

# ***INTEGRAL***

**Science Operations Centre**

## **Announcement of Opportunity for Observing Proposals (AO-11)**



### **Overview, Policies and Procedures**

INT/OAG/13-0378/Dc

Issue 1.0

4 March 2013

Prepared by:

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# 1 The 11<sup>th</sup> INTEGRAL Announcement of Opportunity for observing time proposals

## 1.1 Introduction

This document fulfils several purposes:

**First of all, it provides - in this Section 1 - an overview of the forthcoming AO-11, its schedule and available observing time, and it summarizes recent important changes introduced into the AO process.**

Then, it introduces the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) satellite with descriptions of its orbit, instruments (Section 2), observations types and modes (Section 3), policies on data rights (Section 4), science ground segment (Section 5), and procedures to be followed by observers in preparing INTEGRAL proposals using the appropriate software tools (Section 6).

INTEGRAL AOs are primarily intended for scientists of the ESA Member States and of those countries participating in INTEGRAL (Russia, USA and Poland), but proposals from other countries will also be considered by the Time Allocation Committee.

Scientists from institutions in the United States are welcome to respond to this AO either as Principal Investigators or as co-Investigators on non-US proposals. Accepted US investigators should request funding from NASA via a separate solicitation.

### 1.1.1 AO-11 document package

The available supporting documents for this AO are listed below. It is **mandatory**, that the proposer has read the complete information provided for this AO prior to submission of the proposal.

- “*Overview, Policies and Procedures*” (this document)
- “*IBIS Observer’s Manual*”
- “*SPI Observer’s Manual*”
- “*JEM-X Observer’s Manual*”
- “*OMC Observer’s Manual*”
- “*INTEGRAL AO Tools: Software User Manual*”

All documents are available from ESA’s INTEGRAL Science Operations Centre (ISOC) web page: <http://integral.esac.esa.int/>, where proposers can also find links to various AO software tools including the Proposal Generation Tool (PGT) which is needed to prepare and submit proposals. PGT needs to be installed locally, all other tools run remotely via the ISOC website.

## 1.2 The AO-11 schedule

There will be two calls for proposals in this AO-11: this first one for proposals requesting INTEGRAL observing time (*observing time proposals, AO release on 4 March 2013*), and the

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second one for proposals requesting data rights on specific targets or emission features located within the field of view of all approved AO-11 non-ToO<sup>i</sup> observing time proposals (*data rights proposals, AO release on 9 September 2013*).

The AO-11 cycle of observations will begin on 1 January 2014 and has a duration of 12 months. The schedule for AO-11 including this particular call for observing time proposals is shown in Table 1.

*Table 1: Schedule for AO-11*

Activity	Date
Release of AO-11: Call for observing time proposals	4 March 2013
Deadline for submission of observing time proposals	12 April 2013 (14:00 CEST)
Meeting of the Time Allocation Committee (TAC)	27 – 29 May 2013
Release of AO-11: Call for data rights proposals	9 September 2013
Deadline for submission of data rights proposals	4 October 2013 (14:00 CEST)
Meeting of the Time Allocation Committee	November 2013
Start AO-11 cycle of observations (duration 12 months)	1 January 2014

### 1.3 Scientific observing time available in AO-11

There is approximately 24 Ms of INTEGRAL scientific observing time available for this AO, which can be applied for in observing time proposals. However, the following notes need to be considered:

- 1) Following a recommendation made by the INTEGRAL Users Group in June 2008, the vast majority of observing time shall be made available to non-ToO observations exceeding 1 Ms of exposure (“Key Programmes”).
- 2) About 2.2 Ms will be set aside for the execution of ToO observations in AO-11. Note that this is an a-priori allocation required by ISOC for the long-term planning before the start of AO-11. If justified by the expected scientific results, however, more time will be allocated to ToO observations.
- 3) An amount of 25% of the open time will be reserved for scientists from the Russian Federation in return for their providing of the PROTON launcher, which put INTEGRAL in orbit on 17 October 2002. Given the total amount of open science time for new proposals in this AO-11 (i.e. 24 Ms, see above), the guaranteed return amounts to about 6 Ms for AO-11. Note that in contrast to previous AO’s there will be, in AO-11, no compensation for the under-return of Russian open time observations accumulated during

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<sup>i</sup> *Target of Opportunity*

<sup>ii</sup> *As in previous AOs a “Key Programme” is defined as a non-ToO scientific investigation which requires a*



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all previous AO cycles, because the compensation will be completed during the on-going AO-10 cycle. The Time Allocation Committee (TAC) will award the guaranteed return (about 6 Ms) to successful proposals only, i.e. on the same basis of scientific merit, together with all other proposals.

- 4) The TAC had accepted 3 ‘multi-year’ proposals in the previous AO-10. These proposals cover observations for both the AO-10 cycle and this AO-11 cycle, but the TAC requests that they need to be re-confirmed by the PIs for AO-11 (see Section 1.4.1). Assuming that all ‘multi-year’ proposals, which have been approved in AO-10, will indeed be re-confirmed by the PIs and approved for AO-11 by TAC, then a total observing time of at least 3.2 Ms will be reserved to those observations in AO-11.
- 5) It is planned to schedule about 324 ks (incl. overhead) in AO-11 for public observations of the cosmic diffuse X-ray background (see Section 1.5).

## 1.4 Multi-year proposals

### 1.4.1 Confirmation of on-going multi-year proposals

PIs of on-going multi-year proposals (approved in AO-10) need to re-confirm these observations for AO-11 together with an update on the achieved results so far. Only ***TAC accepted observations*** of the original proposal as submitted in AO-10 can be re-confirmed in AO-11. Details of the previously accepted observations ***cannot*** be changed in confirmation. The "confirmation proposal" should consist of a brief science justification of up to two pages in length, in which the timeliness of the science context of the original proposal is to be discussed in the light of the scientific progress made since its first submission. Where possible, the feasibility of the original proposal should be updated based on the data already taken. The “confirmation proposal” will be evaluated by the TAC together with the original proposal as submitted in AO-10.

### 1.4.2 Submission of new multi-year proposals

It is possible to submit Key Programme<sup>ii</sup> proposals with observations spanning two AO cycles of observation (AO-11 and AO-12). For the first year (AO-11) of such a Key Programme, the scientific justification shall meet the usual requirements as detailed in Sections 6.1 and 7.5. The proposal should describe the science case and the technical feasibility for the total observing time requested. It is the policy for the TAC to always formally approve successful proposals for the AO-11 period of duration only (i.e. approval for one year only). For the second year (AO-12), and if approved in AO-11, a confirmation of the proposal will be required (see Section 1.4.1).

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<sup>ii</sup> As in previous AOs a “Key Programme” is defined as a non-ToO scientific investigation which requires a significant amount of observing time (> 1 Ms) per year in order to achieve its objectives.

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## 1.5 Public observations of the Cosmic Diffuse X-ray background (CXB) radiation via Earth occultation

Following a recommendation by the IUG, ESA will continue to implement a series of public observations of the CXB into the forthcoming cycle of AO-11 observations, and beyond. These observations will be performed using the Earth as an occulting disc and build upon initial shorter INTEGRAL observations which have been performed in 2006 (Churazov et al., A&A 467, 529, 2007; Türler et al., A&A 512, A49, 2010). The goal of the set of new observations is a much better characterization of the hard X-ray spectrum of the cosmic X-ray background in the INTEGRAL range from about 3 keV to 300 keV.

Compared to the initial observations in 2006, which were mainly used to test the non-standard observation technique, this new set of observations will benefit from both, a reduced contamination by foreground sources due to a more favorable target configuration (Earth vs galactic plane and bulge) and a reduced emission of the Earth atmosphere itself above  $\sim 70$  keV due to the increase of solar activity and the corresponding decrease of the cosmic-ray induced radiation by the Earth atmosphere.

After a first set of these observations has been performed in 2012 (AO-9), more observations are planned for 2013 (AO-10), as a set of individual exposures with a duration of about 13 hours each, corresponding to a total exposure time of up to 234 ks in 2013. However, the execution of these observations depends on the positive outcome of a pilot observation, using a modified observing strategy, scheduled for June 2013. If successful, about the same amount of time (230 ks) could be scheduled for 2014 (AO-11), so that the total of all CXB exposures in 2012-2014 will amount to about 700 ks.

These observations are, from an operational point of view, highly “non-standard” because the Earth will have to be inside the field of view (FOV), blinding the star trackers. Additional science time will have to be used prior to and after those dedicated CXB/Earth occultation observations for slews and special s/c pointings in order to safely resume the standard observing programme. The exact amount of this overhead will depend on the targets bracketing the CXB observations. The current estimate is, that to each exposure of 13 hours, an overhead of about 5 hours will have to be added. The total (elapsed) time during AO-11, which will be absorbed by the CXB/Earth occultation observations, is therefore about  $5 \times 18$  hours or 324 ks.

Due to the special nature of these observations and its scientific operations, it has been decided that all scientific data of these observations will be made immediately publicly available to the scientific community at large.

## 1.6 Extended INTEGRAL mission phase and future calls beyond AO-11

The nominal operational mission began on December 16, 2002, two months after the launch, and lasted 24 months. Therefore, the nominal mission ended on December 16, 2004. Since then, INTEGRAL is being operated in its extended mission phase.

This extended mission phase is currently approved by the Science Programme Committee (SPC) to last until 31 December 2014. An extension of INTEGRAL science operations beyond 2014 is currently under discussion. Future AO cycles are planned to run on an annual basis.

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## 1.7 Summary of major changes and modifications for AO-11

The available supporting documents for this AO are listed in section 1.1.

For a proposal to be successful, it is mandatory, that the proposer has read the complete information provided for this AO prior to the submission of the proposal.

Below, we highlight some of the important changes and modifications applicable for this AO-11 document, compared to the one for the previous AO-10. After having read the document package, the reader should verify carefully that he/she is aware of all changes.

AO-11 document package	Section 1.1.1
AO-11 schedule	Section 1.2
Scientific observing time available in AO-11	Section 1.3

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## 2 The INTEGRAL mission

### 2.1 Overview of the mission

The *INTE*rnational Gamma-Ray Astrophysics Laboratory (INTEGRAL) was successfully launched with a PROTON rocket from Baikonour in Kazakhstan on October 17, 2002 at 04:41 UTC. INTEGRAL (Figure 1, Figure 2) is a gamma-ray mission sensitive between 3 keV and 10 MeV, whose payload consists of two main gamma-ray instruments, the imager IBIS (15 keV–10 MeV) and the spectrometer SPI (18 keV–8 MeV), and two monitors, JEM-X (3–35 keV) and OMC (optical V-band, 500–600 nm). The IBIS and SPI instruments both have a very large coded field of view (IBIS: 29°×29° to zero response; SPI: 35° to zero response, corner to corner). In addition, a particle radiation monitor measures charged particle fluxes near the spacecraft.

The scientific goals of INTEGRAL are obtained using high resolution spectroscopy, combined with fine imaging and accurate positioning of celestial gamma-ray sources allowing the 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. Scientific topics addressed by INTEGRAL include (see also Section 5.3.2 for proposal categories):

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

**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.*

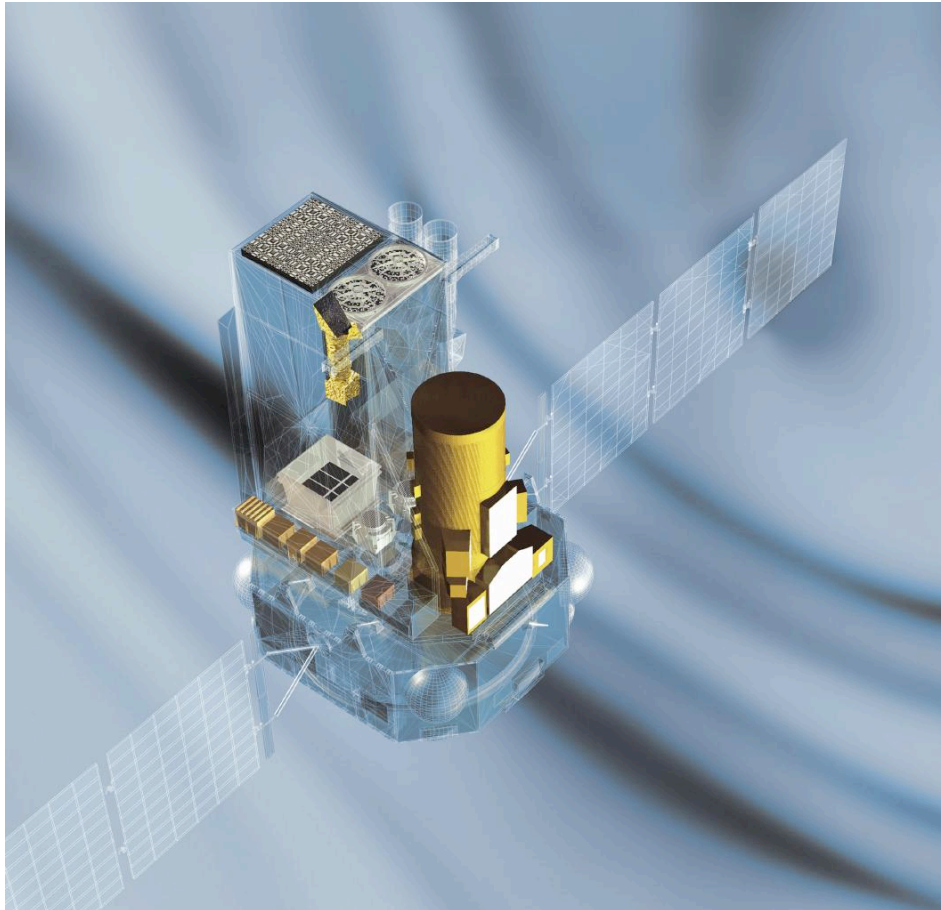
**Unexpected Discoveries.**

More details about the INTEGRAL spacecraft, instruments, scientific aims and first results can be found in A&A Vol. 411 (2003), a special A&A issue dedicated to INTEGRAL. An up-to-date list of refereed and non-refereed publications concerning INTEGRAL, complete as far as possible, and including also proceedings of INTEGRAL workshops, can be accessed at the ISOC web site<sup>iii</sup>.

<sup>iii</sup> <http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Publications>

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## 2.2 The INTEGRAL spacecraft and its orbit



*Figure 1: The INTEGRAL spacecraft. © ESA.*

The INTEGRAL spacecraft (Figure 1, details in Figure 2) 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:** Consists 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 down-linked 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%. On 21 May 2003, the rate for science data was 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.

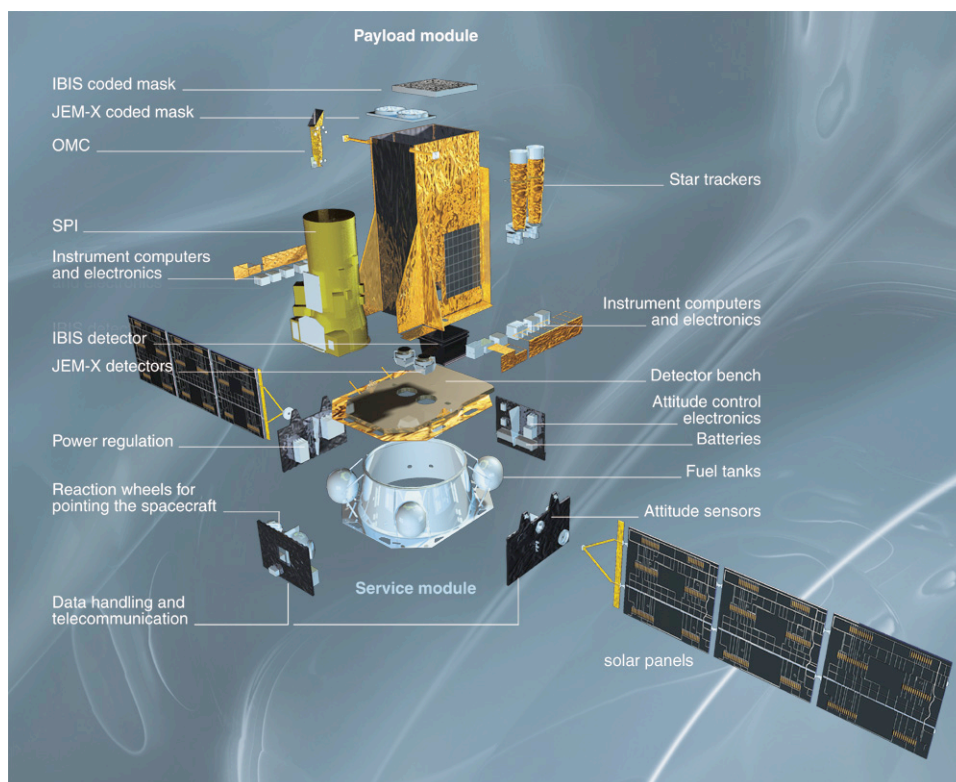


Figure 2: Exploded view of INTEGRAL service and payload modules. © ESA.

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## 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 periodically with time. After the launch the perigee height increased for the first few years from ~9000 to ~12500 km with subsequent descent while the apogee decreased from ~154000 to ~150000 km. During October 2011, INTEGRAL has reached a perigee height of only 2756.4 km, the lowest point in its orbit since October 2002. In the coming years the orbit will again circularize somewhat, reaching a perigee height of close to 10000 km in late 2015. The evolution of the INTEGRAL orbit is shown in Figure 3.

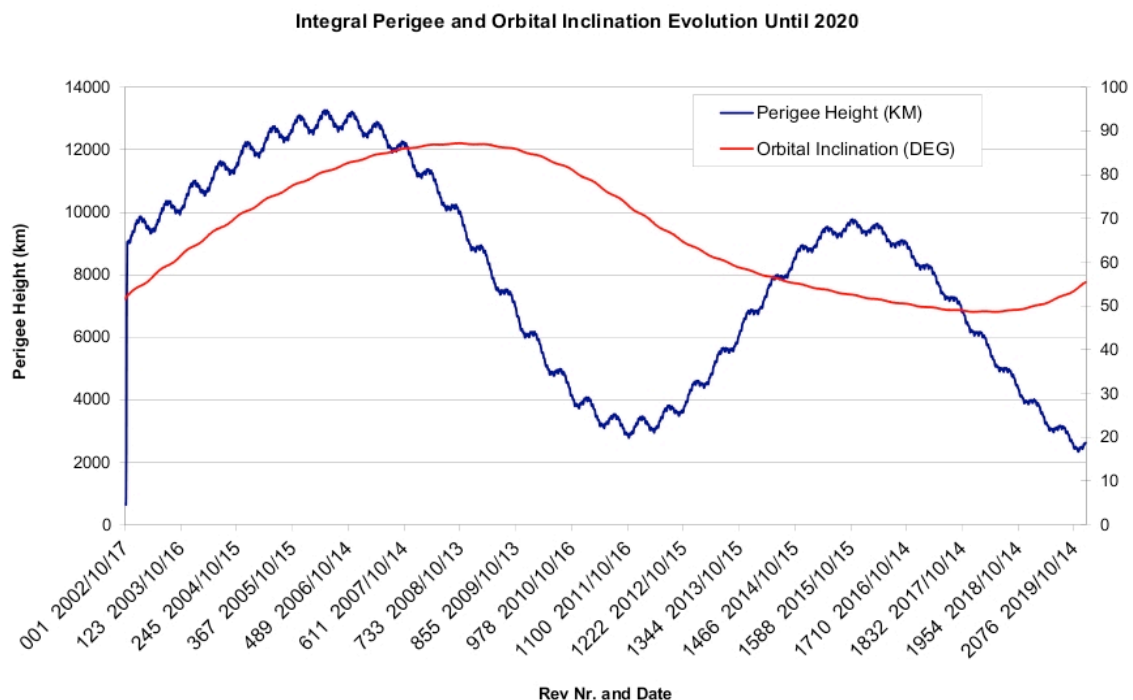


Figure 3: Evolution of perigee height and orbital inclination from launch until 2020.

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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. Generally, scientific observations (lasting up to about 210 ks per revolution) can be carried out if the spacecraft is at an altitude of at least 25000 km (radiation belt entry) or 50000 km (radiation belt exit). These altitude limits are variable and are regularly adjusted throughout the mission. The on-board radiation environment monitor and background data from the payload is being used to dynamically adjust and optimize this limit. Instrument operation is interrupted in case of a higher radiation environment, e.g., during a strong solar flare.

Ground station coverage of the orbit is achieved by ESA's Kiruna station, and augmented by other stations where necessary. The requirement for maximum visibility from the ground station imposes a high inclination angle and an apogee position in the northern hemisphere..

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  $\pm 40^\circ$ . This implies that the pointing angle of the spacecraft must be greater than  $50^\circ$  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 2 is a schematic summary of the complementary features of the instruments on INTEGRAL, and Table 3 and Table 4 list the key performance parameters of the payload. For more details on the instruments, please refer to the appropriate *"Instruments Observer's Manuals"*.

*Table 2: INTEGRAL science and payload: complementarity.*

Instrument	Energy range	Main purpose
Spectrometer SPI	18 keV - 8 MeV	Fine spectroscopy of narrow lines
		Study diffuse emission on $>1^\circ$ 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 3: Key parameters for SPI & IBIS.

Parameter	SPI	IBIS
Energy range	18 keV - 8 MeV	15 keV – 10 MeV
Detector	19 Ge detectors <sup>iv</sup> (6×6×7 cm <sup>3</sup> ), @ 85K	16384 CdTe detectors (4×4×2 mm <sup>3</sup> ), 4096 CsI dets (8.55×8.55×30 mm <sup>3</sup> )
Detector area (cm <sup>2</sup> )	500	2600 (CdTe), 3000 (CsI)
Spectral resolution (FWHM)	3 keV @ 1.7 MeV	8 keV @ 100 keV
Field of View (fully coded)	16° (corner to corner)	8.3° × 8.0°
Angular resolution (FWHM)	2.5° (point source)	12'
Source location (radius)	< 1.3° (depending on source strength)	30"@100 keV (50σ source) 3' @100 keV (5σ source)
Absolute timing accuracy (3σ)	~130 μs	~90 μs
Mass (kg)	1309	746
Power [max/average] (W)	385/110	240/208

Table 4: Key parameters for JEM-X & OMC.

Parameter	JEM-X	OMC
Energy range	3 keV – 35 keV	500 nm - 600 nm
Detector	Microstrip Xe/CH <sub>4</sub> -gas(1.5 bar)	CCD + V-filter
Detector area (cm <sup>2</sup> )	500 for each of the two JEM-X detectors	CCD: (2055 × 1056) pixels Imaging area: (1024 × 1024)
Spectral resolution (FWHM)	3.6 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

<sup>iv</sup> SPI had 19 active Ge detectors at launch. Since then, 4 detectors have failed: Ge detector #2 in December 2003, #17 in July 2004, #5 in February 2009, and #1 in May 2010.

## 2.4 Overview of INTEGRAL observation modes

Table 5 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 “*Instruments Observer’s Manual*”.

*Table 5: INTEGRAL observing modes.*

Instrument	Modes
SPI	Photon-by-photon
IBIS-ISGRI	Photon-by-photon
IBIS-PICSIT	Histogram
JEM-X (Modes in italics are for special circumstances only)	Full Imaging <i>Restricted Imaging</i> <i>Spectral Timing</i> <i>Timing</i> <i>Spectrum</i>
OMC (Mode in italics is for special circumstances only)	Normal <i>Fast</i>

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## 3 Observing with INTEGRAL

### 3.1 Overview and observation types

The four instruments on-board INTEGRAL are co-aligned and are being operated simultaneously, therefore, observers generally receive the data for all instruments together with auxiliary data from the INTEGRAL Science Data Centre. Typical observations can last from few hours to a few weeks, and a single proposal may contain several observations of the same type.

There are four classes of observations that can formally 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, if performed in the standard observing modes. In practice, they do not differ from Key Programme observations except that their exposure time is  $< 1$  Ms. Data rights proposals (see 2<sup>nd</sup> Call of this AO) can be associated with a *Normal* observation.

#### 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 with each one 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, which are different compared to the usual biannual observation window for most celestial sources, should be described in the scientific justification.

The reader should note that a *Fixed Time* Key Programme observation is possible, in principle, but due to the combination of both, fixed time requirement and long exposure requirement, its realisation during the ISOC scheduling process might prove very difficult, if not impossible.

Data rights proposals (see 2<sup>nd</sup> Call of this AO) can be associated with a *Fixed Time* observation.

#### 3.1.3 Target 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 sources (e.g. 3C 273, 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 INTEGRAL science telemetry. External triggers are alerts based on

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observations with other observatories (e.g. Fermi, Agile, Swift, XMM-Newton, Chandra, Suzaku).

All triggers are to be addressed to ISOC via the “*INTEGRAL ToO Notification*” web page at

<http://integral.esac.esa.int/isocweb/TOONotification.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) 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 of a ToO to the re-pointing of the spacecraft is about one revolution. Although neither the ISDC nor the ISOC have staff on duty at 24 h/day, 7 days per week, 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 (daytime) and non-working days.

In general, the following **rules and guidelines** are applicable to ToO proposals<sup>v</sup>:

- The TAC is advised to accept no more than a few ToO proposals per year, all ranked according to their scientific merit as any other proposal.
- 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<sup>vi</sup> 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). If the request concerns a ToO which is not covered by the existing database of accepted ToO proposals, then this request will – if accepted for scheduling - be included in the ISOC proposal database, allowing the tracking, documenting and time-line inclusion of ToO requests, in the same manner as for the proposals accepted by the TAC during the AO cycle.
- The PS or an appointed deputy must decide to declare, or to decline, 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 (earlier, pending) ToO or other high priority observations. The PS will define the priorities and inform the proposer of his decision about the implementation of the ToO request. ToO requests accepted for scheduling will be communicated by ISOC to the scientific community at large.

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<sup>v</sup> A **proposal** for a ToO observation can be submitted during the normal AO process, in anticipation of the event. If accepted, its execution can be requested if its trigger criteria have been met.

<sup>vi</sup> 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, that is, requests for ToO not covered by the database of accepted ToO proposals are possible.

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The submission of a ToO proposal requesting a large amount of observing time, exceeding 1 Ms, e.g. for supernovae (see, however, Section 3.1.6) or Novae, is valid and technically possible. Indeed, similar proposals have been approved in the past. Due to its scientific importance, and an exposure time exceeding 1 Ms, these could be considered as a “Key Programme”. However, the INTEGRAL notion of Key Programmes does not include ToO observations, and, for a number of technical reasons, data rights proposals (see 2<sup>nd</sup> Call of this AO) cannot be associated with any ToO observation.

Please see Section 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 intended as a means to carry out scientific investigations requiring a significant fraction of the total non-ToO observing time (i.e. > 1 Ms) of an AO cycle but also accommodating various scientific aims. A KP can be presented as a “multi-year” proposal and extend over two AO cycles, but it will be subject to a yearly re-evaluation by the TAC (see 1.4 for details). Comparing with the other types of observation described in Section 3.1, the KP cannot be of type ToO.

Data rights proposals (see 2<sup>nd</sup> Call of this AO) can be associated with Key Programme observations.

### 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 project teams have agreed to establish an environment for those scientific programmes that require observations with both the XMM-Newton X-ray observatory and the INTEGRAL observatory 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.

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. Proposers must check, via PGT, the appropriate item asking for XMM-Newton time.

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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. No observations with a reaction time of less than 5 working days from an unknown triggering date will be considered for this cooperative programme. It is the responsibility of the PI to inform both observatories immediately if the trigger criterion is fulfilled. Repeated observations with more than two repetitions (that is, more than three observations in total) 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.*

The ESA science operations teams for XMM-Newton and INTEGRAL 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 Observation of a nearby supernova as a target of opportunity

In this section we are using the following *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:*

- a) 60 kpc (including LMC and SMC) for core-collapse supernovae (SNII, Ib, Ic)*
- b) 1 Mpc (including M31) for thermonuclear supernovae (SNIa)*

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 INTEGRAL data to be made immediately public<sup>vii</sup> to the scientific community at large.

**This decision implies that individual open time ToO proposals for *nearby* supernovae (see the definition given above) cannot be submitted in response to this AO.**

The observing strategy for a nearby SN is described 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 (Clemson University/USA).

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<sup>vii</sup> The term “immediately public” means that general on-line access by the science community to the so-called 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.



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## ***Observing strategy for a nearby supernova***

### ***(1) 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  $^{56}\text{Co}$  decay) are of the order of  $10^{-3}$  photons  $\text{s}^{-1} \text{cm}^{-2}$  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.

### ***(2) 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, <http://lanl.arxiv.org/abs/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 e.g. via the IAU Circulars or ATel. At lower latitudes, first detection could be via X-ray or gamma-ray observations (e.g. Fermi gamma-ray burst monitor, Swift, INTEGRAL), or eventually via radio emission. Again, results would be communicated to ISOC via IAU Circular, ATel, GCN or similar channels.

### ***(3) 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> 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 satellite to) the SN based on changes at other wavelengths (e.g. the onset of circumstellar interactions, seen in X-rays, radio,  $\text{H}\alpha$ ) 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.

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During the first 40 days of observations (i), 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. In any case, the observing strategy of a particular supernova will be optimized as to maximize the scientific return from INTEGRAL

#### ***(4) Data Rights***

Following a recommendation by the IUG, observations of a nearby (see above for a definition) 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 data format (see also Section 5.4.5.1) is suited for this.

#### **3.1.7 Calibration observations**

Dedicated payload calibration observations are occasionally executed during the normal operations phase. Observations of the Crab pulsar/nebula 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. However, we note the recent findings on the short- and long-term variations found in the high-energy emission of the Crab nebula (Wilson-Hodge, C., et al., "When a Standard Candle Flickers", 2011, *Astrophysical Journal Letters*, 727, L40. DOI: 10.1088/2041-8205/727/2/L40)

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 and dark current calibrations to characterise the instrument's response are performed about each month with a duration of about 3.5 hours. Performance verification of the spacecraft (e.g. AOCS calibration), are also performed if required. Proposers should not duplicate calibration observations in preparing open time proposals.

Public observations of the Earth were performed during AO-3, and will continue in 2013 (Section 1.5). These allow 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, leading to improved background modelling.

Annealing of the SPI detectors is not a calibration per se, but is intended to partially recover the time-dependent degradation of the energy resolution. Annealing procedures are performed approximately every six months and last six revolutions (equivalent of about 1.2 Ms of science time). During this time, scientific data are obtained for IBIS, JEM-X and OMC only.

All data obtained during dedicated in-flight calibrations during the extended mission phase are public.

### **3.2 Observation modes**

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



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the target in  $2.17^\circ$  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 is executed.

There are three distinct observation modes: *rectangular dither (standard)*, *hexagonal dither* and *staring*. Note, that the rectangular dither is the standard observing mode. 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 mode, the so-called  $5 \times 5$  dither (see Section 3.2.1). **Any observation to be performed in a non-standard observing mode has to be justified explicitly by the proposer (via an entry in PGT).** Non-standard mode observations are those, which intend to use the hexagonal dither, or staring, or any customized dither patterns including scans. Most of the customized dither patterns reduce the scheduling efficiency.

### 3.2.1 Rectangular dithering

**Rectangular dithering on a  $5 \times 5$  grid is the standard observation mode.** It is well suited for observations characterised by a FOV containing multiple point sources. It is also well suited for observations of extended or weak sources that can be best 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 4. In this implementation, one pointing was with the source on-axis, and 24 other pointings with the source off-axis, each separated by  $2.17^\circ$  arranged on a rectangular grid. The roll angle between pointings was always  $0^\circ$ .

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  $5 \times 5$  dither and consists of  $7 \times 7$  points centred on the target, with a step size of  $0.3^\circ$  (see Figure 4). Thus, the whole COP pattern fits within the inner  $3 \times 3$  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.

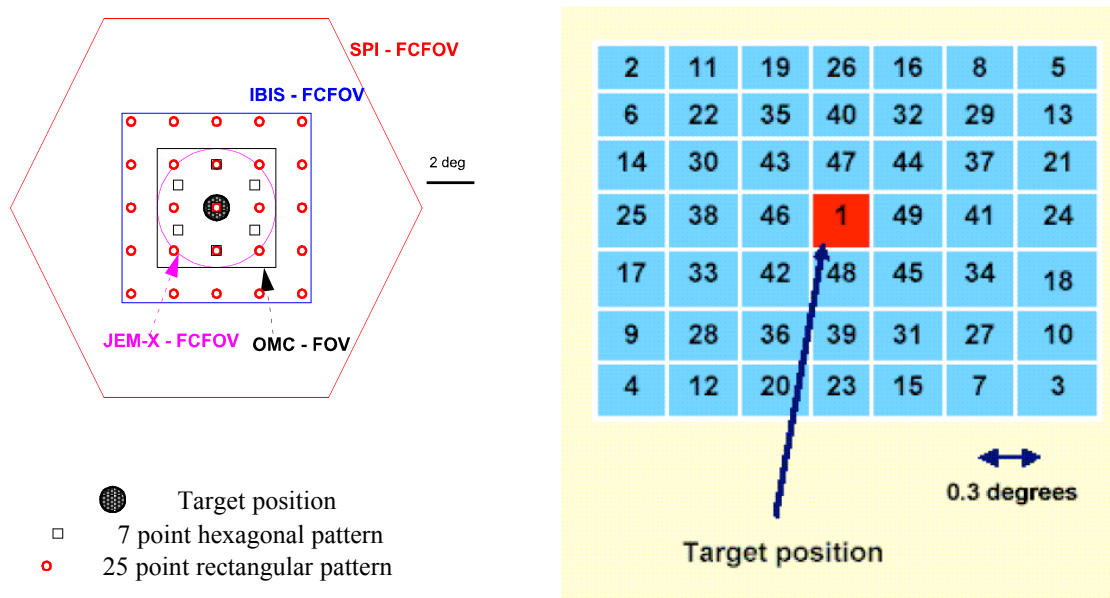


Figure 4: Schematic view of dithering patterns (left) and COP Offset Pattern for a 5x5 dither.

In addition to the moving COP, to further reduce systematic effects in deep mosaics, since June 2005 the orientation of the 5x5 pattern is set such that the axis of the dither pattern is rotated by  $11.3^\circ = \arctan(1/5)$  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 5x5 pattern spans the range from  $+3^\circ$  to  $-3^\circ$ , in steps of  $d\theta = 6/(N-1)$ .

### 3.2.2 Hexagonal dithering

The use of this mode is discouraged, because

- it seriously compromises the imaging capabilities of IBIS and SPI, rendering the data useless for use in large mosaics with or without using archival data, and,
- as such it renders the data useless for any investigation of high energy emission from celestial sources using SPI.

The use of the hexagonal mode must be very well motivated.

*Hexagonal dithering* consists of a hexagonal pattern centred on the nominal target position: one source-on-axis pointing, six source-off-axis pointings  $2^\circ$  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

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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 5), centred around the original centre point of the (blue) dither pattern.

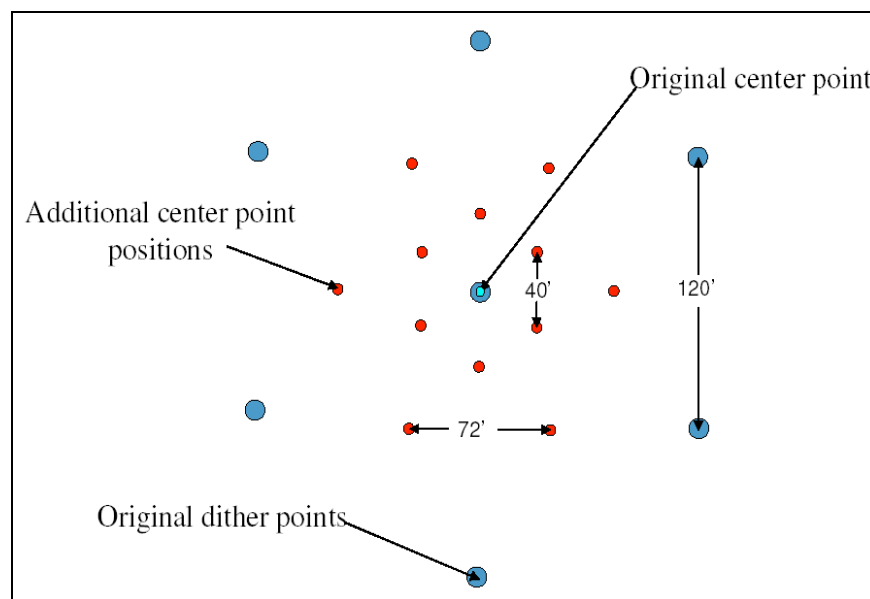


Figure 5: COP Offset Pattern for hexagonal dither pattern.

### 3.2.3 Staring observations

**The use of this mode is strongly discouraged**, for it very seriously compromises the imaging capabilities of IBIS, SPI and JEM-X, rendering the data useless for use in large mosaics, and in particular for the study of high energy emission from celestial sources using SPI. Therefore, staring observations must be extremely well motivated.

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

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## 4 Data rights

INTEGRAL is being operated as an observatory mission executing observations selected after a peer review process. This section outlines the data rights policies for INTEGRAL.

The ESA INTEGRAL Science Management Plan (SMP)<sup>viii</sup> 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.<sup>ix</sup>

### 4.1 Proprietary data

In general, 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 consolidated data have been dispatched by the ISDC. Following this one-year proprietary period, all data will be made publicly available through the archives. Section 4.2 provides an overview for data which will be made publicly available under certain conditions.

In past AOs, a number of observations existed, which made all their data immediately publicly available (see Section 7.9).

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

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<sup>viii</sup> INTEGRAL Science Management Plan, ESA/SPC(94)1, rev.4 (November 2007)  
[http://integral.esac.esa.int/docs/Science\\_Management\\_Plan\\_ESA\\_SPC\\_94\\_1.pdf](http://integral.esac.esa.int/docs/Science_Management_Plan_ESA_SPC_94_1.pdf)

<sup>ix</sup> The data rights policy was endorsed by the INTEGRAL Science Working Team prior to launch based on the INTEGRAL Technical Note INT-TN-1457.

## 4.2 Public data

Table 6 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 6: Public data from INTEGRAL.*

Data type or condition	Section
Observations of the cosmic diffuse background via Earth occultation	<b>1.5</b>
Data from observations of a nearby SNe are publicly available	<b>3.1.6</b>
All private data one year after they have been processed and dispatched by the ISDC.	<b>4.1</b>
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.	<b>4.3.2</b>
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.	<b>4.3.2</b>
For GRB inside the FOV: location (and errors), trigger time, peak flux, fluence, light-curve (plot only), duration.	<b>4.4.1</b>
For GRB outside the FOV: light-curves from SPI ACS.	<b>4.4.2</b>
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.	<b>4.5.3</b>
All data obtained during dedicated in-flight calibrations during extended mission phase.	<b>4.7.2</b>
All data obtained during long slews.	<b>4.8</b>
Soft $\Delta$ -releases of re-processed public data	<b>4.9.2</b>
Hard $\Delta$ -releases of data, originally made public immediately.	<b>4.9.3</b>
All instrument housekeeping and engineering data.	<b>4.10</b>
Data required in support of the activities of ESA and participating agencies.	<b>4.11</b>
Data from observations which are “public” following a specific PI request in the proposal	<b>7.9</b>

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## 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, see Section 7.3) 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 are:

- The ToO event is discovered in the INTEGRAL data of open time observations.
- 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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**Category (1):** The ToO event is *discovered* in the routine scrutiny of the INTEGRAL data performed in the ISDC (Figure 6).

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 may also apply for the on-going observation during which the ToO was discovered..

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 7).

The ToO event is communicated to the Project Scientist by outside information from other space missions or ground observatories, and

(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.

or

(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.

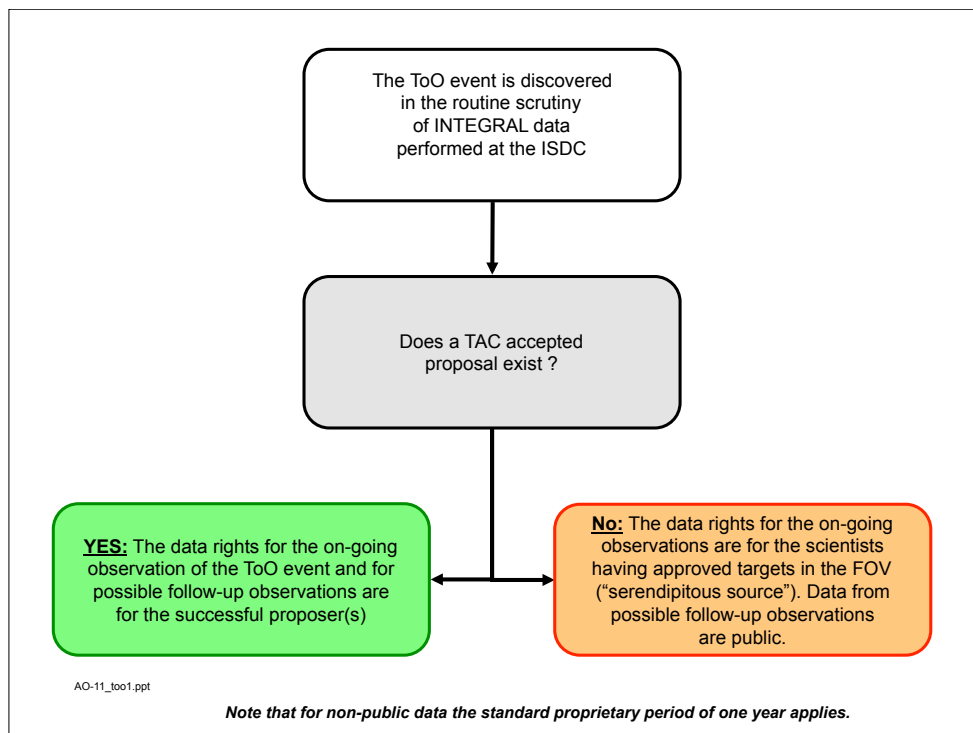


Figure 6

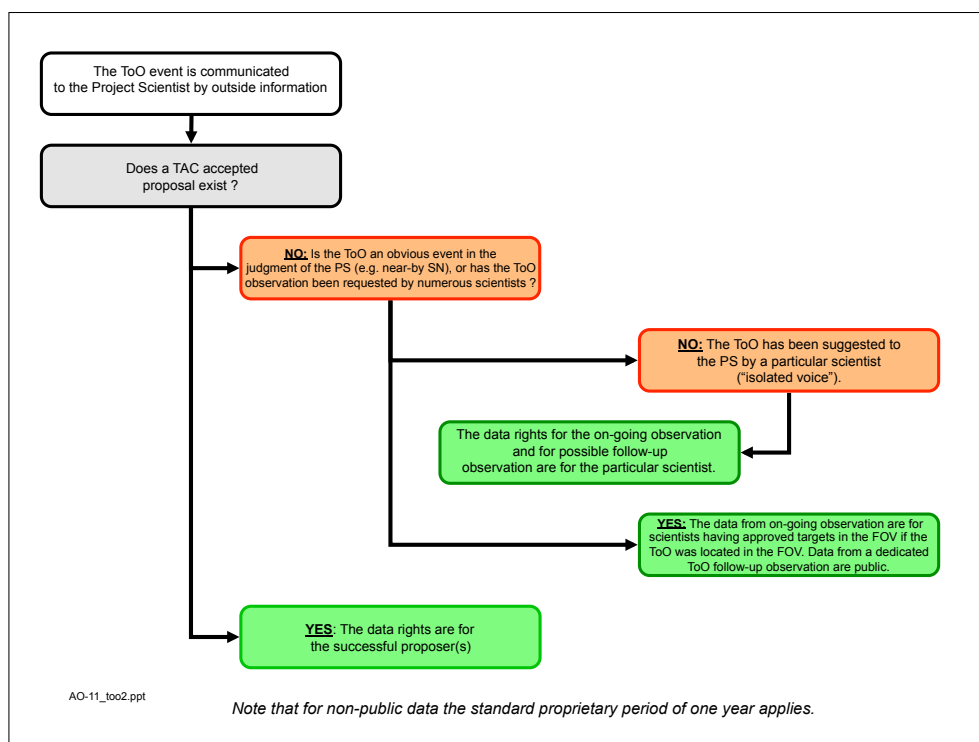


Figure 7



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## 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 FOVs of the INTEGRAL payload. Handling of GRB (associated) data within the ground segment is described in Section 5.5.

### 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<sup>x</sup> - 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  $\sim 10^{-2}$  s to  $\sim 10^{+2}$  s, 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, or an extra near real-time slew manoeuvre onto the GRB position within a short time scale (of typically one hour or less) is not possible.

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 a 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 ( $\sim 10$ 's of seconds) compared to the duration of the on-going observation (typically  $>10^5$  s), 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, Chandra, Swift), data describing the GRB peak flux (20 - 200 keV, 1 s), fluence (20 - 200 keV), light-curve (20 - 200 keV, plot only) and GRB duration (s) are also publicly available, see also Section 5.5.1, and the IBAS website<sup>x</sup> for further details and recent examples.

<sup>x</sup> <http://ibas.iasf-milano.inaf.it/>

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#### 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 omnidirectional GRB detector above  $\sim 75$  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  $5\sigma$  detection significance<sup>xi</sup>. 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 4.10 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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<sup>xi</sup> <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

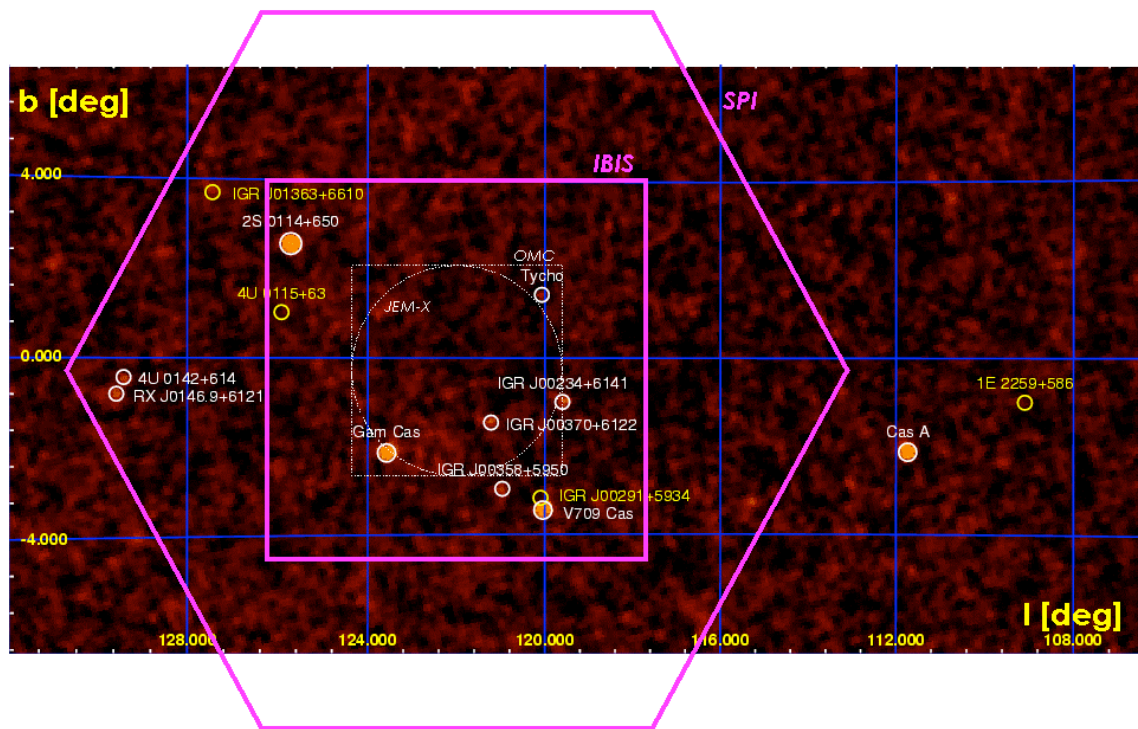


Figure 8: *INTEGRAL* view of the Cas A region (12-60 keV, P. den Hartog et al., *A&A* 451, 587, 2006) overlaid with the large (fully coded) FOV of the *INTEGRAL* payload, to illustrate the unique target multiplicity feature of the *INTEGRAL* mission.

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 a very large FCFOV of  $8.3 \text{ deg} \times 8 \text{ deg}$  [IBIS] and  $16 \text{ deg}$  (corner to corner) [SPI], respectively. In addition, the main instruments and the two monitors are co-aligned with overlapping fields of view (see Figure 8). 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, and, 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.

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The “**amalgamation**” of observations can effectively be performed through two different procedures as shown below. The outcome however, being the execution of one observation containing several sources belonging to several PIs is, concerning the data rights (Section 4.5.2), identical. These two procedures are:

- (i) Two (or more) individual (non-ToO) observations, each individually approved and using observatory time, can be ‘amalgamated’ by the 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. An example (see Figure 8) for this procedure would be the amalgamation of two accepted observations on SNR Cas A, and on SNR Tycho, respectively, which will be executed as one observation but with the payload line-of-sight pointing midway at about  $(l, b) = (116^\circ, 0^\circ)$  allowing to cover both sources in the same FOV.
- (ii) One individual non-ToO 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<sup>xii</sup>. 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 2<sup>nd</sup> call of this AO. An example for this procedure (see Figure 8) would be a pointing at Tycho (where the data on Tycho itself are for the PI having been granted Tycho observing time) while the other sources in the same FOV (e.g. IGR J00234+6141, IGR J00370+6122, Gam Cas, etc.) can be allocated to the PIs for successful data rights proposals.

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 – in most cases - 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 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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<sup>xii</sup> See, however, on GRB in Section 4.5.3 below.

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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 FOV**

In the case in which several targets, that are the objects of different approved non-ToO proposals (for observing time and/or for data rights) are in the field of view during one or several exposures, the 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) to be found in the FOV”.

After completion of the peer review (TAC) process, and after approval by the Director of Science, 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 website<sup>xiii</sup>.

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 as described in Section 4.5.2, 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 and not contained in the information (e.g. target lists) provided by the ISOC to those PIs

<sup>xiii</sup> [http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target\\_Lists](http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists)



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concerned, are “available” for all those PIs participating in that observation (for the duration of the proprietary period).

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 – occasionally - 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 including the outburst for these sources, even if they occurred inside the pointing area during the on-going observation. 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 FOV 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 4.5.1 and 4.5.2 .

#### **4.5.6 Targets list**

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

### **4.6 Data rights for split observations**

INTEGRAL observations with a typical exposure of the order of  $10^5$  s, or more, 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 210 ks. Normally the exposures for one observation will be contiguous in time, as far as allowed by the

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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 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.

## 4.7 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.

### 4.7.1 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 SPI annealing or after strong solar flares. Furthermore, a background data base of sufficient extent is needed to be able to understand

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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.

#### **4.7.2 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. According to the SMP, observing time to be allocated for the scientific observations 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<sup>xiv</sup> during the extended mission phase as described in the sections above are treated as public data.

#### **4.7.3 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 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.

### **4.8 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 OSA analysis tools will become available for slew data.

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

- (i) long distance slews (typically up to 10's of degrees) from target A (after observation of A) to target B (prior to observation B) and
- (ii) short distance slews (typically about 2 deg) during the dithering manoeuvres within a given pattern around the nominal target.

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<sup>xiv</sup> 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.



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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.

## **4.9 Re-processing of scientific data and additional data releases**

### **4.9.1 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  $\Delta$ -releases) of re-processed data. In what follows we discriminate between “soft” and “hard” releases.

### **4.9.2 Soft releases of re-processed data**

Experience shows that a number of soft  $\Delta$ -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  $\Delta$ -releases always improve the quality of the scientific data products but still include flight data of good quality (see Section 4.9.3, below).

Soft  $\Delta$ -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  $\Delta$ -releases of the same original data will always be shorter than one year, and the proprietary period of all soft  $\Delta$ -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  $\Delta$ -releases of re-processed public data will always result in public data.

### **4.9.3 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.

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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  $\Delta$ -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  $\Delta$ -release events, they should normally be discovered during the proprietary period (i.e. within one year), and consequently hard  $\Delta$ -releases of original data which became public after the proprietary period are highly unlikely, but should not be excluded a priori. Therefore, hard  $\Delta$ -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  $\Delta$ -releases of data that, originally, have been made public immediately will always become public.

#### **4.10 Instrument housekeeping data**

The proprietary period for INTEGRAL data (see Section 4.1 and SMP) 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.

#### **4.11 Data for public relation purposes**

As outlined in the SMP, 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 9.



Figure 9: The INTEGRAL flight and ground segments.

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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 website at <http://integral.esac.esa.int/> provides access to important information for proposers and observers. This includes:

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

A helpdesk handles all questions related to the INTEGRAL mission (received via e-mail at [inhelp@sciops.esa.int](mailto:inhelp@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.

We will be happy to react to any query you may have, which is submitted via e-mail to [inhelp@sciops.esa.int](mailto:inhelp@sciops.esa.int)

The INTEGRAL science analysis software is available together with documentation and test data for download from the ISDC web page at

<http://www.isdc.unige.ch/integral/analysis#Documentation>

Further information on ISDC user support is provided in Section 5.4.

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## 5.3 From proposal to observation: ISOC

### 5.3.1 ISOC responsibilities

The INTEGRAL Science Operations Centre, ISOC (<http://integral.esac.esa.int/>), is located at the European Space Astronomy Centre (ESAC), near Madrid, Spain. ISOC is responsible for the definition of scientific operations including instrument configuration for each observation, mission planning and implementation of the observing programme.

In summary, ISOC is responsible for:

- Preparing AOs, receiving the proposals, assessing their technical feasibility and transmitting the assessments to the TAC.
- Scheduling and implementing the observing programme. This includes sending planning files to MOC.
- 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 Proposal submission and Time Allocation Committee

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 Section 3.1.3). All proposals must clearly contain one or several well-defined targets entered into PGT, and the scientific justification (see Sections 6.1 and 7.5).

The TAC evaluates each proposal primarily on the basis of its scientific merit, but obviously considers also its feasibility and related technical issues, see also Section 6.1 describing the scientific justification in more detail. Each accepted proposals will receive a grade (A, B, C) and a mark. The grades define the scientific scheduling priority for ISOC (A = highest, C = lowest). Marks indicate the quality of its contents. 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 "*we request 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 of a proposal must be entered into the proposal using PGT, otherwise it is not considered by the TAC for evaluation. Targets which are listed in the scientific justification only, but not entered in PGT, are not considered by the TAC for evaluation of the proposal. 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 Section 6.

After the deadline for an AO, ISOC will perform a technical feasibility of the submitted proposals using TVP and OTE, and forward the proposals to the TAC for scientific assessment.

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A single, international TAC will review all proposals on their scientific merit. The TAC will be guided by a list of evaluation criteria, established for each AO, but largely formulated prior to AO-1. This committee consists of three panels covering the range of scientific topics relevant to INTEGRAL.

Each observing proposals has to be submitted by indicating one of the three scientific categories:

1. **Galactic astronomy** (point sources only, including stellar-mass collapsed objects, both binaries and isolated systems)
2. **Extragalactic astronomy** (point sources [AGN, Blazars, Seyferts], clusters of galaxies, cosmic diffuse background and GRB)
3. **Nucleosynthesis** (including diffuse continuum and line emissions).

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 consulting the INTEGRAL target lists available via the ISOC web page.

The TAC is advised to allocate time for an oversubscription factor of up to 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 the highest graded proposals.

The TAC will evaluate GRB proposals following the same procedure as for all other proposals. However, they only receive a final mark, not a grade, as they have no scheduling priority of their own. Similarly, data rights 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 Section 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. The TAC will also review and update observing strategies and trigger criteria, if deemed necessary. The recommended programme will be submitted to ESA's Director of Science for approval. **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 proposer by ISOC.

Following the TAC assessment and the 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<sup>xv</sup>. A subset of these data is made available to the ISDC.

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<sup>xv</sup> [http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target\\_Lists](http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists)



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### 5.3.3 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, 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 (grade/rank), and any other special requirements such as fixed-time observations. Some observations are too long to be scheduled as a single time block of about 210 ks per revolution; ISOC must therefore schedule such observations as more than one separate exposure. Long-term and short-term schedules are published on the ISOC website.

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 observation
- Instrument or spacecraft anomaly
- 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 from the receipt of the ISOC re-planning request at MOC to the re-orientation of the satellite can be, at times, as short as about 8 hours or even below that. Any other re-planning, related to the 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 automatically regarded as a justification for re-scheduling. If the prime instrument (IBIS or SPI) is switched off, however, the observation will generally be re-scheduled if the off time amounts to more than 15% of the TAC approved exposure time. This does not apply for ToO observations.

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 as "complete" if at least 85% of its approved time has been executed.

### 5.3.4 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.

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### 5.3.5 User support and communication

The ISOC provides support in regards to the scientific operations planning and execution. ISOC provides, via the website, access to schedule information, target lists, AO documentation, etc. The ISDC will be happy to react to any query you may have, which is submitted via e-mail to [inthehelp@sciops.esa.int](mailto:inthehelp@sciops.esa.int)

## 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: 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.



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### 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 Section 5.3.4, a second archive located at ISOC contains the same data. Further INTEGRAL public archives (and mirrors) are maintained at HEASARC/NASA-GSFC and IKI Moscow (RSDC).

All archived public data can be downloaded from the ISDC via anonymous FTP or through a web archive browser. 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

The typical data download rate from ISDC is 1 Gbyte/hour via FTP. 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, 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.

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#### 5.4.5.1 Availability of scientific data in near real time

The ISDC routinely provides NRT data to the observer. The procedure is as follows:

- PIs for accepted observing proposals, and PIs for associated data right proposals receive e-mails soon after the processing of the first observation has finished, which will describe in detail how they get access to their NRT data.
- NRT data will be made available on an FTP area in the same form as available in the archive. Data will be protected by a special key communicated in the e-mails above. NRT data availability will be about 3.5 hours after data have been taken on board.

NRT data will be deleted when consolidated data have been distributed.

#### 5.4.6 Source naming convention

A source naming convention for new sources detected by INTEGRAL has been established in agreement with the IAU. The INTEGRAL source designation is IGR JHHMMm+DDMM (equatorial coordinates, epoch J2000) in the case of positive declination, or IGR JHHMMm-DDMM for negative declination. In both cases, HHMMm is the right ascension of the source in hours (HH), minutes (MM), and fractions of a minute (m, one decimal), 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<sup>h</sup> 45<sup>m</sup> 08.9173<sup>s</sup>, DEC = -16° 42' 58.017". In the present case, the naming convention would give IGR J06451-1642.

#### 5.4.7 Acknowledgement in publications

Scientific publications making use of INTEGRAL data should acknowledge this<sup>xvi</sup> using the following text:

*Based on observations with INTEGRAL, an ESA project with instruments and science data centre funded by ESA member states (especially the PI countries: Denmark, France, Germany, Italy, Switzerland, Spain), and Poland, and with the participation of Russia and the USA.*

#### 5.4.8 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://www.isdc.unige.ch/integral/analysis#Documentation>. 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 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

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<sup>xvi</sup> via a footnote, to either the title of the publication on the first page, or within the section containing acknowledgements

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(<http://www.isdc.unige.ch/newsletter>) is used to keep the community informed and encourage communications with the ISDC. Subscription is done on the ISDC website.

## 5.5 Gamma-ray bursts (GRB)

Data from GRBs are generally treated as data from a ToO (see Sections 3.1.3 and 4.4). 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://ibas.iasf-milano.inaf.it> for details).

Alerts with the coordinates of GRBs are distributed through internet sockets for robotic telescopes. 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: A new kind of IBAS Alert Packet has been implemented in 2011 (see GCN Circular #11766), that will be automatically sent for possible GRBs of significance **below** the standard threshold currently used. IBAS users can decide to subscribe or not to this new type of alert packet which is meant mainly for **robotic** telescopes - knowing that in most cases these triggers will be just statistical fluctuations. Facilities, which 'automatically' create a request for extra observing time, hence impacting the existing observing schedules of these facilities should not subscribe to this new service. On the other hand, some good GRBs are expected among these low significance triggers, but in most

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cases there is no way to select them based only on the INTEGRAL data. Hopefully, the detection of afterglows (optical, X-ray, radio, IR) could confirm some of these potential GRBs. Only event times and coordinates of the triggers will be distributed. In case it can be confirmed that such a trigger is indeed a GRB, the relevant INTEGRAL data could then be assigned (a posteriori) with the usual ToO notification rules for unsolicited ToOs (see Section 4.3).

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

INTEGRAL is well suited as the near-Earth node of the InterPlanetary Network (IPN) providing large area detectors like SPI's Anti-Coincidence Shield (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 ( $5\sigma$ ) 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  $\sim 1\%$  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.,  $\leq 60$  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.

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The size of the new up-linked OMC sub-window is  $91 \times 91$  pixels, or  $26.6' \times 26.6'$ . 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 the AOCS) are sent in response to a GRB.

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## 6 Proposal submission procedure and tools

### 6.1 Scientific justification

The scientific justification shall demonstrate convincingly the case for the proposed investigation. The Time Allocation Committee will review proposals primarily on their scientific merit, taking into account the overall science return of the proposal to the entire mission. This implies that the scientific case has to focus on the main instruments of the mission, providing its unique hard X-ray and soft gamma-ray capabilities: IBIS and/or SPI. Besides the science case, the justification must address the observing strategy and include a description of its technical feasibility.

The guidelines given to the TAC for the proposal evaluation include:

- a) Effective use of the INTEGRAL observatory (this means: is INTEGRAL the right facility to carry out this project? Can the observation(s) only be done with INTEGRAL?)
- b) Scientific importance of the proposal (including: originality, clarity of thoughts/writing, soundness of proposed science, grasp of the scientific problem)
- c) Technical feasibility (including: correct calculation of the predicted source intensities, likelihood of scientific success (high/low risk), is the adopted observing strategy for this project suitable for the proposed science? Choice of appropriate dither pattern.)

Further technical details about format and submission of the scientific justification are provided in Section 7.5.

### 6.2 Proposal Generation Tool (PGT)

Proposals must be prepared and submitted electronically using the Proposal Generation Tool software. **Other formats will NOT be accepted.** PGT versions for previous AOs can not be used as PGT is not backwards compatible.

PGT for this AO 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. Proposers may wish to “re-use” their proposals from earlier AOs, updating them as necessary. Requests should be addressed to the INTEGRAL helpdesk, quoting the ID of the relevant proposal. **ISOC will send a proposal back to the original PI, only.**

Please see Section 7 for a description of some essential points regarding submitting a proposal using PGT, or “*INTEGRAL AO Tools Software User Manual*” for more details.

### 6.3 Observing Time Estimator (OTE)

The Observation Time Estimator is available via the ISOC web page <http://integral.esac.esa.int/>

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.



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## 6.4 Target Visibility Predictor (TVP)

The Target Visibility Predictor is available via the ISOC web page <http://integral.esac.esa.int/>. 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 Section 6.4.2), which is only considered at the scheduling level.

### 6.4.1 Sun, anti-Sun, Earth and Moon viewing constraints

TVP respects the constraints on the solar aspect angle of the spacecraft, described in Section 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 2), co-aligned with the instruments' pointing axis, the spacecraft has to point at least 15° away from the Earth and 10° 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 which are the framework for the AO. New observations have been performed in 2012 (AO-9) and it is planned, to schedule more observations during 2013-2014 (AO-11 til AO-12), see Section 1.5 for details.

### 6.4.2 Other constraints

#### *Eclipses:*

Observations are usually carried out while the spacecraft is outside the Earth's radiation belts at an altitude of at ~50.000 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 bright source casts a shadow of the SPI mask onto the IBIS detectors. This occurs rarely and only when the 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*".

## 6.5 Exposure Map Tool (EMT)

The Exposure Map Tool is available via the ISOC web page <http://integral.esac.esa.int/>. EMT is used to calculate the exposure time at a given point in the sky. The result is the accumulated time that INTEGRAL has observed at this point according to the exposure maps from IBIS or SPI.

## 6.6 Proposal Query Tool (PQT)

The Proposal Query Tool is available via the ISOC web page <http://integral.esac.esa.int/>

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PQT is used to obtain those approved observing time proposals which match a given point in the sky. The matching is done by the exposure time at that point INTEGRAL is expected to observe in the coming AO, according to the IBIS exposure map.

Note that PQT is to be used during the 2<sup>nd</sup> Call of this AO, inviting data rights proposals.

## 6.7 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 ([inthehelp@sciops.esa.int](mailto:inthehelp@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 to re-apply. Questions concerning the instruments, the AO and anything related to the mission, should be directed to the helpdesk.

## 6.8 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, hence leading to an increase of the cosmic-ray induced instrumental background, while at solar maximum a lower instrumental background is generally expected. 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.



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## 7 Proposals - format and checklists

### 7.1 Introduction

The only interface for submission of proposals is the PGT software. Here, the reader will find some general information and rules for the inputs to PGT. Further details are provided in the “*INTEGRAL AO Tools Software User Manual*”.

### 7.2 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 and where data rights for sources in the FOV must be claimed or can be renounced (see Section 7.9).

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.

### 7.3 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 allows the user to import a list of targets. PGT performs a validation of the coordinates using SIMBAD given the source name entered in the proposal; and 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.**

### 7.4 Choice of dither pattern

The only mode suitable for deep exposures is the standard, rectangular mode, the so-called 5×5 dither (see Section 3.2.1). Any observation to be performed in a non-standard observing mode has to be justified explicitly by the proposer (via an entry in PGT). Non-standard mode observations are those, which intend to use the hexagonal dither, or staring, or any customized dither patterns including scans.

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## 7.5 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 must be in PDF format. The justification should use A4 paper size, and a maximum of five pages, including figures and tables. Font size must not be smaller than 10-point. Multi-year proposals applying for their second year by submitting a “confirmation proposal” should limit the science justification to two pages (see Section 1.4).

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 only, or in the abstract but not entered into PGT will not be considered.

## 7.6 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 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 maximum 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).

## 7.7 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, energy range, instrument, etc.). It is always the proposer’s responsibility to inform the Project Scientist that a trigger has been met. For ToOs discovered in the FOV of INTEGRAL, see Section 4.3.2, category (1), 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 website can be used to either

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request that a TAC-accepted ToO be scheduled, or to request a new ToO for which there is no accepted proposal.

The ToO alert form can be found on the ISOC home page, or directly via the URL: <http://integral.esac.esa.int/isocweb/TOONotification.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 Section 3.1.3 for a discussion on ToO observations.)

## **7.8 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 Section 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 XMM-Newton, Suzaku, Swift, Chandra, and Agile. Note that since INTEGRAL observations are generally long, it may be easier for other observatories to follow the INTEGRAL scheduling (especially ground based observatories).

## **7.9 Claiming (and renouncing) data rights**

With a proposal being accepted, the proposer obtains data rights on the source/target, which are subject of his proposal. Detailed information concerning the source/target has to be provided by the proposer in the Observation Details panel in PGT. In addition, the proposer can claim additional data rights for other point-like sources, or for extended areas which are located within the FOV of his accepted observation, or for given energy intervals including gamma-ray lines. These claims shall be provided via a separate input panel within PGT.

Please note, that the TAC will review the proposed claimed data rights, which can only be made for sources/targets which are compatible and consistent with the scientific objectives of the proposal itself.

It is also possible for a proposer to renounce any data rights associated with the proposed observations, which would make the data obtained publicly available. For this, the proposer deletes all targets in the data rights panel including those, which have been automatically included from the Observations Details panel.

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## 7.10 Checklist for the proposal

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

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

The proposal **MUST** 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, and have you provided the details in the PGT form also?
- If you propose for a ToO, have you provided the trigger criteria (flux levels, energy range, instrument) and a strategy how to observe it (e.g. one observation using the total time, or several observations distributed over a period of specified 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  $5 \times 5$  dither, have you justified the use of any other pattern?
- Can your programme only be done with INTEGRAL observations? Can't it be done using archival data?
- Could your programme benefit from joint INTEGRAL/XMM-Newton observations (Section 3.1.5)? If so, have you activated the dedicated check-box in PGT?
- In case you want to submit a multi-year proposal (Section 1.4), have you checked the appropriate box in PGT ?
- Submit a re-confirmation proposal if you want to seek TAC approval of your multi-year observation for the **second** year.
- If you want to obtain data rights on certain sources in the FOV, did you list the sources in the PGT form ?
- If you want your data to become public immediately, did you renounce the data rights in PGT?
- Remember that proposals for observing nearby SNe (see Section 3.1.6 for a definition of “nearby”) are not accepted.
- Have you checked the latest news on the ISOC web page (<http://integral.esac.esa.int/>)?
- Have you read the entire AO documentation package (See Section 1.1.1) and are you aware of the most recent updates to it?

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## 8 List of acronyms and abbreviations

ACS	Anti-Coincidence Subsystem
AGB	Asymptotic Giant Branch
AGN	Active Galactic Nucleus
AO	Announcement of Opportunity
AOCS	Attitude and Orbit Control System
ATel	Astronomical Telegram
CCD	Charge Coupled Device
CDMU	Command and Data Management Unit
CdTe	Cadmium Telluride
CH <sub>4</sub>	Methane
<sup>56</sup> Co	Cobalt 56-isotope
Co-I	Co-Investigator
COP	Centre Of dither Pattern
CsI	Caesium Iodide
DEC	Declination
EMT	Exposure Map Tool
ESA	European Space Agency
ESAC	European Space Astronomy Centre
FAQ	Frequently Asked Question
FCFOV	Fully Coded Field Of View
FITS	Flexible Image Transport System
FOV	Field Of View
FWHM	Full Width at Half Maximum
Gbyte	Giga bytes
GCN	Gamma-ray burst Coordination Network
Ge	Germanium
GRB	Gamma-Ray Burst
GRO	Gamma-Ray Observatory
GRS	GRanat Source
IAU	International Astronomical Union
IBAS	Integral Burst Alert System

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IBIS	Imager on-Board the INTEGRAL Satellite
IDA	ISOC Data Archive
INTEGRAL	International Gamma-Ray Astrophysics Laboratory
IPN	Interplanetary Network
ISDC	INTEGRAL Science Data Centre
ISM	Inter-Stellar Medium
ISOC	INTEGRAL Science Operations Centre
IUG	INTEGRAL Users Group
JEM-X	Joint European X-ray Monitor
K	Kelvin
kbps	10 <sup>3</sup> bits/s
keV	10 <sup>3</sup> electron Volts
KP	Key Programme
kpc	10 <sup>3</sup> parsec
LMC	Large Magellanic Cloud
MeV	10 <sup>3</sup> keV
MOC	Mission Operations Centre
Mpc	10 <sup>3</sup> kpc
NASA	National Aeronautics and Space Administration
NRT	Near Real Time
OMC	Optical Monitoring Camera
OS	Operating System
OSA	Off-line Science Analysis
OTE	Observing Time Estimator
PDF	Portable Document Format
PGT	Proposal Generation Tool
PI	Principal Investigator
PQT	Proposal Query Tool
PROTON	Russian launch vehicle
PS	Project Scientist
QLA	Quick-Look Analysis
RA	Right Ascension

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RF	Radio Frequency
RKA	Russian Space Agency
SA	Standard Analysis
ScW	Science Window
SGR	Soft Gamma-ray Repeater
SMC	Small Magellanic Clod
SMP	Science Management Plan
SN	Supernova
SNe	Supernovae
SNEWS	Supernova Early Warning System
SNR	Supernova Remnant
SPC	Science Programme Committee
SPI	SPectrometer on INTEGRAL
TAC	Time Allocation Committee
TBD	To Be Defined
ToO	Target of Opportunity
TVP	Target Visibility Predictor
V-band	Johnson V-band
WR	Wolf-Rayet
Xe	Xenon
XMM-Newton	X-ray Multi Mirror observatory
XSA	XMM Data archive