X-ray Spectroscopy of RS Ophiuchi in Outburst

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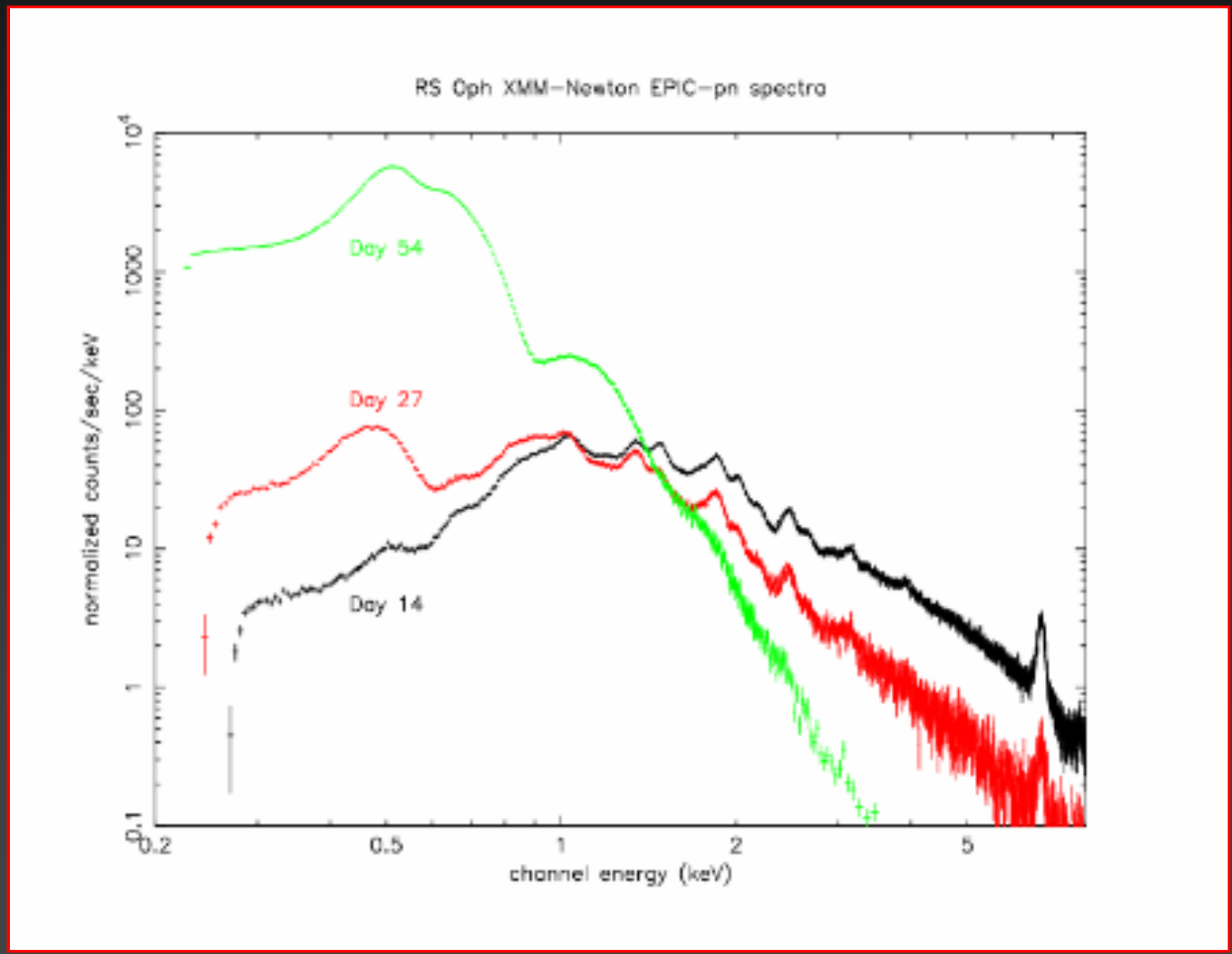
RS Oph Basics

- Symbiotic star: massive white dwarf accreting wind from red giant companion
- 6 recorded outbursts: 1898, 1933, 1958, 1967, 1985, 2006
- A few may have been missed: 1907, 1945
- Wide(ish) orbit, P_{orb} = 456 days, a ~1.5 AU
- Inclination poorly constrained: masses from orbital solution uncertain

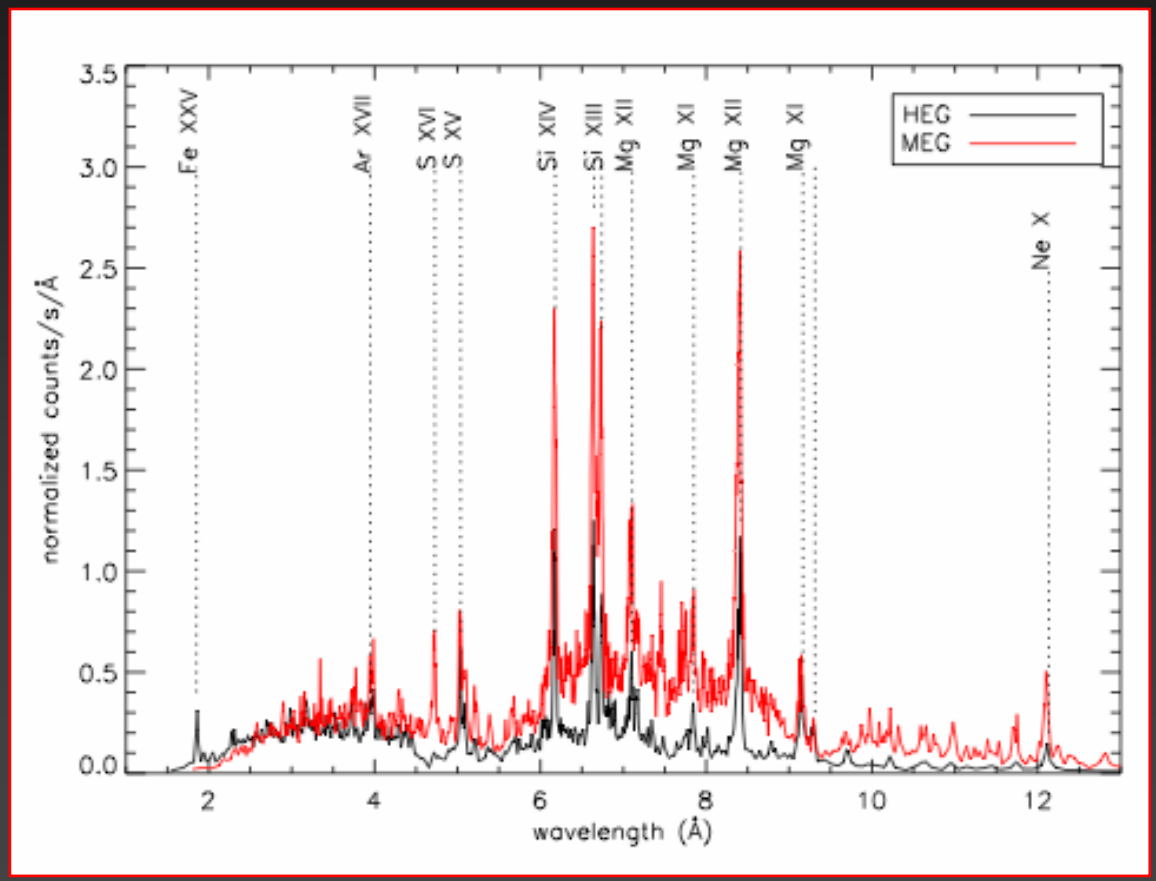
Grating Spectroscopy

- 9 DDT observations: 4 Chandra, 5 XMM
- Every 2 weeks from day 14 till 67, then days 111, 205 and 239
- Coverage of all stages of outburst from early shock dominated phase, through supersoft maximum and then post supersoft emission

EPIC-pn Overview

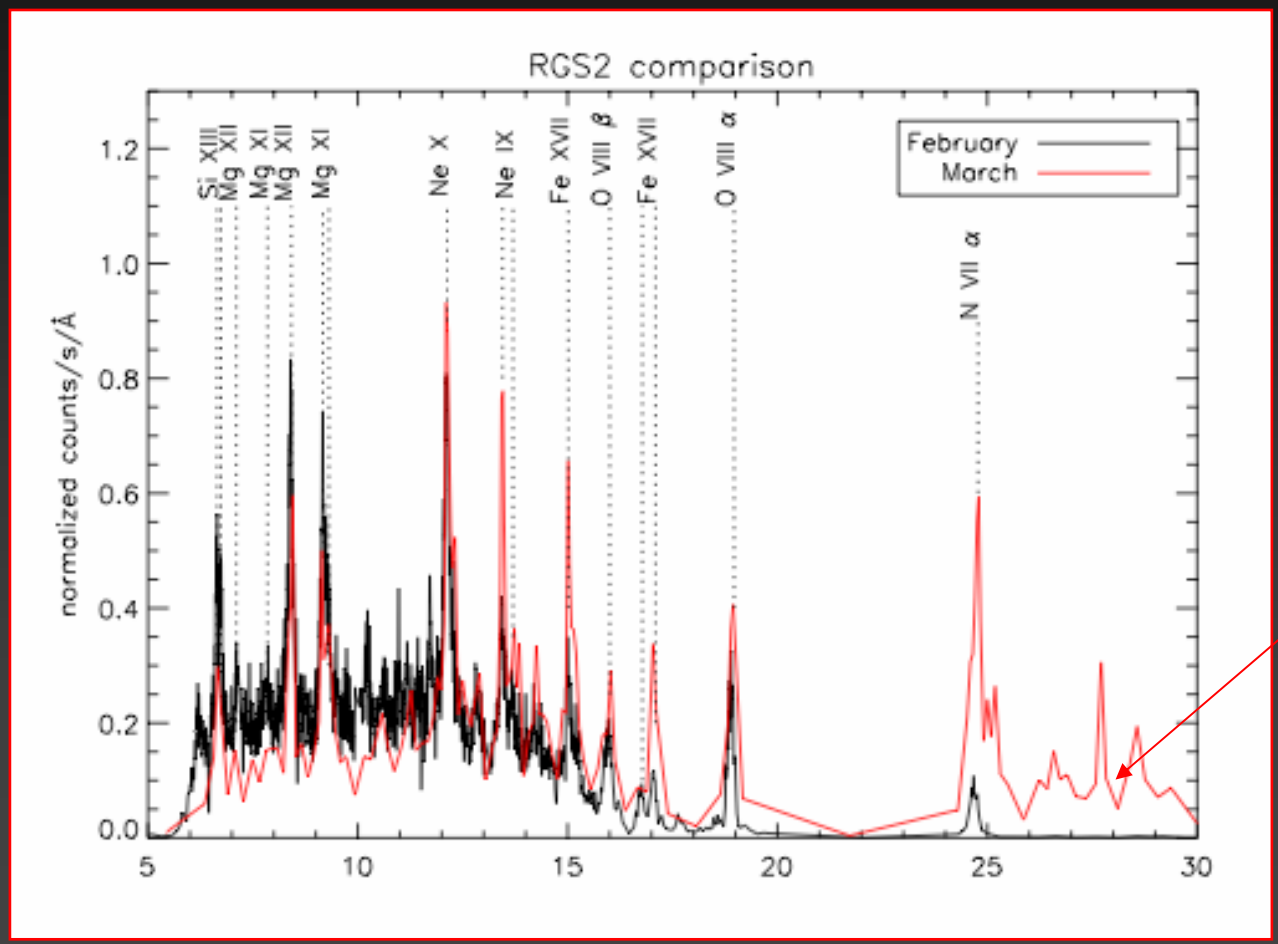


Day 14: Emission From Shocked Gas



Emission dominated by H and He-like ions. Wide range of temperatures indicated by simultaneous presence of Fe XXV and N VII

XMM: day 14 and day 27



Emerging WD continuum?

Velocity Structure

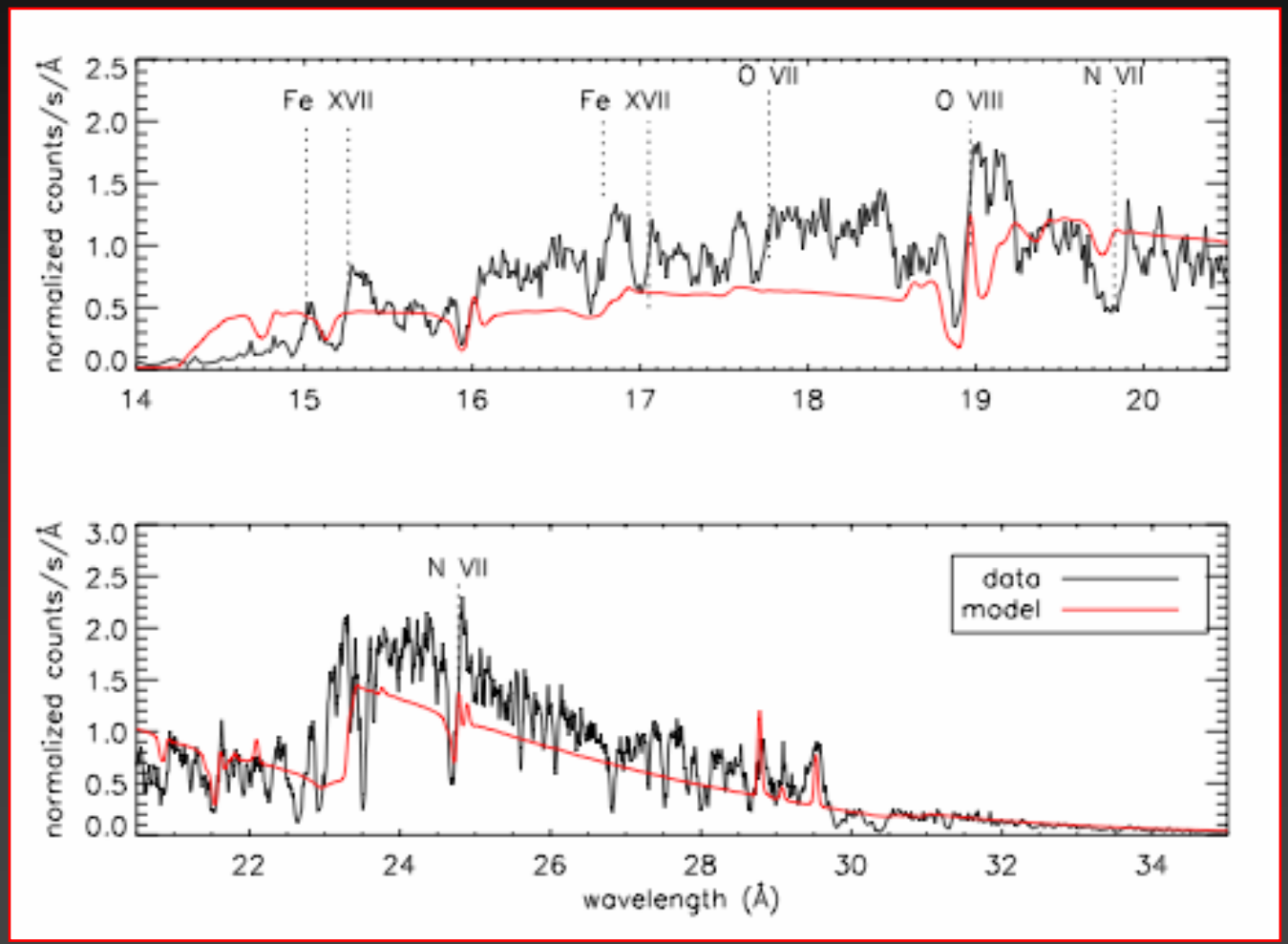
Table 2. Blueshifts of February emission lines

Ion	Grating	log Peak emissivity (K)	Centroid velocity (kms^{-1})	FWHM (kms^{-1})
Fe XXV	HEG	7.7	973 ± 323	3540 ± 323
S XV	MEG	7.2	-595 ± 178	1741 ± 119
Si XIV	MEG	7.2	-496 ± 56	1776 ± 49
Si XIII	MEG	7.0	-632 ± 45	1403 ± 45
Mg XII	MEG	7.0	-926 ± 73	2022 ± 36
Mg XI	MEG	6.8	-1145 ± 74	1918 ± 99
O VIII	RGS2	6.5	-1202 ± 47	2029 ± 48
N VII	RGS2	6.3	-1307 ± 72	2108 ± 73

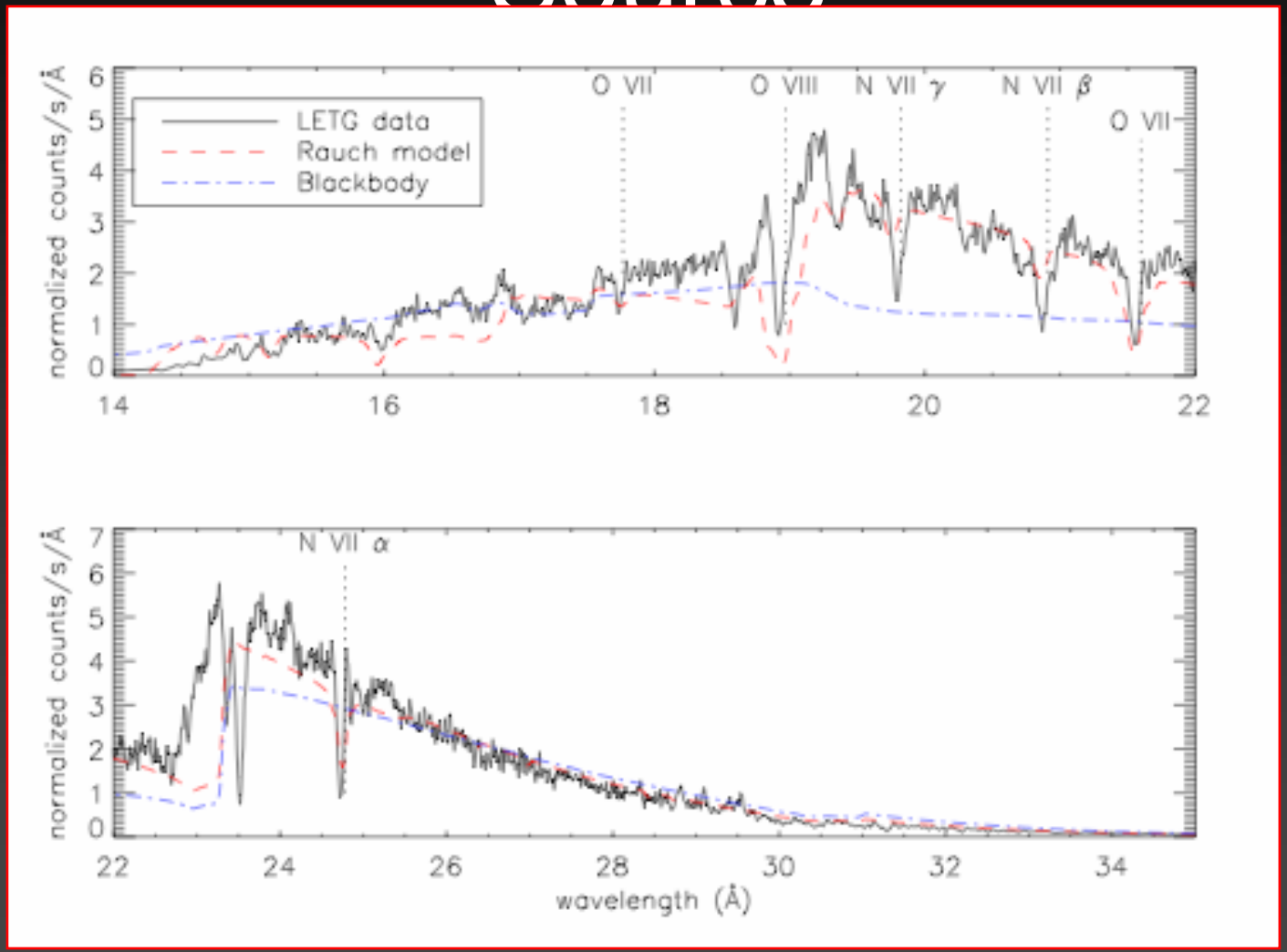
- Larger blueshifts seen for longer wavelengths and lower ionization states
- Similar to structure seen in hot star winds with Chandra

Day 40

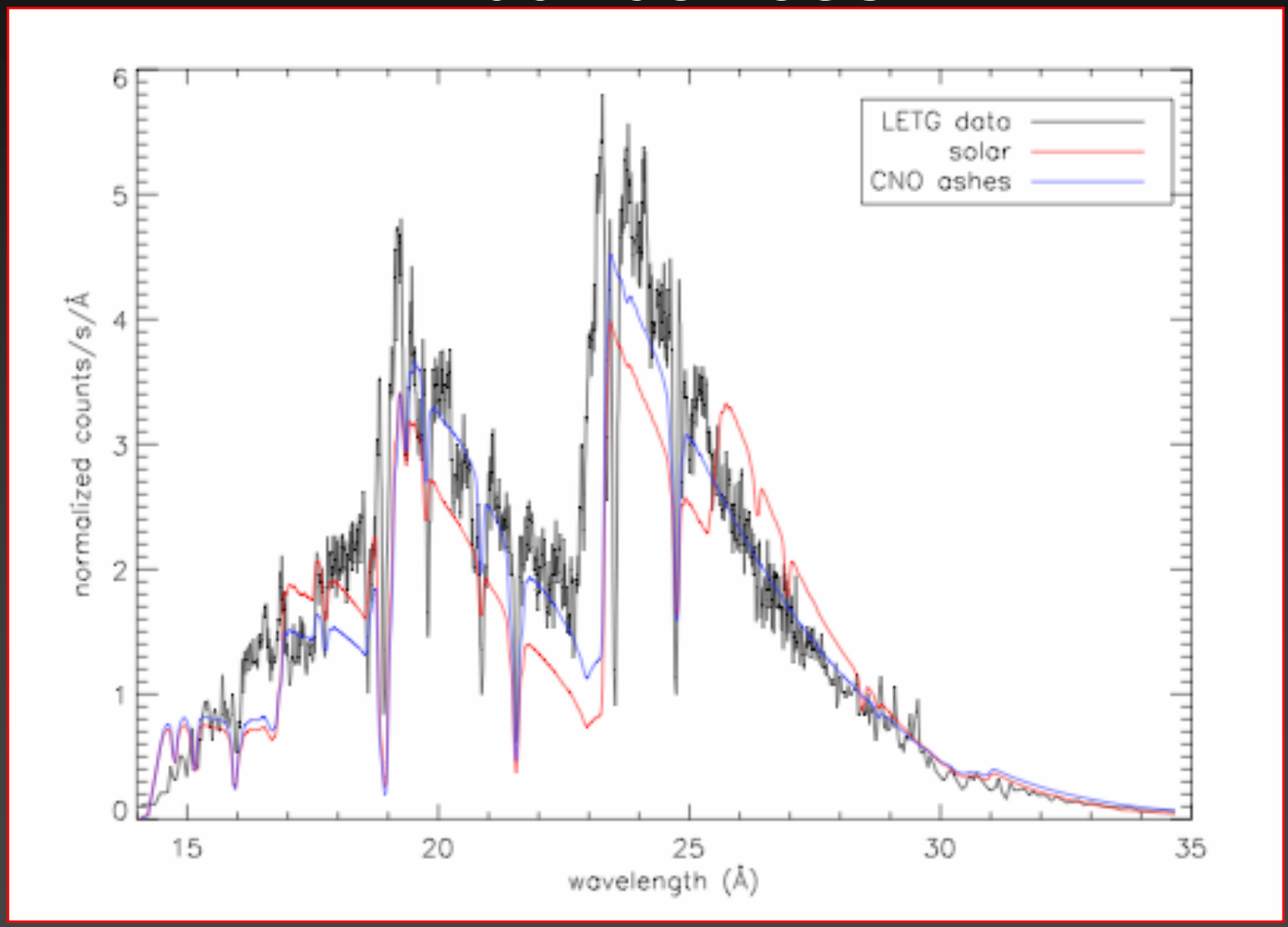
WD continuum dominates the spectrum, although lots of nebular emission still present



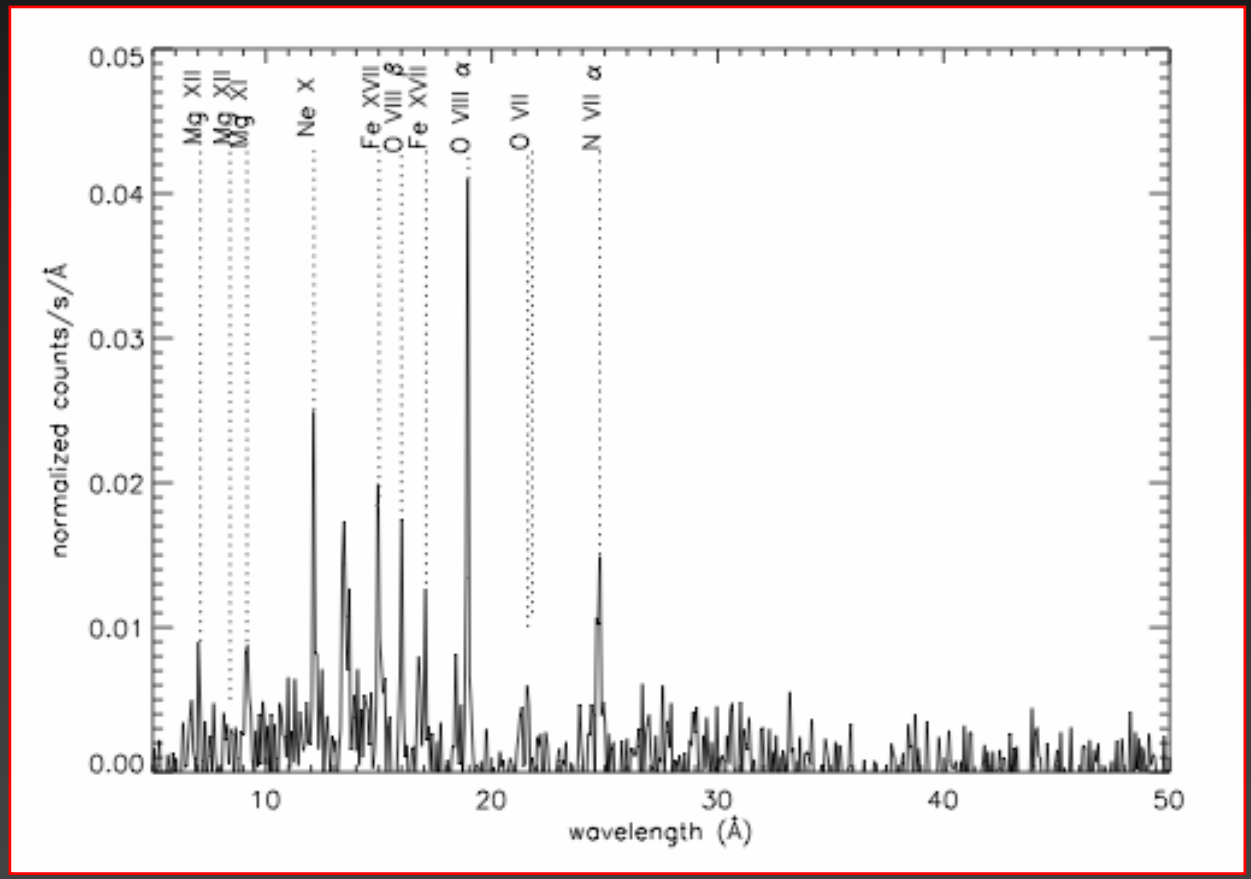
Day 67: A Bright Supersoft Source



Atmospheric Models: Exploring Abundances



Day 111: Emission from the Ejecta?



Flux has decreased by a factor of ~160 since April.

Similar spectrum seen in other novae, including V382 Vel and V4743 Sgr.

What have we learned?

- X-ray emission at all stages complicated by interaction with the nebula
- During supersoft phase, WD has T_{eff} = 810000 ± 5000 K, and log (g) ~ 9
- This is consistent with $M_{WD} \geq 1.2\ M_{sun}$
- X-ray evolution much more rapid than predicted
- Abundances may indicate retention of CNO processed material, although more fine tuning required to be certain (in progress)