IBIS/ISGRI Data Analysis

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- The IBIS instrument
- OSA: behind the scenes
- Hands-on tutorial
- What else?
- ISGRI calibration
The IBIS instrument

Mask:
53 x 53 MURA basic pattern

Positional Detectors:
ISGRI (CdTe): 15 keV – 1 MeV
PICsIT (CsI): 170 keV – 10 MeV

Shielding system, Veto and CU:
Passive (tube, hopper)
Veto Unit: 16 BGO mod
Calibration Unit: $^{22}$Na Source

Imaging properties:
FCFOV 9° x 9°
FC+PCFOV 29° x 29°
Angular Resolution 12’
ISGRI/PICsIT pixels 5’ / 10’

Sensitivity:
6 E-7 ph/sec cm² keV @ 100keV
(ΔE=E/2, 3s, 10^6 sec)

Spectral Resolution
8 keV @ 100 keV (FWHM)
http://www.bo.iasf.cnr.it/Research/INTEGRAL

INTEGRAL IASF/INAF Bologna Local Page

- IBIS/PICsIT
- Scientific Results
- INTEGRAL Related Publications
- Links

The INTEGRAL Team at Bologna is coordinated by Dr. Guido Di Cocco.
## OSA: behind the scenes

| I | COR  
|   | GTI  
<table>
<thead>
<tr>
<th></th>
<th>DEAD</th>
</tr>
</thead>
</table>
|   | • Prepare the data for scientific analysis  
|   | • Mandatory (rev_2!) |

| II | BIN_I  
|    | BKG_I  
|    | CAT_I  
<table>
<thead>
<tr>
<th></th>
<th>IMA</th>
</tr>
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</table>
|    | • Extract images and source properties  
|    | • ~Optional |

| III | BIN_S  
<table>
<thead>
<tr>
<th></th>
<th>SPE</th>
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</table>
|     | • Extract spectra  
|     | • ~Optional |

<table>
<thead>
<tr>
<th>IV</th>
<th>LCR</th>
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</table>
|     | • Extract lightcurves  
|     | • Optional |

There is a script that does all the above for you: *ibis_science_analysis*

You decide start, end and intermediate steps.
I - Prepare the data

- **COR**
  - Computes the deposited energy of the events

- **GTI**
  - Extracts good time interval information and merges it (HK data, satellite stability, data gaps)

- **DEAD**
  - Computes dead time (instrument, veto, calibration)
II - Images

- **BIN_I**
  - Creates shadowgrams in Ebins
  - Computes efficiency maps in Ebins
• BKG_I
  ➔ Use background and uniformity maps to obtain a “correct” shadowgram

• CAT_I
  ➔ Create a catalogue with sources in the FOV

• IMA
  ➔ Sky image reconstruction
  ➔ Source search
  ➔ Mosaic images
II – IMAGES

SUMMARY

RAW Data → Energy Corr Deadtimes

Image Unif. Bkg Correct. → Image Binning Efficiency Map

Mask → Decoding Sky Image

Loop on Sources

Source Parameters → Source Locat (SPSF Fit)

Mosaicked Sky Image → Computing Source Model

Removing Source Ghosts

Mosaics of Cleaned Sky → Cleaned Sky Image

Search mode!

(A. Goldwurm)
III - Spectra

- BIN_S
  - Shadowgrams and efficiency maps in new Ebins

- SPE
  - + source list from the image step

  ➔ For each active source in the FOV (catalog from imaging) it builds a model of the source contribution in each energy band (PIF)
  - Pixel Illuminated Function
    - time consuming!
  - PIF Source_1  PIF Source_2  ...

  ➔ Extract spectra of the sources and background
IV Lightcurves

LCR

- You need PIF from SPE level
- Same as in SPE part with Tbin!
Summary of analysis levels

Launch the script that performs the following

- “Prepares” the data: COR-GTI-DEAD
- Extracts images and source list
- Uses IMA source list (manually modified) to extract SPE
- Uses PIF (SPE) to run LCR

Do this during the hands-on session!
Hands-on tutorial

[A] BUILD A GROUP

(1) Prepare your ascii file

[...]
scw/0175/017500180010.001/swg.fits[1]
scw/0175/017500190010.001/swg.fits[1]
scw/0175/017500200010.001/swg.fits[1]
[...]

(2) Build a group ONCE

(og_create)

og_ibis.fits

Hands-on session: 3 scws, 100Mb, run time ~ 1hour on a 1.5 GHz linux machine

Call the ascii file SCW_IBIS.txt and

og_create idxSwg=SCW_IBIS.txt ogid=IBIS_3scw basedir="./" instrument=IBIS
cd obs/IBIS_3scw
[B] Launch till the IMA step

\textit{ibis\_science\_analysis}
Press “OK” and on the main GUI, “Save” and “Run”
Results:

- each pointing
  isgri_sky_ima.fits
  isgri_sky_res.fits

- mosaic
  isgri_mosa_ima.fits
  isgri_mosa_res.fits

You need info from “sky” and “mosa”!!!

- Summary and “average”
  isgri_srcl_res.fits

This file contains all sources in the FOV (detected or not) with results for the detected sources. Could be 80 sources with only 10 detected (check DETSIG!!!).
1 scw: 4 sources
20-40 keV
Mosaic: 22 sources
20-40 keV
The NEW sources are ghosts (SearchMode=2)!!!!!
(this is on 38 scws)
cd ..../..

og_create idxSwg=SCW_IBIS.txt ogid=IBIS_3scw_mode3 basedir="./" instrument=IBIS

cd obs/IBIS_3scw_mode3

ibis_science_analysis

Force extraction of input catalogue!!
SearchMode=2 (find brighter than....)

SearchMode=3 (force extraction)
[C] EXTRACT SPE AND LCR

Coded mask: you need to extract SPE and LCR for all active sources

```bash
cp isgri_src_res.fits specat.fits
```

in specat.fits keep sources DETSIG > 6

`ibis_science_analysis`

![Image of the IBIS GUI with highlighted settings]

- `BIN_S` for binning level
- `LCR` for level control
- `startLevel`: COR
- `endLevel`: IMA2
- `GENERAL_levelList`: COR, GTI, DEAD, BIN_I, BKG_I, CAT_I, IMA, IMA2, BIN_S, SPE, LCR, COMP, CLEAN
- `CAT_refCat`: $ISDC_REF_CAT[ISGRL_FLAG==1]`
- `SWITCH_disableIsgr`: checked yes
- `SWITCH_disablePICsT`: checked yes
- `SCW1_GTI_gtiUser`: IJD
- `ISGRL_SPE_and_LCR` button highlighted

Save, Save As, Run, Quit, Help, hidden
Specat.fits is IMPORTANT!
Default is isgri_scrl_res.fits: long, useless and might fail!!
specat.fits: POSITION FROM FIT OR FROM CATALOGUE?

OK, Save and Run
Results:

- each pointing

obs/.../scw/017500180010.001/

  isgri_spectrum.fits

  isgri_lcr.fits

  (and isgri_sky_res.fits from IMA)

Interested in all the results from GX 5-1?

**How to collect the results:**

- *src_collect*  IMA
- *lc_pick*      LCR
- *spe_pick*     SPE

*Aim of hands-on session: IMA and stop. Change catalogue and run SPE, LCR. Then collect!***
What else?

Main options

• Prepare the data
  → User GTI

• Images
  → Do mosaic?
  → Fit source position?
  → Background removal
  → Spectrum from image?

• Spectra
  → Spectrum from fit position or catalogue one?
  → Energy binning
  → Background removal
  → Phase resolved spectroscopy
    → Hours to days: scw by scw
    → Minutes to hours: define user GTI
    → Below minutes: start from event list
• Lightcurves
  - up to about 60 sec binning: standard LCR
  - up to about 0.1 sec: \textit{ii\_light}
  - below 0.1 sec: start from event list

• No GUI!
  - You can run the analysis from command line

  \texttt{og\_create \ idxSwg=SCW\_IBIS.txt \ ogid=IBIS\_3scw \ basedir=\"./\" \ instrument=IBIS}

• Database?
  - Analyse science window by science window
    (15000 scws!)
**ISGRI calibration**

![Crab spectrum graphs](image)

**OSA 5 Crab spectrum – staring r. 102**
Exp. ~20 ks – on axis – Fit 20-500 keV
Systematic required: 1 %

**OSA 5 Crab spectrum – 5 x 5 dit r. 102**
Exp. ~54 ks – on axis – Fit 20-500 keV
Systematic required: 1 %

On larger data set:
rev. 65 to 255 in 23-100 keV systematic distortions smaller than 2%
Before rev. 65 and after rev 255 they can reach 5%

See “INTEGRAL cross calibration status for OSA 5.1“
Lubinski, Dubath and Paltani
Soon on ISDC web pages.
Summary & Recommendations

ISGRI is a great instrument!!!!!! but be careful...

Ghosts
new source?

Each source is background for the rest
you have to extract spectra for all the active sources in the FOV (specat.fits)

Read the Cookbook, Calibration report, Known issues, Scientific Validation on ISDC web pages.