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Development of High Spatial Resolution Camera for Characterization of X-ray Optics

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Technological innovations in grazing incidence X-ray optics have been crucial to the advancement of the field of X-ray astronomy. These X-ray focusing optics are capable of improving the sensitivity of X-ray telescopes operating in the energy range above 10 keV by orders of magnitude. Full characterization of the X-ray optics includes measurement of the point spread function, scattering, and reflectivity properties of substrate coatings. This requires a very high spatial resolution, high sensitivity, photon counting and energy discriminating, large area detector. In this paper we describe the construction of a camera using EMCCD that is well suited to meeting these requirements.

Back thinned EMCCD cameras have very high quantum efficiency, high spatial resolution and ability to detect very low light levels because of very low read noise. They can be coupled via a lens to a bright scintillator but this configuration has very low efficiency for detection of the scintillation light and limits the performance of the camera. We overcome this limitation by optically bonding a 3:1 fiber optic taper to the EMCCD chip. This improves the light coupling efficiency and increases the detector active area to 25.2 mm x 25.2 mm with effective pixel size of 49 microns. Furthermore, the sensitivity of the detector is increased without degrading spatial resolution by coupling the detector to micro-columnar CsI(Tl) scintillator that was tailor-made to thickness than can efficiently absorb 10 to 100 keV X-rays with high efficiency. Methods to improve light transport from scintillator to EMCCD were devised by direct deposition on to the fiber optic taper. Characterization of the scintillator performance in terms of its light transport properties and spatial resolution, and the performance of the X-ray camera as a whole will be described.

A prototype version of this camera was used to help characterize the performance of the X-ray focusing optics for the Nuclear Spectroscopic Telescope Array (NuSTAR) mission. Data obtained during the ground calibration of the NuSTAR telescopes demonstrate the advantages of the detector.

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Poster

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