

### §3. Operation Summary of Neutral Beam Injection System in the 16th Campaign

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The neutral beam injection (NBI) system is a main heating system in the LHD, which 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. Until now the high-power NBI heating has greatly extended the LHD plasma parameter regime, and in the 16th campaign the ion temperature was successfully raised to 7.3keV by the NBI heating.

In the negative-NBIs, the total injection power with three injectors is summarized in Fig. 1. High-energy hydrogen beams with the nominal injection energy of 180keV are tangentially injected. Almost all LHD plasmas were produced and heated by the negative-NBIs, and 14MW of the injection power was available during the campaign. The maximum injection power was 14.3MW, which was below the nominal value of 15MW, partially because the largest power was not required in most of LHD plasma experiments in this campaign.

The shot evolutions of the injection power for individual negative-NB injectors of BL1, BL2 and BL3 are shown in Fig. 2. In BL1, 5 to 6MW of the neutral beams were reliably injected for 2sec throughout the campaign, with the injection energy of up to 192keV. In BL2, the injection power was less than 4.3MW. The extraction gap of the accelerator was shortened to increase the extracted negative ion current, together with modification of the cusp magnetic field configuration of the arc chamber for improvement of the plasma production efficiency. However, since the perveance matching condition for the extraction and acceleration of the negative ion beams was not optimized, the injection power did not exceed that achieved in the last campaign. In BL3, the injection power was maintained at around 4.5MW. Small air leak occurred in the arc chamber of the negative ion source at around the first third of the campaign, and, then, temporary repairs were made. That restricted the higher injection powers in the rest of the campaign.

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

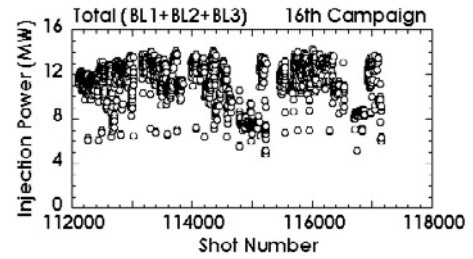


Fig. 1. Shot evolutions of the total injection power for the negative-NB injectors.

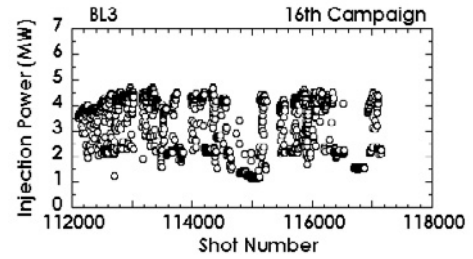
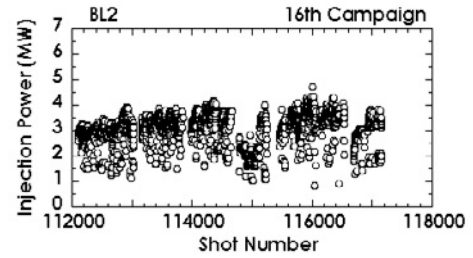
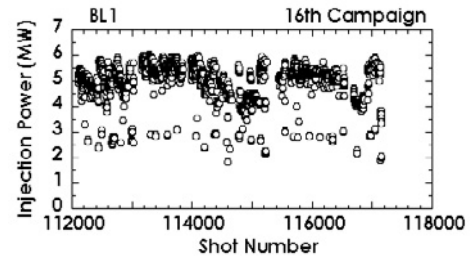


Fig. 2. Shot evolutions of the injection power for BL1, BL2, and BL3.

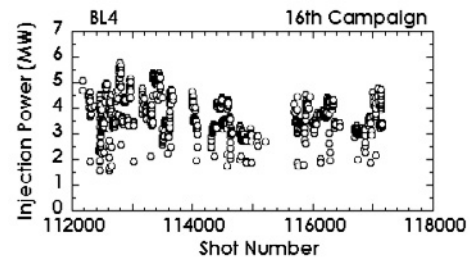


Fig. 3. Shot evolution of the injection power for BL4.

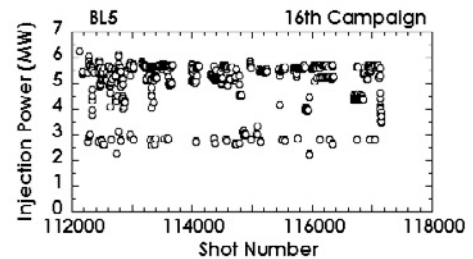


Fig. 4. Shot evolution of the injection power for BL5.