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Solenoid-free inductive startup with HHFW pre-ionization

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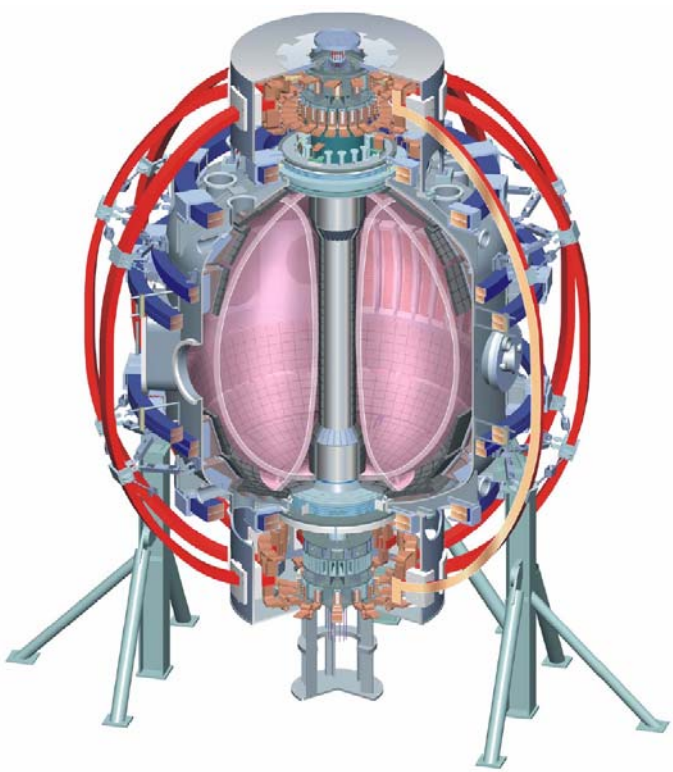

NSTX Research Forum
for FY2004 Run

Princeton Plasma Physics Laboratory
Princeton, NJ
September 22, 2004

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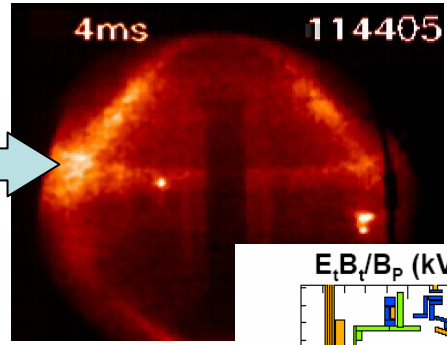
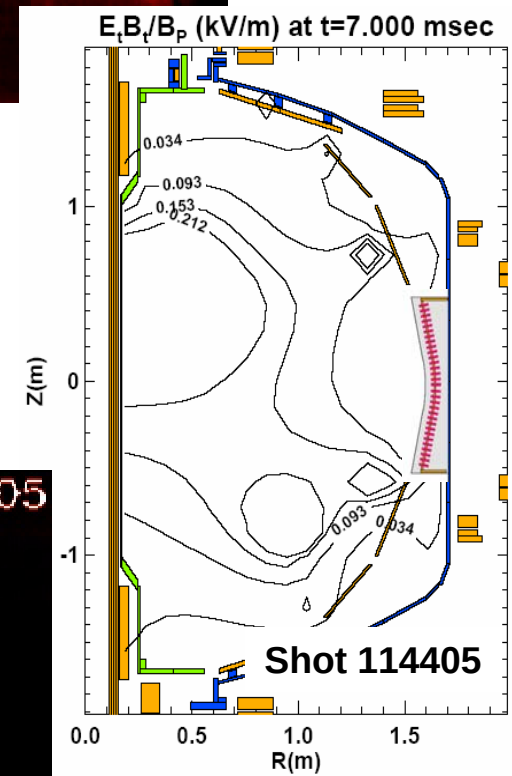
Solenoid-free tokamak formation in NSTX

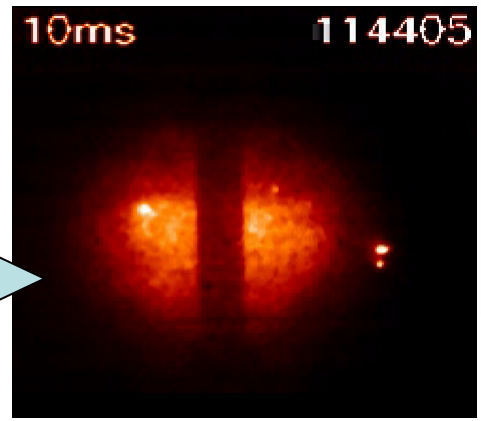
1. Pre-ionize plasma near RF antenna with ECH + 400kW HHFW, $n_{D_2} = 1\text{-}2\times10^{-5}$ Torr



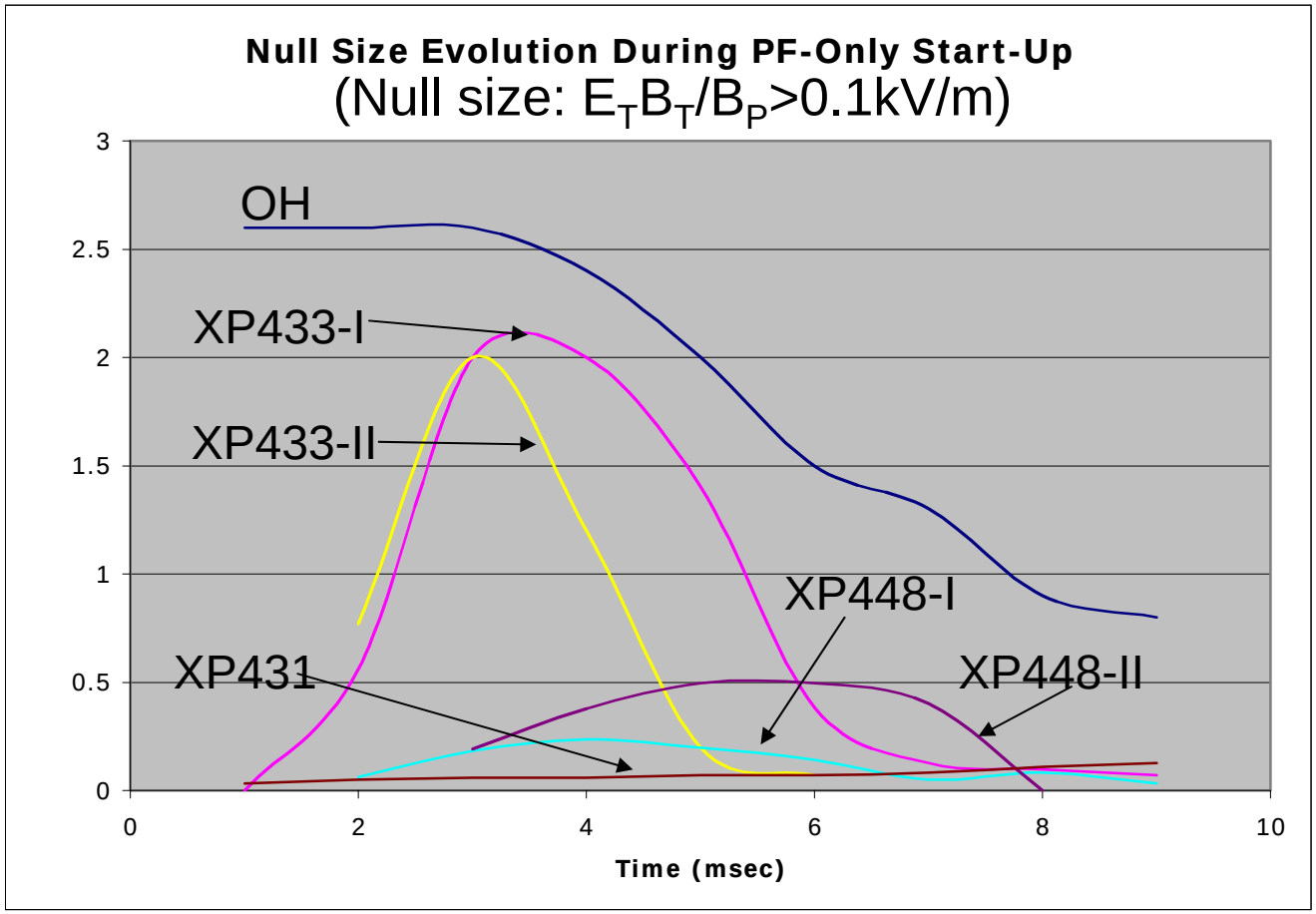
2. Create high-quality field-null with 5-15 loop-volts at antenna - So far, *require $E_\phi B_\phi/B_P$ > 0.1kV/m over substantial plasma volume*



3. Have created 20kA plasmas that terminate near center-stack



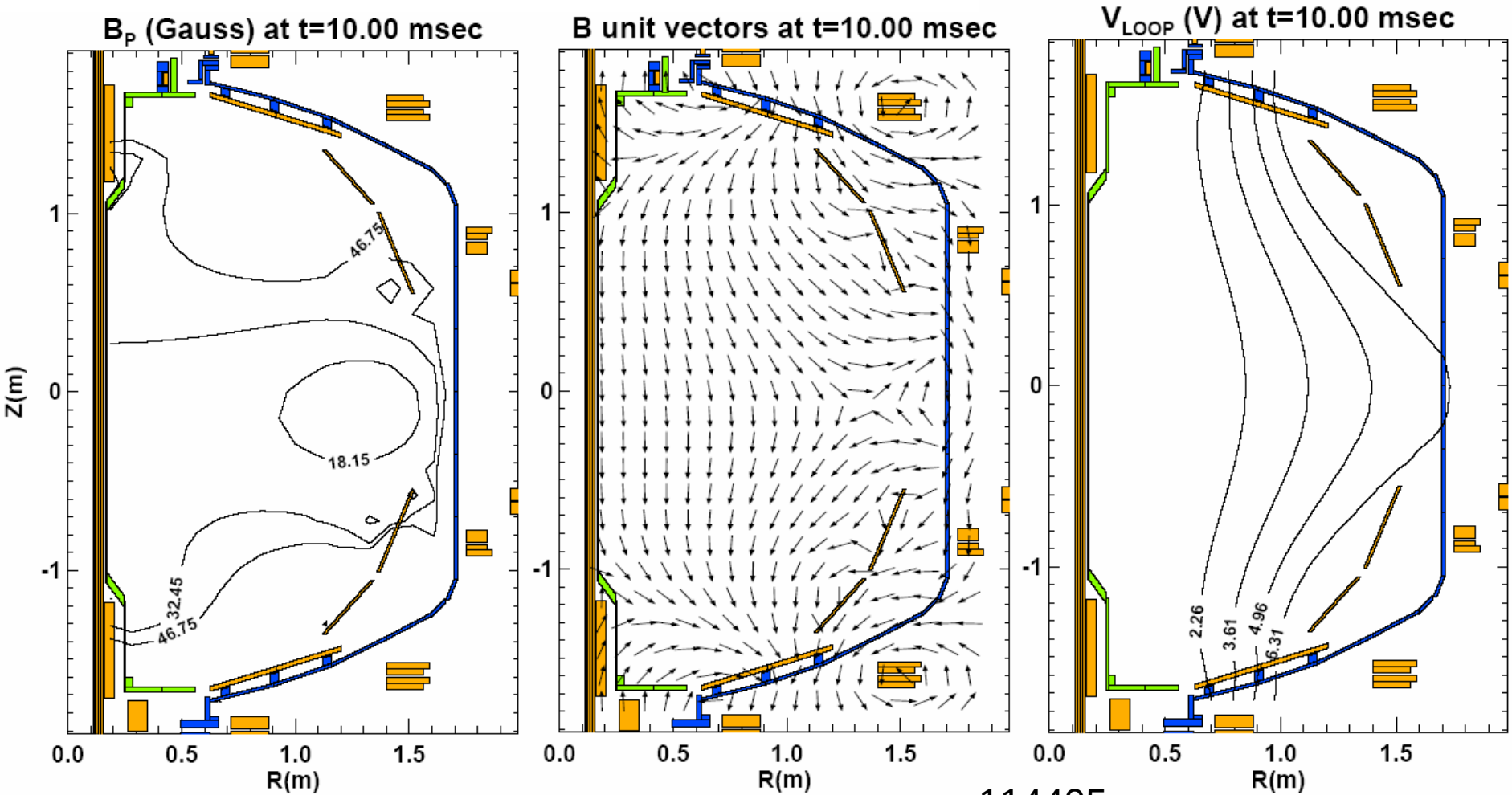
Successful initiation thus far requires a large null region



Successful initiation:
OH:112152, 4.5 kG
XP433-I: 113612, 3.5 kG
XP433-II:114405, 3 kG

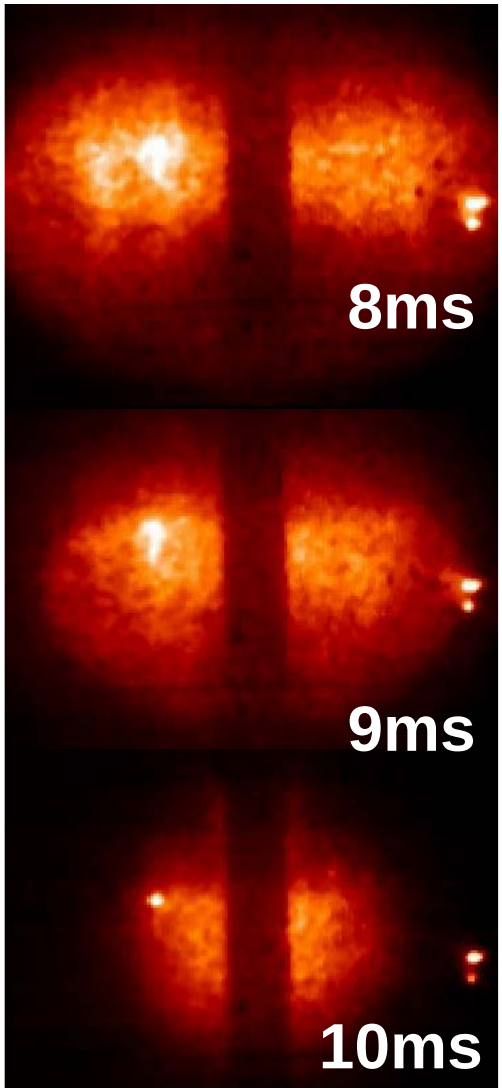
Unsuccessful initiation:
XP431: H:11293, 4.5 kG
XP448-I: 113609, 3.5 kG
XP448-II:114484, 3 kG

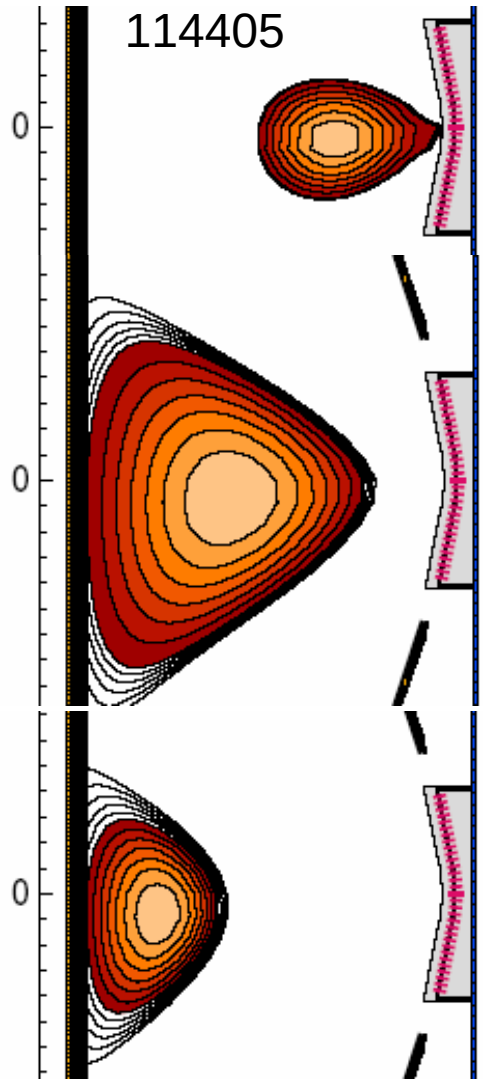
Field and voltage near max. plasma current



114405

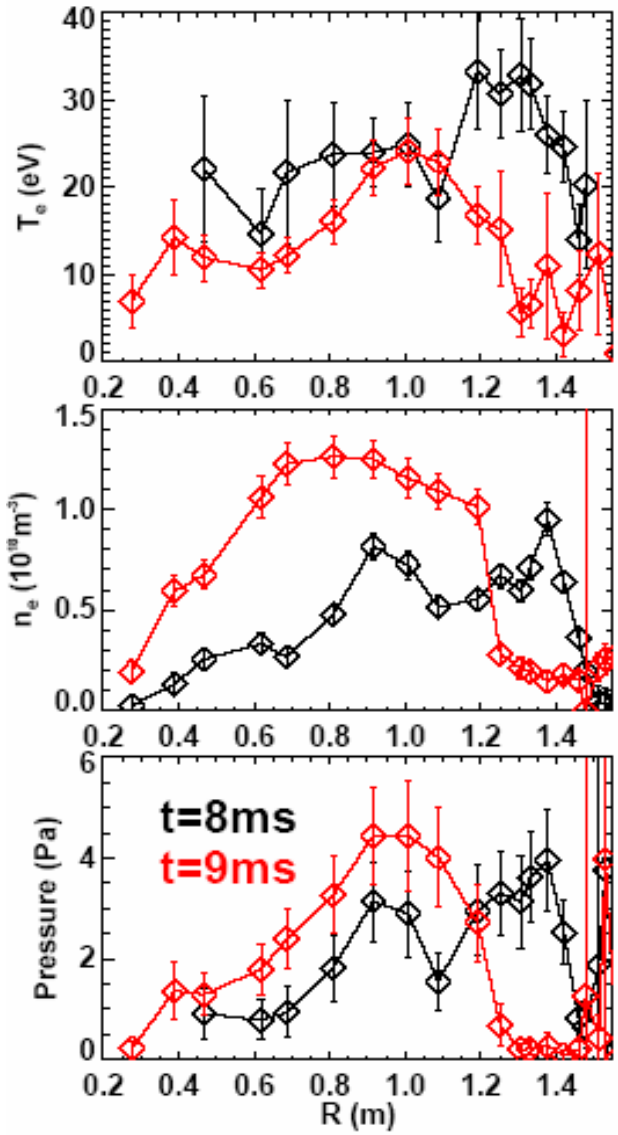
Camera images and reconstructions show plasmas are born on LFS and have an inward radial trajectory

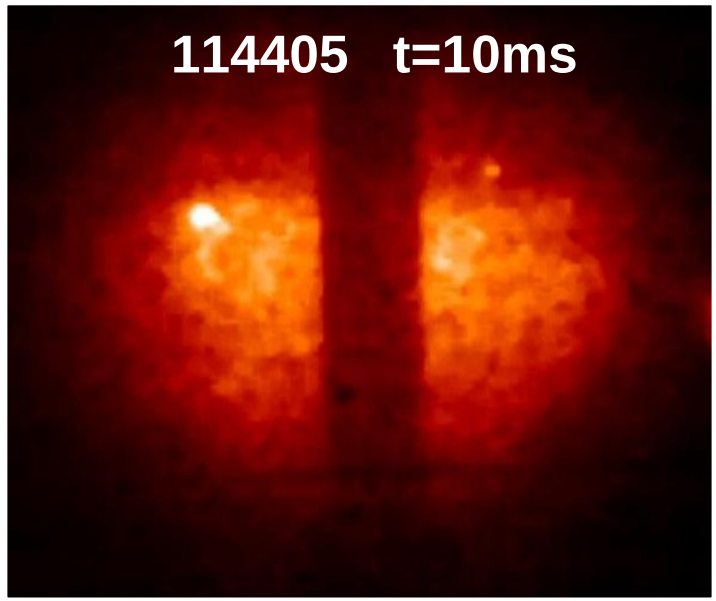




- LRDFIT code used for reconstructions
  - $I_{Vessel} \approx 10 \times I_P$
- Careful control of B_Z after breakdown helped raise I_P from 10kA to 20kA
- More B_Z evolution optimization possible

Thomson measurements consistent with plasma motion and peaked p_e profiles





Thomson T_e < 35eV and camera images consistent with lack of burn-through ➔

need more plasma heating power:

- More HHFW power during breakdown
- Higher V_{LOOP} – keep plasma outboard
- EBW power could be very helpful

Goals of Experiment (1-1.5 run days requested)

- Increase plasma current
  - Increase HHFW pre-ionization power
    - Highest I_P obtained with 500kW on thru breakdown
    - Use all straps, try to get to 1.5MW
  - Optimize vertical field profile, plasma shape
    - Keep plasma off CS longer
      - Change PF3 & 5 ratio and magnitude following breakdown
      - Incrementally add PF2 and PF1A field
    - Elongate plasma more following breakdown
  - Incorporate any help from DINA modeling
- Study null quality requirements for breakdown
  - Either drop TF, or add stray field to find threshold null area for successful breakdown