§6. Development of the New Energy Analyzer for MeV Range Heavy Ion Beam Probes

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A heavy ion beam probe (HIBP) has been developed because it is an important tool to measure space potential and density fluctuation in plasmas. The development of a new energy analyzer is one of the keys for LHD-HIBP to work successfully. Because the beam energy is high, the conventional parallel plate electrostatic analyzer requires unrealistic voltage (~ 1MV). So, the new analyzer was proposed to reduce the required voltage [1]. In the analyzer, the incident angle is small (6 degree) so as to reduce the voltage, and two anodes are used instead. One of the important requirements is that the position of the beam changes as little as possible during the changing in the incident angle. The theoretical calculation shows the new analyzer has the second-order focus for the incident angle. We should demonstrate such good character of the energy analyzer.

A new energy analyzer was built in the Diagnostics Building. The schematic view is shown in Fig.1. Its performance was tested with a singly charged thallium beam whose energy is 30 keV.

Figure 2 shows the results of the test. The horizontal and vertical axes are the incident angle to the first electrode of the analyzer and the normalized position of the beam on the detector (ND), respectively. The relation between the change in the normalized position (ΔND) and the change in the beam energy (ΔW_b) is $\Delta W_b[kV] = -0.068 \times \Delta ND$, that agrees with the design. Moreover, as shown by the line with the filled circles in Fig.2, if the suitable voltages for the second-order focus is applied, ND does not depend on the incident angle within the incident angle range of 0.5 degree. In the actual LHD-HIBP system, the incident angle to the analyzer is limited within 0.5 degree due to the design of the beam line. Therefore, we judged the analyzer could be used for LHD-HIBP.

In fact, however, its angular dependence is quite different from theoretically designed one as shown in figure 3. The difference may be caused by the fringe field near the electrode of the analyzer because the path length of the beam in the fringe field is long due to the small incident angle. The further development is required to demonstrate the new concept of the energy analyzer.

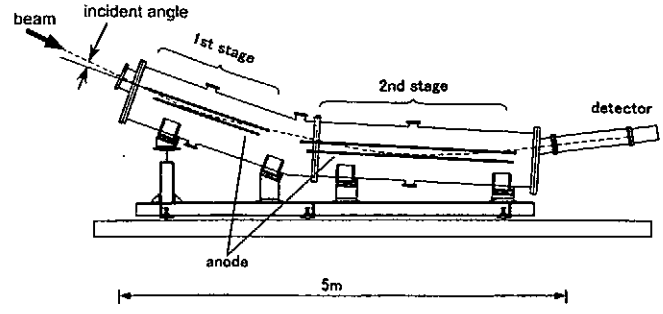

Fig. 1. Schematic view of the new energy analyzer.

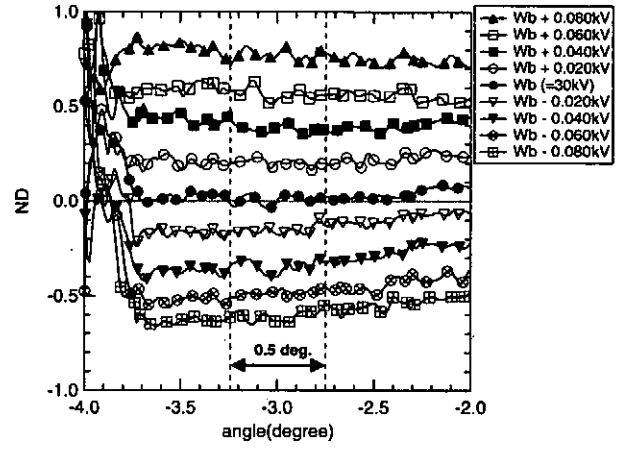

Fig. 2. The parameter dependence of the position of the beam on the detector. The vertical axis is the normalized position of the beam, and the horizontal axis is the incident angle. Each line shows the angle dependence of the beam energy.

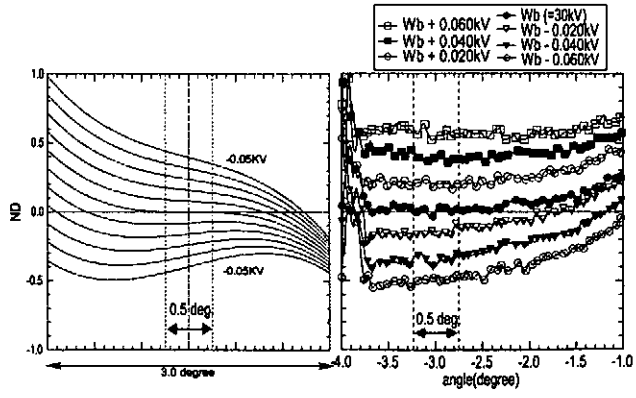

Fig. 3. Difference of the angle dependence between design (left) and experiment(right).

Reference
1) Y. Hamada, et al.: Rev. Sci. Instrm., 68 (1997) 2020