NSTX-U

NSTX-U is sponsored by the
U.S. Department of Energy Office of Science
Fusion Energy Sciences

Overview of Objective 3
NSTX-U 5 year plan (2021-25)

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for the NSTX-U team

Magnetic Fusion Science Meeting
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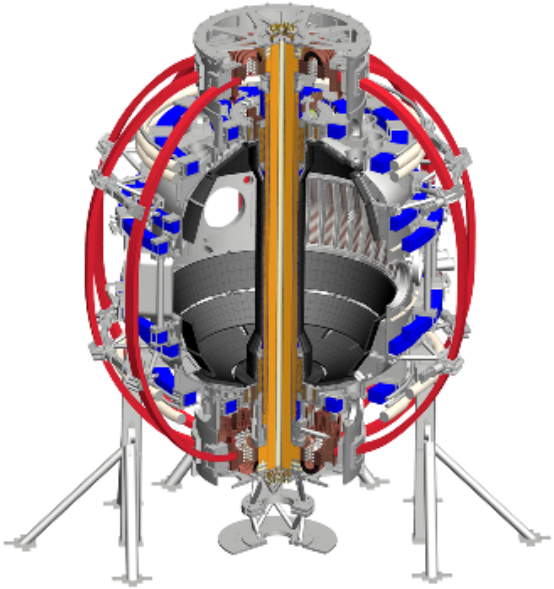


PPPL

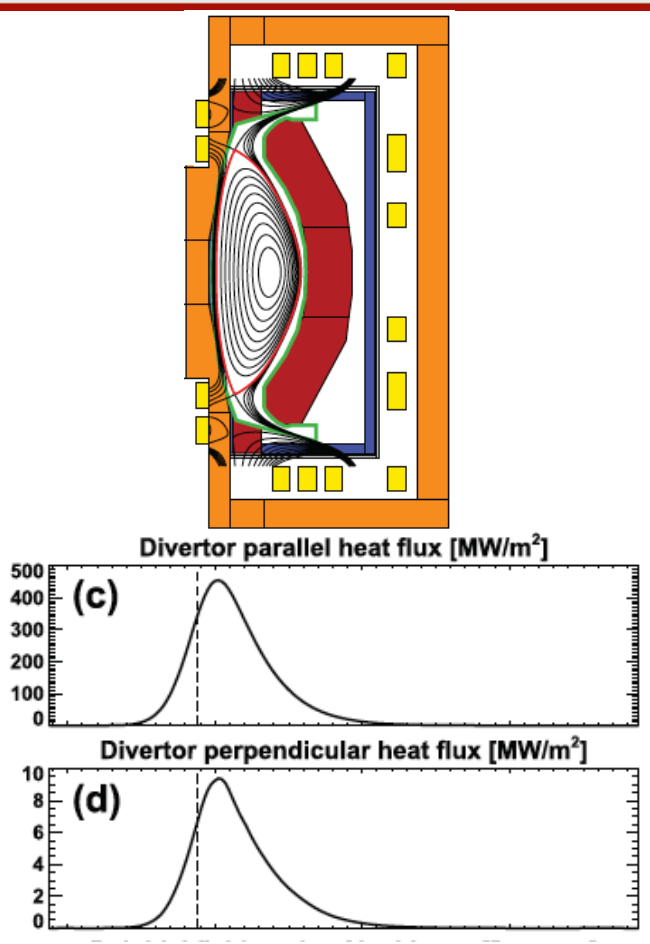
Primary deliverable and impact of Objective 3

Five-year deliverables:

- Develop power exhaust techniques for NSTX-U integrated scenarios, and evaluate their extrapolability to future devices
- Develop particle and ELM control techniques to enable NSTX-U integrated scenarios

Impact:

- Enable NSTX-U integrated scenarios while developing plasma exhaust techniques for high perpendicular heat flux for future devices
- Prepare for possible PMI focus in 2026+ plan



Objective 3 is organized into four Thrusts

1. Assess performance and lifetime of new NSTX-U plasma-facing components, and establish the physics and engineering basis to enable future PFC/divertor upgrade(s)

New

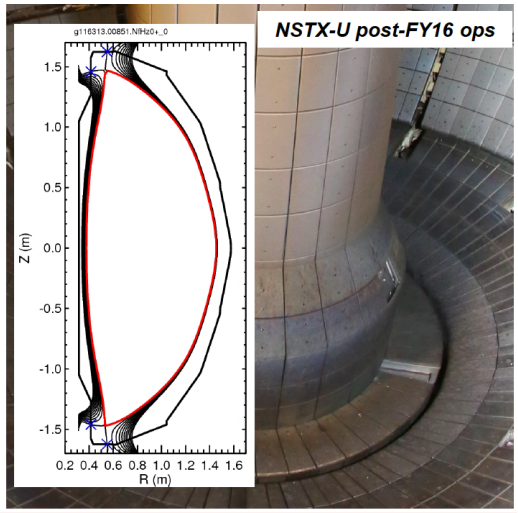
2. Develop and evaluate power exhaust techniques for mitigating high projected NSTX-U heat fluxes
3. Investigate the sustainability of particle exhaust and PMI control via lithium pumping for density and impurity control consistent with integrated scenarios
4. Develop and understand techniques to mitigate/eliminate edge transients and the associated enhancement of PMI, and combine them with an attractive core scenario

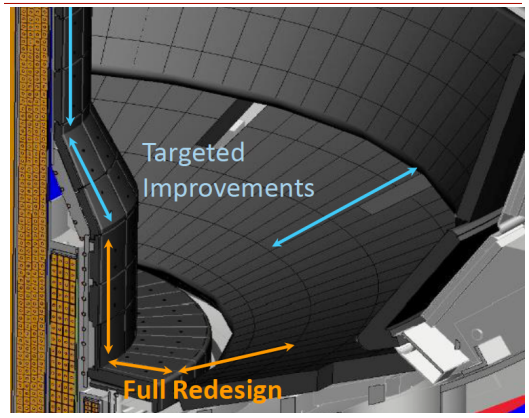
Connect to thrusts in previous 5 YP

Thrust 1: Performance of new NSTX-U PFCs

- Major deliverables:
  - Measure power exhaust and erosion characteristics of new tiles and compare with design values; measure halo currents during disruptions
  - Measure some of the assumed inputs that were used to compute the heat flux limits and incidence angle ranges
  - Assess impact of various 3-D perturbations (RMP, toroidally localized actuators, intrinsic error fields) on highly engineered tile performance

- Impact:
  - Will confirm achievement of acceptable plasma exhaust over the range of NSTX-U scenarios, enabling both integrated scenarios in Objective 2 and the range of power exhaust studies in Thrust 3-2
  - Will enable us to engineer a PFC upgrade to allow a wider range of boundary shapes and field line helicities, if desired

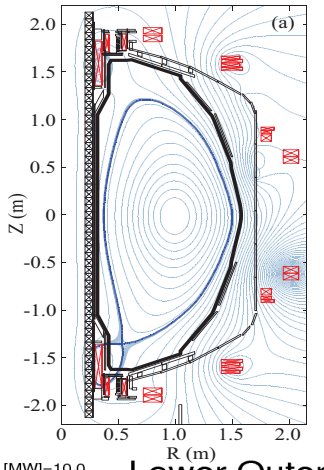


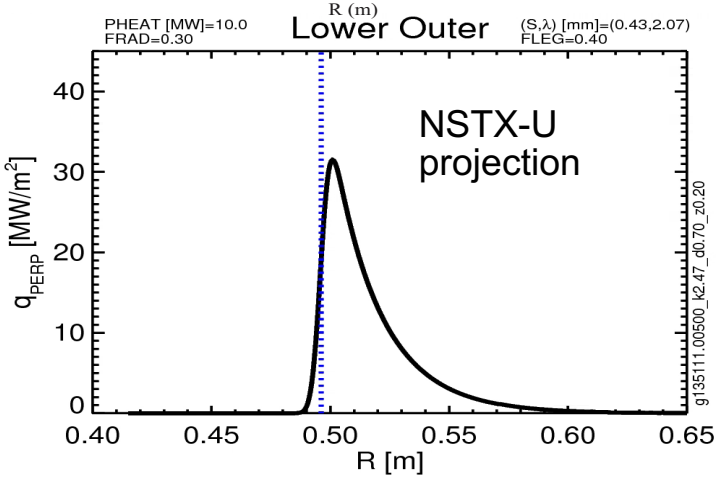


Thrust 2: Conventional and novel power exhaust techniques

- Deliverables:
  - Dependence of heat flux width at full I_p, B_t, over range of heating power and wall conditioning and divertor configurations (Years 1-3)
  - Feedback control of heat flux tied to equilibria over a range of configurations (Years 3-5)
  - Development of divertor and core radiation scenarios with attractive pedestal and core (Years 3-5)
  - Possible test of sample high-Z tile with liquid lithium inserts (Years 4-5 – see next slide)

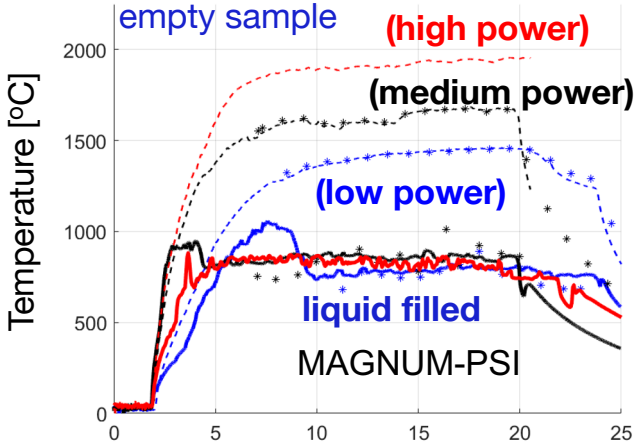
- Impact:
  - Model based heat flux control algorithms available for future higher power density systems
  - Assessment on future usability of snowflake and high flux expansion configurations
  - Preparation for liquid Li PFC program in NSTX-U 2026-2030 Five-Year Plan

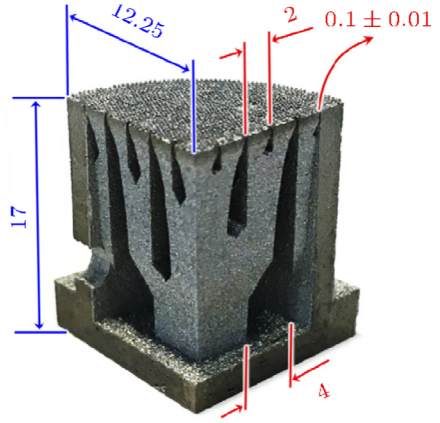




Liquid Li PFCs are one possible focus of the 2026-30 plan

- We will need to go through a mission need statement development (CD-0)
- Small group kicking off deliverables and resource need planning for a liquid Li PFC program 2026+
  - Two concepts: slow flow and/or evaporative systems, and fast flow systems
  - May test pre-filled Li plugs in NSTX-U 2024-5
  - Builds on MAGNUM-PSI results that show favorable use of pre-filled Li reservoirs in 3D printed W mesh

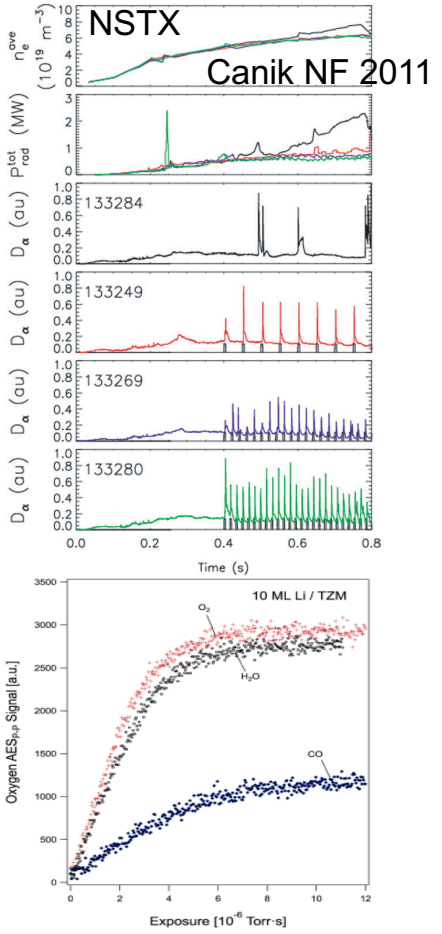




Rindt Ph.D. Thesis, 7/2019

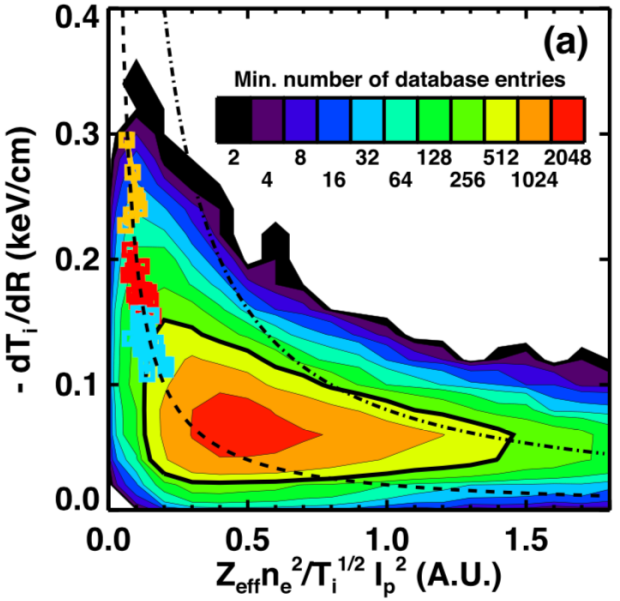
Thrust 3: Particle exhaust and PMI control

- Deliverables:
  - Dependence of wall conditioning and overall plasma performance on ability to condition upper PFCs, in addition to lower divertor PFCs: (Years 3-5)
    - (when) are there diminishing returns?
- Impact:
  - Assessment of future use of pre-discharge and real-time wall conditioning tools; importance of surface chemistry changes on long pulse wall performance



Thrust 4: Control of edge transients

- Deliverables:
  - Investigate ELM control techniques for development in Objective 2 (Years 1-3)
    - Develop ELM pacing (Years 4-5)
  - Assess if EP H-mode and QH-mode can be accessed (Years 1-3)
- Impact:
  - Extrapolability of EP H-mode, and accessibility of QH-mode; if successful, can model scenarios for next step ST-based compact fusion systems
  - Baseline for consideration of naturally ELM-stable regimes for NSTX-U integrated scenarios in Objective 2



Battaglia PoP 2020

Highest priority deliverables in the first run campaign

- Thrust 1: Assess performance and lifetime of new NSTX-U plasma-facing components

- Essential measurements:
  - PFC thermography for heat flux
  - PFC spectroscopy for erosion assessment