§6. ECH Antenna System Low Power Testing and Installation on LHD

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Launching antenna system for ECH are installed on LHD. The system consists of two millimeter wave beam focusing and steering mirror sets which allows local plasma heating experiment. These systems include mirror supporting structures, water cooling channels for each mirror, long distance crank shaft mechanism to allow two dimensional scan of the focal points. Each antenna unit is composed of two sets of four mirror array. This mirror array enables the Gaussian beam strongly and elliptically focused radially and toroidally. The first mirror facing the corrugated waveguide mouth from which a symmetric Gaussian beam is radiated is elliptical beam generating mirror. This concave mirror has different curvature toward radial and toroidal direction so as to generate elliptic Gaussian beam waist on the third mirror. The second mirror is just plane mirror to direct the beam to the third focusing mirror. The third focusing mirror is the main concave mirror. The elliptical beam radiated on this mirror has long axis along effectively radial direction and can be strongly focused in this direction by this focusing mirror. The fourth is again plane mirror but with 2-axis steering mechanisms driven by the super- sonic motor located above the vacuum flange through long distance and complex crank shaft mechanism. The center of each mirror surface is polished within 20 mm diameter for the use of optical axis alignment using He Ne laser.

Water cooling channels are provided in each mirror for the CW high power operation in the future. These mirrors are supported from structures hung from U-port flange of the LHD. Two of the four main structure stainless steel pipes are also used as a water feed through for the mirror cooling. Corrugated waveguide of 88.9 mm in diameter is installed in another structure pipe as a spare millimeter wave power launcher. Fig. 1 is the photograph of one of the antenna system taken from inside the vacuum vessel at 5.5 port.

Low power beam measurement of this system was performed before installing on LHD for both 84 and 168GHz. The test stand for quasi-optical transmission system in the Plasma Heating Laboratory is used for measuring the beam patterns and beam evolution and its steering characteristics. HE11 mode generators for 84 and 168GHz are connected to the input corrugated waveguide and fed few mW of HE11 mode to the antenna system. Figure 2 shows the beam profiles for 84GHz measured at the plane equivalent to the mid-plane of the LHD. Similar results are obtained for 168GHz system. This figure clearly shows the well defined elliptical beam is focused with the designed waist size of 15 mm in radial and 50 mm in toroidal direction. Furthermore, the beam could be steered radially and toroidally without degrading the beam quality within 200 mm toroidally and 150 mm radially in both side.

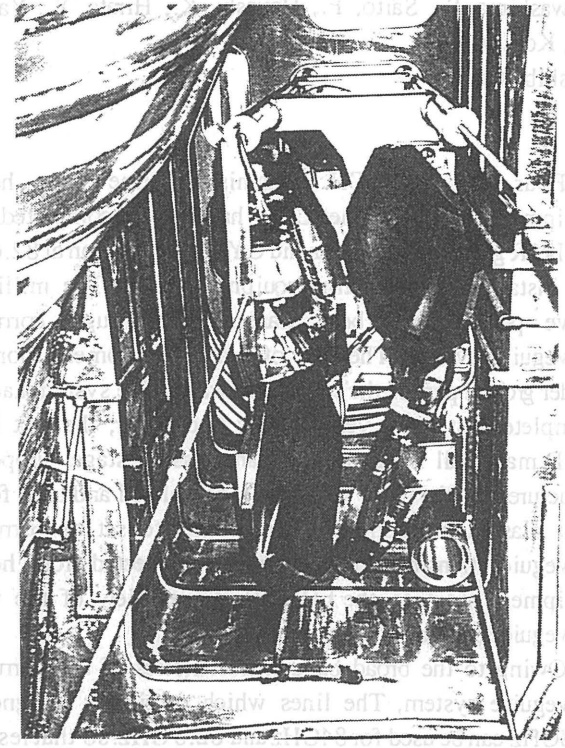

Fig. 1 The photograph of the ECH antenna system installed on LHD 5.5U port. This photo is taken from the inside of the LHD vacuum vessel.

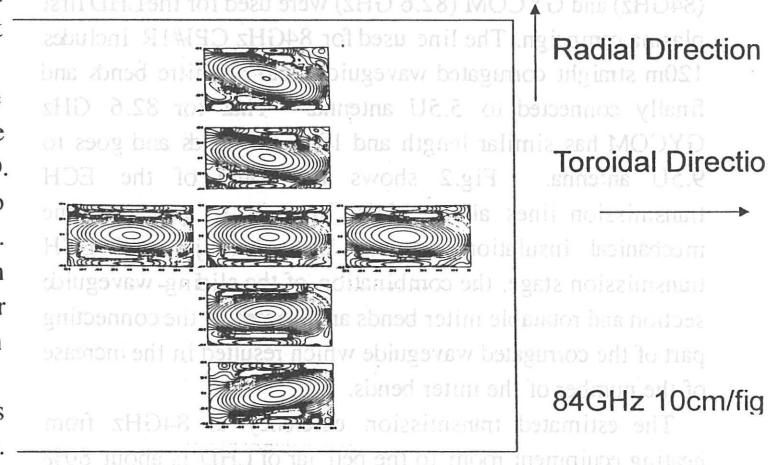

Fig. 2 Elliptical Gaussian beam profile measured with low power at 84GHz. The contour lines are plotted by every 2 dB. The beam profiles measured at several focal point setting are overlaid.