Application of early error field correction to reduced-density advanced scenarios

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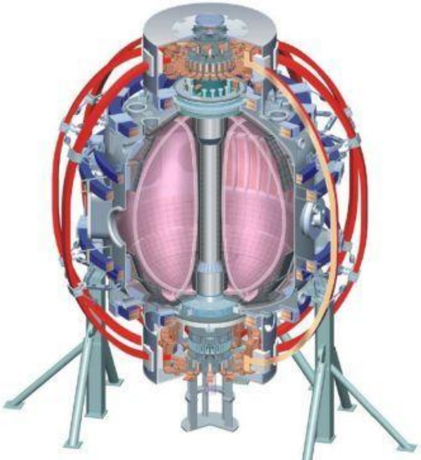
J. Menard, J.-K. Park

NSTX FY2011-12 Research Forum
LSB B318, PPPL
March 16, 2010



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Motivation

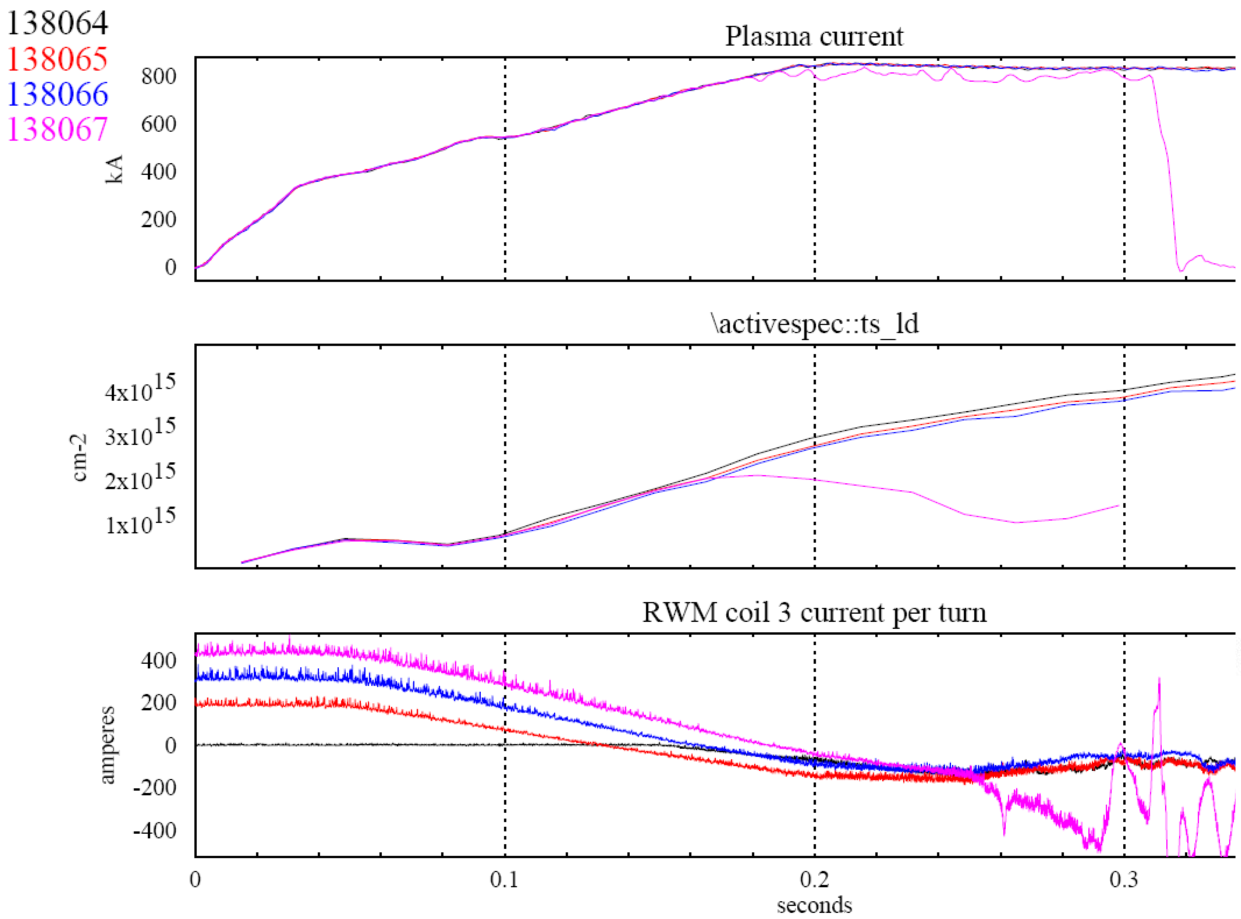
- Insufficient fueling during LiTER generally results in "unstable" plasma early in discharge – ramp-up, early flat-top
  - Can often be caused by "locked-modes" or rotating modes that lock
  - Torque from error fields well-known cause of rotation damping, locking
  - Ample evidence this is occurring on NSTX

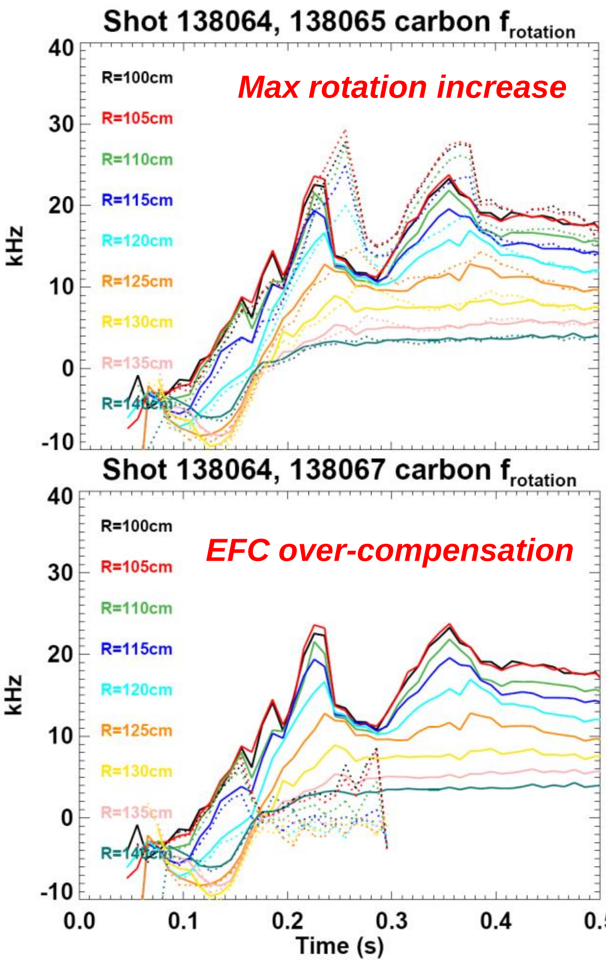
- Reduced early EF could reduce mode locking, lower P_{LH}
  - n=1 EF caused by OHxTF, and we have correction algorithm(s) in PCS

- Supports: R12-3 to assess access to reduced n_e, collisionality
- Also supports other ASC high priorities:
  - "Develop and implement improved plasma control techniques to achieve advanced operating scenarios"
  - "Develop improved plasma formation and ramp-up techniques for reduced density and collisionality"

2010: EFC amplitude scan determined values for increasing max rotation, and for EFC over-compensation (rotation reduction)

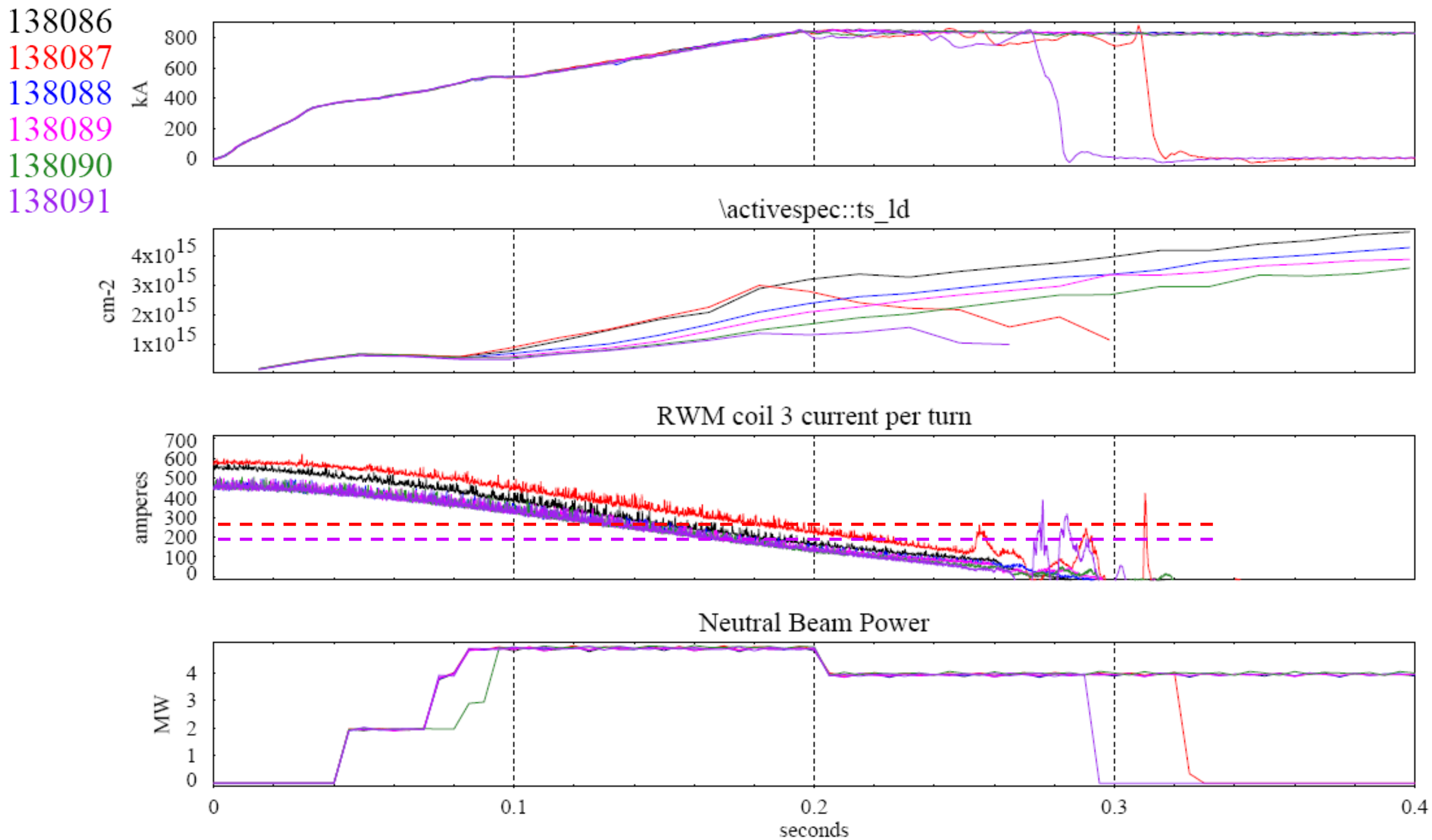
- Impact of EFC is measurable, but only 10-20% increase in rotation at best
  - → **NOTE: EFC is on starting from -50ms (through breakdown)**





2010: Density scan shows plasma is sensitive to EFC amplitude between t=100-200ms when density is reduced

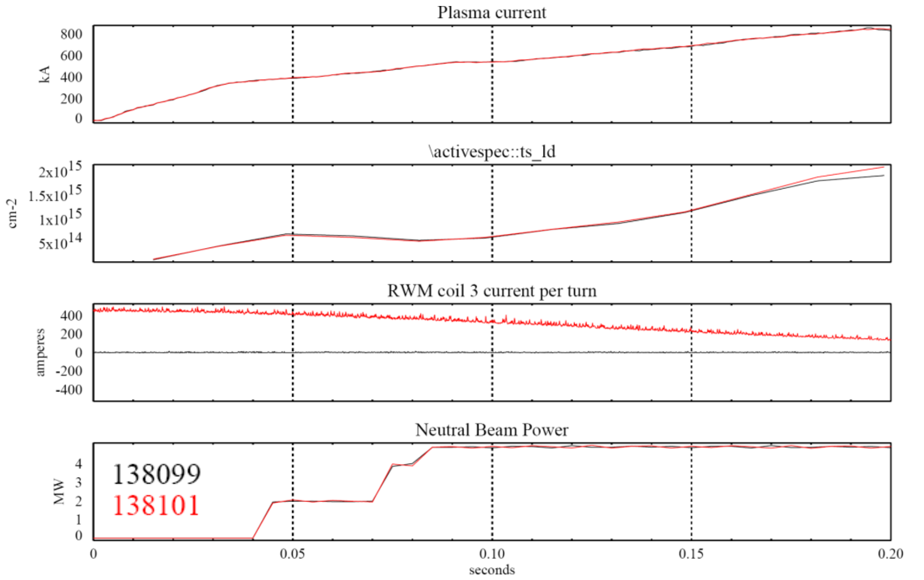
- Density threshold for locking decreases by up to factor of 2 from over-compensated EFC → to near optimal EFC

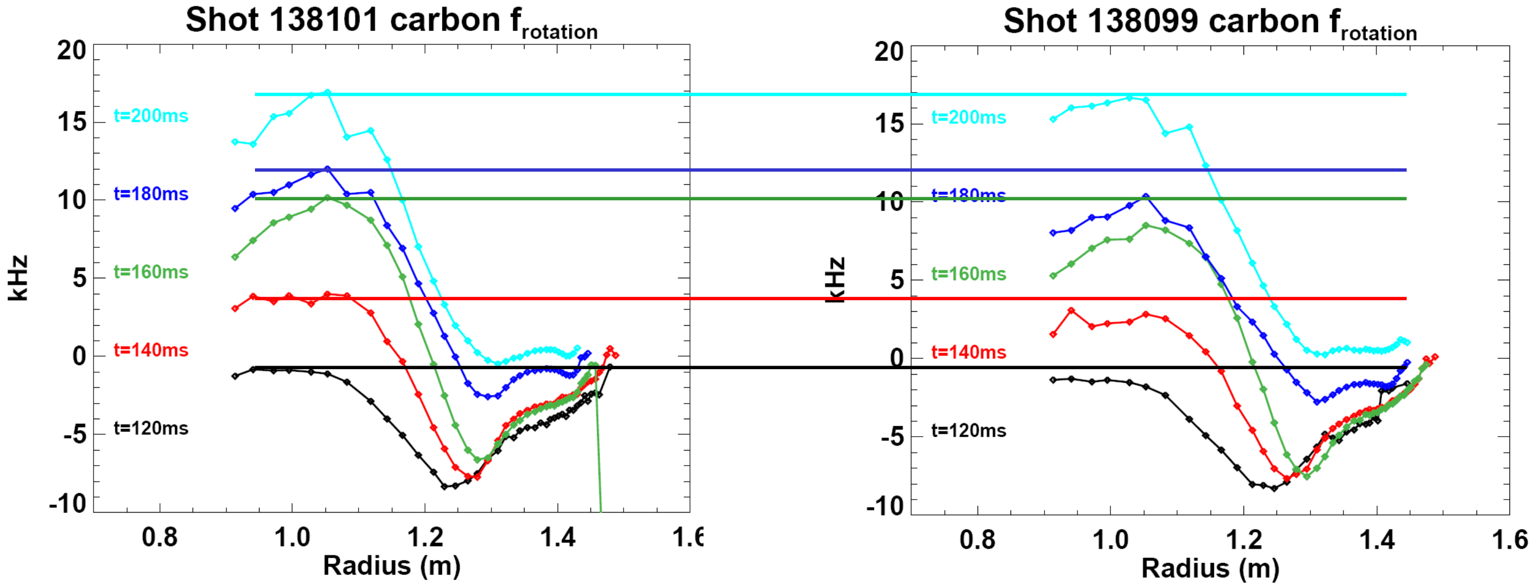


Very carefully matched low density plasmas with and without EFC show EFC increases rotation 10-20% for t=120-180ms

- Delay of early H-mode by reduced early fueling reduces density by 30-40% at t=0.2s (vs. reference)
  - Similar to what typically happens with increased LITER evaporation

- **Additional EFC <u>phase</u>, amplitude scans might be able to further increase rotation at reduced density**





2010 shot plan was partially completed

3. Experimental run plan

A. Reproduce increased rotation w/ n=1 early EFC using fiducial or 700kA shot 135779 (4 shots) — ***Used fiducial***

B. Scan EFC turn-on time, amplitude, phase to optimize EFC

a. Timing scan: -30, -20, -10, 0, +20, +40ms (5-7 shots) — ***Varied timing***

b. Amplitude scan: ×0.6, 0.8, 1, 1.2, 1.4 (4-6 shots) — ***Varied amplitude***

c. Phasing scan: -30, -15, 0, 15, 30° (4-6 shots) — ***Did not vary phasing***

C. Assess stability at low density with and without optimized n=1 EFC

a. Reduce density in 20% steps until LM disruption with n=1 EFC (8 shots) — ***Scanned density with and without EFC***

D. Increase flat-top I_P and assess/optimize n=1 EFC

a. Scan EFC amplitude: ×0.8, 1.2, etc. for 0.9MA, 1.1MA (6 shots) — ***Did not vary I_P***

E. Assess impact of early EFC on breakdown by turning on EFC during OH pre-charge (2 shots) — ***Applied EFC during break-down for many shots***

Issues, shot-plan

1.5 day request, 0.75 day minimum useful (was 0.5 on web)

- Error fields in ramp-up potentially very complex
  - OHxTF "DC" error field is varying rapidly
  - Induced currents in the passive structures/vessel contribute to the total EF at plasma in ways not easily measured with external magnetics
  - Sensor compensation also very challenging (least reliable during ramp)
  - → Systematic quasi-empirical scans of **EFC phase** and amplitude will be utilized to try to reduce plasma rotation damping and mode locking

1. Reproduce increase in rotation with n=1 early EFC
   1. Refine/scan EFC phase and amplitude to optimize EFC to increase early rotation, reduce mode-locking activity
   2. Phasing scan: -90,-60, -30, 0, 30, 60, 90, 135, 180 degrees
   3. Amplitude scan: 0.6, 0.8, 1, 1.2, 1.4 relative to best previous
2. Assess stability at low n_e with/without optimized n=1 EFC to quantify any increase in rotation and/or reduction in density
3. Vary I_P ramp-rate and/or flat-top I_P to assess EFC robustness