§38. Estimation of the Particle Confinement Time of the Helium Ash in LHD

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The ratio of the helium ash confinement time to the energy confinement time ($\tau_\alpha*/\tau_E$) should be lower than 7 in the FFHR helical reactor. However, for maintaining ignition $\tau_\alpha*/\tau_E$=3 is usually assumed. As such data are not yet available in any helical device, it is urgent to measure helium particle confinement time experimentally. While the charge exchange recombination spectroscopy with small S/N ratio has been used in many tokamak experiments, He lines and density decay are monitored by spectrometer and interferometer to estimate the helium particle confinement time roughly.

In 2004 campaign, Helium gas was injected in the helical divertor configuration without pumping. Therefore, the density decay was very slow. In 2005 campaign, LID configuration with active pumping has been used with B_o=2.64T and R_o=3.75 to study the pumping effect on a helium confinement time. Two density regimes with $3x10^{19}$ and $1.5x10^{19}$ m^{-3} are used for comparison. In a higher density regime, H-alpha signal is observed during He gas puffing. Hydrogen gas absorbed in the vacuum chamber or the LID head were released by He gas puffing. Therefore, the density waveform may not be made by He gas alone.

In the lower density regime, hydrogen line is not so strong during He gas puffing [t=2-2.1s] (Fig. 1-(b)) as in the higher density regime. Then we estimated the He confinement time using the density decay waveform (Fig. 1-(c)) assuming the charge neutral condition: $\Delta n_e=2\Delta n_{HE4}$. The helium particle balance equation is

$$\frac{dn_{HE4}}{dt} = S_{HE4} - \frac{n_{HE4}}{\tau_\alpha^*} \tag{1}$$

where τ_α^* is the effective helium particle confinement time. The helium source term S_{HE4} is determined by the waveform of He-I line (4684Å) [Fig. 1-(c)]. The base line of the density during He gas puffing is monitored in the separate shot without He gas puffing and is subtracted from the density waveform [Fig. 1-(c)]. Fitting the density and alpha particle confinement time using Eq. (1) were conducted. The resultant effective helium particle confinement time $\tau_\alpha*$ is 0.16 ~0.29 sec as plotted in Fig. 1-(d), which provides $\tau_\alpha*/\tau_E$=3.2~5.8 for the constant energy confinement time of 50 ms (#57594).

However, the effect of the small amount of Hydrogen injection observed by H-alpha line on the charge neutrality cannot be ruled out. More accurate experiments using the charge exchange recombination spectroscopy with NBI is required and is planned in 2006.

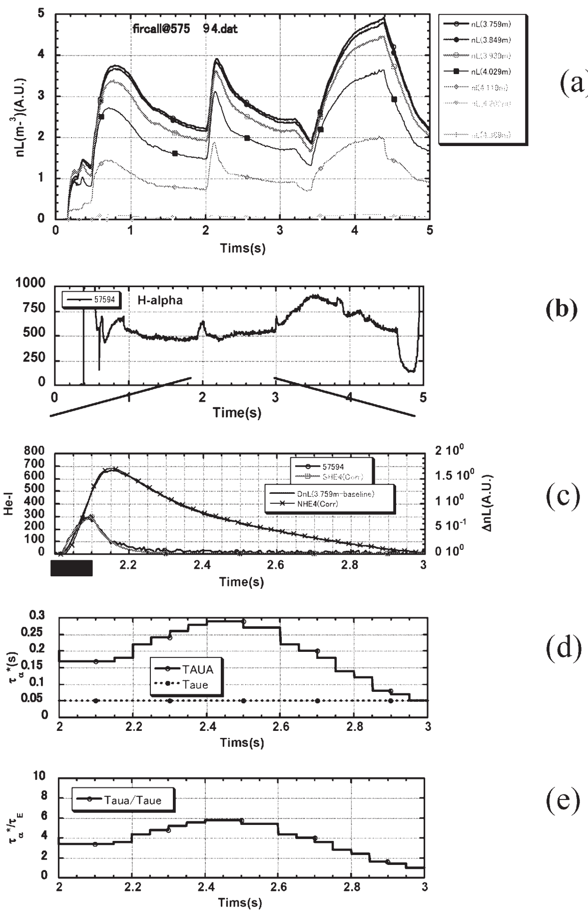

Fig. 1. (a) Density waveforms, observed at the various positions by the far infrared interferometer, by He gas puffing in the LID configuration (#57594). (b) H-alpha signal. (c) Density waveform corrected to the base line and H-I line (4684Å). Black square shows He gas puffing pulse. (d) Estimated effective helium particle confinement. (e) Estimated effective helium particle confinement to the energy confinement time ratio τ_α^*/τ_E.