

Hubble Telescope





Hubble Telescope

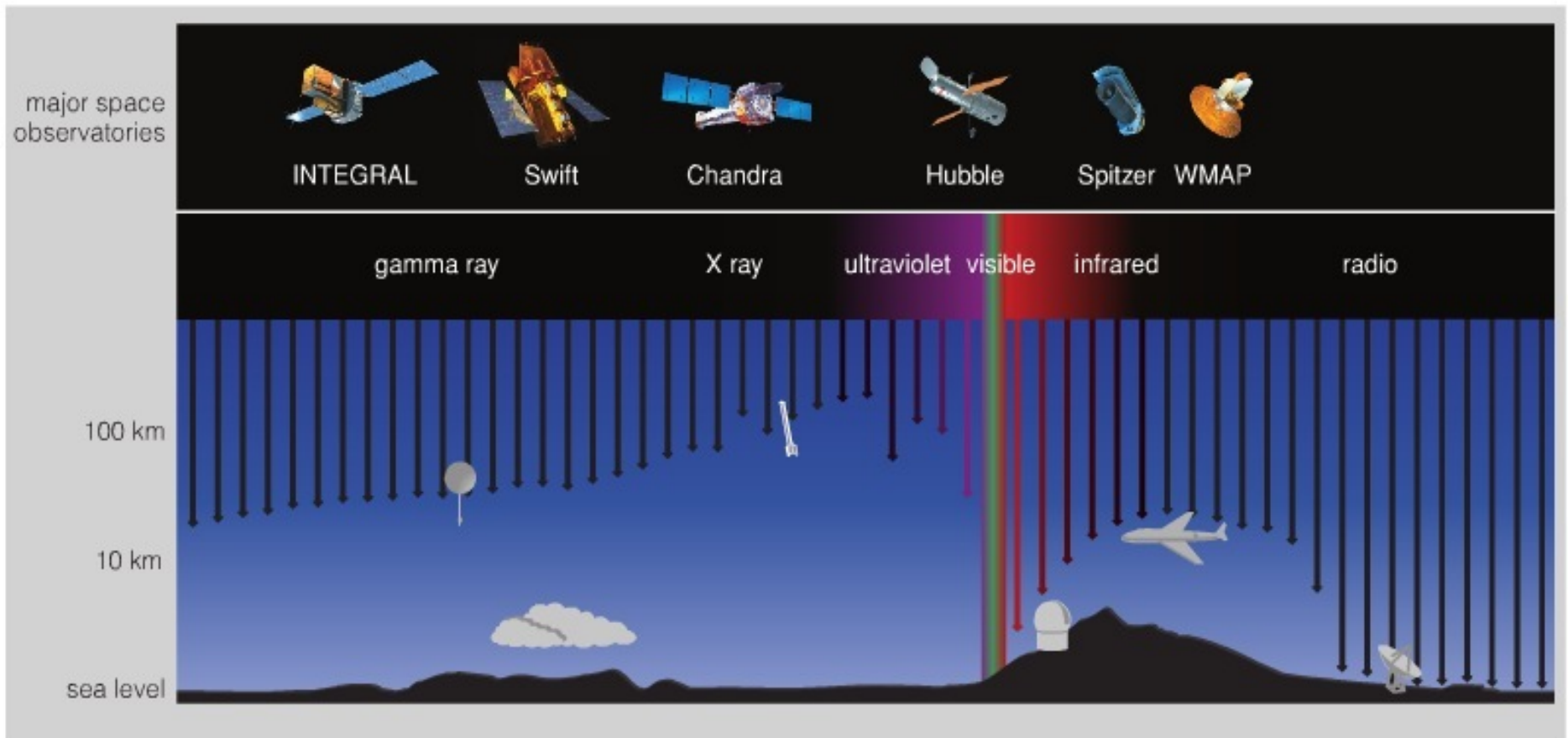
- ★ Looks at the Visual 400nm - 700nm
- ★ <http://hubblesite.org/>
- ★ First Proposed by Lyman Spitzer in 1946
 - ★ More push by Spitzer in 1962
 - ★ Funding agencies began in 1970
 - ★ Original launch date 1983
 - ★ Pushed back repeatedly
 - ★ Challenger blows up 1986
 - ★ Finally launched on Discovery, October 24th, 1990

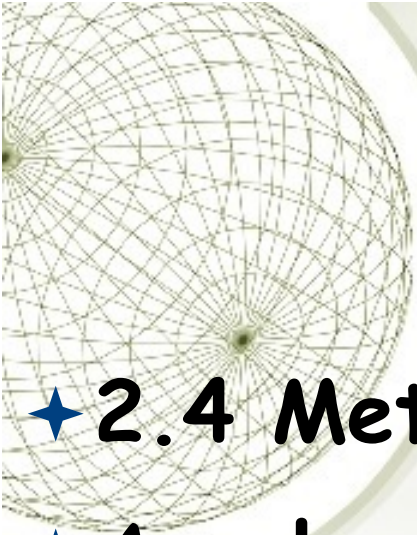


Why go to space?

- ★ Angular resolution - how fine a detail can you see?*
- ★ On earth, shifting turbulent atmosphere limits resolution to around 1 arcsecond which is the angular size of a half dollar 3.3 miles away*
- ★ Theoretical resolution of something like Keck is $\sim .01''$, in reality $.04'' - .4''$ (adaptive optics)*

- ★ Atmosphere messes up seeing
- ★ Atmosphere also blocks a lot of radiation (this is a good thing)





Enter Hubble

- ★ **2.4 Meter Diameter ~ 8 ft across**
- ★ **Angular Resolution is .05" As good as Keck but 4 times smaller and no tricky adaptive optics**



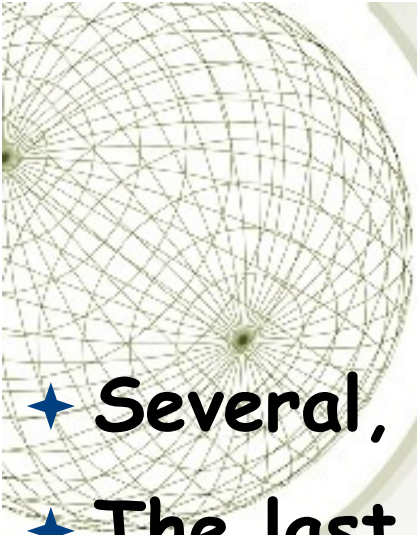
Hubble

- ★ Low Earth Orbit - 347 miles
- ★ Orbits at ~ 17000 miles per hour
- ★ 25000 lbs, about the dimensions of a bus
- ★ Uses gyros to stabilize and point
- ★ Been going for 21 + years
- ★ Primary Mission - Pin Down the Hubble Constant
(how fast is the universe expanding, find distance to cepheid variables)
 - ★ Secondary Mission - explore space nearby

Initial Problems

- ★ Initial mirror polished to an accuracy of 10 nanometers (generally polished to 1/10th wavelength but Hubble was to be used for NUV as well)
- ★ Edges were off by about 2.2 microns - serious image problems
 - ✦ Spherical Aberration - light doesn't come to a focus
- ★ Corrected by COSTAR in first servicing mission





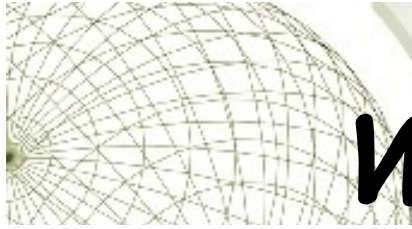
Servicing Missions

- ★ **Several, go to Wikipedia for details**
- ★ **The last one was a god send for astronomy**
 - ★ **Installed Cosmic Origins Spectrograph**
 - ★ **Installed Wide Field Planetary Camera 3**
 - ★ **Replaced guidance units**
 - ★ **Replaced 6 125 lb batteries that were 13 years past their expected service life**
 - ★ **Repaired the Advanced Camera For Surveys**
 - ★ **Repaired The Space Telescope Imaging Spectrograph**

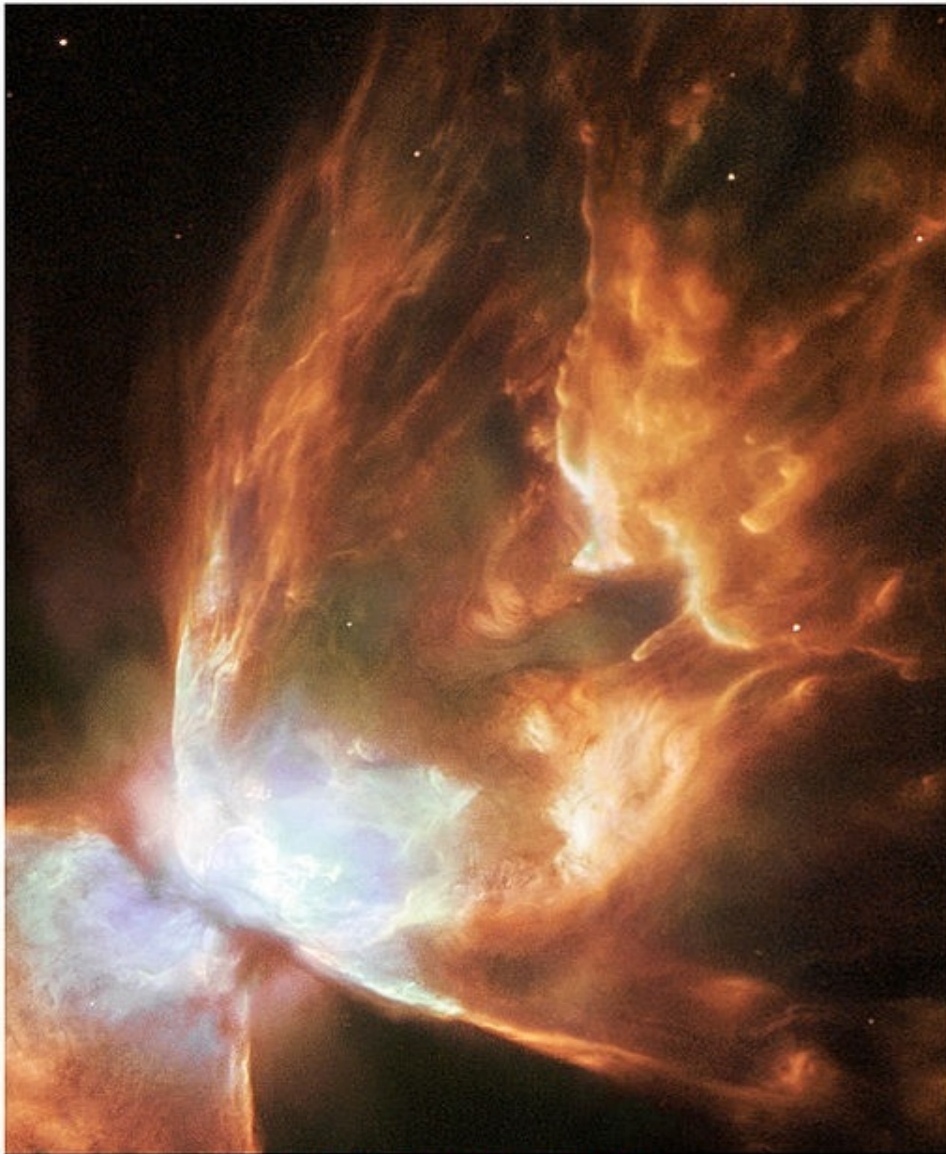


COS

- ★ Designed by Jim Green at CU
- ★ Ultraviolet Spectrograph
- ★ http://en.wikipedia.org/wiki/Cosmic_Origins_Spectrograph
- ★ <http://cos.colorado.edu/>
- ★ This is the type of device that would make a good paper to write about, especially if you explain what it would be looking at and how it advances science



WFC3 200nm-1700nm



Hubble WFC2 image of Bug Nebula



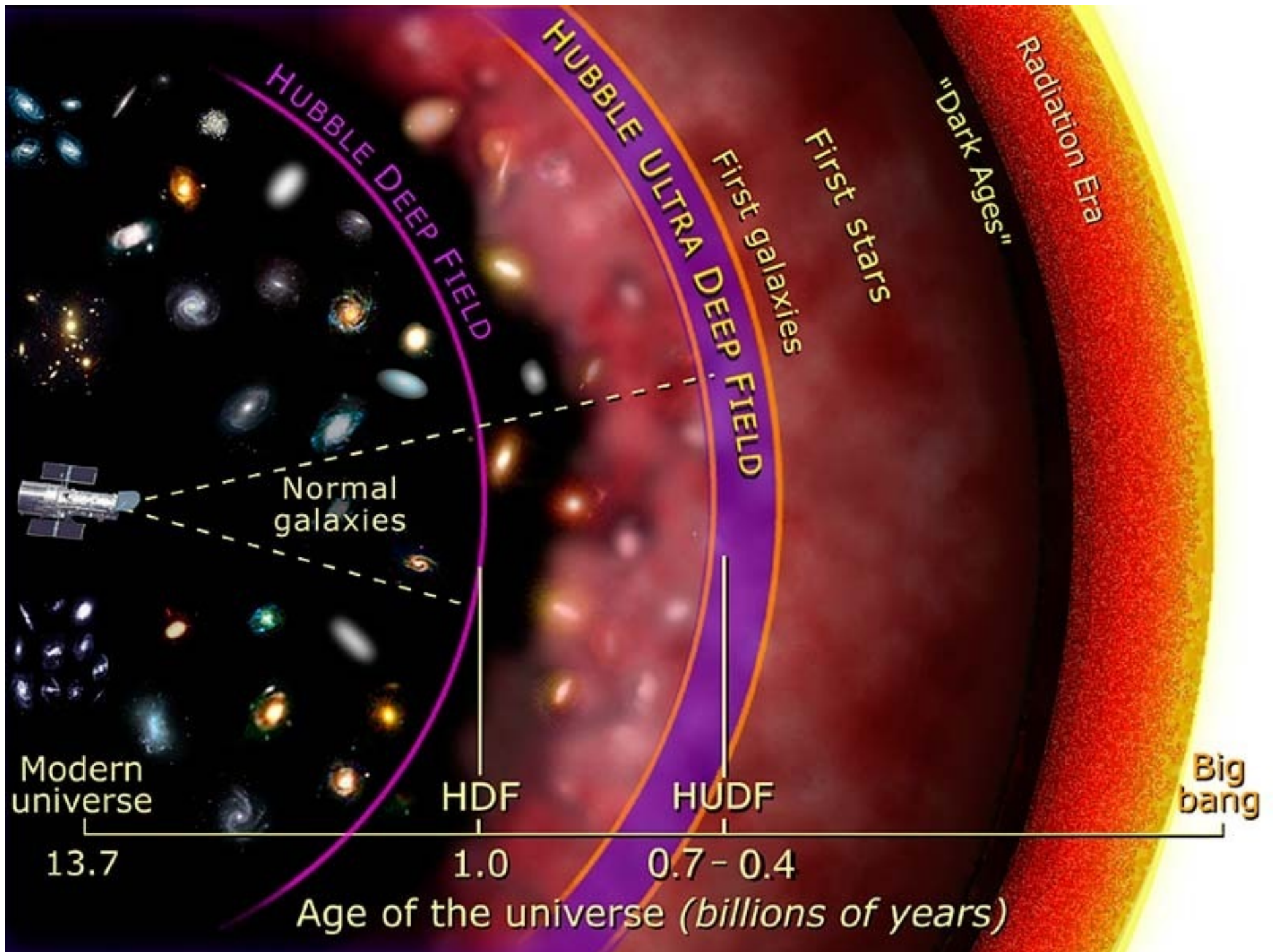
Hubble WFC3 image of Bug Nebula



ACS - more optimized for Visible

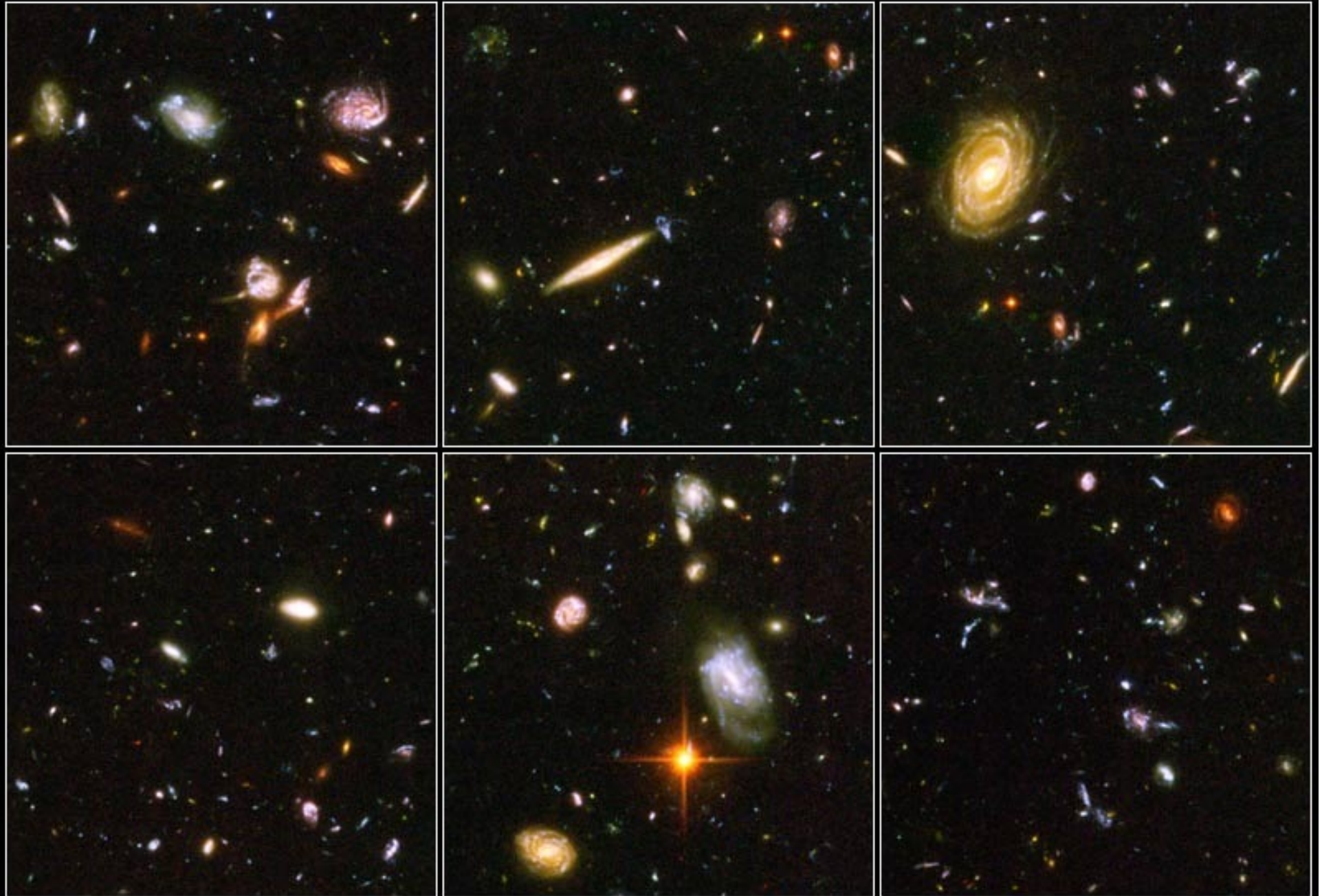
- ★ **Hubble ultra deep field - 1,000,000 seconds, 192 orbits**
- ★ **Deepest image ever, looked back 13 billion years**

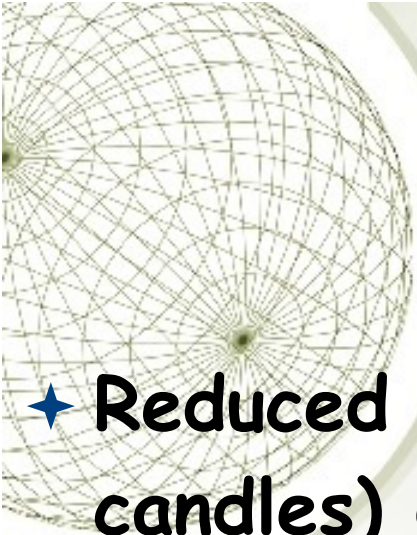




Hubble Ultra Deep Field Details

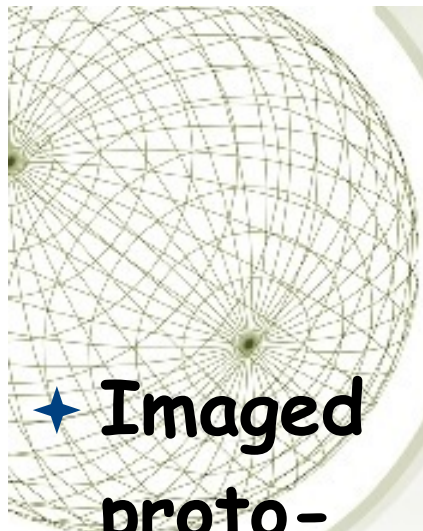
HST ■ ACS






Primary Results

- ★ Reduced errors in cepheid variable (standard candles) distances from 50% to 10% giving us a Hubble Constant of 72 (Km/s)/Mpc $1/H \sim$ age of universe
- ★ Found type 1a supernovae light curves suggested dark energy - new and strange fate for the universe
 - ★ Type 1a are standard candles also, more on this later
- ★ Helped show black holes are in galaxy cores



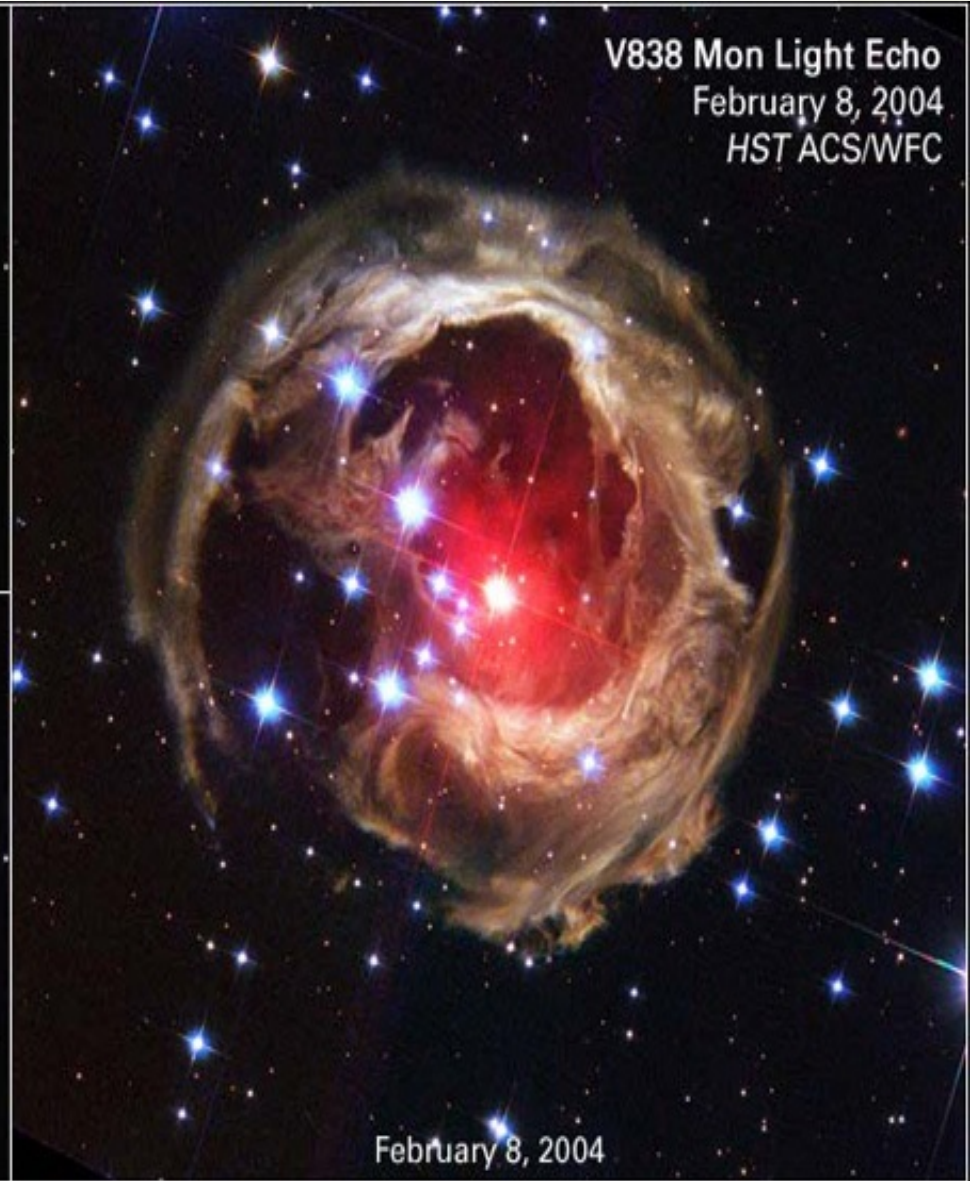
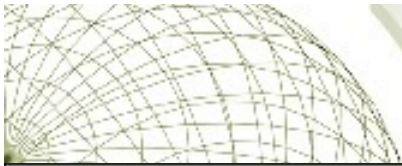
- ★ **Imaged proto-planetary disks (new solar systems)**
- ★ **Provided evidence of exoplanets**

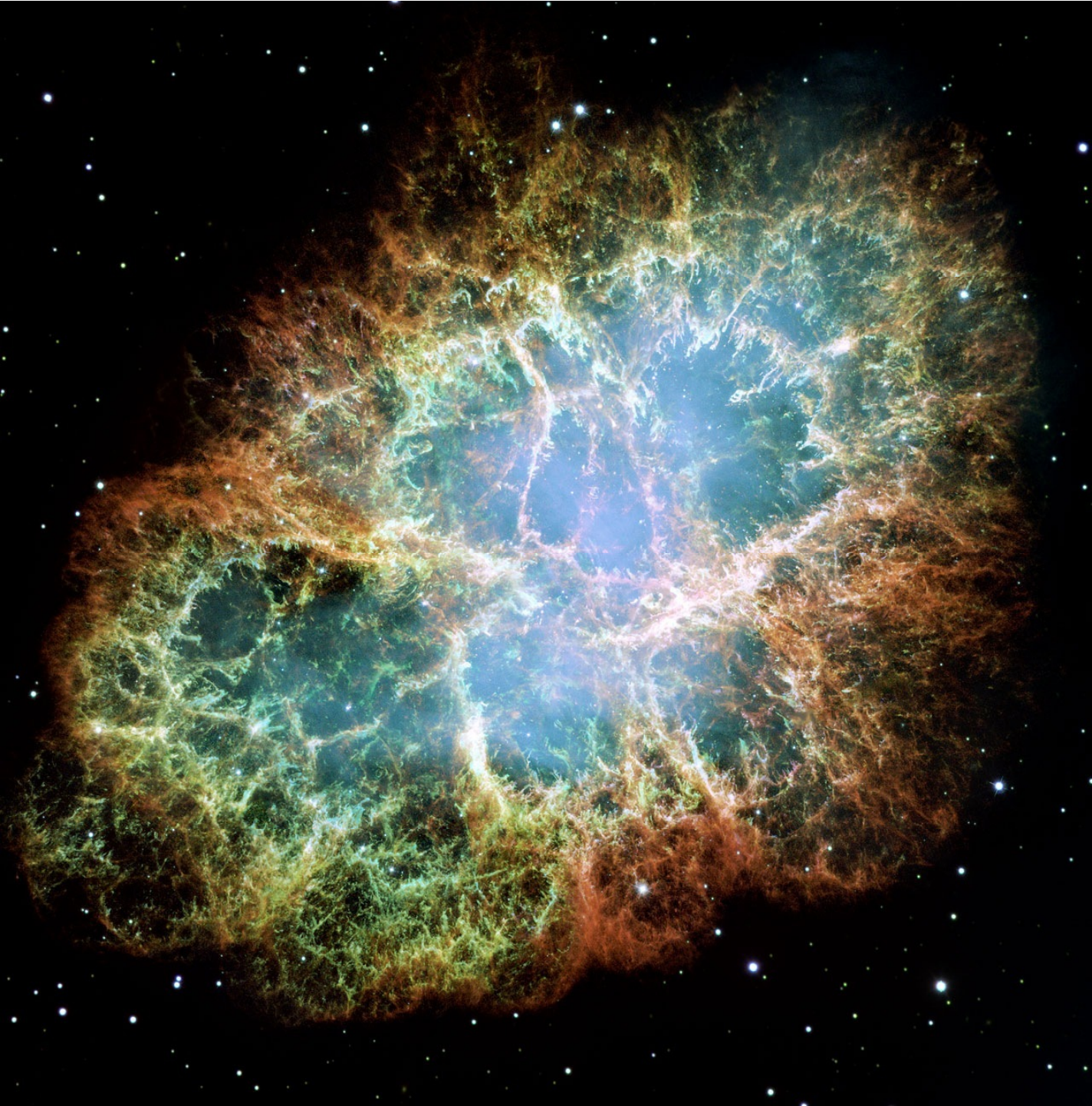


A decorative wireframe sphere is positioned in the upper left corner of the slide. It consists of a grid of lines forming a sphere, with a central point from which lines radiate outwards.

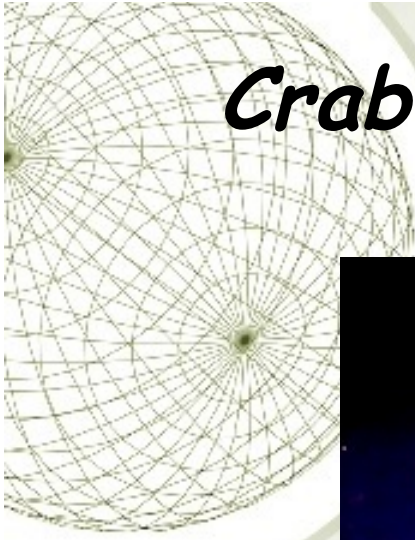
Random Pictures

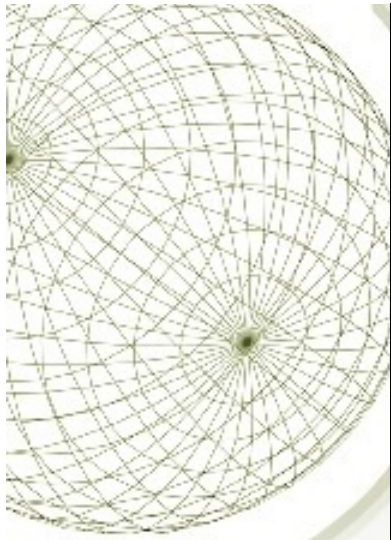
- ★ **V838 Monoceros - burping red giant**
- ★ **Crab Nebula - pulsar left after supernova in 1054**
- ★ **Cats Eye Nebula - Planetary Nebula**
- ★ **Whirlpool Galaxy**
- ★ **Sombrero Galaxy**
- ★ **Eagle Nebula**
- ★ **Supernova 1987a**





*Crab Nebula - 1054 AD supernovae
witnessed by the Chinese*





Cat's Eye Nebula • NGC 6543

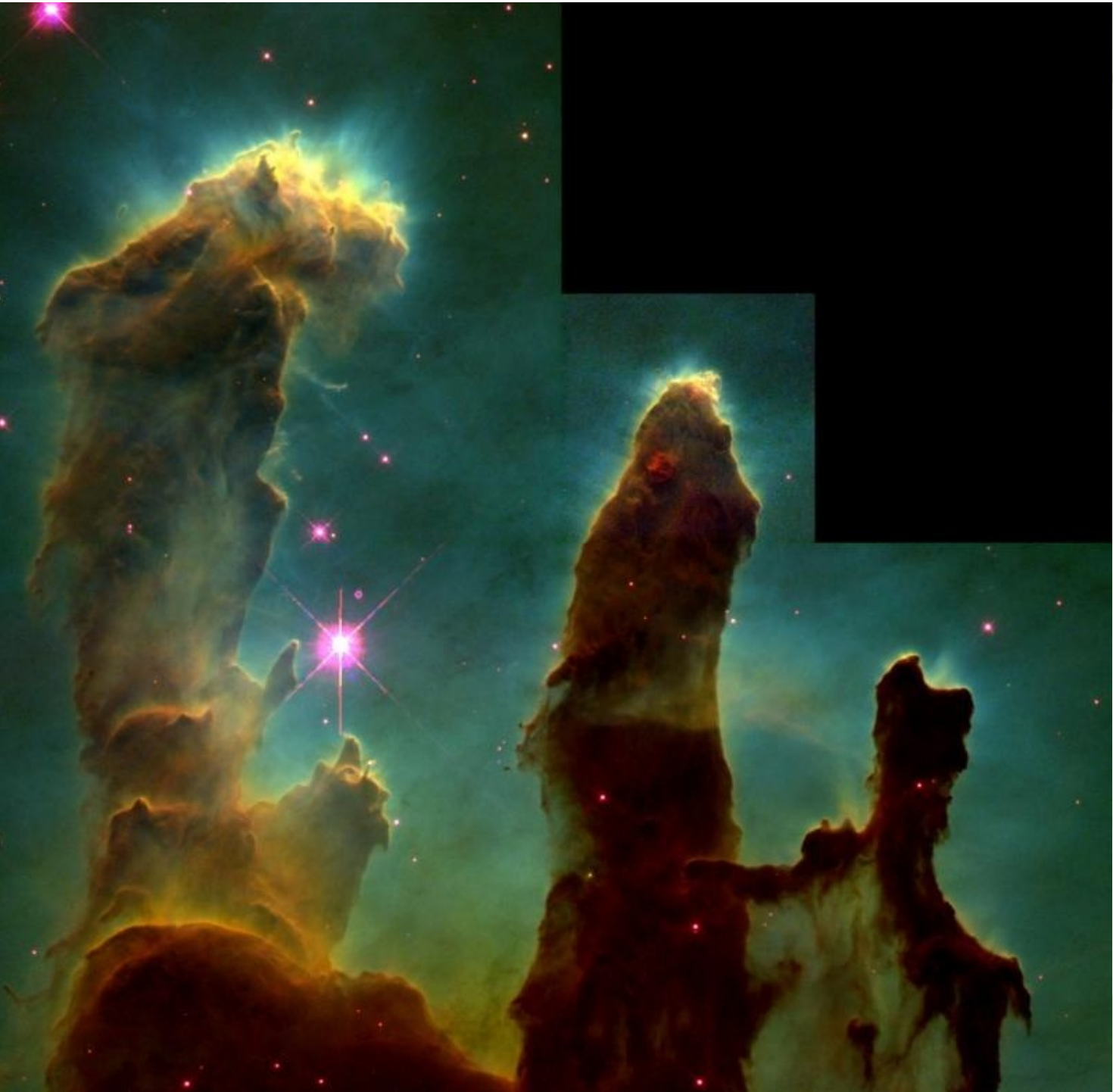


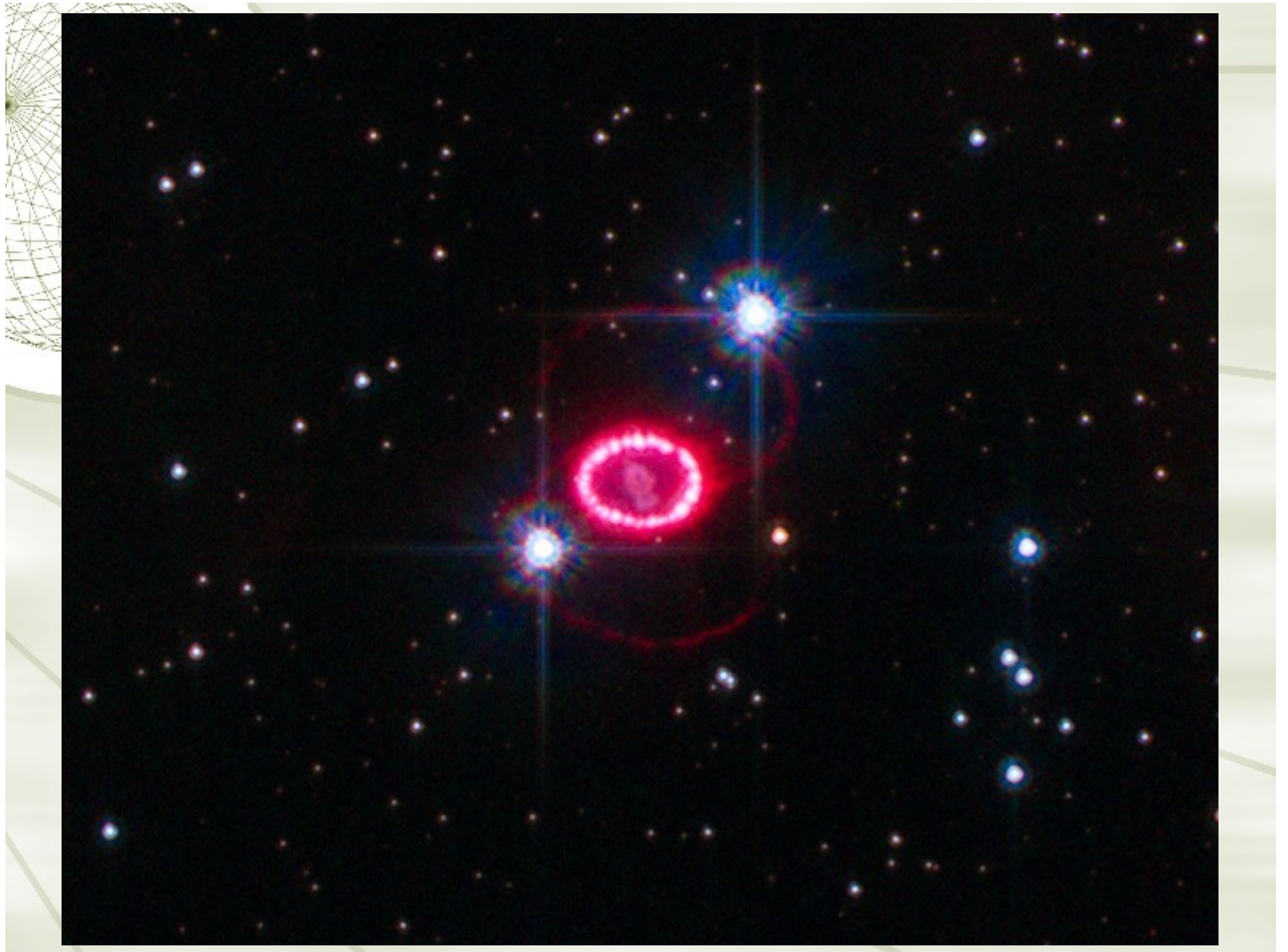
Hubble
Heritage

NASA, ESA, HEIC and The Hubble Heritage Team (STScI/AURA)
Hubble Space Telescope ACS • STScI-PRC04-27









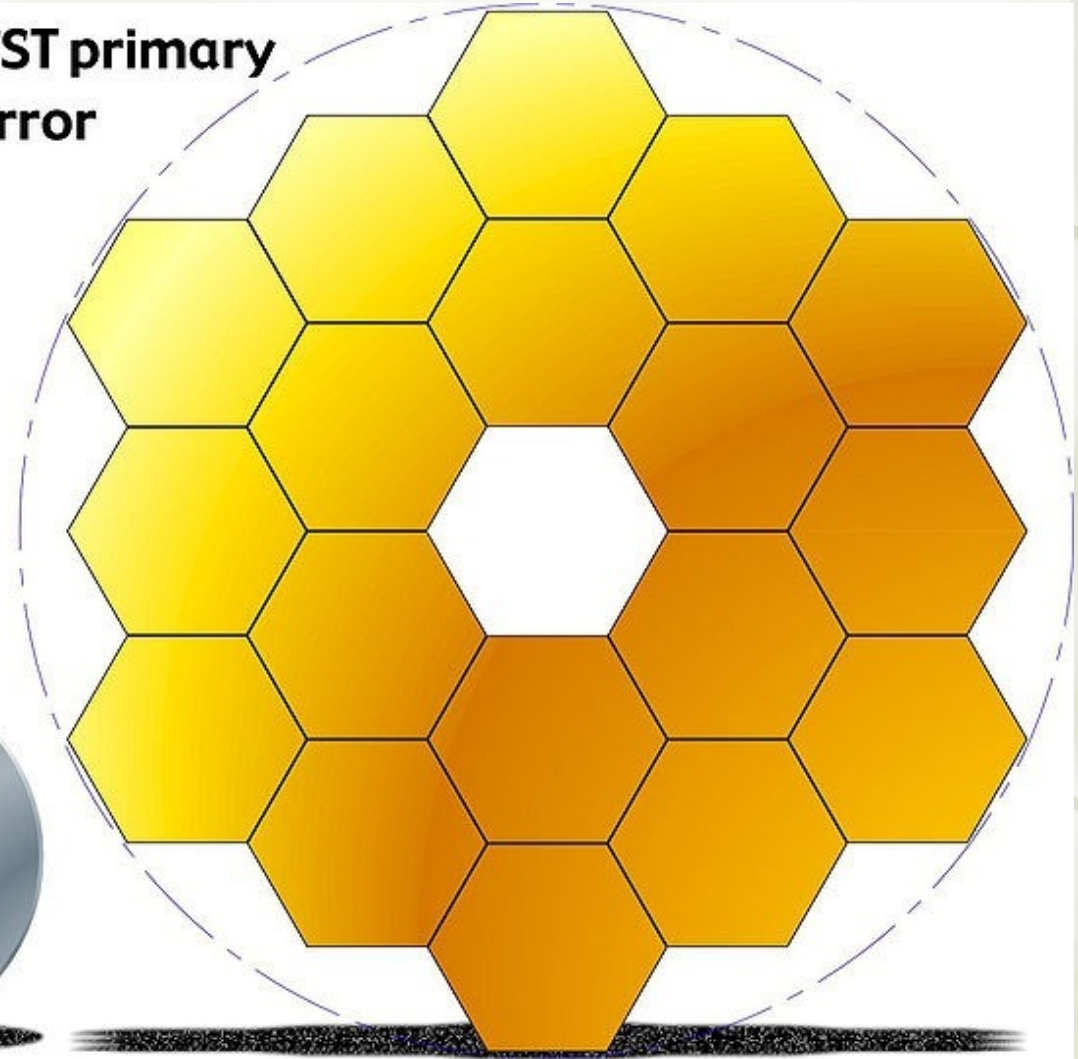


My two cents

- ★ We need to continue to fund these types of things
- ★ Useful, everyday science does come out of this but
- ★ On a deeper level this advances us as a civilization in the same way that the renaissance did or great music or literature does
- ★ Scientists need to make the connection to the public to make people care

Hubble's Successor James Webb

JWST primary mirror



Hubble primary mirror

