X-Ray Grating Observations of Recurrent Nova T Pyxidis

Ben Tofflemire
University of Wisconsin - Madison
July 12th, 2012

Recurrent Novae

- Similar to Classical Novae (CNe):
  - Result of TNR on the surface of an accreting White Dwarf.
- Different in that:
  - Have much higher accretion rates than Typical CNe ($>10^{-8}$ $M_{\odot}$ yr^{-1} for T Pyx, Selvelli et al. 2008).
  - Spectra generally show stronger x-ray emission lines than CNe.
  - Generally have shorter decay times

T Pyx 2011 - SWIFT Lightcurve

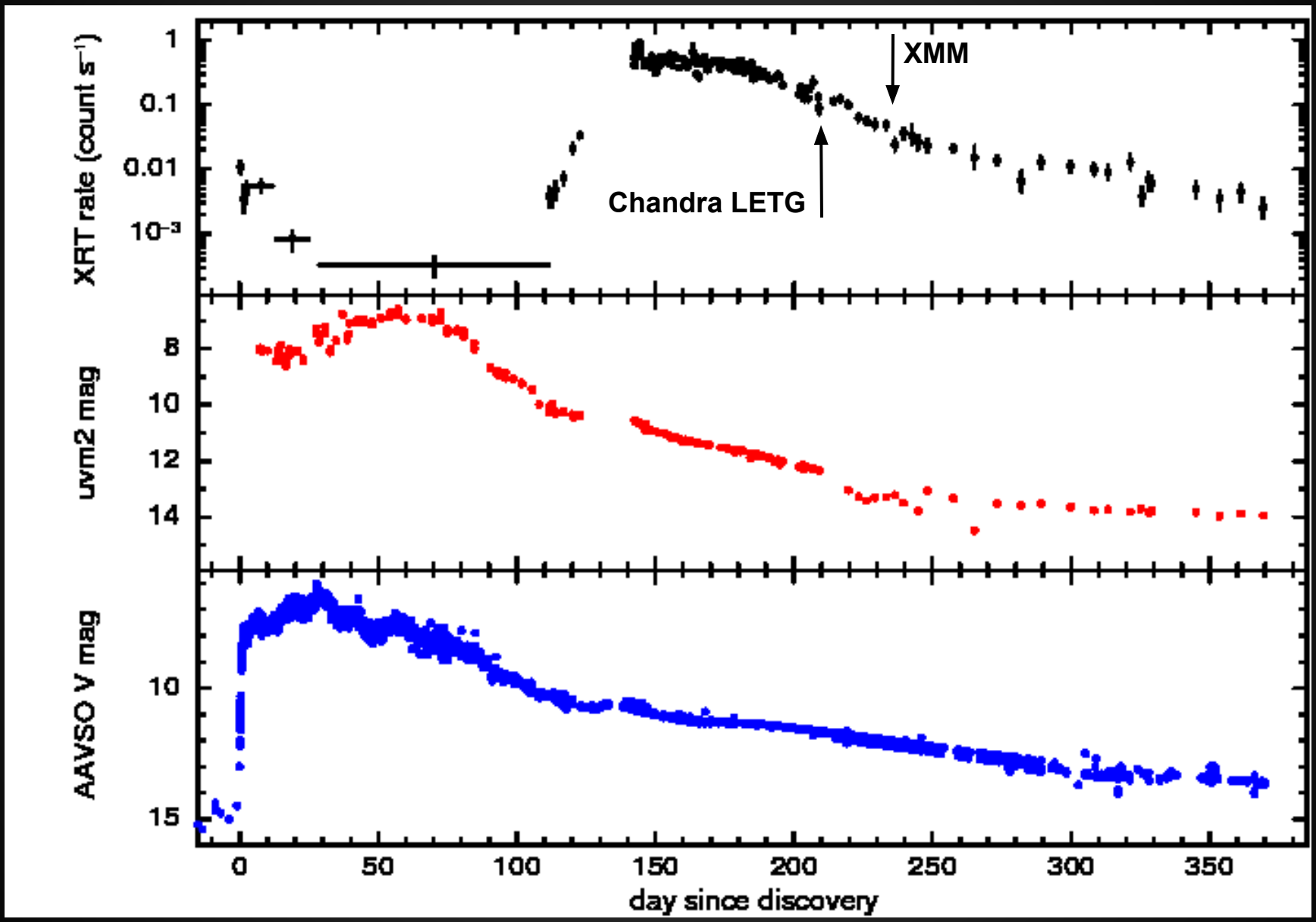


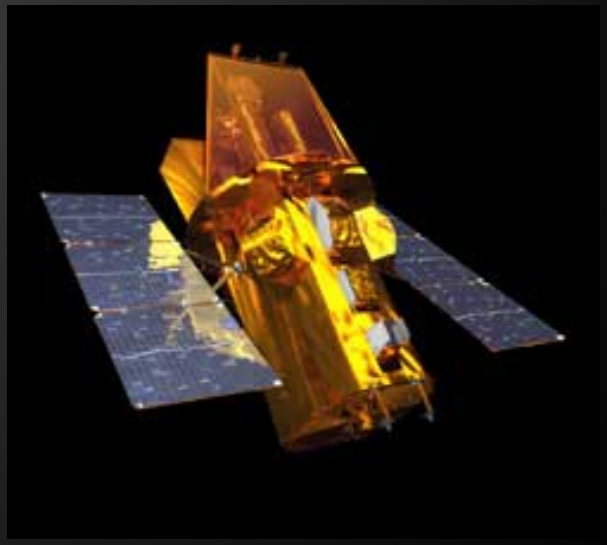
Image Credit: Kim Page (SWIFT)

Observing the White Dwarf

- During decline, nova peaks as a Super-Soft x-ray Source (SSS) as ejecta become optically thin revealing the WD atmosphere.

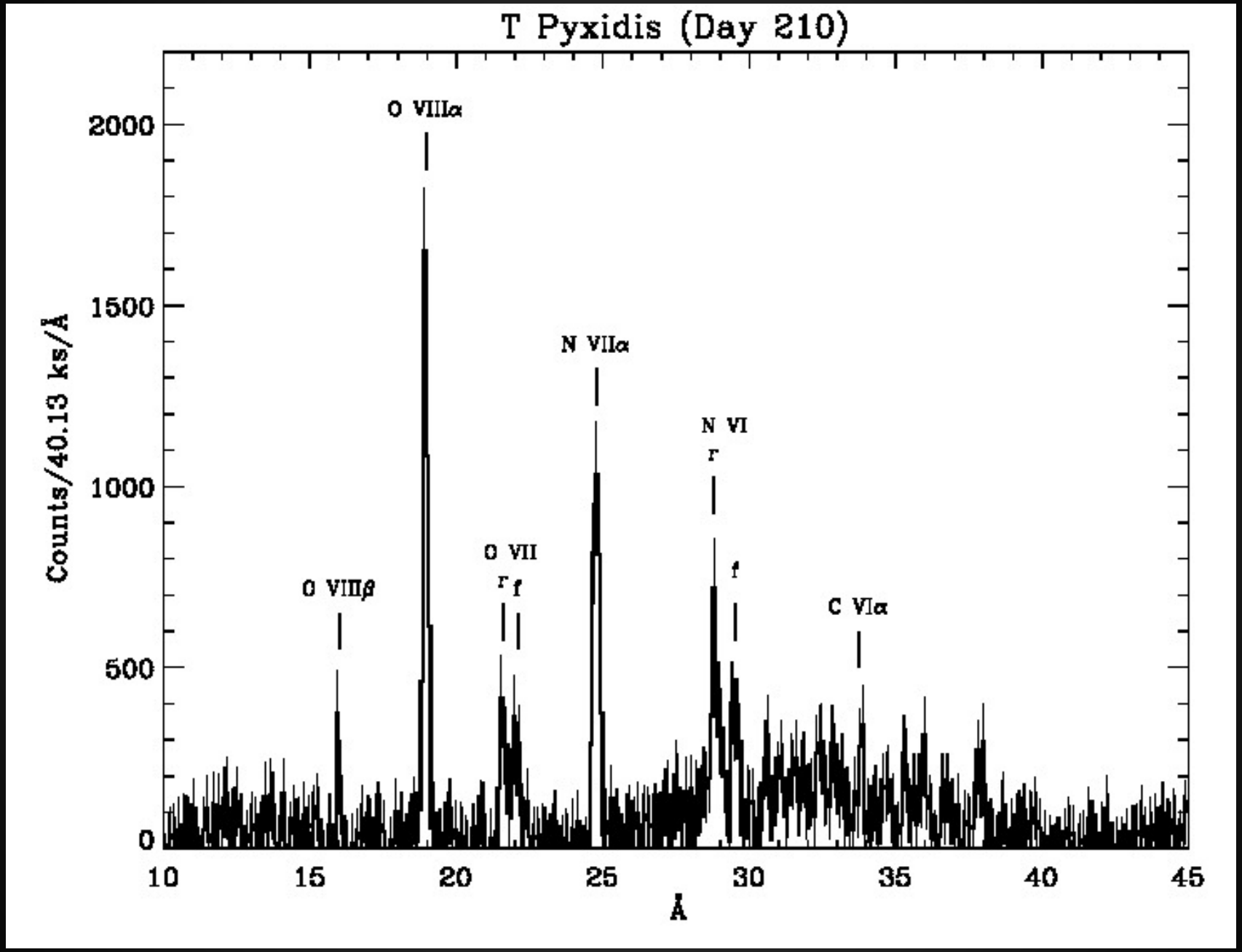
- SWIFT monitoring can identify SSS peak.

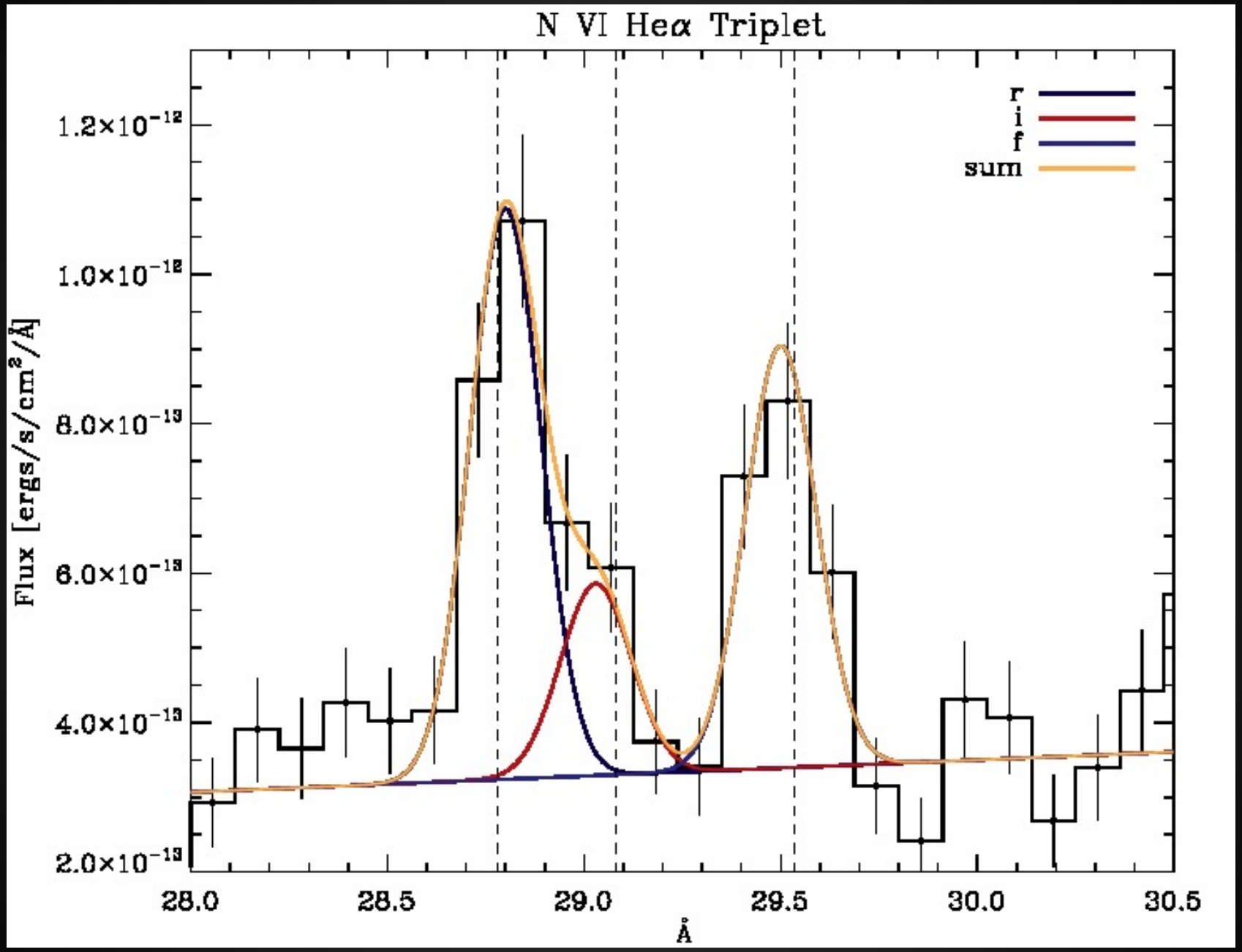
- This SSS phase is the best chance to observe the white dwarf atmosphere.
  - Place constraints on mass, composition, and nucleosynthesis (Rauch et al. 2010).



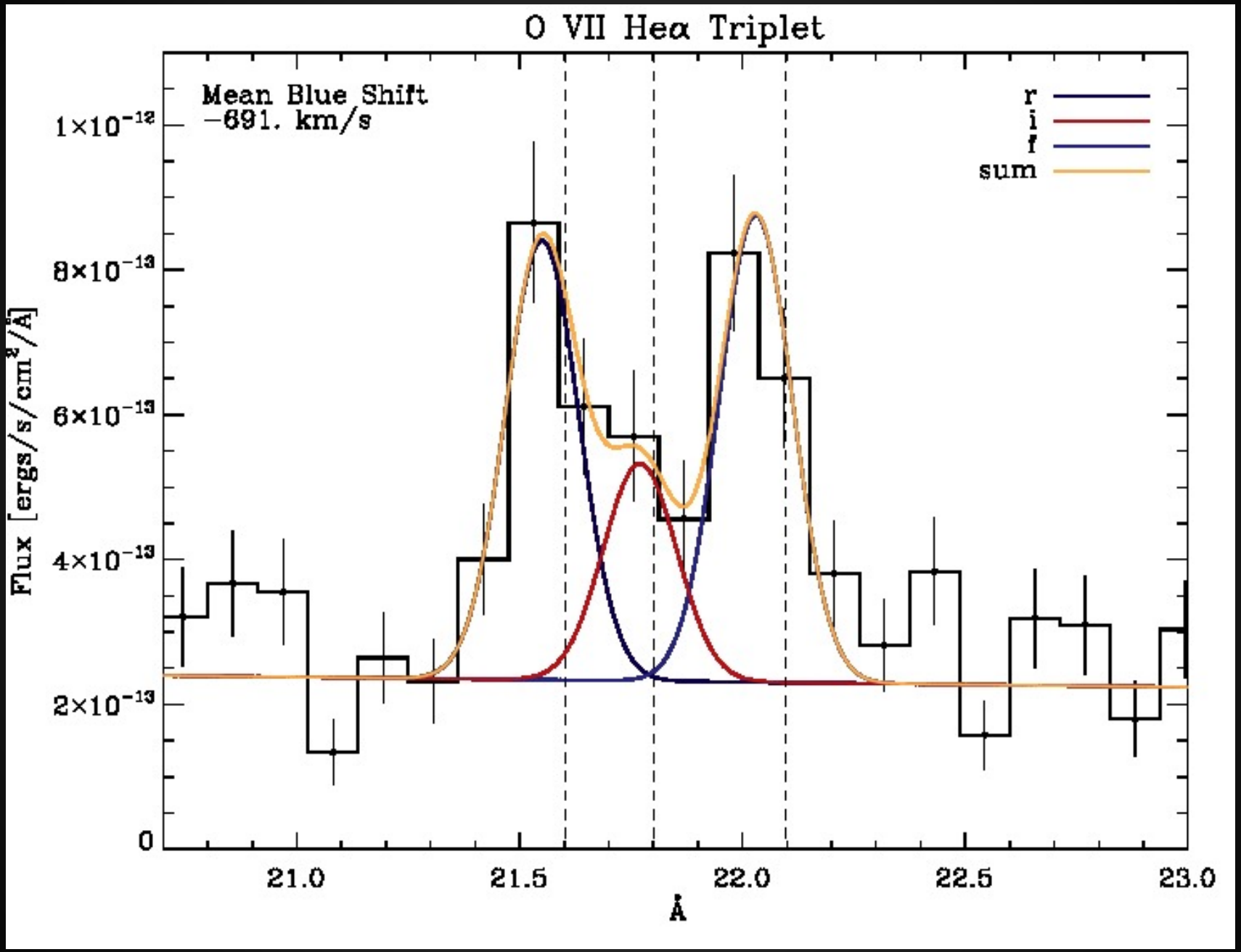
T Pyxidis History

- Recorded outbursts:
  - 1890
  - 1902
  - 1920
  - 1967
  - ***2011***
- Average recurrence time ~20 years until most recent event.
- Schaefer et al. 2010 speculate that T Pyx was headed for a dormant phase.


T Pyxidis (Day 210)
O VIIIα
N VIIα
N VI
r
f
O VII
r
f
O VIIIβ
C VIα
Counts/40.13 ks/Å
2000
1500
1000
500
0
10
15
20
25
30
35
40
45
Å



Collisionally ionized plasma at ~1x10^6 ^{o}K, Porquet & Dubau 2000

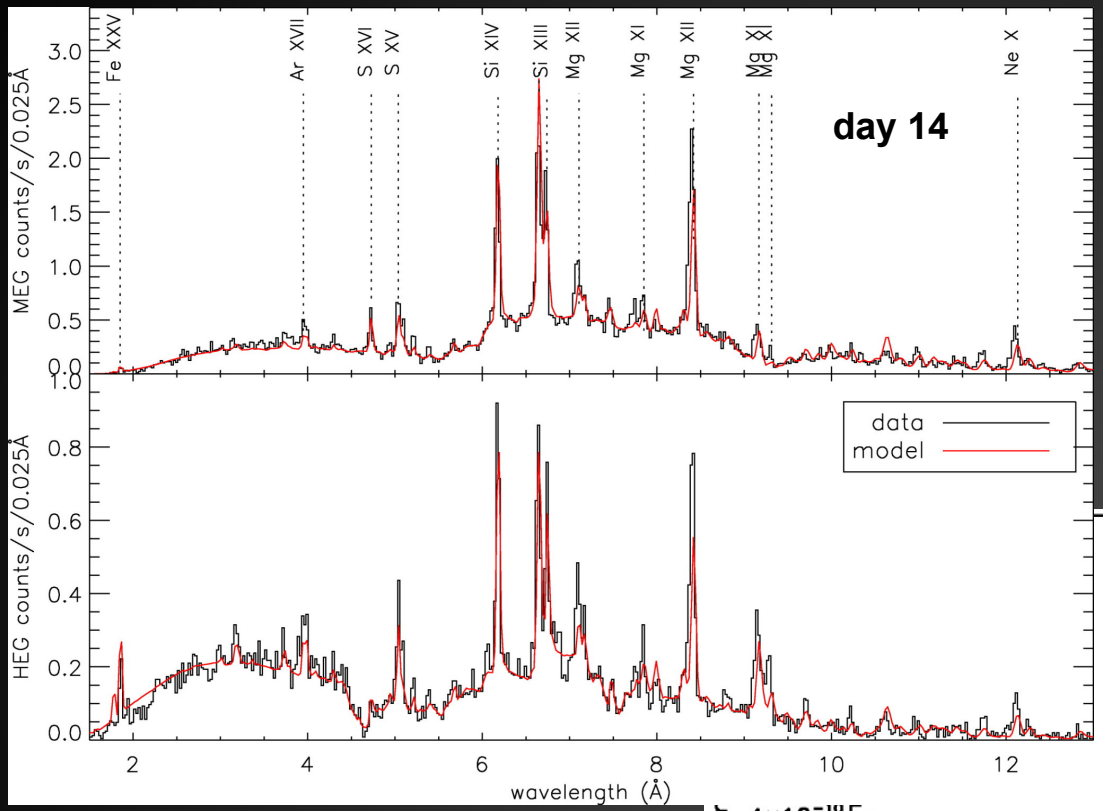


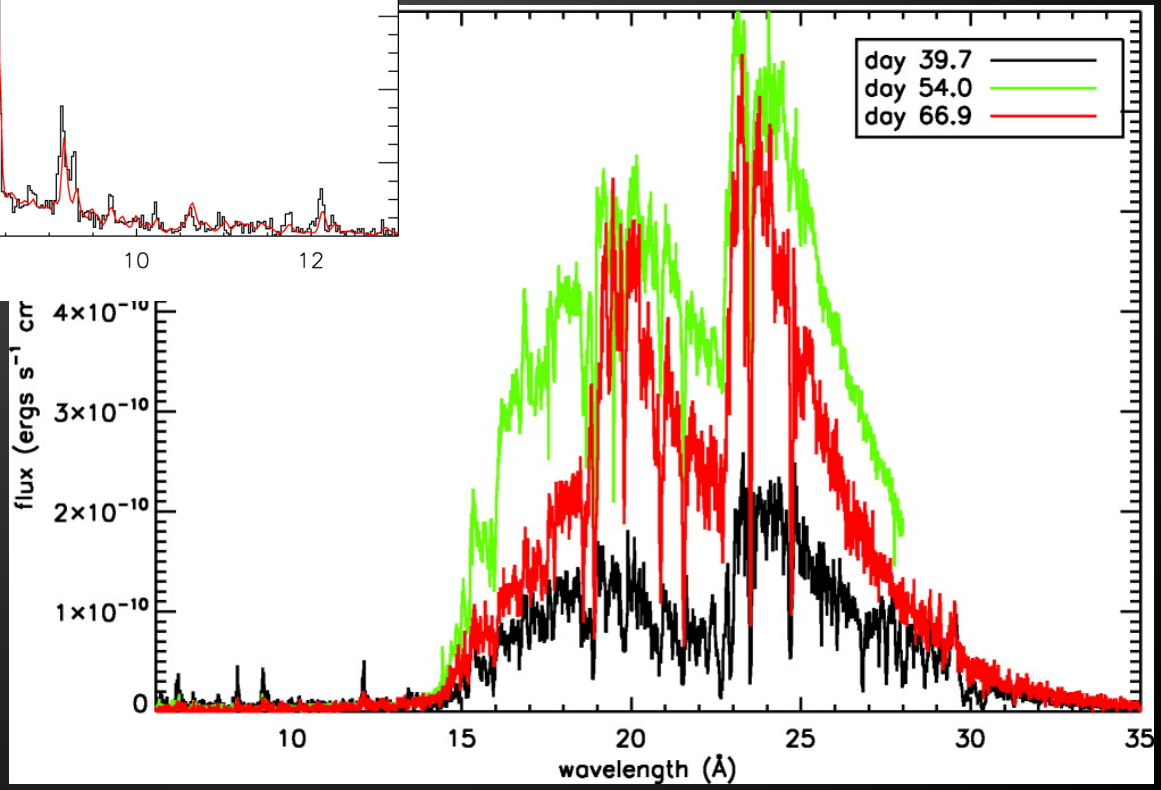
Collisionally ionized with partial photoionization at ~2x10^6 ^{o}K, Porquet & Dubau 2000

Two Emitting Regions

- A two-temperature component apec model is required to fit lines across spectrum.
- Higher energy emission lines are blueshifted.
- High energy lines are asymmetric (similar to O star x-ray wind profiles, Cohen et al. 2010).
- O VII Heα triplet has different ratios compared to N VI Heα consistent with partial photoionization (Porquet & Dubau 2000).

RS Oph (2006 Outburst)

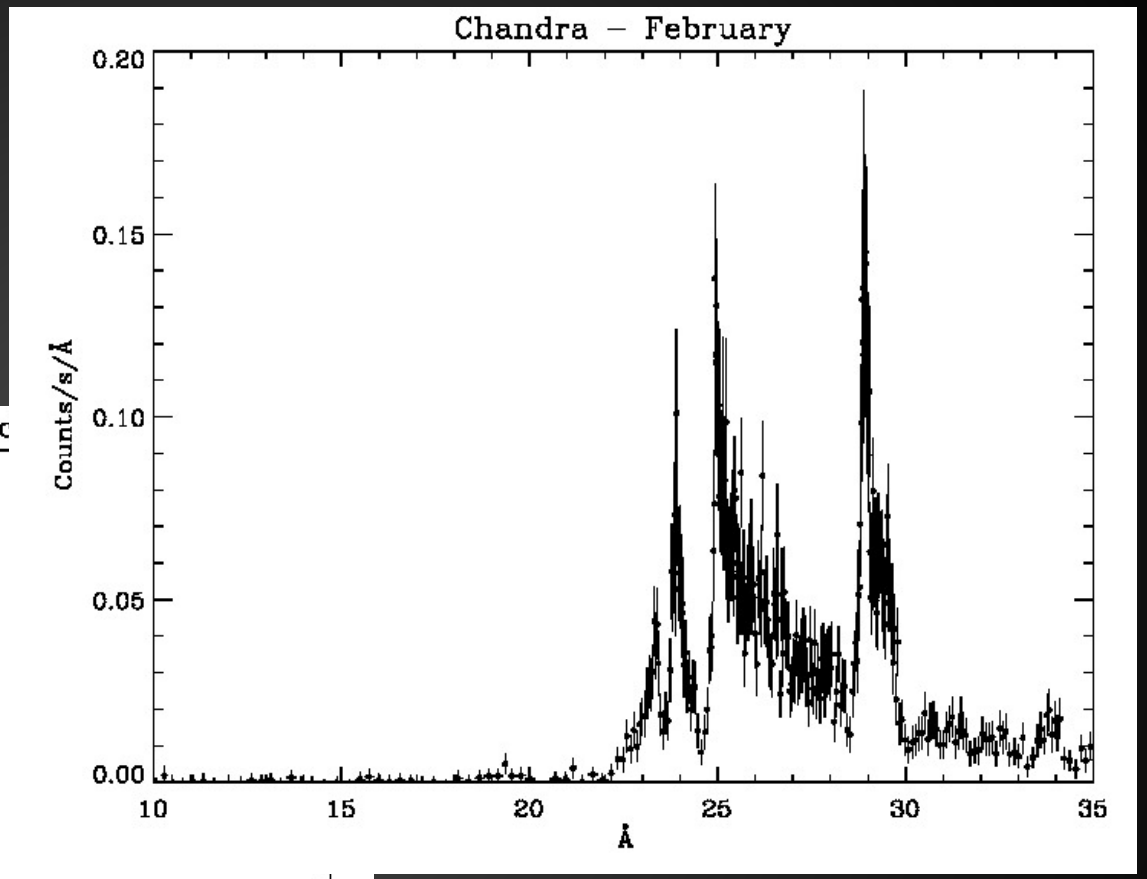


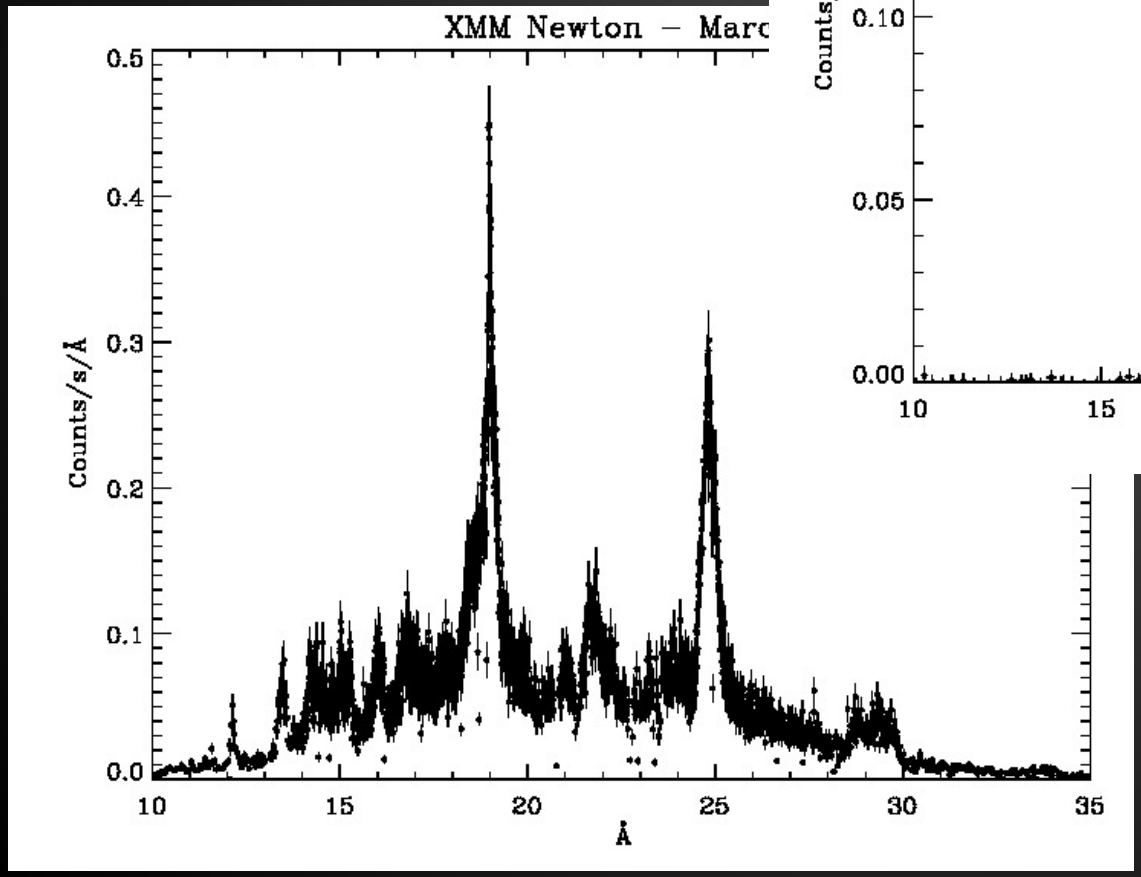


Nelson et al. 2008

U Sco (2010 Outburst)

M. Orio et al. 2012, in prep





Summary

- While missing the soft x-ray peak, we observed continuum and strong emission lines.

- Emission lines from two emitting regions:
  - Cooler collisionally ionized outer ejecta.
  - Hotter collisionally ionized and partially photoionized nova ejecta near the WD.

- Additional XMM observation has same spectral structure with decreased intensity.

- Typical of RNe in that it has it's own unique characteristics.

Thank You

References:

Cohen et al. 2010, MNRAS, 405, 2391

Nelson et al. 2008, AJ, 673, 1067

Porquet & Dubau 2000, A&AS, 143, 495

Schaefer et al. 2010, AJ, 702, 381

Selvelli et al. 2008, A&A, 492, 787

Rauch et al. 2010, AJ, 717, 363

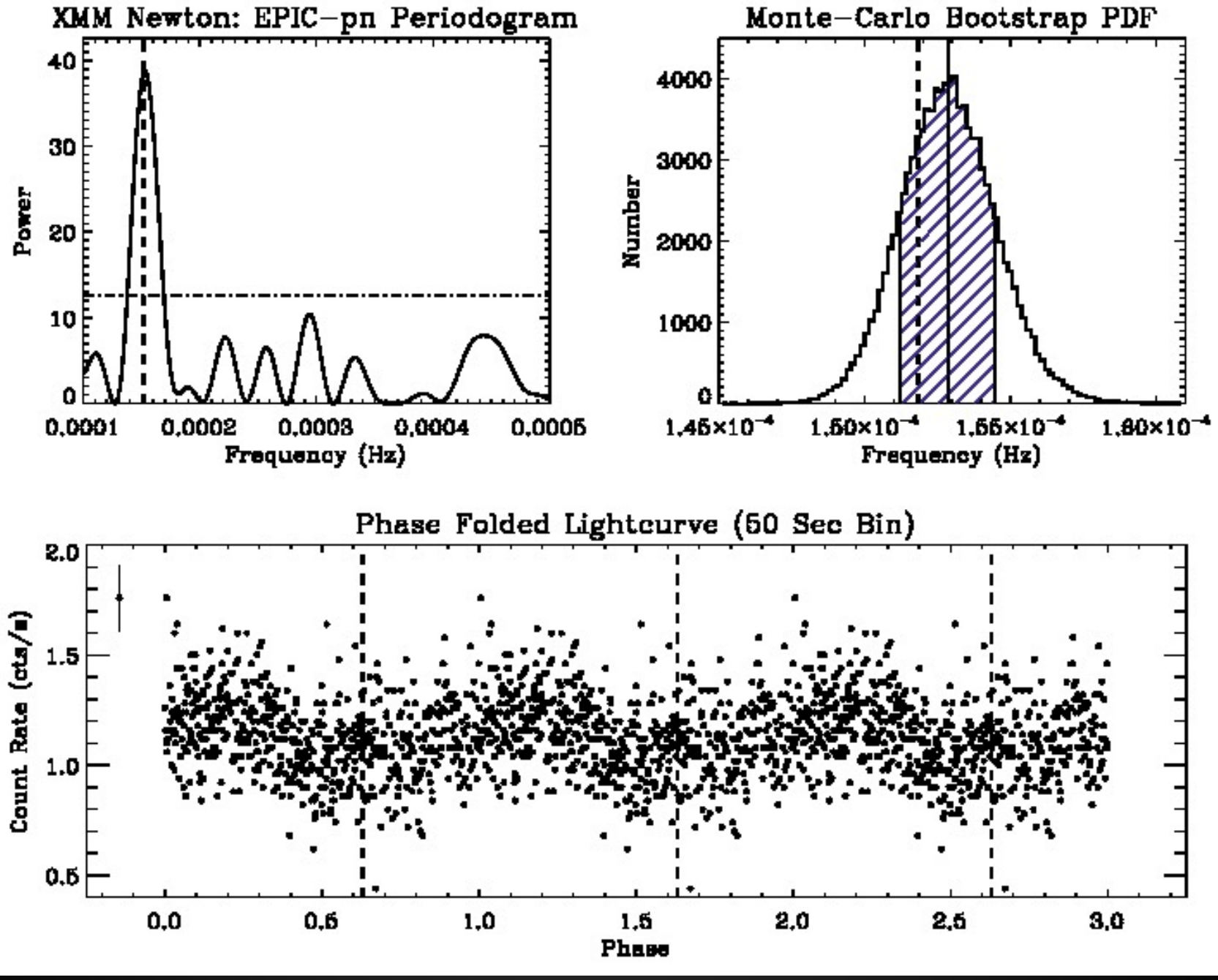
Special Thanks:

Marina Orio

Kim Page

Paper coming soon:

Tofflemire et al. 2012, ApJL


XMM Newton: EPIC−pn Periodogram
Power
Frequency (Hz)
0.0001
0.0002
0.0003
0.0004
0.0005
0
10
20
30
40
Monte−Carlo Bootstrap PDF
Number
Frequency (Hz)
1.45×10⁻⁴
1.50×10⁻⁴
1.55×10⁻⁴
1.60×10⁻⁴
0
1000
2000
3000
4000
Phase Folded Lightcurve (50 Sec Bin)
Count Rate (cts/s)
Phase
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.5
1.0
1.5
2.0