New high-speed spectrometer system for photon-starved applications at HSX

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Further improvements of the diagnostic capabilities in fusion energy research are a key element to a better understanding of plasma behavior and confinement. Here, the development of and first results from a novel single channel Echelle spectrometer are presented. The spectrometer will be employed for motional stark effect spectroscopy in the plasma edge region which simultaneously requires high temporal and high spectral resolution. This is achieved using an Echelle grating, offering very high dispersion, combined with custom made low F/# optics – optimized using a python ray-tracing and global minimization software for low image distortion. Moreover, a round-to-linear fiber bundle is employed in place of a traditional slit, significantly improving light throughput. To filter the light entering the spectrometer, a collimated aspheric optic is used, and a pickoff mirror inside the spectrometer permits operation close to the Littrow configuration. For the light detection, a high-speed low-noise CCD camera with a vertical-binned operational mode is used which permits operation with upto 10 kHz. First results with frame rates in the kHz range and high signal to noise ratios will be presented. The overall design maximizes light throughput beyond that of a traditional spectrometer, while preserving enough image quality and spectral resolution for a wide range of possible future uses in other photon-starved applications.