



# Newsletter of the INTEGRAL Science Operations Centre



No 17

March 2007

## Foreword

*Peter Kretschmar – ISOC Manager*

While INTEGRAL is continuing to operate smoothly, the ISOC staff has been busy first with the special AO for Key Programmes and then with the preparation of AO-5 itself. In addition, a lot of work was done on the Archive at ISOC including the new INVITE tool for data visualization, which is described below.

In-between, Mother Nature has also done her share to keep us busy with several TOO's. For one of them, thanks to special efforts both at ISOC and at MOC, a new speed record was achieved – see below for the details.

In many ways, ISOC is still in transition with respect to people and staff, with more changes coming up as explained near the end of this newsletter.

## 5<sup>th</sup> Announcement of Opportunity (AO-5)

*Celia Sanchez – ISOC Operations Scientist*

The INTEGRAL 5th Announcement of Opportunity calling for proposals for INTEGRAL observations is about to start. It will be released to the community on 12th March 2007. The AO-5 observing cycle will have a duration of one year, starting on 16th August 2007 and ending on 15th August 2008. Of the total INTEGRAL scientific time available for AO-5 (24 Msec), 18.8 Msec will be available for Open Time proposals, of which 6 Msec are devoted to Key Programme proposals. 5.2 Msec are reserved for Core Programme proposals.

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Proposers applying for Open time observations are also invited to submit proposals associated with 3 AO-5 KP regions (see below), and request data rights for sources contained in the fields of view covered by these observations.

Core Program observations during AO-5 will aim to homogenize the exposure along the galactic plane, and to extend the coverage in longitude. Three specific target areas have been selected, centered on Galactic longitudes at 23, 225 and 305 deg, with exposure times of 1.7, 1.5 and 2.0 Msec respectively. In order to support investigations of latitudinal extents of source population, and of diffuse emission, at the selected longitude of 23 deg the exposure will be offset towards northern Galactic latitudes by 8 deg.

## INTEGRAL AO-5 Milestones

Release of AO-5:	12 Mar 07
Due date for Proposals:	20 Apr 07 14:00 CET
TAC Meeting:	29 May - 01 Jun 07
TAC results circulated:	Jun 07
AO-5 observing cycle:	16 Aug 07 - 15 Aug 08

**Key Programmes in AO-5**

*Guillaume Bélanger – Operations Scientist*

INTEGRAL's fifth 12-month observation cycle starting on August 17, 2007, will be unique in that 6 Ms of the total science time are dedicated to Key Programmes. The idea of a Key Programme (KP), a single or set of observations whose scientific aims require long exposures, was introduced in AO-4. The KP on the Galactic Centre region was warmly accepted by the community and successfully carried out.

A dedicated KP announcement of opportunity was issued in October 2006. It generated a lot of interest from the INTEGRAL community since we received 22 proposals with science time requests amounting to about 52 Ms for AO-5 alone (an over-subscription factor of 8.7). The interest was more or less evenly distributed, with seven proposals in each of the "Nucleosynthesis" and "Extragalactic Objects" categories, and four each in "Compact Galactic Objects" and "Others/Miscellany".

Four proposals were recommended by the Time Allocation Committee, two of which were merged. This programme was approved by ESA's Director of Science, Prof. David Southwood, and is summarised below.

We eagerly await the rich scientific studies and inquiries that will stem from these observations; some will likely be extended over several AO

cycles. Several KPs were submitted as multi-year programmes and of those recommended by the TAC, at least two are clearly such. It is probable that the time reserved for KPs will be increased in future cycles, thus allowing for even more deep and long term astrophysical scientific investigations.

**Science Highlights**

*Peter Kretschmar – ISOC Manager*

LS 5039 is the only X-ray binary/micro-quasar persistently detected at TeV energies by the Cherenkov HESS telescope. It is moreover a gamma-ray emitter in the GeV and possibly MeV energy ranges. LS 5039 has been detected along almost all the electromagnetic spectrum thanks to several radio, infrared, optical and soft X-ray detections. However, hard X-ray detections above 20 keV have been so far elusive and/or doubtful, partly due to source confusion for the poor spatial resolution of hard X-ray instruments. Thanks to its imaging abilities, INTEGRAL detected LS 5039 at hard X-ray fluxes which are significantly lower than previous estimates obtained with BATSE in the same energy range but, in the lower interval, agree with extrapolation of previous RXTE measurements (P. Goldoni et al, *astroph/ 0609708*).

A rare X-ray nova (IGR J17497-2821) was detected on 16 September 2006 during KP observations of the Galactic Centre region. Follow-up observations identified the source/companion at X-rays (XMM, Swift) and optical ("Euler" telescope/Chile). A "canonical" black-hole light-curve was observed

**Proposals accepted for the AO-5 Key Programme**

<i>Principle Investigator</i>	<i>Region</i>	<i>Time (ks)</i>
Ajello	North Ecliptic Pole	2000
Belanger	Galactic Centre	2000
Knoedlseder	Cygnus Region	2000
Butt	Cygnus Region	(merged with above)

and the combined INTEGRAL/Swift spectrum features a hard cut-off power law continuum spectrum. The outburst in a low hard state can be explained by accretion through the hot corona of the accretion disc. Further observations of the companion at low energies should reveal more information on the BH mass (R. Walter et al., *A&A*, 461, L17, 2007; Rodriguez et al., *A&A* 655, L97, 2007; Paizis et al., *A&A* 657, L109, 2007).

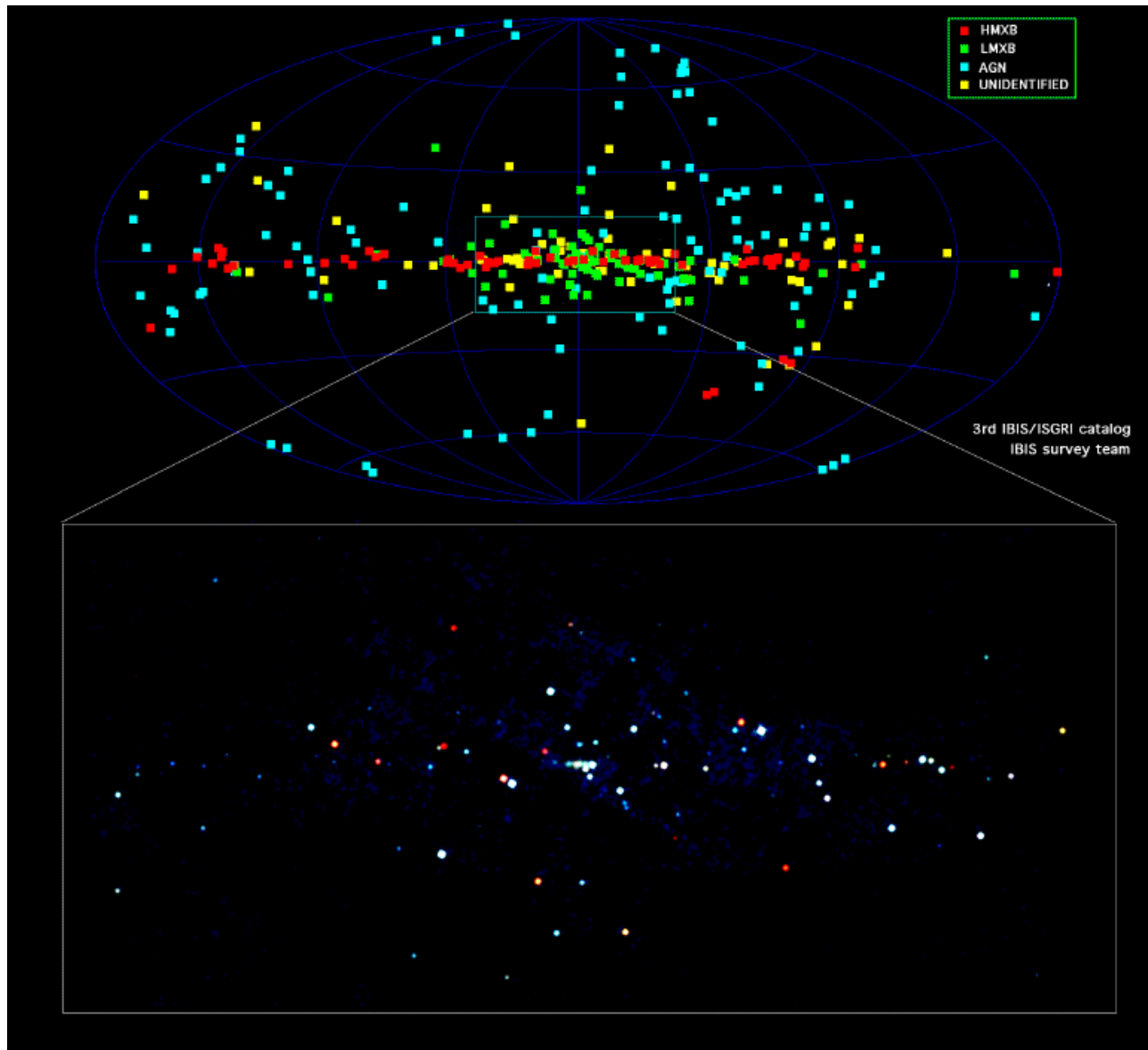
Further detailed analysis of the transient X-ray pulsar V0332+53 observed by INTEGRAL and RXTE during a powerful outburst in 2004/2005 showed that the cyclotron line energy (at about 26 keV) decreases nearly linearly with increasing source luminosity. It could be shown that the height of the line emission region varies proportional with luminosity, and the observations can be explained by a superposition of various emission heights during the outburst. Strong variations of the pulse profile with the energy and source intensity were found and the changes of the pulse profile near the cyclotron line energy are especially drastic, requiring complex geometric and physical modelling (S. Tsygankov et al., *MNRAS*, 371, 19, 2006).

A. Bird et al. have published the 3rd IBIS soft gamma-ray source catalogue (*ApJS* 2007, in press). The scientific dataset is based on more than 40 Ms of high quality observations performed during the first three and a half years of Core Program and public IBIS/ISGRI observations. Compared to previous IBIS/ISGRI surveys, this catalogue includes a substantially increased coverage of extragalactic fields, and comprises more than 400 high-energy sources detected in the energy range 17-100 keV, including both transients and faint persistent objects which can only be revealed with longer exposure times. (see Figure 1, which was also INTEGRAL Picture of the Month, February 2007).

M. Chernyakova et al. (*A&A* 2007, in press) analyzed data obtained during quasi-simultaneous INTEGRAL and XMM monitoring of the blazar 3C273 in 2003-2005. During the observation period the source has reached the historically softest state in the hard X-ray domain with a photon index  $\Gamma=1.82 \pm 0.01$ . Comparing their data with available archived X-ray data from previous years, the authors find a secular evolution of the source toward softer X-ray emission (the photon index has increased by  $\delta\Gamma \sim 0.3-0.4$  over the last thirty years). The authors argue that existing theoretical models have to be significantly modified to account for the observed spectral evolution of the source.

SPI can trace the contributions of diffuse and point-like emission from the hard X-ray into the soft gamma-ray regime. Below 100 keV the population of galactic point sources, mainly X-ray binaries, is most prominent ( $\sim 60$  sources below 50 keV and  $\sim 25$  sources in the 50 -100 keV range). No diffuse emission is visible in the reconstructions, indicating a rather low intensity level. In the 200-300 keV range a diffuse and structured emission band along the galactic plane replaces the point sources in this region, possibly originating from faint and unresolved point source emission. Above 300 keV the picture changes drastically and the 300-500 keV image is clearly dominated by emission of the Galactic bulge, and is very similar in morphology to that of the 511 keV line. Crab and Cyg X-1 are prominent point sources detected in this range. (J. Knödseder et al., ESA SP-662 (Proc. 6<sup>th</sup> INTEGRAL workshop), in press, 2006, see Figure 2, which was also INTEGRAL Picture of the Month, November 2006.)

Integral also caught the centre of our galaxy in a moment of rare quiet. A handful of the most energetic high-energy sources surrounding the black hole at the centre of the Galaxy had all faded into a temporary silence on one occasion when INTEGRAL observed. This tranquil view of our galaxy is shown in Figure 3 and is reported on in a

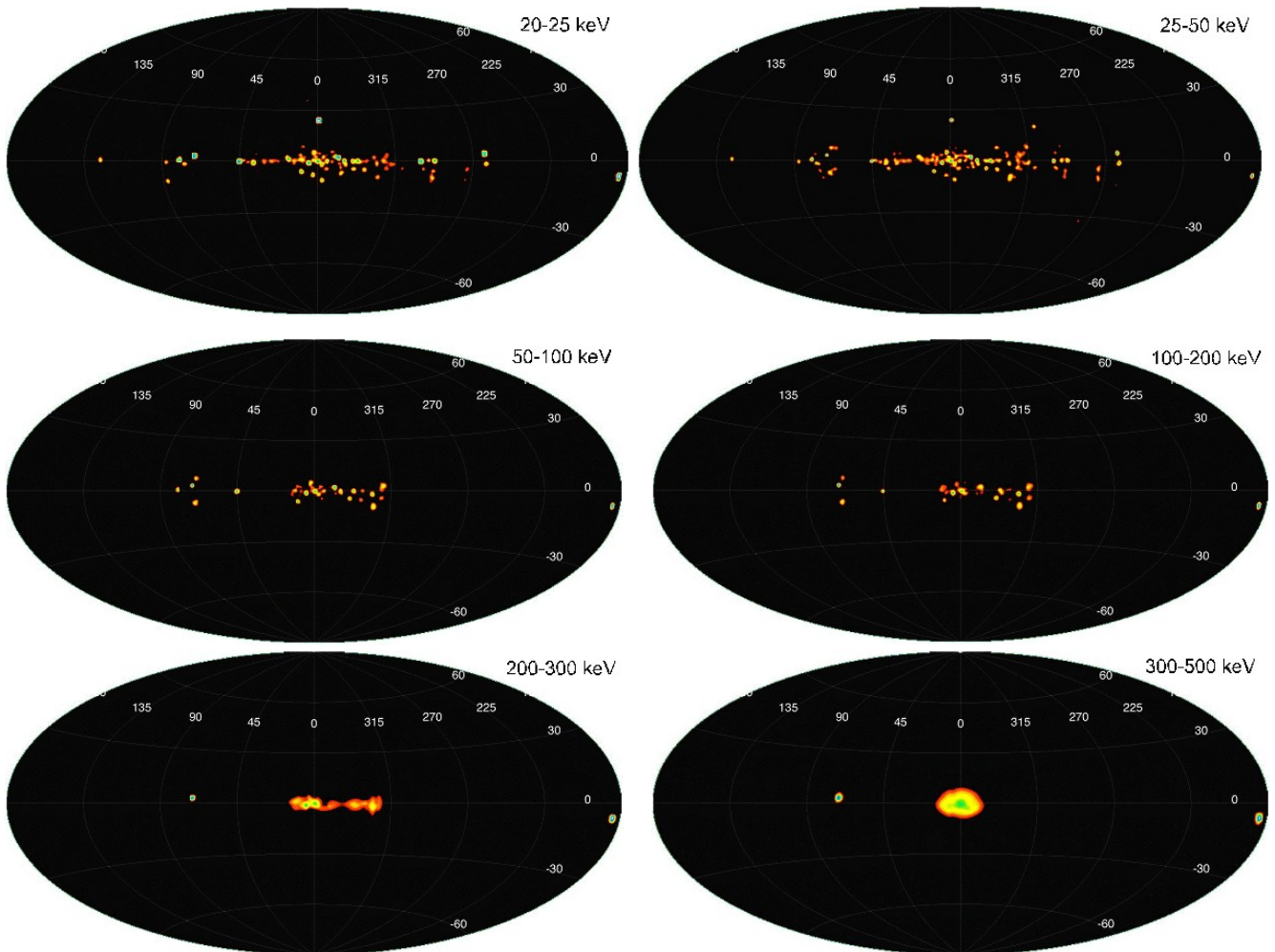


**Figure 1: The third INTEGRAL/IBIS survey catalogue**

The upper image shows the distribution on the sky of four of the main soft gamma-ray source populations observed in the third INTEGRAL/IBIS survey catalogue. This newly-released catalogue contains 421 sources. Of the known systems, the LMXBs are old systems mainly populating the galactic bulge, HMXBs are younger systems seen along the galactic plane, and the AGN are seen over the whole sky. Around one in four of the sources seen by INTEGRAL are unidentified, and their distribution is also shown.

The lower image shows a false colour image of the central region of our galaxy. This is a composite image based on all-sky IBIS/ISGRI maps in three energy windows between 17 and 100 keV and represents the true 'X-ray colours' of the sources. Red sources are dominated by emission below 30 keV, while blue sources have harder spectra, emitting strongly above 40 keV.

Credit: IBIS Survey Team



**Figure 2: SPI images the sky at energies from hard X-rays to soft gamma-rays**

All-sky maps of the gamma-ray continuum emission demonstrate that the spectrometer SPI on INTEGRAL can trace the contributions of diffuse and point-like emission from the hard X-ray into the soft gamma-ray regime. This picture shows 6 all sky images obtained with SPI across the energy range between 20 keV and 500 keV. Below 100 keV the population of galactic point sources, mainly X-ray binaries is most prominent (~ 60 sources below 50 keV and ~ 25 sources in the 50 - 100 keV range). No diffuse emission is visible in the reconstructions, indicating a rather low intensity level.

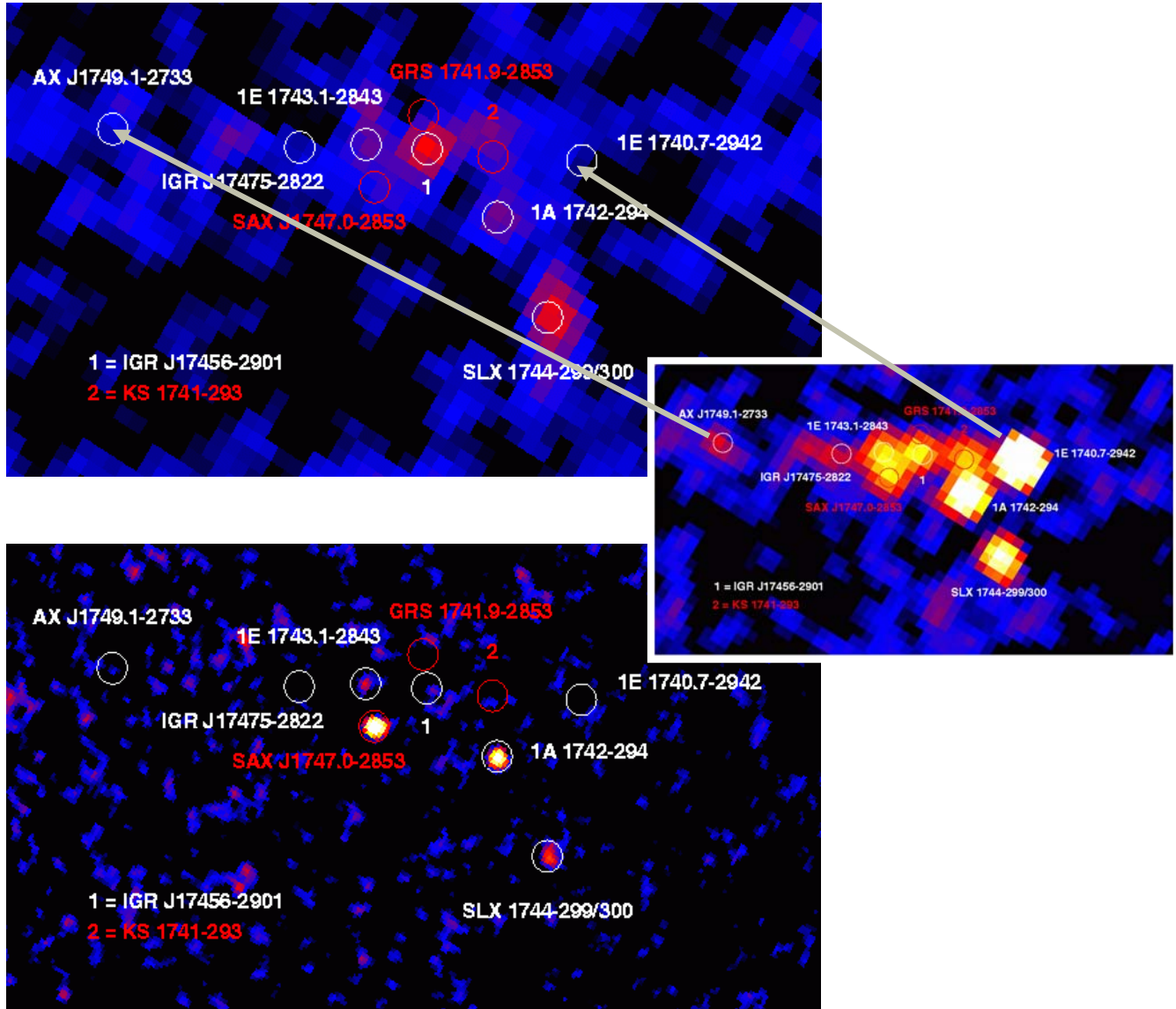
In the 200-300 keV band a diffuse and structured emission band along the galactic plane replaces the point sources in this region, possibly originating from faint and unresolved point source emission. Above 300 keV the picture changes drastically and the 300-500 keV image is clearly dominated by emission of the Galactic bulge, and is very similar in morphology to that of the 511 keV line.

Credit: The SPI Team; J. Knödlseher et al., ESA SP-662 (Proc. 6th INTEGRAL workshop), in press, 2006



paper (<http://lanl.arxiv.org/abs/astro-ph/0701244>) by Kuulkers et al. accepted for A&A. The observation took place during the frequent and regular observations of the Galactic Bulge during

its whole visibility period are performed with INTEGRAL, which started already in AO-3 (PI: Kuulkers).



**Figure 3: The Galactic Centre in a moment of quiet**

*JEM-X (3-20 keV; bottom figure) and IBIS/ISGRI (20-60 keV; top figure) mosaic significance images (total exposure time is 69 ksec) focused on the Galactic Centre region during April 2006. Most of the sources were off during that time, including the normally bright well-known black-hole candidate and micro-quasar 1E 1740.7-2942. This is a very different view than the long-term average, which is shown in the inset on the right.*

*Credit: Kuulkers et al. 2007, A&A in press, astro-ph/0701244*

### Science Operations - Highlights

*Erik Kuulkers – Operations Scientist*

Since the last Newsletter of September 2006 no major operational changes have been implemented. The only notable event has been the 9th SPI annealing period (in order to maintain SPI's high spectral resolution), which started on 2006 Dec 4 (revolution 506) and ended just before Christmas, December 22 (revolution 511). The energy resolution at 882.5 keV was 2.62 keV before annealing and 2.40 keV just after the annealing.

During this SPI annealing period ISOC scheduled mostly observations for which the science was mainly driven by observations from the other main instrument, IBIS. Both Core Program observations and Guest observations took place, i.e., Galactic Plane regions 3 and 4, and MCG -05-23-016 and EXO 0748-676, respectively. However, the observation period was characterised by high solar activity. This resulted in some of these observations being lost due to the instruments being in safe mode for some of the time.

In September 2006 INTEGRAL mainly pointed towards the Galactic Center region. During these observations a new X-ray transient, named IGR J17497-2821, popped up (see the previous section *Science Highlights*). October and part of November was mainly devoted to the region at  $l=0$ ,  $b=-25$ . During the above period regular monitoring of GRS 1915+105, as well as the Galactic bulge region, was performed. From mid November up to the end of 2006, Galactic Plane regions 3 and 4 were the main targets, both Core Program observations.

Various targets, of different natures, were observed in 2007 during January and February. A lot of time was devoted to the Galactic disk latitude scans (around Galactic longitude 320

degrees, and between Galactic latitudes -30 and 30 degrees), as well on observations focussing on SN1006 and Cen X-4. These were interrupted by relatively shorter observations of targets like GX 301-2 (high-mass X-ray binary), 4U 1254-690 (low-mass X-ray binary), and NGC 4151 (AGN).

Usually, normal operations are interrupted by unexpected events in the X-ray/gamma-ray sky. However, the last part of 2006 was unexpectedly quiet. This changed near the end of December when the black-hole candidate binary GX 339-4 was found to be in a hard X-ray outburst by Swift/BAT. As soon as the source became visible by INTEGRAL it had continued to brighten, and it triggered INTEGRAL TOO observations. Observations were performed January 30/February 1, February 17-19, and March 4-6. Observations are currently also foreseen on March 16-18 and end of March. As announced in The Astronomer's Telegram #980, the INTEGRAL data of this TOO program is made publicly available, as soon as possible after the observations have been performed. They can be retrieved via anonymous ftp from: [ftp://isdcarc.unige.ch/arc/FTP/arc\\_distr/GX339-4/](ftp://isdcarc.unige.ch/arc/FTP/arc_distr/GX339-4/)

In the beginning of February a large X-ray burst from the anomalous X-ray pulsar 4U 0142+61 was found. This triggered TOO observations on INTEGRAL which were implemented in a record time in revolution 528, see the following section *The Fastest INTEGRAL TOO*. In the meantime, the high-mass X-ray binary IGRJ 11215-5952, had become active and also triggered TOO observations, which were done a revolution later, i.e. in revolution 529.

Since the end of February the Galactic Centre region has become visible once more, and INTEGRAL has focussed again on this region of the sky. Regular snapshots of the region are taken, as well as some deeper looks using observations belonging to the Key Program. In mid-March we foresee a revolution

(541) devoted to Crab calibrations, which will be partly coordinated with RXTE, Suzaku and Swift.

### **The Fastest INTEGRAL TOO**

*Guillaume Bélanger – Operations Scientist*

Wednesday, February 9, 2007

12h28: ISOC receives a TOO notification from P. den Hartog on the Anomalous X-ray Pulsar (AXP) 4U 0142+61 observed by RXTE to have undergone a large burst with features reminiscent of giant flares from Soft Gamma-ray Repeaters: something that has not yet been observed in AXPs.

12h33 Since a new revolution is just beginning and the request is urgent, ISOC sends an advance warning to MOC (mission operations centre) that a TOO might be scheduled.

13h00: TOO is accepted by Project Scientist C. Winkler, after a short teleconference with all ISOC scientists.

13h27: New POS (preferred observation sequence) files are sent to MOC following a prompt re-planning by the ISOC duty scientist of the current revolution scheduled to start science time less than 6 hours later. Staff at MOC immediately begin to work on the new planning files.

14h45: MOC has validated the new POS files and recalculated the reaction wheel profile for the changed observation sequence.

14h52: MOC sends the TSF (time summary file), thus confirming the new planning of the current revolution.

15h15: Operations of the INTEGRAL satellite are run from the new timeline.

18h20: TOO observation of 4U 0142+61 begins.

This exceptionally fast reaction and turnaround time was made possible only due to the enthusiasm with which everyone involved, both at ISOC and MOC, took on this task and made it happen. Moreover, we were very fortunate not to encounter any serious difficulties in the re-planning process. Less than 6 hours passed between the receipt of the notification and the start of the observations!

This is truly outstanding, and easily the fastest TOO implemented by INTEGRAL.

It is interesting to note that we received another TOO request from L. Sidoli just two days after this one, on Friday at 10h18. Although it was also accepted, it was planned for the next revolution and thus did not require such urgent action on the part of ISOC and MOC. Nonetheless, that was certainly an interesting week in the history INTEGRAL operations.

### **ISOC Science Data Archive Version 2.7**

*Rees Williams – Archive Scientist*

The ISOC Science Data Archive (ISDA) is one of two complete INTEGRAL archives, the other being maintained by the ISDC. The two archives contain nearly identical data, but have very different interfaces. The ISDA has the now standard ESA look and feel, so will be very familiar to users of e.g. the XMM-Newton archive.

Version 2.6 of the ISDA was released in December 2006 and Version 2.7 will be released at the end of March 2007. The principle improvement in ISDA 2.6 was the first release of the INtegral VISualisation Tool and Explorer (INVITE). INVITE is described fully in the next section. Version 2.6 also allowed the user to limit their search to data from a particular revision. This feature will be useful during future re-processing of INTEGRAL data (something which is expected to coincide with major releases of OSA).

ISDA 2.7 will contain a number of new features. Perhaps the most significant of these is a Virtual Observatory (VO) compliant interface. This interface will make INTEGRAL data available to the VO tools for the first time. Initially only images will be available, but light-curves will be added shortly.

ISDA 2.7 will also incorporate a number of small changes to facilitate the download of large data-sets



(more than 1000 science windows). Previously a number of limitations in the ISDA made this a somewhat tedious process.

Future releases of the ISDA will include a number of new features. ISDA 3.0 is planned for July 2007 and will include an INTEGRAL bibliography (already maintained at ISOC) which will be cross-referenced to a source list. This will make it possible to search for publications related not merely to a source, but also to any field observed by INTEGRAL.

### **INTEGRAL Visualisation Tool & Explorer**

*Pieter-Jan Baeck – Young Graduate Trainee*

The INTEGRAL Visualisation Tool and Explorer (INVITE) has been available as part of the ISDA since Dec 2006. It provides an easy and convenient method of manipulating light-curves from INTEGRAL and many other instruments.

INVITE is a compact (1.5 Mbyte) programme written entirely in Java. It needs only for a Java Run time Environment (JRE) of version 1.4 or higher to be available. This means it can be launched from the ISDA and run on the client machine as a Java applet. Subsequent operations on even relatively large data-sets are rather rapid, since it then runs entirely on the client side. INVITE can also be used in a stand-alone mode to manipulate data from one or more OGIP compliant FITS light-curves.

INVITE allows the user: to simultaneously display a number of light-curves, combine light-curves from different energy bands, generate hardness-ratios and to re-bin the light-curves in time. If a number of light-curves covering adjacent bands are available, these can be used to generate a broad-band spectrum which can be passed to XPSEC.

INVITE is currently used in ISDA to display light-curves from the 2<sup>nd</sup> INTEGRAL/IBIS source catalogue. The easiest way of accessing INVITE via the ISDA is as follows:

1. Go to the ISDA home page <http://integral.esac.esa.int/isda> and launch the ISDA.
2. In the first ISDA screen open up the bottom panel, "ISGRI SOURCE CATALOGUE" and type in the name of your favorite INTEGRAL source, before clicking on the "Execute Query" button. This should return the Second ISGRI catalogue entry for the source.
3. Place your cursor over the light-curve icon and use the right-hand mouse button to select "Open with Visualisation Tool".

### **INTEGRAL Publication Status**

*Jean Matagne – ISOC Webmaster*

As reported in previous newsletters, the rate of INTEGRAL publications has increased significantly as the mission progresses: a pattern common also in earlier  $\gamma$ -ray missions.

During 2006 we have recorded 181 papers in the literature, of which 98 were refereed and 83 non-refereed. This compares with a total since launch of 640, of which 239 were refereed and 401 non-refereed. From these numbers we see that during 2006 we have recorded an average rate of 8.1 refereed publications per months, compared with a rate of 3.7 during the first 3 years of the mission.

ISOC maintains a searchable bibliography of both these papers and those published before launch. This can be found at under the section "INTEGRAL Scientific Publications" on the ISOC webpages: <http://integral.esac.esa.int>

### Changes in ISOC

*Peter Kretschmar – ISOC Manager*

The first major change is visible in the lines above. After more than 30 years with ESA, Lars Hansson has retired. Peter Kretschmar has taken over the position of INTEGRAL Science Operations Manager, while remaining Deputy Project Scientist and Ground Segment Coordinator.

Guillaume Bélanger, who obtained his PhD at the CEA in Saclay, joined ISOC as fourth Operations Scientist in October 2006 and has been busily involved in ISOC tasks since then, e.g. AO preparations and planning of calibration observations.

A few weeks later, in November, Marion Cadolle-Bell – also formerly CEA Saclay – joined ESAC and ISOC as an Internal Research Fellow in order to work with Integral and XMM data in the following years. While Marion has no operational role, her presence is a welcome boost to the scientific activities of the ISOC team.

Looking into the future, several more changes are ahead. First of all, both our software engineers, Paul Balm and Marnix Bindels, will leave us this year. Marnix will return to the Netherlands already in April, while Paul will remain with ISOC until August. Silvia De Castro Garcia, previously working at ESRIN, has been selected as the new Senior Software Engineer and began work on 1st March. A suitable candidate for the junior position has been identified.

Later this year, Rees Williams will withdraw from the work as Archive/Operations Scientist and also from weekly commuting between the Netherlands and Spain. A replacement is being sought.

### Contact INTEGRAL science operations

The INTEGRAL science operations team is located at ESAC, while the Mission Manager and Project Scientist are located in ESTEC. Details are provided below.

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Sanchez, C.	Operations Scientist	375
Williams, O.R.	Archive & Operations Scientist	274
Bélanger, G.	Operations Scientist	294
Cadolle-Bell, M.	Research Fellow	390
Balm, P.	Software Engineer	357
Bindels, M.	Software Engineer	335
De Castro Garcia, S.	Software Engineer	
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