Application of an EMCCD Camera for Calibration of Hard X-Ray Telescopes

Recent technological innovations now make it feasible to construct hard x-ray telescopes for space-based astronomical missions. Focusing optics are capable of improving the sensitivity in the energy range above 10 keV by orders of magnitude compared to previously used instruments. The last decade has seen focusing optics developed for balloon experiments [1] and they will soon be implemented in approved space missions such as the Nuclear Spectroscopic Telescope Array (NuSTAR) [2] and ASTRO-H [3]. The full characterization of x-ray optics for astrophysical and solar imaging missions, including measurement of the point spread function (PSF) as well as scattering and reflectivity properties of substrate coatings, requires a very high spatial resolution, high sensitivity, photon counting and energy discriminating, large area detector. Novel back-thinned Electron Multiplying Charge-Coupled Devices (EMCCDs) [4] are highly suitable detectors for ground-based calibrations. Their chip can be optically coupled to a microcolumnar CsI(Tl) scintillator [5] via a fiberoptic taper. Not only does this device exhibit low noise and high spatial resolution inherent to CCDs, but the EMCCD is also able to handle high frame rates due to its controllable internal gain. Additionally, thick CsI(Tl) yields high detection efficiency for x-rays [6]. This type of detector has already proven to be a unique device very suitable for calibrations in astrophysics: such a camera was used to support the characterization of the performance for all NuSTAR optics [7]-[9]. Further optimization will enable similar cameras to be improved and used to calibrate x-ray telescopes for future space missions. In this paper, we discuss the advantages of using an EMCCD to calibrate hard x-ray optics. We will illustrate the promising features of this detector solution using examples of data obtained during the ground calibration of the NuSTAR telescopes performed at Columbia University during 2010/2011. Finally, we give an outlook on ongoing development and optimizations, such as the use of single photon counting mode to enhance spectral resolution.