§21. Development of a Detector with Scintillators for Detecting High-energy and Heavy Ions

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In LHD, the heavy ion beam probe (HIBP) has been installed, and the electrostatic potential can be measured in the core region of LHD plasmas. However, since attenuation of the probe beam inside of the plasma is large, under the present circumstances, the accurate measurement of the potential profiles in plasmas with the electron density of 1 x 10^{19} m^{-3} or more is difficult. Moreover, turbulence measurement, which requires high signal-to-noise ratio and temporal resolution, is performed only in quite low density plasmas (~ 0.1 x 10^{19} m^{-3}). In order to study for the plasma confinement of LHD, the further high precision measurement is required. In this study, the new detector equipped with high detection efficiency and a high multiplication factor for heavy ion beams is developed, and it aims at the high performance HIBP.

In this fiscal year, the possibility of a scintillator as a new detecting element has been investigated. The advantage of the scintillator is as follows. 1) The multiple channel detector with large detectable area can be manufactured easily, and it is not expensive. 2) Two-dimensional distribution and motion of a beam are easily detected. However, no data of the luminous efficiency of the scintillator is available for the probe beam which is gold ion (Au^{2+}) with the energy of MeV order.

Therefore, the luminescence for the high-energy and heavy ions has been tested. Moreover, the front-end amplifier circuit for the detector has been also examined simultaneously.

In order to test the luminescence, a detector with the scintillator was installed in the detection-side beam line of LHD-HIBP[1)]. The general-purpose CCD camera was used to detect the luminescence.

Figure 1 shows the beam-induced luminescence from the scintillators. The beam energy is 1.137 MeV. The luminescence has been detected, successfully. Although the S/N ratio was not good because of using the general-purpose CCD camera, the displacement of probe beams has been also detected as the probing beam has been swept (right figure of Fig. 1). Since the absolute value of beam current was not measured in this campaign, the luminous efficiency has not been obtained. The calibration of the efficiency will be performed in next fiscal year.

Construction of the signal-processing system for reading the signal from the detectors with the large area and multi-channel is indispensable. In this fiscal year, the current amplifier circuits which use the general-purpose operational amplifiers have been designed as a trial. The specification (design intention) is as follows. 1) Gain: > 1x10^7 V/A. 2) Cutoff frequency: > 500 kHz. This characteristic of the response from DC to Cutoff frequency is required flat. 3) Output offset is adjustable. 4) Output impedance is 50 Ω for the coaxial cable drive.

The prototype of the current amplifier circuit is designed using a circuit simulation (SPICE). Broadband general-purpose operational amplifier AD8065 of Analog Devices Inc., the SPICE parameter of which is exhibited, was selected. In the SPICE, the parameters of the operational amplifiers which are active device and the value of resistors and capacitors which are passive components are used. The circuit configuration is under development. After the fundamental design of the circuit, it will be made as the proto-type, and the characteristic will be evaluated in the detector system with the scintillator.

1) Nakamura, M., Master's thesis, Nagoya University (2012)

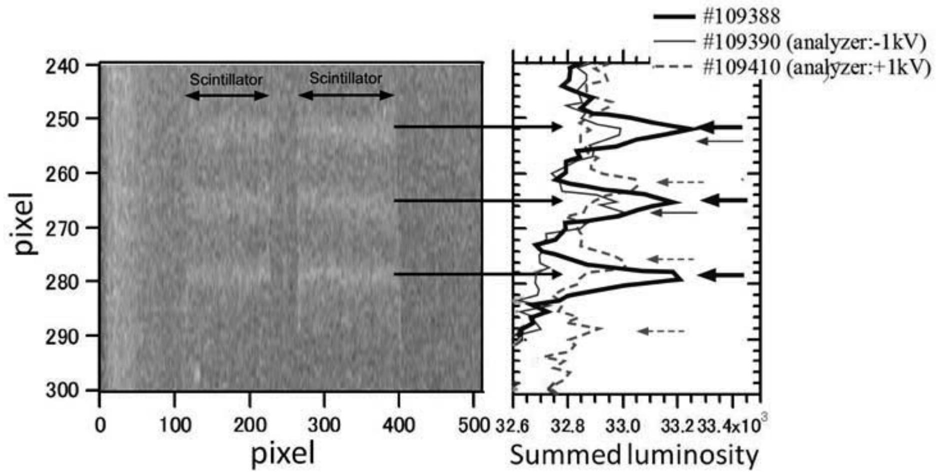

Fig.1 (left) Beam-induced luminescence from scintillators1). Three beams are injected. (right) The thick curve indicates the luminosity summed in the horizontal direction in the left figure. The peaks of summed luminosity move upward (thin curve) and downward (broken curve) as the beams moves upward and downwards.