



NSTX-U FY2018 Year End Report – Executive Summary

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Executive Summary of FY-18 NSTX-U Year-End Report

Executive Summary for FY-18 Notable Outcomes

The NSTX-U Recovery Project supported five PEMP Notable Outcomes in FY-18. The following table summarizes the PEMP outcomes as of September 11, 2018.

	NSTX-U Recovery PEMP Notable Outcome	Defined Finish By Date	Status as of August 16th, 2018
2.1	Successful completion of the Inner PF Coil FDR	3/31/2018	Completed on 3/31/2018
2.2.A	Complete mechanical and electrical testing of one Inner PF1 Prototype coil	7/15/2018	Completed 7/13/2018
2.2.B	Complete a PDR for the repair of the Passive Plate structures	7/31/2018	Completed 7/26/2018
2.2.C	Complete an FDR for the redesigned Plasma Facing Components (PFCs)	9/30/2018	On-Track. The FDR is scheduled for 9/26/2018 and the PFC design team, with support from ORNL, is confident of a positive outcome.
4.2	Successfully complete a Director's Review prior to CDE-2/3A	9/30/2018	Completed. John Post (LLNL) chaired the review Sept 5-7.

Executive Summary for Recovery Project

The Recovery Project held thirty preliminary design reviews (PDRs) and nine final design reviews (FDRs) in FY-18 in support of advancing the project in nine key areas:

1. Six redesigned Inner PF coils (PF1A,B,C-Upper, PF1A,B,C-Lower)

2. Redesigned upper and lower Polar Region structures for support of the new inner PF coils and enhanced NSTX-U vacuum performance
3. Repairs to the Passive Plate structures
4. Redesigned select Plasma Facing Components (PFCs)
5. Design and install improved Bakeout System
6. Design and install Coil and Structural Benchmark and Trending Instrumentation (Stress and Strain)
7. Improve NSTX-U Test Cell safety controls with enhanced test cell neutron shielding and improvements to the Access Control System (ACS)
8. Implement DOE Order 420.2C, "Safety of Accelerator Facilities"
9. Reassemble NSTX-U with alignment of magnets and structures that enable full experimental operating parameters

The most important engineering scope for the Recovery Project in FY-18 was the design and prototype fabrication of the replacement Inner PF Coils. A successful FDR for the redesign of the Inner PF1 coils was completed at the end of March 2018. The FDR showed that the revised Inner PF1 design provides reliable high performance coils that can be manufactured more easily than in the past. Four prototype PF1 coils were fabricated and qualified through electrical and mechanical testing. Prototype coils were built by PPPL as well as at subcontractors ETI, Tesla, and Sigma Phi. Procurement of the production Inner PF1 coils in FY-19 will be based on the prototype experience.

Important engineering advancements were also made in the redesigned Polar Region structures. The Polar Region structures align and support the three inner PF1 coils under large static and transient electromagnetic and thermal loads. Two PDRs were conducted for the Inconel 625 structures. The design and function of the Inner PF1 coils and the Polar Region are tightly integrated on requirements and interfaces. The success of the Polar Region program in FY-18 is tied into the emphasis on Systems Engineering on the Recovery Project and strong interactions between the Polar Region and Coil design teams.

Plasma Facing Component design advanced towards an end-of-September FDR. The PPPL PFCs team, with important contributions from ORNL, worked on the design, material testing, and prototype fabrication of the engineered graphite tiles. Potential scarcity of the preferred graphite material grade forced the PFC team to evaluate tile performance for multiple grades. To mitigate this risk, procurement of bulk graphite was started in FY-18 to buy up preferred graphite grades. When NSTX-U was initially assembled, the alignment of magnets and structures was not handled carefully, and there were issues with plasma performance during the ten week NSTX-U experimental campaign. The Recovery Project took several steps in FY-18 to plan for careful alignment of the magnets, structures, and PFCs to ensure high performance. Detailed accounting of the integrated stack up of component tolerances was used to size the magnets and polar region structures. A trial fit between the Center Stack Casing and the TF/OH (Toroidal Field/Ohmic Heating) bundle was performed to demonstrate there is sufficient clearance between the two to enable TF/OH alignment adjustments. At the end of FY-18, a

metrology subcontractor was brought in to precisely measure the position of the Outer PF Coils with respect to vacuum vessel upper and lower flanges.

A key Recovery Project scope area is the implementation of DOE Order 420.2C, “Safety of Accelerator Facilities” (ASO). The Recovery Project ASO Implementation Plan document was issued in FY-18 to map out how PPPL would accomplish this. NSTX-U will be the first program at PPPL and first fusion facility in the U.S. that operates under the ASO, which made FY-18 a year of discovery and organization for the Recovery Project team in this regard. The team set in motion processes to gain an approved NSTX-U Accelerator Safety Envelope (ASE) and Safety Assessment Document (SAD) and to ensure NSTX-U had a responsive Un-Reviewed Safety Issues (USI) system. DOE ASO implementation specialists were brought to PPPL to consult with the team, and a two-part Accelerator Readiness Review (ARR) plan was established to transition the NSTX-U program from the Recovery Project to Operations. A full time ASO implementation specialist was hired at the end of FY-18 to manage the overall process.

There were a series of Project Reviews, Advisory Boards, and other project assessments in FY-18 to check on project management and the integration of PPPL lab-wide management initiatives in the Recovery Project. A CD-1 style PPPL Capability and Recovery Project OPA review was held Feb 6,7, and 8 followed by a CD-0 style Mission Need review March 14-16, 2018. The Mission Need Review committee confirmed the NSTX-U science program as vital, and the OPA Capability Review recognized the performance of the Recovery Project and PPPL in transforming project culture and running a successful project.

FY-18 saw a large increase in the Recovery Project engineering and project office team. The Recovery Project scope is labor-intensive in design and assembly phases. Mechanical Engineering (ME) subcontractors were hired and other mechanical engineering labor was procured from Oak Ridge National Lab and other sources that brought the ME ranks up to nearly 50 full time employees. The size of the Project Management Office was also doubled in FY-18 to manage the project effectively and satisfy stakeholder reporting obligations.

Executive Summary for Facility and Diagnostics

- The preliminary design of the vacuum vessel and coil strain instrumentation system was completed during FY-18, and a successful preliminary design review (PDR) was held on March 22, 2018. Initiated in response to multiple design, validation, and verification review (DVVR) chits, this system used Fiber-Bragg and Fabry-Perot sensors to measure strains in critical components. This included the TF outer legs and trusses, halo current side load restraints, ohmic heating solenoid preload, TF center bundle twist, poloidal field coil slides, and PF1A/1B preload. Performance of sensors was validated in FY-18 during tests on the legacy PF1A lower coil.
- A successful PDR of the Plasma Facing Component (PFC) diagnostics was completed on January 4, 2018. This review encompassed sensors in the PFCs on the Center

Stack and the upper and lower outboard divertors. The review also covered Mirnov coils, Langmuir probes, thermocouples, halo current shunt tiles, and the Center Stack halo current Rogowski coils. Existing designs from NSTX-U will be redeployed where possible as a result of this PDR, and new designs made necessary by the new PFC configurations were discussed during the review.

Executive Summary of Research Results – FY-18 Milestones

Summary of R(18-1): Develop and benchmark reduced heat flux and thermo-mechanical models for PFC monitoring

- PFC research activities during FY-18 centered around developing new analysis tools for understanding the near- and long-term behavior of PFCs to be deployed in NSTX-U. Heat and particle flux tools were developed by Oak Ridge National Laboratory to aid in predictive capabilities for the highly shaped tiles being designed within the Recovery Project. Erosion estimates based on the steady-state, ELMy, and disruption plasmas contributed directly to the PFC System Requirements Document.
- Researchers developed probabilistic tools to assess the impact of physics uncertainties on the expected heat fluxes in the device. A conservative philosophy has, to date, been applied to the requirements for the PFCs, but this analysis indicated that the actual operation of the device is likely to have engineering margin.
- Options for PFC monitoring diagnostics were explored by NSTX-U collaborators from Oak Ridge National Laboratory and Lawrence Livermore National Laboratory that included both optical methods and embedded sensor methods. Ray tracing for several optical concepts indicated that spatial resolutions of 0.2-0.6 cm/pixel can be achieved with previously-developed periscopes. Neural network-based algorithms were also evaluated that showed it is possible to reconstruct heat flux widths from embedded thermocouples based on training data developed in this milestone.

Summary of R(18-2) Milestone: Develop simulation framework for spherical tokamak breakdown and current ramp-up

- A simulation framework was developed in FY-18 to perform predictive closed-loop simulations of the discharge ramp-up on NSTX-U. This was done to accelerate the realization of high-performance discharges when operations resume.

- The framework builds upon the TOKSYS framework maintained by General Atomics and contains the necessary description of the NSTX-U actuators and conducting structures. A control-oriented model reduction technique was used to simplify the conductor model from the EFIT description in order to increase computational speeds.
- The simulation framework has a simulink capability where the operational plasma control system (PCS) software is executed in a feed-forward or closed-loop simulation. Additionally, the PCS control algorithms are mirrored within the SIMULINK environment to enable rapid development and functional testing of new control schemes.
- The linear plasma model within TOKSYS was extended to a linear time-varying (LTV) model. This was a critical element for completing fast, time-dependent simulations when the current distribution and plasma boundary are evolving, such as during ramp-up.
- The LTV model was employed to examine the vertical growth rates and the effectiveness of the vertical controller for the ramp-up phase on NSTX-U.
- Predictive TRANSP calculations completed for this milestone identified suitable choices of models and free-parameters. These choices and models reproduced the evolution of the global equilibrium parameters for a range of different ramp-up scenarios realized in NSTX-U plasmas.
- Criteria were established to evaluate time dependent vacuum field calculations of the magnetic field evolution during the startup phase. Calculations were completed using the LRDFIT code to develop and optimize startup scenarios for the MAST-U commissioning campaign.

Summary of R(18-3) Milestone: Validate and further develop reduced transport models for electron thermal transport in ST plasmas

- Multiple transport models were tested using TRANSP and TGYRO solvers to predict electron temperature profiles over a wide database of NSTX L-mode and H-mode discharges.
- The Lehigh microtearing mode model, incorporated into the multi-mode model (MMM), was shown to successfully predict T_e profiles in high collisionality NSTX H-modes, but overpredicted transport for low collisionality discharges. Comparisons were made between the model and first-principles gyrokinetic simulations, linear and nonlinear, that identified a few shortcomings in the model scaling. Two upgrades to the model were identified that should partially address these issues. Once implemented, model profile predictions will be retested to clarify the new limits of applicability.
- The TGLF model was found to provide many reasonable NSTX T_e predictions when applied in the electrostatic limit. In particular, T_e predictions for low beta NSTX L-modes agreed well with data, specifically when using the “SAT1” saturation rule that accounts for cross-scale, ITG/TEM-ETG coupling. Similar electrostatic TGLF-SAT1 predictions in

an NSTX H-mode, unstable to ETG, were also found to be in good alignment with T_e measurements. Furthermore, the TGLF flux-gradient relationship in the H-mode was found to agree well with nonlinear gyrokinetic simulations of ETG turbulence. These results confirmed that the TGLF ETG model may be sufficient for modeling electron-scale transport in spherical tokamaks. It also hinted at the possible need for multi-scale gyrokinetic simulations to account for cross-scale coupling. (See additional discussion in the Transport & Turbulence Additional Research Highlights.) Work will continue to compare the flux-gradient relationship predicted by TGLF with nonlinear gyrokinetic for the L-mode plasma.

- Linear stability comparisons between TGLF and the GYRO/CGYRO gyrokinetic codes illustrated that TGLF can capture many of the key scalings relevant to low-beta, electrostatic modes at a low aspect ratio, consistent with the agreement in the above model profile predictions.
- Irregular flux-gradient behavior predicted by TGLF when including electromagnetic effects appropriate for high-beta H-modes made it challenging to obtain converged profile predictions, especially in TRANSP. To address these issues, a number of potential upgrades to TGLF were discussed with Gary Staebler of General Atomics. However, these upgrades will likely necessitate development of a newer version of the model which is outside the scope of FY-18 milestone activity.
- The core of a high- β_{pol} NSTX H-mode, with a large fraction of non-inductive current, has been calculated by gyrokinetic simulations to be near the kinetic ballooning mode/energetic particle mode (KBM/EPM) thresholds. Work continues to test whether the electromagnetic TGLF model with “hand-tweaked,” non-default settings can recover these thresholds and scalings. If successful, profile predictions will be attempted to determine whether KBM/EPM modes set the ultimate limit on T_e profiles in the high beta plasmas envisioned for 100% non-inductive scenarios.

Summary of R(18-4): Optimize energetic particle distribution function for improved plasma performance

- Analysis and simulations during FY-18 of NSTX-U experiments from the FY-16 run confirmed the strong dependence of Energetic Particle (EP) driven instabilities on details of the fast ion distribution function.
- A connection was established between the regime of Alfvénic instabilities (e.g. quasi-stationary vs chirping/bursting) and thermal plasma turbulence. A criterion that predicts the regime of instabilities for given background plasma parameters was developed and validated.
- Reduced EP transport models were used to develop NSTX-U scenarios with optimized NB injection parameters to reduce or suppress Alfvénic instabilities.

- Suppression/mitigation of high-frequency Global Alfvénic instabilities (GAEs) was demonstrated on NSTX-U when the second, more tangential NB sources were used. Results were confirmed through simulations with the HYM code.
- Work continued in FY-18 to extend the use of reduced EP transport models to scenarios that feature multiple types of instabilities, including Alfvénic modes and low-frequency magneto-hydrodynamic (MHD) modes such as kinks, fishbones, and sawteeth.

Executive Summary for Additional Research Highlights

Boundary Science

Summary of Research Highlights for Pedestal Structure and Control

- A velocimetry algorithm was developed in FY-18 to extract accurate velocity field measurements from several diagnostic data, e.g. gas-puff imaging and possibly beam emission spectroscopy. This approach utilized averaging techniques that annihilate the invisible part of the velocity field for the case of incompressible flow, relevant to tokamaks.
- An initial development to extend BES measurement capabilities using carbon emission was successful. This development opens new scientific opportunities for multi-field, fast two-dimensional measurements of turbulence, instabilities, and impurities for NSTX-U.
- Continuing analysis into Enhanced Pedestal (EP) H-mode, an attractive operating regime discovered in NSTX, showed that the large ion temperature gradients achieved surpass the maximum gradients predicted from neoclassical codes such as NCLASS and GTC-NEO. The present analysis supports that the increased gradients in the edge temperature are consistent with the scaling derived from the leading terms of neoclassical transport theory, but quantitative agreement between theory and measurements has yet to be established.

Summary of Research Highlights for Divertor and Scrape-off Layer

- Analysis of the divertor geometry effects in NSTX relevant to high-triangularity NSTX-U divertor configurations continued in FY-18. The standard divertor configurations with lower X-point height, higher connection length, and low poloidal separatrix angle in NSTX appeared favorable for divertor detachment; inherently high flux expansion lead to reduced peak heat flux, and plasma plugging and higher recycling lead to lower divertor temperature and higher density. Such configurations overcome unfavorable effects

created by open horizontal plate divertor configuration, and are naturally created in NSTX-U with the planned divertor coil layout.

- Divertor strike point splitting in NSTX-U in the presence of error fields was calculated with the M3D-C1 and TRIP3D codes. Splitting due to misalignments in poloidal field coils was found to be small, but splitting up to 10 cm was found to be possible for 5 mm / 5 mrad misalignment of the TF inner leg.

Summary of Research Highlights for Materials and Plasma Facing Components

- Progress was made in FY-18 on fundamental surface science studies of Li films on plasma facing components (PFCs) for improved plasma performance in tokamaks. Energetic D_2^+ incident on thin Li films was shown to readily form LiD, which lead to a lower Li sputtering yield than the sputtering yield of pure Li. Measured sputtering yields for thin LiD films agreed with previous simulations and bulk erosion measurements.
- Elemental images of graphite samples from NSTX-U were obtained with a Scanning Auger Microprobe (SAM) at sub-micron resolution. The samples showed strong microscopic variations in deposition, and correlated with 3D topographical maps of surface irregularities. The NSTX-U samples were boronized and exposed to D plasmas. Topographical maps of the samples were performed with a 3D confocal optical microscope and compared to the elemental deposition pattern. The results revealed localized deposition concentrated in areas shadowed from the ion flux.

Core Science

Summary of Research Highlights for Macroscopic Stability

The potential effects of non-axisymmetric magnetic error fields due to PF/TF coil misalignments were investigated in various scenarios using the IPEC and M3D-C1 simulations. Both simulations identified PF4&5 and TF inner legs as the dominant source of error fields that could drive considerable 2/1 resonant fields, as well as neoclassical toroidal viscous damping of rotation in H-mode scenarios. Higher tolerances were recommended for TF inner legs than the others, as an error field from the inboard side is not easily correctable by RWMEF coils located at the outboard midplane.

- Further analysis of NSTX-U error field experiments in FY-18 suggested that large TF errors can also induce catastrophic locking of 1/1 modes in sawtoothed plasmas. This is an important multi-mode error field effect that the next-step device may also have to consider, depending on scenarios.
- Three-dimensional simulations of a vertically unstable NSTX discharge were carried out using M3D-C1 in order to investigate the formation of non-axisymmetric halo currents. A

conclusion of this work is that unmitigated vertical displacement events are subject to secondary instabilities in the plasma edge that result in a fast thermal quench and localized non-axisymmetric halo currents.

- Axisymmetric M3D-C1 simulations were carried out for an NSTX-U model equilibrium with $I_p=2$ MA in order to estimate axisymmetric forces on coils during vertical displacement events. These calculations found that the maximum force on the coils is modestly reduced by the presence of a resistive wall, and is essentially independent of the drift time.
- Disruption prediction and avoidance research has expanded in several ways. The disruption event characterization and forecasting (DECAF) code produced analysis of large databases that were thousands of shot seconds, and upwards of one half million tested sample times per database for NSTX, MAST, and KSTAR for a small set of disruption characterization events. Analysis of the current quench event produced the equivalent of “disruptivity diagrams.” This analysis continues to support the relatively unappreciated conclusion that plasma disruptivity does not increase with plasma normalized beta.
- A local island power balance model to explain the density limit in tokamaks was tested in FY-18 with NSTX data and is being evaluated as a potential disruption forecaster in the DECAF code, presently showing similarities to the global Greenwald density evolution and limit.
- The DECAF code development has significantly increased capability by automatically identifying rotating MHD instabilities, their bifurcation, and their locking. Toroidal mode number is also automatically discriminated for an arbitrary number of modes that occur simultaneously. The information analyzed for these modes, along with plasma rotation profile and other plasma measurements (15 criteria presently used), produces predictive warning signals for the modes, along with a total MHD event warning signal showing initial success as a disruption forecaster.
- DECAF analysis of NSTX plasmas demonstrated that disruption forecasting analysis should start in areas of the parameter space of the larger disruptivity database that are non-intuitive, and that usual areas of disruption investigation from human processing of disruption databases, or black-box machine learning, are not targeting the correct plasma conditions. DECAF disruption event chains for relatively long and relatively slow evolution toward the current quench (which often occur) provide the understanding of the disruption event evolution in such cases.
- The study of resistive MHD activities in NSTX discharges revealed spontaneously growing but saturated modes at very low amplitudes. The precursors of these small-island activities were also identified. Resistive DCON showed that the modes are classically unstable even with stabilizing effects expected by strong curvature and pressure gradients in NSTX, although the rotation shear could stabilize the modes as predicted by M3D-C1 simulations.

- MARS-F/K simulations were carried out to investigate the poloidal structure of the plasma response to magnetic perturbations applied with the NCCs. The study aimed at identifying optimal locations where new toroidal arrays of magnetic probes could be installed to improve the measurement of quasi-stationary, non-axisymmetric magnetic fields. The study highlighted how the addition of 12 toroidal arrays of probes, equally distributed between the top and the bottom of the machine as well as between poloidal and radial sensors, would provide adequate measurements to discriminate the poloidal structure of 3D fields up to $n \leq 6$.
- Resistive M3D-C1 MHD simulations of magnetic islands driven by the proposed Non-axisymmetric Control Coil (NCC) in NSTX-U, with different normalized pressures, have shown that the internal island structure bifurcates before they overlap with neighboring islands. These internal bifurcations produce new sets of X- and O-points that result in an internal island stochastization, which is expected to locally alter the heat and particle transport across the islands prior to the onset of global stochasticity.
- Based on successful tests with the Electromagnetic Particle Injector (EPI-1) system for fast time response disruption mitigation in tokamaks, which was able to verify the critical EPI parameters of fast response time and velocity consistent with the projected values, the much upgraded EPI-2 has been designed and built with field augmenting coils with a capability of $>2T$. EPI-2 will be fully characterized during 2019.
- The collaboration with COMPASS on error field physics showed that the conventional single-mode approximation is still valid to avoid a locking from high-field-side error fields, but the effects of the residual resonant fields are still under investigation. NSTX-U and COMPASS results both indicated the multi-mode effects of the high-field-side error fields can be more significant than other source of error fields.
- The collaboration with DIII-D/KSTAR/EAST on error field physics was also successfully extended. The parametric dependences of the $n=2$ scaling on density, B_T , rotation were investigated and shown to be similar to one of the $n=1$ as expected. The $n=1$ and $n=2$ scaling could be combined accordingly, using the overlap resonant field as a threshold metric, although the relevance of power scaling for rotation and stability index must be further investigated.
- The collaboration with KSTAR on disruption prediction and avoidance produced steady evolution of both linear ideal and resistive MHD analysis for long-pulse KSTAR plasmas. A critical part of this analysis has been extensive kinetic equilibrium reconstruction analysis including motional Stark effect (MSE) data. The analysis concluded that the classical resistive Δ' does not accurately describe the experimental plasma stability. Kinetic MHD analysis of global MHD modes (resistive wall modes) using the MISK code found stability of high beta KSTAR plasmas, consistent with the experiment.

Summary of Research Highlights for Transport and Turbulence

- NSTX-U L-mode discharges have been used to validate local, nonlinear gyrokinetic simulations. Separate ion-scale and electron-scale simulations predict comparable electron thermal transport ($Q_{e,low-k} \sim Q_{e,high-k}$), whose sum is close to experiment. However, cross-scale coupling are likely to be important under these conditions ($Q_{e,low-k} \sim Q_{e,high-k}$), which would require multi-scale simulations to accurately predict. Such simulations are being considered for the NSTX-U L-mode plasmas.
- Electron-scale electron temperature gradient (ETG) simulations can predict electron heat fluxes that match experiments for two different levels of ETG drive (that depend on density gradient) in an NSTX H-mode. Synthetically generated spectra using a new analysis technique can reproduce the qualitative change of measured high-k microwave scattering fluctuations with changing density gradient and corresponding ETG drive. However, in the weak ETG-drive case, ion scale turbulence is predicted to be near marginal such that $Q_{e,low-k} \sim Q_{e,high-k}$ and cross-scale coupling effects cannot be ruled out without multi-scale simulations.
- The NSTX and NSTX-U discharges referenced above, in addition to discussion in the R18-3 Milestone summary, have been identified as potential targets for future multi-scale simulations to investigate cross-scale coupling. Such multi-scale simulations would complement recent simulations at conventional aspect ratio (e.g. Alcator C-Mod, ITER) and would contribute to efforts to improve predictive modeling capabilities in all tokamaks.
- Analysis of the DIII-D FY17 NSTX-U campaign experiment “study of collisionality dependence of ion- and electron-scale turbulence in advanced inductive hybrid scenario with ST-relevant q_{95} on DIII-D” has progressed. Initial analysis found dimensionless confinement scaling of $B \square_E \sim v_{e^*}^{-0.5}$ in $q_{95}=6.5$ hybrid discharges that were similar to DIII-D H-modes. Density fluctuations at low wavenumber measured by Doppler backscattering have lower fluctuation power with decreasing collisionality consistent with improved confinement. Transport analysis found the dominant energy losses to be through the electron channel. While TGLF modeling predicts the correct change in T_i profiles with v_* , it only captures T_e changes at the lowest collisionalities and underpredicts transport at high v_* . However, cross-scale coupling was not included in the model and may be important in the low v_* cases. Global gyrokinetic GTS simulations also predict reasonable ion thermal fluxes, but significantly under predict electron fluxes, further suggesting electron-scale/cross-scale coupling may be important.
- Analysis of the DIII-D FY17 NSTX-U campaign experiment “Validating electromagnetic effects in high performance plasmas” has also progressed. Initial analysis of the QH-mode discharges indicated that the ratio of scattered powers measured by cross polarization scattering (CPS, expected to be proportional to $\sim \delta B$) and DBS ($\sim \delta n$) increased with increasing beta, as expected from theory. To analyze the QH-modes with very large impurity content (run ~ 6 weeks after boronization), the impurity transport code STRAHL was used to estimate impurity content, constrained by soft x-ray and bolometer measurements. The results were included in TRANSP analysis to produce transport and equilibrium solutions

most consistent with neutron and stored energy measurements. These will provide the basis for future gyrokinetic simulations.

- Gyrokinetic simulations have been used to analyze microtearing mode stability in high $\beta \sim 100\%$ Pegasus plasmas that complement $\beta \sim 40\%$ NSTX plasmas. The influence of ∇B drift reversal is found to be stabilizing to $k_{\theta} \rho_s \sim 1$ modes, illustrating the importance of understanding the impact of a deep magnetic well on electromagnetic drift modes.
- Analysis of impurity transport in NSTX H-modes using 3D fields for ELM pacing has moved forward in FY-18. Quasi-linear gyrokinetic simulations were used to predict theoretical turbulent carbon flux profiles resulting from a mix of unstable electrostatic ballooning modes and microtearing modes. Initial tests of centrifugal effects using the CGYRO code indicate they are not critical to include for carbon transport in these particular cases.

Summary of Research Highlights for Energetic Particles

- A correction to the scattered light signal from cold D-alpha was developed during FY-18 to reduce uncertainty in the interpretation of the FIDA signal. The correction is based on results from measurements made both in the laboratory and during plasma operation.
- Processing of experimental and simulation data as inputs to the “kick model” were streamlined by developing a multi-processor procedure. The time required to compute kick model inputs using this procedure was reduced from several hours to 5-30 min.
- Good progress was made in developing the Resonance-broadened Quasi-linear model (RBQ1D) by implementing self-consistent multi-mode simulation capabilities. An important development was the capability to describe transport induced by multiple Alfvén modes acting simultaneously on the fast ion population.
- Experimental scaling of Global Alfvén Eigenmode frequencies and toroidal mode numbers with toroidal field was found to be qualitatively consistent with that from analytic theory. HYM simulations confirmed that fast ions with high parallel velocity from the more tangential beam line in NSTX-U are effective in suppressing the GAEs, opening up a path to scenario optimization through selective neutral beam injection.
- Fully self-consistent HYM simulations revealed strong energetic particle modifications of GAE mode. Large changes in GAE mode frequency through changes in beam injection velocity and in accordance with Doppler-shifted cyclotron resonances, without accompanying changes in mode spectrum, were largely unexpected.
- Repetitive drops in neutron production observed in conjunction with sawteeth were studied using data from FIDA and the ssNPA, and they suggested fast ion redistribution and/or loss. Modeling showed that neither the Kadomtsev full, or Porcelli partial reconnection models were consistent with the observations. The more comprehensive kick model, however,

which determines the redistribution in energy, pitch, and radial location, showed agreement with observations.

Integrated Scenarios

Summary of Research Highlights for Solenoid-Free Start-up and Ramp-up

- Three dimensional MHD NIMROD simulations were carried out in FY-18 to examine whether maximum closure during transient CHI is feasible in the presence of non-axisymmetric 3-D magnetic fluctuations. The simulations were extended to numerically investigate two major effects: 1) the role of three-dimensional magnetic fluctuations on the plasmoid-mediated flux closure, and 2) the effect of the toroidal field on 3-D stability during transient CHI. Closed flux current of about 220kA and large-volume flux closure were obtained even in the presence of non-axisymmetric edge magnetic fluctuations. It was also found that the 3-D physics response was drastically different for simulations at higher toroidal field, and complete stabilization of non-axisymmetric fluctuations were achieved at higher toroidal flux. (A paper covering this is in preparation for presentation at a later date.) Further simulations will be carried out for prediction and accessibility to the regimes of maximum start-up with increased toroidal and injector fluxes in larger STs.
- The CHI systems on QUEST were operated reliably and up to 45 kA of toroidal current was generated by transient CHI.
- Initial scoping studies for a biased divertor CHI configuration for Pegasus were conducted, and the power supply requirements identified.

Summary of Research Highlights for Wave Heating and Current Drive

- Initial modeling on the impact of hydrogen (H) species on High Harmonic Fast Wave were performed for NSTX-U plasmas by the use of the full wave code AORSA. Different H concentrations from 2% to 10% with and without NBI were considered. Furthermore, two wave frequency regimes have initially been considered: 30 MHz, which corresponds to the frequency of the current HHFW heating system, and 60 MHz. These wave frequency regimes have different D & H cyclotron resonances in the plasma.
- Modeling on RF edge losses in NSTX/NSTX-U plasmas by a finite element code FW2D were performed. In particular, two aspects have been considered: the impact of the realistic vacuum vessel boundary conditions on the wave propagation in the SOL, including the evaluation of SOL losses, and the evaluation of the HHFW losses in the FW2D code. This type of numerical study shows that wave propagation in the SOL strongly depends on the boundary shape and the density in front of the antenna.
- RF studies on Large Plasma Device (LAPD) were conducted. To assess the relationship between rectified currents and rectified voltages, detailed experiments have been performed

on LAPD, where an electron current was measured flowing out of the antenna and into the limiters, consistent with RF rectification.

- A study on the effect of ICRF heating on triple-probe signals was carried out as part of an ICRF collaboration with the Experimental Advanced Superconducting Tokamak (EAST). EAST has two ICRF antennas and twelve megawatts of ICRF source power in support of high-power and long-pulse operation. A comparison between EAST and NSTX results was made. It was discovered that in both cases, probes which do not connect to the antenna but whose field lines pass just in front of it experience a negative shift in floating potential. This is consistent with RF rectification occurring in the divertors.
- Electron cyclotron (EC) and electron Bernstein waves (EBW) numerical simulations were performed on QUEST plasmas. Graduate student Ryota Yoneda from Kyushu University (Japan) worked in collaboration with Nicola Bertelli and Masa Ono on EC/EBW modelling for QUEST plasmas employing ray tracing. Numerical simulations of high energy electrons by mean of the Fokker-Planck code CQL3D coupled to the ray tracing code GENRAY were also performed and presented at the annual QUEST workshop. Finally, a grid-based start-up code was developed where plasma parameters, generated plasma currents, and resulting poloidal magnetic fields evolved from the vacuum fields.

Summary of Research Highlights for Advanced Scenarios and Control

- Research milestone R18-2: “Develop simulation framework for spherical tokamak breakdown and current ramp-up” was completed, providing a significant advance for developing and testing scenario and control solutions for realizing high-performance discharges on NSTX-U.
- A high-fidelity neutral beam neural network model, suitable for use in real-time applications, was developed in FY-18 to enable rapid evaluation of the beam heating, torque, and current drive profiles based on measured equilibrium profiles. The model is able to generalize and accurately reproduce NUBEAM calculated profiles and scalar quantities.
- Results of processor-in-the-loop simulations of the NUBEAM neural network model within the NSTX-U plasma control system demonstrated the suitability of the approach for real-time use and accelerated offline analysis.
- The rapid accrual of oxygen impurities over the course of H-mode operations during the NSTX-U commissioning campaign was correlated with vertical disruption events (VDEs) that put considerable power on the inner divertor surfaces. The results supported the thesis that inboard divertor tiles that were not sufficiently baked prior to the start of operations contained the largest source of water trapped in the graphite tiles.

- A collaboration with the Mega Amp Spherical Tokamak Upgrade (MAST-U) advanced the development of common tools for developing scenarios and control on the two complementary ST experiments. Members of the NSTX-U team are actively consulting on the development of the MAST-U commissioning procedures and a planned expansion of the real-time control system.
- Extensive tests with the Dolphin Interconnect Solutions demonstrated that this technology is a suitable reflective memory solution for expanding the computational power of the real-time plasma control system (PCS) in support of future PCS development, such as disruption prediction and avoidance.
- A physics-based multiple-input-multiple-output algorithm was developed for real-time feedback control of the snowflake divertor (SFD). Reduced models for the response of an X-point to changes in poloidal field and for the plasma response to changes in the PF coil currents are used to design a Linear-Quadratic Regulator for the SFD based upon a set of user-defined weights specifying the relative importance of the controlled variables.
- The SFD control algorithm was implemented in the NSTX-U and DIII-D Plasma Control System (PCS). The algorithm was commissioned at DIII-D in March 2018.
- A simple analytical model was derived that describes the partitioning of scrape-off layer power and particle exhaust in the SFD due to diffusive transport to multiple activated strike points (SPs). The model was validated against simulation results from the multi-fluid edge transport code UEDGE and used to analyze a database of 70 SFD-minus equilibria to determine optimal SFDs for heat flux mitigation and particle control.

Performance of FY2018 Notable Outcomes:

- **FES:** For the NSTX-U recovery project, complete final design reviews for six inner poloidal magnetic field coils (viz., PF1A-upper, PF1A-lower, PF1B-upper, PF1B-lower, PF1C-upper, and PF1C-lower) by March 31, 2018 (Objective 2.1).
 - A Final Design Review (FDR) for the Inner PF Coil Production coils was conducted on March 30, 2018 in order to satisfy milestone requirements. The FDR covered all six inner PF coils: PF1A-upper, PF1A-lower, PF1B-upper, PF1B-lower, PF1C-upper, and PF1C-lower. The design and analysis of the interfaces and coils was presented, in addition to cost, schedule, risks, and fabrication plans and strategies that included PPPL and external vendors. The review was attended by both PPPL staff and external coil subject matter experts (SMEs) and was deemed successful.
- **FES:** For the NSTX-U recovery project, build at least one prototype PF1A inner poloidal magnetic field coil. Qualify the coil by operating it at both the maximum required current and at maximum joule heating. Verify the quality of the coil's insulation system through electrical testing followed by destructive sectioning and inspection. Submit a final report documenting the results by July 15, 2018 (Objective 2.2).

- Inner PF Coil Prototype Technical Evaluation Procedure (PTEP) C/D-PTP-NSTX-CL-063 was applied to two prototype coils delivered to PPPL during FY-18. This procedure involved physical inspections, sectioning of the coil for internal inspection, low- and high-voltage testing, power testing, and turn-to-turn insulation electrical testing.

The PTEP generated the following results:

- PF-1a prototype coils from Everson Tesla, Incorporated (ETI) and PPPL were evaluated and passed basic dimensional inspections, low power electrical tests, and mechanical evaluation before and after they were sectioned. The coils also successfully passed high power tests on the Field Coil Power Conversion (FCPC) test stand. The low power electrical tests were repeated, and there was no change in the coil's electrical insulation properties.
- The ETI and PPPL prototype coils were successfully sectioned and visually examined to confirm the quality of the Vacuum Pressure Impregnation (VPI). The ETI coil displayed 2-3 continuous voids along toroidal channels near the turn corners at section ends, and the PPPL coil showed 4-6 small non-continuous voids.
- Turn-to-turn and turn-to-ground insulation of both halves of the sectioned coils was successfully tested using insulation resistance and hi-pot tests. Samples of the fully cured resin material properties were confirmed by a Differential Scanning Calorimetry (DSC) test.
- The NSTX-U Recovery project will get prototype inner PF coils from four suppliers. The technical evaluation of the remaining two prototypes will begin as soon as they are received by the coil test team. The information obtained in the technical evaluation process, along with other factors, will be considered part of the Source Selection Procedure for production coil suppliers. PPPL will continue to use the PTEP procedure on all four coil sections, with the exclusion of the high power test. A complete report will be written to cap this milestone summary once testing is finished.
- The two coils successfully passed all tests, although neither coil was entirely void-free. Since the NSTX-U Recovery project has obtained and evaluated two prototype inner PF coils, one supplied by ETI and another supplied by PPPL, it is concluded, based on test results, that the DOE Notable Outcome Objective 2.2 requirements have been met. These results are also now key elements in the vendor evaluation process.

• **FES:** For the NSTX-U recovery project, complete a preliminary design review (PDR) for the passive plates and helium bake-out line supports by July 31, 2018. (Objective 2.2)

- A PDR was conducted on July 26, 2018. The PDR scope covered a review of the the as-built condition of the passive plates, passive plate support structures, and the hot helium bake piping. The loads on these components and current finite element analysis stress were also reviewed. A design was proposed that would relieve the high stress components and minimize the motion in passive plates. An electrical strap was also proposed to reducing the variation in resistances across the passive plates. The review was deemed successful.

• **FES:** For the NSTX-U recovery project, complete a final design review (FDR) for improved and re-designed plasma facing components by September 30, 2018. (Objective 2.2)

- The full scope of tiles (WBS 1.1.1.1 thru 1.1.1.7 inclusive) will be reviewed as a Final Design Review with a scheduled date of September 26th. This work encompasses as much 1400 unique graphite tiles protecting the machine from the plasma and vice versa.
- All areas of the project were reviewed at a Preliminary Design Review (PDR) as of November 2017. In the time since, a major WAF revision was undertaken to reflect uncovered scope in the PFC WBS areas due to the large number of variants and other procurement challenges associated with the graphite industry.
- Tile designs will meet physics requirements as listed in the PFC SRD and enable high power operations when the NSTX-U Recovery Project concludes. This includes operations and physics diagnostics embedded within the PFCs.

Goal 4.0 - Contractor Leadership/ Stewardship

• **SC/FES:** The University, in concert with PPPL leadership, shall ensure that the necessary support is provided for efficient and effective management of the NSTX-U Recovery effort, such that this project will have completed a Director's Review by September 30, 2018. (Objective 4.2)

- A Director's Review and Independent Cost Evaluation was held on September 5-7, 2018 and was chaired by John Post of Lawrence Livermore National Laboratory. The first day of the review was for plenary presentations, the second day of the review consisted of parallel subcommittee sessions devoted to in-depth exploration of topics, and the third day was for report generation and debrief to the NSTX-U Recovery Team. Recommendations are being assessed and addressed in preparation for an OPA baselining review.

- The review committee was requested to address the following charge questions A, B, C:

A. Please address the draft DOE CDE-2/3A OPA baselining review charge questions 1 through 8 enumerated below:

1A. Are designs supporting the Recovery Project technically sound and likely to meet performance specifications?

1B. Are all design interfaces appropriately defined?

1C. Is the CDE-3A scope appropriate?

1D. Is the design sufficiently mature to establish the baseline and initiate CDE-3A long-lead procurement?

2. Are project risks properly identified and are appropriate mitigation strategies in place?

3A. Are the cost and schedule estimates credible and realistic to support establishment of the baseline?

3B. Do they include adequate contingency based on project risk and uncertainty analysis?

3C. Are the cost estimates traceable and appropriately integrated with the project schedule?

4A. Is the project being managed (i.e., properly organized and adequately staffed) as needed to complete final design and support the project through construction to successful completion?

4B. Is the risk management process being effectively managed?

4C. Are project assumptions (technical/cost/schedule) appropriately documented?

5A. Are environmental, safety & health aspects being properly addressed given the project's current stage of development?

5B. Are integrated safety management principles being followed?

6. Have the recommendations from previous reviews been appropriately addressed?

7. Is the project documentation (e.g., PEP, HAR) complete and ready for approval?

8. Is the project ready for CDE- 2/3a approval?

B. Please provide your assessment of whether the Recovery project scope has appropriate QA/QC oversight and staffing. Similarly, please provide your assessment of whether PPPL engineering policies and procedures adequately support the NSTX-U Recovery project.

C. The project has been asked to consider options to shorten the project duration by deferring (and/or possibly accelerating) scope required to meet the ultimate performance objectives of the facility. Please provide your assessment of the Recovery team's proposals for these options.

NSTX-U Publications

Papers Published by NSTX-U Researchers (Oct. 2017 - Sept. 2018)

1. MENARD JE, Battaglia D, Bedoya F, et al.,
[Overview of first operational and physics results from NSTX Upgrade](#)
NUCLEAR FUSION **57** 102006 (October 2017)
2. ZWEBEN SJ, Stotler DP, Scotti F, et al.,
[Two-dimensional turbulence cross-correlation functions in the edge of NSTX](#)
PHYS. PLASMAS **24** 102509 (October 2017)
Copyright 2017 American Institute of Physics. This article may be downloaded for personal use only. Any other use requires prior permission of the author and the American Institute of Physics.
3. DEN HARTOG DJ, Borchardt MT, Holly DJ, et al.,
[A pulse-burst laser system for Thomson scattering on NSTX-U](#)
JOURNAL of INSTRUMENTATION **12** C10002 (October 2017)
4. HOSEA J, et al.,
[Development of slow and fast wave heating from the C-Stellarator to NSTX](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 02005 (October 2017)
5. KIM E-H, Bertelli N, Johnson J, et al.,
[2D full-wave simulation of waves in space and tokamak plasmas](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 02005 (October 2017)
6. BERTELLI N, Gorelenkova M, Podesta M, et al.,
[Self-consistent calculation of the effects of RF injection in the HHFW heating regimes on the evolution of fast ions in toroidal plasmas](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 03004 (October 2017)
7. LEE J, Wright J, Bertelli N, et al.,
[A new quasilinear formulation for ICRF plasmas in a toroidal geometry](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,

- 22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 03028 (October 2017)
8. PERKINS R, Hosea J, Taylor G, et al.,
[ICRF-Induced Changes in Floating Potential and Ion Saturation Current in the EAST Divertor](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 03039 (October 2017)
 9. POLI, FM, Fredrickson E, Henderson MA, et al.,
[EC power management in ITER for NTM control: the path from the commissioning phase to demonstration discharges](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 03041 (October 2017)
 10. TAYLOR G, Bertelli N, Gerhardt SP, et al.,
[Time-Dependent Simulations of Fast-Wave Heated High-Non-Inductive-Fraction H-Mode Plasmas in the National Spherical Torus Experiment Upgrade](#)
EUROPEAN PHYSICAL JOURNAL Web of Conferences,
22nd Topical Conference on Radio-Frequency Power in Plasmas **157** 03052 (October 2017)
 11. KREBS I, Jardin SC, Gunter S, Lackner K, Hoelzl M, Strumberger E, Ferraro N.
[Magnetic flux pumping in 3D nonlinear magnetohydrodynamic simulations.](#)
PHYS. PLASMAS **24** 102511 (October 2017)
 12. MOYER RA, Paz-Soldan C, Nazikian R, Orlov DM, Ferraro NM, et al.
[Validation of the model for ELM suppression with 3D magnetic fields using low torque ITER baseline scenario discharges in DIII-D](#)
PHYS. PLASMAS **24** 102501 (October 2017)
 13. ONO M, Majeski R, Jaworski MA, et al.,
[Liquid lithium loop system to solve challenging technology issues for fusion power plant.](#)
NUCLEAR FUSION **57** 116056 (November 2017)
 14. PERKINS R, Hosea JC, Bertelli N, et al.,
[Edge loss of high-harmonic fast-wave heating power in NSTX: a cylindrical model.](#)
NUCLEAR FUSION **57** 116062 (2017)
 15. ILHAN ZO, Barton JE, Schuster E, et al.,
[Physics-based control-oriented modeling of the current density profile evolution in NSTX-Upgrade](#)

FUSION ENG. DESIGN **123** 564 (November 2017)

16. BEIERSDORFER P, Lepson JK, Gu MF, et al.,
[Plasma measurements of Fe XVII L-shell emission and blending with F VIII, F IX](#)
ASTROPHYSICAL JOURNAL **850** 57 (November 2017)
17. BERKERY JW, Wang ZR, Sabbagh SA, Liu YQ, Betti R, and Guazzotto L
[Application of benchmarked kinetic resistive wall mode stability codes to ITER, including additional physics](#)
PHYS. PLASMAS **24** 112511 (November 2017)
18. GAN K, Ahn J-W, Gray TK, et al.,
[ELM-free and inter-ELM divertor heat flux broadening induced by Edge Harmonic Oscillations in NSTX](#)
NUCLEAR FUSION **57** 126053 (December 2017)
19. DUARTE VN, Berk HL, Gorelenkov N, et al.,
[Theory and observation of the onset of nonlinear structures due to eigenmode destabilization by fast ions in tokamaks](#)
PHYS PLASMAS **24** 122508 (December 2017)
20. KURODA K, Raman R, Hanada K, et al.
[Current start-up using the new CHI system](#)
PLASMA AND FUSION RESEARCH **12** 1202020 (December 2017)
21. MIKKELSEN DR, Kessel CE, Poli FM, et al.,
[Survey of heating and current drive for K-DEMO.](#)
NUCLEAR FUSION **58** 036014 (January 2018).
22. SUN PJ, Li YD, Ren Y, et al.,
[Experimental identification of nonlinear coupling between \(intermediate, small\)-scale microturbulence and an MHD mode in the core of a superconducting tokamak](#)
NUCLEAR FUSION **58** 016003 (January 2018)
23. SUN PJ, Li YD, Ren Y, et al.,
[Experimental Study of the Effect of 2/1 Classical Tearing Mode on \(Intermediate, Small\)-scale Microturbulence in the Core of an EAST L Mode Plasma](#)
Plasma Phys. Control. Fusion **60** 025019 (January 2018)
24. POLI FM, Fredrickson ED, Henderson MA, et al.,
[Electron cyclotron power management for control of neoclassical tearing modes in the ITER baseline scenario](#)
NUCLEAR FUSION **58** 016007 (January 2018)

25. HAMMOND K, Raman R, Volpe, FA
[Application of Townsend avalanche theory to tokamak startup by coaxial helicity injection](#)
NUCLEAR FUSION **58** 016013 (January 2017)
26. WANG Z, Park J-K, Menard JM, et al.,
[Drift kinetic effects on the plasma response in high beta spherical tokamak experiments .](#)
NUCLEAR FUSION **58** 016015 (January 2017)
27. MYERS CE, Gerhardt SP, Eidietis NW, et al.,
[A multi-machine scaling of halo current duration and rotation](#)
NUCLEAR FUSION **58** 016050 (January 2017)
28. CROCKER NA, Kubota S, Peebles WA, et al.,
[Density perturbation mode structure of high frequency compressional and global Alfvén eigenmodes in the National Spherical Torus Experiment using a novel reflectometer analysis technique](#)
NUCLEAR FUSION **58** 016051 (January 2018)
29. POLI E, BOCK A, LOCHBRUNNER M, et al.,
[TORBEAM 2.0, a paraxial beam tracing code for electron-cyclotron beams in fusion plasmas for extended physics applications.](#)
COMPUTER PHYSICS COMMUNICATIONS 225 **36** (January 2018)
30. HAO GZ, Heidbrink WW, Liu D, et al.,
[Measurement of the passive fast-ion D-alpha emission on the NSTX-U tokamak](#)
PLASMA PHYS CONTROLLED FUSION **60** 025026 (February 2018)
31. MAINGI R, Hu JS, Sun Z, et al.,
[ELM elimination with Li powder injection in EAST discharges using the tungsten upper divertor](#)
NUCLEAR FUSION **58** 024003 (February 2018)
32. de VRIES PC, Luce TC, Bae YS, et al.,
[Multi-machine analysis of termination scenarios with comparison to simulations of controlled shutdown of ITER discharges](#)
NUCLEAR FUSION **58** 026019 (February 2018)
33. WELLER ME, Beiersdorfer P, Soukhanovskii VA, et al.
[Electron-density-sensitive Line Ratios of FeXIII–XVI from Laboratory Sources Compared to CHIANTI](#)
ApJ **854** 102 (February 2018)
34. LUNSFORD R, Sun Z, Maingi R, et al.,

- [Injected mass deposition thresholds for lithium granule instigated triggering of edge localized modes on EAST](#)
NUCLEAR FUSION **58** 036007 (March 2018)
35. BOYER MD, Battaglia DJ, Mueller D, et al.,
[Plasma boundary shape control and real-time equilibrium reconstruction on NSTX-U](#)
NUCLEAR FUSION **58** 036016 (March 2018)
36. GLASSER A, Kolemen E, Glasser AH
[A Riccati Solution for the Ideal MHD Plasma Response with Applications to Real-time Stability Control](#)
PHYS PLASMAS **25** 032507 (March 2018)
37. BATTAGLIA DJ, Boyer MD, Gerhardt S, et al.,
[Scenario Development During Commissioning Operations on the National Spherical Torus Experiment Upgrade](#)
NUCLEAR FUSION **58** 046010 (April 2018)
38. LAU C, Jaeger E, Bertelli N, et al.,
[AORSA full wave calculations of helicon waves in DIII-D and ITER.](#)
NUCLEAR FUSION **58**, 066004 (April 2018).
39. LESTZ JB, Belova EV, Gorelenkov NN
[Energetic-particle-modified global Alfvén eigenmodes](#)
PHYS. PLASMAS **25** 042508 (April 2017)
40. POLI E, Bock A, Lochbrunner, et al.,
[TORBEAM 2.0, a paraxial beam tracing code for electron-cyclotron beams in fusion plasmas for extended physics applications](#)
COMPUTER PHYSICS COMM **225** 36 (April 2018)
41. PFEFFERLE D, Ferraro N, Jardin SC et al.,
[Modeling of NSTX hot Vertical Displacement Events using M3D-C1](#)
PHYS. PLASMAS **25** 056106 (May 2018)
42. WILCOX RS, Rhodes TL, Shafer MW, Sugiyama LE, Ferraro NM, et al.
[Helical variation of density profiles and fluctuations in the tokamak pedestal with applied 3D fields and implications for confinement](#)
PHYS. PLASMAS **25** 056180 (May 2018)
43. LYONS BC, Paz-Soldan C, Meneghini O, et al.,
[Predict-first experimental analysis using automated and integrated magnetohydrodynamic modeling](#)
PHYS. PLASMAS **25** 056111 (May 2018)

44. ASHOURVAN A, Grierson B A, Battaglia D J, Haskey S R, and Stoltzfus-Dueck T, [Validation of the kinetic-turbulent-neoclassical theory for edge intrinsic rotation in DIII-D.](#) PHYS. PLASMAS **25** 056114 (May 2018)
45. LOPEZ N and Poli F
[Regarding the optimization of O1-mode ECRH and the feasibility of EBW startup on NSTX-U](#)
PLASMA PHYS. CONTROLLED FUSION **60** 065007 (June 2018)
46. HAO G, Heidbrink WW, Liu D, et al.,
[On the scattering correction of fast-ion D-alpha signal on NSTX-U](#)
REV. SCI. INST. **18** 063507 (June 2018)
47. MYRA JA, Zweben SJ, Russell DA
[Blob-hole correlation model for edge turbulence and comparison with NSTX gas puff imaging data](#)
PLASMA PHYS. CONTROLLED FUSION **60** 075015 (July 2018)
48. PETRELLA J, Zatz I, Gerhardt S, et al.,
[Forensic analysis of faulted NSTX-U inner poloidal field coil](#)
IEEE Transactions on Plasma Science **46** 2653 (July 2018)
49. FREDRICKSON, ED, Podesta M,
[Editorial: 15th IAEA Technical Meeting on Energetic Particles in Magnetically Confined Systems](#)
NUCL. FUSION **58** 080201 (August 2018)
50. DUARTE VN, Gorelenkov NN, Schneller M, et al.,
[Study of the likelihood of Alfvénic mode bifurcation in NSTX and predictions for ITER baseline scenarios](#)
NUCL. FUSION **58** 082013 (August 2018)
51. GORELENKOV NN, Duarte VN, Podesta M, et al.,
[Resonance broadening quasi-linear \(RBQ\) model for fast ion relaxation due to Alfvénic eigenmodes](#)
NUCL. FUSION **58** 082016 (August 2018)
52. FREDRICKSON ED, Belova EV, Gorelenkov NN, et al.,
[Global Alfvén eigenmode scaling and suppression: experiment and theory](#)
NUCL. FUSION **58** 082022 (August 2018)
53. PODESTA M, Fredrickson ED and Gorelenkova M

- [Destabilization of counter-propagating Alfvénic instabilities by tangential,co-current neutral beam injection](#)
NUCL. FUSION **58** 082023 (August 2018)
54. HEIDBRINK WW, Bardoczi L, Collins CS, et al.,
[The phase-space dependence of fast-ion interaction with tearing modes](#)
NUCL. FUSION **58** 082027 (August 2018)
55. LIU D, Heidbrink WW, Podesta M, et al.,
[Effect of sawtooth crashes on fast ion distribution in NSTX-U](#)
NUCL. FUSION **58** 082028 (August 2018)
56. KIM D, Podesta M, Liu D., et al.,
[Orbit modeling of fast ion redistribution induced by sawtooth instability](#)
NUCLEAR FUSION **58** 082029 (August 2018)
57. ERICKSON K, Boyer M. D., Higgins, D
[NSTX-U advances in real-time deterministic PCIe-based internode communication.](#)
FUSION ENG. DESIGN **133** 104 (August 2018)
<https://doi.org/10.1016/j.fusengdes.2018.02.055>
58. MUNARETTO S, Strait EJ, Wang Z
Conceptual design of extended magnetic probe set to improve 3D field detection in NSTX-U
REV. SCI. INST. **89** 10J108 (2018)
59. CHU P, Wolfe B, Wang Z,
Measurement of incandescent microparticle acceleration using stereoscopic imaging.
REV. SCI INST. **89** 10K101 (2018)

Papers Recently Accepted for Publication

1. REYMOND L, Diallo A , Vekselman V,
Using Laser-Induced Rydberg Spectroscopy diagnostic for direct measurements of the local electric field in the edge region of NSTX/NSTX-U: Modeling
Accepted for publication in REVIEW of SCI INST (2018)
2. YONEDA R, Hanada K, Elserafy H. et al.,
High Field Side RF Injection for Excitation of Electron Bernstein Waves.
Accepted for publication in PLASMA AND FUSION RESEARCH (The Japan Society of Plasma Science and Nuclear Fusion Research) (2018).
3. BARCHFELD R, Domier CW, Ren Y, et al.,
The High-k Poloidal Scattering System for NSTX-U
Accepted for publication in REVIEW of SCI INST (2018)
4. SOUKHANOVSII VA, Blanchard WR, Dong JK, et al.,
Supersonic gas injector for plasma fueling in the National Spherical Torus Experiment.
Accepted for publication in FUSION SCIENCE AND TECHNOLOGY (2018)
5. HASKEY S, Grierson B, Chrystal C, et al.,
Main ion and impurity edge profile evolution across the L- to H-mode transition on DIII-D
Accepted for publication in PLASMA PHYSICS AND CONTROLLED FUSION (July 2018)
6. PARK J.-K, Jeon Y, In Y, et al.
3D Field Phase Space Control in Tokamak Plasmas
Accepted for publication in NATURE PHYSICS (July 2018)

NSTX-U Presentations

Invited / Oral Talks at Scientific Conferences (Oct. 2017 - Sept. 2018)

59TH APS Division of Plasma Physics Meeting on Oct. 23-27, 2017 in Milwaukee, WI

- | | |
|-----------------------|--|
| A. Diallo (PPPL) | Energy Exchange Dynamics across L-H transitions in NSTX. (Invited) |
| E. Fredrickson (PPPL) | Suppression of Alfvénic modes through modification of the fast ion distribution. (Invited) |
| R. Goldston (PPPL) | A new scaling for divertor detachment. (Invited) |
| S.-H. Ku (PPPL) | Gyrokinetic simulation of fast L-H bifurcation dynamics in a realistic diverted tokamak edge geometry. (Invited) |

- D. Pfefferle (PPPL) The ins and outs of modeling vertical displacement events. (Invited)
- F. Poli (PPPL) Integrated tokamak modeling: when physics informs engineering and research planning. (Tutorial)
- T. Stoltzfus-Dueck (PPPL) Parasitic momentum flux in the tokamak core. (Invited)
- J. Menard (PPPL) Status and plans for NSTX-U recovery.
- L. Morton (GA) A first look at resistive MHD stability differences between NSTX and NSTX-U high beta discharges.
- G.Z. Hao (UC Irvine) Simulation of the internal kink-like mode driven by the toroidal rotation in spherical tokamak.
- J. Ruiz Ruiz (MIT) Electron-scale turbulence and transport in an NSTX H-mode plasma using a synthetic diagnostic for high-k scattering measurements.
- F. Scotti (LLNL) Divertor-localized fluctuations in NSTX-U L-mode discharges.
- F. Bedoya (U. Illinois) Characterization of boronized graphite in NSTX-U and its effect on plasma performance.
- C. Skinner (PPPL) Elemental and topographical imaging of microscopic variations in deposition on NSTX-U and DIII-D samples.
- D. Mueller (PPPL) Improvement of vertical stabilization on KSTAR.

RF workshop on. October 3-4, 2017, in Los Angeles CA

- N. Bertelli (PPPL) Understanding the interaction between RF wave fields and fast-ion populations in NSTX plasmas.

Workshop on High-Fidelity Boundary Plasma Simulations on Leadership Class Computers on Oct. 3-4, 2017 in Princeton, NJ

- R. Maingi (PPPL) Cutting edge boundary simulation calculations and validation opportunities for ITER and NSTX-U.

22nd MHD Stability and Control Workshop on Oct. 30-Nov. 1, 2017 in Madison WI

- S. Sabbagh (Columbia U) Progress on disruption event characterization and forecasting in tokamaks (DECAF).
- M. Boyer (PPPL) Feedback control of stored energy and rotation on DIII-D using variable beam voltage and perveance.
- D. Kim (PPPL) Sawtooth period control experiments. (Invited)

FESAC Advisory Board Meeting on Feb. 1, 2018 in Gaithersburg, MD

- R. Maingi (PPPL) Transformative Enabling Capabilities for Efficient Advance Toward Fusion Energy.

6th RIAM Workshop Kyushu University, Kasuga, Japan, 1-2 February 2018

- N. Bertelli (PPPL) Initial Fokker-Planck simulations by using the CQL3D code for QUEST plasmas.
- L. Delgado-Aparicio (PPPL) Multi-energy SXR imaging and its applications to QUEST plasmas.
- M. Ono (PPPL) NSTX-U Plasma Start-up Research Program and Collaboration Strategy.

The KSTAR Conference 2018, Muju, South Korea, Feb. 21-23, 2018.

- N. Bertelli (PPPL) Research plan in support of the helicon wave modeling in KSTAR.
- E.-H. Kim (PPPL) Full-wave simulations of high harmonic fast wave in the scrape-off layer of NSTX.
- D. Mueller (PPPL) Improvement of vertical stabilization on KSTAR.
- K. Erickson (PPPL) PPPL Real-time Advances Applicable to KSTAR.
- D. Boyer (PPPL) Real-time forecasting and feedback control algorithm design enabled by TRANSP.

US-Japan MHD Workshop: Toward development of integrated studies of 3D magnetic field effects in fusion devices” and “31st ITPA MHD Disruption and Control Topical Group on March 5-9, 2018 in Naka, Japan

- S. Jardin (PPPL) Progress on disruption modeling
- J.-K. Park (PPPL) Summary for low-n and low-torque error field correction criteria.

Royal Society Meeting on March 26-27, 2018 in London UK

- J. Menard (PPPL) Compact steady-state tokamak performance dependence on magnet and core physics limits.

National Academy of Science (NAS) Committee on a Strategic Plan for U.S. Burning Plasma Research on April 11-13, 2018 in Princeton NJ

- J. Menard (PPPL) Options and Strategies towards Fusion Net-Electricity.
- S. Gerhardt (PPPL) NSTX-U: An Essential Science Facility for US Fusion Innovation.
- M. Jaworski (PPPL) First-wall, plasma-material interaction, and liquid metals, for fusion.

12th West Lake International Symposium on Plasma Simulation, Hangzhou (China) May 3-5, 2018

- E. V. Belova (PPPL) Numerical simulations of GAE stabilization in NSTX-U

5th IAEA DEMO Workshop on May 7-10, 2018 in Daejeon, South Korea

- P. Titus (PPPL) Structural issues for large fusion magnets.

U.S. Transport Task Force Meeting on May 8-11, 2018 in San Diego CA

- F. Poli (PPPL) Optimization of ramp-up current evolution for improved access sustainment of stable steady.
- J. Ruiz Ruiz (MIT) Two synthetic diagnostics for quantitative comparisons between gyrokinetic simulation and experimental spectra of electron scale turbulence in NSTX plasmas.
- N. Gorelenkov (PPPL) A Quasi-linear modeling of fast ion relaxation due to Alfvénic instabilities.
- T. Stoltzfus-Dueck (PPPL) Towards Quantitative First-Principles Models for Intrinsic Rotation in Axisymmetric Devices (Invited, Plenary)

9th US-PRC Magnetic Fusion Collaboration Workshop on June 5-7, 2018 in Xi'an, China

- R. Maingi (PPPL) Recent Progress on NSTX-U and Future Collaboration Opportunities.
- R. Maingi(PPPL) Results from the US-PRC collaboration on PMI in EAST.

23rd International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI-23) on June 18-22, 2018 in Princeton NJ

- B. Koel (Princeton Univ.) Chemistry at the edge: surface science probes of plasma-materials interactions. (Tutorial)
- R. Goldston (PPPL) SOL physics and heat dissipation (Tutorial)
- R. Majeski (PPPL) The effect of lithium conditioning approaches for plasma-facing surfaces on the edge and core temperature and density profiles.

45TH EPS Conference of Plasma Physics Meeting on July 2-6, 2018 in Prague, Czech Republic

- J.-K. Park (PPPL) Phase Space Visualization and Validation of 3D Field Operating Windows for ELM Suppression in KSTAR. (Invited)

6th Annual Theory and Simulation of Disruptions Workshop, Princeton Plasma Physics Laboratory, Princeton, New Jersey July 16-18, 2018

- S.A. Sabbagh (Columbia U.) Progress on Disruption Event Characterization and Forecasting (DECAF) in Tokamaks.
- J.W. Berkery (Columbia U.) Disruptivity and Density Limits in MAST and other Tokamaks.
- J.D. Riquezes (Columbia U.) Rotating MHD analysis for disruption event characterization and forecasting.

Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, Varenna (Italy) Aug. 27-31, 2018.

- T. Stoltzfus-Dueck (PPPL) Intrinsic rotation in Axisymmetric Devices. (Invited)

US-JAPAN Workshop on RF Heating Physics, Gotemba, Shizuoka (Japan) Sept. 4-7, 2018.

- N. Bertelli (PPPL) The effect of the hydrogen species on the HHFW performance in NSTX/NSTX-U plasmas.
- E.-H. Kim (PPPL) High harmonic fast wave propagation in the scrape-off layer of NSTX and NSTX-U.
- M. Ono (PPPL) Modeling of 2nd Harmonic Electron Cyclotron Heating and Current Drive Solenoid-free Start-up Experiment in QUEST.

4th European Microwave Conference, Nuremberg (Germany) Oct. 8-13, 2017

- N.C. Luhmann, Jr.
(UC Davis) Advances in Fabrication Technologies for Sub-Millimeter Wave and THz Applications at UC Davis.

Seminars and Colloquia by NSTX-U Researchers

1. L. Delgado-Aparicio “Current trends in x-ray spectroscopy for fusion plasmas: Possible applications for QUEST (Kyushu U.) and JT60SA (QST)”, Tokyo Japan, January 2018
2. S. Kaye “Containing a star on earth: the promise of fusion energy”, Princeton NJ, January 2018
3. R. Perkins “Mitigating edge losses of high-harmonic fast-wave heating power on the National Spherical Torus Experiment”, Irvine CA, March 2018
4. Y. Ren “Overview of high-k scattering diagnostics on NSTX and NSTX-U”, ASIPP, China April 2018
5. E.-W. Kim “Recent research on wave modeling for tokamak and space plasmas”, Dartmouth College, April 2018
6. M. Ono “NSTX-U Initial Operations and Solenoid-free Start-up Research Strategy”, Kyoto Japan, April 2018
7. E. Belova “Onset and nonlinear relaxation of coherent current carrying edge filaments during transient events in tokamaks”, Univ. Maryland, May 2018
8. M. Jaworski “Plasma Facing Components for the NSTX-U Recovery Project and Applications of Liquid Technologies to Conventional Energy Sources”, DIFFER, Netherlands, May 2018
9. N. Bertelli “Thrust 1: Production of RF WDM components, interaction with AToM/TRANSP and thrust common development”, VideoCon, June 2018
10. M. Ono “Roles and opportunities of the QUEST program for the Spherical Tokamak reactor development”, Kyushu Japan, July 2018
11. W. Guttenfelder, “Intro to turbulence & concepts” PPPL Graduate Summer School, Aug. 2018
12. W. Guttenfelder, “Flavors of magnetized plasma turbulence” PPPL Graduate Summer School, Aug. 2018
13. W. Guttenfelder, “Modeling turbulence & transport” PPPL Graduate Summer School, Aug. 2018

NSTX-U Awards and Leadership

Major Awards by NSTX-U Researchers

- C.S. Chang (PPPL) Incite Award for 300 million hours of computing time.
- N. Ferraro (PPPL) FES Early Career Award.
- S. Jardin(PPPL) NERSC 2018-2019 ALCC of 40 million hours of NERSC computers.
- D. Mueller (PPPL) Honorary Doctorate from MacMurray College.
- T. Evans (GA) 2018 APS-DPP John Dawson Award for Excellence in Plasma Physics.
- L. Delgado-Aparicio (PPPL) Chinese Academy of Sciences President's International Fellowship Initiative (PIFI).

Hosted / Organized Meetings and Workshops

NSTX-U researchers organized or co-organized the following meetings:

1. TRANSP User's Group Meetings (APS-DPP 2017)
2. Fusion Facilities Coordinating Comm. meetings (Oct. 2017)
3. US Magnetic Fusion Research Strategic Directions Workshop (Dec. 2017)
4. NSTX-U Program Advisory Committee Meetings (Jan. 2018)
5. National Academy of Sciences Meeting (April 2018)
6. Plasma Surface Interaction Meeting (June 2018)

NSTX-U Engineering organized:

1. Low Heat Flux Plasma Facing Components Preliminary Design Review (September 29, 2017)
2. Torus Vacuum Pumping System Backing Pump and Pump Cooling System Preliminary Design Review (September 29, 2017)
3. High Heat Flux Plasma Facing Components Preliminary Design Review (November 15, 2017)
4. Heat Transfer Plate and Heat Transfer Tubing Preliminary Design Review (November 30, 2017)
5. High Temperature Helium Feedthrough Preliminary Design Review (December 1, 2018)
6. Inner PF Coil Preliminary Design Review (December 14, 2017)
7. Innerspace Pumping System Preliminary Design Review (December 20, 2017)
8. Plasma Facing Components Preliminary Design Review (January 4, 2018)
9. Gas Piping Preliminary Design Review (January 11, 2018)

10. Torus Vacuum Pumping System Backing Pump and Pump Cooling System Final Design Review (January 12, 2018)
11. Ex-Vacuum Vessel Heating System Preliminary Design Review (February 1, 2018)
12. DOE/SC Assessment of NSTX-U Recovery Plans, Phase 1 (February 6-8, 2018, with DOE/OPA)
13. NSTX-U Reassembly Peer Review (February 9th, 2018)
14. CAMAC Replacement Phase 1 and 2 Preliminary Design Review (February 16, 2018)
15. Vacuum Vessel Field Scope Preliminary Design Review (February 23, 2018)
16. PF-1b Power Circuit Preliminary Design Review (February 27, 2018)
17. Bakeout DC Connection Preliminary Design Review (April 5, 2018)
18. Outer PF Inspections Preliminary Design Review (March 13, 2018)
19. DOE/SC Assessment of NSTX-U Recovery Plans, Phase 2 (March 14-16, 2018, with DOE/OPA)
20. Machine Instrumentation Preliminary Design Review (March 22, 2018)
21. NSTX-U Project Advisory Committee (March 22-23, 2018)
22. Inner PF Coil Supports Preliminary Design Review (March 27, 2018)
23. Inner PF Coil Final Design Review (March 30, 2018)
24. TF/OH Bundle Reliability Preliminary Design Review (April 3, 2018)
25. Test Cell Shielding Preliminary Design Review (April 10, 2018)
26. Glow Discharge Cleaning Anode Preliminary Design Review (April 19, 2018)
27. Prototype Inner PF Coil Power Test Final Design Review (May 9, 2018)
28. Bakeout PLC Upgrade Preliminary Design Review (May 10, 2018)
29. Gas Delivery System Expansion Tank Burst Disk Preliminary Design Review (May 29, 2018)
30. Risk Registry Workshop (June 11-12, 2018)
31. CAMAC Replacement Pilot Phase 3 Final Design Review (June 6, 2018)
32. Passive Plate & Helium Line Conceptual Design Review (June 8, 2018)
33. CAMAC Replacement Pilot Phase 1 & 2 Final Design Review (June 26, 2018)
34. Passive Plate & Helium Line Preliminary Design Review (July 26, 2018)
35. Machine Reassembly PDR (August 1, 2018)
36. Polar Region Preliminary Design Review (August 2nd, 2018)
37. Test Cell Shielding Preliminary Design Review II (August 6, 2018)
38. Test Cell Radiation Annunciation and Oxygen Deficiency Monitor Preliminary Design Review (August 14, 2018)
39. NSTX-U Project Preliminary Design Review (August 15-16, 2018)
40. NSTX-U Project Director's Review and Independent Cost Evaluation (September 5-7, 2018)

PPPL Theory organized:

1. Boundary Physics Meeting (Oct. 2017)
2. Center for Tokamak Transient Simulations Satellite Meeting (Oct. 2017)
3. Center for Tokamak Transient Simulations Satellite Meeting (April 2018)
4. Exascale Computing Project Annual Meeting (April 2018)
5. SciDAC Fusion Machine Learning Workshop (June 2018)

6. Disruption Workshop (July 2018)
7. LWS Strategic Capabilities Meeting (August 2018)
8. Exascale Computing Project Fall team meeting & Advisory board meeting (Sept. 2018)

NSTX-U PPPL Employee FY18 Leadership in Venues Outside of PPPL

1. Bertelli, N., PPPL PI of the RF SciDAC project
2. Boyer, M., Deputy Leader, USBPO Operations and Control Topical Group
3. Chang, C.S., US Chair for 2018 US-Japan Exascale Simulation of fusion plasmas
4. Delgado-Aparicio, L., Deputy Leader, USBPO Diagnostics Topical Group
5. Ferraro, N., Treasurer, Sherwood Executive Committee
6. Gerhardt, S. Leader, ITPA MDC WG-6
7. Gorelenkov, N., Leader, USBPO Energetic Particles Topical Group
8. Guttenfelder, W., Deputy Leader, U.S. BPO Transport & Confinement Topical Group
9. Guttenfelder, W., Co-Leader, Discussion Group 5, Austin MFE Strategies Workshop
10. Guttenfelder, W., Editor, US BPO eNews
11. Jaworski, M., Leader, USBPO Pedestal and Divertor Topical Group
12. Kaye, S., PI of TRANSP funding grant by DOE
13. Kaye, S., Coordinator, International H-mode Database Update Task (ITPA)
14. Kolemen, E., PSI Conference Local Organizer
15. Maingi, R., Chair, FESAC Transformative Enabling Capabilities (TEC) panel
16. Maingi, R., Chair, 23rd International Conference on Plasma Wall Interactions, Princeton, NJ, 18-22 June 2018, and member of the Program Committee
17. Menard, J., Co-chair, International Advisory Committee for China Fusion Engineering Test Reactor (CFETR)
18. Menard, J., Chair, U.S. DOE FES Fusion Facility Coordinating Committee
19. Menard, J., Co-chair, U.S. Magnetic Fusion Research Strategic Directions organization/workshops
20. Ono, M., Associate Editor, Journal of Fusion Energy
21. Park, J-K, MDC-19 Leader, ITPA MHD, Disruption and Control Topical Group
22. Park, J-K, Deputy Leader, MS Topical Science Group, NSTX-U Team
23. Poli, F., Leader, BPO Topical Group on Integrated Scenarios
24. Poli, F., Co-Leader, Discussion Group, Austin MFE Strategies Workshop
25. Poli, F., PI of ITER Task Agreement on EC modeling and application
26. Poli, F., PI of TRANSP funding grant by DOE
27. Poli, F., ITER Scientist Fellow
28. Ren, Y., Part-time Professor, Harbin Institute of Technology
29. Skinner, C., Chair, Local Organizing Committee, 23rd International Conference on Plasma Wall Interactions, Princeton, NJ, 18-22 June 2018
30. Skinner, C.H., Member ITER Scientist Fellow
31. Wang, W. X., Secretary/Treasurer, Executive Committee of Sherwood Conference
32. Wang, W.X., Institutional PI of SciDAC TDS project
33. Wang, W.X., Visiting Professor, National Institute for Fusion Science, Japan
34. Wang, Z.R., Visiting Professor, Dalian University of Technology, China

NSTX-U PPPL Employee Membership and Participation in Scientific Groups and Meetings Outside of PPPL

1. Bell, R., Expert, ITPA Diagnostics Topical Group
2. Belova, E., Editorial Board of Physics of Plasmas
3. Chang, C.S., Member, ITPA Pedestal and Edge Physics Topical Group
4. Diallo, A., Expert, ITPA Pedestal and Edge Physics Topical Group
5. Diallo, A. NSTX-U Representative for the JRT 2019 on Pedestal
6. Diallo, A. Member of the US Selection Committee for IAEA FEC 2018
7. Delgado-Aparicio, L., Member, ITPA Diagnostics Topical Group
8. Erickson, K., Member, MDSplus Developers Working Group
9. Ferraro, N., Expert, ITPA MHD Topical Group
10. Ferraro, N., Member, APS-DPP Women in Plasma Physics Committee
11. Fredrickson, E., Member, ITPA Energetic Particle Physics Topical Group
12. Gorelenkov, N., Member, ITPA Energetic Particle Physics Topical Group
13. Guttenfelder, W., Member, ITPA Transport and Confinement Topical Group
14. Guttenfelder, W., TTF Executive Committee
15. Jardin, S., Member, ITER Modeling Expert Group
16. Jardin, S., Member, ITPA MHD Topical Group
17. Kaye, S., Expert, ITPA Transport and Confinement Topical Group
18. Kaye, S., Member, U.S. Transport Task Force Steering Committee
19. Kaye, S., Member, U.S. Burning Plasma Organization Research Council
20. Kaye, S., Member, Fusion Advisory Board, UK
21. Kaye, S., Member, Culham Centre for Fusion Energy Advisory Committee
22. Kaye, S., Panel Member, National Academy of Sciences Burning Plasma Study
23. Kolemen, E., Member, ITER Plasma Control System design review committee
24. Lunsford, R., Expert, ITPA Pedestal and Edge Physics Topical Group
25. Maingi, R., Member, US DoE Fusion Energy Sciences Advisory Committee
26. Maingi, R., Member, ITPA Coordinating Committee
27. Maingi, R., Member, Executive Committee of the IEA TCP-CTP
28. Maingi, R., Member, Proto-MPEX Program Advisory Committee
29. Maingi, R., Member, Technical Program Committee of the H-mode Workshop
30. Maingi, R., Expert, ITPA Pedestal and Edge Physics Topical Group
31. Maingi, R., Expert, ITPA Divertor and SOL Topical Group
32. Maingi, R., Expert, ITPA Diagnostics Topical Group
33. Menard, J., Member, Executive Committee of IEA Implementing Agreement for Cooperation on Spherical Tori
34. Menard, J., Expert, ITPA MHD, Disruptions and Control Topical Group
35. Ono, M., U.S. Contact, US-Japan RF Workshop
36. Ono, M., International Visiting Professor, Kyushu University
37. Park, J.-K., Expert, ITPA MHD Topical Group
38. Park, J.-K., Committee Member, Workshop on MHD Stability Control
39. Park, J.-K., Lecturer, Princeton University

40. Podesta, M., Member, ITPA Energetic Particle Physics Topical Group
41. Podesta, M., Member, TTF Executive Committee
42. Podesta, M., Member of the Editorial Advisory Board of Review of Scientific Instruments
43. Poli, F., Member, US ITPA-IOS Topical Group
44. Poli, F. Member, TTF Executive committee
45. Ren, Y., Expert, ITPA Transport and Confinement Topical Group
46. Ren, Y., Member, APS-DPP Program Committee
47. Stotler, D., Member, IAEA Technical Committee on Uncertainty Assessment and Benchmark Experiments for Atomic and Molecular Data for Fusion Applications
48. Taylor, G., Expert, ITPA Diagnostics Topical Group
49. Wang, W.X., Member, Scientific Program Committee of 12th West Lake International Symposium on Plasma Simulation
50. Wang, W.X., Member, Festival de Théorie (Aix-en-Provence, France, held biannually) International Scientific Committee

NSTX-U Collaborator Institutions

Number	Institution	Country
1	College of William and Mary	USA
2	Columbia University	USA
3	CompX	USA
4	Florida International University	USA
5	General Atomics	USA
6	Idaho National Laboratory	USA
7	Johns Hopkins University	USA
8	Lawrence Livermore National Laboratory	USA
9	Lehigh University	USA
10	Lodestar Research Corporation	USA
11	Los Alamos National Laboratory	USA
12	Massachusetts Institute of Technology	USA
13	Nova Photonics, Inc	USA
14	Oak Ridge National Laboratory	USA
15	Old Dominion University	USA
16	Princeton University	USA
17	Purdue University	USA
18	Sandia National Laboratory	USA
19	Tech-X Corporation	USA

20	University of California - Davis	USA
21	University of California - Irvine	USA
22	University of California - Los Angeles	USA
23	University of California - San Diego	USA
24	University of California, Space Sciences Laboratory	USA
25	University of Colorado	USA
26	University of Illinois	USA
27	University of Maryland	USA
28	University of Rochester	USA
29	University of Tennessee	USA
30	University of Texas	USA
31	University of Washington	USA
32	University of Wisconsin	USA
33	University of Costa Rica	Costa Rica
34	Institute of Plasma Physics-Czech Republic	Czech Republic
35	Hiroshima University	Japan
36	Japan Atomic Energy Agency	Japan
37	Kyoto University	Japan
38	Kyushu University	Japan
39	NIFS National Institute for Fusion Science	Japan
40	Niigata University	Japan

41	University of Hyogo	Japan
42	University of Tokyo	Japan
43	FOM Institute DIFFER	Netherlands
44	ASIPP - Institute of Plasma Physics - Chinese Academy Of Sciences	P.R. China
45	Ioffe Physical-Technical Institute	Russia
46	TRINITI - Troitskii Institute of Innovative & Thermonuclear Research	Russia
47	KAIST - Korea Advanced Institute of Science and Technology	South Korea
48	NFRI - National Fusion Research Institute	South Korea
49	Seoul National University	South Korea
50	Ulsan Science Institute of Science & Technology	South Korea
51	Institute for Nuclear Research-National Academy of Science	Ukraine
52	Culham Centre for Fusion Energy	United Kingdom
53	Tokamak Energy	United Kingdom
54	University of York	United Kingdom