Plasma current start-up by the vertical field, and ramp-up by the heating power and the vertical field in NSTX

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1. Why this experiment ?

@ The plasma current ramp-up has been one of the major problems in a low aspect ratio ST.

@ To overcome this problem, the operation scenario has been proposed for ST current ramp-up using the large flux available from the outer vertical field coils in combination with the heating power.

@ If this operation scenario is established, the large plasma current ramp-up would be possible in a ST reactor.

(O. Mitarai and Y. Takase, January issue in Fusion Science and Technology, 2003.)

2. Empirical justification: JT-60U results

Vertical field coils can breakdown, start-up, and ramp-up the plasma current up to 600 kA with ECRH, LHCD, and NBI.

(Y. Takase et al., Journal of Plasma and Fusion Research, Vol.78.No.9 (2002)

3. Expected results in NSTX

3.1. First experimental plan

Plasma current is ramped up by the vertical field with the heating power during the OH coil current free phase in NSTX.

Initial plasma current: I_p =700kA_γ_{HH}=1.0 (IPB(y2) scaling)
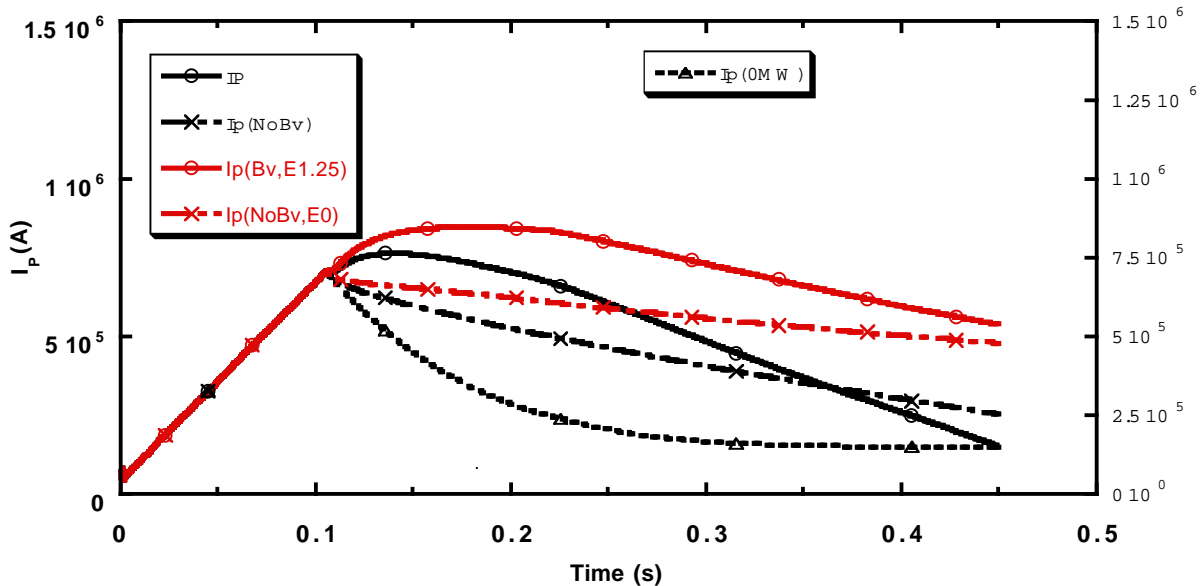

Fig. 1. The temporal evolution of the plasma current during the OH current free-phase and NBI injection of 4.5 MW in NSTX.

3.2. Second experimental plan

(1) To break down the plasma and start-up the plasma current, PF3 and PF5 coils are used to induce the loop voltage combined with ECRH. (See below.)

(2) The OH coil is not activated in this breakdown phase, but subsequently activated to maintain and ramp up the plasma current after the breakdown phase. (HHFW will replace this in future.)

(3) NBI is further injected to ramp up the plasma current while the OH coil current is maintained at the constant.

Breakdown phase by PF3 and PF5 in NSTX:

If the plasma current starts at B_v=-100 Gauss, the best parameters may be I_{PF3}= - 1.5 kA to +1 kA, I_{PF5}=0 kA to +0.5 kA

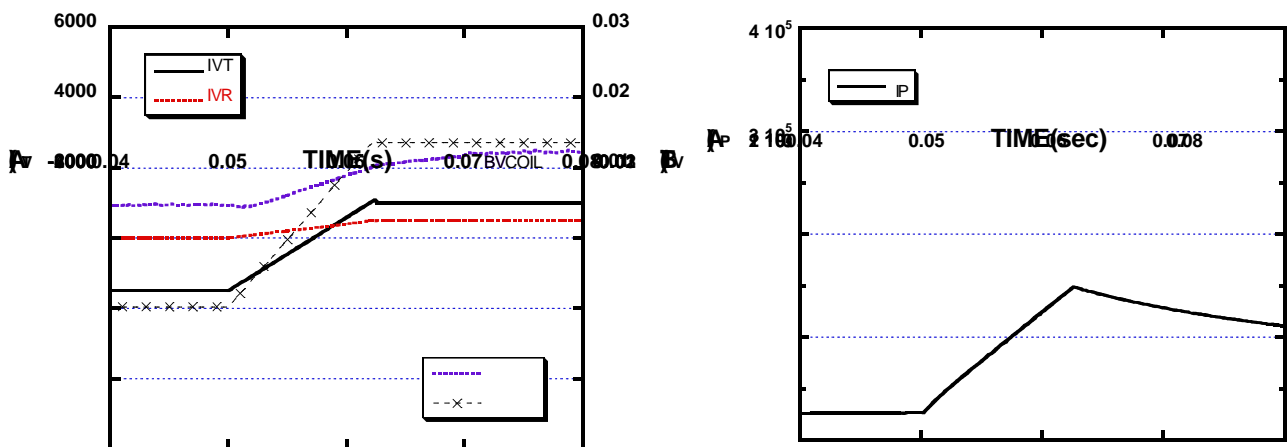$\overline{L_p}$_0.38 μH, Φ_0.056 Vs --> I_p_150 kA

Fig. 2. The PF coil current waveforms and expected plasma current start-up