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MXT: a light X-ray telescope for X-Gamma-Ray Burst afterglow observations

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Abstract. We present the Microchannel X-ray Telescope (MXT), a new telescope that will be flying on the sino-french *SVOM* mission dedicated to Gamma-Ray Burst science. MXT is based on square micro-channel plates (MCP) optics, coupled with a low noise CCD. The MCP optics is based on the design of the MIXS-T telescope on board the ESA *BepiColombo* misson to Mercury, while the CCD is a pn detector, similar to those that will be at the focus of the eRosita telescopes. MXT is a compact and light (<30 kg) telescope with a 1 m focal length, and will provide an effective area of about 50 cm^2 on axis. The MXT PSF is ≤3.7 arc min (FWHM), and it has a sensitivity adequate to detect all the afterglows of the *SVOM* GRBs, and to localize them to better than 1 arc min for 90% of the afterglows (90% confidence radius, no systematics) after 5 minutes of observation. The MXT performance meets the *SVOM* science goals, and proves that small and light telescopes can be used for future small X-ray missions.

Key words. Stars: Gamma-ray burst: general – Instrumentation: miscellaneous

1. Introduction

The Microchannel X-ray Telescope (MXT) is being developed in the context of the *SVOM* mission. *SVOM* (**S**pace-based multi-band astronomical **V**ariable **O**bjects **M**onitor) is a sino-french Gamma-Ray Burst mission developed in cooperation by the French Space Space Agency (CNES), and the Chinese Academy of Sciences (CAS) (e.g. Götz et al. 2012). *SVOM* will carry two wide field instruments - the coded mask telescope ECLAIRs, providing the GRB triggers, and a non-imaging gamma-ray spectrometer GRM - and two narrow field instruments - a visible telescope, VT, and the MXT X-ray telescope - that are pointed at the ECLAIRs error box after an autonomous platform slew to observe the GRB afterglows. *SVOM* alerts will be transmitted to ground through a VHF Network, and will be delivered to the scientific community within 30 seconds from detection in most of the cases.

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2. The MXT concept

The MXT concept developed during its phase A is based on the coupling of the Micro Channel Plate (MCP) optics, designed for the

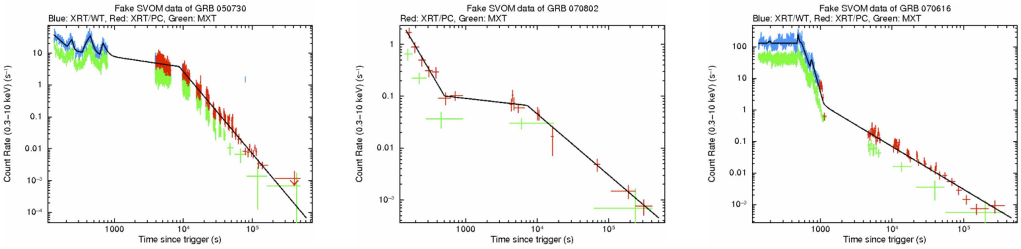

Fig. 1. Simulated MXT GRB X-ray afterglow light curves are shown in green, with the Swift XRT light curves from which they were derived shown in blue and red. The same binning algorithm is used for both instruments' light curves. The first-orbit brightness rank of the afterglows in the Swift sample are: left 65%, centre 21%, right 91%.

MIXS-T instrument (Fraser et al. 2008) on board the ESA *BepiColombo* mission, with a low noise X-ray camera. MXT will make use of pairs of radially packed 20 μ square-pore MCPs, in a conical approximation to the Wolter type I focusing geometry. The glass MCPs are coated with a thin layer of a high Z element (e.g. Platinum, Iridium, etc.) to boost reflectivity, especially at higher energies. The focal length is 1 m, determined by the 4 and 1.33 m slump radii of the front and the rear MCP plates. X-rays entering the first plate are reflected at grazing incidence from an internal channel wall; upon exiting the front MCP, the photons enter a micro-channel in the rear MCP where a second reflection takes place. After two reflections, the beam converges in the focal plane. The currently measured PSF for such a system is 3.7 arc min, and the field of view will be 64×64 arc min (as defined by the CCD size).

The MXT camera design is based on a pn CCD developed by the MPE/HLL for the *DUO* Mission (Meidinger at al. 2006), which is a small scale version of the eROSITA detectors. The pn CCD has an active area of 256x256 pixels of 75 μ, and a reduced frame store area. The CCD is read out in parallel by two CAMEX ASICs, and has an excellent low-energy response coupled to a very low read-out noise, and intrinsic radiation hardness. The detector will be shielded by 3 cm of equivalent Al, and cooled by the thermo electric cooler to -65° C. The camera will include digital and analog front-end electronics, to drive the CCD and to perform its readout, and a "filter wheel" to be also used as a shutter to protect the CCD during the passages in the Southern Atlantic Anomaly, and to put a calibration source (e.g. ^{55}Fe) in front of the detector when needed. The GRB afterglow positions will be computed in real-time, on board, by the MXT Data Processing Unit (DPU).

3. MXT expected performance

The MXT performance has been determined by simulating the entire Swift/XRT afterglow data set through the MXT response. One can see that the MXT is fully adapted to the study of SVOM afterglows. In terms of localizations, 50(90)% of the bursts will be localized to better than 20(60) arc sec (90% statistical error radius) within 5 minutes of the trigger. In addition, despite the smaller effective area with respect to XRT, most of the afterglows will be detected up to 10^5 seconds after trigger, with a good sigal-to-noise ratio, see Fig. 1.

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