NSTX

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Modification of the Early Current Profile Evolution with High Harmonic Fast Waves

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ASC TSG Breakout Session
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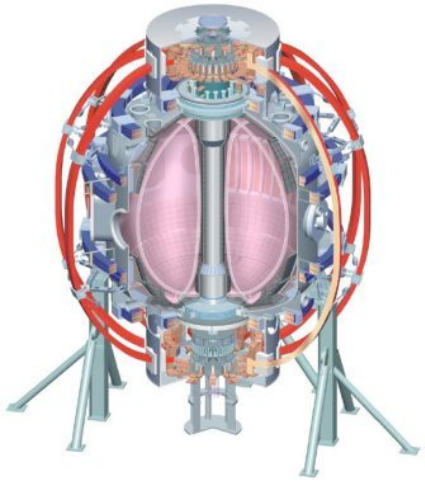


Overview

- Background:
  - NSTX typically uses substantial early NBI:
    - Provides early heating.
    - Provides momentum input.
    - Leads to substantial lost power to plasma facing surfaces.
  - *Control* of the early current profile evolution could be quite beneficial:
    - Enable more exotic scenarios.
    - Improve reliability of ramp-up.
- Goals of Proposed XP:
  - Develop startup techniques to rapidly close to a small outer gap.
  - Couple HHFW to these plasmas.
    - Try various phasings and power levels
  - Demonstrate variation in $q_{min/0}$-evolution as a function of phasing and power.
- Contributes to:
  - Research Milestone (R10-2): Characterize HHFW heating, current drive, and current ramp-up in deuterium H-mode plasmas.
  - Research Milestone R(11-2): Assess the dependence of integrated plasma performance on collisionality.
  - IOS-4.1: Access conditions for hybrid scenario.
  - IOS-5.2: Maintaining ICRH coupling in expected ITER regime.
  - IOS-6.2: l_i control during current ramps.

DIII-D Experiments Showed q_{min}/q_0 Control

- Feed forward experiments to document the effect.
  - 3 & 5 have no ECH
- Later experiments showed feedback control of q_{min}/q_0.
  - rtEFIT with MSE
- Useful for ensuring similar q-profiles at the start of flat-top.
- Could be used for l_i control in near-term, and $q_{0/min}$ if MSE comes in realtime.

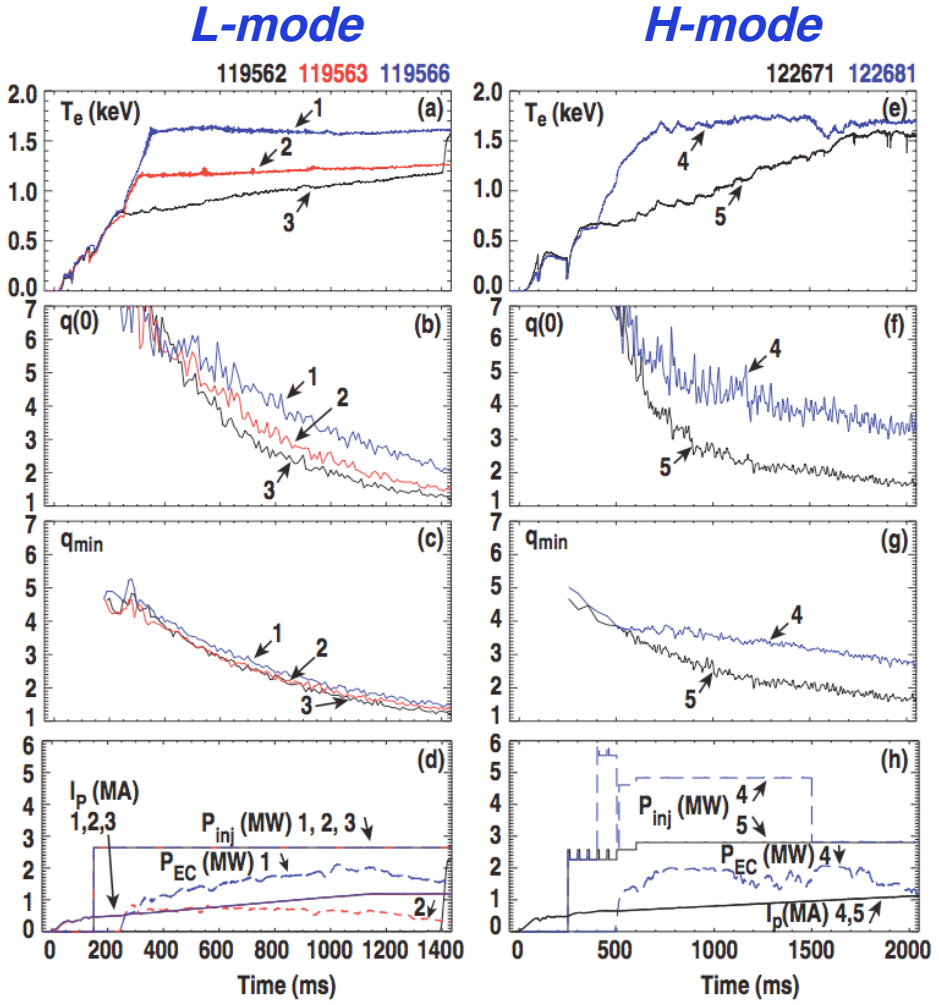


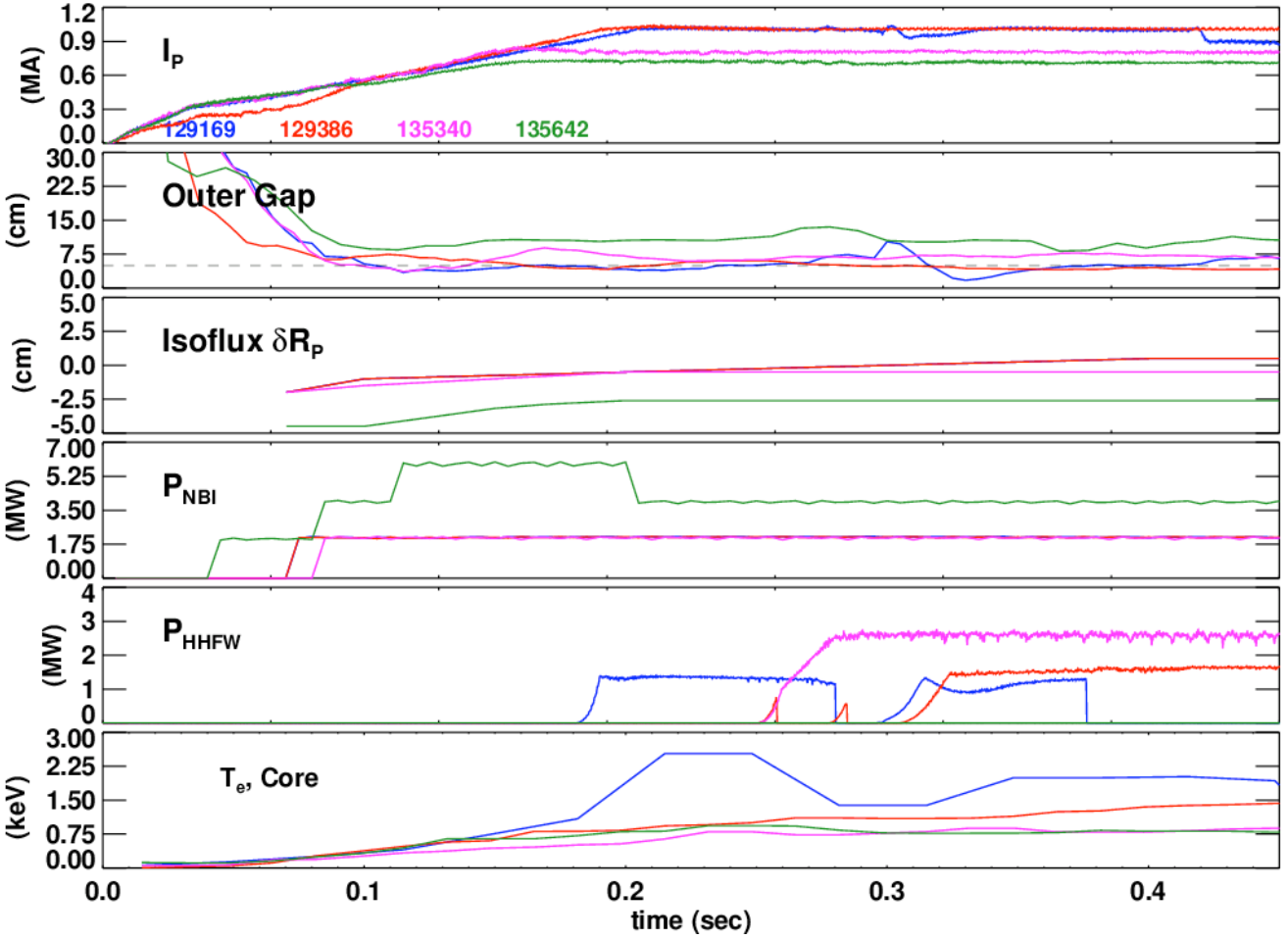
Figure 2. Time evolution of (*a*), (*e*) electron temperature at $\rho \approx 0.4$, (*b*), (*f*) on-axis q, (*c*), (*g*) minimum value of q and (*d*), (*h*) smoothed neutral beam power P_{inj}, smoothed gyrotron power P_{EC} and total plasma current I_p in discharges with various values of T_e. The discharges in (*a*)–(*d*) are L-mode and the discharges in (*e*)–(*h*) are H-mode. In Cases 1, 2 and 4, T_e is feedback controlled using ECH at $\rho \approx 0.4$ while Cases 3 and 5 have no ECH.

Ferron et al, Nuclear Fusion (2006)

Key for Scenario: Small Outer Gap Early in the Discharge

- Need to achieve ~5-8 cm gap as early as possible.
- Looks possible to do this by ~300 kA with some work.
  - Slow I_P ramp?
- Slowly switch from gap-control to isoflux between 0.07 and 0.1.
- Outer gap request in the gap-control phase is not archived in the tree.
  - Irritating!

129169: He shot with early reversed shear.
129386: D_2 shot with good H-mode heating.
135340: Why did I include this?
135642: Fiducial-Like.



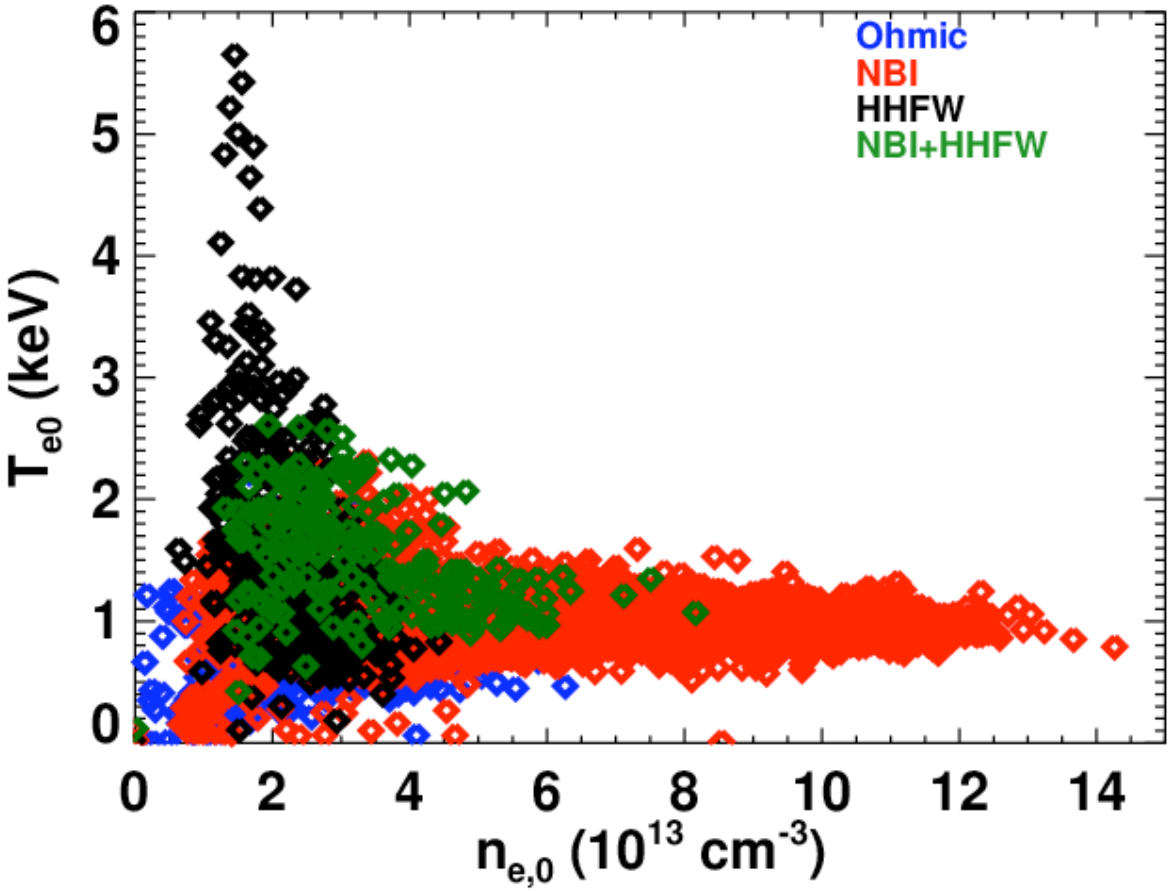
Shot Plan

- Reference shot: high elongation and triangularity D_2, using Src. A.
  - I_P~800 kA and B_T~0.5 T.
  - Or low duty cycle modulation to get MSE every 50 msec?
- Go to smaller outer gap earlier in the discharge.
  - Prefer to have 5cm gap at time of 200-400 kA.
  - Ride plasma on RF limiter with no beam? Less attractive.
- Apply -14 + -18 m^{-1} HHFW at low level (300-500kW)
  - Optimize coupling.
  - Increase power in ~300-500 kW steps.
  - Observe changes in flux-consumption and kinetic and PA profiles.
- Repeat that step with -8 m^{-1} phasing.
- Repeat one scenario with reduced NB heating
  - Isolate role of NB heating and momentum input.
- Repeat one scenario with no HHFW to asses confinement differences.
  - Match β_N evolution with β_N control?

Backup

HHFW May Be Able to Increase the H-mode Core Temperature

$T_{e,0}$ vs $n_{e,0}$, at the time of maximum β_N.



Scan of NB Pre-Heating Showed an Effect on q_{min} & l_i Evolution