22P129-P

Analysis of GAMMA 10 end-loss-ion-flux for application studies of end-loss-plasma-flux

端損失プラズマの応用研究に向けたGAMMA 10端損失イオン流の分析

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Characteristics and capabilities of the GAMMA 10 end-loss-ion-flux are investigated from the view point of utilizing the end-loss flux for studies which need high performance plasma-flux such as divertor simulation experiment. The performance of the end-loss-ion-flux in GAMMA 10 is evaluated from the measurements of the energy distribution and the ion-current density of the ion-flux by using the diagnostics which is called ELIEA (End Loss Ion Energy Analyzer). Some basic heating and fueling equipments: ICRFs and gas puffs are revealed to be the key to control the parameters of end-loss-ion-flux. Furthermore, several additional inputs of heat and particle (Supersonic Molecular Beam Injection (SMBI), ECRH, ICRF…) are found to be effective for the generation of more intense flux of ion.

1. Introduction

The end-loss flux of the world's largest tandem mirror: GAMMA 10 has been focused because of its usefulness to an experiment such as divertor simulation experiment. GAMMA 10 is a tandem mirror device which consists of multi cells: central-cell, anchor-cells, plug/barrier-cells and end-cells (Fig. 1).

The end-loss flux is produced in the confinement region (central-cell, anchor-cells and plug/barrier-cells) of GAMMA 10 and flows into the end-cell. Since the typical plasma in the confinement region has high ion-energy, the end-loss-ion-flux is estimated to be energetic and useful for an experiment which requires high-performance plasma flux [1-3]. The objective of this research is to investigate the characteristics of the end-loss flux from the view point of utilizing the flux.

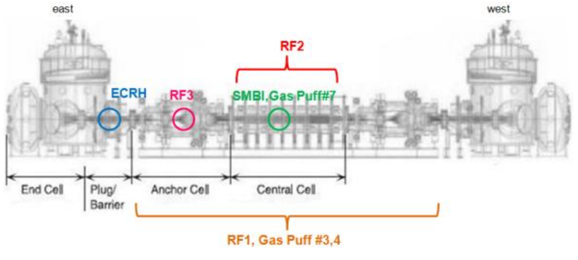

Fig.1. GAMMA 10 and positions of ICRFs (RF1, 2, 3), Gas Puffs (#3, 4, 7), ECRH and SMBI

2. Diagnostics

Ten units of End Loss Ion Energy Analyzer (ELIEA) are equipped in the west end-cells of GAMMA 10 (Fig. 2).

The ELIEA is a diagnostic device consists of a slanted-ion-repeller-grid, a secondary-electron-repeller-grid and a collector plate. Positive ion repeller voltage is applied to the ion-repeller grid during the measurement and ions reflected by the repeller voltage are detected as ion-current by the collector plate facing to the ion-repeller-grid. By sweeping the repeller voltage, ion-energy distribution and ion-current density of the end-loss-ion-flux are examined (Fig. 3).

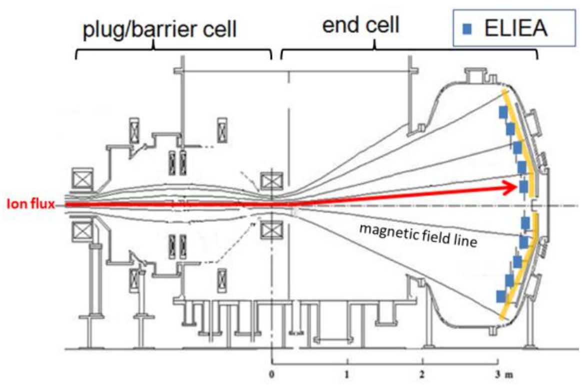

Fig.2. ELIEA installed in the west end cell. Arrow is an example of ion-trajectory

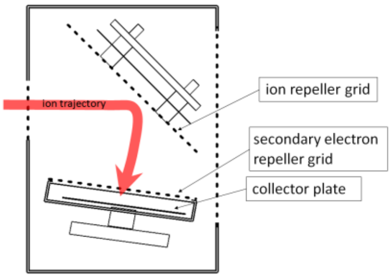

Fig.3. Schematic diagram of ELIEA device

3. Typical Parameters of the end-loss-ion-flux

The most typical plasma of GAMMA 10 is heated only by Ion Cyclotron Resonance Frequencies (ICRF) and fueled by gas puffs installed in the central-cell and anchor-cells. The end-loss-ion-flux of such typical plasma is investigated and the result shows that at the point closest to the center, the ion-current density is about 0.4 mA/cm^2 and the energy of the ion flux is about 300 to 400 eV in ion temperature parallel to the magnetic field line. Since the observed energy distribution of the ion-flux appeared to be multi-components rather than single-component Maxwellian distribution, the evaluation of the ion-temperature was performed by following the idea of multi-components distribution. Results showed linear correlations between the ion-current density and the amount of gas puff (GP #3, 4) input, and also between the ion temperature and the ICRF (RF2) power input.

4. Effects of Additional Inputs

Increase of the ion-current density has been observed during the superimposing of additional inputs such as gas puff (GP#7), Supersonic Molecular Beam Injection (SMBI), ECRH and ICRF (RF3).

Gas Puff and SMBI increases the amount of gas in the central-cell drastically and that leads the increase of ion density. Therefore, more ions flow in to the end-cells and the ion-current density goes up. However, the injection of gas causes the loss of ion-energy in the central-cell which results the decrease of energy of the end-loss flux. The value of end-loss ion temperature in such sequence is evaluated as about 100 to 200 eV which is quite lower than usual ion temperature (around 400 eV).

The additional ECRH input (Fig. 4) forms positive confining potential in the east plug/barrier-cell. Thus, ions escaping to the east end-cell are reflected and the amount of ion flow increases in west end-cell. Here, large loss of the ion-energy which occurred in the gas injection is not observed. In the experiment, the achieved amount of ion- current increase was not very big so far.

The additional ICRF is superimposed in the east-anchor cell. Power of additional ICRF produces more ions in the confinement region and thus, much more ions flow into end-cells without the lowering of energy observed in gas injection.

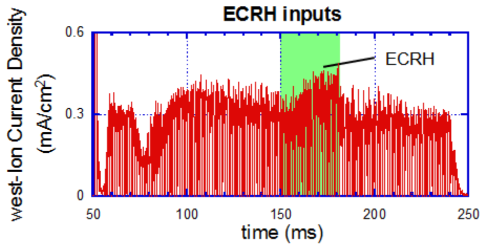

Fig.4. Time profile of ion-current density in the west end-cell with ECRH superimposed

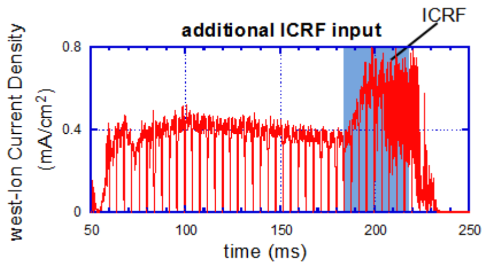

Fig.5. Ion-current density with the additional ICRF (RF3) input measured at the west end-cell.

Summary

The end-loss-ion-flux of GAMMA 10 is analyzed by using ELIEA device. Typical parameters are obtained as 0.4 mA/cm^2 in ion-current density and 400 eV in ion-temperature.

In order to generate more intense ion-flux, effects of several additional inputs are examined. Injection of gas results the increase of ion-current density and decrease of the ion energy. Formation of confining potential by ECRH input also increases the ion-current density. Superimposing of ICRF (RF3) showed the large increase of ion-flux. In future, sequence of superimposing both ECRH and RF3 will be investigated.

References

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