Eyes to the Skies

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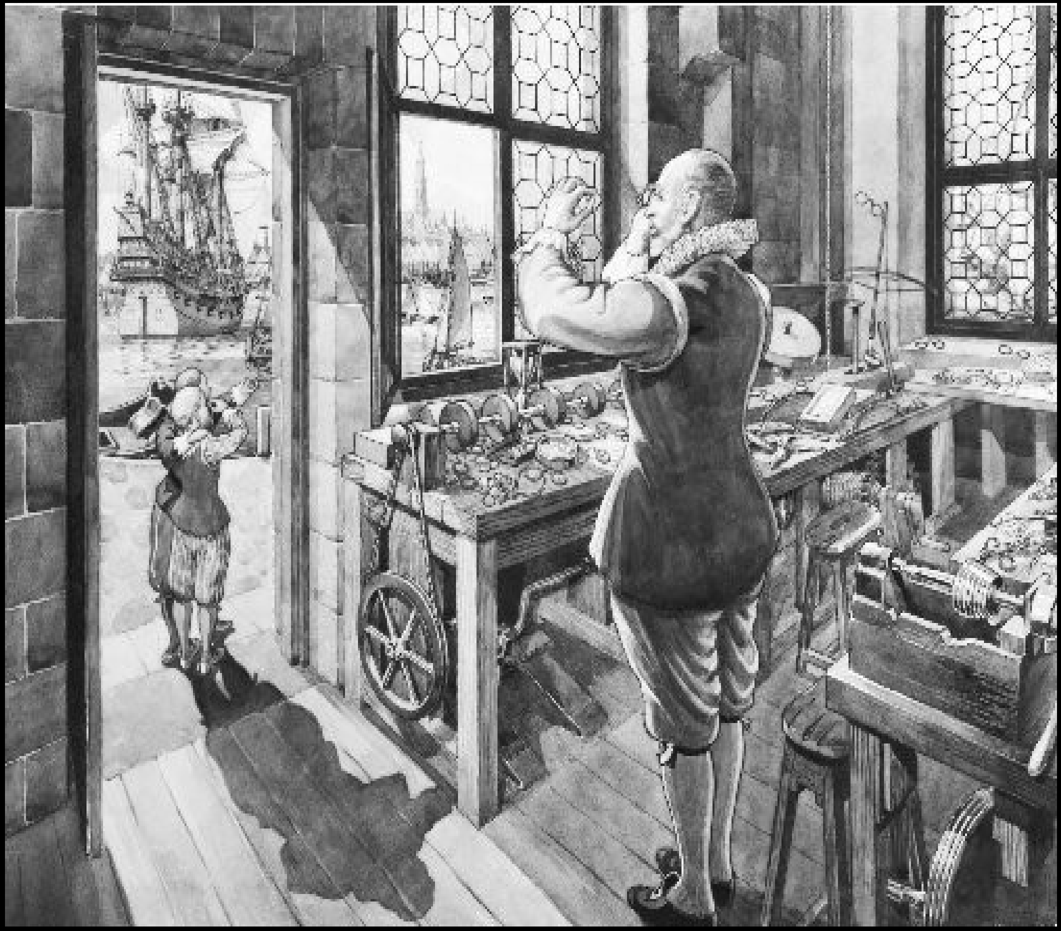
Starry Starry Nights..
Vincent Van Gogh

Fate in our eyes:

- The eye as a detector
- Nature's gift to man
- Minuscule light from stars...
- Always struggle to look beyond....

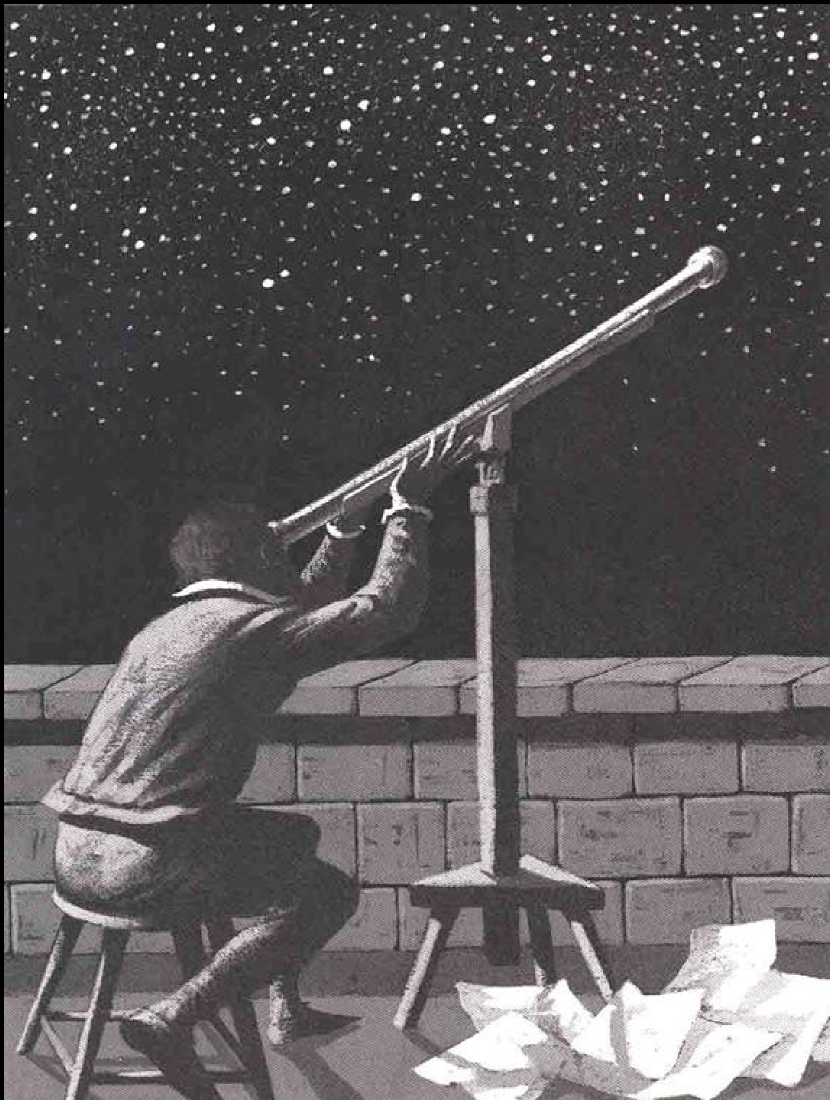
Discovery of telescopes: Child' s play



Hans Lippershey, 1608

Thanks to kids like U!

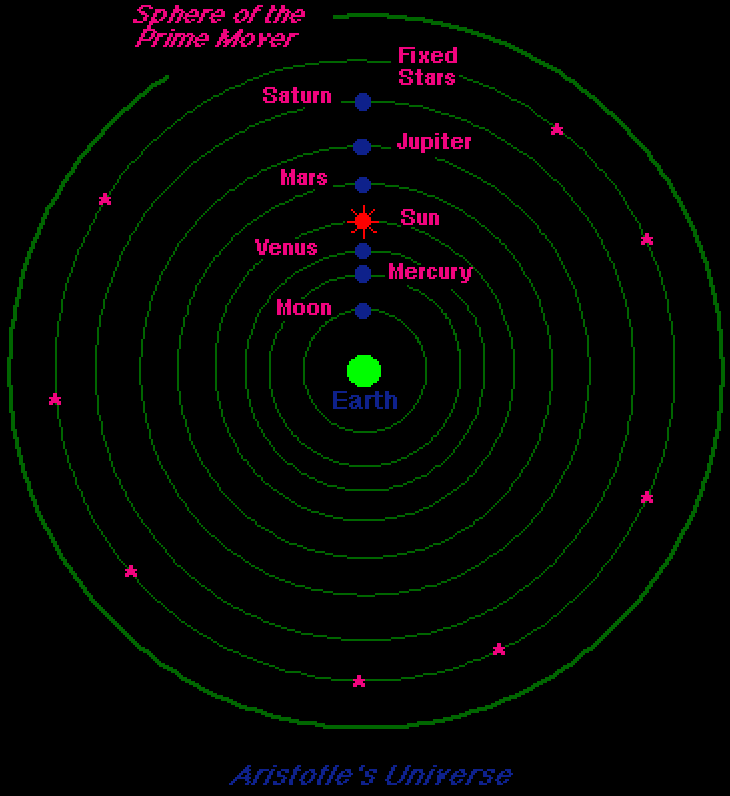
Galileo 1609



GALILEO DESCRIBES HIS DISCOVERIES TO THE CHURCH

Change in world view!

- Jupiter's satellites
- Phases of Venus
- Craters of Moon
- Milky Way



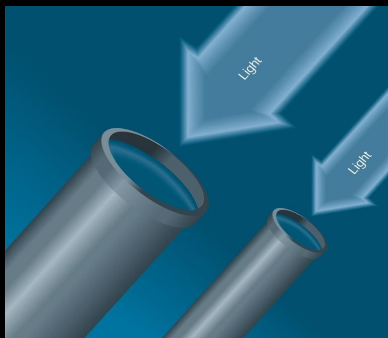
Stephen Hawking *"birth of modern science"*

Albert Einstein *"father of modern science"*

But thats not all......

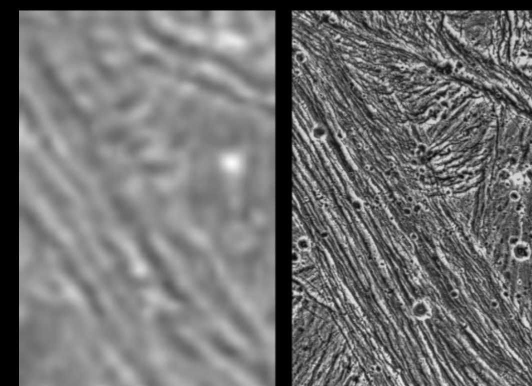
There is always scope for innovations, ideas.....

Eyes to the Skies: Telescope



Light Gathering Power: Large telescopes can intercept and focus more starlight than a small telescope and can detect fainter objects (~D).

Resolving Power: Increases the sharpness of the image and the extent to which fine details can be distinguished.



Magnification: Ability of the telescope to make the image appear large in the field of view.

How to buy a telescope?

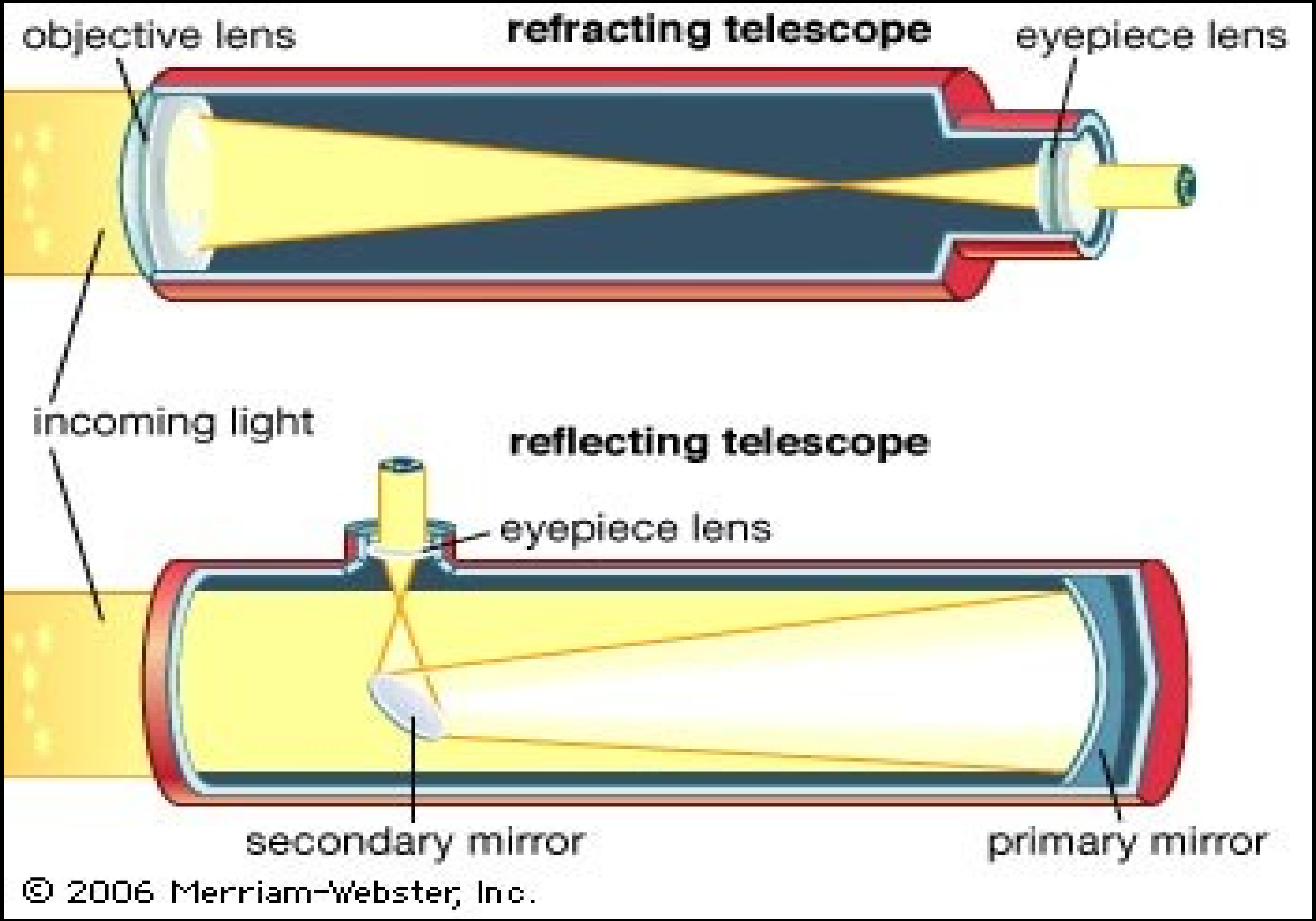
A common question when purchasing a telescope is what "power" it is. The power of the telescope is the ability to magnify an object.

Magnification is really not as important as field of view of Aperture M=f/D (Eyepiece)

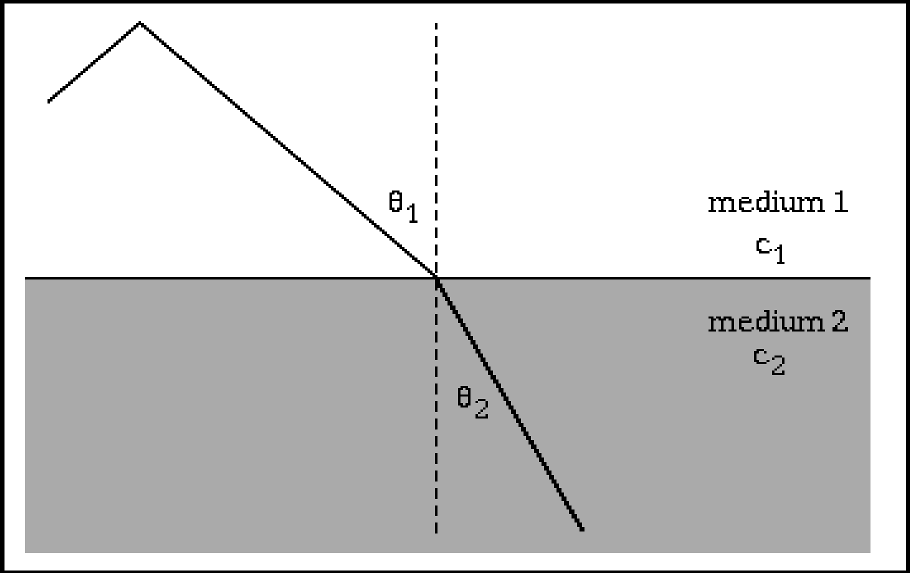
Resolution=116/D(mm)

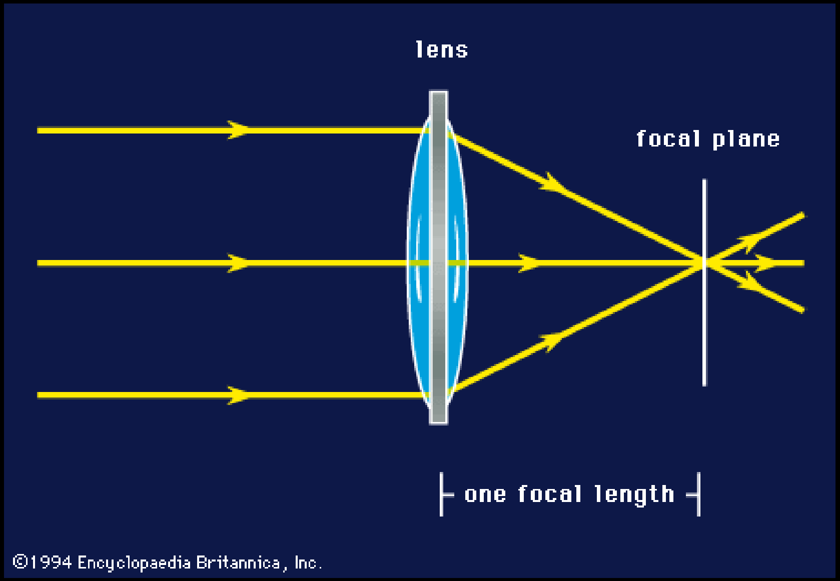
How faint? (not how far!!!)
m=2.7+5*log D (mm)

Types of Telescopes



Refracting Telescopes

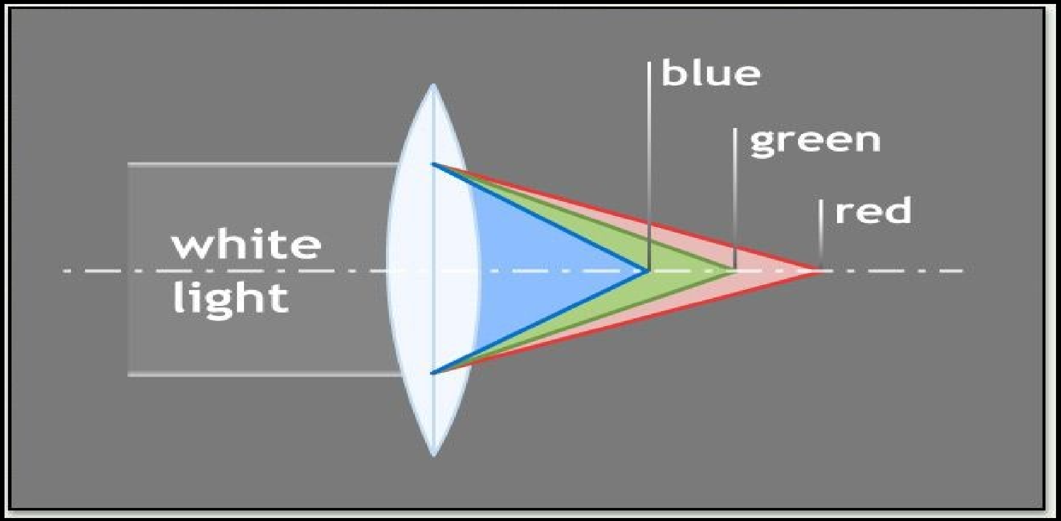




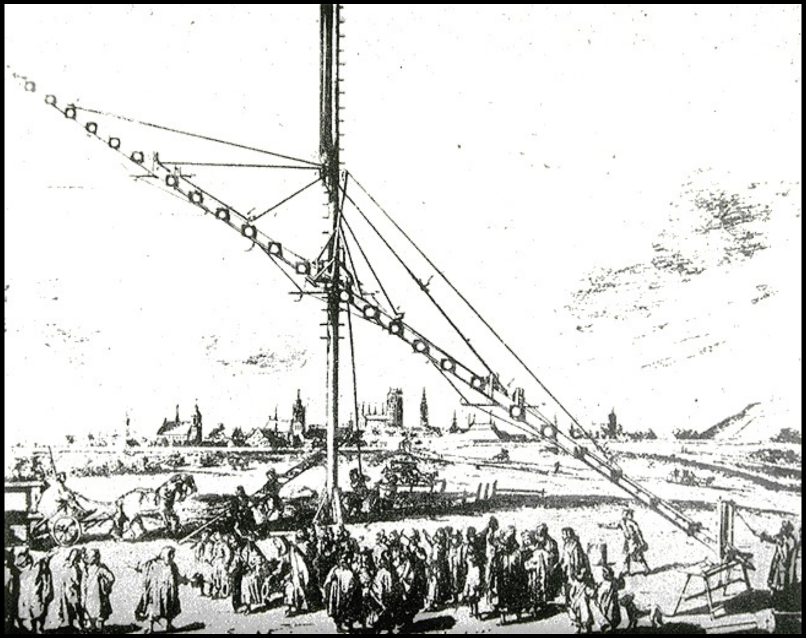
The speed of the wave is lower in medium 2 than in medium 1. As it approaches, the side closest to the interface slows down first resulting in an overall change of direction when the whole wave enters medium 2.By shaping glass appropriately, we can make a lens that brings the light to a focus.

Disadvantages

- Chromatic Aberration
- Production Problems
- Weight of lenses
- Distortion
- Mechanical Problems
- Cost



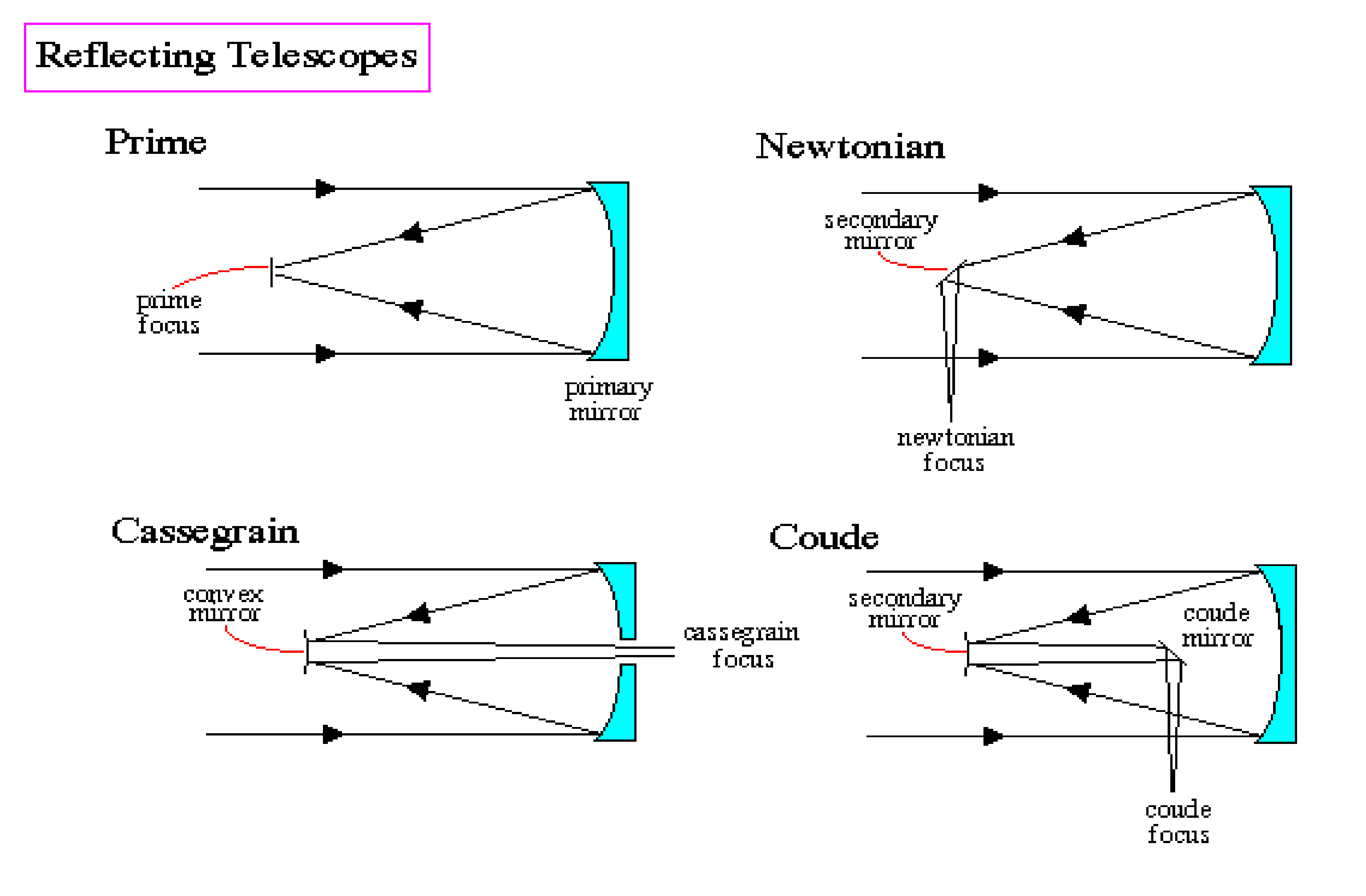
How big can we get?



140-ft Hevelius telescope 1673

40 " Yerkes Telescope

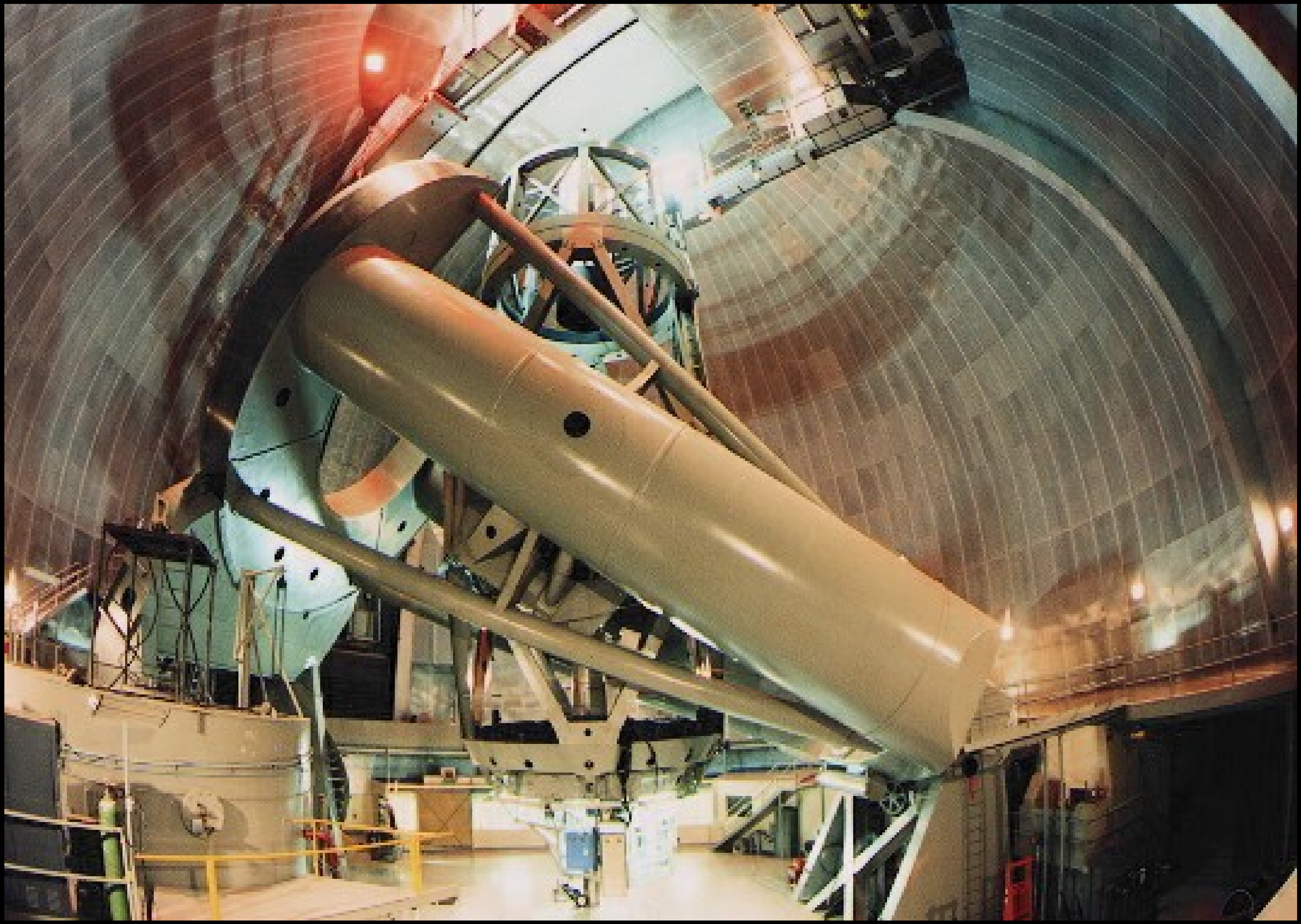
Reflecting Telescope



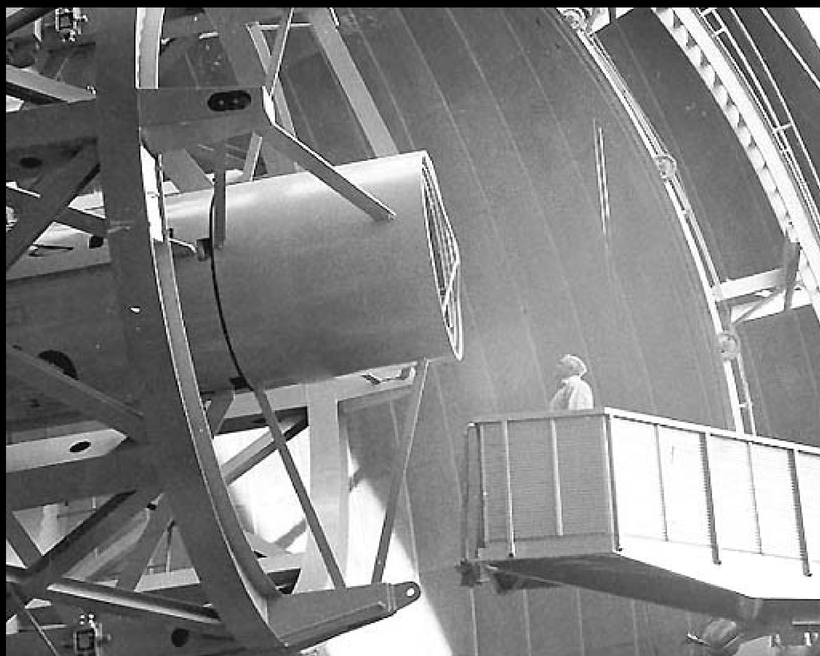
Advantages

- No Chromatic Aberration.
- Spherical Abberation: Parabolic mirrors
- Only one surface to be perfectly polished
- Can be made larger
- Lighter
- Cheaper

Mt Palomar (5m, 1948)

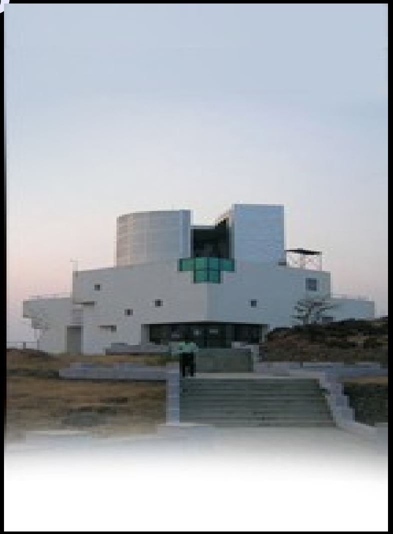


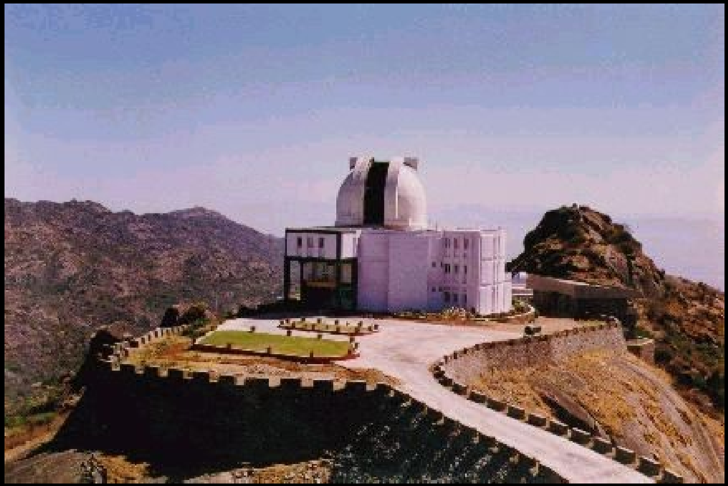
Also some circus skills....



Indian Observatories

JRO
Nainital
IGO
IAO
MIRO

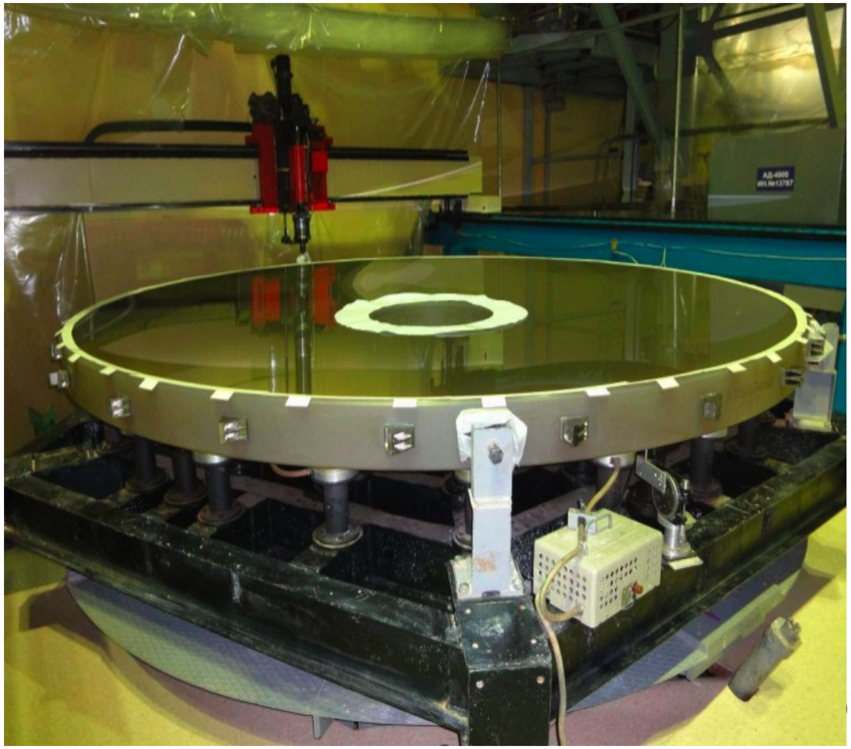


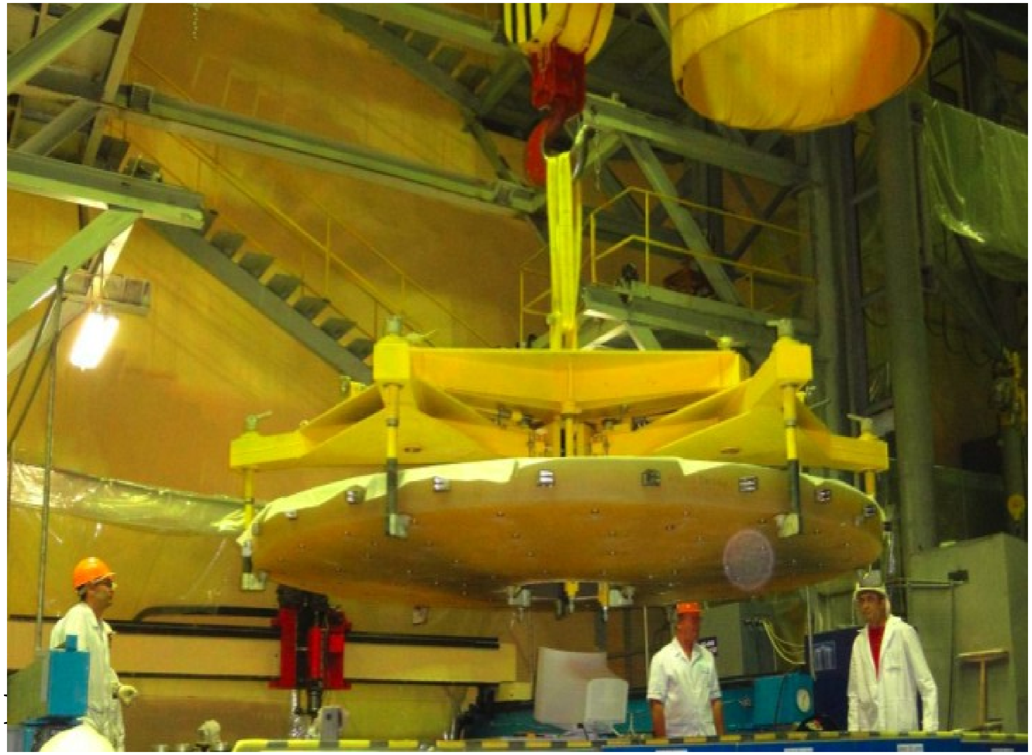


ARIES: 3.6 m

The thermal expansion of glass ("Zerodur") is ~ 10^{-7} - 10^{-8} /K.

The mirror is polished to optical accuracies, in 3.6 meter it is ~33 nm rms





Telescope Enclosure

Dome, Slit and Wind screen

M1 ~ 14 meter above ground

Diameter – 16.5 m

Dome height – 29 m

Dome weight – 170 Ton

Rotation Speed – 7 m/min

Wind speed – 15 m/s (55 m/s)

Ventilation – Pier, air flushing, hot air ducts

Priya Hasan

First light soon....

Instruments

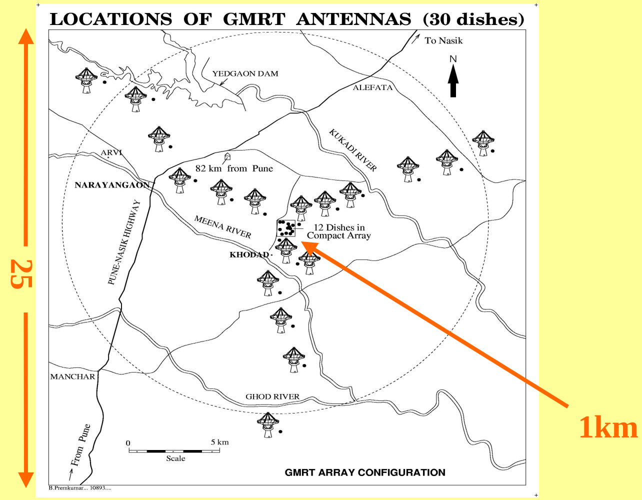
1. Faint object spectrograph and Camera & CCD Imager (ARIES)
   0.35—0.9 μm; Field of View = 14´ X 14 ´ (Imag) & 10´X10´ (Spec)
2. NIR spectrograph (TIFR, Mumbai)
   - design phase, expected completion – 2014
   0.5—2.5 μm; Field of View = 7´ X 7 ´
3. High resolution optical spectrograph (HERMES-like) (ARIES : in collaboration with Belgium)
   -0.38—0.9 μm; R = 30 K and 60 K
4. Integral Field Unit (IUCAA, Pune)

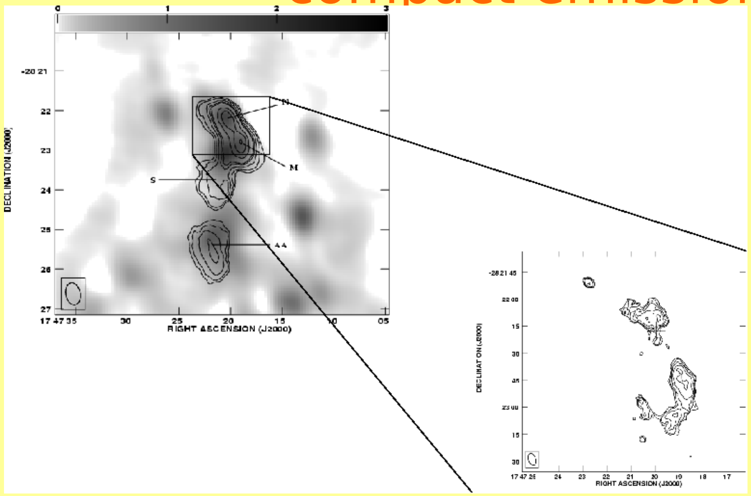
The Giant Metrewave Radio Telescope

- The Giant Metre-wave Radio Telescope (GMRT) is a large aperture synthesis radio telescope optimized for operation at low frequencies
  - Wavelengths of 21cm and longer
- Designed and built (near Pune) primarily by NCRA, a national centre of TIFR.
- Array telescope consisting of 30 antennas, each 45m across
  - Novel ‘SMART’ antenna design
  - The most sensitive synthesis radio telescope in the world at most of its frequencies of operation,

GMRT Antenna Layout

Unique hybrid configuration with mix of long and short baselines – allows simultaneous imaging of extended as well as compact emission

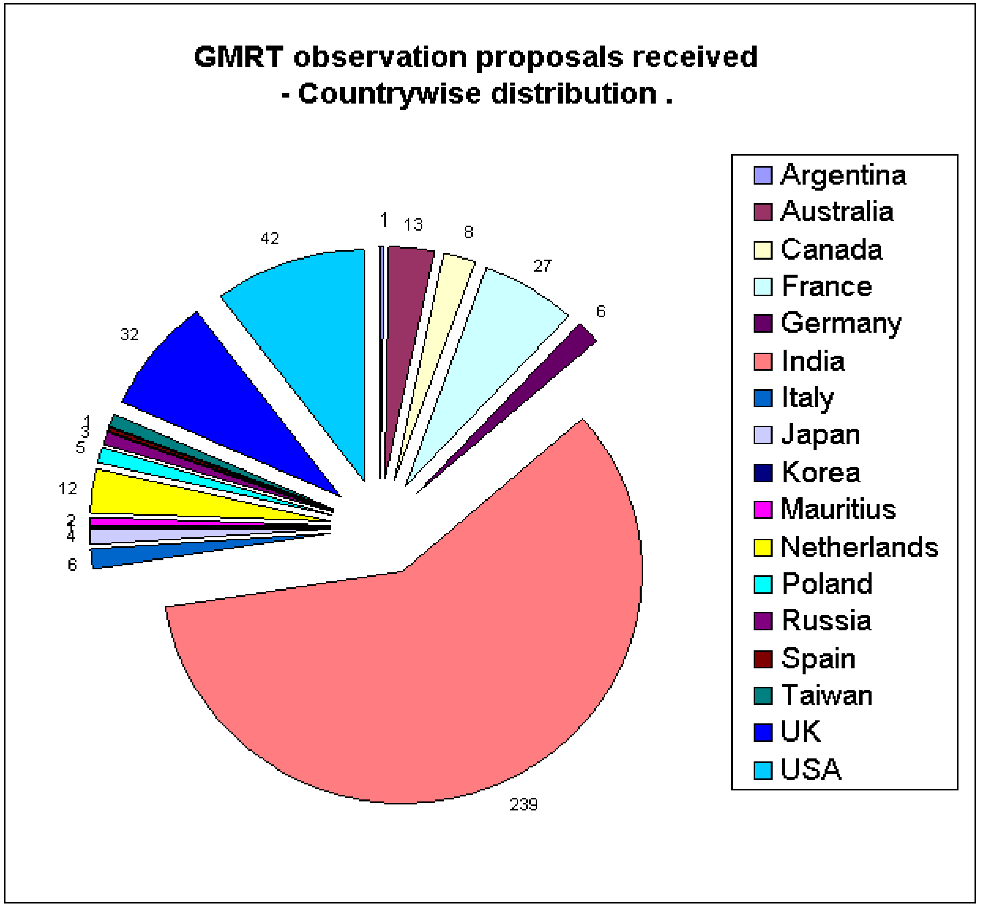




Low and high resolution images of CH_3CHO emission from SgrB2 made from a single GMRT observation

Using the GMRT

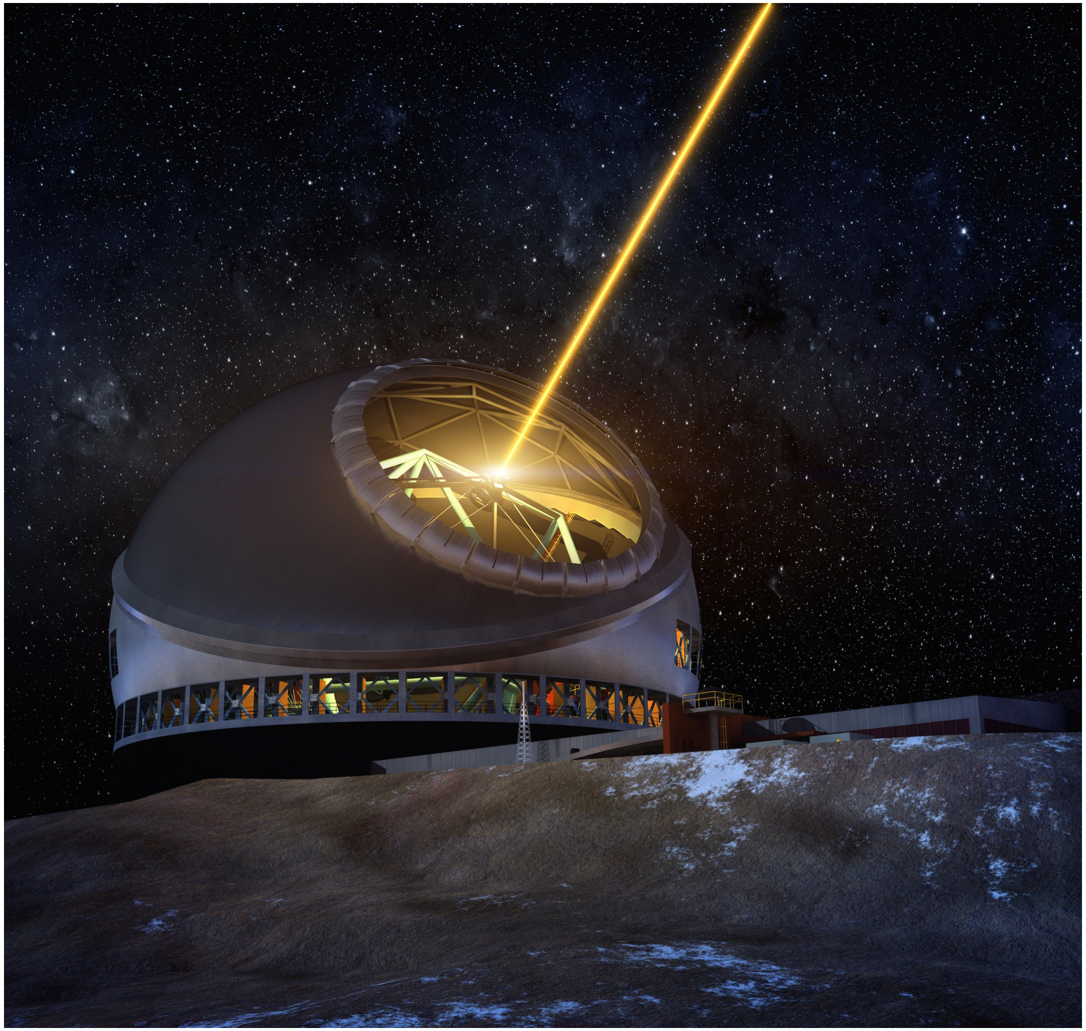
- Time is allocated to proposals by an independent time allocation committee
- Two calls per proposals per year
- At present time allocation is roughly evenly split between Indian and Foreign PI proposals



The Ooty Radio Telescope

- Located in Muthorai near Ootacamund (Ooty), south India.
- Part of the National Centre for Radio Astrophysics (NCRA) (TIFR) which is funded by the Government of India through the Department of atomic energy.
- It is a 530-metre (1,740 ft) long and 30-metre (98 ft) wide Cylindrical Paraboloid telescope.
- It operates at a frequency of 326.5 MHz with a maximum bandwidth of 15 MHz at the front-end.

TMT



- Collecting area:664.2 sq m
- 30 meter, f1 mirror
- 492, 1.45 meter mirror segments
- 0.31 to 28 μm
- Adaptive optics
- 20” FOV
- High angular resolution
- High sensitivity
- International partnership between CalTech, Universities of California, Canada, Japan, China and India.

Indian Contribution (70% kind,30% cash)

Edge Sensors

12 edge sensors and in total 3,234 sensors for entire M1.

Production of 25 prototype sensors initiated by TMT-India at General Optics Asia Limited (GOAL) Puducherry

Actuators:

492 hexagonal mirror segments of the TMT must be precisely positioned to form a 30-meter hyperboloid primary mirror.

Each mirror segment three actuators and 1,476 actuators are required to keep all the segments aligned.

10 such prototype actuators are under manufacture at Avasarala Technologies Limited (ATL), Bangalore.

Segment Support Assemblies (SSAs):

Each mirror segment will be mounted on a Segment Support Assembly. 82 types of SSAs.

TMT-Indias and Mark Sirota (TMT Telescope Controls Group Leader) in the prototype development of the above components.

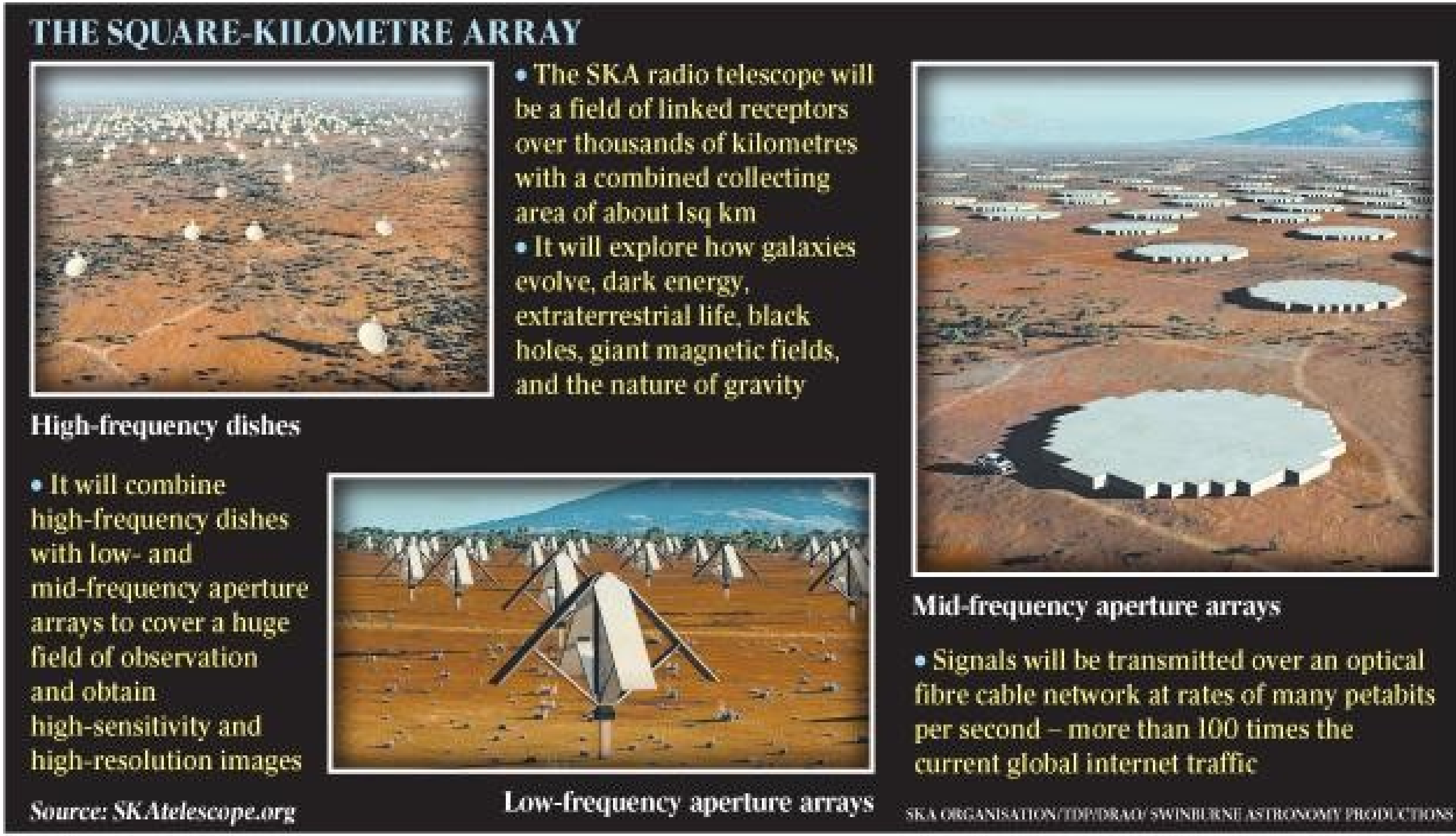
Segment polishing:

India to demonstrate segment polishing capability either using Stress Mirror Polishing (SMP) technique or CNC approach.

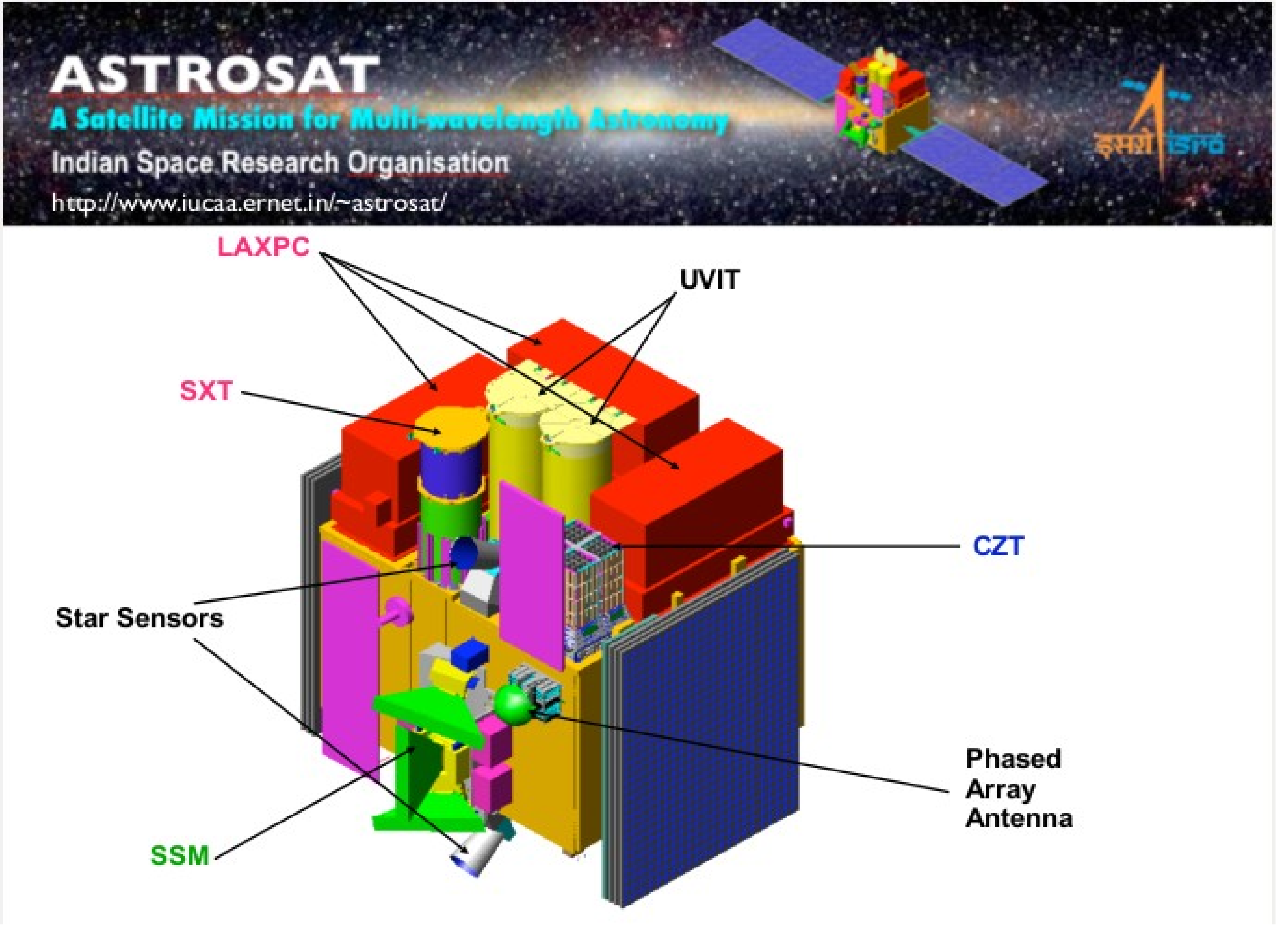
Software:

Observatory Software (OSW), Data Management System (DMS) Image and Object Catalogs (CAT).

- Event Services:
- Generation of Infrared Guide Star Catalog



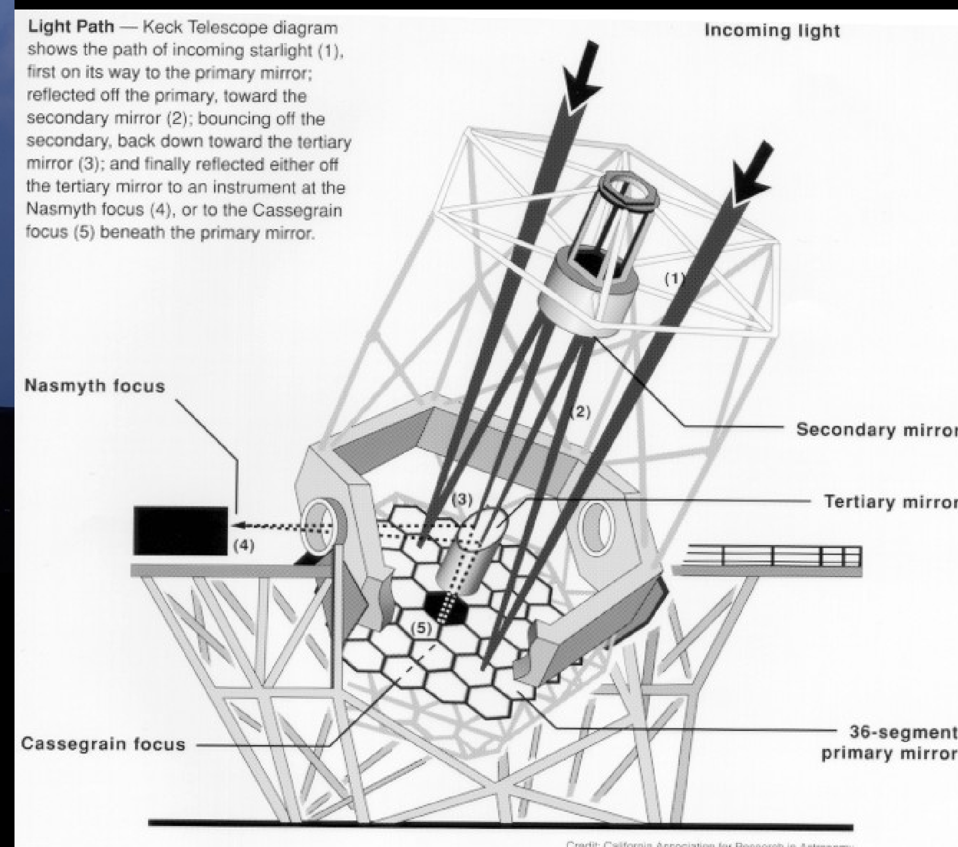
- Australia, Canada, China, Germany, India, Italy, New Zealand, South Africa, Sweden, The Netherlands and the United Kingdom.
- to be built in Australia and South Africa which would have a total collecting area of approximately one square kilometre.


ASTROSAT
A Satellite Mission for Multi-wavelength Astronomy
Indian Space Research Organisation
http://www.iucaa.ernet.in/~astrosat/
LAXPC
UVIT
SXT
CZT
Star Sensors
Phased Array Antenna
SSM

ASTROSAT SCIENCE INSTRUMENTS

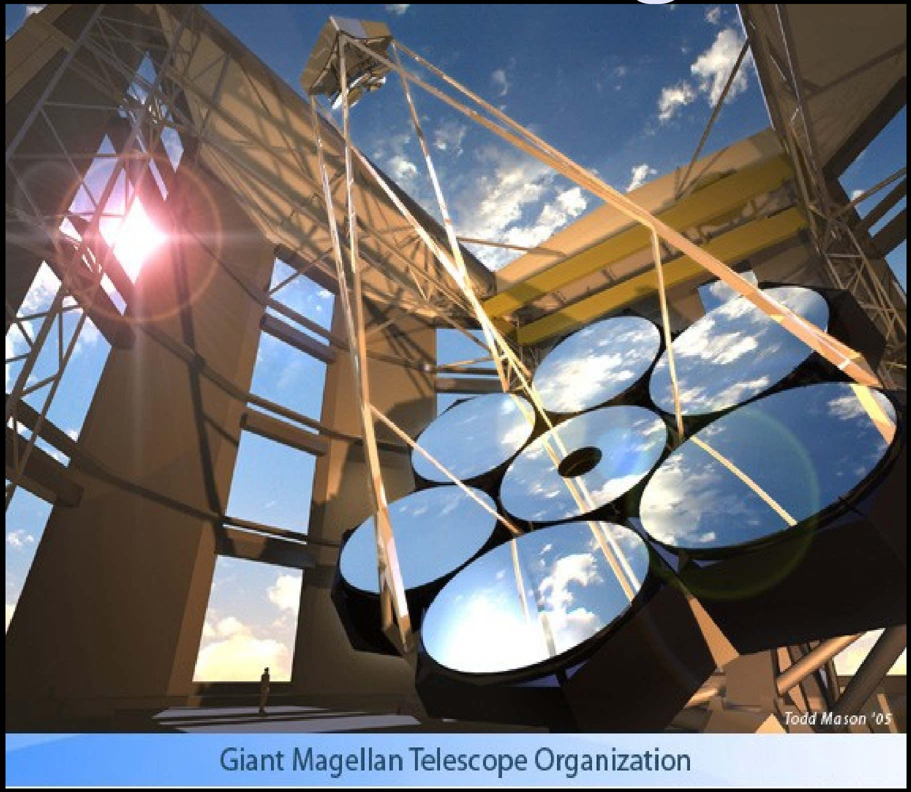
	Energy range	Description	Angular resolution	sensitivity
SXT	0.3 – 8 keV	Focussing X-ray mirror + CCD (39 shells) FOV=42'	3 – 4 arcmin	~0.01milliCrab (10,000 sec)
LAXPC	2 – 80 keV	Large proportional counters (3)	~5arcmin (scan mode)	0.1 milliCrab (1000 sec)
CZT-imager	10 – 150 keV	CZT array (hard X-ray imager)	8 arcmin	0.5 milliCrab (1000 sec)
SSM	2 – 10 keV	All sky monitor (3) on a boom	5 – 10 arcmin	50 milliCrab (300 sec)
UVIT	1300 – 6500 Ang	Twin RC telescopes – 40 cm each (NUV,VIS, FUV)	1.8 arc sec	21 magnitude (1800 sec)

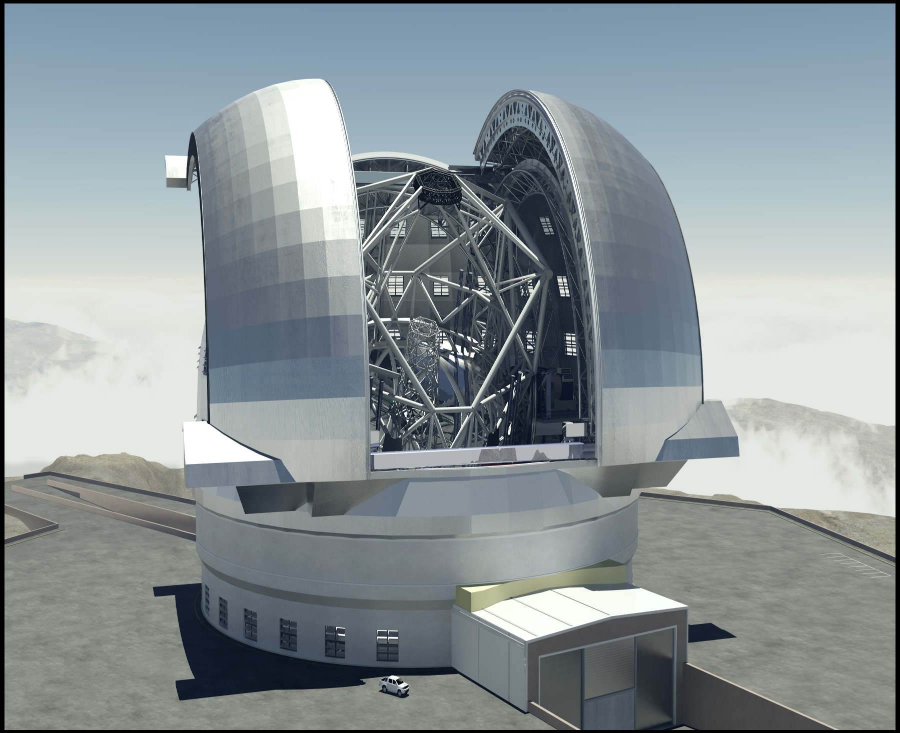
Keck (2X10m), 1996



Observatories at Mauna Kea

As good as it gets!

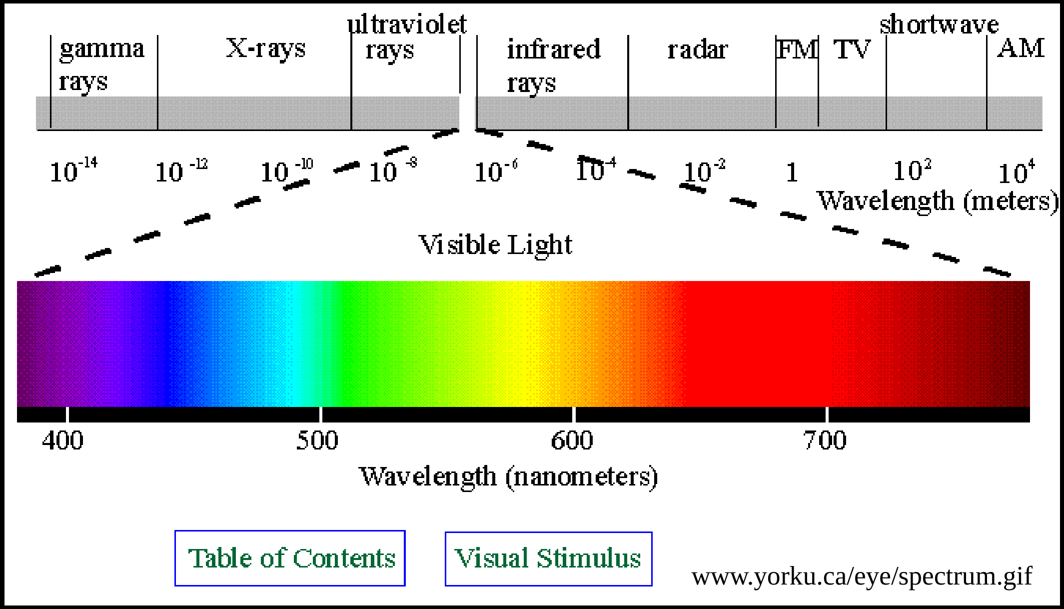




GMT

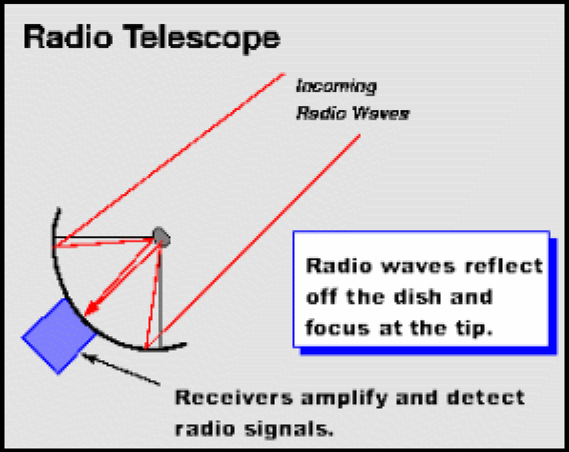
E-ELT

Not everything is visible…

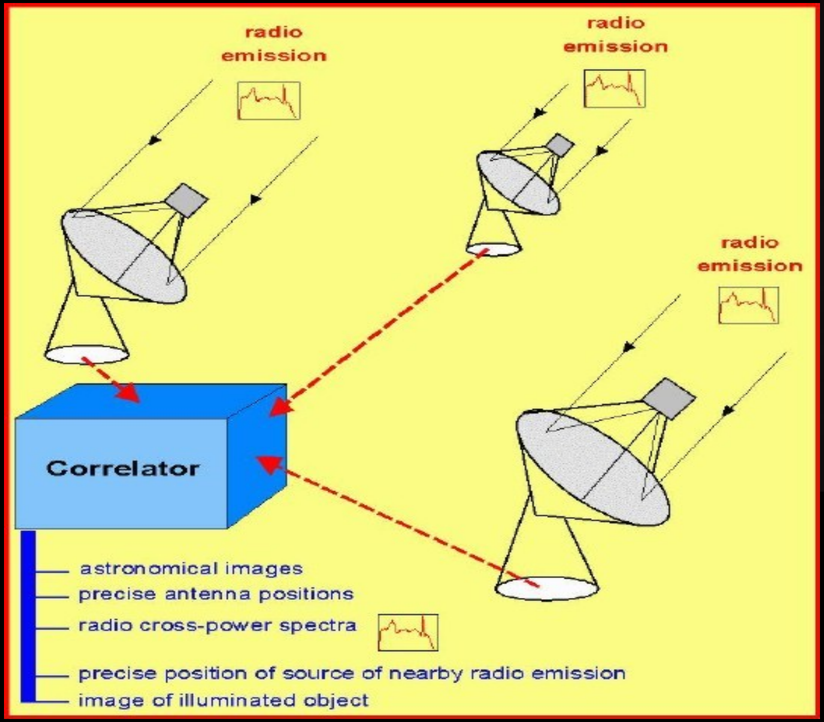


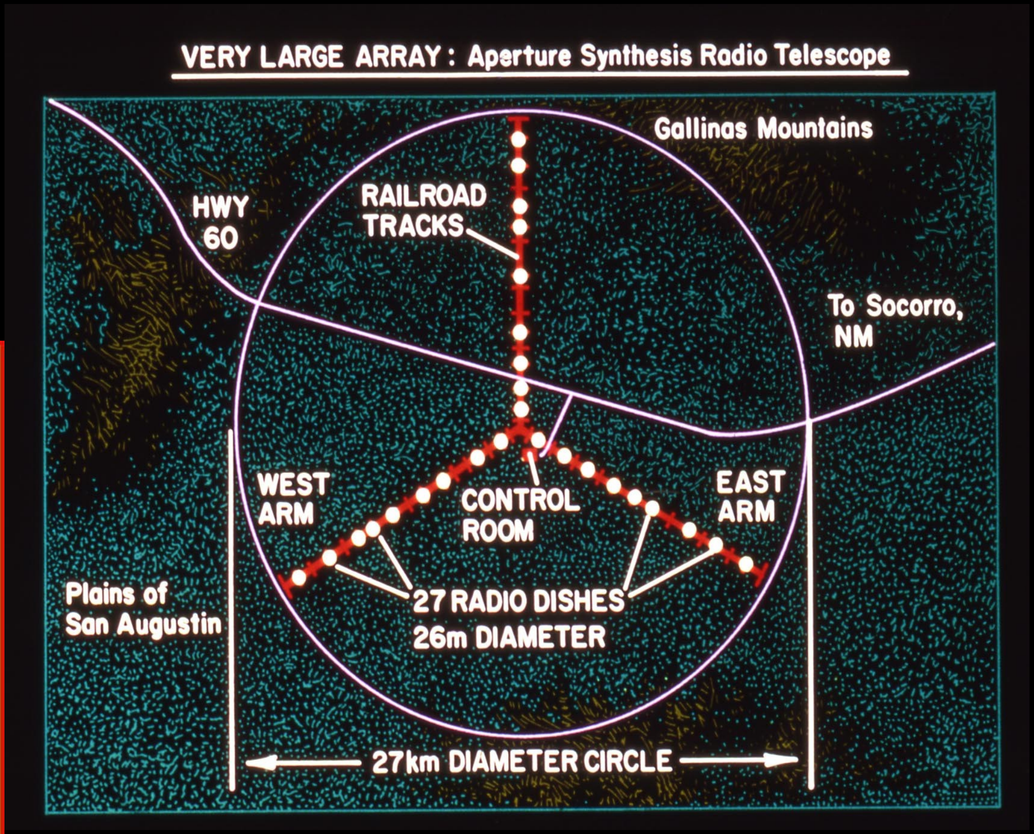
- Visible light is only a small fraction of the electromagnetic spectrum
- Different physical processes to study objects
- Radio , x-ray, gamma-ray telescopes explore the electromagnetic spectrum.

Radio Interferometry& Aperture Synthesis



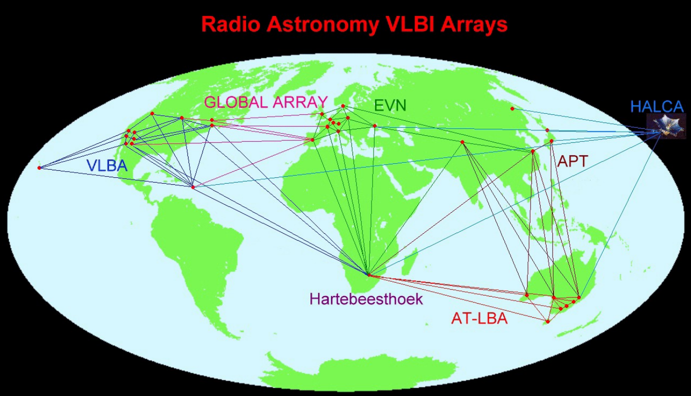
R=λ/D





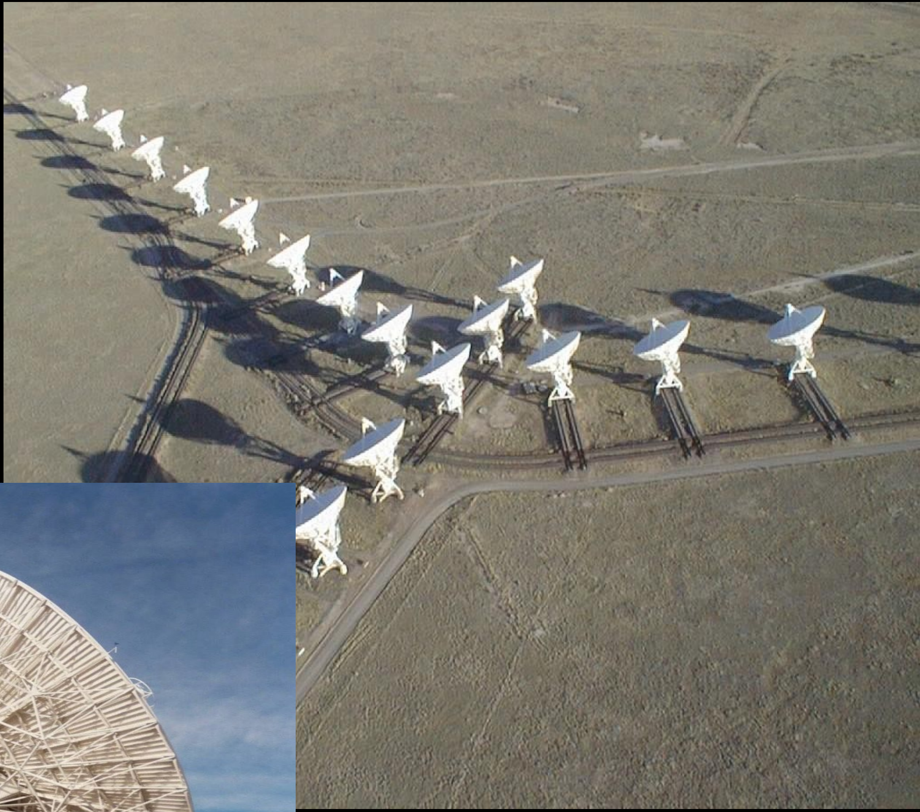
Radio Interferometry

The Very Large Array (VLA): 27 dishes are combined to simulate a large dish of 36 km in diameter.

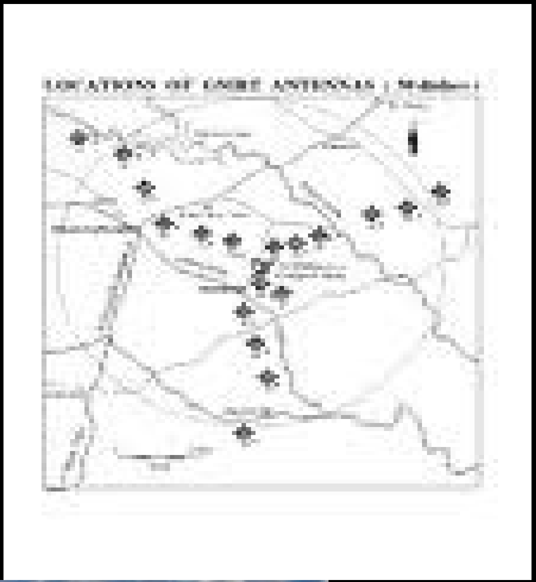


Even larger arrays consist of dishes spread out over the entire U.S. (VLBA = Very Long Baseline Array) or even the whole Earth (VLBI = Very Long Baseline Interferometry)!

VLA



GMRT

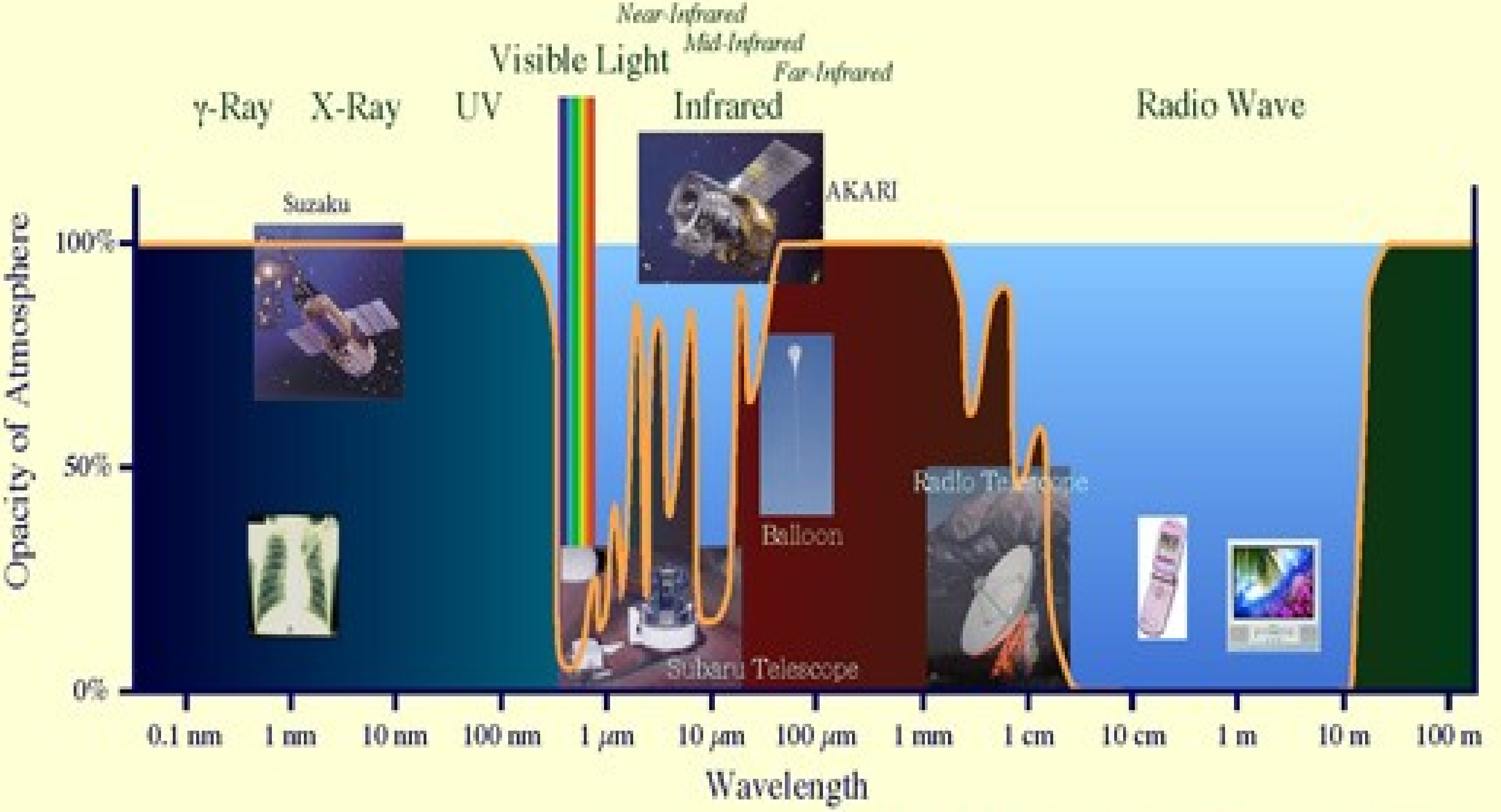


Arecibo (305m)

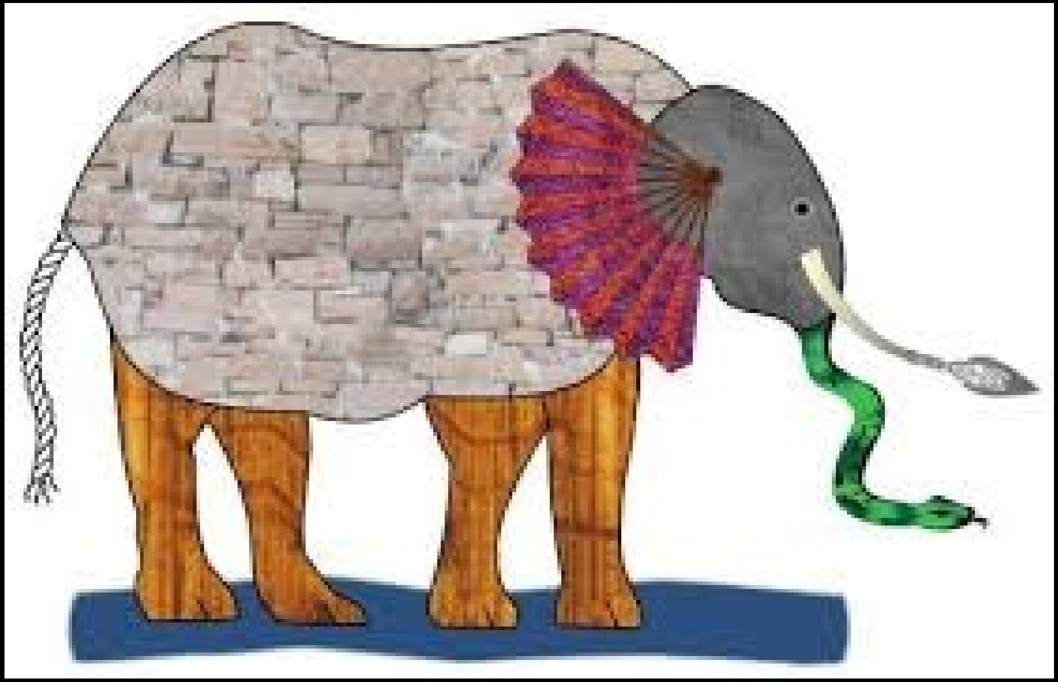
Five-hundred-meter Aperture Spherical Telescope

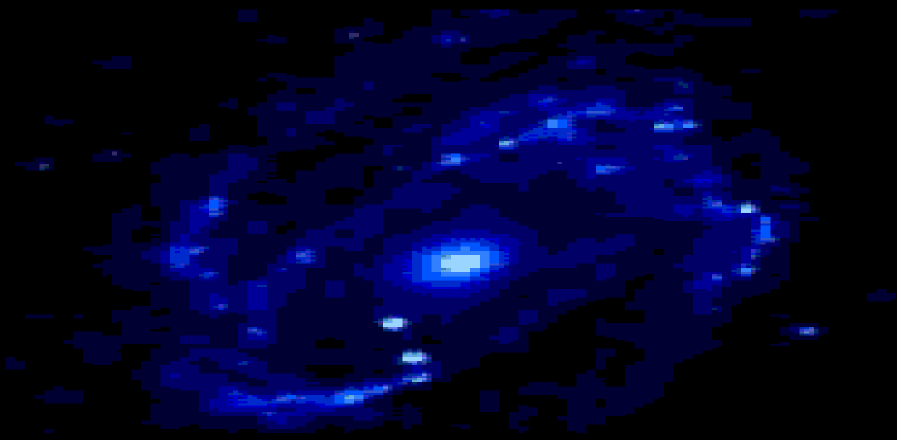
Very large baseline interferometry (VLBI).

Electromagnetic Wave and Astronomical Observations

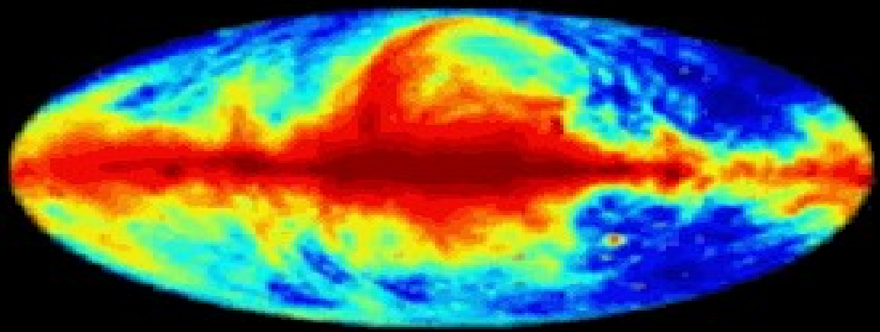


We are the blind men.....





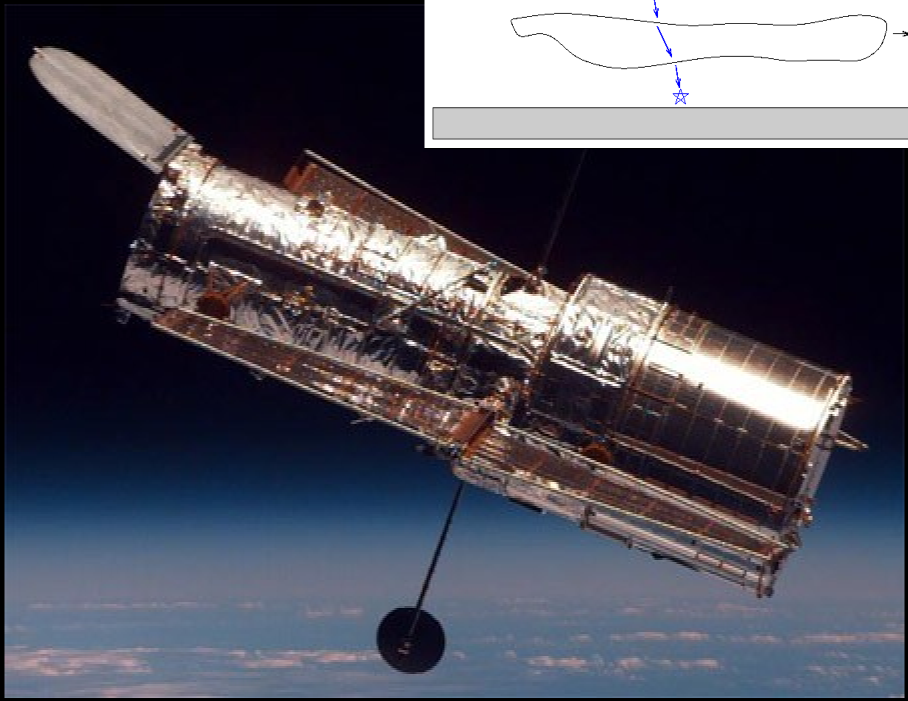
UV (blue) to IR (red)

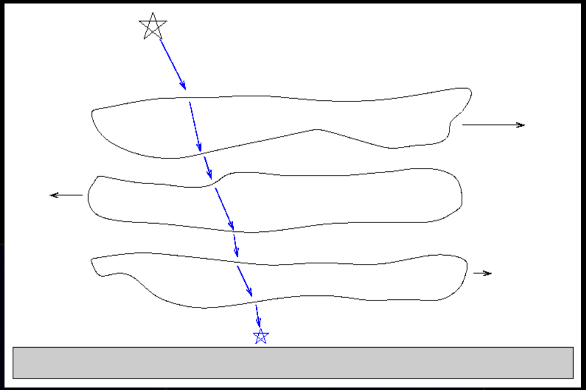


radio


Radio
Microwave
Infrared
UV
X-Ray
Gamma Ray
Radio
60,000 nm
600 K
Infrared
4,500 K
Optical
450-750 nm
6,000 K
Ultraviolet
400-200 nm
10,000 K
X-ray
100-10 nm
10,000,000 K
Multiwavelength Whirlpool Galaxy
COLD GAS: Radio waves reveal regions of gas cool enough for CO_2 molecules to exist.
COOL STARS: Infrared shows smaller cool red stars that make up most of the galaxy.
SOLAR STARS: Optical light comes from stars around the size of the Sun.
HOT STARS: Ultraviolet shows the larger hot blue stars that are less frequent in galaxies.
HOT GAS: X-rays are emitted from the hottest regions of gas where atoms are ionized.
COOL LOW ENERGY RADIATION
VISIBLE LIGHT
HOT HIGH ENERGY RADIATION

Space! Out of this world!





NASA Great Observatories program

Hubble Space Telescope(HST): visible,NIR, NUV

launched in 1990, servicing mission in 1997, last mission in 2009 to fix and extend its life

Compton Gamma Ray Observatory (CGRO): gamma rays, hard x-rays

launched in 1991, de-orbited in 2000 after failure of a gyroscope.

Chandra X-ray Observatory (CXO) : x-rays.

launched in 1999, excellent condition

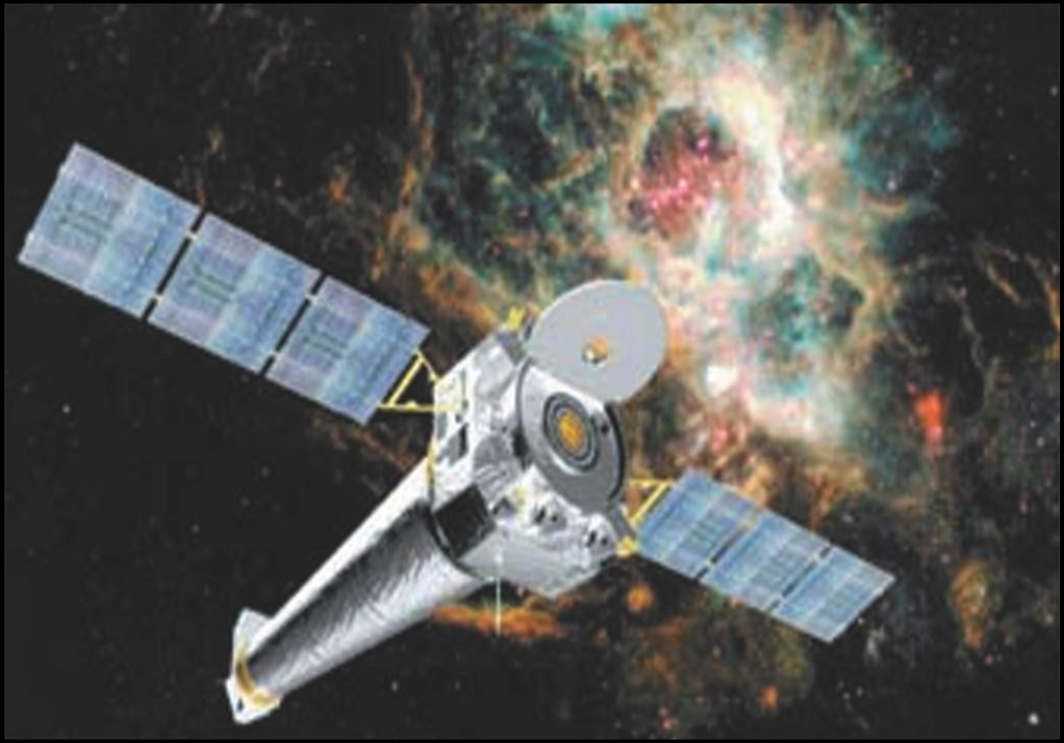
Spitzer Space Telescope (SST): IR

launched in 2003, Depletion of onboard liquid helium 2009

X-Ray Astronomy

X-rays are completely absorbed in the atmosphere.

X-ray astronomy has to be done from satellites.



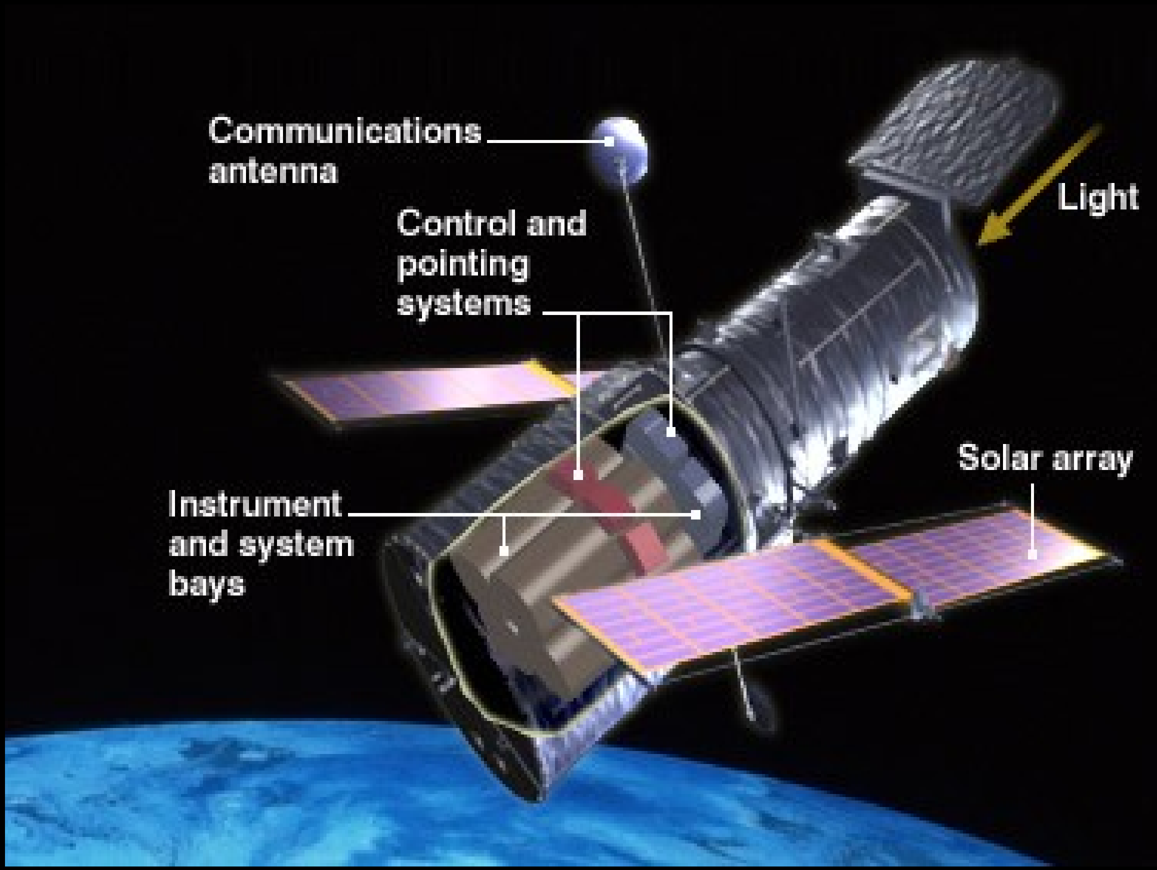
NASA's Chandra X-ray Observatory

Gamma-Ray Astronomy

Gamma-rays: most energetic electromagnetic radiation; traces the most violent processes in the Universe

The Compton Gamma-Ray Observatory

Hubble Space Telescope



Primary 2.4 meters

Instruments:

NICMOS
camera/spectrometer

ACS
optical camera

WFPC3

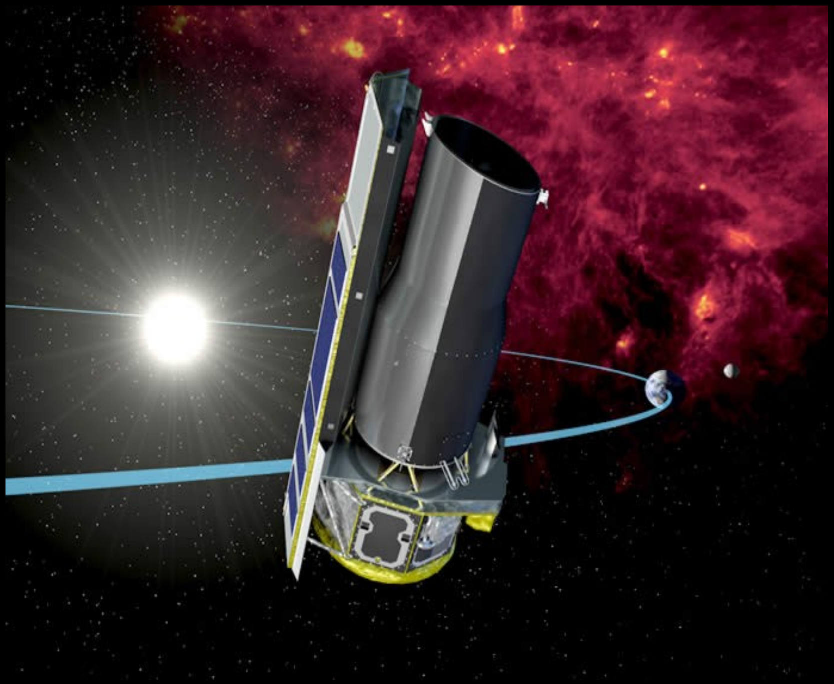
COS ultraviolet
spectrograph

STIS optical
spectrometer/camera

FGS fine guidance
instrument

A whole universe to explore....

Spitzer



Primary 0.85 m

Wavelengths

3.6 to 160 microns

Instruments:

IRAC

Infrared Array Camera

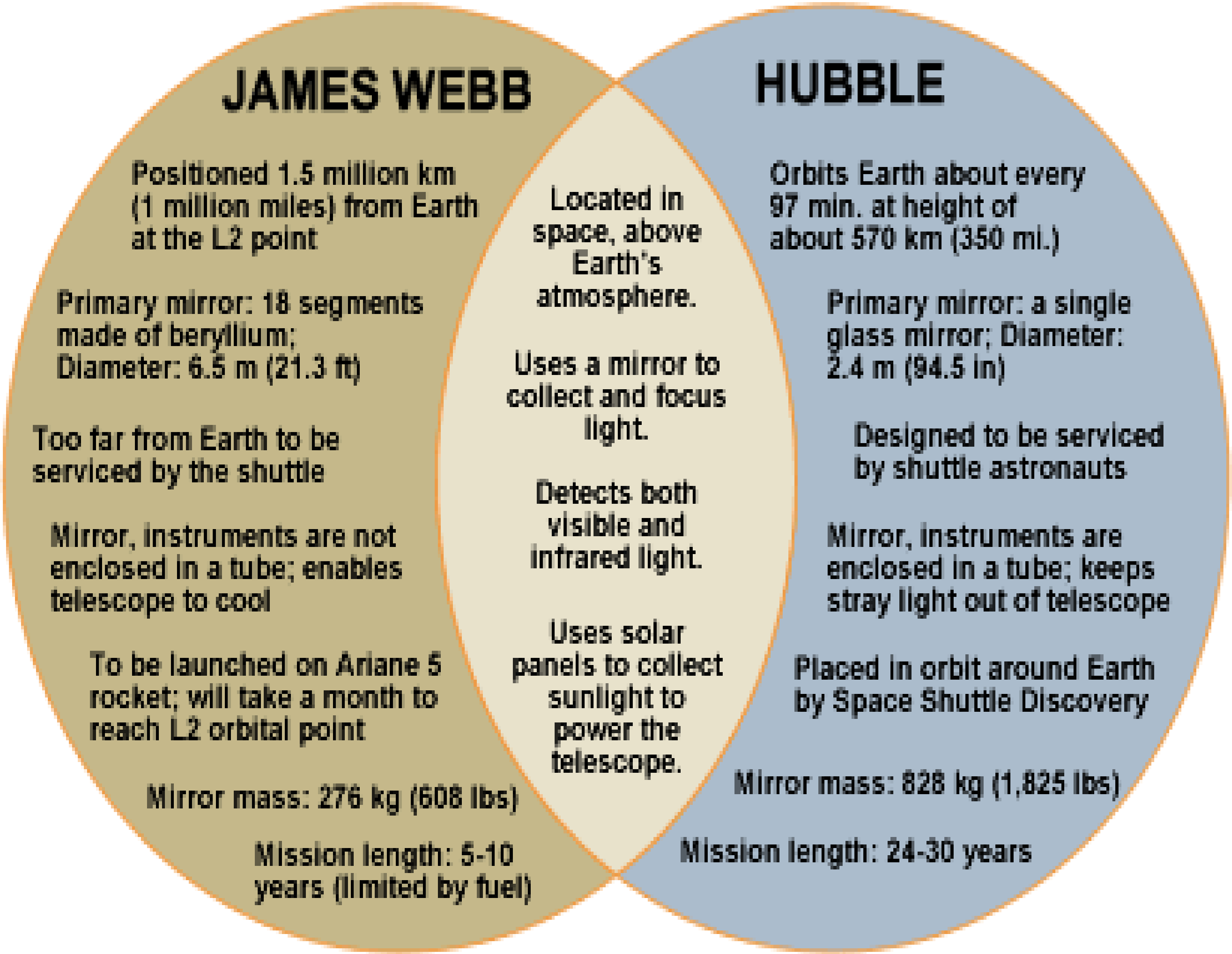
IRS

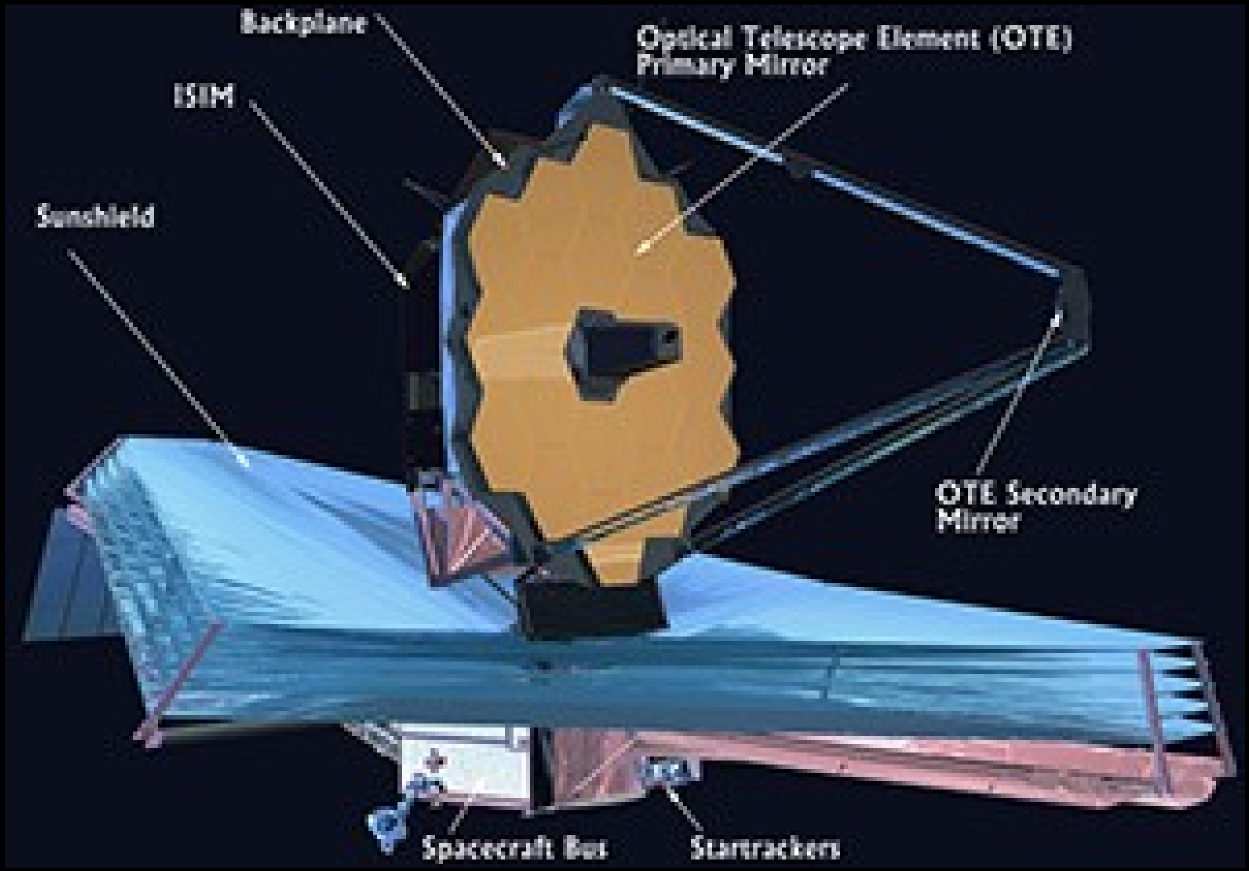
Infrared Spectrograph

MIPS

Multiband Imaging Photometer for Spitzer

Webb will have a 21 ft diameter primary mirror, which would give it about 7 times more collecting area than Hubble. Hubble's mirror is a much smaller 8 ft in diameter and its corresponding collecting area is 48.4 square feet. Webb will have significantly larger field of view than the NICMOS camera on Hubble (covering more than ~15 times the area) and significantly better spatial resolution than is available with the infrared Spitzer Space Telescope.


JAMES WEBB
HUBBLE
Positioned 1.5 million km (1 million miles) from Earth at the L2 point
Primary mirror: 18 segments made of beryllium; Diameter: 6.5 m (21.3 ft)
Too far from Earth to be serviced by the shuttle
Mirror, instruments are not enclosed in a tube; enables telescope to cool
To be launched on Ariane 5 rocket; will take a month to reach L2 orbital point
Mirror mass: 276 kg (608 lbs)
Mission length: 5-10 years (limited by fuel)
Located in space, above Earth's atmosphere.
Uses a mirror to collect and focus light.
Detects both visible and infrared light.
Uses solar panels to collect sunlight to power the telescope.
Orbits Earth about every 97 min. at height of about 570 km (350 mi.)
Primary mirror: a single glass mirror; Diameter: 2.4 m (94.5 in)
Designed to be serviced by shuttle astronauts
Mirror, instruments are enclosed in a tube; keeps stray light out of telescope
Placed in orbit around Earth by Space Shuttle Discovery
Mirror mass: 828 kg (1,825 lbs)
Mission length: 24-30 years



Near-Infrared Camera, University of Arizona

Near-Infrared Spectrograph, European Space Agency (ESA)

Mid-Infrared Instrument, Jet Propulsion Laboratory (JPL), ESA

Fine Guidance Sensor with Tunable Filter Module, Canadian Space Agency (CSA)

Orbit L2 (the Second Sun-Earth Lagrange Point), 1,500,000 km from Earth

Thank You!