Characterization of beam ion loss in high poloidal beta regime on EAST

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One critical issue in achieving integrated operation of steady-state long-pulse high-confinement (H-mode) plasma on EAST is to improve beam ion population confinement during neutral beam injections (NBIs). To study the characterization of beam ion loss and improve beam ion confinement, the steady-state long pulse scenario discharges were conducted on EAST ($\beta_p \geq 2.0$, $\beta_N \geq 1.7$, $q_{95} \geq 6.7$ and $H_{98y2} \geq 1.1$) with NBI heating. Based on the neutron yield, beam voltage and line-averaged electron density were adjusted from 50kV to 60kV and $4.4 \times 10^{19} m^{-3}$ to $5.0 \times 10^{19} m^{-3}$, respectively. The result shows that dominant mechanisms of beam ion loss are shine-through loss, prompt loss, and stochastic ripple loss. The shine-through loss fraction is determined by initial velocity, flight time and entire beam path. The change of prompt loss fraction is caused by the change in the deposition of beam ions. The change of stochastic ripple loss fraction is caused by the change in the initial fraction of trapped-confined ions. Detailed physics shows that the prompt loss fraction during counter-Ip injections (~45%) is far larger than in co-Ip injections (~5%) due to finite orbit width. The lost ions are mainly deposited on the lower divertor or below the midplane since the direction of magnetic drift is vertical down. The orbit types of prompt loss during counter-Ip injections are mainly trapped-lost and ctr-passing lost. To minimize the prompt loss fraction during

counter-Ip injections, a reversed Ip configuration (rev-Ip) discharge #94758 was conducted. The result suggests that the beam ion wall load fraction during counter-Ip tangential injection (~3%) is far lower than that in normal Ip configuration (nor-Ip) discharge #94820. It is also found that the confinement of beam ion population in the counter-Ip injection #94758 was greatly improved when compared to #94820. This study can provide useful information to the improvement of beam ion population confinement and performance evaluation of NBI system on EAST and future tokamaks.

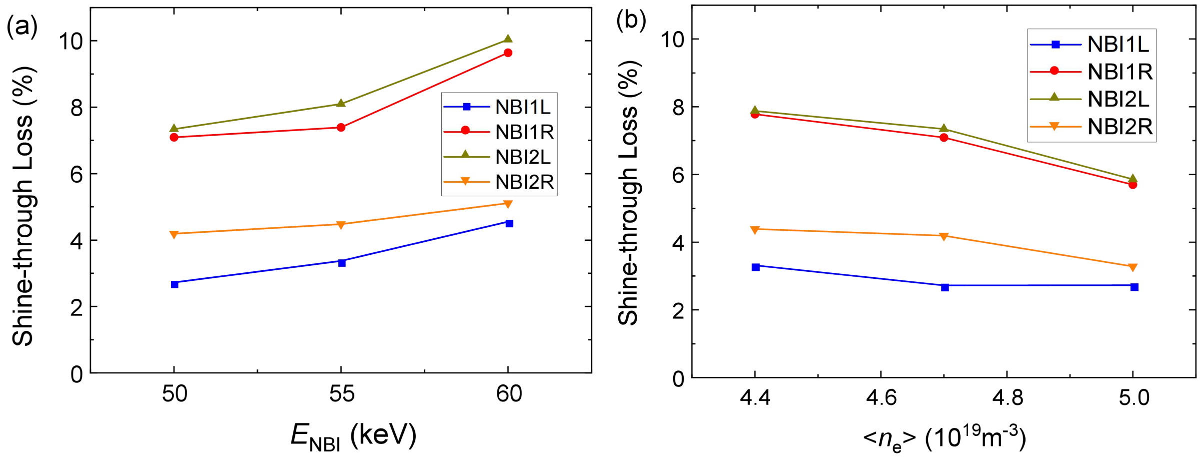

Figure 4. The responses of beam ion shine-through loss fractions under different beam voltages (a) and electron densities (b) for four beam lines, given by NUBEAM/TRANSP.

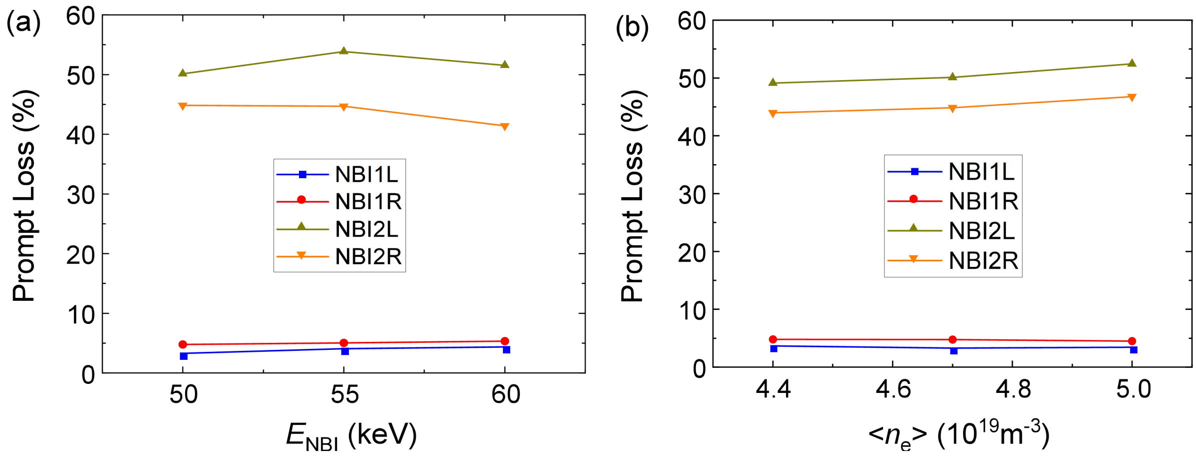

Figure 8. The responses of prompt loss fractions under the different beam voltages (a) and electron densities (b).

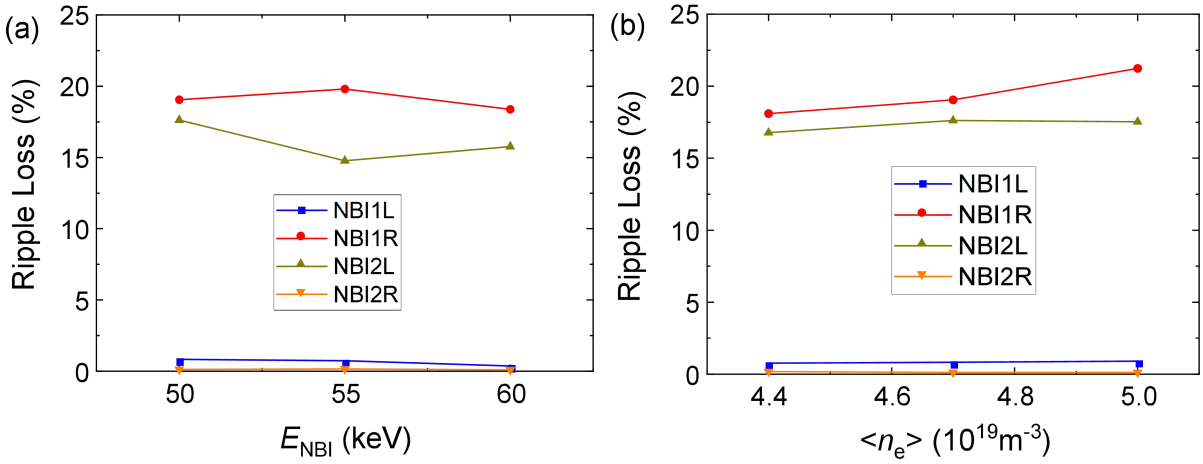

Figure 9. The responses of ripple loss fractions under the different beam voltages (a) and electron densities (b).