## §2. Characteristics of Divertor Pumping in the Closed Helical Divertor in LHD

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In LHD, the closed helical divertor components with the in-vessel cryo-pump are installed in the inboard side of the torus in six toroidal sections, and in one of the toroidal sections, the cyro-pump was activated as a trial. In this study, the divertor pumping characteristics were investigated during the ECH discharges with low electron densities.

The neutral pressure in the divertor in which the cyro-pump was activated was compared with that in the divertor in which the cyro-pump is not installed. Hydrogen gas was puffed for 700 ms during ECH discharges of 2 s. Figure 1 shows the waveforms of the discharges with and without active divertor pumping. The stored energy and line averaged electron density are almost same in both cases. The neutral pressure in the divertor without the in-vessel pump ($P_{9\mathrm{I}}$) is higher in the discharge with divertor pumping. On the other hand, the neutral pressure in the divertor in which the pump is installed ($P_{6\mathrm{I}}$) is lower when the pumping is activated. It suggests that the cryo pump in the divertor exhausts the neutral particles during the discharge. The ratio of $P_{6\mathrm{I}}$ to $P_{9\mathrm{I}}$ shows the difference between with and without the active pumping, that supports the working of the pumping in the divertor during the discharge.

In order to clarify the divertor pumping characteristics, the total particle balance is analyzed using the following equation[1)].

$$\begin{aligned} \frac{dN_e}{dt} &= \Phi_{\mathrm{puff}} - (1 - R_{\mathrm{div}})\Gamma_{\mathrm{div}}, \\ R_{\mathrm{div}}\Gamma_{\mathrm{div}} &= \Gamma_{\mathrm{div}} - \Phi_{\mathrm{puff}} - \tfrac{dN_e}{dt}, \end{aligned}$$

where $N_e = \bar{n}_e \times V_p$ ($V_p$: plasma volume). $\Phi_{\mathrm{puff}}$ denotes the electron flux supplied by gas puffing. $R_{\mathrm{div}}, \Gamma_{\mathrm{div}}$ are the particle flux onto the divertor plates and the recycle coefficient, respectively. $R_{\mathrm{div}}\Gamma_{\mathrm{div}}$ means the recycling flux at the divertor. Figure 2 shows the neutral pressures as a function of the divertor recycling flux. $P_{6\mathrm{I}}/P_{9\mathrm{I}}$ is lower in the discharge with the active pumping, suggesting that the cryo pump exhausts the neutral particles during the discharge. The pumping seems to be more efficient if the recycling flux at the divertor is lower.

1) J. Miyazawa et al., Nucl. Fusion. **44** (2004) 154.

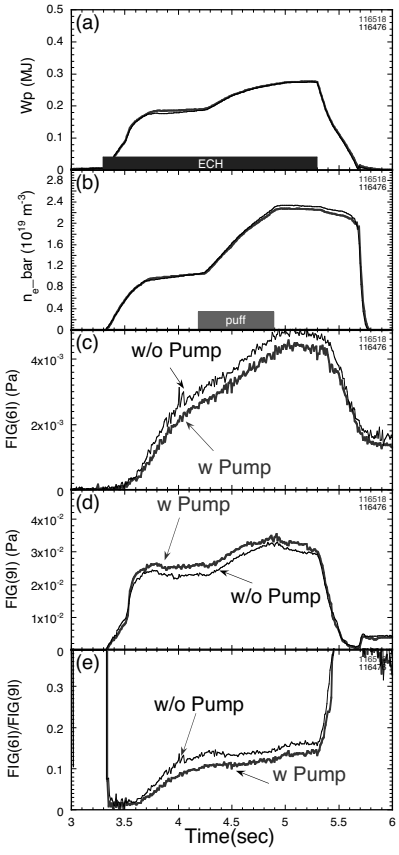


Fig. 1: Time evolution of (a)stored energy, (b)line averaged density, (c) neutral pressure(6I), (d) neutral pressure(9I) and (e) ratio of neutral pressure (6I/9I) at with and without active pumping of divertor.

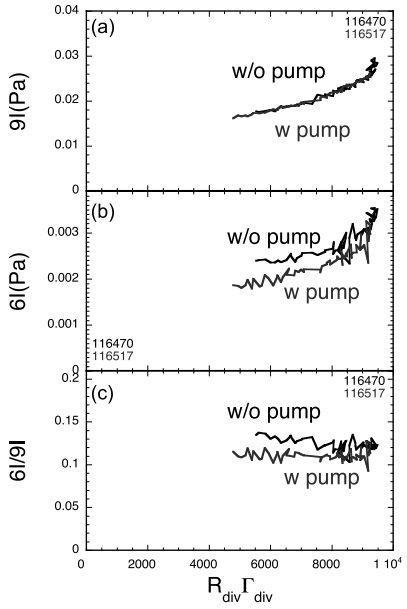


Fig. 2: Dependence of (a)neutral pressure(6I), (b)neutral pressure(9I) and (c)ratio of neutral pressure (6I/9I) on the divertor recycling flux at with and without active pumping of divertor.