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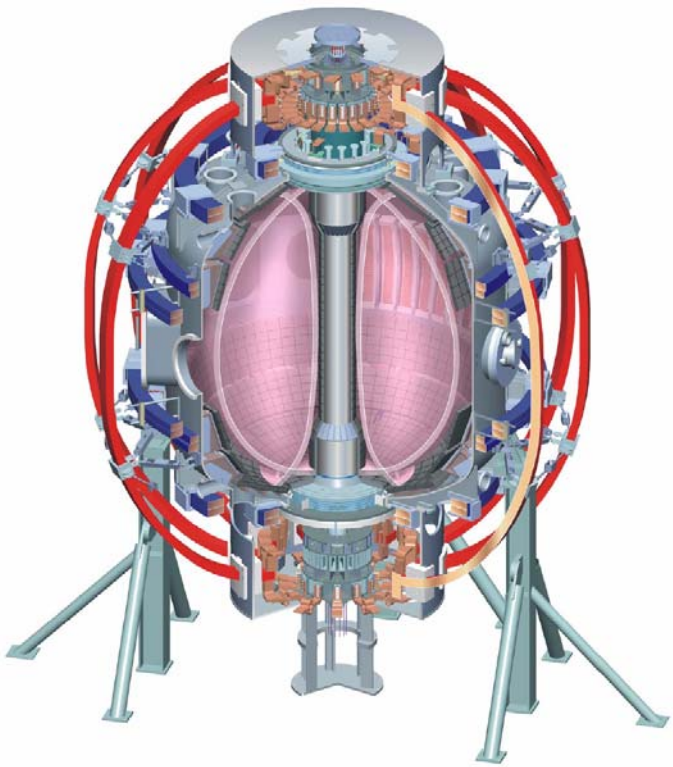
Error field & locked mode studies using NSTX RWM coils

J. Menard, PPPL



NSTX Research Forum for FY2004 Run

Princeton Plasma Physics Laboratory
Princeton, NJ
September 22, 2004

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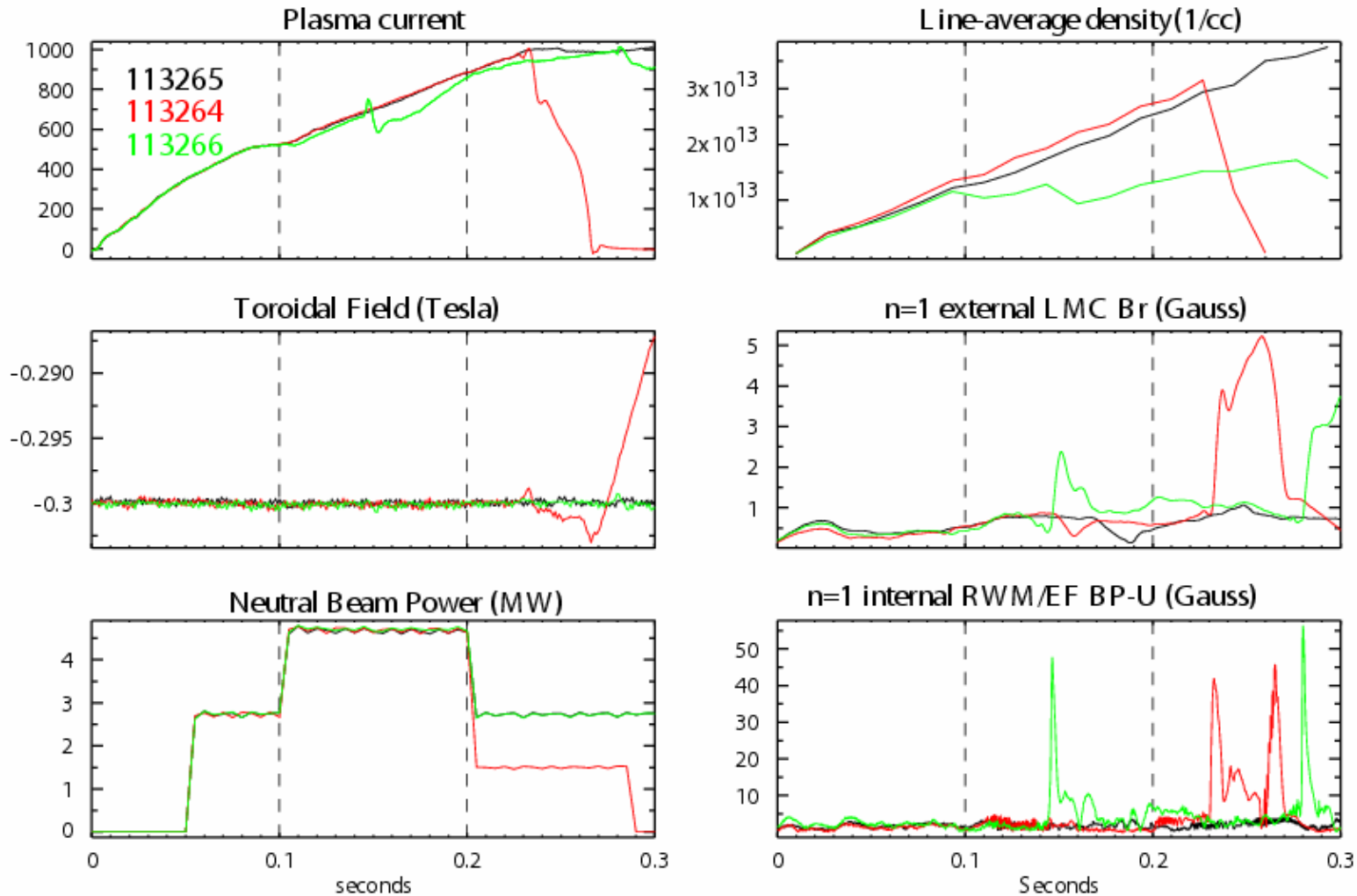
XP415: I_P ramp-up LM threshold near $\overline{n}_e = 1.2\times10^{19}\ m^{-3}$

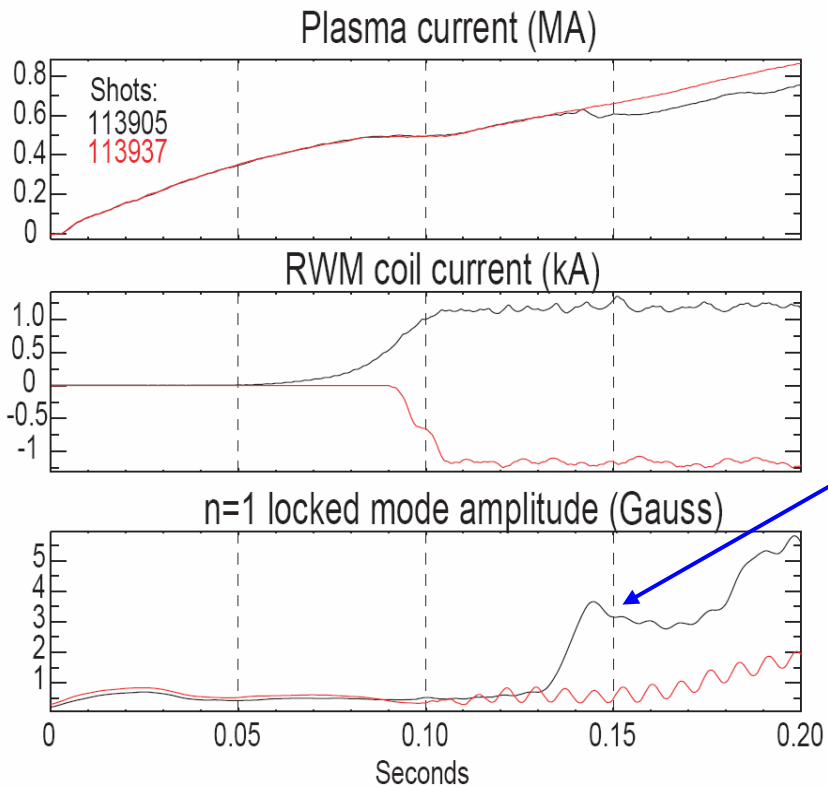
1. **Had to avoid early H-mode to get mode to lock at 3kG**
2. **Rotating mode locks later w/o sufficient NBI**



Mode locking threshold during I_P ramp depends on sign of applied external field

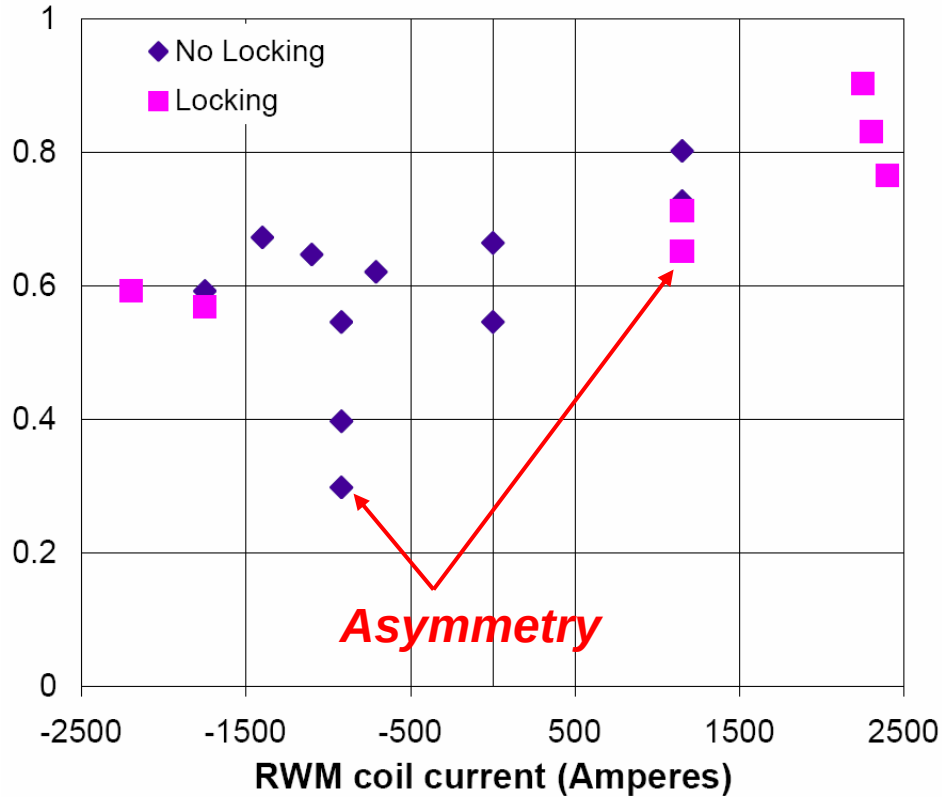
➔ *residual error field during I_P ramp*

Typical 2/1 locked mode signatures during I_P ramp w/ RWM coil current on

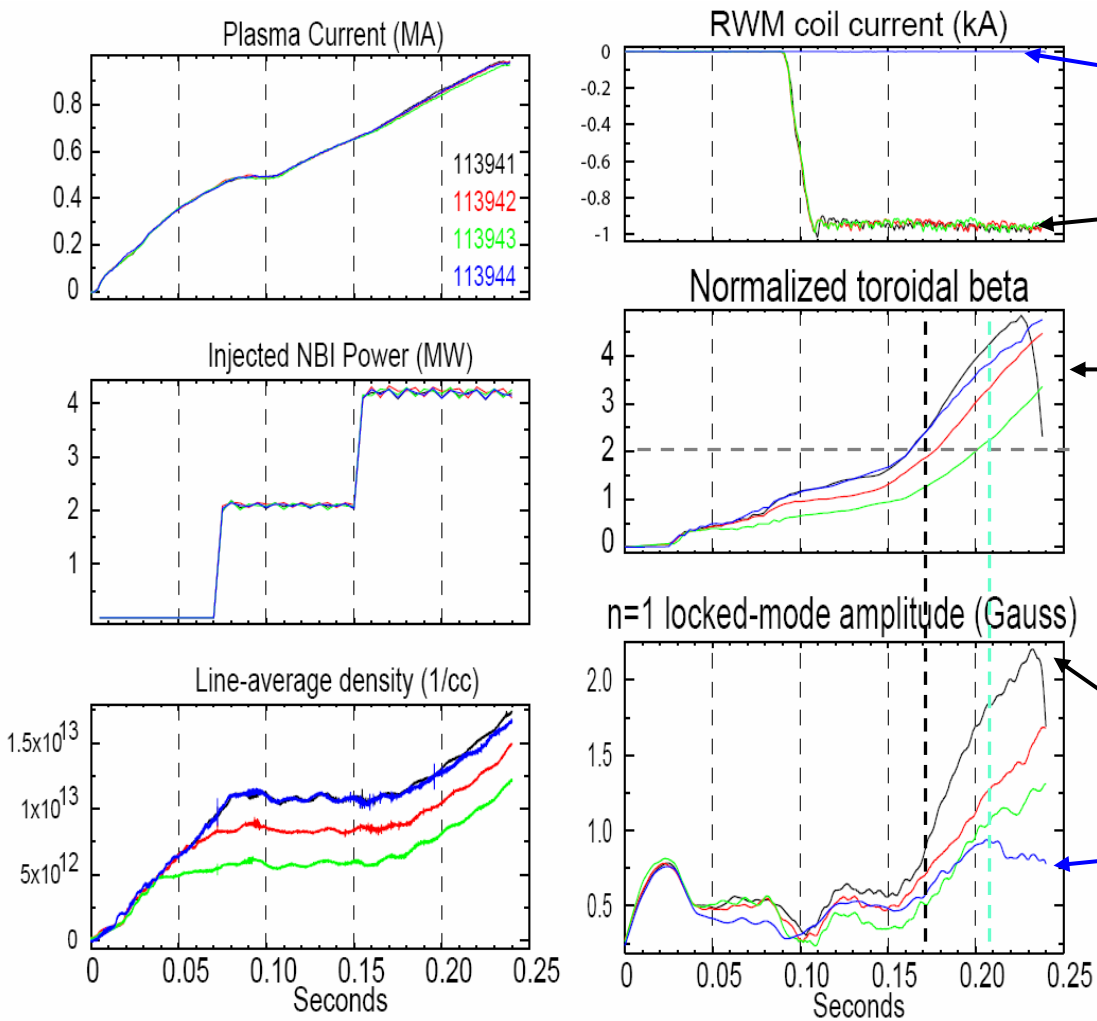


Density threshold vs. RWM coil current:

$\bar{n}_e(20) \times q_{95}^{0.8}$ (DIII-D scaling)



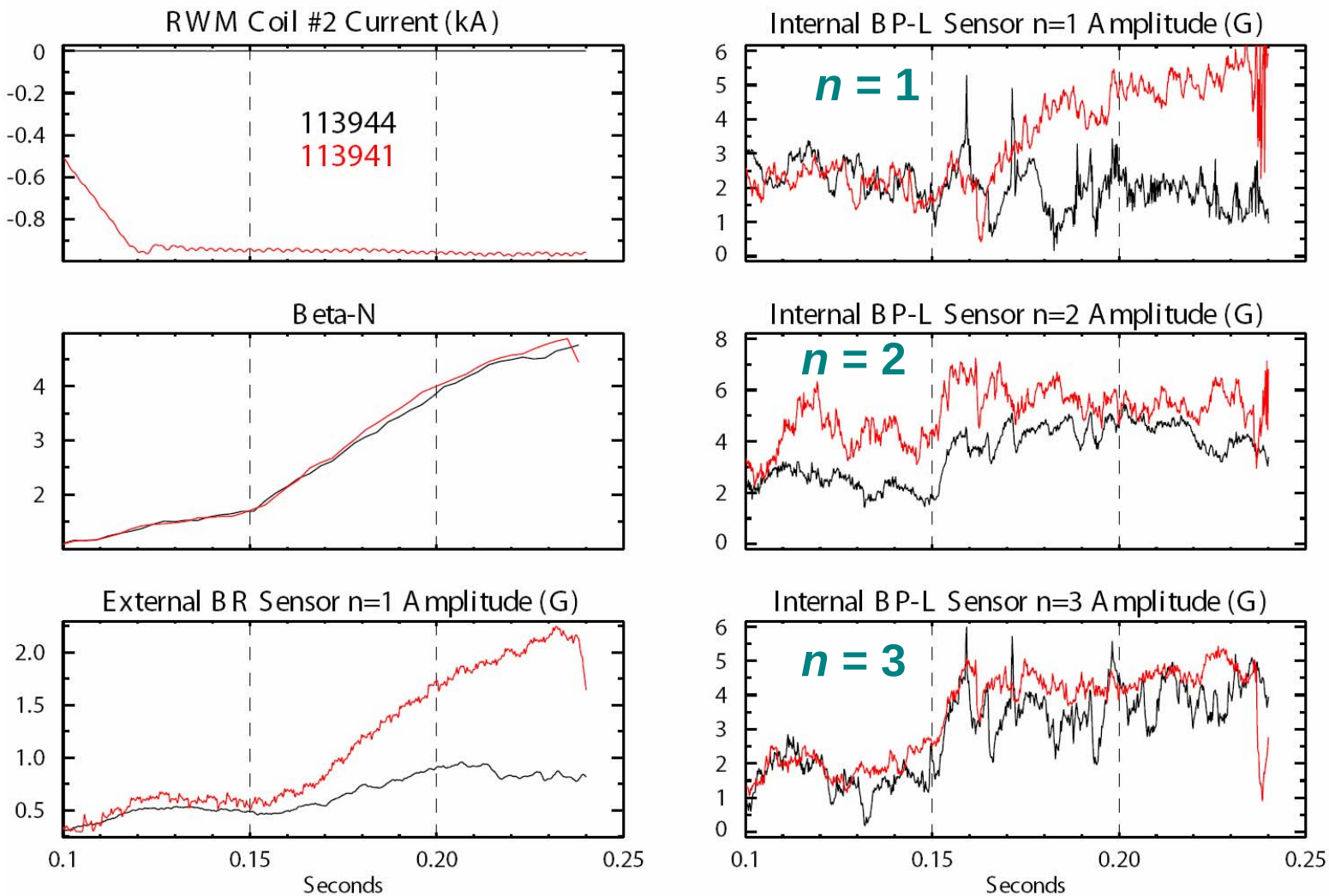
Locked-mode shots also demonstrate error field amplification (EFA) dependence on β_N at low-n_e



- Blue shot has $I_{RWM} = 0$
- Others use I_{RWM} that doesn't cause locking at t=140ms
- n_e scan yields β scan after 2nd source fires
  - NBI waveforms fixed
- Plasma amplifies field when β_N > approx. 2
  - $I_{RWM} = 0$ shot has smallest LM signal ➔ smaller residual error field later in shot?

Internal sensors find only n=1 EFA

- n=1 EFA factor ≈ 2-3 at maximum β_N
- n=2 and n=3 EFA weak or absent



Goals of Experiment

(request 2 run days)

- Use full RWM coil set for locking studies
  - Scan toroidal phase angle of applied field
  - Coil current amplitude scan
    - smaller current increments
  - Find minimum operating density during ramp-up
- Extend results into late ramp, early flat-top
  - Presently need sufficient P_{NBI} to keep rotating mode from locking late in the ramp
  - Use combination of EFA data and phase/current scans to try to eliminate locking of mode

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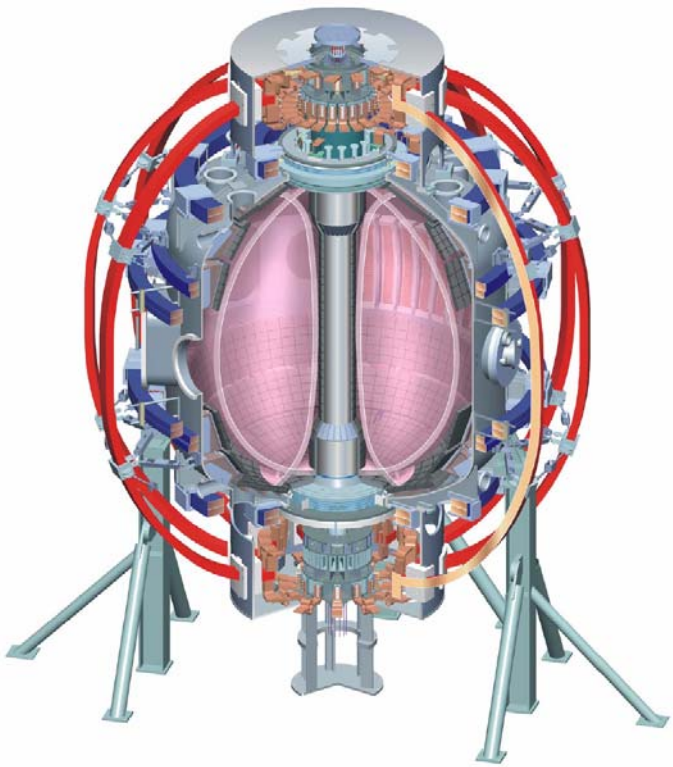
Onset and saturation characteristics of the 1/1 mode



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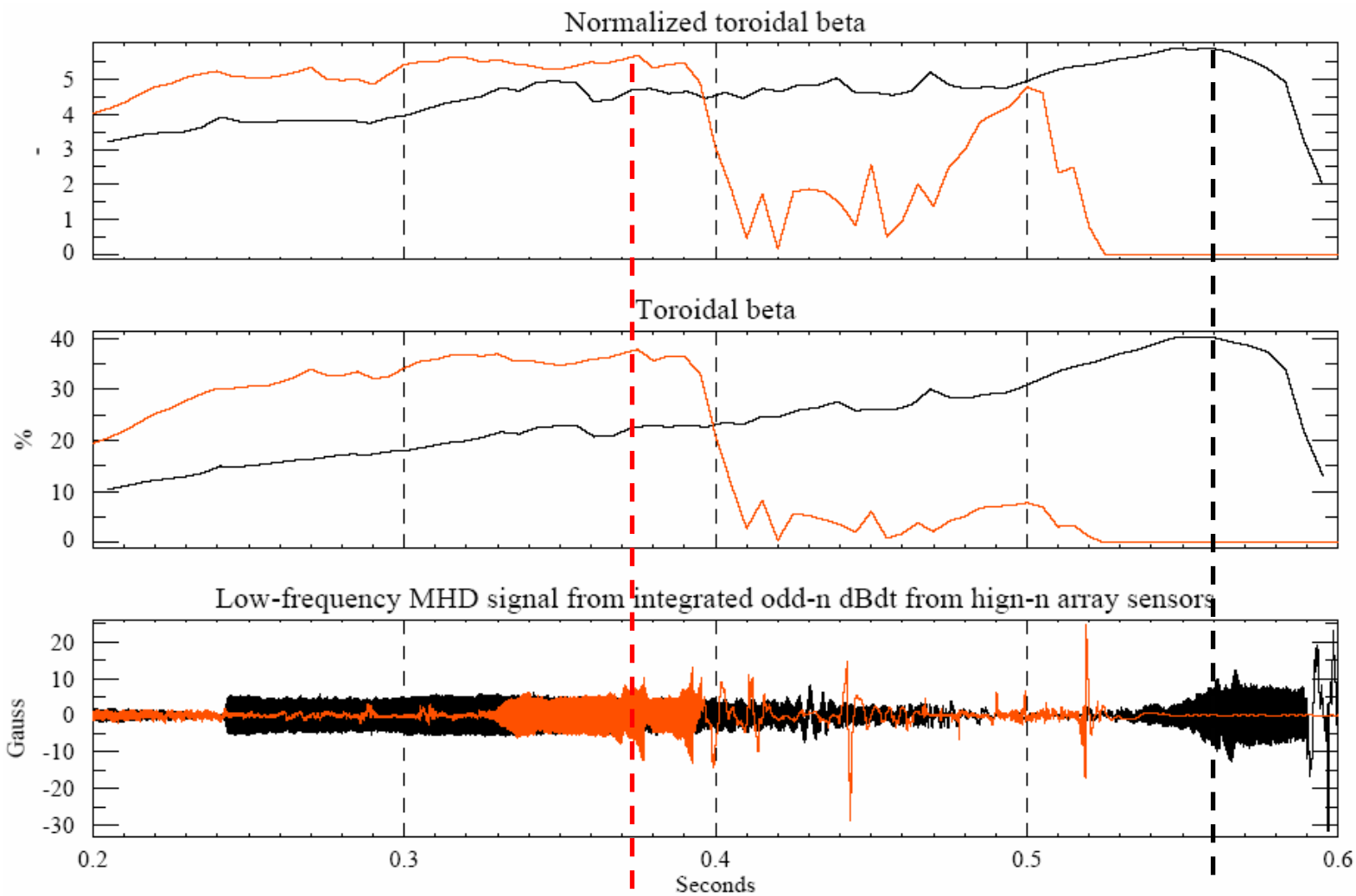
Onset of 1/1 mode can saturate β at low q, and contribute to final collapse of plasma



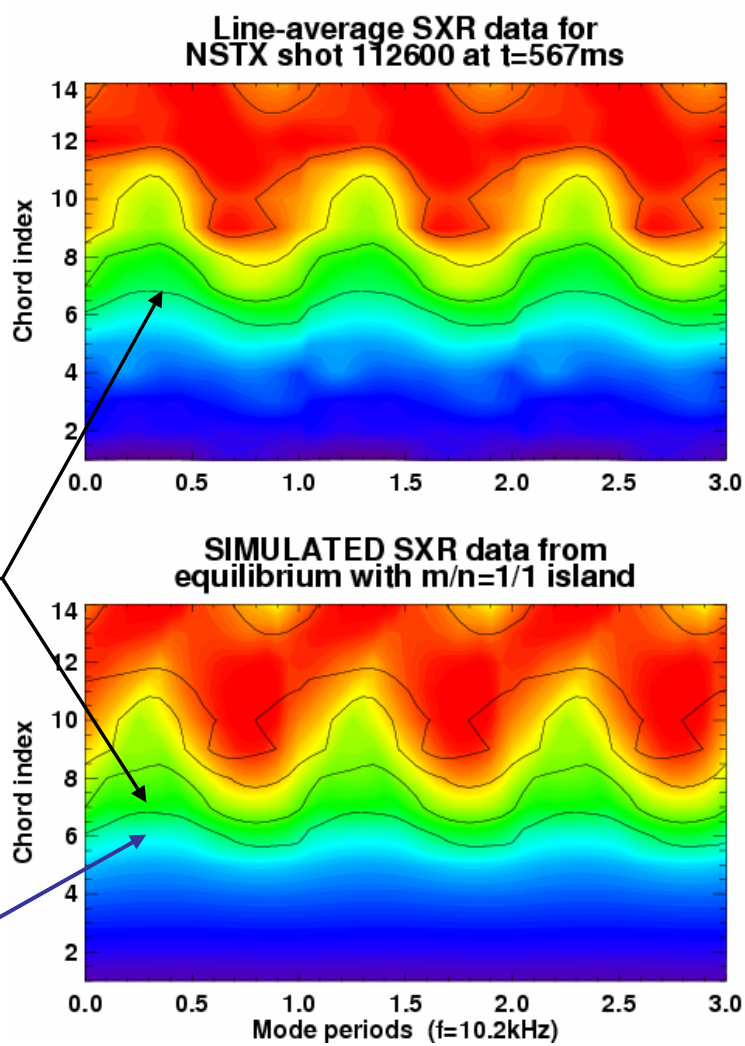
SXR indicates presence of 1/1 mode and location of q=1 surface in high-β shot

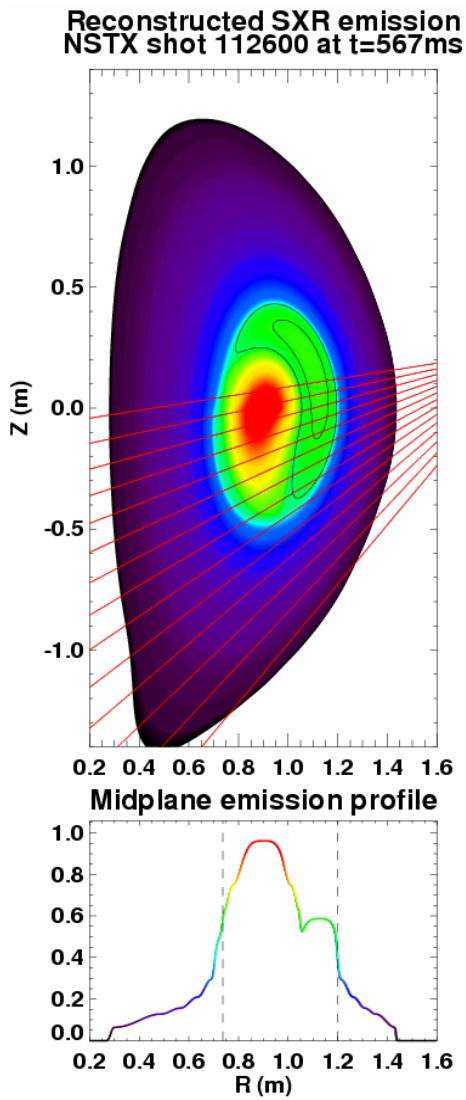
Initial MSE data taken this year – not ready for reconstructions

1/1 mode in SXR remains reasonable way to locate q=1

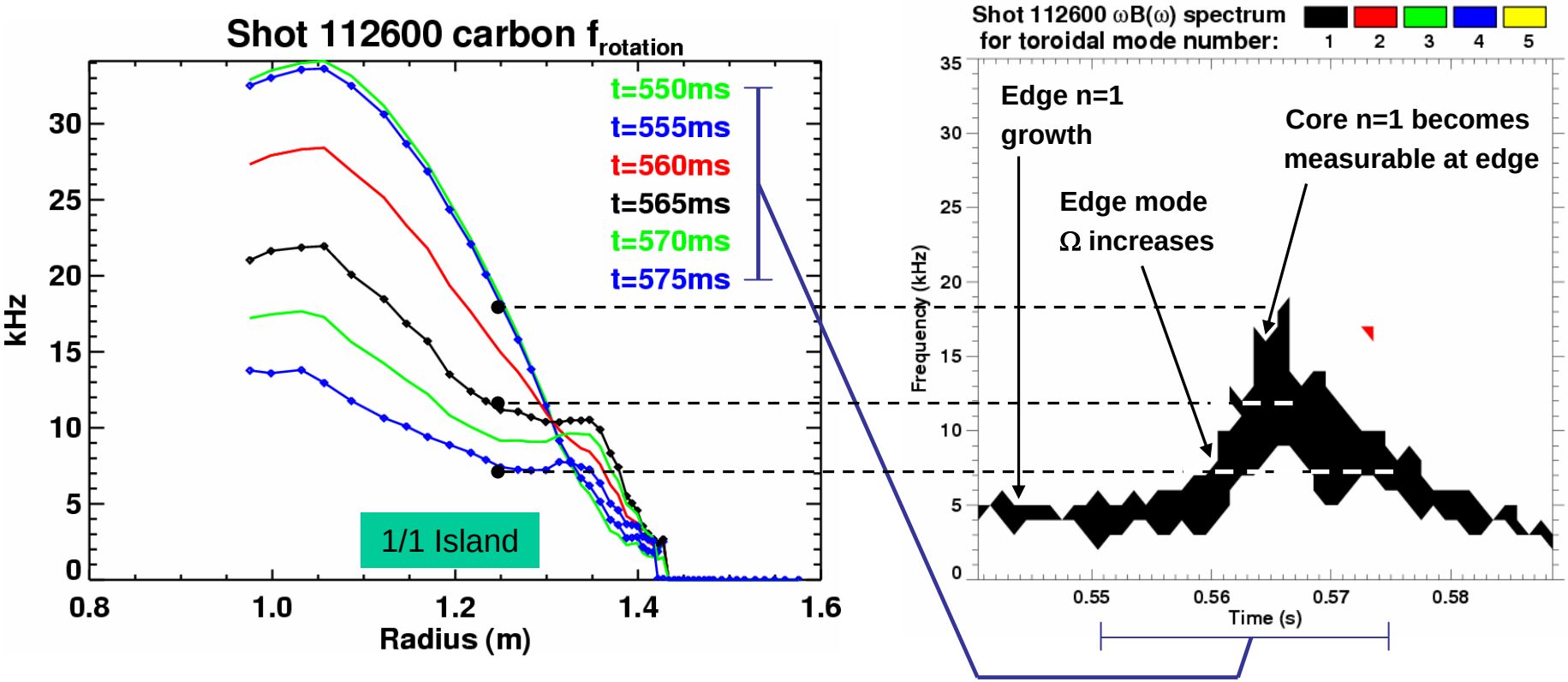
Contours from *SXR data*

Displacement measurable outside q=1 surface



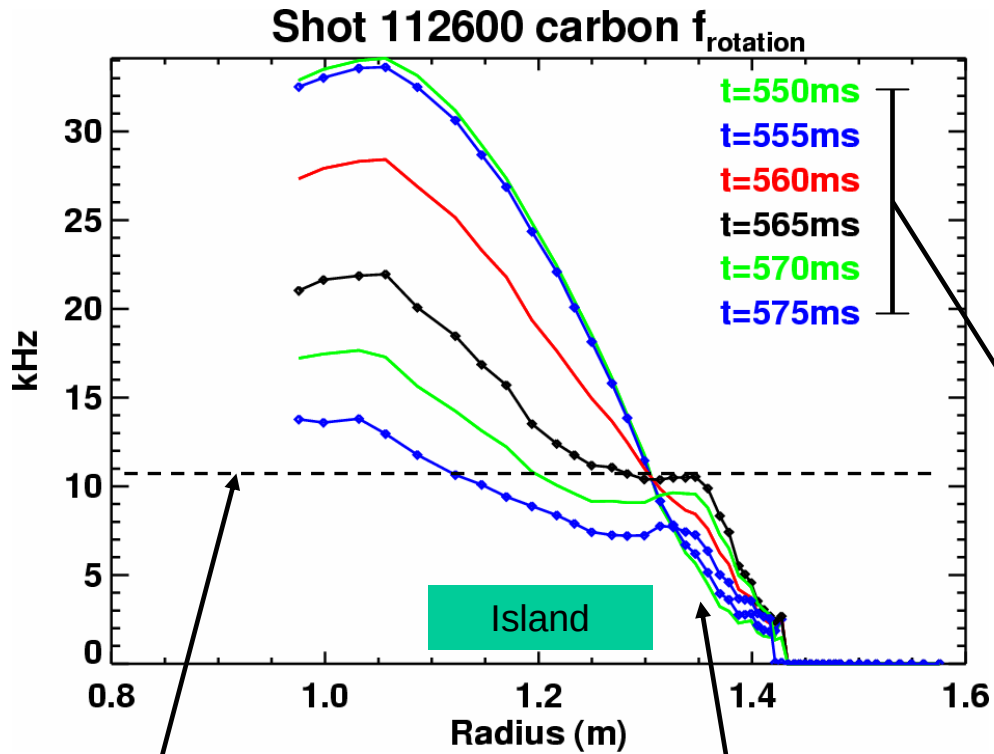


1/1 island locked to local fluid Ω_ϕ during rotation decay



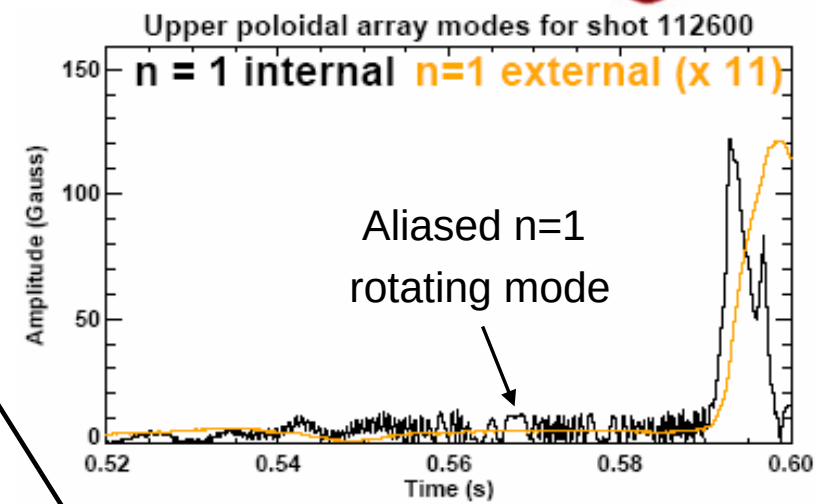
Edge n=1 mode appears to phase-lock with core 1/1 mode which should enhance rotation profile flattening…

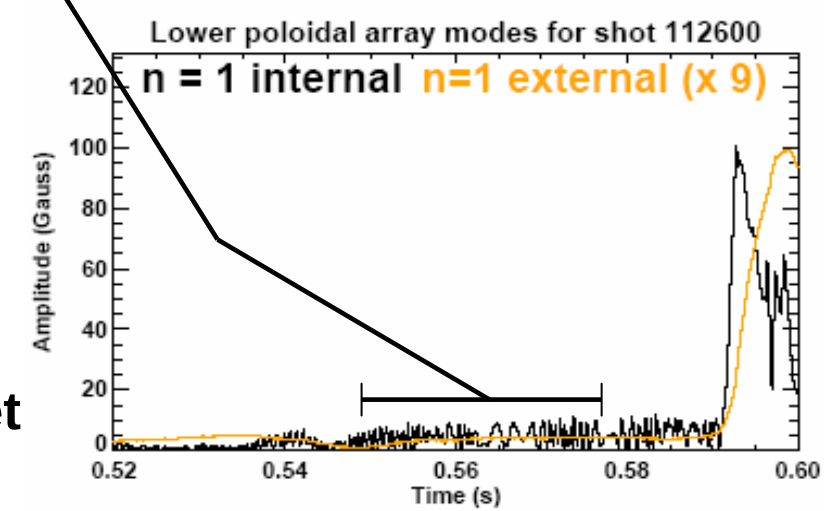
No strong signature of external mode on internal sensors during plasma Ω_ϕ decay for this high-β shot



Mode f_ϕ at 565ms

Edge rotation increases after mode onset





Other shots show stronger signatures of RWM prior to final disruption

Goals of experiment (request 1.5 run days)

- Test proposed saturation mechanisms
  - $dq/d\psi|_{r(q=1)}$ obviously important in linear growth rate
    - Measure with MSE systematically for first time
    - Try to modify with I_P ramp-rate (l_i), density changes
  - Rotational shear
    - Shear should reduce onset growth rate
      - But, mode appears to flatten $\mathbf{v}_\phi$ near island
      - Understand role of coupling to edge mode
    - Use n=3 braking to change Ω_ϕ and Ω_ϕ' at mode onset
  - ω_{*i} non-linear saturation/stabilization
    - ω_{*i} / ω_A scales as $\beta_i\, \delta_i / L_p$ → strong β dependence
      - Competitive with mode γ_{lin} / ω_A at high β
    - Vary β and density at mode onset