The PPPL Highlights for the week ending December 23, 2016 are as follows:

**NSTX-U RECOVERY PROJECT (R. HAWRYLUK):**

The recovery project Responsible Engineer’s continued preparing System Design Descriptions (SDDs) this week. Significant progress on developing draft SDDs has been reported.

Several engineers made a trip to Fermi National Accelerator Laboratory to tour their coil winding facility and discuss the possibility of future support for the NSTXU Recovery Project.

Magnet fabricator Everson Tesla visited PPPL this week to discuss details of coil fabrication with representatives from PPPL.

The lift and removal of the PF1aL coil from the centerstack casing was completed this week. The microtherm was removed from the central solenoid enabling access to the coil.

The Field Coil Power Conversion (FCPC) Test Stand is being reconfigured for power testing of PF Inner Coils, and a test procedure is out for review.

Preparations for the removal of the lower ceramic break from the vacuum vessel continue.

Recommissioning of the coil winding facility continues with vacuum leak checking of the VPI system, and the fabrication/commissioning of tensioning system and the roller assembly.

Hydrostatic testing of the first spare neutral beam (NB) ion source has identified an internal water leak which will now be addressed. A new optical alignment fixture has been set up in the NB source shop to align the accelerator grids of the next ion source in assembly. Another ion source is in the Decon Facility for disassembly and cleaning.

**NSTX-U RESEARCH (J. MENARD):**

The paper “Snowflake Divertor Experiments in the DIII-D, NSTX, and NSTX-U Tokamaks Aimed at the Development of the Divertor Power Exhaust Solution” by V. A. Soukhanovskii et. al. was published in IEEE Transactions on Plasma Science (Volume: 44, Issue: 12, December 2016, p. 3445; DOI: 10.1109/TPS.2016.2625325). The manuscript was based on material presented in an invited talk at the Symposium of Fusion Engineering 2015. The paper summarized experimental results obtained in NSTX and DIII-D: divertor heat flux reduction, radiation distribution and full power detachment in the radiative snowflake divertor, effects on
pedestal profiles and ELM energy, and significant divertor surface peak temperature reduction during ELMs. Magnetic equilibria, divertor transport and radiative divertor modeling results for NSTX-U support the snowflake divertor configuration as a leading divertor heat flux mitigation scenario for 2MA, 12 MW NBI-heated H-mode plasmas.

THEORY (A. BHATTACHARJEE):

D. Stotler attended the International Atomic Energy Agency (IAEA) Technical Meeting on “Uncertainty Assessment and Benchmark Experiments for Atomic and Molecular Data for Fusion Applications”, December 19-21 in Vienna. His invited talk, titled “Sensitivity of Tokamak Transport Modeling to Atomic Physics Data: Some Examples”, described data issues arising in the modeling of the gas puff imaging diagnostic and in the behavior of high-Z impurities in experiments.

D.E. Ruiz, E.L. Shi and I.Y. Dodin, together with J.B. Parker (LLNL), published a paper titled “Zonal-flow dynamics from a phase-space perspective” in Physics of Plasmas. The paper revises the wave kinetic equation (WKE) for drift-wave (DW) turbulence that is widely used in the studies of zonal flows (ZF) emerging from DW turbulence. The formulation of DW-ZF interactions that uses the traditional WKE neglects the exchange of enstrophy between DWs and ZFs and also ignores effects beyond the geometrical-optics limit. In the new paper, a modified theory is derived that takes both of these effects into account, while still treating DW quanta (“driftons”) as particles in phase space. The drifton dynamics is described by an equation of the Wigner-Moyal type, which is commonly known in the phase-space formulation of quantum mechanics. In the geometrical-optics limit, this formulation features additional terms missing in the traditional WKE that ensure exact conservation of the total enstrophy of the system, in addition to the total energy, which is the only conserved invariant in previous theories based on the WKE. Numerical simulations are presented to illustrate the importance of these additional terms. The proposed formulation can be considered as a phase-space representation of the second-order cumulant expansion, or CE2.

M. Churchill published a paper in the IEEE NYSDS 2016 Conference Proceedings, titled “Analyzing large data sets from XGC1 magnetic fusion simulations using Apache Spark”. Apache Spark is explored as a tool for analyzing large data sets from the magnetic fusion simulation code XGC1, which is described in detail on this link. Implementation details of Apache Spark on the NERSC Edison supercomputer are discussed, including binary file reading, and parameter setup. An unsupervised machine learning algorithm, k-means clustering, is applied to XGC1 particle distribution function data, showing that highly turbulent spatial regions do not have common coherent structures, but rather broad, ring-like structures in velocity space.

Lei Shi, a graduate student in the Program in Plasma Physics, Department of Astrophysical Sciences, Princeton University, presented his Final Public Oral Examination (FPOE) on December 21 titled “Synthetic Diagnostics Platform for Fusion Plasma and a Two-Dimensional Synthetic Electron Cyclotron Emission Imaging Code”. Lei’s advisor is W. Tang, and the FPOE committee consists of P. Efthimion (Chair), E. Valeo, and Tang. The abstract of the presentation reads “Magnetic confinement fusion is one of the most promising approaches to achieve fusion energy. With the rapid increase of the computational power over the past decades, numerical simulations have become an important tool to study the fusion plasmas. Eventually, the
Numerical models will be used to predict the performance of future devices, such as the International Thermonuclear Experiment Reactor (ITER) or DEMO. However, the reliability of these models needs to be carefully validated against experiments before the results can be trusted. The validation between simulations and measurements is hard particularly because the quantities directly available from both sides are different. While the simulations have the information of the plasma quantities calculated explicitly, the measurements are usually in forms of diagnostic signals. The traditional way of making the comparison relies on the diagnosticians to interpret the measured signals as plasma quantities. The interpretation is in general very complicated and sometimes not even unique. In contrast, given the plasma quantities from the plasma simulations, we can unambiguously calculate the generation and propagation of the diagnostic signals. These calculations are called “synthetic diagnostics”, and they enable an alternate way to compare the simulation results with the measurements. In this dissertation, we present a platform for developing and applying synthetic diagnostic codes. Three diagnostics on the platform are introduced. The reflectometry and beam emission spectroscopy diagnostics measure the electron density, and the electron cyclotron emission (ECE) diagnostic measures the electron temperature. The theoretical derivation and numerical implementation of a new, two-dimensional ECE imaging code is discussed in detail. This new code has shown the potential to address many challenging aspects of the present ECE measurements, such as runaway electron effects, and detection of the cross phase between the electron temperature and density fluctuations.”

CPPG-TRANSP (S. Kaye, S. Jardin):

The interface for a non-interactive, self-contained namelist-driven standalone program of NUBEAM ('nubeam_comp_exec') has been modified to allow Monte-Carlo RF calculation (RF kick off operator), which was implemented in TRANSP/NUBEAM few years ago, to be used in NUBEAM for ICRH heating by advancing steps through separate executions of the standalone driver "nubeam_comp_exec". The NUBEAM module (Monte Carlo package for time dependent modeling of fast ion species in an axisymmetric tokamak) in (R,Z) geometry has been extended to self consistently handle classical guiding center drift orbiting with an option for the anomalous radial diffusion.

DIRECTOR’S OFFICE (S. ZELICK):

IOI (L. Hill):

Mechanical and electrical isolations in the LSB Annex have been completed. These activities have been supported by staff knowledgeable with the LSB building systems and walk-throughs to confirm the absence of rouge sources of energy. Demolition is well underway in the Annex. Ceiling tiles, the ceiling grid and flooring systems have been removed and work is now progressing on the removal of overhead HVAC equipment. Walk-downs in the C-Site MG Building continue to support demolition in early January. Laboratory support of IOI throughout mobilization including the work week between the holidays is noteworthy.

This report is also available on the following web site:
http://www.pppl.gov/publication-type/weekly-highlights