NSTX-U

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Macroscopic Stability TSG Pre-forum Meeting #2

J. W. Berkery[1], J.-K. Park

[1] *Department of Applied Physics, Columbia University, New York, NY*

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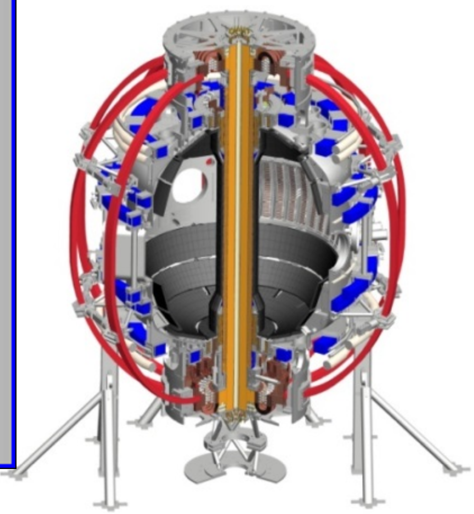
PPPL



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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

XMP suggestions

- Magnetics calibration (with ASC)
- PTP to qualify valves, control systems, gas delivery, interlocks
  XMP to test if they work in presence of plasma. (Raman)
- Automated discharge shutdown method commissioning (Gerhardt)
- Software test for n=1 RWM and error field control with 6 SPAs (Gerhardt)
  - Off-line RWM analysis software must first be demonstrated functional
  - Sensor compensations and mode-ID also must be functional in on-line code
- Quantify vessel-generated EFs in AC vacuum shots (Myers)
  - 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

XMP suggestions

- Dual sensor active RWM PID control checkout (Myers/Gerhardt/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/Sabbagh/Wang)
  - Gather sensor signal/noise vs. (positive) frequency in limited frequency scan
  - Able to see amplitude and phase in RWM sensors

Early XP suggestions

- Low β, low density locked mode studies (Myers/Gerhardt/Park)
  - 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?)
- High β n=1,2,3 compass scans (Myers/Gerhardt/Park)
  - 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
  - Also test n=3 magnetic braking in NSTX-U
- Optimization of PID Dynamic EF Correction (Myers/Gerhardt)
  - 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
- Establish dual field component n = 1 active control capability in new NSTX-U operational regime with 6 independent SPAs (Sabbagh)
  - For general use throughout the run

Early XP suggestions

- Joint with other groups
  - On-- vs. off- axis NBI for fiducial--like H--mode plasmas (Podesta in EP-TSG)

- Possible early in run
  - Determine n=1 tearing onset beta and q_{min} (LaHaye)
    - Vary relative timing of q_{min} dropping and raising NBI (to get H-mode transition which increases beta) to map q_{min} and beta for n=1 tearing onset
    - Follow with step down in NBI to get a marginal condition for comparison to NSTX
  - Test n=1 locking threshold along with n=2-3 applied fields (Park)
    - After n=1 error field investigation, keep the density and ramp-up currents until locking, while varying n=2-3 currents in Ohmic plasmas
    - Follow with step down in NBI to get a marginal condition for comparison to NSTX
  - Multi-mode error field correction using the RWMSC (Sabbagh/YS Park)
    - Would come after "Optimization of PID dynamic EF correction"
  - XP1062: NTV steady-state rotation at reduced torque (HHFW) (Sabbagh)

Supporting slides follow

Collecting specific XP ideas, pre-forum (no priority order pre-assumed here)

- Stability:
  - Assess β_N and q stability limits at the increased aspect ratio of NSTX-U, with new shaping control and off-axis NBI
  - Utilize off-axis NBI to produce initial investigation determining the effect of pressure, q, and v_ϕ profile variations on RWM and NTM stability
  - Investigate the dependence of stability on reduced collisionality through MHD spectroscopy, and compare to kinetic stabilization theory
  - Establish dual field component n = 1 active control capability in new NSTX-U operational regime with 6 independent SPAs (Sabbagh)
  - 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
  - Attempt initial control of internal MHD modes that appear at low density during current ramp-up
  - 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
  - Utilize initial NSTX-U ME-SXR and poloidal USXR diagnostics to characterize the RWM eigenfunction by non-magnetic means

Collecting specific XP ideas, pre-forum (no priority order pre-assumed here)

- Stability:
  - XP1144: RWM stabilization/control, NTV Vf 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)
  - 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 n (independent coil control) (Sabbagh)
  - Multi-mode error field correction using the RWMSC (Sabbagh)
  - Density limit study

Collecting specific XP ideas, pre-forum (no priority order pre-assumed here)

- 3D Fields
  - Low β, low density locked mode studies (Myers)
  - High β n=1,2,3 compass scans (Myers)
  - Optimization of PID Dynamic EF Correction (Myers)
  - Assess NTV profile and strength as a function of plasma collisionality, and examine the NTV offset rotation
  - Investigate the rotation and rotational shear vs. TM/NTM in NSTX-U
  - NSTX-U Tearing Mode Experiments by Varying Plasma Rotation Through NTV Torque in Presence of External Fields (Wang)
  - Plasma Response Study with Nyquist Plot in NSTX-U (Wang)
  - 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 (LaHaye)
  - Investigate resonant error field effects on tearing mode onset
  - Investigate NTV physics with enhanced 3D field spectra and NBI torque profile at increased pulse lengths, and NTV behavior at reduced collisionality regime
  - Test n=1 locking threshold along with n=2-3 applied fields (Park)
  - Test single coil effects on NTV and confinement (Park)

Collecting specific XP ideas, pre-forum (no priority order pre-assumed here)

- Disruptions
  - 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
  - Commission MGI system and diagnostics, test EPI capsule injection
  - Assess total halo current fraction, toroidal structure, and poloidal width
  - Investigate high-Z gas fractions, gas transit times, the amount of gas required, and symmetry of the radiated power profile
  - Investigate halo current loading on the center column, using newly installed center column shunt tiles (Gerhardt)
  - Study spatial extent and timing of the heat deposition during VDEs
  - Construct an MHD spectroscopy database to determine the measured variation of global mode stability as a function of key parameters
  - Compare the mismatch between the RWMSC observer model and sensor measurements, and the occurrence of plasma disruptions
  - Implement and test initial disruption avoidance using the RWMSC observer model in real-time, including open-loop disruption avoidance criteria in low rotation plasmas