SLAC Summer Institute Topical Conference

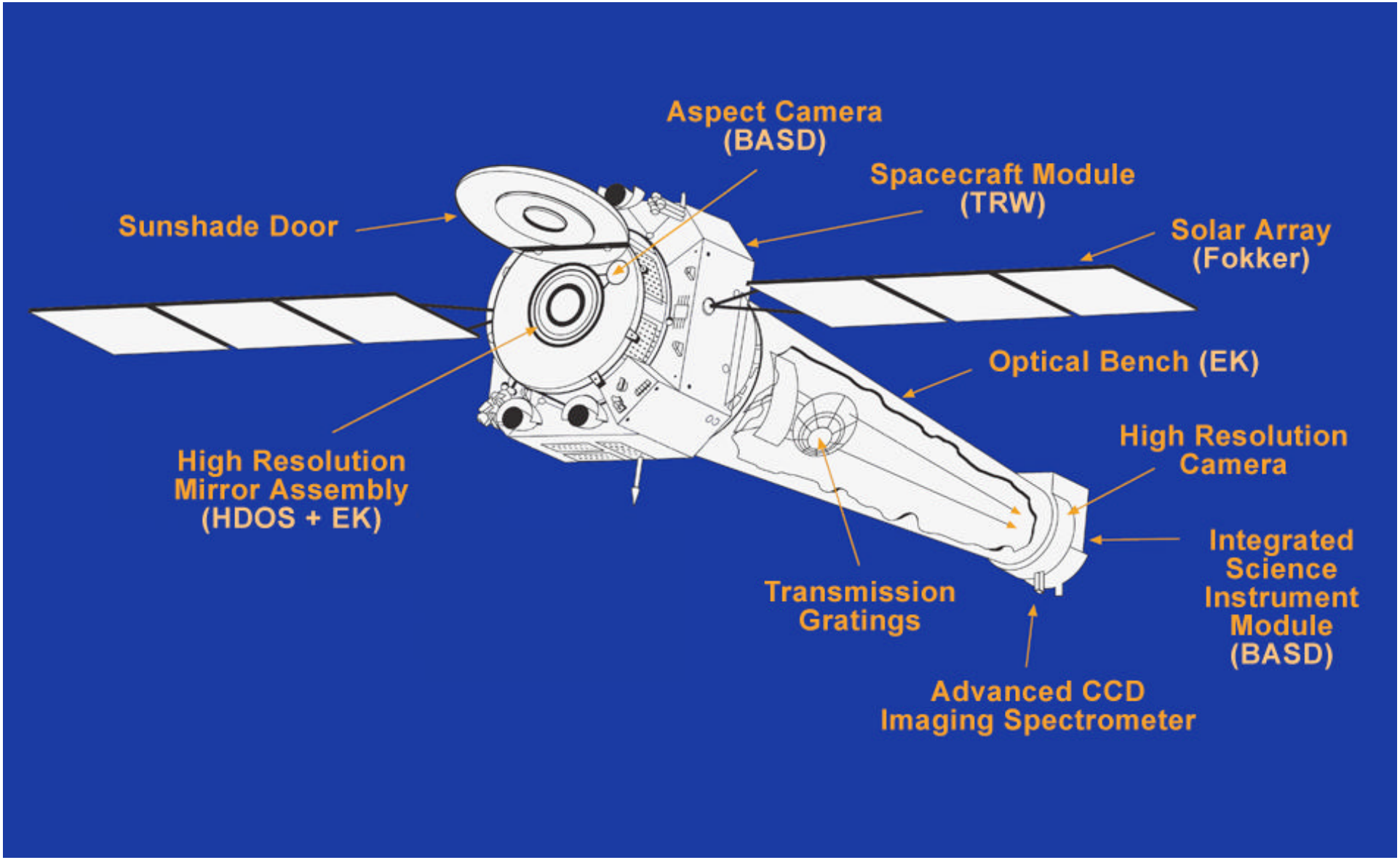
Results from Chandra

Harvey Tananbaum Chandra X-ray Center

August 24, 2001

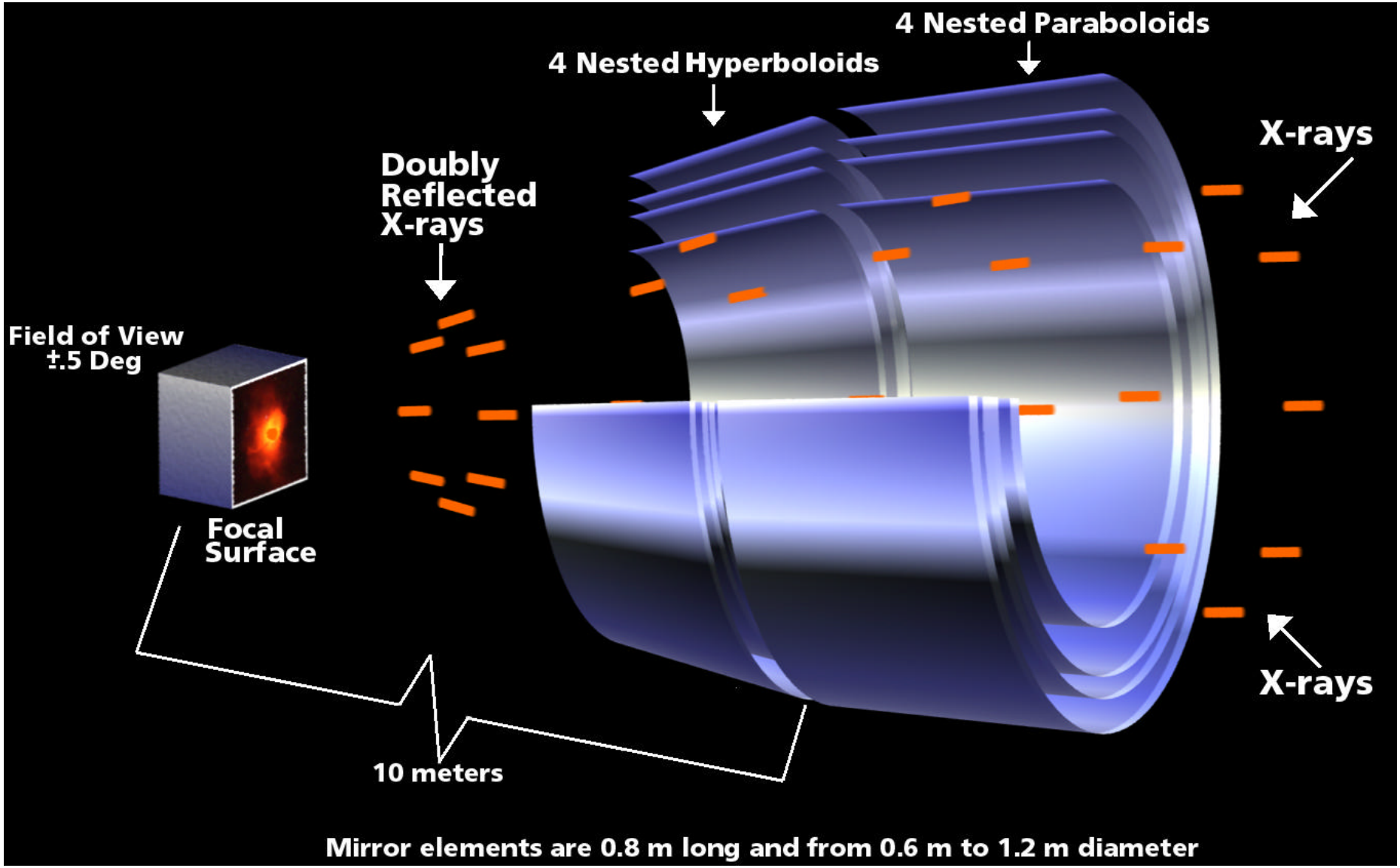
Chandra X-Ray Observatory

Chandra Spacecraft

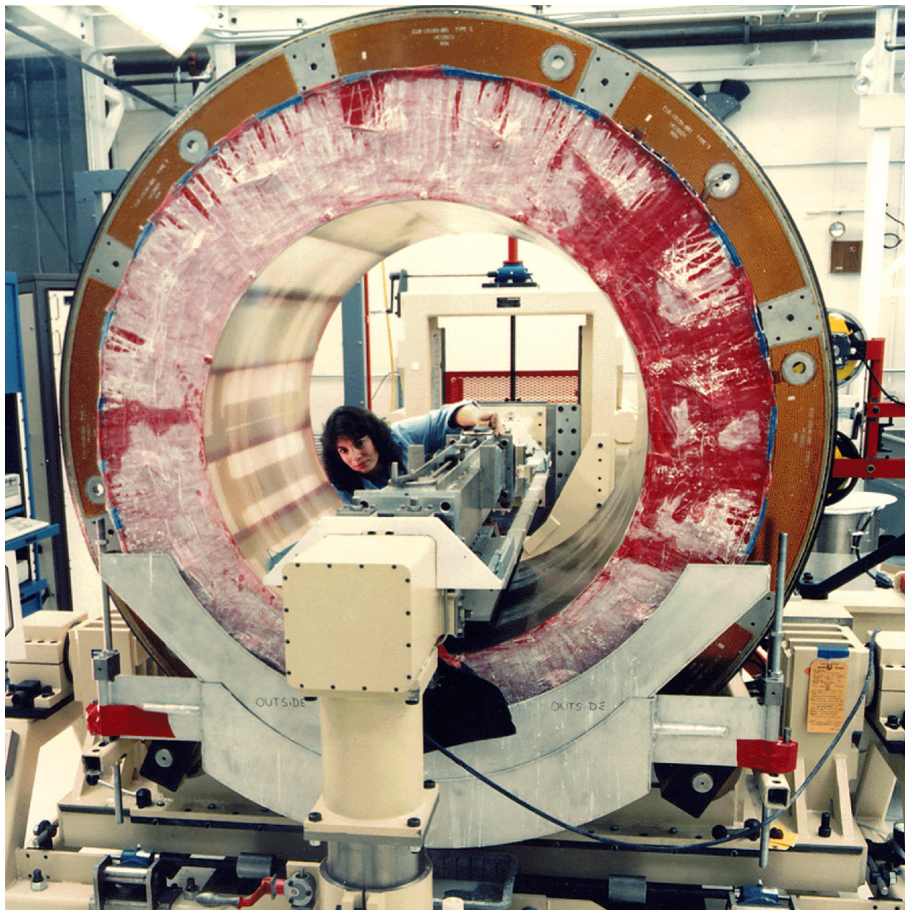


Chandra X-Ray Observatory

Schematic of Grazing Incidence, X-ray Mirror



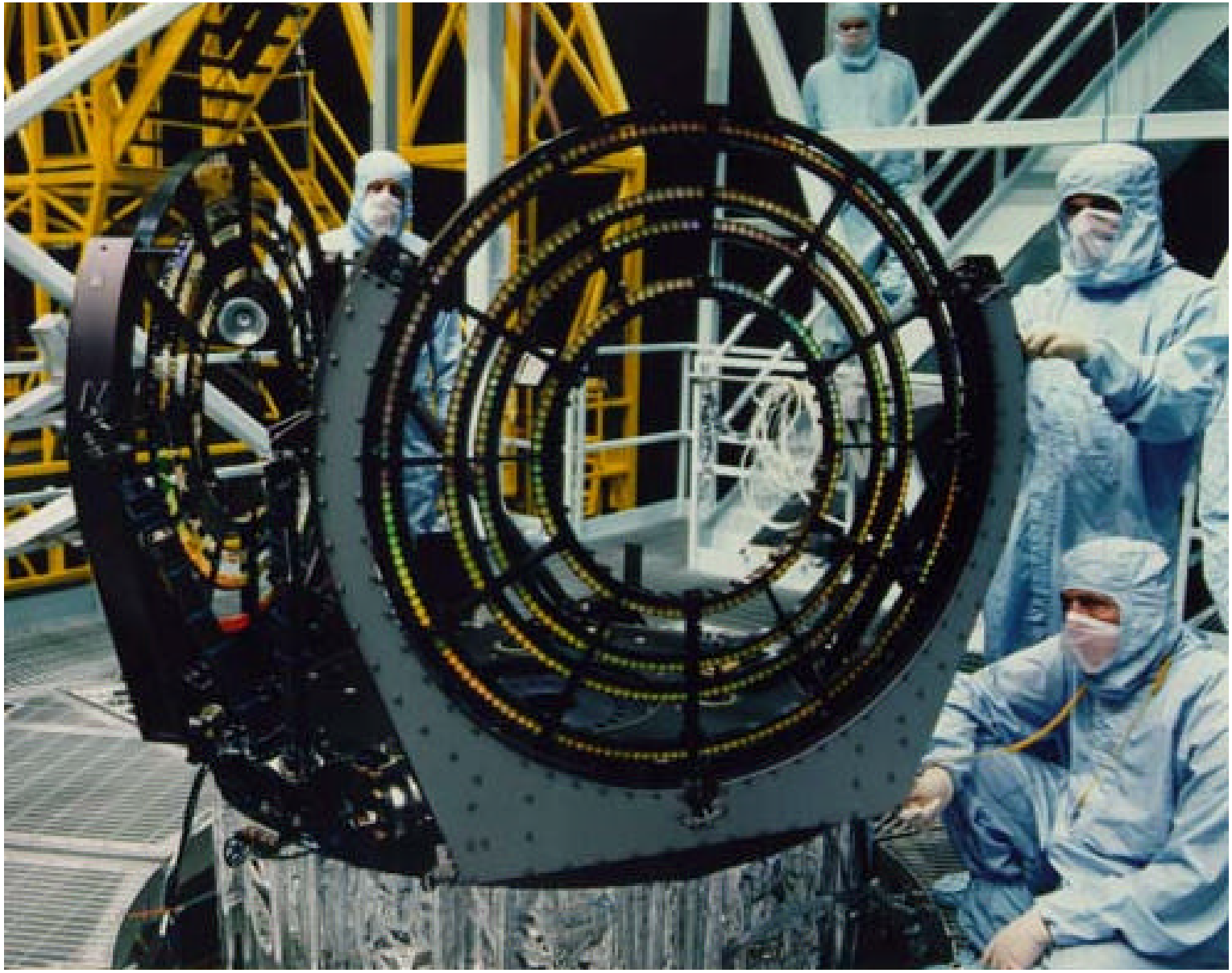
Chandra X-Ray Observatory



Polishing a CXO Mirror Shell

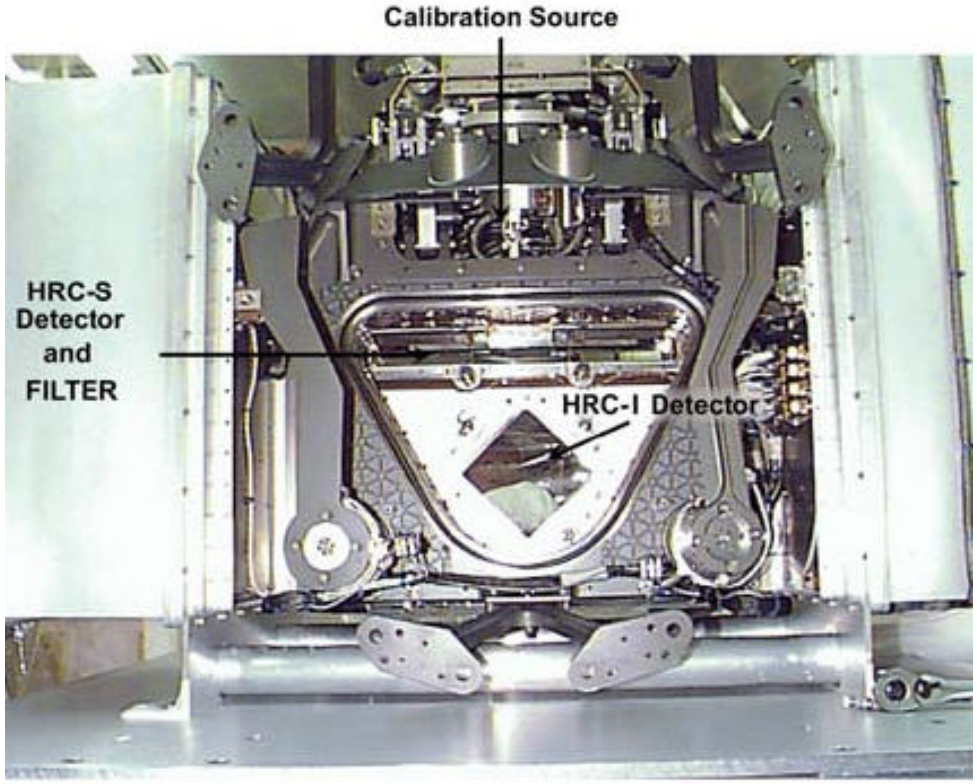
CXO Mirror Fabrication

Chandra X-Ray Observatory

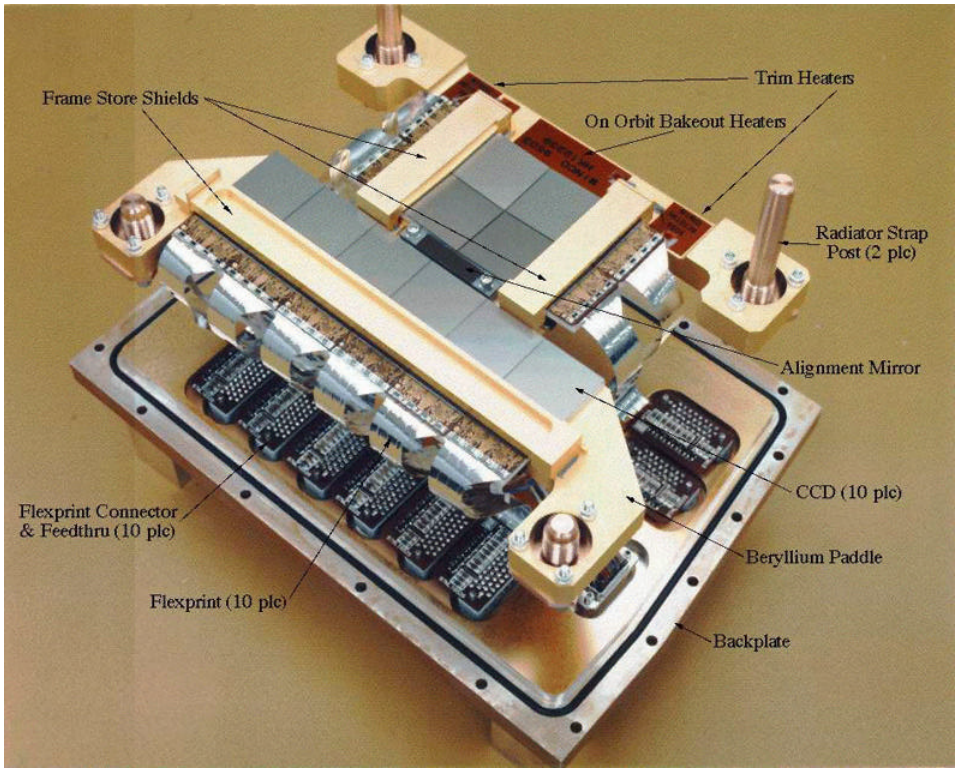


High Energy Grating (PI: C.Canizares) **Low Energy Grating (PI: A.Brinkman)**

Chandra X-Ray Observatory



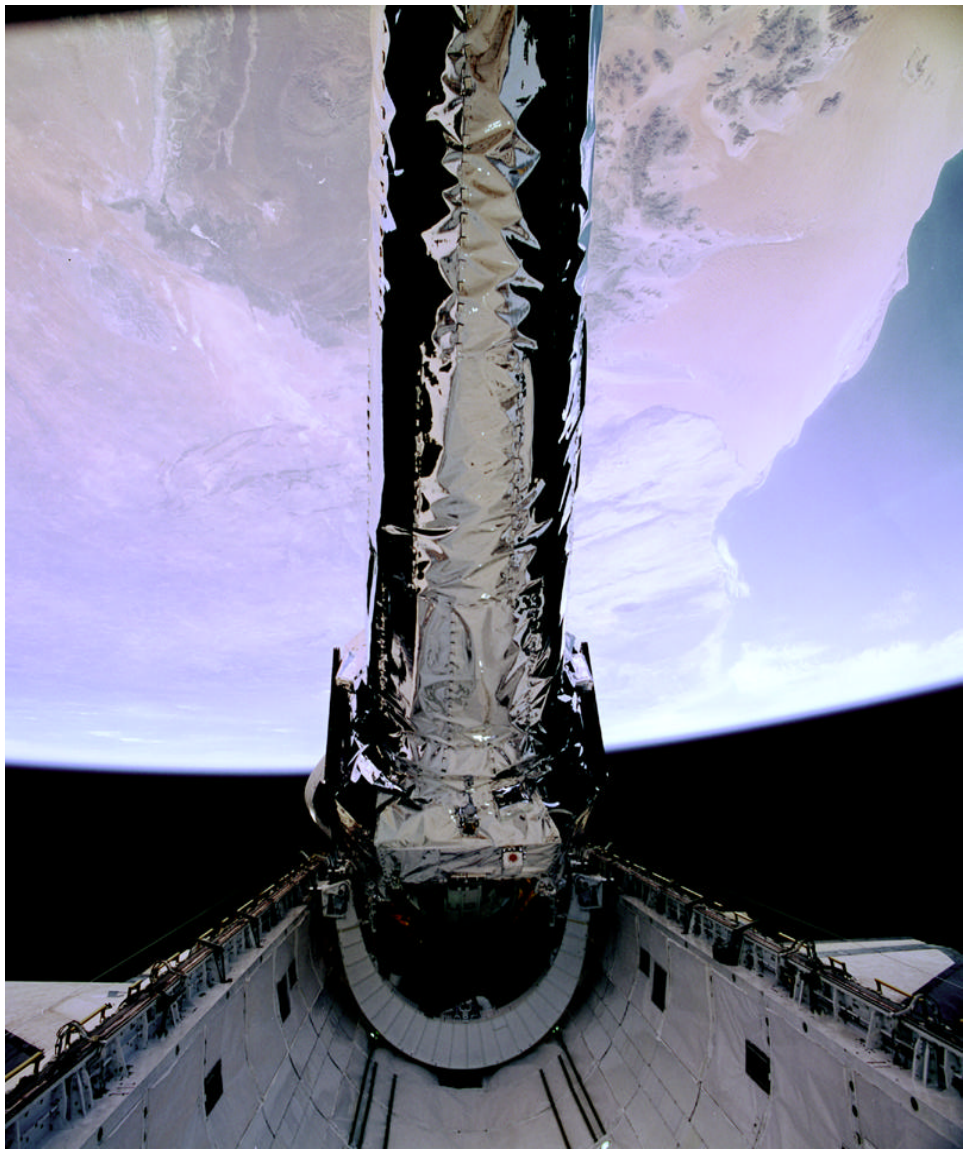
HRC Detector (PI: S. Murray)



ACIS Detector (PI: G. Garmire)

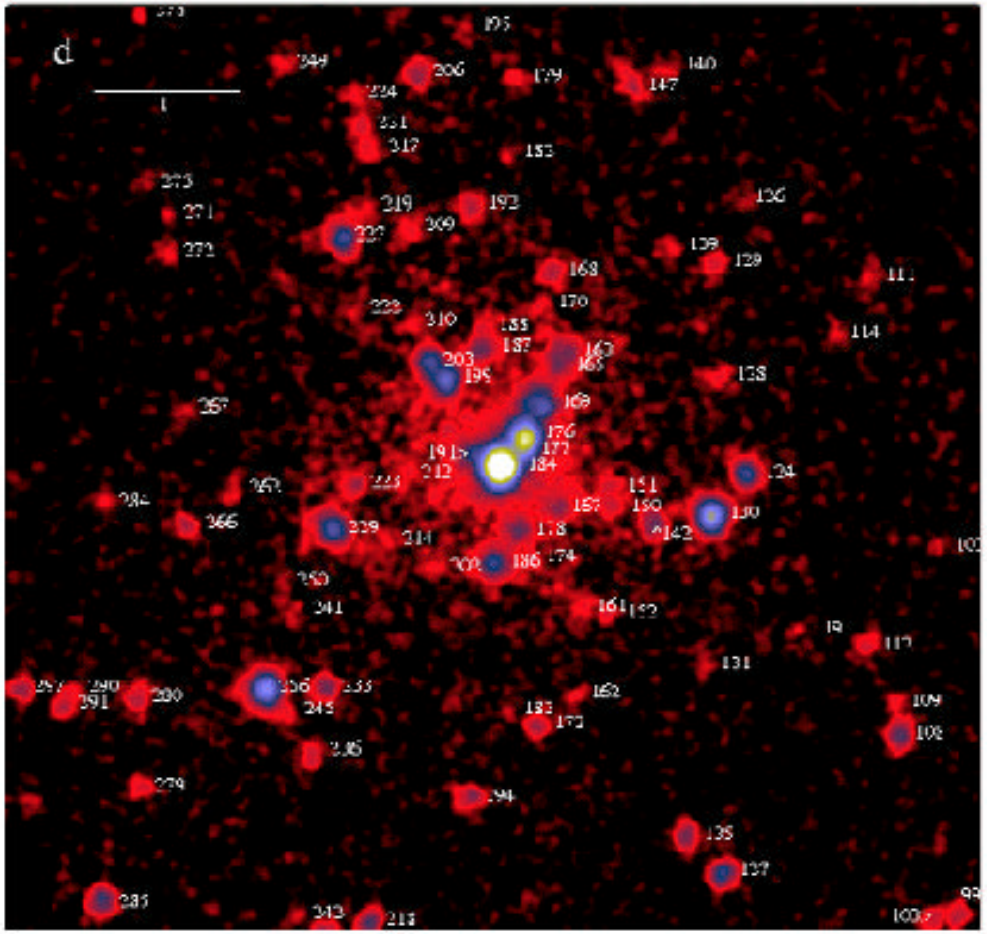
Chandra X-Ray Observatory

Launch & Deploy

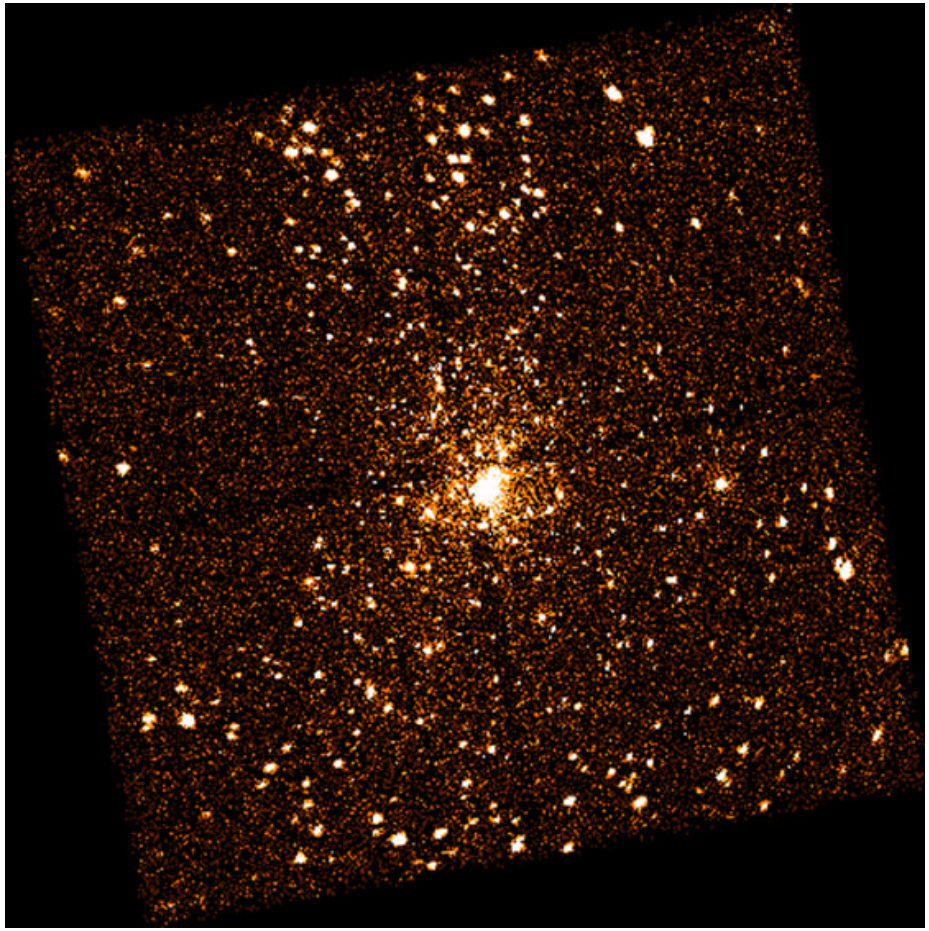


Chandra X-Ray Observatory

Orion Nebula, X-ray

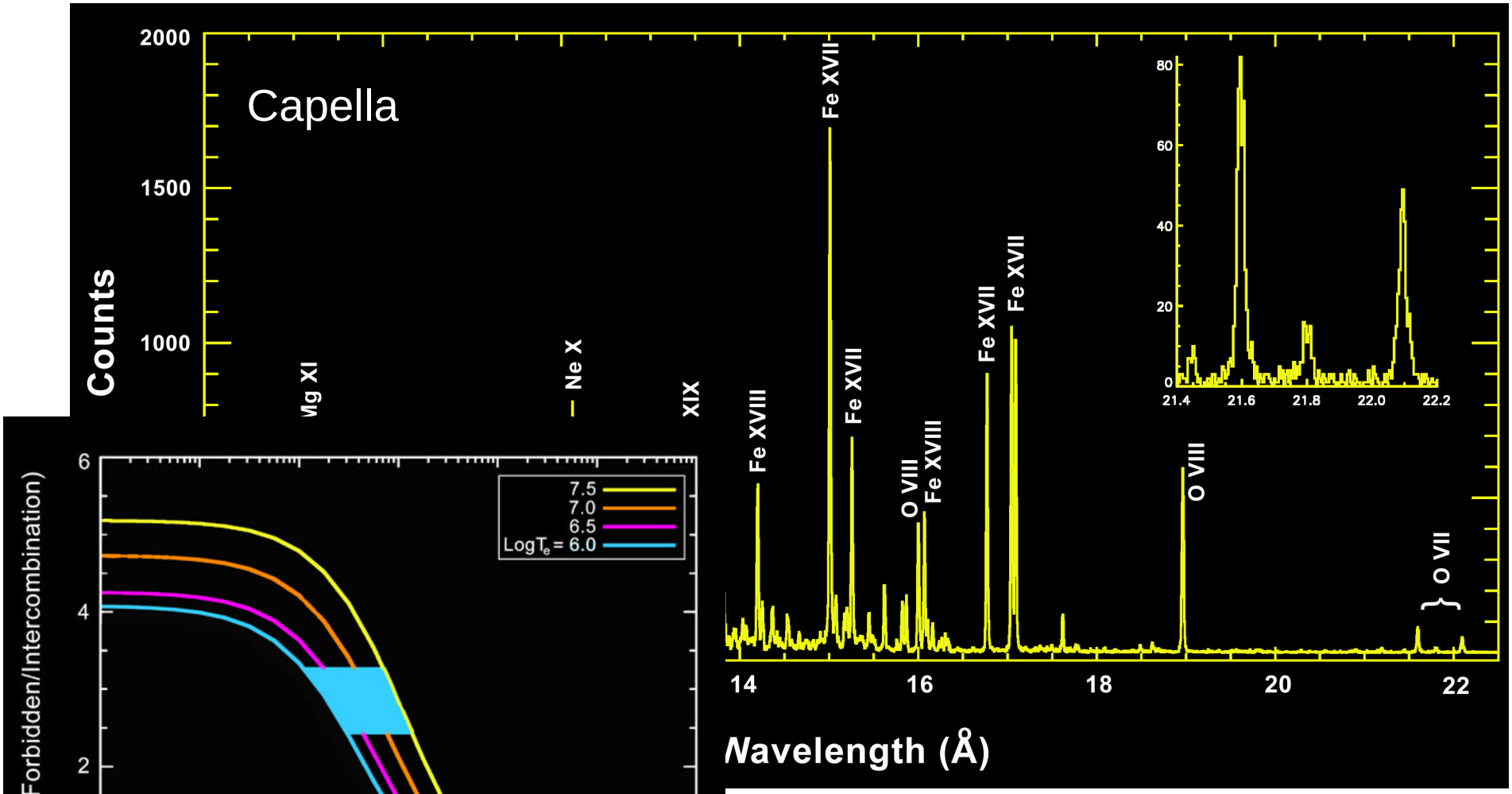


Rosat HRI Observation

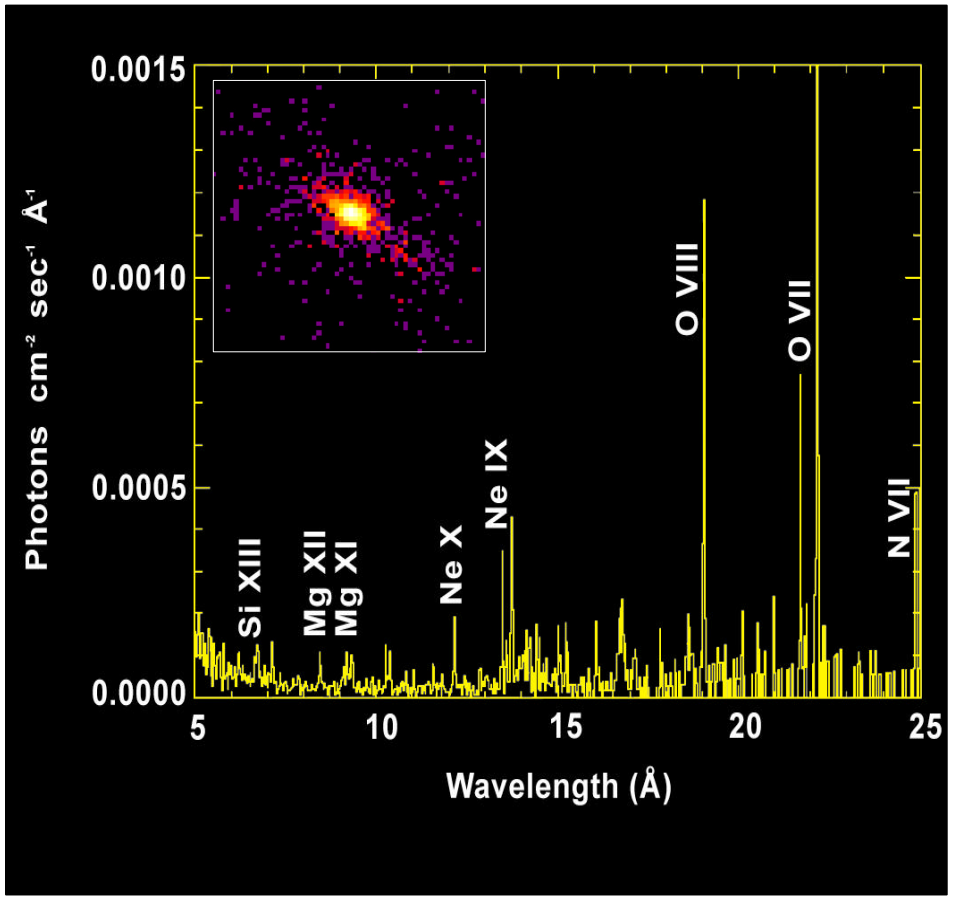


Chandra ACIS Observation

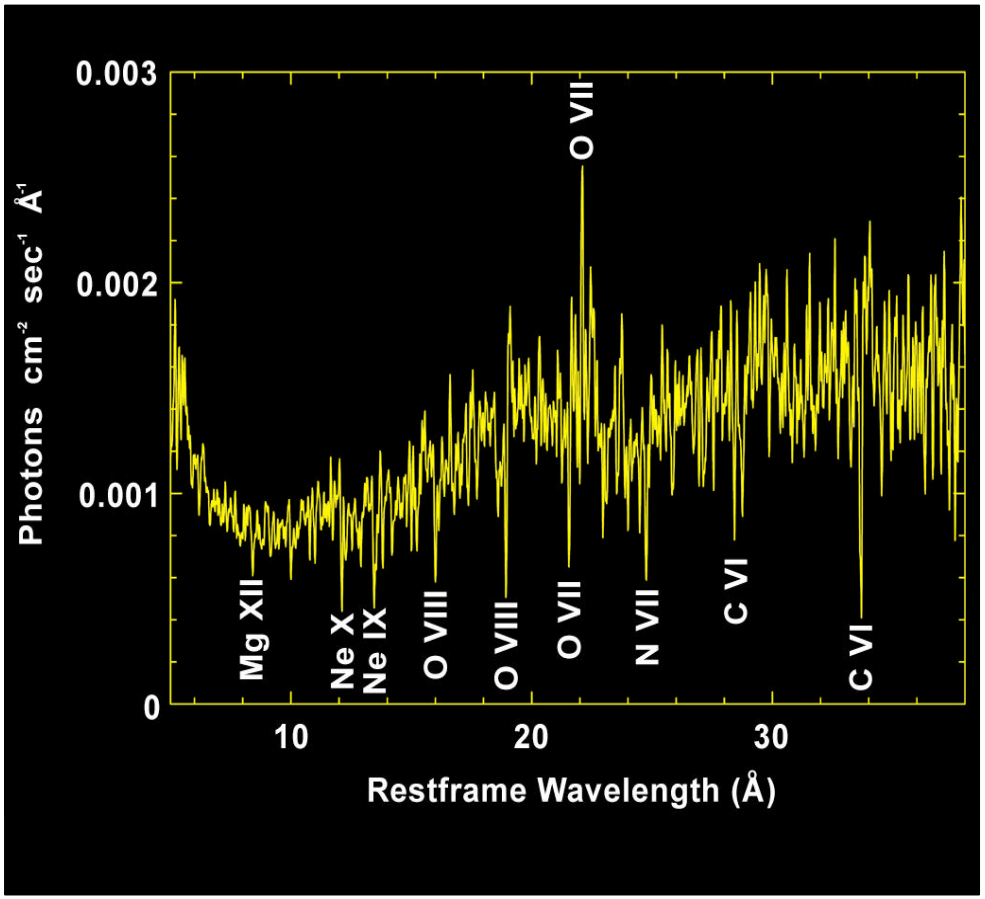
Chandra X-Ray Observatory



Chandra X-Ray Observatory

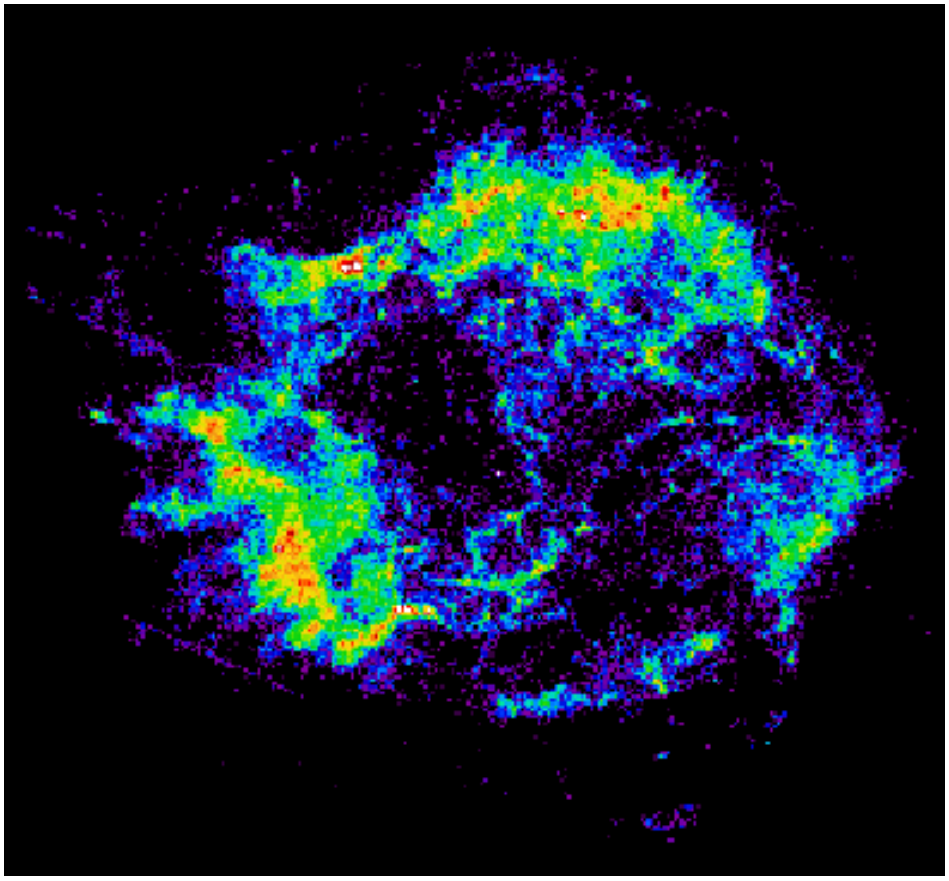


NGC 4151 (HETG)

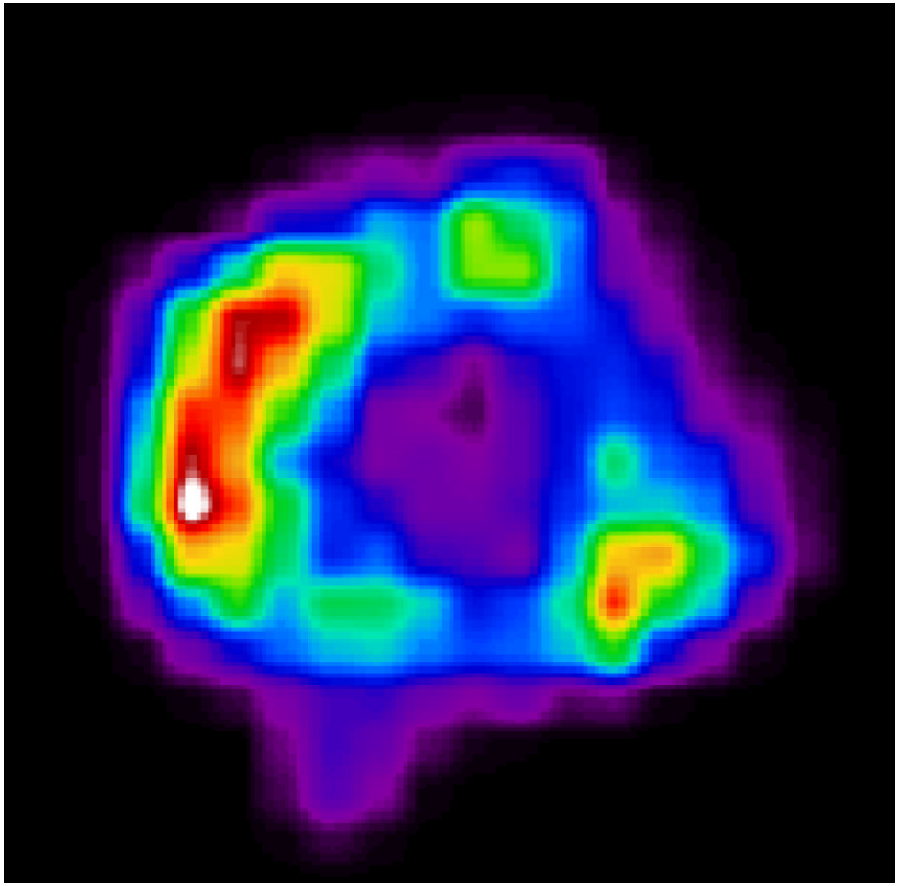


NGC 5548 (LETG)

Chandra X-Ray Observatory



Cas A



SN 1987A

Chandra X-Ray Observatory

Neutron Star Equation of State

- Young neutron stars associated with historical remnants provide temperature vs. age data, if we can separate thermal component from magnetic and accretion effects

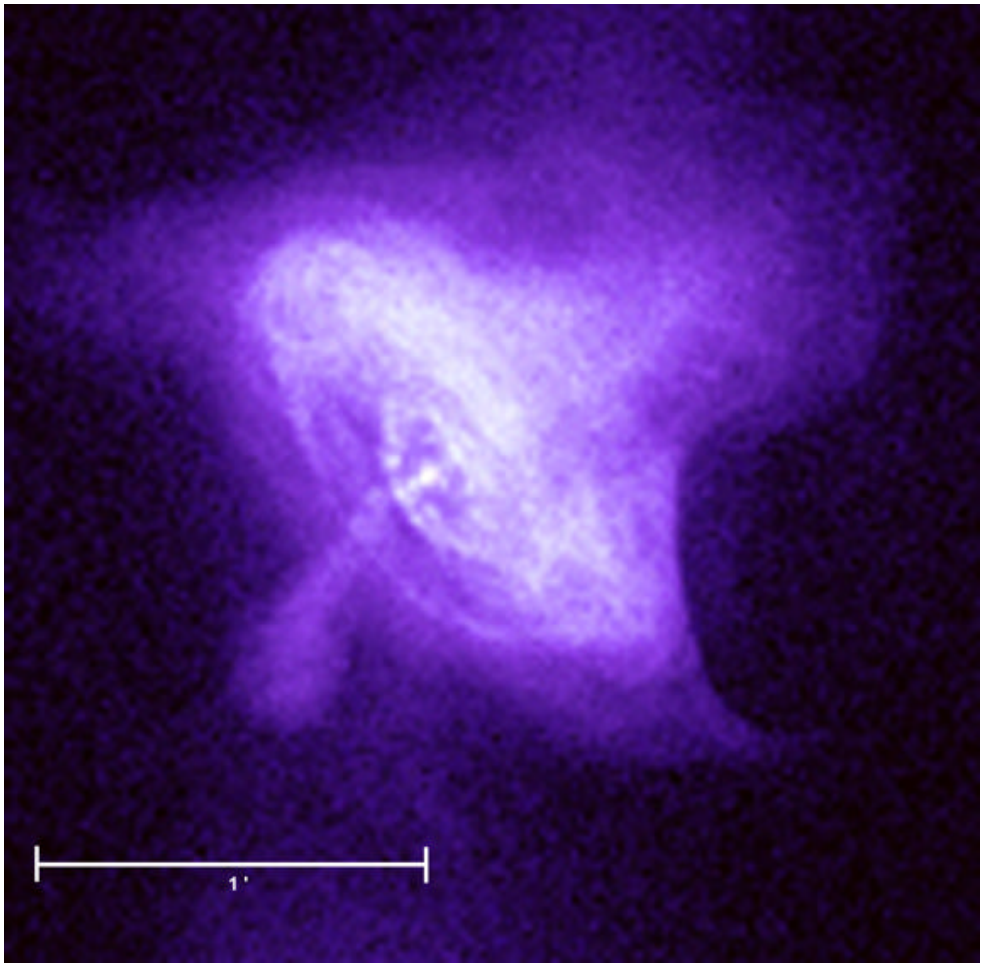
- Cooling of neutron stars depends on processes in superfluid interior and core (pion condensation, strange matter, pinning of vortices, etc.)

- Absorption (or emission) features in X-ray spectra for isolated neutron stars (RXJ185635-3754) can provide M/R via gravitational redshifts and M/R^2 via pressure broadening of lines

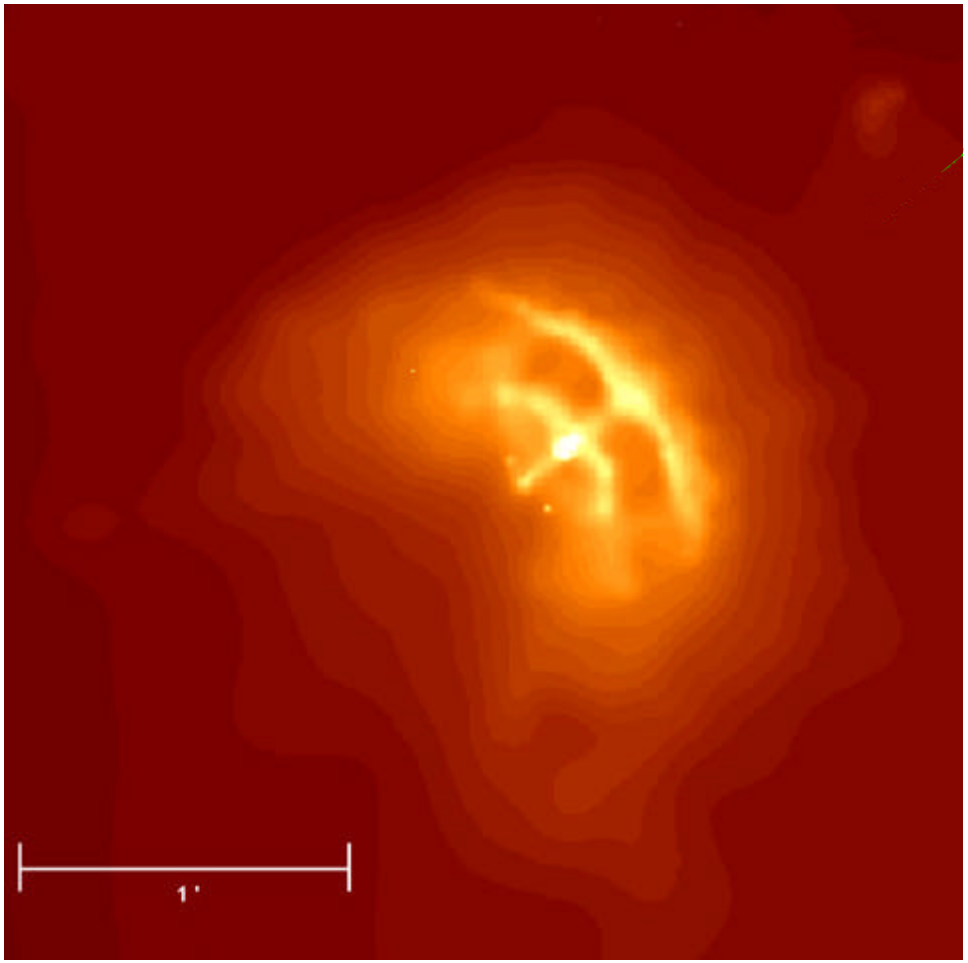
Question: Does gravitational settling float hydrogen (if any) to top resulting in feature-less X-ray spectrum? And/or will radiative levitation (seen in hot white dwarfs) allow metal features?

- Knowledge of M and R tests predictions of various equations of state

Chandra X-Ray Observatory



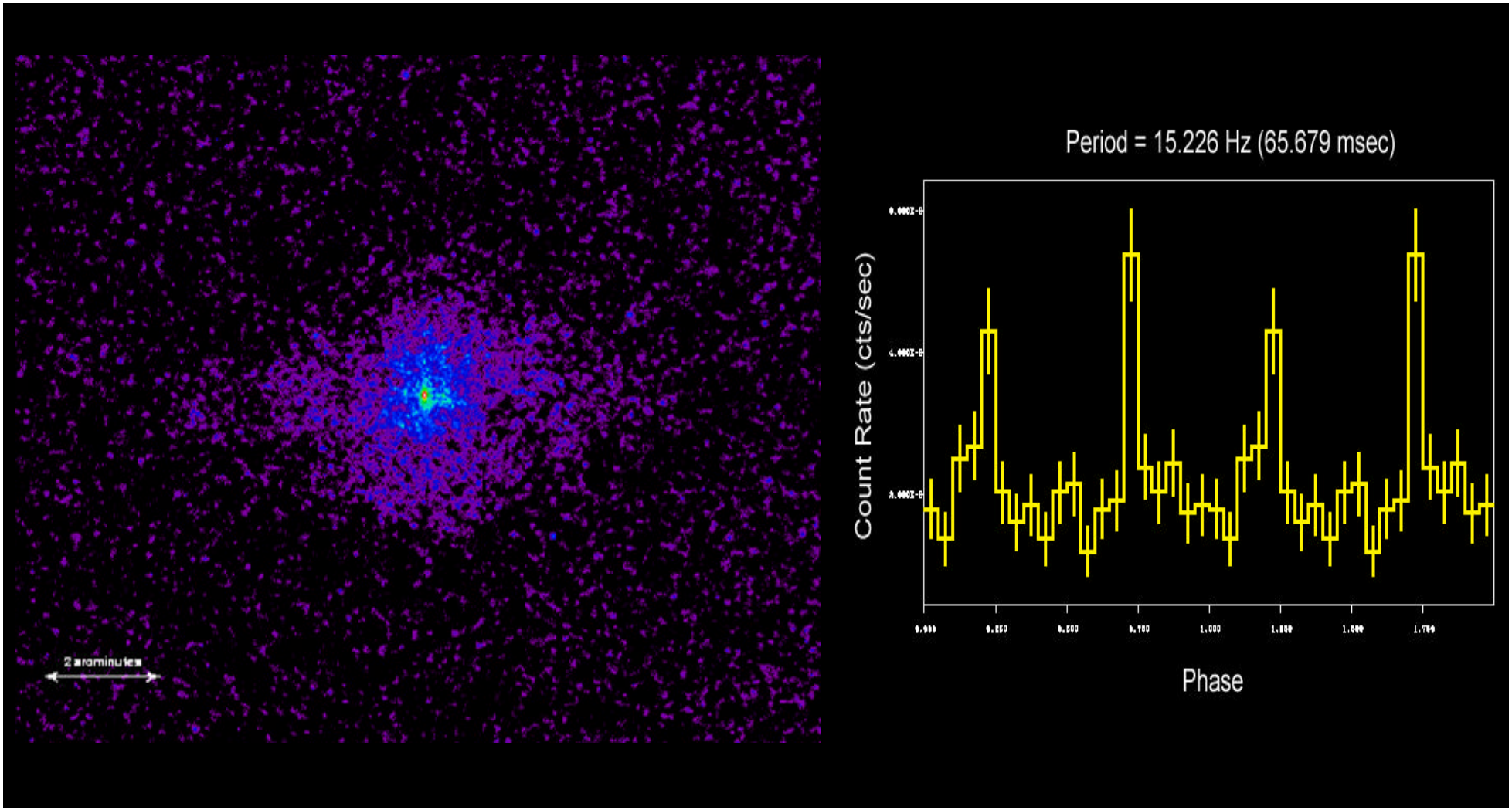
Crab Nebula



Vela Pulsar

Chandra X-Ray Observatory

3C58



Chandra X-Ray Observatory

3C58 Parameters

P = 65.67895ms (Chandra, Murray et al.)

$\dot{P} = 1.94 \times 10^{-13}$ s/s (Chandra + RXTE ~ 3 yrs baseline)

Spin Down Energy = $-4\Pi^2 I \dot{P}/P^3 = -2.6 \times 10^{37}$ erg/s

(assuming $I = 1 \times 10^{45}$ gm cm^{-2} s^{-2} for 1.4 solar mass neutron star)

L_c^{neb} (observed) = 2.9×10^{34} erg/s (0.1-10 keV)

L_c^{pulsar} (observed) = 2.5×10^{33} erg/s

$$B_{surface}^{pulsar} = \sqrt{\frac{3c^3 I P \dot{P}}{8\Pi^2 R^6}} = 3.6 \times 10^{12} \text{ G}$$

Chandra X-Ray Observatory

3C58 Parameters, cont.

$$t = \frac{P}{(n-1)\dot{P}} \left(1 - \left(\frac{P_0}{P}\right)^{n-1} \right)$$

For n=3 (simple vacuum dipole) and P_0 << P

$$t = \frac{P}{2\dot{P}} = 5400 \text{ yrs}$$

Taking t = 820 yrs and n=3

$\Rightarrow P_0 = 60.57$ msec

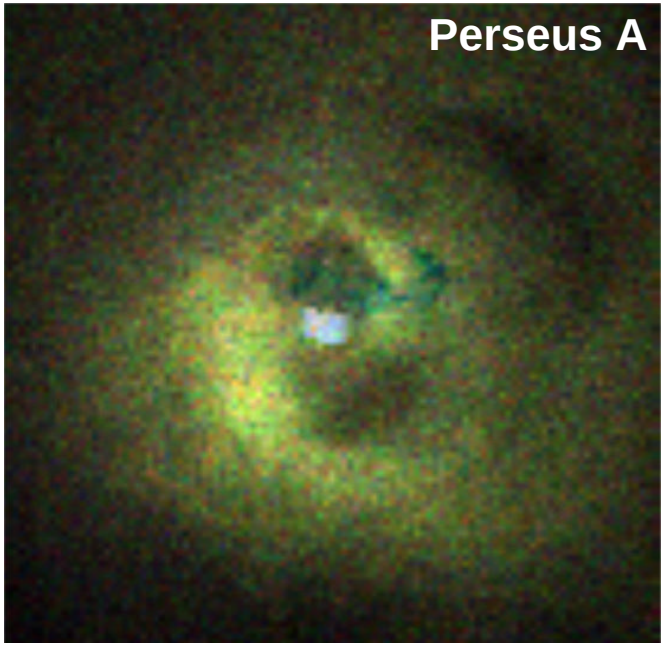
Similar Result for G11.2-0.3 (Kaspi et al.)

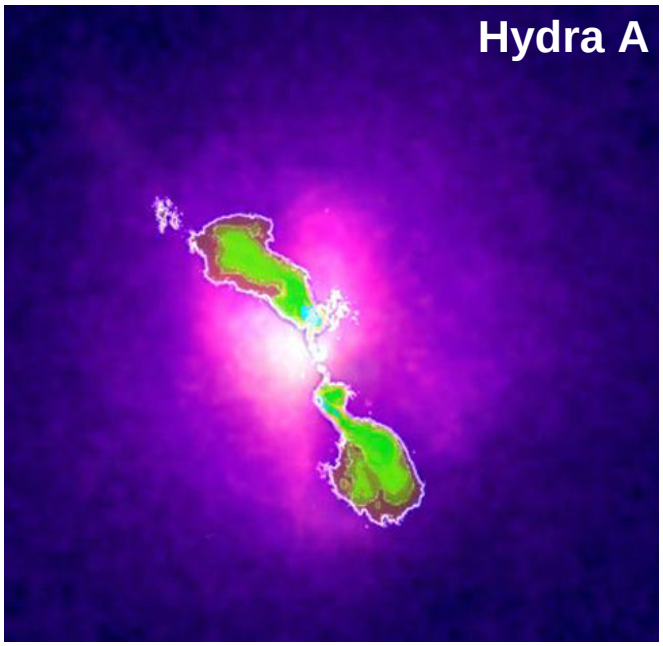
P = 65 ms t = 24,000 yrs

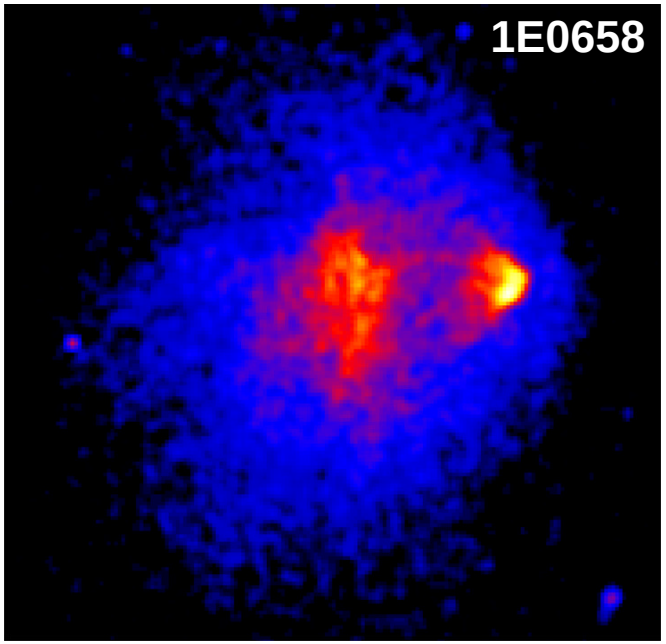
t = 1615 yrs

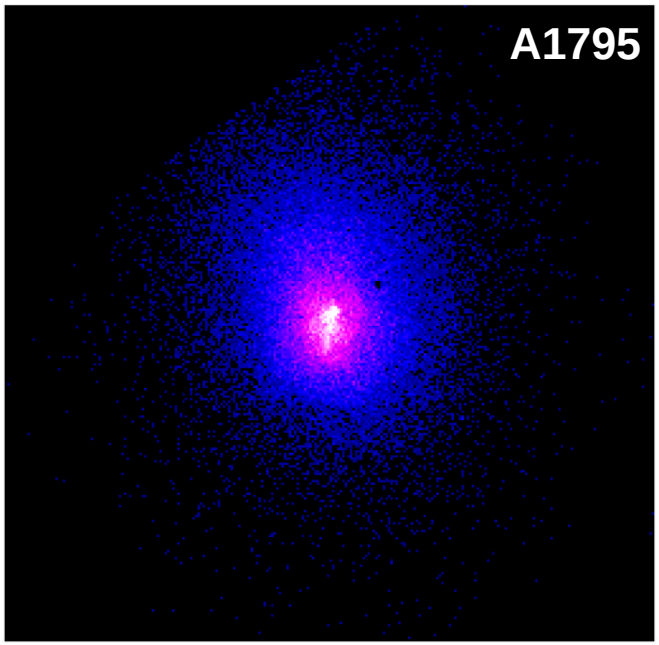
$\Rightarrow P_0 = 62$ms

Chandra X-Ray Observatory









Chandra X-Ray Observatory

X-ray Measurements of Cluster Mass

Hydrostatic Equilibrium

$$\frac{dP_{gas}}{dr} = -\frac{GM(<r)\,r_{gas}}{r^2}$$

Ideal Gas Law

$$P_{gas} = \frac{r_{gas} kT_{gas}}{mm_H}$$

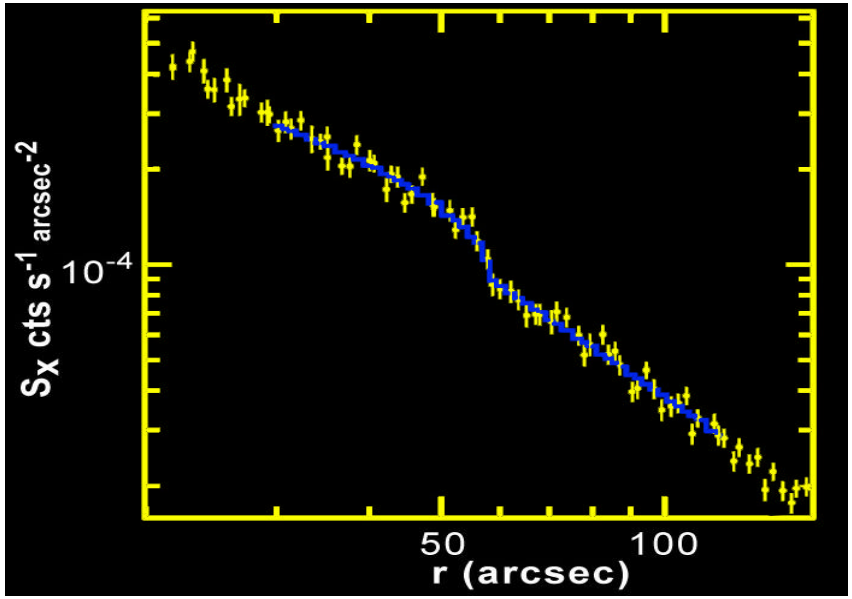
$$M(<r) = -\frac{kT}{Gmm_H}\left(\frac{d\log r}{d\log r} + \frac{d\log T}{d\log r}\right) r$$

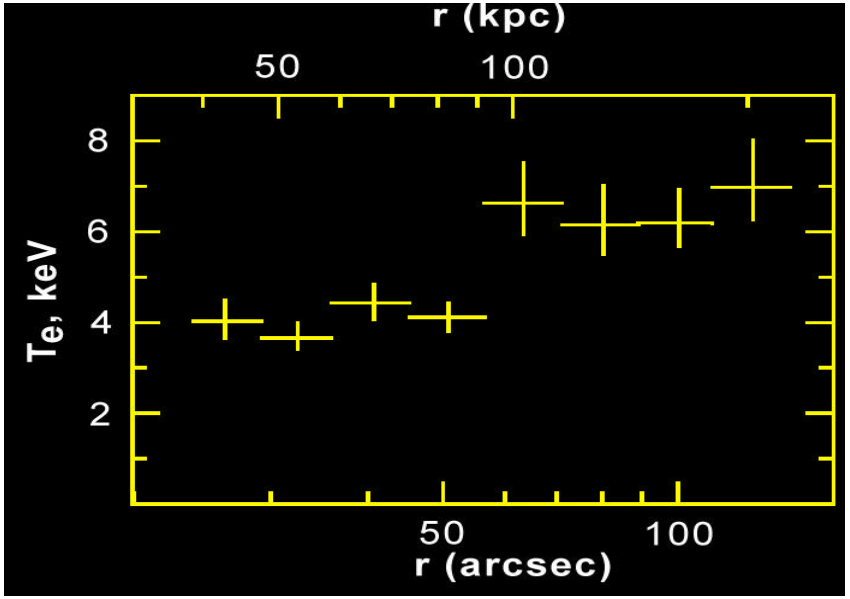
(or)

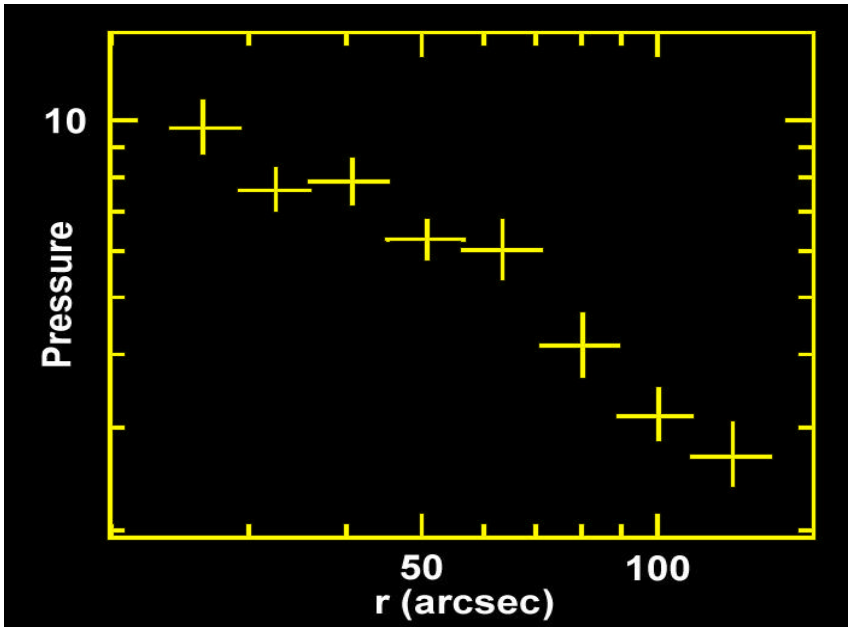
$$M(<r) = -\frac{kT}{Gmm_H}\left(\frac{dr/dr}{r/r} + \frac{dT/dr}{T/r}\right) r$$

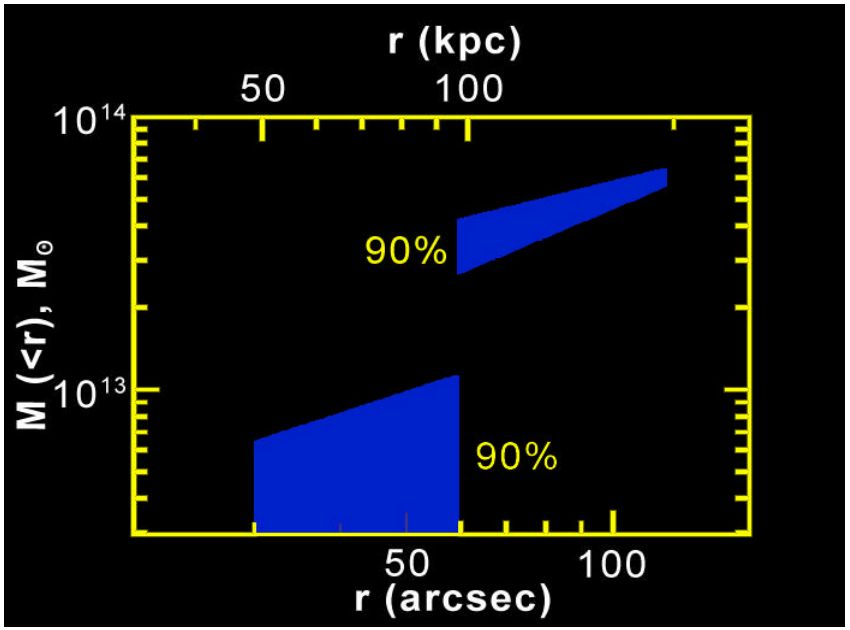
Chandra X-Ray Observatory

A1795 Mass Determination





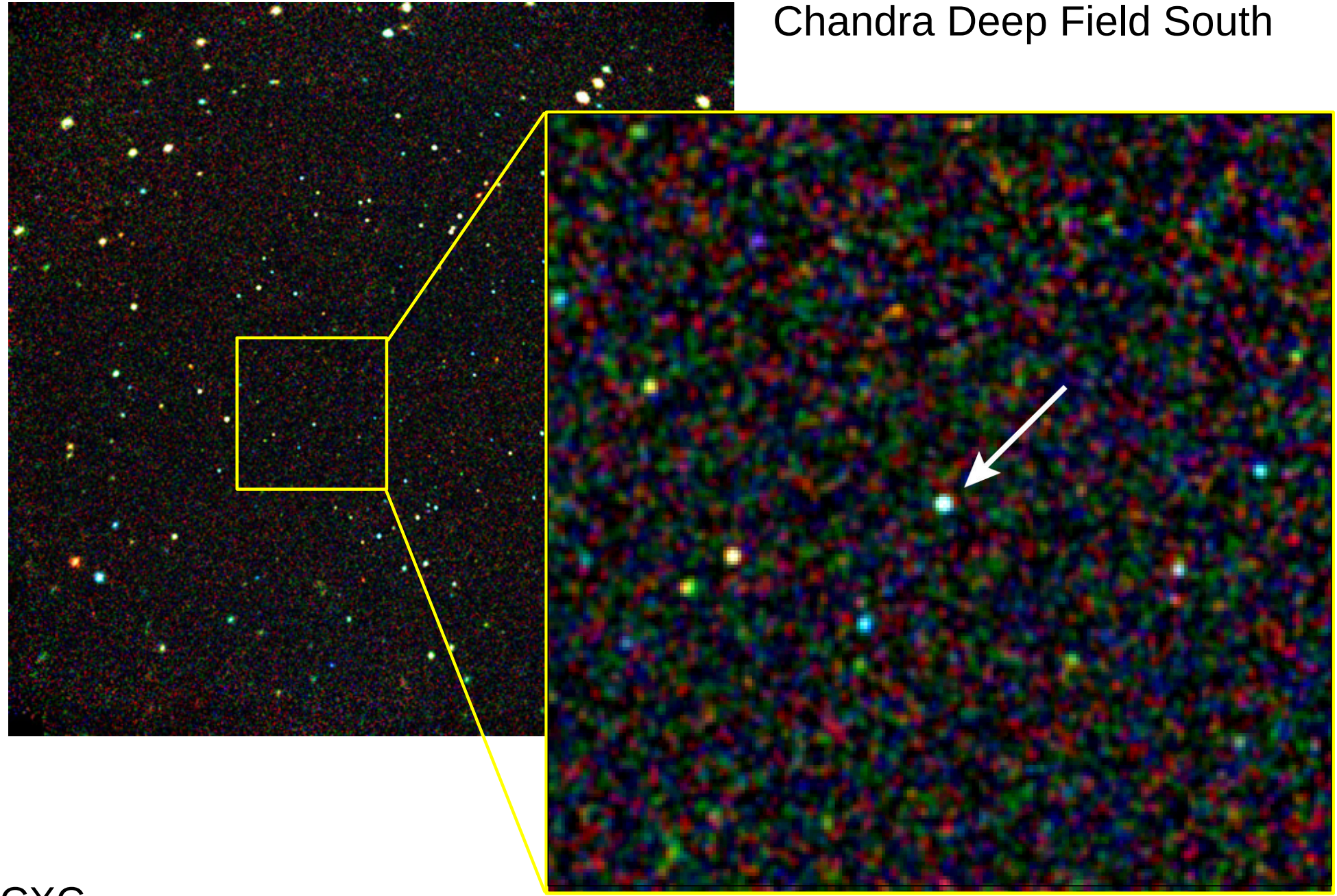




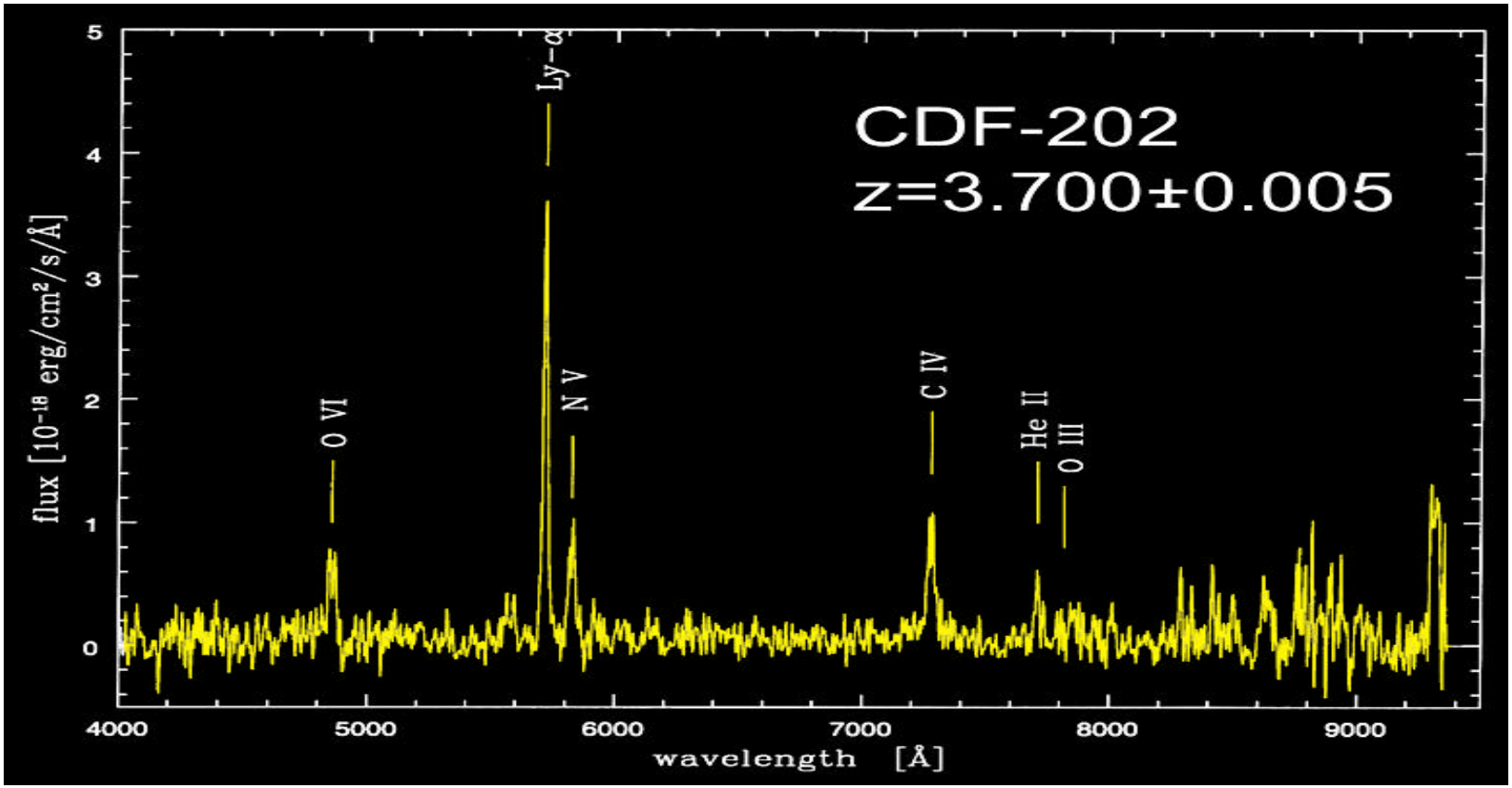
CXC

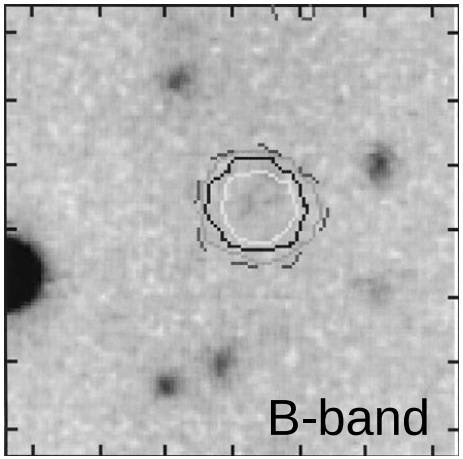
Chandra X-Ray Observatory

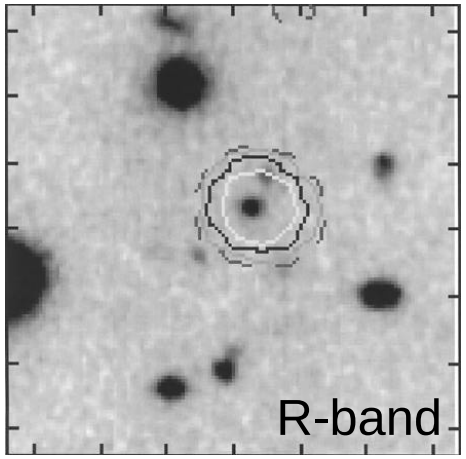
Chandra Deep Field South

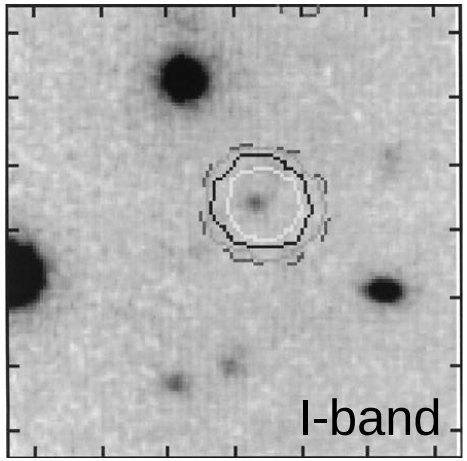


Chandra X-Ray Observatory

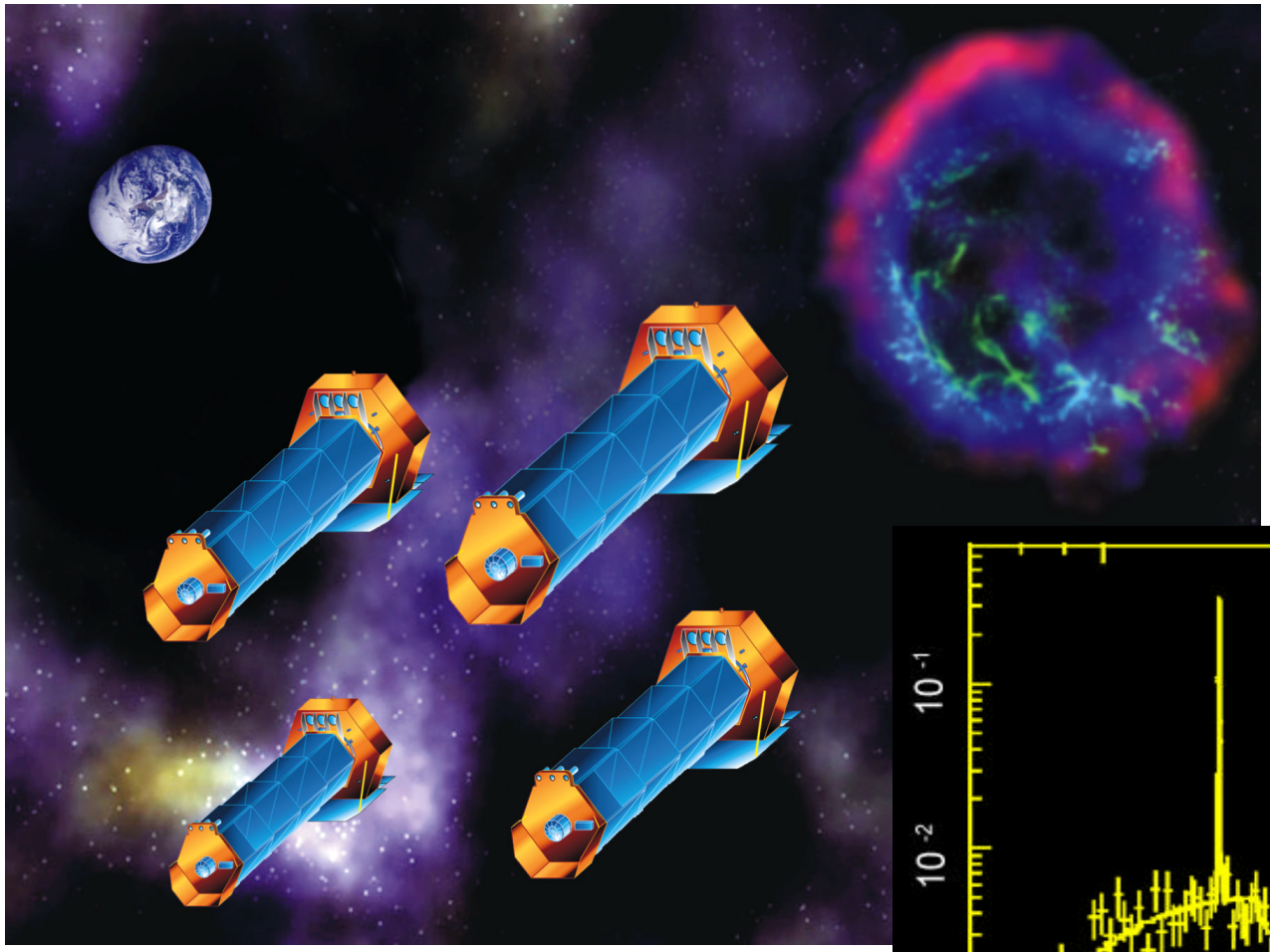


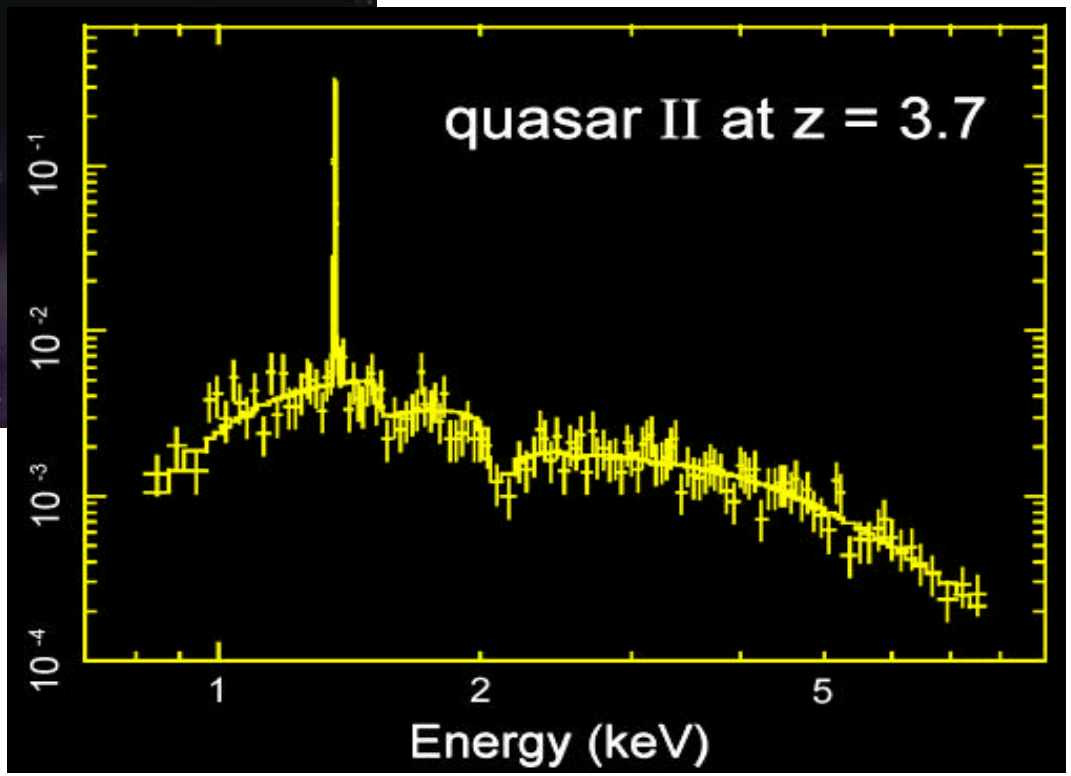




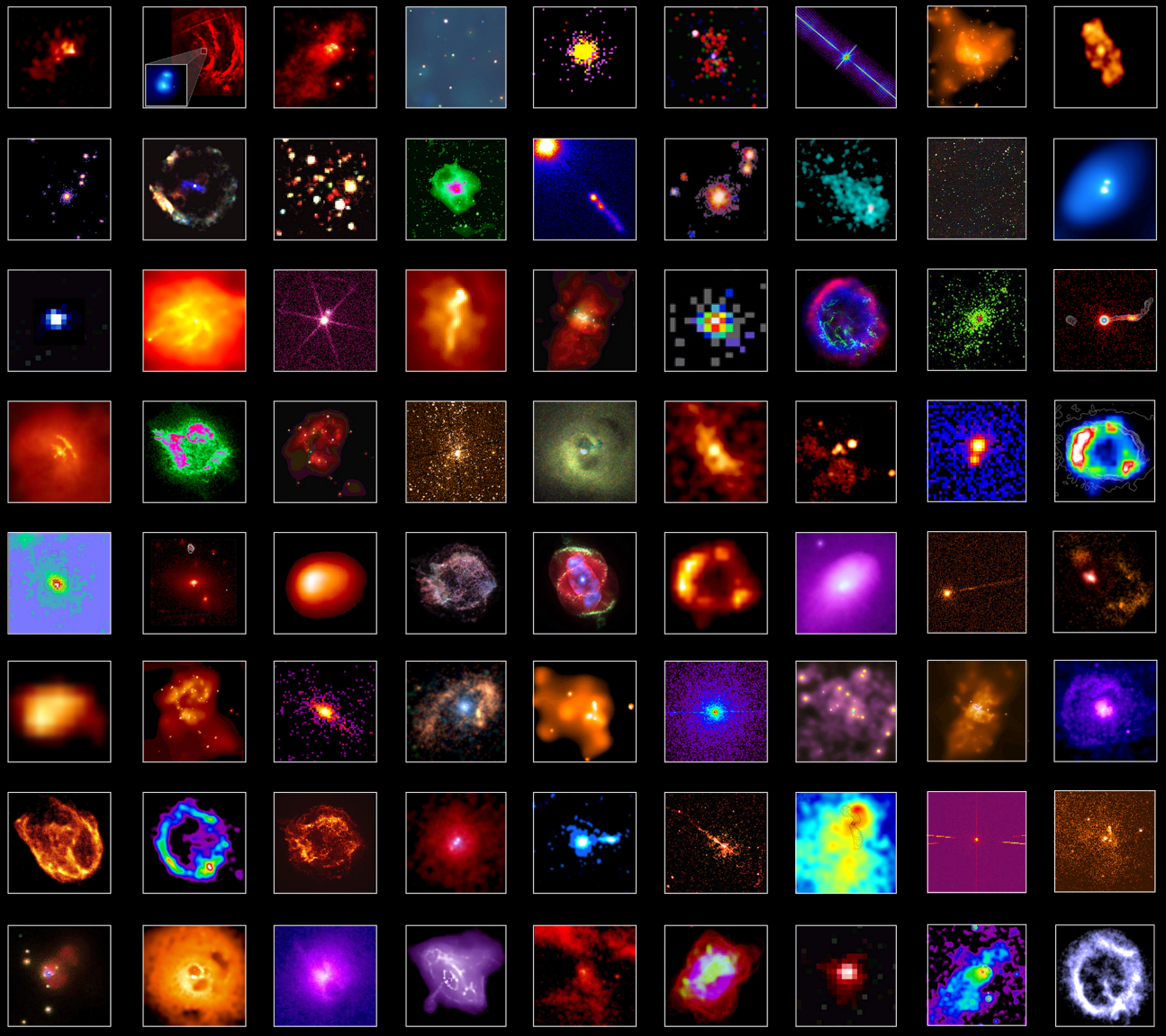


Constellation X-Ray Mission





1999 - 2001: Two Years of Chandra



http://chandra.harvard.edu