Newsletter of the INTEGRAL Science Operations Centre

AO-6 is open

No 19 — March 2008

Foreword

Peter Kretschmar, Science Ops. Manager

The 6th *INTEGRAL* Announcement of Opportunity has just opened. As always, we hope to receive many interesting observation proposals this time again, as in previous AOs. This *Newsletter* marks the opening of this forthcoming AO, and for this occasion, I will briefly describe its opening and its Key Programmes in the first sections below.

Since the last *Newsletter* in October 2007, there have been a number of changes to instrument settings. Celia gives a description of these changes and an overview of what *INTEGRAL* has observed since. Guillaume then summarises a selection of recent scientific highlights, and Erik describes the evolution of our Long Term Observation planning software.

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6th Announcement of Opportunity (AO-6)

Peter Kretschmar, Science Ops. Manager

AO-6 is open for your proposal submissions from 10 March 2008 until **18 April 2008, 14:00 CET**. The main changes with respect to previous AOs are:

1. There are now six Key Programmes for a total of 12 Ms, to which proposals can be associated. An overview is given in the following section, and the complete details are found in the AO-6 documentation.
2. Observers can request short (typically ∼10 ks) observations to be performed with *XMM-Newton* to complement their *INTEGRAL* observations. This *XMM-Newton* time is to be awarded by the *INTEGRAL* TAC. Details can be found in the document *AO-6 Mission Overview, Procedures and Policies*.

As usual, the AO-6 observing cycle will have a duration of one year, with first observations of the new cycle starting in mid August.

Of the total 24 Ms of available observing time, 12 Ms are reserved for Key Programmes, and 1.8 Ms for the remainder of the Core Programme. Uncompleted observations carried over from AO-5 will amount to 1–2 Ms, and SPI annealing to ∼2.4 Ms (12 revolutions, during which observations using SPI as the main instrument are not carried out).

The remaining time of the *INTEGRAL* Core Programme, that will come to an end in December 2008, will be used for a survey of the Perseus Arm region $(l, b) = (160°, 0°)$. Details are given in the document *AO-6 Mission Overview, Procedures and Policies*.

Finally we'd like to remind you that you can request a copy of any of your previously submitted proposals by writing to the Helpdesk at: inthelp@sciops.esa.int.

Key Programmes in AO-6

Peter Kretschmar, Science Ops. Manager

After the success of the Key Programmes in AO-4 and AO-5, the IUG recommended to increase the share of observing time for such programmes in AO-6 and subsequent observation cycles.

In the second call for Key Programmes, which was open from 22 October to 30 November 2007, 13 new proposals were received, in addition to the scientific justification updates from the PIs of the accepted AO-5 Key Programmes with multi-year scopes. All proposals were peer reviewed, and in

Key Programmes in AO-6			
Principle Investigator	Proposal Title	Target area	Time [ks]
Weidenspointner	Confirming the Asymmetry of the Positron Annihilation Radiation from the Inner Galactic Disk	Two regions at $l = \pm 25, b = 0$	2000
Maccarone	Deep observations of 47 Tuc and the SMC	SMC / 47 Tuc	2000
Stella	Giant Flares from Magnetars in the Virgo Cluster	Virgo Cluster	2000
Bélanger	Deep *INTEGRAL* Observations of the Central Molecular Zone	Galactic Center	2000
Ajello	The ultra-deep *INTEGRAL* legacy hard X-ray survey	North Ecliptic Pole	2000
Knödlseder	Nucleosynthesis and anti-matter annihilation in Cygnus X	Cygnus region	2000

January 2008, the TAC recommended to continue the existing multi-year Key Programmes into AO-6, and to add three new programmes, pertaining to the study of e^+e^- annihilation radiation in the Galaxy, the Small Magellanic Cloud and giant magnetar flares.

The complete programme was approved by ESA's Director of Science and will be implemented in AO-6 as summarized in the Table above (Key Programmes in AO-6).

Recent Scientific Highlights

Guillaume Bélanger, Operations Scientist

The detection of a distant blazar—the most distant object yet seen by *INTEGRAL*; of non-thermal, hard X-rays from the Ophiuchus Galaxy cluster and from colliding winds in Eta Carinae; of an asymmetry in the 511 keV annihilation radiation from the bulge of the Galaxy; and what a closer, more detailed look at the emission along the Galactic plane has revealed about its nature, are among the scientific results that *INTEGRAL*, the now mature high-energy astrophysics mission, has presented to the scientific community in the last few months.

INTEGRAL has now detected more than 400 sources. The majority are relatively faint above 20 keV, since the first catalog comprised $\sim$120 sources (*Bird et al. 2004, ApJ, 607, L33*), the second roughly 200 (*Bird et al. 2006, ApJ, 636, 765*), and the third contains around 400 high energy sources (*Bird et al. 2007, ApJ, 170, 175*).

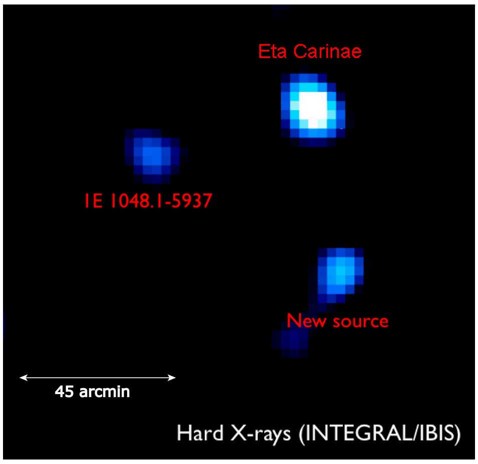
As the overall number of source grows, so does the number of sources discovered for the first time with *INTEGRAL*, and therefore, also the number of unidentified sources. Observation programmes to follow-up on these unidentified sources with other observatories have proven quite effective, and in one particular case, revealed a rather surprising counterpart.

IGR J22517+2218: A Most Unexpected Discovery

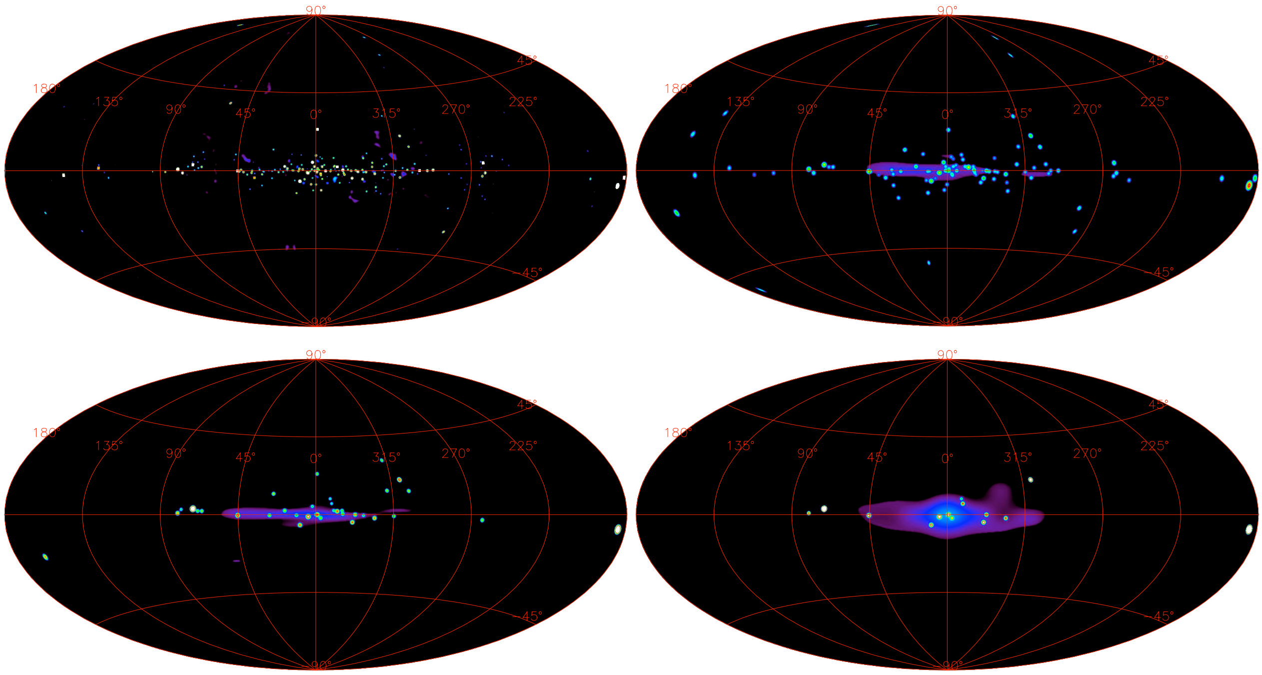
IGR J22517+2218 is a faint, soft γ-ray source, with a 20–100 keV flux of $\sim 4 \times 10^{-11}$ erg cm^{-2} s^{-1}, found to be spatially coincident with MG3 J225155+2217, a quasar at z=3.668. Follow-up observations carried out with Swift revealed a hard and flat X-ray spectrum with strong absorption below 1–2 keV, but highly variable flux over a 6 day period, making it difficult to compare with the soft γ-ray spectrum. The rest frame luminosities are estimated to be 2×10^{48} erg s^{-1} in hard X-rays (20–100 keV), and 5×10^{48} erg s^{-1} in the soft gamma-ray (100–500 keV). This is the highest luminosity seen by *INTEGRAL* in a blazar. See *Bassani, L. et al. 2007, 669, L1* for further details.

Colliding, X-Ray Emitting Winds in Eta Carinae

Imagine two massive stars of about 100 solar masses each, orbiting one another and ejecting as much as the mass of the earth per day through super powerful stellar winds full of charged particles moving at speeds reaching 2000 km s^{-1}. What a sight!



INTEGRAL*'s view of the Carina region, where the brightest source, Eta Carinae, a well known colliding wind binary, is detected for the first time above 20 keV with such angular resolution.*



SPI maps of the Galactic emission showing the evolution as a function of energy, from a point-source dominated morphology, to a truly diffuse emission at the highest energies. The different energy bands are: 25–50 (top left), 50–100 (top right), 100–200 (bottom left) and 200–600 keV (bottom right).

Extreme systems like this are among the most exotic astrophysical objects, with only 30–50 in the entire Galaxy. *INTEGRAL* has recently detected emission from one such colliding wind binary: Eta Carinae. This is the first unambiguous detection of non-thermal emission, attributed to inverse Compton, and of particle acceleration arising from the interaction of the winds in a colliding wind binary.

Please see *Leyder, J.-C., Walter, R., & Rauw, G. 2008, A&A, 477, L29* for further details.

On the Nature of the Galactic Emission

One of *INTEGRAL*'s first important result was the resolution of a long standing question about the nature of the Galactic soft γ-ray emission. It was found that up to $\sim$300 keV, point-sources were by far the main contributor to the Galactic emission (*Lebrun et al. 2004, Nature, 428, L293*). This result was obtained using the first year of IBIS/ISGRI data and was restricted to the central $\pm 45°$ of the Galaxy.

This investigation was extended to cover the entire Galaxy, and much deeper exposures in the central half radian. The main focus of this second study, however, was to map the unresolved emission and compare its morphology, intensity and spectrum with the overall infrared emission tracing the stellar population. The conclusion was that the unresolved hard X-ray emission from 17–60 keV is the high-energy tail of the combined emission from thousands of faint cataclysmic variables that follow the stellar distribution across the Galaxy (*Krivonos et al. 2007, A&A, 463, 957*).

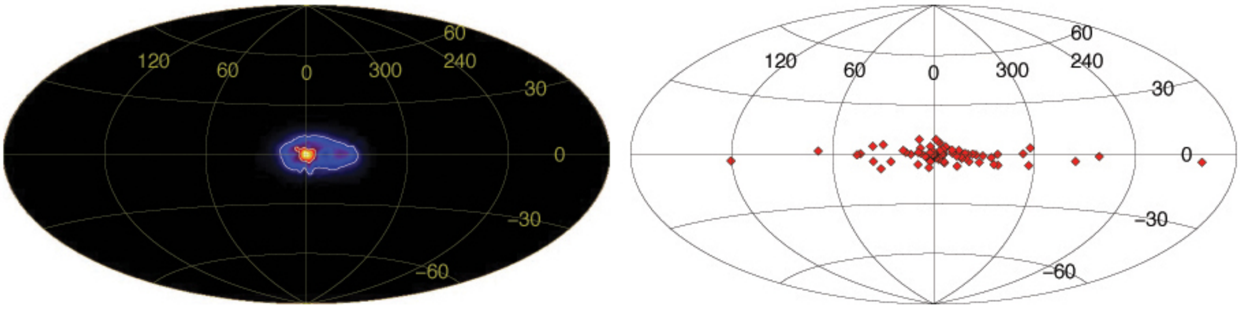
Recently, a study on the nature of the unresolved Galactic emission between 20 keV and 8 MeV was carried out on the basis of 4 years of SPI data, using a total of 51 Ms. This study revealed that the morphology of the emission changes quite radically as a function of energy. In the energy domain below 300 keV, the results confirm earlier estimates of the point-source contribution to the total emission: it was found that the resolved sources account for 88%, 91% and 68% of the total in the bands 25–50, 50–100 and 100–300 keV, respectively.

Moreover, it was found that the morphology of the emission below 50 keV is very similar to that of near-IR maps tracing the stellar distribution in the Galaxy, thus reinforcing the hypothesis that this emission is of stellar origin as metioned above.

Please see *Bouchet, L. et al. 2008, ApJ (accepted)* for more details. See also *Bonnet-Bidaud et al. 2007, A&A, 473, 185* for a discussion of the contribution of CVs to the Galactic emission.

e^+e^- Annihilation in the Galactic Bulge

The discovery of electron-positron annihilation radiation coming from the direction of the Galactic Centre with SPI is scientifically very interesting: it means that there are positrons floating around that



On the left, we see the SPI map of the Galaxy at 511 keV where the asymmetry of the emission from e^+e^- annihilation has become apparent after 4 years of deep and regular observations of the central region, and on the right is show the distribution of LMXB detected with INTEGRAL.

eventually meet an electron and annihilate into 2 photons of 511 keV each. The origin of this emission, however, has remained a mystery.

By continuously refining instrument characterisation and analysis methods, in combination with deeper and more extended observations of the region, the yet unknown nature of the process or astrophysical objects giving rise to this emission is gradually being unveiled.

Although the bulk of distribution of the 511 keV emission seemed very symmetric about the Galactic Centre, and spreading over the Bulge, it has recently been suggested that there is evidence for an asymmetry towards negative Galactic longitudes. Of course, such an asymmetry is clearly a very good indication of what could give rise to this emission if we are able to find a distribution of astrophysical sources that have a similar distribution.

Interestingly, unlike many exotic explanations such as dark matter particles huddled around the supermassive black hole Sgr A*, or a magnetic "magic carpet" transporting positrons towards the centre of the Galaxy, it turns out that there is a much more conspicuous explanation: the distribution of the population of Low Mass X-ray Binaries detected by *INTEGRAL* seem to be is highly akin to the asymmetry seen in the 511 keV line.

See *Weidenspointner et al. 2008, Nature, 451, 159* for further details.

Science Operations

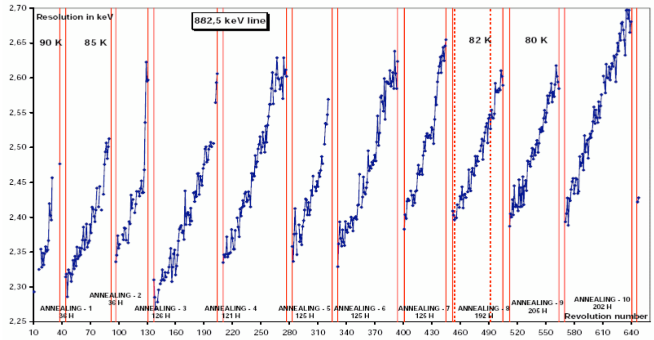
Celia Sanchez, Operations Scientist

Here is a summary of operations at ISOC since the last *Newsletter* of October 2007.

On 19 November 2007, the JEM-X 1 high voltage was lowered from 730 to 720 V in order to protect its microstrip plate against discharges, and maintain its gas gain near the nominal level.

To reduce systematic effects in deep ISGRI mosaics, a new *INTEGRAL* pattern strategy was implemented from 24 November 2007 (rev. 624) onwards. With this new strategy, a sequential roll angle covering the range of ±3° is applied between successive repetitions of the 5×5 pattern: the roll angle for an observation with N repetitions of the pattern spans the range from +3° to -3°, in steps of $\delta\theta = 6/(N-1)$.

The eleventh SPI annealing started on 12 January 2008 (rev. 641) and allowed to recover SPI's high spectral resolution, which progressively degrades due to the interaction of high-energy particles with the detector. The annealing lasted 202 hours (~6 revolutions), and allowed the recovery of the instrument's sensitivity to values similar to those obtained from previous annealings: the energy resolution at 882.5 keV recovered to 2.43 keV. During annealing, ISOC scheduled observations for which IBIS is the main instrument, like the extragalactic sources M31 and PKS 1510-089 and the High Mass X-ray Binary X-Per.



Plot of SPI's energy resolution of the 882.5 keV line as a function of time, showing the effect of the bi-annual annealings.

The rate at which background levels are currently rising would naturally lead to the saturation of SPI's allocated telemetry in about 40 weeks, and cause the loss of science data. To alleviate this bandwidth saturation problem, data compression techniques for Single Events were implemented, and Multiple Event reduction was disabled during the belts passage of rev. 658/659 (6 March). This procedure has been followed since, and is now the standard one.

This concludes the report on instrument-related issues. Here are the targets that have been observed in the last few months:

The first target in the period starting on 17 October 2007, was the eclipsing X-ray binary system SS 443, observed by *INTEGRAL* during an orbital eclipse. The rest of October and most of November were spent observing the Galactic disk, and several regions of the sky around it: various Guest Observer (GO) and Core Programme (CP) observations were executed on the Galactic Plane (Galactic Plane region 1), across it (Galactic latitude scans), and above and below the Galactic Bulge (Mid-latitude 1 and 2).

A TOO on the blazar 3C 454.3, triggered by the Agile detection of γ-ray activity from the source, was executed on 20–24 of November. As is the case with all TOOs, *INTEGRAL*'s Long Term Plan had to be altered to accommodate it.

Following this TOO, the last days of November and most of December were spent on two of the *INTEGRAL* Key Programme Fields: the Cygnus region and the North Ecliptic Pole. After that, *INTEGRAL* pointed to the extragalactic sky, and observed the active galaxies NGC 4151 and 3C 273. The last days of December were shared by CP observations of the Galactic Plane, and GO observations of the field around the Superbubble radio Loops I and IV. By early January 2008, *INTEGRAL* pointed again to the extragalactic sky, to observe the Andromeda galaxy (M31) and the blazar PKS 1510-089, followed by X Per, as referred to above. These observations were simultaneous with the SPI annealing. Galactic Plane region 1 observations and Galactic disc scans were carried out from the end of Januray and beginning of February.

Remarkably, a relatively nearby Supernova, SN 2008S, was detected in the "Fireworks Galaxy" NGC 6946 located at 3 Mpc, thereby triggering an *INTEGRAL* TOO. This gravitational or Type-II SN was observed to monitor the time-evolution of its emission through two observations of 300 ks each, separated by two revolutions.

By then, the Galactic Center was visible again, and the Galactic bulge region monitoring program, executed once every revolution, started immediately after the TOO. The following revolutions, from mid-February to mid-March, were devoted to mid-latitude 1, Orion OB1 and Galactic Plane region 1.

Long Term Observation Planning

Erik Kuulkers, Operations Scientist

A long-term observation plan (which usually spans one observing cycle—generally one year), is needed in order to ensure the greatest scientific return within the time available for a scientific observatory. At the moment *INTEGRAL* uses ad-hoc filling of the long-term plan by taking into account visibility constraints and target priority. Manual trial and error is used to optimize the plan as much as possible. More sophisticated and automated procedures are likely to produce a more efficient planning and save us time. Optimisation of planning schedules is not a new problem, and algorithms for this have been developed in other areas.

In February, ISOC started an initiative with MOC and third parties to design a new *INTEGRAL* long-term planning tool to support, automate and optimise the observation planning process. A good long-term plan has to satisfy many criteria, such as instrument allocation, requirements of and possible conflicts between long and fixed-time observations, impact of restricted visibility, priority of targets, etc. Such criteria create a complex system in which ideally all individual parameters are optimized. The tool shall be developed to be flexible enough in accommodating unforeseen changes in the program (such as TOO observations). On the other hand, one does not want the long-term plan to change too much, because observers sometimes rely on the foreseen dates, when they have coordinated observations with other observatories. It is envisaged that such a tool may in the future also benefit other missions. This would be achieved by a clear separation between generic functionality and mission-specific requirements.

The new long-term planning tool will be developed in the frame of APSI (Advanced Planning and Scheduling Initiative). The APSI is building upon recent experience of introducing artificial intelligence technology in mission operation software. Operational prototypes will first be introduced on a trial basis, in parallel to the standard mission planning systems, with the option of operational usage once the mission planning team is convinced of the reliability and advantages of the new system. This approach has worked in the recent past, (a pre-planning optimisation tool for science operations planning within the Mars Express mission was developed and delivered successfully), and the intention is to extend this experience to a more comprehensive tool kit. The objective of this APSI is to bridge the gap between advanced planning and scheduling techniques and the spacecraft operations environment. Namely to understand and evaluate the feasibility of use, benefits and limits of a suite of Artificial Intelligence based planning and scheduling techniques in support of mission planning tasks.

The development approach foreseen in APSI, is based on a continuous and iterative refinement of the prototype software tool. ISOC hopes to start using the new innovative long-term planning tool before AO-6 observations start (mid-August 2008). Moreover, ISOC will appoint a young-graduate trainee during the second half of this year, to maintain and improve the mission-specific (i.e., *INTEGRAL*) part, and interface to the ISOC observations database.

Changes at ISOC

Peter Kretschmar, Science Ops. Manager

The only change to report is that Rees Williams, after almost three years of commuting between the Netherlands and Spain, has resigned from his job as Operations Scientist and is now back at ESTEC. Marion Cadolle Bel was selected as the new Archive and Operations Scientist and has taken up the job in January 2008.

This *Newsletter* is based on inputs from all members of ISOC, and edited by G. Bélanger.

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