

INTEGRAL

Science Operations Centre

Announcement of Opportunity for Observing Proposals (AO-5)



AO-5 Key Programmes and Associated Observations

INT/SDG/07-0270/Dc

Issue 1

12 March 2007

Prepared by C. Winkler
Authorised by A.N. Parmar



INTEGRAL
AO-5 Key Programmes

Doc.No: INT/SDG/07-0270/Dc

Issue: Issue 1

Date: 12 March 2007

Page: ii of 17

This page was intentionally left blank



Table of Contents

1	Introduction	5
1.1	INTEGRAL key programmes and associated observations	5
2	Overview of Key Programmes for the AO-5 cycle of observations	6
2.1	Introduction	6
2.2	Deep INTEGRAL observations of the central molecular zone (PI: G. Bélanger, 05K0008)	7
2.2.1	Scientific rationale (summary)	7
2.2.2	Observing strategy	7
2.2.3	Data rights	9
2.3	The ultra-deep INTEGRAL legacy hard X-ray survey (PI: M. Ajello, 05K0010)	10
2.3.1	Scientific rationale (summary)	10
2.3.2	Observing strategy	10
2.3.3	Data rights	11
2.4	Nucleosynthesis and anti-matter annihilation in Cygnus X (PI: J. Knödseder, 05K0012)	12
2.4.1	Scientific rationale (summary)	12
2.4.2	Observing strategy	12
2.4.3	Data rights	13
2.5	Imaging the hyperactive Cygnus TeV superstructure in soft gamma-rays (PI: Y. Butt, 05K0018)	14
2.5.1	Scientific rationale (summary)	14
2.5.2	Observing strategy	14
2.5.3	Data rights	14
3	Proposals for targets associated with the KP pointings	15
3.1	Details concerning PGT for associated KP proposals	15
4	Data rights	17



INTEGRAL
AO-5 Key Programmes

Doc.No: INT/SDG/07-0270/Dc

Issue: Issue 1

Date: 12 March 2007

Page: iv of 17

This page was intentionally left blank



1 Introduction

1.1 INTEGRAL key programmes and associated observations

Proposers considering to submit proposals - in response to this AO - which are to be associated with any of the KP observations approved for AO-5, will find in this document further information for the preparation of their proposals.

An INTEGRAL key programme (KP) is a scientific investigation which requires a very significant fraction of the observing time (available per AO cycle) in order to achieve its scientific objectives. A number of selected KP observations will be implemented during the AO-5 cycle of observations (see Section 2). Using the unique “targets multiplicity” feature of INTEGRAL’s coded aperture masks, in combination with the very large field of view, allows to simultaneously accommodate the various requirements of the scientific community at large, both for ultra-long KP studies, as well as for observations of other sources contained in the sky area which is covered by the KP observation itself. The latter observations of other sources are identified as observations *associated* with Key Programmes. These associated observations usually focus on individual compact objects (e.g. point sources) which are contained in those large and deep KP fields, requiring usually less observing time, or on specific extended (diffuse) emission from within this area.

In terms of data rights, the sky area associated with a KP observation is divided between N users including one PI for the KP and N-1 associated PIs, each having his/her own specific data rights associated with individual sources or areas of diffuse emission. In this context, associated observations can not duplicate the scientific objectives (with source ID’s and data rights) of approved KP observations (see Section 2 and Section 4).

Following initial discussions in 2005 within the INTEGRAL Users Group and the INTEGRAL Science Working Team, ESA’s Astronomy Working Group has recommended in September 2005 that “*exploitation of INTEGRAL’s unique capabilities through key programmes should be encouraged*”.

ESA has implemented one KP (as a pilot project) in the on-going AO-4 cycle of observations. A total of 35 associated proposals has been implemented for this initial Key Programme observation of the Galactic Centre region.

The Key Programmes as described in this document are the result of a special Announcement of Opportunity (2006) which called for new KP proposals to be implemented in this forthcoming AO-5 cycle.

Section 2 provides the reader with a brief summary of the selected KPs for AO-5 cycle of observation. Section 3 describes general guidelines for associated proposals and Section 4 addresses some details on data rights.

2 Overview of Key Programmes for the AO-5 cycle of observations

2.1 Introduction

Following ESA's Announcement of Opportunity for Key Programme (KP) proposals for AO-5 (release: 09 October 2006, deadline: 17 November 2006), the Time Allocation Committee (TAC) has recommended to ESA to implement – during the AO-5 cycle of observations – the following KP proposals. This recommendation has been endorsed by ESA.

Proposal ID	Principal Investigator <i>Affiliation</i>	Title	Target area	Exposure (ksec)
05K0008	G. Bélanger <i>ESAC, Spain</i>	Deep INTEGRAL observations of the central molecular zone	Galactic Centre	2000
05K0010	M. Ajello <i>MPE, Germany</i>	The ultra-deep INTEGRAL legacy hard X-ray survey	North Ecliptic Pole	2000
05K0012	J. Knödlseider <i>CESR, France</i>	Nucleosynthesis and anti-matter annihilation in Cygnus X	Cygnus region	2000
05K0018	Y. Butt <i>CfA, USA</i>	Imaging the hyperactive Cygnus TeV super-structure in soft gamma-rays	Cygnus region	To be merged with 05K0012

Table 1. Key programme proposals selected for the AO-5 cycle of observations.

In the remaining part of this Section we summarize, per approved KP proposal, the scientific rationale, the observing strategy and specific data rights, so that proposers in response to this AO will be able to submit proposals for targets to be associated with KP pointings (see Section 3).

The reader should take note, that all approved KP proposals (except 05K0018) have been proposed to ESA as “multi-year” programmes. The exposure times listed in Table 1 are as approved for the AO-5 cycle (one year) only. It is the intention by ESA and the TAC to take the “multi-year” aspects of those programmes into account during the next call for KP proposals (Fall 2007, TBC) and during the evaluation of its response. Further details on the policy will be published in the documentation for that forthcoming AO.

	INTEGRAL <i>AO-5 Key Programmes</i>	Doc.No: INT/SDG/07-0270/Dc Issue: Issue 1 Date: 12 March 2007 Page: 7 of 17
---	---	--

2.2 Deep INTEGRAL observations of the central molecular zone (PI: G. Bélanger, 05K0008)

2.2.1 Scientific rationale (summary)

We underline the importance of deep and continued observations of the central molecular zone (CMZ) of the Galaxy with INTEGRAL, as crucial to gaining a more complete understanding of the origin and nature of the energetic X-rays and gamma-rays detected from this unique part of the Galaxy. We require long cumulative exposure on the CMZ (± 200 pc or $\pm 1.5^\circ$ from Sgr A*, and request 2 Ms per year for 4 years. We point out that given INTEGRAL's large field of view (FOV), an observation programme in the standard dithering mode for which the nuclear region is the main target, and hence within IBIS fully coded FOV, will satisfy the interests of many, as these central 30° abound in sources of all kinds, including that which is responsible for the intense 511 keV line emission. Our primary interests remain the extended emission from the molecular complexes of the CMZ, including the central, compact emission region known as IGR J17456-2901.

2.2.2 Observing strategy

A total of 2 Ms of observing time has been allocated to this KP in AO-5. The observing strategy is a standard 5x5 dithering observation with COP¹ centred on Sgr A*, RA = 17^h45^m40^s, Decl. = -29°00'29", (l, b) = (359°.94, -0°.05). The exposure map resulting from this KP observation is shown in Figure 1 overlaid with contours of exposure time.

¹ COP = Centre of dither pattern

05K0008

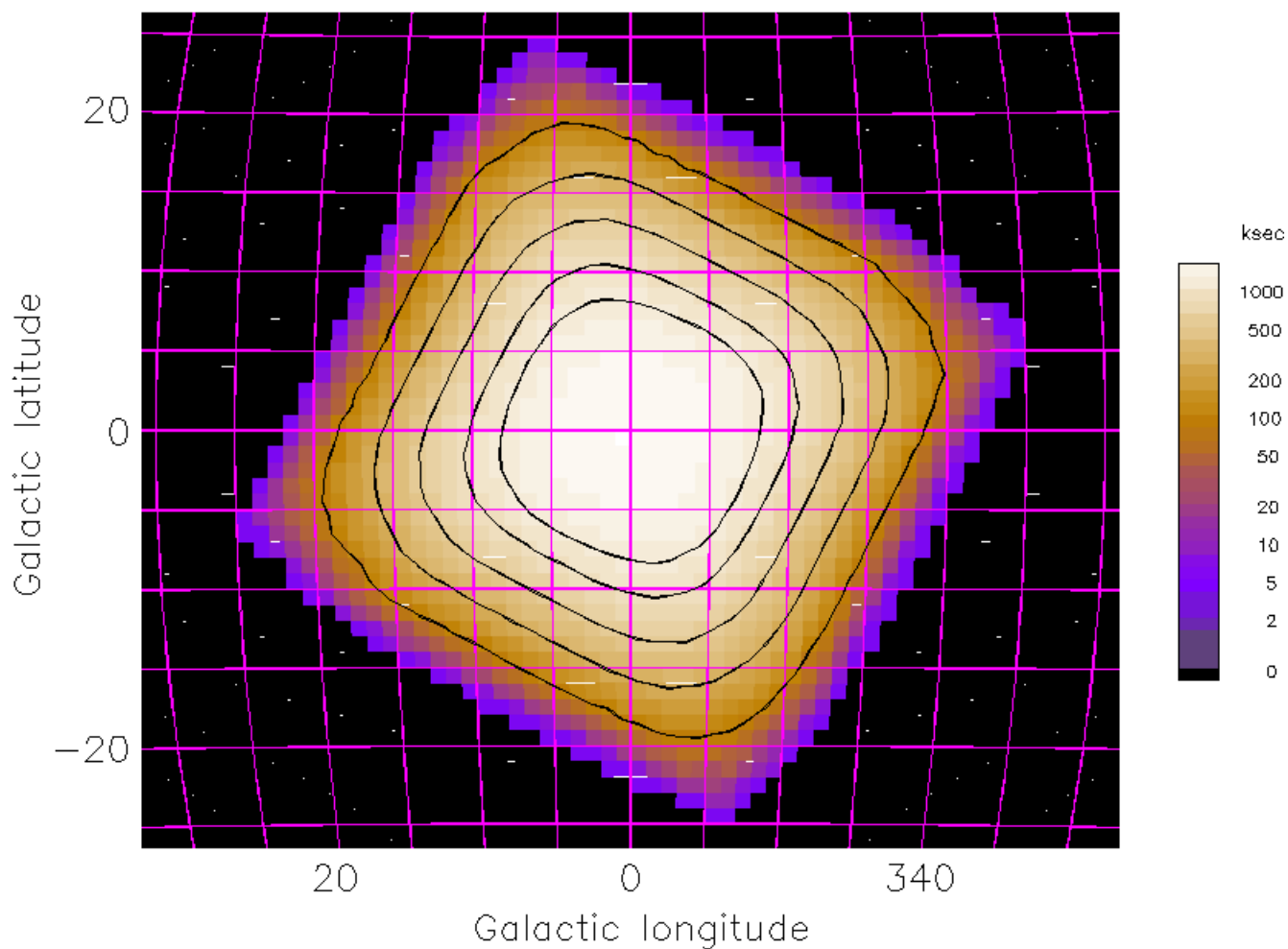


Figure 1. Exposure map (using a total exposure of 2 Ms) for the KP observation *Deep INTEGRAL observations of the central molecular zone (PI: G. Bélanger, 05K0008)* with contours indicating exposure times of 100, 300, 600, 1000 and 1300 ks, respectively.

2.2.3 Data rights

The TAC has allocated the following specific data rights to this KP observation:

Extended emission from molecular cloud complexes, only, of the Central Molecular Zone within a $3^\circ \times 1^\circ$ area ($l \times b$) centred on $(l, b) = (0^\circ, 0^\circ)$, including the central, compact emission region known as IGR J17456-2901 (see Figure 2).

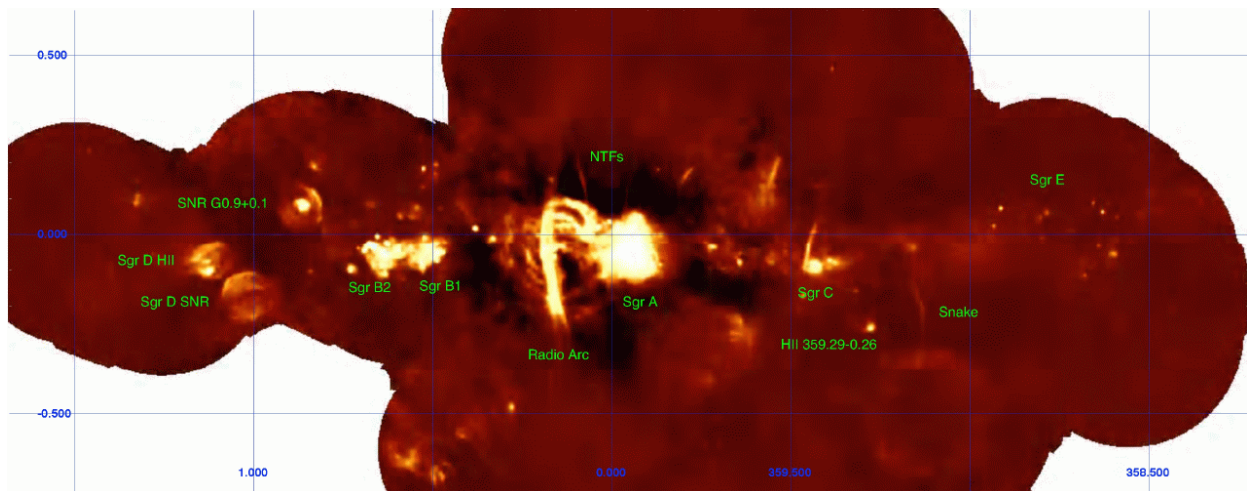


Figure 2. Radio map (20 cm) of the central molecular zone (KP proposal ID = 05K0008), from F. Yusef-Zadeh et al., ApJS, 155, 421, 2005. The coordinate grid is in galactic longitude and latitude (degrees), grid size = $30'$.



2.3 The ultra-deep INTEGRAL legacy hard X-ray survey (PI: M. Ajello, 05K0010)

2.3.1 Scientific rationale (summary)

A deep observation of the North Ecliptic Pole is proposed. The aim is to reach a factor ~ 10 lower in flux than achieved previously. A considerable number of new faint sources are expected, which will be used to test the validity of population synthesis models which try to reproduce the X-ray background spectrum. Some of the faint sources will be Compton-thick AGN. The sample of sources will also be used to study the dependence of the obscured-to-unobscured AGN ratio with either redshift and/or luminosity and thus to test the AGN unification model. The good high-energy response of IBIS and SPI will be used to test the presence of a high-energy (>100 keV) cut-off in the AGN spectra of the brightest objects and in the stacked spectrum of all the detected AGN.

2.3.2 Observing strategy

A total of 2 Ms of observing time has been allocated to this KP in AO-5. The observing strategy is a standard 5x5 dithering observation with COP. The coordinates of the central pointing is: RA = $18^{\text{h}}00^{\text{m}}00^{\text{s}}$, Decl. = $+66^{\circ}33'39''$, (l, b) = (96°.38, 29°.81). The exposure map resulting from this KP observation of the GC area is shown in Figure 3 overlaid with contours of exposure time.

05K0010

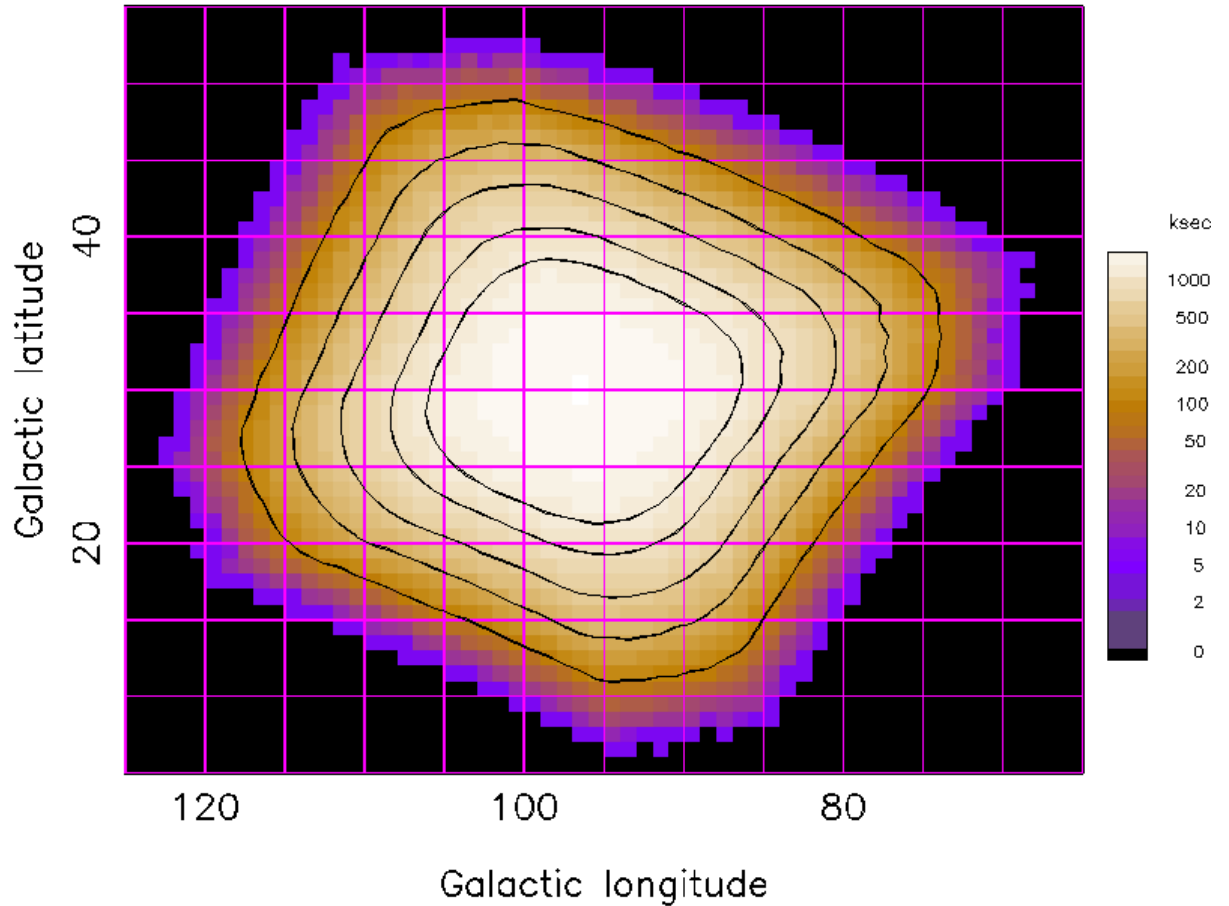


Figure 3. Exposure map (using a total exposure of 2 Ms) for the KP observation *The ultra-deep INTEGRAL legacy hard X-ray survey (PI: M. Ajello, 05K0010)* with contours indicating exposure times of 100, 300, 600, 1000 and 1300 ks, respectively.

2.3.3 Data rights

The TAC has allocated the following specific data rights to this KP observation:

Data rights for the statistical analysis of the source sample only, that is: no exclusive data rights for any individual source in the field.

2.4 Nucleosynthesis and anti-matter annihilation in Cygnus X (PI: J. Knödlseher, 05K0012)

2.4.1 Scientific rationale (summary)

We propose a deep 6 Ms exposure of the Cygnus X region as a multi-year INTEGRAL key program in order to answer a number of central questions related to stellar nucleosynthesis and positron production and diffusion. Cygnus X is the most nearby massive star forming region in our Galaxy, housing several tens of OB associations and massive star clusters at a distance of approximately ~ 1.5 kpc. The proximity of the region brings gamma-ray line emission from individual star clusters in reach of the SPI telescope and the spatial extent of ~ 10 degrees of Cygnus X allows to resolve their contributions. The proposed exposure builds on existing observations of roughly ~ 4.6 Ms of this region. We present analysis results based on the existing observations and illustrate that an additional 6 Ms exposure will allow for a breakthrough in nucleosynthesis and positron annihilation science.

2.4.2 Observing strategy

A total of 2 Ms of observing time has been allocated to this KP in AO-5. Note that this observation will be amalgamated with the KP observation “

Imaging the hyperactive Cygnus TeV superstructure in soft gamma-rays (PI: Y. Butt, 05K0018)”, see Section 2.5, which requested observing time for the same general region of the sky. The observing strategy will be a 10×5 grid, including COP move, centred on RA = $20^{\text{h}}35^{\text{m}}53^{\text{s}}$, Decl. = $+40^{\circ}39'49''$, $(l, b) = (80^{\circ}, 0^{\circ})$ using the standard 2.17° step size between dither points. There will be 10 steps in galactic longitude and 5 steps in galactic latitude. No request is made on the exposure time per grid pointing which will be defined and scheduled by ISOC. The exposure map resulting from this KP observation of the GC area is shown in Figure 4 overlaid with contours of exposure time.

05K0012

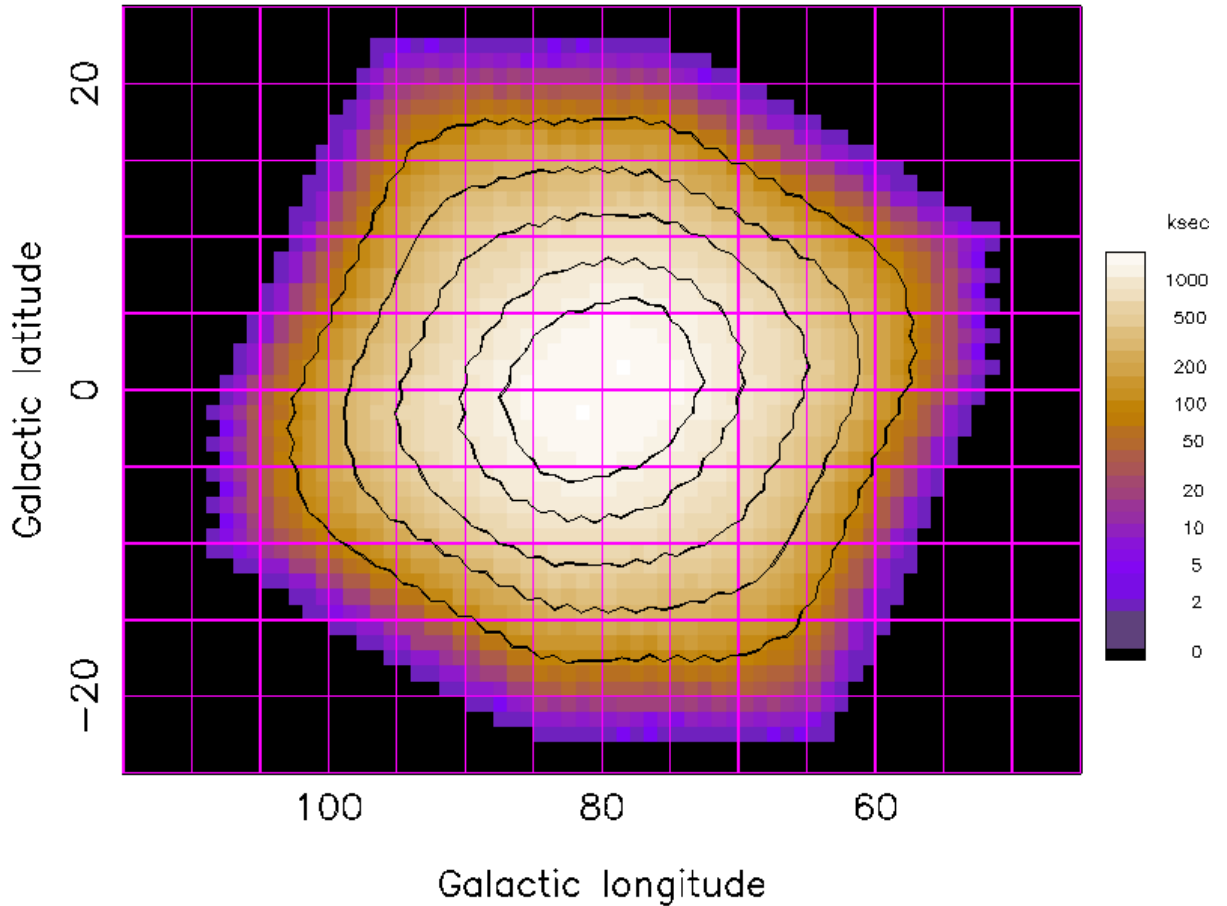


Figure 4. Exposure map (using a total exposure of 2 Ms) for the KP observation *Nucleosynthesis and anti-matter annihilation in Cygnus X* (PI: J. Knödlseher, 05K0012) with contours indicating exposure times of 100, 300, 600, 1000 and 1300 ks, respectively.

2.4.3 Data rights

The TAC has allocated the following specific data rights to this KP observation:

Line emission from ^{26}Al (1.809 MeV), ^{60}Fe (1.173 and 1.332 MeV), and positron/electron annihilation (511 keV) line emission.

2.5 Imaging the hyperactive Cygnus TeV superstructure in soft gamma-rays (PI: Y. Butt, 05K0018)

2.5.1 Scientific rationale (summary)

One of the long-standing aims of gamma-ray astronomy has been to uncover the celestial sites of Galactic Cosmic Ray (GCR) acceleration but, unfortunately, no such nucleonic GCR sources have yet been definitively identified. Superbubbles have been suggested as being able to accelerate cosmic ray nuclei due to their great power, scale and duration. One of the most powerful superbubbles in our Galaxy is the one seen towards Cygnus. Recently the MILAGRO and TIBET air shower arrays have reported on a very large scale ($\sim 10^\circ \times 15^\circ$ wide) diffuse TeV emission region with a flux of ~ 2 Crab above 3 TeV. We propose to map the diffuse soft gamma-ray (>200 keV) counterpart of this TeV emission. This soft gamma-ray Cygnus map will be a critical input to the multiwavelength modeling of the TeV emission and will resolve whether electrons or protons (or both) produce it, and thus whether it really may be a GCR acceleration site.

2.5.2 Observing strategy

This KP observation will be amalgamated with the observation 05K0012, PI: J. Knödlseider (see 2.4) and hence does not receive dedicated exposure time. The dither pattern and pointing strategy as described in Section 2.4.2 and Figure 4 is therefore applicable.

2.5.3 Data rights

The TAC has allocated the following specific data rights to this KP observation:

Data rights for large-scale diffuse continuum hard X-ray/soft gamma-ray emission, and for seven point sources as specified below. No rights on gamma-ray line spectroscopy.

*3EG J2016+3657, size=0.55°; 3EG J2020+4017, size=0.16°;
3EG J2021+3716, size=0.30°; 3EG J2022+4317, size=0.72°;
3EG J2027+3429, size=0.77°; 3EG J2033+4118, size=0.28°;
3EG J2035+4441, size=0.54°*



3 Proposals for targets associated with the KP pointings

Using the unique “targets multiplicity” feature of INTEGRAL’s coded aperture masks, in combination with the very large field of view, allows to accommodate the various requirements of the scientific community at large, both for ultra - long KP studies, as well as for (much) shorter observations of many individual compact objects (i.e. point sources) which are contained in those large fields.

Proposers wishing to submit proposals to be associated with any of the KP observations as described in Section 2 should realize that only source locations for point sources and/or extended targets can be proposed provided their locations are within the 100 ksec exposure contour as shown in Section 2.

In addition, proposers have to respect the exclusive data rights which have been assigned to the PI’s for the KP’s (see Section 2) and which cannot be duplicated,

hence, in summary:

1. Locations of sources/areas receiving a KP exposure of 100 ks or more, can be considered ONLY as candidate sources to be proposed in response to this AO and to be evaluated by the TAC.
2. Data rights assigned to PI’s of selected KP’s need to be observed (see Section 4, and Section 2 for details) and cannot be duplicated.

As is required for all proposals, the exposure required to achieve the scientific objectives has to be justified.

All these proposals will be reviewed by the TAC during the standard AO-5 peer review process, and TAC will assign for successful proposals the data rights on specific source(s), not on the entire FOV, but only per proposal/PI. Concerning un-proposed/non-allocated sources and serendipitous sources in the FOV, we refer to Section 4, and to the AO-5 document on *Science Data Rights*.

A proposal to be associated with the KP may or may not be recommended by TAC to be associated with the KP. If scientifically successful it could also be approved by receiving dedicated exposure time. Likewise, any standard proposal (i.e. disabling the KP flag) may or may not be associated with a KP during the peer review.

3.1 Details concerning PGT for associated KP proposals

In this section we provide some technical information about the submission of proposals to be associated with the KP. The user is referred to the PGT *Users Manual* for further details.

Proposers who are interested to obtain scientific data from KP observations on any target (point or extended diffuse source) as specified in their proposal given the above constraints, i.e. **associated with KP observations**, shall indicate this by enabling the **KP flag** in PGT while



INTEGRAL
AO-5 Key Programmes

Doc.No: INT/SDG/07-0270/Dc
Issue: Issue 1
Date: 12 March 2007
Page: 16 of 17

submitting their proposals in response to this AO-5 release and providing the information required by PGT. Technically, proposers for these observations have less options to choose from in the PGT menu. Obviously, the scientific goals to be obtained by the proposed investigation (e.g. required exposure and/or significance of detection) must be compatible with the observing strategies described for KP observations in Section 2.

In the PGT panel “Proposal Details” a button referring to “Key Programme” shall be enabled. Once this KP flag is set, the following parameters are then disabled in the PGT panel “Observation Details”:

- Duration (of observation)
- Observation Type
- Dither Pattern including preferred orientation,

as these have been already fixed by the observing strategies implemented for the KP itself and cannot be overwritten.

Likewise, all information containing “Instruments modes” in the same panel are disabled.

Note: It is important to keep in mind that the disabled PGT option “Observation Type” actually implies that sources which are proposed to be associated with a KP observation can only be “observed” as “normal type observation”, that is, proposals including sources which rely on specific TOO criteria and/or fixed time requirements are not possible in this context of KP and associated observations.

Note on proposal ID for KP: ID’s for KP proposals which have been submitted and approved by the TAC differ from ID’s which have been assigned for them within PGT and the ISOC database for scheduling purpose. A cross-reference is provided in Table 2.

Proposal ID	PI	ID within PGT and ISOC database
05K0008	G. Bélanger	530000
05K0010	M. Ajello	531000
05K0012	J. Knödseder	532000
05K0018	Y. Butt	532000 (i.e. amalgamated with 05K0012)

Table 2. Cross-reference proposal ID vs database ID.



4 Data rights

The general policy for AO-5, as outlined in the AO document on *Science Data Rights* is applicable.

The execution of the KP observation, which provides data for the KP-PI, as well as for the approved targets from associated proposals for other PIs can be considered as an “amalgamated” observation and the reader is referred for further details to the section on “Multiple targets in the large instrument FOV, and serendipitous sources” as described in the AO document on *Science Data Rights* for general information on data rights for amalgamated observations.

For a specific KP observation (see Section 2) which has been successfully executed so that scientific data can be exploited, the following should be noted:

- a) All PI’s participating in a specific KP observation will receive the entire FOV data for processing and analysis as this is required by the coded aperture characteristics of the instrumentation.
- b) The PI of the KP observation itself (see Table 1 and Section 2) has exclusive data rights assigned by TAC on sources/targets as described in Section 2.
- c) PI’s for targets to be associated with a KP observation have proprietary data rights on those source(s) or extended area(s) only, which have been approved for them by the TAC. After completion of the TAC process, ISOC will inform all participating PI’s about all sources/extended areas which have been allocated by the TAC to individual proposals/PI’s.
- d) All PI’s participating in a KP observation, may publish results on any other source or target contained in that KP observation which is either not proposed or not allocated by TAC. This rule is, in principle, also applicable for all serendipitous sources located in the area covered by the KP with the exception, however, of Gamma-ray bursts (GRB) and their subclass, outbursts from known soft-gamma repeaters (SGR). In previous AO’s, open time (ToO) proposals on GRB and on outbursts from known SGR were awarded to observations of these specific serendipitous sources which are in the prime scientific interest of those open time PIs (for GRB and SGR), while they constitute secondary science objectives only for the PIs participating in the KP. These open time PIs have been granted data rights for a well-specified time interval for these sources (GRB and outbursts from known SGR), even if they occur inside the KP area and during the KP observation. In this case, all PIs involved (open time and KP) will be notified by ISOC. In contrast, any (serendipitous) emission from a new (yet unknown) source (excluding GRB) observed during the KP observation is open for analysis for all PIs (only) who participate in the KP.