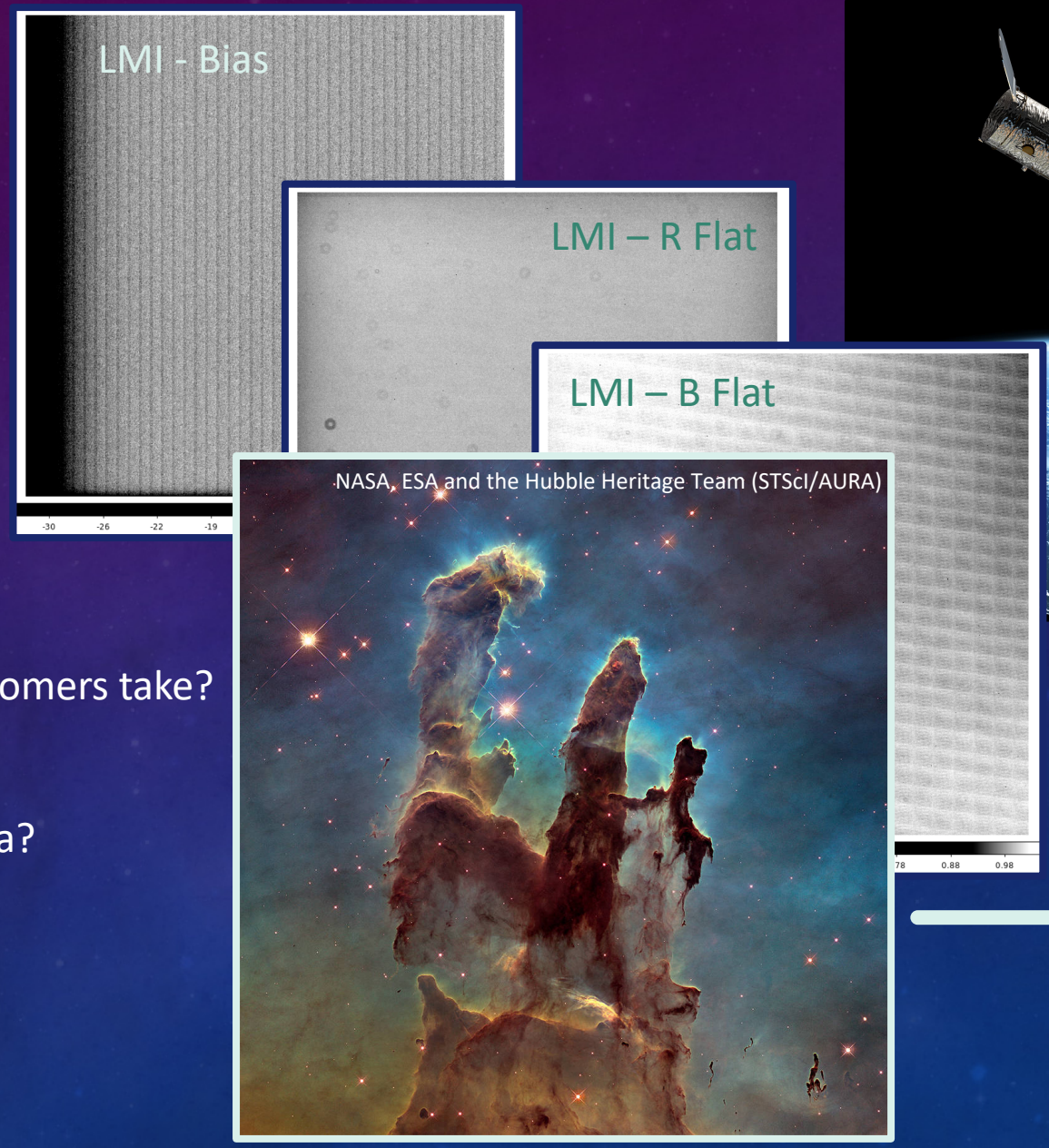
CALIBRATION DATA

LOWELL DISCOVERY TELESCOPE

TUTORIAL SERIES

OVERVIEW

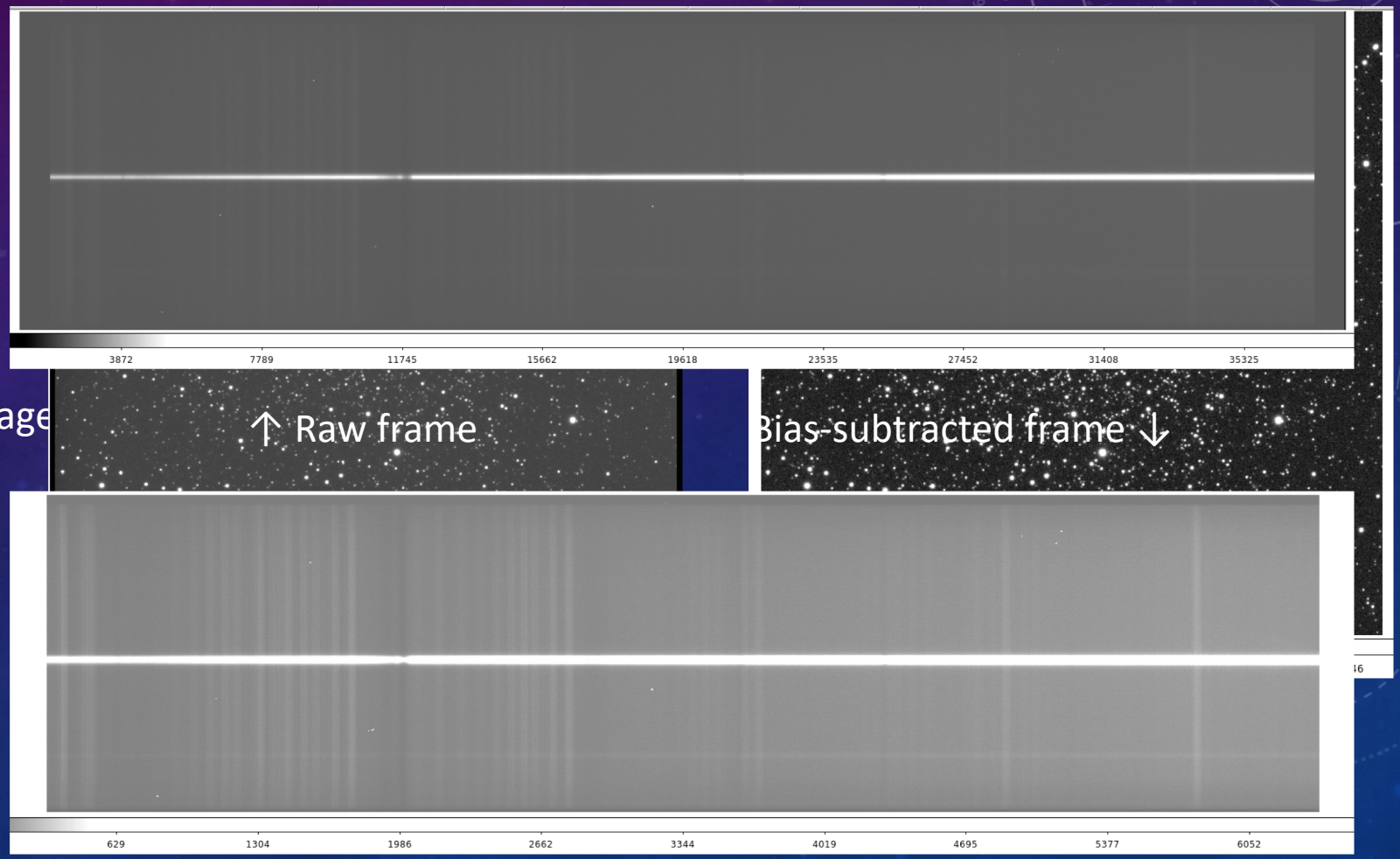
- Calibration Data: Why do it?
- What kind of calibration data do astronomers take?
- What does it mean to “reduce” the data?



RESULTS OF CALIBRATION

- LMI: raw and calibrated images
- DeVeny: raw and bias-subtracted image
- NIHTS: ???

G188-26 (M2V star)
Grating: DV5
NGC 6791 – I band filter
Wavelength Range: 5700Å – 8500Å



TYPES OF CALIBRATION DATA

- Removing pixel-to-pixel variations in sensitivity:
  - Bias (or ‘zero’) frames: zero-point level for each pixel (also includes fixed-pattern noise)
  - Dark current frames: amount of signal produced in the absence of light
  - Flat field frames: multiplicative sensitivity (QE, dust, etc.) per pixel
- Turning ‘counts’ into physical meaning:
  - Imaging: photometric standards
  - Spectroscopy: atomic emission arc lamps, spectrophotometric standards

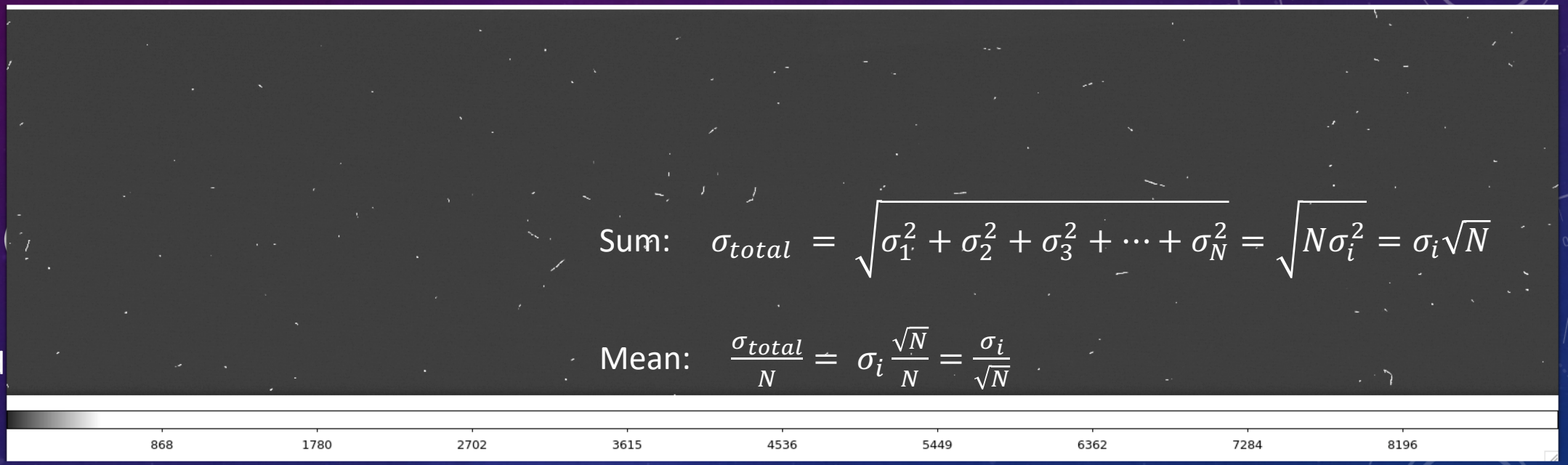
EXAMPLES

- To follow along, download:
  - SAOImageDS9: https://sites.google.com/cfa.harvard.edu/saoimageds9
  - Example Images: http://www2.lowell.edu/users/tbowers/CalibrationDataEx.tgz

- Examples of LMI, DeVeny, and NIHTS raw frames, calibration frames, and calibrated frames

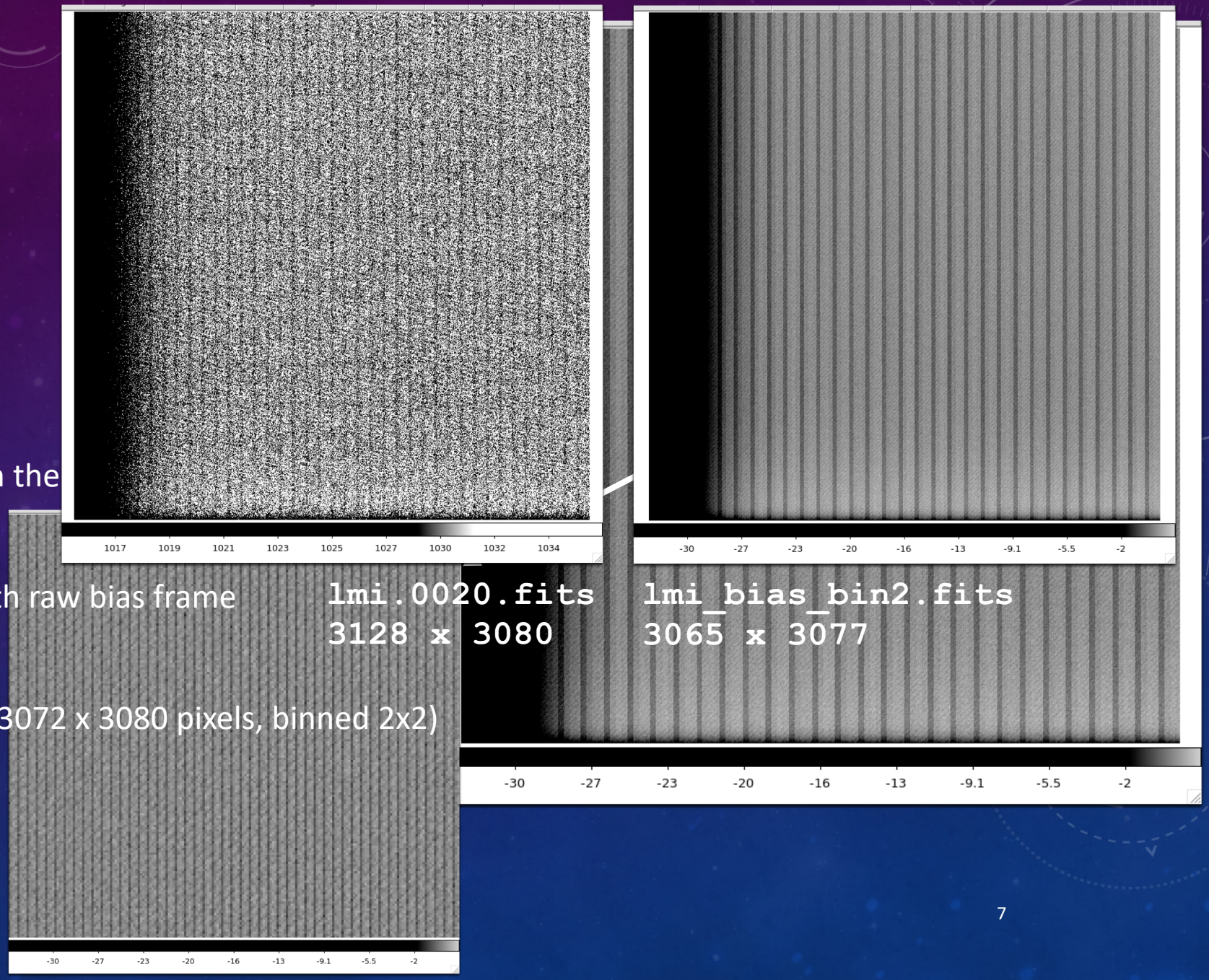
WHY TAKE SO MANY?

- Statistics
- Noise red
- Cosmic ray rejection



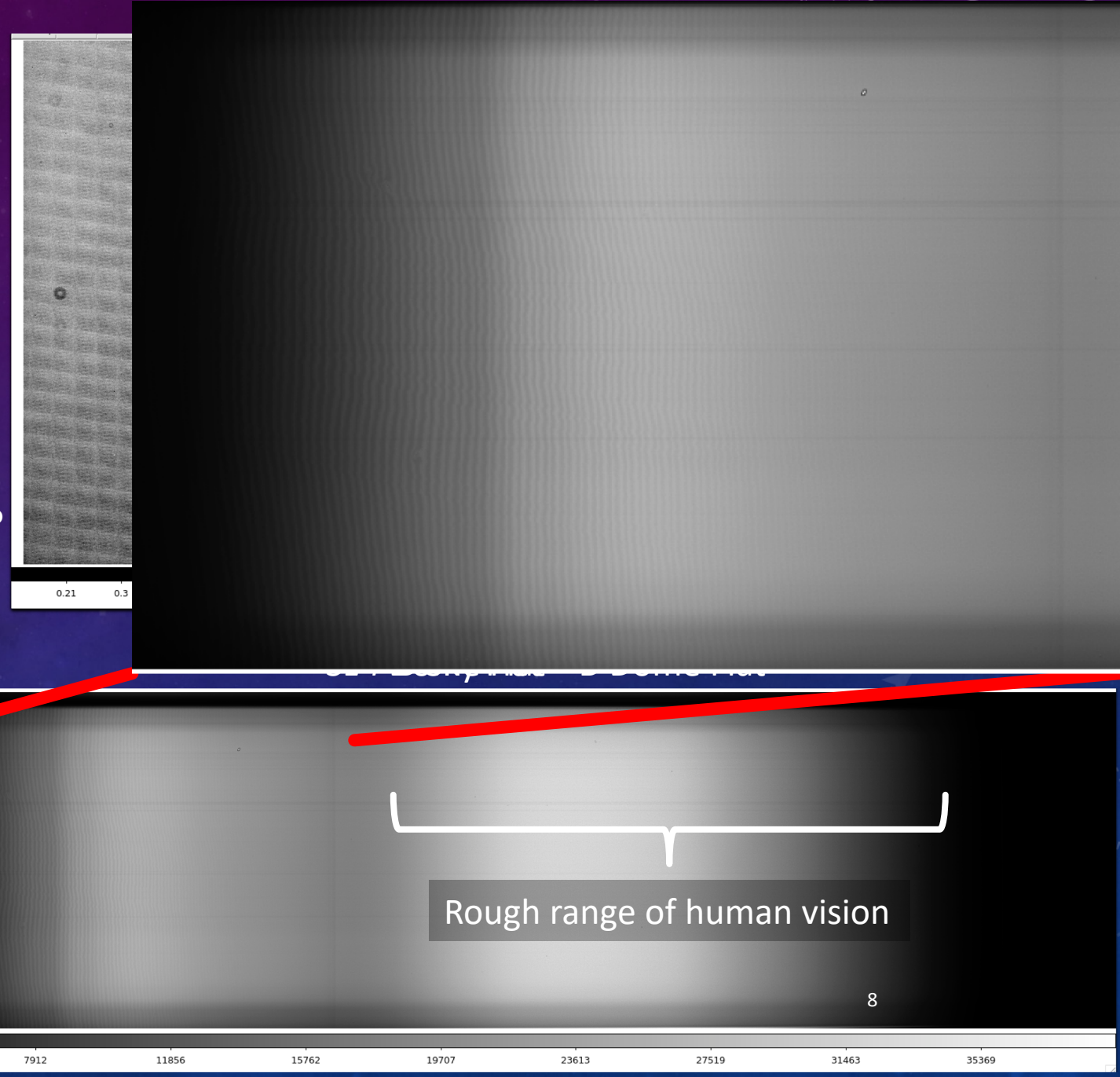
BIAS FRAMES

- What information is contained in the
- The Master Bias: comparison with raw bias frame
- What is ‘overscan’? (LMI CCD is 3072 x 3080 pixels, binned 2x2)



FLAT FIELD FRAMES

- What do they tell us? Why divide by a master?
- Sky Flats vs. Dome Flats
- Examples: Imaging vs. Spectroscopy



ARC LAMP CALIBRATION FRAMES

- What are they, and why take them?

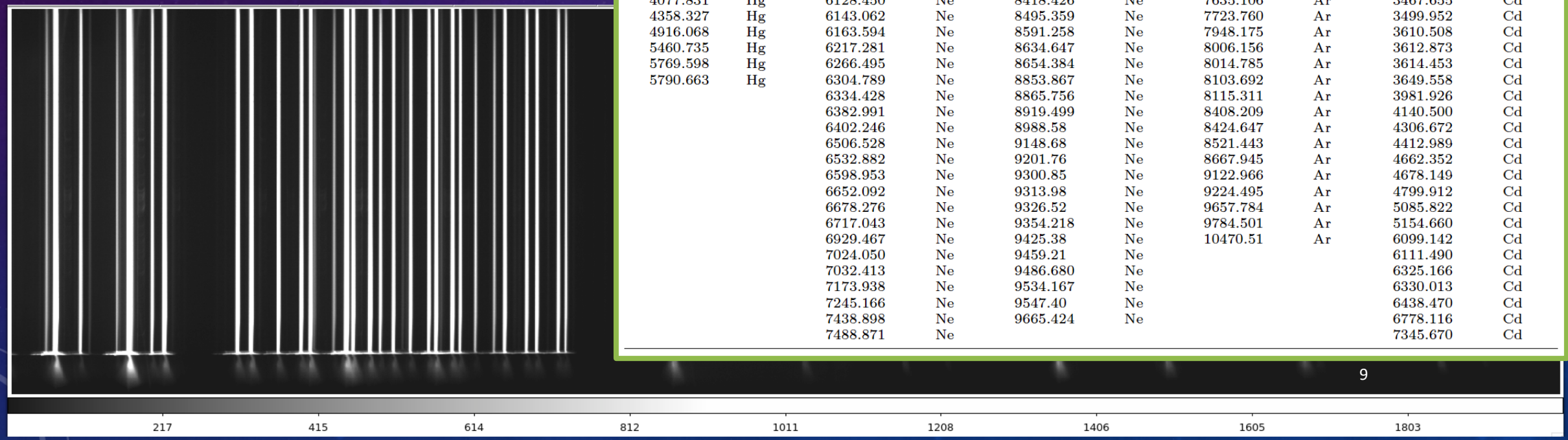
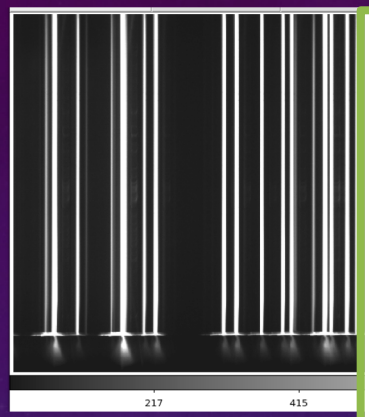
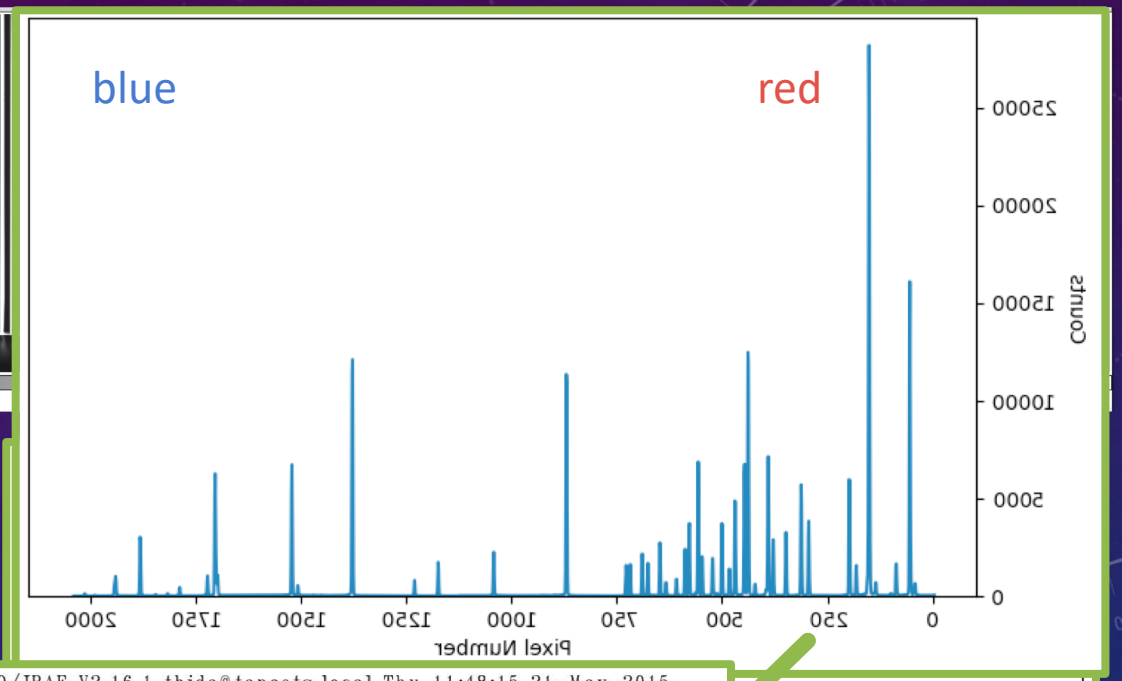


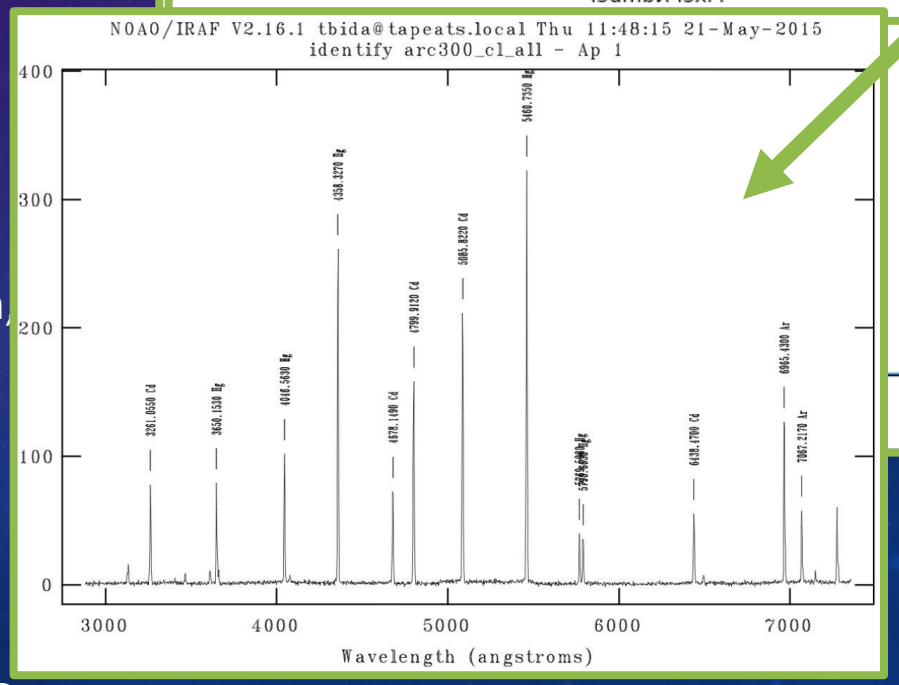
Table 5. Arc Line Identification by Species

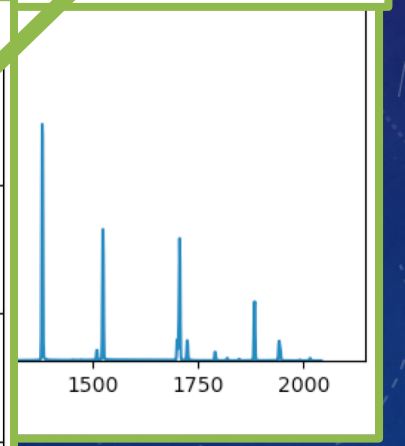
Wavelength (Å)	Species	Wavelength (Å)	Species	Wavelength (Å)	Species	Wavelength (Å)	Species	Wavelength (Å)	Species
3125.67	Hg	5852.488	Ne	7535.774	Ne	6965.430	Ar	3080.822	Cd
3131.70	Hg	5881.895	Ne	7544.044	Ne	7067.217	Ar	3082.593	Cd
3341.48	Hg	5944.834	Ne	7943.180	Ne	7147.041	Ar	3133.167	Cd
3650.153	Hg	5975.534	Ne	8082.457	Ne	7272.935	Ar	3252.524	Cd
3654.84	Hg	6029.997	Ne	8136.406	Ne	7383.979	Ar	3261.055	Cd
3663.279	Hg	6074.337	Ne	8300.324	Ne	7503.868	Ar	3403.652	Cd
4046.563	Hg	6096.163	Ne	8377.606	Ne	7514.651	Ar	3466.200	Cd
4077.831	Hg	6128.450	Ne	8418.426	Ne	7635.106	Ar	3467.655	Cd
4358.327	Hg	6143.062	Ne	8495.359	Ne	7723.760	Ar	3499.952	Cd
4916.068	Hg	6163.594	Ne	8591.258	Ne	7948.175	Ar	3610.508	Cd
5460.735	Hg	6217.281	Ne	8634.647	Ne	8006.156	Ar	3612.873	Cd
5769.598	Hg	6266.495	Ne	8654.384	Ne	8014.785	Ar	3614.453	Cd
5790.663	Hg	6304.789	Ne	8853.867	Ne	8103.692	Ar	3649.558	Cd
		6334.428	Ne	8865.756	Ne	8115.311	Ar	3981.926	Cd
		6382.991	Ne	8919.499	Ne	8408.209	Ar	4140.500	Cd
		6402.246	Ne	8988.58	Ne	8424.647	Ar	4306.672	Cd
		6506.528	Ne	9148.68	Ne	8521.443	Ar	4412.989	Cd
		6532.882	Ne	9201.76	Ne	8667.945	Ar	4662.352	Cd
		6598.953	Ne	9300.85	Ne	9122.966	Ar	4678.149	Cd
		6652.092	Ne	9313.98	Ne	9224.495	Ar	4799.912	Cd
		6678.276	Ne	9326.52	Ne	9657.784	Ar	5085.822	Cd
		6717.043	Ne	9354.218	Ne	9784.501	Ar	5154.660	Cd
		6929.467	Ne	9425.38	Ne	10470.51	Ar	6099.142	Cd
		7024.050	Ne	9459.21	Ne			6111.490	Cd
		7032.413	Ne	9486.680	Ne			6325.166	Cd
		7173.938	Ne	9534.167	Ne			6330.013	Cd
		7245.166	Ne	9547.40	Ne			6438.470	Cd
		7438.898	Ne	9665.424	Ne			6778.116	Cd
		7488.871	Ne					7345.670	Cd

ARC LAMP CALIBRATION









- What are they, and why take them?
- What is wavelength calibration?
- Flexure in the instrument changes wavelength solution,

SCIENCE CALIBRATION FRAMES

- Science frames used for calibration
- Photometric standard stars for photometry
- Spectrophotometric standard stars for spectroscopic flux calibration.

SUMMARY

- Calibration removes the effects of the instrument on the data, leaving a clean image of the sky.
- Three main types of instrumental calibration frames: bias, flat field, arc lamps (spectroscopy only)
- Astronomers can also take science calibration frames to convert observed counts to physical values.

PROBLEM SET

1. Describe a bias frame (what is it, and how is it taken?). What information does it contain? Why do observers take many (≥10) bias frames at the start (or end) of the night? What do observers do with this data?

2. Describe a flat field frame (what is it, and how is it taken?). What information does it contain? What is the difference between a sky flat and a dome flat? What determines which filters an observer uses for flat field frames? What do observers do with this data?

3. Describe a spectroscopic arc lamp calibration frame (what is it, and how is it taken?). What information does it contain? Why will an observer take arc comparison frames throughout the night, and not just at one end? What do observers do with this data?