

The X-ray Evolution of the Supernova SN 1987A

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Vulcano, May 2006

ESO optical images of 30Dor

23 February 1987

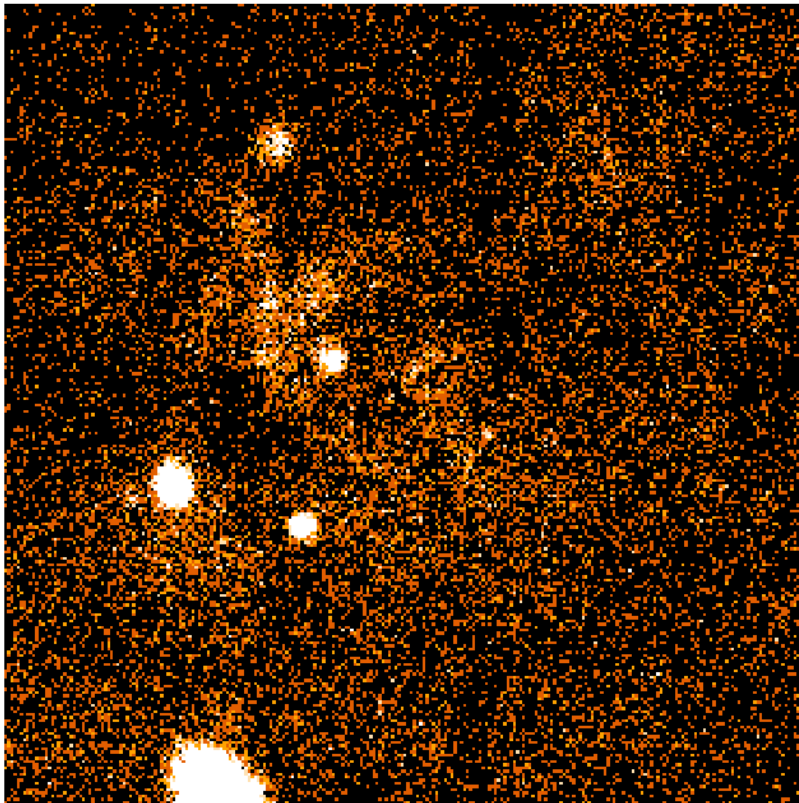


25 February 1987

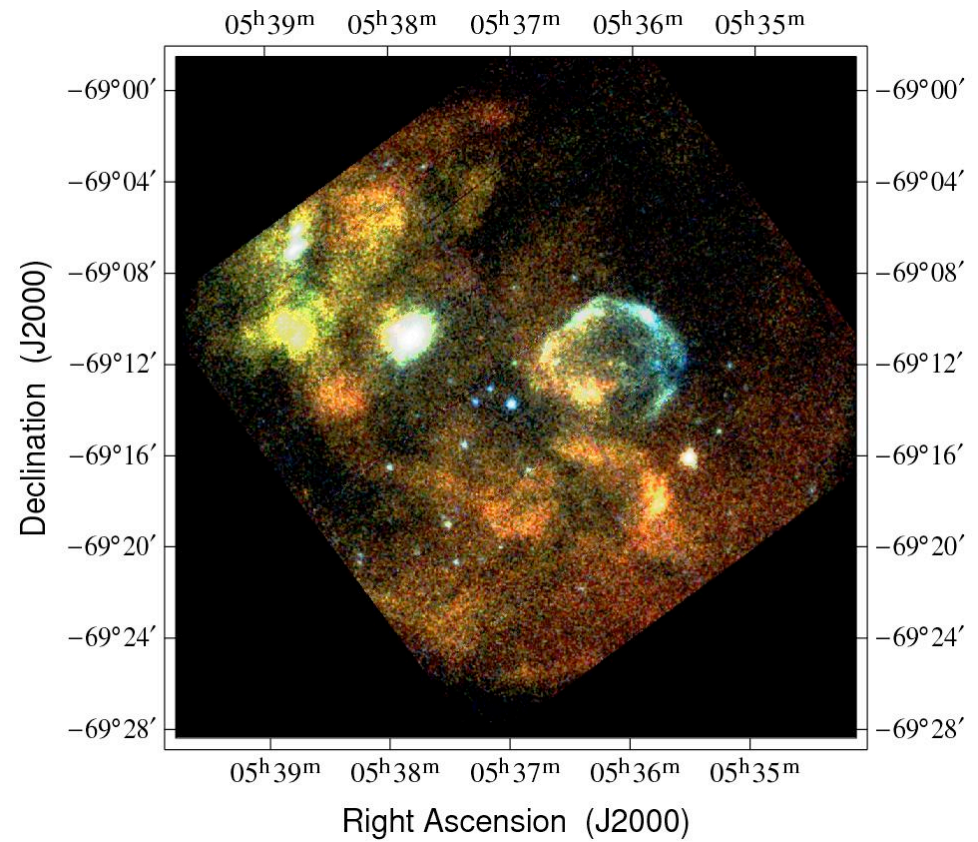


Supernova SN1987A

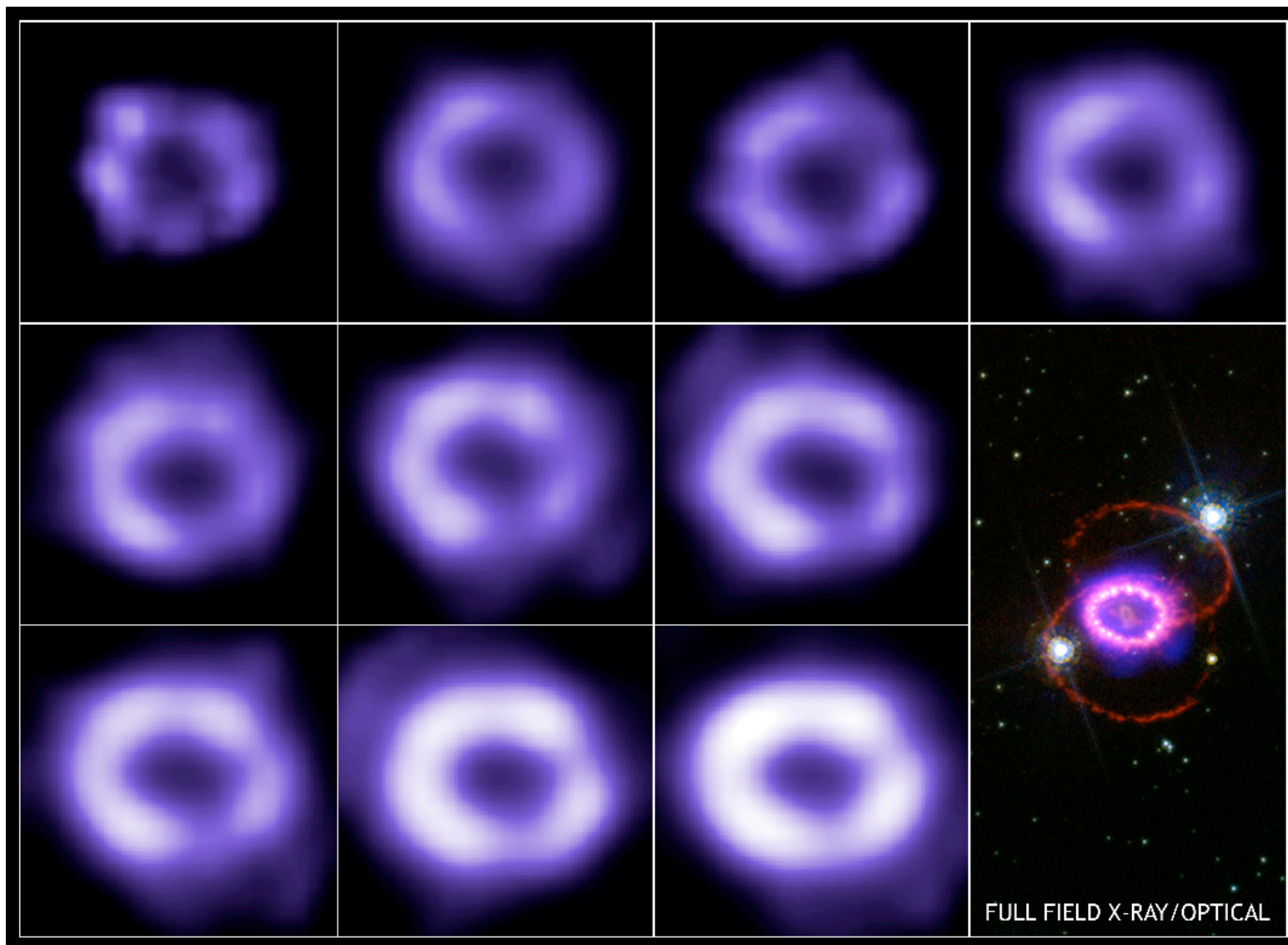
First appearance of soft X-rays
ROSAT, 1991



First Light on LMC
XMM-Newton, 2000



Chandra images, 1999 - 2005



X-ray Spectra of SN 1987A

Chandra, July 2005

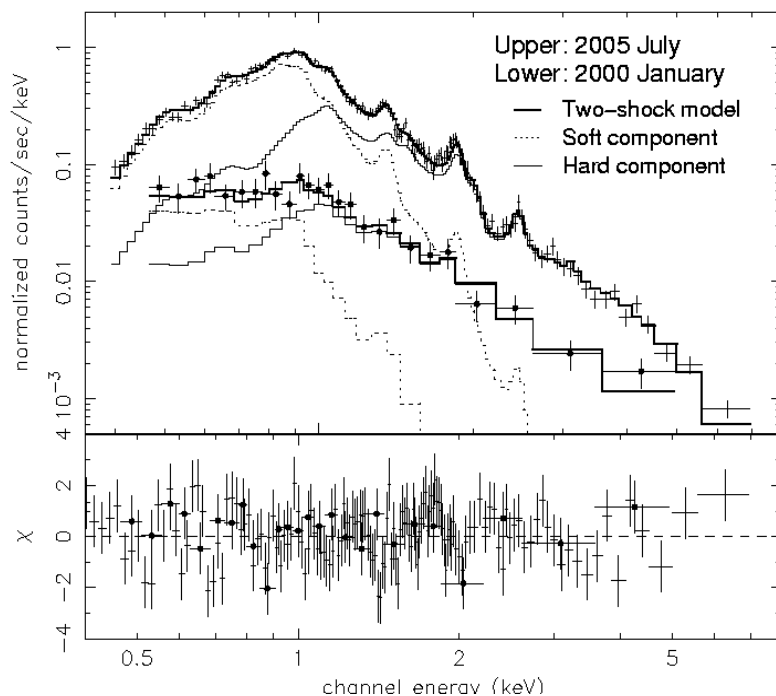
$kT_{1,2} = 0.3, 2.3$ keV

abundances subsolar (0.3 – 0.5)

O, Fe depleted

N enriched

N/O = 7 (9/04)



XMM-Newton, May 2003

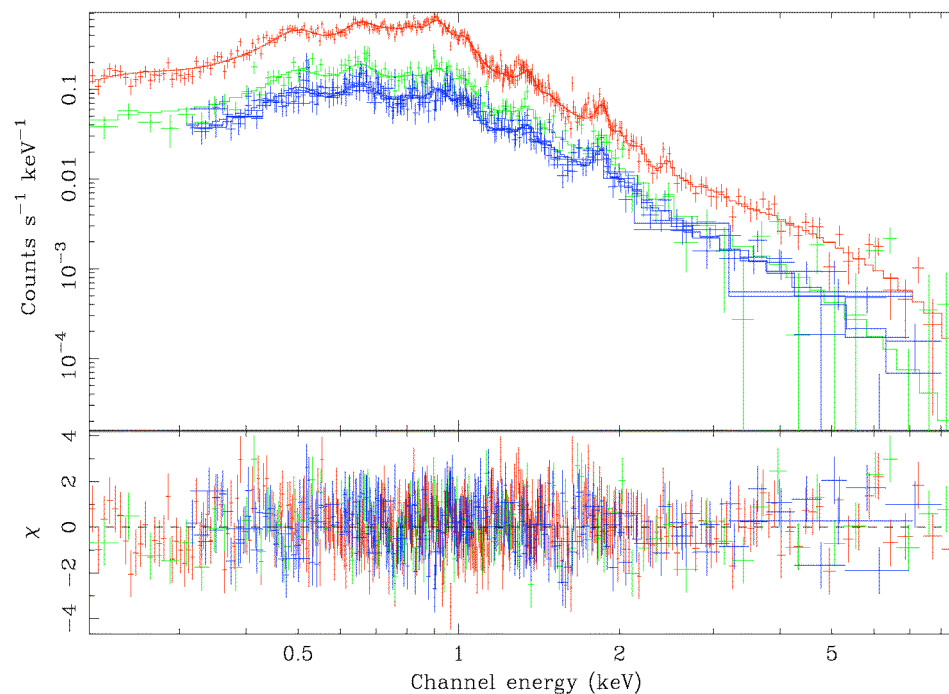
$kT_{1,2} = 0.3, 3.1$ keV

abundances subsolar (0.3 – 0.5)

O, Fe depleted

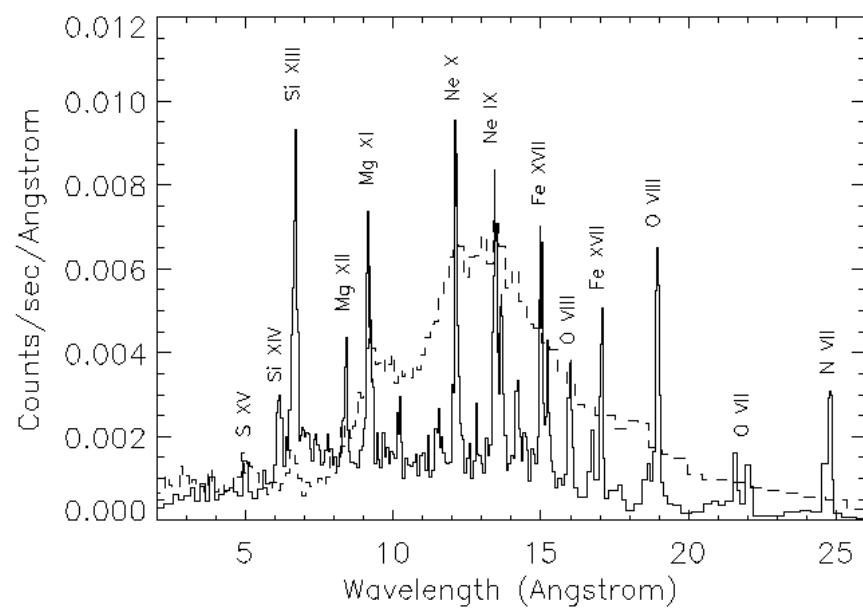
N enriched

N/O = 11 (5/03)

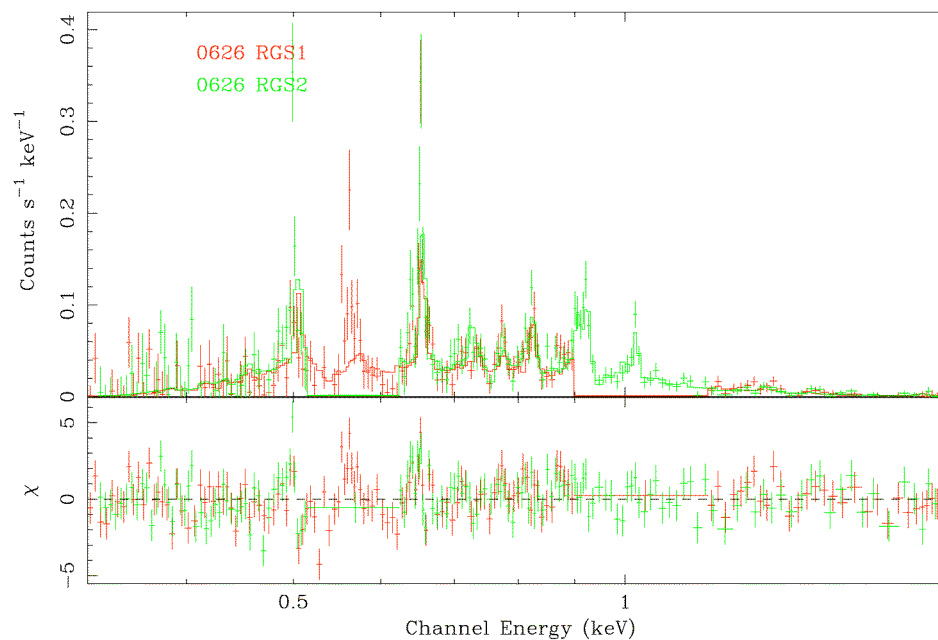


SN87A Emission Line Spectra

Chandra LETG, 09/04

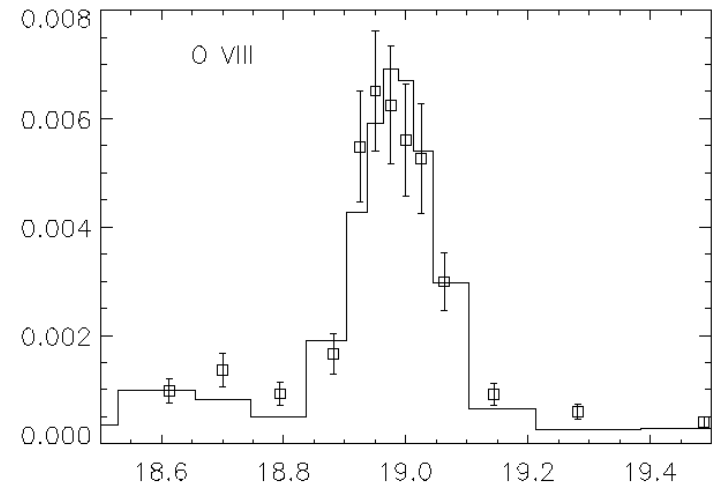
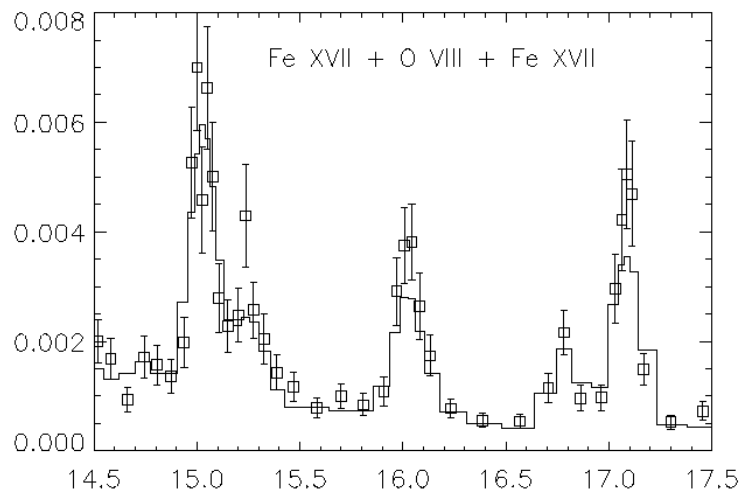
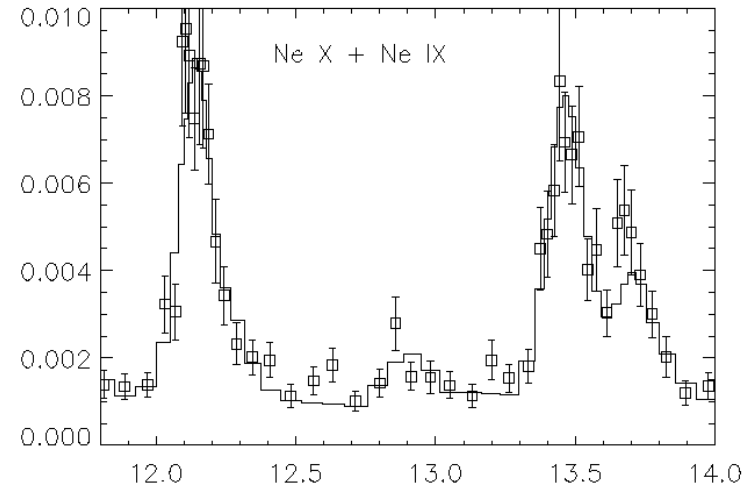
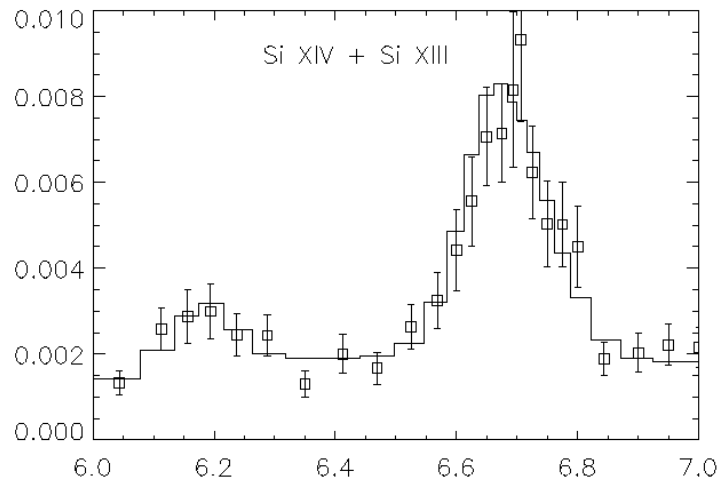


XMM-Newton RGS1&2, 05/03



Chandra LETG Spectra

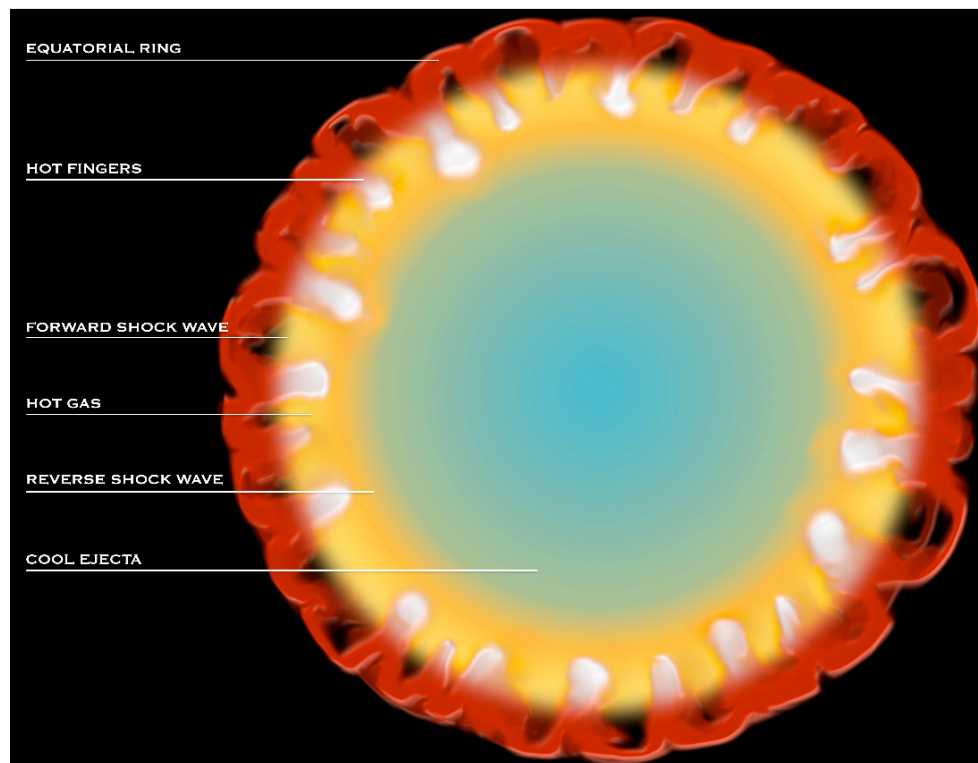
August/September 2004



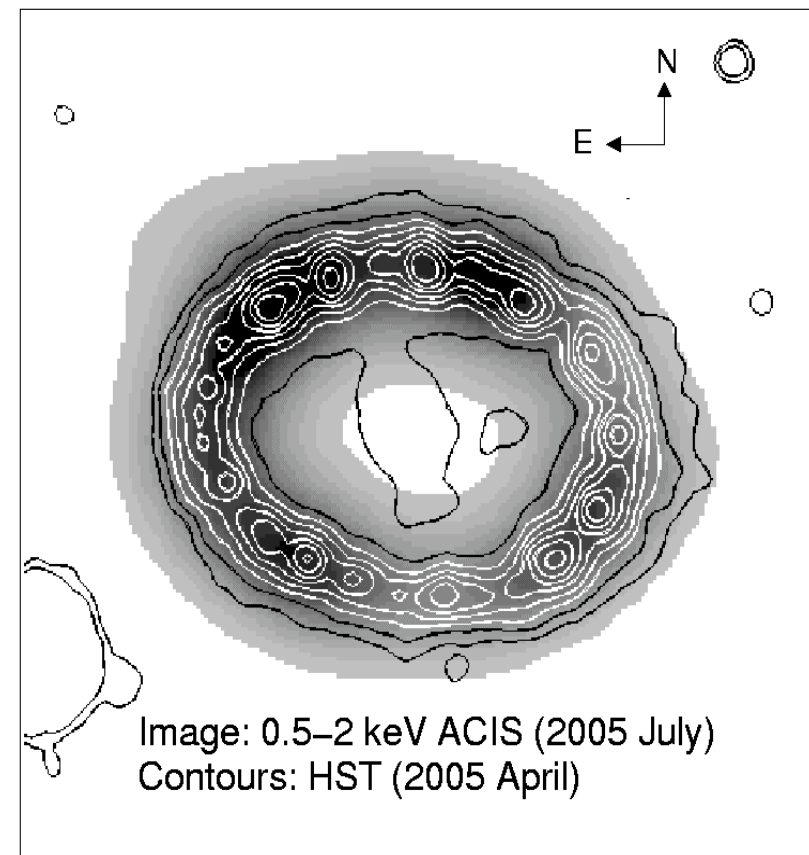
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Interaction with the Circumstellar Medium

Model

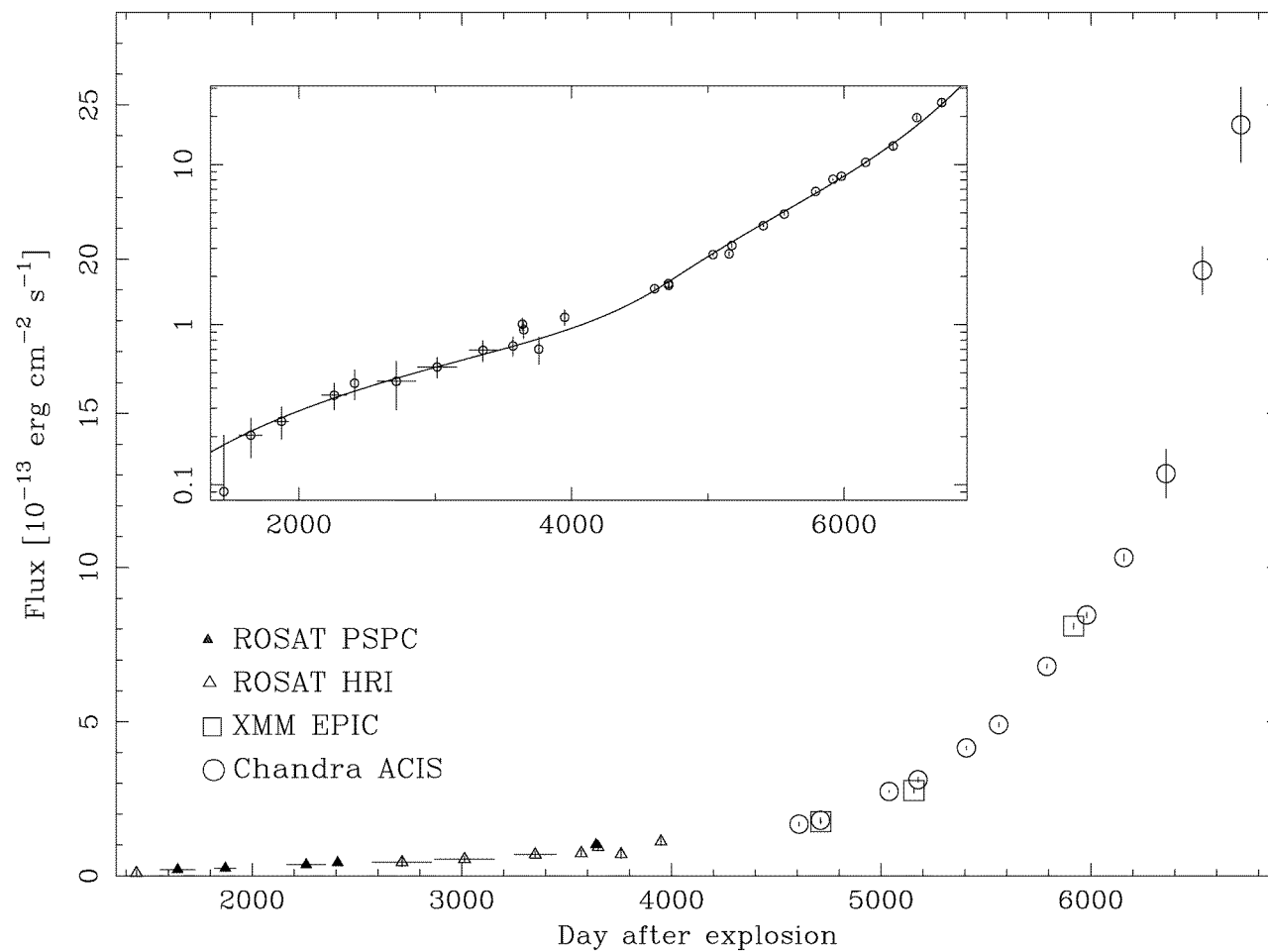


Emitting Region



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The (0.5 – 2 keV) Lightcurve



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Modeling of the soft X-ray Lightcurve

$$L_x(\Delta E) = \Lambda(T, Z, z, \Delta E) \int_0^{r_s} \int_0^{4\pi} n^2(r, \Theta) r^2 dr d\Theta$$

$$\Delta E = 0.5 - 2 \text{ keV}$$

$$dr = v_s \cdot dt, \quad r_s = \int_0^{t_s} v_s \cdot dt$$

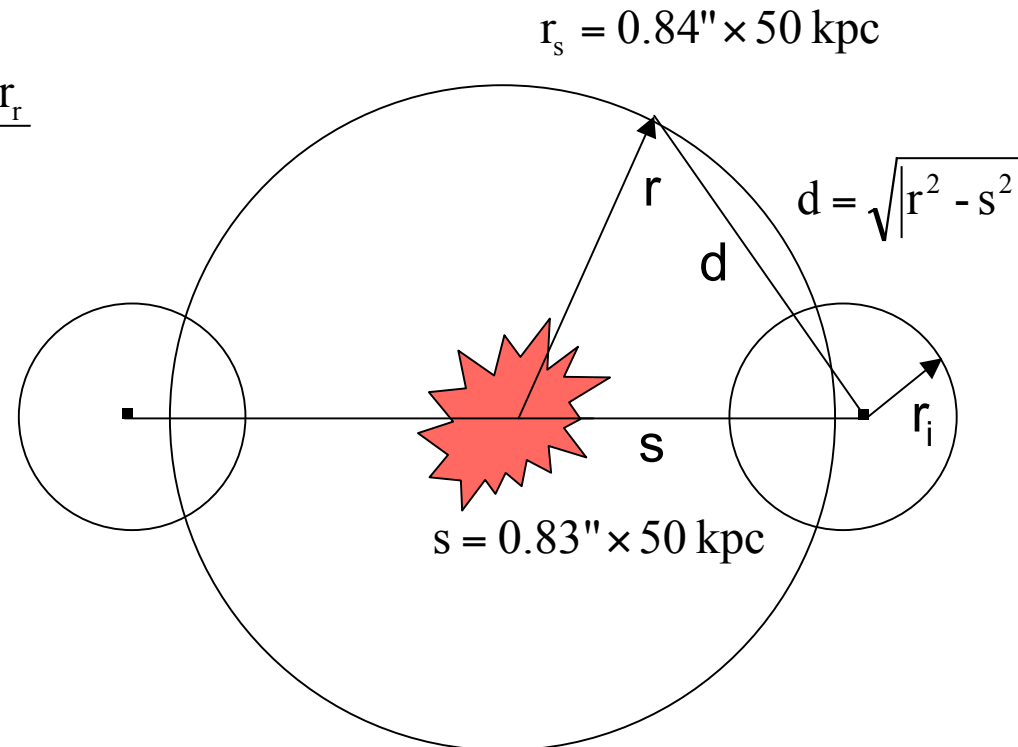
$$v_b = \frac{3}{4} v_s$$

$$n \propto \exp\left[-\left(\frac{d - r_r}{h_o}\right)\right] \times \frac{s - r_r}{r}$$

for $d > r_r$

$$n \propto \exp\left[\left(\frac{r_r - r_i}{h_1}\right)^2\right]$$

for $d \leq r_r$

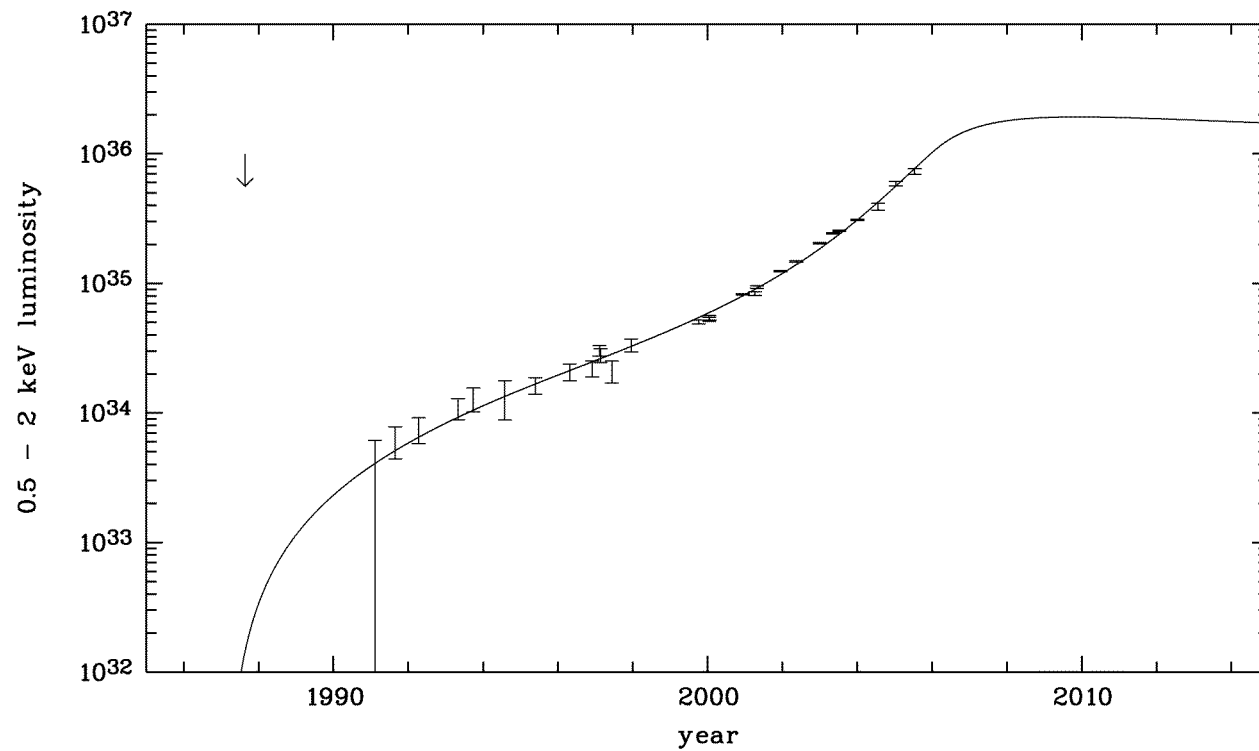


Results of Lightcurve Modeling

$$r_r = 0.48'', r_i = 0.35'', h_0 = 0.09'', h_i = 0.14''$$

$$n_{e,c} = 1.4 \times 10^4 \text{ cm}^{-3} \text{ (UV : } 2 - 4 \times 10^4 \text{ cm}^{-3} \text{)}$$

$$M_{\text{tot}} = 1.2 M_{\text{sun}}, M_r = 0.07 M_{\text{sun}} \text{ (UV : } M_r = 0.03 - 0.05 M_{\text{sun}} \text{)}$$



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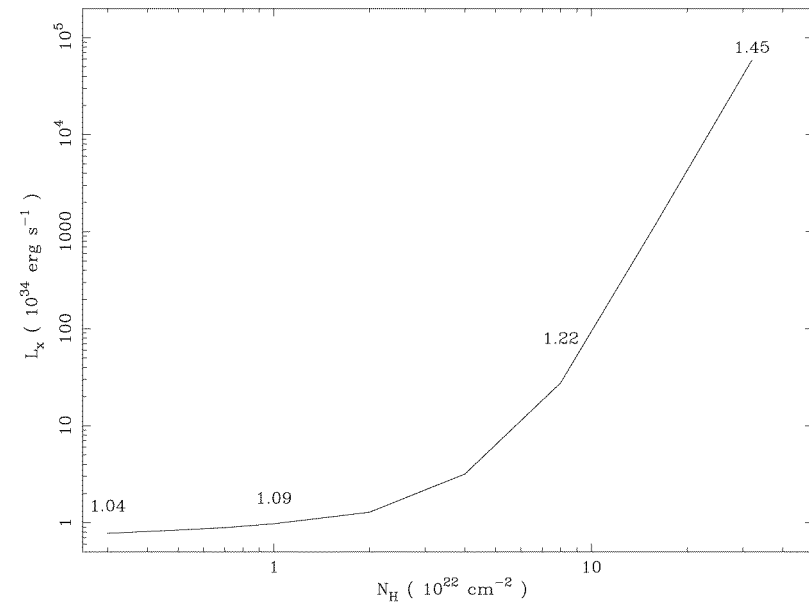
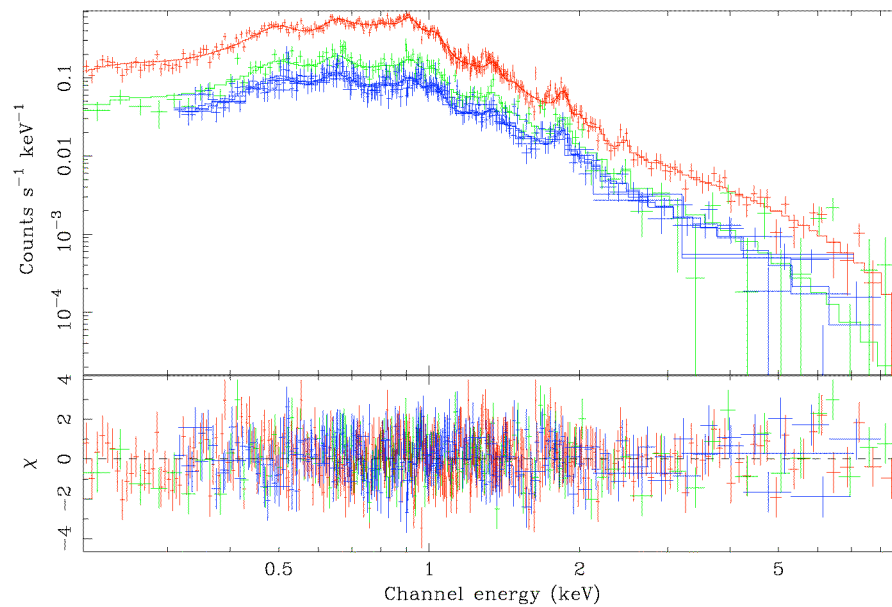
Is there a central point source ?

HST, direct imaging : $L_{\text{opt}} < 5 \times 10^{33} \text{ erg s}^{-1}$

Chandra, direct imaging : $L_{\text{X}} < 1.5 \times 10^{34} \text{ erg s}^{-1}$

Integral, imaging : $L_{\text{hx}} < 1.1 \times 10^{36} \text{ erg s}^{-1}$

XMM - Newton : see below



$$\int_a$$