OBSERVING TIME ESTIMATOR
USER MANUAL

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1. Introduction

The **Observing Time Estimator (OTE)** is a software tool residing on the ISOC system at ESTEC, which may be run remotely over the internet by potential Integral observers.

This issue describes version 2 of the OTE s/w

The purpose of the OTE is to give such users a reliable guide as to how feasible their proposed observations are; i.e. for given source characteristics (spectrum, flux), it will tell them what signal-to-noise ratio is achievable in a requested observing time, or conversely, what integration time is needed to achieve a desired signal-to-noise ratio.

The OTE currently simulates the principle gamma-ray instruments, SPI and IBIS. JEM-X and OMC are not simulated here; for the two monitors, users are referred to the *JEM-X Observer's manua*l and *OMC Observer's manual* respectively.

All proposals made for INTEGRAL should use the OTE calculations for their observation durations. ***These are the figures which ISOC will use in their technical feasibility assessments of observing proposals, upon which the TAC decisions will be based.***

2. Instrumental background

For most astronomical sources, and for most of the energy range of SPI and IBIS, the instrumental background countrate is significantly higher than the source countrate.

Below ~ 100 keV, the IBIS background comes principally from the diffuse cosmic hard X-ray background and may be easily predicted. For most of the energy range of IBIS, and all of SPI, the instrumental background is dominated by charged particles. Cosmic ray hadrons interact with the solid body on INTEGRAL, and the induced radioactivity (β-particles, hadrons and gamma rays) in the spacecraft produces the background (interested users are referred to the *SPI* and *IBIS Observer's Manuals*).

For AO-1, the background was modelled using the INTEGRAL Mass Model at the University of Southampton. Now that in-orbit measurements are available, the OTE uses the real instrumental background where available - otherwise pre-launch values may still be used. Please refer to the AO-2 IBIS and SPI observer manuals.

3. How to use the OTE

OTE can be accessed via the ISOC web site,

http://rssd.esa.int/Integral/isoc/

and clicking on '**Proposal tools**'. OTE is then available directly under '**Observation Time Estimator**' and more indirectly via PGT (see the *PGT Software User Manual*).

3.1 Input to OTE

Once OTE is started, the user must first select the instrument, SPI or IBIS.

Step 2 is to select a continuum or line source. For the continuum the user must set the lower and upper energies for which the calculation is to be performed; or for the line, the central energy and line width (FWHM). If the line is unresolved, a line width of 0.1 keV is sufficient. Please also refer to 3.2 (ii)

Step 3 is to select one of two options; either input a signal-to-noise ratio, in which case the OTE will return the exposure time, or input an exposure time, in which case the OTE will return the signal-to-noise ratio.

Step 4 is to enter the source flux. ***This the in-band flux, photons $cm^{-2}s^{-1}$,*** in either the selected continuum range (for the continuum) or integrated over the full width at zero intensity (for a line). *Beware! The continuum sensitivity curves in the SPI and IBIS Observer's manuals use different units, monochromatic flux density (photons $cm^{-2}s^{-1}keV^{-1}$).*

Also in step 4 the user may optionally enter the source position (J2000). The OTE accesses the Comptel all-sky catalogue and warns the user if there are any nearby

bright sources (within the fully or partially coded field of view) which could affect the observation (especially for 5 x 5 dithers; see the *INTEGRAL manual*).

In step 5 the user should select the desired dither pattern. This has small effect for IBIS but can be very important for SPI! We generally recommend that the 5 x 5 dither pattern be used - see the SPI observer's manual.

Step 6 is self-explanatory: GO!

3.2 Hints and warnings:

(i) Units

Please be careful with units! Input time is kiloseconds! Use broad band flux for source strength!

(ii) Energy band

OTE does not allow the use of a broad energy band, e.g 20keV to 10MeV! This may give misleading results.

OTE calculates the *average* performance across a user defined continuum energy band given the flux of the source in that band. However, the sensitivity of the instruments can vary enormously over their energy ranges. In addition, the gamma-ray instruments can have very rapid changes in sensitivity in a comparatively small range of energies (especially around 511 keV!). Also, many (most) gamma-ray sources exhibit steep spectra so that they are very much fainter at higher energies. Even for hard sources, including the highest energies will reduce in very low signal-to-noise ratio due to the relatively high background at MeV energies, compared to the source flux.

For these reasons, the output of OTE is generally more accurate when applied across energy bands which are narrower than the entire instrumental bandpass. We advise that the prospective observer performs OTE calculations only across the continuum range of interest rather than the whole range of the instrument.

Therefore, OTE does not allow the use of an energy band wider than $\Delta E = E/2$.

Of course the prospective observer may be in a situation where the continuum range of interest is very wide. In such a situation, the observer should run a number of calculations for a set of continuum energy bands which cover the range of interest and take the quadratic sum of the individual signal-to-noise ratios (provided the energy bands do not overlap!).

(iii) Prospective IBIS users should also note the following.

If the continuum range of interest can straddle the energy ranges of ISGRI and PICSIT and be only partialy inside the energy of one or both. We recommend calculating the in-band flux for the energy range of interest covered by ISGRI and by PICsIT separately and combining the results. If only one calculation is done for the entire range of interest, both sub-instruments might report a poorer response than is truly available. If one does go beyond the energy range of a (sub) instrument, a warning is given.

3.2 Output from OTE

OTE returns one screen with;

- The original input values;

- Any nearby strong source information (coordinates, name from the Comptel catalogue);

- Warnings, if part of the selected energy band for the source calculation is outside the energy range of the selected instrument;

- calculated exposure time, or signal-to-noise ratio.

For IBIS, results are given separately for ISGRI single events, PICsIT multiple events and multiple (Compton) events. As discussed in the *IBIS Observer's manual,* we recommend combining the ISGRI and PICsIT results, but not the Compton.

*Also be aware that the returned exposure time may be output in either seconds or kiloseconds, depending on its valu*e.