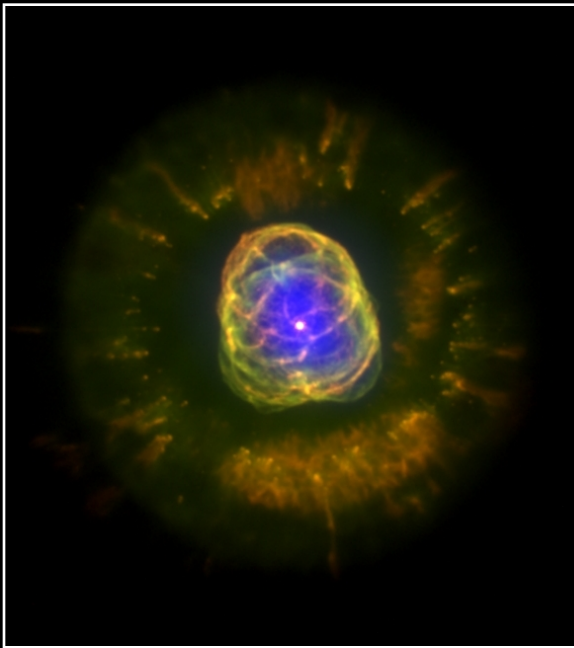


Hot Gas in Planetary Nebulae

X-ray emission detected by Chandra & XMM-Newton

NGC 2392



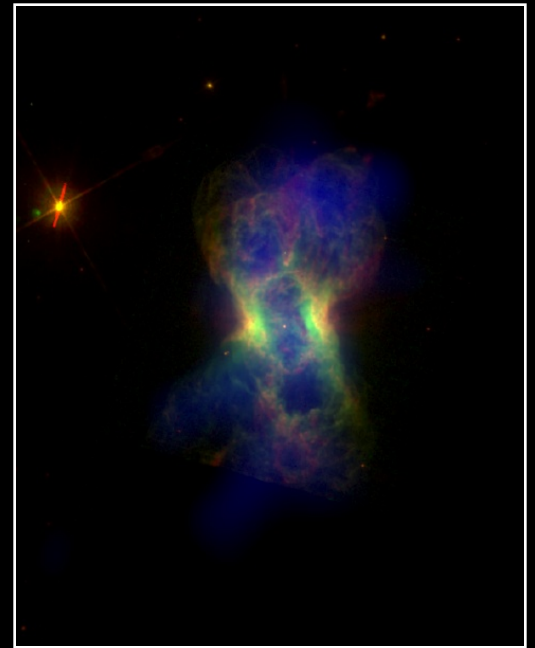
Guerrero et al. (2005)

NGC 6543



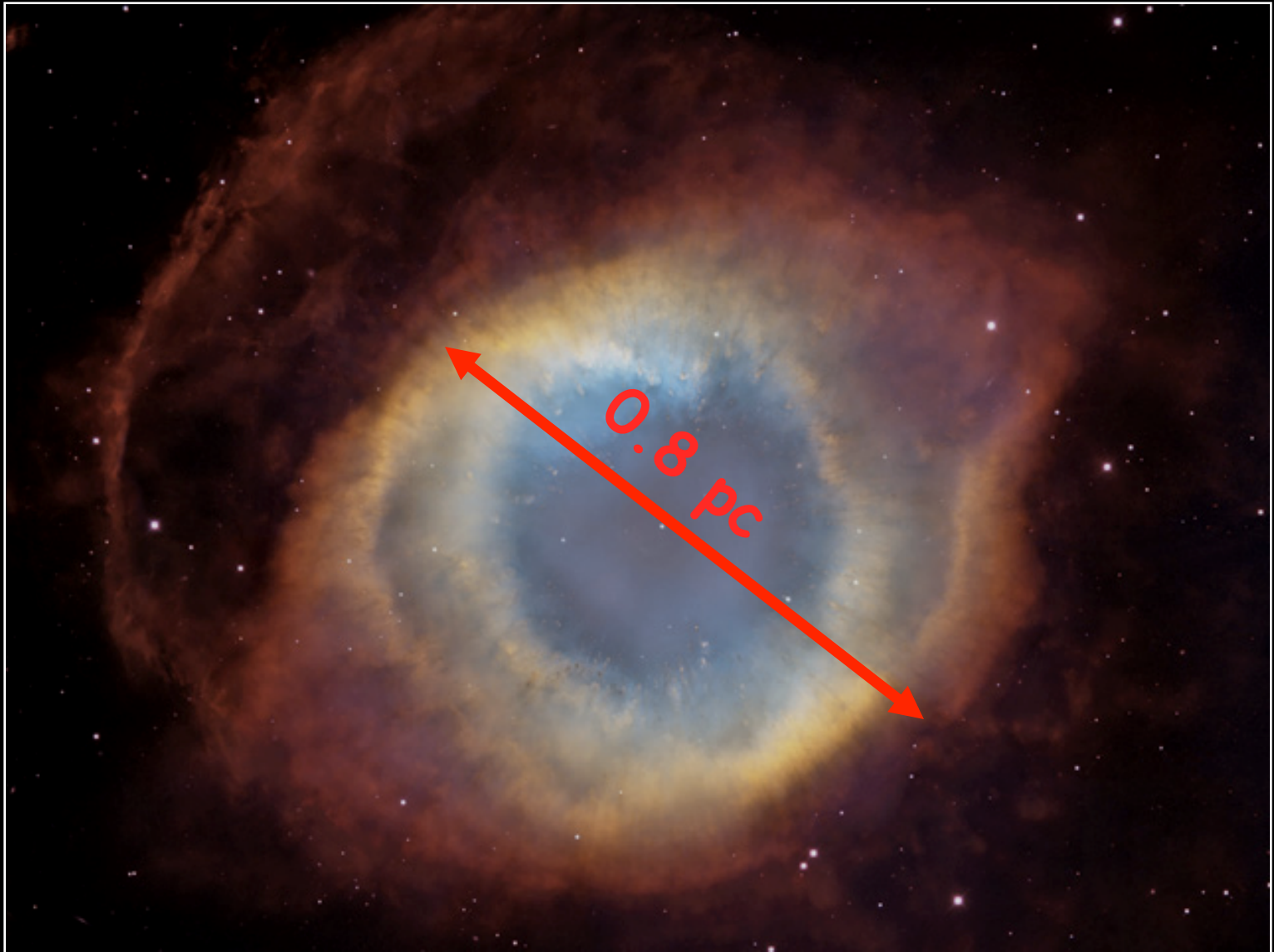
Chu et al. (2001)

NGC 7026

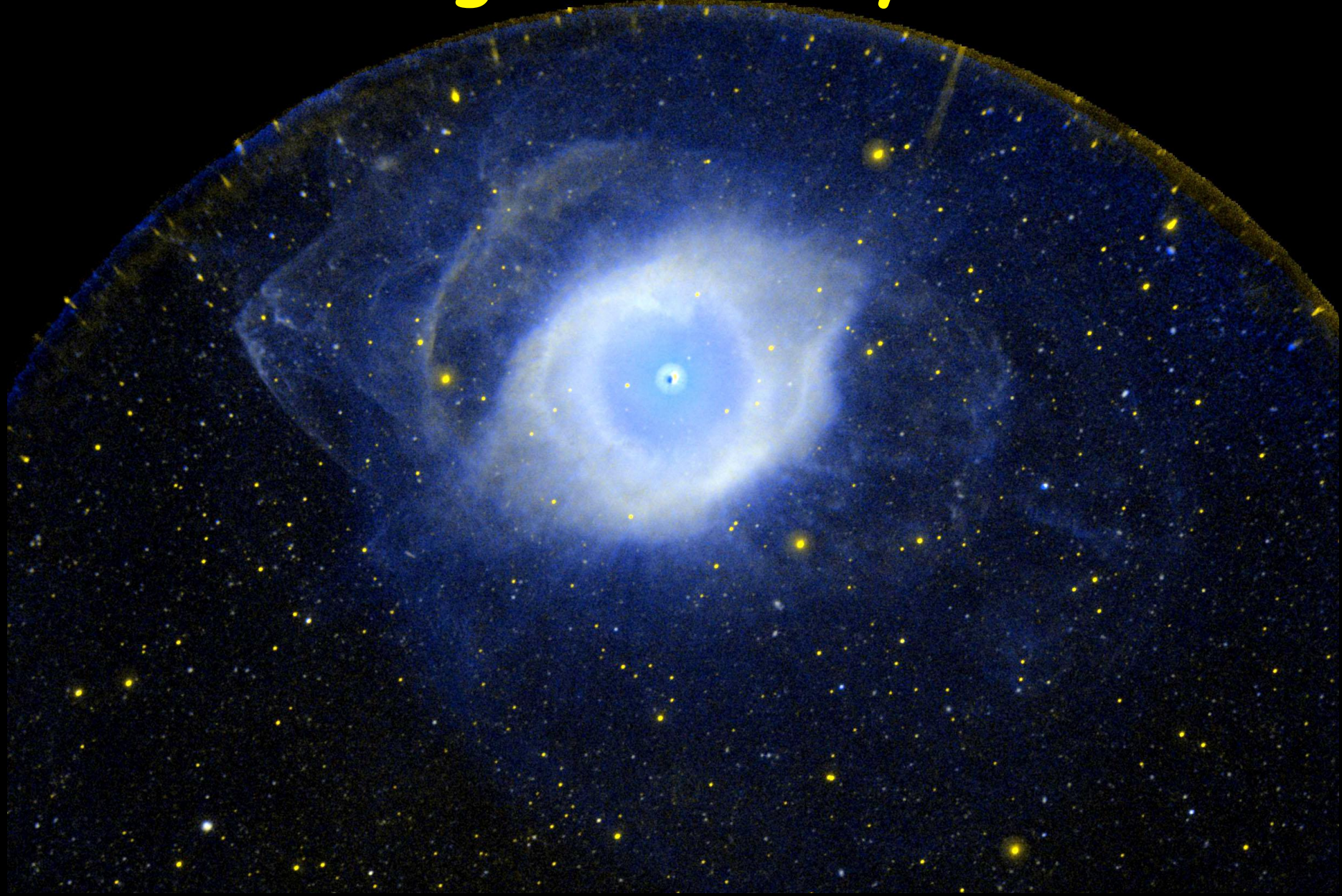


Gruendl et al. (2006)

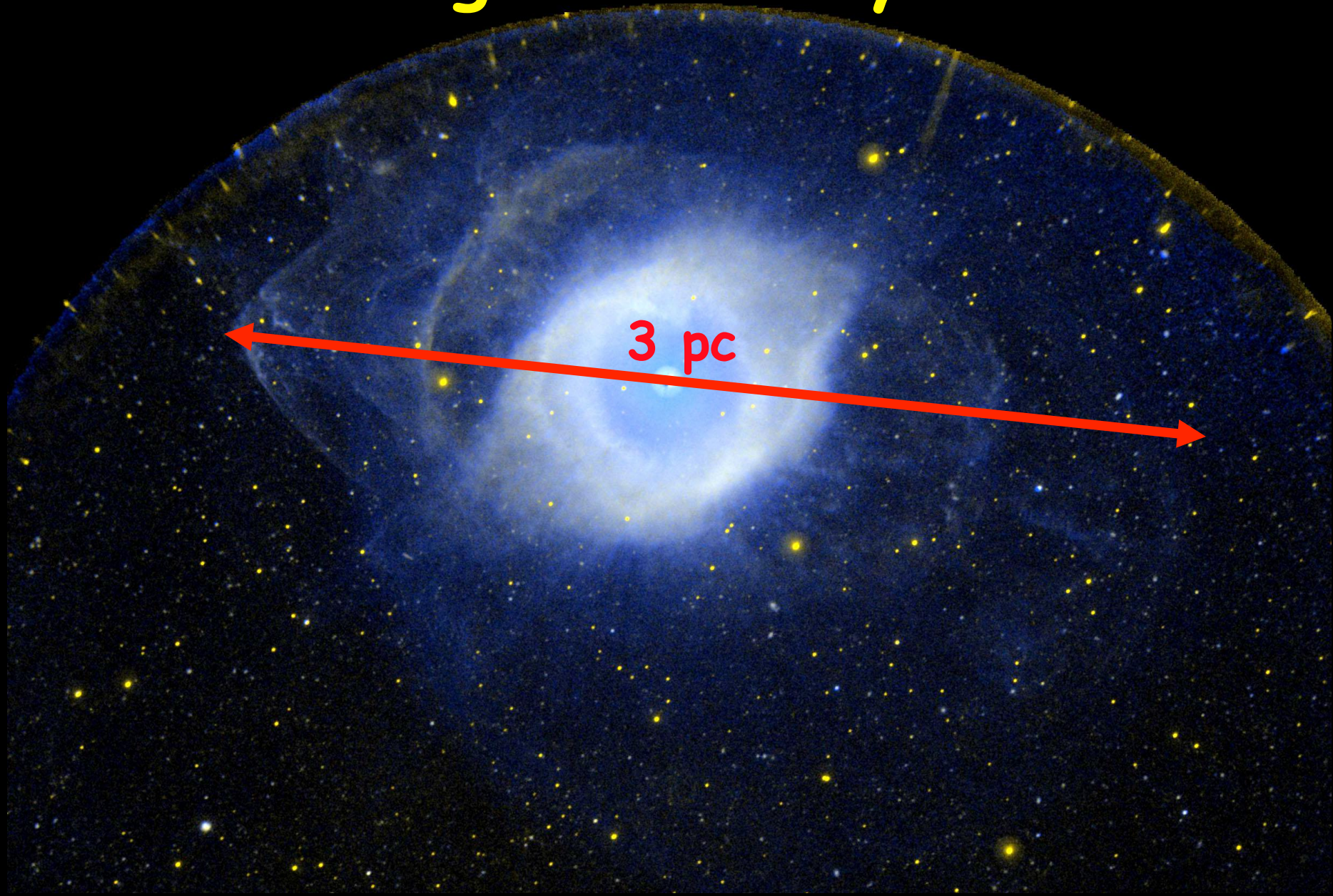
Helix Nebula - HST + KPNO 0.9m



UV Image Taken by GALEX



UV Image Taken by GALEX



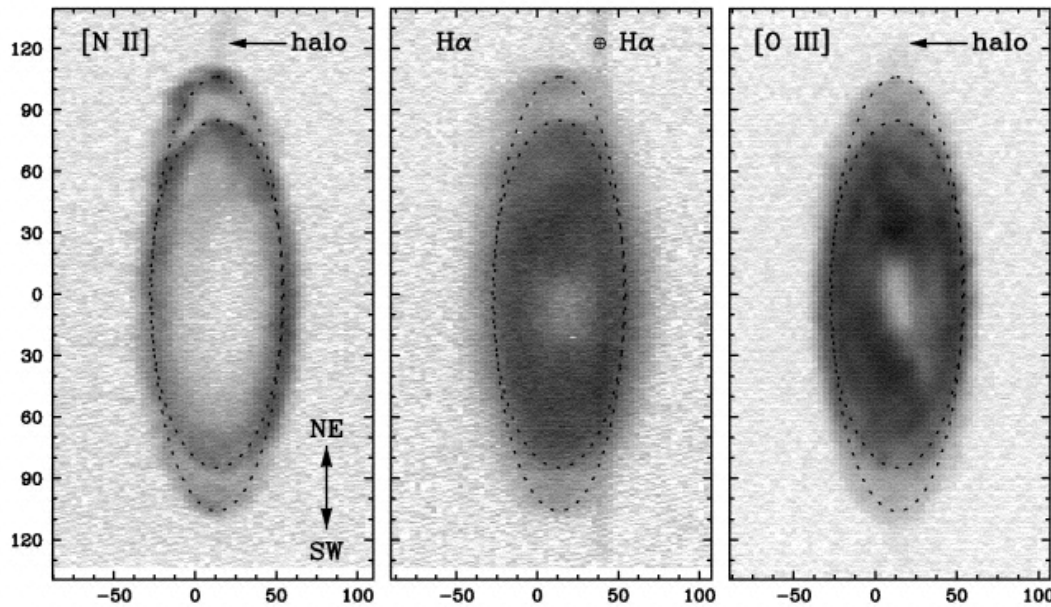
Owl Nebula

$V_{\text{exp}} = 40 \text{ km/s}$
 $\text{Age} \sim 12,900 \text{ d}_{\text{kpc}} \text{ yr}$

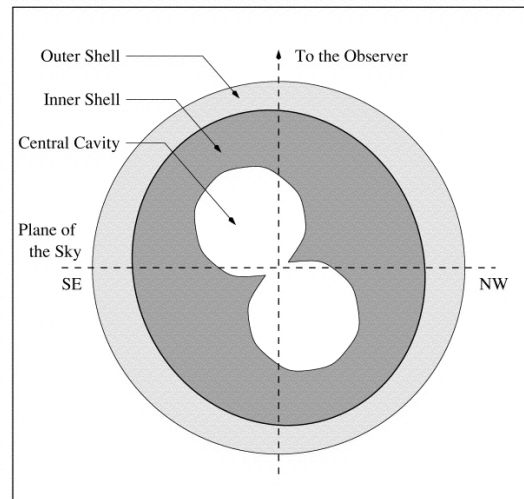
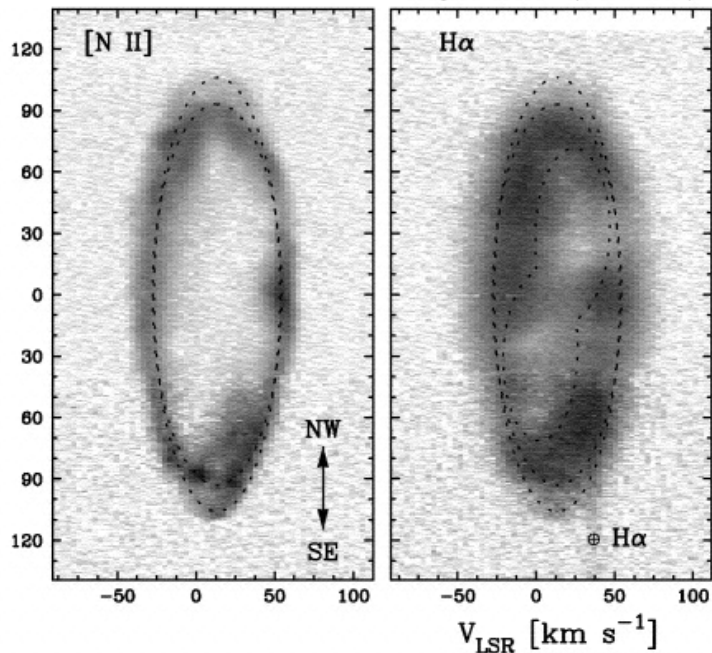
The central cavity is
being back-filled.

Relative position [arcsec]

Minor Axis (PA $+45^\circ$)



Major Axis (PA -45°)



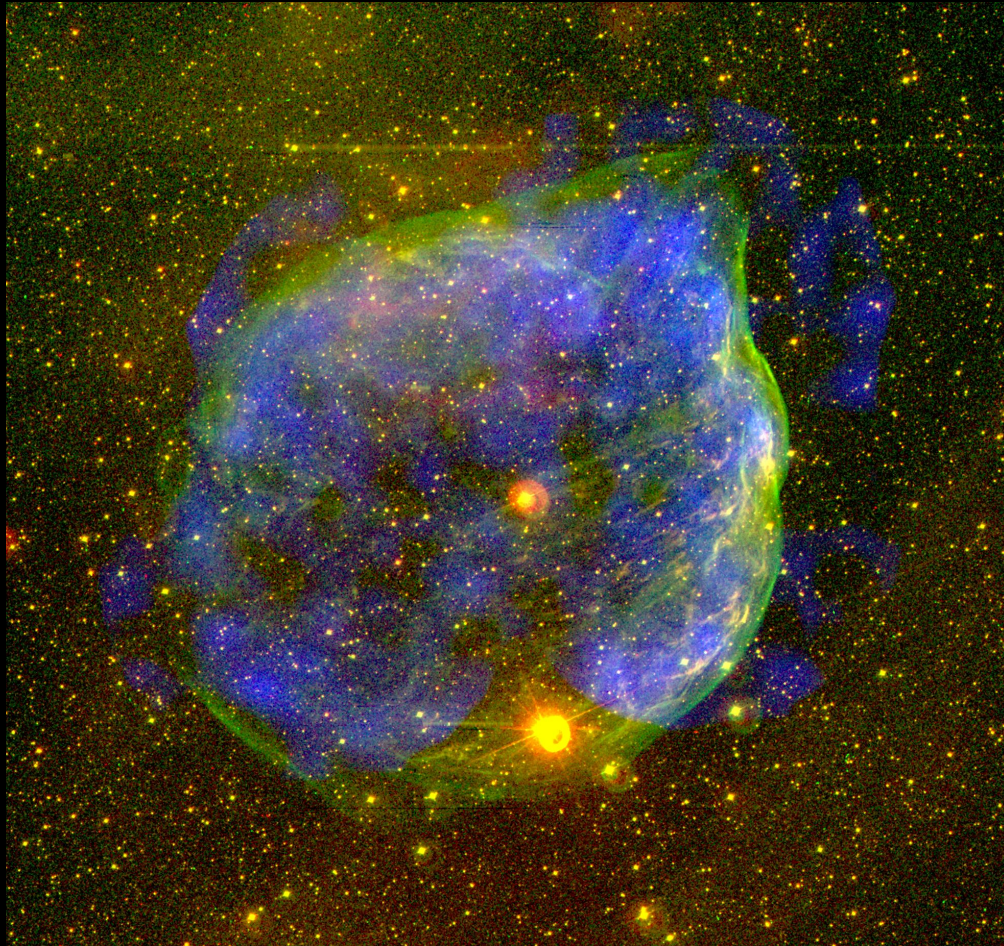
Guerrero et al. 2003

The Bubble Nebula



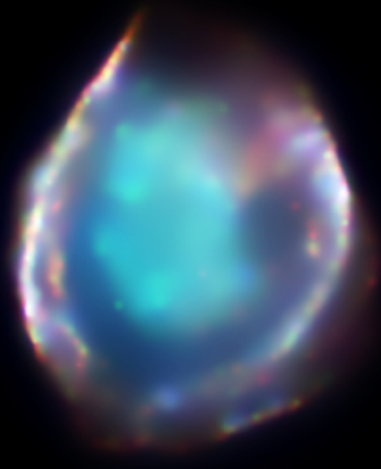
Copyright ©2002-2005 by Russell Croman

S 308 - a WR Circumstellar Bubble



Red: $H\alpha$ Green: [O III] Blue: X-ray

Supernova Remnants



N49



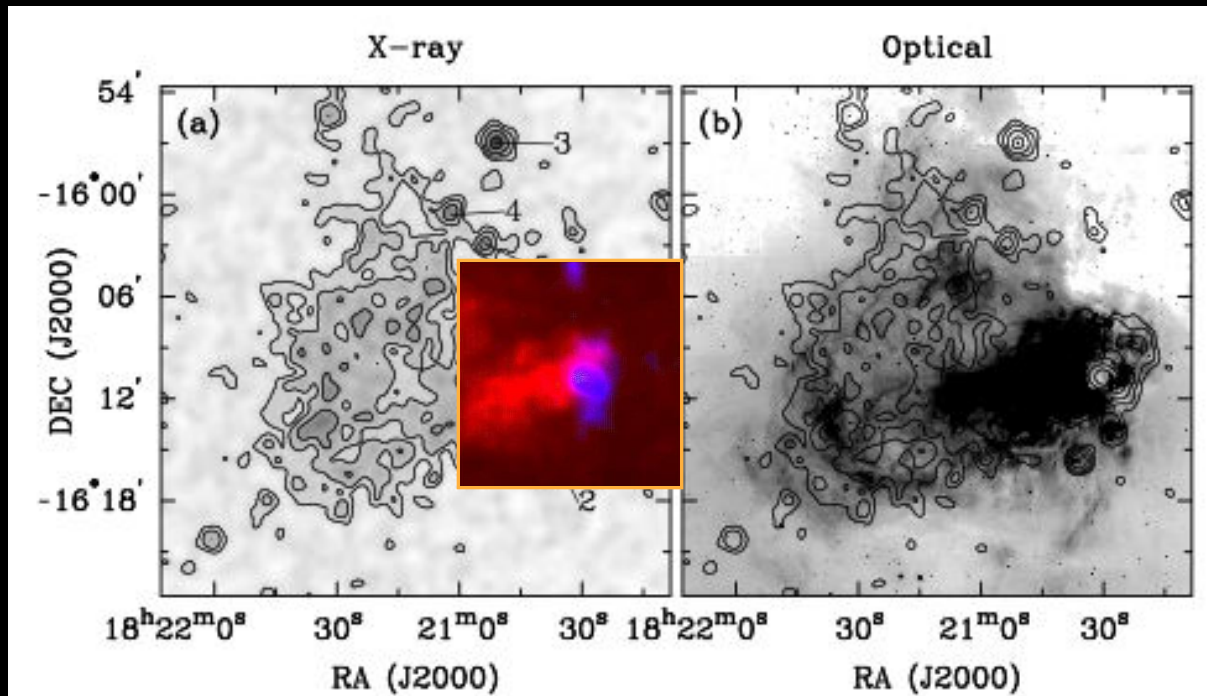
[HTTP://CHANDRA.SI.EDU](http://chandra.si.edu)

Hot Gas in the Omega Superbubble

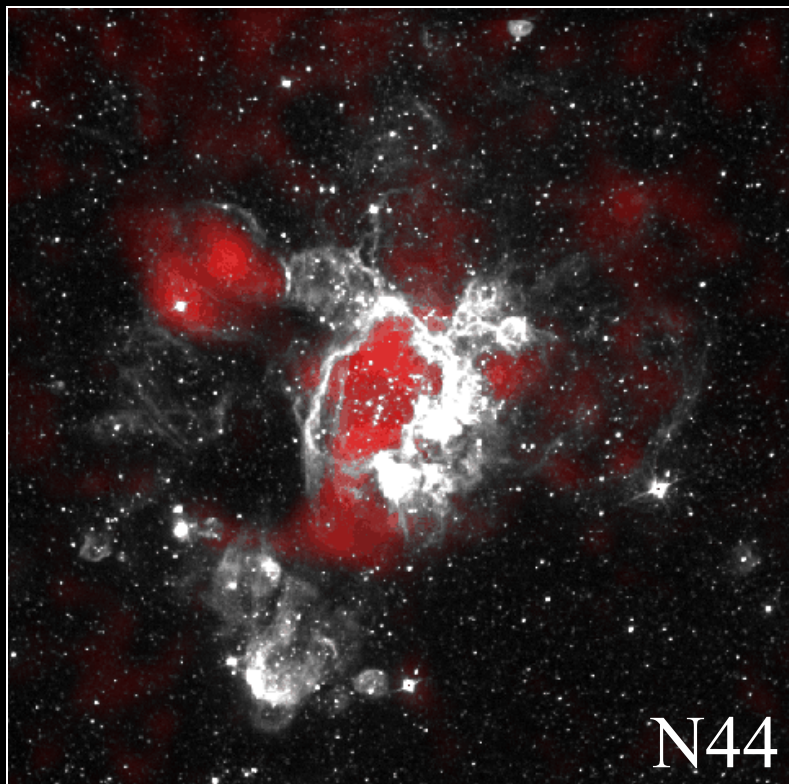
Two young superbubbles are detected in X-rays by Chandra: Omega and (Rosette)

ROSAT - Dunne et al. 2003, ApJ, 590, 306

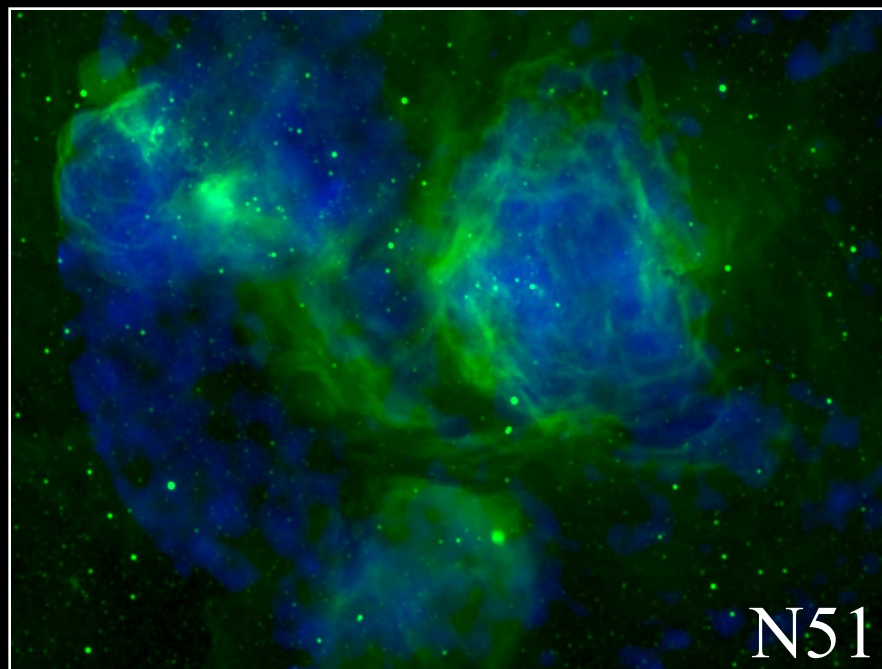
Chandra - Townsley et al. 2003, ApJ, 593, 874



X-ray-bright Superbubble N44 in the LMC

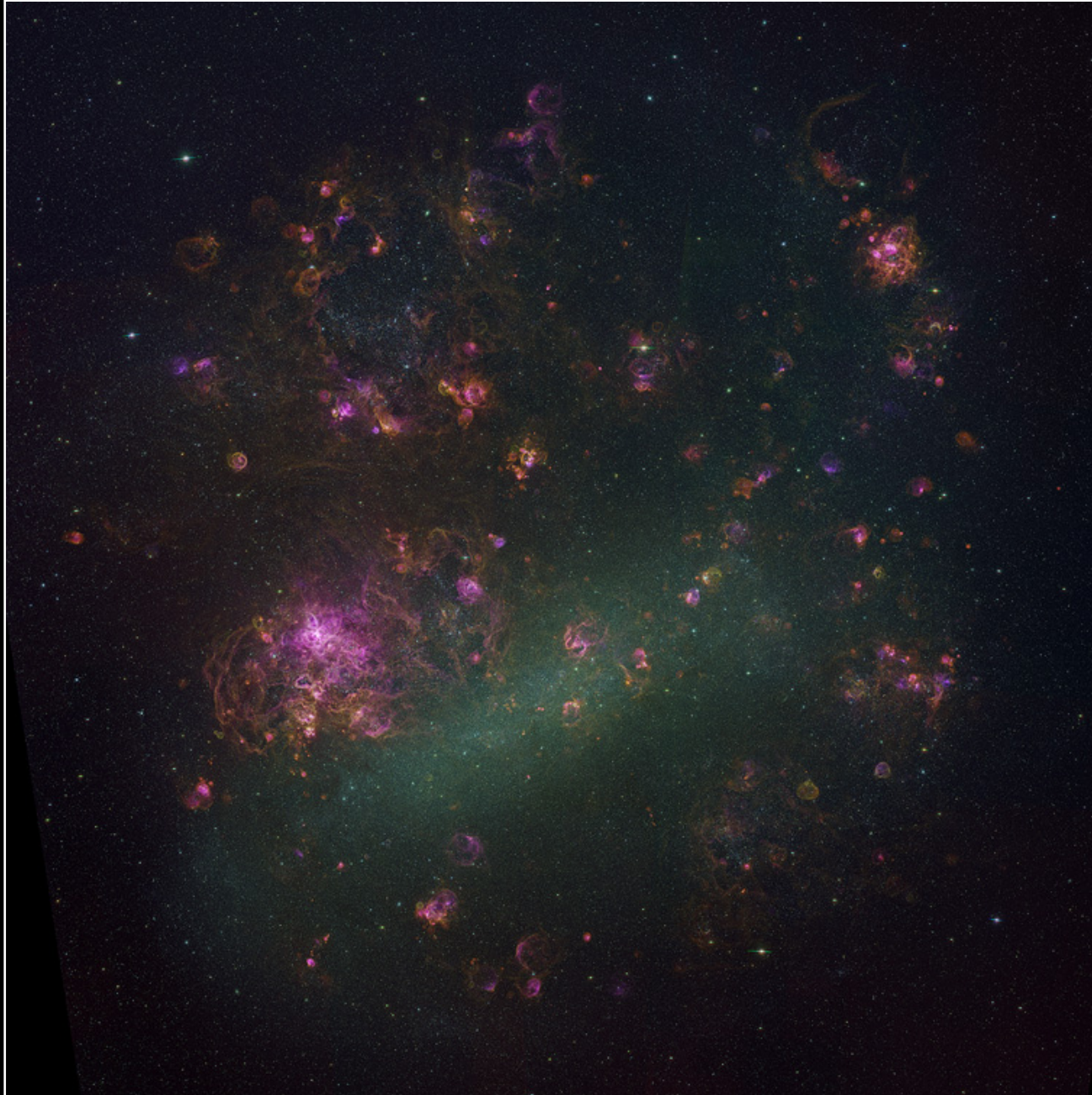


Chu et al. 1993, ApJ



Cooper et al. 2004

Large Magellanic Cloud



$H\alpha$ -red

[O III] -blue

[S II] -green



Bubbles, SNRs

$\sim 10 - 50$ pc

$\sim 10^3 - 10^5$ yr

(single star)

Superbubbles

~ 100 pc

$\sim 10^6$ yr

(multiple stars)

Supergiant shells

~ 1000 pc

$\sim 10^7$ yr

(multi generations)

R - H α

G - [S II]

B - [O III]

500 pc