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Results from ASC XP-956

Impurity evolution versus ∇B drift direction w/ reversed B_T

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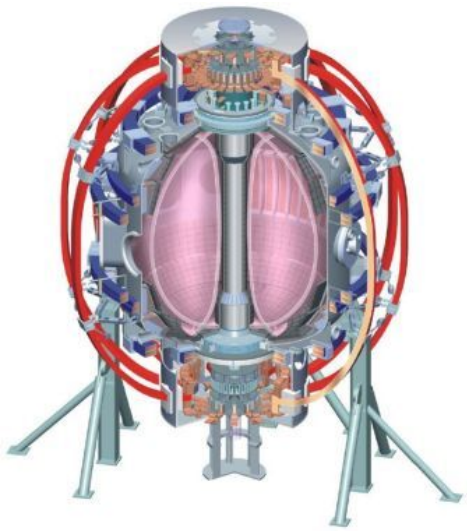
NSTX FY2009 Results Review
PPPL, B318
September 16, 2009



Motivation for studying "Impurity evolution versus ∇B drift direction"

- Impurity accumulation in plasmas with Li-conditioning from LITER problematic
  - Leads to fuel dilution, lack of n_e control, high Z_{eff}, high P_{RAD}, late H→L back-transitions
  - No ELMs → impurities not flushed out
  - C and metallic impurity sources increased?
- Desirable to reduce main-ion and impurity density for NBI non-inductive sustainment

- By changing ∇B direction in C-Mod
  - Observed "Improved L-mode" (I-Mode)
  - I-mode has T_e profiles like H-mode,
  - I-mode has strongly reduced density

➔ **Can ∇B drift direction change particle confinement in NSTX LiTER plasmas, and possibly for next year during LLD ops?**

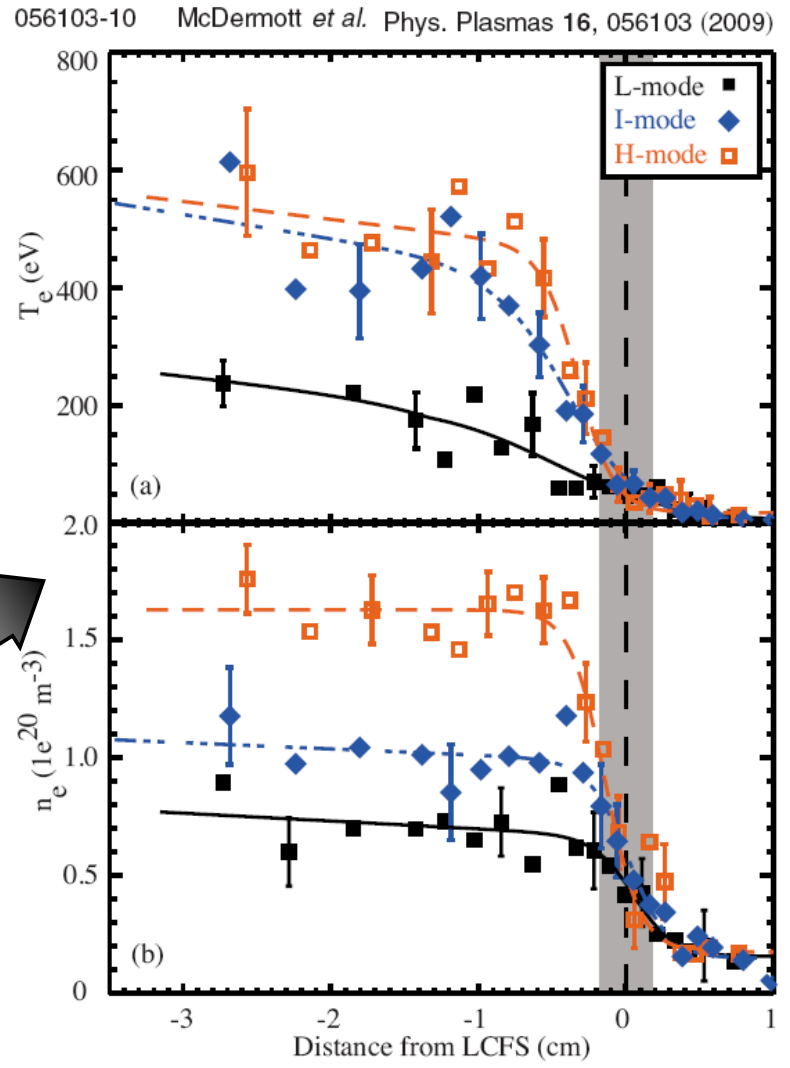


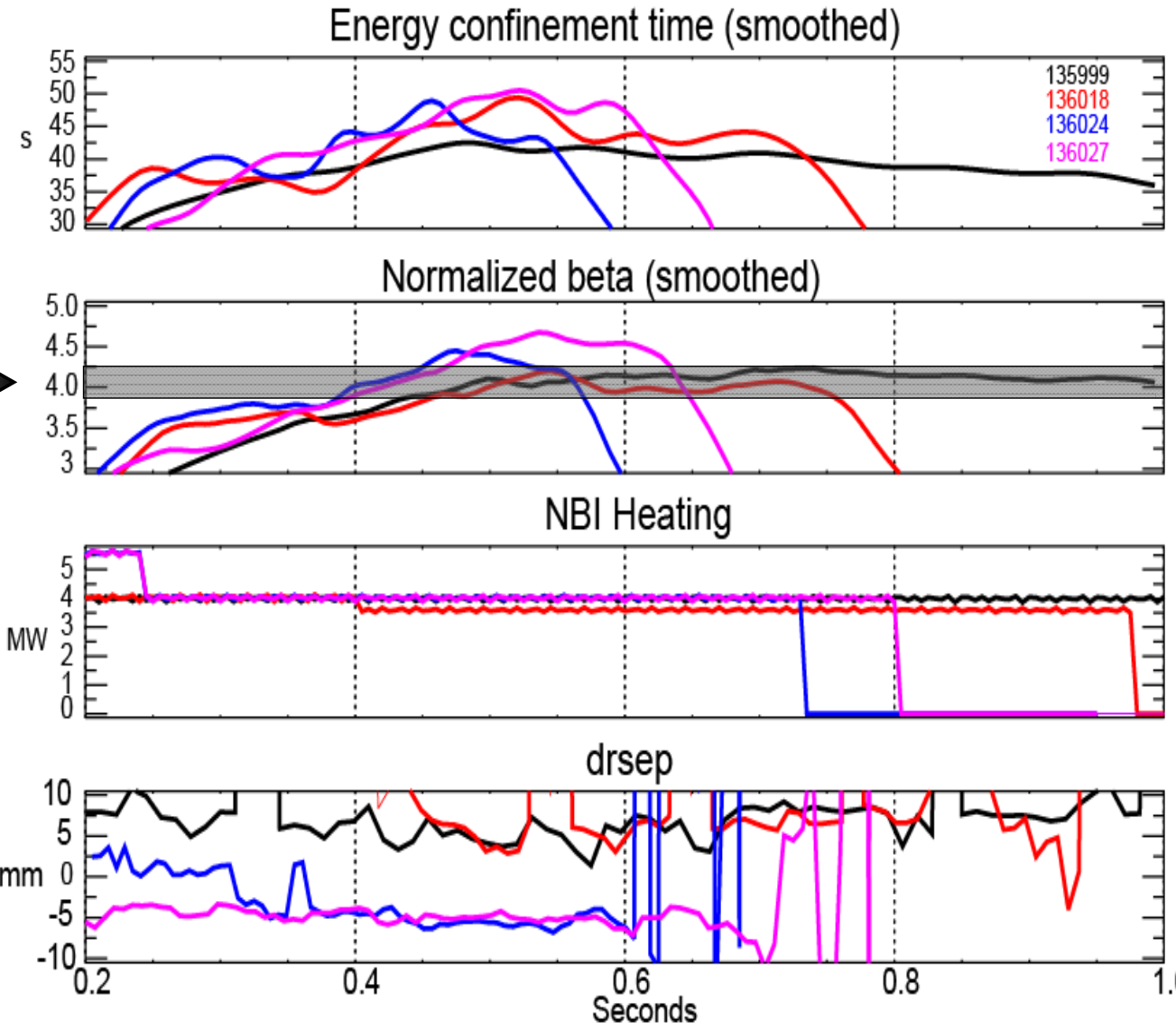
FIG. 14. (Color online) Comparison of (a) edge electron temperature and (b) electron density profiles between *L*-mode, *I*-mode, and *H*-mode plasmas. The *I*-mode temperature profile approaches *H*-mode values, while the *I*-mode density profile remains closer to *L*-mode levels.

Generating long-pulse discharges with τ_{pulse} > 0.7s was very challenging for both USN and LSN plasmas in rev-B_T

- Early NBI heating/fueling modified to achieve early H-mode

- Only a few plasmas lasted past t=1s

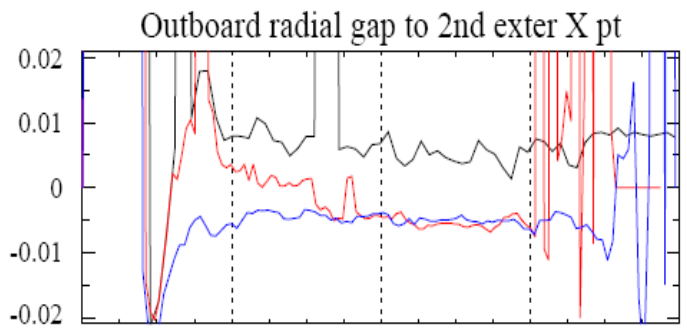
- Most disruptions correlate with stability threshold near $\beta_N \approx 4$ (?)
  - If true, implies EFC and/or RWM control needs optimization in reversed B_T
  - or RFA/RWM physics is modified by rev-B_T?

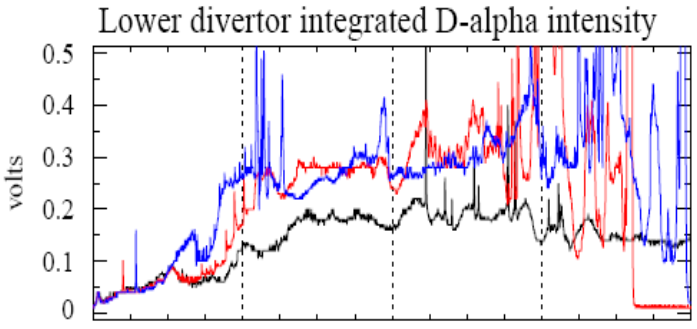


Particle/radiation evolution sensitive to ΔR_{SEP} evolution
(shots shown purposely have no/few-small ELMs due to Li-conditioning)

∇B drift down + USN | ***∇B drift down, USN → LSN*** | ***∇B drift down + LSN***

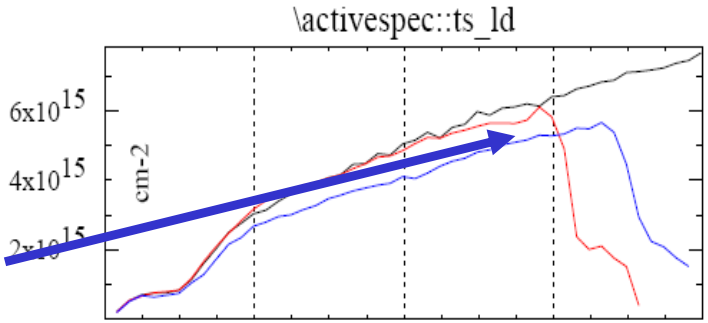
ΔR_{SEP} scan

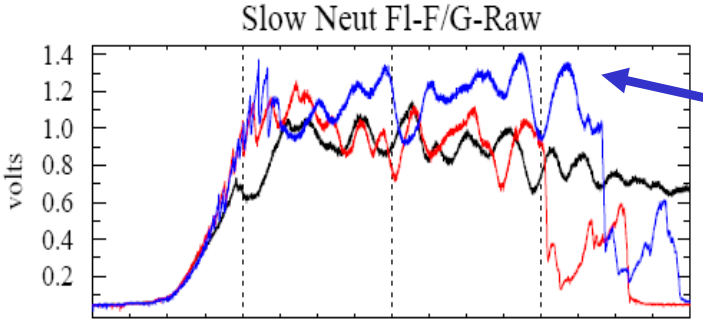




Lower div. D_α increased by 50% for $\Delta R_{sep} < 0$

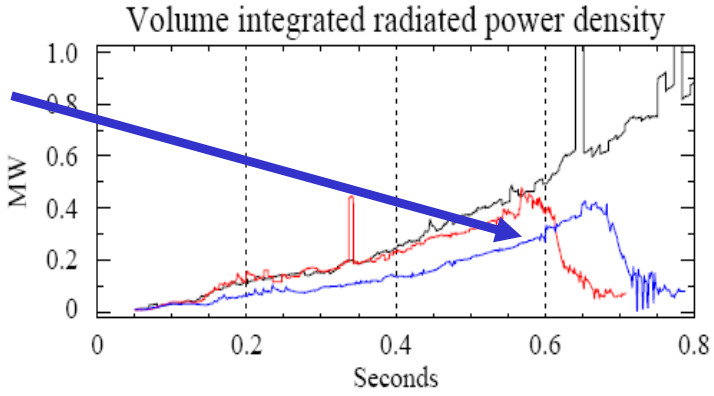
Density reduced 20%

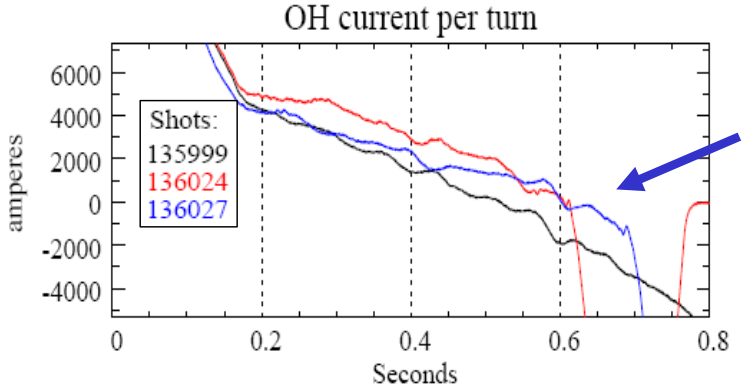




Neutron rate increased

P_{RAD} reduced 40%



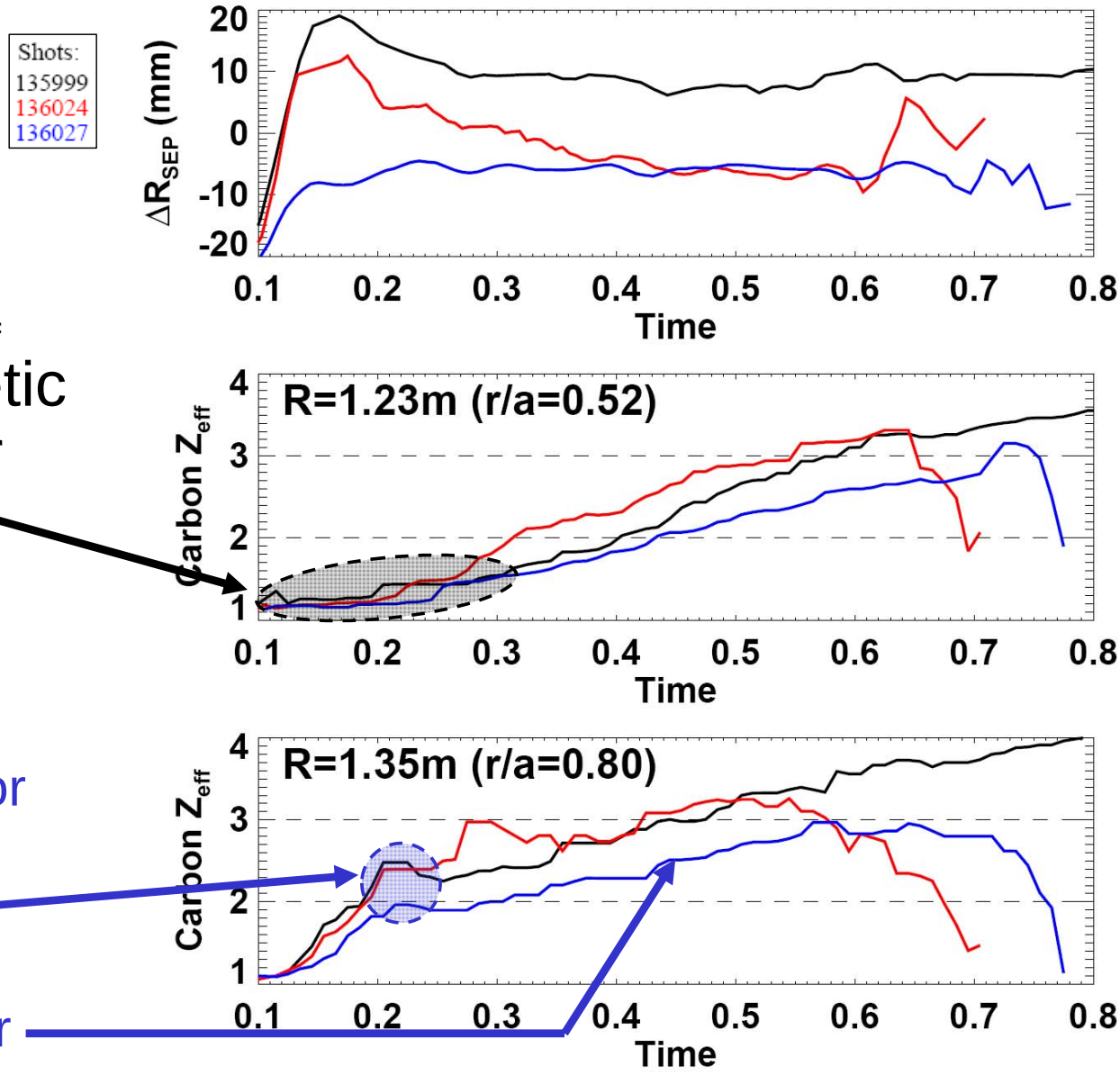


Flux consumption reduced

"Unfavorable" ∇B drift down (away from X-point) with LSN has several favorable properties

Carbon Z_{eff} evolution sensitive to magnetic balance during ramp-up (immediately following early H-mode)

∇B drift down + USN | ***∇B drift down, USN → LSN*** | ***∇B drift down + LSN***

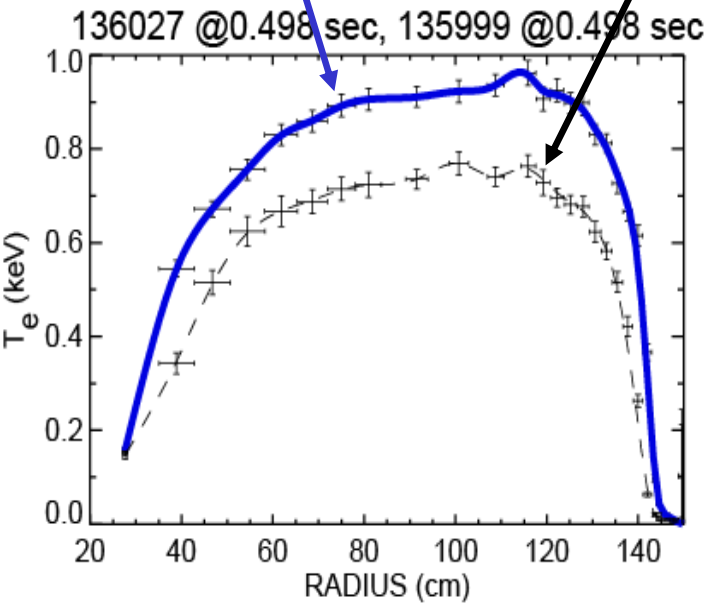


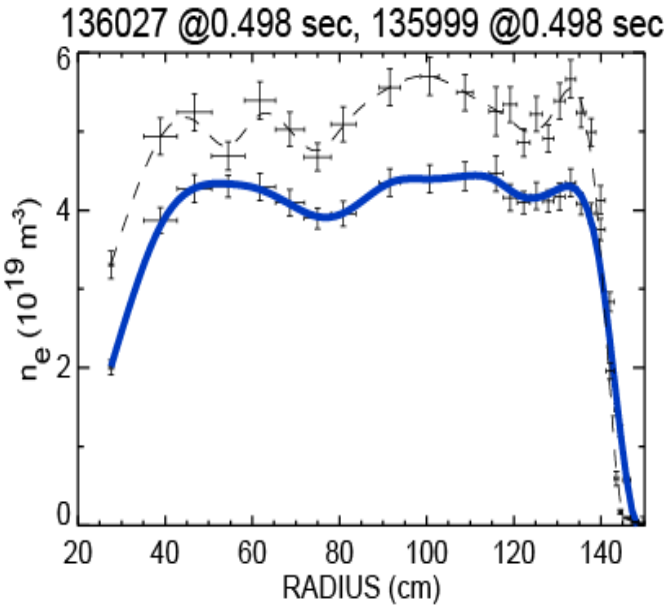
- Core/mid-radius C Z_{eff} similar for all 3 magnetic bias configurations for first ~300ms of shot

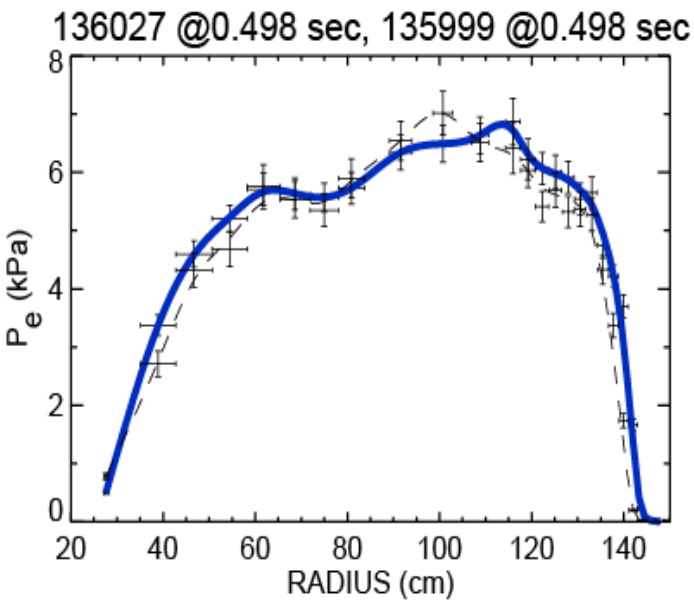
- **∇B drift down + LSN:**
  - Reduces C influx and/or confinement **at top of pedestal** immediately after early H-mode
  - Lowers C Z_{eff} thereafter

∇B drift down + LSN increases T_e and lowers n_e

$\Delta R_{SEP} < 0$ $\Delta R_{SEP} > 0$







T_e increased 20-25%

Density reduced 20%

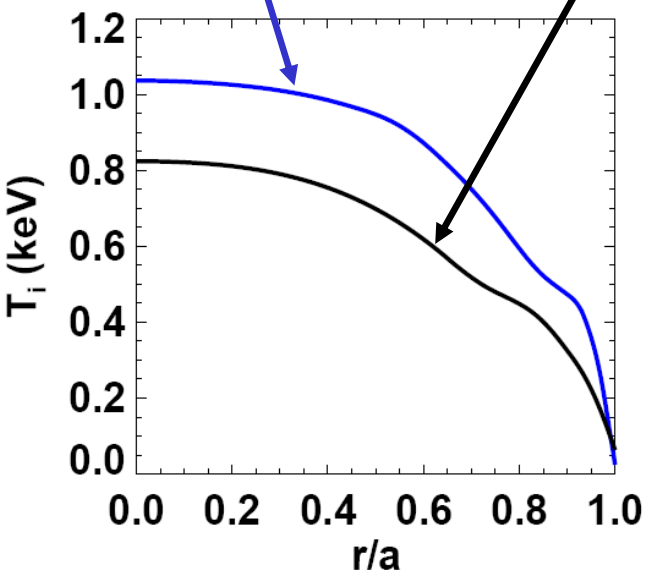
Pressure similar, slightly broader

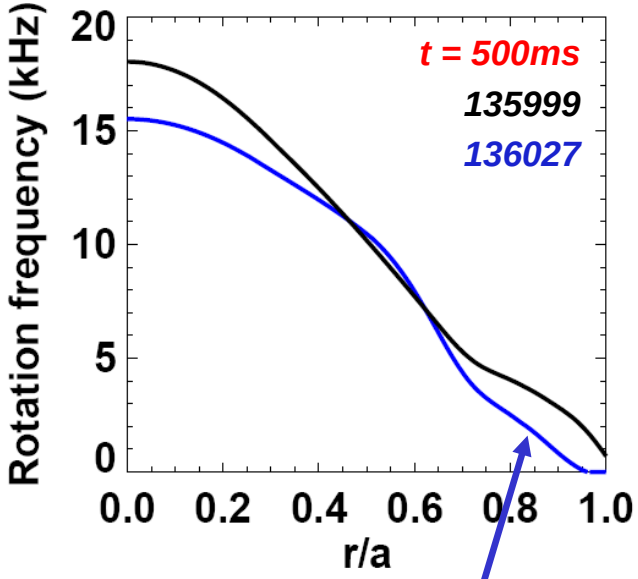
- *Global confinement as high or higher with "unfavorable" ∇B drift*
- ***Results may be influenced by higher Li coverage on lower divertor***

∇B drift down + LSN increases T_i and lowers Z_{eff}

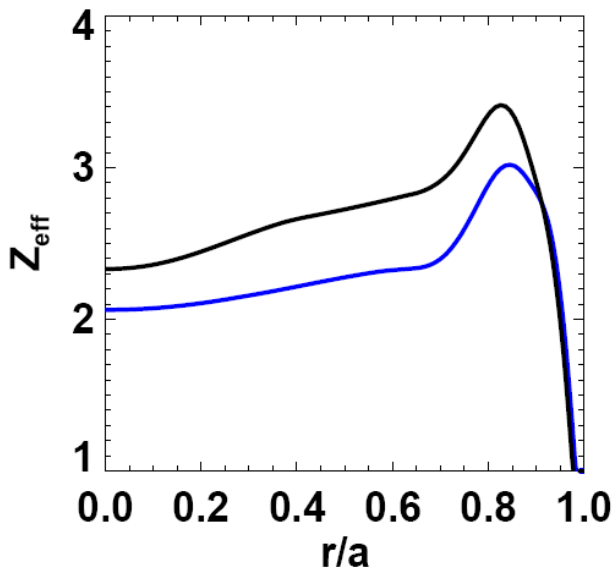
$\Delta R_{SEP} < 0$

$\Delta R_{SEP} > 0$





Absolute C impurity density reduced 40-50%



T_i increased 20-25%

Edge rotation reduced

C Z_{eff} reduced 15-20%

- *Is reduction in edge rotation responsible for reduced MHD stability?*

Summary

- Long-pulse difficult to achieve with reversed TF
  - Could be related to un-optimized EFC
  - Or RFA/RWM stability difference with reversed TF?
  - Is edge rotation modification systematic? (future work)
- Maintaining "unfavorable" bias during ramp-up:
  - Does increase H-mode threshold, but favorably:
  - Reduces carbon Z_{eff} with Li-coated walls from LITER
  - Reduces density, increases electron/ion temperatures
  - Global confinement unchanged (or slightly improved)
- Reversed TF useful for impurity reduction with Li?
  - Future work – could try more negative ΔR_{SEP} in ramp-up