

Swift XRT observations of
INTEGRAL sources

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Introduction

In the following, we provide a short report on a number of *Swift*/XRT observations performed so far on many unidentified *INTEGRAL*/IBIS sources. Results on individual or set of objects are presented and briefly discussed. Only sources detected at a confidence level $\geq 3\sigma$ are considered as likely counterparts. Simple spectral fitting have been performed on the data to obtain information on the source spectrum; quoted column densities are always in excess to the galactic value.

Please note that two objects, IGR J18244-5622 and IGR J21178+5139, have already been presented in Atel 945 (Landi et al. 2006) and are not discussed further here. Other sources, apart from those presented here, are being observed in the meantime and will be discussed in a future report. Suggestions on how to use in the shot-time these results are given at the end of this report in the Summary.

Coma survey by Krivonos et al. 2005

We have now observed all five excesses (IGR J11567+3700, IGR J12313+1214, IGR J12488+3315, IGR J13103+2001 and IGR J13371+1520) detected by *INTEGRAL*/IBIS in a deep observation of the Coma region and reported by Krivonos et al. (2005); all had a confidence level in the range $4.1-4.7\sigma$. The fact that these sources have not been reported afterwards nor are listed in the third IBIS catalogue (Bird et al. 2007) or in the recent russian all sky survey (Krivonos et al. 2007) suggests that they maybe spurious. In the following, we summarize the results of the *Swift*/XRT observations.

IGR J11567+3700

Three observations analyzed with exposures: 1) 1174 s (obscode: 00036100001), 2) 3166 s (obscode: 00036100002), 3) 940 s (obscode: 00036100003) s

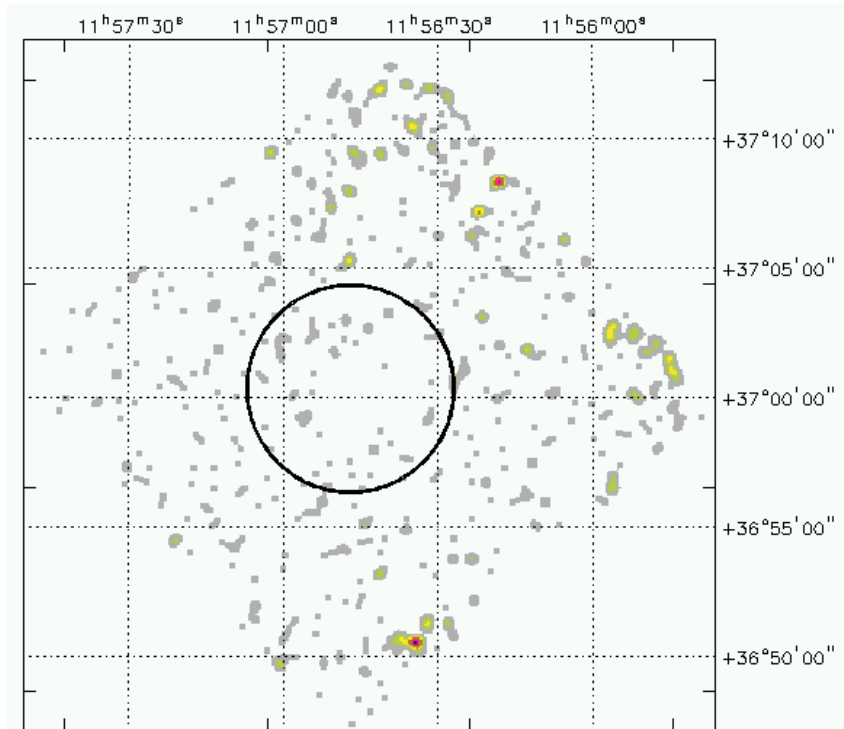


Figure 1: XRT image of the IGR J11567+3700 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

No source is detected in the *INTEGRAL* error box in each of the three XRT observations.

IGR J12313+1214

One observation analyzed with exposure: 1) 1353 s (obscode: 00036102001)

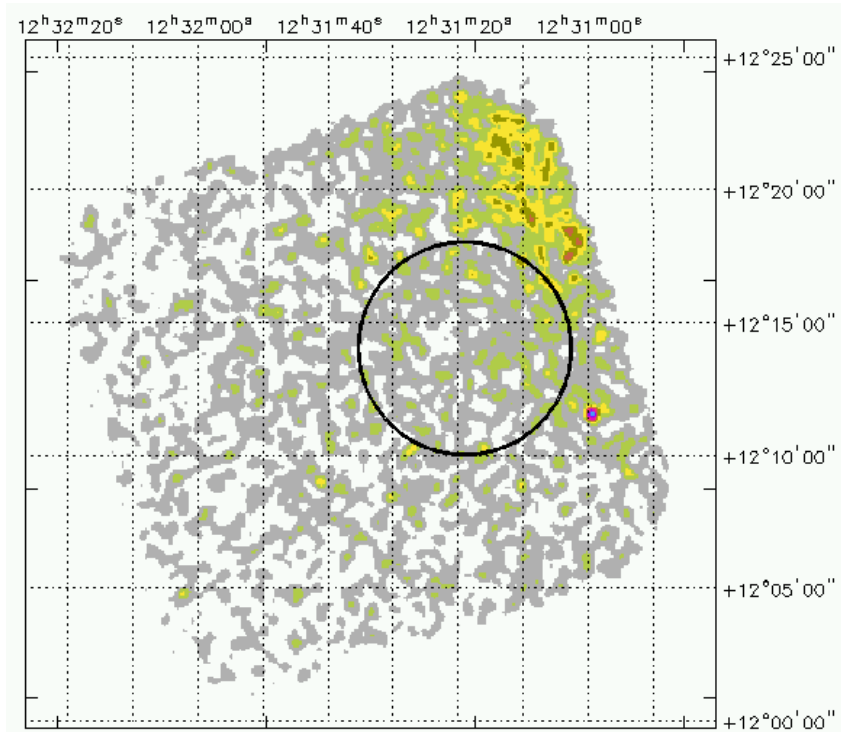


Figure 2: XRT image of the IGR J12313+1214 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

No source is detected in the *INTEGRAL* error box of this XRT observation.

IGR J12488+3315

One observation analyzed with exposure: 1) 4782 s (obscode: 00036103001)

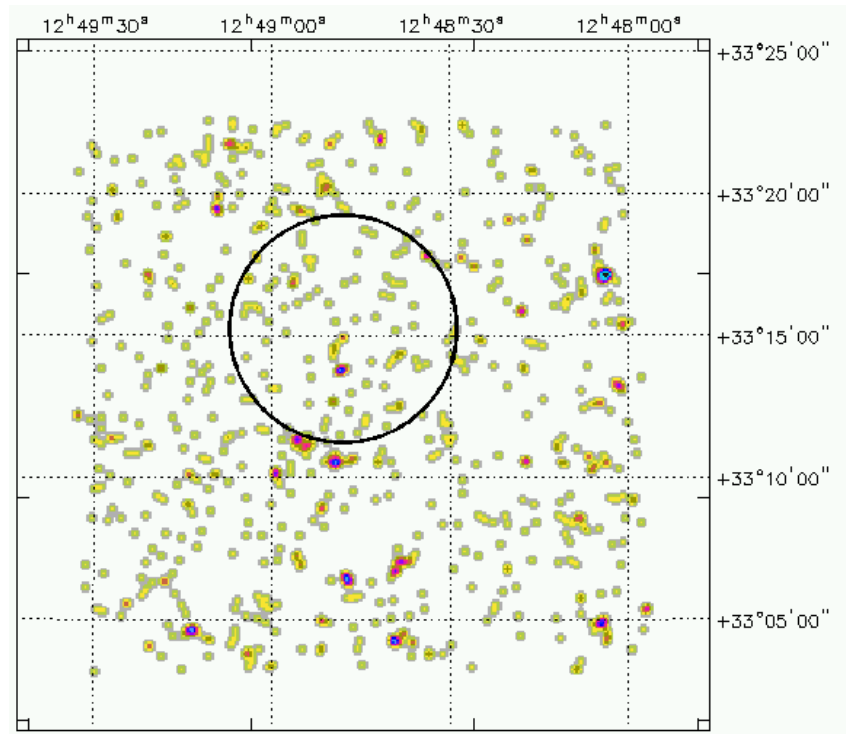


Figure 3: XRT image of the IGR J12488+3315 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

No source is detected in the *INTEGRAL* error box of this XRT observation.

IGR J13103+2001

Two observations analyzed with exposure: 1) 3049 s (obscode: 00036104001), 2) 2299 s (obscode: 00036104002)

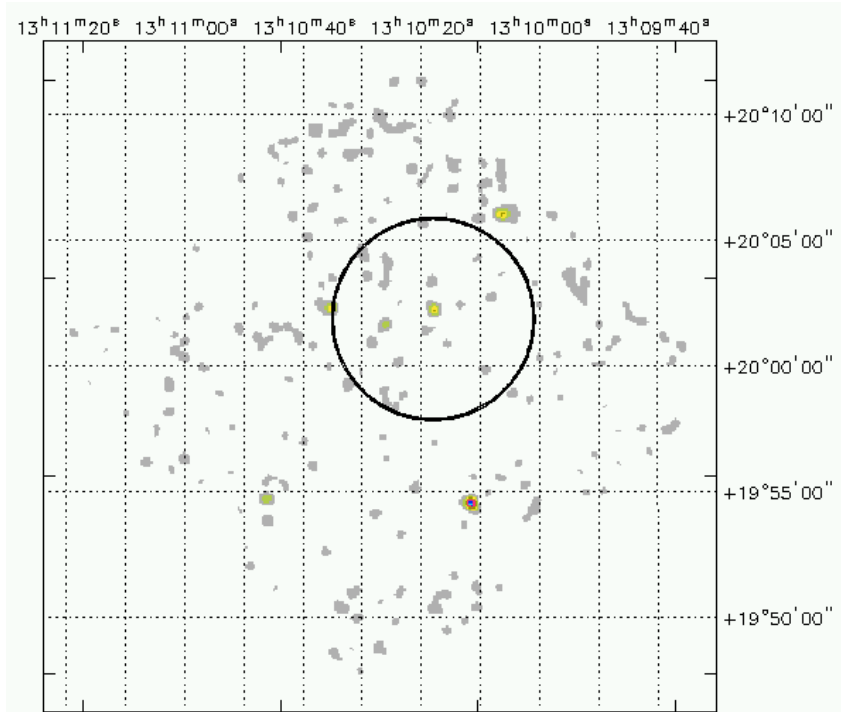


Figure 4: XRT image of the IGR J13103+2001 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

While our own analysis did not detect any source above 3σ confidence level, we notice that a source is detected at 3.1σ (versus our 2.9σ) in the ASDC (ASI SCIENTIFIC DATA CENTER), and well within the IBIS error box, at the following position:

$$\text{RA(J2000)} = 13^{\text{h}}10^{\text{m}}17^{\text{s}}.5$$

$$\text{Dec(J2000)} = +20^{\circ}02'14''.6$$

Within the $6''$ positional uncertainty, we do not find any optical or infrared counterpart.

XRT team can you please check this excess ?

IGR J13371+1520

One observation analyzed with exposure: 1) 8495 s (obscode: 00036106001)

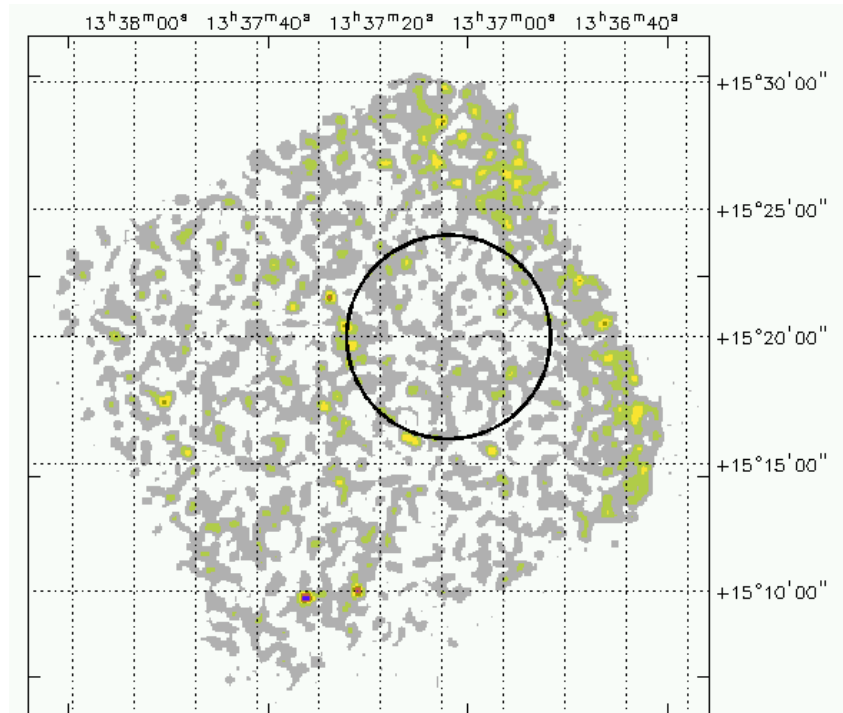


Figure 5: XRT image of the IGR J13371+1520 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

No source is detected in the *INTEGRAL* error box in this XRT observation.

Conclusions

With the possible exception of IGR J13103+2001, no X-ray counterpart is found in the IBIS error box of these Coma region excesses. The overall result is that these are probably spurious excesses rather than positive detections by *INTEGRAL*.

Transients and Variable Sources

A) IGR J10043–8702, IGR J10500–6410, IGR J15283–4443

The following three sources were discovered in the course of a systematic analysis of *INTEGRAL* archival data. Each source was visible only in a single pointing (about 2 ks), implying extreme variability or a transient behavior (Paizis et al. 2006).

IGR J10043–8702

One observation analyzed with exposure: 1) 5626 s (obscode: 00036097001)

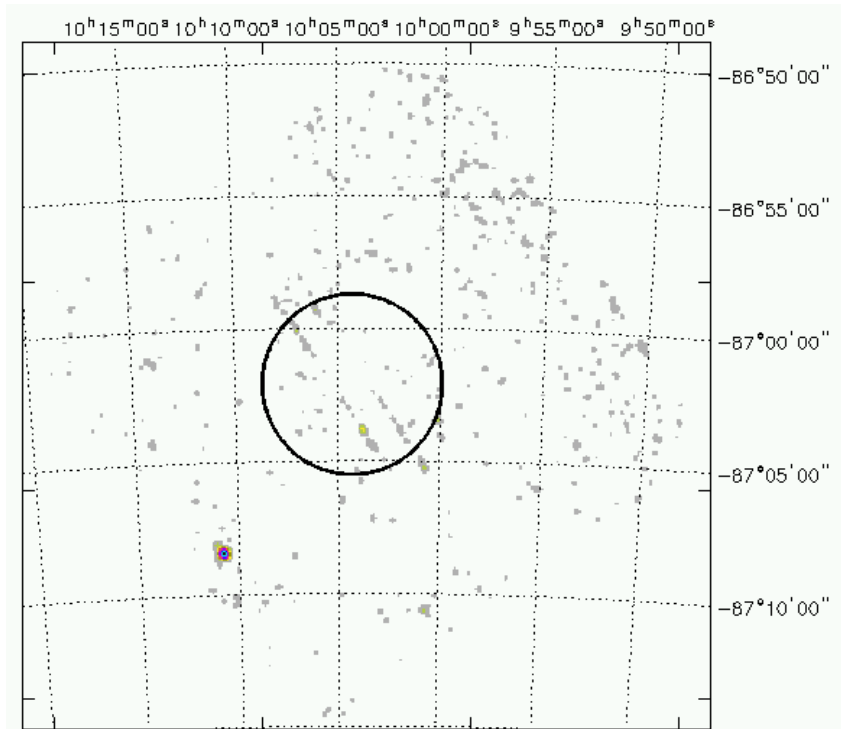


Figure 6: XRT image of the IGR J10043–8702 field. The black circle represents the *INTEGRAL* error box (Paizis et al. 2006).

While our own analysis did not detect any source above 3σ confidence level, we notice that also in this case a source is detected at 3.3σ level in the ASDC (just 3σ in our analysis) at the following position:

$$\text{RA(J2000)} = 10^{\text{h}}03^{\text{m}}42^{\text{s}}.9$$

$$\text{Dec(J2000)} = -87^{\circ}03'48''.6$$

However this excess is suspiciously on a trail. Within the $6''$ positional uncertainty, we do not find any optical or infrared counterpart.

XRT team can you please check this excess ?

IGR J10500–6410

Two observations analyzed with exposures: 1) 2302 s (obscode: 00036098001), 2) 3825 s (obscode: 00036098002)

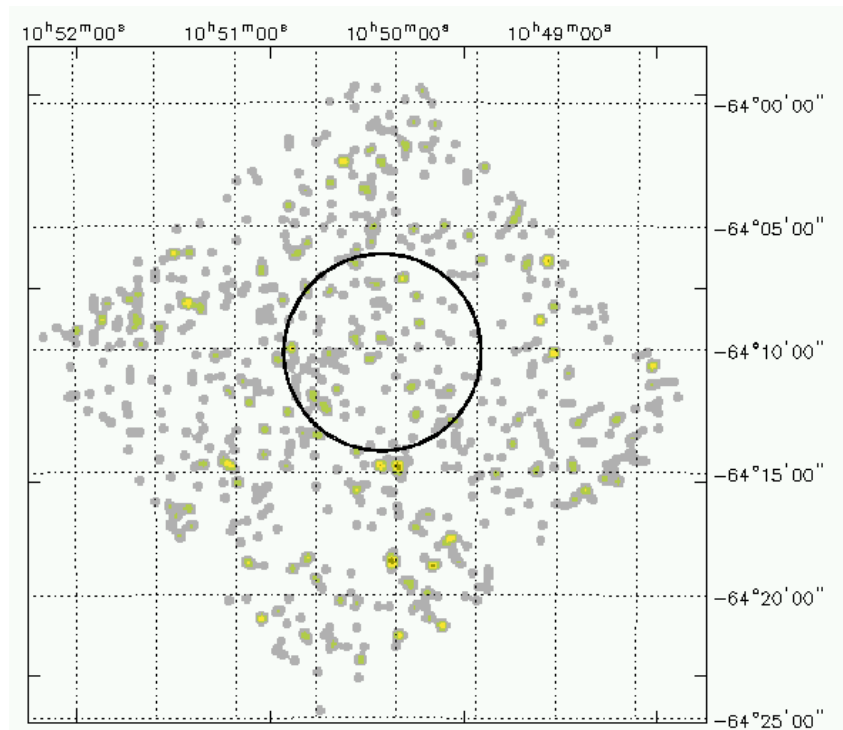


Figure 7: XRT image of the IGR J10500–6410 field. The black circle represents the *INTEGRAL* error box (Paizis et al. 2006).

No source is detected in the *INTEGRAL* error box in each of these two XRT observations.

IGR J15283–4443

One observation analyzed with exposure: 1) 5741 s (obscode: 00036114001)

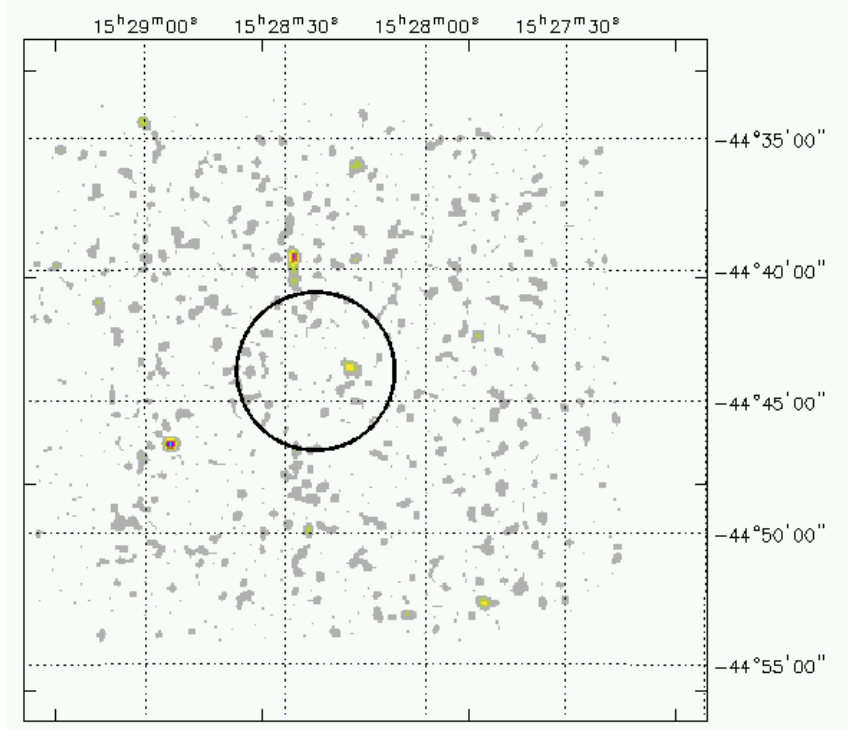


Figure 8: XRT image of the IGR J15283–4443 field. The black circle represents the *INTEGRAL* error box (Paizis et al. 2006).

While our own analysis did not detect any source above 3σ confidence level within the *INTEGRAL* error box again, we notice that a source is detected at 3.4σ level in the ASDC archive (versus our 2.9σ) at the following position:

$$\text{RA(J2000)} = 15^{\text{h}}28^{\text{m}}15^{\text{s}}.6$$

$$\text{Dec(J2000)} = -44^{\circ}43'45''.4$$

Within $6''$ from the XRT position we find a bright star GSC 07847–00975 (USNO–B1.0 position $\text{RA(J2000)} = 15^{\text{h}}28^{\text{m}}15'.95$, $\text{Dec(J2000)} = -44^{\circ}43'41''.8$, with magnitude $R = 10.3$), also detected in Infrared (2MASS magnitudes $J = 10.343$, $H = 10.032$, $K = 9.977$).

XRT team can you please check this excess ?

B) IGR J05319–6601

One observation analyzed with exposure: 1) 1433 s (obscode: 00036094001)

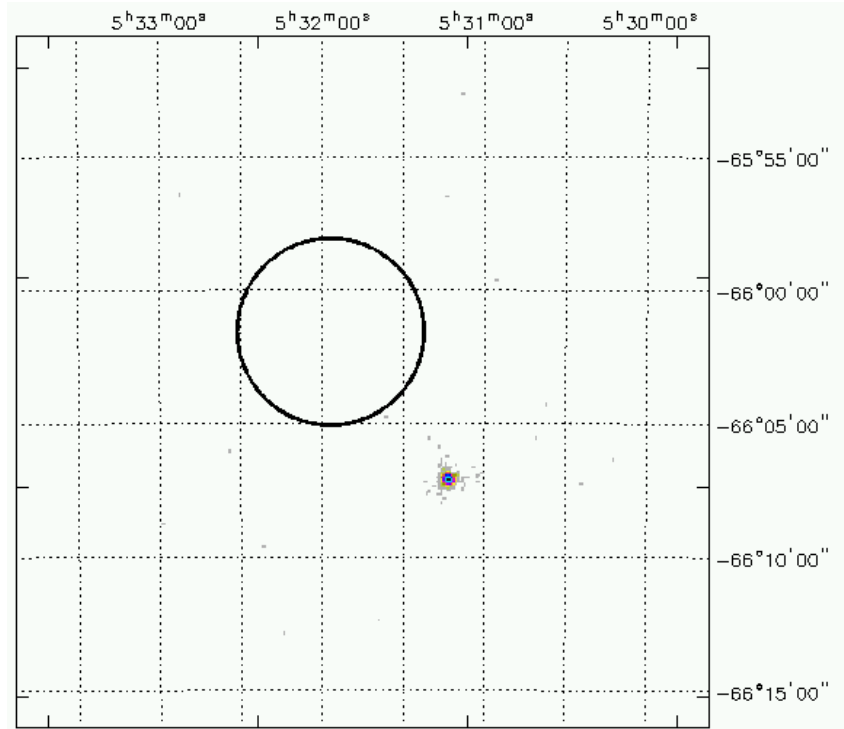


Figure 9: XRT image of the IGR J05319–6601 field. The black circle represents the *INTEGRAL* error box (Gotz et al. 2006)

This source has been reported in the *INTEGRAL* survey of the Large Magellanic Cloud (Gotz et al. 2006); the source was detected at 6σ level in 2003 but not in 2004. However, no source at this position is reported in the third IBIS survey (Bird et al. 2007) nor in the all sky survey by Krivonos et al. (2007).

No source is detected in the XRT field of view within the *INTEGRAL* error box.
The source detected outside the *INTEGRAL* error box and located at:

$$\text{RA(J2000)} = 05^{\text{h}}31^{\text{m}}13^{\text{s}}.23$$

$$\text{Dec(J2000)} = -66^{\circ}07'05''.45$$

$$\text{error box} = 3''.64$$

is identified with the HXB RX J0531.2–6609 (at $0.05'$), which is located at about $7'.5$ from the IBIS excess. Although the IBIS error box reported by Gotz et al. (2006) maybe underestimated, it is unlikely that the excess they reported has been mis-positioned by so much. This suggest the source is highly variable and/or transient or alternatively is spurious.

Crux region survey

The following two sources were reported in the *INTEGRAL* survey of the Crux region (Revnivtsev et al. 2005) with a significance of 5σ (IGR J08023–6954) and 10.5σ (IGR J11321–5311). While the first source is detected in the average sky map, the second was only seen in some observations. Neither is listed in the most recent IBIS catalogue (Bird et al. 2007), while both appears in the catalog of Krivonos et al. (2007)

IGR J08023–6954

Two observations analyzed with exposures: 1) 716 s (obscode: 00036095001), 2) 5825 s (obscode: 00036095002)

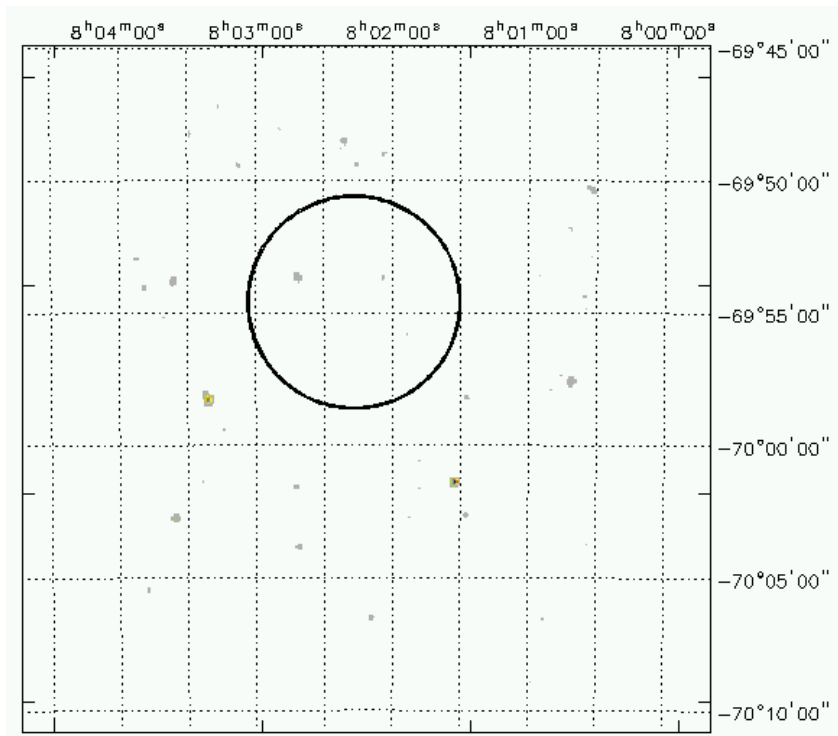


Figure 10: XRT image of the IGR J08023–6954 field. The black circle represents the *INTEGRAL* error box (Revnivtsev et al. 2005)

In the XRT field of view there is an excess, but below our confidence threshold level ($2.6\text{--}2.8\sigma$) at the following position:

$$\text{RA(J2000)} = 08^{\text{h}}02^{\text{m}}40^{\text{s}}.7$$

$$\text{Dec(J2000)} = -69^{\circ}53'35''.8$$

This excess if real is associated to an USNO–B1.0 source (also in the 2MASS catalogue) located at $\text{RA(J2000)} = 08^{\text{h}}02^{\text{m}}41^{\text{s}}.71$, $\text{Dec(J2000)} = -69^{\circ}53'37''.9$, with magnitude $R = 13.6 - 14.3$.

IGR J11321–5311

Two observations analyzed with exposures: 1) 2553 s (obscode: 00036099001), 2) 3311 s (obscode: 00036099002)

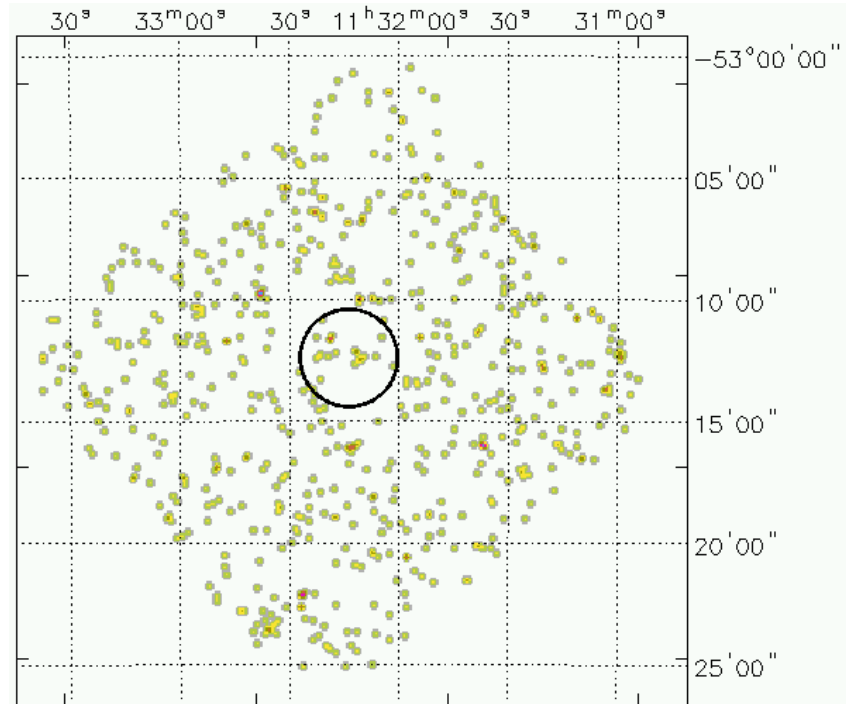


Figure 11: XRT image of the IGR J11321–5311 field. The black circle represents the *INTEGRAL* error box (Krivonos et al. 2005).

No source is detected within the *INTEGRAL* error box in both XRT observations.

Confirmation of two previous associations

The following sources have been associated to ISGRI objects purely on the basis that they were bright galaxies falling within the IBIS error box; indeed they were found to be AGN. However, to definitely associate them to the *INTEGRAL* sources arcsecond positioning of the X-ray counterpart was needed. Both associations have been confirmed as reported below.

IGR J14175–4641

One observation analyzed with exposure: 1) 5641 s (obscode: 00036108001)

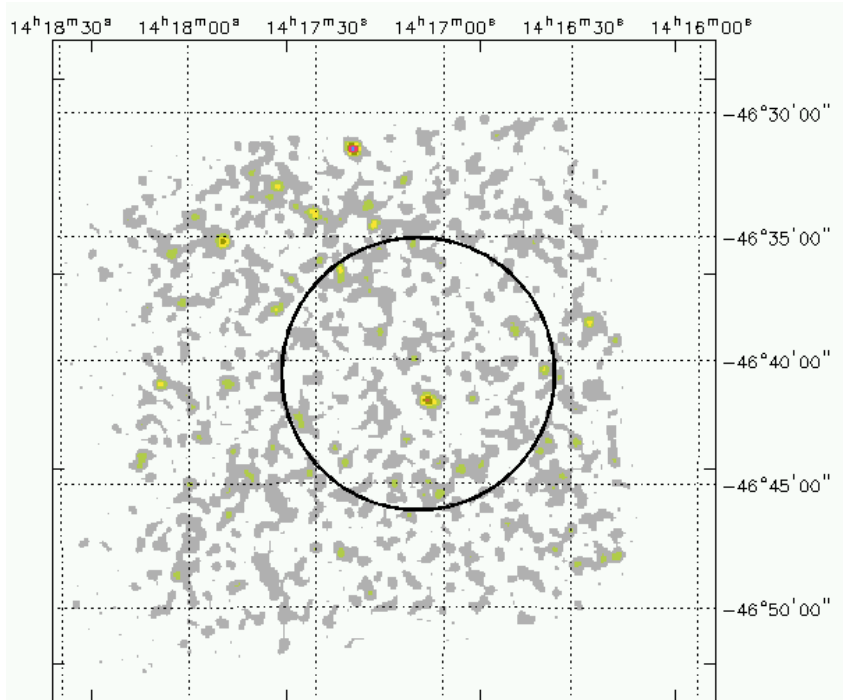


Figure 12: XRT image of the IGR J14175–4641 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

In the XRT field of view there is a weak source (3.3σ) within the *INTEGRAL* error box located at:

$$\text{RA(J2000)} = 14^{\text{h}}17^{\text{m}}03^{\text{s}}.8$$

$$\text{Dec(J2000)} = -46^{\circ}41'39''.7$$

The XRT position confirms a previous association with LEDA 511869, a Seyfert 2 galaxy at $z = 0.076$ (see Masetti et al. 2006 for the optical spectroscopy); the source is too faint to allow X-ray spectroscopy and only the X-ray flux can be estimated (2–10 keV flux of $5.8 \times 10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1}$).

IGR J14552–5133

Two observations analyzed with exposures: 1) 3786 s (obscode: 00036113001), 2) 4749 s (obscode: 00036113002)

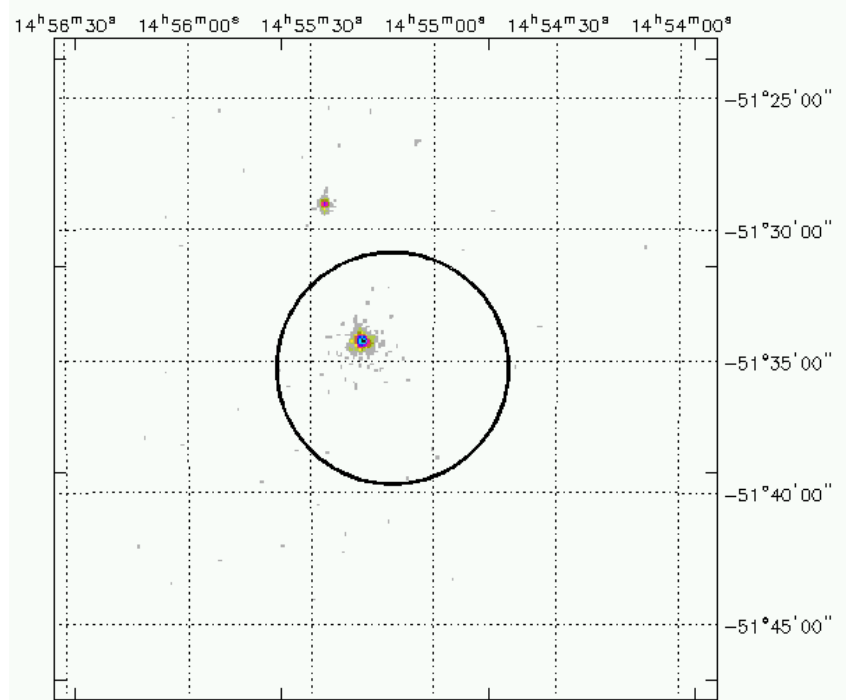


Figure 13: XRT image of the IGR J14552–5133 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

Within the IBIS error box there is a clear excess at:

$$\text{RA(J2000)} = 14^{\text{h}}55^{\text{m}}17^{\text{s}}.93$$

$$\text{Dec(J2000)} = -51^{\circ}34'13''.27$$

$$\text{error box} = 3''.32$$

The XRT position confirms a previous association with WKK4438, a Narrow Line Seyfert1 galaxy at $z = 0.016$ (see Masetti et al. 2006 for the optical spectroscopy); the X-ray spectroscopy indicates an mildly absorbed power law spectrum ($\Gamma \sim 2.06$, $N_{\text{H}} \sim 1.2 \times 10^{21} \text{ cm}^{-2}$).

Objects in the third *INTEGRAL* survey

The following objects are all listed in the third *INTEGRAL* survey of Bird et al. (2007). They all have a counterpart and will be observed and classify in optical in the following months.

IGR J09026–4812

One observation analyzed with exposure: 1) 2791 s (obscode: 00036096001)

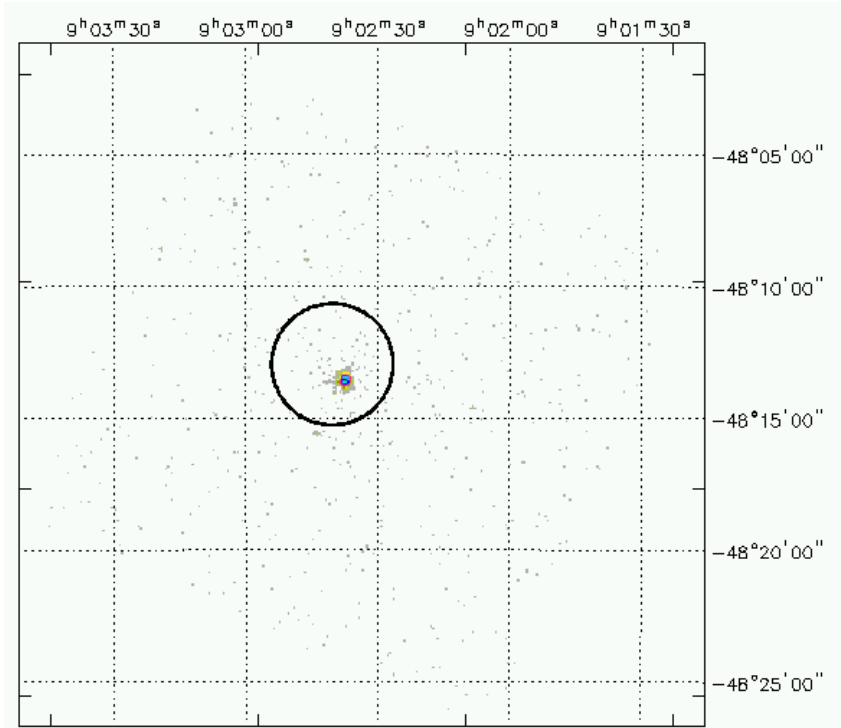


Figure 14: XRT image of the IGR J09026–4812 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

Within the IBIS error box of this source, we find a bright X-ray source at the following position:

$$\text{RA(J2000)} = 09^{\text{h}}02^{\text{m}}37^{\text{s}}.67$$

$$\text{Dec(J2000)} = -48^{\circ}13'36''.18$$

$$\text{error box} = 3''.55$$

The source is associated to 2MASX J09023729–4813339, a 2MASS extended object defined as irregular; it is also very likely (considering the relative uncertainty in position) that this object was already detected in X-rays as a faint ROSAT source (1RXS J090238.4–481408). The infrared/XRT source has no optical counterpart in the USNO–B1.0 catalogue.

The X-ray spectroscopy indicates an unabsorbed flat ($\Gamma \sim 1.2$) spectrum.

1ES 1210–646

One observation analyzed with exposure: 1) 10109 s (obscode: 00036101001)

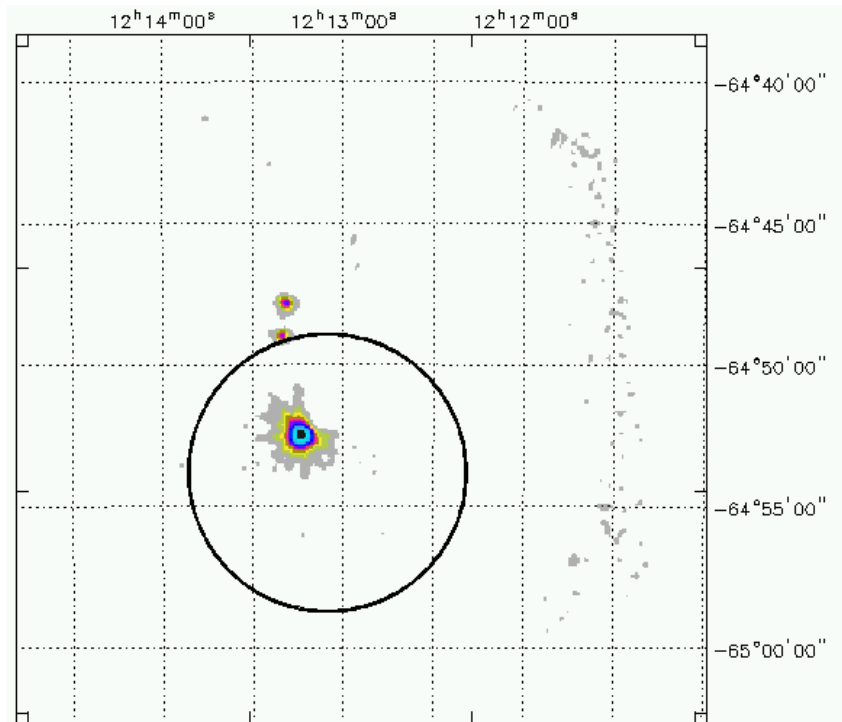


Figure 15: XRT image of the 1ES 1210–646 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

Within the IBIS error box of this source, we find a bright X-ray source at the following position:

$$\text{RA(J2000)} = 12^{\text{h}}13^{\text{m}}14^{\text{s}}.78$$

$$\text{Dec(J2000)} = -64^{\circ}52'28''.42$$

$$\text{error box} = 3''.22$$

This is a source already reported in the the *Einstein* Slew Survey, in the *EXOSAT* Medium-Energy Slew Survey Catalog and as a ROSAT source (2RXP J121315.3–645221). There are two USNO–B1.0 objects within the XRT uncertainty, the brightest of the two (n. 2) being reported in various catalogue and as a 2MASS object. This is probably the most likely candidate.

These two objects are:

$$1) \text{ RA(J2000)} = 12^{\text{h}}13^{\text{m}}14^{\text{s}}.79 \quad \text{Dec(J2000)} = -64^{\circ}52'25''.6$$

(with magnitude $R = 15.1 - 16.3$)

$$2) \text{ RA(J2000)} = 12^{\text{h}} 13^{\text{m}} 14^{\text{s}}.81 \quad \text{Dec(J2000)} = -64^{\circ} 52' 31''.1$$

(with magnitude $R = 13.2 - 13.6$)

The X-ray data analysis provides as best-fit a power law having photon index $\Gamma \sim 1.9$ plus a thermal soft component and an iron Gaussian line at ~ 6.7 keV with an $EW \sim 640$ eV.

IGR J13109–5552

Three observations analyzed with exposures: 1) 2675 s (obscode: 00036105001), 2) 3666 s (obscode: 00036105002), 3) 3030 s (obscode: 00036105003)

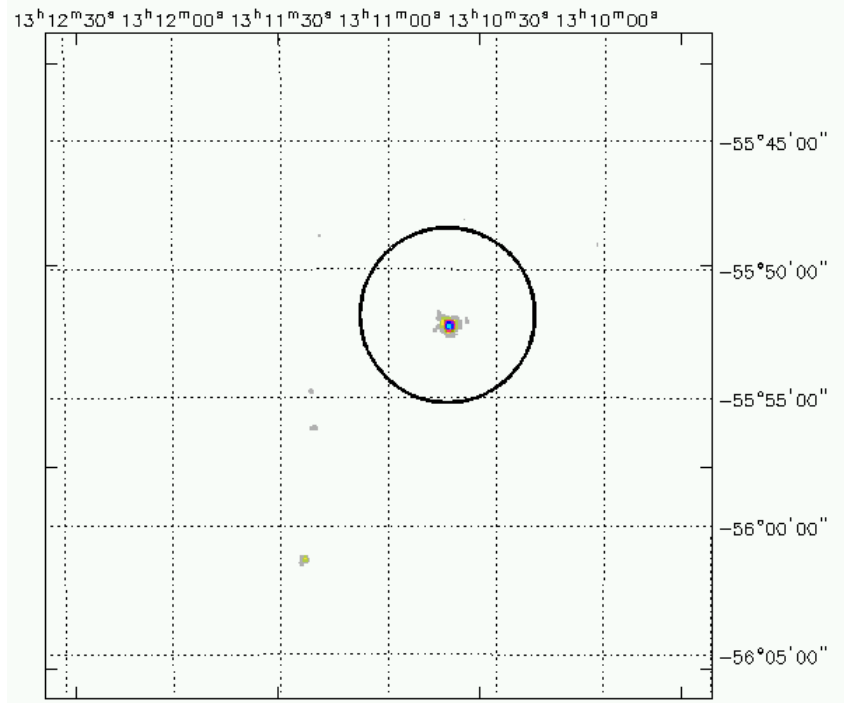


Figure 16: XRT image of the IGR J13109–5552 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

Here too, we have a bright X-ray source inside the IBIS error box at the following position:

$$\text{RA(J2000)} = 13^{\text{h}}10^{\text{m}}43^{\text{s}}.62$$

$$\text{Dec(J2000)} = -55^{\circ}52'10''.56$$

$$\text{error box} = 3''.47$$

This source is very likely XMMSL1 J131042.6–555206 (an *XMM-Newton* slew catalogue object) associated on the basis of the positional coincidence with the radio source PMNJ1310–5552 (353 mJy at 49850 MHz). There is a mismatch in position between us and ASDC, with the ASDC position being more compatible with the *XMM-Newton* one (**XRT team can you please check also this mismatch ?**) If we use *XMM-Newton* position and uncertainty we have the following optical counterpart:

$$\text{RA(J2000)} = 13^{\text{h}}10^{\text{m}}42^{\text{s}}.73 \quad \text{Dec(J2000)} = -55^{\circ}52'01''.7$$

with magnitudes ($R = 17.5 - 16.7$)

If instead we use our position, then we have two counterparts none of which coincides with that of *XMM-Newton* position.

The X-ray spectroscopy provides as best-fit to the data an unabsorbed power law having photon index $\Gamma \sim 1.5$

IGR J14003–6326

One observation analyzed with exposure: 1) 1573 s (obscode: 00036107001)

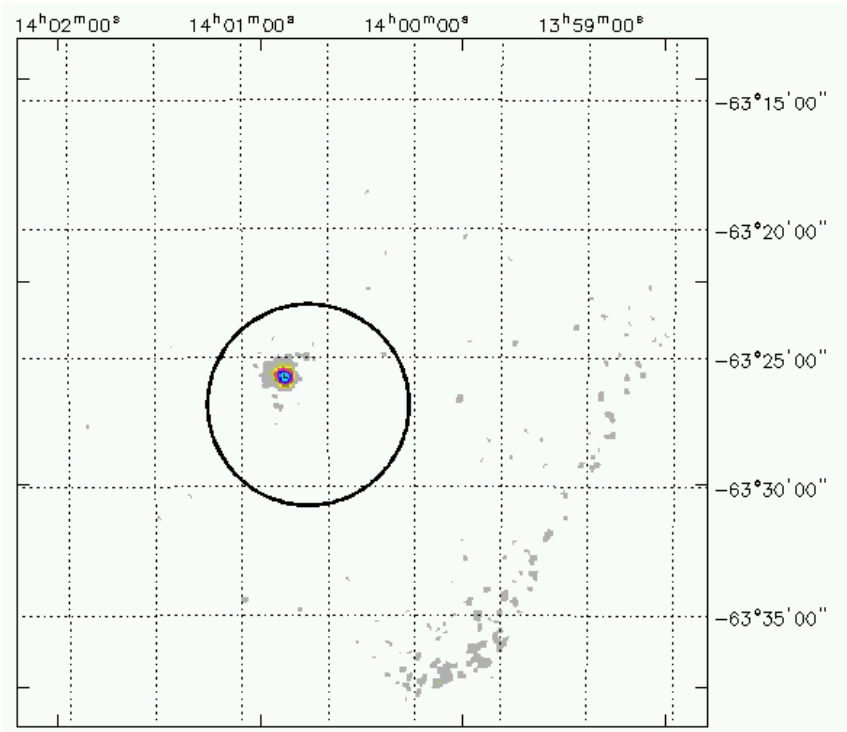


Figure 17: XRT image of the IGR J14003–6326 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

A bright X-ray source is present within the IBIS error box at the following position:

$$\text{RA(J2000)} = 14^{\text{h}}00^{\text{m}}45^{\text{s}}.73$$

$$\text{Dec(J2000)} = -63^{\circ}25'40''.27$$

$$\text{error box} = 3''.54$$

The XRT position is compatible with the radio source PMN J1400–6325 (113 mJy at 4850 MHz), which is possibly also associated to the faint ROSAT source 1RXS J140041.2–632623, 52'' away. There is no USNO–B1.0 nor 2MASS counterpart to this object.

The X-ray spectroscopy indicates an unabsorbed flat ($\Gamma \sim 1.3$) spectrum.

IGR J17445–2747

Two observations analyzed with exposures: 1) 2482 s , 2) 9714.125 s

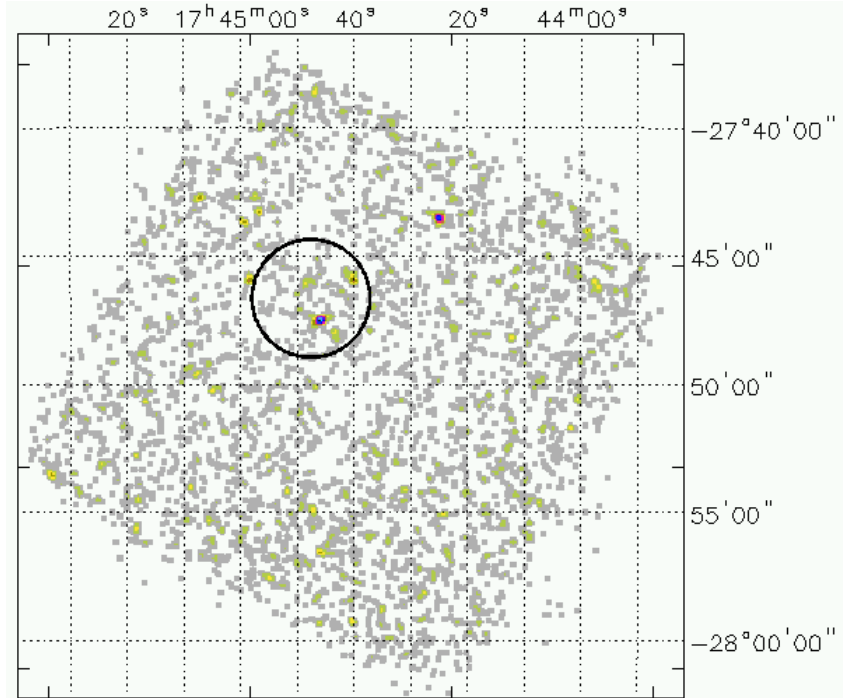


Figure 18: XRT image of the IGR J17445–2747 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

While no source is detected in obs #1 within the *INTEGRAL* error box, in obs #2 (which is longer) we find one source (at 5.4σ confidence level) located at :

$$\text{RA(J2000)} = 17^{\text{h}}44^{\text{m}}45^{\text{s}}.7 \quad \text{Dec(J2000)} = -27^{\circ}47'30''.1$$

$$\text{error box} = 5''.1$$

This IBIS source has been detected in a revolution sequence so likely to be transient or highly variable. The X-ray source detected by XRT is coincident with a ROSAT/PSPC source (see also [SBM2001] 38, Sidoli, Belloni & Mereghetti 2001 A&A 368,835). Within the XRT uncertainty we find a bright USNO–B1.0 object at $\text{RA(J2000)} = 17^{\text{h}}44^{\text{m}}46'.02$, $\text{Dec(J2000)} = -27^{\circ}47'32''.8$ (with magnitude $R = 11.5 - 12.0$), also listed in the 2MASS catalogue (with magnitudes $J = 10.065$, $H = 9.447$, $K = 9.291$).

Due to the low quality of these data, from X-ray data we can only infer a 2–10 keV flux of $1.48 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1}$.

IGR J19443+2117

One observation analyzed with exposure: 1) 11134 s (obscode: 00035642001)

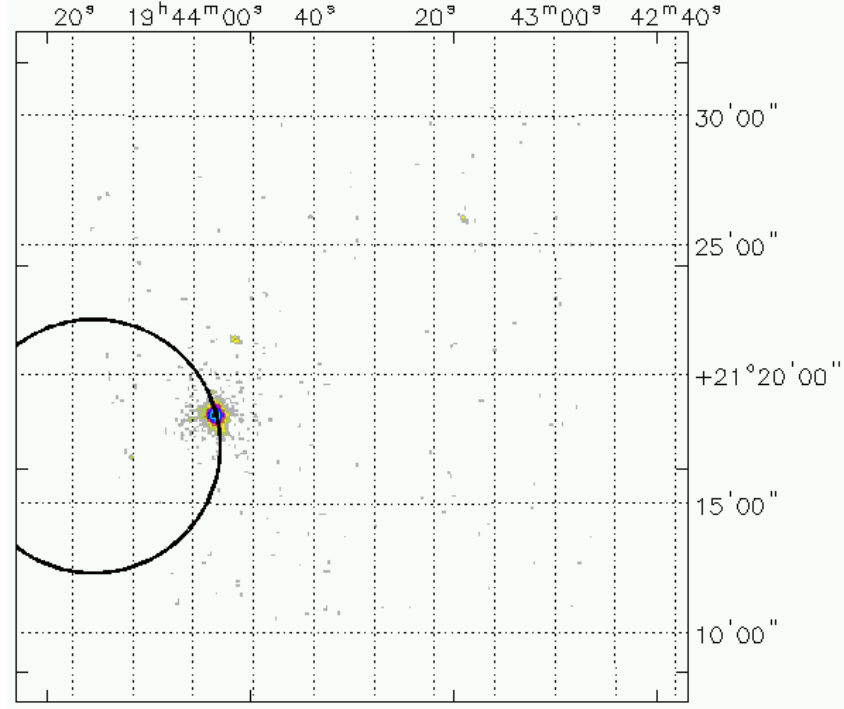


Figure 19: XRT image of the IGR J19443+2117 field. The black circle represents the *INTEGRAL* error box (Bird et al. 2007).

At the border of the IBIS error box, we find an X-ray bright source located at:

$$\text{RA(J2000)} = 19^{\text{h}}43^{\text{m}}56^{\text{s}}.10$$

$$\text{Dec(J2000)} = 21^{\circ}18'23''.22$$

$$\text{error box} = 3''.2$$

The XRT position is compatible with a ROSAT HRI source 1RXH J194356.1+211824 and a NVSS source NVSS J194356+211826 (120 mJy at 20 cm, RA(J2000) = $19^{\text{h}}43^{\text{m}}56^{\text{s}}.14$, Dec(J2000) = $+21^{\circ}18'26''.9$, with positional uncertain $< 1'$). The radio source has a flat (-0.3) spectral index (defined as $S = A\nu^{-\alpha}$). The optical counterpart is likely the USNO-B1.0 source at RA(J2000) = $19^{\text{h}}43^{\text{m}}56^{\text{s}}.36$, Dec(J2000) = $+21^{\circ}18'18''.9$ (with magnitude $R = 16.5 - 17.2$), also a 2MASS object (with magnitudes $J = 14.530$, $H = 13.358$, $K = 13.980$).

The X-ray spectrum is well fitted with a slightly absorbed ($N_{\text{H}} \sim 0.3 \times 10^{22} \text{ cm}^{-2}$) power law having a photon index of ~ 1.96 .

Summary

After discussions here and in view of the observing time we have been granted at various optical telescopes this year, we would like to keep the information gained by the XRT observations within the team hoping to be able to have soon optical classification of most objects with an obvious X-ray counterpart. On the other hand for those sources which have no obvious counterpart or where the already proposed counterpart is confirmed, we may want to do a few Atels.

We therefore suggest for the moment the following Atel:

1) Atel for excesses in the Coma region

Swift/XRT observations of *INTEGRAL* detections in the Coma Field

Five excesses (IGR J11567+3700, IGR J12313+1214, IGR J12488+3315, IGR J13371+1520 and IGR J13103+2001) detected by *INTEGRAL*/IBIS in a deep observation of the Coma region (Krivonos et al. 2005) have recently been observed with the *Swift*/XRT X-ray telescope. Within the 4' IBIS error box (90% confidence) we do not detect any X-ray source above 3σ confidence level.

We further notice that none of the above excess has been reported in the literature afterwards nor is listed in recent *INTEGRAL*/IBIS survey catalogs (Bird et al. 2007; Krivonos et al. 2007). We therefore conclude that they are probably spurious detections and do not correspond to real *INTEGRAL* sources.

2) Atel for confirmations of previous associations:

Swift/XRT observations confirm the AGN nature of IGR J14175–4641 and IGR J14552–5133

Two *INTEGRAL* sources, IGR J14175–4641 and IGR J14552–5133, have recently been observed and detected with the *Swift*/XRT X-ray telescope. In both cases, the XRT position confirms a previous association with two AGN (see Masetti et al. 2006 for the optical spectroscopy).

In the following we report the results of these measurements:

IGR J14175–4641

The XRT observation locates the source at $RA(J2000) = 14^h 17^m 03^s.8$, $Dec(J2000) = -46^\circ 41' 39''.7$, with an error box of $10''$, thus confirming the association with the Seyfert 2 galaxy LEDA 511869 at $z=0.076$; the source is too weak to allow spectral analysis, but the 2–10 keV XRT flux of 5.8×10^{-14} erg cm^{-2} s^{-1} compared with the 20–100 keV IBIS flux of 3.9×10^{-11} erg cm^{-2} s^{-1} suggests that this may be a Compton thick AGN.

IGR J14552–5133

The XRT observation locates the source at $RA(J2000) = 14^h 55^m 17^s.93$, $Dec(J2000) = -51^\circ 34' 13''.27$, with an error box of $3''.32$, thus confirming the association with the Narrow Line Seyfert 1 galaxy WKK4438 at $z = 0.016$; the X-ray spectroscopy indicates an absorbed power law spectrum ($\Gamma \sim 2.06$ and $N_H \sim 1.2 \times 10^{21}$ cm^{-2}).

3) Atel for variable sources

Swift/XRT follow-up of IGR J10043–8702, IGR J10500–6410, IGR J05319–6601 and IGR J11321–5311

The still unidentified *INTEGRAL* sources, IGR J10043–8702, IGR J10500–6410, IGR J05319–6601 and IGR J11321–5311 have recently been observed with the *Swift*/XRT X-ray telescope. All sources are extremely variable, with the first two being visible only in a single 2 ks *INTEGRAL* pointing (Paizis et al. 2006), and the other two being detected in a limited number of observation sequences (Gotz et al. 2006; Revnivtsev et al. 2006). In each of the above cases, we do not detect any X-ray object within the published IBIS/ISGRI error box above 3σ confidence level; similarly no X-ray source is visible within short distance of the *INTEGRAL* uncertainty circle. Only in the case of IGR J05319–6601, a bright X-ray source identified as the High mass X-ray binary RX J0531.2–6609, is detected at $7'.5$ from the best-fit IBIS/ISGRI position.

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