§5. Operation Summary of Neutral Beam Injection System in the 17th Campaign

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The neutral beam injection (NBI) system is a main heating system in the LHD, which has greatly extended the LHD plasma parameter regime until now. The NBI system consists of three negative-ion-based NB injectors (BL1, BL2 and BL3) and two positive-ion-based NB injectors (BL4 and BL5). The total injection power achieved is 27MW. With the high-power NBI heating, the ion temperature was successfully raised to 8.1keV in the 17th campaign.

In the negative-NBIs, high-energy hydrogen beams with the nominal injection energy of 180keV are tangentially injected, and the total injection power with three injectors is summarized in Fig. 1. Almost all LHD plasmas were produced and heated by the negative-NBIs, and the injection power larger than 14MW was constantly available during the campaign. The maximum injection power was 15MW, which corresponded to the nominal value.

Figure 2 shows the shot evolutions of the injection power for individual negative-NB injectors of BL1, BL2 and BL3. In BL1, 5 to 6MW of the neutral beams were reliably injected for 2sec throughout the campaign, with the injection energy of around 190keV. In BL2, reliable operation was carried out during the campaign, with the injection power of 4.5 to 5MW. In BL3, the injection power was gradually increased, and achieved to 5MW in the second half of the campaign. The gas supply system into the arc chamber of the negative ion source was broken at around middle of the campaign. But, it was quickly repaired, and no influence on the operation was made in the rest of the campaign.

The shot evolutions of the injection power for the positive-NBIs of BL4 and BL5 are shown in Figs. 3 and 4, respectively. The positive-NBIs are perpendicular injectors with low-energy beams of 40keV-6MW, which mainly contribute to the ion heating experiments in LHD. BL4 is also utilized for the T_i-profile measurement with the CXS. Thus, in many experiments pulse-modulated injection was performed with a suppressed injection power due to a high-frequency beam modulation. BL5 constantly injected around 40keV-6MW of beams throughout the campaign, and contributed to many LHD plasma experiments in addition to the high-T_i experiments.

In the particle balance study of steady-state hydrogen plasmas in LHD, BL4 was utilized for long-pulse central beam fueling. Four ion sources are sequentially operated every 40s. The port-through power is 0.4MW with the energy of 25keV, and the injected beam is modulated to control the beam fueling rate. The longest total injection duration was 340s.

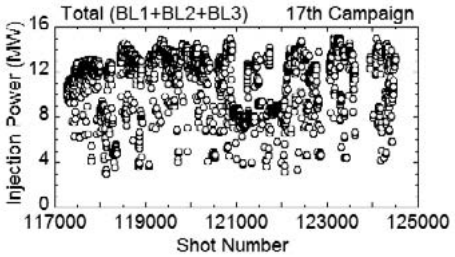

Fig. 1. Shot evolutions of the total injection power for the negative-NB injectors.

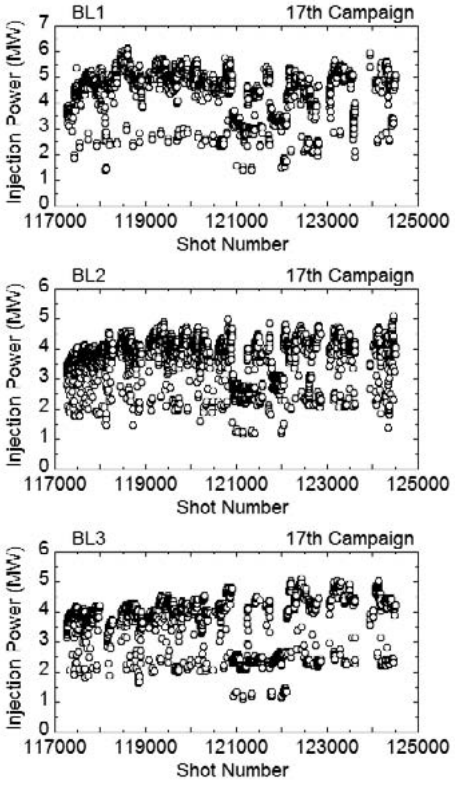

Fig. 2. Shot evolutions of the injection power for BL1, BL2, and BL3.

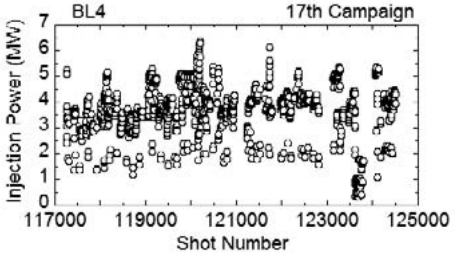

Fig. 3. Shot evolution of the injection power for BL4.

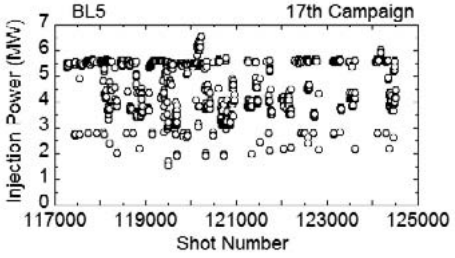

Fig. 4. Shot evolution of the injection power for BL5.