2D X-ray spectrometer on WEST: diffracting crystals study and first temperatures profiles

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A 2D X-ray spectrometer has been installed and operated on WEST. Based on the Bragg's diffraction law, three crystals, mounted on a rotating table, give access to physical parameters such as Te and Ti through the Ar XVII K-α spectrum (∼3.97 Å), the Ar XVIII Lyman-α spectrum (∼3.73 Å) and the Fe XXIV K-α spectrum (∼1.86 Å).

During the first campaigns, the spectrometer results for the ArXVII crystal revealed doubled spectra, presumably because the crystals have been manufactured as two independent pieces standing next to each other on the same curved support. These doubled spectra can be fitted with two parameters, an amplitude ratio and a spectral shift, essentials to extract the temperature profiles of the plasma.

This paper present experimental and ray-tracing evidence that the observed spectral shift is indeed due to the double crystal but also to an intrinsic defect, a non-parallelism between the crystal's optical surface and its inner mesh. Then, it shows how to best model and fit the doubled spectrum by studying how the doubling parameters vary on the surface of the detector. Indeed, significant variations over the entire detector area in spectral shift are demonstrated.

Regarding the variations in the amplitude ratio, several hypothesis are being investigated among which a vignetting by a spectrometer element and an effect of the polarization of the X-rays. Although an absolute calibration of the detector has not been done yet, a rocking curve is numerically estimated in order to characterize the reflectivity power with respect to the incident angle, the wavelength and the polarization of incident photons. Depending exclusively on crystallographic properties, this technique can reveal the influence of crystal defects, and more importantly the non-parallelism, on the diffraction pattern. Numerical curves are used to estimate the effect of the polarization on the rocking curve.

Finally, systematic analysis of the electronic temperature proxy profile estimated by the spectrometer will be carried out, in comparison with the ECE measurements, confirming that the spectrometers yields very valuable profile measurements.