Imaging of radiation during impurity gas puffing in LHD

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Abstract

In LHD, several methods of detachment have been attempted, including impurity gas puffing [1], and the application of an m/n=1/1 magnetic perturbation [2]. LHD is equipped with an imaging bolometer (IRVB) [3] that views the plasma from an upper port. Two scenarios are shown and compared, Ne puffing and N_2 puffing. In the case of Ne puffing, radiation becomes more intense near the helical divertor X-point as the radiation increases. In the case of N_2 puffing, a double stripe pattern evolves around the upper helical divertor X-point, which appears to be localized near the gas puff inlet. In addition, probe data also indicates that the drop in divertor flux with N_2 is localized, while uniform with Ne.

I. Introduction

The operational regime known as detached plasma is important for the control of the heat load to divertor strike plates [4]. In this regime radiation increases and electron temperature drops reducing the heat flux to the divertor. Therefore measurement of the radiation distribution is important for understanding the mechanism of the detachment process. In this paper radiation profiles are shown from two different attempts to achieve detachment in LHD by the puffing of Ne and N_2 gasses.

II. Imaging bolometer diagnostics

Infrared Imaging Video Bolometers (IRVB) measure the radiated power loss from the plasma by using an infrared camera to measure the temperature rise of a thin foil, which absorbs the radiation from the plasma [5]. In this paper data from an IRVB with a top view is shown [3].

III. Radiative divertor via Ne puffing

In Fig. 1 the times traces of the main plasma parameters are shown for a discharge in which Ne is puffed into the plasma from 4.8 to 4.9 s. After the Ne puffing a large increase of over a factor of two in the radiated power is observed, and the inner divertor probe ion saturation current (I_{sat}) signal drops also by over a factor of two indicating decreased flux to the divertor, however the H_γ/H_β ratio does not show an increase indicating a lack of volume recombination. Therefore we designate this behaviour as radiative divertor. In Fig. 2 the I_{sat} signal at various locations around the machine is seen to be very uniform indicating good toroidal symmetry. Looking at the imaging bolometer data from the upper port we note that before the Ne puff, in Fig. 3, the radiation is coming predominantly and quite uniformly from the upper helical divertor X-point (HDX) trace with a slight amount from the lower HDX. The image from after the Ne puffing, Fig. 4, shows almost a doubling of the peak signal level and similar features, though less uniform along the upper HDX and stronger from the lower HDX.

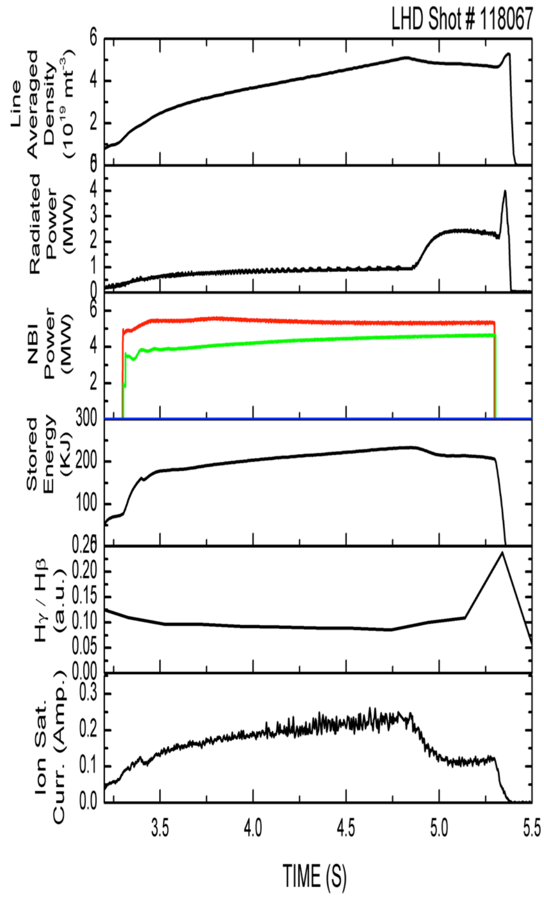

Fig. 1 Plasma parameter evolution during a discharge with Ne puffing.

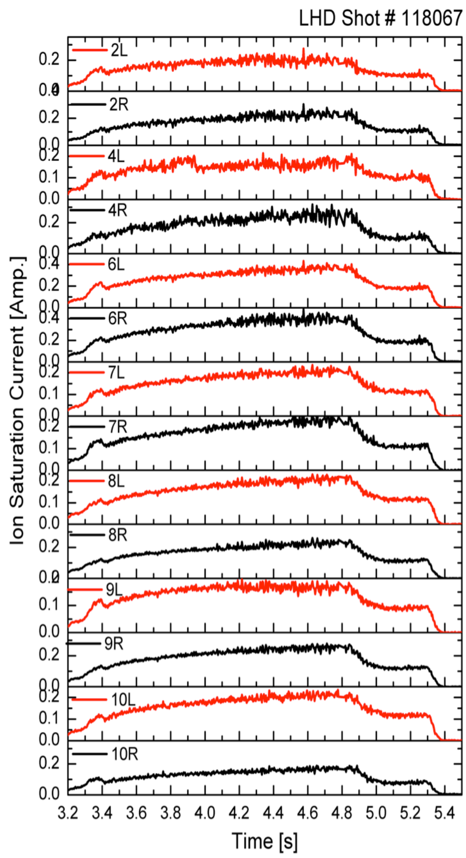

Fig. 2 I_{sat} evolution from left and right probes at various toroidal locations (number indicating field period) in inner divertor plates during discharge with Ne puffing.

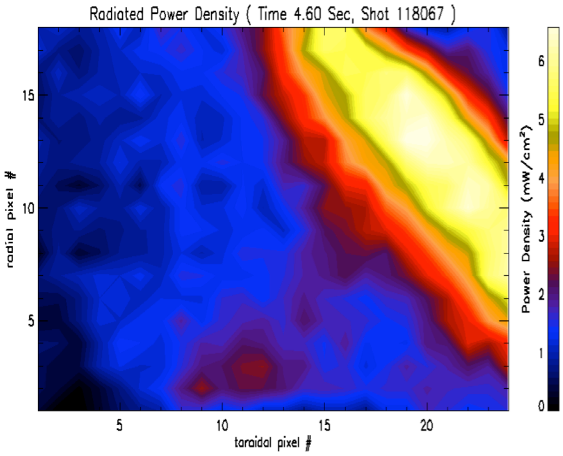

Fig. 3 Bolometric image of radiated power density from an upper port IRVB prior to Ne puffing.

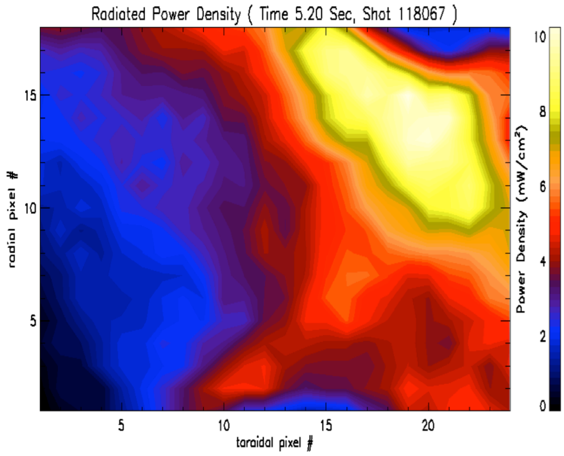

Fig. 4 Bolometric image of radiated power density from an upper port IRVB after Ne puffing.

IV. Radiative divertors via N_2 puffing

In Fig. 5 the times traces of the main plasma parameters are shown for a discharge in which N_2 is puffed into the plasma from 3.8 to 4.8 s. After the N_2 puffing only a slight increase in the radiated power is observed, and the inner divertor probe I_{sat} signal drops by a factor of two indicating decreased flux to the divertor, however once again the H_γ/H_β ratio does not show an increase indicating a lack of volume recombination. Therefore we designate this behaviour also as radiative divertor. In Fig. 6 the I_{sat} signal at various locations around the machine shows both right-left and toroidal asymmetry. In the case of imaging bolometer data from the upper port before the N_2 puff (not shown) is similar to that in Fig. 3 with the radiation is coming predominantly from the upper helical divertor X-point (HDX) trace with a slight amount from the lower HDX. The image from after the N_2 puffing in Fig. 7, shows once again almost a doubling of the peak signal level and a dramatic change in the radiation features. In this case we see a strong double stripe structure. However this structure is not observed from the 10-O IRVB indicating it is very toroidally localized.

V. Discussion and conclusions

Probe data indicate that in the Ne puffing case the divertor plasma is very toroidally symmetric, while the N_2 case is highly asymmetric/localized. The imaging bolometer data from another port separated 126° toroidally from the upper viewing port do not show the double stripe pattern also indicating the highly localized nature of the N_2 radiation pattern. This is possibly explained by the direct connection via magnetic field lines of the N_2 gas

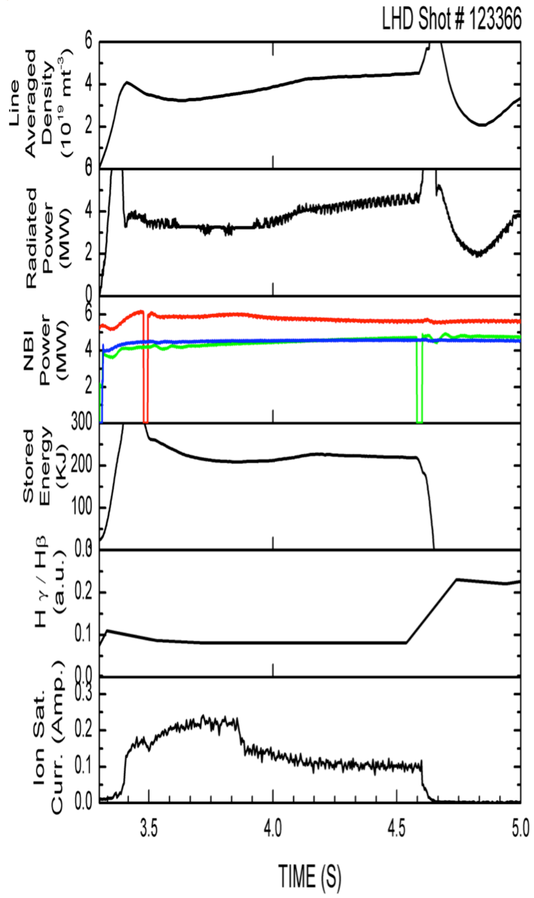

Fig. 5 Plasma parameter evolution during a discharge with N_2 puffing.

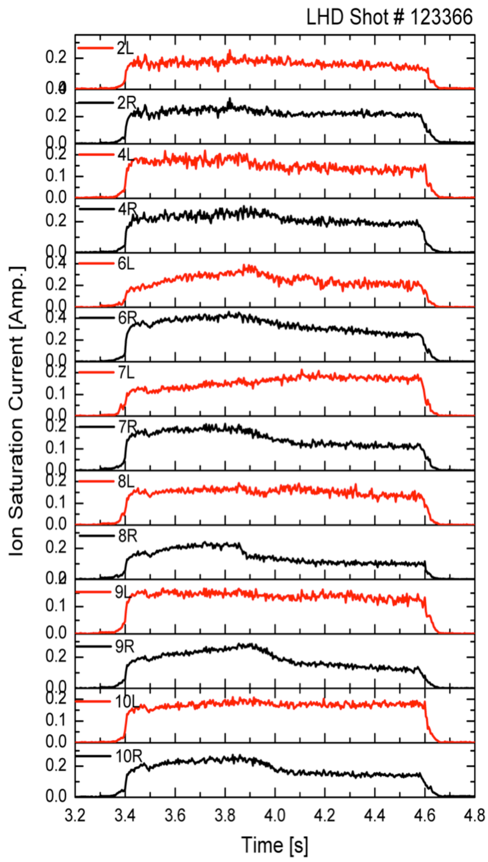

Fig. 6 I_{sat} evolution from left and right probes at various toroidal locations (number indicating field period) in inner divertor plates during discharge with N_2 puffing.

puffing valve which is located 36° away toroidally. The double stripe pattern itself may be explained by the radiation coming from both divertor legs near the x point, when usually it favors one of them.

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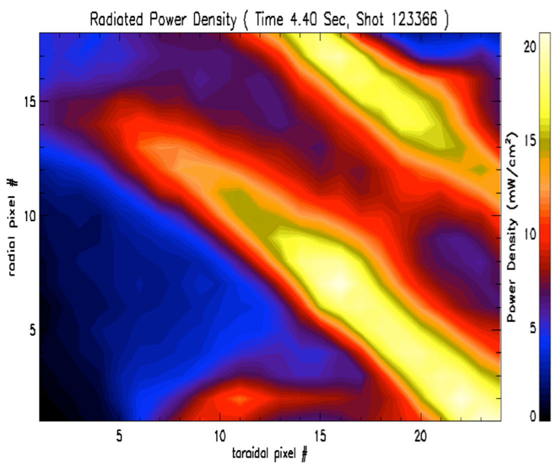

Fig. 7 Bolometric image of radiated power density from an upper port IRVB after N_2 puffing.