The Chandra X-Ray Observatory: Great Science With a Great Observatory

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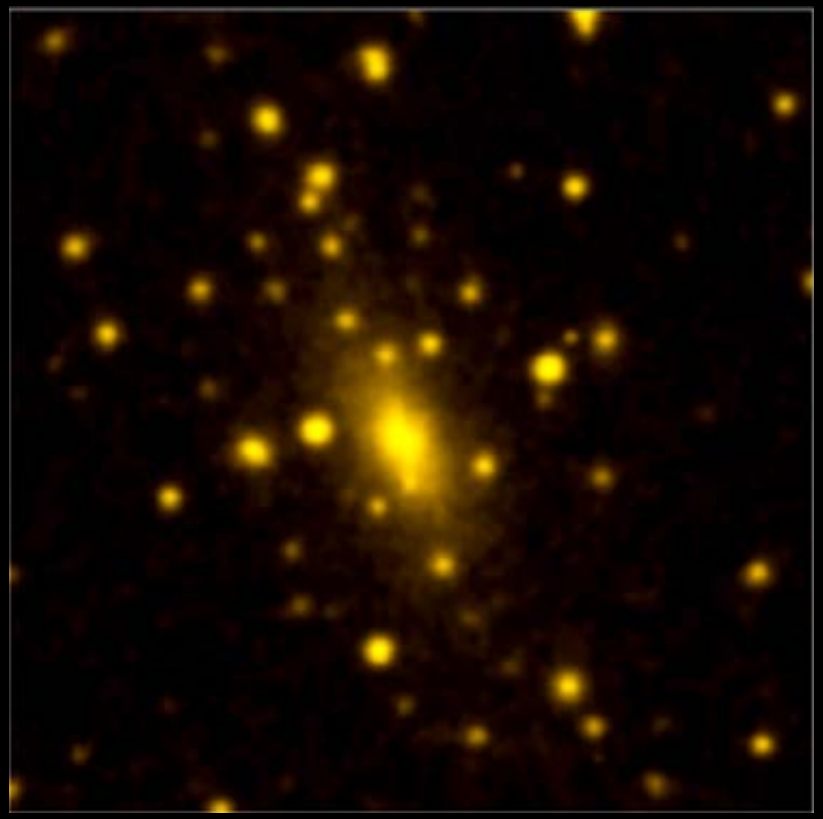
Outline

- Why X-ray Astronomy is so important
- A (very) brief history of X-ray astronomy
- The building of the Observatory
  - Began in 1976
  - Launched in 1999
  - Designed for 3 years of operation with a goal of 5
- Celebrating the 20-th anniversary
- Launch, deployment, first light!
- Some of the wonderful science
- The Nobel for Riccardo Giacconi

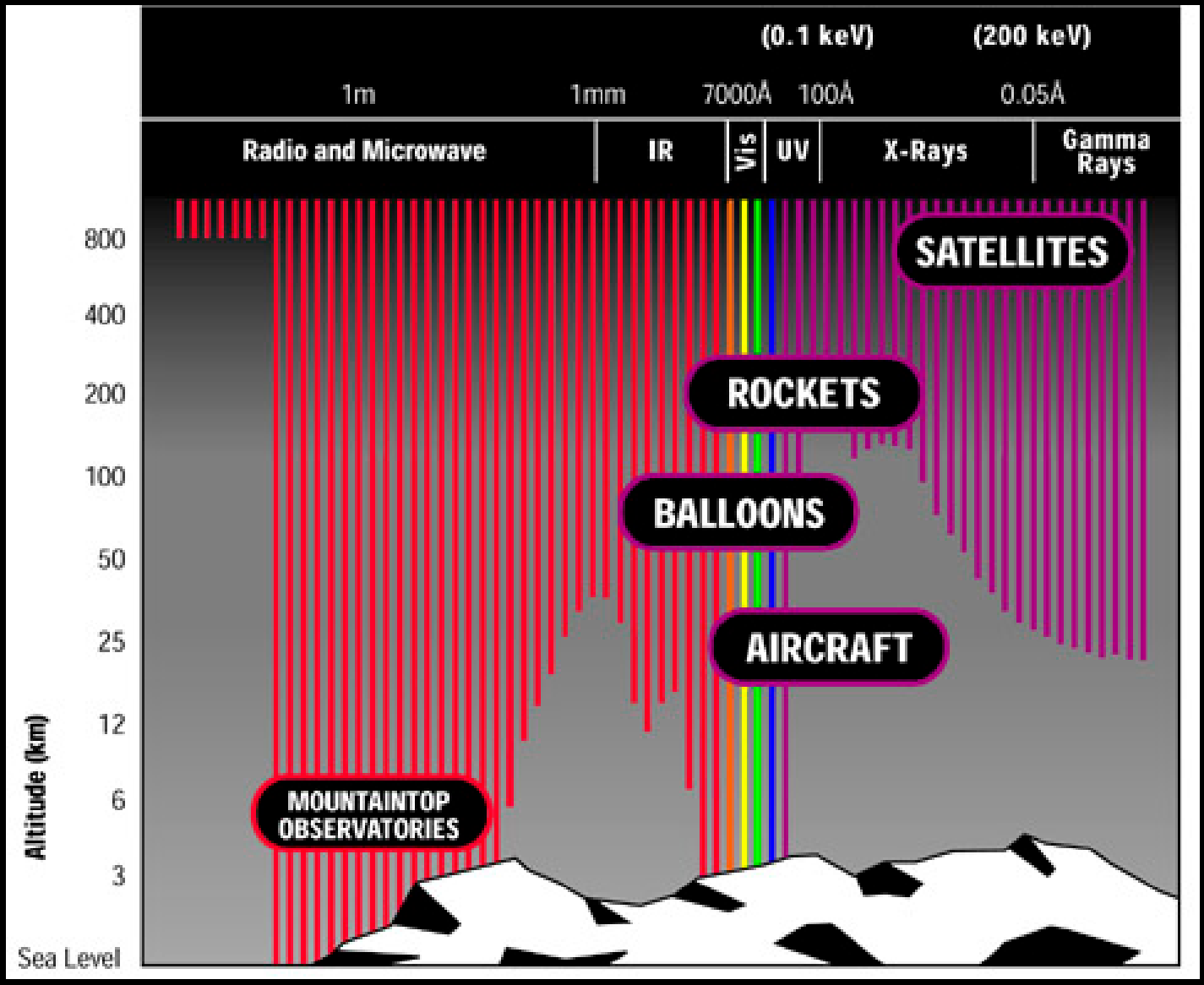
The Importance of X-ray Astronomy



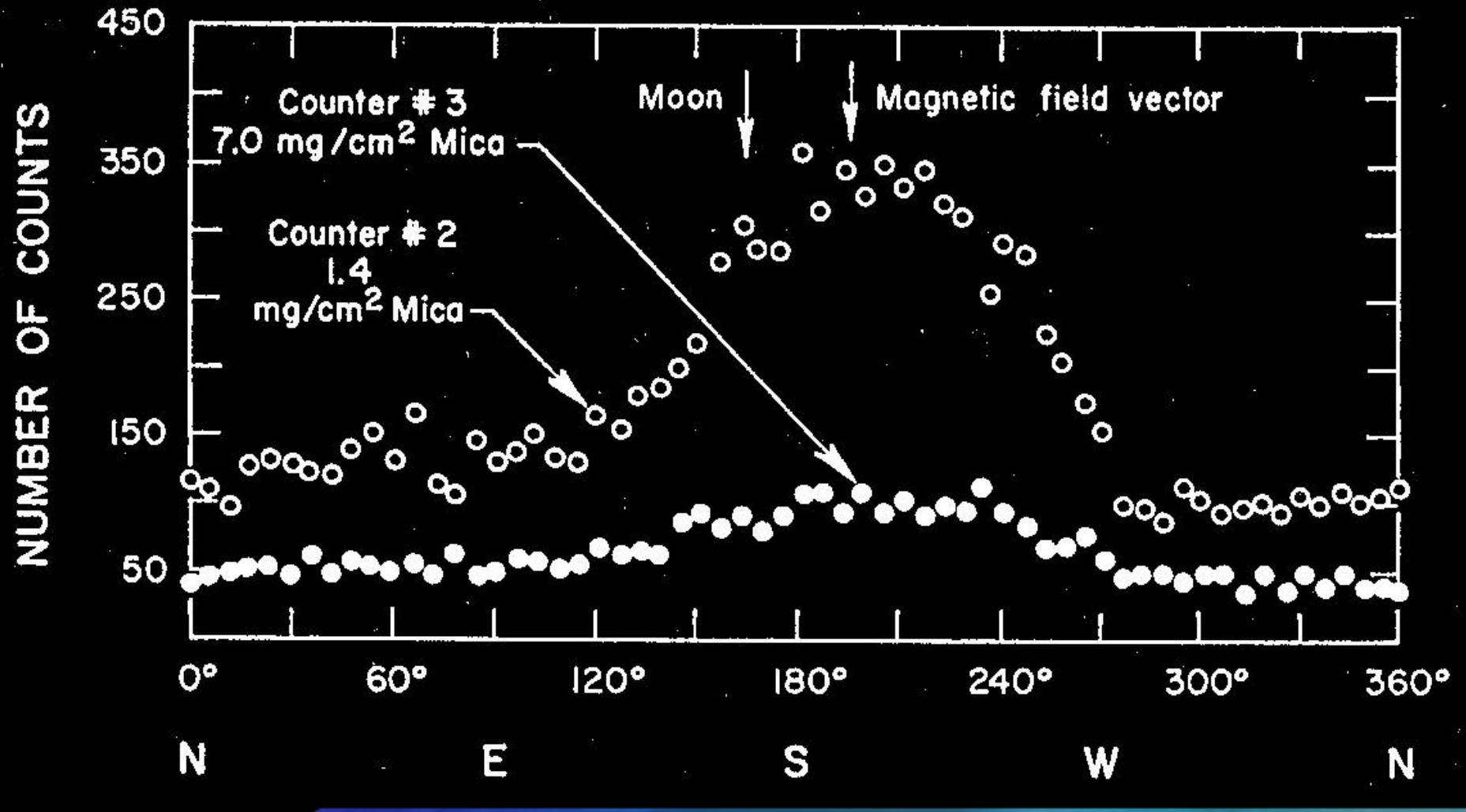
- Most of the matter that we “see” in the universe is via its X-ray emission
- The bulk of this matter is the hot, X-ray-emitting gas in the great galaxy clusters
- Every known class of astronomical objects, from comets to quasars, is an X-ray source

The Atmosphere is a Nuisance

Altitude (km)

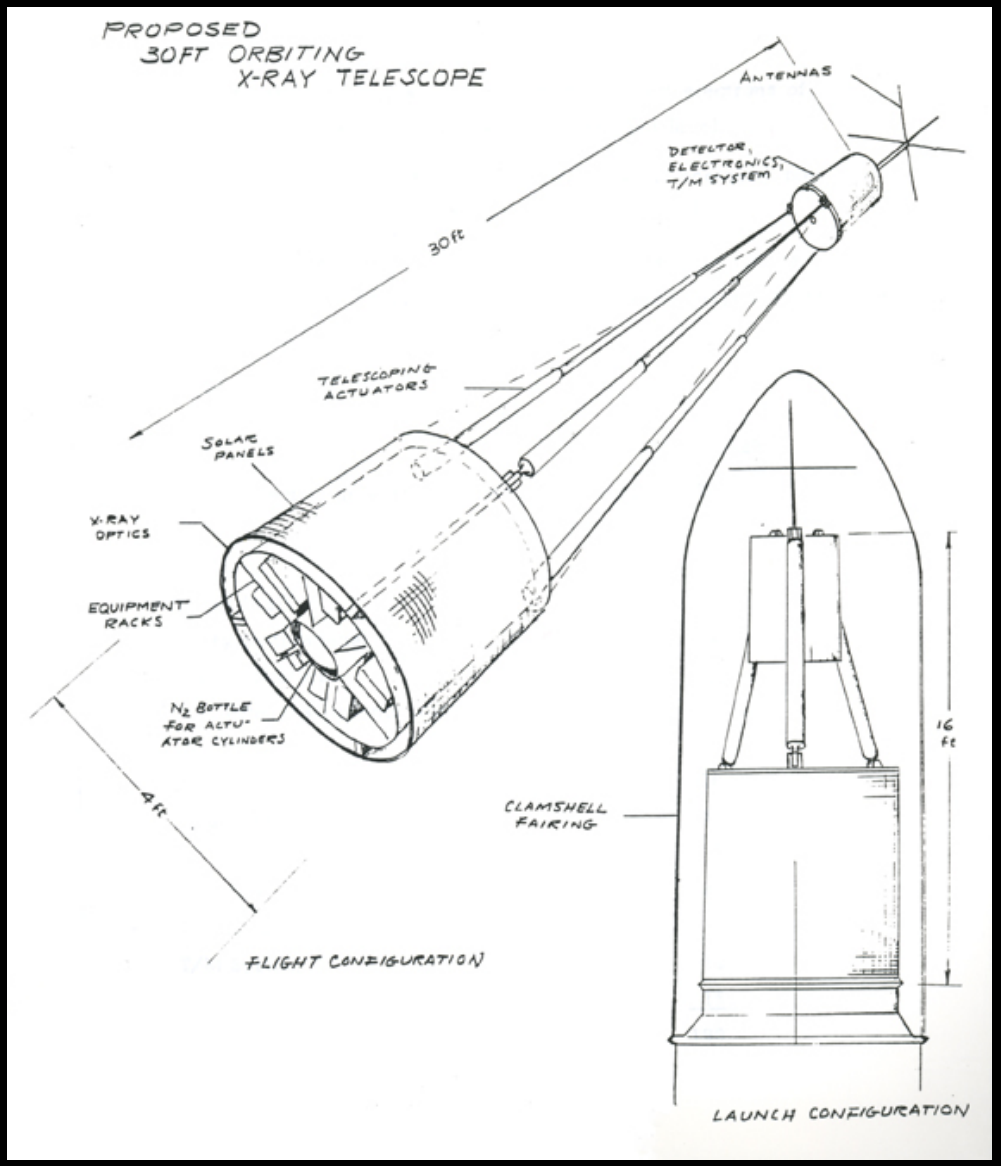


The First Extra-Solar X-ray Source (1962)



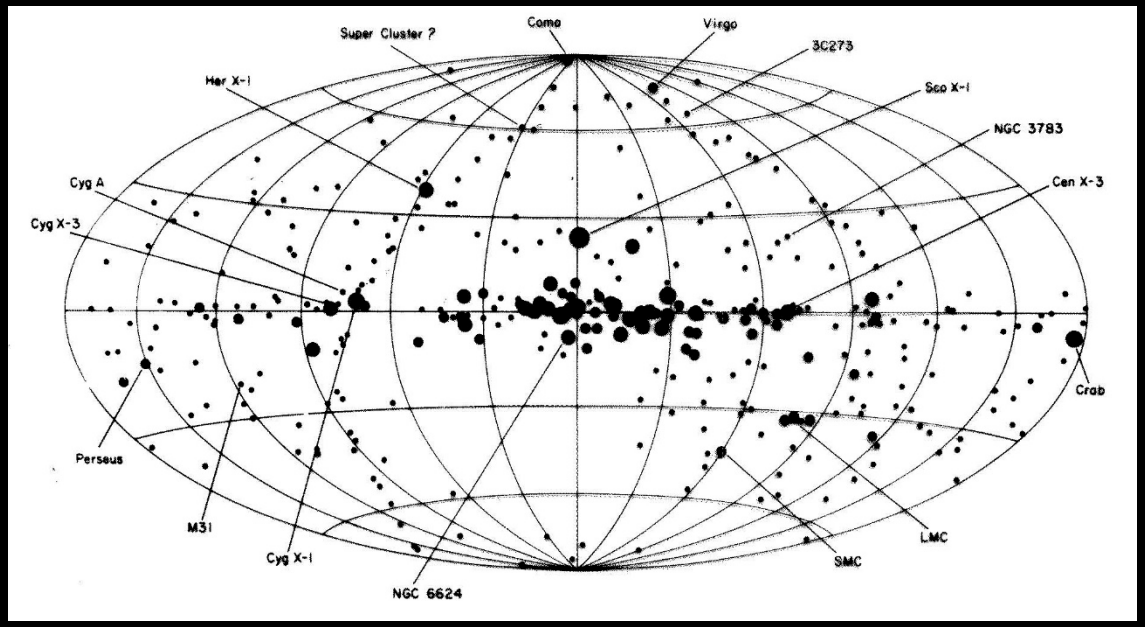
The Vision (1963)

Riccardo Giacconi



The Uhuru Satellite – Dec 1970

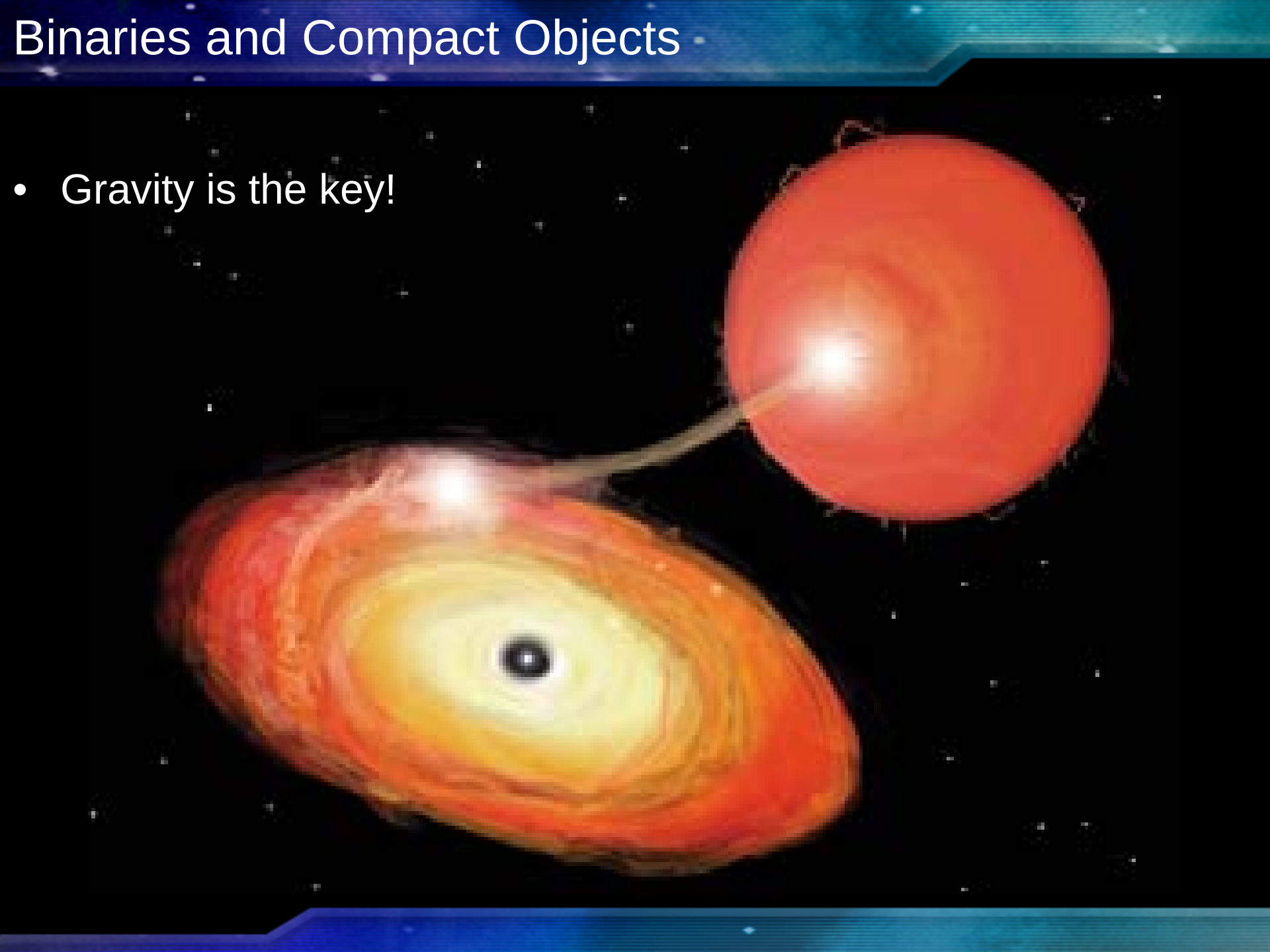
- First satellite fully devoted to X-ray astronomy
- Mission lasted until 1973
- Comprehensive survey of the X-Ray sky with ~1/2 degree angular resolution (the size of the moon)
- 339 sources detected both galactic and extragalactic
- Discovered the first black hole candidate --- Cygnus X-1



Oh yes, Riccardo Giacconi was the Principal Investigator

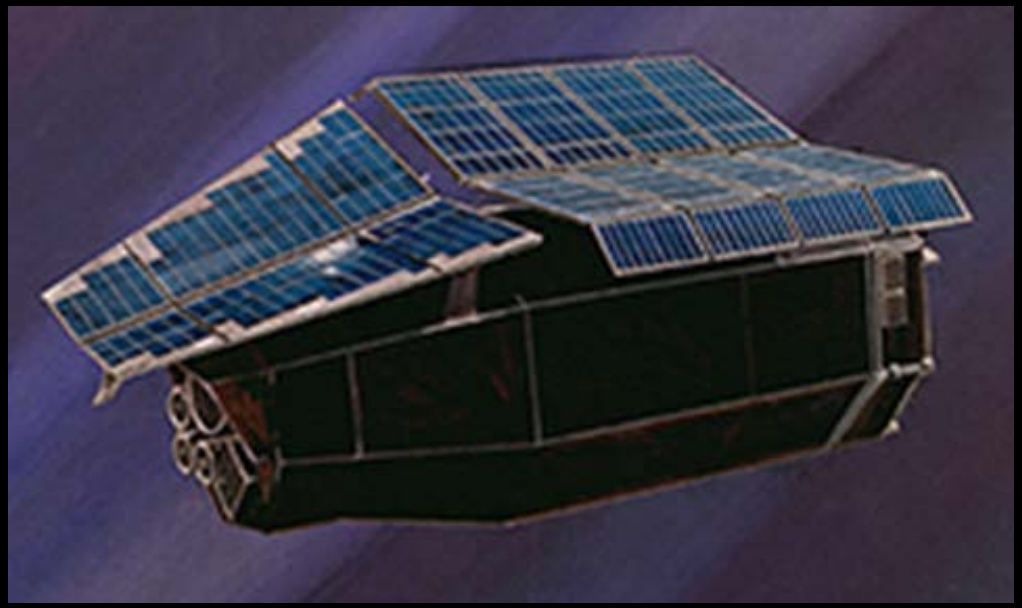
Binaries and Compact Objects

- Gravity is the key!



The Einstein Observatory — Nov 1978

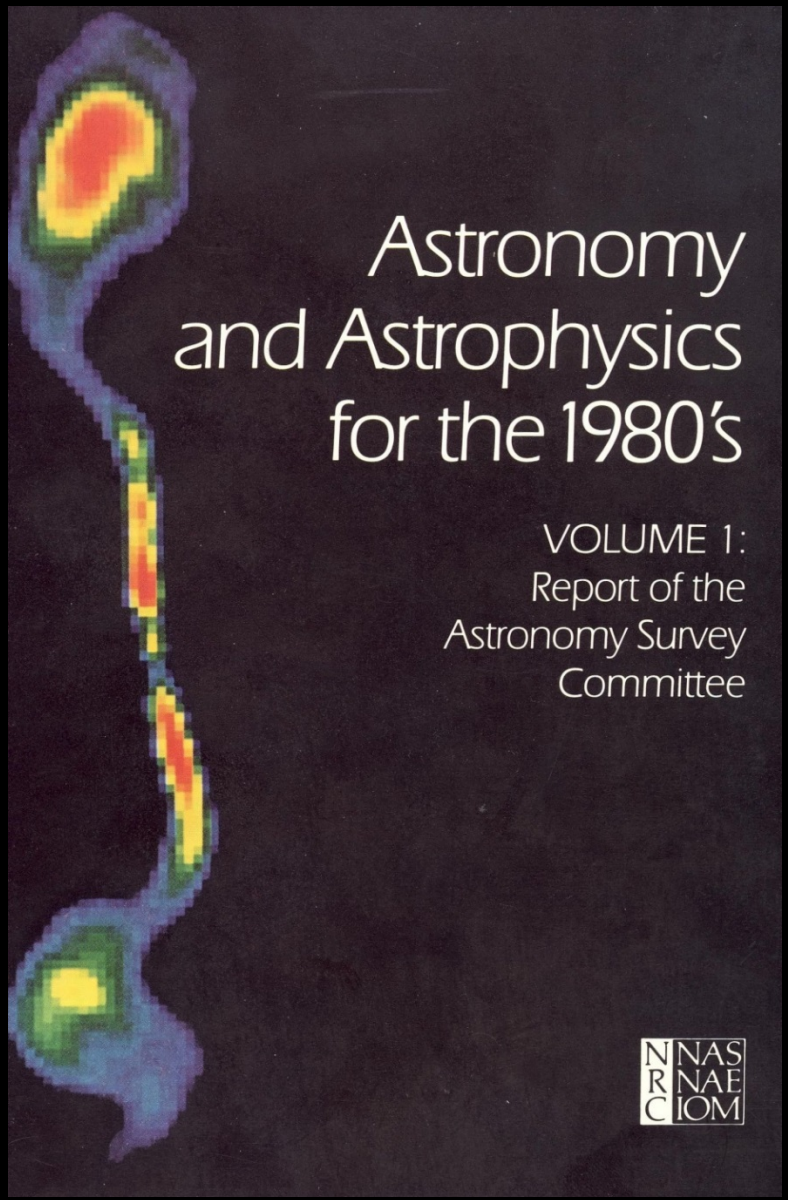
- First fully imaging X-ray telescope
  - Few arcsecond angular resolution
- Completed its mission in Mar 1982
- ***Discovered that every known class of astronomical objects, or a subset thereof, was an X-ray source!***
- Forerunner to Chandra



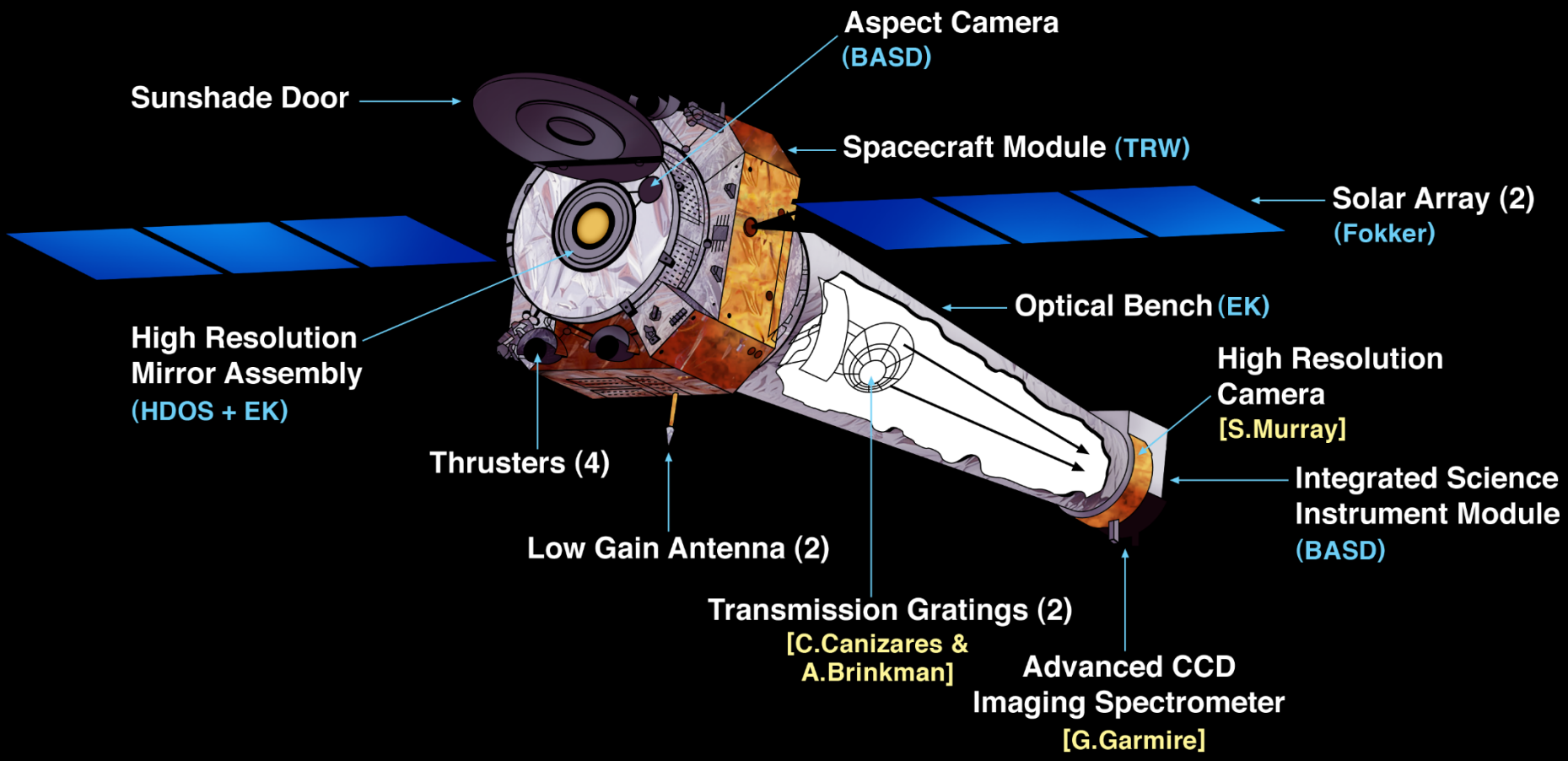
Oh yes, this was a MSFC Project and Riccardo was the PI

National Academy of Sciences

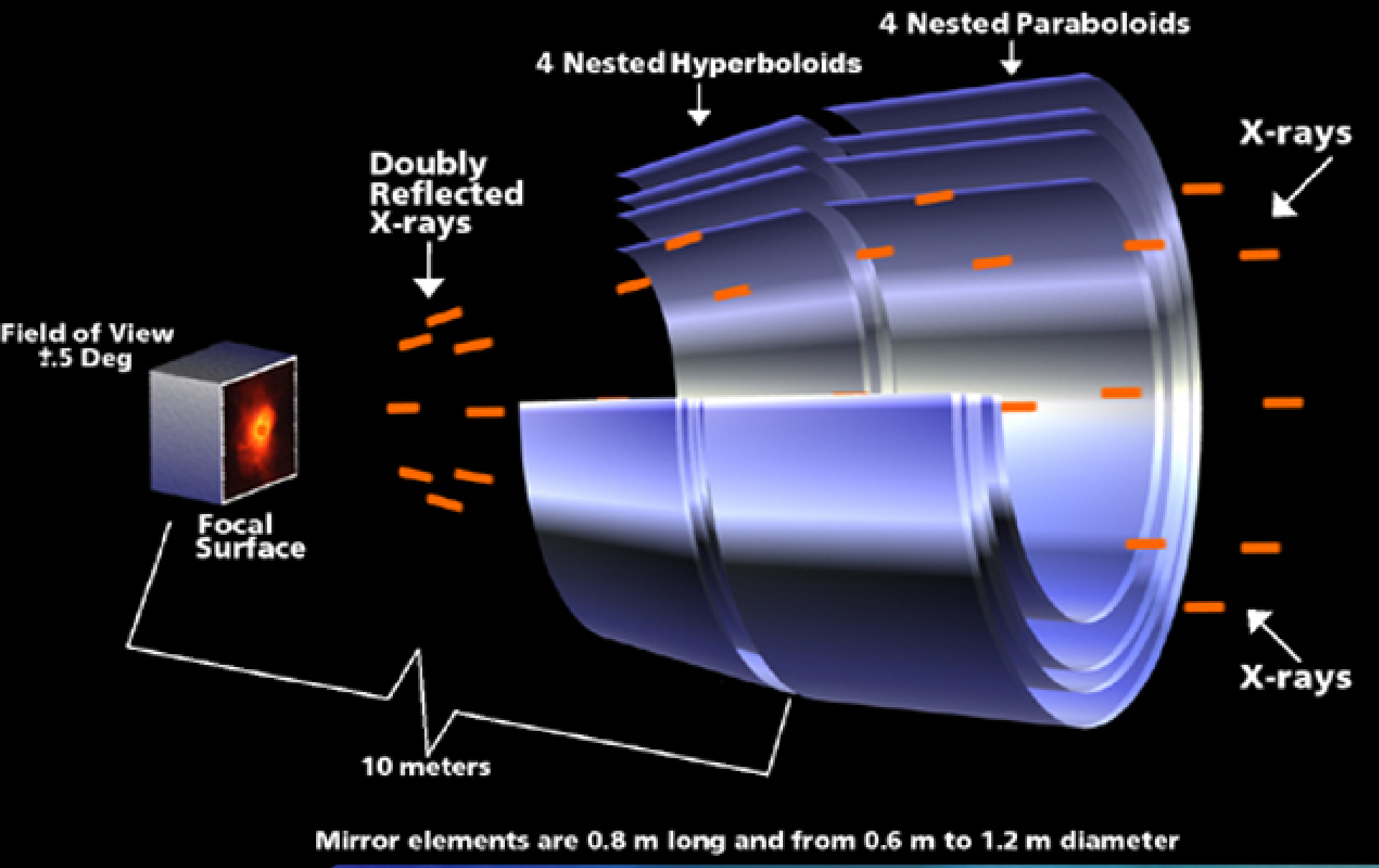
Major New Programs
#1: An Advanced X-Ray Astrophysics Facility (AXAF)



The Observatory

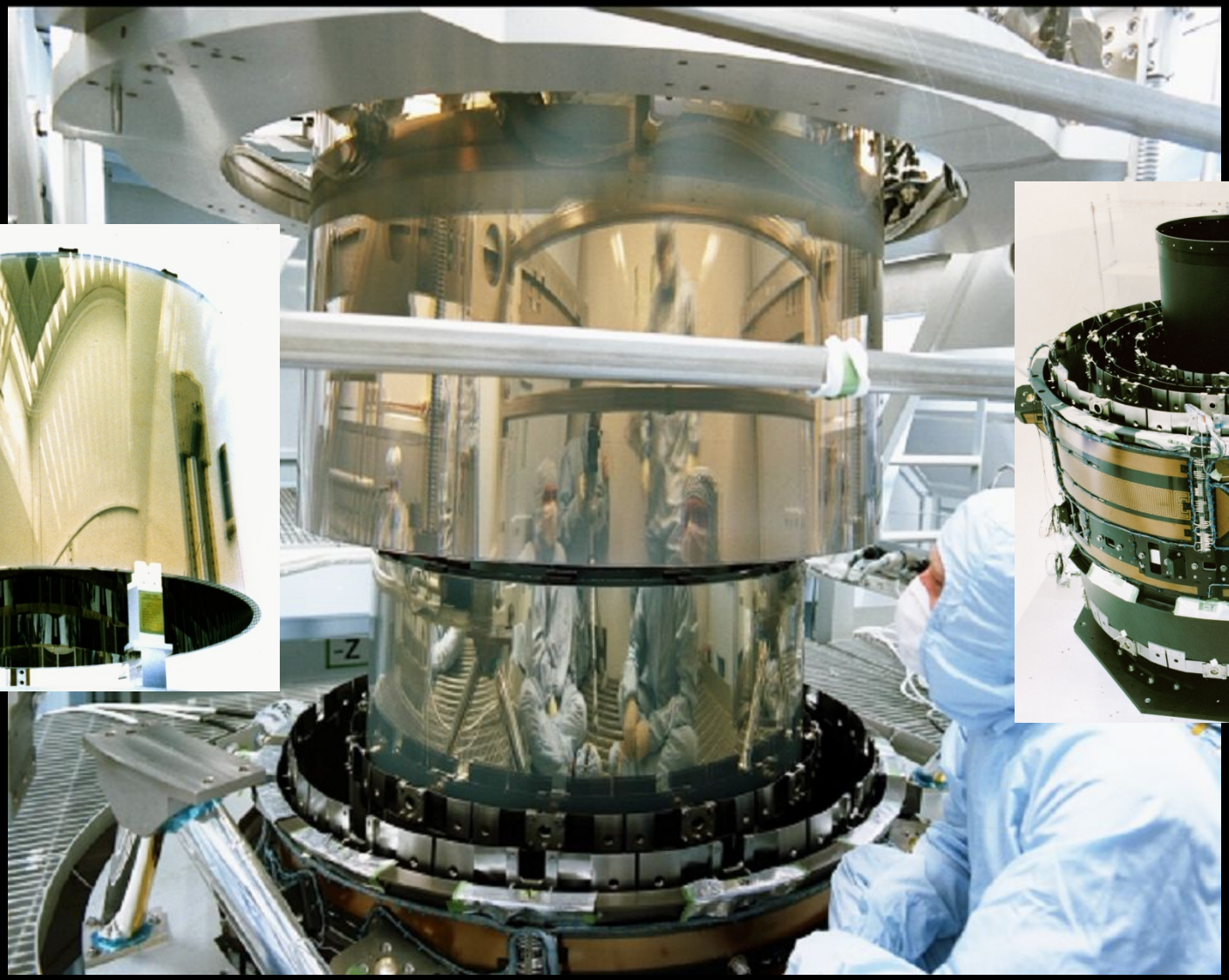


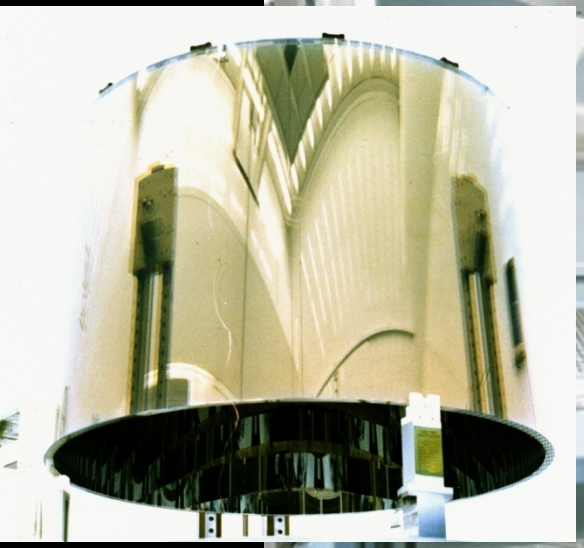
Optics

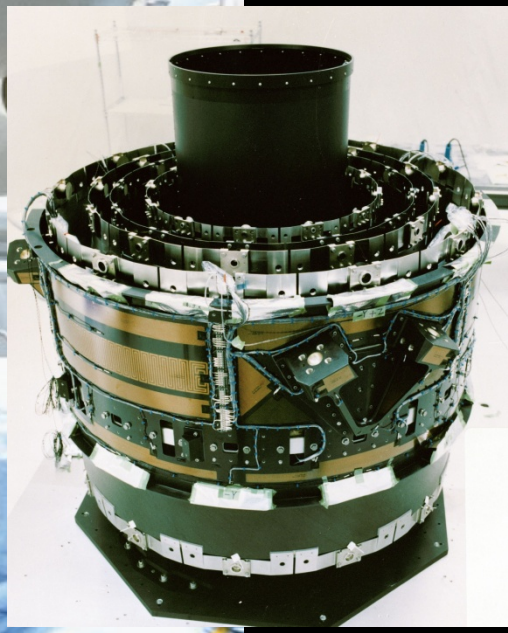


Mirror elements are 0.8 m long and from 0.6 m to 1.2 m diameter

Optics: Coated, Assembled & Aligned

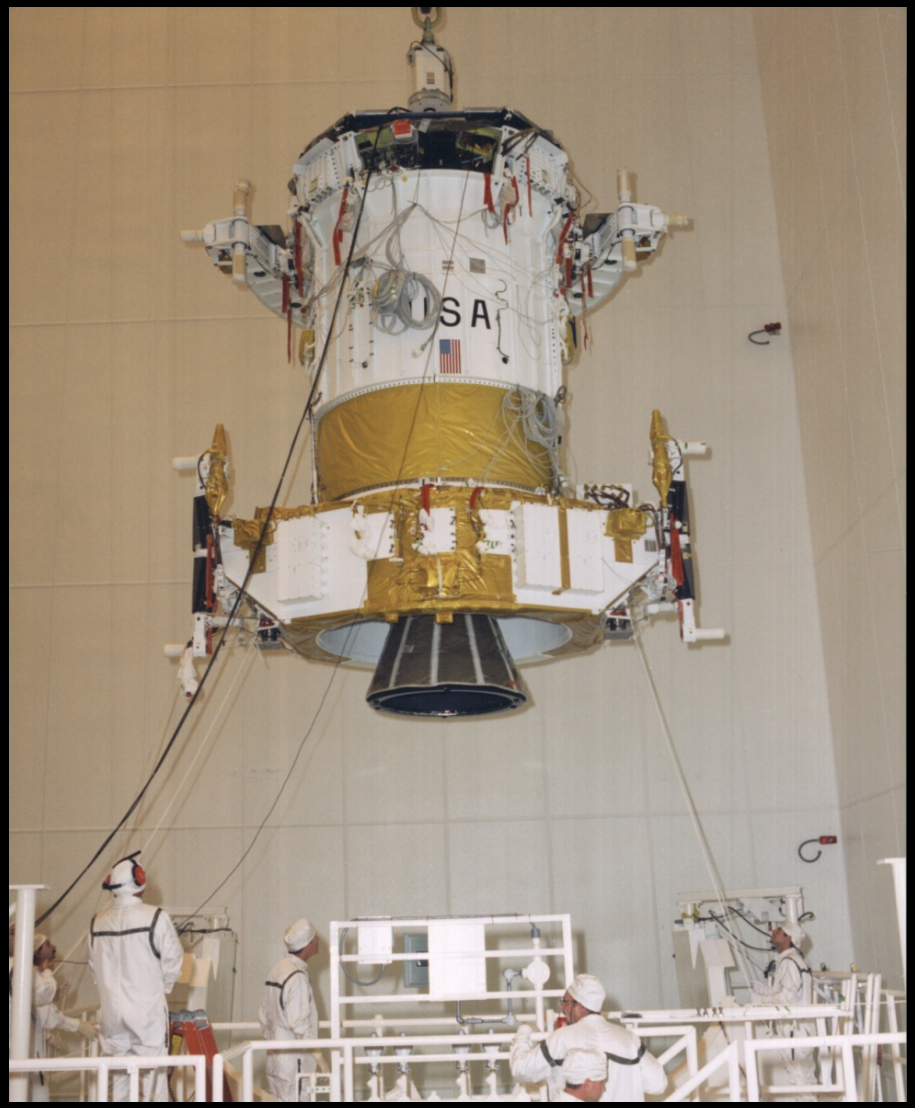






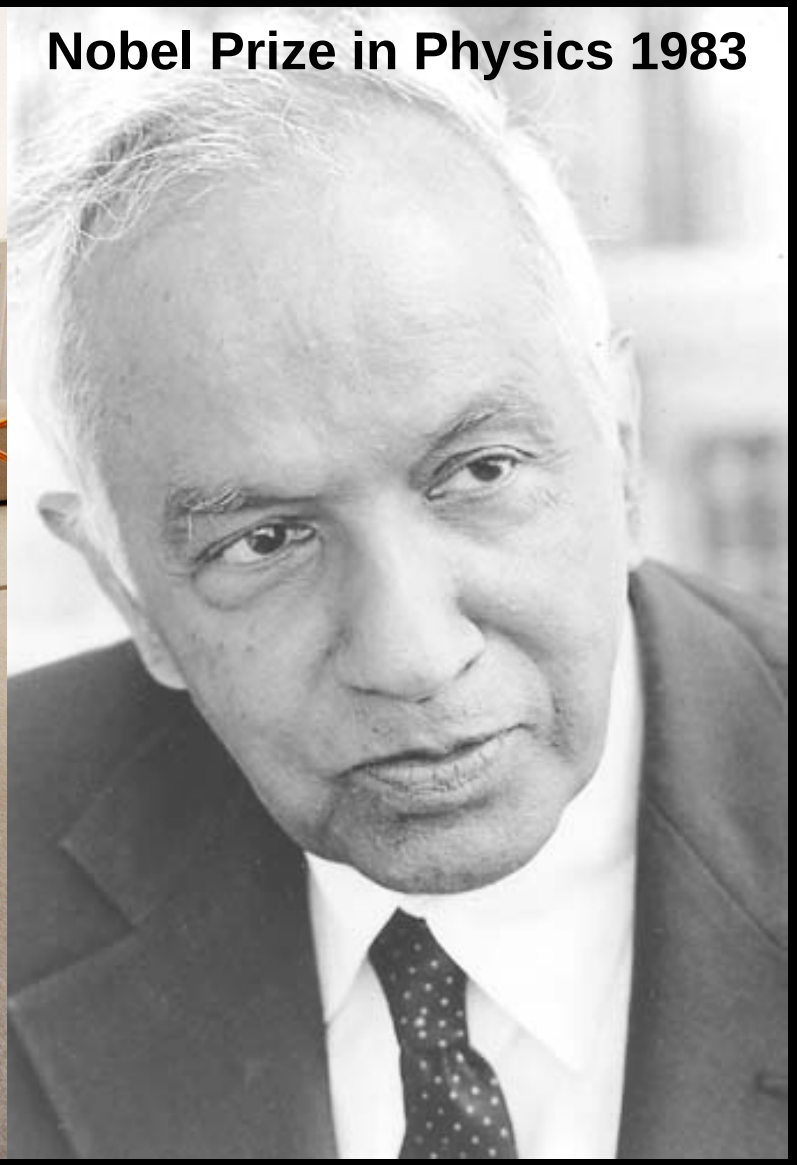
The X-ray Calibration Facility at MSFC

Include the Upper Stage in the Shuttle



The longest and heaviest payload ever launched by the Shuttle

Mrs. and Prof. S. Chandrasekhar



Launch – July 23, 1999

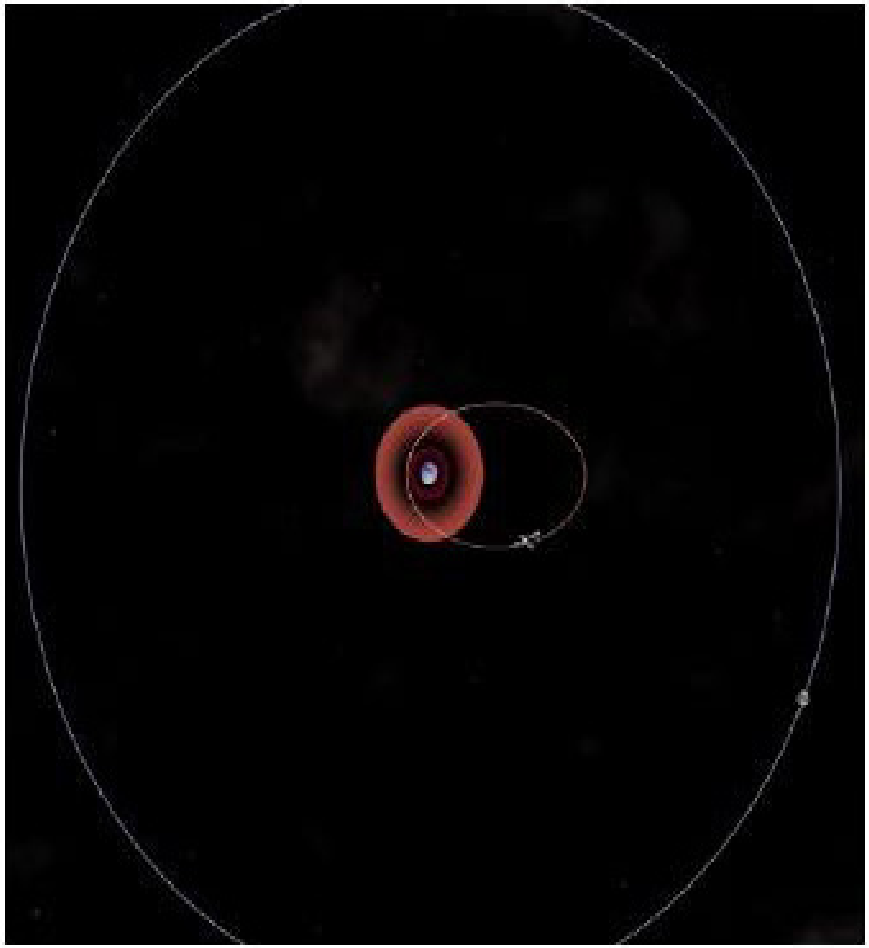
Beyond the Sky

Words and Music by Judy Collins

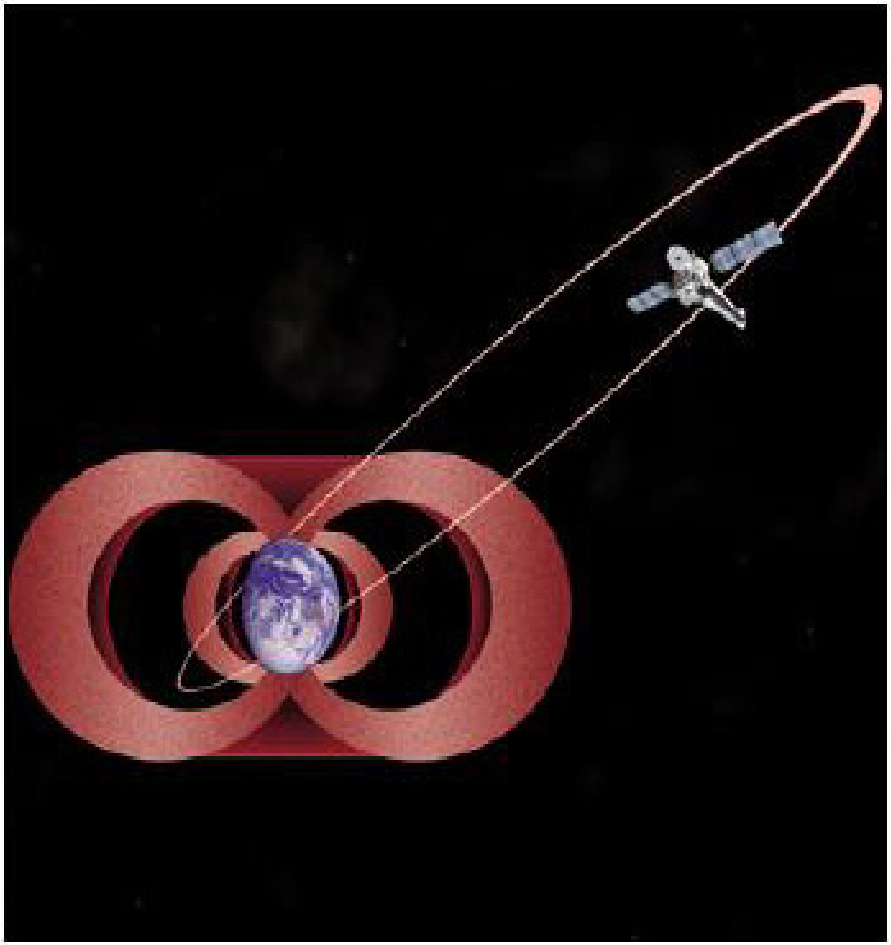
And we will fly beyond the sky
Beyond the stars beyond the heavens
Beyond the dawn we'll carry on
Until our dreams have all come true
To those who fly - we sing to you

Deployment

The Final Orbit

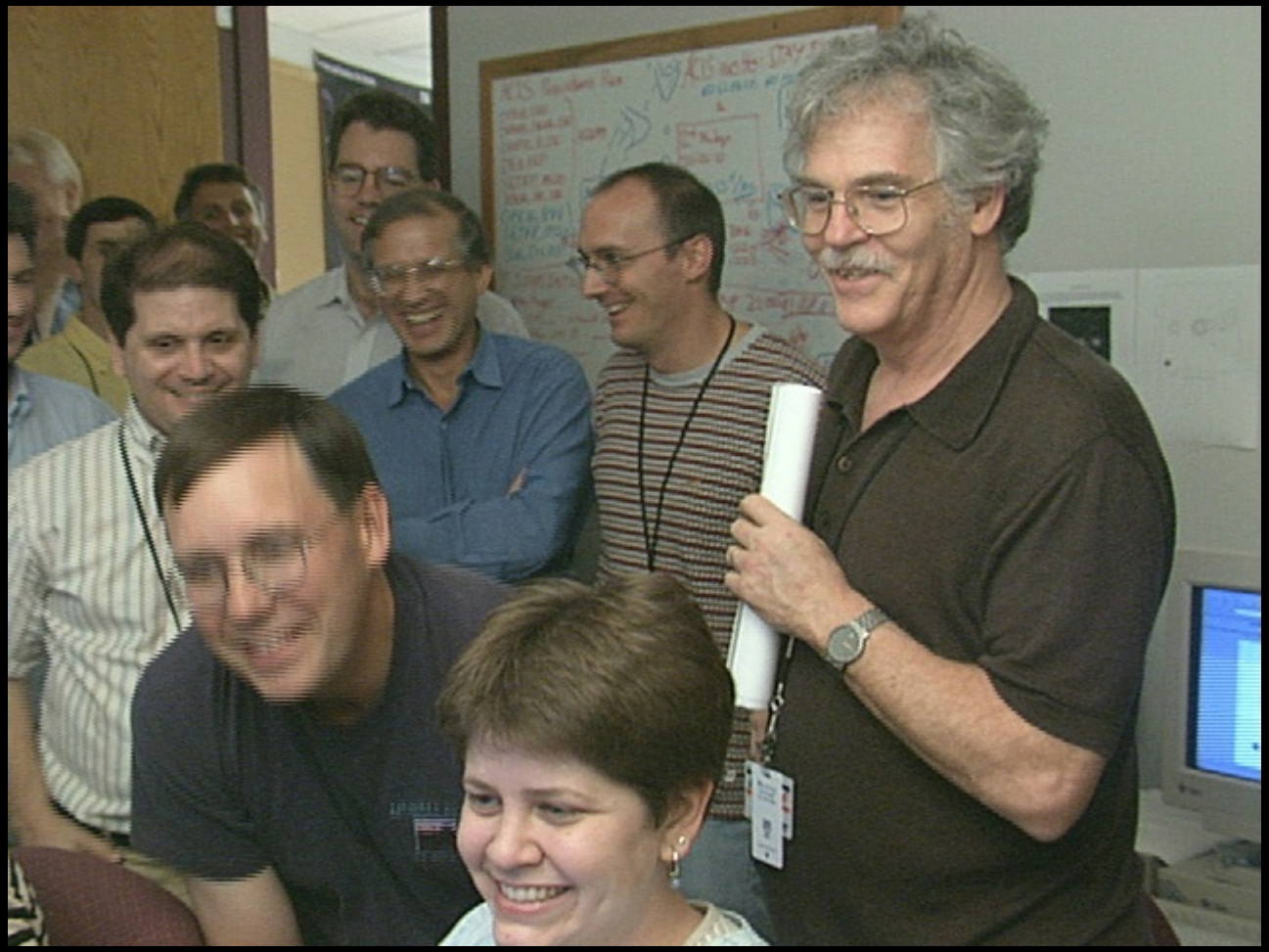


From above, with radiation belts & Moon

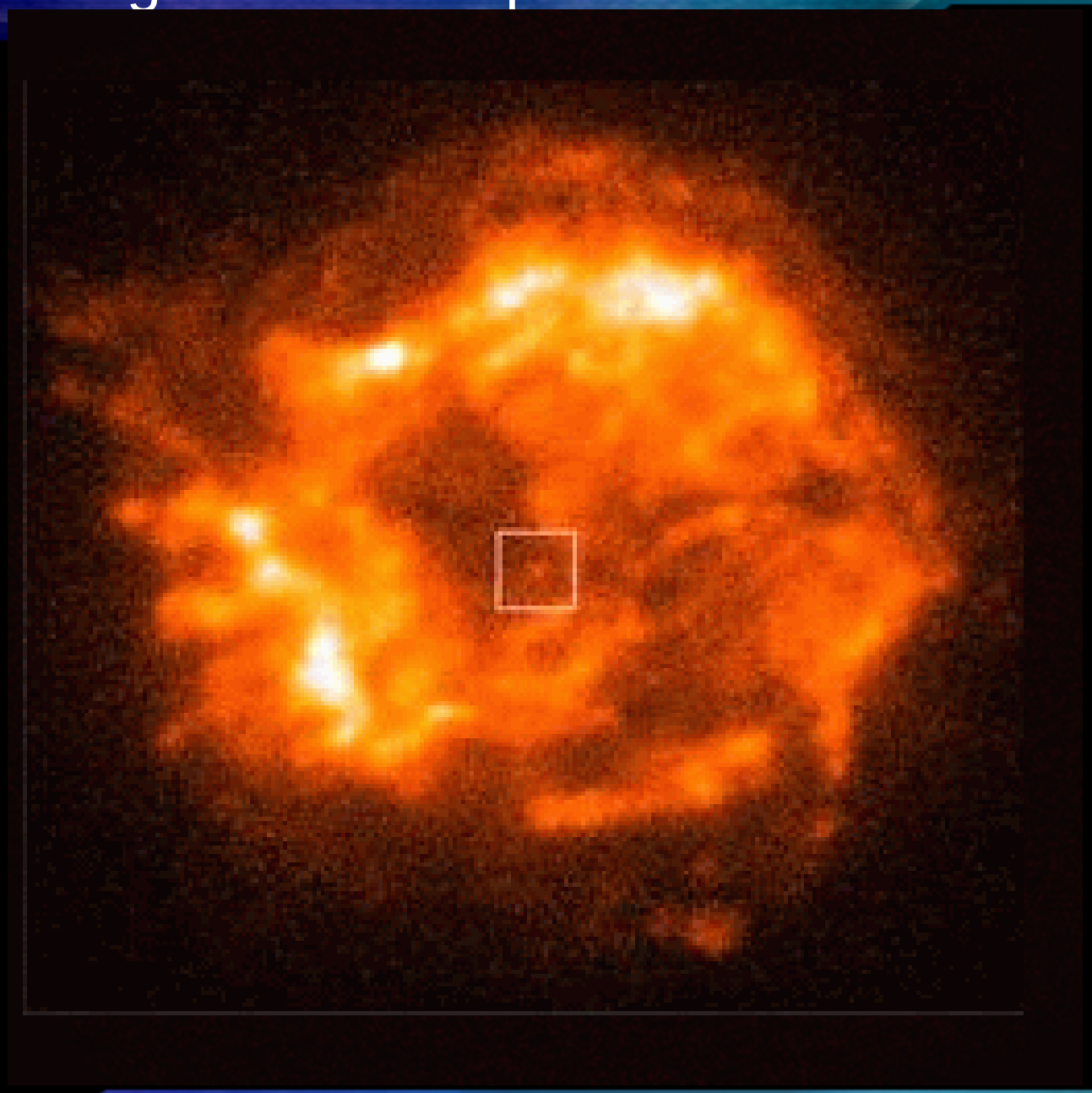


Closer side view

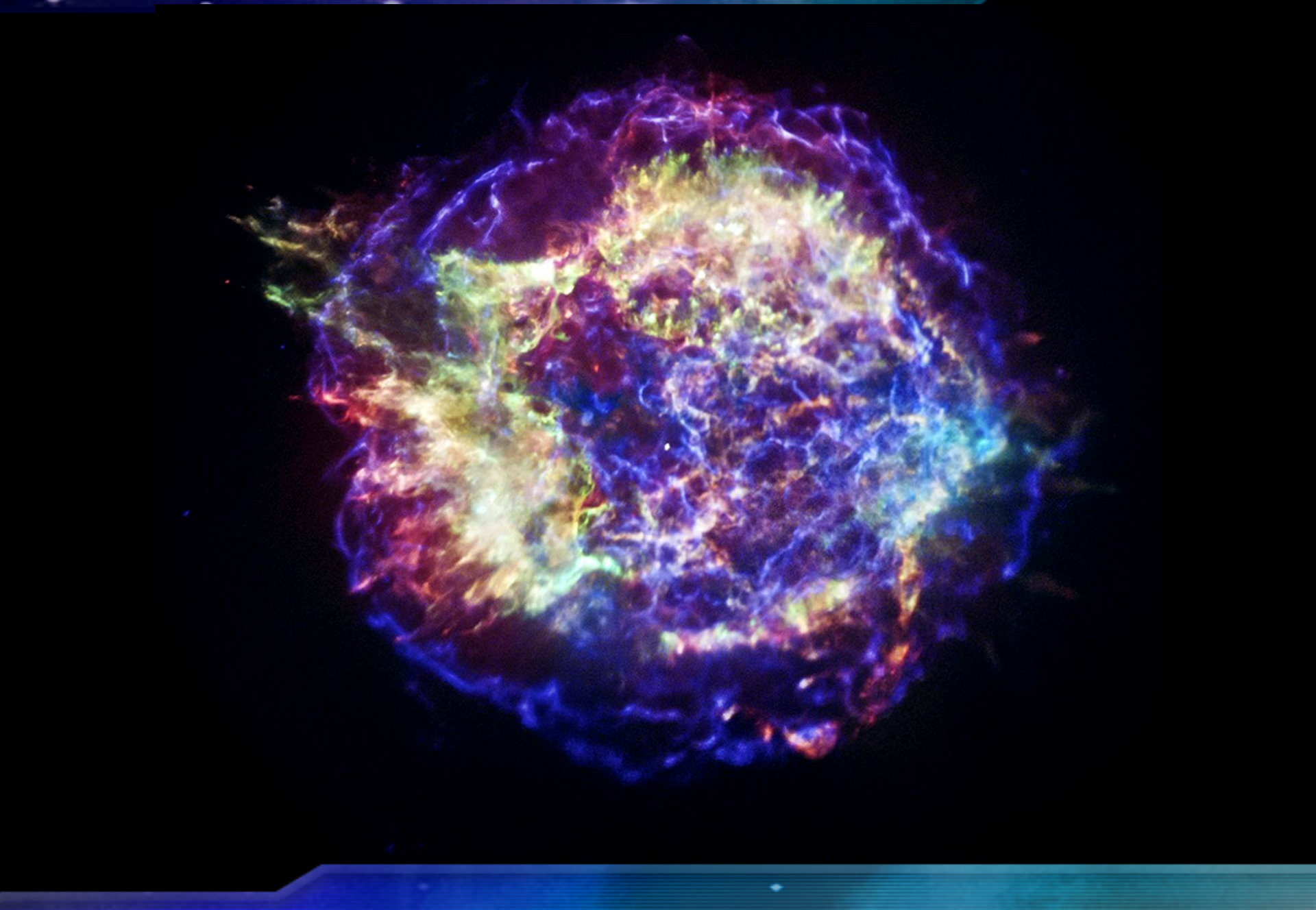
Leon X-1



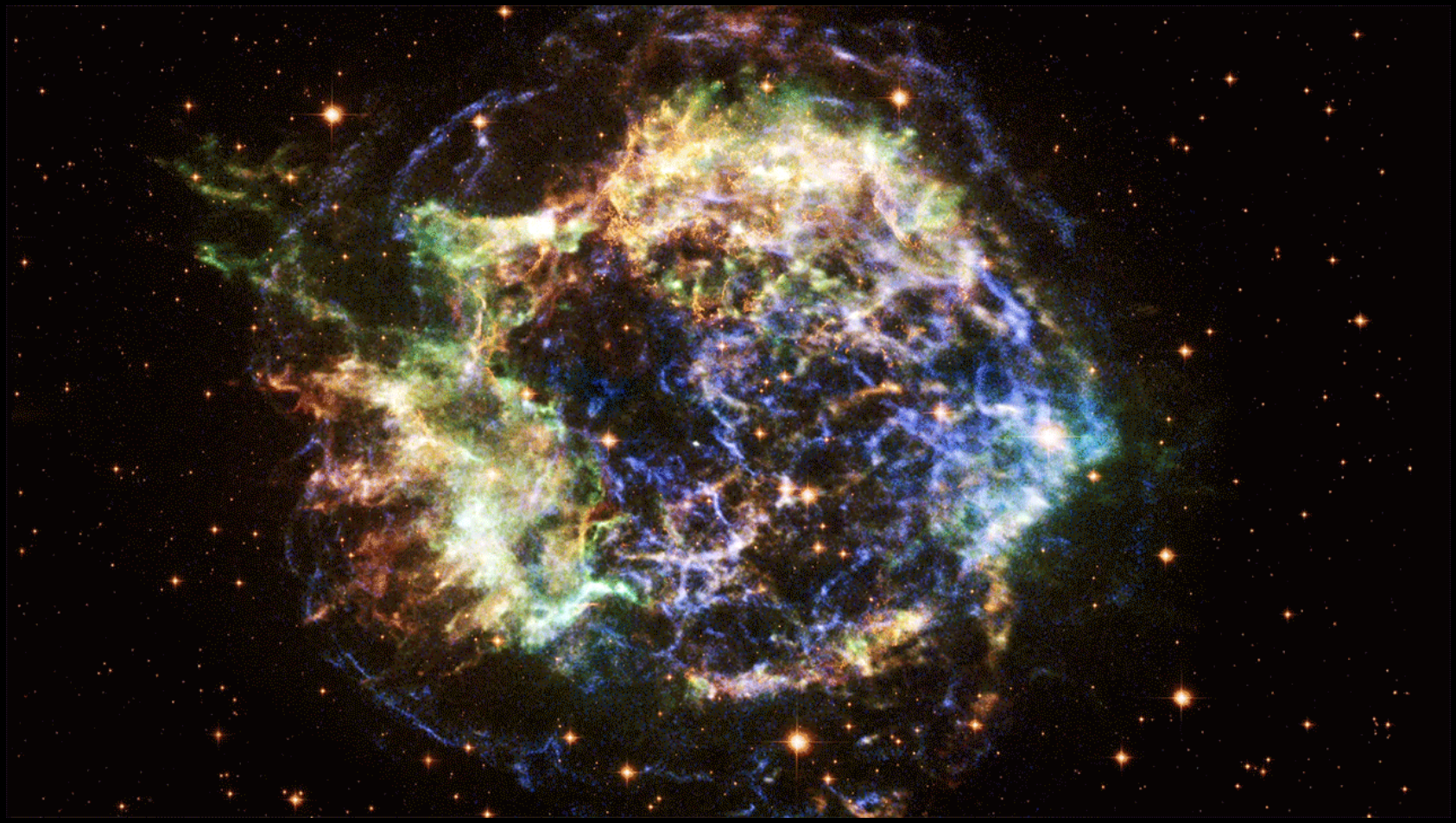
Official First Light — Cassiopeia A



Cassiopeia A

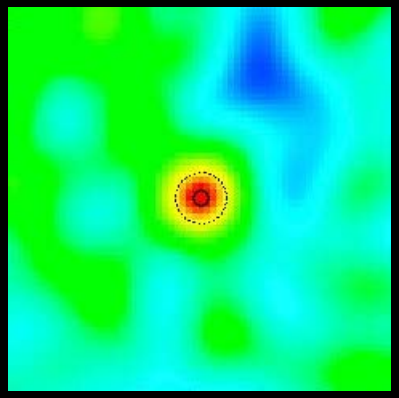


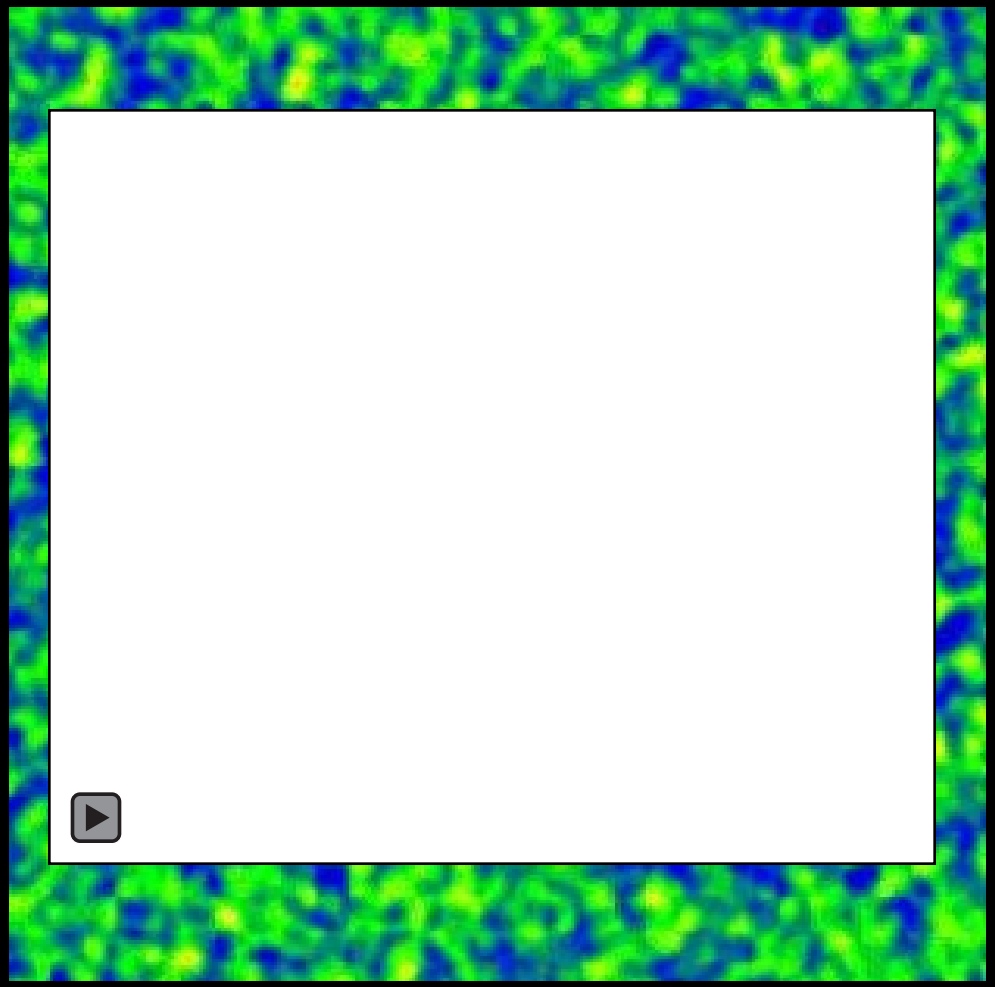
Cassiopeia A — As Time Goes By

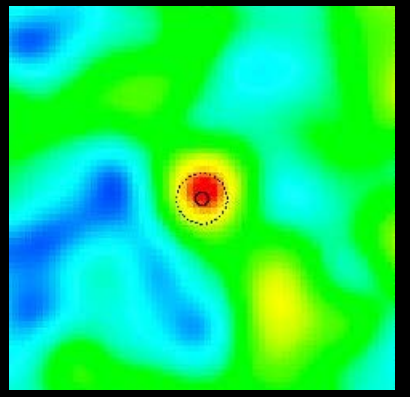


Jupiter and its Moons

Io

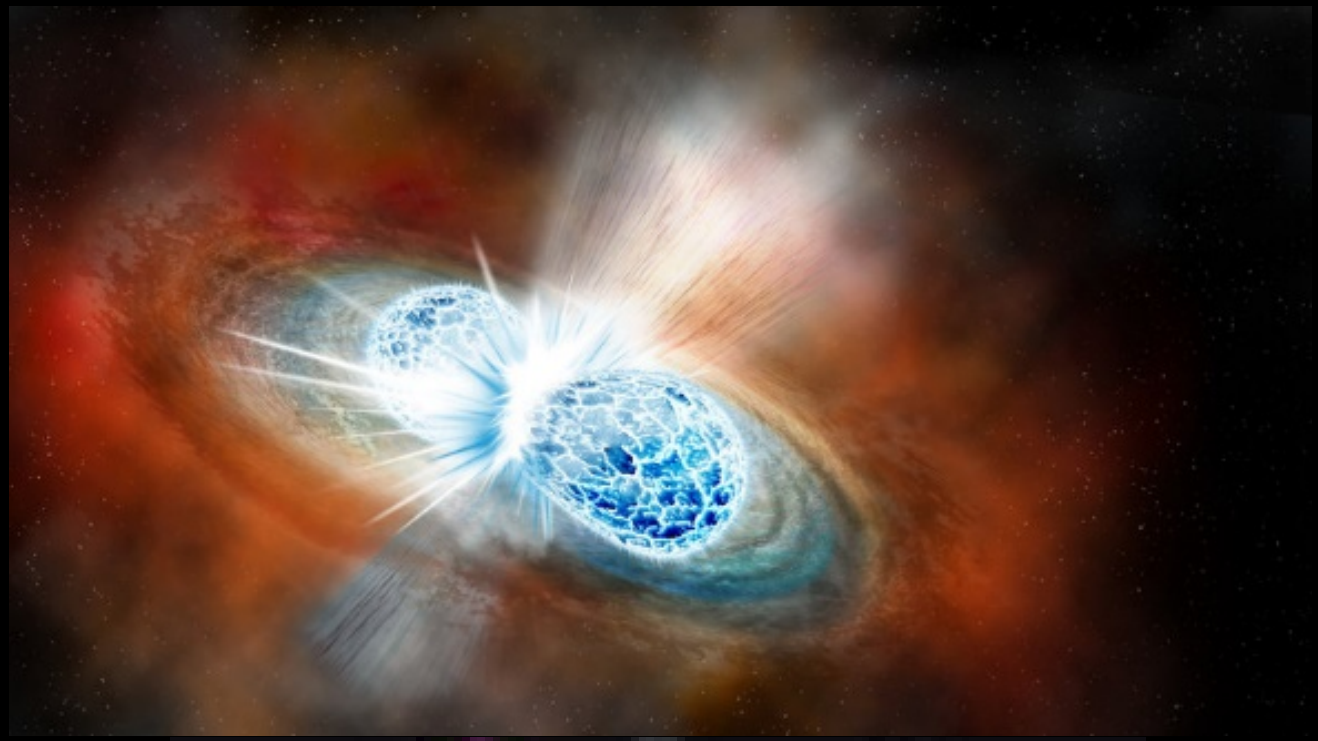


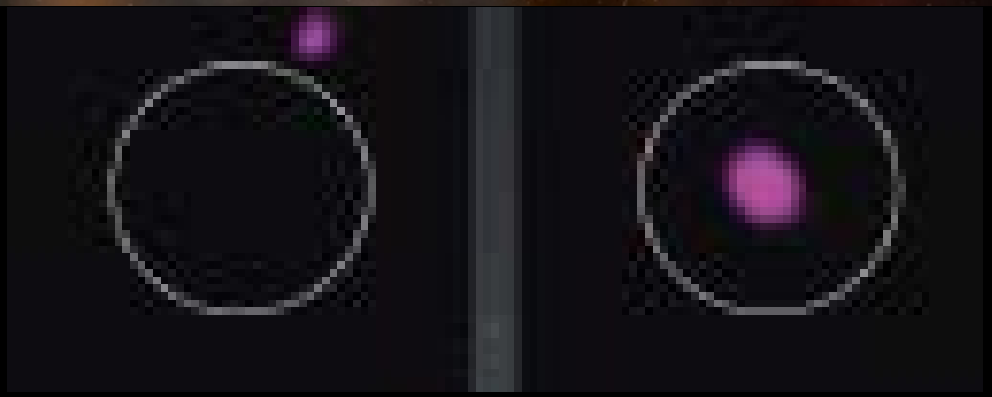




Europa

Two Neutron Stars Collide! (Wow)





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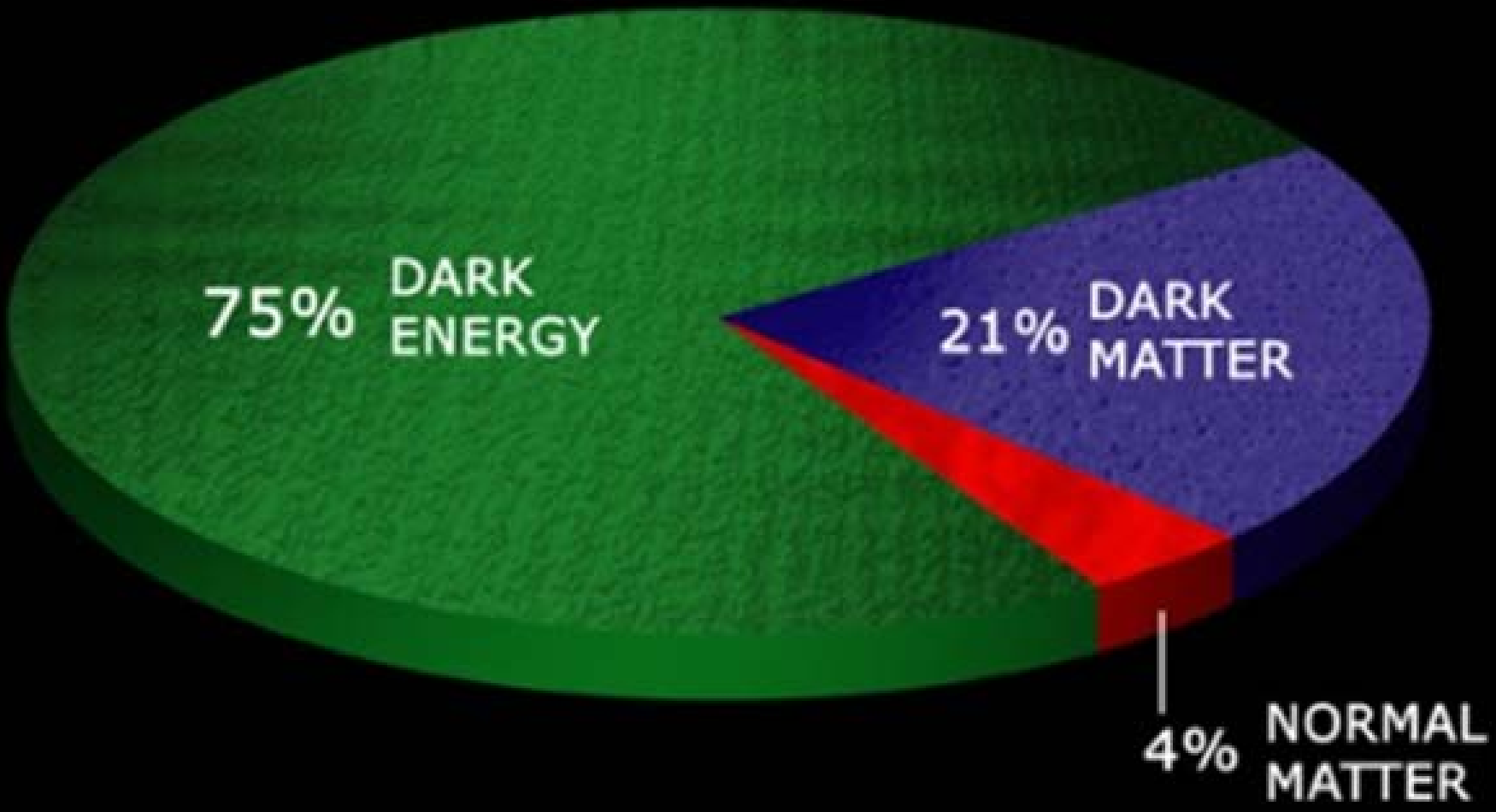
Dark Energy and Dark Matter

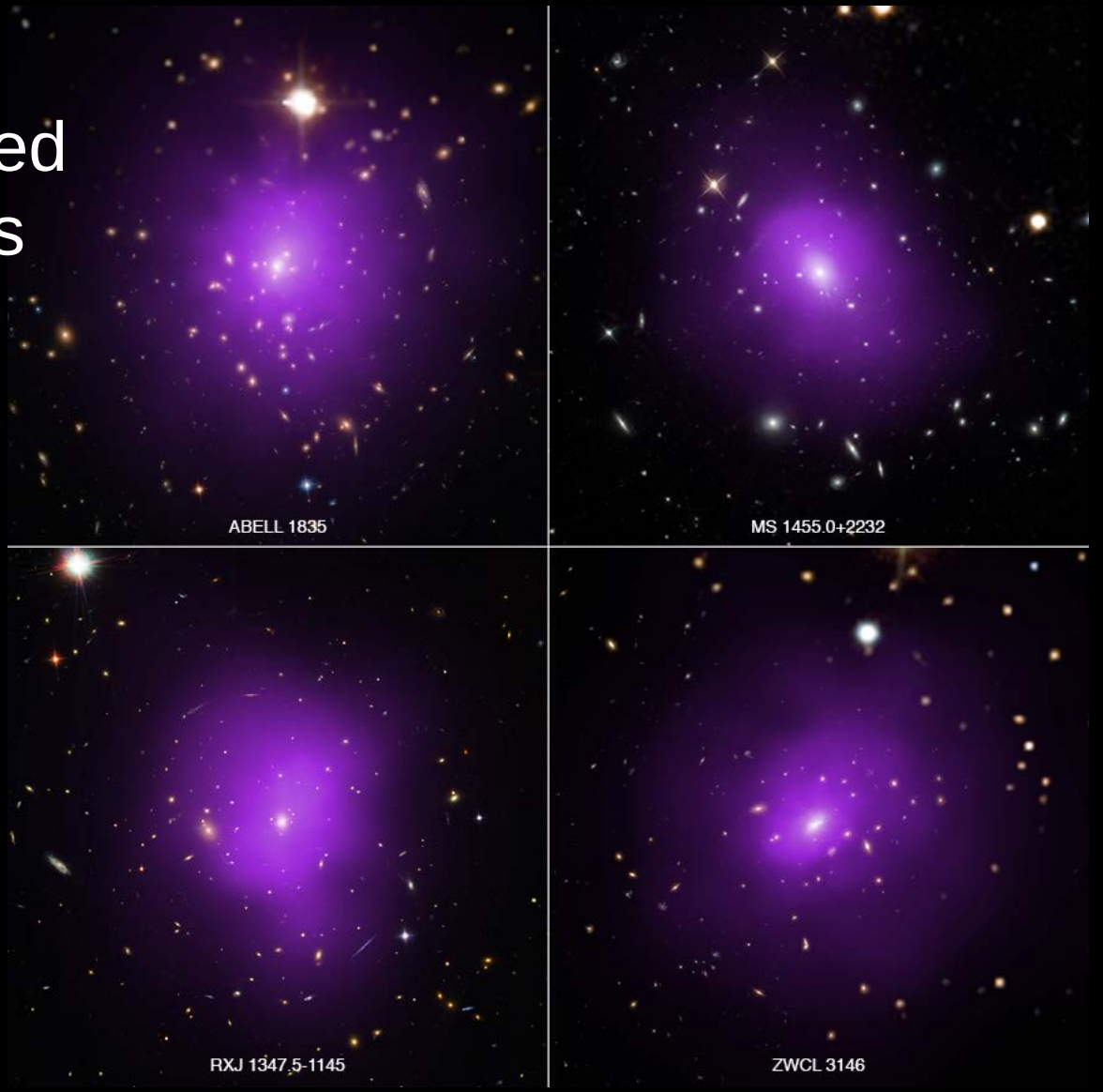


Colliding Clusters of Galaxies & Dark Matter

Blue – the location of the dark matter
Pinkish – the normal matter (the X-ray-emitting hot gas)

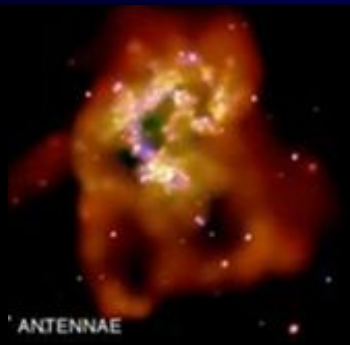
Probing Dark Energy

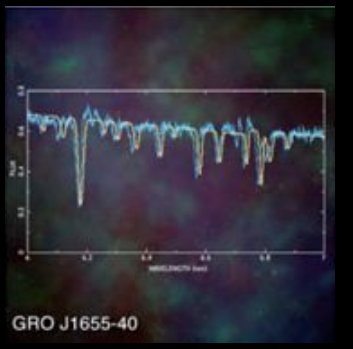
- This study examined 300 galaxy clusters
- Size versus time depends on dark energy
- Confirms the “cosmological constant”



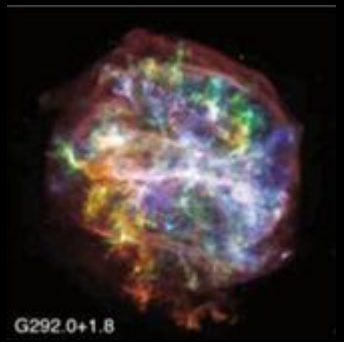
The 2002 Nobel Prize for Riccardo Giacconi

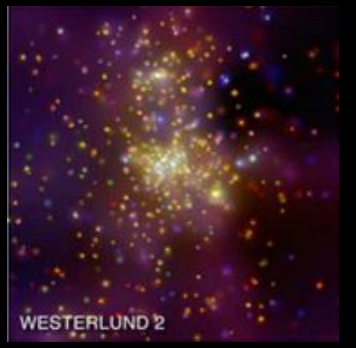
Learn More





http:chandra.harvard.edu





The opportunity for exploration and discovery with Chandra remains as high today as it was at launch