§11. Developments of Scintillator-based SX Diagnostics for High Neutron Flux Environments

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From the multi-channel soft X-ray (SX) emission measurement, the deformation of the flux surface can be measured effectively. This kind of measurement is quite useful for studying the spatial structure of the MHD instabilities. For this purpose, semiconductor-based detectors have been used in hydrogen experiments in LHD.

In the near future, deuterium plasma experiments will start in LHD. In the experiments, it is predicted that 2.45 MeV neutron and secondary γ-rays, which mainly come from the vacuum vessel, damage the semiconductor. To measure SX in such high neutron flux environments, we have been developing scintillation-type SX diagnostic. It is reported in NSTX that this type of diagnostic has worked well even in high neutron flux environments[1)].

The schematic view of the diagnostic is shown in Fig. 1. The main component of the detection system is a pinhole camera with scintillator screen. The SX emissions from a plasma go through the pinhole, and enter the CsI:Tl scintillator (50 μm in thickness). The SX light are converted to visible light (scintillation light) there. The light is converged by lenses and led to the optical fibers. Then the light is transferred and detected by the semiconductor detector array in the box for shielding a neutron and γ-ray located far from LHD.

In the deuterium plasma experiments, neutrons induce various radiations and these enter into scintillators as the scintillation light. To have the scintillator-based SX diagnostic work well in deuterium plasma experiments, at least, it is required that the dominant component of the scintillation light should be SXs, not other radiations.

We estimated absorption powers of CsI due to SXs, neutrons, and γ-rays in our system shown in Fig. 1. It is assumed that the amplitude of scintillation light is proportional to the absorption power. It is assumed that the neutrons directly enter into the scintillator and γ-rays come from the vacuum vessel. The energy spectrum of the neutron and the γ-ray fluxes at the scintillator were calculated using a transport code, DORT. The maximum of the neutron generating quantity in the experiments is assumed here.

A preliminary calculation shows that the absorption power of γ-rays is greater than that of SXs. The stainless steel for shielding the γ-rays is set in front of the scintillator. The shape has a conical hole in a column. The secondary γ-rays induced at the shielding are calculated by PHITS code ver.2.76.

The results of estimations are shown in Fig. 2. The SX is assumed to be bremsstrahlung. The power due to the SX emission is at least one order larger than other contributions when the core plasma electron temperature is 1 keV. We predict that actual SX intensity would be larger than our estimation because measured signals include not only bremsstrahlung but also recombination radiation and impurity radiation. It is noted that recombination radiation and impurity radiation c Scintillator based diagnostics would work well in deuterium experiment from our estimate. Design of the γ-ray shielding is the key point for detecting SXs.

From the design shown in Fig 1, we installed the prototype of the scintillator-based detector and applied it to the 18th campaign experiments with Hydrogen gas. The basic function of the detector was confirmed through the experiments.

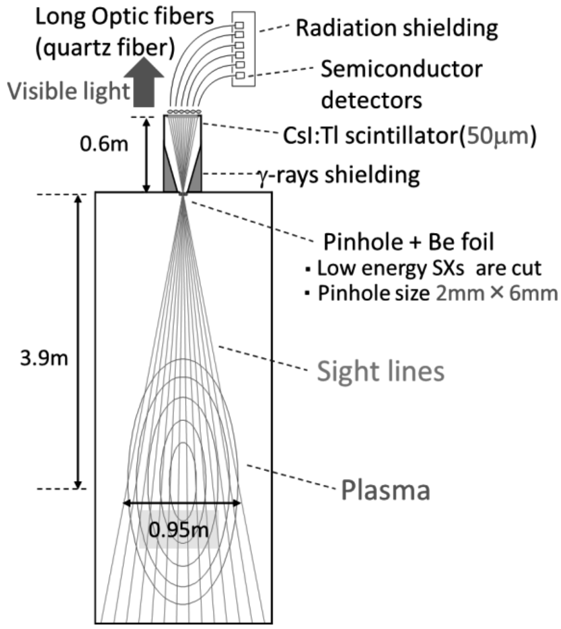

Fig. 1. The schematic view of the design of the diagnostic is shown. Sight lines viewing a plasma cross section are shown as green lines.

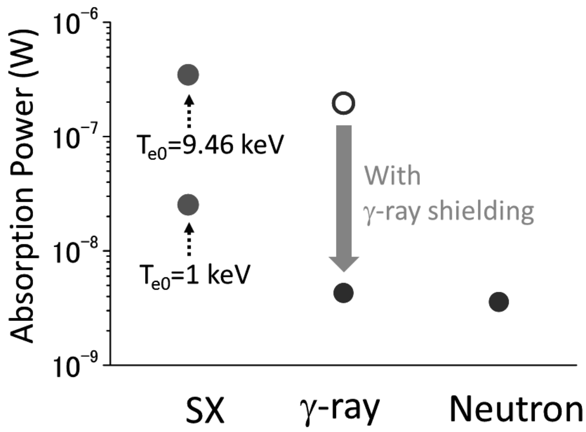

Fig. 2. The absorption powers from SXs, γ-rays, and neutrons are shown.

1) D. Stutman et al.: Rev. Sci. Instrum. **76** (2005) 023505.