

Particle Physics and Telescopes

November 18, 2002

- 1) Dark Matter
- 2) Particle
Physics
- 3) Telescopes

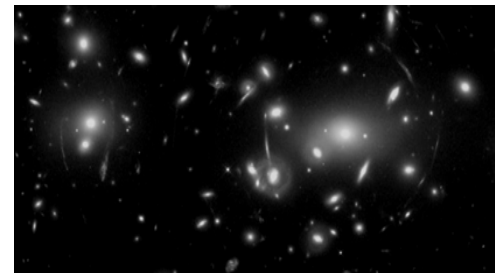


Announcements

- Final Exam will be held in Ruby Diamond Auditorium
 - NOTE THIS!!!
 - not UPL
 - Dec. 11, 2002 10am-noon
- Lenoid shower
 - tonight 4am-sunrise
 - the Earth will pass through the remnants of the tail of Comet Tempel-Tuttle
 - last chance - won't happen again for some time

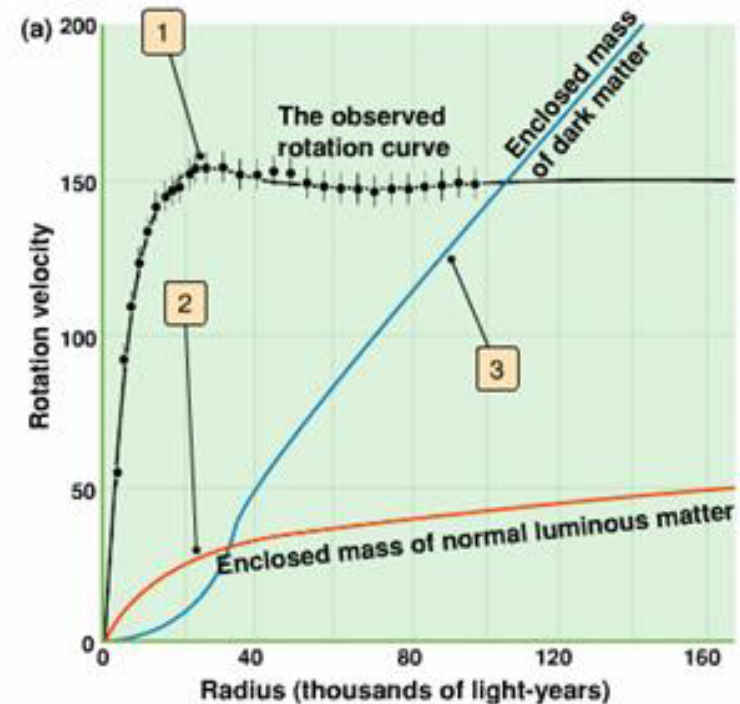
Review of Galaxies

- Messier objects
- Galaxies
 - spiral, elliptical, irregular
- Active Galactic Nuclei (AGNs)
- Spiral Galaxies
 - Disk
 - Arms
 - Bulge
 - Halo
- Globular clusters



Rotation Speeds of Galaxies

- Most of the visible material of a galaxy is near the center
 - material thins out as you move outward
- For spiral galaxies, this means stars farther out should be moving slower
- But we see them all moving with the same speed!
 - must have an explanation



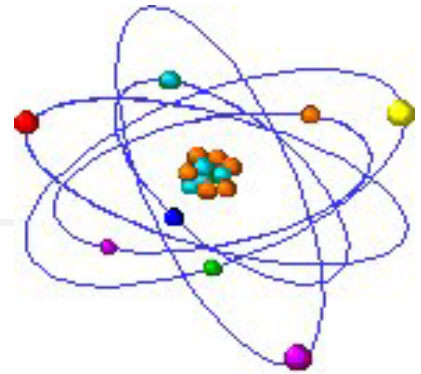
**Dark
Matter!**



What is Dark Matter?

- Dark matter is material we can't see
- We have various evidence the Universe has lots of matter we can't see
 - rotation speeds of galaxies
 - movement of global clusters around galaxies
 - more in the coming weeks
- Two primary theories
 - MACHOs - MAssive Compact Halo Objects
 - planets or brown dwarfs or low-mass black holes
 - unlikely, people are looking, have seen a few, but not enough
 - WIMPs - Weakly Interacting Massive Particles
 - new type of elementary particle

Building Blocks



- Materials are made of atoms and molecules
 - Molecules are made of atoms
- Atoms are made of electrons around a nucleus
- A nucleus is made of protons and neutrons

Particle physics tries to determine what are the building blocks of Nature and how they interact

How to Determine If A Particle Is Elementary

- Slam particles together VERY hard



- Determine if particles have structure
 - will behave differently
- Create new particles
- Most particle physics done at large laboratories with particle accelerators

Fermilab

Fermi National Accelerator Laboratory



- Slam protons into antiprotons
- World's highest energy accelerator
- Outside of Chicago

The D0 Experiment



D0 Ctrl Rm West Mon Jul 9 09:31:23 2001

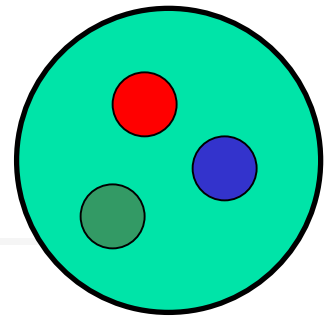


Real live data at

<http://www-d0.fnal.gov/>



Quarks



- Protons and neutrons are made of smaller particles - quarks
 - three quarks in each proton and neutron
- Six types of quarks
 - up, down, strange, charm, beauty, top
- Quarks can only be observed with partners
 - two or three together
 - no quarks in isolation

Table of Elementary Particles

- Most basic particles we know of
 - leptons
 - quarks
 - bosons

ELEMENTARY PARTICLES

Quarks	u up	c charm	t top	γ photon	g gluon	Z Z boson	W W boson	Force Carriers
	d down	s strange	b bottom					
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino					
	e electron	μ muon	τ tau					
Leptons								
I			II	III				
Three Generations of Matter								



More Particles

- There are a number of interesting theoretical ideas for new particles
 - supersymmetry, extra dimensions, string theory, leptoquarks, ...
- These particles must
 - be massive
 - rarely interact with normal matter
- If these were not true, we would have observed them already
- These could be dark matter candidates
 - WIMPS - Weakly Interacting Massive Particles

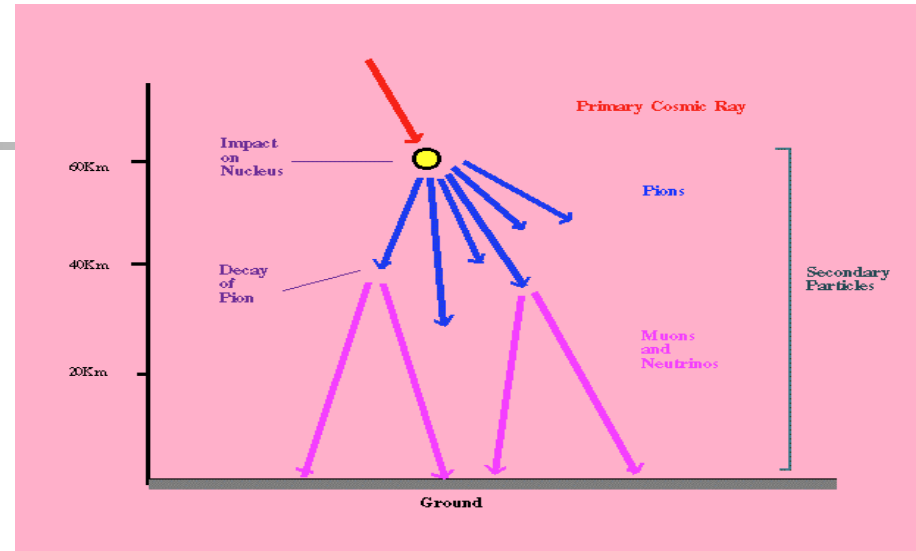


A Great Question

- The nature of dark matter is one of the great questions of astronomy
- Could have very important implications on our understanding of the Universe
 - something is out there which we do not understand
 - could radically change how we think about many things
- Pay attention to this issue in the coming decades...

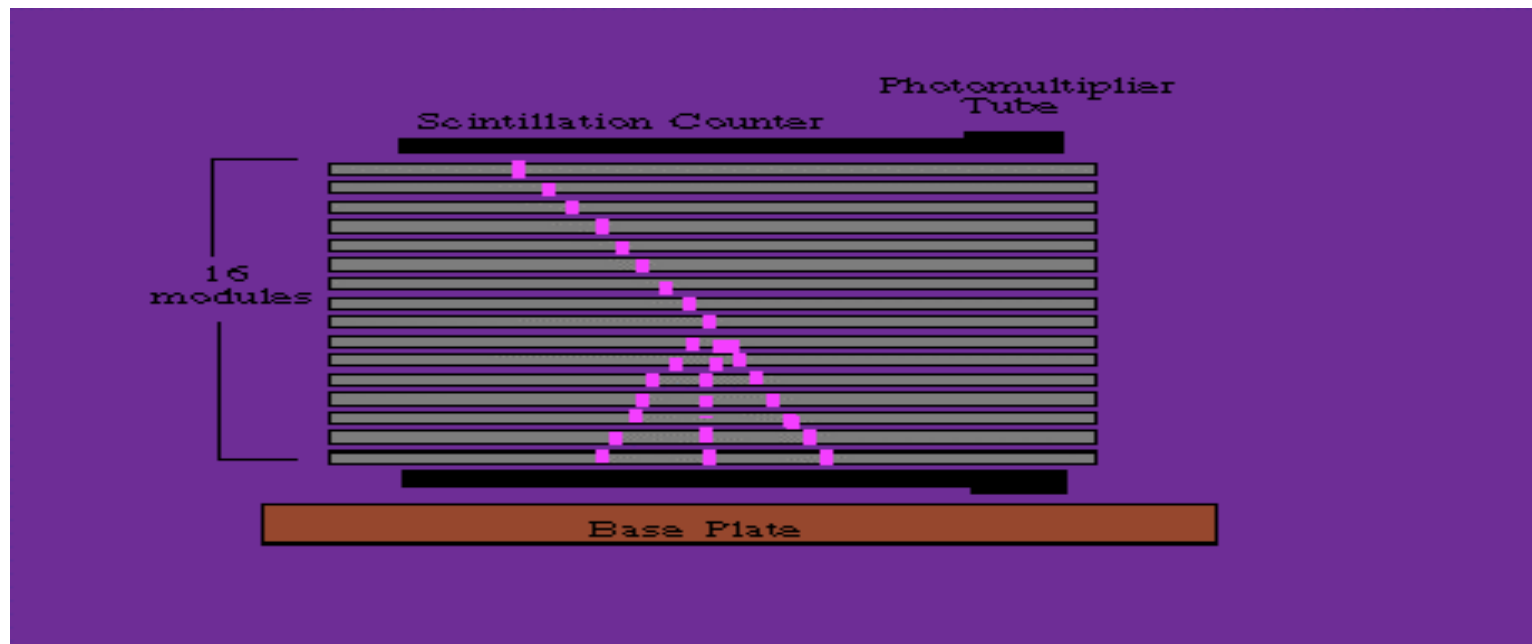
Cosmic Rays

- Charged particles are constantly hitting our atmosphere
 - most come from Sun
 - most energetic cosmic rays come from outside of our Galaxy
- These cosmic rays interact in our upper atmosphere
 - creates showers of particles
- Cosmic rays give us another view of the Universe



Cosmic Rays on Earth

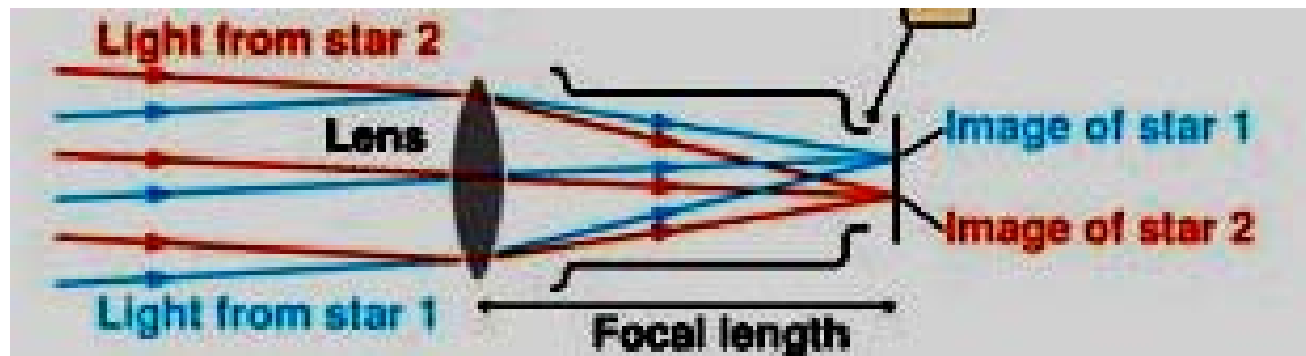
- The spark chamber is observing parts of cosmic ray showers
 - these particles are passing around us all the time



Intro to Telescopes

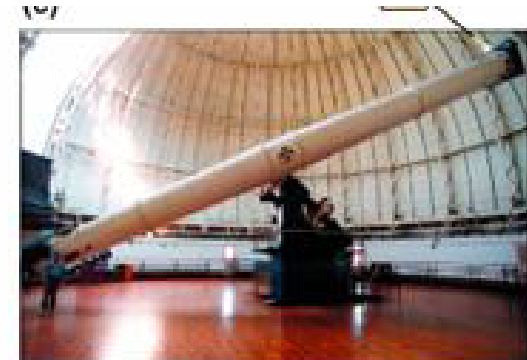
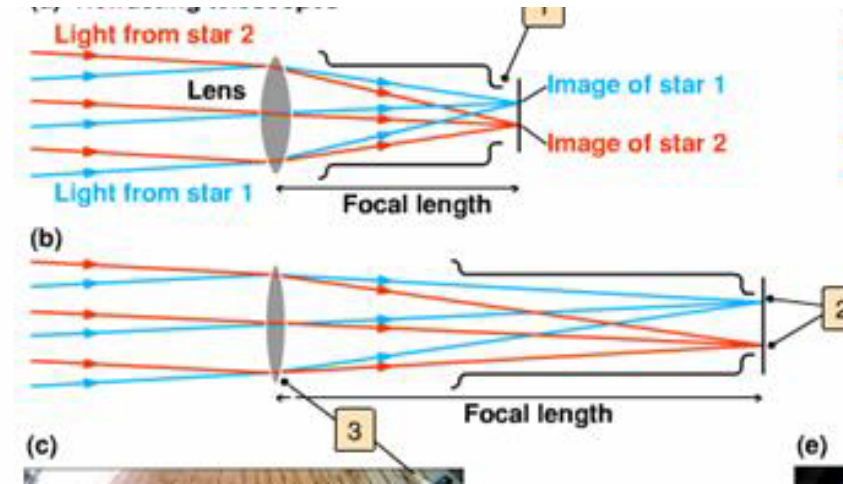
■ Telescopes:

- collect electromagnetic waves (light)
- magnify
- focus it on eye, camera, readout device

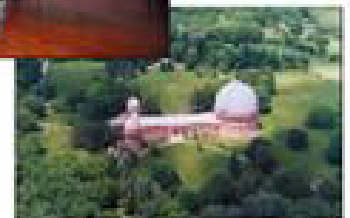


Attributes of Telescopes

- **Focal length**
 - determines separation between objects
- **Resolution**
 - determines smallest object visible
- **Light collection**
 - determines dimmest object visible
- **Which is most important?**



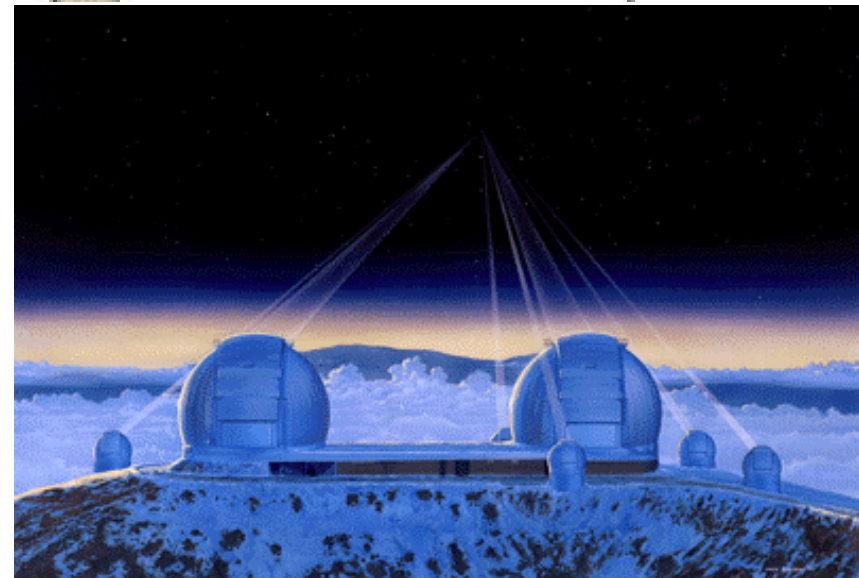
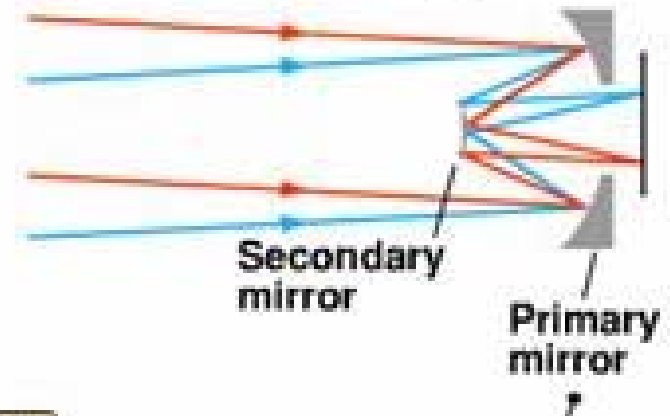
Yerkes: 1 meter diameter lens
World's largest refracting telescope



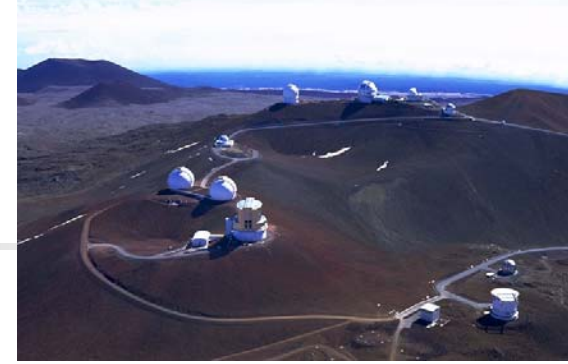
Reflecting Telescopes

- You can use a mirror to have a long focal length with a short physical size
- Keck Observatory
 - located on Mauna Kea, Hawaii
 - twin, 10-meter diameter reflecting telescopes

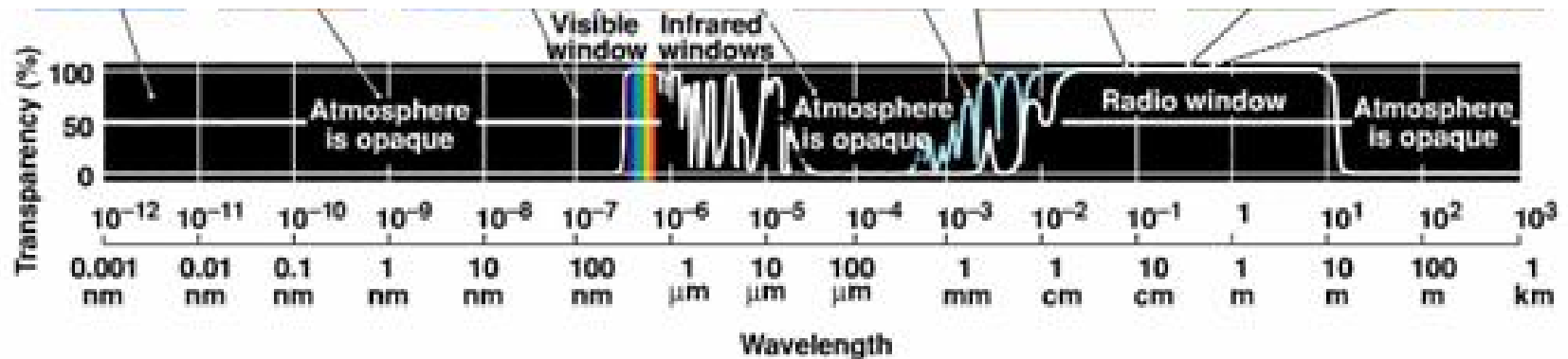
(d)–Reflecting telescopes



Atmospheric Effects



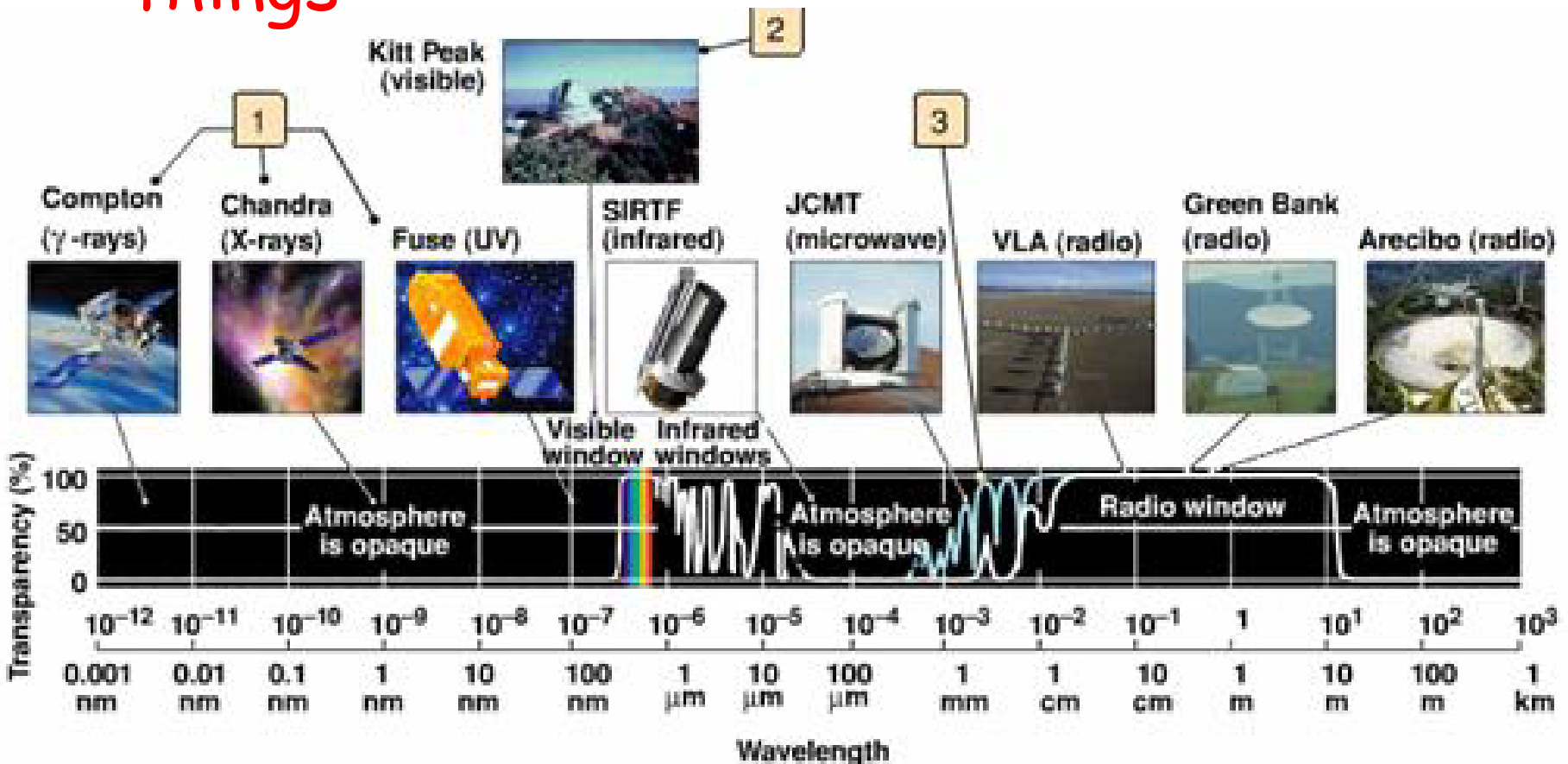
- Atmosphere blocks certain wavelengths



- Humidity affects light transmission
- Moving air influences light transmission
 - "twinkling" of stars
- It is best to put telescopes on mountains in stable weather

Different Kinds of Telescopes

- Different instruments do different things



***Would the Moon
Be a Good Place
to Put a
Telescope?***

Satellites

- Good for getting out of the Earth's atmosphere
 - can observe other wavelengths
- Hubble Telescope
 - 2.4 meter reflecting telescope in space
 - multiple readout instruments
- COBE satellite
 - high resolution microwave satellite

