NSTX-U

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Impact of polar region design changes on Divertor and SOL TSG research

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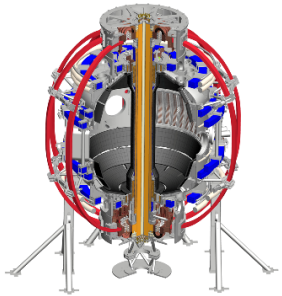
PPPL



NSTX-U Five Year Plan defined three Boundary research thrusts

- **BP-1: Assess and control pedestal structure, edge transport and stability**
  - Pedestal structure, transport and turbulence studies
  - ELM characterization and control

- **BP-2: Assess and control divertor heat and particle fluxes**
  - SOL transport and turbulence, impurity transport
  - Divertor heat flux mitigation with impurity seeding and divertor geometry

- **BP-3: Establish and compare long-pulse particle control methods**
  - Validate cryo-pump physics design, assess density control and recycling
  - Compare cryo to lithium coatings for particle (collisionality) control

Plan for SOL and divertor research from Five Year Plan

- Year 1 of 5 Year Plan
  - Continue analysis of SOL width database and comparison with models
  - Collaboration with DIII-D on snowflake and radiative divertor experiments

- Years 2-3 of 5 Year Plan
  - Establish SOL width and divertor database vs. engineering and physics parameters
  - Re-establish edge turbulence measurements (GPI, BES, cameras, probes)
  - Initial radiative divertor experiments with D_2, CD_4 and Ar seeding and lithium
  - Develop snowflake divertor magnetic control and assess pedestal stability, divertor power balance, turbulence, 3D fields as functions of engineering parameters
  - Comparison with multi-fluid and gyro-kinetic models

Let's focus on this

- Years 4-5 of 5 Year Plan
  - Compare SOL width data with theoretical models and in the presence of 3D perturbations of various types, e.g. RMP coils, HHFW heating, NBI injection
  - Combine snowflake configurations with pedestal control scenarios and tools, cryo
  - Implement radiative divertor control, demonstrate long-pulse H-mode scenario
  - Develop experiment-based model projections for ST-FNSF

NSTX-U engineering and plasma parameters for main DivSOL research areas

- **SOL transport and turbulence (SOL width, Edge/SOL turbulence, divertor database vs. engineering and physics parameters, etc)**
  - ≤2 MA, P_{NBI}≤6 MW, flattop 1-2 s, highly shaped, B_t can be lower than 1 T
  - Main priority λ_q, B2Li, DN vs LSN shape, pitch angle considerations, drsep control
- **Impact of 3D fields on divertor**
  - ≤2 MA, P_{NBI}≤6 MW, flattop 1-2 s, highly shaped, n=3 RMP, B_t can be lower than 1 T
  - Issues: dependence on collisionality, residual n=1 field, snowflake divertor compatibility
- **Boron to Lithium transition**
  - ~1 MA, P_{NBI}≤4-6 MW, flattop 1-2 s, highly shaped, B_t can be lower than 1 T
- **Radiative divertor experiments with D_2, CD_4, N_2, Ar seeding and/or lithium**
  - 1-2 MA,P_{NBI}≤4-10 MW, flattop 1-2 s, highly shaped, B_t can be lower than 1 T
  - Issues: DN/LSN shape control, divertor gas system
- **Advanced divertor configurations (cusp/X, high flux expansion, long leg, etc)**
  - 1-2 MA, P_{NBI}≤4-10 MW, flattop 1-2 s, highly shaped, B_t can be lower than 1 T
  - Issues: equilibria and control with new divertor coils, tile fish-scaling impact on field angles and R_{sp}
- **Snowflake divertor**
  - 1-2 MA, P_{NBI}≤4-10 MW, flattop 1-2 s, highly shaped, B_t can be lower than 1 T
  - Issues: equilibria and control with new divertor coils, tile fish-scaling impact on field angles and R_{sp}

Impact on critical SOL and divertor diagnostics

Measurements	Nature of impact
Magnetics (equilibria reconstructions, sensor locations and proximity to plasma)	New sensor design and new locations
Midplane kinetic profiles	No impact
GPI	No impact
Heat flux measurements (IR cameras, thermocouples, Langmuir probes)	Surface macro-non-uniformity and shadowing due to fish-scaling. Spatial resolution for IR cameras.
Radiated power (bolometers, radiometers)	Potential impact on sightlines?
Particle flux and recycling (probes, spectroscopy)	Surface macro-non-uniformity and shadowing due to fish-scaling. Spatial resolution for spectrometers and cameras. Langmuir probe locations and measurements due to shadowing.
Impurity flux measurements (spectroscopy)	Surface macro-non-uniformity and shadowing due to tile fish-scaling. Spatial resolution for spectrometers and cameras.
Neutral pressure measurements	CHI gap closure may affect conductance

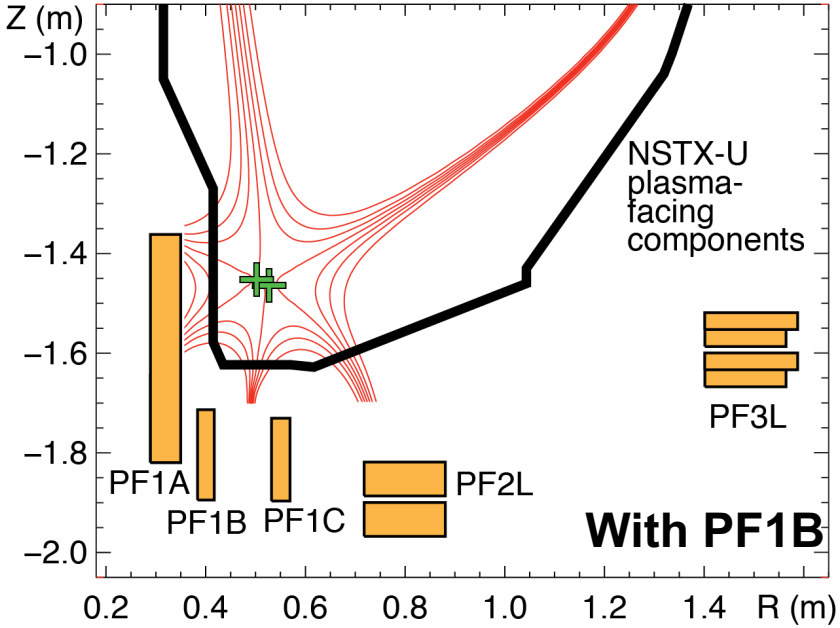
DivSOL TSG research program is impacted

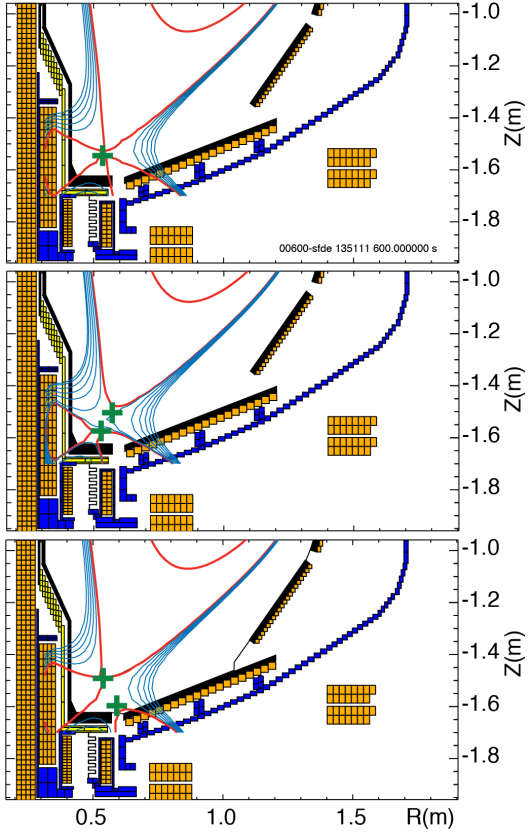
- SOL/divertor diagnostics are significantly affected by proposed polar region design changes
- Some unique research directions (e.g., advanced divertors) may be significantly affected and/or not even possible
- Some “mainstream” research directions not significantly affected

Backup

Snowflake divertor configuration

- Impact of divertor coil set
- Impact of PFC fish-scaling





Without PF1B

Experiments proposed in 2015

1557	Interaction of applied 3D fields with detachment	Ahn
1514	Relationship Between Plasma Turbulence and SOL Width Scaling in NSTX-U	Gray
1538	Radiative divertor experiments	Soukhanovskii
	Relationship between lambda_q, S and Connection Length	Gray
1539	Clarifying Snowflake divertor configuration physics	Soukhanovskii
1558	Toroidal divertor flux deposition asymmetries due to localized gas injection	Lore
	Obtain 2D divertor density image using lithium emission	Schmitz
1559	Assessment of 3D field effects on the properties of the snowflake divertor	Canal
1569	Testing divertor performance metrics for X-divertors on NSTX-U	TBD
1580	Effect of Lithium on SOL Power Balance	Gray
	Detachment comparison study for Snowflake, X-divertor, Standard Divertor and long/short divertor leg	Eldon
	Compare alternative advanced divertor configurations: X-divertor, Snowflake	Kolemen
	S parameter under 3D perturbations	Kolemen
	Transport and radiation in the high flux expansion divertor configuration with cusp-like fields.	Soukhanovskii
1560	Parallel Correlation of SOL Turbulence	Zweben
	Role of plasma response in the formation of lobe structures by 3D fields	Ahn
	Performance optimization of divertor detachment	Ahn
	Distinguishing between 3d magnetic field structures and transport	Canik
	Investigation of ELM heat flux footprints with the variation of ELM regime	gan
	Relaxation of the interchange instability and effect on SOL width with Li wall conditioning	Gray
	Relation between the midplane SOL pressure width and the divertor heat flux width	Hager
	SOL Width Scaling: Goldston's Heuristic Drift Model vs Critical Pressure Gradient Model	Kolemen
	Divertor conditions and detachment characteristics in plasmas with 3-D fields	Loarte
	Studies of low- and high-Z dust transport in NSTX-U	Smirnov
	Boundary diagnostic-optimized configuration (BDOC) for model comparisons.	Soukhanovskii
	Initial NSTX-U edge characterization.	Soukhanovskii
	ENDD Midplane Neutral Density Profiles in NSTX-U	Stotler