NSTX-U

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Particle control task force early run discussion

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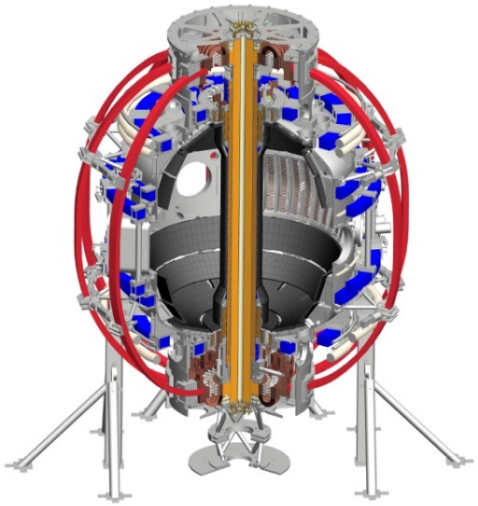
Particle Control Task Force Meeting
PPPL LSB B318
January 20, 2015



Particle Control Task Force (PC-TF) Guidance

- Co-Leaders: Rajesh Maingi, John Canik
- Task force goal:
  - "Develop pumping and fueling tools, operating scenarios, and control systems to achieve main-ion and impurity density control for long-pulse"
- Scope includes XPs related to:
  - Main-ion fueling optimization via PCS and/or real-time control
  - Wall coating and preparation optimization for increased particle pumping
  - Reduction / control of impurity ion source rates
  - Natural and paced ELMs for impurity and main ion flushing
  - Real-time density measurements for density feed-back control
  - Physics design and performance characterization of divertor cryo-pump (if/as resources permit implementation of cryo-pump)
- Due date: ASAP, end of FY16 run for non-cryo elements

Outline

- Task Force Goals (Duration: 2015-2018):
  - Confirm physics design calculations of the cryopump plenum geometry
  - Deploy a number of long pulse particle control techniques
  - Coordinate effort for density feedback implementation with cryo

- Early 2015 run priorities

- Discussion on timing of B -> Li transition

Particle Control Task Force – Cryo physics design

- Task Force Goals:
  - Confirm physics design calculations of the cryopump plenum geometry
    - Semi-analytic model and 2-D calculations used for physics design
    - Need divertor thermography, Langmuir probe data, D_α profiles, which should be available relatively early in run
    - Desire to do this with boronized conditions (<u>early</u>) and lithiated conditions, with follow up experiments in 2016 after installation of high-Z row (joint with M&P)

Particle Control Task Force – Techniques (1)

- Task Force Goals:
  - Deploy long pulse particle control techniques
    - Naturally occurring ELM regimes: easy to obtain in NSTX with boronization (early), but can also achieve with lithiumization with 'low' amounts of inter-shot deposition (50-100 mg)
    - Lithium Granule Injector (LGI) for ELM triggering in discharges with low natural ELM frequency (some LSN with boronization early, 'high' lithium doses for ELM-free)
      - Consider using LGI as tool to controlled B -> Li transition
    - LiTERs to reduce impurity sources
      - Downward facing evaporator available 'early', upward facing one in 2016

Particle Control Task Force – Techniques (2)

- Task Force Goals:
  - Deploy long pulse particle control techniques
    - Snowflake divertor and/or gas puffing to reduce divertor T_e and sources (joint with Boundary Science group)
      - Timing of the snowflake likely paced by PCS optimization
      - Can probably do the source study (piggyback early, including e.g. 3-D asymmetries and tile edges) and dedicated gas puffing first with boronized walls (early)
      - Recycling and particle balance can support these
      - Comprehensive suite of diagnostics to support these
    - 3-D fields for ELM destabilization (mostly with Li)
    - Li dropper for destabilization of micro-edge instabilities (2016+)
    - Cryopump + density feedback (2017+)

Outline

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Particle Control Task Force – Early Priorities

- Early 2015 run priorities:
  - Measure divertor profiles for cryopump physics design validation, under boronized (ELMy) conditions
  - Evaluate efficacy of naturally occurring ELMs for particle control, as basis for future cryo operation under boronized conditions
    - Important to get this for boronized walls in ELMy H-mode: proven density control technique in tokamaks, and a good basis for comparison with Li
    - Impurity sources; particle balance assessed
    - Optimized fueling (joint with ASC)
  - Evaluate LGI, 3D fields for ELM control with boronization
  - Deploy divertor gas puffing, and snowflake if available, with boronized walls
  - *Group discussion: possible early I-mode evaluation?*

Boron to Li Transition Timing – Views in Group

- First month of run (May) will probably be with boronized plasmas to develop 1 MA, 0.5 T H-mode fiducial
  - Provide a needed reference for comparison with Lithium (near term), and for cryopump experiments (longer term)
  - Recommended by PAC on several occasions
- Wide range of opinions on how to long spend on boronized plasmas
  - Span all the way from: spend the whole run with boronized walls to almost none of the run with boronized walls
  - Number of people stated centrist view, i.e. first month of research ops followed by B-> Li controlled transition
  - Machine will give us the operational answer
  - Boronization system was upgraded from NSTX, but PCS 'new'
- The boronized phase should be followed by a controlled introduction of Li as in 2008/2009, and planned for 2011

Boron to Li Transition Timing – When To Decide

- Evaluate after RF prioritization: which XPs require data w/boronization?
  - *Essentially same evaluation from 2011 (but different answer)*
  - R15-1: most groups want data (I_p, B_T, P_{NBI}) with boronized walls
  - Other XPS: for unique boronized walls study (e.g. M&P), and also as baseline comparison with Li evaporation
  - At present all three boundary TSGs, T&T TSG, and PC-TF have indicated a strong desire for high quality discharges with boronized walls (other groups speak up now?)
- Another consideration is evaluating need for vent: easier to do before we put Li into NSTX-U
- In practice, the machine will tell us: if we struggle in the first month re-developing a 1 MA, 0.5 T fiducial with B, then we should set an upper limit (+1 mo?) on additional attempts
  - ➢ Need to re-develop metrics on when to re-boronize: first H-mode required 3 TMB cycles (Nov. 2000)
- If discharges look good, then we should push to reaching NSTX-U first year goals with B, and consider extending B campaign if needed