NSTX-U

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Preparation for pre-FY15 forum meeting #2

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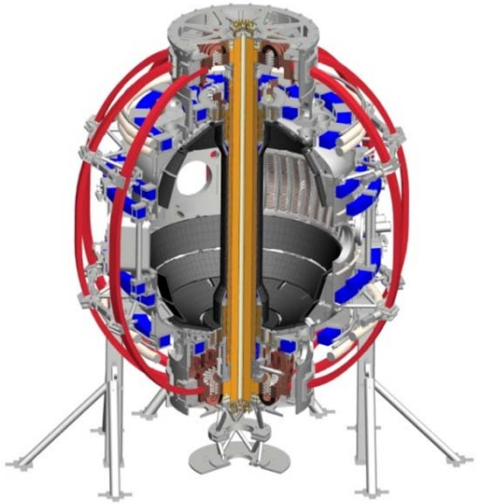
Walter Guttenfelder, *Yang Ren and NSTX-U T&T TSG*

NSTX-U T&T TSG
Jan. 21, 2015



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Our goal is to discuss and provide input to the NSTX-U program related to:

1. The highest-level goals for the T&T TSGs for the FY15 run
2. The run time requirements to meet those goals
3. What can be done in the early part (first two months) of the campaign: specific diagnostic/control system development XMPs, early research XPs, etc.

- We've already had initial discussion on these (see last slide)

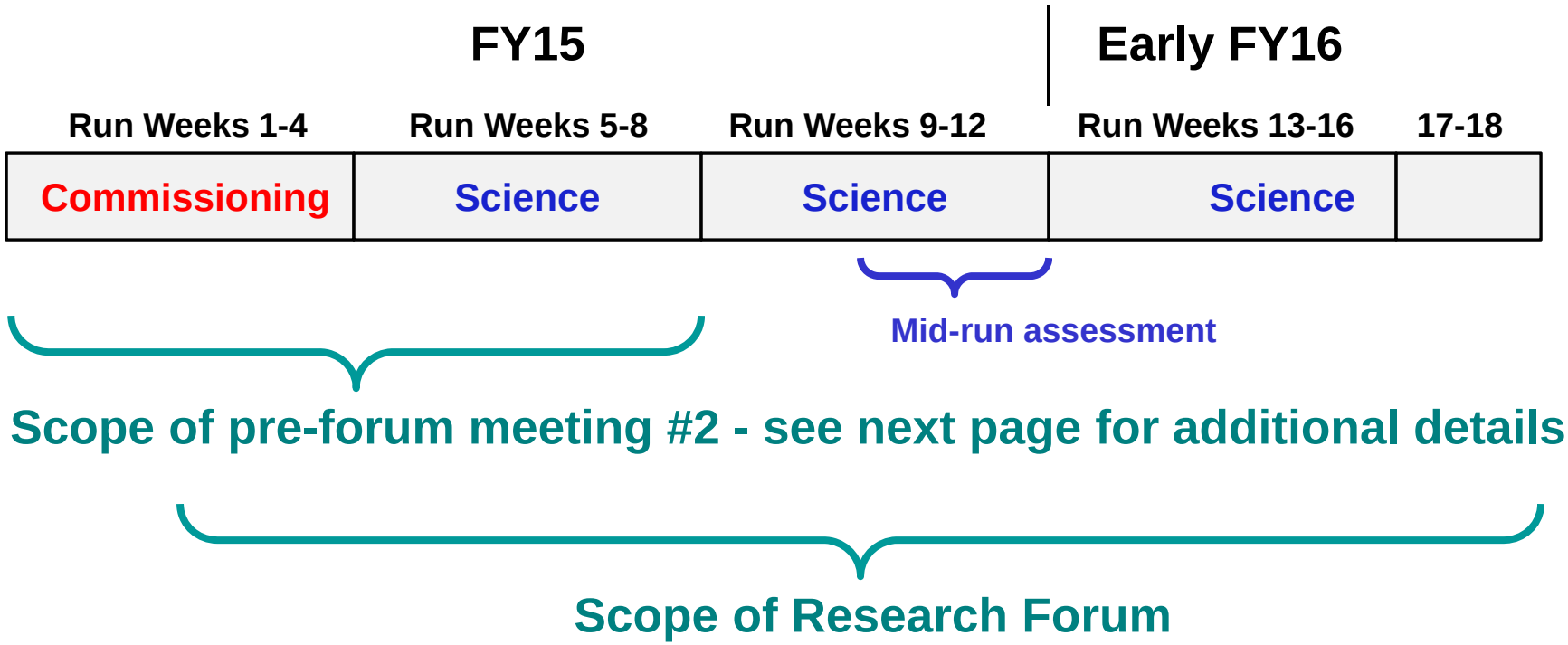
- Also, assuming that plasmas will be conditioned via boronization for the first part of the run, we should also consider:

1. Are there T&T XMPs/XPs that target boronized plasmas specifically?
2. What is a natural breakpoint for transitioning into Li conditioning (scientifically)?
3. What is the "unnatural" breakpoint for transitioning into Li conditioning (if B conditioning does not give us good plasmas; i.e., how long should be attempt to achieve good plasma conditions with B)?

NSTX-U program guidance on initial FY15 operations

Run schedule assumptions

Program guidance



- Pre-forum meeting #2 should emphasize XMP/XP title, goal, author identification to cover first 2 run months (Weeks 1-8)
- Forum should emphasize prioritization of XPs for weeks 3-18, but also document commissioning XMP/XP goals + run-time
- Mid-run (re-)assessment after first 6-8 Science run-weeks

Assumptions for first 2 run-months to use in identifying XMP/XP titles/goals/authors for Jan 29th pre-forum meeting #2

- Machine Commissioning…assume 1 month (run weeks 1-4)
  - Develop basic breakdown, current ramp, shape/position control, diverted plasmas, H-mode access, basic fuelling optimizations.
  - Goal: 1 MA, 0.5 T, NBI-heated H-mode (i.e. ~NSTX fiducial levels)
  - Diagnostic commissioning
  - Boronized PFCs
  - Mostly XMPs
  - **What science (aka XPs) can be done during this phase?**
- 1st Month of Science Campaign (run weeks 5-8)
  - Boronized PFCs, possibly begin lithium coatings
  - Operations and basic profile diagnostics, neutron rate,…
  - Operation up to 1.4 MA and 0.65 T, 2 seconds
  - 6 beam sources up to 90 kV
  - HHFW available for commissioning
  - **What critical XPs can/should be done during this phase?**

Program guidance

T&T priorities from relevant FY15 milestones, PAC35 research goals & NSTX-U 5 year plan

NSTX-U Transport and Turbulence (T&T) research aims to establish predictive capability for performance of FNSF & ITER

- Challenging and exciting as:
  - NSTX-U accesses a variety of drift wave transport mechanisms
  - NSTX-U is unique in achieving high β and low collisionality regime
  - Electron thermal transport can also be driven by Global & Compressional Alfvén eigenmodes (GAE/CAEs)

- Thrust 1: Characterize H-mode global energy confinement scaling in the lower collisionality regime of NSTX-U
- Thrust 2: Identify regime of validity for instabilities responsible for anomalous electron thermal, momentum, and particle/impurity transport in NSTX-U
  - Low-k modes ($k_\perp \rho_s \leq 1$): ITG/TEM/KBM, MT } drift waves
  - High-k mode: ETG
  - CAE/GAE } Alfvén eigenmodes
- Thrust 3: Establish and validate reduced transport models

FY15-16 milestones relevant to T&T research & T&T Research Plans from PAC35

- **(R15-1)** Assess H-mode τ_E, pedestal and SOL characteristics at high B_T, I_p, P_{NBI}
  - Assess confinement scaling at reduced ν_*
- **(R15-2)** Assess the effects of neutral beam injection parameters on the fast ion distribution function and neutral beam driven current profile
  - Investigate sensitivity of GAE/CAE induced χ_e to fast ion phase space
- **(Joint Research Target 2015)** Quantify impact of broadened current and pressure profiles on confinement and stability
  - Study transport and turbulence response with q, s, $p_0/\langle p \rangle$ using expanded NBI flexibility

STATED RESEARCH PLANS FROM PAC35:

- Characterize H-mode confinement scaling at increased B_T/I_p = 0.8 T/1.6 MA
  - Push to lowest collisionality possible (is $\tau_E \sim 1/\nu_*$ still valid?)
  - Characterize changes in multi-channel transport χ_e, χ_i, χ_φ, D_{imp} (e.g., does $\chi_i \approx \chi_{i,NC}$ & $D_i \approx D_{i,NC}$ remain at lower ν_*), compare with theory
- Explore parametric transport and turbulence dependencies with q and flow profiles using expanded NBI flexibility, 3D coils
  - Characterize changes in low-k turbulence (BES, reflectometry), compare with gyrokinetic simulations
- Measure CAE/GAE mode frequencies and structure (BES, reflectometry)
  - Characterize effect of GAE/CAE on experimental χ_e, sensitivity to NBI tangency radii/pitch angle
  - Compare with theory, HYM simulations

- Plus, we got scolded for not addressing particle transport/control

Important T&T questions addressed in NSTX-U 5 year plan (see Chapter 3)

1. Is the ST H-mode global energy confinement scaling still valid in the low collisionality regime achievable by NSTX-U? If not, what is the new scaling in this regime and how does it compare to ITER ELMy H-mode scaling?
2. What is the regime of validity of the instabilities found to be correlated with anomalous electron thermal transport on NSTX? Do predictions from existing first principles simulations and reduced models compare well with experiments with respect to transport levels, multi-field fluctuation level and spectra?
3. Is ion thermal transport still at neoclassical level in NSTX-U H-mode plasmas in the reduced collisionality regime? What are the individual roles of E×B shear and natural shaping of ST in reducing turbulence ion thermal transport?
4. What instabilities are responsible for observed anomalous momentum transport and intrinsic torque/rotation? What is the regime of validity of these instabilities?
5. What are the roles of neoclassical physics and turbulence in driving particle/impurity transport, especially in the reduced collisionality region?

Thoughts on T&T TSG FY15 run priorities following Dec. 2014 meeting

XMPs to recommission T&T systems/diagnostics (1st month, machine commissioning)

- No T&T specific diagnostics require immediate XMPs

- However, do we take ownership for some profile diagnostic XMPs? E.g.:

1. Assess NBI modulation schemes for CHERS measurement/analysis with 2nd NBI?
   - Need T_i, v_{tor}, n_c measurements from CHERs with 2nd NBI for probably most T&T XPs

Priority T&T XPs for FY15 (1)
Confinement & turbulence experiments

1. H-mode confinement & turbulence scaling with higher I_P, B_T, using only 1st NBI
   - Avoid complication of CHERS analysis
   - With Boronization (early)
2. Repeat #1 with 2nd NBI
3. Repeat #1,2 with lithium (later)
4. Measure influence of Ω_{tor} profiles (using 2nd NBI, 3D coil) on turbulence & transport (B or Li conditioning)
5. Measure influence of q profile (using 2nd NBI) on turbulence & transport (B or Li conditioning)

Priority T&T XPs for FY15 (2)
Experiments related to GAE, CAE, KAW

- EP led
- Measure GAE/CAE mode structure to validate with HYM

- T&T relevant

1. Measure GAE/CAE trends with NBI power, tangency and relation to transport & confinement
2. Measure dependence of anomalous electron thermal transport on GAE/CAE mode structure
   - E.g. using varied rotation to vary structure/dispersion
3. Investigation of energy transport via CAE/KAW coupling
   - E.g. trying to identify KAW with FIReTIP and relation to transport
4. Distinguishing KAW channeling vs. stochastic transport via HHFW+NBI

- No distinction between B vs. Li conditioning in the above?

Other T&T experiments for FY15 addressing confinement and transport

1. H-mode confinement and turbulence scaling with ν_*
   - Requires careful parameter matching (I_P~B_T, n~const, T~B^2 by adjusting P_{NBI}), good machine conditions (B or Li?)
2. Measure perturbative particle transport
   - Need SGI & TS
   - First with Boronization?
3. Repeat #2 with lithium?
4. Measure perturbative momentum transport (B or Li)
   - Uncertainty of NBI modulation + CHERS measurement analysis
   - Possibly use 3D fields

- <u>Pedestal XPs</u>
- Explore H-mode access & variation with R_{tan} [PED]
- Measure L-H threshold parametric dependencies [PED]

TASKS

- Need to name XP leaders

- Need to estimate run time requirements

T&T slide from meeting in Dec. 2014

T&T XMP/XPs topics/titles to: (1) recommission T&T systems/diagnostics, (2) run in ~1st month of research ops

- No T&T specific diagnostics require immediate XMPs
- ➢ For profiles: Assess NBI modulation necessary for CHERS measurement

- Almost all T&T XPs will require TRANSP analysis, therefore requiring TS, CHERS, magnetics/EFIT/MSE, neutron detector, bolometers
  - TRANSP can be used to assess self-consistency among diagnostics
  - Between shots TRANSP will be available (BEAST)

- <u>Priority T&T XPs (motivated by Milestones & PAC35 research plans)</u>

1. H-mode confinement & turbulence scaling with higher I_P, B_T (NBI source)
2. Influence of q and Ω_{tor} profiles (with 2nd NBI and 3D coil) on turbulence & transport
3. Measure GAE/CAE mode trends with NBI power, R_{tan}
4. Explore H-mode access & variation with R_{tan} (pedestal physics/Boundary TSG?)

- <u>Other T&T experiments for FY15 – more detailed versions of the above after intial operation</u>

1. H-mode confinement and turbulence scaling with ν_*
   - Requires careful parameter matching (I_P~B_T, n~const, T~B^2 by adjusting P_{NBI})
2. Measure perturbative particle transport
   - Need SGI & TS
3. Measure perturbative momentum transport
   - Uncertainty of simultaneous NBI modulation + CHERS measurement
   - Or possibly use 3D fields
4. Measure GAE/CAE mode structure using reflectometry
5. Measure L-H threshold parametric dependencies (especially on R_{TAN})