NSTX-U

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Macroscopic Stability TSG Pre-forum Meeting #2

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NSTX-U Pre-forum Meeting #2

January 16th, 2015

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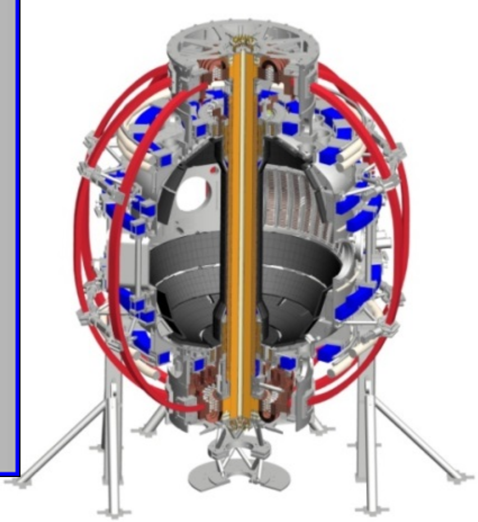

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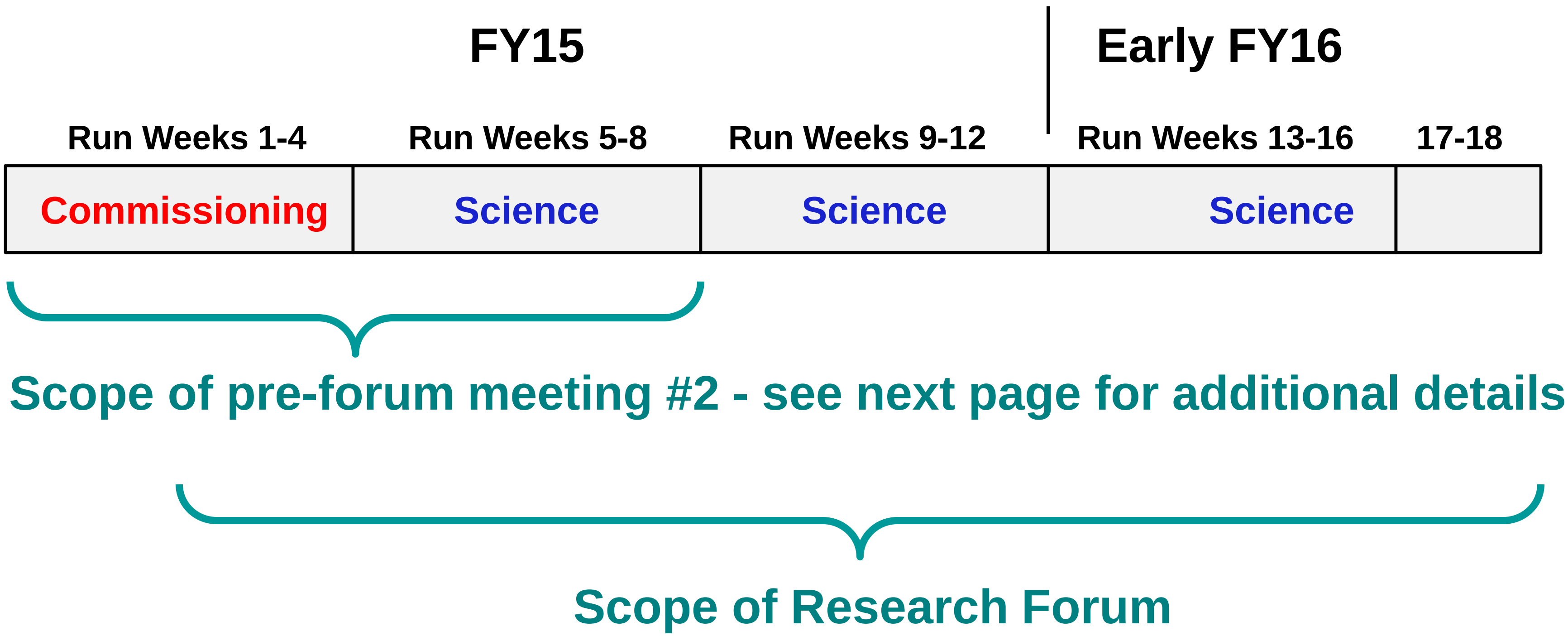
V1.0

Agenda

- Jon and Stan's topics for the meeting
- Highest level goals of MS TSG
- Full list of specific XP ideas called out in the 5 year plan
  - This will <u>not</u> be shown at pre-forum meeting #2 – meant to get people thinking for the actual forum, and to answer Stan's question of "run time requirements to meet the highest-level goals for their TSGs for the run"
- Individual's slides
- XMP suggestions – edit this list as we go
- Early XP suggestions – edit this list as we go

Run schedule assumptions



- 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

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, ~1 sec 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?**

Discussion of Stan's questions

- Are there XMPs/XPs that target boronized plasmas specifically?
- What is a natural breakpoint for transitioning into Li conditioning (scientifically)?
- 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)?

Highest-level goals for MS TSG for FY15 run

- Milestones
  - R15-3: Develop physics+operational tools for high-performance discharges (κ, δ, β, EF/RWM)
  - JRT15: Quantify impact of broadened J(r) and p(r) on tokamak confinement and stability
  - JRT16: Assess disruption mitigation, initial tests of real-time warning / prediction techniques
- Stability:
  - Optimize shaping, RWM/TM control (n>1 using the second SPA), validate internal mode physics, and RWM kinetic physics
- 3D Fields:
  - Optimize error field correction (n>1), dynamic correction, and understand NTV physics in reduced collisionality and controlled rotation
- Disruptions:
  - Study halo currents, disruption loads, and precursors, and test MGI or other mitigation techniques

Specific XP ideas called out in the 5 year plan

- Stability: (red = potential near-term; purple = longer term)
  1. Assess β_N and q stability limits at the increased aspect ratio of NSTX-U, with new shaping control and off-axis NBI.
  2. Utilize off-axis NBI to produce initial investigation determining the effect of pressure, q, and v_ϕ profile variations on RWM and NTM stability
  3. Investigate the dependence of stability on reduced collisionality through MHD spectroscopy, and compare to kinetic stabilization theory
  4. Establish dual field component n = 1 active control capability in new NSTX-U operational regime with 6 independent SPAs
  5. Examine effectiveness of RWM model-based state space control with independent actuation of six control coils, multi-mode control with n up to 3, and plasma rotation-induced stabilization in the controller
  6. Attempt initial control of internal MHD modes that appear at low density during current ramp-up
  7. Determine the degree of global mode internalization by comparing diagnosis by magnetic and SXR means as a function of proximity to the mode marginal stability point
  8. Utilize initial NSTX-U ME-SXR and poloidal USXR diagnostics to characterize the RWM eigenfunction by non-magnetic means

Specific XP ideas called out in the 5 year plan

- 3D Fields: (red = potential near-term; purple = longer term)
  1. Optimize and combine dynamic error field correction with intrinsic error field correction, including n>1 and using 6 SPAs
  2. Assess NTV profile and strength as a function of plasma collisionality, and examine the NTV offset rotation
  3. Investigate the rotation and rotational shear vs. TM/NTM in NSTX-U, compared with NSTX
  4. Understand how n=1 tearing mode stability changes with q-profile. In particular: 1. Sensitivity changes in response to error fields (to induce tearing modes) and 2. Changes to the tearing beta limit (Rob LaHaye)
  5. Investigate resonant error field effects on tearing mode onset
  6. Investigate NTV physics with enhanced 3D field spectra and NBI torque profile at increased pulse lengths, and NTV behavior at reduced collisionality regime

Specific XP ideas called out in the 5 year plan

- Disruptions: (red = potential near-term; purple = longer term)
  1. Perform initial experiments using open-loop plasma rotation, current profile, and energetic particle control to demonstrate the ability to avoid encountering disruptive global mode stability boundaries based on kinetic RWM models
  2. Commission MGI system and diagnostics, test EPI capsule injection
  3. Assess total halo current fraction, toroidal structure, and poloidal width
  4. Investigate high-Z gas fractions, gas transit times, the amount of gas required, and symmetry of the radiated power profile
  5. Investigate halo current loading on the center column, using newly installed center column shunt tiles
  6. Study spatial extent and timing of the heat deposition during VDEs
  7. Construct an MHD spectroscopy database to determine the measured variation of global mode stability as a function of key parameters
  8. Compare the mismatch between the RWMSC observer model and sensor measurements, and the occurrence of plasma disruptions
  9. Implement and test initial disruption avoidance using the RWMSC observer model in real-time, including open-loop disruption avoidance criteria in low rotation plasmas

Error Fields (Myers, Gerhardt, Park, and Menard)

- NSTX-U error field considerations
  - The PF5 coils may have changed shape → could produce n=2 EF
  - New current feeds for OH and divertor coils → different (smaller?) EFs
  - New J/K cap for NB2 → non-axisymmetric EFs during current ramp?
  - Unanticipated EF sources are possible (or even probable)
- Error Field PTP: Coil shape measurements in the test cell
  - Assess PF3/4/5 coil shapes with a ruler and plumb bob
  - Measure coil-to-vessel and coil-to-coil positions at multiple toroidal locations
- Error Field XMP: Vessel-generated EFs in AC vacuum shots
  - The new J/K cap is likely to carry non-axisymmetric induced currents during the current ramp → the importance of this effect is unknown
  - Swing the OH + PF3/4/5 during vacuum shots to quantify the axisymmetry of the induced vessel currents

Error Fields (Myers, Gerhardt, Park, and Menard)

- Error Field XP #1: Low β, low density locked mode studies
  - *n*=1 compass scans (multiple phases and amplitudes)
  - Should run early in the campaign (the RWM sensors are required)
  - Disruptions as the primary diagnostic (rotation available?)
- Error Field XP #2: High β *n*=1,2,3 compass scans
  - Intra-shot modulation and/or “spiral” *n*=1,2 scans during long pulse operation
  - Rotation and disruption as diagnostics
  - Flip the *n*=3 polarity to optimize and compare to the NSTX *n*=3 settings
- Error Field XP #3: Optimization of PID Dynamic EF Correction
  - Tune amplitudes, phases, and gains of the PID DEFC algorithm
  - Requires the real time RWM controller to be operational
  - Utilize low pass filter to isolate the effect of DEFC from fast RWM control

Gerhardt slides

Columbia U. group experiments in prep for the NSTX-U Forum

Columbia U. Group 2011-12 Macrostability TSG experiments

NOTE: MOST are possible for 2nd month of run

- Macrostability TSG (proposed for 2011)
  - XP1144: RWM stabilization/control, NTV V_ϕ alteration of higher A ST targets (Sabbagh)
  - XP1145: RWM state space active control physics (independent coil control) (Sabbagh)
  - XP1146: RWM state space active control at low plasma rotation (Y-S Park)
  - XP1062: NTV steady-state rotation at reduced torque (HHFW) (Sabbagh)
  - XP1111: RWM PID optimization (Sabbagh)
- Macrostability TSG (proposed for FY 2012)
  - XP1149: RWM stabilization dependence on energetic particle profile (Berkery)
  - XP1147: RWM control physics with partial control coil coverage (JT-60SA) (Y-S Park)
  - XP1148: RWM stabilization physics at reduced collisionality (Berkery)
  - XP1150: Neoclassical toroidal viscosity at reduced ν (independent coil control) (Sabbagh)
- Further ideas:
  - New XP: Multi-mode error field correction using the RWMSC (to follow Clayton's initial EFC XP)

- Further ideas for 2015 NSTX-U run will be presented at the forum

Wang and Park slides

XMP suggestions

- XMP suggestions:
  - Error field XMPs (see Clayton Myers slide)
  - Dual sensor active RWM PID control checkout (Sabbagh)
    - Test operation of both B_r and B_p sensors (in real time and offline)
    - Test that feedback works through limited phase and gain scans in a fiducial plasma
  - RWM state-space controller (RWMSC) checkout (Sabbagh)
    - Turn on RWMSC with overall gain on feedback current set small to test functionality gather RWMSC Observer data on each shot (piggyback)
    - Run with "standard" gain matrices and operational-level gain on feedback current and perform limited phase scan with/without pre-programmed n = 1 field
    -
  - MHD spectroscopy checkout (Berkery)
    - Gather sensor signal/noise vs. (positive) frequency in limited frequency scan

Early XP suggestions

- Early XP suggestions:
  - Error field XPs. See Clayton Myers slides
  - Characterization of EPs with new NBI (name?)
    - with EP group, or really team-wide
    - A few bullet points on what each XMP/XP is supposed to accomplish scientifically and operationally…
  - Testing 3D physics capabilities including the new six independent SPAs plus n=3 magnetic braking (name?)
    - How does magnetic braking work in NSTX-U vs. NSTX?
    - A few bullet points on what each XMP/XP is supposed to accomplish scientifically and operationally…
  - Establish dual field component n = 1 active control capability in new NSTX-U operational regime with 6 independent SPAs (Sabbagh)
    - A few bullet points on what each XMP/XP is supposed to accomplish scientifically and operationally…
  - XP1062: NTV steady-state rotation at reduced torque (HHFW) (Sabbagh) contributes to 3D Fields #5)

Supporting slides follow