

# XP1567 – NBI overdrive w/o RF

- Motivation:

- Non-inductive ramp-up requires combination of RF+NBI

- (EC+NBI)

- (HHFW+NBI)

- (EC+HHFW+NBI)

- Or coupling of NBI directly to the CHI target (unlikely)

- Startup/ramp-up plasma not the same as stationary, 300kA

- Issues:

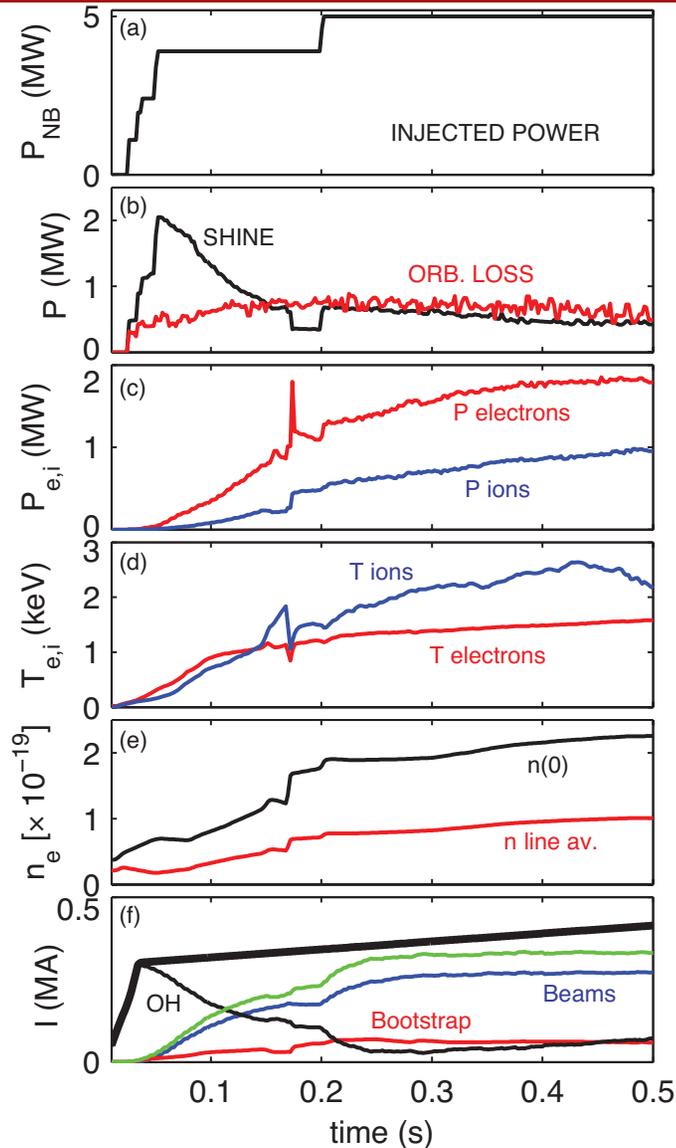
- Plasma becomes over-dense to EC => leaving current gap

- HHFW driven current drops after L-H transition => same

- NBI losses are large at low current

- Current profiles need to be tailored to avoid disruptions => aim at broader deposition, avoid peaked profiles

# Aim at optimal NBI mix to minimize losses and maximize current drive



- Optimize beam configuration to:
  - minimize shine-thru and losses
  - maximize non-inductive current

Simulations indicate that:

- Using the 2<sup>nd</sup> beamline at low current/density ( $t < 200$ ms) not possible unless energy is low ( $\sim 60$ - $65$ keV)
- Combining 2<sup>nd</sup> and 1<sup>st</sup> beamline needed for current profile tailoring (for broader profiles)
- The plan is to combine NBI#1 (all lines of injection) and NB#2 (1 up)

# Experimental plan, part I (1/2 day)

- Focus: “fill-up” current with non-inductive, **broad** profiles
- Target 300-400 kA,  $n \sim 0.65 n_G$
- Start with NBI#1
  - 1C (70kV)@100ms, 1B (70kV)@400ms, 1A (70kV)@500-600ms (add 1/shot to build-up) [4 shots]
  - 1C (65kV)@50ms, 1B (70kV)@200ms, 1A (75kV)@400ms [4 shots, on top]
- Add NBI#2
  - Start with 60kV, 3 shots (2A, 2B, 2C) start@400ms, @300, @200, @100ms
  - Increase to 65kV, 3 shots (2A, 2B, 2C) start @400ms, @300ms, @200ms
  - Depending on results:
    - Anticipate 2<sup>nd</sup> and 3<sup>rd</sup> source from NB#1 (with 1 chosen 2A/B/C)
    - Add sources to NB#2 and/or increase energy

NOTE: plan for CHERS measurements, 1 window of 20ms during each NBI power step

# Experimental plan, part II (1/2 day)

- Target 400-600 kA => focus: NBI overdrive, rampup
- Start from previous day and clamp OH at 300kA
- Combine heating+current (modulate NB#2@higher kV)
  - Use NBI#1 for heating/current
  - Use NBI#2: 1 source at 60-65keV for heating (from 50ms), 1-2 sources at higher energy, but modulated (for current, starting 300 and 400ms).
  - depending on results, increase energy of 1A (up to 90kV)
  - or move 1B, 1A ahead
- Add NBI#2 (low energy for heating, high energy for current)
  - 1 source 60kV (2A/B/C ?) start @earliest achievable (previous day)
  - Add 1 source at a time, higher energy, modulated (for current)
  - Depending on results:
    - Change timing of switch-on, increase energy of source

**NOTE: plan for CHERS measurements, 1 window of 20ms during each NBI step**

# Simulations in preparation of XP

- Simulate combinations of NBI sources (to avoid combinations of switch-on, energy and tangency radius that disrupt already in the simulations)
- Run the simulations w/o PF1A (and probably wait for new scenario development at restart)

# Expected output from these experiments

- Plasmas with NBI at low current and density that can be used to improve EC/EBW-NBI in preparation of fully non-inductive operation [N. Lopez, APS+paper]
- Data for optimization of current control in startup/rampup [W. Wehner, APS+paper]
- Data for validation of NUBEAM/transport at low current
- First demonstration of NBI overdrive and non-inductive ramp-up up to 500-600kA, validation of transport in transient conditions [F. Poli, publication]