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Observing Fast Fluctuations in Condensed Matter: X-Ray Photon Correlation Spectroscopy (XPCS) Performed with the Fast CCD (FCCD)[1]

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Fast, small-pixel, hard-x-ray-sensitive, area detectors capable of faithfully recording small numbers of scattered photons in short exposure times with high fidelity are key for advancing the capability of multispeckle XPCS to observe spontaneous fluctuations in condensed matter across a wide range of time and length scales. Also desirable is an open control architecture that enables the development of high-performance, closely-integrated application-specific detector data processing as far upstream as possible in the acquisition sequence. The FCCD is ideally suited to meet these requirements. I will describe Advanced Photon Source (APS) beamline 8-ID-I's implementation of the FCCD to perform fast multi-speckle XPCS with full-frame time sensitivity to 10 ms and effectively no dead time between frames using frame-transfer mode. We have leveraged this capability to provide a variably-sized area of interest mode that provides even faster time sampling over reduced collection areas. I will also discuss the integration of the FCCD with high-performance computing capabilities (HPC) in the control crate for producing upstream-compressed data streams that allow the acquisition of 100,000 or more detector frames without pausing. Upstream compression also enables rapid streaming of FCCD data away from the detector and close integration with external HPC resources that rapidly reduce speckle pattern time sequences to physically meaningful time autocorrelation functions. Beamline productivity is greatly increased by this capability. Lastly, I will present selected science applications in soft matter enabled by the FCCD system, namely unusual diffusion observed in nanoparticle fluids and in polymer nanocomposites.

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