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XP1005: Modifications to the early discharge evolution to reduce late impurity content

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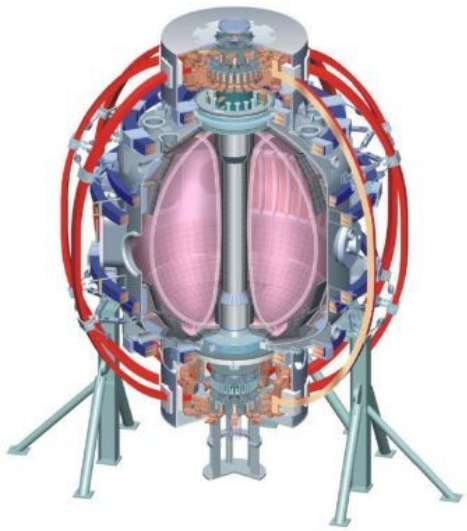
March 9, 2010

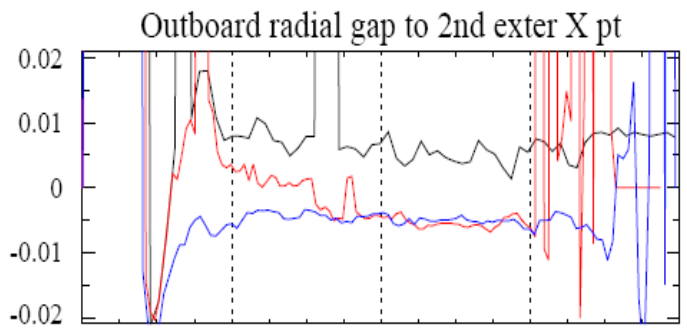
NOTE: All data shown has "reversed B_T" = CCW from above = $B_\phi \times \nabla B$ upward

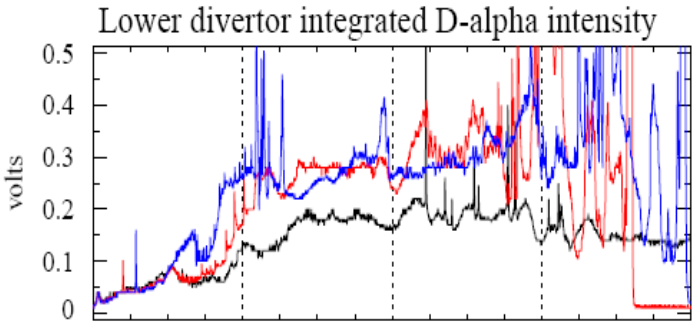


Particle/radiation evolution sensitive to ΔR_{SEP} evolution
(shots shown purposely have no/few-small ELMs due to Li-conditioning)

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

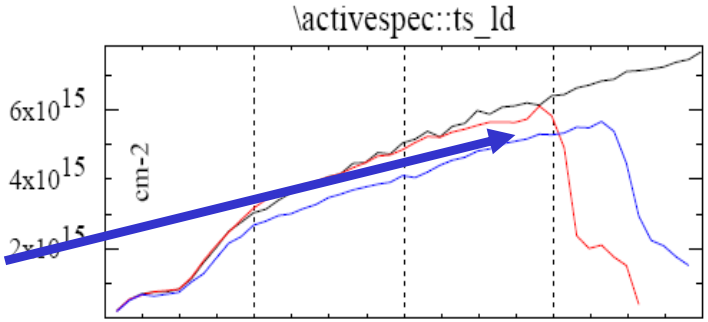
ΔR_{SEP} scan

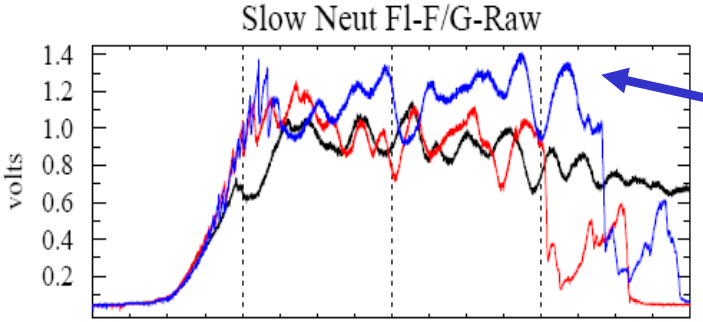




Lower div. D_α increased by 50% for $\Delta R_{sep} < 0$

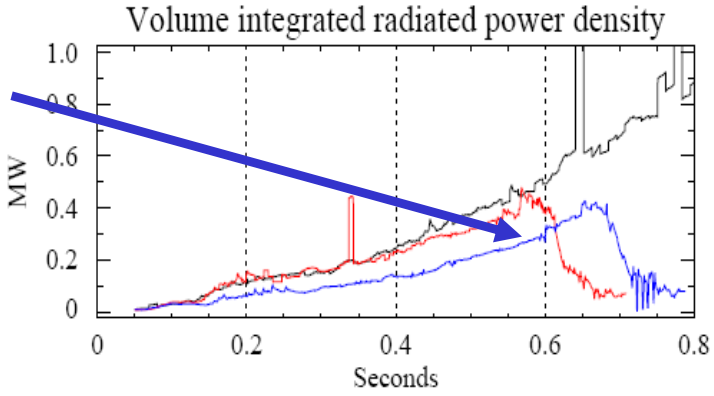
Density reduced 20%

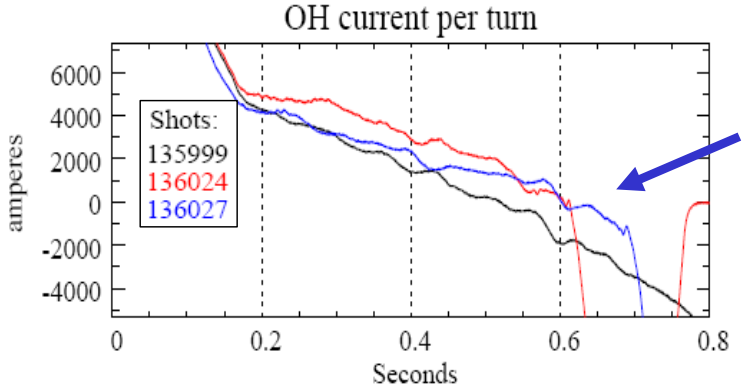




Neutron rate increased

P_{RAD} reduced 40%



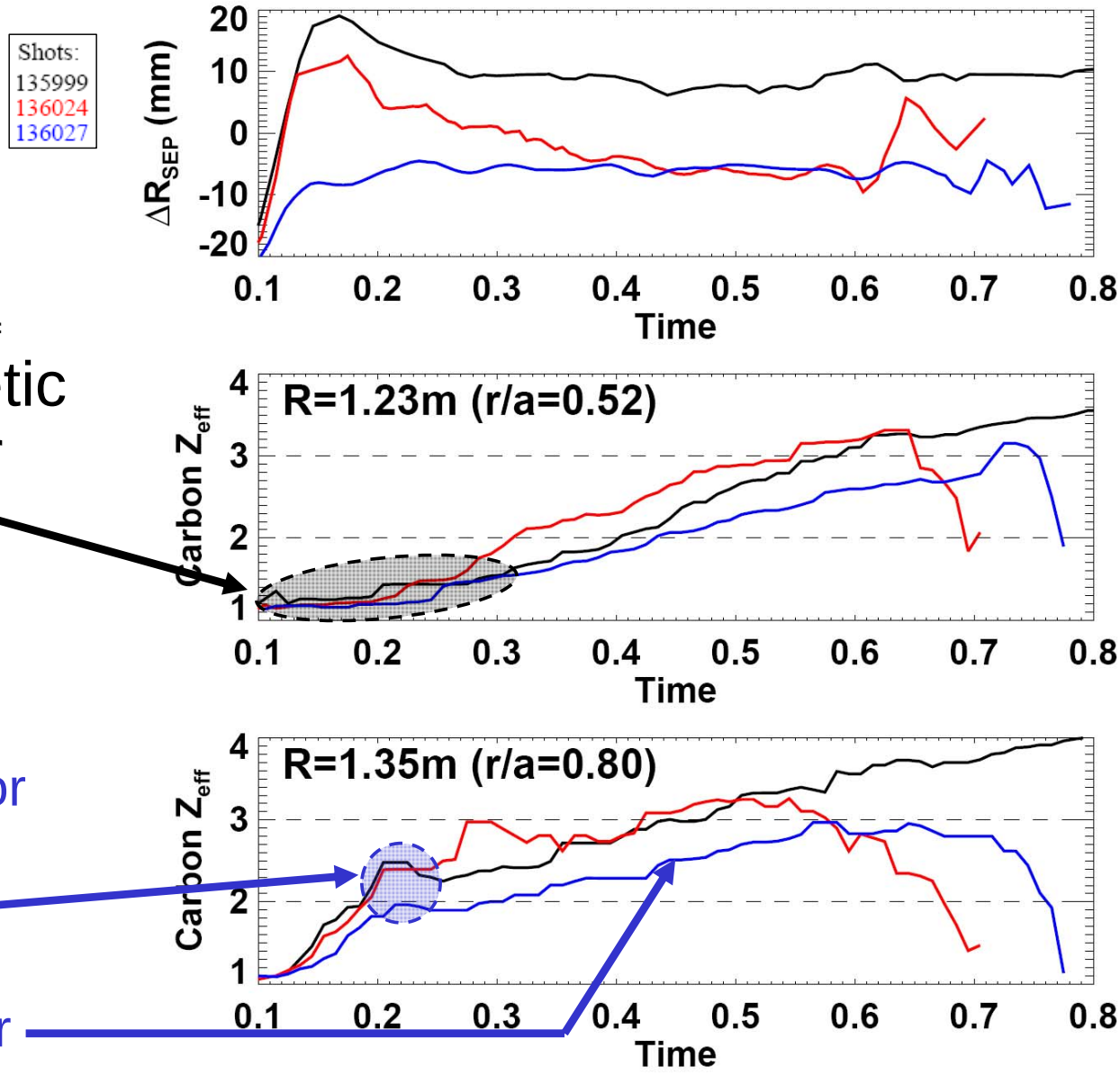


Flux consumption reduced

"Unfavorable" ∇B drift up (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)

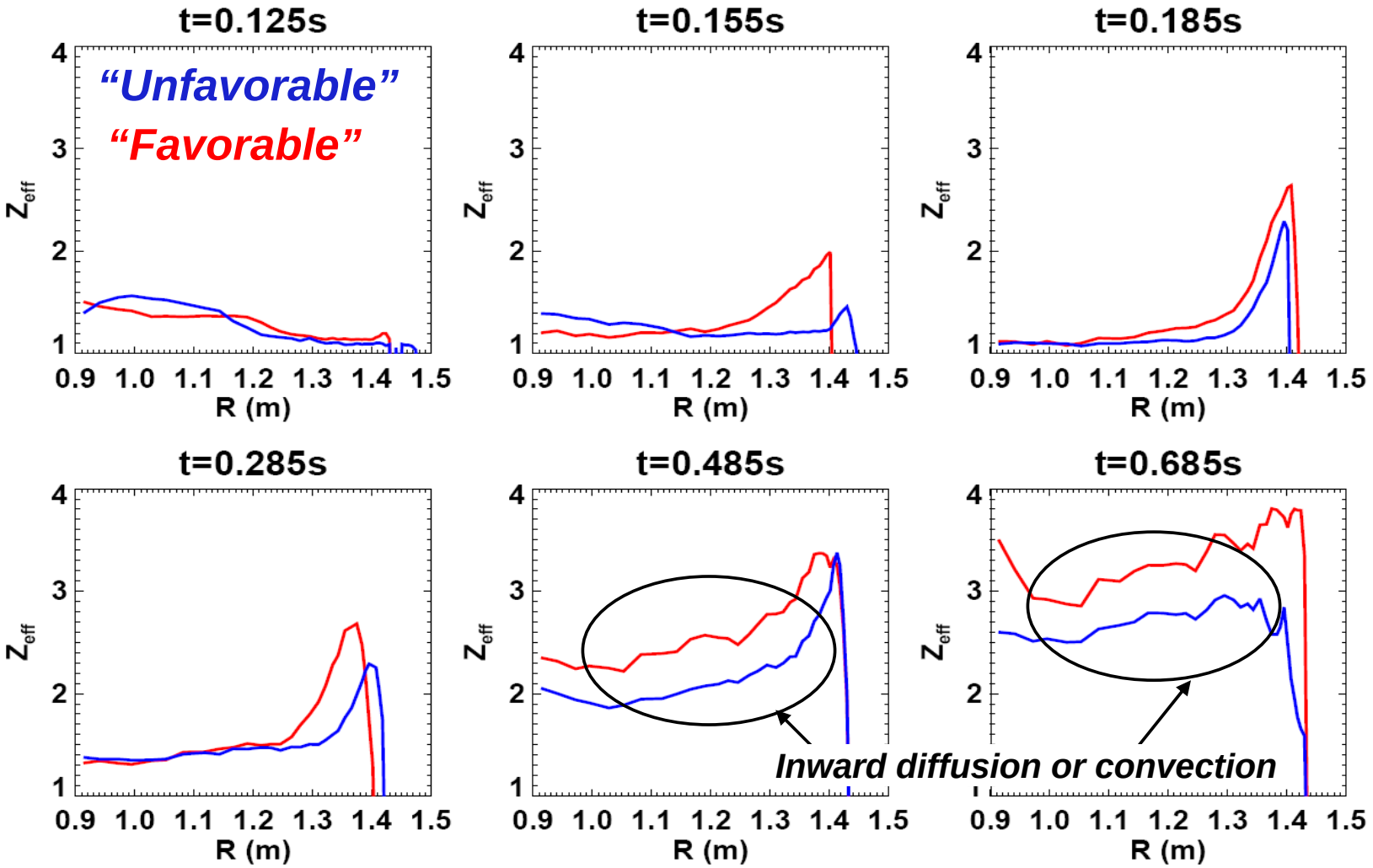
∇B drift up + USN	∇B drift up, USN → LSN	∇B drift up + LSN



- Core/mid-radius C Z_{eff} similar for all 3 magnetic bias configurations for first ~300ms of shot
- **∇B drift up + LSN:**
  - Reduces C influx and/or confinement **at top of pedestal** immediately after early H-mode
  - Lowers C Z_{eff} thereafter

"Unfavorable" direction reduces width and height of edge region where carbon is concentrated

- Question for XP: Can minimizing / flushing the C early keep it from diffusing into the core later in the discharge?



Experimental Approach/Plan:
1-1.5 day request (0.5-0.75 day DRSEP, 0.5-0.75 nRMP)

1. Reproduce long-pulse scenario w/ LITER/LLD which is ELM-free w/ strong C impurity accumulation in edge — 3 shots

2. Scan magnetic balance direction (DRSEP) before, during, after early H-mode, assess impact on early impurity accumulation to determine discharge phase most responsible for C accumulation:
   1. During t=0.05-0.4s, scan DRSEP = -2, -1, 0, 1, 2 cm (constant in time) — 9 shots
      - Add NBI power as needed to trigger/retain early H-mode during ramp-up
   2. After above scan, for case with lowest C content, scan late DRSEP to assess changes in late C accumulation (DRSEP ramp between 0.3-0.5s) — 6 shots

3. In conditions w/ minimized C content, add n=3 RMP pulses during ramp-up + early flat-top, i.e. t ≈100-300ms (i.e. attempt to "clip" ears) — 12-18 shots
   1. Optimize amplitude, duty-factor, start-time to reduce C during ramp
      - Use 50Hz (20ms period), start 50ms before, during, after early H-mode, and off at 0.3s
      - 1, 1.5, 2kA and Δt = 8ms to 4ms
   2. Modify amplitude/duration to minimize early rotation damping and MHD instability