

Mon 25<sup>th</sup> Feb 2008 reporting meeting – XP810 and 801 report:

# Error field and rotation sensitivity of 2/1 NTM onset and decay thresholds

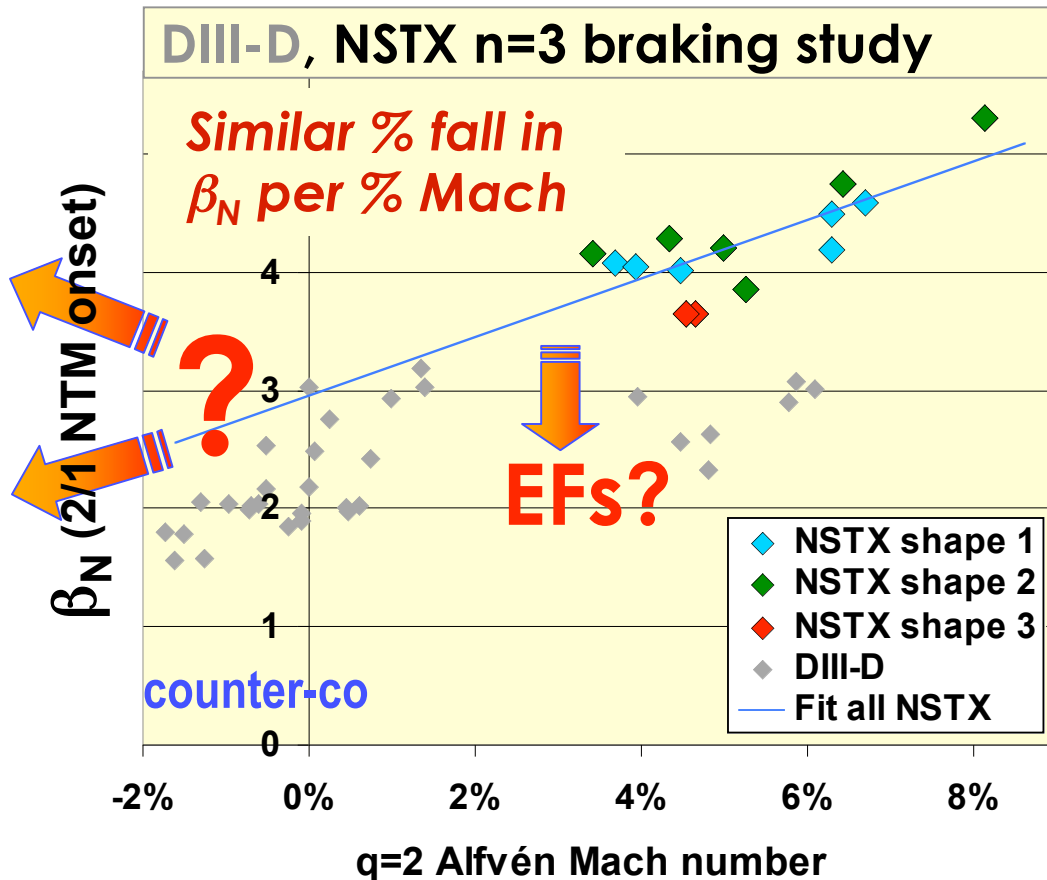
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# Basis of NSTX NTM rotation experiments...

DIII-D & NSTX show strong rotation dependence in NTM physics:



To explore:

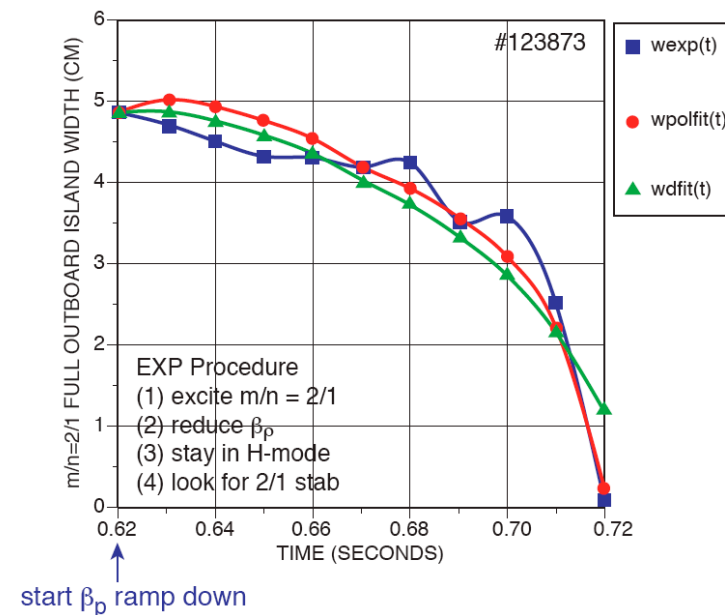
- Do error fields lower thresholds further?
- How does rotation impact thresholds?
  - Rotation or rotation shear?
  - Triggering physics or underlying stability?
- Explore with mode onset and decay experiments on NSTX
  - n=1 and n=3 brake plasma differently

Later (if reverse  $I_p$  operation possible):

- Does counter rotation stabilise mode or not?

## Part II Goal : Restabilization of Mode (SPG)

- Ramp Down Beam Power, and thus  $\beta_p$ , to restabilize the mode.
  - Sensitive Test of Small Island Physics.
- One good example of doing this last year (see below).
  - Stay in H-mode throughout rampdown (similar experiment in DIII-D this June).
  - Restabilize the mode before it locks.
  - Scan  $n=3$  braking and  $I_p$  during rampdown



# Technical Progress – day 1

- **Lot of problems with machine conditions:**
    - Poor conditions required 3 beam operation
      - Attempts with 2 beams & optimisation of elongation, but mode struck too early...
    - Beam C limited by SPA pick up (**fixed by mid-afternoon**)
      - Got 3 points without SPAs, then 2 more with  $n=3$ ...
    - Then **central stack problem cost 1.5 hours**
      - Got one final point with 3 beam mode onset...
- >> 3 beam target made for ramp-down but not optimised to provide ramp-down data...**

# Technical Progress – day 2

- **Started with target from day 1...**
  - Beam A failed (MSE) for **whole morning**
    - We persevered with development of a lower Ip 2 beam scenario
      - *has limited scope of scans, but allowed us to get scenarios working while MSE beam fixed*
      - *Provided some tests of ramp down techniques for XP801*
    - ✓ **Then obtained 4 point scan with n=1 field**
    - Further tests for ramp-down with n=1 error correction
      - *But unknown error field – could not avoid locking*
    - Lost 1.2 hours to earth fault on centre column
      - ✓ **Then managed 2 point n=1 scan with n=3 applied**
        - *(one or two vertical stability and RTEFIT problems)*
  - **General point:**
    - Using a lot of flux swing (not yet that well conditioned) and 2 beam mode  $\beta_N$  threshold quite low (limited scan scope)

# Physics progress summary

- Scenario redeveloped for 2 beam and 3 beam operation
- Ramp-down techniques implemented but mode locking problem
  - Possibly related to machine conditions and intrinsic error fields
- **4 point 2/1 NTM onset scan obtained vs. n=1 field**
  - Error fields act to lower rotation and decrease NTM  $\beta$  threshold
    - ***Some uncertainties in intrinsic error level***
- **2 point scan of n=1 field obtained while modest n=3 braking**
  - n=1 braking has an effect in lower thresholds here...
  - ...analysis required to determine differences cf zero n=3
    - ***scope very limited by available time - higher n=3 & n=1 levels desired to explore key question – is error sensitivity worse at low  $\omega$ ?***

*Combined data does provide useful extension of 2007 database to resolve questions of role rotation vs rotation shear...*

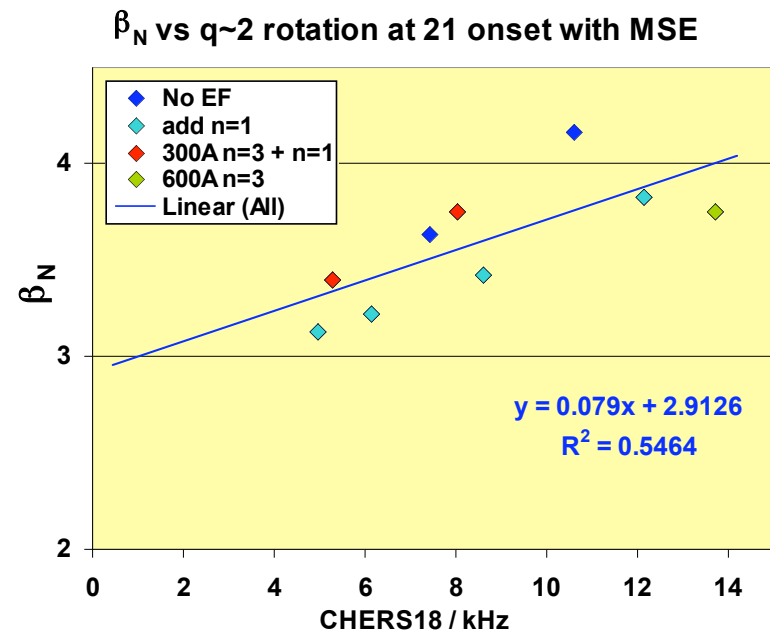
# Preliminary results – mode onset

- Preliminary onset scan obtained with  $n=1$  fields & 2 beam recipe...

- ...but very limited data with  $n=1$  applied when lowering rotation from  $n=3$  braking...
  - *(this was main objective)*

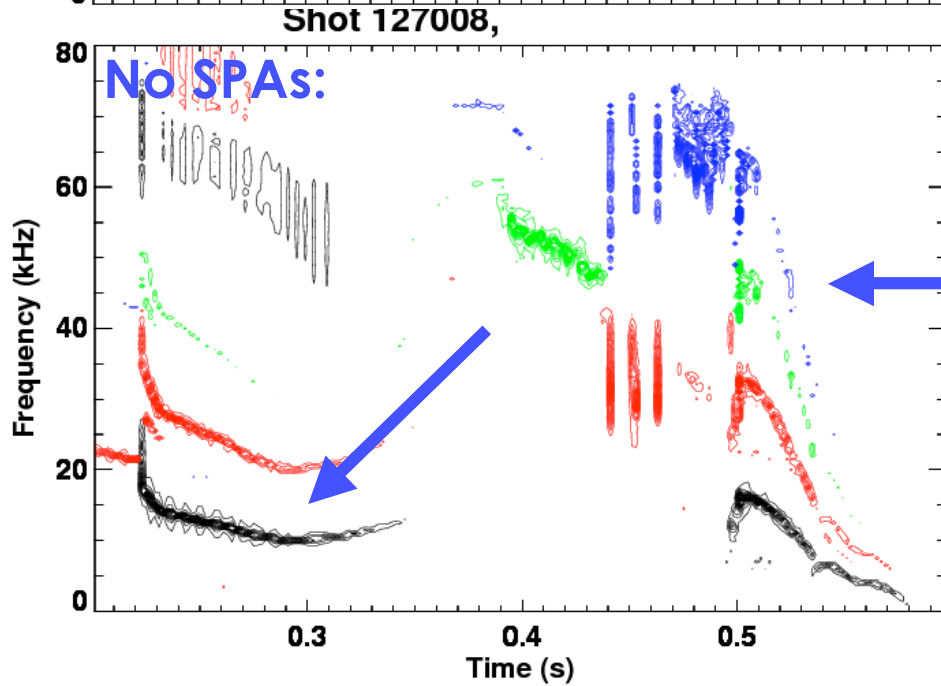
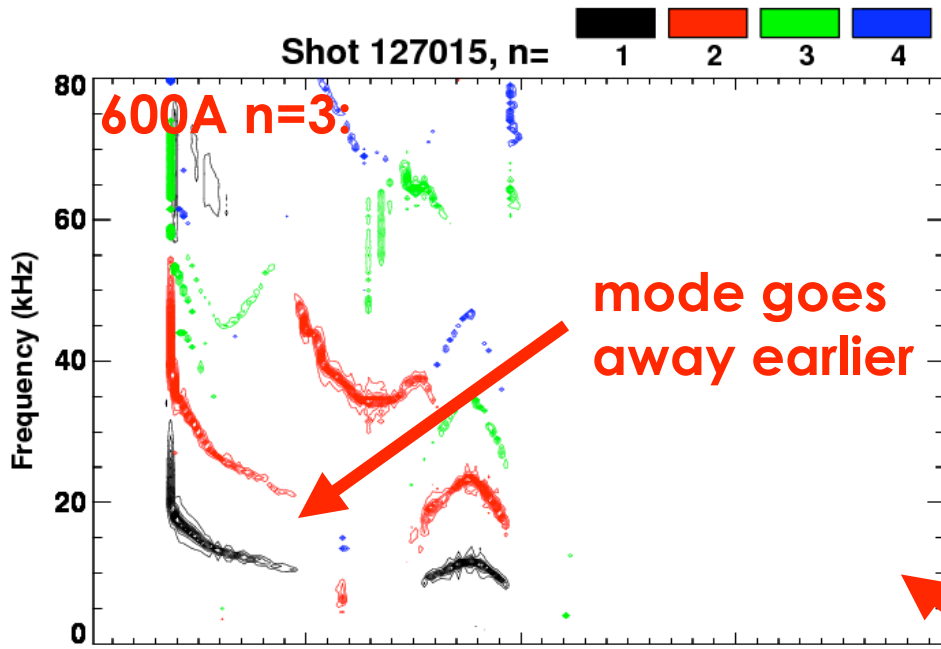
- **Nevertheless, useful extension of NSTX database to get at rotation vs. rotation shear issue...**

(SPG) Detailed Analysis Awaiting Full Profile Data (Mainly 30 pt. TS.)

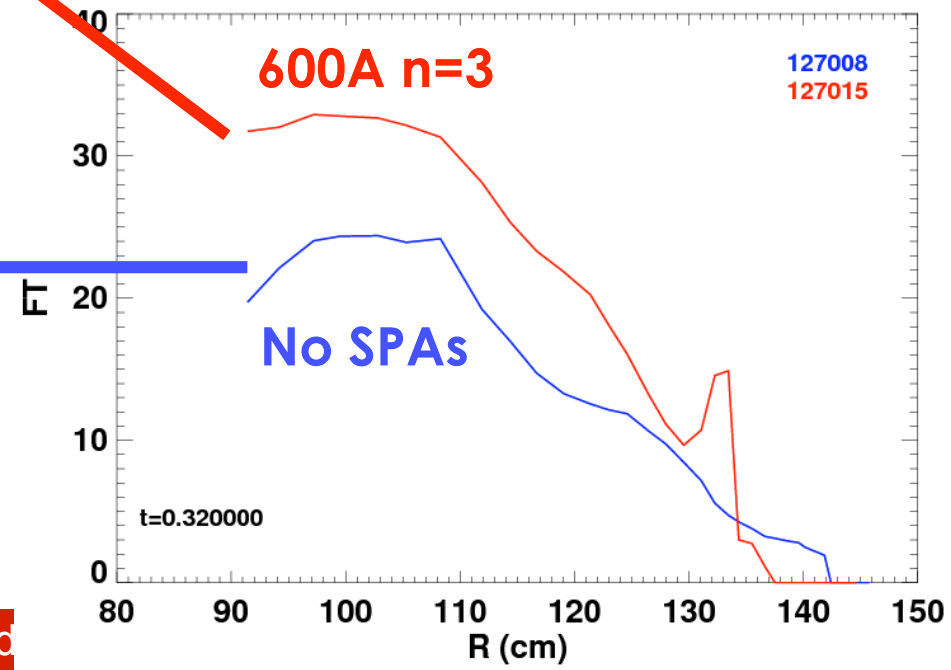




# Machine conditions introduced some scatter...

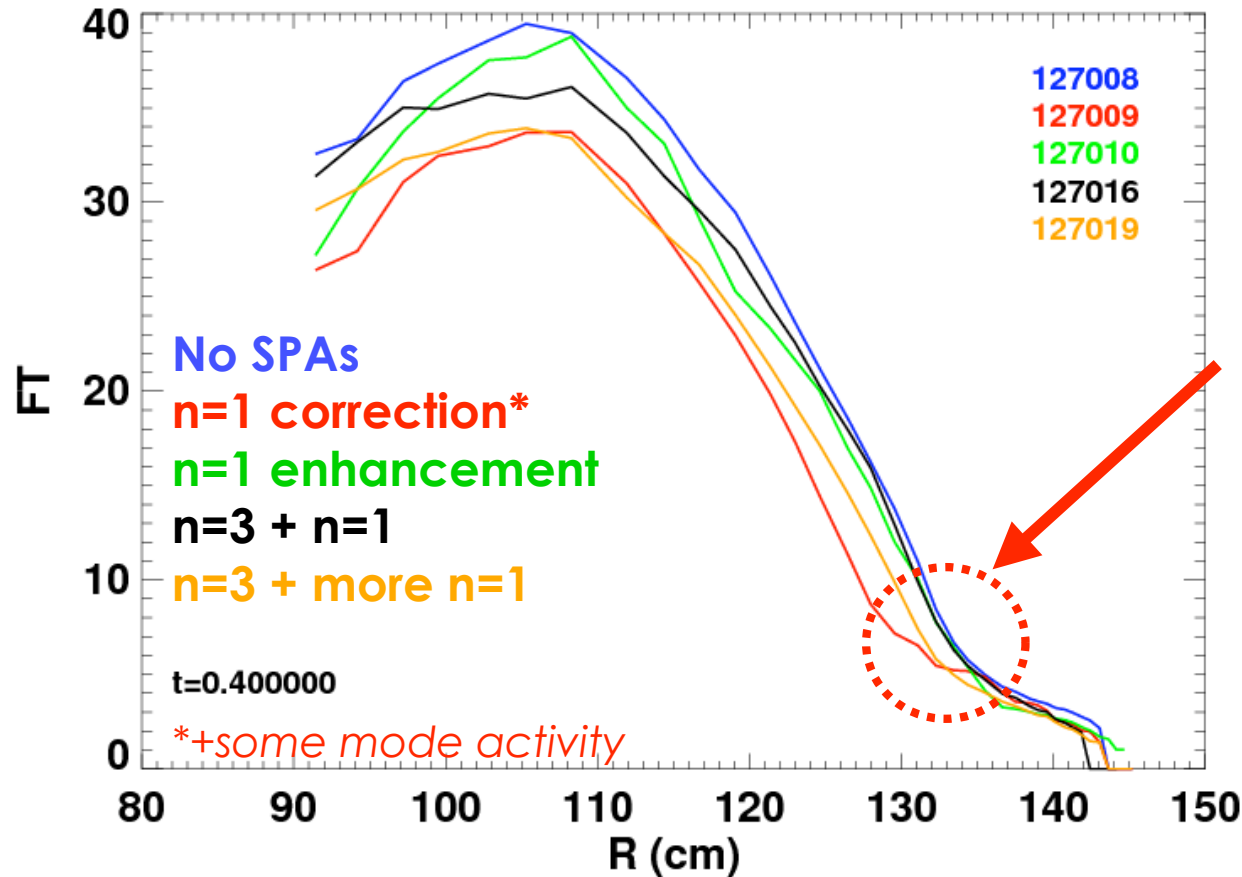


- Operating close to early modes as limited time in Ohmic coil swing
  - These impact rotation
  - Variations in mode time history impacts profiles
  - *Outweighs n=3 braking!*





# Nevertheless, considerable variation in target rotation profiles before mode...



• Particularly in  $q \sim 2$  region of interest

...and superb CER data (best RJB's ever seen!)

# Key outstanding goals

- **XP 801 – ramp-downs for NTM self-stabilisation point**
  - Need to achieve ramp-down with dynamic error correction
  - Then scan ramp-down vs rotation using  $n=3$  and  $n=1$  braking
- **XP 810 – NTM onset threshold in  $\beta_N$** 
  - Need to resolve issues of intrinsic error  $n=1$  field to understand contribution to that scan
  - Need to extend scan with  $n=3$  braking to get better variation, with higher  $n=3$  braking, and wider range of  $n=1$  fields

***This would greatly benefit from improved machine conditions (→ longer time window and higher  $\beta$  threshold) and dynamic error correction (→ to remove / measure  $n=1$  fields)***

- *Upcoming XP by SG/JM will provide latter; continued ops – former*

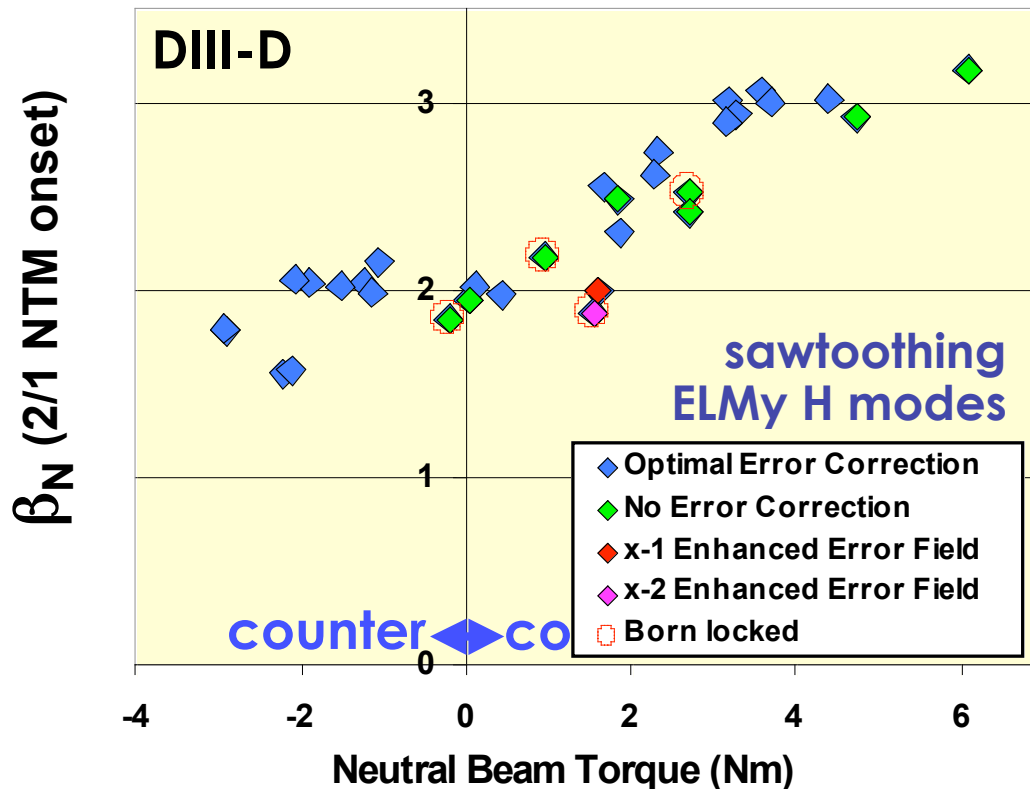
**→ Propose completion day after that, shared between 801 & 810**

***Many thanks to the NSTX  
team for hosting us and  
working hard to help our  
experiments work.***

- **RESERVE OLD STUFF...**

# 2/1 NTM co vs counter rotation dependence

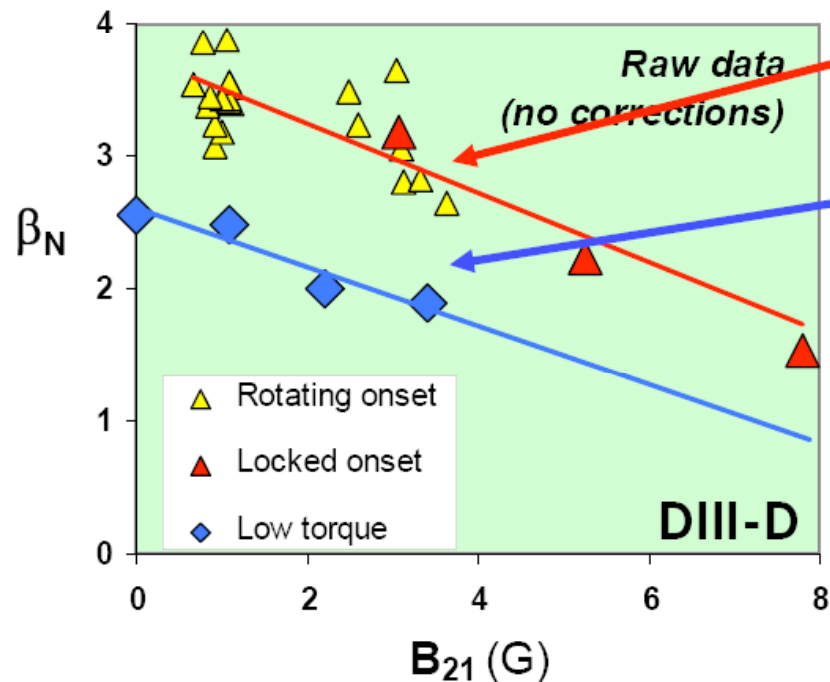
DIII-D: shows strong rotation dependence in 2/1 NTM  $\beta_N$  limit



- But what is physics?
- Does counter rotation stabilise mode?
- Is threshold dependent on rotation shear relative to magnetic shear (à la theory)
- *Need to test and explore this important result...*

# Part A: Error field effects on 2/1 NTM $\beta$ limit

JET and DIII-D show error fields can lower 2/1 TM threshold



- Lowering of  $\beta_N$  limit for 2/1 NTMs with 100%co NBI
- Similar effect on DIII-D with 65:35 mix of co:counter NBI (low torque)

## Need to probe further:

- Error field expected to trigger modes more easily at low rotation (???)
- Need to understand correction requirements in medium  $\beta_N$  plasmas
- Helps understand NTM physics & rotation role

**NSTX experiment:** up to 1 shift

Ramp  $\beta_N$  to trigger modes (ref shot 123876); scan error field level shot to shot.

Repeat scan with high  $n=3$  field applied to explore braking

*(May be desirable to compare with an Ohmic version of the experiment... see next)*

*(Some points with EF ramps at constant  $\beta_N$  also desirable).*



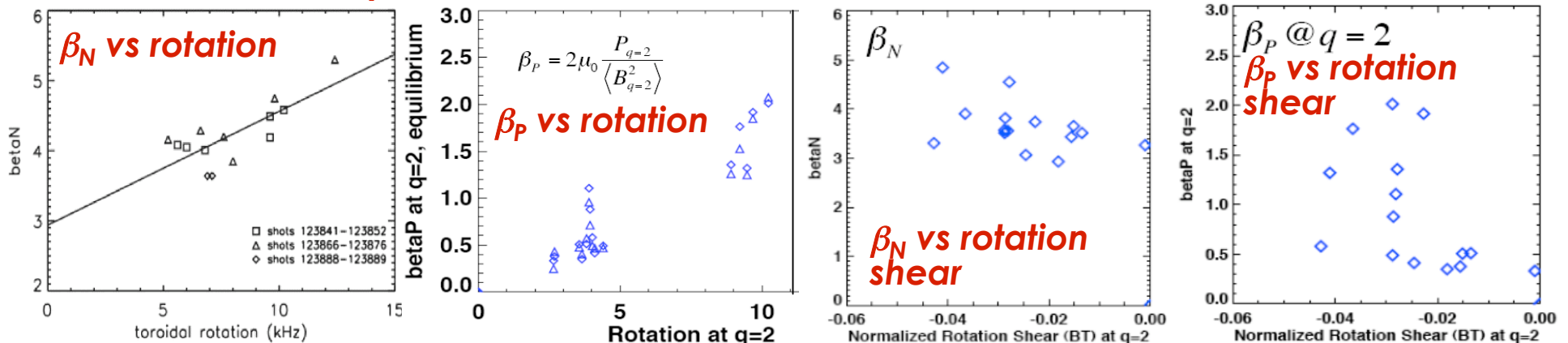
# Key issues NSTX can shed light on

- **NSTX can probe error field effects**
  - To see if increased sensitivity at low rotation
- **NSTX can explore rotation profile effects**
  - Distinguish between rotation and rotation shear models?
  - Assisted by varying mix of n=1 & n=3 braking
- **NSTX can readily address the counter rotation question**
  - Does trend go up or down in counter direction?
  - *Just reverse Bt and Ip... (later, but covered by this XP)*

Part A

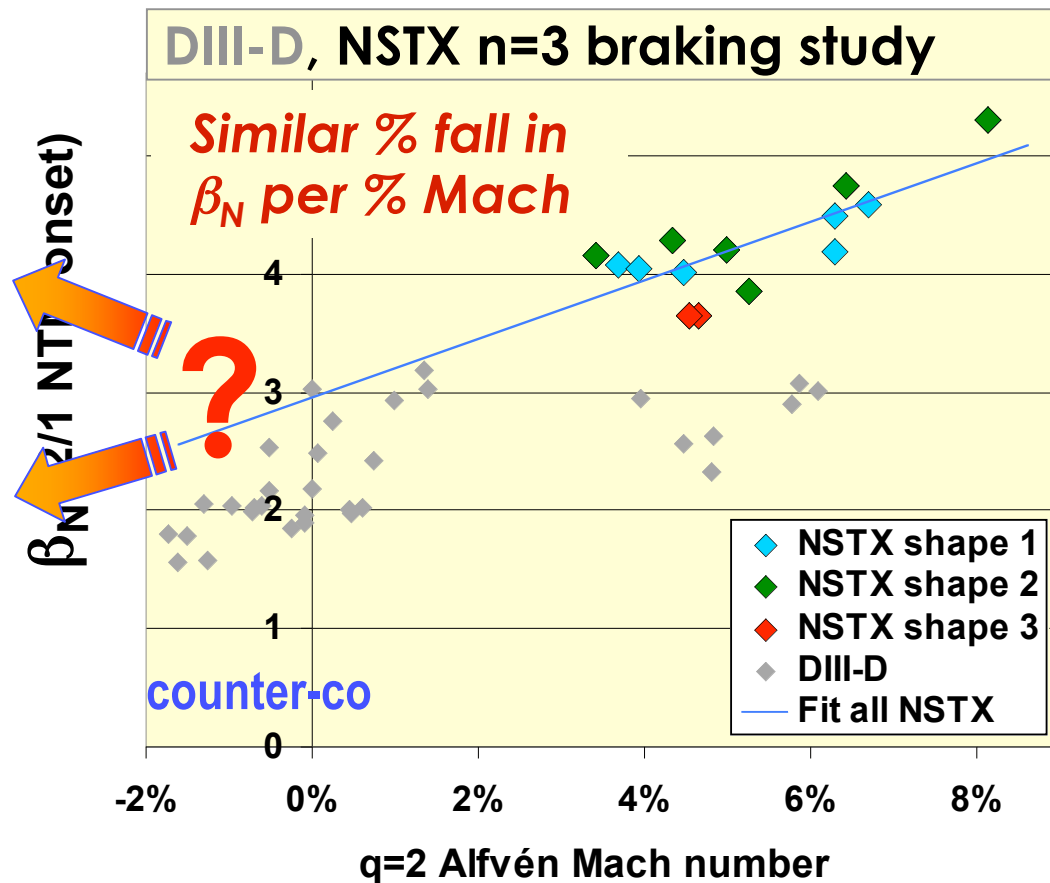
Part B

## Stefan Gerhardt analysis... :



# Part B (later): counter Bt and Ip scans

Recall previous NSTX and DIII-D scans:



- Simple technique is to reverse  $I_p$  and  $B_t$  to get strong counter data

– Key test of underlying theory governing rotation dependence

**NSTX: about 0.5 shifts, counter  $B_t$  and  $I_p$**

Apply ramps in  $\beta$  to trigger 2/1 NTM (ref shot 123876)

May need co- comparison, and vary rotation with  $n=3$ ...