§2. Calibration of Potential Profile by Gas Ionization

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Since the ratio of the plasma potential to the beam energy is very small in the high voltage heavy ion beam probe, the calibration of the total system utilizing the ionization of the injected probing beam by the puffed neutral gas into the vacuum vessel, is very important for the accurate measurement of the potential profile. The gas ionization may be considered to be an ideal method for the calibration of HIBP because of the small energy loss in the ionization process and because of the fact that the space potential can be considered to be the same with that of the vacuum vessel. In adition it is extremelly useul for the estimate of the error due to the change of the in-plane entrance angle to the analyzer when the sample volume is swept across the plasma cross-section. We found recently, however, that we have to be very careful in the interpretation of the data for gas calibration in JIPP T-IIU because of the difference of the region of presence of gas and the plasma. Last year we found for the first time that the intensity of the secondary beam generated by the neutral gas in the tokamak vacuum vessel increases abruptly and is terminated when the primary beam is swept poloidally across the vacuum vessel. We named this phenomena as the divergence of the sample volume. Altough the sample volume divergence can be used as a point of reference for the assignment of the position in the cross-section of vacuum vessel, we recently found that near the divergence of the sample volume there are two secondary beams with different entrance angles to the energy analyzer, which induce serious error in the calibration of the system. Figure 1 shows the trajectories of primary and secondary beams in JIPP T-IIU HIBP. The secondary beam generated in the upper injection port and the beam generated near the center of the plasma hit together the entrance slit of the analyzer as shown in Fig.1.

The ionization point of the upper branch is outside the plasma cross-section which is limited by the limiter plate or divertor configuration. The neutral gas puffed into the vacuum vessel easily filled the vacum vessel and all ports including the injection port. Accordingly, the additional beam in the gas ionization causes serious effect in the calibration by neutral gas. In Figure 2 the sum ($I_u + I_d$) of the upper detector current I_u and the lower detector current I_d and ND (normalized difference of the detector currents ($I_u - I_d$)/($I_u + I_d$)) at different detector set at multiple detection points are shown. ND is proportional to the change of the bem energy (potential) in case of no error due to the change of the entrance angle to the analyzer. The large change in ND is observed and most of this change can be considered to be due to the upper branch of the secondary beam. The elimination of the contribution from the upper branch is possible when we set the movable obstacles on the trajectories. In our case, most of the contribution from the upper branch is blocked by the obstacle in the analyzer and the calibration curve applicable to the case of plasma measurement is obtained in a certain measurement point.

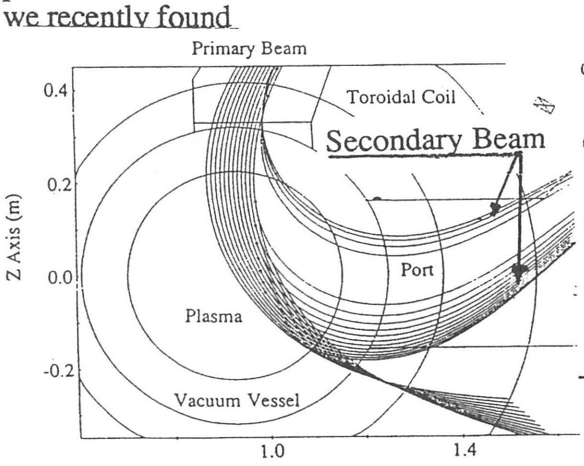

Figure 1. The detailed view of the observation point and trajectories of primary and secondary beams neart the plasma column.

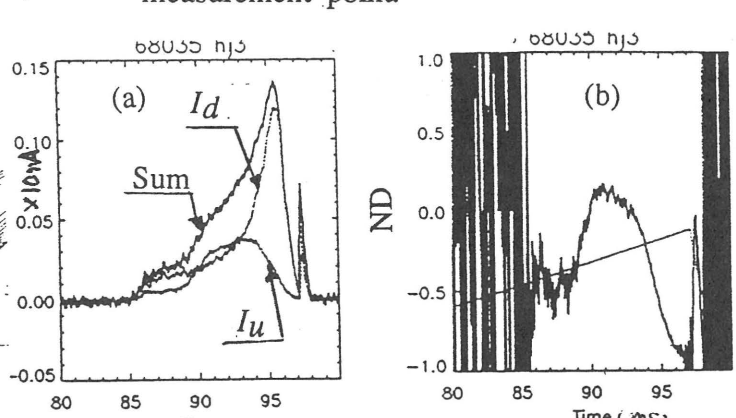

Figure 2. The sum (a) and normalized difference (ND) (b) of detector currents by gas ionization in case of the significant contribution from the upper branch.