PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
June 19, 2017

THIS WEEK

MONDAY, JUNE 19

Information Session on Performance Management System
1–2 p.m. ◆ MBG Auditorium

TUESDAY, JUNE 20

All-hands meeting on the budget and the NSTX-U Recovery Project
2:30 p.m. ◆ MBG Auditorium
See page 3 for details.

WEDNESDAY, JUNE 21

Summer Solstice Ice Cream Social
12:30 p.m. ◆ LSB Lobby
See page 8 for details.

UPCOMING

THURSDAY, JUNE 29

Information Session on Performance Management System
11 a.m.–12 p.m. ◆ MBG Auditorium

INSIDE

PPPL engineers describe their global contributions to fusion development at SOFE

By John Greenwald

The plenary session. *(Photo by Fageng Zhou, ASIPP)*

Engineers and researchers at PPPL outlined the roles they are playing in global fusion projects during the 27th IEEE Symposium on Fusion Engineering (SOFE) in Shanghai, China. The gathering, held June 4-8, drew nearly 450 engineers, students and researchers from around the world to the first meeting outside the United States in the 52-year history of the biennial conference.

PPPL staffers gave talks and presented posters describing their engineering for state-of-the-art fusion facilities. Included was key work for ITER, the international experiment under construction in France to demonstrate the feasibility of fusion power, together with contributions to major fusion projects in Europe, Asia and the United States. Also discussed was PPPL work on related fusion developments, such as the Laboratory's design of a first-of-a-kind x-ray camera for studying fusion plasmas.

PPPL played a substantial role in organizing the event. Hutch Neilson, head of Advanced Projects and ITER Fabrication at PPPL, chaired the conference. Other PPPL planners and organizers included Charles Neumeyer, deputy head of engineering, who served as finance chair; administrators Kathleen Lukazik and Pamela Serai, the registration chair and publications assistant, respectively; and Chris Cane, manager of digital strategy and visual communication, who served as webmaster for the conference and created the SOFE website. The Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP), with whom PPPL has extensive research ties, joined as a partner in organizing SOFE-2017.

continued on page 4

Student interns get a week-long lesson in plasma

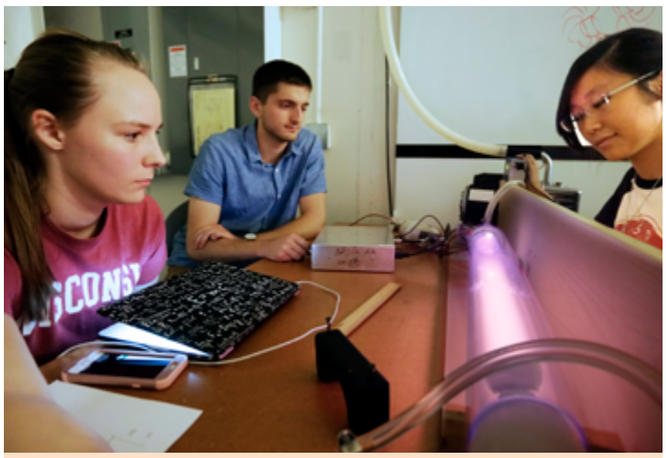
There was a large influx of young people into the Laboratory last week as some 60 students from the U.S. Department of Energy's (DOE) Science Undergraduate Laboratory Internship (SULI) and other programs attended a week-long course in plasma physics at the Laboratory.

The course was organized by Arturo Dominguez, senior program leader and Deedee Ortiz, program manager, both of the Science Education Department. Researchers from national laboratories and universities across the country gave lectures and PPPL's Sam Cohen, Nat Fisch, Robert Goldston and Matt Kunz were featured speakers.

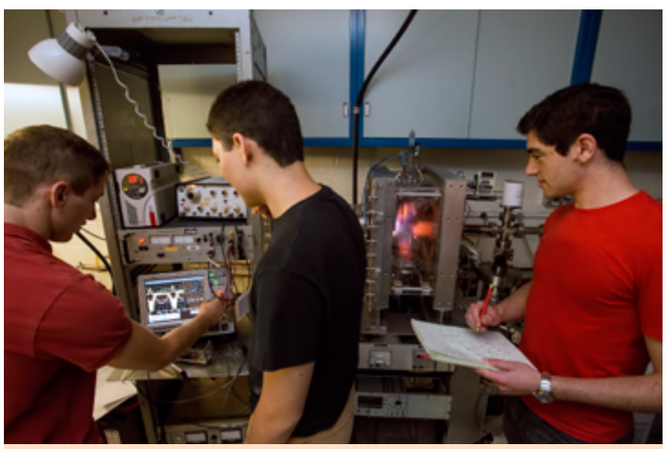
In addition to hearing lectures, the students took tours of the Laboratory and did plasma experiments in the Science Education Laboratory and in Cohen's graduate laboratory.

The students are from colleges and universities across the United States, along with a few students from the University of Tokyo. They will spend the summer doing hands-on research experiments with mentors at PPPL and other institutions.

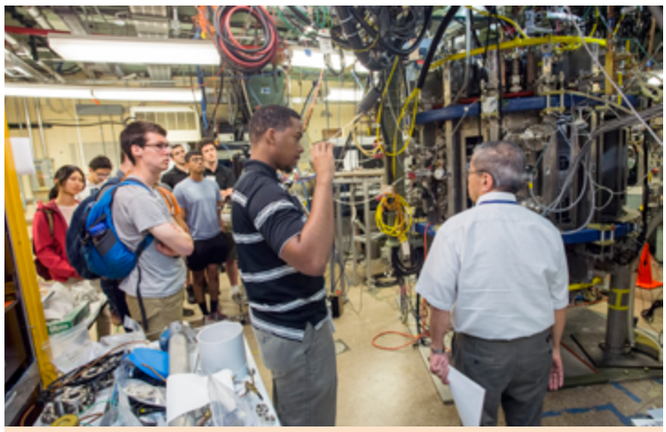
The group of students included 32 SULI students, 21 of whom are staying at PPPL for a summer of research and 11 of whom are going to General Atomics to work with researchers. It also included students from: the DOE's Community College Internship program; Columbia University, the Princeton Plasma Science & Technology program, PPPL's Japanese exchange program, and PPPL's high school internship.



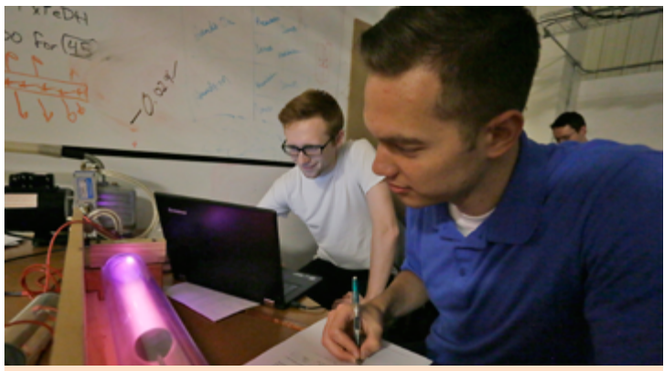
Observing the plasma they created in the Science Education Laboratory are from left: Megan Tabbutt, University of Wisconsin-Madison; Evan Leppink, University of Michigan–Ann Arbor; and Jessica Li, Columbia University. *(Photo by Elle Starkman)*



Students do plasma experiments in the graduate laboratory. From left, Jacob Adams, Virginia Tech, Carl Fremlin, of the Rose-Hulman Institute of Technology in Terre Haute, Indiana; and Robert Cohen, Princeton University. *(Photo by Elle Starkman)*



Robert Kaita shows students the Lithium Tokamak Experiment (LTX) on a tour of the Laboratory. *(Photo by Elle Starkman)*



Jared Carlson, a Community College Internship student from Mason Community College, jots down results, along with Logan Stahl, of Rutgers University. *(Photo by Elle Starkman)*

A group photo outside the Lyman Spitzer Building of all the students attending the one-week plasma course. *(Photo by Elle Starkman)*

Students try out the Van de Graaff experiment in the Science Education Laboratory as Arturo Dominguez looks on. *(Photo by Elle Starkman)*

A summer of opportunity at Princeton University's Transfer Program

By Jeanne Jackson DeVoe

Michael Consulmagno, a maintenance worker at PPPL, will have a different commute this summer when he spends 10 weeks working as an apprentice in the Plumbing Shop at Princeton University.

Consulmagno is taking advantage of Princeton's Service Employees International Union (SEIU) Summer Transfer Program that gives union employees an opportunity to advance by working and learning skills in different positions.

"I was so overwhelmed when I got the letter, I was jumping around!" Consulmagno said. "I feel really blessed."

The Summer Transfer Program began more than 25 years ago. It is open to full-time employees who apply in early February. Applicants attend an interview day in which they interview with department representatives for a few minutes before moving on to the next interview when the bell rings. "It's actually like a dating game," Consulmagno said.

The Transfer Program offers summer transfer jobs in the electric, elevator, HVAC, paint, roof and carpenter shops, as well as in groundskeeping.

In addition to summer transfer jobs at numerous shops at Princeton University, some of the positions included office assistant jobs in various departments, and a technical support specialist job in the Office of Information Technology.

Consulmagno said he was also thrilled when he got a job at PPPL just a few months ago. His new job allowed him to spend time with his family – a big improvement over his previous job working nights doing maintenance for a school district. Previous to that job, he did maintenance and custodial work for JFK Hospital for 10 years.

Building and Grounds Supervisor Margaret Kevin-King, Consulmagno's manager, said she always informs employees about the program. Consulmagno was the only one who applied this year. "It's an avenue for advancement, moving up in their careers, developing different skills," King said. Since its inception, Consulmagno is the second SEIU member to apply from PPPL Facilities and Site Services. "I try to let folks know every year when it comes up that it's available to everyone."

Michael Consulmagno *(Photo by Elle Starkman)*

A few years ago another janitor at PPPL, Teodora Todorova, took courses through the Excelling at Princeton Program and worked in Building Services at the University through the Transfer Program. She got a permanent job a few months later with Building Services as a database report writer. (Read more about Todorova on the Facilities website: http://facilitiesinsider.princeton.edu/2016/09/14/teodora-todorova-taking-risks/#more-2083.)

"It's a good thing," Kevin-King said. "People want to advance in their careers and you have to be willing to support that and mentor people to help them advance. As managers and supervisors we can't hold folks back. Princeton University provides the avenue for staff members to develop skills and advance"

More information about the Summer Transfer program is available at: https://www.princeton.edu/hr/progserv/lr/seiusumtran/.

All-hands informational meeting

Tuesday, June 20

2:30 p.m.

MBG Auditorium

All staff members are invited to an informational meeting where leadership will brief staff on the federal budget and the NSTX-U Recovery Project. We will also hear from Patricia Hoffman, Acting Under Secretary for Science and Energy, U.S. Department of Energy.

SOFE

continued from page 1

Here is a look at some PPPL presentations during the four-day conference:

ITER

The Laboratory is leading the design of seven diagnostic instruments that will provide essential data for researchers seeking to understand the behavior of ITER plasma — ultra-hot matter composed of atoms and free-floating electrons and ions — and to optimize the performance of the international tokamak. PPPL engineer Russ Feder, manager of the design of the U.S.-provided diagnostics, described the vital importance of risk management of the instruments. The project, he said, involves high technical challenges and the need for complex integration.

For example, design of the "Upper Wide Angle View Visible and Infrared Camera," the largest U.S.-supplied diagnostic, must deal with highly limited space in the upper port plugs that will house the instrument. A solution being considered will be for the cameras to share light-collecting optics with another diagnostic to be installed in the same port.

The extremely harsh ITER environment poses another key issue. "This is a critical risk category because the cameras will sit in high radiation areas and will have to be radiation hardened," said Feder, who outlined the PPPL approach to the task. Such risks bear directly on design costs and scheduling, he explained, because the challenges must be met through detailed analysis and/or prototype development.

Prior to the talk, Feder participated in a mini-course on plasma diagnostics, organized by PPPL physicists Robert Kaita and Brent Stratton. Kaita also gave a talk on the development of liquid metal technologies as alternatives to solid divertors that exhaust plasma heat and particles. The mini-course, organized for engineers and early career researchers, presented topics ranging from an overview of fusion plasma diagnostics to plasma stability and confinement diagnostics and current trends in x-ray spectroscopy for fusion plasmas.

Charles Neumeyer, Chair of the IEEE Fusion Technology Committee, presenting the Early Achievement Award to Chao Chang, from Xi'an Jiaotong University. *(Photo by Linda Neilson)*

Each diagnostic must be precisely integrated into the port plug from which it will peer into the plasma. Overseeing the integration of diagnostics into the opening called "Diagnostic Upper Port 14" is PPPL engineer Yuhu Zhai, who detailed the progress of the effort in an overview talk.

This upper port will house four separate diagnostics to view the plasma during ITER operations. The instruments will be set behind shield modules and a first wall that will protect them from 150-million degree heat, high neutron blasts and intense radiation. The devices will deliver wide-angle viewing, inject cryogenic pellets to mitigate disruptions, control hydrogen outgassing from plasma-facing components, and define the boundary of the plasma.

Zhai outlined the steps he has taken to integrate the instruments. Included was a detailed analysis of factors such as neutron shielding, structural integrity and the weight of the diagnostics. Also examined were various disruption management configurations and the ability of the port to withstand the impact of sudden shakeups called "vertical displacement events" of the plasma. Such events can strike port plug walls plug with heavy electromagnetic loads that could cause damage.

PPPL'ers at the conference, from left: Luis Delgado-Aparicio, Soha Aslam, Pamela Serai, Tom Brown, and conference chair Hutch Neilson. *(Photo by Mary Brown)*

Zhai, who chaired an afternoon session focused on the topic of "Magnet," also gave several other poster presentations as the ITER analysis team leader.

Also planned for ITER are a pair of diagnostics that will measure the temperature of plasma ions with the Core Imaging X-ray Spectrometer (CIXS) and the temperature of plasma electrons with the Electron Cyclotron Emission (ECE) system. In a poster, PPPL engineer Feng Cai described the Laboratory's extensive testing of CIXS and ECE electronics. In ITER, both diagnostics will have to operate in high magnetic fields. Cai outlined the magnetic field testing process, including the mechanical setups and instrumentation that the Laboratory utilized. He also described the safety aspects of the project and the procedures employed. "The tests for CIXS and ECE components were successfully completed," Cai reported, "and the results are provided for ITER applications."

Wendelstein 7-X (W7-X)

This fusion facility is the world's largest and most complex stellarator, which confines plasma in twisty magnetic fields, as compared with the symmetrical fields that tokamaks use. The W7-X began running in 2015 and will investigate the suitability of the twisty design to serve as a power plant when the stellarator becomes fully operational in 2019. Under consideration is the fact that the stellarator's divertors, which will exhaust particles and energy when the fusion device operates in a steady state for up to 30 minutes, could be struck by more heat than they can withstand.

To test that possibility, PPPL, Oak Ridge National Laboratory and the Max Planck Institute of Plasma Physics in Germany have collaborated on an experimental component called a "Test Divertor Unit (TDU) scraper element," which will check for scenarios that could damage the divertors. The plasma-facing scraper, described in a poster by PPPL engineer Doug Loesser, is designed to protect vulnerable regions around the target area of the divertors. Loesser also organized a Women in Engineering reception at the conference, featuring Jing Dong from China's Institute of Automation, and providing a forum for participants to discuss career issues that women engineers face.

continued on page 5

continued from page 4

Robert Kaita, who organized a mini-course on diagnostics, and Kathleen Lukazik, the registration chair and one of the main PPPL organizers. *(Photo by Hutch Neilson)*

The TDU that Loesser worked on is to be installed later in 2017 and will be used to determine whether it will be necessary to intercept some of the hot plasma before it can reach the divertors. If so, a water-cooled component called a "high heat flux scraper element" could be added to the stellarator to protect the divertors when W7-X moves to full steady-state operation.

The TDU is the latest PPPL component for the Wendelstein stellarator. The Laboratory previously designed and delivered a system of trim coils that fine-tuned the magnetic fields and made their measurement possible, and an x-ray imaging crystal spectrometer (XICS) that measures the plasma temperature.

Korea Superconducting Tokamak Advanced Research (KSTAR)

PPPL engineer Robert Ellis presented an invited talk on the two-channel electron cyclotron heating (ECH) launcher that he is designing for this South Korean facility. The design builds upon previous launchers that Ellis has engineered for KSTAR and will provide two megawatts of ECH power to increase the heat of the plasma and drive electric current to enable steady state — or long pulse — KSTAR operation.

The new system, which must withstand heavy electromagnetic forces and heat loads, features a pair of 3-D-printed steel, copper and water-cooled mirrors that can be steered to deposit heat in different parts of the plasma. "The greatest design challenge is to create a reliable durable steering mechanism with robust steady state cooling" for the mirrors, Ellis said.

His talk summarized the evolution of the system from the original KSTAR ECH launchers, which Ellis had provided for KSTAR. A prototype based on the new design has already been built and is to be tested, he added, and will be delivered to KSTAR later this year. Steps still to be taken include preparation of a final design, and manufacturing, installation and operation of the new two-channel launcher.

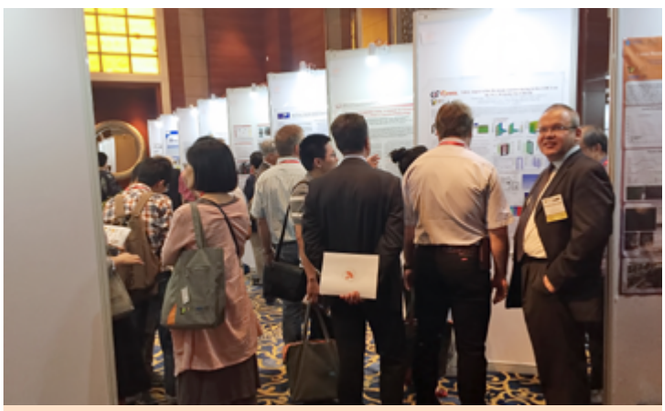
The IT team at work. From left, Chunchun Li, Rong Yan, both from the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP), Pamela Serai, the publications assistant. *(Photo by Hutch Neilson)*

China Fusion Engineering Test Reactor

PPPL engineer Andrei Khodak gave an invited talk on a key issue facing plans for a next-generation Chinese tokamak. The facility, called a Chinese Fusion Engineering Test Reactor, will breed tritium, which will react with deuterium to produce powerful fusion reactions.

Khodak discussed simulation of a type of plasma-facing wall cover, or blanket, in which the breeding will take place inside the tokamak. Embedded in the blanket will be millions of granules of pure beryllium that will multiply the neutrons from fusion reactions, creating more particles to strike alloyed beryllium granules in the blanket and intensify tritium production.

Khodak modeled what could happen if a cooling water pipe broke inside the blanket, producing steam that reacted with the pure beryllium in exothermic, or explosive heat releasing, fashion. The detailed analysis, performed with a 3-D code in collaboration with the Institute of Plasma Physics Chinese Academy of Science, replaced both the pure beryllium multiplier granules and the beryllium alloy breeder granules with porous material to reduce the size of the model, which still had tens of millions of programming elements due to the geometric complexities of the blanket. The simulation indicated the production of beryllium oxide that occurs when steam reacts with pure beryllium, and past experimental data validated the model.



Andrei Khodak at a poster session. *(Photo by Hutch Neilson)*

Linear pellet feeder for the DIII-D National Fusion Facility

PPPL engineer Alex Nagy and physicist Alessandro Bortolon, working with technicians at General Atomics, have designed an upgrade for a DIII-D device that reduces and mitigates edge localized modes (ELMs) — instabilities that can damage plasma-facing components inside tokamaks. Nagy, who heads PPPL engineering on DIII-D, which General Atomics operates for the DOE in San Diego, outlined the series of prototypes and tests that were used to create the improvement.

As Nagy explained, the upgrade will add a linear pellet feeder to the Impurity Granular Injector, a PPPL-developed device that injects pellets of lithium or other materials to pace and mitigate the occurrence of ELMs at the edge of DIII-D plasmas. The feeder, to be installed on DIII-D later this year, will inject granules one at a time to enable smaller and less detrimental ELMs to be triggered on demand. The current device adds pellets in an uncontrolled manner, allowing a number to drop into the plasma at the same time. This sequence can be highly irregular, limiting the ability of the device to control ELMs.

continued on page 6

continued from page 5

Nagy described details of the feeder and several versions of the design, explaining the construction of the prototypes and how they were tested and calibrated. "The goal is a robust mechanism that can deliver single particles at a time for a variety of materials and different sizes of granules from the same injection apparatus," he said.

Novel x-ray cameras for magnetically confined plasmas

PPPL has developed a novel, first-of-a-kind camera that provides simultaneous measurement of plasma properties such as electron temperature and density and detects the prevalence of impurities that can impair plasma performance. The instrument, described in a talk by PPPL physicist Luis Delgado-Aparicio, collects soft — or relatively low energy — x-rays using state-of-the art detectors with nearly 100,000 pixels that can capture a range of energy emissions.

The camera, first tested on the Alcator C-Mod tokamak at MIT, improves resolution and image throughput, Delgado-Aparicio said. It could be widely used in tokamaks to study impurity transport, and could become an essential part of components for minimizing the accumulation of impurities in such fusion devices. A recent study showed the camera's ability to operate in magnetic fields up to 3.4 teslas, higher than that found in most magnetic resonance imaging systems, and to tolerate ITER-like high neutron fluxes. Such capabilities promise to make the instrument suitable for next-generation fusion facilities.

Plasma Instrumentation for Spaceflight Missions

In an invited talk, Scott Weidner, Princeton University assistant vice president for engineering at PPPL, discussed a wide range of science instruments for studying space plasma and planetary conditions. For example, NASA's Solar Probe Plus Mission, which launches in 2018, will fly within nine solar radii of the surface of the sun and use such instruments to explore the sun's corona — or outer atmosphere — which is the source of the solar wind. At the other extreme, plasma instrumentation on the New Horizons mission to Pluto has measured the tenuous solar wind and discovered unique and unexpected interactions with Pluto.

Closer to home, plasma instruments on the Magnetospheric Multiscale Mission are making rapid measurements of the space environment at an unprecedented rate. That four spacecraft venture, which is orbiting Earth in tight formation, studies magnetic reconnection, the convergence and high-energy separation of magnetic fields that can set off space storms and other violent processes throughout the universe.

Still other plasma instruments are on the Juno Mission, which is orbiting Jupiter to study a range of conditions. "A wide variety of techniques and sensor technologies are employed to make the [Jupiter] measurements," Weidner said, "sometimes requiring special shielding and coincidence techniques to reduce background from the harsh space environment," which can be more extreme than anything encountered in nature on Earth.

Information sessions on changes to PPPL's Performance Management system

PPPL will hold information sessions to discuss changes to PPPL's Performance Management system on the following dates in the MBG Auditorium:

Monday, June 19, 1–2 p.m.

Thursday, June 29, 11 a.m.–12 p.m.

An Open Letter to PPPL from John DeLooper

Folks,

After 29 years of service to Princeton University and the Princeton Plasma Physics Laboratory, I am retiring. It has been my privilege and honor to work for the University at a Department of Energy National Science Laboratory. I will miss the wonderful individuals who make up the Laboratory community and the fusion mission (changing the world is a pretty impressive goal).

I have been very fortunate to serve four wonderful directors at PPPL: Harold Furth, Ron Davidson, Rob Goldston, and Stewart Prager. They along with Stew Smith gave me opportunities that I would not have imagined at the start of my career at Princeton.

However, my success at the Laboratory has always been based on the staff helping me get the work done. When I asked for help for the "tiger team review" or an open house or science bowl or dedications or a VIP visit, University personnel, laboratory staff, as well as family and collaborators always responded. For that I am ever grateful and thank each and every one that has helped!

I came to PPPL from an architect-engineering firm designing power plants (fission and fossil) because I wanted to make an energy source that would be beneficial to my children. Although our staff and others around the world have made a great deal of progress, this noble goal remains unfulfilled.

I encouraged each of you to work together to make fusion a reality now for my grand children (who will get much more of my attention now).

I wish nothing but the best for the University and the Laboratory.

Thanks!

John DeLooper

Reminder: Central campus parking option available for PPPL staff

Do you have business or meetings on Princeton University's central campus? PPPL staff now have use of a limited number of "Official Business Cards" (OBC) that allow two-hour parking in many campus locations. The locations are:

- Numbered Lots (except restricted lots 8, 9, & 18)
- Front of Dillon Gym
- Brown Hall OBC spaces
- Rear of Edwards Hall
- Visitor spaces behind Baker Rink, Lot 12 (close to MacMillan)

The parking cards can be checked out from Carol Ann Austin in the Director's Office. So don't leave for campus without it!

Summer Solstice Ice Cream Social

Wednesday, June 21
12:30 p.m.
LSB Lobby

Take a break in your work week on Wednesday and come socialize with your colleagues at the Summer Solstice Ice Cream Social! Lab leaders and managers will scoop ice cream as PPPL celebrates the summer solstice and the beginning of summer!

A worker unloads containers of ice cream for this week's Summer Solstice Ice Cream Social. *(Photo by Carol Ann Austin)*

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 June 19	Tuesday June 20	Wednesday June 21	Thursday June 22	Friday June 23
COMMAND PERFORMANCE **Chef's Feature**	**Honey-Barbecue Ribs** with Potato Salad and Baked Beans	**Tricolor Tortellini Alfredo** with Chicken served with Garlic Bread	**Caprese Chicken** with Orzo Pilaf	**Taco Meatloaf** with Rice and Beans	**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	**Smoked Ham and Gouda Melt** with Apple-Caramelized Onion	**Baja Fried Flounder Hero** with Crunchy Slaw and Pico de Gallo	**Pastrami and Swiss on Marble Rye**	**Chipotle Roast Beef Melt** on Focaccia	**Breaded Chicken Cutlet** with Ham, Swiss Cheese, Lettuce & Honey Mustard 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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Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://w3.pppl.gov/communications/weekly/.