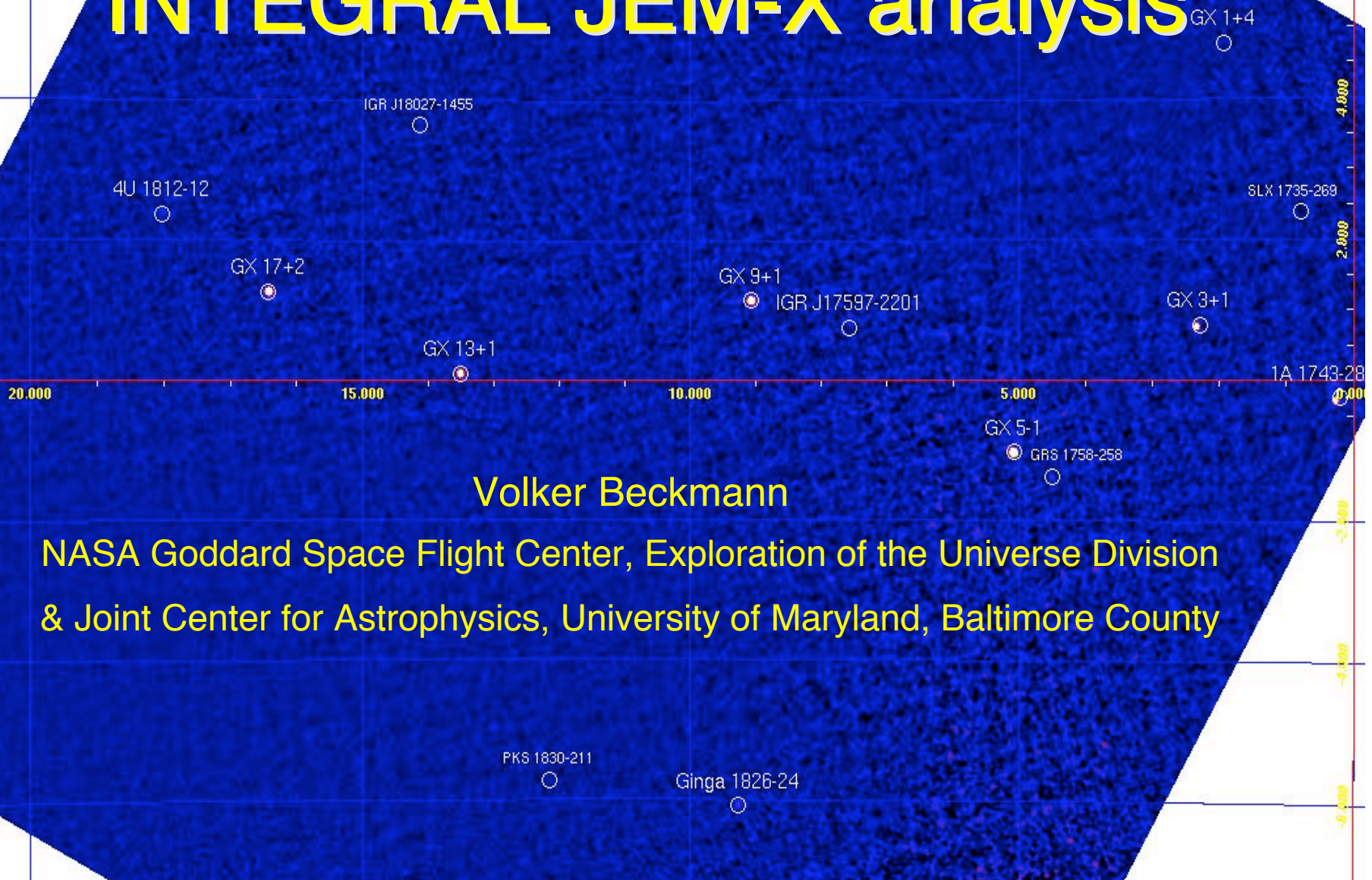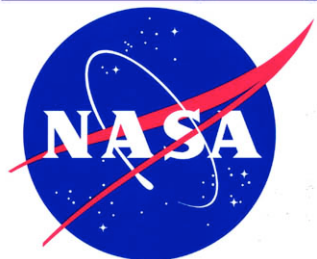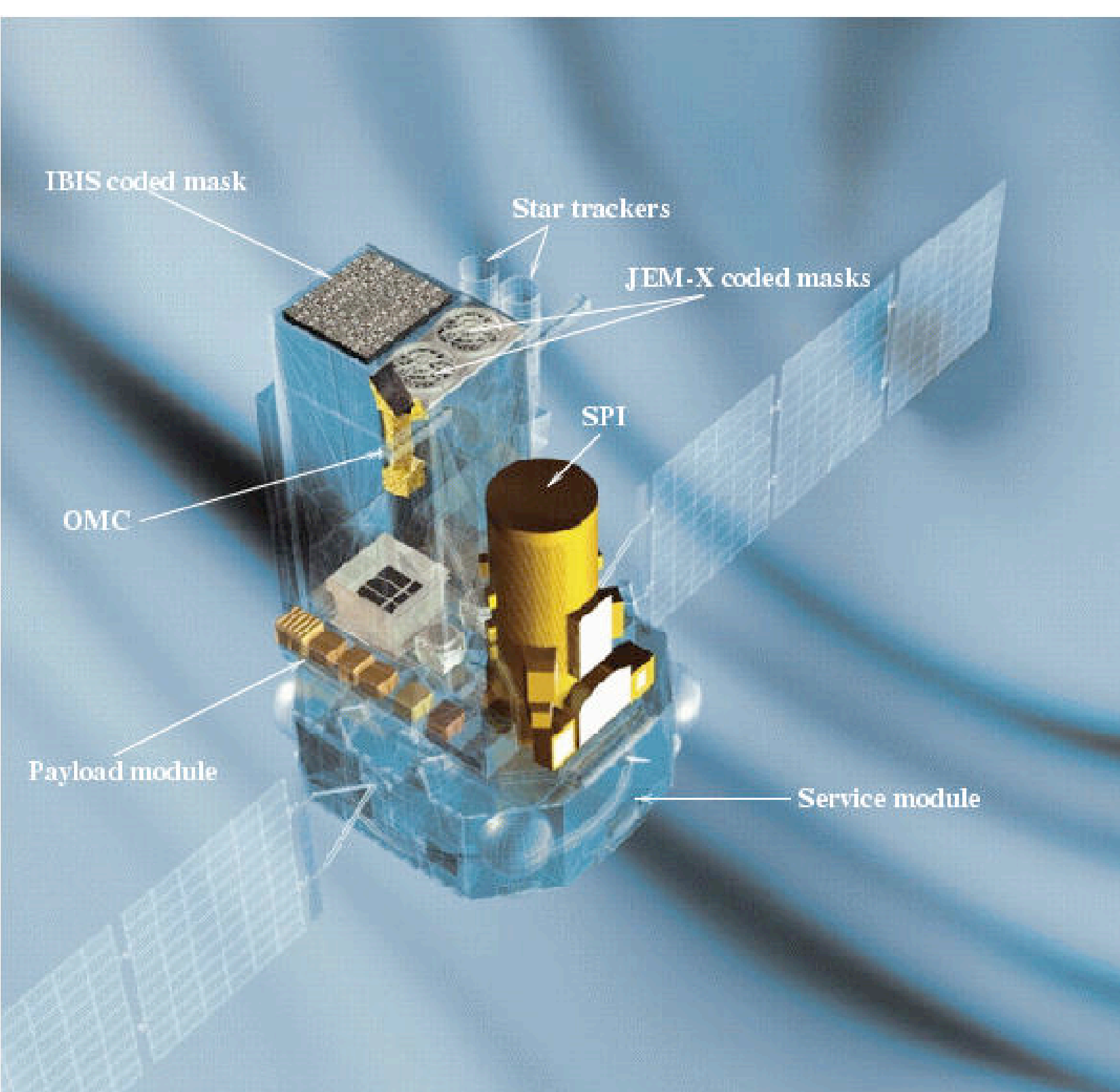# INTEGRAL JEM-X analysis

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JEM-X data analysis

- JEM-X - the X-ray monitor of INTEGRAL

- What can we do with JEM-X ?

- Running the pipeline jemx_science_analysis

- Data products - images and spectra

- JEM-X spectra in XSPEC

- Summary

ISGRI:
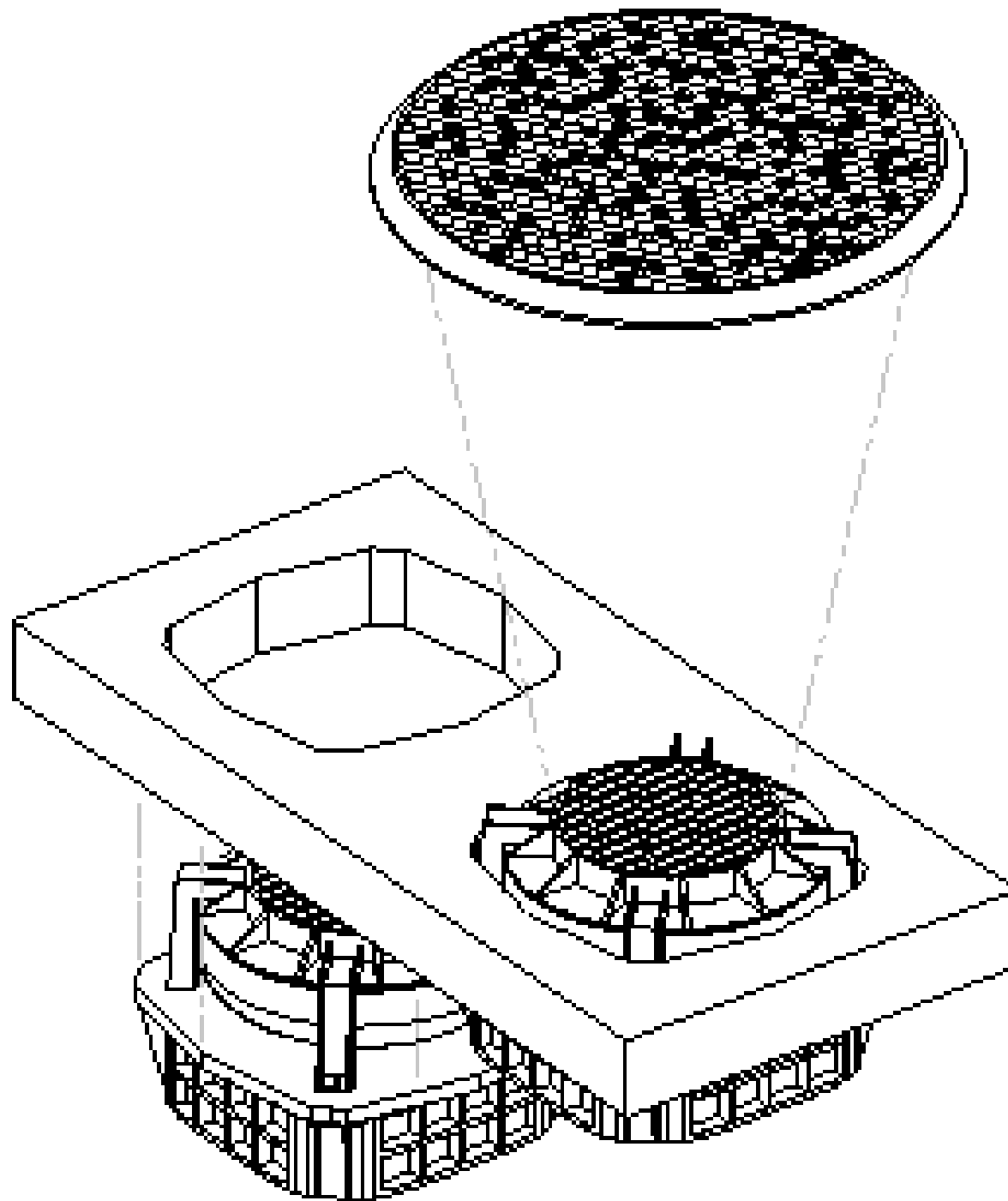20-400 keV
fov: 9º x 9º
12 arcmin

JEM-X:
2-30 keV
fov: 5º, 3 a
FWHM ~0

SPI:
20-8000 ke
fov: 16º
2º resolutic
1.3 keV @

OMC:
V-band im

Labels on figure: IBIS coded mask, Star trackers, JEM-X coded masks, SPI, OMC, Payload module, Service module

JEM-X consists of two identical detectors, JEM-X1 and JEMX2

INTEGRAL
JEM-X
detector

CODED
MASK
(535 mm Ø)

3.4 m

INCOMING
PHOTONS

Collimator
above X-ray
window

"Pan-shaped"
detector
chamber
filled with
Xenon (90%)
and
Methane (10%)
gas at 1.5 bar

ionisation
cloud

electron
'avalanche'

strong
electric
fields

microstrip
plate
(250 mm Ø)

electric impulse
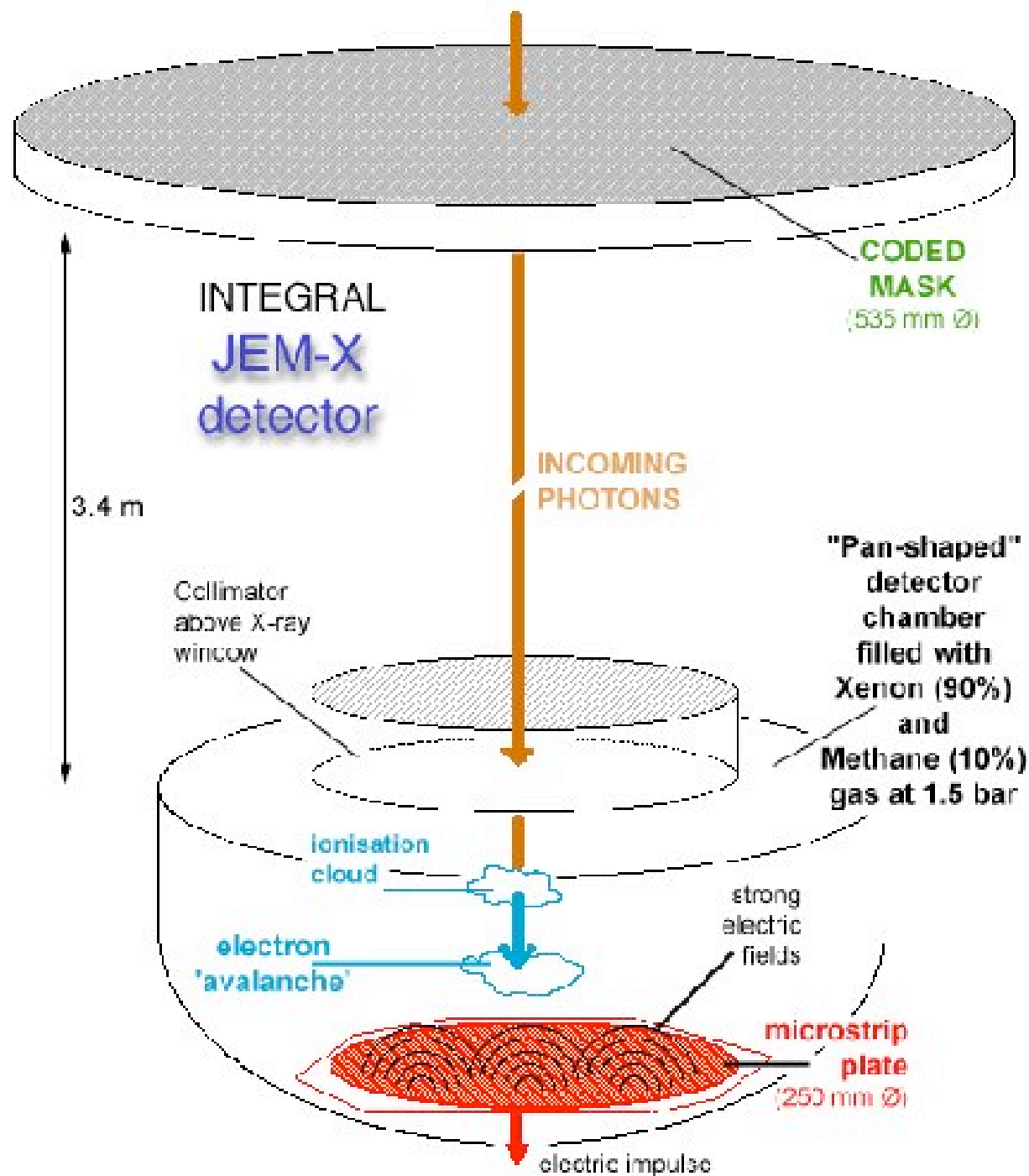
Functional design of the JEM-X detector
(Graphic: ESA/JEM-X instrument team)

Some numbers...

Energy rangeFWHM3 – 35 keV0.40 E[ke`

$\sqrt{}$

σ

μ

JEM-X Effective Area

Window: 250 μm Be, Gas: 1.5 atm. 5.5 cm Xe/10%CH$_4$

Graphic: DSRI

SPI - FCFOV

IBIS - FCFOV

z deg

JEM-X - FCFOV   OMC - FOV
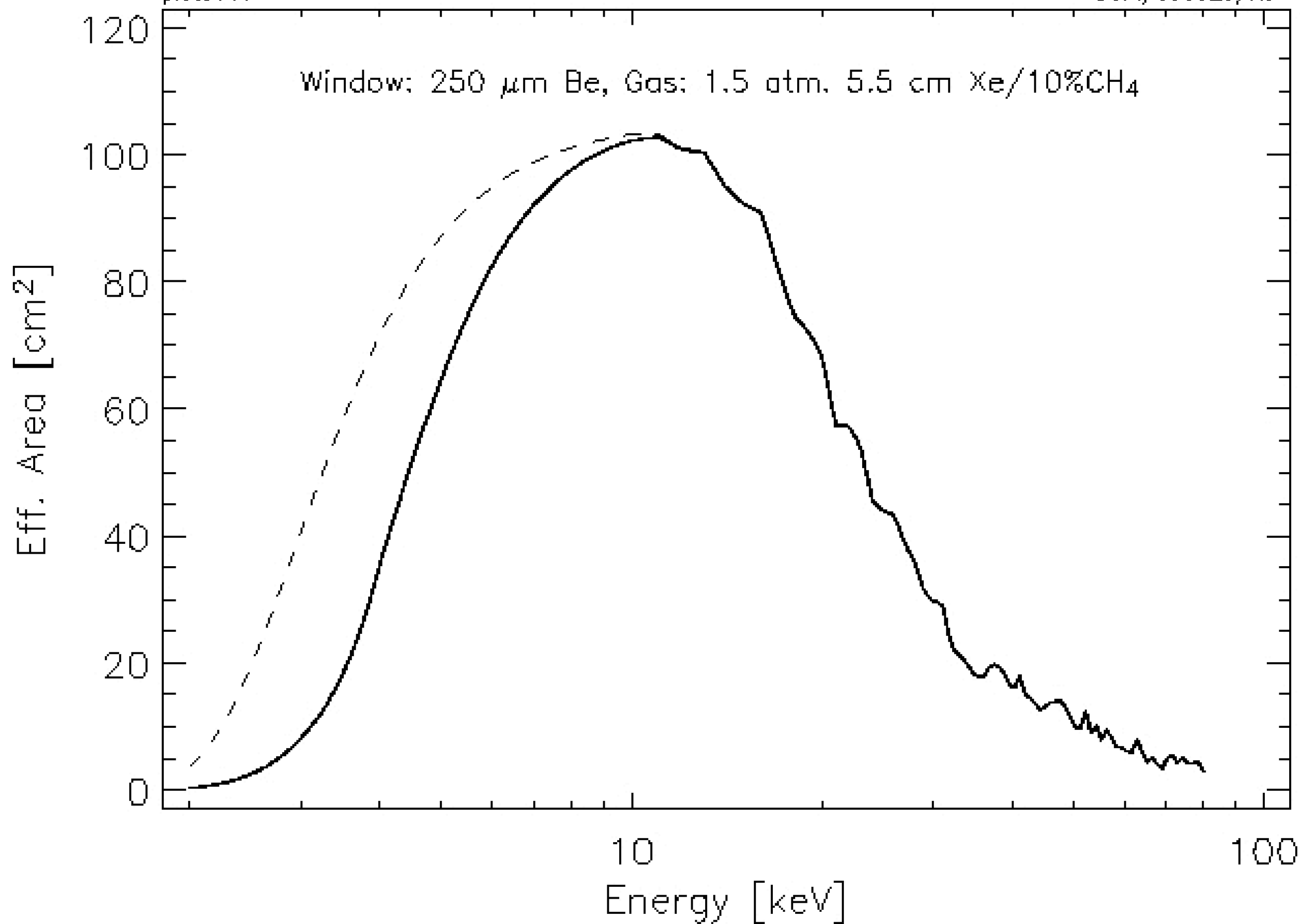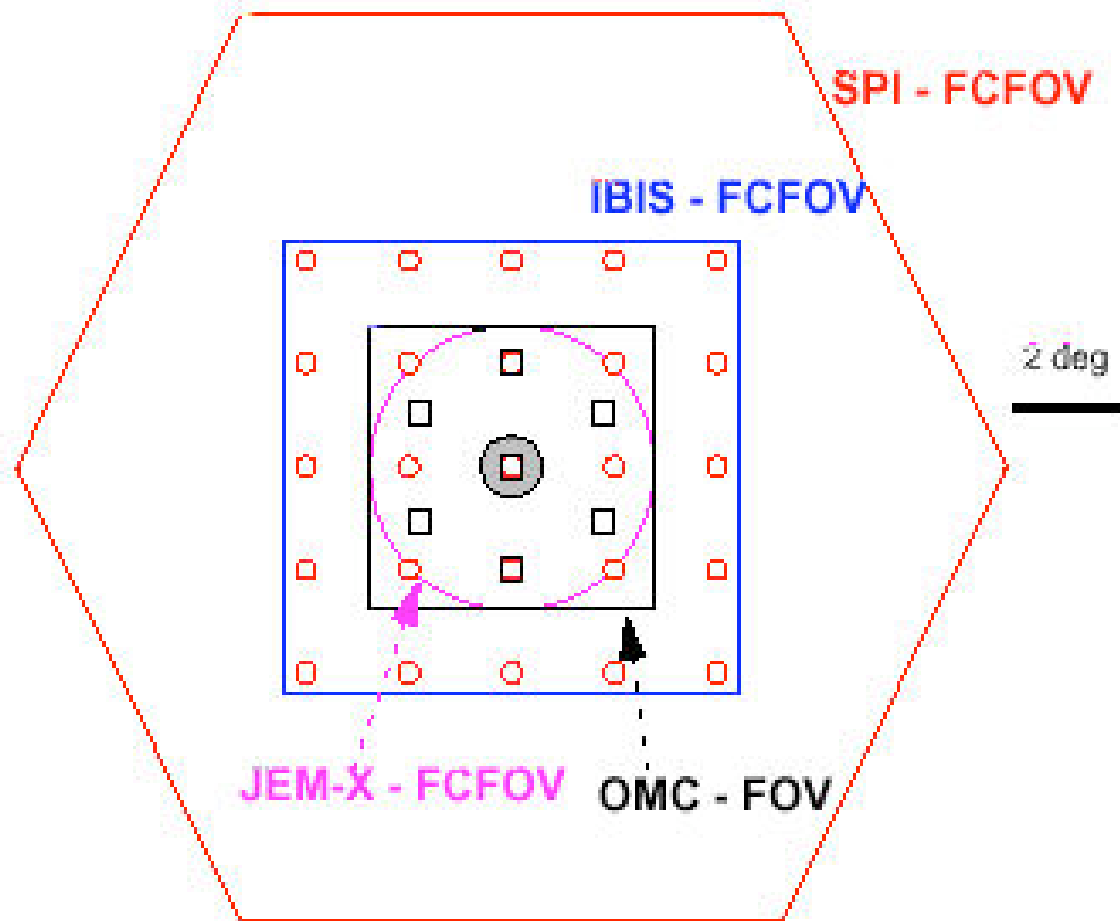
Target position

7 point hexagonal pattern

25 point rectangular pattern

Graphic: ISDC

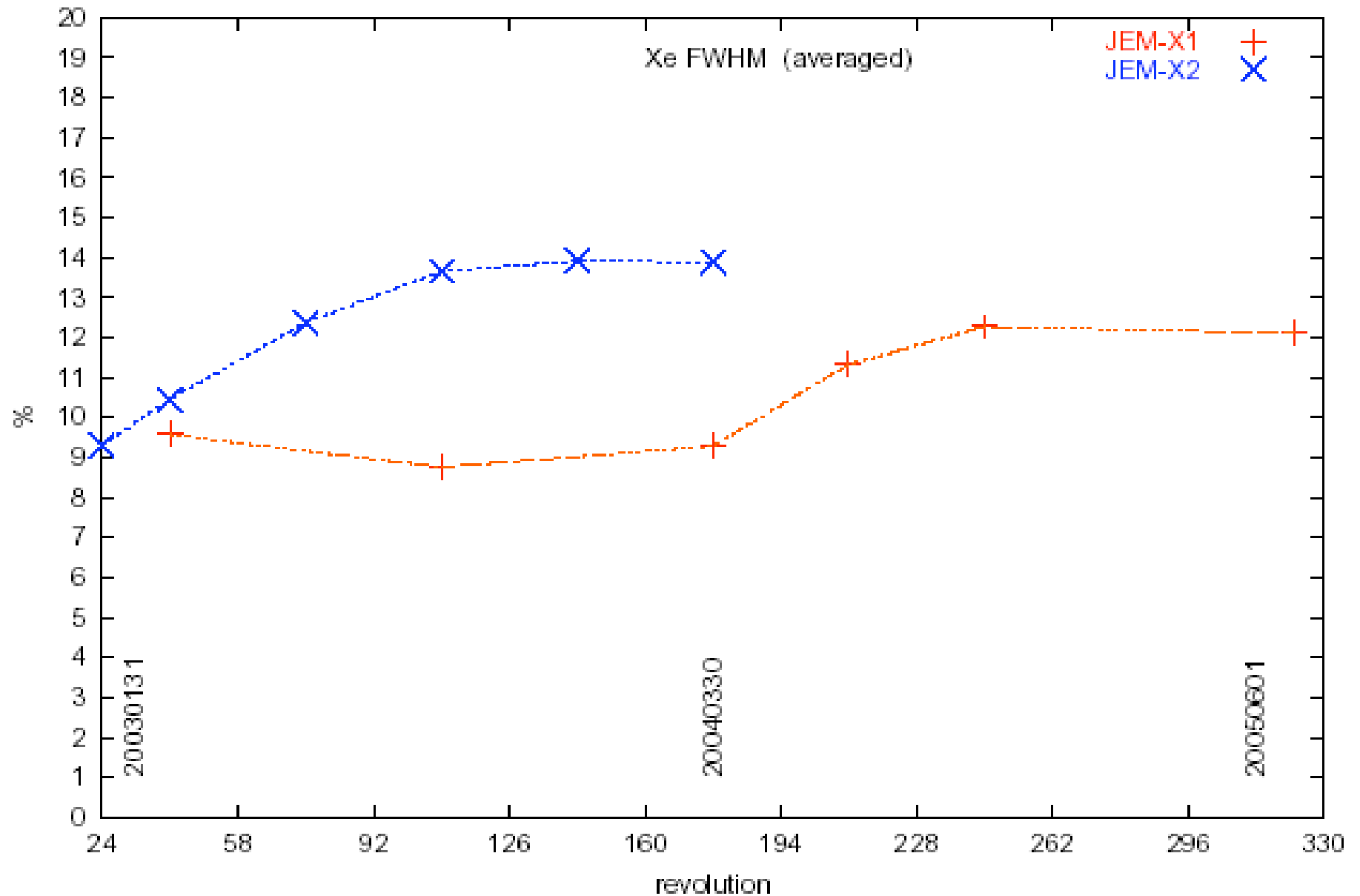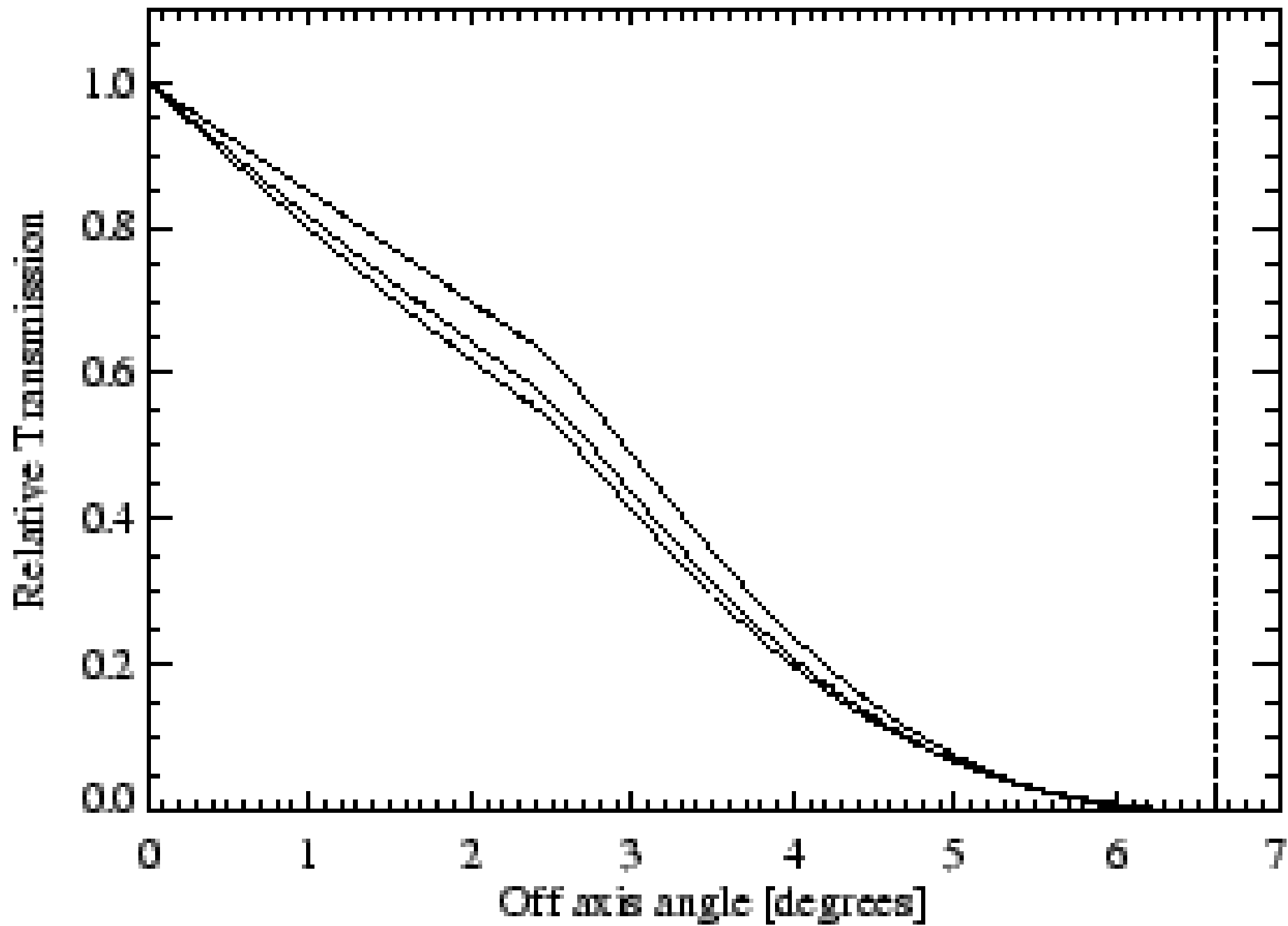Figure 2.7: The energy resolution of the two JEM–X instruments determined from the 30 keV Xe line. To improve statistics results from several science windows are added.

Graphic: JEM-X Science Validation Report 5.0

Graphic: JEM-X user manual

JEM−X Position Resolution

Gas: 1.5 atm. 5.5 cm Xe/10%CH$_4$

JMX1 Gasgain 500

JMX2 Gasgain 750

JMX1

JMX2

pixel_size

FWHM Resolution [mm]

Energy [keV]

Graphic: DSRI
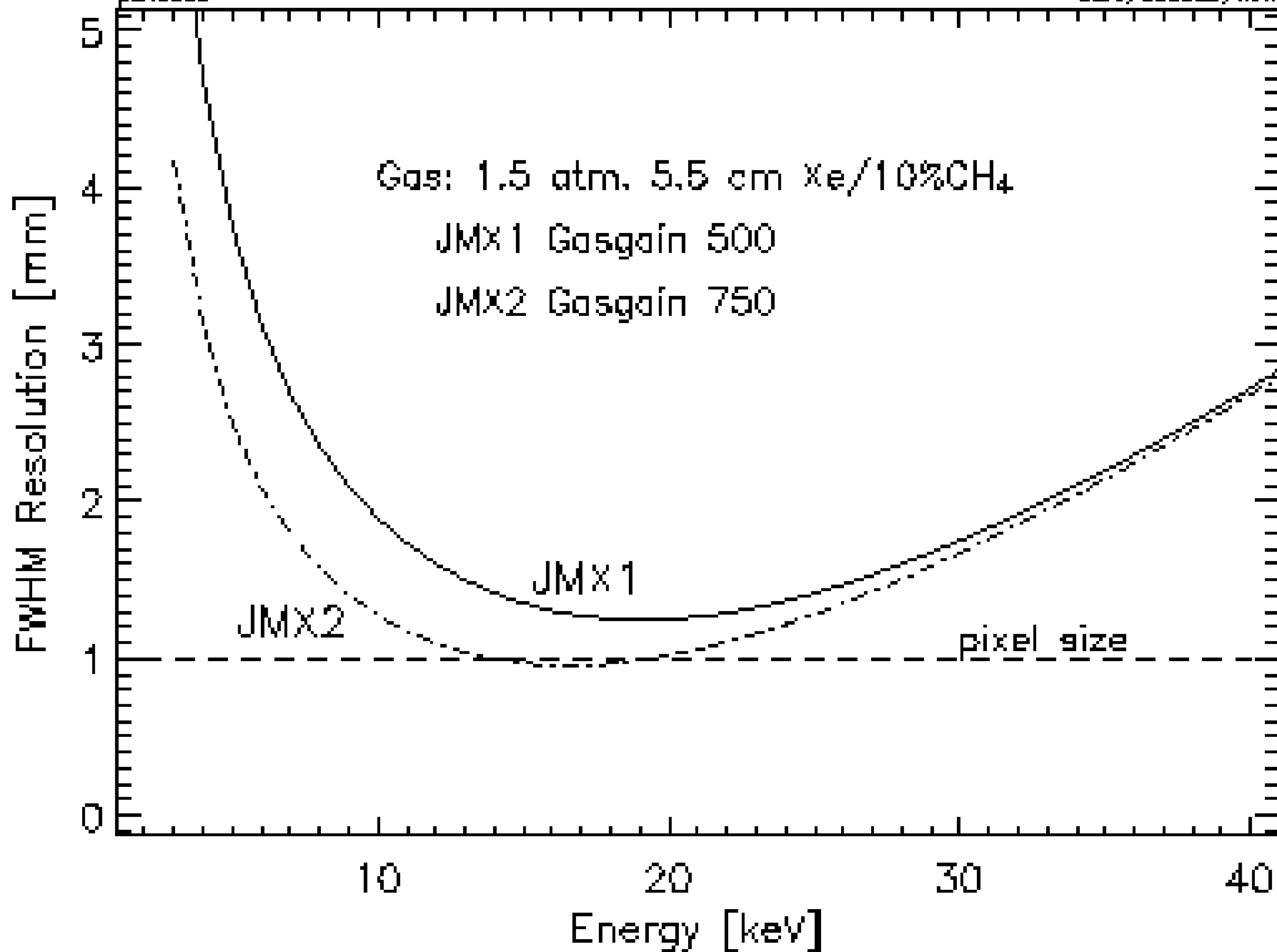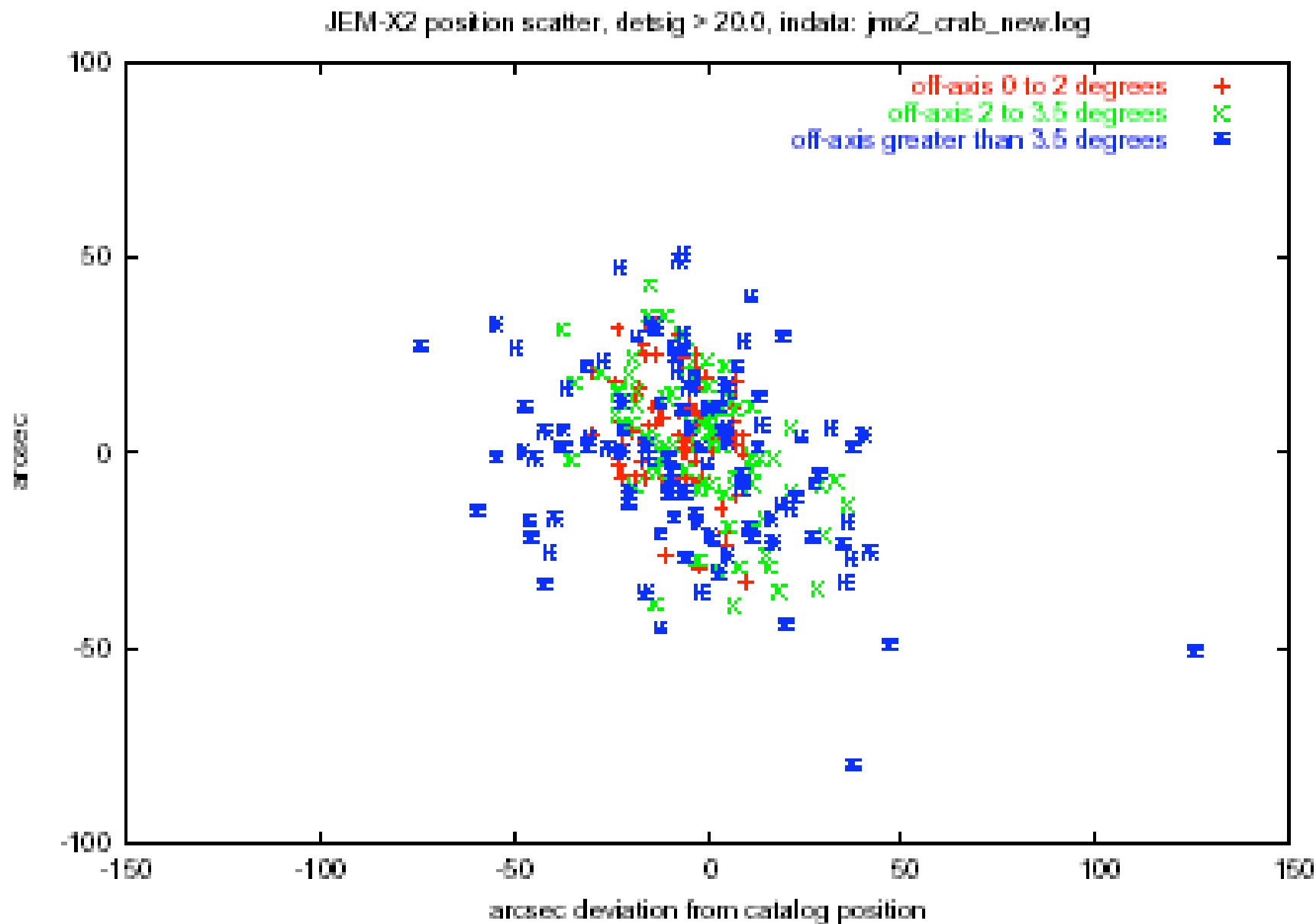
Figure 4.4: Position scatter of 350 detections of the Crab by JEM–X2. A detection significance limit of *detsig*> 20 has been used.

Graphic: JEM-X Science Validation Report 5.0

JEM-X1 and -2 flux values for Crab obs., indata: jmx1 and -2_crab_new.log
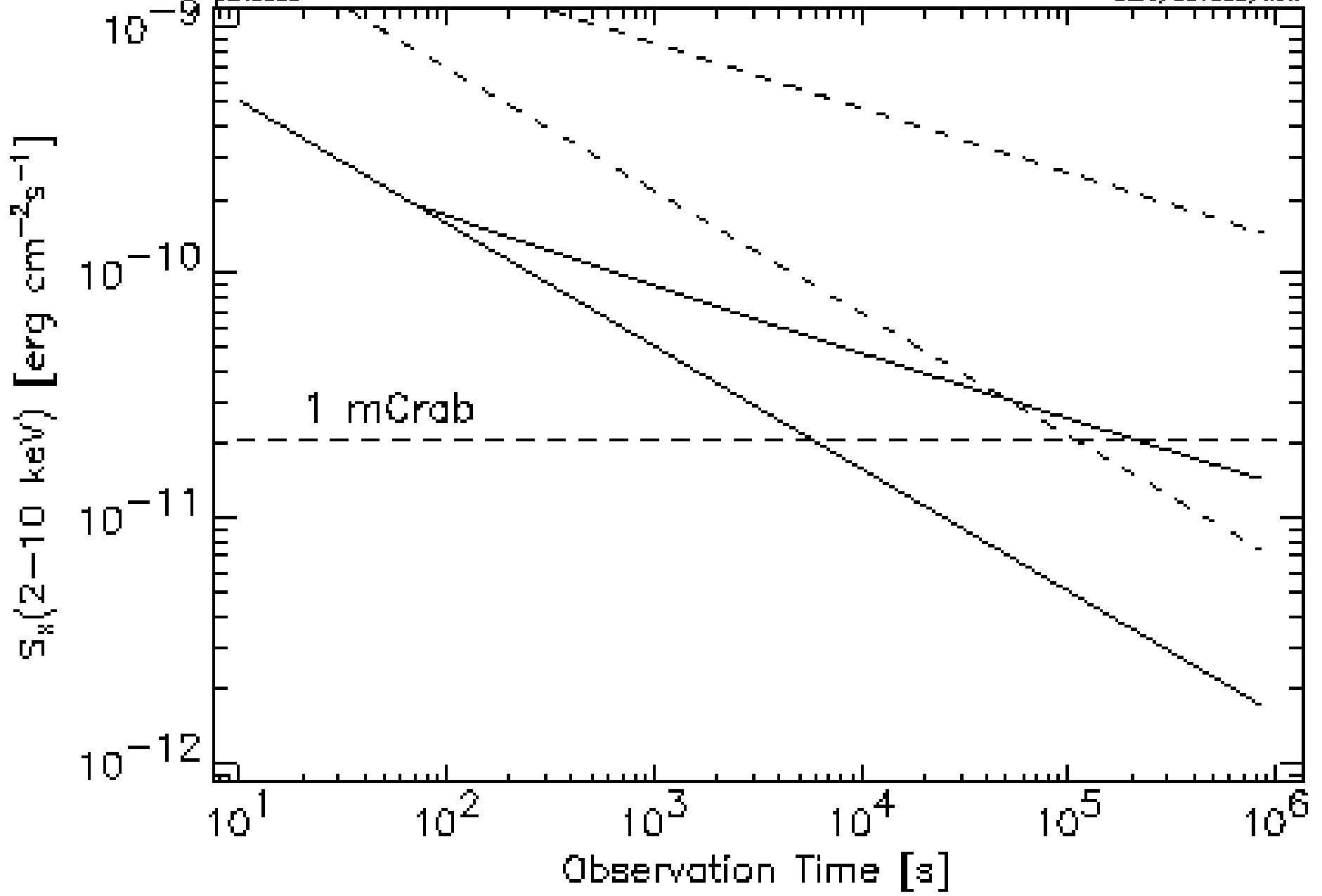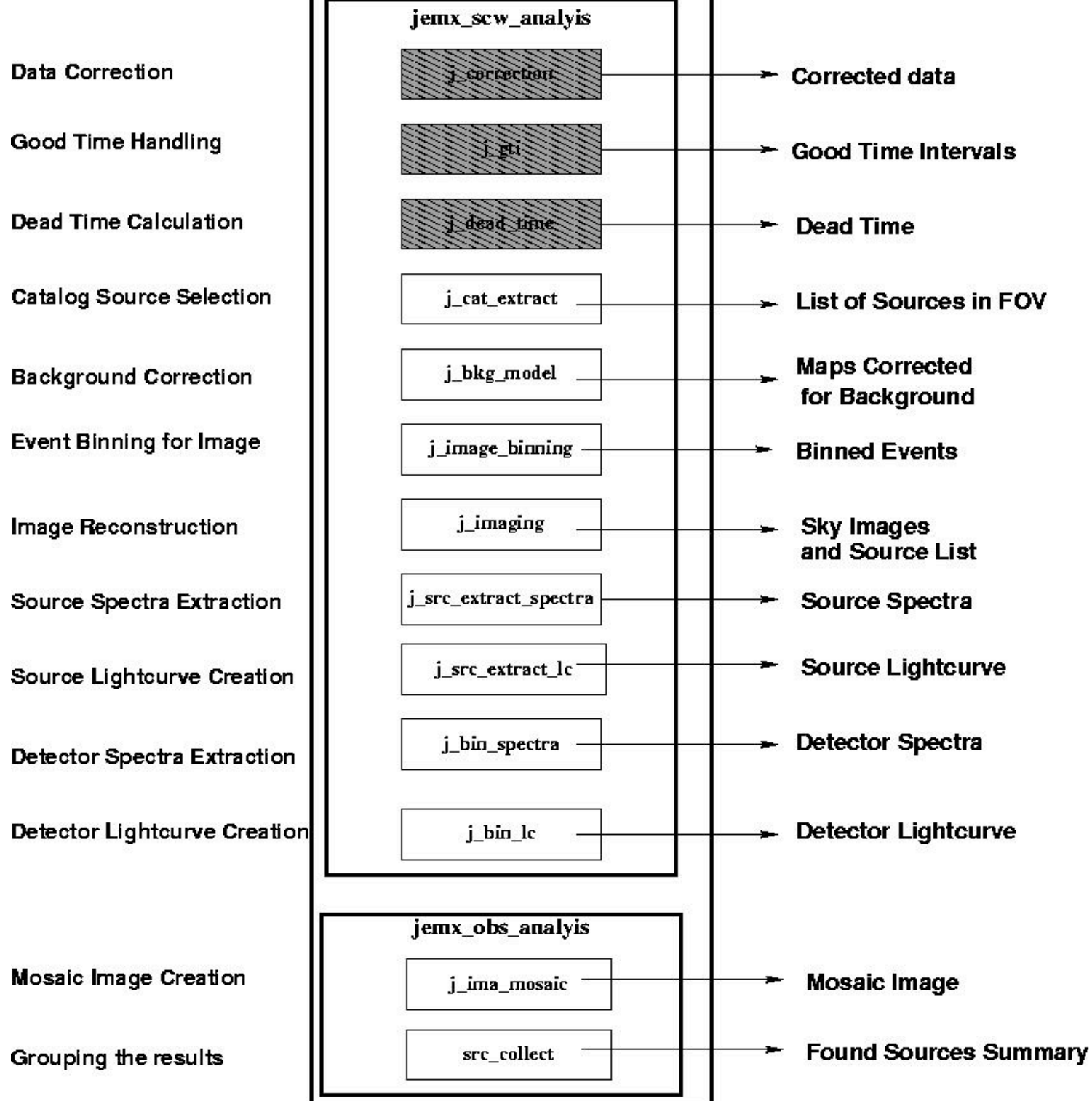
Graphic: JEM-X Science Validation Report 5.0

5σ source detection limit

1 mCrab

Observation Time [s]

S_x(2–10 keV) [erg cm^{-2}s^{-1}]

Graphic: DSRI

jemx_science_analyis

jemx_scw_analyis

Stage	Module	Output
Data Correction	j_correction	Corrected data
Good Time Handling	j_gti	Good Time Intervals
Dead Time Calculation	j_dead_time	Dead Time
Catalog Source Selection	j_cat_extract	List of Sources in FOV
Background Correction	j_bkg_model	Maps Corrected for Background
Event Binning for Image	j_image_binning	Binned Events
Image Reconstruction	j_imaging	Sky Images and Source List
Source Spectra Extraction	j_src_extract_spectra	Source Spectra
Source Lightcurve Creation	j_src_extract_lc	Source Lightcurve
Detector Spectra Extraction	j_bin_spectra	Detector Spectra
Detector Lightcurve Creation	j_bin_lc	Detector Lightcurve

jemx_obs_analyis

Stage	Module	Output
Mosaic Image Creation	j_ima_mosaic	Mosaic Image
Grouping the results	src_collect	Found Sources Summary

JEM-X science analysis GUI

JEM-X science analysis

_ Which JEM-X was on? Set jemxNum

_ Run from COR to IMA2

_ Select energy channels for the images - you find the channel/energy correlation in the cookbook

_ use the general reference catalog or your personalized catalog

_ set the timing step

_ set IMA_DetSigSingle to <12 for weak sources

_ jemx_science_analysis on GCDE revolution 175 (38 pointings) takes about 1 hour

```
tgrosf:/data/darius/Integral/high_level/obs/ESO209-12_JEMX

Log_1    2005-11-05T01:17:41 j_ima_mosaic 5.0.4: This is the Exposure time map --STAMP-- OBS_TIME_180.fits[JMX2-MOSA-I
MA,1,IMAGE]
Log_1    2005-11-05T01:17:41 j_ima_mosaic 5.0.4: -> Plot effective exposure Time map in OBS_TIME_180.fits[3]
Log_1    2005-11-05T01:17:42 j_ima_mosaic 5.0.4: This is the Effective exposure time map --STAMP-- OBS_TIME_180.fits[J
MX2-MOSA-IMA,2,IMAGE]
Log_2    2005-11-05T01:17:43 j_ima_mosaic 5.0.4: Work completed: status is 0

Log_1    2005-11-05T01:17:43 j_ima_mosaic 5.0.4: Task j_ima_mosaic terminating with status 0
Log_0    2005-11-05T01:17:43 jemx_obs_analysis 4.5.5: Current working directory is /net/darius/Integral/high_level/obs
/ESO209-12_JEMX
Log_0    2005-11-05T01:17:43 jemx_obs_analysis 4.5.5: Running /data/anu/isdc/osa_sw-5.0/bin/src_collect group="og_jmx2
.fits[GROUPING,1]" instName="DEFAULT" results=".////jmx2_obs_res.fits(JMX2-OBS.-RES.tpl)" select="" attach="yes" chatt
er="2"  2>> data_analysis.log
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Task src_collect running in SINGLE mode
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Beginning parameters
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter group = og_jmx2.fits[GROUPING,1]
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter instName = DEFAULT
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter results = .////jmx2_obs_res.fits(JMX2-OBS.-RES.tpl)
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter select =
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter attach = yes
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Parameter chatter = 2
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Ending parameters
Log_1    2005-11-05T01:17:44 src_collect 1.1.1: Running in scripting mode, no parameter prompting
Log_2    2005-11-05T01:17:54 src_collect 1.1.1: JMX2 observation group, will collect JEM-X results
Log_1    2005-11-05T01:17:58 src_collect 1.1.1: Combined source results --STAMP-- jmx2_obs_res.fits[JMX2-OBS.-RES,1,BI
NTABLE]
Log_0    2005-11-05T01:17:58 src_collect 1.1.1: Wrote 2 entries to output table
Log_1    2005-11-05T01:17:58 src_collect 1.1.1: Task src_collect terminating with status 0
Log_1    2005-11-05T01:17:58 jemx_obs_analysis 4.5.5: Task jemx_obs_analysis terminating with status 0
Log_0    2005-11-05T01:17:58 jemx_science_analysis 4.5.5: jemx_obs_analysis(): Program was finished successfully !
Log_1    2005-11-05T01:17:58 jemx_science_analysis 4.5.5: Task jemx_science_analysis terminating with status 0
tgrosf 1331 [beckmann]: ls
data_analysis.log  J_MOSAIC_1.fits  J_MOSAIC_3.fits    OBS_TIME_180.fits  scw
J_MOSAIC_0.fits    J_MOSAIC_2.fits  jmx2_obs_res.fits  og_jmx2.fits       swg_idx_jmx2.fits
tgrosf 1332 [beckmann]: ls scw/013700980010.001
jmx2_dead_time.fits  jmx2_full_cor.fits  jmx2_gti.fits      jmx2_srcl_cat.fits  swg_jmx2.fits
jmx2_evts_shd.fits   jmx2_full_dsp.fits  jmx2_sky_ima.fits  jmx2_srcl_res.fits
tgrosf 1333 [beckmann]: []
```
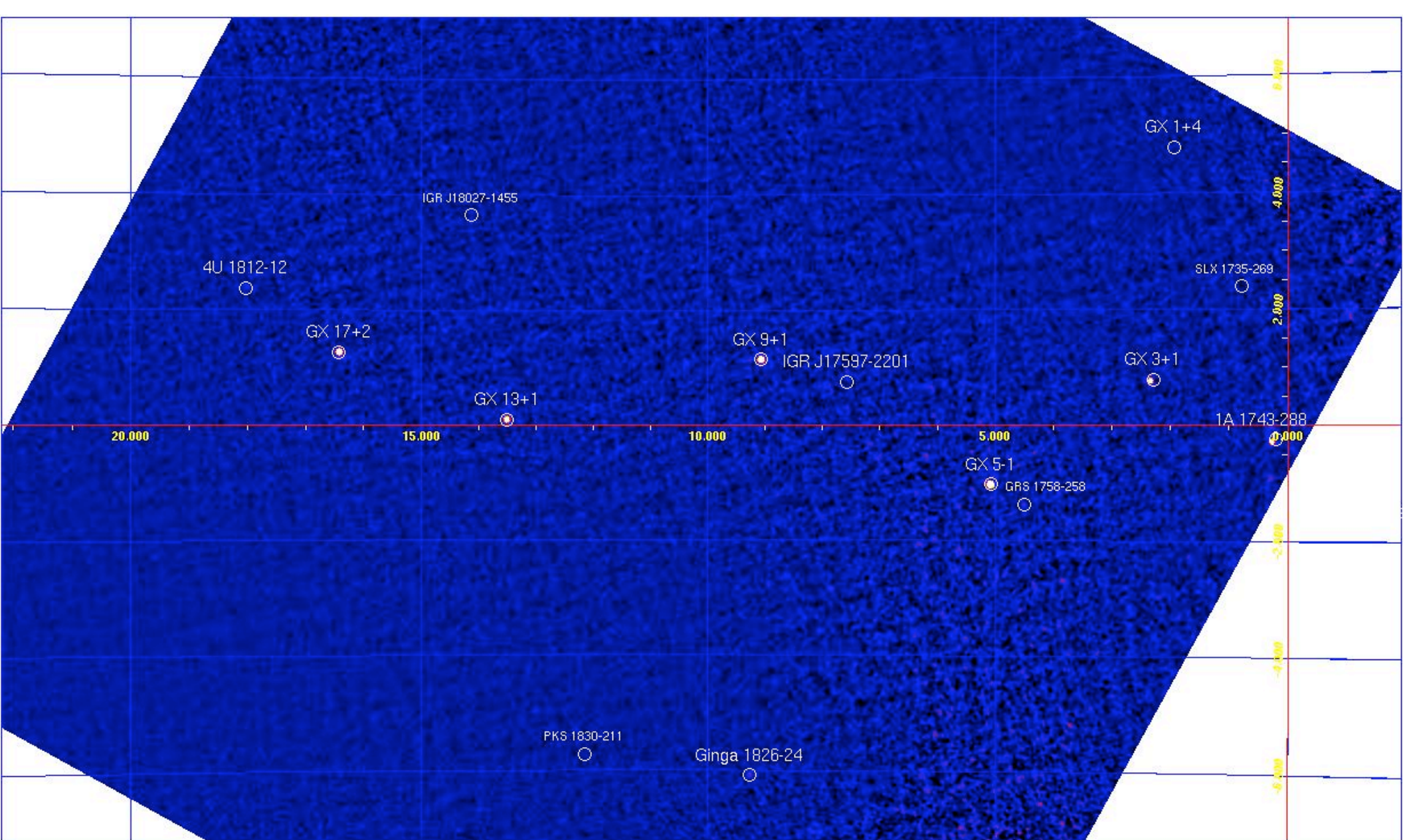
Screenshot after running
iemx science analysis

JEM-X science analysis

OBSTIME: observation time, effective exposure time

J_MOSAIC_0.fits : intensity, significance image

JEM-X and SPI use the IROS method
scw/ directories: jmx2_sky_ima.fits (raw, variance, residual, residual + source)

JEM-X mosaic image (1.5 - 12 keV) of the GCDE revolution 175 observation.

JEM-X science analysis

_ in order to combine spectra:
_ spe_pick group="og_jmx2.fits[1]"
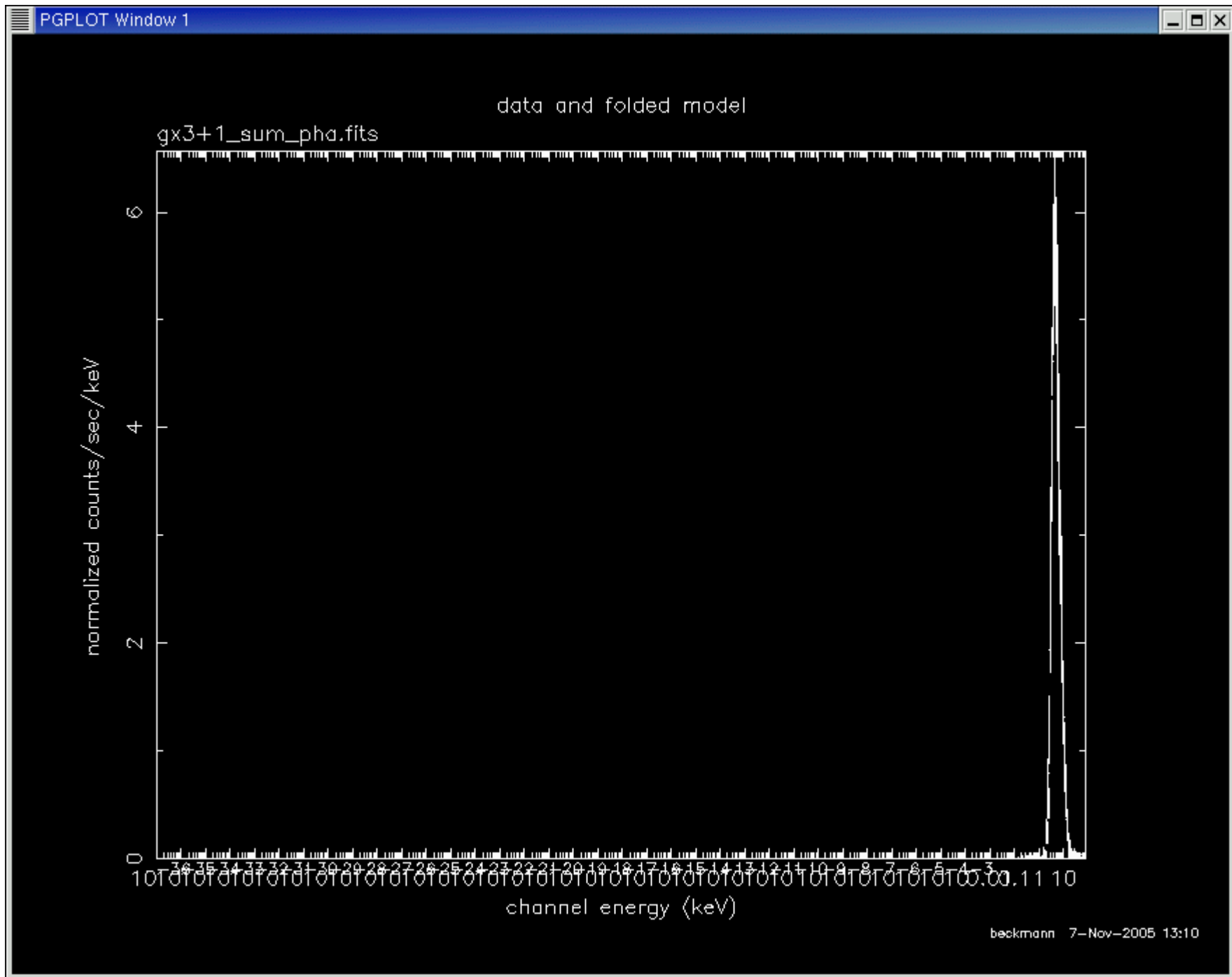instrument="JMX2" source="J….."
rootname="GX3+1" sum =y

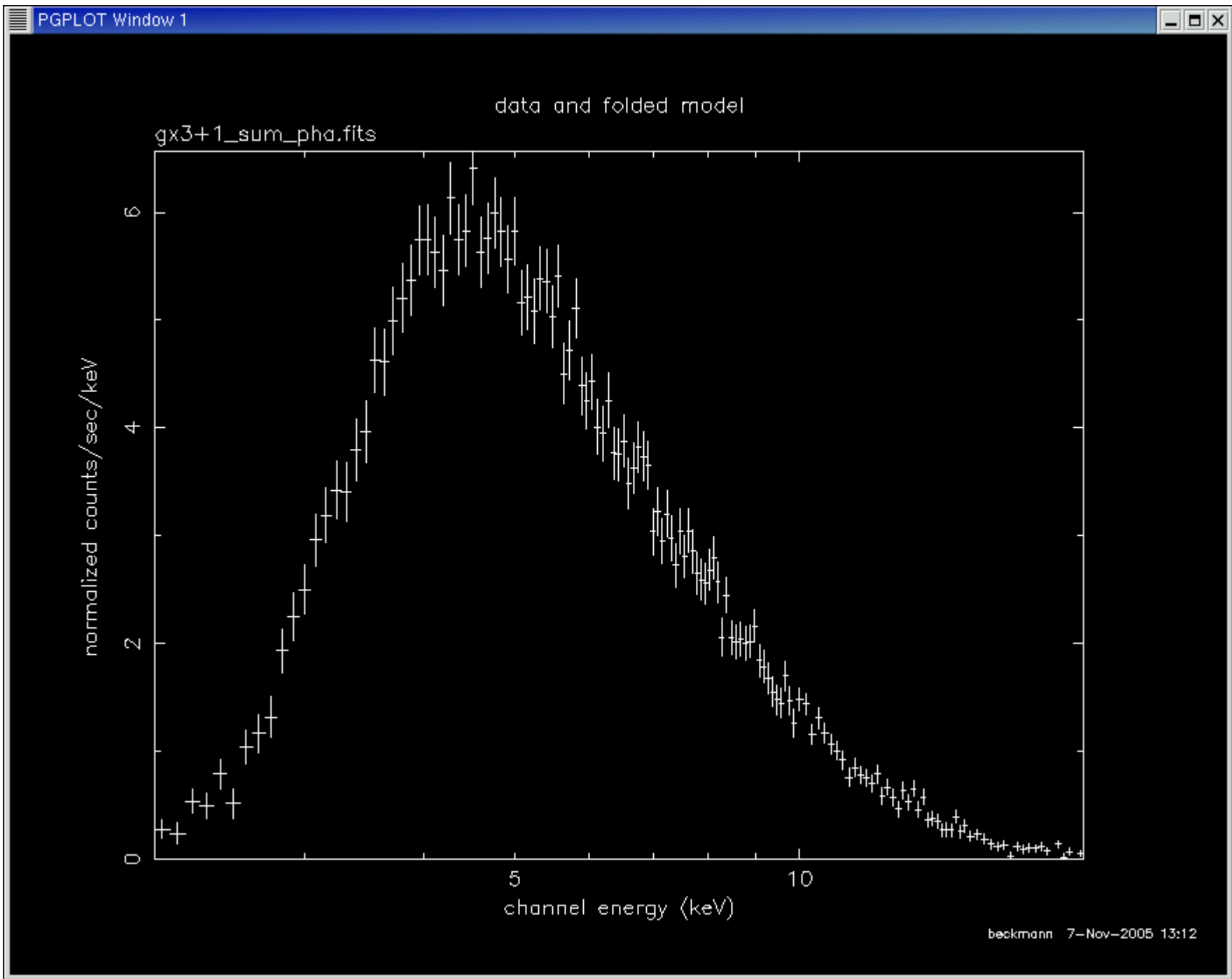_ GX3+1_single_pha2.fits
_ GX3+1_single_arf2.fits
_ GX3+1_sum_pha.fits
_ GX3+1_sum_arf.fits

_ RMF is already linked

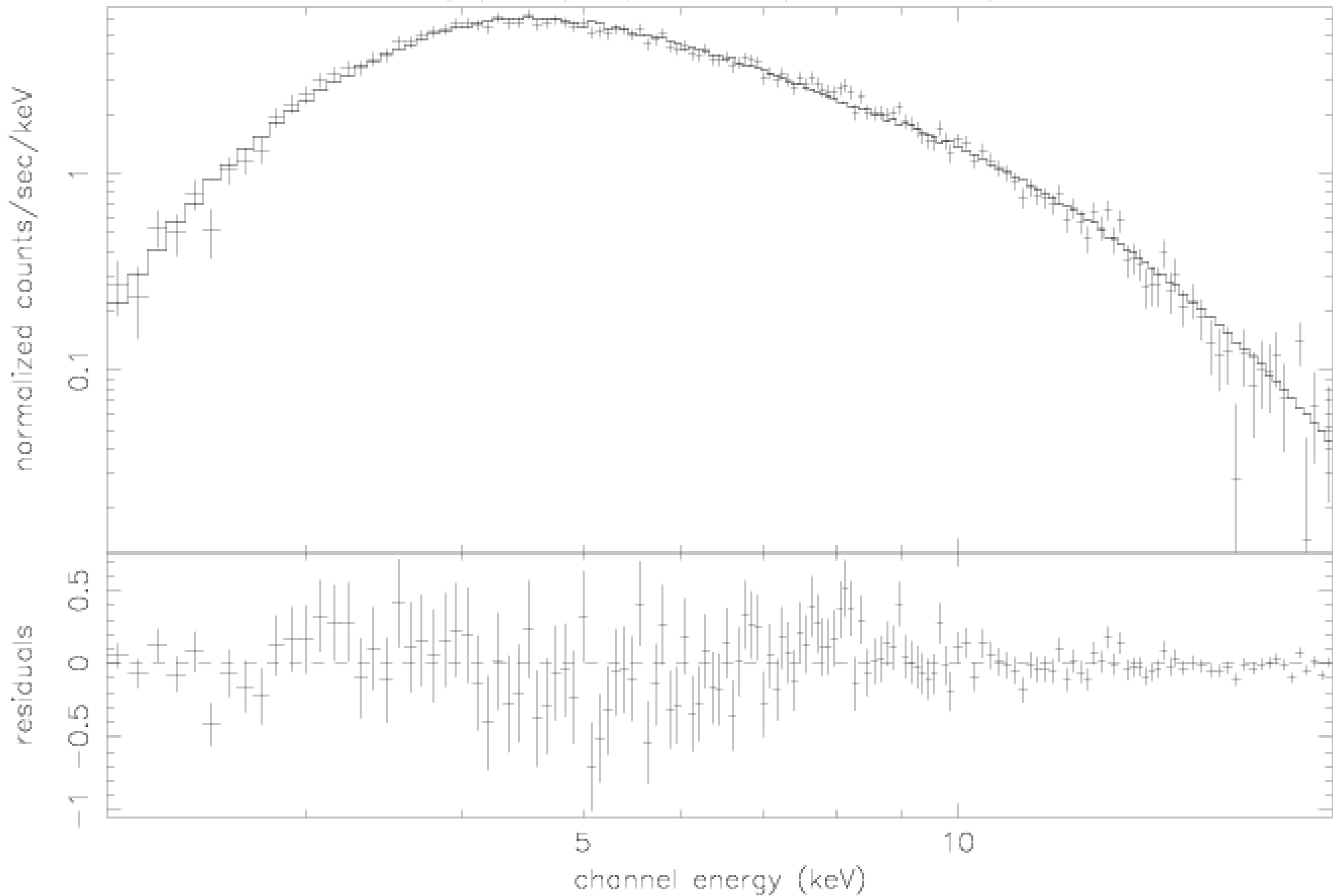Spectrum loaded into XSPEC 11: cpd /xs   setplot energy   plot ldata

ignore **-2.0   ignore 20.0-**   plot ldata

INTEGRAL JEM-X spectrum of GX 3+1

absorbed bremsstrahlung (4 keV) + power law (Gamma = 8.6) model
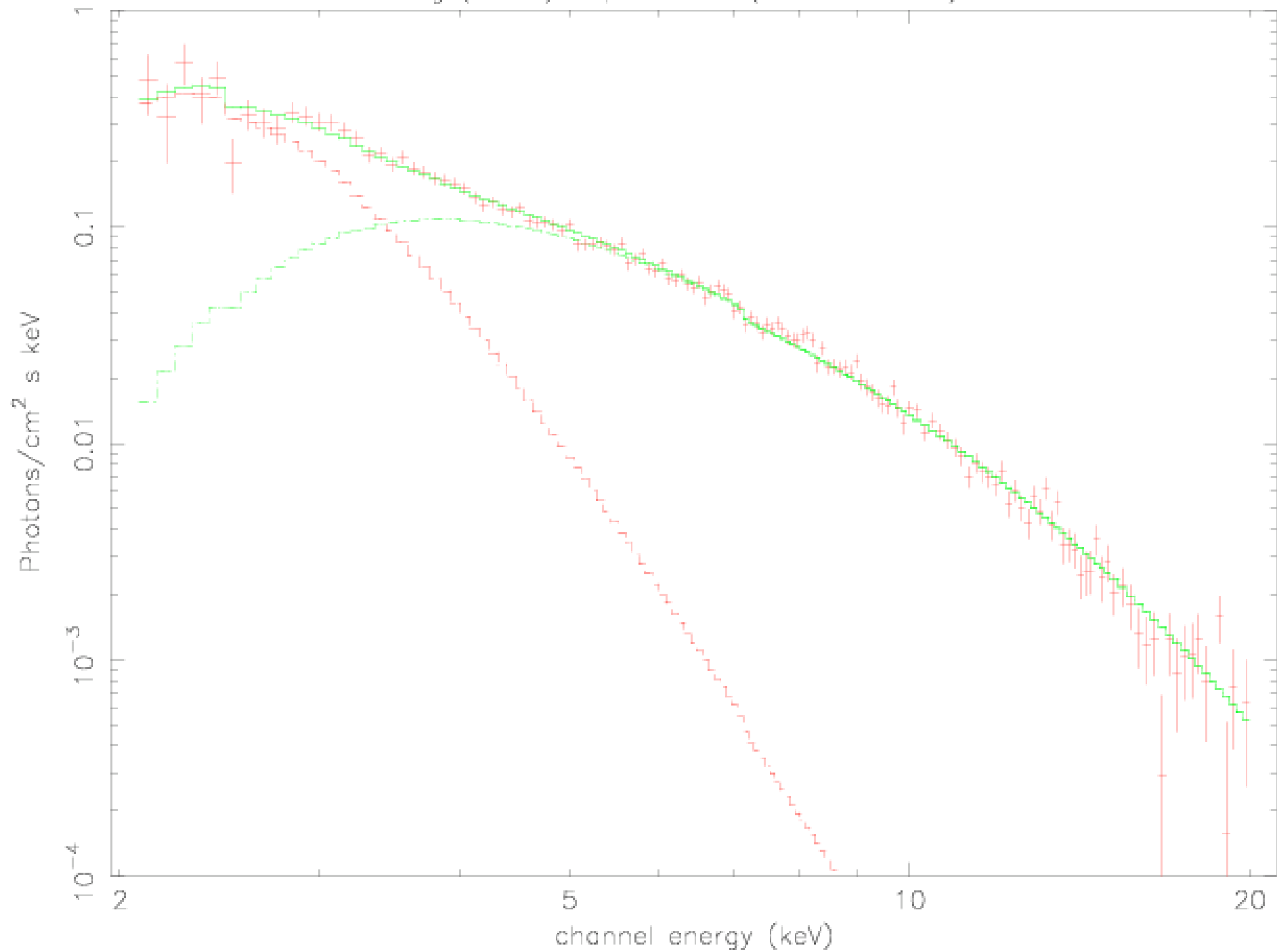
model wa brems pow   fit   plot ldata res

INTEGRAL JEM-X spectrum of GX 3+1
absorbed bremsstrahlung (4 keV) + power law (Gamma = 8.6) model

plot ufspec

JEM-X science analysis

_ spectrum from a given position (where nothing was detected) :
_ create a catalog and include the position
_ add this catalog to all the catalogs in the science window tree (see cookbook for instructions)

_run jemx_science_analysis from SPE to SPE

_ fluxes only from spectral extraction

JEM-X science analysis summary

_ Use og_create with JMX1 or JMX2
_ go to the directory in the obs/ branch
_ run jemx_science_analysis from COR to IMA2
_ cat2ds9 for creating a region file
_ look at the mosaic significance image with
ds9 "J_MOSAIC_0.fits[2]"
_ extract the spectrum with spe_pick
_ use the extracted spectrum in XSPEC to
determine the flux