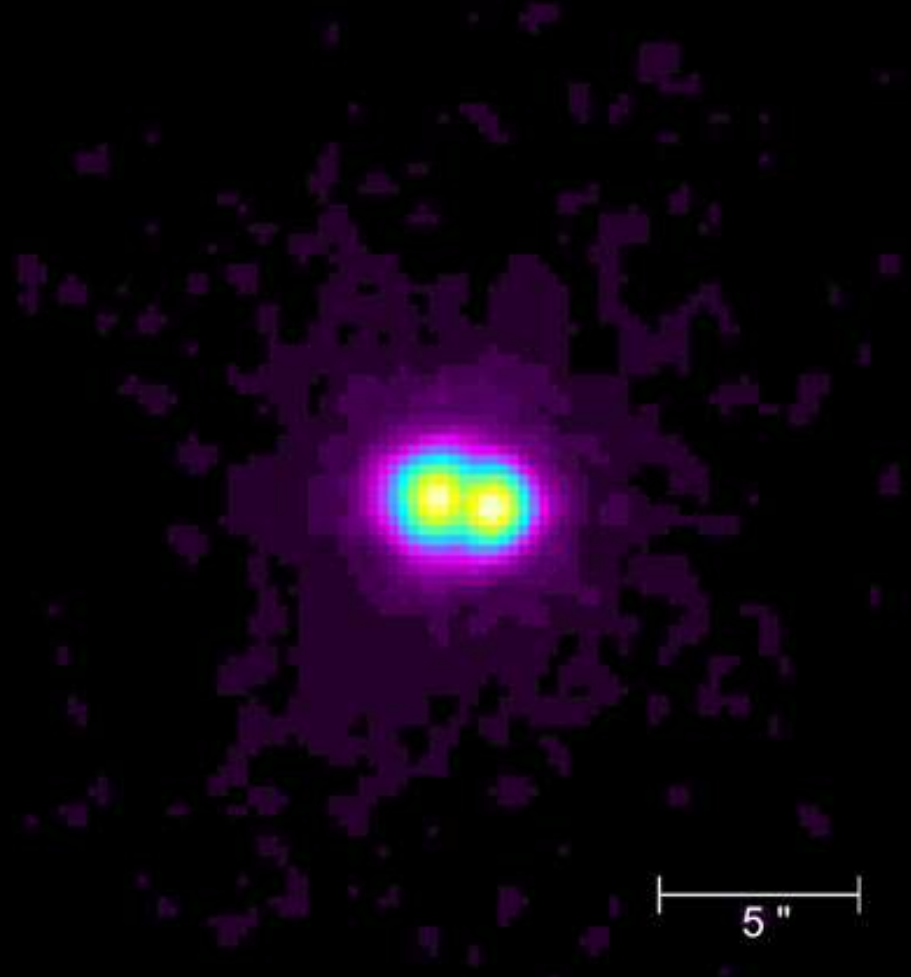
The Chandra View of X-ray Binaries



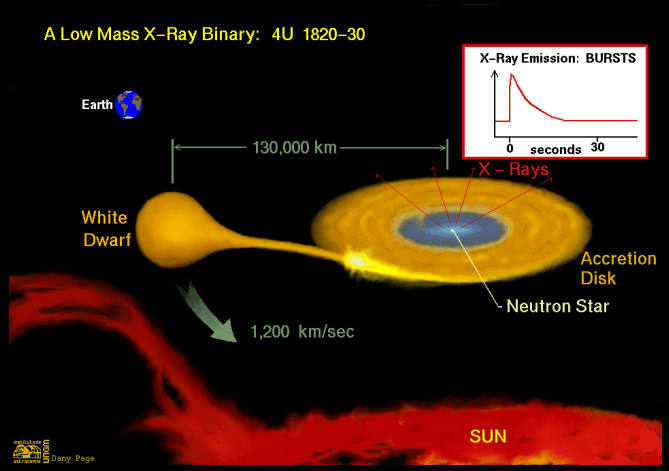
Saeqa Vrtilek
Harvard-Smithsonian
Center for Astrophysics

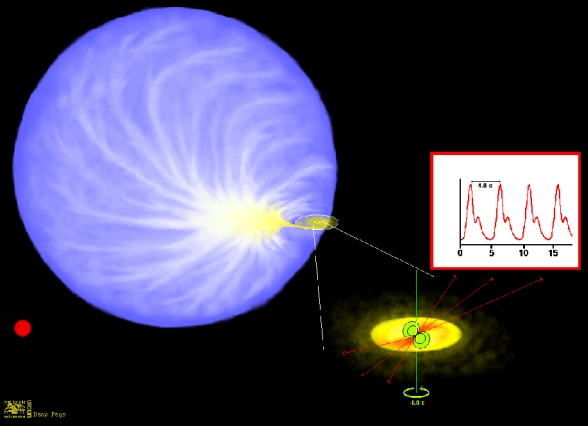
- Why X-ray Binaries?

- Spatial
  - XRB Location/Identification
  - XRB Populations
    - M31 (Garcia)
  - XRB Luminosity Functions (Gilfanov)
  - X-ray Scattering Halos
    - GX 13+1
    - Cygnus X-1
- Spectral
  - Elements and Abundances
    - Her X-1
    - GX301-2
    - Cyg X-3
  - Jets and Winds
    - Circinus X-1
    - Black Holes (Miller)
    - SS433 (Marshall)
- Timing
  - Gravity Waves
    - J0806.3+1527
  - Pulse Phase Spectroscopy
    - SMC X-1
- Future
  - Constellation-X
  - Gen X
  - X-ray polarimetry
  - X-ray interferometry?

Why X-ray Binaries?

- Most efficient energy release mechanism known
- Behavior of matter under extreme conditions
- Endpoints of stellar evolution
- Most nearby, easily studied example of accretion process





What remains to be understood?

- The mass-transfer process
- Angular momentum transfer/disk structure
- Equation of state of neutron stars

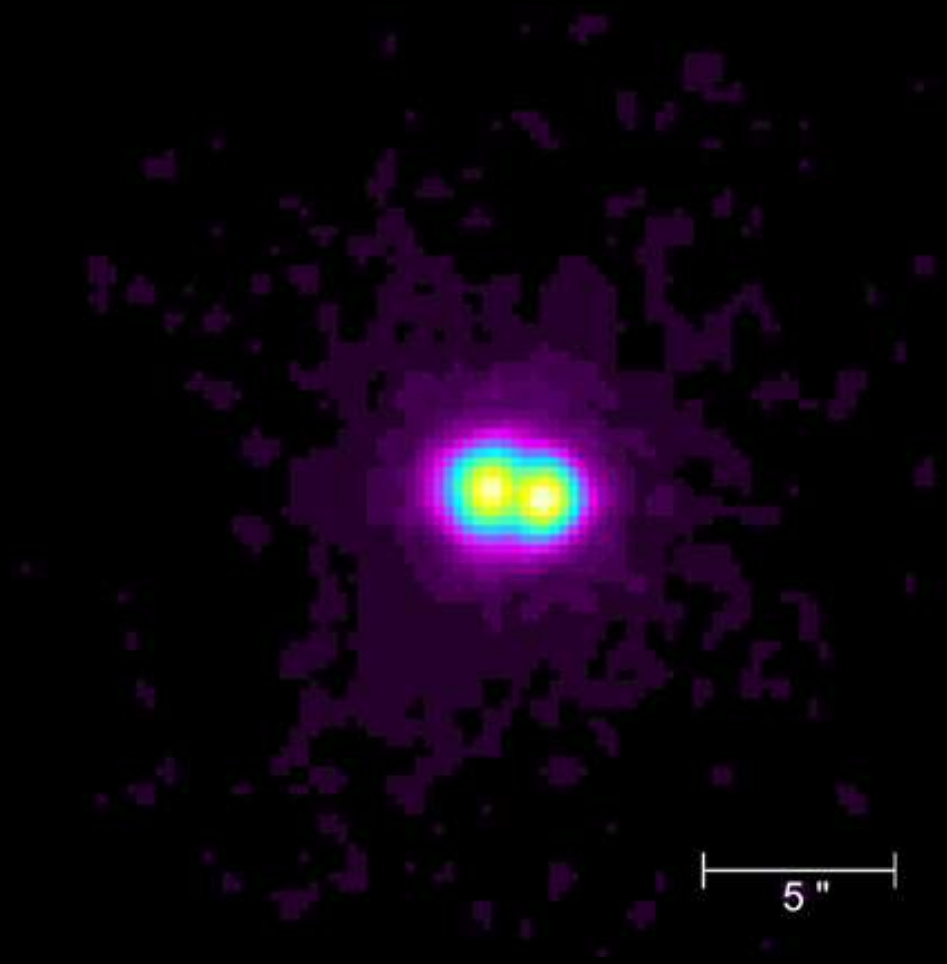
See poster 2.5 Jonker et al

- Formation process of compact objects
- Origin and evolution of binary systems

Spatial

Double XRB in M15

4U2127 & M15 X-2

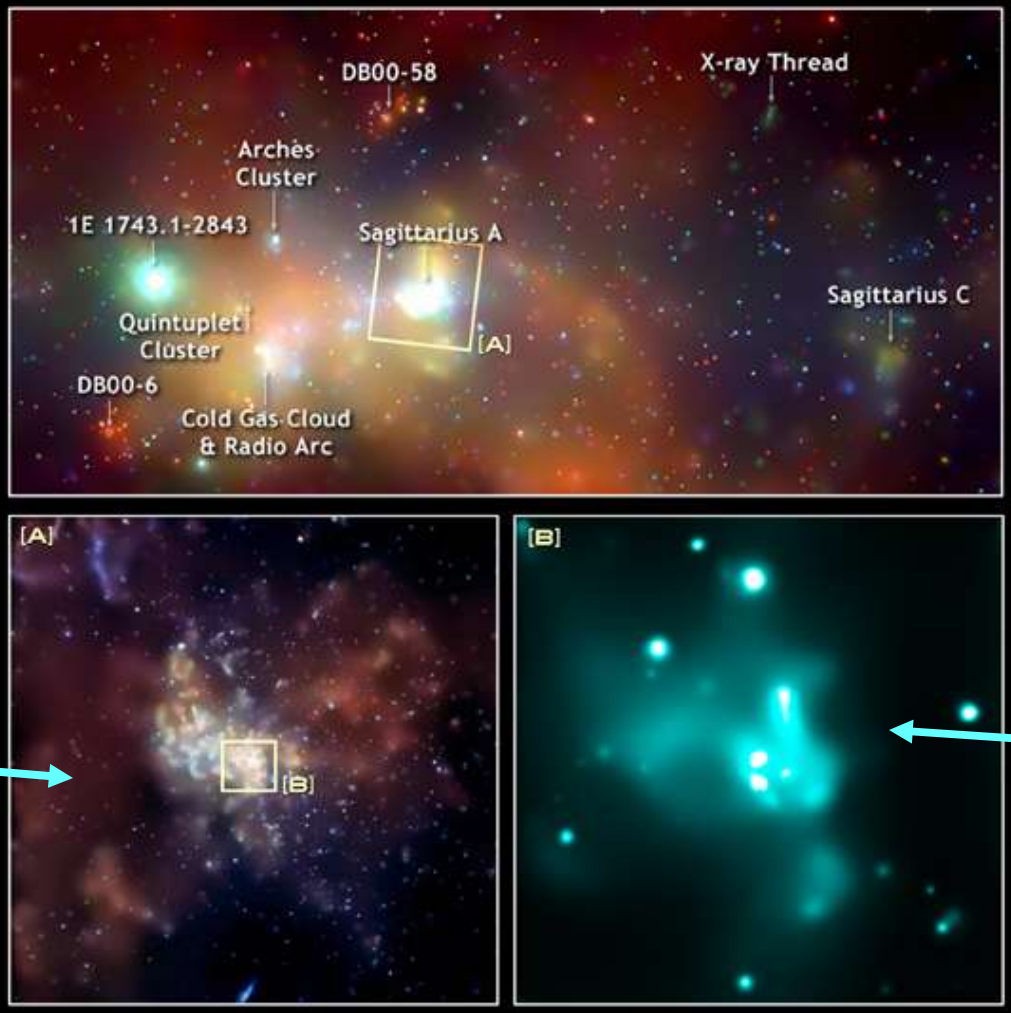


ACIS/HETG

White & Angelini 2001

Spatial

Galactic Center XRBs

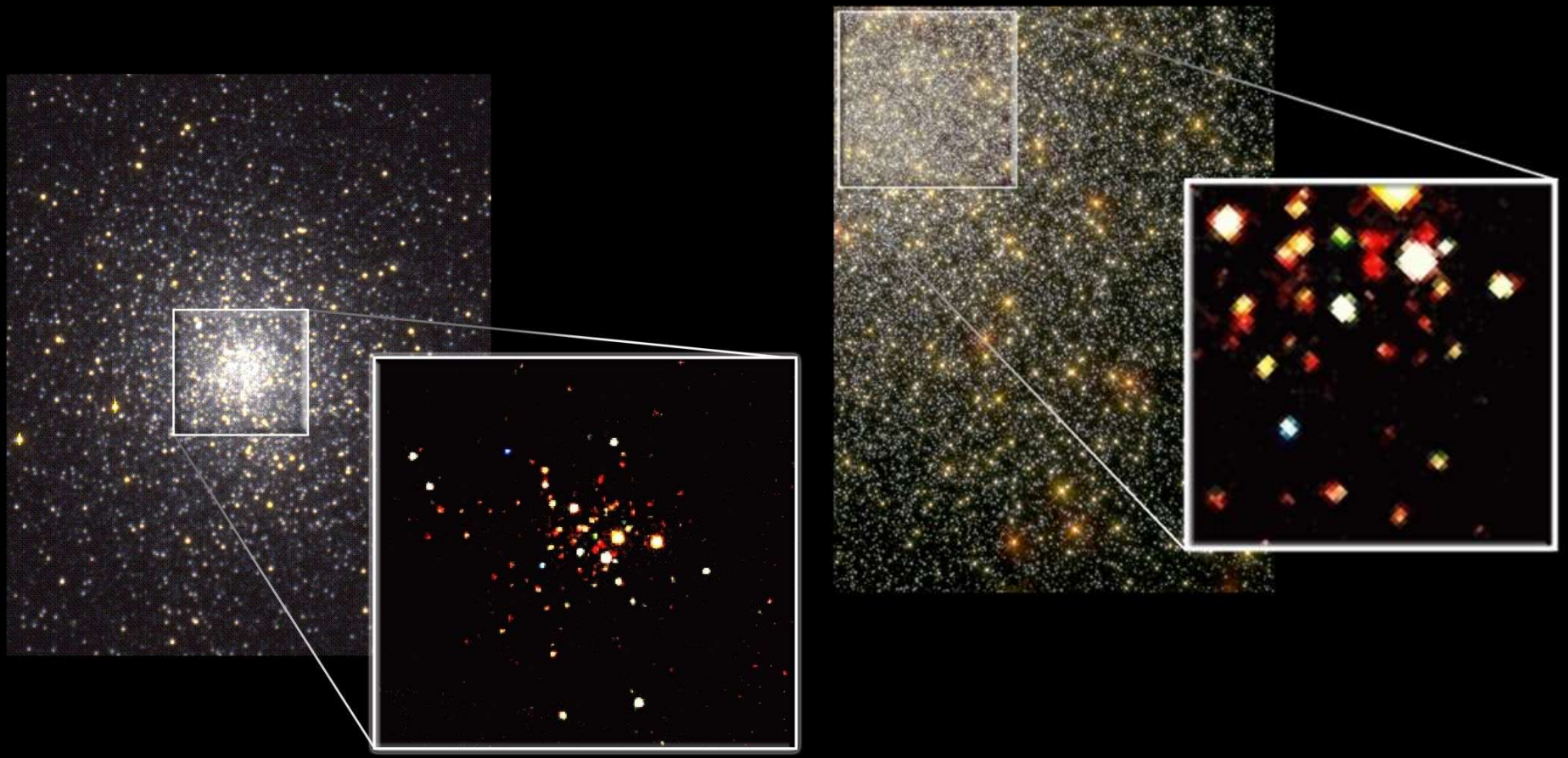


2000 X-ray sources

4 XRBs within a parsec!

Top: NASA/UMass/D.Wang et al. 2002
Bottom Left: NASA/CXC/MIT/F.K.Baganoff et al. 2003
Bottom Right: NASA/CXC/UCLA/M.Muno et al.) 2005

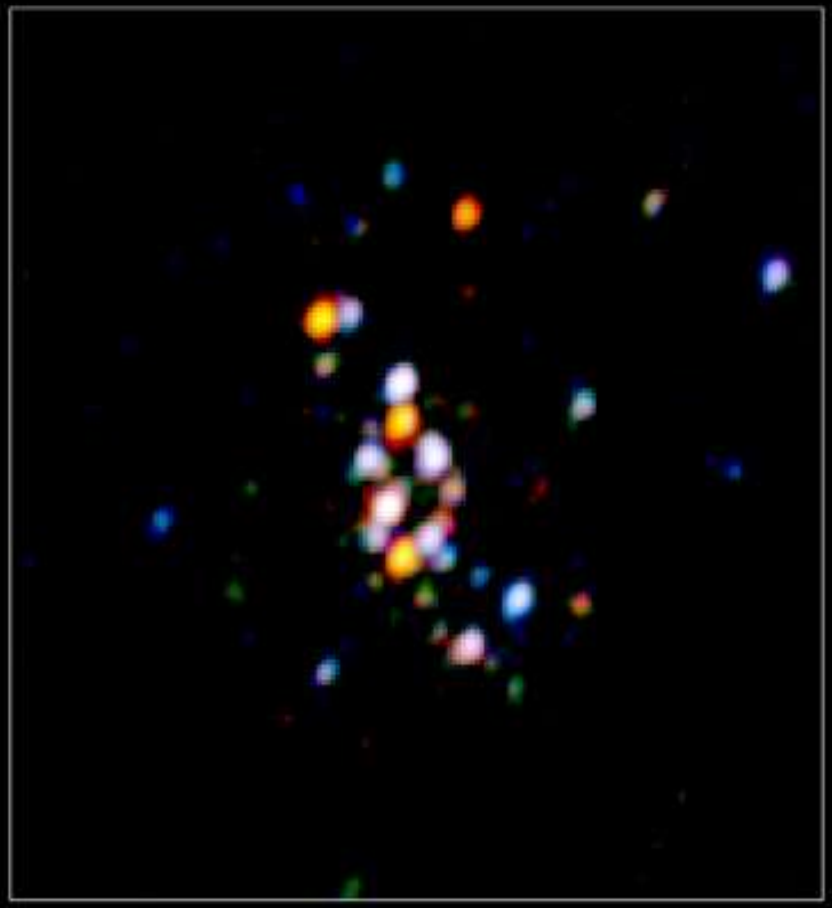
Globular Cluster: 47 Tuc



108 sources within central 2.5’

Grindlay et al 2001

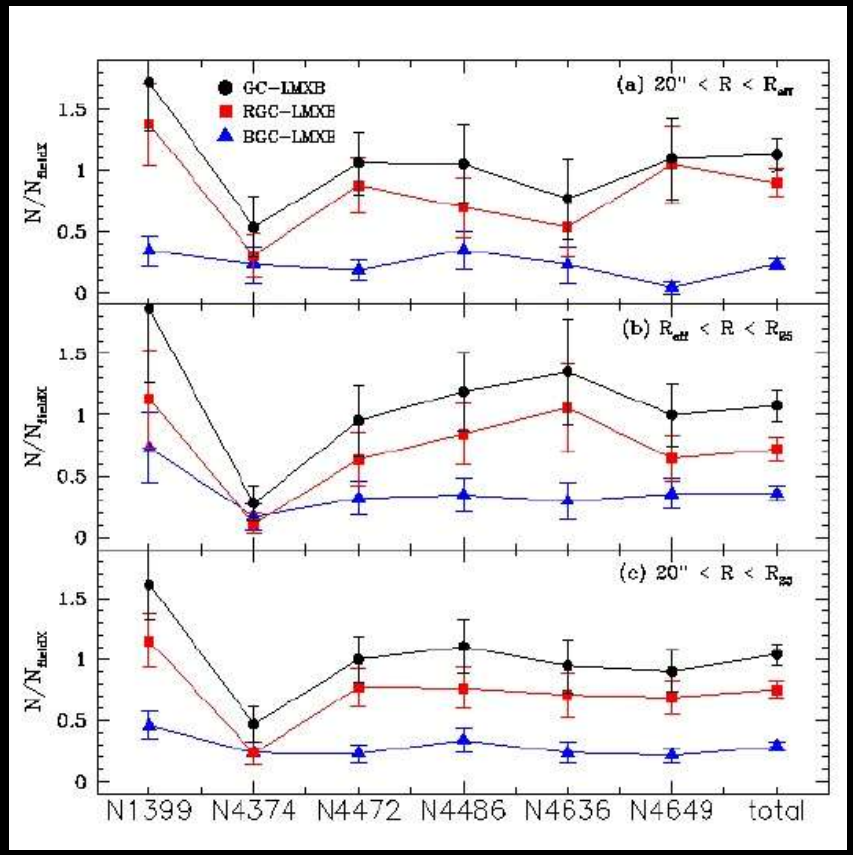
Globular Cluster Surveys



Pooley et al 2003 (12 clusters); Heinke et al 2003(# clusters)

Number of XRBs in cluster closely correlated to rate of encounters

LMXBs in Globular Clusters



3 times as many LMXBs form in Red GCs as in BLUE GCs

↓

Metallicity is important

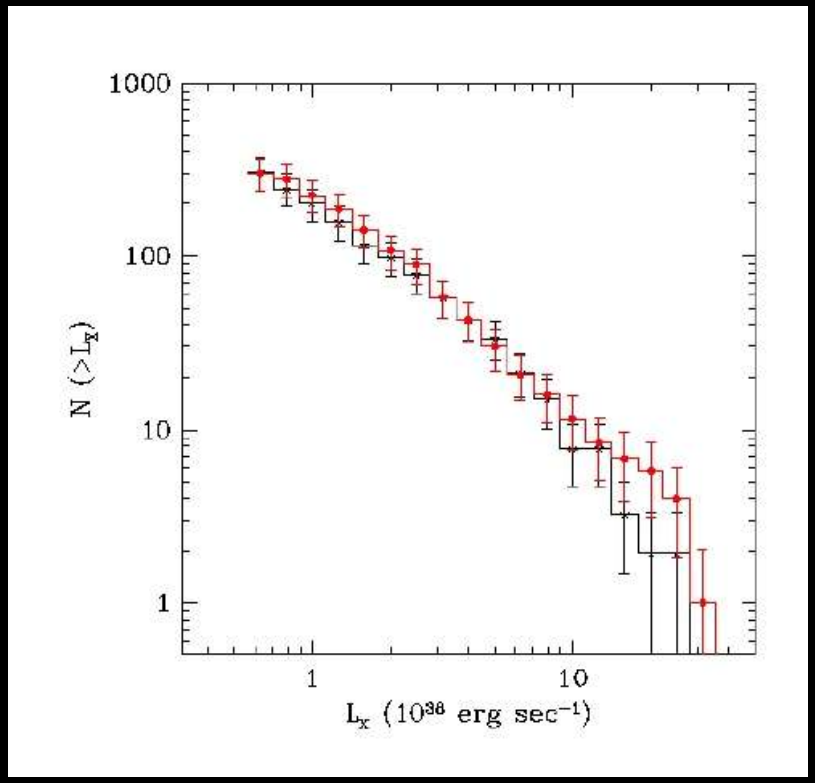
X-ray spectra identical

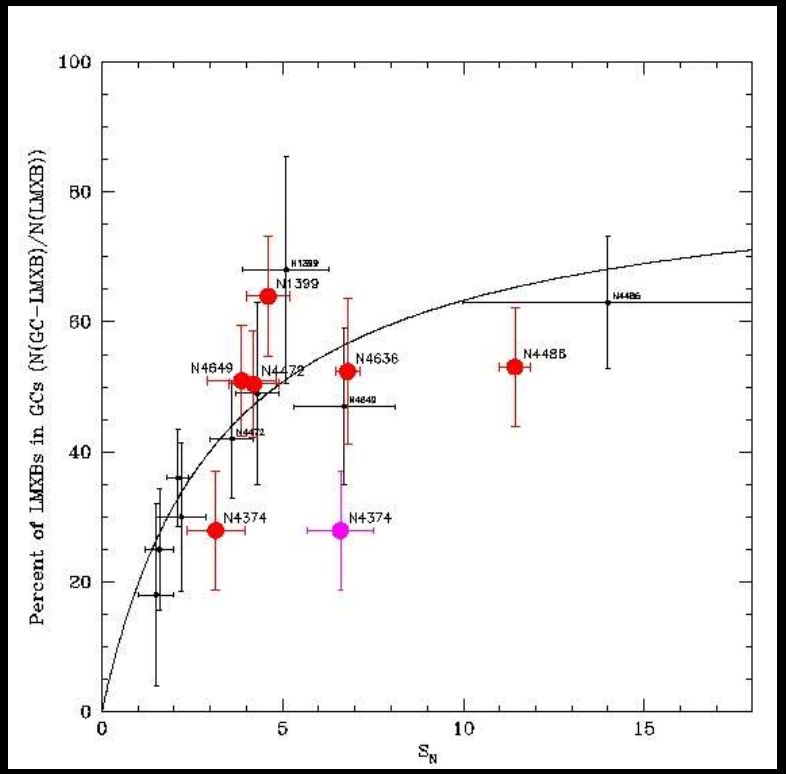
GCs near galaxy center harbor more LMXBs

Kim et al. 2005

See Poster 7.9 Sivakoff et al

LMXBs in Globular Clusters

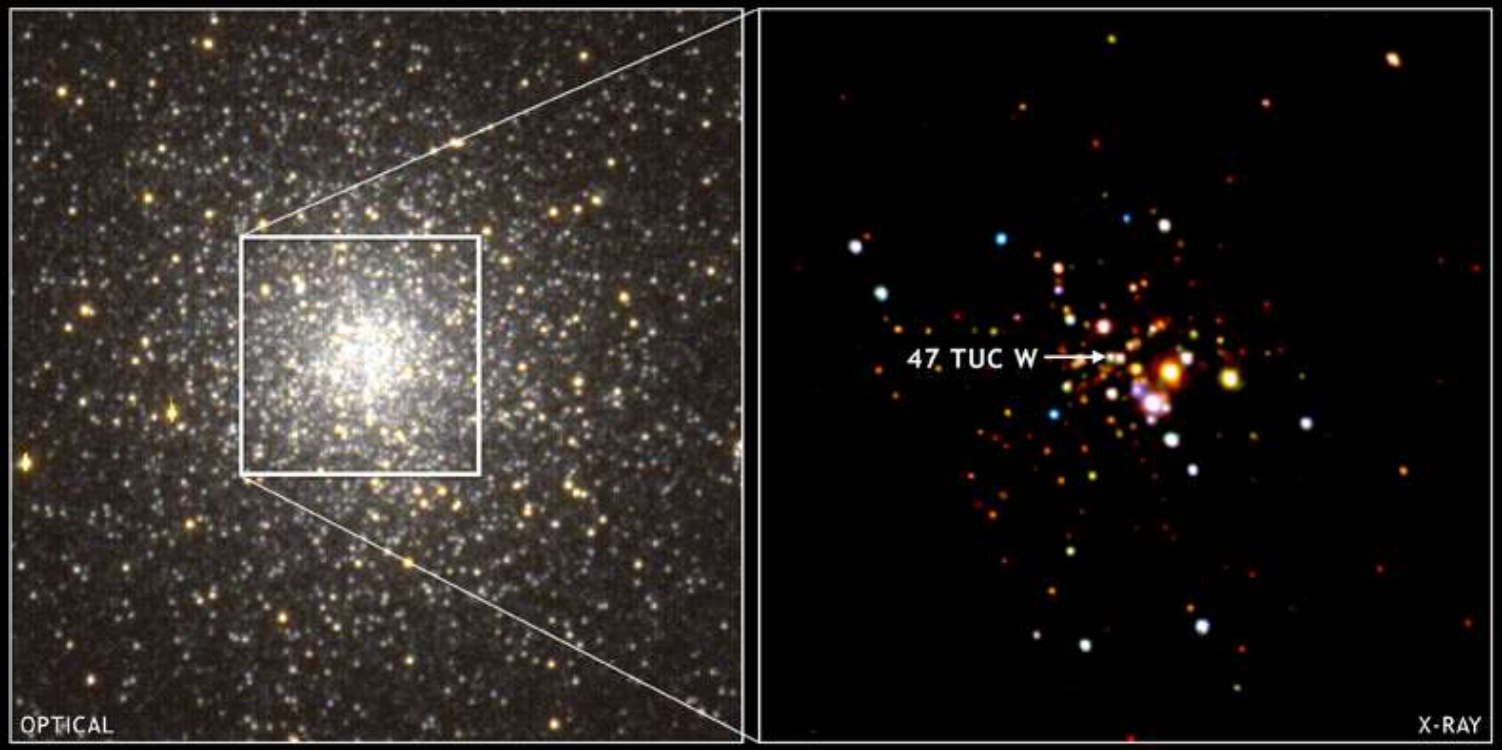




No difference between field and GC XRBS

Kim et al. 2005

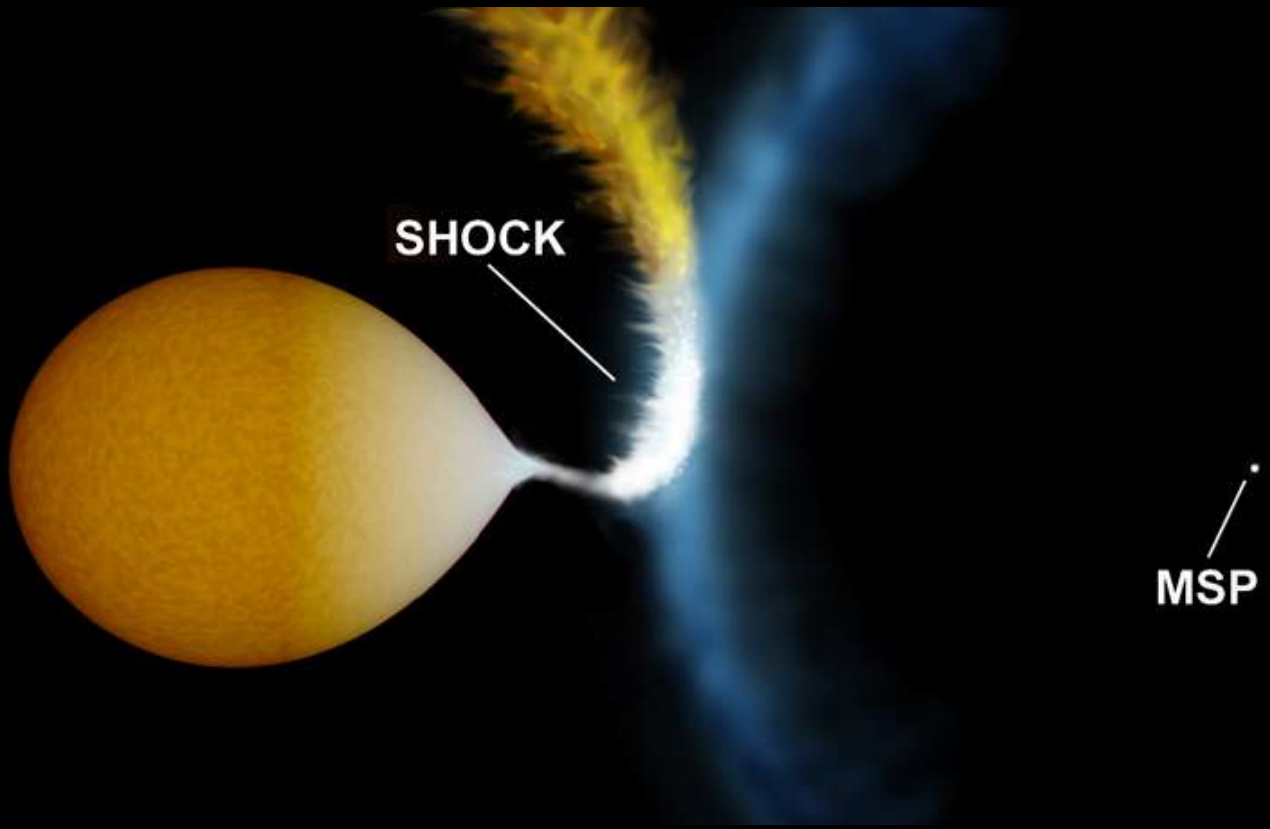
47 Tuc W: MSP to LMXB connection?



X-ray and optical behavior nearly identical with XRB J808

X-ray: NASA/CXC/CfA/J.Grindlay & C.Heinke; 2005
Optical: ESO/Danish 1.54-m/W.Keel et al. 2005

47 Tuc W

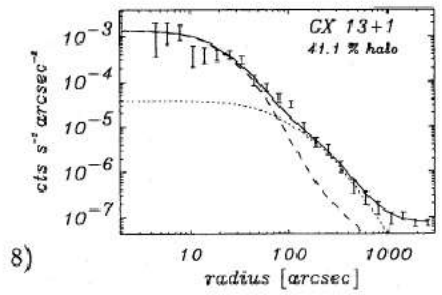


NASA/CfA/S.Bogdanov
2005

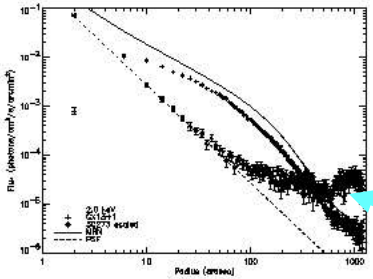
X-ray Halos: GX13+1

ROSAT

ACIS-I



ROSAT All-sky survey observation of GX 13+1 (from Predehl & Schmitt 1995)



Chandra ACIS-I observation of GX 13+1 at 2.0 keV, with 3C273 shown as a point source and a simple halo model (courtesy Randall Smith).

Predehl & Schmitt 1995

25 sources with ROSAT

Data = crosses

Fit = solid line

PSF = dashed line

Halo model = dotted line

ROSAT to 100 arcsec

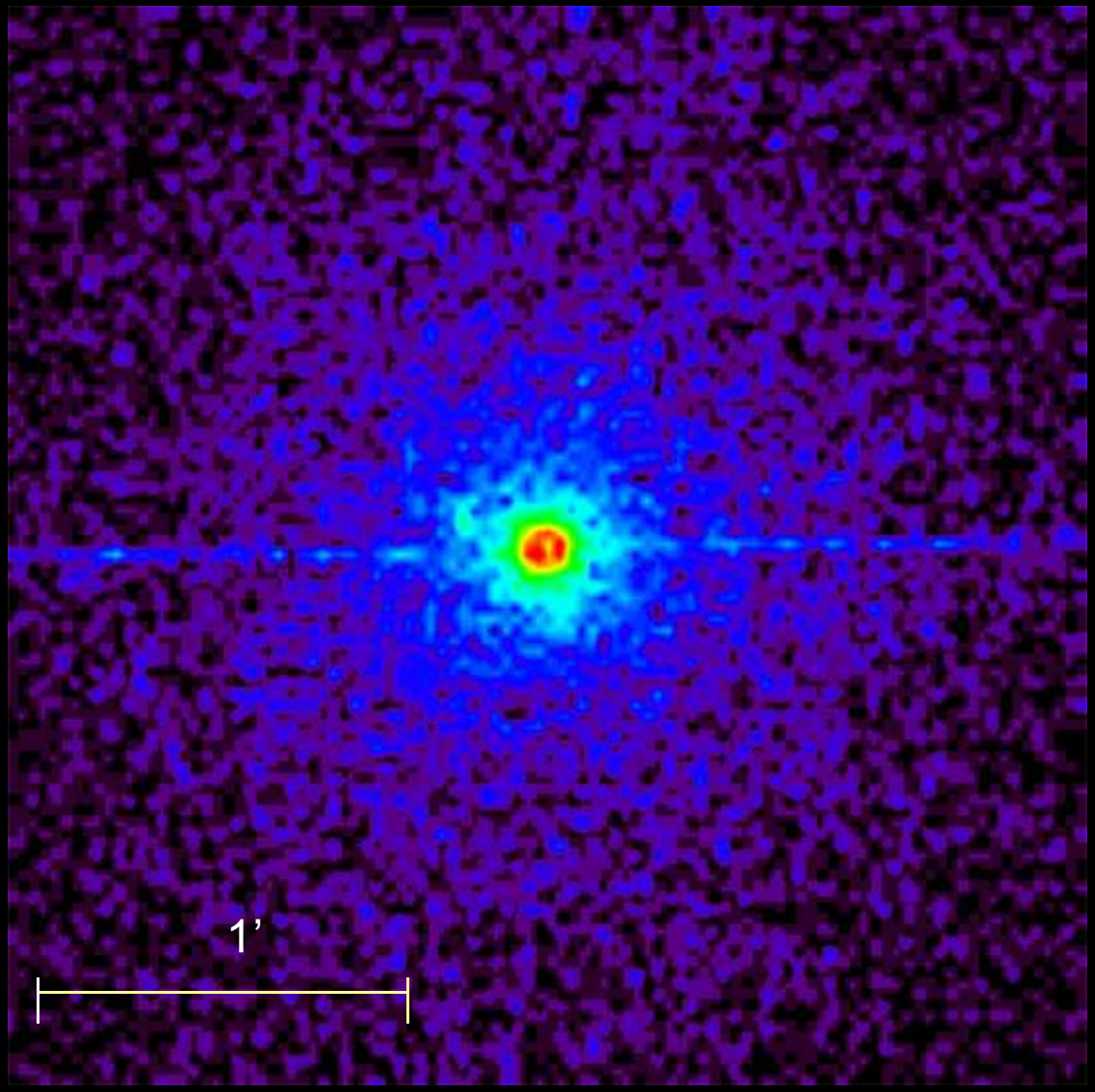
Chandra to 8 arcsec

PSF=3C273

Smith 2000

Cygnus X-3 Halo

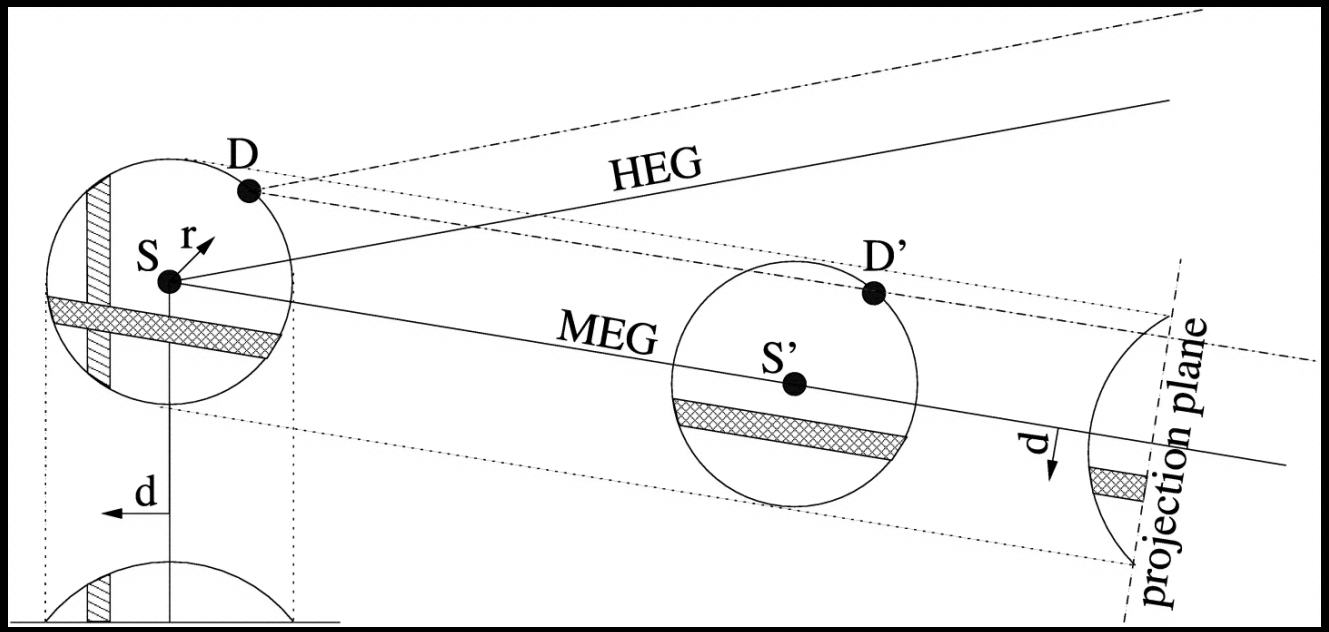
ACIS/HETG



Predehl et al 2000

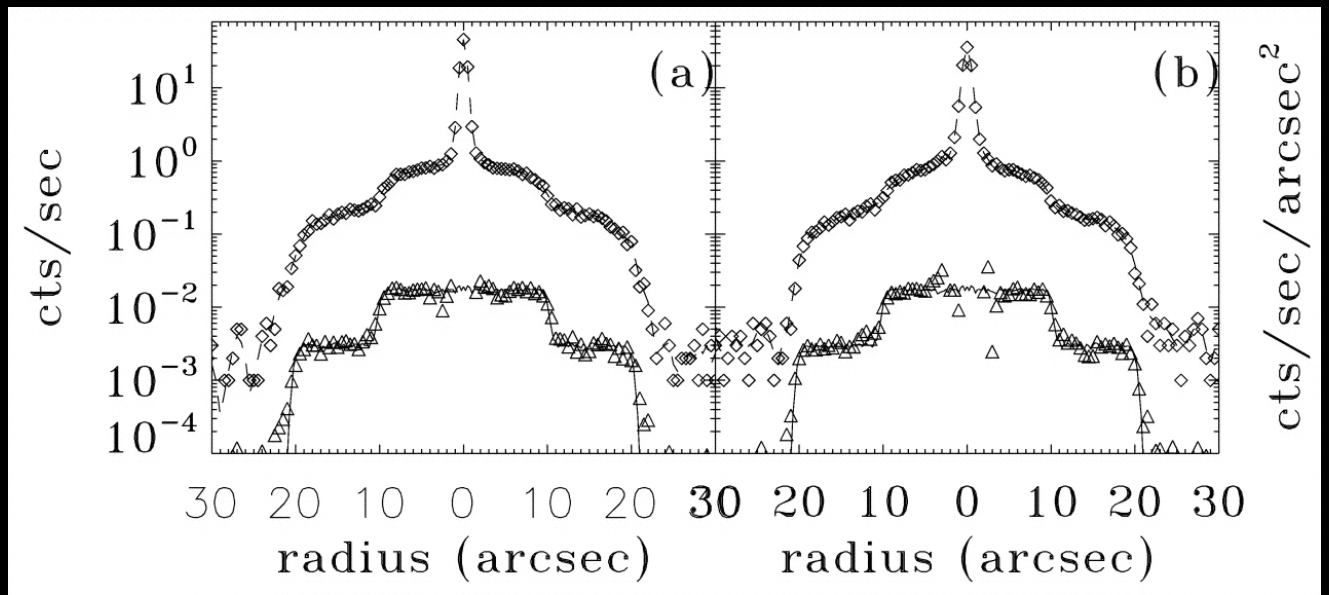
See Poster 2.10 Thompson et al

X-ray Halos to 1”



Geometry of reconstruction

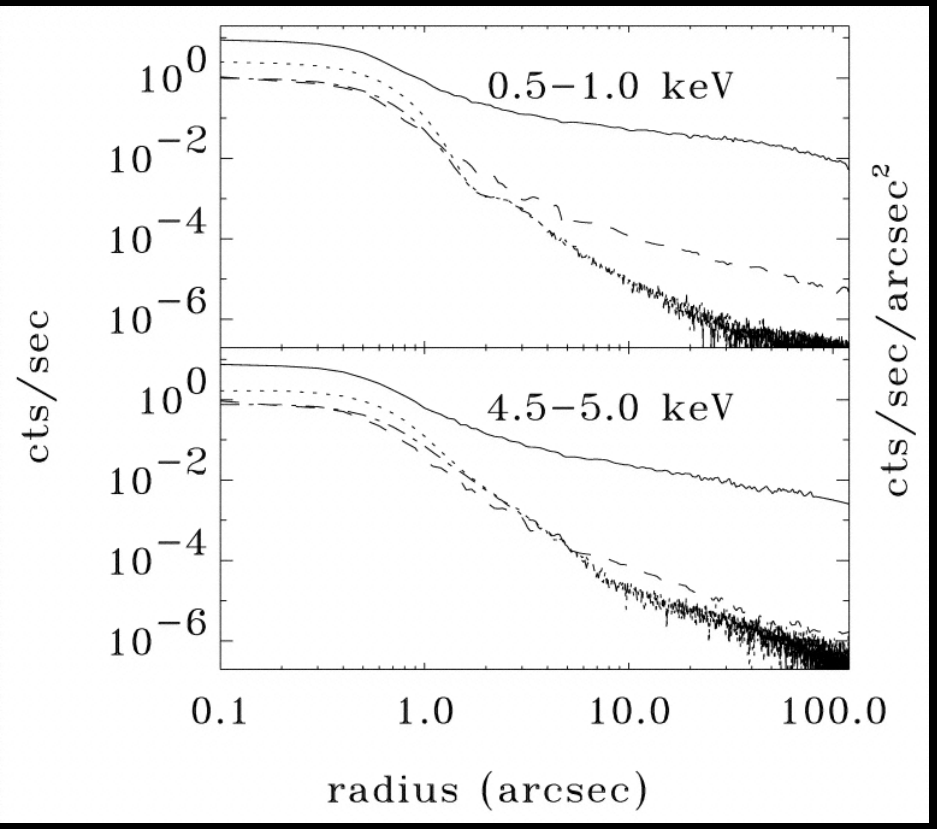
Yao et al 2003



MARX simulation

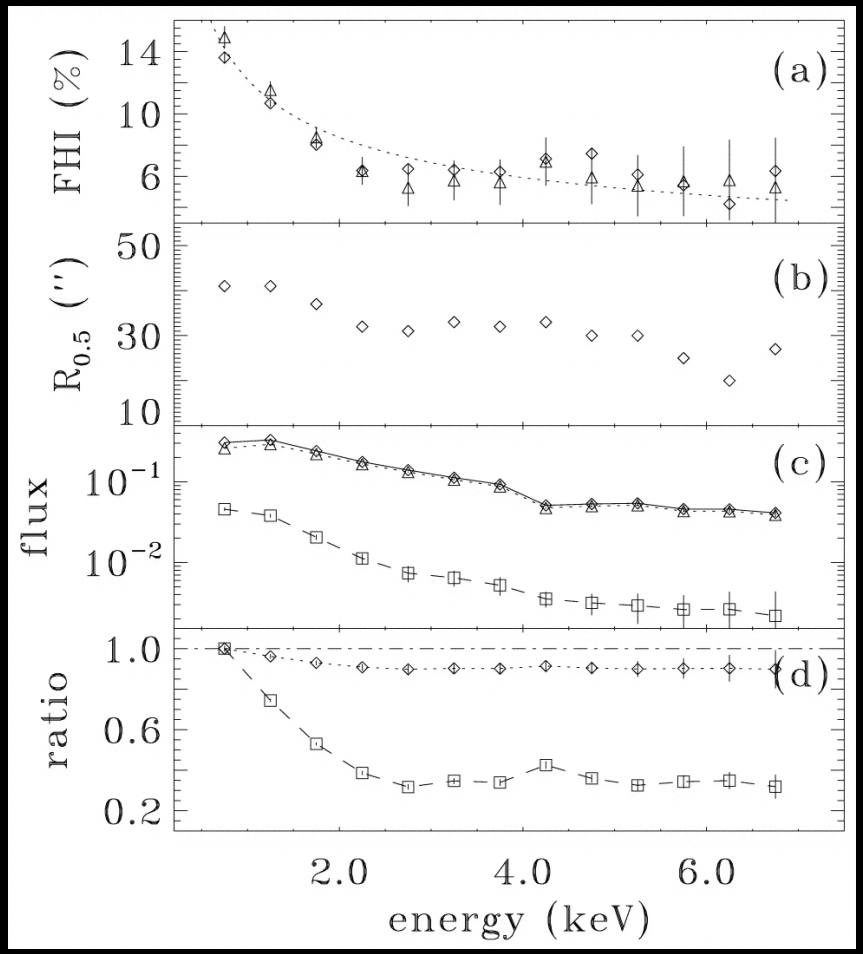
Left: MEG – order
Right: Zero order
Upper curve: total
Lower curve: halo

X-ray Halo: Cygnus X-1



ACIS/HETG in CC mode

Halo=dashed line

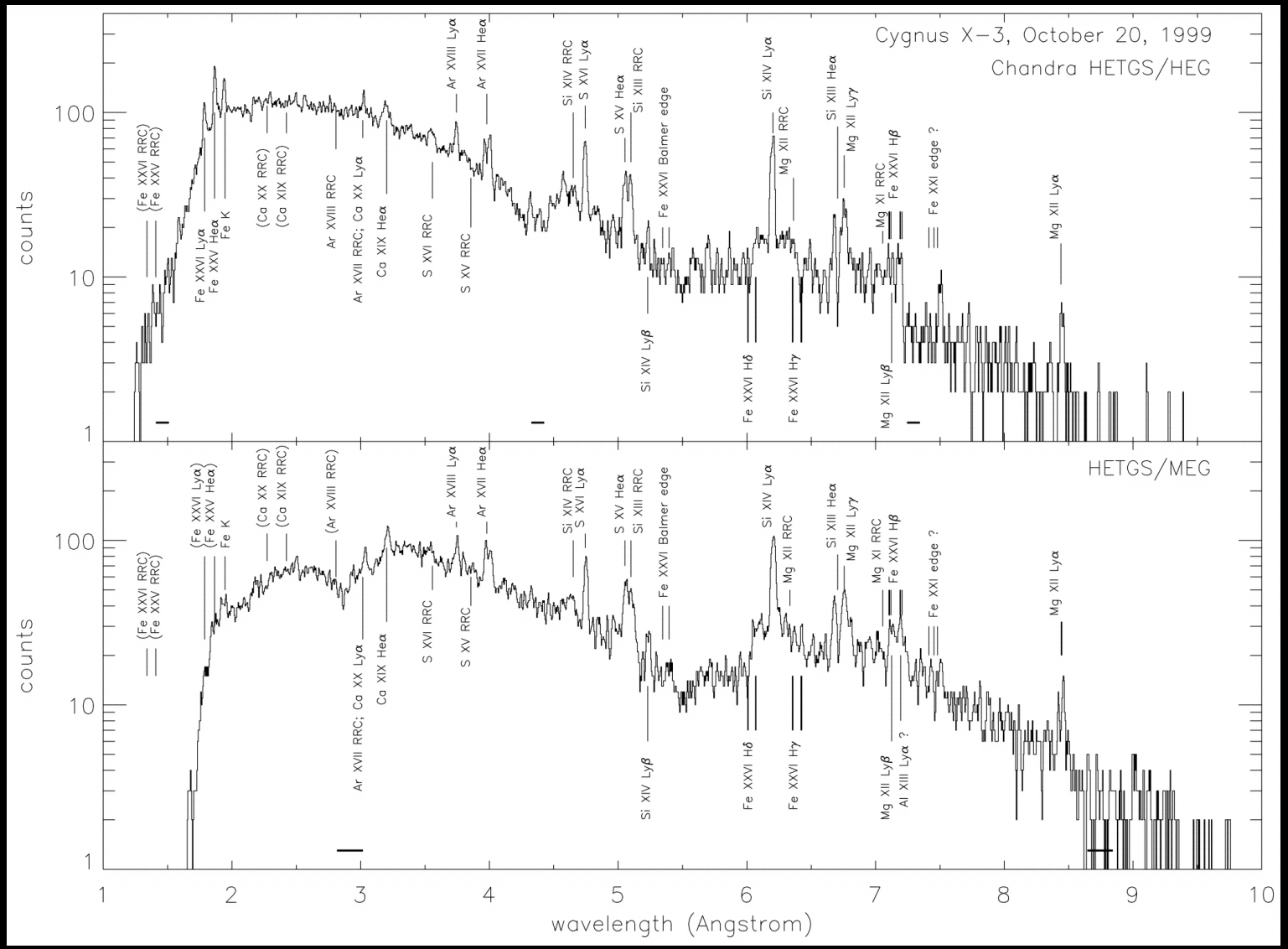


Net source: dotted; Halo: dashed

Yao et al 2003

Spectral

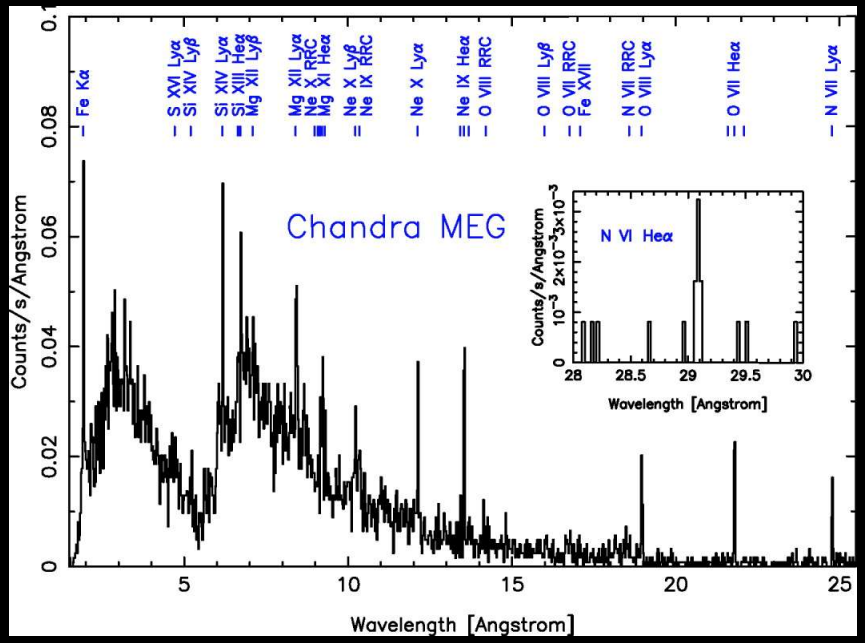
Cyg X-3 with Chandra HETG

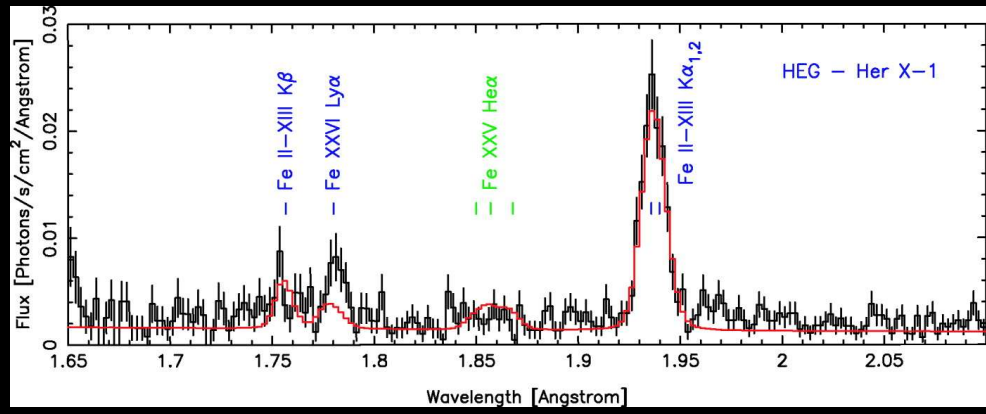


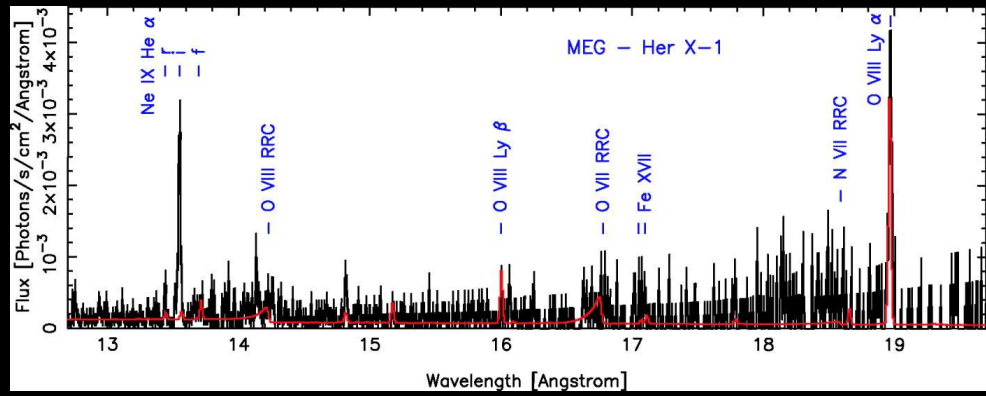
See Poster 2.6 McCollough et al

Paerels et al 2000

HETG observations of Her X-1



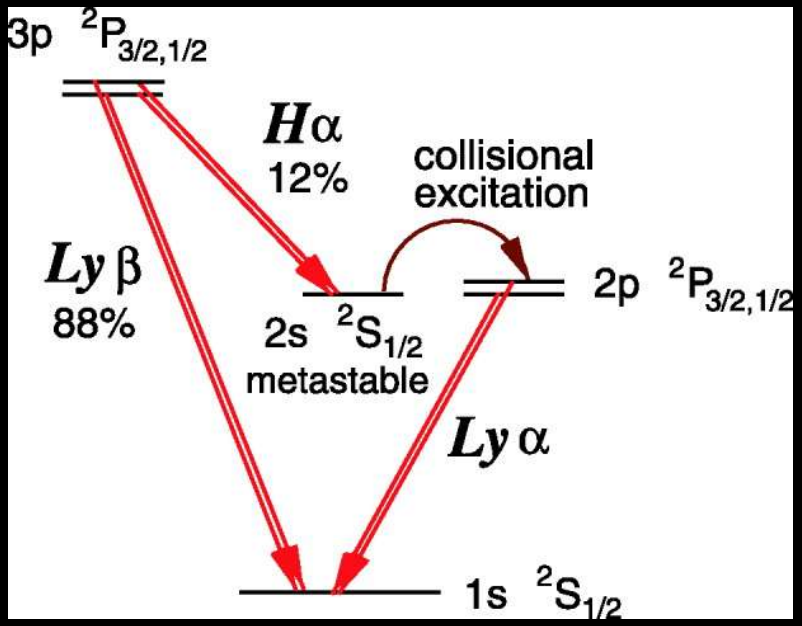




Density using Mg XI
Temperature from Ne IX
Spatial distribution
Elemental composition
Kinematics of plasma

Jimenez-Garate et al 2005

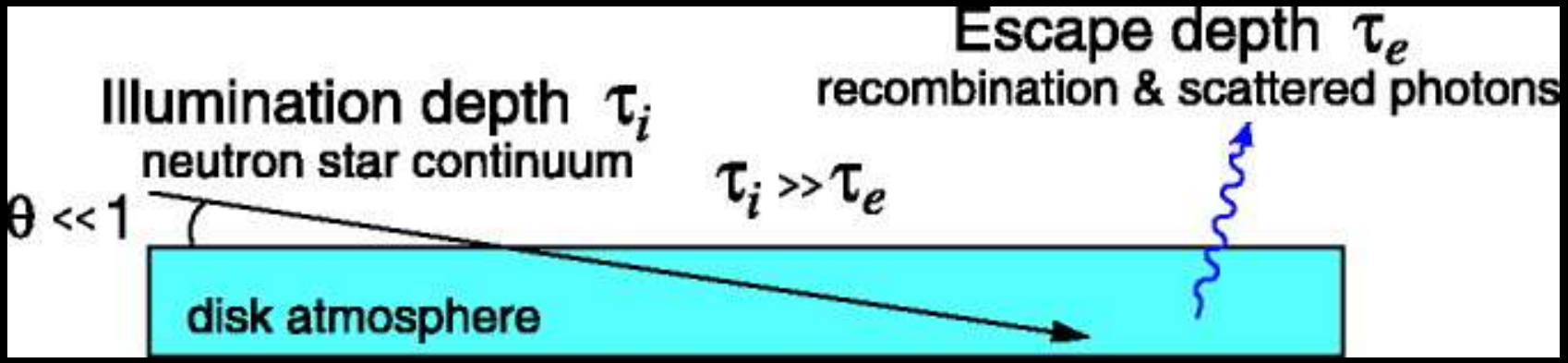
Accretion Disk Corona in Her X-1



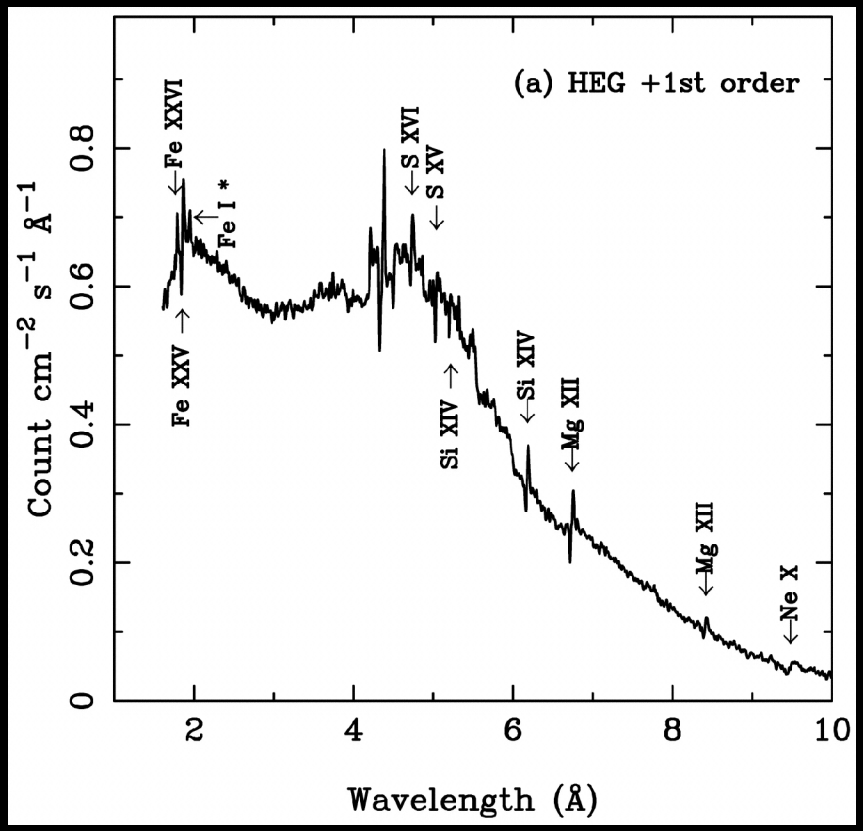
Jimenez-Garate et al 2005

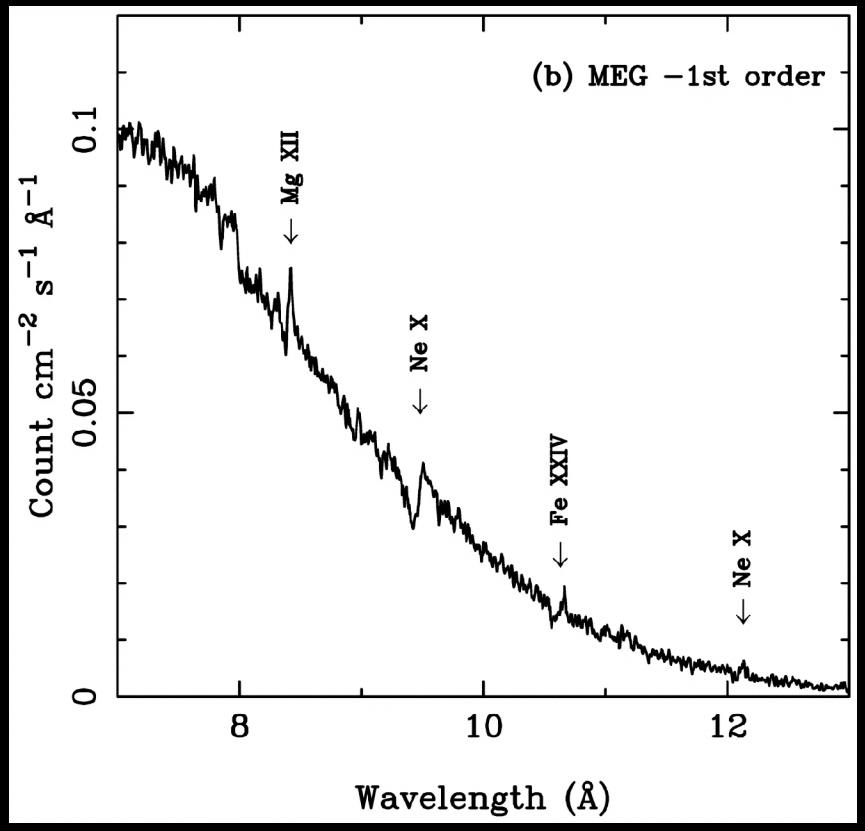
Disk atmosphere radius 8 x 10^{10} cm

Corona radius 1 X 10^{11}cm



Circinus X-1: X-ray P-Cygni!



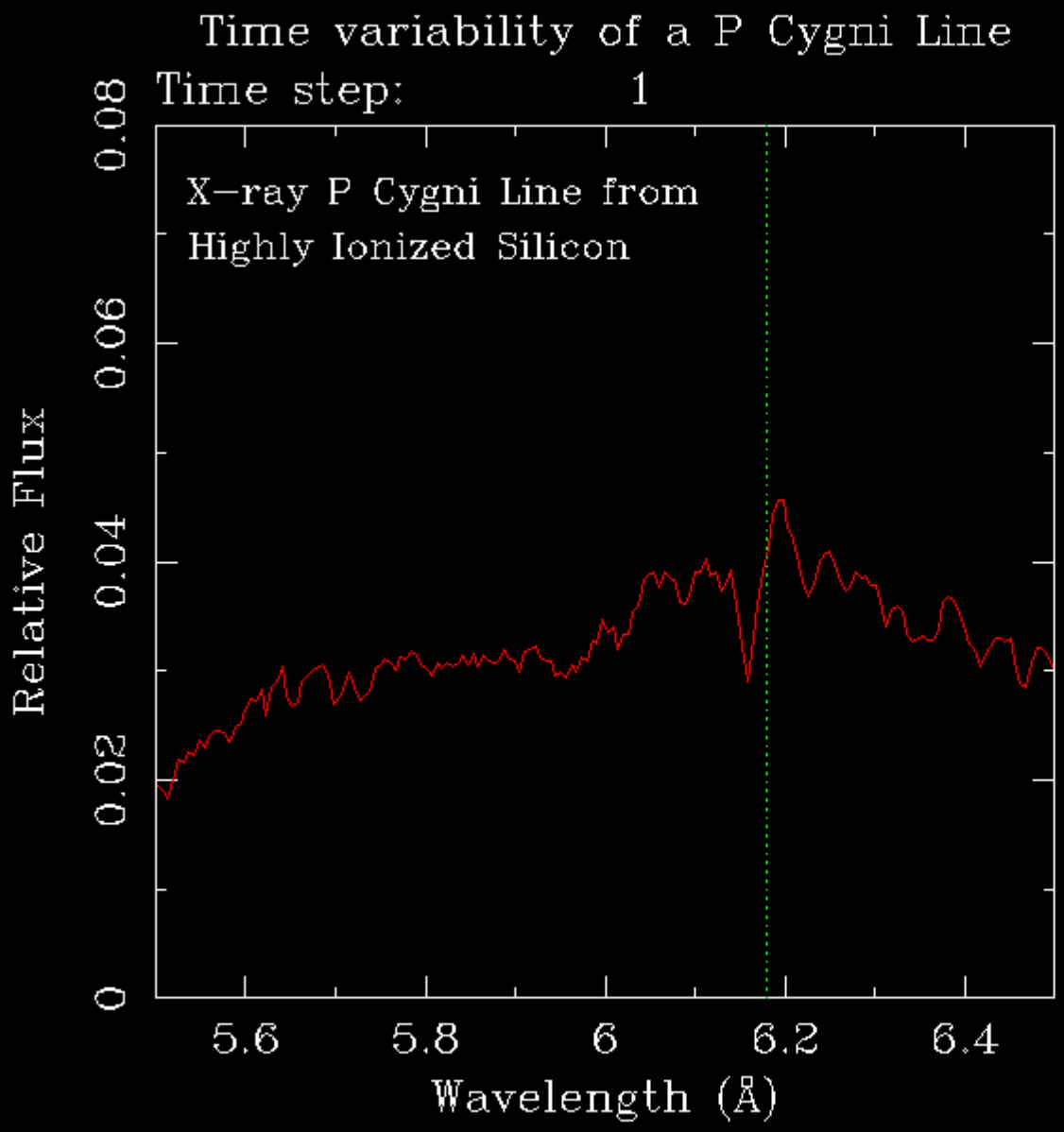


ACIS/HETG

Schulz et al 2000

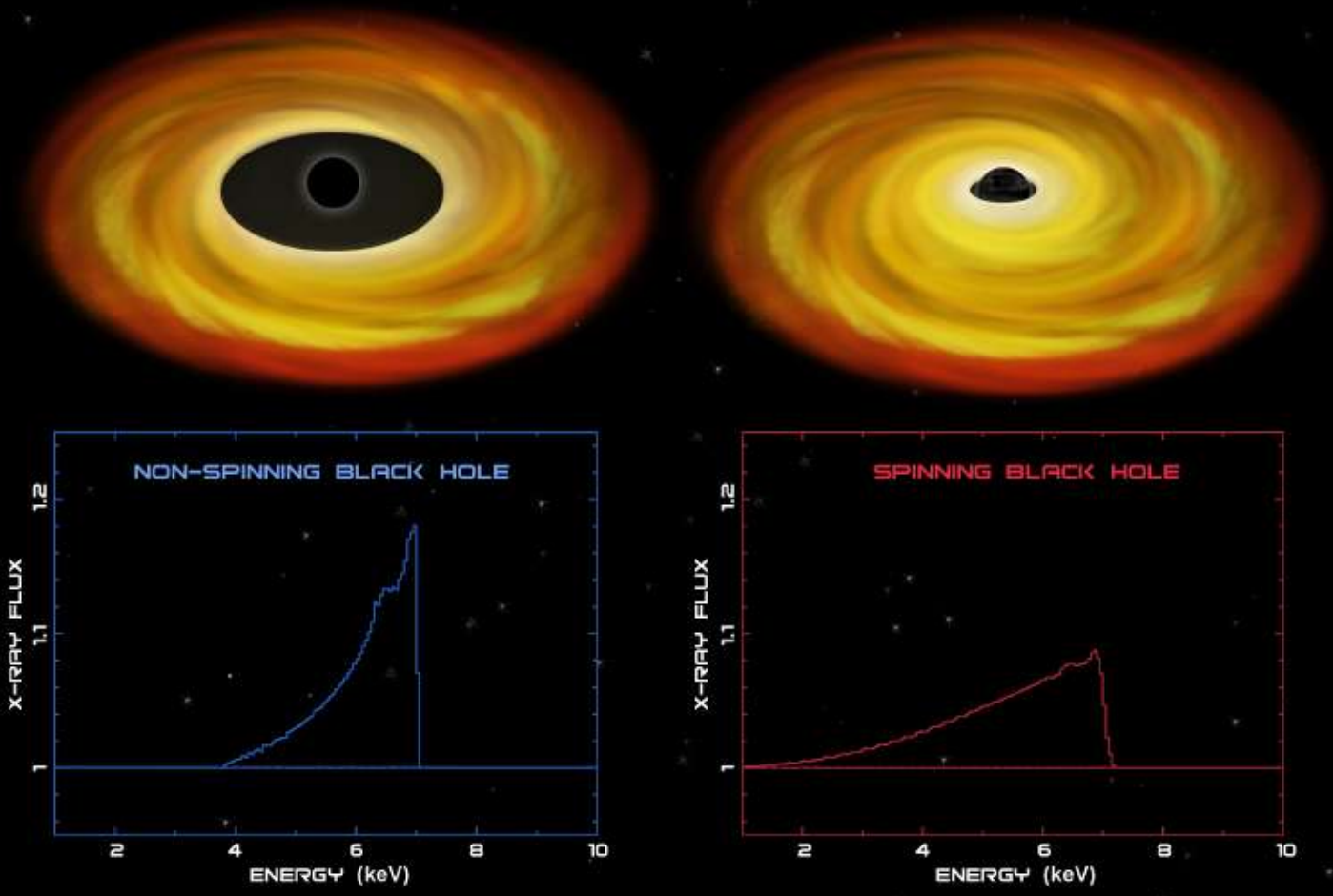
See Poster 2.8 Schulz et al

Spectral



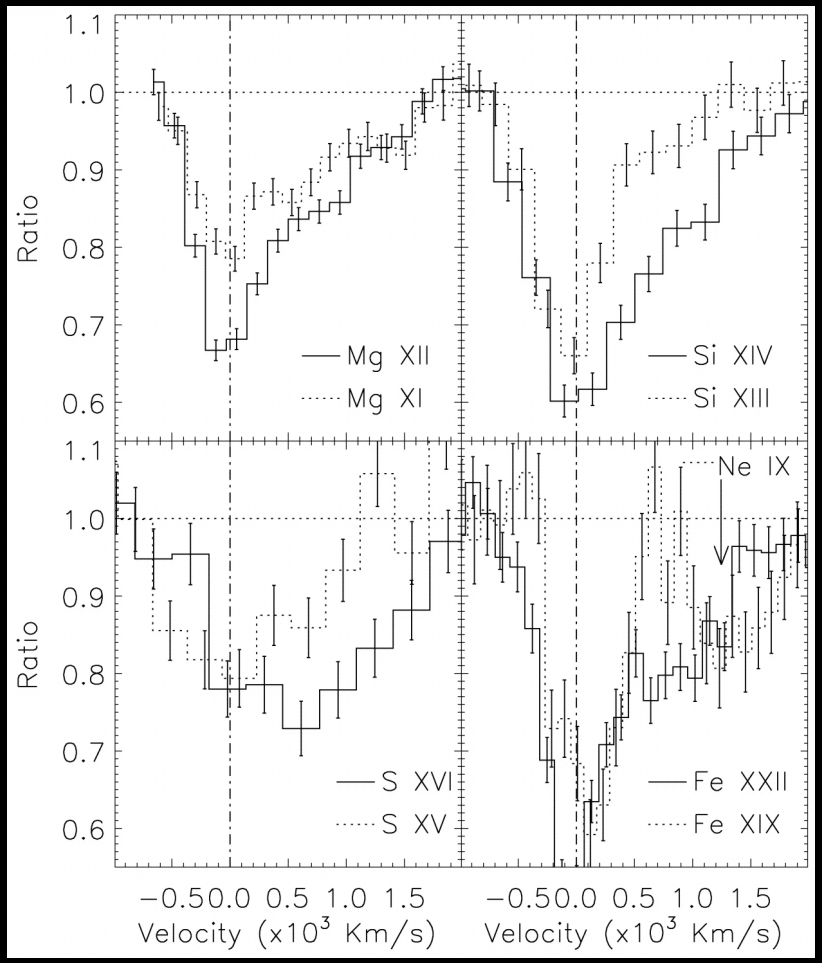
Brandt & Schulz 2000

Relativistic Fe Lines

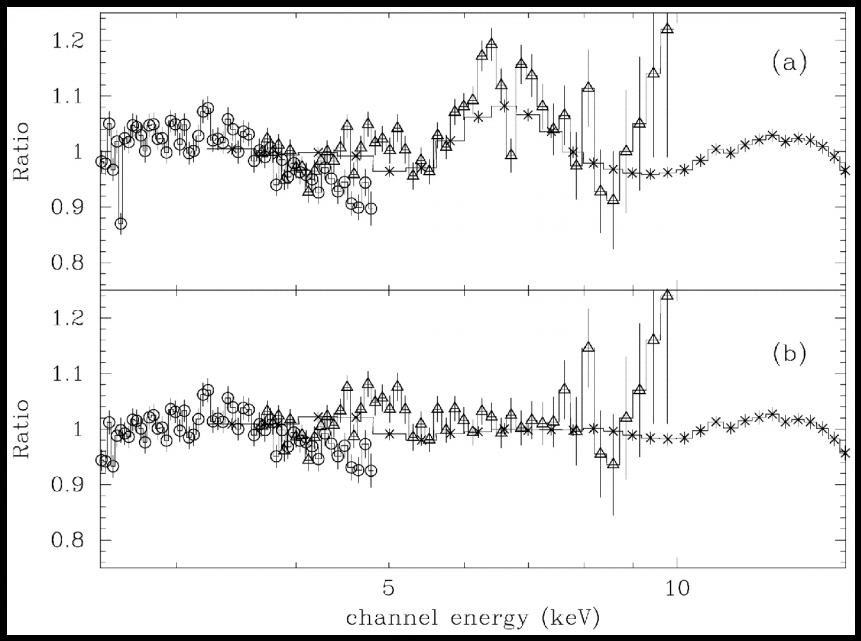


Miller et al 2003

Cyg X-1 with HETG



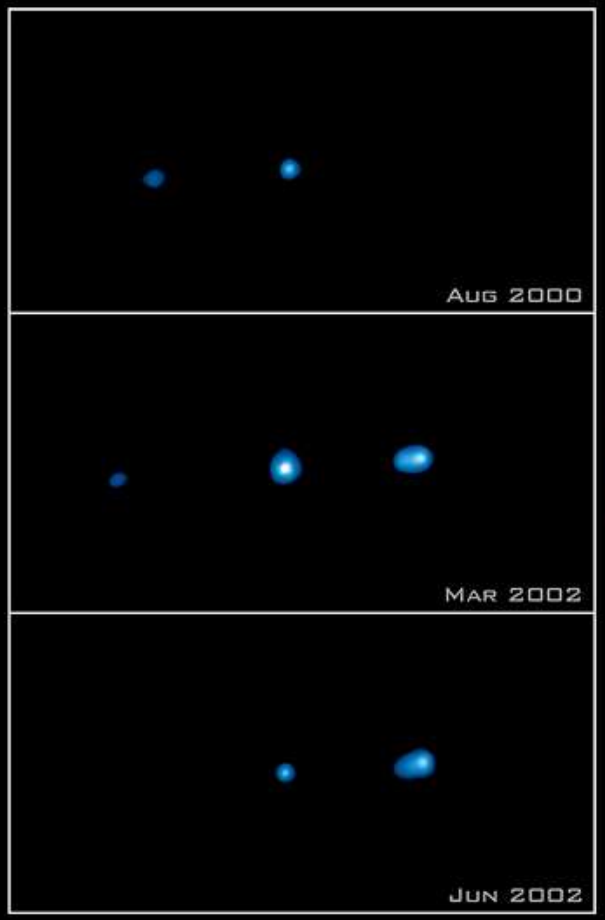
6.5 keV feature symmetric:
fit with Gaussian rather than Laor

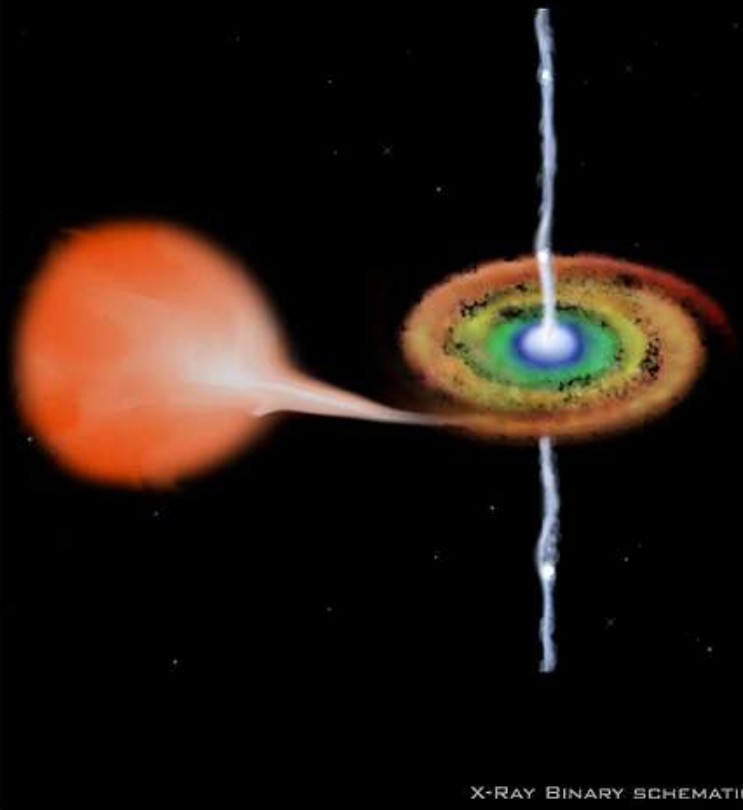


Feng, Tennant, & Zhang 2003

Spectral + Spatial

Jets: XTE J1550-564

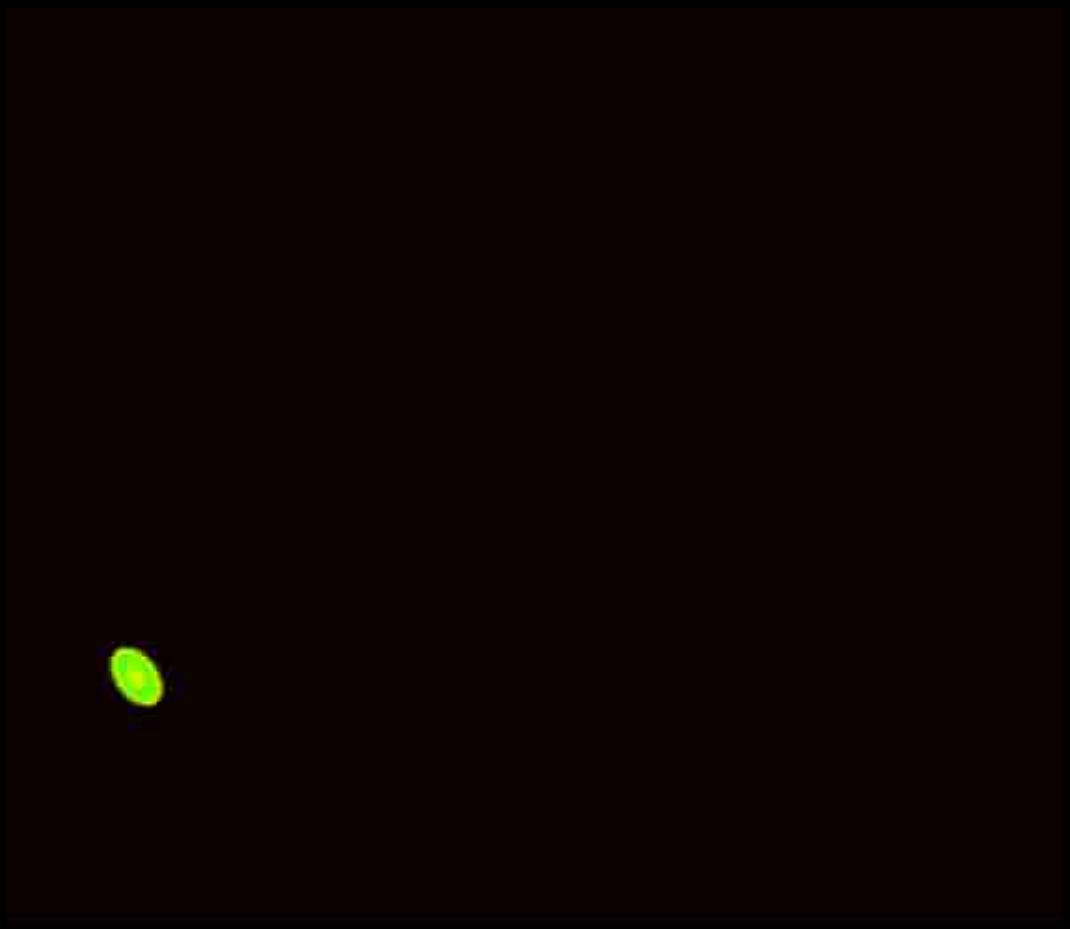




ACIS/HETG

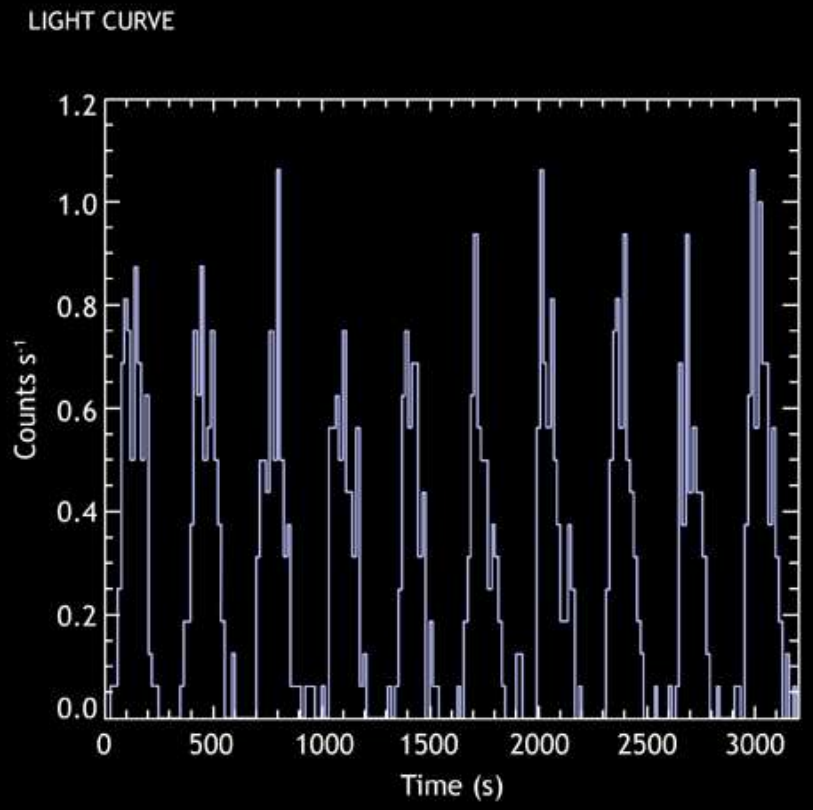
Corbel et al 2002

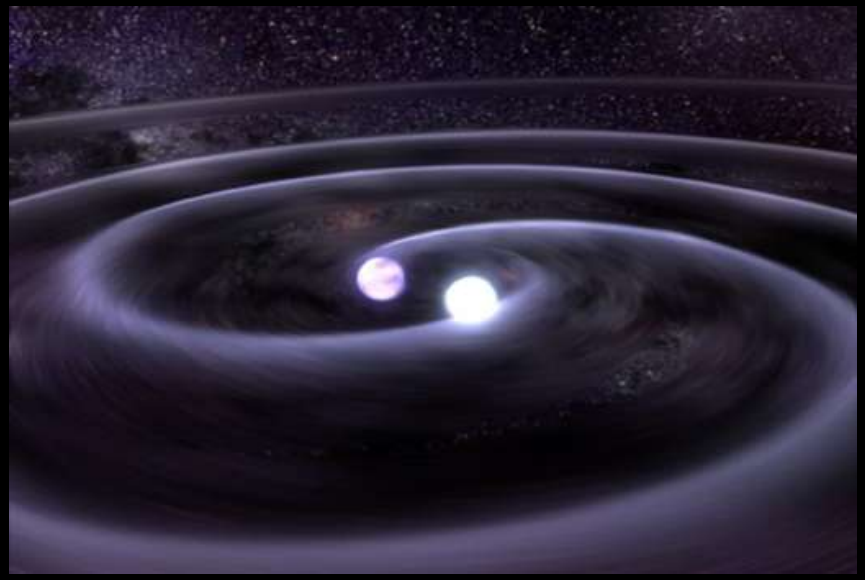
Jet Model XTE J1550-564



Tregillis, Jones, and Ryu 2002

RX J0806.3+1527



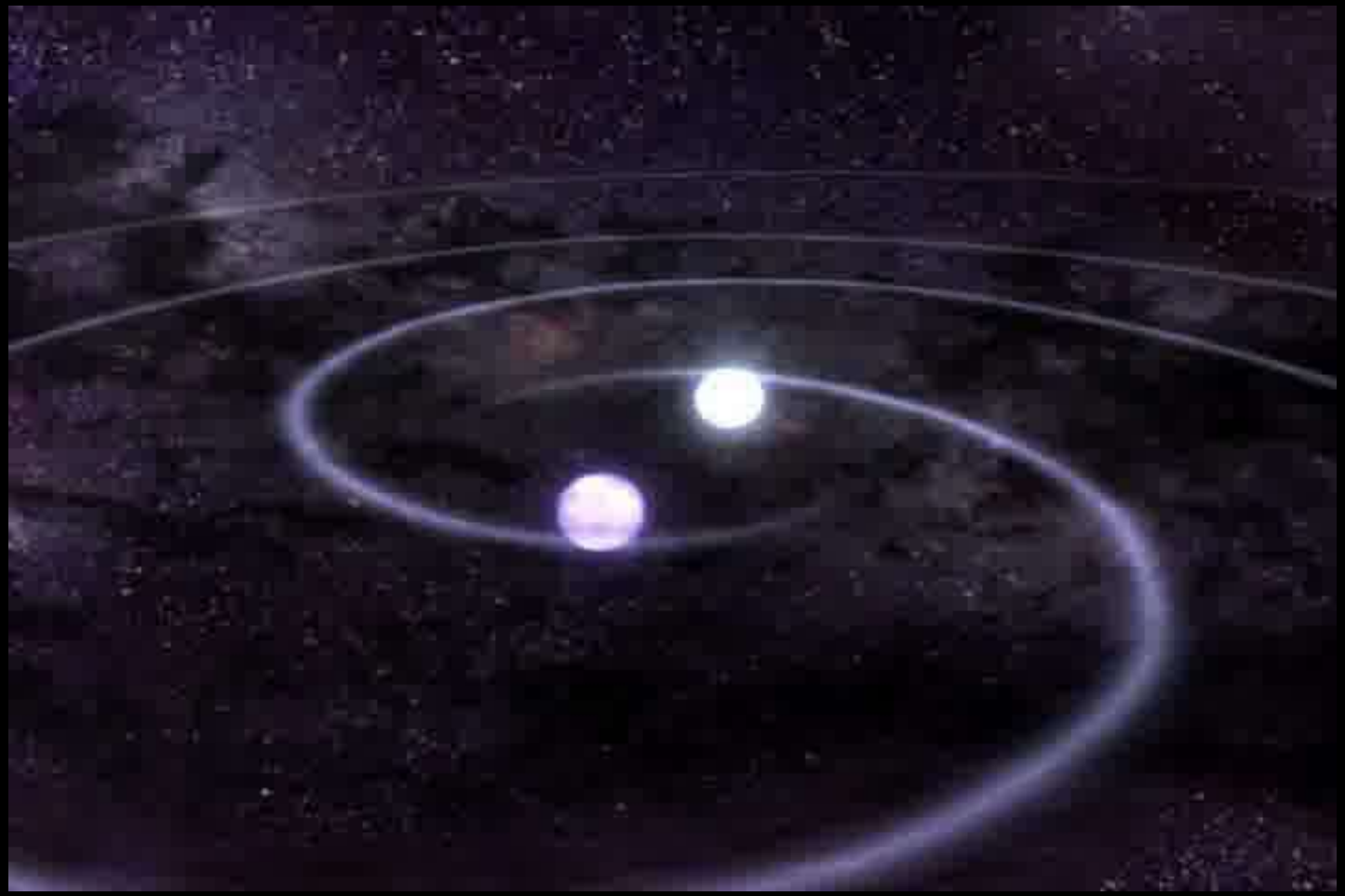


3.11mHz frequency increasing by 3.77 X 10^{-16} Hz s^{-1}

Gravitational radiation should drive spin-up with a magnitude of 10^{-16} Hz s^{-1}

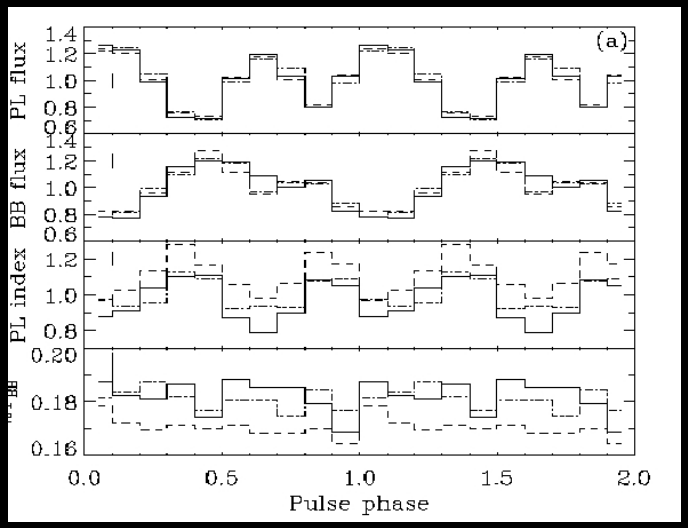
NASA/CXC/GSFC/T. Strohmayer; Illustration: GSFC/D. Berry 2005

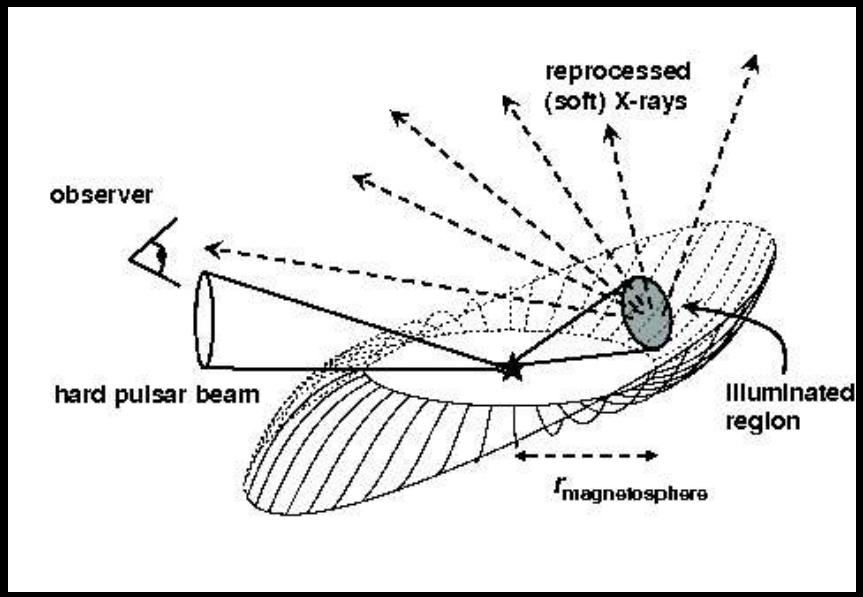
RX J0806.3+1527 Animation

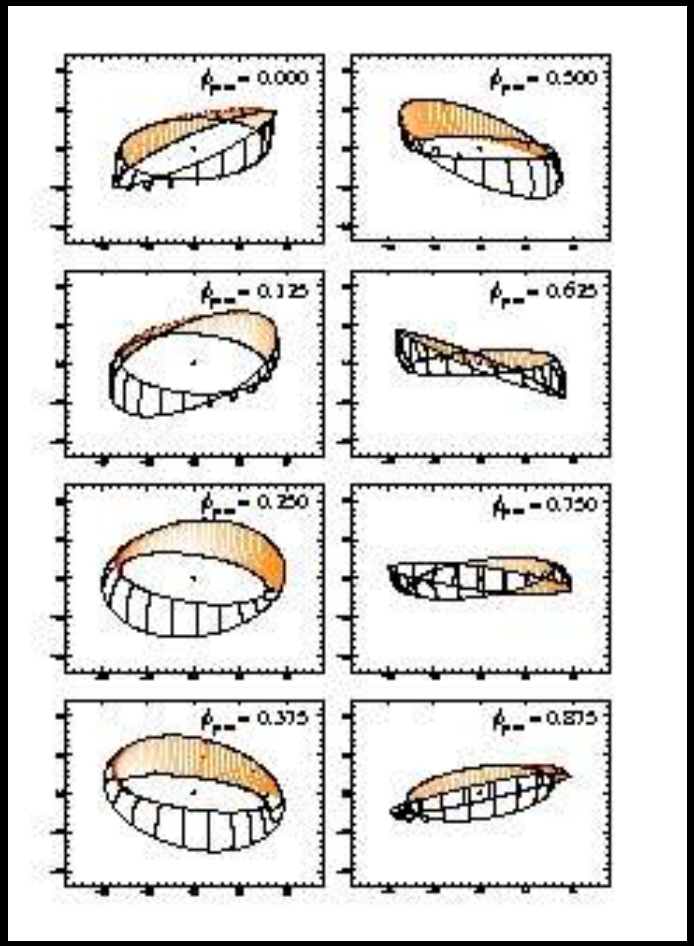


GSFC/D.Berry 2005

Reprocessing in a Precessing Disk







Hickox & Vrtilek 2005

Six Years of XRBs with Chandra

Relevant Talks:

J.M. Miller Accretion Disk Winds in BH XRBs

H. Marshall Relativistic Jets in SS433

D.Swartz ULX Sources in Nearby Galaxies

M. Garcia M31

M. Gilfanov Populations of XRBs in Galaxies

K.D. Kuntz The M101 Ms

Relevant posters in Sessions 2 and 7

NASA ADS