Tests of fast wave current drive for core q profile control and MHD avoidance

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ASC + HHFW groups

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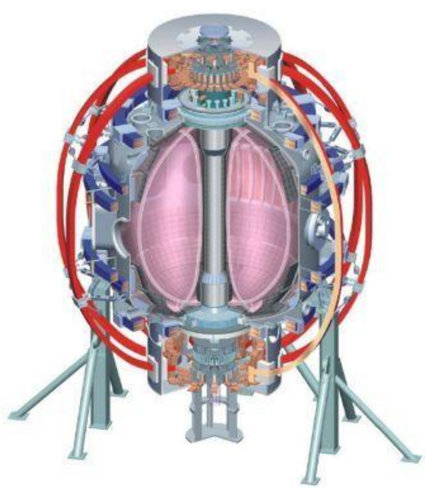

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Overview

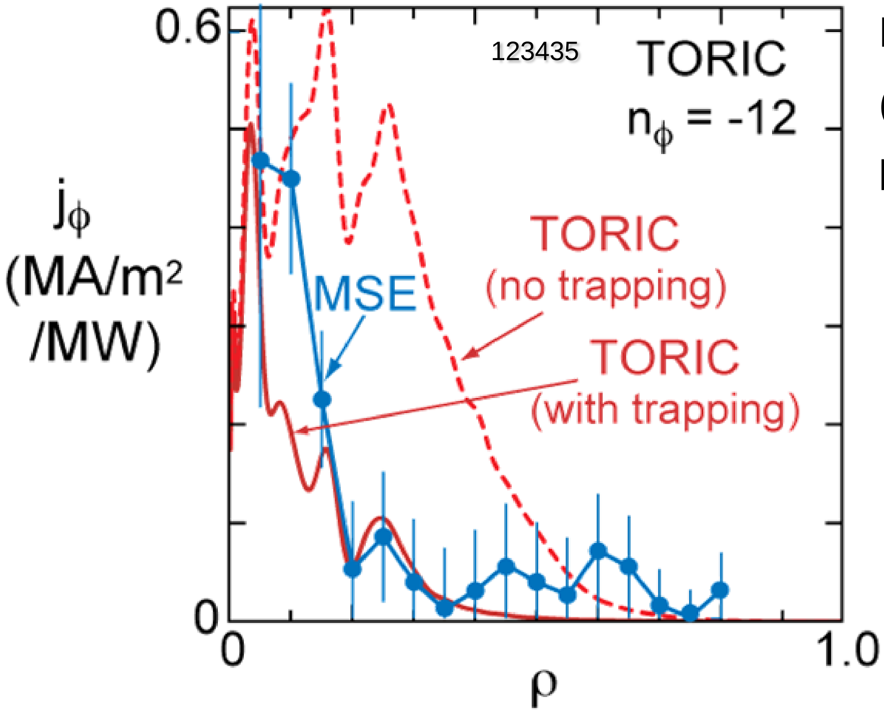
- **Brief Description:**

  Assuming successful HHFW coupling and heating of an NBI-heated H-mode plasma, co and <u>counter</u> HHFW CD will be applied to attempt to modify the core q profile and assess changes in transport and MHD instability behavior.

- **Motivation:**
  - The core q profile is important for confinement and MHD stability - in particular via transport barrier formation and avoidance of the q=1 surface entering the plasma.
  - In addition to modifying plasma evolution via direct electron heating, HHFW CD is projected to be effective near the magnetic axis in driving current and modifying the central q

- **Supports:** Scenario optimization, R12-2, R12-3, IOS-5.2, IOS-6.2

HHFW driven current density is sufficiently high to modify q in high NI-fraction H-mode scenarios



P_{rf} = 1.7 MW

(65% absorbed)

$k_{||}$ = - 8 m^{-1}

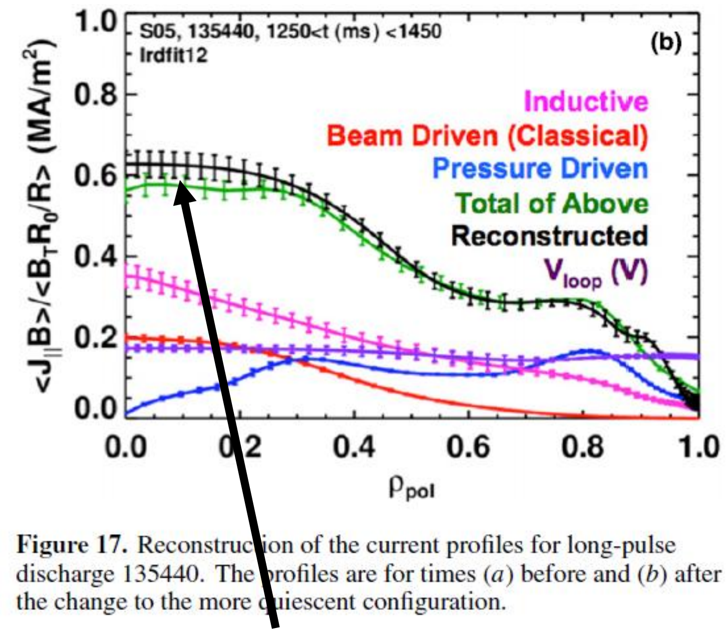
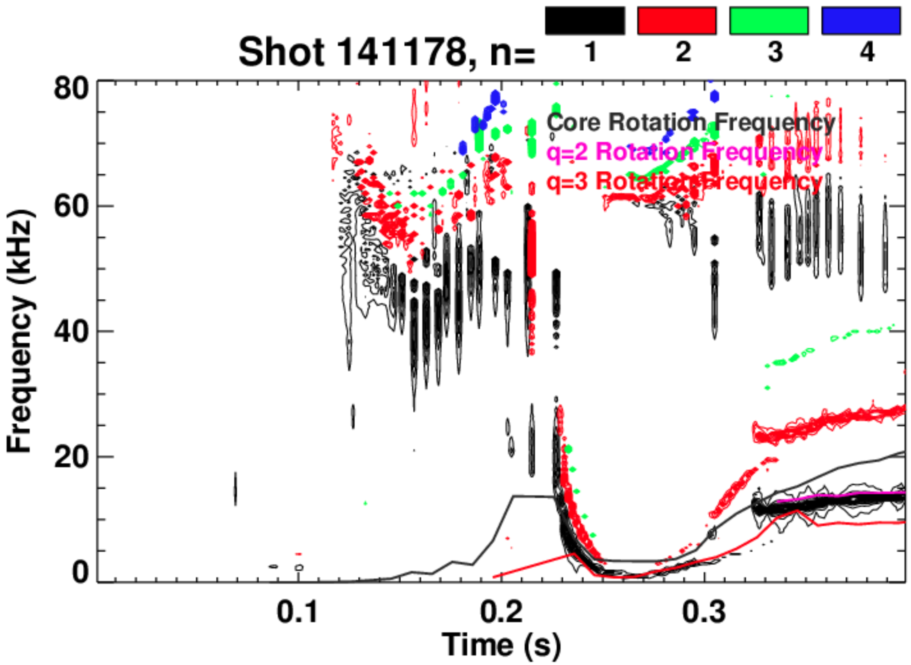


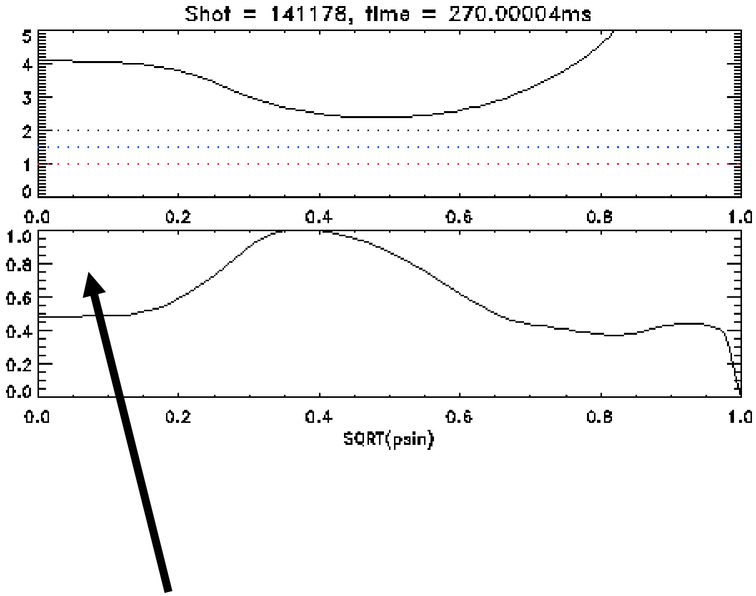
Figure 17. Reconstruction of the current profiles for long-pulse discharge 135440. The profiles are for times (*a*) before and (*b*) after the change to the more quiescent configuration.

- High non-inductive fraction H-mode J_ϕ ~ 0.5-0.7MA/m^2
  - NB H-mode shown has 3x higher n_e, 4x lower T_e → η_{RFCD} = 12x lower
  - 4MW RF → 0.1-0.12MA/m^2 → **+/- 15-20% change in $J_\phi(0)$**
    - **Ignores any core heating from HHFW and/or fast-ion interactions**

Early co-CD could reduce early shear reversal and MHD?



•Typical q and $J_{||}$ profile during time of q=2 & 3 entering

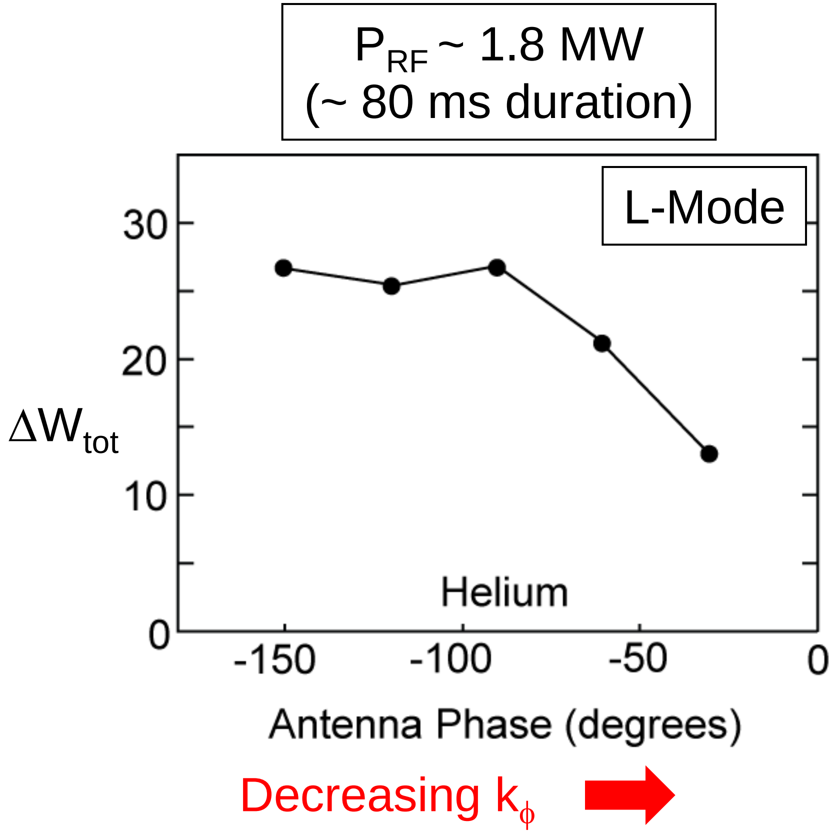


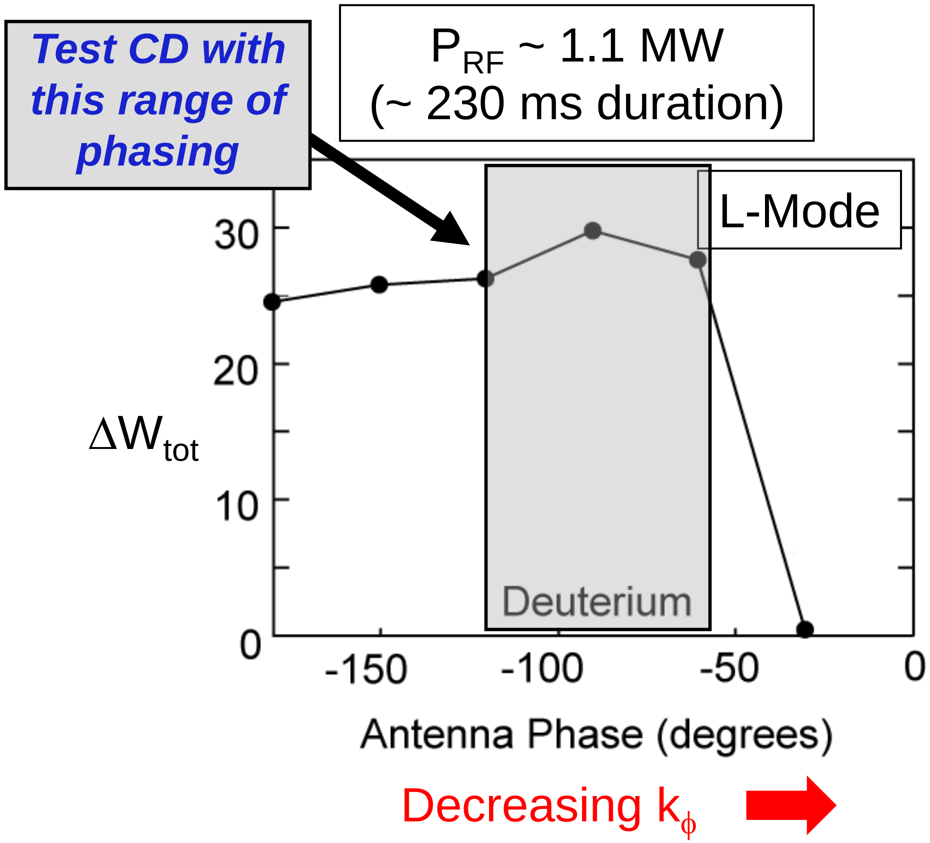
- RFCD of 0.1-0.2MA/m^2 may be enough to modify shear to vary *AE and TM behavior

Experimental Approach/Plan:
(1.5 day request, 1 day minimum useful)

- Re/produce NBI-heated H-mode plasma with substantial core T_e increase from 2-4MW of HHFW in heating phasing
  - Use plasma with 2-3MW NBI to reduce NBI-antenna interactions
  - **Use plasma with late n=1 MHD onset (~0.8-1s) as test case**
- Switch HHFW phasing to drive current in co-Ip direction
- Perform HHFW power scan to find maximum allowable FW power input for range of phasings: 90°, 60°, 120°
  - Assess plasma response: $\Delta T_e(0)$, **variations in q evolution, late MHD**
- Repeat above for counter CD phasing
- Move HHFW heating progressively earlier into ramp-up and assess plasma response
- For heating/CD scenarios with largest plasma modification:
  - Increase plasma current and/or decrease B_T to assess possible q* range accessible without late n=1 MHD onset

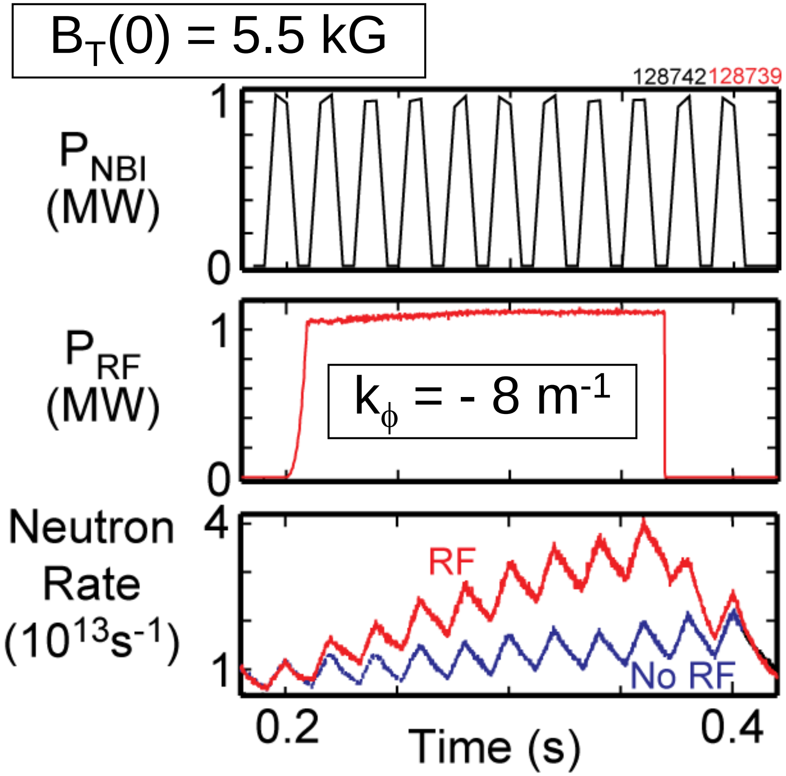
Taylor APS09: Core Heating Efficiency Degrades with Decreasing k_ϕ in L-Mode & H-Mode Plasmas

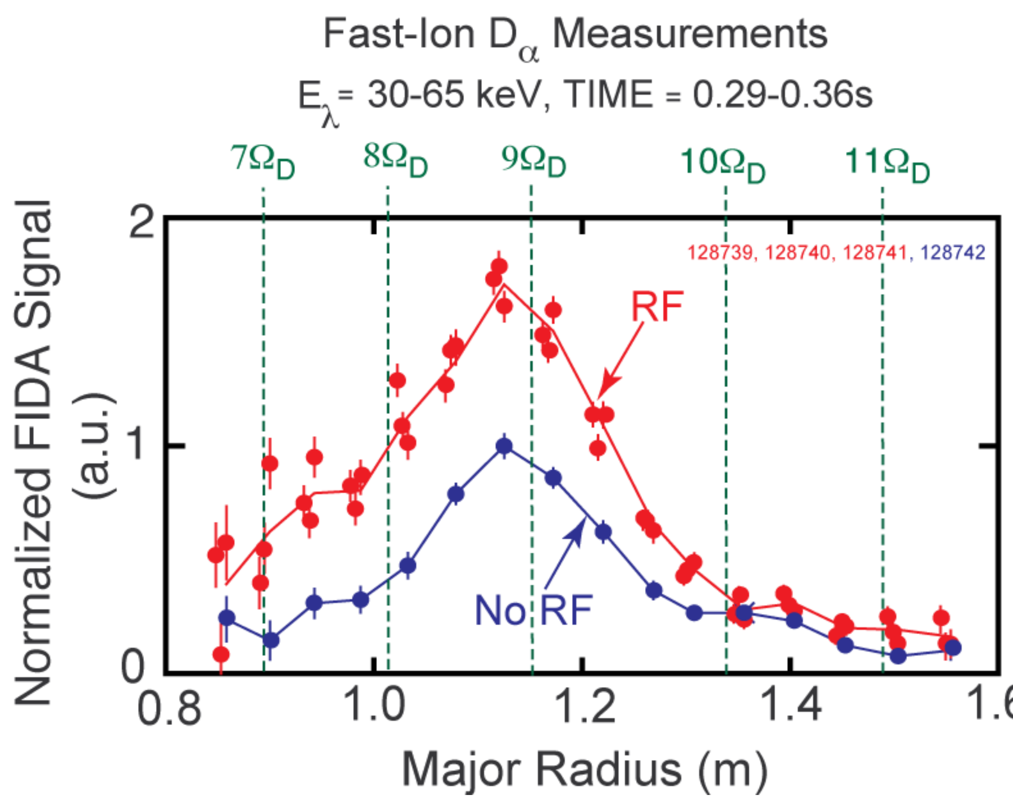




- Also measure a degradation in core heating efficiency with decreasing k_ϕ In D_2 H-mode:
  - ~ 66% efficiency at $k_\phi = -13\ m^{-1}$, decreasing to ~40% at $k_\phi = -8\ m^{-1}$

Taylor APS09: Interaction Between NBI Ions & HHFW Can Be Significant





- Measured acceleration of NBI fast-ions and large increase in neutron rate during HHFW + NBI plasmas
  - ➢ As predicted originally by CQL3D/GENRAY
- Measured significant enhancement & broadening of fast-ion profile when HHFW power is applied