

High Resolution X-ray Spectroscopy of Neutron Star Surfaces

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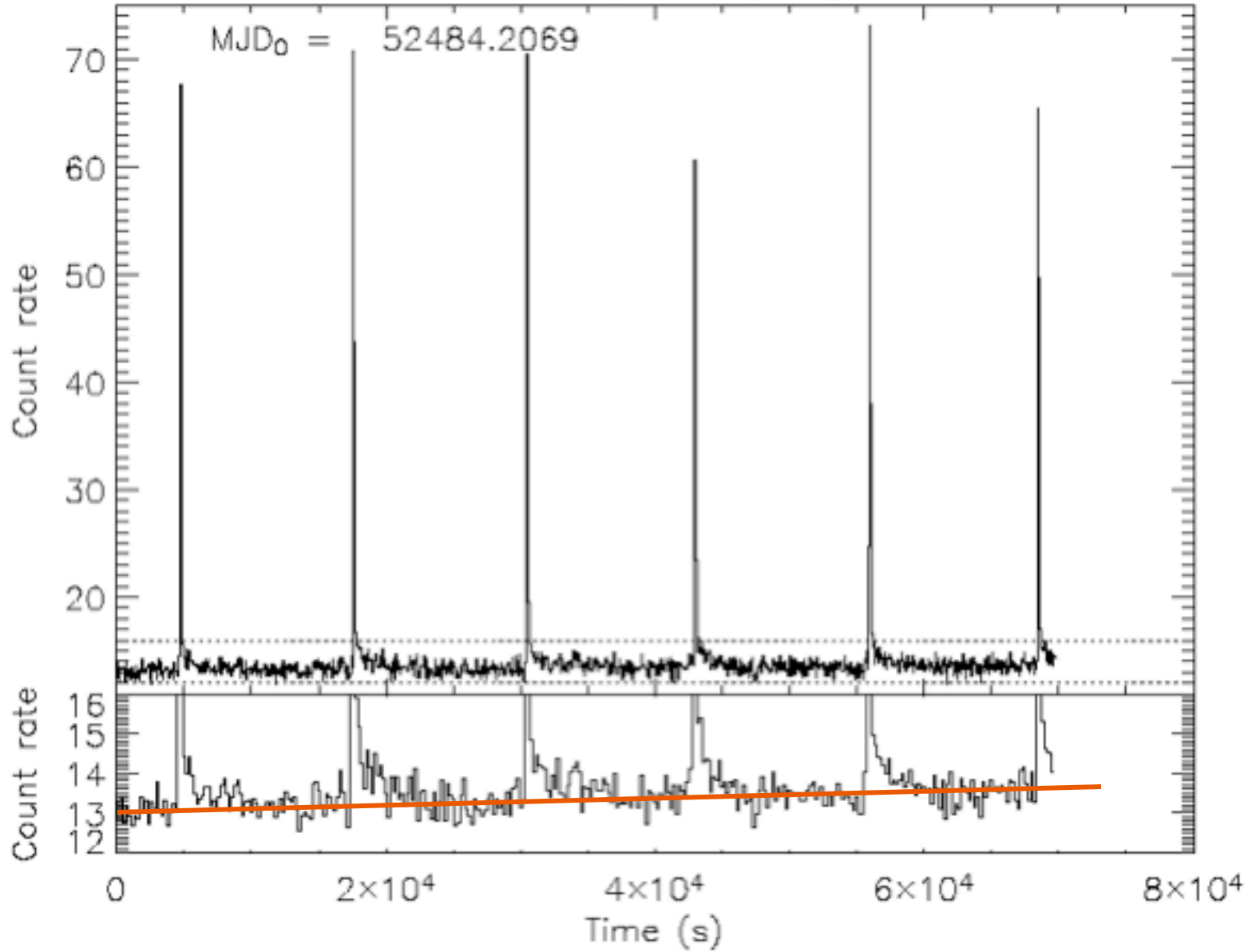
Objectives

- Find absorption lines or edges from heavy elements in thermal atmosphere
 - Identify elements in atmosphere
 - Measure surface redshift --> M/R
- Measure radiation radius, temperature
 - Previous results ambiguous for thermally powered neutron stars: Some fit by blackbody, some require H
 - Radii of X-ray bursts under study for 25 yr
 - Color temperature differs significantly from T_{eff}

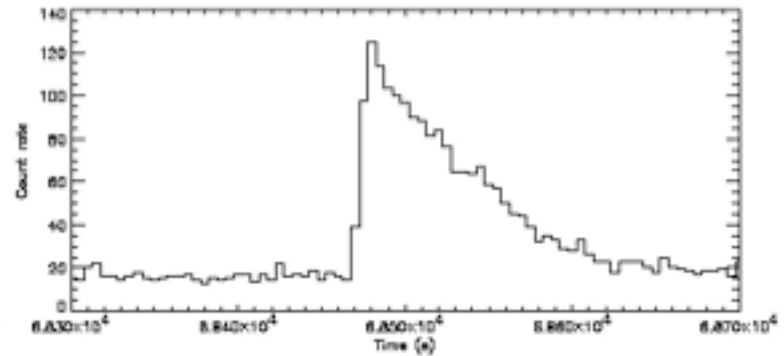
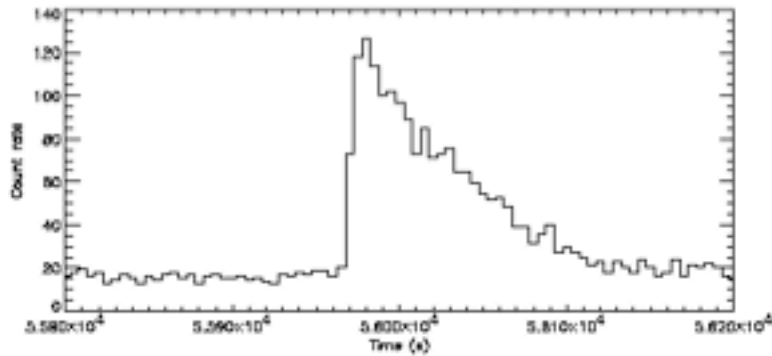
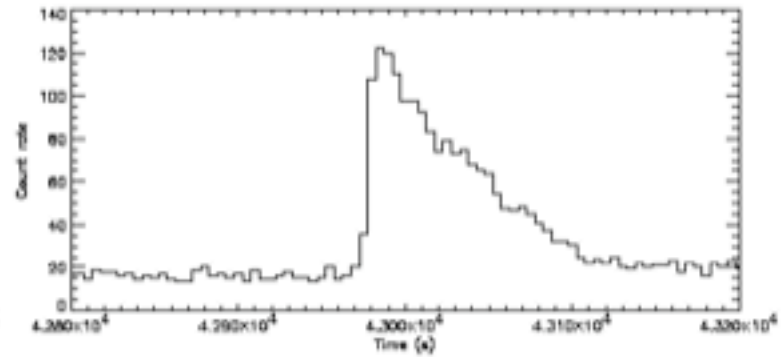
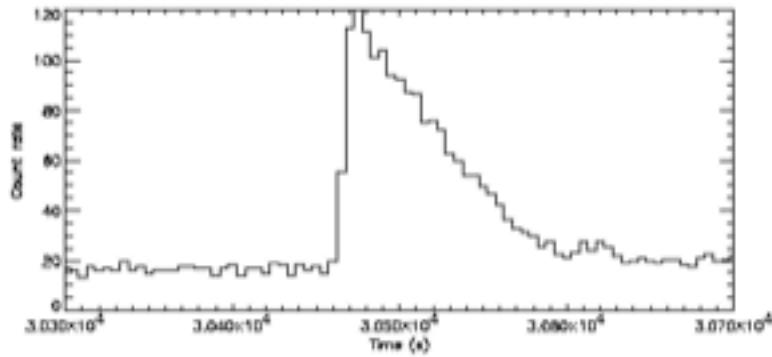
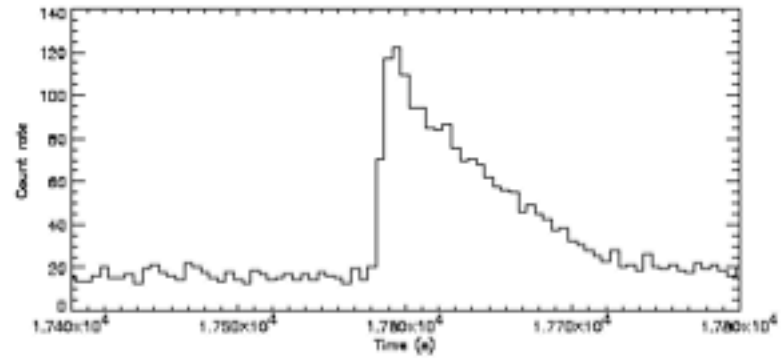
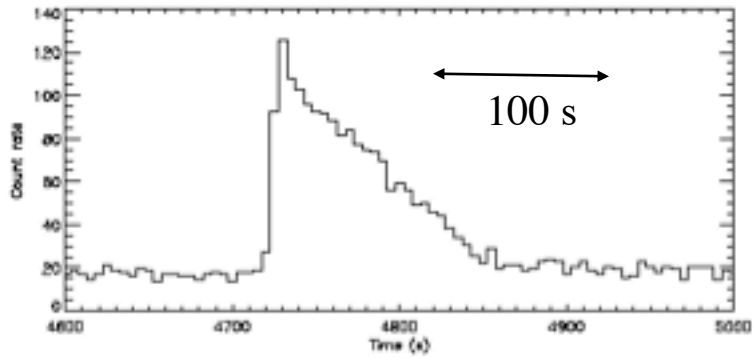
Relevant Targets

- EXO 0748-676
 - No burst oscillations
 - Highly inclined system: dips, occultations
 - Fe Balmer absorption reported (Cottam et al. 2002)
 - HETGS data show no strong features — weak limits
- GSI826-283
 - No burst oscillations
 - Steady accretion
 - HETGS data show no significant features

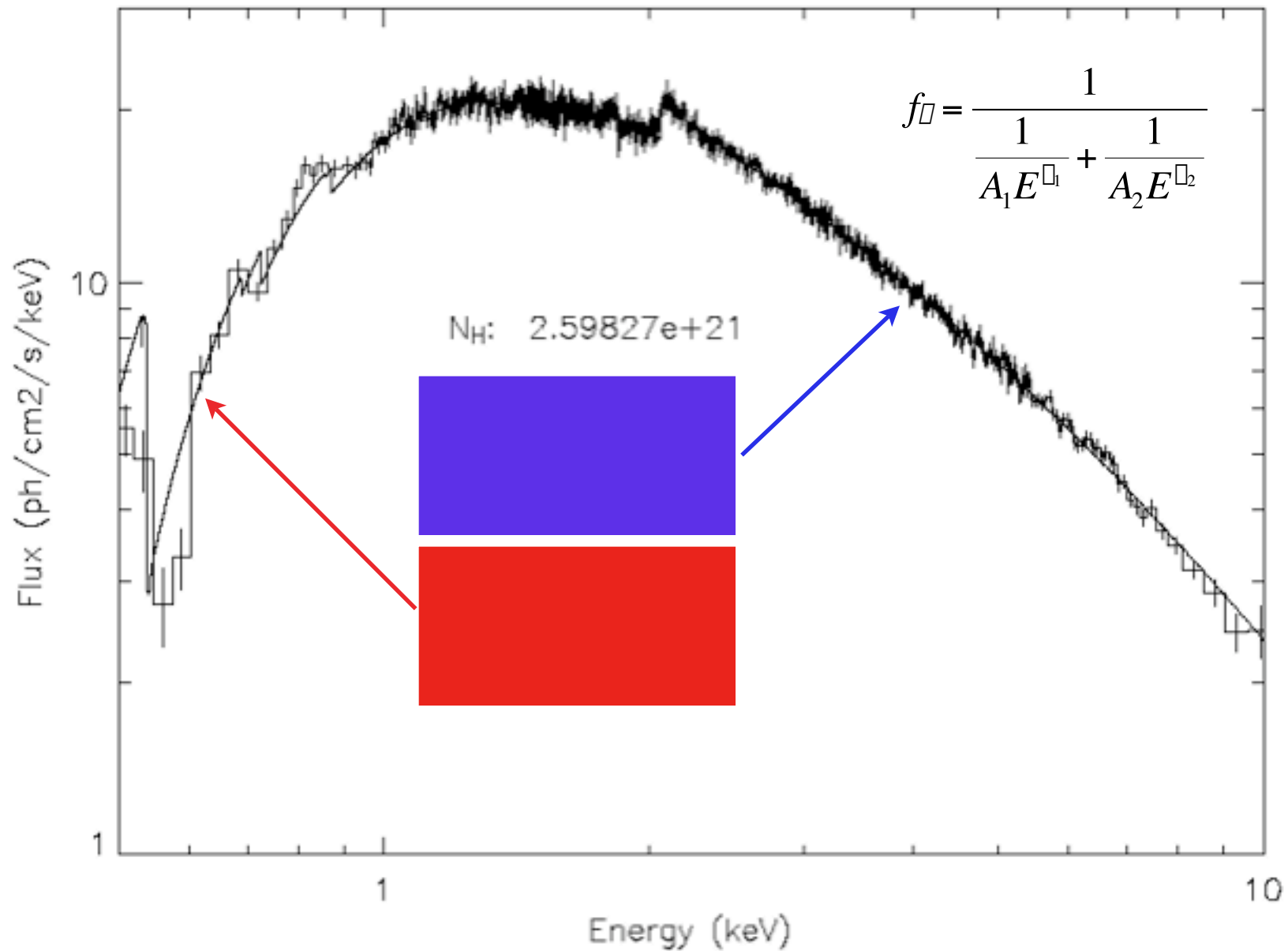
GS 1826-238 (HETGS) Light curve



GS 1826-23 Bursts: Identical



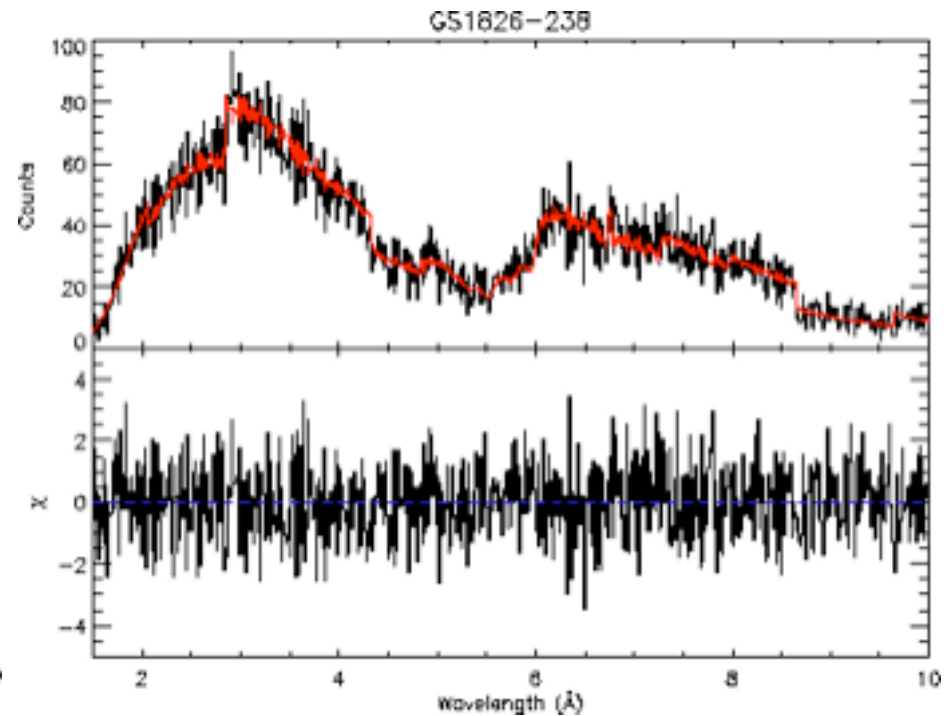
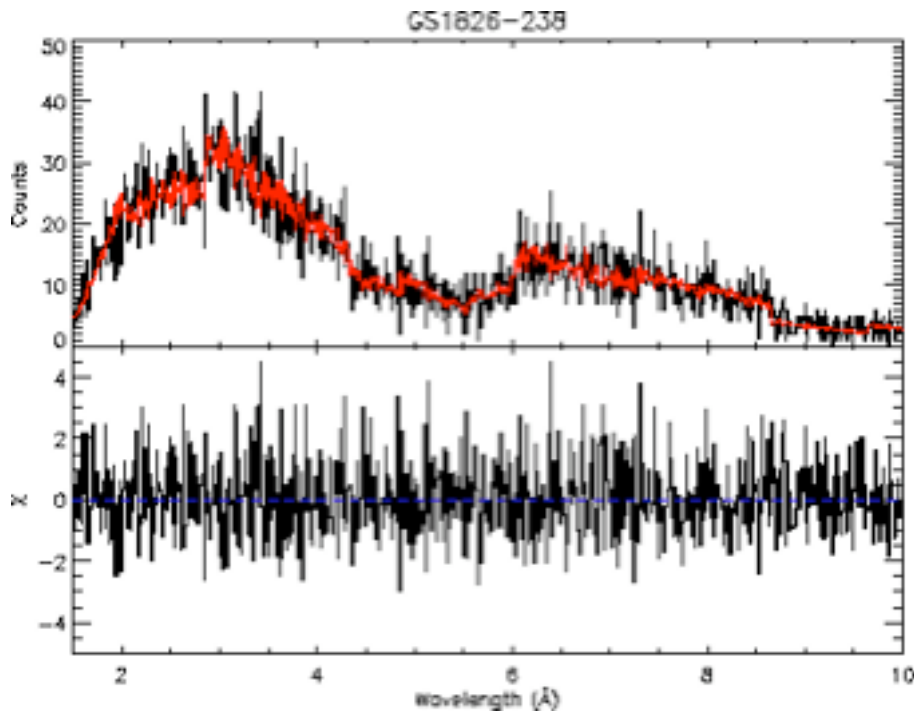
GS 1826-23 Non-Burst Emission



Featureless HETGS Burst Spectra

Peaks ($kT = 2.04$ keV)

Tails ($kT = 1.58$ keV)

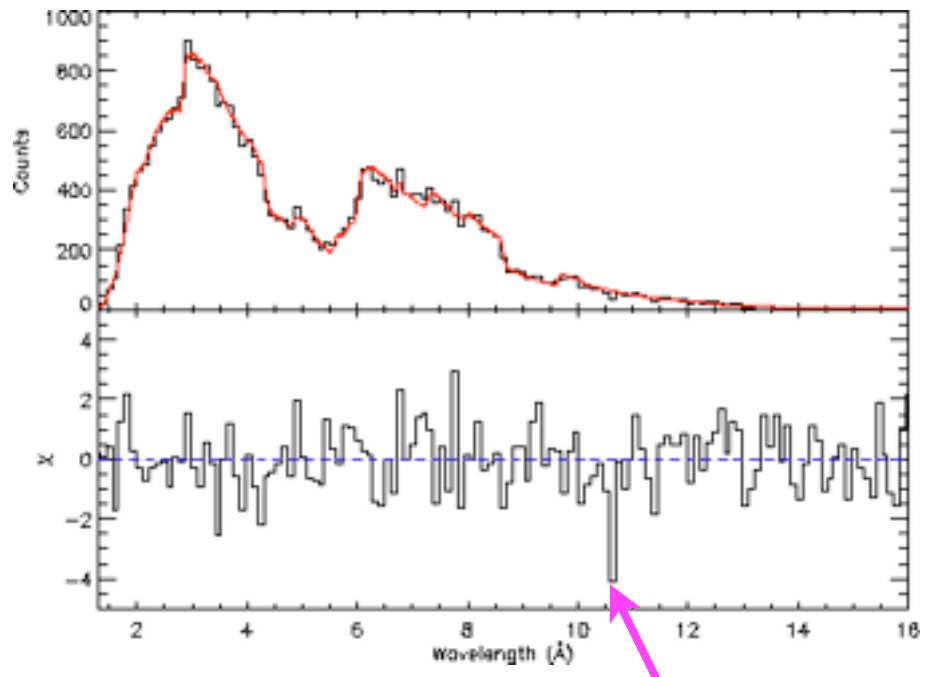
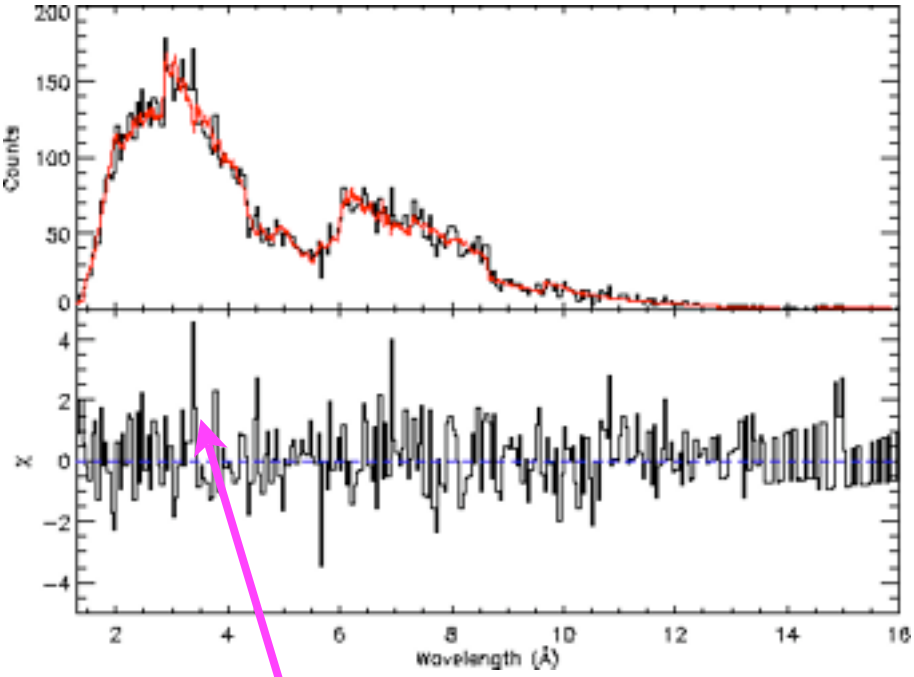


Fit to Blackbody, binned at 0.01 \AA

Featureless (?) HETGS Burst Spectra

Peaks

Tails



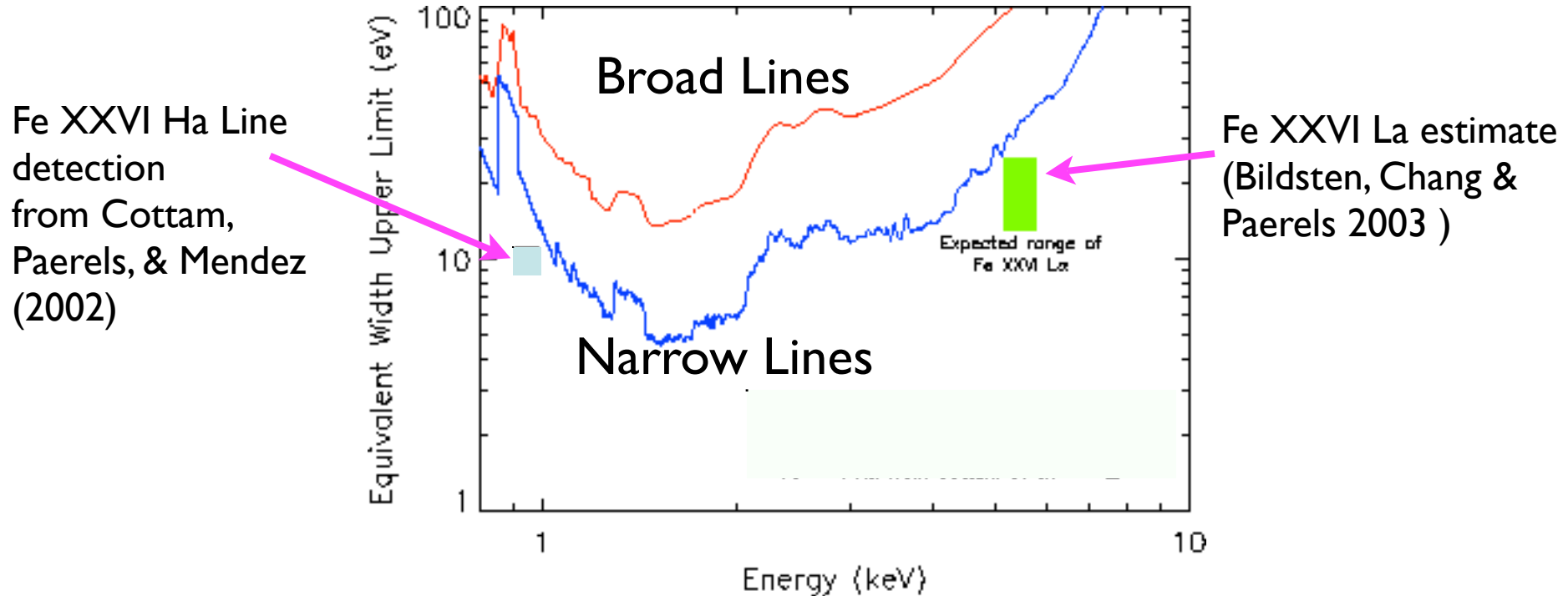
Possible unidentified feature

Fit to Blackbody, binned at 0.1 Å

Possible unidentified feature (Mg XII at z=0.25?)

Possible emission feature in burst peaks, absorption in burst tails
4 sigma only — no clear identifications!

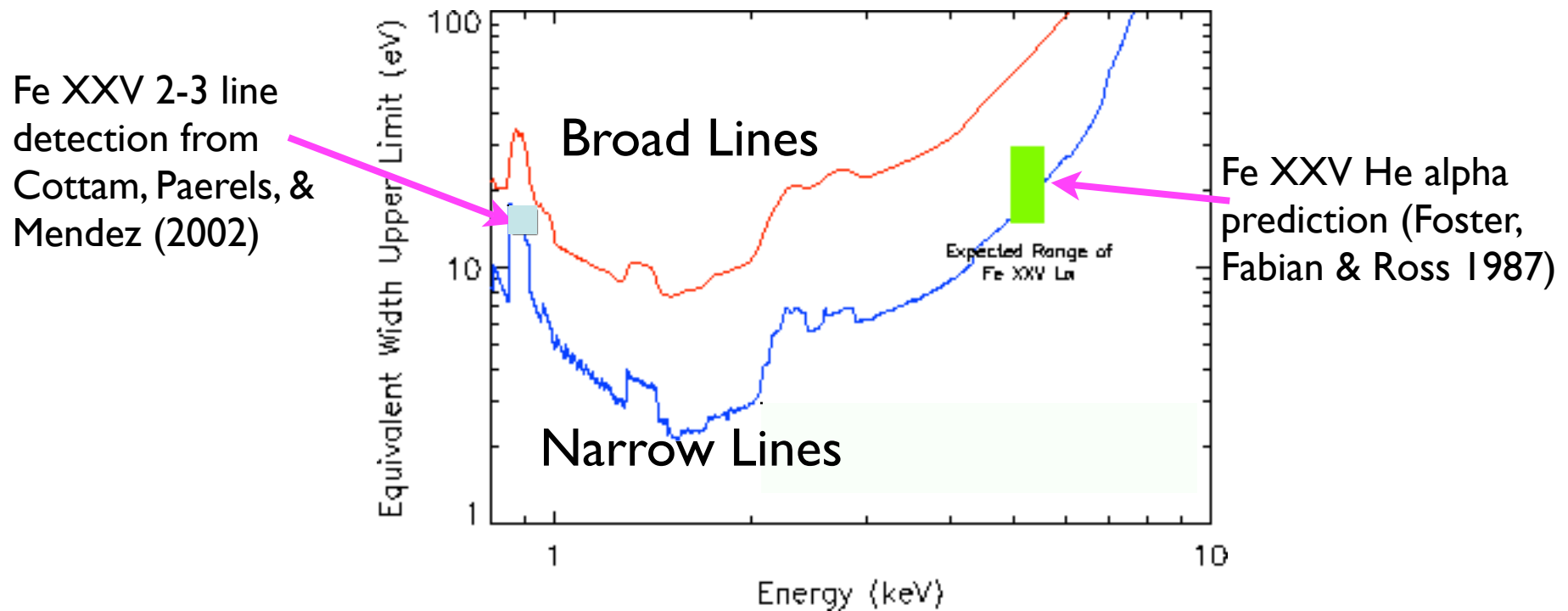
Lines Limits: Burst Peaks



Fe XXV La limit does not yet constrain models

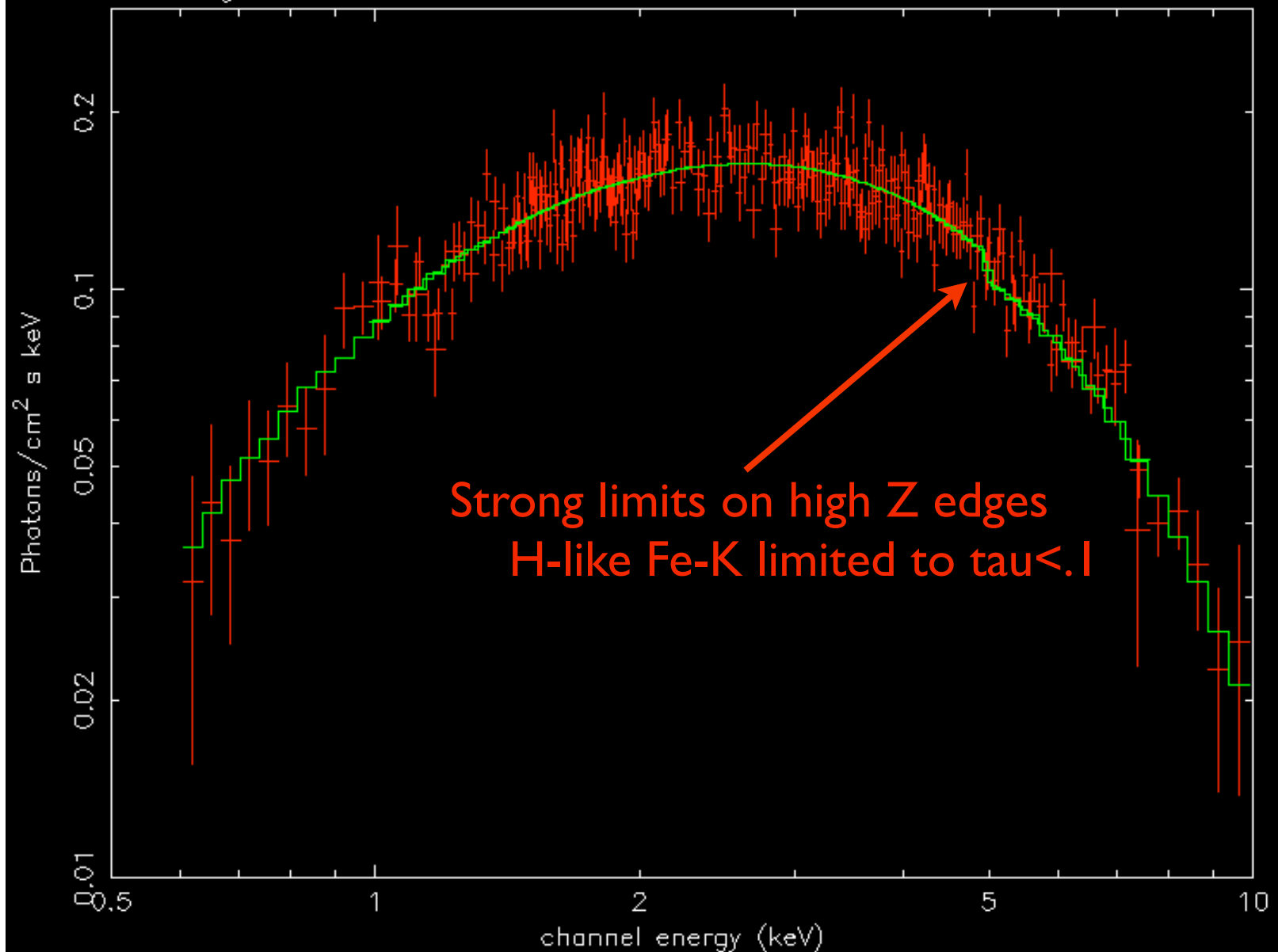
Fe XXV Ha limits do not approach detection in EXO 0748-676

Line Limits: Burst Tails



Fe XXV He alpha limit almost requires

- rotation > 60 Hz to broaden line or
- reduced abundance of Fe or
- coronal Compton scattering

Fe K edge at $z=.35$ and $\tau=.1$ 

Summary

- These burst spectra do not have deep spectral lines or edges (0.8-8.0 keV)
 - Fe XXVI Ly α , XXV He α resonance lines would be broadened by rotation but hard to detect
 - GS 1826 bursts do not show kHz oscillations
 - Coronal scattering?
 - Ionized Fe, Ar, Ca (& other) edges might be expected
 - Accreted material may have low abundances
 - Burst shapes support low CNO (Galloway et al. 2003)
 - Burning products are not transported up from the burn layer
 - Spallation (Bildsten et al. 2003) products not detected
- Combine bursts from different sources?
 - Neutron star z , Z may vary between sources
 - Better: long Chandra observations of a single burster
 - Best: Constellation-X studies of individual bursts