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XP935: Search for multiple RWM behavior at high β_N

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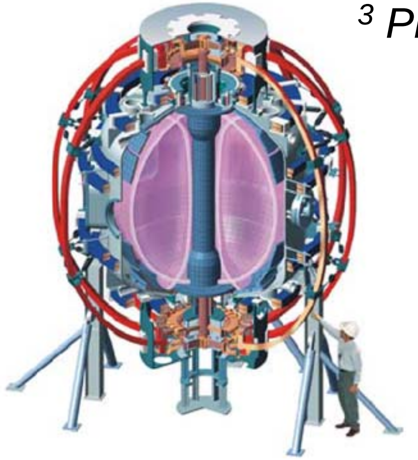

NSTX Research Team Review

May 11th, 2009

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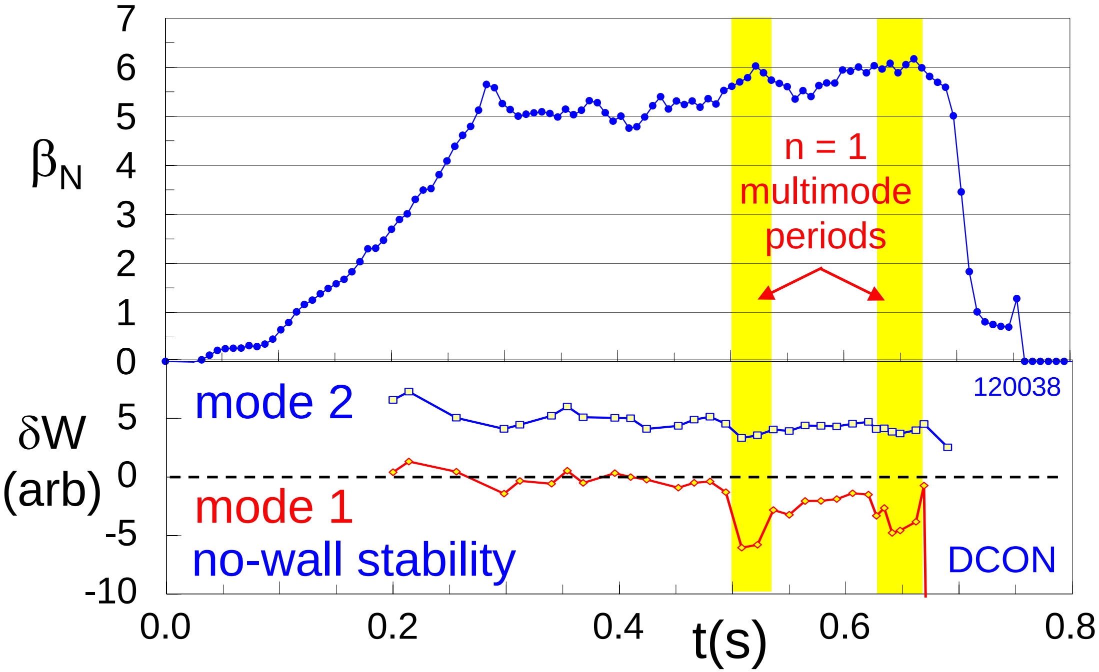
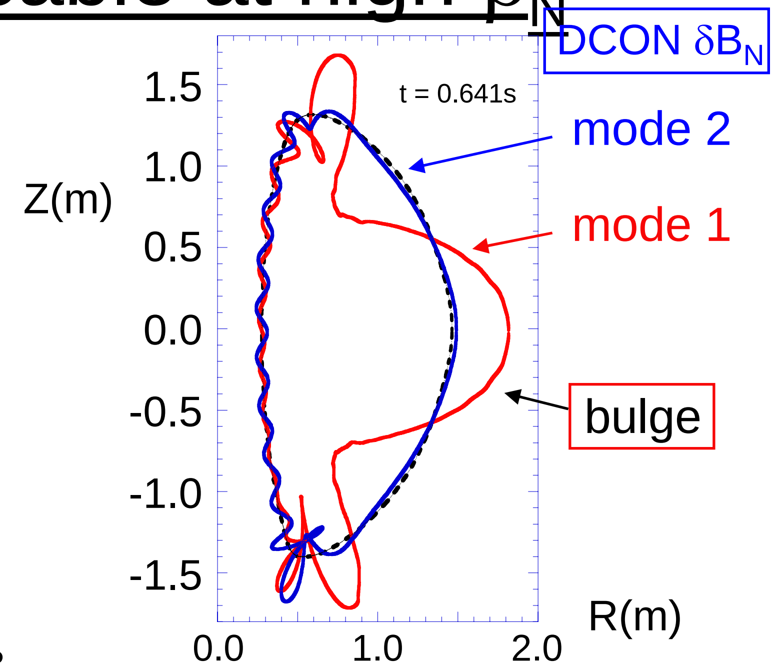
XP935: Search for multiple RWM behavior at high β_N

- Goals
  - Determine if unstable RWM is born from observed, stable RWM (with frequency at peak resonant field amplification – XP931), or a 2nd mode
    - Either result is important
    - If same mode, supports single mode physics model; key conclusion for RFA control of NBI (future milestone)
    - If second mode, supports multi-mode theory, PRL-level conclusion, key conclusion for RWM control in ST, also, key conclusion for RFA control of NBI
  - Determine β_N dependence of RFA for these modes near marginal stability
  - Determine effect of ω_ϕ on both modes as marginal stability approached
  - Determine effect of active n = 1 control for these modes near marginal stability
- Addresses
  - NSTX R(09-1) and (##) milestones,
  - ITPA joint experiment MDC-2.1, MDC-2.2

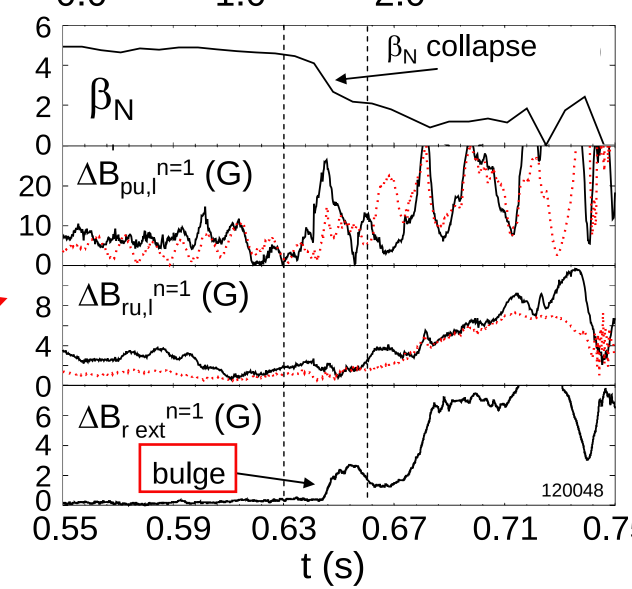
Multimode theory applicable at high β_N





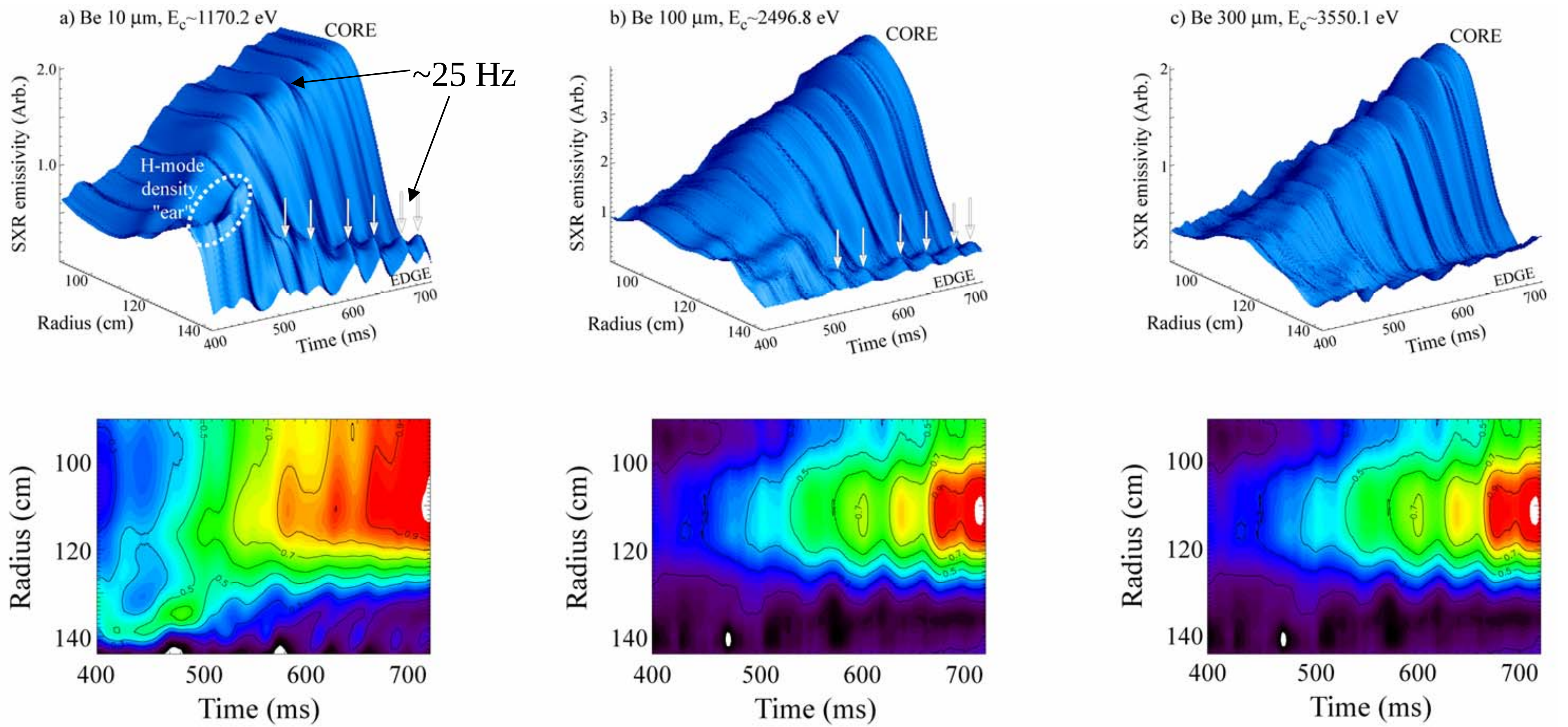
- Boozer multimode criterion for n = 1 met at high β_N (PoP 10 (2003) 1458.)
  - $|\delta W|$ smallest for 2nd n = 1 eigenfunction
- Multiple n > 1 RWM also observed in NSTX (Sabbagh, et al., Nucl. Fusion **46** (2006) 635.)
- Multiple n = 1 modes may explain observations
  - Upper/lower sensor phases do not always match single mode
  - Poloidal deformation of mode during feedback (mode "non-rigidity")

S.A. Sabbagh, et al., PRL **97** (2006) 045004.



NSTX

Multi-energy SXR reconstructions of actively stabilized RWMs



- $n=3$ braking and $n=1$ stabilizing fields modified kinetic profiles at early times.
- Are the RMPs taking out the H-mode density "ears"?
- Increased edge n_Z blobs during stabilization; good correlation with drops in $\boldsymbol{T_{e0}}$ & S_n.
- ***May have identified a stable RWM near the natural RFA resonance***.

L. Delgado-Aparicio

Direct approach to observe multiple RWMs

- Approach
  - Past approach: determine ideal mode structure and compare to external magnetics
  - ME-SXR allows direct approach to finding mode
    - direct observation of stable, rotating RFA as RWM is driven unstable
    - RFA to be diagnosed in XP931 with ME-SXR
  - Unstable RWM will either
    - Grow from stable, rotating RFA as marginal stability is approached
    - Grow independent of stable RFA as instability threshold is crossed
- Mode distinction
  - Examine frequency and global extent of mode
    - RFA observed with ME-SXR at ~ +30 Hz (co-rotation), radial extent determined from signal inversion; correlate with RWM magnetic sensors
    - Unstable RWM can be born rotating, “wobbling”, or (typically) grows locked; typical mode growth, rotation measured by RWM sensors
      - Supplement with ME-SXR and USXR measurements

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Task	Number of Shots
1) Create target plasma (use Li conditioning)	
A) Start from high performance fiducial w/n=1 FB (133078), adjust I_p for maximum β_N	4
B) Ramp n = 3 from correction to braking to reach RWM marginal stability, n = 1 FB off	2
C) Add n = 1 AC pre-programmed +30Hz to quasi-steady-state, n = 1 FB off	2
2) Vary ω_ϕ and β_N	
A) Reduce ω_ϕ with n = 3 braking at highest β_N (full NBI power)	4
B) Reduce ω_ϕ with n = 3 braking at reduced $\beta_N > \beta_N^{no\text{-}wall}$ (reduced NBI power)	4
3) Compare results under active n = 1 RWM control	
A) Repeat conditions from (2a) with AC pre-programmed +30 Hz off, n = 1 FB on	3
B) Repeat conditions from (2a) with AC pre-programmed +30 Hz off, n = 1 FB on	3
4) Control shots	
A) Magnetics only shot with n = 3 waveform and n = 1 AC pre-programmed field	1

Total: 23

XP935: Search for multiple RWMs - Diagnostics

- Required diagnostics
  - ME-SXR and USXR, filters set for optimal RFA/RWM diagnosis (determined from XP931)
  - Internal RWM sensors
  - CHERS toroidal rotation measurement
  - Thomson scattering
  - MSE
  - Toroidal Mirnov array / between-shots spectrogram with toroidal mode number analysis
  - Diamagnetic loop
- Required capabilities
  - n = 1 feedback
  - LITER operation