The Swift-XRT Deep Serendipitous Survey: SXDSS

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Outline:

• What is the Swift-XRT Deep Serendipitous Survey?
• Why carry out the Swift-XRT Deep Serendipitous Survey?
• The Swift-XRT Serendipitous Survey Deep in a context.
• The point-like catalog: numbers!
• The High Galactic sample: X-ray number counts, hardness ratio analysis, angular correlation function.
• Future projects.
The Swift-XRT Deep Serendipitous Survey (SXDSS)

- X-ray serendipitous point-like sources detected in the XRT observations of the Gamma Ray Burst Fields (GRBs). The extended X-ray sources are included in a separate catalog (Moretti et al. in preparation).

- The detection algorithm was applied on a total event file, obtained, for each GRB by the sum of the individual sequences.

- We have analyzed the GRBs followed by XRT from January 2005 to December 2008 with exposure time $\geq 10$ ks

- 372 fields ($\sim 32.46$ deg$^2$)
- 253 fields ($\sim 22.08$ deg$^2$) at high Galactic latitude, i.e. $|b| \geq 20^\circ$
WHY the SXDSS? Many advantages!

1. Long exposure time: afterglow follow-up up to 1.17 Msec, GRB060729.

3. Very low XRT background (~1-2×10^-4ct/arcmin^2/s in the 0.3-3 keV band).

⇒ long exposure times + low background = DEEP Survey!
   (Flux limit (0.5-2 kev) ~ 7×10^{-16} erg cm^{-2}s^{-1})

3. The XRT Point Spread Function and vignetting factor, approximately constant across the field of view.

⇒ a rather uniform sky sensitivity.

4. Large AREA => ~32.46 deg^2, and ~22.08 deg^2 at high Galactic latitude, i.e. |b|>=20°

⇒ rare objects!

5. The GRBs explode randomly in the sky, with isotropic distribution (Briggs 1996) 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.

⇒ unbiased investigation of the clustering properties of the X-ray sources!
The SXDSS in a context

0.5-2 keV flux limit

Area coverage

- **BLACK**: Medium large not contiguous surveys: A: H2XMM, B: ChaMP, C: SEXSI, D: XMM-BBS, E: AXIS, Q: twoXMM (|b|>20)
- **RED**: Very deep survey: F: CDFN, G: CDFS, H: LockmanHole
- **Blue**: Shallow contiguous survey: I: CCOSMOS, L: XMMCOSMOS, M: ELAIS-S1, N: ECDFS, O: AEGISX, P: SXDS
The point-like catalog

- For source detection and characterization of the X-ray pointlike sources, we used the 'detect' routine of XIMAGE, that uses a sliding-cell method to locate point sources.

- We used a significance level corresponding to a Poisson probability that the excess is a statistical fluctuation of the background of $2 \times 10^{-4}$.

- We applied the detection algorithm to three energy bands: 0.3-10 keV (full), 0.3-3 keV (soft), and 2-10 keV (hard).

- Accurate visual inspection of each GRB field to eliminate spurious detections (e.g. on PSF wings of bright sources, extended emission, optical stars).
The point-like catalog

- The first release of the pointlike catalog conservatively contains sources that are detected with a significance level <= $2 \times 10^{-5}$ in at least one energy band. This level corresponds to less than 1 spurious source for field.

Total sample: 9333 sources, of which 7014 are in the high galactic fields.

- 0.5-2 keV flux limit ~ $7 \times 10^{-16}$ erg cm$^{-2}$s$^{-1}$
- 2-10 keV flux limit ~ $4 \times 10^{-15}$ erg cm$^{-2}$s$^{-1}$
The X-ray number counts are normalized to the Euclidean slope (multiplied by \( S^{1.5} \)). The deviation from the Euclidean slope are clearly evident, as is the flattening of counts towards faint fluxes.

The XRT number counts nicely matches with previous measurements.

At bright fluxes, XRT provides a more robust evaluation of the source counts, thanks to better statistics of the data.
To roughly separate obscured sources from unobscured, following Hasinger et al. (2003), we used a threshold of the hardness ratio \( (H-S)/(H+S) \) corresponding to \( N_H > 21.5, 22.2, 22.7 \) at redshift = 0, 1, 2 respectively (assuming a photon index = 1.8).

We found that \(~37.0\% \pm 0.5\%\) of the 2-10 keV sources turn out to be obscured, consistently with the \(~36\% \pm 4\%\) in ELAIS-S1 (Puccetti et al. 06), which similar flux limit.
The fraction of obscured sources increases with the energy of the X-ray band, consistently with the XRB models (see e.g. Gilli et al. 2007, dashed and dotted lines in figure).

Large surveys are complementary to shallow-deep contiguous surveys to find obscured sources in a large flux interval!
The High Galactic latitude sample: clustering

Understanding the large-scale clustering of AGN will provide precious information on the environment of AGN and how it is linked to the formation of the SMBH, since it is thought to be triggered by major mergers or close interactions between galaxies (see e.g., Kauffmann & Haehnelt 2000, Cavaliere & Vittorini 2002).


Large AREA and random survey is mandatory!

We have evaluated the angular correlation function using the Landy & Szalay (1993) estimator:

\[ w_{\ell}(\theta) = \frac{DD - DR + RR}{RR} \]

- Very preliminary results indicate very weak clustering!
  - \( \Theta_0 < 1.2'' \) for the hard band
  - \( \Theta_0 < 2.7'' \) for the soft band

- We didn’t find strong difference between the soft and the hard sample!
Future projects

- Catalog release in 1 month.
- Paper I: X-ray catalog and X-ray number counts, will be submitted to A&A in the next weeks.

Works in progress

- Detailed study of the clustering properties of the high galactic latitude point-like X-ray sources.
- Optical counterparts in the Sloan Sky Digital Survey (~40% of the high galactic latitude GRB fields have SSDS).
- Analysis of the high galactic latitude obscured point-like X-ray sources using the X-ray data and the optical data from the SSDS.
- Analysis of the blazar candidate sample, using a multiwavelength approach.
- We hope to improve the area and sensitivity of the XRT survey with many other XRT GRB fields!!