A new hard x-ray spectrometer for suprathermal electron studies in TCV

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The first camera of a novel hard x-ray tomographic spectrometer (HXRS) diagnostic [1] was installed and operated successfully on the TCV device for the purpose of investigating the physics of suprathermal electrons generated by ECRH and by internal MHD events. In its basic configuration, its 24 lines of sight cover the whole poloidal plasma cross section; in addition, the instrument can be rotated to a horizontal arrangement to observe the plasma in both toroidal directions simultaneously. The CdTe detectors have an energy resolution of 7keV in the range 13 – 300keV and are connected via fast amplifiers to a digital acquisition system acquiring 12 Msamples per second. The robustness of the diagnostic was proven by its flawless operation during more than 1000 plasma discharges.

The analysis freedom afforded by direct pulse acquisition allows an optimized balance of time, space and energy resolution depending on the photon statistics. Several pulse detection algorithms were studied and compared with the aim to handle count rates up to several hundred kHz. Radial emission profiles are obtained through general inversion techniques. The data are analyzed in conjunction with Fokker-Planck modeling to explore the underlying suprathermal electron dynamics.

This new diagnostic is performing measurements that were hitherto not possible. For instance, the asymmetric Bremsstrahlung emission of suprathermal electrons generated by ECCD in the forward cone due to relativistic effects was observed and quantified for the first time. A more general though preliminary study of the response of the electron population to ECRH and ECCD was also performed for a limited plasma parameter range. Additionally, initial measurements of the electron dynamics associated with sawtooth crashes were performed, with high time resolution achieved through conditional averaging. While the emission profiles in the low energy range correspond to the typical soft x-ray signal with a fast decay at the crash, a sharp emission peak of high energy photons can be observed immediately after the sawtooth crash.

The full power of the diagnostic will be realized with the imminent installation of 3 more cameras, which will permit a full tomographic analysis of the highly shaped plasmas of TCV.

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References