Low beta, low-density locked mode studies

Clayton E. Myers
S. P. Gerhardt, J.-K. Park, and J. E. Menard

**XP 1506
MS TSG Review
May 20, 2015**

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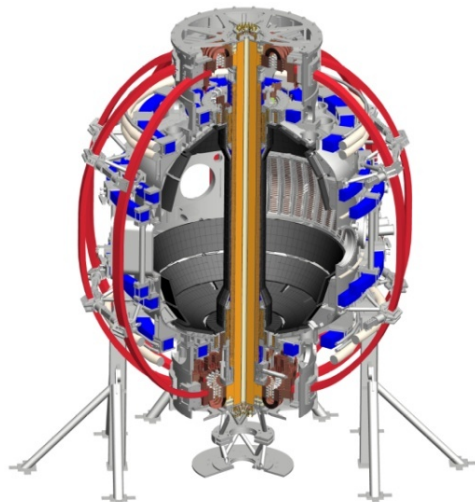
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XP 1506: Low-beta, low-density locked mode studies

- Goals:
  - Initial assessment of n=1 error fields in NSTX-U
  - Obtain optimal feed-forward n=1 correction (compass scans)
  - Connect to the NSTX locked mode database (multiple targets)?
  - Address transient error fields during startup?

- Allocation:
  - 0.5 run days (non-XMP CCE) → ~12 shots
  - 25% in weeks 1-4, 75% in weeks 5-8

Error field considerations for NSTX-U

- ## New PF5 mechanical supports
  - Previous $n=1,3$ spectrum modified (worse?)
  - New supports could produce $n=2$ component

- ## New CS → modified/absent OH×TF
  - New coaxial OH leads should alleviate the previous OH×TF error fields

- ## Vacuum vessel modifications
  - New J/K cap for NB2 → non-axisymmetric vessel currents during ramp?
  - New NB armor inside vessel

- ## Unanticipated EF sources are possible or even probable
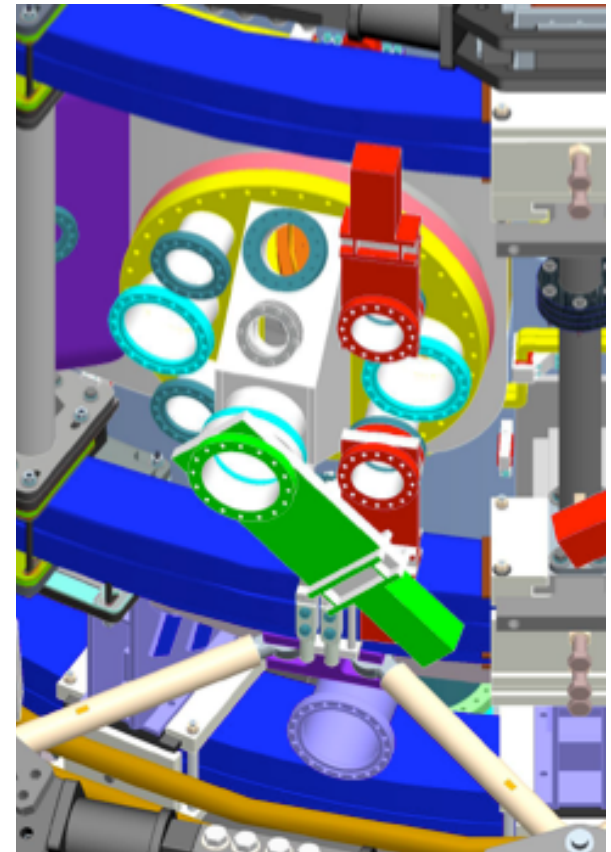
New Bay J Port

Preparation for plasma operations

- ## Coil shape measurements
  - Physically measure the PF3/4/5 coil shapes prior to plasma operations
  - Characterize deviation from 2010 measurements (see right)

- ## AC vacuum shots (XMP)
  - Fire during magnetics calibration
  - Assess axisymmetry of vessel eddy currents during the ramp phase
 - Important for assessing the impact of vessel changes on low-density startup
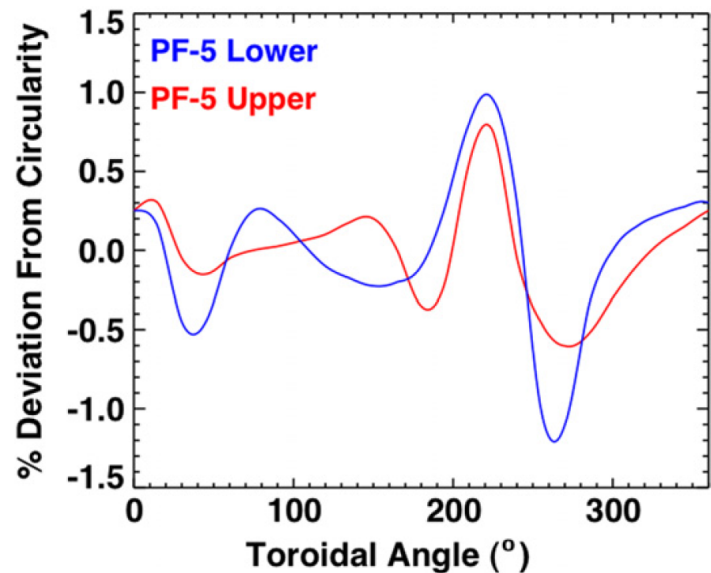
Gerhardt et al., *PPCF* **52** 104003 (2010)

Diagnostic & target plasma requirements

- Diagnostics:
  - RWM/EF sensors (locked modes)
  - CHERS (rotation)
  - Disruptions

- Target plasmas:
  - Best L-mode discharge from the commissioning phase
  - Use NB1 only to get routine CHERS operation
  - Move toward lower density L-mode target?

- Hardware requirements:
  - RWM coils + SPAs
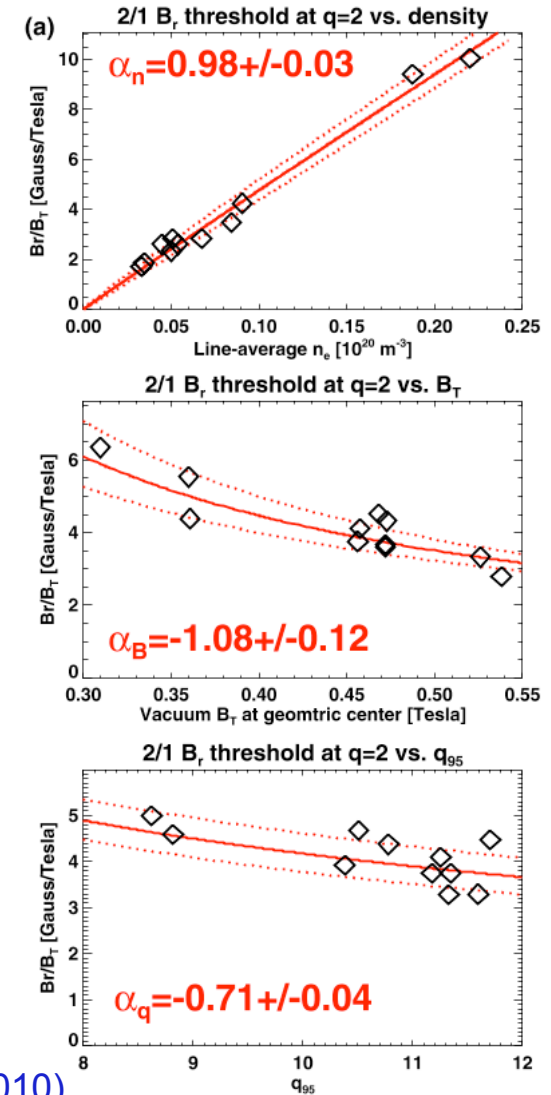
Initial compass scan (3-4 shots)

- Ramp applied *n*=1 amplitude at fixed phase (early flat top)
- Three-point compass scan on L-mode target from commissioning
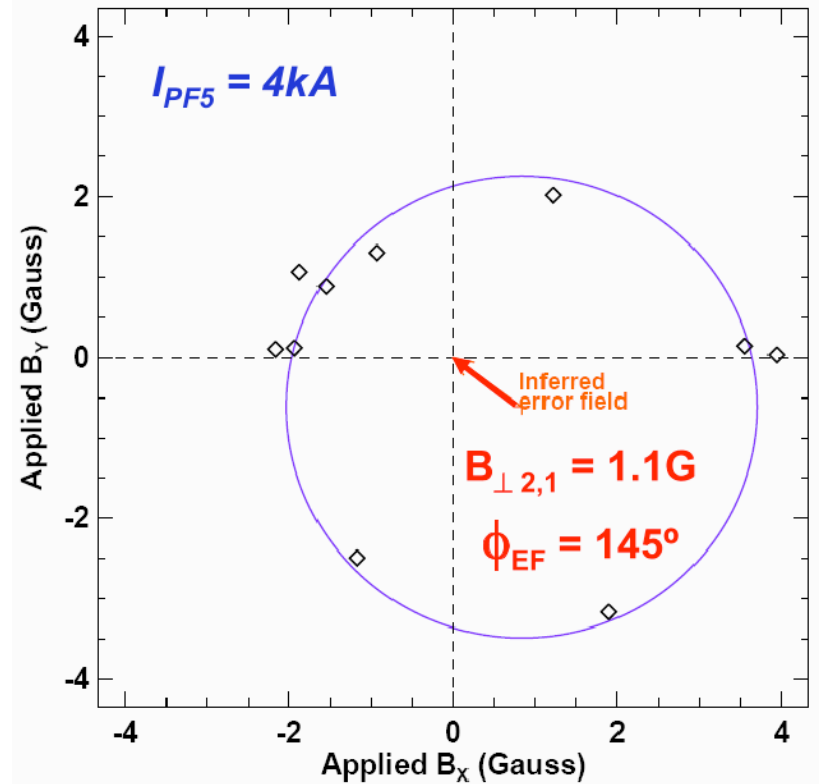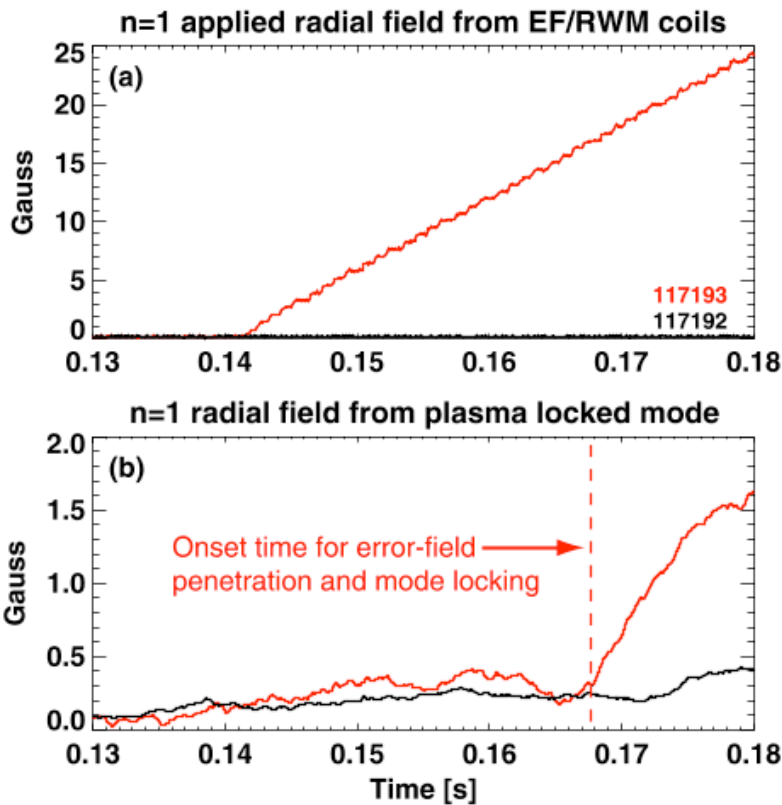
Menard et al., *NF* **50**, 045008 (2010)
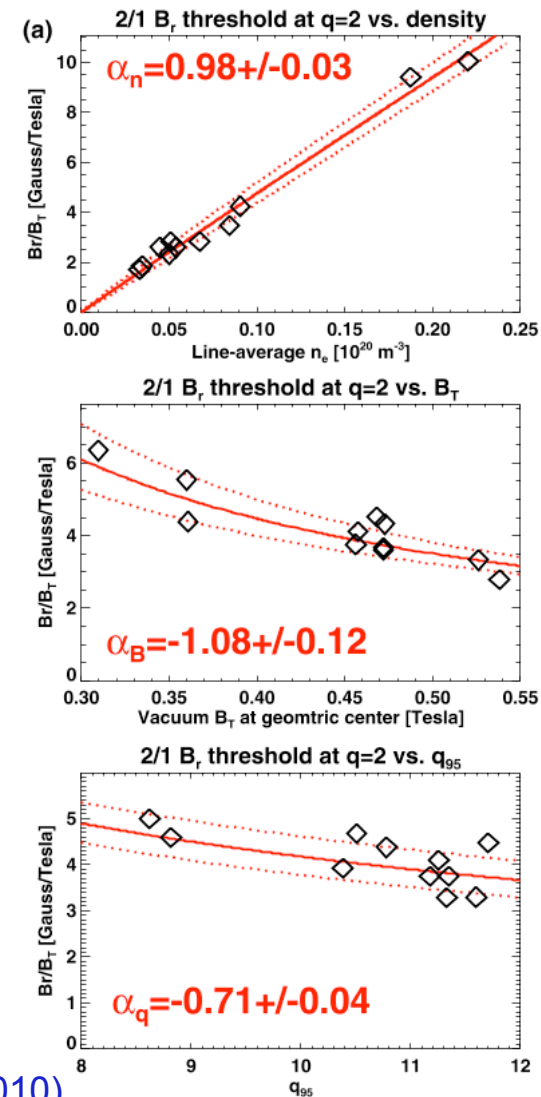
How to best use the remaining 8-9 shots?

- **Option 1: Connect to the NSTX locked mode database**
  - Strong density scaling
  - BT and q95/li also important

- **Compass scans on new targets:**
  - Lower the density?
  - Related to Devon's low density startup XP?

2/1 B_r threshold at q=2 vs. density
α_n=0.98+/-0.03

2/1 B_r threshold at q=2 vs. B_T
α_B=-1.08+/-0.12

2/1 B_r threshold at q=2 vs. q_{95}
α_q=-0.71+/-0.04

Menard et al., *NF* **50**, 045008 (2010)

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- **Option 2: Improve transient EFC during startup**
  - Assess transient vacuum EFs from XMP
  - Link applied n=1 amplitude to PF5 current
  - Scan different phases
  - Compare rotation and/or locking

(a) 2/1 B_r threshold at q=2 vs. density

α_n=0.98+/-0.03

2/1 B_r threshold at q=2 vs. B_T

α_B=-1.08+/-0.12

2/1 B_r threshold at q=2 vs. q_{95}

α_q=-0.71+/-0.04

Menard et al., *NF* **50**, 045008 (2010)

Preliminary shot plan (~12 shots total)

- ## Initial compass scan (3-4 shots):
  - Ramp n=1 perturbation during flat top

- ## Option 1: Connect to NSTX locked mode database
  - Compass scans on lower density targets

- ## Option 2: Transient EFC during startup
  - Link n=1 amplitude to PF5 current, scan phase

- ## Analysis:
  - Determine optimal n=1 correction from compass scan
  - Compare to physical measurements of PF5 coil
  - If transient EFC addressed, compare to XMP findings