§9. Accuracy Enhancement of a Millimeter Wave Interferometer for Study of Helical RFP Plasma Performanc

Sanpei, A., Ishii, G., Himura, H., Masamune, S. (Kyoto Inst. Tech.), Ejiri, A. (Univ. Tokyo), Akiyama, T., Suzuki, C.

A spontaneous transition to the quasi-single helisity configuration is observed in the low aspect ratio reversed field pinch device RELAX[1]. Studies of its formation mechanism and confinement properties will provide important knowledge which is common among magnetically confined torus plasmas including helical system. Since the behavior of the electron density is necessary especially in the high density range (2-3 $\times$ 10^{19} m^{-3}), a millimeter-wave interferometer which uses a Gunn oscillator with a frequency of 140 GHz is developing.

We had already developed and installed a 60 GHz interferometer with a cross-detector via this research collaboration[2]. The main target of the interferometer is low density plasmas, less than 10^{19} m^{-3}. For measurement of higher density plasmas, higher frequency is preferable to suppress the beam deviation in a plasma. Hence we start to develop the 140 GHz interferometer. Figure 1 shows a schematic view of the 140 GHz millimeter-wave interferometer on RELAX. As a first step, we installed a 140 GHz heterodyne interferometer with a frequency-swept Gunn oscillator. One of advantages of the method is that only one Gunn oscillator is necessary and the interferometer system becomes simple. However, the amplitude of the intermediate frequency (IF) signal was strongly modulated when the frequency was swept. Hence the phase evaluation with a phase counter was so perturbed. Then, we will add another Gunn oscillator with a frequency difference of 1 GHz as shown in fig. 2. In addition to that, we will place the microwave system away from the RELAX device and transmit the microwave with an over-sized waveguide to reduce the electromagnetic noises at the capacitor discharges.

As a second step, we check the overall quality of developed system by a table-top examine. It was found out that frequencies among filter-amplifiers and IQ detector aren't matching by the test measurement. Then, we modified and optimized each components, and retry a test measurement. Significant transparent wave-signal and a fine Lissajous figure are obtained by modification and optimization. As a third step, the developed interferometer system have been adopted to RELAX. As a result, it's recognized that probe signal and signal-to-noise ratio significantly decay. We figured out that distribution of the microwave is modulated deeper-than-expected by a focal lens located on injection horn. Then, properties of focal lens and horn have been examined by measurement of beam profile, as shown in fig.3. The system has been redesigned based on obtained properties of lens and horn.

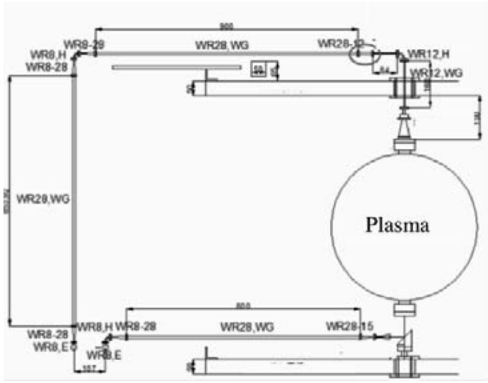

Fig. 1: A schematic view of a waveguide system of a 140 GHz heterodyne interferometer on RELAX.

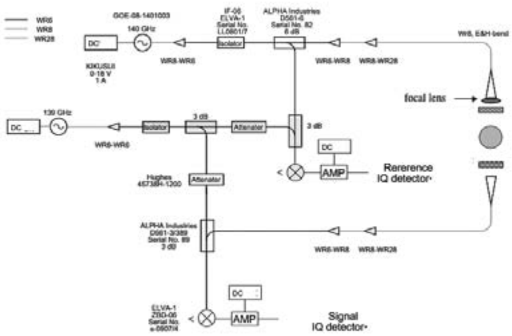

Fig. 2: A schematic view of a 140 GHz heterodyne interferometer with Gunn oscillators with a frequency of 140 and 139 GHz.

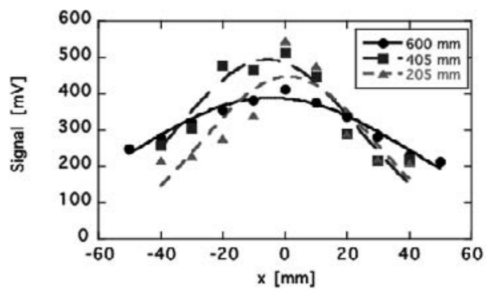

Fig. 3: Dependence of beam profiles on distance from the focal lens.

1) S. Masamune *et al.*, 24th IAEA Fusion Energy Conf., EX/P4-24 (2012).

2) M. Sugihara *et al.*, Plasma Fusion Res., **5**, S2061 (2010).