The Swift-XRT Deep Serendipitous Survey

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Abstract

The Swift-XRT Deep Serendipitous Survey is a large ($\sim$ 32.5 deg.^{2}) rather deep (0.5-2 keV flux limit $\sim 7\times10^{-16}$ erg cm^{-2} s^{-1}) X-ray survey obtained by searching for serendipitous sources around 372 Gamma Ray Burst (GRB) observed with the XRT telescope on board of the Swift satellite, from January 2005 to December 2008. Here, we report on the strategy, design and execution of the survey, and we present first results on the catalog of point-like X-ray sources detected in the observations carried out between January 2005 to June 2007 (237 fields). For the high Galactic latitude fields (i.e. |b| >=20 deg.), we also present the X-ray number counts (i.e. LogN-LogS), that is consistent with previous results.

Key words: X-ray, surveys, Active Galactic Nuclei.

1. Introduction

An efficient way to complete the census of Active Galactic Nuclei (AGN) is to use X-ray surveys, which have been found to select efficiently AGN of many varieties, and at higher surface densities than ever (e.g. $\sim$ 2000 deg^{-2} at the limiting flux of C-COSMOS, Elvis et al. 2009, in comparison with less than $\sim$ 500 deg^{-2} in the most recent optical surveys). Up to date, *Chandra* and *XMM-Newton* have perfomed numerous deep pencil beam surveys and shallow wide contiguos surveys (see Fig. 1). These two types of surveys are complementary to each other. Deep pencil beam surveys are essential to study the population of faintest X-ray sources; yet, since they sample very small regions of the sky, they are strongly affected by cosmic variance. On the other hand, wide shallow contiguos surveys are less affected by cosmic variance, and are sensitive at relatively high fluxes, where only a small fraction of AGN can be detected.

The gap beetwen the deep pencil beam surveys and the wide contiguos shallow surveys is filled by the very large, not contiguos, shallow-medium deep surveys. This type of surveys, exploiting the very large amount of archival data from *Chandra* and *XMM-Newton* satellites, covers very large sky area, thus permitting the discovery of rare objects, like e.g. high luminosity obscured AGN.

Within this context we have started a large rather deep survey using the GRB fields, observed by the XRT Telescope on board of the Swift satellite (Gehrels et al. 2004), the *Swift-XRT Deep Serendipitous Survey* (SXDSS). This survey presents a few advantages compared to other large area X-ray surveys. First, Swift is a mission devoted to discover GRBs and follow-up their afterglows, thus the same sky region can be observed for very long exposures (up to 1.17 Msec, GRB060729). This, together with the very low background of the XRT camera ($\sim 1{-}2\times10^{-4}$ counts/arcmin^2/sec in the 0.3-3 keV band), allows to reach a flux limit of $\sim 7\times10^{-16}$ erg cm^{-2} s^{-1} in the 0.5-2 keV band, that is definitely deeper than the other similar large area surveys, and comparable only with the CHAMP survey (see Fig. 1). Second, the XRT Point Spread Function and vignetting factor, being approximately constant across the field of view, secure a rather uniform sky sensitivity. Third, the GRBs explode randomly in the sky, with isotropic distribution (Briggs 1996, see Fig. 2) and SXDSS does not suffer of possible biases towards already known bright X-ray sources, as the large serendipitous surveys based on X-ray archival data, like Einstein, ROSAT, Chandra and XMM-Newton data.

2. Observations and data reduction

The SXDSS is made up of 372 GRB fields observed with XRT from January 2005 to December 2008, with a total exposure time $\gtrsim$ 10 ksec for each field. Here, we present the first 237 fields, observed from January 2005 to June 2007. The XRT data were processed with the XRTDAS software (Capalbi et al. 2005[1]) developed at the ASI Science Data Center and included in the HEAsoft 6.4 package distributed by HEASARC. The observations of each GRB were processed, and the final cleaned event

*1 http://heasarc.nasa.gov/docs/swift/analysis/xrt_swguide_v1_2.pdf

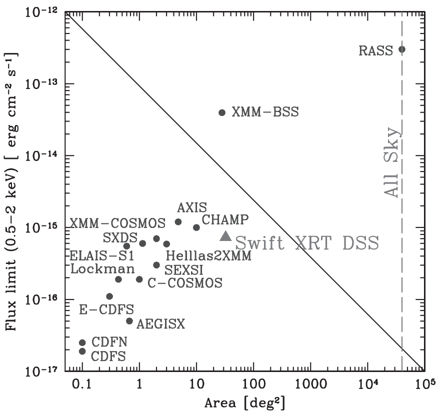

Fig. 1. The 0.5-2 keV flux limit vs. the area coverage for various surveys (solid dots) and for the total SXDSS (solid triangle).

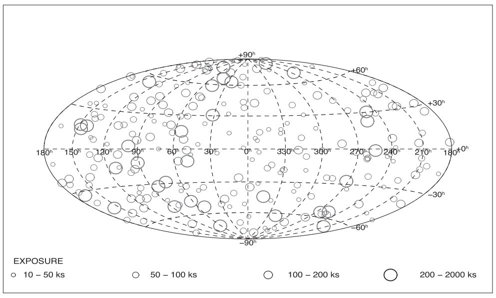

Fig. 2. Aitoff Projection in Galactic coordinates of the 237 GRB fields observed from January 2005 to June 2007. The symbol sizes are proportional to the exposure time.

files were then merged to obtain a single event file for each GRB field.

3. The catalog and X-ray number counts

The X-ray point source catalog was produced using the detection algorithm *detect*, a tool of the XIMAGE PACKAGE version 4.4.1[2], on each deep GRB field. *Detect* locates the point sources using a sliding-cell method. We ran *detect* on the summed GRB event file and produced a catalog using a significance level of P$= 4\times10^{-4}$. Here we present only a more conservative cut to a significance level of P$= 2\times10^{-5}$, to minimize the number of spurious sources. This probability corresponds to about 1-2 spurious sources for each GRB field. We applied *detect* on the XRT image using the original bin size, and in the three energy bands: 0.3-10, 0.3-3 and 2-10 keV. For each GRB field we detected only sources in a circular area of 10 arcmin radius centered in the median of the individual aim-points. This candidate source list has been also cleaned from obvious spurious sources, like detection on the wings of the PSF or near the edges of the XRT CCD, spurious fluctuations on extended sources etc., through visual inspection of the XRT images in the three bands. We detected 6689 and 4950 sources with a significance level $\leq 2\times10^{-5}$ in at least one band, in the 237 fields and in the 162 fields at high Galactic latitude ($|b| \geq 20$), respectively (see Fig. 3). Fig. 4 shows the X-ray number counts of the high Galactic latitude sample in two energy bands, nicely consistent with the results from other surveys.

*2 http://heasarc.gsfc.nasa.gov/docs/xanadu/ximage/ximage.html

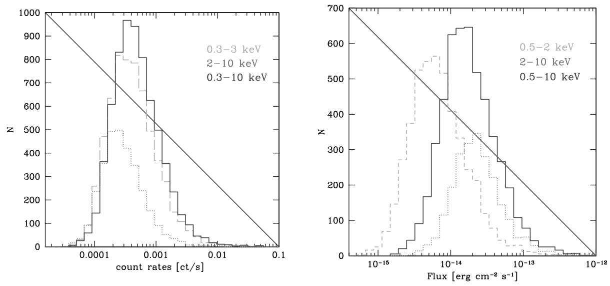

Fig. 3. Left panel: the distribution of the count rates of the sources detected in the S (green dashed histogram), H (red dotted histogram) and F (blue solid histogram) band of the total sample. Right panel: the distribution of the fluxes of the sources detected in the S, H and F band of the high Galactic sample (symbols as in the left panel).

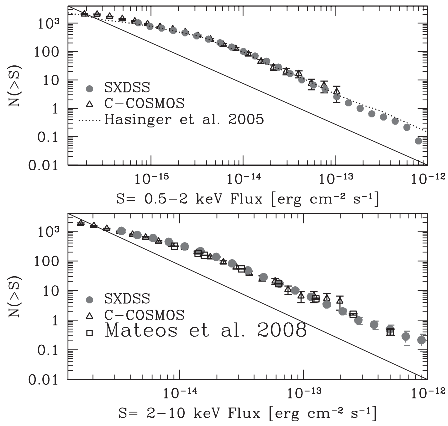

Fig. 4. The X-ray number counts for the high Galactic latitude sample. The top panel shows three 0.5-2 keV band curves: SXDSS (solid dots), C-COSMOS (open triangle, Elvis et al. 2009) and the Hasinger et al. (2005, dotted line). The bottom panel shows three 2-10 keV band curves: SXDSS (solid dots), C-COSMOS (open triangle, Elvis et al. 2009) and the Mateos et al. (2008, open squares) compilation.

References

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