§61. Development of Fine Resolution Computer Tomography Using Multi-channel Visible Spectroscopic System

Fujisawa, A. (Kyushu Univ.), Ohyama, N. (Kyushu Univ.), Tobimatsu, Y. (Kyushu Univ.), Shimizu, A.

Computed tomography is a possible method to deduce internal spatial pattern and its evolution of plasma without giving any disturbance to the plasma. In fact the X-ray tomography for high temperature plasmas has contributed to clarifying the plasma evolution in magneto-hydro-dynamics (MHD) phenomena such as sawtooth oscillation. If the spatial resolution with the detector used for the computed tomography can be increased sufficiently in future, the method can be used to deduce the pattern and its evolution of plasma turbulence and contribute to the clarification of plasma turbulence and resultant transport.

However, usages of the detectors with a usual size of 1cm order give a limit of the number of the channels; in fact approximately several dozen channel can be equipped at a port at maximum so far. Therefore, the spatial resolution should not be improved and not to be used for identifying micro-scale structure, possibly the size of ion Lamor radius, of turbulence structures. Therefore, an invention should be necessary to increase the number of the channels of the detector to perform the computed tomography of plasma turbulence with a sufficient spatio-temporal resolution. Here we propose a diagnostic system for computed tomography of plasma turbulence, utilizing optical fibers whose radius is less than 1 mm to increase the detection channels, and utilizing several different lights with wavelengths to cover the whole region of plasma, so-called super multi-channel detection with multi-wavelengths. The purpose of the study is to make a prototype or a test system of such a multi-channel detectors for the computed tomography of plasma turbulence, using an efficient use of optical fiber arrays, to realize a fine spatial resolution.

In this system, the visible light can be led into the optical fiber directly, while the other rays, for example, X-ray and ultra-violet lights are indirectly led into transmission fiber arrays after converting to visible lights using scintillator and fluorescence medium, respectively. The light signals are conveyed through the transmission fibers to the amplifier system located sufficiently away, therefore, the electric interference can be avoided to reduce the noise. This property is advantageous in improving the signal-to-noise ratio of the system. We made a prototype for visible light, that is, multi-channel detection of H-alpha in QUEST tokamak.

The prototype is composed of optical feed-through, collimator, filter, and fiber transfer, where the optical feed-through is the vacuum flange with fibers to transfer the filtered photons from the vacuum side to the atmosphere side. The conceptual view of the system is shown in Fig. 1. Here, the fluorescence fiber is used as the elements of optical feed-through for future detection of ultra-violet lights; the ultra-violet light is converted to visible light at the optical feed-through. The top view of the prototype is shown in Fig. 2, where the optical feed-through is made in ICF152 flange. The system has 45 channels aligned to observed both poloidal and toroidal directions of QUEST tokamak. The shape of the H-alpha light filter is chosen as an octagon. The length of the transmission fibers is 10 m, and interfaces are made to connect the optical feed-through to the transmission fibers.

Using the developed system of 45 spatial channels, the propagation of the waves or patterns can be measured both in toroidal and poloidal directions. The propagation velocity can be evaluated using the method of time delay estimate (TDE), which has been used in beam emission spectroscopy (BES) [1]. In the following fiscal year, we will prepare sufficient number of digitizers and amplifiers for the multi-channel detection, and make the first trial to evaluate the plasma flow velocity using the TDE method.

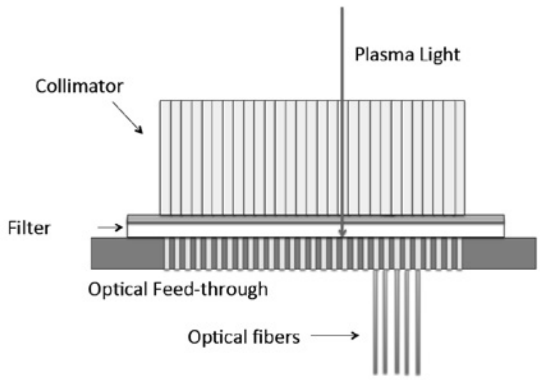

Fig.1. A conceptual view of a light detection system for computed tomography. Collimator and filter are used to limit the line-of-sight and wavelength of the detected lights, respectively. The optical feed-through is made of fluorescence fibers to convert ultra-violet light to visible one for avoid the reduction of light signals for the transfer of optical fibers outside.

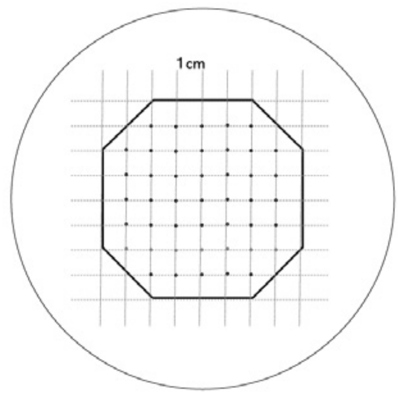

Fig. 2. The prototype made for H-alpha detection of QUEST tokamak. The system on an ICF152 flange has 45 channels aligned both in toroidal and poloidal directions.

[1] G.R. McKee et al., Rev. Sci. Instrum. 77 10F104 (2006)