

The Chandra X-Ray Observatory



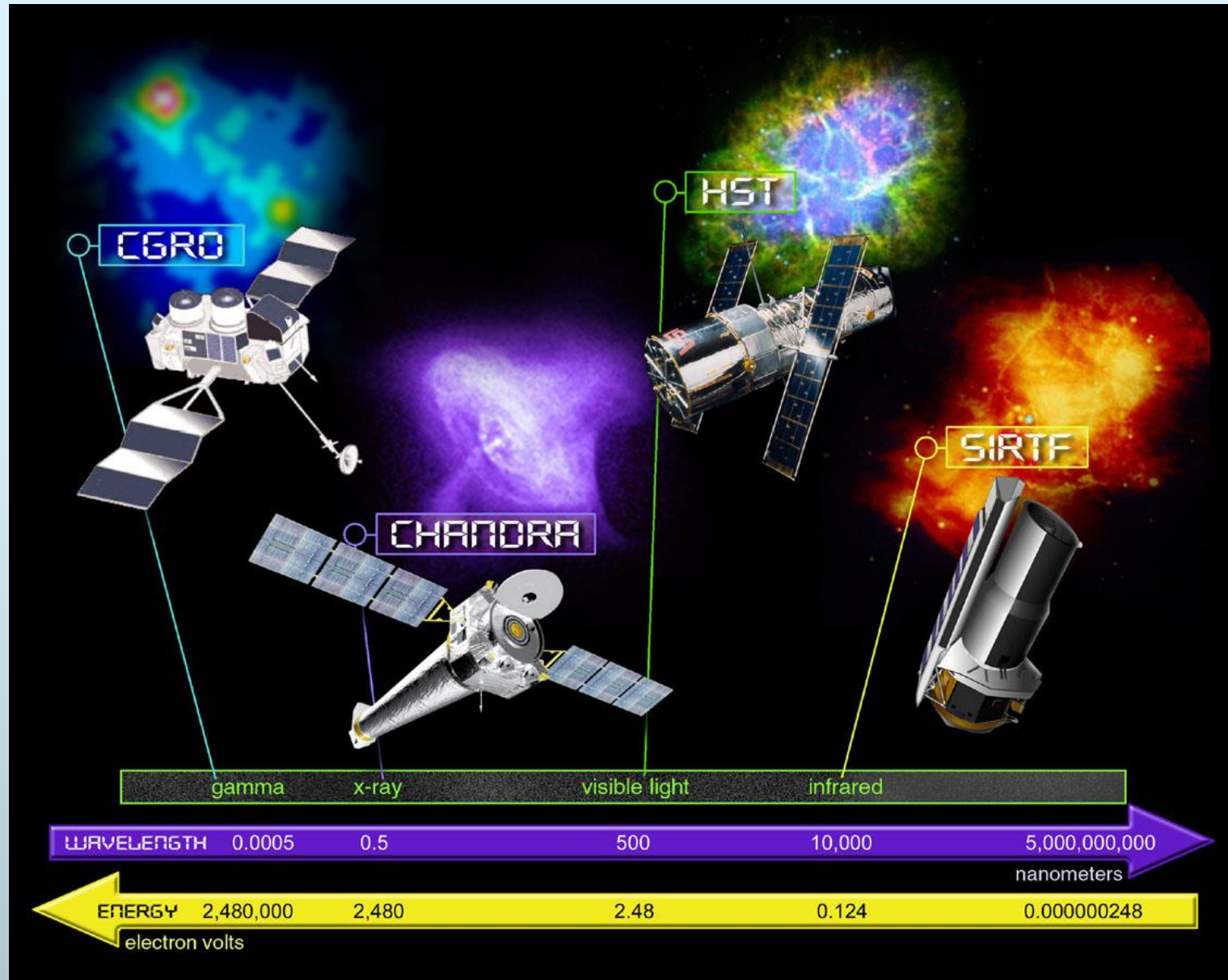
Great Science with a Great Observatory

Martin C. Weisskopf 10/1/2015

Overview

- **Chandra is one of NASA's Great Observatories**
 - The Compton Gamma-Ray Observatory (1991 - 2000)
 - The Hubble Space Telescope (1990 -)
 - The Spitzer Infrared Telescope Facility (2003 -)
 - **Most sensitive telescope for detection of X-ray sources**
 - The superb angular resolution makes Chandra unique
 - Sub-arcsecond angular resolution is comparable to that of the best ground-based optical telescopes
 - Improvement relative to previous X-ray telescopes is analogous to the improvement of HST relative to ground-based telescopes
 - **Beginning its 16-th year of operation**
 - Launched 7/23/1999
 - First light 8/12/1999
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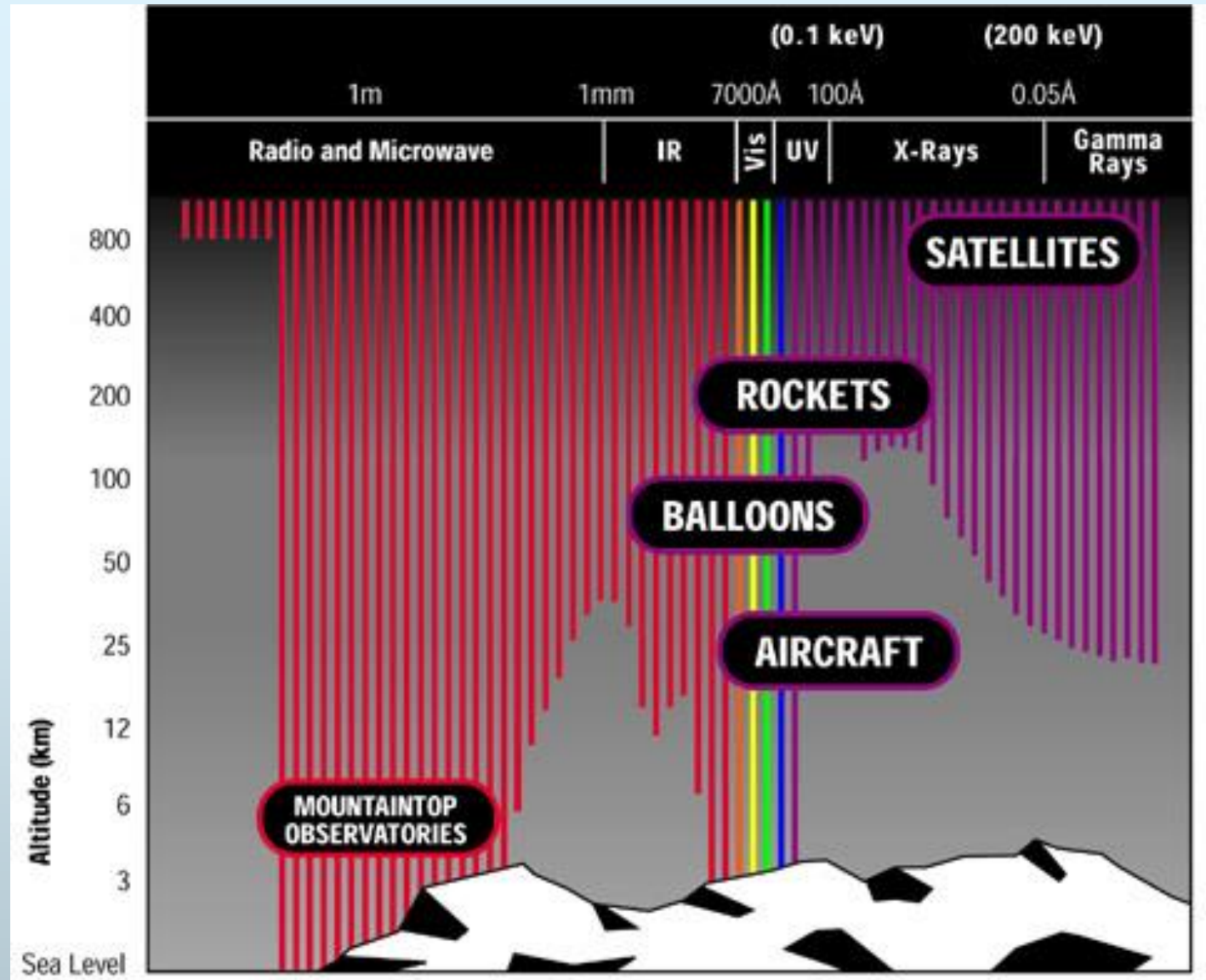
NASA's Great Observatories



Overview - Continued

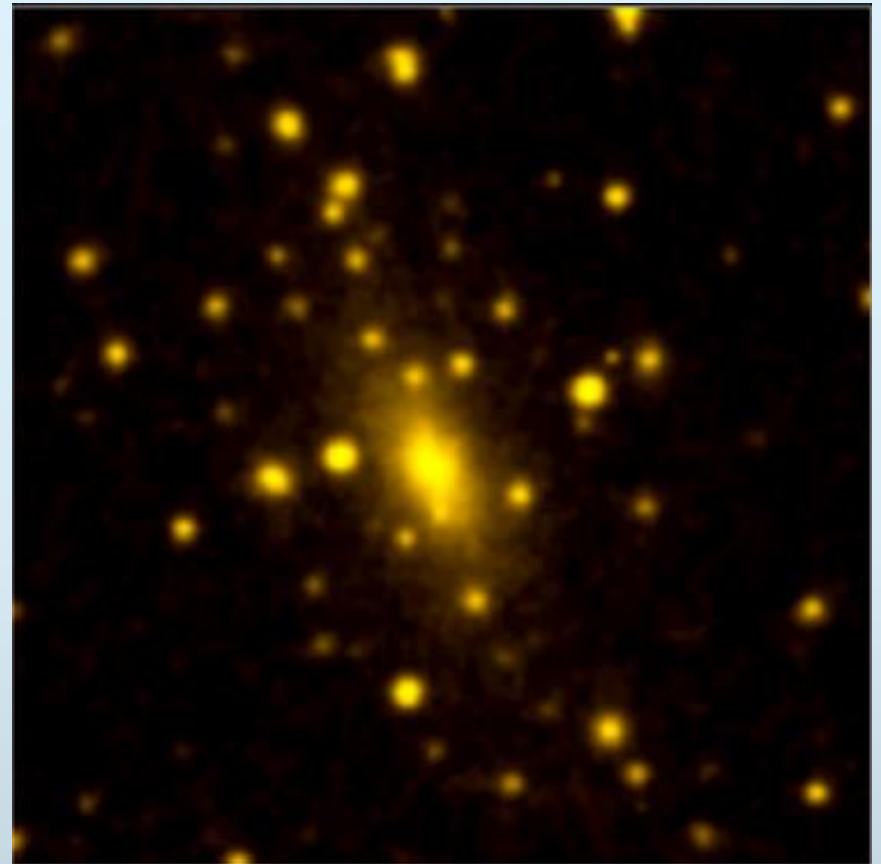
- **Chandra discoveries have impacted our understanding of *all* classes of astronomical objects**
 - Planets and comets
 - Stars
 - Supernova remnants
 - Compact objects (white dwarfs, neutron stars, black holes)
 - Galaxies and their constituents
 - Active galaxies
 - Clusters of galaxies
 - Unidentified objects!
 - **Chandra's impact on all areas of astronomy and astrophysics exceeds all of our expectations**
 - Insights into Dark Matter
 - Measurements of cosmological parameters
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The Atmosphere is a Nuisance



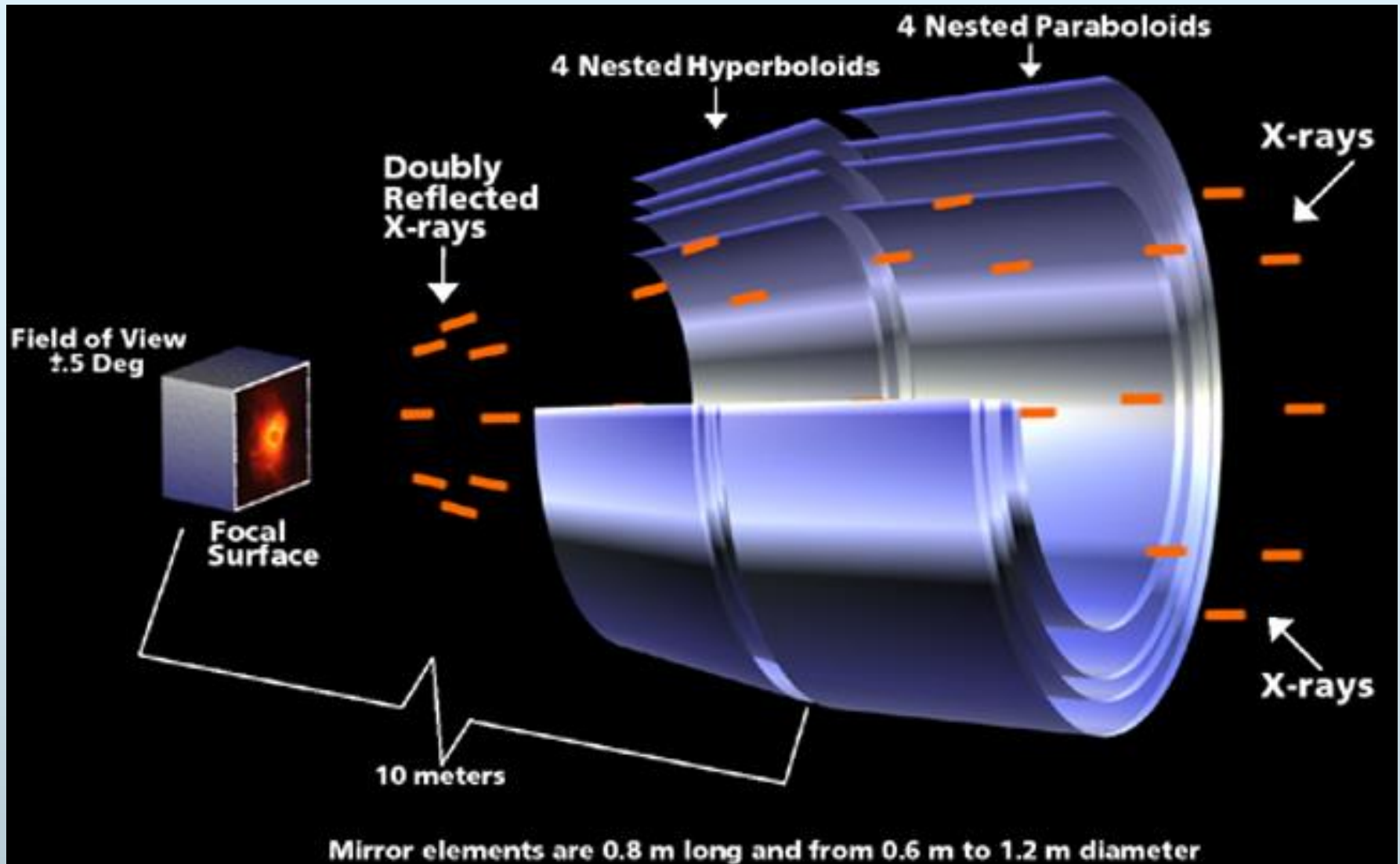
Altitude (km)

The Importance of X-Ray Astronomy

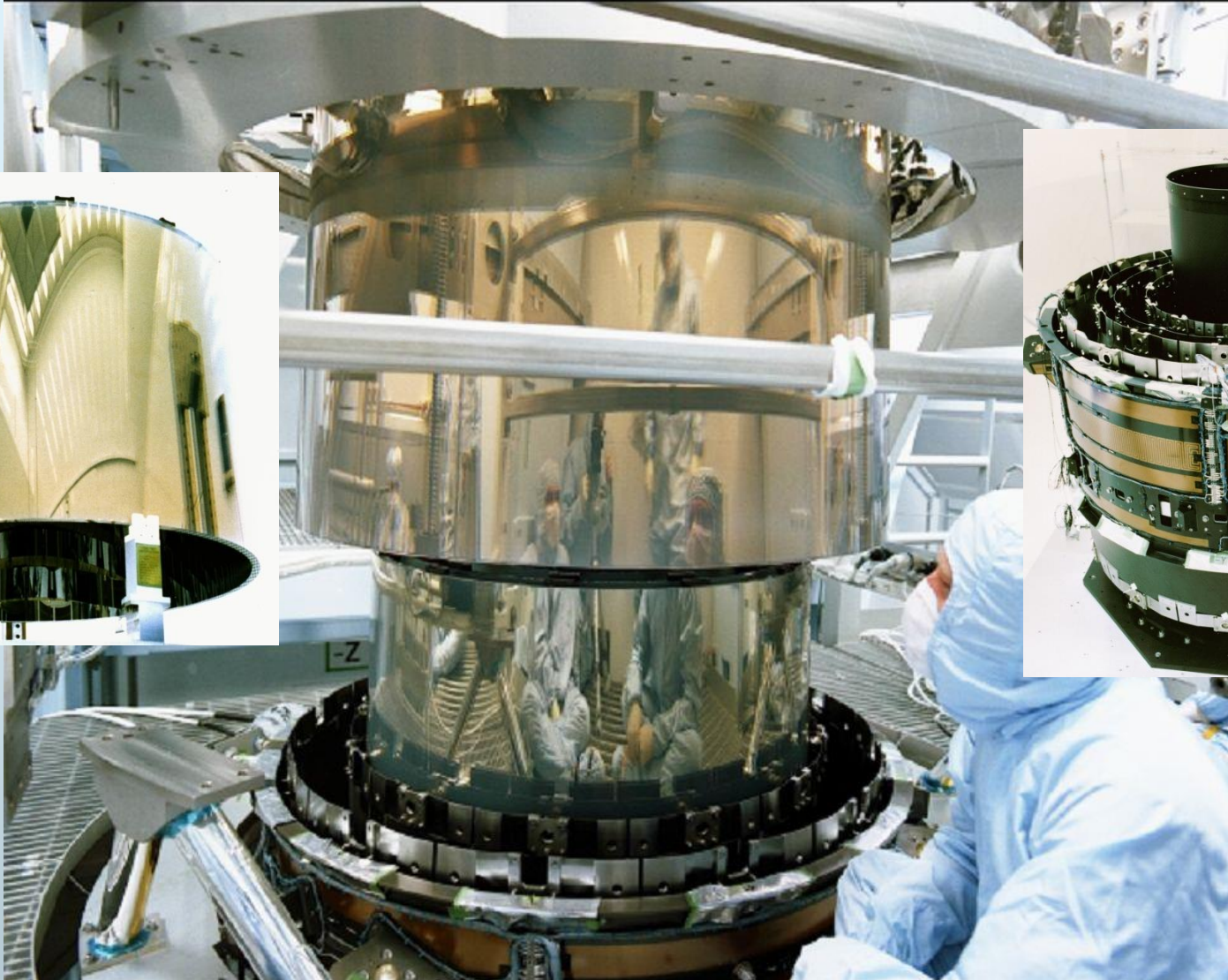


- Most of the matter that we “see” in the universe is via its X-ray emission
 - The bulk of this matter is the hot, X-ray-emitting gas in the great galaxy clusters
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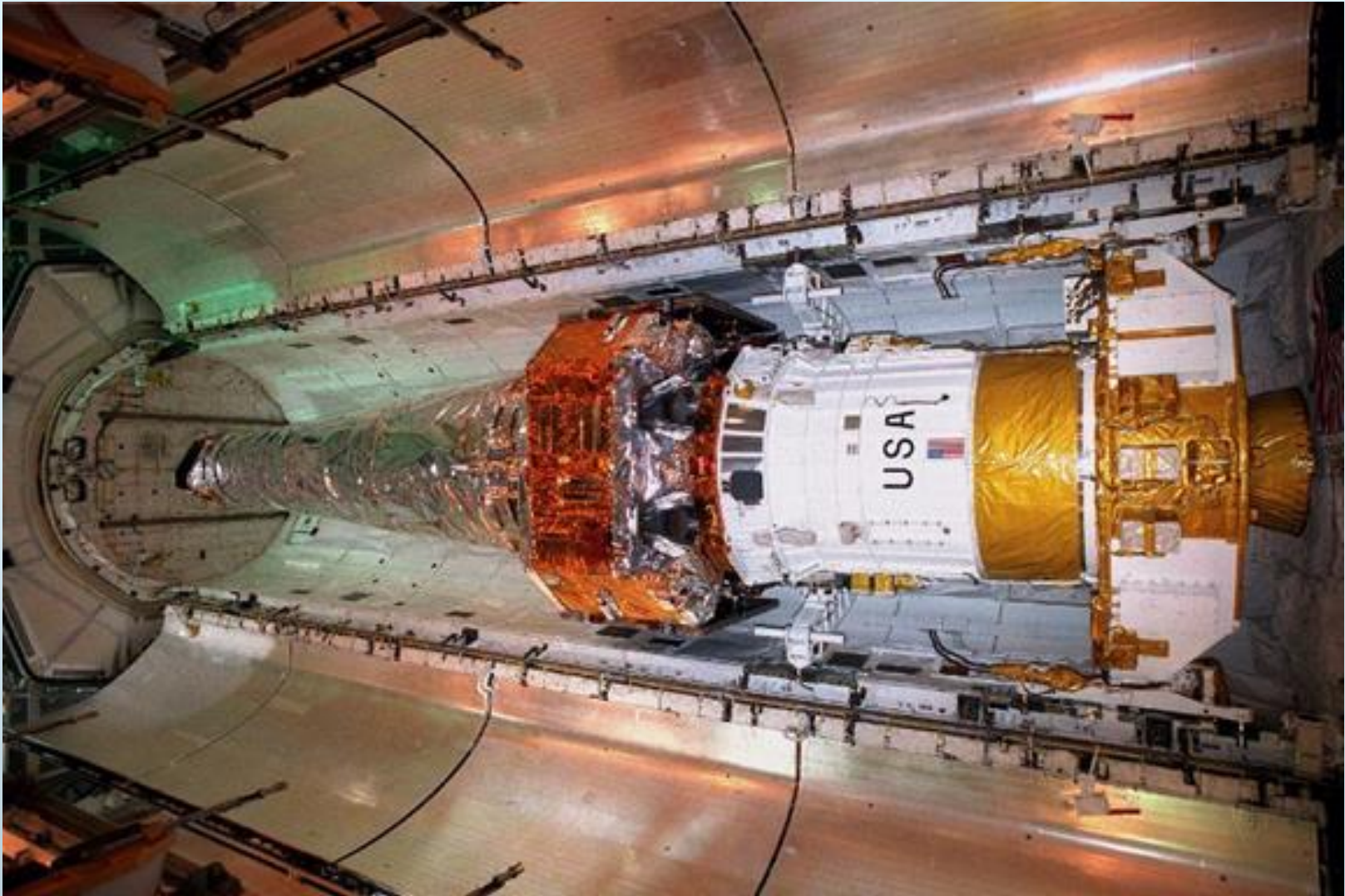
Focusing X-rays



The Optics



Chandra with Upper Stage in the Cargo Bay



- The longest and heaviest payload ever launched by the Shuttle

The Launch July 23, 1999

- **Beyond the Sky: Words and Music by Judy Collins**

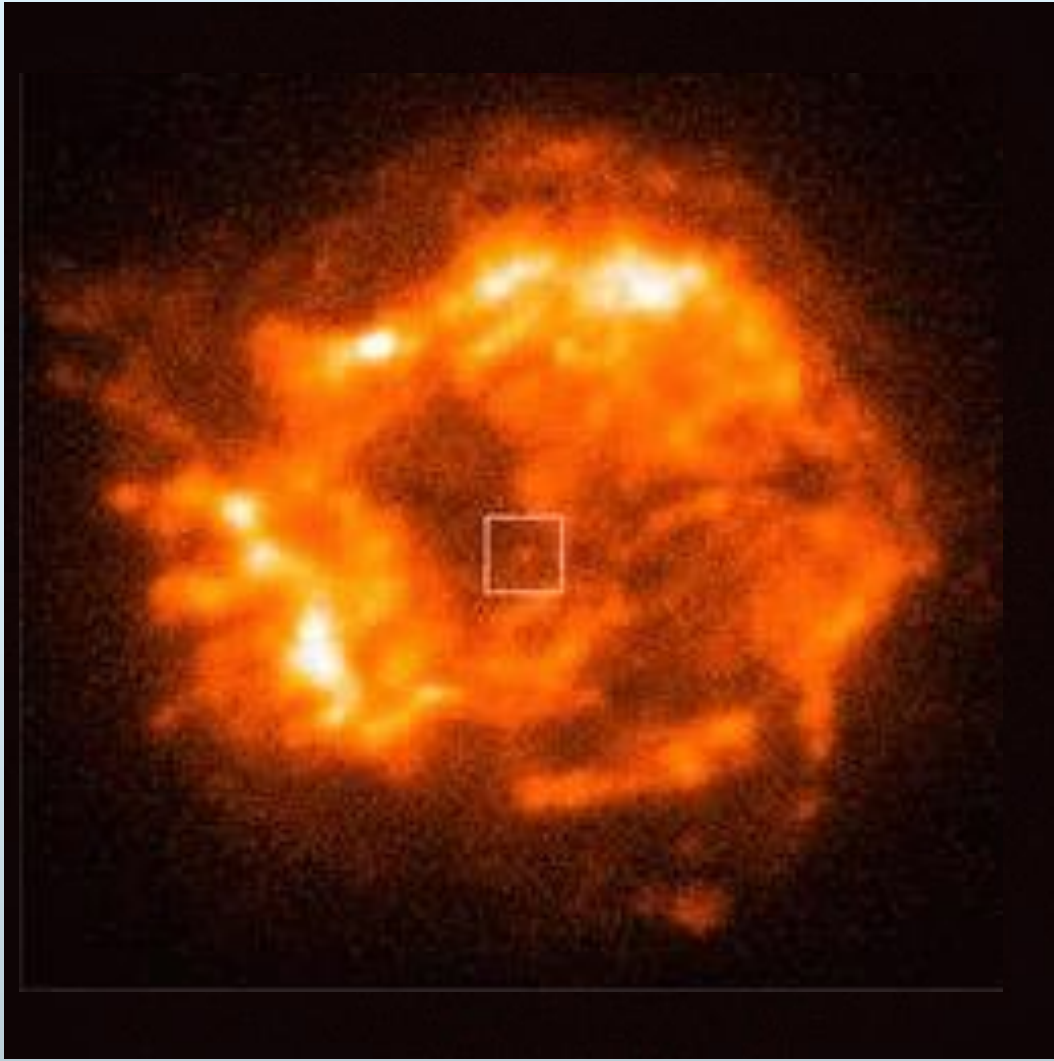
**“And we will fly beyond the sky
Beyond the stars beyond the heavens
Beyond the dawn we'll carry on
Until our dreams have all come true
To those who fly - we sing to you”**



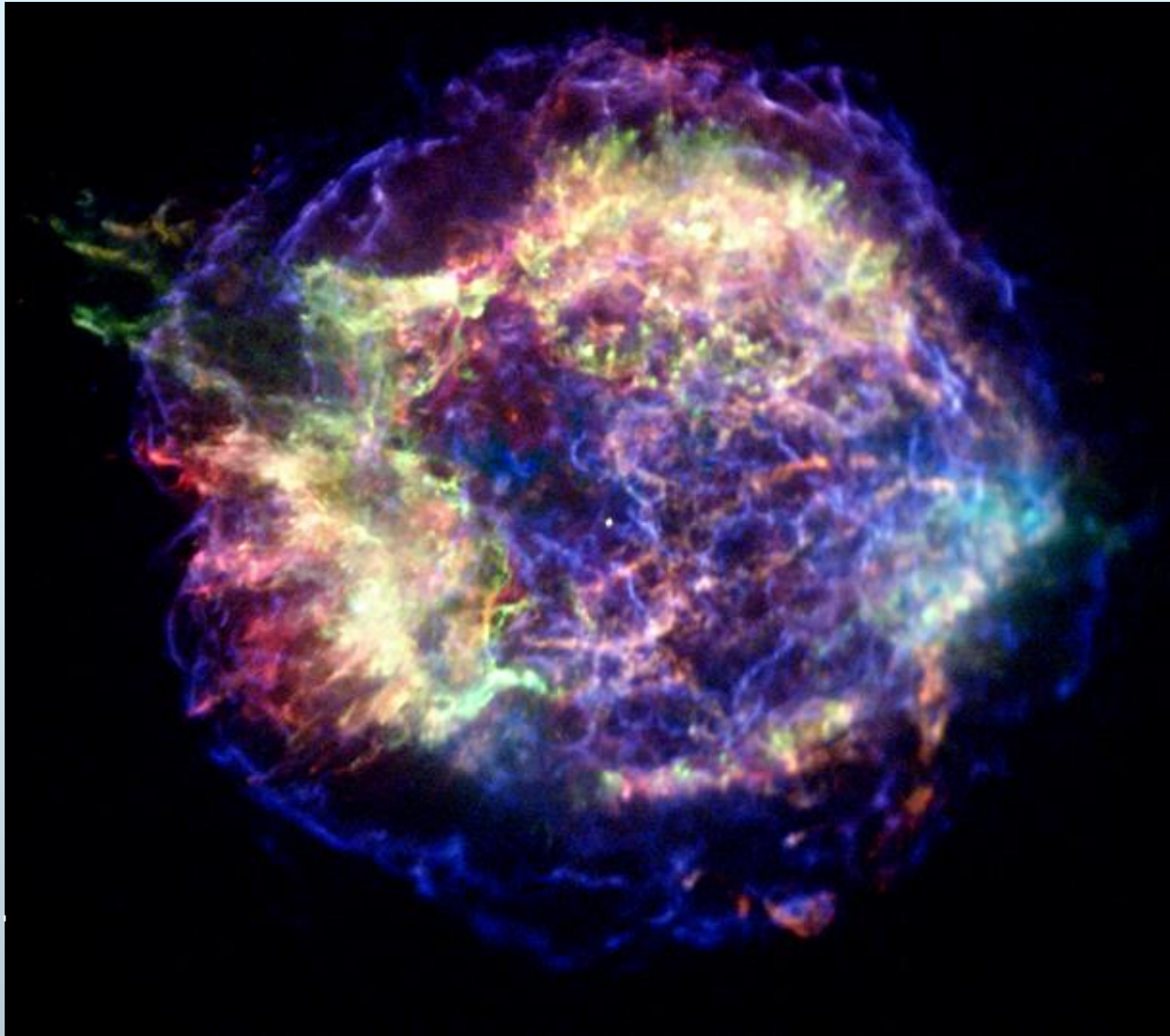
On orbit in Columbia's Cargo Bay



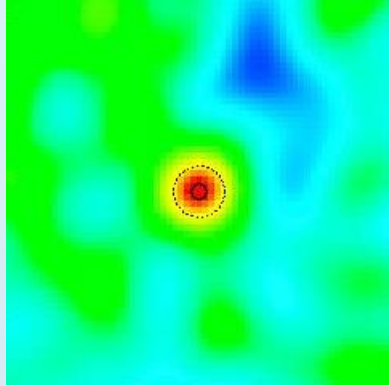
First Light – CAS A an Exploded Star



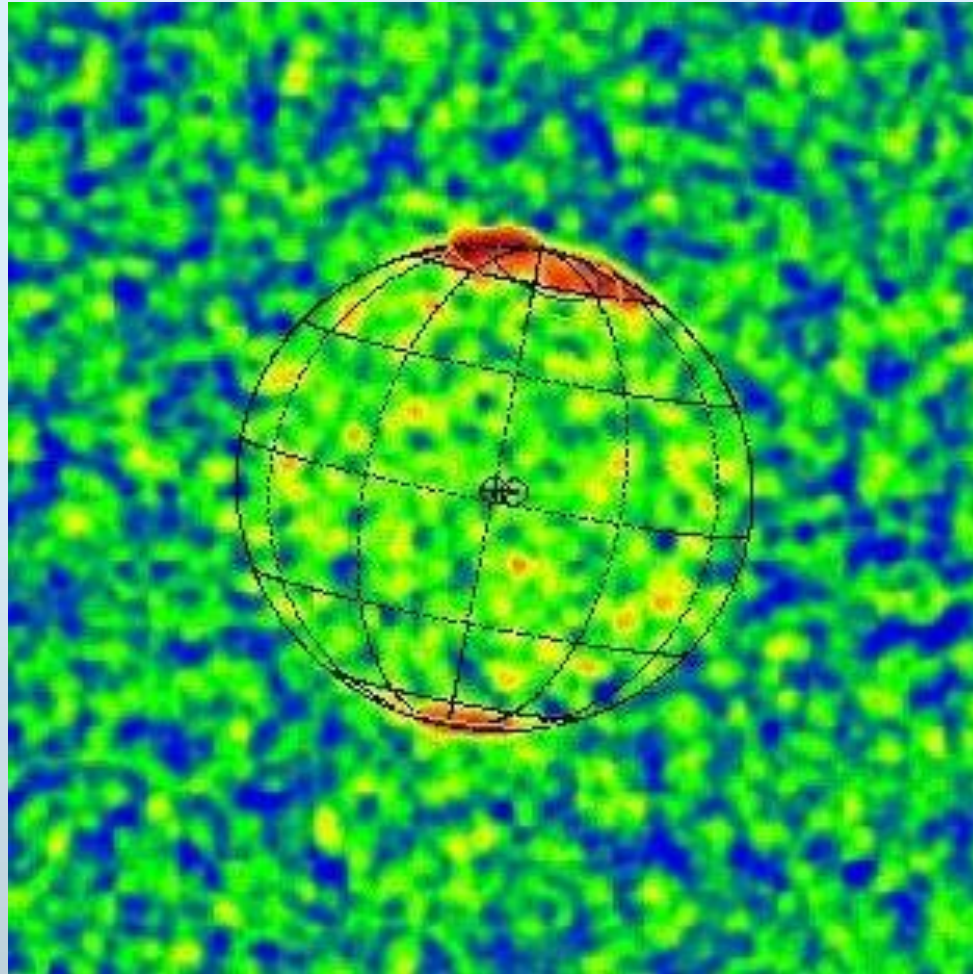
CAS A – The Chemical Composition



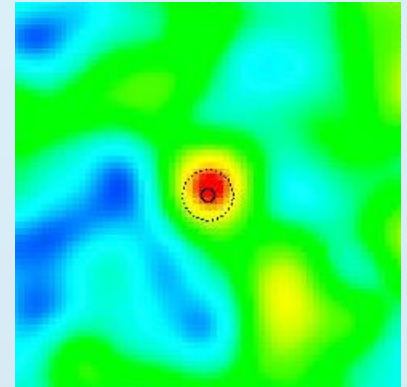
Planets and Their Moons



Io

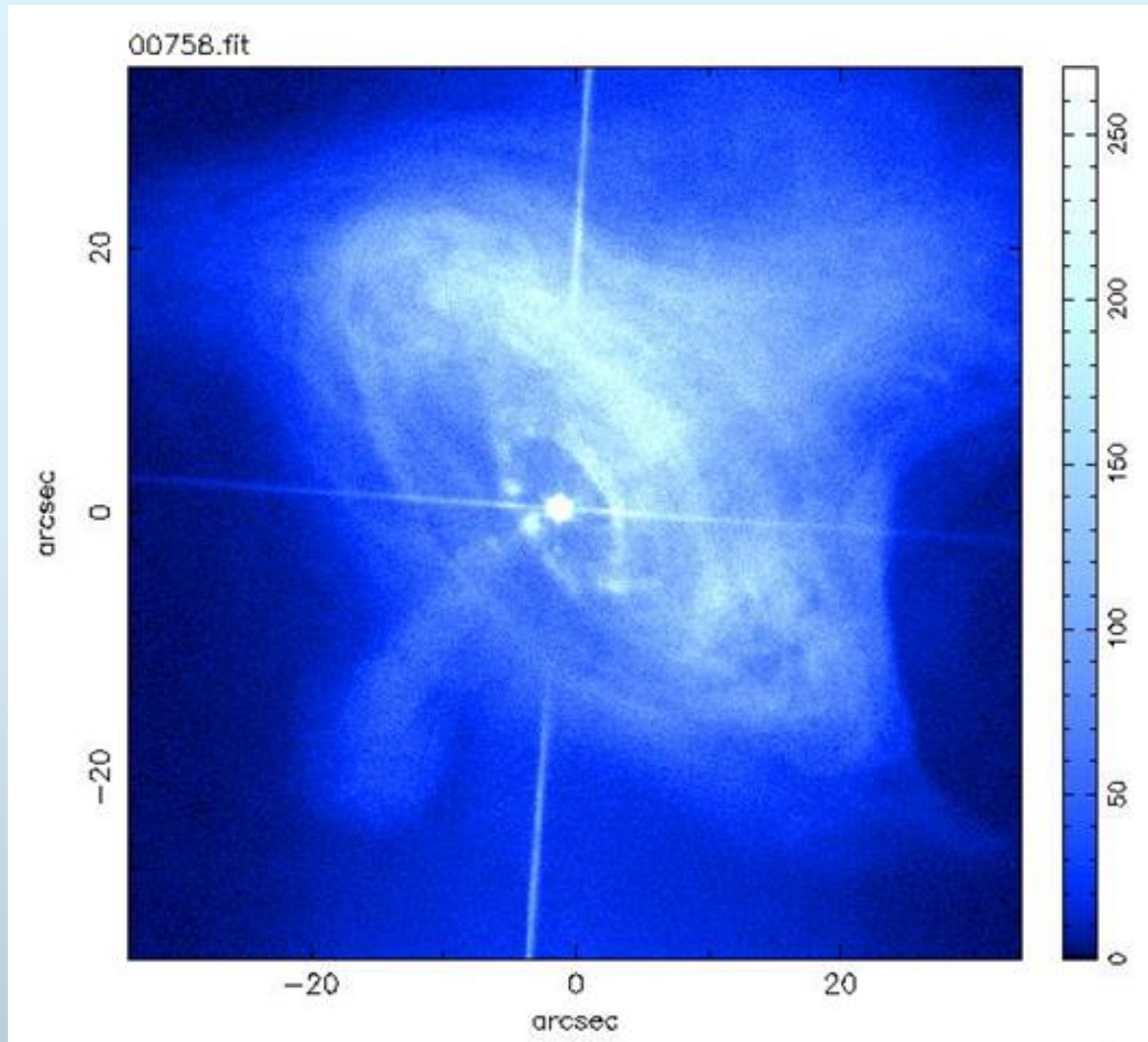


Jupiter

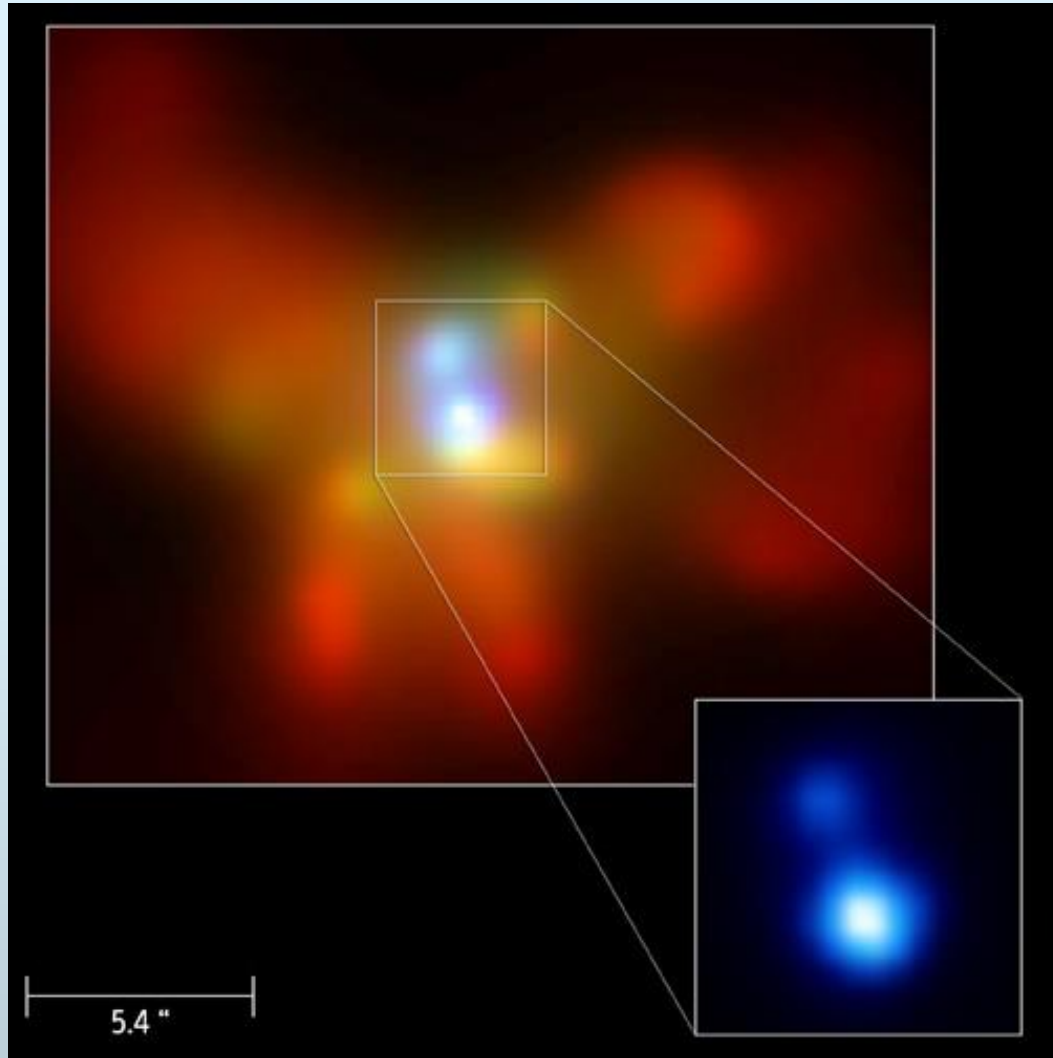


Europa

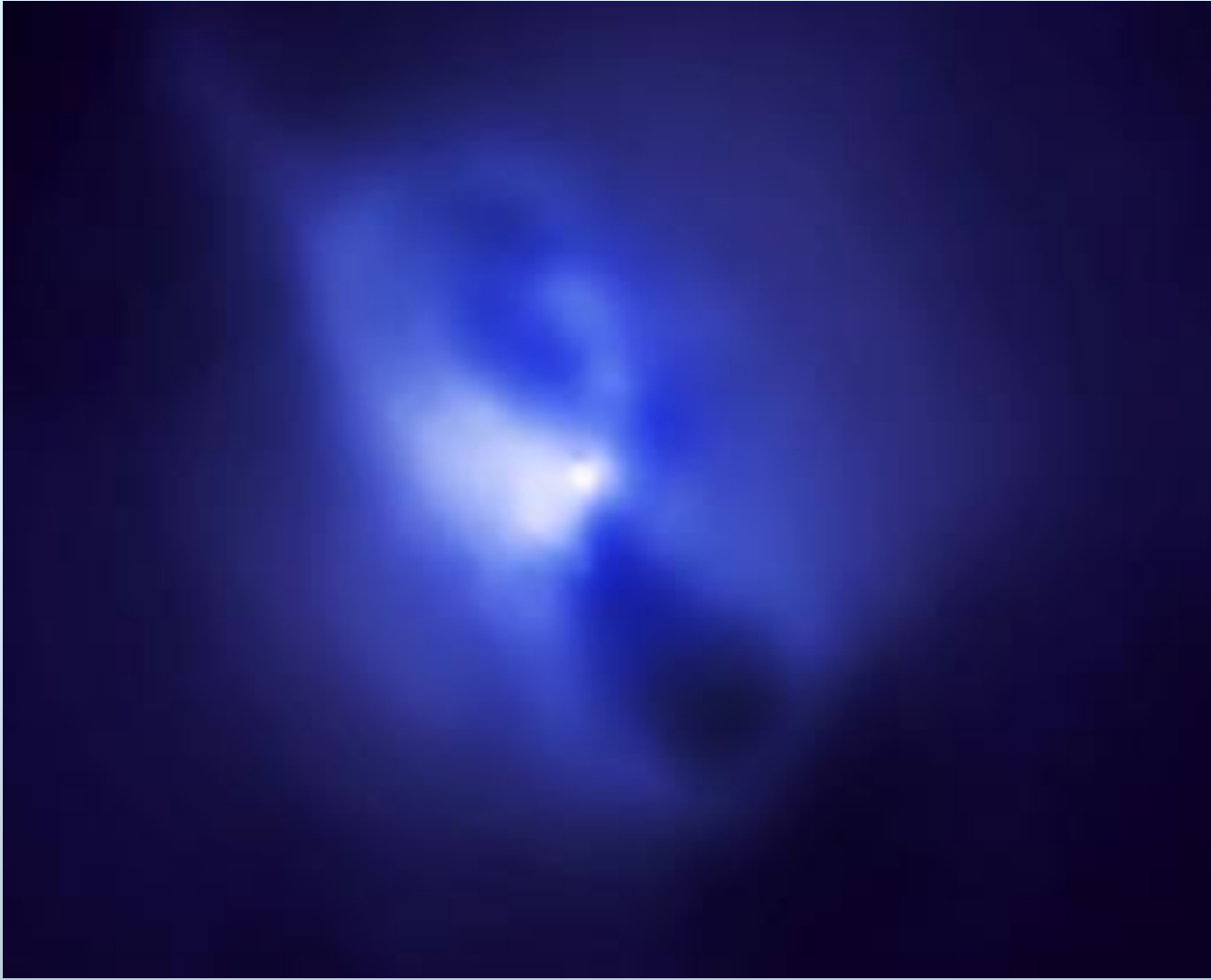
The Crab Nebula and its Pulsar



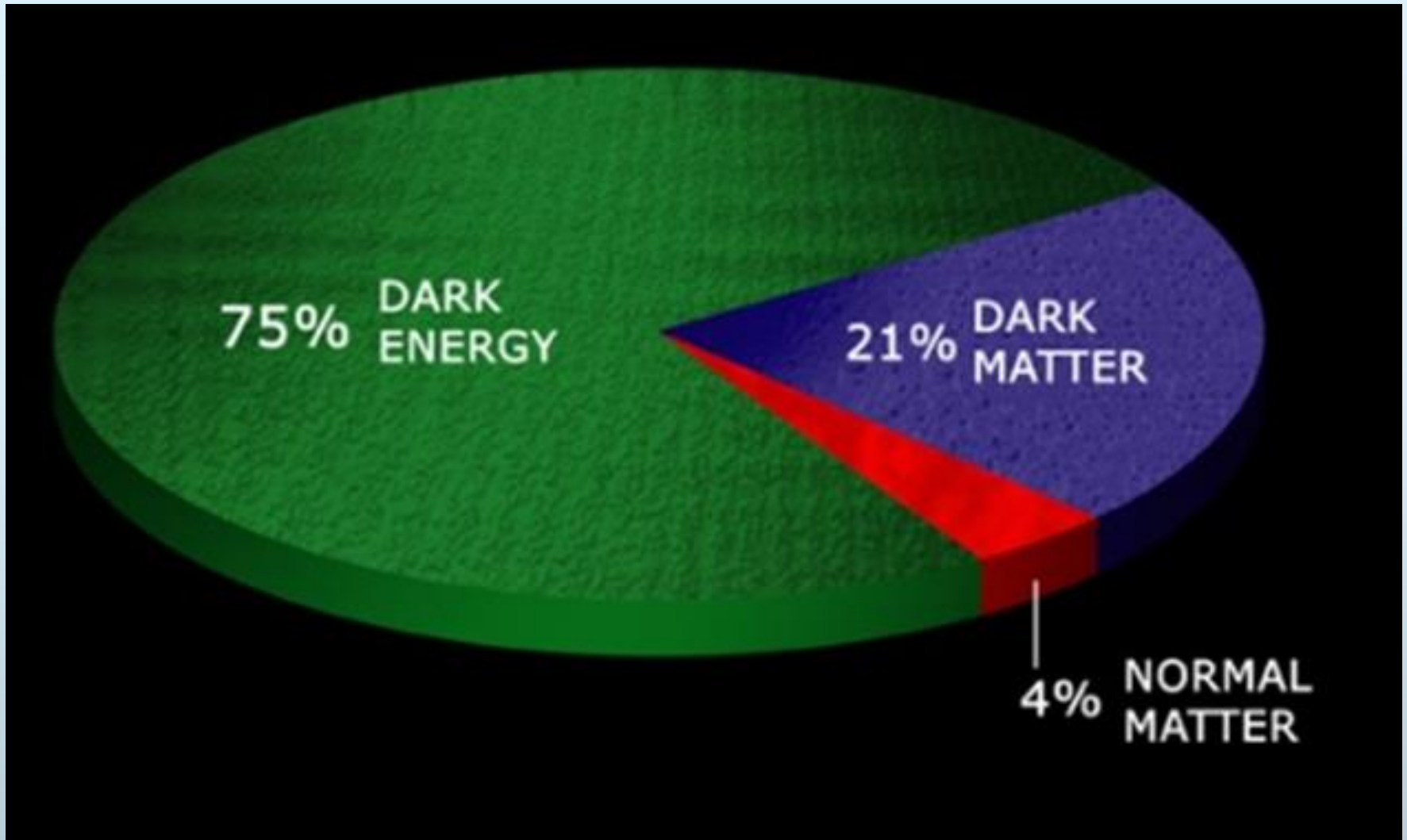
Two Supermassive Black Holes



Cosmic Feedback



Dark Matter and Dark Energy



Dark Matter – Galaxy Clusters in Collision

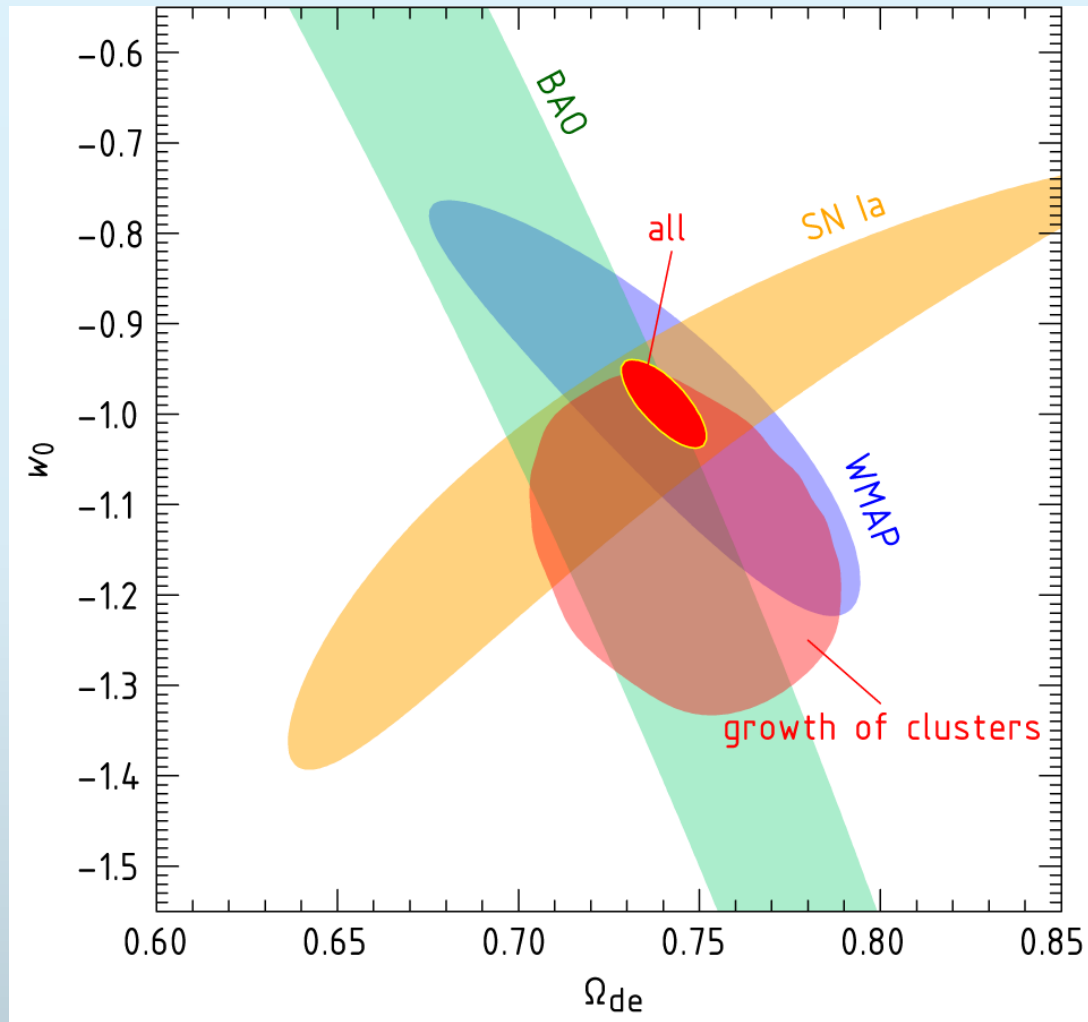


- X-ray data (pink) highlight the normal matter
- Optical data (blue) highlights total (normal+dark)

Dark Energy – Stifles Growth of the Galaxy Clusters

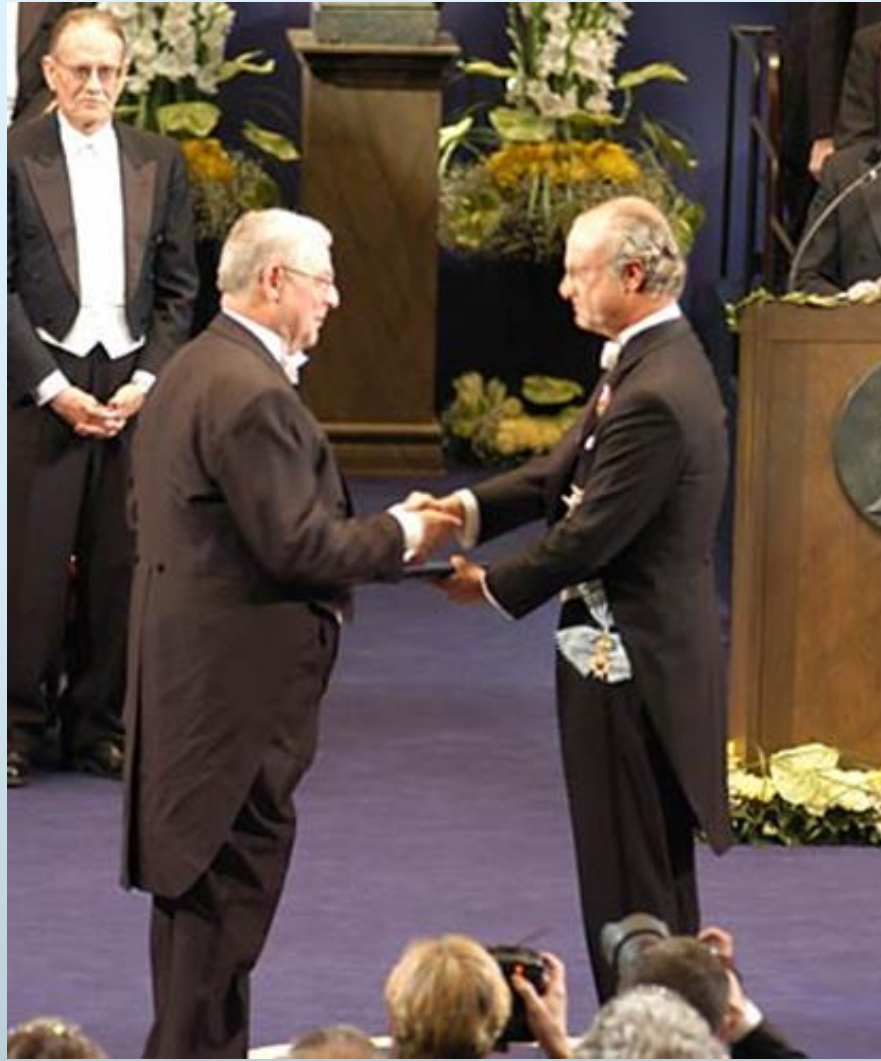


Constraining Cosmological Models

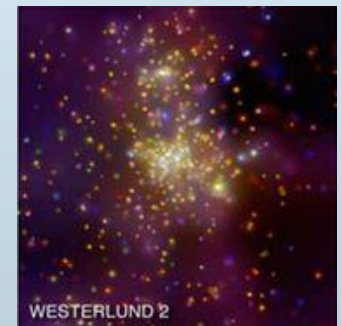
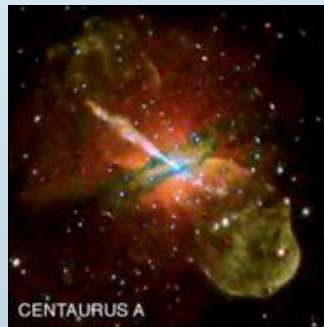
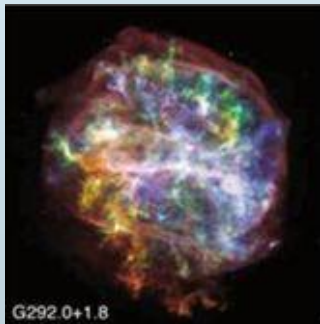
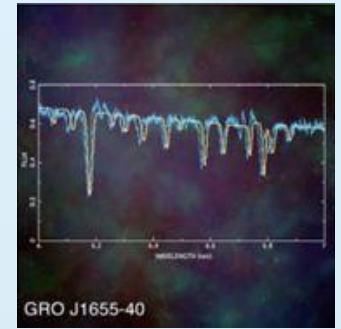
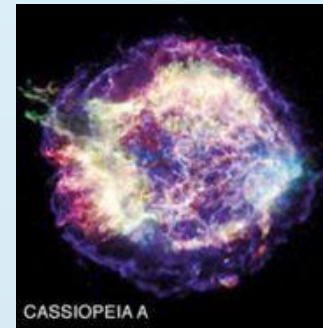
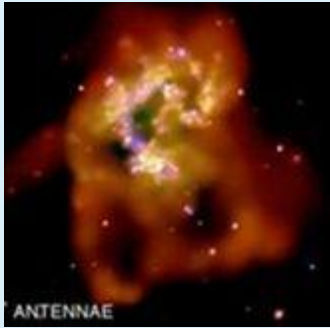


- Chandra measurements of the cluster mass function constrain cosmological parameters, gravity models, and neutrino mass

2002 Nobel Prize to Riccardo Giacconi



<http://chandra.harvard.edu>



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