§17. Development of a Beam Emission Spectroscopy for Density Fluctuations in CHS

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It has widely been recognized that microturbulence in plasmas is a leading candidate to drive anomalous transport in torus plasmas. This microturbulence manifests itself as fluctuations in the plasma densities, potentials, and temperatures. Beam emission spectroscopy (BES) has been proposed as a method for the measurement of long wavelength plasma density fluctuations in CHS device.

The BES system measures emission from the collisionally excited neutral atoms of a high energy beam injected to the plasma. The fluctuation level of the intensity of emission is considered to be the fluctuation of plasma density because the intensity of the emission is proportional to the density of plasmas at reasonable plasma parameters. The emission from the beam atoms can be distinguished from the bulk plasma emission by taking advantage of Doppler shift. Balmer- α emission from H beam atoms injected from 1O port (NBI#2) is used for the fluctuation measurement, and a detection system of the BES on the CHS was developed.

A top view of the sight lines of BES in the CHS is shown in Fig.1 together with the beam line of NBI#2. In order to have a good spatial resolution, the sightlines from 8O port are approximately tangent to the local magnetic field and nearly parallel to the beam line to yield large Doppler shift of the beam emission. An object lens having the focal length of 71.5mm is placed to image about 172mm in the poloidal cross section onto the 16 channel fiber array, each of which has 880 μm core diameter. At present, we have 8 detectors and arbitrary 8 channels out of 16 sightlines can be selected.

The detection system is shown in Fig.2. This system consists of 8ch optical band-pass tunable interference filter system, 8 avalanche photo-diode (APD) detectors and isolation digitizers (YOKOGAWA WE7000 system, WE7275 module). The interference filters transmit the wavelength range including the Doppler-shifted full energy (E) beam emission only and eliminate the emission from the bulk plasma, impurity lines, and other beam components such as second (E/2) or third (E/3) energy fractions.

The emission from different sightline has different Doppler shift depending on the angle between the beam line and the sightline. For example, the Doppler-shifted wavelength of Balmer- α line from the NBI#2 beam with the acceleration voltage of 30keV is 652.00nm at the inner-most channel and 651.40nm at the outer-most channel. Therefore, interference filters were selected so that their band centers corresponded to the Doppler-shifted emission from each sightline. Central wavelength of the filter needs to be finely tuned corresponding to the beam energy variation from 25 to 30keV. In the inner-most channel, the wavelength of emission from 30 and 25keV beams are 652.00nm and 652.34nm, respectively. The beam emission observed should have an additional broadening in wavelength due to the beam divergence and focusing at the port and due to the finite solid angle of the imaging optics. These effects result in the broadening of about 0.4nm. Therefore, filters having the pass band in FWHM of 0.5nm typically centered at 652nm were employed. Central wavelength of the filters can be tuned by controlling their temperature by 0.018nm/K, which covers the energy range mentioned above by changing the temperature by 30K.

For the temperature control, filters are set in the thermal insulator housings equipped with a heater and a thermistor. Heating powers for each filter are controlled by the potentiometer. The temperatures are measured with the resistance of thermistors using 10 Ω shunt resistors inserted in series with each thermistor. To tune the central wavelength of the filter to the wavelength of measurements, calibration between the central wavelength of the filter and the resistance of the thermistor is needed. The calibration curve can be obtained by measuring central wavelength of light after passing through the filter with spectrometer by scanning the temperature from 30 to 60℃ which is within the controllable temperature range.

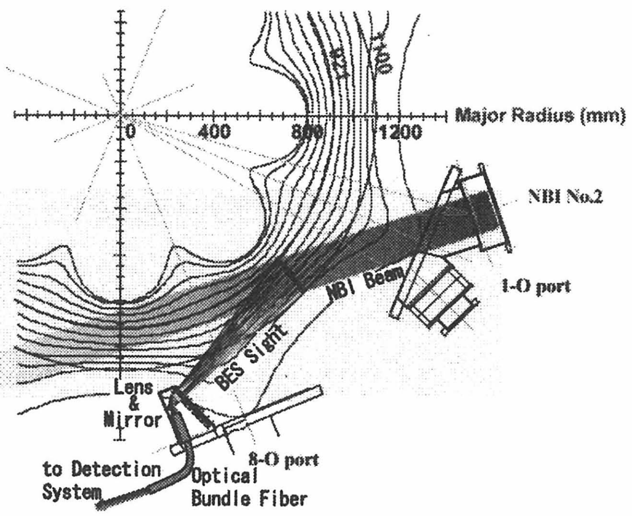

Fig.1. Schematic of the BES system on CHS device.

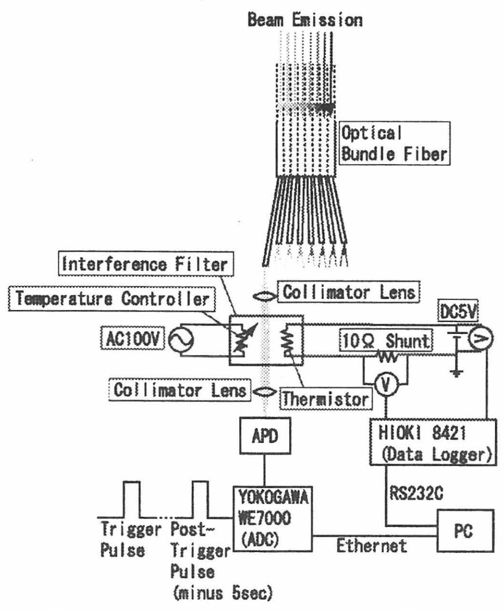

Fig.2. The system detecting signals of beam emission.