The X-ray spectra of the SSS phase of V2491 Cyg

Jan-Uwe Ness

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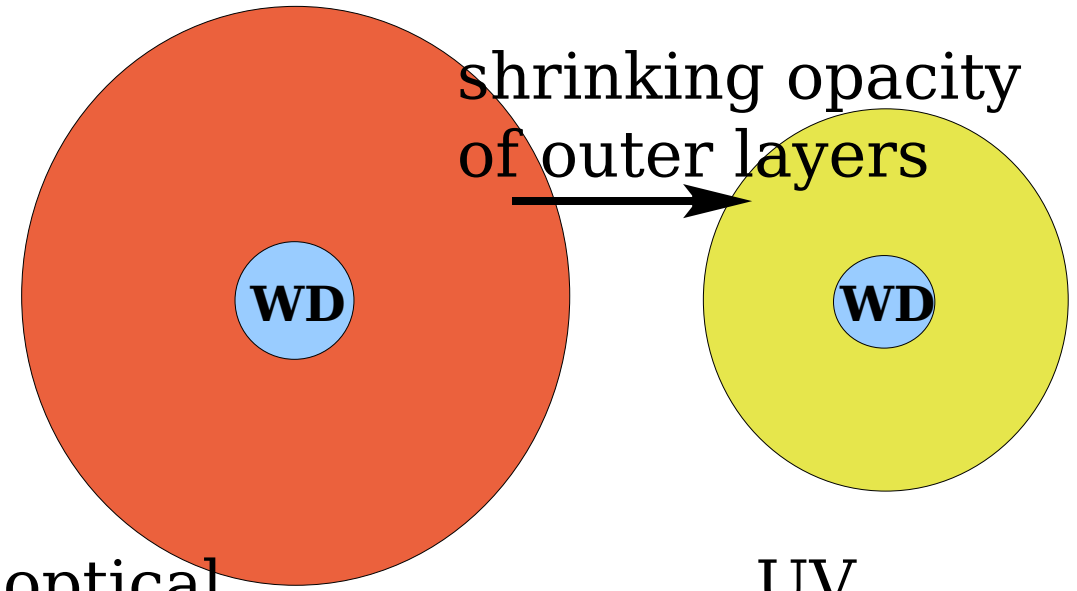
What can we learn from all the data we have?

We can already see a lot in the SSS spectra
=> ask the right questions to the theorists.

Jan-Uwe Ness

Constant Bolometric Luminosity phase



$L_{bol}=10^{38}$ erg/s

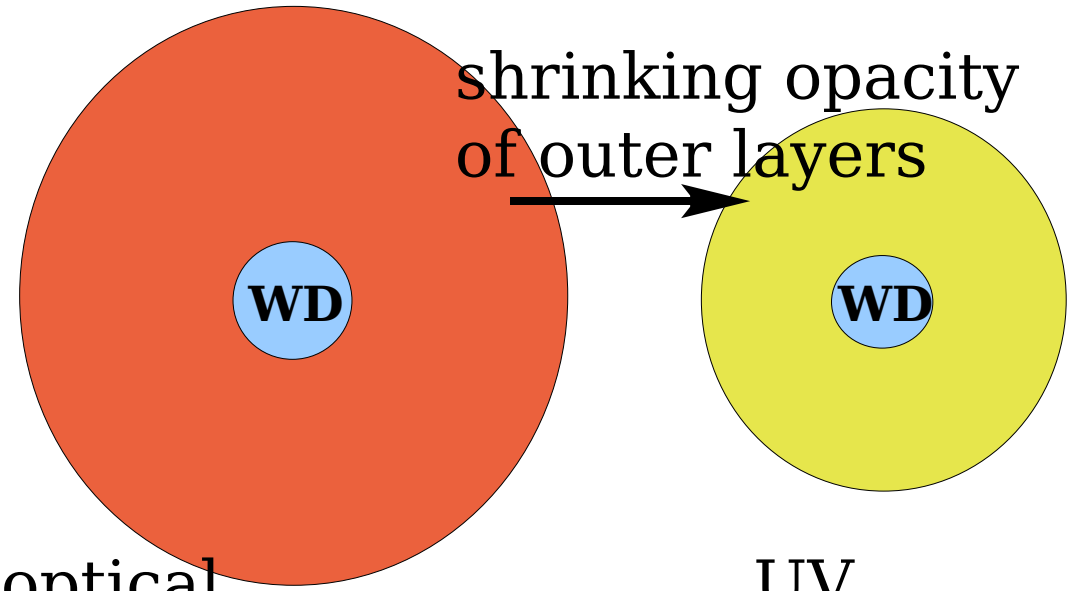
SSS phase

optical

UV

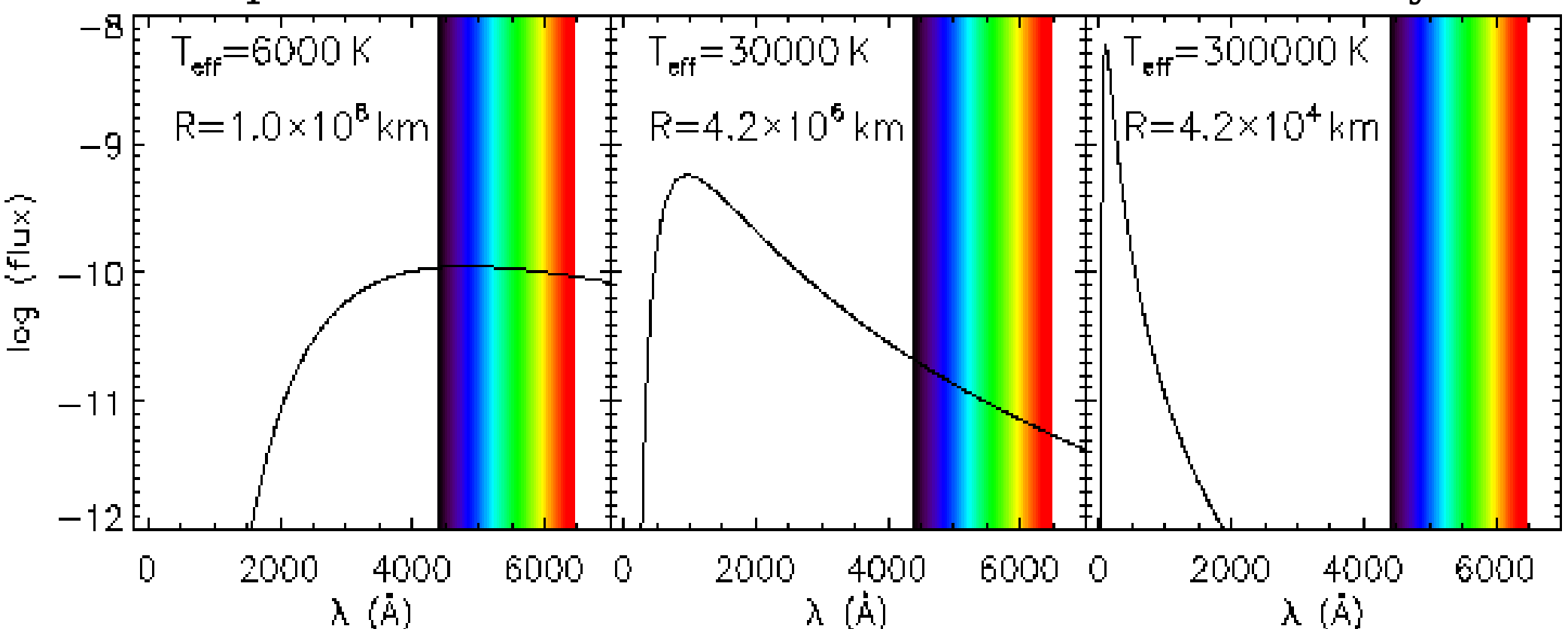
X-ray

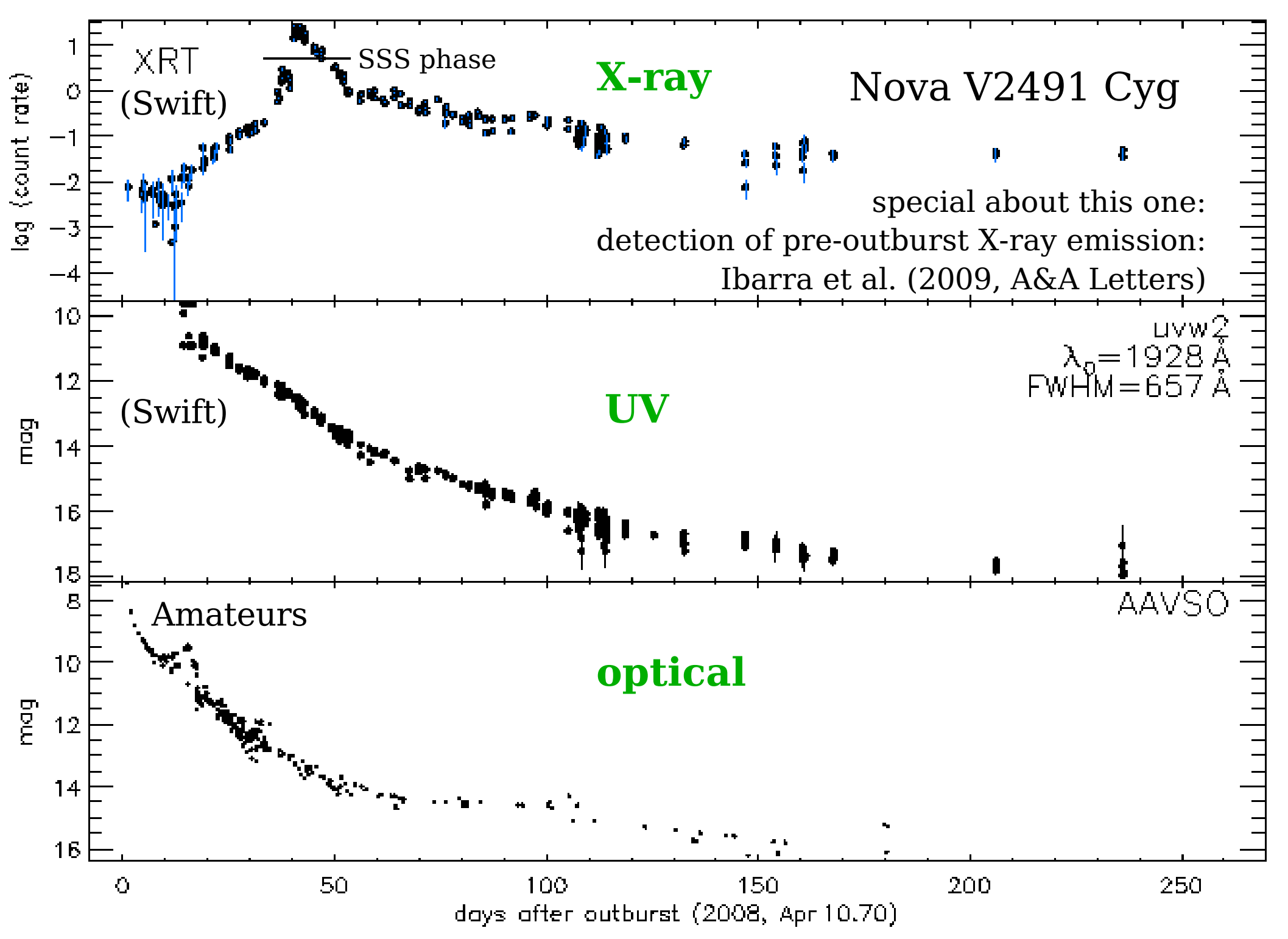
Constant Bolometric Luminosity phase

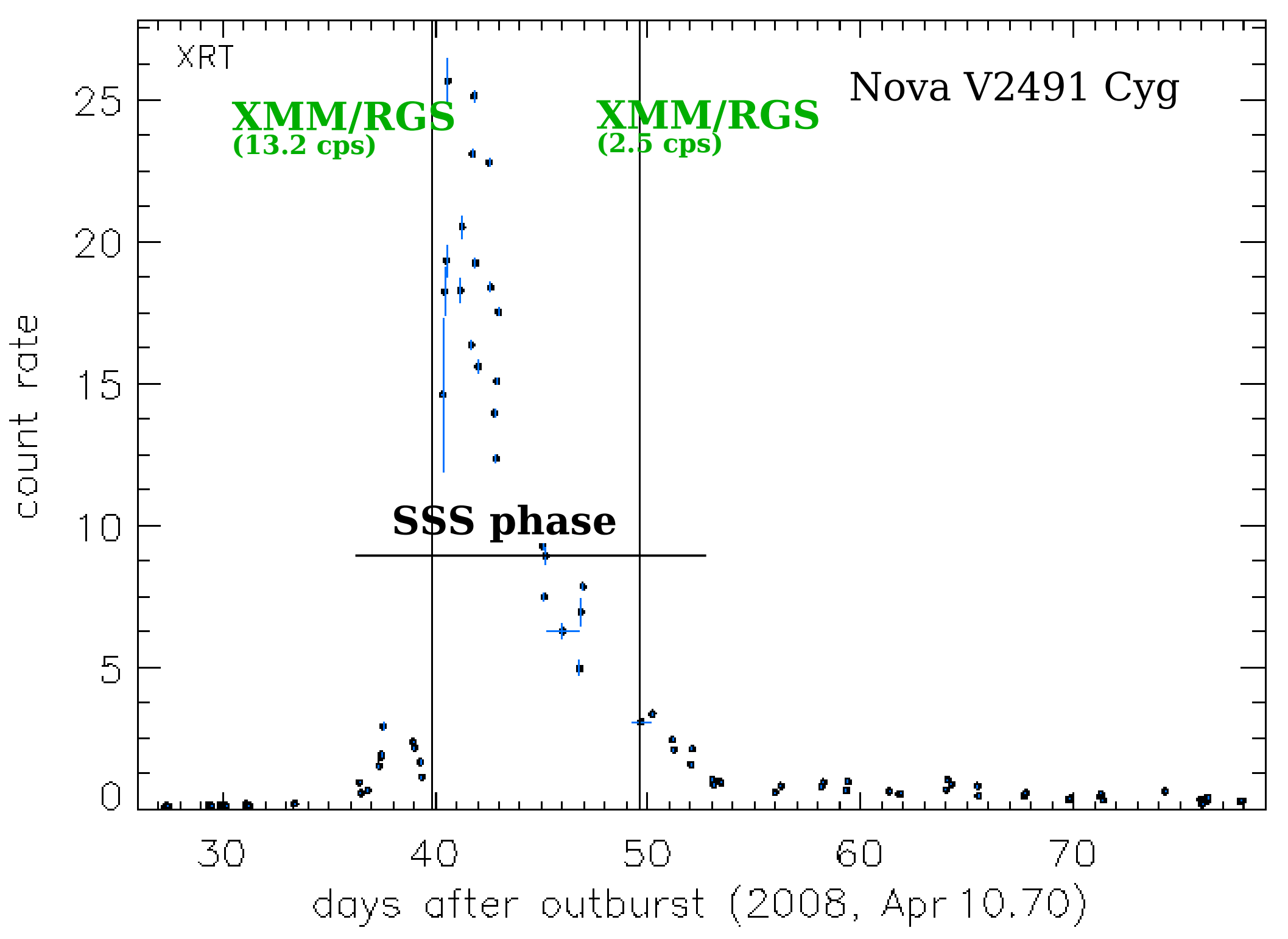


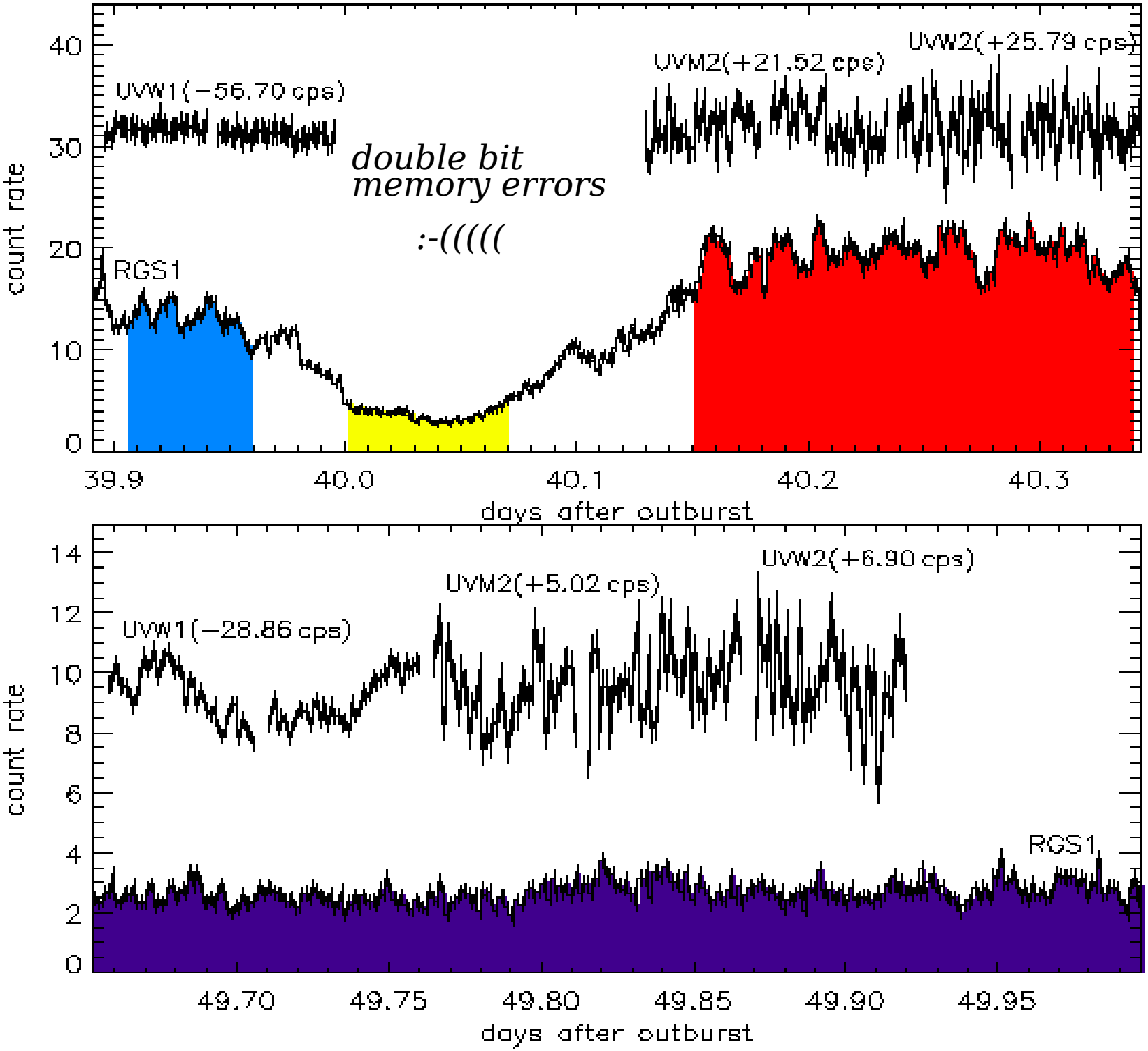
$L_{bol}=10^{38}$ erg/s

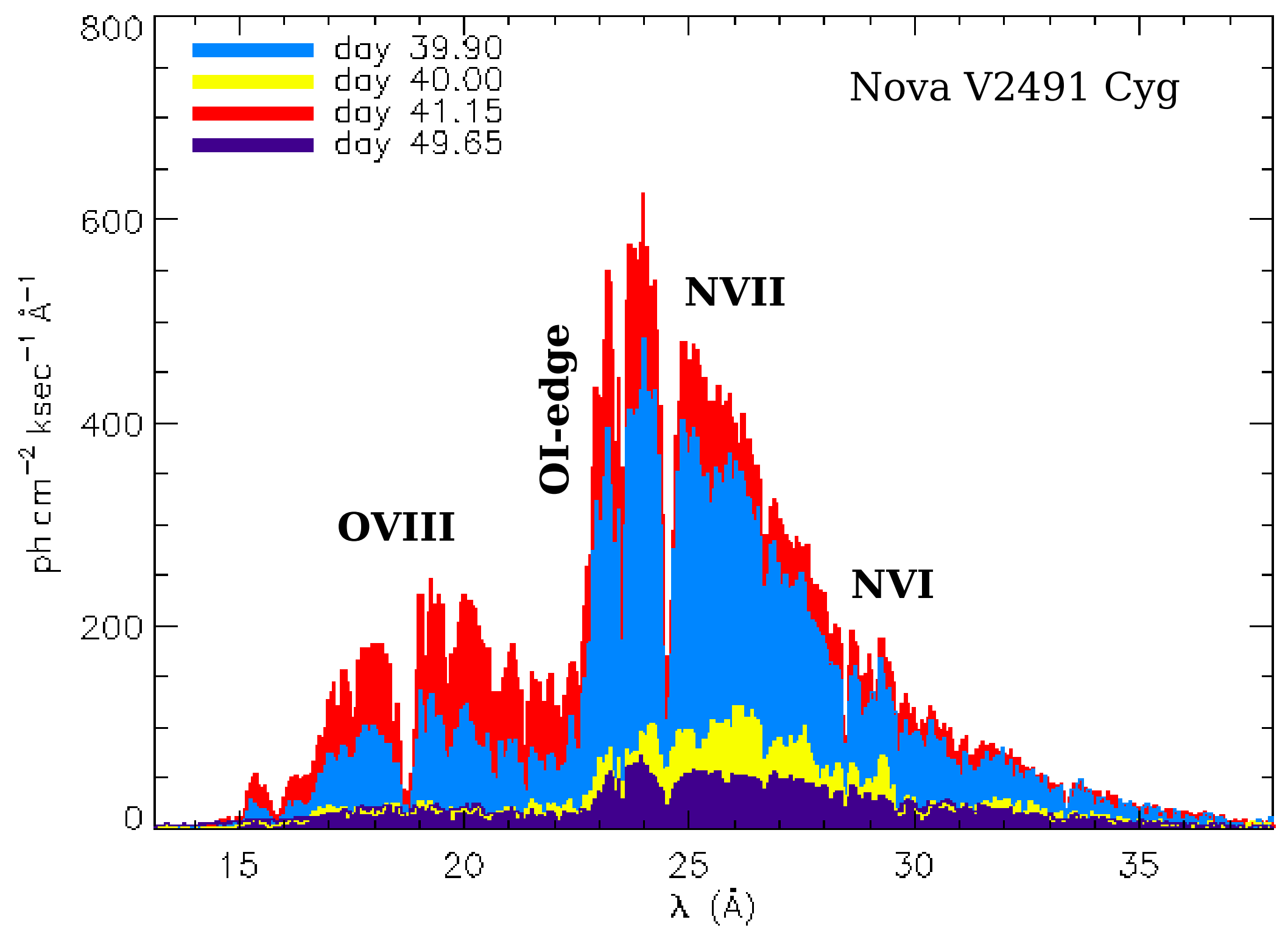
SSS phase

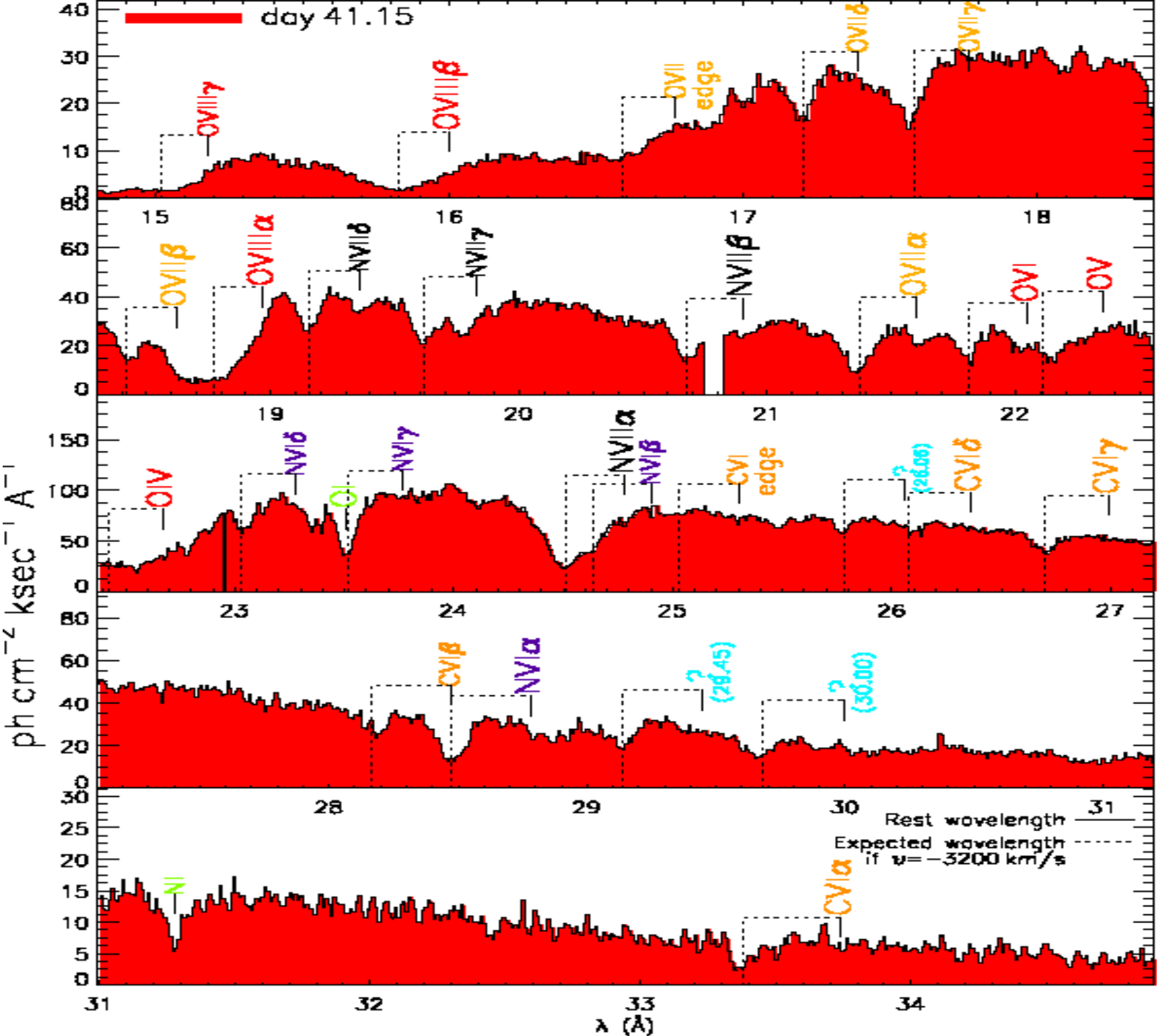


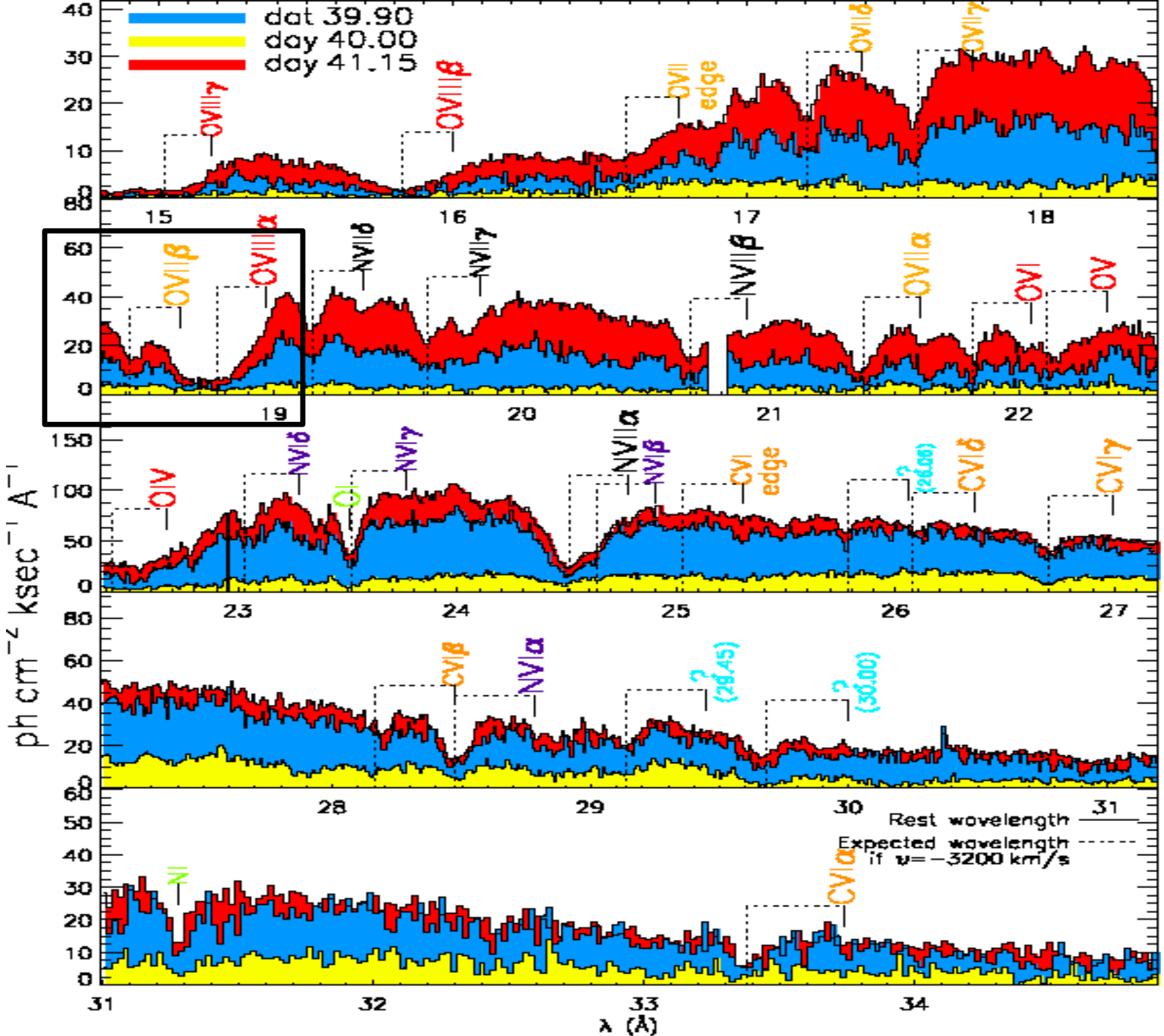

XRT
(Swift)
SSS phase
X-ray
Nova V2491 Cyg
special about this one:
detection of pre-outburst X-ray emission:
Ibarra et al. (2009, A&A Letters)
log (count rate)
(Swift)
UV
uvw2
λ0=1928 Å
FWHM=657 Å
mag
Amateurs
optical
AAVSO
mag
days after outburst (2008, Apr 10.70)

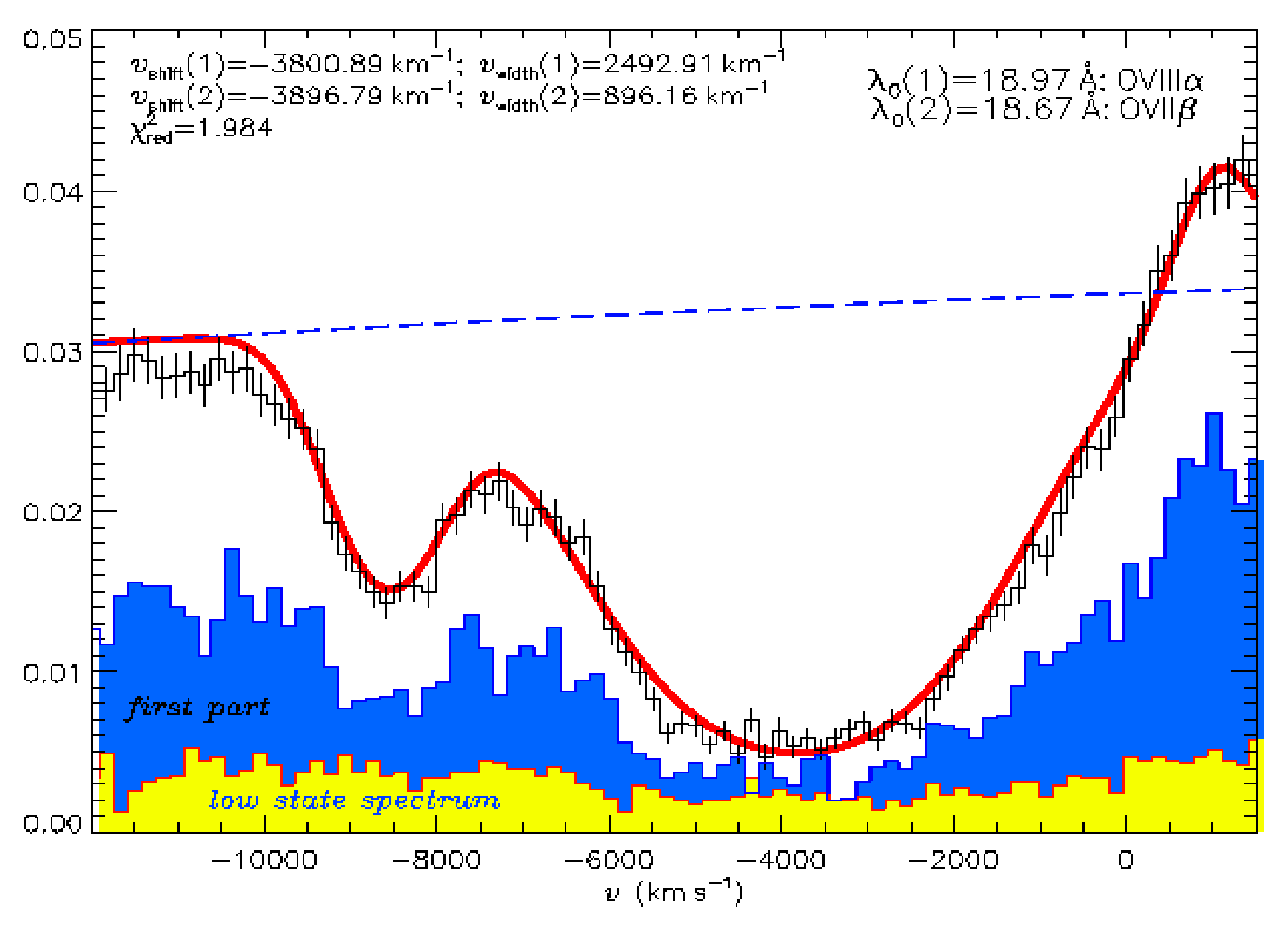

XRT
Nova V2491 Cyg
XMM/RGS
(13.2 cps)
XMM/RGS
(2.5 cps)
SSS phase
count rate
0
5
10
15
20
25
30
40
50
60
70
days after outburst (2008, Apr 10.70)

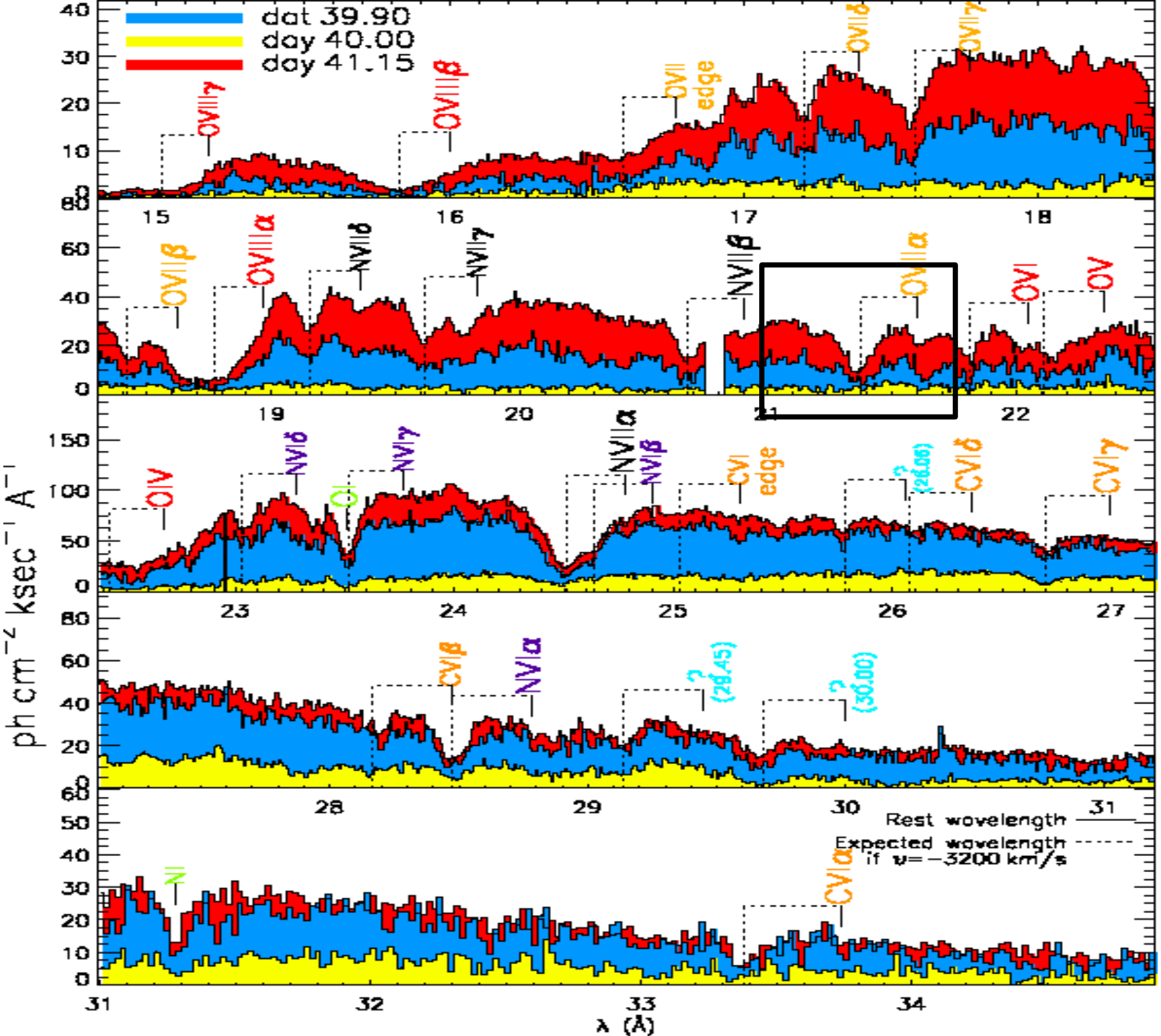

UVW1(−56.70 cps)
UVM2(+21.52 cps)
UVW2(+25.79 cps)
double bit
memory errors
:-(((((
RGS1
count rate
days after outburst
UVW1(−28.86 cps)
UVM2(+5.02 cps)
UVW2(+6.90 cps)
RGS1
count rate
days after outburst

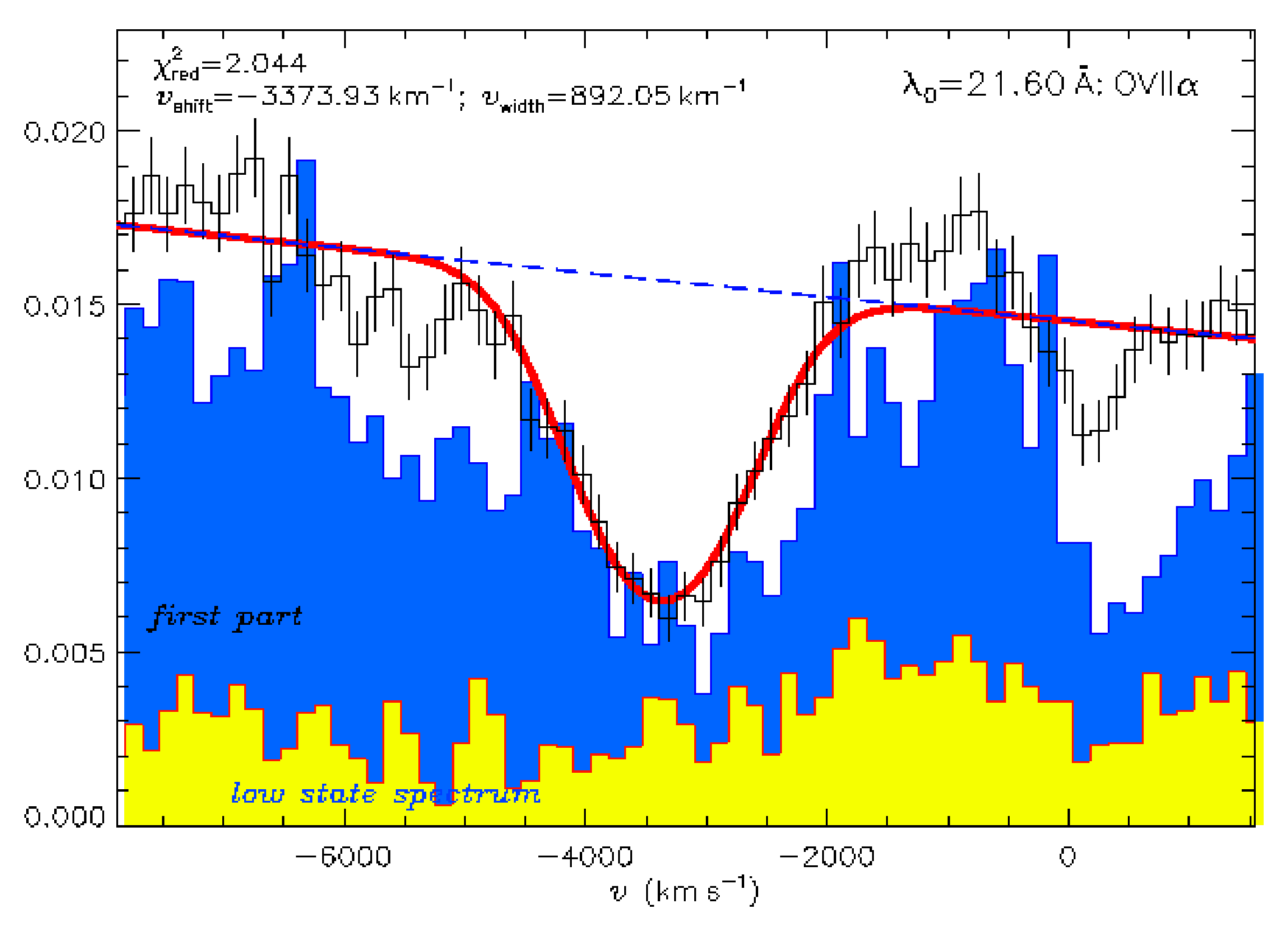

day 39.90
day 40.00
day 41.15
day 49.65
Nova V2491 Cyg
NVII
OI-edge
OVIII
NVI
800
600
400
200
0
15
20
25
30
35
λ (Å)
ph cm^{-2} ksec^{-1} Å^{-1}

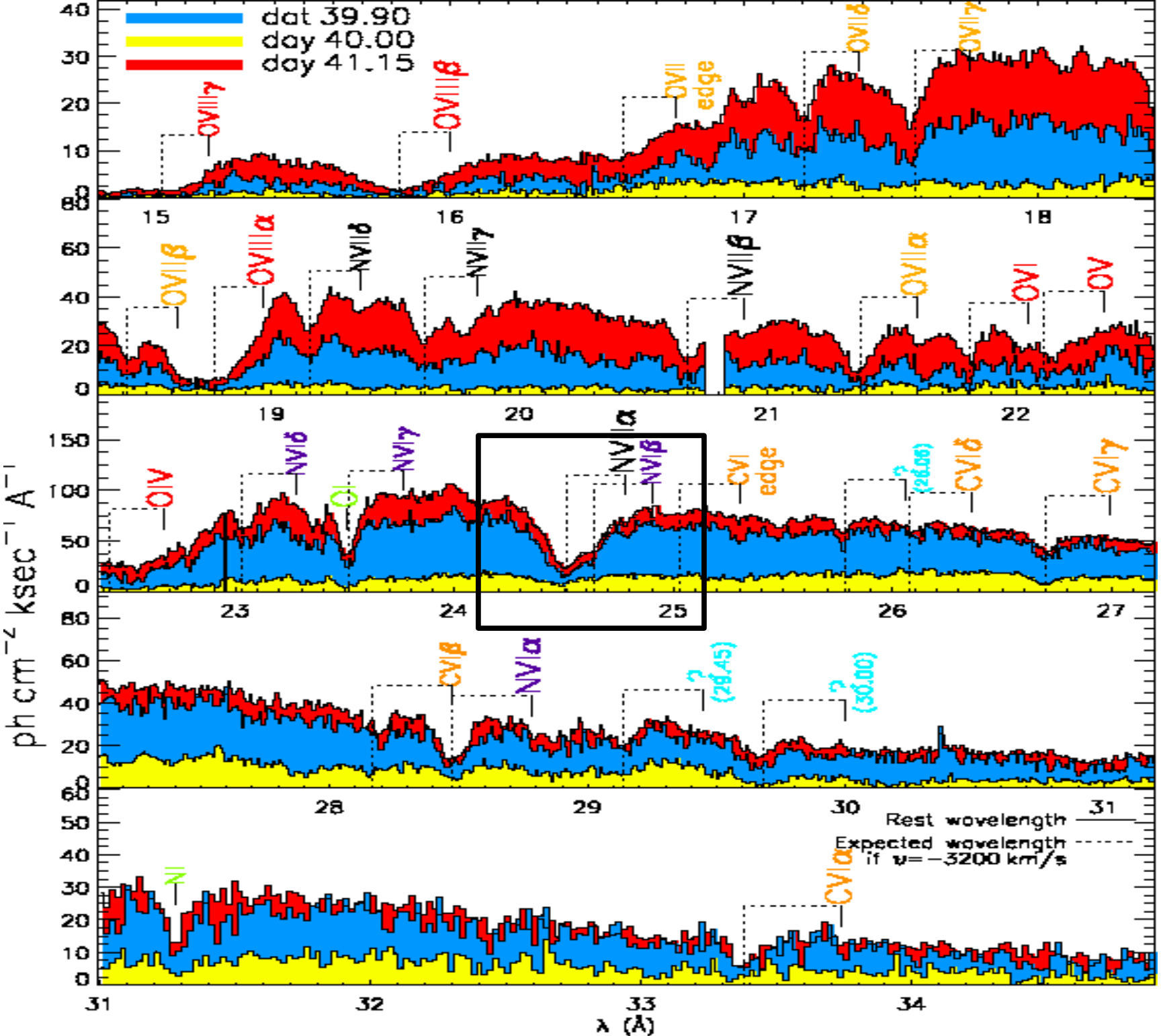

day 41.15
OVIIIγ
OVIIIβ
OVII edge
OVIIδ
OVIIγ
OVIIβ
OVIIIα
NVIIδ
NVIIγ
NVIIβ
OVIIα
OVI
OV
OIV
NVIδ
OI
NVIγ
NVIIα
NVIβ
CVI edge
?(26.06)
CVIδ
CVIγ
CVIβ
NVIα
?(29.45)
?(30.00)
NI
CVIα
Rest wavelength
Expected wavelength if v=−3200 km/s
ph cm⁻² ksec⁻¹ A⁻¹
λ (Å)

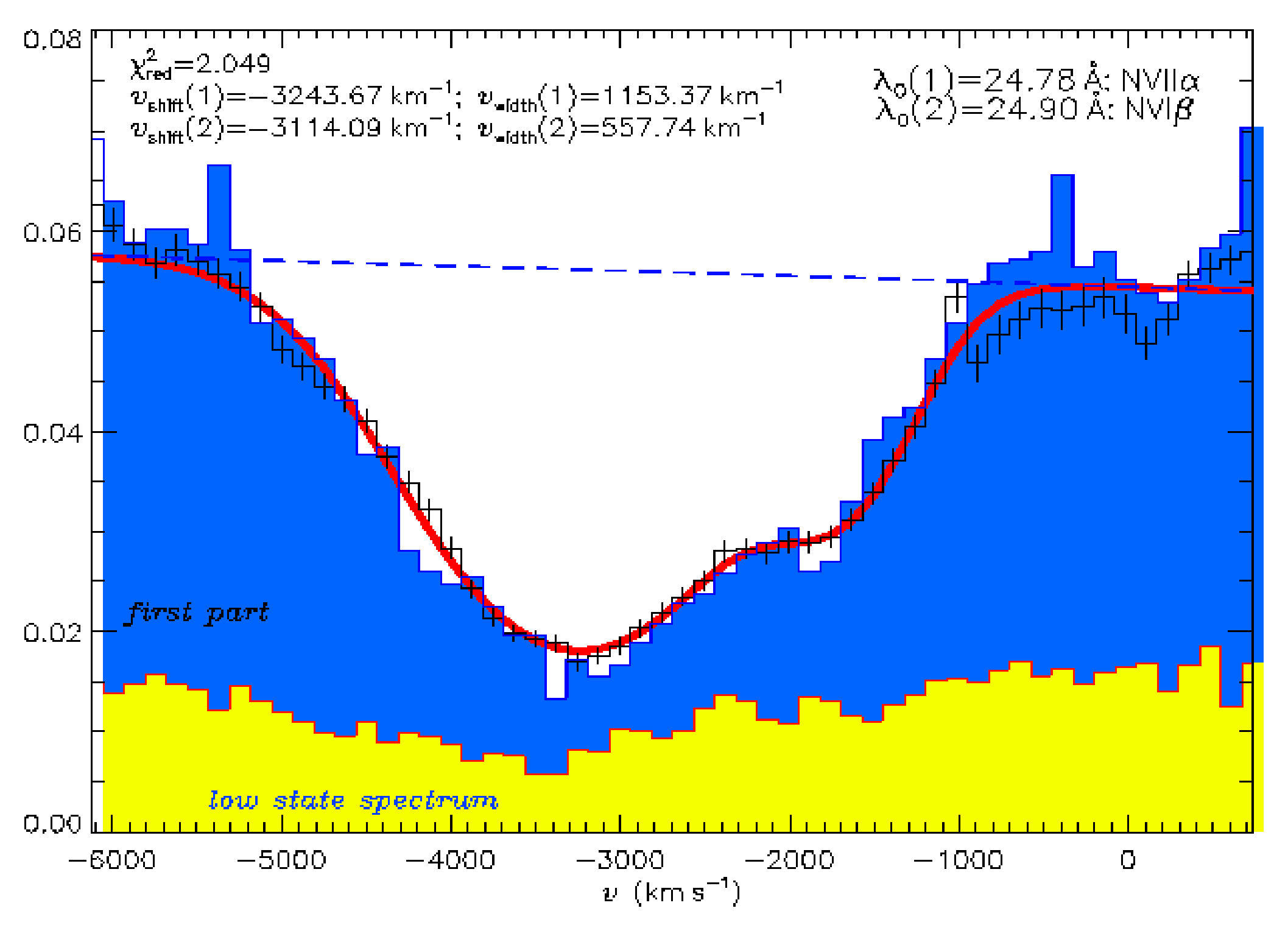

dat 39.90
day 40.00
day 41.15
OVIIIγ
OVIIIβ
OVII edge
OVIIδ
OVIIγ
OVIIβ
OVIIIα
NVIIδ
NVIIγ
NVIIβ
OVIIα
OVI
OV
OIV
NVIδ
OI
NVIγ
NVIIα
NVIβ
CVI edge
? (26.06)
CVIδ
CVIγ
CVIβ
NVIα
? (29.45)
? (30.00)
NI
CVIα
Rest wavelength
Expected wavelength if v=−3200 km/s
ph cm⁻² ksec⁻¹ A⁻¹
λ (Å)

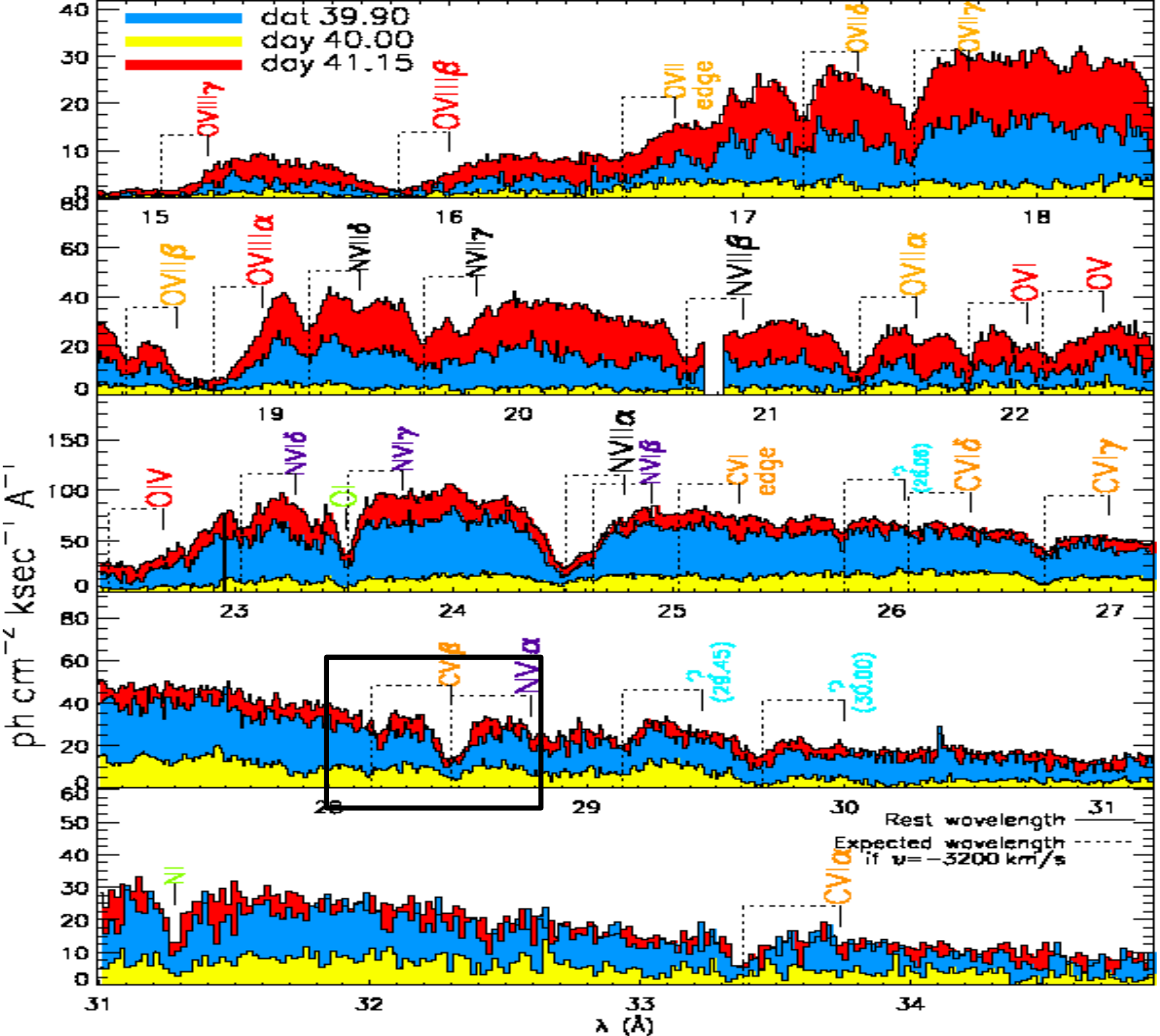

$v_{shift}(1)=-3800.89\ km^{-1}$; $v_{width}(1)=2492.91\ km^{-1}$
$v_{shift}(2)=-3896.79\ km^{-1}$; $v_{width}(2)=896.16\ km^{-1}$
$\chi^2_{red}=1.984$
$\lambda_0(1)=18.97$ Å: OVIIIα
$\lambda_0(2)=18.67$ Å: OVIIβ
first part
low state spectrum
0.05
0.04
0.03
0.02
0.01
0.00
−10000
−8000
−6000
−4000
−2000
0
v (km s^{-1})

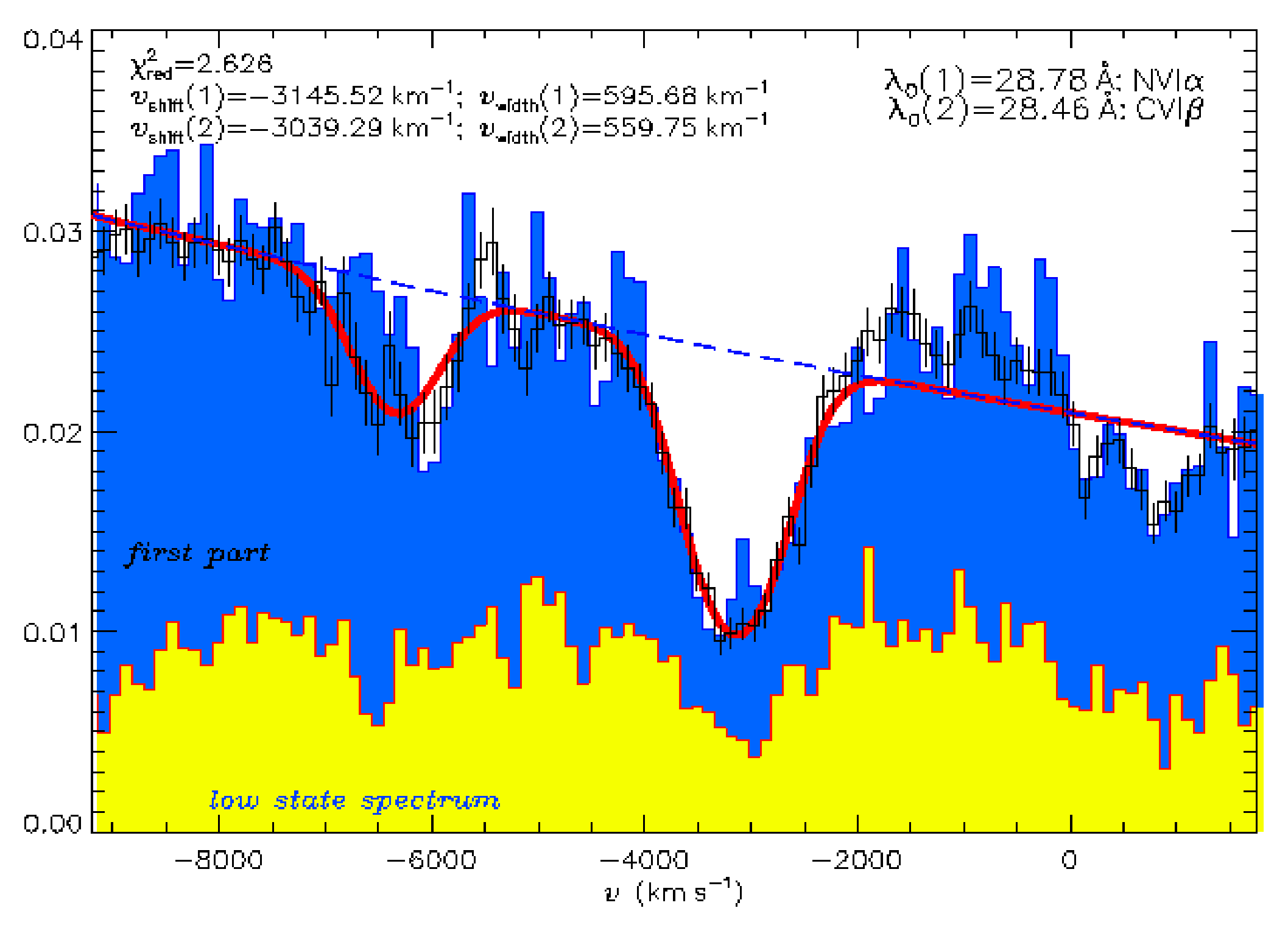

day 39.90
day 40.00
day 41.15
OVIIIγ
OVIIIβ
OVII edge
OVIIδ
OVIIγ
OVIIβ
OVIIIα
NVIδ
NVIγ
NVIIβ
OVIIα
OVI
OV
OIV
NVIδ
OI
NVIγ
NVIα
NVIβ
CVI edge
? (26.06)
CVIδ
CVIγ
CVIβ
NVIα
? (29.45)
? (30.00)
NI
CVIα
Rest wavelength
Expected wavelength if v=−3200 km/s
ph cm⁻² ksec⁻¹ A⁻¹
λ (Å)


χ^2_{red}=2.044
v_{shift}=−3373.93 km^{-1}; v_{width}=892.05 km^{-1}
λ_0=21.60 Å: OVIIα
0.020
0.015
0.010
0.005
0.000
first part
low state spectrum
−6000
−4000
−2000
0
v (km s^{-1})

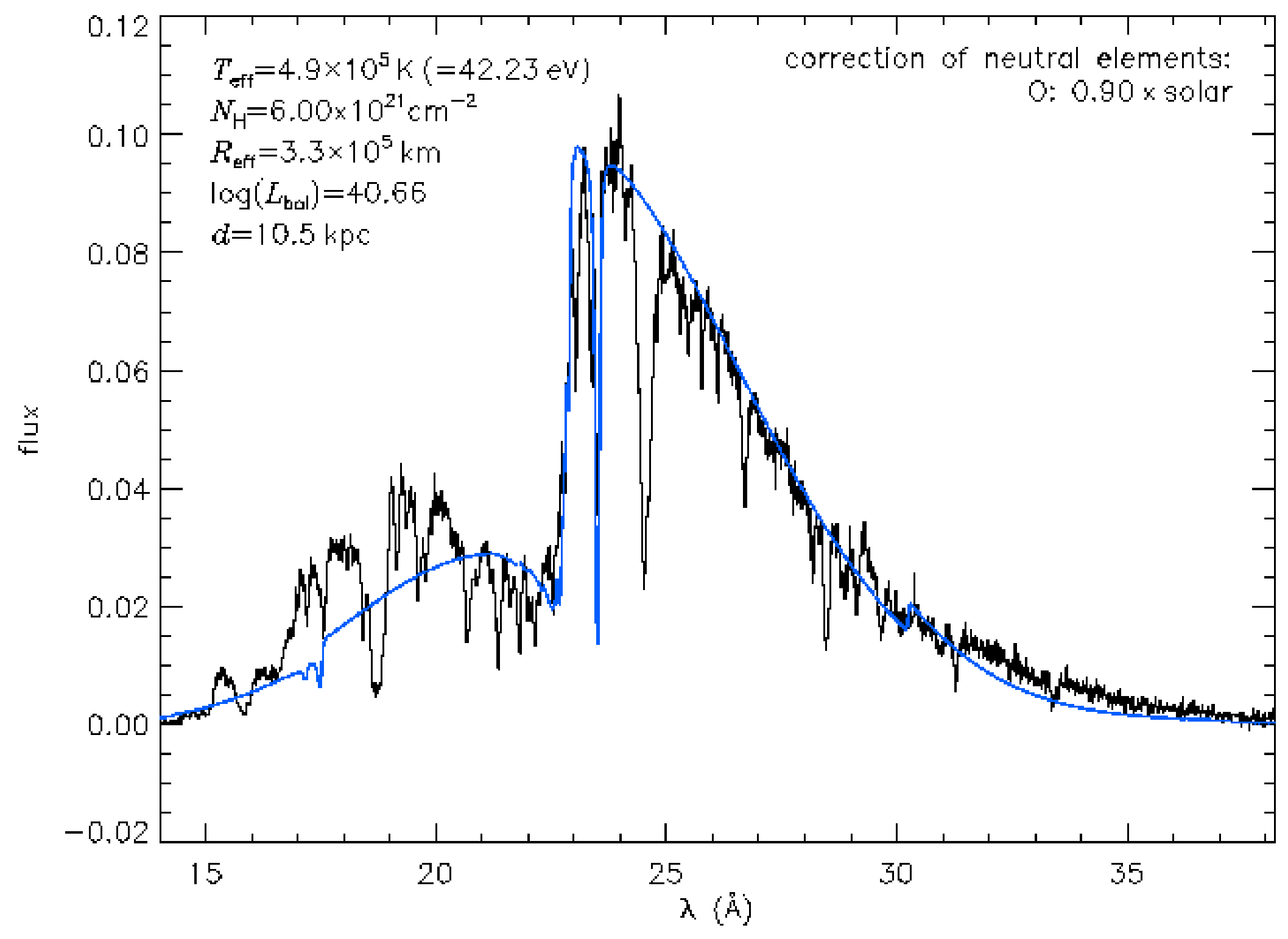

day 39.90
day 40.00
day 41.15
OVIII γ
OVIII β
OVII edge
OVII δ
OVII γ
OVII β
OVIII α
NVI δ
NVI γ
NVII β
OVII α
OVI
OV
OIV
NVI δ
OI
NVI γ
NV α
NV β
CVI edge
? (26.06)
CVI δ
CVI γ
CVI β
NVI α
? (29.45)
? (30.00)
NI
CVI α
Rest wavelength
Expected wavelength if v=−3200 km/s
ph cm⁻² ksec⁻¹ A⁻¹
λ (Å)

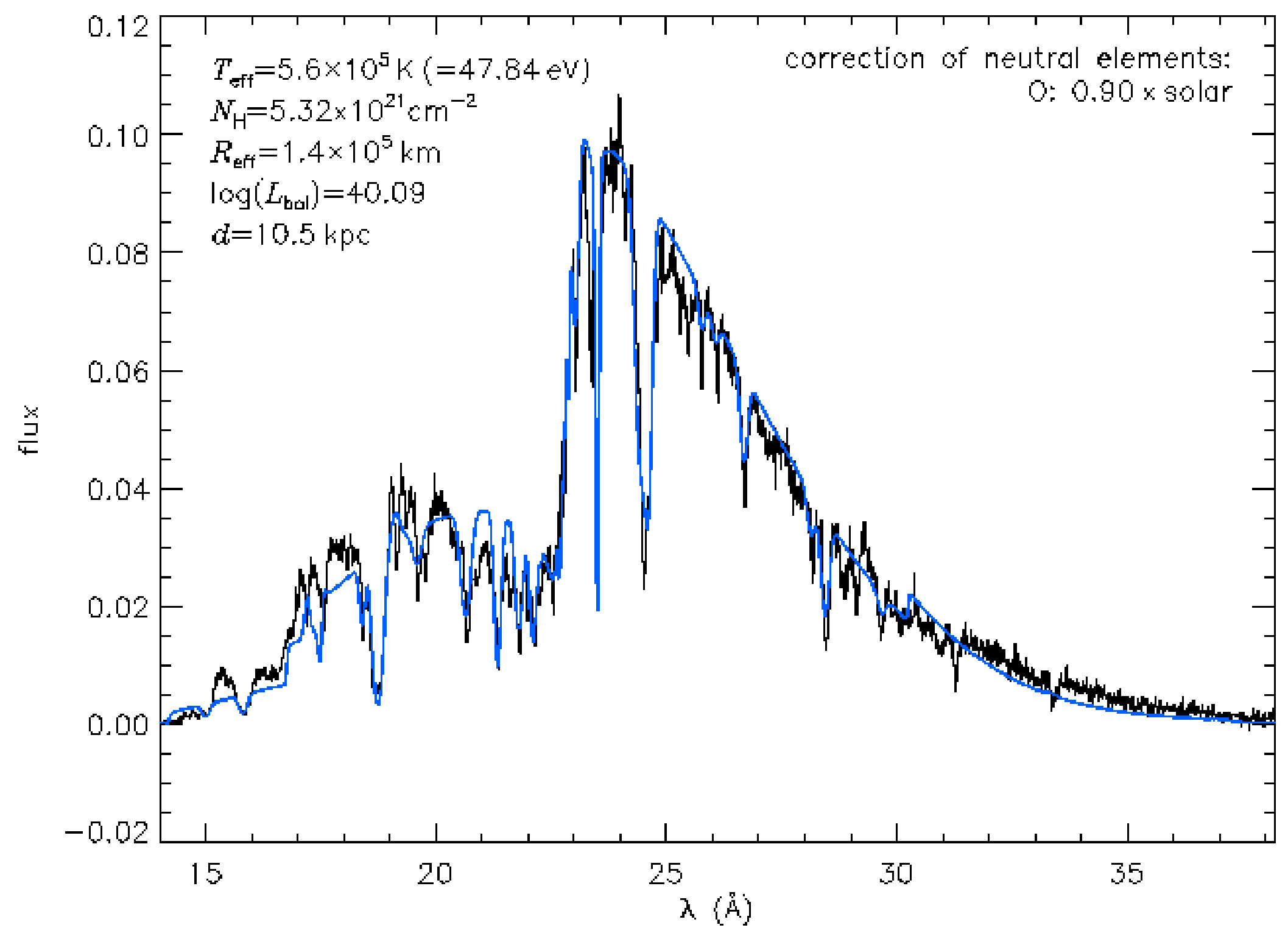

χ^2_{red}=2.049
$v_{shift}(1)$=−3243.67 km^{-1}; $v_{width}(1)$=1153.37 km^{-1}
$v_{shift}(2)$=−3114.09 km^{-1}; $v_{width}(2)$=557.74 km^{-1}
$\lambda_0(1)$=24.78 Å: NVIIα
$\lambda_0(2)$=24.90 Å: NVIβ
first part
low state spectrum
0.08
0.06
0.04
0.02
0.00
−6000
−5000
−4000
−3000
−2000
−1000
0
v (km s^{-1})

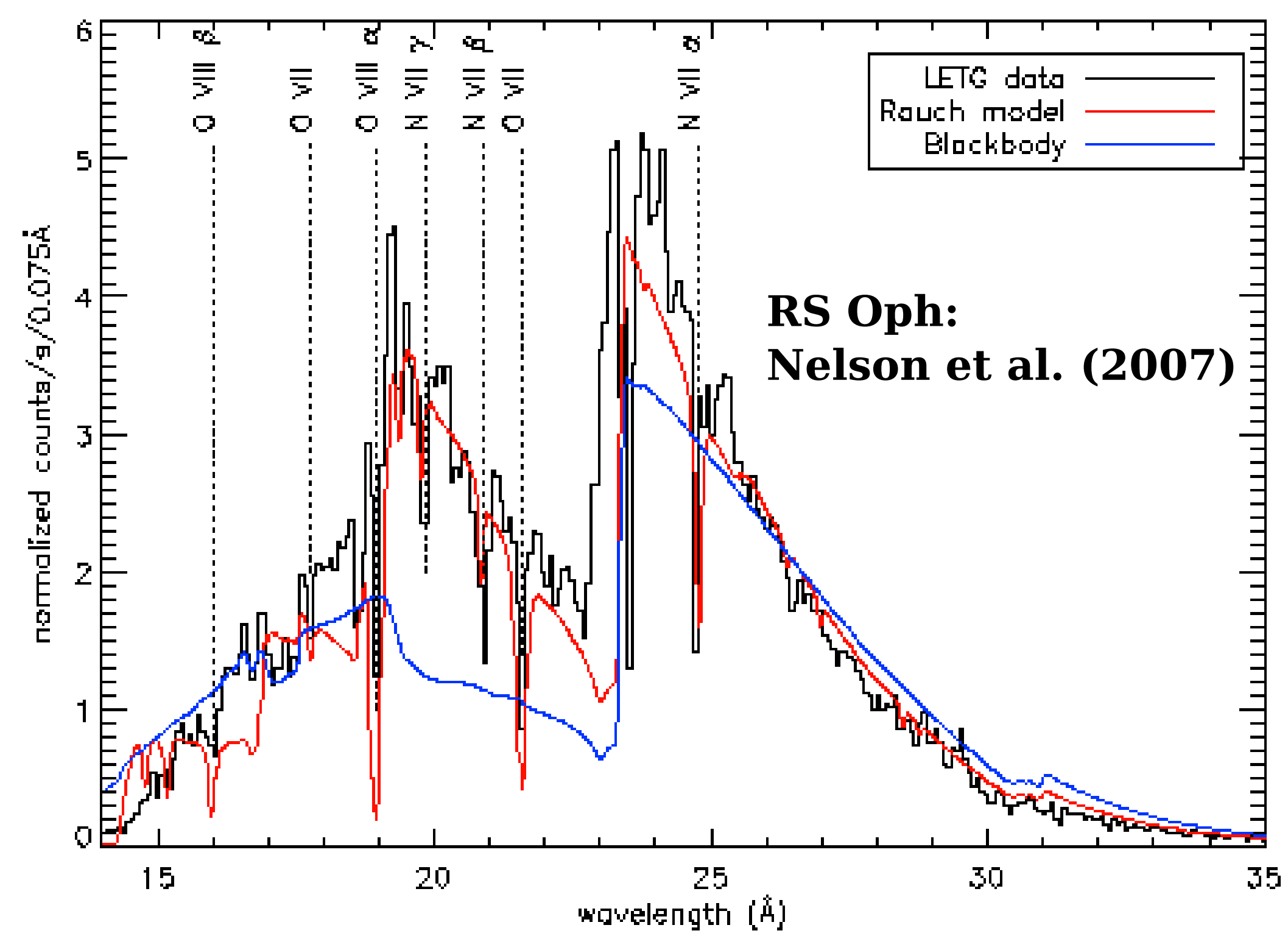

day 39.90
day 40.00
day 41.15
OVIIIγ
OVIIIβ
OVII edge
OVIIδ
OVIIγ
OVIIβ
OVIIIα
NVIIδ
NVIIγ
NVIIβ
OVIIα
OVI
OV
OIV
NVIδ
OI
NVIγ
NVIIα
NVIβ
CVI edge
?
(26.06)
CVIδ
CVIγ
CVβ
NVα
?
(29.45)
?
(30.00)
NI
CVIα
Rest wavelength
Expected wavelength
if v=−3200 km/s
ph cm⁻² ksec⁻¹ A⁻¹
λ (Å)


χ^2_{red}=2.626
$v_{shift}(1)$=−3145.52 km^{-1}; $v_{width}(1)$=595.68 km^{-1}
$v_{shift}(2)$=−3039.29 km^{-1}; $v_{width}(2)$=559.75 km^{-1}
$\lambda_0(1)$=28.78 Å: NVIα
$\lambda_0(2)$=28.46 Å: CVIβ
first part
low state spectrum
0.04
0.03
0.02
0.01
0.00
−8000
−6000
−4000
−2000
0
v (km s^{-1})

What can we learn?


T_{eff}=4.9×10^5 K (=42.23 eV)
N_H=6.00×10^{21} cm^{-2}
R_{eff}=3.3×10^5 km
log(L_{bol})=40.66
d=10.5 kpc
correction of neutral elements:
O: 0.90 x solar
flux
λ (Å)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
15
20
25
30
35


T_{eff}=5.6×10^5 K (=47.84 eV)
N_H=5.32×10^{21} cm^{-2}
R_{eff}=1.4×10^5 km
log(L_{bol})=40.09
d=10.5 kpc
correction of neutral elements:
O: 0.90 x solar
flux
λ (Å)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
15
20
25
30
35


LETG data
Rauch model
Blackbody
O VIII
O VII
O VIII
N VII
N VII
O VII
N VII
RS Oph:
Nelson et al. (2007)
normalized counts/s/0.075Å
wavelength (Å)
0
1
2
3
4
5
6
15
20
25
30
35

All absorption lines are blue-shifted

Therefore:

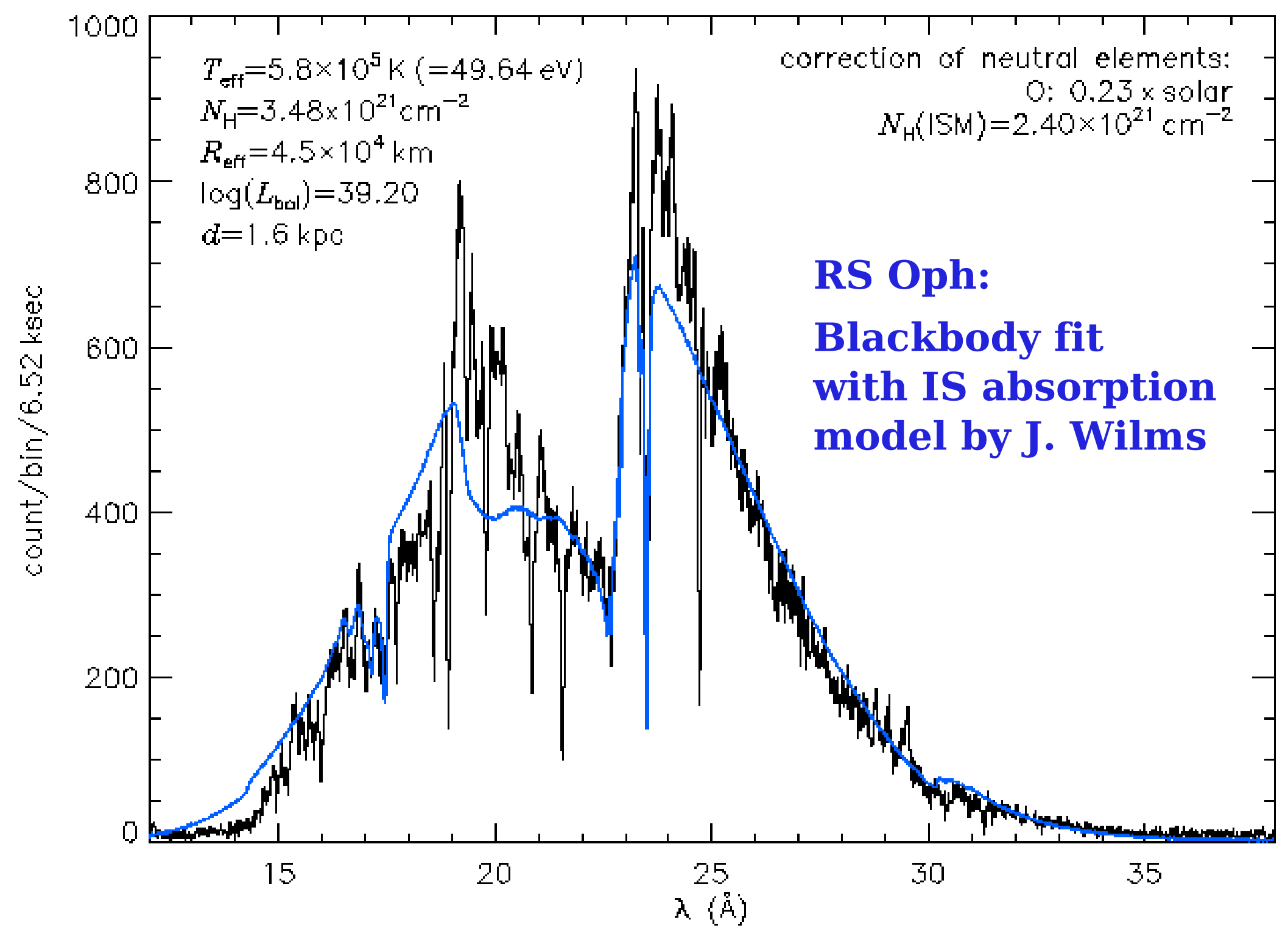
The shell is **expanding**

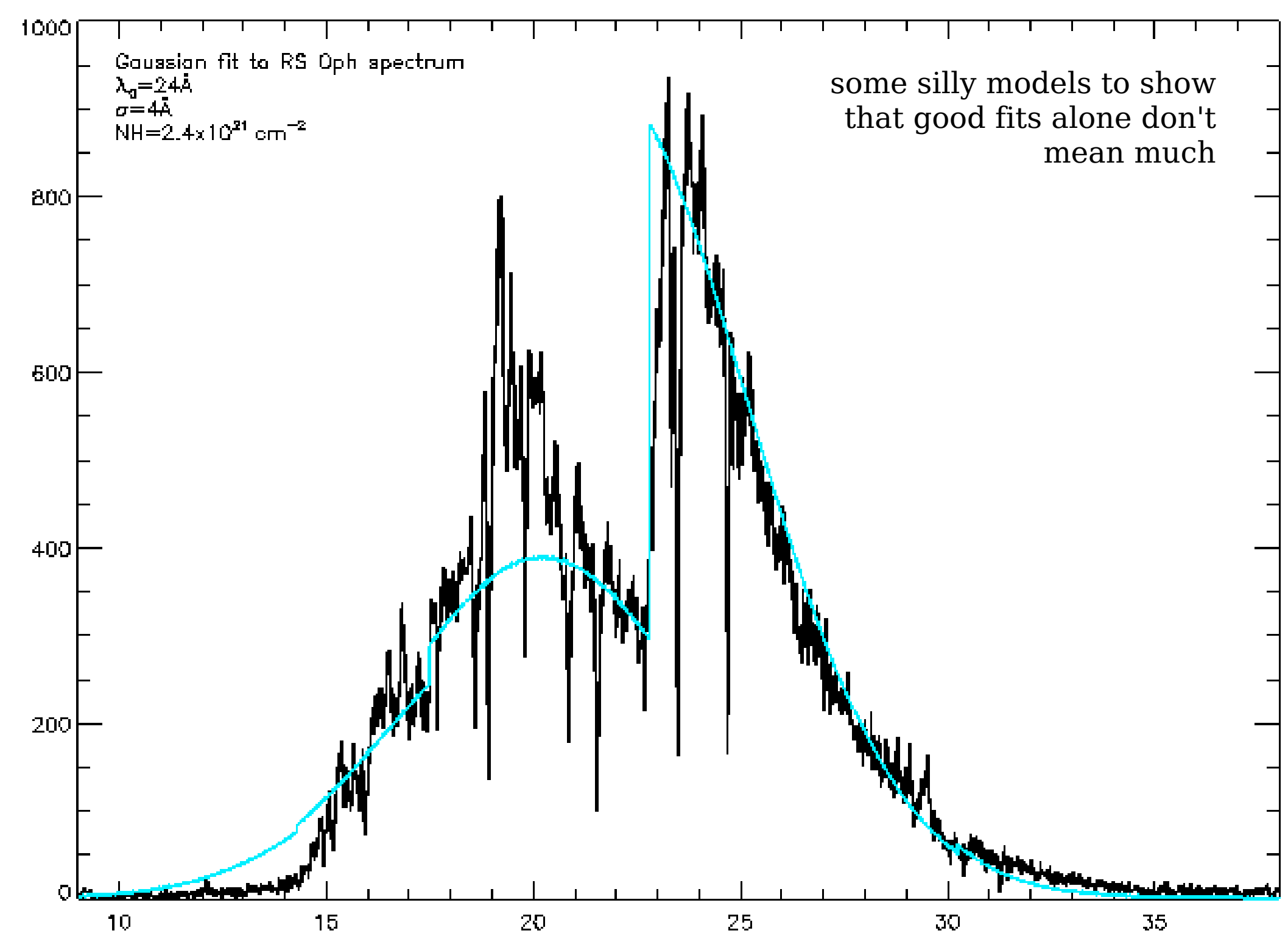
Therefore:

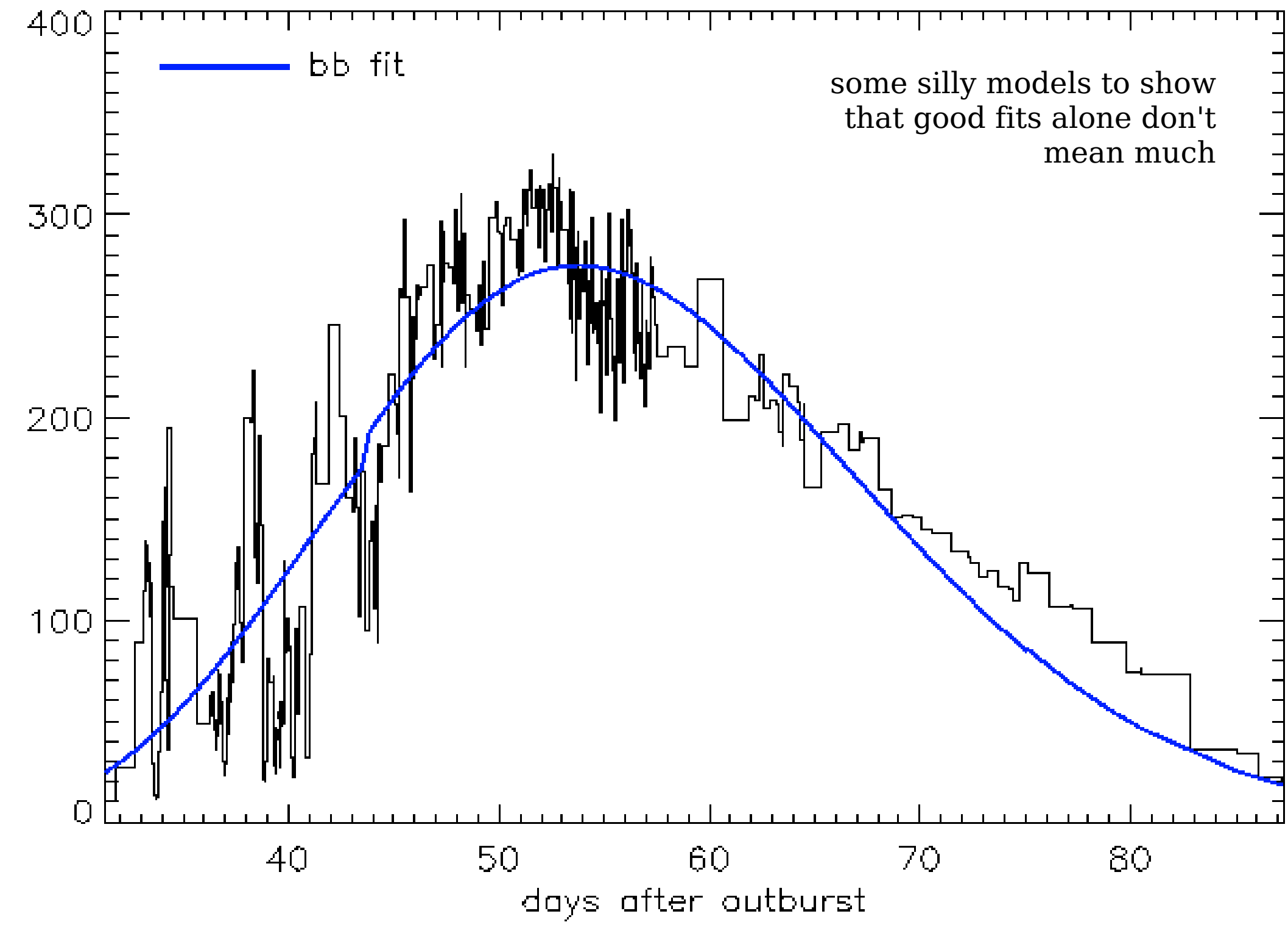
Static WD atmosphere don't describe the Physics, and the derived parameters can not be trusted. Even if they reproduce the spectra.

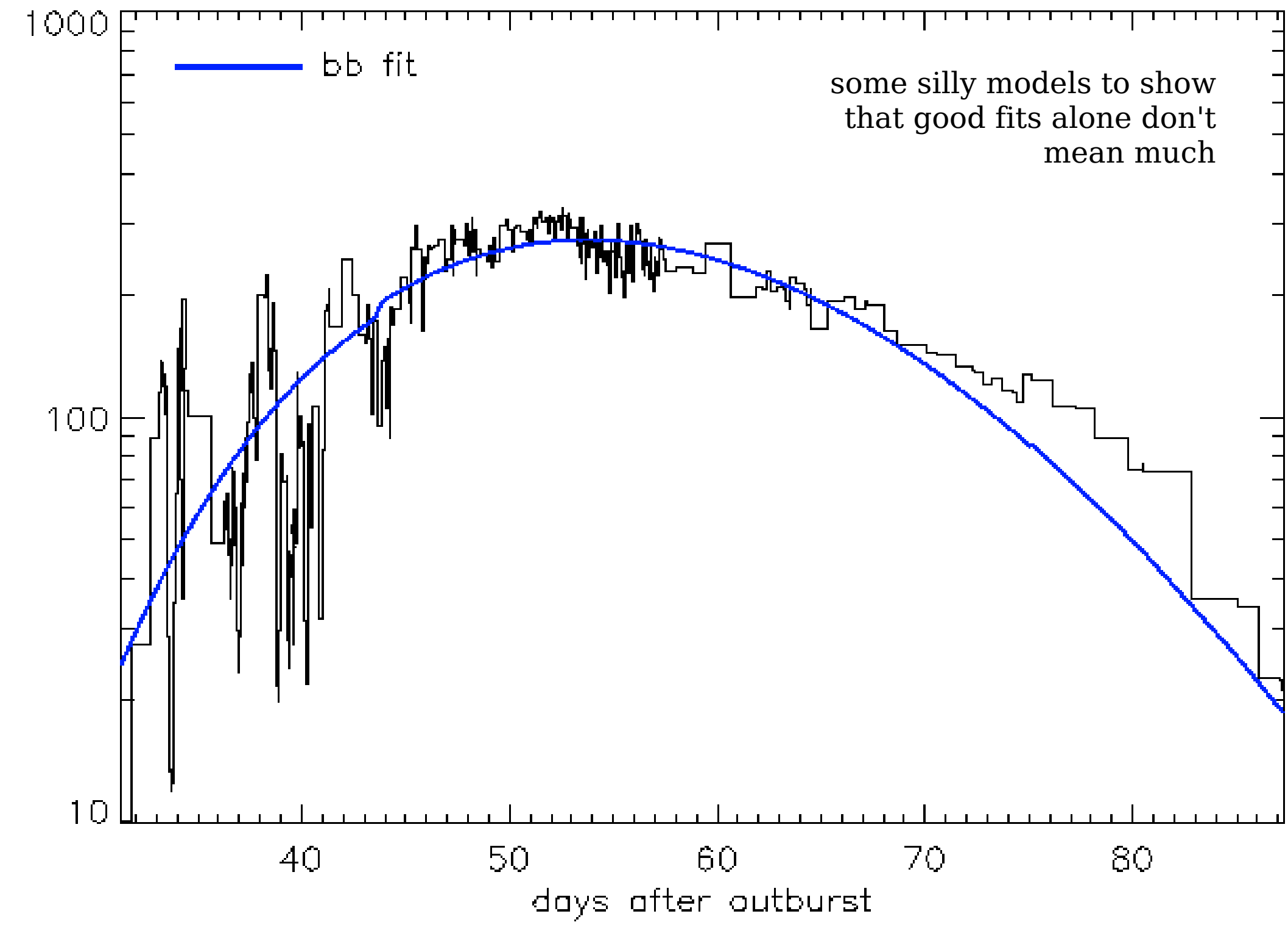
=> new models needed;

see Daan van Rossum's presentation

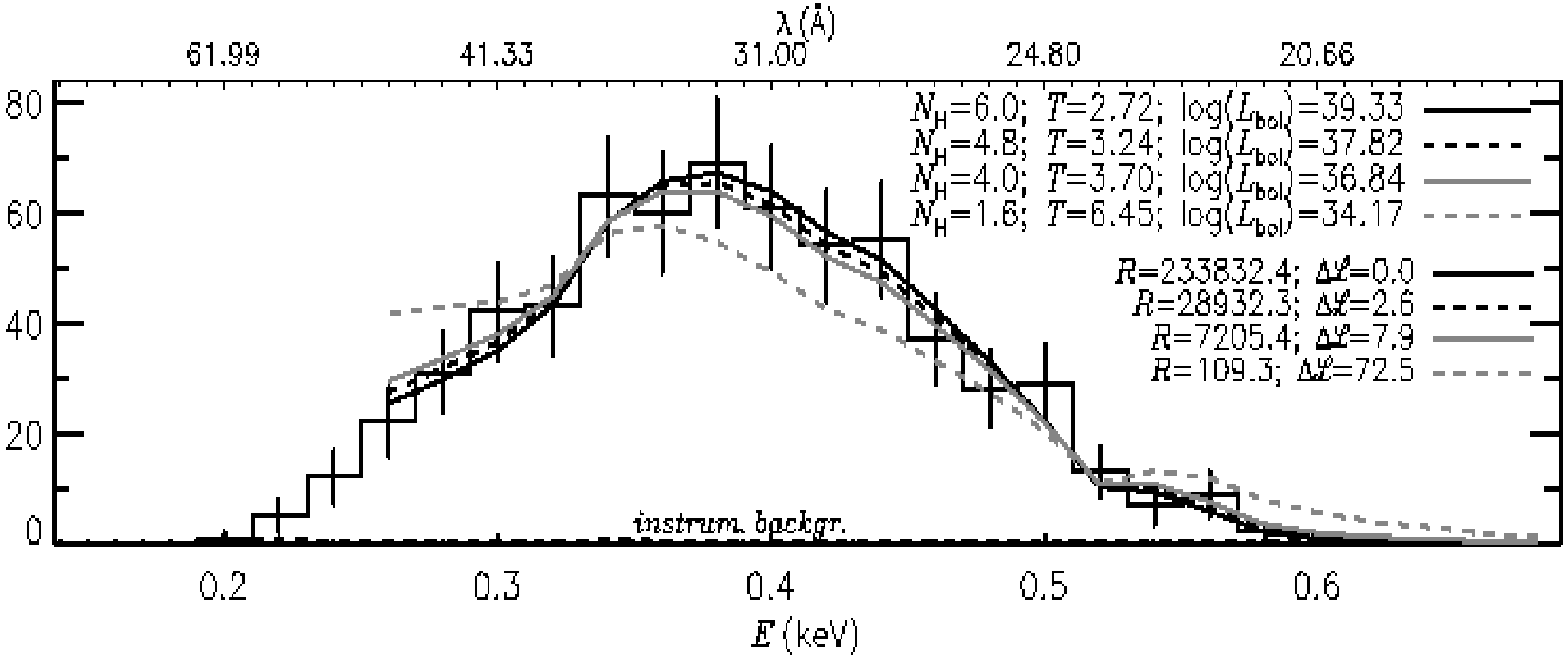

T_{eff}=5.8×10^5 K (=49.64 eV)
N_H=3.48×10^{21} cm^{-2}
R_{eff}=4.5×10^4 km
log(L_{bol})=39.20
d=1.6 kpc
correction of neutral elements:
O: 0.23 x solar
N_H(ISM)=2.40×10^{21} cm^{-2}
RS Oph:
Blackbody fit
with IS absorption
model by J. Wilms
count/bin/6.52 ksec
λ (Å)
0
200
400
600
800
1000
15
20
25
30
35

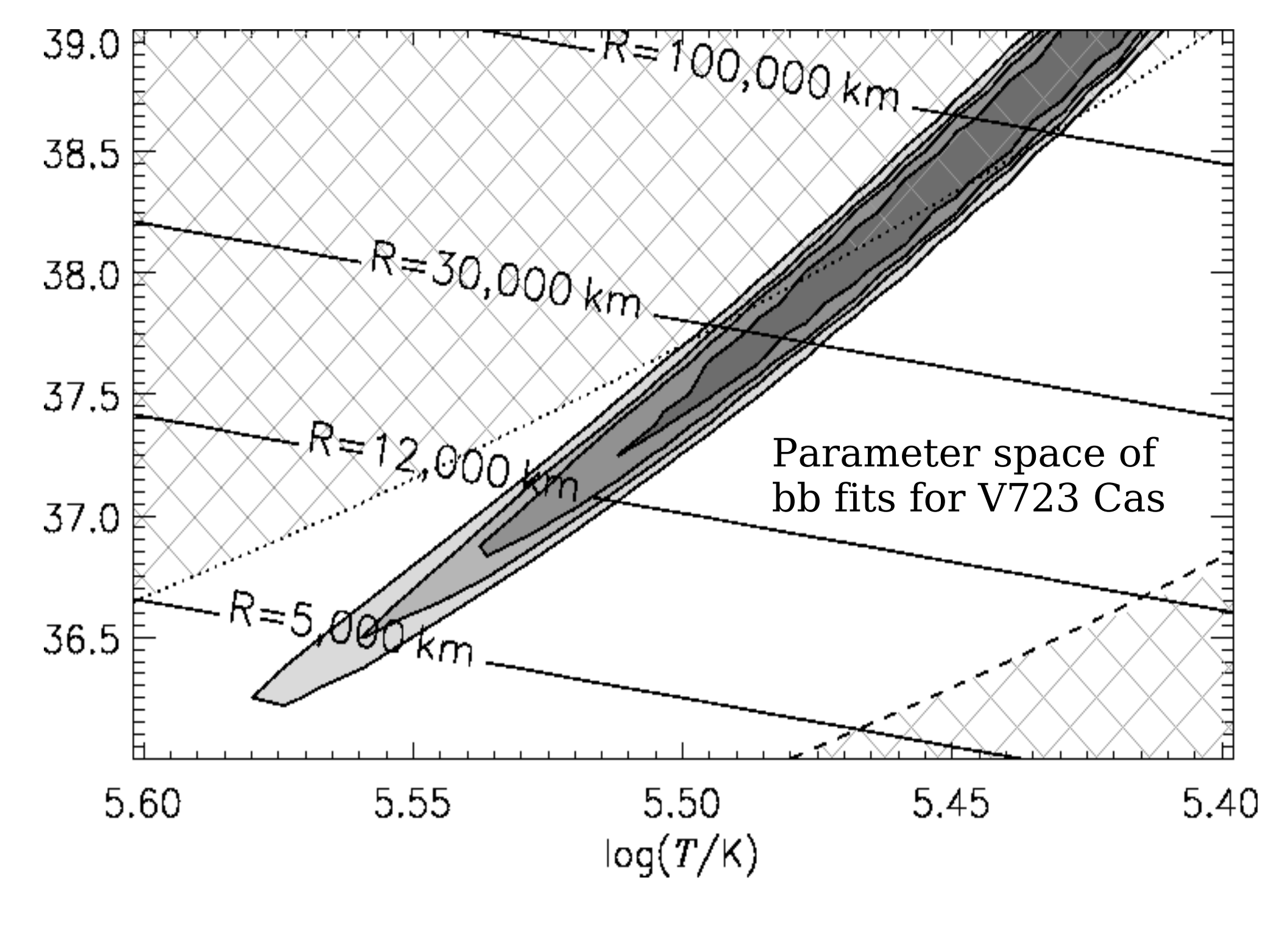

Gaussian fit to RS Oph spectrum
λ_0=24Å
σ=4Å
NH=2.4x10^{21} cm^{-2}
some silly models to show
that good fits alone don't
mean much
1000
800
600
400
200
0
10
15
20
25
30
35


bb fit
some silly models to show
that good fits alone don't
mean much
400
300
200
100
0
40
50
60
70
80
days after outburst


1000
100
10
bb fit
some silly models to show
that good fits alone don't
mean much
40
50
60
70
80
days after outburst

Blackbody fits to V723 Cas




39.0
38.5
38.0
37.5
37.0
36.5
R=100,000 km
R=30,000 km
R=12,000 km
R=5,000 km
Parameter space of
bb fits for V723 Cas
5.60
5.55
5.50
5.45
5.40
log(T/K)

Summary

- Without the use of models, we can already identify lines and determine expansion velocity
- The line depths tell us about abundance trends
- Variations in X-ray brightness can be studied by extracting spectra from different times
- Blackbody fits are not realistic, but they fit the shape of the continuum
- The line shifts prove that plane-parallel static atmosphere models do not describe the physics
- Theorists and Observsers need to work together