XP 740: NTM threshold at low plasma rotation

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DIII-D NATIONAL FUSION FACILITY
GENERAL ATOMICS

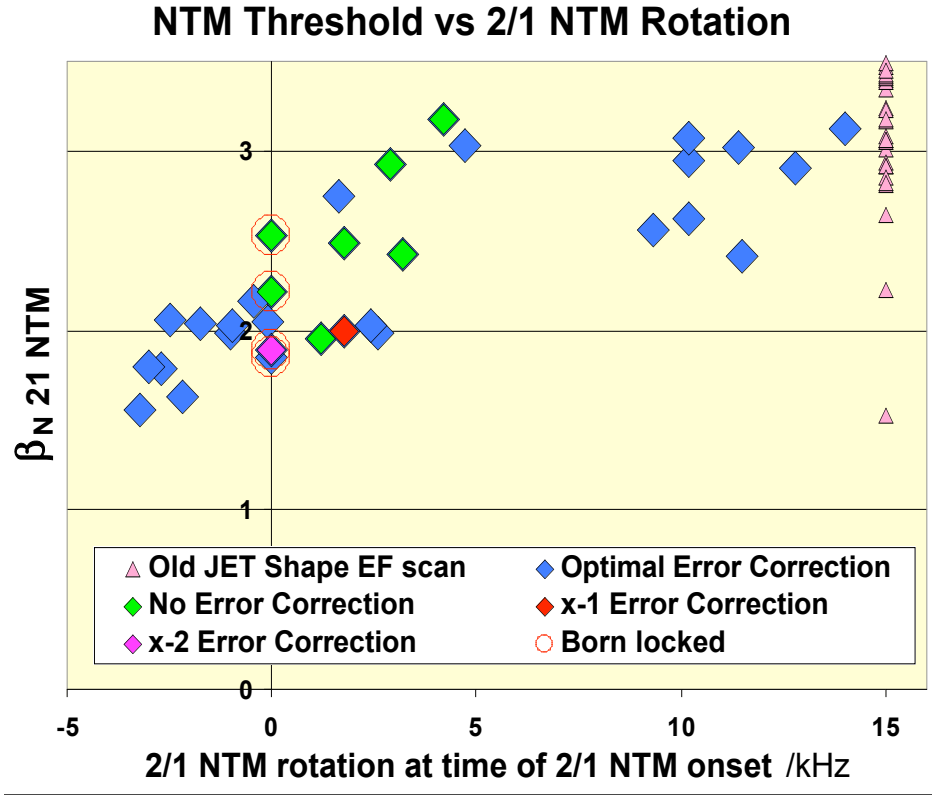
XP 740: NTM threshold at low plasma rotation

(R. Buttery, R. La Haye, E. Strait)

DIII-D experiment with varying NBI torque

- 2/1 NTM threshold falls as rotation is reduced
- n=1 error field leads to further decrease of β_N
- Qualitatively similar results with 3/2 mode in JET

➢ *Implications for ITER or CTF at low plasma rotation?*



Possible influence of rotation on NTM stability

- **NTM seeding**
  - Decreased rotational shear between resonant surfaces may enhance coupling of sawteeth, ELMs, etc.

- **NTM threshold terms**
  - Ion polarisation introduces rotation dependence:

$$a_{pol} \quad \rho_{i\theta}^2 \; g(\nu,\varepsilon) \; \omega \, (\omega_{i*} - \omega)/\omega_{e*}^2$$

    - *Depends on rotation in ExB frame of reference*
    - *Sets size of seed required or rise in $\Delta'(\beta_N)$ to trigger NTM*

- **"Classical" tearing mode stability**
  - Wall stabilization of rotating islands
  - Or enable error field to help drive the island

Run plan: general approach

- **Obtain a discharge with a reproducible n=1 mode**
- **Ramp beta down late in the discharge**
  - Stabilization as beta decreases is a signature of NTM
  - Preparation and additional data for XP 739
- **Vary the plasma rotation with early n=3 braking**
  - Look for dependence of the mode onset beta

- **Apply a resonant (n=1) field**
  - Possible enhanced seeding of the n=1 mode
  - Stronger braking (if needed)

Target discharge: high β_N, strong rotation

- Core rotation ~25 kHz
- Tearing mode appears late in the discharge

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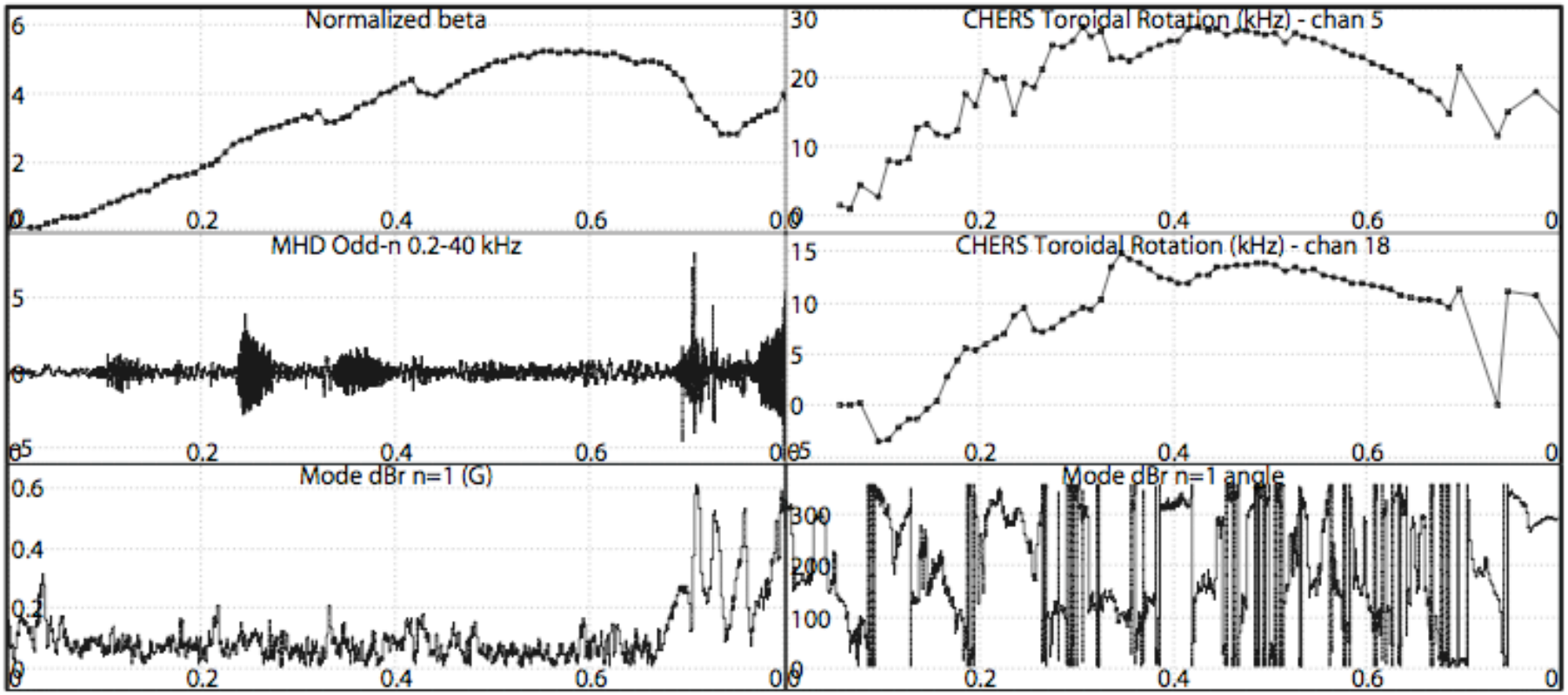

Non-resonant magnetic braking reduces rotation

- **Core rotation ~15-20 kHz**
- **Tearing mode appears earlier and at lower β_N**

n=3 braking

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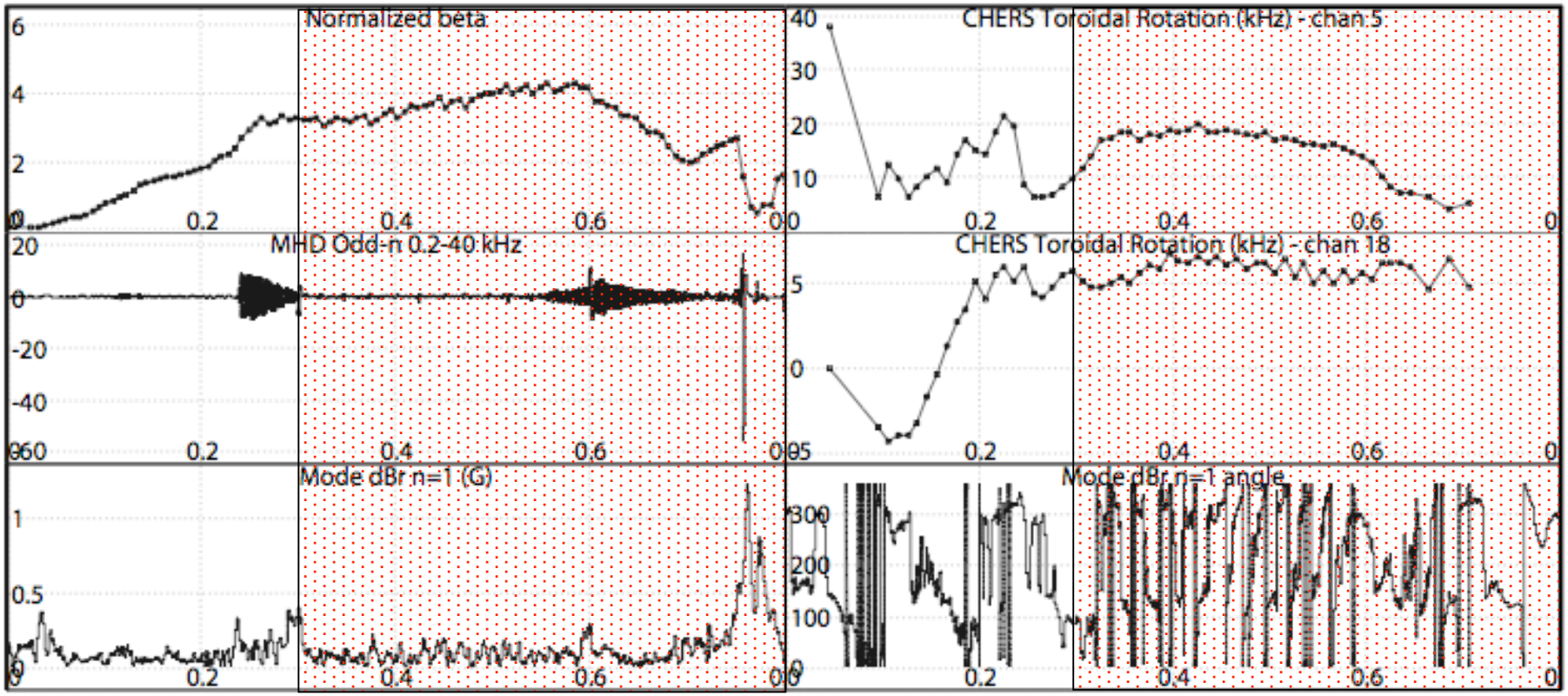
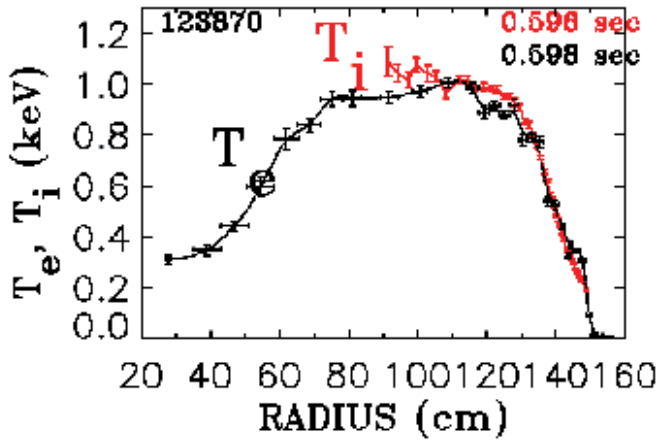
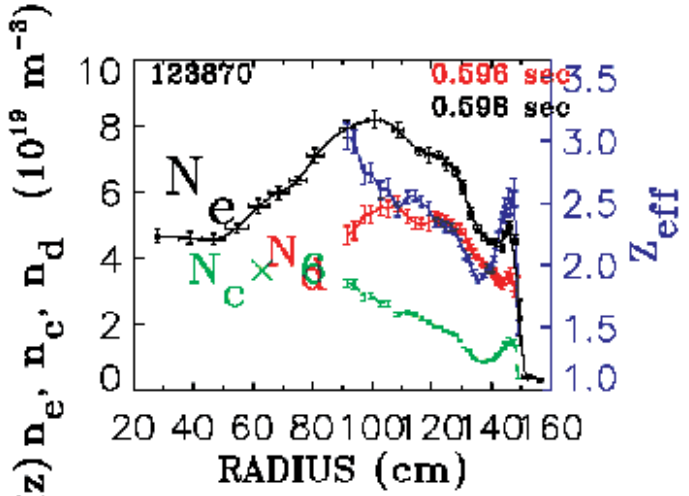
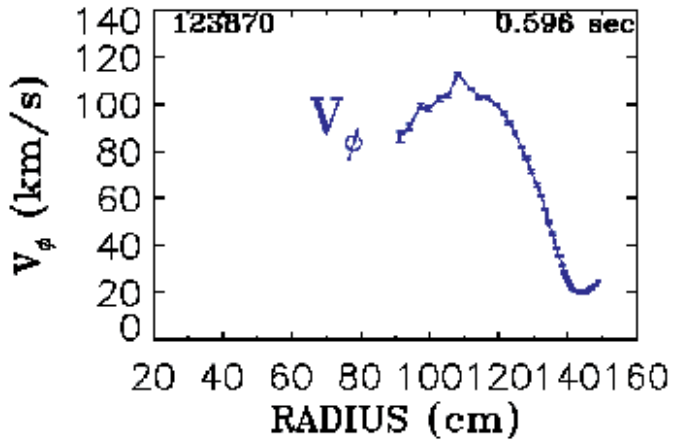
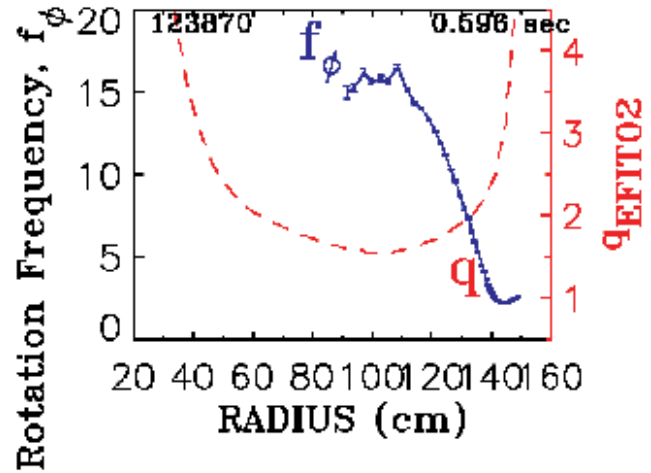


Rotation is centrally peaked before NTM onset

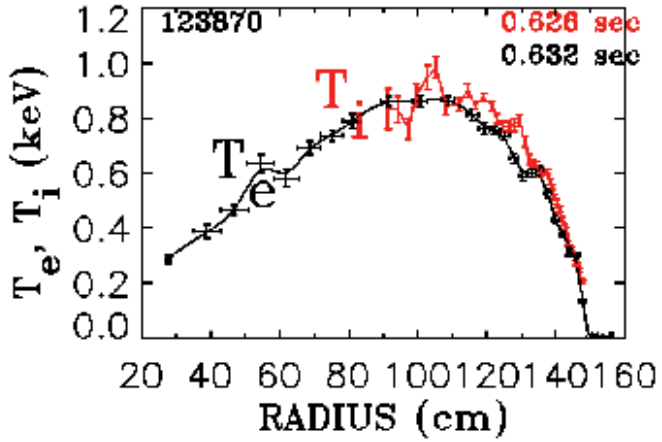


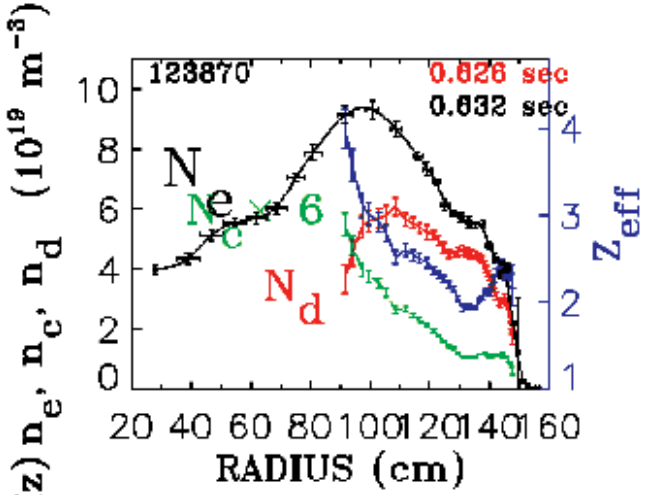


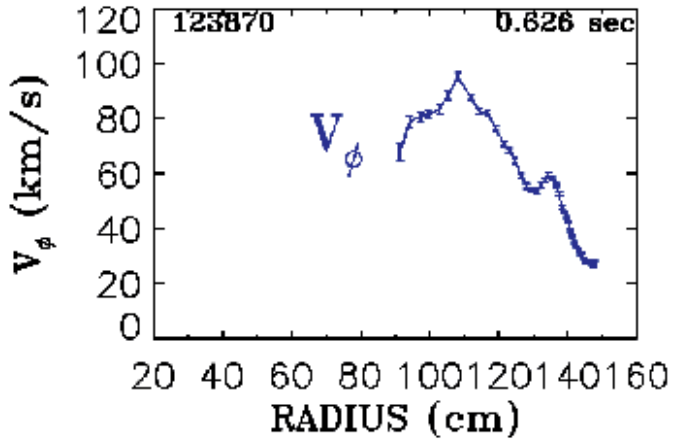


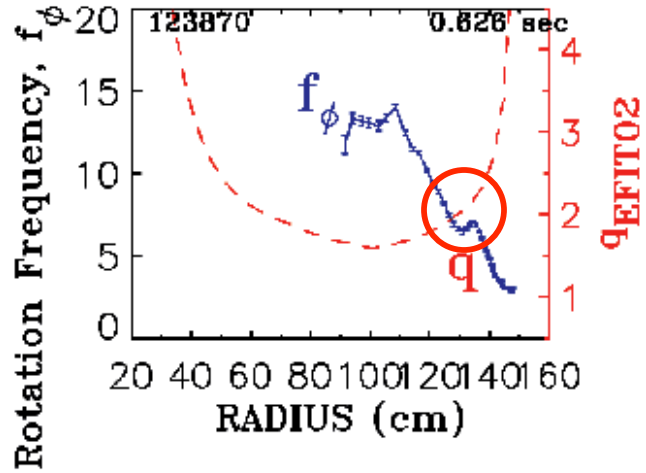


Rotation profile has a flat spot near q=2 after onset



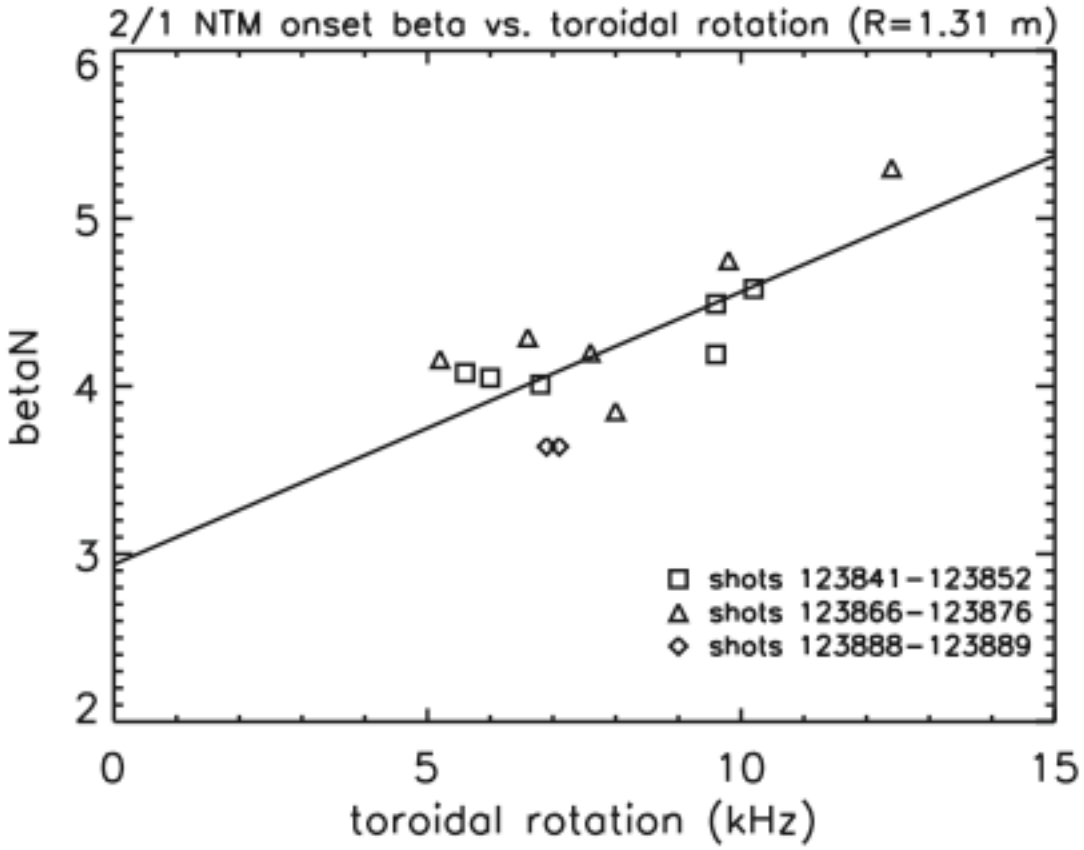






β_N of NTM onset is correlated with rotation near q=2

- **Two scans of n=3 braking current with slightly different plasma shape give consistent results**



- **Current varied from 700 to 1000 Amps**
  - Stronger braking and lower rotation led to RWMs.
- **~30% reduction in β is qualitatively consistent with DIII-D results**

Conclusions

- **β_N threshold for onset of 2/1 NTM decreases as rotation decreases**
  - Consistent with DIII-D and JET results

- **Detailed analysis of equilbrium, rotation profile, and mode frequency is needed to distinguish rotation effects:**
  - Plasma rotation vs. rotational shear
  - Mode rotation vs. ExB rotation