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Low I_p HHFW Heating Experiments

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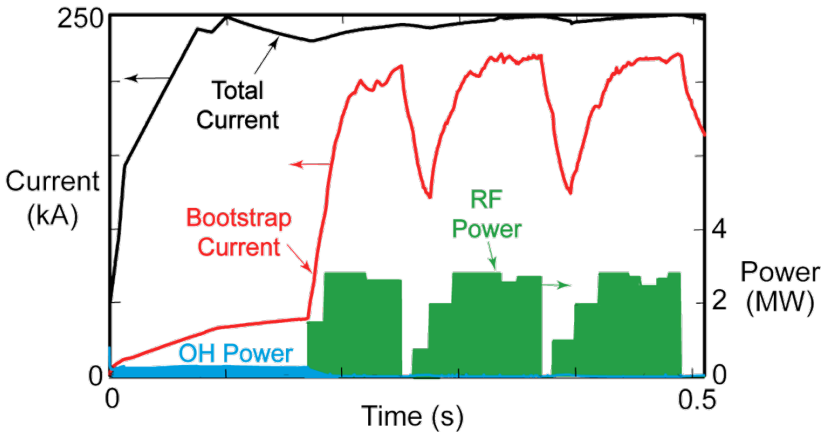
HHFW Heating of Low I_p Plasmas Since 2005 Show Promise, But Also Problems with Plasma Control

2005: (XP-521)

- 60-85% bootstrap current in HHFW heated (k_ϕ = -14 m^{-1}) H-mode D_2 plasmas at I_p = 250 kA
- Transiently produced $V_{loop} \leq 0$ and $dI_{OH}/dt \approx 0$



2007: (XP-731)

- Problem with rtEFIT control at I_p = 250 kA, used 300 kA
- Many trips with k_ϕ = 14 m^{-1}
- Up to 2.7 MW of k_ϕ = -8 m^{-1} heating, produced transient H-mode

2008: (XP-817)

- Li conditioning reduced edge density, improving HHFW core heating, even in CHI start-up plasmas with $n_e(0) \sim 4x10^{18} m^{-3}$

Propose two low I_p HHFW experiments in WPI TSG that will contribute to R10-2 milestone in 2010:

- **(1)** HHFW Heating of Low $T_e(0)$, I_p Plasmas (XP-920)
- **(2)** Sustainment of HHFW-Driven 100% Non-Inductive H-Mode Plasmas

(1) HHFW Heating of I_p ~ 200 kA Plasmas (XP-920); Develop HHFW I_p Ramp-Up Later in SFSU TSG

- Experimental Approach/Plan:
  - Setup D_2 plasma with I_p = 500 kA, B_T = 5.5 kG, and add k_ϕ = -8 m^{-1} RF power and to ~ 3 MW, while adjusting Li evaporation rate, gas injection rate and outer gap to optimize HHFW heating efficiency (5-10 shots)
  - Reduce I_p in 100 kA steps to 300 kA, then ~ 50 kA steps below 300 kA while coupling RF (10 shots). Repeat with k_ϕ = 14 + 18 m^{-1} heating (10 shots)
  - If I_p = 200 kA RF heating successful reduce I_p in ~ 25 kA steps to as close to 150 kA as possible while maintaining outer gap ~ 5-10 cm (5-10 shots)
  - Couple k_ϕ = ± 8 m^{-1} & k_ϕ = 14 + 18 m^{-1} power to ~ 3 MW (15 shots)
  - Perform n_e scan with k_ϕ = -8 m^{-1} heating (5-10 shots)
  - If sufficient CD is observed, adjust RF pulse to start as soon as I_p reaches flattop, then use open loop OH programming to provide no ohmic drive after I_p reaches minimum value (< 200 kA at approximately 25 ms) (10 shots)
- Request 2 run days (minimum useful runtime ~ 1 day)

(2) Sustainment of HHFW-Driven 100% Non-Inductive H-Mode; Develop Later in ASC TSG

- Brief Description:
  - Couple ~ 5 MW of HHFW power into an I_p ~ 300-400 kA plasma
  - Based on past experiments and modeling 5 MW should be sufficient power to drive plasma into a fully non-inductive H-mode
- Background:
  - 60-85% bootstrap fraction already achieved with ~ 2.5 MW of k_ϕ = 14 + 18 m^{-1} RF power in an I_p = 250 kA plasma (XP-521)
  - New double end-fed antenna should be able to couple ~ 5 MW
  - LLD + LITER's should provide low edge density for better RF coupling
- Experimental Approach/Plan:
  - Experiment should be preceded by XP-920
  - Setup 600 ms I_p flattop D_2 plasma with I_p ~ 300-400 kA, B_T = 5.5 kG
  - Add 5 MW of k_ϕ = -8 m^{-1} and/or 14 + 18 m^{-1} heating, adjusting Li evaporation, gas injection rate and outer gap to optimize HHFW heating to obtain L-H transition and H-mode sustainment
- Request 1 run day (minimum useful runtime ~ 0.5 days)