PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
October 9, 2017

THIS WEEK

WEDNESDAY, OCT. 11

Council Café Lunch
12 p.m. ◆ Cafeteria
Amitava Bhattacharjee,
Head of Theory Department

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Overview of the Basic Plasma Science Facility
Troy Carter, University of California - Los Angeles

UPCOMING

WEDNESDAY, OCT. 18

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Properties and Degradation of Polyimide in Extreme Hygrothermal Environments
Alan Zehnder,
Cornell University

THURSDAY, OCT. 19

Open Forum with Dave McComas
2 p.m.
See page 5 for details.

OCT. 23–27

59th Annual Meeting of the APS Division of Plasma Physics
Milwaukee, Wisconsin

INSIDE

New designs for NSTX-U magnets among recommendations of Extent of Condition report

By Jeanne Jackson DeVoe

PPPL is moving ahead with design of the National Spherical Torus Experiment-Upgrade (NSTX-U) Recovery Project after submitting a required 384-page corrective action report to the U.S. Department of Energy (DOE) on Sept. 30.

The report was one of two reports, along with an Extent of Cause report, required by the DOE. It outlines how the Laboratory will address numerous issues with the National Spherical Torus Experiment-Upgrade (NSTX-U) identified in a series of external reviews that scrutinized each system of the machine. These included 12 Design, Verification, and Validation Reviews (DVVRs), and two Extent of Condition reviews, all aimed at identifying issues with the device that are critical to the start-up and operations of NSTX-U. These issues will be addressed with new designs, which were reviewed at a conceptual design review in early August. The cost and schedule for implementing these changes was addressed at a cost and schedule review in early September.

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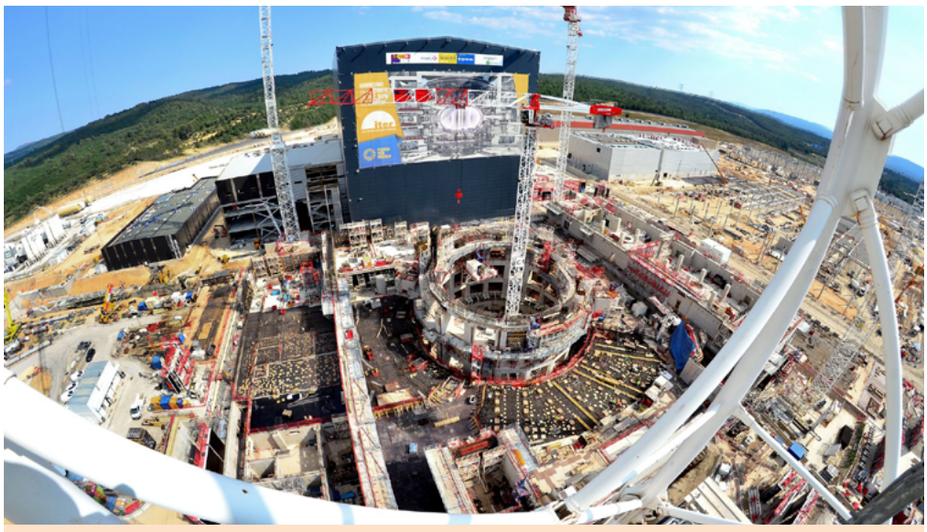
Research led by PPPL provides reassurance that heat flux will be manageable in ITER

By John Greenwald



Fish-eye view of ITER construction with tokamak site in center.
(Photo courtesy of © ITER Organization, http://www.iter.org/)

A major issue facing ITER, the international tokamak under construction in France that will be the first magnetic fusion device to produce net energy, is whether the crucial divertor plates that will exhaust waste heat from the device can withstand the high heat flux, or load, that will strike them. Alarming projections extrapolated from existing tokamaks suggest that the heat flux could be so narrow and concentrated as to damage the tungsten divertor plates in the seven-story, 23,000 ton tokamak and require frequent and costly repairs. This flux could be comparable to the heat load experienced by spacecraft re-entering Earth's atmosphere.

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Extent of Condition

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The Extent of Cause report outlines proposed changes in PPPL's policies, procedures, work processes, and organization in work planning, quality assurance and other areas.

Rich Hawryluk, interim director, announced Friday that both plans will be discussed at an all-hands meeting on Wednesday, Oct. 11 from 11 a.m. to noon in the MBG Auditorium. He added that the Recovery Project plans will be subject to further DOE reviews and decisions in the months ahead and "the Laboratory will keep everyone informed as these important events take place."

"This report represents a major step forward for the Recovery Project and the entire Laboratory and represents a great deal of hard work by the NSTX-U Recovery Team over the past year," Hawryluk said. "I am very grateful to them for getting us to this point."

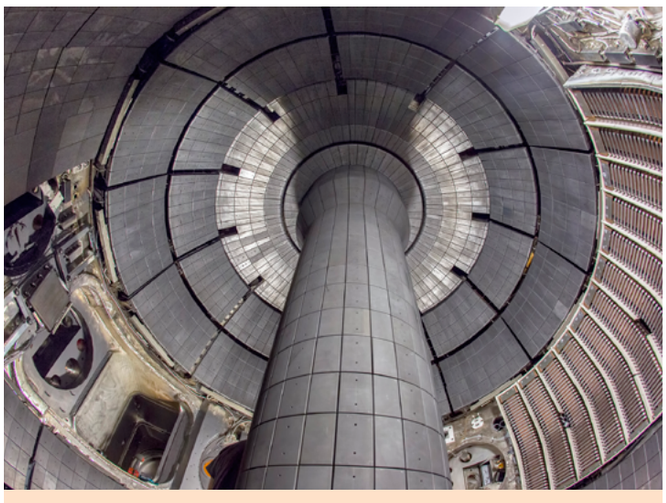
Completion of the report provides the technical basis to move ahead with designs and production of new components that will change some major features of the NSTX-U, said Stefan Gerhardt, deputy director of the Recovery Project. "It shows that the Lab and the NSTX-U team have really done their homework in addressing the issues with the facility and recommending a path forward," Gerhardt said. "It kind of clears the deck by addressing what the issues are."

One of the major changes outlined in the report is a new design for six magnets, called inner poloidal field coils. The failure of one of the magnets, the PF-1A upper coil, caused the shutdown of the NSTX-U last summer. The magnet, along with its twin, the PF-1A lower, and two additional pairs of coils, the PF-1Bs and the PF-1Cs, were similarly manufactured and are being replaced.

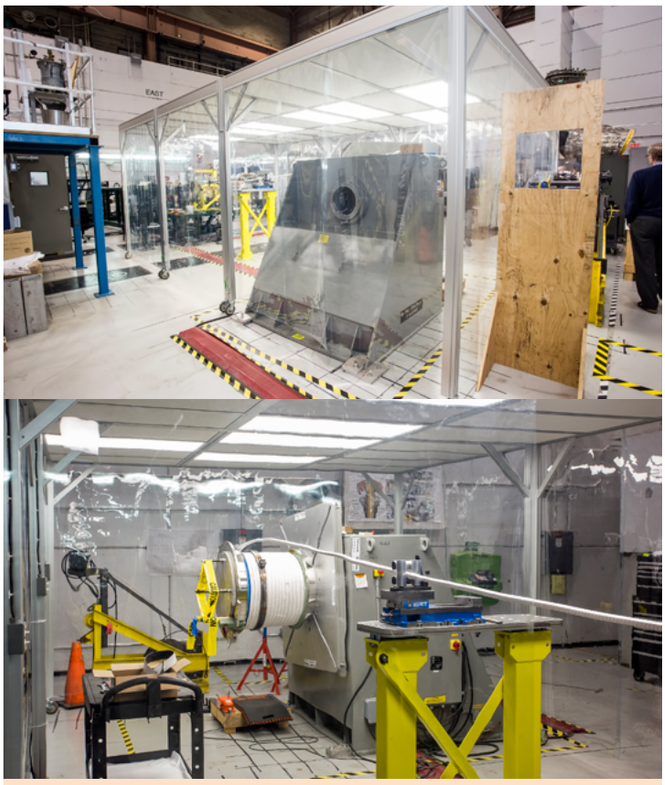
The coils will be designed without a mandrel, a metal spool at the center of the coil. Eliminating the mandrel will make it easier for engineers to do turn-to-turn electrical tests during and after fabrication. The new designs will be simpler to build and more reliable because they will not have features in the previous coils such as abrupt layer to layer transitions called "joggles" and in-line braze joints.

The first step will be to produce prototype coils, one of which will be produced at PPPL and the others at external manufacturers. The prototype coils will be manufactured identically to the actual production coils with the same controls in place.

After PPPL receives the prototype coils, engineers will subject them to extensive electrical tests, and will then cut them into sections to inspect them to determine if they were manufactured successfully. Both the outside vendors and PPPL will have to successfully pass those tests, proving they can produce successful coils before being permitted to manufacture the production coils. The production coils will also be subject to full-power electrical tests on a test stand the Laboratory has set up for this purpose.



The inside of the NSTX-U before the center stack was removed. *(Photo by Elle Starkman)*



PPPL has set up a clean room around the coil-winding apparatus on C Site. The clean room is required of all facilities producing coils for PPPL. *(Photos by Elle Starkman)*

PPPL has built a coil winding facility at C Site with a strictly-regulated clean room. Before producing the prototype, PPPL engineers plan to produce a "straight log" bundle to test the vacuum pressure impregnation process in which the coils are injected with an epoxy inside a mold.

The coils were one of six major scope items identified in the report. The other items were:

Redesign and replace the polar region: The plan calls for the replacement of components in the upper and lower regions of the machine.. The Recovery Team decided to eliminate these elements to make the machine more reliable. Among the issues with the existing design was that the PF-1C coil could be exposed to heat from the plasma and damaged. Additionally, the PF-1B coil was thermally connected to the vacuum chamber. This adversely affected the ability to heat the vessel and graphite tiles to the temperatures necessary for a bake out. The redesign thermally isolates the PF1-B coil, protects the PF-1C coils from the hot plasma, eliminates a ceramic insulator, and replaces single O-rings with more reliable double O-rings.

Redesign and replace plasma-facing components: The configuration and materials of tiles in certain areas will be redesigned and replaced so they can withstand the intense heat and halo currents, the currents that flow outside the confined plasma during a disruption. The new designs rely on a feature known as castellations, where the tile top is "sliced" into smaller regions, thus reducing the stresses in the tile.

Design and install machine instrumentation: New sensors will be installed on the NSTX-U coils and their supports. These sensors will ensure the machine is operating as expected and will provide trending data as the machine parameters are increased during experiments.

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Extent of Condition

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Design and install shielding in the NSTX-U test cell: The Recovery Project will install shielding on several penetrations in test cell walls, and construct a concrete labyrinth on the south test cell door in preparation for eventual full power NSTX-U operations.

Design and implement bake out system improvements: The DVVRs identified a potential problem with the hot-water system used to regulate the vessel temperature during bake out. A loss of gas pressure in that system could result in the water turning into steam, potentially rupturing the pipes and creating a potential safety problem. The report recommended the system be revised to eliminate this risk as well as installing equipment to measure and control the flow of hot helium through the various manifolds.

The Recovery Project is focusing on the future. "The engineering team has a forward-looking fix-it mentality," Gerhardt said. As Charles Neumeyer, head of engineering for the Project puts it, "It's time to open a new chapter."

Past and present members of PPPL's ITER team helped contribute to ITER SSEN project

Past and present members of PPPL's ITER team helped contribute to the completion of the five-year, $34 million project to procure and ship steady state electrical network components on behalf of US ITER for the international fusion experiment's electrical system. From left: Don Howe, Procurement; John Dellas, head of electrical systems and team leader for the project; Emil Nassar, ITER & Tokamak Department; Chi Man Cheung, Procurement; Barry Jedic, Quality Assurance; Kathleen Lukazik, ITER Fabrication department administrator; Charles Neumeyer, former head of the ITER SSEN project; Arlene White, Procurement; Frank Malinowski, Quality Assurance; Pat Schurott, director of Procurement; and Adolfo Amaya, Quality Assurance. *(Photo by Elle Starkman)*

Explore Life through the Lens *with Photo Clique*

The Photo Clique's first meeting will be Tuesday, Oct. 24 at 12 p.m. in the café.

This photo club is open to all regardless of experience and imaging product preference.

Questions? Contact Elle Starkman at x2090 or estarkma@pppl.gov

ITER heat flux

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New findings of an international team led by PPPL physicist C.S. Chang paint a more positive picture. Results of the collaboration, which has spent two years simulating the heat flux, indicate that the width could be well within the capacity of the divertor plates to tolerate.

Good news for ITER

"This could be very good news for ITER," Chang said of the findings, published in August in the journal Nuclear Fusion. "This indicates that ITER can produce 10 times more power than it consumes, as planned, without damaging the divertor plates prematurely."

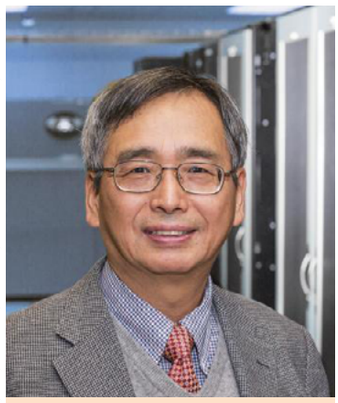
At ITER, spokesperson Laban Coblentz said the simulations were of great interest and highly relevant to the ITER project. He said ITER would be keen to see experimental benchmarking, performed for example by the Joint European Torus (JET) at the Culham Centre for Fusion Energy in the United Kingdom, to strengthen confidence in the simulation results.

Chang's team used the highly sophisticated XGC1 plasma turbulence computer simulation code developed at PPPL to create the new estimate. The simulation projected a width of 6 millimeters for the heat flux in ITER when measured in a standardized way among tokamaks, far greater than the less-than 1 millimeter width projected through use of experimental data.

Deriving projections of narrow width from experimental data were researchers at major worldwide facilities. In the United States, these tokamaks were the National Spherical Torus Experiment before its upgrade at PPPL; the Alcator C-Mod facility at MIT, which ceased operations at the end of 2016; and the DIII-D National Fusion Facility that General Atomics operates for the DOE in San Diego.

Widely different conditions

The discrepancy between the experimental projections and simulation predictions, said Chang, stems from the fact that conditions inside ITER will be too different from those in existing tokamaks for the empirical predictions to be valid. Key differences include the behavior of plasma particles within today's machines compared with the expected behavior of particles in ITER. For example, while ions contribute significantly to the heat width in the three U.S. machines, turbulent electrons will play a greater role in ITER, rendering extrapolations unreliable.



C.S. Chang
(Photo by Elle Starkman)

Chang's team used basic physics principles, rather than empirical projections based on the data from existing machines, to derive the simulated wider prediction. The team first tested whether the code could predict the heat flux width produced in experiments on the U.S. tokamaks, and found the predictions to be valid.

Researchers then used the code to project the width of the heat flux in an estimated model of ITER edge plasma. The simulation predicted the greater heat-flux width that will be sustainable within the current ITER design.

Supercomputers enabled simulation

Supercomputers made this simulation possible. Validating the code on the existing tokamaks and producing the findings took some 300 million core hours on Titan and Cori, two of the most powerful U.S. supercomputers, housed at the DOE's Oak Ridge Leadership Computing Facility and the National Energy Research Scientific Computing Center, respectively. A core hour is one processor, or core, running for one hour.

Researchers from eight U.S. and European institutions collaborated on this research. In addition to PPPL, the institutions included ITER, the Culham Centre for Fusion Energy, the Institute of Atomic and Subatomic Physics at the Technical University of Vienna, General Atomics, MIT, Oak Ridge National Laboratory and Lawrence Livermore National Laboratory.

Support for this work comes from the DOE Office of Science Offices of Fusion Energy Sciences and Office of Advanced Scientific Computing Research.

Flu Vaccine Has Arrived

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 schedule an appointment.

Thank you. ***—OMO Staff***

A new colloquium team takes the reins

A new colloquium team has begun organizing this year's colloquiums. From left: Nate Ferraro, Masa Ono, Tori Sikkema, Charles Gentile, and Carol Ann Austin. *(Photo by Elle Starkman)*

COLLOQUIUM

Overview of the Basic Plasma Science Facility

Troy Carter
University of California - Los Angeles

Wednesday, Oct. 11
4:15 p.m., M.B.G. Auditorium, Lyman Spitzer Building

Register for an Open Forum with Dave McComas

Thursday, Oct. 19 at 2 p.m.

Register for PPPL's first open forum. It is intended to be an open dialogue with staff and leadership, without managers present. Please register here. Registration is anonymous.

For more information, contact Tori Sikkema, tsikkema@pppl.gov.

Council Café Lunch

This Week:

Amitava Bhattacharjee,

Head of Theory Department

Wednesday, Oct. 11
12 p.m., PPPL Café

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 Oct. 9	Tuesday Oct. 10	Wednesday Oct. 11	Thursday Oct. 12	Friday Oct. 13
COMMAND PERFORMANCE **Chef's Feature**	**Chicken-fried Steak Melt** with Mashed Potatoes and Corn	**Four Cheese Baked Macaroni and Cheese** with Stewed Tomatoes	**Chicken Gyro** served with Greek Salad	**Pineapple Chicken** served over White Rice	**Fried Fish** with Potato Salad and Greens
Early Riser	**Banana-Walnut Pancakes**	**Greek Breakfast Wrap**	**Chicken Omelette**	**French Toast Sticks**	**2 Eggs,** Choice of Breakfast Meat & Tater Tots
Country Kettle	**Spring Vegetable**	**Chicken Noodle**	**Tuscan Bean**	**Split Pea**	**New England Clam Chowder**
Deli Special	**Liverwurst** with Onion and Stone-Ground Mustard	**The Carnegie—** Pastrami, Corned Beef, Swiss, Russsian Dressing and Cole Slaw on Rye	**Vegetable Sub** with Hummus	**Turkey** with Cheddar, Bacon and Cranberry Mayo	**Italian Chopped Antipasto Wrap**
Grill Special	**The Plasma—** Chicken, Bacon, and Swiss on French Bread	**BBQ Pork Rib Sandwich** with Cheddar and Onion Straws	**Beef Quesadilla**	**The Simple Man Burger**	**The Carbonara—** Chicken, Bacon, Mozzarella and Mushrooms with Alfredo on French Bread
Panini	**3-Cheese Panini** with Cheddar, Swiss, Blue Cheese & Tomato on Sourdough	**Spicy Pepperoni Ciabatta**	**Pretzel Melt** with Ham and Swiss	**Falafel Wrap**	**Tuna Melt English Muffin** with Fries

MENU SUBJECT TO CHANGE WITHOUT NOTICE

HEART HEALTHY

VEGETARIAN OPTION

WEEKLY

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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/.