NSTX-U

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NSTX-U 5 year plan outline/timeline for Macroscopic Stability (MS)

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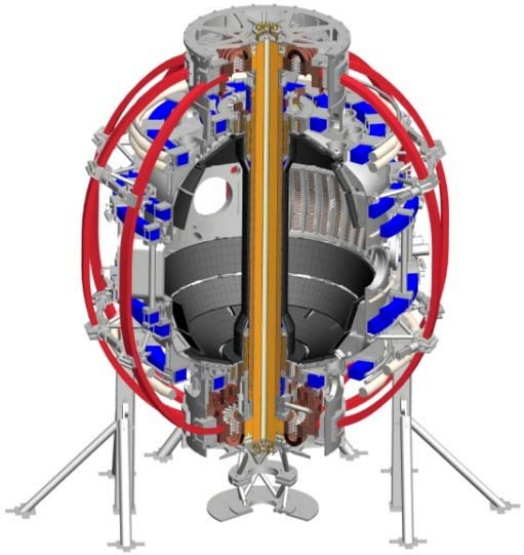

Summary of high-level research thrusts/goals

- Three thrusts in MS
  - Stability: Advance passive and active control to sustain macroscopic stability at high non-inductive current fraction
  - 3D: Achieve predictive capability of 3D field effects to produce sustained stability and profile control
  - Disruption: Investigate and test stability physics for disruption avoidance, detection, and mitigation in high performance ST plasmas
- Research in each topical area will be tightly linked gradually along the year of research
  - 3rd-4th year: 3D field physics understanding and control will be utilized for and combined with stability control
  - 4th-5th year: 3D and stability control will be utilized for disruption avoidance scenarios and combined with mitigation protection

Note for NCC (Non-axisymmetric Control Coil)

- The 4th-5th year research plans for stability and 3D topical area strongly motivate NCC
  - Stability: RWM/TM vs. rotation profiles, RWM multi-mode control vs. various 3D coil combinations
  - 3D: Rotation-profile control by NTV, non-resonant and resonant error field effects
- Issues:
  - Research plans with NCC and without NCC in each TSG?
  - Compiled NCC physics studies under MS?
  - Another NCC action plan meeting?

Summarized theory topics in MS

Category	Existing efforts	Associated physics issues
More robust equilibrium reconstruction and modeling including toroidal rotation and SOL, and stability analysis	- EFITs including rotation - LRDFITs including rotation - (E,LRD)FITs + FLOW - (E,LRD)FITs + FLOW + M3D-C1	- Stability boundary with toroidal rotation? - Stability boundary including separatrix? - Can be routinely available as GEQDSK in NSTX-U?
Quasi-linear 3D equilibrium modeling including islands, neoclassical, and kinetic MHD effects	- IPEC with tensor pressures and islands + POCA + Inner-layer - FLOW, MARS-F, MARS-K - M3D-C1	- 3D equilibrium with opened islands? - 3D equilibrium with rotation? - 3D equilibrium with anisotropic pressures? - Self-consistent modeling for NTV in NSTX-U?
Quasi-linear stability modeling including neoclassical and kinetic MHD effects	- MISK with anisotropic pressures and fast ions - MARS-K, NOVA-K - M3D-C1	- RWM passive stability with 2nd NBIs in NSTX-U? - Effects by Self-consistent eigenfunction? - Second RWM code with full kinetic treatment?
Non-linear (as well as linear) 3D modeling for time-evolving dynamics of islands, neoclassical, full kinetic MHD effects	- M3D-C1 with distribution function solver (Ramos theory or NTV theory) - XGC0	- Non-linear effects in 3D equilibrium and stability, including SW (q=1) and NTM? - Two fluid effects in 3D equilibrium and stability? - Full kinetic effects in 3D equilibrium and stability?
Gas penetration physics modeling including MGI and runaway electrons and disruption simulation	- DEGAS2 for gas penetration - TSC for runaway electrons - M3D for disruption simulation - Use of 3D equilibrium sequence	- Gas penetration with atomic physics? - Runaway electrons in NSTX-U? - Coupling gas and plasma modeling? - Why mode locking cause a disruption? - What is the origin of a density limit disruption?
Full 3D modeling for external structure for RWM dynamics	- Multi-mode VALEN3D - Plasma permeability with neoclassical and kinetic MHD effects - VALEN3D + Plasma permeability	- Full 3D current effects on RWM? - Effects of full 3D + kinetic plasma permeability on RMW stability and control?

Important diagnostics for MS topics were identified and will be under proposal and/or development

Diagnostics	Resolution	Related topics
Magnetic refurbishment	kHz-MHz	Whole MS area
Radial and poloidal magnetic sensors		3D, global
rtMSE	1-3cm, 5ms	Global, tearing
Internal magnetic fluctuation measurement	18CH, 100kHz, 5-10ms	3D, Tearing
rtMPTS	10-20CH, 11-16.7ms	Global, tearing
Toroidally displaced ME-SXR	1-3cm, 10-100kHz	3D, global, tearing, disruption
Core X-ray Imaging Spectrometer	<1cm, >5ms	3D, global, tearing
Disruption force diagnostics		Disruption
RTV (Real Time Velocity) measurements	4-6CH, <5kHz	3D, global, tearing
Neutron collimator	3-4CH, 5-20ms	Global, tearing
Tangential FIDA, High density FIDA	1cm, 5ms	Global, tearing
NPA, ssNPA	5-10cm, 1MHz, 10keV	Global, tearing
SOLC with magnetic probes, electrodes, sensors		3D, global, tearing, disruption
Additional RWM sensors near upper and lower divertors		3D, global
EBW measurements for magnetic field	1-3mm (rho=0.7-0.9)	3D, global, tearing, disruption
MSE-LIF	1-3cm, 5ms	3D, global, tearing
Radiation tomography		Disruption
Improved reflectometer system	1-10kHz	Global, ASC
Fast thermography, thermocouples	5-10cm, 1ms	Disruption
Visible bremsstrahlung imaging	1cm, 20us	Global
Error field measurements with external coils		3D