INTEGRAL: THE INTERNATIONAL GAMMA-RAY ASTROPHYSICS LABORATORY

Christoph Winkler

ESA/ESTEC, Space Science Department, Astrophysics Division, NL–2200 AG Noordwijk, The Netherlands
e-mail: cwinkler@estsa2.estec.esa.nl

ABSTRACT

The International Gamma-Ray Astrophysics Laboratory (INTEGRAL) is dedicated to the fine spectroscopy (ΔE: 2 keV FWHM @ 1 MeV) and fine imaging (angular resolution: $12'$ FWHM) of celestial gamma-ray sources in the energy range 15 keV to 10 MeV. The scientific payload consists of two gamma-ray instruments and two monitors: the Ge spectrometer (SPI) and the CdTe/CsI imager (IBIS); the X-ray monitor (JEM-X) and optical monitor (OMC). INTEGRAL was selected by the ESA Science Programme Committee in 1993 as the next ESA medium-size scientific mission (M2) to be launched in 2001. The mission is conceived as an observatory led by ESA with contributions from Russia and NASA. The INTEGRAL observatory will provide to the science community at large an unprecedented combination of imaging and spectroscopy over a wide range of X-ray and gamma-ray energies including the optical band. Most of the observing time will be open to the scientific community interfacing with the INTEGRAL Science Data Centre. This paper summarises the key scientific goals of the mission, the current status of the payload and spacecraft and it highlights elements of the science ground segment including data centre, science operations and the observing programme.

Keywords: Gamma-ray astronomy, nuclear astrophysics, coded mask imaging, spectroscopy, observatory, ESA

1. INTRODUCTION

The International Gamma-Ray Astrophysics Laboratory (INTEGRAL) is dedicated to the fine spectroscopy (ΔE: 2 keV FWHM @ 1 MeV) and fine imaging (angular resolution: $12'$ FWHM) of celestial gamma-ray sources in the energy range 15 keV to 10 MeV. INTEGRAL was selected by the ESA Science Programme Committee in 1993 as the next ESA medium-size scientific mission (M2) to be launched in 2001. The mission is conceived as an observatory led by ESA with contributions from Russia and NASA.

ESA is responsible for the overall spacecraft and mission design, instrument integration into the payload module, spacecraft integrations and testing, spacecraft operations including one ground station, science operations, and distribution of scientific data. Russia will provide a PROTON launcher and launch facilities, and NASA will provide ground station support through the Deep Space Network. Following an ESA Announcement of Opportunity (issued in 1994), the scientific payload complement, the INTEGRAL Science Data Centre (ISDC), and Mission Scientists were selected in May 1995. The scientific instruments and the ISDC will be provided by large collaborations encompassing many scientific institutes in ESA member states, USA, Russia and Poland, nationally funded, and led by Principal Investigators (PI).

The INTEGRAL observatory will provide to the science community at large an unprecedented combination of imaging and spectroscopy over a wide range of X-ray and gamma-ray energies including optical monitoring. Further information on INTEGRAL can be found in Winkler 1993, Matteson et al. 1994, Winkler 1994, Winkler 1996 and references therein.

2. SCIENTIFIC OBJECTIVES

INTEGRAL is a 15 keV - 10 MeV gamma-ray mission with concurrent source monitoring at X-rays (3 - 35 keV) and in the optical range (550 - 850 nm). All instruments - co-aligned with large FOV's - cover simultaneously a very broad energy range of high energy sources.

The scientific goals of INTEGRAL will be attained by fine spectroscopy (ΔE: 2 keV FWHM @ 1 MeV) with fine imaging (angular resolution: $12'$ FWHM) and accurate positioning of celestial sources of gamma-ray emission. Fine spectroscopy over the entire energy range will permit spectral features to be uniquely identified and line profiles to be determined for physical studies of the source region. The fine imaging capability of INTEGRAL within a large field of view will permit the accurate location and hence identification of the gamma-ray emitting objects with counterparts at other wavelengths, enable extended regions to be distinguished from point sources and provide considerable serendipitous science which is very important for an observatory-class mission. In summary the scientific topics to be addressed include:

- Compact Objects (White Dwarfs, Neutron Stars,

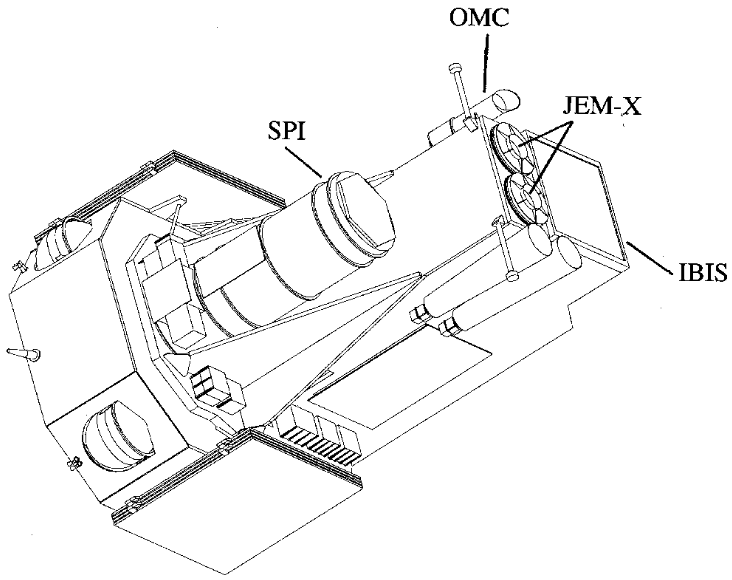

Figure 1: The INTEGRAL spacecraft (solar arrays stowed) with the payload module on top the service module which is common with XMM. The coded masks for the Imager (IBIS) and X-ray Monitor (JEM-X) are located at 3.2 m above the detector planes. IBIS and JEM-X detectors are inside the payload module structure. The overall dimensions of the service and payload modules are 6 m x 4 m (h x w), the deployed solar arrays span $\sim$ 16 m, the total dry mass is 3600 kg (including 2019 kg for the payload).

Black Hole Candidates)

- Stellar Nucleosynthesis (Hydrostatic Processes, Supernovae, Novae)
- High Energy Transients
- Galactic Structure (Cloud Complex Regions, Mapping of continuum and line emission, ISM, CR distribution)
- The Galactic Centre
- Particle Processes and Acceleration
- Transrelativistic Pair Plasmas
- Extragalactic Astronomy (Nearby Galaxies, Clusters, AGN, Cosmic Diffuse Background)
- Identification of High Energy Sources
- Unidentified Gamma-Ray Objects as a Class
- PLUS: Unexpected Discoveries

An essential factor for the achievement of the scientific goals, which consequently impacts the payload design (see below), is the capability to achieve - to the maximum extent possible - complementarity in fine spectroscopy and accurate imaging.

This shall be illustrated in a sample observation of the Galactic Centre region. Consider a deep (few 10^6 s) exposure of that region (i.e. typically $60° \times 15°$, centred on (l, b) = (0, 0)). Our knowledge of the Galactic Centre region at high energies is largely determined by the results on point sources detected at hard X-rays/low energy gamma-rays as provided by the GRANAT instruments SIGMA (Vargas et al. 1996) and ART - P (Pavlinsky et al. 1994), as well as the results on diffuse galactic emission as measured by the CGRO instruments COMPTEL at 1.8 MeV of Al^{26} (Diehl 1997) and OSSE at 511 keV (Purcell 1997). The following list shows what can be studied in great detail with the INTEGRAL instruments. The letter *S* denotes that this task will be mainly achieved through fine spectroscopy, while the *I* denotes that this task will be mainly achieved through accurate imaging:

- Map diffuse 511 keV and 1.8 MeV emission in great detail on large angular scale (*S*)
- Measure the spectrum of the diffuse Galactic continuum emission (*S*, *I*)
- Image known sources, identify new point sources, companions of compact sources and hot spots from diffuse mapping in the G.C. region with high accuracy (*I*)
- Determine the point source contribution to the observed 511 keV flux (*S*, *I*)
- Study the continuum characteristics of an ensemble of point sources (spectral classes and shapes) (*I*)
- Perform spectroscopic studies of individual point sources: narrow lines (cyclotron and nuclear lines), broad lines (511 keV features including backscattering lines), line shifts (gravitational redshift ?), line shapes and line profiles (*S*, *I*)
- Perform continuum and line studies of "hot spots" identified in diffuse maps, i.e. the cosmic

ray/dust ratio and cosmic ray/gas ratio in case of narrow and broad lines, respectively, with line profile analysis and isotope determination (*S*, *I*)

- Timing, variability (QPO's) and polarisation analysis of compact sources (*I*)

3. SCIENTIFIC PAYLOAD

The INTEGRAL payload consists of two main gamma-ray instruments: Spectrometer SPI and Imager IBIS, and of two monitor instruments, the X-ray Monitor JEM-X and the Optical Monitoring Camera OMC.

The design of the INTEGRAL instruments is largely driven by the scientific requirement to establish a payload of scientific complementarity. As shown in Tab.1, the payload does meet this goal.

Each of the main gamma-ray instruments, SPI and IBIS, has both spectral and angular resolution, but they are differently optimised in order to complement each other and to achieve overall excellent performance. This optimisation also takes recent observations at high energies into account, which show that - in general - line emissions do occur on a wide range of angular and spectral extent: That is, broad lines seem preferably to be emitted from point-like sources and narrower lines from extended sources (v. Ballmoos et al. 1995). The two monitor instruments (JEM-X and OMC) will provide complementary observations of high energy sources at X-ray and optical energy bands. An overview of the INTEGRAL payload is given below, detailed descriptions can be found in the instrument papers presented at this workshop.

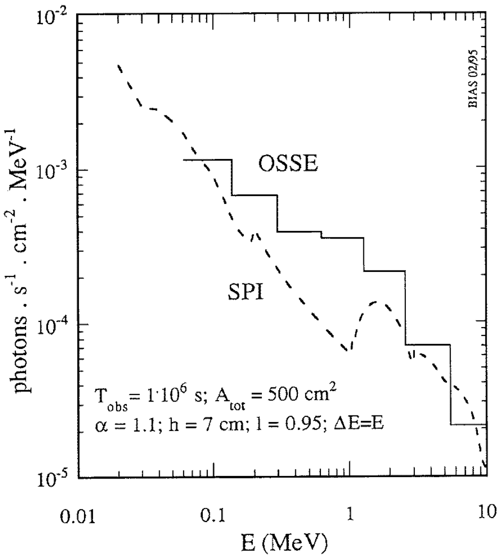

Figure 2: SPI continuum sensitivity (3σ, 10^6 s, ΔE = E).

Part of the payload also is a small particle radiation monitor, which continuously measures the particle environment. Therefore it is possible to provide essential information to the payload in case high particle background (radiation belts, solar flares) is being encountered. This information is used to decide on switch - off and switch - on of instrument high voltages and to provide actual background information for sensitivity estimates.

Spectrometer SPI
The Spectrometer SPI (Tab.2, Figs. 2 and 3) will perform spectral analysis of gamma-ray point sources and extended regions with an unprecedented energy resolution of 2 keV (FWHM) at 1 MeV.

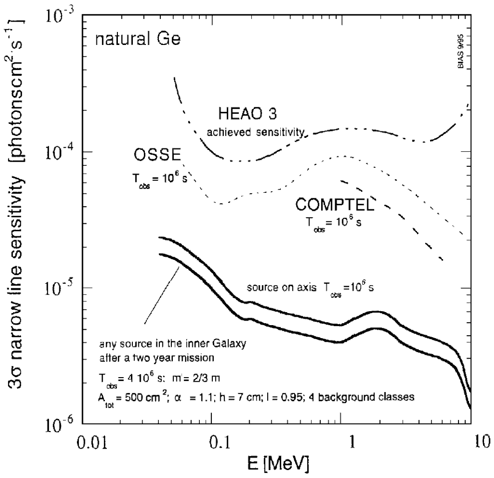

Figure 3: SPI narrow-line sensitivity. Upper solid curve is for 3σ detection in 10^6 s. The line sensitivity at 511 keV is 2×10^{-5} ph cm^{-1} s^{-1}.

This will be accomplished using an array of 19 hexagonal high purity Germanium detectors cooled by active cooling to an operating temperature of 85 K. The total detection area is 500 cm^2. A hexagonal coded aperture mask is located 1.7 m above the detection plane in order to image large regions of the sky (fully coded field of view = $16°$) with an angular resolution of $2°$.

In order to reduce background radiation, the detector assembly is shielded by an active BGO veto system which extends around the bottom and side of the detector almost completely up to the coded mask. The SPI collaboration is led by the Co-PI's G. Vedrenne (CESR, Toulouse/France) and V. Schönfelder (MPE, Garching/Germany) with collaborating institutes in France, Germany, Italy, Spain, Belgium, UK and USA.

Imager IBIS
The Imager IBIS (Tab.2, Figs. 4 and 5) provides powerful diagnostic capabilities of fine imaging (12 arcmin FWHM), source identification and spectral sensitivity to both continuum and broad lines over a broad (15 keV - 10 MeV) energy range. The energy resolution is < 7 keV @ 0.1 MeV and 60 keV @ 1 MeV. A tungsten coded aperture mask (located at 3.2 m above the detection plane) is optimised for high angular resolution imaging. Sources ($> 10\sigma$) can be located to $< 60''$. As diffraction is negligible at gamma-ray wavelengths, the angular resolution obtainable with a coded mask telescope is limited by

the spatial resolution of the detector array. The IBIS design takes advantage of this by utilising a detector with a large number of spatially resolved pixels, implemented as physically distinct elements.

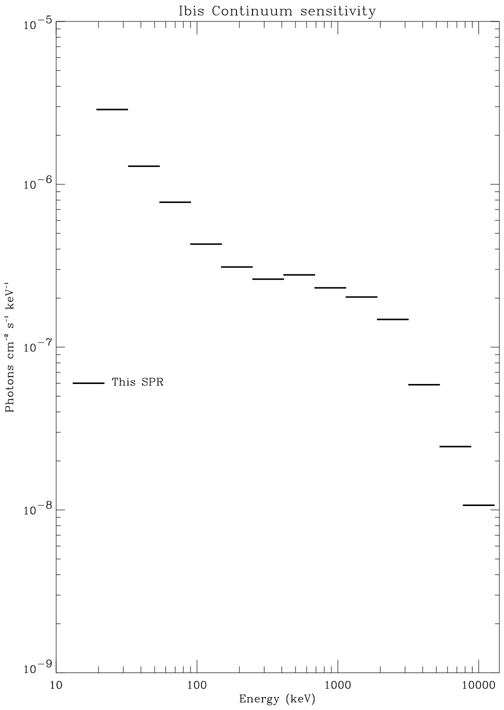

Figure 4: Continuum sensitivity (3σ, 10^6 s, ΔE = E/2) for IBIS.

The detector uses two planes, a front layer (2600 cm^2) of CdTe pixels, each (4x4x2) mm (wxdxh), and a second one (3100 cm^2) of CsI pixels, each (9x9x30) mm. The detector provides the wide energy range and high sensitivity continuum spectroscopy required for INTEGRAL. The division into two layers allows the paths of the photons to be tracked in 3D, as they scatter and interact with more than one element. The aperture is restricted by a passive tungsten shield. The detector array is shielded in all other directions by a BGO scintillator veto system. The Imager collaboration is led by the PI P. Ubertini (IAS, Frascati/Italy), with collaborating institutes in Italy, France, Spain, Germany, Norway, USA, Poland, UK and Switzerland.

X-Ray Monitor JEM-X

The Joint European X-Ray Monitor JEM-X (Tab.2, Figs. 6 and 7) supplements the main INTEGRAL instruments (Spectrometer and Imager) and plays a crucial role in the detection and identification of the gamma-ray sources and in the analysis and scientific interpretation of INTEGRAL gamma-ray data. JEM-X will make observations simultaneously with the main gamma-ray instruments and provides images with $3'$ angular resolution in the 3 - 35 keV prime energy band (extension up to 100 keV possible).

The baseline photon detection system consists of two identical high pressure imaging microstrip gas chambers (Xenon at 5 bar) each viewing the sky through a coded aperture mask (4.8° fully coded FOV), located at a distance of 3.2 m above the detection plane.

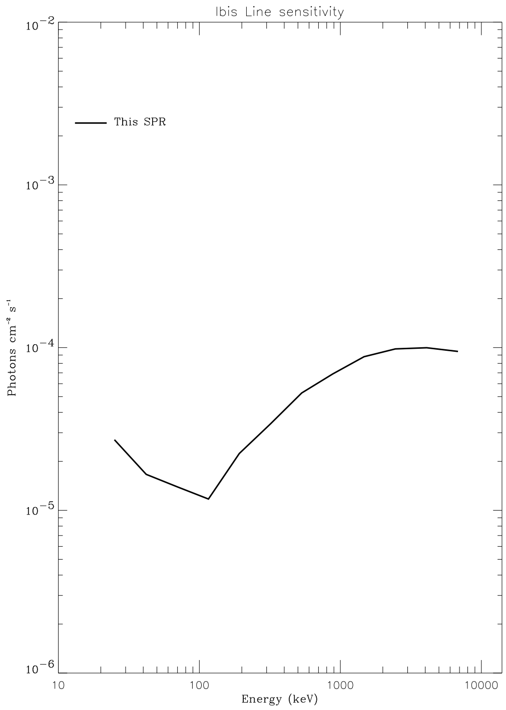

Figure 5: Line sensitivity (3σ, 10^6 s) for IBIS.

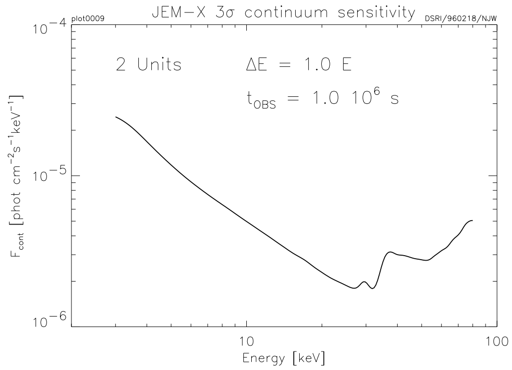

Figure 6: Continuum sensitivity (3σ, 10^6 s, ΔE = E) for JEM-X

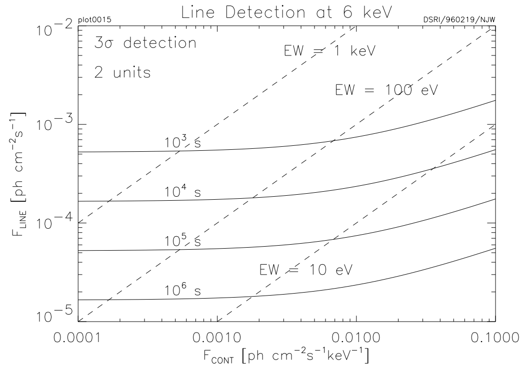

Figure 7: Line detection sensitivity at 6 keV (3σ) for JEM-X

Table 1: INTEGRAL science and payload complementarity

Instrument	Energy range	Main purpose
Spectrometer SPI	20 keV - 8 MeV	Fine spectroscopy of narrow lines Study diffuse emission on >deg 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 Monitoring @ X-rays
Optical Monitor OMC	500 - 850 nm	Optical monitoring of high energy sources

Table 2: Key parameters of the INTEGRAL scientific payload

	Spectrometer SPI	Imager IBIS	X-ray Monitor JEM-X	Optical Monitor OMC
Energy range	20 keV - 8 MeV	15 keV - 10 MeV	3 keV - 35 (100) keV	(500 - 850) nm
Detector area (cm^2)	500	2600 (CdTe) 3100 (CsI)	1000 (2 units each 500 cm^2)	CCD + V-filter (2048 $\times$ 1024 pixels)
Spectral resolution $\Delta E/E$ (%)	0.2 (at 1 MeV)	$<$ 7 (at 100 keV) 6 (at 1 MeV)	$47/\sqrt{(E/1\ keV)}$	–
Field of view (fully coded)	$16°$	$9°$ x $9°$	$4.8°$	$5.0°$ x $5.0°$
Angular resolution	$2°$ FWHM	$12'$ FWHM	$3'$ FWHM	$17.6''$/pixel (size)
Typical source location	$20'$	$< 1'$	$< 20''$	$< 8''$
Continuum sensitivity (3σ, 10^6 s)	7×10^{-8} @ 1 MeV (ph cm^{-2} s^{-1} keV^{-1})	4×10^{-7} @ 100 keV (ph cm^{-2} s^{-1} keV^{-1})	9×10^{-6} @ 6 keV (ph cm^{-2} s^{-1} keV^{-1})	19.2^{m_v} (3σ, 10^3 s)
Line sensitivity (3σ, 10^6 s)	5×10^{-6} @ 1 MeV (ph cm^{-2} s^{-1})	1×10^{-5} @ 100 keV (ph cm^{-2} s^{-1})	1.7 $\times10^{-5}$ @ 6 keV (ph cm^{-2} s^{-1})	–
Timing accuracy (3σ)	0.1 ms	$<$ 1 ms (timing) few minutes (imaging)	10 μs	variable in units of 1 s
Mass (kg)	1309	628	65	17
Power (W)	250	220	52	12
Data rate (kbps)	25 (avge)	37 (avge)	6.7	1.7

The total detection area is 1000 cm^2. The JEM-X collaboration is led by the PI H. Schnopper (DSRI, Copenhagen/Denmark) with collaborating institutes in Denmark, Finland, Spain, Poland, Italy, USA, UK, Sweden and Russia.

Optical Monitoring Camera OMC

The Optical Monitoring Camera OMC (Tab.2) consists of a passively cooled CCD in the focal plane of a 50 mm lens. The CCD (1024 x 2048 pixels) uses one section (1024 x 1024 pixels) for imaging, the other one for frame transfer before readout. The FOV is $5° \times 5°$ with a pixel size of 17.6″. The OMC will observe the optical emission from the prime targets of the INTEGRAL main gamma-ray instruments with the support of the X-Ray Monitor JEM-X. OMC offers the first opportunity to make long observations in the optical band simultaneously with those at X-rays and gamma-rays. Variability patterns ranging from 10's of seconds, hours, up to months and years will be monitored. The limiting magnitude will be 19.2^{m_v} (3σ, 10^3 s), which corresponds to $\sim$40 photons cm^{-2}s^{-1}keV^{-1} (@ 2.2 eV) in the V-band. Multi-wavelength observations are particularly important in high-energy astrophysics where variability is typically rapid. The wide band observing opportunity offered by INTEGRAL is of unique importance in providing for the first time simultaneous observations over seven orders of magnitude in photon energy for some of the most energetic objects in the Universe. The OMC collaboration is led by the PI A. Gimenez (INTA, Madrid/Spain) with collaborting institutes in Spain, Ireland, Belgium and UK.

The gamma-ray observatory INTEGRAL, with an energy range – covered by the three high energy instruments – of 3 keV to 10 MeV is complemented in the energy domain by future X-ray observatories XMM (0.1 - 12 keV), AXAF (0.1 - 10 keV) and Spectrum X/γ (0.1 - 100 keV). Interestingly, all 4 missions will be operational during the 2001+ timeframe hence offering to the scientific community a unique opportunity for co-ordinated observations of high energy sources over 5 continuous decades in energy.

4. MISSION SCENARIO

The INTEGRAL spacecraft (Fig. 1) consists of a service module (commonly designed with the service module of the ESA XMM mission) containing all spacecraft subsystems, and a payload module containing the scientific instruments. The simplicity of the interface between service and payload module is a major design driver. The modular approach has been conceived to allow for a parallel development, assembly, integration and test of service and payload module, respectively. Details on the current spacecraft design can be found in Carli et al. (1997).

INTEGRAL (with a payload mass of 2019 kg and a total launch mass of < 4000 kg) will be launched in April 2001 into a geosynchronous highly eccentric orbit with high perigee in order to provide long periods of uninterrupted observation with nearly constant background and away from trapped radiation. The baseline is to launch INTEGRAL with a Russian PROTON. The parameters for the baseline orbit (Fig. 8) are: period 72 hours, inclination 51.6°, perigee height 48 000 km, apogee height 115 000 km. Alternatively, the ESA ARIANE 5 launcher (period 48 hours, inclination 60.0°, perigee height 4000 km, apogee height 117 000 km) can be used. The spacecraft design is compatible with both launchers. Owing to background radiation effects in the high-energy detectors, scientific observations will be carried out while the spacecraft is above an altitude of typically 40 000 km. This means, that 100% of the time spent in the orbit provided by PROTON can be used for scientific observations (real-time scientific data rate: 67 kbps), whereas the spacecraft will stay 85% of its time above 40 000 km if placed in the ARIANE 5 orbit. Particle background of the local environment will be continuously measured by the on-board radiation monitor: this device allows the optimisation of the observing time before or after radiation belt passages and solar flare events, and provides essential information about the actual background.

The spacecraft employs fixed solar arrays: this means, that the target pointing of the spacecraft (at any point in time) will remain outside an avoidance cone around the sun. This leads to a minimum angle between any celestial source and the sun of 50° during the nominal mission life (2 years) and 60° during extended mission life (year 3+). The sky access is 64% (50%) at any point in time, respectively.

Because of the imaging deconvolution requirements by SPI, the spacecraft will routinely, during nominal operations, perform a series of off-source pointing manouevres, known as "dithering". These dithering patterns consist of 6 up to about 24 different pointings to sky positions around the nominal target position, separated by typically 2°. The exposure time per point is about 20 minutes.

5. GROUND SEGMENT

The ground segment (Fig. 9) consists of two major elements, the Operations Ground Segment (OGS) and the Science Ground Segment (SGS): The OGS, consisting of the ESA and NASA ground stations and ESA's Mission Operations Centre (MOC) at ESOC, will implement the observation plan received from the ISOC within the spacecraft system constraints into an operational command sequence. In addition, the OGS will perform all classical spacecraft operations, real-time contacts with spacecraft and payload, maintenance tasks and anomaly checks (i.e. including payload critical health and safety). MOC will determine the spacecraft attitude and orbit, and will provide raw science data to the SGS.

The SGS consists of two components, the INTEGRAL Science Operations Centre (ISOC) and the INTEGRAL Science Data Centre (ISDC). The ISOC (provided by ESA and located at ESTEC) will issue the AO for observing time and handle the incoming proposals. Accepted observation proposals (see below) will then be processed at ISOC into an optimised observation plan which consists of a timeline of target pointings plus the corresponding instrument configuration. This observation plan will

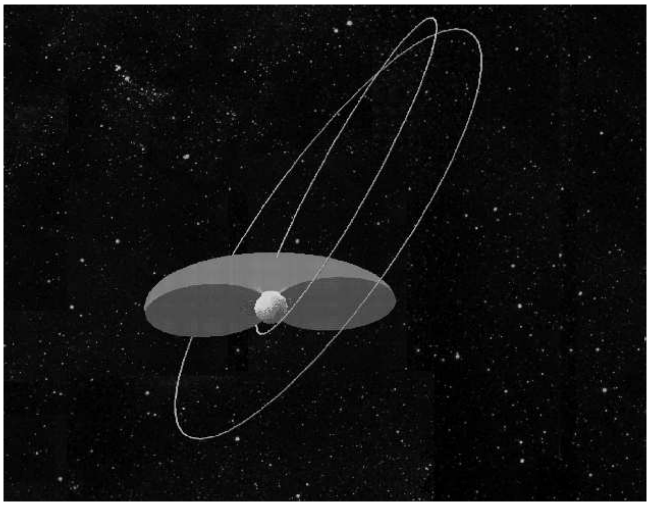

Figure 8: Operational orbits for INTEGRAL. On the baseline PROTON orbit (outer elliptical curve) with period: 72 hours, inclination: 51.6°, perigee height: 48 000 km and apogee height: 115 000 km, the spacecraft will completely stay outside the denser regions of the electron radiation belts (shown schematically in grey with the Earth in the centre). On the alternative ARIANE 5 orbit (inner elliptical curve, period: 48 hours, inclination: 60.0°, perigee height: 4000 km, apogee height: 117 000 km), the payload would not be operated while below $\sim$ 40 000 km (i.e. inside the electron belts).

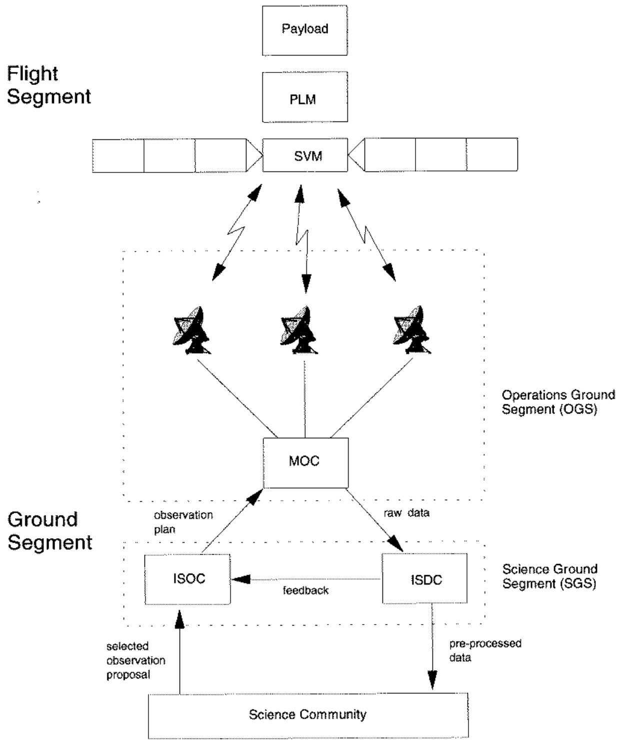

Figure 9: The INTEGRAL flight and ground segments.

then be forwarded to MOC to be uplinked to the spacecraft. Furthermore, the ISOC will validate any changes made to parameters describing the on-board instrument configuration and it will keep a copy of the scientific archive produced at the ISDC. Finally, the ESA Project Scientist at the ISOC will decide on the generation of TOO alerts (Target of Opportunity) in order to update and reschedule the observing programme.

The ISDC, located in Versoix, Switzerland, will receive the complete raw science telemetry plus the relevant ancillary spacecraft data from the OGS/MOC. Science data will be processed, taking into account the instrument characteristics, and raw data will be converted into physical units. Using incoming science and housekeeping information, the ISDC will routinely monitor the instrument science performance and conduct a quick-look science analysis. Most of the Targets of Opportunity (TOO) showing up during the lifetime of INTEGRAL will be detected at the ISDC during the routine scrutiny of the data and will be reported to ISOC. Final data products obtained by standard analysis tools will be distributed to the observer and archived for later use by the science community. Facilities will be provided to support the science community in the analysis of INTEGRAL data. The ISDC will be provided by the scientific community led by the PI T.Courvoisier, Geneva Observatory, with collaborating institutes in Switzerland, Ireland, Denmark, Italy, France, Germany, UK, USA and Poland. Further details on the ISDC can be found in e.g. Courvoisier (1997).

6. OBSERVING PROGRAMME

INTEGRAL will be an observatory-type mission with a nominal lifetime of 2 years, an extension up to 5 years is technically possible. Most of the observing time (65% during year 1, 70% (year 2), 75% (year 3+)) will be awarded to the scientific community at large as the General Programme. Typical observations will last from 10's of minutes up to two weeks. Proposals, following a standard AO process, will be selected on their scientific merit only by a single Time Allocation Committee. These selected observations are the base of the General Programme. The first call for observation proposals will be issued one year prior to launch. In principle, observers will receive data from all co-aligned and simultaneously operating instruments onboard INTEGRAL.

The remaining fraction of the observing time (i.e. 35% (year 1), 30% (year 2), 25% (year 3+)) will be reserved, as guaranteed time, for: (i) the institutes (PI collaborations) which have developed and delivered the instruments and the ISDC (guaranteed PI time), (ii) for Russia and NASA for their contributions to the programme (PROTON launcher and Deep Space Network ground stations), and to a smaller extent, (iii) for ESA/ISOC and the Mission Scientists from Europe, USA and Russia. This fraction, the Core Programme, will be devoted to:

- a Galactic Plane Survey (i.e. slow scans along the Galactic plane at fixed time intervals) in order to (i) map its (diffuse) gamma-ray emission, (ii) detect as yet unknown persistent sources (e.g. recent Galactic supernovae), and (iii) to facilitate the detection and study of transient sources (TOO's)

- pointed (deep) observations of selected regions, yet to be determined by the members of the INTEGRAL Science Working Team (PI's, Mission Scientists et al.).

The scans of the Galactic plane (Galactic Plane Survey) will be performed – using all instruments – along that part of the Galactic plane (Δl, Δb) which is accessible for the spacecraft at a given point in time. In fact, each scan consists of a number of individual exposures at discrete points. A typical step size between two exposures is few degrees, and the exposure would be in the range of a few to apx. ten minutes per point. The frequency of these scans depends on the time scales for high energy transient events, on the source detection sensitivity and total time allocated for scans within the total Core Programme time budget.

The continuum sensitivity of the payload to detect sources at 3σ within an exposure of 5 minutes is about 10 mCrab (@ 20 keV), 100 mCrab (@ 200 keV) and 1 Crab (@ 1 MeV). The current design of the INTEGRAL Core Programme including Galactic Plane Survey is described in more detail by Gehrels et al. (1997). The full details of the Core Programme will be made available at the issue of the first AO (at 12 months before launch).

The ISDC will serve the entire guest observer community and it is the place where the archive and derived scientific products will be built and made accessible to the wide astronomical community. Scientists will have the possibility to visit the ISDC to familiarise themselves with INTEGRAL data. In accordance with ESA's policy on data rights, all scientific data will be made available to the scientific community at large one year after they have been released to the observer. This guarantees the use of the scientific data for different investigations beyond the aim of a single proposal.

ACKNOWLEDGMENTS

This paper has been written on behalf of the INTEGRAL Science Working Team: G. Vedrenne (SPI), V. Schönfelder (SPI), P. Ubertini (IBIS), F. Lebrun (IBIS), H. Schnopper (JEM-X), A. Gimenez (OMC), T. Courvoisier (ISDC), N. Gehrels, W. Hermsen, J. Paul, G. Palumbo, S. Grebenev (Mission Scientists), B. Teegarden (NASA/USA), R. Sunyaev (IKI/Russia) and C. Winkler (ESA).

For up-to-date information on the status of the project please consult the INTEGRAL pages on the WWW: http://astro.estec.esa.nl/SA-general/Projects/Integral/integral.html

REFERENCES

v. Ballmoos, P., Dean, A.J., and Winkler, C. 1995, Proc. 17th Texas Symp., Ann. New York Acad. of Sciences 759, 401

Carli, R., et al. 1997, these proceedings

Courvoisier, T. 1997, these proceedings

Diehl, R. 1997, these proceedings

Gehrels, N., et al. 1997, these proceedings

Matteson, J.L., Dean, A.J., and Winkler, C. 1994, Proc. 2nd CGRO Symp., AIP 294, 89

Pavlinsky, M., et al. 1994, ApJ 425, 110

Purcell, W. 1997, these proceedings

Vargas, M., et al. 1996, SAP-Saclay preprint No. 1996/32

Winkler, C. (Editor) 1993, Report on INTEGRAL Phase A Study, ESA SCI (93)1

Winkler, C. 1994, ApJSS 92, 327

Winkler, C. 1996, A&ASS (Proc. 4th CGRO Symposium), in press