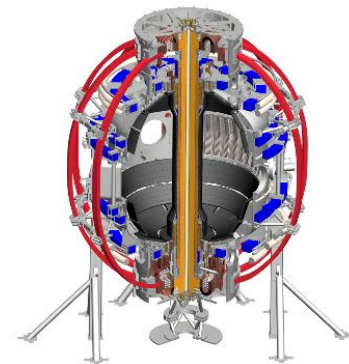# Present and Future ORNL Contributions to NSTX-U Research

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FES Quarterly Review
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Present ORNL Research on NSTX-U Focuses on Boundary and RF Physics

- boundary physics elements
  - power and particle exhaust
    - lead SOL heat flux width experiments
    - physics design of cryo-pumping system
  - H-mode pedestal physics
    - impact of lithium on recycling and edge microstability & turbulence
  - effects of 3D fields on edge the edge plasma
    - ELM control via pulsed and steady 3D perturbations
    - modification of divertor characteristics with 3D fields
- RF heating and current drive program elements
  - support HHFW design, operations, experiments & modeling
  - diagnose RF/plasma/antenna interactions, supporting experiments and modeling towards high power & reliability
  - assist in design and evaluation of ECH/EBW options

FY16 ORNL Diagnostic Activities

- responsible for NSTX-U infrared imaging diagnostics that measure heat flux to PFCs
  - wide-angle, 30 Hz IR camera for 3D structures
  - upper/lower divertor 1.6 kHz for outer strike point
- key tools to understand local HHFW/SOL interactions
  - fast (20 μs/sweep) X-mode reflectometer for n_e profile, fluc.
  - RF-compensated double probe, probes for local n_e, T_e
- developing prototype divertor IR-imaging bolometer
- contributing to analysis for other NSTX-U tools
  - AXUV diode-based P_{RAD} measurements (JHU/PPPL)
  - VUV/SXR impurity spectroscopy (LLNL)
  - tangential IR camera viewing RF antenna (PPPL)
  - centerstack & upper divertor spectroscopy (UT-K)

Complementary ORNL Modeling Expertise

- 2D and 3D fluid boundary modeling tools
  - SOLPS, EMC3-EIRENE
- edge turbulence simulation
  - GS2 and GENE gyrokinetic codes to study impact of Li on pedestal
  - exploring ways to extend to fluid turbulence modeling (BOUT++)
- 3D equilibrium and perturbed plasma response
  - VMEC (+STELLOPT code suite for transport, stability)
  - collaboration with IPEC/GPEC, M3D-C1 teams on simulating combined magnetic + transport response using EMC3-EIRENE
- using MHD codes for linear stability of pedestal (ELITE)
- tools for modeling RF physics and technology
  - AORSA, COMSOL

interest in linking multiple tools to give a "pedestal-to-wall" picture for exhaust solutions

Near-Term Research Priorities

- leading high priority, FY16 milestone experiments
  - XP 1514 "Heat Flux and SOL Width Scaling in NSTX-U" **Gray**
  - XP 1536 "Resonant ELM frequency behavior as a function of q95 with 3D fields" **Lore, Ahn**
  - XP 1557 "Interaction of applied 3D fields with detachment" **Ahn** (ITER/ITPA), XP 1558 "effects of 3D gas puffing" **Lore**
- important contributions to characterization of HHFW SOL losses in H-mode plasmas (XP 1510)
  - assisting in XPs on HHFW current drive (1566), RF/NBI interactions (XP 1533) led by PPPL
- experiments that prepare for facility enhancements
  - XP 1528 "Characterize Plasma Near Plenum Entrance" **Canik**
  - assisting with XP 1526 "high-Z reference discharge" for testing of FY17 role of high-Z tiles **Gray**

FY17+ Diagnostic Extensions

- expand IR coverage to look at inner strike point and center-stack & more (30 Hz cameras)

- extend fast IR by using multi-color optics, test spectrally resolved IR to improve heat flux on coated PFCs

- development of radiated power diagnostics for core and boundary using resistive bolometers
  - 24-ch tangential midplane (never done on NSTX)
  - re-engineering lower x-point views for divertor radiation

- investigating active/passive emission spectroscopy to enhance diagnoses of RF/plasma interactions

- exploring potential of fiber-optic temperature sensing to avoid EM interference on bolometry and tile calorimetry

Longer-Term Research Contributions

- ORNL excited to contribute and lead aspects of the exploitation of a high-Z NSTX-U
  - high-Z experience via research on DIII-D, JET and C-Mod
  - diagnostics (IR, bolo) & boundary modeling for low-Z seeding
  - RF tech. (HHFW, EBW), diag./modeling for high-Z control
  - *can ORNL help accelerate the PFC changeover and use NSTX-U as a platform for large scale materials tests?*
- continue strong emphasis on the impact of 3D fields on pedestal and boundary physics (NCC upgrade?)
- enhance integration of boundary modeling expertise with wider NSTX-U pedestal/boundary diagnostics
  - ORNL collaborators key leaders in 2D and 3D boundary modeling for NSTX, need to continue and extend for NSTX-U