MS XP-801
Marginal Island Width for the 2/1 NTM

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Goals:

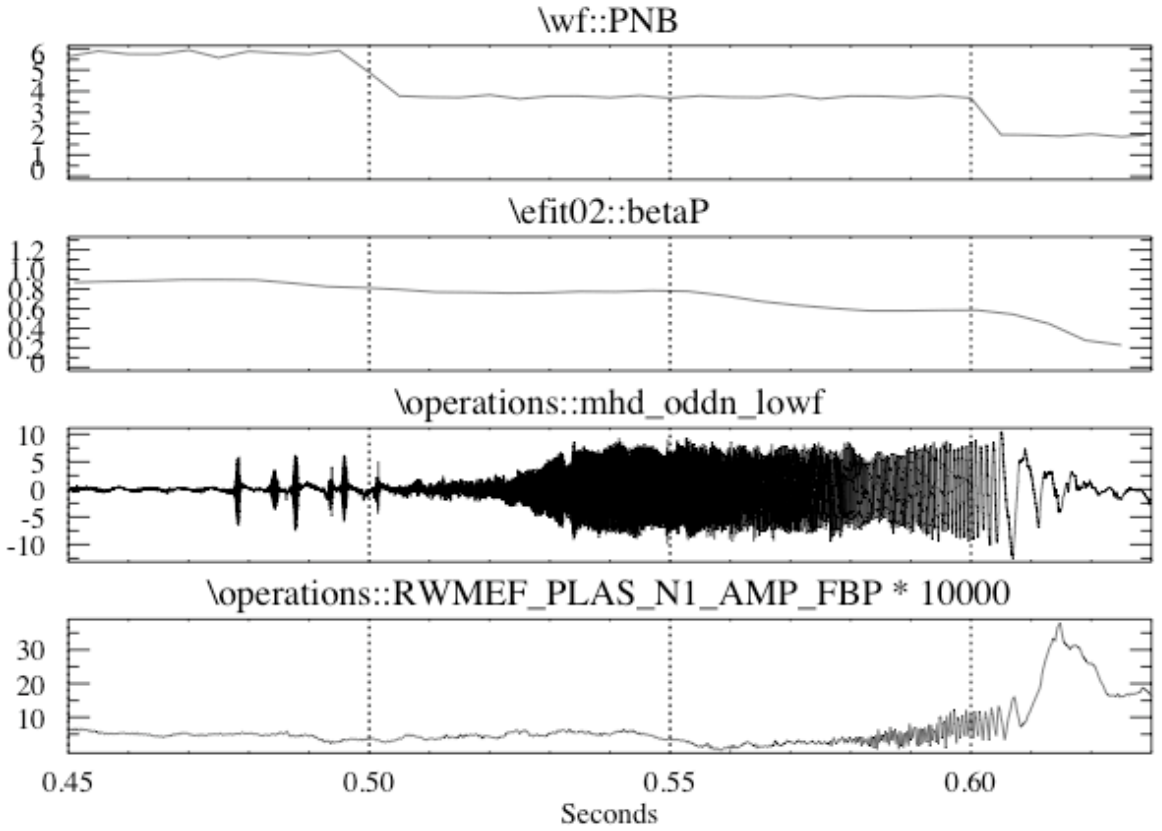
- Find a reproducible β_P-rampdown scenario where the 2/1 NTM is restabilized.
  - Directly measure of the marginal island width for 2/1 neoclassical island.
- Repeat the restabilization at different values of plasma rotation.
  - Does the 2/1 marginal island width depends on rotation or rotation shear?

Had one successful restabilization example in 2007

This Presentation:

- Were unable to achieve the desired conditions (slides by SPG).
- A DIII-D/NSTX comparison based on the data we have (slides by RJL).

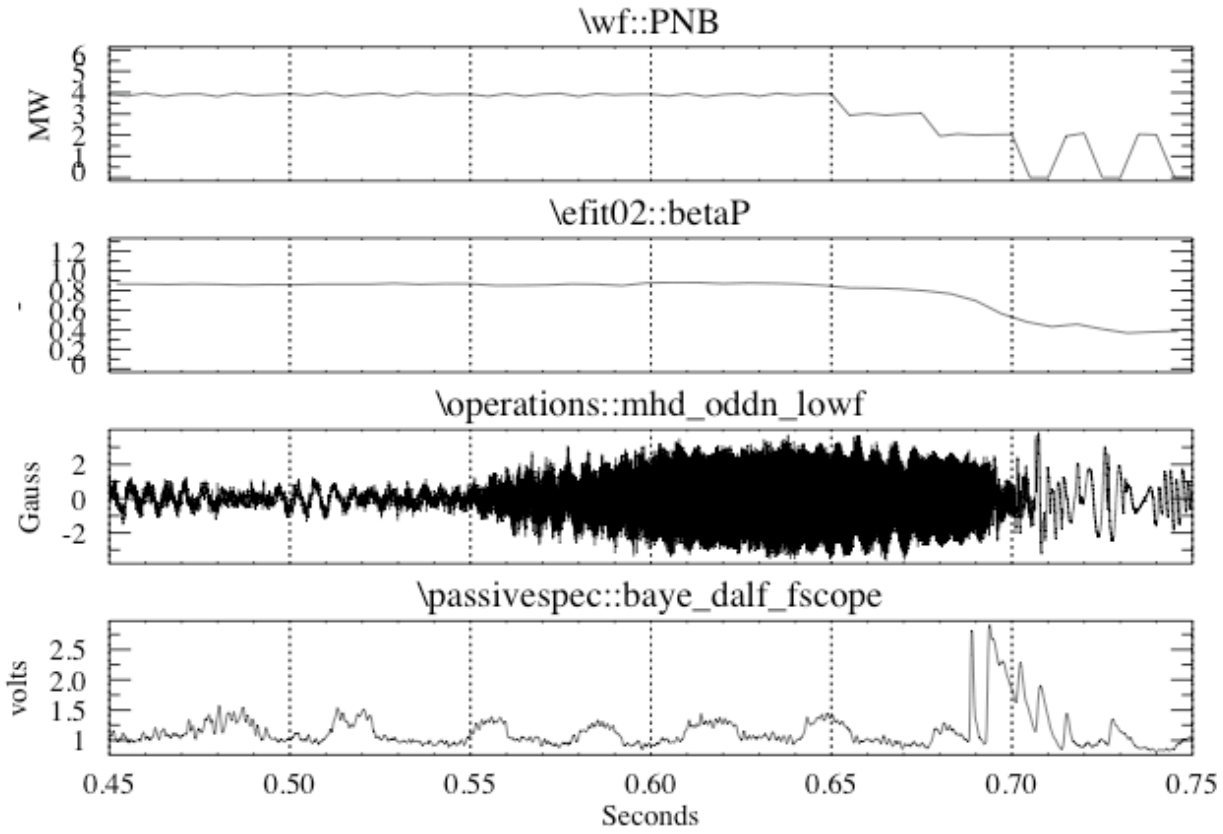
Feb 19th Attempt Was Limited by Mode Locking



- Typical example shows that mode locks (to external error field) at t=0.6.
- Solution: Repeat with DEFC

June 26 Attempt Limited By H-Mode Loss at lower P_{NBI}

- Rampdown limited by loss of H-mode, followed by locking.
- NSTX high-κ, high-δ plasma is essentially metastable to the 2/1 NTM as long as it is in H-mode (like ITER)
- Likely Solution: Take a shot with a lower L→H threshold, by reducing triangularity.



If you don't get the data you want, you analyze the data you have.

Δ' is a Key Parameter for (Neoclassical) Tearing Modes Sustained by a Helically Perturbed Bootstrap Current

$$\frac{\tau_R}{r^2}\frac{dw}{dt} = \Delta' + \varepsilon^{1/2}\frac{L_q}{L_{Pe}}\beta_{\theta e}\frac{1}{w}\left[1-\frac{w_{pol}^2}{w^2}\right], \qquad w_{pol} \approx \left(\frac{L_q}{L_P}\right)^{1/2}\varepsilon^{1/2}\rho_{\theta i}$$

Consider Slowly Evolving Islands: dw/dt≈0

Large Islands ($w=w_{sat}>>w_{pol}$):

$$0 = \Delta' + \varepsilon^{1/2}\frac{L_q}{L_{Pe}}\beta_{\theta e}\frac{1}{w_{sat}}$$

$$\Delta' = -\varepsilon^{1/2}\frac{L_q}{L_{Pe}}\beta_{\theta e}\frac{1}{w_{sat}}$$

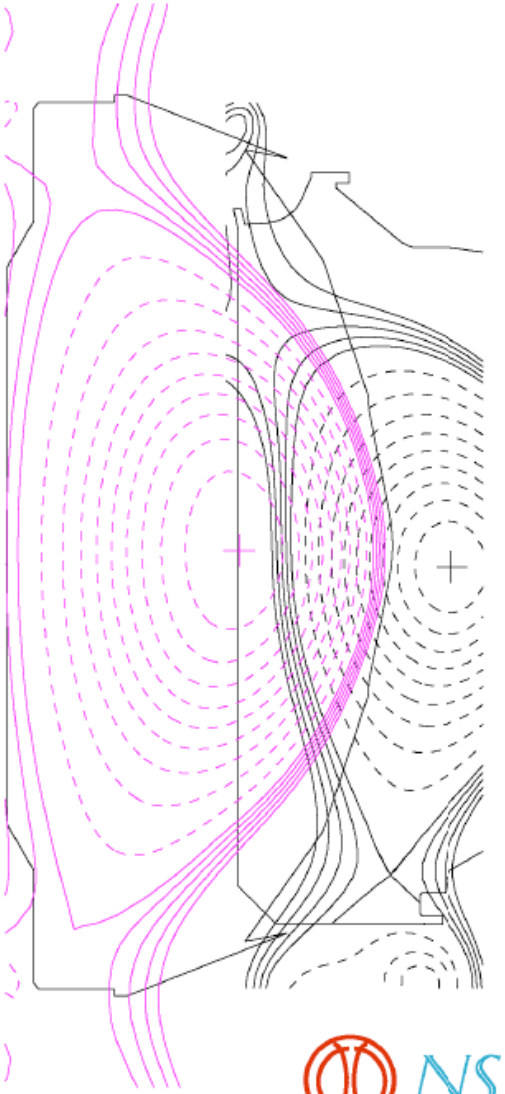
Marginal Islands: "Slowly" reduce β_P, and thus the island width, until the island quickly disappears.

$$\Delta' = -\frac{2}{3}\varepsilon^{1/2}\frac{L_q}{L_{Pe}}\frac{\beta_{\theta e}}{w_{m\,\arg}}$$

$$w_{m\,\arg} = \sqrt{3}w_{pol}$$

DIII-D and NSTX m/2=2/1 NTM Comparisons Allow Testing Aspect Ratio Effects on Stability of Islands

- Similar cross-section
  - ★ 1.9m^2 (DIII–D), 2.4m^2 (NSTX)
- Similar q95
  - ★ 6.7 (DIII–D), 7.5 (NSTX)
- Large aspect ratio difference
  - ★ R_o/a = 2.7 (DIII–D), 1.3 (NSTX)
- Large I/aBT(0) difference
  - ★ 0.6 (DIII–D), 3.6 (NSTX)
- Both ELMing H-mode



DIII-D NATIONAL FUSION FACILITY

NSTX

224-08/RJL/jy

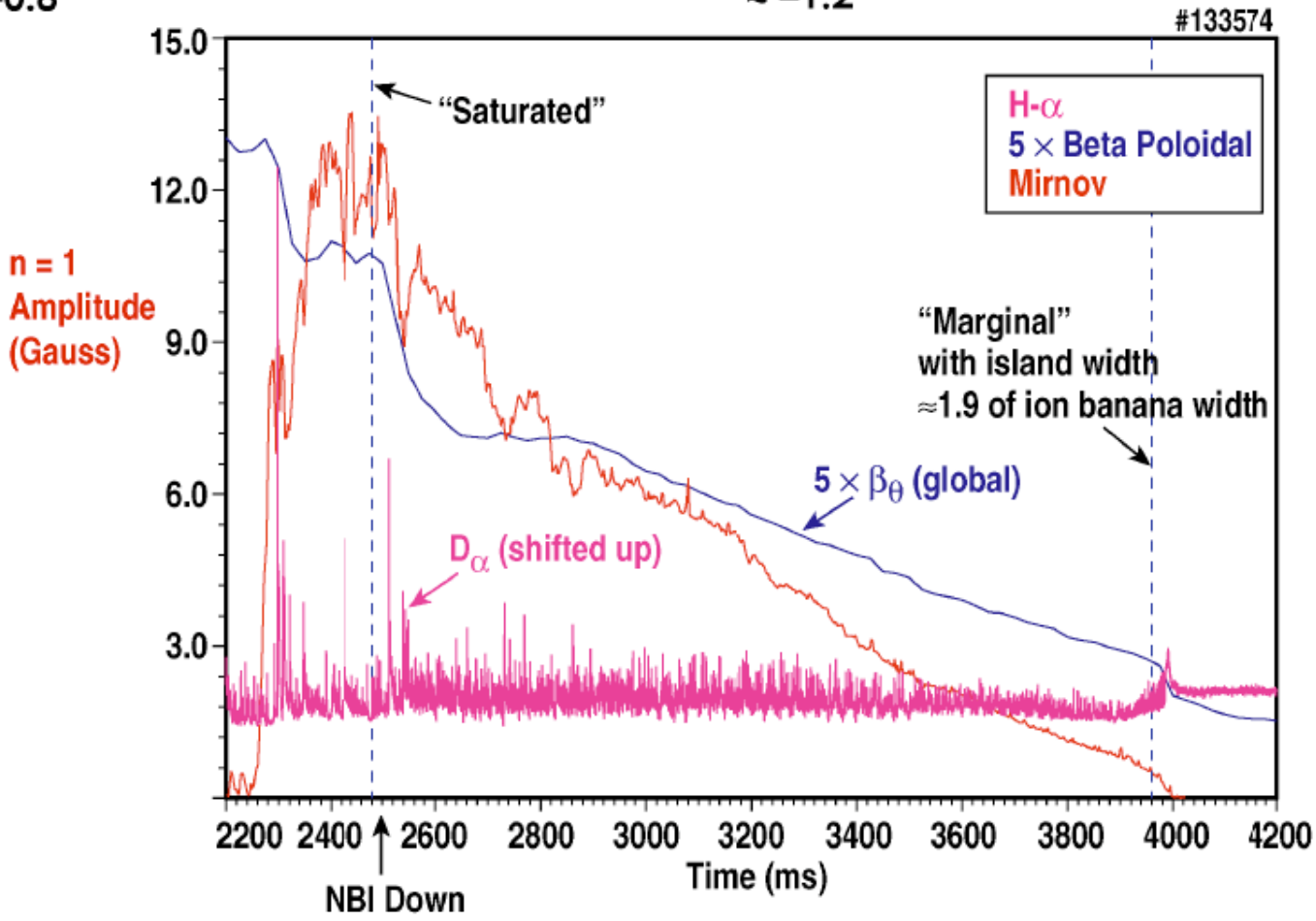
Appraising Marginal Island Width & Δ' in DIII-D for m/n=2/1 Neoclassical Tearing Modes

- **Helically perturbed bootstrap current balanced by negative Δ´ in MRE**

★ $\Delta' r \approx -\varepsilon^{1/2} (L_q/L_{pe}) (r/w_{sat}) \beta_{\theta e}$ ★ $\Delta' r \approx -(2/3)\, \varepsilon^{1/2} (L_q/L_{pe}) (r/w_{marg}) \beta_{\theta e}$

$\approx -0.42\ (0.116/0.323)\ (0.308/0.074)\ 0.92$ $\approx -0.667 * 0.41\ (0.165/0.169)(0.282/0.019) 0.30$

≈ -0.8 ≈ -1.2

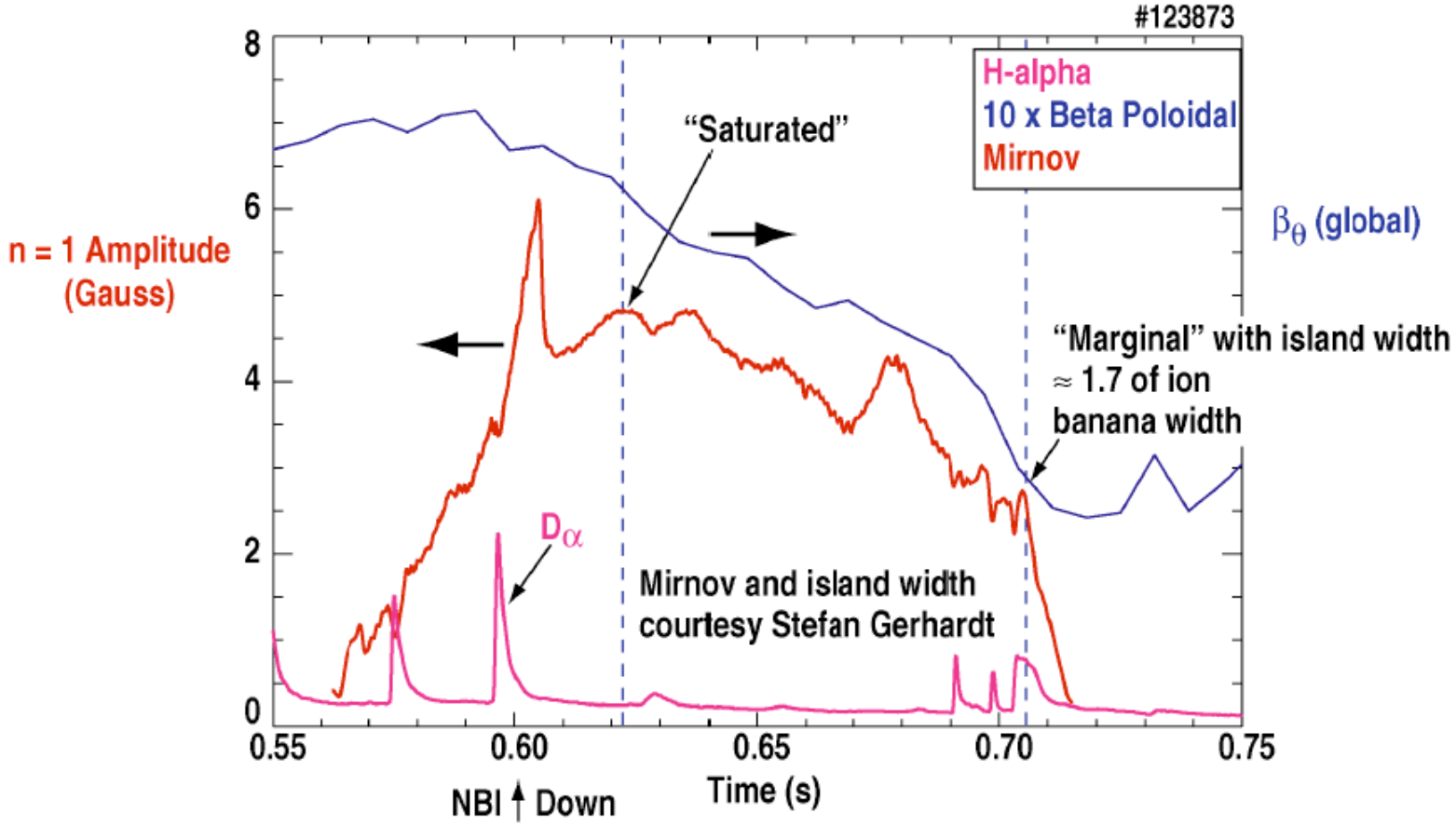


Appraising Marginal Island Width & Δ' in NSTX for m/n=2/1 Neoclassical Tearing Modes

- **Helically perturbed bootstrap current balanced by negative Δ´ in MRE**

★ $\Delta' r \approx -\varepsilon_B^{1/2} (L_q/L_{pe}) (r/w_{sat}) \beta_{\theta e}$
$\approx -0.65\ (0.083/0.158)\ (0.447/0.060)\ 0.22$
≈ -0.6

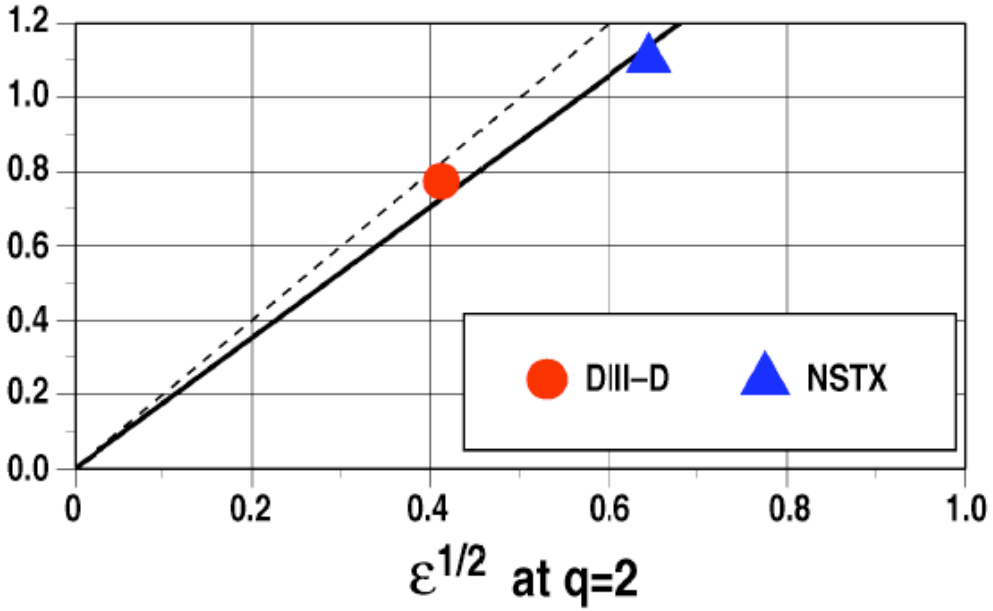
★ $\Delta' r \approx -(2/3)\ \varepsilon_B^{1/2} (L_q/L_{pe}) (r/w_{marg}) \beta_{\theta e}$
$\approx -0.667 * 0.65\ (0.128/0.081)(0.436/0.045) 0.135$
≈ -0.9



Conclusions on DIII-D & NSTX m/n=2/1 NTM Island Stability

- **Marginal island width is ≈1.8 × ion banana width in both devices**

$\frac{w_{marg}}{\rho_{\theta i}}$ @ q=2



$$w_{m\,\arg} = \sqrt{3} w_{pol}$$

$$w_{pol} \propto \varepsilon^{1/2} \rho_{\theta i}$$

- **$\Delta' r \approx -1$ at the marginal condition for q95 ≈ 7 ELMing H-mode**
  - ★ **noting that w, the flow shear, and β are all small ... thus negligible effects on Δ'?**
  - ★ **less negative at "saturation" due to larger w, flow shear and/or β?**

Brief Note on XP-834

XP-834 Attempted to Study the Small Island Physics of the (comparatively rare) 3/2 NTM

Method

- Use a 1 min. D_2 glow to delay H-mode, and rapid steps in beam power to trigger a 3/2 mode.
- This method was inadvertently discovered by P. Ross and D. Gates, before LITER operation.
- Having triggered the mode, use the previously discussed β-rampdown technique to restabilize it.

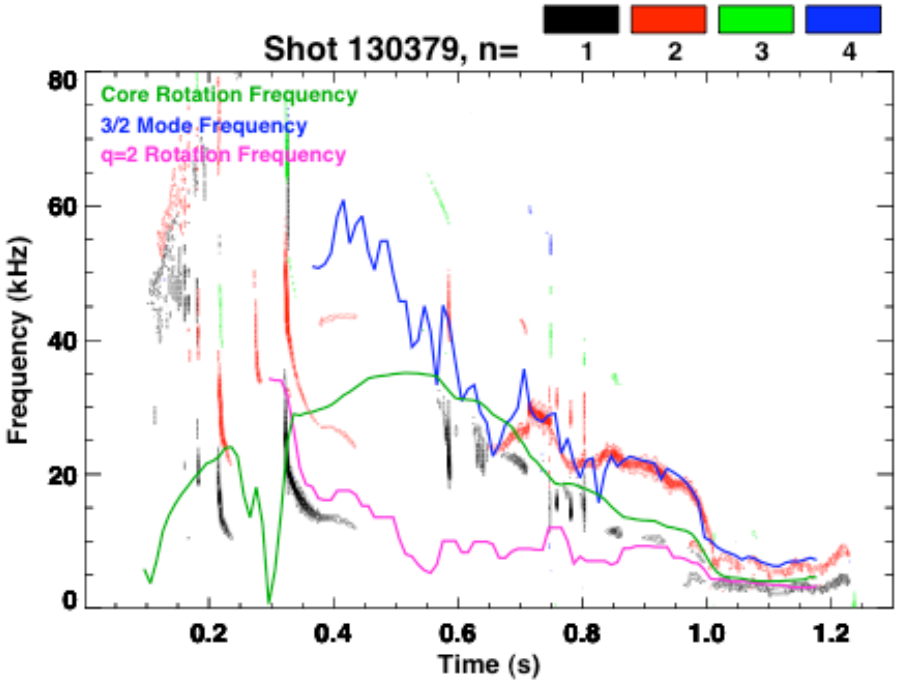
Result on June 30.

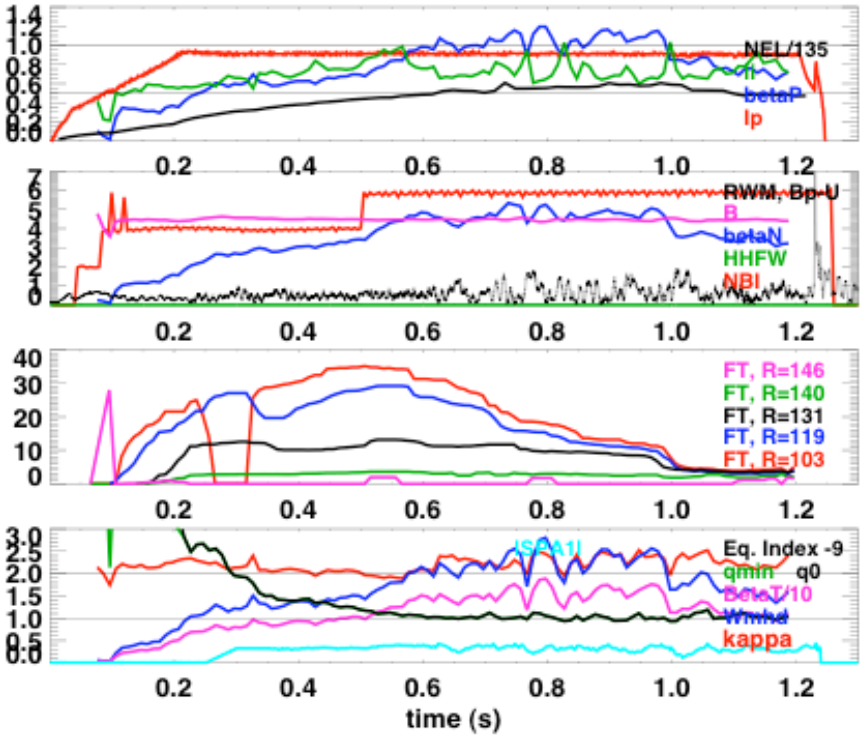
- NSTX ran well, but the recipe was unable to reliably generate 3/2 modes.
- Modes, when generated, appeared to "spontaneously" restabilize.
- We tried various modifications to the shot front end, developed a scenario with intermittent late n=2 modes interspersed with n=1.
- Summary: Achieved some examples, but unable to do systematic studies

Then, on the Li powder day…

Nicest 3/2 Modes SPG has ever seen were generated during Li Powder XP

- Mode struck on four shots: 130379,130384, 130386, & 130387
- Provides at least limited data to study tiggers, compare to the 2/1 mode





Need to rethink how we do the 3/2 mode studies.
Explore sawtooth triggers (larger V·s capacity of NSTX-U will really help)