Lab 2

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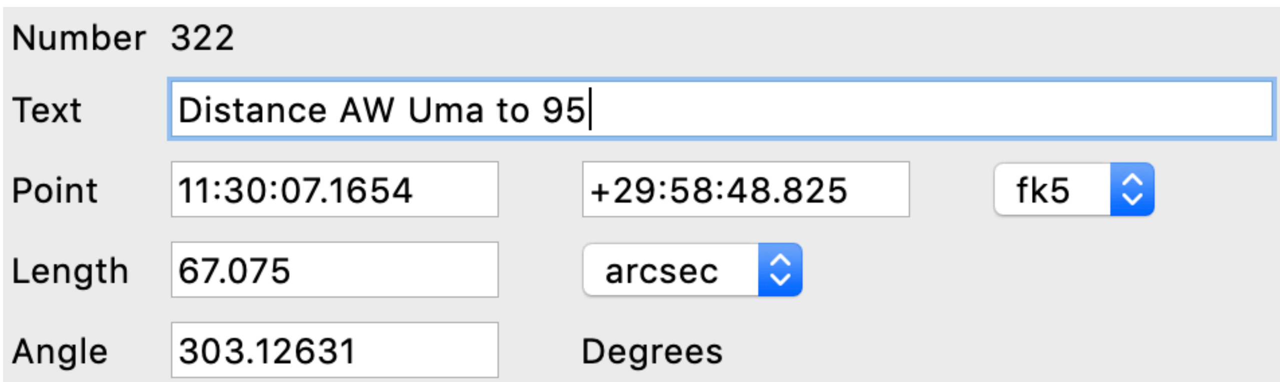
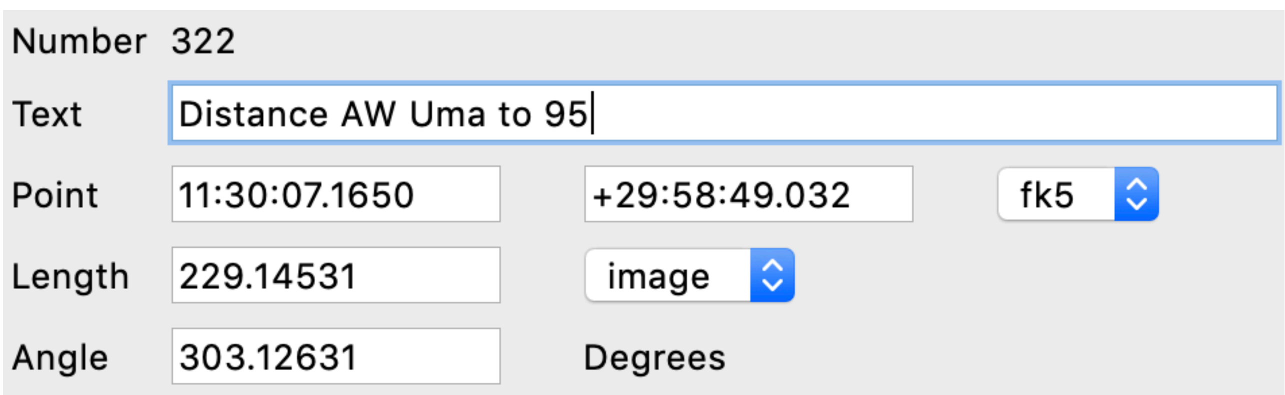
Plate Scale

Measurement of the plate scale was done using an image of AW Uma. The image was overlayed with the USNO catalog. A vector was measured from AW UMA to a nearby comparison star. A line was measured between those same stars.





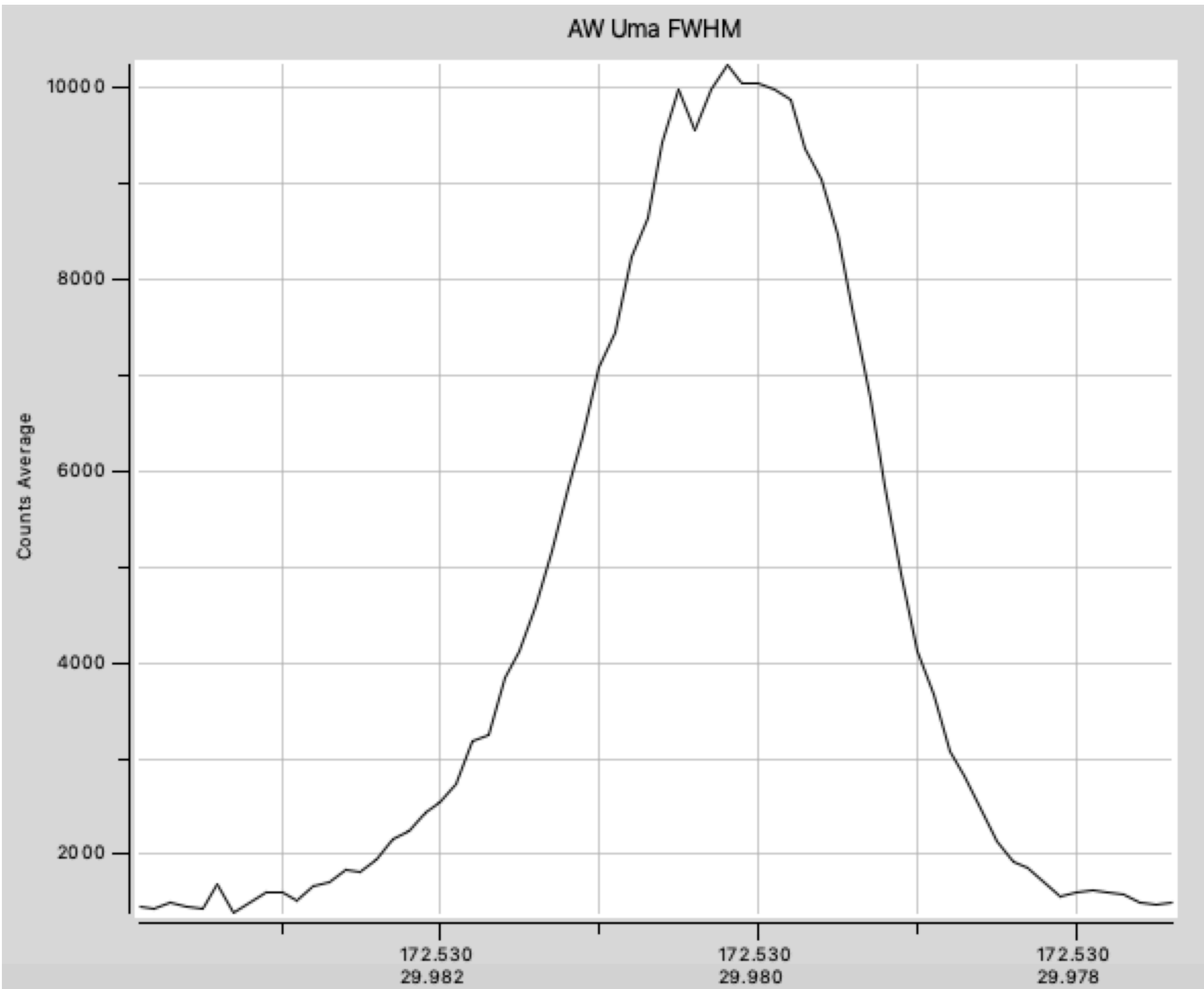
The plate scale is the angle divided by the line length in pixels. Its units are arc seconds per pixel.

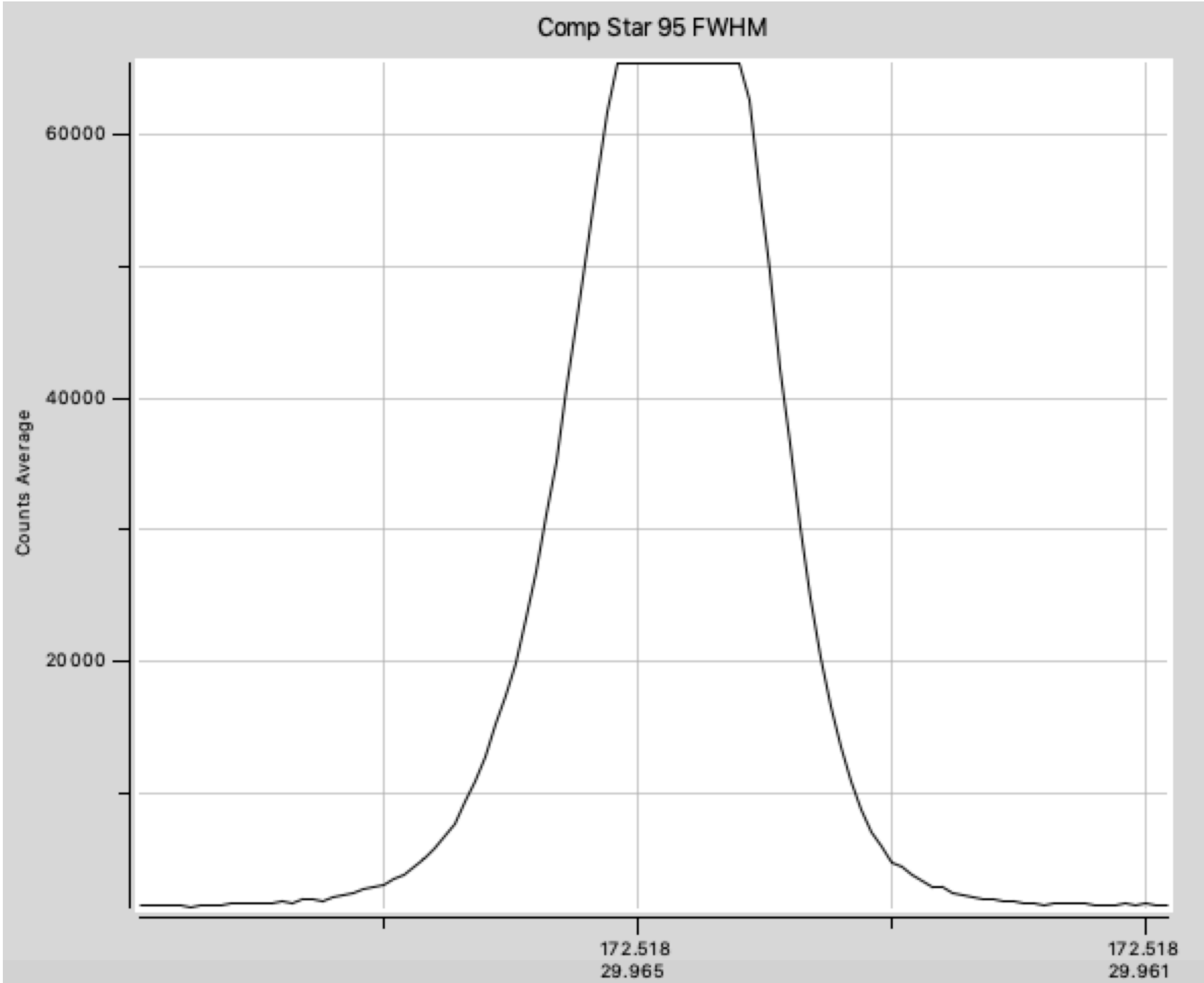
In [11]:
```
Arcsecs = 67.075
Pixels = 229.14531
PlateScale = Arcsecs/Pixels

print("Plate Scale = {:.4f} arcsec/pixel".format(PlateScale))

#print("gain: {:.3f}, readnoise: {:.3f}".format(gain, readnoise))


```

```
Plate Scale = 0.2927 arcsec/pixel
```

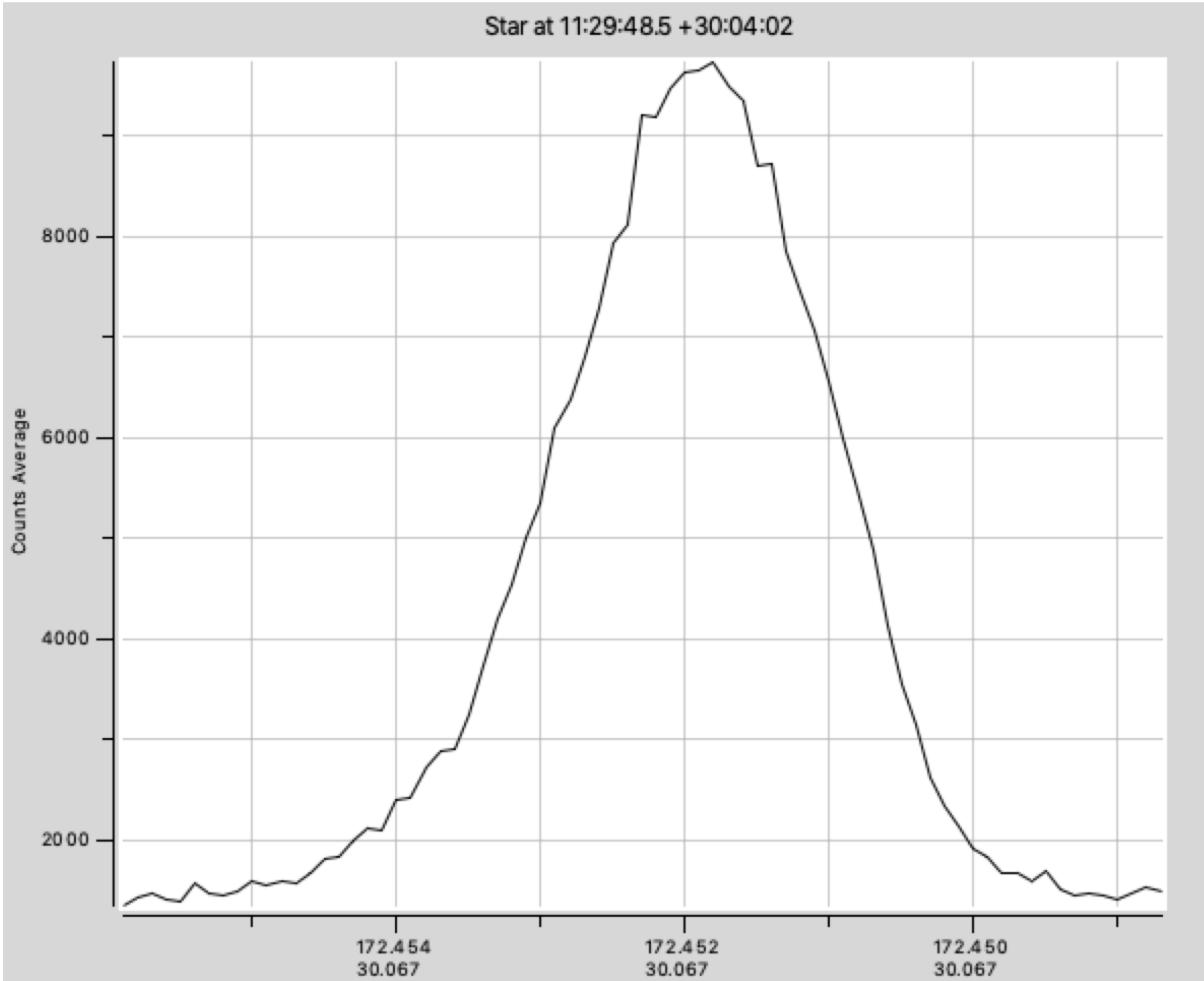
Seeing / FWHM

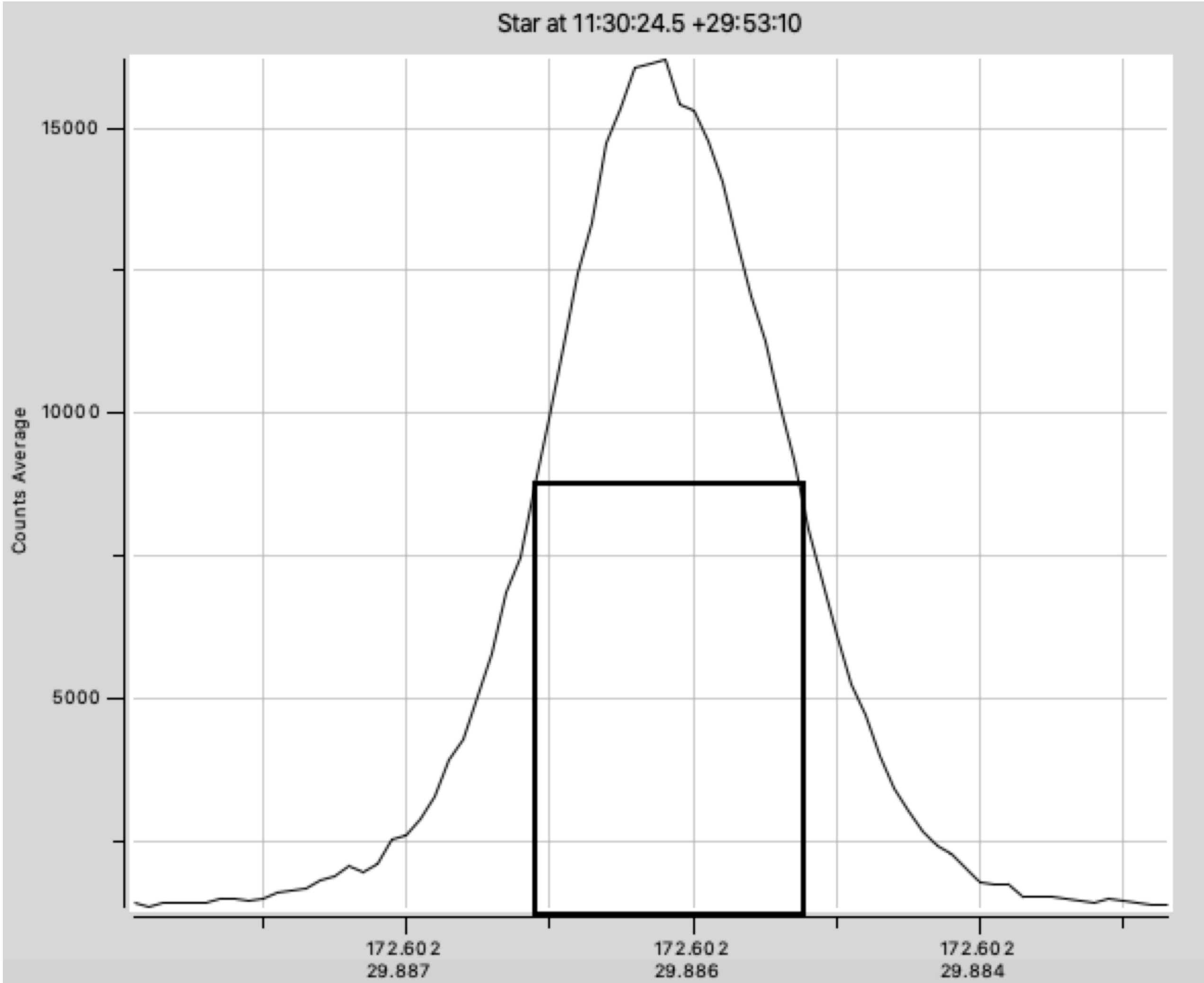
The Full Width / Half Max is a measure of the seeing. The plots show the four most prominent stars. The brightest was saturated.





Comp Star 95 FWHM
Counts Average
60000
40000
20000
172.518
29.965
172.518
29.961


Star at 11:29:48.5 +30:04:02
Counts Average
8000
6000
4000
2000
172.454
30.067
172.452
30.067
172.450
30.067

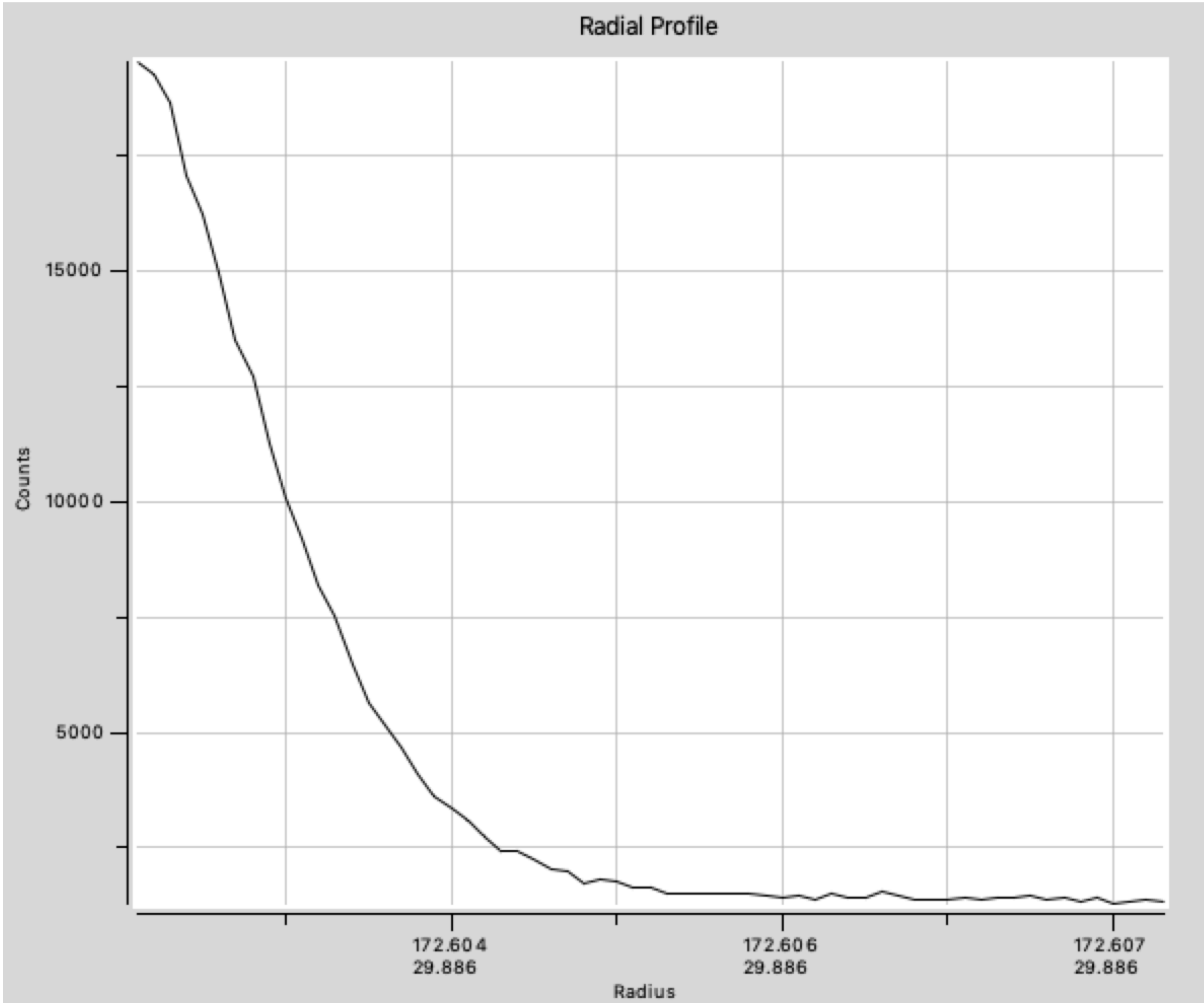


From the width at half the maximum we can estimate the FWHM. From the data underlying the plot we can get a more refined estimate.

In [68]:

```python
Upper = 29.8865625
Lower = 29.8856250

Width = (Upper - Lower)*3600

#print("Width at half max =", Width)

WatHM = 20

FWHM = WatHM * PlateScale

print("FWHM = 20 pixels * the Plate Scale = {:.4f} arcsec".format(FW


```

```
FWHM = 20 pixels * the Plate Scale = 5.8544 arcsec
```



Flat Fields

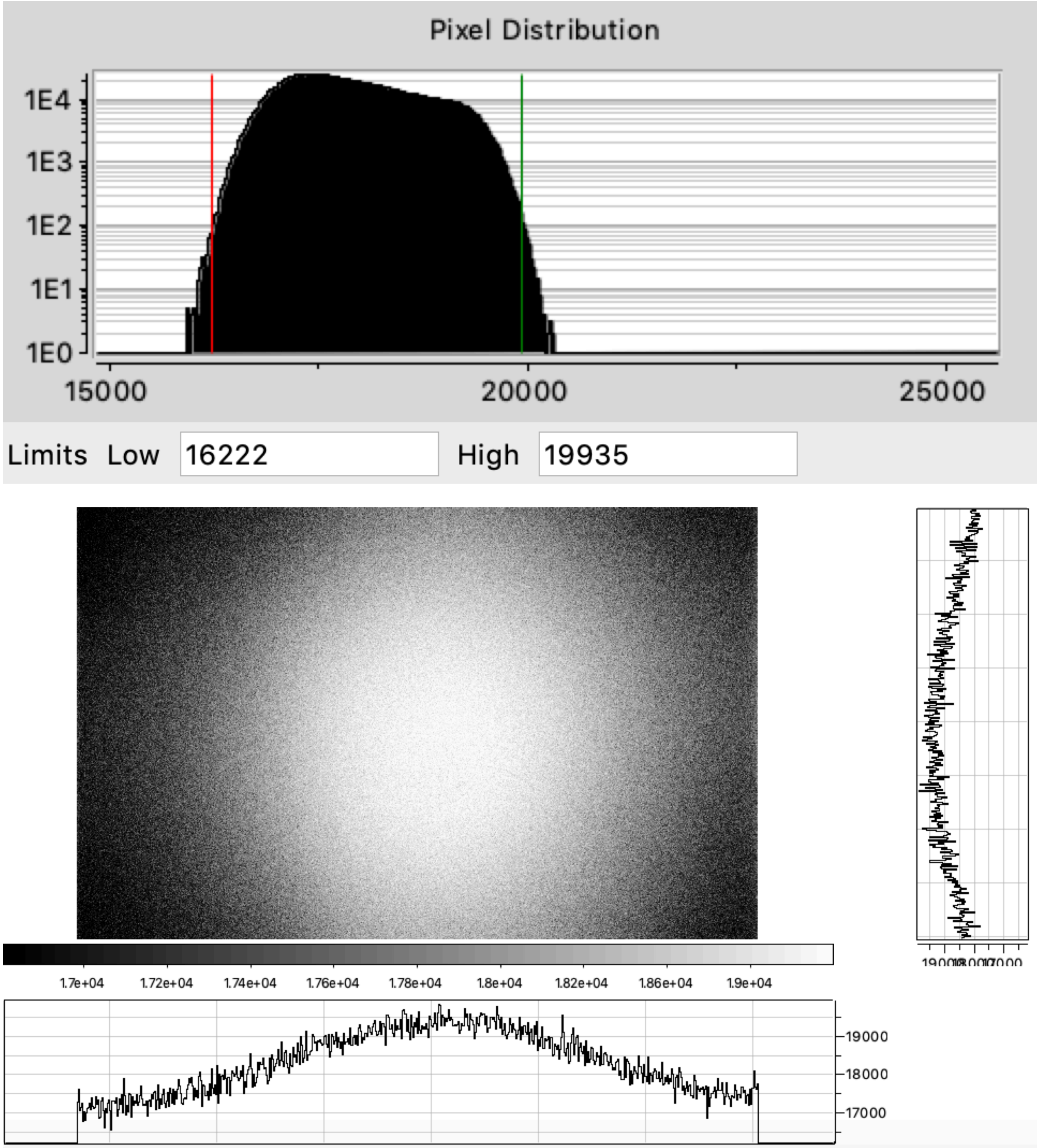
Both 'dome' flats and sky flats were taken.

The flatness can be compared through the pixel distribution. The horizontal and vertical distribution are also illuminating.

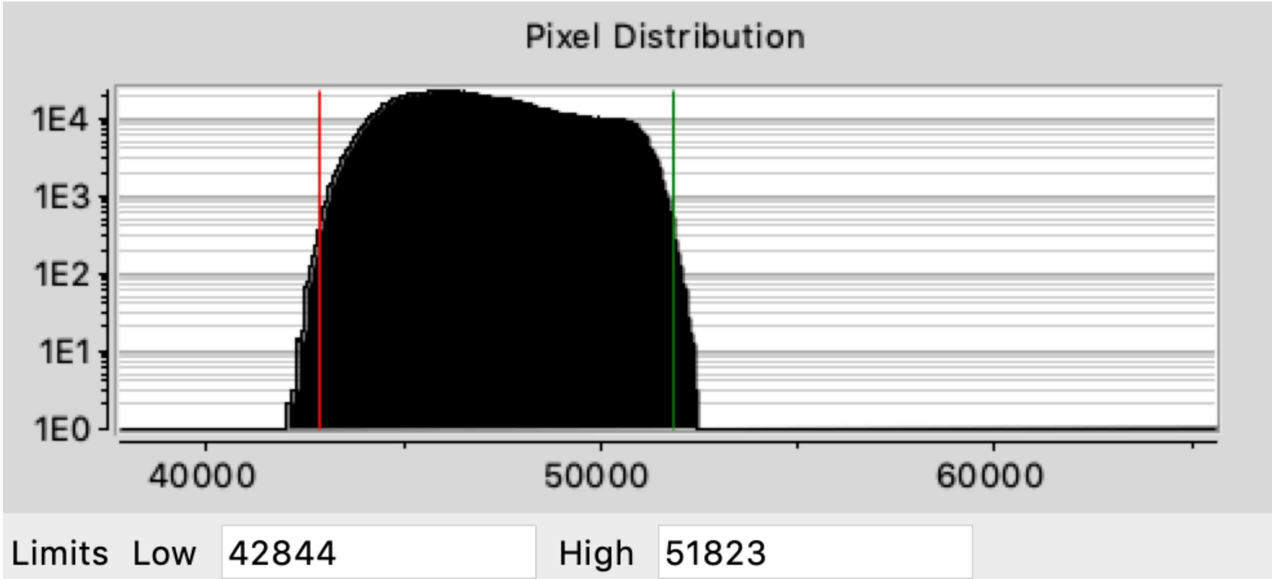
Sky Flats

Various exposures were used as the sky got darker.

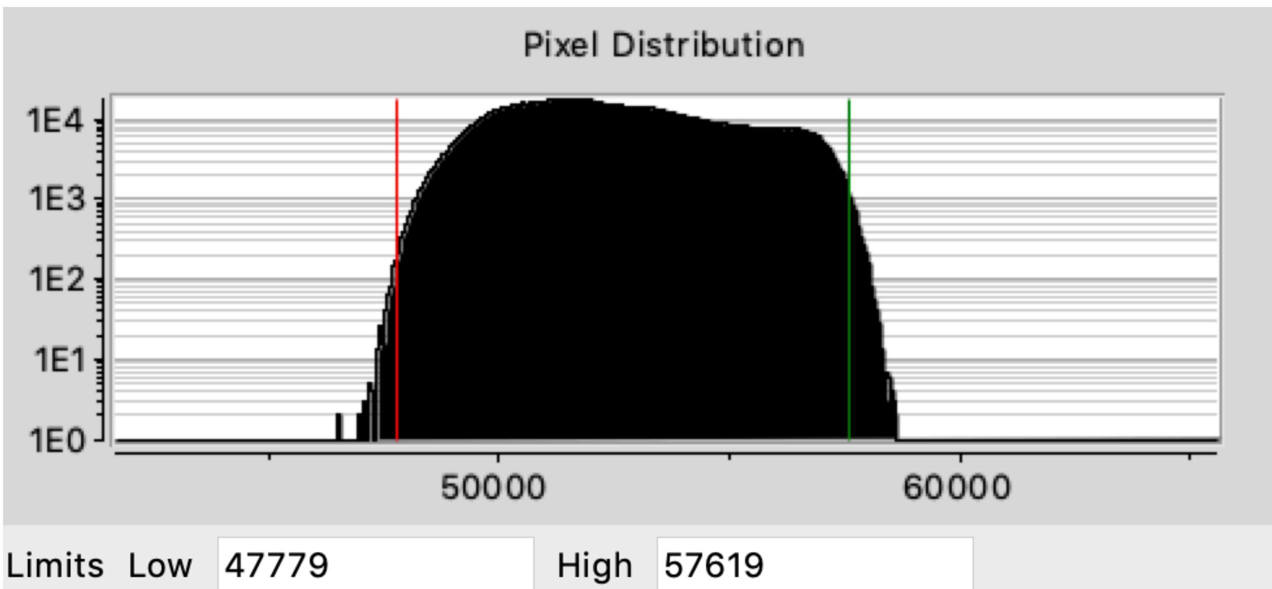
.5 sec exposure:



2 sec exposure



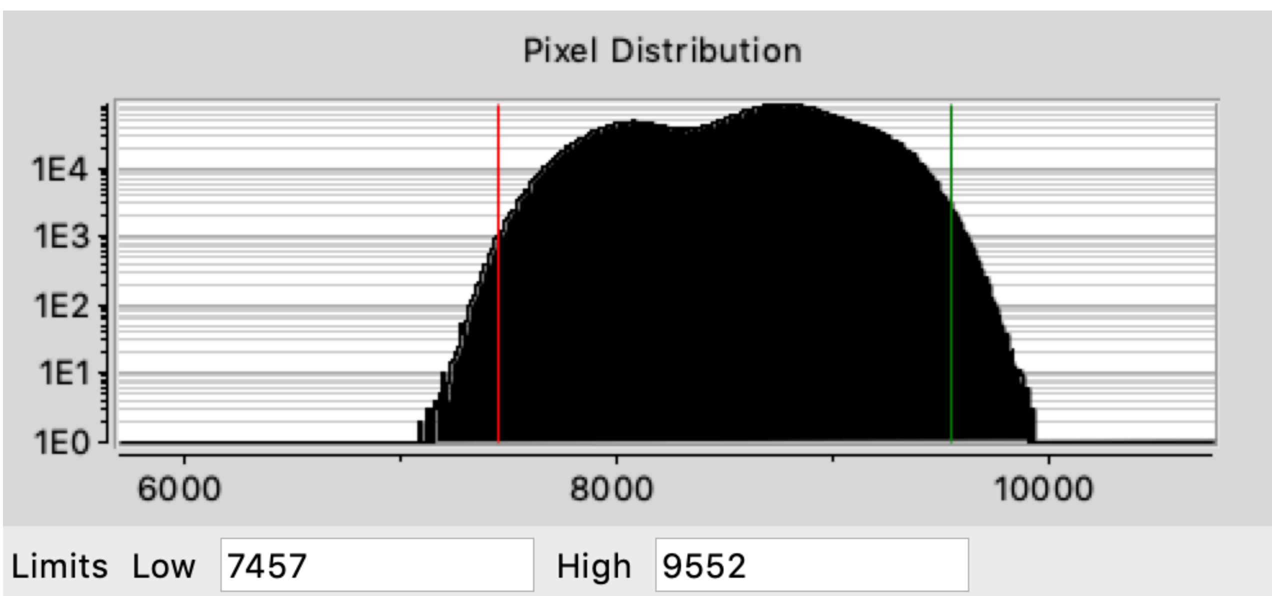
3 sec exposure

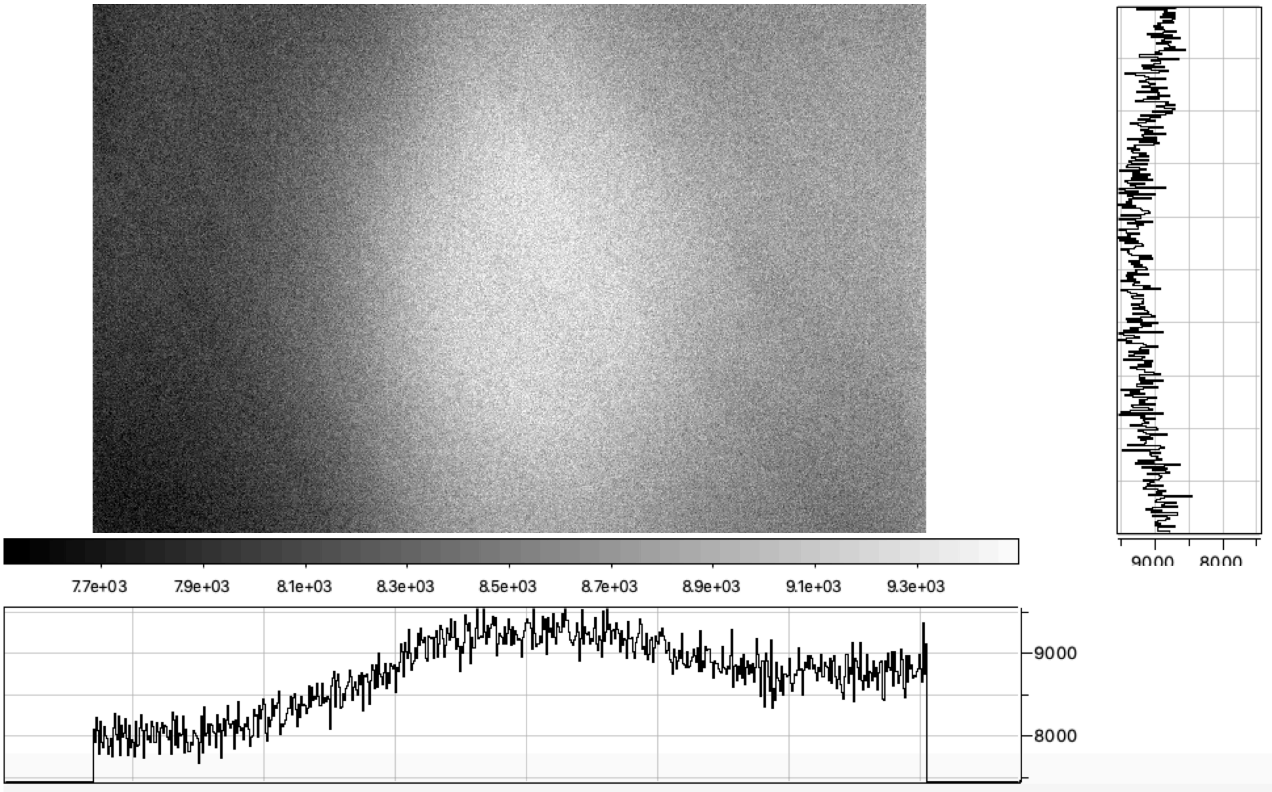


Dome Flats

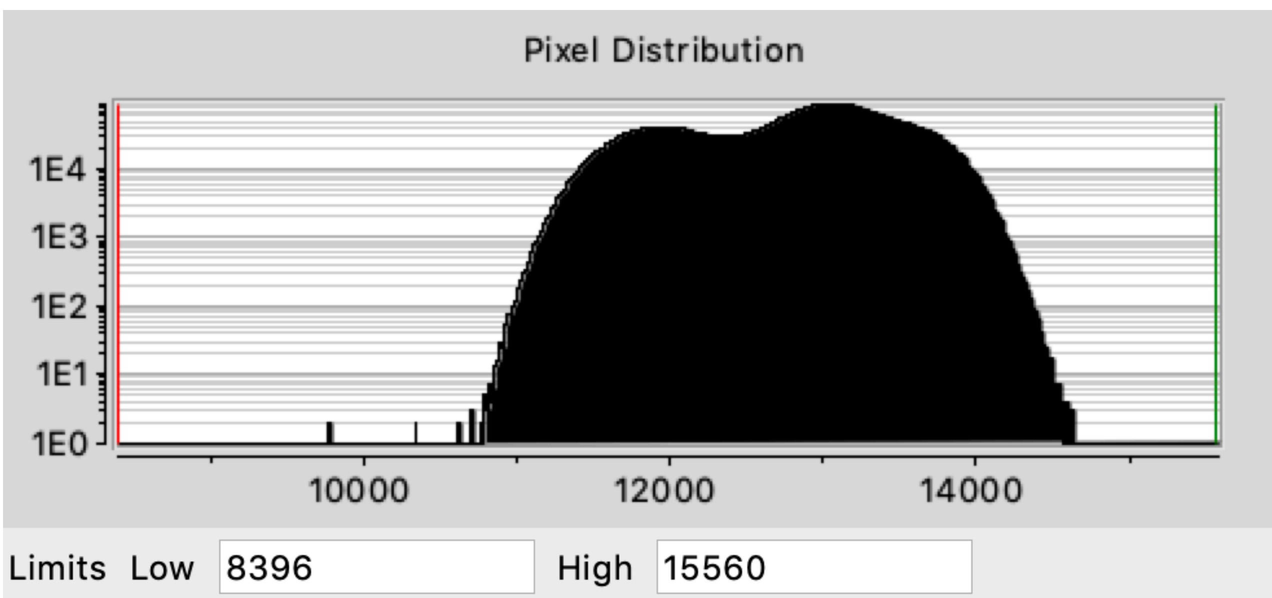
Dome flats were taken using a similar arrangement as was used on the benchtop.

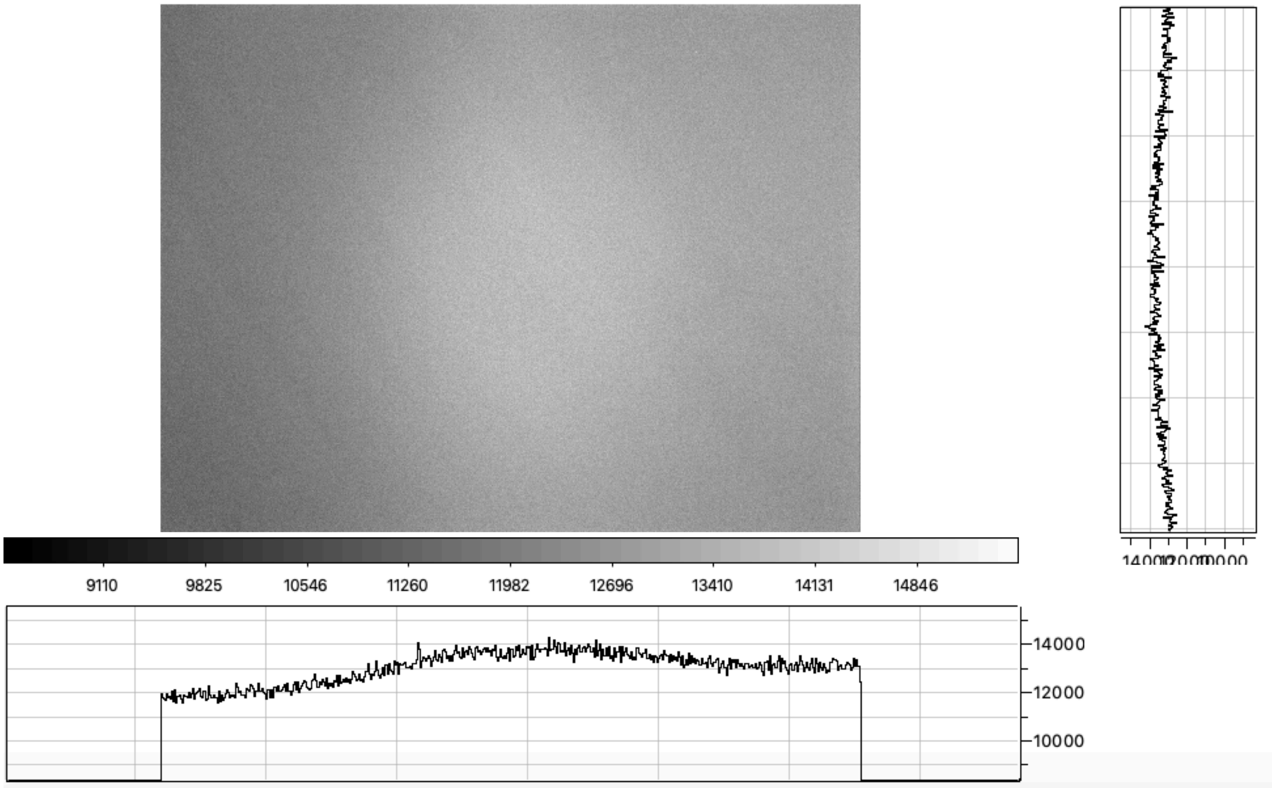
0.025 sec exposure





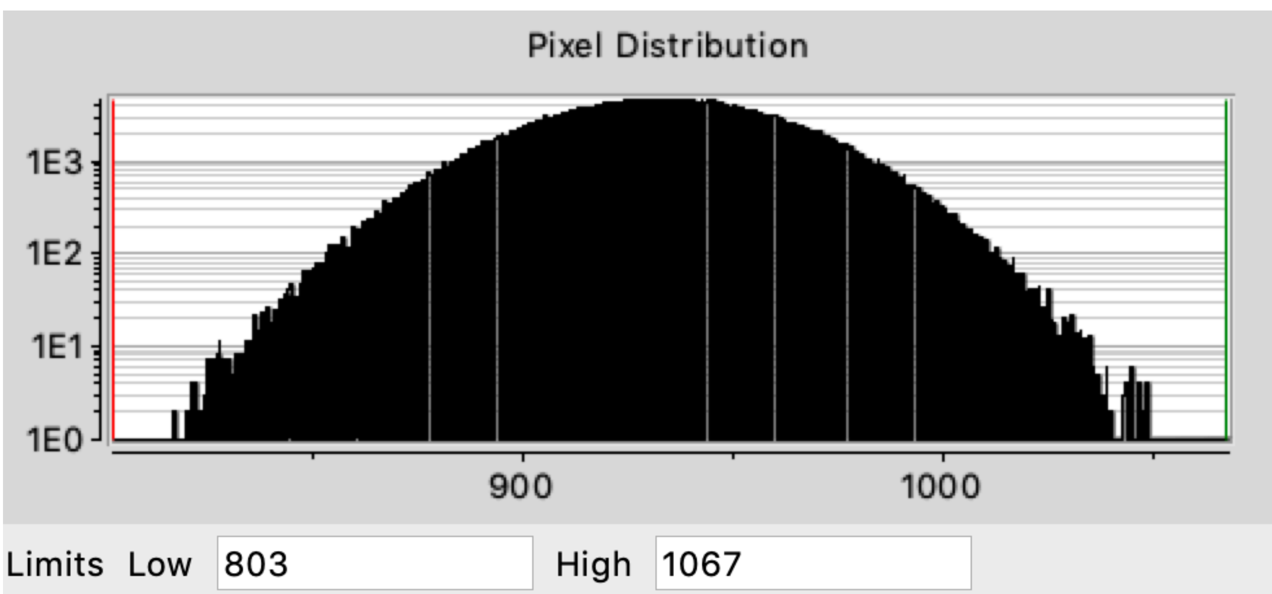
0.2 sec exposure

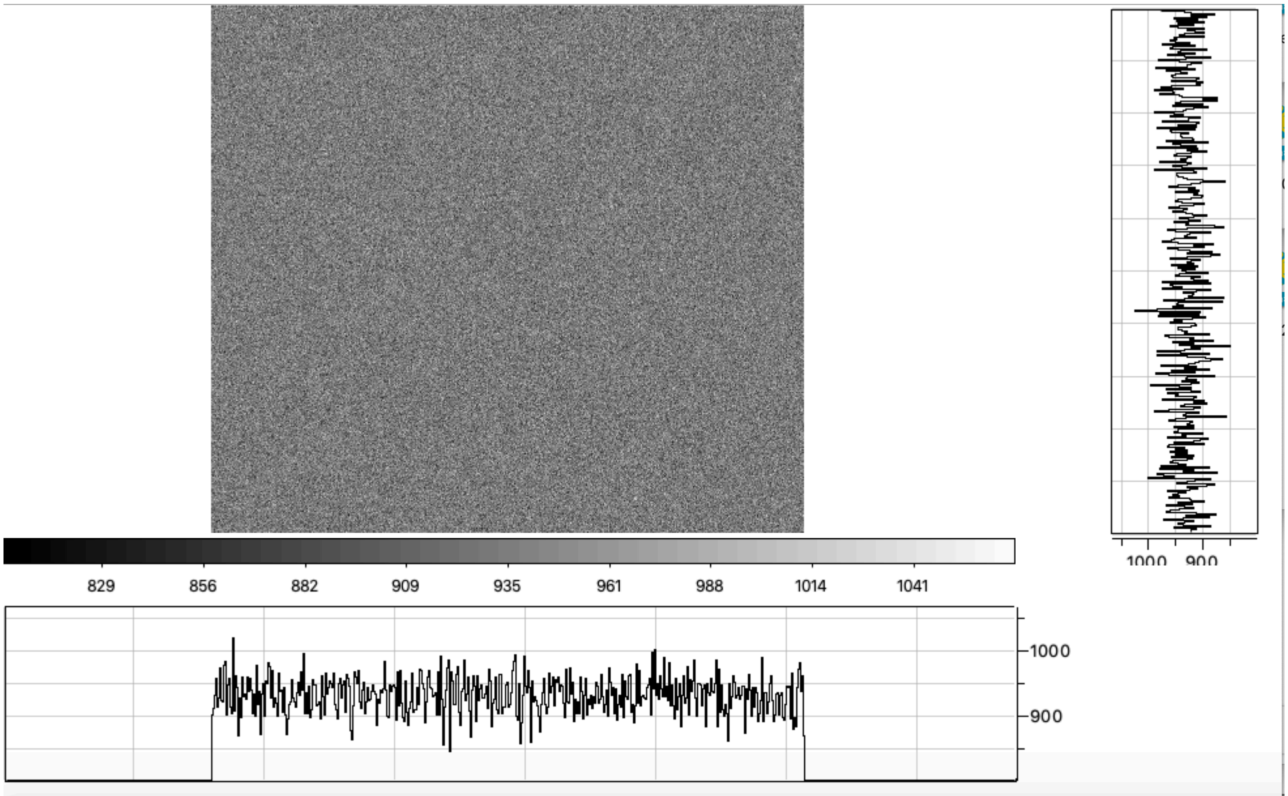




Bias

The bias images were done using the camera's Bias setting.



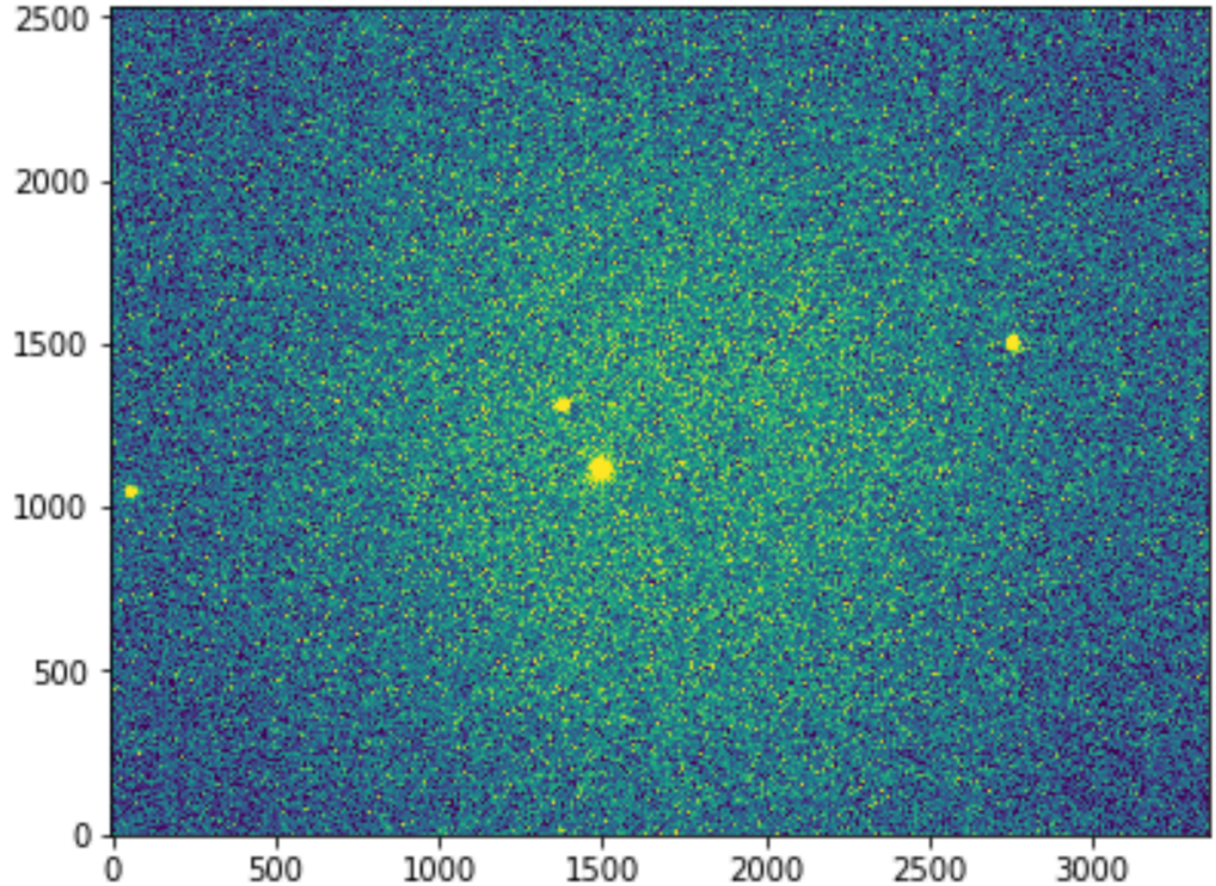


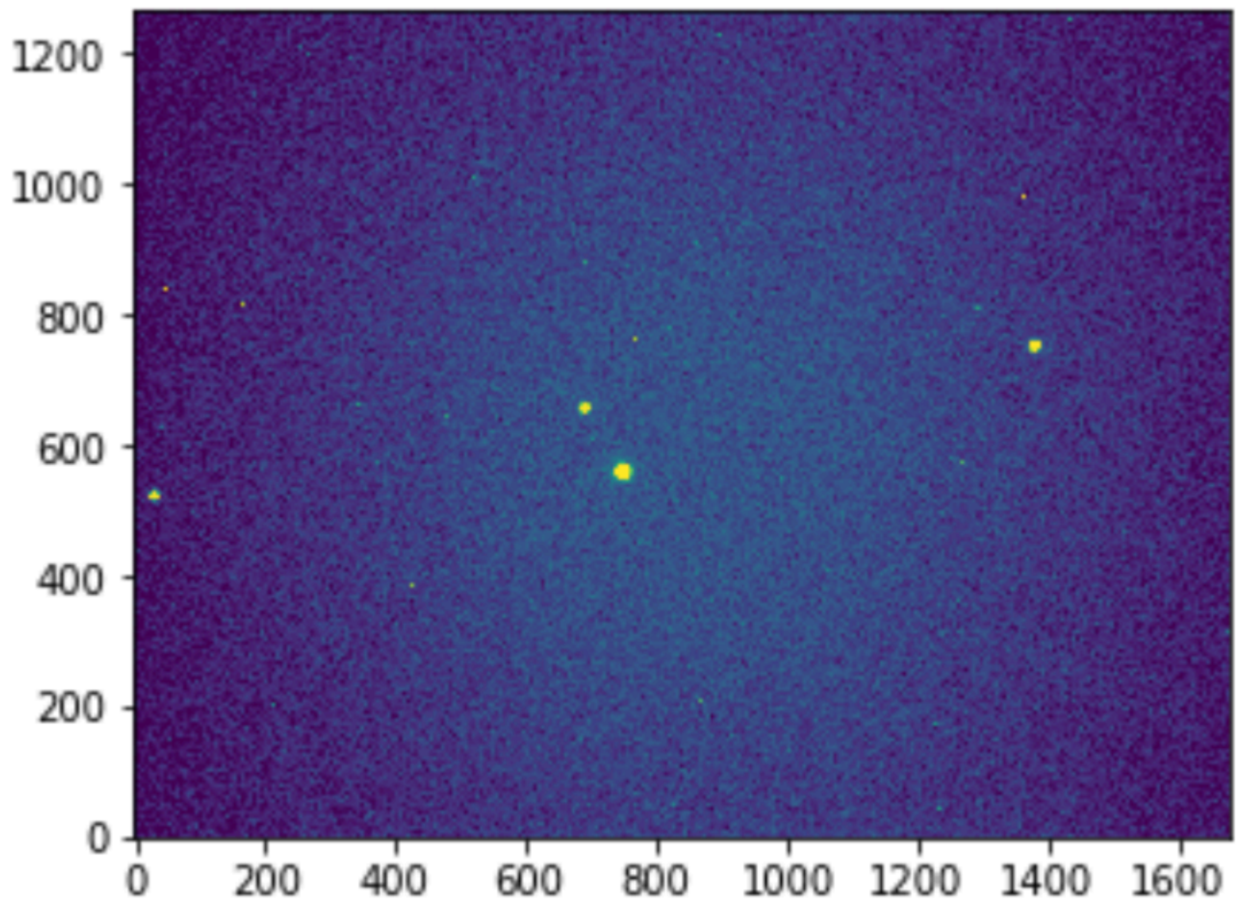
Type *Markdown* and LaTeX: α^2

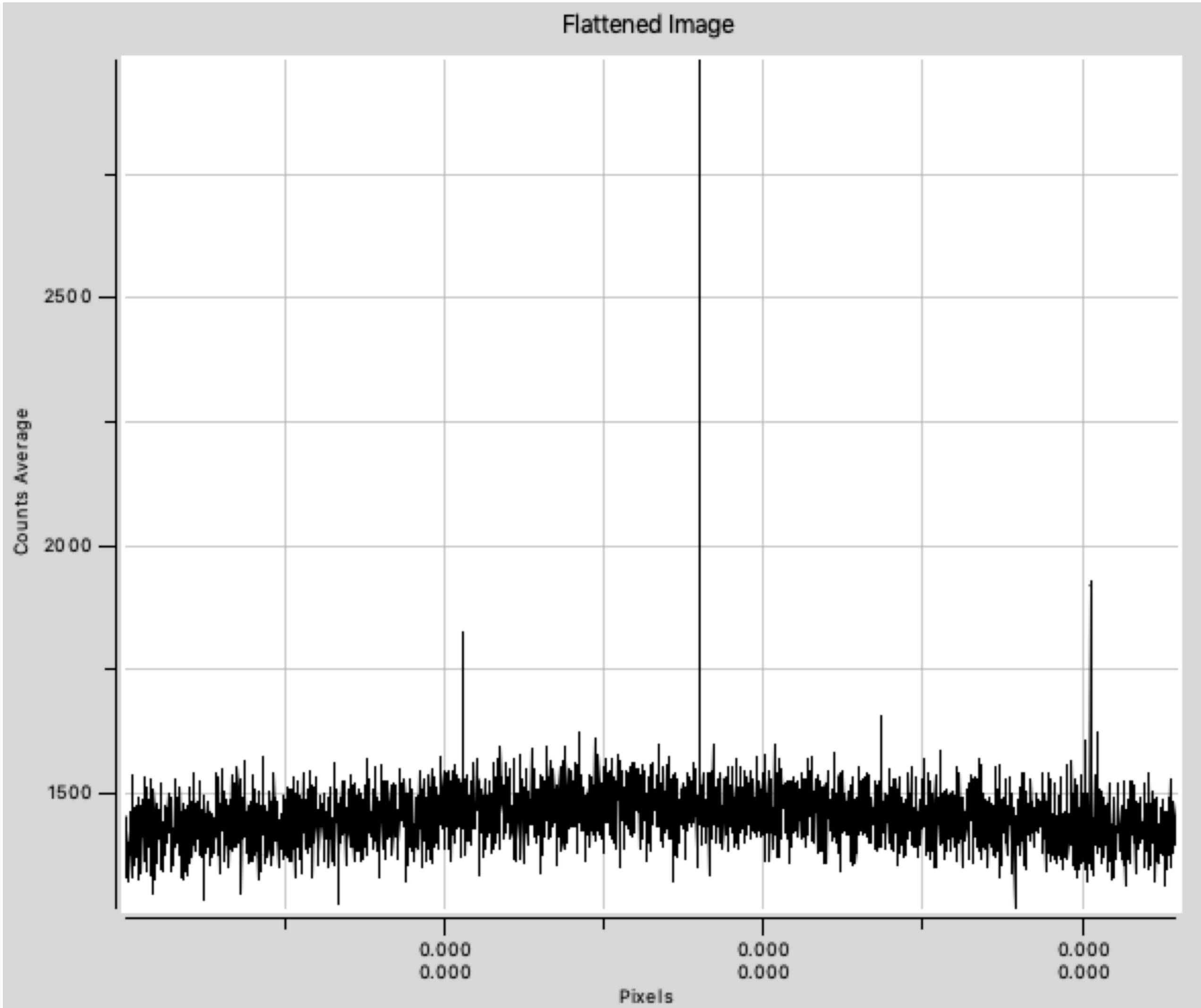
Image Reduction

Running through the image reduction process adapted from the Growth Summer School, I was able to debias and flatten the image file.

The initial and final files are shown.


2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000


1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600

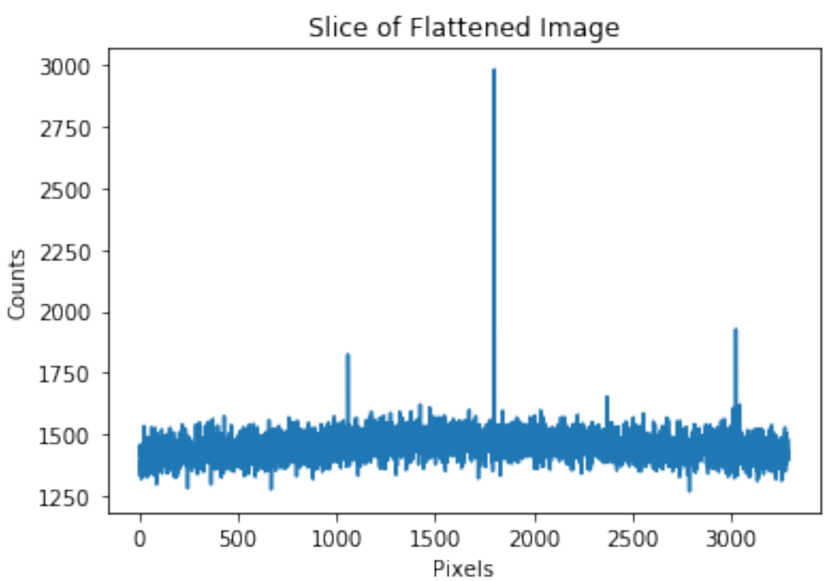


min 1270.000 max 2982.000 mean 1453.626 median 1452.000 var 3417.298 sdev 58.458

In [67]:

```
import numpy as np
import matplotlib.pyplot as plt
from astropy.stats import sigma_clipped_stats


xy = np.loadtxt("flattened.dat", delimiter=' ')

x, y = xy.T
mean, median, std = sigma_clipped_stats(y)
print(min(y),max(y),mean,median,std)
plt.plot( x, y )

plt.title('Slice of Flattened Image')
plt.xlabel('Pixels')
plt.ylabel('Counts')

plt.show()
```

```
1270.0 2982.0 1452.9003048780487 1452.0 50.189277106693005
```



Photometric Calibration

Selecting a circular region around a star will give its statistics.

center=172.53001 29.980057
fk5
1 pixel = 0.28921592 arcsec

reg	sum	error	area (arcsec**2)	surf_bri (sum/arcsec**2)	surf_err (sum/arcsec**2)
1	9557453	3091.51	296.357	32249.8	10.4317

reg	sum	npix	mean	median	min	max	var	stddev	rms
1	9557453	3543	2697.56	1707	1312	12112	4.71797e+06	2172.09	3463

This is a star with known magnitude used as a comparison star.

The signal from our target object, in counts is N_t.

We convert this to an instrumental magnitude, using the formula:

$$m_{inst} = -2.5log_{10}(N_t/t_{exp})$$

$$m_{inst} = -2.5log_{10}\kappa(F)\lambda = -2.5log_{10}F - c'$$

The instrumental magnitude can be adjusted by a correction based on a star of a known magnitude and then that correction used to predict the magnitudes of other stars in the image.

The results were as follows:

In [63]:

```
N_t = 9557453
t_exp = 25

m_inst = -2.5*np.log10(N_t/t_exp)

print("m_inst: ",m_inst)

correction = 9.451 - m_inst

print("correction = ",correction)
print("catalog value: 9.451")
```

```
m_inst:  -13.956005405813766
correction =  23.407005405813766
catalog value: 9.451
```

AUID	RA	Dec	Label	V	B-V
000-BJV-341	11:30:24.53 [172.60220337°]	29:53:03.9 [29.88441658°]	**89**	8.923 (0.019)[28]	0.584 (0.029)
000-BJV-342	11:30:07.05 [172.52937317°]	29:58:47.0 [29.97972298°]	**95**	9.451 (0.037)[28]	0.712 (0.061)

A similar comparison star is found nearby.

```
center=172.60194 29.885874
fk5
1 pixel = 0.28921592 arcsec

reg     sum              error   area            surf_bri        surf_err
                                 (arcsec**2)     (sum/arcsec**2) (sum/arcsec**2)
---     ---              -----   -----------     --------------- ---------------
1       11786507         3433.15 310.493         37960.6         11.0571

reg     sum      npix    mean    median  min     max     var        stddev  rms
---     ---      ----    ----    ------  ---     ---     ---        ------  ---
1       11786507 3712    3175.24 1710    1302    20202   1.13818e+07 3373.69 4632
```

In [62]:

```python
N_t = 11786507
t_exp = 25

m_inst = -2.5*np.log10(N_t/t_exp)

print("m_inst: ",m_inst)

print("predicted:", m_inst + correction)
print("catalog value: 8.923")
```

```
m_inst:  -14.183612774478412
predicted: 9.272392631335354
catalog value: 8.923
```

Brightest Stars

AW Uma

This bright star is near saturation in this image. At a shorter 10 second exposure this star can be reliably imaged without saturation. Certain star such as Betelgeuse and Sirius cannot be imaged without saturation even at the shortest exposure possible.

```
center=172.51755 29.964329
fk5
1 pixel = 0.28921592 arcsec

reg      sum               error    area             surf_bri         surf_err
                                    (arcsec**2)      (sum/arcsec**2)  (sum/arcsec**2)
---      ---               -----    -----------      ---------------  ---------------
1        56137862          7492.52  631.693          88868.8          11.861

reg      sum       npix    mean     median   min      max      var         stddev   rms
---      ---       ----    ----     ------   ---      ---      ---         ------   ---
1        56137862  7552    7433.51  1891     1336     65535    1.98903e+08 14103.3  15942.4
```

In [65]:

```python
N_t = 56137862
t_exp = 25

m_inst = -2.5*np.log10(N_t/t_exp)

print("m_inst: ",m_inst)

print("predicted:", m_inst + correction)
print("catalog value: 6.83 to 7.13")
```

```
m_inst:  -15.87828964979256
predicted: 7.528715756021207
catalog value: 6.83 to 7.13
```

Another star of similar magnitude is in the field of view.

```
center=172.45182 30.067086
fk5
1 pixel = 0.28921592 arcsec

reg      sum             error    area           surf_bri          surf_err
                                  (arcsec**2)    (sum/arcsec**2)   (sum/arcsec**2)
---      ---             -----    -----------    ---------------   ---------------
1        10049985        3170.17  333.412        30142.8           9.50826

reg      sum       npix   mean     median  min     max     var         stddev  rms
---      ---       ----   ----     ------  ---     ---     ---         ------  ---
1        10049985  3986   2521.32  1599    1247    12733   4.41583e+06 2101.39 3282
```

In [66]:

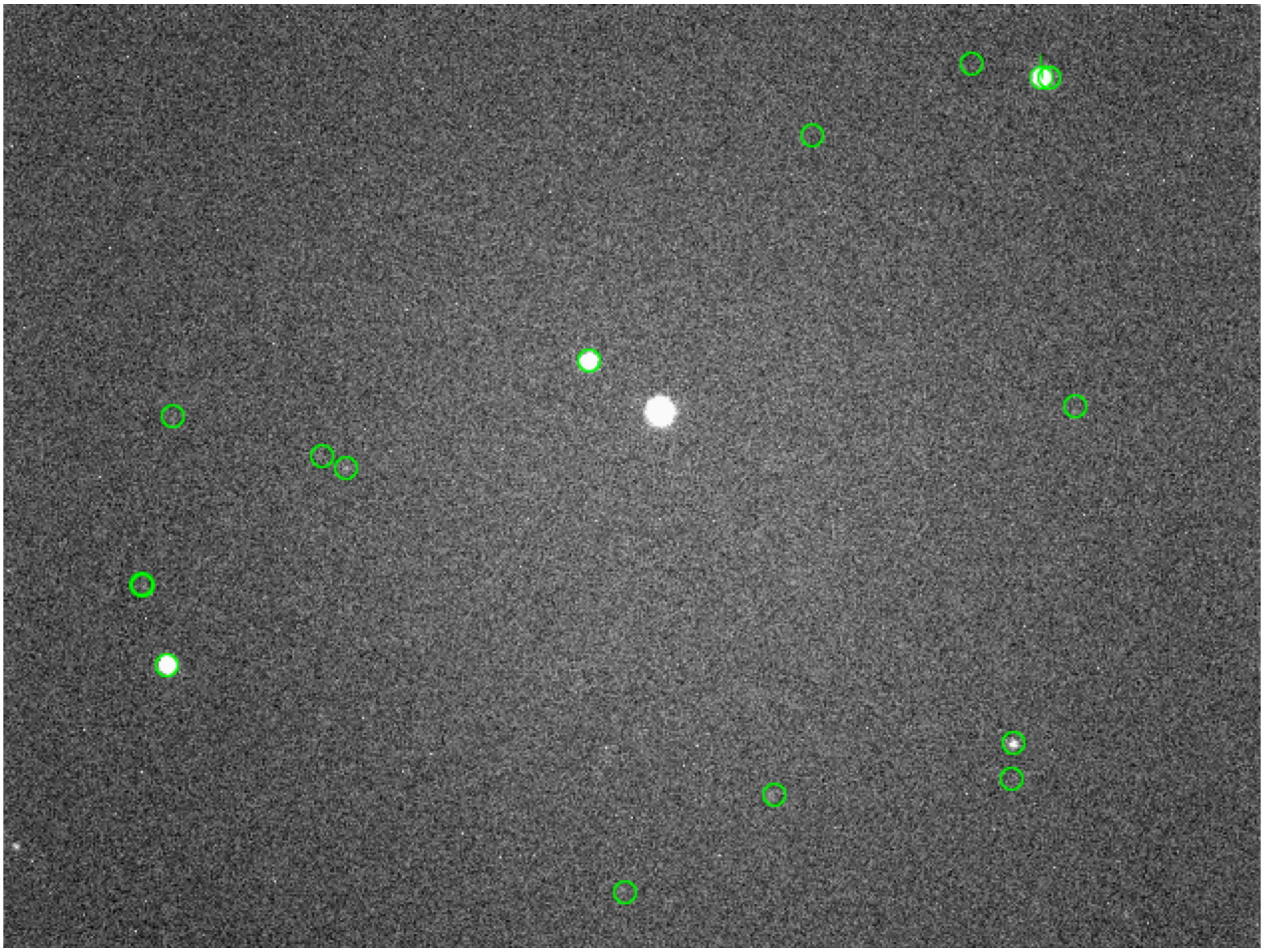
```
N_t = 10049985
t_exp = 25

m_inst = -2.5*np.log10(N_t/t_exp)

print("m_inst: ",m_inst)

print("predicted:", m_inst + correction)
print("catalog value: 9.77")
```

```
m_inst:  -14.010563512208167
predicted: 9.3964418936056
catalog value: 9.77
```

Faintest stars

Two faint stars can be seen in the image barely discernable above the background sky. At a shorter exposure they would not be detected at all. At longer exposures they become more prominent.

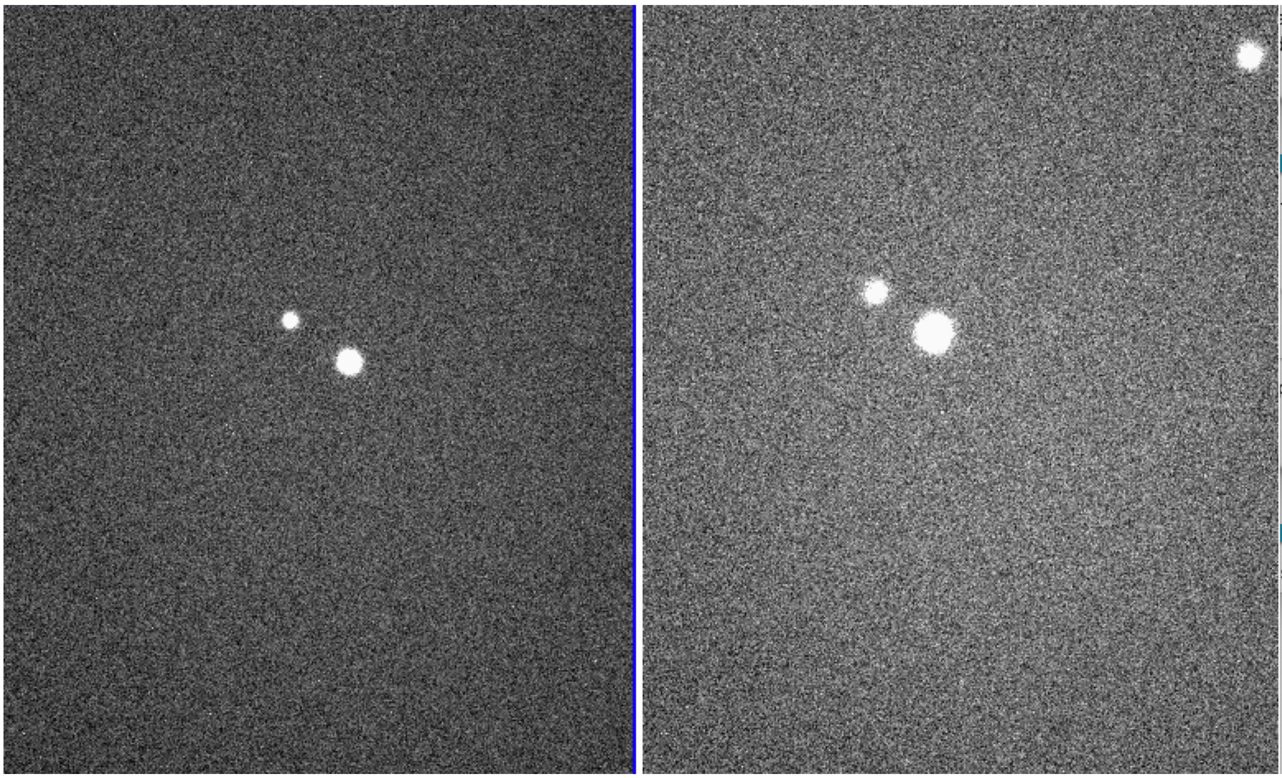
Some stars listed in the catalog are not visible in the image. it appears that the limiting magnitude of this image is 15.



2UCAC	RAJ2000	e_RAJ2000	DEJ2000	e_DEJ2000	UCmag
42237487	172.3995474	43	+29.9690973	23	15.12
42237492	172.4245333	27	+29.9376753	20	14.09
42237493	172.4298380	34	+29.8864900	65	16.14
42237495	172.4384565	23	+29.8862862	24	12.46
42237500	172.5210703	22	+29.8750734	48	15.26
42237501	172.5298053	11	+29.9802323	11	9.32
42237507	172.5867283	15	+29.9348848	35	15.81
42237509	172.6023277	8	+29.8842800	10	8.91
42237511	172.6054636	66	+29.9013667	34	15.52
42411280	172.4520395	1	+30.0673278	1	9.77
42411283	172.4711374	30	+30.0729914	15	14.72
42411286	172.5019639	21	+30.0307667	19	14.13
42411288	172.5046398	47	+30.0362445	28	14.71
42411289	172.5131330	20	+30.0681237	25	14.39

Tracking

No images were taken with a long enough exposure to see the tracking errors directly. The brighter stars would saturate after 100s. However, it can be seen from two images taken some time apart that the stars in the images are progressively moving across the field of view. If the exposure was long enough the images would have smeared the stars with this kind of tracking error.



In [ ]:

```
1
```