INTEGRAL/IBIS deep extragalactic survey: M81, LMC and 3C 273/Coma fields

Ilya A. Mereminskiy1⋆, Roman A. Krivonos1, Alexander A. Lutovinov1, Sergey Yu. Sazonov1,2, Mikhail G. Revnivtsev1 and Rashid A. Sunyaev1,3

1 Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, 117997 Moscow, Russia
2 Moscow Institute of Physics and Technology, Institutsky per. 9, 141700 Dolgoprudny, Russia
3 Max Planck Institute for Astrophysics, Karl-Schwarzschild-Strasse 1, D-85741 Garching, Germany

2 February 2016

ABSTRACT
We present results of deep surveys of three extragalactic fields, M81 (exposure of 9.7 Ms), LMC (6.8 Ms) and 3C 273/Coma (9.3 Ms), in the hard X-ray (17–60 keV) energy band with the IBIS telescope onboard the INTEGRAL observatory, based on 12 years of observations (2003–2015). The combined survey reaches a 4σ peak sensitivity of 0.18 mCrab (2.6 × 10^{-12} erg s^{-1} cm^{-2}) and sensitivity better than 0.25 and 0.87 mCrab over 10% and 90% of its full area of 4900 deg^2, respectively. We have detected in total 147 sources at S/N > 4σ, including 37 sources observed in hard X-rays for the first time. The survey is dominated by extragalactic sources, mostly by active galactic nuclei (AGN). The sample of identified sources contains 98 AGN (including 64 Seyfert galaxies, 7 LINERs, 3 XBONGs, 16 blazars and 8 AGN of unclear optical class), two galaxy clusters (Coma and Abell 3266), 17 objects located in the Large and Small Magellanic Clouds (13 high- and 2 low-mass X-ray binaries and 2 X-ray pulsars), three Galactic cataclysmic variables, one ultraluminous X-ray source (ULX, M82 X-1) and one blended source (SWIFT J1105.7+5854). The nature of 25 sources remains unknown, so that the surveys identification is currently complete at 83%. We have constructed AGN number-flux relations (log N-log S) and calculated AGN number densities in the local Universe for the entire survey and for each of the three extragalactic fields.

Key words: catalogues – surveys – X-rays: general.

1 INTRODUCTION
Deep X-ray surveys of extragalactic fields with focusing X-ray telescopes (see, e.g., Brandt & Alexander 2015, for a review) are essential for studying the evolution of active galactic nuclei (AGN) and physical processes powering their activity, but have a number of limitations. In particular, their small covered areas prevent finding a sufficient number of bright objects, whereas the soft X-ray energy band (E ≲ 10 keV) used in most surveys introduces a strong bias against obscured (i.e. those with substantial intrinsic absorption) AGN. These drawbacks can be partially overcome using wide-field hard X-ray surveys performed with coded-mask telescopes like IBIS/INTEGRAL (Winkler et al. 2003) or BAT/Swift (Gehrels et al. 2004).

As was shown in previous studies (see e.g. Paltani et al. 2008; Krivonos et al. 2010a), the IBIS telescope aboard the INTEGRAL observatory is able to achieve high sensitivity in extragalactic fields. The sensitivity grows nearly proportionally to the square root of exposure showing no significant contribution of systematic noise and allowing IBIS to find sources at the tenths-of-mCrab flux level with a low number of false detections. In combination with IBIS large field of view (FOV, 28° × 28°, 9° × 9° fully coded), this opens up a possibility to collect a significantly large sample of hard X-ray emitting AGN with fluxes down to a few 10^{-12} erg s^{-1} cm^{-2}. Note that such objects, due to their rarity (~0.05 AGN per deg^2), evade NuSTAR deep surveys (Mullaney et al. 2015).

The observational program of INTEGRAL has been mainly dedicated to Galactic source studies (see, e.g., Barlow et al. 2006; Revnivtsev et al. 2008; Bodaghee et al. 2012;}

1 One mCrab corresponds to 1.43×10^{-11} erg s^{-1} cm^{-2} in the 17–60 keV energy band assuming a spectral shape 10(E/1keV)^{-2.1} photons cm^{-2} s^{-1} keV^{-1}.

* E-mail:i.a.mereminskiy@gmail.com

© 2016 The Authors
Lutovinov et al. 2013; Walter et al. 2015), whereas the high Galactic latitude sky has been observed less intensively and very inhomogeneously. Nevertheless, on-going extragalactic surveys carried out with IBIS expand our knowledge about populations of extragalactic hard X-ray sources, mainly AGN, (Krivonos et al. 2007, 2010b; Bird et al. 2010, 2016) and provide observational input for AGN studies (Sazonov et al. 2007, 2008, 2015; Beckmann et al. 2009; Malizia et al. 2009).

A number of multi-year campaigns have been recently performed in the extragalactic sky, in particular of regions around the M81 galaxy, the Coma cluster and the Large Magellanic Cloud. In each of these fields the total accumulated exposure (per position) exceeds 3 Ms, making them interesting for population studies of extragalactic hard X-ray sources and especially AGN in the so far poorly explored domain of sub-mCrab fluxes, which is the main purpose of the present paper.

The region around the M81 and M82 galaxies was targeted during two main campaigns: the study of hard X-ray spectra of the ultraluminous X-ray sources (ULXs) HoIXX-1 and M82X-1 (Sazonov et al. 2014) and recent observations of the type Ia supernova SN 2014J in M82 (Churazov et al. 2014). This field has a total exposure of 9.7 Ms (hereafter all quoted exposures are dead time corrected ones) at the position of the M81 galaxy.

Another INTEGRAL deep field, around the LMC galaxy, has a peak exposure of 6.8 Ms. The major part of the observing time was gained by the SN 1987A multi-year observational campaign (Grebenyev et al. 2012). The previous hard X-ray survey of the LMC region was presented by (Grebenyev et al. 2013) and had reached a peak exposure of 4.8 Ms. Note that this field is rich in X-ray binaries located in LMC/SMC.

The field around the North Galactic pole was often observed as it includes a number of interesting extragalactic sources, such as the bright AGN 3C 273 and NGC 4151 and the Coma cluster. The region of the Coma cluster was first surveyed at hard X-rays with INTEGRAL by Krivonos et al. (2005) who studied serendipitous extragalactic source counts down to a limiting flux of 1 mCrab. Later estimations (Krivonos et al. 2007) showed that the Coma region has an enhanced population of AGN, which probably reflects the local overdensity of AGN in the nearby Universe. This result was later confirmed by Swift/BAT (Ajello et al. 2012). The sky region around 3C 273/Coma (total area 2500 deg², exposure 4 Ms) was also selected to conduct an INTEGRAL extragalactic survey and to measure the source counts and AGN luminosity function (Paltani et al. 2008).

Given the IBIS FOV size and 5 × 5 standard observational pattern, we chose for our present study 35°×35° regions for the M81 and LMC fields with centers at J2000 coordinates RA=85°.0, Dec=−69°.0 and RA=148°.9, Dec=69°.1, respectively. For the 3C 273/Coma field, we chose an extended 35°×70° region with the aimpoint at RA=190°.0, Dec=17°.0 (J2000).

2 SURVEY

For the current survey we used all publicly available data acquired with INTEGRAL before June 2015 (spacecraft revolution 1553). The data from ISGRI, the first detector layer of the IBIS telescope, were utilized, as having the highest sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays. We selected 17–60 keV as our working energy band where ISGRI has the highest effective sensitivity at hard X-rays.

To apply the latest ISGRI energy calibration (Caballero et al. 2013), we first reduced the list of registered events for each field and for the combined survey.

Figure 1. Distribution of pixel significances for the combined survey of three extragalactic fields (blue histogram). The red dashed line shows the normal distribution with unit variance and zero mean.

Figure 2. Sky area covered as a function of 4σ limiting flux for each field and for the combined survey.
The peak sensitivity of the survey is 0.18 mCrab (2.6 and individual fields as a function of the 4 μJy.

We expect no more than 4 false detections in all three independent pixels of the size of the IBIS angular resolution (12'). By setting a 4σ detection threshold for the current survey, we expect no more than 4 false detections in all three fields.

Fig. 2 shows the area covered by the combined survey and individual fields as a function of the 4σ limiting flux. The peak sensitivity of the survey is 0.18 mCrab (2.6×10^{-12} erg s^{-1} cm^{-2}), with 10% and 90% of the total area having been covered with sensitivity better than 0.25 mCrab (3.6×10^{-12} erg s^{-1} cm^{-2}) and 0.87 mCrab (1.2×10^{-11} erg s^{-1} cm^{-2}), respectively.

We analyzed the mosaic maps for positive excesses with S/N > 4σ and found 147 source candidates. We cross-checked the list of the detected sources with the current INTEGRAL source catalog4, the Swift/BAT 70-month catalog (Baumgartner et al. 2013) and the all-sky hard X-ray survey by Bird et al. (2016) as the most complete and up-to-date hard X-ray source catalogs. We also used the 66-month Palermo Swift/BAT online catalog5 (Cusumano et al. 2010) as a complementary catalog. For all identified extragalactic sources we collected known redshifts or distances from the NASA/IPAC Extragalactic Database6 (NED).

Fig. 3 shows the mosaic images along with exposure contours for the three studied fields. Note that the M81 and 3C 273/Coma fields do not show any systematic noise, which suggests that IBIS/ISGRI can be used to perform even deeper extragalactic surveys. The source statistics for each field is discussed below.

The high Galactic latitude (b \approx 40°) M81 field contains 37 detected sources: 28 known AGN including 5 blazars, one ULX (M82X-1), two Galactic binary systems (MU Cam and DO Dra), five new hard X-ray sources of unknown type, and SWIFT J1105.7+5854 – a known pair of sources with 6' separation (Baumgartner et al. 2013). This field hosts the most distant object in our survey – the quasar QSO B0836+710 at z = 2.172 (Stickel & Kuehr 1993). Thus, the M81 field is dominated by AGN.

In the LMC field, 46 sources are detected, including 11 objects previously unknown as hard X-ray sources. This field is different from the other two because it hosts 17 objects located in the Magellanic Clouds (both LMC and SMC), including 13 high-mass X-ray binaries, two low-mass X-ray binaries and two rotation-powered pulsars; it also contains the Galactic cataclysmic variable TW Pic. Among 21 extragalactic sources in this field there are 20 AGN, including three blazars, and the cluster of galaxies Abell 3266. The nature of 7 sources remains unknown.

In the vicinity of the bright (~20 mCrab) X-ray pulsar LMCX-4, the presence of two hard X-ray sources was reported earlier: IGR J05319−6601 (Götz et al. 2006) and IGR J05305−6559 (Krivonos et al. 2007). Due to the small angular distance from LMCX-4, these sources cannot be resolved on the average map. Nevertheless, taking into account a peculiar property of LMCX-4 (the source periodically goes to the "off"-state) and using the corresponding subset of revolutions, Grebenev et al. (2013) showed that the persistent hard X-ray emission actually originates from the sky region coinciding with the position of another X-ray pulsar, EXO 053109−6609.2. This conclusion was supported by an independent detection of this source in the standard X-ray energy band by the INTEGRAL/JEM-X telescope, which allowed Grebenev et al. (2013) to reconstruct the source spectrum in a broad energy band and demonstrate that it is typical for accreting X-ray pulsars. Based on the extended data set obtained with INTEGRAL and using the current ephemerides for LMCX-4 (Molkov et al. 2015), we have repeated such an analysis and verified the result of Grebenev et al. (2013). Summarizing the above, we can conclude that the hard X-ray emission detected by INTEGRAL from the vicinity of LMCX-4 is associated with the X-ray pulsar EXO 053109−6609.2 and that the hard X-ray sources IGR J05319−6601 and IGR J05305−6559 are actually the same source – the X-ray counterpart of EXO 053109−6609.2. We finally note that since our maps are averaged over many revolutions, the position and flux for this source in the catalog (referred to as IGR J05305−6559) are strongly affected by LMCX-4 and should thus be treated carefully.

The 3C 273/Coma field is the largest one and naturally contains the largest number of sources. We have detected here 64 sources including 16 objects detected in hard X-rays for the first time. All the identified sources are of extragalactic origin: there are 47 known AGN, including 7 blazars, and three clusters, and the cluster of galaxies Abell 3266. The Galactic cataclysmic variable TW Pic. Among the identified sources are of extragalactic origin: there are 47 known AGN, including 7 blazars, and the cluster of galaxies Abell 3266. The nature of 7 sources remains unknown.

In summary, we have detected 147 sources in all three fields, which are listed in Table 1, including 37 detected in hard X-rays for the first time. Two fields (M81 and 3C 273/Coma) are dominated by extragalactic objects, while a significant fraction of sources in the LMC field are nearby ones (X-ray binary systems) located in LMC and SMC.

Fig. 5 shows the fluxes of the detected sources as a func-
Figure 3. Hard X-ray maps of the M81, LMC and 3C 273/Coma fields, shown in terms of significance. The square-root color map ranges from 0 to 25. Yellow circles denote new sources and green circles already known ones. Some of the brightest sources are marked for easy navigation. North is up and east is to the left on all maps. a) M81 field. The peak exposure 9.7 Ms, contours show exposures of 2, 4 and 8 Ms. b) LMC field. The peak exposure 6.8 Ms, contours drawn at 2 and 4 Ms. c) 3C 273/Coma field. The peak exposure 9.3 Ms, contours drawn at 2, 4 and 8 Ms.

The exposure time, along with an expected sensitivity curve $F_{\text{lim}} = 0.77 \times (T/\text{Ms})^{-0.5}$ mCrab provided by Krivonos et al. (2010b). We see that the IBIS/ISGRI extragalactic survey continues to operate in a statistically limited regime, with the sensitivity increasing as the square root of the exposure. The factor of $\sim 2$ improvement in sensitivity with respect to the 7-year all-sky survey (Krivonos et al. 2010b) is clearly visible.

It is interesting to compare our catalog with an INTEGRAL all-sky survey catalog recently published by Bird et al. (2016) based on IBIS data taken before spacecraft orbit 1000 (December 2012). The catalog of Bird et al. (2016) contains only 65 sources out of the 147 sources detected in our survey (14/37 in the M81 field, 17/46 in LMC and 34/64 in 3C 273/Coma), which is not unexpected given that several extensive INTEGRAL observational campaigns of these fields have been undertaken after December 2012 and we have taken advantage of these additional data.
the 2° × 2° fields around the Coma (left) and Abell 3266 (right) clusters of galaxies. The contours denoting the surface brightness in the 0.1–2.4 keV energy band from ROSAT data are overplotted.

Figure 4. The 2° × 2° fields around the Coma (left) and Abell 3266 (right) clusters of galaxies. The contours denoting the surface brightness in the 0.1–2.4 keV energy band from ROSAT data are overplotted.

Figure 5. The 4σ limiting flux as a function of the exposure. Red circles denote sources from the current survey. Green stars are high Galactic latitude (|b| > 15°) sources detected in the 7-year all-sky survey (Krivonos et al. 2010b). The green line represents an analytical approximation of the nominal sensitivity versus time.

other hand, since our survey was not designed for source detection at different time scales, it misses 12 short and 3 long transients listed in Bird et al. (2016) with typical outburst timescales of weeks and months, respectively. In addition, 10 persistent weak sources from Bird et al. (2016) catalog fall below our detection threshold, including three sources in the M81 field (IGR J08447+6610, Mrk 18 and IGR J09034+5329), two in LMC (PKS 0312-770 and SWIFT J0450.7-5813) and five in 3C 273/Coma (IGR J12562+2554, IGR J13166+2340, SWIFT J1344.7+1934, IGR J12319-0749 and IGR J11486-0505), which may indicate that these sources became dimmer in the latest INTEGRAL observations.

2.2 Identification of new sources

For the identification of 37 newly detected sources we utilized the SIMBAD database and HEASARC databases as well as the Swift/XRT point source catalog (1SXPS, Evans et al. 2014) and the third XMM-Newton serendipitous source catalog (3XMM-DR5, Rosen et al. 2015). Based on XMM-Newton or Swift/XRT archival observations, we selected X-ray counterparts in the soft X-ray band (2–10 keV) within a 4.2′ (2σ) error circle around the best-estimate positions of hard X-ray sources. The favored source was that which had the highest flux and a hard spectrum consistent with the INTEGRAL 17–60 keV flux. We found firm soft X-ray counterparts for 13 sources of 37, and list them in Table 1. In some cases we propose an optical counterpart based on positional coincidence with a known bright source, e.g. an AGN. Below we discuss a few cases of source identifications in which additional observations are needed to validate the proposed association.

IGR J08501+6630

Our search for a soft X-ray counterpart in the HEASARC archival data did not yield a potential candidate within the INTEGRAL error circle of IGR J08501+6630. However, we found two bright sources in optical/IR bands: the star TYC 4134-706-1 (ESA 1997) and the edge-on spiral galaxy MCG+11-11-029 (z = 0.037). The latter is proposed as

7 http://simbad.u-strasbg.fr/simbad/
8 http://heasarc.gsfc.nasa.gov/
a possible optical counterpart of IGR J08501+6630. The absence of a soft X-ray counterpart and non-detection of IGR J08501+6630 in the ROSAT all-sky survey (Voges et al. 1999) indicates a strong intrinsic absorption.

IGR J05329−7051

The error circle of IGR J05329−7051 contains one obvious soft X-ray counterpart—3XMM J053257.8−705112, located $20\arcmin$ away from the INTEGRAL position (Fig. 6) and having a flux of $\approx 2 \times 10^{-13}$ erg s$^{-1}$ cm$^{-2}$ in the 0.2–12 keV band (Rosen et al. 2015). The optical counterpart of 3XMM J053257.8−705112 is a distant ($z = 1.238$, Kożłowski et al. 2012) AGN, MQS J053258.11−705112.9. We extracted the source spectrum from the data of an XMM-Newton observation in October 2001 (ObsId 0089210901, exposure 22 ks). Fitting it with the phabs*zpowerlw model from the XSPEC package we obtained a low absorption column density $N_H = (1.7 \pm 0.8) \times 10^{21}$ cm$^{-2}$ consistent with the absorption in the Milky Way in this direction, and a moderate photon index of $2.2 \pm 0.4$. The corresponding model flux in the 0.2–10 keV energy range is $1.4 \times 10^{-13}$ erg s$^{-1}$ cm$^{-2}$. Due to its high hard X-ray luminosity $L_{17−50}$ keV $\sim 3 \times 10^{46}$ erg s$^{-1}$ we classify this source as a candidate blazar.

IGR J13100+0830

We found four soft X-ray counterparts in the 1SXPS catalog (Evans et al. 2014) within the 4.2$''$ error circle of IGR J13100+0830, as shown in Fig. 7. Table 2 lists offsets, count rates and optical counterparts for these objects.

Because of the highest 2–10 keV flux and nearest position to the INTEGRAL coordinates, we propose 1SXPS J131004.4+082936 as a probable counterpart, although contribution from other sources cannot be excluded. Observations with the NuSTAR hard X-ray focusing telescopes should be considered with caution.

Table 1. Part of the catalog of sources detected in the combined survey of three fields: M81, LMC and 3C 273/Coma. The description of the columns can be found in Sect. 2.3. The full version of the table is available in Appendix 1.

| Id  | Name$^1$        | R.A. deg | Dec. deg | S/N | Flux mCrab | $D$ Mpc | $z$ | log $L$ erg s$^{-1}$ | Type | Notes |
|-----|----------------|----------|----------|-----|------------|--------|-----|---------------------|------|-------|
| 1   | Mrk 3          | 93.950   | 71.039   | 39.4| 5.81±0.15  | 0.013  | 43.56| Sy2                 |      |        |
| 2   | IGR J06253+7334| 96.370   | 73.585   | 7.6 | 0.99±0.13  |        |     |                     |      | CV    |
| 3   | Mrk 6          | 103.043  | 74.427   | 22.4| 2.37±0.11  | 0.019  | 43.46| Sy2                 |      |        |
| 4   | IGR J06571+7802| 104.277  | 78.044   | 4.2 | 0.47±0.11  |        |     |                     |      |        |
| 5   | QSO B0716+714  | 110.576  | 71.304   | 5.9 | 0.50±0.08  | 0.300  | 45.34| Blazar              |      |        |
| 6   | IGR J07563+5919| 119.091  | 59.321   | 4.0 | 0.62±0.16  |        |     |                     |      |        |
| 7   | PG 0804+761    | 122.929  | 76.034   | 9.4 | 0.63±0.07  | 0.100  | 44.39| Sy1                 |      |        |
| <...> | IGR J13486+1554| 207.168  | 15.901   | 4.8 | 0.57±0.12  |        |     |                     |      |        |

$^1$ The names of sources previously unknown in the hard X-ray band (17–60 keV) are highlighted in bold. Sources with spatial confusion are indicated by a star, their measured fluxes should be considered with caution.

Table 2. 1SXPS sources in the 4.2$''$ error circle around the IGR J13100+0830 position. The table is based on the 1SXPS catalog (Evans et al. 2014).

| 1SXPS Id | Offset$^1$ | R.A., Dec. (error$^2$) | Count rate $\times 10^{-4}$ cts s$^{-1}$ | Flux$^3$ $\times 10^{-14}$ erg s$^{-1}$ cm$^{-2}$ | Optical counterpart (type) |
|----------|------------|------------------------|-----------------------------------------|-----------------------------------------|----------------------------|
| J131004.4+082936 | 1.1$'$ | 197.5184, 8.4935 (4.8$''$) | 13.0 | 5.5 | 7.5$^{+1.8}_{-1.6}$ | SDSS J131004.26+082938.9 (QSO candidate, $z = 1.22$) |
| J131008.5+082826 | 2.6$'$ | 197.5356, 8.4741 (4.4$''$) | 13.8 | 3.4 | 7.0$^{+1.7}_{-1.5}$ | SDSS J131008.34+082826.4 (galaxy, $z = 0.27$) |
| J131014.2+083137 | 3.3$'$ | 197.5592, 8.5270 (4.9$''$) | 16.2 | 3.5 | 8.0$^{+1.8}_{-1.6}$ | SDSS J131014.24+083135.9 (QSO candidate, $z = 1.55$) |
| J130947.2+083049 | 3.6$'$ | 197.4467, 8.5138 (5.3$''$) | 5.5 | 1.7 | 3.0$^{+1.1}_{-1.0}$ | USNO-B1.0 0985-0230131 (foreground star) |

$^1$ Angular offset from the INTEGRAL position of IGR J13100+0830 in arcminutes.

$^2$ Radius of the 90% confidence error circle.

$^3$ The 0.2–10 keV flux ($\pm 1\sigma$ error) calculated from a power-law model with $\Gamma=1.7$ and Galactic absorption toward the source (see details in Evans et al. 2014).
Figure 6. XMM-Newton EPIC MOS 0.2–10 keV image of the field around IGR J05329−7051. The circle denotes the INTEGRAL error region of 4.2′ in radius.

Figure 7. Swift/XRT 0.3–10 keV image of the field around IGR J13100+0830. The large circle of 4.2′ in radius denotes the INTEGRAL error region. The smaller circles denote sources from the 1SXPS catalog (Evans et al. 2014).

scope (Harrison et al. 2013) or the planned Astro-H mission (Takahashi et al. 2010) could help establish the nature of IGR J13100+0830 and find its optical counterpart.

2.3 Catalog

The list of the detected sources with S/N > 4 is presented in Table 1, which consists of three blocks corresponding to the M81, LMC and 3C 273/Coma fields. The columns of the table are described below.

Column (1) "Id" – source number in the catalog.

Column (2) "Name" – source name. For sources previously detected in hard X-rays we use their catalog or common name. We assign an "IGR" name for sources detected for the first time (also highlighted in bold).

Columns (3,4) "R.A., Dec." – right ascension and declination in equatorial coordinates (J2000 epoch).

Column (5) "S/N" – signal-to-noise ratio of the detected source.

Column (6) "Flux" – average source flux (17–60 keV) in mCrab and the associated 1σ error.

Columns (7,8) D, z – metric distance or redshift for extragalactic sources. For the calculation of luminosities (column 9) we used the metric distance for nearby sources (z ≤ 0.01) and the luminosity distance estimated from the redshift for the more distant sources. Distances and redshifts were obtained from the SIMBAD and NED databases.

Column (9) log L – the logarithm of the 17–60 keV luminosity of the source. We only calculated luminosities for sources classified as AGN; a standard ΛCDM cosmology with H₀ = 67.8 km s⁻¹ Mpc⁻¹, Ωm = 0.308 was used.

Column (10) "Type" – astrophysical type of the object: HMXB (LMXB) – high(low)-mass X-ray binary; CV – cataclysmic variable; pulsar – rotation powered X-ray pulsar; cluster – cluster of galaxies; Sy1, Sy2 (and intermediate types Sy1.2, Sy1.5, Sy1.8, Sy1.9) – Seyfert galaxies of different types; NLS1 – narrow-line Seyfert 1 galaxies; LINER – low ionization nuclear emission-line region galaxy; XBONG – X-ray bright optically normal galaxy; blazar – BL Lac object or flat-spectrum radio quasar; NLRG - narrow emission-line radio-galaxy. For all sources associated with galaxies but without known activity type we ascribe an "AGN" type.

We should note, that there are few sources which classified as LINER based on optical observations but shows unusually high hard X-ray luminosities - more than 10⁴³ erg s⁻¹, we decided to denote them as "LINER?".

Column (11) "Notes" – For known sources, we present an optical or IR counterpart name. For sources detected for the first time, we specify the soft X-ray counterpart and associated optical association. Some additional remarks are also provided.

3 AGN SAMPLE AND STATISTICS

Our resulting source catalog is dominated by extragalactic objects: the total sample of 98 AGN includes 64 Seyfert galaxies, 7 LINERs, 16 XBONGs, 15 blazars (or candidate blazars) and 8 AGN of unclear type. The catalog also contains 25 unidentified sources, thus the survey’s identification is complete at 83%.

The INTEGRAL/IBIS deep extragalactic survey can be used to construct a number-flux relation for AGN, assuming that they are uniformly distributed in space (we check this assumption below). To this end, we excluded from the full AGN sample M81, NGC 4151 and 3C 273, since these were dedicated targets of long INTEGRAL observations, and 15 (3C 273 already excluded) blazars. The resulting sample of 80 confirmed non-blazar AGN is referred to as a confirmed AGN sample hereafter.

Fig. 8 shows the cumulative log N–log S distribution derived from the confirmed AGN sample and corrected for the survey’s sky coverage (Fig. 2). This distribution can be well described by a power law N(S > S) = AS⁻α. Using the maximum likelihood estimator (Crawford et al. 1970) and

MNRAS 000, 1–11 (2016)
Figure 8. Number–flux (17–60 keV) relation for AGN. Blue points represent the full AGN sample (80 confirmed non-blazar AGN and 25 unidentified sources), while the black solid line shows the corresponding best-fitting power law model (the best-fit parameters are given in Table 3). The shaded area represents the 1σ error region for the confirmed AGN sample composed of 80 non-blazar AGN. The power-law fit for this sample is shown by the gray dashed line.

Figure 9. Number–flux (17–60 keV) relations for sources in the three extragalactic fields. The colored dots show both known non-blazar AGN and unidentified sources, and the black solid lines represent the corresponding power-law fits (the parameter values are given in Table 3). The shaded areas represent the 1σ regions of best-fit parameters excluding unidentified sources. Power-law fits for samples without unidentified sources are shown as dashed gray lines.

Taking into account the high Galactic latitudes of the extragalactic fields under consideration, it is reasonable to expect that most of the unidentified sources in our sample have an extragalactic nature. We therefore also constructed a larger full AGN sample by adding all 25 unidentified sources to our confirmed AGN sample. The new sample includes 105 hard X-ray sources spanning down to a flux of $\approx 3 \times 10^{-12}$ erg s$^{-1}$ cm$^{-2}$, which is a factor of two deeper than the all-sky extragalactic $\log N$–$\log S$ relation constructed by Krivonos et al. (2010b). Using the same approach as before, we derived the best-fit slope $\alpha = 1.56 \pm 0.13$ and normalization $A = (3.1 \pm 0.3) \times 10^{-3}$ deg$^{-2}$ at the flux of $2 \times 10^{-11}$ erg s$^{-1}$ cm$^{-2}$ for the number-flux relation constructed from the full AGN sample (see Fig. 8 and
We have analyzed the deepest INTEGRAL hard X-ray survey of three extragalactic fields: around M81, LMC and 3C 273/Coma, with the peak exposure of 6.8 Ms in the LMC field and above 9 Ms in the two other fields. The peak achieved sensitivity is 0.18 mCrab in the 17–60 keV energy band. The catalog of sources detected in the combined survey contains 147 objects detected above the threshold of $S/N > 4$, with 37 of them having been detected in hard X-rays for the first time. We have identified 13 of the newly detected objects using archival soft X-ray observations. Twenty-five sources (24 of new and SWIFT J0826.2–7033) remain unidentified making the completeness of the survey at the level of 83%.

The catalog is dominated by extragalactic sources. The cumulative log $N$–log $S$ distribution of non-blazar AGN is consistent with a power law down to fluxes $\lesssim 3 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$, which is deeper by a factor of two compared to the previous (all-sky) measurement of Krivonos et al. (2010b). The AGN number counts for the M81 and 3C 273/Coma fields are consistent with each other, while the LMC field demonstrates a steeper number-flux distribution ($2\sigma$ deviation from the expected $–3/2$ slope) and a lack of bright AGN with flux higher than $2\times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$.

ACKNOWLEDGEMENTS

This work is based on observations with INTEGRAL, an ESA project with instruments and the science data centre funded by ESA member states (especially the PI countries: Denmark, France, Germany, Italy, Switzerland, Spain), and Poland, and with the participation of Russia and the USA. The data were obtained from the European9 and Russian10 INTEGRAL Science Data Centers. This research was supported by the Russian Science Foundation (grant 14-22-00271). The authors thank the Max-Planck-Institut für Astrophysik for computational support.

9 http://isdc.unige.ch
10 http://bea.iki.rssi.ru/rsdc

Figure 10. Hard X-ray luminosity vs. redshift for the identified non-blazar AGN. The sources from shaded region were used for estimating the AGN space density (see text for details).
Table 3. Best-fit parameters for the number-flux relations and estimated AGN space densities.

| Parameter | Units | M81 | LMC | 3C 273/Coma | Total |
|-----------|-------|-----|-----|------------|-------|
| $\alpha$  |       | 1.51±0.23 | 2.26±0.36 | 1.50±0.17 | 1.56±0.13 |
| $A_1$    | $10^{-3}$ deg$^{-2}$ | 3.8±0.7 | 1.3±0.3 | 4.0±0.5 | 3.1±0.3 |
| $N^2$    |       | 27 | 23 | 55 | 105 |

| Parameter | Units | M81 | LMC | 3C 273/Coma | Total |
|-----------|-------|-----|-----|------------|-------|
| $\alpha$  |       | 1.52±0.27 | 2.34±0.46 | 1.37±0.19 | 1.43±0.14 |
| $A_1$    | $10^{-3}$ deg$^{-2}$ | 3.0±0.6 | 0.9±0.2 | 4.0±0.6 | 2.9±0.3 |
| $N^3$    |       | 22 | 16 | 42 | 80 |
| $N^4$    |       | 12 | 5 | 27 | 44 |
| $N^5$    |       | 9 | 4 | 18 | 31 |

AGN space density estimated by the $1/V_{\text{max}}$ method

| $\rho$  | $\times10^{-5}$ Mpc$^{-3}$ | 14.8±11.6 | 3.2±2.1 | 5.4±2.1 | 7.6±3.5 |

1 The normalization $A$ is derived at the flux $2 \times 10^{-11}$ erg s$^{-1}$ cm$^{-2}$.
2 The number of confirmed non-blazar AGN and unidentified sources in the field.
3 The number of confirmed non-blazar AGN in the field.
4 The number of confirmed non-blazar AGN at $D < 150$ Mpc.
5 The number of confirmed non-blazar AGN at $D < 150$ Mpc with $L > 10^{42}$ erg s$^{-1}$.
6 Number density of AGN at $D < 150$ Mpc with $L > 10^{42}$ erg s$^{-1}$.

REFERENCES

Ajello M., et al., 2009, ApJ, 690, 367
Ajello M., Alexander D. M., Greiner J., Madejski G. M., Gehrels N., Burlon D., 2012, ApJ, 749, 21
Barlow E. J., Knigge C., Bird A. J., J Dean A., Clark D. J., Hill A. B., Molina M., Sguera V., 2006, MNRAS, 372, 224
Baumgartner W. H., Tüller J., Markwardt C. B., Skinner G. K., Barthelmy S., Mushotzky R. F., Evans P. A., Gehrels N., 2013, ApJS, 207, 19
Beckmann V., et al., 2009, A&A, 505, 417
Bird A. J., et al., 2010, ApJ, 186, 1
Bird A. J., et al., 2016, preprint, (arXiv:1601.06074)
Bodaghee A., Tomskich J. A., Rodriguez J., James B. J., 2012, ApJ, 744, 108
Brandt W. N., Alexander D. M., 2015, AApR, 23, 1
Caballero I., et al., 2013, preprint, (arXiv:1304.1349)
Churazov E., et al., 2014, Nature, 512, 406
Crawford D. F., Jauncey D. L., Murdoch H. S., 1970, ApJ, 162, 405
Cusumano G., et al., 2010, A&A, 524, A64
ESA ed. 1997, The HIPPARCOS and TYCHO catalogues. Astrometric and photometric star catalogues derived from the ESA HIPPARCOS Space Astrometry Mission ESA Special Publication Vol. 1200
Evans P. A., et al., 2014, ApJS, 210, 8
Gehrels N., et al., 2004, ApJL, 611, 1005
Götz D., Mereghetti S., Merlini D., Sidoli L., Belloni T., 2006, A&A, 448, 873
Grebenev S. A., Lutovinov A. A., Tsygankov S. S., Winkler C., 2012, Nature, 490, 373
Grebenkov S. A., Lutovinov A. A., Tsygankov S. S., Mereminskiy I. A., 2013, MNRAS, 428, 50
Harrison F. A., et al., 2013, ApJ, 770, 103
Huchra J., Sargent W. L. W., 1973, ApJ, 186, 433
Jarrett T., 2004, PASA, 21, 396
Kozłowski S., et al., 2012, ApJ, 746, 27
Krivonos R., Vikhlinin A., Churazov E., Lutovinov A., Molkov S., Sunyaev R., 2005, ApJ, 625, 89
Krivonos R., Revnivtsev M., Lutovinov A., Sazonov S., Churazov E., Sunyaev R., 2007, A&A, 475, 775
Krivonos R., Revnivtsev M., Tsygankov S., Sazonov S., Vikhlinin A., Pavlinsky M., Churazov E., Sunyaev R., 2010a, A&A, 519, A107
Krivonos R., Tsygankov S., Revnivtsev M., Grebenev S., Churazov E., Sunyaev R., 2010b, A&A, 523, A61
Krivonos R., Tsygankov S., Lutovinov A., Revnivtsev M., Churazov E., Sunyaev R., 2012, A&A, 545, A27
Lutovinov A. A., Vikhlinin A., Churazov E. M., Revnivtsev M. G., Sunyaev R. A., 2008, ApJ, 687, 968
Lutovinov A. A., Grebenev S. A., Tsygankov S. S., 2012, Astronomy Letters, 38, 492
Lutovinov A. A., Revnivtsev M. G., Tsygankov S. S., Krivonos R. A., 2013, MNRAS, 431, 327
Malizia A., Stephen J. B., Bassani L., Bird A. J., Panessa F., Ubertini P., 2009, MNRAS, 399, 944
Molkov S. V., Lutovinov A. A., Falanga M., 2015, Astronomy Letters, 41, 562
Mullaney J. R., et al., 2015, ApJ, 808, 184
Paltani S., Walter R., Mchardy I. M., Dwelly T., Steiner C., Courvoisier T. J.-L., 2008, A&A, 485, 707
Revnivtsev M., Lutovinov A., Churazov E., Sazonov S., Gilfanov M., Grebenev S., Sunyaev R., 2008, A&A, 491, 209
Rosen S. R., et al., 2015, preprint, (arXiv:1504.07051)
Sazonov S., Revnivtsev M., Krivonos R., 2008, A&A, 482, 57
Sazonov S., Krivonos R., Revnivtsev M., Churazov E., Sunyaev R., 2007, A&A, 462, 57
Sazonov S., Krivonos R., Revnivtsev M., Churazov E., Sunyaev R., 2014, Astronomy Letters, 40, 65
Sazonov S. Y., Lutovinov A. A., Krivonos R. A., Churazov E., 2013, MNRAS, 431, 327
Sazonov S., Krivonos R., Revnivtsev M., Churazov E., Sunyaev R., 2008, A&A, 482, 517
Sazonov S. Y., Lutovinov A. A., Krivonos R. A., 2014, Astronomy Letters, 40, 65
Sazonov S., Churazov E., Krivonos R., 2015, MNRAS, 454, 1202
Schmidt M., 1968, ApJ, 151, 393
Stickel M., Kuehr H., 1993, A&S, 100, 395
Takahashi T., et al., 2010, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series. p. 0 (arXiv:1010.4972), doi:10.1117/12.857875
Voges W., et al., 1999, A&A, 349, 389

MNRS 000, 1–11 (2016)
Walter R., Lutovinov A. A., Bozzo E., Tsygankov S. S., 2015, 
A&ARv, 23, 2
Winkler C., et al., 2003, A&A, 411, L1
Appendix 1. The complete catalog of hard X-ray sources detected in the combined survey of three fields: M81, LMC and 3C 273/Coma. The description of the columns can be found in Sect. 2.3 of the paper.

| Id | Name$^1$ | R.A. | Dec. | S/N | Flux | D | z | log L$_{\text{erg s}^{-1}}$ | Type | Notes |
|----|---------|------|------|-----|------|---|---|----------------------|------|-------|
| M81 field |
| 1 | Mrk 3 | 93.950 | 71.039 | 39.4 | 5.81±0.15 | 0.013 | 43.56 | Sy2 |
| 2 | IGR J06253+7334 | 96.370 | 73.585 | 7.6 | 0.99±0.13 | 0.019 | 43.56 | Sy2 |
| 3 | Mrk 6 | 103.043 | 74.427 | 22.4 | 2.37±0.11 | 0.019 | 43.46 | CV |
| 4 | IGR J06571+7802 | 104.277 | 78.044 | 4.2 | 0.47±0.11 | 0.016 | 43.54 | Blazar |
| 5 | QSO B0716+714 | 110.576 | 71.304 | 5.9 | 0.50±0.08 | 0.300 | 43.54 | Blazar |
| 6 | IGR J07563+5919 | 119.091 | 59.321 | 4.0 | 0.62±0.16 | 0.016 | 43.54 | Blazar |
| 7 | PG 0840+761 | 122.929 | 76.034 | 9.4 | 0.63±0.07 | 0.100 | 44.39 | Sy1 |
| 8 | QSO B0836+710 | 130.333 | 70.905 | 62.2 | 3.27±0.05 | 2.172 | 48.24 | Blazar |
| 9 | IGR J08501+6630 | 132.547 | 66.515 | 6.9 | 0.38±0.06 | 0.036 | 43.54 | Sy2 |
| 10 | IGR J08557+6420 | 133.839 | 64.391 | 11.2 | 0.67±0.06 | 0.036 | 43.54 | MCG +11-11-032 |
| 11 | NGC 2655 | 133.901 | 78.250 | 6.3 | 0.43±0.07 | 24.4 | 41.64 | LINER |
| 12 | Mrk 110 | 141.292 | 52.292 | 12.2 | 3.44±0.28 | 0.035 | 44.19 | Sy1 |
| 13 | IGR J09253+6929 | 141.455 | 69.481 | 13.1 | 0.61±0.05 | 0.036 | 43.52 | Sy1.5 |
| 14 | SWIFT J0929.7+6232 | 142.413 | 62.556 | 10.2 | 0.62±0.06 | 0.026 | 43.15 | Sy2 |
| 15 | SWIFT J0935.9+6120 | 143.991 | 61.314 | 4.5 | 0.29±0.07 | 0.039 | 43.20 | Sy1 |
| 16 | SWIFT J0950.5+7318 | 147.509 | 73.248 | 9.3 | 0.45±0.05 | 0.058 | 43.74 | VIIZw 292 |
| 17 | M81 | 148.898 | 69.080 | 19.8 | 0.90±0.05 | 3.7 | 40.33 | LINER |
| 18 | M82 X-1 | 148.973 | 69.675 | 7.5 | 0.34±0.05 | 0.039 | 43.31 | Sy2 |
| 19 | SWIFT J1001.7+5543 | 150.489 | 55.709 | 11.7 | 1.55±0.13 | 19.1 | 41.99 | NGC 3079 |
| 20 | IGR J10252+6716 | 156.324 | 67.273 | 7.9 | 0.38±0.05 | 0.039 | 43.31 | Sy2 |
| 21 | SWIFT J1033.6+7303 | 158.576 | 73.016 | 8.3 | 0.41±0.05 | 0.022 | 42.84 | XBOING |
| 22 | IGR J10380+8435 | 159.513 | 84.587 | 4.4 | 0.63±0.14 | 0.034 | 43.3 | Sy2 |
| 23 | SWIFT J1044.1+7024 | 161.072 | 70.431 | 10.2 | 0.51±0.05 | 0.034 | 43.3 | MCG +12-10-067 |
| 24 | QSO J1044+8054 | 161.240 | 80.862 | 5.7 | 0.50±0.09 | 1.260 | 46.84 | Blazar |
| 25 | IGR J11015+7224 | 165.392 | 72.409 | 4.0 | 0.22±0.05 | 1.459 | 46.64 | Blazar |
| 26 | IGR J11030+7027 | 165.758 | 70.463 | 4.1 | 0.22±0.05 | 0.039 | 43.31 | Sy2 |
| 27 | SWIFT J1105.7+5854 | 166.456 | 58.913 | 6.0 | 0.67±0.11 | 0.039 | 43.31 | Sy2 |
| 28 | NGC 3516 | 166.694 | 72.566 | 31.9 | 1.76±0.06 | 52.5 | 42.92 | Sy1.5 |
| 29 | IGR J11079+7106 | 166.992 | 71.199 | 6.6 | 0.36±0.05 | 0.060 | 43.68 | AGN |
| 30 | SWIFT J1114.3+7944 | 168.978 | 79.698 | 5.0 | 0.42±0.08 | 0.037 | 43.31 | Sy2 |
| 31 | SWIFT J1136.7+6738 | 174.155 | 67.595 | 6.8 | 0.47±0.07 | 0.134 | 44.53 | Blazar |
| 32 | SWIFT J1142.7+7149 | 175.909 | 71.686 | 6.2 | 0.42±0.07 | 0.134 | 44.53 | CV |
| 33 | SWIFT J1143.7+7942 | 176.199 | 79.681 | 9.1 | 0.85±0.09 | 27.2 | 42.03 | Sy1.2 |
| 34 | IGR J12171+7047 | 184.288 | 70.797 | 5.2 | 0.48±0.09 | 25.0 | 41.71 | AGN |

Continued on next page
| Name     | R.A.  | Dec.  | S/N   | Pulsar | Notes           |
|----------|-------|-------|-------|--------|-----------------|
| LMC X–2  |       |       |       |        |                 |
| SWIFT J0422.7–7252 | 22.384 | -73.144 | 5.2 | 0.52±0.10 |                 |
| SWIFT J0422.7–7252 | 22.384 | -73.144 | 5.2 | 0.52±0.10 |                 |
| HMXB     |       |       |       |        |                 |
| RX J0520.5–6932 | 5.184 | -69.759 | 0.48 | 0.059 |                 |
| HMXB     |       |       |       |        |                 |
| 3SXPS J053430.8-601617, | 44.16 |         | 44.16 | 0.007 |                 |
| Sy2      |       |       |       |        |                 |
| LMC X–4  |       |       |       |        |                 |
| 2MASX J05052442-6734358 | 16.233 | 12.4 | 1.24±0.10 | 0.85 |                 |
| Sy1      |       |       |       |        |                 |
| Sy2      |       |       |       |        |                 |
| LMC X–4  |       |       |       |        |                 |
| SWIFT J0505.6–6735 | 1.238 | 1.238 | 1.238 | 1.238 |                 |
| Sy1      |       |       |       |        |                 |
| Sy2      |       |       |       |        |                 |

Continued on next page
Table 4 – continued from previous page

| Id | Name                          | R.A.  | Dec.  | S/N | Flux mCrab | D Mpc | z     | log L erg s\(^{-1}\) | Type | Notes                  |
|----|-------------------------------|-------|-------|-----|------------|-------|-------|----------------------|------|-----------------------|
| 69 | IGR J05414–6858*              | 85.387| -68.944| 12.0| 0.71±0.06  |       |       |                      |      | HMXB                  |
| 70 | SWIFT J0541.5–6826            | 85.420| -68.398| 6.2 | 0.36±0.06  |       |       |                      |      | HMXB                  |
| 71 | IGR J06075–6148              | 91.899| -61.814| 4.2 | 0.34±0.08  | 19.9  | 41.36 |                      | AGN | 3XMM J060730.3–614827, ESO 121–G006 |
| 72 | SWIFT J0623.3–6438            | 95.784| -64.580| 6.0 | 0.43±0.07  | 0.129 | 44.46 | 2MASX J06230765–6436211 |
| 73 | IGR J06239–6052              | 95.925| -60.987| 14.8| 1.36±0.09  | 0.040 | 43.90 | 2ESO 121–28          |
| 74 | SWIFT J0634.7–7445            | 98.712| -74.764| 5.8 | 0.43±0.07  | 0.112 | 44.33 | Sy1                  |
| 75 | IGR J06354–7516              | 98.892| -75.249| 9.8 | 0.74±0.08  | 0.653 | 46.31 | Blazar               |
| 76 | IGR J06380–7536              | 99.525| -75.616| 4.1 | 0.31±0.08  | 0.089 | 43.97 | Sy1.8                |
| 77 | IGR J06503–7742              | 102.599| -77.701| 4.4 | 0.41±0.09  | 0.037 | 43.30 | AGN                  |
| 78 | IGR J06569–6534              | 104.210| -65.570| 6.2 | 0.51±0.08  | 0.030 | 43.22 | Sy1                  |
| 79 | IGR J07296–5854              | 112.413| -58.905| 4.2 | 0.72±0.17  |       |       |                      |      | 2MASX J07473839–7325533 |
| 80 | SWIFT J0747.6–7326            | 116.989| -73.449| 6.8 | 0.70±0.10  | 0.036 | 43.51 | LINER?               |
| 81 | EXO J0748–676                | 117.097| -67.756| 28.7| 3.25±11.0  |       |       |                      |      | 2MASX J12005792+0648226 |
| 82 | SWIFT J0826.2–7033            | 126.584| -70.527| 9.2 | 1.31±0.14  |       |       |                      |      | NGC 4074              |
| 83 | IGR J09025–6814              | 135.680| -68.219| 4.3 | 0.68±0.15  | 0.013 | 42.62 | XBONG                |

3C 273/Coma field

| Id | Name                          | R.A.  | Dec.  | S/N | Flux mCrab | D Mpc | z     | log L erg s\(^{-1}\) | Type | Notes                  |
|----|-------------------------------|-------|-------|-----|------------|-------|-------|----------------------|------|-----------------------|
| 84 | SWIFT J1144.1+3652            | 176.118| 36.924| 5.9 | 0.56±0.10  | 0.038 | 43.46 | Sy1                  |
| 85 | IGR J11477+0557               | 176.931| 5.966 | 4.6 | 0.40±0.09  |       |       |                      |      | KUG 1141 +371         |
| 86 | SWIFT J1148.3+0901            | 177.025| 9.049 | 4.2 | 0.35±0.08  | 0.069 | 43.79 | Sy1.5                |
| 87 | SWIFT J1148.7+2941            | 177.171| 29.609| 5.1 | 0.72±0.14  | 0.023 | 43.12 | Sy1                  |
| 88 | 3PBC J1152.9+3307             | 178.186| 33.104| 4.0 | 0.43±0.11  | 1.398 | 46.89 | MCG +05–28-032       |
| 89 | SWIFT J1200.8+0650            | 180.237| 6.810 | 11.9| 0.75±0.06  | 0.036 | 43.54 | Sy2                  |
| 90 | SWIFT J1201.1–0341            | 180.334| -3.906| 5.6 | 0.58±0.10  | 0.020 | 42.88 | Sy1                  |
| 91 | IGR J12024–1127              | 180.622| -11.469| 4.3 | 0.91±0.21  |       |       |                      |      | NGC 4051              |
| 92 | NGC 4051                      | 180.769| 45.522| 19.9| 2.18±0.11  | 14.0  | 41.86 | Sy1                  |
| 93 | IGR J12038–1210              | 180.958| -12.178| 4.0 | 0.87±0.22  |       |       |                      |      | NGC 4074              |
| 94 | NGC 4074                      | 181.115| 20.328| 8.8 | 0.94±0.11  | 0.022 | 43.21 | Sy2                  |
| 95 | 3PBC J1204.7+3109             | 181.121| 31.193| 4.9 | 0.55±0.11  | 0.025 | 43.08 | Sy1.9                |
| 96 | SWIFT J1207.5+3555            | 181.949| 33.854| 4.6 | 0.44±0.10  | 0.079 | 44.01 | Sy2                  |
| 97 | SWIFT J1209.5+4702            | 182.323| 47.036| 7.3 | 0.98±0.13  | 0.024 | 43.30 | Sy2                  |
| 98 | NGC 4138                      | 182.363| 43.688| 12.8| 1.33±0.10  | 20.7  | 41.99 | Sy1.9                |
| 99 | IGR J12095–0420               | 182.394| -4.344| 4.0 | 0.38±0.09  |       |       |                      |      | NGC 4151              |
| 100| NGC 4151                      | 182.628| -39.408| 30.5| 27.67±0.09 | 13.4  | 42.93 | Sy1.5                |
| 101| IGR J12107+3822               | 182.671| 38.343| 10.8| 0.97±0.09  | 0.023 | 43.24 | KUG 1208+386         |
| 102| NGC 4180                      | 183.253| 7.036 | 10.7| 0.57±0.05  | 39.2  | 41.97 | LINER                |

Continued on next page
| Name | R.A. | Dec. | S/N | Flux | D | z | log L | Notes |
|------|------|------|-----|------|---|---|--------|-------|
| Was 49 | 183.571 | 29.578 | 5.2 | 0.56±0.11 | 0.061 | 43.88 | Sy1 |
| IGR J12172+0710 | 184.302 | 7.187 | 45.3 | 2.32±0.05 | 25.0 | 42.39 | Sy1.2 |
| M81 | 184.600 | 29.828 | 13.2 | 1.35±0.10 | 0.013 | 42.89 | Sy1 |
| NGC 4258 | 184.727 | 47.298 | 7.1 | 0.90±0.11 | 7.5 | 40.97 | Sy2 |
| LMC | 185.022 | 2.065 | 4.1 | 0.23±0.06 | 0.240 | 44.78 | Sy1.8 |
| 3C 273 | 185.120 | 4.868 | 4.0 | 0.24±0.05 | 0.149 | 44.14 | PKS 1217+023 |
| Coma Cluster | 185.212 | -7.192 | 4.5 | 0.46±0.10 | 0.118 | 44.4 | Blazar |
| SDSS J122208.78+030718.4 | 185.351 | 30.169 | 6.0 | 0.60±0.10 | 0.184 | 44.94 | Blazar |
| IGR J12224+0306 | 185.606 | 3.110 | 4.3 | 0.23±0.05 | 0.255 | 44.84 | QSO? |
| IGR J12304+0946 | 187.620 | 9.776 | 4.2 | 0.21±0.05 | 0.158 | 46.15 | Blazar |
| IGR J12375+2156 | 189.392 | 21.944 | 4.3 | 0.36±0.08 | 0.387 | 46.18 | Blazar |
| NGC 4579 | 189.412 | 11.804 | 9.5 | 0.50±0.05 | 19.8 | 41.52 | LINER |
| SWIFT J1238.6+0928 | 189.665 | 9.440 | 9.2 | 0.46±0.05 | 0.032 | 43.22 | AGN |
| VCC 1759 | 189.925 | -5.356 | 47.3 | 3.86±0.08 | 44.0 | 43.10 | Sy1 |
| NGC 4593 | 190.260 | 27.505 | 5.4 | 0.50±0.09 | 0.057 | 43.77 | Sy2 |
| KUG 1238+278A | 190.302 | 30.125 | 5.4 | 0.49±0.09 | 0.158 | 42.84 | NLS1 |
| IGR J12412+3007 | 192.636 | -6.151 | 4.5 | 0.50±0.11 | 5.0 | 40.33 | LINER |
| NGC 4736 | 193.078 | -13.415 | 5.9 | 0.95±0.16 | 0.015 | 42.84 | NLS1 |
| IGR J12546+1139 | 193.672 | 11.663 | 4.6 | 0.27±0.06 | 0.873 | 46.18 | Blazar |
| RX J1254.6+1141 | 194.025 | -6.806 | 11.9 | 1.10±0.09 | 0.536 | 46.28 | Blazar |
| Coma Cluster | 194.892 | 27.932 | 13.0 | 1.18±0.09 | 0.023 | 43.34 | Cluster |
| SWIFT J1300.1+1635 | 195.072 | 16.545 | 4.7 | 0.35±0.08 | 0.080 | 43.93 | Sy1 |
| 2MASX J13005533+1632151 | 195.741 | 16.396 | 12.7 | 0.97±0.08 | 0.067 | 44.21 | NLS1 |
| M81 | 196.042 | -5.569 | 6.9 | 0.70±0.10 | 21.2 | 41.73 | Sy2 |
| NGC 4941 | 196.067 | -10.347 | 8.3 | 1.15±0.14 | 38.8 | 0.010 | 42.62 | Sy2 |
| NGC 4939 | 197.288 | 11.641 | 27.1 | 1.98±0.07 | 0.025 | 43.64 | XBONG |
| NGC 4992 | 197.507 | 8.508 | 4.1 | 0.29±0.07 | 0.195 | 44.95 | AGN |
| IGR J13100+0830 | 198.319 | -11.177 | 4.1 | 0.68±0.17 | 0.034 | 43.45 | Sy1 |
| 2MASX J13100580-1107424 | 198.357 | 36.583 | 5.2 | 0.64±0.12 | 18.7 | 41.58 | Sy1.9 |
| IGR J13124+0500 | 198.557 | -5.014 | 4.1 | 0.47±0.12 | 0.187 | 44.45 | AGN |
| Mrk 248 | 198.823 | -4.434 | 8.2 | 1.14±0.14 | 0.037 | 43.73 | Sy2 |
| IGR J13169+3733 | 199.237 | 37.553 | 4.1 | 0.54±0.13 | 0.195 | 44.95 | AGN |
| RX J1316.0+3735, 2MASX J13170290+373529 |
| Id | Name           | R.A.  | Dec.  | S/N | Flux D | z    | log L  | Type  | Notes                  |
|----|----------------|-------|-------|-----|--------|------|--------|-------|------------------------|
| 141| SWIFT J1321.2+0859 | 200.271 | 8.941 | 7.3 | 0.63±0.09 | 0.032 | 43.35 | LINER? | NGC 5100 NED02          |
| 142| IGR J13310–1355   | 202.756 | -13.931 | 4.0 | 1.18±0.29 | 0.023 | 43.96 | Sy1.9 |                        |
| 143| NGC 5252         | 204.555 | 4.550 | 43.5 | 4.94±0.11 | 0.040 | 43.82 | Sy2    |                         |
| 144| Mrk 268          | 205.300 | 30.392 | 8.8 | 1.18±0.13 | 0.010 | 41.64 | Sy1.9 | NGC 5273                |
| 145| 3PBC J1342.0+3539 | 205.546 | 35.699 | 5.9 | 1.01±0.17 | 16.0  | 44.18 | Sy1.2 | 2MASX J13462846+1922432 |
| 146| IGR J13466+1921   | 206.696 | 19.404 | 4.6 | 0.57±0.12 | 0.084 | 44.18 |        |                        |
| 147| IGR J13486+1554   | 207.168 | 15.901 | 4.8 | 0.57±0.12 |        |        |        |                        |

1 The names of the sources previously unknown in hard X-ray band (17 – 60 keV) are highlighted in bold. The sources in spatial confusion are indicated by star. The measured flux of the sources in spatial confusion should be taken with the caution.