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Error field threshold study in high-β plasmas with reduced input torques

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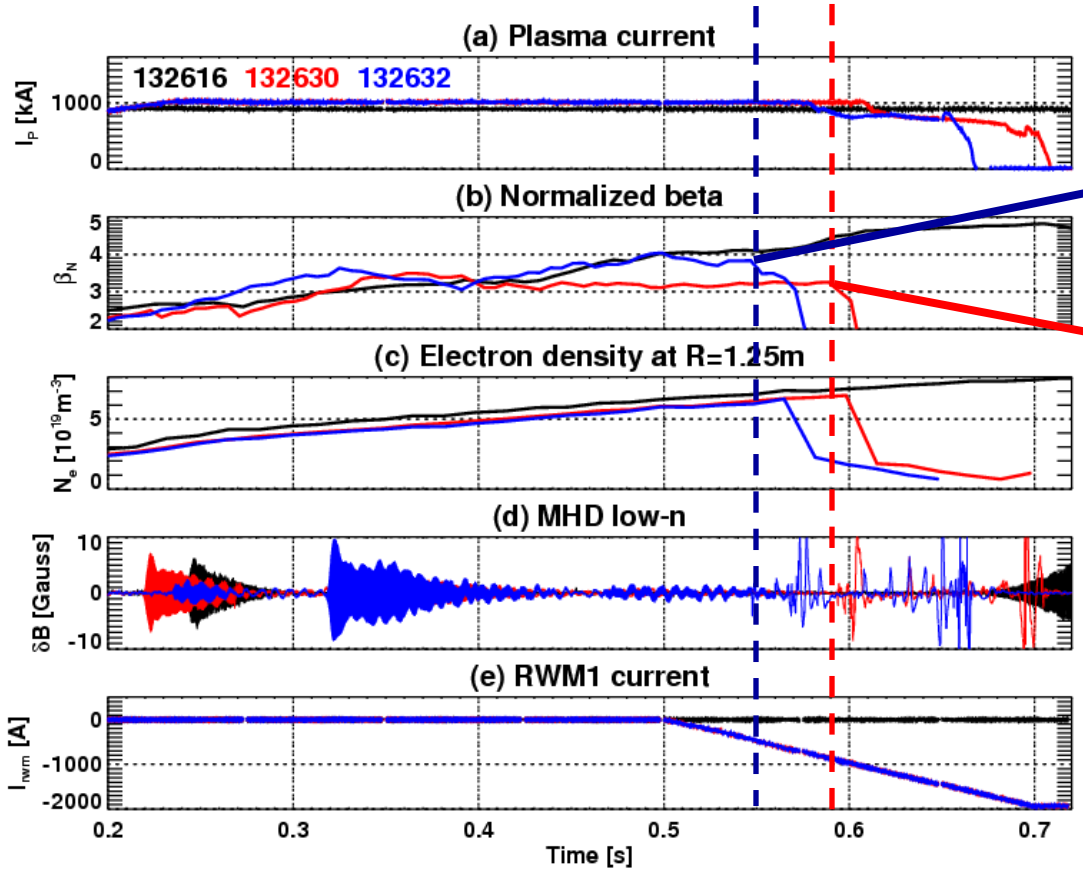
Error field threshold study for in high-β plasmas showed greater sensitivity of plasmas to n=1 applied field

- Error field threshold (measured by RWM currents) for locking was decreased when β was increased



Higher-β locked earlier (w/ smaller RWM currents)

Lower-β locked later (w/ larger RWM currents)

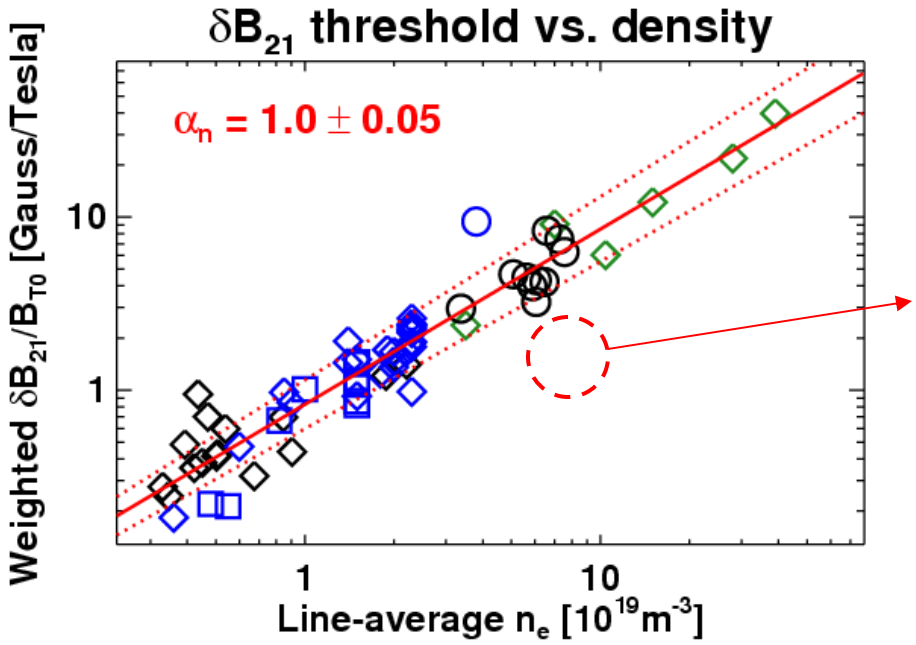
XP903 enlarged parametric space of tokamak error field threshold database

- The best four-parameter scaling with total resonant field:

$$\frac{\delta B_{21}}{B_{T0}} \le 3.7\times10^{-4}\left(n[10^{19}m^{-3}]\right)^{1.0}\left(B_{T0}[T]\right)^{-1.4}\left(R_0[m]\right)^{0.85}\sigma_{NR0}^{-0.44}$$

Where $\sigma_{NR0}=\left[\frac{\sum_{nmm'} n^2\delta^2_{nmm'}F^{-1/2}_{nm0}F^{-1/2}_{nm'0}}{\delta B^2_{21}}\right]^{1/2}$ *is the ratio of non-resonant field to resonant field*

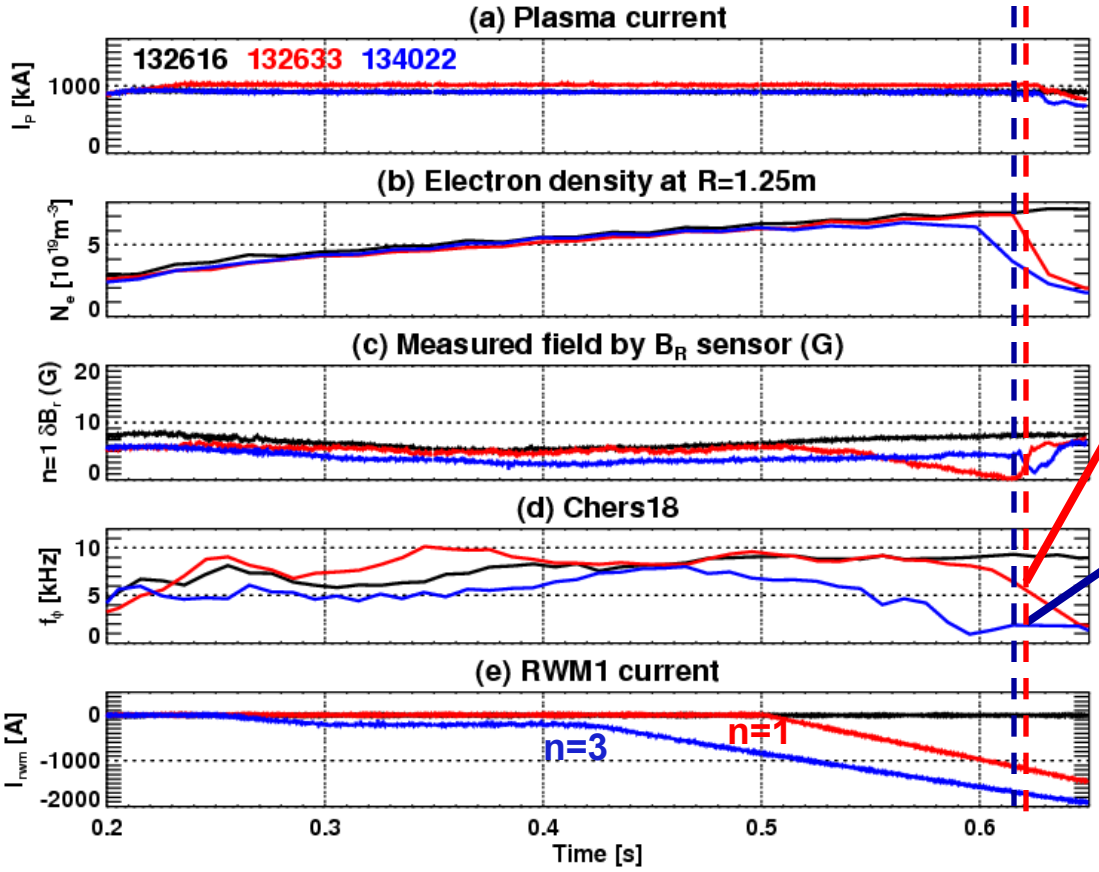
◇ Low-β NSTX ◇ Low-β DIII-D ◇ Low-β CMOD □ Low-β DIII-D with Right-handed config.
○ High-β NSTX ○ High-β DIII-D



However, NSTX locking data with large n=3 are not included in this scaling

Error field threshold clearly changes when n=3 magnetic braking is applied in addition

- Large n=3 reduces n=1 error field threshold (XP915)

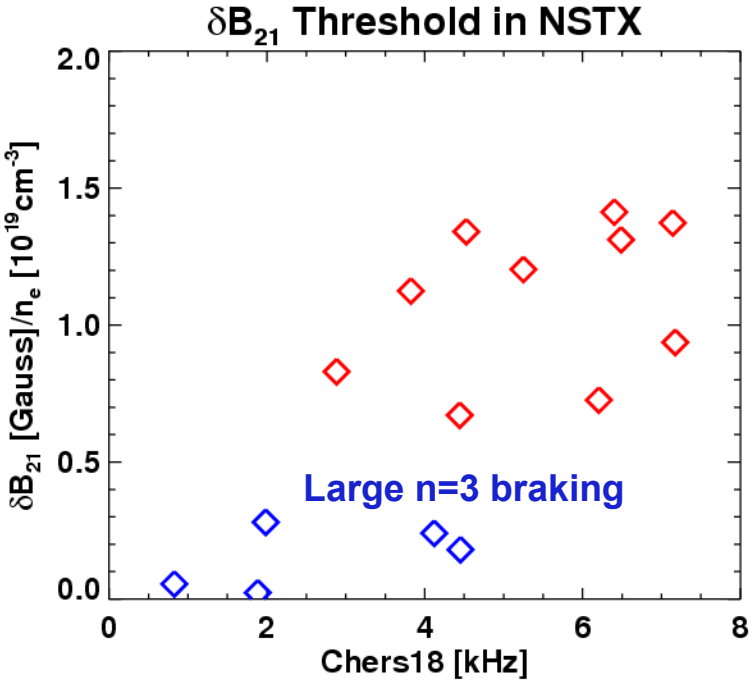


High rotation without n=3
RWM n=1 ~ 1kA

Small rotation with n=3
RWM n=1 ~ 0kA

Question :
Is rotation the key to error field threshold?

- Reduced n=1 threshold with large n=3 is evident, but
  - Does it imply that rotation is the key to error field threshold? Or n=3 non-resonant components matter?
  - What if torque is reduced by HHFW heating?
  - What if n=2 braking is used?



Shot plan (1~1.5 days)

- Study n=1 error field threshold in HHFW-heated plasmas (0.7 day)
  - Use HHFW heated target plasmas
  - Use n=3 EF corrections only if target is not stable enough
  - Adjust RF 2~3MW power to get to β_N=3~4
  - Ramp up n=1 RWM currents (~1kA during 0.2s) until locking
  - Measure rotation for reference
- Study n=1 threshold with NBI 2MW (0.3 day)
  - Reduce NBI further from 2MW using NBI on-offs
  - Ramp up n=1 RWM currents until locking
- Study n=3 (or n=2) threshold (0.5 day)
  - Use NBI 2~3MW heating
  - Ramp up n=3 (or n=2) until locking