§6. Design and Install of New Electron Cyclotron Emission Diagnostic Antenna in LHD

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Electron Cyclotron Emission (ECE) Diagnostic is one of the important measurements for electron temperature, and has been used in many magnetized plasma devices. Until 13th campaign LHD experiment, ECE diagnostics have been used for the electron temperature profile and its fluctuations[1]. For 14th campaign, new ECE antenna is designed and installed, because of the change of heating and measurement ports arrangements. New sight line is on the mid plane form out of torus. Helical magnetic configuration has magnetic filed peak around the center of plasma unlike tokamaks. In case of LHD, the profile is on around R=3.5m. Therefore, only the outer half of plasma can be measured using the outer ECE antenna.

Figure 1 is a layout representation of ECE antenna system. Antenna is consisted of 4 ellipsoidal mirrors, which are shown by M1, M2, M3 and M4. The fine-tuning mechanism is equipped in each mirror. The mirrors are made of aluminum 5052 and coated by Ni after mirror finish. To improve the measured microwave strength, M4, which is called main mirror, is desirable to be enlarged. The size of mirrors is follows, M1: 8cm * 11cm (in air), M2: 8cm * 11cm (in air), M3: 21cm * 29cm (in vacuum), M4: 27cm *37cm (in vacuum). M1 and M3 are plane mirrors. M2 and M4 are concave mirrors. By use of 2 concave mirrors, the degree of freedom of beam size design is improved. The previous mirrors installed in outer ECE antenna were parabolic mirror surface. Note that the propagating of microwave follows Gaussian optics law, the mirror surface of the new concave mirrors is designed with the concept of the constant phase [2]. The focusing point (the waist position) is the center of plasma. Fig.2 shows the spot size of Gaussian Beam, which is corresponding to polidal spatial resolution. The waist size is 50GHz: 6.0cm at R=3.7m, 160GHz: 2.2cm at R=3.7m.

The shutter is installed before quartz vacuum window in order to protect the window from the glow discharge cleaning and Boronization. The ECE radiation collected by the antenna directed into a circular corrugated waveguide with the inner diameter of 63.5mm which is made by General Atomics. The corrugated waveguide is designed to transfer the microwave from 50 to 220 GHz. The waveguide is connected to the spectrometer. The total length of waveguide is approximately 100m.

The ECE is divided to the heterodyne radiometer and Michelson Interferometer by use of the 10 micrometer wire grid. Michelson Interferometer is useful for the measurement of electron temperature profile. The frequency resolution is 4 GHz, the scanning frequency is 20 Hz in LHD experiments. There are 2 heterodyne radiometer systems. The frequency of Radl in fig.3, which has 70GHz local Gunn oscillator, is well suited to the low B filed experiment (<1.5T). Radh is used in high B field experiment. The radiometers provide electron temperature fluctuations. The frequency resolution is 1GHz, and number of channels is 75 (Radl :36ch, Radh:39ch). The sampling rate is 250kHz.

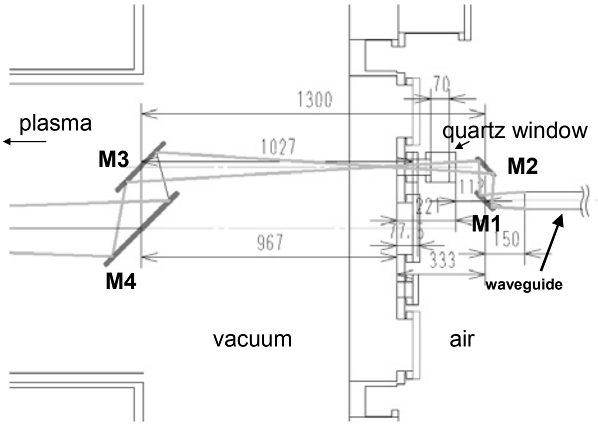

Fig.1 The layout of ECE antenna system

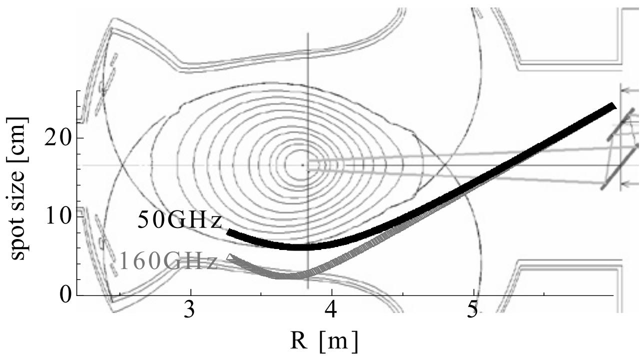

Fig.2 spot size of 50GHz and 160GHz Gaussian Beam.

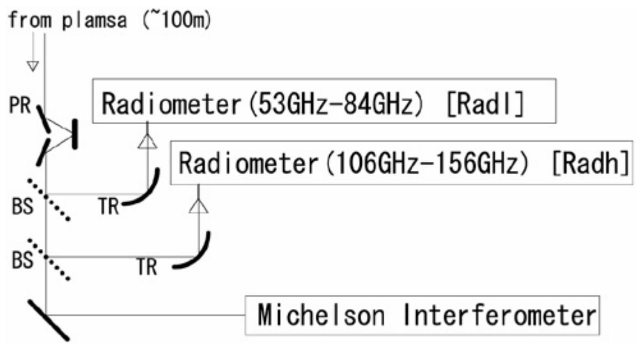

Fig.3 Schematic diagram of the ECE diagnostic system. Each component is connected by corrugated waveguide. PR: polarization rotator, BS: beam splitter, TR: transition from corrugated waveguide to WR12 rectangular waveguide

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[2] S. Kubo, K. Ohkubo, H. Idei, M. Sato et al., Fusion. Eng. Design **26**, 319 (1995).