Phase 2 Project Summary

Firm: Radiation Monitoring Devices, Inc.
Contract Number: NNX12CA83C
Project Title: High Resolution Detector for AT Wavelength Metrology of X-ray Optics

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

The recent Decadal Survey highlights the important contribution that X-ray astronomy can make in addressing some of the most pressing scientific questions and recognizes the research needed to mature the key enabling technology of X-ray optics. The development of next-generation X-ray optics will also need better imaging data to quantify performance and to calibrate flight-ready instruments. The reported development directly addresses this need by providing a unique detector designed specifically to support the development of the next generation of X-ray telescopes, allowing researchers and engineers to characterize such devices with high accuracy to optimize their performance.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The goal of the proposed research was to develop a high spatial resolution detector for at-wavelength metrology of X-ray optics. In addition to its superior spatial resolution, the detector will provide spectral information over a wide energy range of 8 keV to 100 keV, permit X-ray photon counting with rates exceeding tens of KHz, have a large active imaging area, and offer ease of use. The detector has undergone meticulous calibration using various X-ray sources. The work involved 1) Fabrication and characterization of high-performance scintillator sensors, 2) Design and assembly of a specialized CCD camera, 3) Algorithm development for improved spatial and energy resolution, and 4) Detector integration and detailed evaluations at RMD and at NASA's MSFC.

All the tasks were successfully performed, and the performance of the detector was demonstrated by performing experiments at RMD, LLNL, and MSFC.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

A new high resolution, large-area, high sensitivity X-ray/gamma-ray imaging detector was developed for X-ray optics calibration and metrology. The detector consists of a low readout noise sensor coupled to a bright, high efficiency scintillator through a 3:1 fiberoptic taper. The scintillators were developed in microcolumnar format to provide high resolution. The 3:1 fiberoptic taper provides the large imaging area needed for X-ray optics calibrations. The detector is capable of detecting single X-ray photon with high signal-to-noise ratio. To enable rapid and automated detection of single X-ray events, photon counting algorithms were also developed. The detector was fully tested in the laboratory using various X-ray and gamma ray sources. The final detector configuration was tested at the Stray Light Facility at NASA's MSFC.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

The Phase I prototype detector played a crucial role in the ground calibration of the two X-ray telescopes of NASA's SMEX mission, the Nuclear Spectroscopic Telescope Array (NuSTAR), launched in 2012. The Phase II detector, with its enhanced performance, will allow its use for several specific new missions and mission areas, including future X-ray missions for space astronomical observatories, which include the Focusing Optics X-ray Solar Imager (FOXSI), Spectrum Roentgen Gamma (SRG), and the Warm-Hot Intergalactic Medium Explorer (WHIMex) Mission. It can also be used for in-situ characterization during X-ray mirror assembly, as is performed at NASA's GSFC and MSFC.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

Due to its high intrinsic spatial resolution, individual X-ray and gamma-ray photon counting ability, spectral resolution suitable for many applications, and large imaging area, the proposed detector is expected to find numerous applications in fields of high resolution X-ray/gamma-ray detection, small animal single photon emission computed tomography (SPECT) and other nuclear medicine applications, X-ray medical imaging (including mammography, digital tomosynthesis and computed tomography), time-resolved X-ray diffraction studies at synchrotron sources, dynamic X-ray imaging of hypervelocity projectiles, X-ray microscopy, and low-light optical tomography. With its very high spatial resolution and high frame rate performance, this imaging detector may also be used for dynamic nondestructive evaluations (NDEs) of spacecraft and other components, which are routinely performed for quality assurance and design improvement purposes. The current annual commercial market for X-ray and nuclear imagers is estimated to be several billion dollars, a significant fraction of which represents areas where the proposed detector technology may be utilized.

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