NSTX-U

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MS-TSG
Research Milestones for FY18-19

Jong-Kyu Park
for NSTX-U research team

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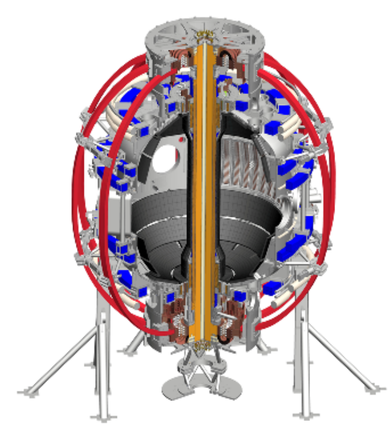

3 MS proposals for FY18-19 milestones

- R(18-3): Validate tearing mode physics to develop mitigation and avoidance strategies in advanced tokamak operations – revised (J.-K. Park)

- R(19-X): Validation of non-axisymmetric plasma response modeling to address capability with core and edge constraints – new proposal (N. Ferraro)

- R(19-1): Expand disruption and avoidance capability for tokamaks – revised (S. Sabbagh)

R(18-3): Validate tearing mode physics to develop mitigation and avoidance strategies in advanced tokamak operations

- Goals: Physics validation on (N)TM mode onset & evolution
- Modeling tools:
  - TM onset: PEST-III, (R)DCON, MARS, linear M3D-C1
  - TM evolution: MARS-Q, non-linear M3D-C1
  - NTM onset/evolution: GRE, WDM, DECAF
- Data analysis and validation (NSTX, DIII-D, FY16 NSTX-U):
  - Equilibrium dependency: β_N/l_i limit, shaping and q-profile effects
  - Kinetic and two-fluid effects: Torque (ω_E, $\omega_{\perp e}$ or shear) dependency
- Predictive modeling and control (DIII-D, MAST-U, KSTAR):
  - TM stability trends for DIII-D high β_P and low torque IBS
  - Early TM stability trends for MAST-U (compare to FY16 NSTX-U)
  - NTM evolution and/or entrainment in DIII-D and KSTAR

Expected contributions from group to R(18-3)

- Z. Wang & J.-K. Park: Toroidally generalized Δ' validation – resistive DCON, benchmarking with PEST-III and MARS
- Z. Wang & F. Poli: Improved GRE application in WDM
- N. Ferraro: Rotation and two-fluid effects on TM, non-linear simulations for TM evolution using MDC-C1
- D. Brennen: PEST-III and inner-layer model V&V
- L. Morton & R. La Haye: Experimental validation of non-linear Rutherford model (focused on NSTX-U and DIII-D comparison)
- J. Berkery & S. Sabbagh: Reduced model in DECAF
- Y. S. Park & S. Sabbagh: TM analysis and NTM entraintment (focused on KSTAR)
- M. Okabayashi : NTM entrainment (focused on DIII-D)

R(18-3): Validate tearing mode physics to develop mitigation and avoidance strategies in advanced tokamak operations

Tearing modes (TMs) and neoclassical tearing modes (NTMs) are common macroscopic instabilities prohibiting access to high-performance tokamak regimes, but accurate prediction of mode stability in realistic tokamak conditions still remains a challenge. The goal of this milestone is to validate TM/NTM physics models and simulations, particularly in advanced tokamak regimes with strongly shaped plasmas, to develop robust predictive capability and avoidance strategies of TM/NTMs. Existing experimental data from NSTX, FY-16 NSTX-U, and DIII-D will be investigated for validation, and predictive simulations will be performed on DIII-D and KSTAR advanced scenarios as well as MAST-U initial operations. Each of the key physics components influencing the onset of tearing instabilities will be systematically examined and compared with applicable codes. The effects by shaping including aspect ratio, and by equilibrium profiles and parameters including q_{min} will be extensively analyzed with resistive MHD codes such as DCON or PEST-III on TM databases, and the effects by kinetic profiles including rotation, multi-species effects, or the interaction with 3D fields, will be studied with extended MHD codes such as M3D-C^1 or MARS on selected TM/NTM datasets. The toroidally-generalized TM stability index in the simulations will be compared with the onset conditions observed in experiments, and will be tested for predictive TM avoidance. TM/NTM evolution with islands in experiments will also be analyzed, and compared with extended MHD codes to develop various stabilizing techniques including NTM entrainment. Any proposed reduced TM/NTM physics models will be integrated into whole device modeling, and will be utilized for TM/NTM mitigation and avoidance in various future device operations including NSTX-U.