

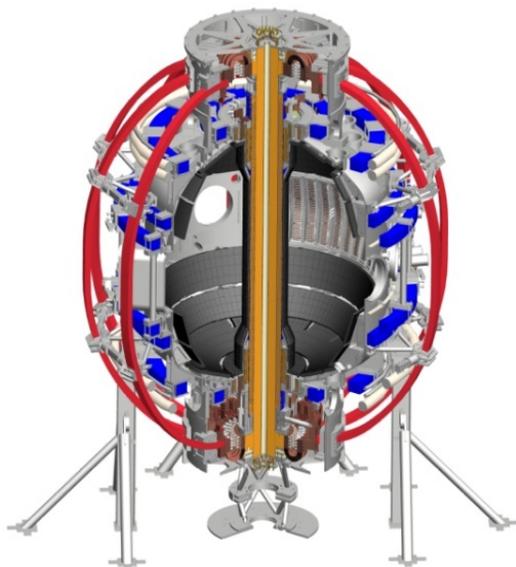
Characterization of 2nd NBI draft of XP plan

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NSTX-U Monday Meeting

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Primary goal of the XP over 2½ run days: initial characterization of 2nd NBI in H-mode plasmas

- Characterize NB heating and current drive with 1st + 2nd NBI
- Assess resulting modifications of pressure profile
- Explore variety of NBI configurations
 - Scan of tangency radius at fixed NBI power
 - Two-points I_p scan

> *Provide consistent data set for JRT-15, R15-2, ITPA*

- Builds upon “basic” XMPs:
 - Neutron calibration; FIDA/ssNPA/sFLIP checkout
 - NUBEAM sanity check, 2nd NBI checkout
- Complements “ I_p/B_t scan” XP (see SK’s presentation)
- Incorporates some cross-TSG needs/development/scoping

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Experiment has three parts with different focus: NB-CD, pressure profile, post-Li comparison

- All three parts run at same $B_t \sim 0.65T$
- Repeat each condition twice

- NB-CD vs NBI mix, 1 day
 - Run at low $I_p \sim 700kA$ for increase J_{NB} fraction
- Pressure profile vs NBI mix, 1 day
 - Increase $I_p \sim 1MA$ for better confinement
 - Also provide 2-points I_p scan for NB-CD
- Post-Li comparison shots, $\frac{1}{2}$ day
 - Planned $\sim 1/2$ day for subset of discharges from first 2 days

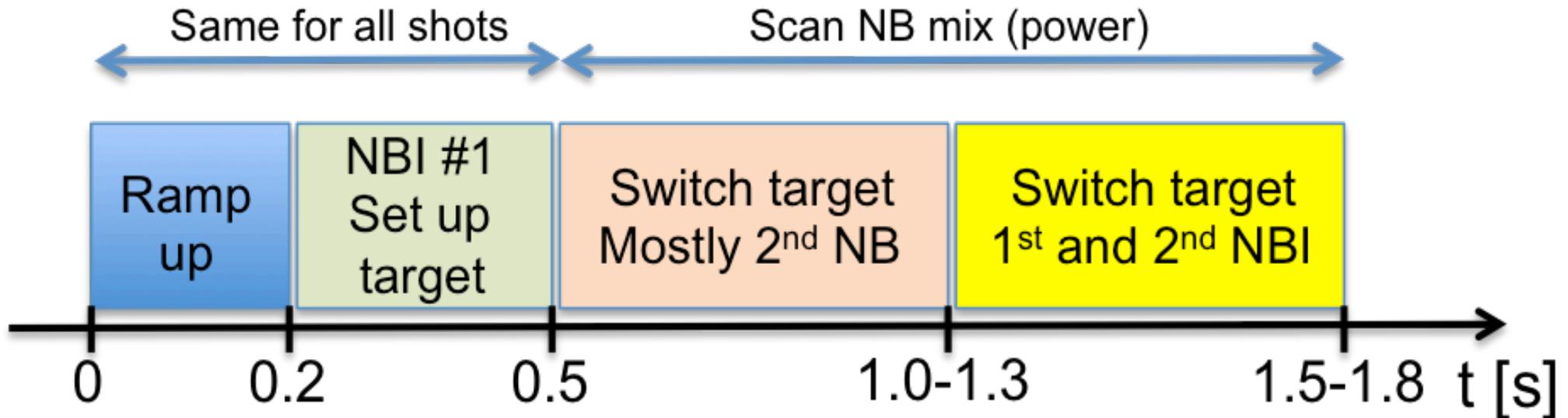
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- > ***Boron or Lithium? Tension between:***
 - *Running early, arguably with boronized PFCs*
 - *Wait for longer pulses, improved machine/diagnostics conditions*

Planned XP discharges include four main phases



- Phases #1, #2 are the same for all conditions
 - Modeled upon “fiducial-like” H-mode (minimize development time)
 - Provide reference for multi-run-day XP
 - Exception: low- n_e start-up, if/when available - discussed later
- Phase #3: main experiment w/ NBI scan
- Phase #4: additional data, home for secondary experiments
 - Transition from phase #3 also provides useful data for main XP

NB current drive studies explore J_{NB} profiles resulting from 1st + 2nd NBI mix

NB-CD scan, 1 day

| ID# | phase #1 | phase #2 | phase #3 | phase #4 | Notes |
|-----|---------------|----------|------------|------------|---|
| 1 | 1A, 1B (, 1C) | 1A, 1B | 1A,1B | 1A,1B | Reference for 4MW shots. Use NBI #1 only. Use 1C if additional pre-heating is required to slow down qmin evolution. |
| 2 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C | 1A, 2B | Part 1, 4MW shot, on-axis |
| 3 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2B | 1A, 2A | Part 1, 4MW shot, intermediate |
| 4 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2A | 1A, 2C | Part 1, 4MW shot, off-axis |
| 5 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 1C | 1A, 1B, 1C | Reference for 6MW shots. Use NBI #1 only. Use 1C if additional pre-heating is required |
| 6 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1C, 2C | 1A, 2C, 2B | Part 1, 6MW shot, intermediate |
| 7 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1C, 2B | 1A, 2B, 2A | Part 1, 6MW shot, intermediate |
| 8 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B | 1A, 2B, 2A | Part 1, 6MW shot, on-axis |
| 9 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2B, 2A | 1A, 2C, 1B | Part 1, 6MW shot, off-axis |
| 10 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B | 1A, 2C, 2B | Part 1, 4MW-equiv. with sources 2C, 2B, 2A @65kV, on-axis |
| 11 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2A | 1A, 2C, 2A | Part 1, 4MW-equiv. shot, intermediate |
| 12 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2B, 2A | 1A, 2B, 2A | Part 1, 4MW-equiv. shot, off-axis |
| 13 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2B, 2A | 1A, 2C, 2B | Part 1, 4MW-equiv. shot, intermediate |

priority 1
 priority 2

- Source 1A required for MSE measurements
- First run day provides *minimum* set of data for JRT, milestone
 - Should run early in the Run - most probably with boronized PFCs

Pressure profile studies target peaked vs broad profiles as NBI mix is varied

pressure broadening with boronized PFCs, 1 day

| ID# | phase #1 | phase #2 | phase #3 | phase #4 | Notes |
|-----|---------------|----------|----------------|------------|--|
| 14 | 1A, 1B (, 1C) | 1A, 1B | 1C, 2A | 1C, 2A | Part 2, 4MW shot, broad pressure, steady |
| 15 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2B | 1A, 2B | Part 2, 4MW shot, intermediate peaking |
| 16 | 1A, 1B (, 1C) | 1A, 1B | 2C, 2B | 2C, 2B | Part 2, 4MW shot, most peaked |
| 17 | 1A, 1B (, 1C) | 1A, 1B | 2C, 2B | 1C, 2A | Part 2, 4MW shot, transition peaked -> broad |
| 18 | 1A, 1B (, 1C) | 1A, 1B | 1B, 1C, 2A | 1B, 1C, 2B | Part 2, 6MW shot, broad pressure |
| 19 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 2C | 1A, 1B, 2B | Part 2, 6MW shot, intermediate peaking |
| 20 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 2B | 1A, 1B, 2C | Part 2, 6MW shot, intermediate peaking |
| 21 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B | 1A, 2C, 2B | Part 2, 6MW shot, most peaked |
| 22 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B | 1C, 1B, 2A | Part 2, 6MW shot, transition peaked -> broad |
| 23 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 1C, 2A | 1C, 1B, 2A | Part 2, 8MW shot, broad pressure |
| 24 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 2B, 2A | 1A, 2B, 2A | Part 2, 8MW shot, intermediate peaking |
| 25 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B, 2A | 1A, 2C, 2B | Part 2, 8MW shot, intermediate peaking |
| 26 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 2C, 2B | 1A, 2C, 2B | Part 2, 8MW shot, most peaked |

 *priority 1*
 *priority 2*

- Relax requirements on source 1A (insert 'blips' as needed)
- If sufficient progress is made on low- n_e start-up:
 - Repeat conditions #14 through #17 at lower (initial) density
 - Move #23 through #26 ($P_{NB}=8\text{MW}$ conditions) to lower priority

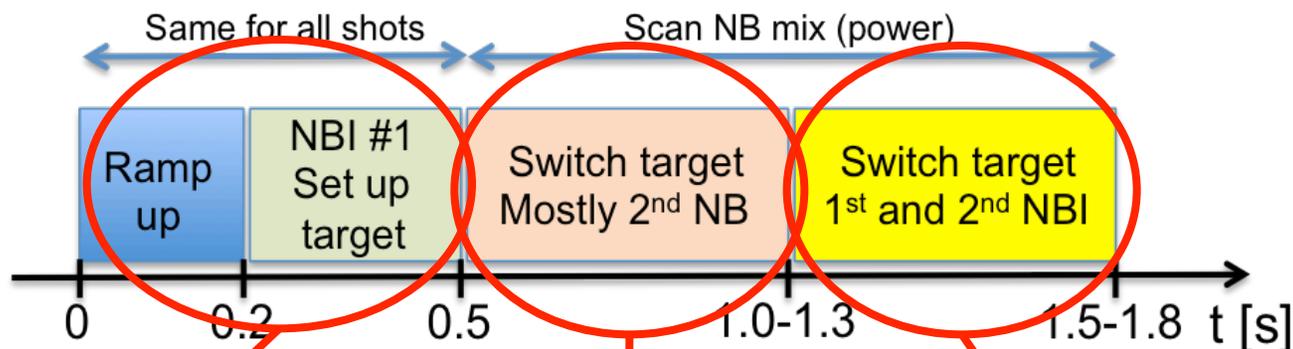
A subset of conditions will be revisited after transition to lithiated PFCs

pressure broadening with Li-PFCs, 1/2 day

| ID# | phase #1 | phase #2 | phase #3 | phase #4 | Notes |
|-----|---------------|----------|------------|------------|--|
| 28 | 1A, 1B (, 1C) | 1A, 1B | 1C, 2A | 1C, 2A | Part 2, 4MW shot, broad pressure, Li-PFC |
| 29 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C | 1A, 2C | Part 2, 4MW shot, intermediate peaking |
| 30 | 1A, 1B (, 1C) | 1A, 1B | 2C, 2B | 2C, 2B | Part 2, 4MW shot, most peaked |
| 31 | 1A, 1B (, 1C) | 1A, 1B | 1B, 1C, 2A | 1B, 1C, 2B | Part 2, 6MW shot, broad pressure, Li-PFC |
| 32 | 1A, 1B (, 1C) | 1A, 1B | 1A, 1B, 2C | 1A, 1B, 2B | Part 2, 6MW shot, intermediate peaking |
| 33 | 1A, 1B (, 1C) | 1A, 1B | 1A, 2C, 2B | 1A, 2C, 2B | Part 2, 6MW shot, most peaked |

- Repeat sub-set of conditions for pressure profile (some NB-CD) studies after transition to Lithiated PFCs
- Assuming first 2 run days in Boronized PFCs - TBD

Discharges can accommodate needs for development shots, scoping activities – but NO room for “complete” XPs



“Passive” measurements that do not perturb the main XP

CAUTION
KEEP
HANDS OFF

More flexibility in varying settings for diagnostics, RMP/NTV, et al.

- Example: NTV set-up discharges in part #4 (~14 shots)
- Other possible scoping activities:
 - Transients for rotation, q-profile control (ASC TSG)
 - HHFW in H-mode (WHCD TSG)
 - Controlled ramp-down (ASC TSG)

> *Bring up your ideas, let's discuss if/how they fit into phase #4*

Considerations on NBI, diagnostics settings

NBI

- Need reduced injection voltage for “4MW equivalent” shots
- NB notches required for diagnostic purposes

Diagnostics

- Assume MSE is ~OK with 2nd NB injecting
 - To be confirmed
- Main issues is CHERS measurements with 2nd NBI
 - Conservative approach – notch 2nd NBI every ~100ms in phase #3
 - Use 10-20ms ‘blips’ with 1st NBI sources for n_c , Z_{eff} , n_i , T_i , v_{tor} data
 - Different strategy may be required for phase #4 (e.g., NTV exp’t)
 - Will re-evaluate during early phase of the Run

Backup

List of conditions for NTV set-up

| A) Shots taken as part of "2nd NBI XP" (Podesta, et al.) | | | | | | | | | | | |
|--|-------------------|------------|--------------------|-------------------|----------------|-----------------------------|------------------------|-------------------|-------------------------------------|----------------------|---|
| - expected plasma condition: $B_t = 0.65T$, $I_p = 0.7$ MA, most likely with Li wall conditioning, but could be B wall conditioning | | | | | | | | | | | |
| - operation of 3D field during "Phase #4" of the shot (last phase, with potential duration $\sim 0.5s$) | | | | | | | | | | | |
| - Period with no strong rotating MHD needed | | | | | | | | | | | |
| - Aim to have T_i higher than in NSTX in some shots, but this is not required | | | | | | | | | | | |
| "2nd NBI XP" ID# | NTV condition ID# | NBI mix | Planned I_p (MA) | Planned B_t (T) | NBI Power (MW) | (Planned) Wall conditioning | 3D field configuration | 3D field waveform | Default 3D field step duration (ms) | Number of good shots | Comments |
| 4 | 0b, 1a | 1A, 2C | 0.7 | 0.65 | 4 | B | n = 3 | stepped | 75 | 1 | "off-axis" configuration |
| 5 | 0a, 1a | 1A, 1B, 1C | 0.7 | 0.65 | 6 | B | n = 3 | stepped | 75 | 1 | Shot with all NBI#1 sources only - for Neal Crocker, add NBI notches for Deyong Liu |
| 7 | 0b, 2a | 1A, 2B, 2A | 0.7 | 0.65 | 6 | B | n = 2 | stepped | 75 | 1 | "intermediate" configuration |
| 8 | 0b, 1a | 1A, 2B, 2A | 0.7 | 0.65 | 6 | B | n = 3 | stepped | 75 | 1 | "on-axis" configuration, add NBI notches for Deyong Liu |
| 9 | 0b, 1a | 1A, 2C, 1B | 0.7 | 0.65 | 6 | B | n = 3 | stepped | 75 | 1 | "off-axis" configuration |
| 19 | 0b, 3 | 1A, 1B, 2B | 1.0 | 0.65 | 6 | B | n = 3 to n = 2 | stepped | 75 | 1 | |
| 19 | 0b, 3 | 1A, 1B, 2B | 1.0 | 0.65 | 6 | B | n = 3 to n = 2 | stepped | 75 | 1 | May need a second shot for this request |
| 20 | 0b, 5 | 1A, 1B, 2C | 1.0 | 0.65 | 6 | B | single coil | stepped | 75 | 1 | SUGGEST adding n = 1 active control |
| 20 | 0b, 5 | 1A, 1B, 2C | 1.0 | 0.65 | 6 | B | single coil | stepped | 75 | 1 | May need a second attempt at this |
| 21 | 0b, 2a | 1A, 2C, 2B | 1.0 | 0.65 | 6 | B | n = 2 | stepped | 75 | 1 | add NBI notches for Deyong Liu |
| 23 | 0c, 1a | 1C, 1B, 2A | 1.0 | 0.65 | 8? | B | n = 3 | stepped | 75 | 1 | Q: 8 MW in Phase #4?? Add NBI notches for Deyong Liu |
| 24 | 0c, 2a | 1A, 2B, 2A | 1.0 | 0.65 | 8? | B | n = 2 | stepped | 75 | 1 | Q: 8 MW in Phase #4?? Add NBI notches for Deyong Liu |
| 32 | 0b, 1a, 4 | 1A, 1B, 2B | 1.0 | 0.65 | 6 | Li | n = 3 to n = 1 | stepped | 75 | 1 | "intermediate peaking" configuration |
| 33 | 0b, 2a, 4 | 1A, 2C, 2B | 1.0 | 0.65 | 6 | Li | n = 3 to n = 1 | stepped | 75 | 1 | "most peaked" configuration |