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SSC Pipeline Processing

- The SSC performs pipeline processing at Leicester of all ODFs sent by the SOC, returning them for distribution to the user
- The aim of the pipeline is to eliminate the need for substantial user data processing, and to provide multiple entry points and views of the observation
- The pipeline processes all science exposures, mostly as independent entities. The pipeline does not combine observations
- Pipeline processing is fully automatic (but for a visual screening step)
- The pipeline makes use of public SAS tasks, producing FITS and graphics files in compressed formats

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SSC Pipeline Processing: system design

- The pipeline consists of Perl modules which start as soon as their input data are ready
- This non-sequential system (similar to that used for HST) is well suited to a multiple CPU environment
- The modules invoke the SAS tasks which do the bulk processing
- Many ODFs may be present in the system (at various stages of processing) at any time
- ODFs and pipeline products are moved between the SOC & SSC via a dedicated line

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SSC Pipeline Processing: major steps

- For each ODF the pipeline consists of the following major stages
  - ODF ingest
  - Exposure and GTI selection
  - OM processing
  - EPIC processing
  - RGS processing
  - EPIC source catalogue correlation
  - HTML product generation
  - Visual screening
  - Compression, grouping & dispatch

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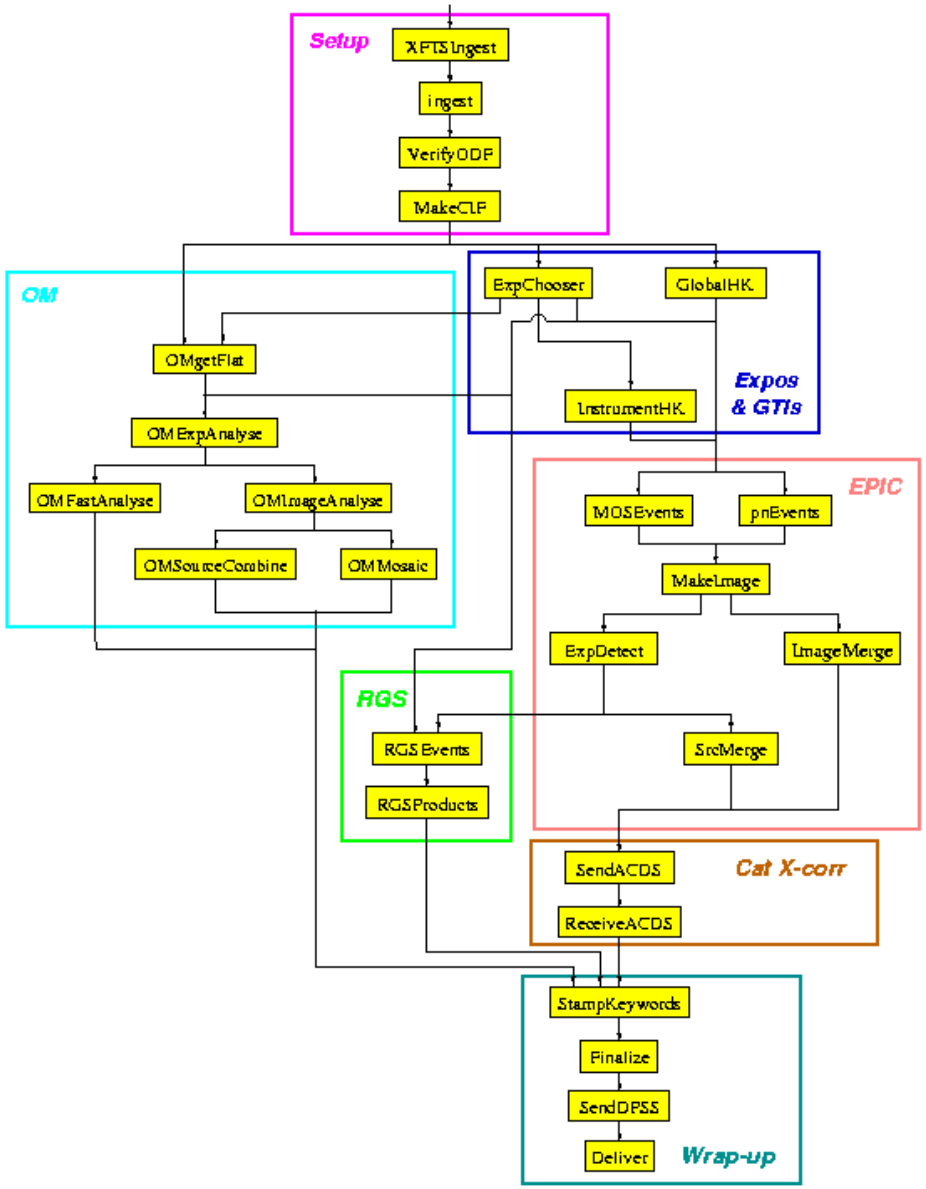

Pipeline module dependency chart

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SSC Pipeline Processing: 1 - ODF ingest

- Initial actions in the pipeline processing of an ODF are:
  - untar & uncompress ODF from XMM file transmission system
  - check essential files present
  - run *odfingest* to make enhanced ODF summary file
  - enter ODF into pipeline database & move ODF to processing directory
  - identify ODF to a specific pipeline (e.g. test or production)
  - make observation summary html product & copy to INDEX.HTML
  - define CCF set for this pipeline run
  - make CALINDEX product

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SSC Pipeline Processing: 2 - exposure selection & GTI creation

- This step selects those exposures to be processed and creates good time intervals based upon attitude and, for the EPIC MOS, HK limits:
  - check that ODF event lists exists for this exposure
  - get filter wheel position & instrument mode
  - ignore exposure if filter = Cal/Unknown/Blocked/Grism/Magnifier/Closed
  - ignore exposure if mode = Undefined/HTR
  - use *atthk* to make attitude timeseries product
  - use *tabgtigen* to make attitude GTI file (att exists & {att-median} < 3 arcmin)
  - use hkgtigen to make MOS HK GTIs (using HKPARMINT CCF file to select instrument subsystem settings, temperatures, thresholds)

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SSC Pipeline Processing: 3a - OM exposure & image science window

- use *omflatgen* to get flatfield and *omprep* to put keywords in tracking files
- use *omthconv* to make tracking star intensity timeseries fits product
- use *omdrifthist* to make tracking history plot
- if Eng-2 use *omcomb* to reconstitute the full field image

- If SW in image mode:
  - use *omprep* to insert keywords into SW files
  - use *omcosflag* to apply tracking history to the bad pixel map
  - use *omflatfield* to apply tracking history to the flatfield and devide into image
  - use *ommodmap* to determine & apply event detection pattern correction
  - use *omdetect* to make multi-scale source list (extension of Sextractor)
  - use *ommag* to convert source intensities to instrumental magnitud
  - use *ommat* to add RA & Dec to source lists, and to rotate SW images to N up

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SSC Pipeline Processing: 3b - OM fast mode & multi-exposure

- If SW in fast mode:
  - use *omprep* to insert keywords into SW files
  - use *omfastshift* to apply tracking history to the ‘event list’
  - use *omfastflat* to make the flatfielded image
  - use *omdetect* to make multi-scale source list (extension of Sextractor)
  - use *ommat* to rotate SW images to North up
  - per source:
    - use *omregion* to make circular source & annular background regions
    - use *evselect* to make the source and background timeseries
    - use *omlcbuild* to make timeseries fits file products
    - use *lcplot* to make timeseries plot product

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SSC Pipeline Processing: 3c - OM observation-wide products

- Use *omsrclistcomb* cross-identify OM sources from all independent windows, making an observation-wide source list with UBV standard magnitudes if colours are available
- Use *ommosaic* to make multi-exposure, full field of view images for each filter and for each of the following OM setups:
  - Rudi-5 (standard sequence of exposures to fill FOV, low resolution SWs only)
  - engineering-2 (full field low resolution)
  - engineering-4 (full field high resolution) - but not yet
  - User defined (i.e. any other low resolution window configuration)

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SSC Pipeline Processing: 4a - EPIC MOS processing

- For each CCD event list:
  - use *emframes* to allocate times to frames and make CCD GTI files
  - if image mode, flag bad pixels using background flare screened data
  - use *emevents* to perform full event resolution (use offset/var map if available)
  - use *attcalc* to add projected celestial coordinates to event list
  - use *emenergy* to add CCD-independent (PI) energies to event list
  - use *evselect* to clean event list of bad events
- For total event list:
  - use *evlistcomb* to combine CCD events lists
  - use *evselect* to add selection information to event list, copy CIF into event list
  - use *evselect* to make timeseries of Gatti events (E>12 kev) from exterior CCDs
  - use *tabgtigen* to make background flare GTI file from this timeseries

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SSC Pipeline Processing: 4b - EPIC PN processing

- For each CCD event list:
  - use *epframes* to reformat event list, allocate frame times & make CCD GTI files
  - use *bapixfind* to make mask for background events
  - use *badpixfind* & *badpix* to flag bad pixels
  - use *epevents* to perform event reconstruction and calibrate event energies
  - use *attcalc* to add projected celestial coordinates to event list
  - use *evselect* to clean event list of bad events (& PI<150 eV, remove edge pix)
- For total event list:
  - use *evlistcomb* to combine CCD events lists
  - use *evselect* to make GTI filtered event list, add selection info & copy CIF
  - use *evselect* to make timeseries of events (E=7-15 kev) from masked area
  - use *tabgtigen* to make background flare GTI file from this timeseries

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SSC Pipeline Processing: 4c - EPIC image & source list creation

- For each energy band (0.2-0.5, 0.5-2.0,2.0-4.5,4.5-7.5,7.5-12 keV):
  - use *evselect* to make 4” pixel sky coord fits image products (patt .le.12 for PN)
  - use *implot* to make image plot products
- For each EPIC exposure:
  - use *eexpmap* to make exposure maps (all bands) & *emask* to limit detection area
  - use *eboxdetect* on all band-limited images together to make box local source list
  - use *esplinemap* to fit model background to source-excluded image
  - use *eboxdetect* with model background to make box map source list
  - use *emldetect* to make max likelihood source list
  - use *evselect* to make image & *esensemap* to make 0.5-4.5 keV sensitivity map
- Use *srcmerge* to make all-epic cross-identifed source list (fits & html)
- Use *emosaic* to make full band all-epic image plot

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SSC Pipeline Processing: 5a - RGS event list creation

- Use *rgssources* to make list of sources >0.2 c/s & in RGS FOV from the appropriate MOS list (will use proposal position if none)
- For each CCD:
  - use *rgsframes* to timestamp & quality flag CCD frames
  - use *evselect* to remove bad frames and bad attitude intervals
  - use *rgsbadpix* to identify known & new bad pixels
  - use *rgsevents* to reconstruct and energy calibrate events
- Use *rgsangles* to define event dispersion & cross-dispersion coordinates (based on prime source)
- Use *rgsfilter* to make clean event list and exposure map products

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SSC Pipeline Processing: 5b - RGS source products creation

- Use *rgsregion* to make source extraction regions in (dispersion, X-dispersion) & (dispersion, PI energy) spaces
- Use *evselect* to remove events PI < 170 eV, and to make (dispersion, energy) and (dispersion, X-dispersion) fits image products
- Use *rgsimplot* to make plots of these, including extraction regions
- For selected sources in RGS source list:
  - use *rgsspectrum* to make background & background-subtracted source 1st & 2nd order spectrum fits products
  - use *rgsspecplot* to make spectrum plot products

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SSC Pipeline Processing: 6 - EPIC source catalogue correlation

- The all-EPIC source lists is dispatched via secure ftp to OAS (Strasbourg) for catalogue cross-correlation, products return by the same means
- Products are in fits, html or graphics formats and include:
  - X-ray catalogue objects in the field of view
  - EPIC source correlations in a large number of selected catalogues
  - the list of catalogues searched
  - descriptions of the fields of the catalogue extracts
  - plot of catalogue entries on EPIC image
  - plot of EPIC countours on Rosat All Sky Survey image
  - DSS finding charts for each source

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SSC Pipeline Processing: 7 - final stages

- Essential keywords are inserted into all fits products to identify the revolution, various software versions and the product type
- The product index file (listing all products) is made
- The html summary products are made by *ppssumm*
- The products are distributed by secure ftp to SSC sites for screening, this consists of:
  - completeness check
  - visual examination of plot products
  - examination of fits images together with EPIC source lists
  - brief report
- The products are compressed & grouped, then sent via XMM file transmission system to SOC

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SSC Pipeline Processing: more info

- Since 20 Dec 2000 there have been 8 pipeline revisions, many incorporating pipeline-specific SAS revisions
- I have described the pipeline revision expected to become operational about now, there will be a further significant revision when the next public SAS release occurs
- Summary & detailed release notes for all pipeline versions, as well as pipeline module code and software version number information, is all available from:

http://xmmssc-www.star.le.ac.uk/pipeview/prod

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OBS Summary | PPS Summary | EPIC Summary | OM Summary | RGS Summary | Catalogue Summary

0112570401 Observation Data File Summary

Revolution	Target	Obs Length	Observer
0100	M31 Core	59262 seconds	Dr Michael Watson

Guest Observer Information

Dr Michael Watson
University of Leicester
Dept.of Physics & Astronomy
University of Leicester
Leicester
UNITED KINGDOM
LE1 7RH
mgw@star le.ac.uk

Proposal Target Information

```
Target          : M31 Core
RA              : 00h42m43 00s (0.7119 hours)
Dec             : 41D15m46 00s (41.2628 deg)
Obs Length      : 59262 seconds
Alt Names       : N/A
Boresight RA    : 00h42m43 00s (0.7119 hours)
Boresight Dec   : 41D15m46 00s (41.2628 deg)
Lower Pos Ang   : 0
Upper Pos Ang   : 360
SC Pos Ang      : N
AO Number       : 1
Science Type    : E
```

Observation Record

```
Observation ID : 0112570401
Revolution     : 0100
Scheduled Start: 2000-06-25T08:12:41.000
Scheduled Stop : 2000-06-25T20:59:33.000
```

Instrument Information

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OBS Summary | PPS Summary | EPIC Summary | OM Summary | RGS Summary | Catalogue Summary

0112570401 EPIC Processing Summary

Revolution	Target	Observer
100	M31 Core	Dr Michael Watson

EPIC Multi-Exposure Products

Filename	Content
P0112570401EPX0000BSMLI0000.FIT	EPIC SUMMARY SOURCE LIST
P0112570401EPX0000BSMLI0000.HTM	EPIC SUMMARY SOURCE LIST
P0112570401EPX0000IMAGE0000.FIT	EPIC OBSERVATION IMAGE
P0112570401EPX0000IMAGE0000.PNG	EPIC OBSERVATION IMAGE

EPIC Exposures Processed by PPS

Instrument	ExpID	Mode	Filter	Start time	Duration	Stop time
EMOS1	U009	PrimeFullWindow	MEDIUM	2000-06-25T10:44:42	34837	2000-06-25T20:25:19
EMOS2	U009	PrimeFullWindow	MEDIUM	2000-06-25T10:44:51	34828	2000-06-25T20:25:19
EPN	U002	PrimeFullWindow	MEDIUM	2000-06-25T11:43:22	31232	2000-06-25T20:23:54

EPIC Exposure-Specific Products

Instrument	Exposure ID	Inst Mode	Filter	Start time	Duration	Stop time
EMOS1	U009	PrimeFullWindow	MEDIUM	2000-06-25T10:44:42	34837	2000-06-25T20:25:19

Filename	Content	Band (keV)	V&V Flags
P0112570401M1U009EBLSLI0000.FIT	EPIC EXPOSURE BOX-LOCAL SOURCE LIST	--------	----------
P0112570401M1U009EBMSLI0000.FIT	EPIC EXPOSURE BOX-MAP SOURCE LIST	--------	----------
P0112570401M1U009EMSRLI0000.FIT	EPIC EXPOSURE ML SOURCE LIST	--------	----------

XMM workshop 2001, ESTEC, 27/11/01,
Julian Osborne, Leicester University, SSC

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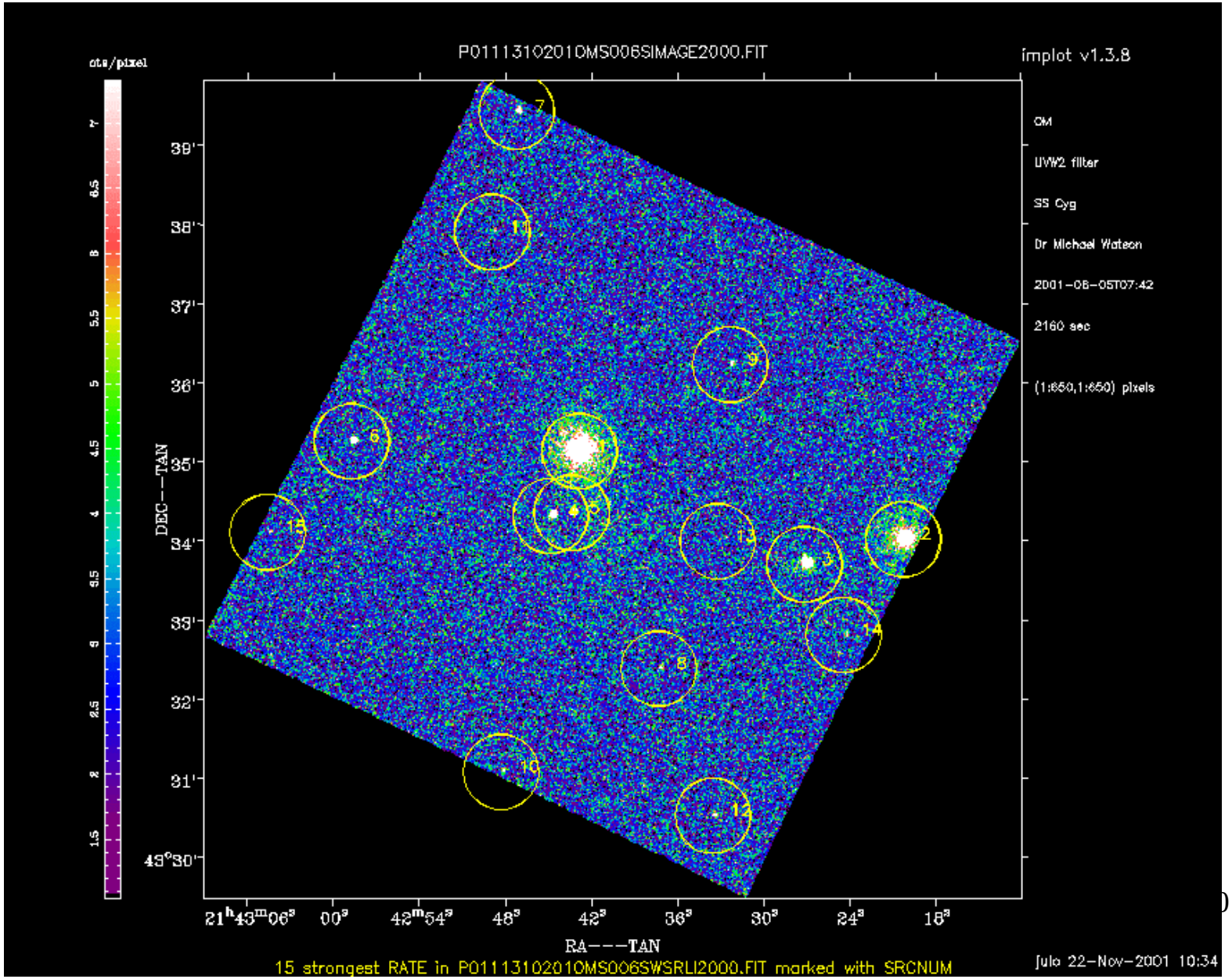

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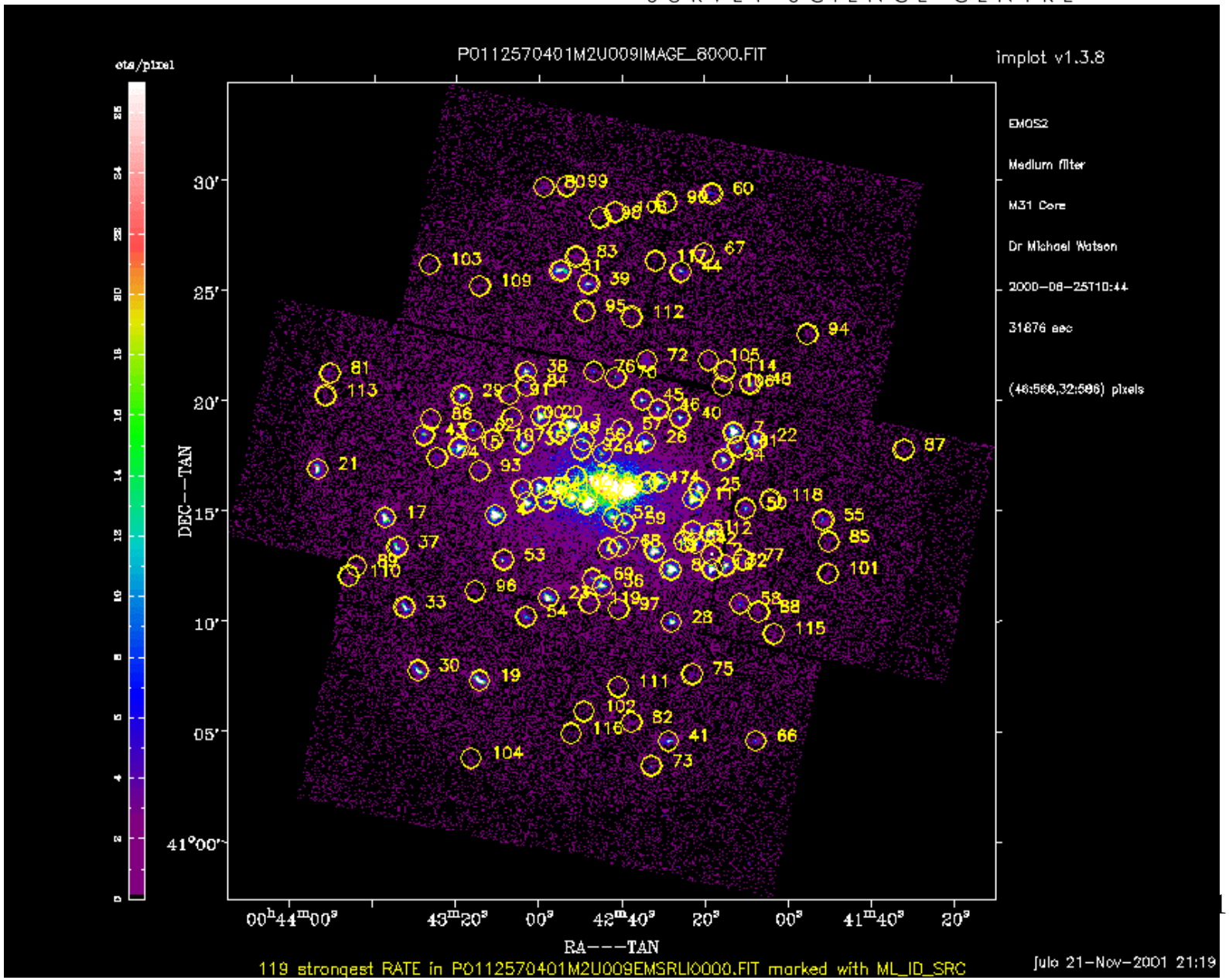

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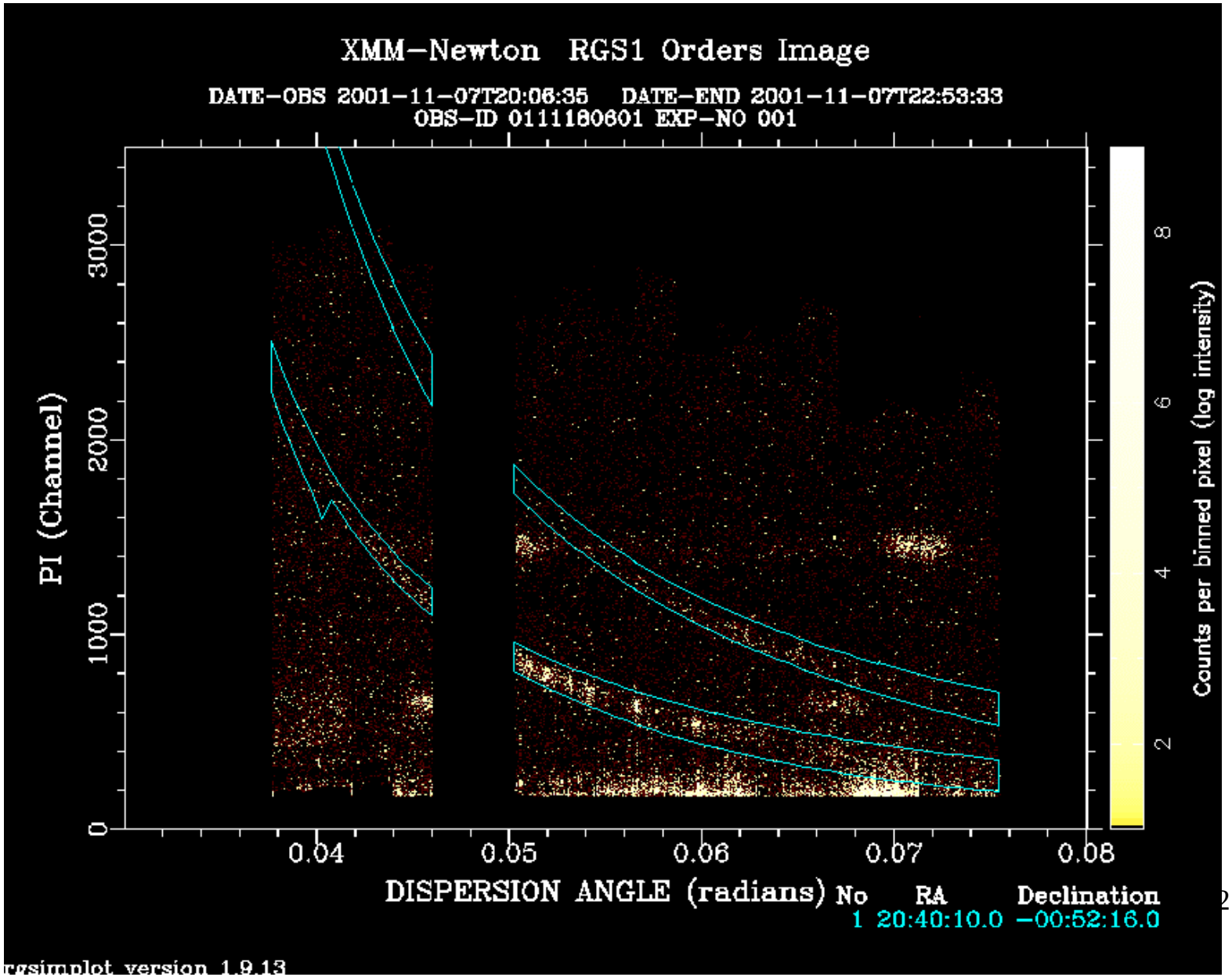

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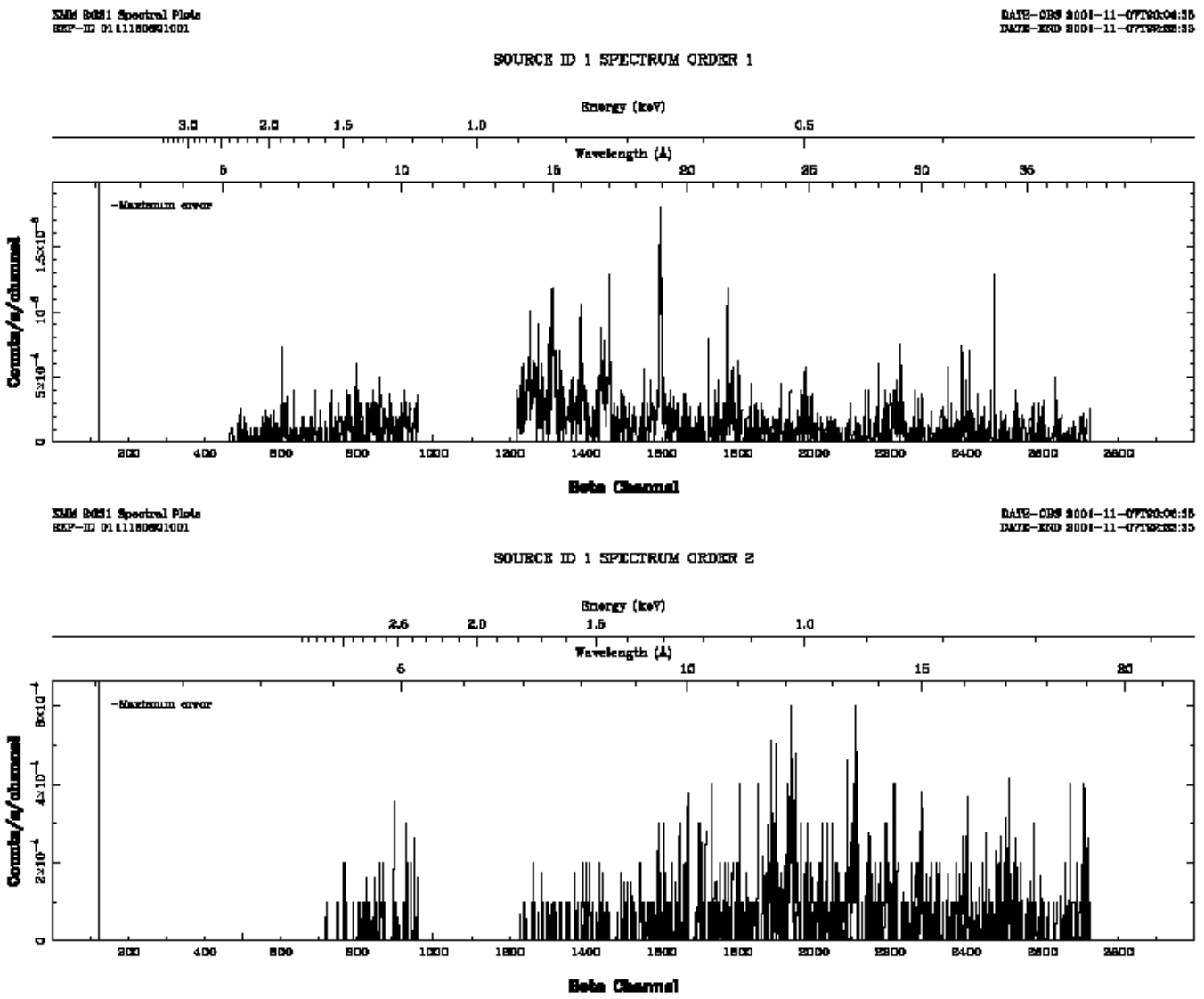

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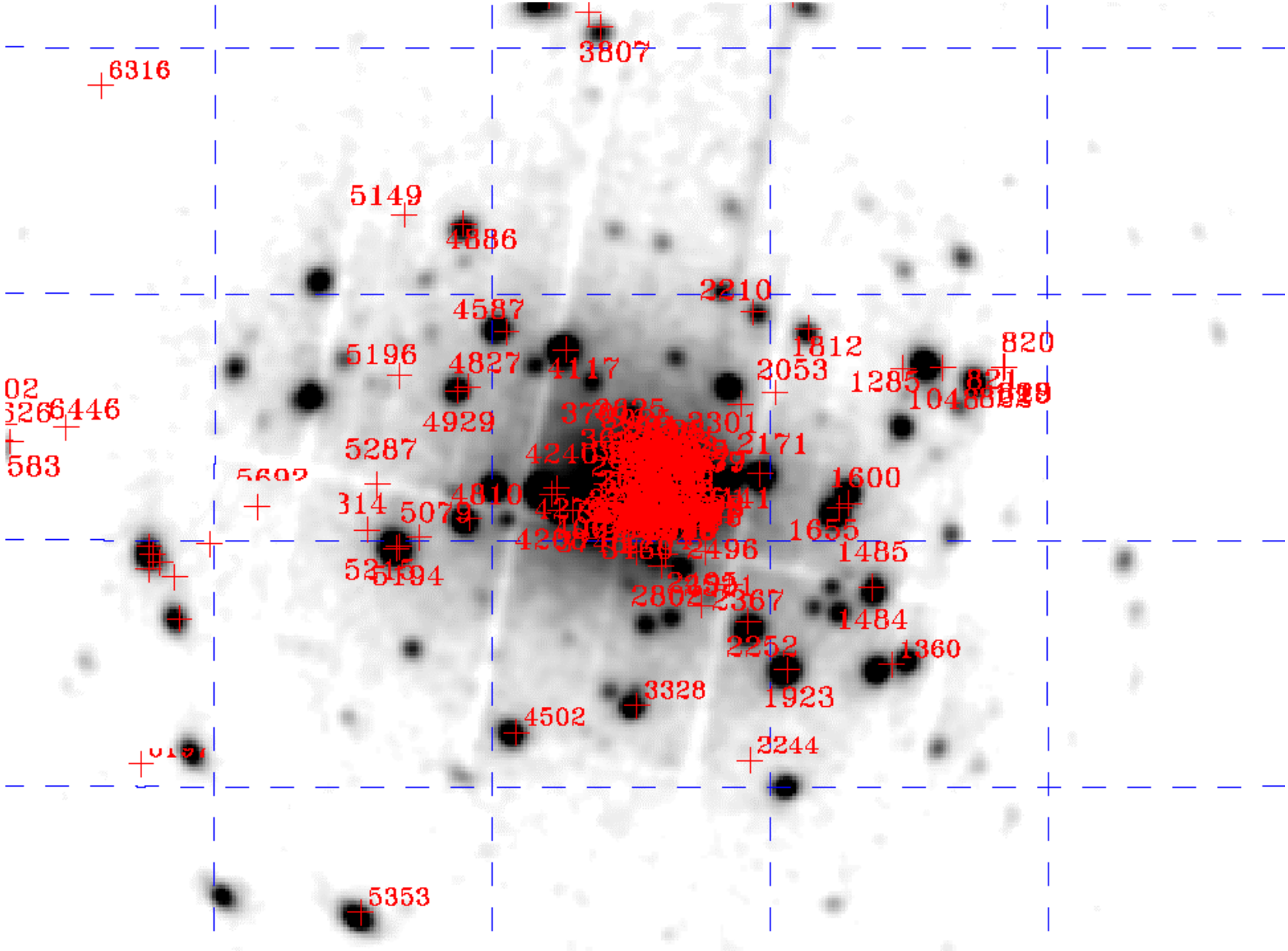

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