NSTX-U

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TSG/SG discussion on XPs for the characterization of 2nd NBI line

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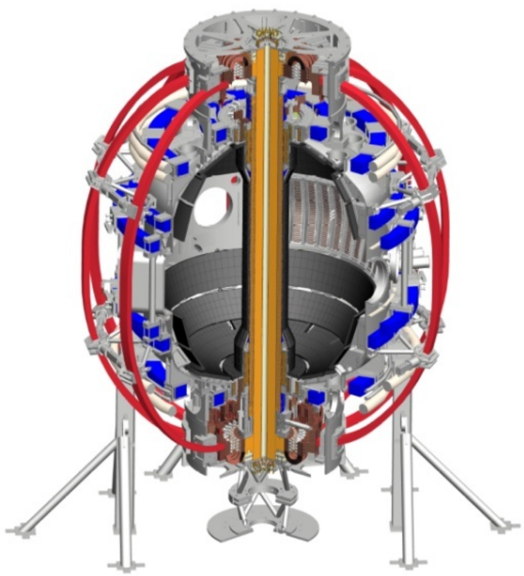
M. Podestà *et al.*

Feb. 18, 2015



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Layout

- *Expected NB capabilities*
- *Update on diagnostics for NB characterization XPs*
- *Goals*
- *Planned XPs (EP-TSG et al.)*
- *Discussion*

What can we expect from NBI systems?

- Modulation allowed after initial NB checkout/commissioning
  - How long is that phase expected to be?
- Number of pulses limited ~20 cycles/source
- Minimum modulation cycle: 20ms/20ms ON/OFF
  - May be revised depending on source de-conditioning resulting from modulation
- Injection voltage: 65-90kV
  - Exception: V_{inj}~40kV for neutron calibration XMP?
- Voltage scan possible on shot-to-shot basis
  - May affect shot cycle

Update on critical diagnostics

- MPTS
- CHERS
- MSE
- Fast ion diagnostics (neutrons, FIDA, NPAs, sFLIP)
- *Other diagnostics on critical path?*

Constraints of NB and Diagnostics Operations

- NB: limited modulations (no faster than 20ms on 20ms off to protect ion source, <20 blips for each source

  1A: R_{tan}=70cm, 1B: R_{tan}=60cm, 1C: R_{tan}=50cm

  2A: R_{tan}=120cm, 2B: R_{tan}=110cm, 2C: R_{tan}=100cm

- Discharge cycle: 1 shot every 20 minutes → ~20 shots/day max

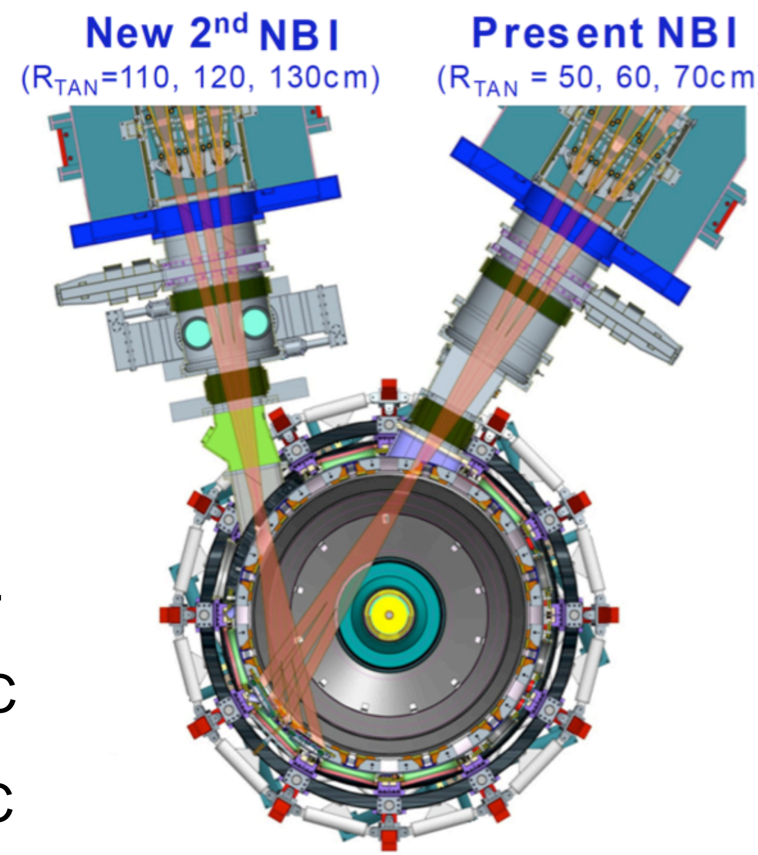
- MSE: optimized for NB source 1A at 90kV

- CHERS: require 1A/B/1C, two sources greatly improve S/N;
- 2A/2B/2C cause uncertainties in background views

- FIDA: require 1A/1B/1C, prefer low-medium density.

- r-SSNPA: require at least one source from 1A/1B/1C

- t-SSNPA: require at least one source from 2A/2B/2C



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XP goals expected to shift from initial "basic" characterization/checkout to NB-CD, confinement physics

Initial 4 weeks

NB checkout:

Are different NB lines behaving "as expected"? Are results consistent with "classical" expectations (NUBEAM)?

After initial 4 weeks

Milestone R15-2:

Assess effects of NBI parameters on fast ion distribution function, NB driven current profile.

FY15 FES Joint Research Milestone:

Quantify impact of broadened current and pressure profiles on confinement and stability.

(Arguably) 2-year time-scale

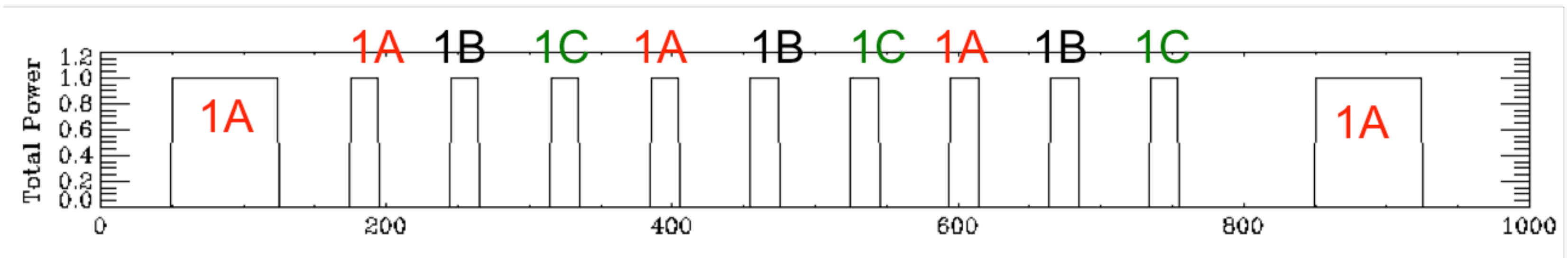
ITPA-EP Joint Experiment on NB-CD

NSTX-U/PPPL to lead the task (details to be discussed at March ITPA-EP meeting).

Initial NB checkout: compare NB performance (neutron rate, prompt losses, etc.) to *classical* predictions from NUBEAM

- **Goal: To verify consistency between exp't and NUBEAM modeling in quiescent plasmas (where classical fast ion physics is expected) with on-axis and off-axis neutral beams**
  i. Compare neutron build-up/decay rates from beam blip experiments with TRANSP calculation
  ii. Compare prompt losses (sFLIP) with predictions through I_p scan

Ex: beam blips for **on-axis beams** (NSTX-like plasma 0.5T, 0.8MA)



1A: 20ms pulses
1B: 20ms pulses
1C: 20ms pulses
50ms between blips

- Shots w/ 1A(90kV)-1B(90kV)-1C(90kV), unlikely a quiescent discharge
- Shots w/ 1A(65kV)-1B(65kV)-1C(65kV), weak CHERS signal, no MSE data

Target for first ~8 weeks of EP research: establish baseline for JRT-15 & R15-2

Proposed topics for initial XPs:

- On- vs. off-axis NB for “fiducial-like” H-mode
  - Use “standard” H-mode target(s) with P_{NB}=4-8MW
  - Perform initial assessment of J_{NB} vs NBI source mix
  - Perform initial assessment of pressure/stability vs NBI source mix

Possible spin-offs from main (cross-TSG/SG) XPs:

- Power scan, explore P_{NB}>6-8MW (beta limit)
- Dependence of fast ion distribution on NBI parameters
  - Systematic scans of tangency radii, *NBI energy*
  - Assess resulting F_{NB}; initial characterization of *AEs vs. F_{NB}
- *Others …*

Proposed matrix for J_{NB} vs. NBI mix XP [adapted from J. Berkery's table]

	4MW	6MW	8MW*
On-axis	50, 110	50, 60, 110	50, 60, 70, 110
Balanced	50, 120	50, 110, 120	50, 60, 110, 120
Off-axis	50, 130	50, 120, 130	50, 60, 120, 130

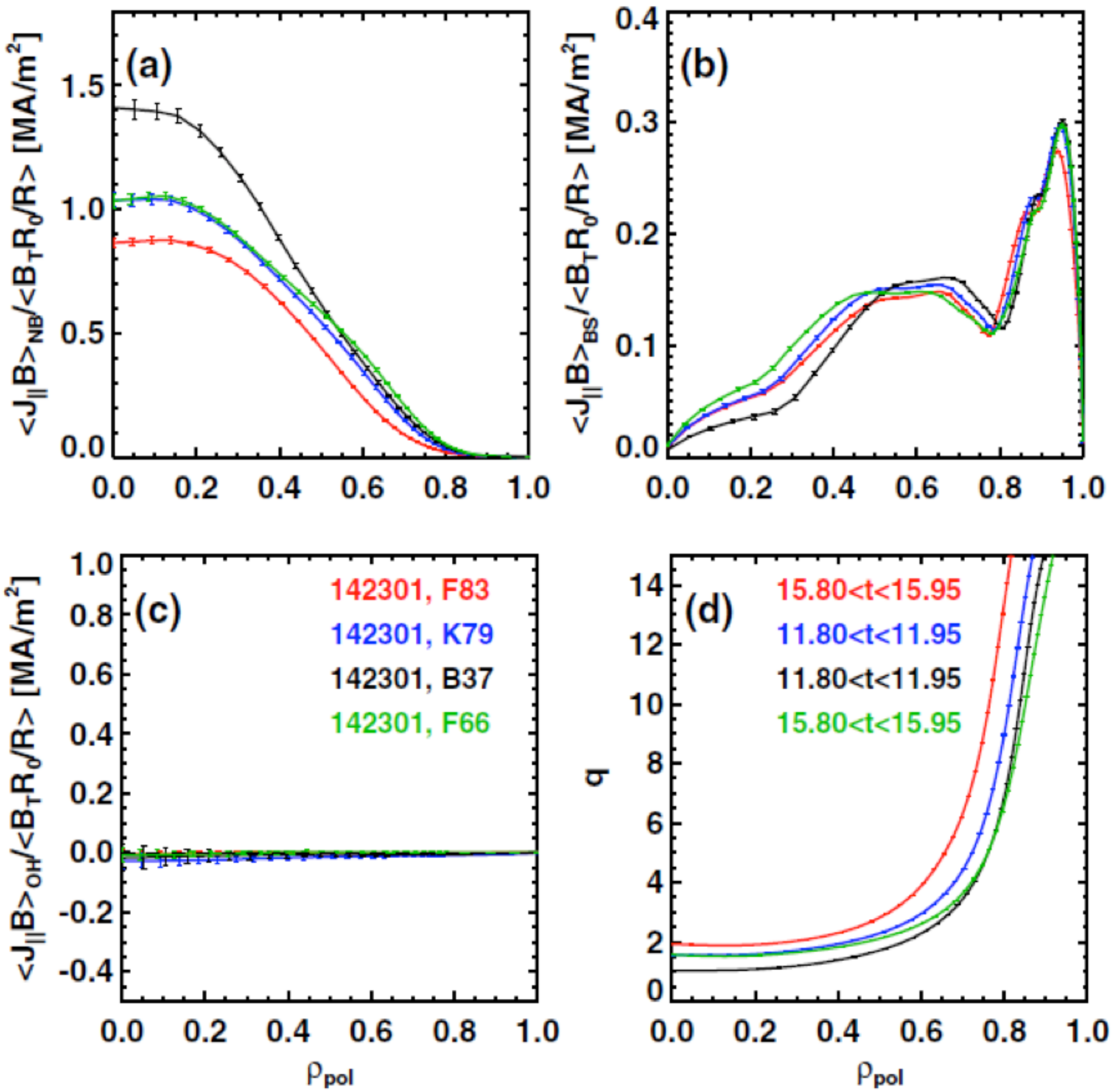
- In fiducial H-mode condition?
  - Yes, to limit discharge development & have reliable target
- More than one I_p, B_t setting?
  - Favor low-I_p ~700kA for high non-inductive fraction; high B_t~0.7T for f.i. confinement
  - To be coordinated with I_p/B_t scan XPs
- 10MW? 12 MW? How high in power can we go initially?
  - (Arguably) easier to characterize J_{nb} contribution from different source at lower P_{NB}

Proposed matrix for pressure/stability vs. NBI mix XP [adapted from J. Berkery's table]

	4MW	6MW	8MW*
Least peaked	50, 130	50, 60, 130	50, 60, 70, 130
Mix	70, 110	60, 70, 110 or 70, 110, 120	70, 110, 120, 130
Most peaked	110, 120	70, 110, 120	60, 70, 110, 120

- In fiducial H-mode condition?
  - Yes, to limit discharge development & have reliable target
- More than one I_p, B_t setting?
  - Requires I_p/B_t scans; extend previous table to high I_p
  - To be coordinated with I_p/B_t scan XPs
- *10MW? 12 MW? How high in power can we go initially?*
- *Should be repeated after transition to Li-PFCs (broader profiles)?*

Examples from *S.P. Gerhardt et al., NF 52, 083020 (2012)*



All: E_{inj}=90 kV, P_{inj}=8.4 MW, B_T=1.0 T, $H_{98y,2}$=1, f_{GW}=0.7, f_{NI}=100%

R_{tan}=[50,60, 70, 130] cm, I_p=675 kA, q_{min}=1.88

R_{tan}=[50,60, 120,130] cm, I_p=740 kA, q_{min}=1.54

R_{tan}=[60,70, 110,120] cm, I_p=770 kA, q_{min}=1.03

R_{tan}=[70,110,120,130] cm, I_p=800 kA, q_{min}=1.51