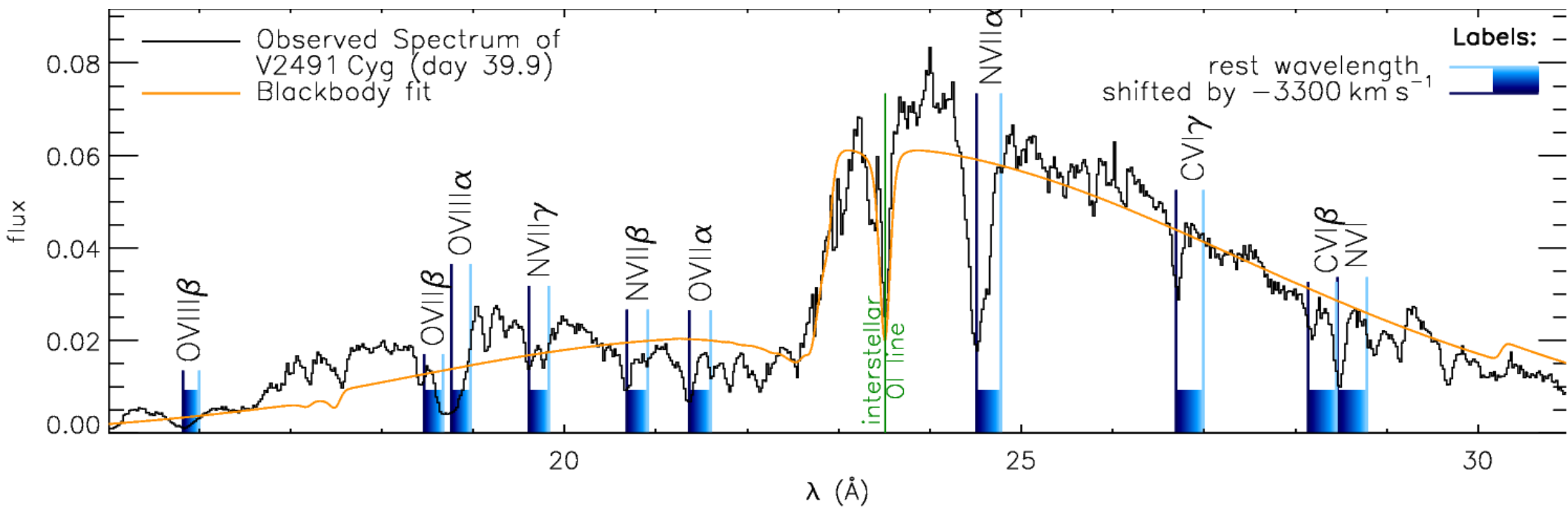
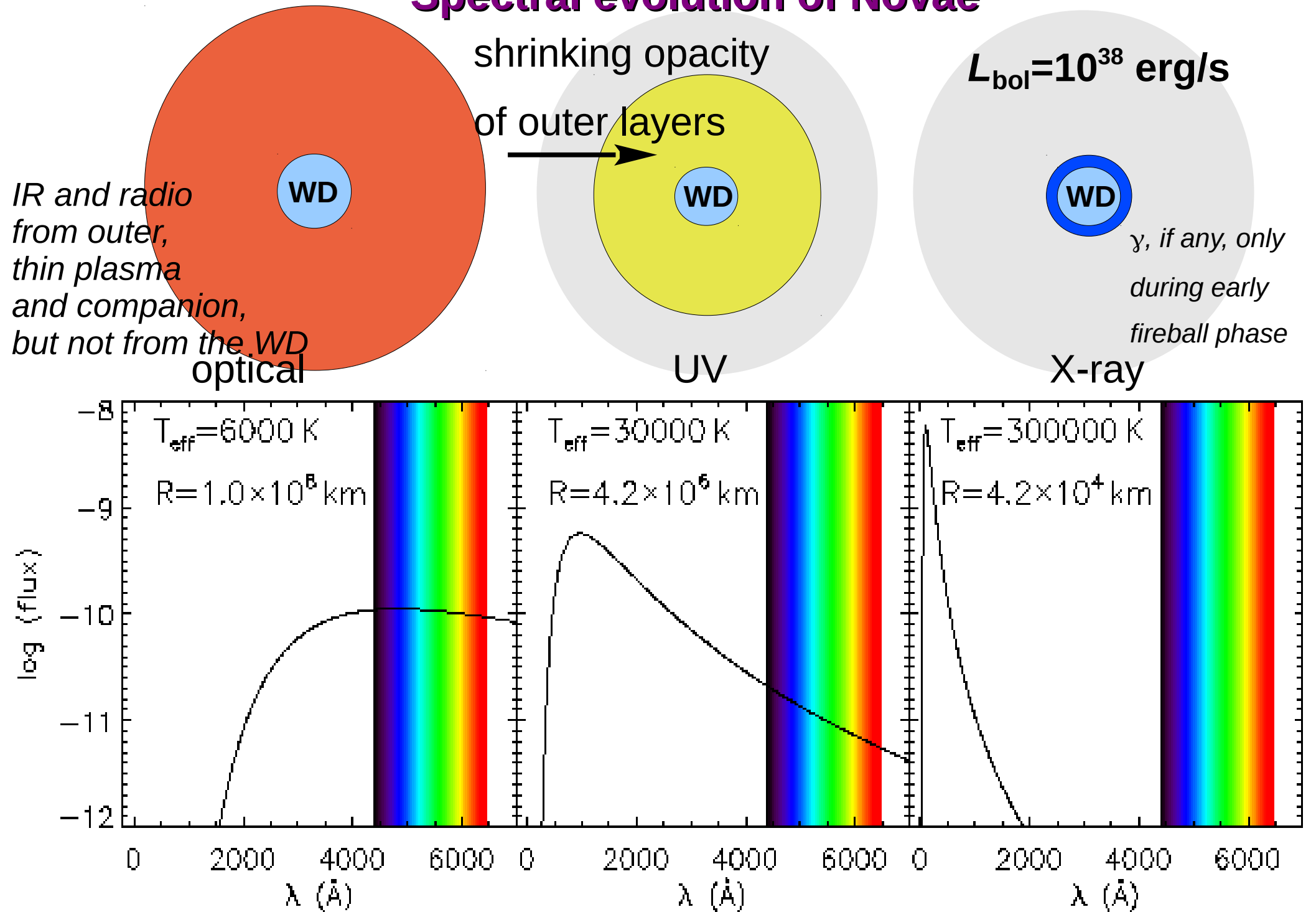
The value of qualitative conclusions for the interpretation of Super Soft Source grating spectra

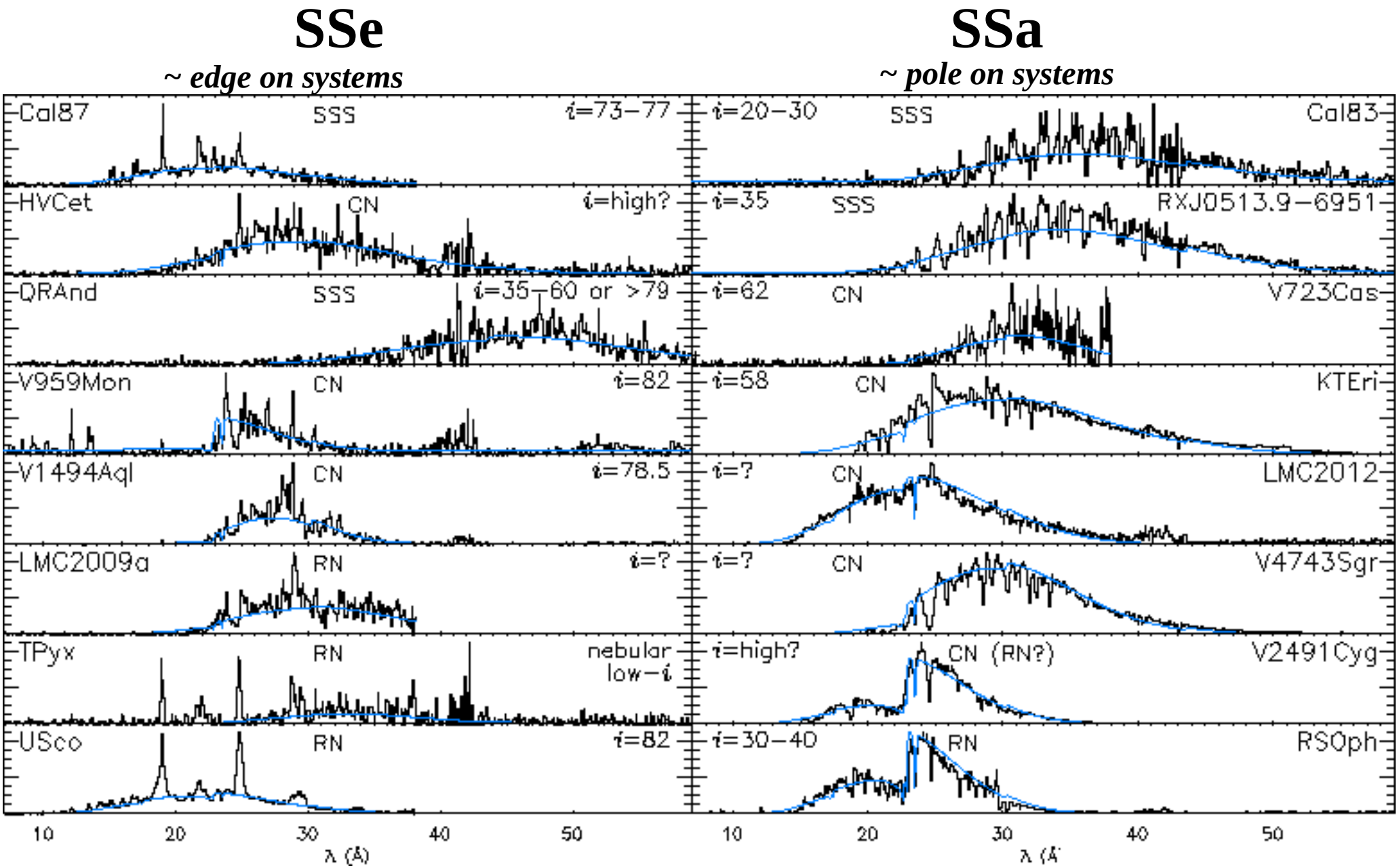
Jan-Uwe Ness
XMM-Newton Science Operations Centre
European Space Astronomy Centre (ESAC)
Madrid, Spain

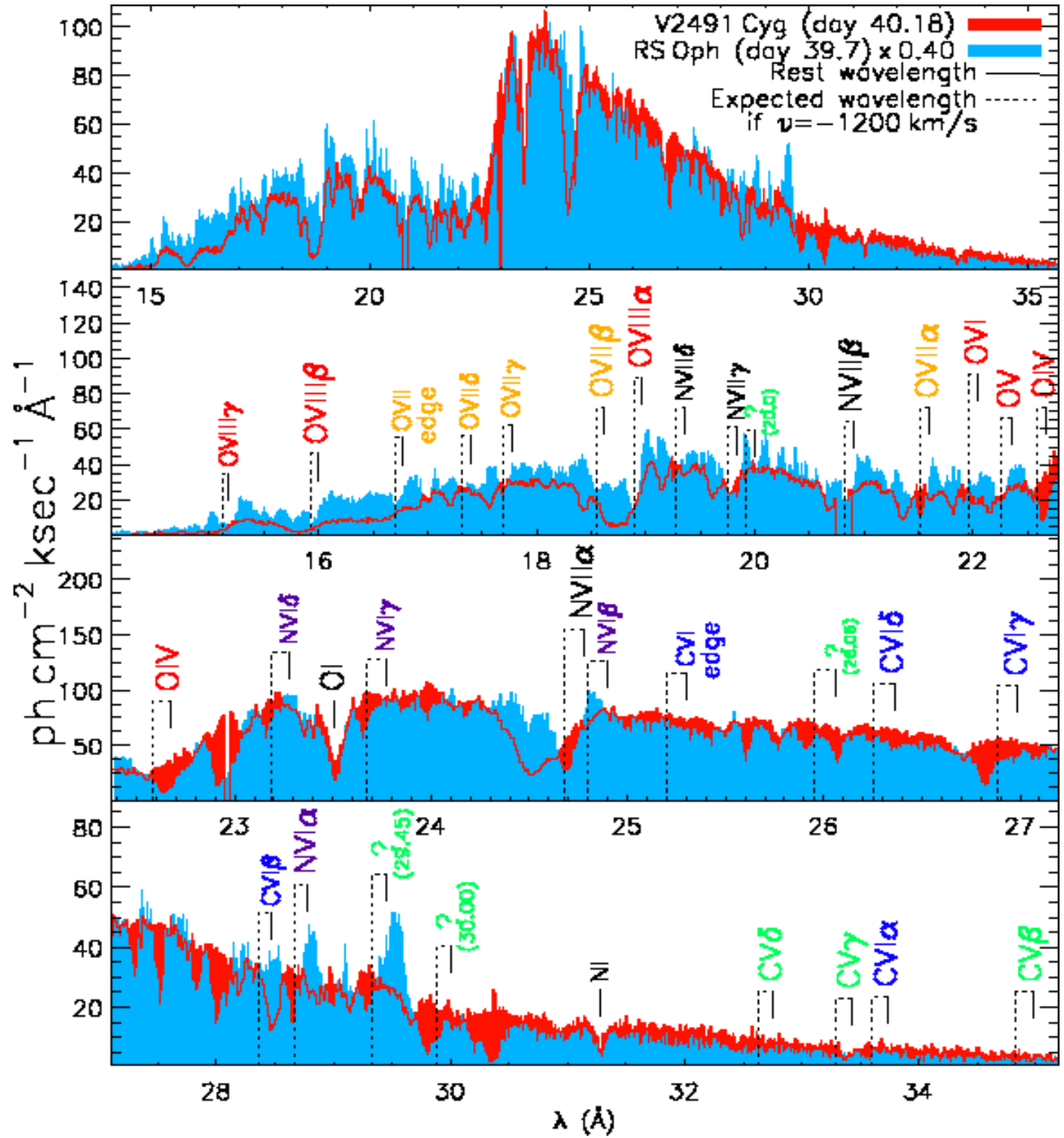


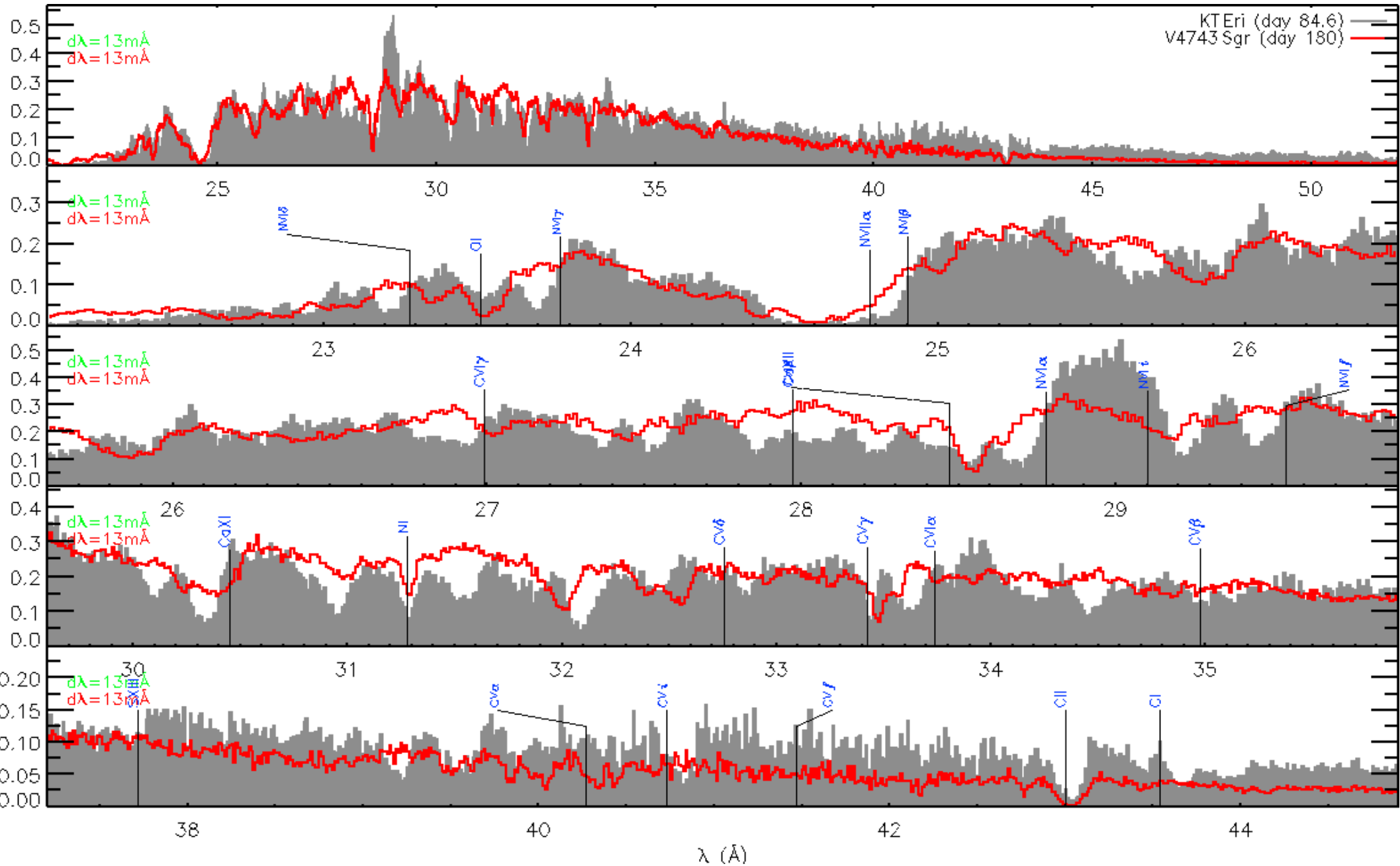
Spectral evolution of Novae

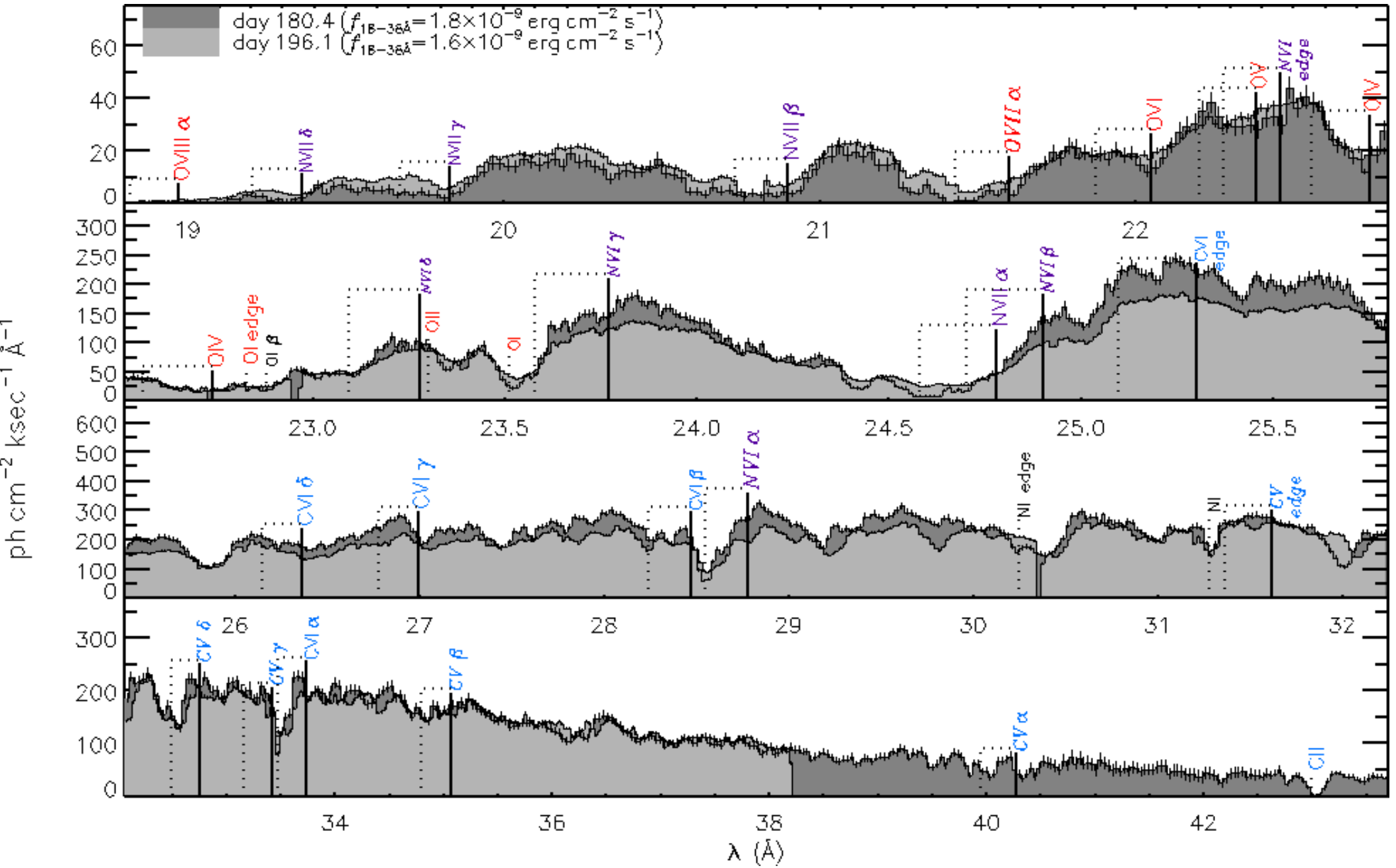


X-ray grating spectra of
- Super Soft Sources (SSS)
- Classical Novae (CN)
- Recurrent Novae (RN)

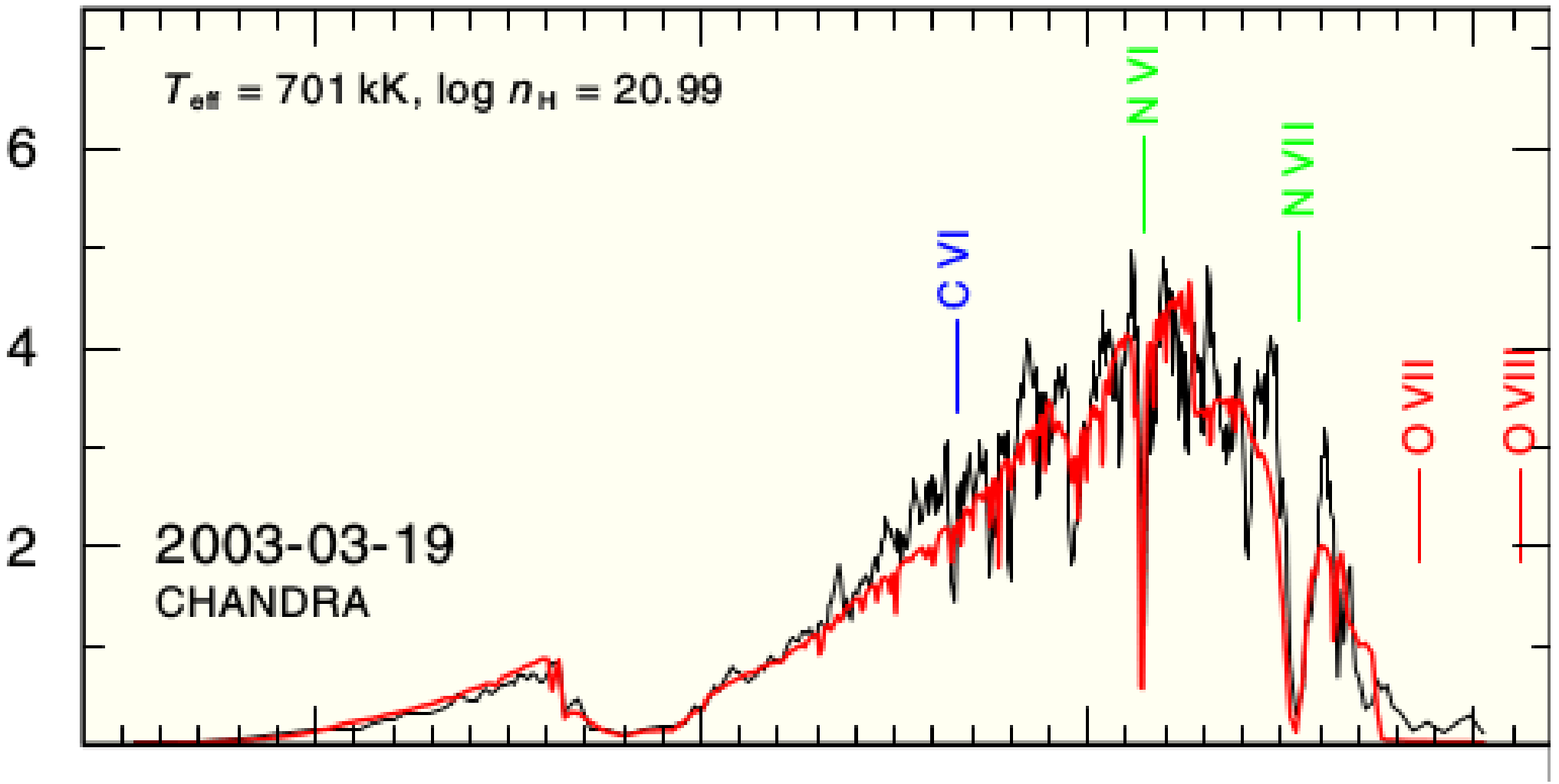



V2491 Cyg (day 40.18)
RS Oph (day 39.7) x 0.40
Rest wavelength
Expected wavelength if v=−1200 km/s
ph cm−2 ksec−1 Å−1
λ (Å)
OVIIIγ
OVIIIβ
OVII edge
OVIIδ
OVIIγ
OVIIβ
OVIIIα
NVIIδ
NVIIγ
?(2d0)
NVIIβ
OVIIα
OVI
OV
OIV
OIV
NVIδ
OI
NVIγ
NVIIα
NVIβ
CVI edge
?(2d0,0)
CVIδ
CVIγ
CVIβ
NVIα
?(2d1,45)
?(3d0,00)
N
CVδ
CVγ
CVIα
CVIβ

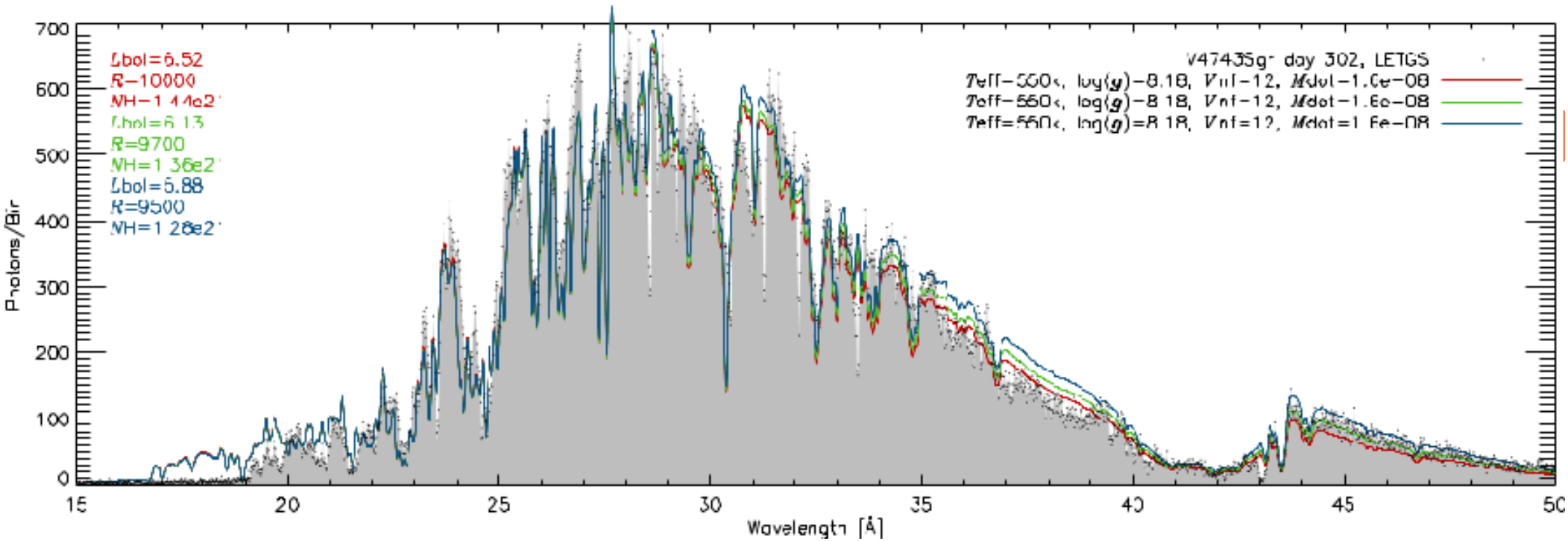

KT Eri (day 84.6)
V4743 Sgr (day 180)
dλ=13mÅ
dλ=13mÅ
NVIIIδ
OI
NVIIγ
NVIIα
NVIIβ
CVIγ
CaXII
NVIα
NVIε
NVIζ
CaXI
NI
CVδ
CVγ
CVIα
CVβ
CVα
CVε
CVζ
CII
CI
λ (Å)

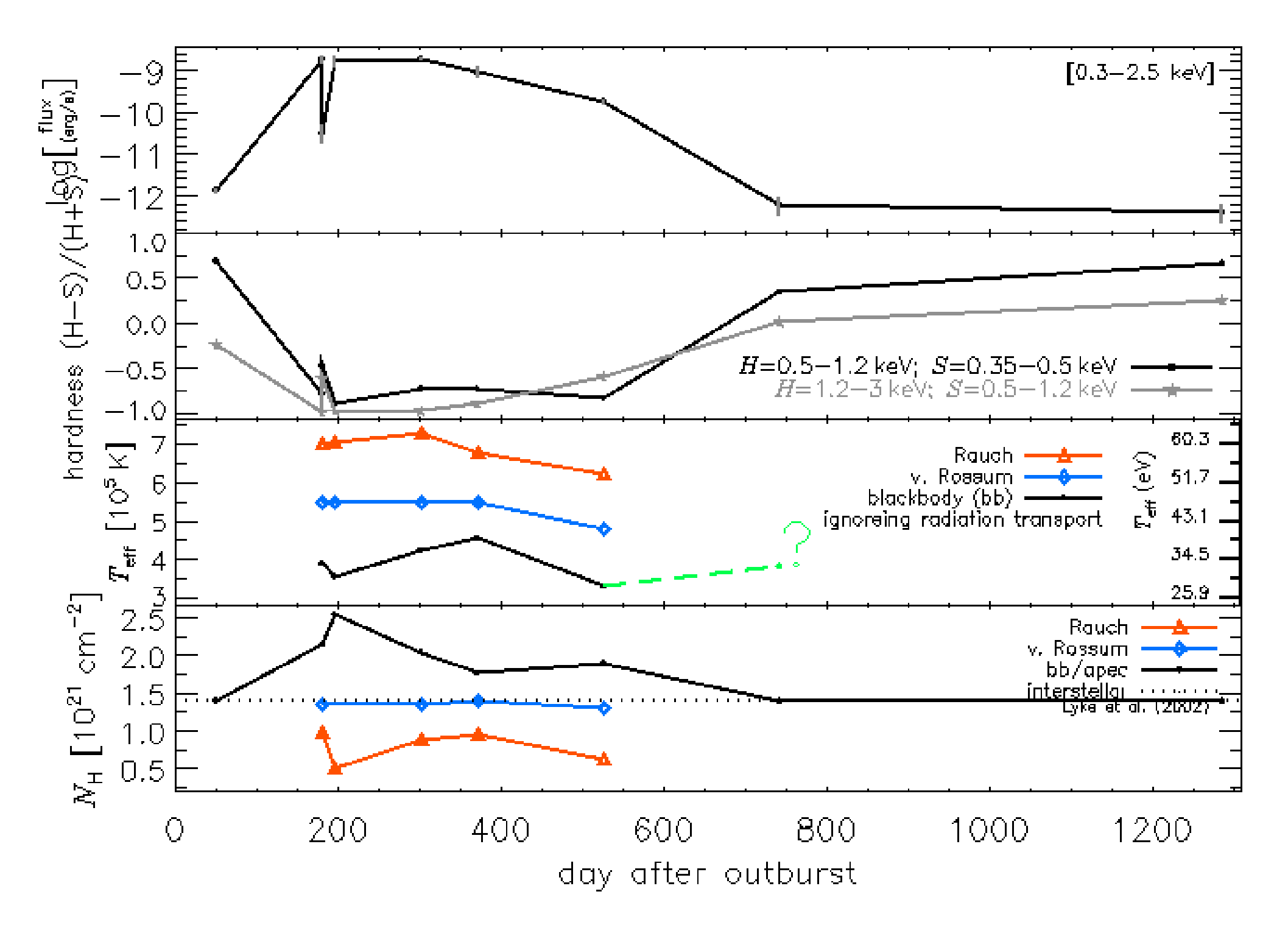

day 180.4 ($f_{1B-36Å}$=1.8×10^{-9} erg cm^{-2} s^{-1})
day 196.1 ($f_{1B-36Å}$=1.6×10^{-9} erg cm^{-2} s^{-1})
OVIII α
NVII δ
NVII γ
NVII β
OVII α
OVI
AO
NVI edge
AO
OV
19
20
21
22
OIV
OI edge
OI β
NVII δ
OII
OI
NVI γ
NVII α
NVI β
OVI edge
23.0
23.5
24.0
24.5
25.0
25.5
CVI δ
CVI γ
CVI β
NVI α
NI edge
NI
CV edge
26
27
28
29
30
31
32
CV δ
CV γ
CVI α
CV β
CV α
CII
34
36
38
40
42
λ (Å)
ph cm^{-2} ksec^{-1} Å^{-1}

SSS spectrum of V4743 Sgr with TMAP Atmosphere model Rauch et al. (2010)



Series of SSS spectrum of V4743 Sgr with Wind-type Atmosphere model van Rossum (2012)




[0.3–2.5 keV]
log[flux (erg/s)]
hardness (H–S)/(H+S)
H=0.5–1.2 keV; S=0.35–0.5 keV
H=1.2–3 keV; S=0.5–1.2 keV
T_eff [10^5 K]
Rauch
v. Rossum
blackbody (bb)
ignoreing radiation transport
E_eff (eV)
60.3
51.7
43.1
34.5
25.9
N_H [10^21 cm^-2]
Rauch
v. Rossum
bb/apec
interstellar
Lyka et al. (2002)
day after outburst

Summary I/II:

SSS spectra are powered by nuclear burning on surface of White Dwarf

Bright and soft => Perfect targets for XMM-Newton/Chandra gratings!

Blackbody shape but EXTREMELY complex in the details:

- Blue-shifted absorption lines → Expanding material
  (produced in photosphere or further out?)
- Complex profiles that vary with time
- Also systems with strong emission lines on top of bb continuum
- Some spectra from different systems very similar
  (e.g., sub-classes of SSe and SSa)

Summary II/II:

Atmosphere models provide the right fundamental physics to draw **quantitative** conclusions (mass, temperature, composition, luminosity).

But:
Hydrostatic models probably too limited in assumptions (line blue shifts)

Expanding codes more promising, but also have limitations
e.g., observed complexity of profiles not modeled
Both: Unidentified lines

Ludwig Wittgenstein (1889-1951):
"The limits of my language means the limits of my world."

=> We need to LOOK at the spectra
and also learn from **qualitative** conclusions:

- Line of sight has complex density profile
- Changes of profiles with time indicate non-static absorbing material
- Subclasses of SSe and SSa

Example of qualitative conclusion:

The variations in hardness are caused by variations in the column density of OI (23.5A), longwards of which, there is systematically more emission during soft phase (orange)