INTEGRAL

Science Operations Centre

Announcement of Opportunity for Observing Proposals (AO-5)

AO-5 Guaranteed Time

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1 Introduction

According to the Science Management Plan for INTEGRAL, the observing time is defined as that time during which the scientific instruments on INTEGRAL are in nominal operation, less idle time and less time necessary for slewing, uplink commands, calibration, testing and maintenance.

Scientific observing time for the observing programme during the nominal and extended mission phases is divided into the open time for the General Observer (General Programme) and the **guaranteed time** for the INTEGRAL Science Working Team (**Core Programme, CP**). The breakdown into these two programme elements is shown in Figure 1.

The observing time (**guaranteed time**) during the **Core Programme** is the return to the INTEGRAL Science Working Team (ISWT) for their contributions to the development and execution of the INTEGRAL programme. The ISWT[1] is composed of two Co-PI's for the spectrometer SPI; one PI and one Co-PI for the imager IBIS; one PI each for the optical monitor OMC, X-ray monitor JEM-X and INTEGRAL Science Data Centre, respectively; five Mission Scientists (three from Europe, one from Russia, one from USA); one scientist each representing the participating partners Russia and USA; and the ESA Project Scientist. It is a task of the ISWT to define the Core Programme in full detail.

1.1 The Core Programme for AO-5

This document describes the scientific rationale, the detailed observing strategy and exposure times for CP observation in AO-5. It should be noted that these observations are considered as "survey observations" (see AO document on *Science Data Rights* for further details).

1.2 Time allocation for Core Programme elements

Given the characteristics of the INTEGRAL operational orbit, described in the *INTEGRAL Manual* in detail, and using the annual share of the Core Programme (CP) time (Figure 1), the allocation of observing time as shown in Figure 1 has been derived, assuming that science observations will only be performed above an altitude of 60,000 km prior to perigee entry and above 40,000 km following perigee exit. Scheduled observations during previous AO's have been used to refine pre-launch estimates.

[1] http://www.rssd.esa.int/index.php?project=INTEGRAL&page=ISWT

It follows from Table 1**, that a total of 5.2 Ms of observing time will be available for guaranteed (Core Programme) time observations.**

It has to be noted, that scheduling of in-flight calibrations during the operational phase will occur, like it was done during in previous years. In line with the definition of observing time (see above), exposure time for in-flight calibration will lead to some reduction in the Core Programme time and General Programme (open) time. The total amount of that required time is yet to be determined. Data from those in-flight calibrations are publicly available.

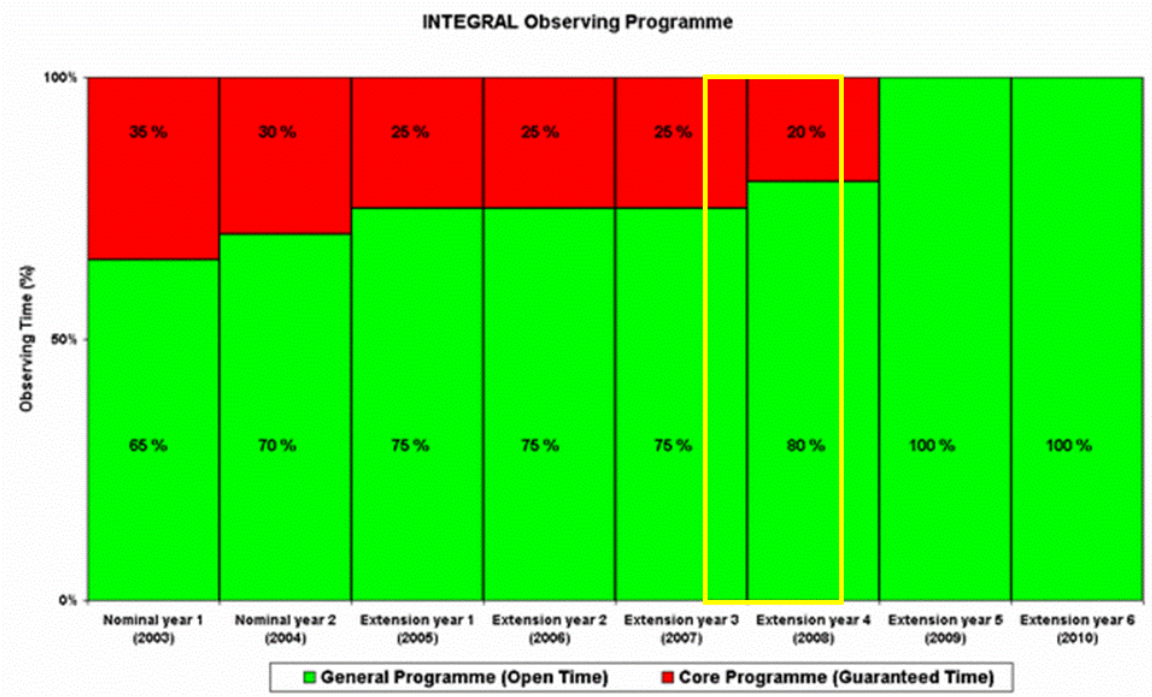

Figure 1. Breakdown of INTEGRAL observing time as a function of time. Launch took place on 17 October 2002. Nominal mission (year 1) began on 17 December 2002, extended mission began on 17 December 2004. The time window covered by the AO-5 cycle of observations is indicated (yellow box). Note that the proposed reduction of the Core Programme to 0% in 2009 and beyond is to be confirmed by ESA's Science Programme Committee later in 2007.

Table 1. Estimated time allocation for guaranteed time observations (Core Programme, CP) in AO-5. The cycle of observations in AO-5 lasts 12 months, starting on 16 August 2007. See also Figure 1.

Item	Estimated Time [Ms]
Total scientific time available for AO-5: open time (including KP) and guaranteed time (Core Programme) (12 months duration)	**24**
Core Programme share of total time in period from 16 August 2007 until 31 December 2007 = 25%	*2.2*
Core Programme share of total time in period from 01 January 2008 until 15 August 2008 = 20%	*3.0*
Sub-total Core Programme in AO-5	**5.2**
Total open time (General Programme) only, including Key Programmes for AO-5 = 24 Ms – 5.2 Ms	**18.8**

2 The Core Programme for AO-5

2.1 Scientific rationale

The survey of the Galactic plane is one of INTEGRAL's main scientific objectives, targetting the populations of point sources of different types, but also diffuse emission in continuum and gamma-ray lines. During the past years, INTEGRAL obtained a wealth of new scientific results from its Galactic plane survey, which was focussed on the densely-populated inner Galaxy region in the nominal mission years. Among the results from this survey are:

- the discoveries of new, highly obscured sources (e.g. Walter et al., 2003),
- the catalogues of soft gamma-ray sources including mostly binaries with a high fraction of black-hole candidates (Bird et al., 2004, 2006, and 2007; Bazzano et al., 2006; Krivonos et al., 2007) with the interesting and much-debated transition between source-dominated and possibly diffuse-dominated Galactic ridge emission around 150 keV (Lebrun et al., 2004, Terrier et al., 2004; Bouchet et al., 2005; Strong et al. 2005; Krivonos et al., 2006),
- the surprising puzzle of the map of positron-annihilation gamma-rays (Knödlseder et al., 2005; Weidenspointner et al., 2006),
- spectacular high-resolution spectroscopy of the ^{26}Al line emission (Diehl et al., 2006), and,
- important detections of nucleosynthesis gamma-rays from ^{60}Fe (diffuse Galactic; Harris et al., 2005; Wang et al., 2007) and from ^{44}Ti both as detections of lines from Cas A and important limits from core-collapse supernova expectations (Renaud et al., 2006).

Many of these results came from the deep observations of major portions of the Galactic plane, including spiral arm tangents. Population statistics for all these types requires homogeneous, deep, and unbiased/uncontaminated exposures of large portions of the Galactic plane; symmetry or asymmetry tests are often an important argument for astrophysical interpretations.

As the mission continues, the targets of the General Programme (open time) have led to deeper exposures in specifically interesting regions of the Galactic plane, while other regions which appeared less interesting have lagged behind (Figure 2). Galactic source population studies require a uniform coverage of the disk. Therefore, the ISWT invested its Core Programme time during the extended mission into homogenization of the exposure along the plane, and into extensions of longitude coverage. This was done as a response to above results and the issues opened up by these, but also bearing in mind that (a) a major part of INTEGRAL's legacy will be the unique Galactic-plane dataset in the hard-X-ray to low-gamma-ray energy range, and that (b) targeting less populated Galactic-plane regions would not be a likely outcome of the General Programme competition. This complementary strategy has supported much of the above results. It will support refinements in spatial resolution, also reacting to the new puzzles presented in the form of partly-degenerate source components (such as annihilation bulge-to-disk ratio, continuum point-source versus diffuse emissions, nucleosynthesis asymmetries along the plane of the Galaxy). With new opportunities like SWIFT, GLAST, AGILE, HESS and MAGIC-II, which also target the sources of high-energy emission, a variety of issues on source brightnesses

in the INTEGRAL band will arise, and can be addressed efficiently through an INTEGRAL deep-survey database for all steady sources.

The INTEGRAL Galactic source catalogue will also be the reference, guiding future narrow field-of-view projects (e.g. SIMBOL-X, GRI, ACT), and for this purpose the catalogue should be as complete and unbiased as possible.

Therefore, the AO-5 Core Programme will continue to fill exposure deficits and deepen the exposure in regions critical for large-scale studies. Specific target areas will be centered on Galactic longitudes at 23°, 225°, and 305° (Table 2, Figures 2 to 4). In order to also support investigations of latitudinal extents of source populations and, more importantly, of diffuse emission, at a selected longitude of $l = 23°$ the exposure will be offset towards northern Galactic latitudes by +8°. This exposure aims specifically:

i. at a discrimination of bulge and disk components of the positron annihilation emission,
ii. at signatures of disk-to-halo interactions near spiral arms, and
iii. at discriminations of continuum sources and diffuse emission along the Galactic ridge.

It is to be expected that the AO-5 open time observations will again increase the contrast of the exposure map in prime regions of past interest. Only the Core Programme part can be coordinated to consider the following points:

- Imaging results from long exposures (>5 Ms) may be limited by background residuals. We do not have so far a detailed view on the systematic errors for IBIS in long exposures. Covering overlapping sky regions at different episodes provides a tool on such systematics.
- Results from very long exposures (>15 Ms) of crowded regions may also be limited by source confusion (Galactic Centre).
- A significant gain in sensitivity for large-scale studies is more easily obtained by observing the yet less exposed regions.
- A variety of candidate future Key Programmes indicate a demand for deeper exposure in the disk parts of the Galactic plane. Building on a more homogeneous base increases the scientific power of such programs.
- The pointing and visibility/scheduling constraints require to distribute the total observing time to not more than ~ 3 Ms in any given direction.
- Spiral arms are not precisely defined and known (e.g. spiral arm tangents have $\Delta l \sim 5°$).
- Imaging of diffuse emission obtained over substantially large sky regions is hampered by exposure contrasts.
- Challenging its design lifetime, failures of key components may arise and limit future options to compensate for the observing biases during the early mission phase.
- The Key Programme components of AO-5 have been identified, and can be accounted for in the Core Programme strategy. This led us to not pursue additional exposures at Galactic longitudes of 60° and 97°.
- The SWIFT mission with its large field of view will survey the hard X-ray sky for transients, replacing what was the implemented as 'INTEGRAL Galactic Plane Scan (GPS)' in earlier AO's.
- Finally, we note that the Core Programme observations in AO-5 will also allow for detecting and monitoring transient point sources.

2.2 Observing Strategy

The observing strategy for the CP pointings will be a standard 5 x 5 dither pattern including COP move centred at the galactic co-ordinates as specified in Table 2.

Table 2. Pointings for the Core Programme in AO-5

Observation	galactic longitude	galactic latitude	Exposure [Ms]
1	23°	+8°	1.7
2	225°	0°	1.5
3	305°	0°	2.0

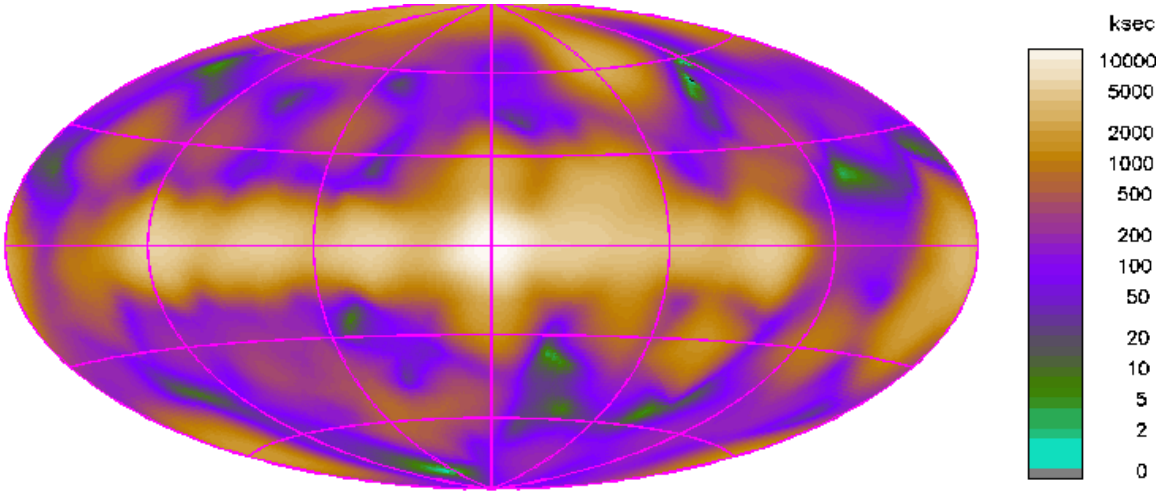

Figure 2. Exposure map (IBIS fully and partially coded FOV). From launch up to Aug 2007 (end of AO-4, extrapolated).

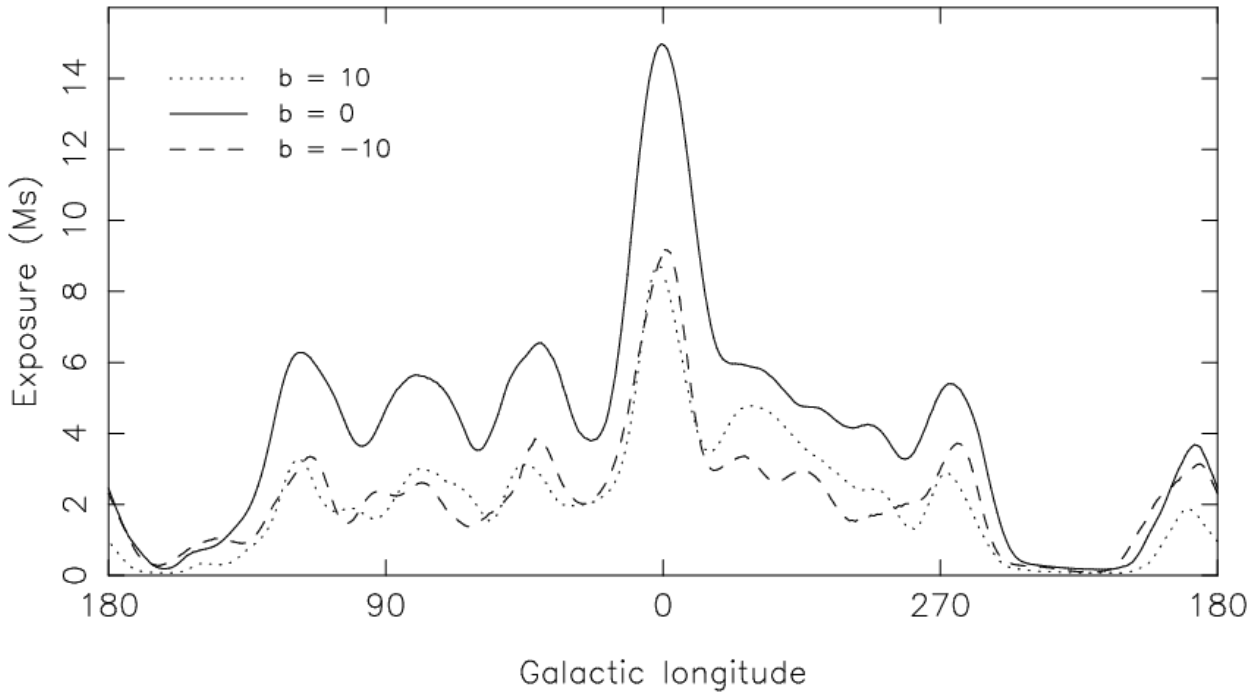

Figure 3. Longitude profile of exposure map (Figure 2) at selected galactic latitudes b = 10º(dotted), 0º (solid), and -10º (dashed). Each selected latitude is 1º wide.

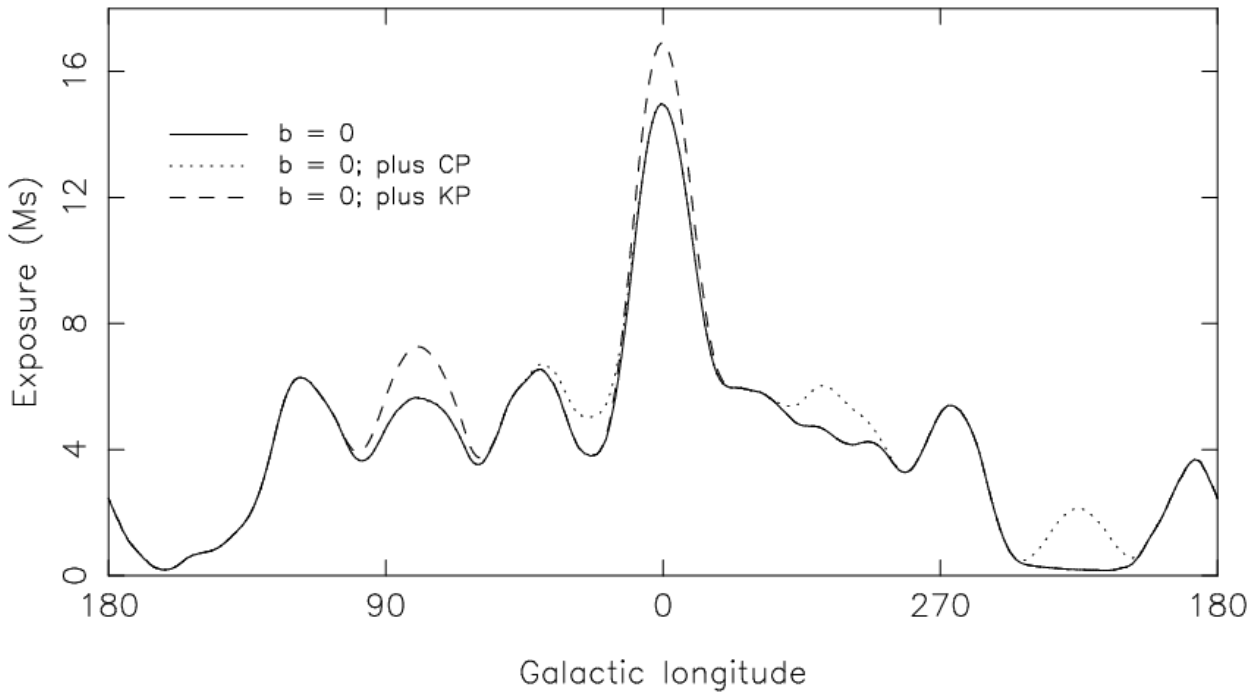

Figure 4. Longitude profile of exposure map (Figure 2) at galactic latitude b = 0º (solid, 1º wide), and including exposure of the proposed CP for AO-5 (dotted), and including exposure for the AO-5 Key Programmes 05K0012 and 05K0008 (dashed), see also AO-5 document on Key Programmes for further details.

3 Data rights

According to the INTEGRAL Science Management Plan, the data from the Core Programme belong to the ISWT for the usual proprietary period of one year after the data under consideration have been made available to the ISWT by the ISDC. Further details on scientific data rights and TOO rules and guidelines, are described in the AO documents on *Science Data Rights* and *INTEGRAL Manual*.