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Proposal for FY15 Milestone on fast ion physics

G. Taylor, M. Podestà, N. Gorelenkov, E. Fredrickson

and the NSTX-U Research Team

PPPL

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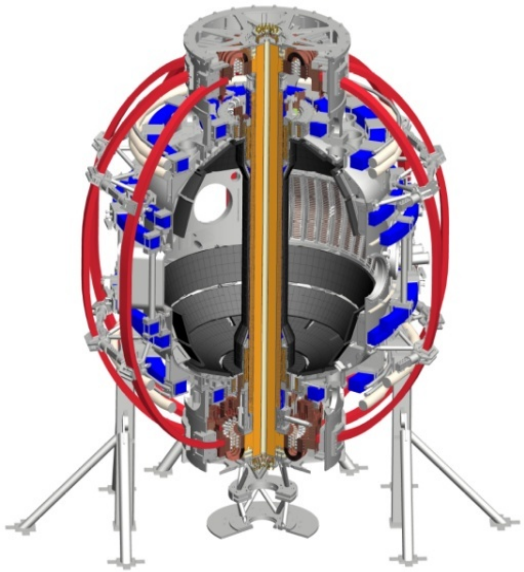

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Agenda

- From NSTX-U Team discussion on FY15 milestones:

  "Fast ions" (w/ focus on 2nd NB line)
  identified as candidate topic

- Need to define scope, tools
  - Must be consistent with 5 Year Plan
  - Must be consistent with expected NSTX-U capabilities in Year 1

- This meeting:
  - Review draft proposal: context, tools, strategy
  - Discuss/finalize/agree on goals & tools; identify open issues
  - *NOT (yet) a fine-tuning of final text*
  - *NOT a discussion on detailed XP plans!*
  - "Final" milestone proposal will be circulated by the end of the week (!)

Draft proposal targets characterization of new parameter regimes enabled by 2nd NB line on NSTX-U

- 2nd NB line is a crucial element of NSTX Upgrade
  - Characterization of its effects on fast ion distribution required in Year 1
- Proposed research encompasses many TSGs
  - WEP, ASC, SFSU, MS
- Main deliverables:
  - Characterize fast ion distribution from new NB sources, compare with 1st NB line (NSTX)
  - Compare with predictions on 'classical' fast ion behavior (NUBEAM)
  - First assessment of MHD effects vs. classical behavior
  - Extend to other *perturbations*: rf, 3D fields, others?

Draft milestone elements: context

Assess the effects of NB injection parameters on fast ion distribution function and beam driven current profile

- Fast ion behavior in **MHD-quiescent** tokamak plasmas can be reliably predicted by numerical codes based on **classical processes**, such as NUBEAM/TRANSP.
- However, more realistic **scenarios contemplate the presence of Alfvénic instabilities, rf injection, external perturbations (3D fields)**.
- Therefore, **improved understanding** of fast ion physics and wave-particle interaction processes **is required** to enable predictive capabilities for future devices (e.g. ITER, FNSF and **future ST-based devices**).
- **NSTX-U will broaden the parameter space of ST's, with significant overlap with conventional tokamaks.**
- **NSTX-U is well equipped to characterize the fast ion dynamics and** the resulting **NB driven current profile** in tokamak geometry, including the effects of fast ion driven instabilities and of additional rf heating.

Draft milestone elements: tools /1

- **NSTX-U will have three additional neutral beam (NB) sources** aimed at larger tangency radii than the original three sources on NSTX.

- The **improved flexibility in NB injection parameters** will enable more refined tailoring of the fast ion distribution, hence of the beam-driven current profile.

- The more tangential, **off-axis fast ion distribution from the new NB sources will modify the fast ion resonance with Alfvénic modes**.

Draft milestone elements: tools /2

- **The stronger magnetic field will also affect the mode** frequency and the resonance condition. In turn, instabilities may induce fast ion transport, thus determining a departure of the fast ion evolution from classical predictions.

- **In addition to NBI**, heating from the **30 MHz FW system** will shift from High to Medium Harmonic regime in the stronger magnetic field plasmas of NSTX-U. At lower harmonics, fast waves are expected to interact more strongly with ions.

- **Other tools** available to affect the fast ion distribution: **3D fields, others?**

- **Theoretical tools will be upgraded for more quantitative modeling**, e.g. improve modeling of **fast ion distribution**, include proper **rotation** model in NOVA, address the **strong non-perturbative drive** for stability calculations. Tools to be used and developed are ORBIT, NOVA-KN, SPIRAL, etc.

Draft milestone elements: strategy

- The **fast ion distribution will be characterized** through the upgraded set of NSTX-U fast ion diagnostics **as a function of NB injection parameters** (tangency radius, beam voltage) **and magnetic field**.

- **First, low NB power, single-source scenarios will be used** to compare fast ion behavior with classical models in the absence of fast ion driven instabilities.

- **Dedicated scans of FW injected power and spectrum** will provide data on the wave-particle interaction processes. **3D fields may also be used** to perturb the fast ion distribution in these well-controlled scenarios.

- **Then, experiments at progressively higher power** will explore the effects of instabilities on fast ion distribution modifications.

> ***NB driven current profile modifications will be assessed and modeled*** *for the parameter space attainable during the first year of NSTX-U operation.*

Discussion

- Do we want/need to include rf, 3D fields?
  - Important topics, but maybe too much for a Year 1 milestone?
  - Not mentioning them in the milestone doesn't mean we'll not have XPs on those topics
  - *Fast ion interaction with rf may well deserve a dedicated milestone in FY16*
- Will all relevant tools/diagnostics be available?
  - E.g.: rf experiments would greatly benefit from E//B NPA data – missing on day#1?
  - FIDAs, ssNPA, neutrons, sFLIP, magnetics, etc. are expected to be up & running
  - Other concerns?
- Modeling tools expected to be ready
  - NUBEAM/TRANSP w/ improved capabilities (fast ion transport, 3D halos, …)
  - Fast ion/*AEs codes available (NOVA-K, M3D-K, HYM, ORBIT, SPIRAL, …)
  - Upgraded rf codes eager to have new data for Verification&Validation
- Other issues?

Please email additional comments, suggestions to
G. Taylor, M. Podestà, N. Gorelenkov by noon Thu. 01/31