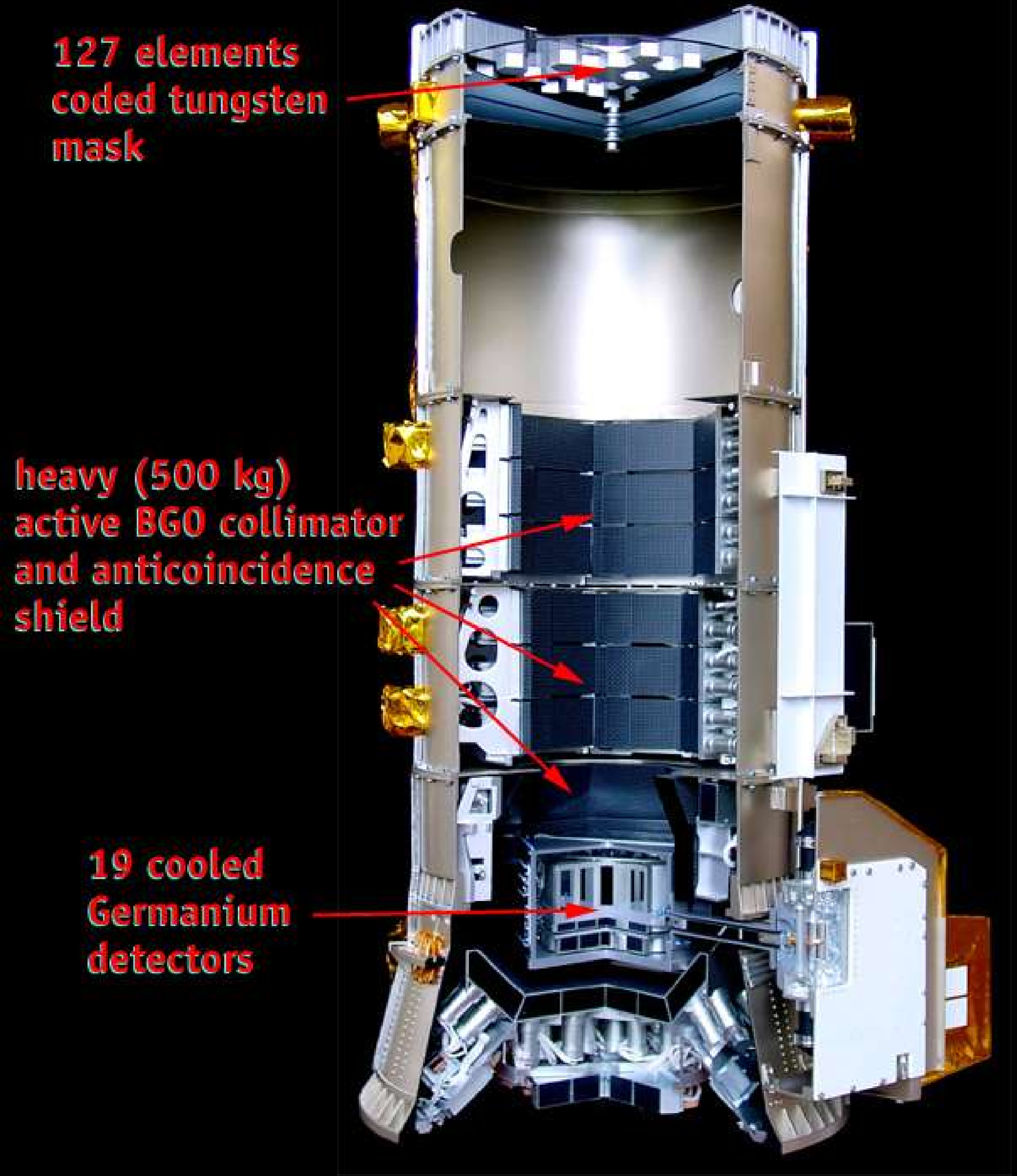
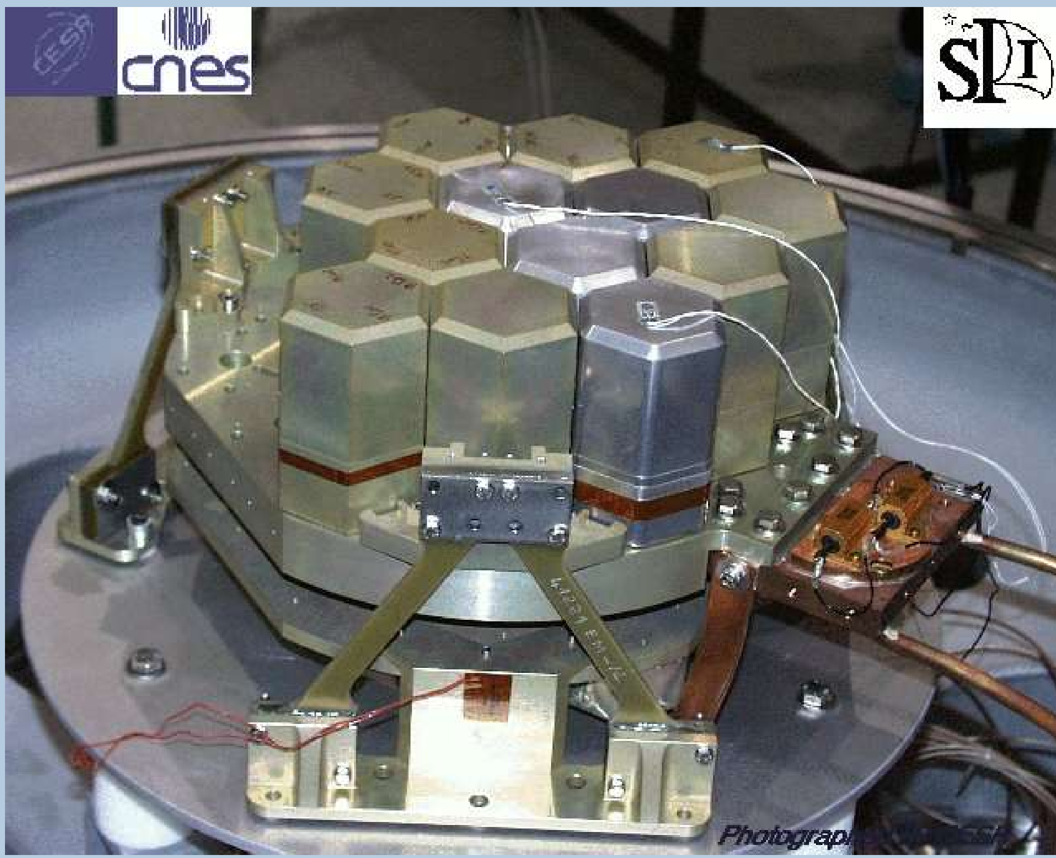
# *SPI data analysis Outlines:*

- The SPI instrument – event data
- Analysis steps (SPIROS)
- Scientific validation
- GRB and phase resolved analyses
- Analysis philosophy – building the minimum sky model
- Tutorial introduction – spi_science_analysis

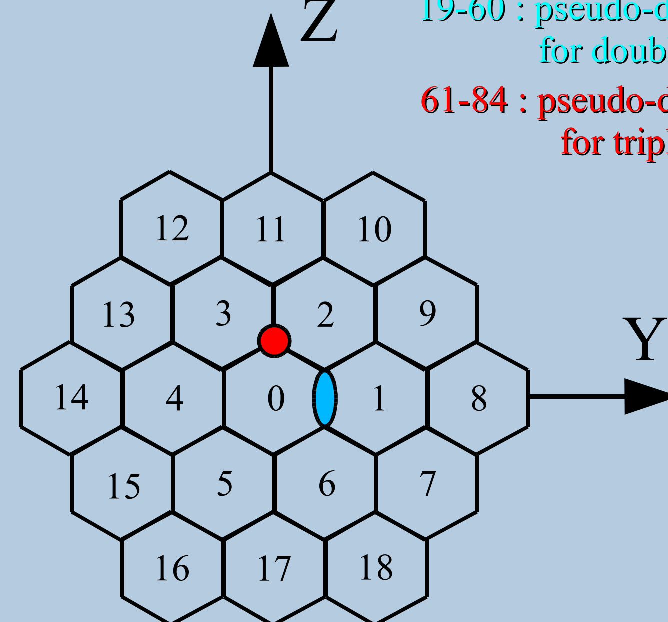

127 elements coded tungsten mask
heavy (500 kg) active BGO collimator and anticoincidence shield
19 cooled Germanium detectors

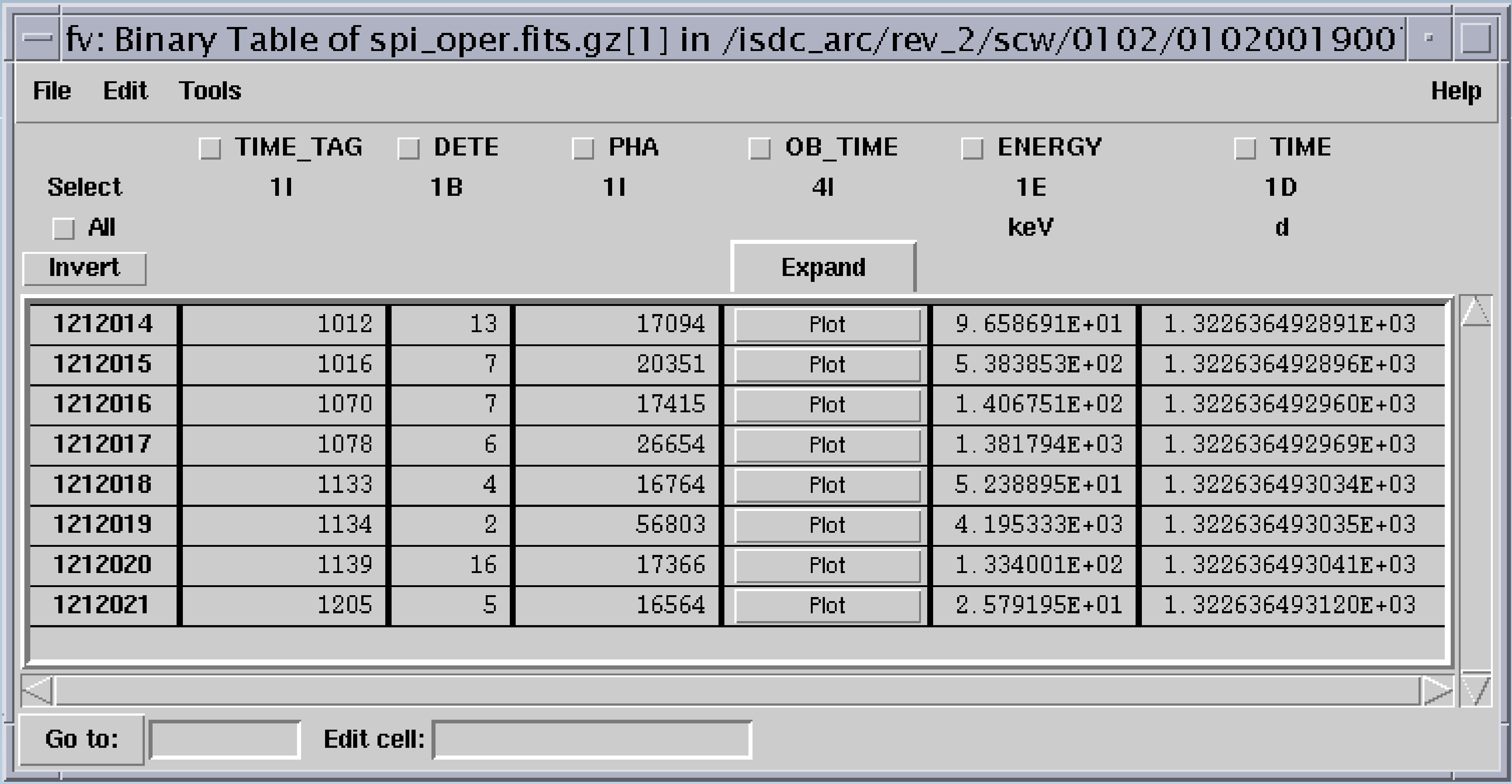


0-18 : real detectors

19-60 : pseudo-detectors for double events

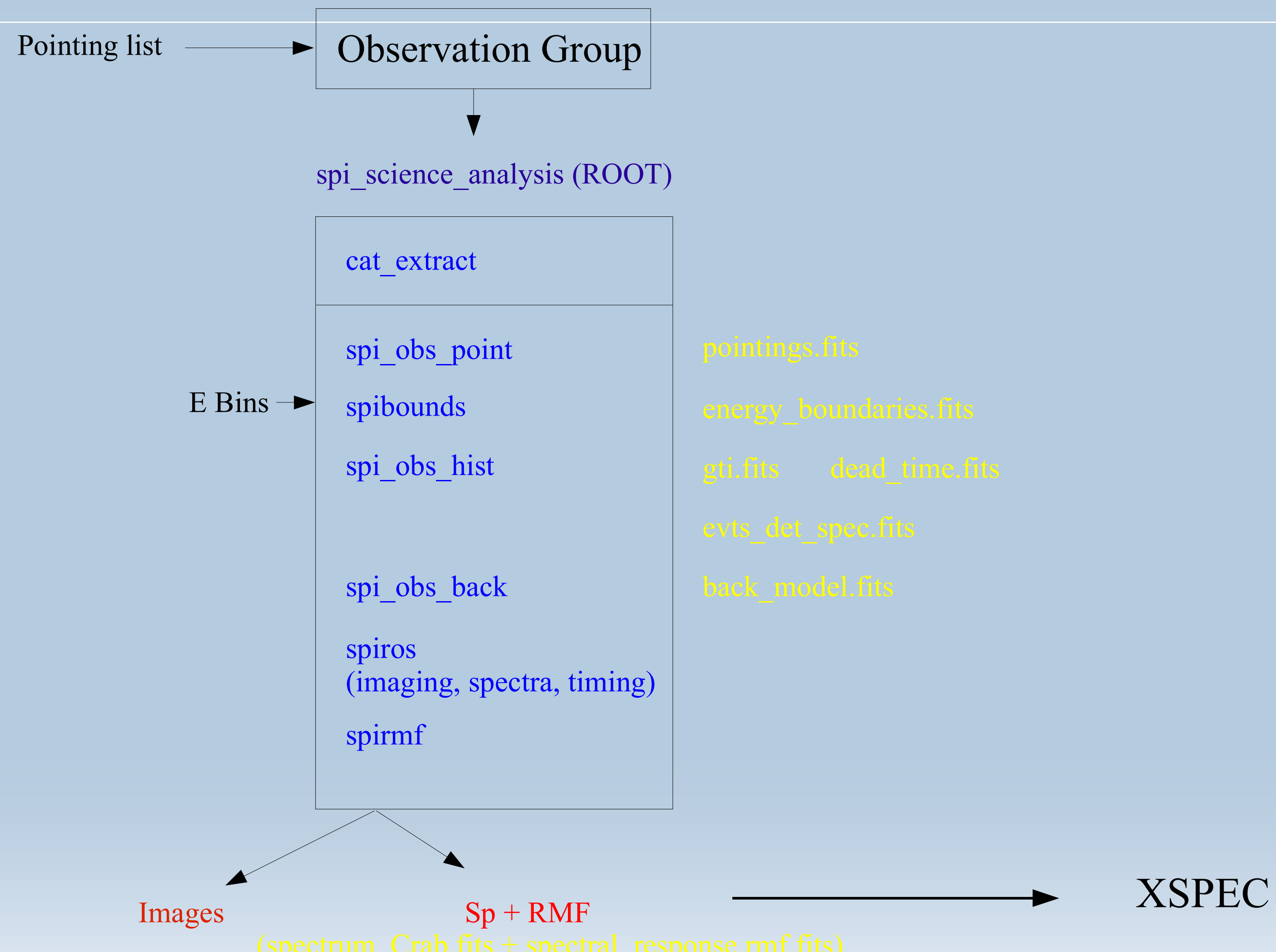
61-84 : pseudo-detectors for triple events

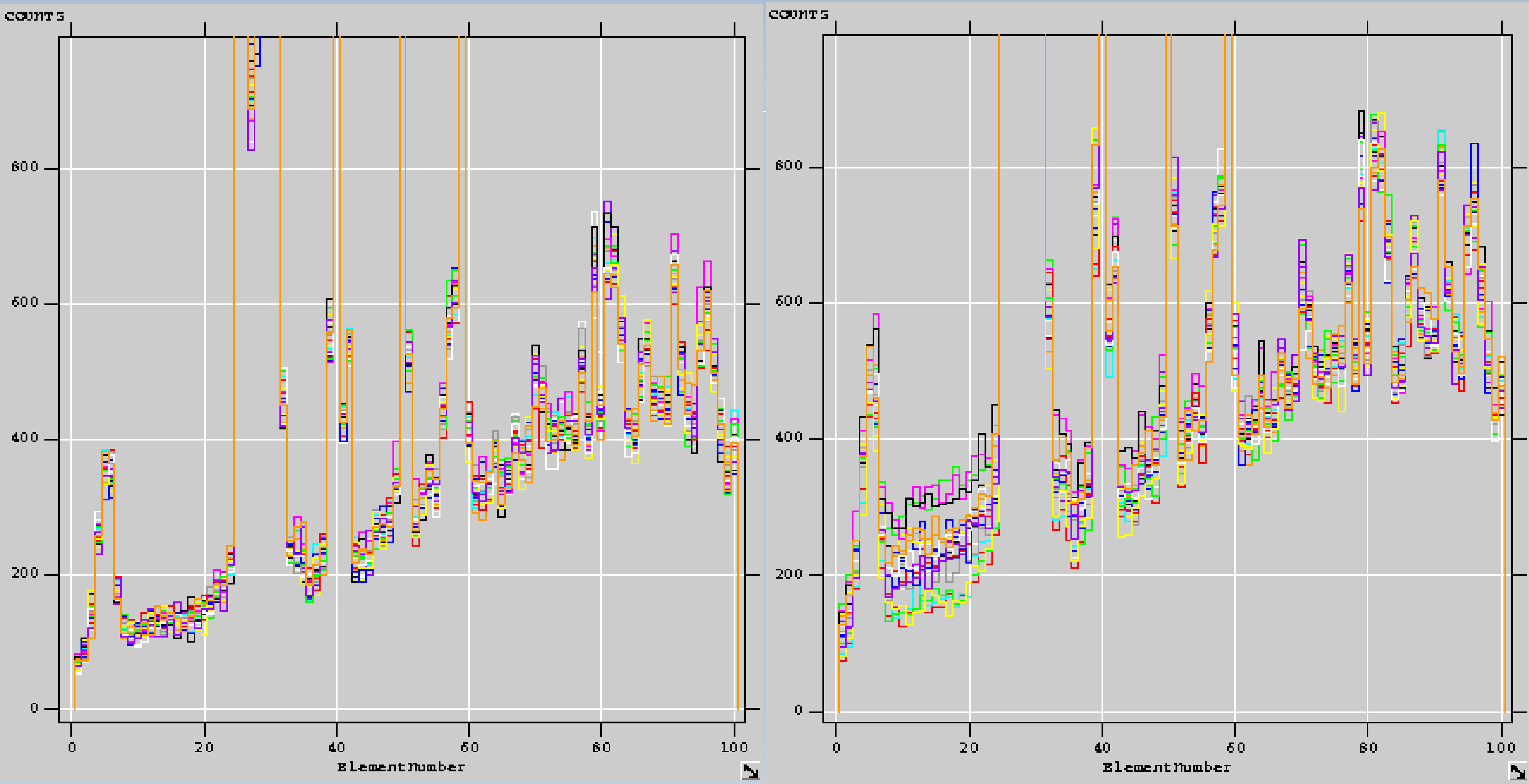





| | TIME_TAG 1I | DETE 1B | PHA 1I | OB_TIME 4I | ENERGY 1E keV | TIME 1D d |
|---|---|---|---|---|---|---|
| 1212014 | 1012 | 13 | 17094 | Plot | 9.658691E+01 | 1.322636492891E+03 |
| 1212015 | 1016 | 7 | 20351 | Plot | 5.383853E+02 | 1.322636492896E+03 |
| 1212016 | 1070 | 7 | 17415 | Plot | 1.406751E+02 | 1.322636492960E+03 |
| 1212017 | 1078 | 6 | 26654 | Plot | 1.381794E+03 | 1.322636492969E+03 |
| 1212018 | 1133 | 4 | 16764 | Plot | 5.238895E+01 | 1.322636493034E+03 |
| 1212019 | 1134 | 2 | 56803 | Plot | 4.195333E+03 | 1.322636493035E+03 |
| 1212020 | 1139 | 16 | 17366 | Plot | 1.334001E+02 | 1.322636493041E+03 |
| 1212021 | 1205 | 5 | 16564 | Plot | 2.579195E+01 | 1.322636493120E+03 |

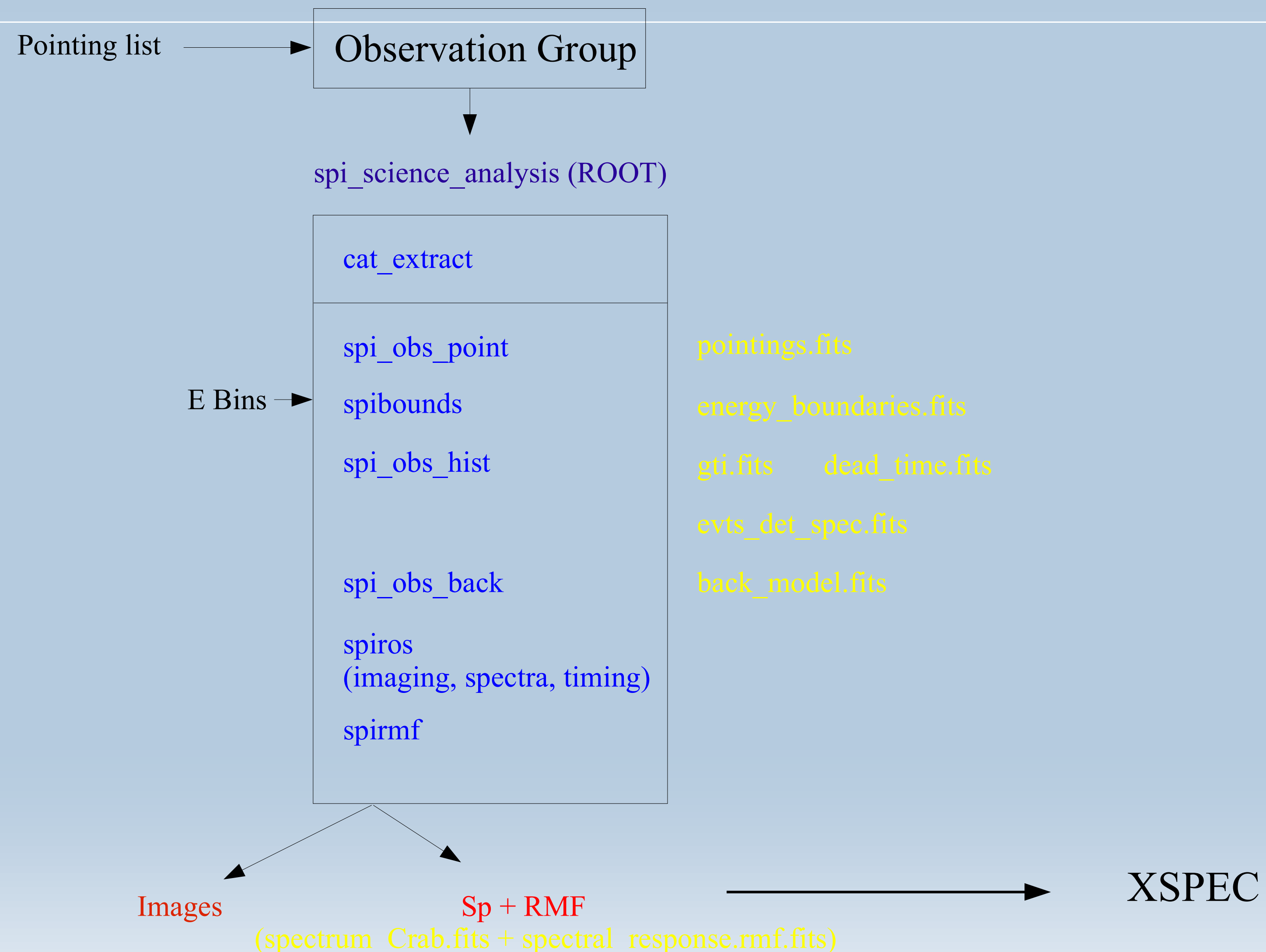
# Analysis Steps

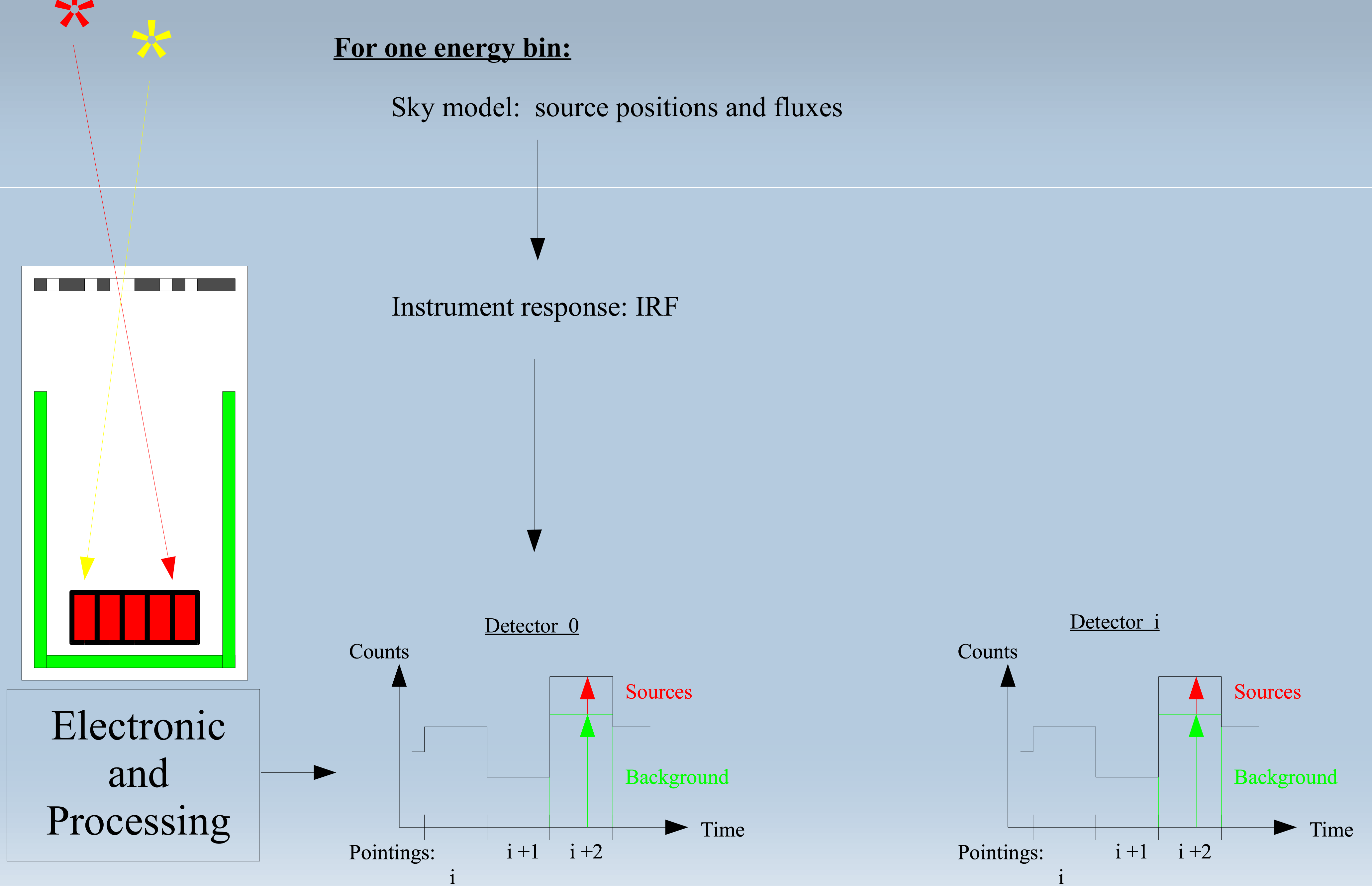




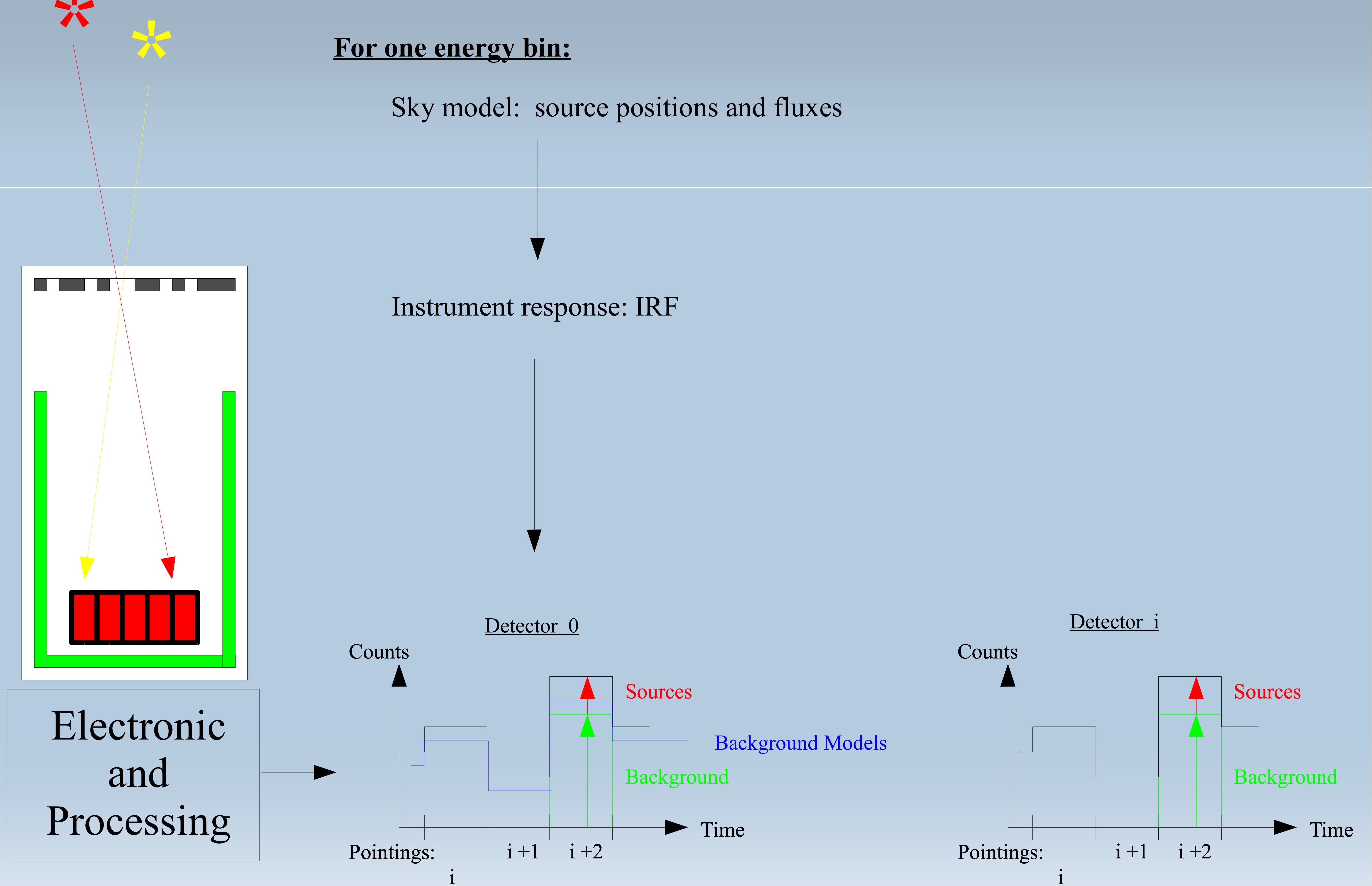
COUNTS
800
600
400
200
0
0
20
40
60
80
100
Element Number
COUNTS
800
600
400
200
0
0
20
40
60
80
100
Element Number

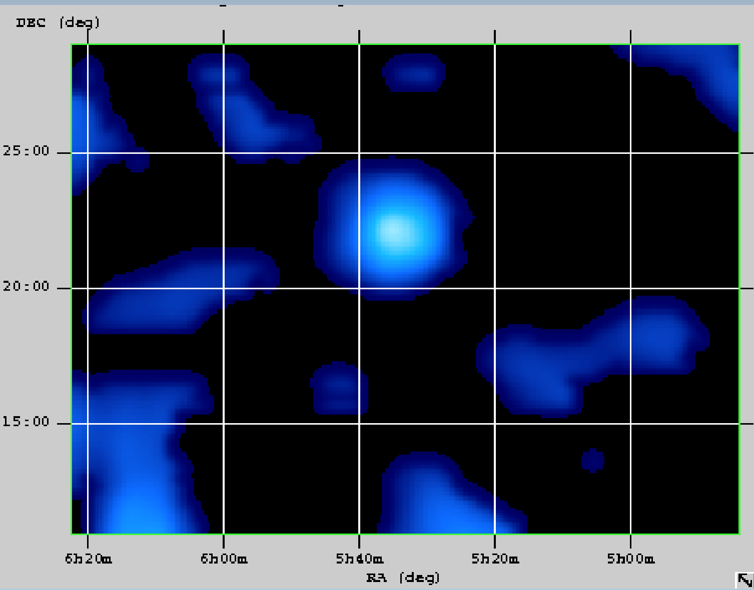
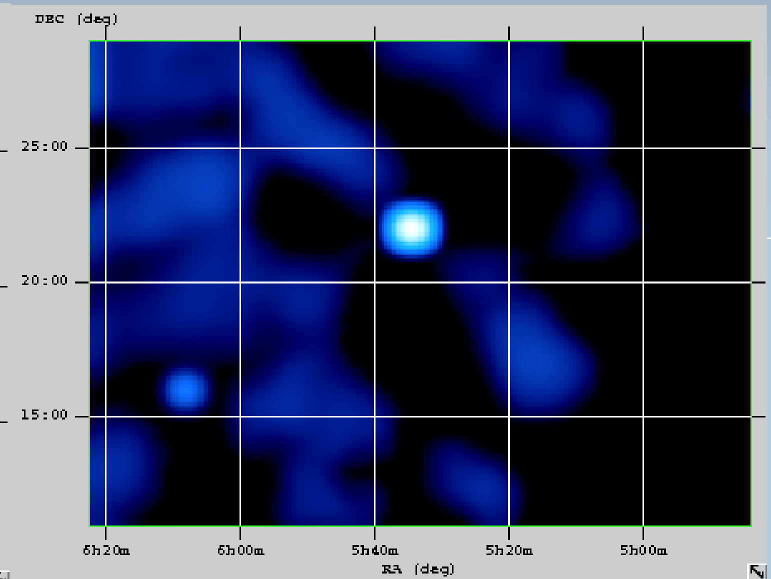
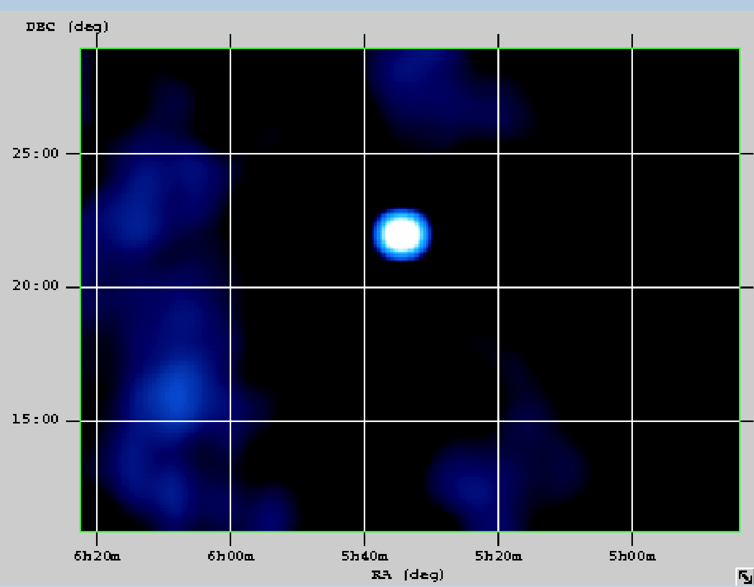
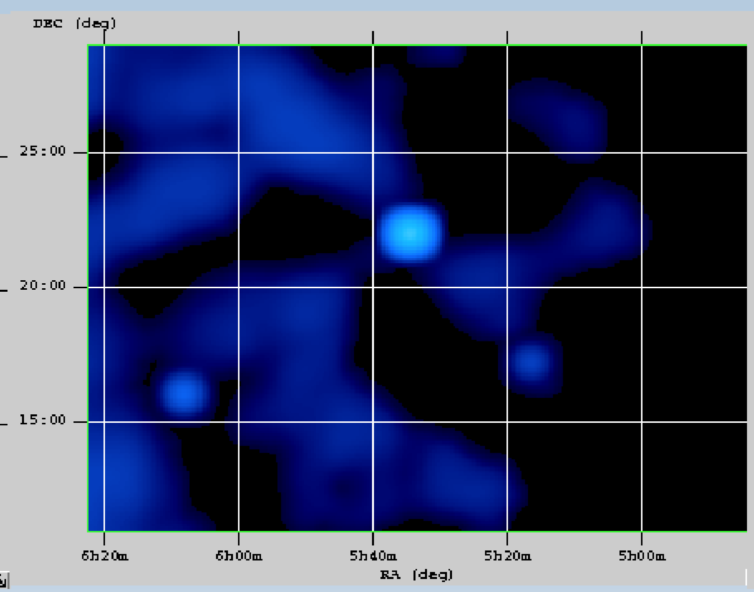
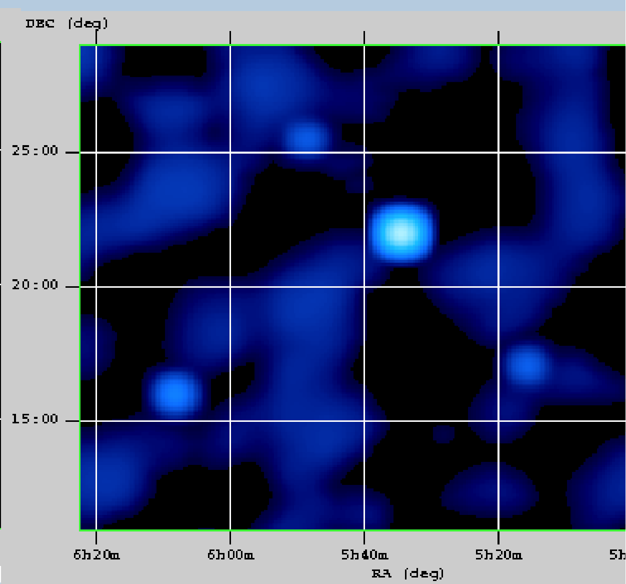
# Analysis Steps





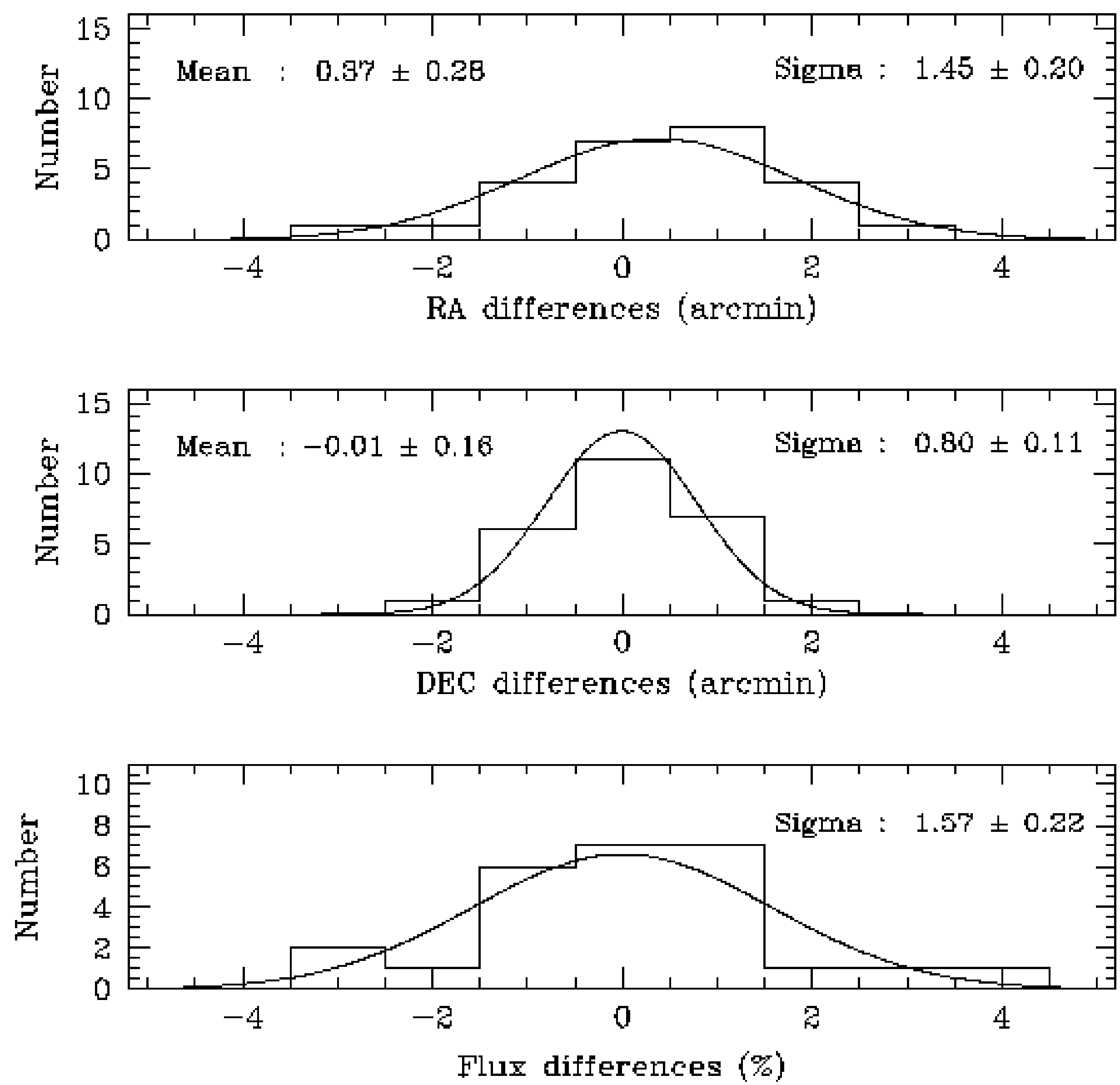
For one energy bin:
Sky model: source positions and fluxes
Instrument response: IRF
Electronic and Processing
Detector 0
Counts
Sources
Background
Time
Pointings:
i
i +1
i +2
Detector i
Counts
Sources
Background
Time
Pointings:
i
i +1
i +2


For one energy bin:
Sky model: source positions and fluxes
Instrument response: IRF
Electronic and Processing
Detector 0
Counts
Sources
Background Models
Background
Time
Pointings:
i
i +1
i +2
Detector i
Counts
Sources
Background
Time
Pointings:
i
i +1
i +2

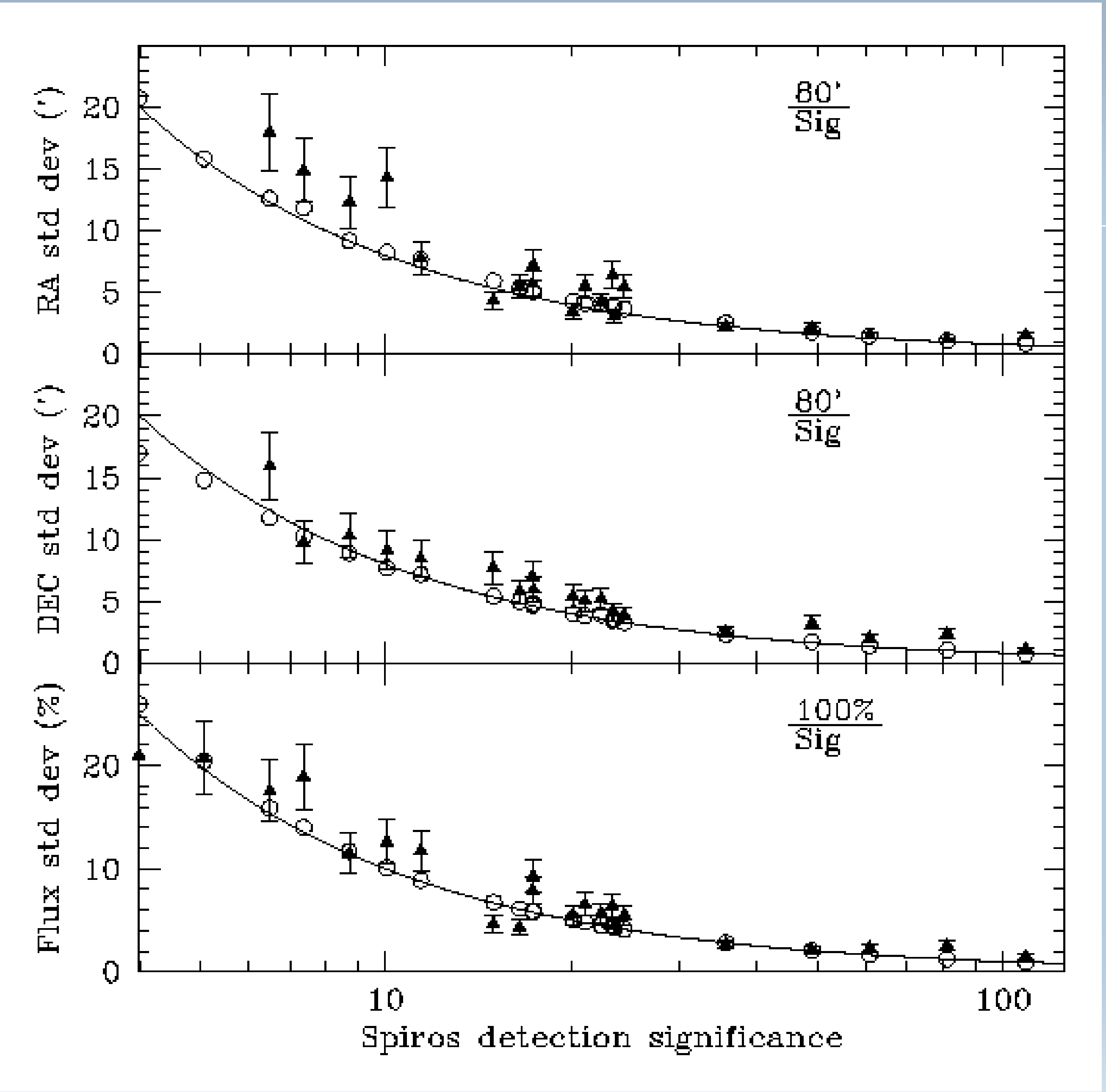

DEC (deg)
25:00
20:00
15:00
6h20m
6h00m
5h40m
5h20m
5h00m
RA (deg)

DEC (deg)
25:00
20:00
15:00
6h20m
6h00m
5h40m
5h20m
5h00m
RA (deg)

DEC (deg)
25:00
20:00
15:00
6h20m
6h00m
5h40m
5h20m
5h00m
RA (deg)

DEC (deg)
25:00
20:00
15:00
6h20m
6h00m
5h40m
5h20m
5h00m
RA (deg)

DEC (deg)
25:00
20:00
15:00
6h20m
6h00m
5h40m
5h20m
RA (deg)

# *Scientific Validation*

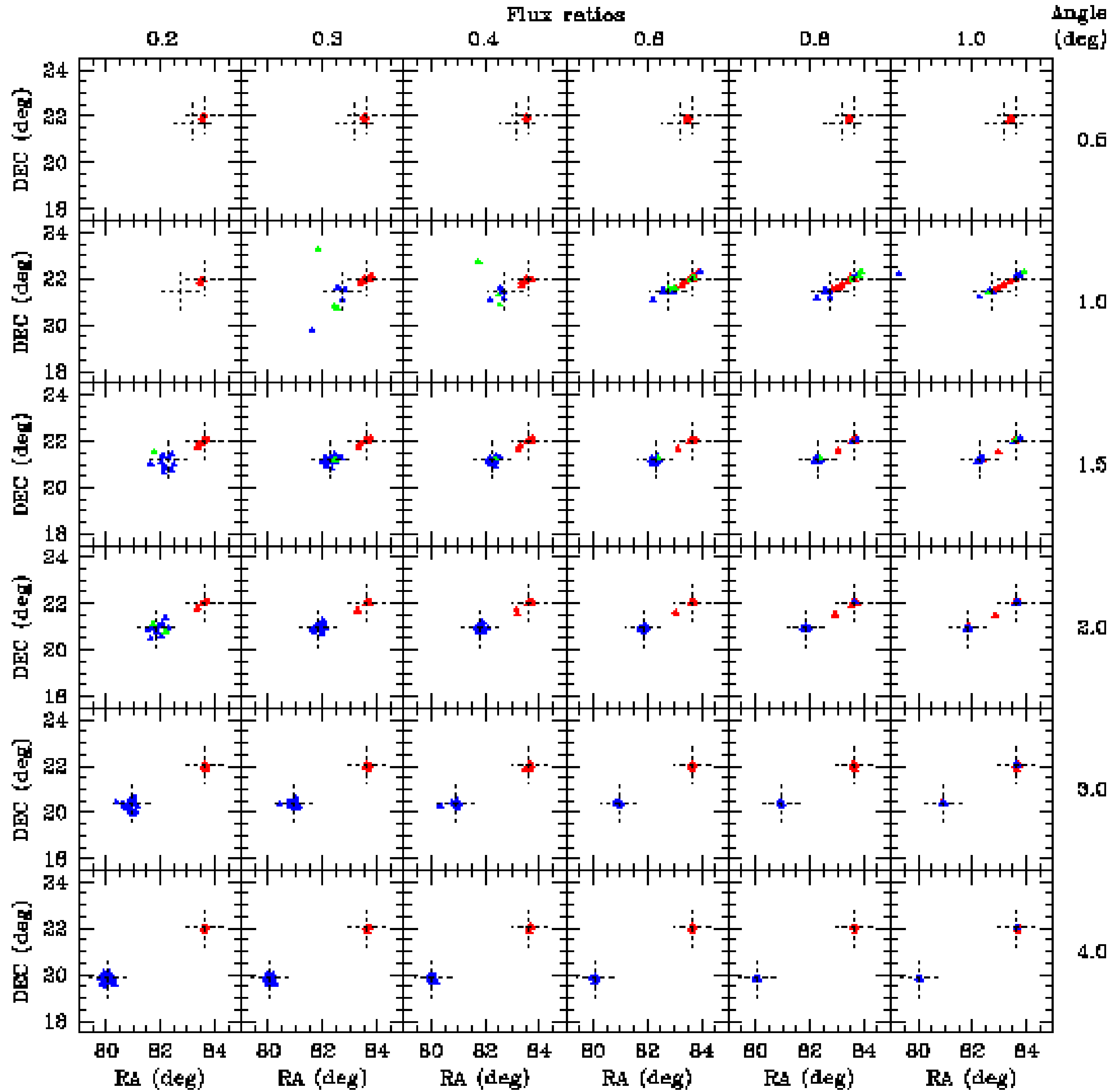
- Cut the Crab data set in independent pieces (e.g. 26 independent groups of 10 pts).
- Look at the distributions of the results (source positions and fluxes) and compare them with the errors provided by spiros



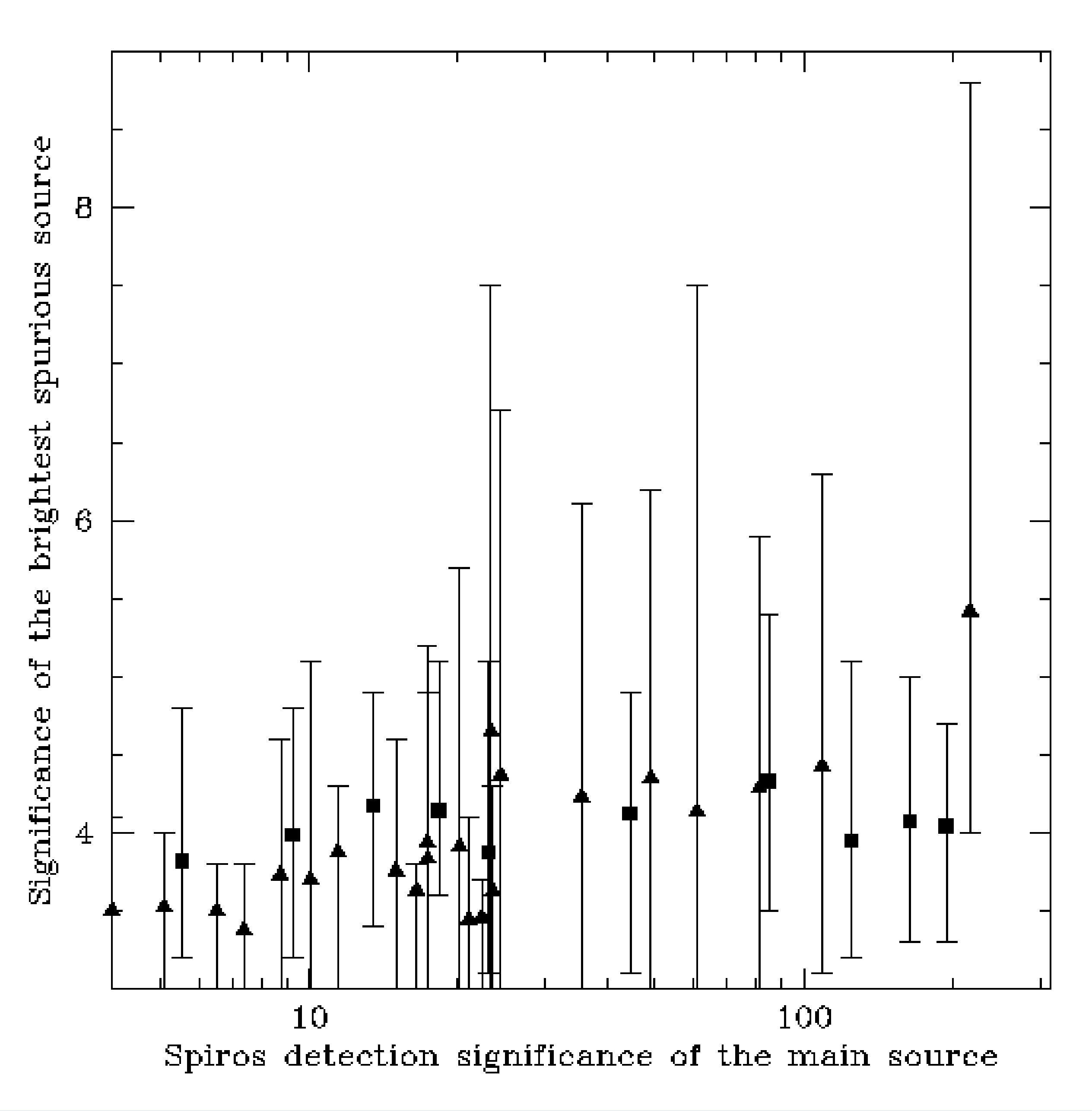
Mean : 0.37 ± 0.28
Sigma : 1.45 ± 0.20
Number
RA differences (arcmin)
Mean : −0.01 ± 0.16
Sigma : 0.80 ± 0.11
Number
DEC differences (arcmin)
Sigma : 1.57 ± 0.22
Number
Flux differences (%)



RA std dev (')
80'
Sig
DEC std dev (')
80'
Sig
Flux std dev (%)
100%
Sig
Spiros detection significance



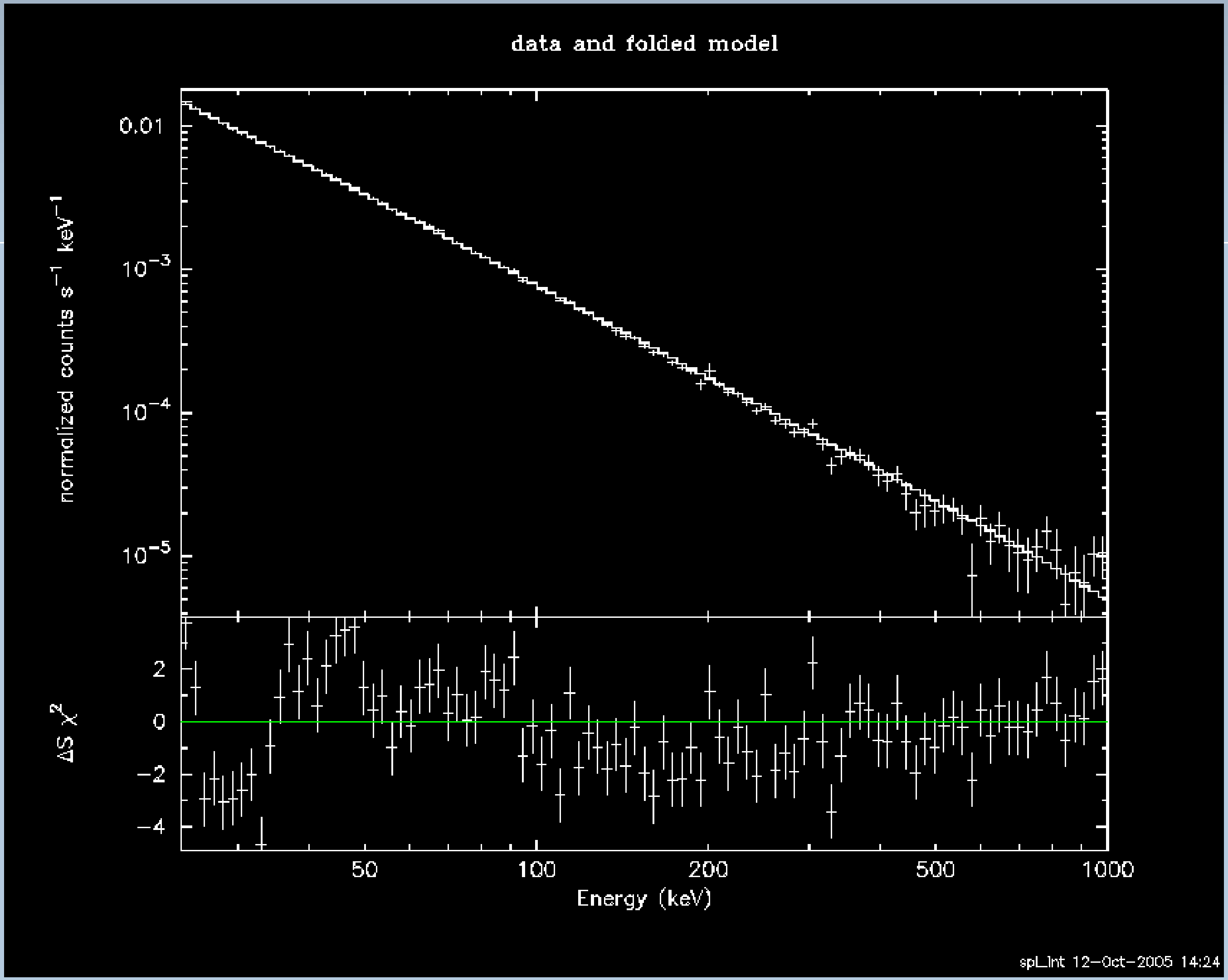
Flux ratios
0.2
0.3
0.4
0.6
0.8
1.0
Angle (deg)
0.5
1.0
1.5
2.0
3.0
4.0
DEC (deg)
RA (deg)



Significance of the brightest spurious source
4
6
8
10
100
Spiros detection significance of the main source

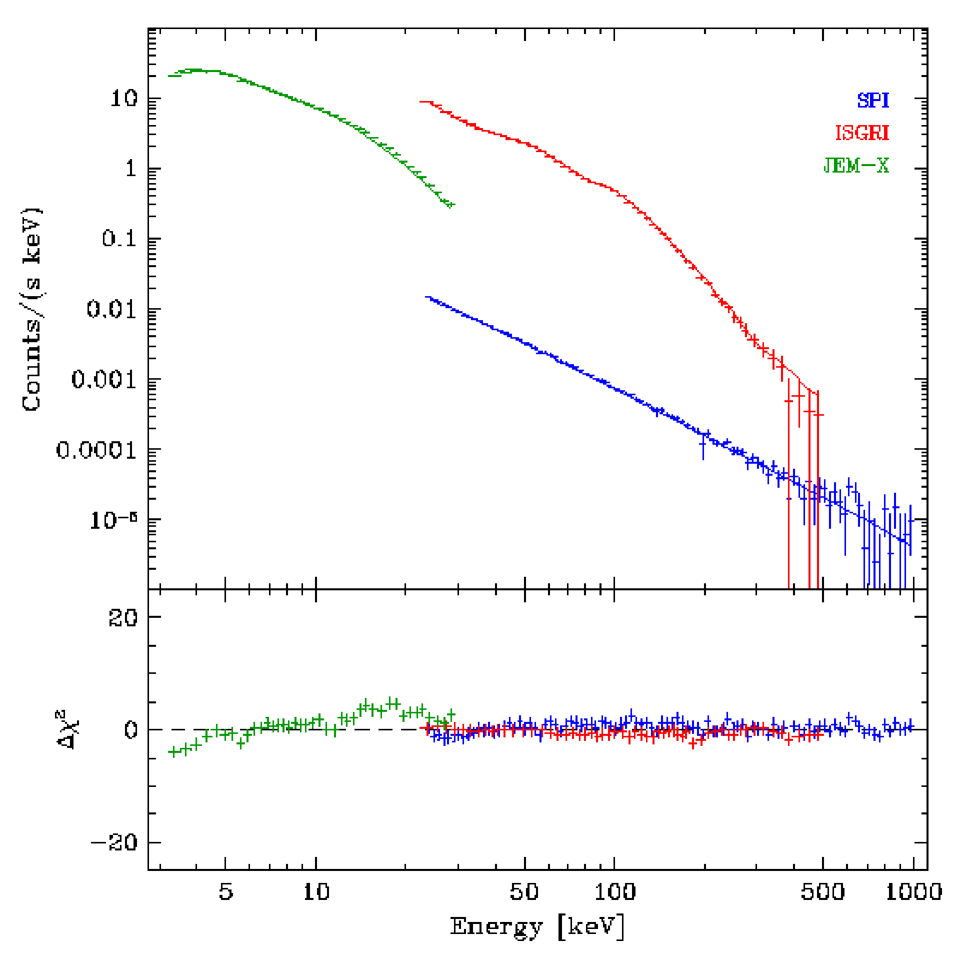
# *Spectral Fitting Validation*

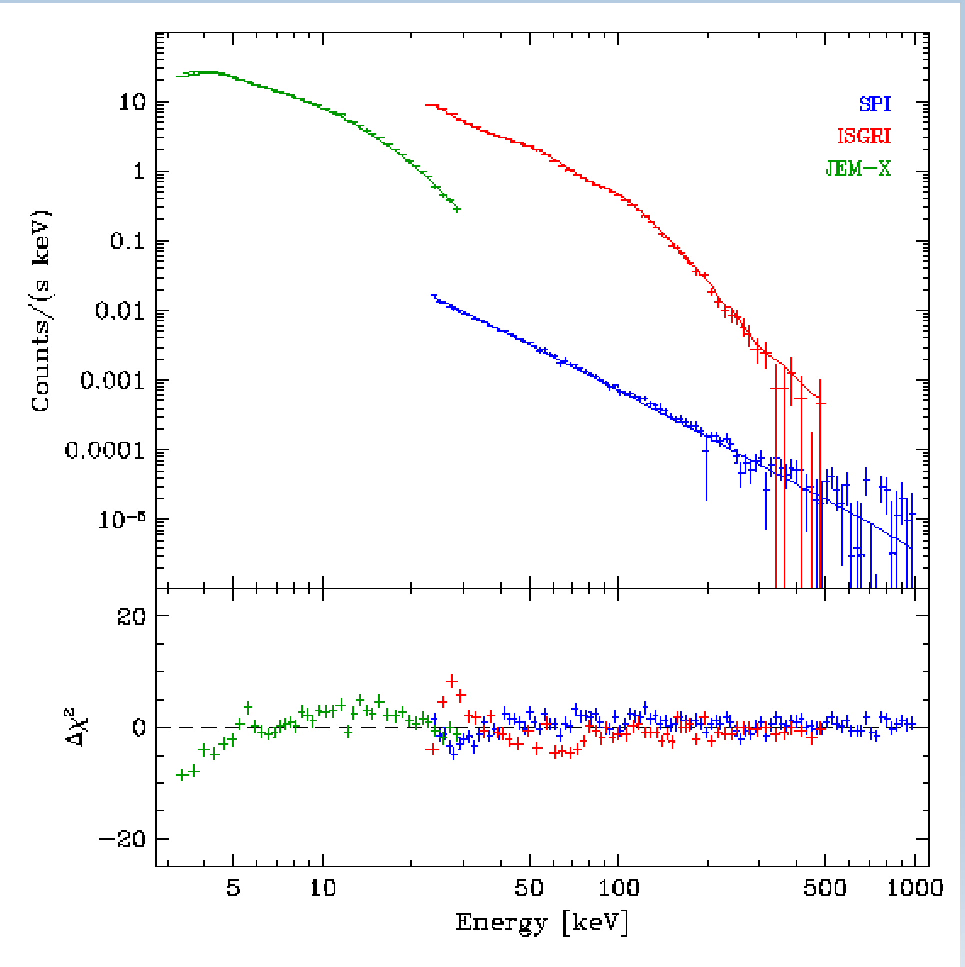
- Extensive BLC ground calibrations
- Response derived through GEANT simulations (GSFC)
- The Crab spectrum is well fitted by a single power law, for different datasets, detector lists,  background models, statistic, E range (> 40 keV)




- Photon index = 2.14-2.15
- F (50-100 keV) = 7.85 10-9 erg/cm2/sec

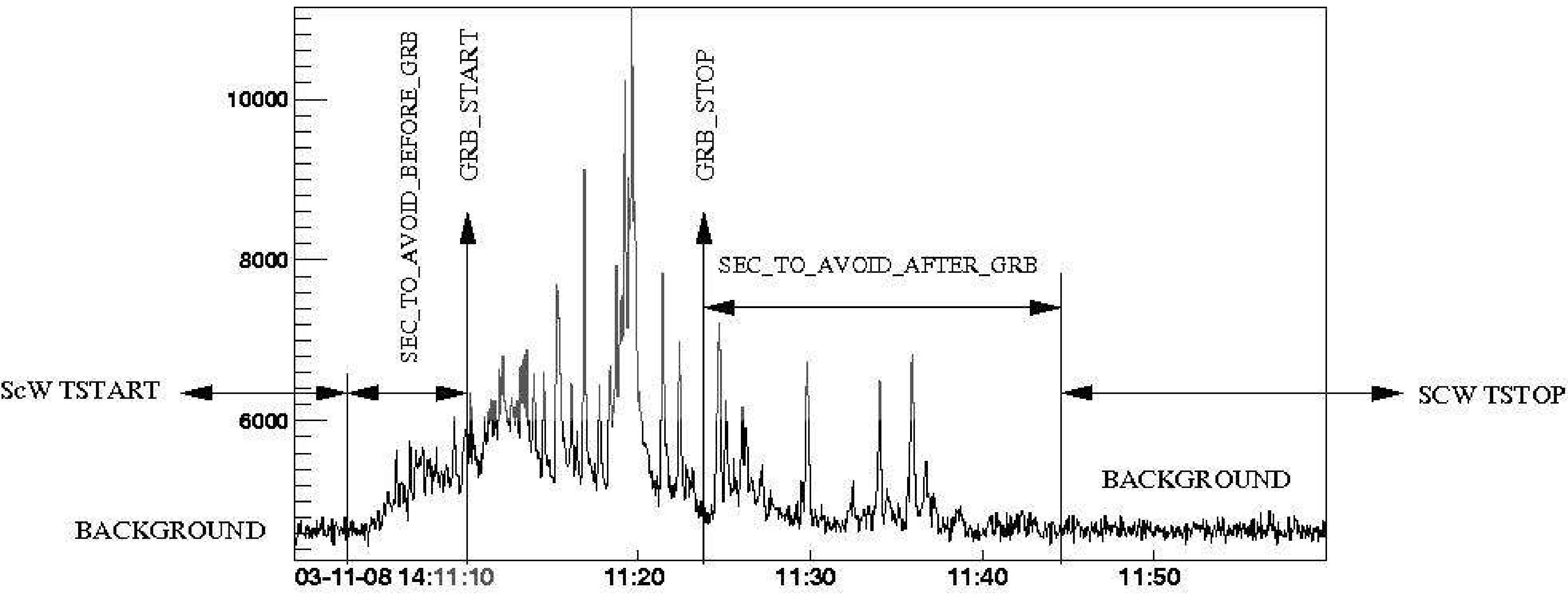
# Instrument cross-calibration



# GRB: SPI analysis

- spi_grb_analysis <grb_start> <grb_stop> UTC/IJD <sec_to_avoid_before_grb> <sec_to_avoid_after_grb>



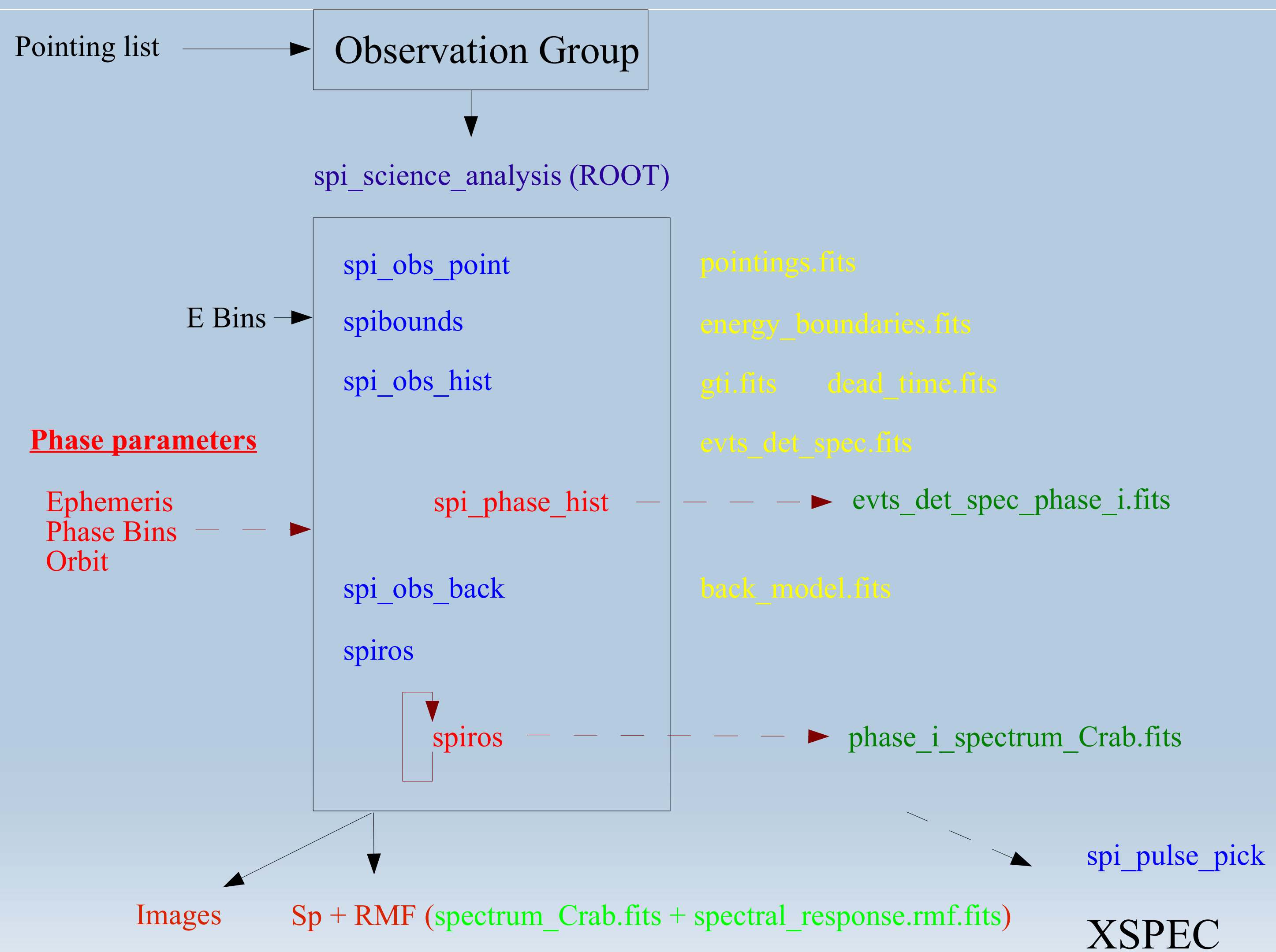
# *GRB analyses*

- Follow the tutorial “GRB image analysis” and “GRB spectral analysis” from the WWW SPI pages.
  1) Set up the environement
  2) Create an OG with the (single) ScW
  3) Run spi_science_analysis to enter the analysis parameters
  4) Run spi_grb_analysis

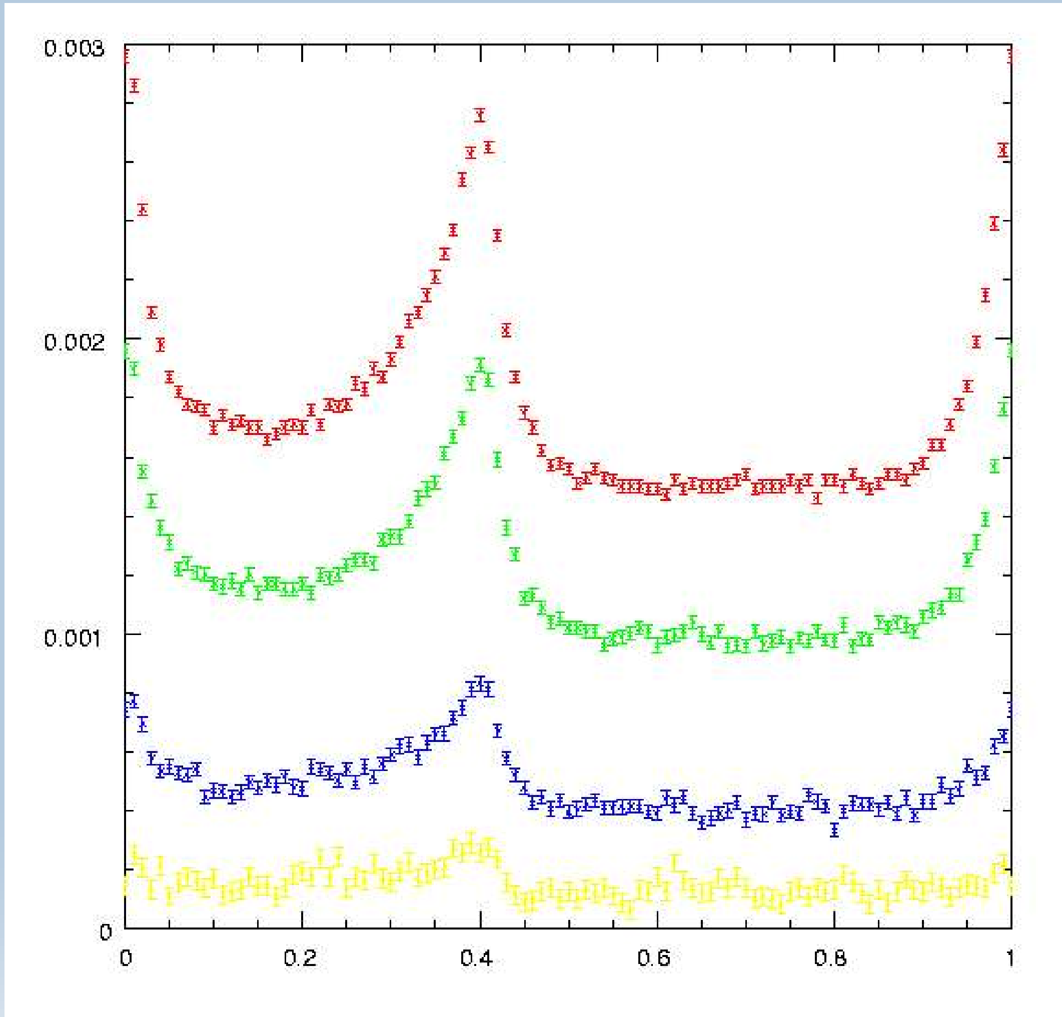
# *GRB analyses*

- spi_grb_analysis <grb_start> <grb_stop> UTC/IJD <sec_to_avoid_before_grb> <sec_to_avoid_after_grb> (shell script calling spi_science_analysis, spi_obs_gti, spi_dsp2back)
  1) Derive background before the burst
  2) Derive background after the burst
  3) Sum, rescale, and subtract background
  4) Run spi_science_analysis on the burst time interval

# *Phase resolved analysis*



# Phase resolved analysis: Crab pulse



# *SPI complex analysis principle*

Derive a model (sources + background) which fit the count data within the statistical uncertainties, i.e., with analysis residuals consistent with DOF.

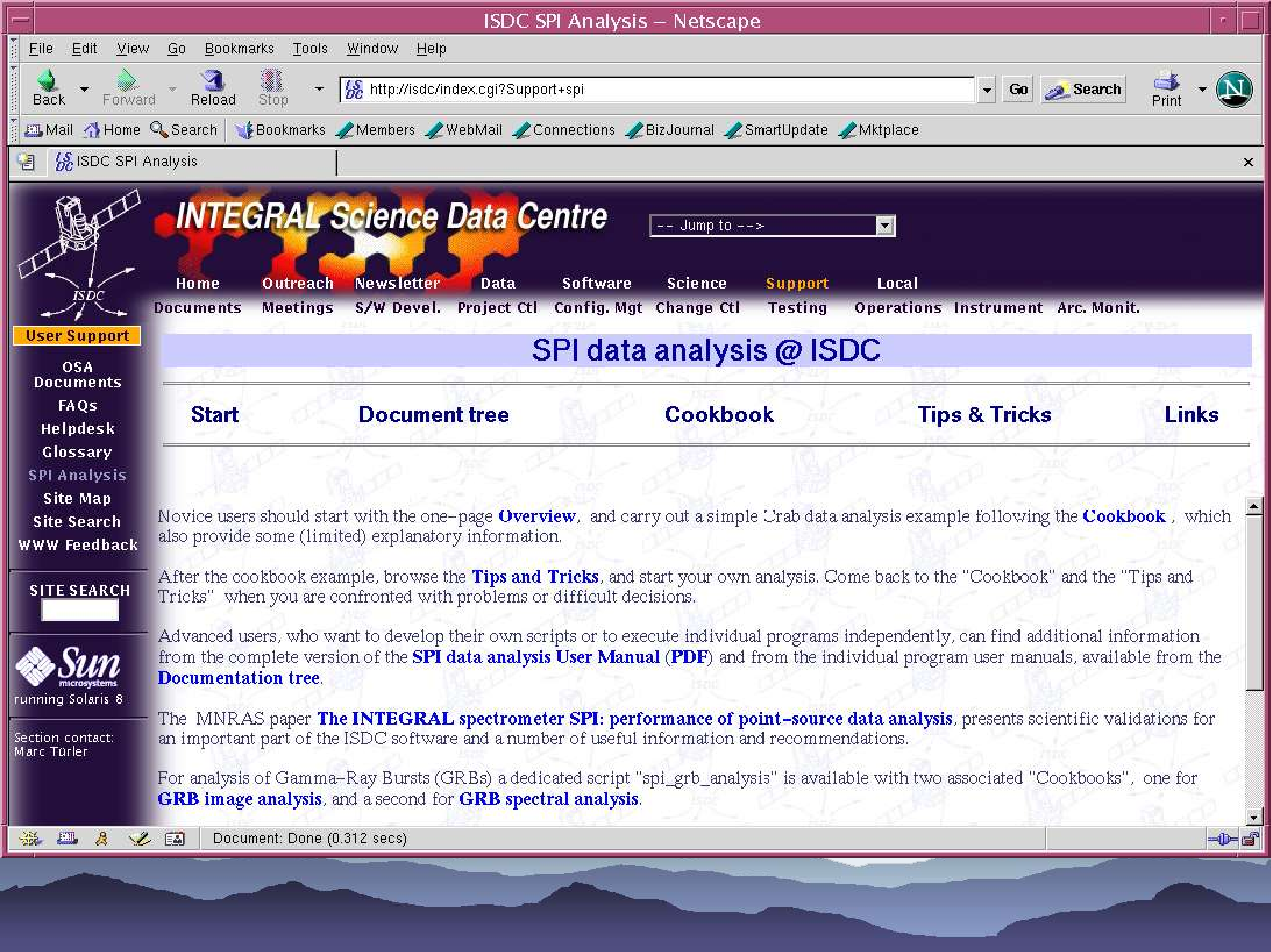
Start with the simplest model and add complications only if the residuals can be significantly reduced

- Build the minimum set of significant (constant) sources
- Test different background models/approaches
- Using prior information allows for one source (at a time) to vary with a given time scale (with spiros in timing mode)
- Extract spectra using catalogue positions and timing information

# SPI data analysis tutorial

Following the “Cookbook” and using additional data from rev 170

- Copy rev170_data.tar into your $REP_BASE_PROD and untar it (contain 10 pointings of Crab observation)
- Make sure your environment is OK (see Cookbook if necessary)
- Use og_create to build an OG from the list of DOLs
- Move into the obs/”obs_id” directory and type spi_science_analysis

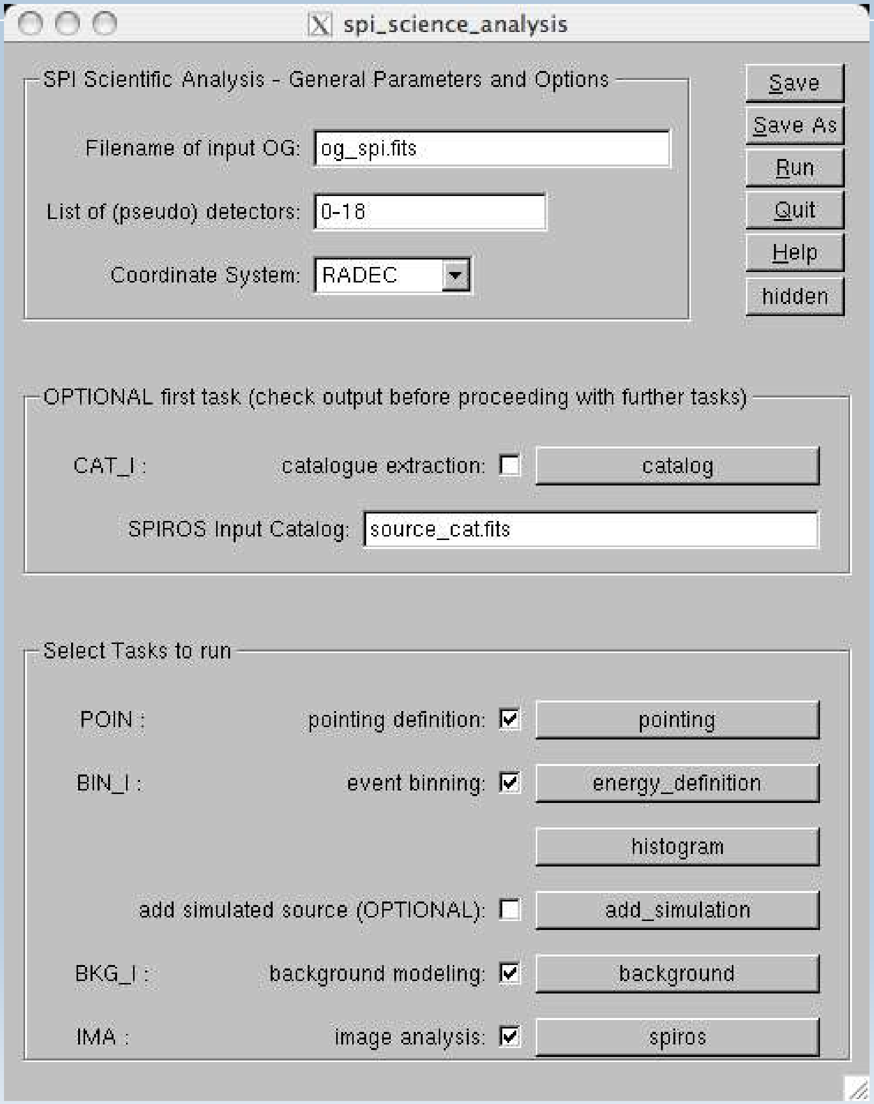

ISDC SPI Analysis – Netscape
File Edit View Go Bookmarks Tools Window Help
Back Forward Reload Stop
http://isdc/index.cgi?Support+spi
Go Search Print
Mail Home Search Bookmarks Members WebMail Connections BizJournal SmartUpdate Mktplace
ISDC SPI Analysis
INTEGRAL Science Data Centre
-- Jump to -->
Home Outreach Newsletter Data Software Science Support Local
Documents Meetings S/W Devel. Project Ctl Config. Mgt Change Ctl Testing Operations Instrument Arc. Monit.
ISDC
User Support
OSA Documents
FAQs
Helpdesk
Glossary
SPI Analysis
Site Map
Site Search
WWW Feedback
SITE SEARCH
Sun microsystems
running Solaris 8
Section contact: Marc Türler
SPI data analysis @ ISDC
Start
Document tree
Cookbook
Tips & Tricks
Links
Novice users should start with the one-page Overview, and carry out a simple Crab data analysis example following the Cookbook, which also provide some (limited) explanatory information.
After the cookbook example, browse the Tips and Tricks, and start your own analysis. Come back to the "Cookbook" and the "Tips and Tricks" when you are confronted with problems or difficult decisions.
Advanced users, who want to develop their own scripts or to execute individual programs independently, can find additional information from the complete version of the SPI data analysis User Manual (PDF) and from the individual program user manuals, available from the Documentation tree.
The MNRAS paper The INTEGRAL spectrometer SPI: performance of point-source data analysis, presents scientific validations for an important part of the ISDC software and a number of useful information and recommendations.
For analysis of Gamma-Ray Bursts (GRBs) a dedicated script "spi_grb_analysis" is available with two associated "Cookbooks", one for GRB image analysis, and a second for GRB spectral analysis.
Document: Done (0.312 secs)

# *SPI data analysis tutorial*

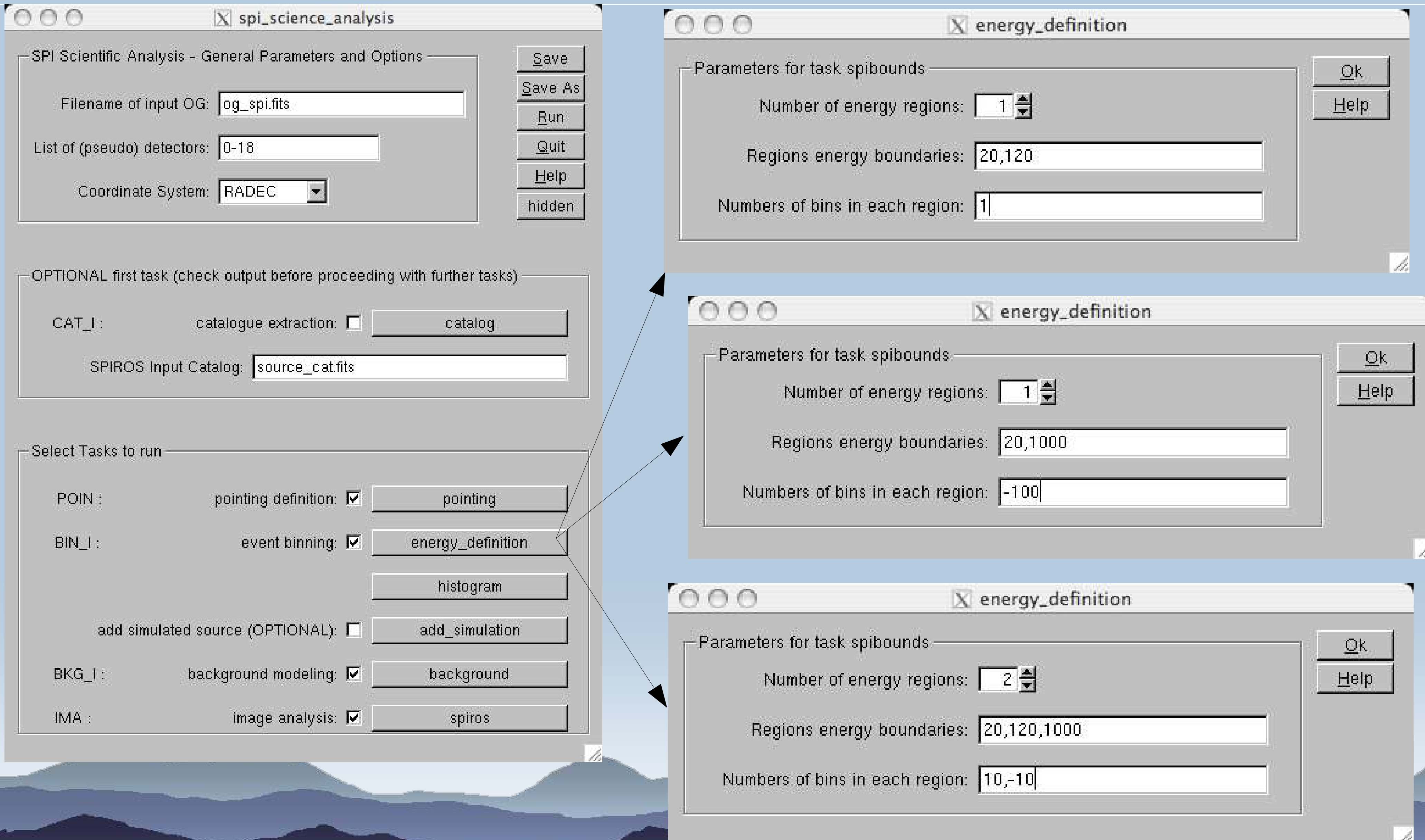
Following the “Cookbook” and using additional data from rev 170

- Copy rev170_data.tar into your $REP_BASE_PROD and untar it (contain 10 pointings of Crab observation)
- Make sure your environment is OK (see Cookbook if necessary)
- Use og_create to build an OG from the list of DOLs
- Move into the obs/”obs_id” directory and type spi_science_analysis

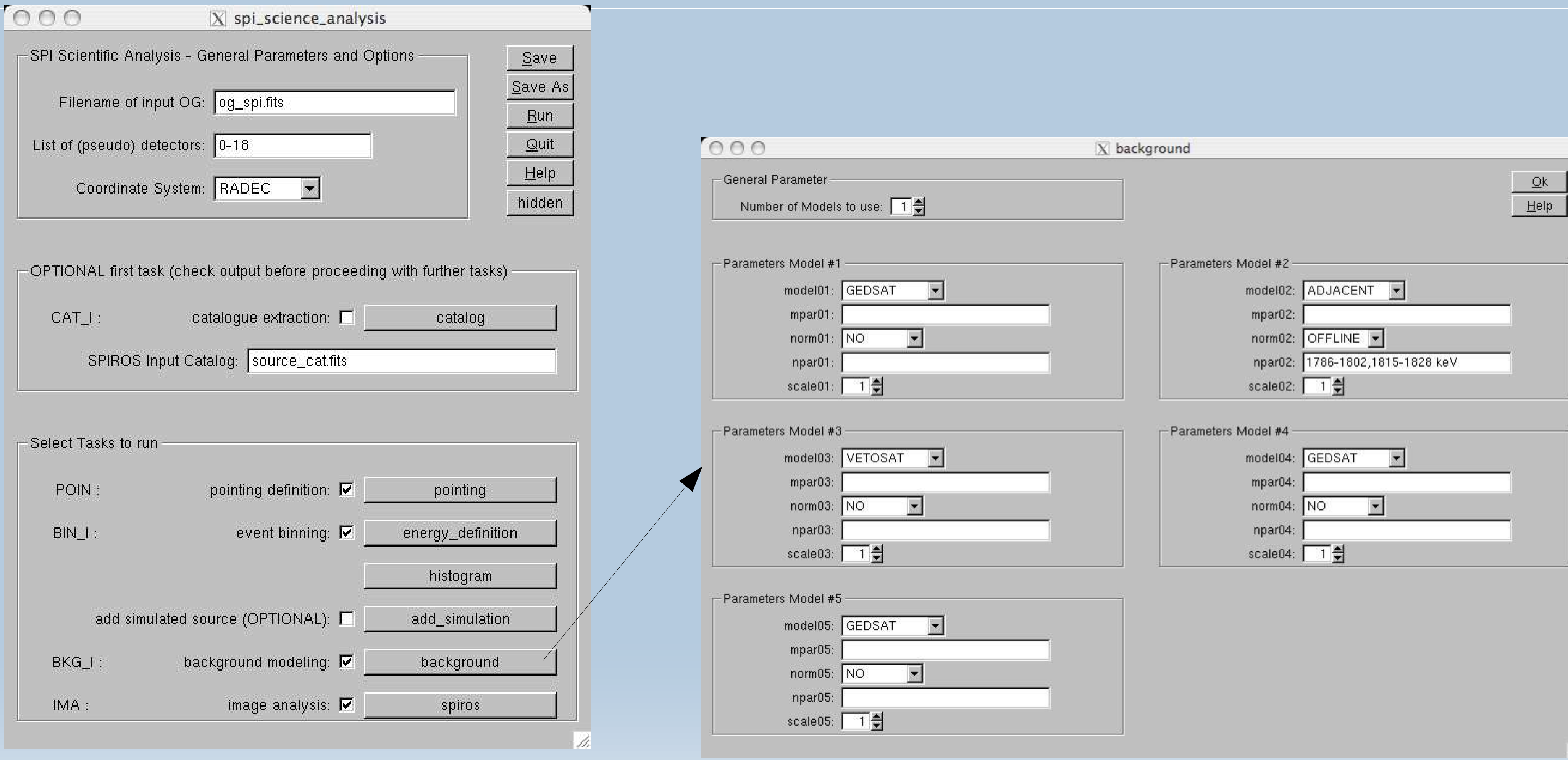
# *spi_science_analysis*



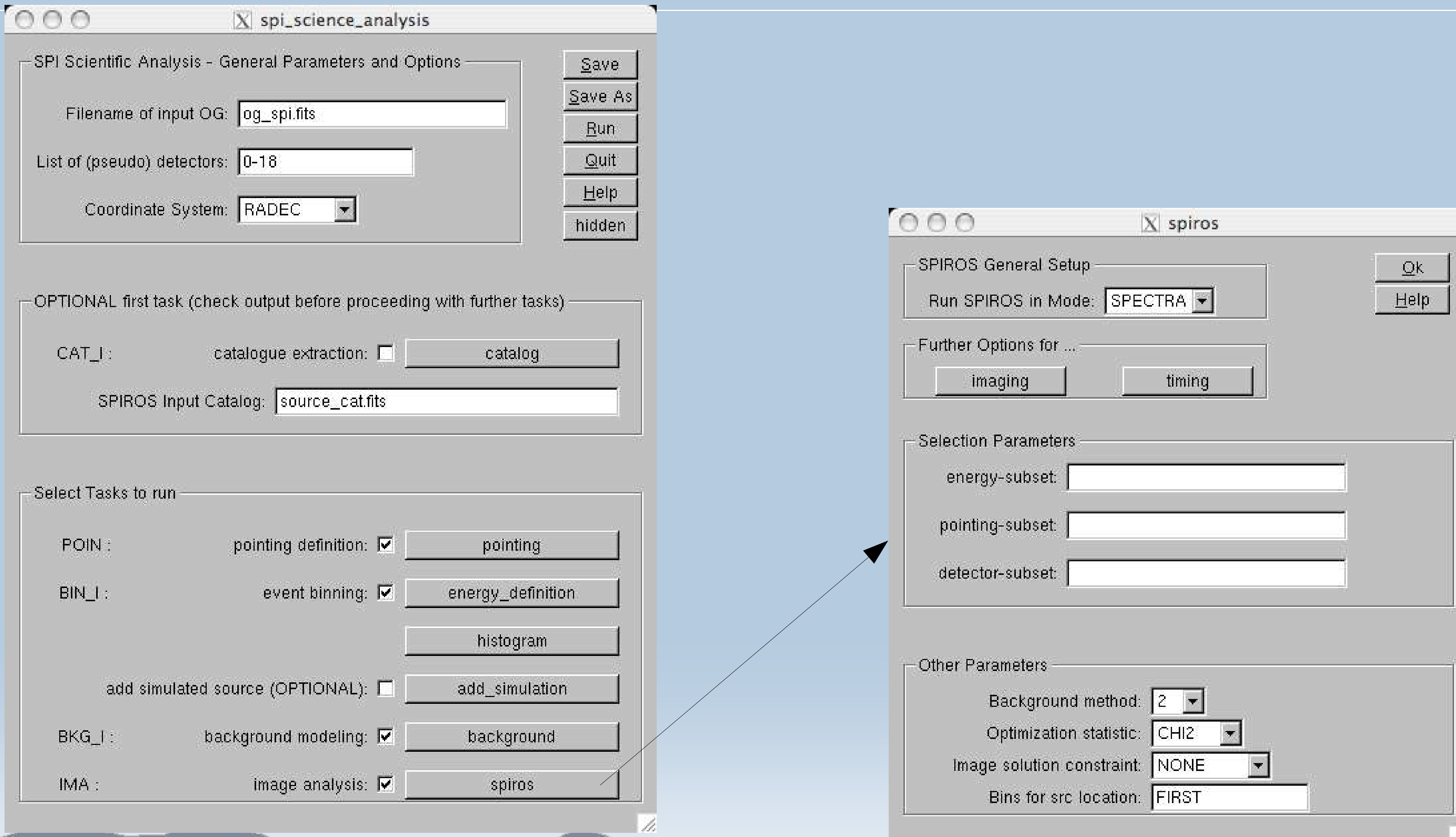
# spi_science_analysis



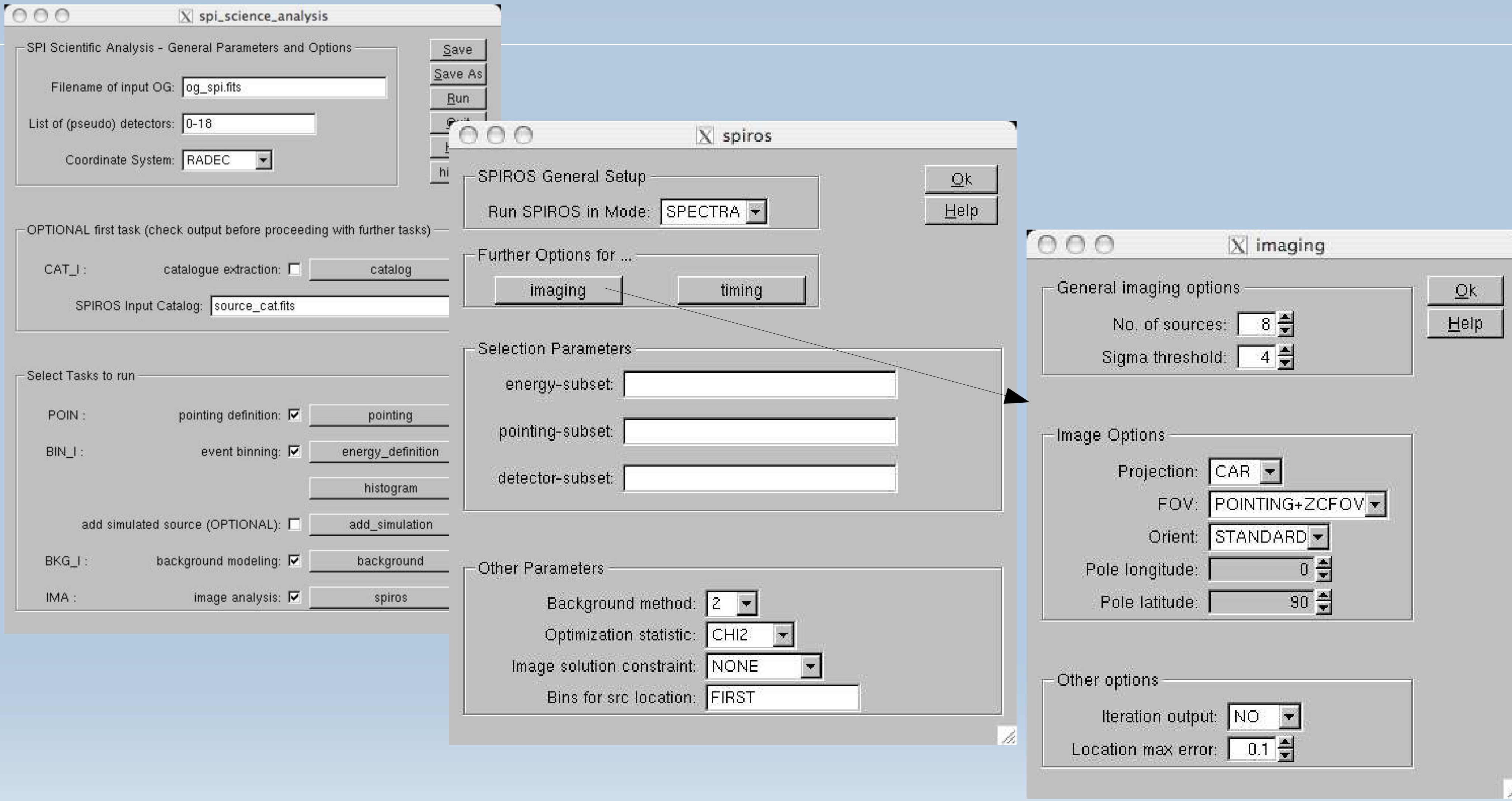
# *spi_science_analysis*



# *spi_science_analysis*



# spi_science_analysis



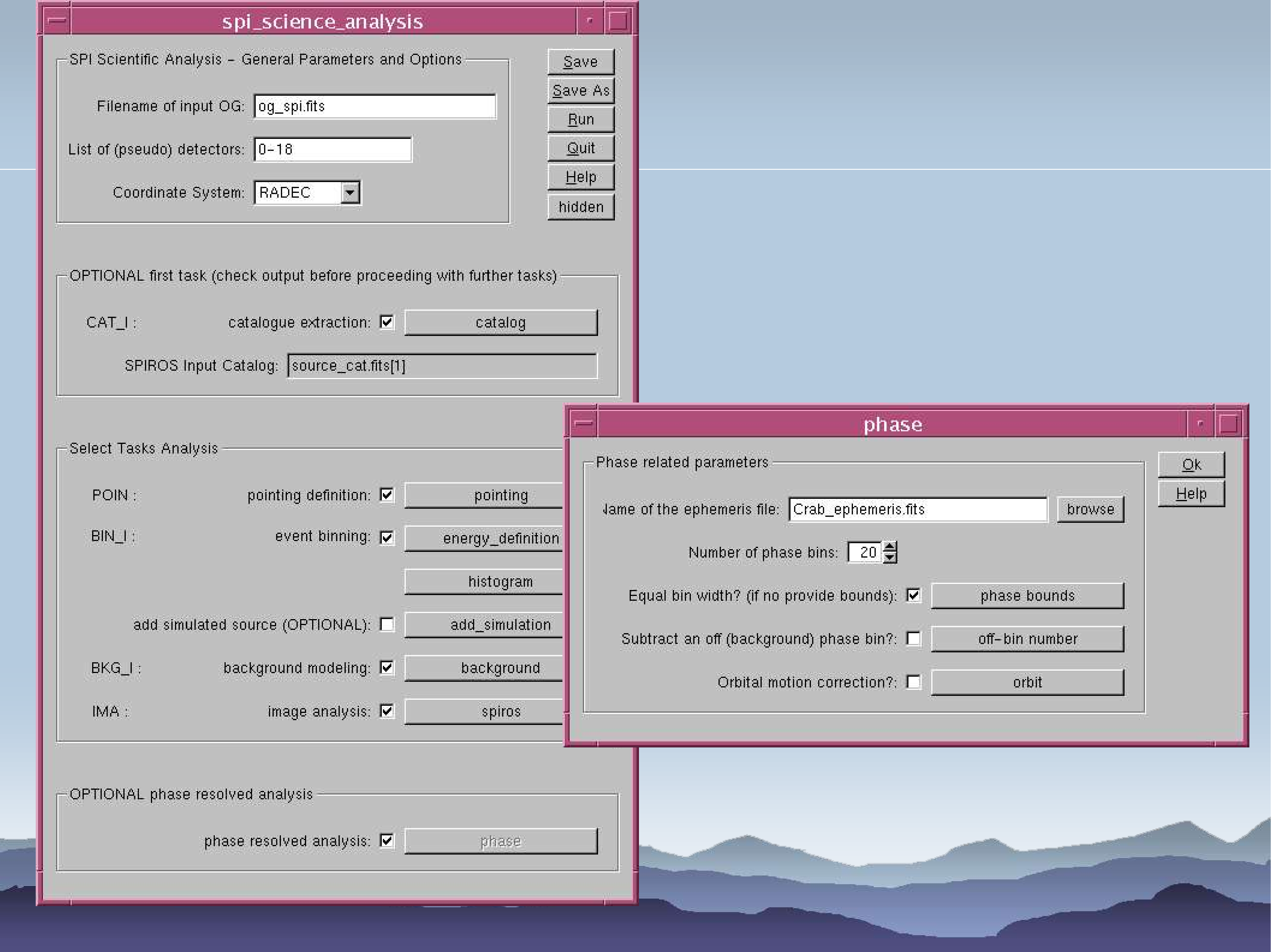
# *SPI data analysis tutorial*

Following the "Cookbook" and using additional data from rev 170, try:

- Build an OG with data from the 10 science windows. Make an image in a wide energy bin without  input catalog from the 10 scw data and check that the Crab is found at the right position.
- Extract a Crab spectrum with 100 log bin from 20 to 1000 kev and fit it with a single power law model in Xspec.
- Compared Crab spectra derived with different statistics (Chi2 or likelihood) and different background method (2 or 5).

For the more adventurous, try

- Analyze 10 scw from revolution 175, with and without an input catalog


spi_science_analysis
SPI Scientific Analysis – General Parameters and Options
Filename of input OG:
og_spi.fits
List of (pseudo) detectors:
0-18
Coordinate System:
RADEC
Save
Save As
Run
Quit
Help
hidden
OPTIONAL first task (check output before proceeding with further tasks)
CAT_I :
catalogue extraction:
catalog
SPIROS Input Catalog:
source_cat.fits[1]
Select Tasks Analysis
POIN :
pointing definition:
pointing
BIN_I :
event binning:
energy_definition
histogram
add simulated source (OPTIONAL):
add_simulation
BKG_I :
background modeling:
background
IMA :
image analysis:
spiros
OPTIONAL phase resolved analysis
phase resolved analysis:
phase
phase
Phase related parameters
Ok
Help
Name of the ephemeris file:
Crab_ephemeris.fits
browse
Number of phase bins:
20
Equal bin width? (if no provide bounds):
phase bounds
Subtract an off (background) phase bin?:
off-bin number
Orbital motion correction?:
orbit

# Further Developments

# *Analysis Steps*

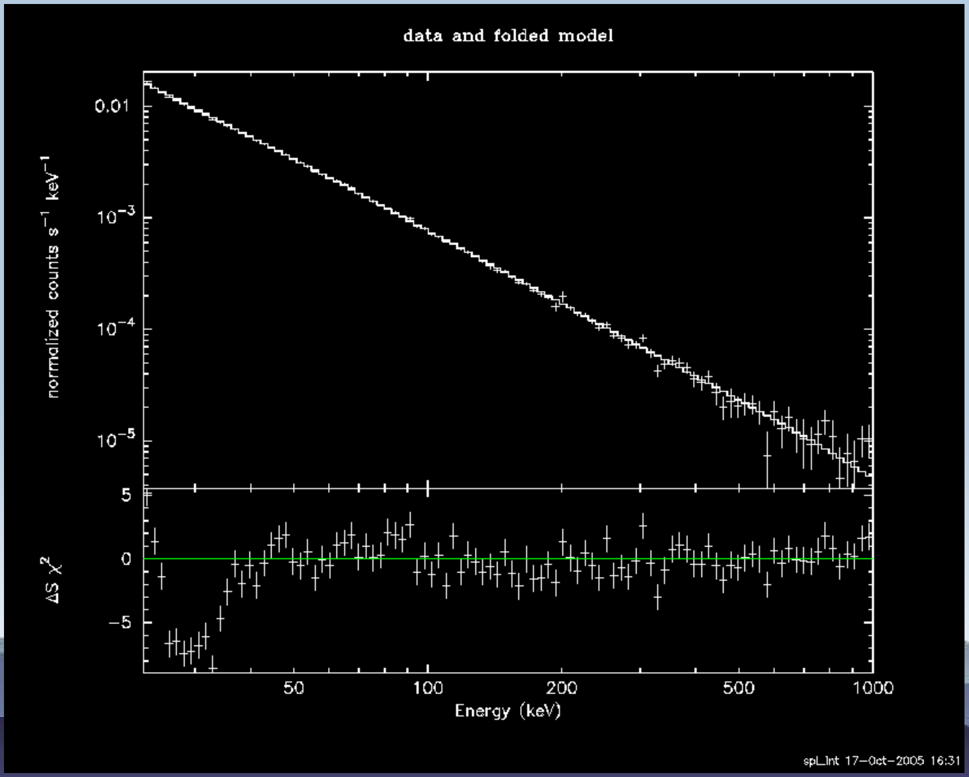
1) ( Energy Correction )
2) Catalogue extraction
3) Pointing Definition
4) GTI
5) Dead Time
6) Energy Bin Definition
7) Event binning
8) Background modeling
9) Imaging (SPIROS)
10) Spectrum extraction
11) XSPEC

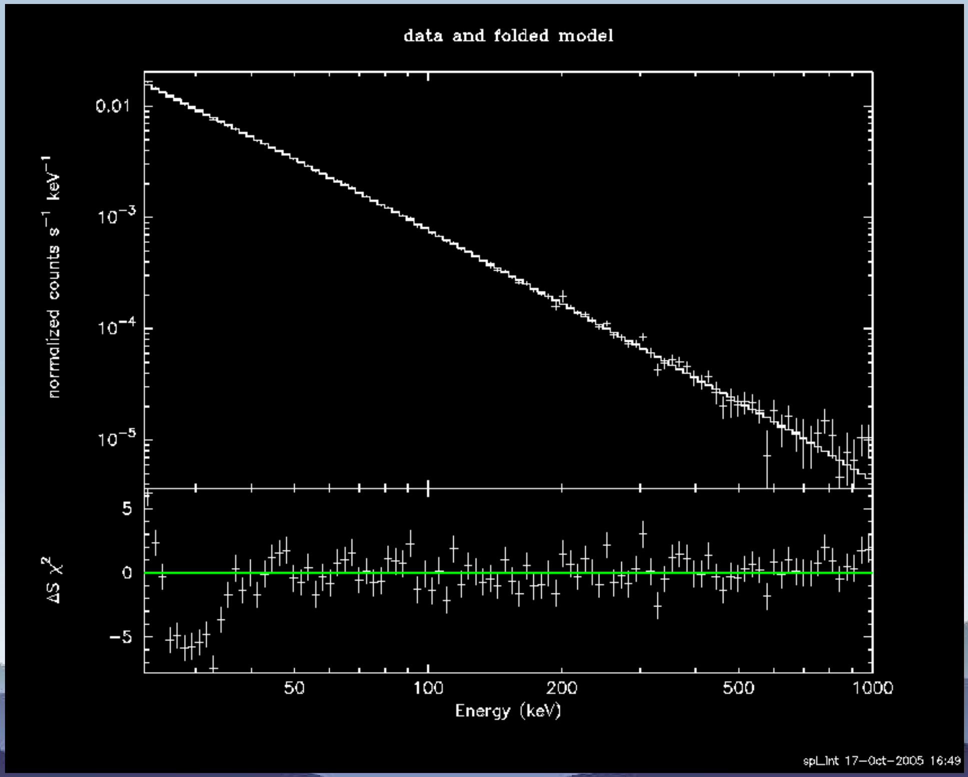
# *The Crab spectrum with spirmf*

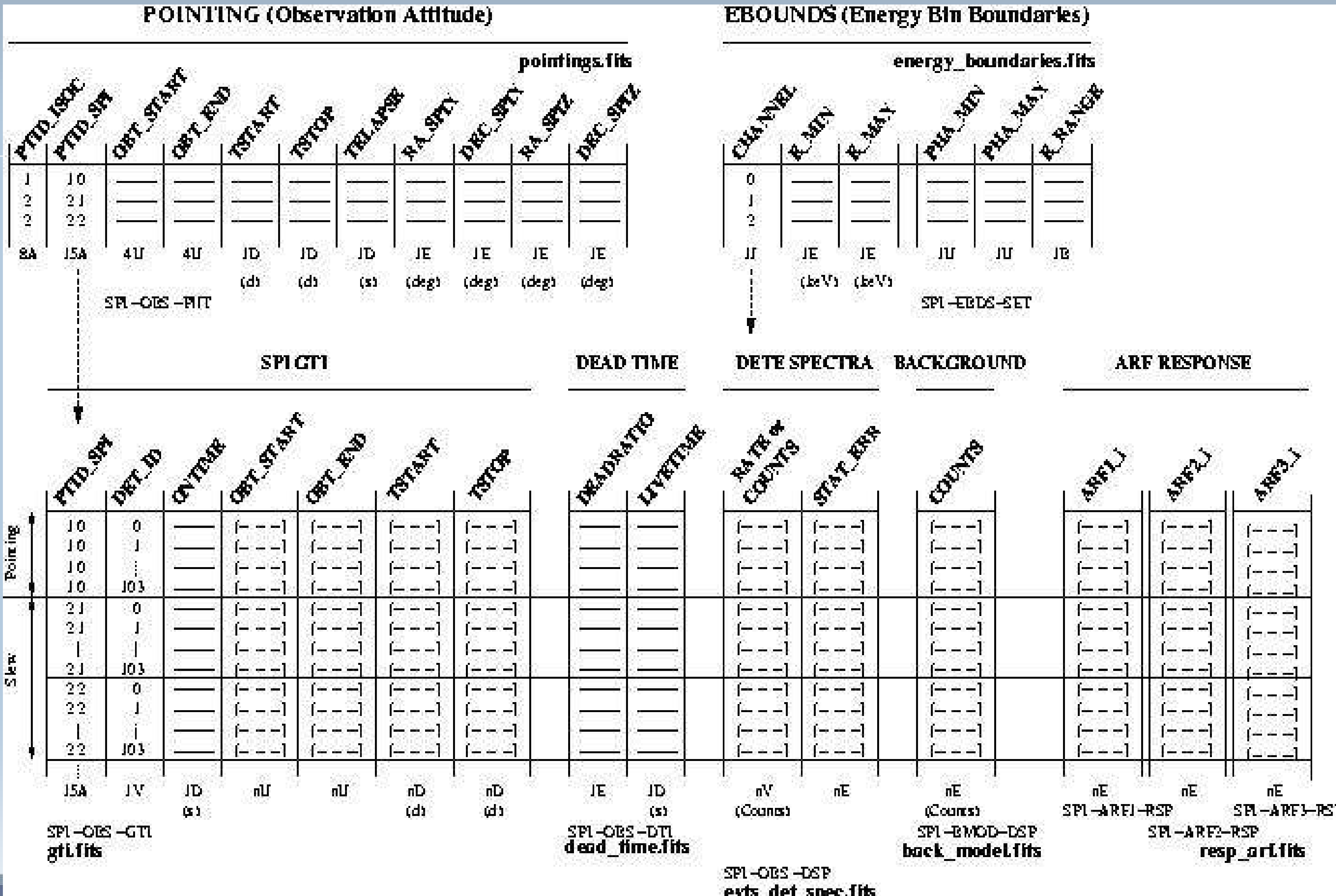
- 138 pointings from rev 43 and 44, fit in the 35 to 100 KeV range

Index = 2.17
F(50-100) = 7.9 10-9 erg/cm2/sec
Reduced Chi2 = 1.45

Index = 2.15 (86) 2.20
F(50-100) = 7.9 10-9 erg/cm2/sec
Reduced Chi2 = 1.27




POINTING (Observation Attitude)
pointings.fits
PTID_ISOC
PTID_SPI
OBT_START
OBT_END
TSTART
TSTOP
TELAPSE
RA_SPIX
DEC_SPIX
RA_SPIZ
DEC_SPIZ
SPI-OBS-PNT
EBOUNDS (Energy Bin Boundaries)
energy_boundaries.fits
CHANNEL
E_MIN
E_MAX
PHA_MIN
PHA_MAX
E_RANGE
SPI-EBDS-SET
SPI GTI
DEAD TIME
DETE SPECTRA
BACKGROUND
ARF RESPONSE
PTID_SPI
DET_ID
ONTIME
OBT_START
OBT_END
TSTART
TSTOP
DEADRATIO
LIVETIME
RATE or COUNTS
STAT_ERR
COUNTS
ARF1_i
ARF2_i
ARF3_i
Pointing
Slew
SPI-OBS-GTI
gti.fits
SPI-OBS-DTI
dead_time.fits
SPI-OBS-DSP
evts_det_spec.fits
SPI-BMOD-DSP
back_model.fits
SPI-ARF1-RSP
SPI-ARF2-RSP
SPI-ARF3-RSP
resp_arf.fits

# Conclusions

- SPIROS imaging and spectral extraction are reliable
  - OK for sources with separation > ~2 degrees
- Well validated response - spectral continuum fitting accurate to a few %.
- Lightcurve extraction on pointing timescale possible
- Tools available for GRB and phase resolved analysis
- Further improvements planned for OSA6.0