# RXTE Observations of BL Hyi and V2301 Oph

Michael T. Wolff (NRL)
Kent S. Wood (NRL)
James N. Imamura (Univ. of Oregon)
Thomas Steiman-Cameron (Indiana Univ.)
John Middleditch (LANL)

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# Abstract

We acquired x-ray data for the AM Herculis systems BL Hyi and V2301 Oph using the PCA detector on the Rossi X-Ray Timing Explorer during September-November 1997. We also obtained broad-band optical photometry for BL Hyi using the 1.5m telescope at the Cerro Tololo Inter-American Observatory during September 1997, that was simultaneous with one short stretch of RXTE x-ray observations. In both systems the x-ray emission is consistent with a bright pole and a fainter pole. We find an orbit-modulated optical QPO in BL Hyi consistent with previous results. We characterize the hard x-ray properties of these two systems in this poster.

# BL Hyi Observations

The white dwarf in the BL Hyi system is believed to have a relatively weak magnetic field ($\mathbf{B}_*$ ~ 13 MG; Wickramasinghe etal. 1984) and an orbit period of P = 113.7 minutes (Pickles & Visanathan 1982). During our observations BL Hyi was in an unusual high luminosity state with average visual magnitude $m_V$ ~ 14.4. We employed the standard FTOOLS package of software to analyze the RXTE data. We have accumulated approximately 50 ksec of RXTE data on this source. The x-ray light curves suggested that two accretion poles were active. The primary x-ray emission region covered ~45$^o$ in longitude on the white dwarf. The secondary x-ray emission region flux was 33% of the bright phase flux and was consistent with a point source.

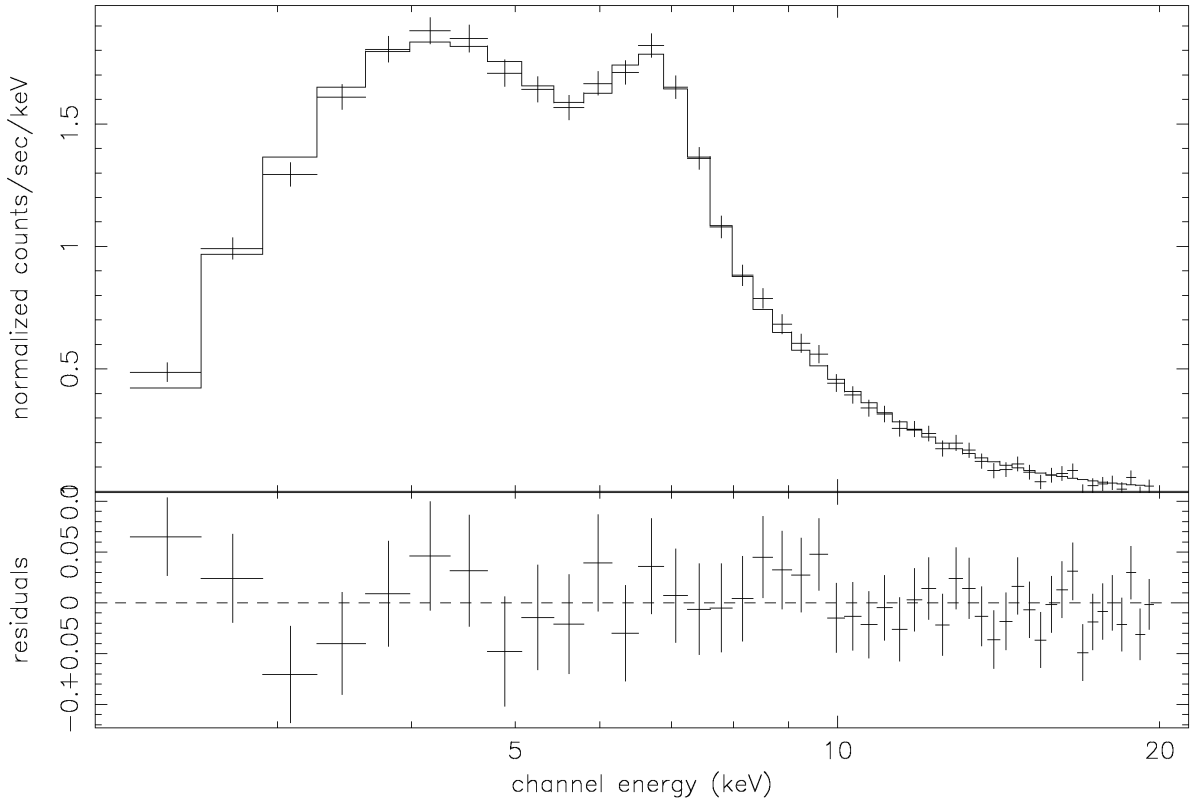
# BL Hyi: Spectra and Light Curve

The x-ray spectra were well-fit by a model consisting of an absorbed bremsstrahlung with Gaussian emission line. For the thermal models, the x-ray spectra had $kT_x$ ~ 11.5 keV, an emission line at E ~ 6.80 keV with equivalent width EW = 0.86 keV, and absorption column $n_H$~ 1.28 x $10^{22}$ $cm^{-2}$ for the bright pole and $kT_x$ ~ 10.8 keV, an emission line at E ~ 6.72 kev with EW ~ 1.25 keV, and $n_H$ ~ 3.23 x $10^{22}$ $cm^{-2}$ for the faint pole. The bright-pole flux was 2.30 x $10^{-11}$ erg $cm^{-2}$ $s^{-1}$ over the energy range E = 2 keV to 10 keV and 7.62 x $10^{-12}$ erg $cm^{-2}$ $s^{-1}$ for the faint pole.

The optical emission showed strong, 2.7% $\pm$ 0.2%, quasi-periodic oscillations (QPOs) over the frequency range 0.2 Hz - 0.8 Hz. We found that the QPO amplitude was modulated strongly on the orbital period. The inference that the QPOs were connected with the dominant accretion hot spot was strong. We did not find QPOs in the x-ray emission of BL Hyi. An upper limit of 20% - 25% was placed on 0.2 Hz - 0.8 Hz x-ray QPOs, but we are working to lower this limit. There were no detections of other short period QPOs or coherent features in both the optical and x-ray data.

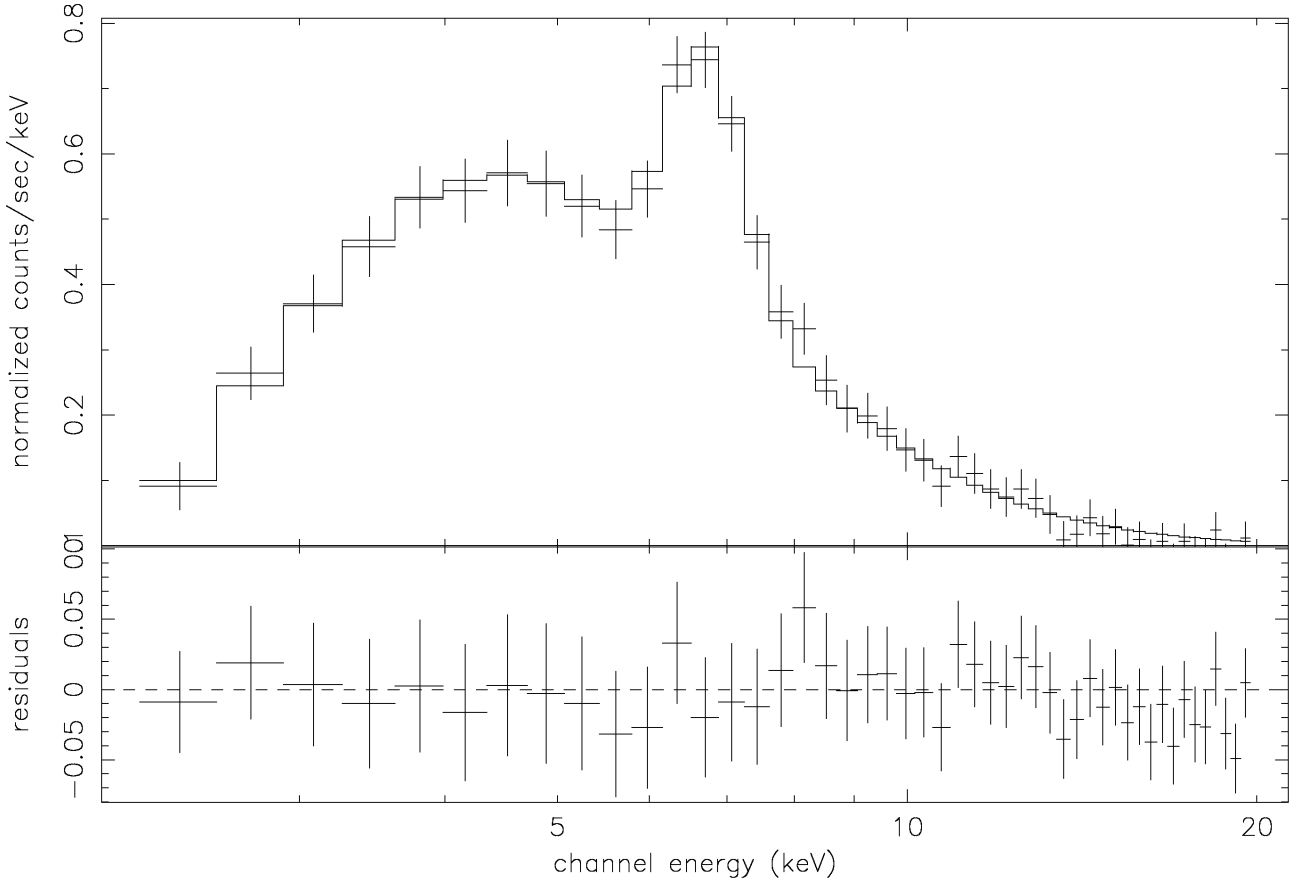
# BL Hyi Bright Pole Spectrum

Figure 1: Background-corrected PCA hard x-ray spectra for BL Hyi for the bright pole. In addition, the best-fit thermal model and residuals are shown.



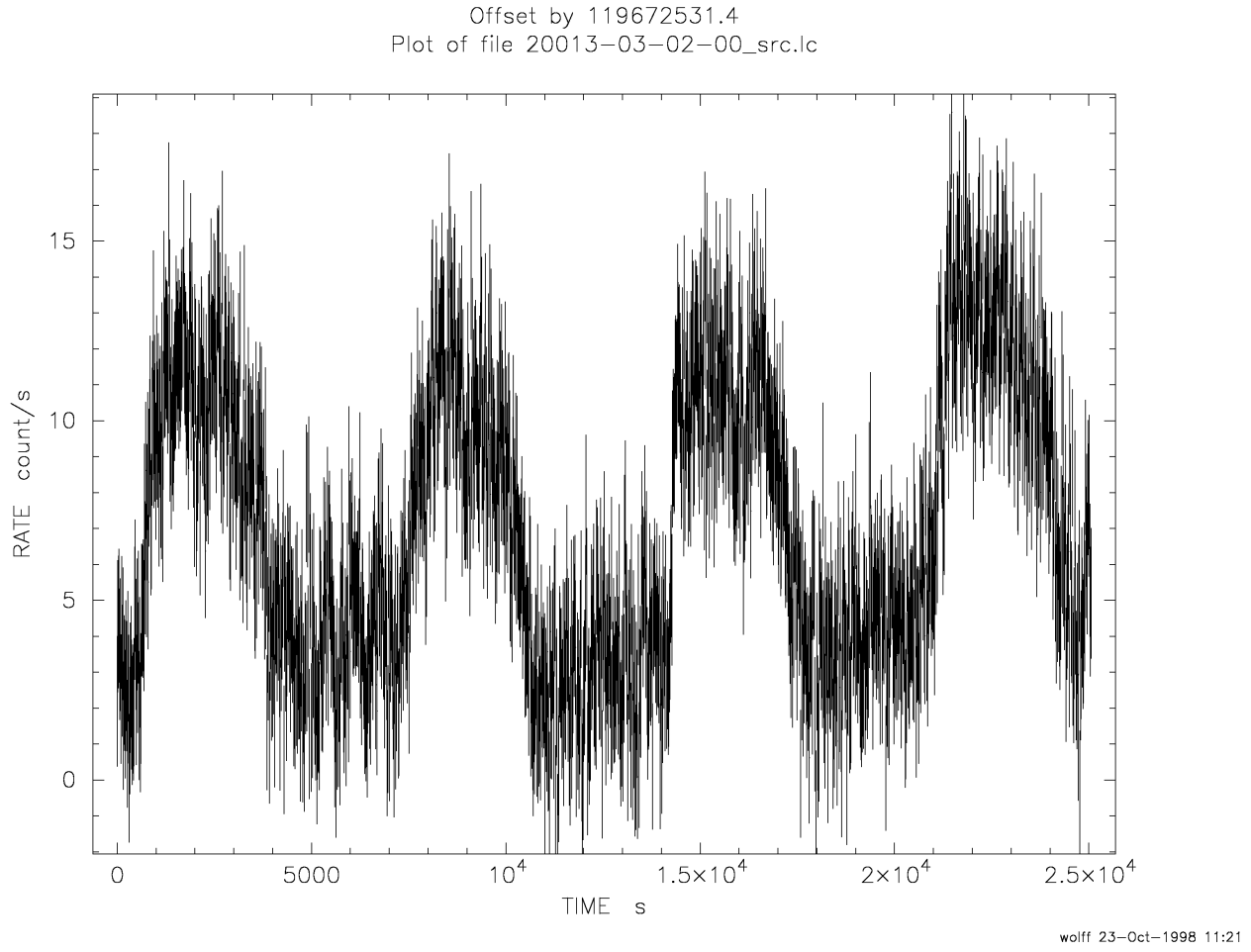
# BL Hyi Faint Pole Spectrum

Figure 2: Background-corrected PCA hard x-ray spectra for BL Hyi for the faint pole. In addition, the best-fit thermal model and residuals are shown.



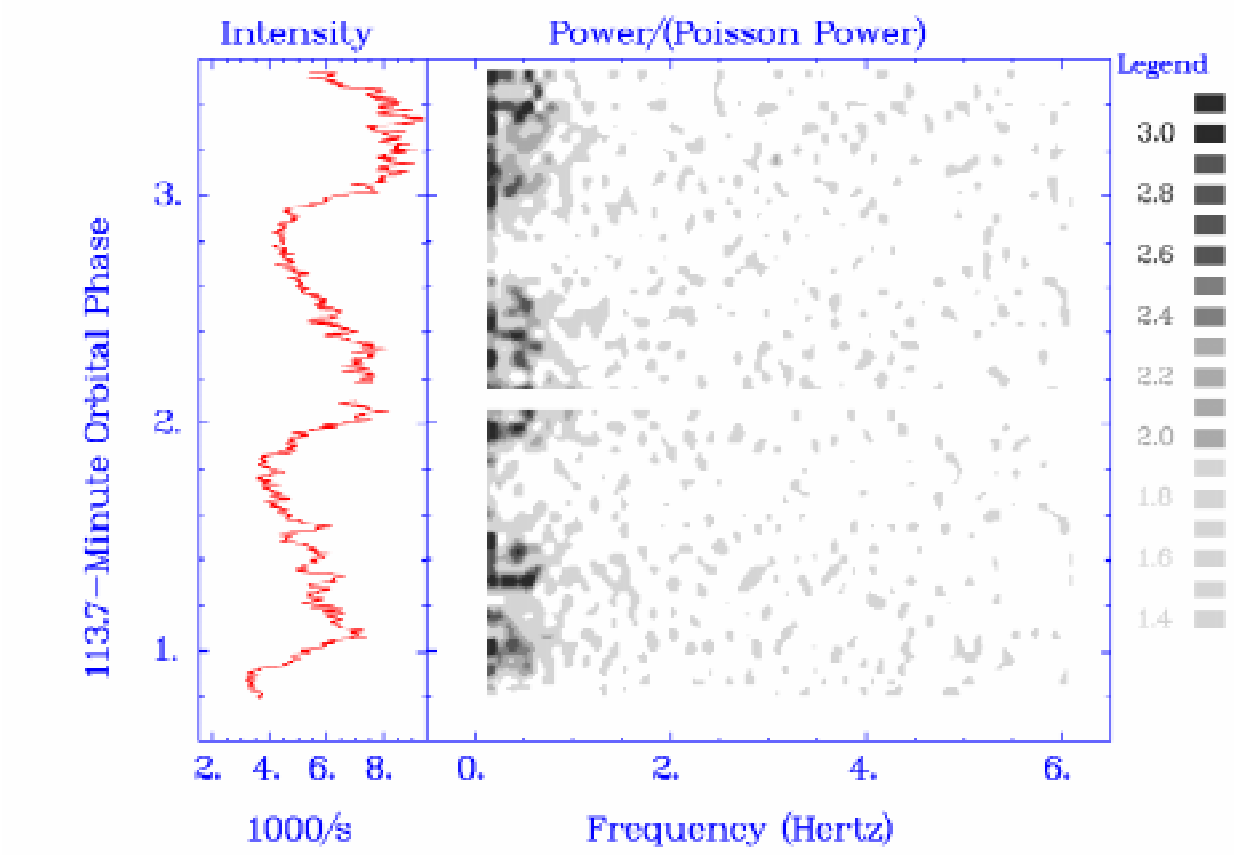
# BL Hyi PCA Light Curve

Figure 3: Background-corrected PCA hard x-ray light curve for BL Hyi. The energy band is 2 keV to 20 keV. The data are binned in intervals of 16 seconds. The orbital phase is based on the ephemeris of Shope and Beuermann (1995).



# BL Hyi: Optical QPO

Figure 4: The time-frequency plot and intensity for our optical observation of BL Hyi on September 24, 1997. The QPO was pulsed 2.7% $\pm$ 0.2% over the frequency range 0.2 to 0.8 Hz. Note the strong correlation between QPO amplitude and orbital phase, $\Phi$.



# V2301 Oph: Observations

V2301 Oph is an AM Herculis system where the white dwarf has a very weak magnetic field, $\mathbf{B}_*$ ~ 7 MG (Ferrario etal. 1995). The binary period is 113.0 minutes (Siber etal. 1994). The x-ray data were acquired using the PCA detector over the extended period September 27, 1997 to November 24, 1997. We accumulated a total of ~ 50 ksec of data from this source, although that data is scattered over a number of discrete observations due to numerous passages through the South Atlantic Anomaly. We employed the standard package of FTOOLS software to analyze the RXTE data.

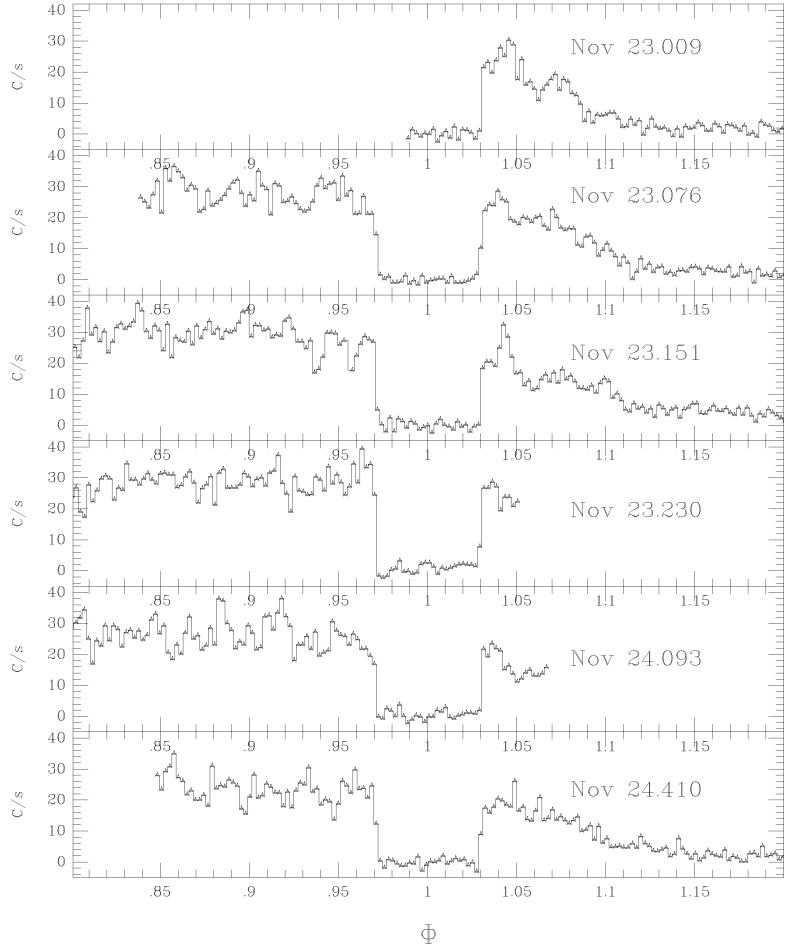
# V2301 Oph: Spectra and Light Curve

Figure 5 shows the light curve of V2301 Oph during our RXTE observation of November 22-24, 1997. the light curve shows that our observations caught a number of eclipses of the white dwarf. The system ephemeris used in our analysis is that of Barwig etal. (1994).

The bright pole (pre-eclipse) x-ray spectra were well-fit by an absorbed bremsstrahlung plus Gaussian emission line spectra with $kT_x$ ~ 15.2 keV, an emission line at E ~ 6.80 keV with equivalent width EW = 0.38 keV, and absorption column $n_H$~ 0.96 x $10^{22}$ $cm^{-2}$. The x-ray flux was 3.49 x $10^{-11}$ erg $cm^{-2}$ $s^{-1}$ over the energy range E = 2 keV to 10 keV. The faint pole emission, while greater than zero in our data, proved too weak a detection to allow a well constrained fit using XSPEC.

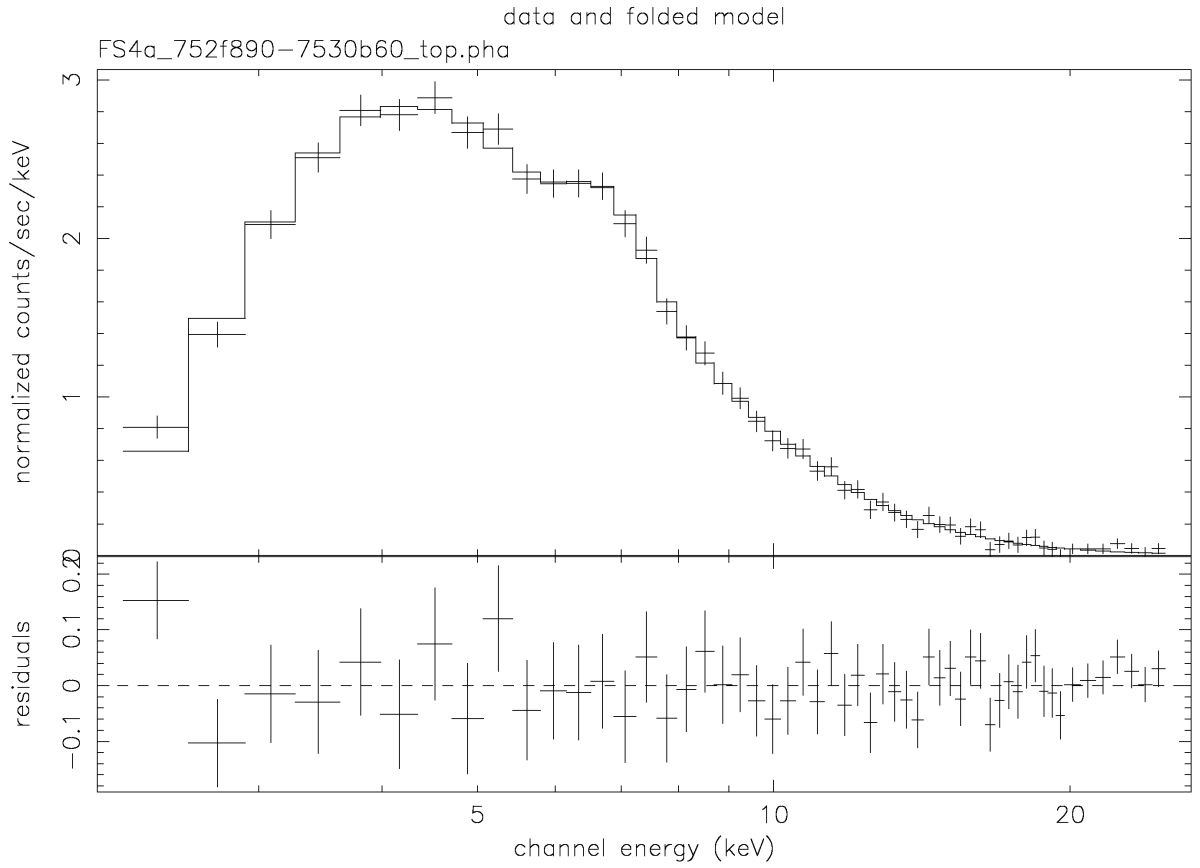
# V2301 Oph PCA Light Curve

Figure 5: Background-corrected PCA hard X-Ray light curve for V2301 Oph. The energy band is 2 keV to 20 keV. The data are binned in intervals of 16 seconds. The orbital phase is based on the ephemeris of Barwig etal. (1994).



# V2301 Oph Bright Pole Spectrum

Figure 6: Background-corrected PCA hard x-ray spectra for V2301 Oph for the bright pole. In addition, the best-fit thermal model and residuals are shown.



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