NIR Image Reduction of NICFPS APO Data of SACS X-Ray Detected Galaxy Clusters

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What is a Galaxy Cluster?

- A structure that has hundred to thousands of galaxies that are together through gravity that have the mass of around 10^14 solar masses.
- Mostly made up of dark matter, hot gases, and stars/galaxies.

https://www.universetoday.com/30522/galaxy-cluster/

Why? And Where we are getting the data

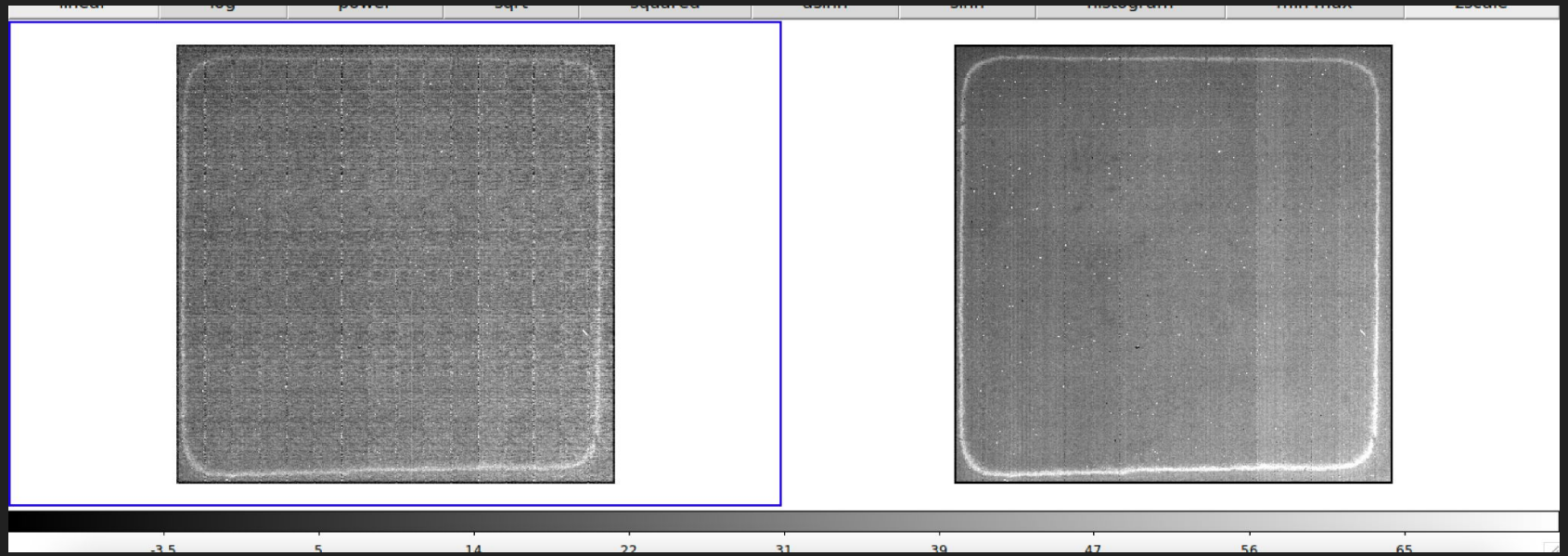
- Learn about how the galaxy cluster formation
- To learn more about galaxy formation, and evolution
- Find out more about dark matter.

Where?

- Apache Point Observatory
- APR (Astrophysical Research Consortium) a 3.5 meter telescope
- The telescope uses a NICFPS. NICFPS is a near infrared camera and Fabry Perot Spectrometer.

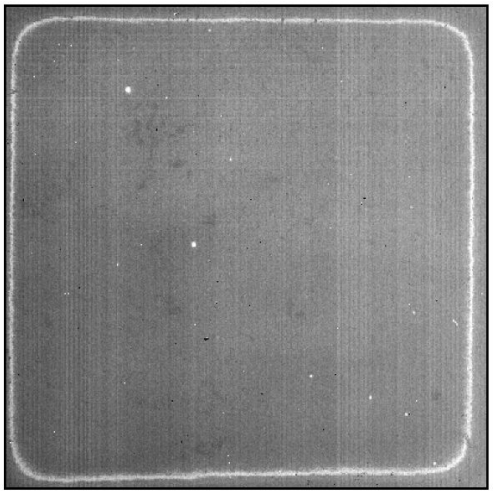
Dark Combine

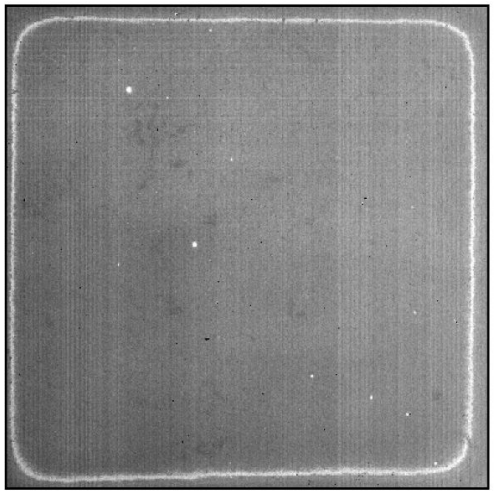
- IRAF = General Image Reduction and Analysis
- Dark frames
- Typically around 10-20 images per combine.



Correcting Dark using ccdproc

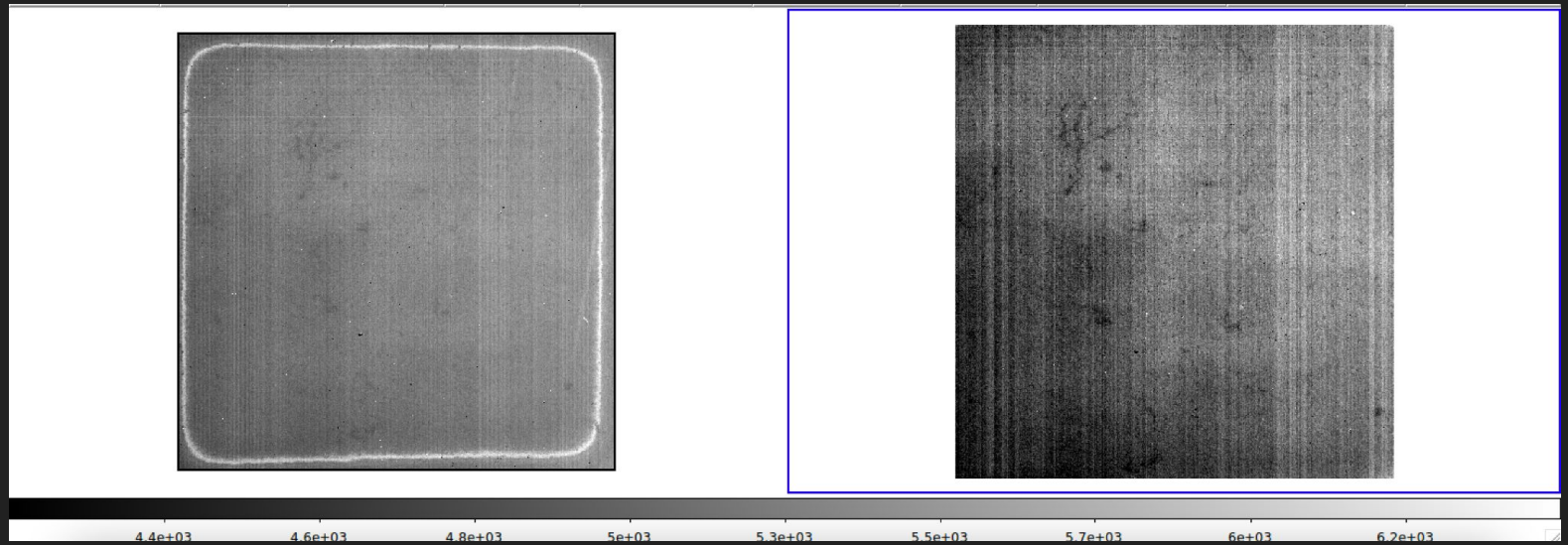
- In this process, we are removing the dark current and we subtract the combined dark frames.





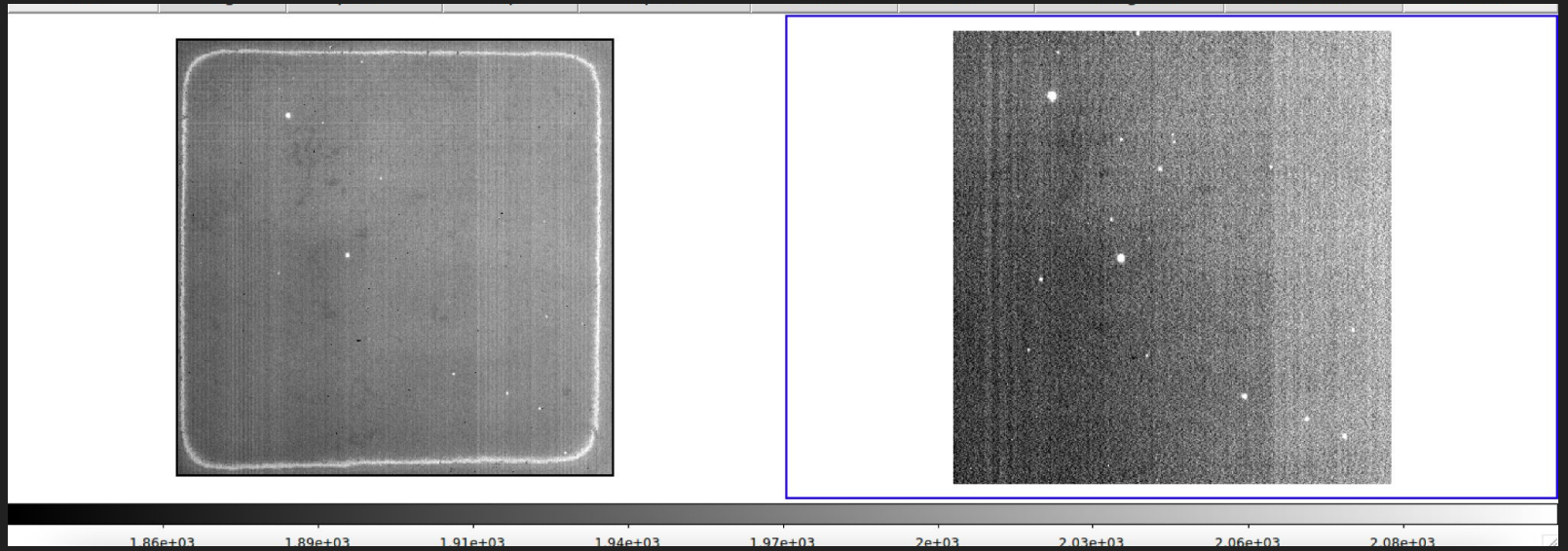
Flat Combine

- Flat images/flat combine
  - Remove the dark shadows caused by dust motes
- Minimum number of files is 4 to combine but typically we have at least 10 files.



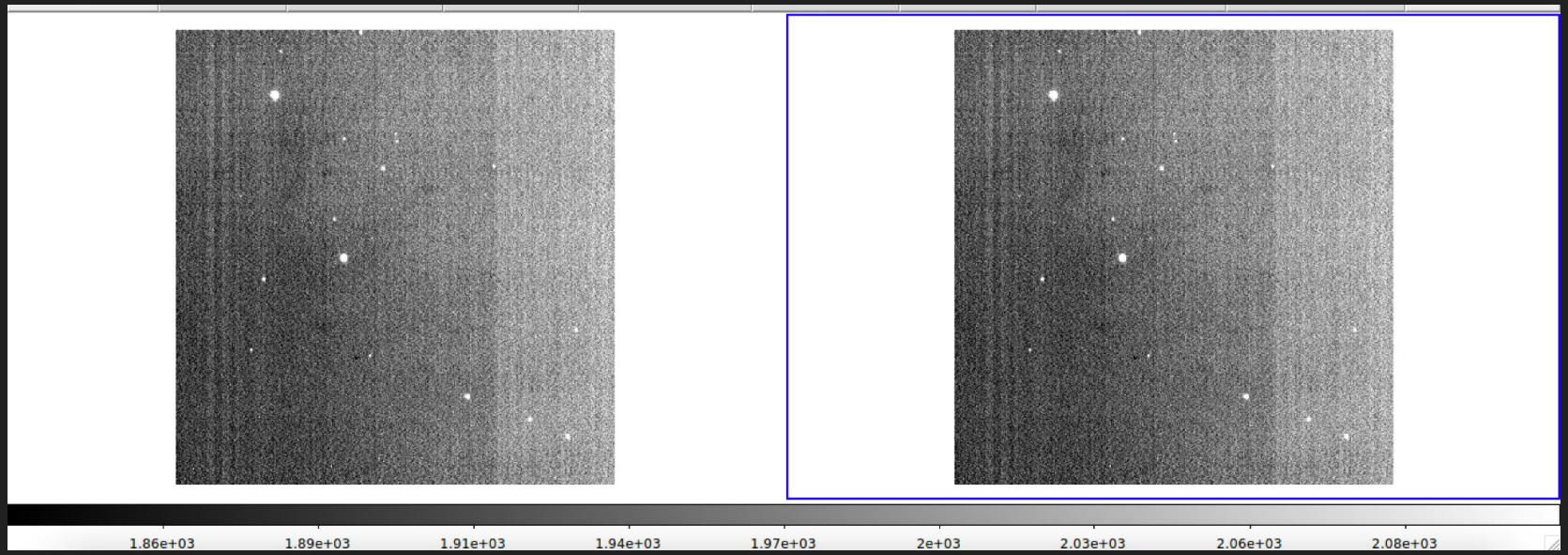
Flat Correction Using ccdproc

- Normalized the image based on the combined flat frame and take off the edges.



Craverage

- Remove all of the cosmic rays in the images



Starfind

- In this program of iraf, it is finding all of the stars and tells you where to find them.

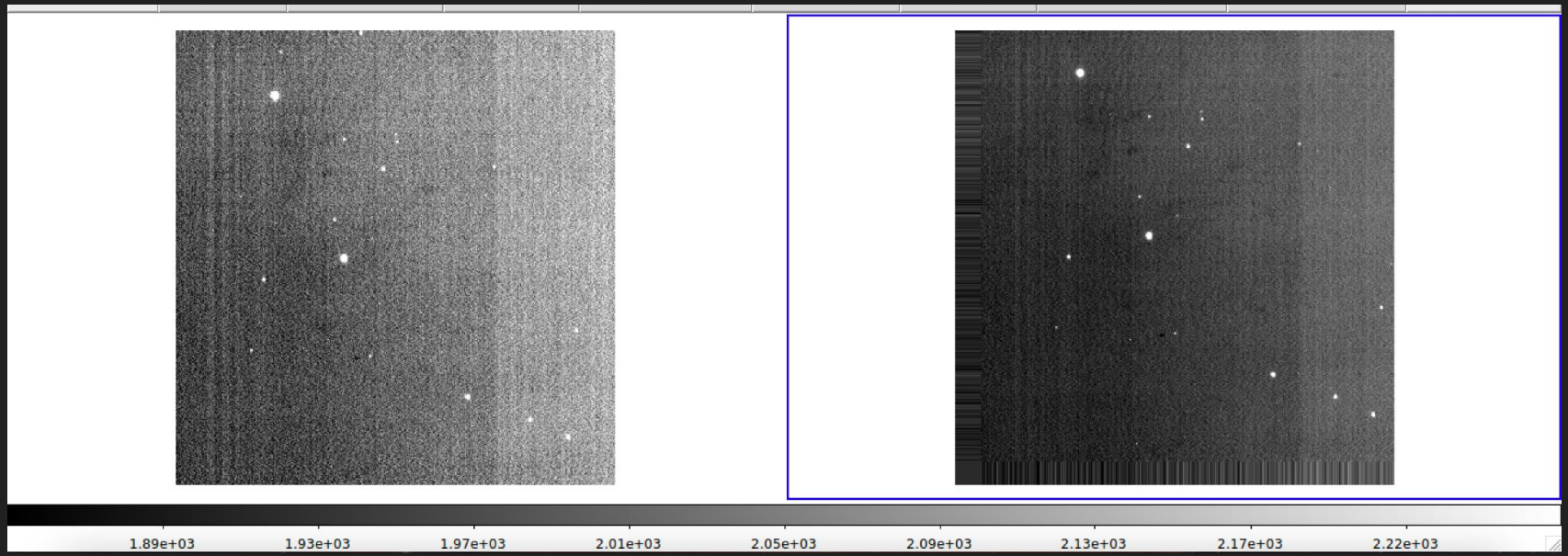
```
# Image: cfd_nicfps-d3-run9.0683.fits  Output: cfd_nicfps-d3-run9.0683.fits.obj.1
# Detection Parameters
#     Hwhmpsf: 5.000 (pixels)  Threshold: 100. (ADU)  Npixmin: 5
#     Datamin: INDEF (ADU)  Datamax: INDEF (ADU)
#     Fradius: 2.5 (HWHM)  Sepmin: 5. (HWHM)
# Selection Parameters
#     Maglo: INDEF  Maghi: INDEF
#     Roundlo: 0.000 Roundhi: 0.200
#     Sharplo: 0.500  Sharphi: 2.000
# Columns
#     1: X      2: Y
#     3: Wx     4: Wy
#     5: Mag    6: Area
#     7: Hwhm   8: Roundness
#     9: Pa    10: Sharpness

    787.780    96.021    103.6249   71.955042  -12.06    328   3.23  0.041  153.5   0.646      1
    711.743   131.556   103.60633   71.957736  -11.86    303   3.15  0.066   91.0   0.629      2
    586.618   176.568   103.57577   71.961147  -12.54    359   2.83  0.121   97.9   0.565      3
    390.843   258.282   103.52792   71.967328  -10.18    255   5.69  0.056   96.0   1.138      4
    152.440   270.281   103.46963   71.968225   -9.94    242   5.58  0.090   37.5   1.117      5
    804.146   310.718   103.62898   71.971267  -11.06    249   3.59  0.024   67.8   0.717      6
    176.906   411.909   103.47558   71.978931  -11.38    333   4.07  0.086  106.7   0.815      7
    319.635   533.118   103.51048   71.988099  -10.39    276   5.01  0.117    1.7   1.002      8
    416.096   633.923   103.53409   71.995719  -11.28    321   3.87  0.027  155.7   0.773      9
    641.306   639.180   103.58924   71.996109  -10.07    257   5.60  0.142   94.7   1.121     10
    444.216   688.189   103.54098   71.999821  -10.38    294   5.51  0.152   84.1   1.102     11
    339.096   693.754   103.51524   72.000241  -10.58    297   5.06  0.118   80.1   1.013     12
    199.902   781.069   103.48113   72.006834  -14.61    449   2.77  0.143   95.8   0.554     13
    211.739   869.148   103.48401   72.013492  -10.49    274   4.91  0.112   70.6   0.982     14
~
~
~
~
```

Using python to find the offset of the two images

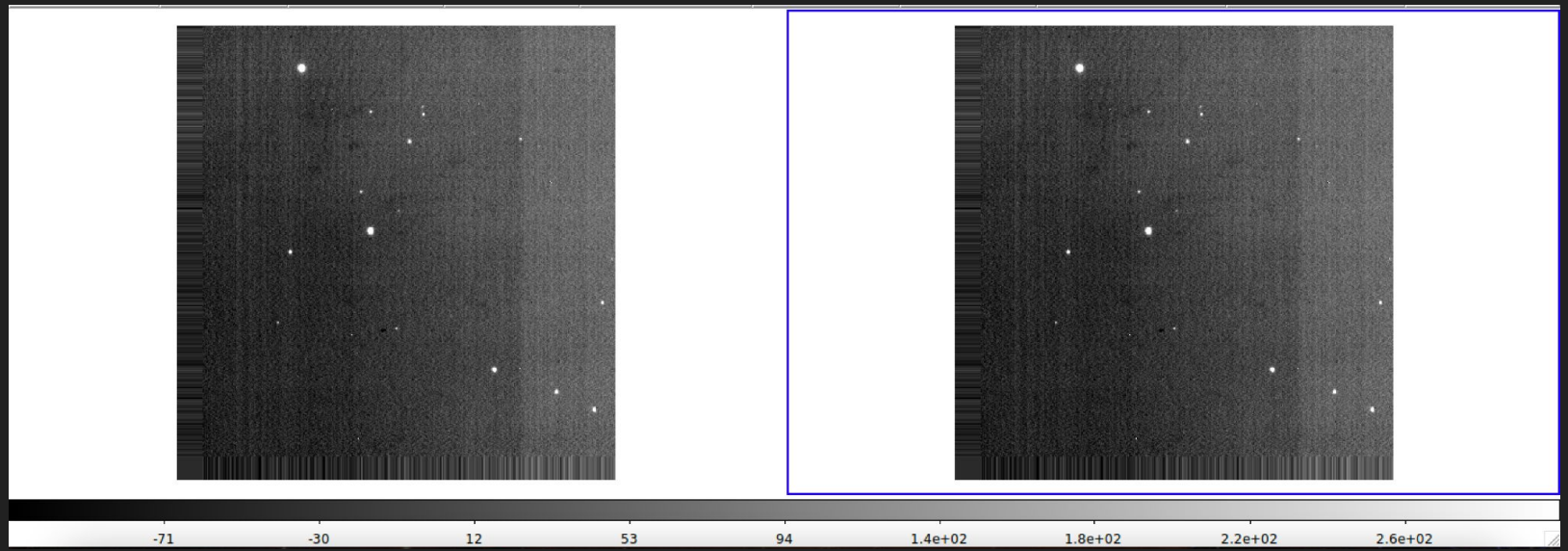
- In this program we took the two images and matched the stars and found the offset from the two images.
- It finds all of the offsets so that we can shift the images in the next step.

Before The Images are Shifted.



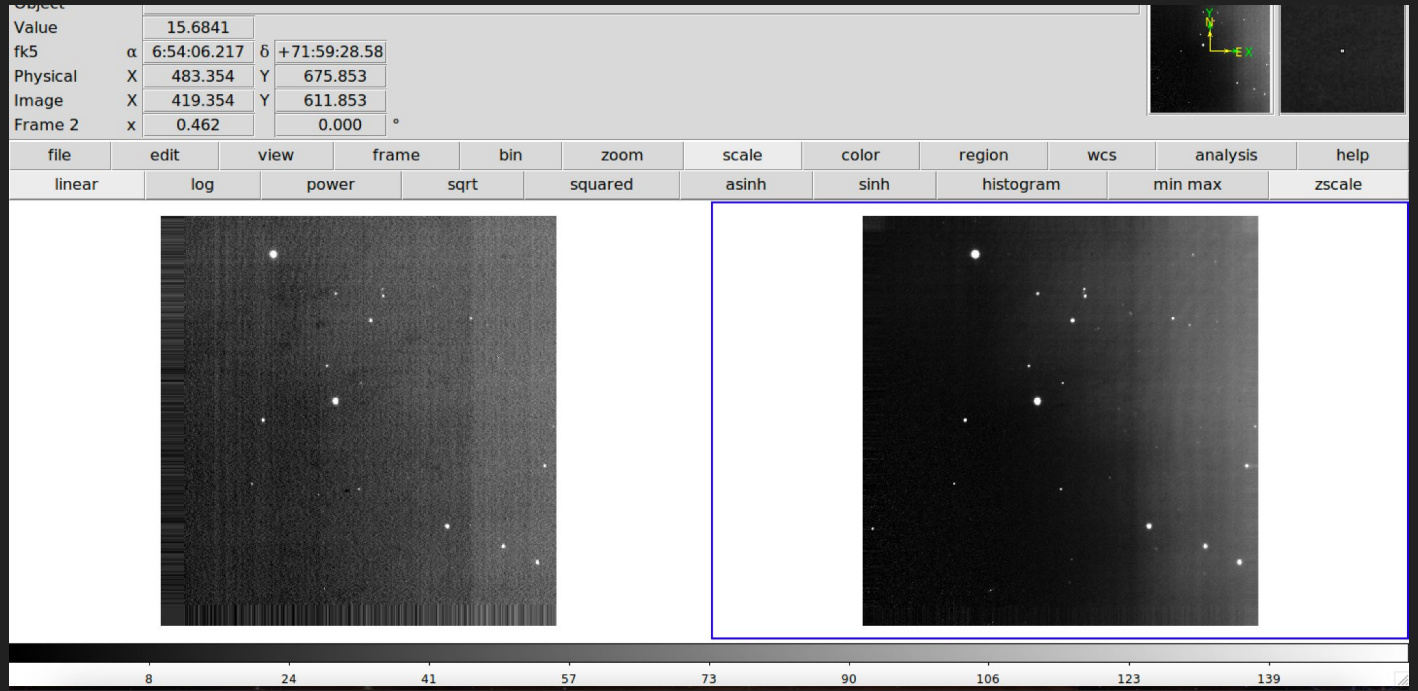
Shifted images

- In this process, we confirm that all the images are shifted to the correct offset.

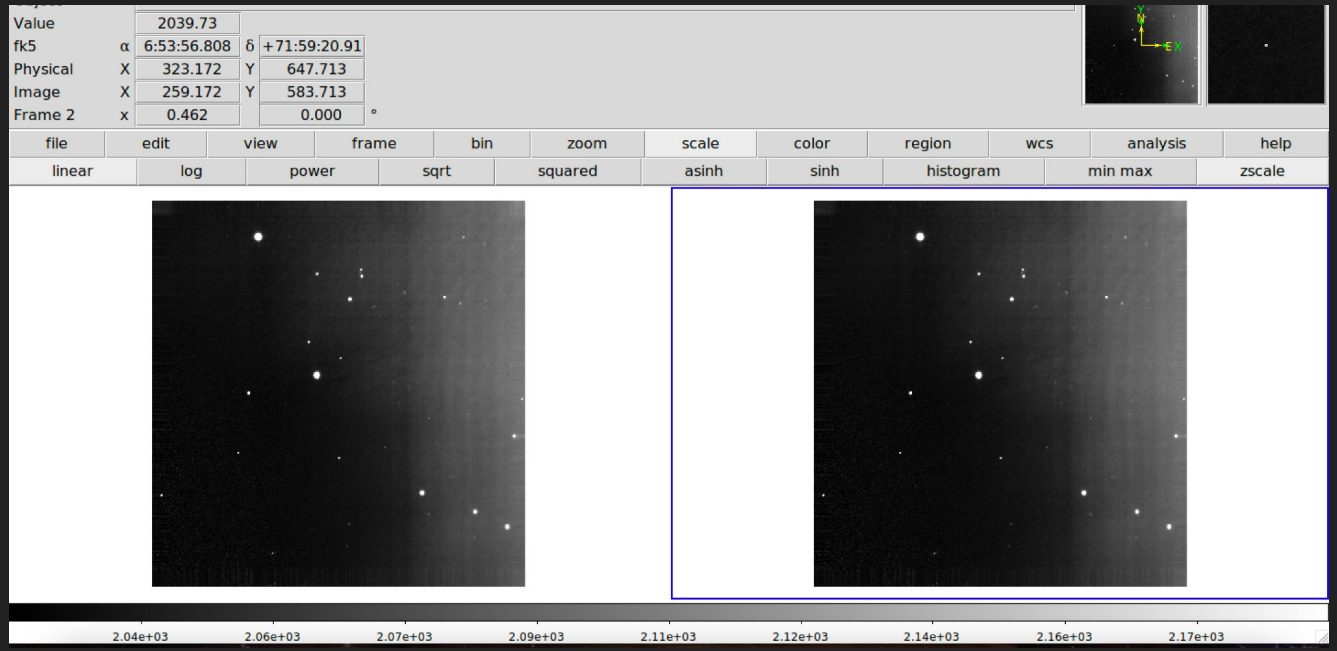


Median combine and taking away the sky value

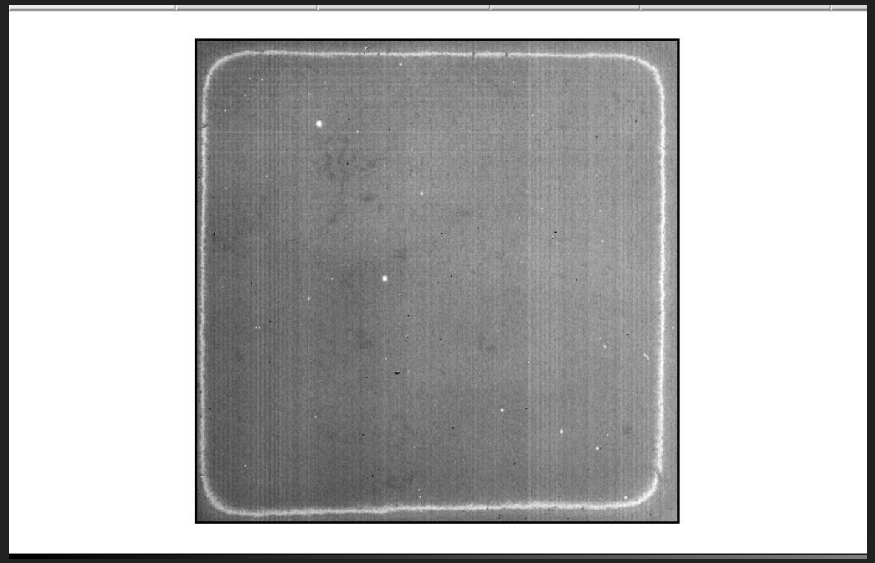
- Using a median combine for the target images.



Returning the skyvalue



Final Results



Reference Page

https://www.apo.nmsu.edu/arc35m/Instruments/NICFPS/

https://iraf-community.github.io/doc/beguide.pdf

https://www.apo.nmsu.edu/

https://www.universetoday.com/30522/galaxy-cluster/