Newsletter of the INTEGRAL Science Operations Centre

No. 8 **June 2003**

Forword

Christoph Winkler - Project Scientist

INTEGRAL is deep in its AO-1 observing programme and things are looking very good. A lot of scientific results are being obtained already now - during the early phase of the mission: 10 new INTEGRAL (IGR) sources detected up to May, 511 keV and 1.8 MeV (^{26}Al) spectra (see below) and distributions, etc. On 20 May, ESA conducted a Mission Performance Verification Review and the Board concluded that *"the INTEGRAL spacecraft, instruments, and ground segment are all performing extremely well and [that] there are no major open issues."* It was further recommended that AO-2 shall be released as planned and the Board was convinced *"that INTEGRAL would be able to carry out its foreseen 5-year mission (2 years nominal, 3 years extended) and that further extensions might be possible"*. In that respect, preparation for AO-2 are in full swing (see below), and work has also begun to prepare the request to ESA advisory bodies for a mission extension approval beyond the current end of nominal mission (December 2004).

A special issue of A&A (to appear in November 2003) will provide detailed descriptions about instrument in-flight performances, calibration, and first scientific results from the early mission phase (preprints will be made available via astro-ph).

Science Highlights

Erik Kuulkers - Operations Scientist
Tim Oosterbroek - Operations Scientist

INTEGRAL and the diffuse gamma-ray line emission

One of the aims of the Galactic Centre Deep Exposure (GCDE) is the study of diffuse line emission near the Galactic Centre. Almost half of the GCDE has been completed in the spring window (the rest will be finished during the autumn window), and some first results are becoming available. The study requires a careful analysis, since the astrophysical lines of interest are very close to (or even on top of) instrumental lines. In particular, the background subtraction needs to be well taken care of. Another complication in the analysis is, e.g., the fact that the energy resolution of the SPI instrument is not completely constant and degrades slowly with time (therefore the need of an annealing operation about every 6 months). This needs to be taken into account when subtracting background/instrumental lines (the background is not necessarily obtained close in time) from the observed line profiles, otherwise it will lead to artifacts.

Nevertheless, when all the complications are taken into account the first results look very promising. One of the prime targets is the study of the 511 keV positron/electron annihilation line. Earlier measurements (which were derived using e.g. CGRO/OSSE data) have revealed that the line strength varies as a function of galactic longitude and peaks near the galactic center. INTEGRAL observations already confirm this picture after only observ-

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ing for half a year (see Figure 1). The fluxes are comparable to those obtained from the OSSE measurements.

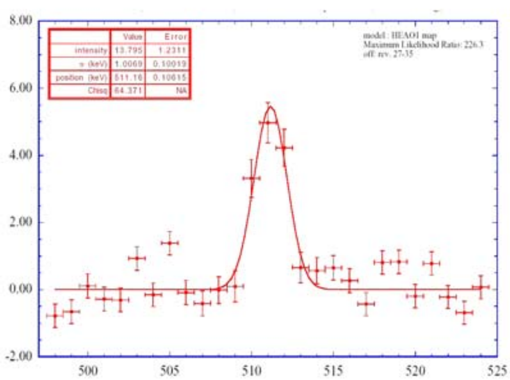

Figure 1: 511 keV line as observed by SPI from the Galactic Centre region. Shown are arbitrary flux vs. keV. Credit: J. Knoedlseder (CESR, Toulouse) and SPI team.

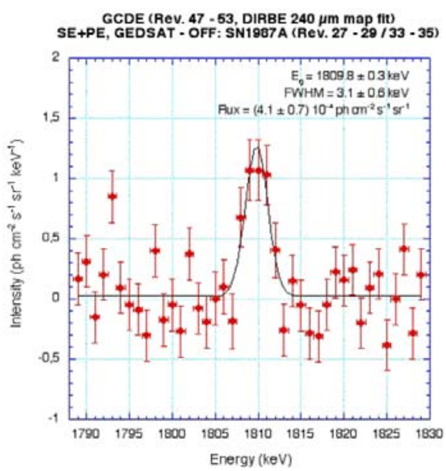

Figure 2: 1809 keV line as observed by SPI from the Galactic Centre region. Credit: J. Knoedlseder (CESR, Toulouse) and SPI team.

The 1809 keV line from ^{26}Al has also been observed by SPI. This line has a relatively short life time (1 million years) and is therefore a good tracer of recent star-formation. Detection of this line also needs long observation times. The obtained line profile can be seen in Figure 2. The line is narrow and the flux is consistent with earlier CGRO/COMPTEL results.

INTEGRAL and Gamma-ray bursts

Although Gamma-Ray Bursts (GRBs) are a secondary objective for INTEGRAL, a number of interesting results have already been obtained now. Due to the large Field of View (FOV) of SPI and IBIS, GRBs are expected to be detected regularly (about once per month) in their FOV. Thanks to IBAS (the INTEGRAL Burst Alert System, a near-real time analysis system running at the ISDC) accurate positions (~ 5') can be disseminated through the internet very quickly (~ 10 sec after GRB trigger). IBAS is not only triggered by GRBs in the FOV of the instruments, but also by GRBs detected with the Anti-Coincidence Shield (ACS) of SPI, which basically covers the whole sky and which produces light curves (50 ms resolution) for triangulation by the IPN.

At the time of writing in total 6 GRBs have been observed in the FOV of the gamma-ray instruments on-board INTEGRAL: GRB021125, GRB021219, GRB030131, GRB030227, GRB030320, and GRB030501.

GRB030327 had a position distributed within 30 seconds after the start of the burst with an uncertainty of only 4.5 arc minutes. Follow-up observations with XMM-Newton showed the X-ray afterglow of this burst. The X-ray spectrum of the afterglow can be described by a power-law, but requires additional absorption which points to a redshift of the source of greater than 1. Results have been described in Mereghetti et al. (2003, ApJ 590, L73).

Optical observations of the area around the position of GRB030131, showed a fading optical counterpart (GCN #1866 and #1971). It is expected that INTEGRAL will continue to

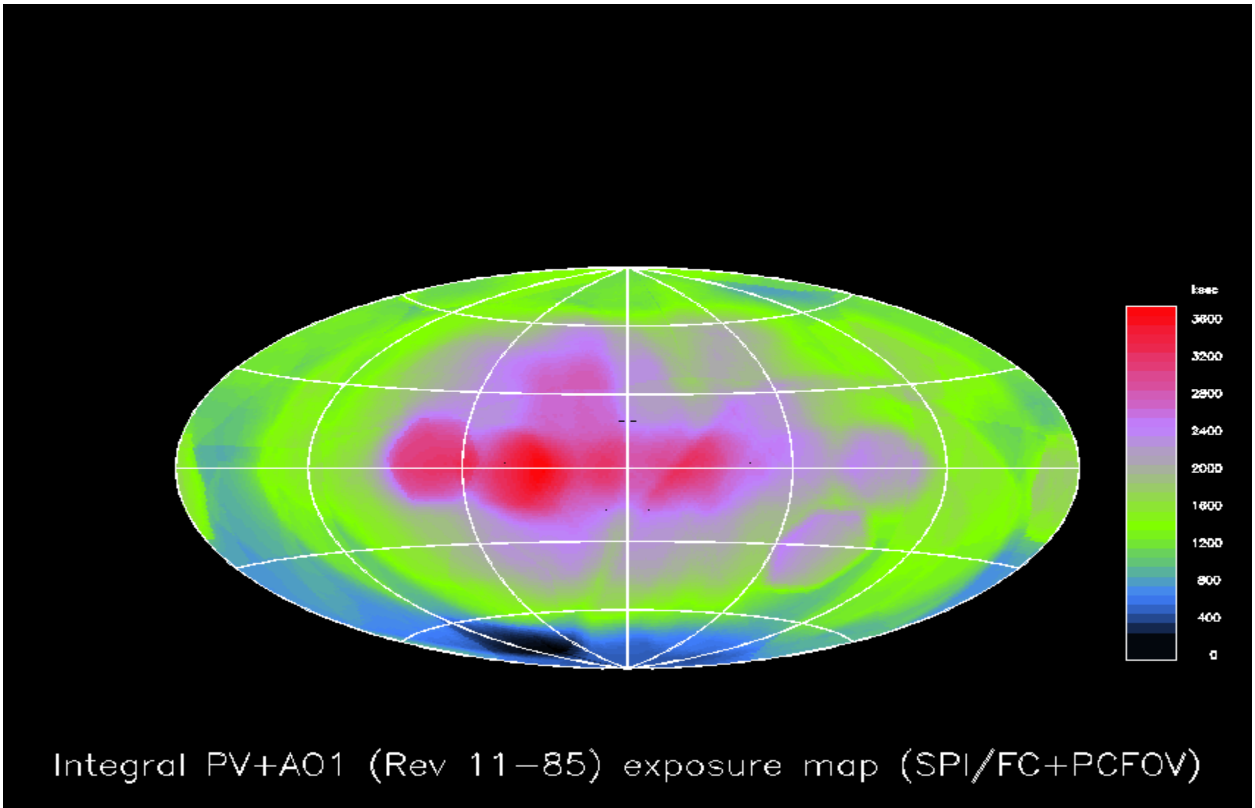

Fig. 3 INTEGRAL/SPI exposure map

contribute significantly in the future with its regular detections (and positioning) of GRBs.

INTEGRAL observing programme

After about 6 months of nominal mission, INTEGRAL has observed a large variety of sources. Five Target-of-Opportunity (ToO) observations (four Black-Hole Candidates, and one neutron star, Aql X-1, in outburst) have been performed so far. During the spring visibility window of the Galactic Centre a large fraction of the available science time has been spent on the GCDE. Considerable time has also been spent on the Galactic Plane Scan (GPS) which are performed about every 12 days and consist of a saw-tooth pattern along the galactic plane. Both the GCDE and GPS have resulted in the discovery of various new variable sources (see below). Furthermore about 25 "persistent" targets have been observed. Many of the shorter observations have been completed, but some of the longer observations have run out of visibility and need to be completed in the next visibility window. Some of the longer observations worth mentioning here are, the Coma Cluster (PI: Vikhlinin) which has been observed for close to 500 ks, and SN1987A (amalgamated observation) which has been observed for almost 1 Ms.

Figure 3 shows the current INTEGRAL exposure map, as seen by SPI, which has a hexagonal field of view. This is based on all pointings scheduled by the ISOC during the Performance and Verification (PV) phase and AO-1 up to revolution 85 (i.e. June 27, 2003). Up to now the region around Cyg X-1 has had the maximum exposure, mainly due to calibration observations during the PV phase. Also visible is the enhanced exposure of the Galactic Centre due to the GCDE and the GPS. Taken into account are the fully coded (13.2 degrees flat-to-flat; 16 degrees corner-to-corner) and partially coded (30.5 degrees flat-to-flat; 35 degrees corner-to-corner) SPI FOVs. Note that not all instruments may have been on during an individual exposure, especially during dedicated calibration observations. Note also that the position angle of the satellite has not been taken into account. A similar exposure map, for IBIS fully and partially coded FOV, can be viewed as the "INTEGRAL/ISOC June Picture of the Month" on http://www.rssd.esa.int/integral.

INTEGRAL and new sources

During the first half of 2003, INTEGRAL has already discovered various new (variable) sources. The first (non-GRB) source discovered was **IGR J16318-4848** on Jan. 29, 2003 during a GPS scan (IAUC #8063). The source flux in the band 15-40 keV was 50-100 mCrab, and varied significantly on a timescale of about 1000 s. Subsequent ToO XMM -- Newton (IAUC #8072), as well as archival ASCA (IAUC #8070) observations showed a clear X-ray source, with a highly absorbed spectrum, and strong Fe lines (ATel#119; MNRAS 341, L13; see also ATel #128). It was also found to be present in IR archival images (IAUC #8076). This source is possibly a high-mass X-ray binary enshrouded by a dense envelope, and may represent an new, overlooked, population of sources (astro-ph/0303274).

During an open time observation of 4U 1630-47 on Feb 1, 2003 another variable hard X-ray source was found, **IGR J16320-4751** (IAUC #8076). The 15-40 keV source flux varied from <10 to 50 mCrab on a time scale of about 1000 s. Its position was found to be consistent with a source already discovered earlier by ASCA, i.e. AX J1631.9-4752 (IAUC #8076). Archival analysis of the BeppoSAX/WFCs showed the source to be persistently active during 1996-2002 at flux levels between 10 and 16 mCrab (5-10keV; IAUC #8077). A bright X-ray source was found during a subsequent ToO observation by XMM-Newton. Spectral differences with respect to the ASCA and WFC were reported, suggestive of spectral transitions similar to those occurring in X-ray binaries (IAUC #8096). This source may be a high-mass X-ray binary containing a neutron star (astro-ph/0304139).

On Mar 6, 2003 the discovery of **IGR J19140+098** was announced during an open time observation of GRS 1915+105 (IAUC #8088). The source, which varied significantly during a span of 2000 s, had a flux in the 15-40 keV band of 50-100 mCrab. The RXTE/PCA found significant irregular variability on time scales longer than 100 s; on top of the power-law continuum an Fe-line complex was found (ATel #128).

Another source close-by 4U 1630-47 was found during a GCDE scan on Mar 19, 2003, namely **IGR J16358-4726**. The source flux varied by a factor of about 2 on time scales of hours; the average fluxes were about 50 mCrab in the energy band 15-40 keV and 20 mCrab in the band 40-100 keV (IAUC #8097). Archival ASCA and BeppoSAX data revealed a weak, highly absorbed X-ray source at the INTEGRAL position (ATel #131). The source was also serendipituously seen during a Chandra observation of SGR 1627-41 (IAUC #8109). Pulsations with a period of 5850 (+/- 50) s were directly visible in the X-ray light curve with an energy-dependent amplitude; the pulse fraction between 2 and 10 keV was 63 (+/- 6) %, peak-to-peak. A possible IR counterpart was suggested based on the Chandra position.

IGR J17464-3213 was discovered during a GCDE scan on Mar 21. The source flux increased by a factor of 3 from March 21 to March 26. The average spectrum during Mar 24-2 6 was rather hard (~60 mCrab, ~60 mCrab, and ~70 mCrab, in the 15-40 keV, 40-

100 keV, and 100-200 keV energy band, respectively), suggesting the source to be a black-hole candidate (Atel #132). The source was also detected by the RXTE/PCA (as XTE J1746-322), and a strong quasi-periodic oscillation (QPO) with a period of ~20 sec, and r.m.s. amplitude of ~25%, was clearly seen in the X-ray light curve (ATel #133). QPO with frequencies near 240 Hz (width of 30 Hz, ~2% arms, 6-21 keV) and between 5 and 10 Hz were found during RXTE/PCA observations at the end of April (ATel 162). The source position is consistent with the HEAO source H1743-322 (also known as H1741-322; ATel #133, #136). A compact, variable radio source was found at the same position (ATel #137, #139, #142, IAUC #8105, #8112). Likely IR (IAUC #8112) and optical counterparts (ATel #146) were reported.

During an open time observation of H1734-322 on Apr 14 2003 another transient source was found, I**GR J17091-3624**. It had a flux of <10 mCrab and ~20 mCrab in the 15-40 keV and 40-100 keV band, respectively, suggestive of a hard spectrum. During subsequent GCDE scans the source flux had increased to ~40 mCrab and ~25 mCrab, respectively, showing a considerable softening of the source (ATel #149). Archival observations by the KVANT/TTM and BeppoSAX/WFC revealed it to be a moderately bright variable X-ray source (ATel #150, #160). A possible radio counterpart was reported (ATel #152).

On Apr 17 2003 the transient source **IGR J18539+0727** was reported, found during a GPS scan. It exhibited a rather hard spectrum, with fluxes of ~20 mCrab in both the 15-40 keV and 40-100 keV energy bands (ATel #151). No obvious optical counterpart was present in the R-band (ATel #158).

During GCDE scans starting on Apr 23 2003, the transient **IGR J18325-0756** was found (ATel #154). The highly variable source displayed fluxes between ~10 mCrab and ~5 mCrab in the 15-40 keV and 40-100 keV bands, respectively, up to ~40 mCrab and ~25 mCrab, in the respective energy bands.

IGR J17597-2201 was detected during GCDE scans. The flux was ~5 mCrab (15-40 keV) on March 30-April 1 and increased to 10-15 mCrab on April 15-April 24. In the latter period the source was also detected in the 40-100 keV band with a flux of ~10 mCrab (ATel #155). The source was already to be seen active for somewhat more than two years in RXTE/PCA galactic bulge scans (hence called XTE J1759-220). It is a variable X-ray source with calm and flaring periods. A period of 1-3 hours is seen in X-rays, based on dipping behavior (~30% dips; ~5 min. duration). During one of the RXTE/PCA bulge scans, an apparent X-ray burst was detected from a position consistent with the source. This source may be a neutron star in a short-period binary (Atel #156).

The transient **IGR J18483-0311** was detected in the period Apr 23-28, 2003 during GCDE scans. At that time it displayed average fluxes of ~10 mCrab and ~5 mCrab in the 15-40 keV and 40-100 keV bands, respectively, with an occasional flare up to ~40 mCrab in the 15-40 keV band (ATel #157).

Mission Status

Rudolf Much - Deputy Project Scientist

Already in the commissioning phase it became obvious that the background due to cosmic particle radiation is at the high end or even higher than prelaunch estimates. The instruments were faced with limitations in the telemetry budget. Major efforts of the instrument teams went into the reduction of their telemetry needs, and the available telemetry was shared between the instruments according to the needs in a good cooperation. In parallel, efforts went into the preparation of a spacecraft software patch to clock out the telemetry at a higher rate. After it was confirmed that the radio frequency link margin is high enough and after a successful test of the software patch using the spacecraft qualification model the software patch was uploaded on May 21, 2003. Since then INTEGRAL operates at a higher telemetry rate, increased by 20%. The increase is sufficient for the instruments to operate as expected before launch and also provides a good margin for operation in future when the background is expected to be higher moving towards solar minimum.

In the past, occasional short data gaps were seen in the telemetry data stream. The reason for this was identified in the communication link between the ground stations and the Mission Operation Center (MOC) which was geared for fast response (telecommand verification) rather than data security (no data losses). Although it was in general possible to retrieve the missing data in the data consolidation process, additional overhead was involved. Therefore the communication links were upgraded recently. The science data are now routed in a secure line (online complete mode) to MOC and the short data gaps have disappeared, while a fast line (online timely mode) is used for housekeeping data to ensure that telecommand verifications timely arrives at MOC.

The observations scheduling at ISOC is proceeding smoothly. The overall efficiency of the INTEGRAL operation is excellent and higher than was expected before launch. The current scheduling efficiency is 93%, i.e. on average 93% of the time outside the radiation belts is used for science observations, the remaining time is spent on slews or reaction wheel biases.

The communication and interaction between the ground segment sites proceeds smoothly as planned. The schedules generated by ISOC are routinely translated into telecommands at MOC and the observations are executed as planned without major problems. The downlinked data are routed via MOC to ISDC and processed there routinely. In conclusion, the spacecraft, the instruments and the different sites of the ground segment are all performing extremely well. The spacecraft resources are large enough to look forward to a long INTEGRAL mission.

Instrument Status and Performance

Rudolf Much - Deputy Project Scientist

Substantial progress has been made by the instrument teams calibrating their instruments and understanding the scientific performances since the end of the commissioning phase in December 2002. During the INTEGRAL commissioning phase the Crab Nebula -- the standard candle in gamma-ray astronomy -- was not visible. Therefore, an extensive Crab calibration programme was executed in the period from February 7 to 27, 2003 once the Crab Nebula became visible for INTEGRAL for the first time.
In addition to the continuos monitoring of the instrument behavior the instrument teams evaluated the instrument performances based on data from the commissioning phase and the Crab observations. The results of this tremendous effort were summarized during the INTEGRAL Mission Performance Verification Review (MPVR). The MPVR took place from May 5 to 20 and culminated in 2 days of presentations by the instrument teams and the various parts of the ground segment on May 19, 20.

The SPI energy range, spectral resolution, field of view, angular resolution, and timing accuracy are all consistent with those given in the AO-1 documentation. However, the line and continuum sensitivities at 1 MeV are approximately by factors of 4 and 8 lower, respectively, than given in the AO-1 documentation. The reduction in sensitivity depends on energy, and is significantly smaller at other energies. The loss of continuum sensitivity can be partially recovered by using IBIS data. The SPI in-flight sensitivities do essentially agree with the last pre-launch estimates, when significantly improved background models were used considering induced background radiation from the entire satellite. The reduction in sensitivity compared to the AO-1 documentation arises because the background is higher than foreseen at that time and because of the preliminary nature of the data analysis techniques which are currently applied. The latter is expected to improve during the next months, allowing further improvements in sensitivity.

Annealing of the SPI detectors is routinely required every ~6 months as the harsh radiation environment in space causes radiation damage in the Germanium crystals of the detectors. The defects in the crystal cause a degradation of the energy resolution. During the annealing process the detectors are warmed up from the operating temperature of -188 degree Celsius to +100 degree Celsius. The high temperature is maintained for 36 hours and the radiation damage in the crystals is cured and any contamination on the detectors is baked out. The detectors are then cooled down and switched on again at a temperature of about -150 degree Celsius.

The first in-orbit SPI annealing cycle was successfully executed from February 5 to February 18, 2003. The goals of the annealing were achieved, namely the cleaning of the detector system from contamination and the "repair" of radiation damage in the detector crystals. The former is confirmed by the much better performance of the cooling system and the recovered energy resolution at lower energies, the latter by the recovered energy resolution at higher energies (> 1 MeV). After annealing, all detectors have an energy resolution in excellent agreement with specified pre-launch values. Especially detector #15 which showed after launch a non-optimum performance after initial switch-on (ΔE= 2.53 keV @ 883 keV and 5.08 keV @ 2.75 MeV) has obtained its nominal performance (ΔE= 2.31 keV @ 883 keV and 3.87 keV @ 2.75 MeV).

Meanwhile, almost five months later, the next annealing cycle is in preparation. It is planned around end of July. While during the February annealing IBIS Crab calibration observations were executed, normal science observations are planned during the next annealing. Special observations will be selected, which do not require SPI in order to achieve their scientific goals.

The IBIS energy range, continuum sensitivity, energy resolution, angular resolution, field of view and timing accuracy are all close to the values given in the AO-1 documentation. The IBIS line sensitivity has not yet been evaluated, but given that the continuum sensitivity and energy resolution are nominal, this is not expected to differ significantly from the value given in the AO-1 documentation.

The IREM is working nominally. A recently uploaded onboard software patch enables more appropriate (higher resolution) information about the radiation environment to be distributed onboard to the other instruments.

The OMC is working nominally with over 10,000 individual targets already observed. The field of view and limiting magnitude are all close to the values presented in the AO-1 documentation. The sensitivity to optical variations is somewhat less than predicted and the reason is under investigation. However no major effect on the scientific return is expected.

Due to a reduction in the JEM-X operating voltage, the energy coverage is slightly less than stated in the AO-1 documentation with the low-energy threshold increasing from 3 to 4.2 keV. The line and continuum sensitivities are also affected by the voltage reduction. However, because of the conservative assumptions used in the prelaunch sensitivity calculations, the current JEM-X sensitivities are very similar to those given in the AO-1 documentation assuming that both detectors are used.

When only one JEM-X is used (as currently), the sensitivity is a factor 1.4 lower. The spectral resolution, field of view, angular resolution, and timing accuracy are all comparable to the values presented in the AO-1 documentation. In summary, the instrument performance is good and the calibration status of the instrument is excellent, considering the very early phase of the mission. In preparation for AO-2, all instrument documentation is being updated to reflect the measured in-flight performance of the instruments. The documents will be issued on the INTEGRAL Web page with the release of AO-2 on July 15, 2003.

Analysis Software and Data Release

Julian Sternberg - System Engineer
Tim Oosterbroek - Operations Scientist

Observers can now make use of a new public release (version 1.1, release date May 21st) of the INTEGRAL "Off-Line Science Analysis" software. This goes together with versions 1.1 of the "Instrument Characteristics" and 7.0 of the "High-Energy Catalogue". Full details and instructions are available via the ISDC web site http://isdc.unige.ch.

A similar package, but tailored for routine data production, is also in use at ISDC for generating data sets from raw telemetry. Generally speaking, this processing takes place in chronological order of the observation programme, however the final stage (Standard Analysis) is only executed when all necessary input data are available. This is assessed jointly by ISOC and ISDC, taking into account the data quality as determined during the earlier processing - the so-called Exposure Completion Status. In practice an observation must have been either completed or suspended owing to scheduling constraints, before the Standard Analysis is performed. In the latter case, ISDC will still generate data sets, but covering just the completed portion of the observation.

Based on the above, the Table below summarizes a list of AO-1 targets which currently have the go-ahead for Standard Analysis, together with their actual durations in seconds. Data distribution to the corresponding PIs will take place, as soon as each observation has completed all processing. GPS and GCDE observations are excluded from the list.

Table 1: AO-1 observations ready for Standard Analysis and distribution

Proposal ID Target	PI	Exposure (ksec)
0110010 GRS 1915+105	ISWT	200
0120014 XT 1741-322	Parmar	300
0120023 3C 273	Courvoisier	240
0120068 NGC 4736	Della-Ceca	100
0120105 XTE J1550-564	Lewin	300
0120112 4U 1630-47	Tomsick	391
0120118 XTE J1720-318	Goldwurm	175
0120126 Centaurus A	Rothschild	150
0120133 SN 1006	Reynolds	251
0120192 Aql X-1	Molkov	330
0120206 Perseus Cluster	Hornstrup	100
0120214 MR 2251-178	Orr	167
0120230 Mrk 273	Dermer	100
0120252 GRS 1915+105	Hannikainen	300
0120125/0120198 Cas A (amalgamated)	Vink, Decourchelle	175
0120026/0120146/ 0120148/ 0120227 SN 1987A (amalgamated)	Mereghetti, Lutovinov, Knoedlseder, Kanbach	1080

Announcement of Opportunity #2 (AO-2)

Paul Barr - Resident Astronomer

The second INTEGRAL Announcement of Opportunity (AO-2) will be released on 15 July 2003. The AO is open to proposals from all over the world. The deadline for receipt of proposals is 5 September 15:00 CEST. Proposals will be assessed by peer review and the results will be known by late October 2003 (see Table 2 for more details). The AO-2 programme itself runs from December 2003 to December 2004. The proposal submission is essentially the same as used in AO-1, namely that proposals **must** be submitted using the INTEGRAL Proposal Generation Tool (PGT), which will be downloaded from the INTEGRAL web site http://www.rssd.esa.int/integral/ and runs locally on the proposer's machine.

There are several minor changes to PGT; users should consult the PGT on-line help for details. One improvement is that a Proposer ID is no longer needed to submit proposals. **THE AO-1 VERSION OF PGT CAN NO LONGER BE USED.** Since the AO-1 process, ISOC has made major improvements to the system and AO-1 PGT, and proposals generated with it, are no longer compatible with the current ISOC system and the AO-2 version of PGT must be used.

However, it is accepted that many proposers may wish to re-use their old AO-1 proposals, especially when long target lists are involved. Therefore the ISOC will, upon request to helpdesk, convert an AO-1 proposal into the AO-2 format and send it back to the original PI.

Table 2: Schedule AO-2

Activity	Date
Release AO-2	15 July 2003
Deadline for proposal reception at ISOC	05 Sep 2003
Proposal evaluation by Time Allocation Committee	October 2003
ESA release of AO-2 observing programme	27 Oct 2003
AO-2 observing programme	17 Dec 2003 - 16 Dec 2004

Any Other Business

Christoph Winkler - Project Scientist

The first circular for the 5th INTEGRAL Workshop *The INTEGRAL Universe* has been circulated in Spring. The workshop will take place in Munich, Bavarian Academy of Sciences, 16-20 February 2004, and it will be the first major workshop addressing INTEGRAL science results from more than one year of observations. Abstracts for contributed papers and posters are invited by 01 November 2003. Details can be found at:
http://www.mpe.mpg.de/gamma/instruments/integral/workshop/www/workshop.html

How to reach the ISOC?

ESA-ESTEC, Science Operations and Data Systems Division (SCI-SDG), Keplerlaan 1,
2201 AZ Noordwijk, The Netherlands
Fax: +31-(0)71-56-55434,
Phone: +31-(0)71-565-xxxx (see below)

http://www.rssd.esa.int/integral/
E-mail:name@rssd.esa.int
(name = first initial and surname, max 8 characters)
ISOC helpdesk: inthelp@rssd.esa.int

Table 3: ISOC personnel

Name	Function	Phone	Mailcode
Parmar, A.	Mission Manager	4532	SCI-SA
Winkler, C.	Project Scientist	3591	SCI-SD
Texier, D.	Project Science Coordinator (located @ ISDC)	4754	SCI-SD
Hansson, L.	ISOC Manager	3471	SCI-SDG
Much, R.	Deputy Project Scientist	4756	SCI-SDG
Sternberg, J.	System Engineer	4001	SCI-SDG
Nolan, J.	Operations Engineer	3401	SCI-SDG
Barr, P.	Resident Astronomer	5139	SCI-SDG
Orr, A.	Operations Scientist	3943	SCI-SDG
Kuulkers, E.	Operations Scientist	6145	SCI-SDG
Oosterbroek, T.	Operations Scientist	3612	SCI-SDG
Dean, N.	Software Engineer	3959	SCI-SDG
Jacobs, F.	Software Engineer	4507	SCI-SDG
Jeanes, A.	Software Engineer	4246	SCI-SDG
Treloar, J.	Software Engineer	4528	SCI-SDG
Williams, O.R.	Software Engineer	4645	SCI-SDG
Riemens, M.	Secretary	4754	SCI-SD