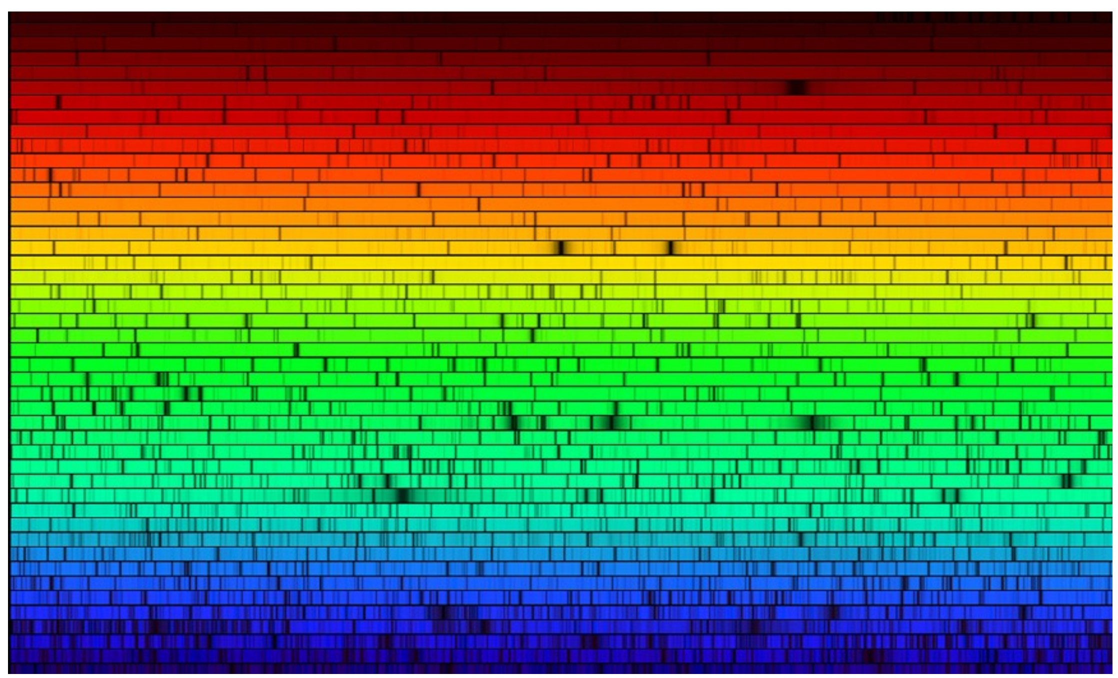
Welcome to AST 296LB

Astronomy with Python

Life as an Astronomer

What kind of data do we get, and why?



David Sand
U of Arizona

PimaCommunityCollege

Welcome to AST 296LB

Outline

One of the goals of the class is to give you a feel for what real life is like for a scientist.

Today I'll talk about my path as a scientist and some other paths. You'll hear more about this throughout the semester.

And then we will talk about some tools for the astronomer. Telescopes, imagers and spectrographs.

David Sand
U of Arizona

PimaCommunityCollege

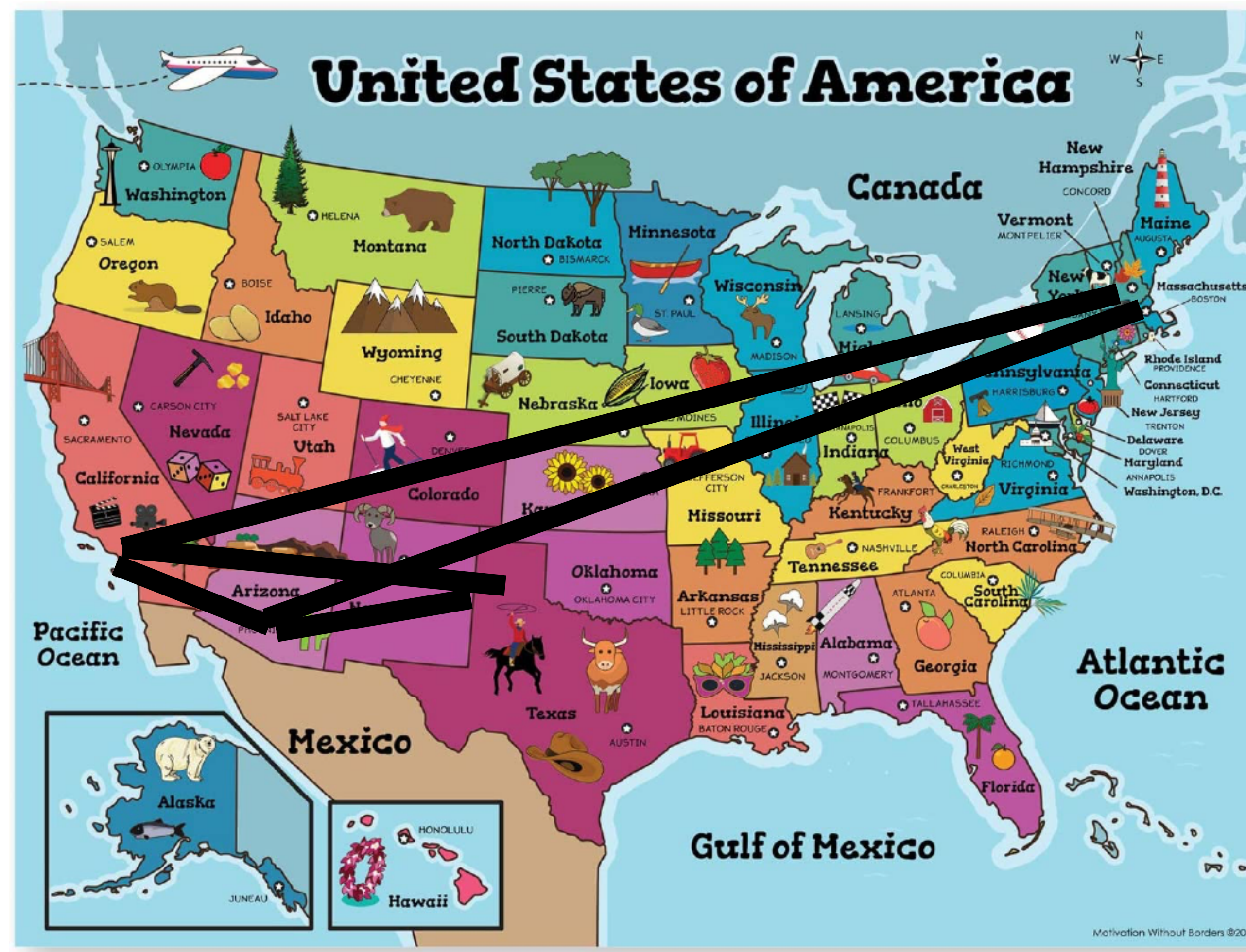
Who am I?

Professor at the University of Arizona

Went to UCLA for undergrad,
Caltech for my PhD.
I had several postdoctoral research positions: Arizona, Santa Barbara, Harvard

Fairly typical for an ‘academic’ astronomer.

From there I was a professor at Texas Tech
And then I came back to Tucson ~4 years ago. I love it here!



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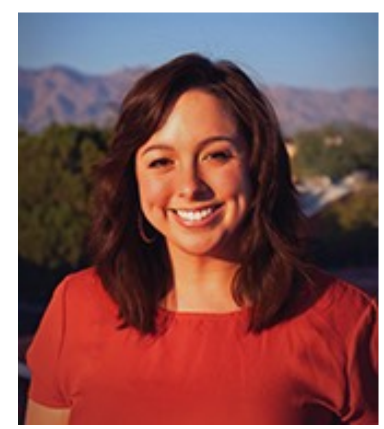


Daily Life:

1. Normal adult stuff.
2. I teach, but not too much
3. I do some research.
4. I write proposals so that people on my team can do research.
5. I sit on committees to run the department. Hiring committees, outside panels. 'Service'
6. I work with and on Steward Observatory's telescopes.

I have three graduate students, three postdocs, and an extended network of young people I work with. This is where the 'real' science gets done.

What do astronomers do?

- Observers: Go to telescopes, take data, test theories, write programs to analyze data, discover new classes of objects, etc.

Twin Magellan telescopes, Chile

LBT Control Room, Mt. Graham, AZ

What do astronomers do?

- Observers: Go to telescopes, take data, test theories, write programs to analyze data, discover new classes of objects, etc.

We also live in the era of ‘large surveys’ where large collaborations of people spend hundreds of nights collecting data for a big project.

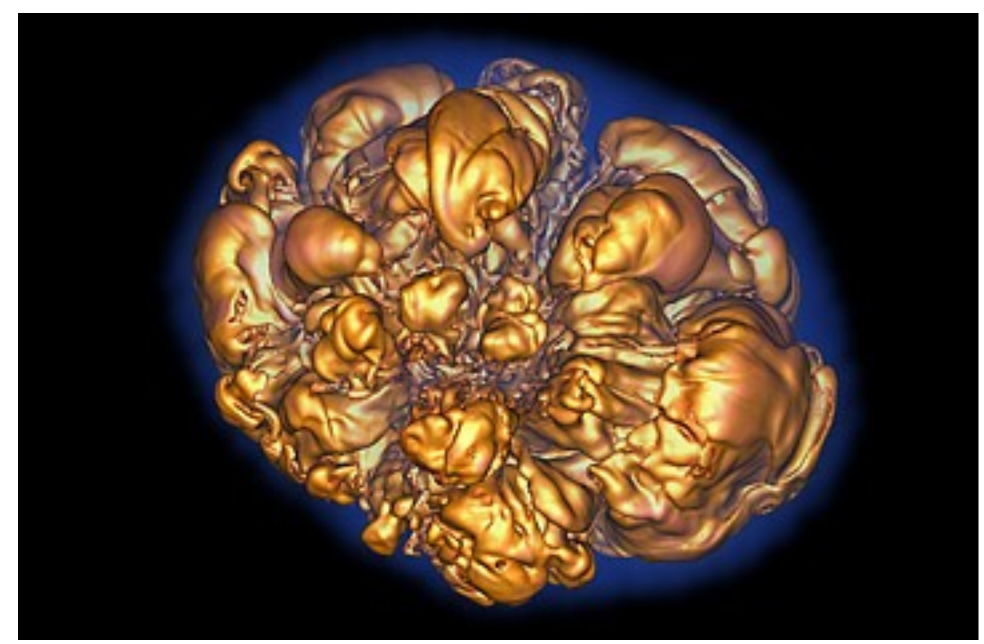
Vera Rubin Observatory, Chile

Dark Energy Spectroscopic Instrument, Kitt Peak

What do astronomers do?

- Theorists: Perform calculations, usually on a computer (rarely on paper) to understand the physics of astronomical objects. They should also make predictions that observers can then test. They write code, interpret simulations, talk with observers to understand what is possible.

High Performace Computing, U Arizona



3D Supernova Simulation

What do astronomers do?

- Instrumentalists: Build new types of cameras, using the latest technology, optics and software to look at the Universe in new ways. Hardware/technical skills, software, some understanding of the science is necessary.

South Pole Telescope instrumentation

What tools do astronomers use?

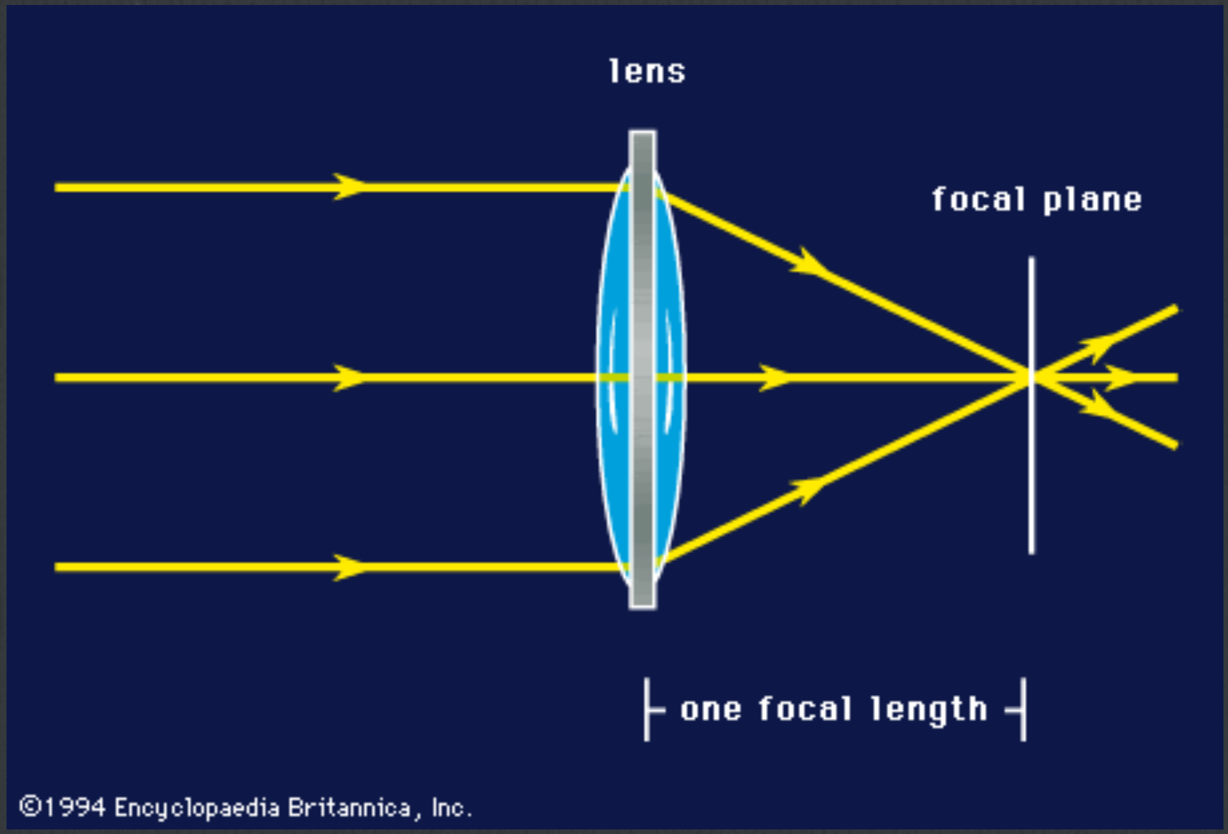
Lets Focus on Telescopes

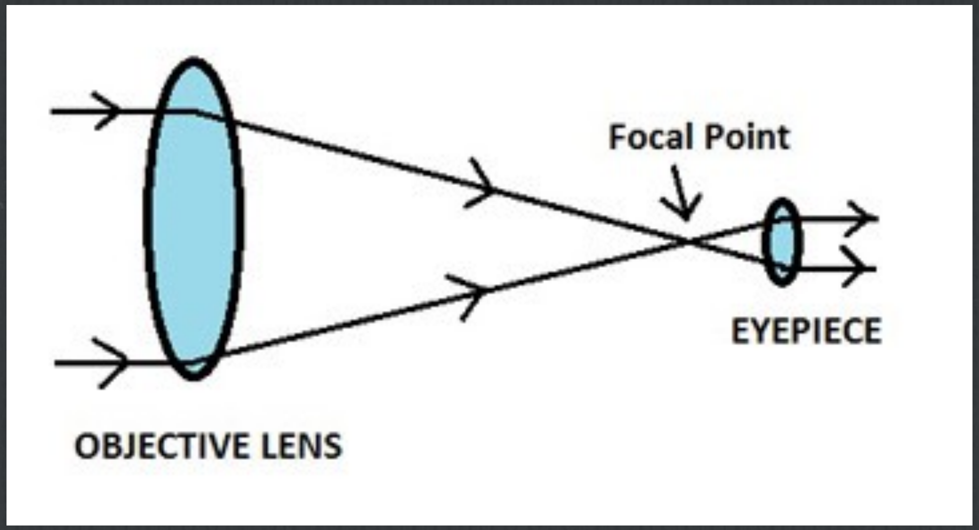
PimaCommunityCollege

Telescopes!
Two basic types

Refracting telescope

Telescopes that use lenses to gather light and bend it towards the focal plane.

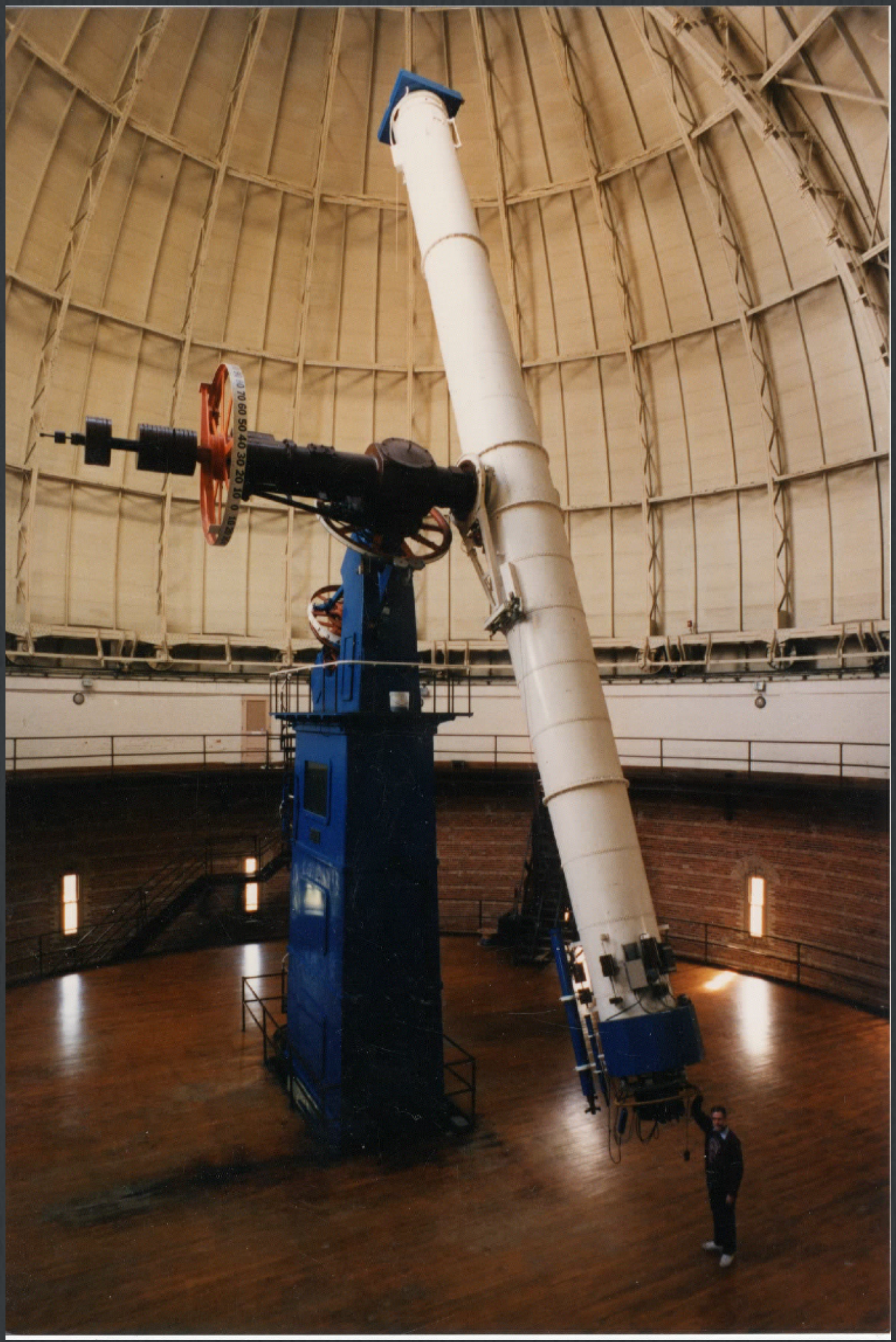




World's largest refracting telescope
Yerkes Observatory

1-m lens, in Wisconsin!

Opened in 1897. Tells you something.



Telescopes!
Two basic types

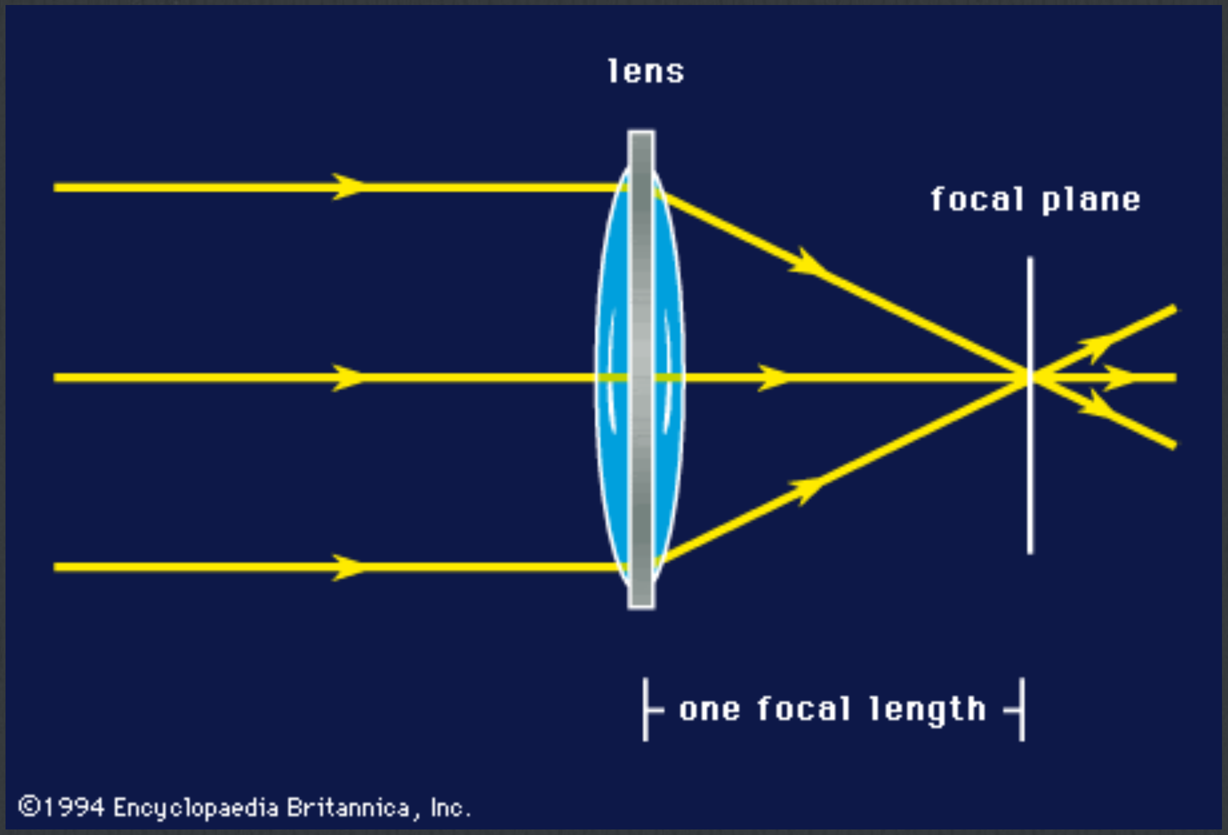
Refracting telescope

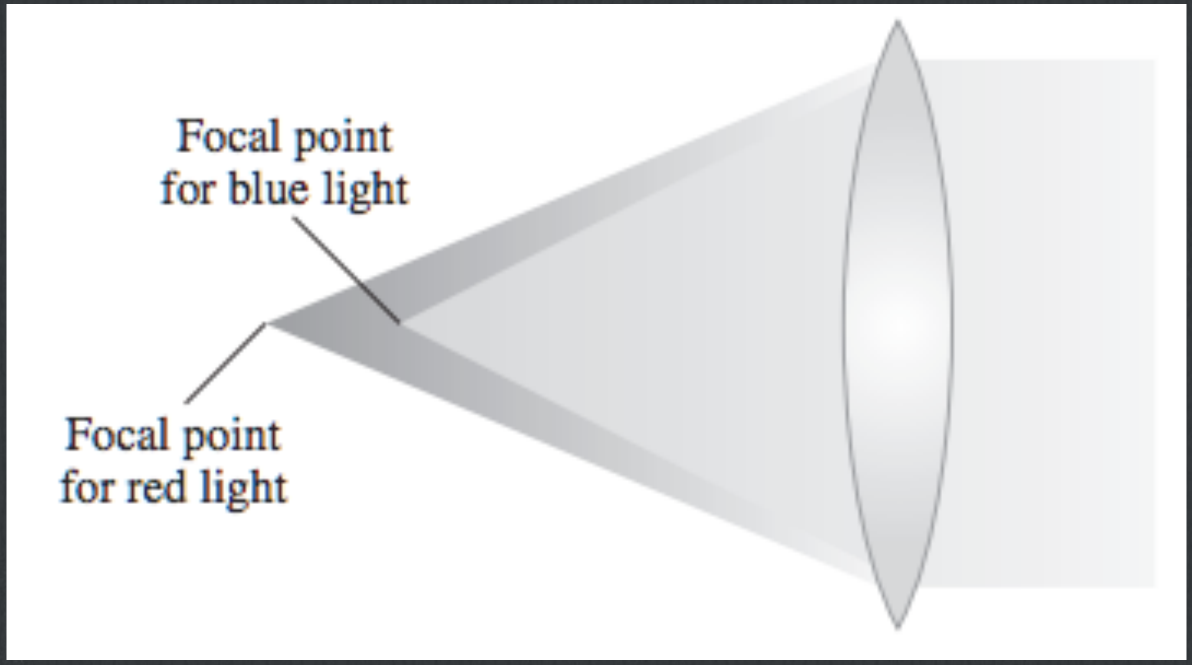
Practical problems:

1. Big lenses are hard to hold at their edges with long lever arms.

2. Long tube must fight the effects of gravity.

3. Lenses suffer from chromatic aberration. Refractive index of the glass leads to different focal lengths for red and blue light.





Telescopes!
Two basic types

Reflecting telescope

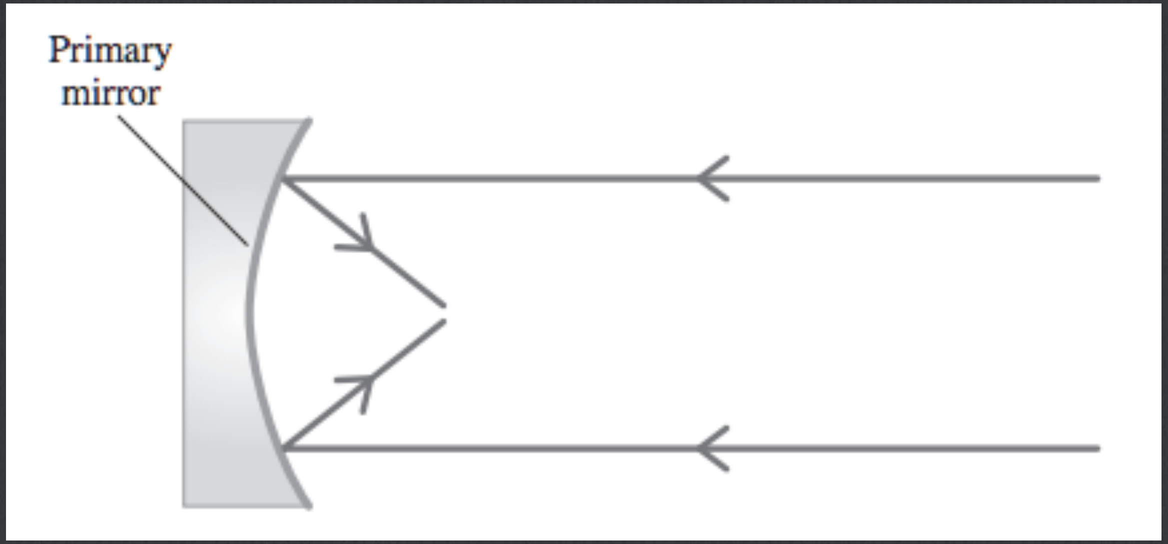
Concave mirror that can be cradled.

Like lenses, a mirror can be characterized by a focal length and diameter.

No chromatic aberration

Usually made of glass, with a coating, which can be shaped to high accuracy…like at our Mirror Lab!

Good rule of thumb — imperfections should be $<\lambda/4$ in size.



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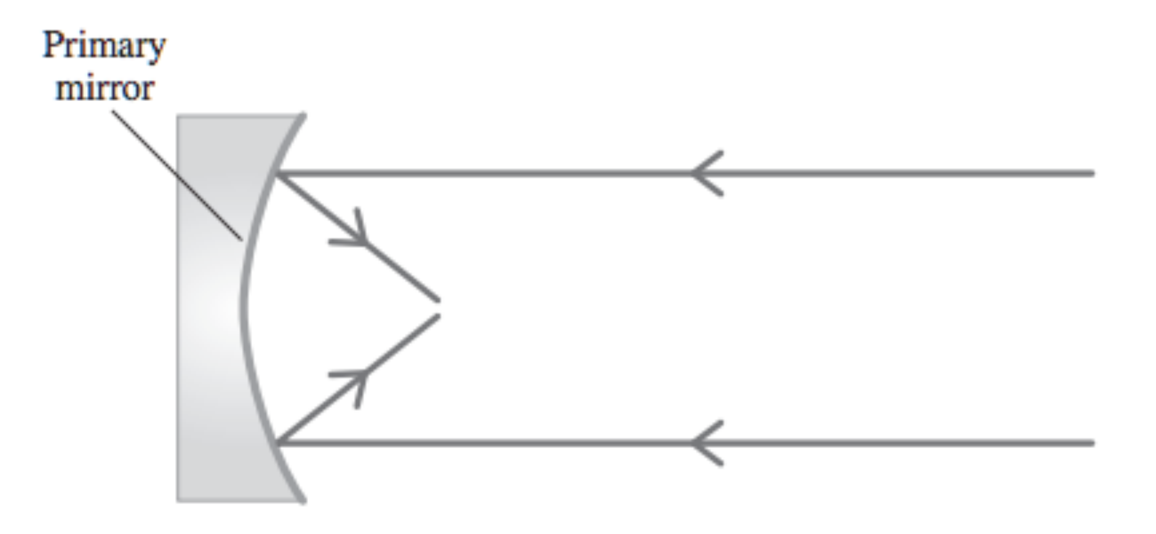
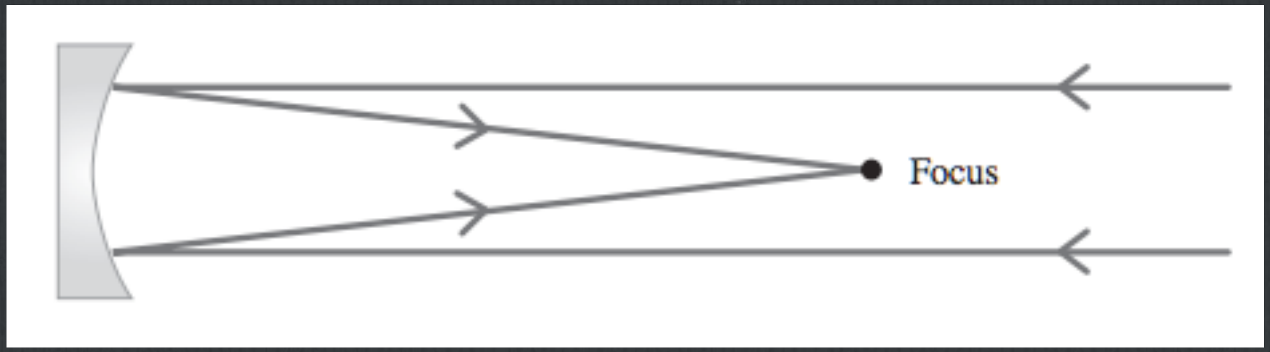


One problem: focal plane lies between mirror and light source. Your camera blocks incoming light!

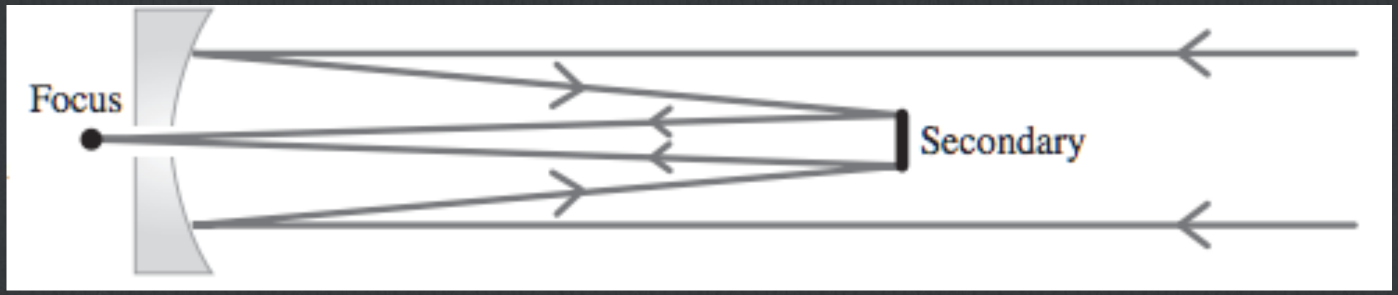
Configurations for Reflecting Telescopes



Prime Focus: good for small detectors and wide field of views. Challenge is to minimize detector footprint to block out a minimum amount of light.

90Prime at Bok 90” on Kitt Peak

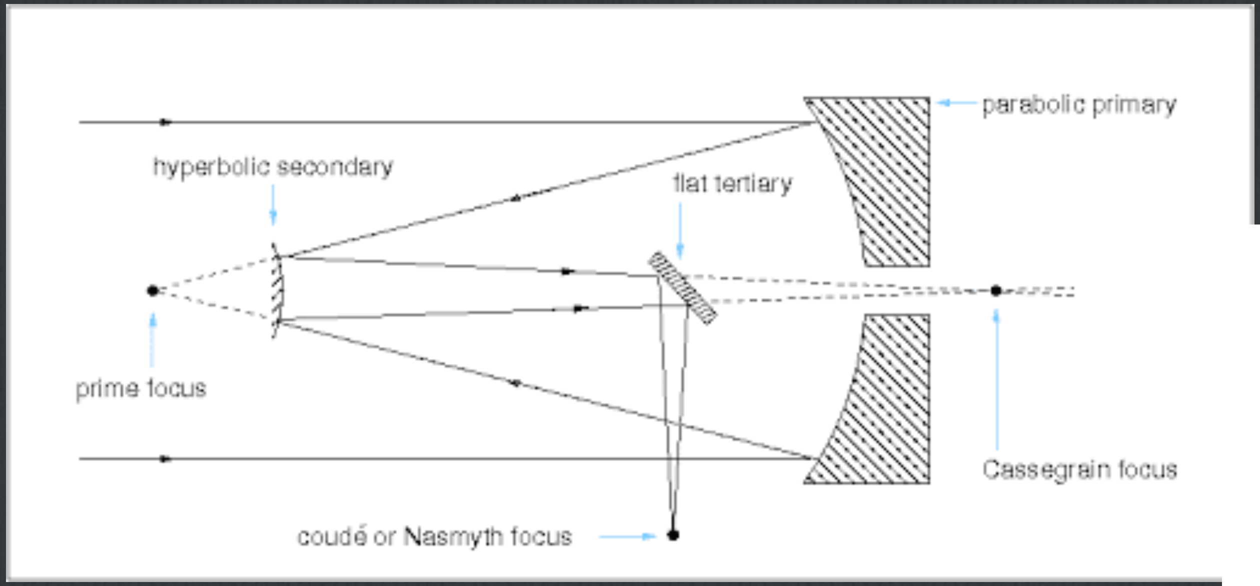
Configurations for Reflecting Telescopes

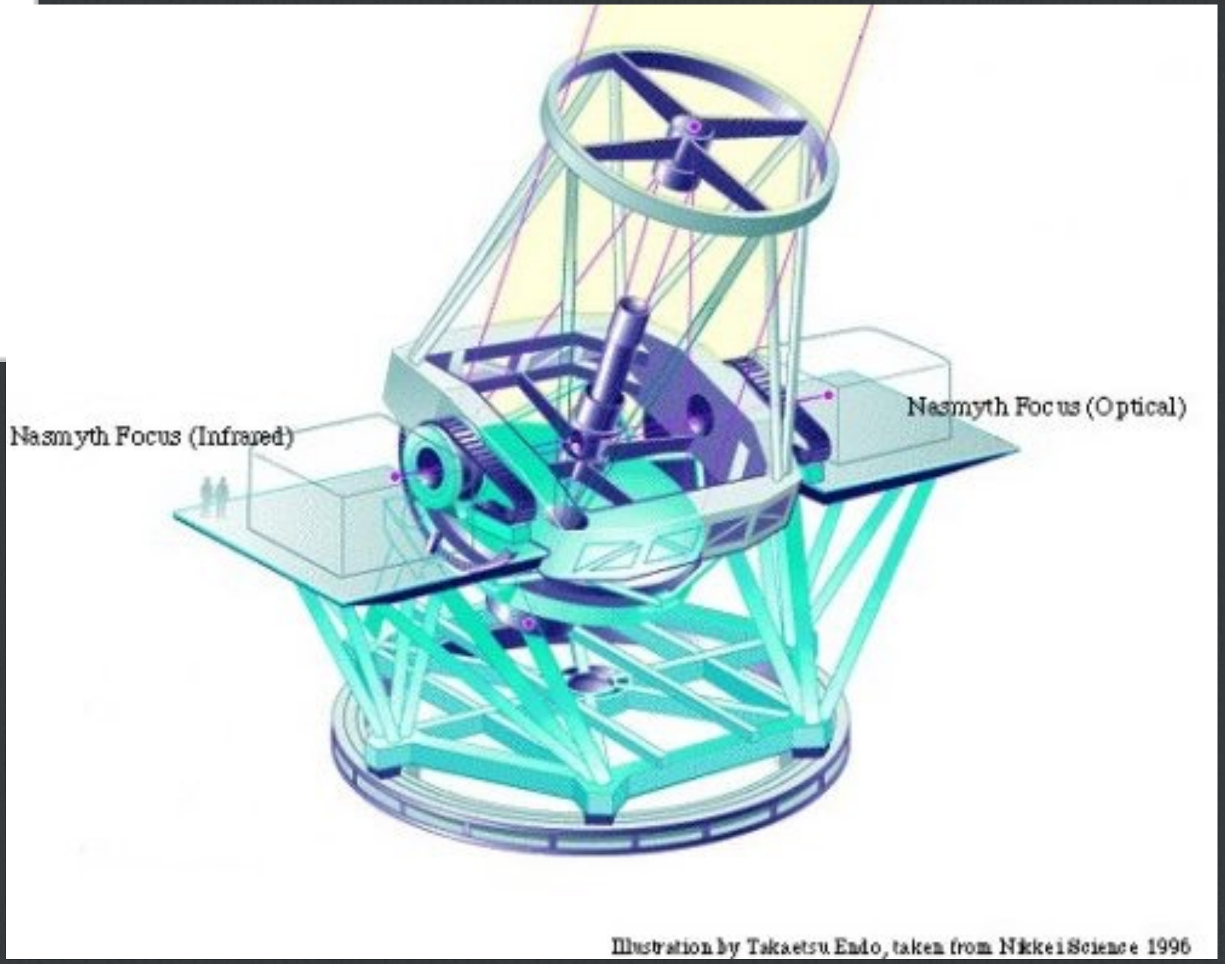


Cassegrain Focus: secondary hyperbolic mirror. Hole in primary mirror so light can be focused behind the telescope. Allows heavier instruments strapped to the back of the telescope.

MMIRS at the MMT

Configurations for Reflecting Telescopes

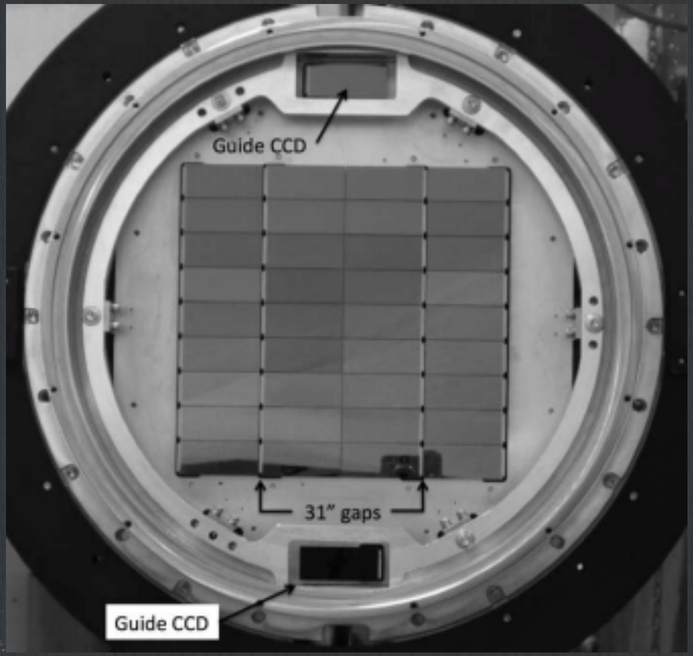




Coude and Nasmyth Focus:

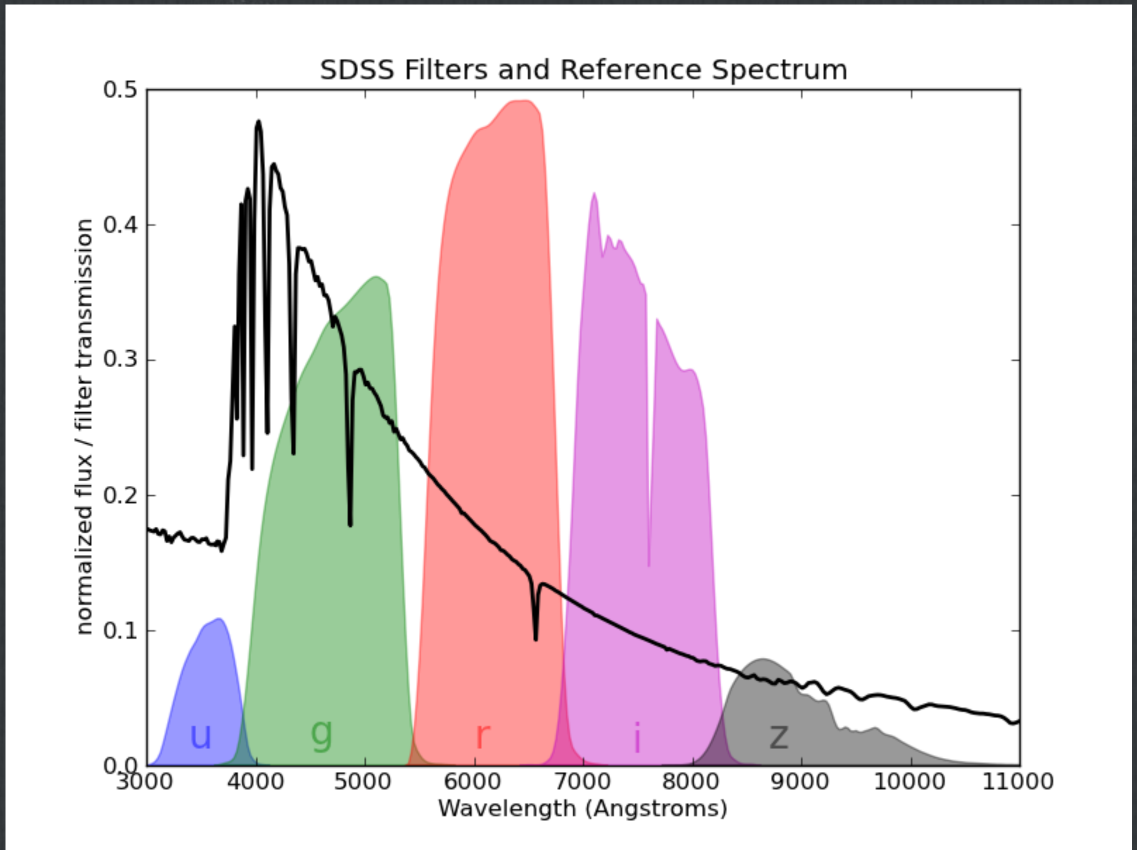
Multiple mirrors send light off to a stable location. Often used for very big telescopes, or when you want to be able to switch between instruments easily.

Two general types of Astronomical Instruments



1. **Imagers:** take images over some portion of the sky. Usually with a set of interchangeable filters for admitting light at different wavelengths.

Useful for understanding luminosity, color, temperature of objects. Also useful for morphology of galaxies and other structures.



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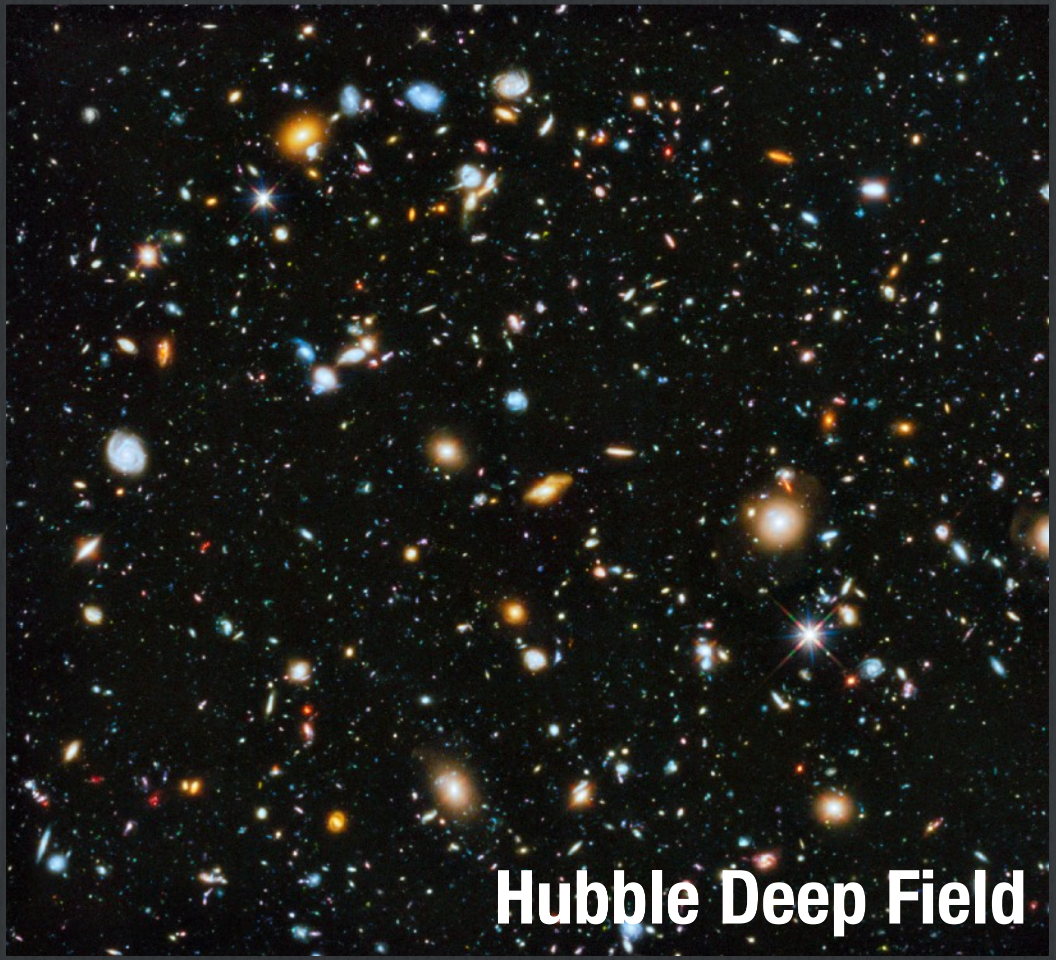
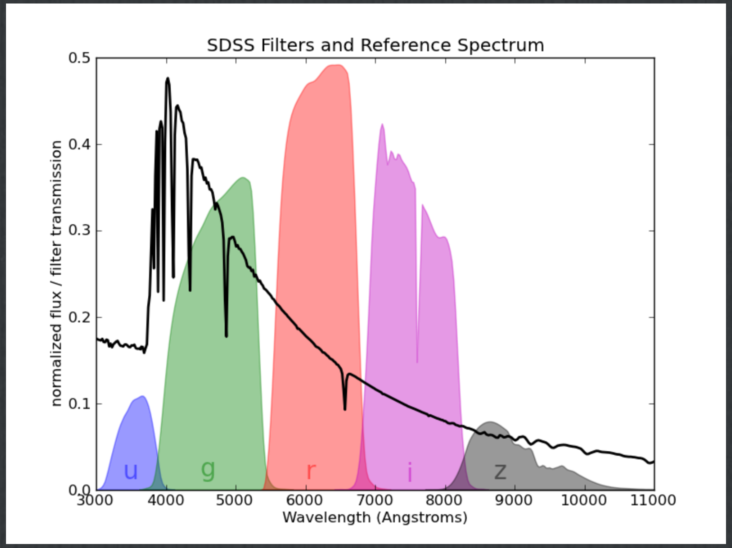
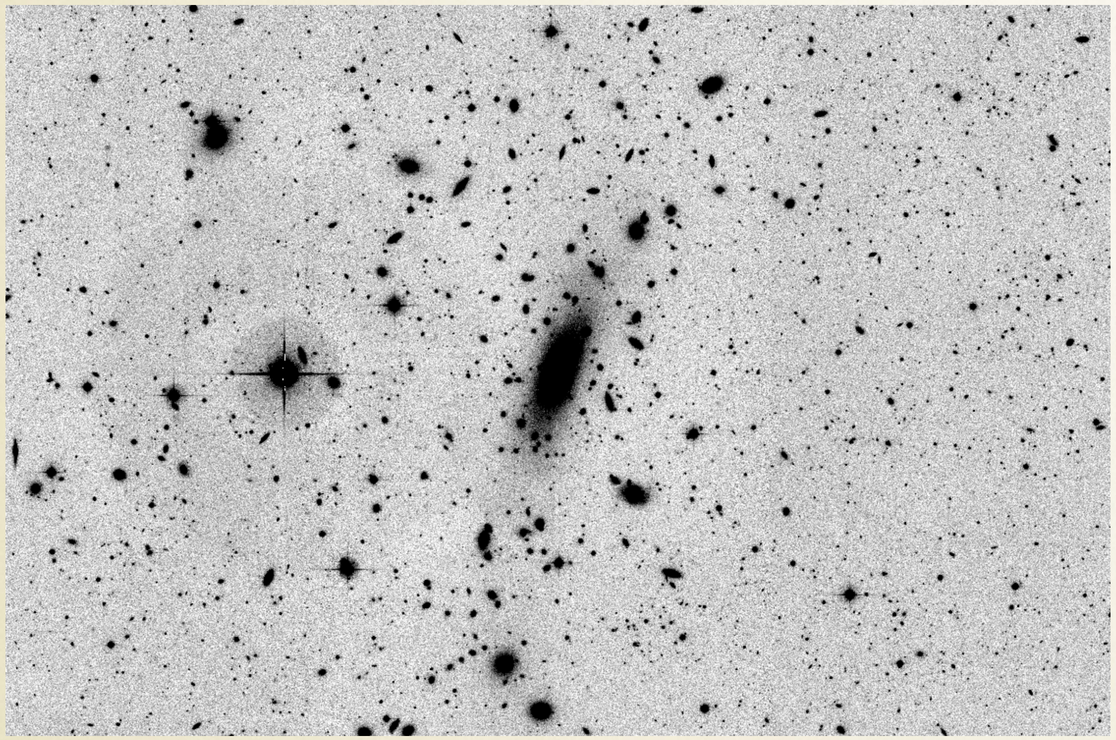
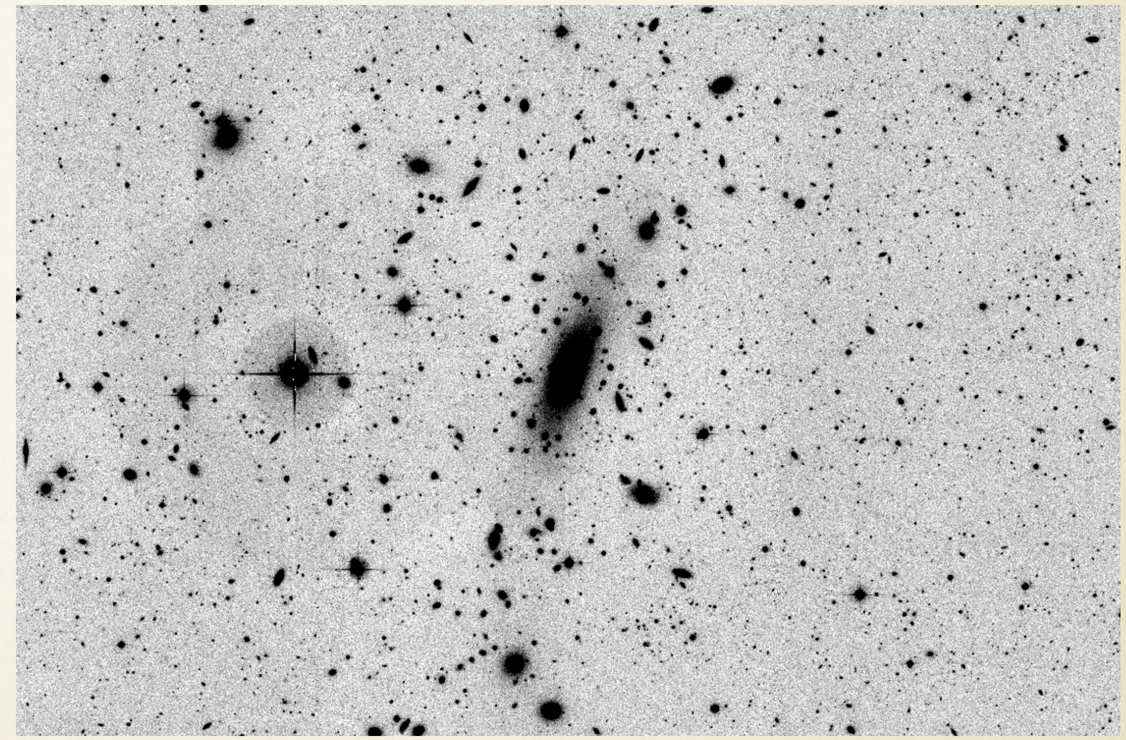




Aside: How to find a supernova



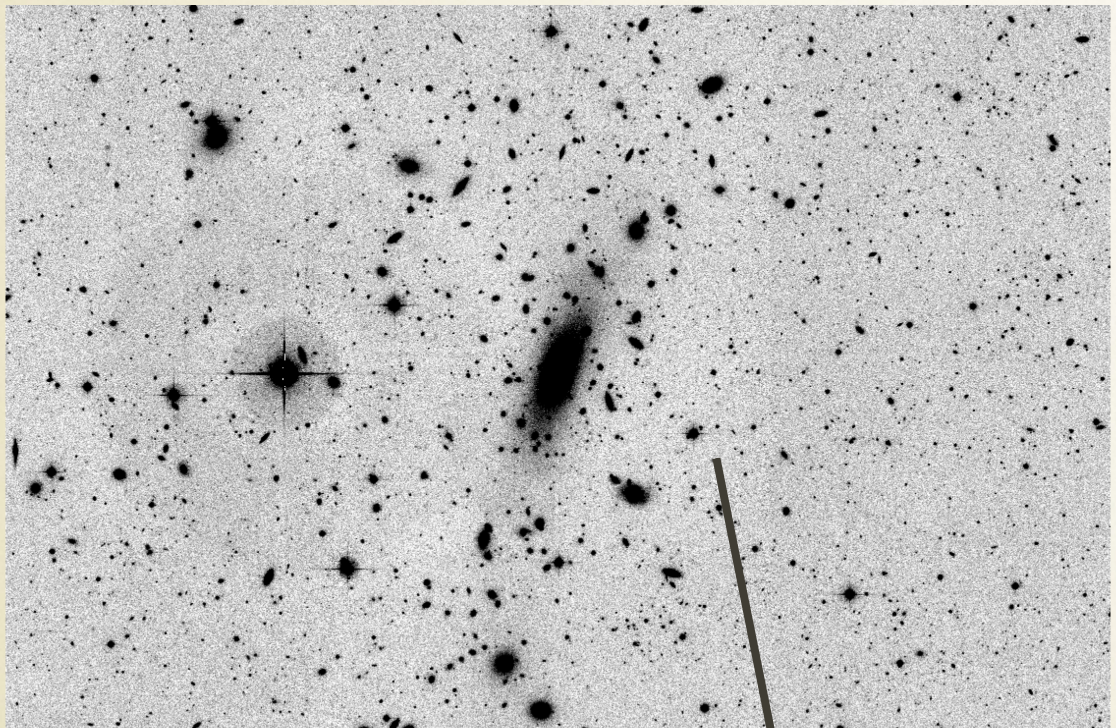
Day 1 from Sand et al. 2012



Day 5 (or whenever)

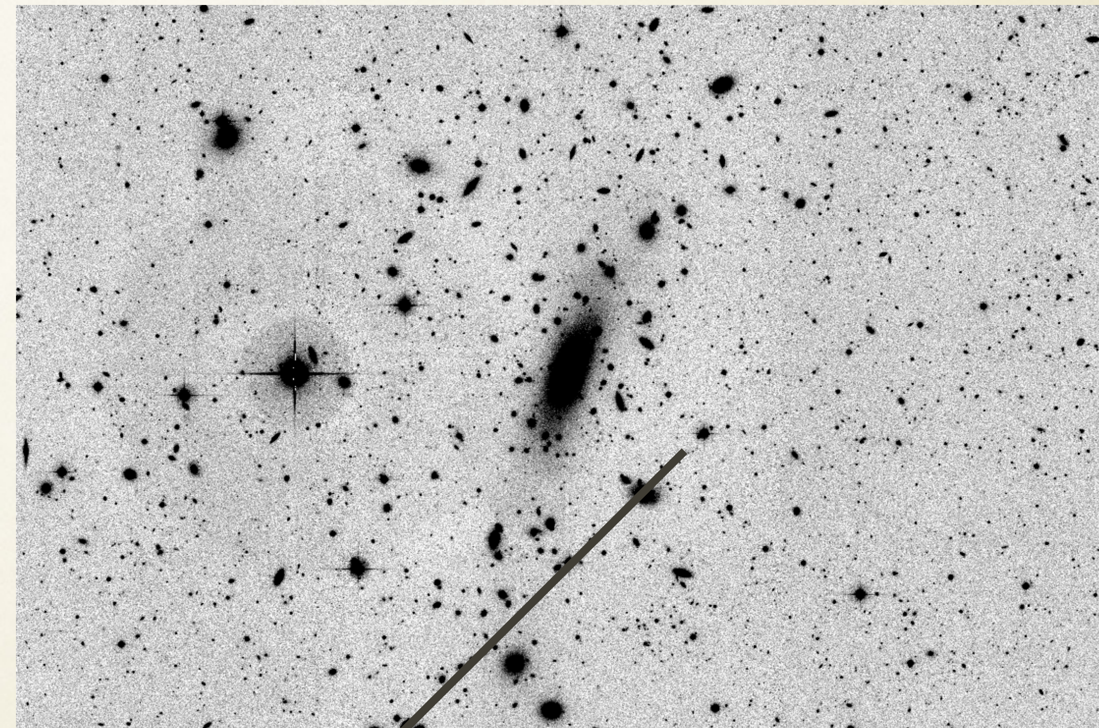
Convolve 'better' image with Gaussian to match 'worse' image, and then subtract

How to find a supernova



Day 1

from Sand et al. 2012



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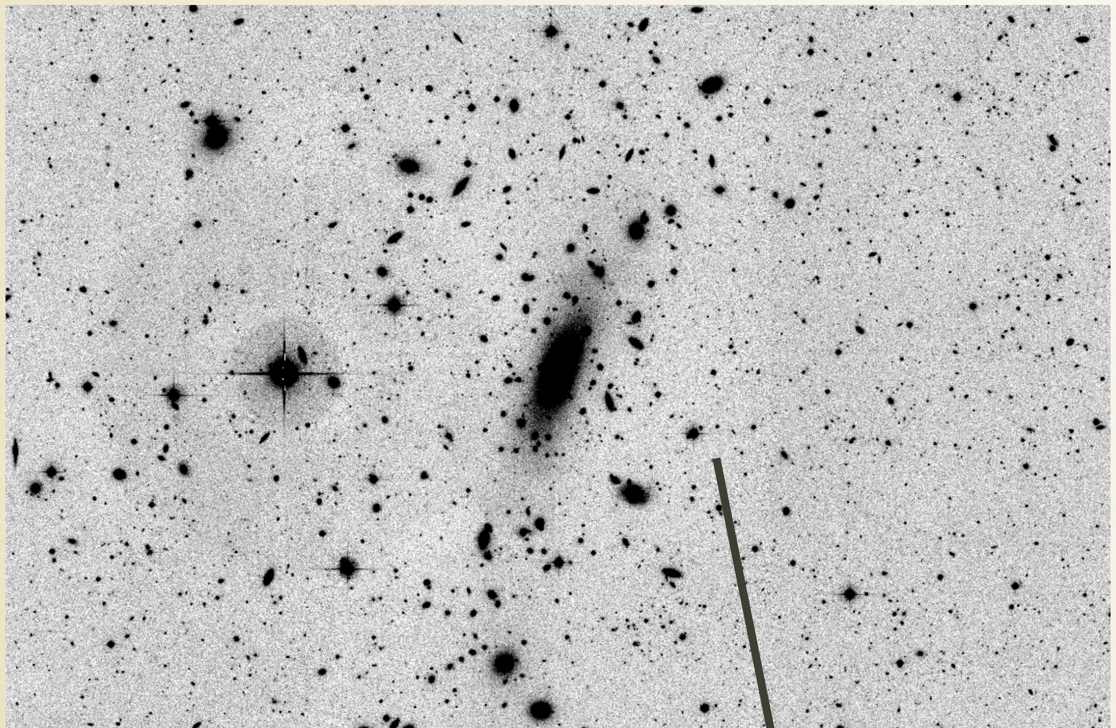
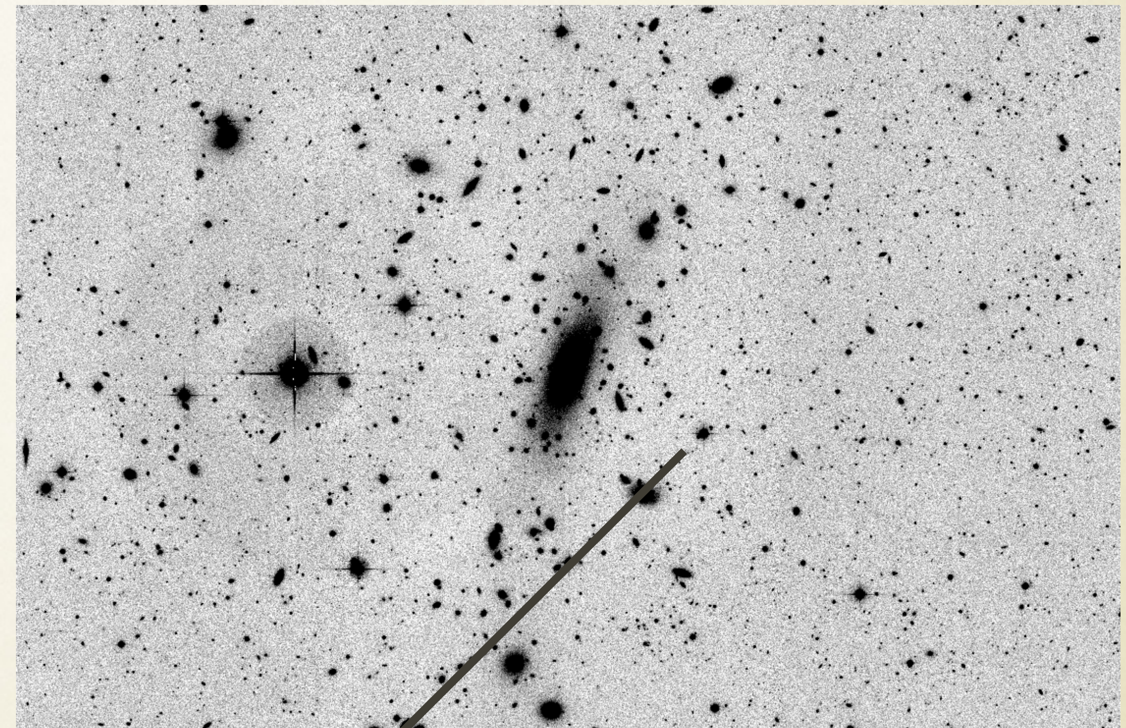
How to find a supernova





Day 1

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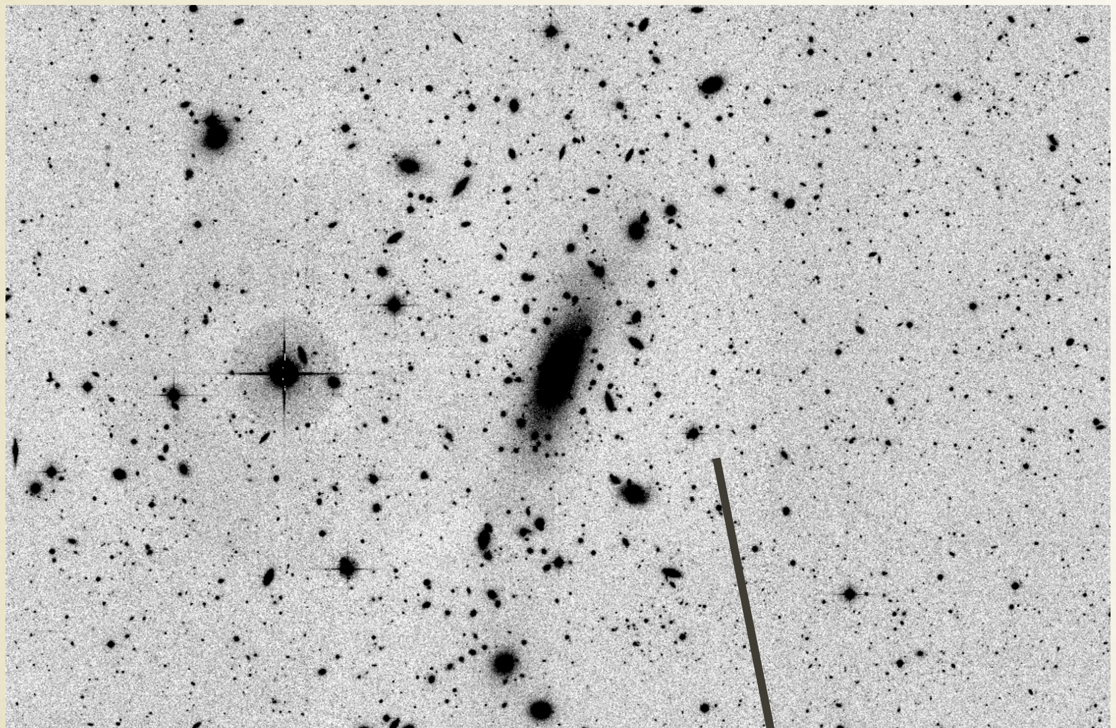
But what is it!?

How to find a supernova



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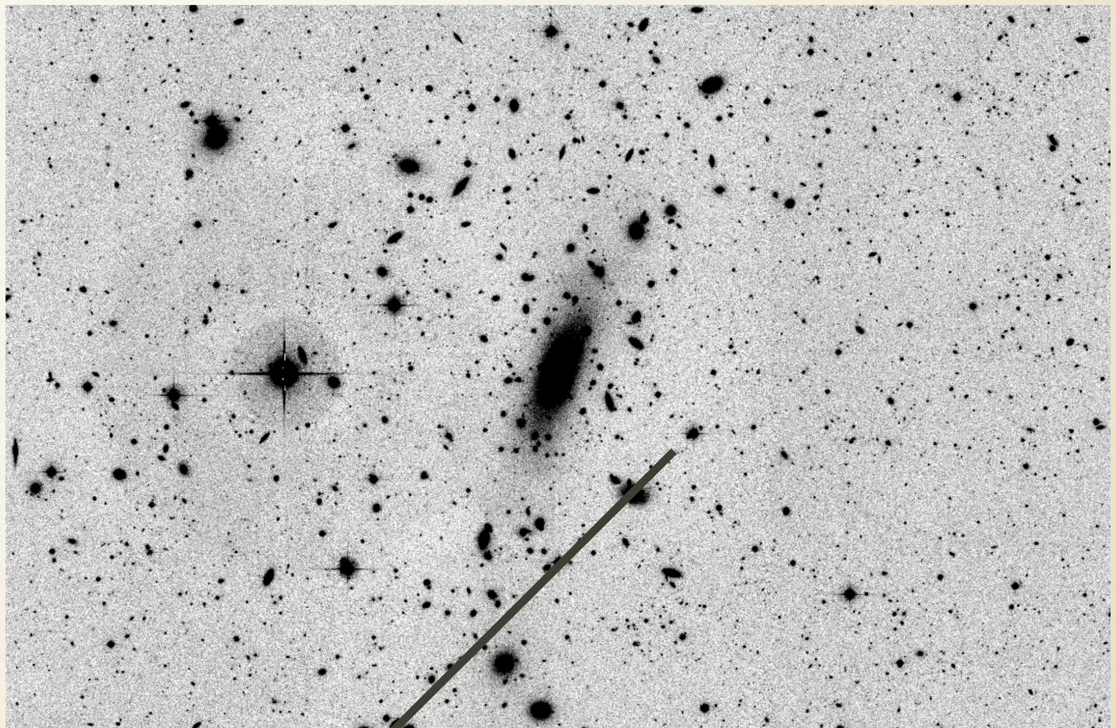
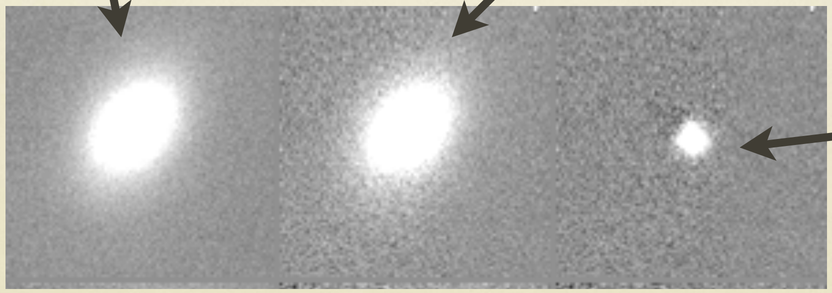


Day 5 (or whenever)

Convolve 'better' image with Gaussian to match 'worse' image, and then subtract



But what is it!?

Two general types of Astronomical Instruments

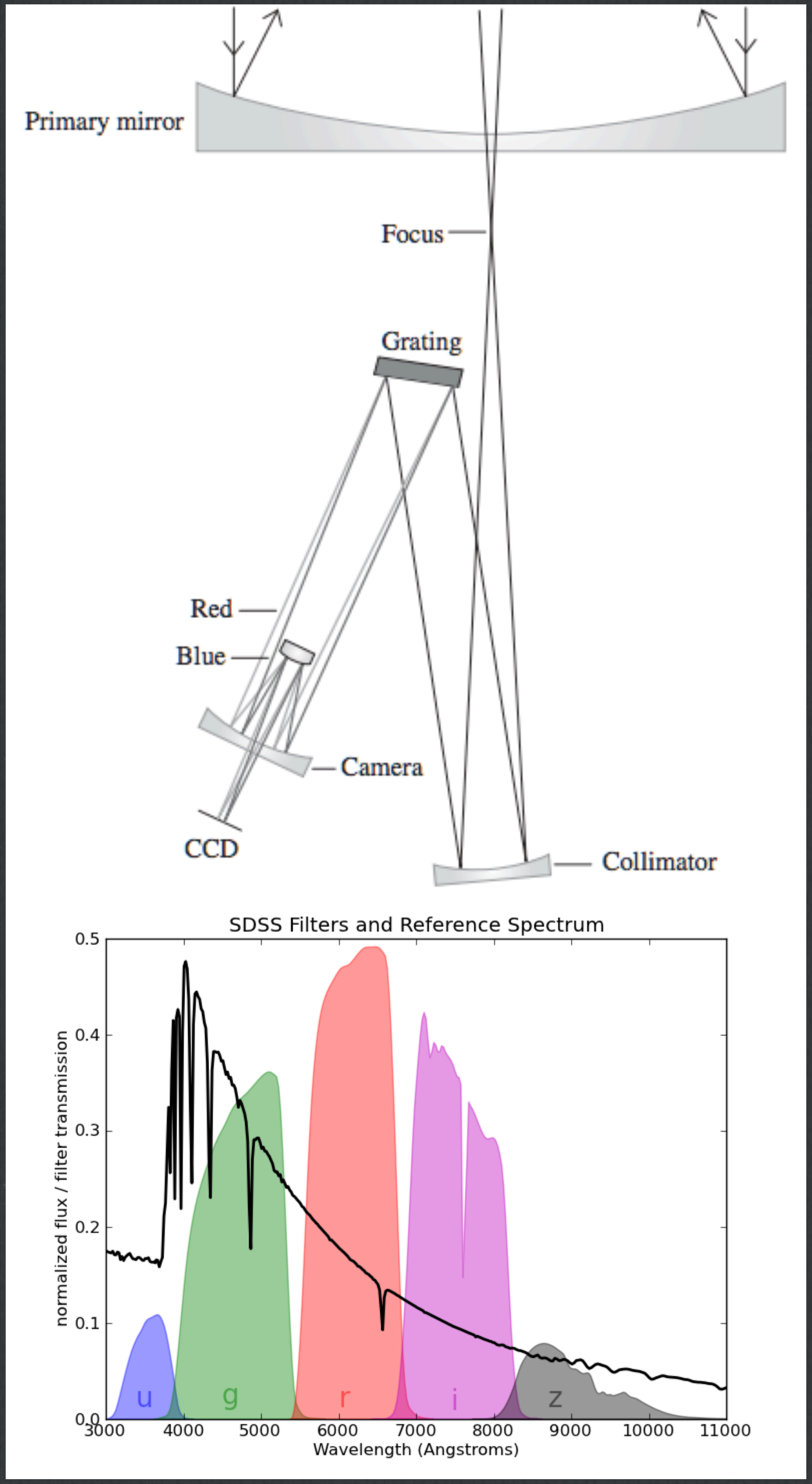
1. **Spectrographs:** disperse light into the 'colors of the rainbow'. Disperse light by wavelength.

Normally a grating or grism is used instead of a prism.

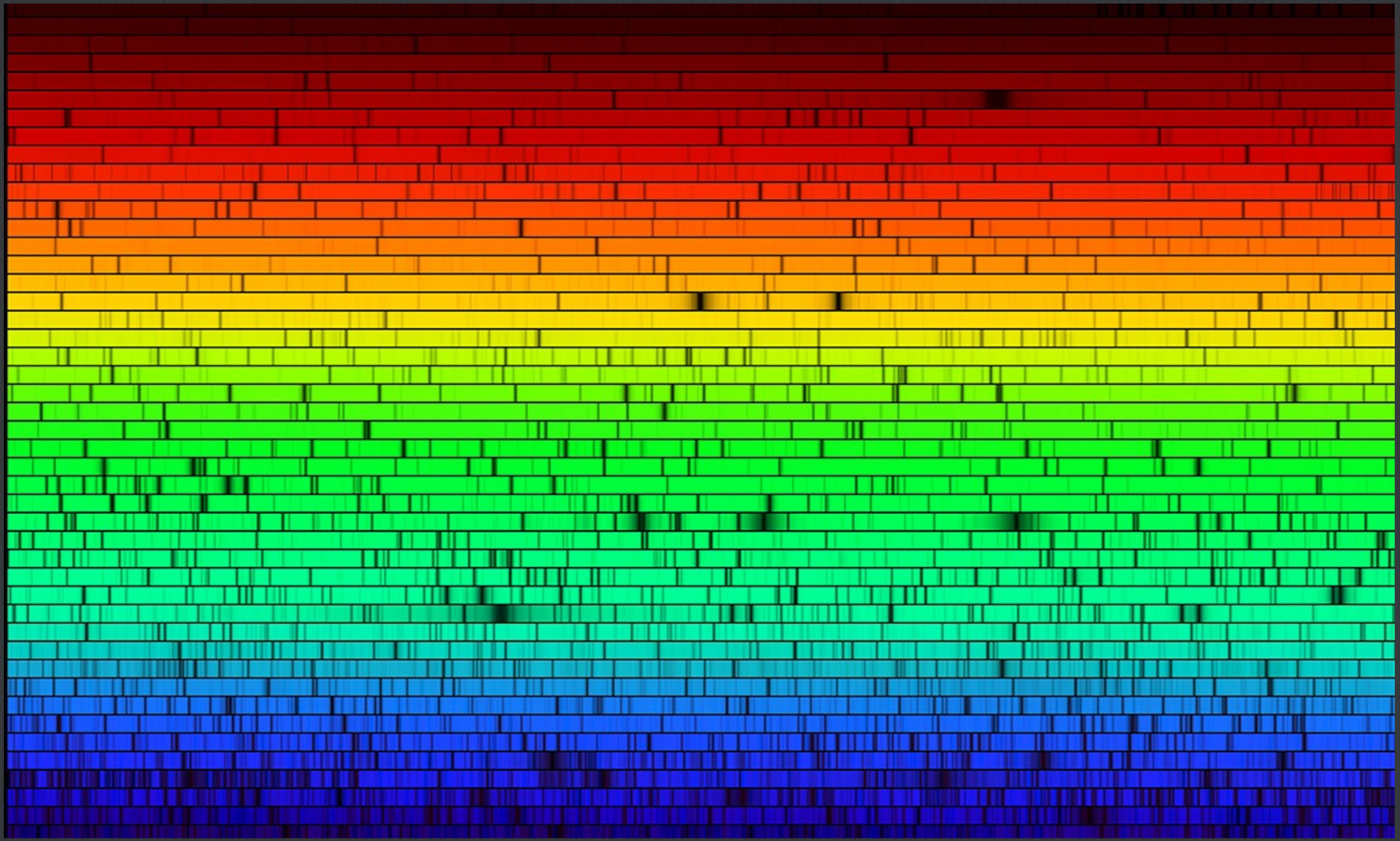
Spectral resolution:

$$R = \lambda / d\lambda.$$

Can just distinguish featues between: λ and $\lambda + d\lambda$,

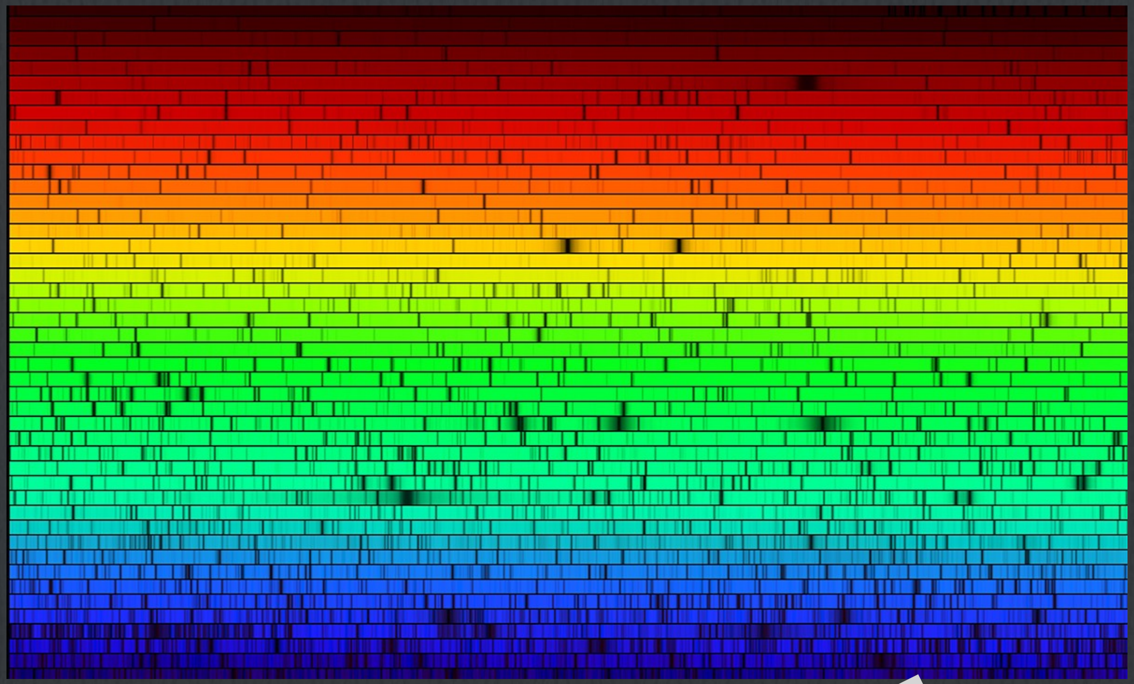


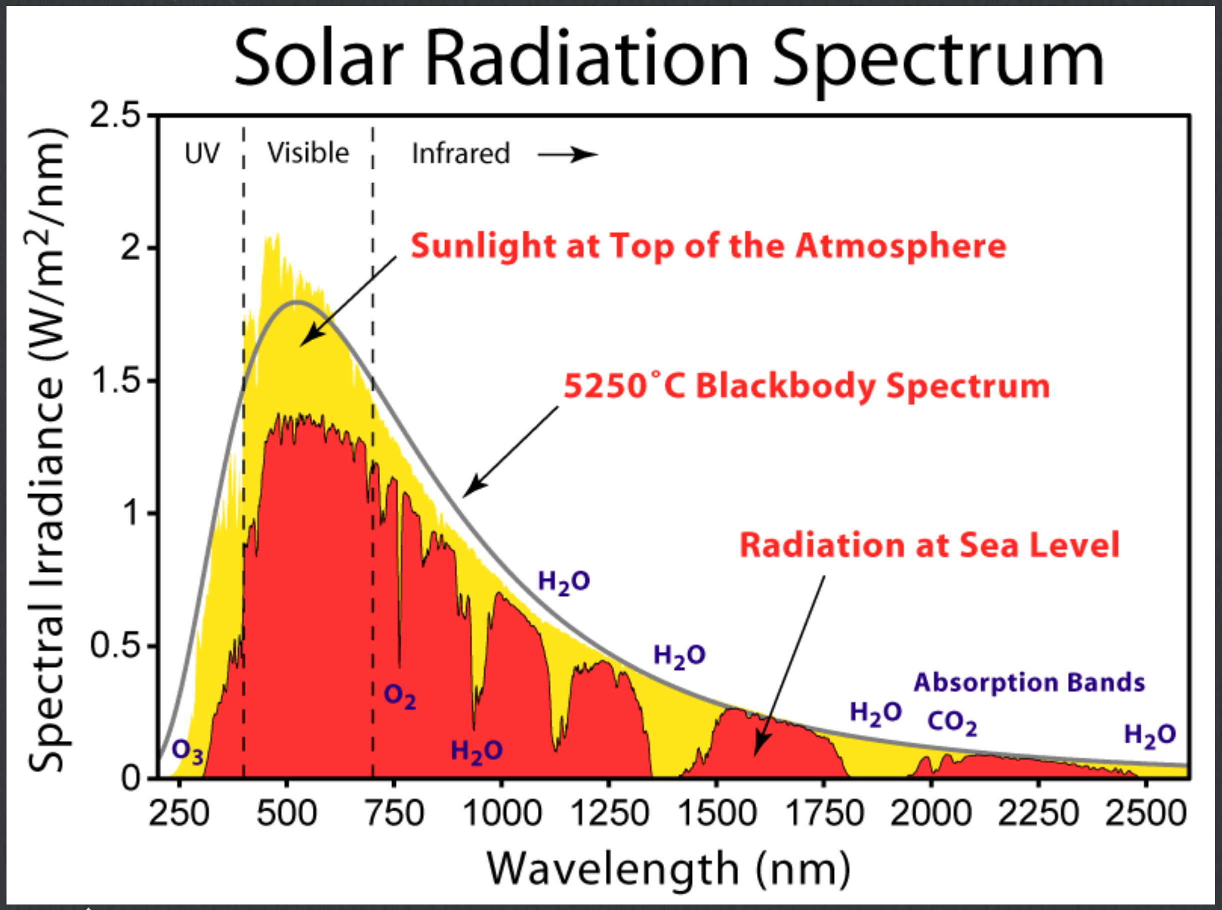
Solar Spectrum



Spectra can teach us about the chemical makeup, temperature and even velocity of an object

Solar Spectrum





This can be plotted like this, so that we know how much light there is as a function of wavelength.

Simple Detector Characteristic: Quantum Efficiency

Quantum Efficiency: How effectively does detector respond to light.

QE = # photons detected/#photons hitting detector

Photographic Plates:

Human Eye:

Photoconductive detectors (CCDs):

Photoconductive Detectors are solid state devices that accumulate charge when photons strike.

Simple Detector Characteristic: Quantum Efficiency

Quantum Efficiency: How effectively does detector respond to light.

QE = # photons detected/#photons hitting detector

Photographic Plates: ~1%

Human Eye: <10%

Photoconductive detectors (CCDs): ~80-90%

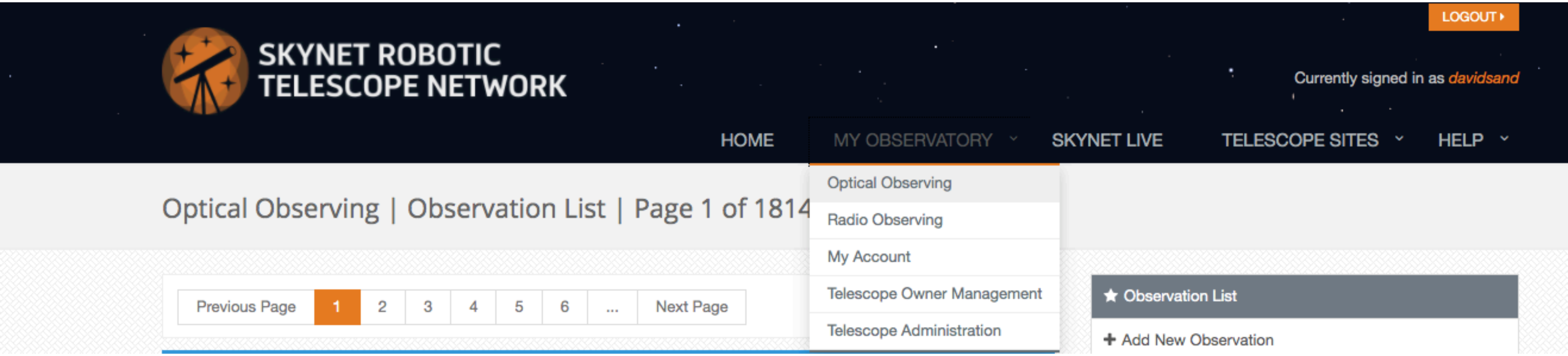
Photoconductive Detectors are solid state devices that accumulate charge when photons strike.

skynet

With your browser, navigate to:
https://skynet.unc.edu/
davidsand
bacon1

skynet

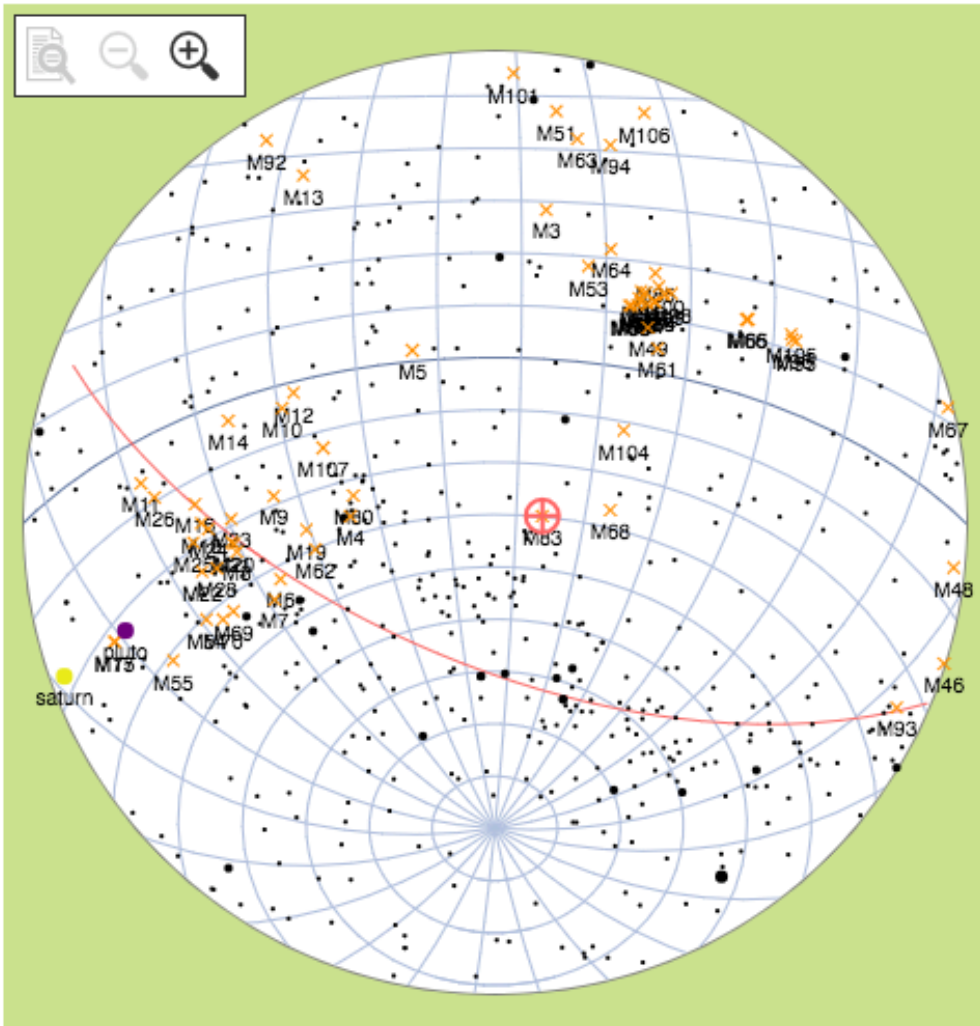
With your browser, navigate to:
https://skynet.unc.edu/



Target Finding Interface

Sky Viewer: Graphical display of observable targets

Clicking on a target in the SkyViewer will automatically fill in coordinates in the form below.



2021/3/23 11:26:00 AM US/Arizona Time Zone

Meckering Observatory

PROMPT-MO-1

hour

sunset

- [ ] Az/El Grid
- [x] RA/Dec Grid
- [x] Galactic Plane
- [x] Stars
- [x] Solar System
- [x] Messier Catalog
- [ ] Large/Bright Galaxies
- [ ] Bright Radio Catalog
- [x] Sky Brightness

Observation Name:	Right Ascension (J2000):	Declination (J2000):
M83_DS	13:37:00.912	-29:51:56.88
Max Sun Elevation:	**Min Target Elevation:**	**Min Visible Hours:**
-18.0	30.0	1.0

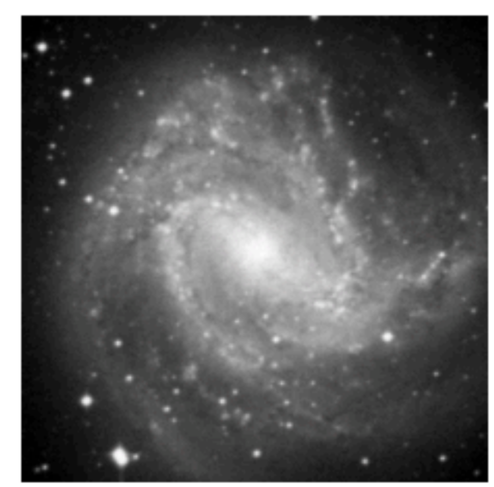
- Observation List
- **Add New Observation**
- Campaign List
- Add New Campaign
- Batch Observation Upload
- Open Afterglow

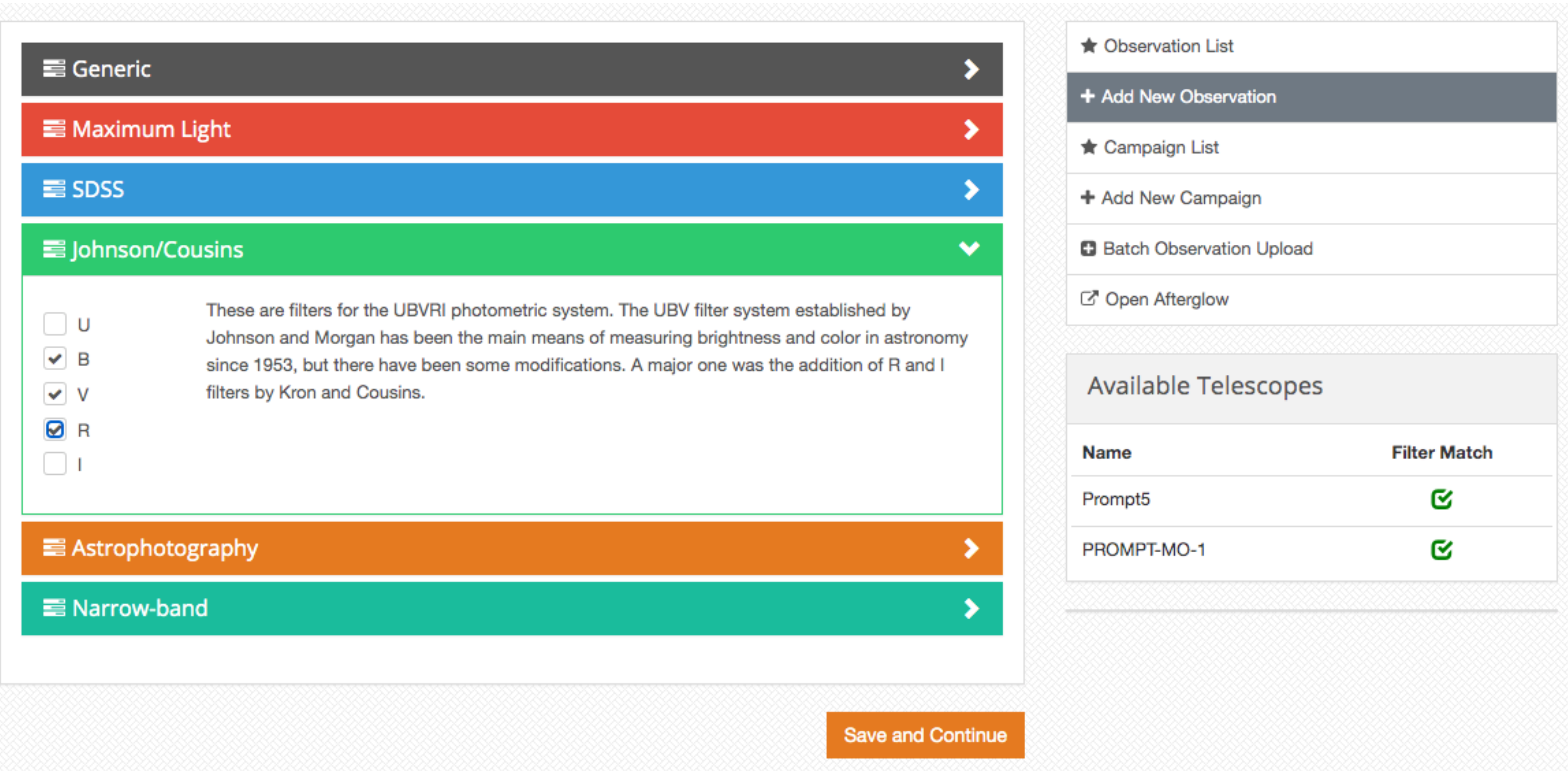
Target Lookup

keywords:

Search

DSS Preview




Generic
Maximum Light
SDSS
Johnson/Cousins
U
B
V
R
I
These are filters for the UBVRI photometric system. The UBV filter system established by Johnson and Morgan has been the main means of measuring brightness and color in astronomy since 1953, but there have been some modifications. A major one was the addition of R and I filters by Kron and Cousins.
Astrophotography
Narrow-band
Save and Continue
Observation List
Add New Observation
Campaign List
Add New Campaign
Batch Observation Upload
Open Afterglow
Available Telescopes
Name
Filter Match
Prompt5
PROMPT-MO-1

Optical Observing | Add Observation

Target → Filters → **Telescopes** → Exposures → Review

CTIO | La Serena, Chile

MO | Meckering, Australia

Name	Diameter	Field of View	Pixel Scale
☑ PROMPT-MO-1	0.41 m	10.2' X 10.2'	0.60 "/pixel

Save and Continue

- Observation List
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- Campaign List
- Add New Campaign
- Batch Observation Upload
- Open Afterglow

Available Time Accounts

Sponsor	Balance	Available
TTU	974,524,569	☑

PROMPT-MO-1, PROMPT-USASK, Prompt5

Choose Exposure Efficiency

The exposure lengths you provide below are intended for your primary telescope.

If Skynet dispatches your observation to a different telescope, the exposure lengths will be automatically adjusted to compensate for telescope size.

PROMPT-MO-1 - 0.41m

Add Exposures

The shortest allowed exposure length is 0.03 seconds.

	Filter	# Exps	Duration (s)	Max	Total	
	B	1	60	N/A	1.0 min	✖
	V	1	60	N/A	1.0 min	✖
	R	1	60	N/A	1.0 min	✖

Add Row

Total Observing Time: 3.0 mins

Preview adjusted exposure lengths by hovering over a telescope name below

PROMPT-MO-1

Select Time Account

ID	Sponsor	Balance	Priority
8728	ttu	974,524,569 credits	1

Advanced Options

Save and Continue

OBSERVATION NAME:	M83_DS
RIGHT ASCENSION:	13:37:00.912
DECLINATION:	-29:51:56.88
MAX SUN ELEVATION:	-18.0 degrees
MIN TARGET ELEVATION:	30.0 degrees
TELESCOPES:	PROMPT-MO-1
EFFICIENCY:	0.73
EXPOSURES:	B | 1x | 60.0 seconds V | 1x | 60.0 seconds R | 1x | 60.0 seconds
CANCEL AFTER:	2021-04-22 19:37:00 UTC
TIME ACCOUNT:	8728 - TTU

BALANCE:	974,524,569 credits
TOTAL COST:	132 credits
ENDING BALANCE:	974,524,437 credits

Submit