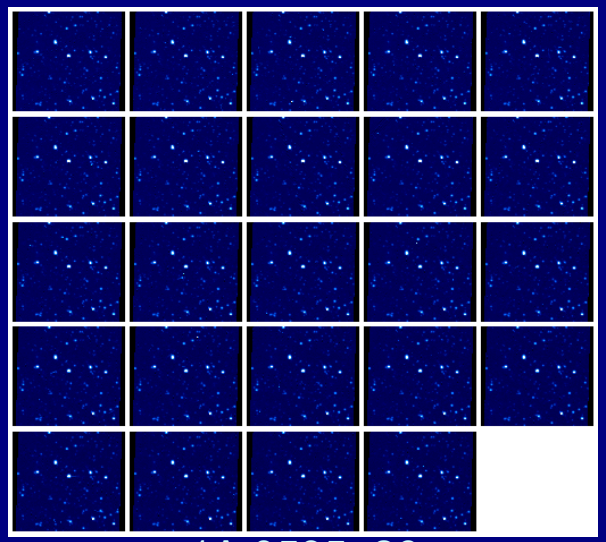
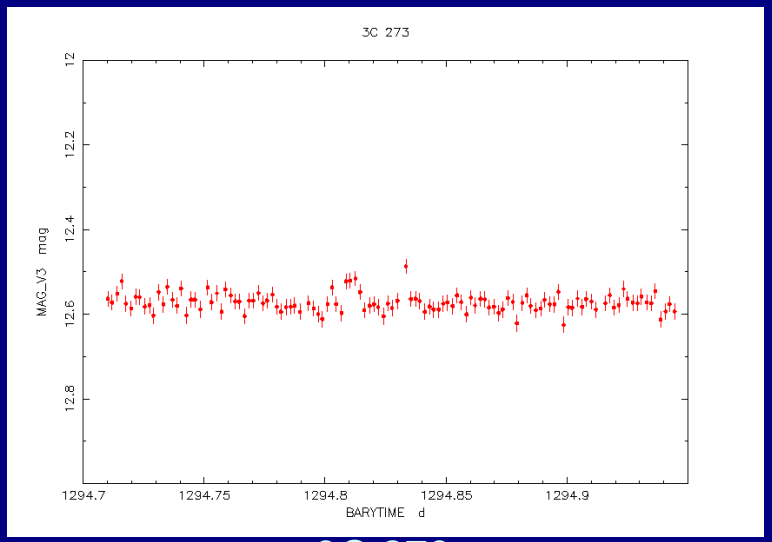
Data analysis with OMC: Examples



1A 0535+26



3C 273

LABORATORIO DE ASTROFÍSICA ESPACIAL Y FÍSICA FUNDAMENTAL
LAEFF
INTA
LABORATORY FOR SPACE ASTROPHYSICS AND FUNDAMENTAL PHYSICS

Daniel Rísquez

Talk outline

- Create light curves.
  - Executing the Standard Offline Analysis.
  - Understanding the results.
  - Caveats.
- Create images.
  - Subwindows.
  - Mosaics: Images for extended sources, or sources with inaccurate coordinates.
  - Triggers: These images are similar to mosaics, but they are not corrected by CCD effects (BIAS, dark current and flatfield).

Required information

1. Observation group.
   - The standard analysis will process all sources in SCWs.
   - You may create an observation group with the SCWs where your source is observed.
2. OMC identification number or object coordinates. You can search the OMC identifier at:
   - LAEFF *http://sdc.laeff.esa.es/omc*
   - ISDC *http://isdc.unige.ch*

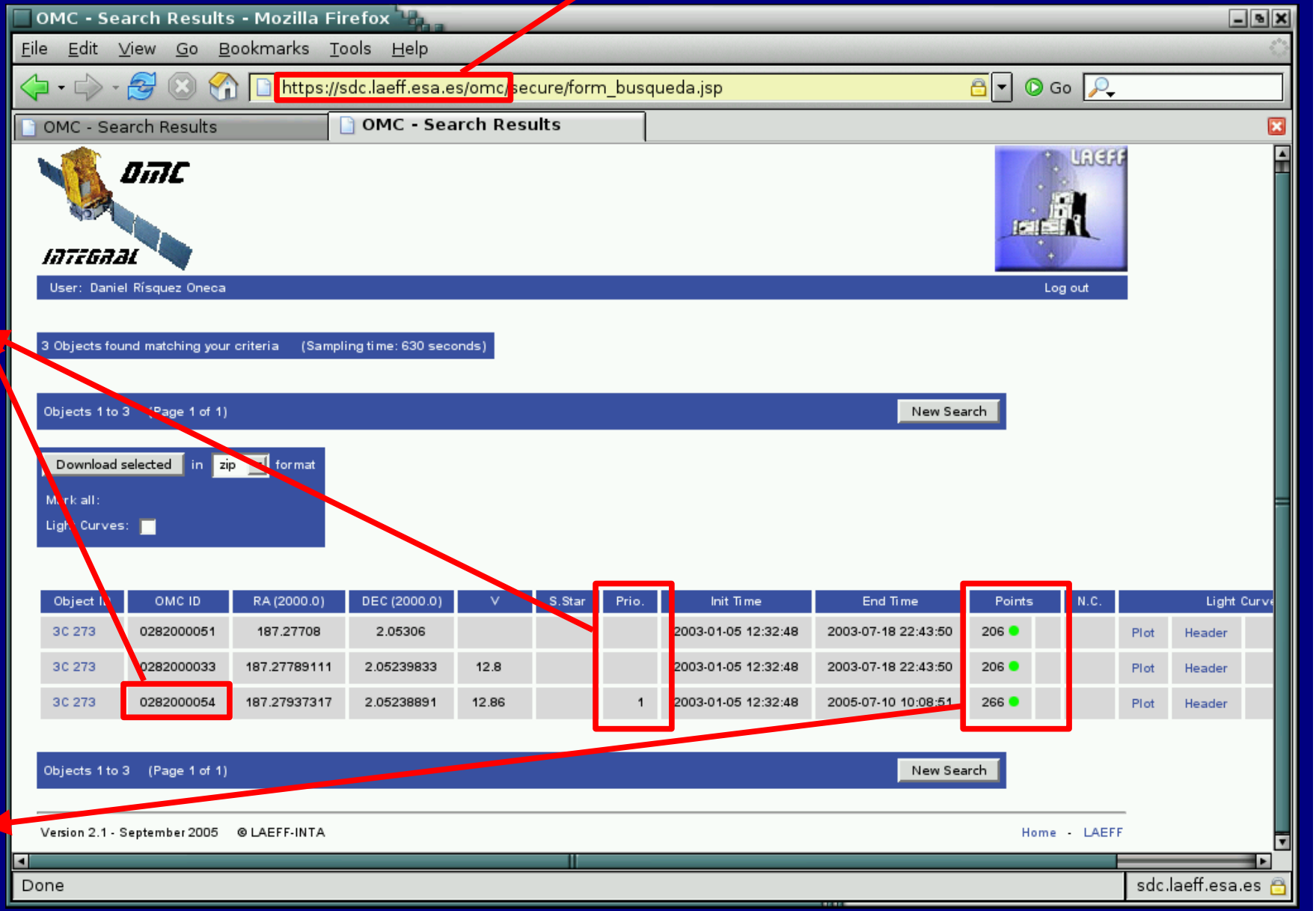
   Example: 3C 273 = IOMC 0282000054

OMC identifier

OMC web database

Choose the OMC ID with the lowest number in the priority column.

It should have the greatest number of observed points.

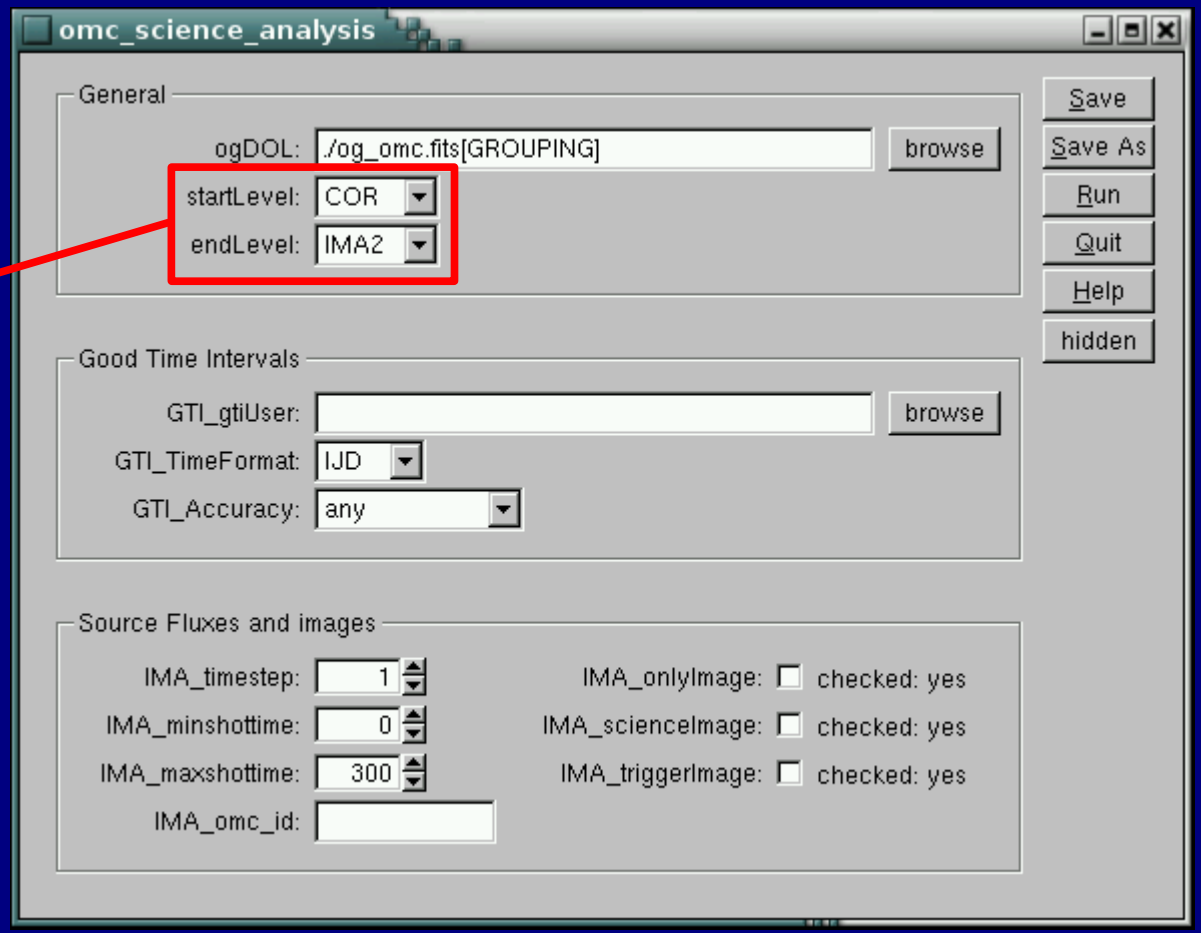


Executing the Offline Standard Analysis

omc_science_analysis

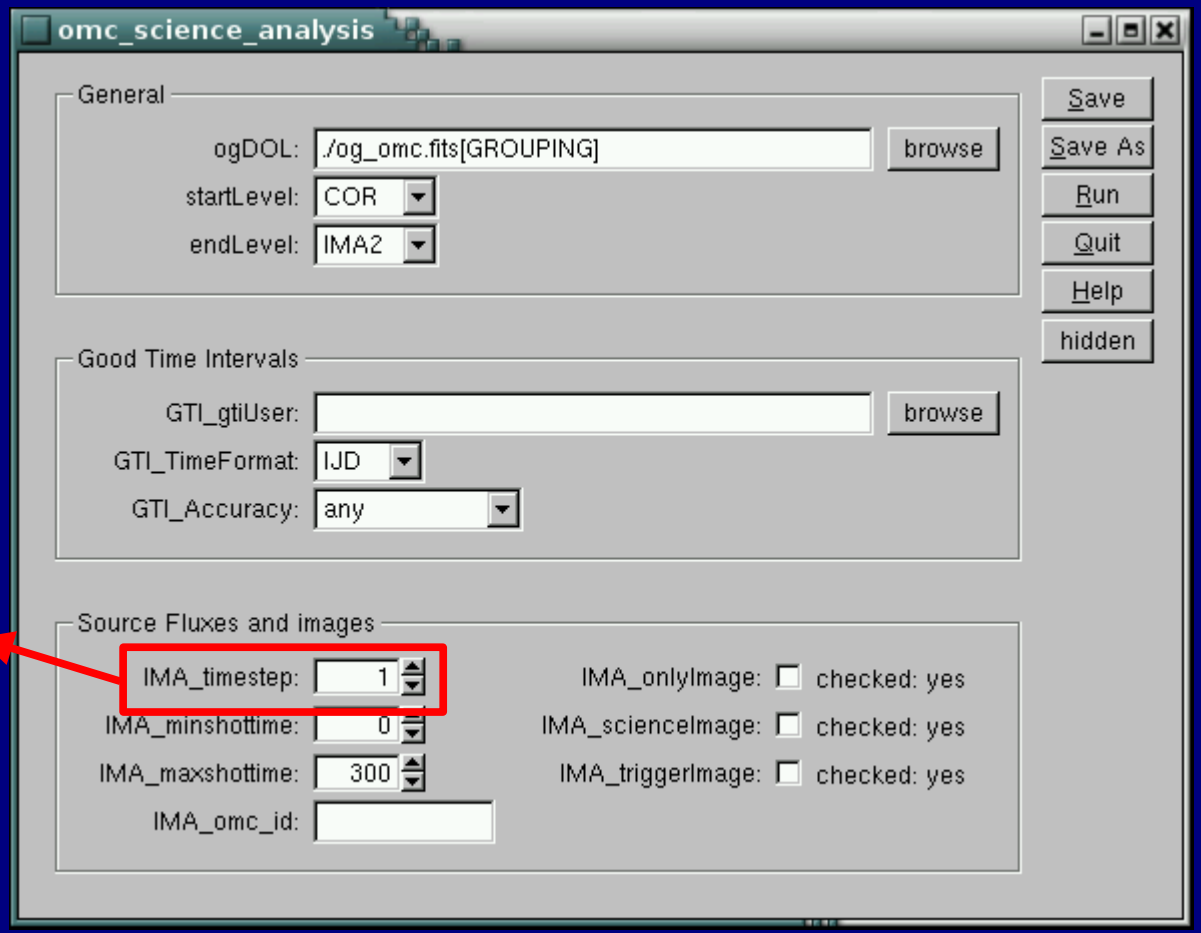
We will process 3C 273 as example.

- COR: standard optical CCD processing: BIAS, dark current, and flatfield.
- GTI: Good Time Intervals.
- IMA: Create fluxes and build images.
- IMA2: Collect data.



Executing the Offline Standard Analysis

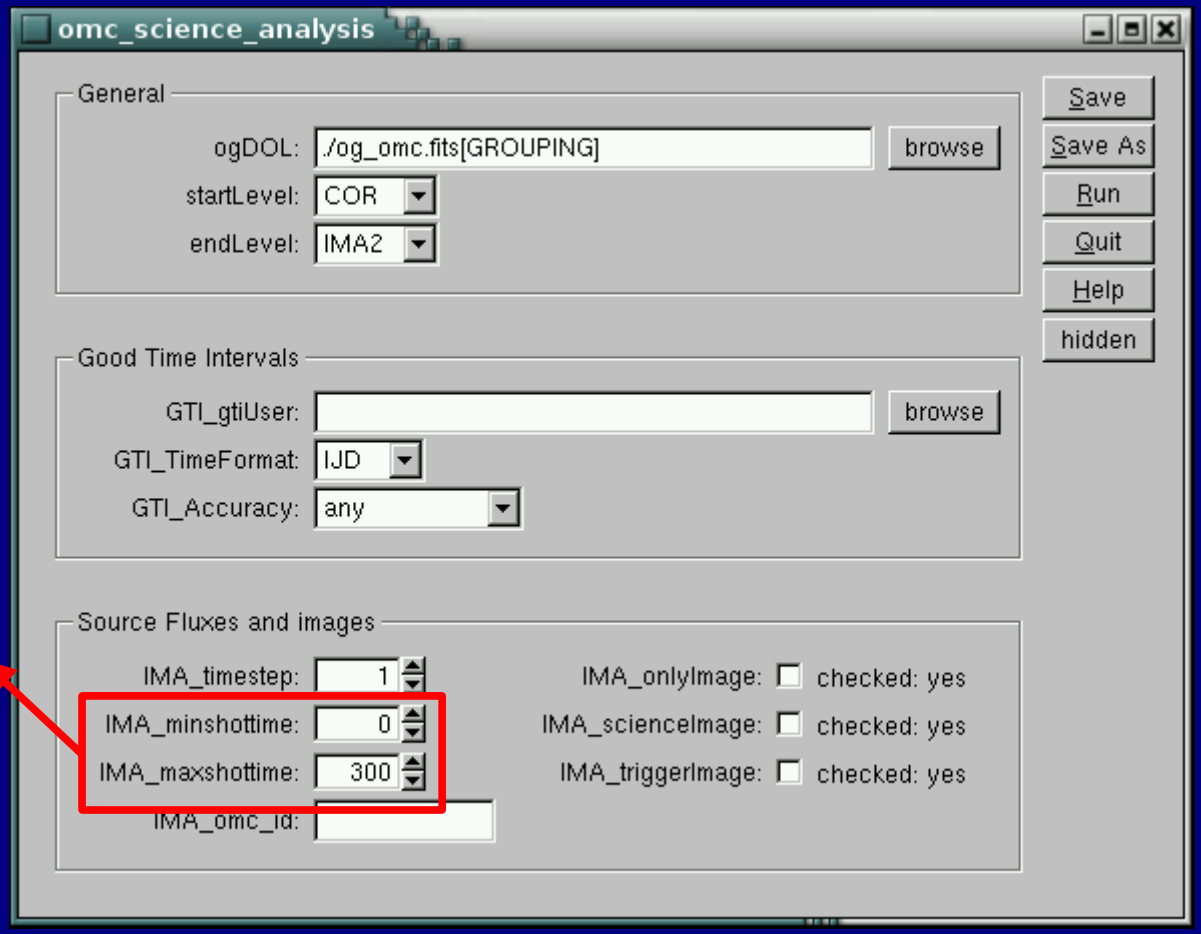
- You could combine shots up to *timestep* exposure in seconds. It increases the signal to noise ratio.
- The first time it is a good idea not to combine (**timestep=1**).
- Remember exposure cycles:
  - 10, 30 and 100 sec (until 2004/august).
  - 10, 50 and 200 sec (nowadays).
- Typical *timestep* values:
  - 1: do not combine. Process image by image.
  - 630 sec: the standard.
  - 9000 sec: combine all images in SCW (maximum).



Executing the Offline Standard Analysis

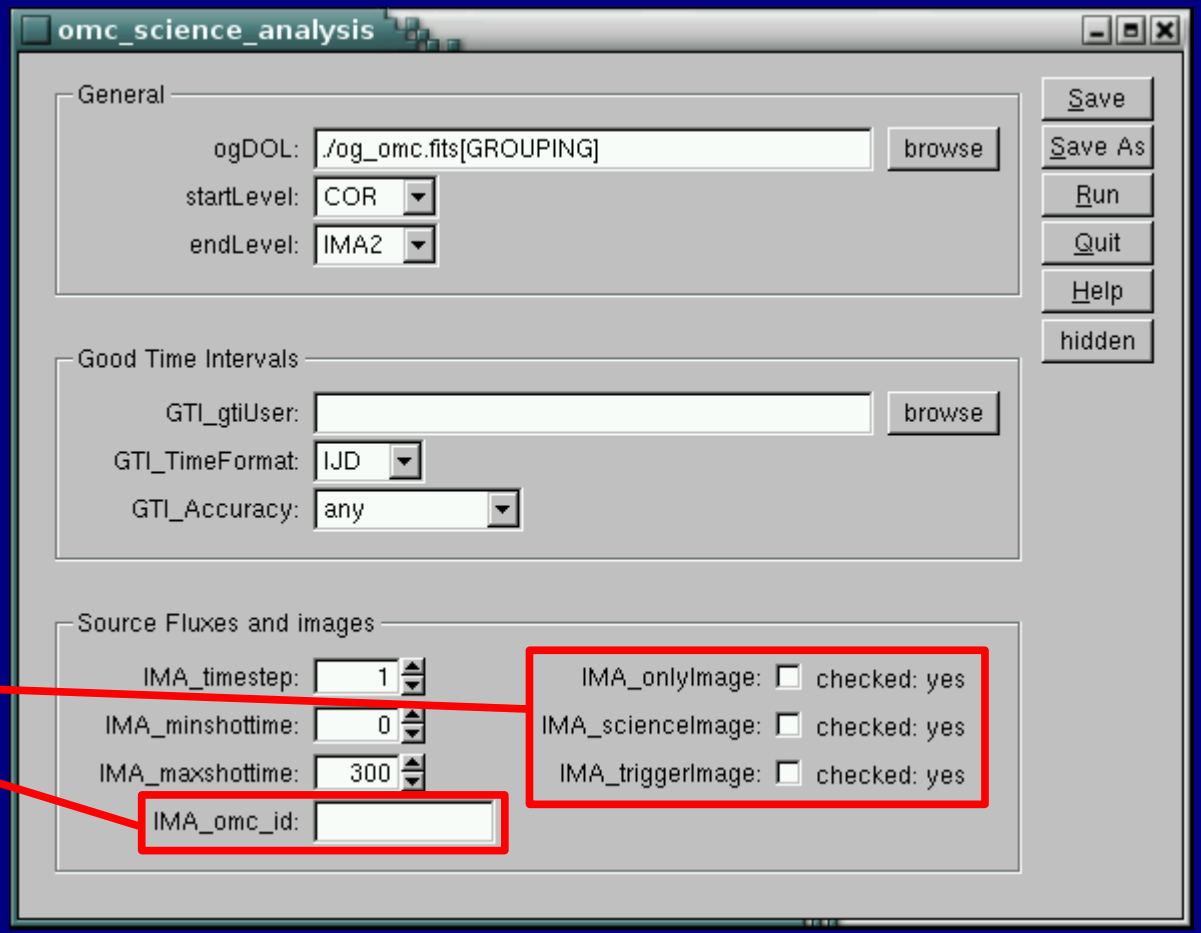
omc_science_analysis

- Process only shots with exposures between these values in seconds.
- These values process all shots (it is a good idea with timestep=1).
- Weak sources (V>12mag): Ignoring shorter shots (10, 30, even 50 sec) can increase the signal to noise ratio of the combined images.
- Bright sources (V<10mag): Long shots could saturate, ignore them.



Executing the Offline Standard Analysis

omc_science_analysis

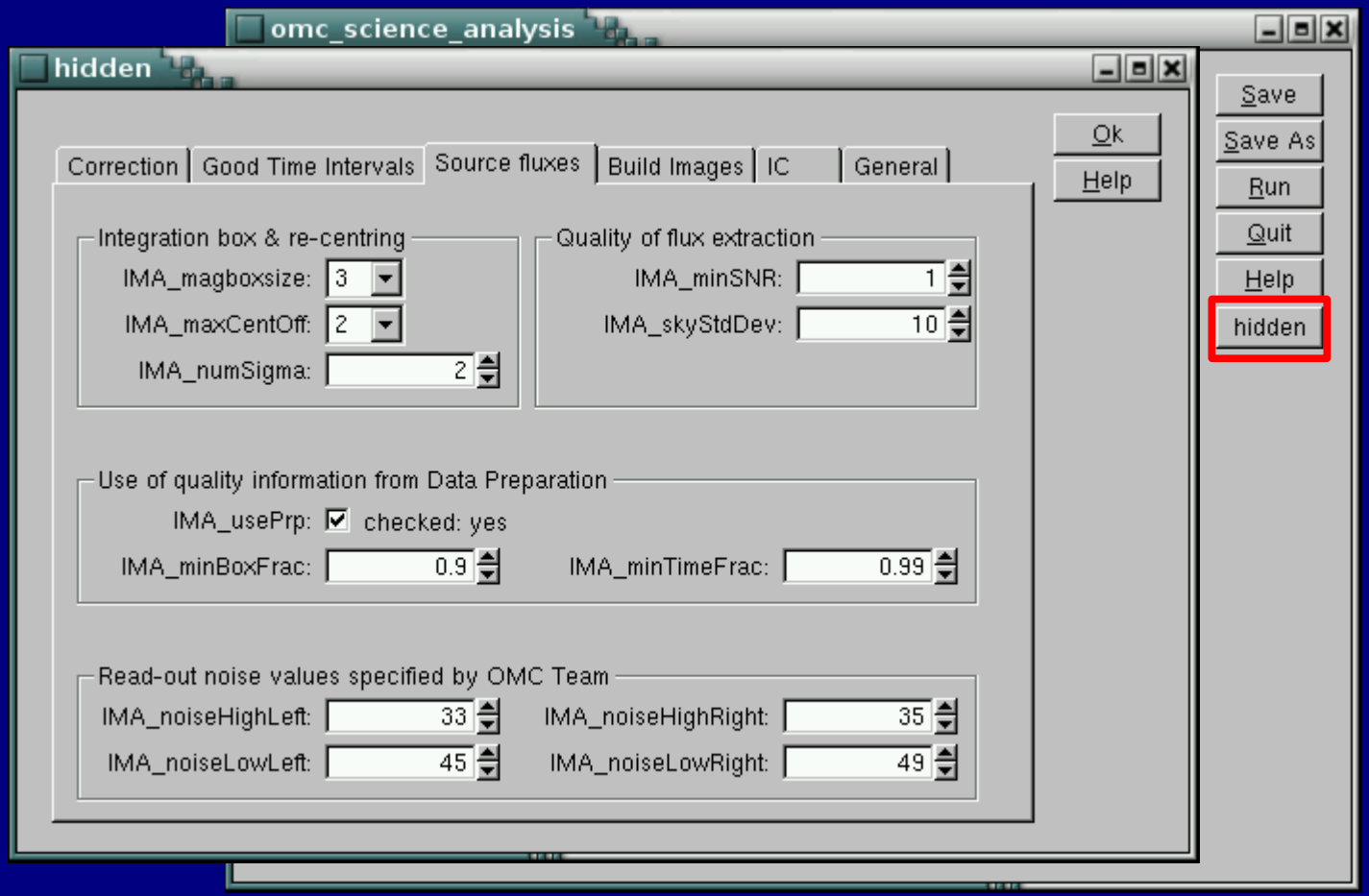


- Options for creating images.
- Uncheck them for light curves.

Executing the Offline Standard Analysis

omc_science_analysis

Hidden parameters have been chosen by the OMC team and should not be modified by a novel user.

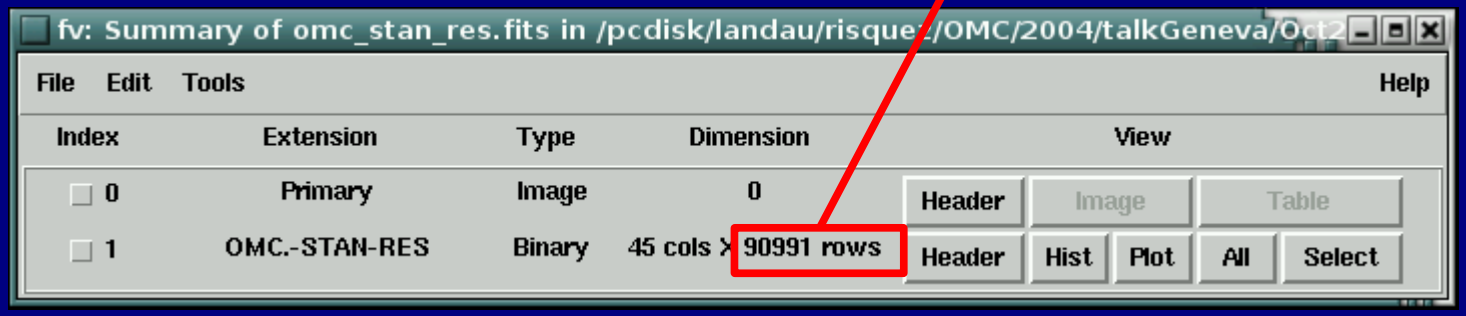


Understanding the results

fv omc_stan_res.fits

fv (Fits View) is a *ftool* utility

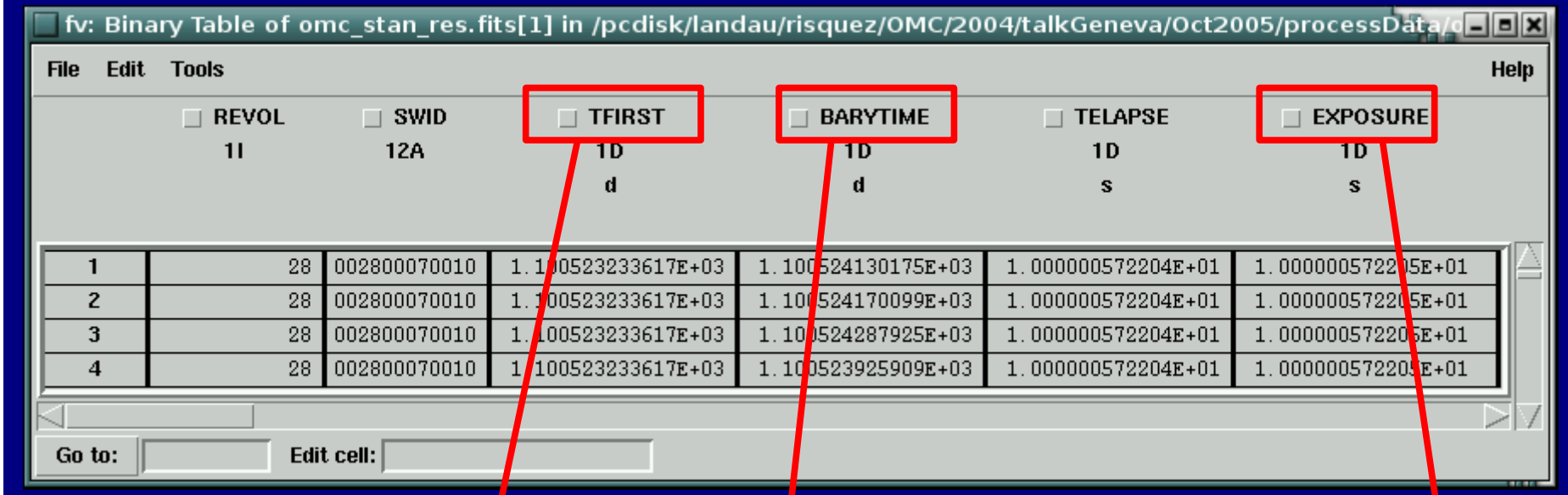
90991 photometric points



- 3C 273 results table. All photometric points in those SCWs are together in the same file:
  - Photometric stars (TYPE_TAR==1).
  - Our source, in this case 3C 273 (TYPE_TAR==2 and OMC_ID=='0282000054').
  - Other science sources (TYPE_TAR==2).

Understanding columns

fv omc_stan_res.fits



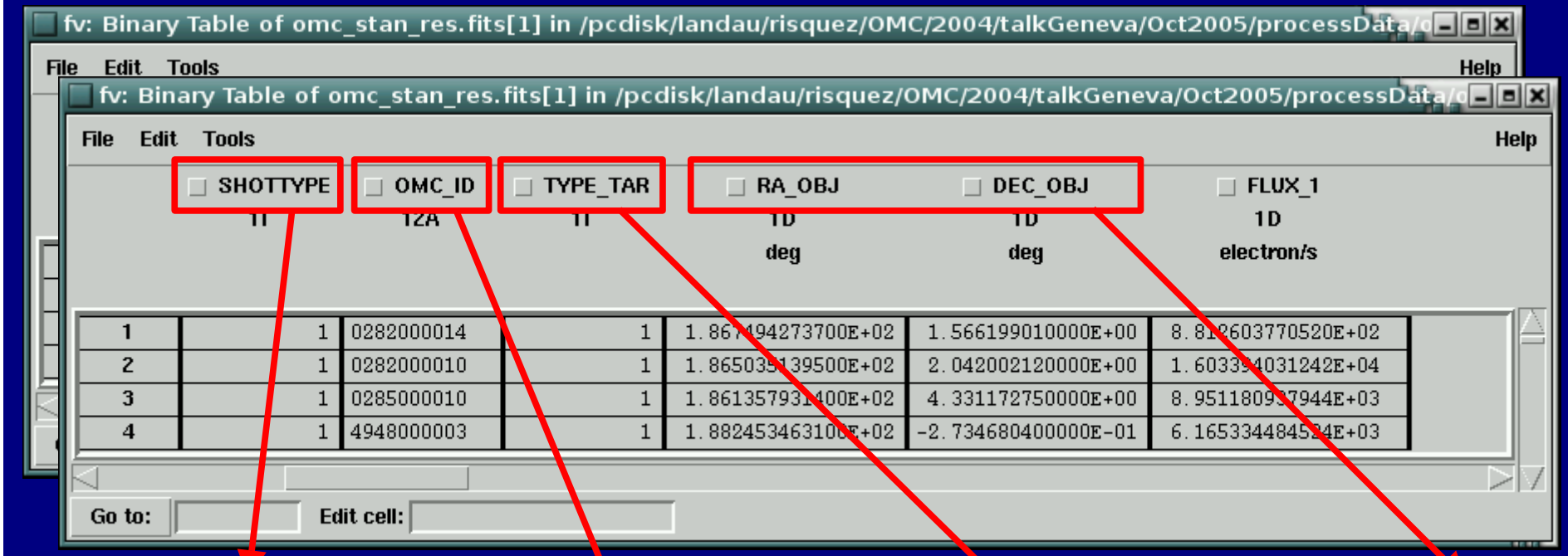
Time of the first data element in ISDC Julian days.

Barycentric time for the first data element in ISDC Julian days.

Effective integration time in seconds.

Understanding columns

fv omc_stan_res.fits



Shot:
1: Photometric
2: Science

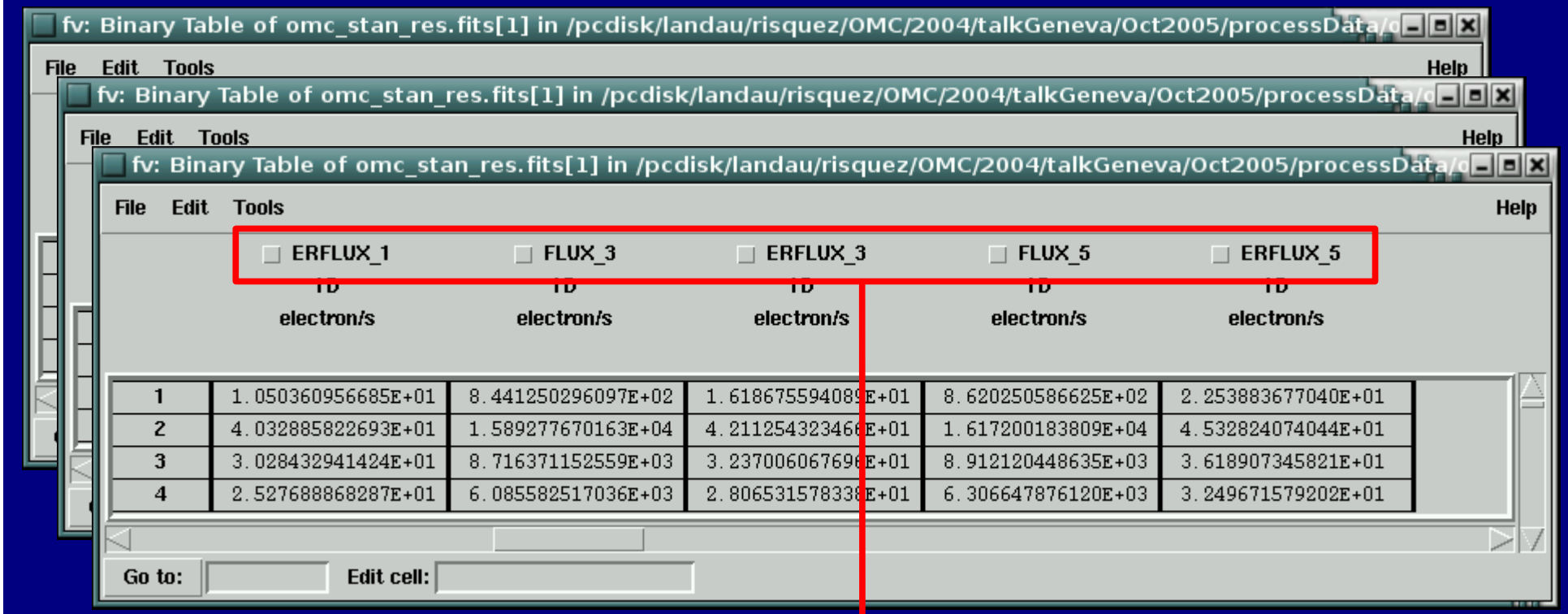
OMC identifier.
9888000001 is the first observer source.
9888000002 the second one, and so on.

Source:
1: Photometric
2: Science

Coordinates from the Input Catalogue.

Understanding columns

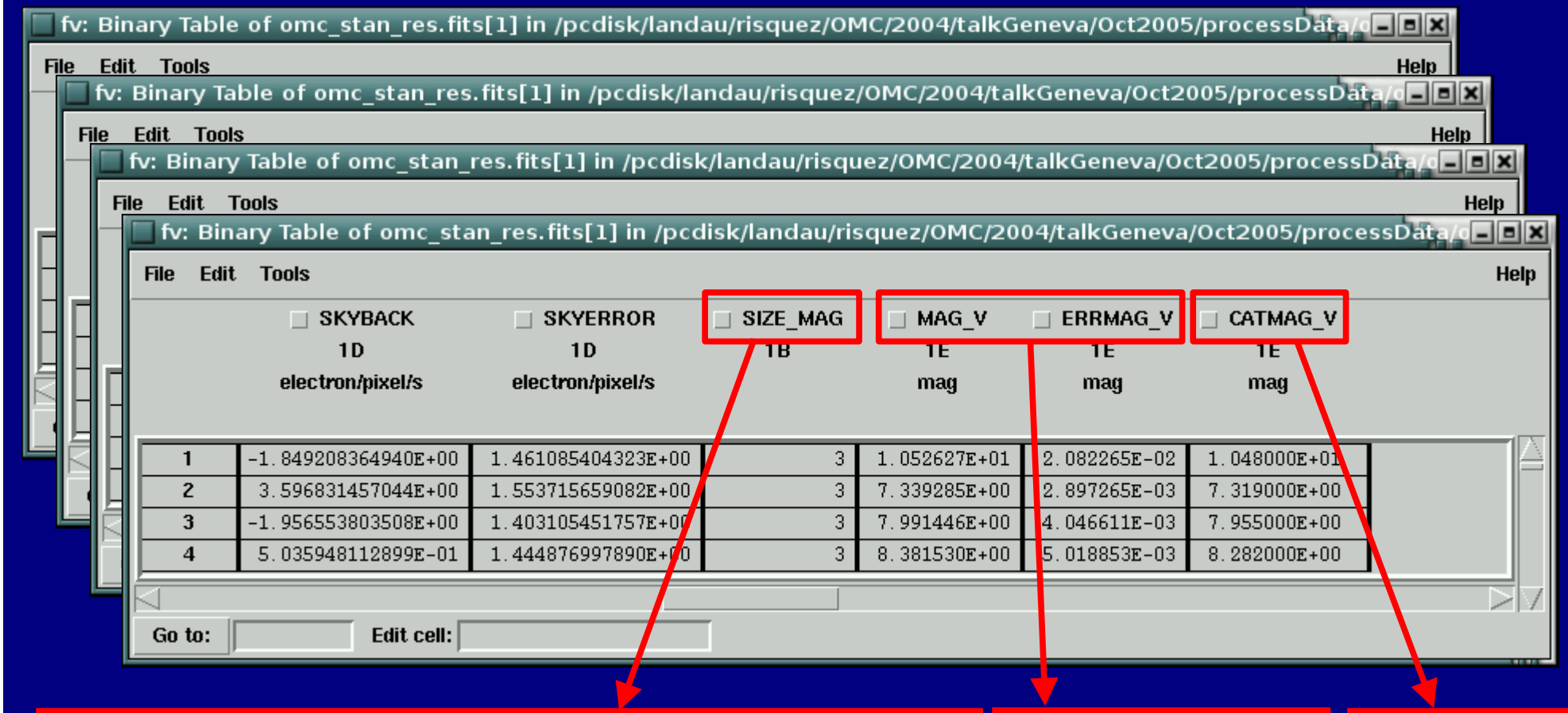
fv omc_stan_res.fits



Fluxes and errors calculated in 3 different aperture diameters (1, 3 and 5 pixels). **The analysis software assumes in all cases point sources**.

Understanding columns

fv omc_stan_res.fits



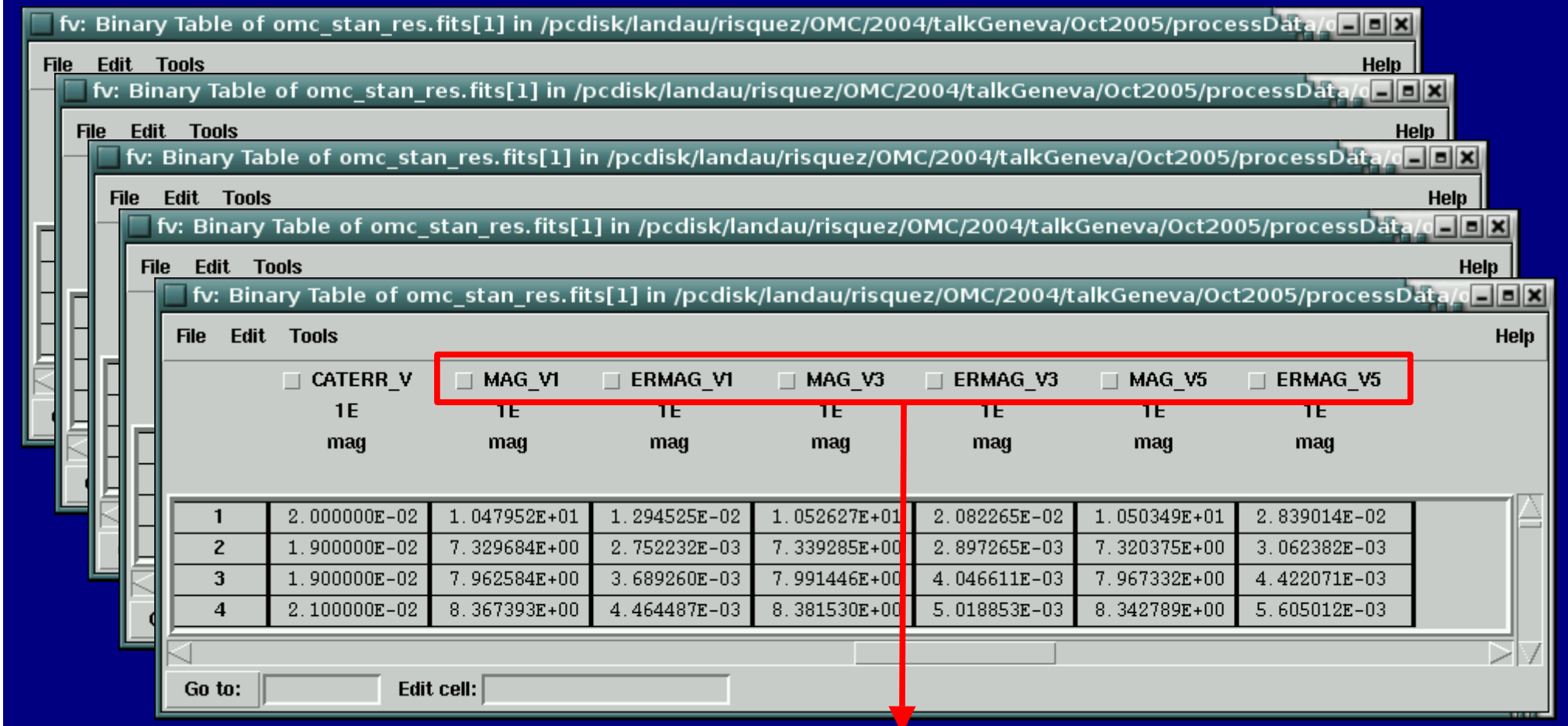
MAG_V is calculated with this aperture diameter in pixels. It is the hidden parameter IMA_magboxsize in *omc_science_analysis*.

Default calculated magnitude.

Magnitude from the Input Catalogue.

Understanding columns

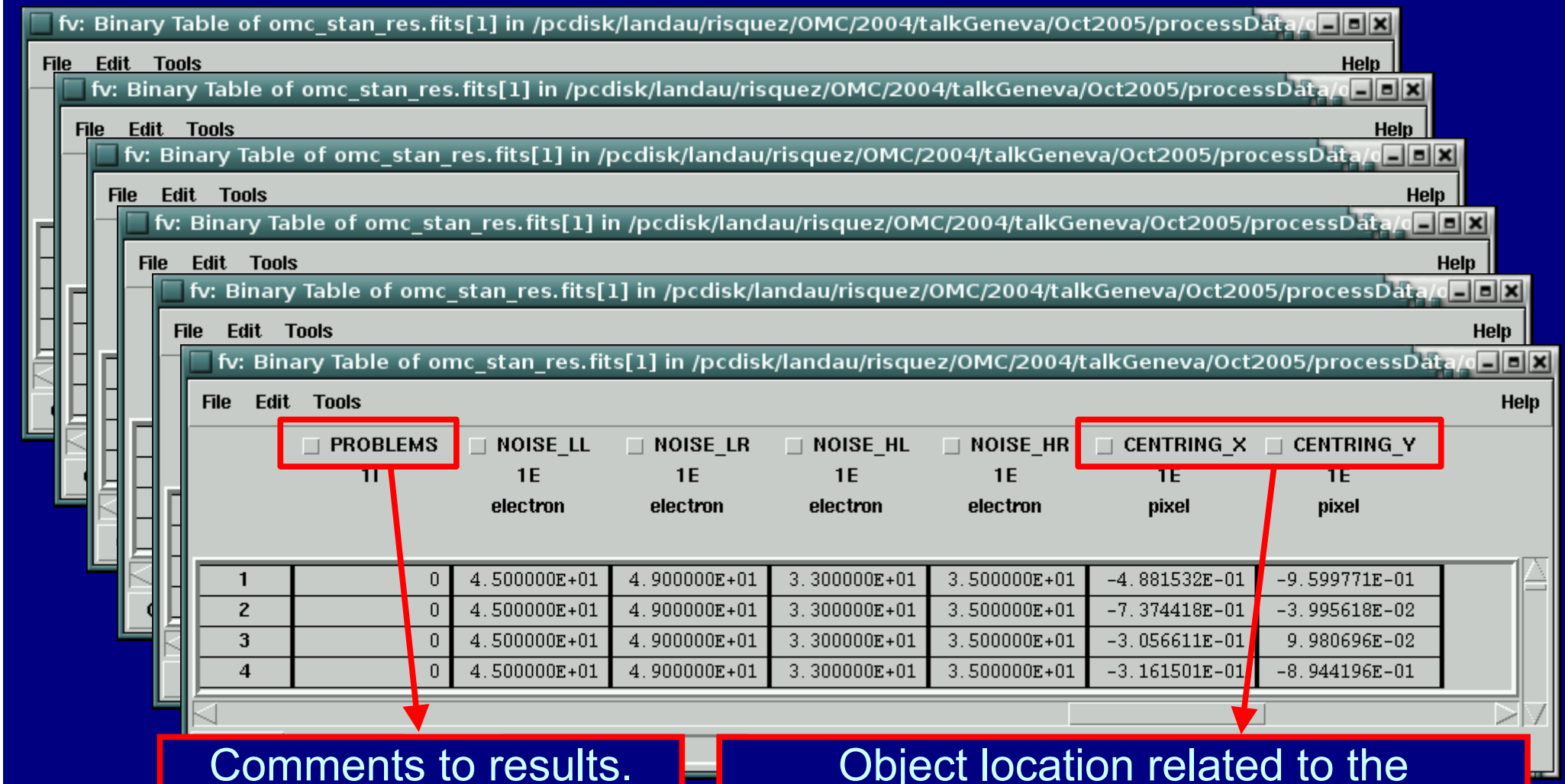
fv omc_stan_res.fits



Magnitudes calculated with each aperture diameter.
In this case, MAG_V=MAG_V3 (because SIZE_MAG=3)

Understanding columns

fv omc_stan_res.fits

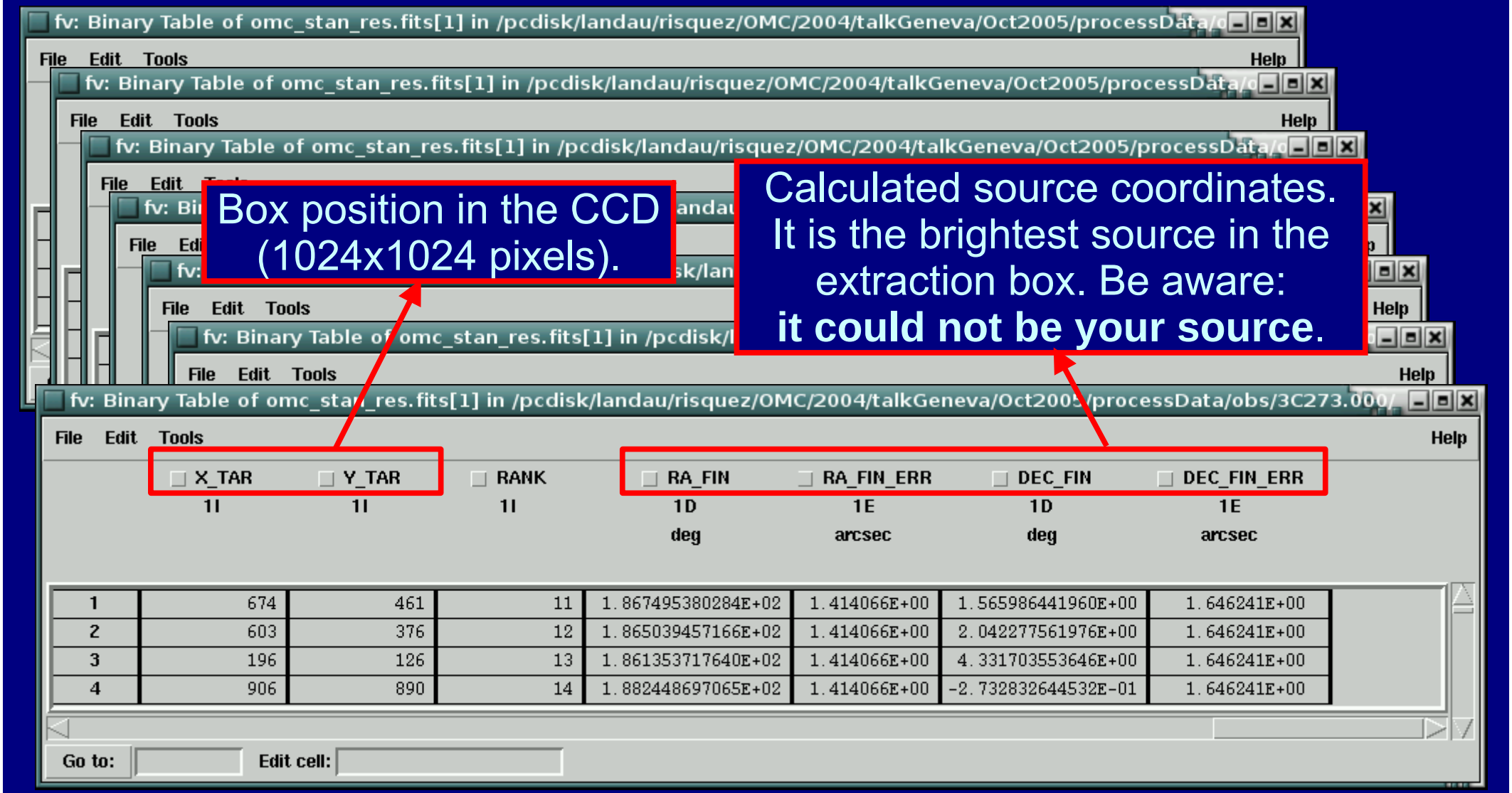


Comments to results. Smaller values are better.

Object location related to the centre of central pixel in the subwindow.

Understanding columns

fv omc_stan_res.fits



Select source

- Now, we have the file with all photometric results in the observation group.
- You must select your data from the file.
  - By OMC_ID:

fcopy “omc_stan_res[OMC_ID=='0282000054']” 3C273.fits

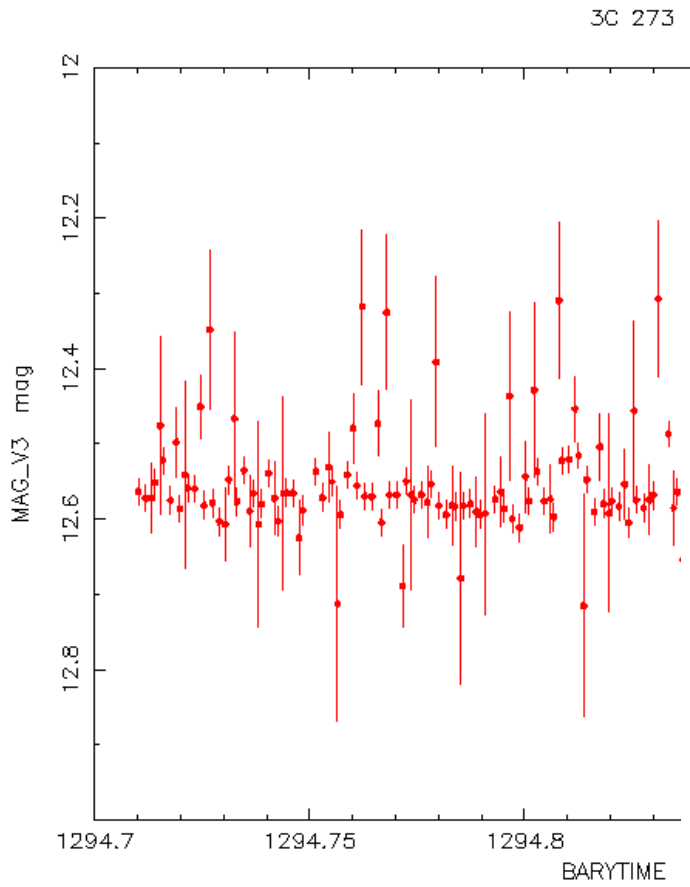
  - By coordinates:

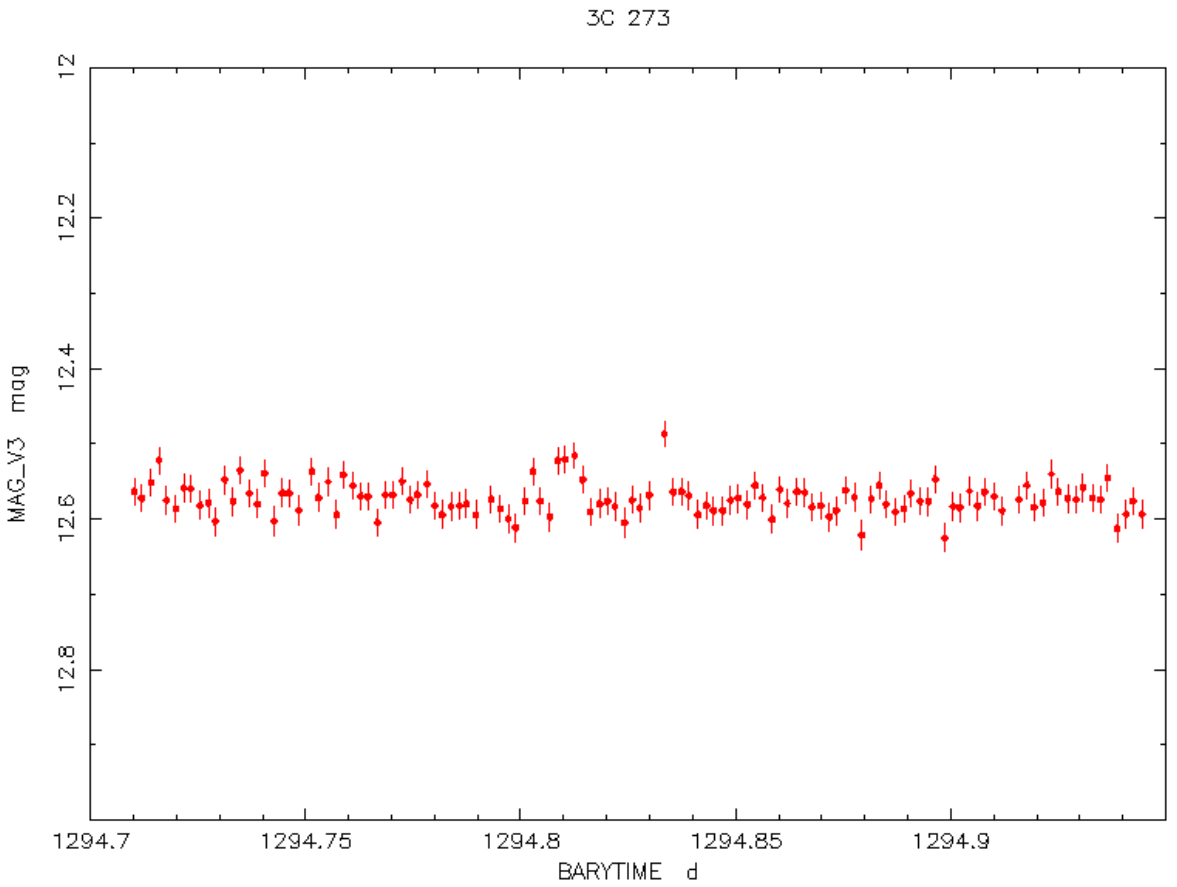
fcopy “omc_stan_res[RA_OBJ>187.277&&RA_OBJ<187.278&&DEC_OBJ>2.052&&DEC_OBJ<2.053]” 3C273.fits

Some arcsecs around the Input Catalogue coordinates.

Understanding the results

MAG_V3





Use long exposures (100 seconds in this case) for weak sources.

MAG_V3, EXPOSURE>60

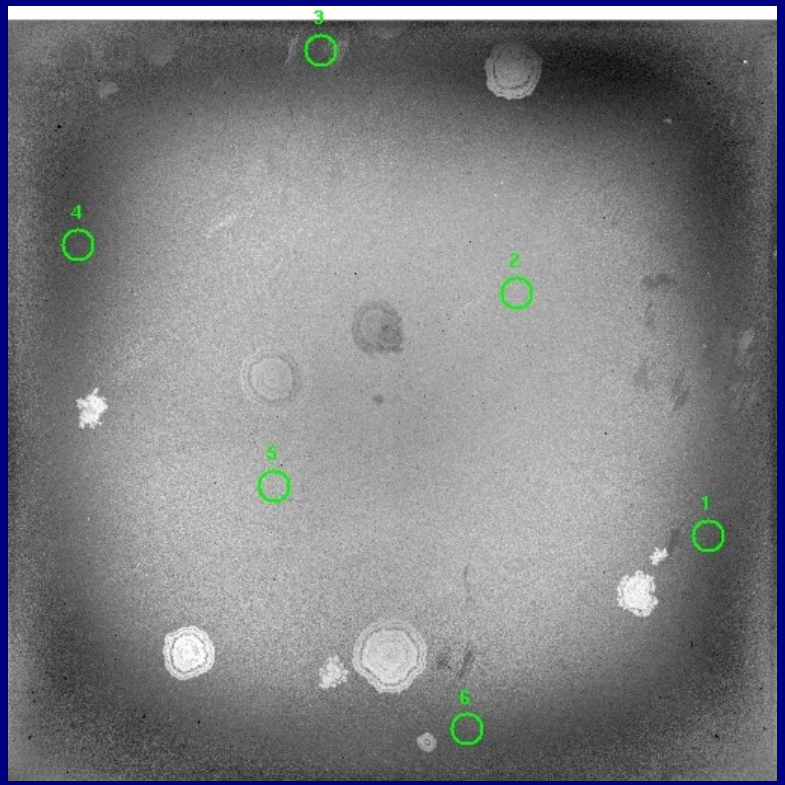
Caveats

- **Dithering**. Check X_TAR and Y_TAR.
- **Saturations**. Check your expected magnitude. Check magnitude versus EXPOSURE.
- **Contaminated flux**. Check images, you could have a close companion. Flux contaminations from other sources may include systematic effects. Check centroid coordinates.
- **Global CCD sensitivity**. At the beginning of the mission, the CCD sensitivity changed quickly. Check photometric stars.
- **Centring in a close source**. The magnitude could be calculated for the other source! Check RA_FIN and DEC_FIN.
- **Cosmic rays and readout noise**. Check images. They do not have a gaussian profile.

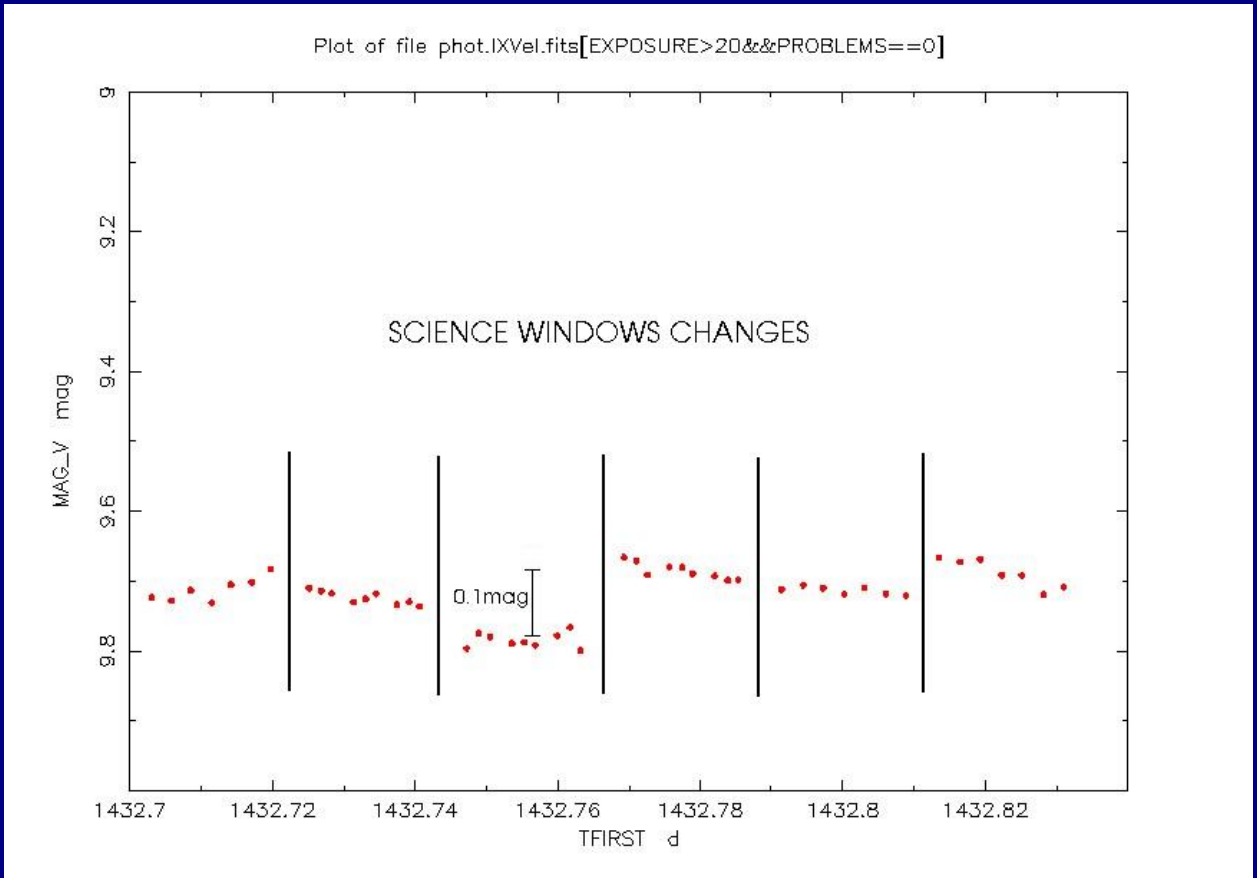
Caveats: dithering

- Sometimes you can have small offsets (up to 0.1 mag) due to the dithering pattern. This can be identified easily because it is constant for the full SCW.

IX Vel. Green circles: X_TAR and Y_TAR in SCW. Flatfield at background.

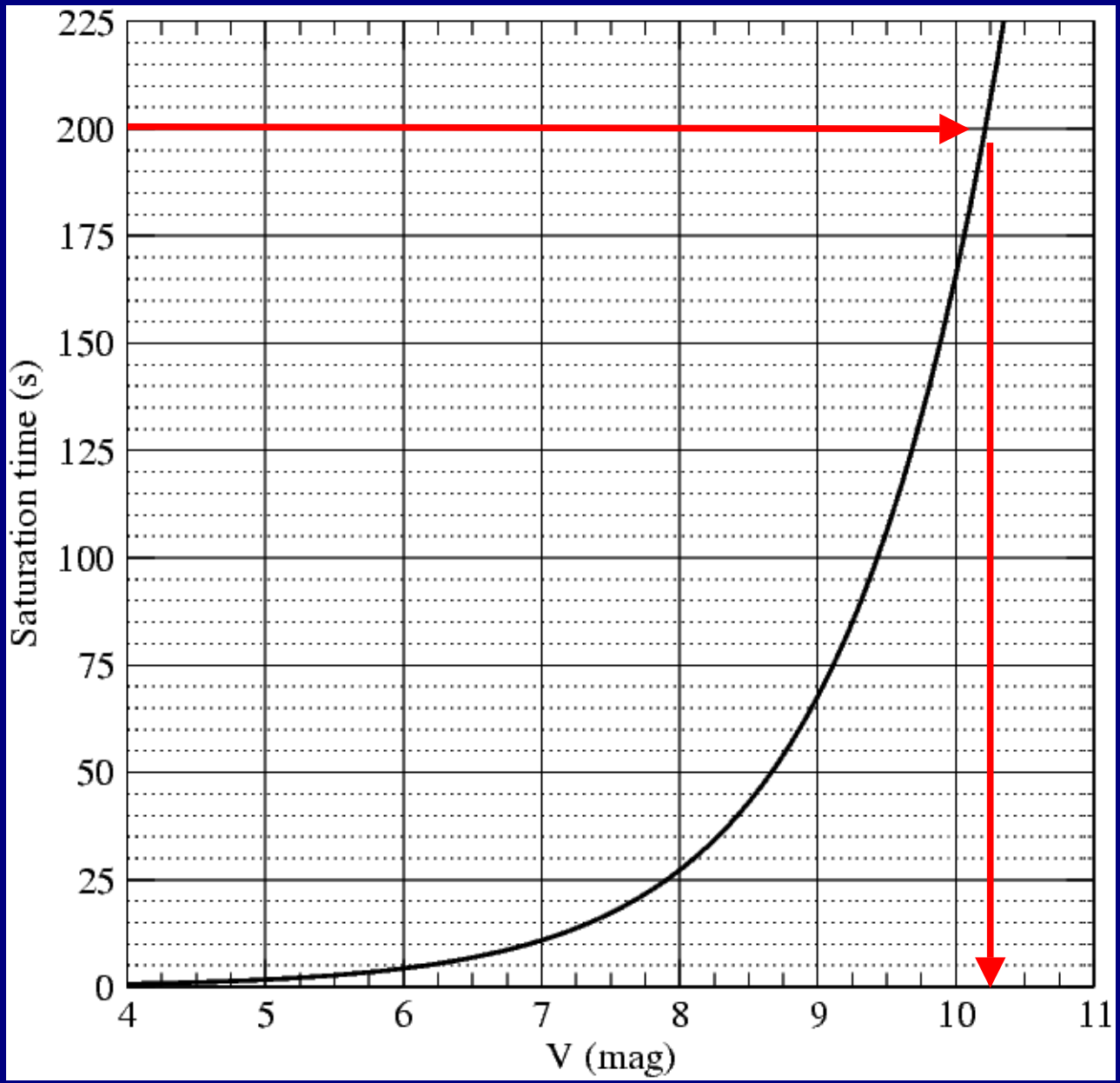


IX Vel. Black lines mark SCW changes.

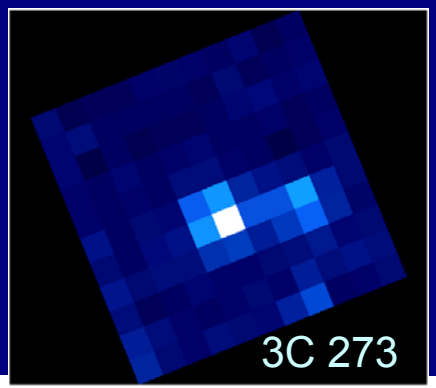


Caveats: saturations

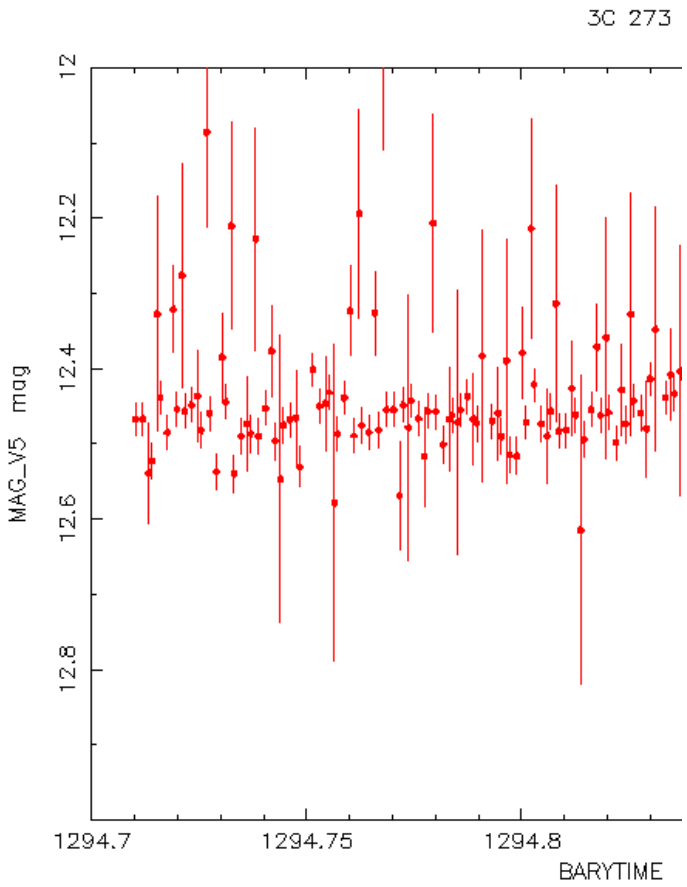
- Saturation curve (see User Manual).
- 200 seconds is the longest exposure. It saturates sources with V≈10.2 mag.
- 3C 273 has V≈12.8 mag, then **it will never saturate**.



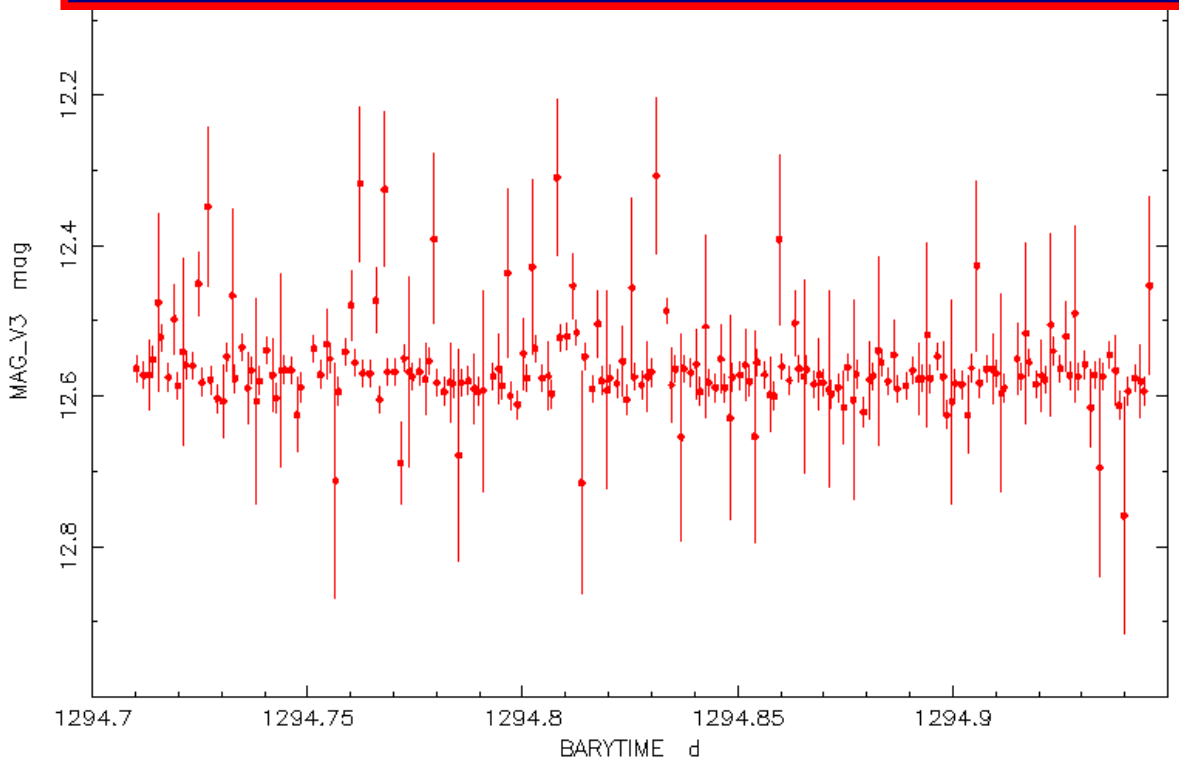
Caveats: contamination



MAG_V5



Note the lower noise (less pixels in aperture) and the lower flux (less contamination) in MAG_V3.

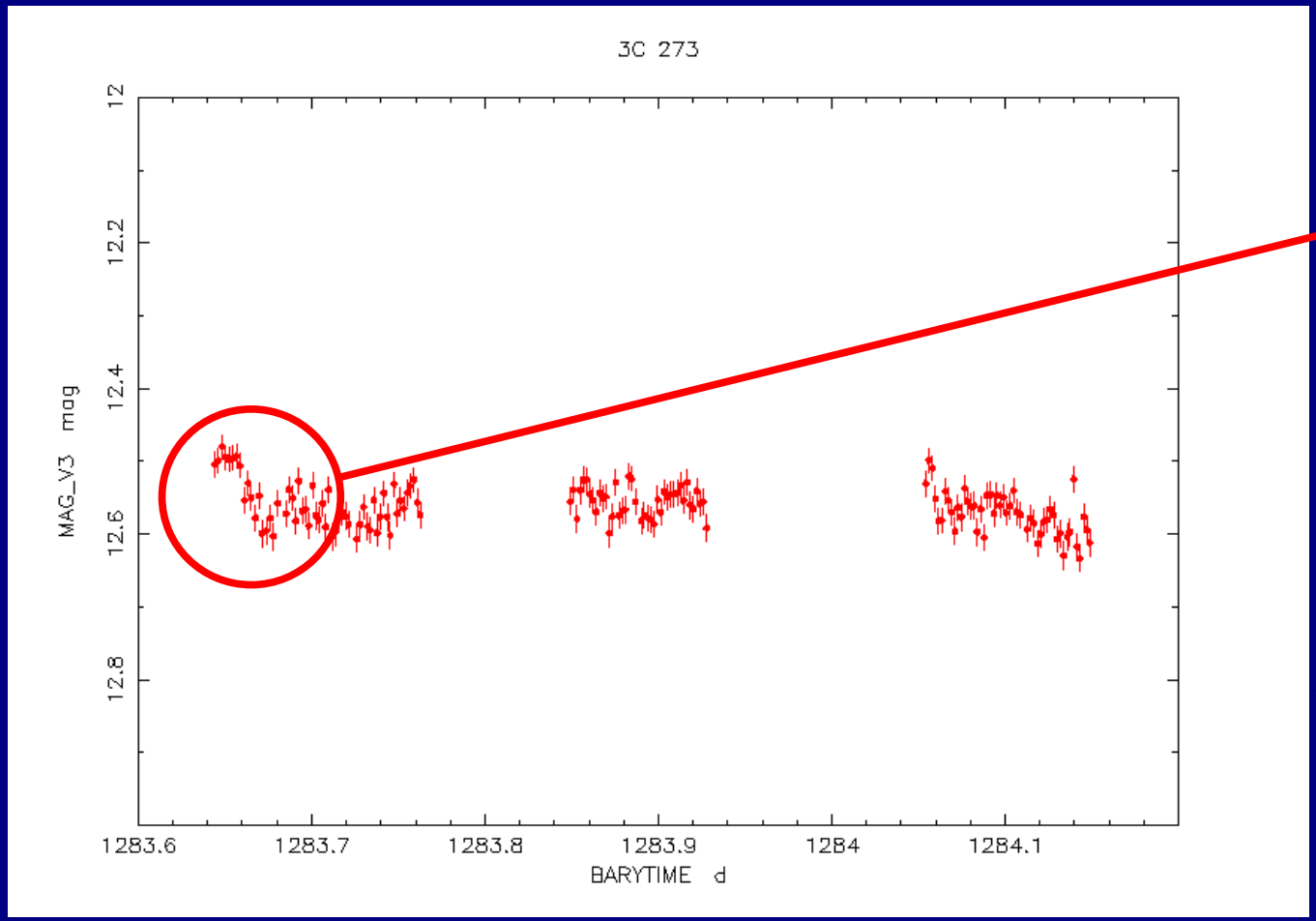


MAG_V3

- Standard analysis process always 1, 3, and 5 pixels aperture diameters.
- Choose MAG_V5 for bright and isolated sources, MAG_V3 for weak or contaminated sources.
- Remember: <FWHM>≈1.3pix

Caveats: check photometric stars

MAG_V3, EXPOSURE>60

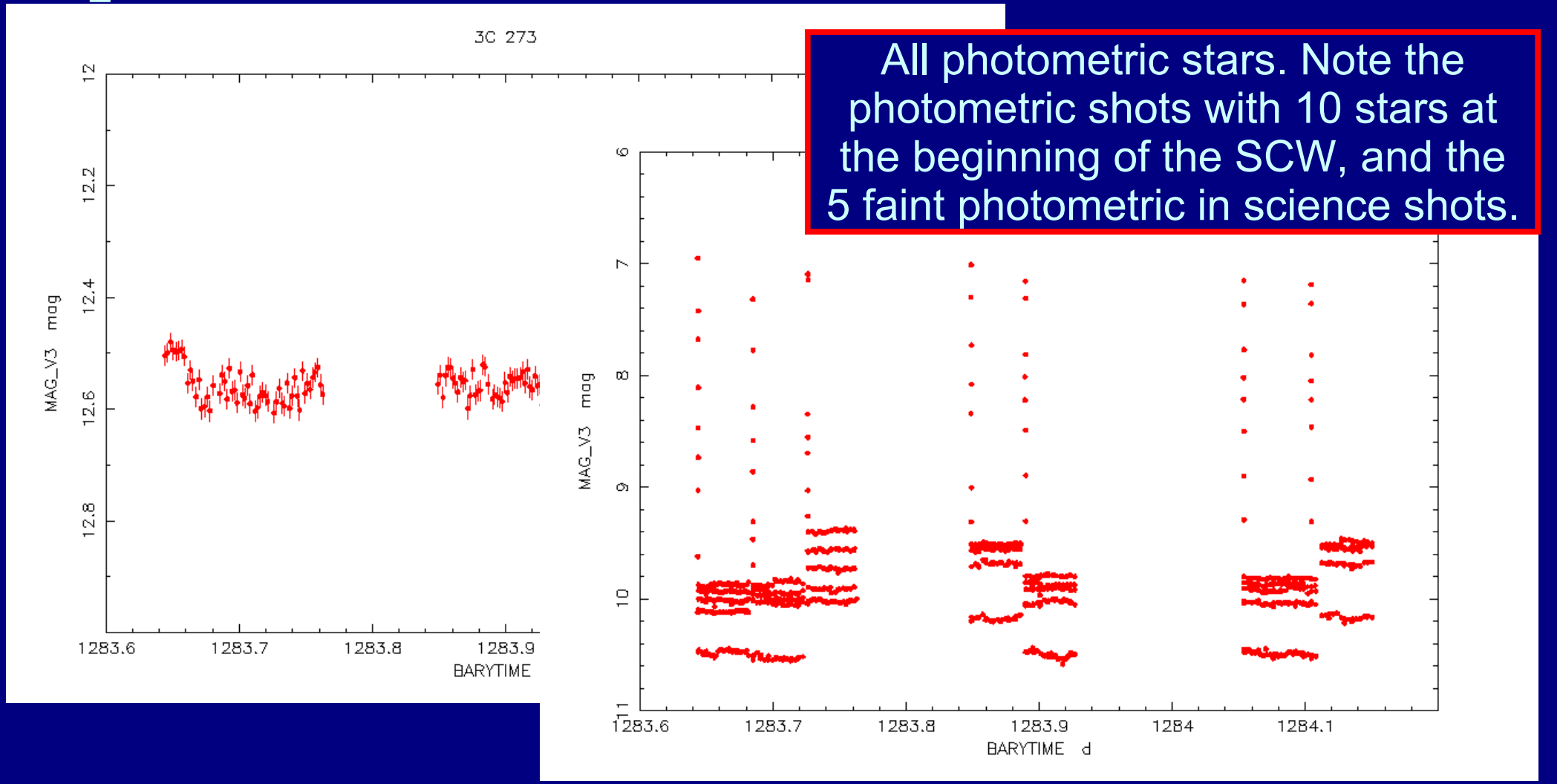


Is this 0.1 magnitude variation real?

You could find CCD sensitivity changes in first revolutions.

Caveats: check photometric stars

MAG_V3, EXPOSURE>60

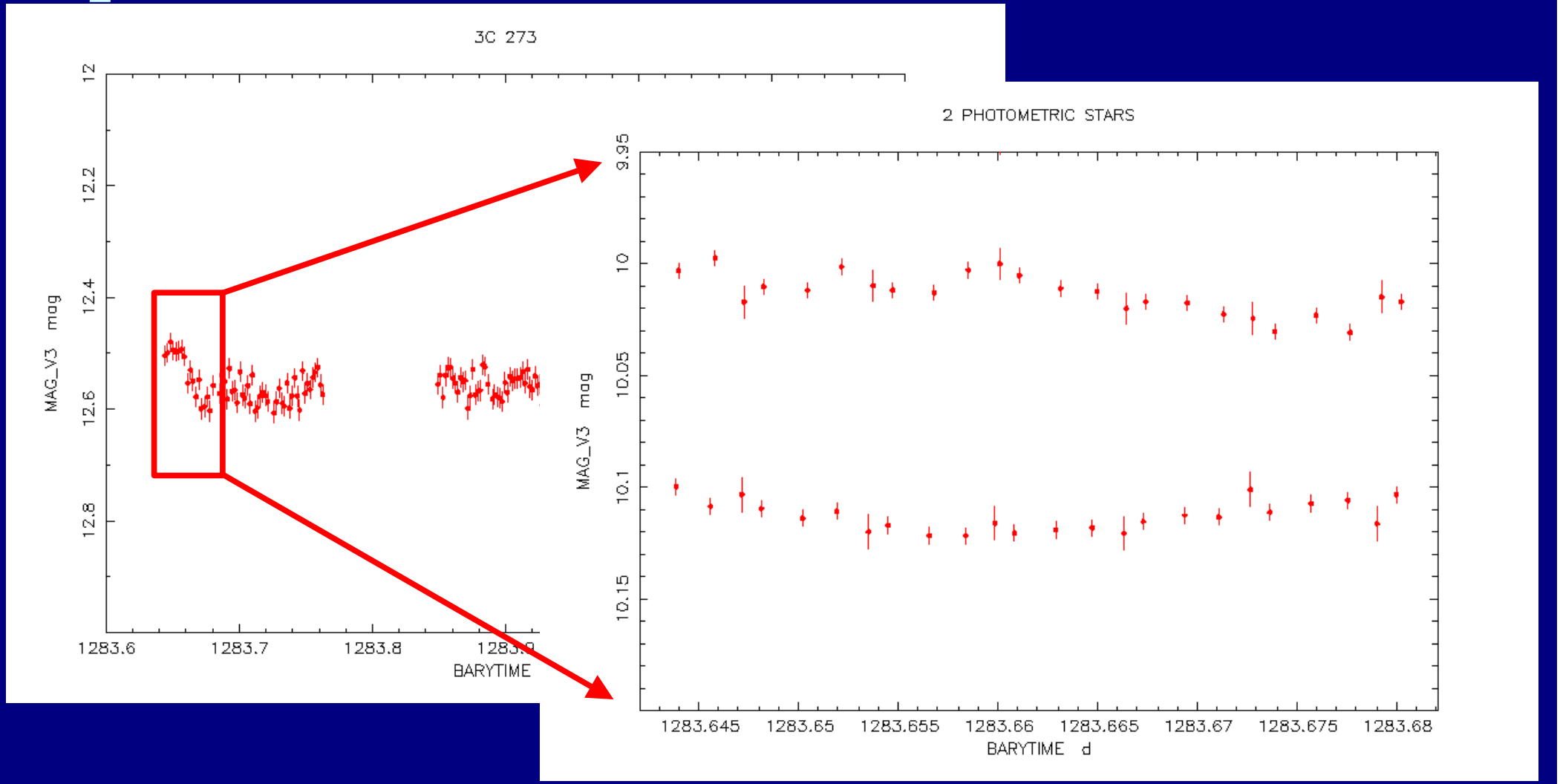


All photometric stars. Note the photometric shots with 10 stars at the beginning of the SCW, and the 5 faint photometric in science shots.

TYPE_TAR==1

Caveats: check photometric stars

MAG_V3, EXPOSURE>60

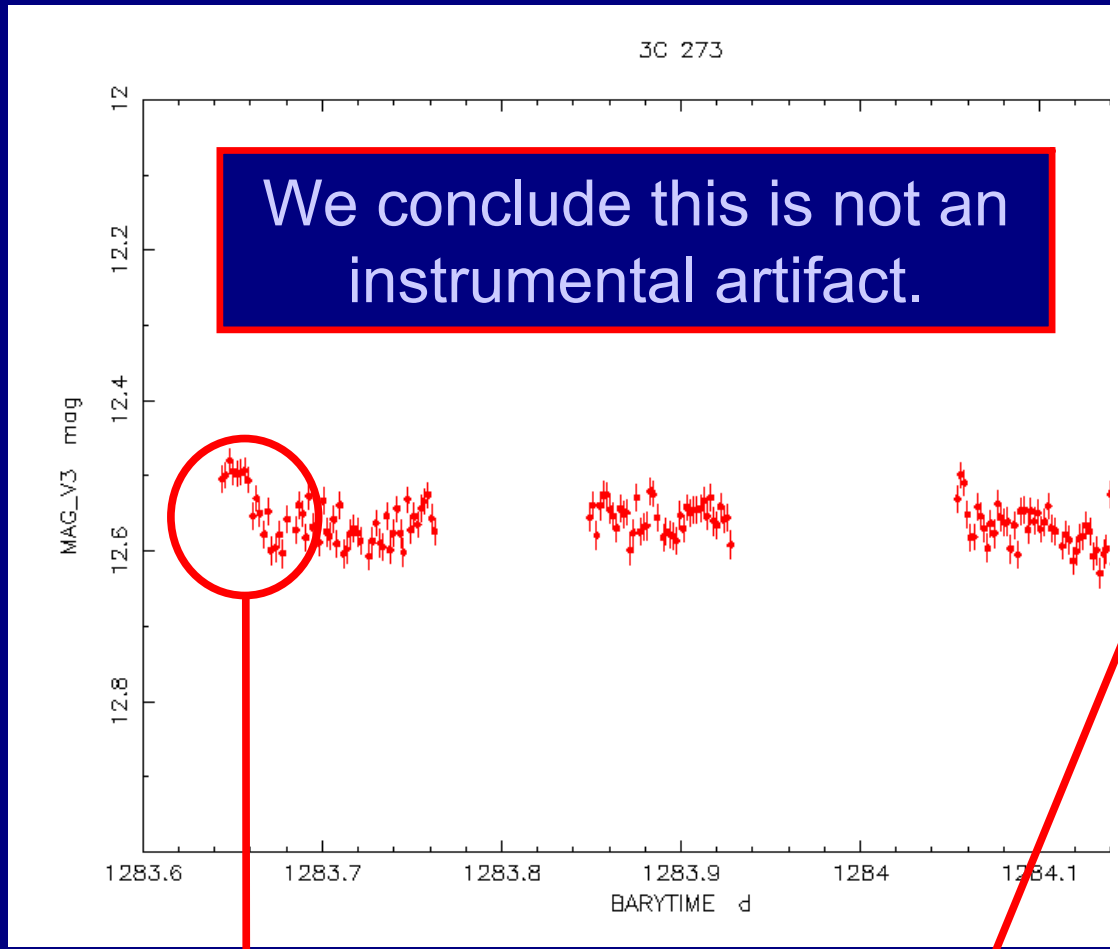


Zoom to 2 photometric stars in the same time scale.
Their variations are smaller than 0.1 magnitude.

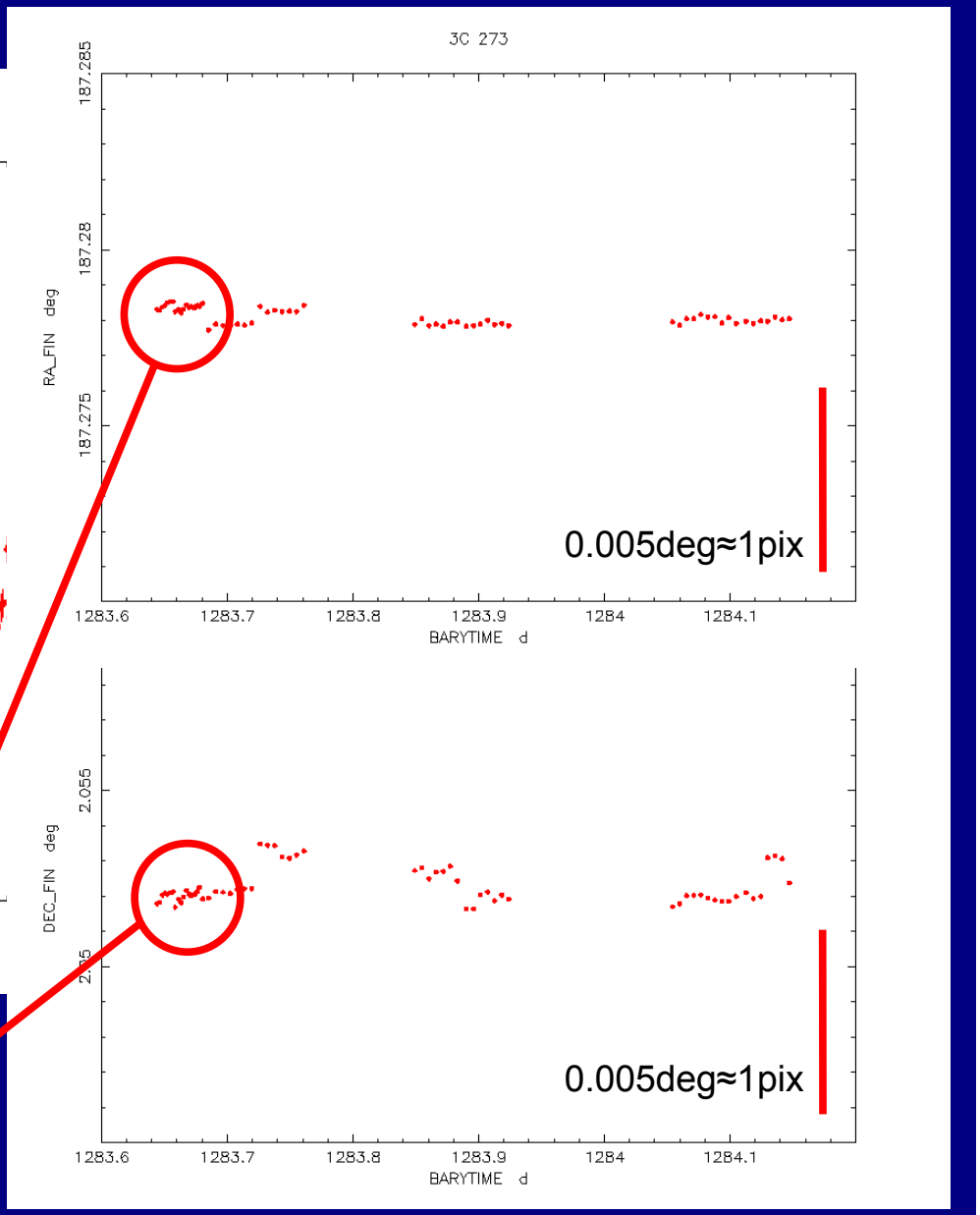
TYPE_TAR==1, ZOOM

Caveats: bad centring

MAG_V3, EXPOSURE>60



We conclude this is not an instrumental artifact.



RA_FIN and DEC_FIN are constant.

Caveats: PROBLEMS column

fv: Binary Table of omc_stan_res.fits[1] in /pcdisk/landau/risquez/OMC/2004/talkGeneva/Oct2005/processData/c

File Edit Tools Help

	PROBLEMS 1I	NOISE_LL 1E electron	NOISE_LR 1E electron	NOISE_HL 1E electron	NOISE_HR 1E electron	CENTRING_X 1E pixel	CENTRING_Y 1E pixel
1	0	4.500000E+01	4.900000E+01	3.300000E+01	3.500000E+01	-4.881532E-01	-9.599771E-01
2	0	4.500000E+01	4.900000E+01	3.300000E+01	3.500000E+01	-7.374418E-01	-3.995618E-02
3	0	4.500000E+01	4.900000E+01	3.300000E+01	3.500000E+01	-3.056611E-01	9.980696E-02
4	0	4.500000E+01	4.900000E+01	3.300000E+01	3.500000E+01	-3.161501E-01	-8.944196E-01

Go to: Edit cell:

Remember: Lower values are better.

Terminal

```
        Name                          Value       Meaning
-------------------------------------------------------------------------
OMC_PROBLEM_NONE                        0         No problems

OMC_PROBLEM_EXTRAPOLATED_MAG            2  (2^1)  The mag was extrapolated
OMC_PROBLEM_BAD_CENTROID                4  (2^2)  No centroid is available or is inaccurate
OMC_PROBLEM_BAD_PSF                     8  (2^3)  Bad PSF. A default value was used
OMC_PROBLEM_ANOMALOUS_PSF              16  (2^4)  The PSF shape is anomalous
OMC_PROBLEM_LOW_FLUX_1                 32  (2^5)  Flux of central pixel too low

OMC_PROBLEM_BADPIXEL_SKY              128  (2^7)  Bad pixel found in sky bgnd
OMC_PROBLEM_BADPIXEL_RIM_5            256  (2^8)  Bad pixel found in 5x5 rim
OMC_PROBLEM_BADPIXEL_RIM_3            512  (2^9)  Bad pixel found in 3x3 rim
OMC_PROBLEM_BADPIXEL_RIM_1           1024  (2^10) Central pixel bad

OMC_PROBLEM_SKY_ERROR                4096  (2^12) Sky error larger that accepted limit
OMC_PROBLEM_UNKNOWN_MAG              8192  (2^13) Magnitude could not be calculated
OMC_PROBLEM_EXTND_SRC               16384  (2^14) Source is extended - flux not valid
landau:obs/3C273.000 151 >
```

o_src_get_fluxes --help

Images

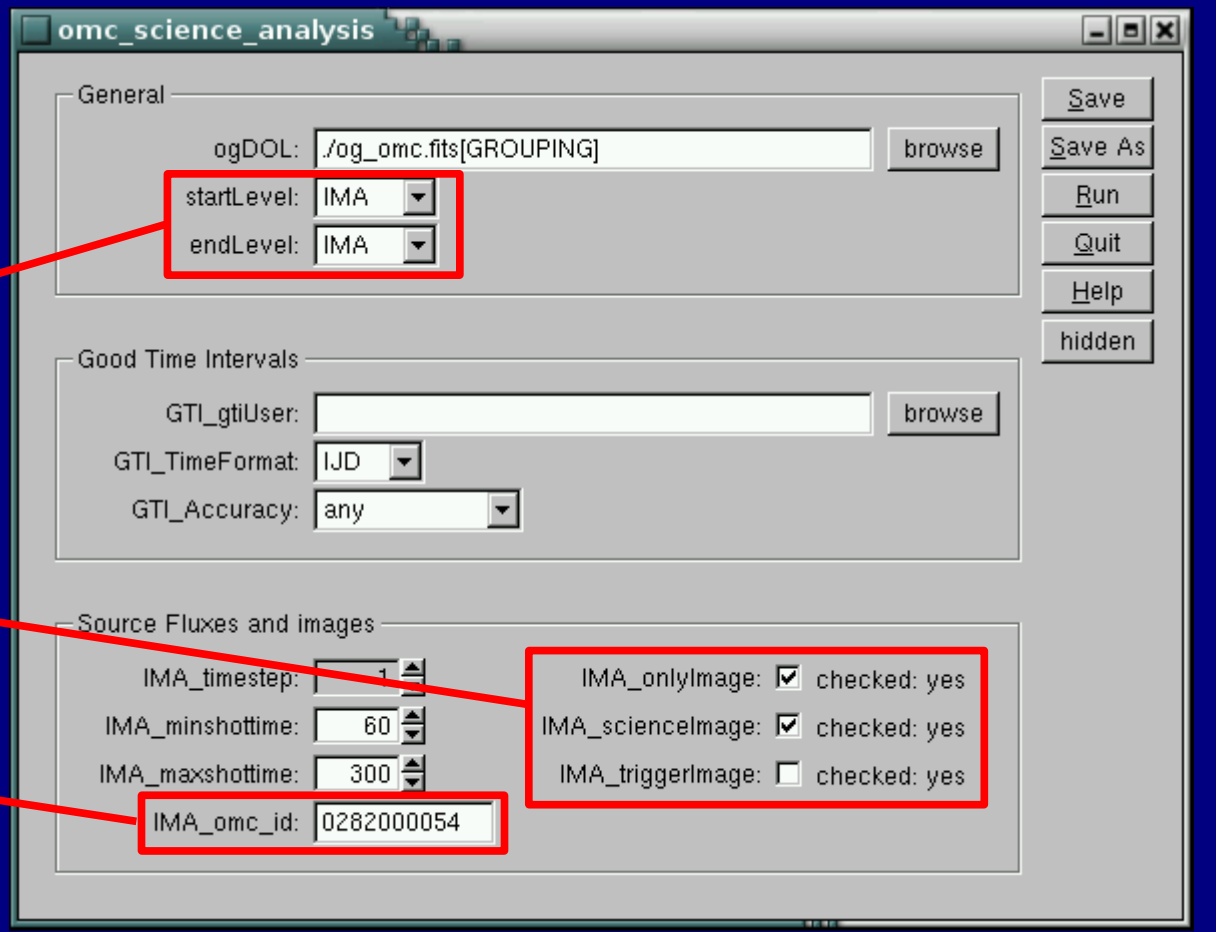
- Check the field. Are there other sources? Where is the photometric algorithm centring?
- Check strange photometric points. Is there any cosmic ray or readout noise lines in the image?
- It creates files *./scw/XXXXXXXXXXX.001/omc_sky_ima.fits*

omc_science_analysis

Light curve previously processed

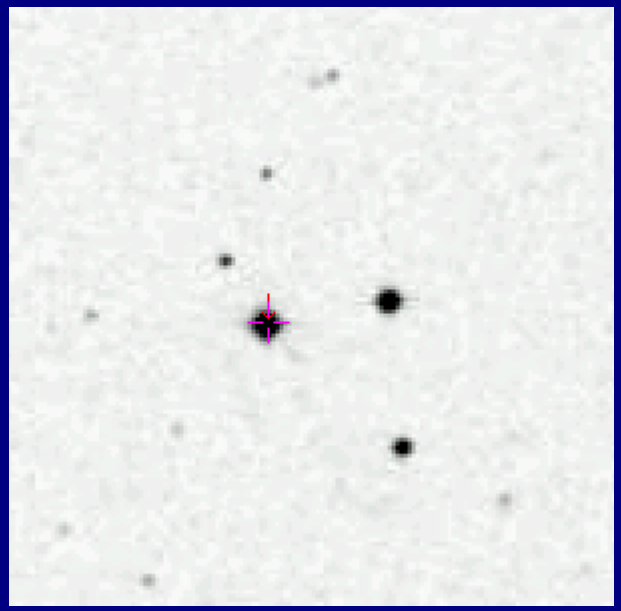
Only images.

Only 3C273 subwindows. **This field empty creates full CCD images**.

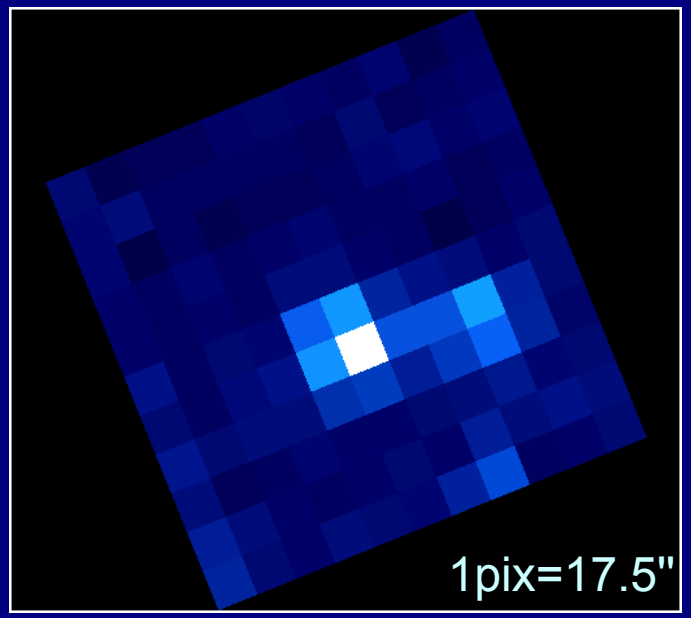


Images

- Be aware with contamination. Other sources can increase the flux measured in your aperture.
- 1' (≈3 pixels) distance between different sources is a typical limit for photometric results.
- To avoid contamination, you should use a small aperture (3 pix diameter in this case).



SERC.J.DSS1, Filter B

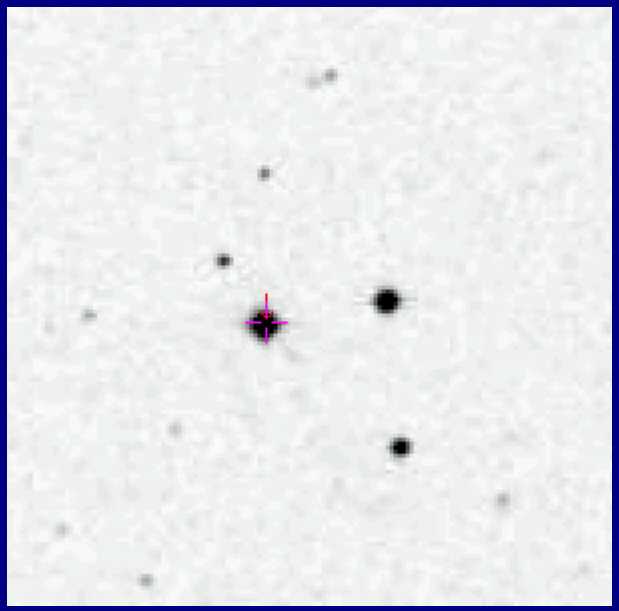


OMC, Filter V

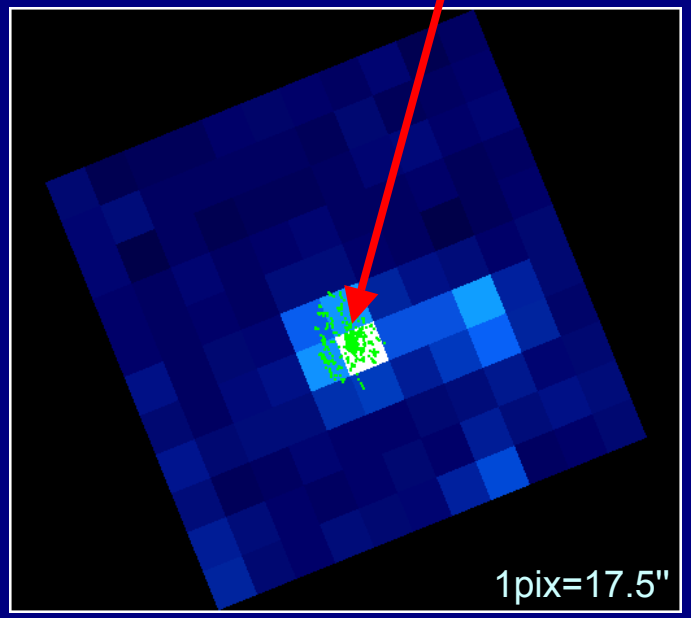
Images

- The calculation of coordinates is a new option in OSA 5.
- We use 2 different methods:
  - Satellite attitude.
  - The 5 photometric stars in science shots.

Green points: calculated source centroids. In the worst case, the precision is better than 1pix (1σ).



SERC.J.DSS1, Filter B

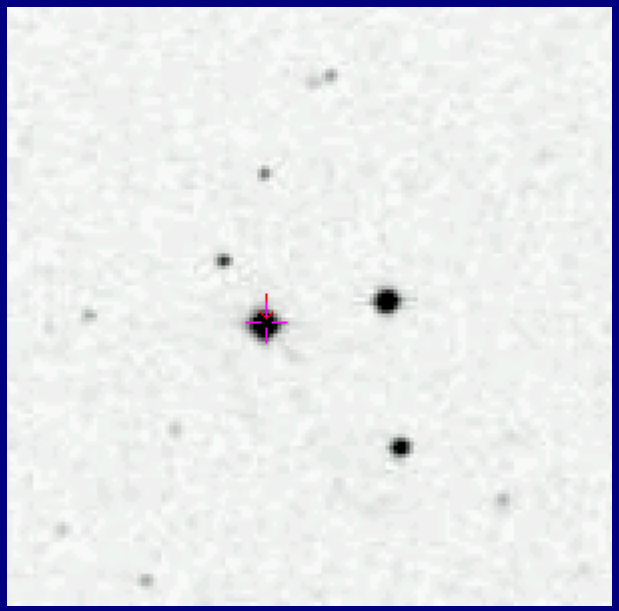


OMC, Filter V

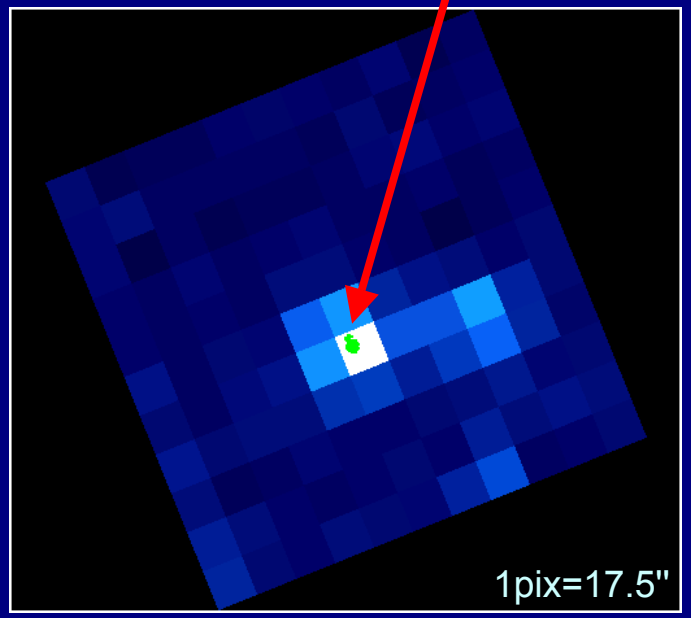
Images

- Nowadays we uses almost always the 5 photometric stars in science shots.
- This method gives better results than using only the satellite attitude.

Best calculated source centroids (more than 300 points during 7 months)
1σ(RA_FIN) = 0.066pix = 1.2"
1σ(DEC_FIN) = 0.074pix = 1.3"



SERC.J.DSS1, Filter B



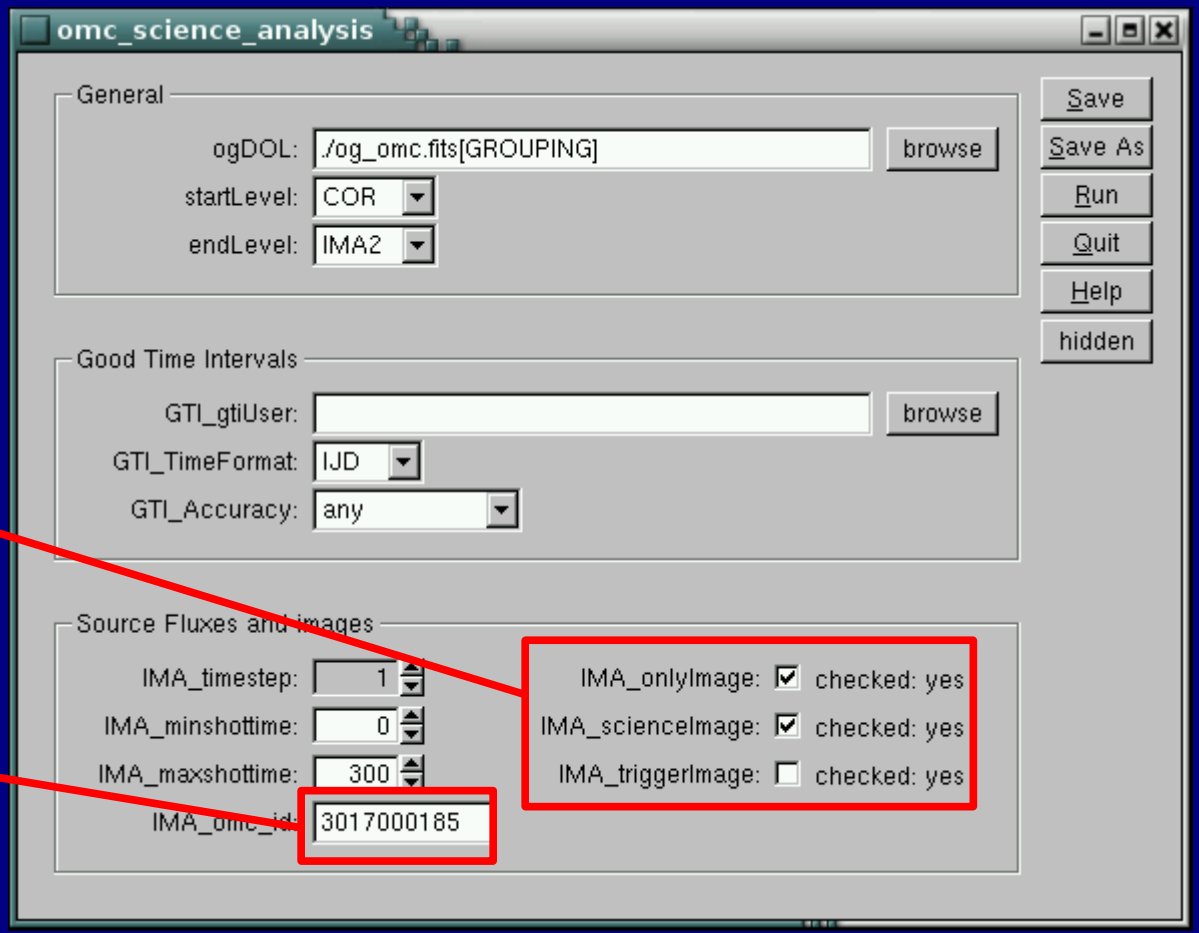
OMC, Filter V

Create mosaic images

- Example: NGC 4151.
- It is a Seyfert 1 galaxy.

Create only science images, no triggers.

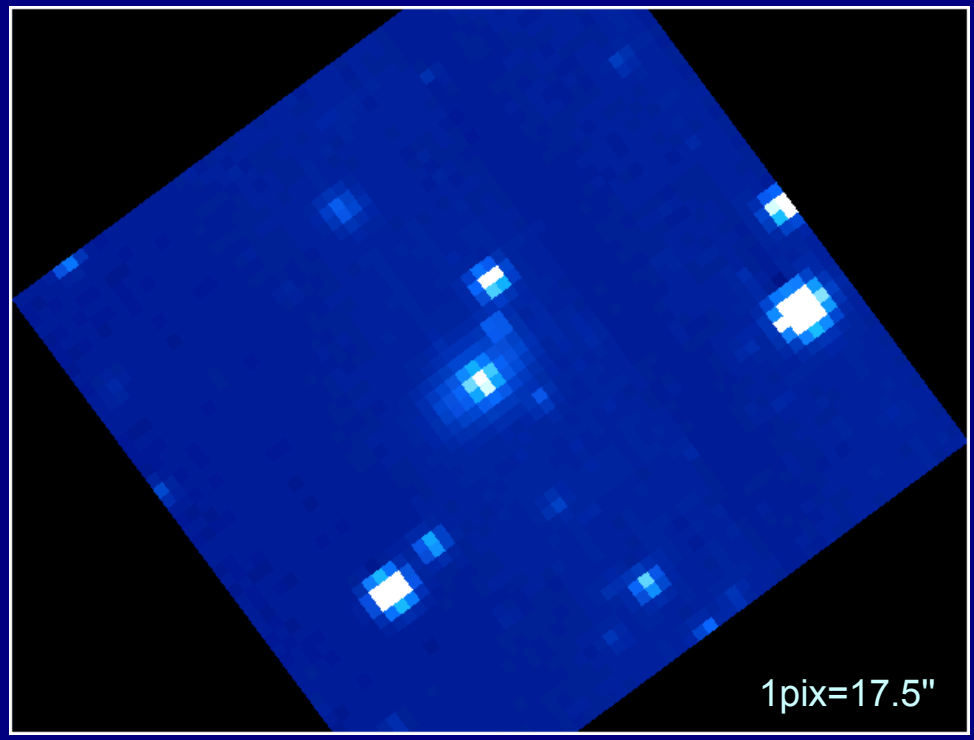
Its OMC ID is 3017000185.



Create mosaic images

- Images are created and corrected (BIAS, dark current, flatfield and photometric zero point) by the Offline Standard Analysis.
- OMC Standard Analysis has not been designed to extract photometric light curves of mosaics.

DSS2, filter B

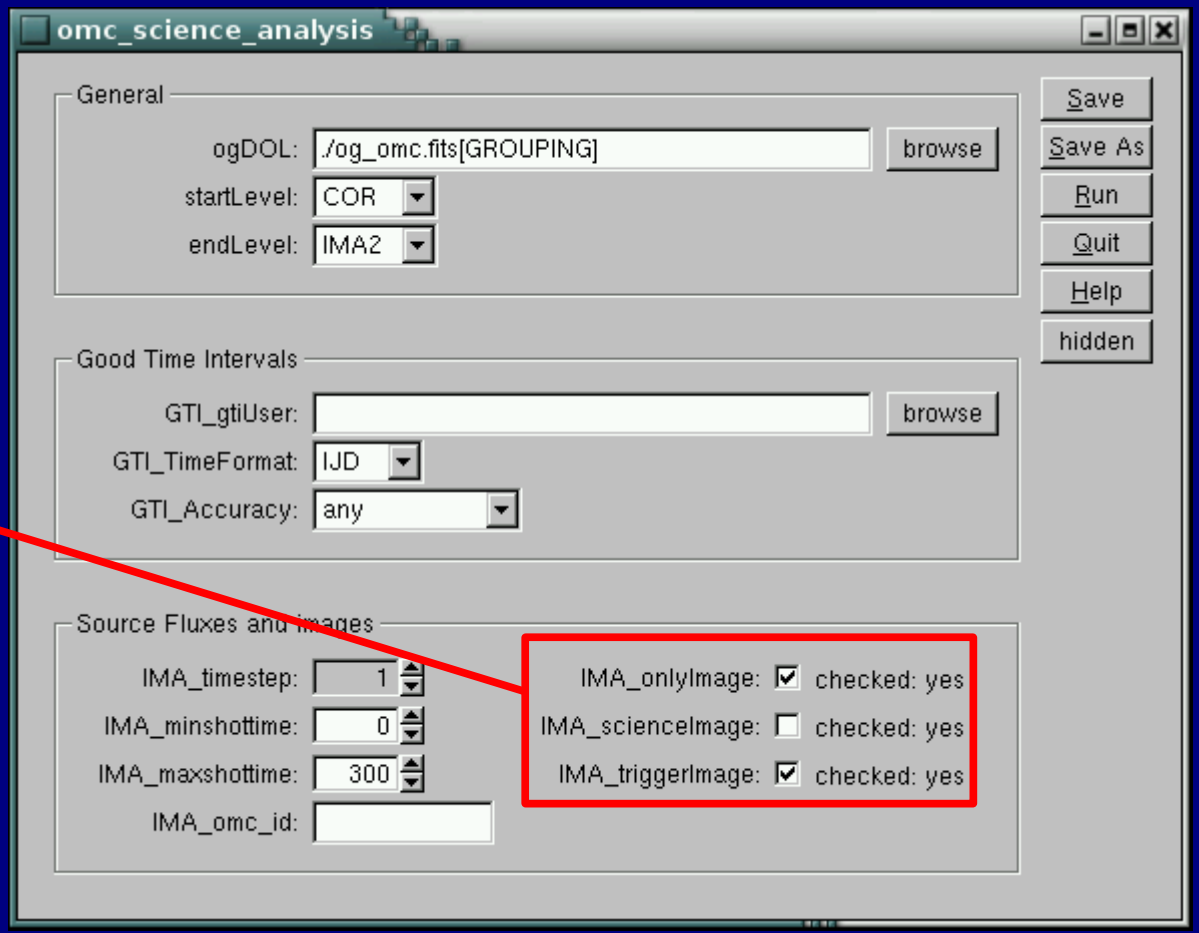


OMC, filter V

Create trigger images

- Example: 1A 0535+26.
- It is a Be/X-ray binary pulsar.

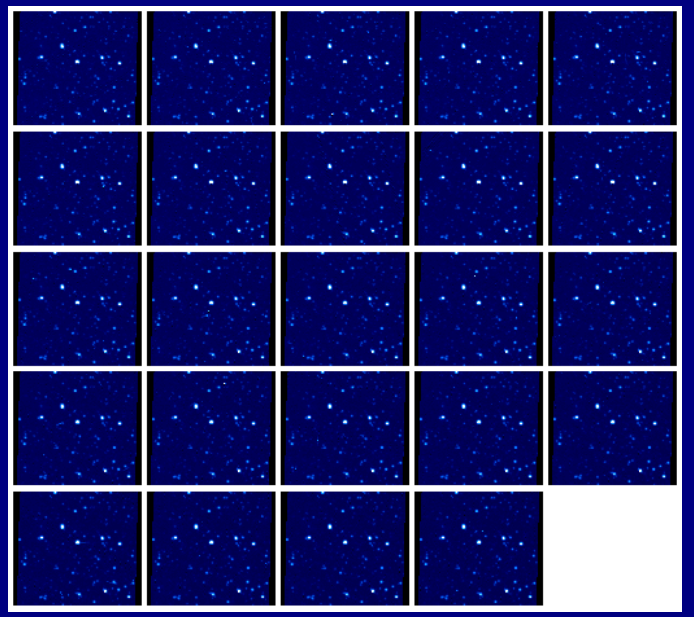
Create only trigger images.



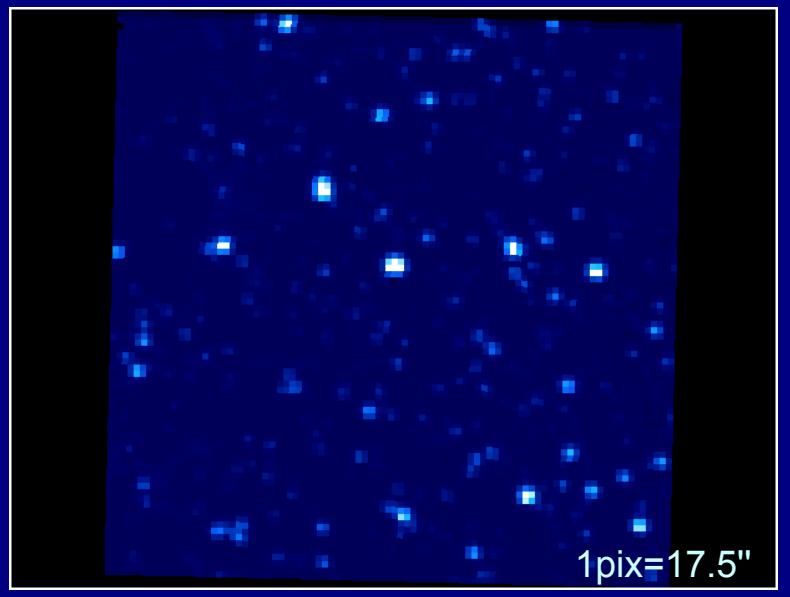
Create trigger images

- **COR level is not available for trigger data** (they are built up to level PRP).
- Then, the user should subtract BIAS, dark current, apply flatfield and photometric zero point. All what you need is in the data structures.

All OMC shots



DSS2, filter B



OMC, one shot, filter V

These are a few examples, but new OMC light curves are waiting for you.