



XMM-NEWTON



XMM-Newton Optical-UV Monitor: data reduction

OM data reduction using SAS

Antonio Talavera

XMM-Newton Science Operation Centre, ESAC, ESA

Simon Rosen, Chris Brindle & Vladimir Yershov

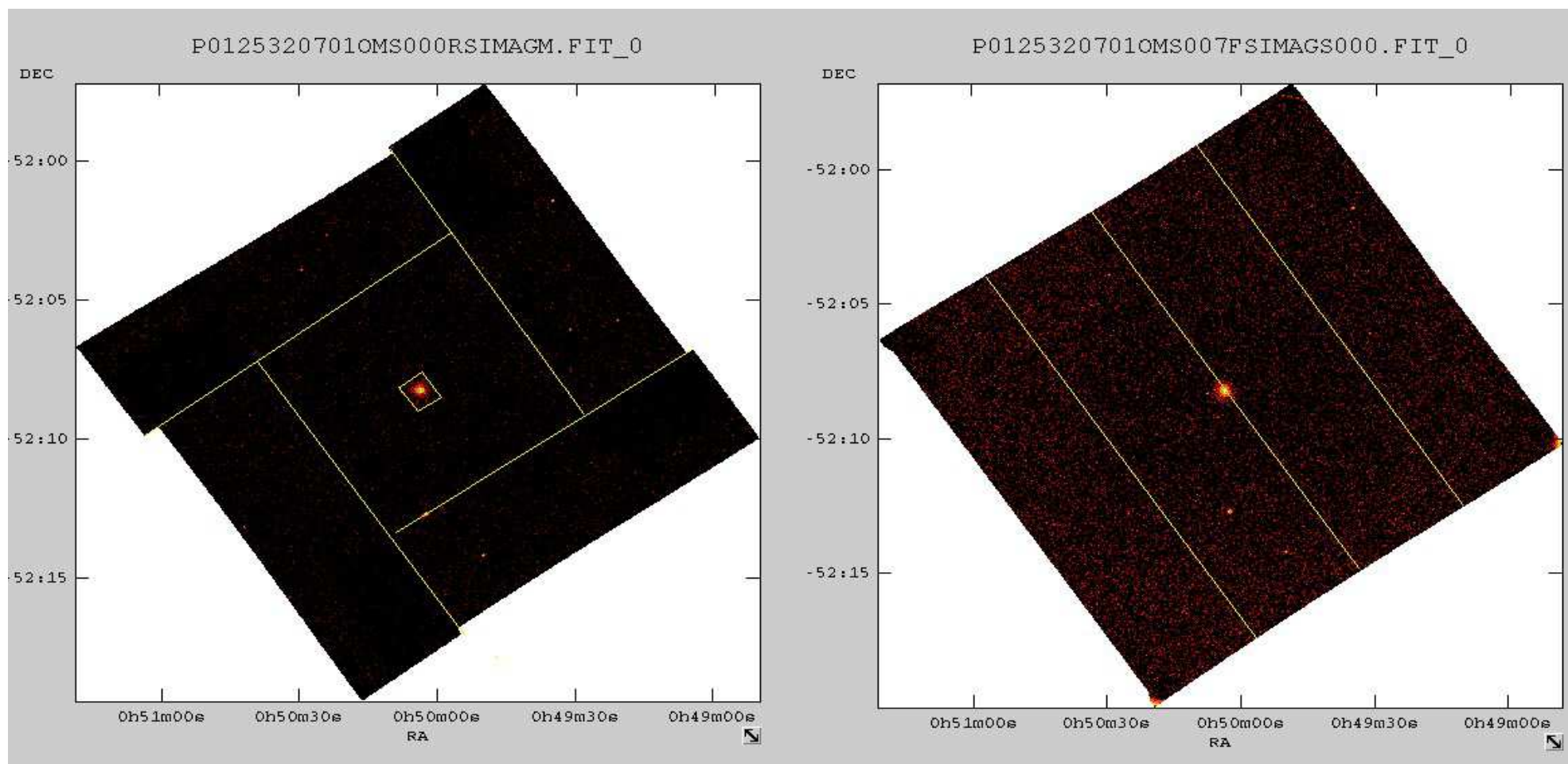
MSSL, UCL, UK

- **Default image, default image/fast, and user defined mode:**
 - Up to five different windows in the same exposure
 - A maximum of 2 of them can be in fast mode
- ⇒ **As many image and/or event list files as windows**
- **Full frame image modes: the whole FOV is obtained in a single exposure**
- ⇒ **One image file (High res.) or 4 image files (Low res.)**
- **There are additional files containing instrument configuration and house-keeping data for each exposure**
- **Observing with OM grisms produces image data in user defined mode or in full frame low resolution**

OM observing modes & data types

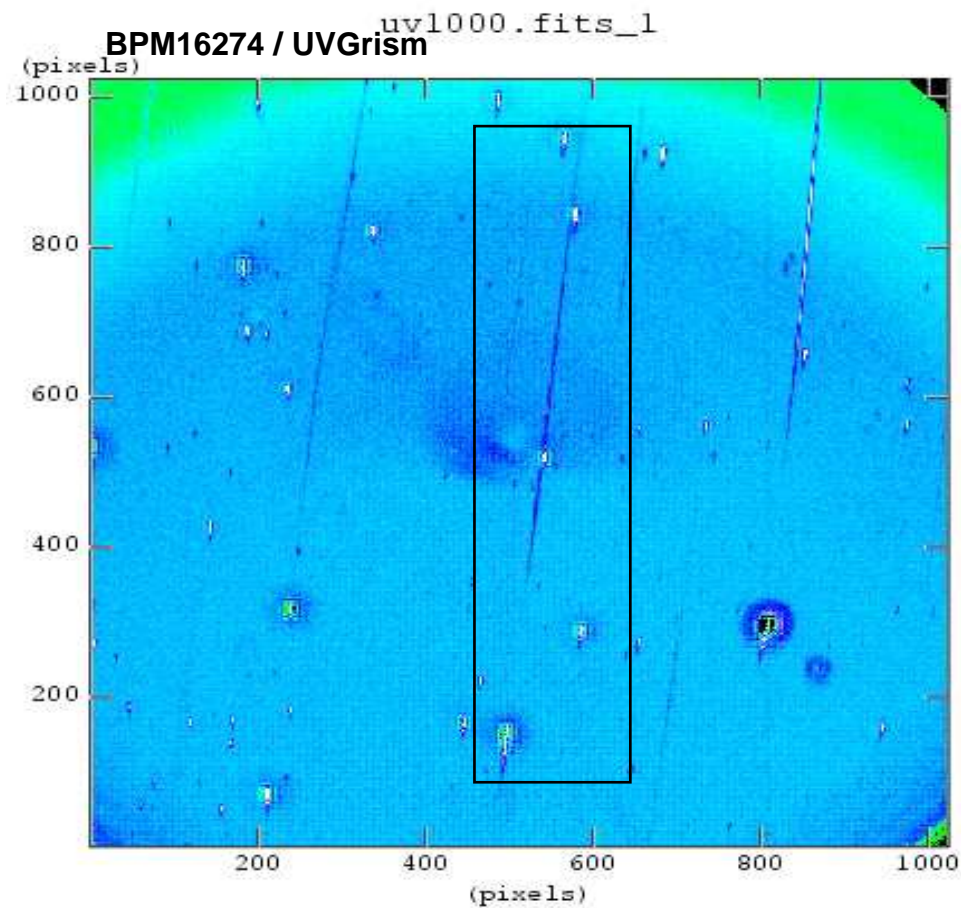
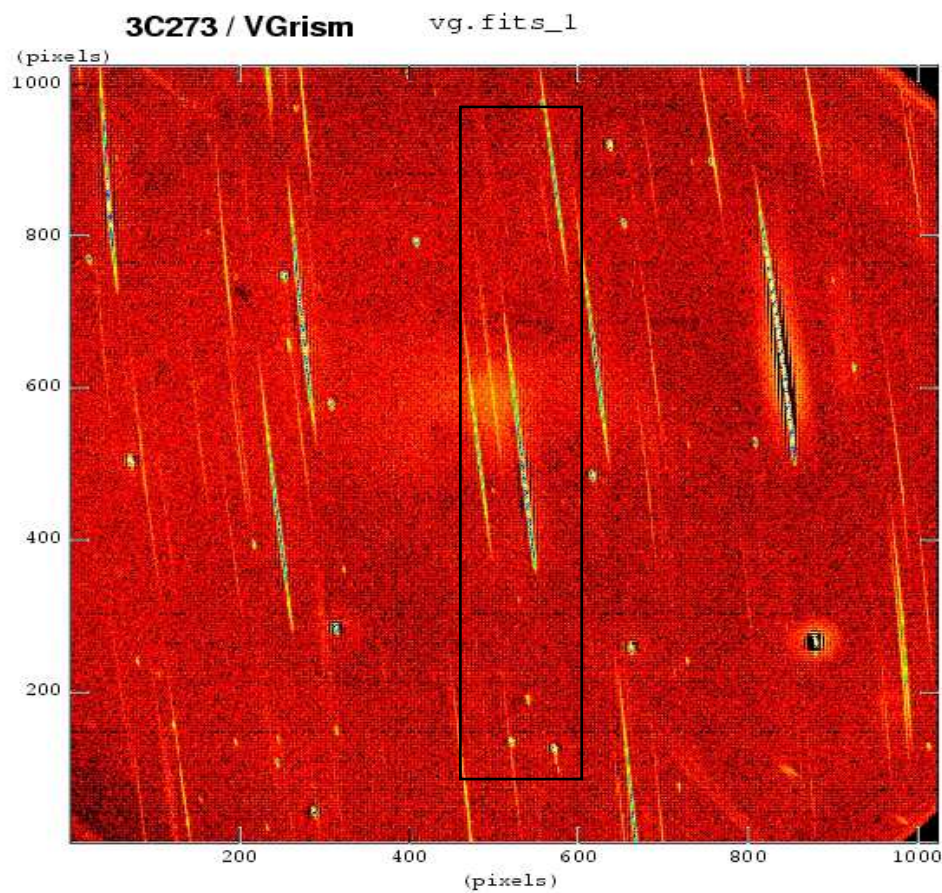


Difference between default windows configuration and full frame



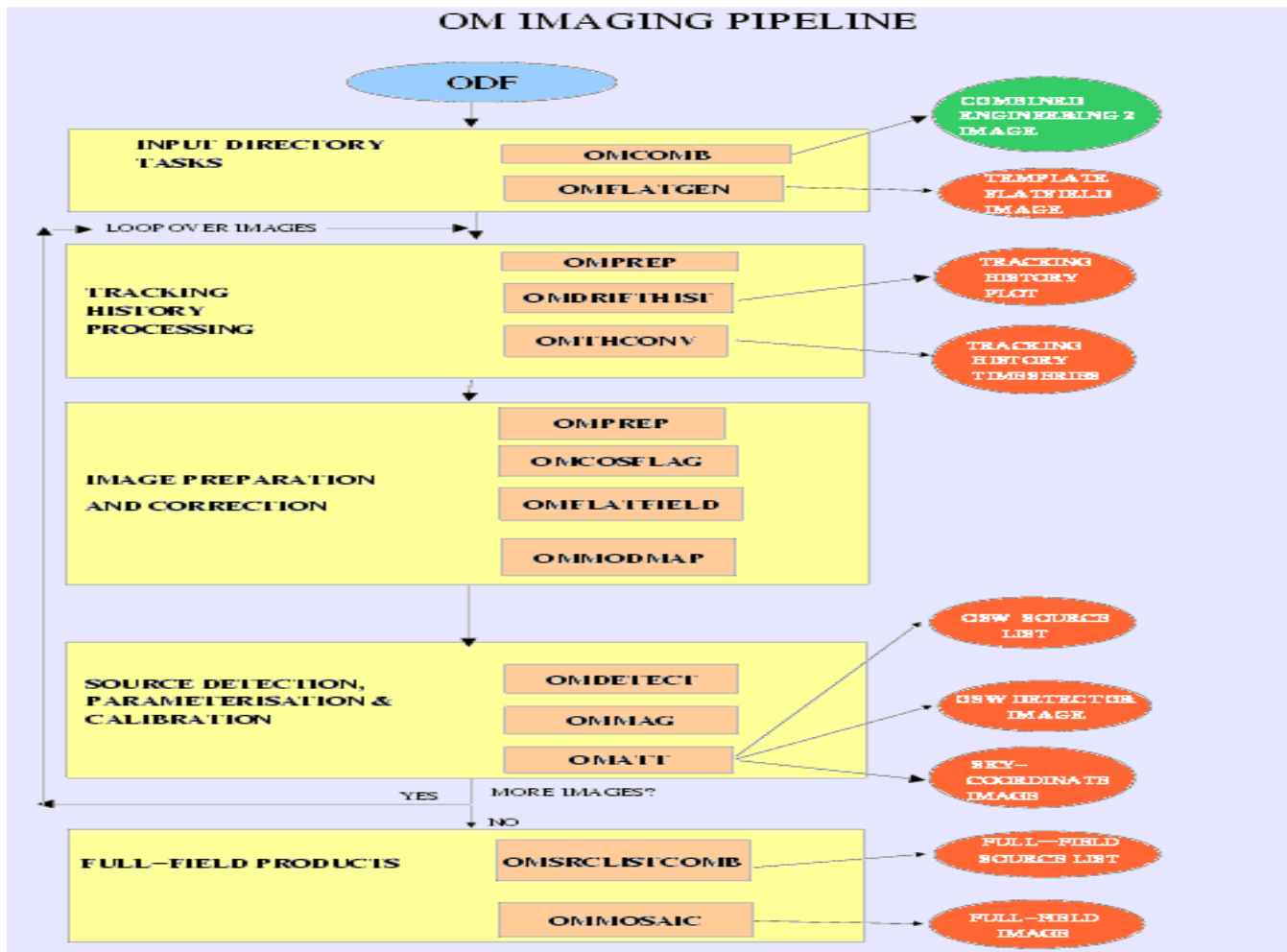
Observing with OM grisms

Image mode full frame low res. Or user def. window centred on target spectrum.



- All operations to be applied to OM data (SAS tasks) are combined into processing chains: **(Perl scripts where all tasks are concatenated, with default parameters and naming convention)**
 - **omichain:** for image data, to perform photometry of all sources in the field of view
 - **omfchain:** for fast mode data, to derive light curves of the sources in the fast mode window
 - **omgchain:** to extract flux calibrated spectra obtained with OM grisms
- The standard pipeline executes the chains on all exposures, with predefined parameters
- The chains can be applied “by hand” to an observation, or in case of *omichain* to a given filter(s) or a given exposure(s). (Some parameters are adjustable)
- Individual tasks can be run by hand, although most of them need as input the output from another task previously run

OM image mode data reduction: omichain



➤ Data preparation

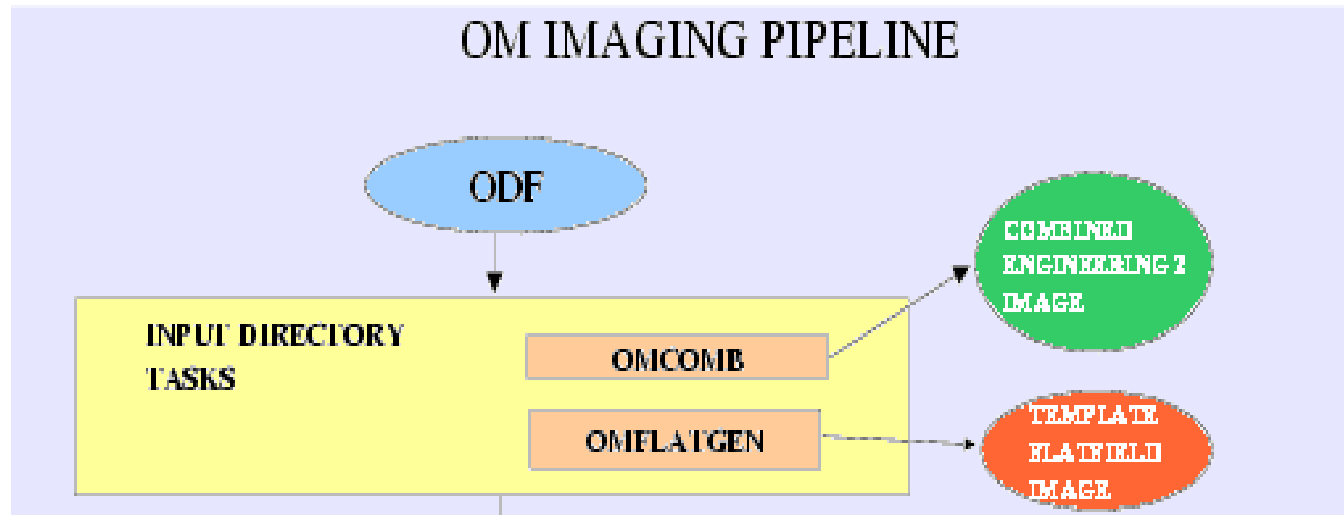
- combine full frame low resolution files
- get flat-field

➤ Processing (per exposure)

- all corrections, source detection, astrometry & photometry

➤ Final combined results

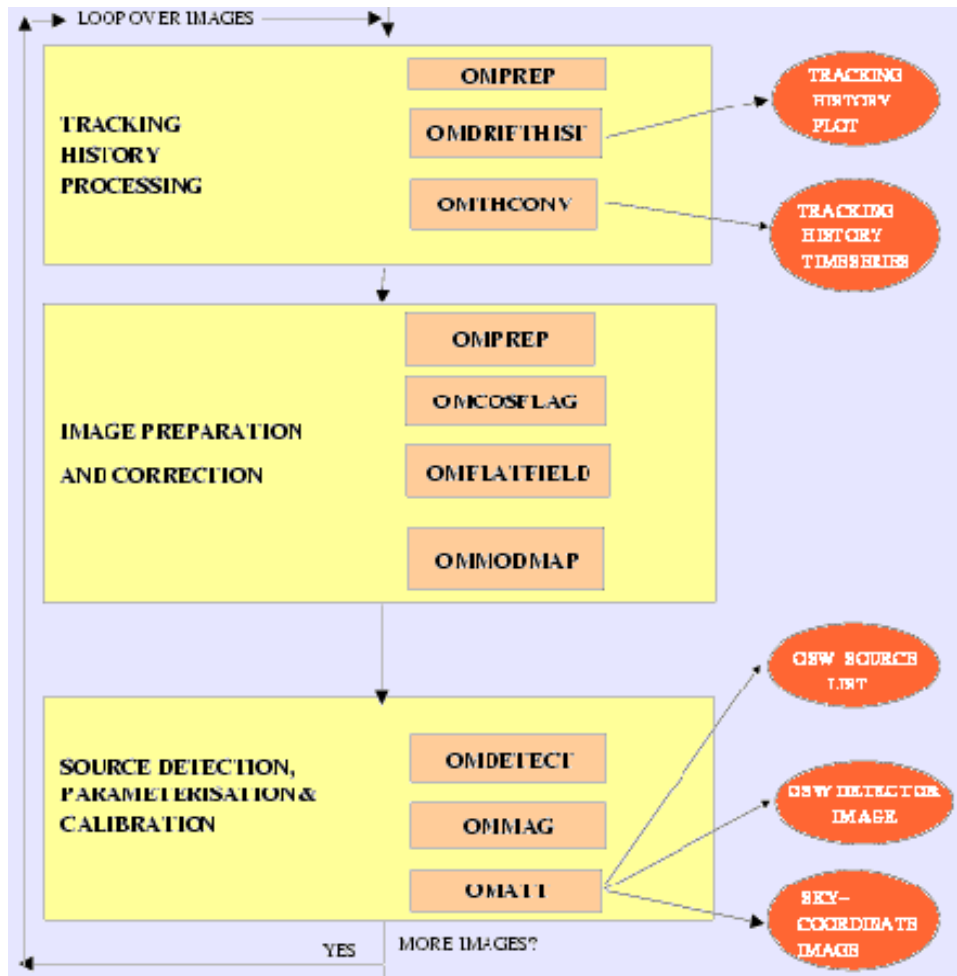
- all exposures and filters



➤ Data preparation

- **omcomb:** combines full frame low resolution files (4) into single full field file
- **omflatgen:** obtains flat-field template

OM image mode data reduction



➤ Preparation of tracking correction

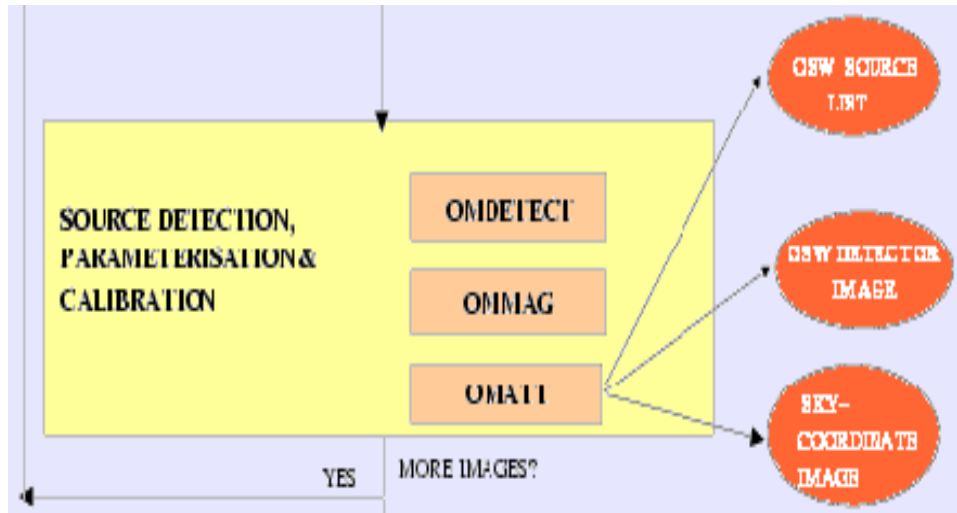
- omprep
- omdrifthist
- omthconv

➤ Corrections: bad pixels, fixed pattern (mod8), flat-fielding

- omprep
- omcosflag
- omflatfield
- ommodmap

➤ Source detection, astrometry and photometry

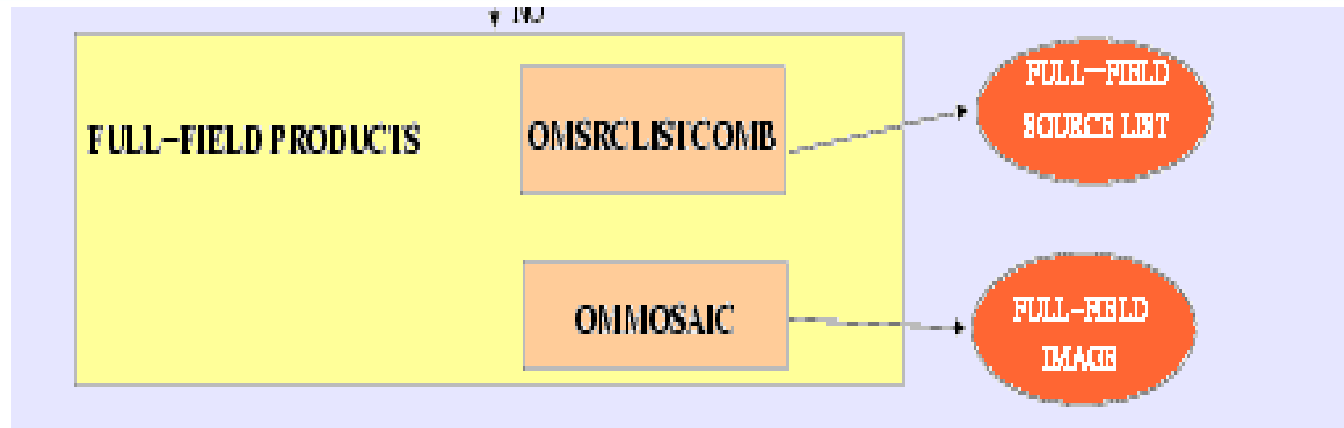
- omdetect
- ommag
- omatt



➤ Source detection, astrometry and photometry

- **omdetect**
- **ommag**
- **omatt**

- **omdetect: source detection (sextractor like), positions, shape, errors, count rates (sources & background), coincidence loss and dead time corrections,,.... Detection depends on parameters:**
 - **nsigma, boxscale, smothsize, contrast**
- **ommag: PSF corrections, computation of magnitudes and colour corrections**
- **omatt: astrometry: distortion correction, sky images, coordinates (catalogue X-correlation)**



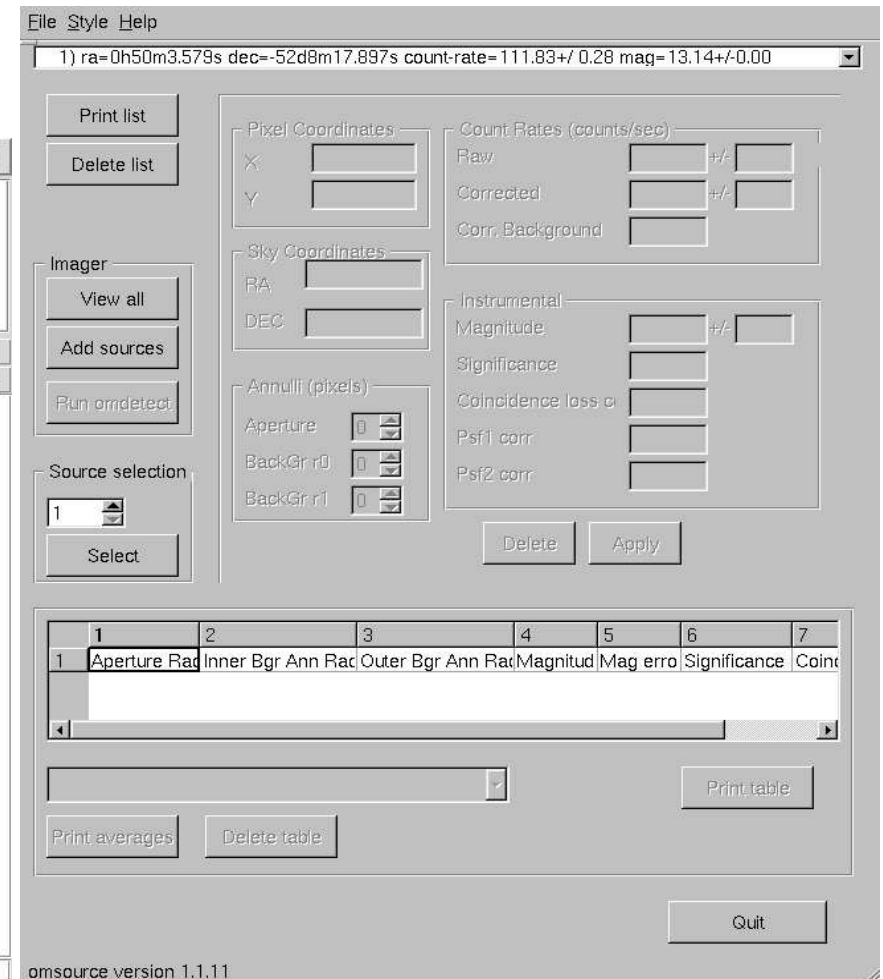
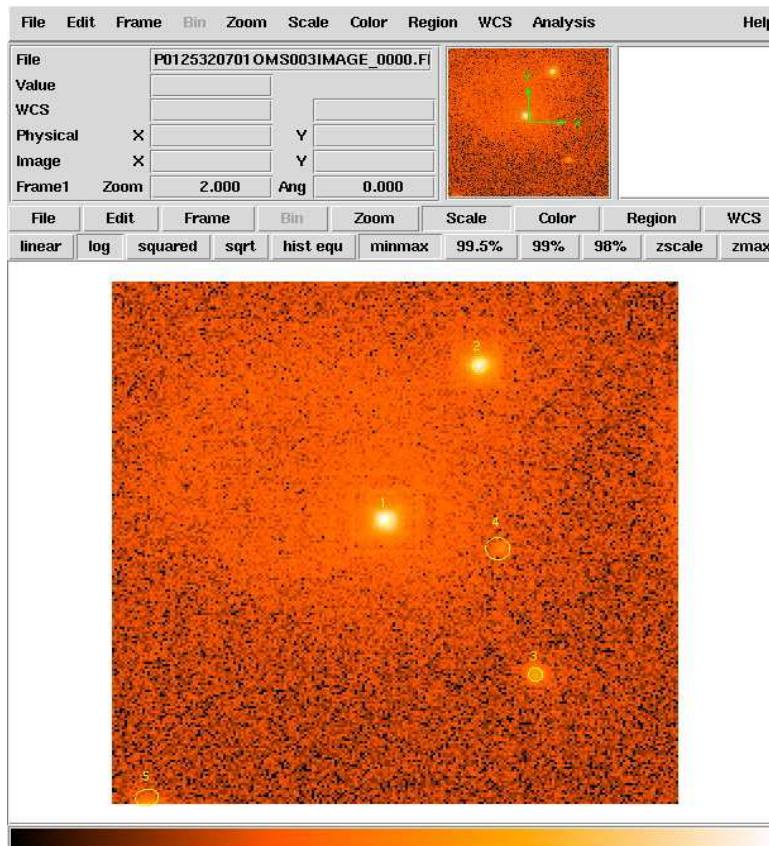
- **Final combined results**
 - all exposures and filters
 - **omsrclistcomb**: merges results from all filters and exposures
 - **ommosaic**: merges exposures obtained with the same filter into full field images
- **With SAS 9.0 and newer:**
 - deeper detection on mosaiced co-added images
- **With SAS 10:**
 - **omvariability**: in multiple exposures with the same filter

OM image mode: interactive photometry



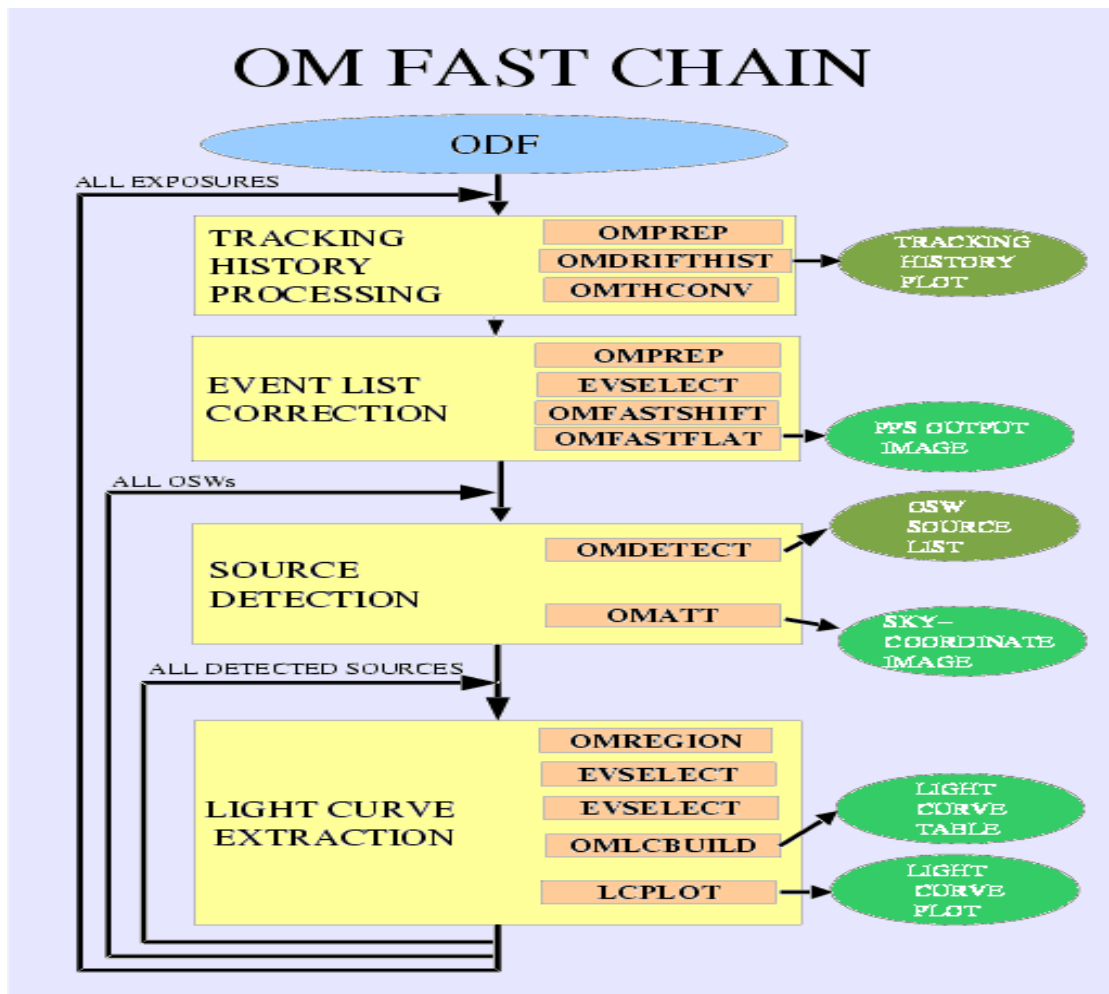
You can select interactively your source in a processed image, and *omsorce* will perform aperture photometry

omsorce
input image
[old source list]
new source list



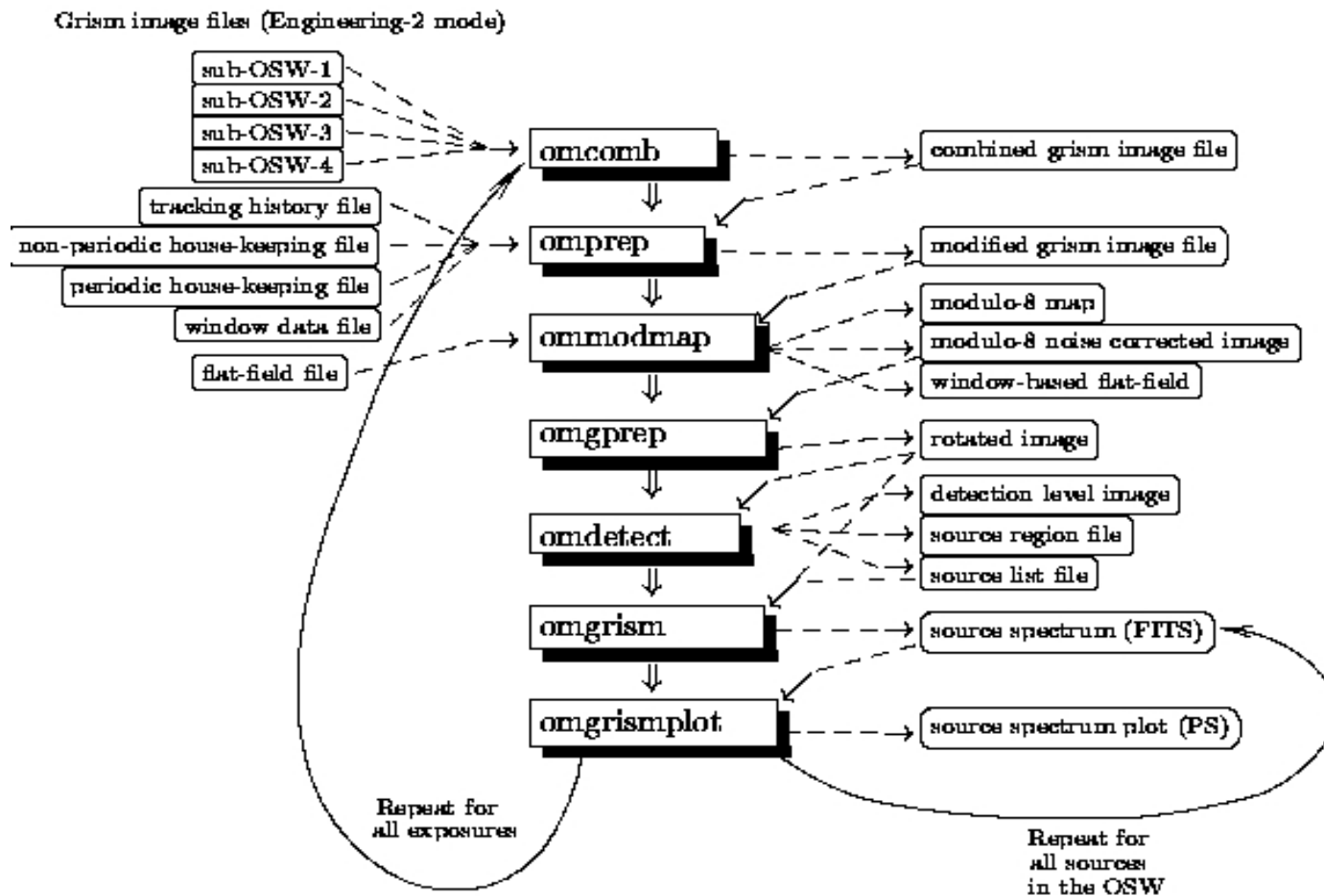
Omphotom:

- **Allows a user to recompute the photometry of one or more sources in an OM source-list in one of several different ways, using specified parameters.**
- **It can reprocess a list of sources from various source-list files.**
- **Also allows the photometry to be re-computed using several different methods.**
- **The program allows OM fast mode data to be reprocessed, and in order to estimate the background more reliably the appropriate image can be used to determine it.**



- **Preparation: tracking correction**
 - omprep
 - omdrifthist
 - omthconv
- **Event selection & corrections: tracking, flat-fielding**
 - omprep
 - evselect
 - omfastshift
 - omfastflat
- **Source detection & astrometry**
 - omdetect
 - omatt
- **Light curve:**
 - omregion
 - evselect (source & bckgd)
 - omfcbuild
 - lcplot

OM grisms data reduction: omgchain



➤ Data preparation

- combine full frame low resolution files

Image processing

- mod_8 correction
- un-distortion
- rotation

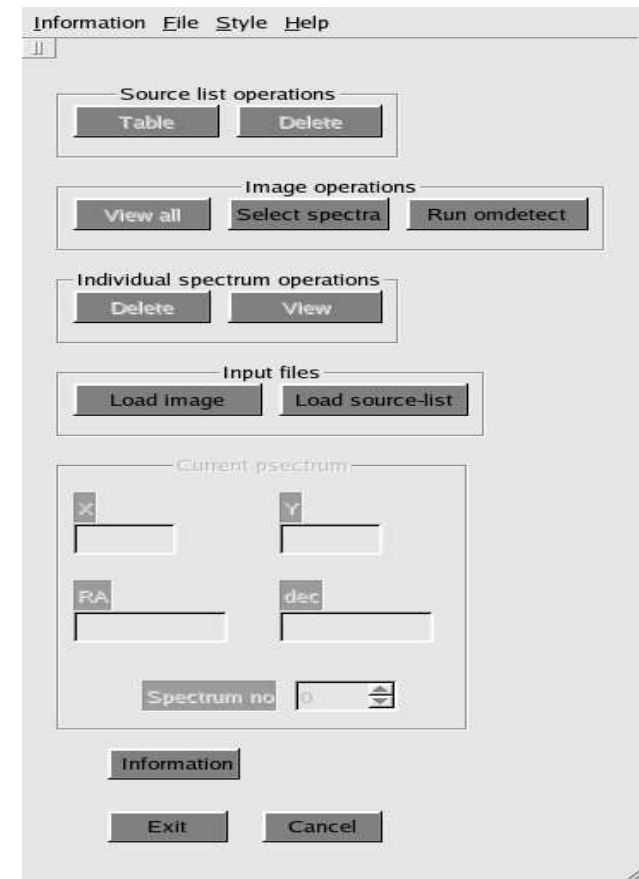
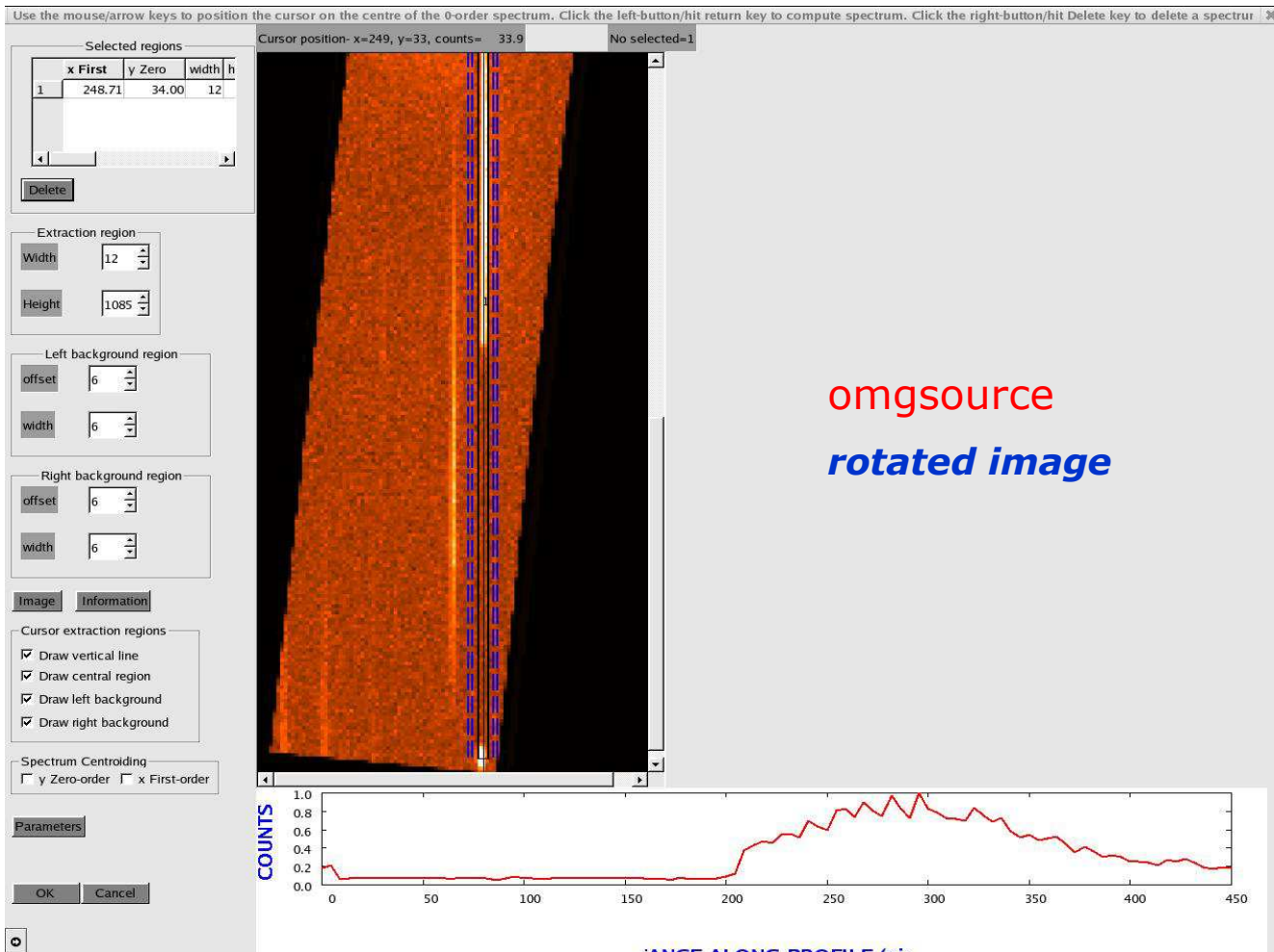
Source detection, spectral extraction and calibration

- look for all spectra (zero and 1st orders), correlate them, extract them and calibrate them (wavelength, flux)

OM grisms interactive extraction



You can select your source in a rotated image, and *omsource* will extract its spectrum



- The pipeline (omichain, omfchain) should produce final calibrated results.
However, some checks are necessary!
- Imaging analysis:
 - detection algorithm may fail in presence of straylight features:
 - *parameters in omdetect should be modified*
 - *omsource or omphotom can be run interactively*
 - the PSF is used to derive count rates (crowded fields)
 - photometry of extended sources
 - catalogue X-correlation needs additional external data (catalogue file)
- Timing analysis:
 - fast mode in crowded fields
 - contamination by nearby objects
 - source miss-centring or S/C drift
 - contiguous light curves (*not available in SAS yet*)
- Grisms spectra:
 - faint spectra: *omgsource can be run interactively*
 - overlapping orders and background : *omgsource can help*
 - source identification: *astrometry is included*

OM count rate to flux conversion

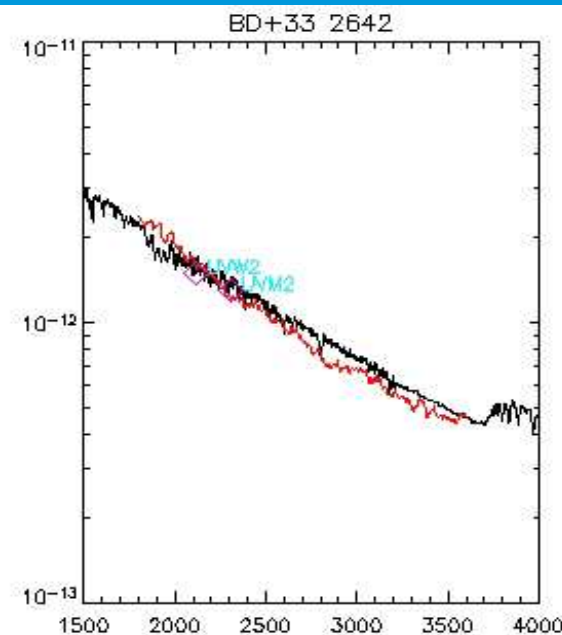
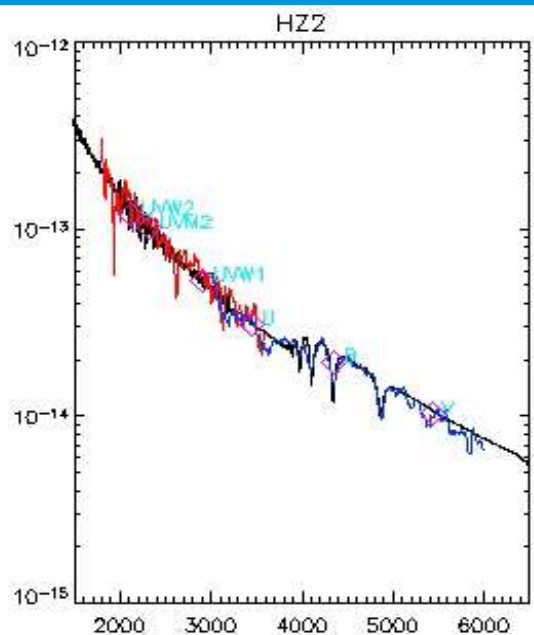
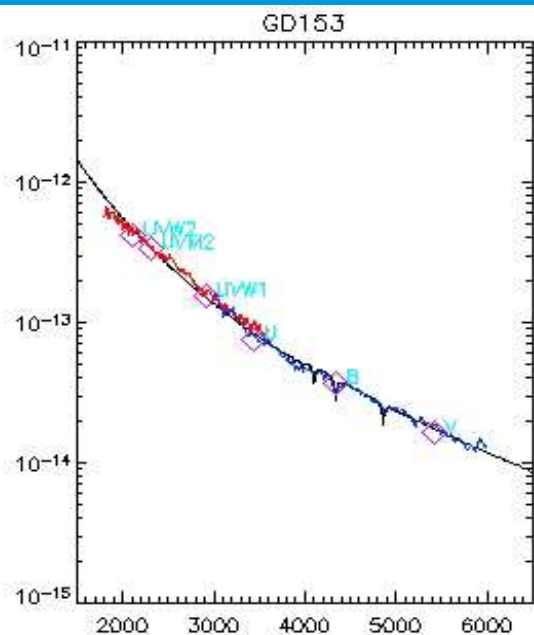


Count rate to Flux conversion :

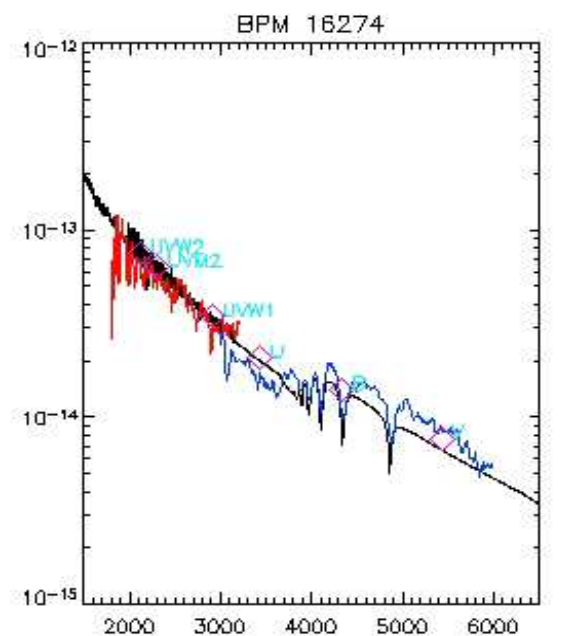
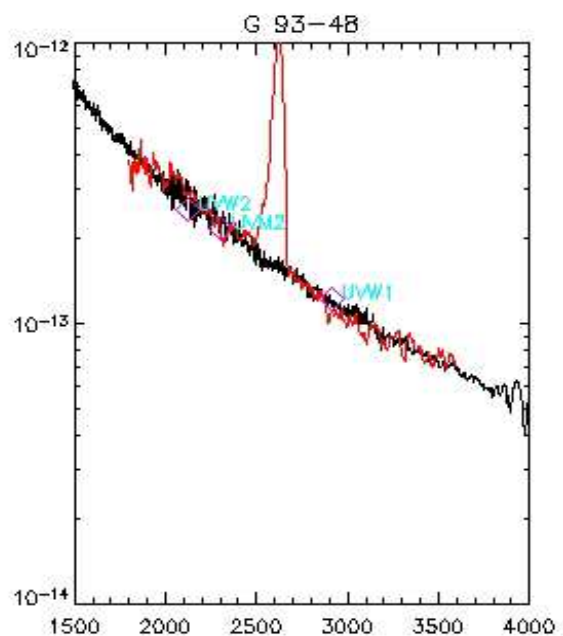
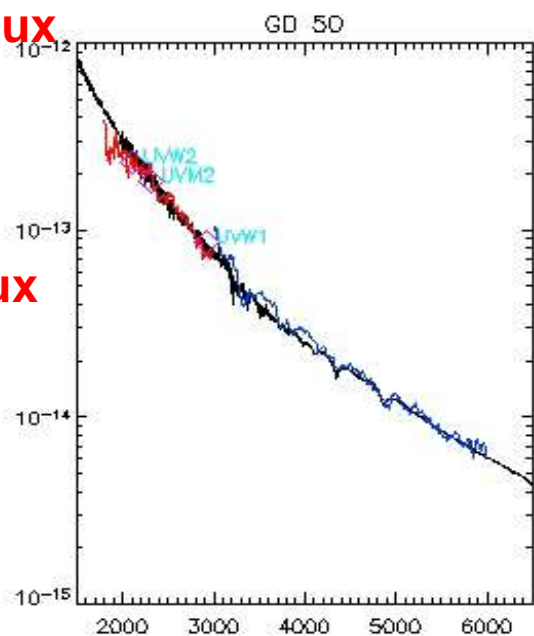
- **Average conversion factors for time sensitivity variation corrected count rate, based on white dwarfs are:**

	UVW2	UVM2	UVW1	U	B	V
lambda (A)	2120	2310	2910	3440	4500	5430
factor	5.71	2.20	4.76	1.94	1.29	2.49
(erg/ct/cm2/A)	E-15	E-15	E-16	E-16	E-16	E-16

- **Spectral type dependencies are provided as recipe in SAS Web pages**
AB magnitude and flux included in SAS processing



**OM filters flux
and grisms
versus
standard flux**



First exposure of a default image + fast mode observation:

•Data from the exposure:

```
0261_0125320701_OMS00200IMI.FIT / ODF Constituent
0261_0125320701_OMS00200PFX.FIT / ODF Constituent
0261_0125320701_OMS00200RFX.FIT / ODF Constituent
0261_0125320701_OMS00200THX.FIT / ODF Constituent
0261_0125320701_OMS00200WDX.FIT / ODF Constituent
0261_0125320701_OMS00201FAE.FIT / ODF Constituent
0261_0125320701_OMS00202IMI.FIT / ODF Constituent
```

•OM house-keeping data:

```
0261_0125320701_OMX00000NPH.FIT / ODF Constituent
0261_0125320701_OMX00000PEH.FIT / ODF Constituent
```

•S/C data:

```
0261_0125320701_SCX00000ATS.FIT / ODF Constituent
0261_0125320701_SCX00000TCS.FIT / ODF Constituent
0261_0125320701_SCX00000SUM.SAS / ODF Constituent
```

Output data files: Pipeline/XSA products



OM Exposure-Specific Products

Instrument	Exposure ID	Inst Mode	Filter	Start time	Duration	Stop time
OM	S002	Image	V	2001-05-12T20:39:21	1001	2001-05-12T20:56:02

Filename	Content	V&V Flags	OM Science Window	Source Number
P0125320701OMS002TSHPLT0000.PDF	OM TRACKING HISTORY PLOT	-	-	-
P0125320701OMS002TSTRTS0000.FIT	OM TRACKING STAR TIMESERIES	-	-	-
P0125320701OMS002IMAGE_0000.FIT	OM OSW IMAGE	-	0	-
P0125320701OMS002SIMAGE0000.FIT	OM OSW SKY IMAGE	-	0	-
P0125320701OMS002SIMAGE0000.PNG	OM OSW SKY IMAGE	-	0	-
P0125320701OMS002SWSRLI0000.FIT	OM OSW SOURCE LIST	-	0	-
P0125320701OMS002IMAGF1000.FIT	OM FAST MODE OSW IMAGE	-	1	-
P0125320701OMS002SIMAGF1000.FIT	OM FAST MODE OSW SKY IMAGE	-	1	-
P0125320701OMS002SWSRLI1000.FIT	OM OSW SOURCE LIST	-	1	-
P0125320701OMS002TIMESR1001.FIT	OM OSW SOURCE TIMESERIES	-	1	1
P0125320701OMS002TIMESR1001.PDF	OM OSW SOURCE TIMESERIES	-	1	1
P0125320701OMS002IMAGE_2000.FIT	OM OSW IMAGE	-	2	-
P0125320701OMS002SIMAGE2000.FIT	OM OSW SKY IMAGE	-	2	-
P0125320701OMS002SIMAGE2000.PNG	OM OSW SKY IMAGE	-	2	-
P0125320701OMS002SWSRLI2000.FIT	OM OSW SOURCE LIST	-	2	-

Image mode data: **omichain**

Interactive aperture
photometry: **omsource**
omphotom

Fast mode data: **omfchain**
omphotom

Grism spectra extraction: **omgchain**

Grism interactive
extraction: **omgsource**