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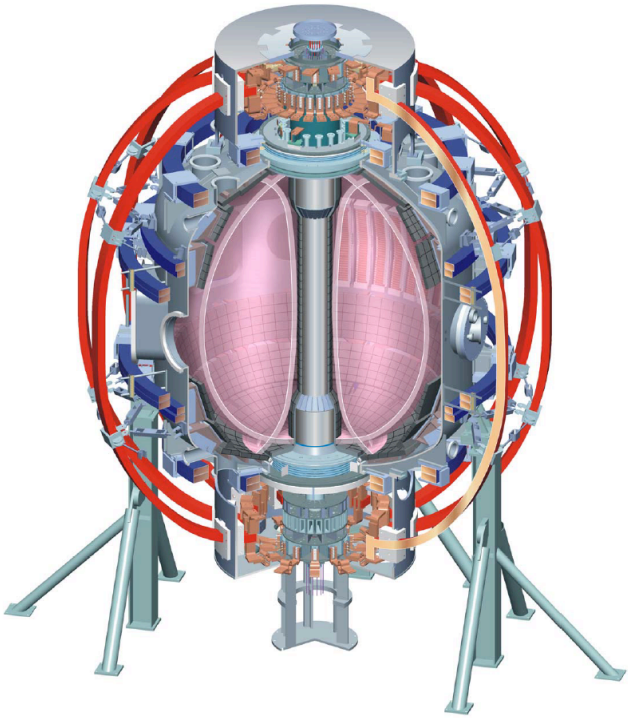
PF-Only Solenoid-Free Start-Up Research



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NSTX Research Forum

Solenoid-free Start-up Session
Sept. 22, 2004

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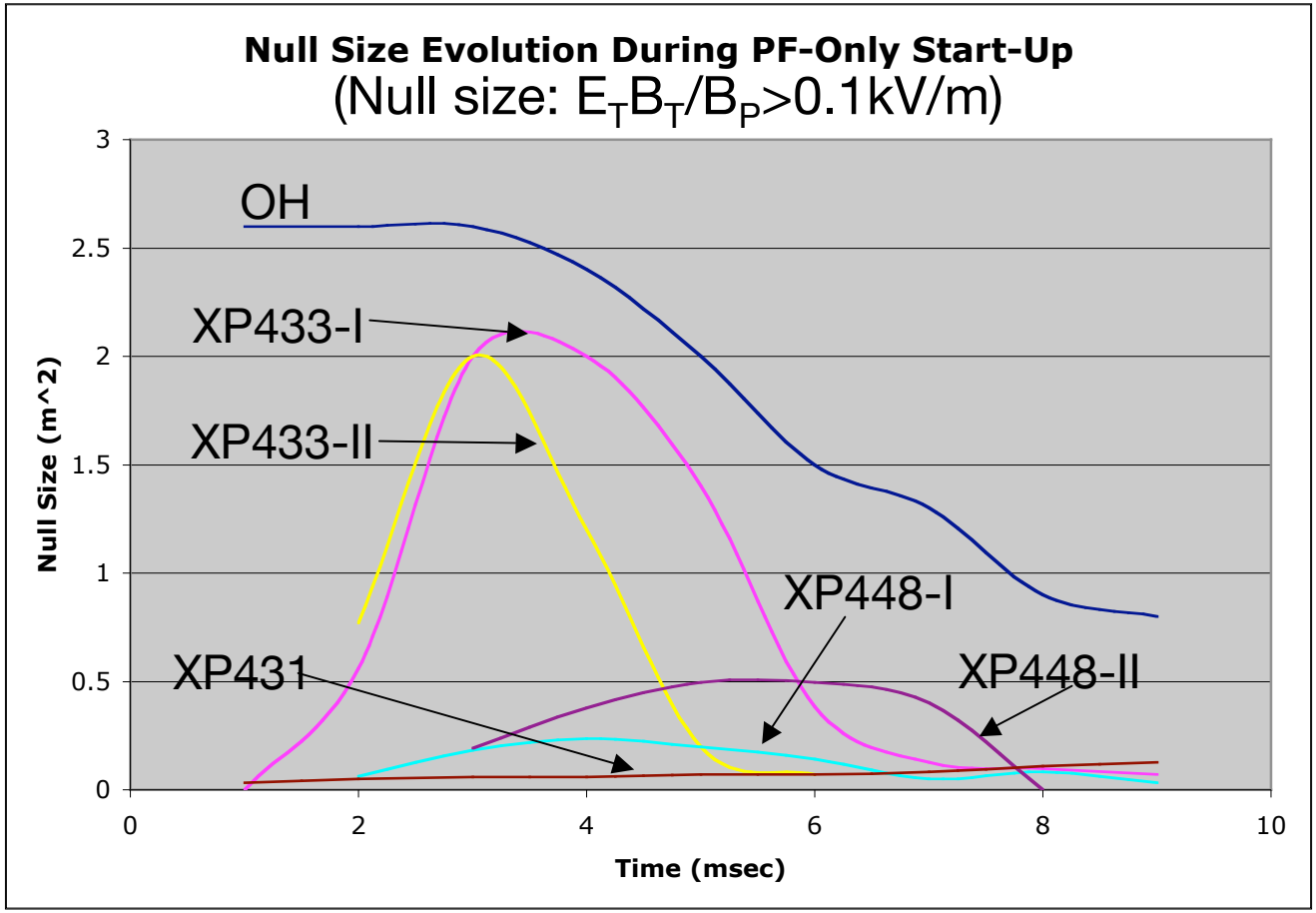
FY 04 Campaign showed that successful initiation thus far requires a large null region



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

Not successful initiations:
XP431: H:11293, 4.5 kG
XP448-I: 113609, 3.5 kG
XP448-II:114484, 3 kG

What is results telling us:

- XP 433 with help of HHFW pre-ionization achieved 20 kA of plasma current.

- Agreed with LRDIAG simulation. The DINA modeling was successfully utili zed to explain the results.

- The XP433 appears to have some dependence on the HHFW power level.
  - Required HHFW for initiation
  - Show improvement with higher HHFW power
  - Start-up is pretty robust!

- However, the field null requirement thus far appear to be quite large
  - XP 433 creates ~2 m^2 null region (nearly full cross section!)
  - XP 448 created a null region of up to ~ 0.5 m^2 but initiation was no quite successful
  - XP 448 attempt to test ~ 1m^2 was not successful because of the unintended power supply limitation of 1 kV on PF 4. The needed 2 kV capability should be available in FY 05

Possible improvements in FY 05:

Broadening initiation parameter space is a crucial near term issue:

- Smaller null tends to yield more flux opportunities
- Earlier initiation makes more flux available for current ramp up

• Work on improved plasma initiation:

Key words: high T_e, relatively low n_e, reduced fill pressure

- Driven current tends to go up with $T_e^{1.5}$ so T_e is a critical factor
- Electron heat loss goes up with T_e and n_e
- As Ip ramps up resistive heating will eventually take over but until then "pre-electron heater" is needed
- T_e tends to go up with $1/P_{fill}$ so reducing P_{fill} is crucial

• Possible approach to reduce P_{fill} :

- More HHFW power with more antennas?
- Mixed antenna phasing? Some in-phase for break down and some in 0-pi for heating?
- Use deuterized methane?
- 8 -10 GHZ source for direct ECH heating in the null region
- CT injection? (as longer term option)

FY 448 approach in FY 05:

- To test ~ 1 m^2 null region with correct PF 4 power supply voltage of 2 kV to explore the null size requirements between FY 04 XP 448 and XP 433 parameters.

- Test original Choe / Kim scenario:
  - It maintains the null for ~ 10 msec. Test null duration requirements
  - Was not tried in FY 04 because of the engineering requirement of same polarity of PF 4 and 5. This requirement should be removable by engineering analysis and some support refurbishment (e.g., high strength bolts.)

- Improve scenarios further to improve available flux per given null size.

- Hopefully higher B_T of 4. 5 kG will be available in FY 05.