Absolute value measurement of ion-scale turbulence by 2D-PCI in LHD

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Ion-scale turbulences in magnetically confined plasmas play a significant role in a plasma confinement. Phase contrast imaging (PCI) is one of the promising techniques to measure density fluctuations caused by ion-scale turbulence in high-temperature plasmas[1]. In the Large Helical Devise (LHD), a PCI using a CO_2 laser as a light source and a 6×8 two-dimensional photoconductive mercury tellurium cadmium (MCT) detector shown in Figure 1 for detection is in operation and is called a two-dimensional PCI (2D-PCI). The advantage of PCI is that it can theoretically determine the absolute value of the turbulence amplitude which is less than 1% of the electron density from $I_{AC}/(2\times I_{DC})$. Here, I_{AC} and I_{DC} are AC and DC components of a detected intensity signal. In addition, 2D-PCI can measure the time evolution of the spatial profile of the turbulence by applying the magnetic shear technique[1]. However, in practice, the MCT detector has nonlinear response characteristics of the incident laser power[2], making the absolute measurement difficult. In the previous work, an absolute value evaluation method was established by simultaneously performing sound wave measurements with HeNe laser interferometer [2]. In this study, the turbulence profile in LHD is evaluated in absolute value according to the process shown in Figure 2. First, the line-integrated turbulence amplitudes are evaluated for each channel and their average and standard deviation are obtained, as shown in Fig. 2(a). Then the turbulence profile is evaluated in arbitrary units as shown in Fig. 2(b). Finally, the integrated value of the turbulence profile in the line-of-sight direction and the average value of the line-integrated turbulence amplitude are determined to coincide, and errors were evaluated from standard deviations, as shown in Fig. 2(c). In this study, in addition to the above, we report the results compared with other diagnostics and nonlinear gyrokinetic simulations.

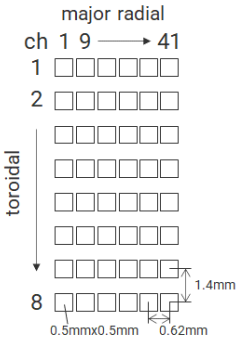

Figure 1. Layout of MCT detector for 2D-PCI

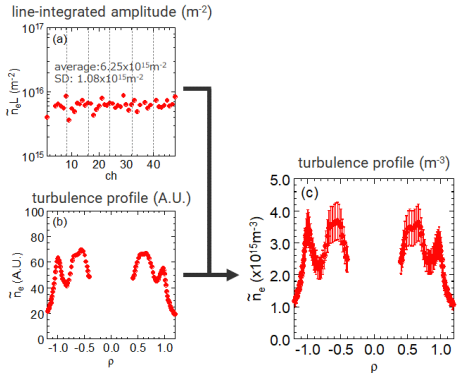

Figure 2. Process for evaluating the absolute value of fluctuation distribution.

[1] K. Tanaka *et al.*, Rev. Sci. Instrum. **79** (2008) 10E702

[2] T. Kinoshita *et al.*, JINST **15** (2020) C01045

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