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XP1004: Application of early error field correction to advanced scenarios

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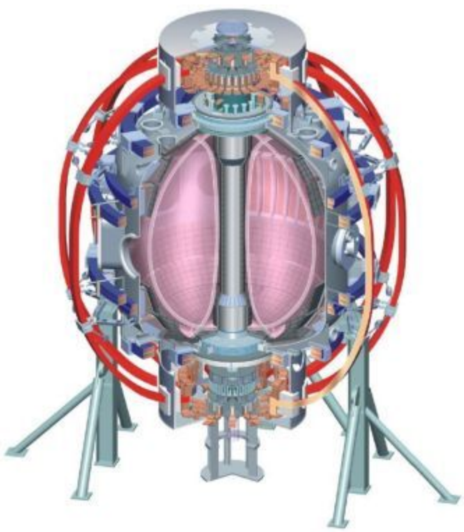

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Overview

Brief Description:

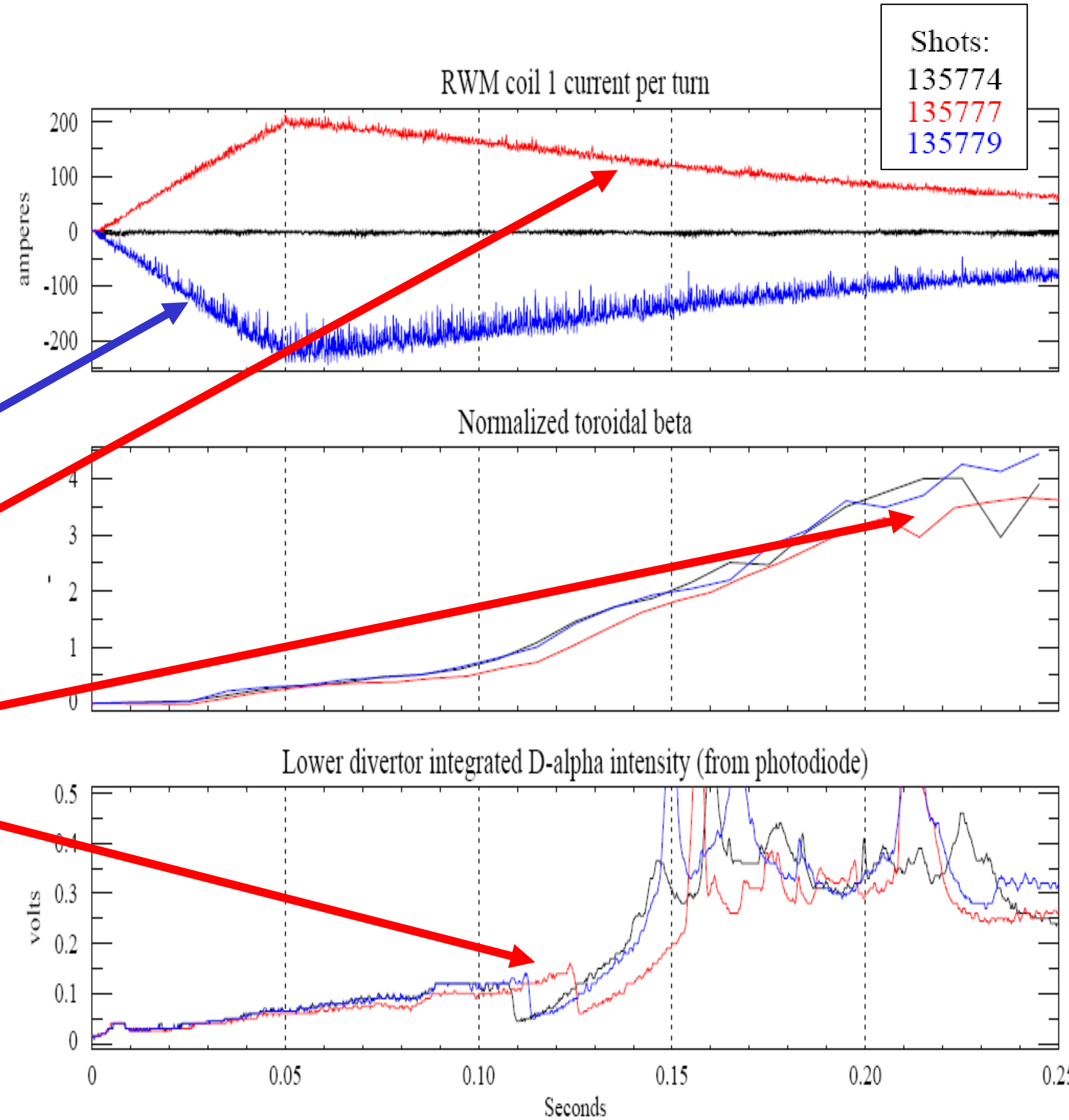
- We propose to further optimize early n=1 error-field correction for range of plasma scenarios and current ramp-rates
- **Such correction could be important for reduced density scenarios expected with the LLD**

Background:

- In the FY2009 run, preliminary application of OH×TF n=1 EFC was shown to increase early plasma rotation, reduce locking
- There are only 1 or 2 examples of such increased rotation and reduced locking (due to limited run time)
- More systematic investigation is warranted, since details of the EFC amplitude and turn-on time are important

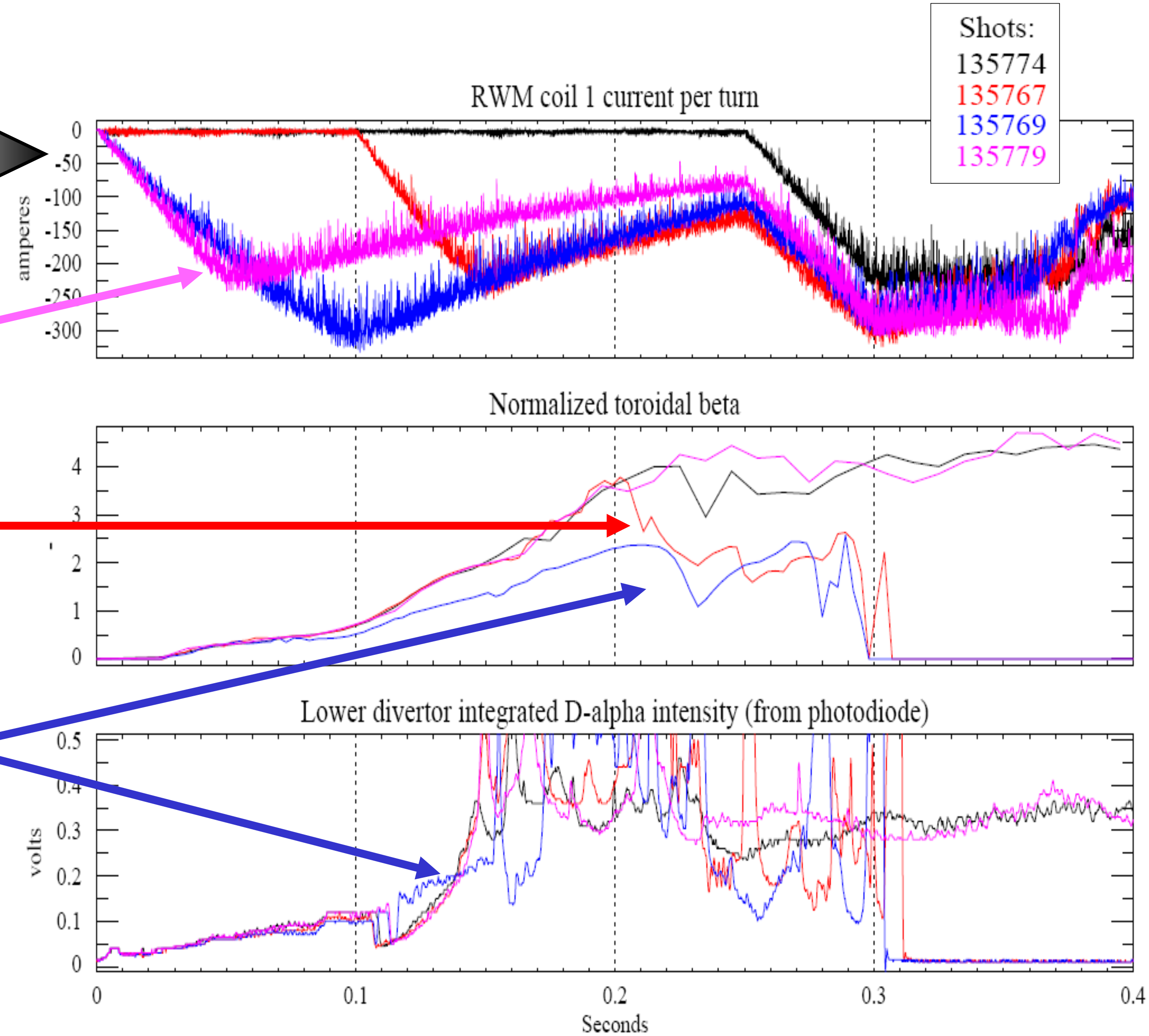
Early n=1 EFC using OH×TF EF compensation algorithm impacts H-mode access and confinement

- Compared to corrective polarity, anti-corrective polarity of n=1 field
  - reduces confinement, β
  - delays early H-mode



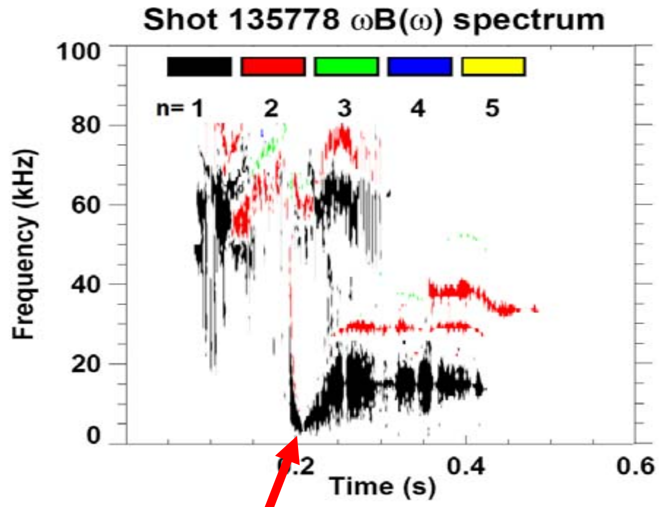
Early n=1 EFC using OH×TF EF compensation algorithm has significant impact on early plasma stability

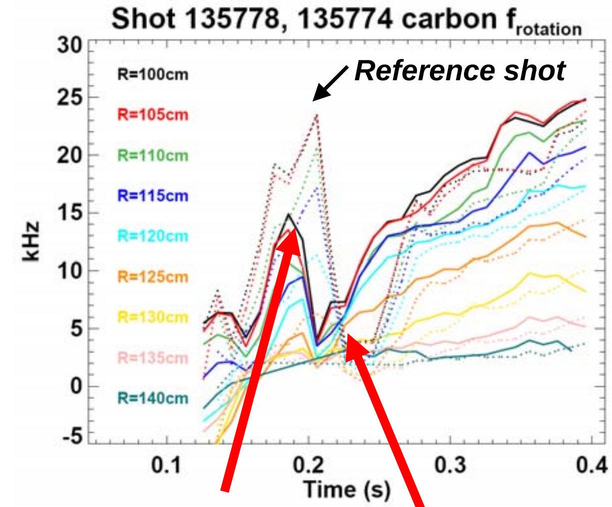
- **Timing and amplitude scan for early OH×TF n=1 EF correction**
  - Optimal correction
- EFC over-compensation can lead to β collapse
- Larger n=1 EFC over-compensation eliminates H-mode access



Optimal early n=1 EFC reduces early locking tendency of n=1 tearing mode and substantially increases early rotation

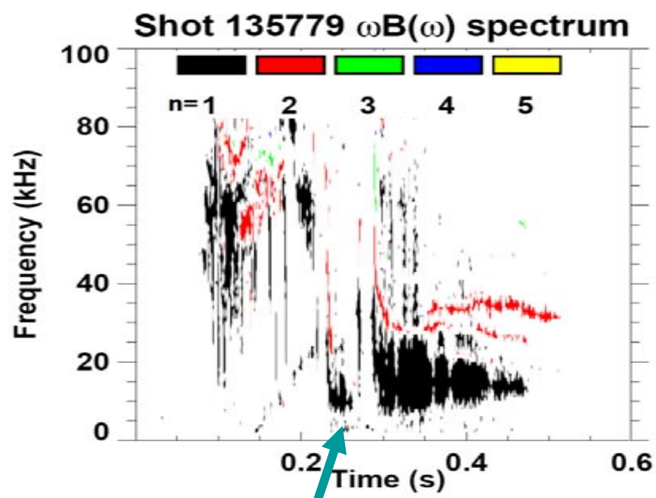
- **Anti-corrective n=1 field** (135778) vs. reference (135774)

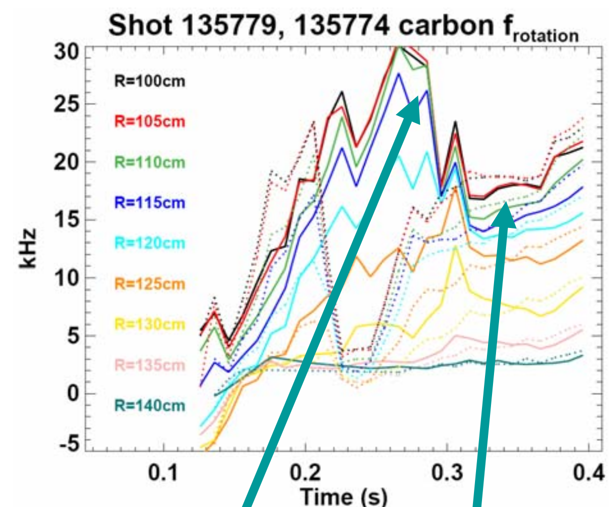




- *n=1 tearing mode nearly locks*
- *Rotation reduced 30-40%*
- *n=1 TM flattens rotation to low f_ϕ=3-4kHz*

- **Optimal corrective n=1 field** (135779) vs. reference (135774)





- *n=1 tearing delayed, no locking, duration shortened*
- *Rotation increased 30%*
- *Core rotation maintained above 15kHz*

Experimental Approach/Plan:

(1.0 day request, 0.5 day minimum useful)

1. Reproduce increase in rotation with n=1 early EFC — 4 shots
2. Refine/scan EFC turn-on time, amplitude, phase to optimize EFC to increase early rotation, reduce mode-locking activity
   1. Timing scan: -30, -20, -10, 0, +20, +40ms — 5-7 shots
   2. Amplitude scan: ×0.6, 0.8, 1, 1.2, 1.4 — 4-6 shots
   3. Phasing scan: -30, -15, 0, 15, 30° — 4-6 shots
3. Assess stability at low n_e with/without optimized n=1 EFC
   1. Reduce n_e in 20% steps until LM disruption with n=1 EFC — 8 shots
4. Increase flat-top I_P and assess/optimize n=1 EFC
   1. Scan EFC amplitude ×0.8, 1.2, etc. for 0.9MA, 1.1MA — 6-8 shots

Backup

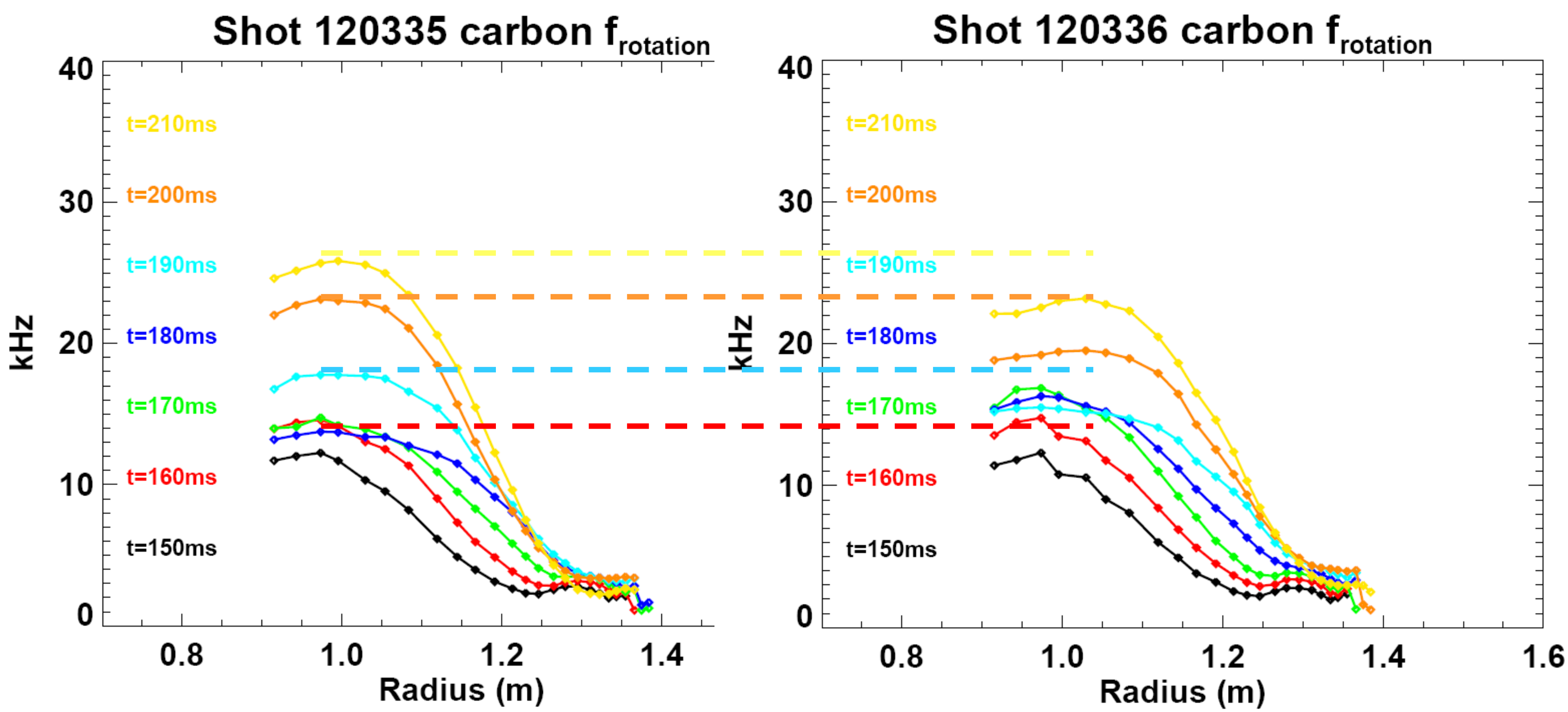
Motivation for "Early error-field correction in long-pulse plasmas"

- Insufficient fueling during LiTER generally results in "unstable" plasma early in discharge
  - Commonly attributed to "locked-modes"
    - Likely seeded by intrinsic error fields
  - But there are other effects of LiTER:
    - Confinement improvement from Li → hit beta limit at fixed P_{NBI}
    - Delayed H-mode mode, likely due to reduced density
  - Most (but not all!) EFC XPs rightly focused on sustaining high beta
- Strong fueling during high-evap LiTER defeats purpose of Li
  - May not even be possible during (effective) LLD operation

- Reduced early EF could reduce mode locking, lower P_{LH}
  - Now "know" n=3 EF is from PF5 → early correction easy to test
  - n=1 EF caused by OH×TF, and have correction algorithm in PCS

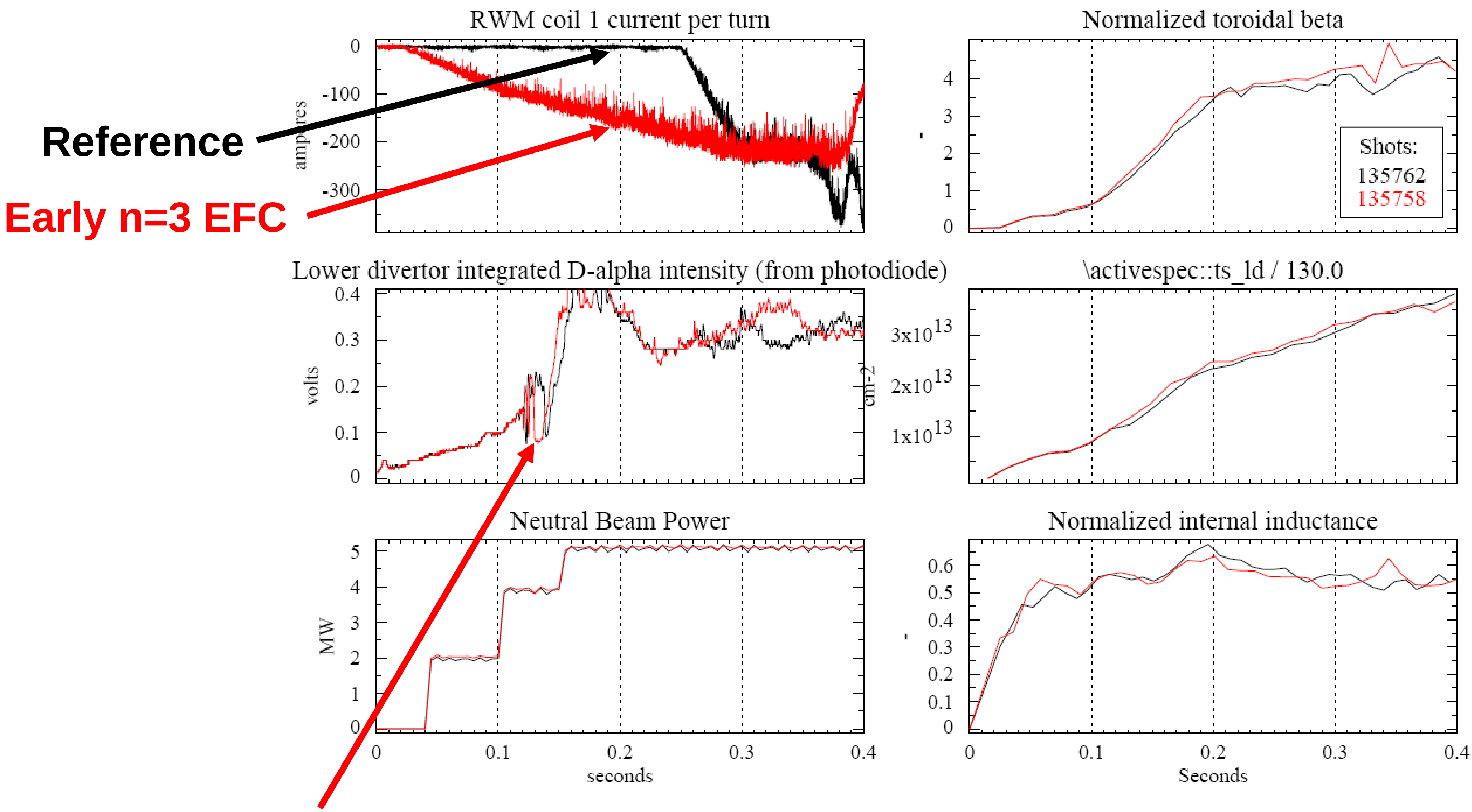
2006: XP614 demonstrated applying early n=1 EFC (based on OH×TF intrinsic EF) can increase early plasma rotation

Predictive OHxTF EFC on by t=150ms | **EFC off**



Goal of XP-954 is to explore/extend these results further

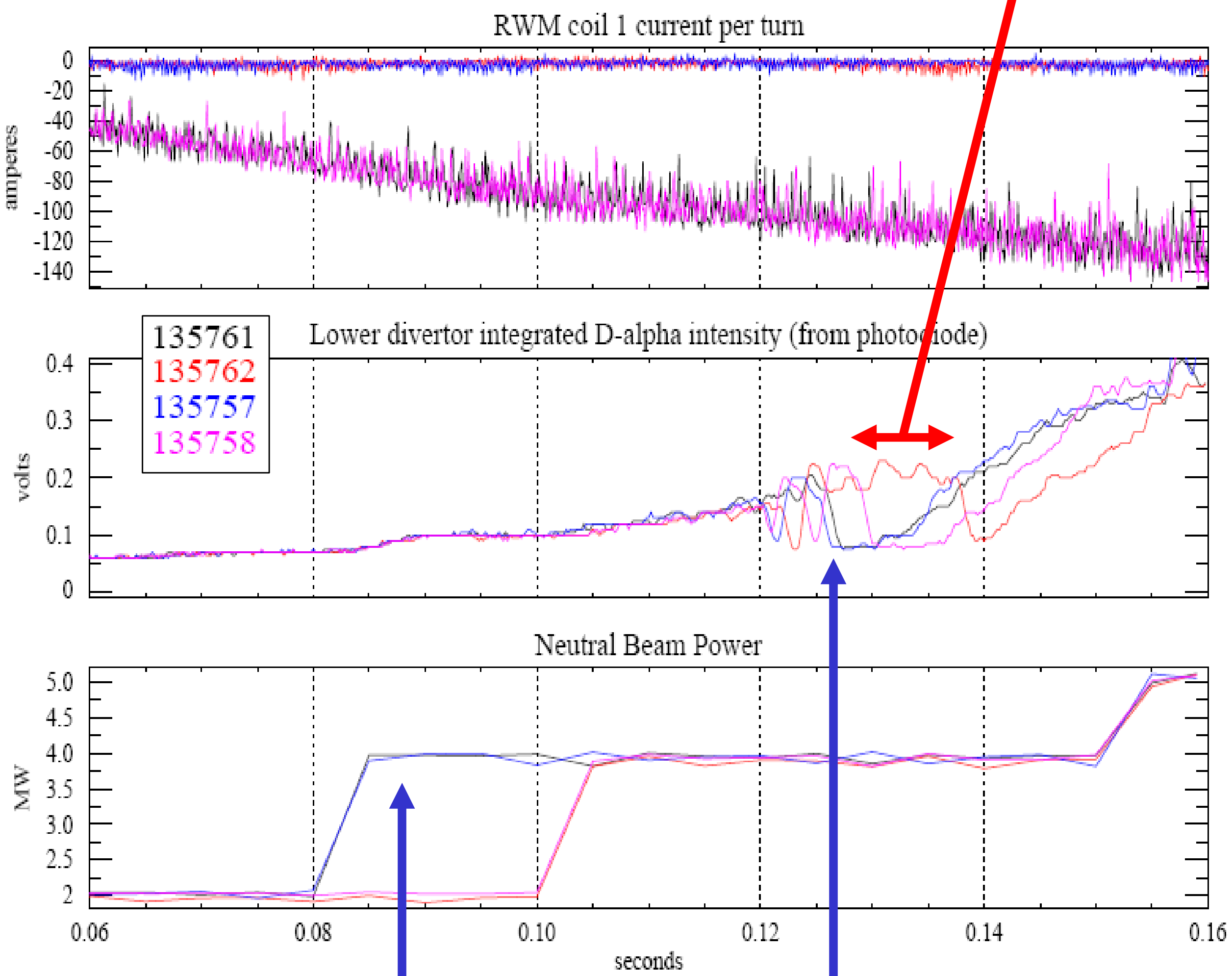
Early n=3 EFC approx. proportional to PF5 current (known n=3 EF source) has modest impact on plasma evolution



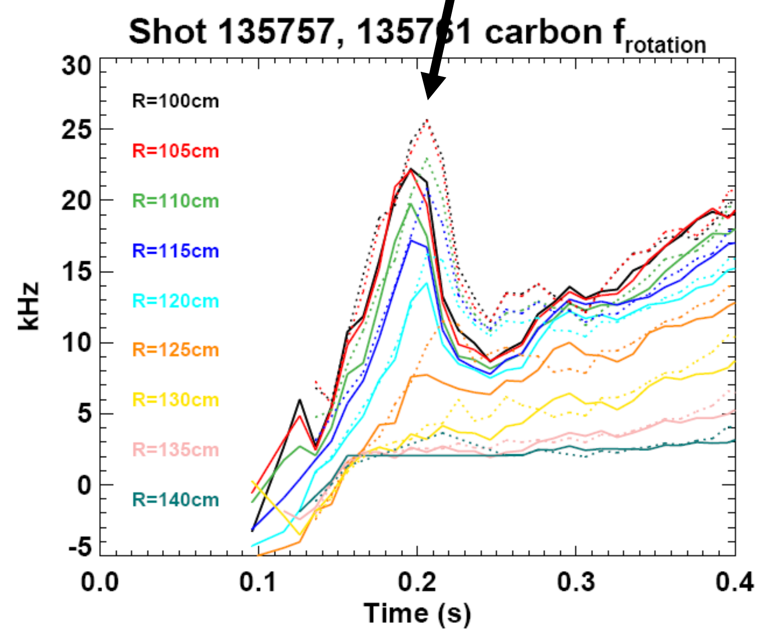
Early n=3 EFC induces earlier H-mode transition – reduced flow damping?

Both early n=3 EFC and NBI timing impact early H-mode transition

Early n=3 EFC induces transition ~10ms earlier relative to late n=3 EFC



Rotation is ~10% higher with early n=3 EFC



Earlier NBI heating to 4MW also important for early transition