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

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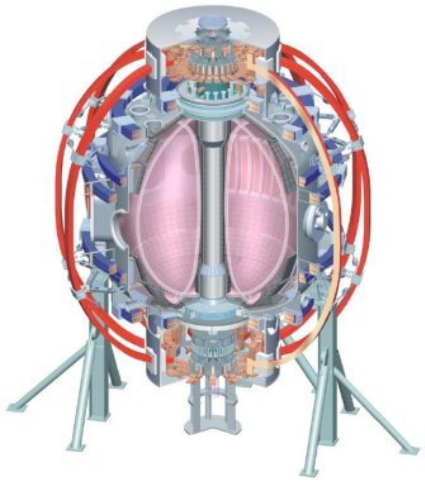
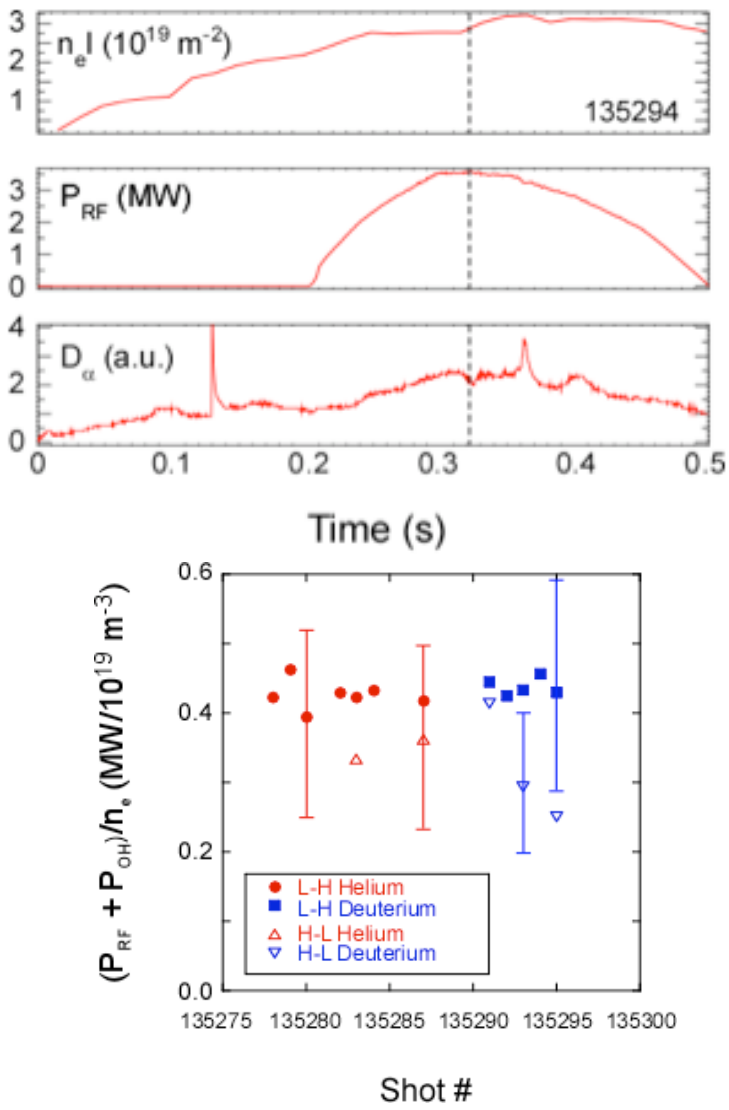
March 4, 2010



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

- I_p = 600 kA, B_t = 5.4kG
- HHFW with 90° phasing
- 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



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

- I_p/B_t = 200 kA/kG for T&T diagnostics
  - GPI: Comparison of RF and NBI heated LH transition
  - BES: Turbulence in OH L-mode, OH+RF L and H-mode
  - Trade off between I_p and B_t
    - Large I_p → OH H-mode, short flattop
    - Small B_t → Difficult RF coupling
- 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} in L-mode
  - ETG turbulence is sensitive to Z_{eff}

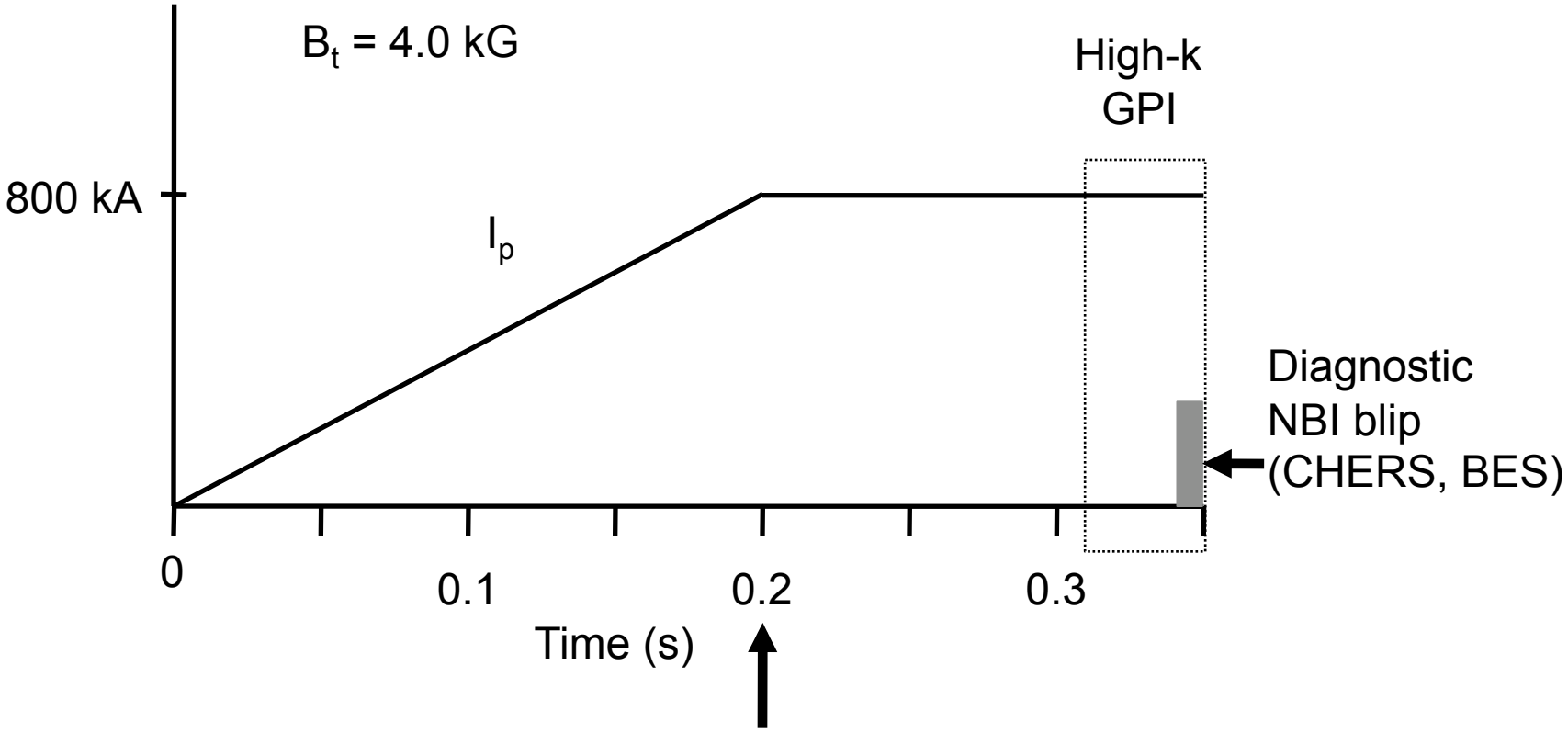
XP 1036 overview

- Conditioning XP …
  - Determine compatibility of XP941 shape with LLD
  - May develop I_p = 800 kA, B_t = 4.0 kG target for symmetric phasing
- OH-only L-mode with He (1 – 4 shots)
  - May need to develop target with I_p/B_t = 0.6MA/0.3T ➔ 1.0MA/0.5T
  - Baseline GPI, high-k measurements
- RF power ramp with He (1 – 2 shots)
  - Ramp RF power following start of flattop
  - Establish power threshold
- RF ramp to H-mode level with He (3 – 5 shots)
  - Repeat LH transition ~ 3 times for GPI
- RF power steps in L-mode with He (1 – 2 shots)
  - dW/dt following P_{RF} steps used to determine RF heating power
  - High-k measurements
- Repeat with D (8 – 15 shots)
  - May need to scan RF power steps in order to match T_e and n_e profiles to He shots

First target discharge: OH-only L-mode

Establish L-mode OH-only discharge
Take reference measurements

1 – 4 shots

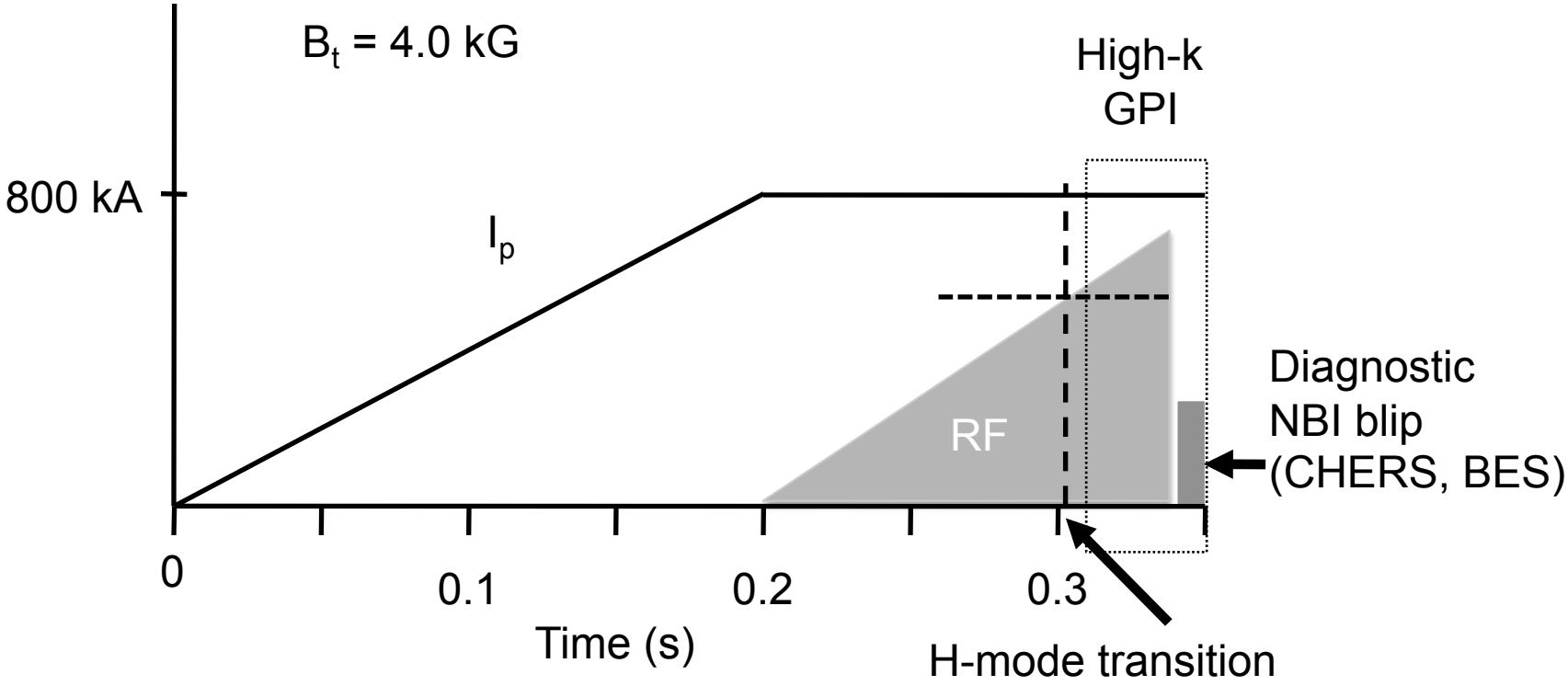


Might have to suppress LH transition at 200 ms
(Increase n_e, increase S via elongation or less abrupt change in dI/dt)

Second target discharge: OH + RF ramp

Ramp RF power to find power threshold
No NBI pulse needed

1 – 2 shots

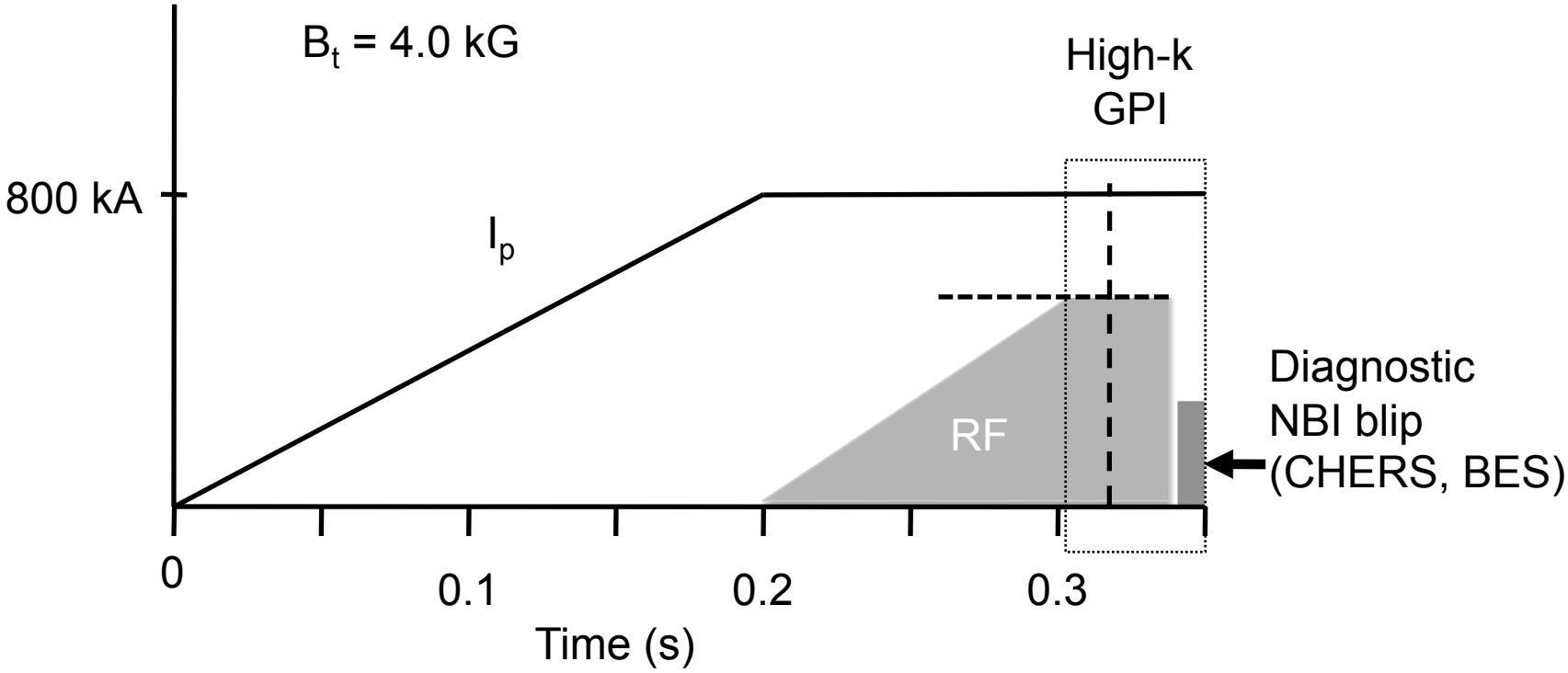


Keep GPI on for these shots for consistent gas injection

Third target discharge: LH transition with GPI

Level-off RF power at value needed for LH transition
Set GPI timing accordingly & repeat measurement three times
Get NBI pulse close to measurement time

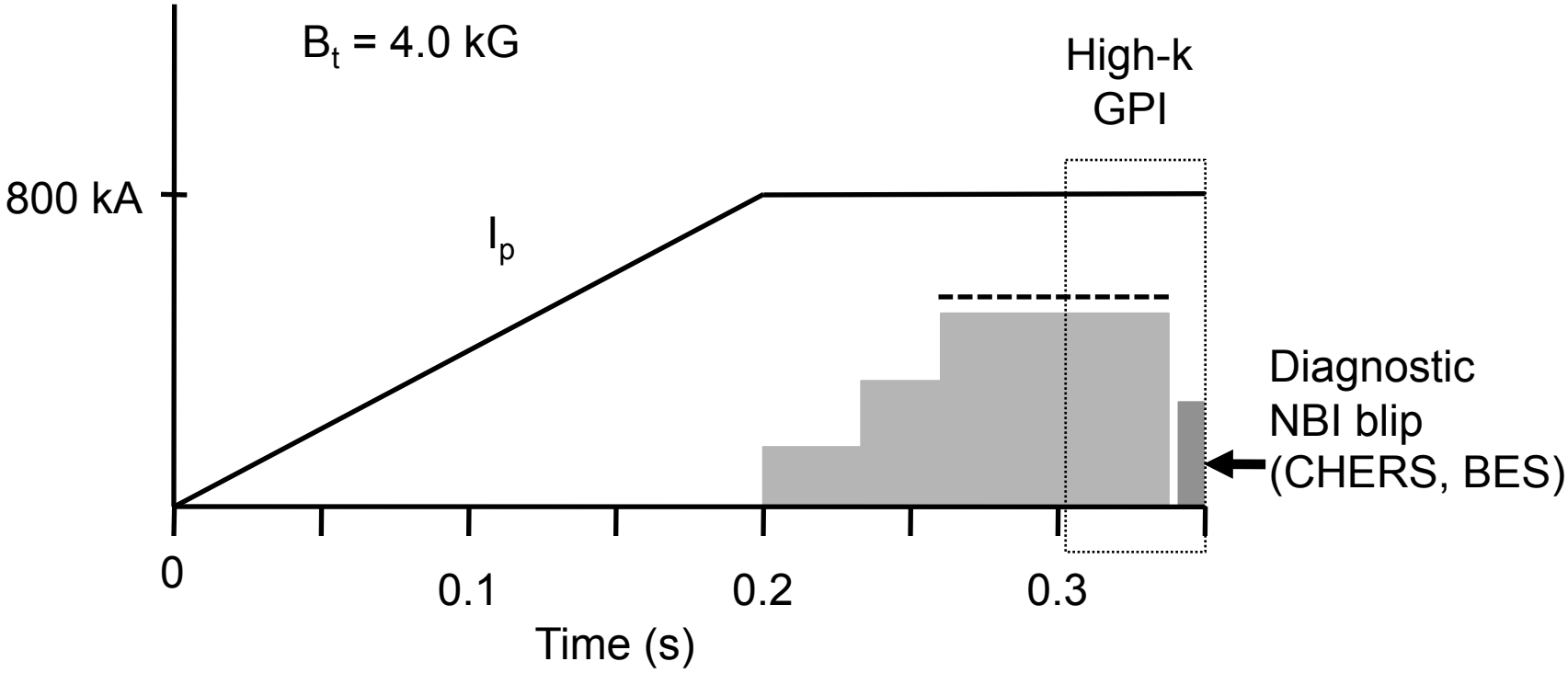
3 – 5 shots



Fourth target discharge: RF power steps in L-mode

Two or three steps in RF power to level below LH power threshold
Take high-k data in long L-mode period
Get NBI pulse close to measurement time

1 – 2 shots



XP1036 Requirements

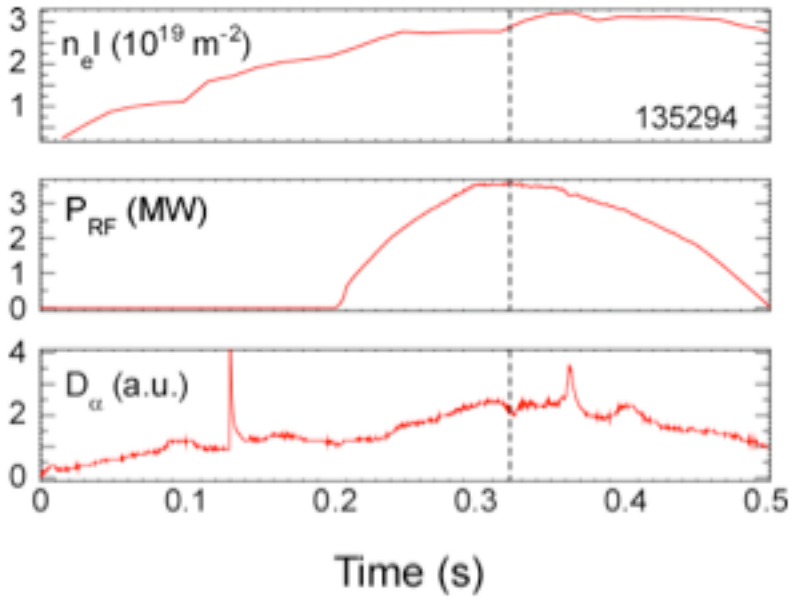
- Requirements:
  - HHFW compatible with LLD (hot or cold)
  - LLD compatible with He discharges
  - Reliable coupling of 4 MW of RF power into OH plasmas
  - High-k, GPI, MPTS, CHERS, filterscopes, magnetics,
  - n=1 error field correction

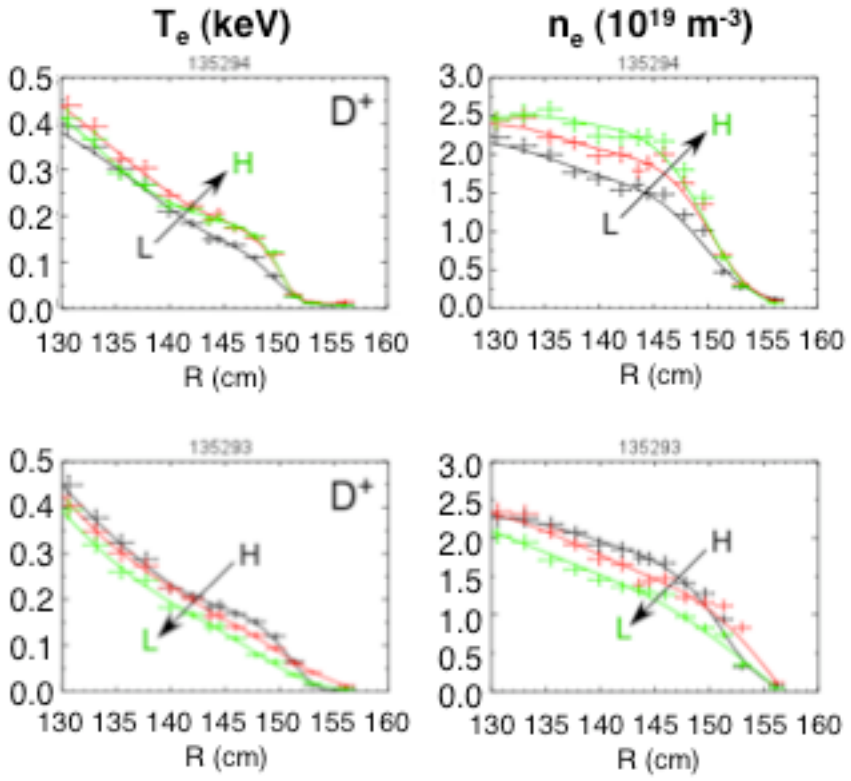
- Desires:
  - 2D fast soft x-ray camera (examine fast dynamics near transition)
  - Bolometer, reflectometer, FIReTip, USXR, BES, Edge D_α, ERD

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

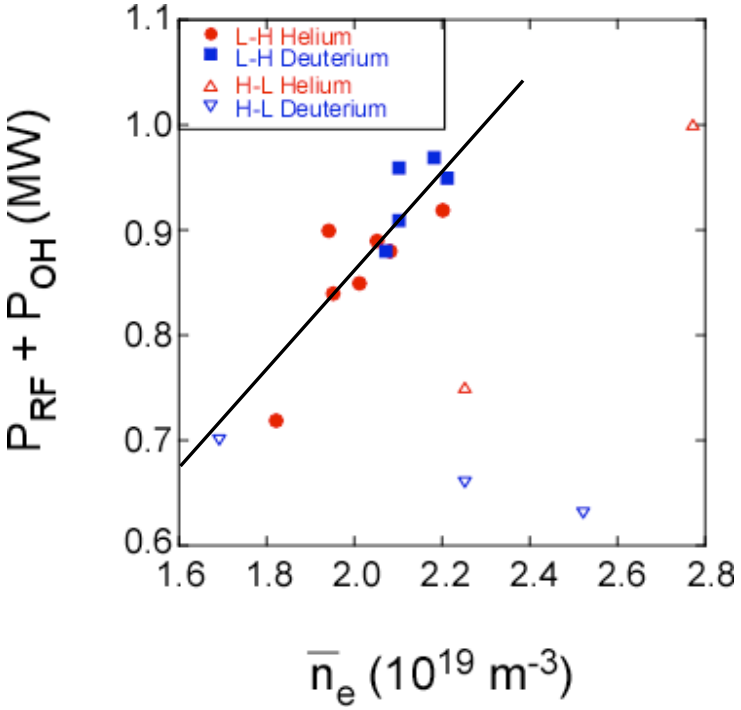


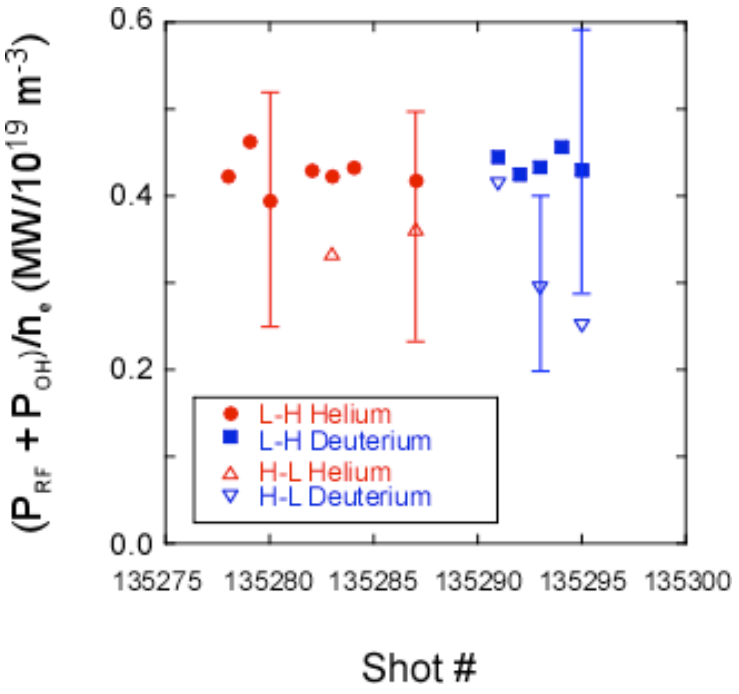


L-H power thresholds for He and D are similar

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

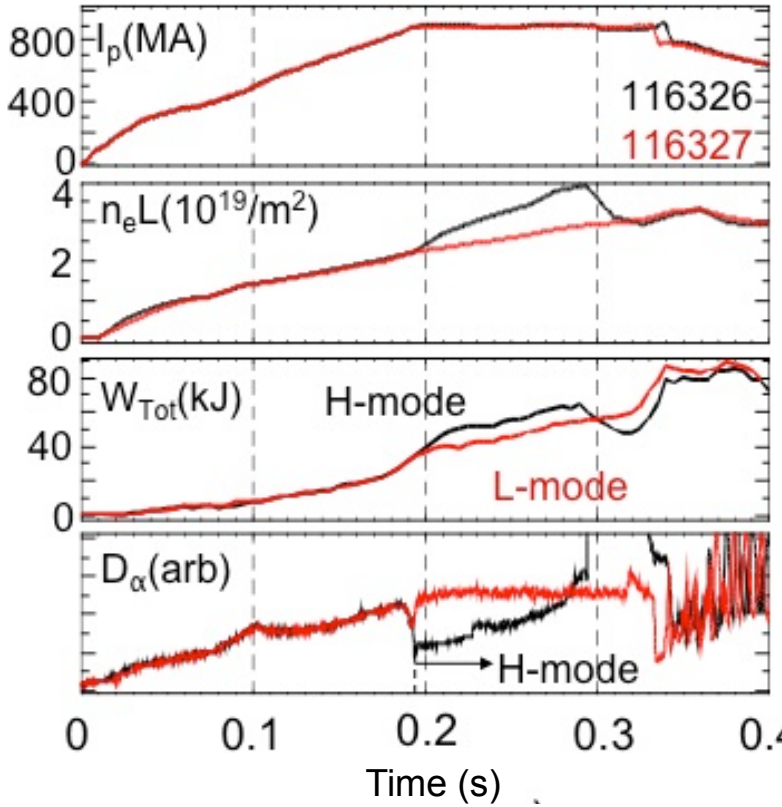
- Large error bars due to uncertainty in RF heating efficiency

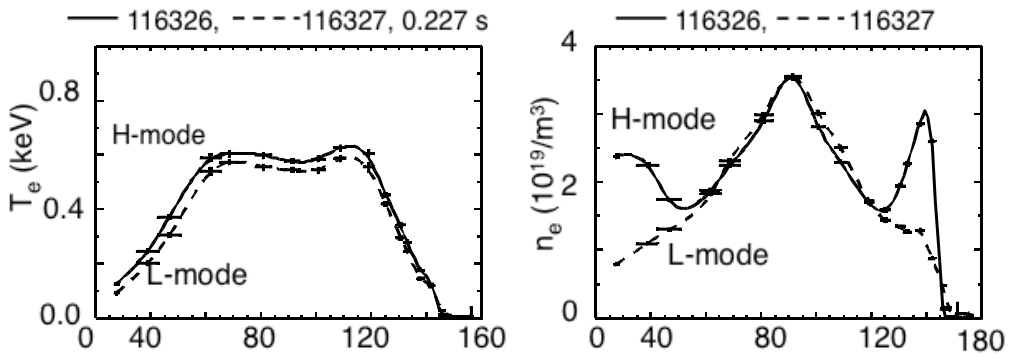




H-mode achieved for I_p = 900kA, B_t = 4.5kG with OH heating

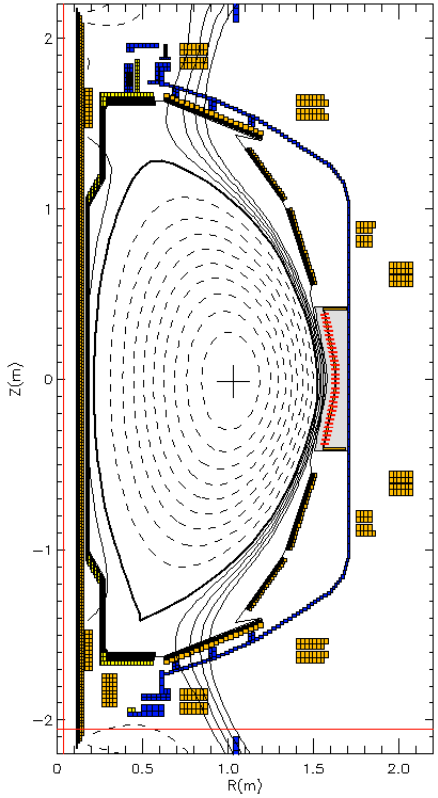
- OH-only discharges achieve ~ 130 ms flattop
  - Suitable for measurements?
  - Current relaxation?
- LH transition occurs when V_{loop} drops
  - Phenomenon often observed but not explained
  - Target: OH-only discharge that remains in L-mode



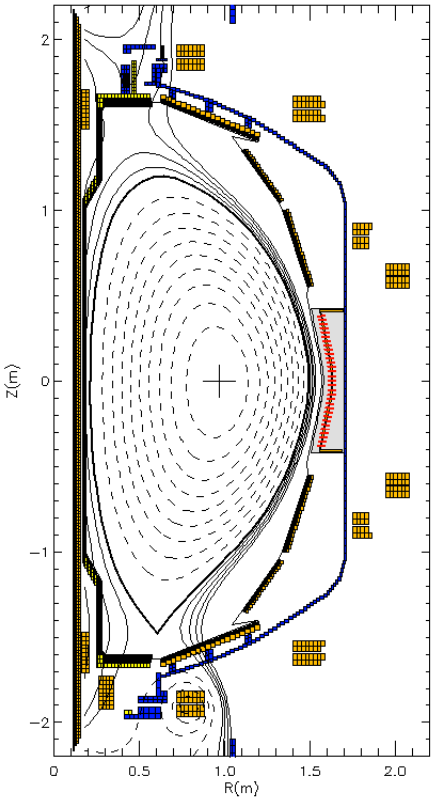


C. Bush, NSTX Results Review - Dec 2005

Comparison of XP shapes



OH + RF H-mode
135294 at 320 ms



OH H-mode
116326 at 200 ms