NSTX

Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

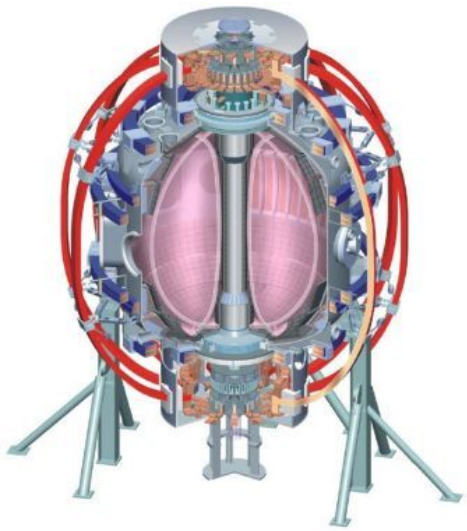
Results from ASC XP-954
Early error-field correction in long-pulse plasmas

College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin

J. Menard

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

NSTX FY2009 Results Review
PPPL, B318
September 16, 2009



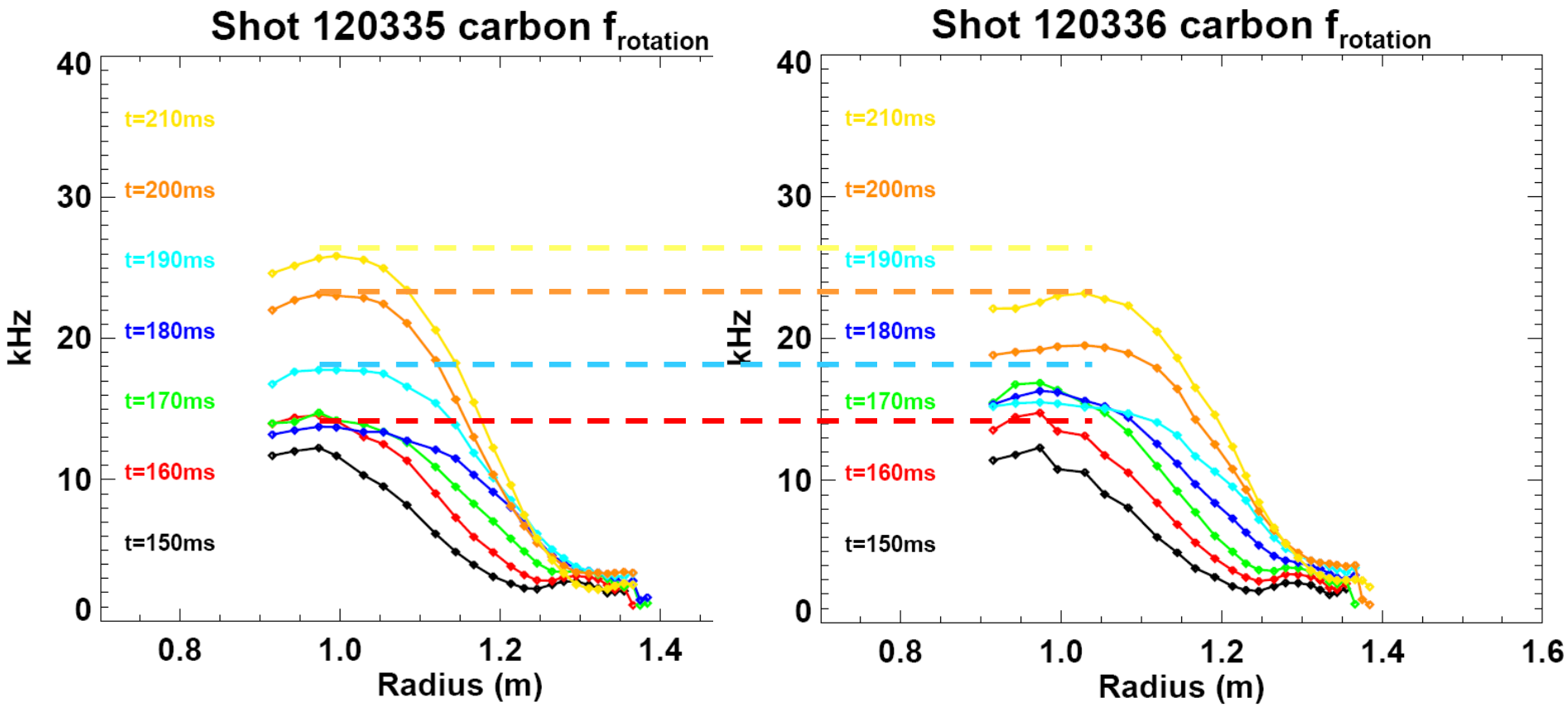
Motivation for "Early error-field correction in long-pulse plasmas"

- 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**

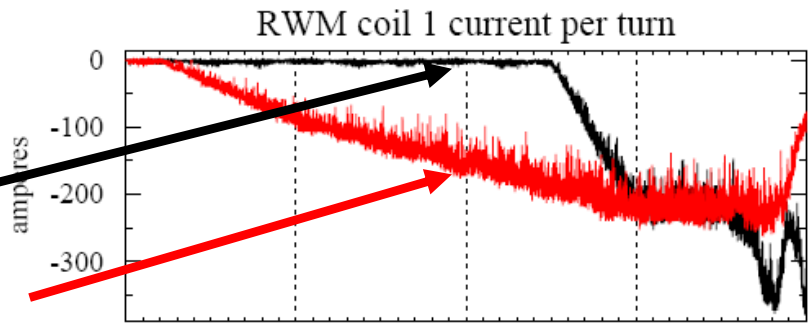


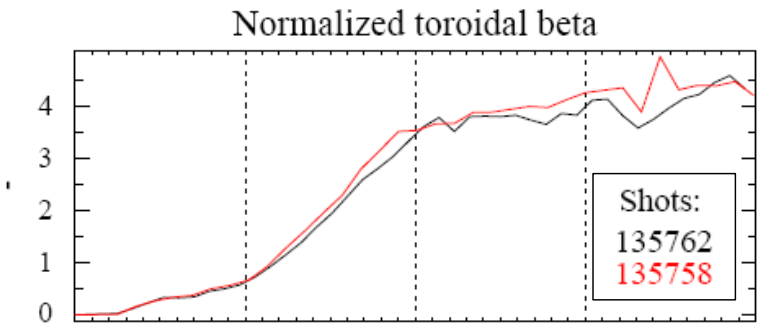
Goal of XP-954 is to explore/extend these results further

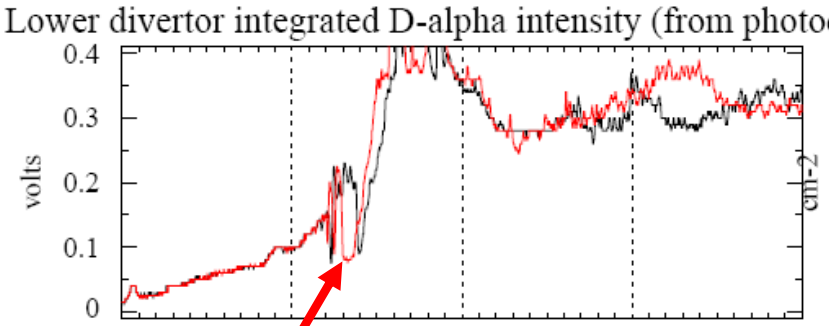
Early n=3 EFC approx. proportional to PF5 current (known n=3 EF source) has modest impact on plasma evolution

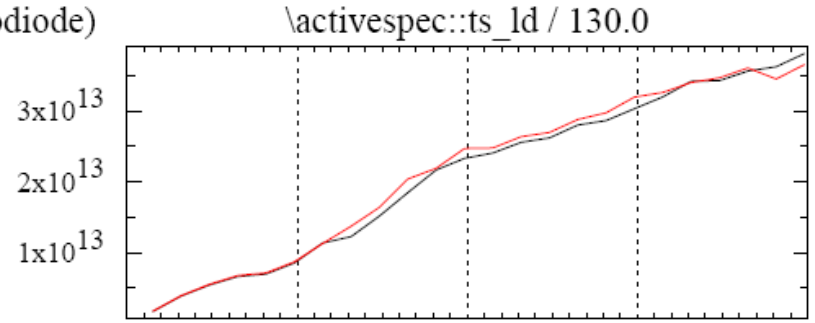
Reference

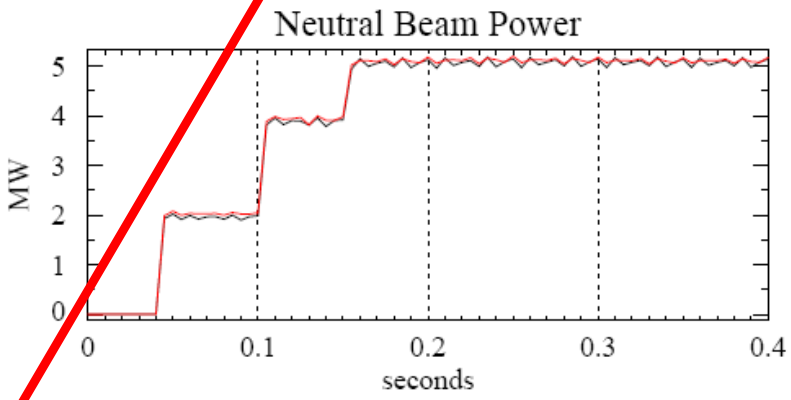
Early n=3 EFC

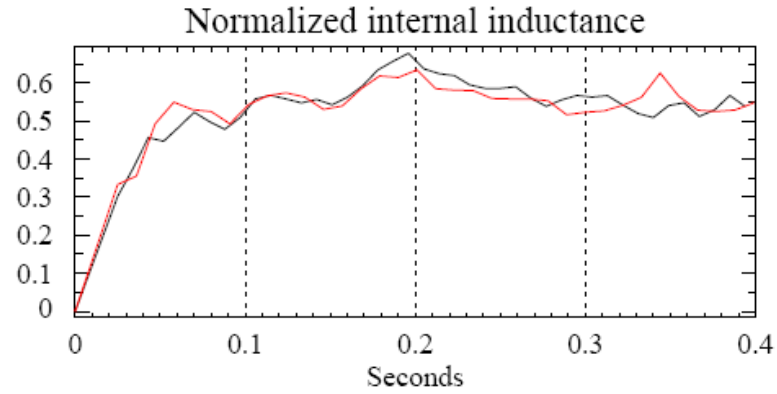








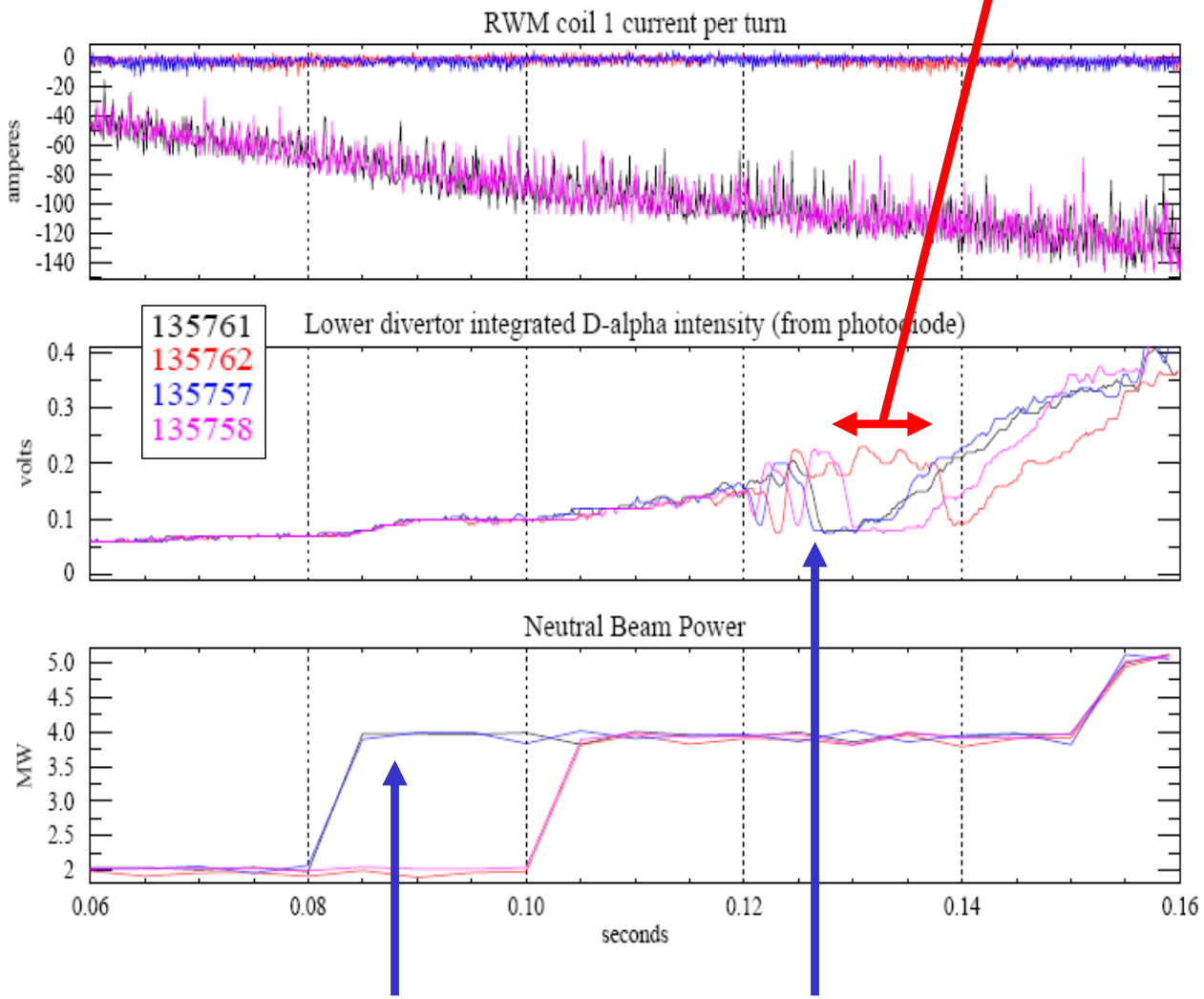




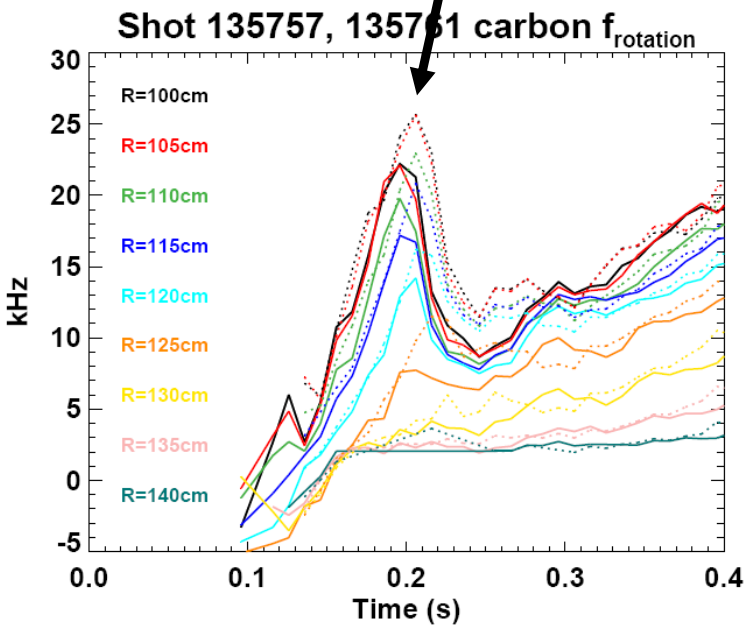
Early n=3 EFC induces earlier H-mode transition – reduced flow damping?

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



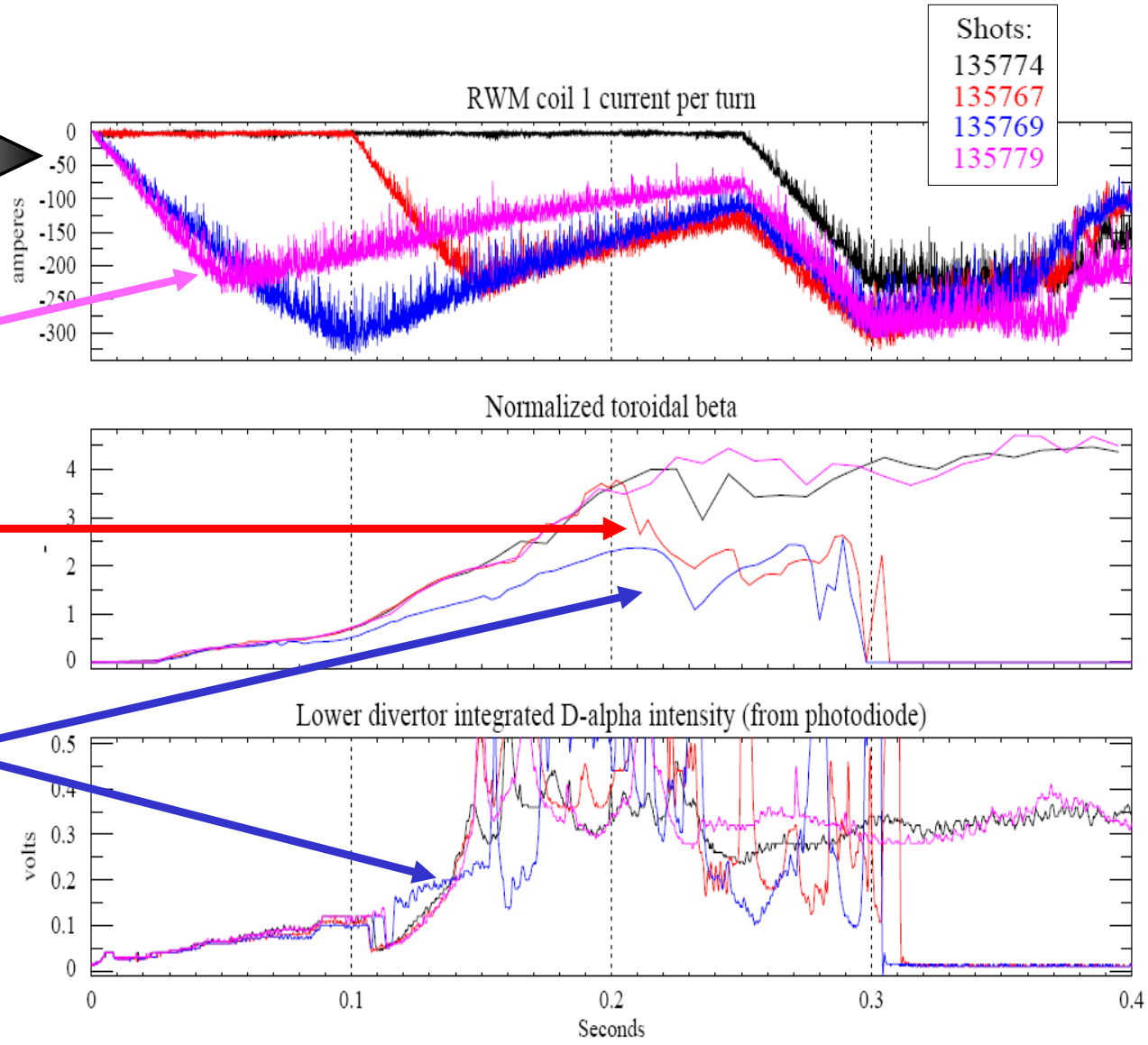
Rotation is ~10% higher with early n=3 EFC



Earlier NBI heating to 4MW also important for early transition

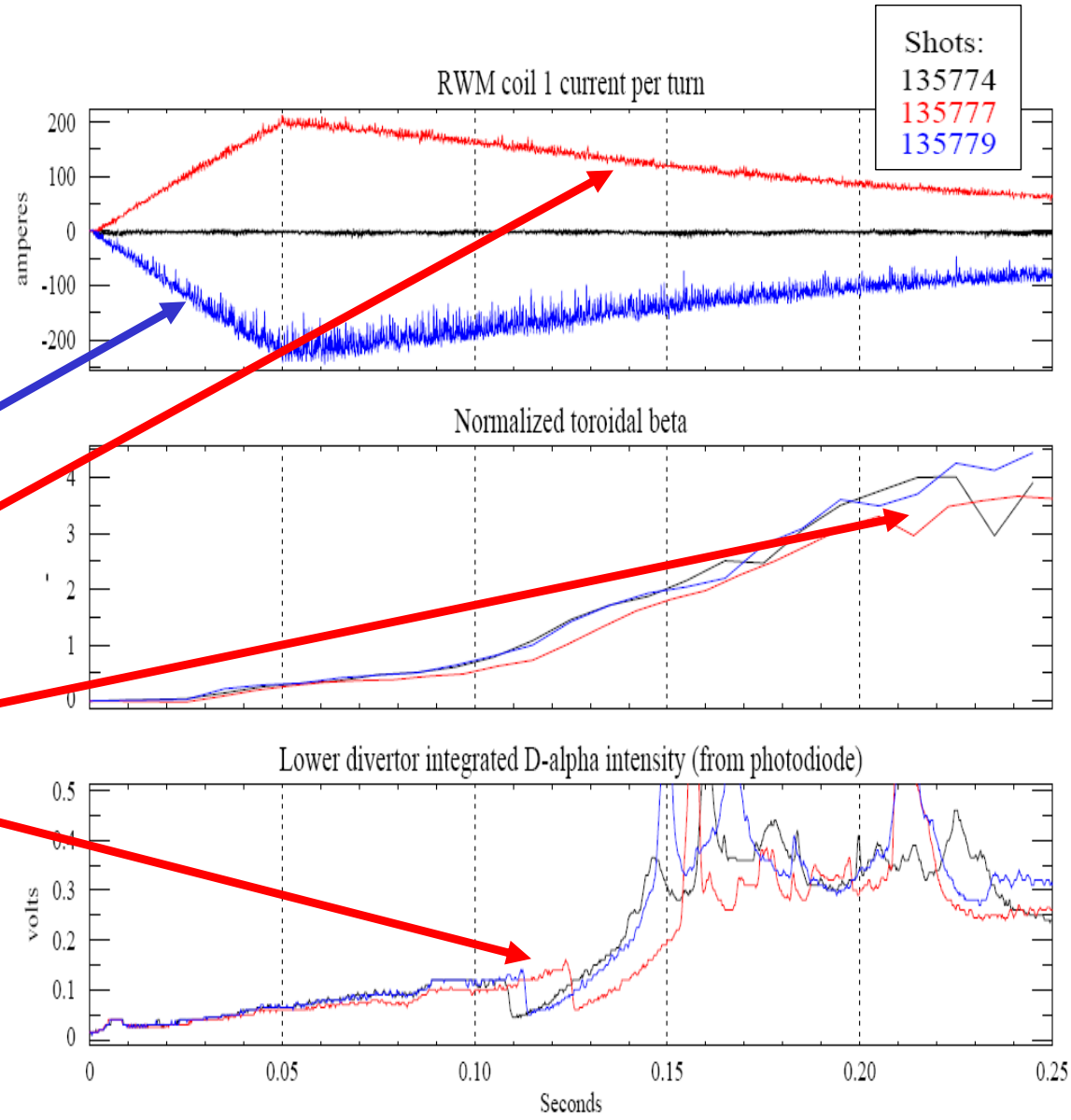
Early n=1 EFC using OH×TF EF compensation algorithm has significant impact on early plasma stability

- **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



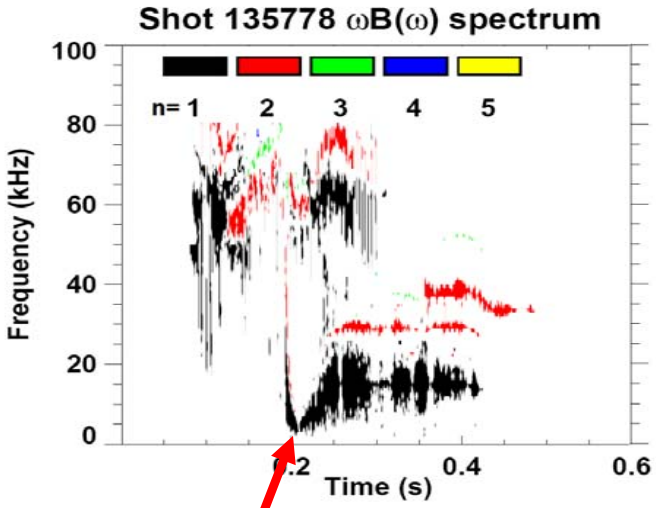
Early n=1 EFC using OH×TF EF compensation algorithm impacts H-mode access and confinement

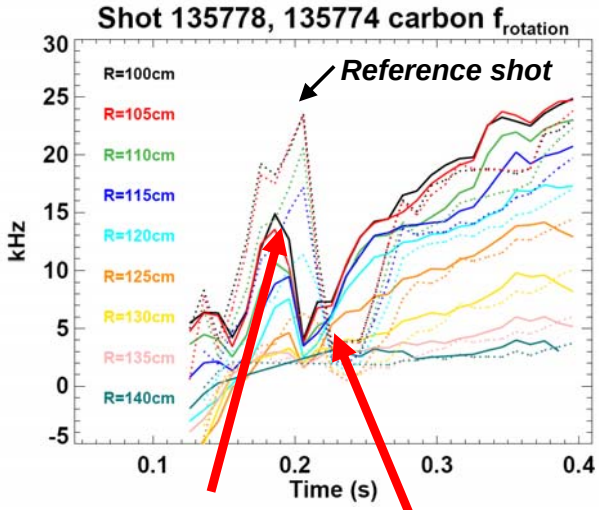
- Compared to corrective polarity, anti-corrective polarity of n=1 field
  - reduces confinement, β
  - delays early H-mode



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

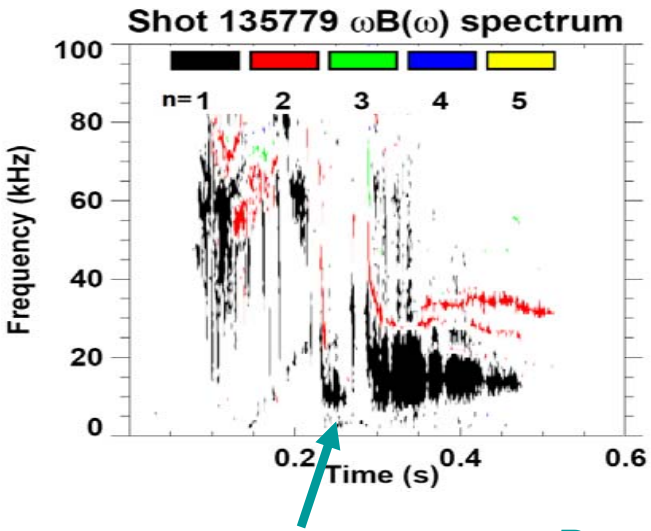
- **Anti-corrective n=1 field (135778) vs. reference (135774)**

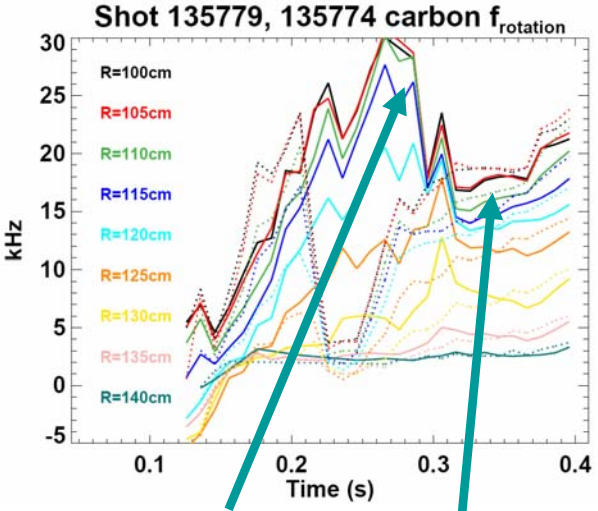




- *n=1 tearing mode nearly locks*
- *Rotation reduced 30-40%*
- *n=1 TM flattens rotation to low f_ϕ=3-4kHz*

- **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*

Summary

- Early n=3 EFC has modest impact on plasma, but does aid early H-mode access perhaps by increasing early rotation
- Early n=1 EFC has significant impact on plasma
  - **Locking tendency of early n=1 tearing mode (TM) reduced**
  - **Early rotation increased 30%, rotation remains high during TM**
- Need to assess OH×TF EF model w/ reversed B_T (future work)
- Combination of early n=3 + n=1 EFC could aid H-mode access and rotation sustainment at reduced density with LLD