§52. Development of a New NBI System by Washer Gun-type Ion Beam Source

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The Low-voltage and high-current neutral beam injector (NBI) has been developed using a washer gun for sustainment of ultra-high beta ST experiment [1,2]. The idea of this low-cost and maintenance-free NBI system was obtained by combining the washer-gun plasma source techniques with the electrode design technique. In the fiscal year 2011, we extended the NBI duration time from 0.1ms to 1ms using oscillating discharge of washer gun current. Figure 1(a) shows the experimental setup of three NBIs installed on the TS-4 device. The maximum NBI power ~ 0.6MW (40A, 15kV) is significantly higher than our initial design value 0.3MW[1] but its power was reduced to 0.4MW in the 1msec operation mode. In the present power supply, the duration time of 1msec is determined by decay time of LC oscillation of the gun current. The maximum beam power is determined by plasma mass balance inside the plasma source. Figure 1(b) shows time evolutions of the radial profile of electron density of spherical tokamak (ST) plasma with and without the NBI. A new finding is that this NBI maintained the plasma density of ST for 50μsec, even if the NB power is maintained for 1msec[1]. As shown in Fig. 2, just the Co-NBI maintained the magnetic energy of ST unlike the Counter NBI and no NBI cases. The beam current maintained by the NBI stabilized the whole ST during the NBI duration time. The next issues are to increase the duration times of washer gun current further to 10msec depending on amount of the new capacitor and gas injection by upgrading the present hand–made washer gun power supply and the gas injector.

1) T. Ii, Y. Ono et al., "Merging Start-up and Neutral Beam Injection in the University of Tokyo Spherical Tokamak Experiments", Rev. Sci. Instrum in press.
2) Y. Ono, H. Tanabe, et al. "Ion and Electron Heating Characteristics of Magnetic Reconnection in a Two Flux Loop Merging Experiment", Phys. Rev. Lett. 107, (2011), 185001.

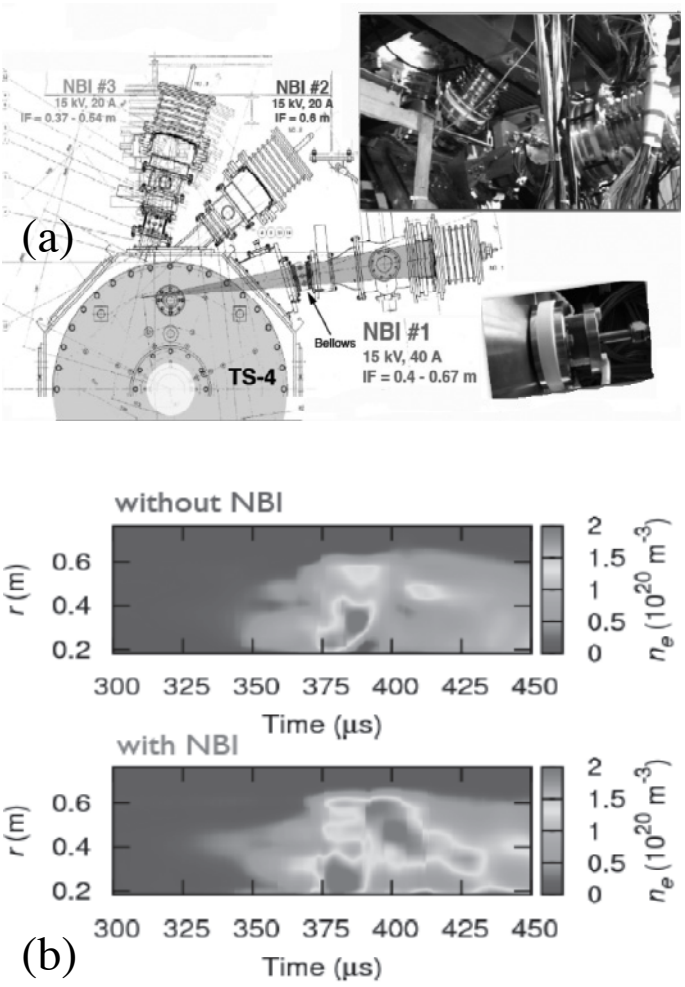

Figure 1(a): Setup of three new NBI systems for TS-4 CT/ST merging device, (b): Time evolution of radial electron density profile of spherical tokamak (ST) with and without NBI.

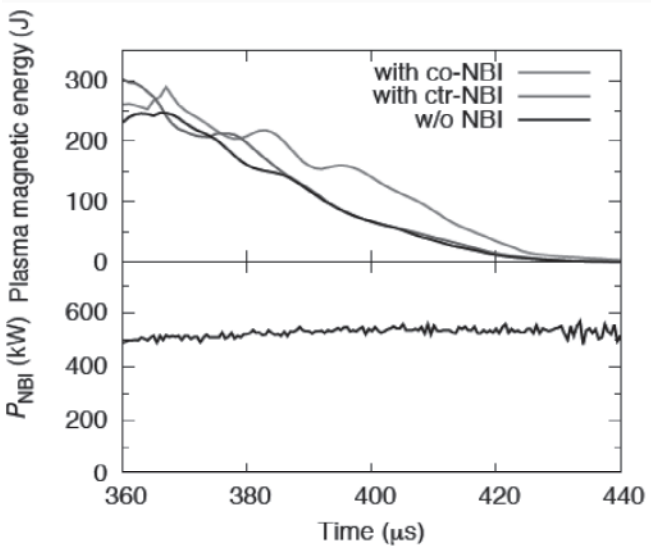

Figure 2: Time evolutions of plasma magnetic energies under co and counter helicity NBI and without NBI and another evolution of the NBI power.