4th Asia-Pacific Conference on Plasma Physics, 26-31Oct,2020, Remote e-conference

Application of the Abel-inversion method for the hard X-ray camera on the HL-2A tokamak

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Energetic electrons existing widely in magnetic confinement fusion plasma emit hard X-rays via bremsstrahlung. Hence, hard X-ray diagnostics plays an important role in the behavior research of energetic electrons in magnetic confinement fusion plasma. In order to study the distribution of energetic electrons and its evolution in plasma, hard X-ray cameras[1] can be used to perform such measurements via measuring the hard X-ray emission profiles in real time. For this purpose, the HL-2A tokamak[2] has equipped with an excellent hard X-ray camera[3], which was introduced from CEA in 2018. The hard X-ray camera has performed some detailed researches of the energetic electron bremsstrahlung emission in the hard X-ray (HXR) energy range from 20 to 200 keV on the TORE SUPRA tokamak during lower hybrid (LH) current drive experiments[4]. In order to evaluate the local HXR emission profile, a reconstruction procedure based on the Abel-inversion method has been developed.

Verification for the profile reconstruction procedure is necessary since its accuracy and practicability is important for its application. Its accuracy was verified under ideal conditions [Fig. 1(a) and (b)], and its practicability was verified under an actual condition [Fig. 1(c)].

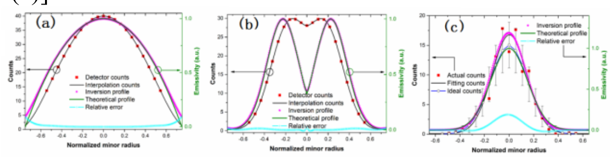

Fig. 1. Accuracy verification with a conic shape profile (a) and a Gaussian shape profile (b); Practicability verification with a Gaussian shape profile (c).

Experiments have been carried out for the HXR emission profile study. Time traces of some LHCD plasma parameters for discharge shots #36443 and #36579 are shown in Fig. 2. The HXR counts in Fig. 2 are recorded by the central chord of the hard X-ray camera. It shows that HXR counts depend mainly on the competitive relations among the loop voltage, the electron density and the power of lower hybrid wave.

The local HXR emission profiles during LHCD for shot #36579 and shot #36443 were reconstructed with the profile reconstruction procedure developed in this work. The time evolutions of the local HXR emission profiles are shown in Fig. 3. Fig. 3(a) indicates that all the profiles are peaked in the plasma center region ; Fig. 3(b) demonstrates that although most of the profiles are peaked in the plasma center region, a fraction of them cover the plasma peripheral region, which means a degradation of the confinement quality for the energetic electrons. The degradation can be interpreted as mainly due to the more prominent fluctuations of n_e for shot #36443.

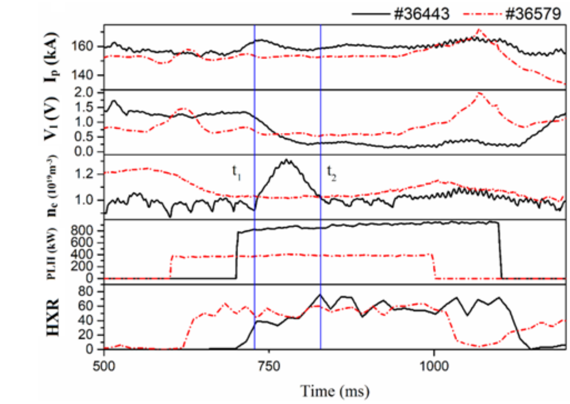

Fig. 2. Time evolution of some relative parameters for discharge shots #36443 and #36579.

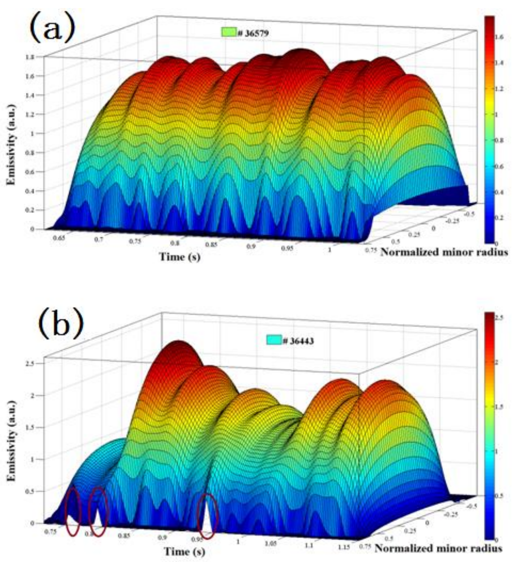

Fig. 3. Time evolution of the reconstructed Abel-inverted HXR profile for shot #36579 (a) and shot #36443 (b).

This work was supported by the Talent Pyramid Plan of SWIP Innovation Action (Grant No. 201901XWCXRC004).

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