EXIST: Surveying the birth and evolution of Black Holes

ProtoEXIST1

Antonio Copete1, B. Allen1, J. Hong1, J. Grindlay1, N. Gehrels2, S. Barthelmy3, R. Baker3, J. Apple3, C. Benson3, T. Garson4, H. Krawczynski4, R. McLean5, R. Cook5
1Harvard-Smithsonian CfA, 2GSFC, 3MSFC, 4Washington University, 5Caltech.

Introduction

ProtoEXIST1 is the first in a series of balloon-borne experiments for the development of the High Energy Telescope (HET) on the Energetic X-ray Imaging Survey Telescope (EXIST). EXIST is a next-generation wide-field hard X-ray survey mission with onboard X-ray/Optical/IR imaging/spectroscopy capability to explore the birth and evolution of black holes on all scales (see 217.08 and 435.04). The HET is a coded-aperture telescope employing a large-area CdZnTe detector (4.5 m²).

The feasibility of the construction and operation of a large array of tiled, finely pixellated CZT imaging detectors, as will be required for the EXIST HET, is the primary goal of the ProtoEXIST program. The ProtoEXIST payload consists of two coded aperture telescopes, each with a 264 cm² CZT detector, a 10x10 deg field of view and an angular resolution of ~10' (the pressure tank is designed to accommodate 4 independent telescopes for the future). The first flight out Ft. Sumner, NM is scheduled for the spring of 2009.

Coded Mask and Shield

A coded-aperture telescope employs shadowgram imaging modulated by a coded mask. The mask patterns on both ProtoEXIST1 telescopes are 2x2 cycles of 32x32 pixel Uniformly Redundant Arrays (URA) of 4.8 mm pixel elements, for an image oversampling factor of ~2. They are made of 10 stacked 41x41 cm sheets of 0.3 mm Tungsten (99.9%), each precision-etched with the URA pattern, for a total thickness of 3 mm, which effectively modulates photons of up to ~300 keV.

Both telescopes feature passive side shielding based on the graded Z-shield used for Swift-BAT and composed of layers of Pb/Ta/Sn/Cu.

Future Work

In order to demonstrate the CZT detector technology required for the EXIST HET (0.6 cm pixel pitch, 4.5 m² total area), ProtoEXIST2 will employ the DB-ASIC for NuSTAR with 1024 channels. In this configuration (2x2 cm², 0.6 mm pixel pitch) CZT detectors will be read out through a 1:1 interposer board coupled to a DCA controller board. The DCA and DCA modules for ProtoEXIST2 are illustrated in the figure to the immediate right. In ProtoEXIST3 the DB-ASIC will be superseded by the EX-ASIC (a 20µW/pixel version of the DB-ASIC) and the gaps required for the DB-ASIC readout channels will be removed to enable gapless tiling. For ProtoEXIST2 and 3 we will make use of all 4 independent telescope modules available in the ProtoEXIST pressure vessel, in order to test multiple 264 cm² detector configurations in a near-space environment.

Displayed in the top-left panel is the resolution map from a single DCA on the detector plane, which shows an average energy resolution of 3.1 keV (FWHM) at 59 keV. For the top-right figure, an 241Am source was shined through a 3 mm thick Pb mask with the word “EXIST” etched into it, in order to demonstrate the imaging capability of the tiled DCA array. The left panel shows the summed pulse height histogram of raw (black) and calibrated (red) data.

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