

# The INTEGRAL AO-9 programme and INTEGRAL's legacy



- Minutes IUG Meeting Dec 2010, item #8:

*“...at the next meeting, IUG will review the match of the approved AO-9 programme with the long-term science goals. Depending on this match, further steps might be taken (e.g., future special legacy programmes) to make sure the long term goals will be secured.”*

This intention was mentioned in the AO-9 documentation, and the science case for mission extension (incl appendices) is part of the AO-8 data package for the science community and for the TAC.

**EXECUTIVE SUMMARY**

ESA's hard X-ray and soft gamma-ray observatory INTEGRAL is covering the 3 keV to 10 MeV energy band, with excellent sensitivity during long and uninterrupted observations of a large field of view (>100 °<sup>2</sup>), with ms time resolution and keV energy resolution. It takes the energy band of pointed soft X-ray missions such as XMM-Newton with that of hard gamma-ray facilities such as Fermi and ground based TeV observatories. User interest in the observatory is high. No technical issues prevent an extension of the mission until 20 December 2014. For the foreseeable future, INTEGRAL will remain the only observatory allowing the study of nucleosynthesis due to massive stars in our Galaxy, including the long overdue next galactic supernovae, through high-resolution gamma-ray line observations. Further expected key science results cover a wide span of high-energy astrophysics, including studies of the distribution of positrons in the Galaxy, reflection of gamma-rays off clouds in the interstellar medium near the Galactic Centre, studies of black holes and neutron stars, particularly in high-mass systems, gamma-ray polarisation measurements for X-ray binaries and gamma-ray bursts, and sensitive detection capabilities for observed active galaxies, with more than 2000 expected to be found until 2014. The INTEGRAL Users Group unanimously and strongly recommends the mission extension.

**INTRODUCTION**

ESA's hard X-ray and soft gamma-ray observatory INTEGRAL provides the scientific community with a unique energy coverage (3 keV – 10 MeV) and excellent sensitivity in the hard X-ray and soft gamma-ray band (Fig. 1). INTEGRAL therefore complements X-ray missions like XMM-Newton, Chandra, Suzaku, Swift, and NuSTAR (as planned from the end of 2010) with high-energy gamma-ray facilities such as Fermi, AGILE, and ground based gamma-ray telescopes.

INTEGRAL will remain the only observatory world wide providing these capabilities to the community in this decade.

The observing programme, established through annual Assessments of Opportunity, is characterised by deep (x 1 Ma) and often multi-year Programme observations, and, in contrast, also by flexible Target of Opportunity observations, enabling INTEGRAL to react to transient events of astro-

physical significance on the strongly variable gamma-ray sky. The non-subscription in observing time for AO-8 observations (starting in 2011) remains at a high value (x 10) and is comparable to the over-subscription of ~10-year Key Programmes of other high-energy astrophysics missions. To make the best possible scientific use of the entire large field of view, the community can also propose for data rights on individual point sources or extended sky regions, which are located in the field of view of the observing programme, but not included in their original science goals. These sources are simultaneously covered during the observation of the main target. This approach allows the most efficient and timely exploitation of the entire field of view data by various scientific teams. On average, no distinct groups of users work on exploiting the science of each observation. Until June 2010, INTEGRAL observations have resulted in 945 refereed papers and a total of 148 publications. We identified at least 74 PhD theses related to INTEGRAL science, which have been completed since launch, and another 24 PhD theses are in-going (appendix B). During 2009, on average, 2.7 TeV of scientific data was downloaded per month from the INTEGRAL archive at the INTEGRAL Science Data Centre, at SAKAIBASARA, and at BRISICK. More than 200 unique visitors per month were counted, and about 2000 visits to archive servers (including ftp, sub, browse) were registered each month.

**Key science areas of INTEGRAL are:**

- Studies of nucleosynthesis through gamma-ray lines from elements formed in supernovae.
- Studies of the physics of emission mechanisms of white dwarfs, neutron stars, and black holes.
- Deep surveys for supermassive black holes in Active Galactic Nuclei, and
- Observations of gamma-ray bursts.

INTEGRAL is a pathfinder for future missions, providing extremely good synergy with current and future missions. Numerous new astronomical detectors dedicated to the visible Universe are going to be operational during the extension period, which will start the epoch of multi-messenger astronomy. Among others, these include large radio telescopes (LOFAR, ALMA, SKA), large Cherenkov telescopes (CTA), new ultra high-energy cosmic-ray detectors (AGASA, Auger), large neutrino detectors (IceCube, KM3NeT), and advanced gravitational radiation detectors (Advanced LIGO, Virgo), all allowing simultaneous observations of various violent phenomena even in other bands of the electromagnetic spectrum or even with gravitational

INTEGRAL Mission Extension 2010: Science Case, 31 August 2010

**INTEGRAL**  
The International Gamma-Ray Astrophysics Laboratory

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**APPENDIX A**

Submitted by the INTEGRAL Users Group  
31 August 2010

This document is available for download at  
<http://www.esa.int/InfoSite/Products/INTEGRAL/AppendixA>

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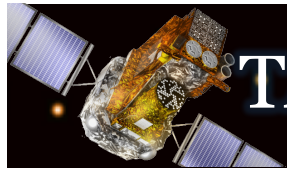
**Mission Extension 2010: INTEGRAL Science Case**

**APPENDIX B**

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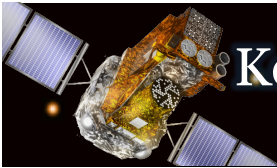


# TAC AO-9 recommendations (non-ToO)



- 8 June 2011: TAC recommended the AO-9 observing programme
- Approval by Director of Science is pending.

 The following table shows – for the sole purpose of this IUG discussion – the necessary “elements” of this AO-9 recommended programme (but leaving out proposal ID, PI and exact proposal title)



# Key elements of the TAC recommended AO-9 programme



Objective	MY (confirmed/new)	Recomm. exposure (Ms)
LMC/SN 1987A	MY – new	3.0
511 keV longitude distribution		2.5
Ultra-lum X-ray sources/low lum AGN	MY – new	2.0
Galactic plane scans	MY – confirmation	2.0
Galactic centre survey	MY – new	2.0
Galactic anti-centre survey (l = 150)		2.0
Galactic halo diffuse emission	MY – confirmation	1.6
3C 273 region	MY – confirmation	1.5
Monitoring: inner spiral arms (Per/Nor, Scu/Sgr)		1.2
Microquasars GRS 1915+105 + Cyg X-1	MY – confirmation	1.2
Carina arm/galactic diff emission		1.0
GC/ galactic diff emission		1.0
NGC 4151 monitoring		0.8
Cyclotron lines		0.6
Monitoring: galactic bulge		0.5
Ultra compact binary		0.5
SS 43		0.4
Circumstellar environment of SFXT		0.2