Lecture 4: Telescopes

- Web site
- Stuff from last time
- Naked eye and magnitudes
- Development of telescopes
- Types of telescopes

http://www.pa.msu.edu/courses/2003spring/ast312/

This is the class web page. Be sure to check it often. Class notes will be posted there roughly one week after class. Assignments and announcements will also be posted.

Once we begin observing, check the web page for announcements regarding location and to see if we have canceled due to weather.

Previous Topics

- How can you tell if a star is circumpolar from your location?
- Why do we have time zones?
- How can you use the stars to get your latitude and longitude?


WORLD
Northwest Airlines
KLM Royal Dutch Airlines
Northwest Airlines or KLM service
KLM Asia
Kenya Airways
Ansett Australia
Sun Air
Braathens
Air China
WORLDWIDE KLM RELIABILITY
7.00 a.m.
8.00 a.m.
9.00 a.m.
10.00 a.m.
11.00 a.m.
Noon
1.00 p.m.
2.00 p.m.
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ARCTIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTHERN OCEAN
PACIFIC OCEAN
Tropic of Cancer
Equator
Tropic of Capricorn
International date line
Monday
Sunday
Longyearbyen
Tromso
Oslo
Helsinki
Stockholm
St. Petersburg
Copenhagen
Amsterdam
London
Frankfurt
Moscow
Warsaw
Kiev
Paris
Vienna
Budapest
Lyon
Nice
Milan
Madrid
Barcelona
Rome
Lisbon
Bucharest
Istanbul
Athens
Baku
Tehran
Almaty
Beirut
Damascus
Tel Aviv
Amman
Cairo
Kuwait
Dhahran
Bahrain
Dubai
Abu Dhabi
Muscat
Karachi
Delhi
Calcutta
Mumbai (Bombay)
Jeddah
Sana'a
Khartoum
Kano
Lagos
Lome
Accra
Abidjan
Douala
Entebbe/Kampala
Nairobi
Kilimanjaro
Zanzibar
Dar es Salaam
Seychelles
Lilongwe
Lusaka
Harare
Johannesburg
Durban
Cape Town
Beijing
Seoul
Osaka
Tokyo
Nagoya
Sapporo
Shanghai
Taipei
Hong Kong
Manila
Saipan
Guam
Bangkok
Kuala Lumpur
Singapore
Jakarta
Cairns
Brisbane
Sydney
Canberra
Adelaide
Melbourne
Anchorage
Honolulu
Edmonton
Calgary
Saskatoon
Vancouver
Seattle
San Francisco
Los Angeles
Las Vegas
Phoenix
Minneapolis/St. Paul
Houston
Cabo San Lucas/ Los Cabos
Puerto Vallarta
Ixtapa/Zihuatanejo
Acapulco
Guatemala
Mexico City
Montreal
Boston
New York (JFK)
Newark
Washington
Orlando
Miami
San Juan
St. Maarten
Montego Bay
Aruba
Curaçao
Bonaire
Caracas
Paramaribo
Quito
Guayaquil
Lima
Rio de Janeiro
Sao Paulo
Santiago de Chile
Buenos Aires
60°
30°
0°
90°
120°
150°
180°
Designed and produced for Northwest Airlines by
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Shackleton Expedition, 1914-1916

Crew members traveled over 800 miles in one of the life boats navigating by dead reckoning and the Sun's position to reach help.

The Magnitude Scale

- Introduced by Ptolemy, 2^{nd} century A.D.
  - Catalog included ~1000 stars
  - Brightest stars given a 1, slightly fainter were given a 2, etc.
  - Some problems
    - Broad range of things fall into "magnitude 1"
    - Brightness ratio between two magnitudes not quite uniform
- Refined in 1850 by N. R. Pogson
- Magnitude difference of 5 is a brightness ratio of 100/1
  - So a mag 1 star is 100 times as bright as a magnitude 6 star

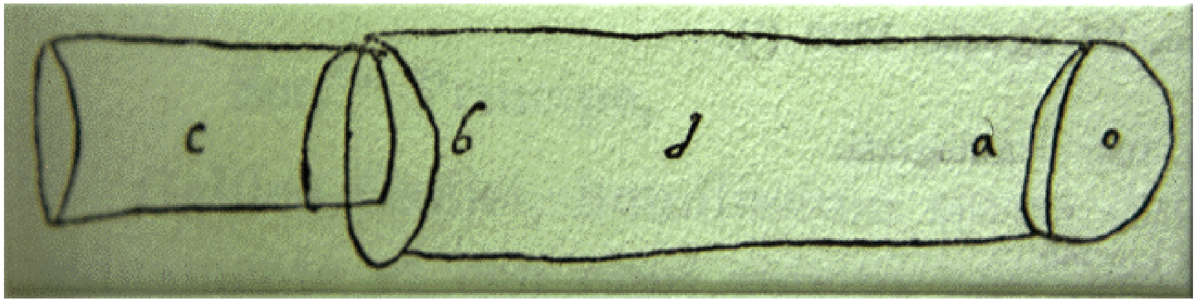
Brightness α Amount of Radiation received from object

$$m2 - m1 = 2.5 \log (B1 / B2)$$

History Highlights

- Pre-Galileo
- Galileo (first astronomical use)
  - The moon
  - Galilean satellites
- Newton (reflector)
- Modern designs

Earliest known sketch of telescope
(1609)



Telescope first unveiled in Netherlands in 1608 and described as a device for "seeing faraway things as though nearby."

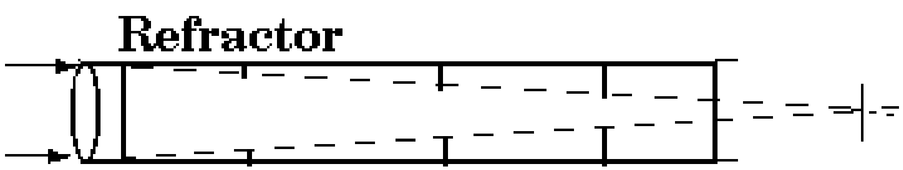
Most practical applications were maritime use; spotting ships or land from far off.

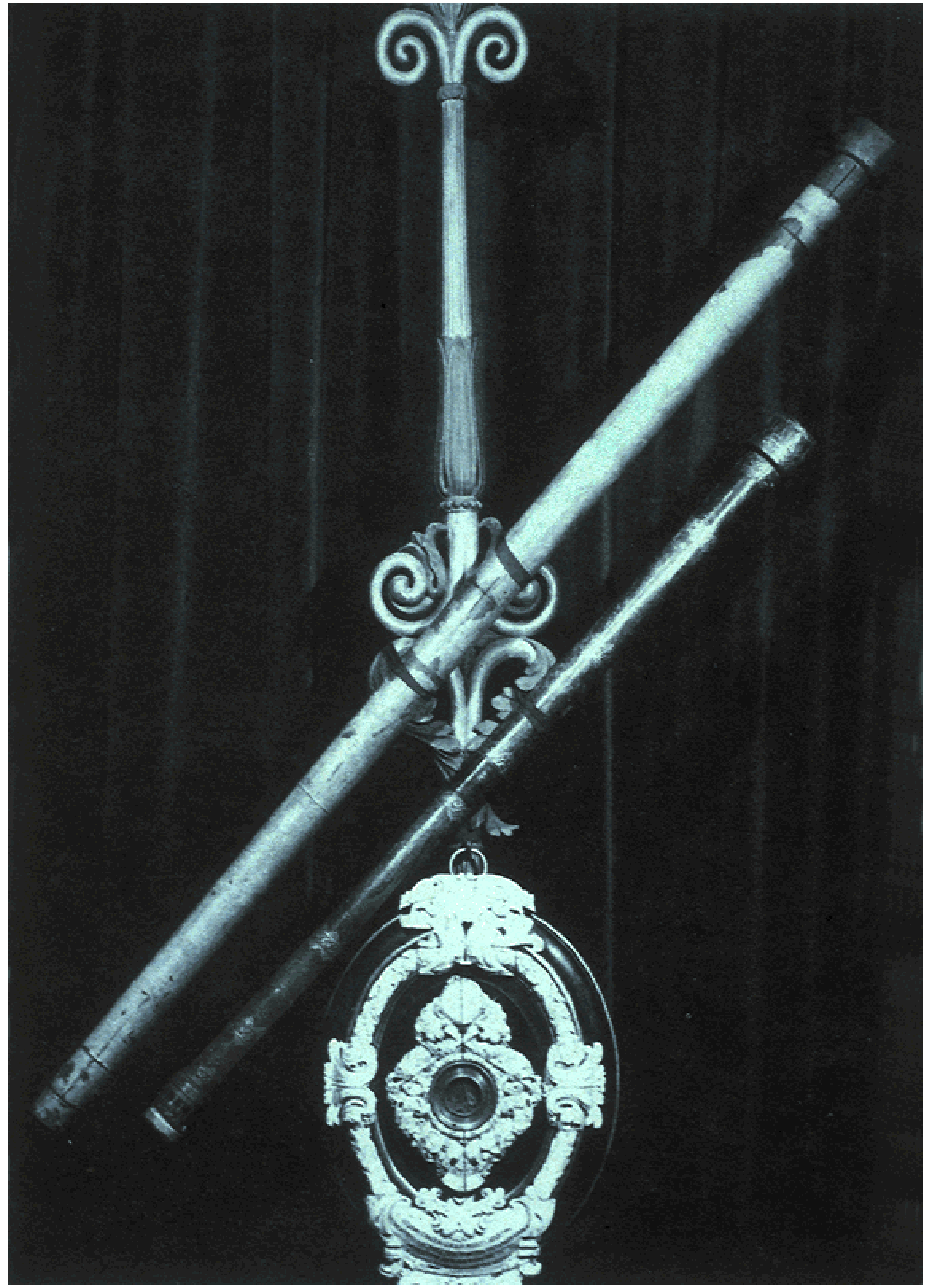
Thomas Harriot actually observed the moon with a telescope *prior to* Galileo (April 1609), but his work was not published until much later.
(Remember this general rule: Publish or Perish!)

Galileo's telescopes:

2" aperture
~ 20 x magnification

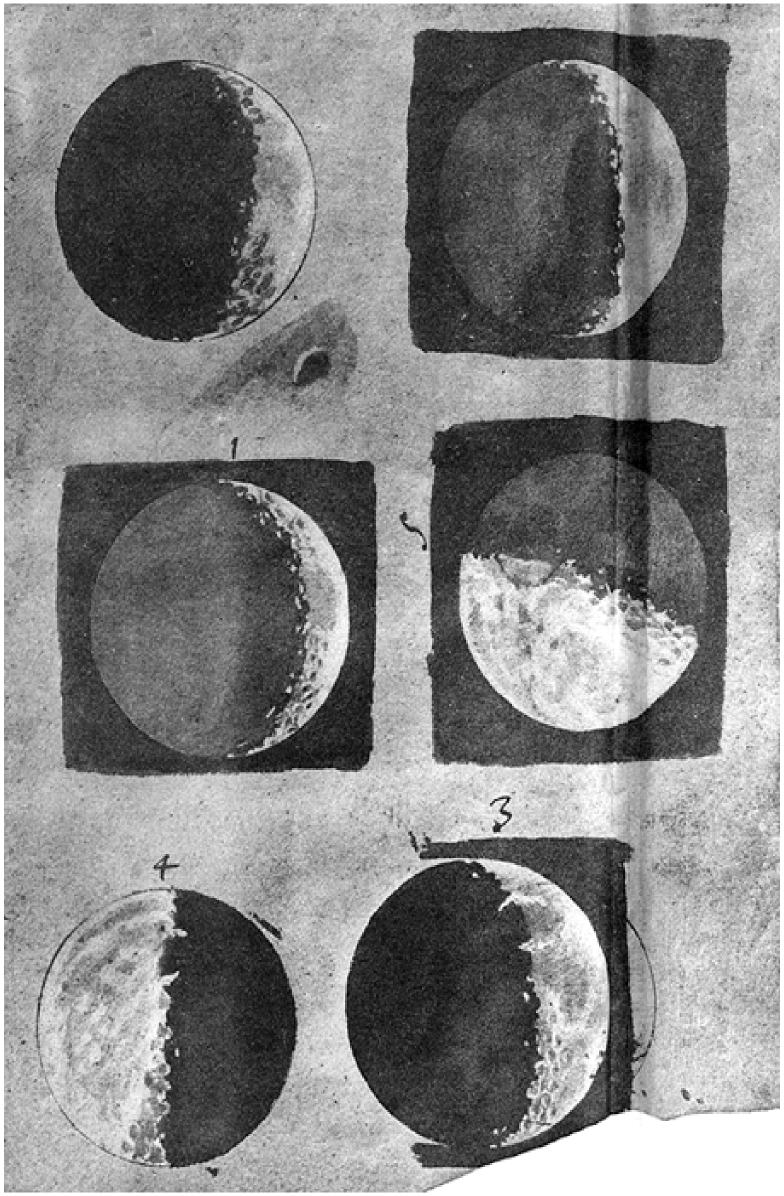
Although of extraordinary quality for his time, you can build one for less than $30 in parts.



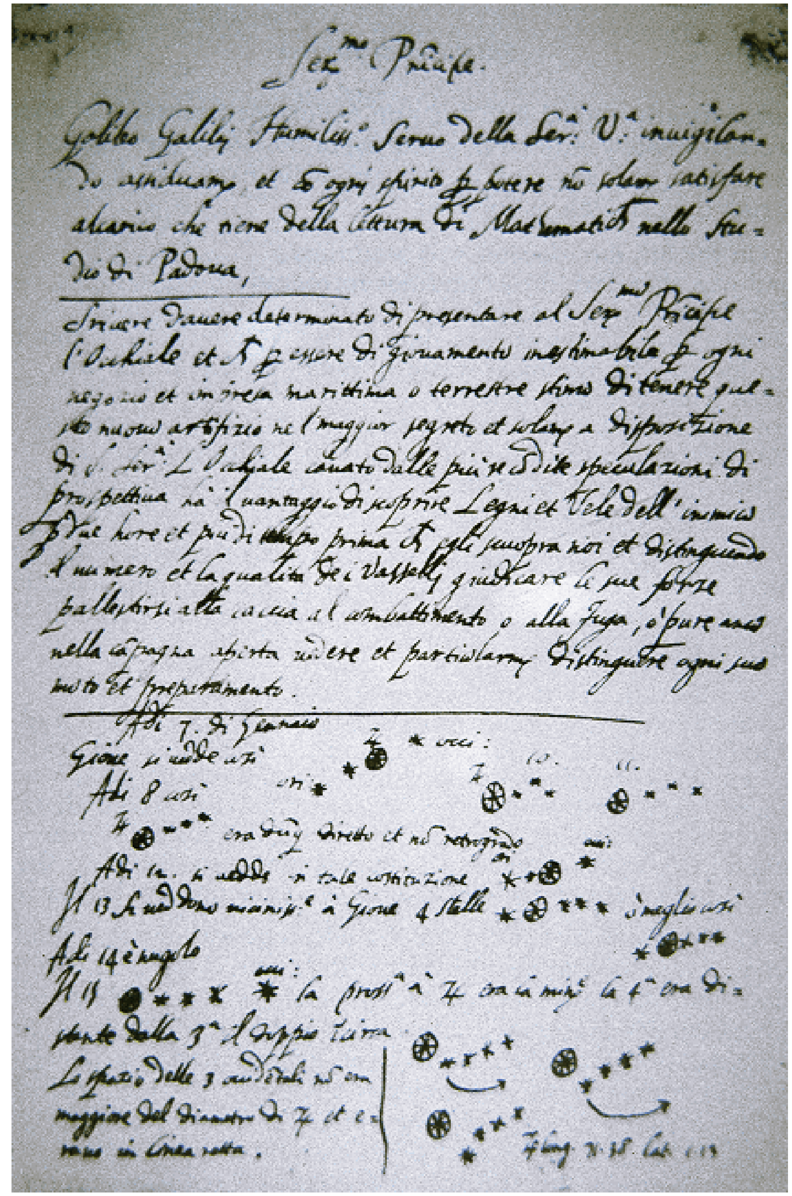


1609-1610

Galileo's moon drawings (Thomas Harriot actually beat him to it)



Jupiter's moons



Ser.mo Principe.

Galileo Galilei Humiliss.o Servo della Ser.tà V.a invigilando assiduam.te et con ogni spirito per potere non solam.te satisfare al carico che tiene della lettura di Mathematiche nello Studio di Padova,

Invero d'avere determinato di presentare al Ser.mo Principe l'Occhiale et per essere di giovamento inestimabile per ogni negozio et impresa marittima o terrestre stimo di tenere questo nuovo artifizio nel maggior segreto et solam.te a disposizione di V. Ser.tà L'Occhiale cavato dalle più recondite speculazioni di prospettiva ha il vantaggio di scoprire Legni et Vele dell'inimico due hore et più di tempo prima che egli scuopra noi et distinguendo il numero et la qualità dei Vasselli giudicare le sue forze ...

Adì 7 di Gennaio Giove si vedeva così

Adì 8 così

Adì 13 si veddono vicinis.e à Giove 4 stelle

FOV- Angular size of the viewing field. Usually given in degrees, arcminutes (1/60 th of a degree) or arcseconds (1/60 th of an arcminute)

Magnification - ratio of the focal length of telescope and focal length of eyepiece (f_telescope / f_eyepiece)

Light Gathering Power - proportional to the square of the size of the mirror (area of the light bucket) Limiting magnitude for a telescope is

$$m = 2.7 + 5 \log D$$

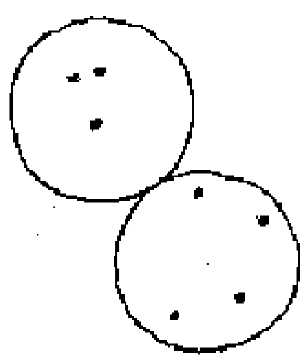
Where D is telescope aperture in millimeters.

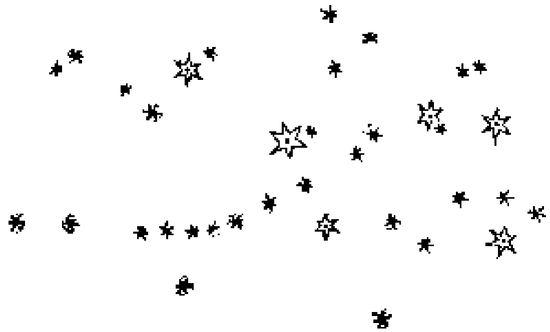
Resolving Power - Smallest angular separation that the telescope can resolve

4.56 / diameter of primary in inches

Or

116 / diameter of primary in millimeters

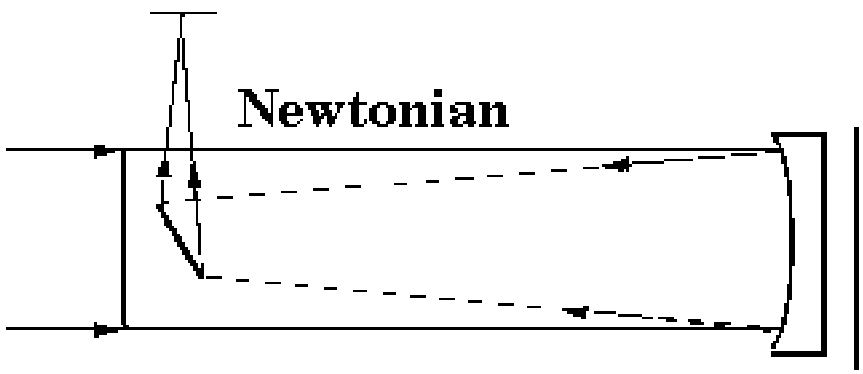




Galileo's observations on the Pleiades

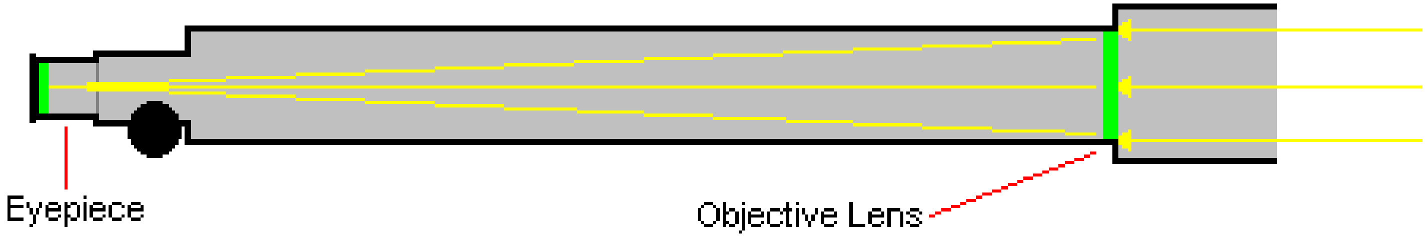
Newton's reflector (1671)

The "mirror" was actually highly polished metal. With this technique, you could make telescopes with a larger field of view, but the metal tended to oxidize and needed to be removed and polished regularly.



Types of telescopes

- Refracting
- Reflecting
- Catadioptic
  - Schmitt Cassegrain
  - Maksutov



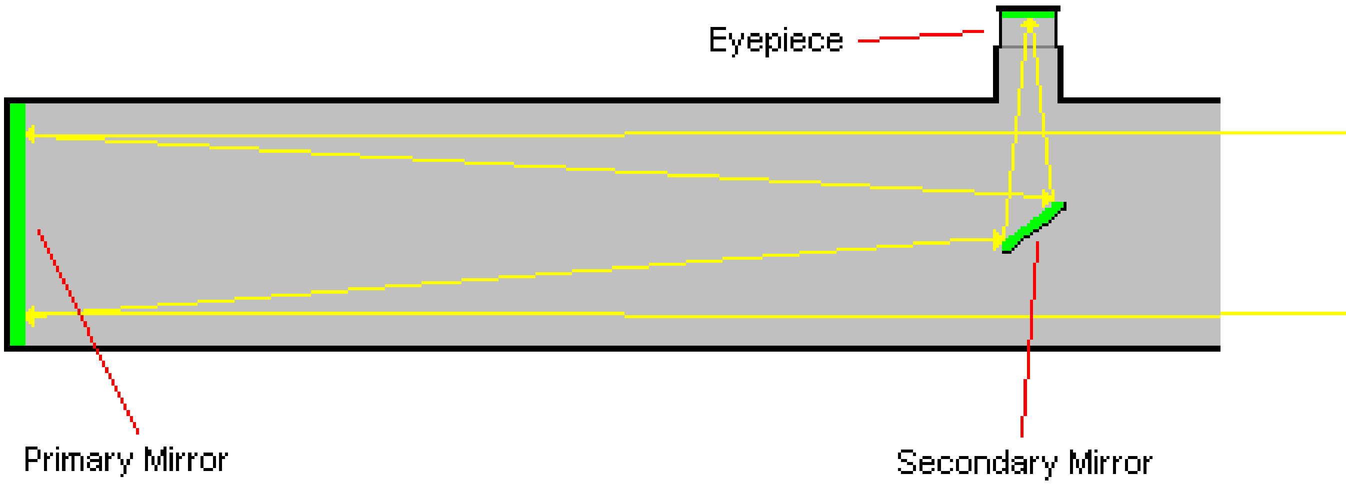
Refractor

Advantages

- Good image definition and contrast
- Optics hold alignment well

Disadvantages

- Expensive for large aperture
- Large aperture are bulky
- Glass lenses can only be made so large



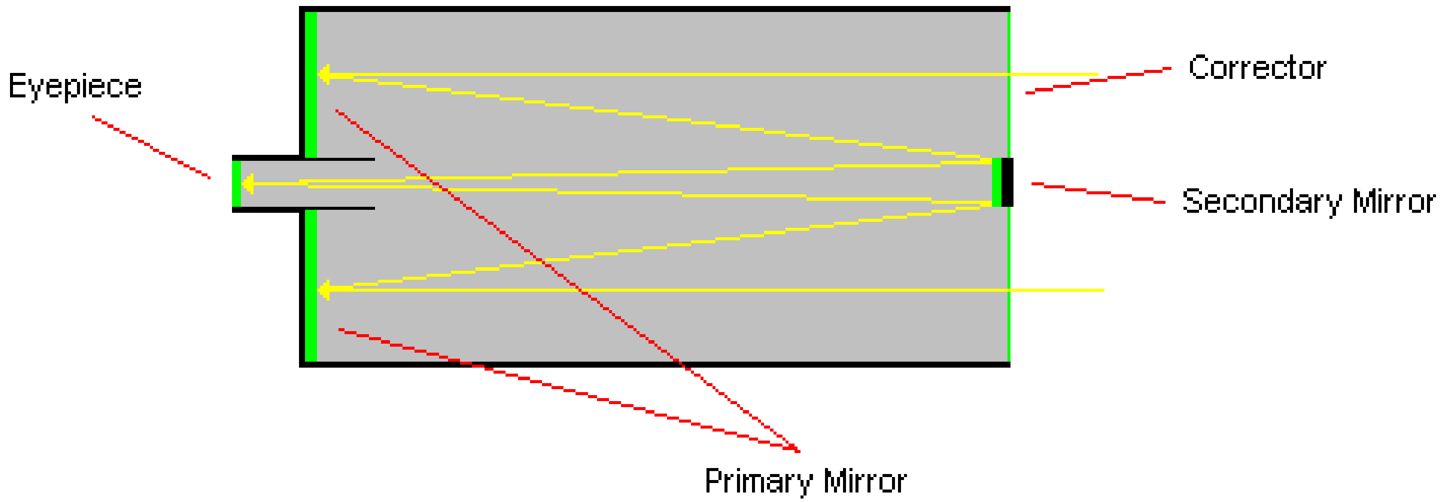
Reflector

Advantages

- Inexpensive for their size
- Eyepiece in comfortable spot
- Easy to make large aperture

Disadvantages

- Sensitive to optical alignment
- Aluminized mirror surfaces deteriorate
- Secondary blocks some of the light



Catadioptric

Advantages

- Very compact for aperture
- Due to size, easy to view any part of sky from comfortable position

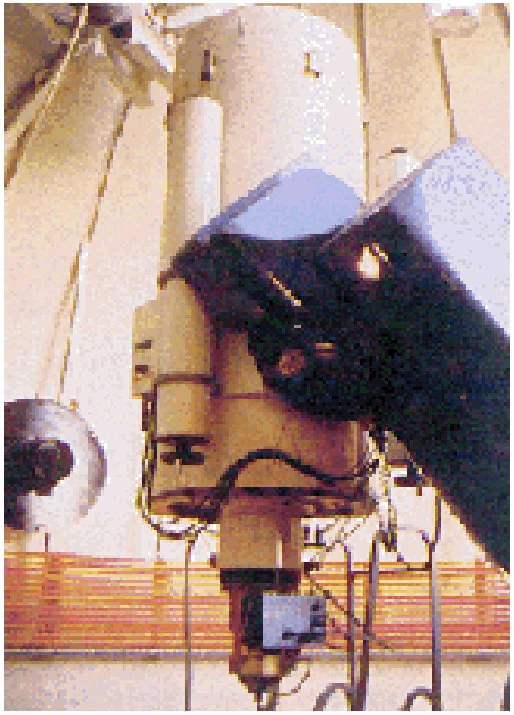
Disadvantages

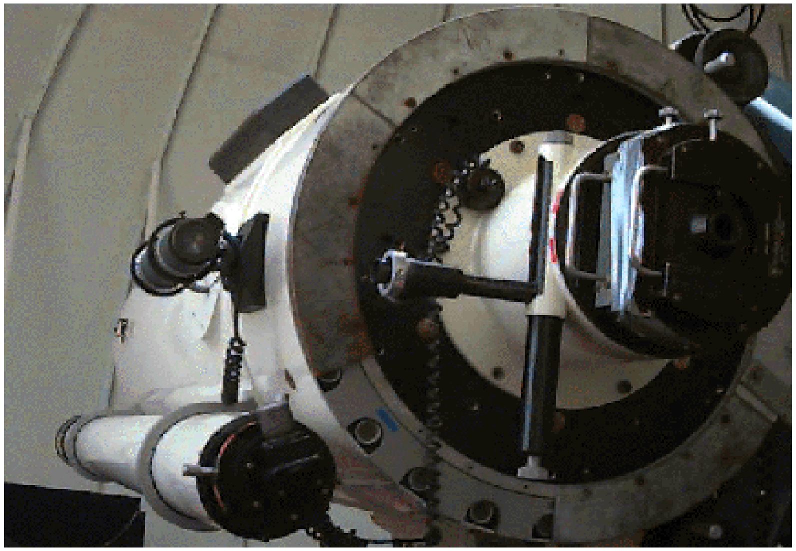
- Large secondary blocks a lot of light; so lower contrast images
- Secondary can also cause "blind spot" in center of field

MSU's Telescope

24 inch Cassegrain
6 inch refractor finder scope

Magnification up to 295X
FOV 17' or 28' (secondary mirror can be changed)

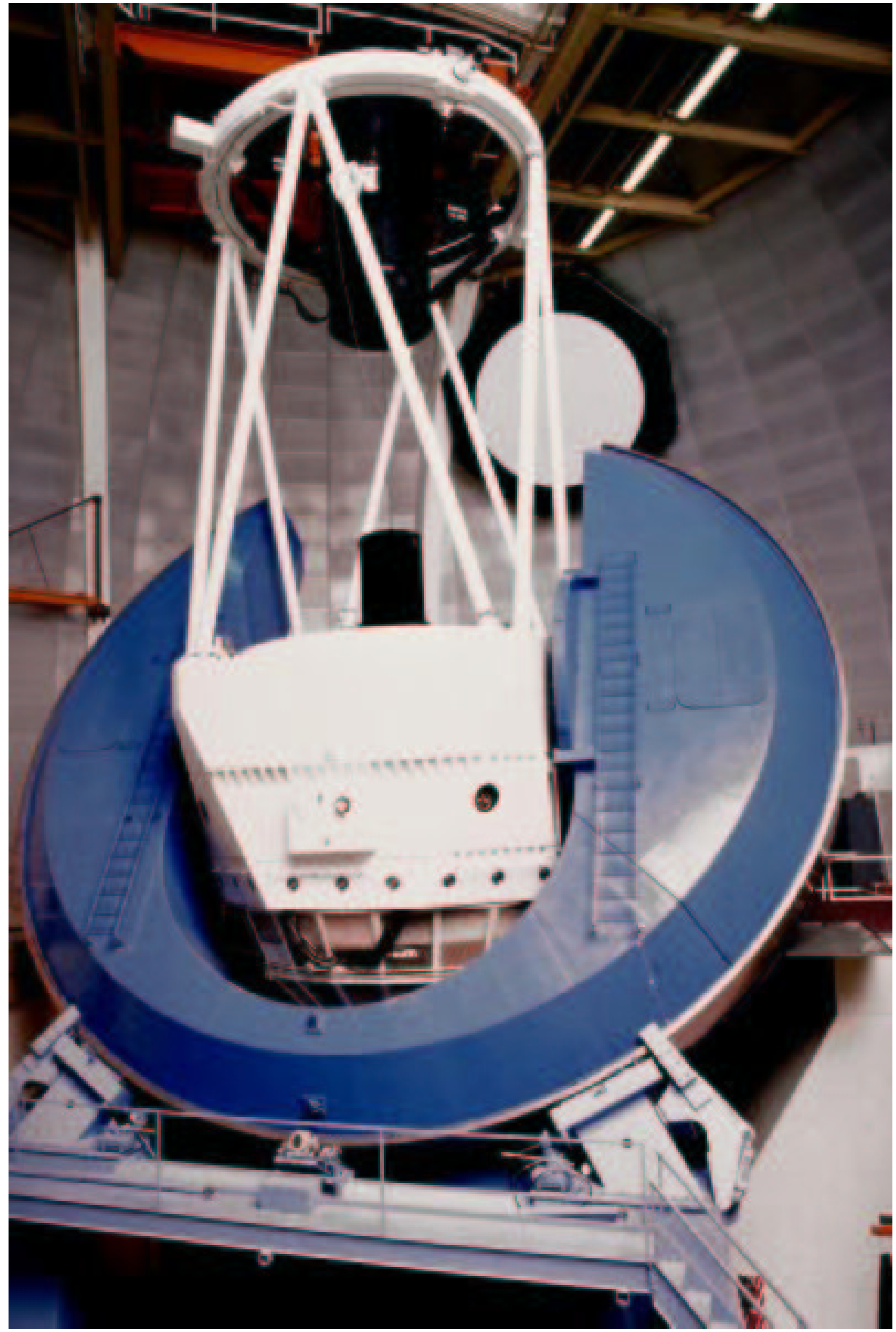


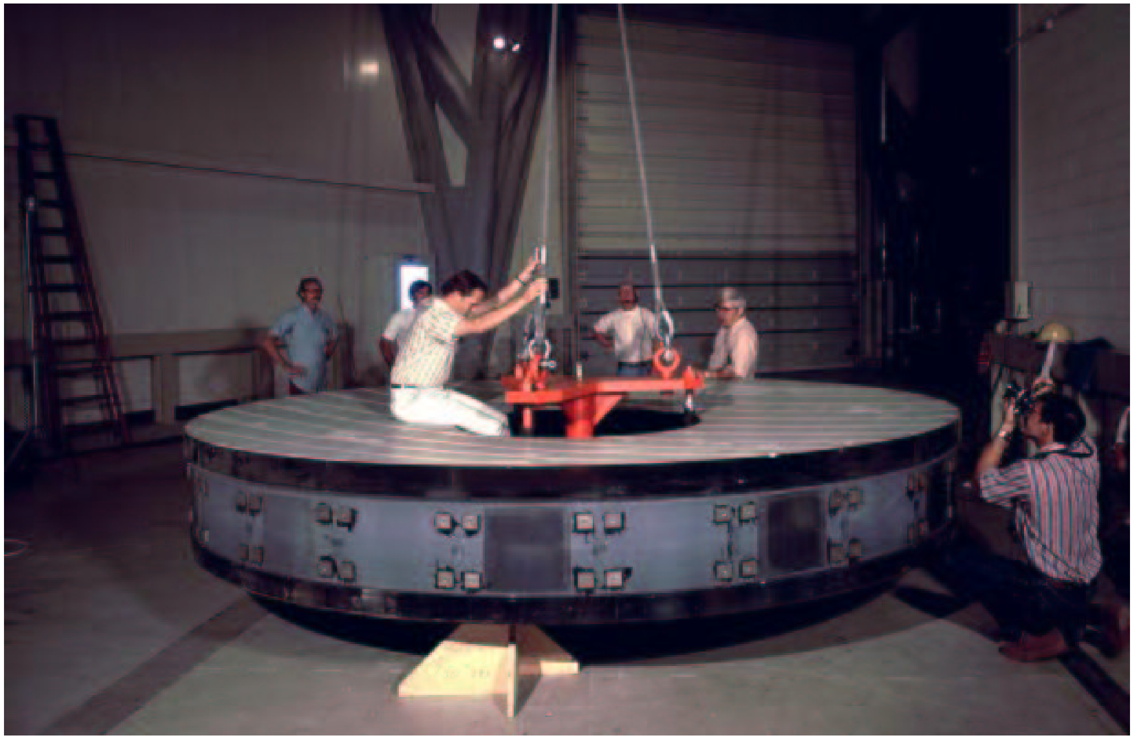


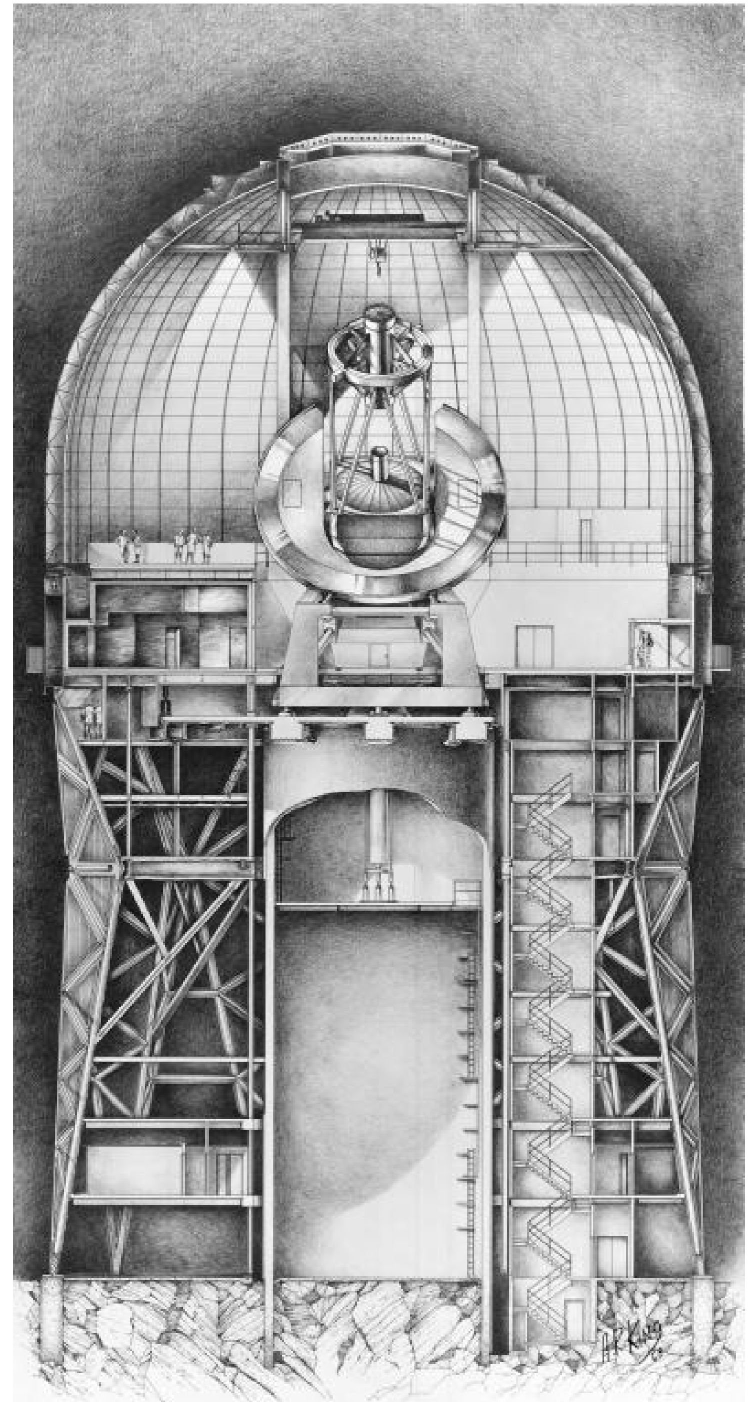
Kitt Peak

- Outside Tucson, AZ
- 26+ telescopes
- 4-m Mayall is largest

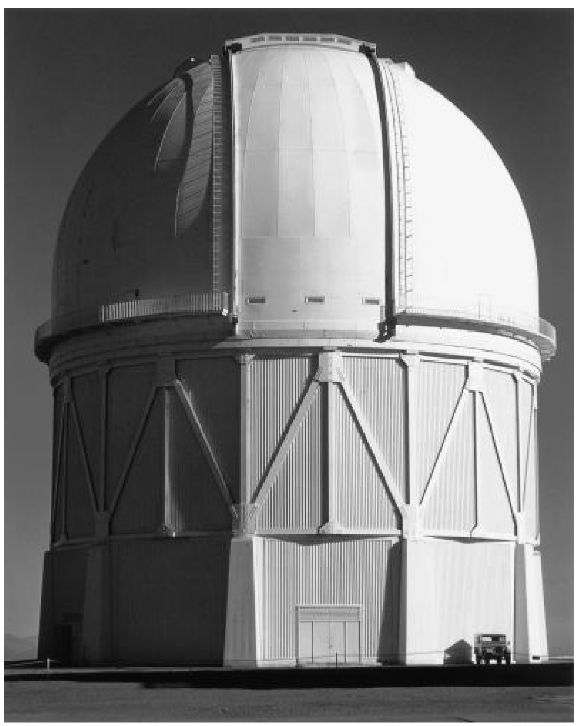
4-m Mayall (KPNO)







The 4-m mirror at KPNO (above)



There is a "twin", the 4-m Blanco at CTIO in Chile (left)

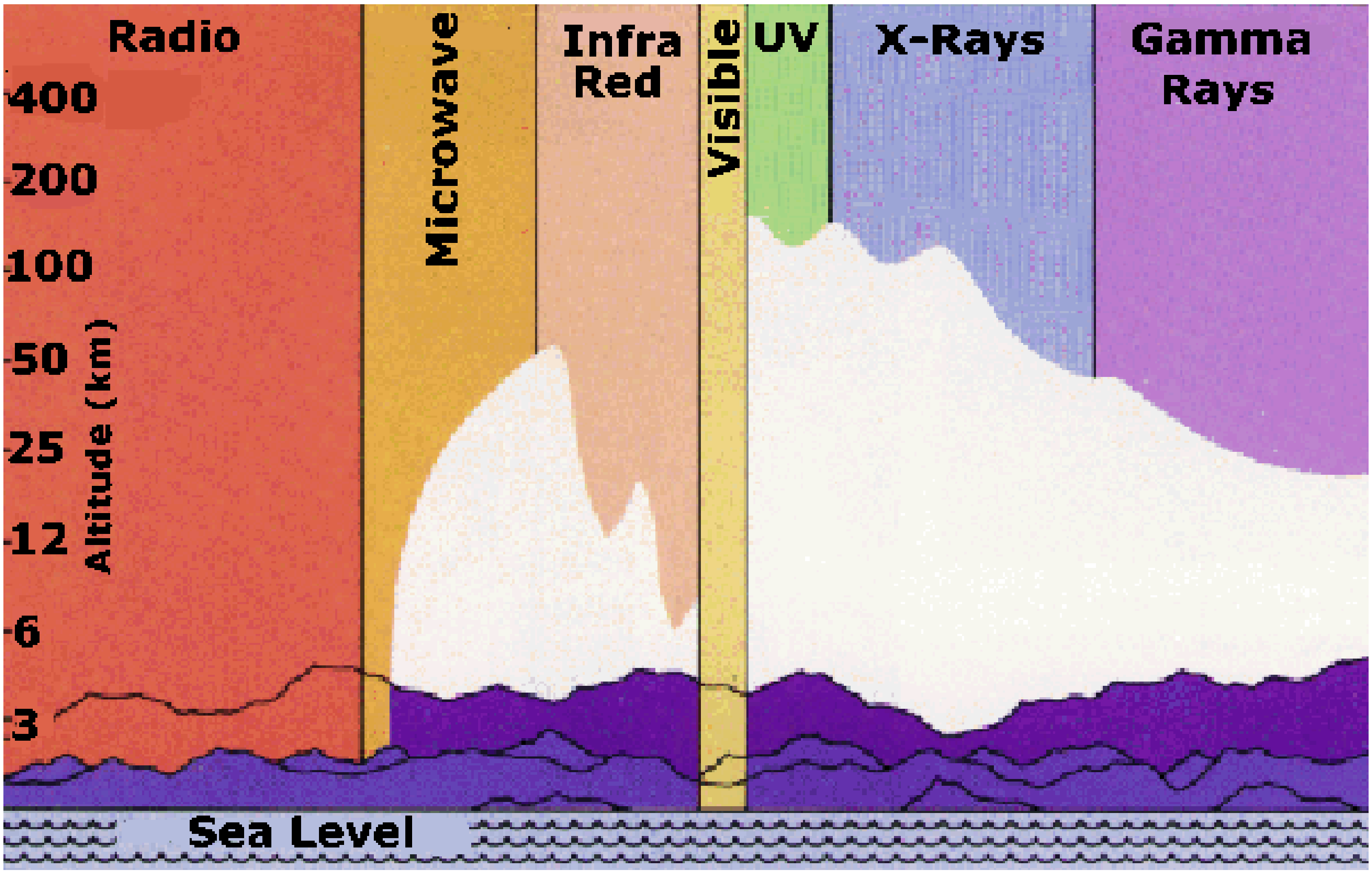
Problems with Ground Based

- Weather
- Weather
- Weather
- Seeing
- Location
  - Is your object actually viewable from your location?
- Light / radio pollution
- Daylight
  - Not so much of a problem with radio

Seeing: the quality of observing conditions induced by turbulence in Earth's atmosphere, which blurs the images of astronomical objects.
-Astronomy magazine

Absorption

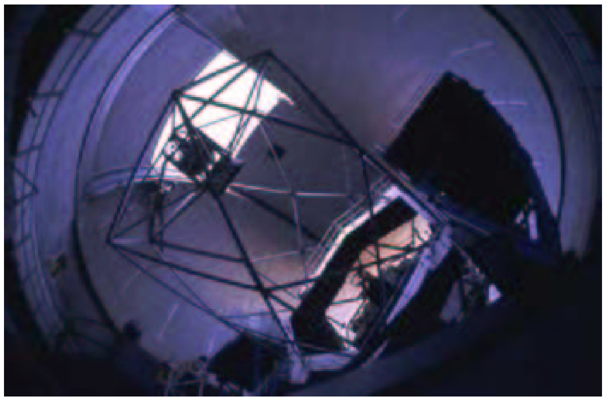
Our atmosphere blocks radiation, preventing broadband observations. It also allowed life to exist.



I guess it's a fair trade...

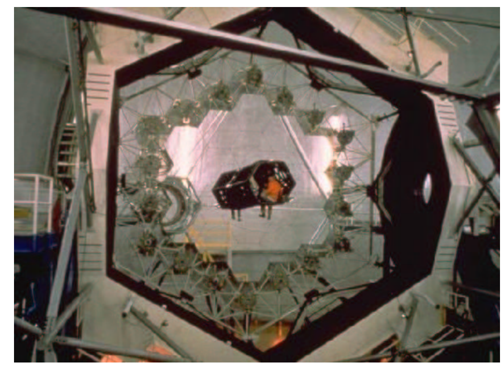
Keck Mauna Kea, Hawaii

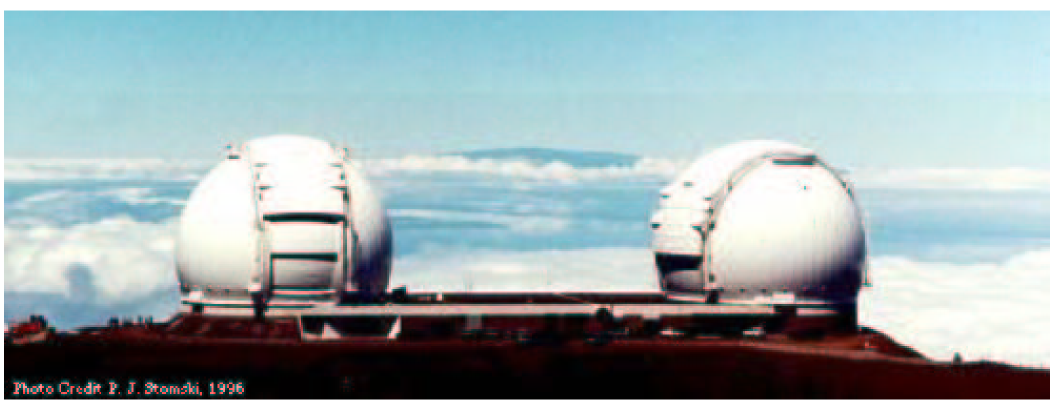
10 m .... now we are talking....

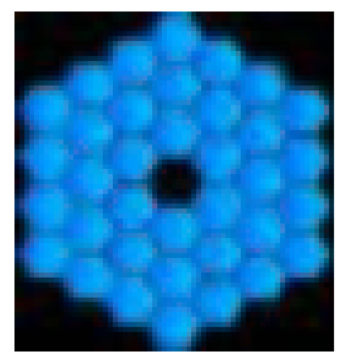


36 independent segments are used to make up the 10 m mirror.

Much easier to build than a single large mirror, but difficulty is in keeping them aligned...



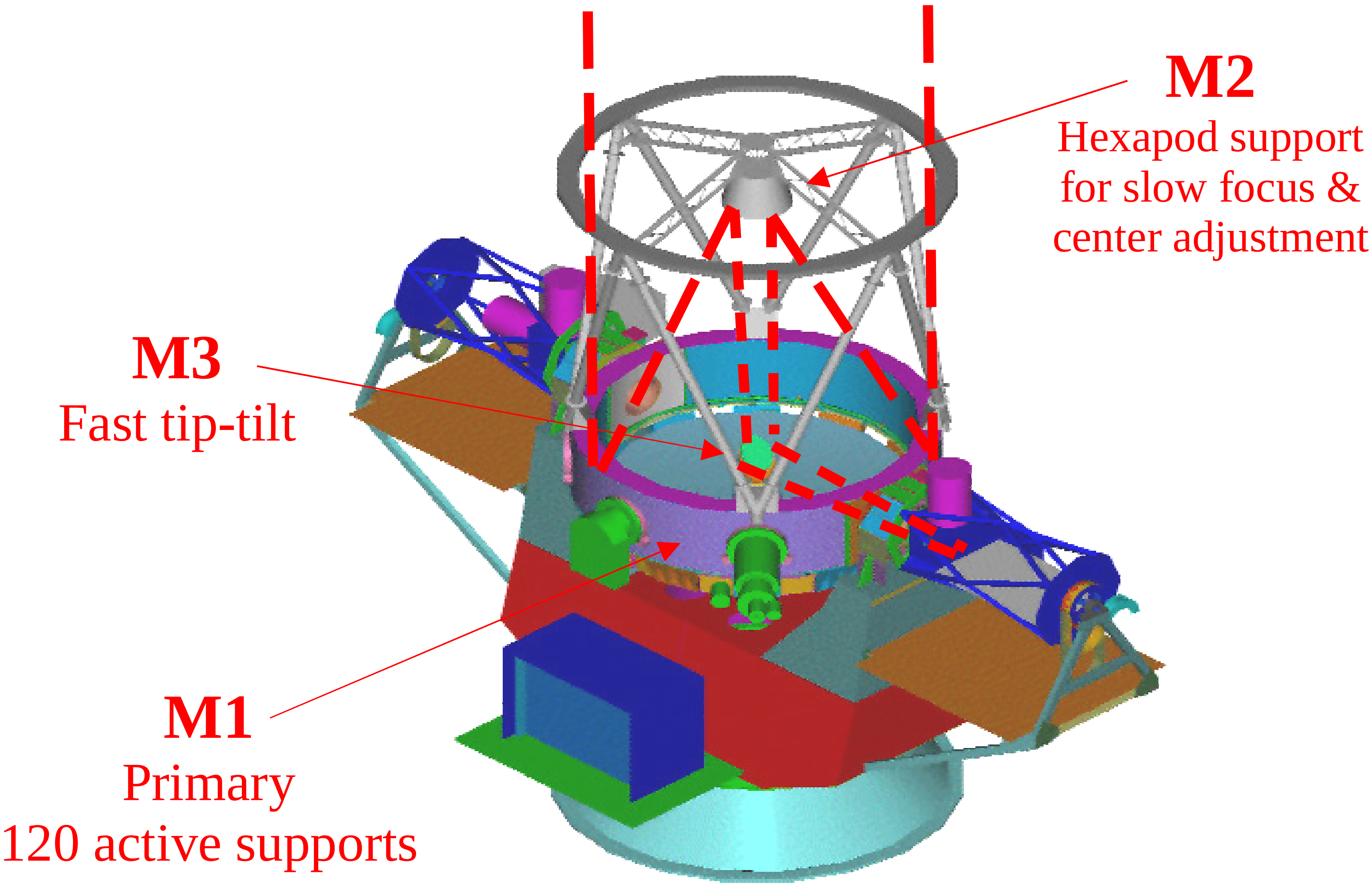




SOAR Cerro Pachón, Chile

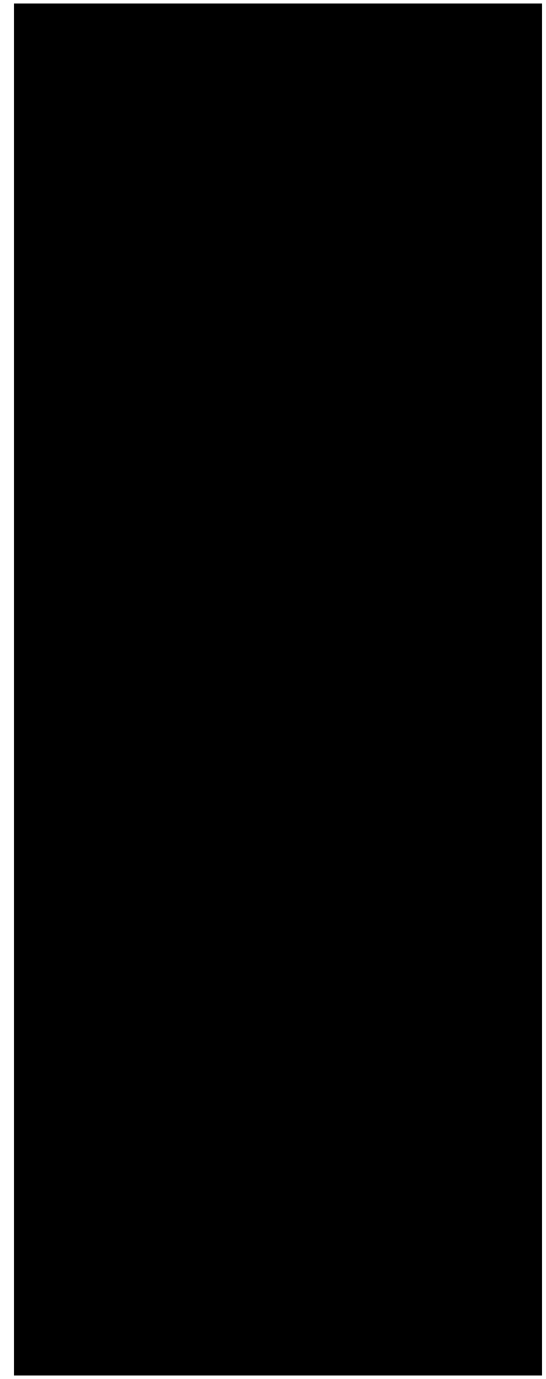
4.2 m, designed for IR, with full adaptive optics

3-mirror optical path

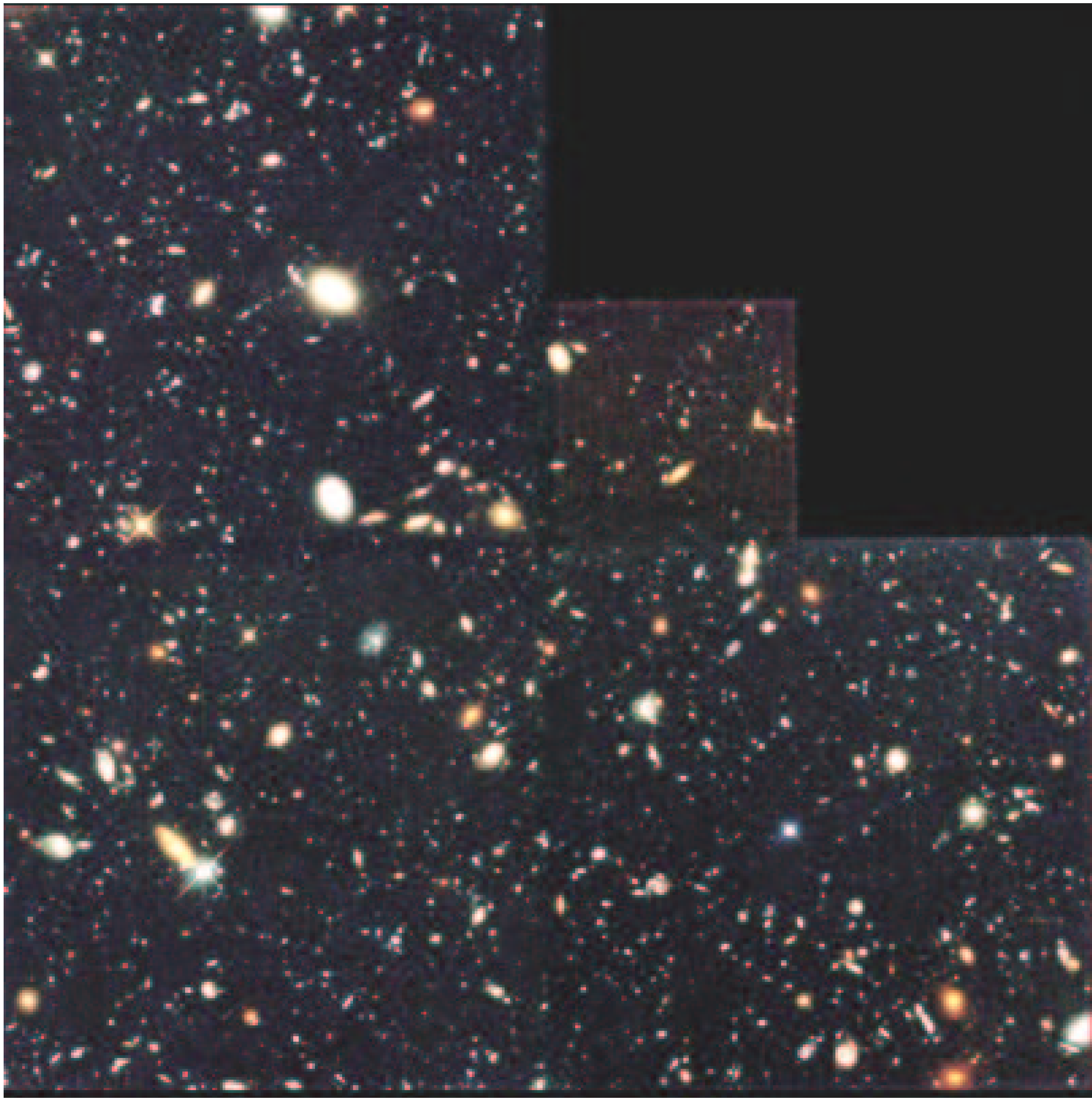


Why Chile?
The view of course...

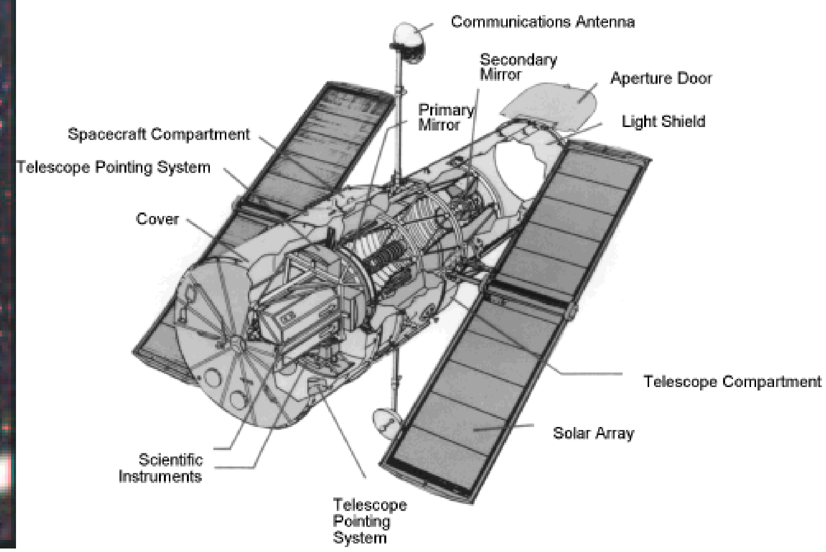
4m Blanco Telescope at Cerro Tololo



Hubble Space Telescope

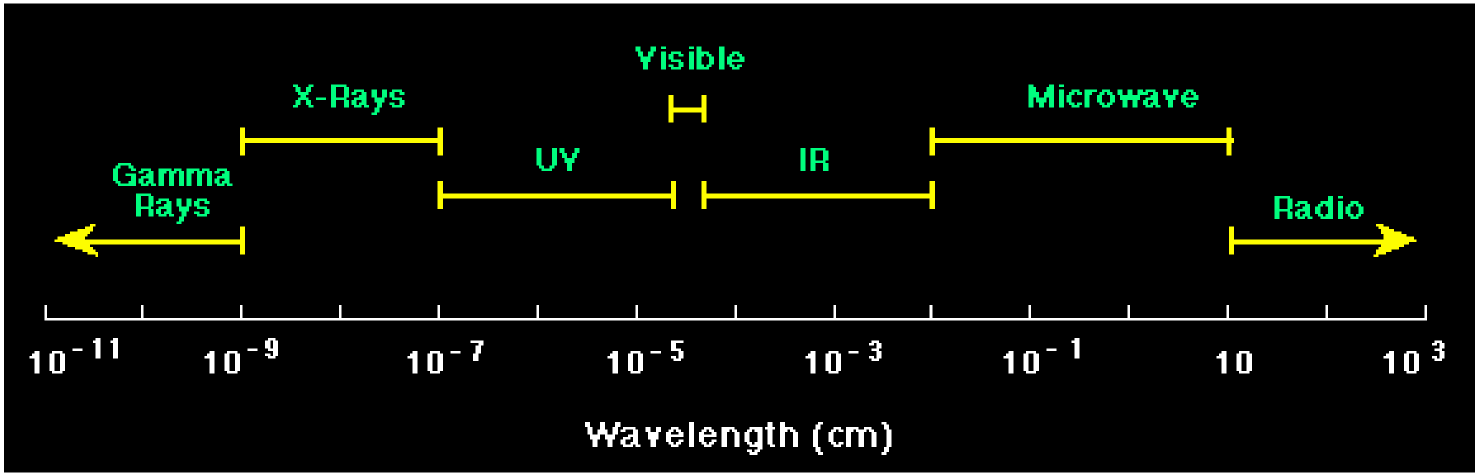


- 2.4 m telescope
- Image is deepest ever taken (1 week of observations)
  - 20 stars
  - 5000 galaxies



Non-Optical

- Most emission does not fall within the optical wavelengths.
- We can build instruments to probe other parts of the spectrum



Arecibo Radio Telescope, Puerto Rico
(As seen in Contact)

- 305 m (1000 ft) dish
- Largest single dish telescope in the world
- Used to study many radio phenomena
  - Pulsars
  - Interstellar molecular gas
  - SETI
  - Can also broadcast

VLA Radio Telescope,

Socorro New Mexico

(Images courtesy of NRAO/AUI)

- 27 radio telescopes
  - Each 25 m (82 ft) diameter
- Used together, acts like a single dish of 36 km diameter