Today

- Telescopes
- Solar System Overview

Next time

- Homework 3 Due

Exam statistics

- average: 94 (out of 120)
- median: 100
- high: 115
- low: 56

Graded work is available for pick up during regular business hours from the Astronomy administrative assistant Agnes Torontali (Sears 567).

Telescopes

- Telescopes collect more light than our eyes ⇒ **light-collecting area**
- Telescopes can see more detail than our eyes ⇒ **angular resolution** (magnification)
- Telescopes/instruments can record light more sensitively than our eyes, and detect electromagnetic radiation that is invisible to our eyes (e.g., infrared, ultraviolet)

Bigger is better

1. Larger light-collecting area

   can see fainter things

2. Better angular resolution

   can see smaller things

Bigger is better

For a telescope with mirror of diameter D,

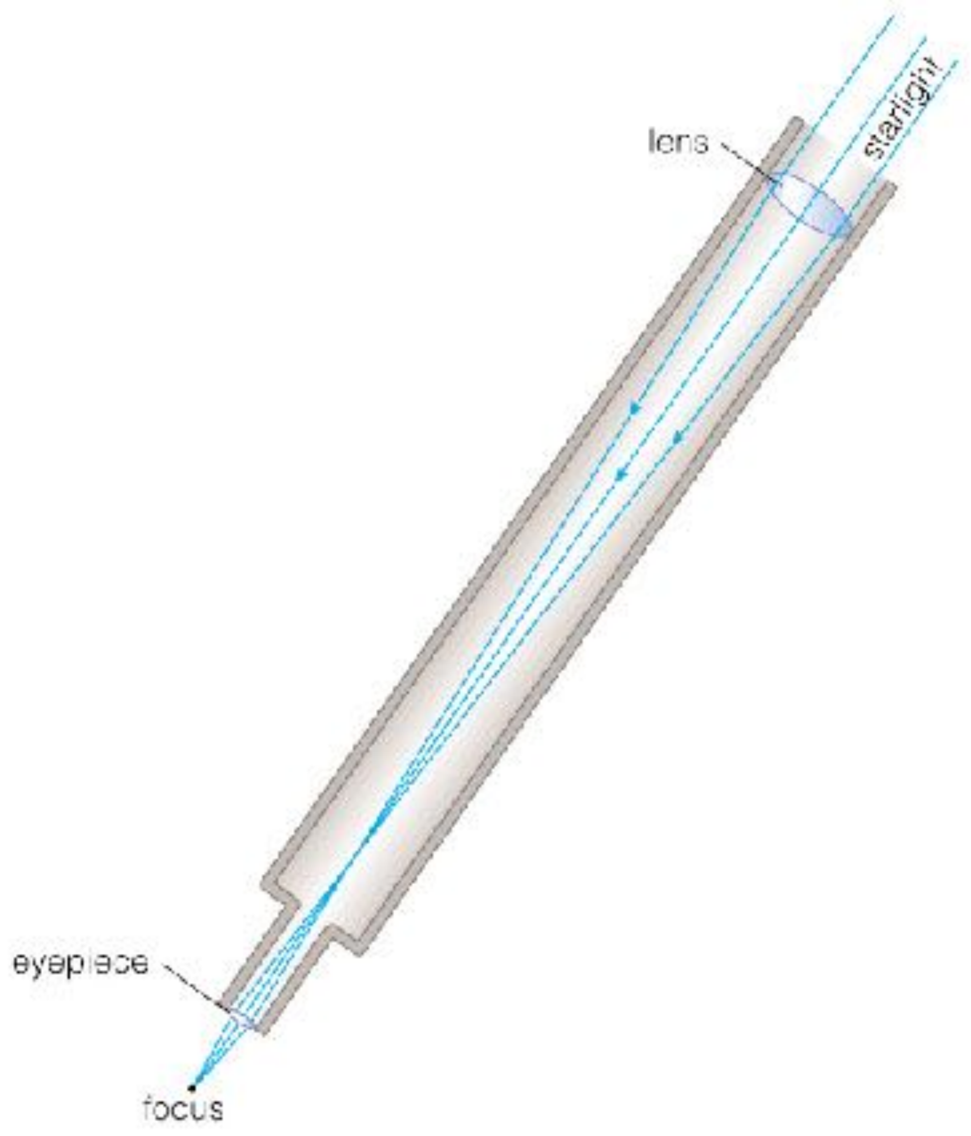
can see fainter: $$b^{-1} \propto D^2$$

with higher resolution: $$\theta \propto \frac{\lambda}{D}$$

PLAY 05_LightCollectingArea 05_MirrorAngularRes

Basic Telescope Design

- Refracting: lenses

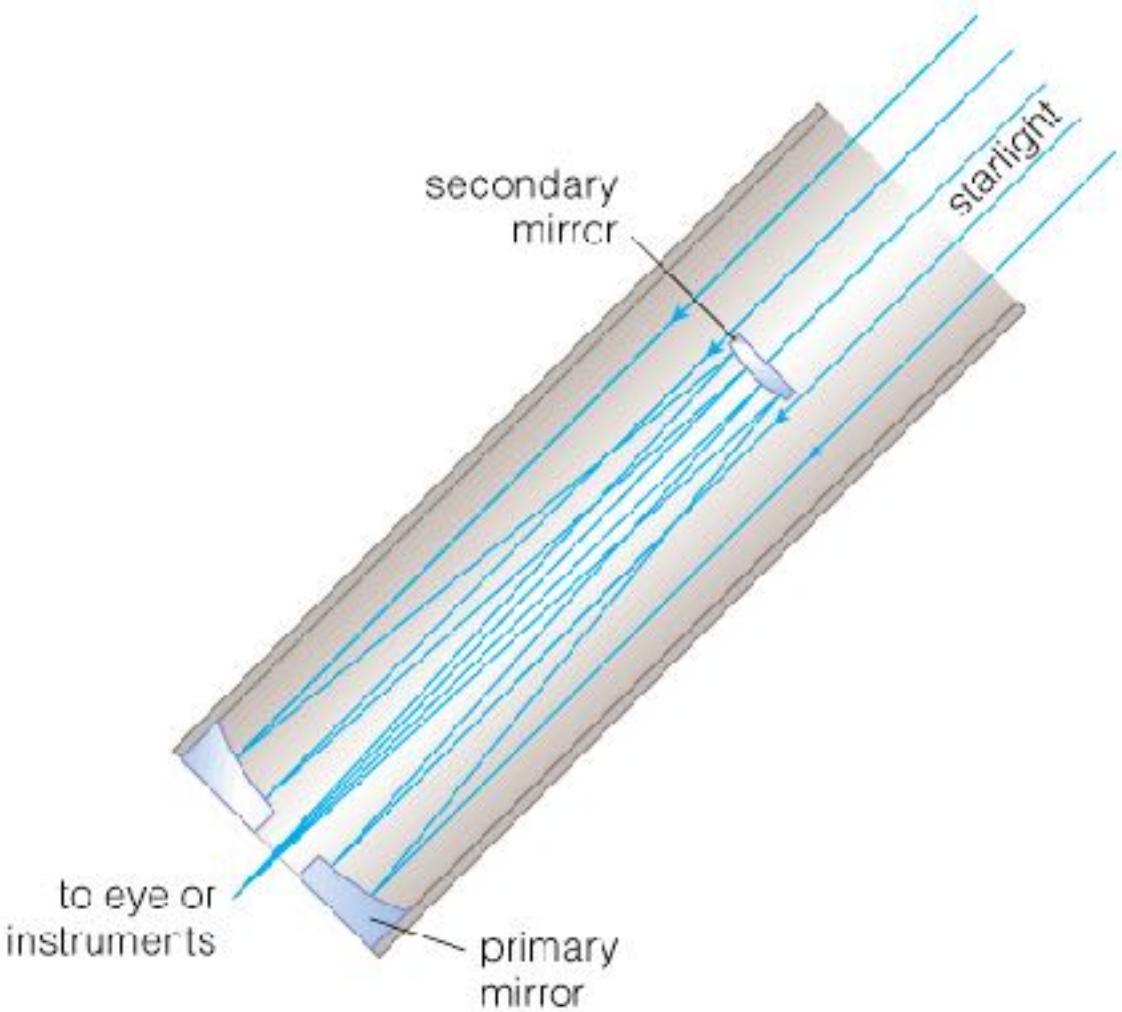


Refracting telescope

Yerkes 1-m refractor

Basic Telescope Design

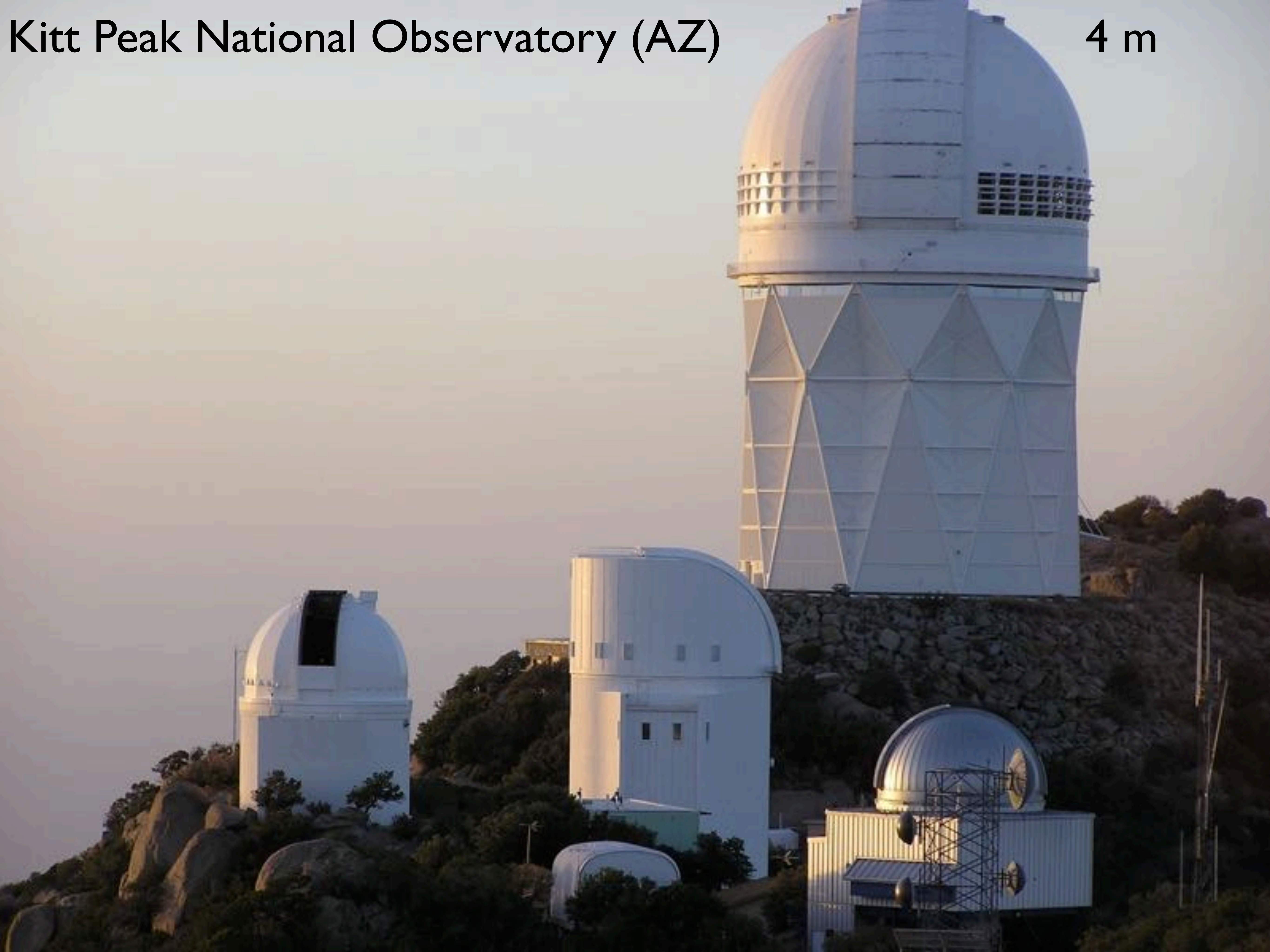
- Reflecting: mirrors
- Most research telescopes today are reflectors

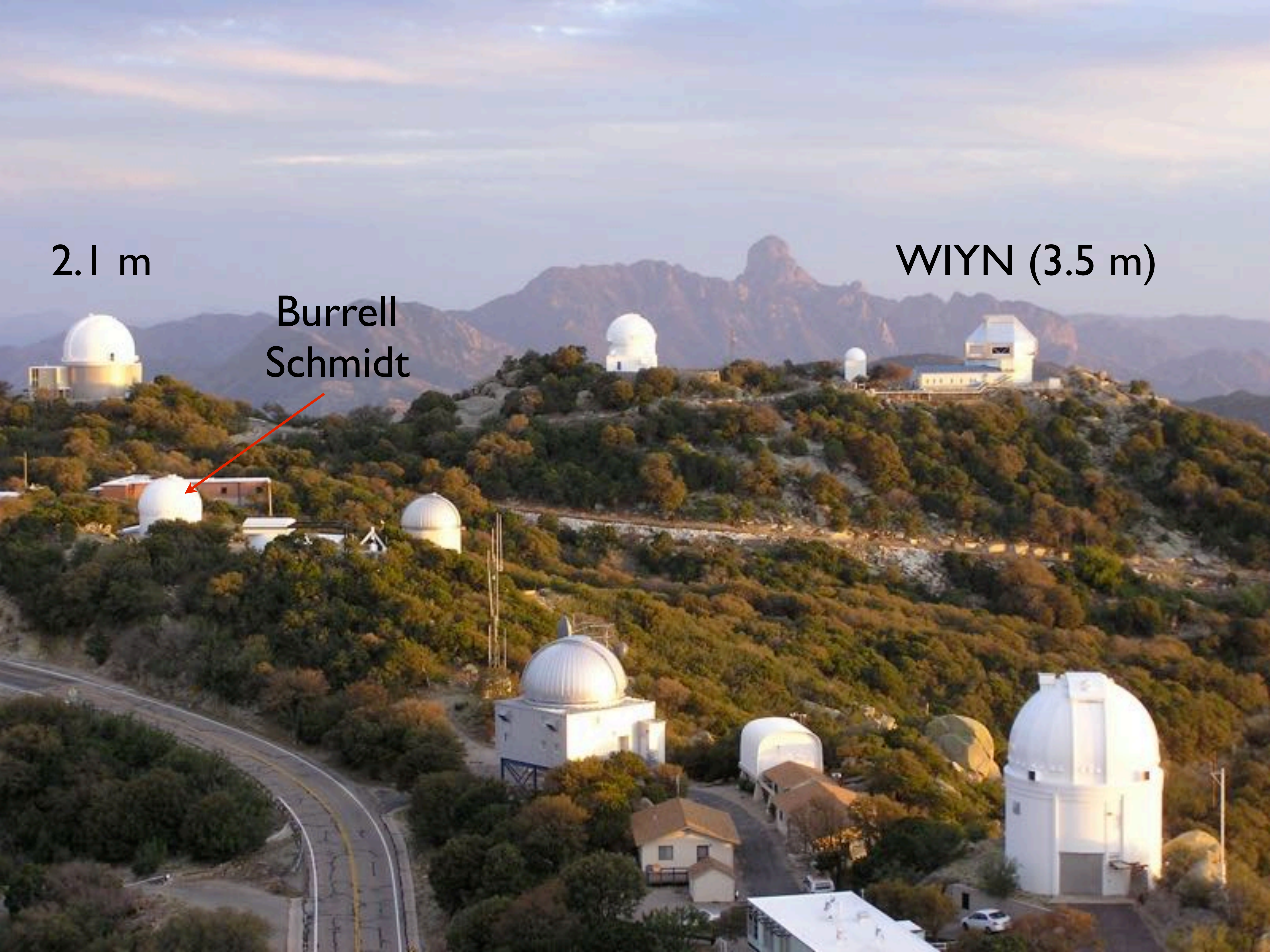


Reflecting telescope

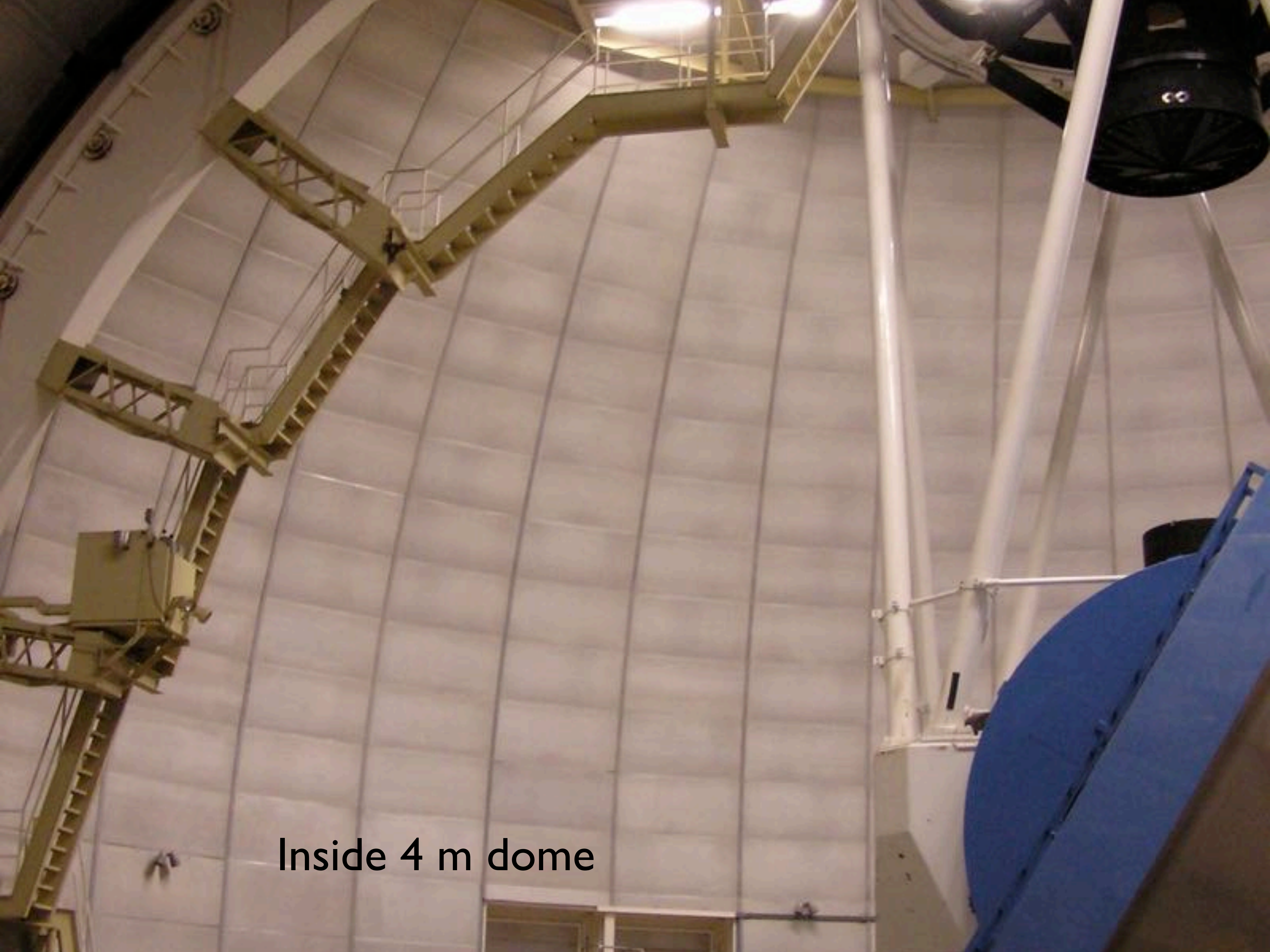

Gemini North 8-m

Kitt Peak National Observatory (AZ) 4 m



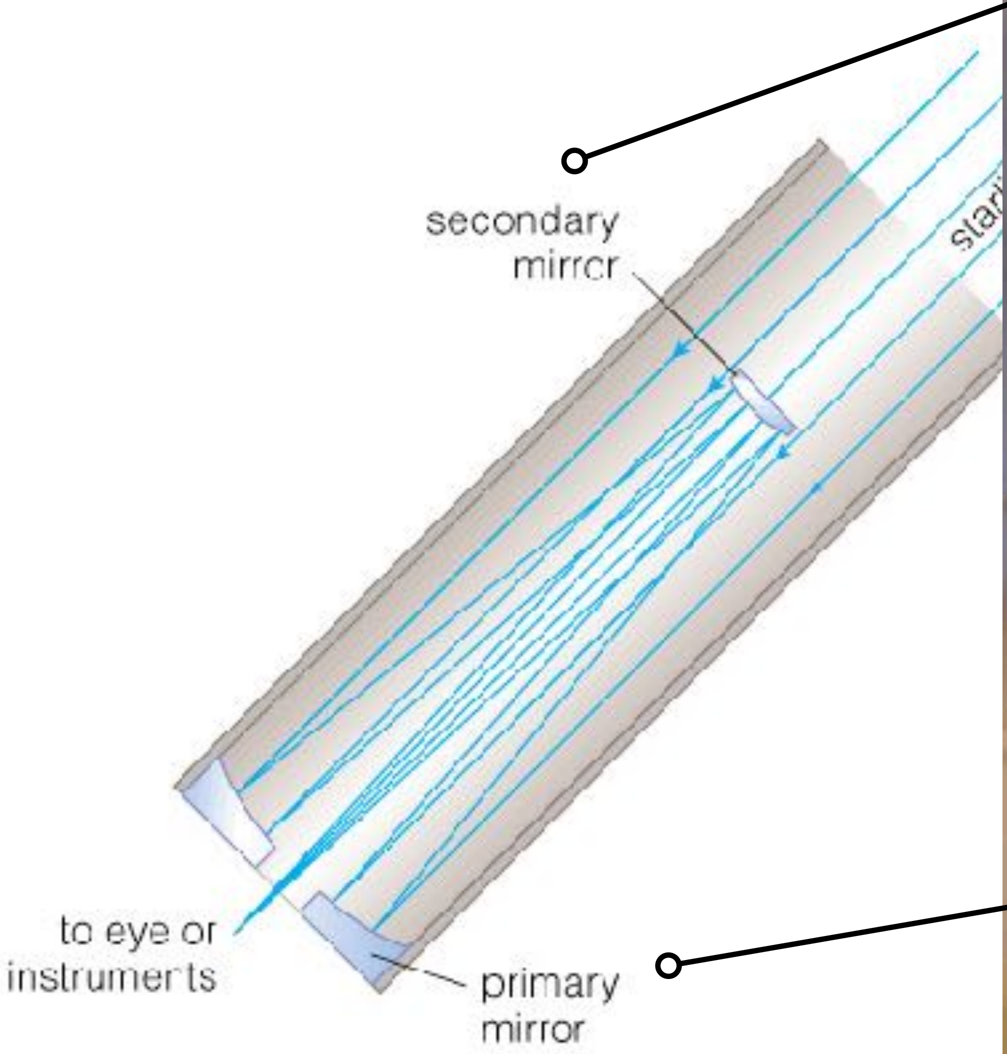

2.1 m
Burrell
Schmidt
WIYN (3.5 m)

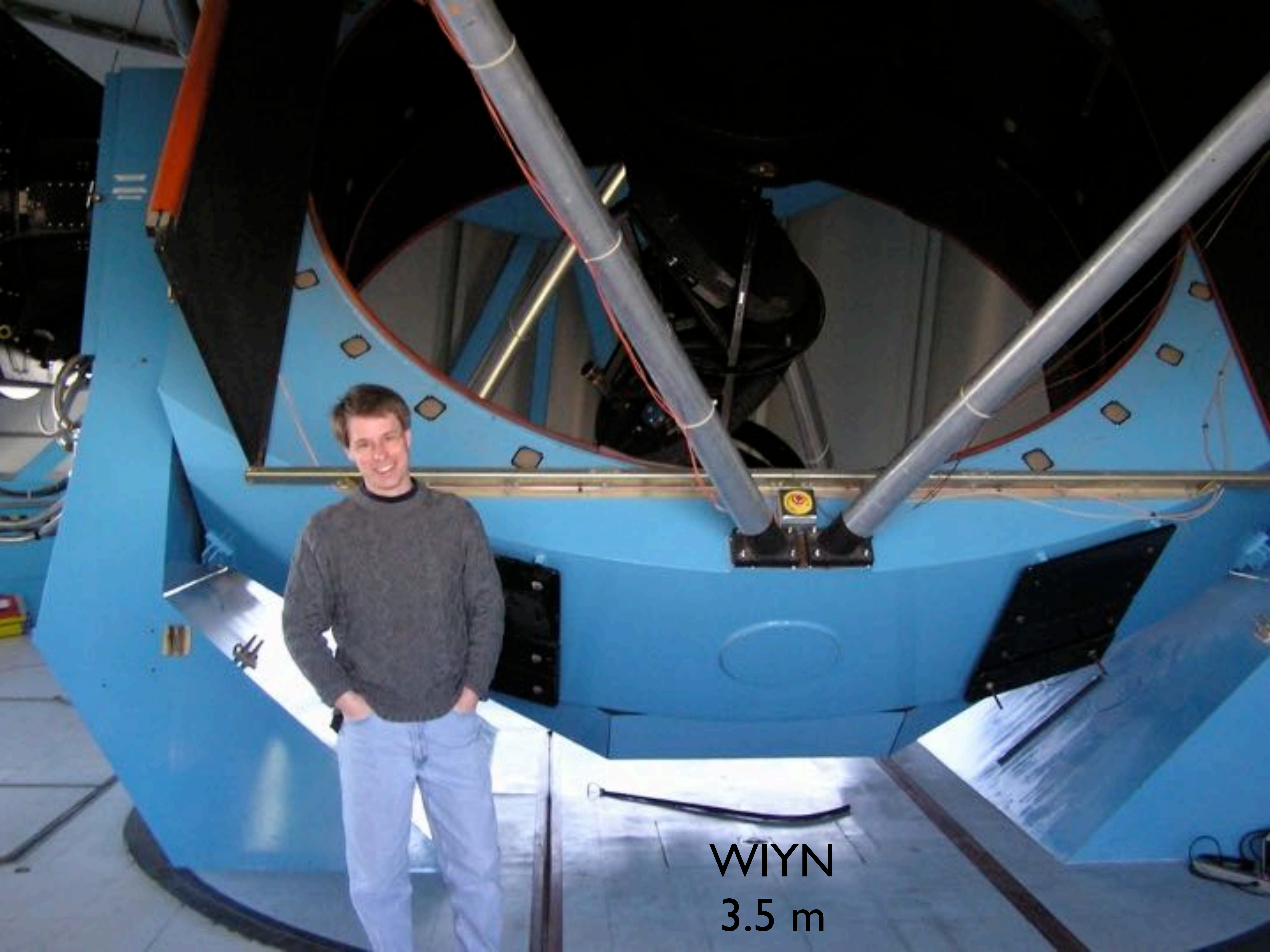
2.1 m

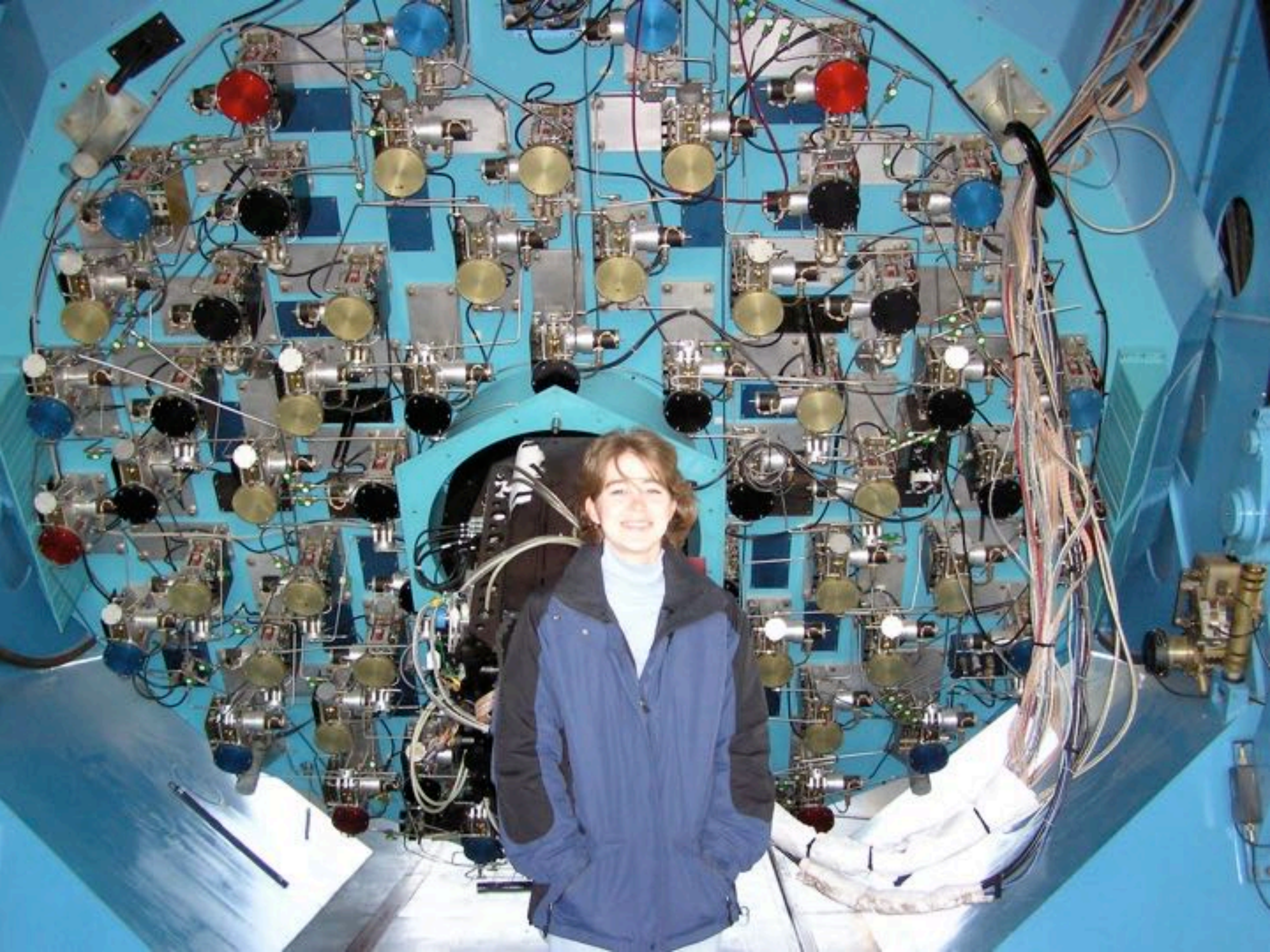


Inside 4 m dome

4 m




WIYN
3.5 m



Different designs for different wavelengths of light

Radio telescope (Arecibo, Puerto Rico)

Longer wavelengths need larger "mirrors"

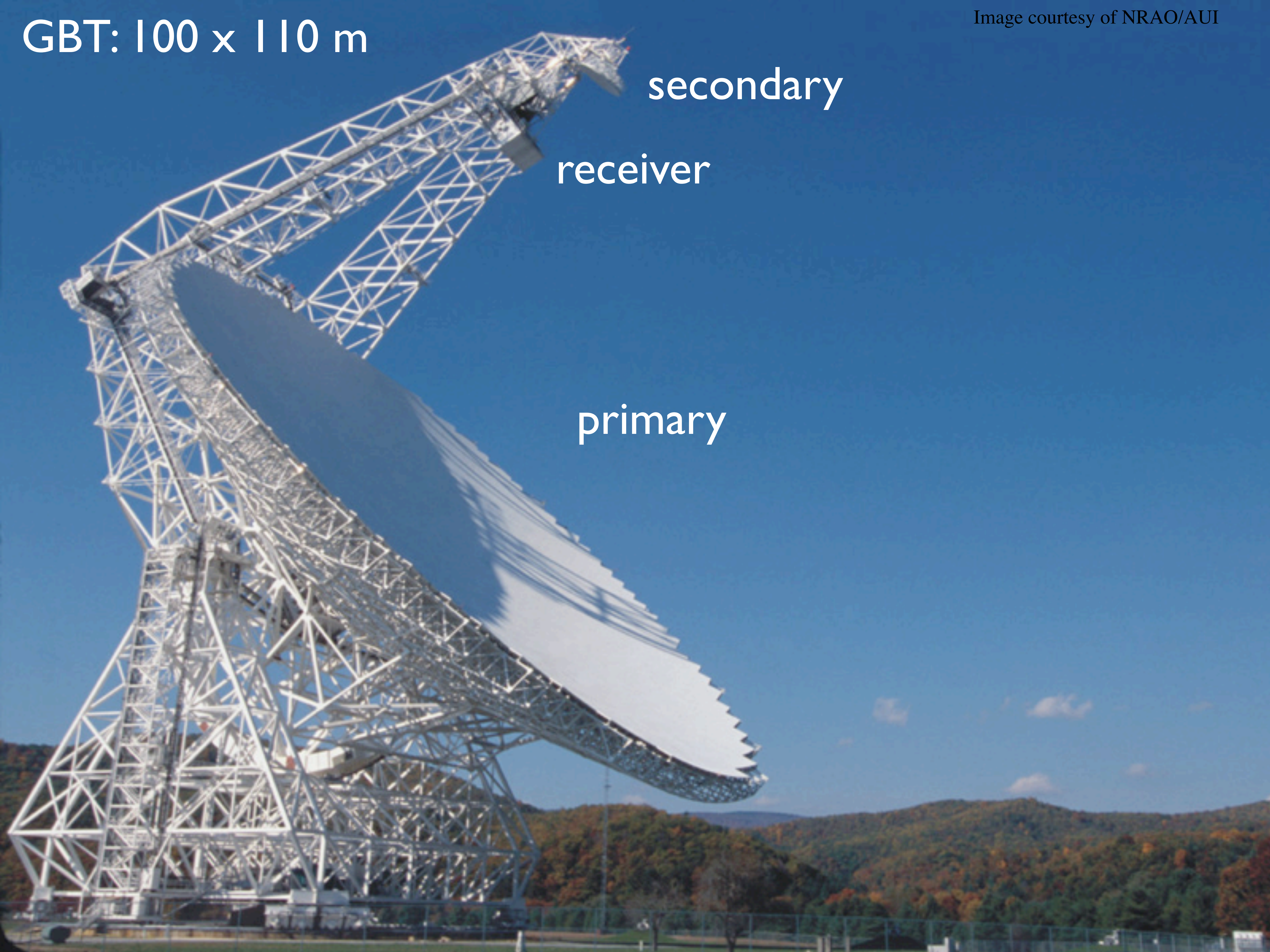

Aricebo 305 m

Aricebo 305 m


Aricebo 305 m

FAST 500 m (China)

Got this far Fall 2016
Skipped a few slides of telescopes for time.


GBT: 100 x 110 m
Image courtesy of NRAO/AUI
secondary
receiver
primary

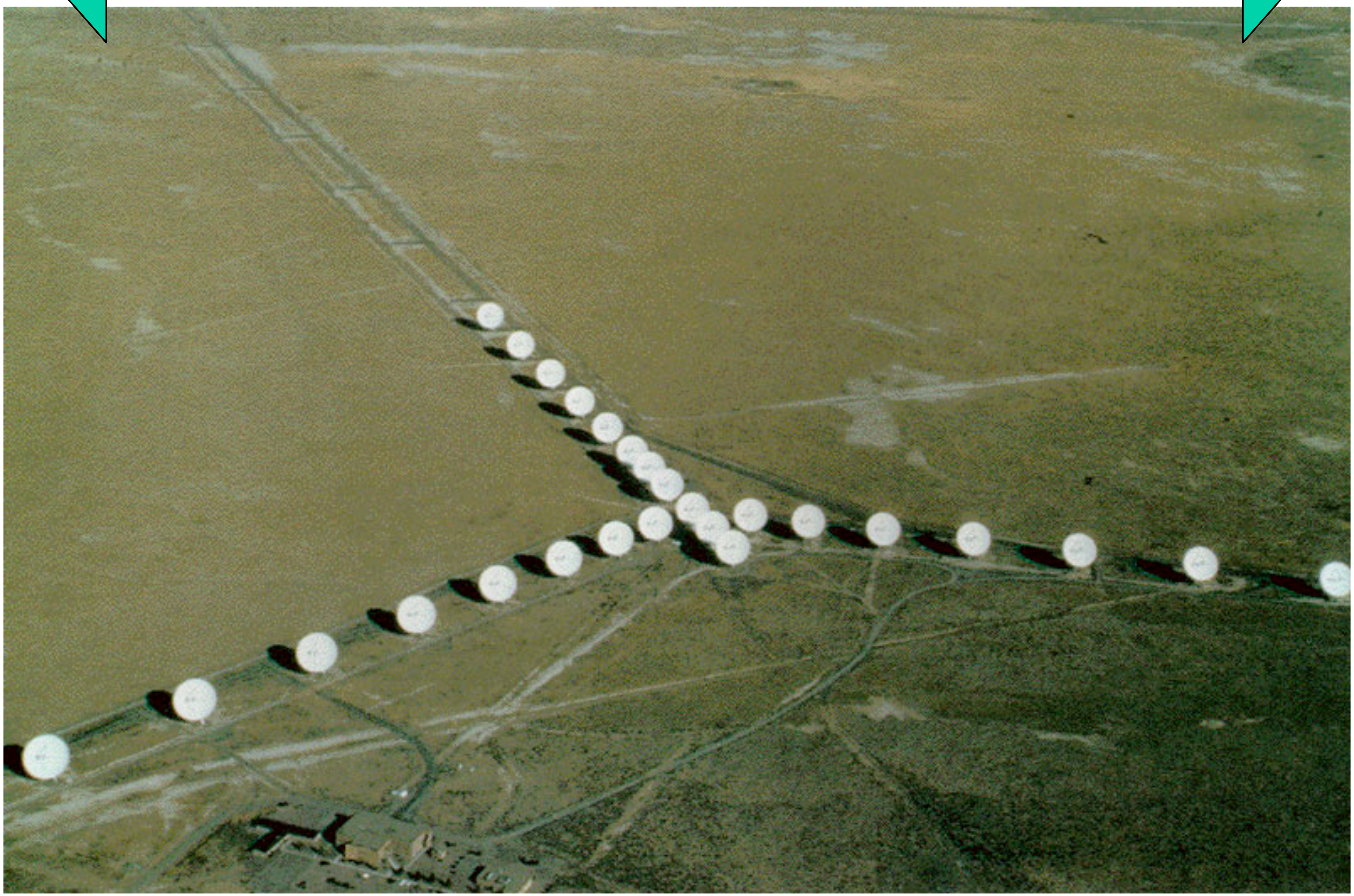
Interferometry

- This technique allows two or more small telescopes to work together to obtain the *angular resolution* of a larger telescope.

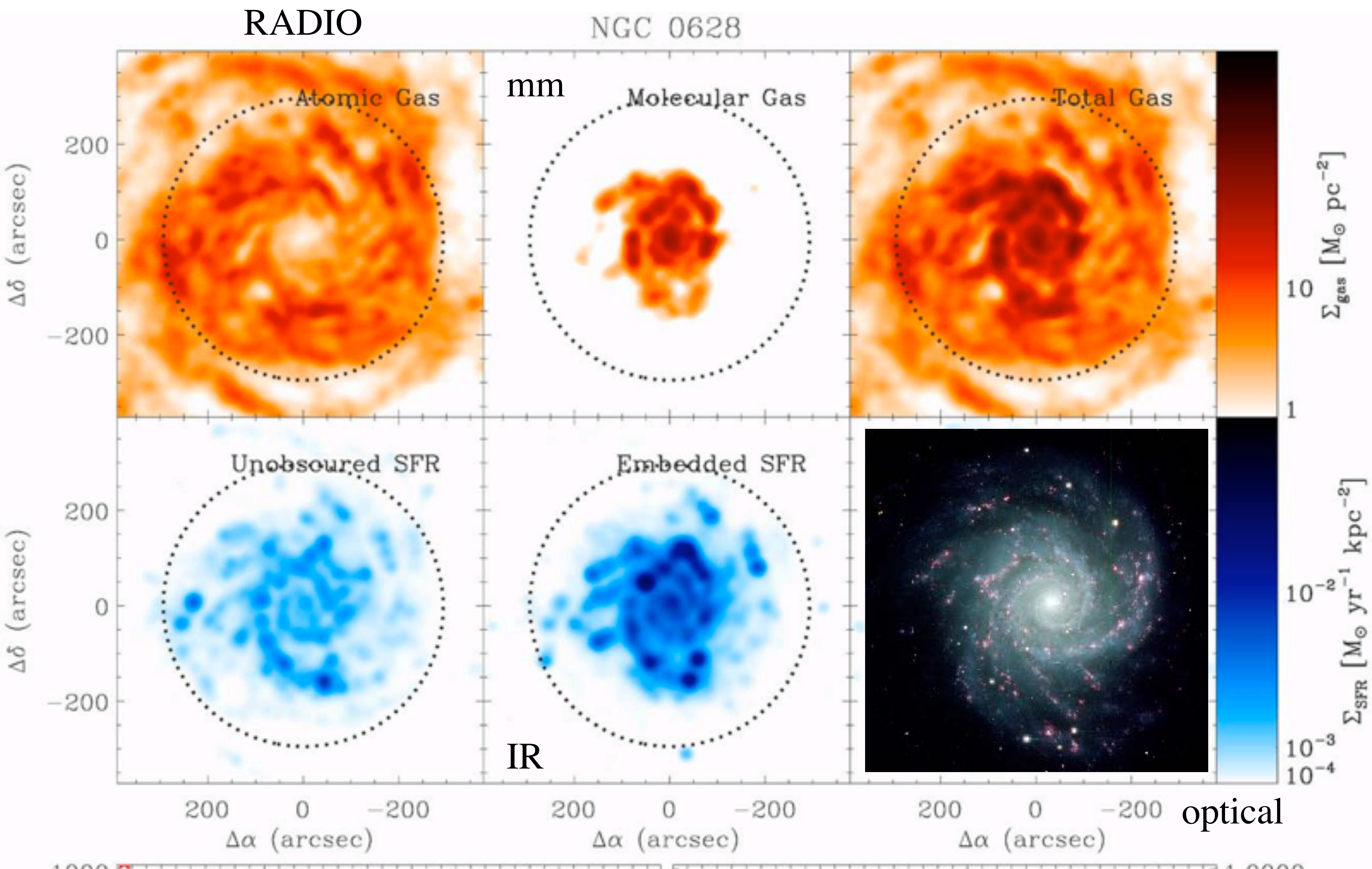
Very Large Array (VLA), New Mexico

Very Large Array (VLA), New Mexico

angular resolution of a telescope this size



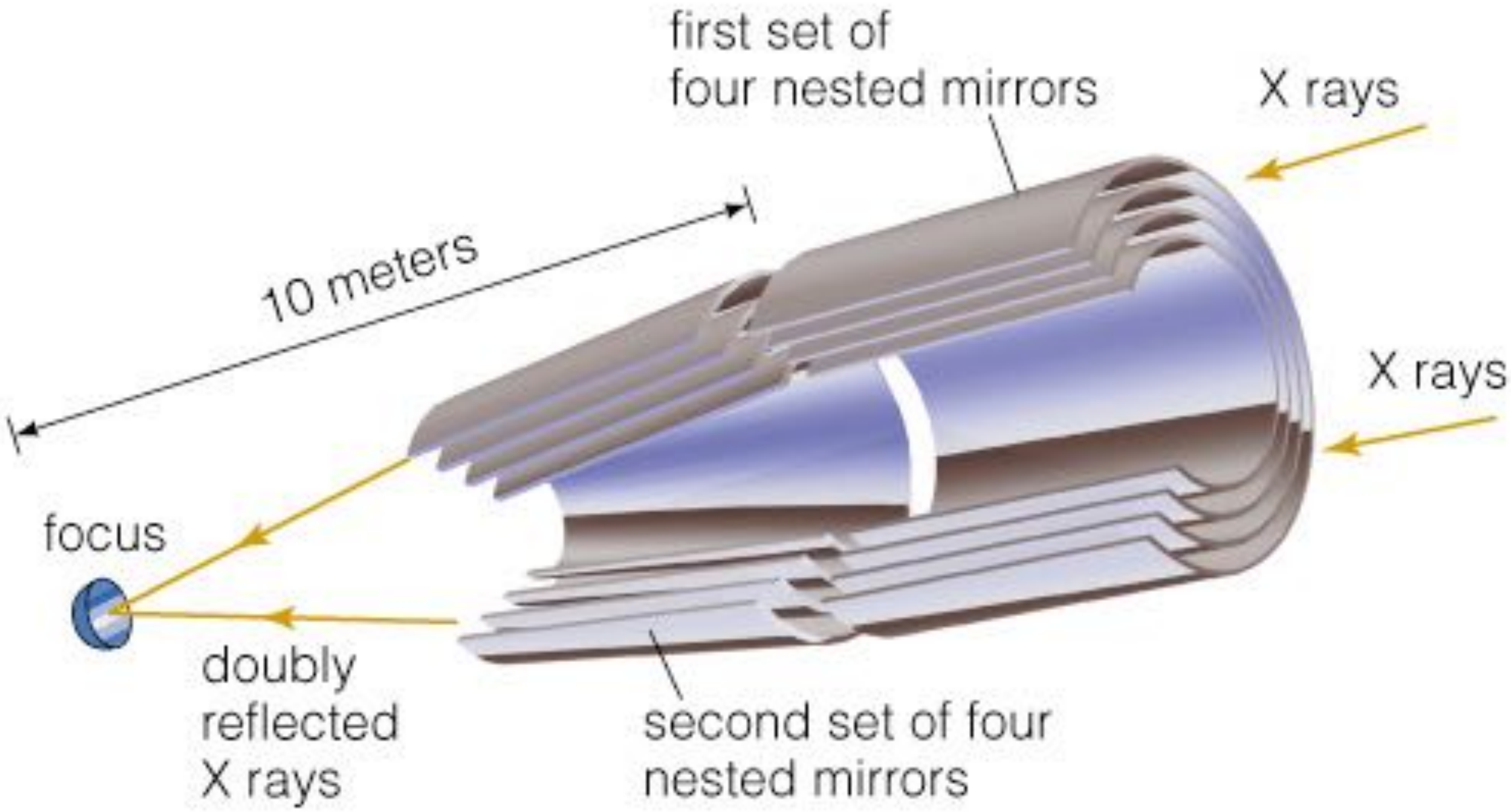
JVLA (HI @ 21 cm) CARMA (CO @ 2.6 mm)


RADIO
NGC 0628
mm
Atomic Gas
Molecular Gas
Total Gas
Unobsoured SFR
Embedded SFR
IR
optical
Δδ (arcsec)
Δα (arcsec)
200
0
−200
10
1
Σ_{gas} [$M_\odot$ pc^{-2}]
10^{-2}
10^{-3}
10^{-4}
Σ_{SFR} [$M_\odot$ yr^{-1} kpc^{-2}]

Event Horizon Telescope
Black hole imaged by global scale interferometer

Event Horizon Telescope
Black hole imaged by global scale interferometer

X-ray telescope: “grazing incidence” optics



Mirror elements are 0.8 m long and from 0.6 m to 1.2 m in diameter.

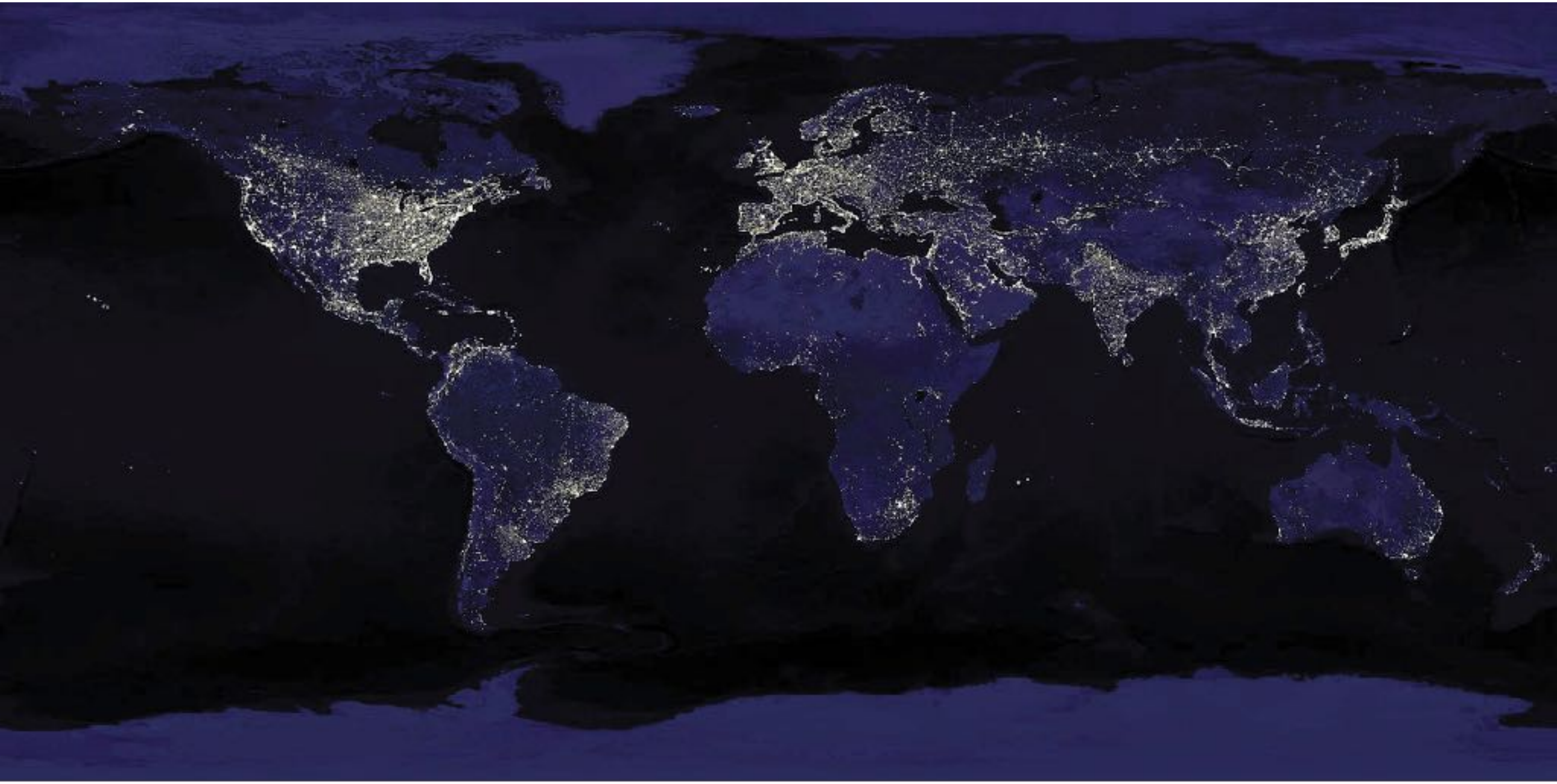
Advantages of telescopes in space

Hubble
optical & infrared

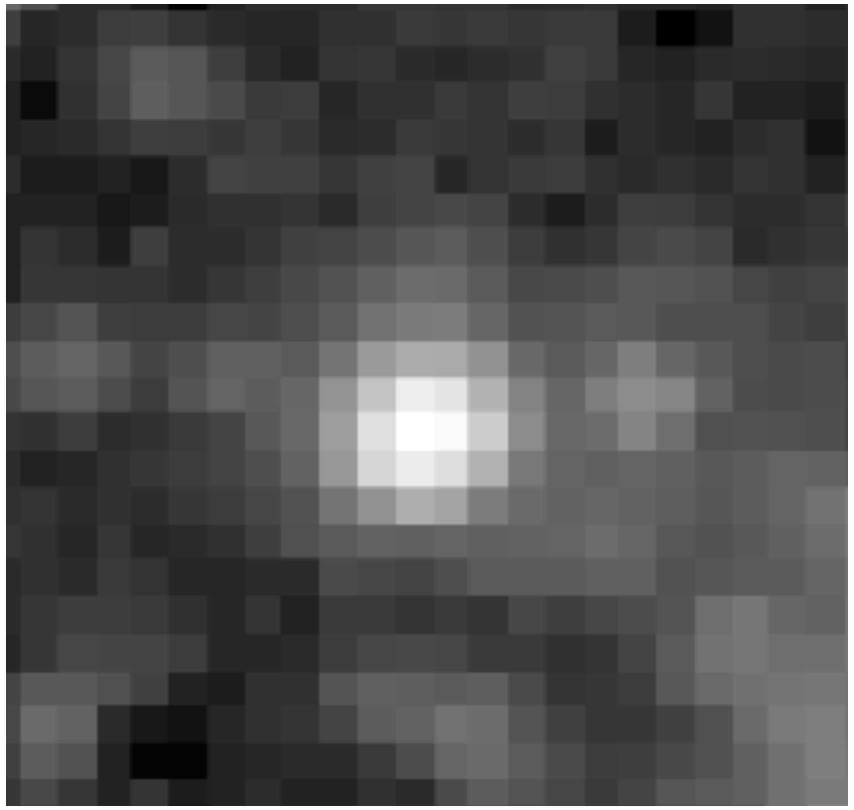
Chandra
X-ray

Observing problems due to Earth's atmosphere

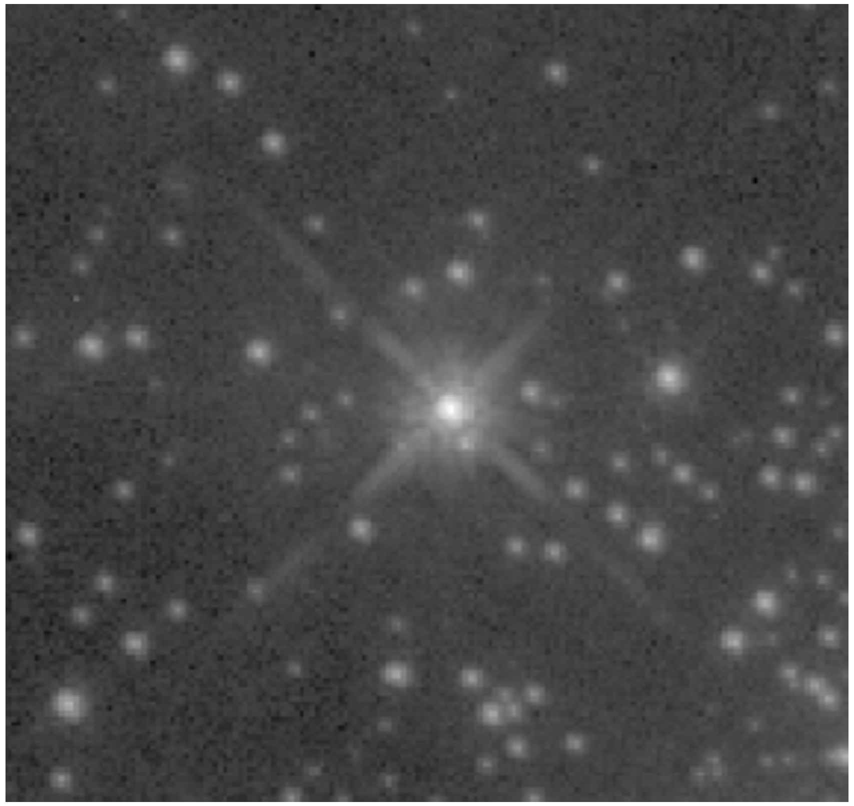
1. Light Pollution



2. Atmospheric Turbulence causes *twinkling* ⇒ blurs images (called "seeing" by astronomers).



Star viewed with ground-based telescope



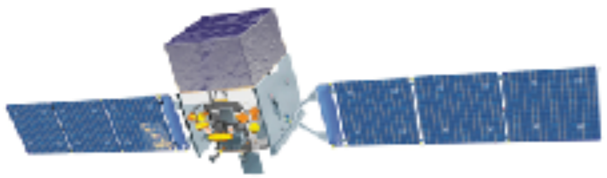
View from Hubble Space Telescope

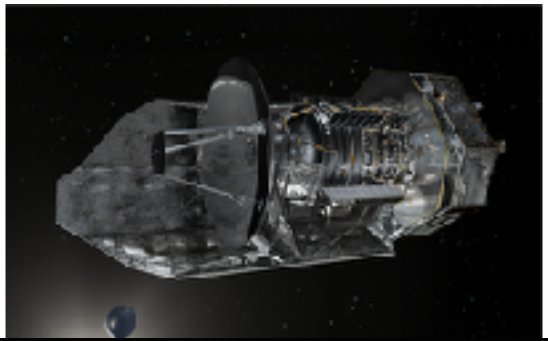
Atmospheric blurring is the limiting factor for most ground-based telescopes

file:///Users/ssm/Documents/Courses/UMd/ASTR100/Fall2008/Media/Chapter5/MultimediabyChapter/05_StarlightDistort.swf

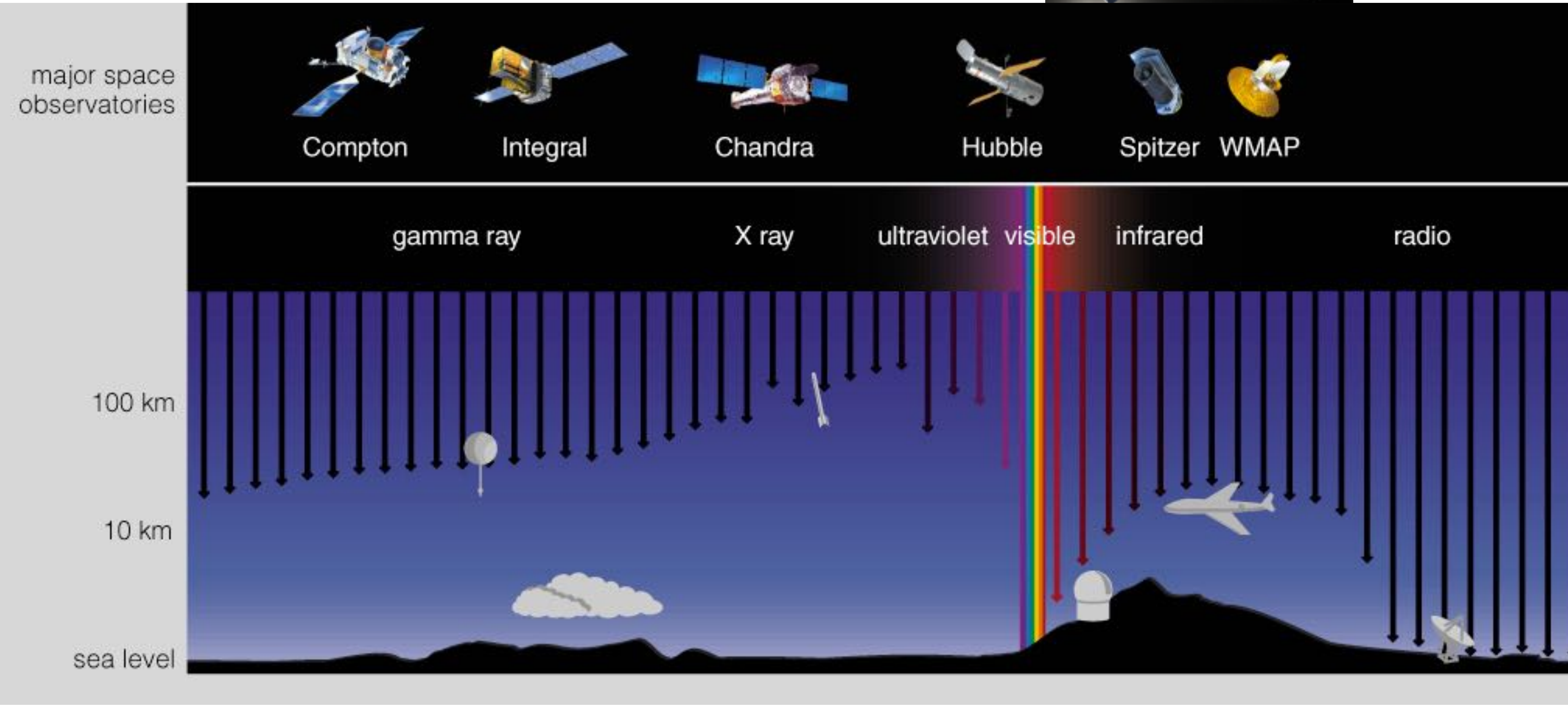
3. Atmosphere absorbs most of EM spectrum, including all UV and X ray and most infrared.

Fermi





Herschel



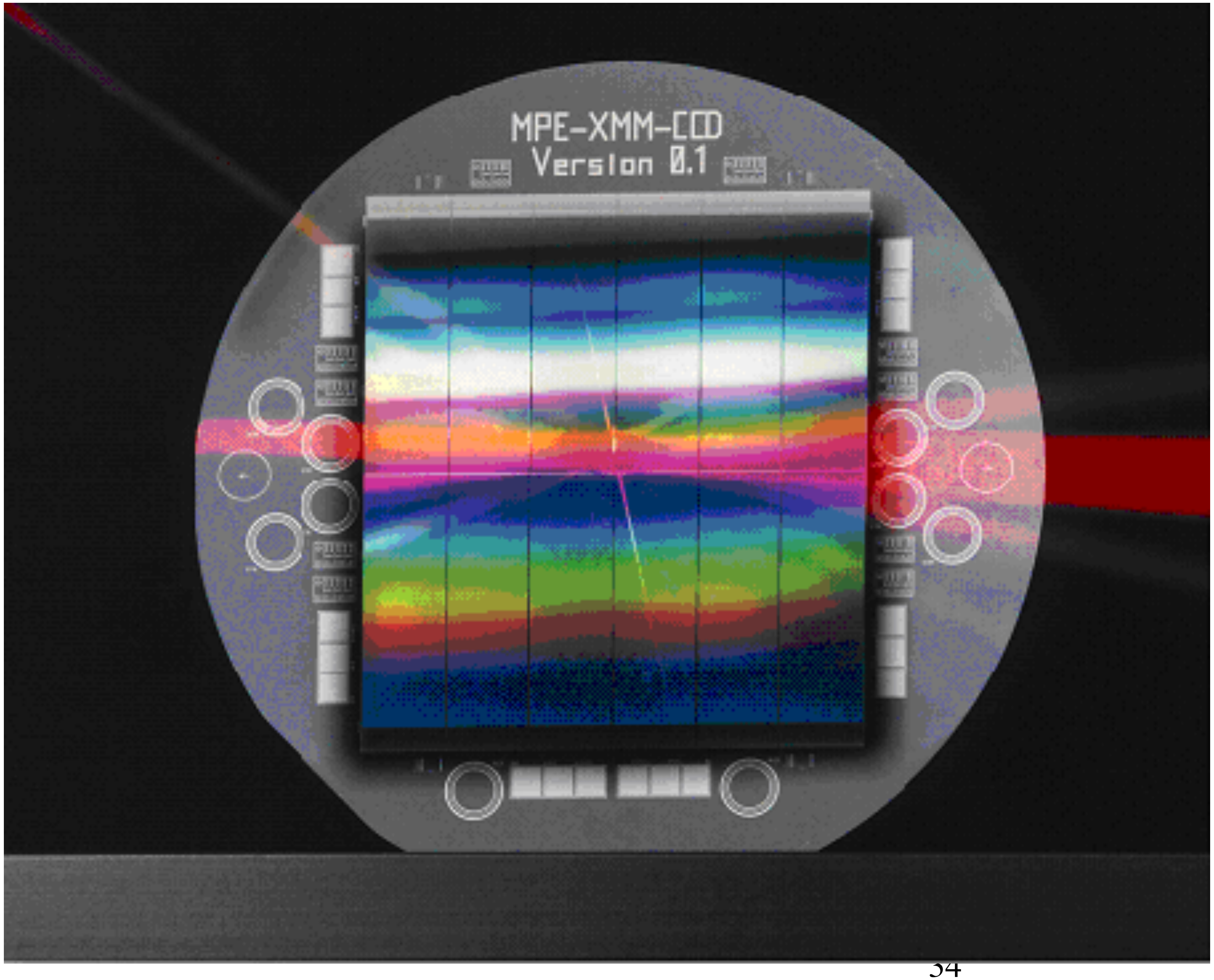
Telescopes in space solve all 3 problems.

Chandra X-ray Observatory

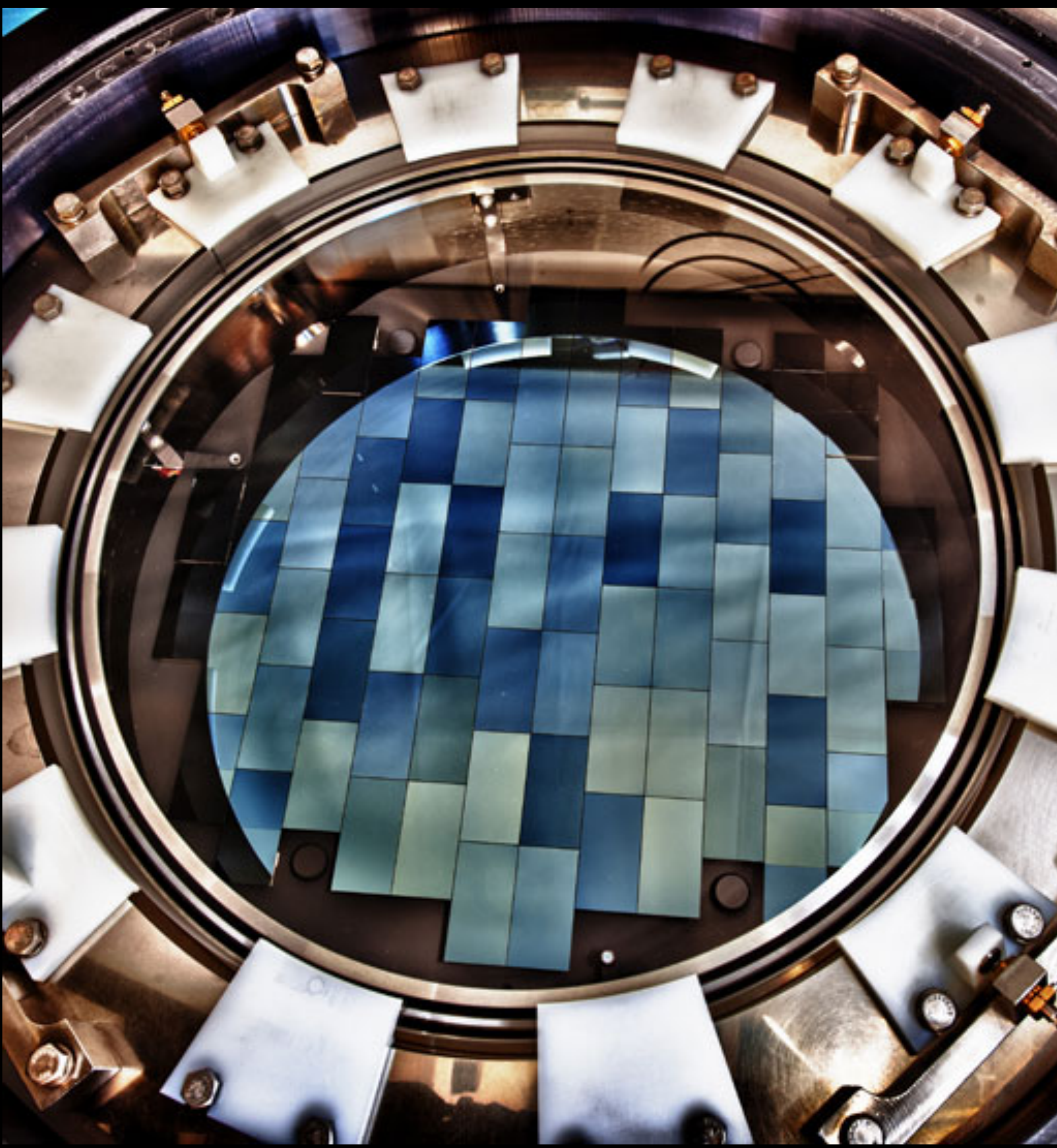
Instruments

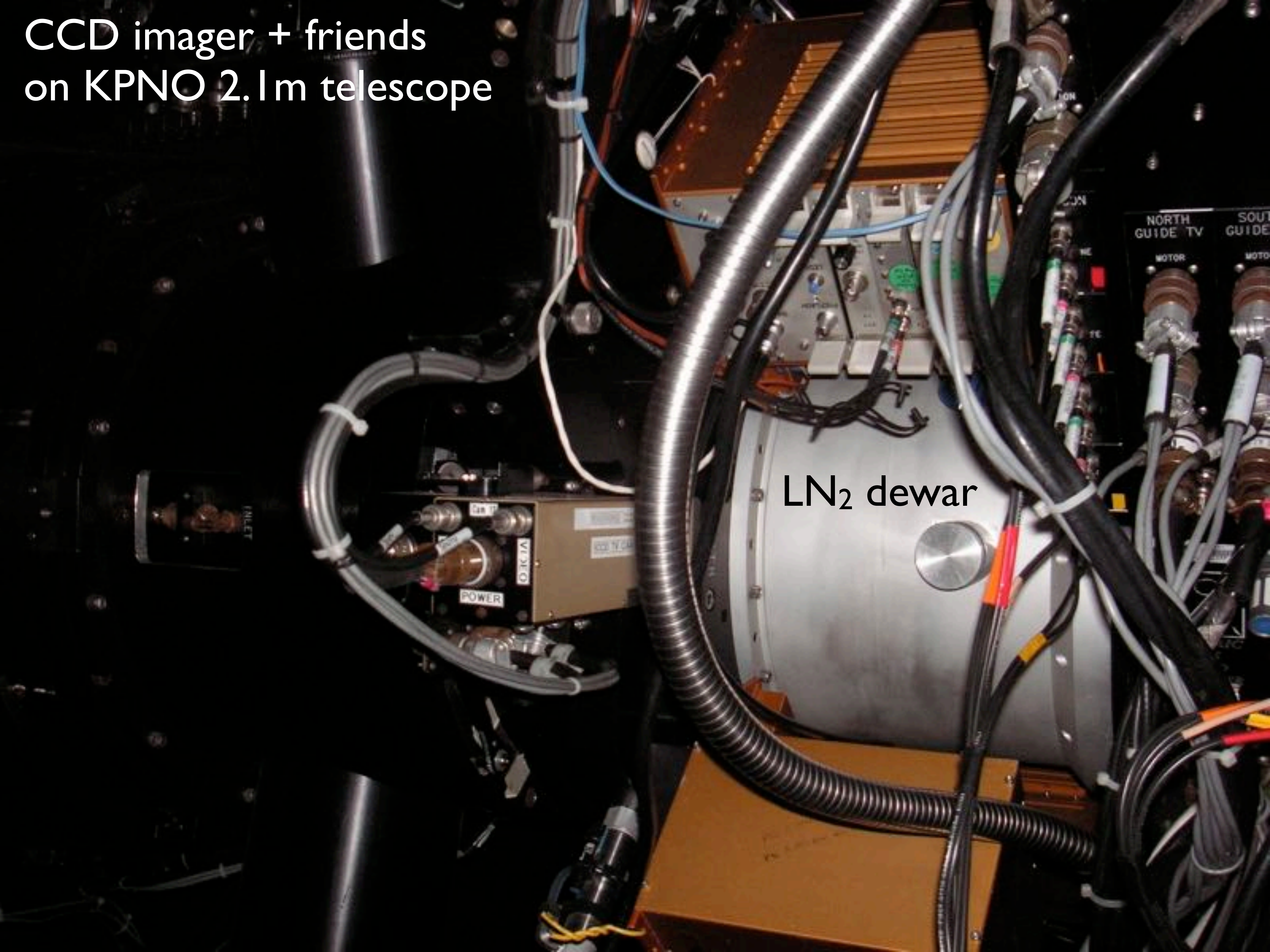
Telescopes collect photons; instruments record them

- Cameras



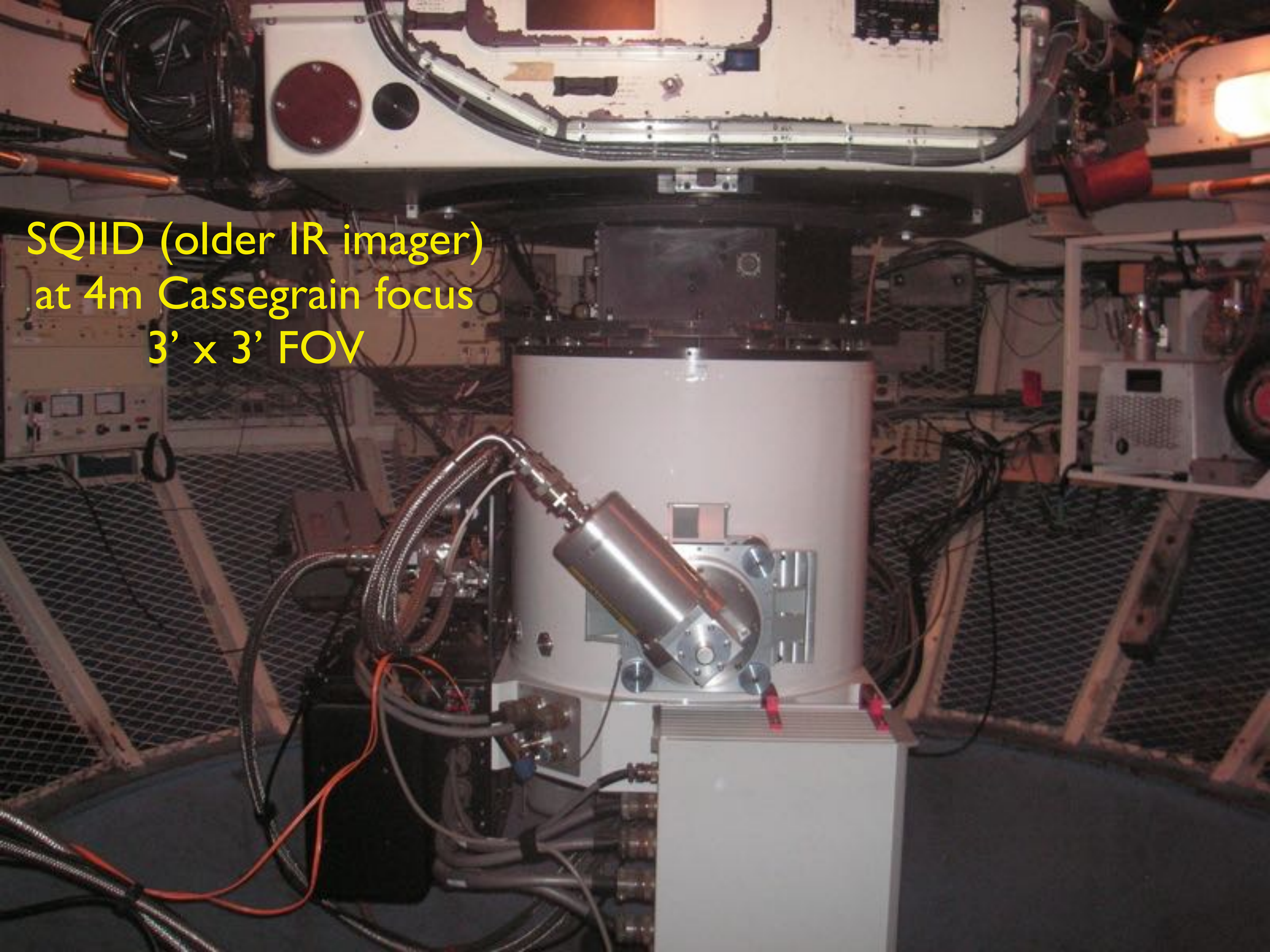
Dark Energy Camera
570 Megapixel




CCD imager + friends
on KPNO 2.1m telescope
LN$_2$ dewar
NORTH GUIDE TV
MOTOR
VIDEO
POWER
INLET

NGC 628 - bright spiral imaged with 2.1m telescope + CCD

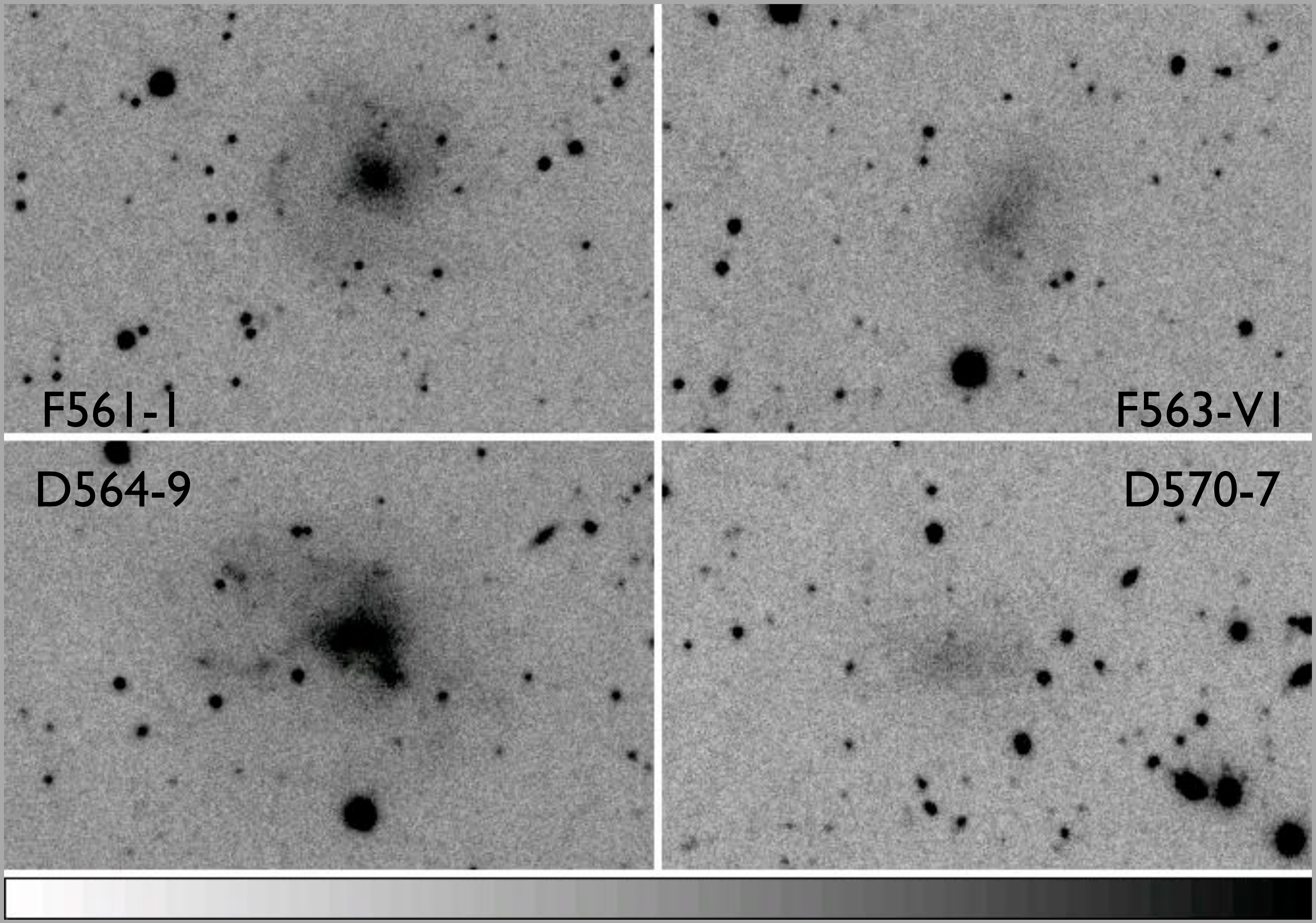
Hα emission line (pink) traces recent Star Formation


SQIID (older IR imager)
at 4m Cassegrain focus
3’ x 3’ FOV


SQIID

NEWFIRM near-IR imager
28’ x 28’ FOV

Stellar mass maps from near-IR data (2.2 or 3.6 microns)

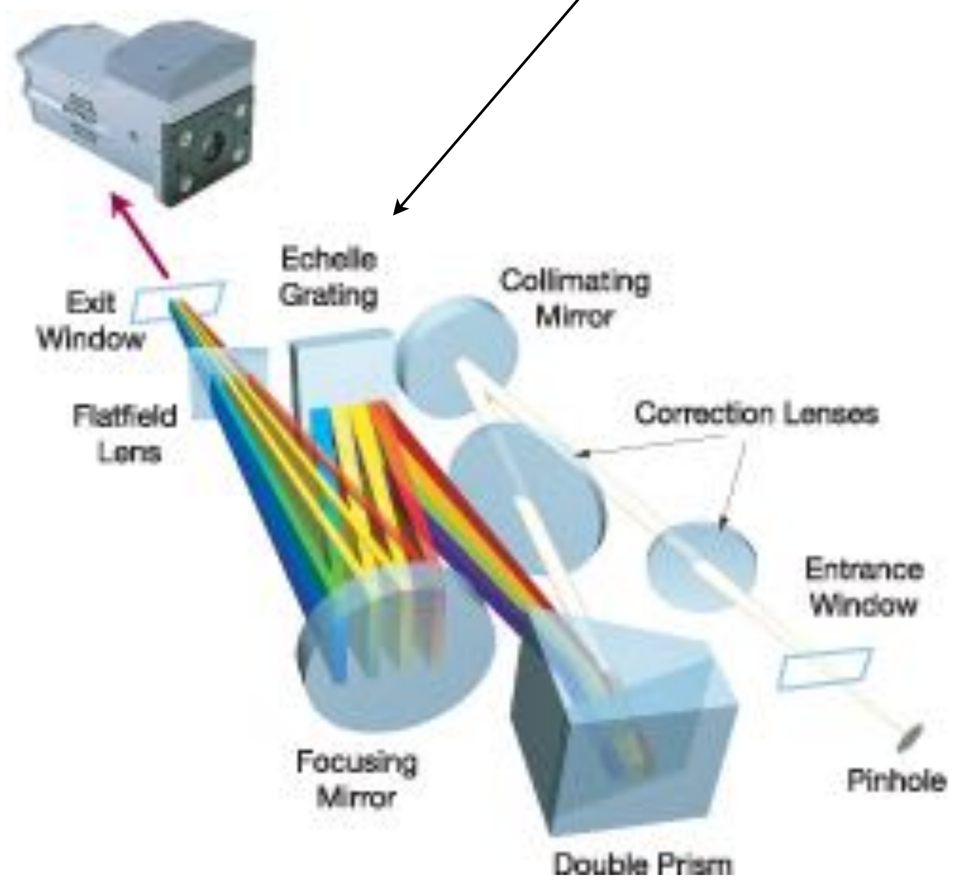


Kitt Peak 4m + NEWFIRM K’-band (2.2 micron)

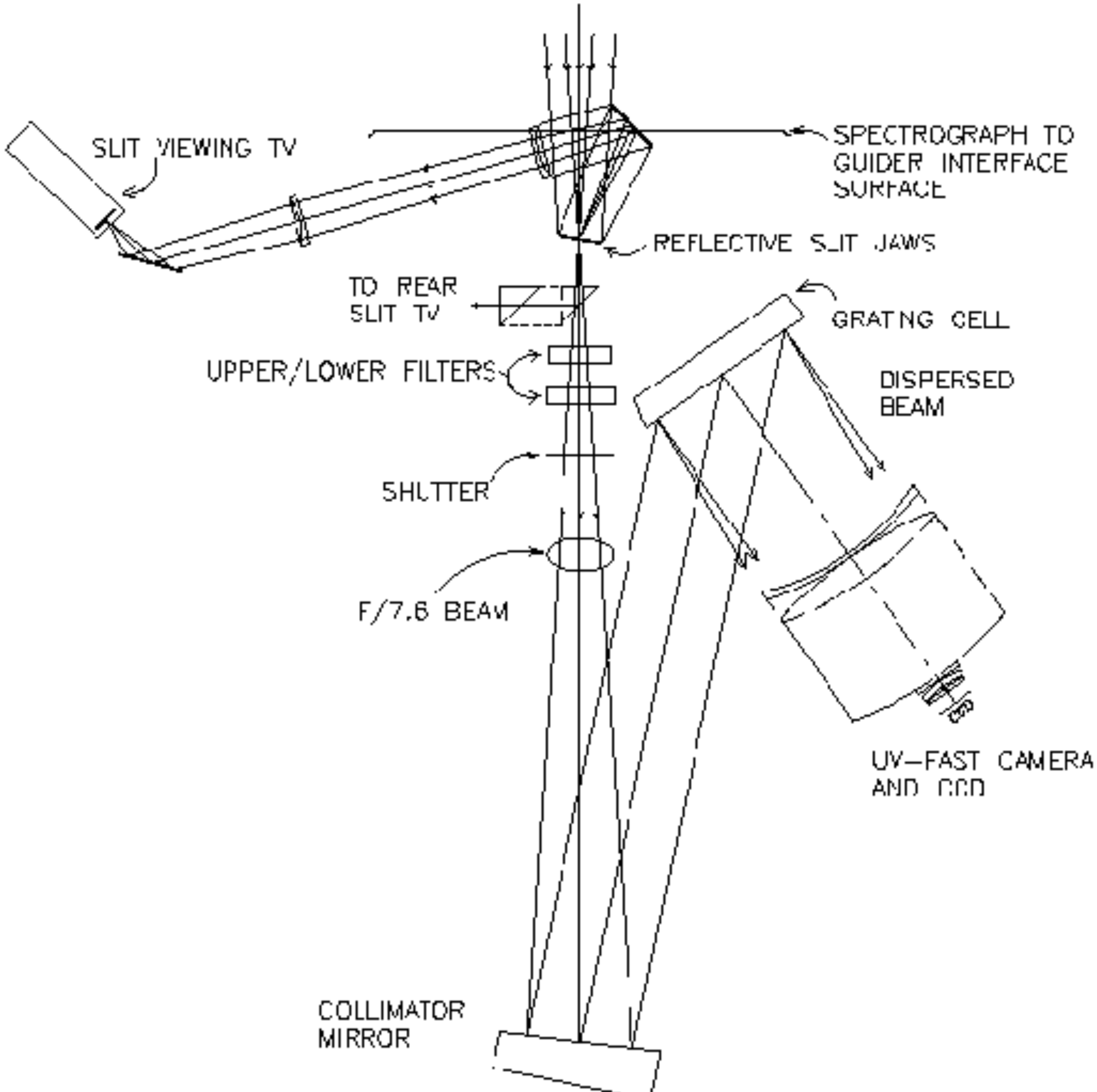
Instruments

- Spectrographs

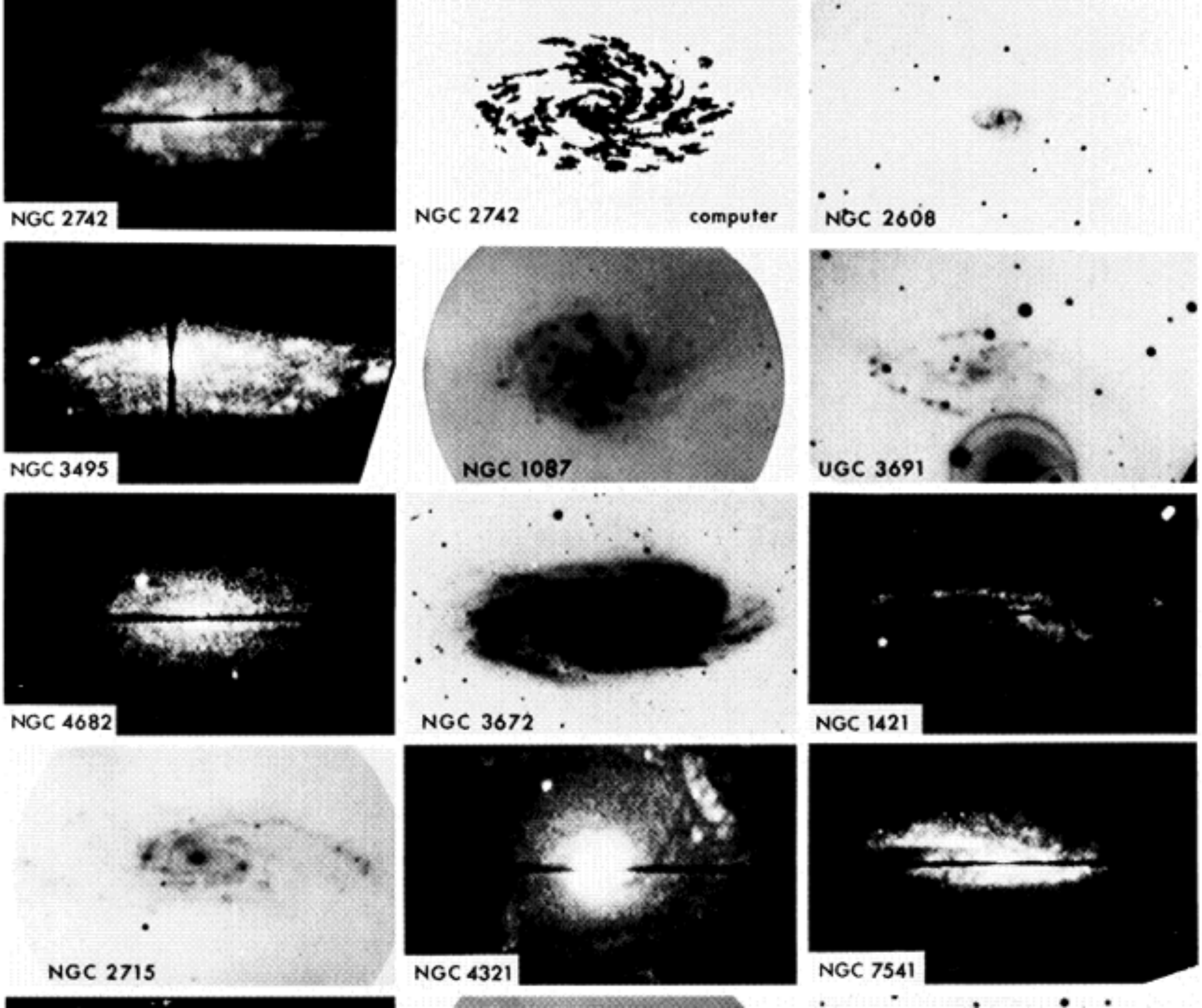
grating



4—METER TELESCOPE — R.C. SPECTROGRAPH
— — OPTICAL DIAGRAM — —



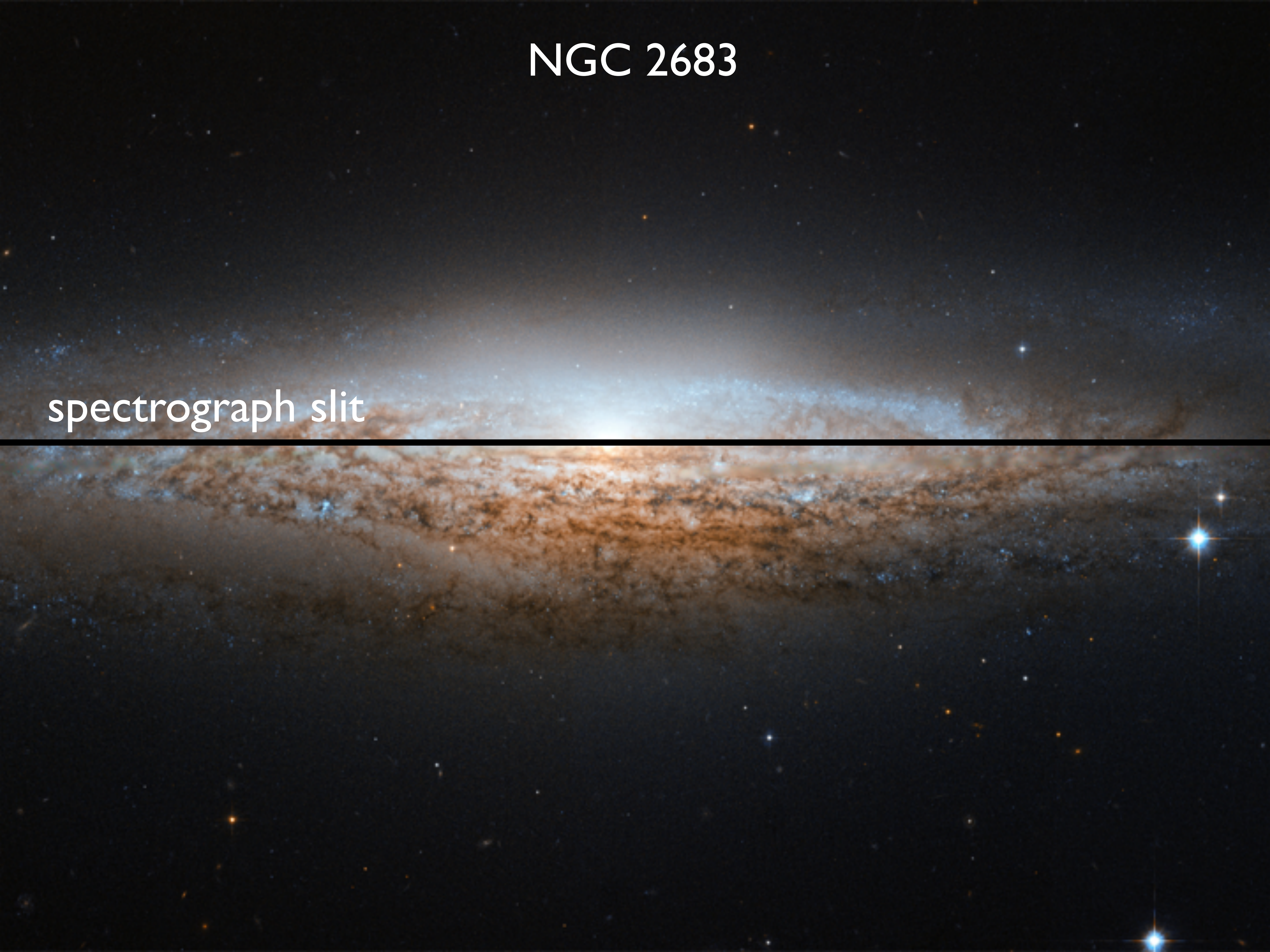
slit view



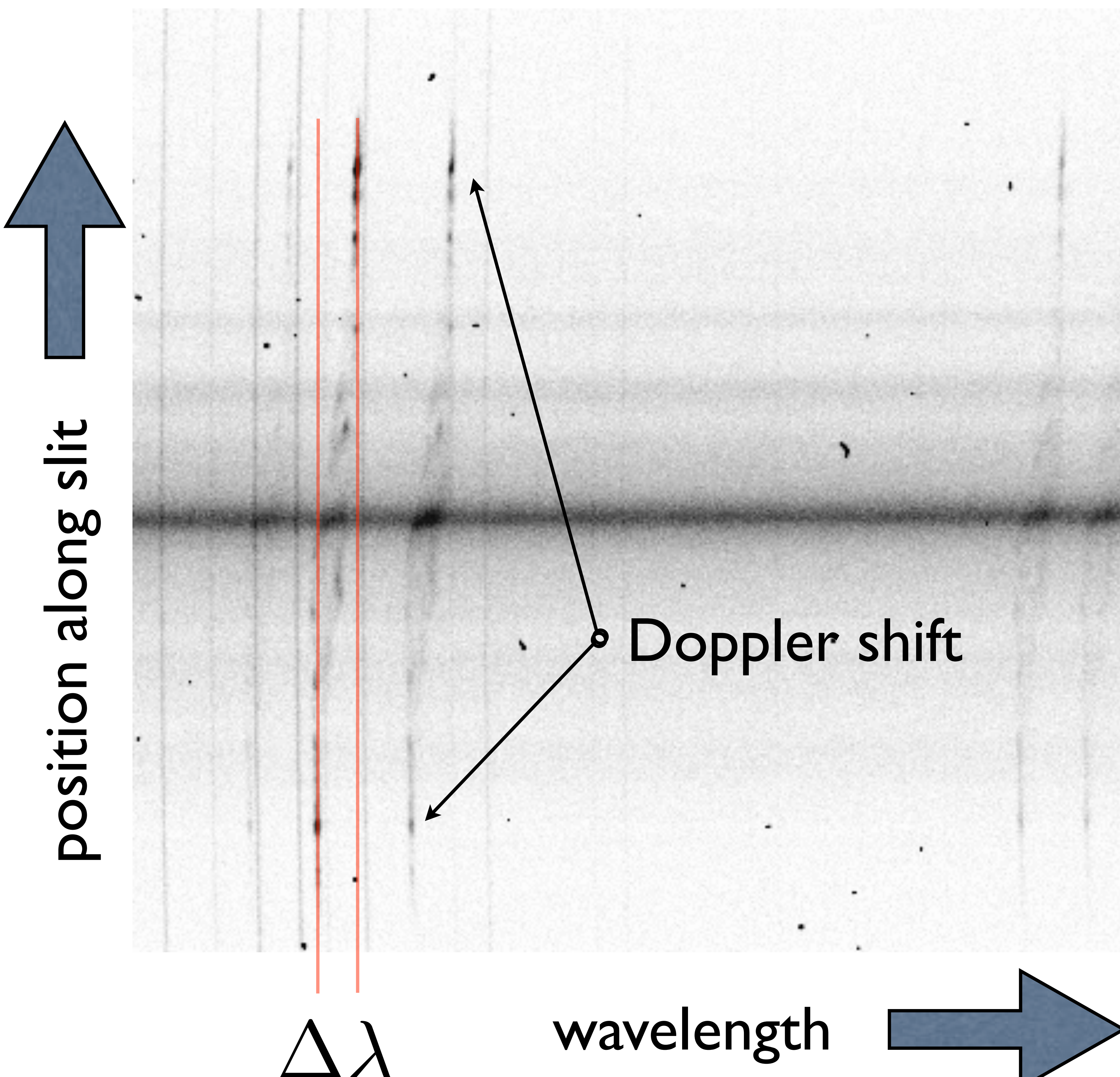
NGC 2742
NGC 2742
computer
NGC 2608
NGC 3495
NGC 1087
UGC 3691
NGC 4682
NGC 3672
NGC 1421
NGC 2715
NGC 4321
NGC 7541


spectrograph


grating


NGC 2683
spectrograph slit

Spectrum



Doppler shift
position along slit
wavelength
$\Delta\lambda$