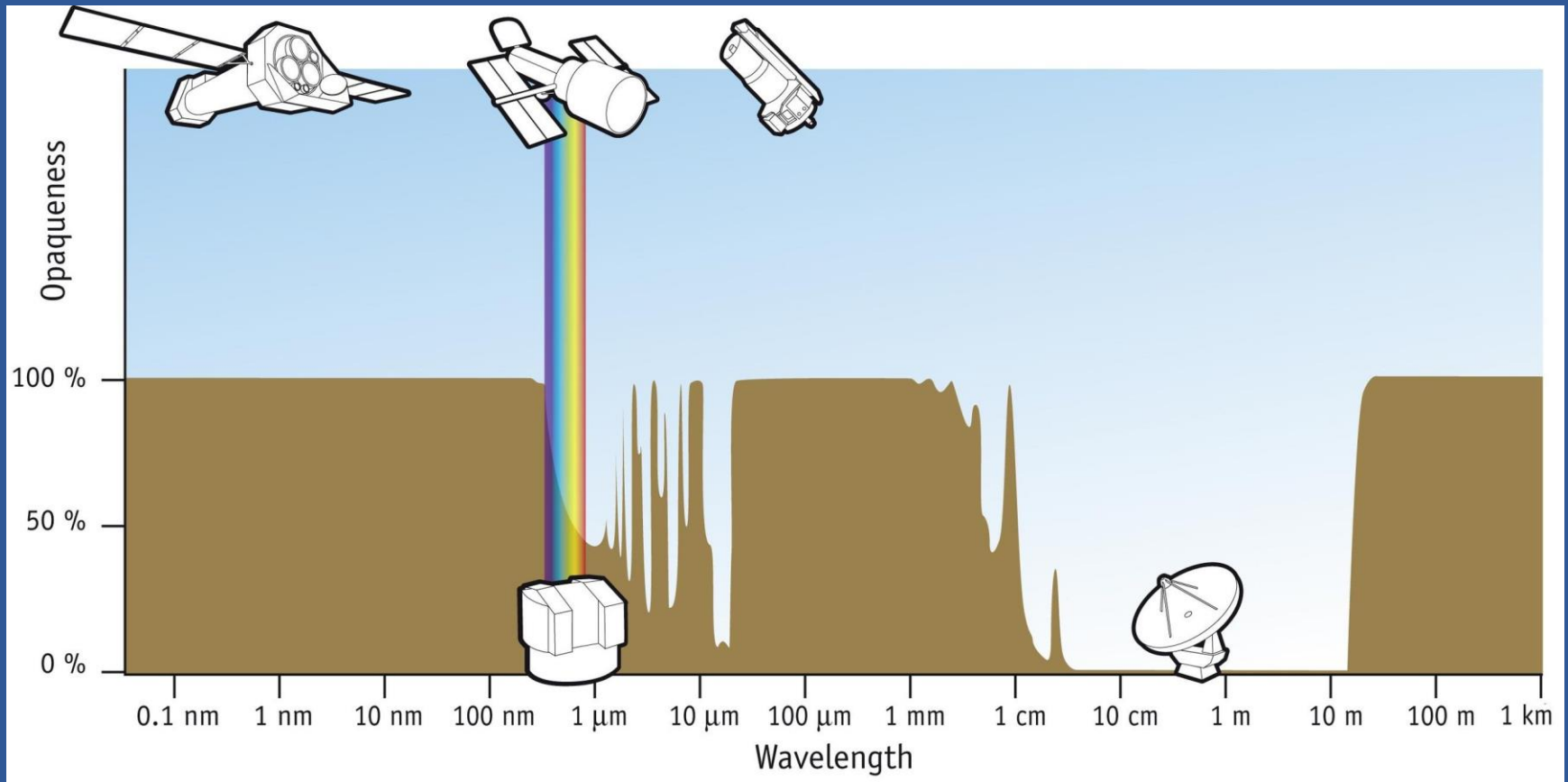


X-Ray Astronomy

Rick Dower
Boston QuarkNet Workshop
August 4, 2021

Celestial x-rays are blocked by Earth's atmosphere



V-2 Rocket

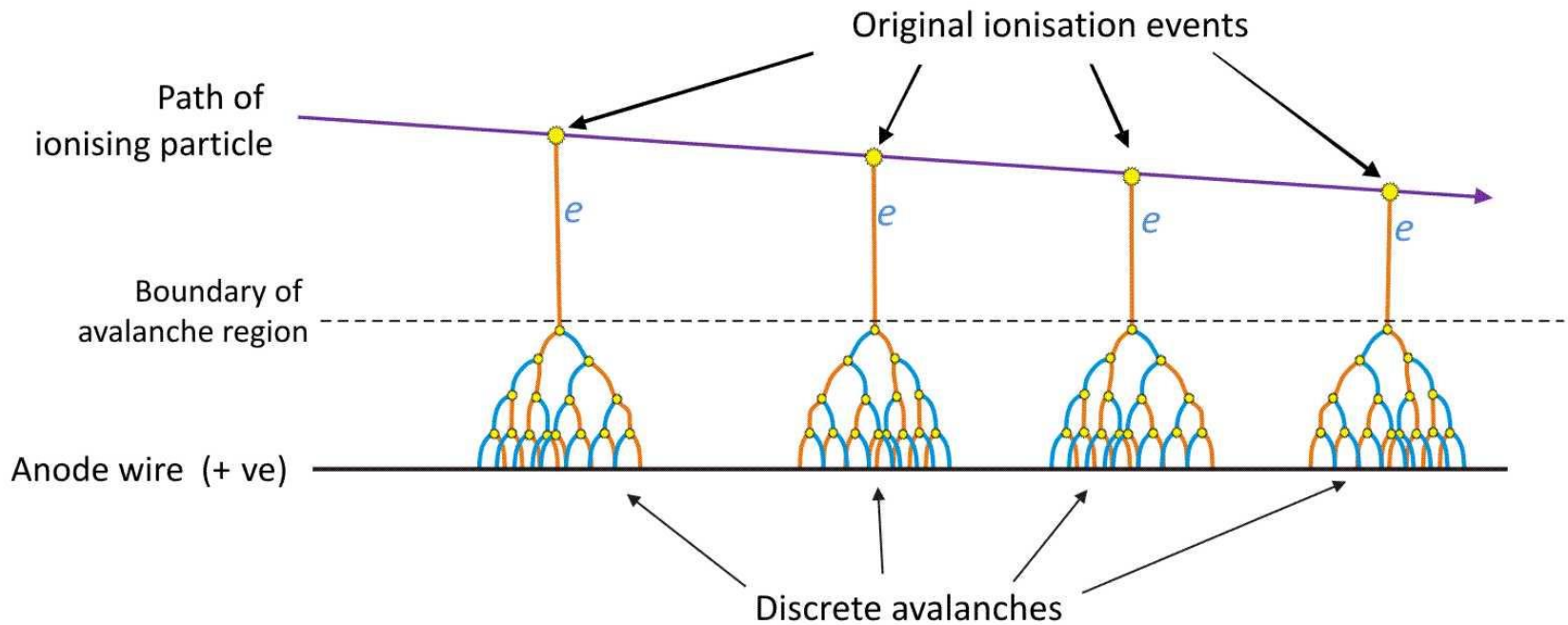


Aerobee Rockets of the type used to discover Scorpius X-1 in 1962



Proportional Counter

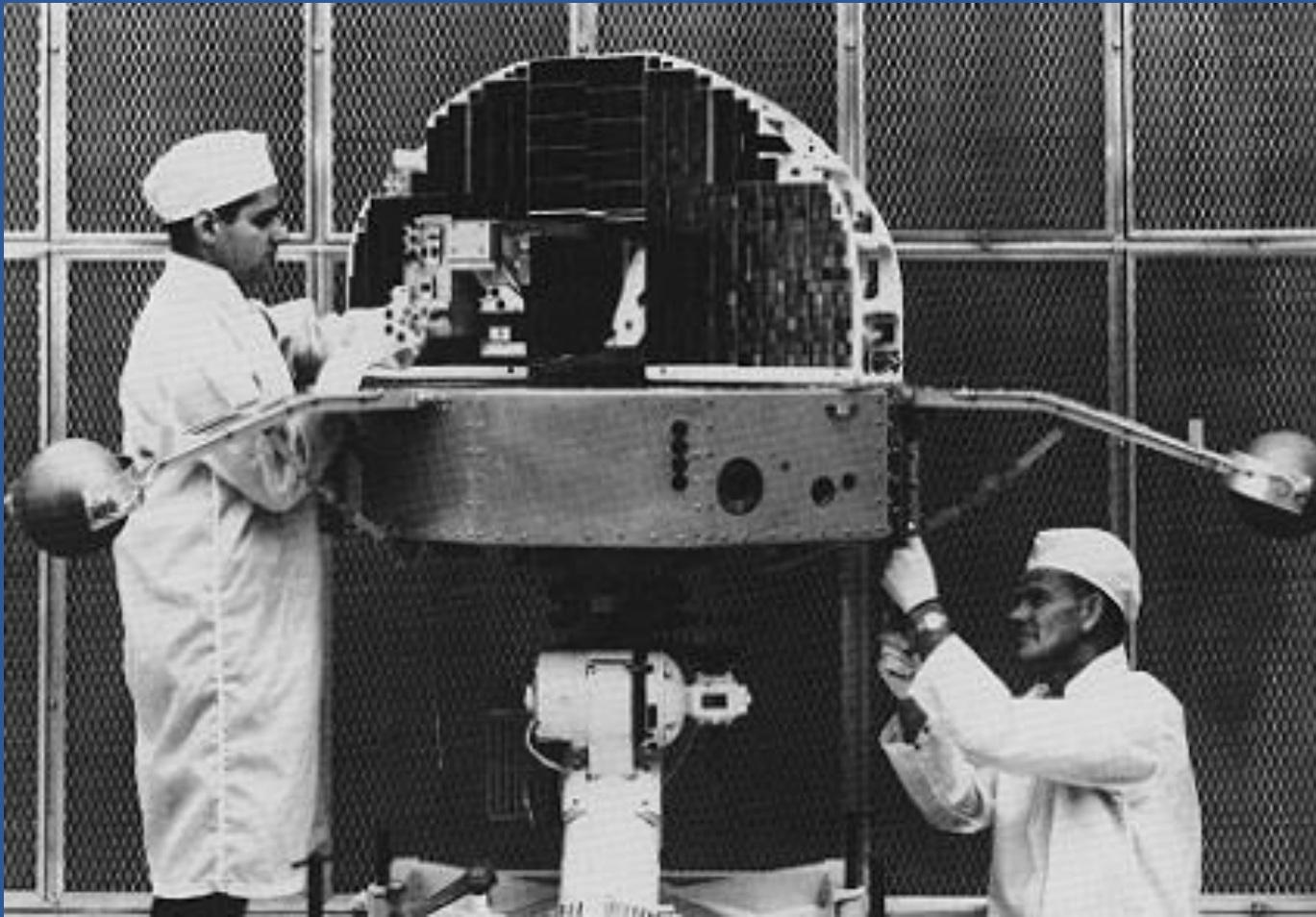
Creation of discrete avalanches in a proportional counter



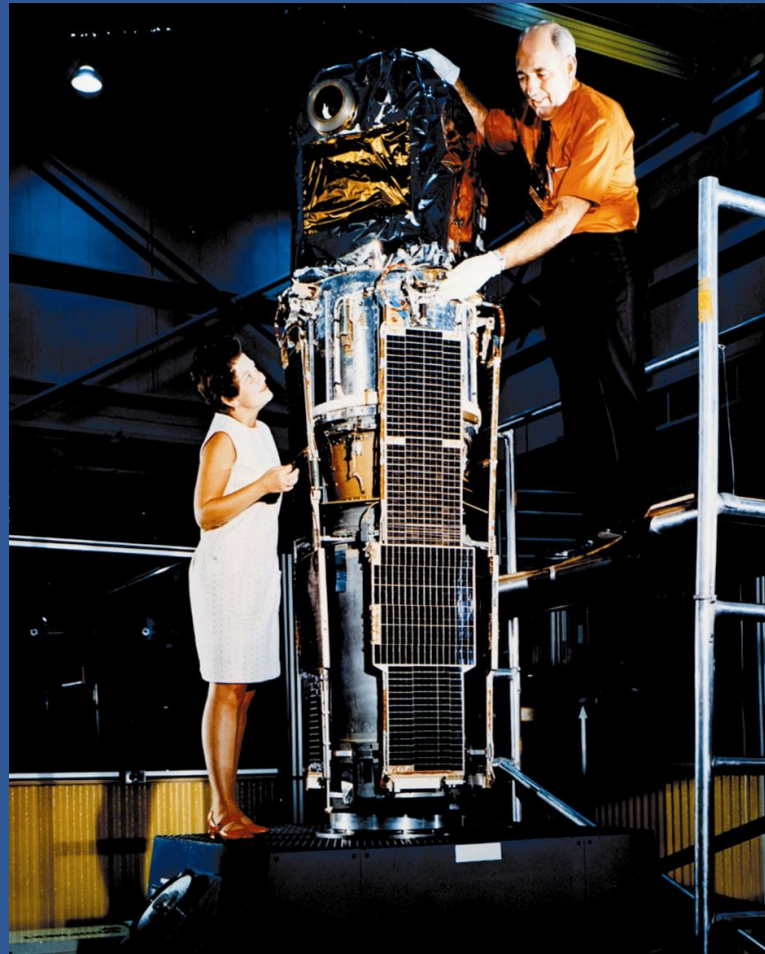
Balloon-borne Large Aperture Submillimeter Telescope (BLAST) launch - 2005



OSO 4 Solar UV – X-ray Satellite (1967-1971)



Bruno Rossi and Marjorie Townsend with SAS-1 “Uhuru” Satellite (1970-1973)

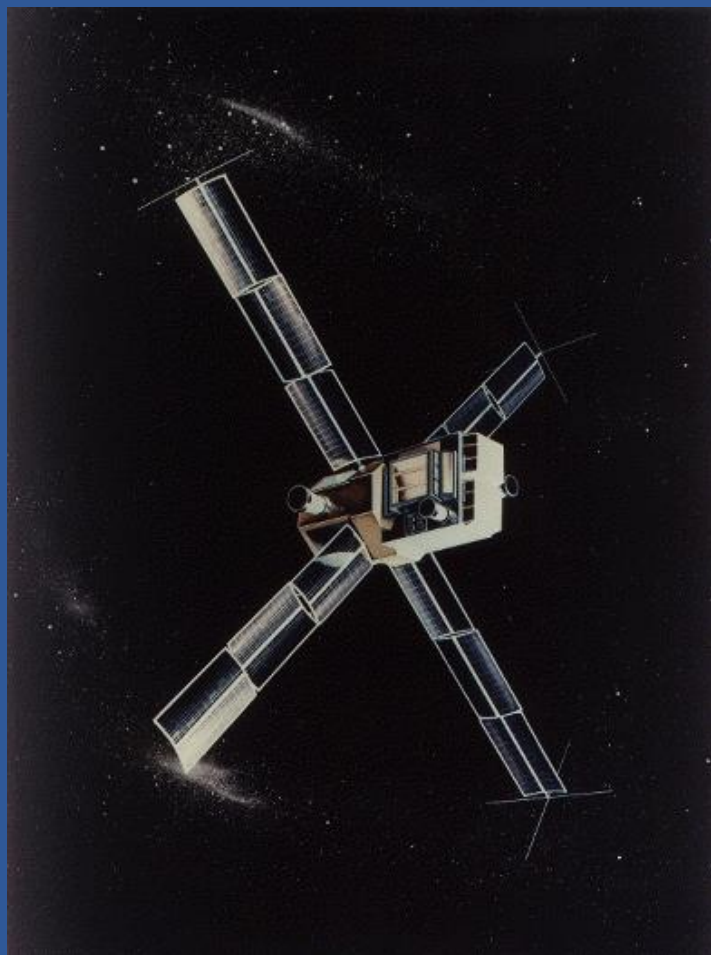


Riccardo Giacconi (1931-2018)

Nobel Prize in Physics 2002

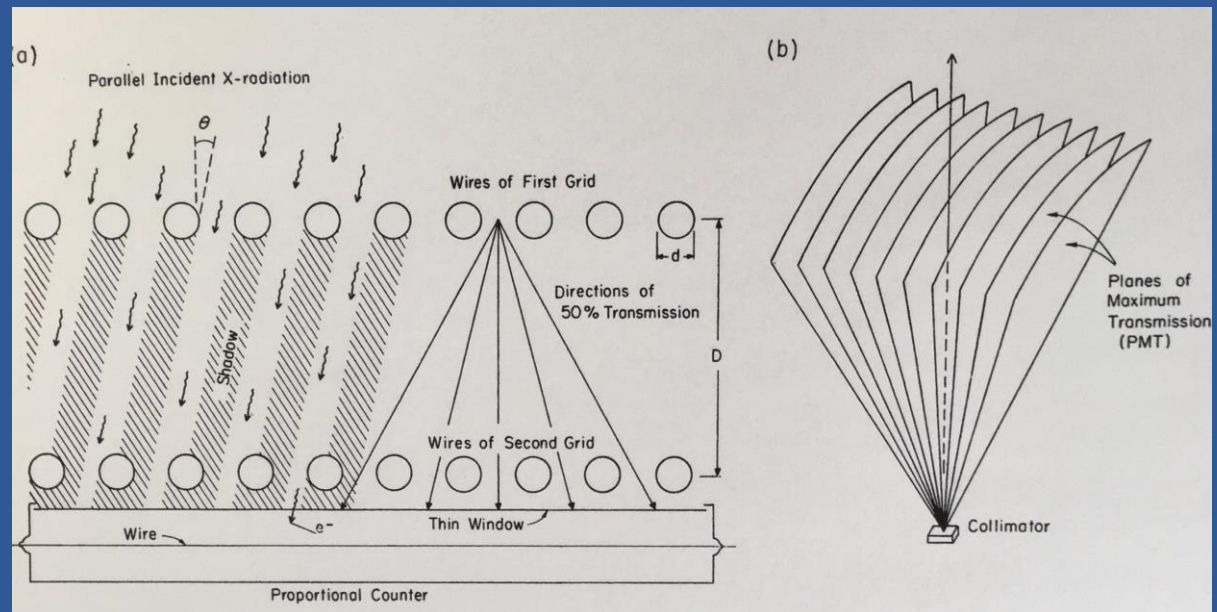


SAS-3 Satellite (1975-1979)

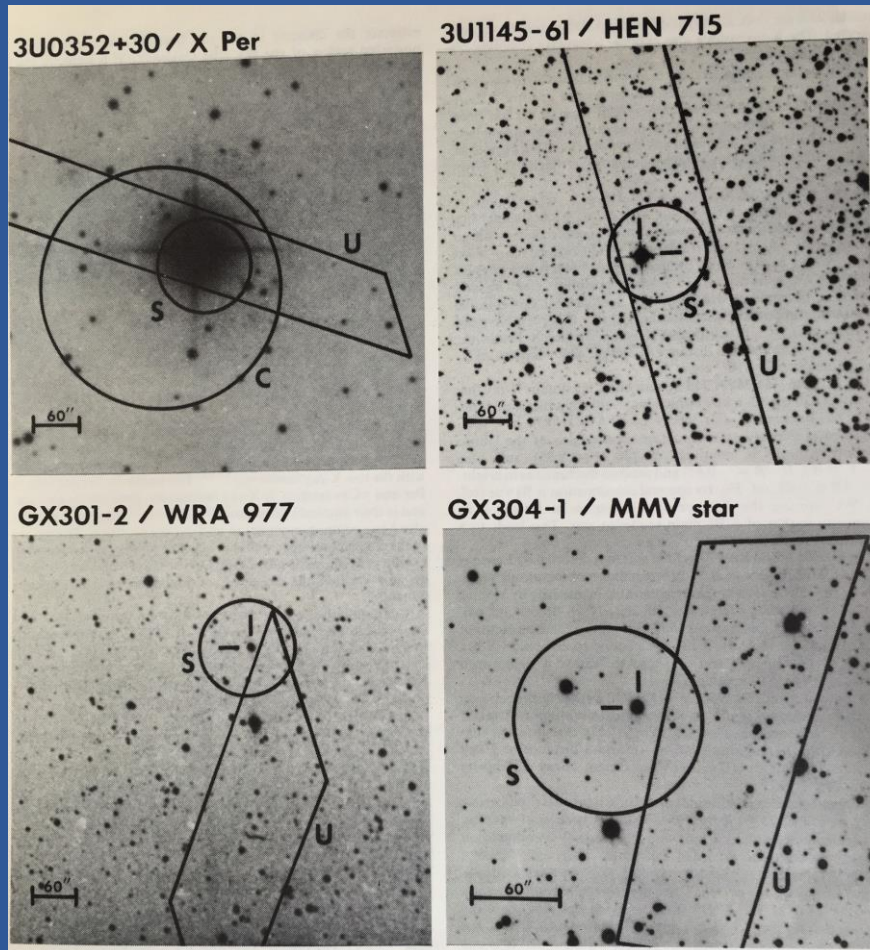


Position Location: Collimators

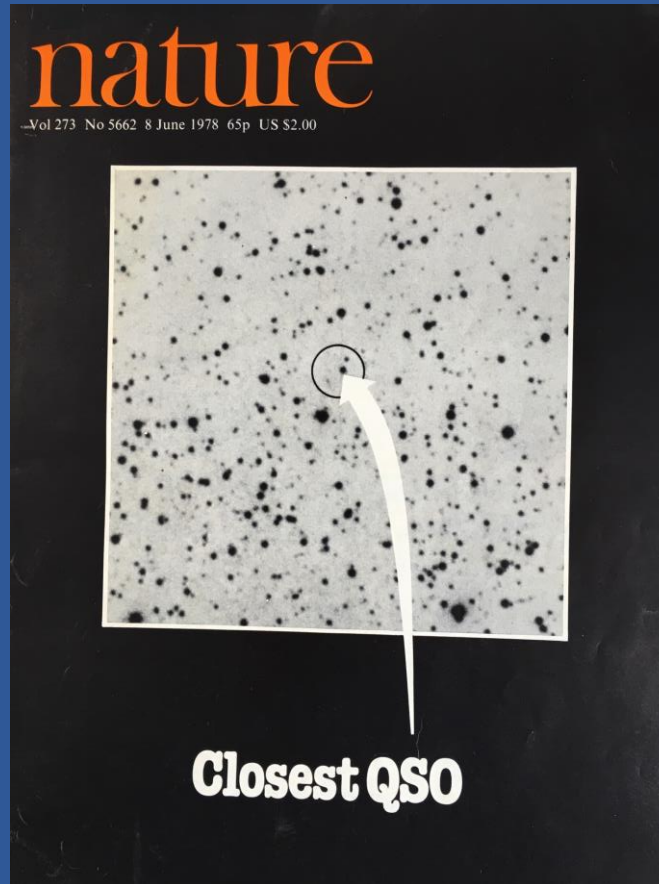
- Slats - blinders
- Tubes - straws
- Wire grids



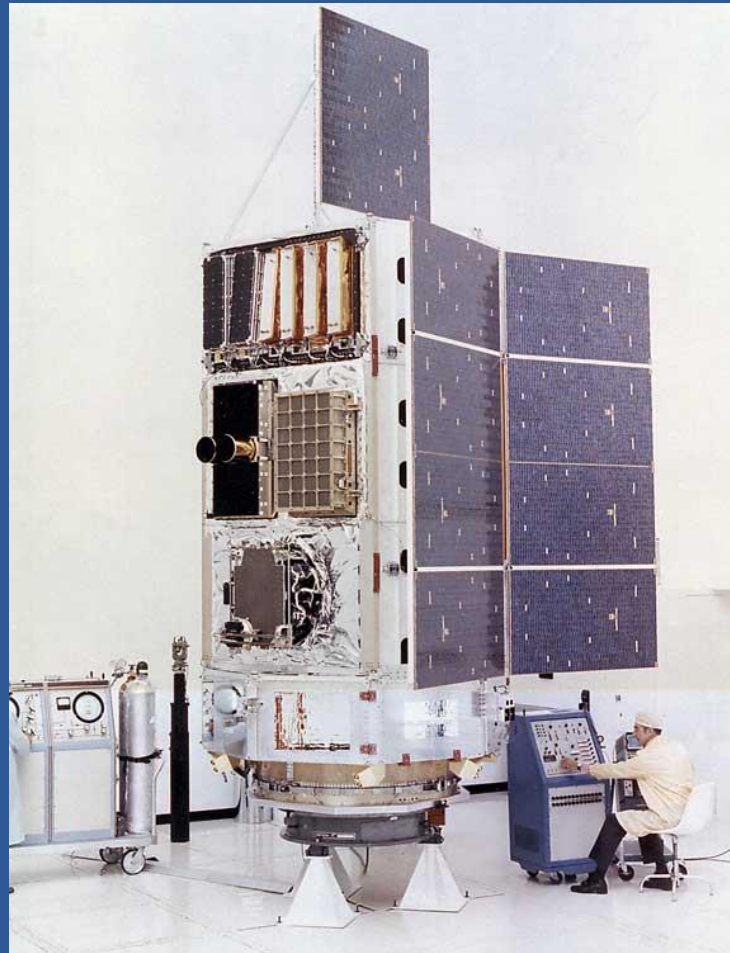
Error Boxes - Stars



Nearest Quasar



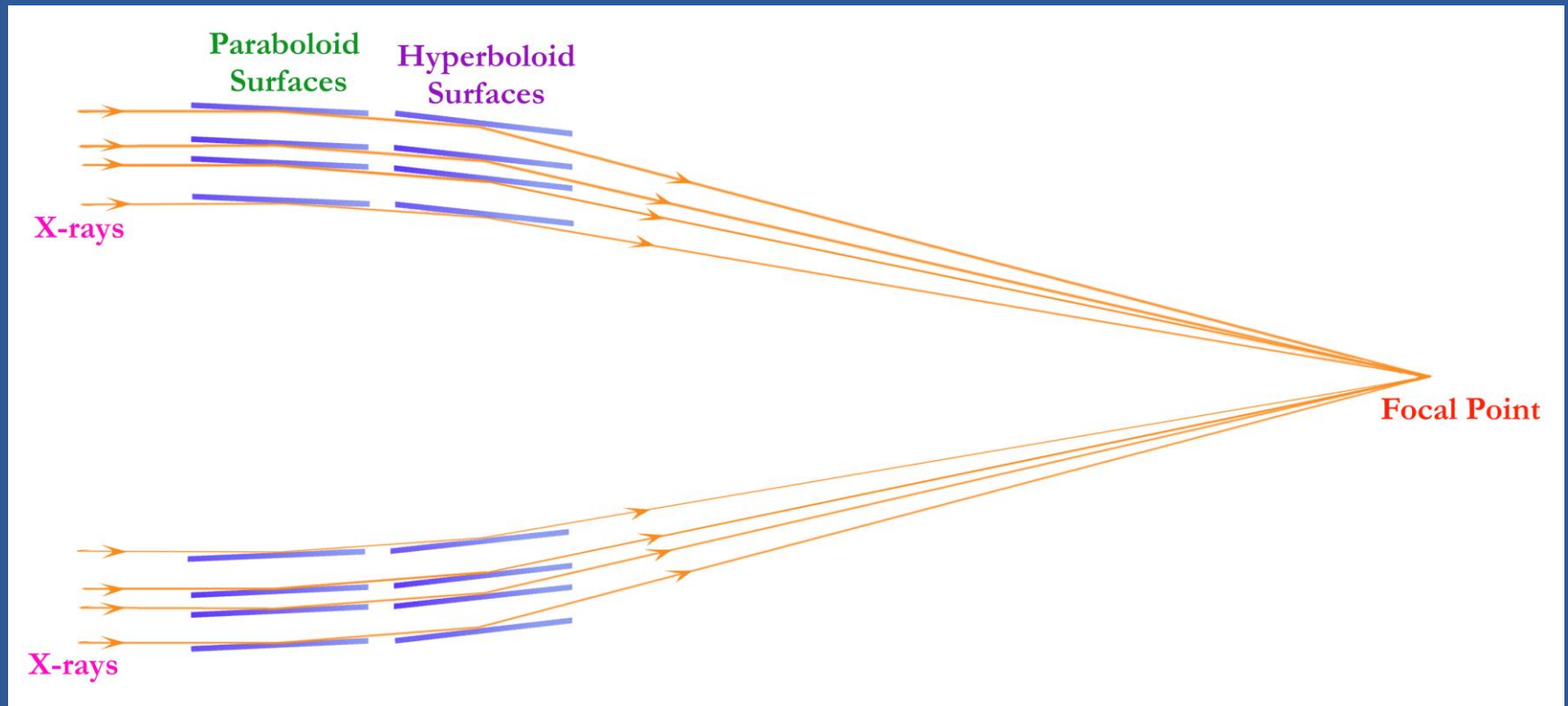
HEAO-1 (1977-1979)



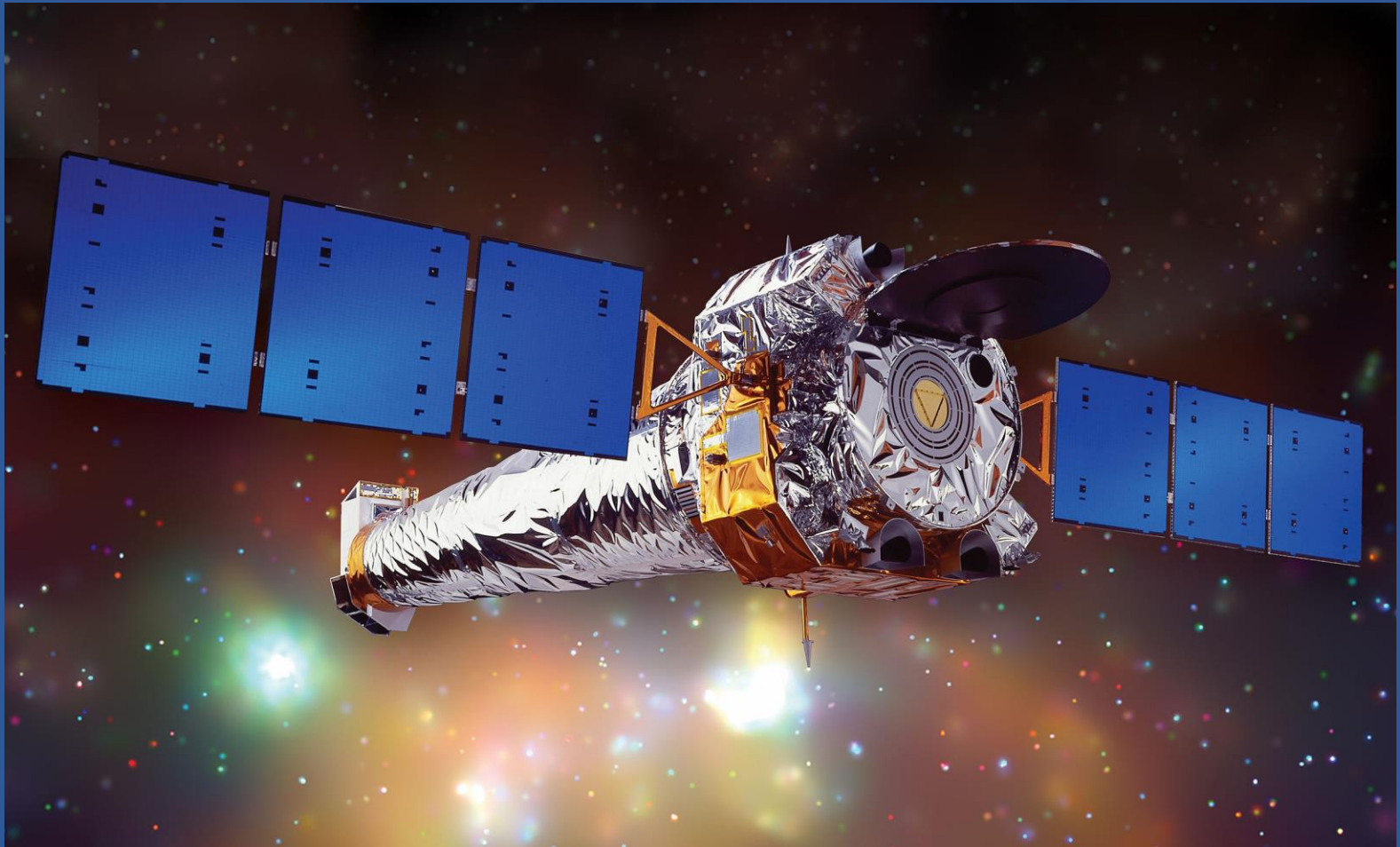
HEAO-2 "Einstein" (1978-1982)



Grazing Incidence X-ray Mirrors



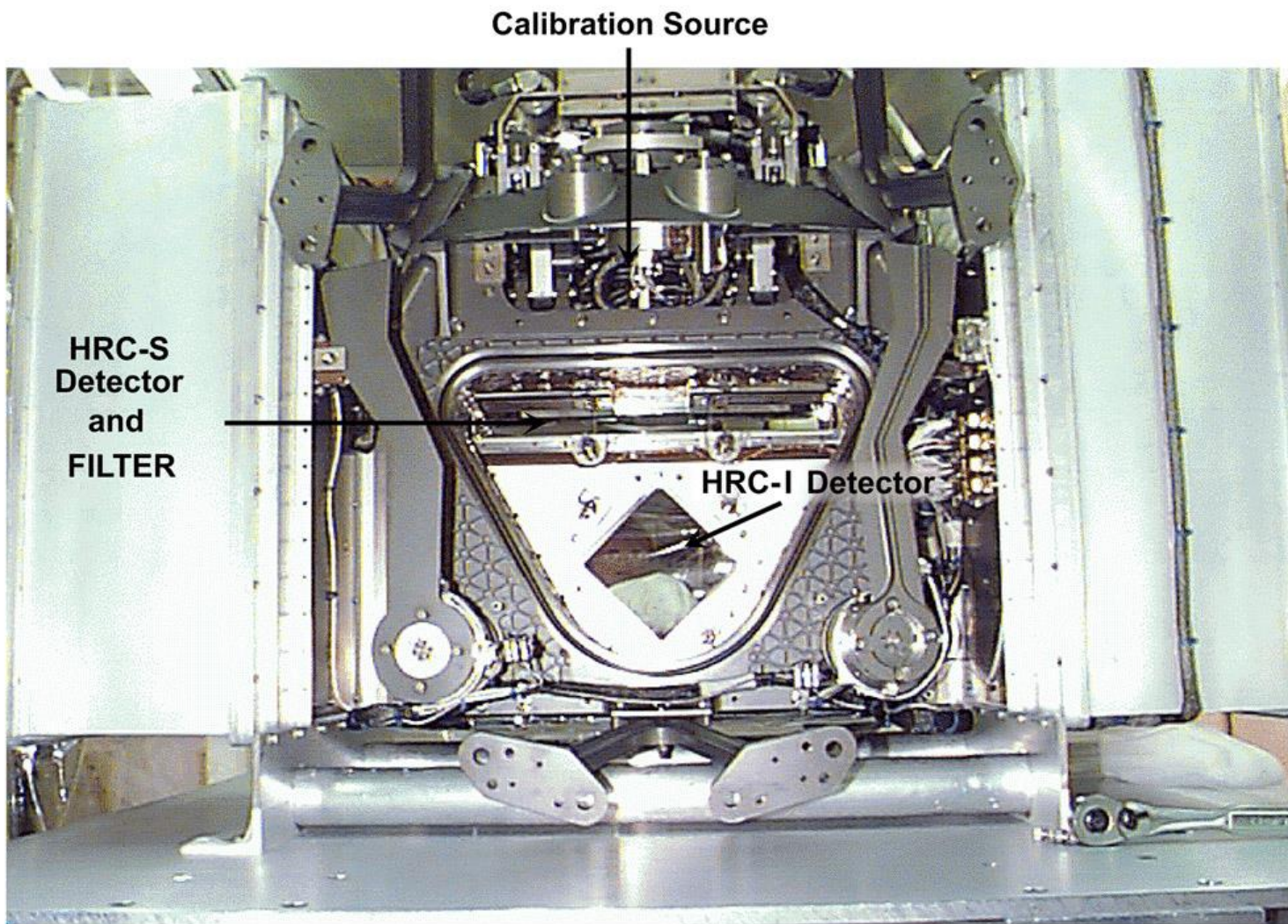
Chandra X-ray Observatory(1999 -)





Chandra X-ray Observatory

HRC Flight Unit

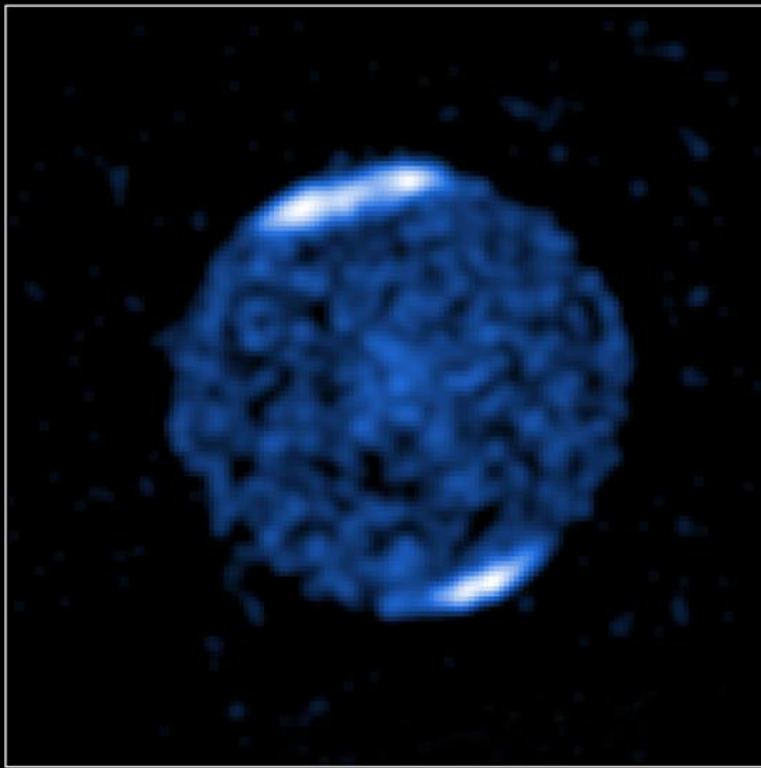


Looking into the HRC Vacuum Housing

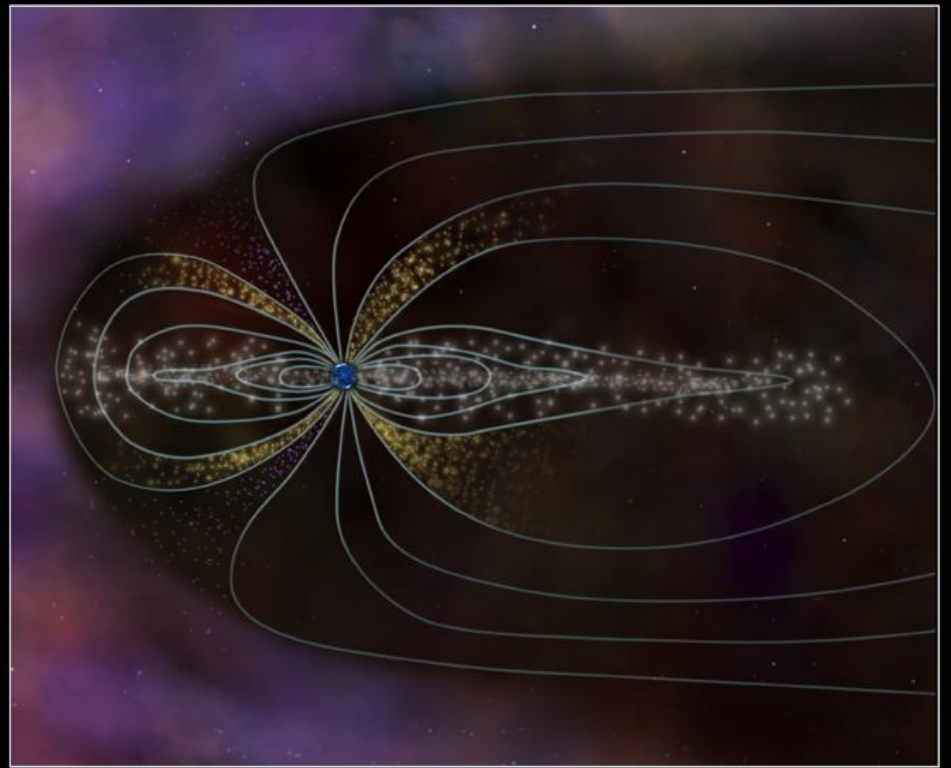
Celestial X-ray Production

- X-ray production requires high energy particles, e.g.
- Hot gases (10^6 K) in stellar coronas, as in the Sun,
- Hot gases in expanding supernova remnants,
- Hot gases in accretion disks around white dwarfs, neutron stars, or black holes,
- Hot gases between galaxies in clusters,
- Electrons spinning around magnetic field lines of neutron stars.

X-rays from Jupiter's Poles



CHANDRA X-RAY OF JUPITER

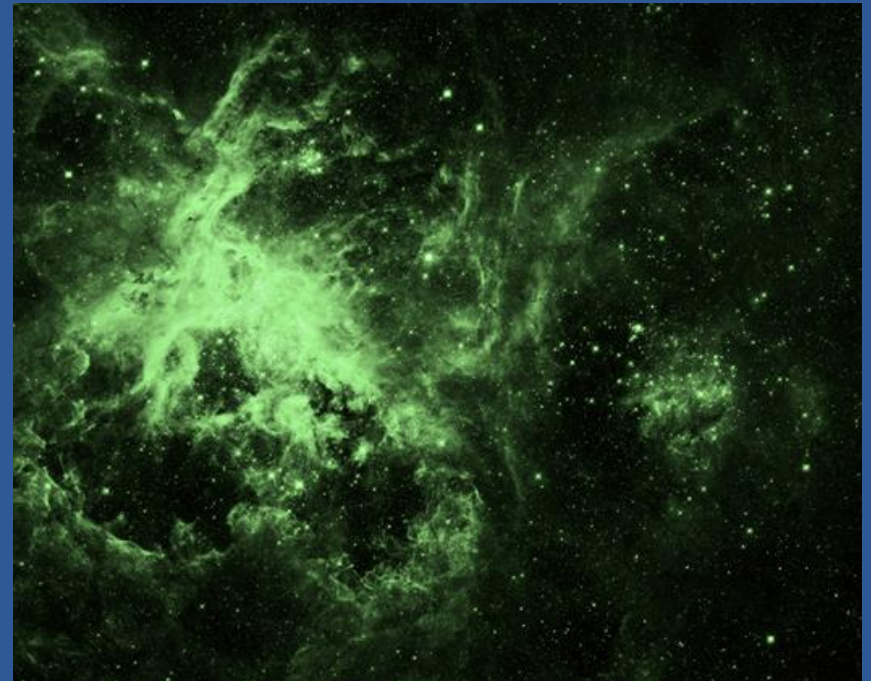
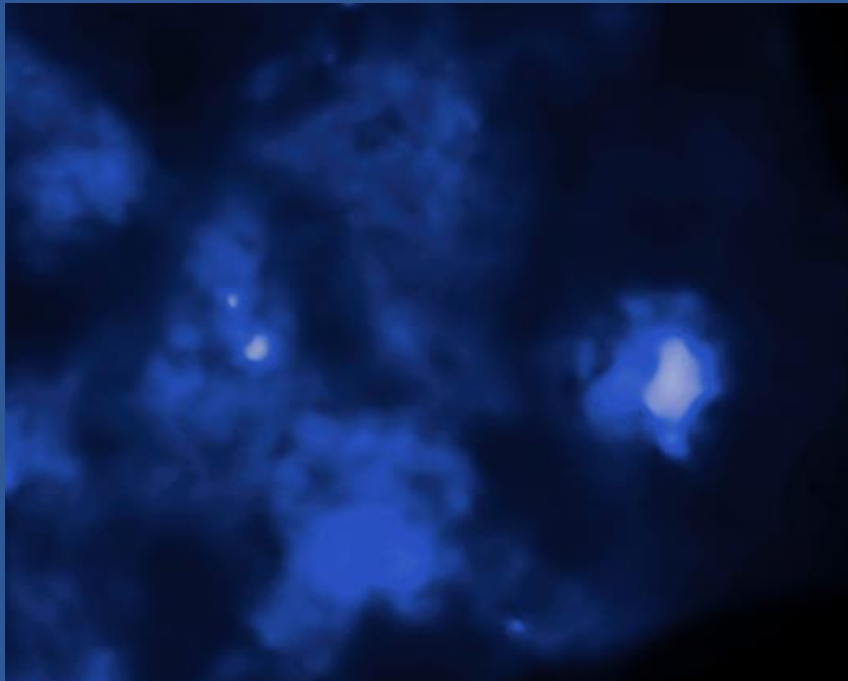


ILLUSTRATION

Star forming region 30 Doradus in the Large Magellanic Cloud

Chandra – X-rays

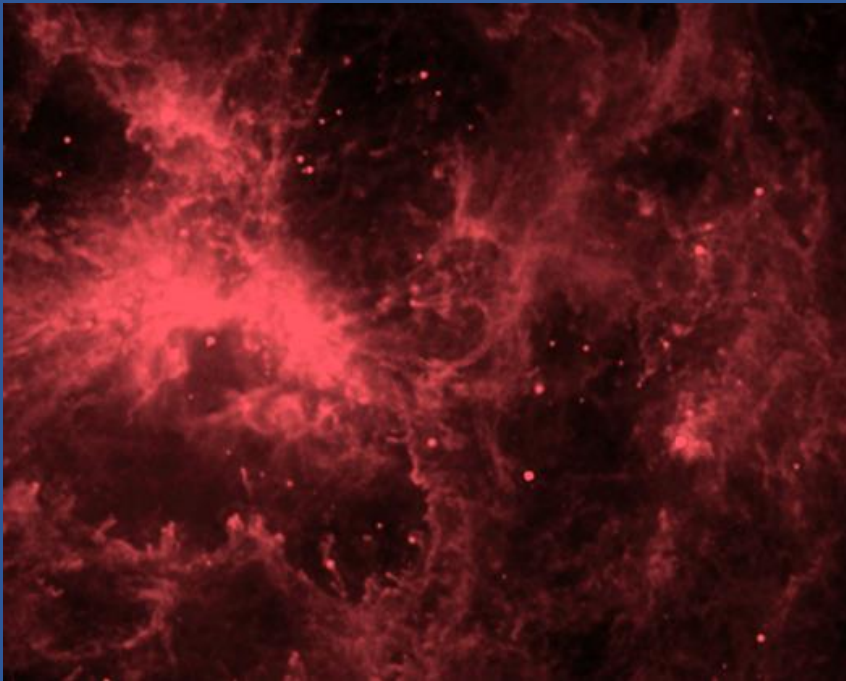
Hubble - Optical



Star forming region 30 Doradus in the Large Magellanic Cloud

Spitzer - Infrared

Composite Image



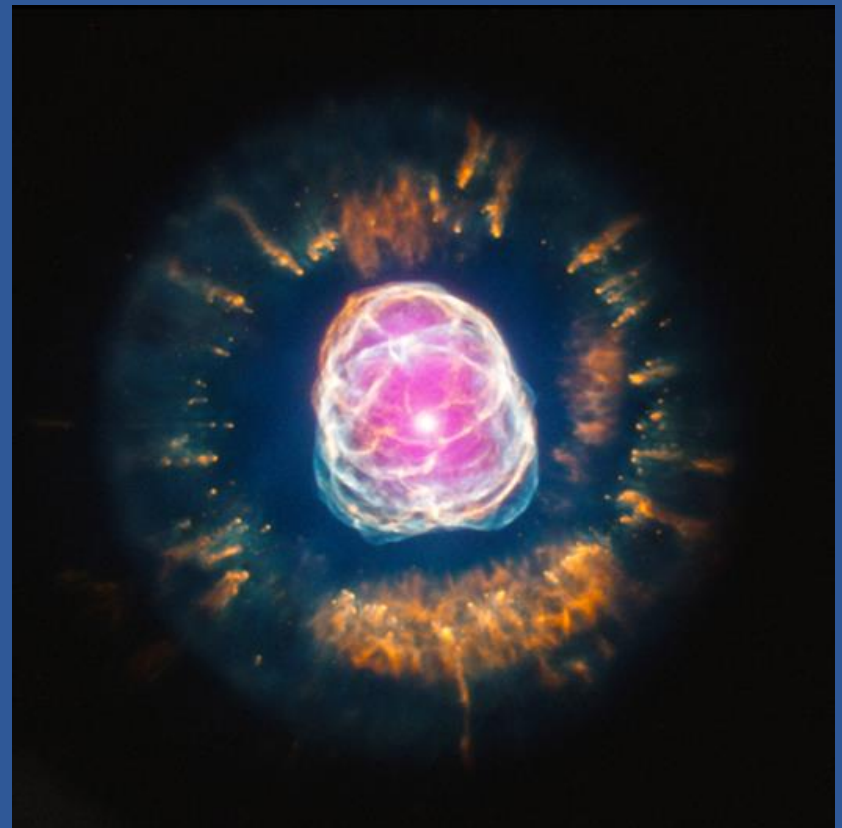
NGC 2392 – Eskimo Nebula

White Dwarf in Center

Chandra – X-rays

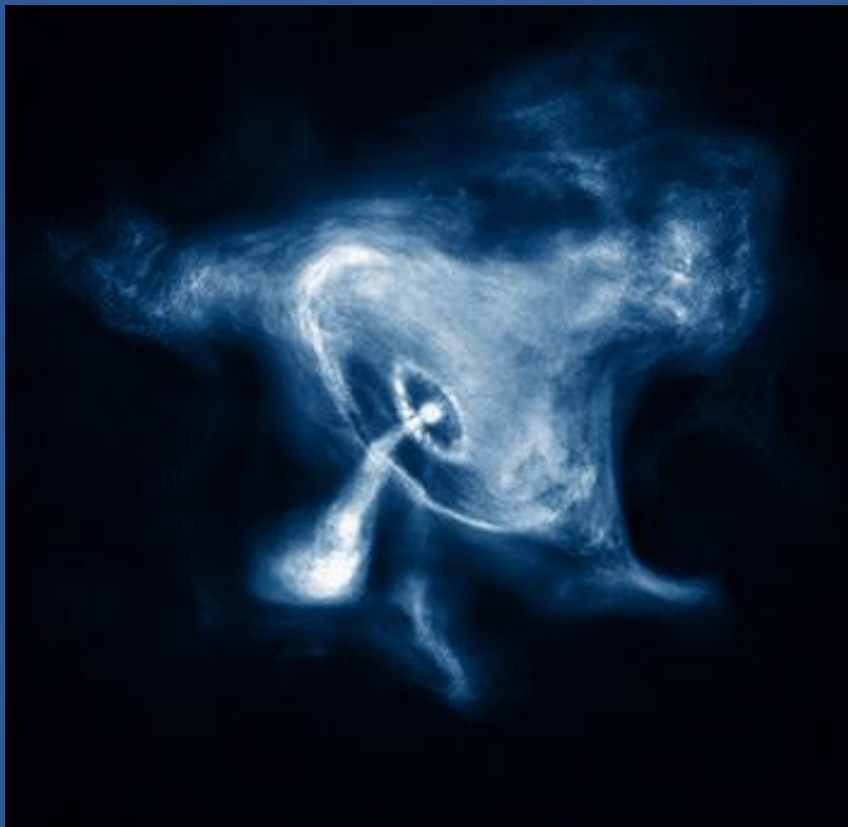


X-ray – Optical Composite



Neutron Star and Supernova Remnant (1054 CE) Crab Nebula (NGC 1952)

Chandra – X-ray



X-ray – Optical - Infrared

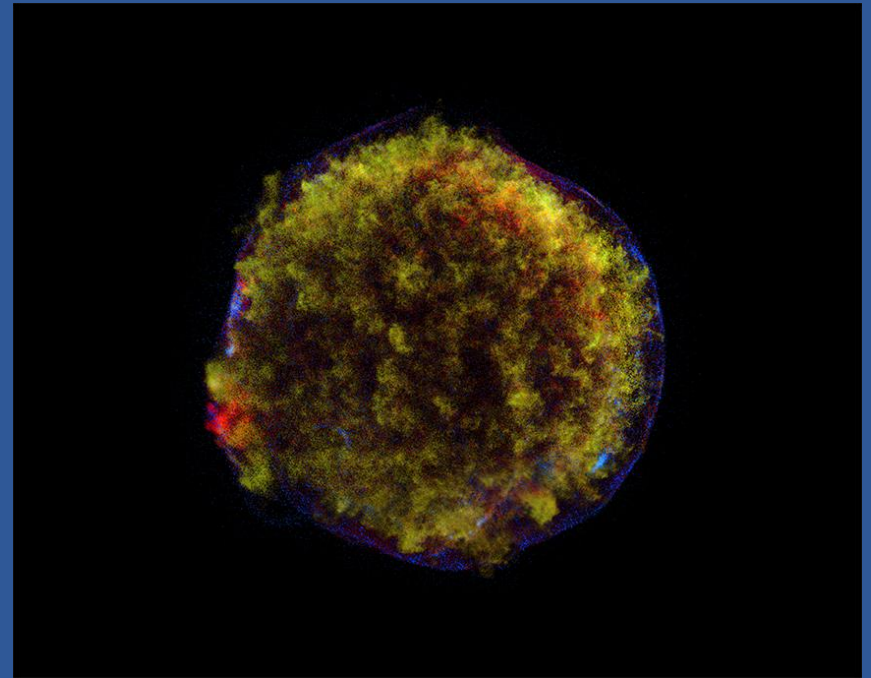


Tycho's Supernova 1572

Explosion Remnant

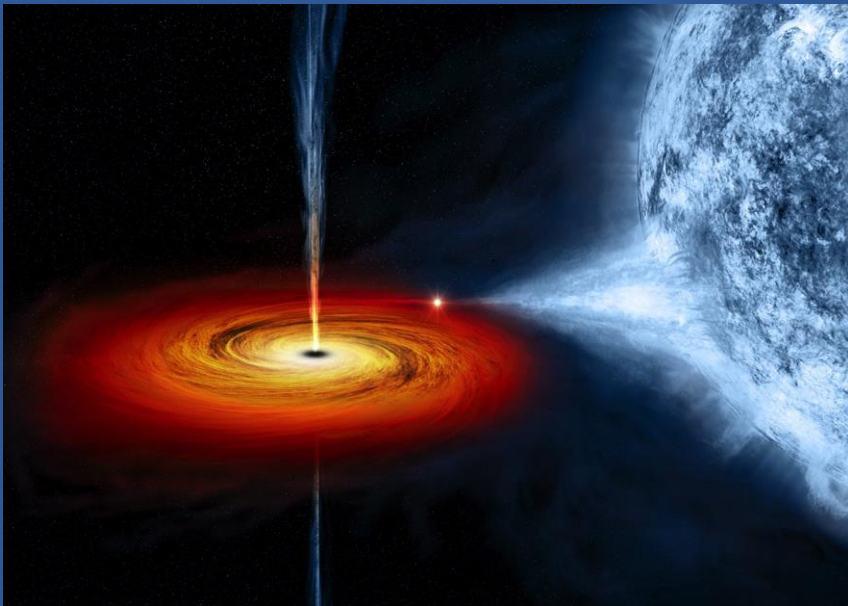
Woodcut of 1572 Nova

Chandra – X-ray



Cygnus X-1 ($15 M_{\text{Sun}}$) Orbiting HDE 226868 ($19 M_{\text{Sun}}$)

Artist's View

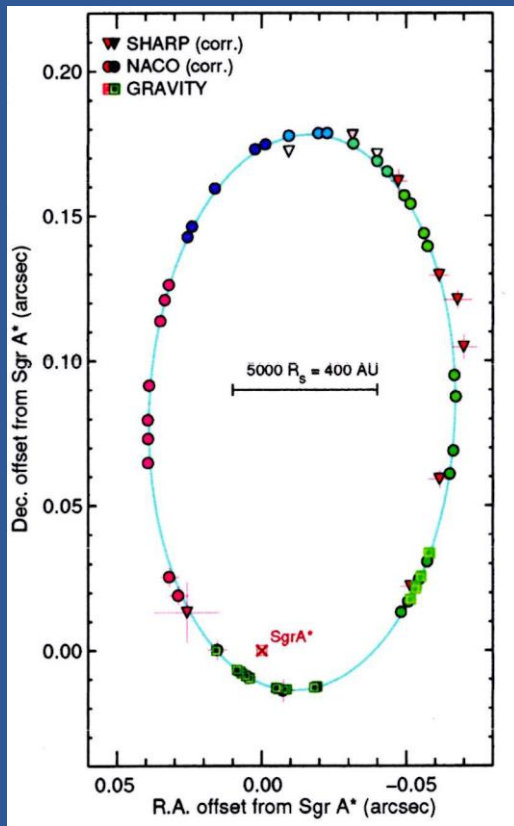


Chandra X-ray

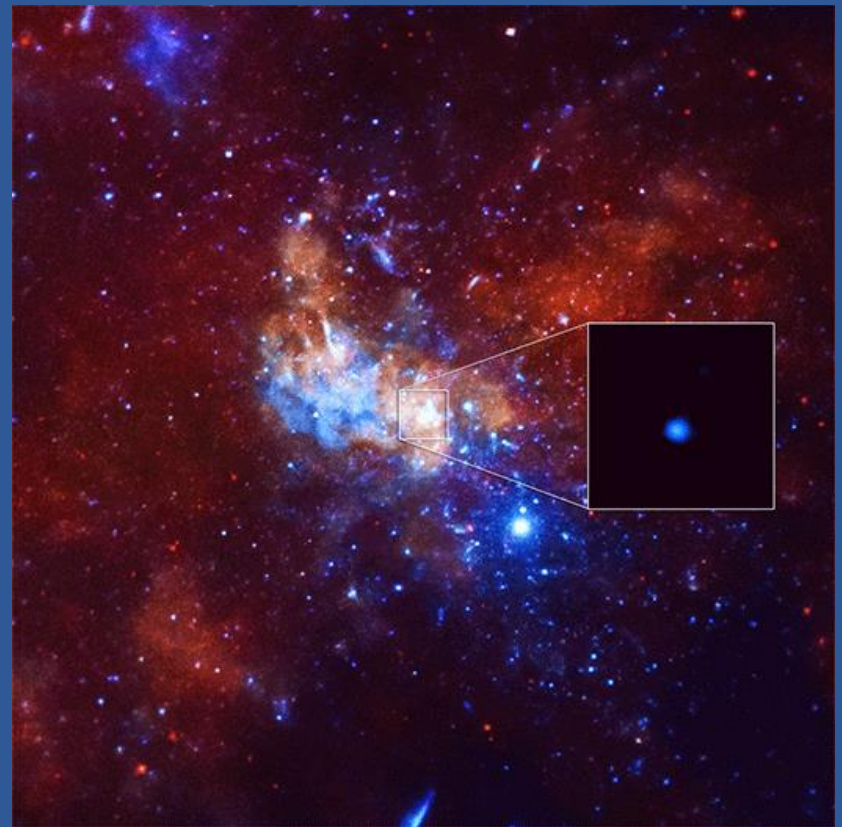


Supermassive Black Hole Sgr A*

Orbit of S-2 around Sgr A*



Chandra – X-ray Flare



Hot Gas in the Coma Cluster of Galaxies

Optical Image

Composite with Chandra X-ray
Image in Pink

