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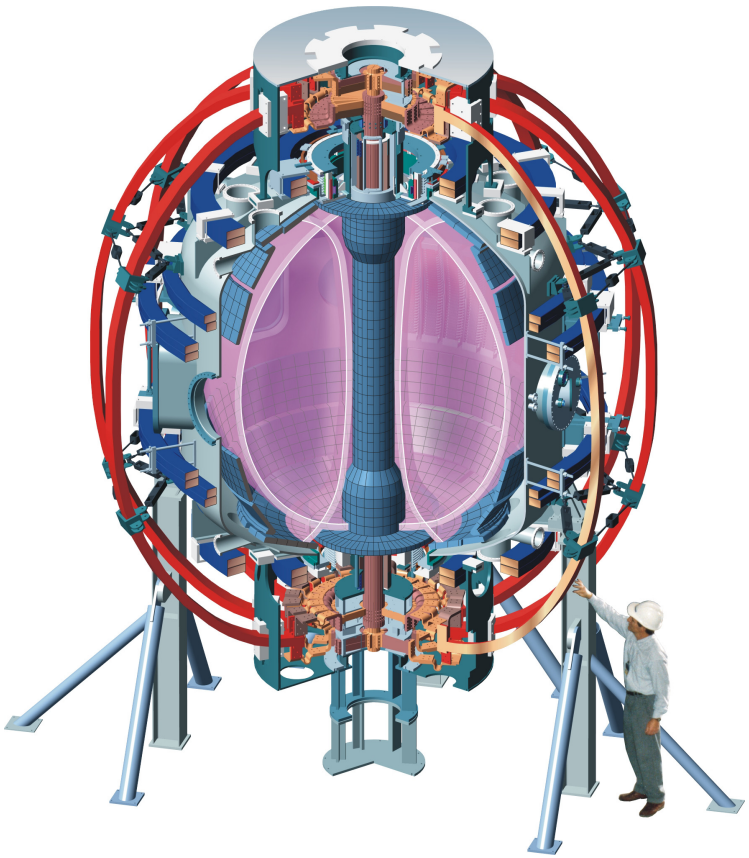
HHFW-assisted PF-only startup in NSTX



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NSTX Research Forum

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Princeton, NJ

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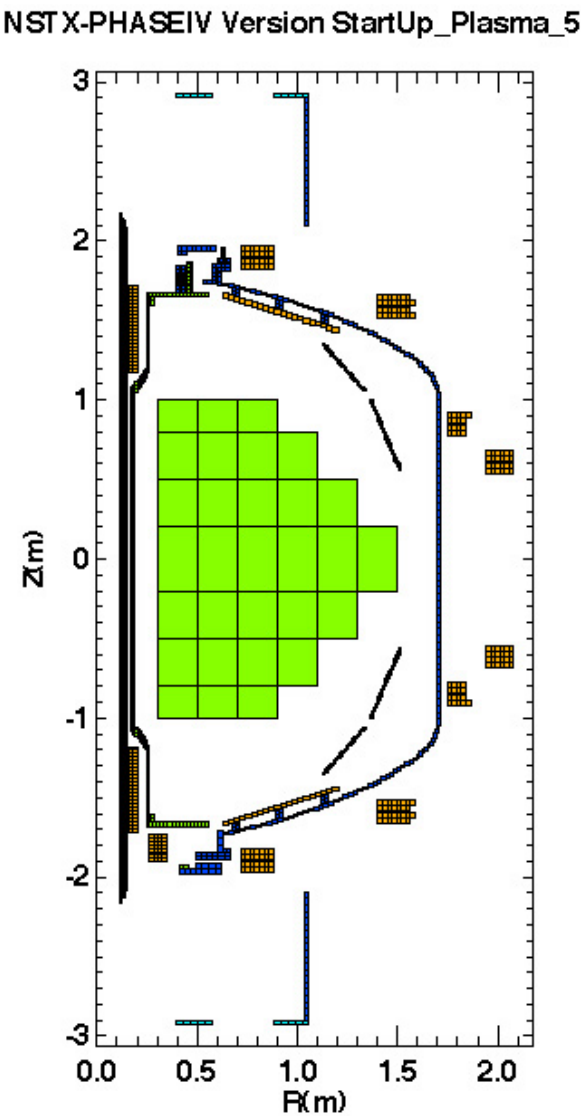
PF-only scenario development for NSTX

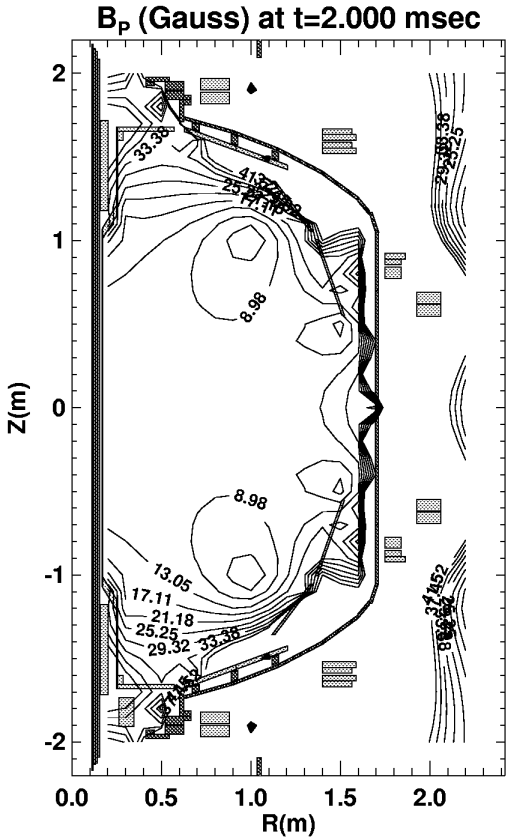
Analysis using LRDIAG

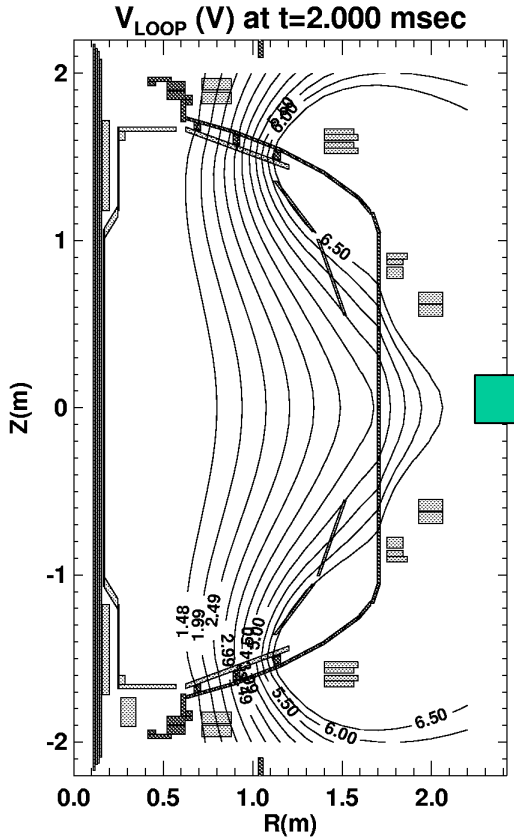
- Circuit equation solver
  - Coils and conducting structures
  - Eddy currents accounted
  - No plasma equilibrium
- Plasma modeled by passive coils
  - Distribution of “plasma” coils
  - Variable resistivity profile in space but constant in time
  - Model selected to reproduce 1MA NSTX plasma (~70eV equivalent Te)

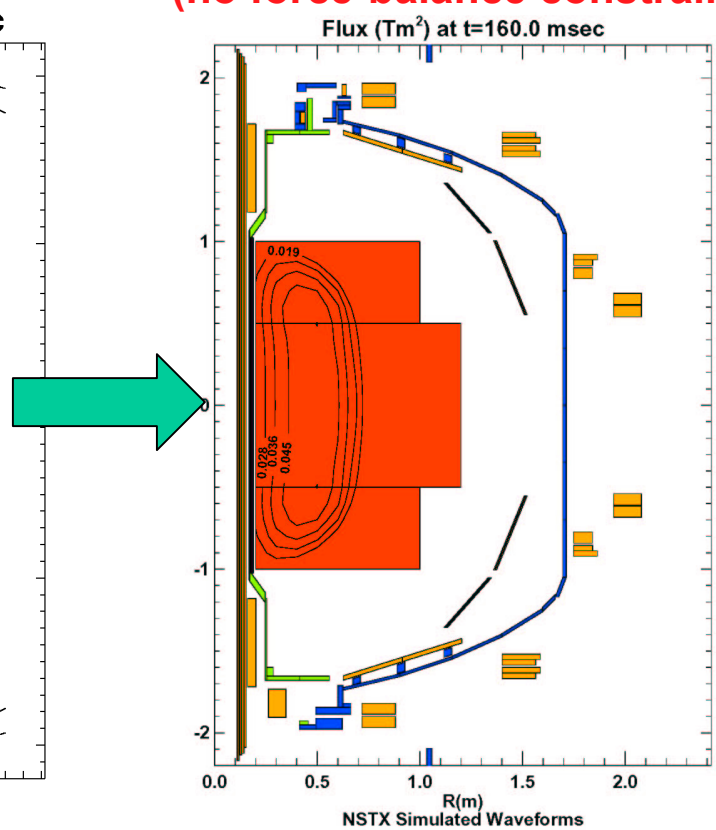


Outer-PF ramp from near zero current & flux

Good null + **Significant V_{LOOP}** → **Can form closed flux**
(no force-balance constraint)







1. Use HHFW to initiate high-n_e plasma breakdown at outboard side
2. Ramp PF coils to drive ≈ 50-100kA with some closed flux
3. Then, use HHFW to heat and drive BS and RF current
   - Current hole relaxation process could allow high I_P w/ small initial stored flux

Elements of experiment

1. Create plasma in front of HHFW antenna
   - Use ECH for pre-ionization
     - Adjust pre-fill to maximize density
   - Match to plasma loading at low P_{RF} (< 100kW) and short pulse-width
     - Once HHFW breakdown is achieved, increase gas puff pressure & width
     - Increase power (100-500kW) and pulse-width to increase density
     - Adjust RF match to increased density plasma
   - Previously successful on CDX-U with TF-only (100kW, $10^{12}cm^{-3}$)

2. Ramp outer PF coils
   - Use PF3/PF5 current ratio with marginally stable field index
   - Start with ramp-rate similar to that in OH discharges
   - Scan ramp-rate from 2-20MA/s to maximize driven current

3. Change from heating to co-CD phasing during ramp-up
   - Increase HHFW power to several MW and re-match in CD phasing
   - Modify PF ramp trajectory to maximize plasma I_P

The CDX-U HHFW pre-ionization experience

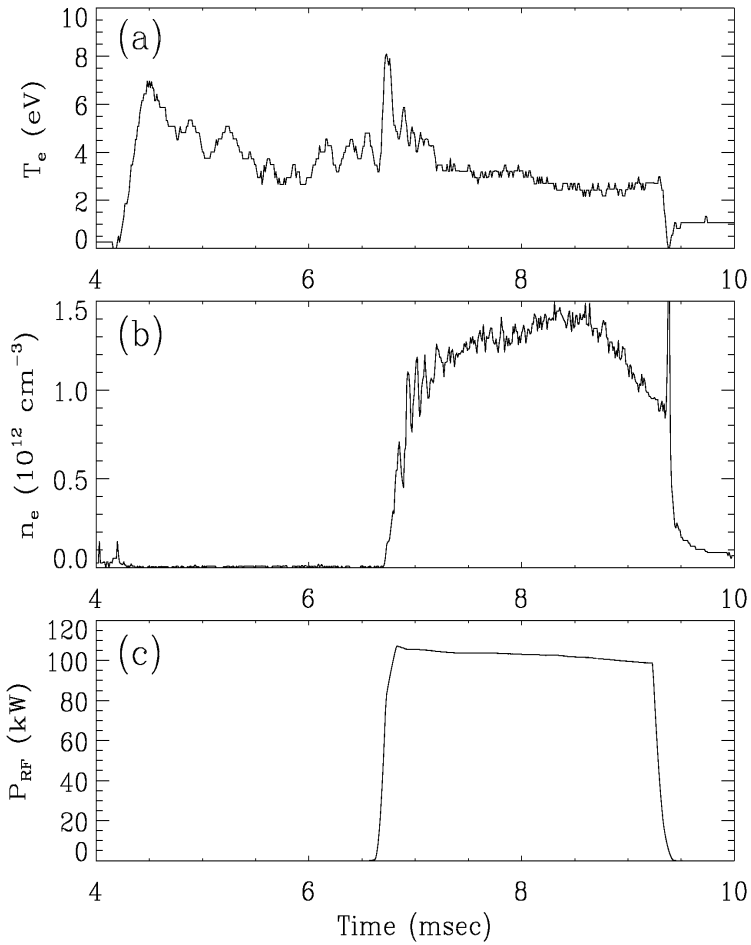


Figure 6.13: Plasma and antenna parameters during higher-density plasma formation experiments. (a) Electron temperature, (b) electron density, and (c) coupled RF power. Data taken 10/30/97 in deuterium with 0-π phasing and vertical straps.

- Line-avg. 10^{12}/cc with 100kW
- The recipe:
  - ECH for pre-ionization
    - 10x ohmic pre-fill
  - Loading similar to FW loading even with vertical straps
  - LH res. @ antenna was best
    - Higher TF lowered n_e to 3×10^{11}
- Implications for NSTX:
  - B_{T0}=1.2kG for $\omega=\omega_{LH}$(antenna)
  - Perform TF scan to scan HHFW density production
  - TF ramp during I_P ramp?
    - too slow to match LH resonance and have high TF for I_P ramp?