INTEGRAL

Science Operations Centre

Software User Manual

Observing Time Estimator

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Prepared by M. Bindels
Authorised by L. Hansson

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1 Introduction

The **Observing Time Estimator (OTE)** is a software tool residing on the ISOC system at ESAC, which may be run remotely over the internet by potential Integral observers. This software user manual describes OTE version 4.

The improvements over the previous version include the use of the 2nd ISGRI catalogue of bright sources and slight changes in the presentation of results.

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 values which the ISOC will use in their technical feasibility assessment 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. There is one exception; fluorescence from the coded mask dominates near 20 keV. For the rest 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 of 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. Please refer also to the AO-4 *IBIS* and *SPI observer manual*s.

3 How to use the OTE

OTE can be accessed via the ISOC web site,

http://integral.esac.esa.int

and clicking on '**Proposal tools**'. OTE is then available directly under '**Observation Time Estimator**'.

3.1 Input to OTE

Step 1. 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 a continuum calculation the user must set the lower and upper energies. The allowed range is 15 keV - 10 MeV. OTE will assume a power law spectrum and the photon spectral index is needed as input to the GUI. ***If you wish to perform calculations for a continuum source, please make sure to read section 3.2***.

- for a line source, input the central energy and line width (FWHM). If the line is unresolved, a line width of 0.1 keV is sufficient.

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 is the broad-band flux, in units of photons $cm^{-2}s^{-1}$**,** in either the selected energy 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 in either degrees or sexagesimal notation (J2000). The OTE accesses the 2^{nd} ISGRI catalogue and warns the user if there are any nearby bright sources - for example, a bright source in the partially coded field of view can cause ghosts in the final image.

In step 5 the user should select the desired dither pattern.

- This will take into account the off-axis response of the instruments as INTEGRAL dithers. This is very important for SPI! The effect of the off-axis dither points on the IBIS sensitivity is small but staring is not recommended We generally recommend that the 5 x 5 dither pattern be used - see the *IBIS* and *SPI observer's manuals*.

Step 6 is self-explanatory:

- GO!

3.2 Continuum calculations; a note on energy ranges

While a broad energy range is allowed in the OTE i*nput*, the OTE back-end *calculations* themselves do not allow the use of a broad energy band, e.g 20keV to 10MeV.

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 result in very low signal-to-noise ratio due to the relatively high background at MeV energies, compared to the source flux.

For these reasons, in previous AOs OTE was restricted to energy bands which are narrower than the entire instrumental bandpass.

Of course the prospective observer may be in a situation where the continuum range of interest is rather wide. To allow this the front-end (GUI) of OTE allow the user to specify a wider band.

A "wrapper" underneath the GUI splits the input energy range into narrower sub-bands and, assuming a power law spectrum (with the flux and spectral index as user inputs), calculates the flux within each sub-band.

It then performs individual calculations on these sub-bands, of the S/N, or observation duration, and finally combines these results into a global figure for the entire input energy band

3.3 Hints and warnings

(i) Units

Please be careful with units!

- Input time is kiloseconds

- Output time is kiloseconds

- All fluxes, both for lines and continua, should be given in units of photons $cm^{-2}s^{-1}$

(ii) Prospective IBIS users should also note the following:.

The continuum range of interest can straddle the energy ranges of ISGRI and PICSIT and be only partially inside the energy range of one or both. 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.

In such a case, we recommend calculating the broad-band flux for the energy range of interest covered by ISGRI and by PICsIT separately and combining the results later.

The contributions of Compton photons to the signal-to-noise ratio or observing time are not included in the output.

3.4 Output from OTE

OTE returns:

- the original input values

- any nearby strong source information (coordinates from the 2nd ISGRI catalogue)

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

- for continuum sources, the calculated exposure time, or signal-to-noise ratio for the individual sub-bands used in the back-end calculations. These may be useful, for example, for determining the energy above which the source fades into the background

- calculated exposure time, or signal-to-noise ratio for the entire input energy range (for continuum sources) or for the FWZI (line sources)

For IBIS, results are given separately for ISGRI single events, PICsIT multiple events and (where applicable) combined ISGRI plus PICsIT events - but see note 3.3 (ii) above.