§8. Operation Summary of Neutral Beam Injection System in the 14th Campaign

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The neutral beam injection (NBI) system is a main heating system in the LHD. In the 14th campaign, a positive-ion-based NB injector started its operation as the 5th injector (BL5), in addition to both working three negative-ion-based NB injectors (BL1, BL2 and BL3) and one positive-ion-based NB injector (BL4).

Although BL5 is designed so as to make it possible to inject 80keV-9MW of deuterium beams by future upgrade, it was presently optimized to inject 6MW of hydrogen beams. BL5 is a perpendicular injector, and the injection history of BL5 is shown in Fig. 1. The injection power is quickly increased and reaches 5.5MW within one month from the start of operation. Then, reliable and stable injection above 5.5MW is maintained to the end of the campaign. The maximum injection power was 5.8MW with the energy of 45keV. The successful BL5 operation led to enhancement of the ion heating power in the LHD plasmas, and 6.5keV of the ion temperature was achieved.

An existing positive-NBI of BL4, in which low-energy beams are perpendicularly injected at 40keV, was stably operated without any troubles. The shot evolution of the injection power for BL4 is shown in Fig. 2, and it is found that the injection power is as high as 6MW throughout the campaign. In addition to the contribution to the ion heating experiments, pulse-modulated injection was frequently utilized for the T_i-profile measurement with the CXS.

High-energy hydrogen beams are tangentially injected at 180keV with the negative-NB injectors of BL1, BL2 and BL3. The total injection power with three injectors is summarized in Fig. 3. The designed injection power of 15MW was available during the campaign, and the maximum injection power was 15.7MW.

The shot evolutions of the injection power for individual negative-NB injectors are shown in Fig. 4. In BL1, a water leak occurred at the water manifold in the vacuum chamber just before the start of the campaign, due to water freeze caused by an accidental power cut. As a result, it took a little longer time to achieve 6MW of the injection power than usual. After that, more than 6MW is stably injected to the end of the campaign.

In BL2 and BL3, a shape of the filament holder was modified to avoid the local abnormal arcing, which led to the damages of the arc chambers in the previous campaign. As a result, stable and reliable operation was maintained throughout the campaign. While the injection power is no more than 4.5MW in BL2, the highest injection power of 5.4MW was achieved in BL3 due to successful optimization of the operation.

The total injection power with the negative- and the positive-NBIs are achieved to 27MW, which greatly contributes to the LHD experiments.

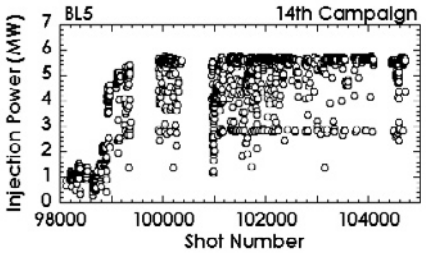

Fig. 1. Shot evolution of the injection power for BL5.

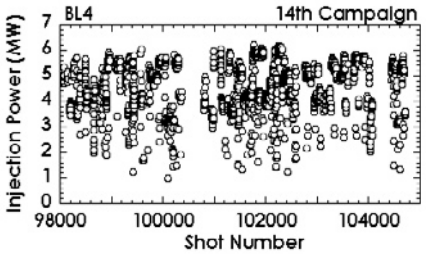

Fig. 2. Shot evolution of the injection power for BL4.

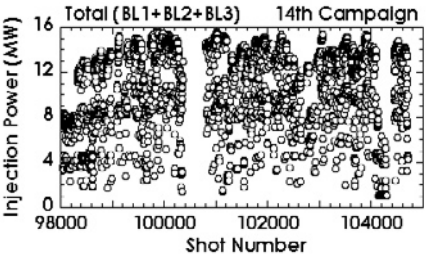

Fig. 3. Shot evolutions of the total injection power for the negative-NB injectors.

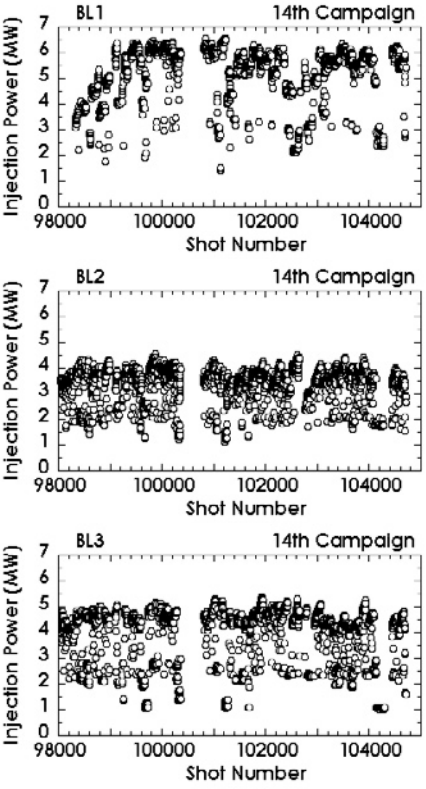

Fig. 4. Shot evolutions of the injection power for BL1, BL2, and BL3.