NSTX-U

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Assess NSTX-U ideal wall limit with 2nd NBI*

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+ anyone else interested

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PPPL

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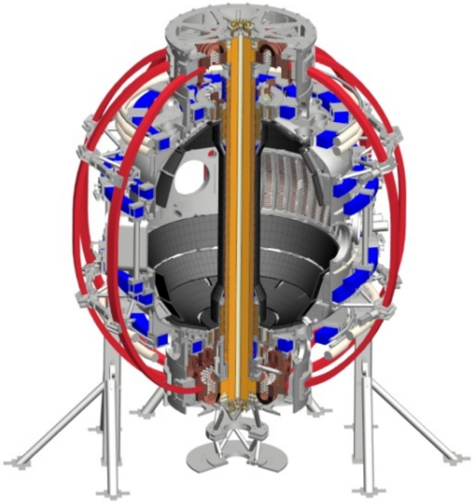

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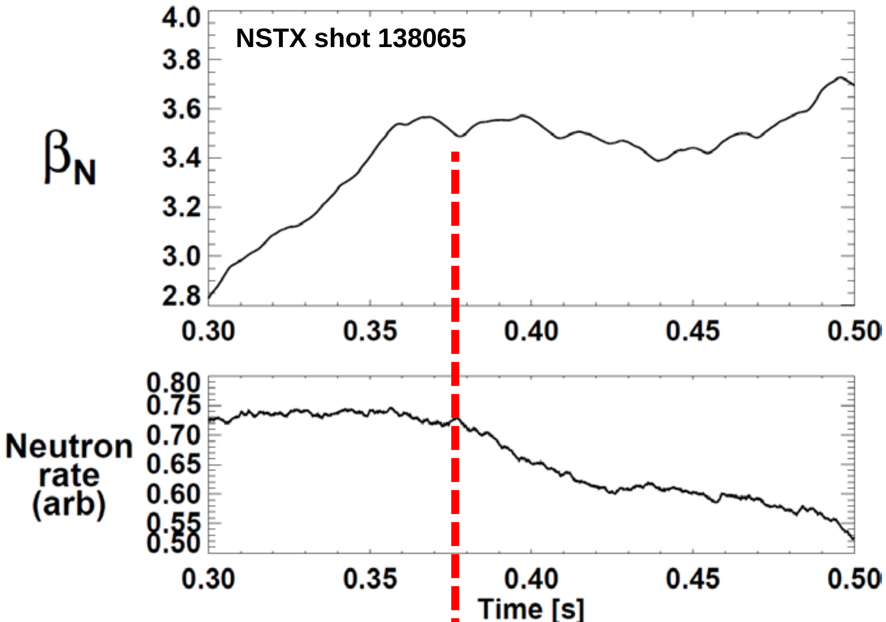
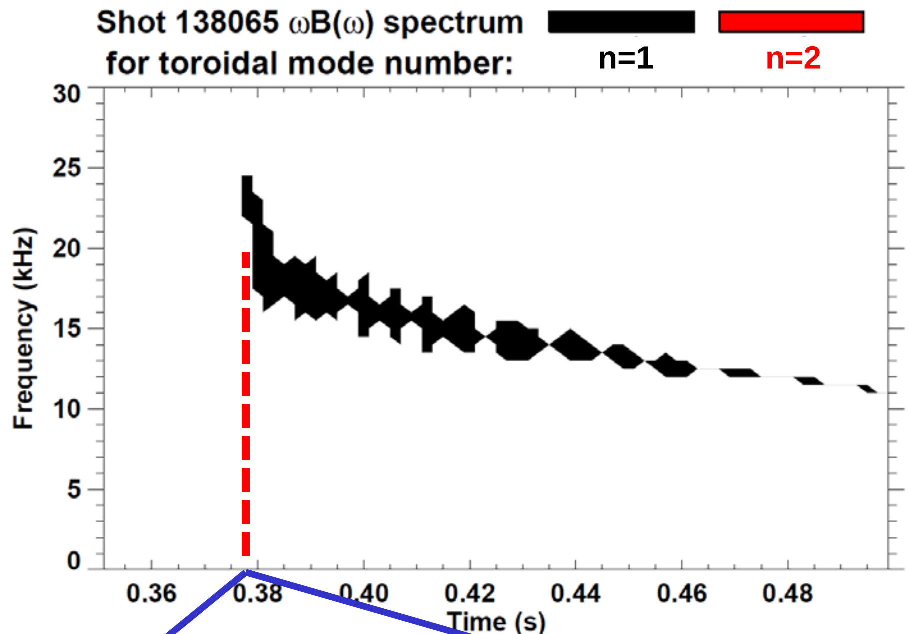
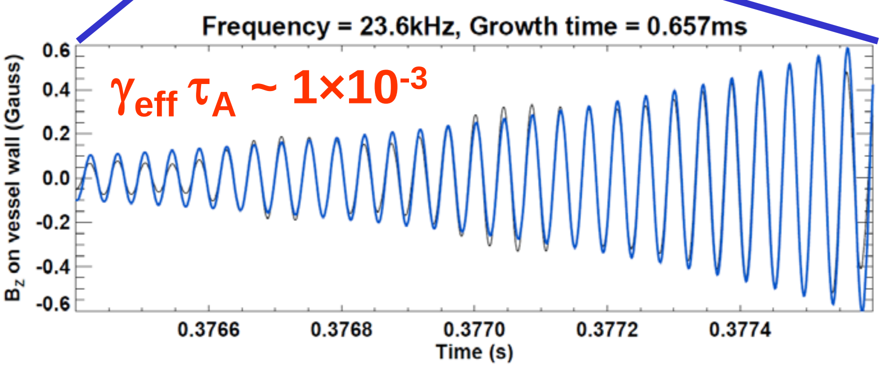
2012-2014 – Investigated stability of low β_N ~ 3.5 saturated f=15-30kHz n=1 mode common during early I_P flat-top phase

(and several other higher beta regimes…)

Fixed P_{NBI} = 3MW, I_P = 800kA, β_T=10-15%





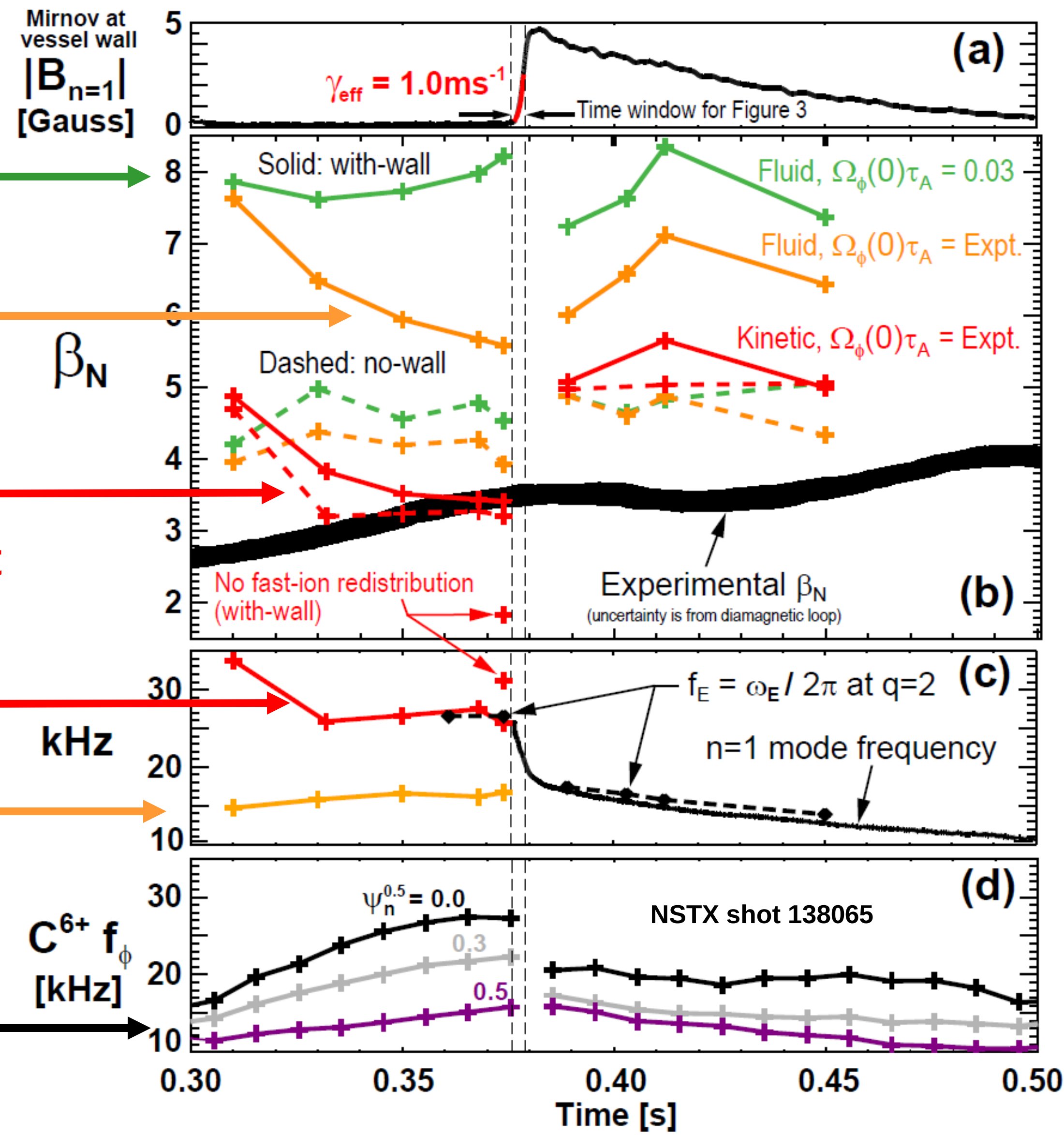


Mode clamps β_N to ~3.5, reduces neutron rate ~20%

sometimes slows → locks → disrupts

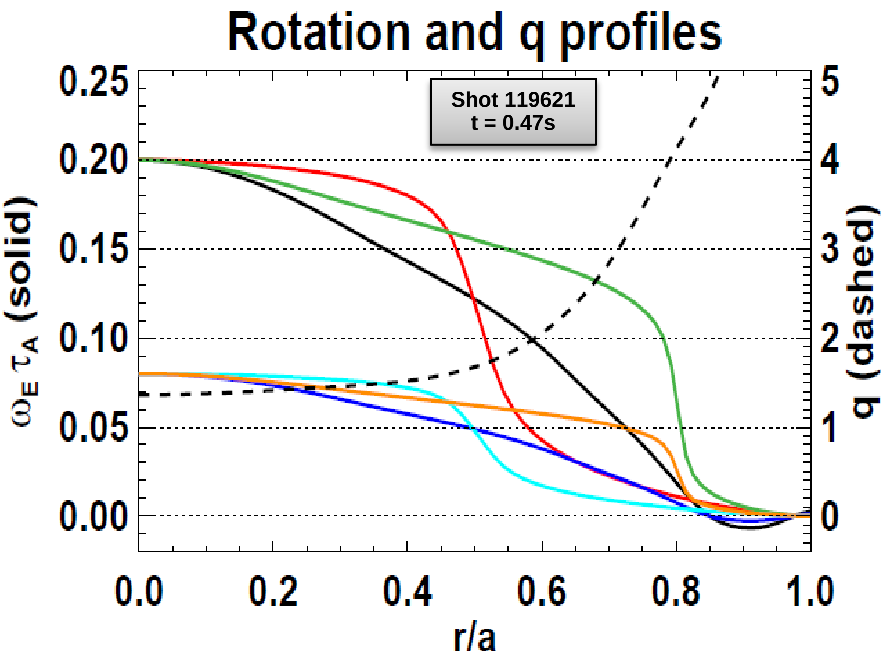
MARS-K drift-kinetic MHD calculations → rotation shear, high (enough) $\beta_{fast} / \beta_{tot}$ strongly destabilizing

- Mode grows quickly, but decays slowly – kink or tearing mode?
- Low-rotation fluid with-wall limit is very high → marginal β_N ~ 7-8
- Increasing rotation lowers max β_N to ~5.5 at mode onset time
- Full kinetic treatment including fast-ions → marginal β_N ~3.5 → **most consistent with experiment**
- Full kinetic: predicted mode *f* matches measured *f* ~ 26kHz
- Fluid model under-predicts *f*
- Rotation increasing until mode onset, then drops, then remains lower while mode is present

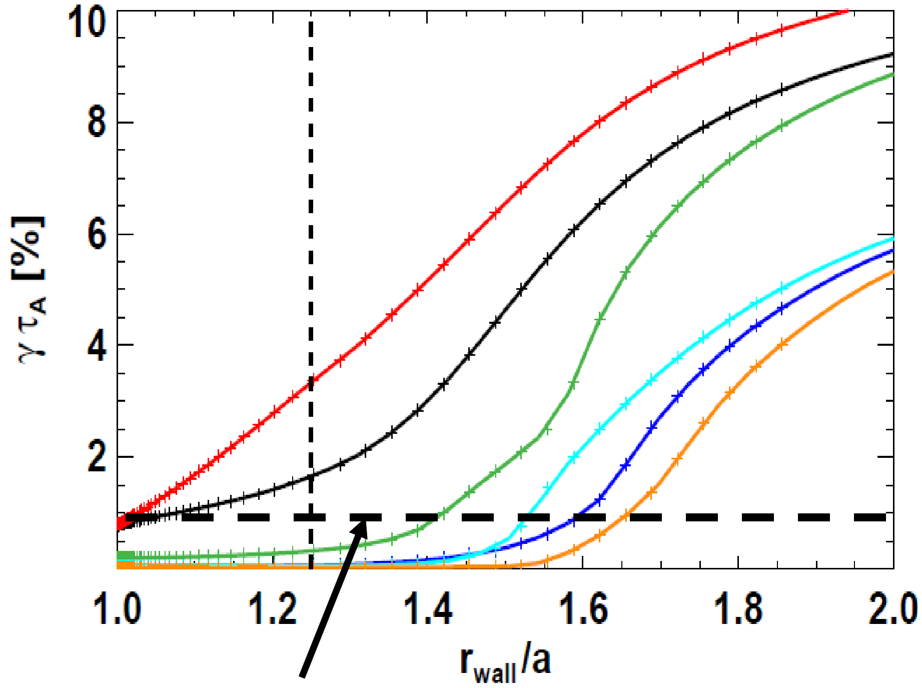


PRL 113 255002 (Dec 2014)

Increased core rotation shear destabilizing, edge rotation shear stabilizing (consistent with Kelvin-Helmholtz-like modes)



These are all fluid (non-kinetic) calculations



Very crude/loose estimate of threshold for kinetic re-stabilization

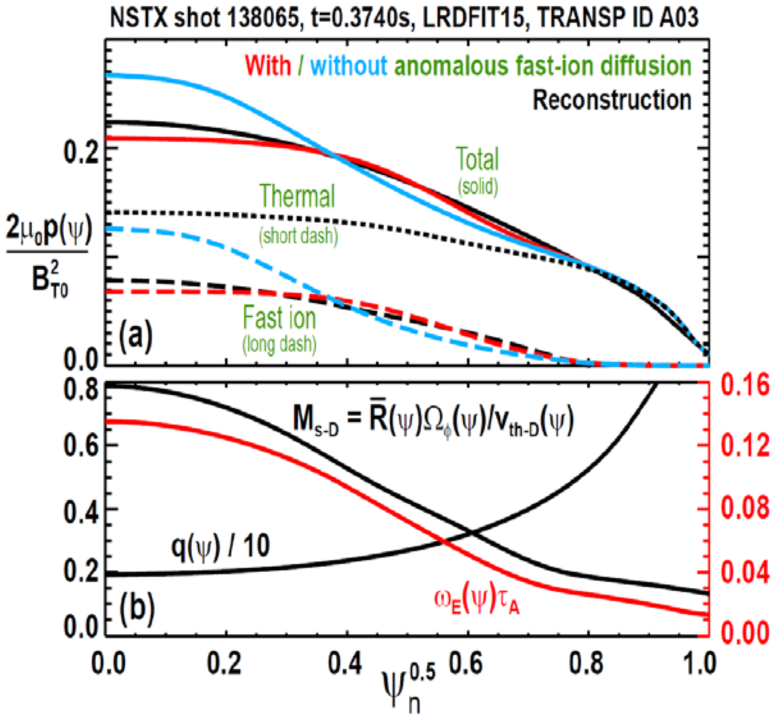
- When central rotation is decreased more than factor of 2 from $\omega_E\tau_A$ = 0.2 to 0.08, mode stabilized, but still observe increased rotation shear in plasma core destabilizing, edge stabilizing

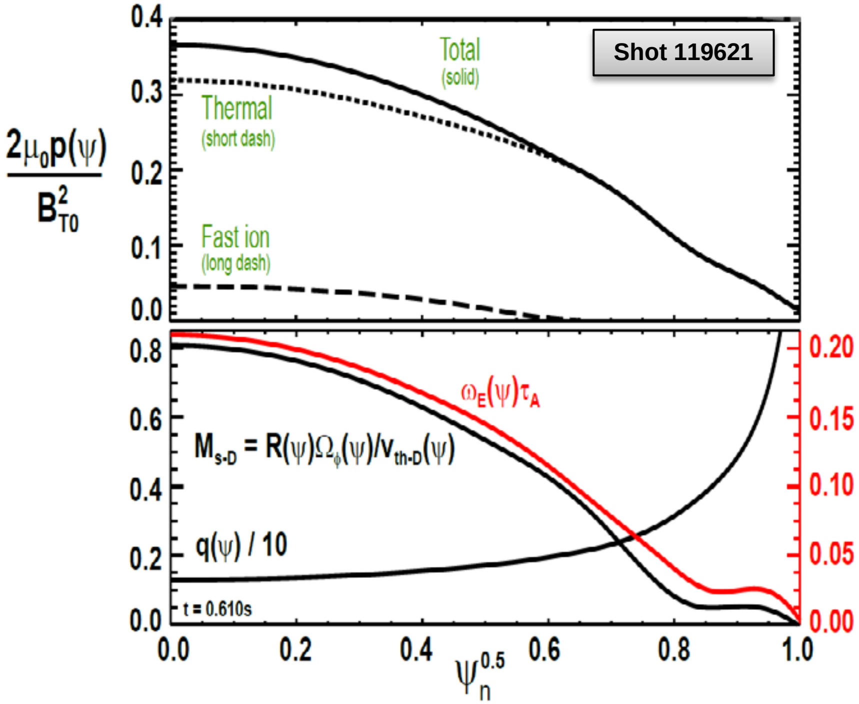
Inclusion of slowing-down distribution of fast-ions can significantly modify marginal β_N

$\beta_{fast}(0) / \beta_{tot}(0) = 0.3\text{-}0.35$
→ $\Delta\beta_N$ = -2 to -2.5

$\beta_{fast}(0) / \beta_{tot}(0) = 0.1$
→ $\Delta\beta_N$ = -0.5 to -1

Need to use reconstructed / redistributed fast-ion pressure





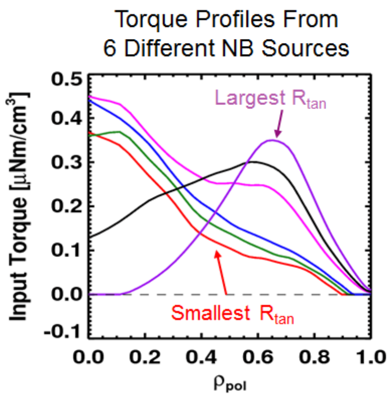
- D sound Mach number $M_{s\text{-}D}$ → 0.8 on-axis
  → significant drive for rotational instability

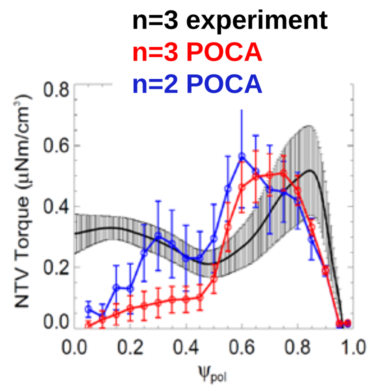
$$\delta\hat{W}_{rot} \sim \delta W_{\nabla p} \Rightarrow v_\phi \sim v_{th-ion}/\sqrt{q}$$
$$\Rightarrow \Omega_\phi \tau_A \sim \sqrt{\beta_{thermal}/2q}$$

Idea / shot plan: (1.5 days requested)

- There has never been a dedicated experiment to isolate the relative importance of rotation / shear and fast-ion effects for the ideal-wall limit

- Approach:
  - Vary tangency radius of NBI to broaden & peak rotation to vary shear and magnitude
    - Use NTV n=2 (maybe a tad of n=1) for global braking to lower rotation → can IW beta limit actually be higher if rotation is suppressed/optimized???
  - Vary plasma density (by at least 30-40%) to vary fast ion content
    - Factor of 2 would be better… may need to look at different times in shot for density scan
    - Ideally would have similar q profiles for different densities





Some progress in particle control task force would be valuable

  - Use ≤ 2/3 of available power, then go to high / full power to push through beta / rotation limit to trigger instability to identify thresholds
  - Need target plasma that is passively stable to RWM (or feedback stabilizable) above the no-wall limit