XMM-Newton Optical-UV Monitor: data reduction

OM data reduction using SAS

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OM observing modes & data types

- Detector windows: 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

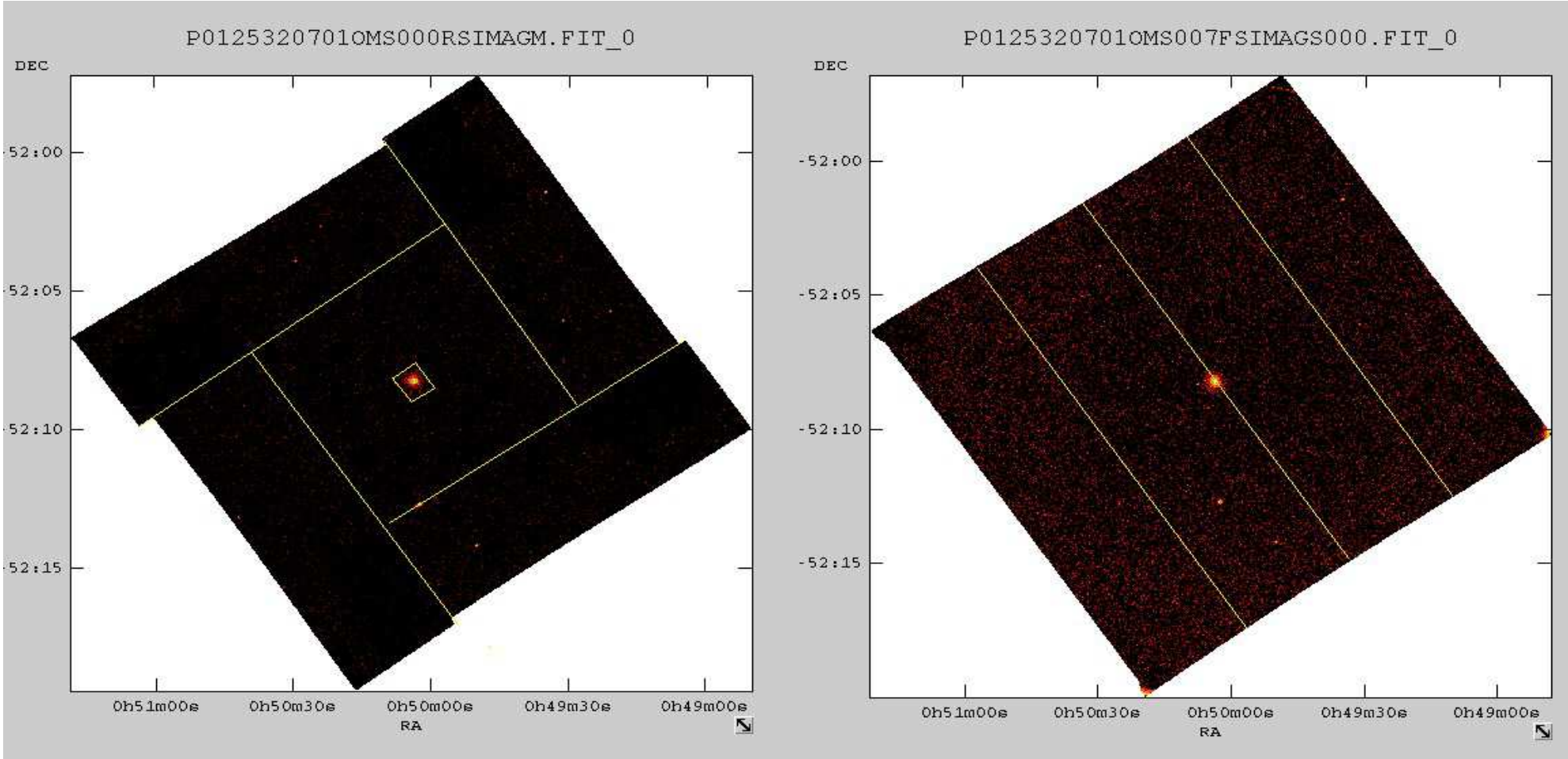
- Full frame image modes: the whole FOV is obtained in a single exposure

⇒ 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

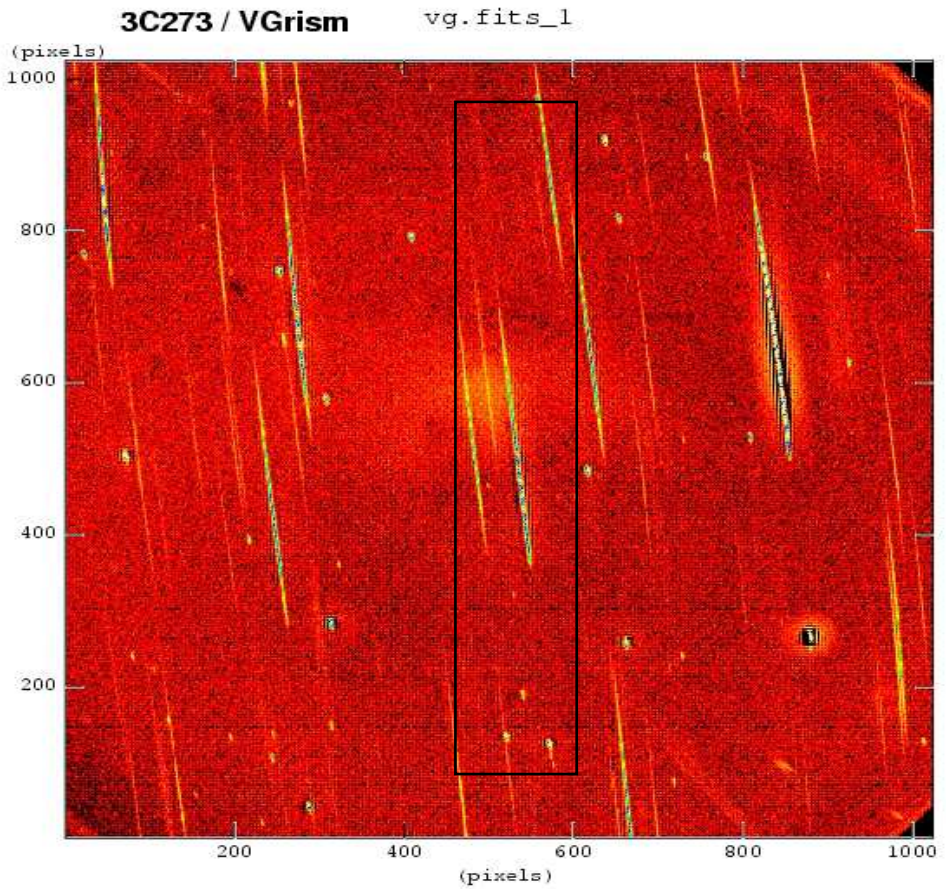
OM observing modes & data types

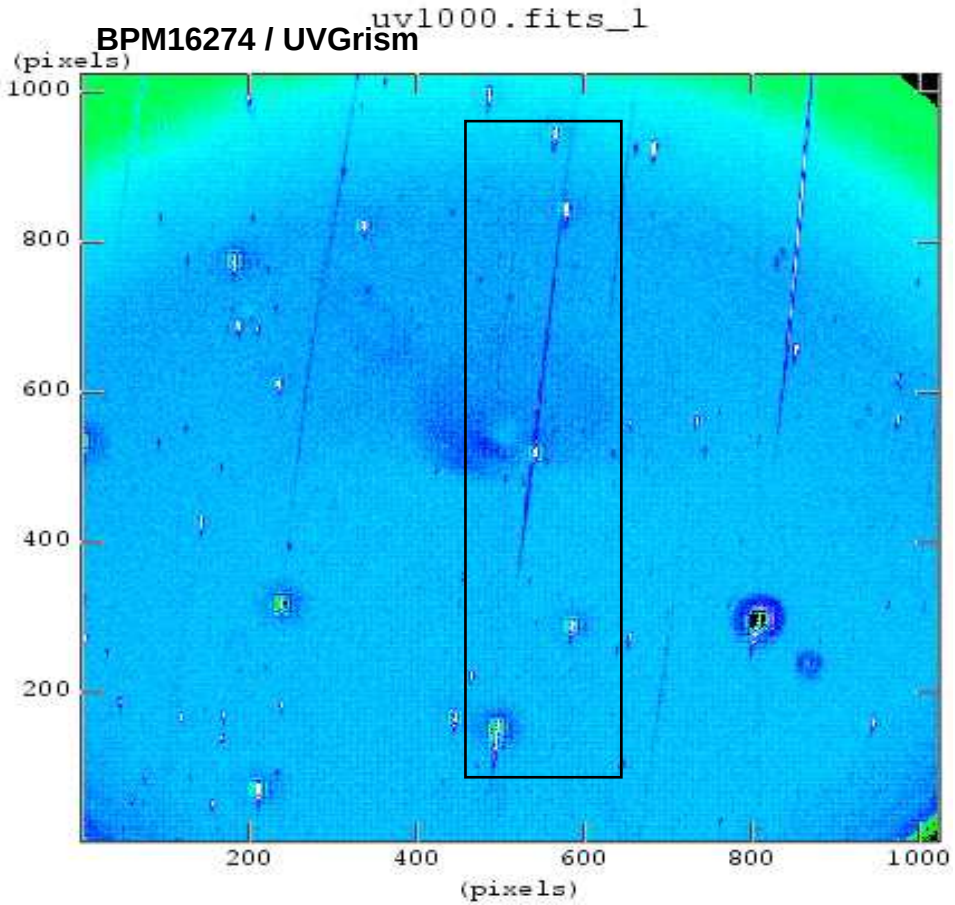
Difference between default windows configuration and full frame



Observing with OM grisms

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

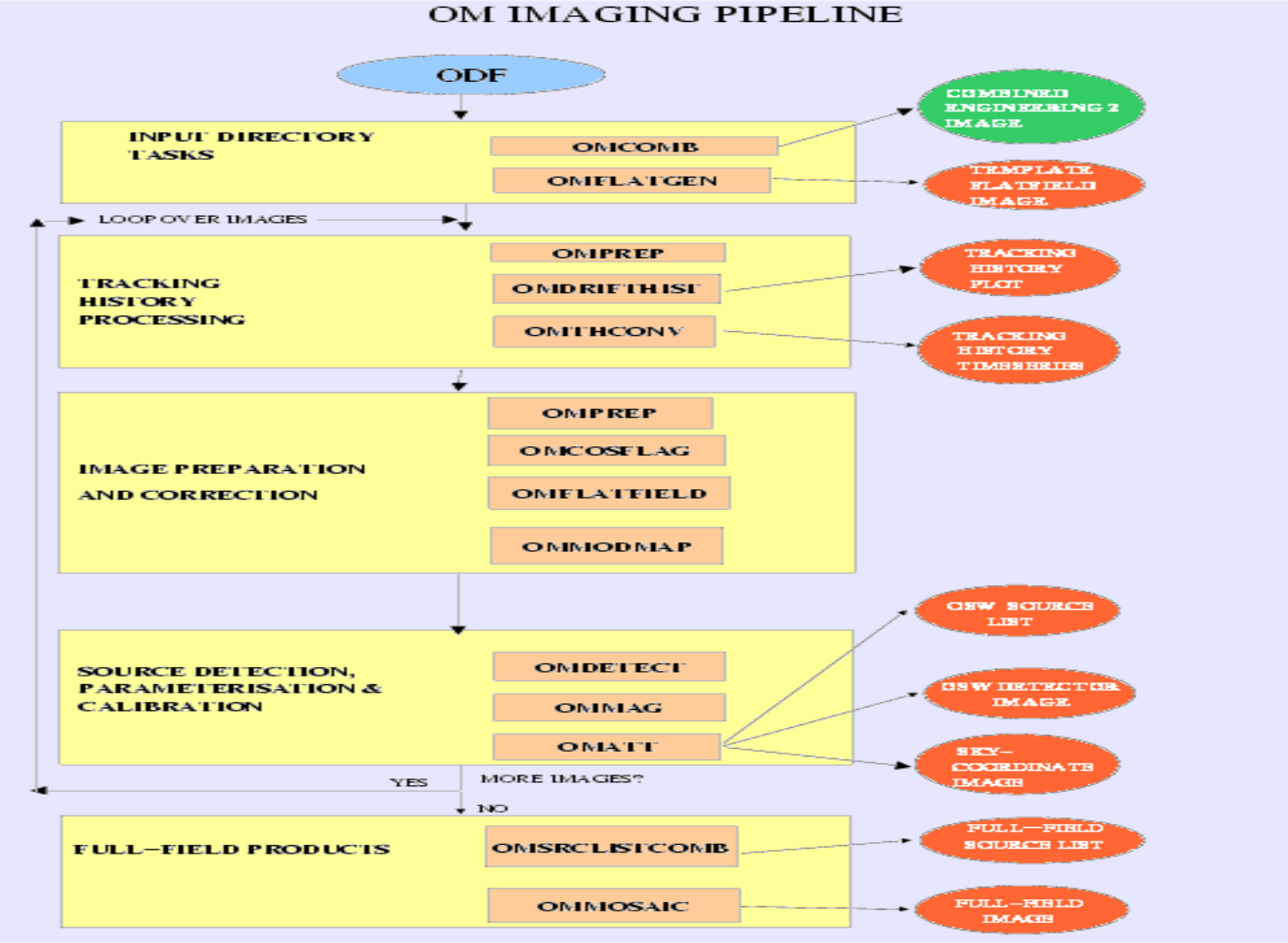




SAS OM data reduction

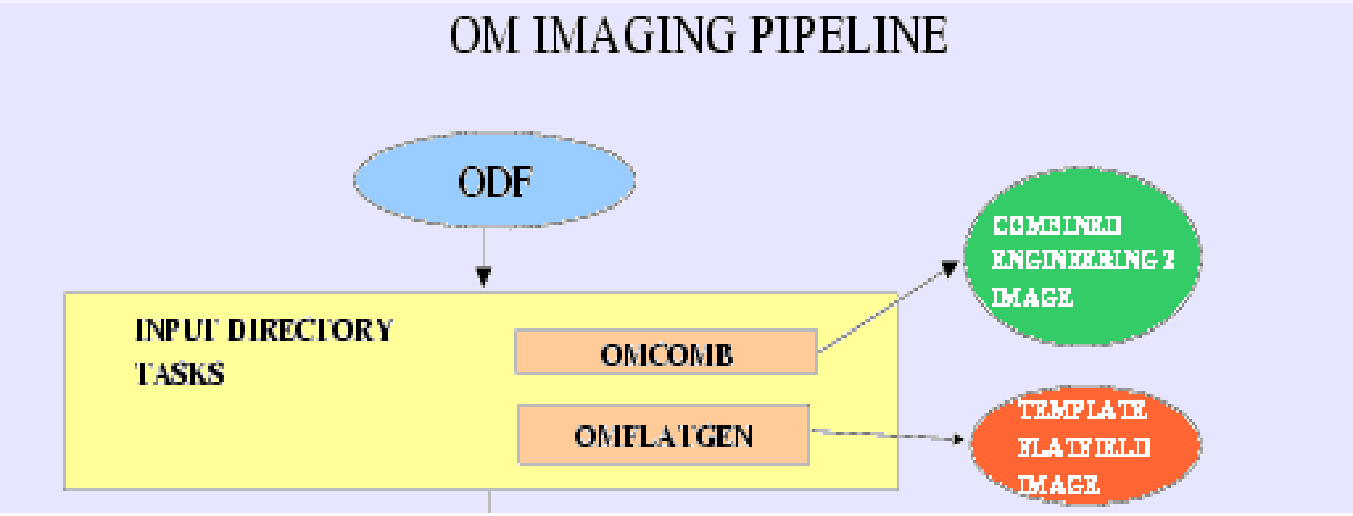
- All operations to be applied to OM data (SAS tasks) are combined into processing chains: **(Perl scripts where all tasks are concatenated, with default parameters and naming convention)**
  - **omichain:** for image data, to perform photometry of all sources in the field of view
  - **omfchain:** for 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

OM image mode data reduction

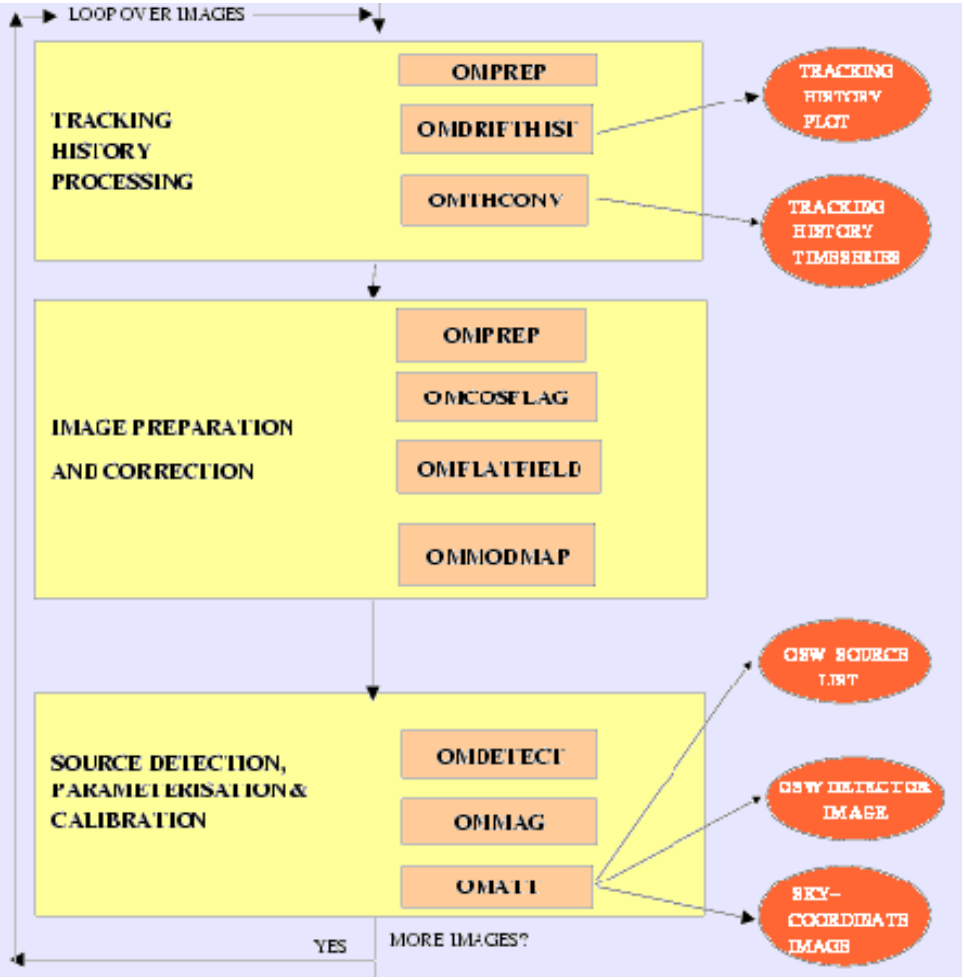


- Data preparation

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

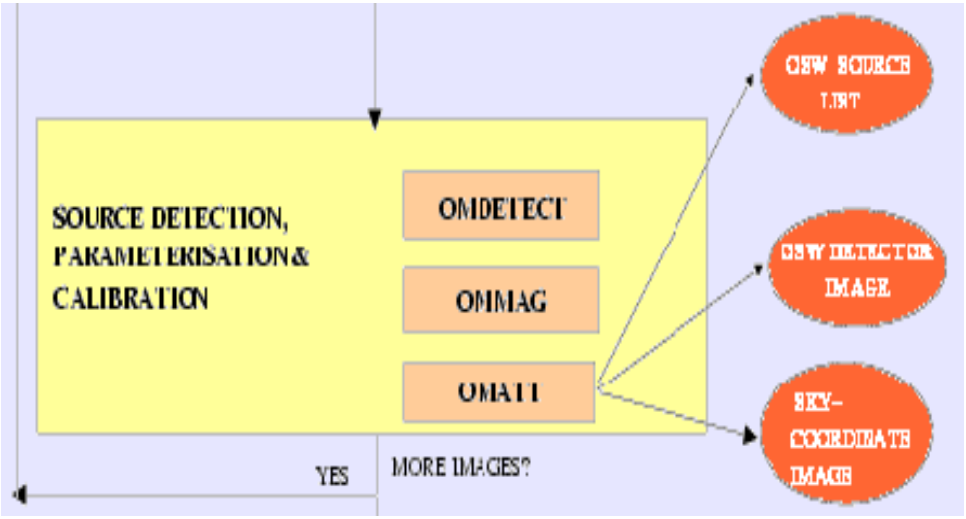
  - **omflatgen:** obtains flat-field template

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**

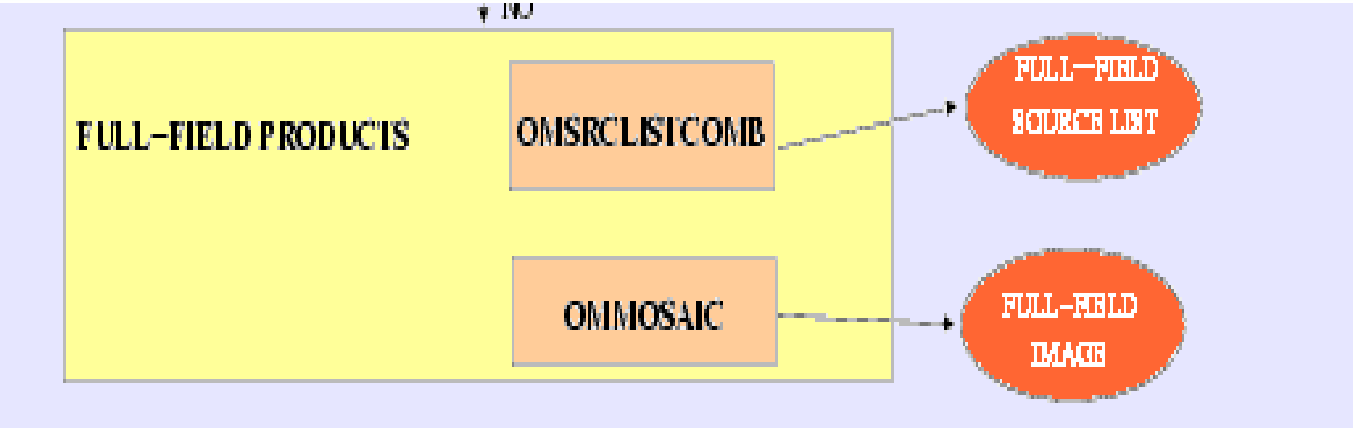
OM image mode data reduction



- **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)**

OM image mode data reduction



- 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

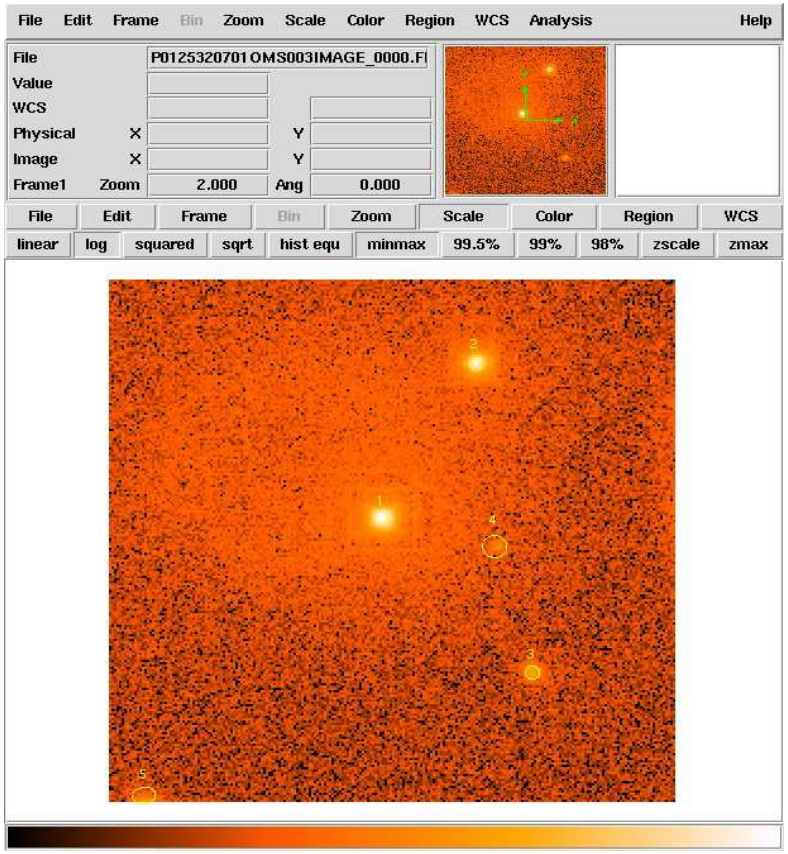
You can select interactively your source in a processed image, and *omsource* will perform aperture photometry

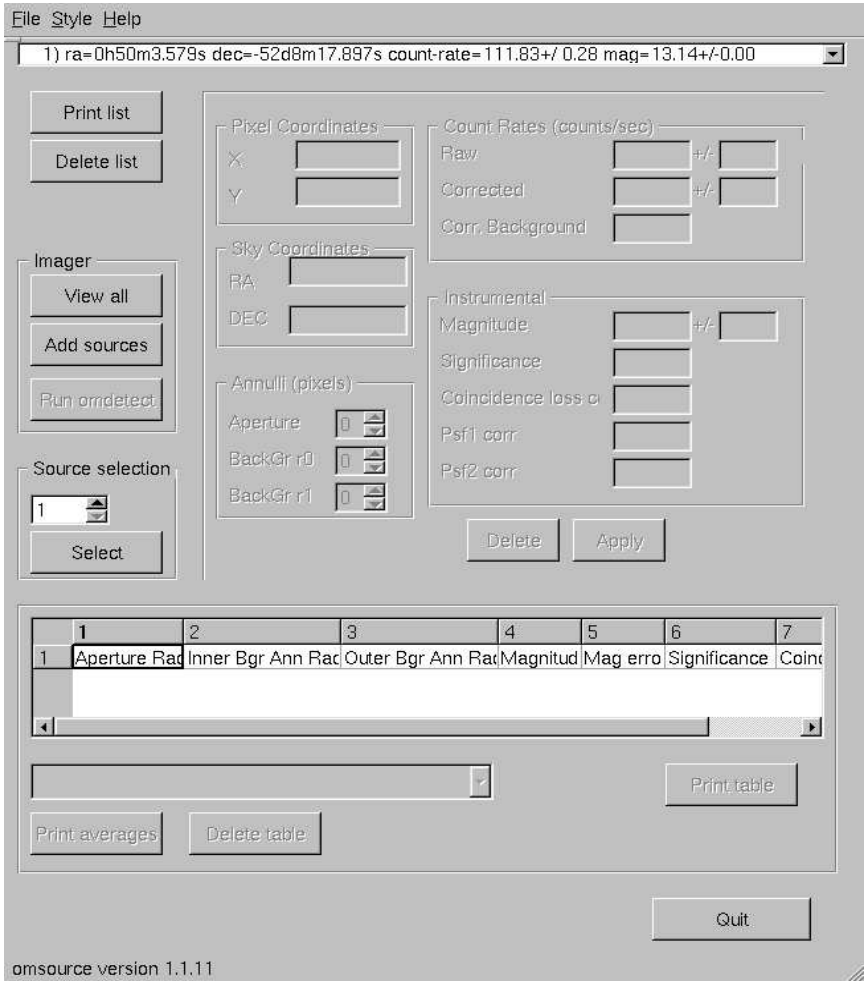
omsource

input image

[old source list]

new source list



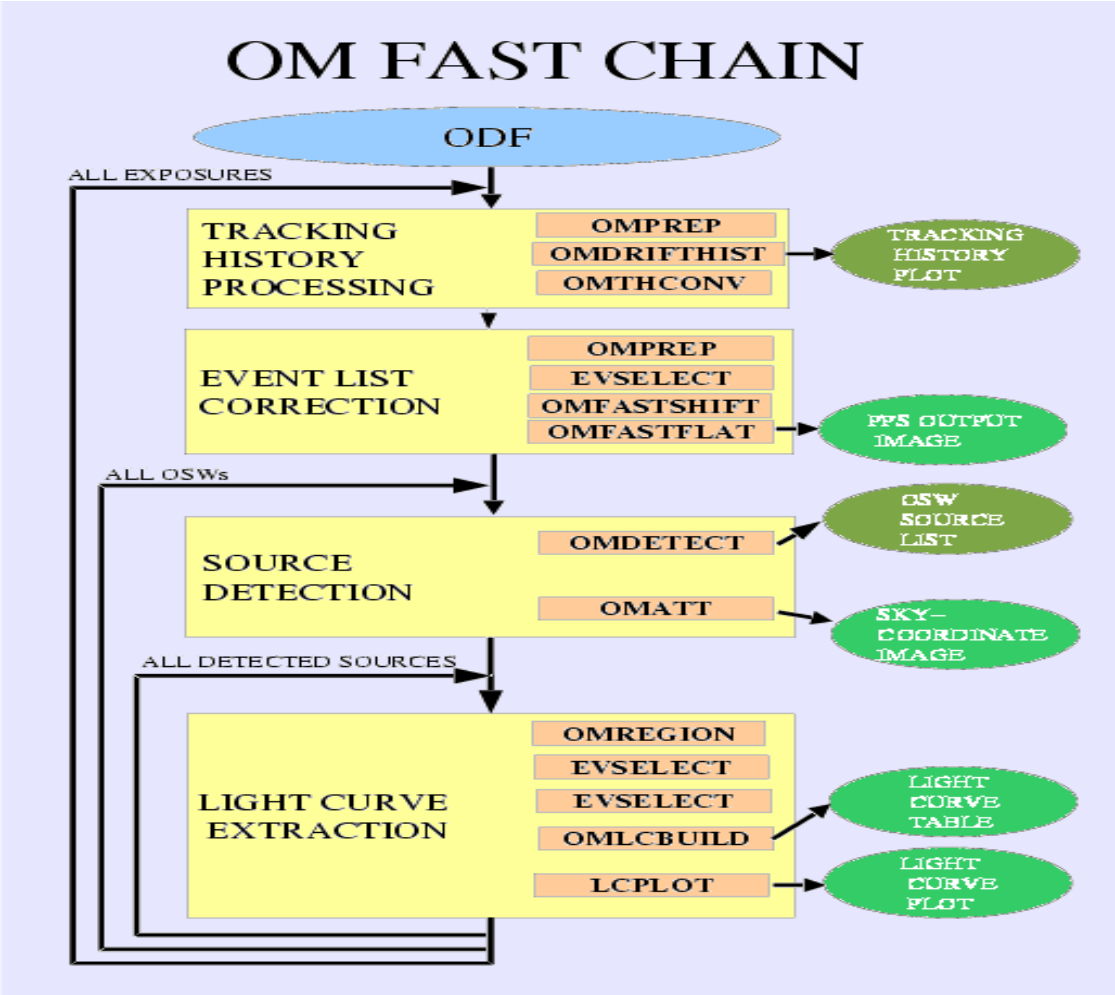


OM image mode: interactive photometry

Omphotom:

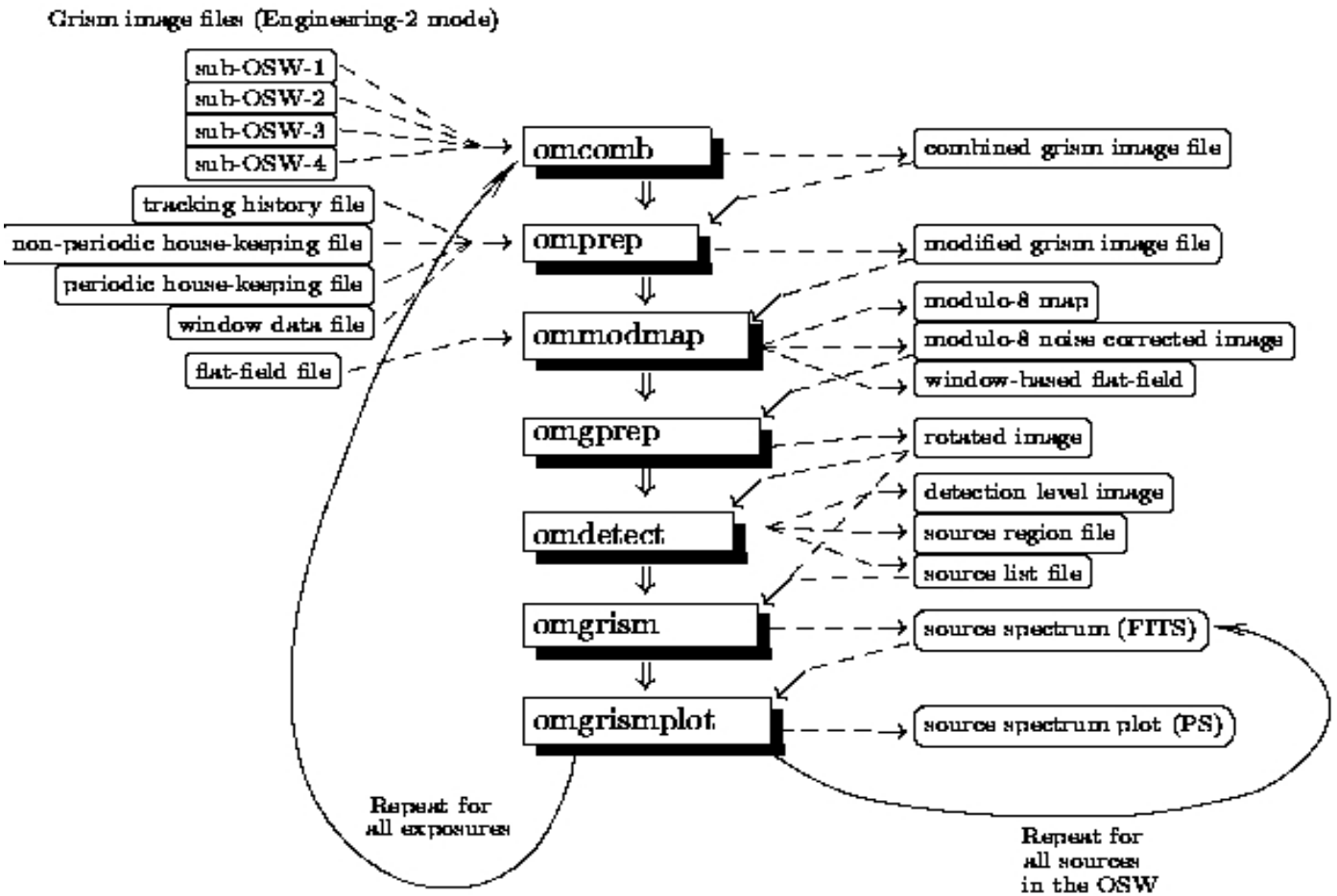
- **Allows a user to recompute the photometry of one or more sources in an OM source-list in one of several different ways, using specified parameters.**
- **It can reprocess a list of sources from various source-list files.**
- **Also allows the photometry to be re-computed using several different methods.**
- **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.**

OM fast mode data reduction: omfchain



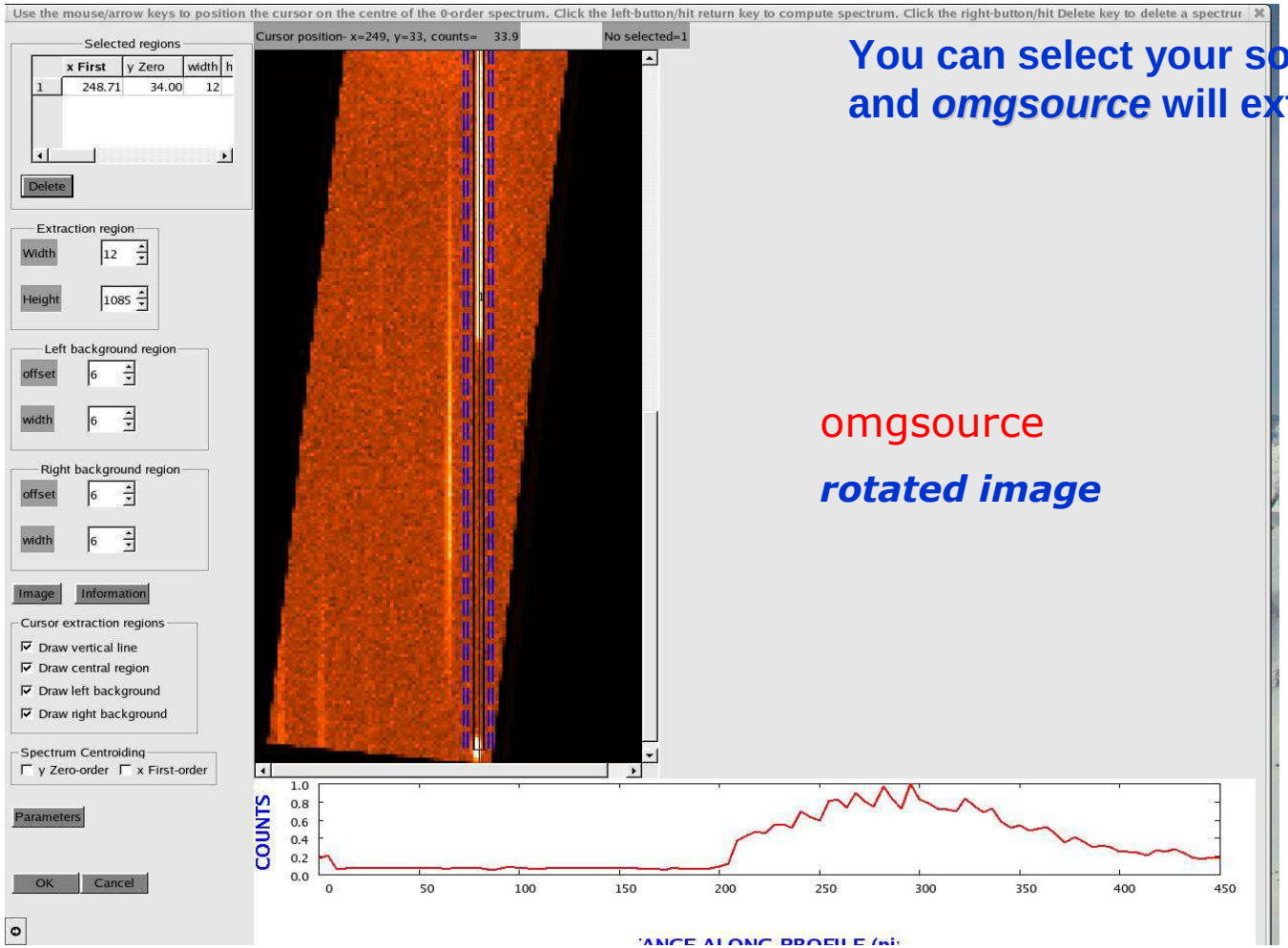
- **Preparation: tracking correction**
  - **omprep**
  - **omdrifthist**
  - **omthconv**
- **Event selection & corrections: tracking, flat-fielding**
  - **omprep**
  - **evselect**
  - **omfastshift**
  - **omfastflat**
- **Source detection & astrometry**
  - **omdetect**
  - **omatt**
- Light curve: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

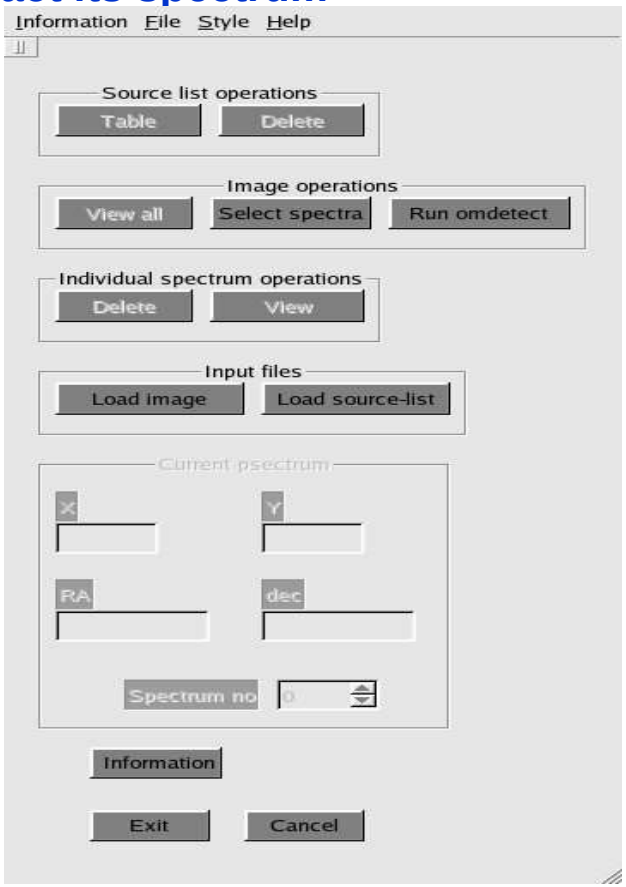
OM grisms interactive extraction



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

omgsource

rotated image



Critical issues / Known problems

- 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)*
- 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 :

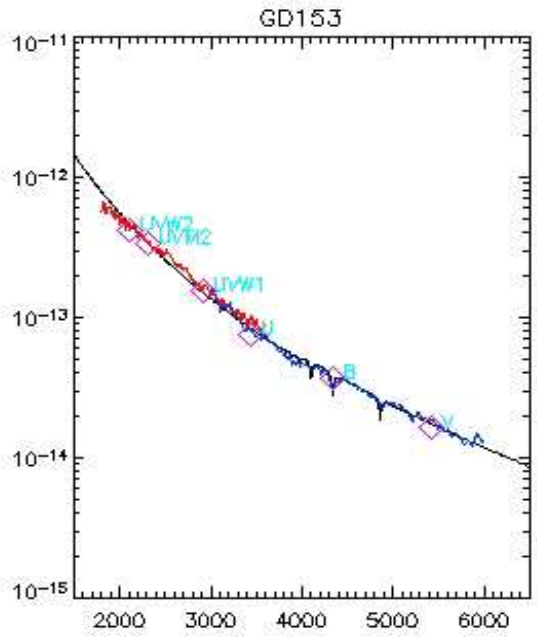
- **Average conversion factors for time sensitivity variation corrected count rate, based on white dwarfs are:**

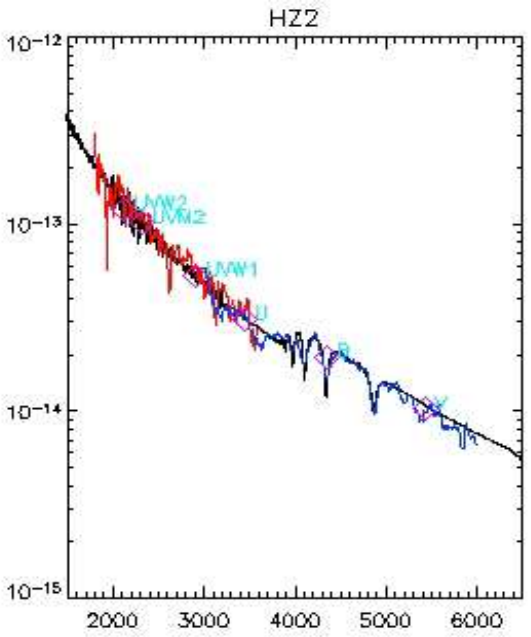
	UVW2	UVM2	UVW1	U	B	V
lambda (A)	2120	2310	2910	3440	4500	5430
factor	5.71	2.20	4.76	1.94	1.29	2.49
(erg/ct/cm2/A)	E-15	E-15	E-16	E-16	E-16	E-16

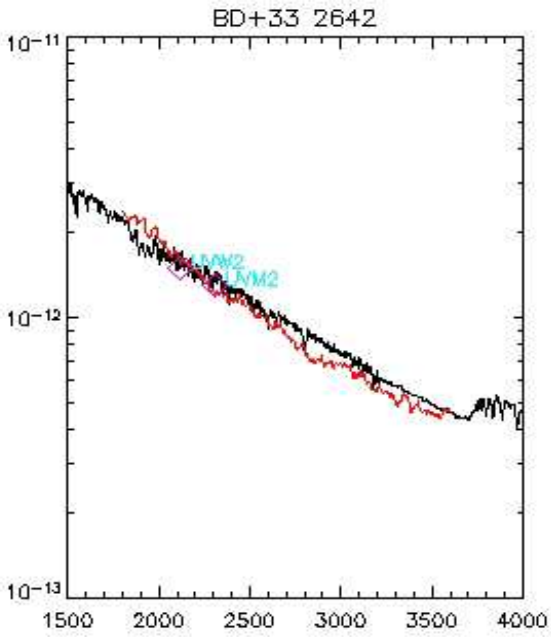
- **Spectral type dependencies are provided as recipe in SAS Web pages**

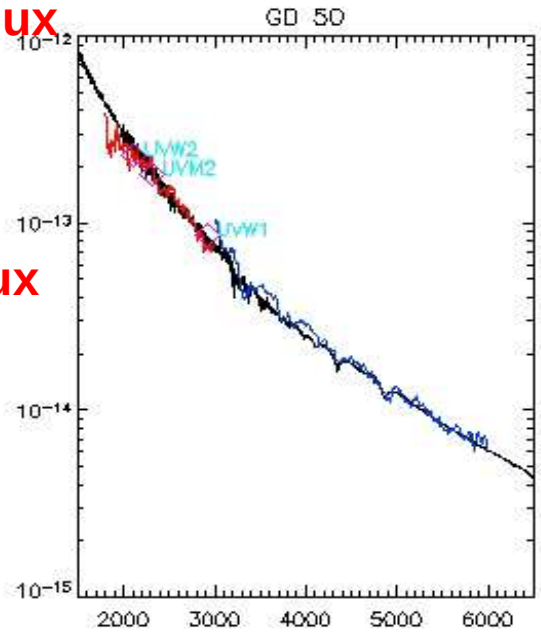
AB magnitude and flux included in SAS processing

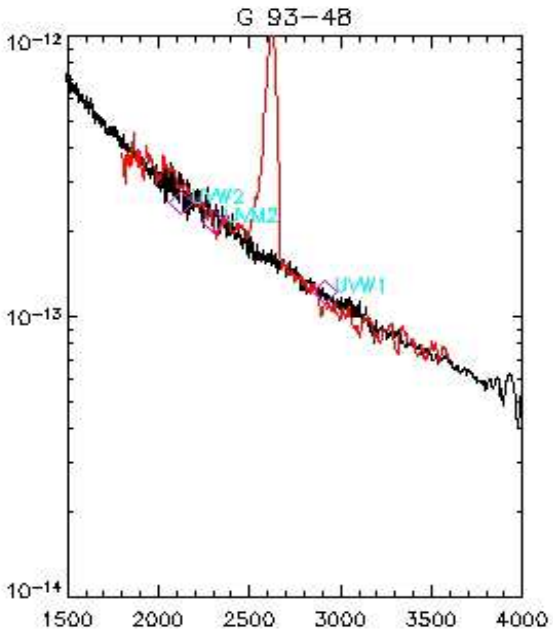
OM filters flux and grisms versus standard flux

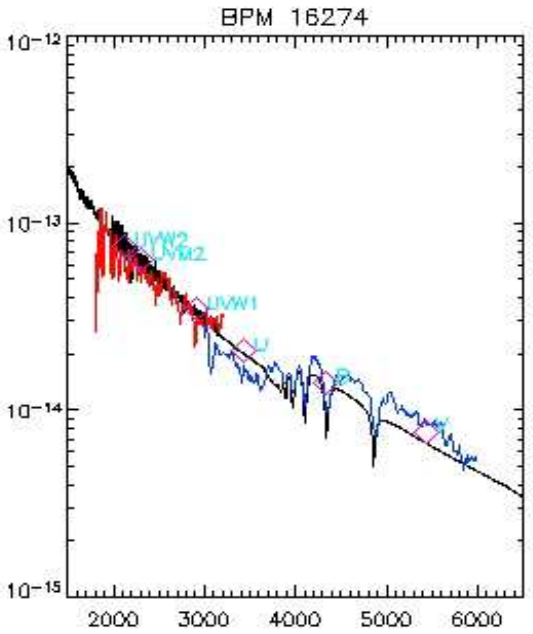












Input data files: ODF

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	-
P0125320701OMS002IMAGEF1000.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	-

SAS OM processing chains and interactive tasks

Image mode data:	**omichain**
Interactive aperture photometry:	**omsource** **omphotom**
Fast mode data:	**omfchain** **omphotom**
Grism spectra extraction:	**omgchain**
Grism interactive extraction:	**omgsource**