§1. Studies of the Divertor-simulating Boundary Plasma and Transport Control in Making Use of Open End Magnetic Field and Effects of Electric Potential and Field

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As the magnetic field of the Scrap Off Layer (SOL) plasma in torus system crosses the first wall, the mirror configuration resembles the edge (SOL) plasmas. The control of both core and edge plasma transport is a key to achieve both good confinement and practical wall heat load on the fusion reactor. Since the electric field structure/profile affects the plasma flow in both radial and axial directions, studies of effects of electric field structure on the core and edge transport are crucial issues for fusion plasma researches. The GAMMA 10 is the world largest tandem mirror, and the plasma confinement is achieved by a magnetic mirror configuration as well as positive and negative potentials at the plug/barrier region by electron cyclotron heating (ECH). The mirror system having open magnetic-field provides advantages for the control of radial and axial potential structures by ECH and high heat flux by strong ICRF, EC and NBI heating schemes. Therefore, mirror-based systems enable both core and edge plasma experimental studies with these remarkable characteristics. In addition to these main subjects of the GAMMA 10, the development of high power gyrotron for the ECH, main tool for these experiment, is one of the major research topics, too.

The most recent emphasis is on the divertor plasma simulating experiments, which is a new major objective of the second medium research plan. For this purpose, the west end section of the GAMMA 10 has been modified to install the new divertor module as shown in FIG. 1. This module has closed divetor structure with V shaped plates, which can change the plate angle. It also enable to feed gasses to the divertor region and to control the pumping speed of the compressed region. We will start the detailed studies of the divertor plasma experiments with this module from next FY. In parallel, the characterization of the high heat flux at the mirror throat for simulating divertor plasma. It is found that half width of the half maximum is around 4 cm in case of the ITER level heat flux density (~ 10 $MWmm^2$) at the 30 cm from the mirror throat. It is also found that heat flux up to and particle flux can control with ICRF power and the ion temperature is 100 to 400 eV.[1), 2)]

The intensive studies of correlations between the radial electric field, drift type fluctuations and radial transport had been done. It is clearly seen that the Plug (P)-ECH changed the potential profile and successive suppression of the fluctuations and hence the radial transport were observed.[3)] To study these phenomena more, multi-channel detector of the Gold Neutral Beam Probe (GNBP) has been developed, which determines the radial electric field directly with simultaneous measurements of two radial point potentials.[4)] It is clearly seen the radial electric field profile increases with the application of the P-ECH and it changes from negative to positive in the core region and fluctuations of the drift type wave is also suppressed by ECH formed E-field. Using this powerful tool, detailed studies of the radial plasma transport will be done more.

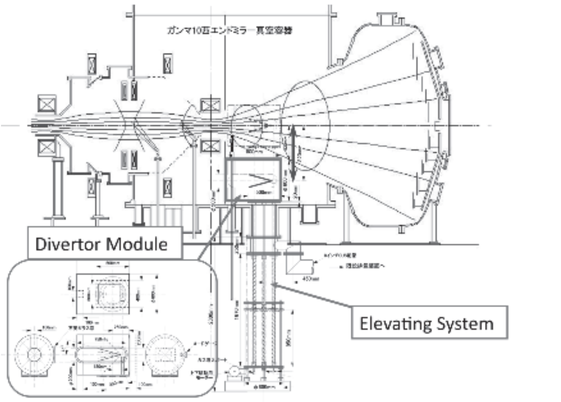

FIG. 1 The schematics of the new Divertor module installed on the west end section of the GAMMA 10 (PDX) for divertor plasma simulation experiment.

In gyrotron development in collaboration with NIFS, the output of 1.8 MW for 1 sec, the world record, was achieved. Based on this, we started to develop 154 GHz 1 MW tube for LHD high density plasma and completed the design and fabrication. The test and application of the new 154 GHz tube will be in the next FY. In the development of 1MW-28 GHz gyrotron for GAMMA 10, long pulse operation of 0.54 MW x 2sec, which is 2 times larger output energy than the last year, has been obtained. The collaboration with Kyushu Univ. has been started for the QUEST EBW and ECH/ECCD studies. The design of the new 28 GHz new CW gyrotron has progressed. As shown in FIG. 2, the diffraction loss inside the tube is substantially reduced and total transmission efficiency is improved from 94.7% to 98.5%, which is a key to achieve CW operation.[5)]

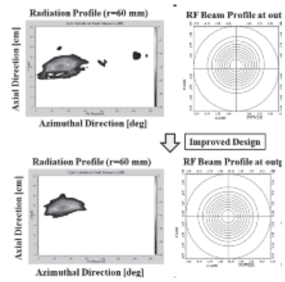

FIG. 2 The comparison between the present mode convertor radiation pattern design (upper) and new improved one (lower) of the 28 GHz 1 MW gyrotron.

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2) T. Imai, et al.,. Trans. of Fusion Sci. and Tech. **59**, 1T, (2011) 1-8.
3) M. Yoshikawa, et al., Fusion Sci.&Tech. 57 (2010) 312.
4) Y. Miyata, et al., PFR, 6, 1202090 (2011).
5) T. Kariya, et.al., Plas Conf 2011, Ishikawa (22P143-P).