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XP 1036: L-H power threshold for D and He plasmas using HHFW with symmetric phasing

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R. Maingi, S. Kaye

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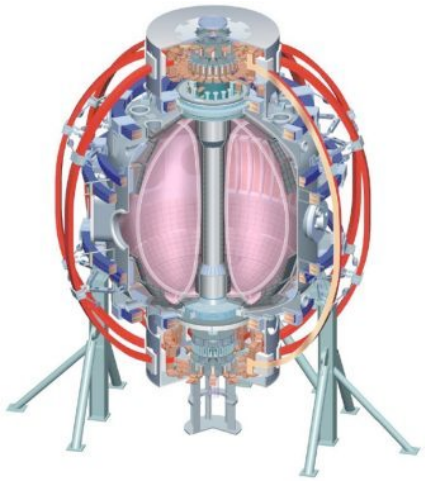
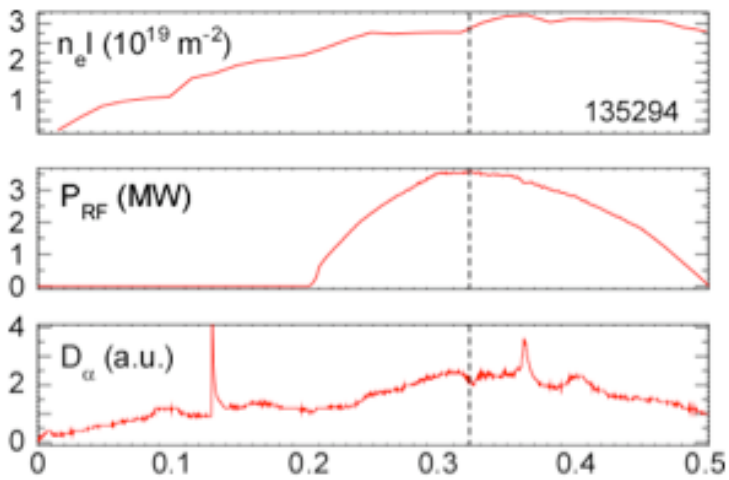
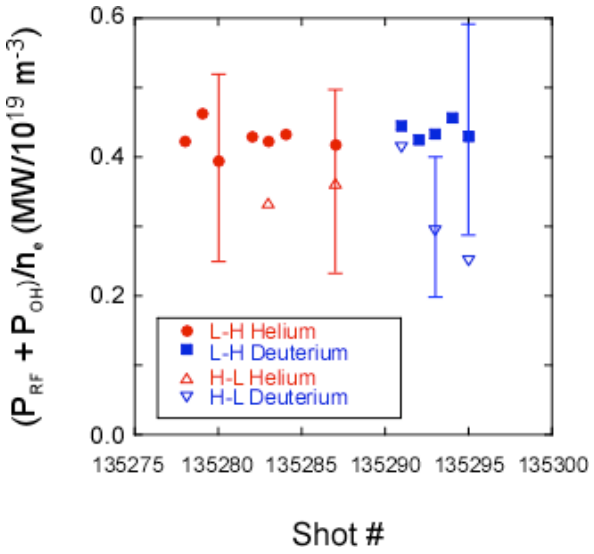
April 5, 2010



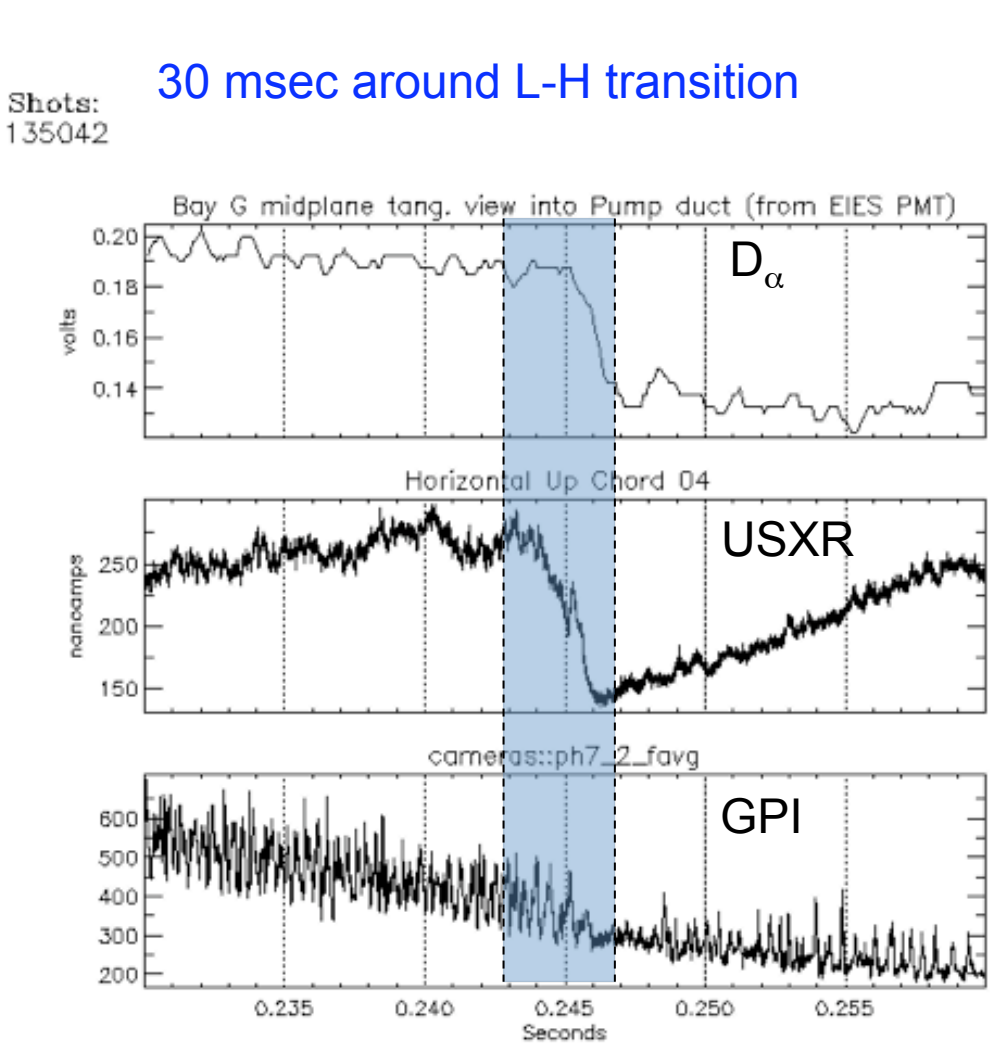
In 2009, XP941: Species dependence of P_{LH} and P_{HL}

- I_p = 600 kA, B_t = 5.4kG
  - D and He in 1/2 day
- HHFW with -90° phasing
  - Sensitive to edge density
  - About 20% heating efficiency
- Continuous ramp in HHFW provided fine P_{RF} resolution
- "Perturbation technique" for determining e^- heating
  - P_{RF} = <0.16> +- 0.1 MW
- Observations:
  - P_{LH}/n_e similar for D and He
  - $P_{HL} < P_{LH}$ (hysteresis)
  - Slower pedestal buildup compared to NBI

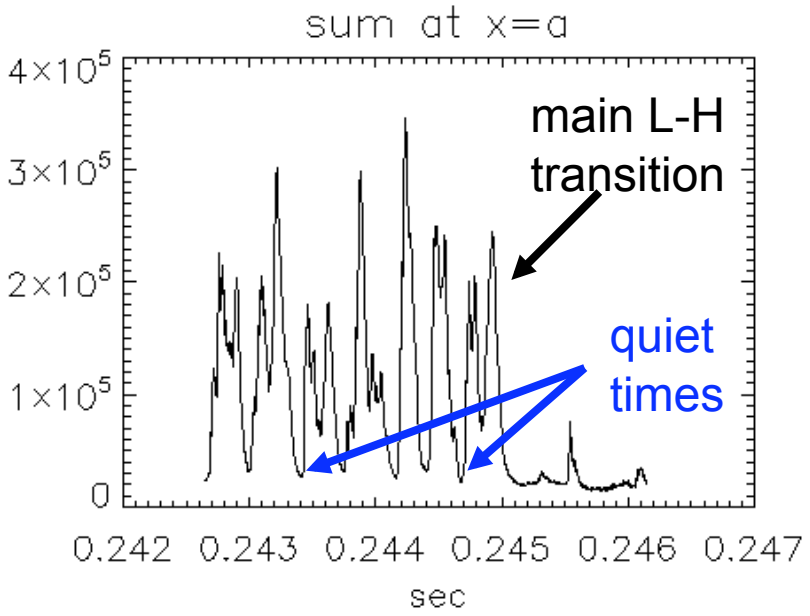




In 2009, XP929: Edge turbulence imaging during LH transition in NBI heated discharges using GPI



- Unparalleled measurements of edge turbulence during LH transition
- Do HHFW heated discharges exhibit different turbulence characteristics?



XP1036: Characterize the LH power threshold, the edge turbulence and the high-k turbulence for D and He plasmas

- I_p/B_t = 2 MA/T for T&T diagnostics
  - GPI: Comparison of RF and NBI heated LH transition
  - BES: Turbulence in OH+RF L and H-mode
- Symmetric (180°) phasing
  - Reduce variation in e^- heating (smaller P_{RF} error bars)
  - Easier to couple to lower B_t
- High-k scattering vs Z_{eff} and RF power in L-mode
  - ETG turbulence is sensitive to $Z_{eff}T_e/T_i$

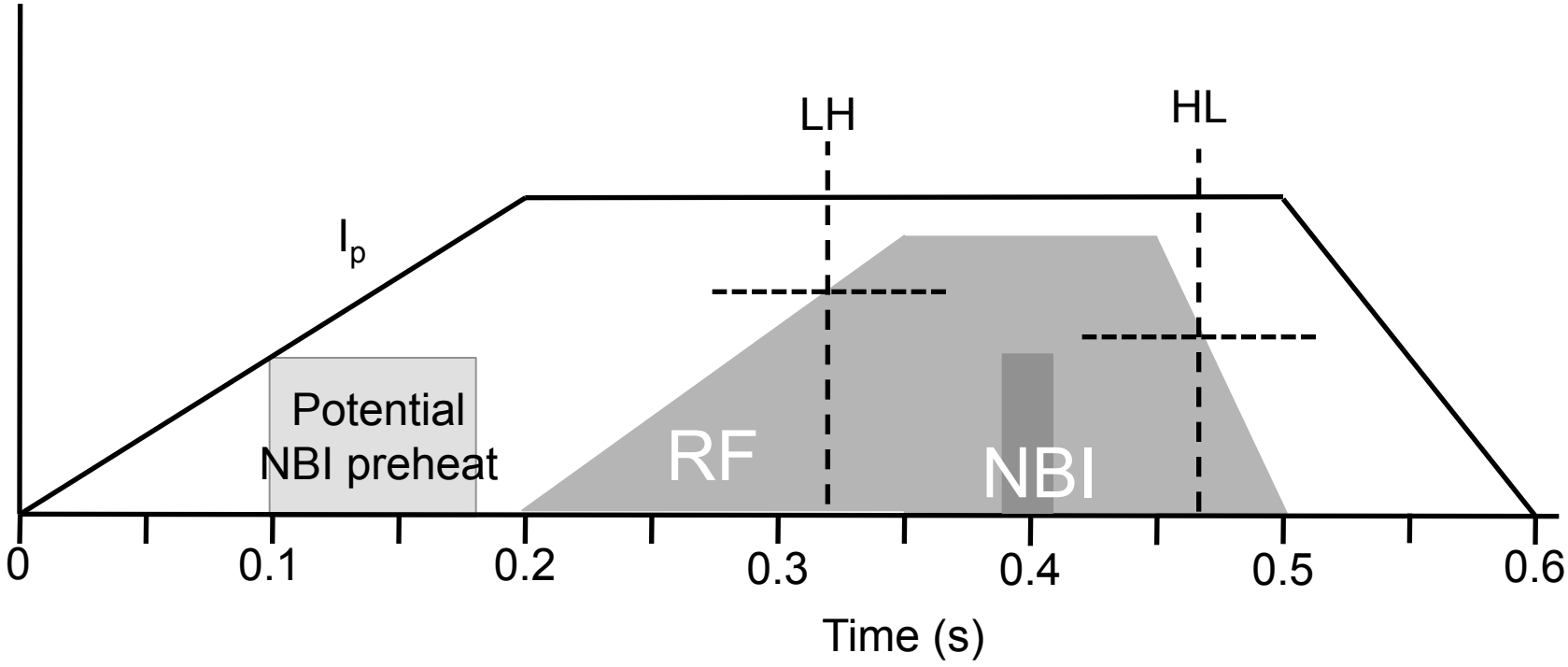
XP 1036 overview

- Conditioning XP …
  - Determine shape, lithium deposition and LLD parameters for RF operation
  - Develop I_p = 900 kA, B_t = 4.5 kG target
  - Demonstrate coupling of 4 MW HHFW in He and D with 180° phasing
- RF ramp to maximum power with He (1 – 4 shots)
  - Ramp RF power following start of flattop
  - Establish LH and HL power thresholds
- RF power steps to power threshold with He (6 – 10 shots)
  - dW/dt following P_{RF} steps used to determine RF heating power
  - RF power flattop near power threshold
    - If LH transition, useful for GPI. Next shot lower max P_{RF} by ~10%.
    - If no LH transition, useful for high-k. Next shot decrease max P_{RF} by ~10%.
  - Aim to get ~ 3 shots with and ~3 shots without transition
- If time, OH only H-mode using sharp decrease in V_{loop}
  - GPI during transition
- Repeat with D (7 – 14 shots)

First target discharge: RF ramp

Ramp RF power to find LH power threshold
May also get HL threshold

1 – 4 shots

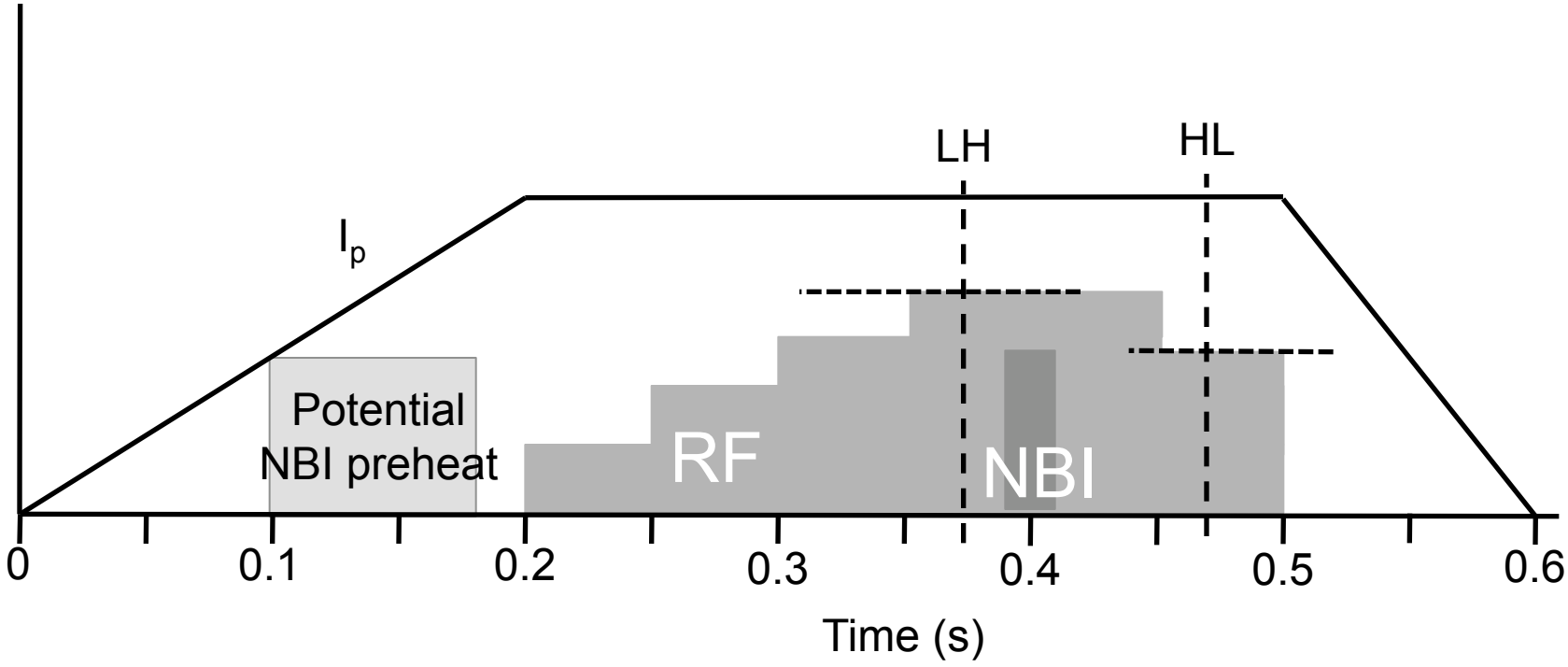


Keep GPI on for these shots for consistent gas injection

Second target discharge: RF steps

Three or four 50 ms steps to LH power threshold level
GPI near anticipated LH transition time
Raise and lower max RF and power step down between shots

6 – 10 shots



XP1036 Requirements

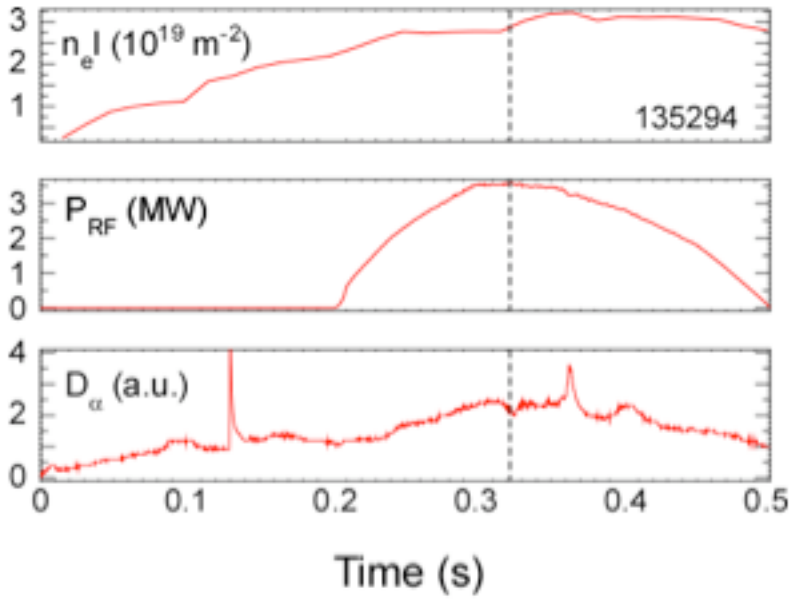
- Requirements:
  - HHFW compatible with LLD (hot or cold)
  - Reliable coupling of 4 MW of RF power into plasmas with I_P/B_T = 2 MA/T
  - Source A NBI only
  - High-k, GPI, MPTS, CHERS, filterscopes, magnetics
  - EFIT, TRANSP

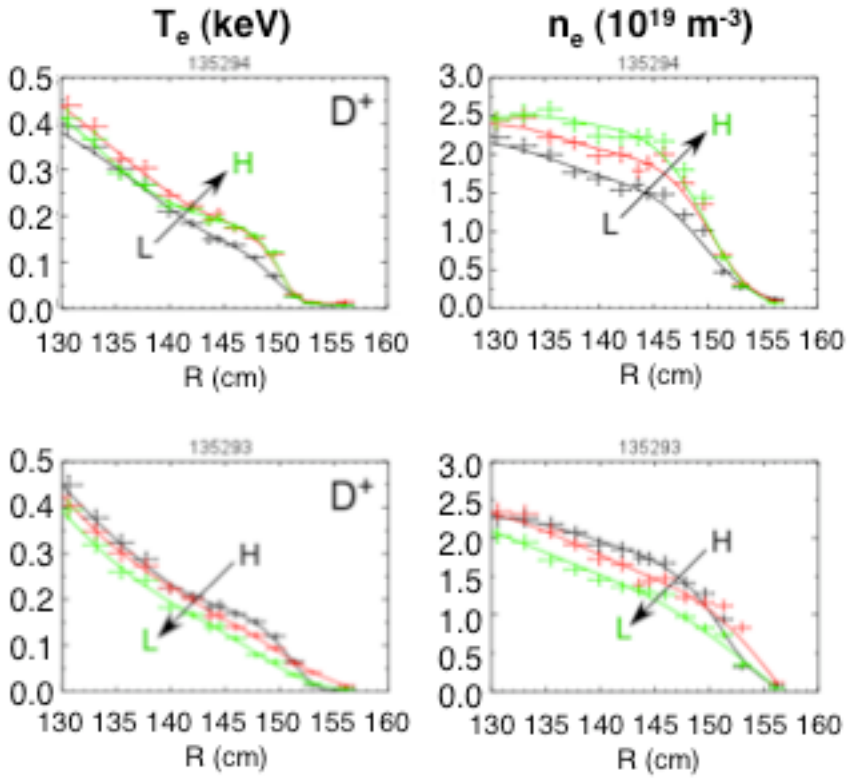
- Desires:
  - Bolometer, reflectometer, FIReTip, USXR, BES, Edge D_α, ERD

Backup slides

Slow scans of HHFW power used to measure the L-H/H-L thresholds in pure He and D plasmas

- Use change in edge profiles to determine transitions
  - Transitions not always obvious in D_α signal with slow power scan
  - No D_α signal in pure He plasmas

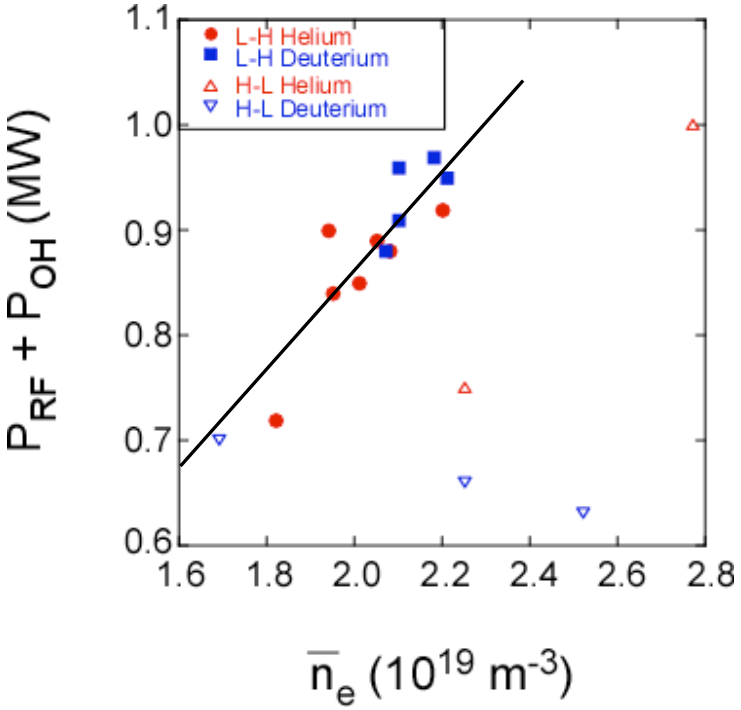


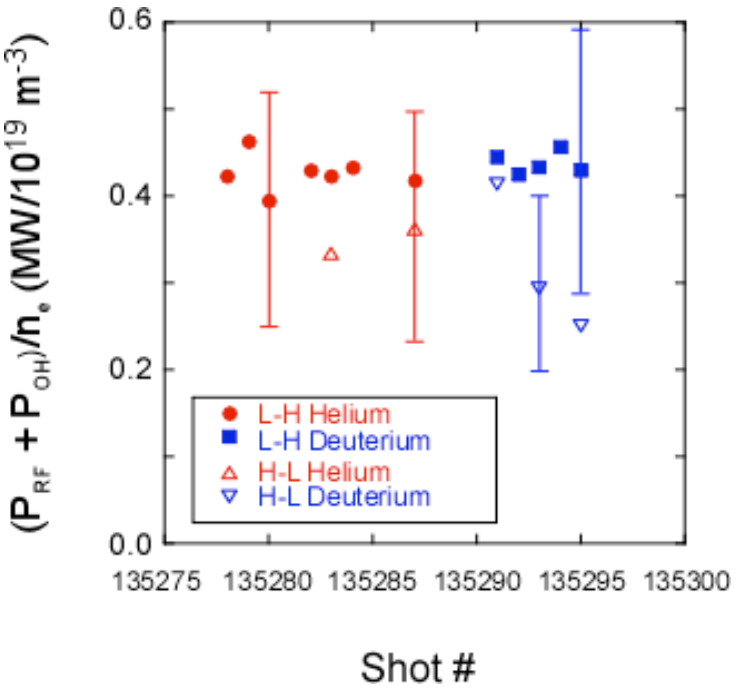


L-H power thresholds for He and D are similar

- $(P_{RF} + P_{OH})/n_e$ similar for P_{LH} thresholds with D and He
  - P_{HL} not effectively normalized by n_e
- H-L thresholds indicate some hysteresis

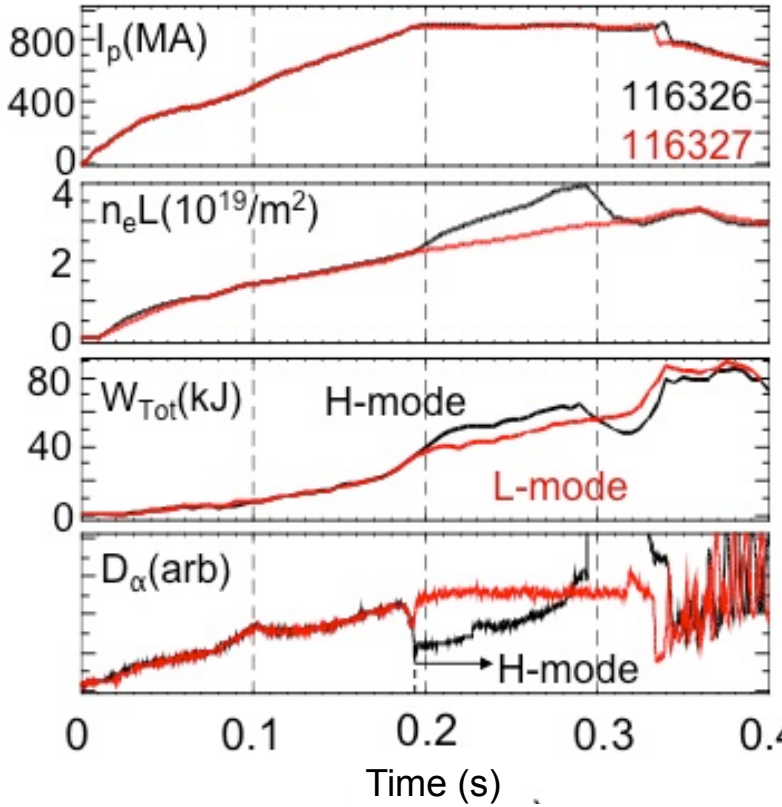
- Large error bars due to uncertainty in RF heating efficiency

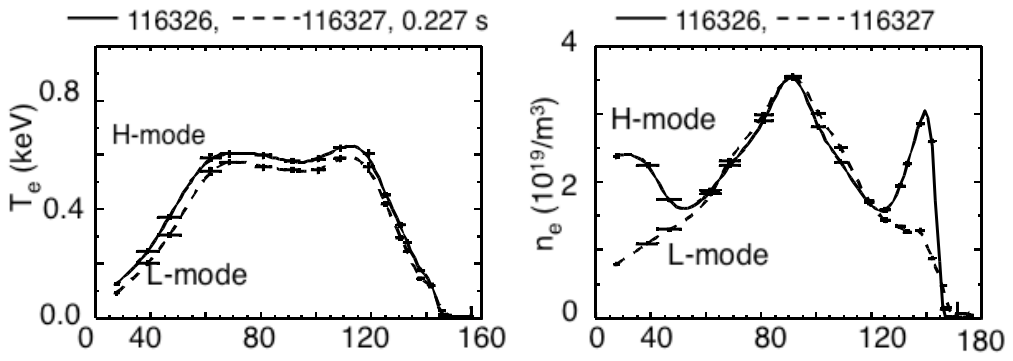




H-mode achieved for I_p = 900kA, B_t = 4.5kG with OH heating

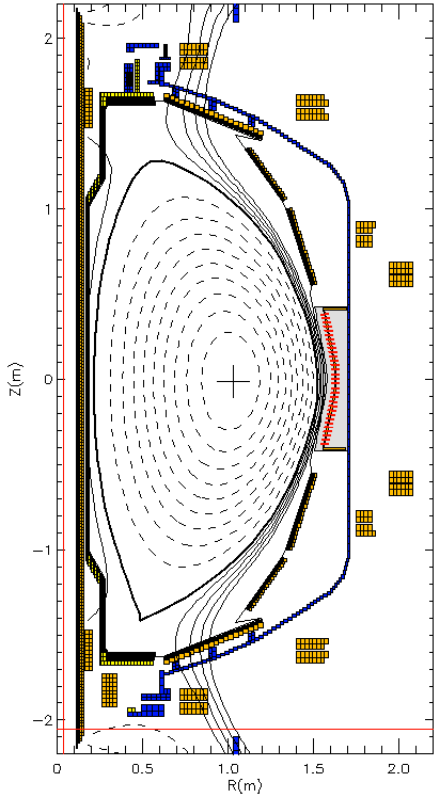
- OH-only discharges achieve ~ 130 ms flattop
  - Suitable for measurements?
  - Current relaxation?
- LH transition occurs when V_{loop} drops
  - Phenomenon often observed but not explained
  - Target: OH-only discharge that remains in L-mode



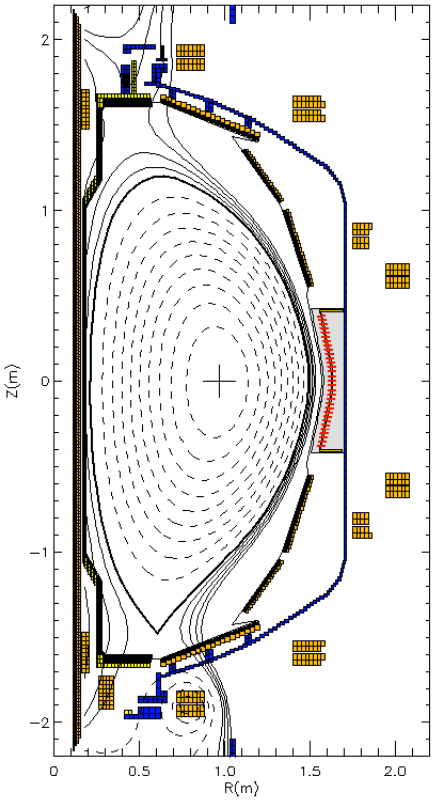


C. Bush, NSTX Results Review - Dec 2005

Comparison of XP shapes



OH + RF H-mode
135294 at 320 ms



OH H-mode
116326 at 200 ms