and uranium enrichment will be limited to 3.7 percent, von Hippel said. The number is well below the 7,000 centrifuges needed to create enough weapons-grade uranium for a nuclear weapon, von Hippel said. The Arak plant will be converted into a research facility.

Sahithi Muthyala, 14, of East Windsor, with her father Narender, at the lecture.

Iran also agreed to limit its supply of low-enriched uranium to 200 kilograms for 15 years. Iran agreed to ship spent nuclear fuel out of the country and promised not to produce weapons-grade plutonium.

Von Hippel said, in his opinion, the "obvious heroes" of the deal are President Obama and Secretary of State John Kerry,

continued on next page

Science on Saturday: Frank von Hippel

continued from page 5

whom von Hippel referred to as "the poor president and the poor secretary of state who had to deal with a lot of opposition, not only with Iran but also from Israel and the Republicans."

On the Iranian side, von Hippel said he believes the heroes are President Rouhani and Foreign Minister Javad Zarif. Both are western-educated and both understand the world much better than Ali Khamenei, Supreme Leader, who has never been out of Iran, he said. Both leaders also had to deal with internal negotiations in their country to get the deal approved.

The local hero

Von Hippel credited Seyed Hossein Mousavian, a research scholar in the Science & Global Security program at Princeton, as the "local hero" of the Iranian deal. Mousavian is a former diplomat for Iran who was head of the Foreign Relations Committee of Iran's National Security Council. He served as an expert consultant who was able to "explain Tehran to Washington and Washington to Tehran." He added: "I don't think we would have gotten to the agreement if Mousavian hadn't been involved.".

But von Hippel said the nuclear deal is obviously limited by its timeframe. "We solved the problem for 10 to 15 years but we haven't solved the problem forever," he said.

Mohammedi Kanpurwala, of West Windsor, left, and Mark Bergman, of South Brunswick, have been coming to the lectures since 1998.

The Science on Saturday lectures are held each Saturday at PPPL at 9:30 a.m. but seats fill up quickly, so plan to get there early. They can also be streamed live from home at https://mediacentral.princeton.edu/id/1_wdp1m3et. You can view archives of the lectures at http://www.pppl.gov/sos-listing. If Science on Saturday is canceled due to inclement weather or other emergency, an announcement will be posted on the PPPL website at pppl.gov and a message will be left on the Science on Saturday Hotline, (609) 243-2121.

PPPL Welcomes New Employees!

JOHAN CARLSSON
Computational scientist
Theory

ROBIN CHANG
Travel/administrative assistant
Business Operations

LAN GAO
Staff research physicist
Plasma Science & Technology

AMBICA NANDANAVANAM
Senior business analyst - financials
Business Operations

PETER PORAZIK
Computational scientist
Theory

MIRJAM SCHNELLER
Associate research physicist
Theory

Volunteers needed for the Science Bowl Feb. 19 and 20

It's Science Bowl season again and the Science Ed. Department really needs your help. Please volunteer to help with the New Jersey Regional Science Bowl Feb. 19 to Feb. 20.

On Friday, Feb. 19, PPPL will host 16 middle school teams for the Middle School Science Bowl from 9 a.m. to 3 p.m., with registration starting at 8 a.m. On Saturday, Feb. 20, PPPL will host 32 high school teams for the High School Science Bowl from 9:30 a.m. to 5 p.m., with registration starting at 8 a.m.

If you are interested in volunteering, please click on the link below that best suits you and complete the form with your preferences. If you've never volunteered before, no worries. We will train you. Please contact Deedee Ortiz at dortiz@pppl.gov or ext. 2785 to sign up or for more information.

Non-technical volunteer roles:

- Registration assistant (morning only)
- Score/Time Keeper (Because we use electronic software to keep time and score at our regionals, we combined these two roles)
- Lunch assistant
- Other help as needed before/after competitions

Technical volunteer roles:

- Moderator
- Science/Rules Judge (We combine the Science Judge role and the Rules Judge role at PPPL)

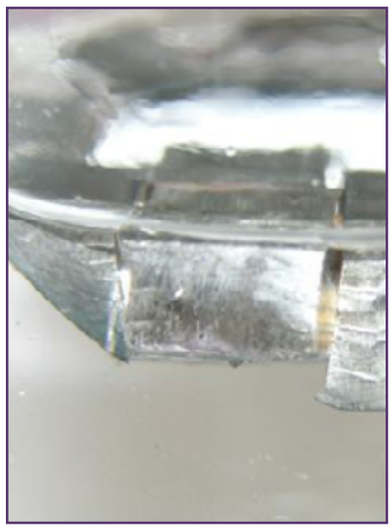
Feel free to forward the links to anyone that might be interested in volunteering. We promise that you're going to have a lot of fun!

Thanks in advance for your time and assistance!!

- The Science Education Department

COLLOQUIUM

Assessing First Wall Materials at the Atomic Scale and Energy Writ Large at Princeton



Professor Emily Carter
Princeton University

Wednesday, Feb. 10
4:15 p.m., M.B.G Auditorium, Lyman Spitzer Building

Ronald E. Hatcher
Science on Saturday LECTURE SERIES

Feb. 13	**Music and 3D Audio** **Edgar Choueiri,** Princeton University
Feb. 20	**No Science on Saturday due to DOE New Jersey Regional High School Science Bowl**
Feb. 27	**Brutal Efficiency: How Mating and Reproduction Influence C. Elegans Longevity** **Coleen Murphy,** Princeton University
Mar. 5	**Reimagining the Possible: Scientific Transformations Shaping the Path Towards Fusion Energy** **Ed Synakowski,** DOE
Mar. 12	**Taking the Universe's Baby Picture** **David Spergel,** Princeton University

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

Volunteers wanted for Mercer Science and Engineering Fair

Organizers of the Mercer Science and Engineering Fair are looking for scientists and engineers to volunteer as judges of fourth to twelfth-grade science projects during the fair next month at Rider University.

Students from Mercer County schools show off their original science projects at the fair from March 12 to March 15. Judging for the elementary division (grades 4 to 5) and the junior division (grades 6 to 8) takes place Sunday, March 12. Judging for the senior division takes place March 12 and March 13. Additional information about the fair is available at https://mercersec.org/about/msef.

To volunteer, create an account online and check off judge to volunteer at https://mercersec.org/help/BecomeAJudge.

BROCK

MARK GAZO
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 February 8	Tuesday February 9	Wednesday February 10	Thursday February 11	Friday February 12
COMMAND PERFORMANCE **Chef's Feature**	**Italian Baked Breaded Chicken Breast** served with Pasta, Garlic & Oil with Artichoke, Tomato Cucumber Salad	COMMAND PERFORMANCE **Create Your Own Gumbo Bar**	**Fried Catfish** served with Corn Bread Pudding and Vegetable	**Penne Pasta** with Chicken, Sausage, Broccoli Rabe, Banana Peppers, Garlic & Olive Oil served with a Breadstick	VALENTINE'S DAY BEACH PARTY!!! **Ham Stuffed Hawaiian Pork Loin** with Pineapple Glaze & Hawaiian Macaroni Salad
Early Riser	**Kielbasa & 2 Eggs any style**	**Eggs Benedict** with Hash Browns	**Vegetarian Omelet** served with Hash Browns	**Sausage, Egg & Cheese Stromboli**	FITNESS FRIDAY **Apple & Pecan Cinnamon Quinoa**
Country Kettle	**Mushroom Barley**	**Chicken Sausage Gumbo**	**Cream of Cauliflower**	**Manhattan Clam Chowder**	**Navy Bean & Ham**
Grille Special	BURGERLICIOUS **My Big Fat Greek Turkey Burger** Grilled Turkey Burger with melted feta cheese, tomato, red onion, banana peppers & spinach topped with cucumber sauce on a grilled whole wheat roll (Available All Week)	**Catfish Torpedo** served with Rice & Beans	**Salmon Burger** with Cucumber Sauce	**Grilled Chicken,** Spinach Feta Cheese & Kalamata Olives on Ciabatta Bread	**2 Cheeseburgers** served with Fries
Deli Special	**Fresh Mozzarella, Tomato, Basil** & Pesto Mayo on Ciabatta	**New Orleans Muffaletta**	**Tuna Club Sandwich** with Hard-Cooked Egg	**Seafood Salad Croissant**	**Deviled Egg Salad Wrap**
Panini	**Meatball Parmesan Torpedo**	**Popcorn Chicken Po' Boy**	**Breaded Chicken Cutlet** on Ciabatta Bread with Lettuce & Tomato	**Grilled Eggplant,** Roasted Peppers, Tomato, Balsamic Onions & Provolone on Ciabatta	**2 Hot Dogs with all the Fixins** with Baked Beans & Macaroni Salad

MENU SUBJECT TO CHANGE WITHOUT NOTICE

VEGETARIAN OPTION

WEEKLY
Editor: **Jeanne Jackson DeVoe** ◇ Layout and graphic design: **Kyle Palmer**
Photography: **Elle Starkman** ◇ Science Editor: **John Greenwald** ◇ Webmaster: **Chris Cane**

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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/.