Data reduction II
Photometry with IRAF

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Research workshop on evolved stars
September 2025

Introduction

- Text in **yellow** is for typing into IRAF terminal
- In my slides IRAF terminals are black or papaya colour

Why data *reduction*?

- We need to subtract – or reduce – instrumental effects and background contamination.

Reducing instrumental effects:

- **BIAS**: image with ‘zero’ exposure time.
  (not possible with Perek! We will use the overscan region)
- **FLAT**: image of a uniformly illuminated surface.
  Estimate sensitivity difference throughout the CCD + dust grains, scratches etc.
- **DARK**: image with the same exposure time of the science image with the shutter closed.
  Estimate the level of background current.

More is more

- Each of the counts on the images has an associated uncertainty.
- If we take n images, each with an uncertainty σ_i, the uncertainty on the average will be $\sigma_i/\sqrt{n}$.
- Therefore, the first step in data reduction is to calculate the average for BIAS, FLAT, and DARK images.

More is more

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- If we take n images, each with an uncertainty σ_i, the uncertainty on the average will be $\sigma_i/\sqrt{n}$.
- Therefore, the first step in data reduction is to calculate the average for BIAS, FLAT, and DARK images.

  BIAS: not available for the Perek telescope.

  FLAT: master flat has already been created.

  DARK: we need to calculate the median dark.

IRAF – Image Reduction and Analysis Facility

- We'll use the package

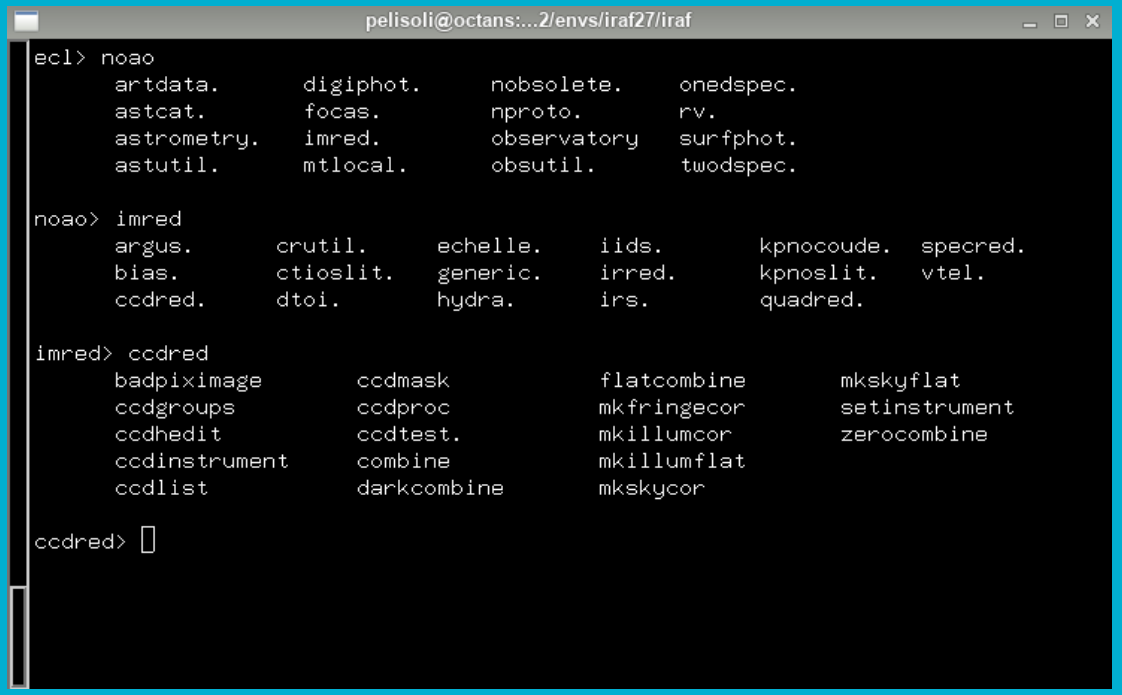
  noao imred ccdred

for the data reduction, and

noao digiphot daophot

for the photometry.

- Load each part of the packages by typing their name followed by enter.



Preparing working directory

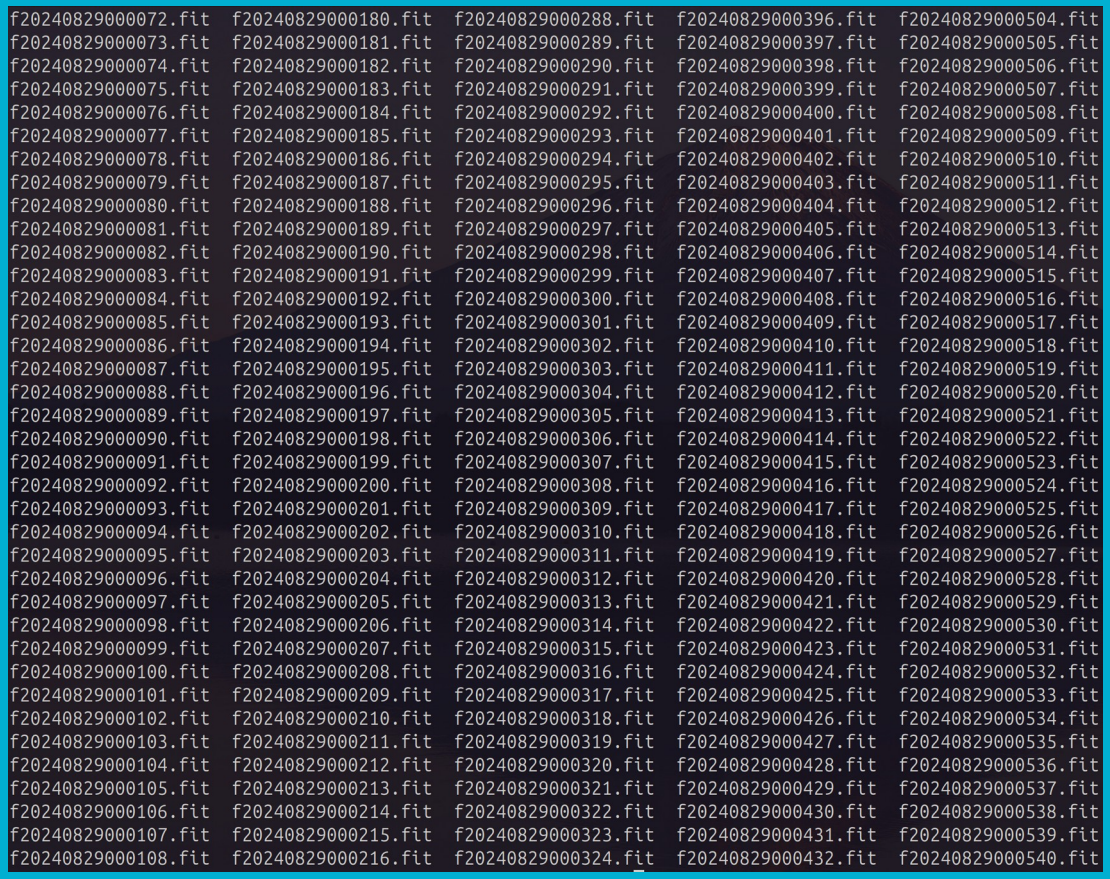
- Always have a copy of original raw data!

- **!mkdir reduction**
- **!mkdir reduction_copy**

- All the files that we work with have to be in the same directory:
  - science frames
  - masterflats (same filters as your science frames!)
  - darks

Check your data

— This is what you'll get…



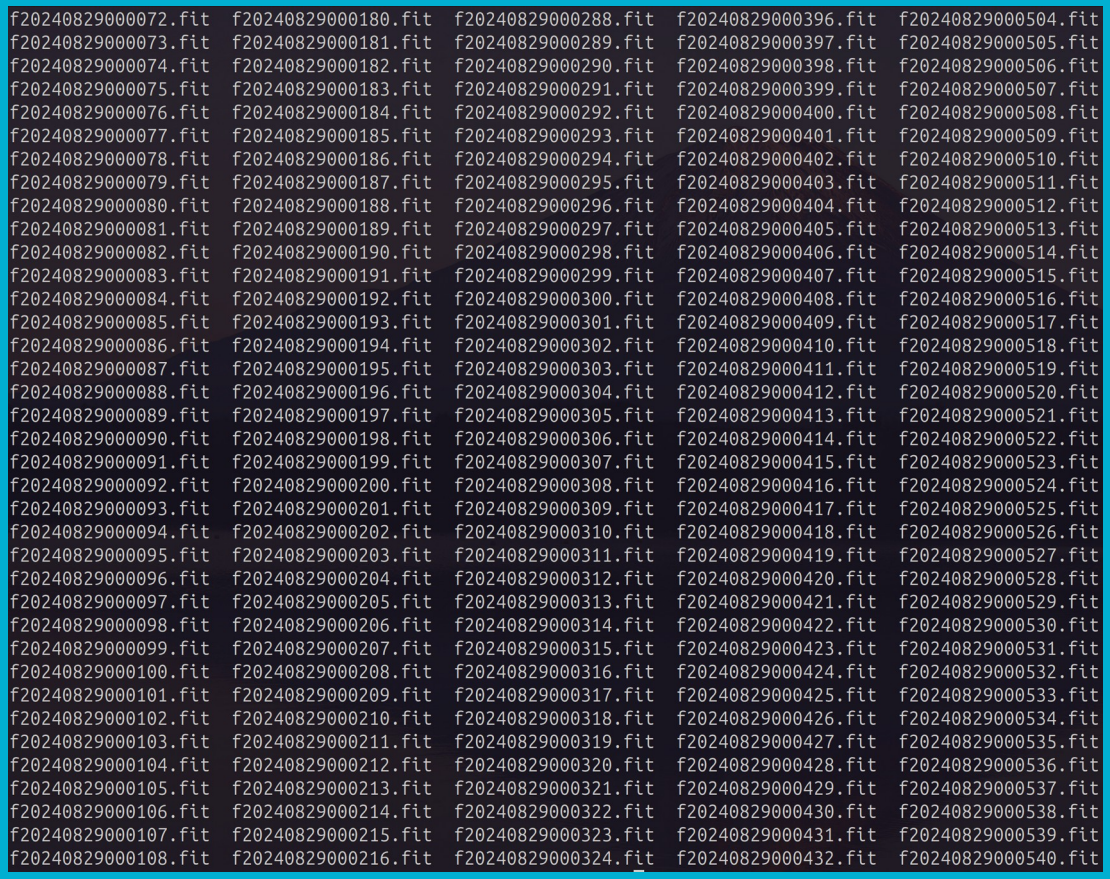
```
f20240829000072.fit  f20240829000180.fit  f20240829000288.fit  f20240829000396.fit  f20240829000504.fit
f20240829000073.fit  f20240829000181.fit  f20240829000289.fit  f20240829000397.fit  f20240829000505.fit
f20240829000074.fit  f20240829000182.fit  f20240829000290.fit  f20240829000398.fit  f20240829000506.fit
f20240829000075.fit  f20240829000183.fit  f20240829000291.fit  f20240829000399.fit  f20240829000507.fit
f20240829000076.fit  f20240829000184.fit  f20240829000292.fit  f20240829000400.fit  f20240829000508.fit
f20240829000077.fit  f20240829000185.fit  f20240829000293.fit  f20240829000401.fit  f20240829000509.fit
f20240829000078.fit  f20240829000186.fit  f20240829000294.fit  f20240829000402.fit  f20240829000510.fit
f20240829000079.fit  f20240829000187.fit  f20240829000295.fit  f20240829000403.fit  f20240829000511.fit
f20240829000080.fit  f20240829000188.fit  f20240829000296.fit  f20240829000404.fit  f20240829000512.fit
f20240829000081.fit  f20240829000189.fit  f20240829000297.fit  f20240829000405.fit  f20240829000513.fit
f20240829000082.fit  f20240829000190.fit  f20240829000298.fit  f20240829000406.fit  f20240829000514.fit
f20240829000083.fit  f20240829000191.fit  f20240829000299.fit  f20240829000407.fit  f20240829000515.fit
f20240829000084.fit  f20240829000192.fit  f20240829000300.fit  f20240829000408.fit  f20240829000516.fit
f20240829000085.fit  f20240829000193.fit  f20240829000301.fit  f20240829000409.fit  f20240829000517.fit
f20240829000086.fit  f20240829000194.fit  f20240829000302.fit  f20240829000410.fit  f20240829000518.fit
f20240829000087.fit  f20240829000195.fit  f20240829000303.fit  f20240829000411.fit  f20240829000519.fit
f20240829000088.fit  f20240829000196.fit  f20240829000304.fit  f20240829000412.fit  f20240829000520.fit
f20240829000089.fit  f20240829000197.fit  f20240829000305.fit  f20240829000413.fit  f20240829000521.fit
f20240829000090.fit  f20240829000198.fit  f20240829000306.fit  f20240829000414.fit  f20240829000522.fit
f20240829000091.fit  f20240829000199.fit  f20240829000307.fit  f20240829000415.fit  f20240829000523.fit
f20240829000092.fit  f20240829000200.fit  f20240829000308.fit  f20240829000416.fit  f20240829000524.fit
f20240829000093.fit  f20240829000201.fit  f20240829000309.fit  f20240829000417.fit  f20240829000525.fit
f20240829000094.fit  f20240829000202.fit  f20240829000310.fit  f20240829000418.fit  f20240829000526.fit
f20240829000095.fit  f20240829000203.fit  f20240829000311.fit  f20240829000419.fit  f20240829000527.fit
f20240829000096.fit  f20240829000204.fit  f20240829000312.fit  f20240829000420.fit  f20240829000528.fit
f20240829000097.fit  f20240829000205.fit  f20240829000313.fit  f20240829000421.fit  f20240829000529.fit
f20240829000098.fit  f20240829000206.fit  f20240829000314.fit  f20240829000422.fit  f20240829000530.fit
f20240829000099.fit  f20240829000207.fit  f20240829000315.fit  f20240829000423.fit  f20240829000531.fit
f20240829000100.fit  f20240829000208.fit  f20240829000316.fit  f20240829000424.fit  f20240829000532.fit
f20240829000101.fit  f20240829000209.fit  f20240829000317.fit  f20240829000425.fit  f20240829000533.fit
f20240829000102.fit  f20240829000210.fit  f20240829000318.fit  f20240829000426.fit  f20240829000534.fit
f20240829000103.fit  f20240829000211.fit  f20240829000319.fit  f20240829000427.fit  f20240829000535.fit
f20240829000104.fit  f20240829000212.fit  f20240829000320.fit  f20240829000428.fit  f20240829000536.fit
f20240829000105.fit  f20240829000213.fit  f20240829000321.fit  f20240829000429.fit  f20240829000537.fit
f20240829000106.fit  f20240829000214.fit  f20240829000322.fit  f20240829000430.fit  f20240829000538.fit
f20240829000107.fit  f20240829000215.fit  f20240829000323.fit  f20240829000431.fit  f20240829000539.fit
f20240829000108.fit  f20240829000216.fit  f20240829000324.fit  f20240829000432.fit  f20240829000540.fit
```

Contains science frames, darks, flats…

Check your data

— This is what you'll get...

!python3 sort_full.py



```
f20240829000072.fit  f20240829000180.fit  f20240829000288.fit  f20240829000396.fit  f20240829000504.fit
f20240829000073.fit  f20240829000181.fit  f20240829000289.fit  f20240829000397.fit  f20240829000505.fit
f20240829000074.fit  f20240829000182.fit  f20240829000290.fit  f20240829000398.fit  f20240829000506.fit
f20240829000075.fit  f20240829000183.fit  f20240829000291.fit  f20240829000399.fit  f20240829000507.fit
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f20240829000077.fit  f20240829000185.fit  f20240829000293.fit  f20240829000401.fit  f20240829000509.fit
f20240829000078.fit  f20240829000186.fit  f20240829000294.fit  f20240829000402.fit  f20240829000510.fit
f20240829000079.fit  f20240829000187.fit  f20240829000295.fit  f20240829000403.fit  f20240829000511.fit
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f20240829000082.fit  f20240829000190.fit  f20240829000298.fit  f20240829000406.fit  f20240829000514.fit
f20240829000083.fit  f20240829000191.fit  f20240829000299.fit  f20240829000407.fit  f20240829000515.fit
f20240829000084.fit  f20240829000192.fit  f20240829000300.fit  f20240829000408.fit  f20240829000516.fit
f20240829000085.fit  f20240829000193.fit  f20240829000301.fit  f20240829000409.fit  f20240829000517.fit
f20240829000086.fit  f20240829000194.fit  f20240829000302.fit  f20240829000410.fit  f20240829000518.fit
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f20240829000088.fit  f20240829000196.fit  f20240829000304.fit  f20240829000412.fit  f20240829000520.fit
f20240829000089.fit  f20240829000197.fit  f20240829000305.fit  f20240829000413.fit  f20240829000521.fit
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f20240829000092.fit  f20240829000200.fit  f20240829000308.fit  f20240829000416.fit  f20240829000524.fit
f20240829000093.fit  f20240829000201.fit  f20240829000309.fit  f20240829000417.fit  f20240829000525.fit
f20240829000094.fit  f20240829000202.fit  f20240829000310.fit  f20240829000418.fit  f20240829000526.fit
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f20240829000100.fit  f20240829000208.fit  f20240829000316.fit  f20240829000424.fit  f20240829000532.fit
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f20240829000103.fit  f20240829000211.fit  f20240829000319.fit  f20240829000427.fit  f20240829000535.fit
f20240829000104.fit  f20240829000212.fit  f20240829000320.fit  f20240829000428.fit  f20240829000536.fit
f20240829000105.fit  f20240829000213.fit  f20240829000321.fit  f20240829000429.fit  f20240829000537.fit
f20240829000106.fit  f20240829000214.fit  f20240829000322.fit  f20240829000430.fit  f20240829000538.fit
f20240829000107.fit  f20240829000215.fit  f20240829000323.fit  f20240829000431.fit  f20240829000539.fit
f20240829000108.fit  f20240829000216.fit  f20240829000324.fit  f20240829000432.fit  f20240829000540.fit
```
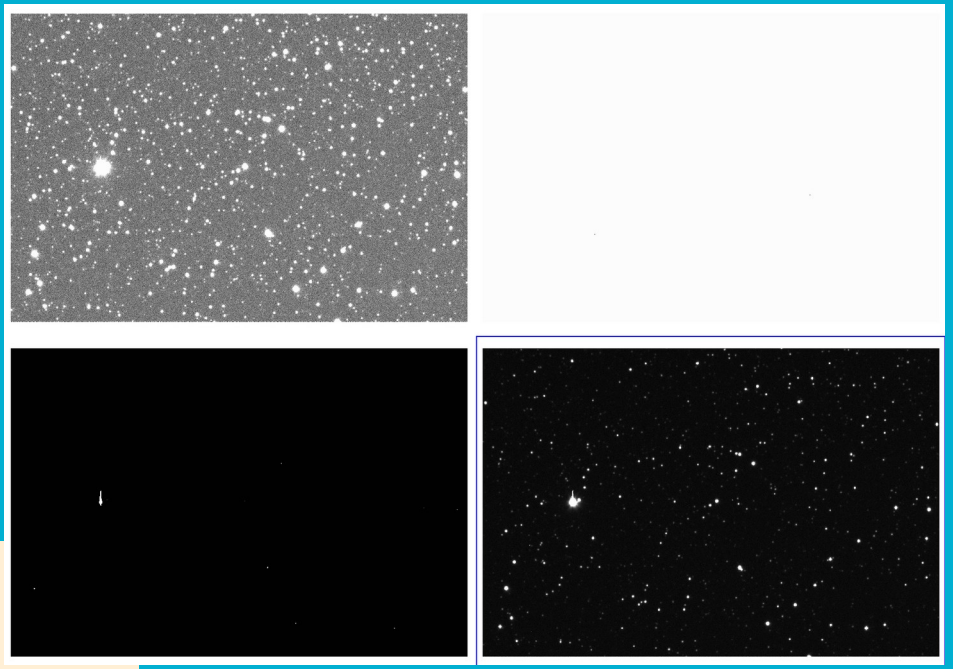

Contains science frames, darks, flats...

Check your data

epar display



```
                                Image Reduction and Analysis Facility
PACKAGE = tv
   TASK = display

image    =                          image to be displayed
frame    =                        1 frame to be written into
(bpmask =                      BPM) bad pixel mask
(bpdispl=                     none) bad pixel display (none|overlay|interpolate)
(bpcolor=                      red) bad pixel colors
(overlay=                         ) overlay mask
(ocolors=                    green) overlay colors
(erase   =                     yes) erase frame
(border_=                       no) erase unfilled area of window
(select_=                      yes) display frame being loaded
(repeat =                       no) repeat previous display parameters
(fill    =                      no) scale image to fit display window
(zscale =                      yes) display range of greylevels near median
(contras=                     0.25) contrast adjustment for zscale algorithm
(zrange =                      yes) display full image intensity range
(zmask  =                         ) sample mask
(nsample=                     1000) maximum number of sample pixels to use
(xcenter=                      0.5) display window horizontal center
(ycenter=                      0.5) display window vertical center
(xsize   =                      1.) display window horizontal size
(ysize   =                      1.) display window vertical size
(xmag    =                      1.) display window horizontal magnification
(ymag    =                      1.) display window vertical magnification
(order   =                       0) spatial interpolator order (0=replicate, 1=linear)
(z1      =                         ) minimum greylevel to be displayed
(z2      =                         ) maximum greylevel to be displayed
(ztrans =                      log) greylevel transformation (linear|log|none|user)
(lutfile=                         ) file containing user defined look up table
(mode    =                      ql)
```

Play around with these default values to get an image you're happy with

display (image name)

Check (all) your data (science, darks, flats)

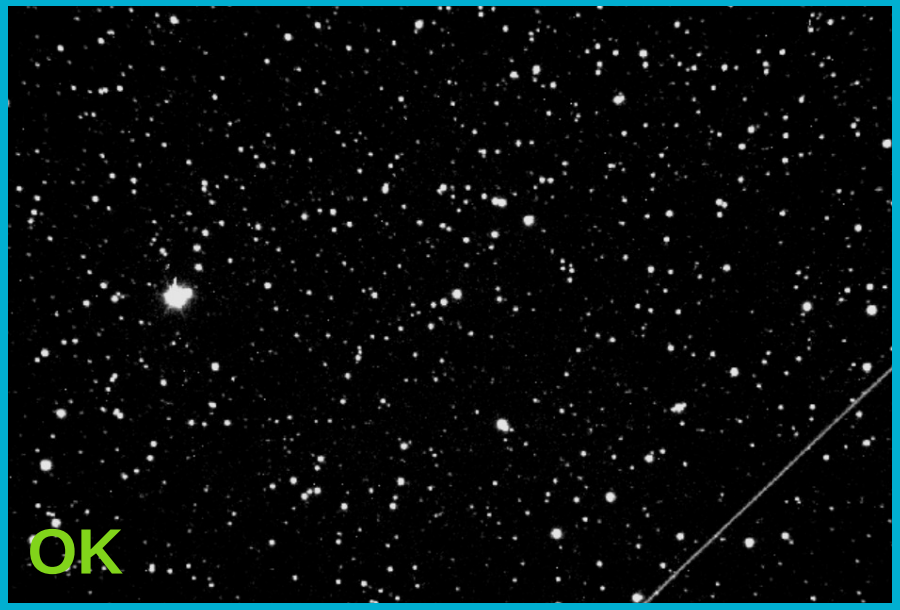
- After sorting, the data should be in different directories, check all!

  !ds9 &

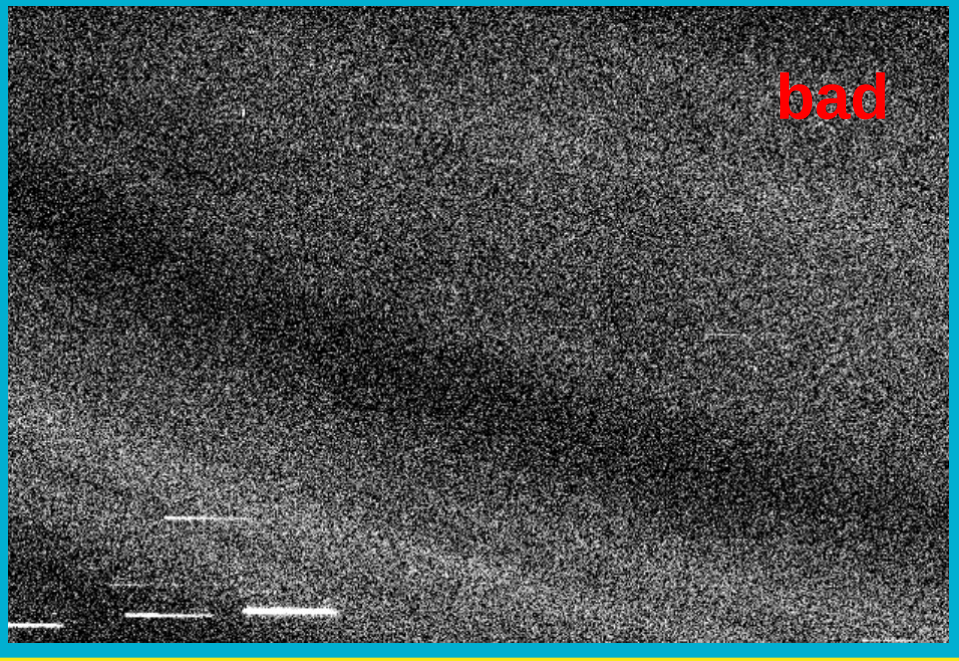
- Create a list with e.g. science frames (do this for darks and flats too).
  ls filename*.fits > list_science

- Display images in ds9 and relocate useless frames
  imexam @list_science 1
  (n next frame
  p previous frame
  q quit)

- Remove useless science frames: clouds? Satellites? tracking problems? Etc.
  But avoid removing unnecessarily!!



Unless it goes straight through your star!



Fixing the fits headers (optional?)

- Add the following to ALL fits headers (new camera)

hedit *.fit BIASSEC '[1058:1062,2:1022]' add+ ver-
hedit *.fit TRIMSEC '[1:1056,1:1026]' add+ ver-
hedit *.fit datasec del+ ver-

- Move the darks and flats into separate directories (if needed)

- Change the image type in the science images to ‘object’

hedit *fit imagetyp 'object' add+ ver-

Creating a master dark

- What is the exposure time of the images we will analyse?
  Check the header!
  Single frame: **imhead [image name] lo+ | page**
  Multible frames: **hsel Object*fits $I,exptime yes**
  (“exptime” is the fits header keword)

- Which dark images should we use?
  imhead df–* lo+ | grep EXPTIME or **hsel**

- Create a list (text document) containing the names of the dark frames using the same exposure time as the science images.

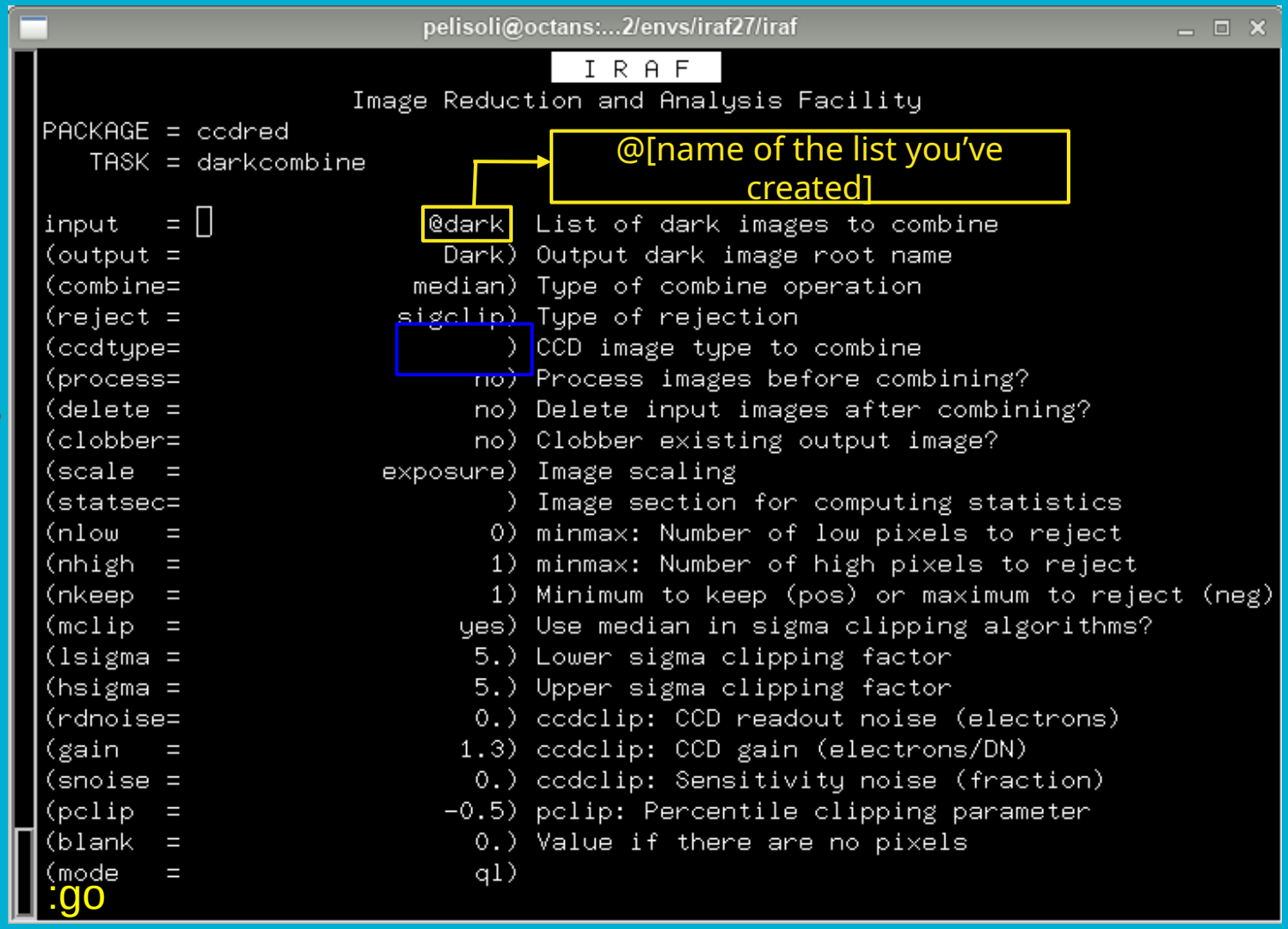
  ls df* > df_60s_list

Each exposure time needs its own master dark!

Creating a master dark – epar darkcombine

Check parameters!

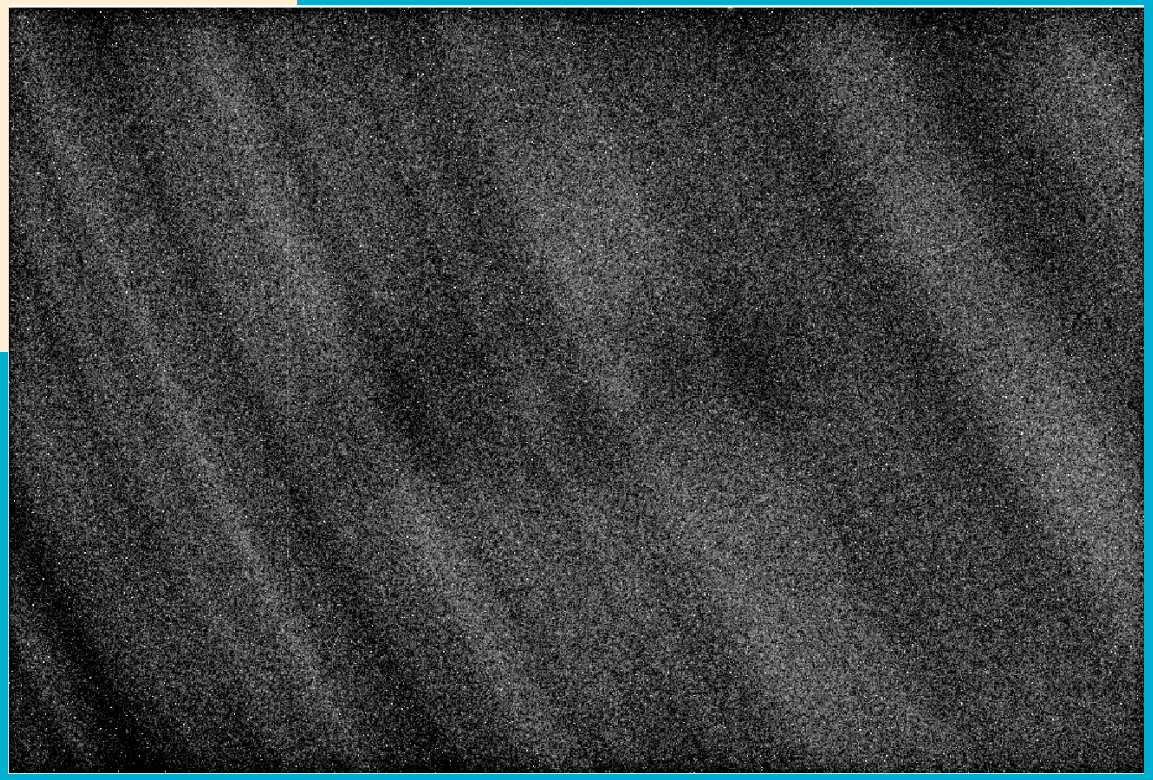
ccdtype has to be empty! Just put space.



":go" + enter

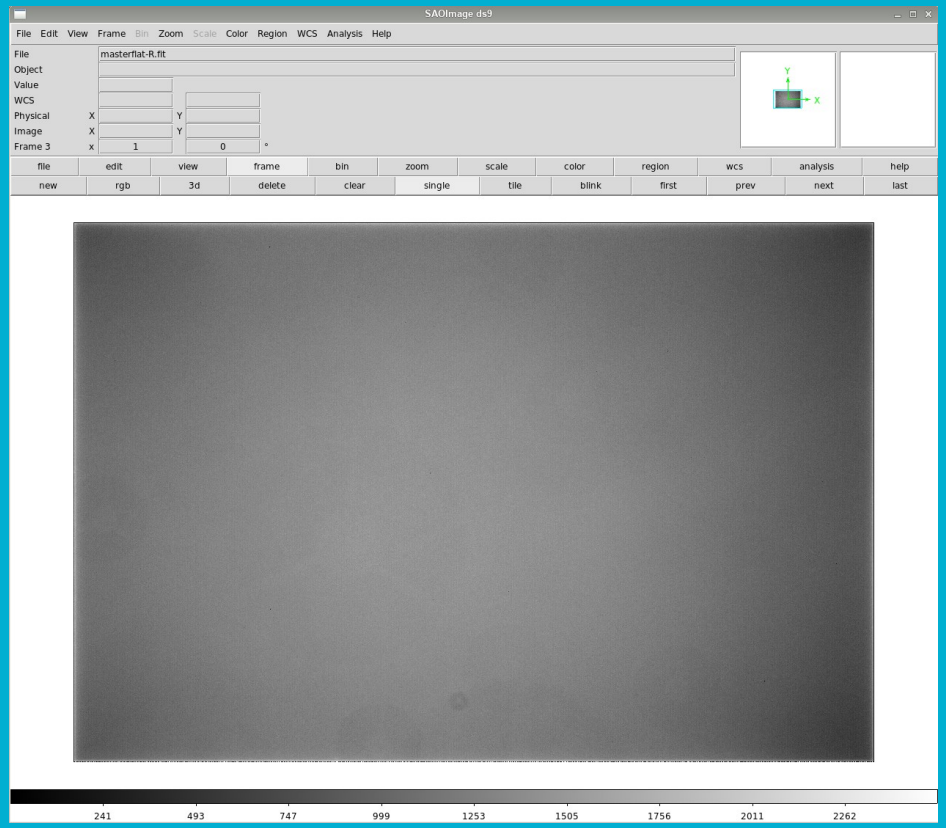
Creating a master dark –

```
Aug 30 16:01: IMCOMBINE
  combine = median, scale = exposure, zero = none, weight = none
  reject = sigclip, mclip = yes, nkeep = 1
  lsigma = 5., hsigma = 5.
  blank = 0.
                Images
        df60s__0001.fits
        df60s__0002.fits
        df60s__0003.fits
        df60s__0004.fits
        df60s__0005.fits
        df60s__0006.fits
        df60s__0007.fits
        df60s__0008.fits
        df60s__0009.fits
        df60s__0010.fits

  Output image = Dark, ncombine = 10
```



- Check what you got!
  display
  imstat

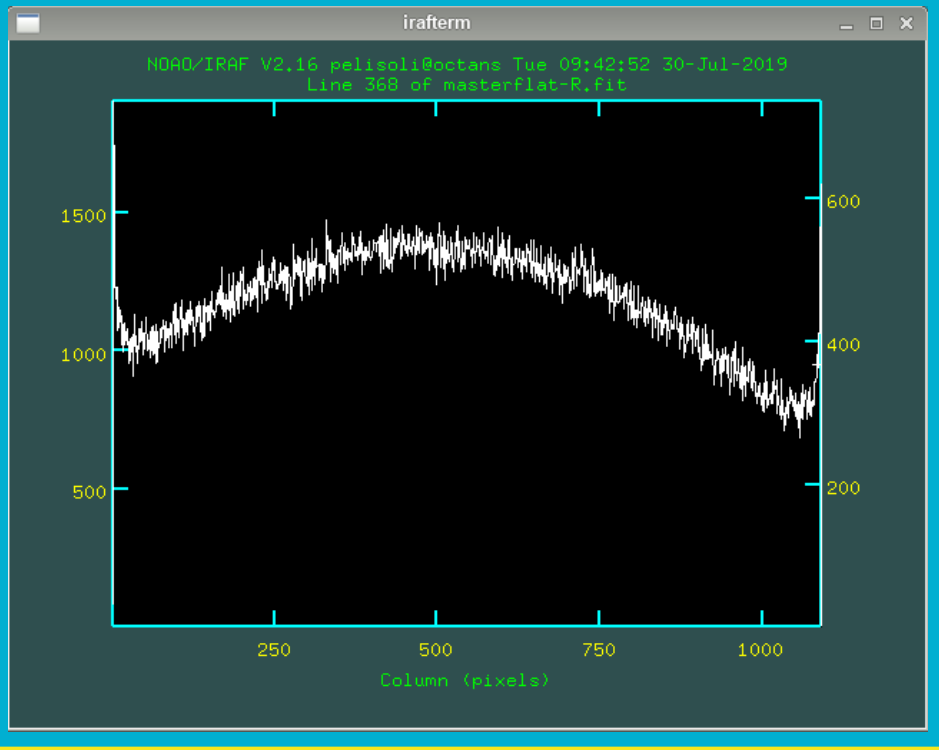
Master flat



Each filter AND exptime needs its own master flat!

Same procedure as the the master dark but use the ‘flatcombine’ task.

epar flatcombine



Reducing the science images

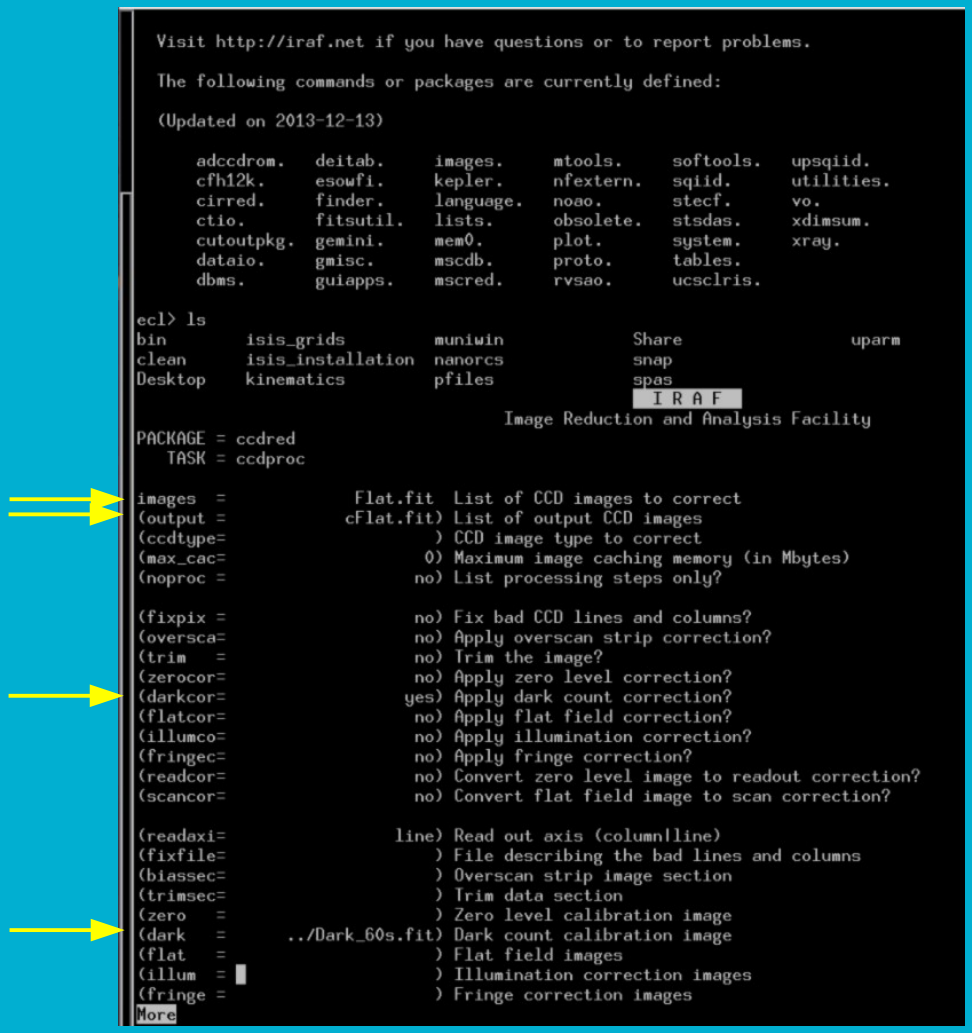
- We likely have images of different filters: e.g. R and V.
  You have to use the correct master flat for each of them.
- Make a list containing the R images, and another containing the V images, e.g.

  ls Cyg2*R*.fit > Rimgs
  ls Cyg2*V*.fit > Vimgs

- Use the task **ccdproc** to divide the images by the flat and subtract the dark current. Do it separately for R and V images.

  (Remember to subtract your masterdark from the masterflat!)

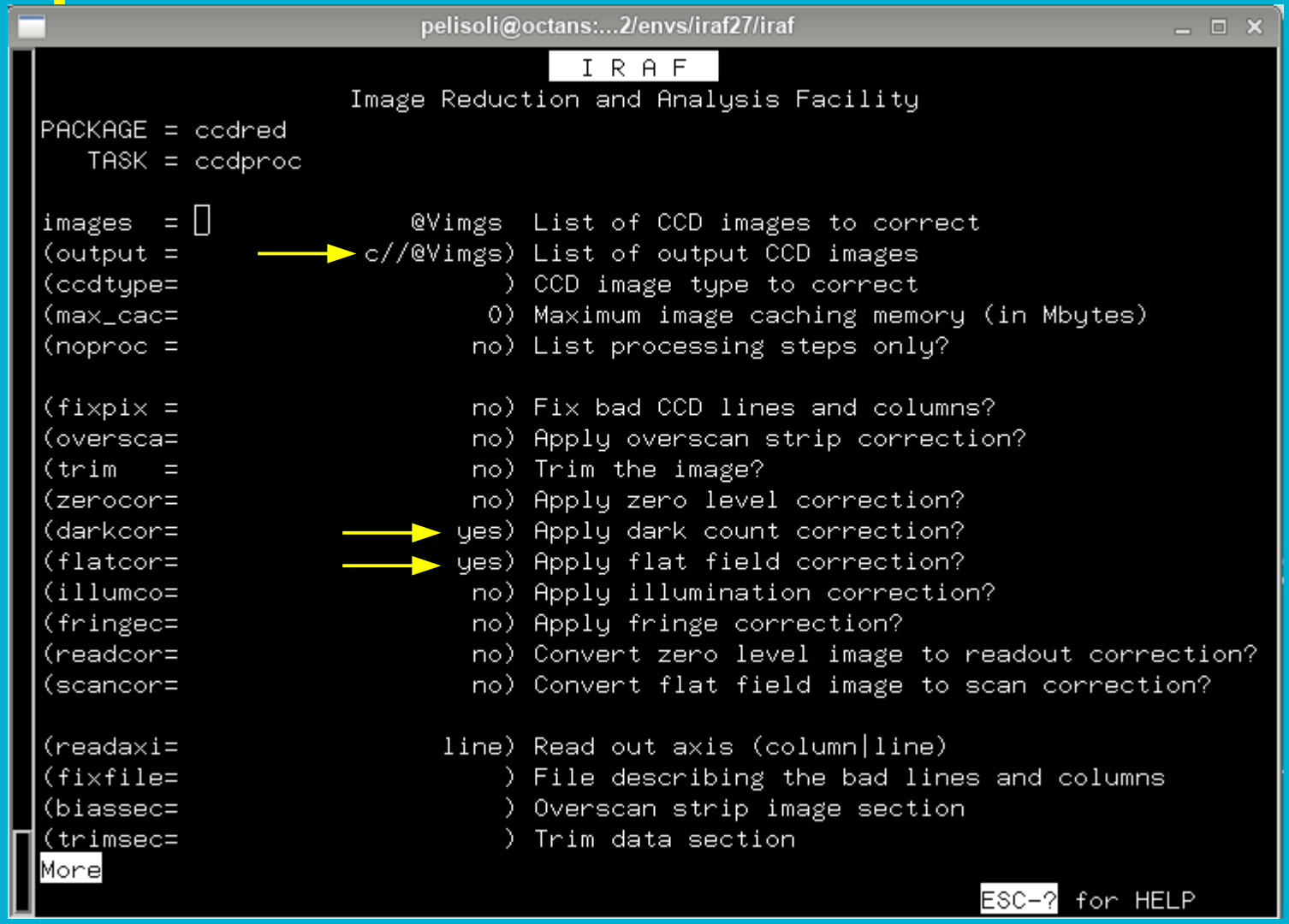
Subtract the master dark from the master flat -> epar ccdproc



Continues ...

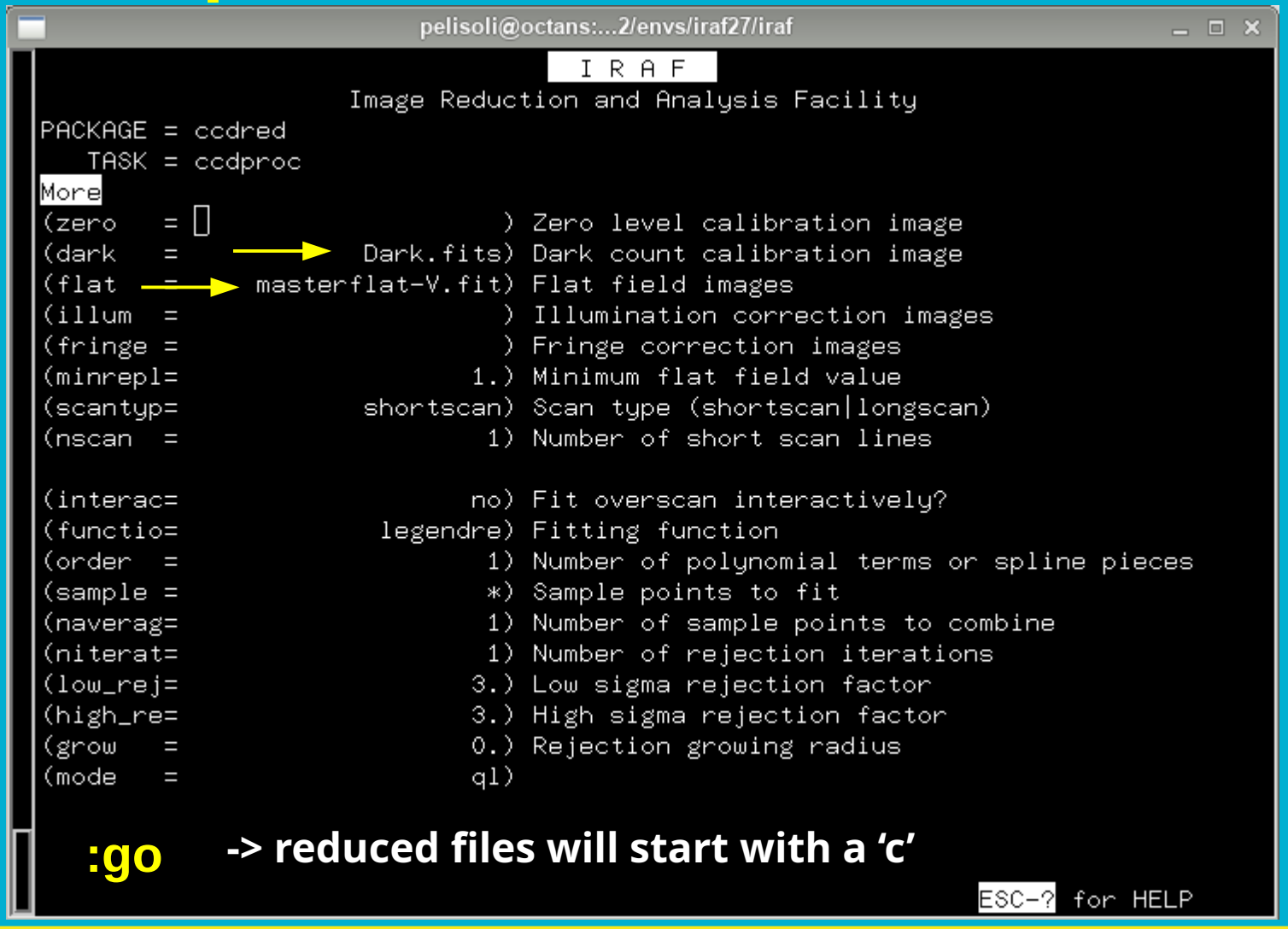
Reducing the science images 1 - epar ccdproc

Check parameters!



Continues ...

Reducing the science images 2 - epar ccdproc



Photometry

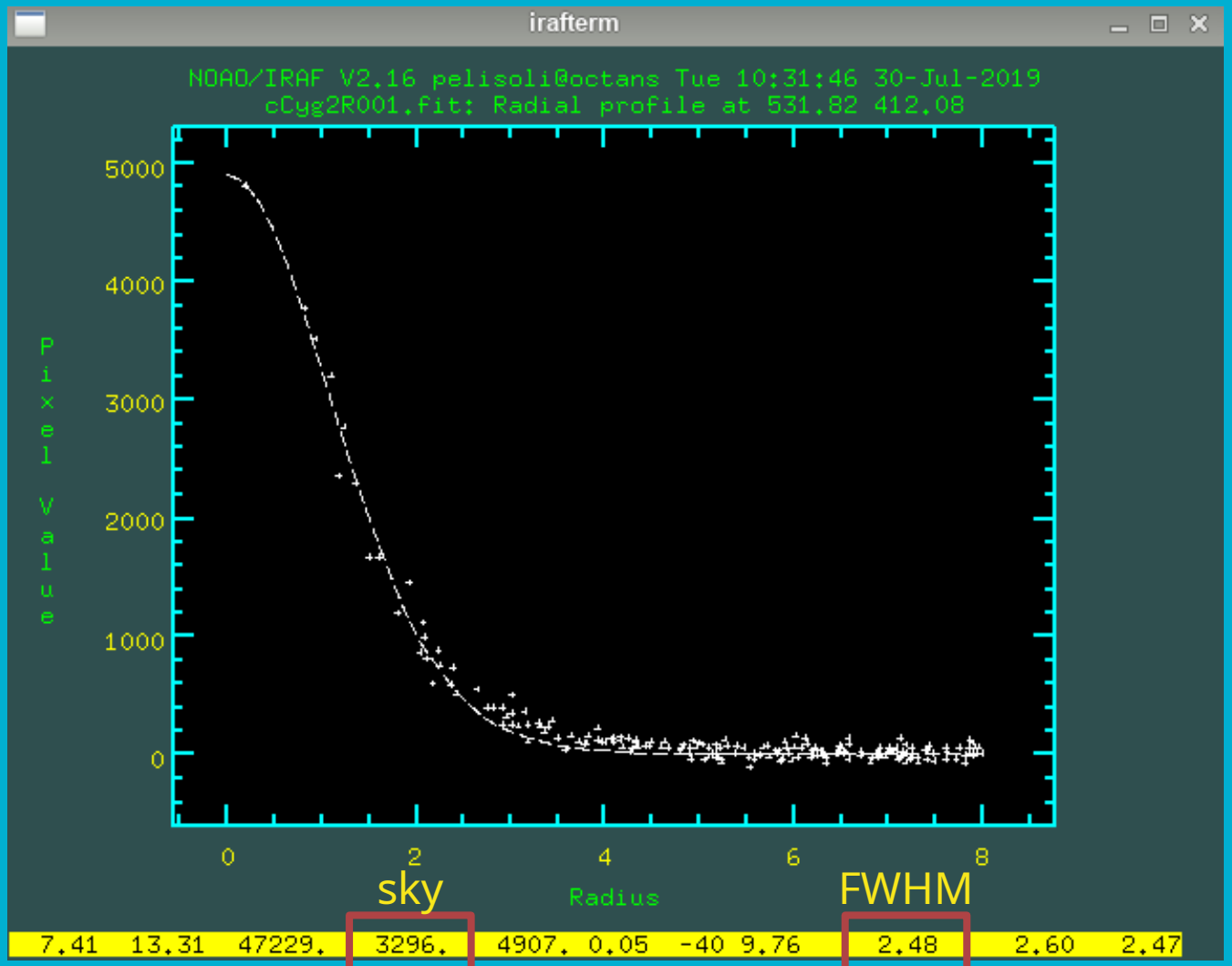
- Now that the images have been reduced, we can perform photometry.
- The first step is to run the task **daofind**, which will find the stars in our images.
- There are a few parameters we need to measure in our image to best setup daofind: the sky and the **F**(ull)**W**(idth)**H**(alf)**M**(aximum)
- For that, display an image at the beginning of the sequence, middle, and end:

display cCyg2R001.fit 1
display cCyg2R111.fit 2
display cCyg2R223.fit 3

- Use the task **imexamine** – choose a relatively bright star near the centre of the image. Centre the cursor on this star.

r → display the radial profile
e → show contours
a → write measurements to the screen

Photometry


irafterm
NOAO/IRAF V2.16 pelisoli@octans Tue 10:31:46 30-Jul-2019
cCyg2R001.fit: Radial profile at 531.82 412.08
Pixel Value
5000
4000
3000
2000
1000
0
0
2
4
6
8
Radius
sky
FWHM
7.41 13.31 47229. 3296. 4907. 0.05 -40 9.76 2.48 2.60 2.47

Photometry

- Check the sky values in the three images. We will use this to set our initial guess for the background. The value of sigma is in turn the square-root of the background (assuming Poissonic noise).

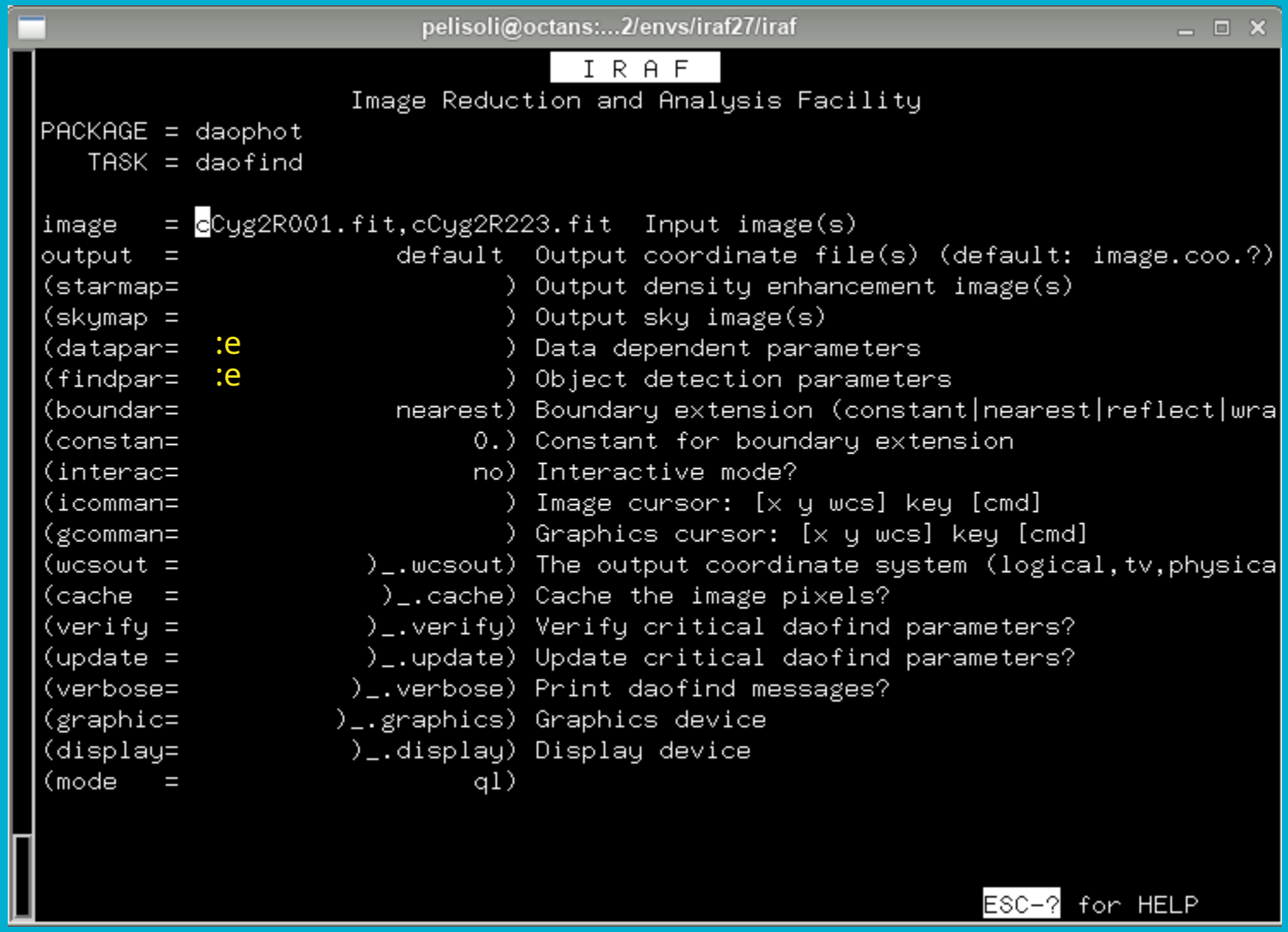
  If the values are very different, use the median; if they are similar, use the mean.

  E. g.

  sky = 415.
  sigma = 20.4

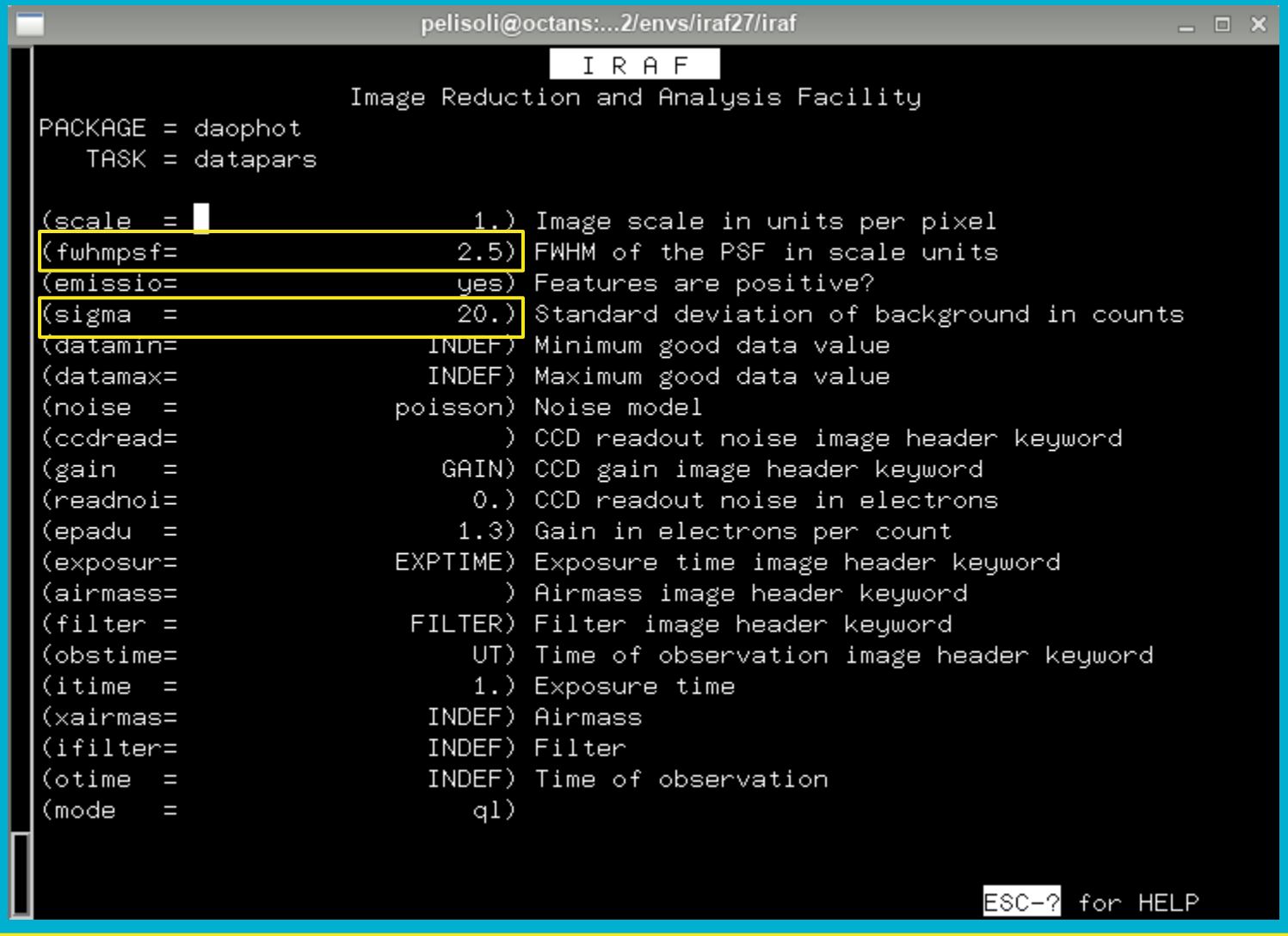
- Check the FWHM in the three images. We will use this to set the aperture and the sky region for the photometry.

epar DAOFIND (to find the stars coordinates)

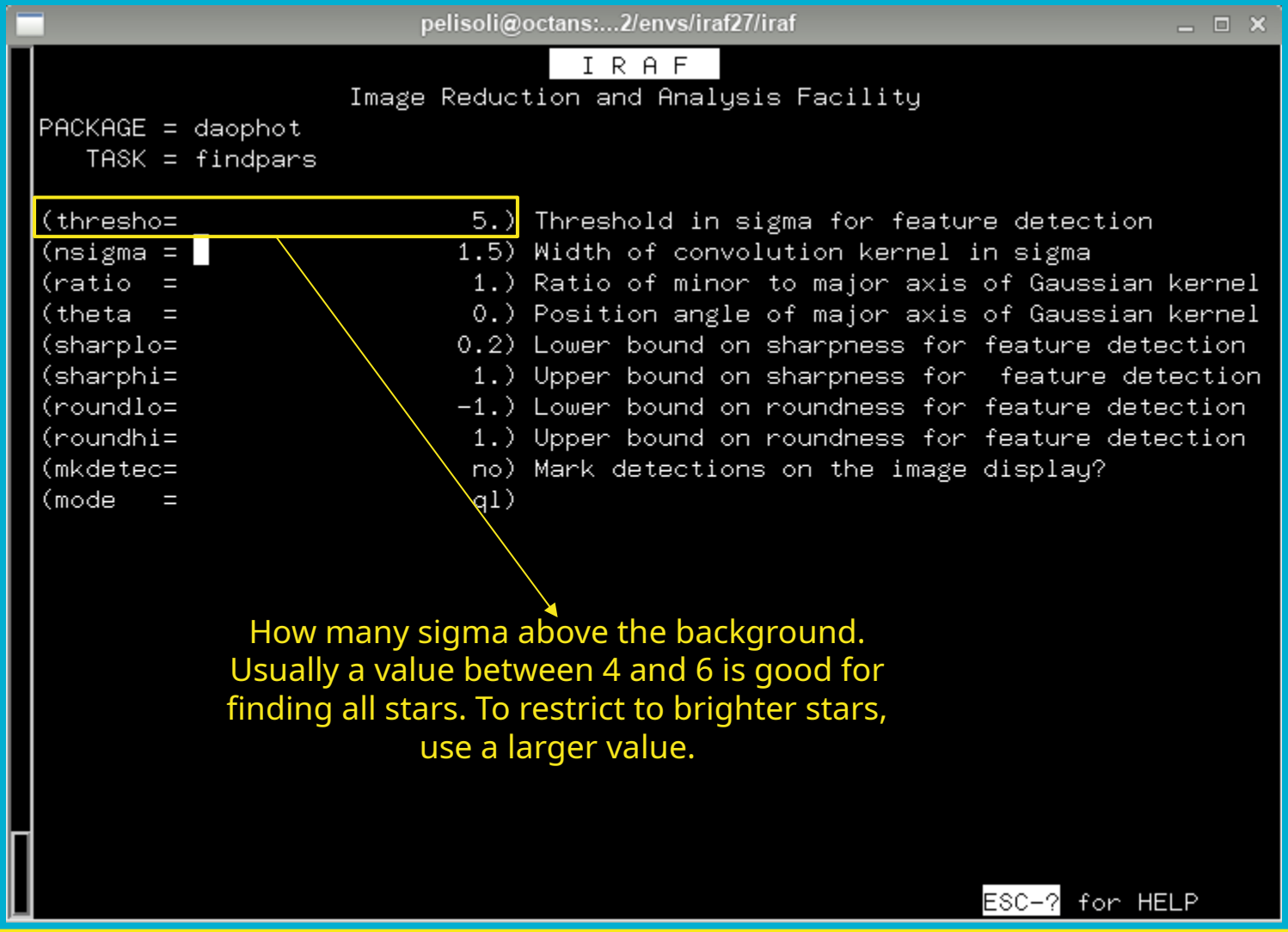


DAOFIND (datapars)

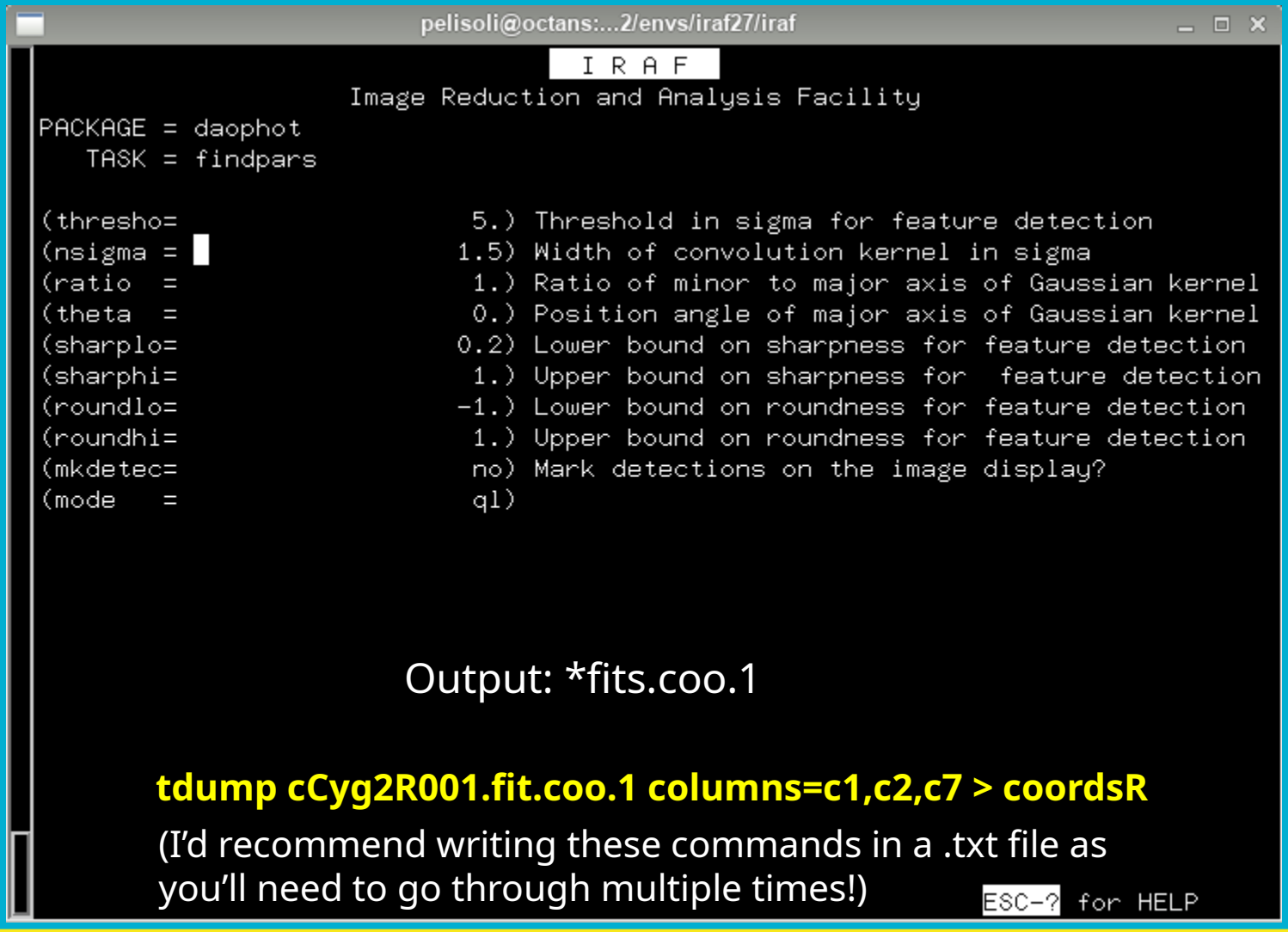
“**:q**” to go back



DAOFIND (findpars)



DAOFIND (findpars)



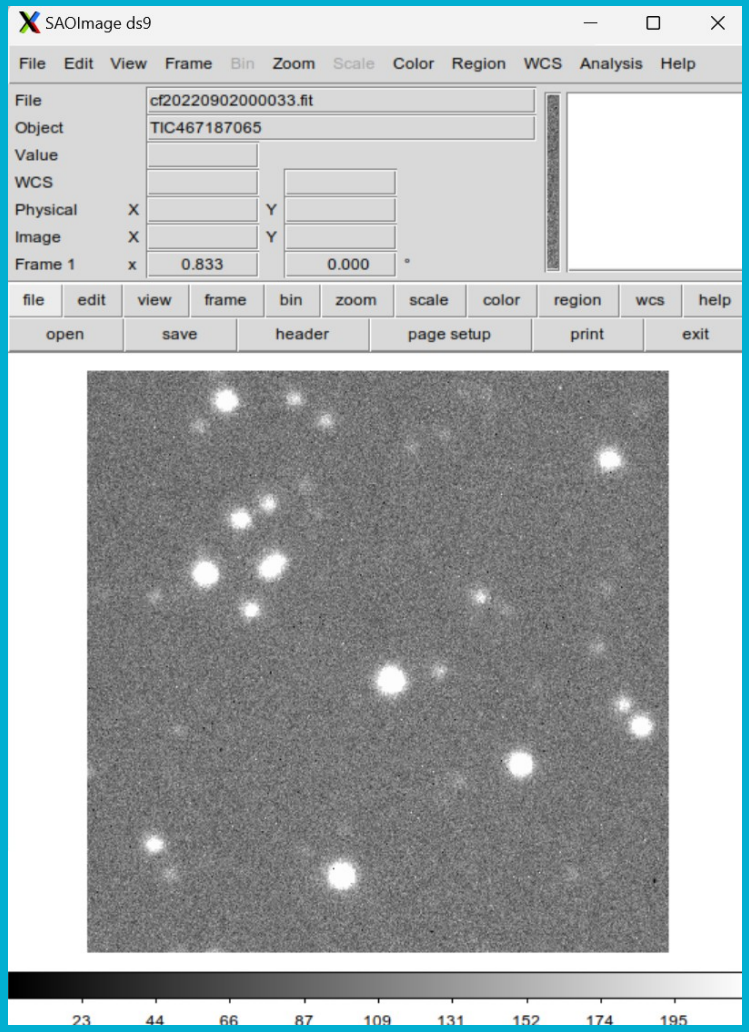
Output: *fits.coo.1

tdump cCyg2R001.fit.coo.1 columns=c1,c2,c7 > coordsR

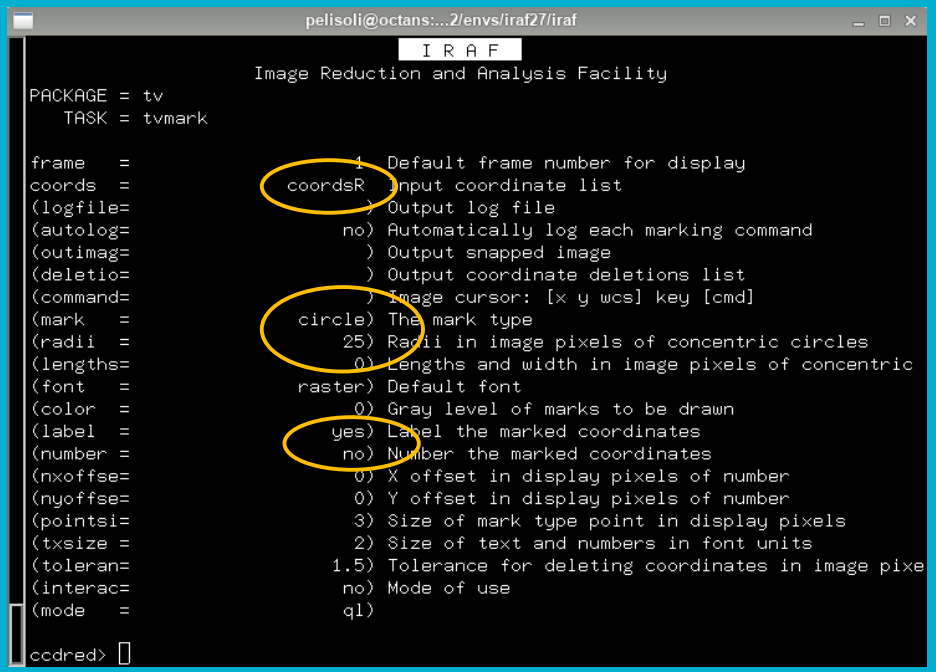
(I'd recommend writing these commands in a .txt file as you'll need to go through multiple times!)

DAOFIND (tvmark: to display the found stars)

display cObject...

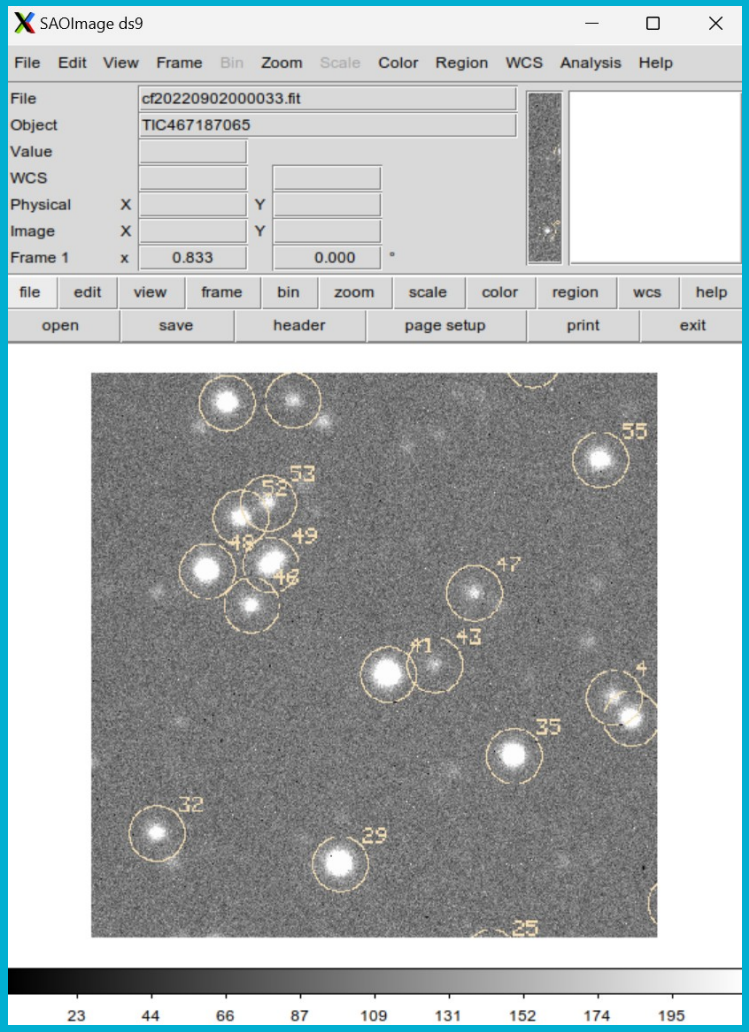


epar tvmark
:go

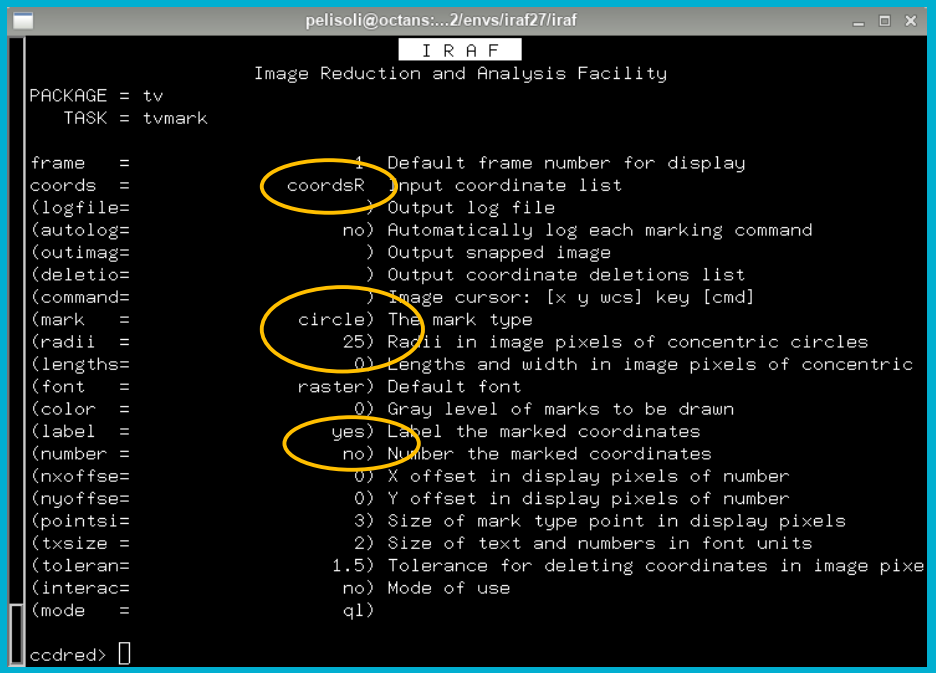


DAOFIND (tvmark: to display the found stars)

display cObject...

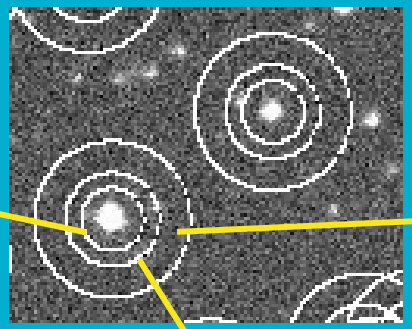


epar tvmark
:go



Photometry

- tvmark is also useful to help us define the aperture, annulus, and dannulus



Aperture (radii): where the flux of the star will be measured.
Usually ~2.5 x FWHM

Dannulus: width of the ring to count the background.
~5-10 pixels

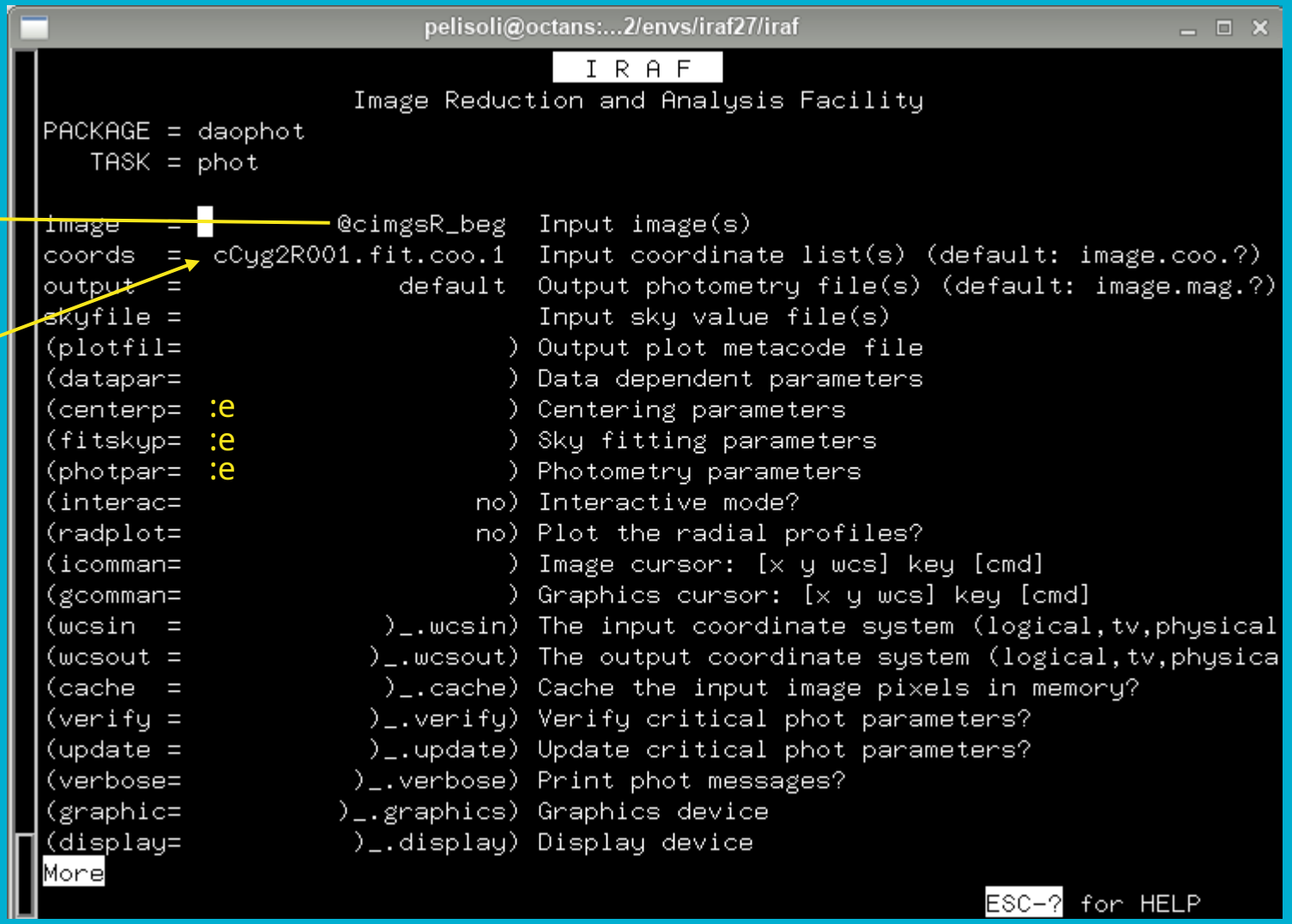
Annulus (radii): distance at which to start counting the background.
At least 2.5 x FWHM
~4 x FWHM in our example

* For a Gaussian distribution:
FWHM = 2.35σ
99.99% of the light is contained within
4σ = 1.7FWHM

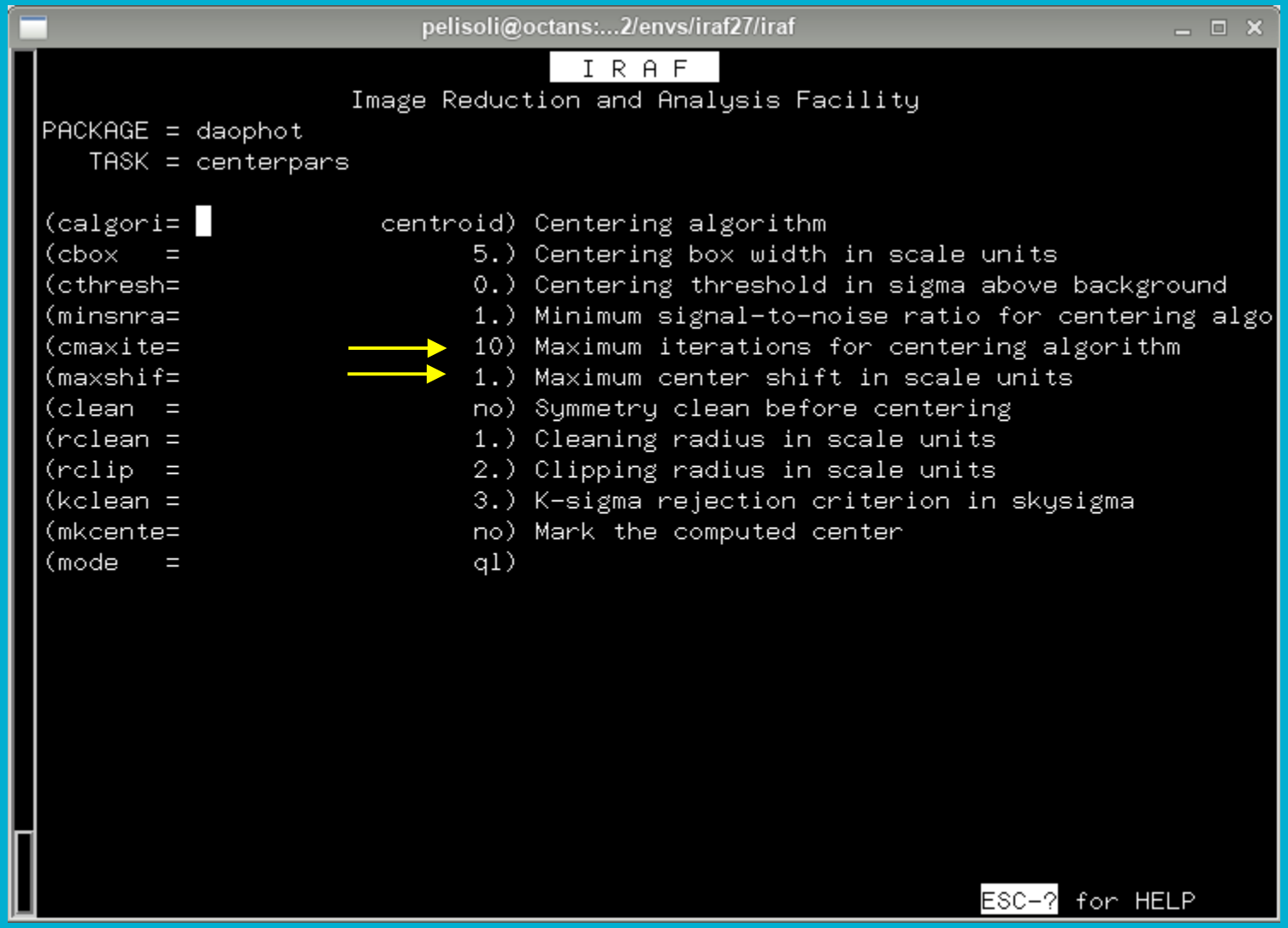
DAOPHOT – epar phot

List of reduced R (or V/I/R) images.

NB!
One coordinate file for all frames

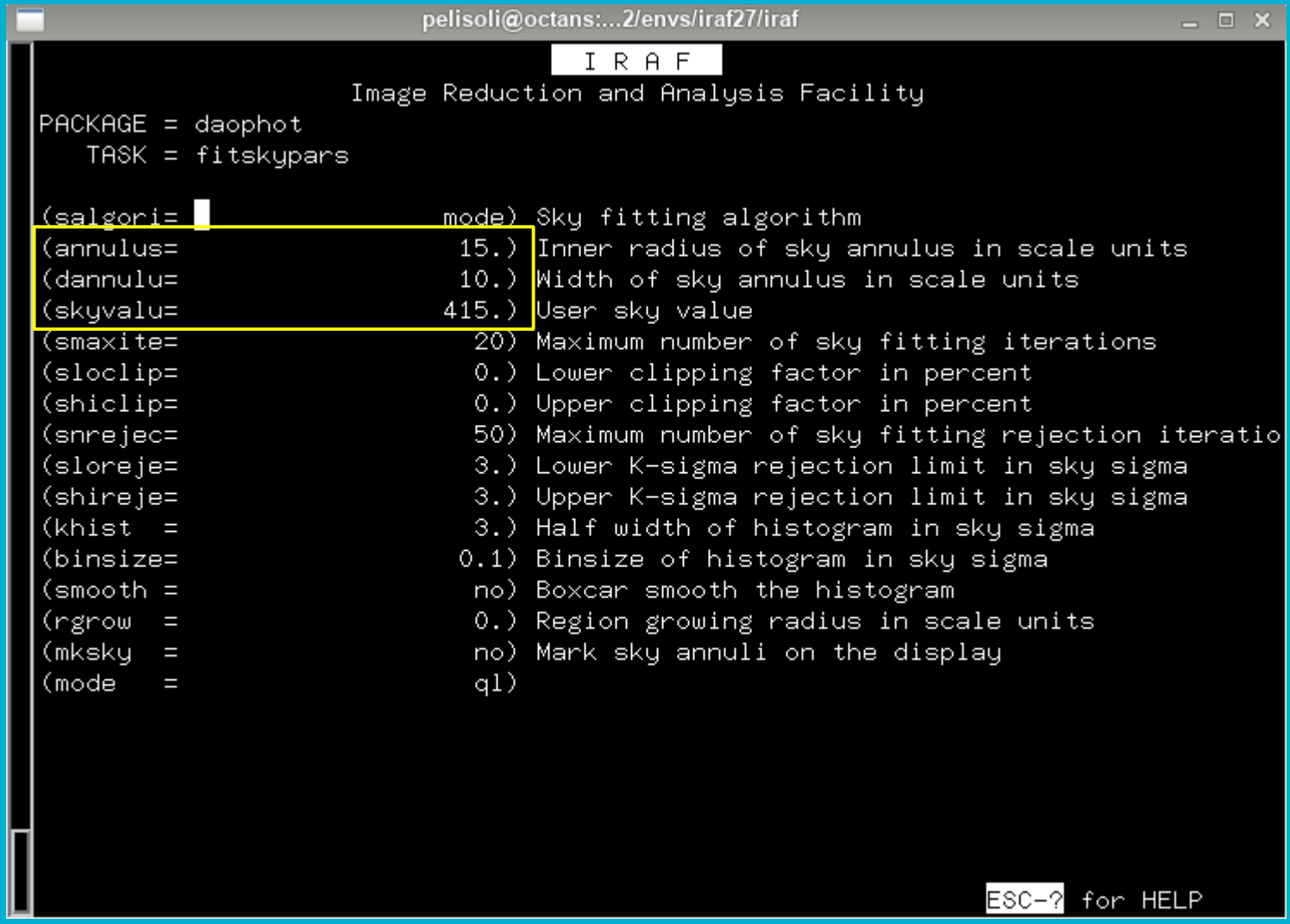


DAOPHOT (centerpars)

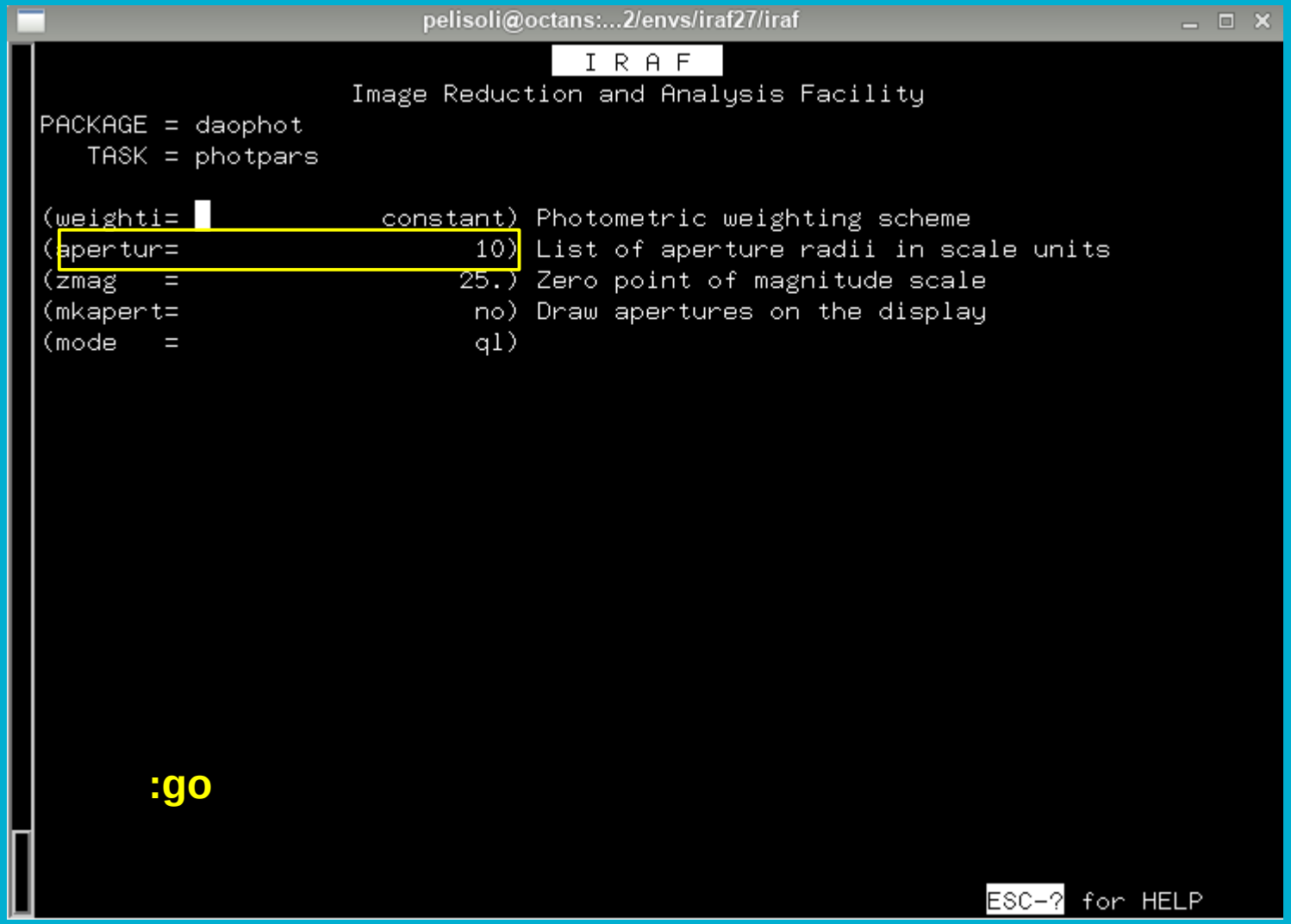


PHOT (fitskypars)

Your data specific!

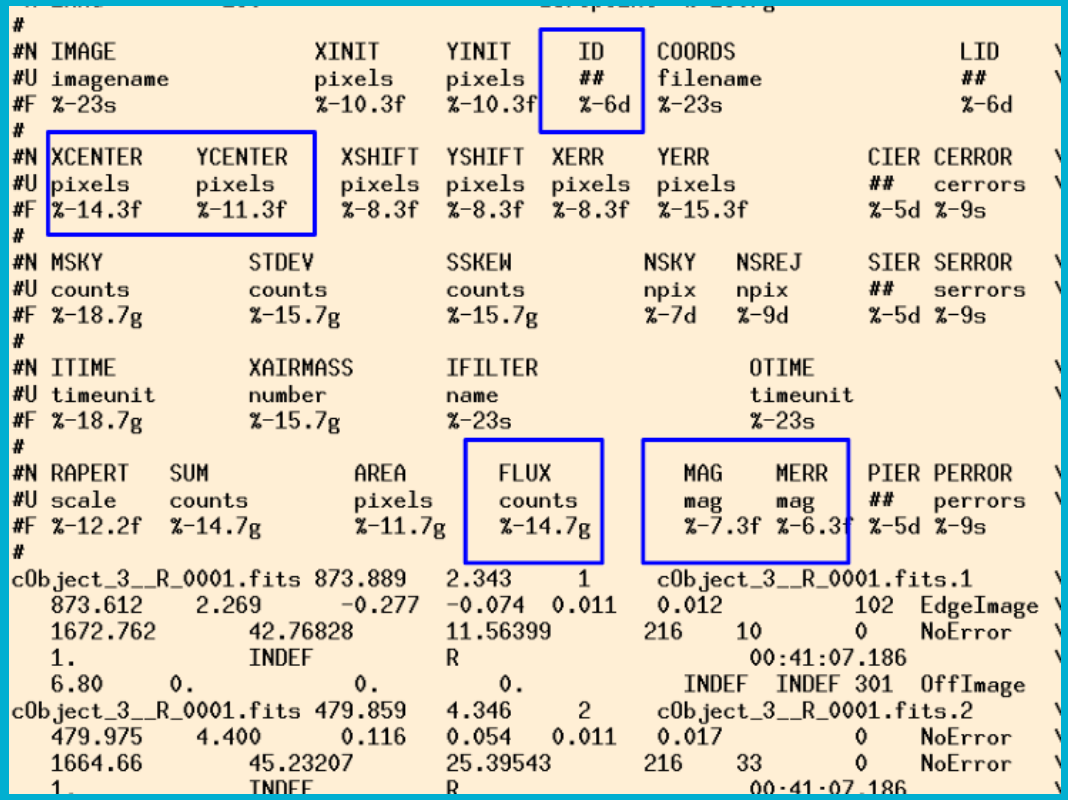


PHOT


pelisoli@octans:...2/envs/iraf27/iraf
I R A F
Image Reduction and Analysis Facility
PACKAGE = daophot
TASK = photpars
(weighti= constant) Photometric weighting scheme
(aperture= 10) List of aperture radii in scale units
(zmag = 25.) Zero point of magnitude scale
(mkapert= no) Draw apertures on the display
(mode = ql)
:go
ESC-? for HELP

PHOT
(outputs)

- Text files:
  ***.fits.coo.1.mag.1**
  or ***mag.2** if done twice



```
#
#N IMAGE                XINIT     YINIT     ID    COORDS                  LID     \
#U imagename            pixels    pixels    ##    filename                ##      \
#F %-23s                %-10.3f   %-10.3f   %-6d  %-23s                   %-6d
#
#N XCENTER    YCENTER   XSHIFT    YSHIFT    XERR     YERR          CIER CERROR   \
#U pixels     pixels    pixels    pixels    pixels   pixels        ##   cerrors  \
#F %-14.3f    %-11.3f   %-8.3f    %-8.3f    %-8.3f   %-15.3f       %-5d %-9s
#
#N MSKY          STDEV          SSKEW          NSKY   NSREJ     SIER SERROR   \
#U counts        counts         counts         npix   npix      ##   serrors  \
#F %-18.7g       %-15.7g        %-15.7g        %-7d   %-9d      %-5d %-9s
#
#N ITIME         XAIRMASS       IFILTER                 OTIME                 \
#U timeunit      number         name                    timeunit              \
#F %-18.7g       %-15.7g        %-23s                   %-23s
#
#N RAPERT   SUM           AREA        FLUX        MAG      MERR     PIER PERROR   \
#U scale    counts        pixels      counts      mag      mag      ##   perrors  \
#F %-12.2f  %-14.7g       %-11.7g     %-14.7g     %-7.3f   %-6.3f   %-5d %-9s
#
cObject_3__R_0001.fits 873.889   2.343     1      cObject_3__R_0001.fits.1      \
   873.612    2.269     -0.277  -0.074  0.011   0.012          102  EdgeImage \
   1672.762          42.76828        11.56399        216    10       0    NoError   \
   1.                INDEF           R                       00:41:07.186          \
   6.80     0.              0.          0.                INDEF  INDEF 301  OffImage
cObject_3__R_0001.fits 479.859   4.346     2      cObject_3__R_0001.fits.2      \
   479.975    4.400     0.116   0.054   0.011   0.017          0    NoError   \
   1664.66           45.23207        25.39543        216    33       0    NoError   \
   1.                INDEF           R                       00:41:07.186          \
```

IMPORTANT COLUMNS

c4 = star ID

c5 = x coordinate

c6 = y coordinate

c29 = magnitude

c30 = magnitude error

c28= flux.

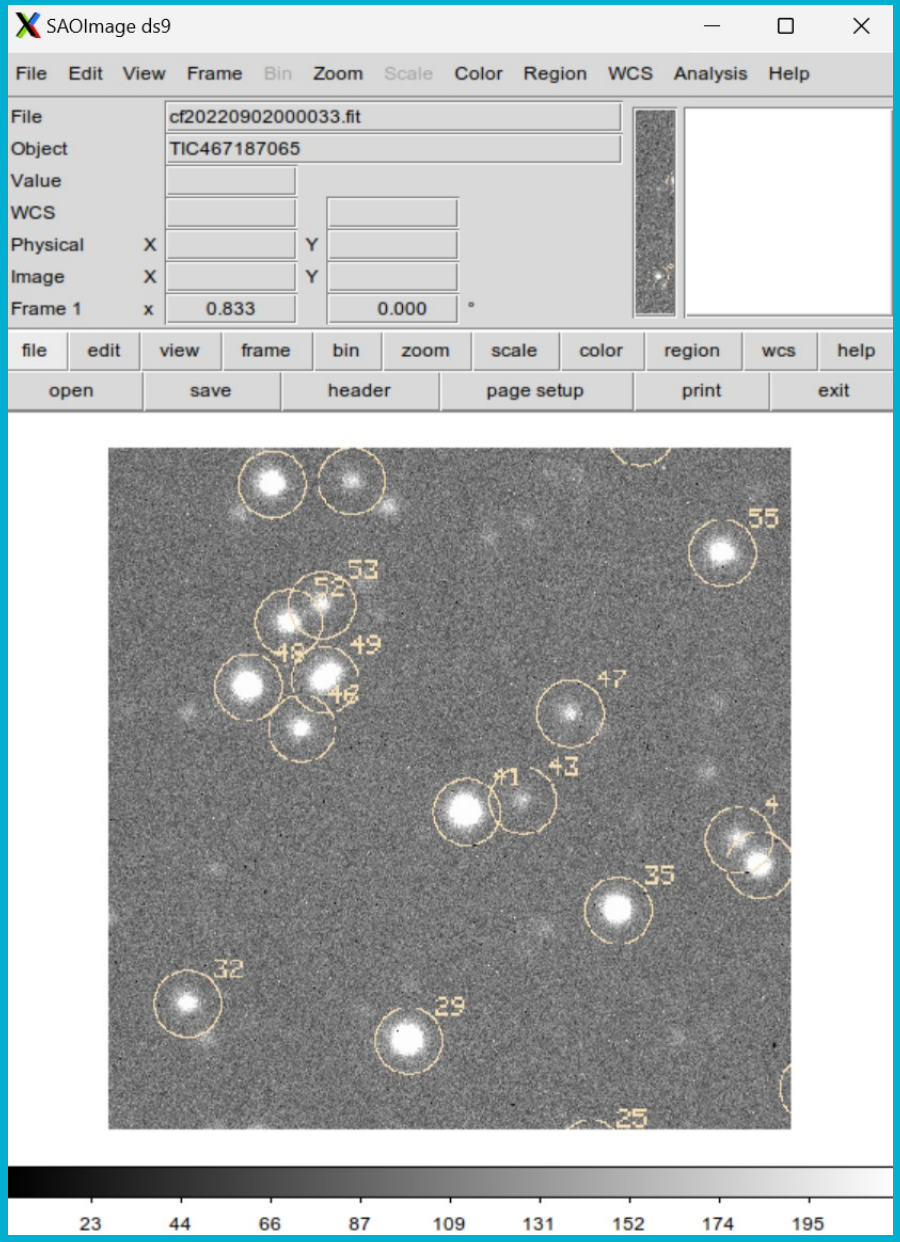
Make a list of photometry files:

ls *R*mag.1 > Rmag_files

txdump @Vmag_files fields=ID,XCENTER,YCENTER,FLUX,MAG,MERR > R_mags

Photometry

- Check the ID of your star and of a few comparison stars with tvmark. https://aladin.u-strasbg.fr/AladinLite/ might be useful to help identify your star.
- Comparison stars are needed to remove background variations from the light curve.



Photometry (more *massaging* of text files)

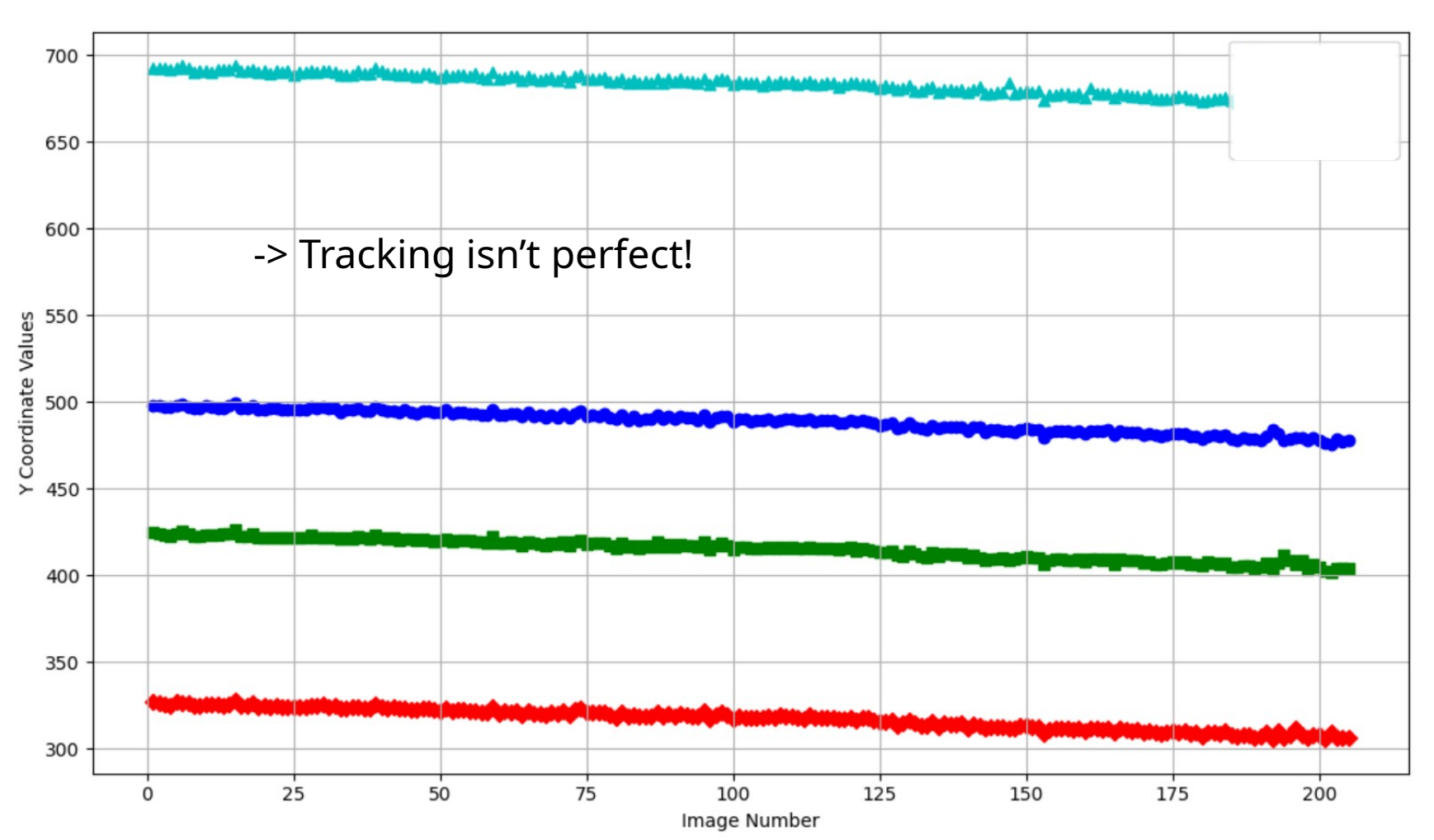
- Copy the photometry of the star and each comparison into separate files.

```
! awk '{if ($1==41) print;}' R_mags > R_star
! awk '{if ($1==43) print;}' R_mags > R_comp1
! awk '{if ($1==55) print;}' R_mags > R_comp2
! awk '{if ($1==29) print;}' R_mags > R_comp3
! awk '{if ($1==32) print;}' R_mags > R_comp4
```

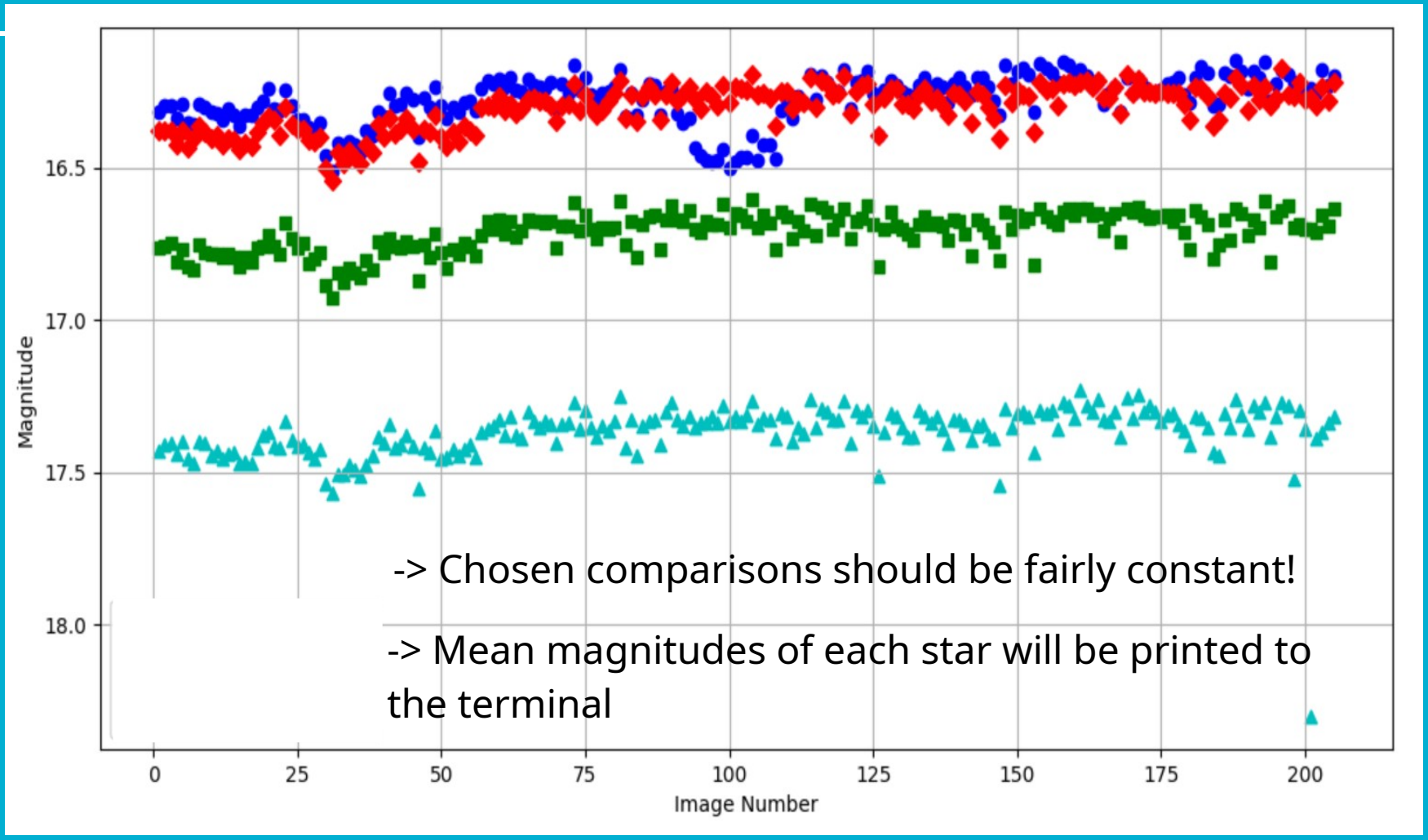
(Replace with correct Ids)

- Plot these files using the provided code: ‘plot_mag_files.py’

Photometry – shifting images



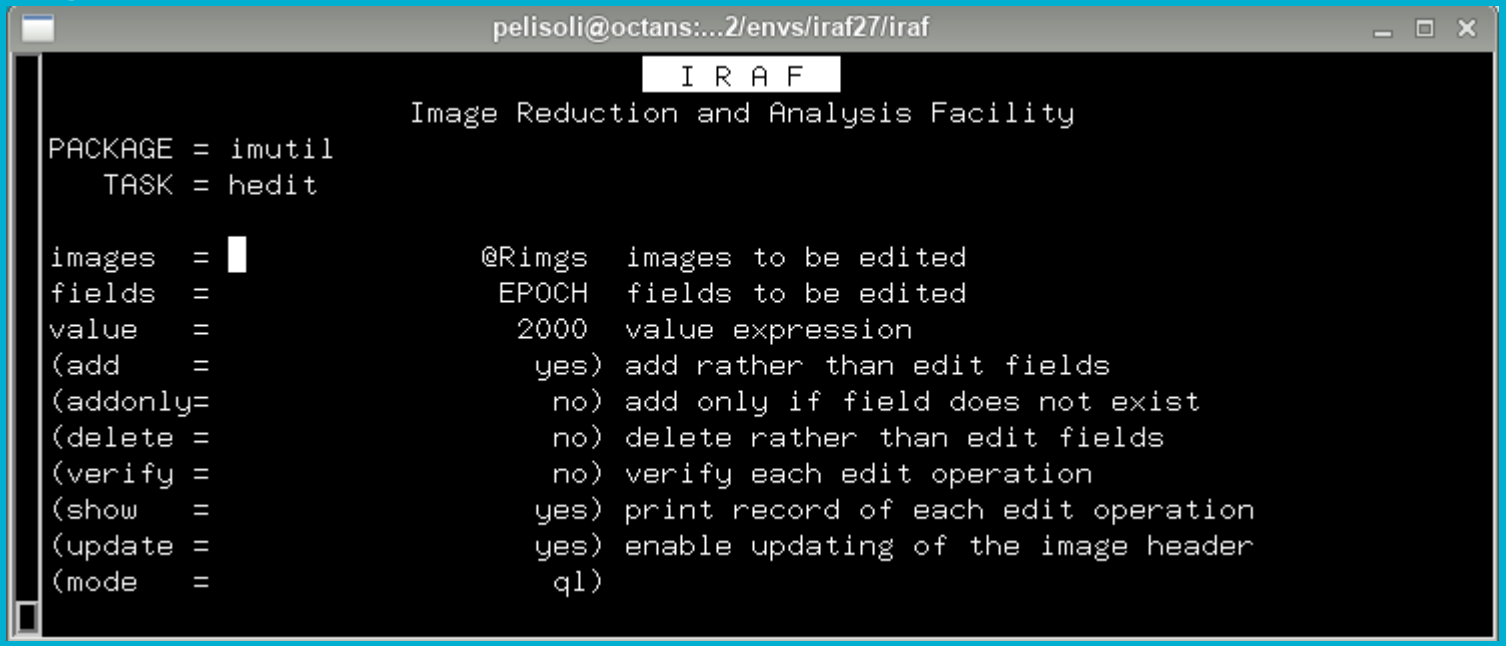
Photometry - magnitudes



Building the light curve

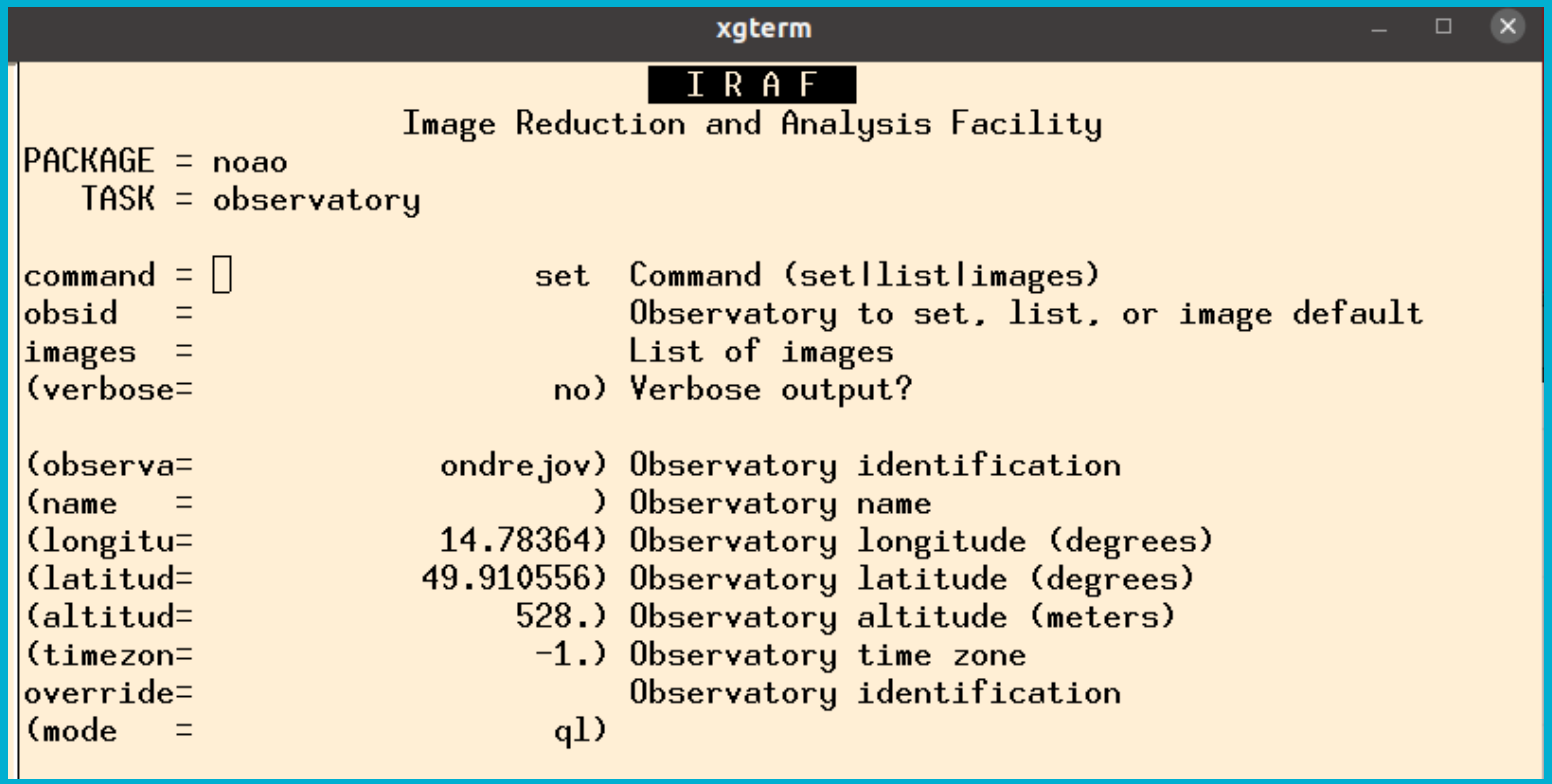
RA and DEC in a format
279.8767083356 (18h:39m:30.4s)
-5.902749998734 (-5d:54m:09.8s)

- To turn our measurements into a light curve, we need the times for each observation. We will use the task **setjd** to obtain that.
- The headers of our images are missing one important information: coordinates (RA, DEC, Epoch). Use the task **hedit** to add those to all images.



Building the light curve

- We also need to set the observatory parameters to be used for setjd. We do that with the task **observatory**:



Exit “ctrl+d” or “:go”

Building the light curve (setjd)

```
het: McDonald Observatory - Hobby-Eberly Telescope
jcdo: Jack C. Davis Observatory, Western Nevada College
lno: Langkawi National Observatory
obspars:  Use parameters from OBSERVATORY task

Observatory identification (ondrejov):
```

pelisoli@octans:...2/envs/iraf27/iraf

```
                                    I R A F
                        Image Reduction and Analysis Facility
PACKAGE = onedspec
   TASK = setjd

images  =                   @Rimgs  Images
(observa=                 obspars) Observatory of observation
(date   =                date-obs) Date of observation keyword
(time   =                      ut) Time of observation keyword
(exposur=                 exptime) Exposure time keyword
(ra     =                      ra) Right ascension (hours) keyword
(dec    =                     dec) Declination (degrees) keyword
(epoch  =                   epoch) Epoch (years) keyword

(jd     =                      jd) Output Julian date keyword
(hjd    =                     hjd) Output Helocentric Julian date keyword
(ljd    =                     ljd) Output local Julian date keyword

(utdate =                     yes) Is observation date UT?
(uttime =                     yes) Is observation time UT?
(listonl=                      no) List only without modifying images?
(mode   =                      ql)

                                                          ESC-? for HELP
```

Hold down the enter key until all images have been done.

setjd > R_jd (R_jd is an output file. Check it!)

Building the light curve

Check your column numbers! Might be different.

- To do differential photometry, we need to normalise the magnitudes of the star and of the comparison stars. First, check what is the average magnitude (6th column):

All the following commands have been compiled in ‘process_lightcurve.sh’!

(**5**: mag column, **6**: mag error column)

- Repeat that for all the comparison stars, and combine them into one file:

```
! paste mag_comp1 mag_comp2 mag_comp3 mag_comp4 > all_comp
```

- Average the comparison stars:

```
! awk '{printf "%7.4f %6.4f\n", ($1+$3+$5+$7)/4.0, sqrt($2*$2+$4*$4+$6*$6+
$8*$8)}' all_comp > mag_comp
```

Building the light curve

Check your column numbers! Might be different.

- To do differential photometry, we need to normalise the magnitudes of the star and of the comparison stars. First, check what is the average magnitude (6th column):

```
! awk '{sum+=$5;n++} END {print sum/n;}' R_star
```

- Then subtract it from each value: replace with calculated average

```
! awk '{printf "%7.4f %6.4f\n", $5-18.7529, $6}' R_star > mag_star
```

(**5**: mag column, **6**: mag error column)

- Repeat that for all the comparison stars, and combine them into one file:

```
! paste mag_comp1 mag_comp2 mag_comp3 mag_comp4 > all_comp
```

- Average the comparison stars:

```
! awk '{printf "%7.4f %6.4f\n", ($1+$3+$5+$7)/4.0, sqrt($2*$2+$4*$4+$6*$6+
$8*$8)}' all_comp > mag_comp
```

Building the light curve

- Combine the magnitudes of the star and the comparison magnitude:

  ! paste mag_star mag_comp > comb_mag

- Subtract the comparison from the star to remove background variations:

  ! awk '{printf "%7.4f %6.4f\n", ($1-$3), sqrt($2*$2+$4*$4)}' comb_mag > diff_mag

- Select the column containing the Heliocentric Julian Date from the file created with setjd:

  awk '!/#/ {print $3}' R_jd > R_hjd

  (Type this in a regular terminal. Does not work in IRAF)

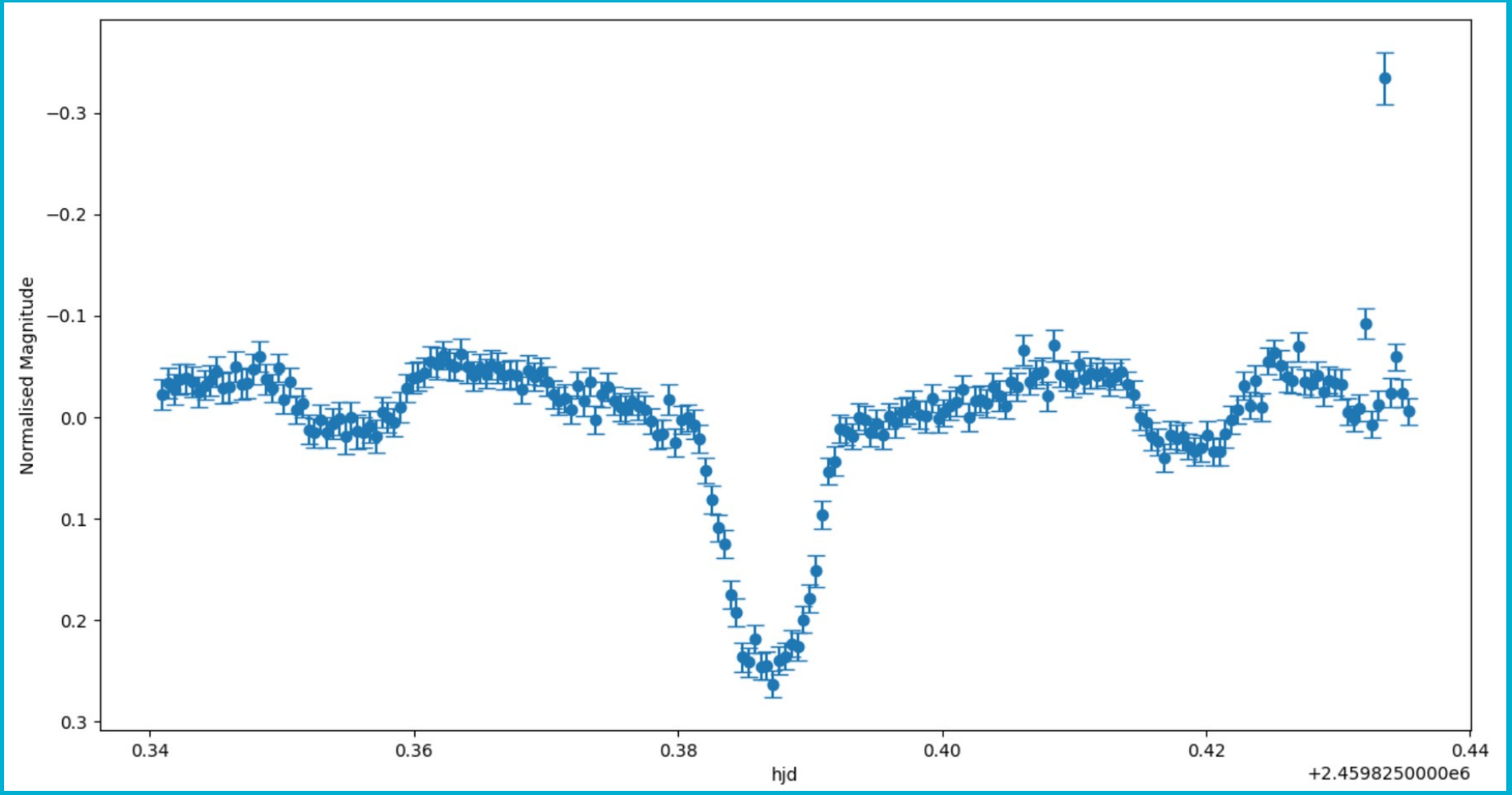
- Combine that with the magnitude to obtain the lightcurve:

  ! paste R_hjd diff_mag > R_lightcurve

Voilà! Now you have a light curve.

Repeat the same for the other filter.

Light curve – ta da!



To be continued in the light curve analysis starting Friday (photometry group only)

Photometry – summary

- Create master files for bias, flat, and dark (zerocombine, flatcombine, darkcombine).
- Reduce the science images using ccdproc.
- Measure sky and FWHM with imexamine.
- Use the dask daofind to find the stars; do not forget to change the datapars according to your measurements, and set the threshold in findpars.
- Use the task phot to do the photometry; do not forget to update centerpars, fitskypars and photpars.
- Check ID for your star and comparison stars using display and tvmark.
- Inspect the coordinates for the star and comparison stars to guarantee there was no misidentification.
- Inspect the magnitudes of the comparison stars; they should be fairly constant.
- Use observatory and setjd to obtain the times of observation.
- Paste the times and differential magnitude (star - averaged comparison) into one file to obtain the light curve.