Macrostability TSG Suggested FY-12 Milestones – Address key ReNeW issues for ST development

All of these address high-level ReNeW Thrust 16 Actions

- 1) Assess sustained operation above the no-wall limit at reduced collisionality
  - From incremental milestone IR(11-2) – critical for steady-stated ST operation
    - Promote to major milestone if not performed as incremental milestone in FY-11
    - Revise to add new capabilities of FY-12 (2^{nd} SPA, initial rotation control, etc.); add EP effects on Macrostability; change name if desired

- 2) Assess sustained operation at reduced plasma internal inductance
  - Key for burning/driven burn ST development; start this investigation, which would gain full prominence in NSTX-U
  - Couple to milestone suggestion #1 above?

- 3) Assess physics of rotation control for sustained high beta ST operation
  - Couples strongly to ASC suggestion, which has many Macro TSG aspects
  - Suggest that milestone couple Macro, ASC, Transport TSG elements

S.A. Sabbagh for NSTX Macrostability TSG

Macro TSG #1: Assess sustained operation above the no-wall limit at reduced collisionality

1. **Provide a short, specific, actionable title describing the milestone:**
   (see title)
2. **Why is this issue important to fusion?**
   Key for ST development toward low collisionality burning/driven-burn applications. This is a ReNeW Thrust 16 Action.
3. **Why is this issue important to NSTX?**
   NSTX is moving to lower collisionality. Understanding the stability physics ramifications is key to support high beta, continuous operation of the device.
4. **What general research is proposed to address this issue?**
   Given in detail in IR(11-2). Suggestion is to promote this milestone to full milestone if 20 run weeks not granted in FY-11, and also add some topics recently uncovered as important. Topics include RWM stability dependence at low ν and due to effects of EPs, NTV scaling with ν, alteration of stability vs. density and collisionality, etc.
5. **What specific measurements and or experiments are needed to perform this research, and what diagnostics and theory/simulation capabilities are required?**
   Plasma rotation control a major plus, but not required. LLD operation needed. 2nd SPA. Theory includes further development of the MISK code for stability, IPEC code for plasma response, VALEN code for multi-mode stability, continued NTV theory development.
6. **What comparisons between experiment and theory will be carried out?**
   Dedicated experiments to determine effects of collisionality, EPs, multi-mode RWM, etc. to codes mentioned in (5).
7. **What are the scientific implications of successful completion of the milestone?**
   Will provide required scientific understanding of stability at reduced collisionality critical for NSTX-U, future burning STs, ITER.

Macro TSG #2: Assess sustained operation at reduced plasma internal inductance

1. **Provide a short, specific, actionable title describing the milestone:**
   (see title)
2. **Why is this issue important to fusion?**
   Key for ST development toward burning/driven-burn applications, which operate at reduced plasma internal inductance. This is a ReNeW Thrust 16 Action.
3. **Why is this issue important to NSTX?**
   To support (2) above, NSTX is moving to lower l_i. Understanding the stability physics ramifications is key to support high beta, continuous operation of the device.
4. **What general research is proposed to address this issue?**
   Essentially, preparation for the main focus that will come with 2nd NBI in NSTX-U – plasma targets that operate as close to future ST target l_i as possible and assessment of instabilities in this regime – current-driven kink at all values of betaN, NTM, ELM, RWM stability (all functions of current profile).
5. **What specific measurements and or experiments are needed to perform this research, and what diagnostics and theory/simulation capabilities are required?**
   Plasma rotation control a major plus, but not required. LLD operation and 2nd SPA a plus. SXR and global mode diagnostic expansion. MISK code for stability, IPEC code for plasma response, multi-mode VALEN code, ELM stability tools, NTV theory development.
6. **What comparisons between experiment and theory will be carried out?**
   Dedicated experiments to determine effects of l_i, EPs, multi-mode RWM, etc. to codes mentioned in (5).
7. **What are the scientific implications of successful completion of the milestone?**
   Will provide required scientific understanding of stability at reduced l_i critical for NSTX-U, future burning STs, ITER.

Macro TSG #3: Assess physics of rotation control for sustained high beta ST operation

1. **Provide a short, specific, actionable title describing the milestone:**
   (see title)
2. **Why is this issue important to fusion?**
   Key for sustained ST operation in burning/driven-burn applications. This is a ReNeW Thrust 16 Action.
3. **Why is this issue important to NSTX?**
   NSTX is supporting (2) above. Demonstrating controlled rotation profiles is key to support high beta, continuous operation of the device.
4. **What general research is proposed to address this issue?**
   Physics governing plasma rotation control, including resonant and non-resonant magnetic braking over entire range of NSTX operations. Key aspects here are saturation (or not) of NTV at low collisionality, physics of observed NTV increase at low ω_E, accurate plasma response (including shielding) to applied 3D fields, etc.
5. **What specific measurements and or experiments are needed to perform this research, and what diagnostics and theory/simulation capabilities are required?**
   Real-time plasma rotation measurement and control required. LLD operation and 2nd SPA a plus. Further development of IPEC code for plasma response, continued NTV theory development. MISK development, calculations of rotation profiles for best stability.
6. **What comparisons between experiment and theory will be carried out?**
   Verify detailed resonant and non-resonant magnetic braking physics theory. Support development of simple, accurate models for rotation control. MISK stability vs. experiment.
7. **What are the scientific implications of successful completion of the milestone?**
   Will provide required scientific understanding of rotation control and associated plasma stability critical for NSTX-U, future burning STs, ITER.