INTEGRAL

Science Operations Centre

Announcement of Opportunity for Observing Proposals (AO-7)

The INTEGRAL Mission: Overview, Data Rights and Procedures

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1 Introduction

This document fulfils several purposes: It introduces the INTEGRAL satellite with descriptions of its orbit, instruments (Chapter 2), observations types and modes (Chapter 3), policies on data rights (Chapter 4), science ground segment (Chapter 5), and procedures to be followed by observers in preparing INTEGRAL proposals using the appropriate software tools (Chapter 6). This document is intended as a general overview, covering all aspects of the INTEGRAL mission that do not change in time.

Issues relating to specific updates to procedures, policies and data rights are presented in a separate document entitled *"AO-7 Schedule and Updates"*.

2 The INTEGRAL Mission

2.1 Overview of the mission

The INTErnational Gamma-Ray Astrophysics Laboratory was successfully launched with a PROTON rocket from Baikonour in Kazachstan on October 17, 2002 at 04:41 UTC. INTEGRAL is a gamma-ray mission sensitive between 3 keV and 10 MeV, whose payload consists of two main gamma-ray instruments, the imager IBIS and the spectrometer SPI, and two monitors, JEM-X (3–35 keV) and OMC (optical V-band, 500–600 nm). The IBIS and SPI instruments both have a large field of view (FOV; 29°×29° to zero response), simultaneously cover a broad energy range (15 keV to 10 MeV), and their design and function are complimentary. In addition, a particle radiation monitor measures charged particle fluxes on the spacecraft.

The scientific goals of INTEGRAL are reached by means of its high resolution spectroscopy allowing spectral line studies, combined with fine imaging and accurate positioning of celestial gamma-ray sources allowing their identification with counterparts at other wavelengths. Moreover, these characteristics can be used to distinguish extended emission from point sources and thus provide considerable power for serendipitous science: a very important feature for an observatory-class mission. Here is a list of scientific topics addressed by INTEGRAL:

Compact Objects: *white dwarfs, neutron stars, black-holes, high energy transients and GRBs*.

Extragalactic Astronomy: *AGN, Seyferts, blazars, galaxies and clusters, cosmic diffuse background*.

Stellar Nucleosynthesis: *hydrostatic nucleosynthesis (AGB and WR stars), explosive nucleosynthesis (supernovae and novae).*

Galactic Structure: *mapping of continuum and line emission, ISM, cosmic-ray distribution*.

Galactic Centre: *cloud-complex regions, mapping of continuum and line emission, cosmic-ray distribution*.

Particle Processes and Acceleration: *trans-relativistic pair plasmas, beams, jets*.

Identification of High Energy Sources: *unidentified gamma-ray objects as a class*.

Unexpected Discoveries.

More details about the INTEGRAL spacecraft, instruments and scientific aims can be found in A&A Vol. 411 (2003). This is a special issue dedicated to INTEGRAL.

2.2 The INTEGRAL spacecraft and its orbit

The INTEGRAL spacecraft has two main components: the *payload module* and the *service module*. The payload module comprises the instruments with which the observations are performed. The service module provides the necessary infrastructure for the payload module. This includes functions such as attitude control and communication with the ground stations. Below is a detailed description of these.

2.2.1 The service module

The service module of the INTEGRAL spacecraft is a re-build of that developed for the XMM-Newton project and is composed of the following key sub-systems:

Mechanical Structure: Consists of a primary structure (central cone and shear panels) supporting the launch loads, and a secondary carrying the sub-system units and the tanks.

Thermal Control System: Consist of active and passive thermal controls.

Attitude and Orbital Control Subsystem (AOCS): Provides control, stabilisation, and measurements about the three satellite axes. This is done using star and sun sensors for primary attitude measurements and Reaction Wheels for torque actuation and momentum storage. The AOCS also controls the Reaction Control System; its thrusters provide the ability to dump momentum from the reaction wheels for orbit maintenance. A hard-wired Emergency Sun Acquisition Mode is implemented to acquire a safe Sun-pointing attitude in case that an AOCS failure results in uncontrolled attitude conditions.

Electrical Power System: Regulates the function of power generation (solar arrays), storage (batteries), control and conditioning, distribution of the required power on a regulated 28 V main and redundant power bus.

Radio Frequency Function: Ensures permanent up and down link of tele-commands and telemetry using a quasi omni-directional antenna and two redundant S-band transponders.

Data Handling System: Provides the ability to acquire, process and format data for downlink. It consists of a single failure tolerant Command and Data Management Unit (CDMU – the central on-board computer) and two Remote Terminal Units: one on the service and the other on the payload module. These are used for data acquisition from peripheral units. Spacecraft telemetry is downlinked in real-time: there is no on-board data storage. Once it was confirmed that the link RF margin was sufficiently large, it was decided to increase the telemetry clocking frequency and thus to increase the bit rate by ~25%. The rate for science data was hence increased from 86 to 108 kbps.

Launcher Adapter: A special adapter including the separation system that provided the connection of the service module with the Russian PROTON launcher.

2.2.2 The payload module

The INTEGRAL payload module consists of an equipment platform accommodating the detector assemblies and an empty box supporting the "upper floor" at a height of about 3.2 m on which the coded masks are fixed. The detector bench provides the interface to the service module cone upper flange and carries SPI, IBIS and the relevant electronics and data processing units. System units (Payload module power distribution unit and remote terminal unit) are accommodated on the lower side. The vertical panels carry the OMC, the IBIS calibration unit and lead shields, as well as the star trackers, while providing support for the IBIS mask and the JEM-X mask support panel. Sun acquisition sensors (part of AOCS) are accommodated on dedicated brackets. The detailed instrument descriptions can be found in the instruments' Observer's Manuals.

2.2.3 The orbit

INTEGRAL follows a highly elliptical 72-hour orbit with an apogee of about 150000 km and a perigee of a few thousand km. The orbit evolves with time. After the launch the perigee height increased for the first few years from ~9000 to ~12500 km while the apogee decreased from ~154000 to ~150000 km. Currently it is evolving to a more elliptical shape with a minimal perigee height of less than 4000 km predicted for 2011/2012.

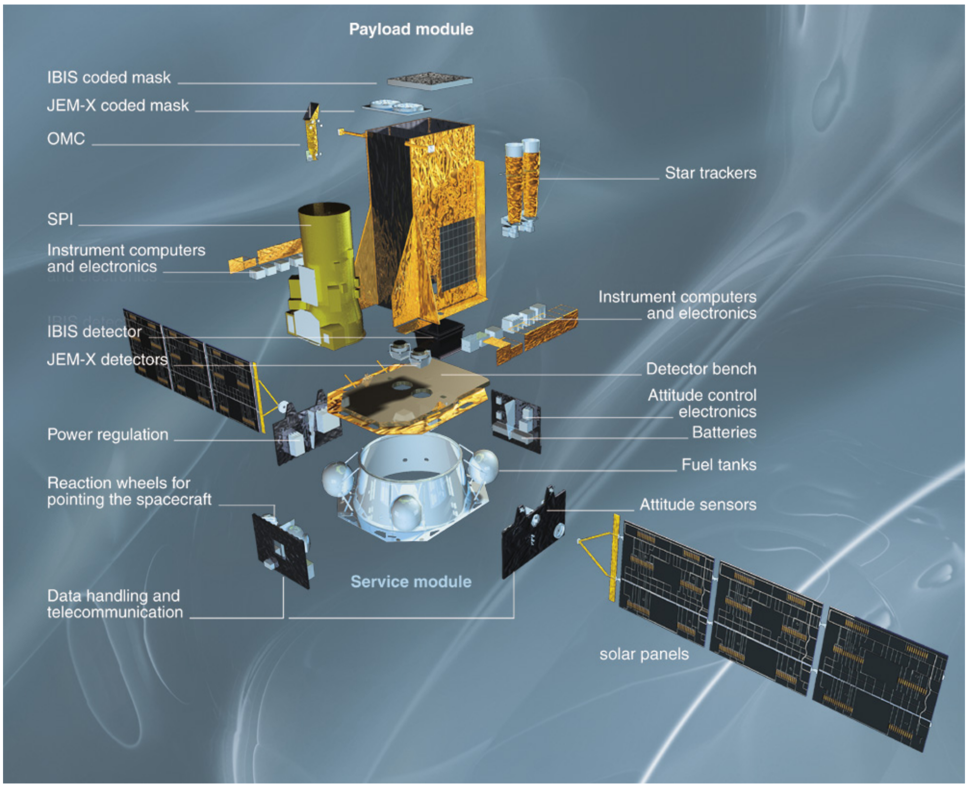

Figure 1: Exploded view of INTEGRAL service and payload modules

In order to allow for undisturbed scientific measurements and guarantee maximum science return, it is required to optimize the time spent outside the Earth's radiation belts. The real-time nature of the INTEGRAL mission requires full ground station coverage of the operational orbit above 40000 km with maximum use of available coverage below.

Generally, scientific observations can be carried out if the spacecraft is at an altitude of at least 40000 km, but the on-board radiation environment monitor can be used to adjust this limit. Scientific observations—about 220 ks per revolution—are currently performed between an altitude of 40000 km (ascending leg of the revolution) and 60000 km (descending leg of revolution). Instrument operation is interrupted in case of a higher radiation environment, e.g., during a strong solar flare.

Ground station coverage of the orbit above 40000 km is achieved by the combined use of the Redu (ESA) and Goldstone stations (NASA DSN) that offer simultaneous coverage during a large part of the orbit. The requirement for maximum visibility from ESA's European ground stations imposes a high inclination angle and an apogee position in the northern hemisphere. For critical operations like orbital manoeuvres, simultaneous coverage from two stations is required.

The satellite requirements on the orbital scenarios are dictated by power consumption, thermal and operational considerations. In order to guarantee sufficient power throughout the mission, the solar aspect angle is currently constrained to $\pm 40^{o}$. This implies that the pointing angle of the spacecraft must be greater than about 50^{o} away from the Sun and the anti-Sun. The maximum duration of eclipses (umbra plus penumbra) cannot exceed 1.8 hours due to thermal and energetic constraints.

2.3 Overview of scientific instruments

Table 1 is a schematic summary of the complimentary features of the instruments on INTEGRAL, and Table 2 and Table 3 list the key performance parameters of the payload. For more details on the instruments, please refer to the appropriate instrument Observer's Manuals.

Table 1: INTEGRAL science and payload complemetarity.

Instrument	Energy range	Main purpose
Spectrometer SPI	18 keV - 8 MeV	Fine spectroscopy of narrow lines
		Study diffuse emission on $>1^{o}$ scale
Imager IBIS	15 keV - 10 MeV	Accurate point source imaging
		Broad line spectroscopy and continuum
X-ray Monitor JEM-X	3 - 35 keV	Source identification
		X-ray monitoring of high energy sources
Optical Monitor OMC	500 - 600 nm (V-band)	Optical monitoring of high energy sources

Table 2: Key parameters for SPI &IBIS.

	SPI	IBIS
Energy range	18 keV - 8 MeV	15 keV - 10 MeV
Detector	17 Ge detectors [1] ($6\times6\times7$ cm^3), @ 85K	16384 CdTe detectors ($4\times4\times2$ mm^3), 4096 CsI dets ($8.55\times8.55\times30$ mm^3)
Detector area (cm^2)	500	2600 (CdTe), 3000 (CsI)
Spectral resolution (FWHM)	3 keV @ 1.7 MeV	8 keV @ 100 keV
Field of View (fully coded)	16^{o} (corner to corner)	$8.3^{o} \times 8.0^{o}$

[1] *There were 19 active Ge detectors at launch. One failed in December 2003, and a second in July 2004.*

Angular resolution (FWHM)	2.5° (point source)	12'
Source location (radius)	< 1.3° (depending on source strength)	30"@100 keV (50 σ source) 3' @100 keV (5 σ source)
Absolute timing accuracy (3σ)	~130 μs	~90 μs
Mass (kg)	1309	746
Power [max/average] (W)	385/110	240/208

Table 3: Key parameters for JEM-X & OMC.

	JEM-X	**OMC**
Energy range	3 keV - 35 keV	500 nm - 600 nm
Detector	Microstrip Xe/CH_4-gas(1.5 bar)	CCD + V-filter
Detector area (cm^2)	500 for each of the two JEM-X detectors	CCD: (2055 × 1056) pixels Imaging area: (1024 × 1024)
Spectral resolution (FWHM)	2.0 keV @ 22 keV	--
Field of view (fully coded)	4.8°	5.0° × 5.0°
Angular resolution (FWHM)	3'	23"
10σ source location (radius)	1' (90% conf., 15 σ source)	2"
Absolute Timing accuracy	~1 ms	> 3 s
Mass (kg)	65	17
Power [max/average] (W)	50/37	26/17

The investigative power of the INTEGRAL observatory is best illustrated by showing how we can obtain scientifically valuable information from all the high-energy instruments simultaneously. For example, Figure 2 presents the spectrum of the Crab, made with OSA 7.0 in 2007. Recent updates concerning the cross-calibration can be found in a report by E. Jourdain et al. 2008: http://adsabs.harvard.edu/abs/2008arXiv0810.0646J).

2.4 Overview of INTEGRAL observation modes

Table 4 summarises the observation modes available for each instrument. Those shown in italics are used in exceptional circumstances only. More details are given in the relevant "*Instrument Observer's Manual*" and should be consulted especially in the case of JEM-X, where the operation strategy had to be adjusted for operations with one of the JEM-X cameras.

Table 4: INTEGRAL observing modes.

Instrument	Modes
SPI	Photon-by-photon
IBIS-ISGRI	Photon-by-photon
IBIS-PICSIT	Histogram
JEM-X[2] (Modes in italics are for special circumstances only)	Full Imaging *Restricted Imaging* *Spectral Timing* *Timing* *Spectrum*
OMC	Normal *Fast*

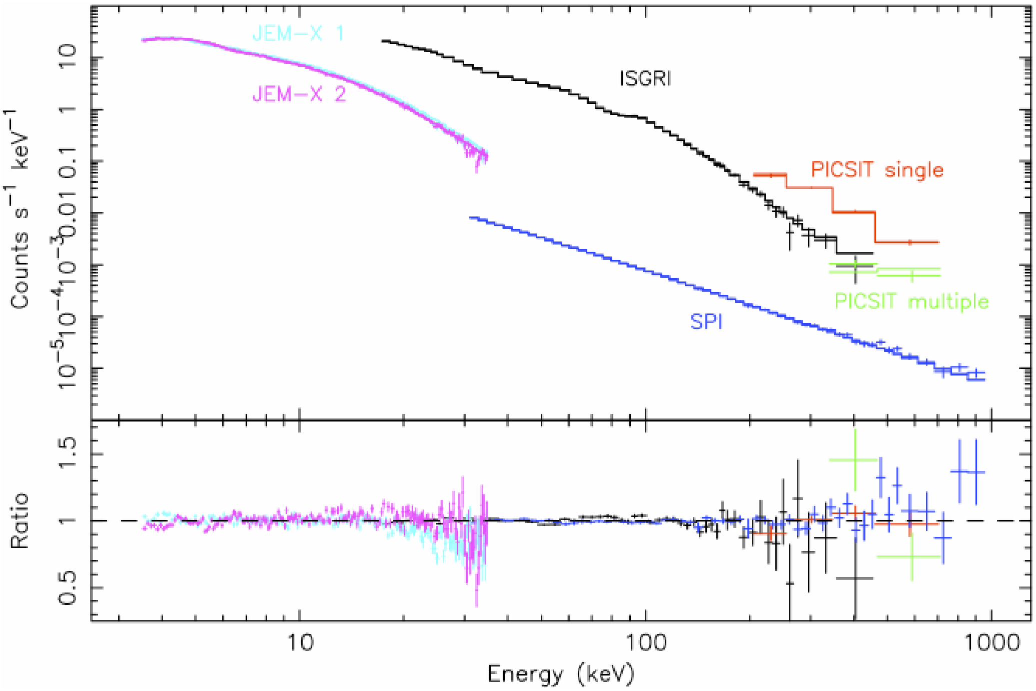

Figure 2: INTEGRAL Crab spectrum with JEM-X, IBIS and SPI. The model was taken from the [ISDC Newsletter No. 21](), and results from a fit to ISGRI and SPI data only. The JEM-X and PICSIT spectra have been added for illustration purposes. See also E. Jourdain et al. 2008: http://adsabs.harvard.edu/abs/2008arXiv0810.0646J for recent updates

[2] *Only JEM-X 1 of the two JEM-X detectors is currently used.*

3 Observing with INTEGRAL

3.1 Overview and observation types

Since the four instruments on-board INTEGRAL are co-aligned and operated simultaneously, observers generally receive the data for all instruments together with auxiliary data including that of the particle radiation monitor from the INTEGRAL Science Data Centre (ISDC, see §5.4). Typical observations can last from ~1 day to a few weeks, and proposals may contain several observations.

There are four classes of observations that can be applied for: Normal, Fixed Time, Target of Opportunity (TOO), and Key Programme observations. Calibration observations constitute another class of observations, but it is not possible to apply for these. Each class has implications for science operations and are described in detail below.

3.1.1 Normal observations

Normal observations do not have special scheduling requirements, and therefore allow for the most efficient scheduling.

3.1.2 Fixed time observations

Fixed Time observations have special scheduling requirements. For example, phase-dependent observations of a binary system, or coordinated multi-wavelength observations would be part of this category. A sequence of observations separated by a time interval, e.g., three observations separated by two weeks, are also considered as fixed time observations. Such observations reduce scheduling efficiency since the spacecraft must be pointing towards a particular source at a particular time.

The exact scheduling requirements for a fixed time observation may not be known at the time of proposal submission, but should be clearly stated in the proposal and flagged as such by setting the *Observation Type* to *Fixed Time* in the *Observation Details Panel* of PGT. Once the proposal is approved, ISOC will contact the observer to determine the best time to schedule the observation. Visibility constraints different than the usual biannual observation window for most sources, should be described in the scientific justification.

3.1.3 Targets of opportunity (TOO) observations

Target of Opportunity observations have very special scheduling requirements and are meant as a fast response to “new” phenomena, like outbursts of X-ray novae, AGN flaring, SNe, and high states of galactic micro-quasars. TOOs can be targeted towards known (e.g., 3C 279, GRS 1915+105, GRO J0422+32) or unknown sources identified by their probable class.

TOOs can have either internal or external triggers. Internal triggers come from the ISDC by screening the incoming science telemetry. External triggers are alerts based on observations with other observatories. All triggers are addressed to ISOC via the INTEGRAL TOO Notification Web page: http://integral.esac.esa.int/isoc/html/too/my_too_alert.html.

Once the Project Scientist (PS) has decided on declaring a TOO, ISOC changes the planning accordingly. This updated command schedule is subsequently sent to the Mission Operations Centre (MOC) in Darmstadt, Germany, where it is implemented.

TOO observations require re-scheduling, interruption of the pre-planned schedule, and re-pointing of the spacecraft. They are, therefore, a very heavy load on the scheduling system and, like fixed time observations, significantly reduce the mission's overall observing efficiency. The typical response time from detection to re-pointing of the spacecraft is ~8 hours. Although neither the ISDC nor the ISOC have staff around the clock, the ISDC has an automatic TOO detection system and one on-call scientist outside working hours. Both the ISOC and MOC also provide an on-call service on weekends and non-working days.

In general, the following **rules and guidelines** are applicable to TOO proposals[3]:

- The TAC is advised to accept no more than a few TOO proposals per year, all ranked according to their scientific merit from A to C.
- A TOO will displace another observation if the latter can be rescheduled by the ISOC and MOC. In some cases, observations can be pushed back to the next observation cycle. KP observations are more difficult to displace given their importance and inherent difficulty in rescheduling.
- The proposer is responsible for requesting[4] the TOO when the trigger event occurs.
- The request is made by submitting a TOO Notification using the ISOC Target of Opportunity Alert Web page (see above). The PS or appointed deputy must include this request in the ISOC proposal database, allowing the tracking, documenting and time-line inclusion of TOO requests, in the same manner as for the standard proposals accepted by the TAC during the AO cycle.
- The PS or an appointed deputy must decide to declare, or not, a TOO by assessing whether the overall science of the mission will be enhanced by this TOO. It is possible that the TOO observation would conflict with a time-critical observation, another TOO (first one has priority) or other high priority observations. In such situations the PS will define the priorities and inform the scientific community of his decision about the TOO.

Please see §4.4 for details on Gamma-ray bursts.

3.1.4 Key Programme observations

The concept of an INTEGRAL Key Programme was introduced for the first time in AO-4. A KP is intented as a means to carry out scientific investigations requiring a significant fraction of the total observing time of an AO cycle but also accommodating various scientific aims. A KP can be presented as a "multi-year" proposal and extend over several AO cycles, but subject to a yearly re-evaluation by the TAC.

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[3] *A **proposal** for a TOO observation can be submitted during the normal AO process, in anticipation of the event.*

[4] *A **request** for a TOO observation is understood to be made after a scientific event occurred which may justify such an observation. The occurrence of this event may or may not match an existing proposal.*

3.1.5 Joint XMM-Newton and INTEGRAL observations

With the aim of taking full advantage of the complementarity of ESA's high energy observing facilities, both projects have agreed to establish an environment for those scientific programmes that require observations with both the XMM-Newton X-ray observatory and the INTEGRAL satellite to achieve outstanding and competitive results.

The issue of the XMM-Newton announcement of opportunity is separated by half a year from the INTEGRAL announcement of opportunity such that coordinated programmes can easily be proposed on the basis of observations accepted by one of the two projects.

By agreement with the XMM-Newton observatory, the INTEGRAL TAC may award up to 300 ks of XMM-Newton observing time for observations that are difficult to accommodate within the scheme described above:

- short (~10 ks) XMM-Newton observations simultaneous to long (>>10 ks) INTEGRAL observations
- short (~10 ks) snapshot-type XMM-Newton observations of newly detected and likely variable sources which require scheduling within one year after the INTEGRAL observation and subsequent detection.

Proposers wishing to make use of this opportunity will have to submit a single proposal in response to the INTEGRAL announcement of opportunity. Although time is requested on both observatories, it will be unnecessary to submit proposals to two separate review boards. A proposal submitted to INTEGRAL will be reviewed exclusively by the INTEGRAL TAC.

The primary criterion for the award of observing time is that both INTEGRAL and XMM-Newton data are required to meet the scientific objectives of the proposal. The allocated XMM-Newton time should not exceed the allocated INTEGRAL time. Neither TOO nor any other type of observations with a reaction time of less than 8 weeks from an unknown triggering date will be considered for this cooperative programme. Repeated observations are excluded from this joint programme.

It is the proposers' responsibility to provide a full and comprehensive scientific and technical justification for the requested observing time on both facilities. *The observation must be flagged as "request XMM-Newton" in PGT.*

Both projects, the XMM-Newton and INTEGRAL observatories, will perform feasibility checks of the proposals. They each reserve the right to reject any observation determined to be unfeasible for any reason.

Apart from the above, both missions' general policies and procedures currently in force for the final selection of the proposals, the allocation of observing time, the execution of the observations, and the data rights remain unchanged.

3.1.6 Nearby supernova as Target of Opportunity

Following a recommendation from the INTEGRAL Users Group it has been decided that the unique and highly important event of a nearby Supernova should be treated as a TOO with all its data to be made immediately public[5] to the scientific community at large. **Note that this decision implies that individual open time proposals for nearby Supernovae cannot be submitted in response an AO.**

The observing strategy for a nearby Supernova is described in some detail below in order to inform the community about the selected approach to conduct the public INTEGRAL observations. This strategy has been defined by the IUG, using substantial input from Mark Leising (U Clemson/USA).

Definition

The term "nearby" is understood to describe the distance to a Supernova event that occurs in the Local Group up to a distance of:

1. 60 kpc (i.e. including LMC and SMC) for core-collapse SN (II, Ib, Ic)
2. 1 Mpc (i.e. including M31) for thermonuclear SN (Ia)

Introduction

The possibility of a nearby Supernova presents an exciting prospect for INTEGRAL. There is a significant chance of such an event during the extended mission operations phase. We might well learn more about that type of SN from this one object than all previous objects combined and INTEGRAL will be a key contributor to that knowledge.

The modeling of typical supernova explosions suggests that fluxes of brightest lines (e.g. 847 keV and 1238 keV lines of the ^{56}Co decay) are of the order of 10^{-3} photons s^{-1} cm^{-2} at the distances of 60 kpc and 1 Mpc for SNII and SNIa, respectively. At such high fluxes INTEGRAL is expected to deliver extremely valuable science. For SNII this means that a supernova in LMC and SMC would be an excellent target for INTEGRAL. For a type SNIa, an explosion in Andromeda is expected to be an equally bright event for INTEGRAL.

Discovery

The method of discovery will depend on the SN type: *core-collapse* or *thermonuclear* explosion.

1. *Core-collapse SN*: Core collapse Supernovae (SN type II, Ib, Ic) will most probably release neutrinos escaping the collapsing system hours before the escape of photons. The Supernova Early Warning System (SNEWS, cf. P. Antonioli, 2004, New J. Phys. 6, 114, astro-ph/0406214) utilising a network of neutrino and gravitational wave detectors, notifies interested subscribers. ISOC has subscribed to the SN alert system at http://snews.bnl.gov/alert.html

2. *Thermonuclear SN*: The discovery of Galactic SN of type Ia will probably be made in the visible regime if the event occurs at sufficiently high Galactic latitudes. These announcements are available via the IAU Circulars. At lower latitudes, first detection could be via X-ray or gamma-ray observations (e.g. Fermi Gamma-ray burst monitor,

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[5] *The term "immediately public" means that general on-line access by the science community to the so-called "near real-time (NRT) data" at the ISDC will be provided by ISDC. The consolidated data, usually available few weeks after the observations, will be accessible via the public archives.*

Swift, INTEGRAL), or eventually via radio emission. Again, results would be communicated to ISOC via IAUC, ATel, GCN or similar channels.

Follow-up observation strategy

The science objectives can be achieved through the observation of the time evolution of fluxes (light curves) and line spectroscopy. **It is important to observe the SN as soon as possible**.

The strategy for the first year after the event includes:

i) Observe the SN immediately and continuously for 40 days.

ii) If SN type Ia (thermonuclear): continue to observe for intervals of TBD[6] Ms duration at 50% duty cycle thereafter.

iii) If SN type II, Ib, Ic (core-collapse), continue to observe for 2 Ms at 33% duty cycle thereafter.

iv) Then, possibly, re-observe (re-point) the SN based on changes at other wavelengths (e.g. the onset of circumstellar interactions, seen in X-rays, radio, Hα) or based on results from INTEGRAL data themselves and as decided by the Project Scientist.

Note that item i) will be implemented regardless of the SN type. During the first 40 days of observations, the PS will reconvene with the IUG, and additional experts if required, to optimize and fine tune the strategy as laid out in items ii) to iv) as well as to devise a strategy for the long term (beyond first year). One also has to bear in mind the substantial diversity of supernova properties. It is not excluded that the observing strategy of a particular supernova will be optimized to maximize the science return from INTEGRAL.

Data Rights

Following a recommendation by the IUG, observations of Galactic SN shall be performed such that all data associated with the observations are made public immediately to the scientific community at large. This implies that the ISDC is requested to make these data publicly available with minimum delay. The NRT (Near-Real Time) data format currently in place for KP observations will be suited for this.

3.1.7 Calibration observations

Dedicated payload calibration observations are occasionally executed during the normal operation phase. Observations of the Crab are usually carried out during every visibility period in order to continually monitor, assess and verify the scientific performance of the instruments. This helps to refine our knowledge of the instruments and thus our ability to characterise their performance. This is particularly important after annealing of the SPI detectors or after strong solar flare events.

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[6] *TBD by the PS in consultation with the IUG and additional experts, if required.*

An initial long Crab calibration observation took place in February 2003. Currently one or two revolutions per viewing period are devoted to Crab calibrations. OMC flat field calibrations to characterise the instrument's response are performed ~1/month with a duration of ~4.5 hours. Performance verification of the spacecraft (e.g. AOCS calibration), are also performed regularly. Proposers should not duplicate such calibration observations in preparing open time proposals.

Public observations of the Earth were performed during AO-3. This allowed an accurate estimate of the cosmic X-ray background—an important and long-standing problem in high energy astronomy—while providing a better estimate of the instrumental background, which lead to improved background modelling.

Annealing of the SPI detectors is not a calibration per se, but it is intended to partially recover the gradual time-dependent degradation in energy resolution. These annealings are performed approximately every six months and last six revolutions (2.5 Ms). During this time, scientific data are obtained for IBIS, JEM-X and OMC only.

3.2 Observation modes

There are three distinct observation modes: *rectangular dither*, *hexagonal dither* and *staring*. During all observations, the spacecraft provides stable pointings within 7.5″ of the pointing direction. The only mode suitable for deep exposures is the standard, rectangular or 5×5 dither.

In order to minimize systematic effects due to spatial and temporal background variations in the IBIS and SPI instruments, **a controlled and systematic spacecraft dithering manoeuvre is required**. This manoeuvre consists of several off-pointings of the spacecraft's pointing axis from the target in 2.17° steps. The integration time for each pointing (all instruments) on the raster is between 30 and 60 minutes, adjusted so that an integer number of complete dither patterns are executed. Two different dither patterns and the staring mode are used and described below. Note that the hexagonal dither pattern is implemented as it was in AO-4.

3.2.1 Rectangular dithering

Rectangular dithering on a 5×5 grid is the standard observation mode. It is well suited for observations characterised by a FOV containing multiple point sources whose positions are unknown. It is also well suited for observations of extended or weak sources that can best be studied by accumulating exposure time through a sum of individual pointings ("mosaic"). This observation mode should always be used as the default.

During AO-1 and most of AO-2, this mode consisted simply of a square pattern centred on the nominal target position, as shown in Figure 3. In this implementation, one pointing was with the source on-axis, and 24 other pointings with the source off-axis, each separated by 2.17^{o} arranged on a rectangular grid. The roll angle between pointings was always 0^{o}.

Starting in AO-3, the pattern was optimised to reduce systematic effects in the IBIS images. This implies that for observations requiring several dither cycles, an offset between the centre of each dither cycle is introduced. This ensures that no pointing attitude is repeated over the course of the observation. Hence, the Centre Of dither Pattern (COP) moves around in a pre-defined manner during the course of an observation. The COP pattern is parallel to the original 5×5 dither and consists of 7×7 points centred on the target, with a step size of 0.3^{o} (see Figure 3). Thus, the whole COP pattern fits within the inner 3×3 points of the original dither. The 49 points in the COP pattern allow for an observation time of 2.2 Ms without repetition of a given pointing.

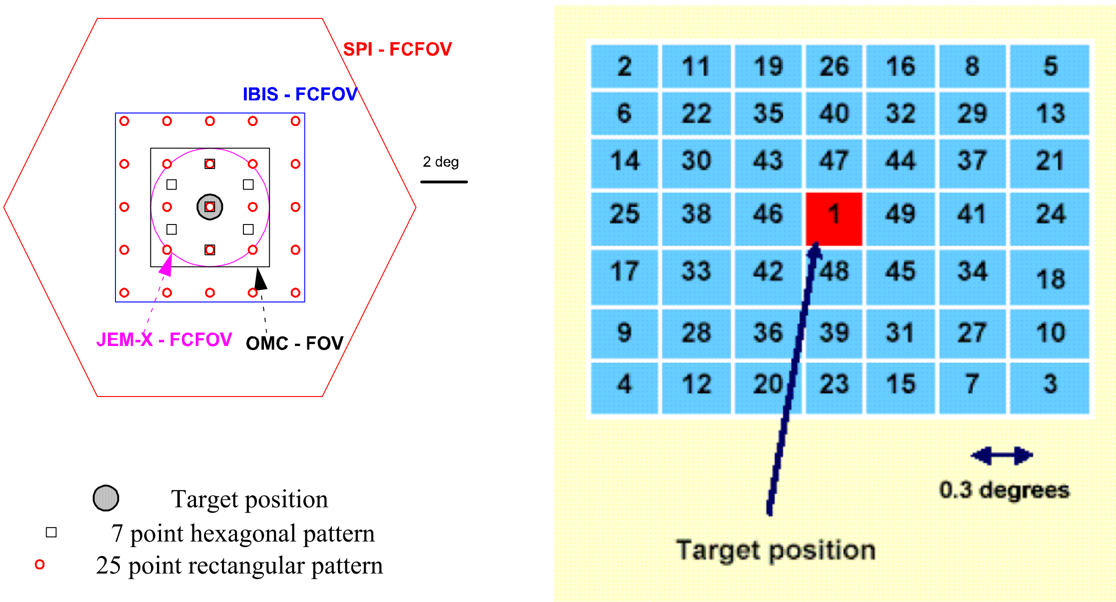

Figure 3: Schematic view of dithering patterns (left) and COP Offset Pattern for a 5x5 dither.

In addition to the moving COP, to further reduce systematic effects in deep mosaics, since June 2005 the orientation of the 5×5 pattern is set such that the axis of the dither pattern is rotated by 11.3° = arctan(1/5) with respect to the instrument axes. As the instrument axes depend on the relative position of the Sun, the exact dither pattern pointing directions depend on the time of execution of the observation.

The most recent optimization to reduce systematic noise in mosaics involves a stepping in roll angle, and was implemented for the first time at the end of November 2007 in revolution 624. With this strategy, the roll angle for an observation with N repetitions of the 5×5 pattern spans the range from +3° to -3°, in steps of $d\theta = 6/(N-1)$.

3.2.2 Hexagonal dithering

The use of this mode is strongly discouraged, for it seriously compromises the imaging capabilities of IBIS and SPI, rendering the data useless for use in large mosaics.

Hexagonal dithering consists of a hexagonal pattern centred on the nominal target position: one source-on-axis pointing, six source-off-axis pointings 2° apart, in a hexagonal pattern. This mode should generally only be used for a single point source whose position is known and where no significant contribution from out-of-view sources is expected. Earlier observations have shown that this is rarely the case because of bright or transient sources, and observers are generally discouraged from using this mode, except if their scientific goals require continuous monitoring of the main target by JEM-X. Such a strategy would however be at the expense of SPI data quality if there are even a few sources in the FOV (see the "*SPI Observer's Manual*").

This observation mode was altered in the middle of AO-3 (November 2, 2005) to allow for a wandering COP offset to the hexagonal dither pattern. This COP pattern consists of 2×6 points that define two hexagons (red dots in Figure 4), centred around the original centre point of the (blue) dither pattern.

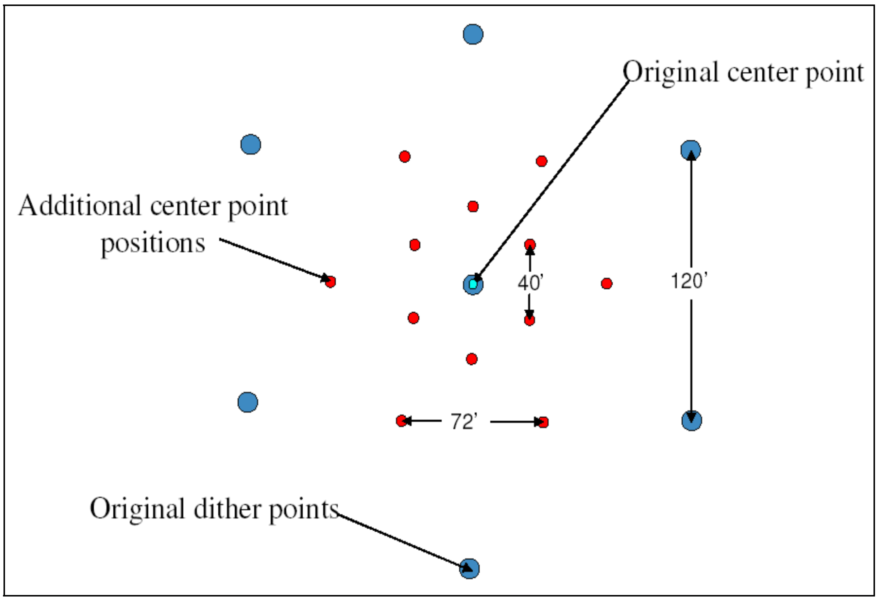

Figure 4: COP Offset Pattern for hexagonal dither pattern.

3.2.3 Staring observations

The use of this mode is strongly discouraged, for it seriously compromises the imaging capabilities of IBIS, SPI and JEM-X, rendering the data useless for use in large mosaics. For this reason, staring observations must be very well motivated.

There are however circumstances that require long, uninterrupted, on-axis observations of a source, such as in studies of time variability or QPOs.

4 Data Rights

The contents of this chapter are taken directly from the *"Data Rights"* document (see previous AOs), which will therefore no longer be found as such, and is included here in its entirety with very few minor changes.

The ESA INTEGRAL Science Management Plan (SMP)[7] defines the policy on data rights on all scientific data obtained from the INTEGRAL scientific instruments during the entire mission. Scientific instruments of INTEGRAL are SPI, IBIS including particle radiation monitor (IREM), JEM-X, and OMC. Some aspects of the INTEGRAL mission, however, require specific data rights policies beyond the SMP; these are laid out in this document.[8]

4.1 Proprietary data

Each observer will receive the data relevant to his/her observation from all instruments, and will retain exclusive rights on these for one year from the time the data have been dispatched by the ISDC. Following this one-year proprietary period, all data will be made publicly available through the archives. Some data, however, are made publicly available under different conditions overviewed in §4.2.

In agreement with the general policy on data rights for all ESA science missions, this simple propriety rule is applicable to all INTEGRAL scientific observations. The following special cases, however, require specific rules that are described herein.

- Targets of Opportunity
- Multiple targets in the FOV including serendipitous sources
- Selected subsets of data
- Split observations
- Calibration data
- Data obtained during slews
- Re-processed data
- Instrument housekeeping data
- Data for public relation purposes

[7] *INTEGRAL Science Management Plan, ESA/SPC(94)1, rev.4 (November 2007)*

[8] *The data rights policy was endorsed by the INTEGRAL Science Working Team prior to launch based on INTEGRAL Technical Note INT-TN-14571, and updated since for each AO.*

4.2 Public data

Table 5 presents a summary of data types and conditions that lead to the release of public data, and provides the relevant section number in this document for each particular case.

Table 5: Public data from INTEGRAL.

Data type or condition	Section
All private data one year after they have been processed and dispatched by the ISDC.	**4.1**
Data from a dedicated TOO follow-up observation are publicly available, if the TOO event is discovered in the routine analysis of INTEGRAL data performed at the ISDC, and there is no proposal accepted by the TAC.	**4.3.2**
Data from a dedicated TOO follow-up observation are publicly available, if the TOO event is suggested to the Project Scientist by outside information, and there is no proposal accepted by the TAC, and the TOO is an important event in the judgment of the Project Scientist or is requested by numerous scientists.	**4.3.2**
Data from observations of a nearby SN are publicly available (no proposals are accepted).	**3.1.6**
For GRB inside the FOV: location (and errors), trigger time, peak flux, fluence, light-curve (plot only), duration.	**4.4.1**
For GRB outside the FOV: light-curves from SPI ACS.	**4.4.2**
Source position and flux for serendipitous sources detected during QLA analysis at ISDC, at the latest one week after the observer (PI) has been notified by ISDC.	**4.5.3**
All data from “de-selected” instruments (any observation)	**4.6**
All data obtained during dedicated in-flight calibrations during extended mission phase.	**4.8.2**
All data obtained during long slews.	**4.9**
Soft Δ-releases of re-processed public data	**4.10.2**
Hard Δ-releases of data, originally made public immediately.	**4.10.3**
All instrument housekeeping and engineering data.	**4.11**
Data required in support of the activities of ESA and participating agencies.	**4.12**

4.3 Data from Targets of Opportunity (TOO) observations

4.3.1 Introduction

Routine INTEGRAL science operations are being implemented using a pre-planned sequence of observations as a baseline.

The gamma-ray sky is highly variable and many of the mostly unpredictable TOO events are scientifically important and often warrant to modify the pre-planned observing schedule. Many of these events in the INTEGRAL range are caused by Galactic compact objects, others by AGN and Blazars Other TOOs will be reported from other space missions or ground based observatories.

It shall be noted that proposals for TOO follow-up observations (with sources at known or unknown locations) can be made in response to this AO. Once the event satisfied the TOO criteria as specified by the proposer (and approved by TAC), and the observation has been executed, the usual data right policy is applicable for these data as it is for any other source.

4.3.2 The TOO data rights

For the INTEGRAL mission the main criteria determining TOO data rights[9] are:

- The TOO event is discovered in the INTEGRAL data of the General Programme (open time) observations[10]
- The TOO observation is suggested to the Project Scientist by outside information from other space missions or ground based observatories.
- There does exist a TOO proposal accepted by the TAC.
- There does not exist a TOO proposal accepted by the TAC.

The data rights for different combinations of the above criteria are presented below, starting from the following two categories:

Category (1): The TOO event is discovered in the routine scrutiny of the INTEGRAL data performed in the ISDC.

Category (2): The TOO event is communicated to the Project Scientist by outside information from other space missions or ground observatories.

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[9] *"Data rights" are understood following [1] as the usual one year proprietary period (see Section 4.1)*

[10] *Key Programme (KP) observations are part of the General Programme*

Category (1): The TOO event is discovered in the routine scrutiny of the INTEGRAL data performed in the ISDC (Figure 5).

The TOO event is discovered in the routine scrutiny of the INTEGRAL data, and

i) it is covered by a TAC accepted observing proposal: The successful proposer(s) also obtain the data rights for the on-going observation in which the event was detected, and for possible follow-up observations. Note, however, that section 4.5 on multiple sources in the FOV does also apply for TOO observations.

or

ii) it is not covered by a TAC accepted observing proposal: The data collected during the on-going observation will remain the property of those scientists having approved targets in the FOV, similar to the case for serendipitous sources (see also section 4.5). The data of possible follow-up observations will immediately be placed in the publicly available archive at the ISDC. The Project Scientist (via ISOC) will announce this widely to the general community.

Category (2): The TOO event is communicated to the Project Scientist by outside information from other space missions or ground observatories (Figure 6).

(2a) The TOO is covered by an observing proposal accepted by the TAC: the successful proposer obtains the data rights for possible follow-up observations.

(2b) The TOO is not covered by an accepted observing proposal, and

i) the TOO is an obvious event in the judgement of the Project Scientist (e.g. a nearby Supernova, see Section 3.1.6), or the TOO observation is requested by numerous scientists: The data from a dedicated TOO follow-up observation will immediately be placed in the publicly available archive at the ISDC. The Project Scientist (via ISOC) will announce this widely to the general community. If the TOO detection was located in the FOV of an ongoing observation, the data from that ongoing observation will remain the property of those scientists having approved targets in the FOV of that observation.

or

ii) the Project Scientist is told of a TOO event by a particular person, and that person is an isolated voice: The Project Scientist can award the data rights to that person for the ongoing observation as well as for possible follow-up TOO observations.

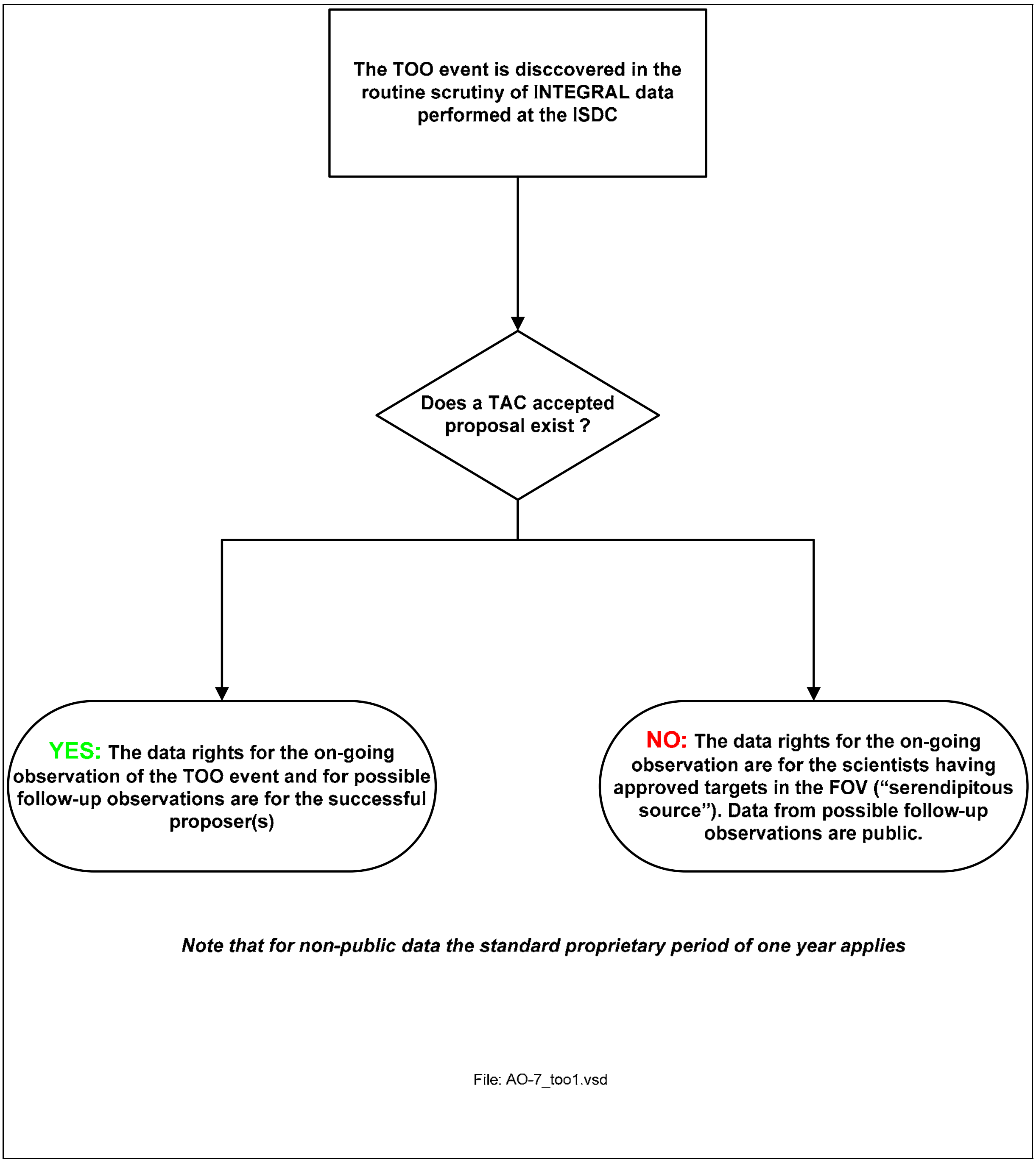
The TOO event is disccovered in the routine scrutiny of INTEGRAL data performed at the ISDC
Does a TAC accepted proposal exist ?
YES: The data rights for the on-going observation of the TOO event and for possible follow-up observations are for the successful proposer(s)
NO: The data rights for the on-going observation are for the scientists having approved targets in the FOV ("serendipitous source"). Data from possible follow-up observations are public.
Note that for non-public data the standard proprietary period of one year applies
File: AO-7_too1.vsd

Figure 5

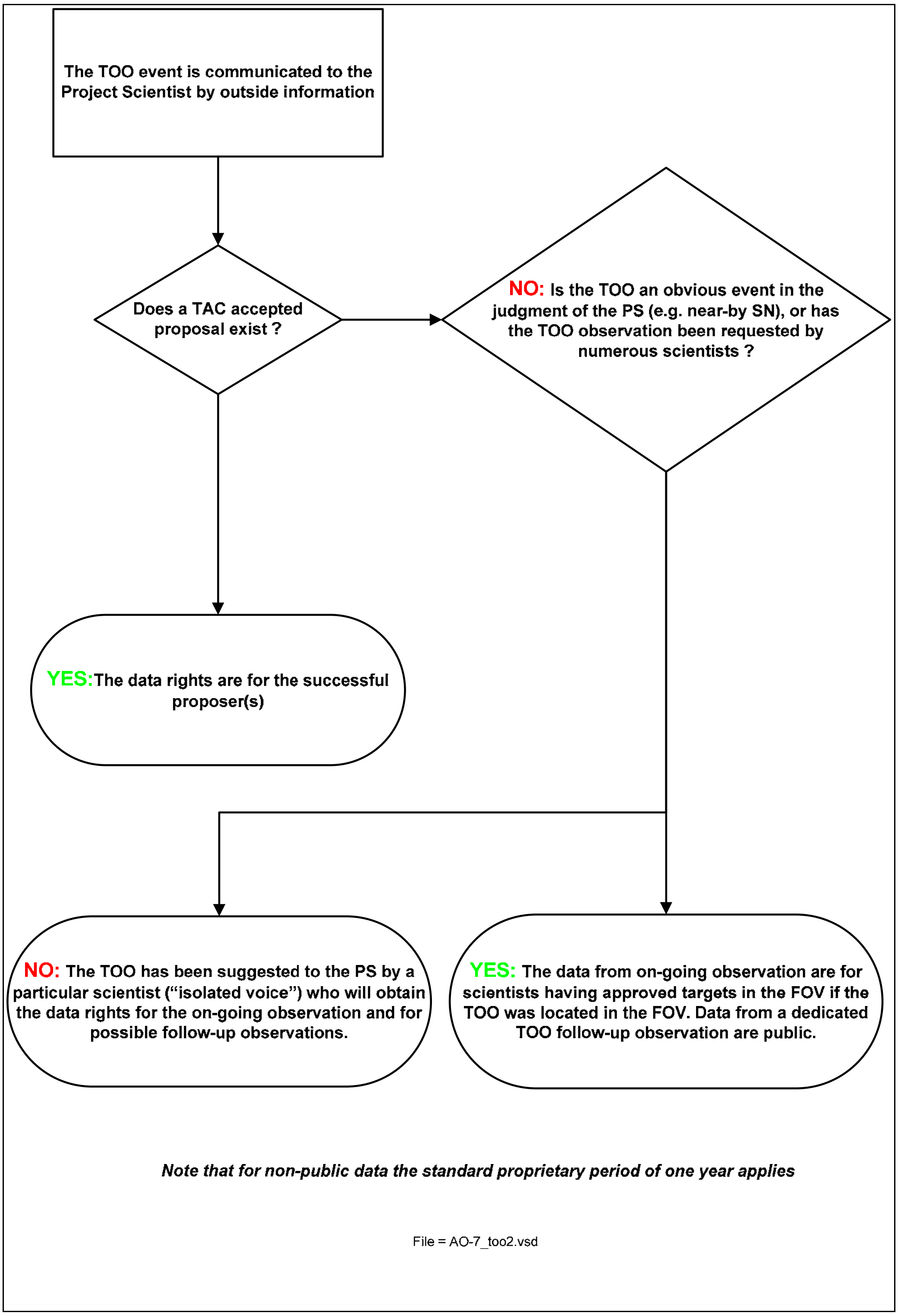
The TOO event is communicated to the Project Scientist by outside information
Does a TAC accepted proposal exist ?
NO: Is the TOO an obvious event in the judgment of the PS (e.g. near-by SN), or has the TOO observation been requested by numerous scientists ?
YES:The data rights are for the successful proposer(s)
NO: The TOO has been suggested to the PS by a particular scientist ("isolated voice") who will obtain the data rights for the on-going observation and for possible follow-up observations.
YES: The data from on-going observation are for scientists having approved targets in the FOV if the TOO was located in the FOV. Data from a dedicated TOO follow-up observation are public.
Note that for non-public data the standard proprietary period of one year applies
File = AO-7_too2.vsd

Figure 6

4.4 Gamma-ray bursts

In principle, gamma-ray bursts (GRB) are considered as a subset of TOO events and general rules/guidelines do apply as described in the previous sections, see, however below for further specific details on data rights. GRB do occur randomly in time and space, thereby naturally both inside and outside the coded FOVs of the instruments IBIS, SPI and JEM-X.

4.4.1 GRB inside the FOV of instruments

Data from these events will be contained in the science data of INTEGRAL instruments operating in the modes selected for the on-going observation. Typically one event per month is being observed[11] - consistent with pre-launch estimates - and the data rights on data obtained from the GRB event itself are described above as for TOOs in general, covering both existence and non-existence of TAC approved proposals.

Concerning GRB follow-up observations initiated from GRB events detected by INTEGRAL or suggested from the outside it has to be kept in mind with the current knowledge on GRB, that these events are of rather short duration, covering a typical range of $\sim 10^{-2}$ sec to $\sim 10^{+2}$ sec, compared to other TOOs. Afterglow or counterpart observations with INTEGRAL following immediately a GRB detection, are possible only if (i) the GRB event occurs inside the FOV of the on-going observation and it will be covered during the on-going nominal dithering manoeuvres, or (ii) if the event occurs outside the FOV but the spacecraft will dither onto that position during the nominal dithering manoeuvre of the on-going observation during which the event occurred. A near real-time interruption of the on-going dither pattern in order to prevent the GRB location from moving out of the FOV and/or an extra near real-time slew manoeuvre onto the GRB position within a short time scale (of typically one hour or less) does not constitute the operational baseline of the mission for observation re-planning.

Concerning the GRB data rights, data on the GRB event itself (e.g. spectral data, event light-curve data etc.) are treated, in principle, as TOO event: if TAC accepted proposals for GRB events in the FOV exist and a GRB is detected during an INTEGRAL observation, then the successful proposer will receive the GRB event data, obtained during this on-going observation. However, and differing from TOO cases in general (see Section 4.3.2), because of the short duration of the GRB event (~ 10's of seconds) compared to the duration of the on-going observation (typically $>10^5$ sec), the GRB event data will be extracted within a contiguous time window (for instance the TAC recommended "duration" of GRB observation) from the data of the on-going observation (e.g. as a number of contiguous science windows) and those data only will be provided to the observer. The reader is also referred to GRB as 'serendipitous sources' in Section 4.5.3 .

GRB locations and errors, and trigger times are, due to the nature of the rapid alert system, publicly available. In order to facilitate rapid follow-up observations (e.g. using XMM-Newton or Chandra), data describing the GRB peak flux (20 - 200 keV, 1 sec), fluence (20 - 200 keV),

[11] http://ibas.iasf-milano.inaf.it/

light-curve (20 - 200 keV, plot only) and GRB duration (sec) are also publicly available, see the IBAS website[12] for further details and recent examples.

4.4.2 GRB outside the FOV of instruments

In this section, "GRB outside the FOV" are considered as events which trigger the veto logic of the SPI instrument, the SPI anti-coincidence (ACS) subsystem, which acts as a nearly omni-directional GRB detector above ~ 75 keV. These triggers result in count-rate light-curves (time histories) from the SPI ACS with a time resolution of 50 ms. The event rate is about one GRB/day based on current instrument performance and 5σ detection significance[13]. These GRB light-curve data from the SPI ACS are part of the instrument housekeeping/engineering data as provided by the ISDC and are therefore public data via the archive (see Section 4.11 below). However, the prime scientific need in the SPI ACS time history data from GRB lies in the correlation of the photon arrival timing with time histories obtained by other spacecraft constituting the Interplanetary Network (IPN). GRB locations obtained by the IPN often produce small GRB error boxes crucial for follow-up observations at other wavelengths. Therefore, GRB time histories as obtained from the SPI ACS will be provided in near real-time via the ISDC GRB rapid alert system (see above) to the scientific community. As such these data become public immediately.

Note that intense and hard GRB events which occur at large off-axis angles may also produce detectable effects on the photon detection planes of the high energy instruments (see 4.4.1), and these events are not considered in this section any further. However, applying Compton imaging techniques, it is possible to analyse those data from the IBIS telescope (e.g. R. Marcinkowski et al. A&A 452, 113, 2006).

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[12] http://ibas.iasf-milano.inaf.it/

[13] http://www.mpe.mpg.de/gamma/instruments/integral/spi/acs/grb/trigger/ACSTriggerTab.html

4.5 Multiple targets within the large instrument FOV

4.5.1 Introduction

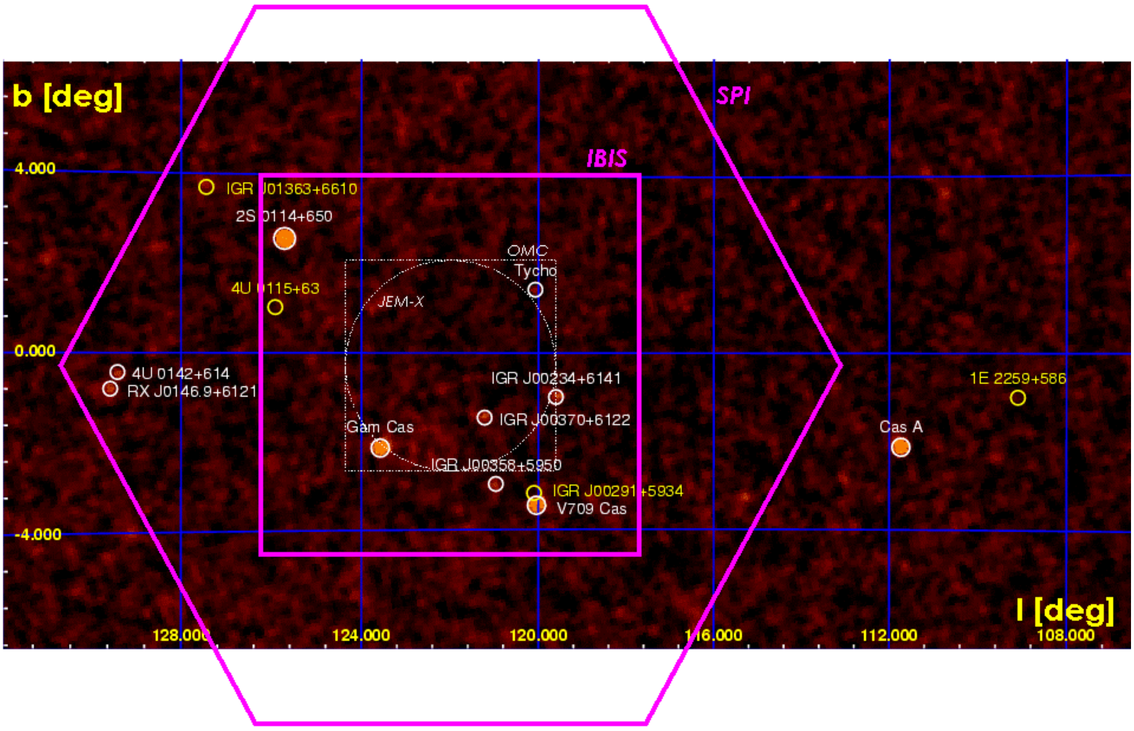

Figure 7: Schematic view of the large (fully coded) FOV of the INTEGRAL payload, overlaid with an observation of the Cas A region (12-60 keV, den Hartog et al., 2005), to illustrate the unique target multiplicity feature of the INTEGRAL mission.

The original INTEGRAL science objectives include observations of the diffuse gamma-ray emission and observations of galactic source populations in the Galactic Centre region. These requirements have led to a design of the two main gamma-ray instruments (SPI and IBIS) which incorporates very large fully coded fields of view (FOV) of 8.3 deg × 8 deg [IBIS] and 16 deg (corner to corner) [SPI], respectively. In addition, the main instruments and the two monitors are re co-aligned with overlapping fields of view (see). The SPI requirement to “dither” the spacecraft X-axis (co-aligned with the pointing axis of all instruments) around the nominal target position , results in an even larger sky coverage around the source position. Finally, the INTEGRAL Science Operations Centre may combine (“amalgamate”) close-by targets in one “dithering” pattern in order to save slewing time and to maximize the observation efficiency (see below).

These factors render the occurrence of multiple sources in the FOV highly probable, in addition, serendipitous sources including TOO detections are to be expected. Consequently, there will be a number of observers having their "own" sources in the same field of view during an observation.

The "amalgamation"[14] of observations can be performed in two different procedures, the outcome however, being the execution of one observation containing several sources belonging to several PIs is, what concerns the data rights, identical. These two procedures are:

(i) Two (or more) individual (non-TOO) observations, each using observatory time, can be 'amalgamated' by ISOC, after the peer review process, into one observation using an optimised pointing pattern and exposure, after fulfilling a number of technical requirements like an upper limit on the angular distance between sources.

(ii) One individual observation, requesting observatory time, may contain inside its FOV a number of individual targets (or extended areas of diffuse emission) which are of interest to other scientists and these targets or areas have not been assigned by the TAC to the PI of that individual observation. That observation can be any type of approved observation: "normal" or "fixed time" with exposures < 1 Ms, or Key Programme observations with exposure > 1 Ms, but observations of type "TOO" are excluded from this process[15]. All known sources (or extended areas) located in that FOV are open for so-called "data right proposals", which can ask for data rights on these sources, to be submitted in the response to the 2nd call of this AO. Usually an important criterion to select such a source is its location within the exposure map of that approved observation (for example "inside the 100 ksec contour") which requests observatory time.

Both cases lead to a situation where several scientists own several targets. These targets will be simultaneously exposed in a joint (amalgamated) observation. The only difference between (i) and (ii) is the number of participating PIs (observers): in (i), the "physical amalgamation", there are usually a few (2-3), while in (ii), the "data-right amalgamation", the number of sources/PIs may add up to several 10's (for example for a Key Programme observation of the Galactic Centre region).

This situation has not been addressed in the SMP [1] and this Section summarizes the results of a pre-launch case study, using recommendations from the INTEGRAL Users Groups IUG and details the necessary procedures.

Basic principle: All the data relevant to an observation are given to the scientists with rights on any target which have been approved for that observation.

Rationale: The data obtained by INTEGRAL are the result of the convolution of the sky field with the coded aperture masks (except in the OMC case as treated in Section 4.5.4.). As a result of the coded mask imaging process, the information on any region of the sky is distributed onto the complete detector plane. Analysis can, therefore, only be done using all the available data

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[14] *The amalgamation of observations is a process performed by the ISOC to enhance observation efficiency, and combines several targets within one observation utilising the large FOV.*

[15] *See, however, on GRB in Section 4.5.3 below.*

from the entire FOV. The observers must then also receive the data relevant to those targets on which they have no rights. Note that targets discussed in this section may also include TOOs appearing during the on-going observation as described in Section 4.3. This is detailed further below.

4.5.2 Data rights for more than one approved target in the field of view

In the case in which several targets, that are the objects of different approved proposals of an amalgamated observation (as described in the section above), are in the field of view during one or several exposures, the Time Allocation Committee (TAC) will grant rights to publish the data related to the different targets to the respective different observers. Granting the data rights is based on the scientific justification provided by the observer in the proposal, and approved (in some cases also modified) by the TAC. This includes the source and the surrounding background field. All PIs participating in the observations and having data rights for their targets will receive the entire FOV data for processing an analysis as this is required by the coded aperture characteristic of the instrumentation.

A proposer can never ask for "data rights for the entire FOV", or, "data rights for all sources (known/unknown) in the FOV".

After completion of the peer review (TAC) process, ISOC will inform all PIs participating in an observation about all sources/extended areas which have been allocated by the TAC to all individual proposals/PIs. A list of all approved targets will be maintained on the ISOC Web site[16].

It is expected and understood as good scientific practice that the scientists (who will have gained knowledge on the other sources in the course of their analysis) will not attempt to publish data pertaining to other proprietary sources/targets during the proprietary period. Any non-observance of this rule will be notified by the Project Scientist to the TAC who might take this into account for subsequent rounds of AO, and to the journal involved.

4.5.3 Serendipitous and non-approved known targets

The policy on target data rights, as described in Section 4.5.2 above, is concerned with approved known targets (i.e. targets at known positions) located in the FOV.

Other target categories exist, namely:

i) known targets (located in the FOV) which have not been asked for or which have not been approved by the TAC for this observation.

ii) New (transient) sources, not known at the time of proposal acceptance or programme execution

All PIs participating in an observation, may publish results on any other source or target contained in the FOV of that observation which is either not proposed, or not allocated by the TAC. Logically, for a given observation, all sources contained in the FOV, but not contained in the information provided by the Project Scientist via ISOC to the PIs concerned, are "open" for all PIs participating in that observation (for the duration of the proprietary period).

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[16] *http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists*

According to the basic principles of INTEGRAL data allocation, the data are distributed to all those scientists who have approved targets in the field of view for that observation.

Sufficiently bright (serendipitous) sources will be detected by the Quick-Look Analysis system of the ISDC. The ISDC will inform those observers who have approved targets in the field of view for that observation about those serendipitous sources as soon as possible. Information concerning position and flux only of these sources will be made publicly available by the ISDC at the latest one week after the observer has been notified by the ISDC.

Given this situation, it is possible to submit proposals on e.g. gamma-ray bursts (GRB) being truly serendipitous sources. We draw the attention of the reader to the fact that, in previous AOs, open time (TOO) proposals on gamma-ray bursts (GRB) and also on outbursts from known soft gamma-repeaters (SGR) were awarded by TAC to PIs. Observations of these specific serendipitous sources were in the prime scientific interest of those PIs (for GRB and SGR), while they may constitute secondary science objectives only for all the other PIs participating in the observation. Therefore, those PIs had been granted FOV data rights for a well-specified time interval, usually much less than the duration of the observation and typically a few hours covering a number of contiguous science windows[17] including the outburst for these sources (GRB and outbursts from known SGR), even if they occurred inside the pointing area during the on-going observation. Technically this case could be considered as a "post-event" amalgamation. While assigning "a posteriori" data rights to a GRB PI (usually from within a group of approved PIs, depending on various selection criteria), all participants in that observation obtaining data rights will be informed by ISOC about the time interval concerned.

4.5.4 OMC data

Observers will get within their proprietary data the OMC data pertinent to their target gamma-ray source and all sources from the other OMC CCD sub-windows.

4.5.5 Whole field images

Images of the complete field of view may be analysed by all the parties with data rights on any target. Discussion and details (e.g. source flux and spectrum) are, however, to be limited to the targets for which the authors have the rights according to Section 4.1.

4.5.6 General considerations

The Project Scientist (via ISOC) will publish a list of targets for which there exist approved proposals and allocated target data rights. This list will be kept up to date and be distributed by the Project Scientist (via ISOC) to the PIs of the accepted proposals.

4.6 Selection of subsets of INTEGRAL data

As stated in Section 5 of the SMP [1], the data rights for observations performed during the General Programme (open time) include in principle the delivery of data from all instruments to the PI (observer). This is a consequence of the complementary nature of the INTEGRAL

[17] *See also Section 4.4.1 for details.*

scientific payload. Following common practice, in order to obtain data from any instrument requires of course the scientific justification to be included in the proposal.

On the other hand it shall be possible during the AO process, that a proposer will be able to specify any instrument(s) in which he/she is not interested in for the specific observation (see Proposal Generation Tool PGT).

Consequently, data from those instruments which have been “de-selected” by the proposer a priori, will be made immediately publicly available so that these data can be used without delay.

4.7 Data rights for split observations

Typical INTEGRAL observations with an exposure of the order of 10^5 s, will have to be broken up into several exposures, separately scheduled, and consistent with constraints such as sun avoidance, times of ground station handovers, etc. Note that per revolution (orbit) the maximum contiguous time available for scientific observations is of the order of 220 ksec. Normally the exposures for one observation will be contiguous in time, as far as allowed by the constraints. But many observers are expected to request such long observation times (several days to weeks), that a contiguous scheduling by ISOC is no longer possible or desirable.

The visibility constraints, and consequently the limited amount of time a certain area in the sky is visible, mean that the individual exposures that constitute one observation may not always be scheduled in consecutive orbits, they could even be scheduled months apart (this is especially true for areas of the sky with limited visibility, where a high concentration of observations is expected, such as the Galactic Centre). Also, scheduling of Target of Opportunity (TOO) observations will often cause a re-scheduling of (parts of) pre-planned observations.

If there is no gap longer than about 6 weeks between consecutive exposures, the entire observation will be processed together by ISDC, resulting in one data set; the data rights will be for the usual proprietary period as described in Section 4.1 of this document.

If, however, there is ever a gap of about 6 weeks or longer, then ISDC will process the data before and after the gap separately, at the earliest possible time, resulting in more than one data set. In other words the gap in the schedule does not cause a hold-up in the processing of the earlier data. Such a case is called a “split observation”, and the data rights for each data set will be as described in Section 4.1, with each data set having its own public release date. Note that the data processing of parts of observations will be cumulative, i.e. when part N is processed, all previous (N-1) part(s) should in general be included (reprocessed) too.

4.8 Calibration data

Calibration of the scientific payload, in-flight,

i. has taken place after launch during the commissioning phase in 2002, i.e. prior to the nominal operations phase, and,
ii. has been performed for SPI, IBIS, and JEM-X about twice per year during nominal mission and extended mission, so far, and

iii. has been performed for OMC about every 12 revolutions during nominal mission and extended mission, so far, and

iv. will be continued and refined, for the entire payload, during the extended operations phase as required by instrument PIs. This is required to continuously assess, verify and to complete the database describing the scientific performance of the instruments, for instance after annealing of the SPI detectors or after strong solar flare events.

In what follows we will consider in-flight calibrations during the extended mission operations phase only.

4.8.1 Calibration during extended operations phase

This section describes data rights concerning calibration data taken during extended mission phase, i.e. after the commissioning and nominal mission phases (see also 3.1.7).

A detailed and thorough in-flight calibration of INTEGRAL instruments is a major challenge. Exposures of astronomical sources e.g. under different aspect angles and background conditions are needed. Other examples include re-calibration after each SPI annealing or after strong solar flares. Furthermore, a background data base of sufficient extent is needed to be able to understand trends and fluctuations of instrumental performance parameters, in particular response information. This knowledge can be used to substantially improve both the scientific performance of the instruments and the science quality of the observations throughout the entire mission.

4.8.2 Dedicated calibration observations

The targets and frequency of such dedicated in-flight calibration observations will be recommended by the PI instrument teams which also may use special instrument settings in order to achieve the objectives as laid down in the in-flight calibration plan. Following [1], observing time to be allocated for the General Programme does not contain time required for those calibration observations. However, because of the nature of the large field of view of the instruments, it is realistic to expect that, also depending on specific instrument parameters used for those dedicated calibration observations, very useful scientific data can be obtained from the calibration source itself or from any other source within the same field of view. Therefore all data obtained during dedicated in-flight calibration observations[18] during the extended mission phase are treated as public data.

4.8.3 Calibration analysis using data from other observations

Data from any scientific observation obtained during the observing programme may be used within the proprietary period by the instrument teams and/or by the ISDC team (through the PIs), and, if needed, supported by the ISOC/ESA team (through the ESA Project Scientist) for the mandatory and critical tasks of instrument health and performance control, engineering trend

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[18] *Occasionally, spacecraft operations require re-calibrations of spacecraft subsystems such as the AOCS (attitude and orbit control system). In case scientific data are being collected during these spacecraft subsystem calibrations, the data are publicly available.*

analysis and instrument (re-) calibration only. In particular, during the proprietary period, these data can never be used by those teams for scientific analysis and publication, if they are not owner (observers) of these data. The strict adherence to this rule will be closely monitored by ESA.

4.9 Data obtained during slews of the spacecraft

Science data will be obtained and down-linked during spacecraft slews, however, coded aperture mask data obtained while slewing are of substantial complexity and difficult to analyse. Given the complexity, it is unlikely that ISDC's standard analysis tools will become readily, or at all, available for slew data.

There will be basically two different slew manoeuvres throughout the mission:

(i) long distance slews (typically up to 10's degrees) from target A (after observation of A) to target B (prior to observation B) and

(ii) short distance slews (typically 2 deg) during the dithering manoeuvres within a given pattern around the nominal target.

Data obtained during long slews will be made publicly available immediately, as they are not related to the previous or subsequent observation.

Dithering slew data belong - for the usual proprietary period - always to the observer(s) of the target on which the dithering manoeuvre is being performed.

4.10 Re-processing of scientific data and additional data releases

4.10.1 Introduction

Routinely, data from any observations are processed and subsequently released by the ISDC to the observer after the data have successfully passed a number of quality checks performed at the ISDC. After release, these data will become public at the end of the proprietary period as described in Section 4.1.

Based on experience with previous scientific space observatories it is possible, however, that at a given point in time after the original data have been released to the observer, the ISDC may take the decision to re-process these original data and subsequently release those re-processed data.

This section describes the policy for additional releases (so-called Δ-releases) of re-processed data. In what follows we discriminate between "soft" and "hard" releases.

4.10.2 Soft releases of re-processed data

Experience shows that a number of soft Δ-releases can occur: these could include e.g. data produced using updated/improved instrument responses and/or calibration information, improved software tools etc. It is expected that quite a number of soft releases may occur during mission lifetime. Soft Δ-releases always improve the quality of the scientific data products but still include flight data of good quality (see Section 4.10.3, below).

Soft Δ-release(s) resulting from (several) re-processing(s) of the same original data set containing one observation do not lead to an update of the time stamp associated with the data released originally, that is, the proprietary period of all further soft Δ-releases of the same original data will always be shorter than one year, and the proprietary period of all soft Δ-releases resulting from the re-processing of the same original data will therefore terminate at that point in time which is valid for the original data (that is "the clock keeps ticking").

Soft Δ-releases of re-processed public data will always result in public data.

4.10.3 Hard releases of re-processed data

It can not be completely excluded that significant problems may be discovered in data which have already been released to the observer, or to the public. These problems are major anomalies and could for example be instrument specific, system wide (e.g. problems with on-board event timing) or severe s/w problems rendering wrong or corrupted data on ground. The PI has to provide strong evidence that the data are affected by these anomalies in a sense that the scientific objectives of the observation can not be achieved with the existing data. Only the re-processed data will improve the quality significantly such that these original goals can be achieved.

In this case, in consultation between the observer, the ISDC PI and the Project Scientist, the proprietary period of the original corrupted data can be extended for the re-processed data (hard Δ-release) in order to guarantee the proper proprietary period ("reset of clock"). Clearly these are individual decisions made on a case - by - case basis.

It is noted that a "clock reset" may be applicable only for data from individual instrument(s) manifesting significant problems.

Given the significance of these hard Δ-release events, they should normally be discovered during the proprietary period (i.e. within one year), and consequently hard Δ-releases of original data which became public after the proprietary period are highly unlikely, but should not be excluded a priori. Therefore, hard Δ-releases of re-processed data which have already become public may result in a new proprietary period for the original owner, rendering the existing public data largely obsolete.

Hard Δ-releases of data which, originally, have been made public immediately will always become public.

4.11 Instrument housekeeping data

The proprietary period for INTEGRAL data (see Section 4.1 and [1]) is applicable for all scientific data. All instrument housekeeping data and other engineering data - derived at the MOC or ISDC - obtained during an observation, will be made available to the owner of that observation, together with the scientific data. Because of the need for instrument and spacecraft experts to routinely monitor and verify the state of health and technical performance of the instruments including long-term trends, all instrument housekeeping and engineering data will be made publicly available. The public status is achieved once these data have been archived by the ISDC, which is typically 3 weeks after receipt of the near real-time telemetry from ESOC/MOC.

4.12 Data for public relation purposes

As outlined in the SMP [1], and in the agreement between the participating agencies (ESA, NASA, RKA), the agencies and the Russian Academy of Sciences shall have the right to use any INTEGRAL scientific data in support of their respective responsibilities or for the sole purpose of public relations. In this context, they undertake not to violate the observer's rights.

5 The INTEGRAL science ground segment

5.1 Introduction

The INTEGRAL science ground segment is constituted by the ISOC and ISDC, shown in the bottom part of Figure 8.

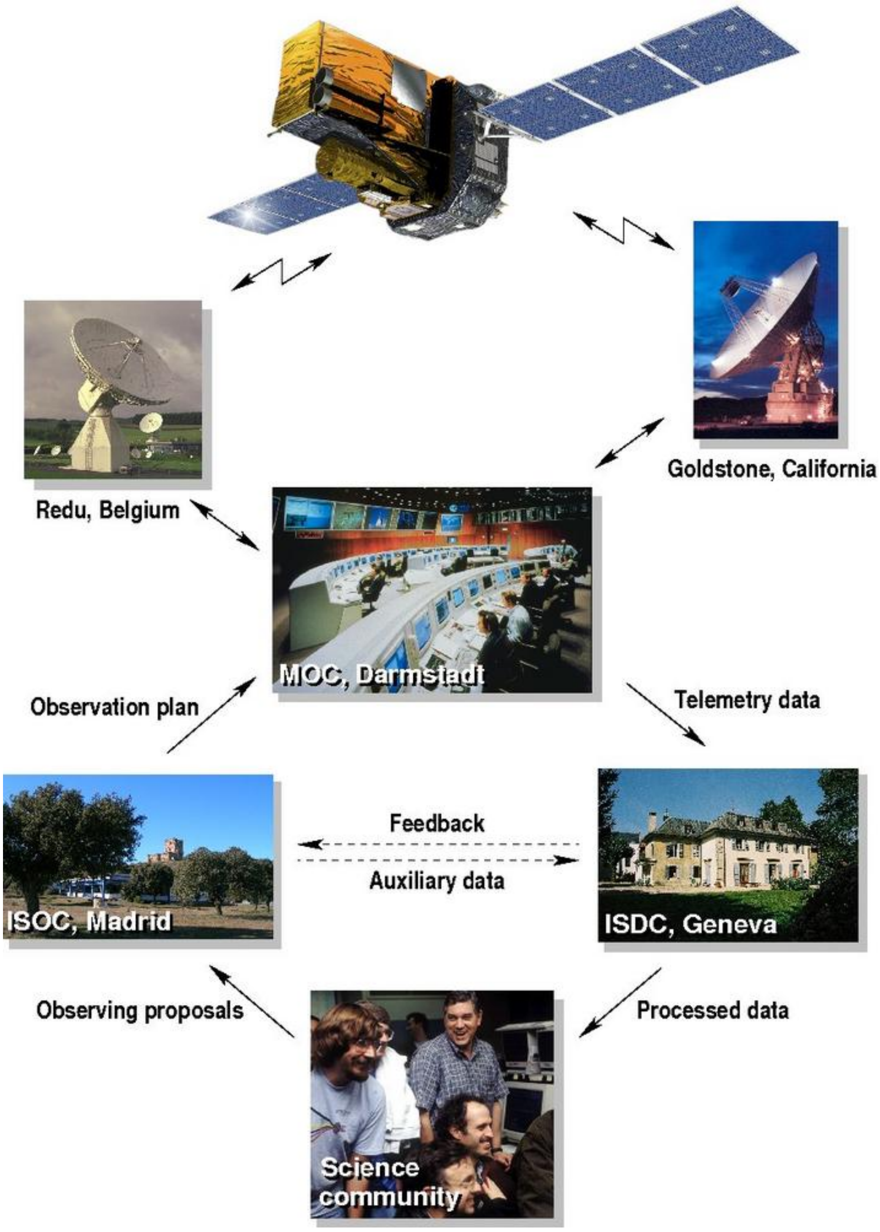

Figure 8: The INTEGRAL flight segment (upper half) and ground segment (lower half).

ISOC receives observation proposals and optimises the accepted ones into an observation plan consisting of a time line of target pointings together with the corresponding instrument configurations. The ISDC receives the science telemetry plus the relevant ancillary spacecraft data from the MOC, responsible for the operations of the spacecraft and payload. The ISDC processes these raw data, and generates standard data products that are distributed and archived. ESA also maintains a copy of this archive at the ISOC.

5.2 Science ground segment support for observers

The INTEGRAL ISOC web site at http://integral.esac.esa.int/ provides access to important information for proposers and observers. This includes:

- INTEGRAL Announcement of Opportunity
  - AO announcement key dates
  - AO documentation
  - Proposal support tools: Proposal Generation Tool (PGT), Observing Time Estimator (OTE), Target Visibility Predictor (TVP)
  - Links to (mainly high energy) astronomical catalogues.
- INTEGRAL Target and Scheduling Information
  - Scheduling Information
  - Long and short term scheduling
  - Approved Target List
  - ISOC & ISDC data archive.
- INTEGRAL Helpdesk and Frequently Asked Questions.

A helpdesk handles all questions related to the INTEGRAL mission (received via e-mail at inthelp@sciops.esa.int or submitted on the web from http://integral.esac.esa.int/helpdesk/). The helpdesk is organized such that questions relating to proposals, observation modes, scheduling and INTEGRAL in general, are handled by ISOC staff; questions about the data, analysis software, instrument calibration and data delivery are handled by ISDC staff. The sharing of this responsibility is transparent to users. A list of frequently asked questions (FAQ) is maintained on the ISOC and ISDC web pages.

The INTEGRAL science analysis software is available together with documentation and test data for download from the ISDC web page at http://isdc.unige.ch/index.cgi?Soft+download. Further information on ISDC user support is provided in §4.4.

5.3 From proposal to observation: ISOC

5.3.1 ISOC responsibilities

The INTEGRAL Science Operations Centre, ISOC (http://integral.esac.esa.int/), was relocated to the European Space Astronomy Centre (ESAC), Villafranca del Castillo, Madrid, Spain in early 2005. ISOC is responsible for the definition of scientific operations including instrument configuration for each observation, mission planning and implementation of the observing programme. A newsletter is published as a means to keep the INTEGRAL community informed (http://integral.esac.esa.int/newsletters/).

In summary, ISOC is responsible for:

- Preparing AOs, receiving the proposals, assessing their technical feasibility and transmiting the assessments to the TAC.
- Scheduling and implementing of the observing programme.
- Defining science related operations and instrument configuration for each observation.
- Receiving TOO alerts, and implementing the Project Scientist's decision in regards to the planning of an accepted TOO.
- Keeping an archival copy of all scientific data created and maintained by ISDC.

5.3.2 Proposals

Scientists submit proposals in response to an Announcement of Opportunity, issued by ESA/ISOC at regular intervals during routine, in-orbit operations. Proposals must reach ISOC before the AO deadline. Requests to observe newly identified "Targets of Opportunity", however, can be submitted to ISOC at any time (see §3.1.3). All proposals must clearly contain one or several well-defined targets entered into PGT, and the scientific justification.

The TAC evaluates each proposal primarily on the basis of its scientific merit, but obviously considers its feasibility and related technical issues. Two examples of observations that will normally be rejected are: unrealistically small observation duration where the scientific goal will not be achieved, and survey-type proposals of the kind "*I want the data of all observations with sources from the supplied list/or from all observations with sources of type 'x' in the FOV, but do not request any extra time*".

Each requested observation for each target of a proposal must be entered into the proposal using PGT, otherwise it is not considered by the TAC for evaluation. Hence, targets listed in the scientific justification but not entered in PGT, are not considered by the TAC. The Principle Investigator can request a PGT compatible version of their proposal submitted in response to an earlier AO via the helpdesk. Instructions on downloading and using PGT and other supporting observation tools are given in §6.

5.3.3 Proposal handling and Time Allocation Committee

After the deadline for an AO, ISOC will perform a technical feasibility of the submitted proposals using the Target Visibility Predictor (TVP) and the Observing Time Estimator (OTE), and forward the proposals to the TAC for scientific assessment.

Proposals are reviewed by a single, international TAC based on scientific merit and guided by a list of evaluation criteria, established during the first AO. This committee consists of three panels covering the range of scientific topics relevant to INTEGRAL:

- **Compact objects**: black holes, neutron star and white dwarf binaries, pulsars, isolated neutron stars and galactic jet sources.
- **Active Galactic Nuclei**: Seyferts, Blazars, quasars, but also normal galaxies, clusters of galaxies and cosmic background.
- **Nucleosynthesis and miscellaneous**: including supernovae, supernova remnants, novae, Wolf-Rayet stars, diffuse (line) emission, inter-stellar phenomena, gamma-ray bursts, gamma-ray burst sources and anything not in the two categories given above.

The TAC is advised to reject proposals for observations whose aims have been addressed or attained within past AOs. Proposers should therefore carefully check any possible duplication of their observations by looking at the INTEGRAL target list available via the ISOC web page, by clicking on either 'Observing Programme' or 'Approved Target Lists'.

The TAC is advised to allocate time for an oversubscription factor of about 1.5 to increase scheduling efficiency. This means that not all accepted proposals can be scheduled within the AO. Preference will always be given to higher ranked proposals.

GRB proposals will be evaluated by the TAC following the same procedure as for all other proposals. However, they only receive a final mark and will not be graded A-C, as they have no scheduling priority of their own. Similarly, associated proposals are recommended or not, without being ranked.

The TAC is advised to accept only a limited number of proposals for Targets of Opportunity (see §3.1.3); scheduling of TOO observations reduces the overall efficiency of the mission by deviating from the long term scheduling plan.

Based on the results of the assessments, the TAC will recommend for each proposal its approval (i.e. all requested observations), partial approval (some of the requested observations, possibly with reduced observation time), or rejection. In addition, all accepted proposals are ranked with a letter grade and a mark. The recommended programme is then approved by ESA. **The decision of accepting or rejecting a proposal is final and non-negotiable**. The TAC must provide comments for each proposal, including the reasons for rejection, and these are subsequently communicated to each PI by ISOC.

Following the TAC assessment and endorsement by the ESA Science Director of the recommended observing programme, the PIs will be informed, and a database of approved observations is created and maintained by ISOC. This database contains General Observer and Key Programme observations.[19] A subset of these data is made available to the ISDC.

5.3.4 Scientific mission planning

This section describes the scientific mission planning including execution of observations, scheduling and re-scheduling.

During routine observations, ISOC generates and maintains detailed observing schedules based on the approved observations (from the GO, KP and CP), and delivers these schedules to MOC for uplink and execution. The ISOC scheduling takes into account: celestial viewing constraints, observation efficiency (i.e. observing versus slewing time), scientific value, and any other special requirements such as fixed-time observations. Some observations are too long to be scheduled as a single time block; ISOC must therefore schedules such observations as more than one separate exposures. Both ISOC and MOC provide details of the "live" schedules to ISDC.

Sometimes, the need to reschedule may entail important changes to the pre-planned sequence of observations/operations. Such circumstances are encountered in the case of:

- TOO trigger
- Instrument or spacecraft anomaly

[19] http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists

- Unforeseen ground station outages.

Re-planning at MOC can be done at most once per orbit, and can only be justified in the case of a TOO trigger or an anomaly. The reaction time is typically 8 hours from the receipt of the ISOC request. Any other re-planning, related to optimization of instrument configuration, for example, is generally implemented by MOC in the revolution starting at least 8 hours after the request from ISOC.

The rescheduling of an observation is considered by ISOC only if the ISDC deems that it did not yield useful scientific results. An abnormally high background level, due to solar activity for example, is not regarded as a justification for re-scheduling. If the prime instrument is switched off, however, the observation will generally be re-scheduled if the off time amounts to more than 15% of the approved observation.

ISOC aims to schedule and execute 100% of an observation's approved time. However, ESA endorsed the TAC recommendation that any observation should be considered "complete" if at least 85% of its approved time has been executed.

5.3.5 INTEGRAL archive at ISOC

ISOC offers public access to INTEGRAL data, as does the ISDC. The ISOC Science Data Archive (ISDA) can be accessed through http://integral.esac.esa.int/isda. It uses the same browser technology as that developed for the XMM-Newton Science Archive (XSA) and ISO Data Archive (IDA). It is a highly flexible system for browsing and downloading the data and products, either at the level of observations, individual dither pointings, or so-called observation groups. Interactive tools are available for examining data from the original FITS image files and performing simple analysis tasks. ISOC continues to develop high-level data products and tools to visualize and manipulate these products.

5.4 From observation to data products: ISDC

5.4.1 Introduction

The INTEGRAL Science Data Centre, http://isdc.unige.ch/, is the link between the scientific output of the instruments on the spacecraft and the astronomical community. It is responsible for the receipt, analysis, archiving and worldwide distribution of all INTEGRAL data.

The ISDC was established in Versoix, near Geneva, Switzerland in 1996. The staff is made up of several scientists and engineers funded by an international consortium of twelve institutes with support from the European Space Agency. The ISDC works in close collaboration with the instrument teams to ensure that the software developed and maintained by these is integrated in a coherent data analysis system.

5.4.2 ISDC responsibilities, data flow and data analysis

The ISDC receives all the INTEGRAL telemetry and auxiliary data and converts these raw data to a FITS compliant format. It also monitors the scientific instruments on the spacecraft and works with the instrument teams to solve the problems that may arise. It performs a quick-look analysis of the data, and alerts the astronomical community when unexpected features and events such as gamma-ray bursts are detected.

The data flows in real-time from MOC to ISDC at a rate of ~113 kbits/s. The ISDC performs a *Quick-Look Analysis* (QLA) in *Real-Time*. The data stream is cut into a series of contiguous *Science Windows* (ScW): a 30-60 minute pointing in a dither mode or a slew of the spacecraft. Every few days, the telemetry is sent again to the ISDC on CD-ROM, in the form of *consolidated data,* where all recoverable telemetry losses (e.g. at station handover) have been corrected. These consolidated data include auxiliary files and the current observing plan, and are used in the standard scientific analysis.

The purpose of the QLA is to rapidly detect bright transient sources, large flux changes in known sources and instrument anomalies. In the case of an unusual event, the QLA results are communicated to the PI of the observation and ISOC is contacted if the event could potentially trigger a TOO or follow-up observation. Once the consolidated data have been received, the ISDC uses the *Offline Science Analysis* (OSA) software to perform a standard analysis that yields reconstructed sky images in several pre-defined energy bands, spectra and light-curves of individual sources. OSA is a pipeline of high-level software components developed primarily by the instrument teams and integrated by the ISDC. The standard analysis (SA) is generally completed within three weeks after receipt of the consolidated data. The results are stored in the INTEGRAL archive.

5.4.3 INTEGRAL data

One three-day revolution yields a telemetry volume of 2.7 GBytes. Processing of this telemetry stream yields ~17 Gbytes of uncompressed data products. These data are stored in FITS files and consist of:

- **raw data** (4.5 GBytes): reformatted data of the telemetry,
- **prepared data** (7.2 GBytes): includes additional timing information,
- **corrected data** (2.7 GByte): includes gain corrected event energy, and
- **high-level products** (2.7 GBytes): SA products including images, spectra and light curves.

They are made available to the observer in compressed format (~9 Gbytes per revolution). Raw and prepared data are stored by ScW, whereas corrected data, intermediate results of the analysis and high level data products are stored per observation, usually consisting of 10–100 ScWs. The FITS standards are used throughout and for all data products. All data delivered by the ISDC are calibrated relying on the instrument teams' expertise.

5.4.4 INTEGRAL archive at ISDC

The main archive, located at the ISDC, contains all INTEGRAL data including SA products, as well as calibration and response files, auxiliary data and source catalogues. As mentioned in see §5.3.5, a second archive located at ISOC contains the same data.

All archived public data can be downloaded from the ISDC via anonymous FTP or through a web archive browser (W3Browse). FTP download is more direct but requires knowledge of the exact name or location of the data, whereas the web interface allows queries to the database by object name, coordinates, time interval and other parameters. The selected data are then extracted from the archive in tar files, compressed and prepared for retrieval.

5.4.5 Data distribution

A general observer can chose the means through which the data will be made available in PGT. The typical data download rate from ISDC is 1 Gbyte/hour via FTP, and generally smooth. Distribution takes place after ISDC has received the consolidated data from ESA, processed and archived them. The whole process takes about one month from the end of the observation. Note that ISDC does not assume any responsibility for the public network capacity in regards to the transfer of large data volumes.

Observers visiting the ISDC can have a first look at the data from their observation within a few hours. The ISDC, with the permission of ESA (amalgamated observations require the approval of all PIs), gives to an observer access to the data of their observation at the ISDC. This is true for all observers wishing to look at their data before the official distribution.

5.4.6 Source naming convention and acknowledgement in publications

A source naming convention for new sources detected by INTEGRAL has been established in agreement with the IAU. Source designation is IGR J*HHMMm+DDMM* (equatorial coordinates, epoch J2000) in the case of positive declination, or IGR J*HHMMm–DDMM* for negative declination. In both cases, *HHMMm* is the right ascension of the source in hours, minutes and fractions of a minute, and *DDMM* is the declination of the source in degrees and arcminutes. Coordinates must be truncated, not rounded, to comply with this convention. For example, Sirius has the following 2000.0 coordinates: RA = $06^h\ 45^m\ 08.9173^s$, DEC = -16° 42’ 58.017”. In the present case, the naming convention would give IGR J06451-1642.

Scientific publications making use of INTEGRAL data should acknowledge this via a footnote to the title of the publication on the first page using the following text: *Based on observations with INTEGRAL, and ESA project with instruments and science data centre funded by ESA member states (especially the PI countries: Denmark, France, Germany, Italy, Switzerland, Spain), the Czech Republic and Poland, and with the participation of Russia and the USA.*

5.4.7 User support and communication

The ISDC provides support in regards to the data analysis. The INTEGRAL science analysis software, together with the associated documentation and test data, can be downloaded from the ISDC web pages at http://isdc.unige.ch/index.cgi?Soft+download. Observers are also welcome to visit the ISDC for local support and direct access to data analysis tools.

The ISDC software includes scripts to run the standard analysis and applications to visualize the data products and manage the off-line analysis. The software is available for SUN/Solaris, Mac OS X and Linux. The ISDC organizes regular INTEGRAL data analysis workshops, aiming to discuss issues relating to calibration, data analysis methods, software and results. A newsletter (http://isdc.unige.ch/Newsletter/) is used to keep the community informed and encourage communications with the ISDC. Subscription is done on the web site.

5.5 Gamma-ray bursts

Data from GRBs are generally treated as for a TOO (see §3.1.3). In such instances, however, three additional features are specified to facilitate follow-up observations:

- GRB position, trigger time, duration and flux estimate.

- GRB time history derived from the SPI Anti Coincidence Shield subsystem.
- Fast uplink of special OMC sub-window.

These are described in greater detail below.

5.5.1 GRB position and trigger time

INTEGRAL has no on-board GRB detection and triggering system. However, it continuously downlinks its acquired data to Earth allowing for constant, near real-time, monitoring. At the ISDC all data are automatically analysed to detect transient events. In addition, a fast analysis is performed by the INTEGRAL Burst Alert System (IBAS) with several detection algorithms running in parallel.

As soon as a GRB candidate event is detected, it must pass a screening that involves a more detailed off-line analysis. The GRB position, trigger time, flux and duration are submitted to the alert generation process and broadcasted. The rate of GRBs is about one burst per month within the IBIS and SPI FOVs. Localization accuracy is a function of the event's S/N ratio, the spacecraft attitude and stability, the angular resolution, and whether the event took place in the fully or partially coded FOV. The first alert broadcast message has rather crude information. Therefore, subsequent alert messages are sent out to subscribers with more accurate information on the position and source characteristics. In order to facilitate rapid follow-up observations (e.g. using XMM-Newton, Chandra, Swift and Suzaku), data describing the GRB peak (2–200 keV, 1 s), fluence (20–200 keV), lightcurve (20–200 keV, plot only), and duration are made available shortly after (see http://isdc.unige.ch/index.cgi?Soft+ibas for details).

Alerts with the coordinates of GRBs are distributed through internet sockets for robotic telescopes using the UDP transport protocol. The required software can be requested from the ISDC. E-mail alerts are distributed via GCN circulars. The typical uncertainty is smaller than a few arcminutes. The interactive analysis used to confirm the event and to derive the most accurate GRB position, is generally performed within a few hours after the automatic delivery of the first alert message(s).

In operating an automatic GRB alert system, users must be aware that this implies that some IBAS alerts may be spurious, i.e., unrelated to an actual GRB.

5.5.2 GRB data from the SPI anti-coincidence (veto) subsystem

INTEGRAL is well suited as the near-Earth node of the **I**nter**P**lanetary **N**etwork (IPN) providing large area detectors like SPI's **A**nti-**C**oincidence **S**hield (ACS). The ACS collects GRB data in time bins of 50 ms, time-tagged to an accuracy of 1 ms at energies above 75 keV. Thus the data of about 300 (5σ) bursts per year, located mainly perpendicular to the instruments' FOV, are used by the IPN. These time series (contained in the instrument housekeeping data) are also provided via the ISDC GRB alert system to the scientific community and thus immediately publicly available.

5.5.3 OMC window handling in case of a GRB alert

Due to the limitation of telemetry rate, it is not possible to download all OMC data. Thus it is necessary to pre-define specific OMC CCD sub-windows (covering ~1% of the total CCD area) for routine observations (see *"OMC Observer's Manual"*). It is possible that a GRB, detected by IBIS via the ISDC alert system, is in principle observable by the OMC as it is taking place in its

FOV, but the pre-selected sub windows (selected prior to the observation) do not cover its position. To enable GRB monitoring by the OMC, it is necessary to promptly order a change of the sub-window such that it covers the GRB, overriding the pre-defined sub-windows for the **duration of the on-going (dither) pointing only** (i.e., ≤60 minutes), until the next set of pre-defined OMC sub-window commands associated with the following dither pointing.

In order to allow a near real-time implementation of the required new OMC window commands the required functions are split between ISDC and MOC only. In summary the ISDC software:

- identifies a GRB from IBIS near real-time science data
- identifies the GRB location in IBIS detector coordinates
- converts IBIS detector co-ordinates to OMC detector coordinates
- checks whether location is within OMC FOV
- provides necessary input to MOC, only if the previous check is positive

Upon receipt of this message, MOC

- accepts and checks (syntactical) correctness of input
- generates necessary telecommands
- uplinks necessary telecommands

This process has been successfully used in flight.

The size of the new up-linked OMC sub-window is 91 × 91 pixels. The data collected from all other pre-defined sub windows during that pointing are lost. It is estimated that the new OMC sub-window will be effective about one minute after the detection of the event (nominal case). It is noted that this mechanism has been established only to provide the described functionality for the OMC. As it violates some of the basic mission principles, including safety considerations, it cannot be applied for other cases. No other commands (especially to AOCS) are sent in response to a GRB.

6 Proposal submission procedure and tools

6.1 Proposal Generation Tool (PGT)

Proposals must be prepared and submitted electronically using the Proposal Generation Tool software. ***Other formats will NOT be accepted***.

PGT must be downloaded from the ISOC web page (http://integral.esac.esa.int/) and run locally. It is written in JAVA and requires the correct version of the JAVA run time libraries. PGT is used for the preparation, editing, printing and submission of INTEGRAL proposals. The scientific justification for the proposals must not be in PDF format, at most five A4 pages in length, and is uploaded and submitted electronically with the proposal through PGT.

Proposers may wish to 're-use' proposals from earlier AO's, updating them as necessary. PGT can read proposals generated for AO-6 and beyond. ISOC will, on request only, generate a copy of an old proposal in the new format. Requests should be addressed to the INTEGRAL helpdesk, quoting the ID of the relevant proposal. ***ISOC will only send a proposal back to the original PI***.

Please see Appendix A: *"Proposals – format and checklist"*, for a description of some essential points regarding submitting a proposal using PGT, or *"INTEGRAL AO Tools Software User Manual"* for more details.

6.2 Observing Time Estimator (OTE)

The Observation Time Estimator is available via the ISOC web page.

OTE is the only official way to calculate the observing times for the two main INTEGRAL instruments: IBIS and SPI. It is also used by the ISOC for evaluating the technical feasibility of observations. Observers should use OTE to calculate requested observing times: it is imperative that sufficient information is provided in the proposals to allow for feasibility checks by ISOC.

6.3 Target Visibility Predictor (TVP)

The Target Visibility Predictor is available via the ISOC web page.

In principle, any point on the sky is observable by INTEGRAL. This is not, however, true for any point in time. TVP can be used to calculate visibility for each celestial source taking into account the constraints discussed below, with the exception of the SPIBIS effect (see §5.3.3), which is only considered at the scheduling level.

6.3.1 Sun, anti-Sun, Earth and Moon viewing constraints

TVP respects the constraints on the solar aspect angle of the spacecraft, described in §2.2.3. As a consequence of this constraint, the sun cannot be observed within the FOV at any time. It can, however, be observed indirectly through the SPI ACS.

In order to ensure correct functioning of the spacecraft's star trackers (see Figure 1), co-aligned with the instruments' pointing axis, the spacecraft has to point at least 15^{o} away from the Earth and 10^{o} away from the Moon limb during standard observations. TVP uses these constraints.

Note that observations of the Earth have been performed in AO-3, but such observations require elaborate non-standard mission planning and execution, and hence cannot be performed as part of the routine operations.

6.3.2 Other constraints

Eclipses:
Observations are usually carried out while the spacecraft is outside the Earth's radiation belts at an altitude of at 40 000 km or more. The exact limits are occasionally adapted, as required by changes in the extent of the belts. No observations are performed within 30 minutes prior to and following an eclipse (i.e. when INTEGRAL is in the Earth shadow with respect to the Sun).

SPIBIS:

SPIBIS is an effect by which a shadow of the SPI mask is cast onto the IBIS detectors. This occurs rarely and only when a bright source, like the Crab nebula or Cygnus X-1, is positioned 30–50° off-axis and within a narrow azimuth angle range around the spacecraft's Z-axis. This effect can be avoided by excluding from the scheduling, time periods during which a bright source lies within the critical area. ISOC avoids scheduling such observations as much as possible. More details can be found in the current AO's "*IBIS Observer's Manual*".

6.4 Software updates

It is highly recommended to use the latest version of the software and AO documentation. ISOC avoids updates of these between the issue of an AO and the deadline for proposals. Users are therefore advised to sign-up to the email distribution list by sending an email to the INTEGRAL helpdesk (inthelp@sciops.esa.int), with the text "update distribution list" in the subject. This will provide information on the software and documentation provided by ISOC. Observers who have signed-up during previous AOs, need not re-apply. Questions concerning the instruments, the AO and anything related to the mission, should be directed to the helpdesk.

6.5 Modifications to an accepted observing programme

During in-orbit operations, changes to the instrument performances may occur. In addition, the instrumental background varies with the solar cycle: at Solar minimum, the Sun's magnetic field can propagate more easily into the inner Solar System. These changes may influence the integration time required for the observations. The effects of any such changes on the instrumental performance are routinely monitored. If the expected changes in integration time or signal-to-noise ratio are significant, the observers will be notified, the TAC chairman will be consulted, and the integration times modified by ISOC. In principle, once an observation is approved, it will be carried out even if the required integration time increases, provided that it is still feasible. Moreover, the TAC can also re-classify the type of an observation, but the following changes are not allowed:

- Change of source or pointing direction.
- Change from standard to fixed time observation.
- Change from standard or fixed time to TOO observation.
- Change from TOO to standard or fixed time observation.

Appendix A: Proposals - format and checklists

A.1 Introduction

The only interface for submission of proposals is the PGT software. Here, you will find some general information and rules for the inputs to PGT. More details are found in the "*INTEGRAL AO Tools Software User Manual*".

A.2 PGT inputs

The PGT inputs are split into several screens:

- The Main screen, where the Proposal ID can be entered.
- The Admin Details screen, where the administrative details of the PI and Co-Is need to be entered (e.g., names, addresses etc.)
- The Proposal Details screen, where general information about the proposal is given (title, abstract, category and scientific justification). The scientific justification is appended to the proposal as an attachment.
- The Observation Details screen, where information for each observation is given.

The Proposal ID is assigned by the Proposal Handling System at ISOC and sent to the observer by email upon successful reception of the first proposal submission. It is needed subsequently only for submitting an updated version of the same proposal.

A.3 Target coordinates

While ISOC does perform verifications on the validity of the source coordinates, it is nonetheless ultimately the responsibility of the proposer to make sure that the coordinates (J2000) entered into PGT for the target are correct. (PGT performs a validation of the coordinates using SIMBAD given the source name entered in the proposal; only a warning is given if the values of the coordinates do not match those returned by SIMBAD). Since changes to the source or pointing are not allowed after TAC approval (except in the case of obvious errors discovered by the proposer), observations for which target coordinates are incorrect could be lost. ***Proposals for new (unknown) TOOs or GRBs in the FOV can use coordinates (0,0) in PGT***.

A.4 Scientific justification

The scientific justification has to be written in English and should be attached to the proposal in the Proposal details panel, using the "New Attachment" button at the bottom of the page. The attached file should be in PDF format. The justification should use A4 paper size, and a maximum of 5 pages, including figures and tables. Font size must not be smaller than 10-point.

The Observation Details panel in PGT allows only a small amount of information on the source flux to be entered in the proposal. In many cases this may not be sufficient information to judge the technical feasibility of the proposal, and the proposer is advised to give details on fluxes, spectral shape, line strength, line width, etc. for his sources in the scientific justification. These details will be taken into account by ISOC when doing the technical feasibility check.

Only targets included in the PGT will be considered for approval. Observations mentioned in the scientific justification or abstract but not entered into PGT will not be considered.

A.5 Integration times and GRB observations

For all observations of an observing time proposal, an integration time must be specified in PGT (mandatory field). In general this integration time should be calculated using the Observing Time Estimator software (OTE), which will calculate the time required to achieve a given significance for a given flux. ISOC uses OTE to perform the technical feasibility checks on the proposals.

This calculation is not useful for GRBs the duration of which is of the order of 100 seconds, with a possible afterglow of a few hours, and thus very short compared to the typical duration of an INTEGRAL observation. Furthermore, GRBs cannot be treated as standard TOO follow up observations, since no re-pointing is possible on such short time scales. Therefore, observers interested in data from GRBs that occurred in the FOV cannot estimate their integration times using the OTE. However, OTE can still be used to estimate the minimum detectable flux in a given energy band with the SPI and IBIS instruments, allowing to estimate the detection sensitivity for a GRB. Proposers should specify in PGT the period of time for which they want to receive the data of a detected GRB. This can be before and after the event (the split between the time before and after the event needs to be specified in the scientific justification).

A.6 TOO and fixed time observations

For TOO and Fixed Time observations, the proposer has to fill in a short justification for each observation in PGT in addition to the scientific justification for the proposal. These justifications must be entered in the appropriate window in the PGT observation details screen. For TOOs, this should specify why the observation should be regarded as a TOO, and what are the trigger criteria (flux levels, etc.). It is always the proposer’s responsibility to inform the Project Scientist that trigger has been met. (For TOOs discovered in the FOV of INTEGRAL and for which a proposal exists, the proposer will be informed that this TOO is active, after which the proposer decides whether to activate the TOO follow-up observation or not). The TOO alert form on the ISOC web site can be used to either request that a TAC-accepted TOO be scheduled, or to request a new TOO for which there is no accepted proposal. The form can be found under the link ‘Target of Opportunity Alert’, on the ISOC home page, or directly via the URL: http://integral.esac.esa.int/isoc/html/too/my_too_alert.html.

In the case of fixed time observations the proposer must specify in the scientific justification, why a fixed time observation is required, and when the fixed time observation should be performed (if this is known). This information will be used by ISOC to determine when to schedule the observation. Note that for fixed time observations, for which a time or date for the observation is already known, it is imperative that the proposers check the visibility of their sources using the Target Visibility Predictor for the dates and times they want their observation to be performed. (See §3.1.3 for a discussion on TOO observations.)

A.7 Coordinated observations with other facilities

ISOC provides support for coordinated observations with other facilities. Proposers are particularly encouraged to apply for coordinated observations with XMM-Newton (see §3.1.5).

Proposers who want their observation to be coordinated with another facility should enter it as a fixed time observation, indicating that the reason for the fixed time is that it is coordinated with another observatory, and specify its name. ISOC will try to accommodate the coordinated observation, but the proposer remains responsible for the coordination between observatories. ISOC mission planners are nonetheless, in regular contact with mission planners on other missions such as RXTE, XMM-Newton, Suzaku, Swift and Chandra. Note that since INTEGRAL observations are generally long, it may be easier for other observatories to follow the INTEGRAL scheduling (especially ground based observatories).

A.8 Checklist for the proposal

The proposal text **must** contain at least the following three items:

1. **the scientific case**
2. **the observation strategy**
3. **demonstration of the feasibility of the observations**

The proposal should be checked against the following questions:

- Is your science justification complete? Does it contain the mandatory three sections mentioned above? Do you have a special justification if requesting more than 1 Ms?
- Have you filled in the Observations Details Panel for *all* observations for *every* source?
- If your observation has any scheduling constraints, have you marked it as Fixed Time?
- If your proposal is for GRB data, have you supplied the trigger criteria and the time interval of the data you request?
- If you are not using the standard 5 × 5 dither, have you justified the use of the other pattern?
- Can your programme only be done with INTEGRAL? Can't it be done using archival data?
- Could your programme benefit from joint INTEGRAL/XMM-Newton observations? If so, have you activated the dedicaded check-box in PGT?
- Remember that proposals for observing nearby SNe (§3.1.6) are not accepted.
- Have you checked the latest news on the INTEGRAL page (http://integral.esac.esa.int/)?