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A search for heavily obscured AGN in the 2nd Palermo BAT catalogue

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Thanks to its peculiar observing strategy and to its large field of view, Swift-BAT has produced the most complete to date survey of the sky in the 15-150 keV band. It covers the whole sky achieving a nearly uniform limiting flux of ~10^{-11} erg s^{-1} cm^{-2} in 54 months of observations.
The 2nd Palermo BAT Catalogue (2PBC, Cusumano et al 2010, A&A, 524, 64), derived from the first 54 months of survey, contains 1256 sources, and is the largest collection of hard X-ray emitters produced till now, providing the possibility of population studies on large samples of sources. We are using the 2PBC subsample of extragalactic objects to study their spectral properties, focusing on their obscuration characteristic. Using their position on a flux ratio / column density plot (as developed by Malizia et al 2007, ApJ, 668, 81), we identify some Compton thick (or heavily absorbed) candidates, that will be the subject of a broad-band study, combining the Swift XRT (0.2-10 keV) and Swift-BAT (15-150 keV) spectra.

The sample

Among the 1256 sources included in the 2PBC, 735 objects are confidently associated with extragalactic counterparts. Excluding clusters of galaxies and blazars, the 2nd PBC includes 568 extragalactic objects with a Swift-XRT spectrum available. For the work presented here, we have furthermore excluded sources with less than 50 counts in the XRT spectrum and sources with no measure of redshift. This yield a sample if 424 sources. According to the classification of the soft X-ray counterpart, as resulting from Simbad and NED, the sample is composed as illustrated in the table, and contains 22 Compton Thick (CT) sources already known in literature. In the following, the results obtained for the whole sample are compared with those obtained for the CT subsample

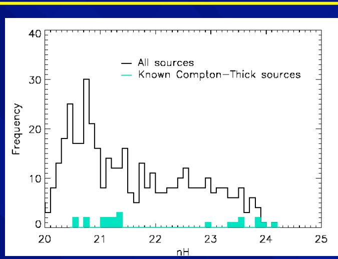
Seyfert 1	239
Seyfert 2	104
QSO/AGN	31
LINERs	9
Galaxies	41

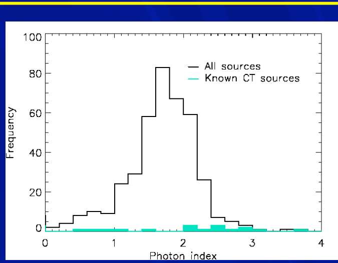
Spectral Analysis

For each source we extracted the 0.2-10 keV spectrum from the available Swift-XRT observations and the 15-150 keV time averaged spectrum from the 54 months of BAT survey data. In this phase of the work, the hard and soft spectra have been fitted separately to build the flux ratio/nH plot.

- Analysis of the soft X-ray spectrum. A simple absorbed power law model was used to fit all the spectra. The absorption accounts for two distinct components: the Galactic line of sight component (fixed to the tabulated value in the direction of the source, Kalberla et al. 2005, A&A, 440, 775) and an intrinsic component, corrected for the object redshift. After a visual inspection of the residuals, for all sources where this model was evidently inadequate, a second component was included, in the form of an unabsorbed power-law with the same photon index as the primary component.

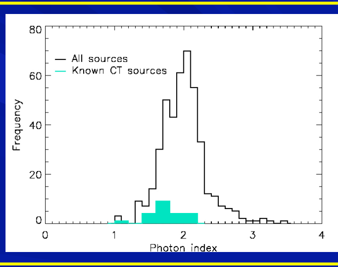
- Analysis of the hard X-ray spectrum with a simple (unabsorbed) power law component.





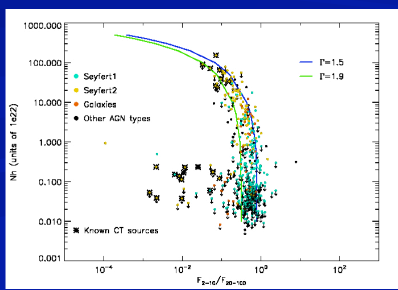
Left. Distribution of N_H from the best fit of the soft X-ray spectrum using a simple absorbed power-law. Right. Distribution of XRT photon index from the best fit of the soft X-ray spectrum.
For some of the CT sources known in literature, the best fit Nh is well below 1e22 because only the reprocessed components are visible with no apparent absorption. Moreover, for the same reason we observe a large spread of photon index values for the same sources.
This confirms that the analysis of the soft X-ray spectrum alone can easily fail in identifying heavily absorbed sources

Distribution of BAT photon index from the best fit of the hard X-ray spectrum. CT sources seems, on average, harder (the difference in the two distributions is significant at 3.5σ according to a KS test) probably because the absorption affects the first channels of the BAT spectrum.



The flux ratio vs nH plot

Following Malizia et al 2007, we have built a graph where the absorbing column resulting from the best fit of the soft X-ray spectrum is plotted versus (2-10 keV) / (20-100 keV) flux ratio. This is a good diagnostic tool to put in evidence highly obscured source candidates, which are characterized by a low flux ratio (as the direct power-law component is strongly absorbed and not visible in the soft spectrum) and low apparent absorption column (only the reprocessed components are visible with no apparent absorption). The two lines represents the expected position of sources with a power-law spectrum with photon index 1.5 and 1.9 at different values of N_H.



We find 34 sources populating the plot region with flux ratio lower than 0.1 and nH lower than 1e22. Among them, 14 are CT or heavily obscured sources already known in literature. The remaining 18 include 6 objects optically classified as Sy1, 8 as Sy2, 3 as galaxies.
For 8 of the known CT sources in the sample the N_H value as determined by the XRT spectrum is very close to the real value: these source are located correctly in the upper region of the plot.

The work is still in progress. The broad band 0.2-150 keV spectral analysis on the candidate obscured sources will be performed to get a reliable estimation of the column density. This will also allow to confirm the goodness of the flux ratio/N_H plot as a valid tool to identify highly absorbed sources.