Very high-spatial and spectral resolution spherical crystal X-ray Kα spectrometer for the study of warm dense matter in laser produced plasmas

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Study of warm dense matter in laser produced plasma is one of the most important subject in plasma physics since more than a decade. The emergence of X-ray Free Electron Lasers (XFEL) and fs-lasers generated plasmas made their diagnostic essential for a good understanding of all observable phenomena. In the meantime, simulation for these plasma conditions is extremely difficult to perform accurately.

On another hand, study of hot electrons is a fundamental topic in plasma physics for laser-matter interaction. Their non-Maxwellian energy distribution as well as their impact on ionic fractions and atomic processes make them very challenging to apprehend.
At the very beginning of their interaction with matter, they propagate inside a warm and dense plasma making them even more difficult to diagnose.

In order to improve our understanding of these problematics, we implemented, during an experiment at the LULI2000 facility using the NANO2000 kJ-laser, a specific configuration of a FSSR X-ray spectrometer (HiSp FSSR-1D) centered on the warm X-ray emission of Copper providing an extremely high spatial resolution ($\delta x \approx 6.5\mu m$) and a high spectral resolution ($\lambda/\Delta\lambda \approx 3100$). This configuration provides a very fine description of the plasma expansion while providing precious information on atomic physics processes occurring during the first instants of the laser-plasma interaction. Combined with other diagnostics, this tool might improve our description of warm dense matter.

We report this spectrometer configuration in the context of a kJ-ns-laser experiment, the associated challenging experimental procedure and the recorded spectra.