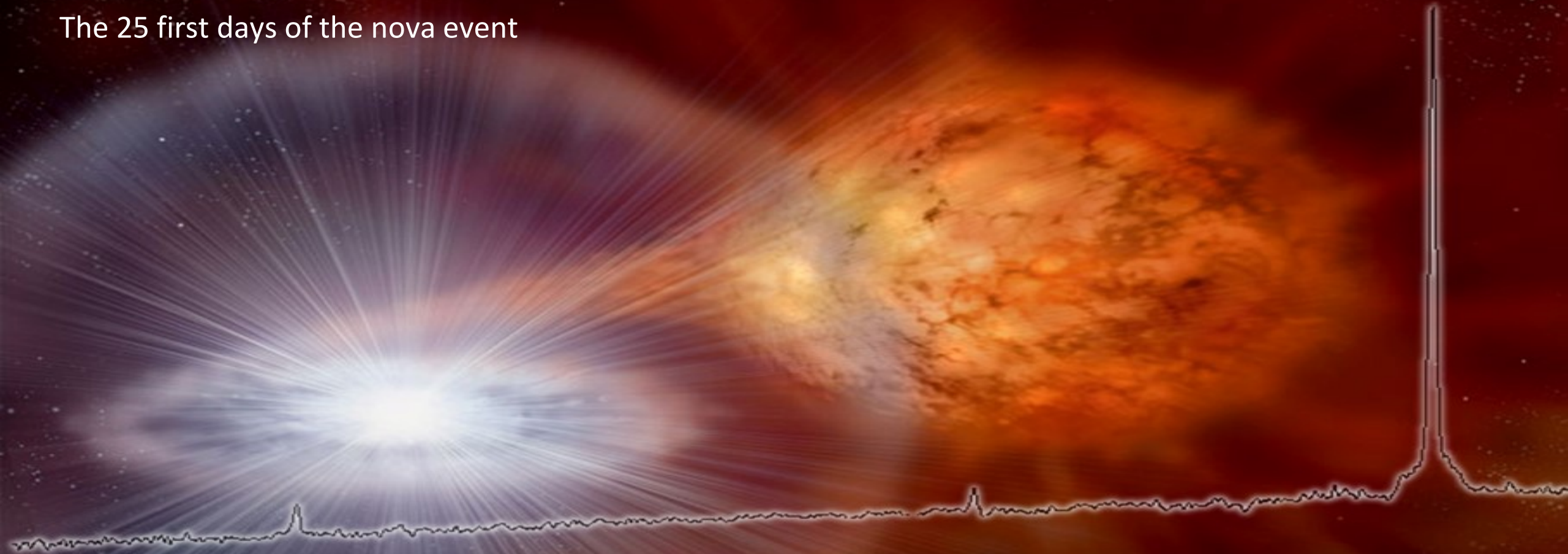


RS Oph 2021

The 25 first days of the nova event



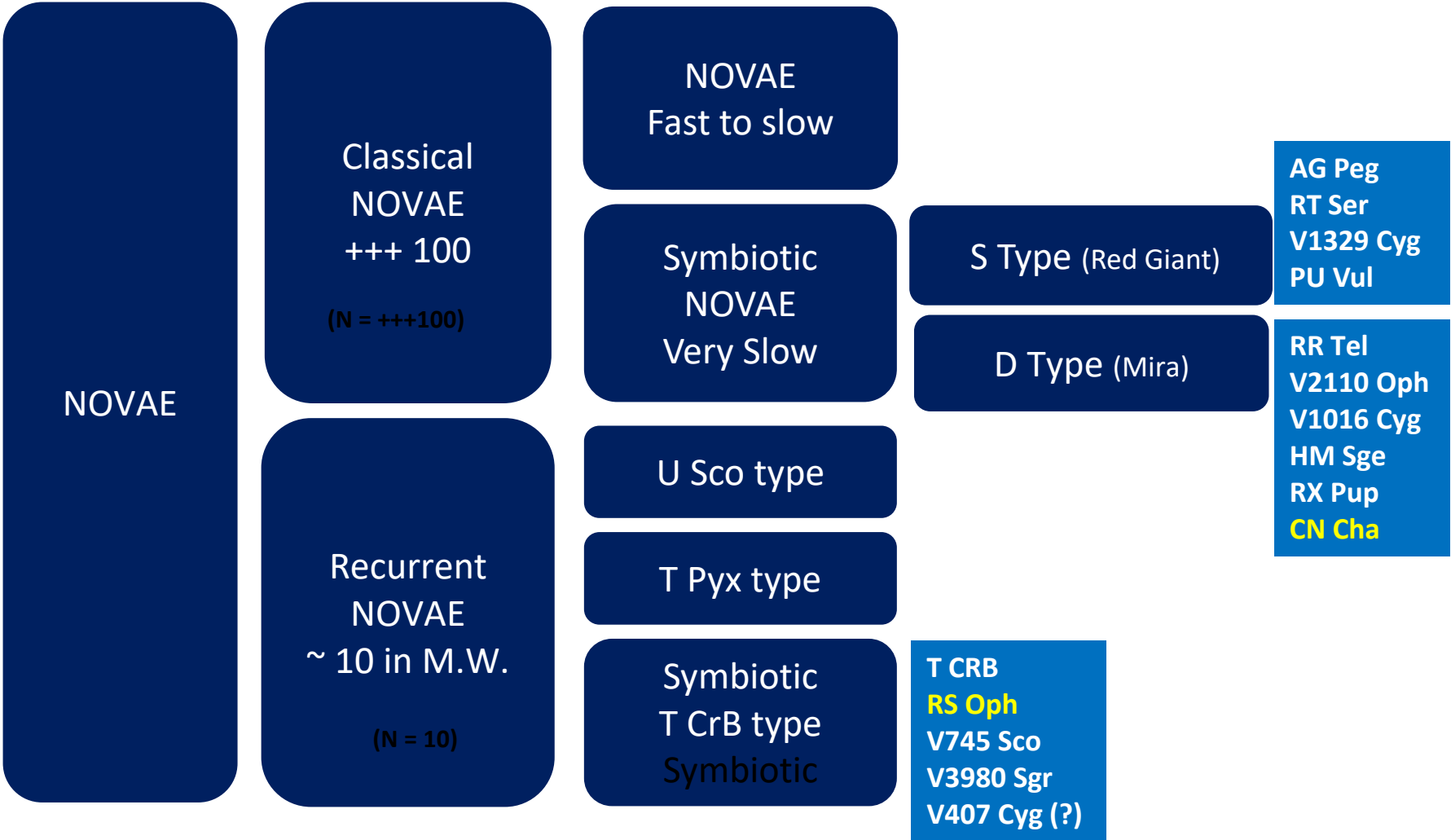
Mons,
23-04-201

François Teyssier
www.astronomie-amateur.fr

Novae Classification

Explosive event (TNR) in the degenerated envelop
(accreted from a main sequence star or a red giant) at the surface of a white dwarf

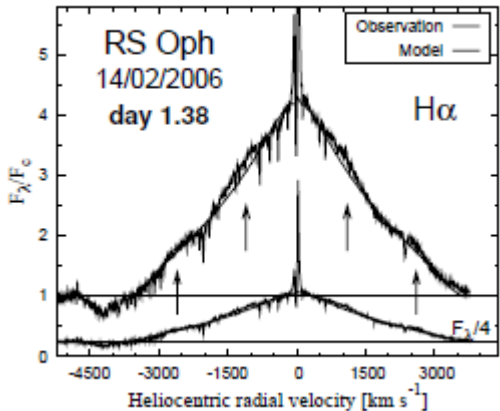
Recurrence = +++ 100 to +++ 1000 y for « classical novae » (observed once)
 < 150 y for recurrent novae (several nova outbursts observed in « modern times »)



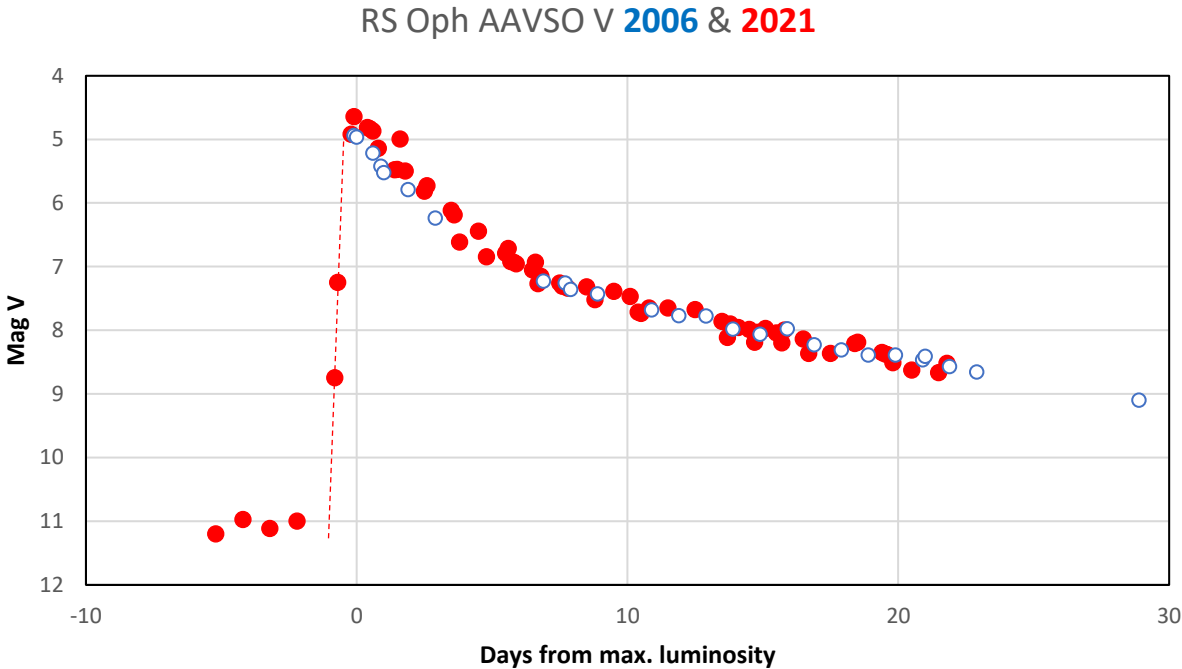
Previous nova events

- 1898
- 1907 (?) solar conjunction
- 1933
- 1945 (?) solar conjunction
- 1958
- 1967
- 1985
- 2006
- 2021

Very short
Recurrence time scale ~ 20 y



Skopal+ 2008
Spectrum obtained by Christian Buil



Max. 2021 ¹: JD 2459435.8 +/- 0.1
 Mag V. = 4.6 +/- 0.1

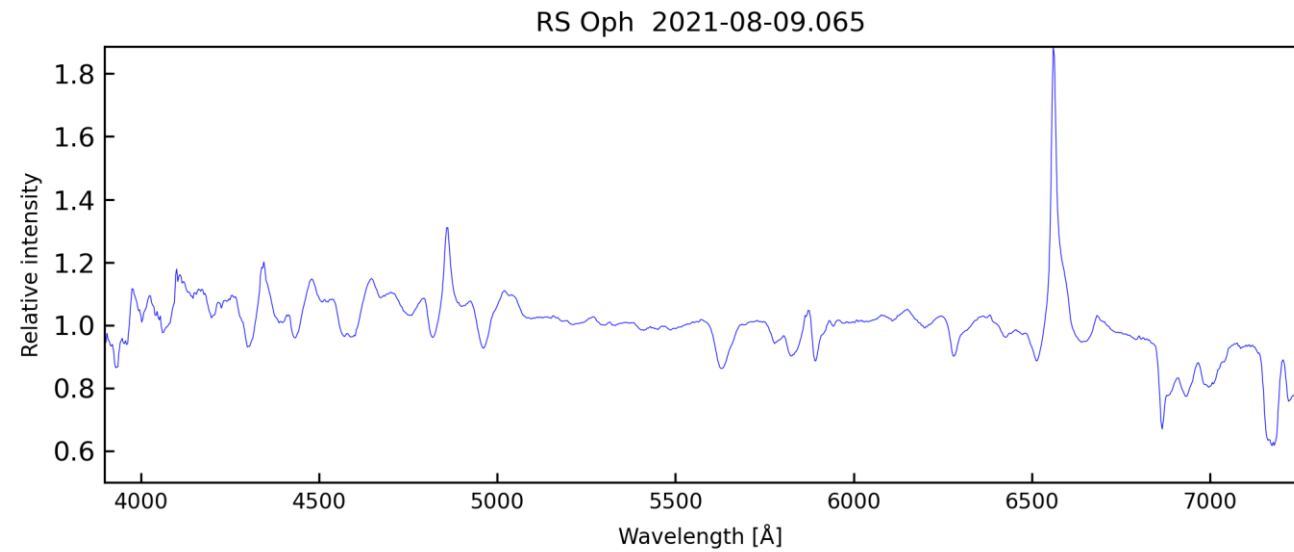
Rise $\Delta V \sim 6.4$ in 1.3 d
 $\Delta V/\Delta T \sim 4.9$ mag/d

Decline $t_2 = 4.7$ d
 $t_3 = 10.4$ d

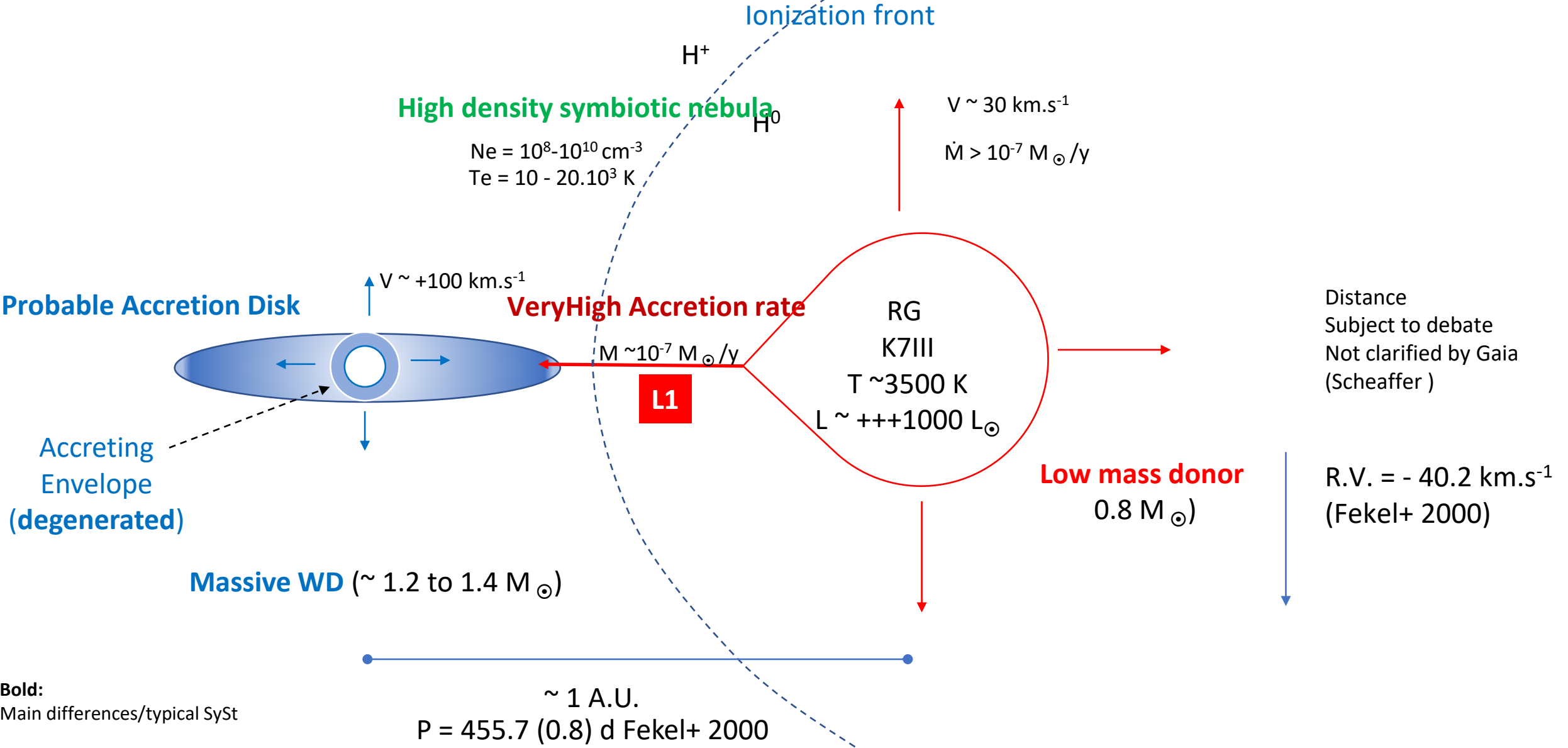
¹ Munari+, 2021 : 2459436.2 +/- 0.05

First spectrum of the event in the database
Secured by J.B. Desrosiers
Alpy R = 600

Near Maximum Luminosity



RS Oph in quiescence - simplified model

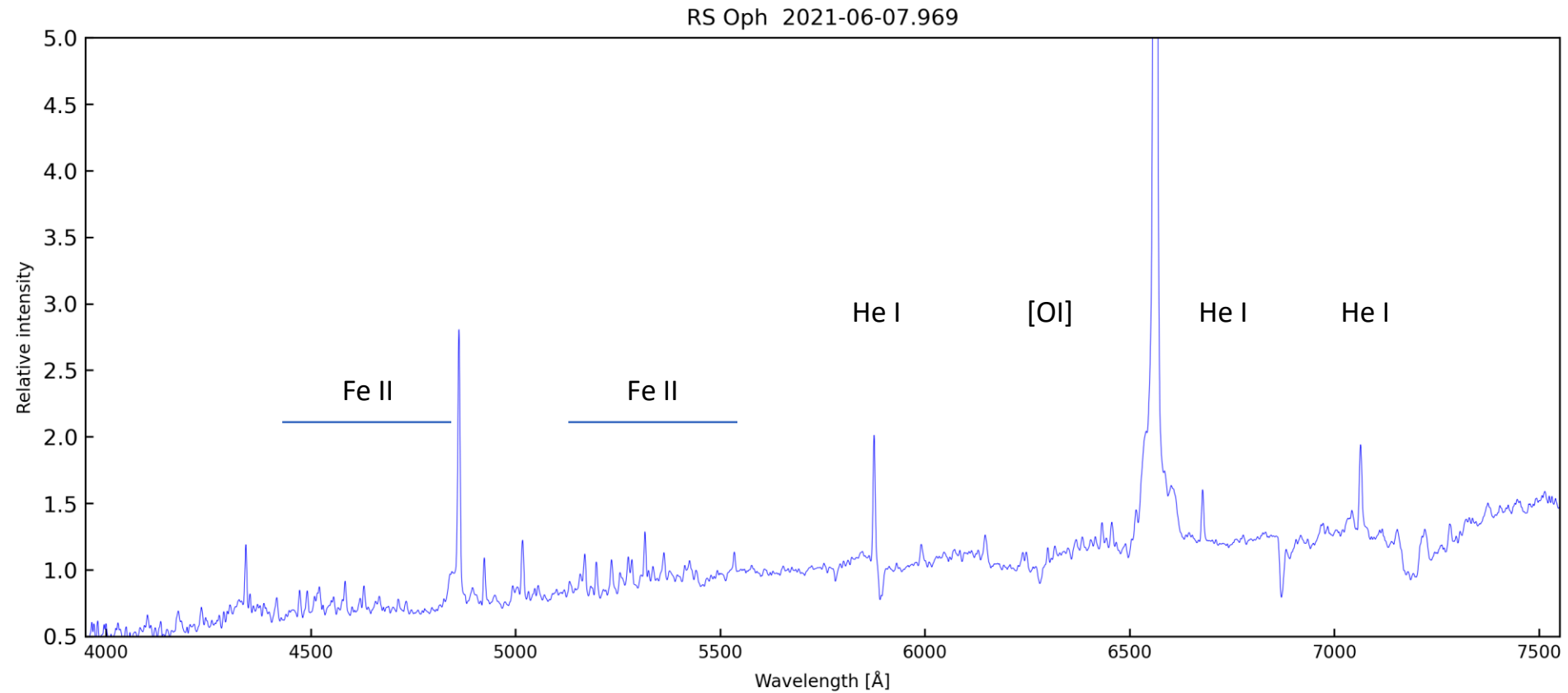


RS Oph in quiescence

Monitoring upon a request of Natalia Shagatova and Augustin Skopal

Last spectrum in quiescence

P. Dubovsky
LISA R = 1000



H I

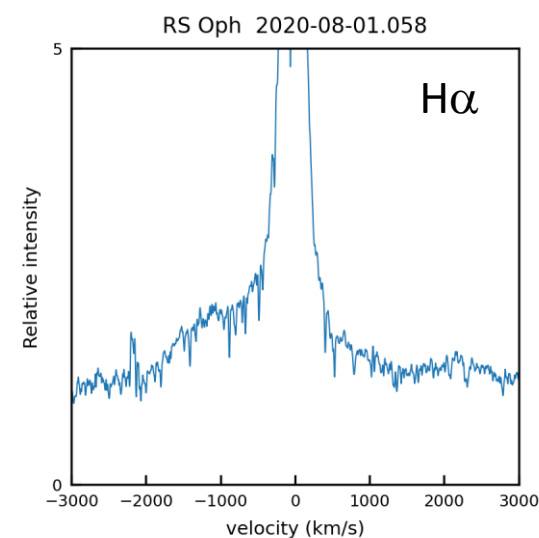
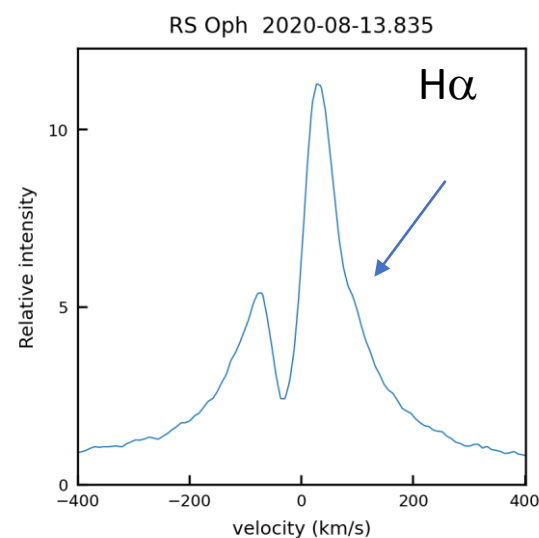
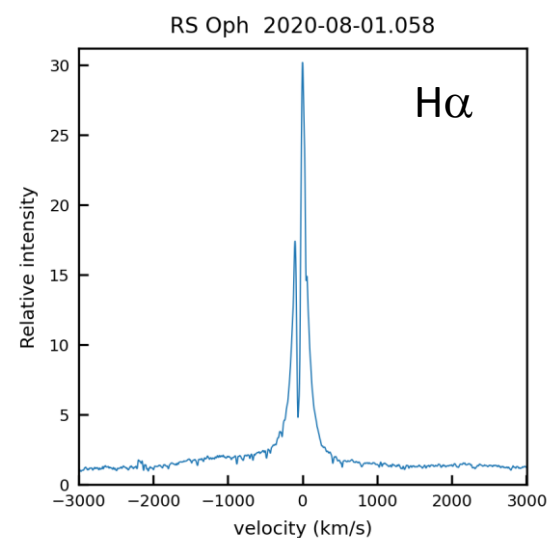
He I

Metals 1⁺ Fe II

He II missing: ionisation temperature ~ 25 eV (25000 K)

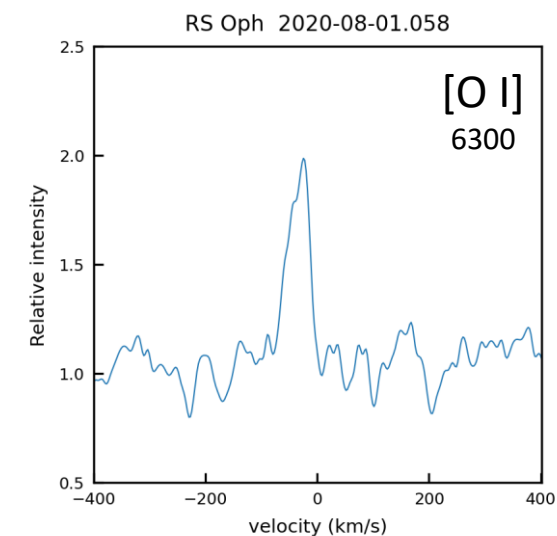
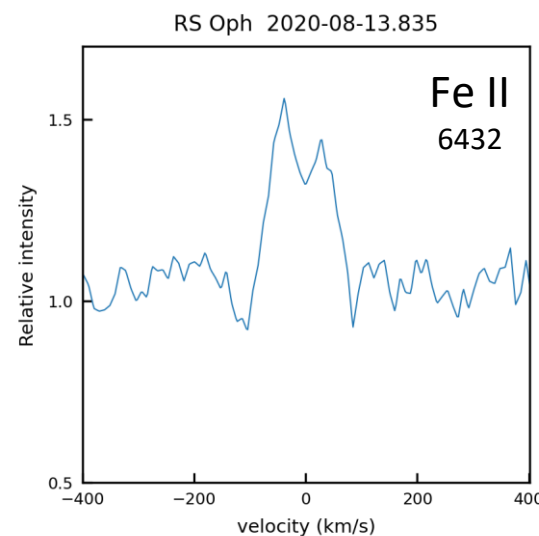
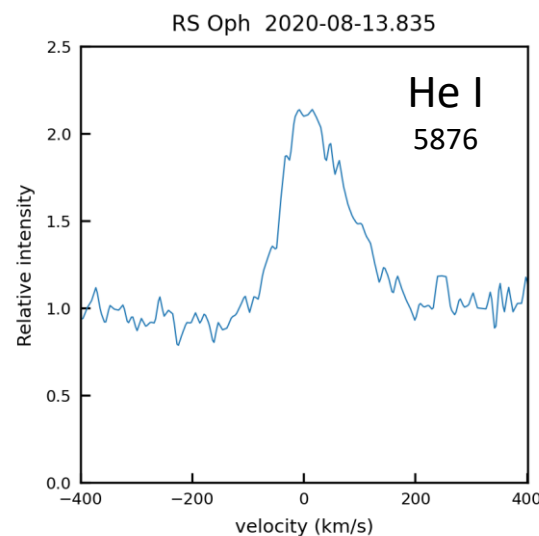
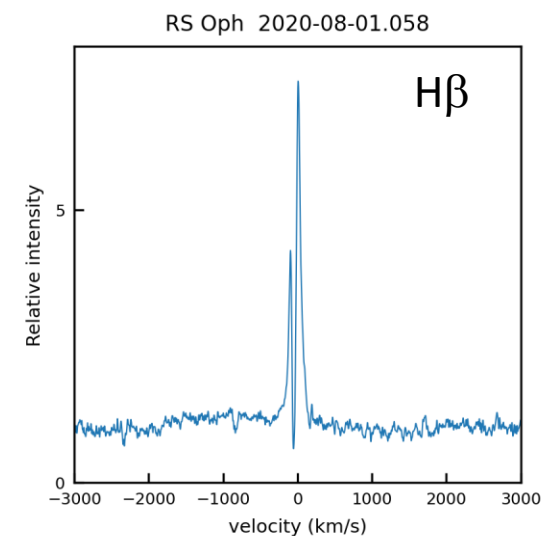
No trace of [NII] 5755, [OIII] ...

RS Oph in quiescence



1. Main emission FWHM = $\sim 160 \text{ km.s}^{-1}$
+ shoulder in the red part
2. **Deep** Central absorption RV = -63 km.s^{-1}
3. **Very broad –variable-** pedestrial RV $\sim 1900 \text{ km.s}^{-1}$

Spectra:
Tim Lester
Echelle R = 14000



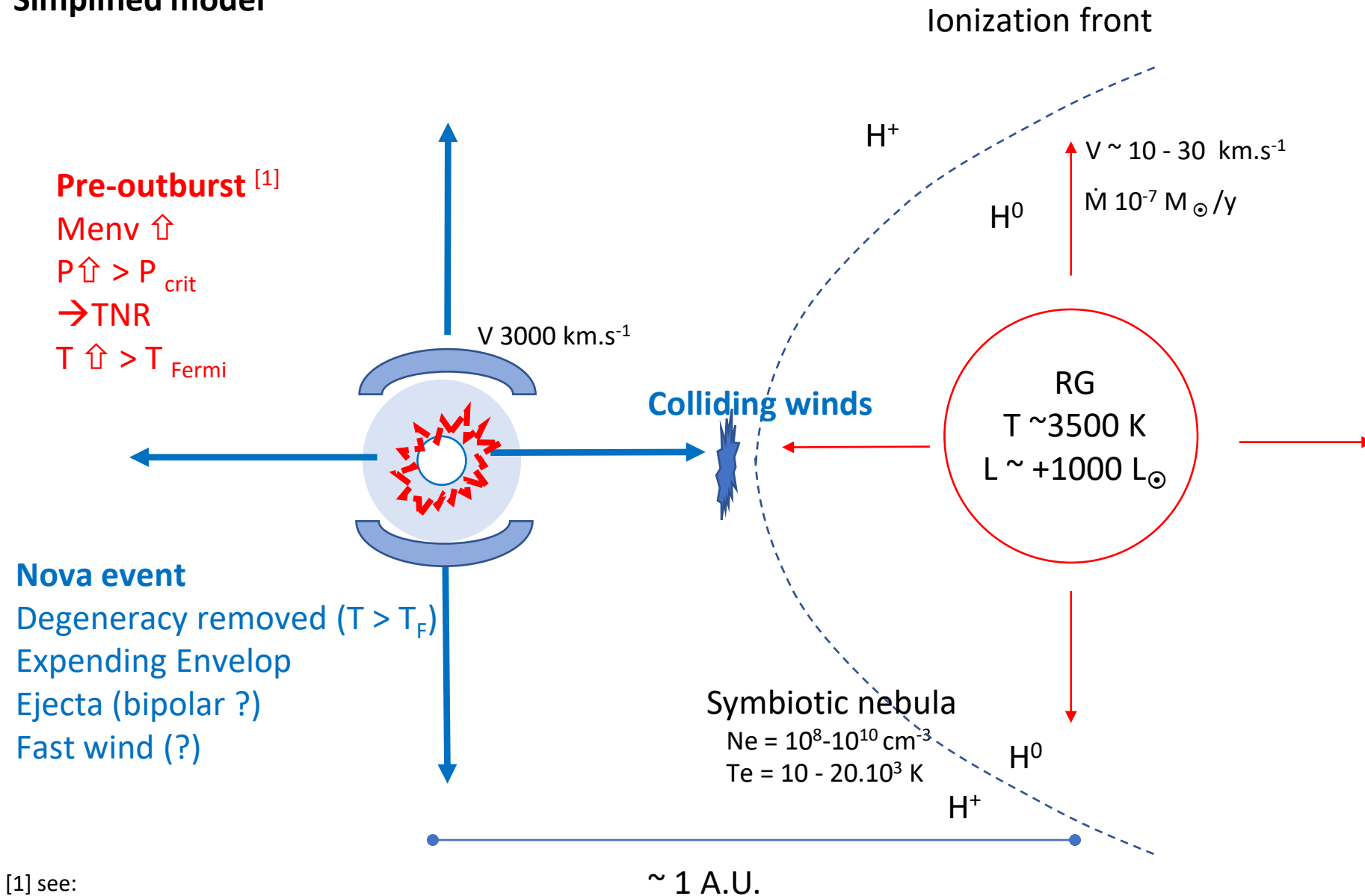
Very Deep Central absorption

FWHM = 156 km.s^{-1}

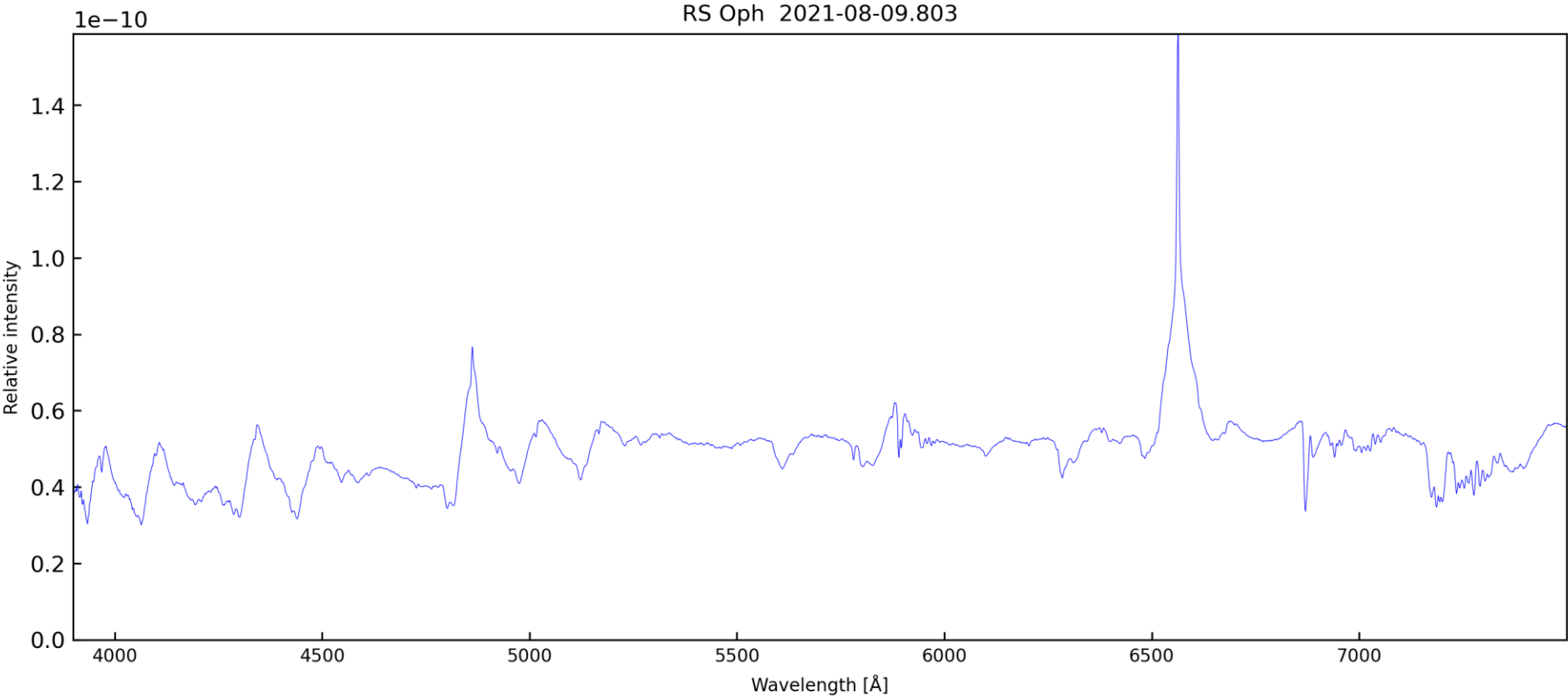
Double peaked FWHM = 110 km.s^{-1}

FWHM = 40 km.s^{-1}

Simplified model

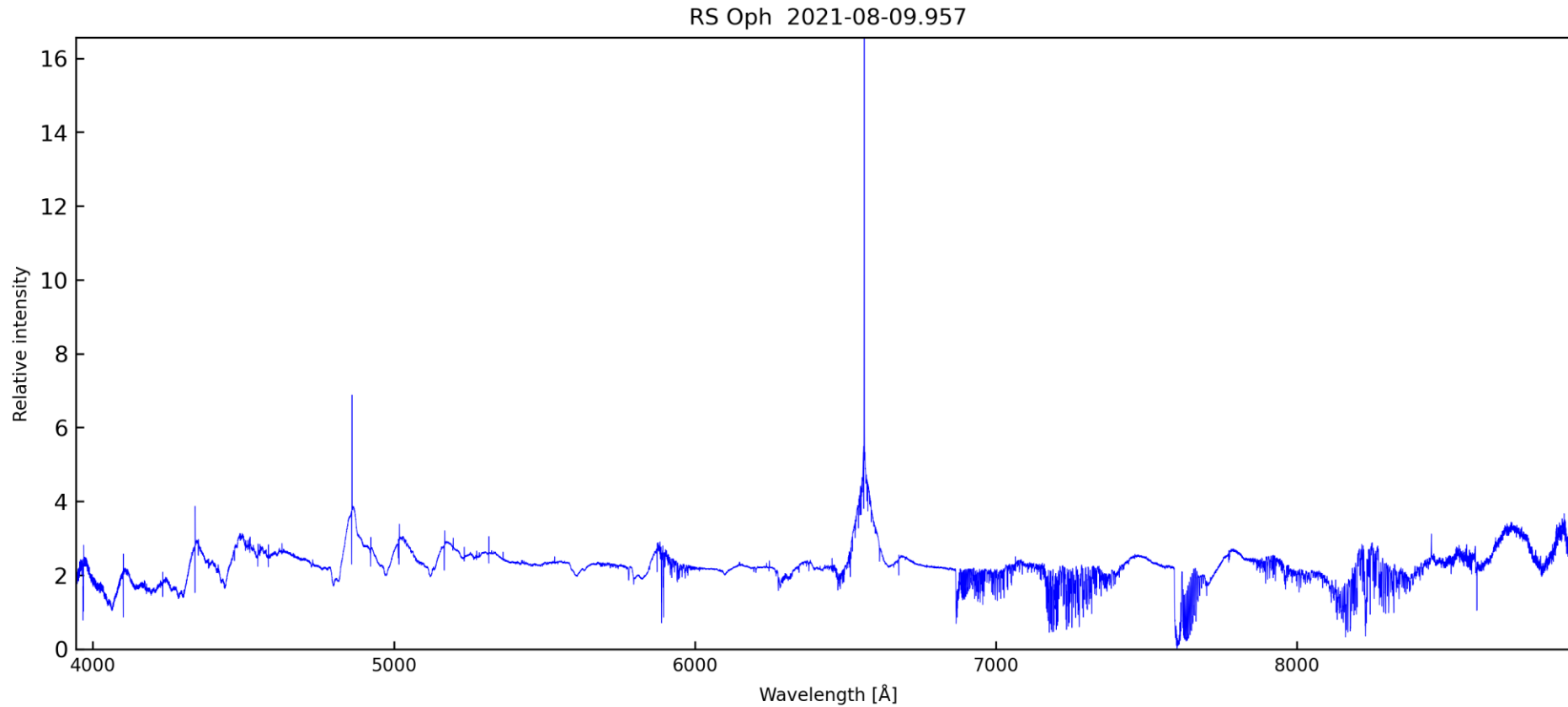


[1] see:

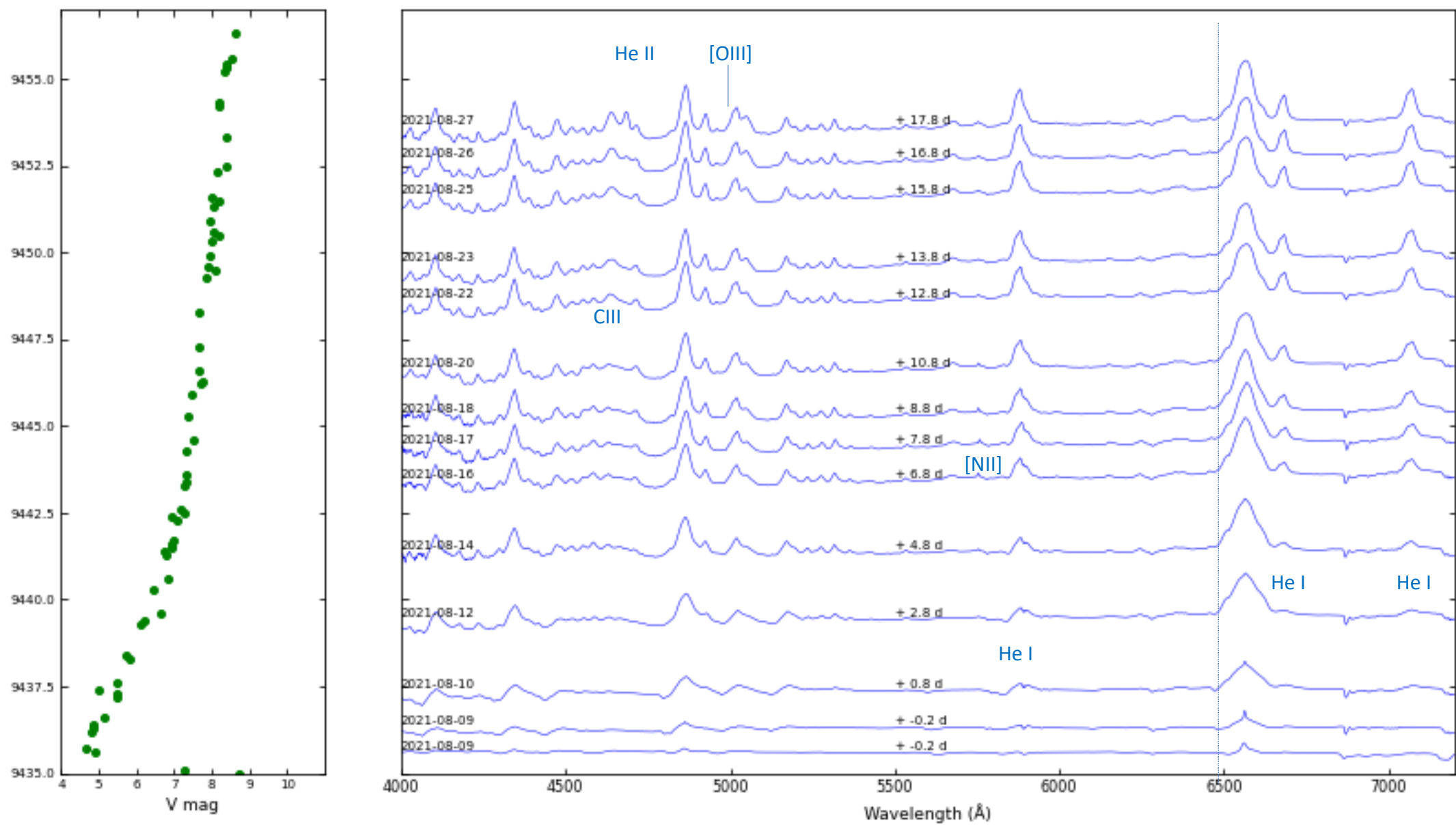


Pavol Dubovsky LISA R – 1000 Flux calibrated spectrum – See also David Boyd spectra

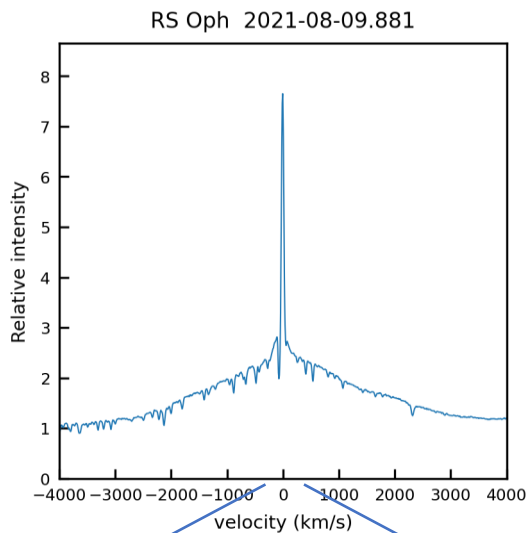
Echelle spectrum
Near Peak



F. Teyssier Remote station SMM-SP with a NOUT- Joan Guarro- (R =9000) mounted at the focus of a SC 16''

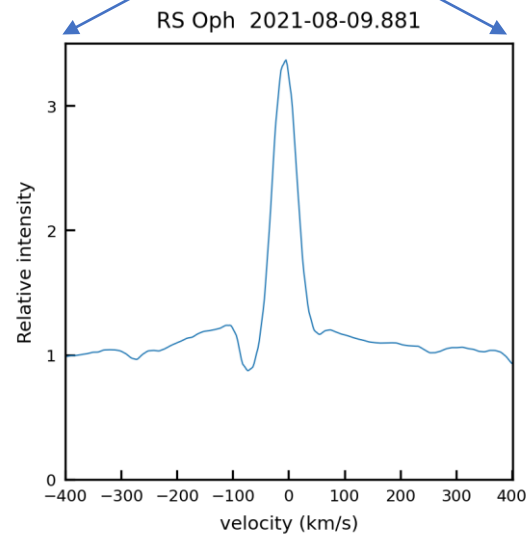


RS Oph 2021 Nova outburst day ~ 1.5 (max + 0.5d)

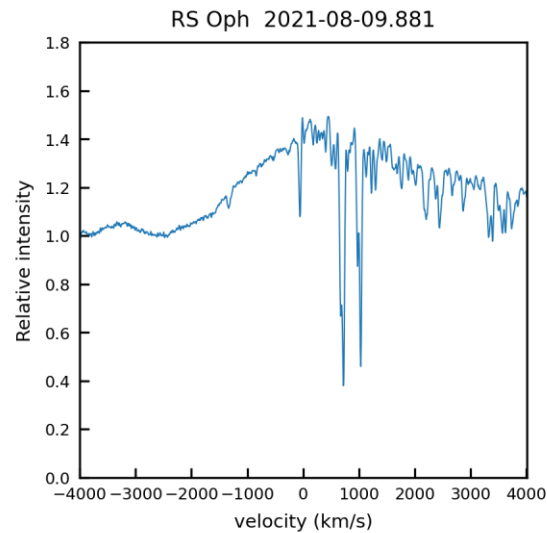


H α

- 1. Broad component
Triangular
 $\sim 3000 \text{ km.s}^{-1}$



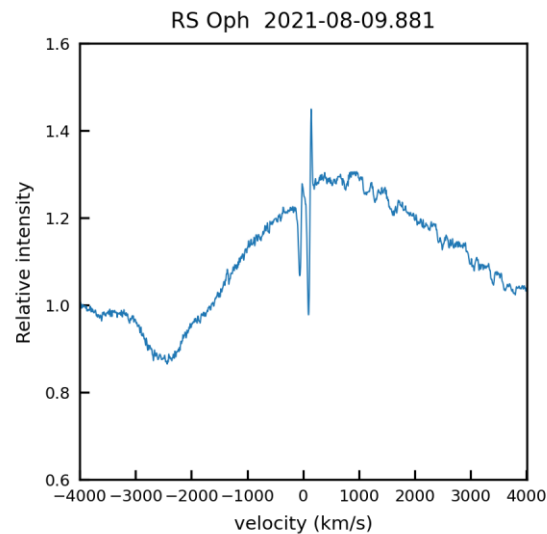
- 2. Narrow emission
FWHM $\sim 49 \text{ km.s}^{-1}$
- 3. Narrow absorption
VR(max abs) $\sim 71 \text{ km.s}^{-1}$
VR_{max} $\sim 100 \text{ km.s}^{-1}$



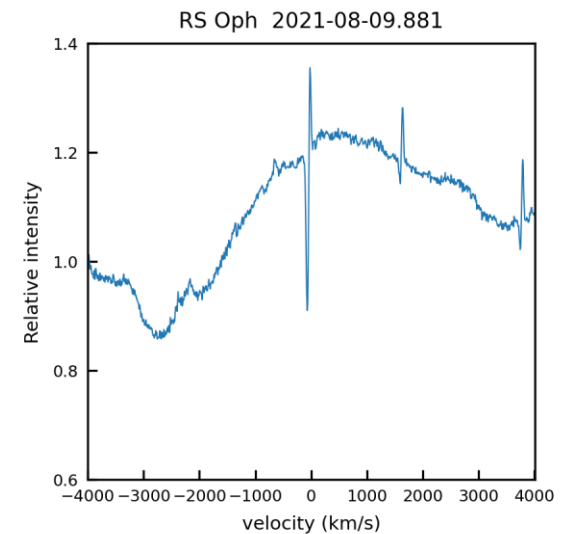
He I 5876

Very faint emission
+ Na I D narrow absorption
No sign of emission
-> T $\sim 10\text{-}20 \text{ kK}$
for the forming zone of narrow components

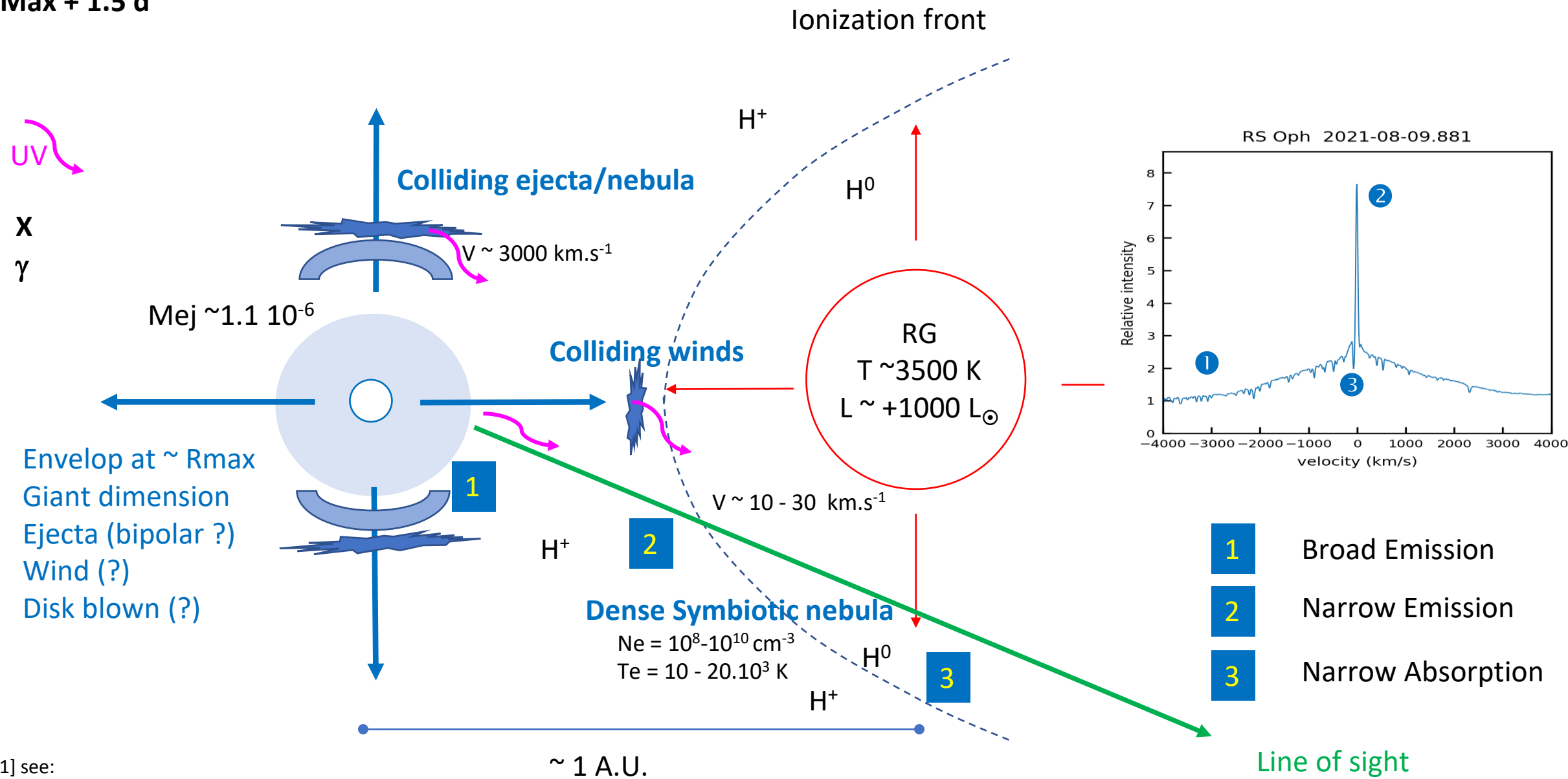
He I + Fe II 4922-4924 blend



Fe II (46) 5169



Max + 1.5 d



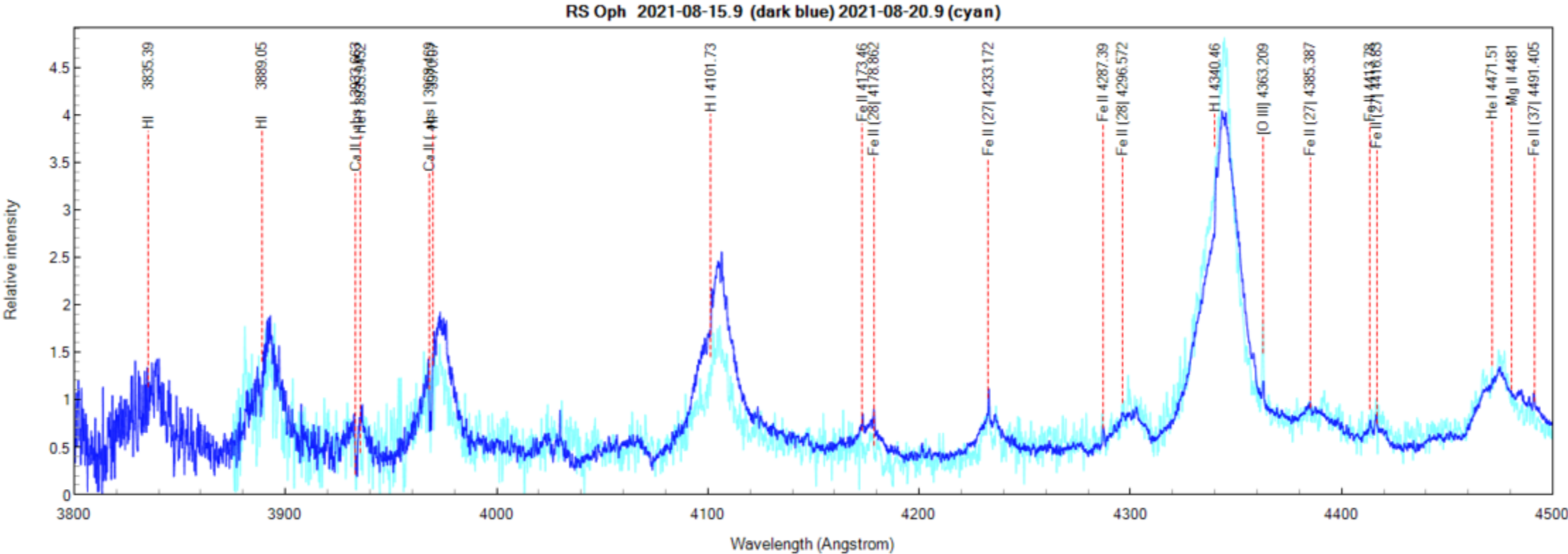
[1] see:

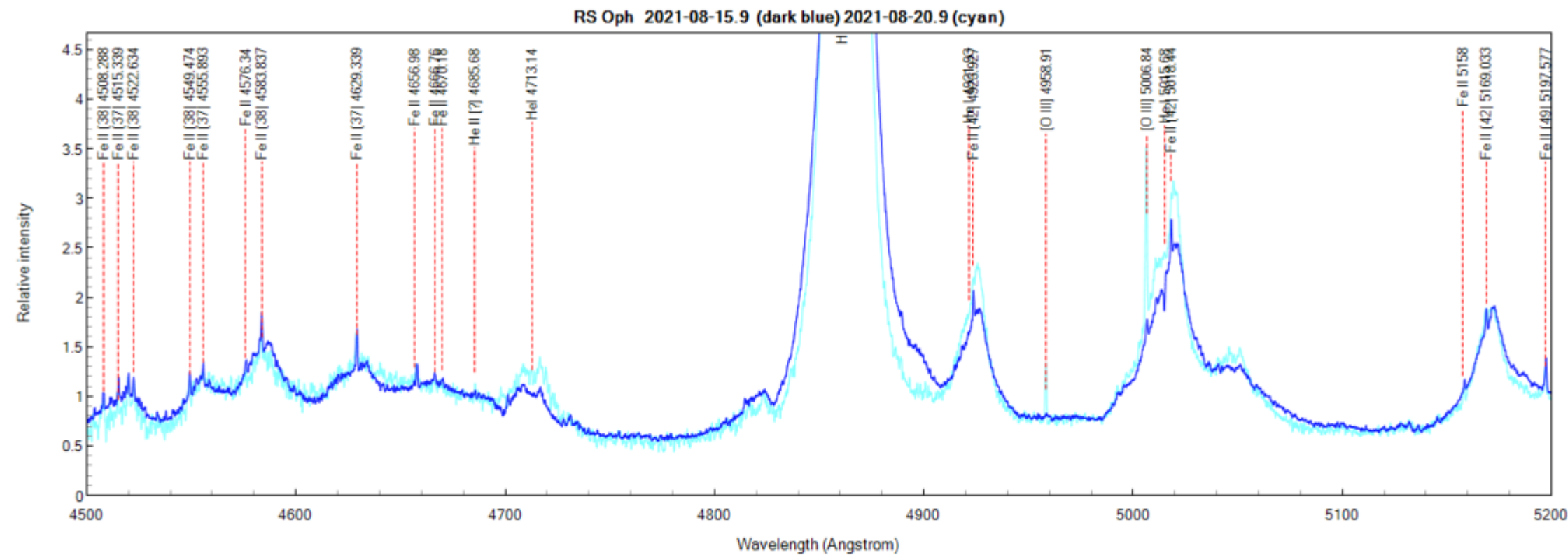
ARAS Database: <https://aras-database.github.io/database/rsoph.html>
339 spectra at resolution 500 to 30000 from 23-03-2011 to 03-09-2021

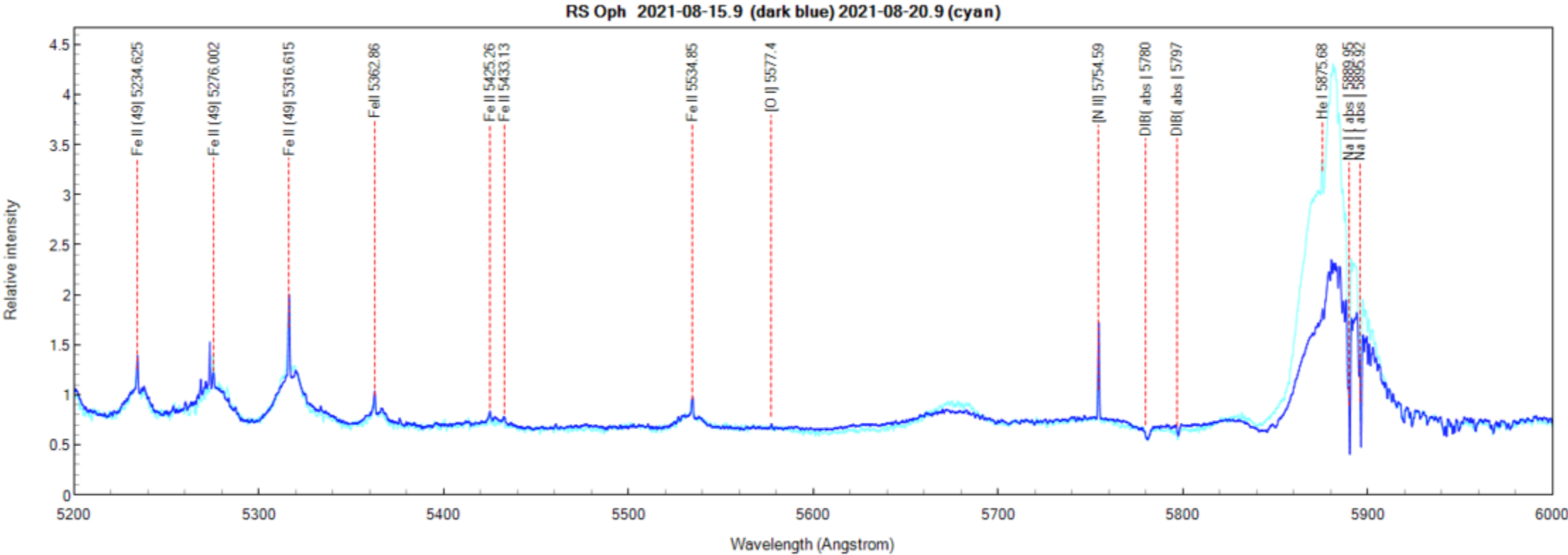
Daily monitoring with echelle spectra ($R = 9000$ to 11000)
and for the first time with echelle spectra on 14th of August: 12 hours time scale
⇒ **Very fine timing (+/- 0.5 d)** of the major events, notably the rise of high ionized lines
AND
⇒ **Detection of fluctuations** which were unknown despite the modern observations of several outbursts

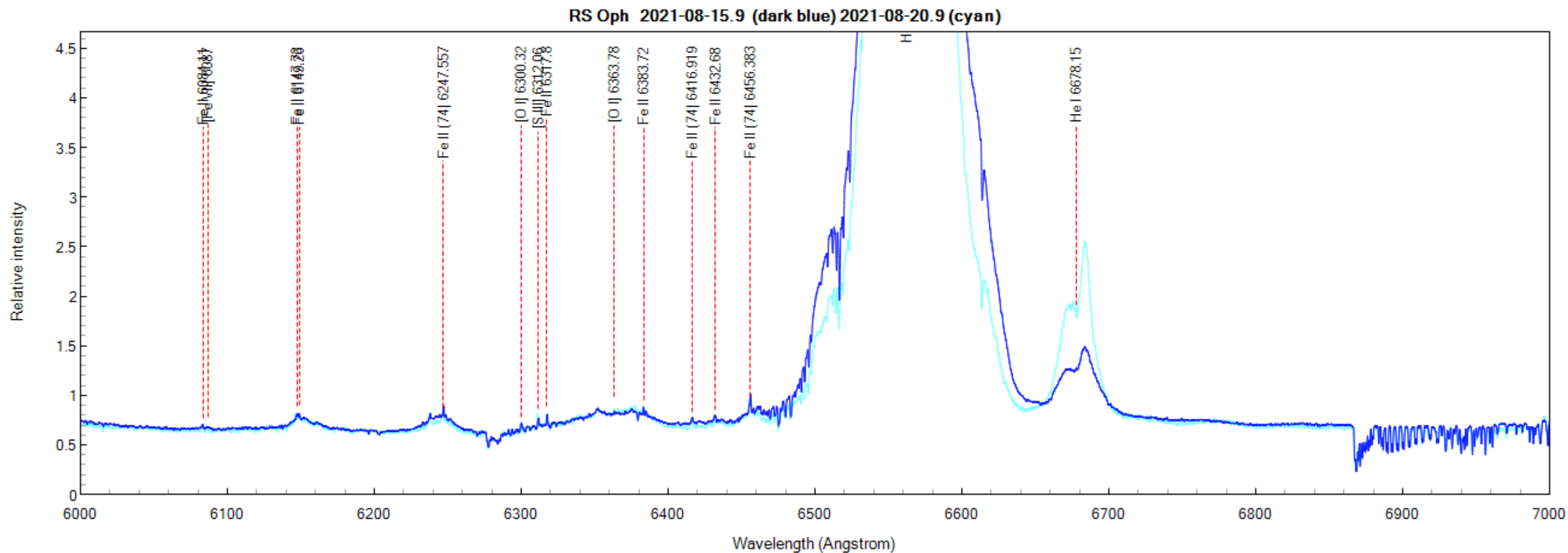
Echelle spectra used in this presentation were secured by:
Stephane Charbonnel (FR), Colin Eldridge (AU), Olivier Garde (FR),
Joan Guarro (SP), Olivier Thizy (FR), François Teyssier (FR-SP)

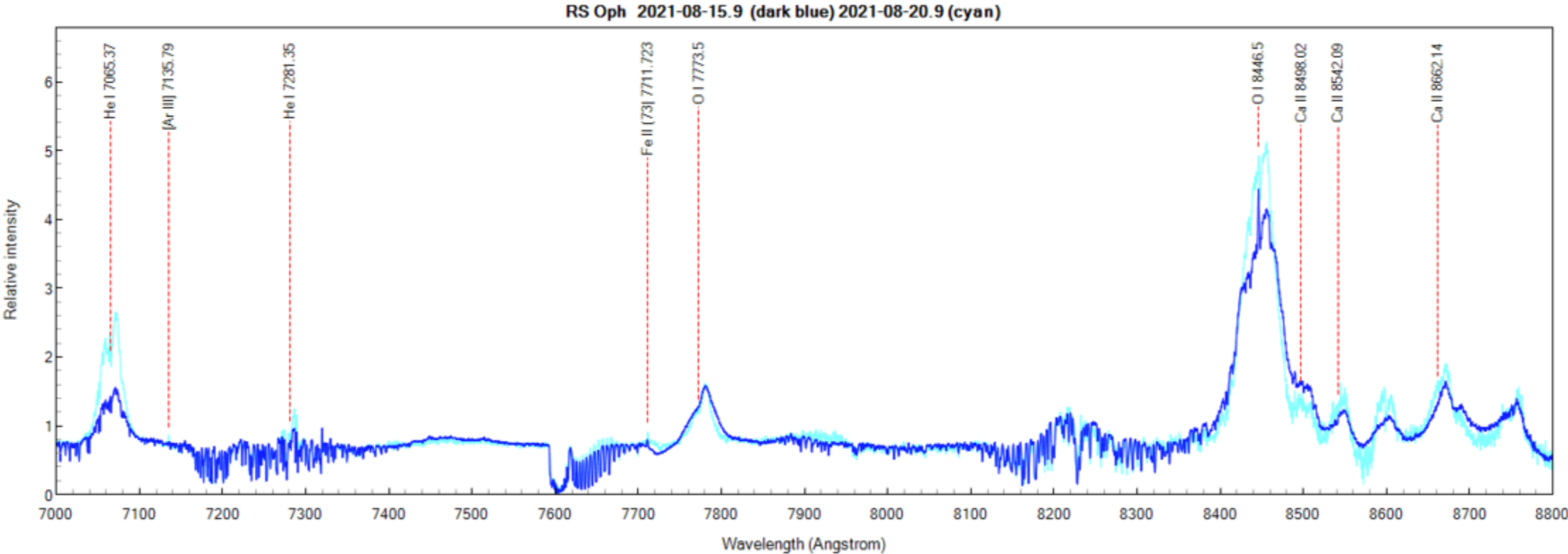
Page 11: the development of the spectrum
using LISA spectra ($R = 1000$) obtained by David Boyd, Pavol Dubovsky, Keith Shank
and Alpy spectrum obtained by Jean-Bruno Desrosiers



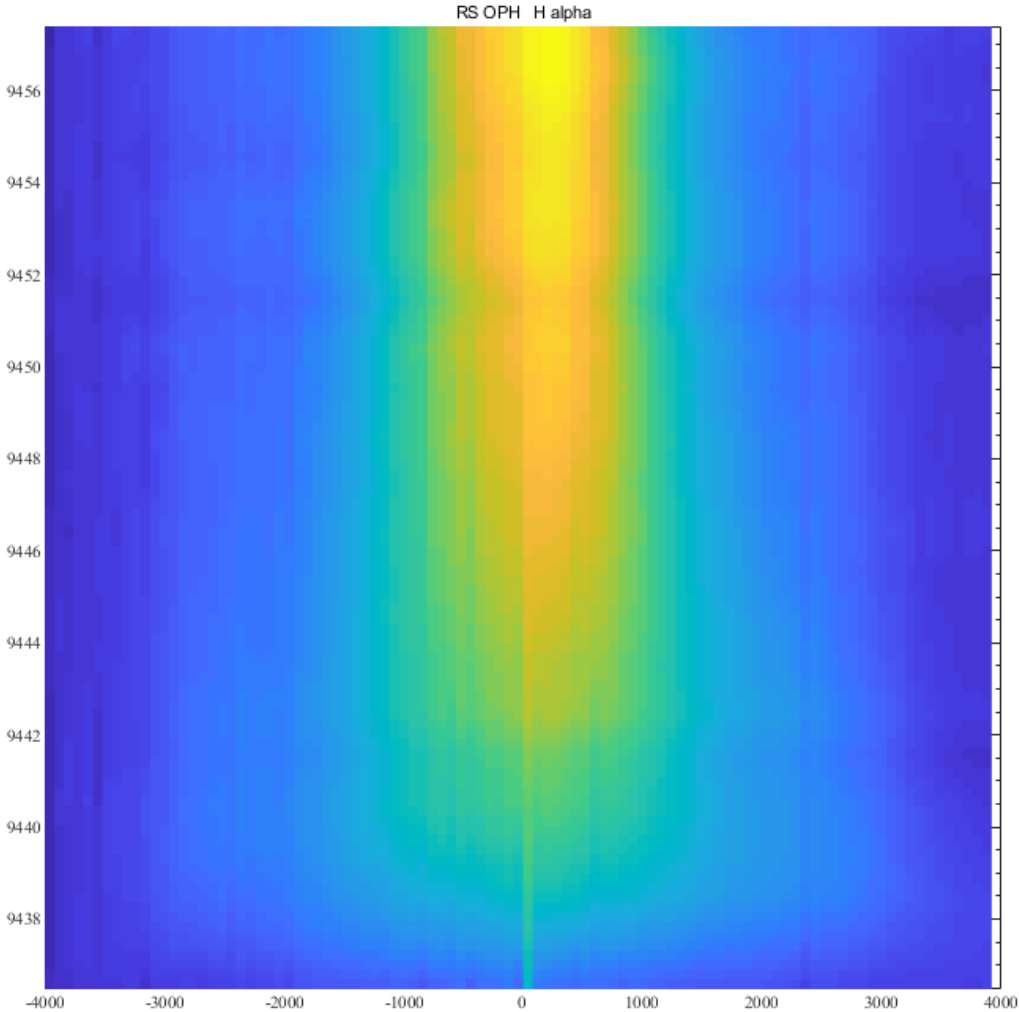
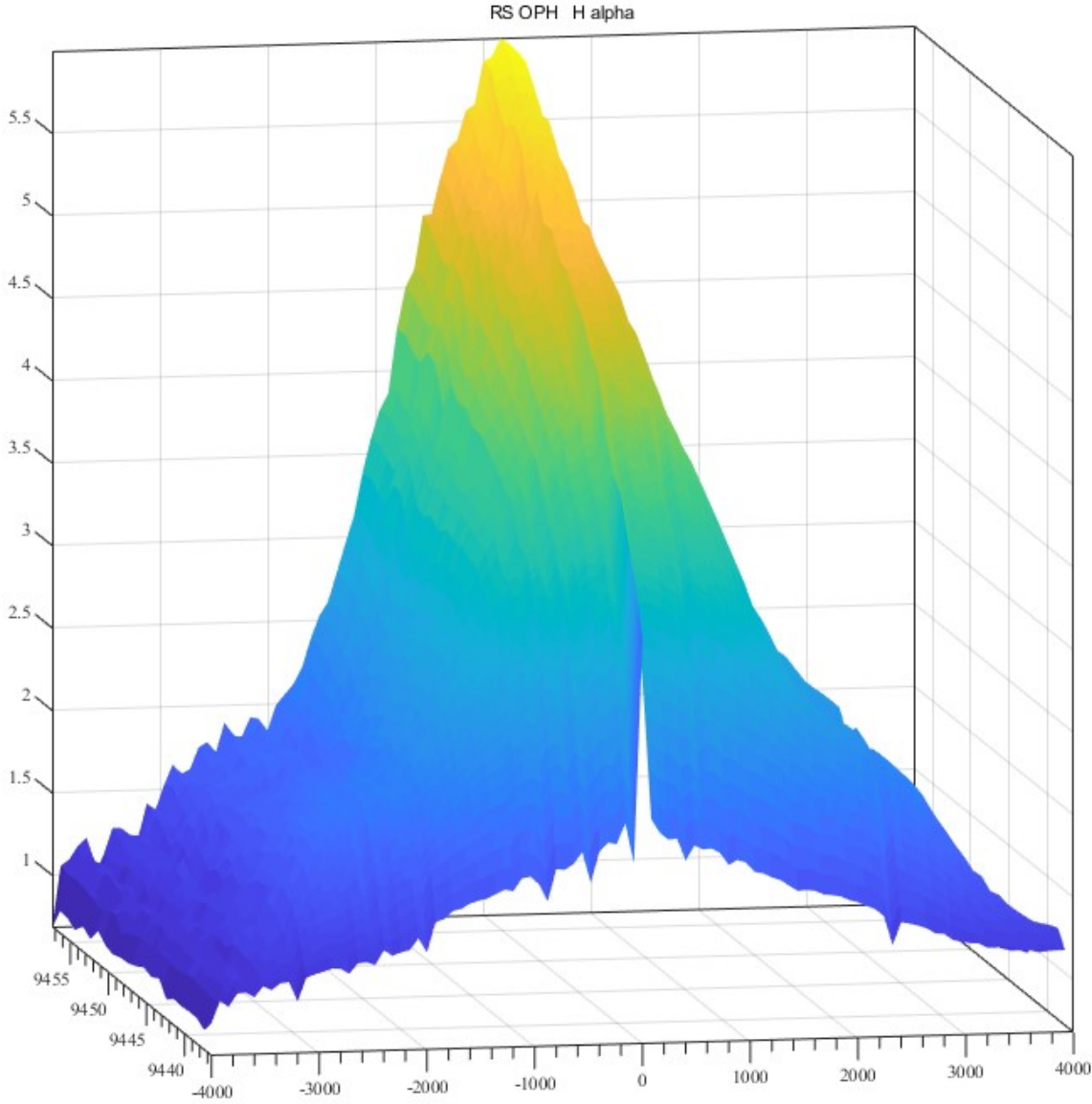




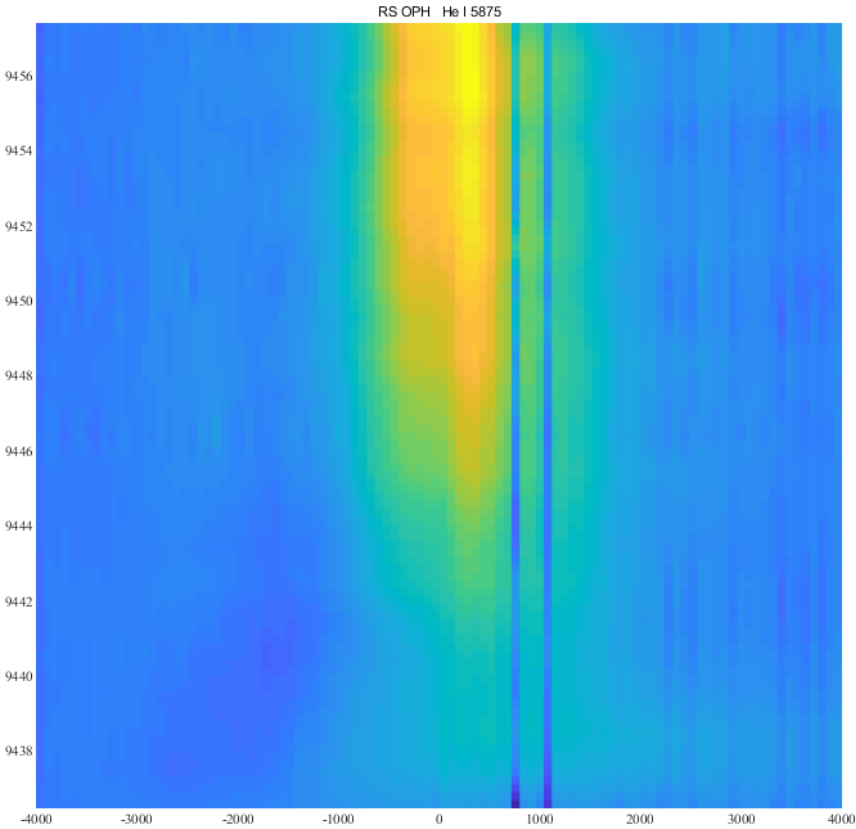
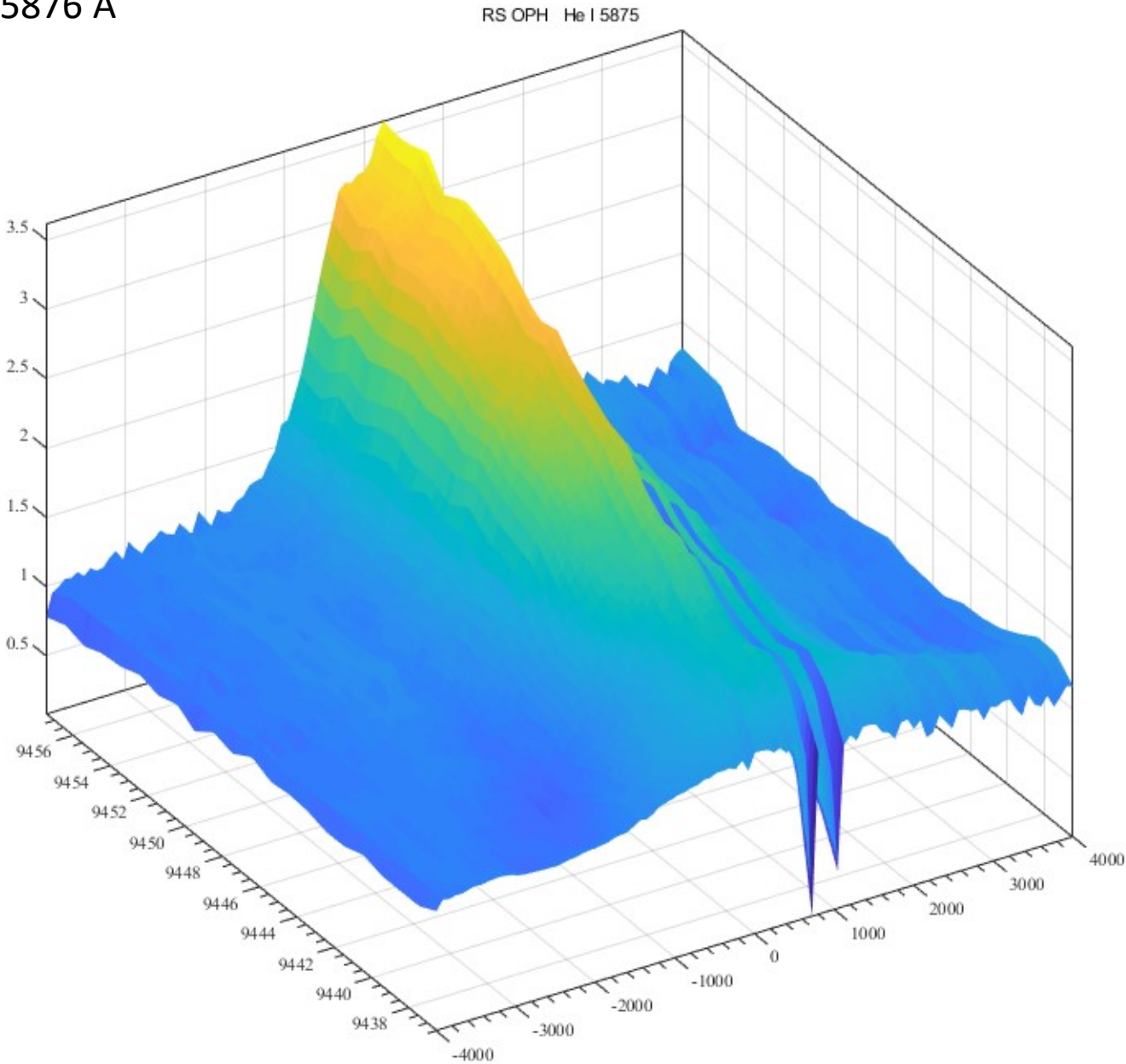




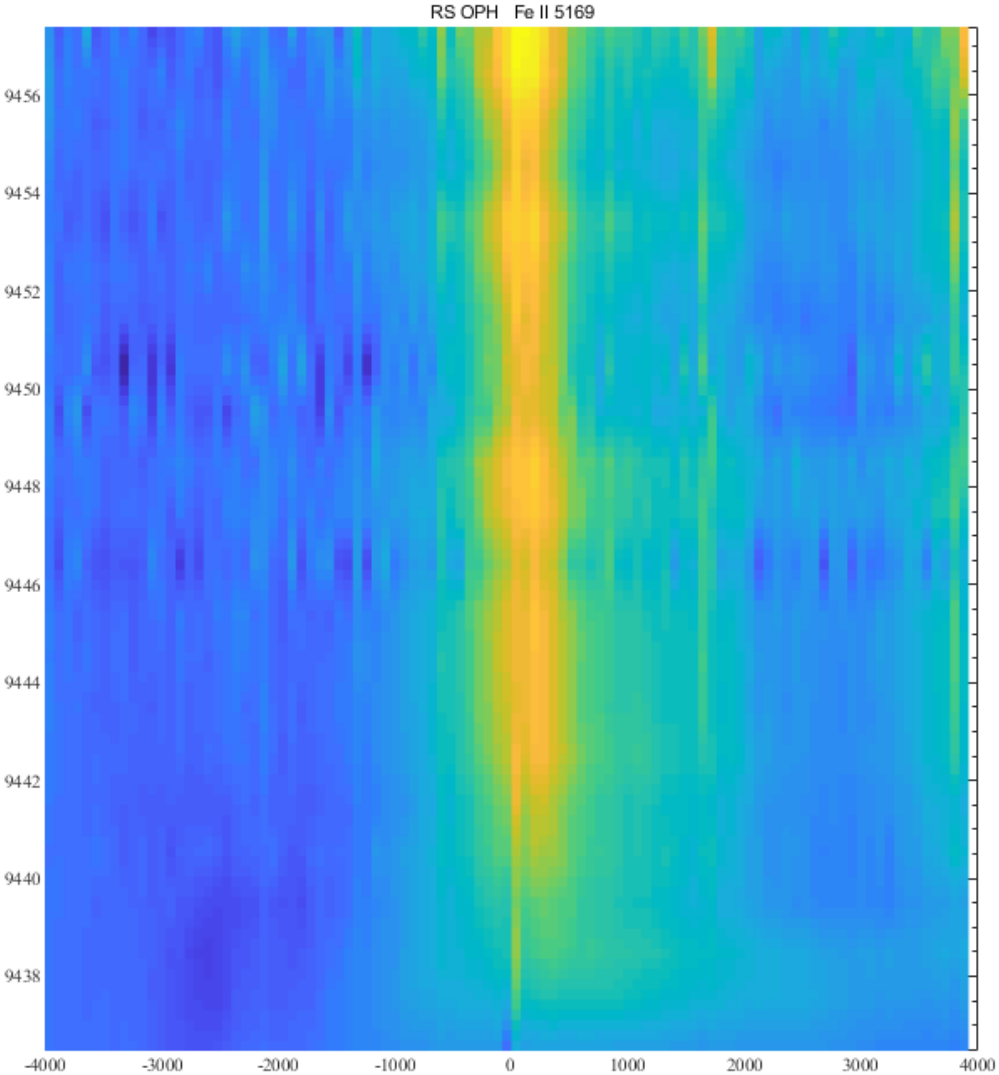
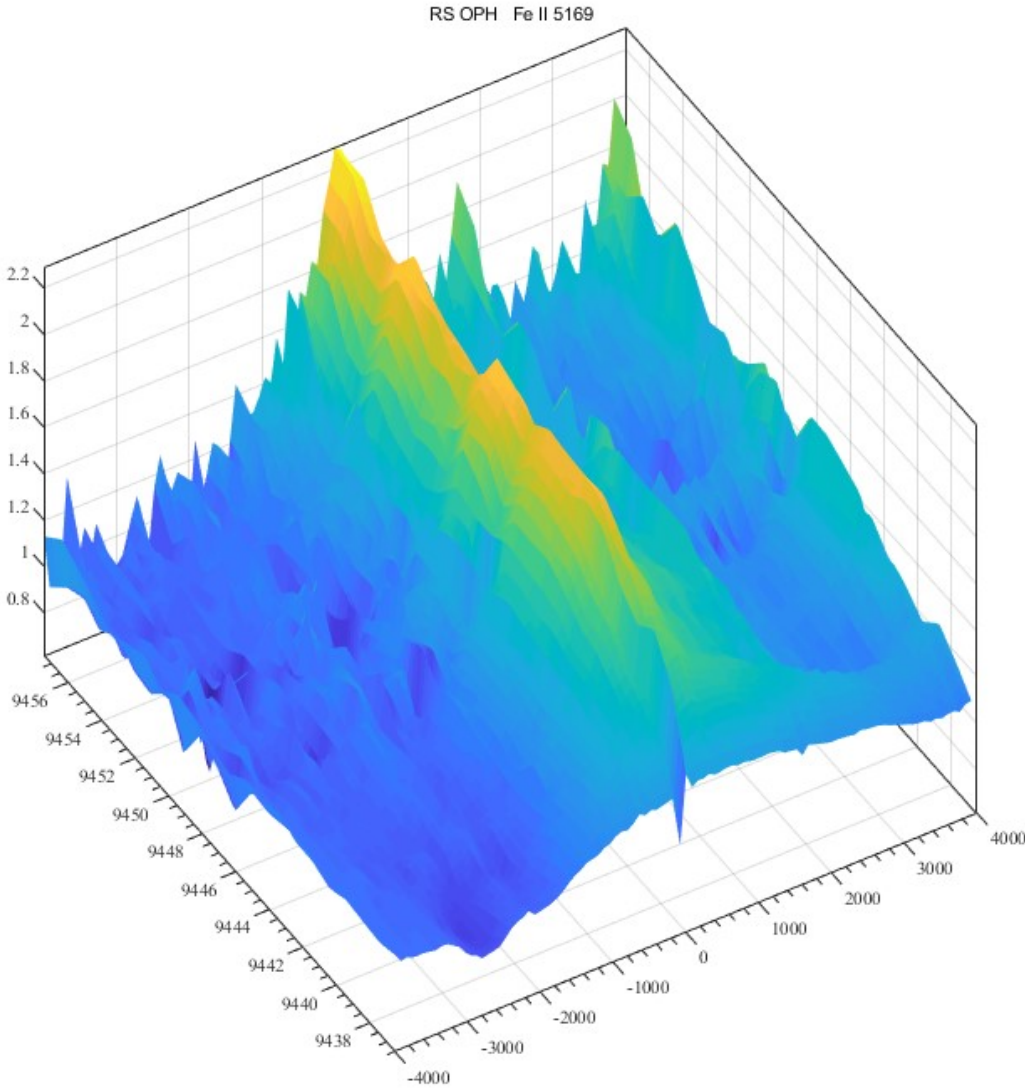
H alpha



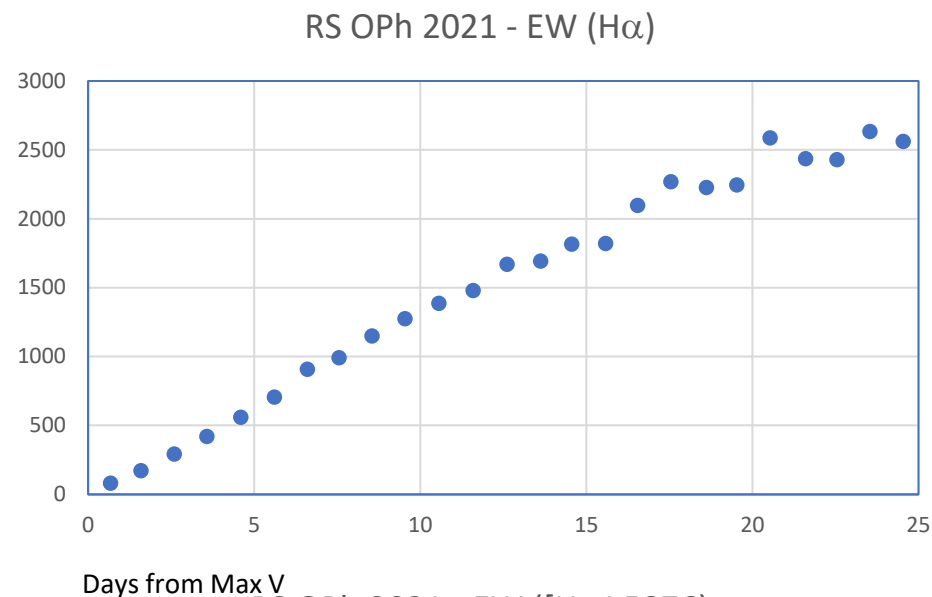
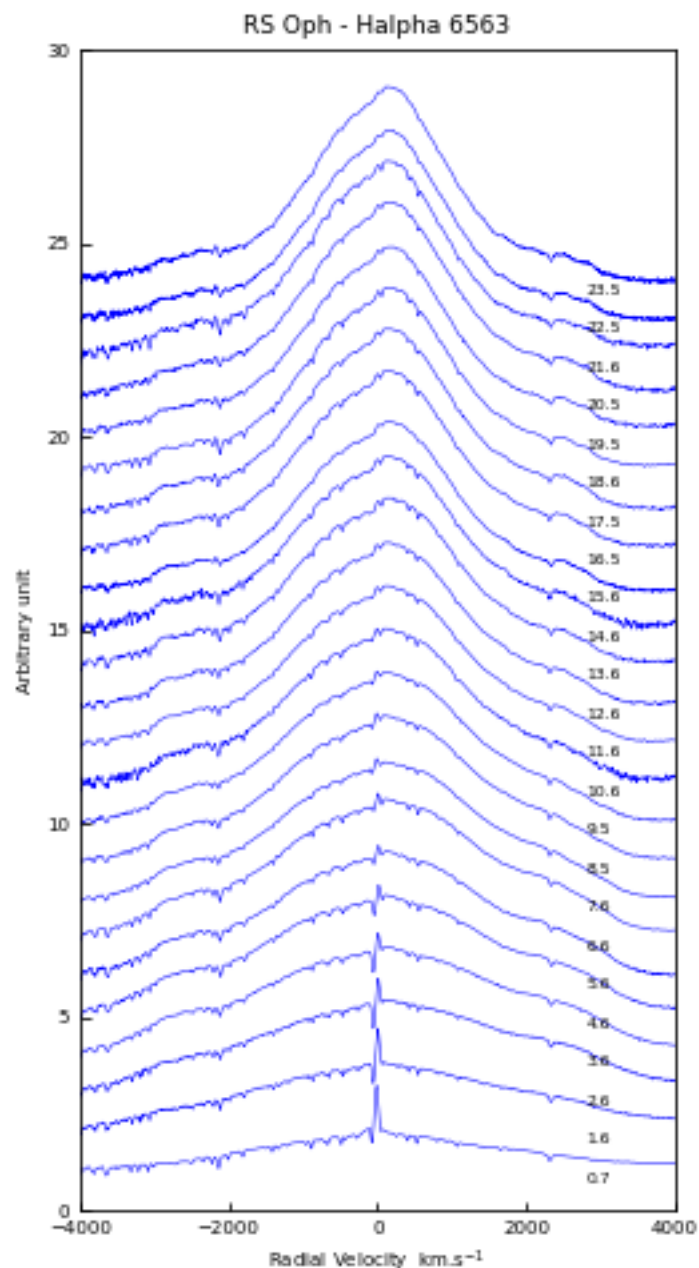
He I 5876 Å



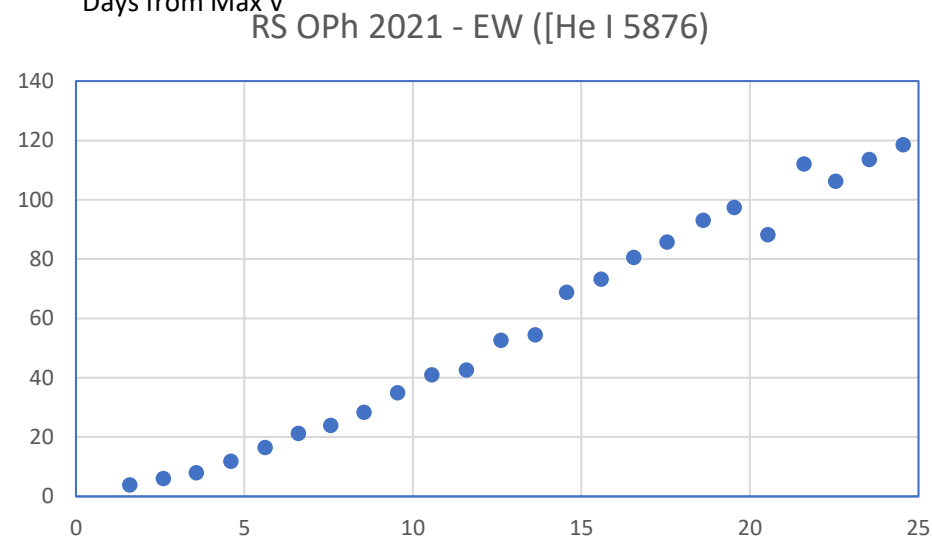
Fe II (42) 5269 Å



RS Oph 2021 Nova outburst The first 24 days

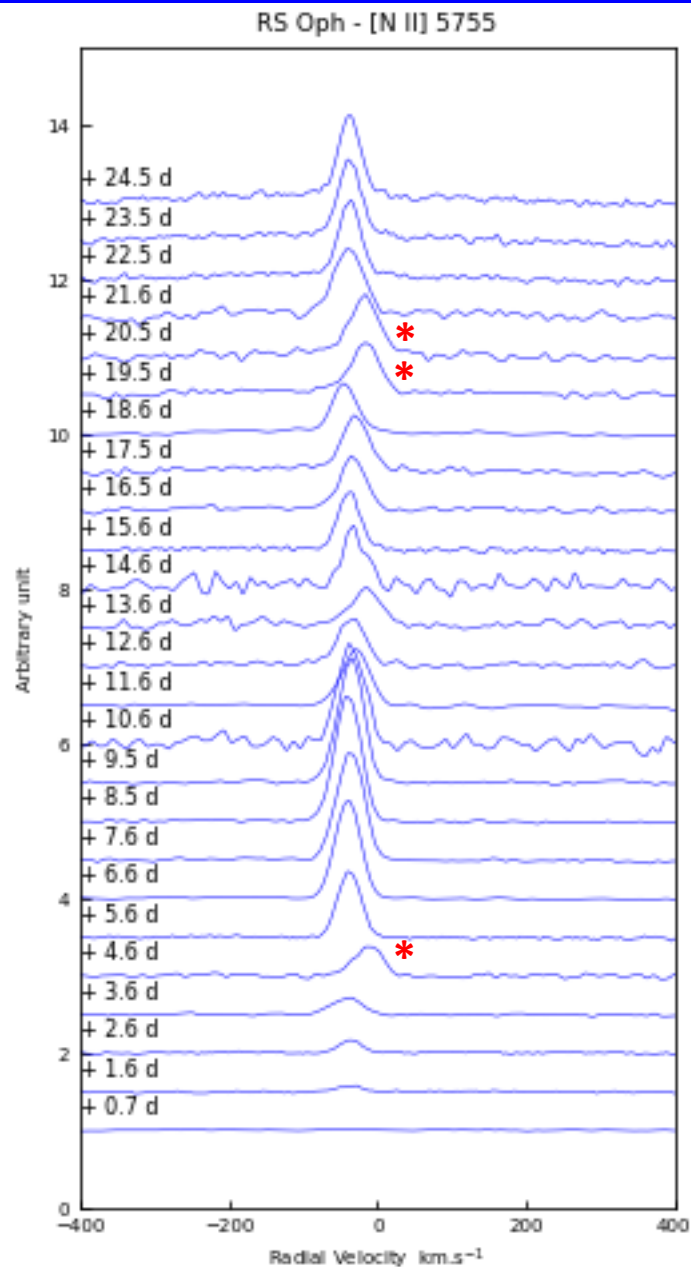


Preliminary
but promising
results

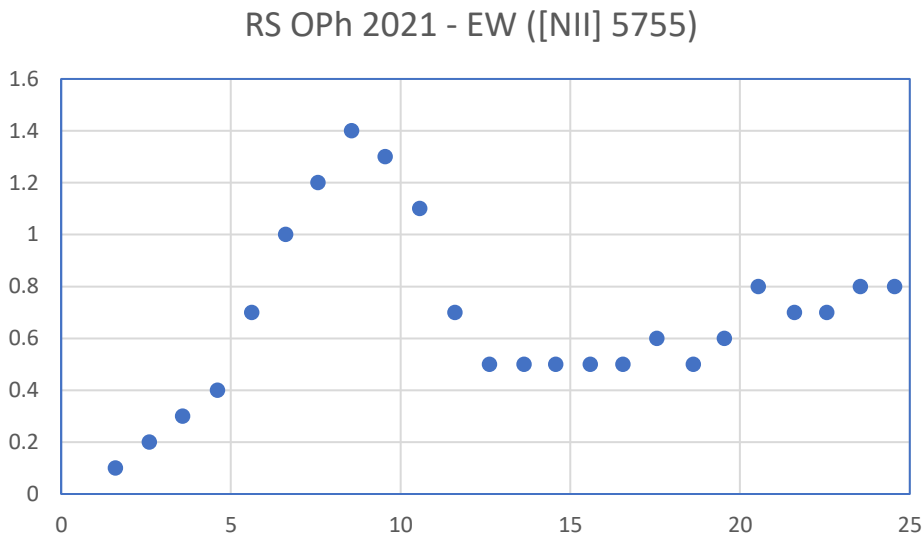


Relative flux in log scale

RS Oph 2021 Nova outburst The first 25 days

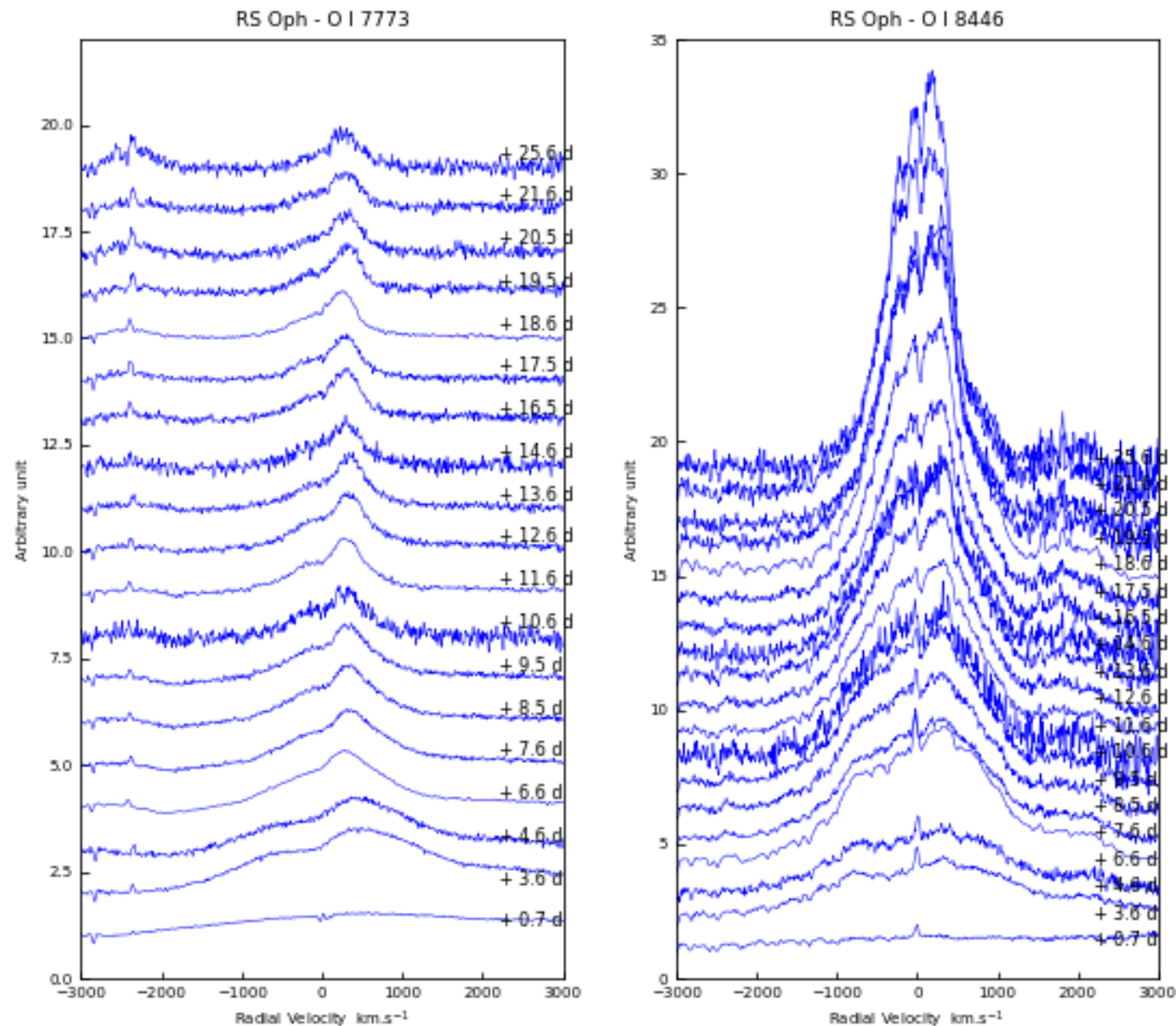


[N II] 5755 Å
I.E. = 14.5 eV
 $\text{Ne}_{\text{crit}} =$



Detected early at day +1.6
As a narrow line (FWHM $\sim 46 \text{ km.s}^{-1}$)
 $\text{RV} \sim -12 \text{ km.s}^{-1}$

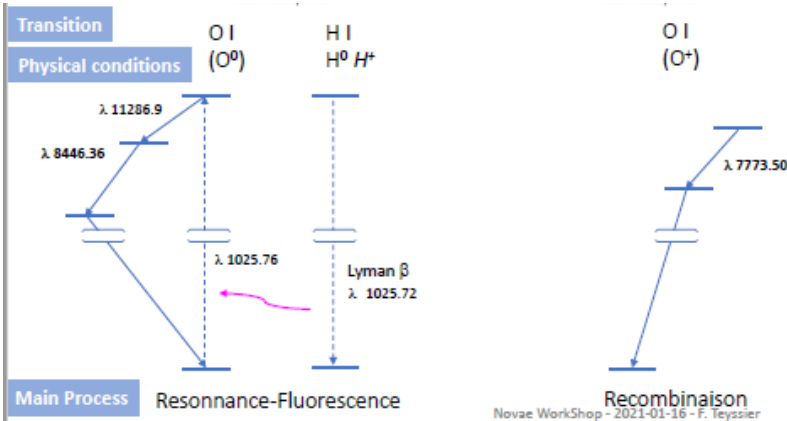
* : HRV to be corrected



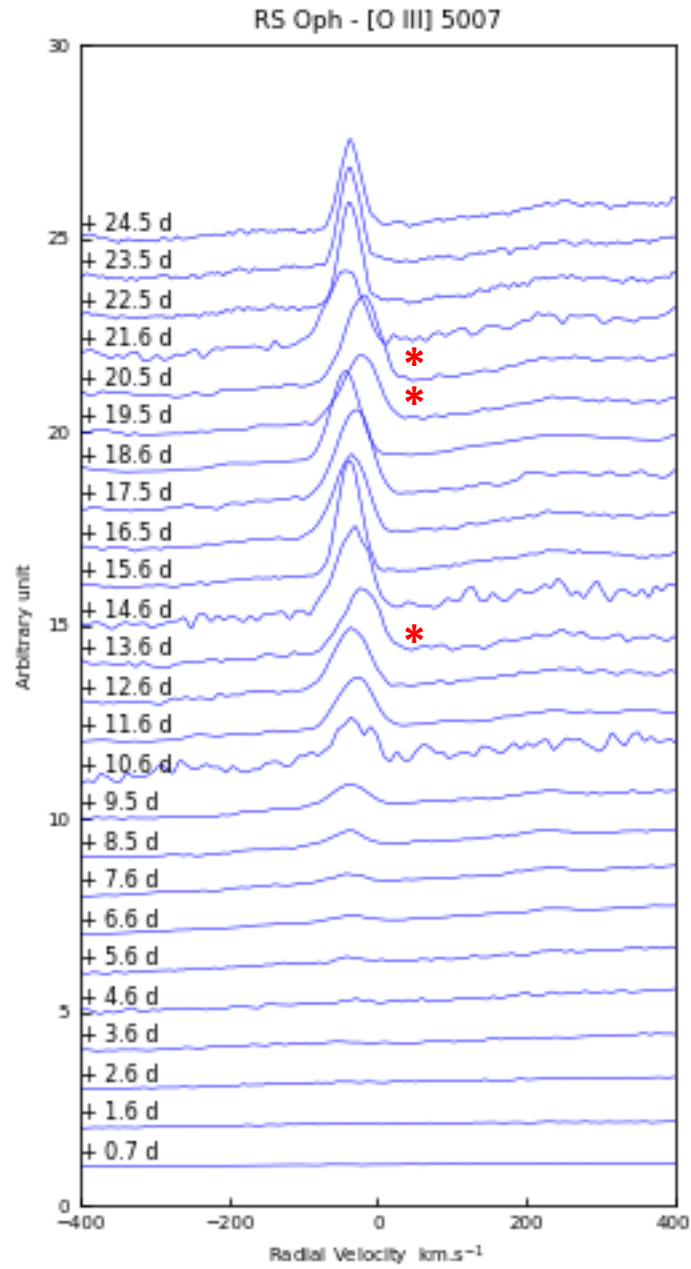
O I 7773, 8446 Å

From spectra obtained with NOUT
At SMM-SP and PIE-SP observatories

See also Paolo Berardi spectra
Obtained with Lhires III

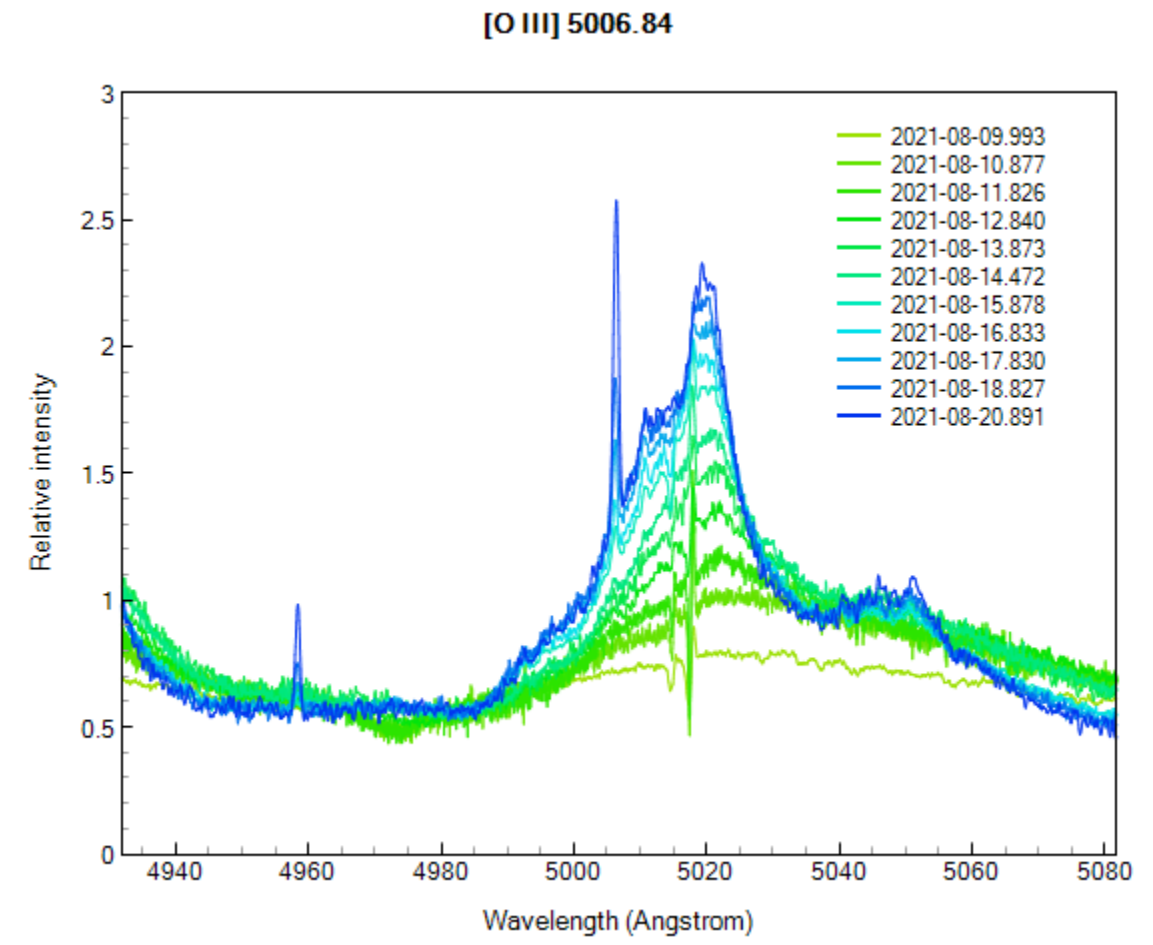


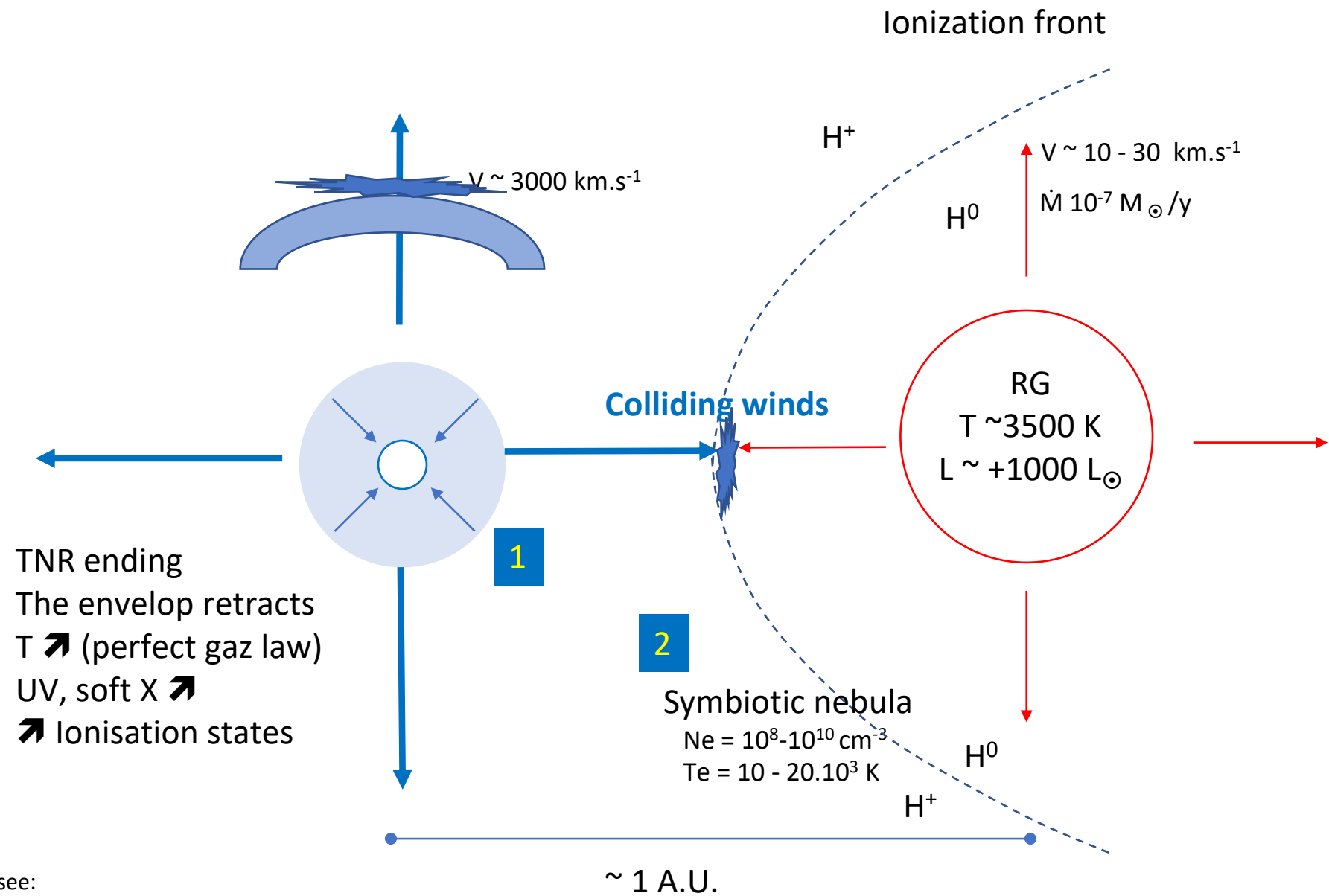
RS Oph 2021 Nova outburst The first 24 days



I.E. = 35.1 eV
 $Ne_{crit} = 3.6 \cdot 10^3$

Detected as soon as day +5
As a narrow line (FWHM ~ 55 km.s-1)
RV ~ -36 km.s-1





[1] see:
http://www.astronomie-amateur.fr/Talks/2020_Novae_Part1_EN.pdf

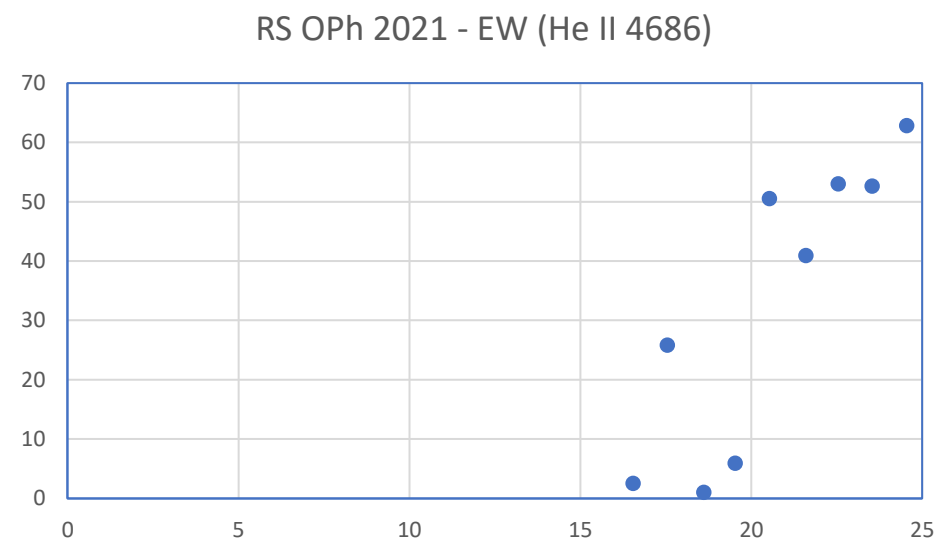
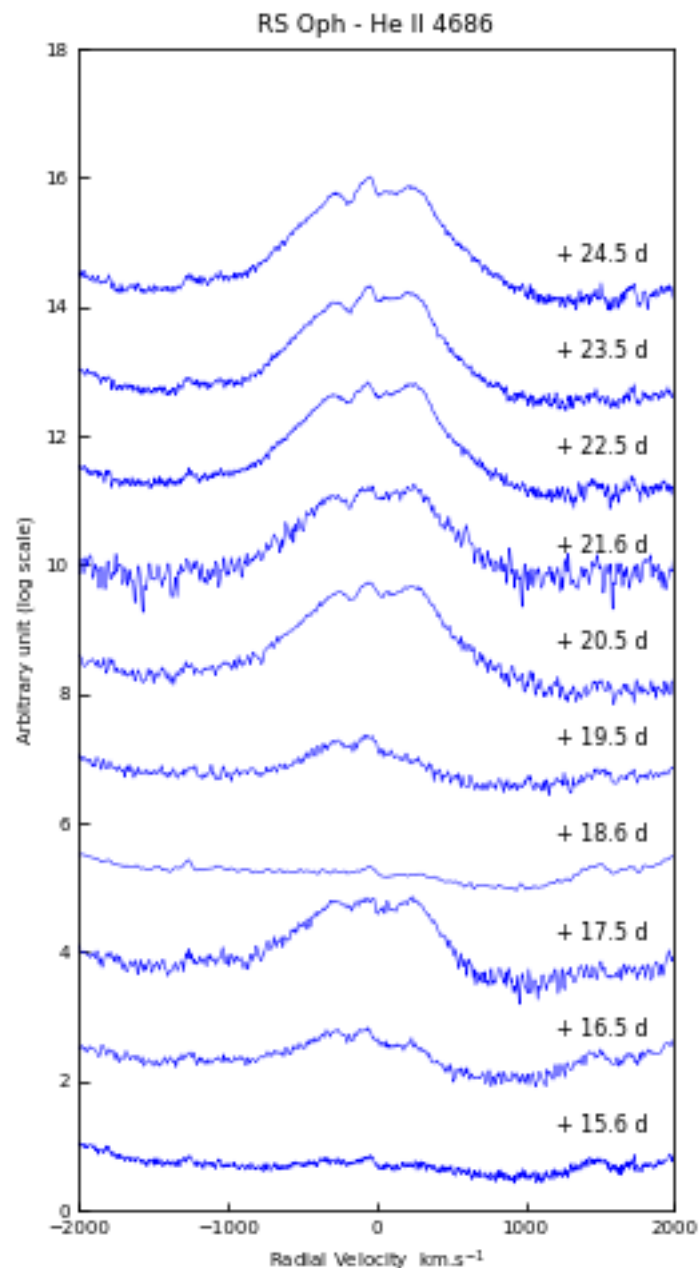
He II λ 4686 Å Recombination I.E. = 54.4 eV

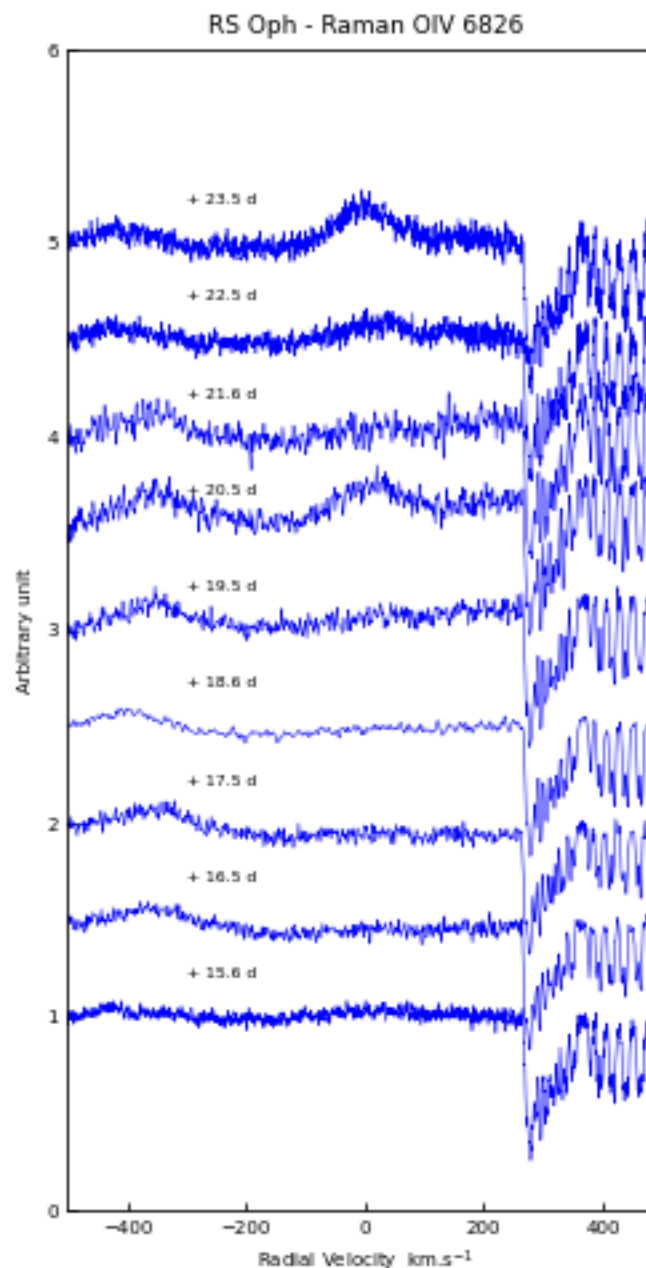
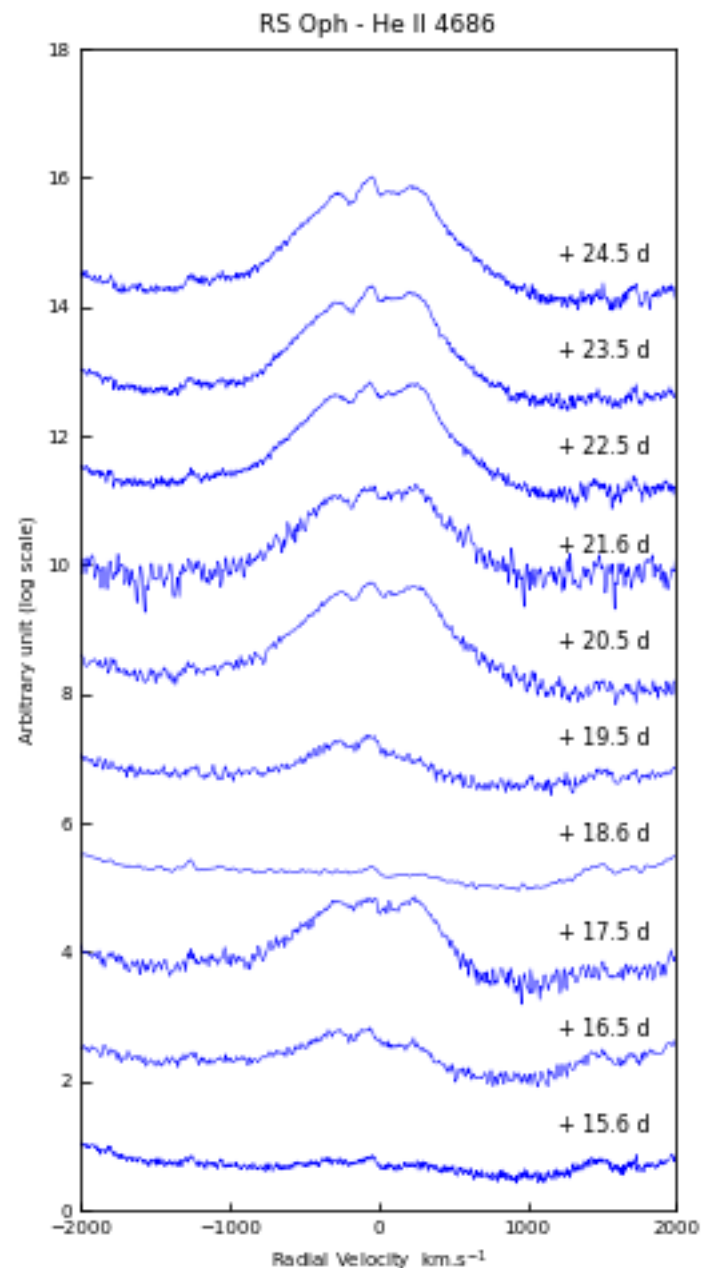
Sudden appearance
On day 16 (+/- 0.5)
Then **fading to near 0**
on day 18.6
And recovers
from day 19.5

**First detection
of this rapid variation
during an outburst
of RS Oph
as a result of high cadency
monitoring**

The result was so unexpected
that we use low res spectra
for confirmation
(H. Allen, V. Lecoq,
K. Shank, P. Velez)

ATel #14883





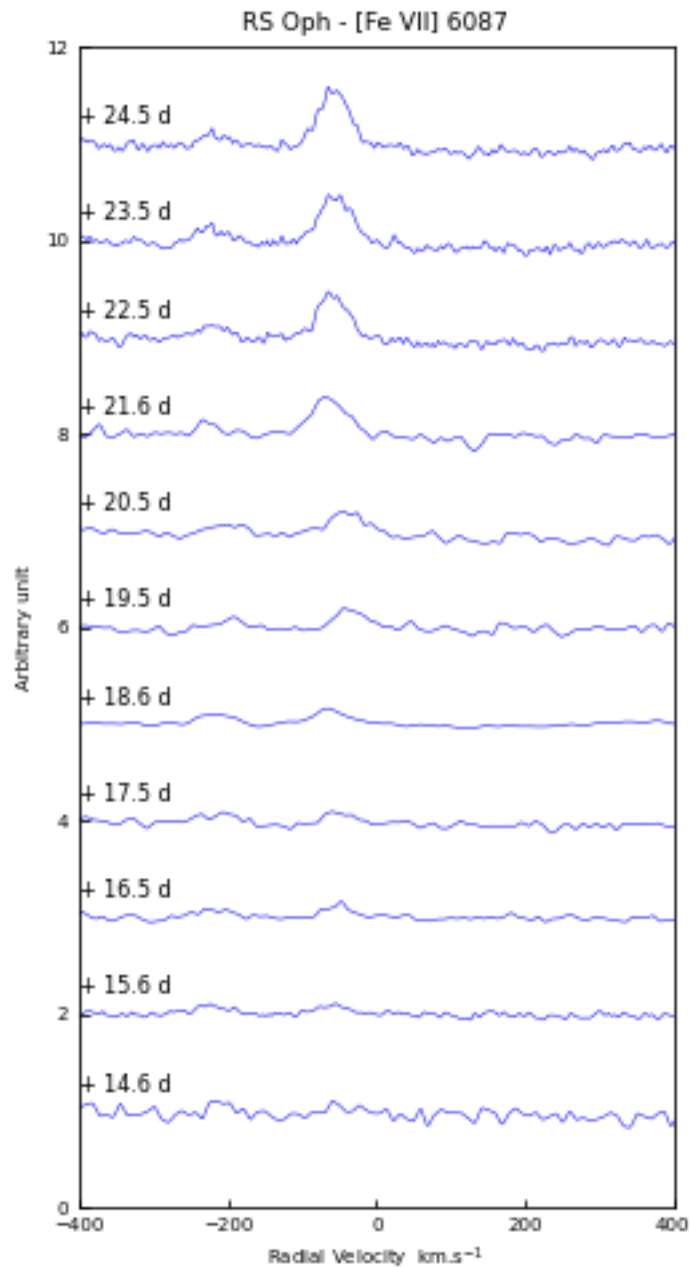
Raman OVI λ 6825 Å
Raman scattering
of OVI $\lambda\lambda$ 1032, 1038
I.E. = 138 eV

Detected on day 19.5
($\pm$ 0.5)
Variations

FWHM $\sim$
Narrow

Iijima 2006 detection
at days 5-7
Is very doubtful

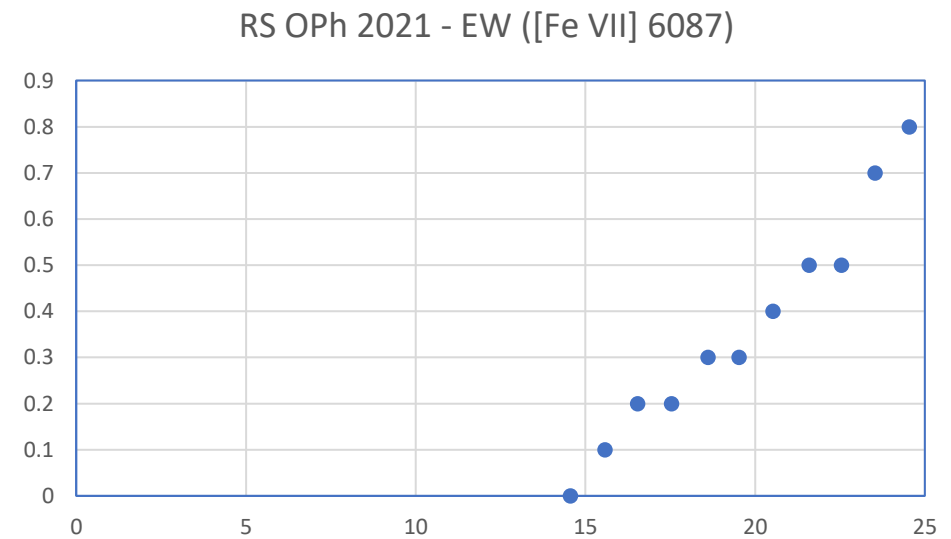
Note: radial velocity
in the space of OVI 1032
i.e. divided by 6.7



[Fe VII] 6087 Å

I.E. = 75 eV

Detected,
very faint
on day 15.6 (+/- 0.5)



Provisional assessment

1day cadency monitoring at $R = 9000\text{--}11000$ on the visual range

We produced –very probably- the best monitoring of a nova event in RS Oph system- But see also: <https://arxiv.org/abs/2109.01101>

- Fine timing of the evolution ± 0.5 day
- Demonstration of significant short-term fluctuations in the evolution of certain lines

Ongoing monitoring at 1 day cadency

- With perhaps new surprises
- Towards very high ionized species

High cadence of both photometric and spectroscopic observations as provided by AAVSO and ARAS databases allows a detailed mapping of usually fast events of outbursts
A. Skopal, 2019

Thanks to amateur photometric and spectroscopic data, we are now able to monitor the evolution of symbiotic systems on timescales which were not previously available.
R. Gális & al., 2019

Follow the monitoring

On ARAS Forum

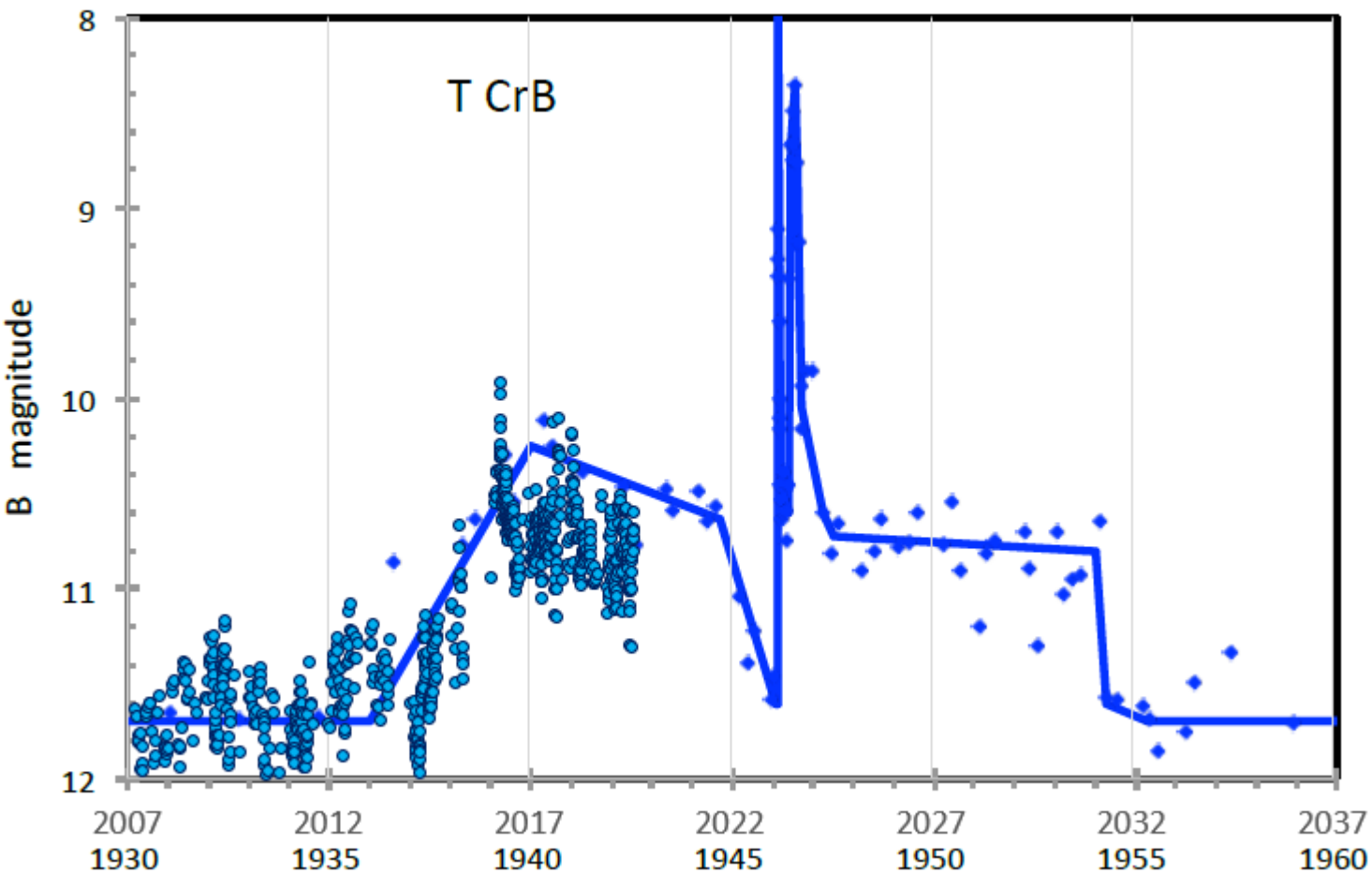
<http://spectro-aras.com/forum/viewtopic.php?f=36&t=2804&start=80>

Your observations, taken with higher cadence than usually followed in the literature will be key to understanding this in a broad range of systems. S. Shore, 2015

Your dedication, interest, and persistence are continuing gifts to the community, to future generations who may eventually be able to understand these phenomena because of the precision and care of your contributions. You may think it's just one spectrum, or one datum, but without the history any inferences are tentative at best and misleading at worst. S. Shore, 2020

T CrB

Pre-nova outburst monitoring



Adapted from Brad Schaeffer

Diamonds : 1946 Brad Shaeffer data

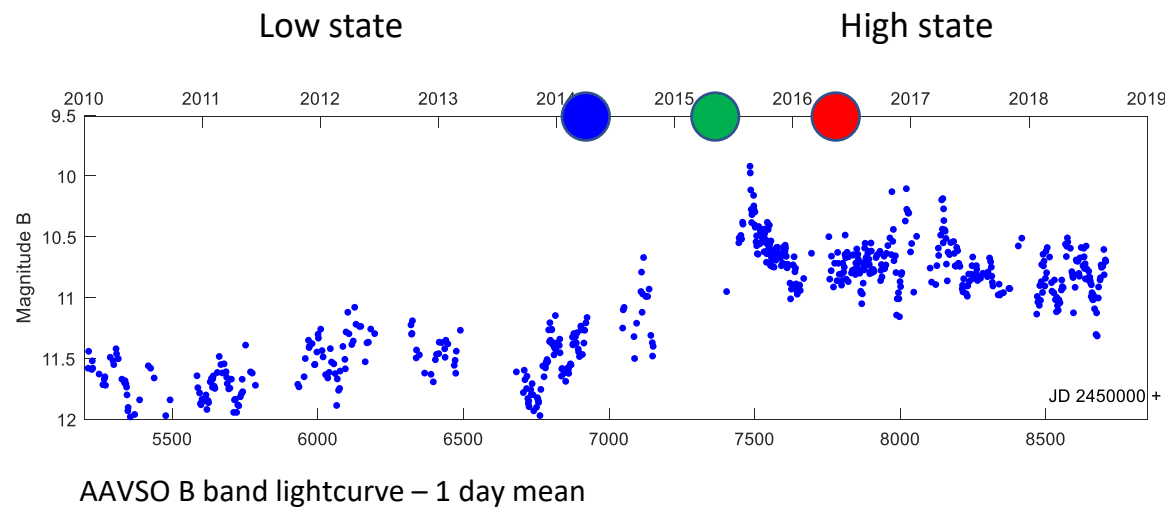
Dots : AAVSO B band - 1 day mean

Outburst predicted : 2023.6 +/-1

T CrB

T CrB high state since 2015

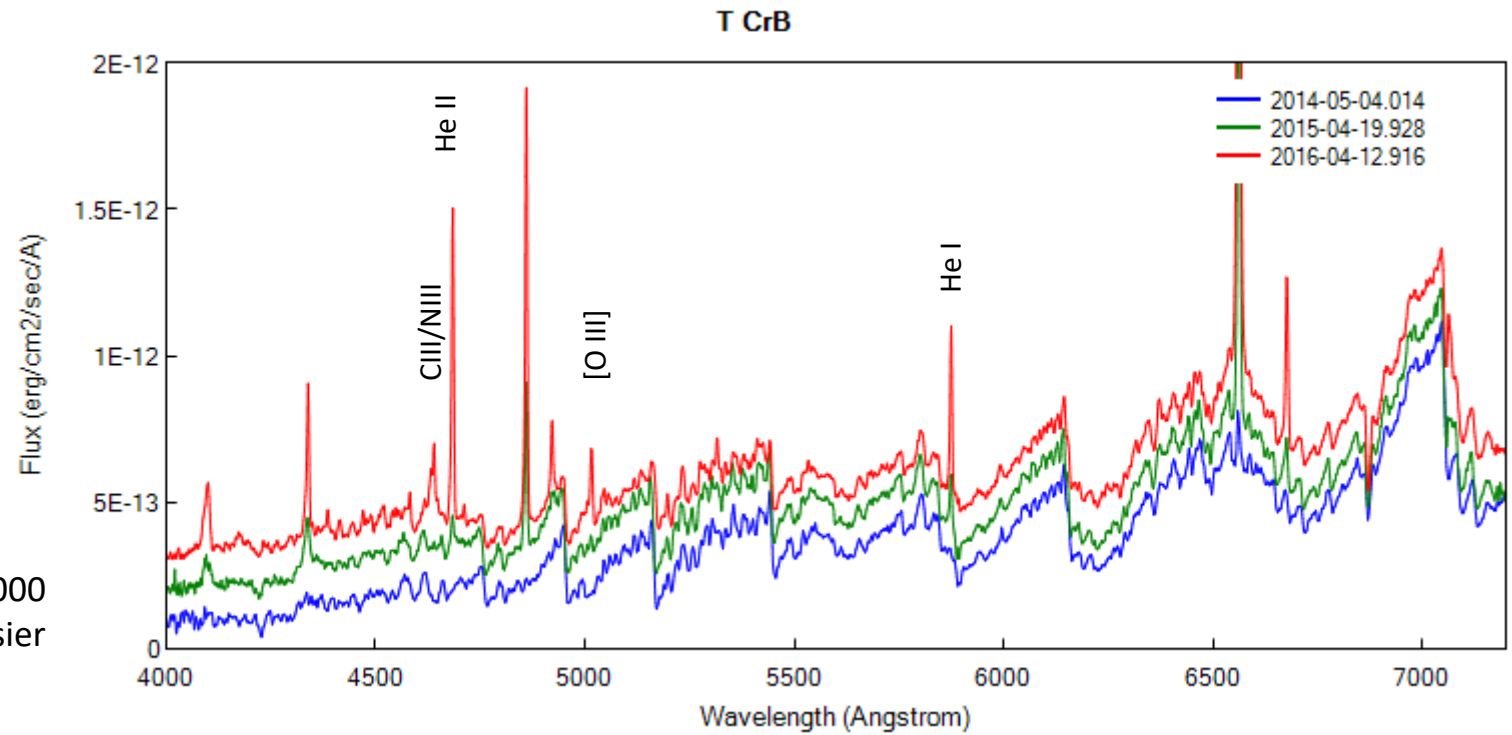
see e.g. :
Munari +, 2016
Ielkiewicz+,



Low state : MIII + weak Balmer lines

- High state
- Increase of
- Balmer, He I
 - He II, CIII/NIII, [OIII]

LISA spectroscope R = 1000
D. Boyd, F. Teyssier



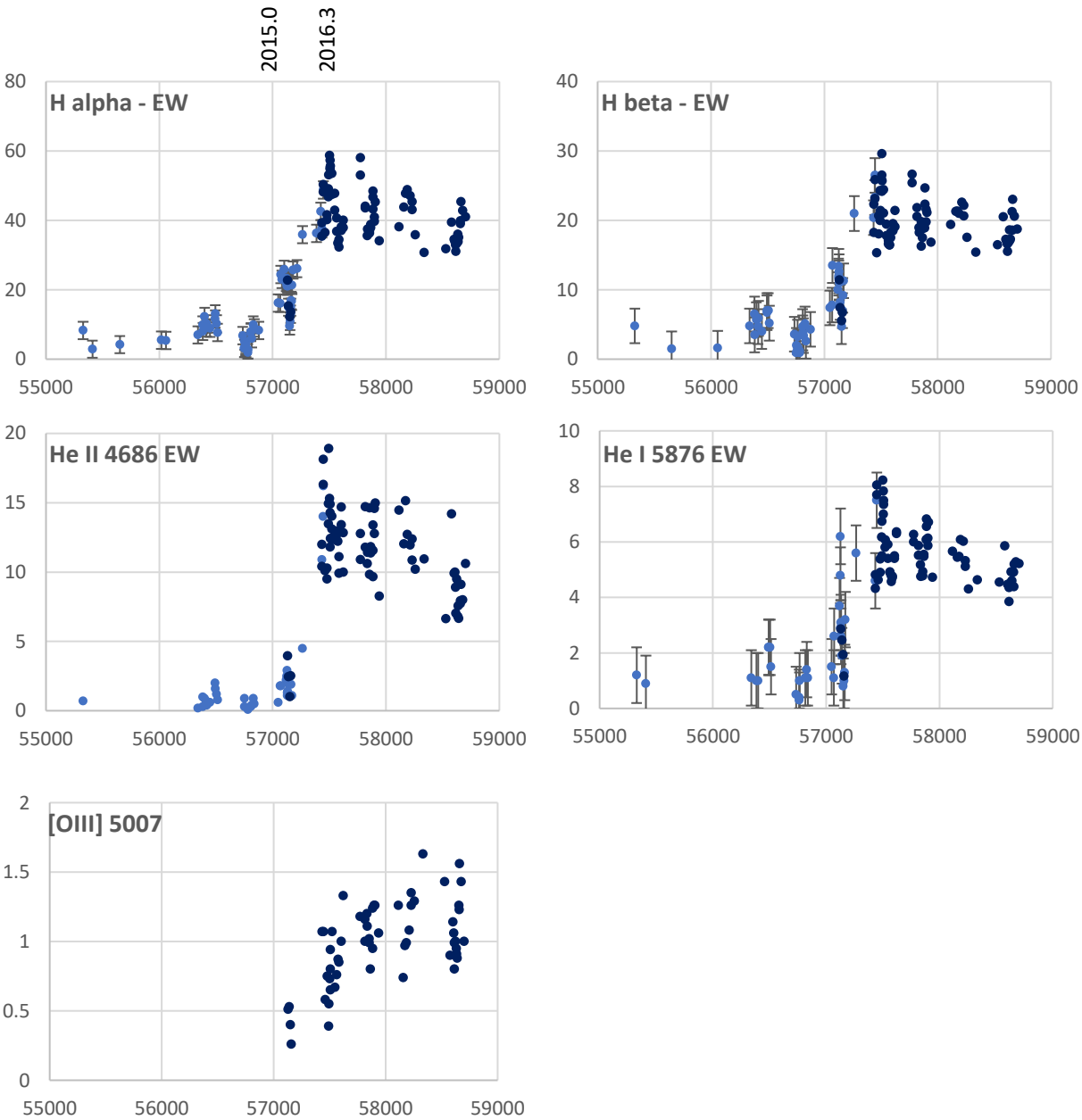
T CrB

Continuing analysis following
Ilkiewicz & al. (2016)

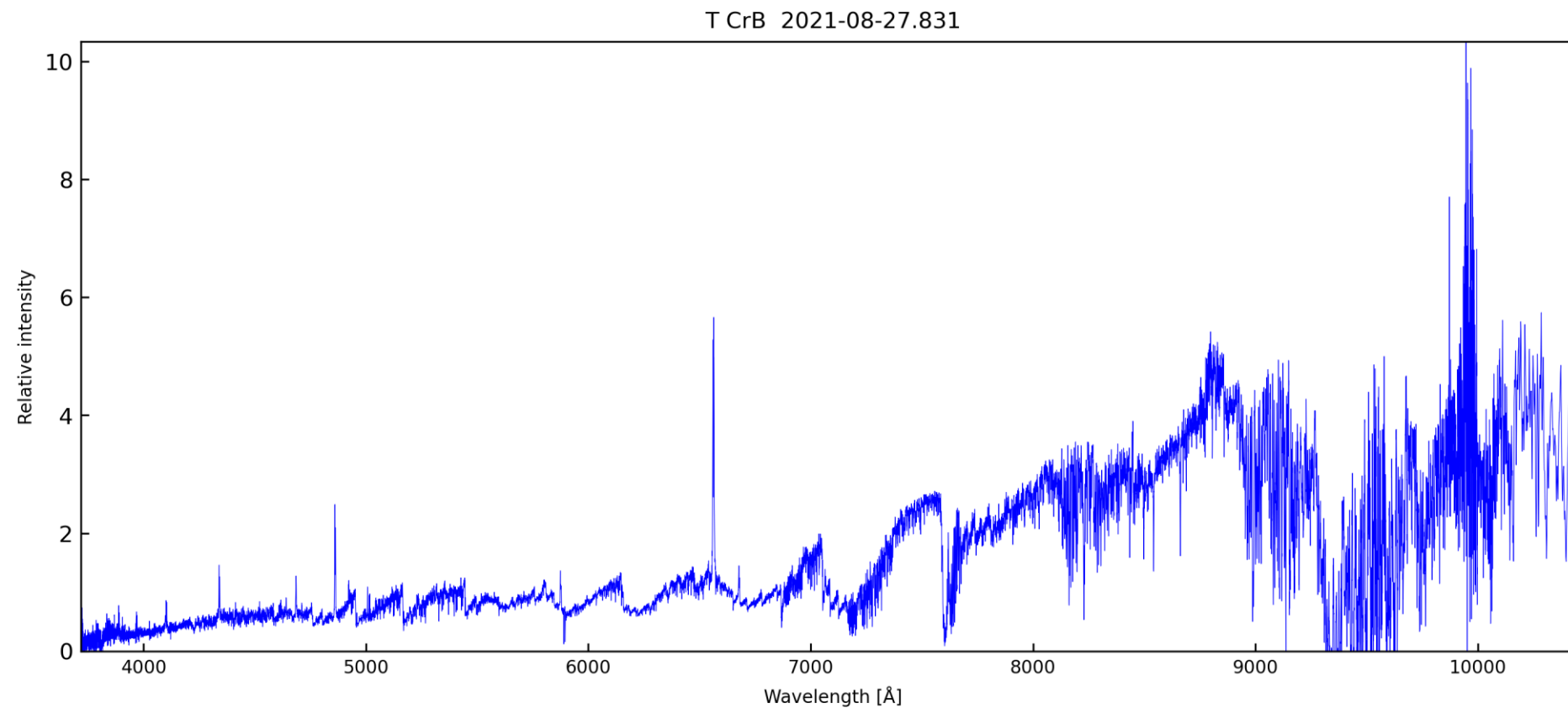
Pale blue: published values
Dark blue: our analysis

Global trend of decline
In parallel to the fading of the luminosity
BUT
Increase of [OIII]

Maximum EW(H α) = 60



Last échelle spectrum



Last échelle spectrum obtained by Joan Guarro

Christian Buil
Christophe Boussin
Colin Eldridge
Dave Doctor
David Boyd
Erik Bryssinck
François Teyssier
Hamish Barker
Hugh Allen
Jack Martin
Jean-Bruno Desrosiers
Jean-Loup Lemaire
Jean-Michel Vienney
Joan Guarro
Kevin Bazan
Lorenzo Franco
Mariusz Bajer
Olivier Garde
Olivier Thizy
Paolo Berardi
Pascal Le Dû
Peter Velez
Pierre Dubreuil
Robin Leadbeater
Sean Curry
Stéphane Charbonnel
Terry Bohlson
Umberto Sollecchia
Vincent Lecocq

All my (and our)
deep gratitude to Steve
for his tireless support

Many thanks
to all the observers
who are contributing
to the monitoring
of RS Oph 2021 event

The Astronomer's Telegram

ARAS Group spectroscopic monitoring of the latest outburst of RS Oph

ATel #14868; *S. N. Shore (Univ. of Pisa), H. Allen, M. Bajer, H. Barker, K. Bazan, P. Berardi, T. Bohlson, C. Boussin, D. Boyd, E. Bryssinck, C. Buil, S. Charbonnel, S. Curry, J. B. Desrosiers, D. Doctor, P. A. Dubovsky, P. Dubreuil, C. Eldridge, L. Franco, O. Garde, J. Guarro, P. Le Dû, R. Leadbeater, V. Lecocq, J. Martin, F. Teyssier, O. Thizy, P. Velez (ARAS Group)*
on 23 Aug 2021; 11:31 UT

Continuing ARAS Group spectroscopic monitoring of RS Oph: appearance of high ionization lines

ATel #14881; *S. N. Shore (Univ. of Pisa), F. Teyssier, O. Thizy (ARAS Group)*
on 28 Aug 2021; 12:30 UT

ARAS Group monitoring of RS Oph 2021: Rapid profile variations of He II detected

ATel #14883; *S. N. Shore (Univ. of Pisa), F. Teyssier, J. Guarro, H. Allen, V. Lecocq, K. Shank, P. Velez (ARAS Group)*
on 29 Aug 2021; 00:36 UT

Some lectures

What to expect and why:

RS Oph and Symbiotic-like recurrent novae (2021)

by Steve Shore

http://www.astrosurf.com/aras/novae/InformationLetter/ARAS_EruptiveStars_2020-04a.pdf

ARAS observing proposal: Recurrent symbiotic nova RS Oph A. Skopal & N. Shagatova (2019)

<https://ui.adsabs.harvard.edu/abs/2019ESIL...42....2T/abstract>

Multi-wavelength Spectroscopic Study of Shock Phenomena Driven by Explosive Outbursts in Symbiotic-like Recurrent Novae.

Alessandra Azzollini Thesis (Supervisor Steve Shore)

http://www.astronomie-amateur.fr/Documents%20Novae/Tesi_Azzollini.pdf