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Modification of Charge Exchange Neutral Particle Analyzer for Study of MHD Effects on Fast-Ions Behavior in Heliotron J
ヘリオトロンJ における高速イオン損失研究のための荷電交換中性粒子分析器の高時間分解能化

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In this study, time resolution of CX-NPA is improved to observe fast response of CX flux due to fast ion induced MHD activity. The current mode measurement is adopted and carbon foil stripper is used to improve the time resolution. The stripping efficiency of carbon foil stripping is expected to be about 100 times higher than that of the gas stripping. From the comparison between the current mode and the count mode measurements in the same condition plasmas, the CX flux can be measured by the current mode.

1. Introduction

Fast ions in magnetically confined plasmas may cause an excitation of MHD instability, resulting anomalous loss of fast ions. In order to solve this problem, it has been actively studied the relationship between MHD instabilities and fast ion transport.

The time resolution of the CX-NPA in Heliotron J has been 0.2ms. However, due to the fast ion induced MHD activity has faster time response around ~10μs. Therefore it is necessary to improve the time resolution of the CX-NPA. In this study, in order to examine the fast ion transport due to the fast ion induced MHD activities, we tried to improve the time resolution of the CX-NPA diagnostics.

2. Experimental Equipment and Current Mode Measurement

Fig.1 shows the CX-NPA system installed in Heliotron J. The CX neutral particle escaping from plasma is ionized in the gas (H_2) stripping cell. The ionized CX particle goes to the detector using Micro Channel Plate (MCP) through the vending magnet and the electrode. At present, the CX-NPA measures by count mode which count the number of particles detected in MCP per unit time. In the conventional count mode measurement, a discriminator is used to distinguish the real CX particles count to the noise signal. In order to improve enough the time resolution, the measurement method will change to the current mode which directly measures the MCP signals. In this case, the time resolution of measurement will depend on how much CX particles are detectable. To observe the CX flux by the current mode measurement, the current mode signals should be compared with the CX flux by the count mode. To achieve the current mode measurement, the MCP signal is converted using I-V amplifier (NF Corporation, LI-76) with the cut-off frequency of 100kHz. The converted signal is acquired using an 1MHz ADC.

Fig.2 (a) and (b) show the time evolution of the CX flux by count mode measurement and the current mode signals, respectively. The two signals are seem to be synchronized with each other. However, due to some noise contribution, a negative offset is seen in the current mode signals. Figure 3 shows the comparison between the current mode and the count mode signals.

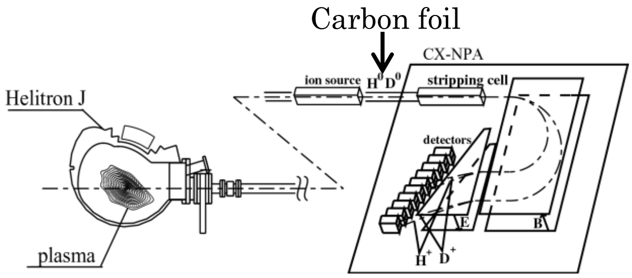

Fig.1 Schematic of CX-NPA system in Heliotron J

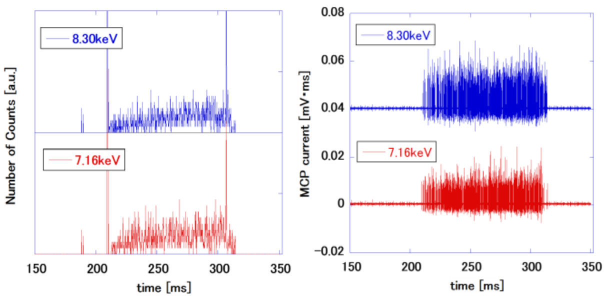

Fig.2 (a) Time revolution of the CX flux by the conventional count mode (shot No.55257), and (b) current mode signals (shot No.55259)

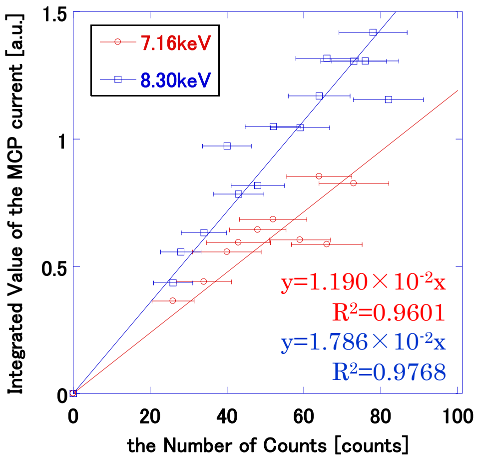

Fig.3 Comparison between the current mode and count mode signals.

These data were analyzed with the time integral of 5ms to obtain a significant signal to noise ratio. The integrated value of the current mode signals increases according to the number of counts. The two signals have a proportional relationship. However several points are scattered. It is considers that the noise in the current mode signals as shown in Fig.2 (b). Thus noise reduction is needed, to improve the accuracy of the current mode measurement in future.

Number of particles is required more than at present in order to observe the fast time response with significant signal to noise ratio. This problem will be solved by applying a high efficiency stripping with carbon foil.

3. Application of Carbon Foil Stripping to CX-NPA Measurements

We are installing carbon foil stripping system to improve the stripping efficiency. The stripping efficiency of carbon foil stripping is depends on the incident energy [1]. When the stripping method was changed to carbon foil method from the gas method, stripping efficiency is expected to become about 100 times higher in the energy range more than 2keV. High time resolution measurement by current mode will become possible due to this. The carbon foil whose thickness in 100Å is placed in front of the gas stripping cell as shown in Fig.1.

However, in the case of carbon foil stripping, detection efficiency at MCP of low energy neutral particles (lower than 10keV) would be degraded, because there is an influence of scattering by the carbon foil. Therefore, a manipulator mechanism shown in Fig. 4 is used to easy change the hydrogen gas stripping to the carbon foil one arbitrary.

4. Summary

In order to improve the stripping efficiency of CX neutral particles, a new mechanism is installed in CX-NPA that can be inserted a carbon foil on the stripping cell to upstream of the neutral particle flux. The proportional relationship was observed in the count mode measurement and current mode measurement, which indicates the CX flux can be estimated by the current mode measurements.

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Fig.4 Carbon foil insertion manipulator