XMM Survey Science Centre
University of Leicester
Leicester, LE1 7RH, UK

SSC-LUX-TN-0077
Issue 1.0
17 May 2010

Sean A. Farrell (saf28@star.le.ac.uk)

Target Classification for the 2XMM Serendipitous Source Catalogue — with up-dates for 2XMMi-DR3

1 Preface

This document is based on SSC Technical Note SSC-LUX-TN-0065[1] (Schröder et al. 2008), describing the target identification process used for the 2XMM and 2XMMi catalogues (DR1 and DR2 respectively). Here I describe the process used to identify the target sources in each of the 836 observations that were added to the catalogue in the 2XMMi-DR3 release on April 28th 2010. The process used for DR3 is slightly different to that used for DR1 and DR2, and so the DR2 target list was modified slightly to bring it into line with the DR3 list. As a result, some of the statistics presented here for the 2XMM (DR1) and 2XMMi (DR2) target lists differ from the previous document. The cross-identification of the 2XMM detections with the target objects was done by hand with each case examined individually. As such, a certain level of subjectivity is unavoidable. Therefore, while all care was taken during the process outlined in this document, the identifications in the target list should be taken as best estimates.

A number of columns that were present in the target list for 2XMMi (DR2) have been removed from the 2XMMi-DR3 list, as they were deemed to be obsolete due to changes in the XSA or catalogue compilation. Additional columns have been added including the IAU designator name, right ascension and declination of the detected target source. Furthermore, a column listing the HEASARC object classification code[2] has been added, giving information on the nature of the intended target for 99% of the observations. These codes have been supplied by the investigators of each observation and were extracted from the XSA (XMM-Newton Science Archive)[3]. A description of each of the columns is provided at the bottom of the online target list table[4], followed by notes on individual problematic observations.

[1] `http://xmmssc-www.star.le.ac.uk/Catalogue/2XMMi/SSC-LUX-TN-0065.ps`
[2] `http://heasarc.gsfc.nasa.gov/W3Browse/class_help.html`
[3] `http://xmm.esac.esa.int/external/xmm_data_acc/xsa/index.shtml`
[4] `http://xmmssc-www.star.le.ac.uk/Catalogue/2XMMi-DR3/xcat_targets.html`

2 Introduction

The XMM-Newton satellite is typically used for pointed observations where one or more target objects are of scientific interest to the observers. On the other hand, the 2XMM Serendipitous Source Catalogue, which is compiled from these pointed observations, is a catalogue of all sources in the field-of-view (FOV). To avoid the selection bias introduced by the target objects it is worthwhile identifying and flagging these non-serendipitous detections.

The target classification scheme used for the 2XMMi-DR3 catalogue is an attempt to identify and classify the targets. By the nature of the pointed observations such an identification/classification process can only be complete with the input of the proposers. This, however, is not feasible with the available time and resources, therefore the identification and classification of target sources is only possible on a best effort basis and is thus necessarily subjective. We have therefore decided to use formal information provided with the processed data as well as a manual classification scheme to give the user a choice regarding detail and reliability. The results are presented in a table of all 4953 fields from which the 2XMMi-DR3 catalogue was compiled (see App. A.1 in the User Guide[5]).

We describe the extraction of positions and field names from observation and proposal data in Sec. 3, and the manual identification and classification of the target objects in Sec. 4. In Sec. 5 we present a statistical analysis of the 2XMM fields and detections based on the final target list.

3 Formal target information supplied with the data

There are several positions associated with an XMM observation:

- The spacecraft boresight direction, which is always the same position on the detector.
- The proposal position refers to the position given by the observer; this position is placed at a specified detector location which depends on the prime instrument (EPIC or RGS) and which avoids chip gaps, dead spots etc, unless an offset is indicated by the investigator.
- The XSA gives the coordinates of the prime instrument viewing direction (median values [MAHFRA, MAHFDEC] in the attitude file), which are corrected for the star tracker mis-alignment.

Unlike the DR1 and DR2 target lists, we do not give the XSA coordinates for each OBSID in the DR3 target list. Instead, the proposal position is given as in most cases it provides the best representative of the target object as chosen by the investigators. In the target list table, we give proposal positions and names derived from keywords in the header of the fits-file products: RA_PROPOSAL and DEC_PROPOSAL (in J2000) were taken from the `RA_OBJ` and `DEC_OBJ` fields in the attitude time series file (*ATTTSR*), while TARGET_PROPOSAL was taken from the `OBJECT` field in the pipeline produced source list file (*EP*OBSMLI*). The proposal CATEGORY was taken from the PPS summary page (INDEX.HTM) which is extracted from the ODF summary file.

[5] `http://xmmssc-www.star.le.ac.uk/Catalogue/2XMMi-DR3/UserGuide_xmmcat.html`

4 Manual identification and classification scheme

In order to identify the 2XMMi-DR3 detection that corresponded to the target of each observation, we primarily utilised the LEDAS[6] summary pages in order to identify the likely target source, and then performed a search around the source position in the SIMBAD[7] and NED[8] databases to check whether the source was coincident with a database entry that was consistent with the target name given by the proposers. These databases recognise object names only when they are given in a certain (official) format (*e.g.*, with a registered prefix or with the correct precision of coordinates in the name). However, the XMM investigators are free to give their targets any name they want, which often includes offset information, abbreviated coordinates, or non-standard names. As such, a direct match between 2XMMi-DR3 and either SIMBAD or NED was not possible.

We first manually inspected the LEDAS images for the brightest source in each field. In ~60% of the observations the brightest source detected in the field was the target source. For those ~40% of observations where the brightest source was not the target, we investigated successive sources starting with the one closest to the proposal position, moving radially outwards until the target was identified. A few observations had two target objects (either point sources or small, symmetric extended objects), including double stars and galaxy clusters as well as a few other assorted objects (e.g. ULXs, merging galaxies etc.). In these instances the 2XMM detections for both objects are given, with two rows per observation listed in the table. In this manner, the target sources (single or double) were matched to 2XMM source detections ~64% of the time.

In a further ~26% of cases the proposal target was identified as a 'field' observation, i.e. multiple targets (>2 per observation) were present within the FOV (e.g. observations of star clusters, deep field pointings, point sources/diffuse emission in nearby galaxies, X-ray shadow experiments etc.). Observations of large or asymmetric extended objects such as nearby supernova remnants and galaxy clusters were also flagged as 'field' observations, as it was not logical to assign a single discrete detection to the position of the intended target. For the cases where a 2XMM source could not be identified as the target or the objective was not immediately clear, the proposal abstract was scrutinised in an attempt to determine the aim of the observation. In ~10% of cases the target could not be identified or was not detected, though it should be highlighted that these cases also included large offset observations (where the target was outside the FOV) and special observing modes of bright sources where either the source did not fall on an active CCD (typically when the RGS was the prime instrument) or source detection was not performed or failed due to the observing mode and/or flux of the target. In a few cases the field observed was not the intended field, either due to incorrect coordinates provided by the proposers or slew failures.

For those observations where a target or field target could be identified, the SIMBAD name, type and coordinates were recorded in the target list alongside the 2XMM DETID and related information. For instances where a match was found in NED but not in SIMBAD, the NED information is instead provided (with '[ned]' appended to the SIMBAD name in the table). Where matches could not be found in either SIMBAD or NED, no information is given in the SIMBAD fields. Each observation was classified using the criteria outlined above according to the target type (see Table 1).

For Solar system objects such as planets and comets, no match will be found in SIM-

[6]http://www.ledas.ac.uk/

[7]http://simbad.u-strasbg.fr/simbad/

[8]http://nedwww.ipac.caltech.edu/

BAD or NED. In these cases, where the target could be identified the 2XMM source information (i.e. the SRC_NUM, DETID, IAUNAME, RA_SRC, and DEC_SRC columns) will be provided but there will be no entries in the SIMBAD columns. For these observations, notes are provided at the end of the table html page[9] explaining that SIMBAD or NED information cannot be provided.

Table 1: Field classification

Field class	Description
P	Point source (as determined from fitting the PSF model to the source emission)
E	Small, symmetric extended source (as determined from fitting the PSF model to the source emission). Significantly asymmetric and/or large extended sources that could not be matched with a single obvious detection were instead flagged as 'field' observations
F	'Field' observation, that is all detections are potential targets. This flag was applied when it was judged that more than two detections were associated with the targets, e.g. when the target of the observation was a region of sky, a large and/or assymetric extended source (e.g. a supernova remnant or galaxy cluster with multiple detections), or multiple resolved sources (e.g. in a nearby galaxy or star cluster)
T	Two clearly identified targets (*e.g.*, a double star); in this case two rows for the OBSID are given stating the two detections associated with the targets. In a small number of cases the second target was not detected, and so only one row is present for the observation
U	Unknown/undetected: the target could not be identified and/or was not detected. This flag was also applied to offset observations where the target lay outside of the field of view, and cases where source detection failed or was not performed due to a very bright target source (e.g. the Crab)

5 Some statistics of the 2XMM, 2XMMi and 2XMMi-DR3 catalogues

There are 4953 fields in total in the 2XMMi-DR3 catalogue representing an increment of 836 observations over the 2XMMi release (DR2). Tables 2 and 3 give the statistical breakdown for the proposal science categories and for the field classifications.

[9] `http://xmmssc-www.star.le.ac.uk/Catalogue/2XMMi-DR3/xcat_targets.html`

Table 2: Proposal category from the ODF summary file

Class	Description	2XMM	2XMMi	2XMMi-DR3
A	Stars, White Dwarfs and Solar System	16%	12%	12%
B	White Dwarf Binaries, Neutron Star Binaries, Cataclysmic Variables, ULXs and Black Holes	15%	18%	19%
C	Supernovae, Supernova Remnants, Diffuse Emission, and Isolated Neutron Stars	15%	14%	14%
D	X-ray Background and Surveys	8%	0%	<1%
E	Galaxies and Galactic Surveys	15%	6%	7%
F	Active Galactic Nuclei, Quasars, BL Lac Objects, and X-ray Background	19%	28%	26%
G	Groups of Galaxies, Clusters of Galaxies, and Superclusters	12%	22%	13%
H	Cosmology, Extragalactic Deep Fields, and Area Surveys	0%	0%	9%

Table 3: Field classification

Field class	Description	2XMM	2XMMi	2XMMi-DR3
P	Point source	44%	39%	53%
E	Extended	20%	18%	9%
F	Field	25%	29%	27%
T	Two targets	1%	1%	1%
U	Unknown/undetected target	10%	13%	10%