Error Field Correction in NSTX-U

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NSTX-U Research Forum
MS TSG Breakout Session
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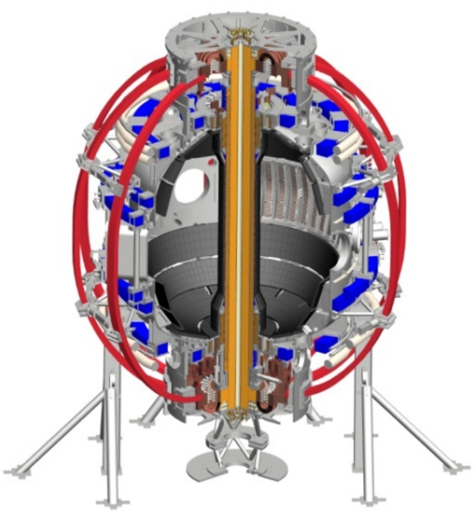
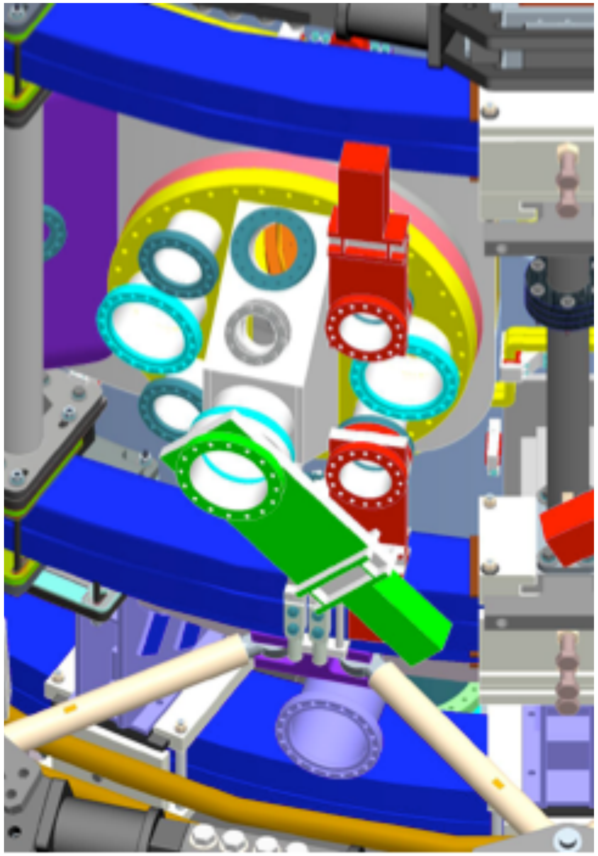


Error Field Considerations for NSTX-U

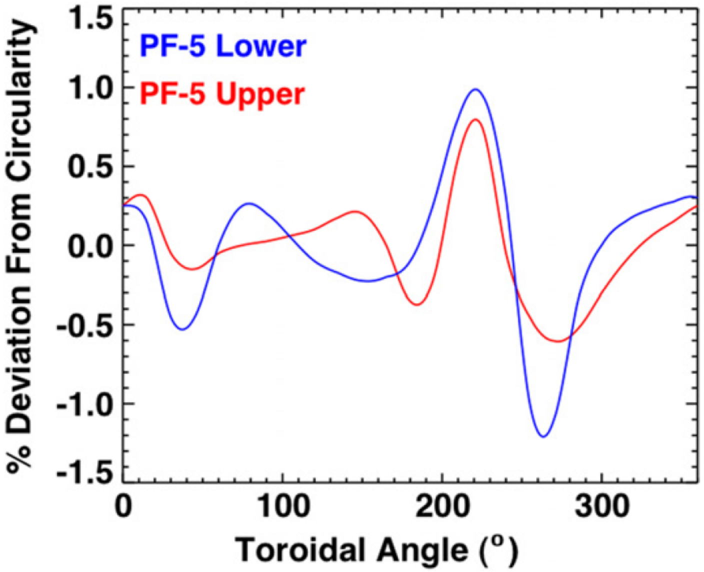
- New PF5 mechanical supports
  - Previous n=1,3 spectrum modified (worse?)
  - New supports could produce n=2 component
- New CS → modified/absent OH×TF
  - New coaxial OH leads should alleviate the previous OH×TF error fields
- Vacuum vessel modifications
  - New J/K cap for NB2 → non-axisymmetric EFs during current 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
  - 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)

Compass Scan Error Field XPs

- Goal: Assess NSTX-U error fields at low and then high β
- Error Field XP #1: Low-β, low-density locked mode studies
  - *n*=1 compass scans at multiple phases and amplitudes
  - Should run early in the campaign (the RWM sensors are required)
  - Diagnose with locked modes + disruptions (rotation available?)
  - Quick look at *n*=2,3 time permitting
  - Applications for low-density startup → ASC long pulse XP

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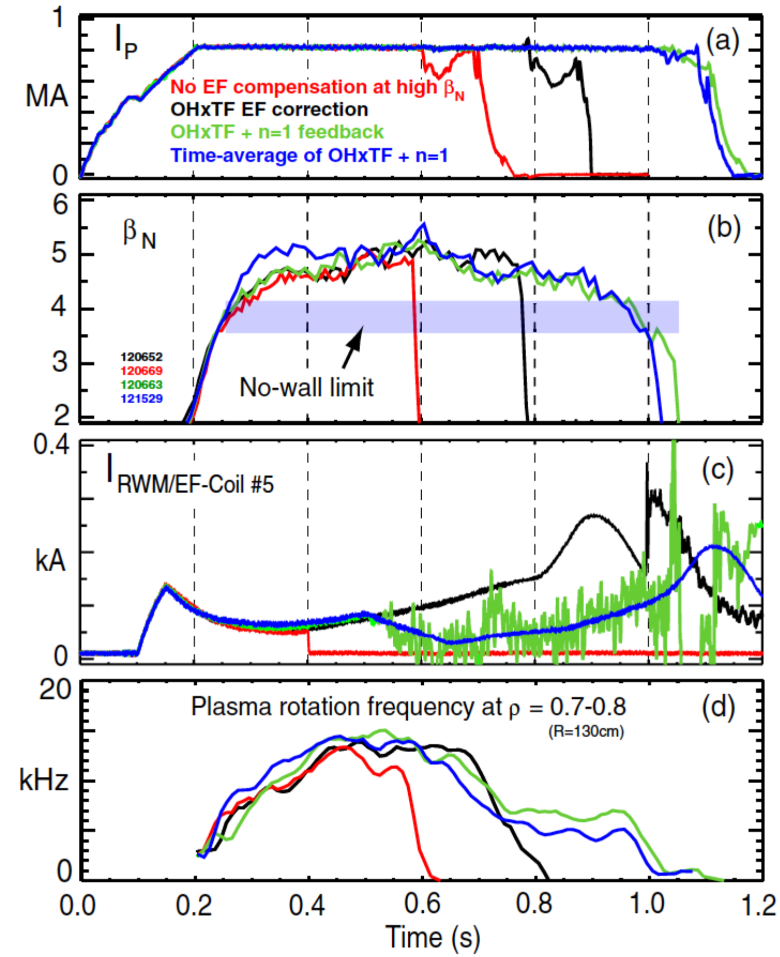
  - Applications for low-density startup → ASC long pulse XP
- Error Field XP #2: High-β *n*=1,2,3 compass scans
  - Intra-shot modulation and/or "spiral" *n*=1,2 scans
  - Diagnose with both rotation and locked modes + disruptions
  - Best if run with inter-shot rotation data → beam constraints?
  - Flip *n*=3 polarity and scan amplitude to compare to NSTX [Gerhardt 2010]
  - Apply sufficient *n*=3 amplitude for magnetic braking (Berkery/Columbia)

Dynamic Error Field Correction XP

- Previous results
  - Longest NSTX discharges achieved with real time n=1 EF correction
  - Standard component of NSTX operation
- Error Field XP #3: Optimization of PID dynamic error field correction
  - The mode ID upgrade (miu) algorithm corrects for static and AC pickup on the RWM sensors
  - Tune the amplitudes, phases, and gains in the miu-based PID feedback algorithm
  - Utilize low pass filter (already available in PCS) to isolate the effect of rtEFC from RWM control



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

NSTX-U
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Identification of q profiles that avoid *n*=1 core kink/tearing modes

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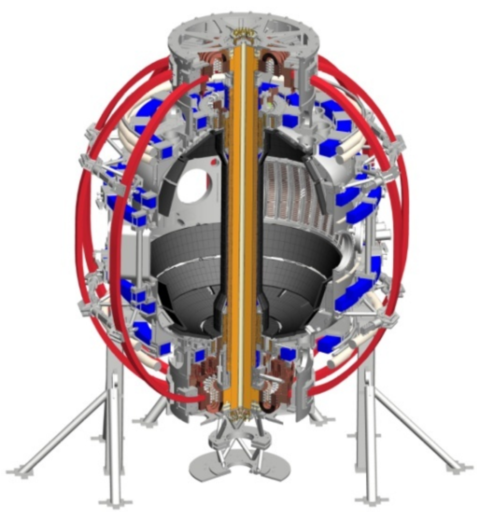

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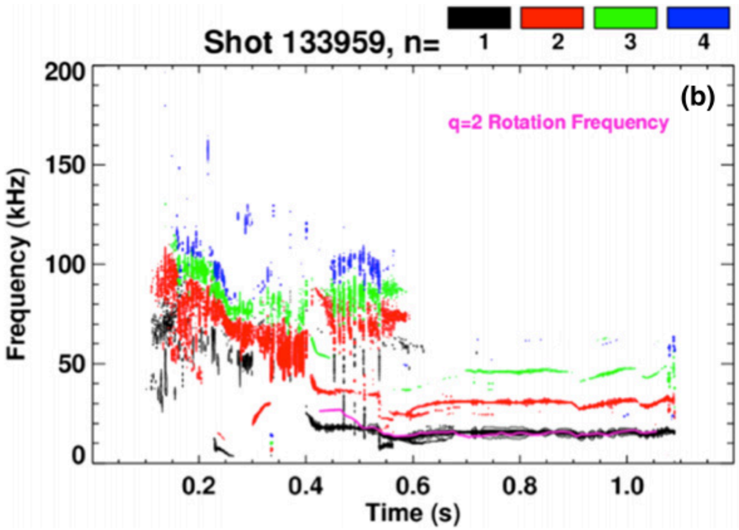
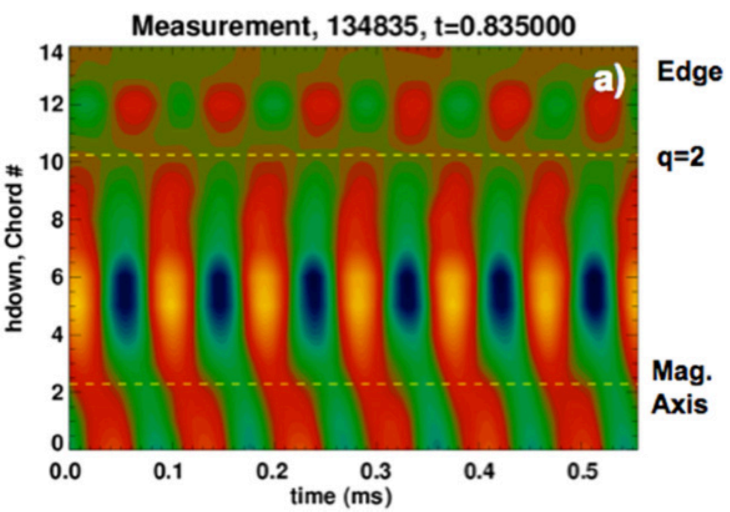
Background

Many NSTX plasmas suffered from n=1 core kink/tearing modes:

- Modes rotated at the frequency of the q=2 surface.
- Could be triggered by ELMs, EPMs, or were “triggerless”
- Modes had clear core 1/1 part along with 2/1 part.
- Tended to onset as q_{min} approached 1.
- Dropped confinement and redistributed current.





S. P. Gerhardt, et al., *Nuclear Fusion* **51**, 073031 (2011)

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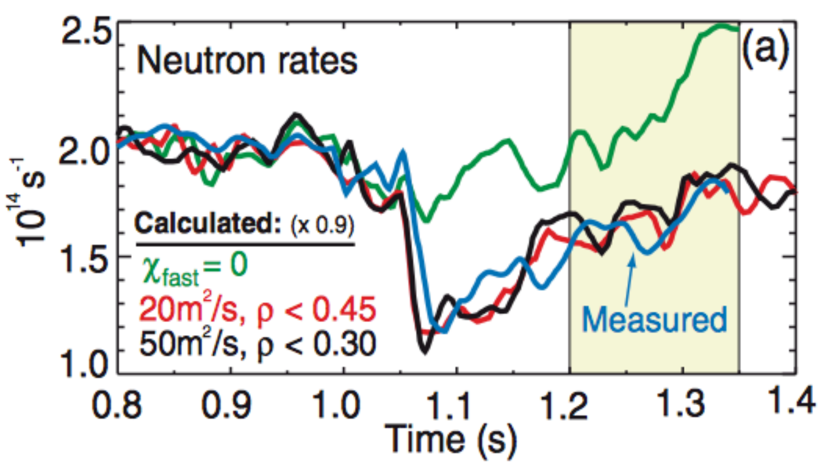
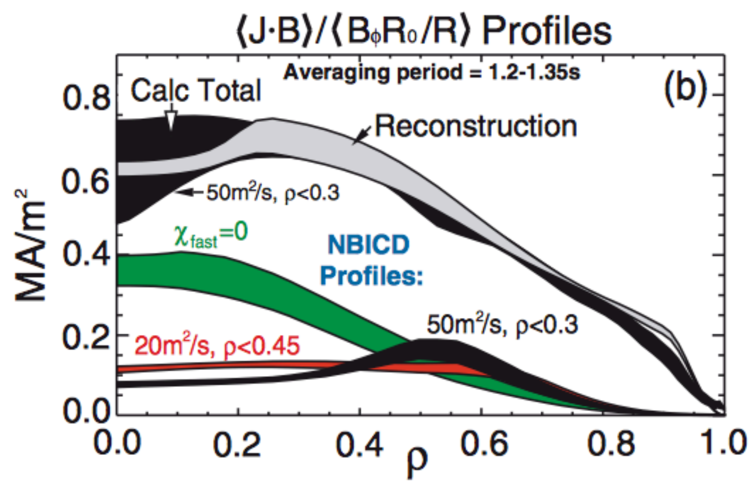




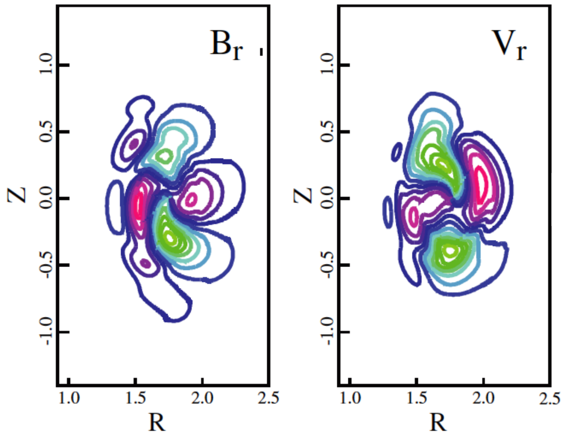
J. E. Menard, et al., *PRL* **97**, 095002 (2006)

How To Avoid These Modes

- Maintain the right amount of rotation shear
- Avoid disturbances in the plasma.
  - Avoid ELMs → One of the ways that lithium helps
  - Avoid EPMs → Keep the density high enough
- Get the right q-profile:
  - The value of q_{min} is important
  - The value of q-shear is important for the ideal stability.

This proposal: Use 2nd beam to assess conditions for avoiding these modes

- Step 1: Piggyback on the dedicated beam tangency XP
- Step 2: Asses stability as q_{min} approaches 1:
  - Attempt to pick different current profiles that relax to values $q_{min}>=1$
    - Potentially vary the ramp rate and or early heating to modify the q-shear as the profile evolves.
    - Repeat at two different beam powers to separate betaN/betaP effects
  - Other constraints
    - Fix betaN (or at least, fix the beam power) within the scan.
    - Use braking to maintain the same rotation parameters?
    - Use lithium to eliminate ELMs?
- Step 3: Theory
  - Work with M3D-C1, NIMROD teams?
  - For example: compare changes in core mode character with proximity to $q_{min}=1$



D. P. Brennan, et al., *NF* **52**, 033004 (2012)