Analysis of OM data

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1 Overview

The presentation will cover the following

- Types of OM observation and consequent data
- A review of significant recent changes/additions/improvements
- A walk through the OM IMAGING and FAST mode pipelines
- A resumé of known problems
- The outlook for the OM SAS
- Workshop analysis

2 OM observations

- OM has two primary observing modes, IMAGING and FAST (timing).

- One can have up to 5 OM windows in an exposure. Up to 2 of these can be in FAST mode so OM exposures can comprise both imaging and fast mode data

- IMAGING mode science data is taken in 4 modes

  1. Rudi-5 format (default): Five separate exposures covering the full FOV. Each consists of 2 windows. One is always a ∼2'x2' high resolution (0.5"/pixel) image centred in the field. The other is a larger, lower resolution (1"/pixel) window whose location is moved between exposures to cover first a large central (∼8'x8') window and then 4 surrounding strips (figures 2 and 2). A single fast mode window at the boresight can also be accomodated.

  2. Full Frame low resolution mode (also known as ENG-2 mode), available to GO's from AO2. Full FOV, captured in a single exposure but currently arrives as 4 image segments (figure 2).

  3. Full frame high resolution (also known as ENG-4) mode, available from AO2. Arrives as a single full FOV image.

  4. User defined - size and location of windows dependent on memory and avoiding partial overlaps.

- FAST mode science data is obtained in a standard way and arrives as an event list. The PI can request up to 2 fast mode windows in a given exposure (each no larger than 11x11 arcsecs), though simultaneous imaging windows may be present.

Rudi–5 window pattern

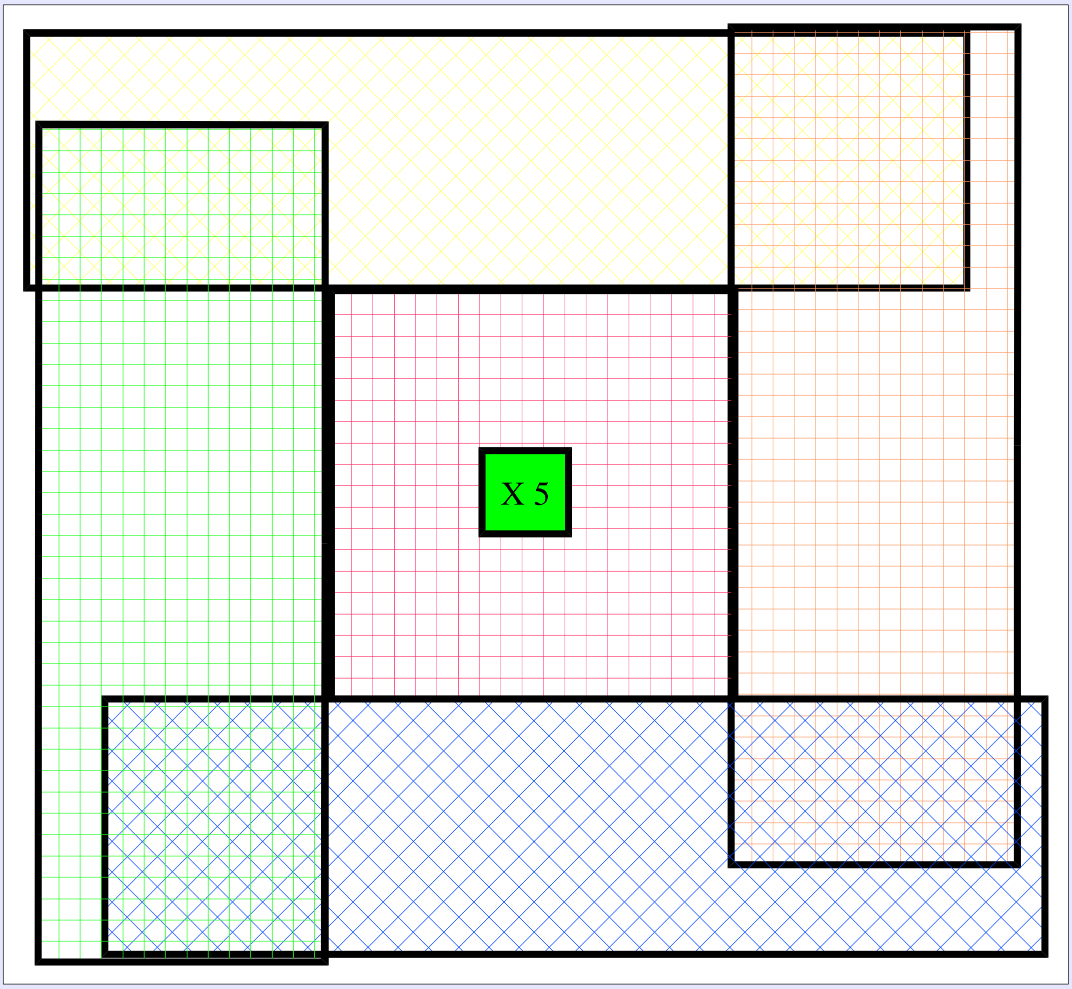

Figure 1: Rudi-5 window pattern

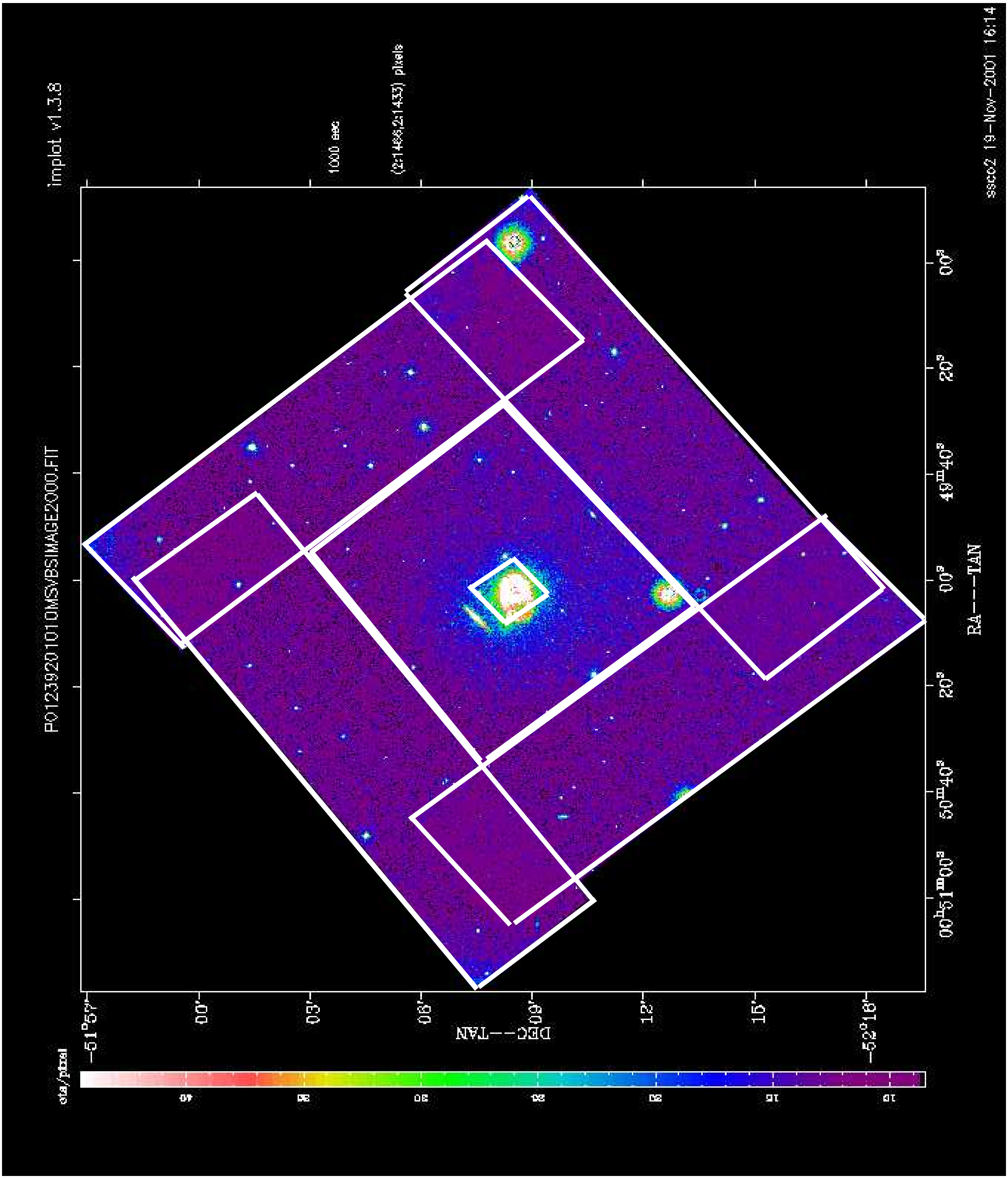

Figure 2: Rudi-5 window configuration on the sky

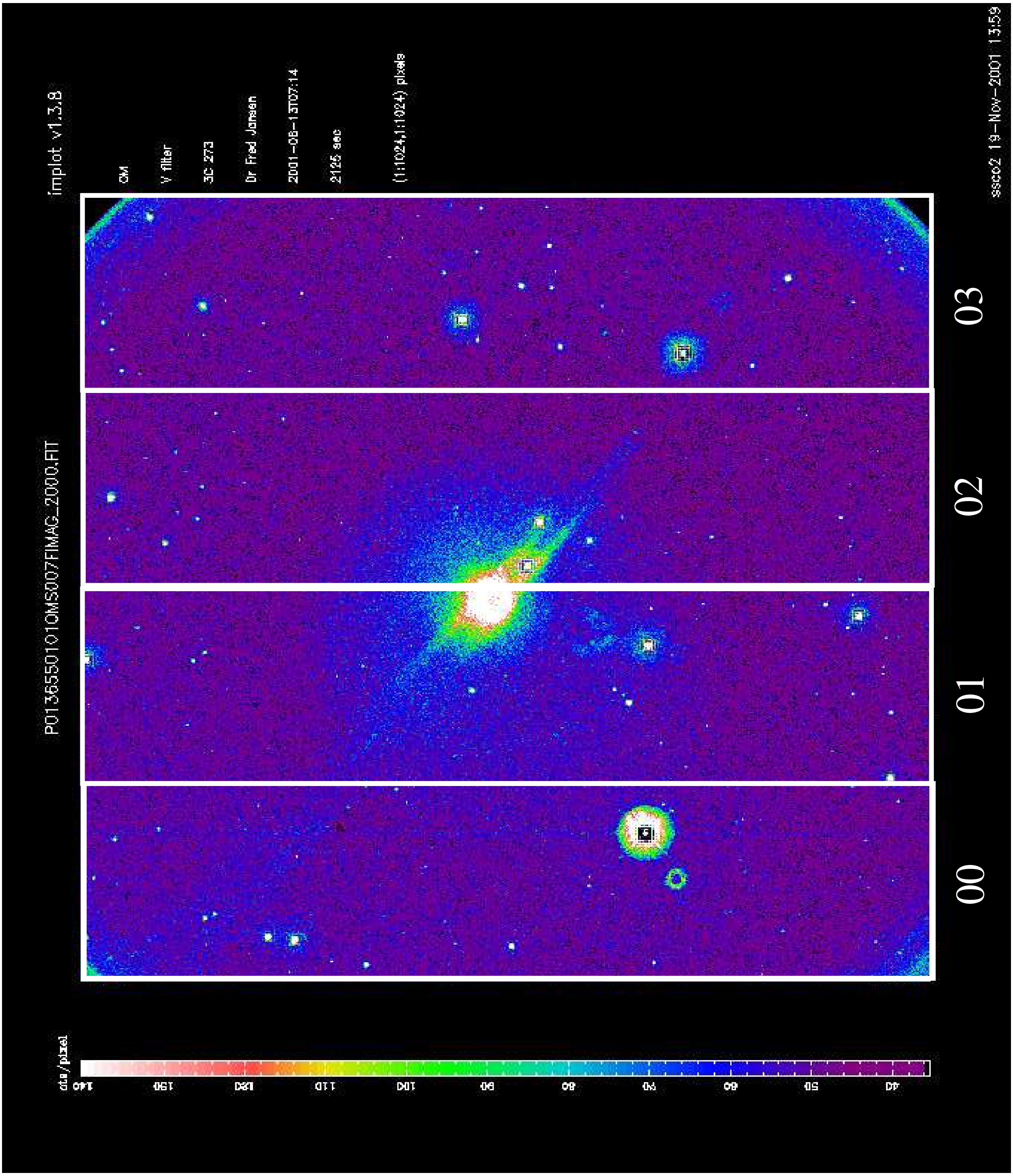

Figure 3: Window configuration of Full-frame low resolution (ENG-2) mode OM exposures

3 Image artefacts

OM images contain a variety of 'features' caused by the operation of the detector or by scattering within it (figure 3). The most common ones are:

- scattered light loops - large, generally elliptical loops, radiating from the centre of the field: The origin is light from bright stars in an annulus on the sky, 12-13 arcmins off-axis, being scattered from a beveled surface in the detector window housing. These features are less evident with the UV filters.

- Central enhancement - a roughly symmetrical brightening in the centre of the OM FOV: The cause is similar to the loops, but due to background light.

- Ghost rings - small annular images slightly displaced from bright stars: Caused by light from such stars scattering from the back side of the window.

- Readout streaks - enhanced emission along a few columns of pixels, passing through bright stars: The reason is that the unshuttered CCD continues to record data during the short frame transfer period.

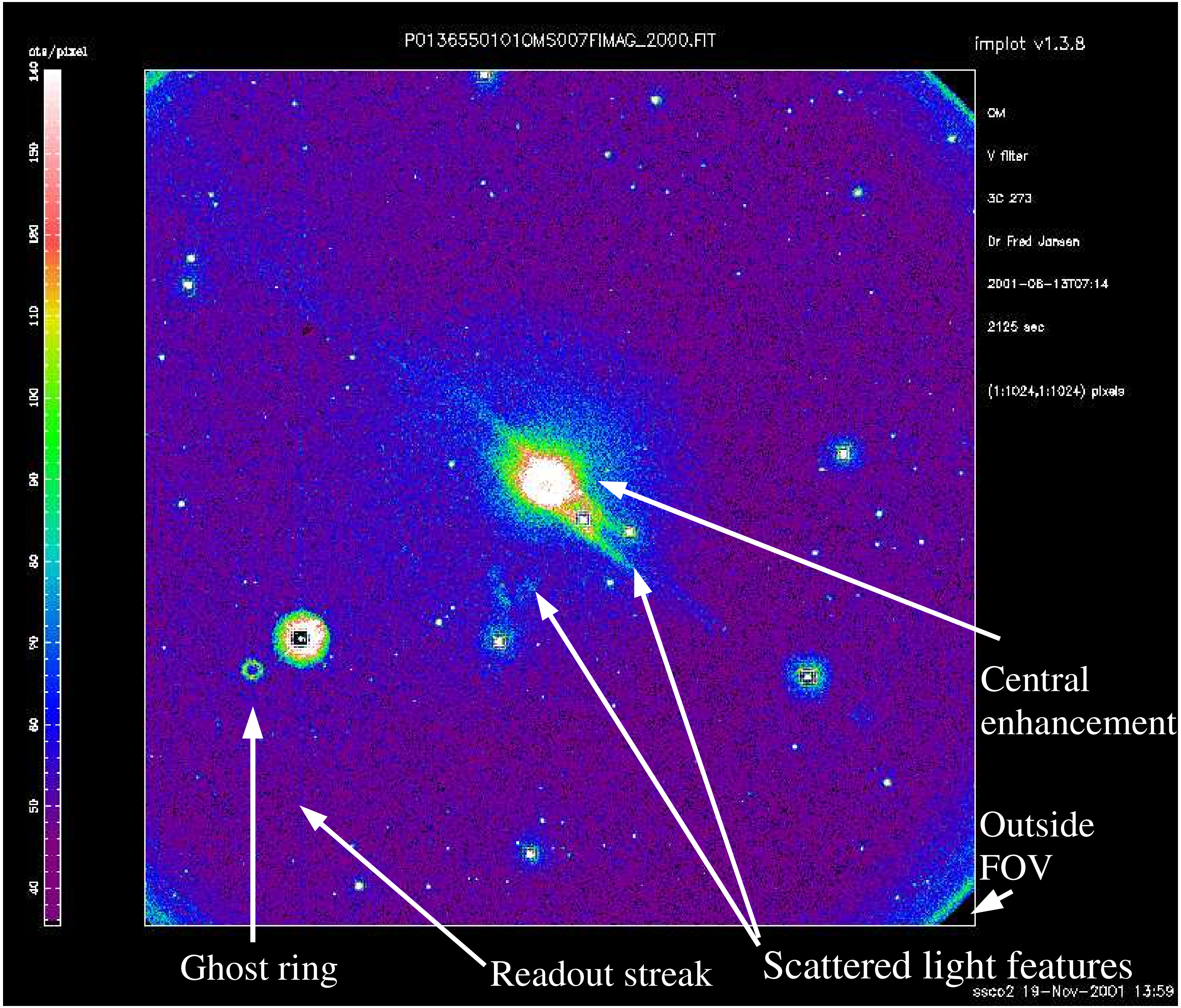

Figure 4: Artefacts commonly seen in OM images

4 Recent developments

The OM SAS software has advanced substantially in the last 6 months. Principal changes since SAS version 5.2 include

- Bringing the fast mode analysis pipeline into operation. Very substantial modifications have been made to the original software to improve its reliability and accuracy. In particular, the detection of sources and the correction of their light curves has been much improved.

- The imaging chain can now process all forms of imaging mode data - ENG-2 and ENG-4 data could not previously be processed.

- The ability to produce mosaiced full-FOV images (especially useful for Rudi-5 patterns) has been added.

- Treatment of the photometry has been revamped to bring the original code into line with the Cal definitions. For a 1000s V band exposure, this reduced ~0.5 magnitude systematic offsets (at V~19) to a scatter ~0.1 or better.

- internal astrometry is now correct (no catalogue X-correlation as yet though) - previously found 2-3 arcsec offsets between images and sources.

- Many changes have been implemented to enhance robustness.

5 The OM chains

Currently, OM data is mainly processed via two chains of tasks, *omichain* (Imaging mode) and *omfchain* (Fast mode). Individual ODF or intermediate files can be processed manually using separate OM SAS tasks but no distinct procedures yet exist that will perform specific processing tasks from intermediate points within the processing flow - e.g. it is not yet possible to select a specific object in a flat-fielded image and extract its magnitude or position. This will be remedied soon.

5.1 Image analysis

The *omichain* task is designed to process imaging observations or exposure subsets of an observation automatically.

The key stages of this processing sequence are described (stages 2, 3 and 4 are performed in a loop over all windows) - see also figure 5.1.

1. Directory level preparation: A flat-field is extracted from the Calibration data. Also, ENG-2 image segments, if present, are combined into full-frame images.

2. Tracking: Tracking information is extracted, where available, to make files required later and graphical products.

3. Image preparation: Images header information is augmented from housekeeping and summary files, bad pixel information is inserted and the image is flat-fielded and mod-8 noise corrected.

4. Source analysis: Images are source searched and detected objects are parameterised with magnitudes and astrometry being added. A sky image is produced.

5. Observation level analysis: Once all windows are processed, the resulting source lists are merged and sky maps are mosaiced to yield full FOV sky images on a per-filter basis. Mosaiced data is only suitable for cosmetic use - no corrections are applied.

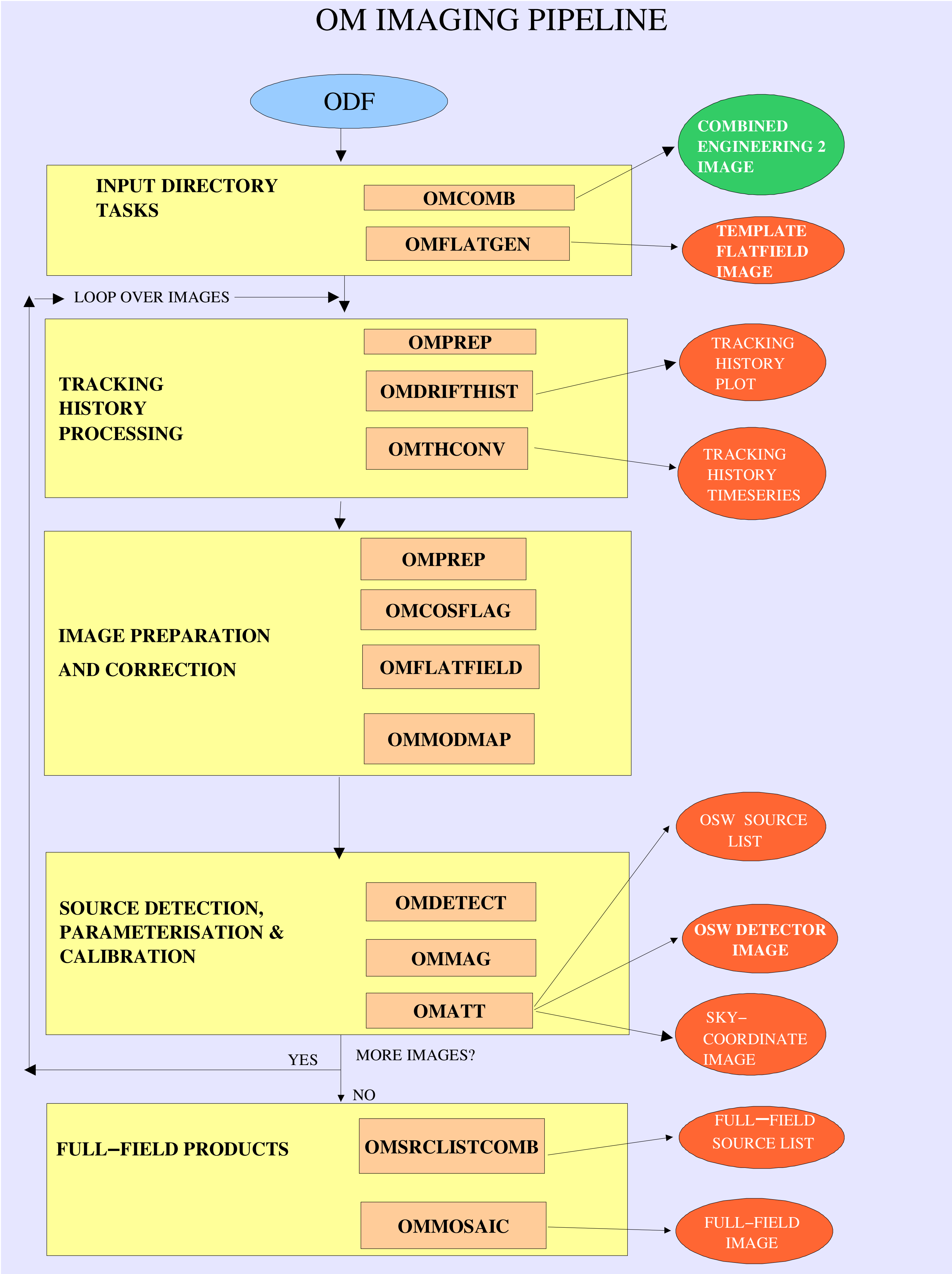

Figure 5: The OMICHAIN data processing flow

5.2 Fast mode analysis

The *omfchain* task performs a similar job for fast mode data which arrives in the form of an event list.

The key components of this processing sequence are outlined below (see also figure 5.2) - note stages 2 to 5 are performed in a loop that operates over all fast-mode windows

1. Directory level preparation (not shown in figure 5.2): A flat-field is extracted from the Calibration data.

2. Tracking: Tracking information is extracted, where available, to make files required later and graphical products.

3. Event list preparation: Event list header information is augmented from housekeeping and summary files. The events are tracking shifted and flat-fielded. An image of the fast mode window is generated.

4. Source analysis: The images are source searched and region files for the source(s) and background(s) are created. Astrometry is applied and a sky image is generated.

5. Light curve extraction: Light curves are extracted for source and background regions. A source light curve is derived and corrected for dead-time, coincidence-loss and any missing PSF. The resulting time-series is plotted.

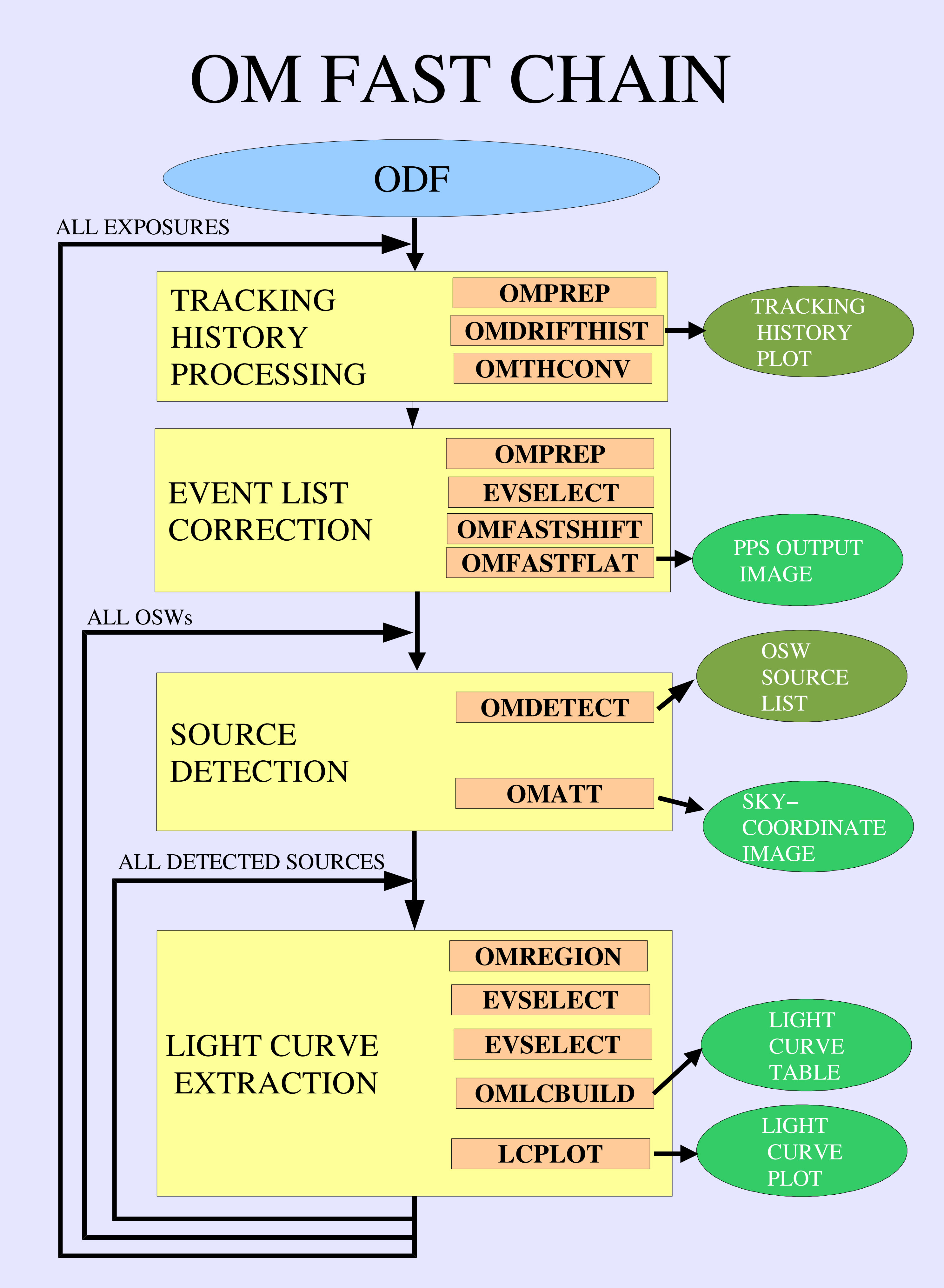

Figure 6: The OMFCHAIN data processing flow

6 Known problems

The following issues are the subject of ongoing work.

Imaging analysis

1. *omdetect* sometimes fails to find bright sources.
2. *omdetect* occasionally leaves a large region devoid of detected sources. Detection problems are sometimes witnessed around scattered light features and extended objects.
3. Flat-fielding currently uses a unit flat. A ‘real‘ flat is needed.
4. Treatment of photometry for extended objects is inadequate.
5. Photometric analysis needs refining but is awaiting a better PSF description and flat-field.
6. Catalogue cross-correlation to provide better astrometry is not yet enabled.
7. Magnifier exposures can not currently be processed.

Timing analysis

1. Further improvements to the analysis of fast mode objects is required. In particular, crowded fields need to make use of reduced apertures.
2. Reduction when contaminating sources are present needs further work.
3. Treatment of sources that extend beyond the fast mode window is complicated (by drift) but can be made more robust.
4. Observation-level, contiguous light curves are not provided (only exposure based data).

7 Future development

Several upgrades and developments are envisaged for SAS V5.3 and V5.4. These include

- Parameter interfaces to 'chains' to be overhauled to allow control of internal tasks (SAS V5.3).
- Creating persistent intermediate files (V5.3).
- Improve treatment of extended sources (V5.3/5.4).
- Interactive tasks for imaging data to compute photometry/astrometry for user selected objects (V5.4).
- Interactive tasks to compute corrections (i.e. coincidence loss and dead time) (V5.3/V5.4).
- Develop grism tasks (V5.4).

8 Workshop data processing

The workshop data sets have been chosen to illustrate the reduction of Rudi-5 (obs ID=0123920101) and Full-frame low resolution (ENG-2) (obs ID=0136550101) imaging modes and the Fast mode (obs ID=0099010101).

For the fast mode data one can perform a step by step analysis of the separate fast mode windows from any exposure (or all using the *omfchain*).

For the imaging mode data, it is suggested that the user perhaps perform a step-by-step reduction (with the Rudi-5 data) of a V-band window and then either repeat for a different filter (e.g. B) or use provided PPS products for the second filter, to create a combined source list file.

One can also use the products, for example the V-band Rudi-5 segments, to construct a mosaiced image.

The ENG-2 data highlight some of the artefacts that one can encounter and again allows the user to experiment with combining source lists etc.

References