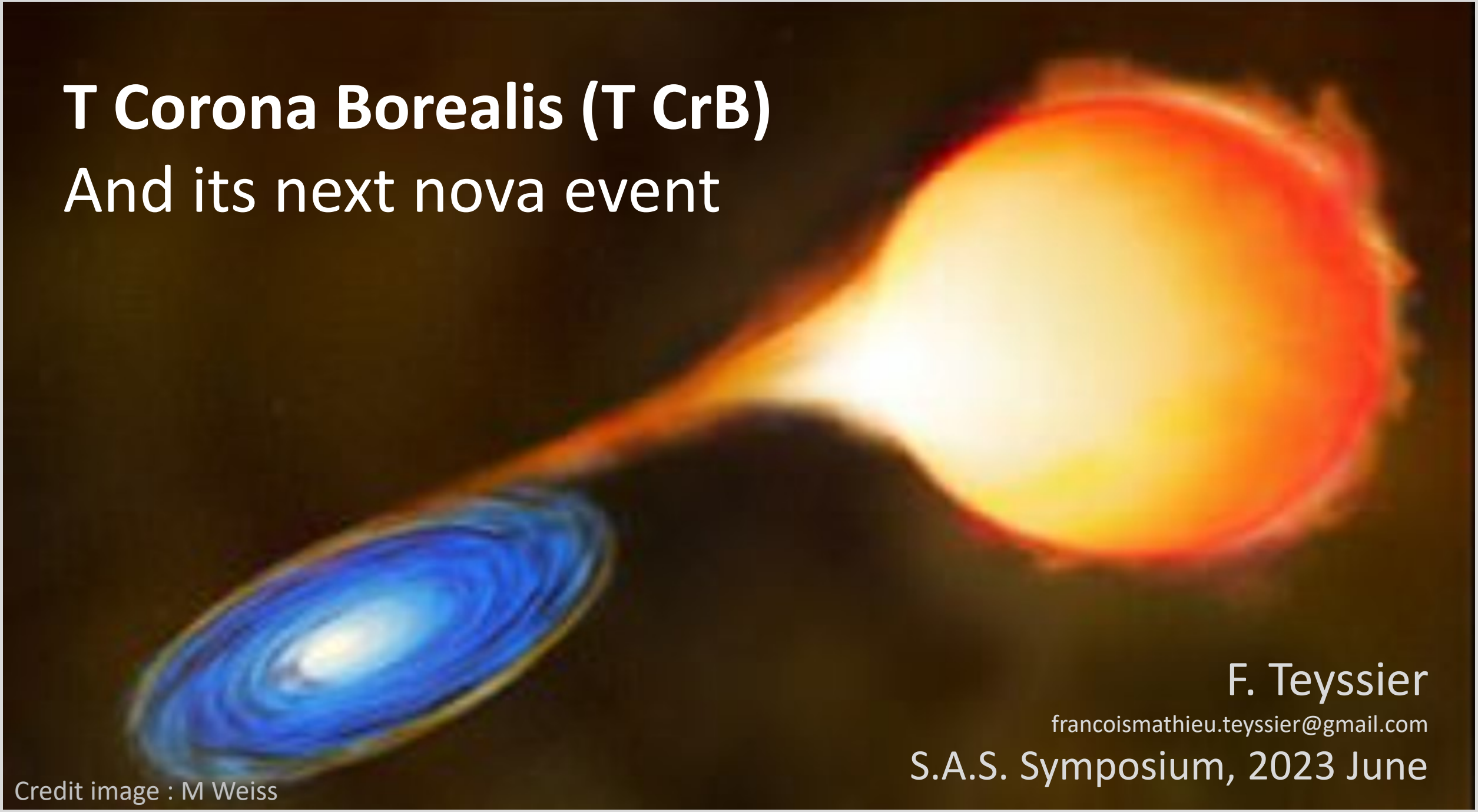
T Corona Borealis (T CrB)

And its next nova event



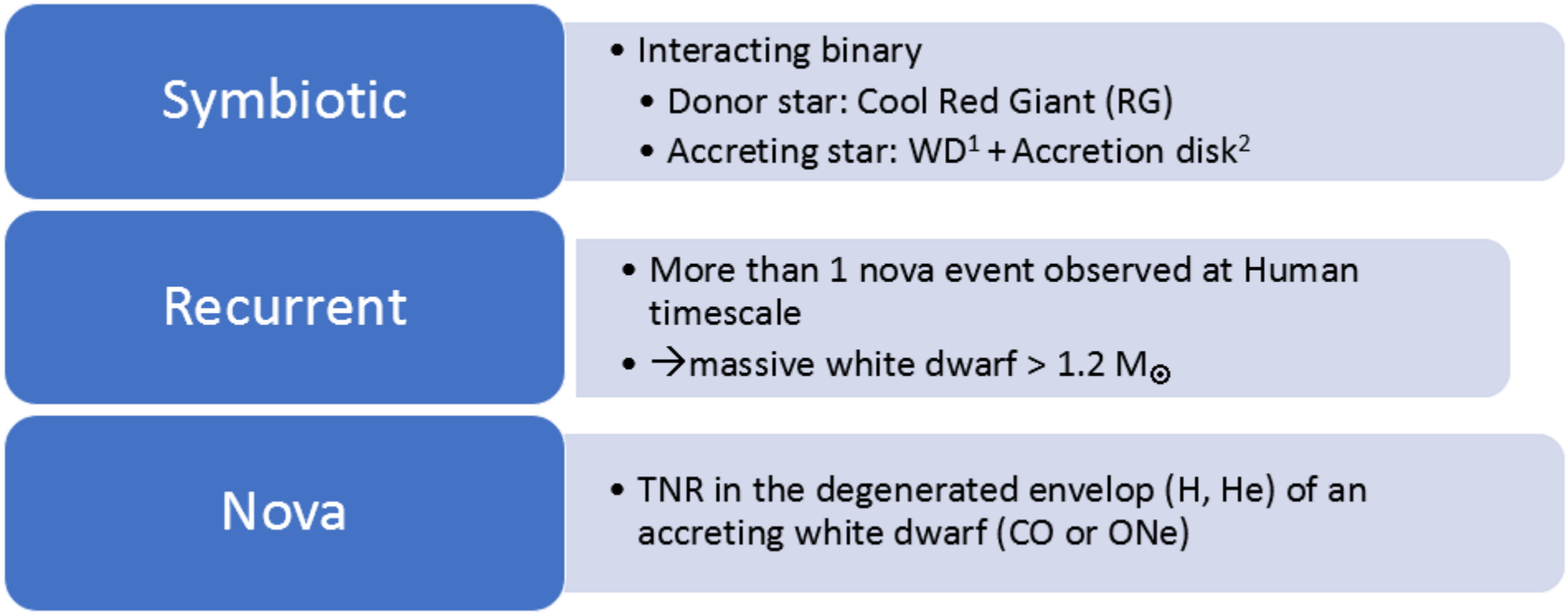
F. Teyssier

francoismathieu.teyssier@gmail.com

S.A.S. Symposium, 2023 June

Credit image : M Weiss

T CrB as a recurrent symbiotic nova



SyRN

- RS Oph
- T CrB
- V745 Sco
- V3890 Sgr
- V407 Cyg (?)

T CRB nova events

- 1866
- 1946

Notes:
[1] Neuton star in a few cases
[2] in some symbiotics

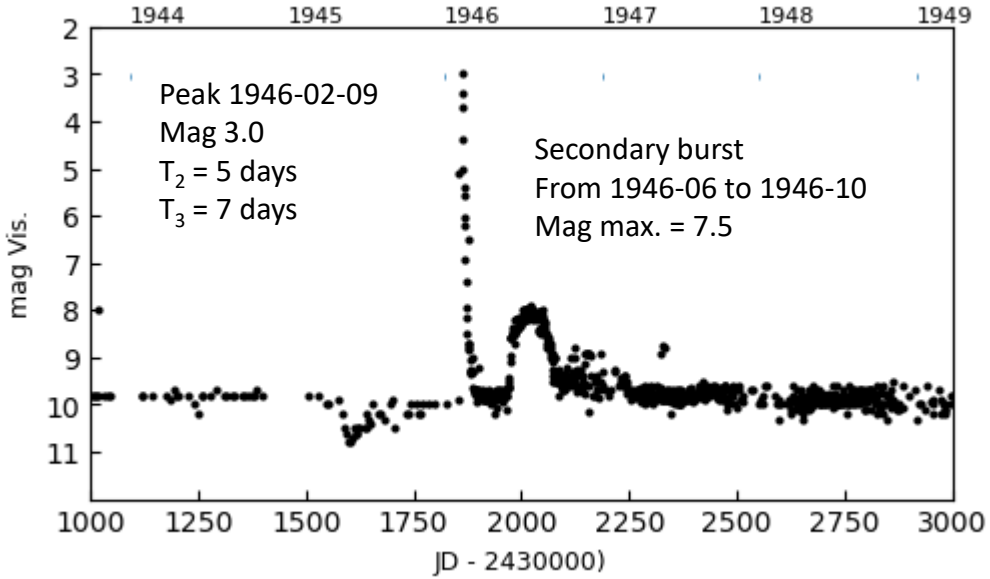
T CrB - SAS Symposium 2023, June - F. Teyssier

2

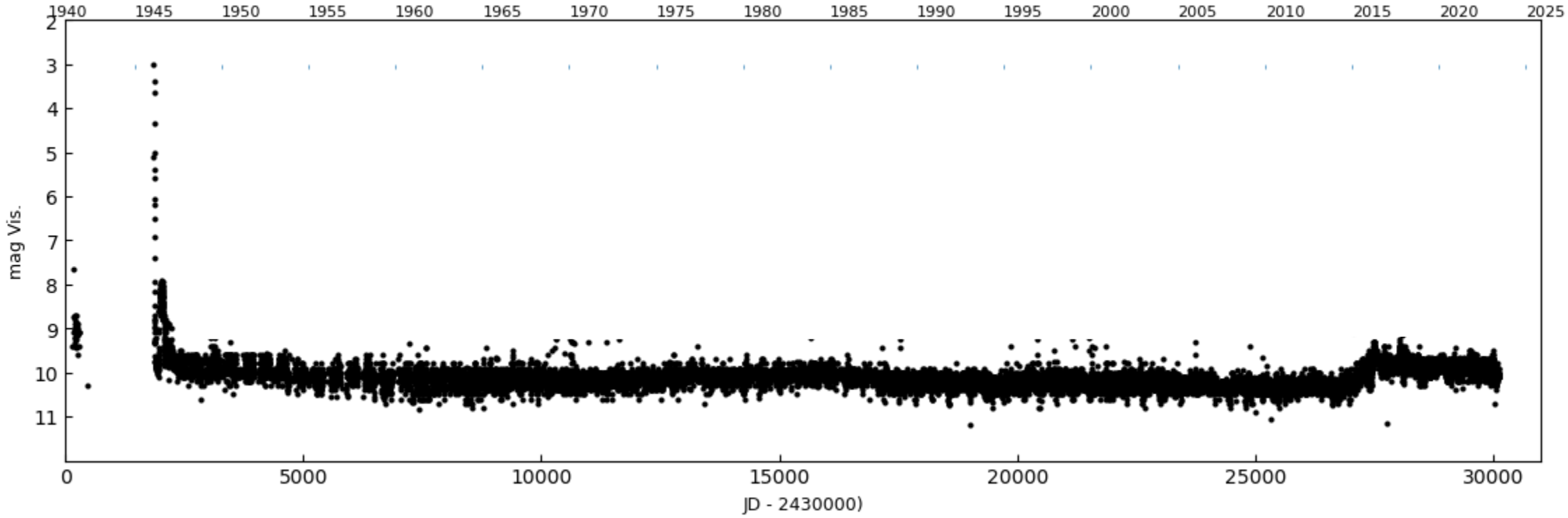
T CrB The 1946 nova event

AAVSO Visual*

*** More than 150 000 points !**



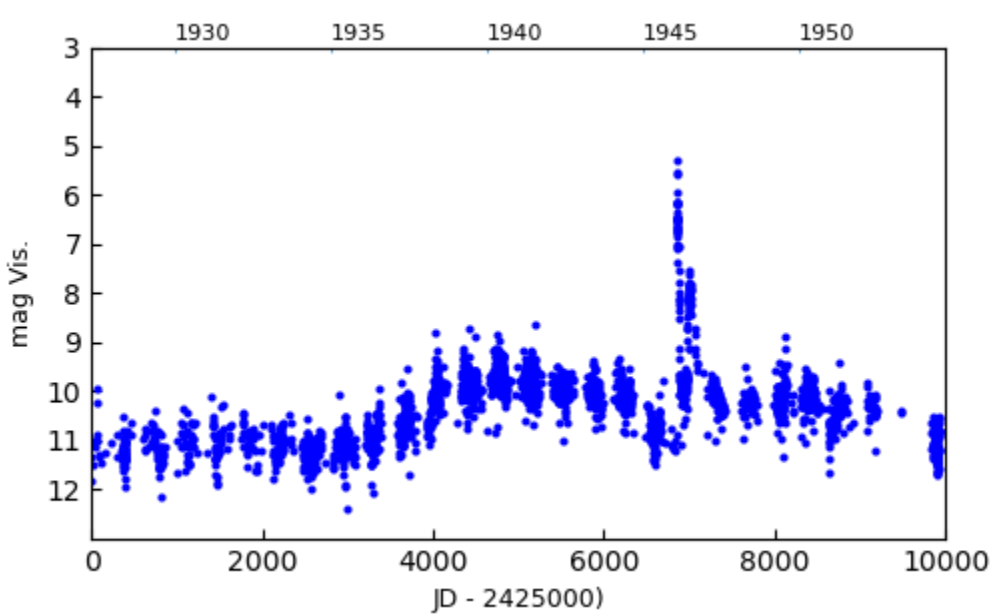
T_2 = time for a 2 mag decrease

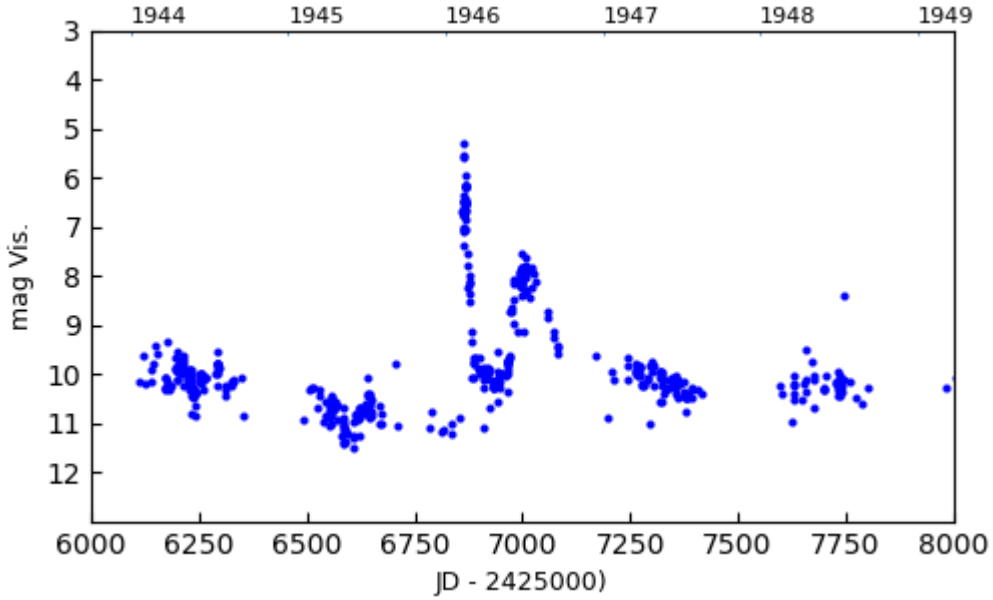


T CrB The 1946 nova event

DASCH

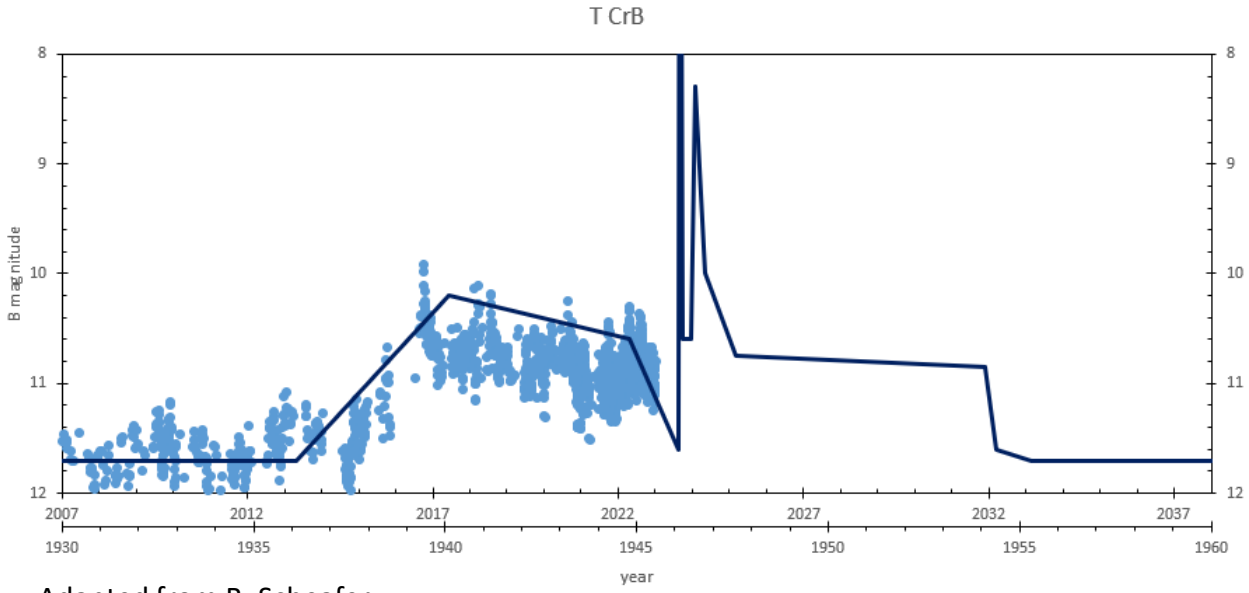
(Digital Access to a Sky Century @ Harvard**)**



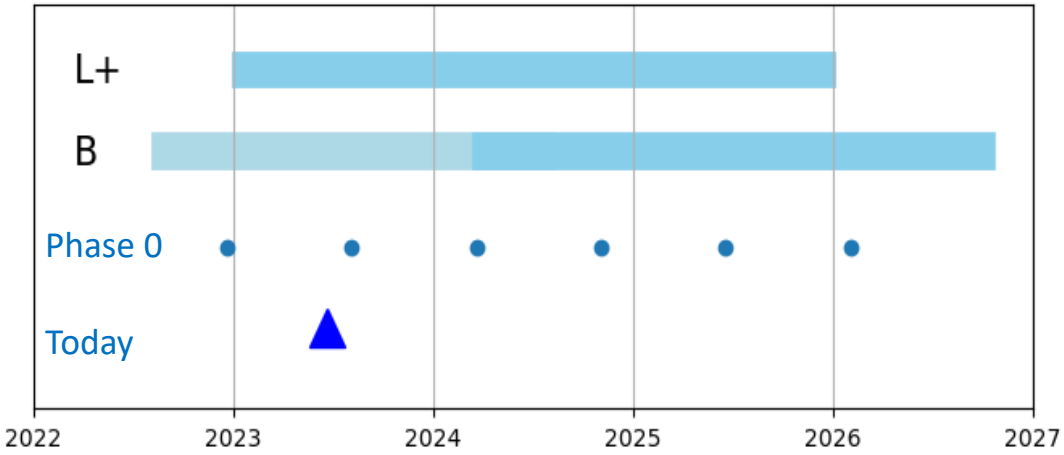


T CrB The 1946 nova event and predictions

AAVSO Visual 2007-2023
B. Shaefer 1930 – 1960 Schematic



Adapted from B. Scheafer



L+ : G. Luna+, 2020
B : B. Schaefer 2019, 2023
Ephemeris: Lines, 1988

T CrB system: key observations

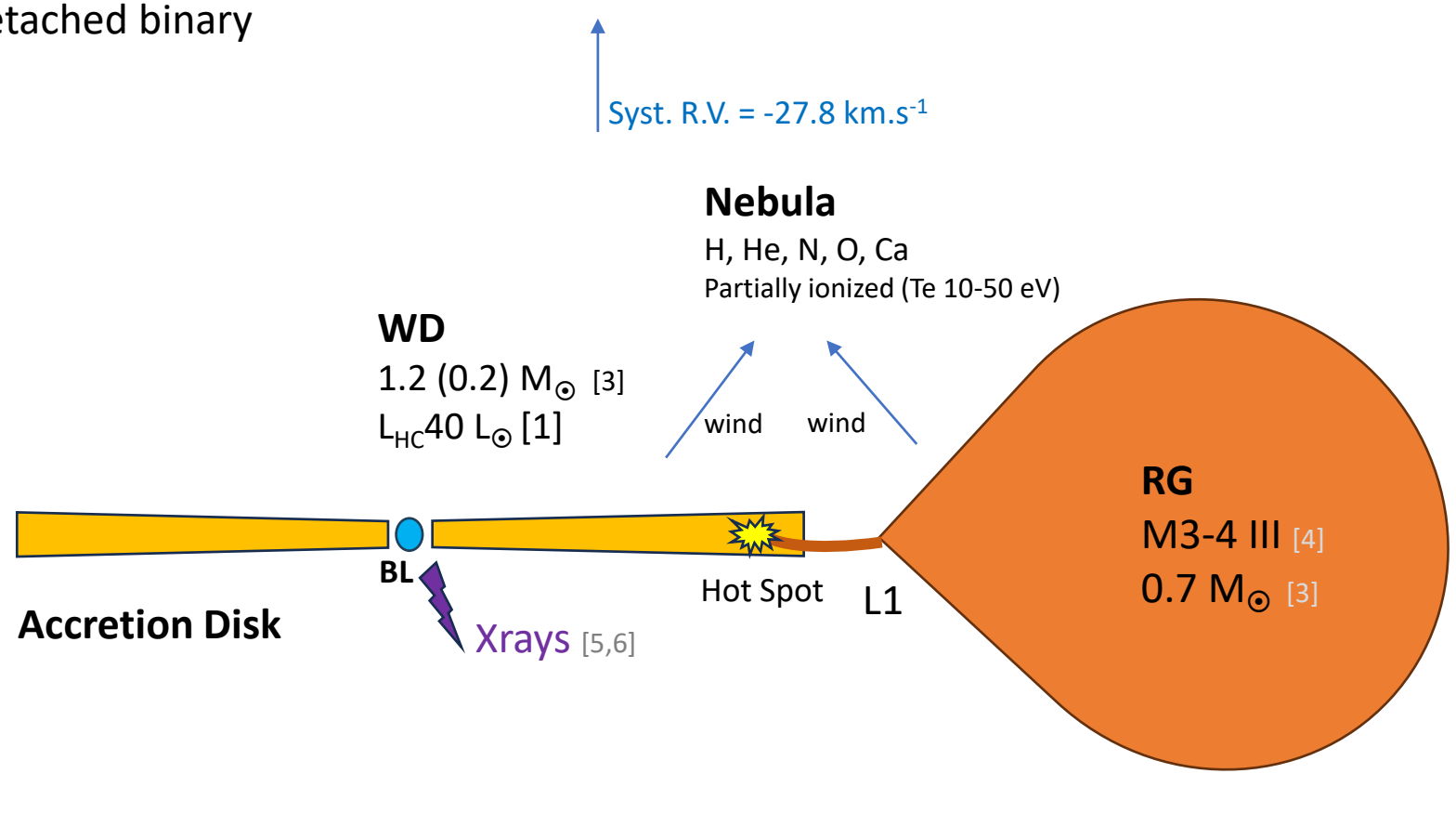
2 nova outbursts	• Degenerated envelop H, He + Massive WD
Hot component L = 40 $L_\odot$	• Accretion powered symbiotic [1]
Ellipsoidal variations	• Red giant fills its Roche Lobe
Flickering B, V, X, emission lines	• Accretion disk [2]
X rays	• Boundary layer disk-white dwarf
Quiescent & Active States	• Mass transfer instabilities

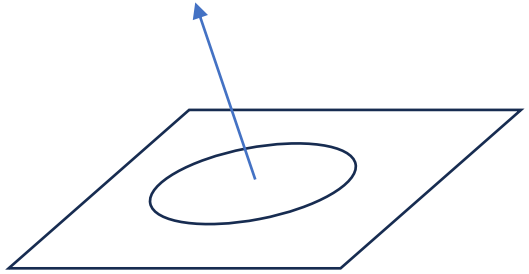
[1] most of symbiotics are fueld by nuclear steady burning leading to luminosity of the hot component to 1000 $L_\odot$ As an order of magnitude.

[2] flickering and accretion disks are uncommon in most of symbiotic systems

T CrB system: a schematic view

Interacting semi-detached binary





Inclination 60-70 °

Distance= 806 (33) pc [7]

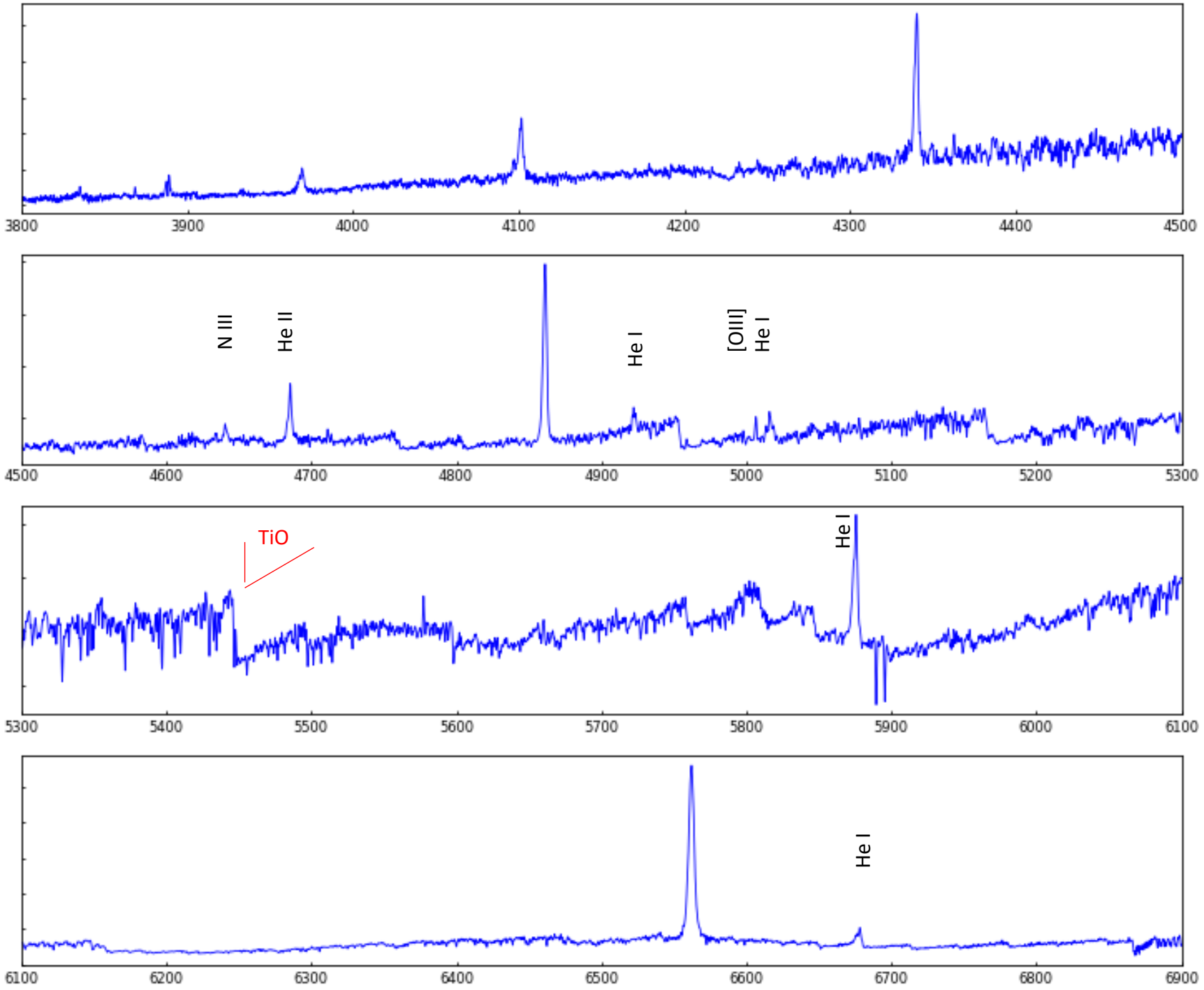
[1] Selvelli+, 1992
[2] Kenyon & Garcia, 1986
[3] Belczinski Mikolajewska, 1988
[4] Mürset & Schmid, 1999
[5] Cordova, 1981
[6] Luna+, 2008
[7]

T CrB

The spectrum (active state)

« pseudo continuum »
TiO bands
Lines neutral metals

Balmer HI
He II
He I
OIII, NIII Bowen
[O III]
[Ne III]



J. Guarro Flo
NOUT spectroscop
R = 9000

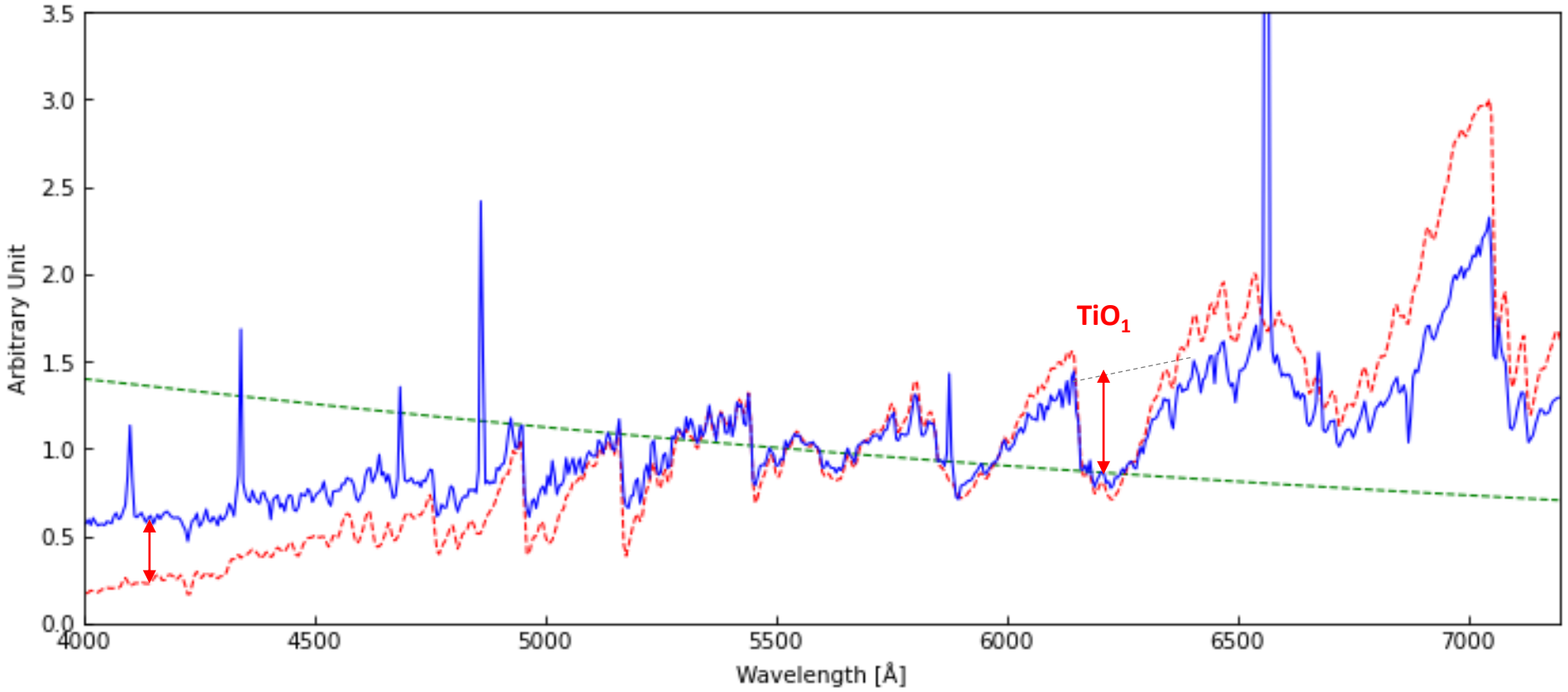
T CrB

A composite continuum

T CrB

M4 III [10]

Blackbody 20000 K [11]



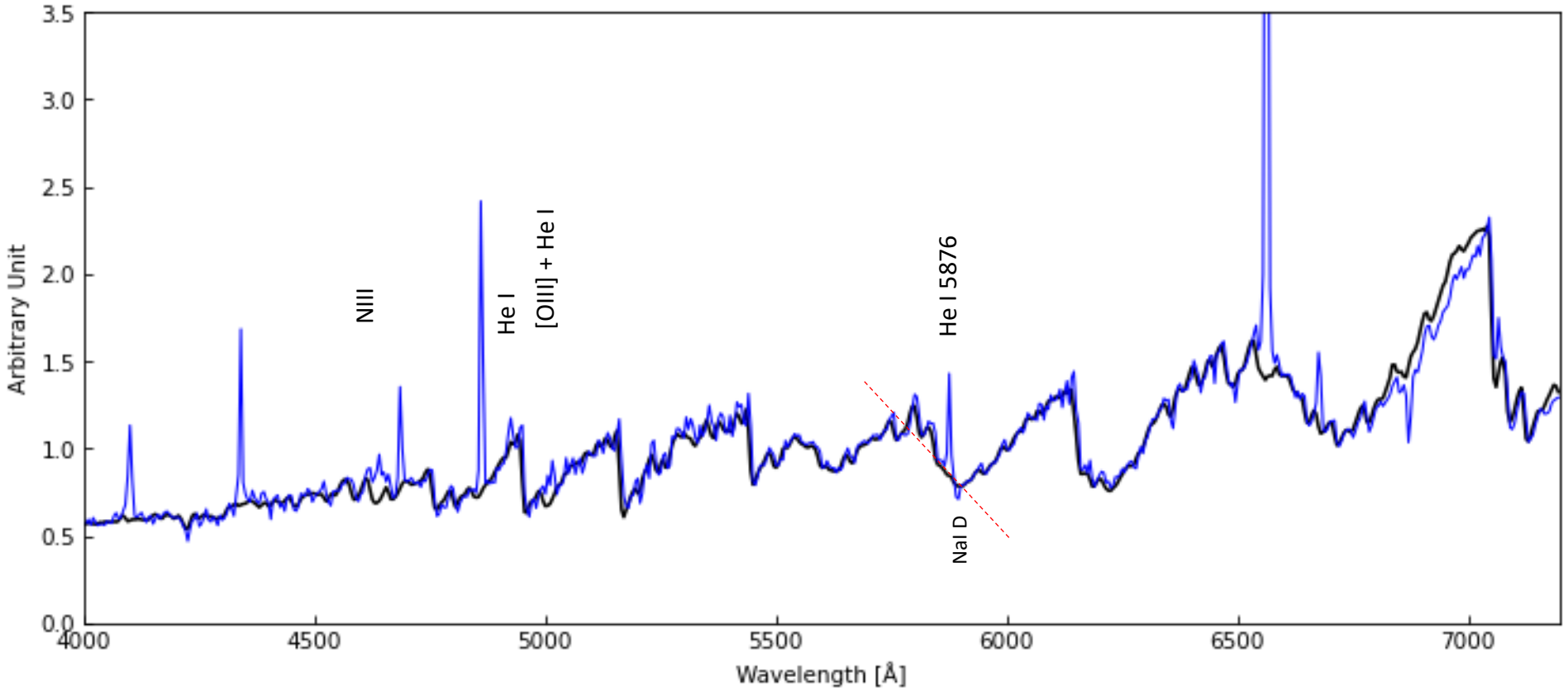
Spectrum:
Forrest Sims
LISA R = 1000
2020-04-07

T CrB

A composite continuum

T CrB

Composite « continuum »
0.7 * M4III + 0.3 * B.B 20000 K



Luminosities
& Temperatures

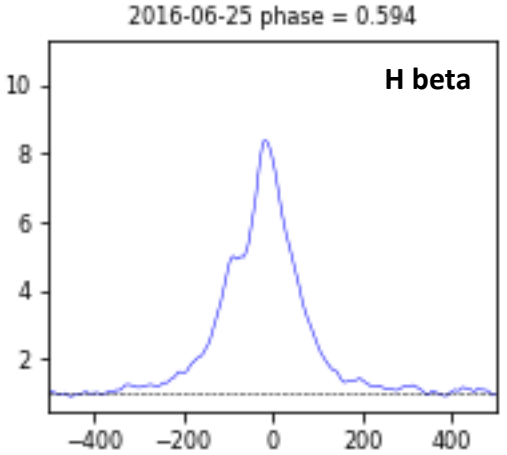
Faint lines

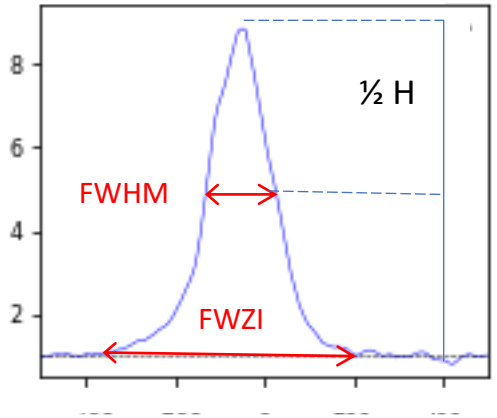
Shape of the continuum
For lines analysis -----

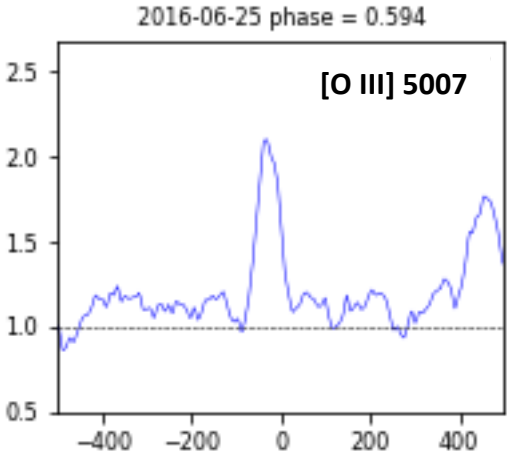
➔ Good atmospheric correction needed!

T CrB

Lines Profiles

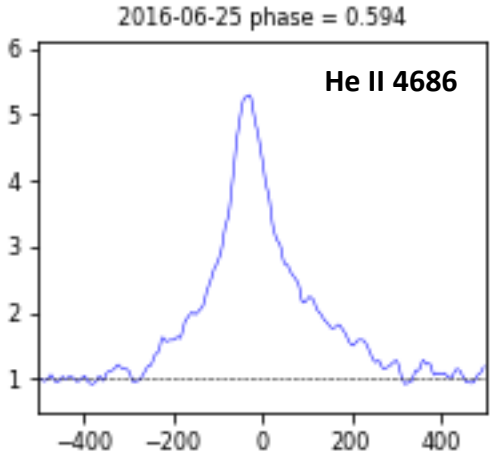




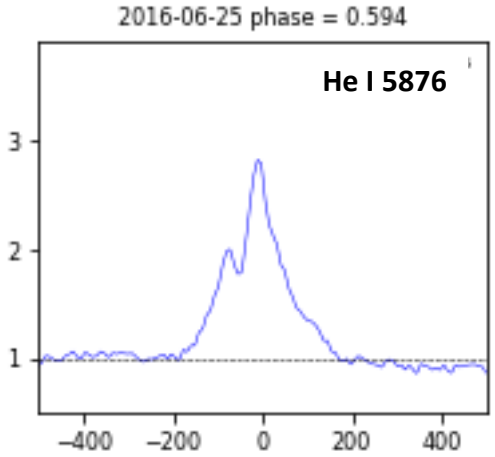


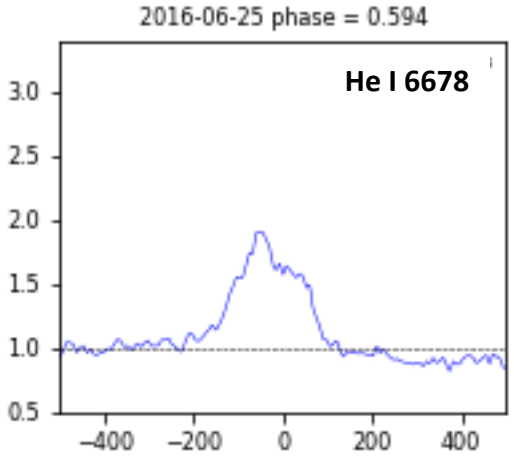
2 components

FWHM = 55 km.s^{-1}



FWZI = 610 km.s^{-1}

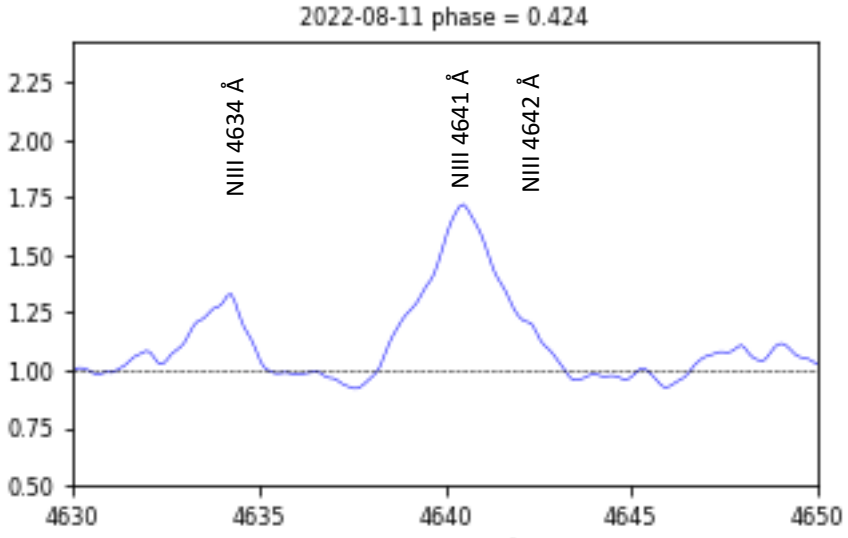


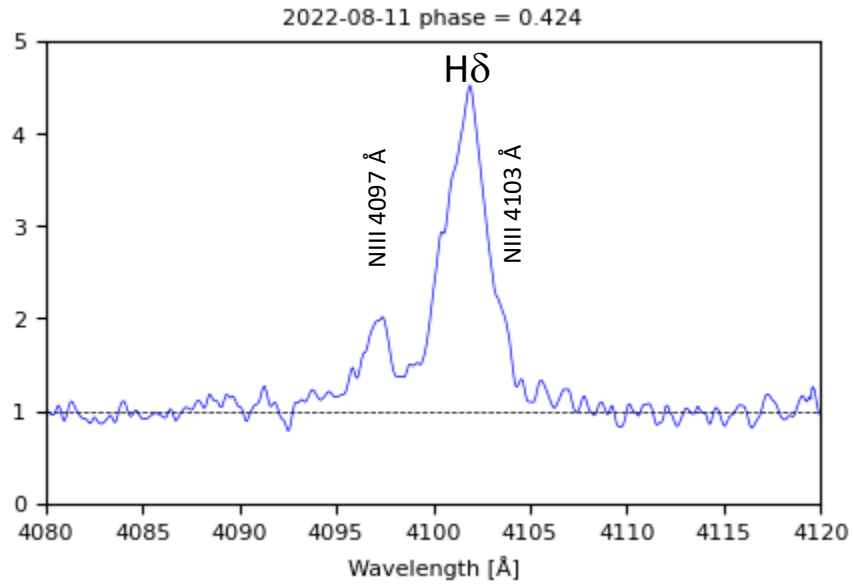


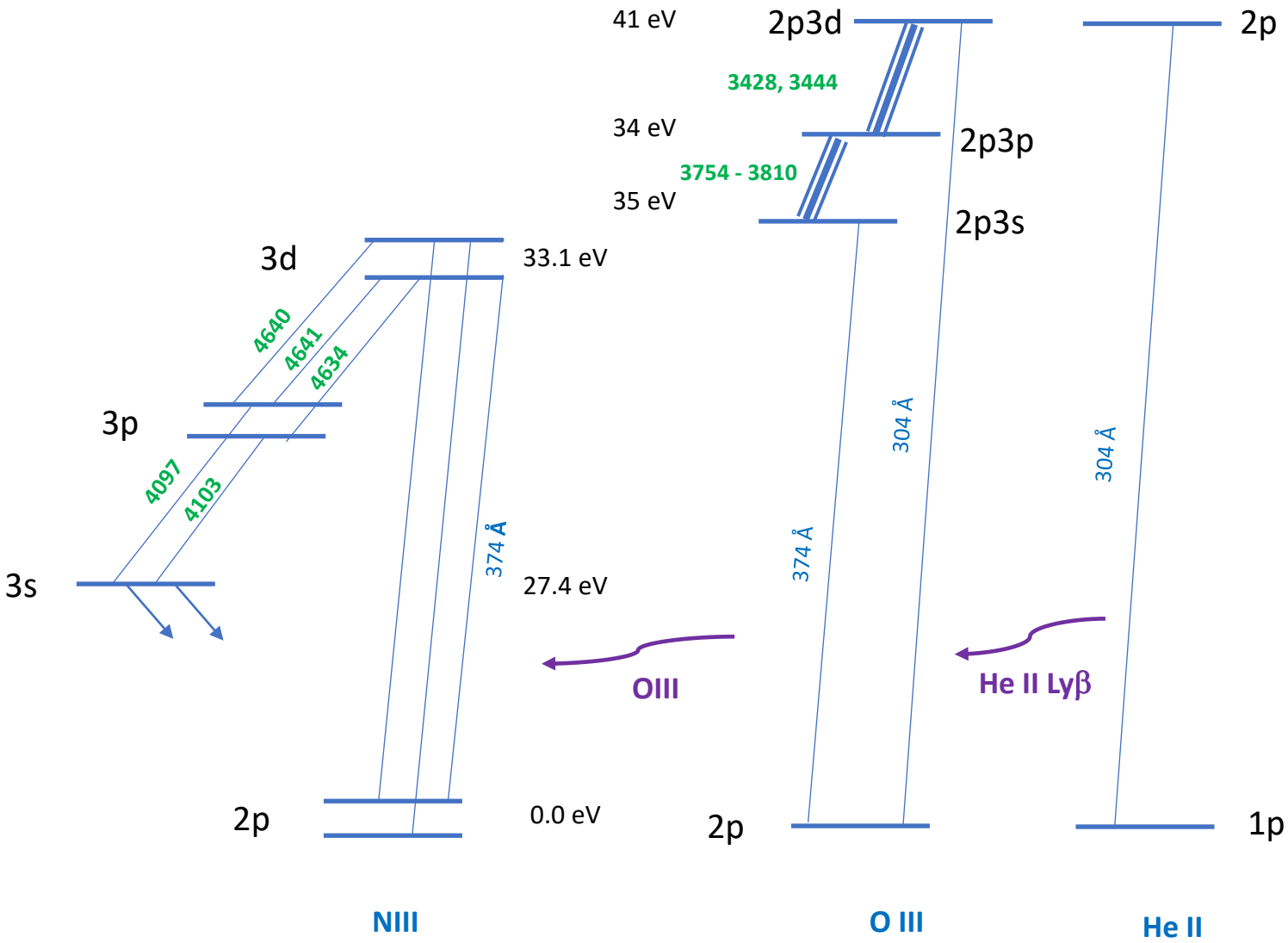
- Wind from hot component
- Accretion disk and/or Self absorption
- Nebula

T CrB

OIII NIII Bowen



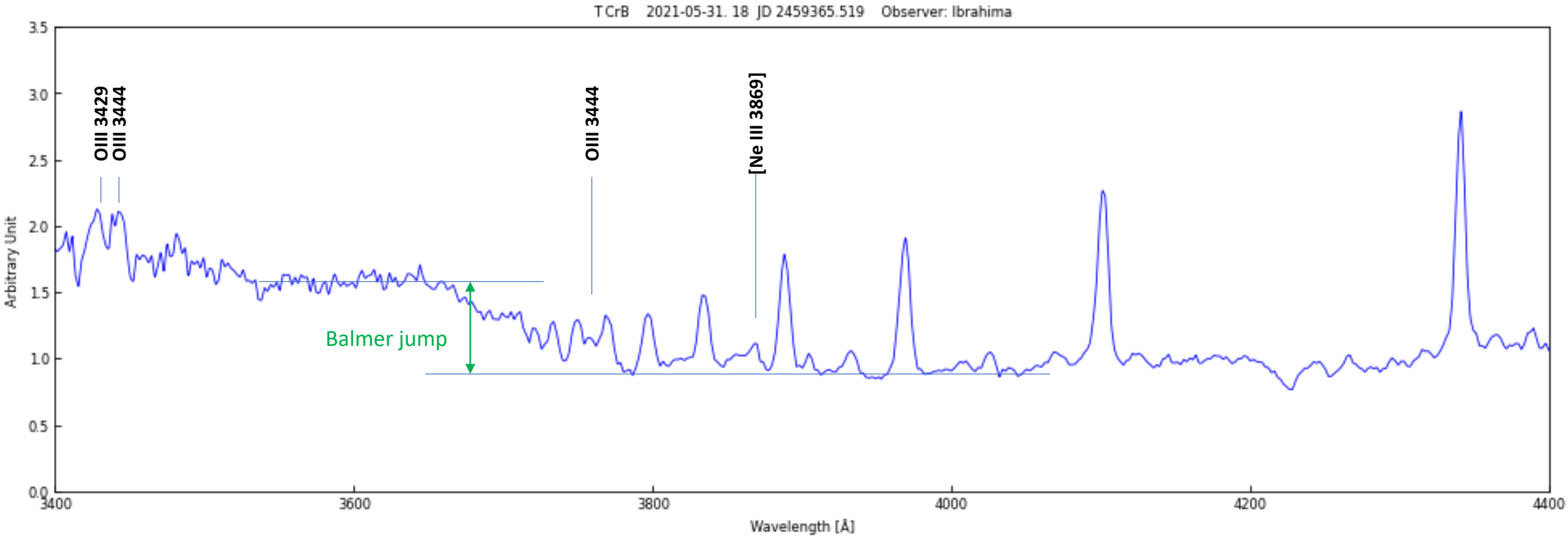




T CrB

The emission line spectrum

In near UV



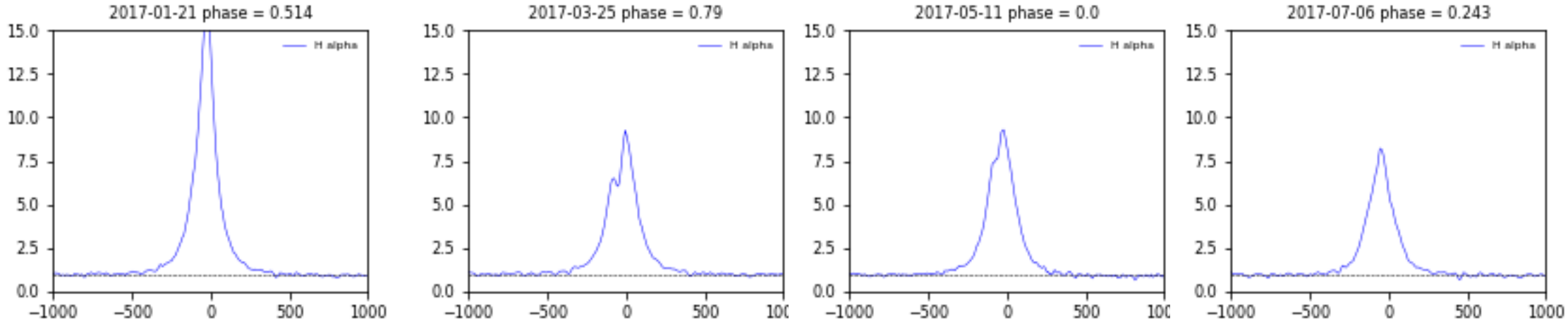
I. Diabassoura
UVEX R = 700

T CrB

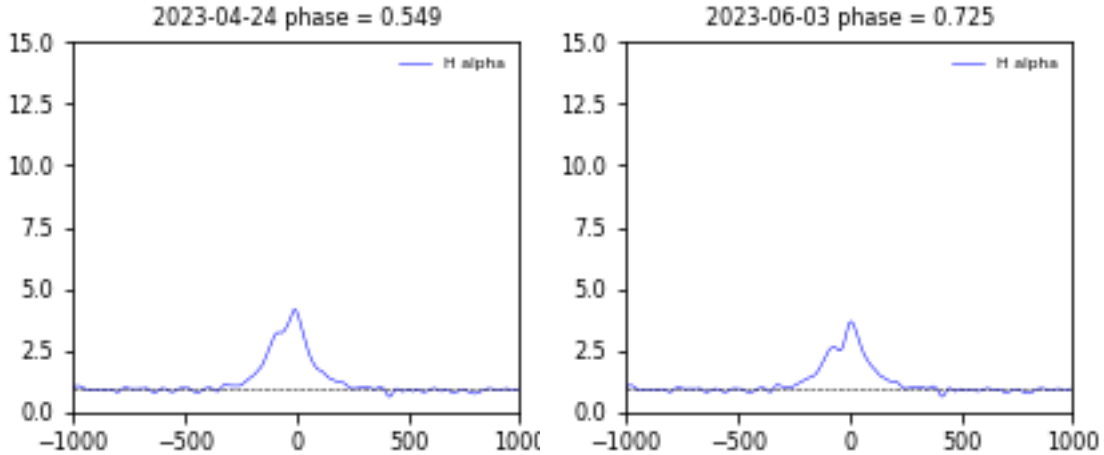
Orbital variations: an example H alpha

$\phi \sim 0.5$ $\phi \sim 0.75$ $\phi \sim 0.0$ $\phi \sim 0.25$

2017



2023



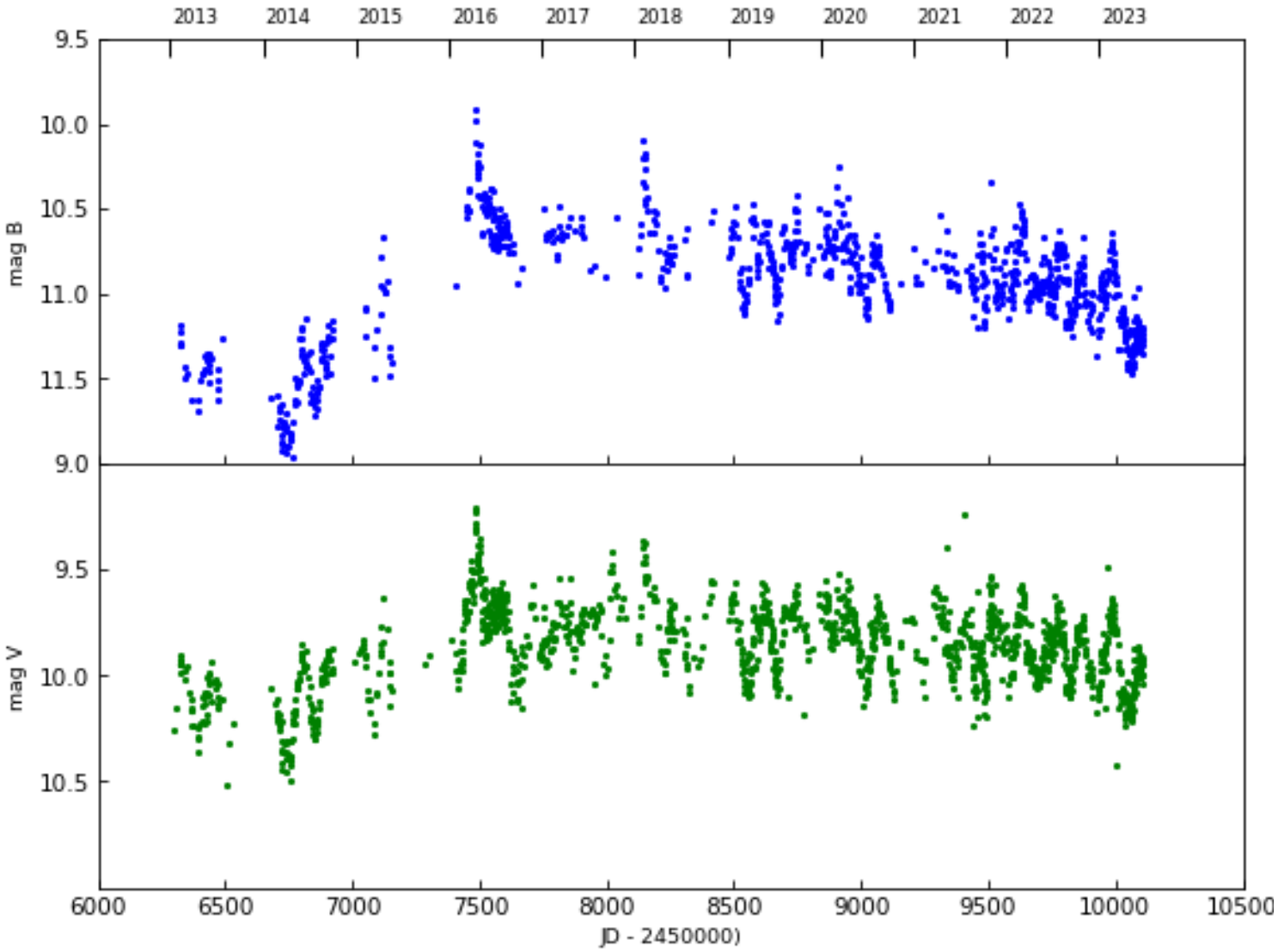
x scale : radial velocity in km.s^{-1}

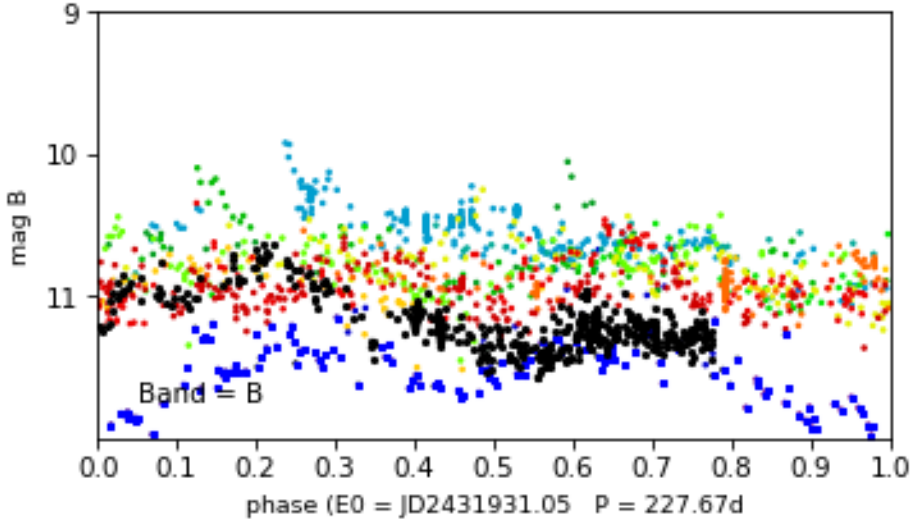
Echelle spectra
F. Teyssier
J. Guarro Flo
T. Lester

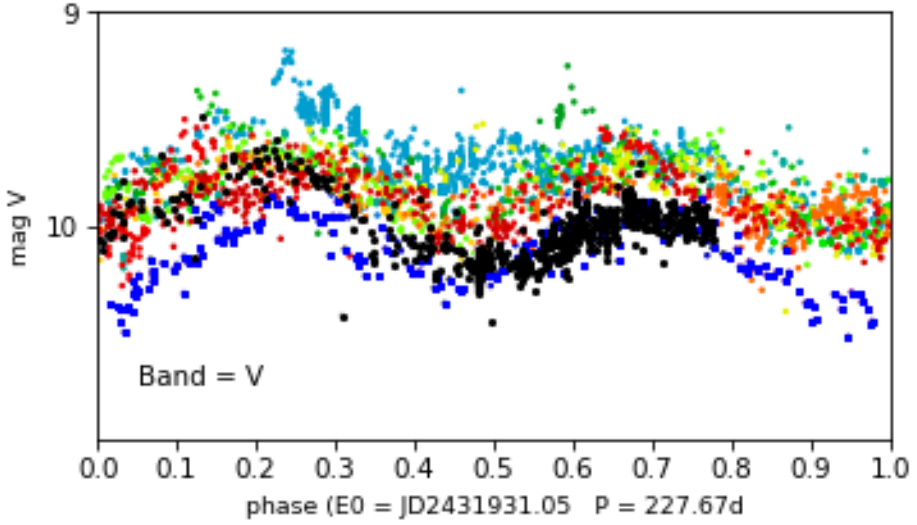
T CrB Active State

Data: AAVSO
Ephemeris: Lines+, 1988

Blue: pre active sate (2013-2014)
Black: current cycle

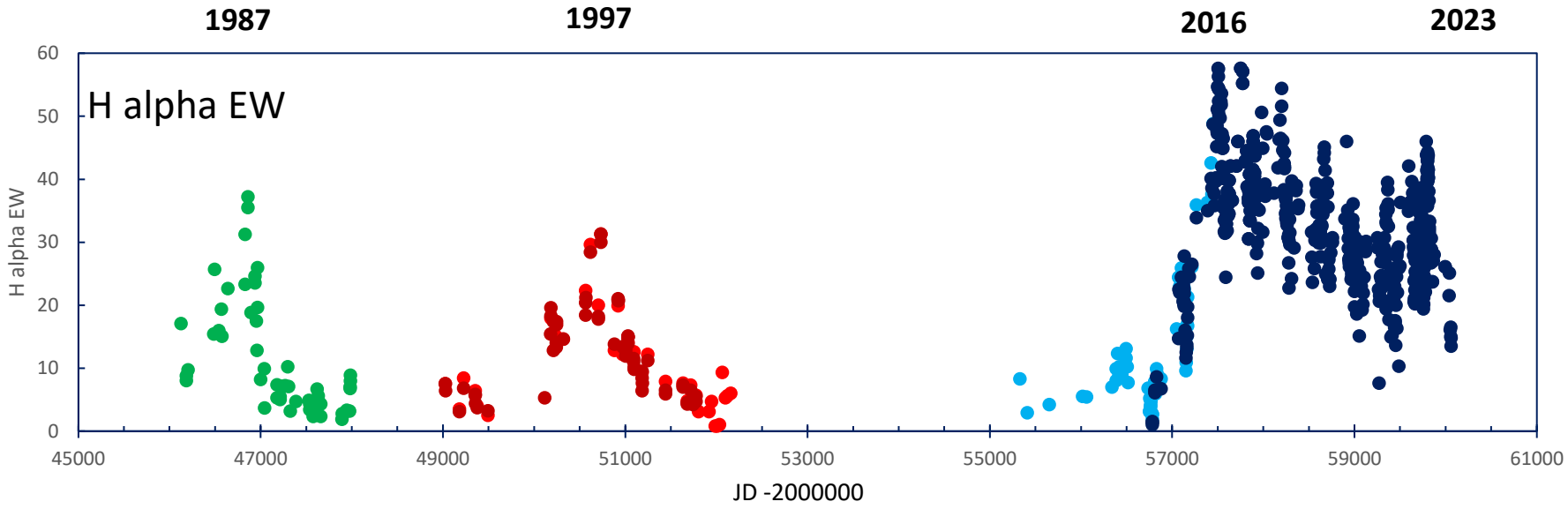






T CrB Active States

E.W. (equivalent width)
Measure of the flux of a line
relative to the nearby continuum

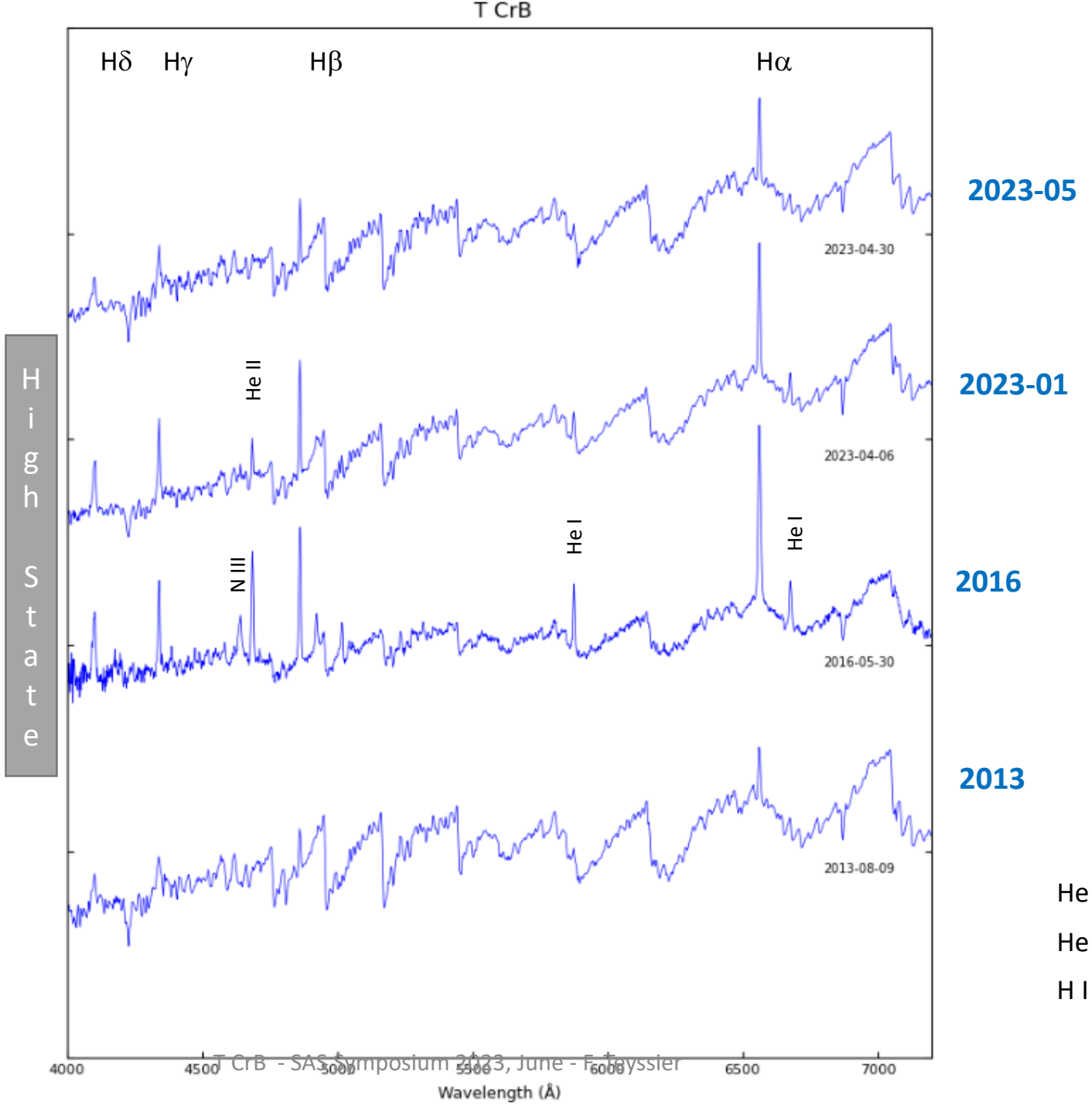


Anupama, 1991
Stanishev, 2004
Zamanov, 2001
Ilkiewitcz, 2016
ARAS

Ilkiewycz+:
Essentially based on ARAS data

T CrB

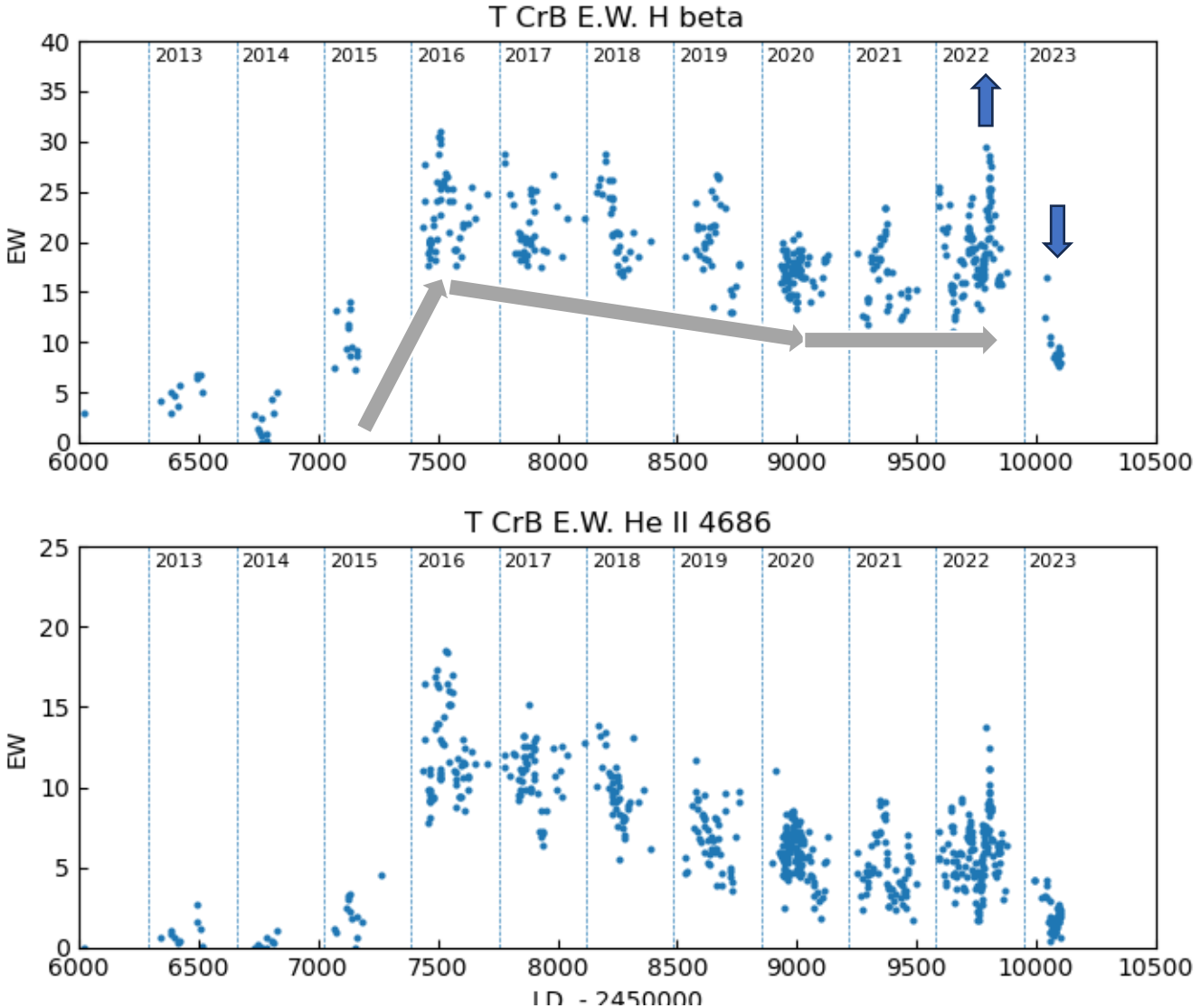
The spectrum
10 years evolution
during the active phase



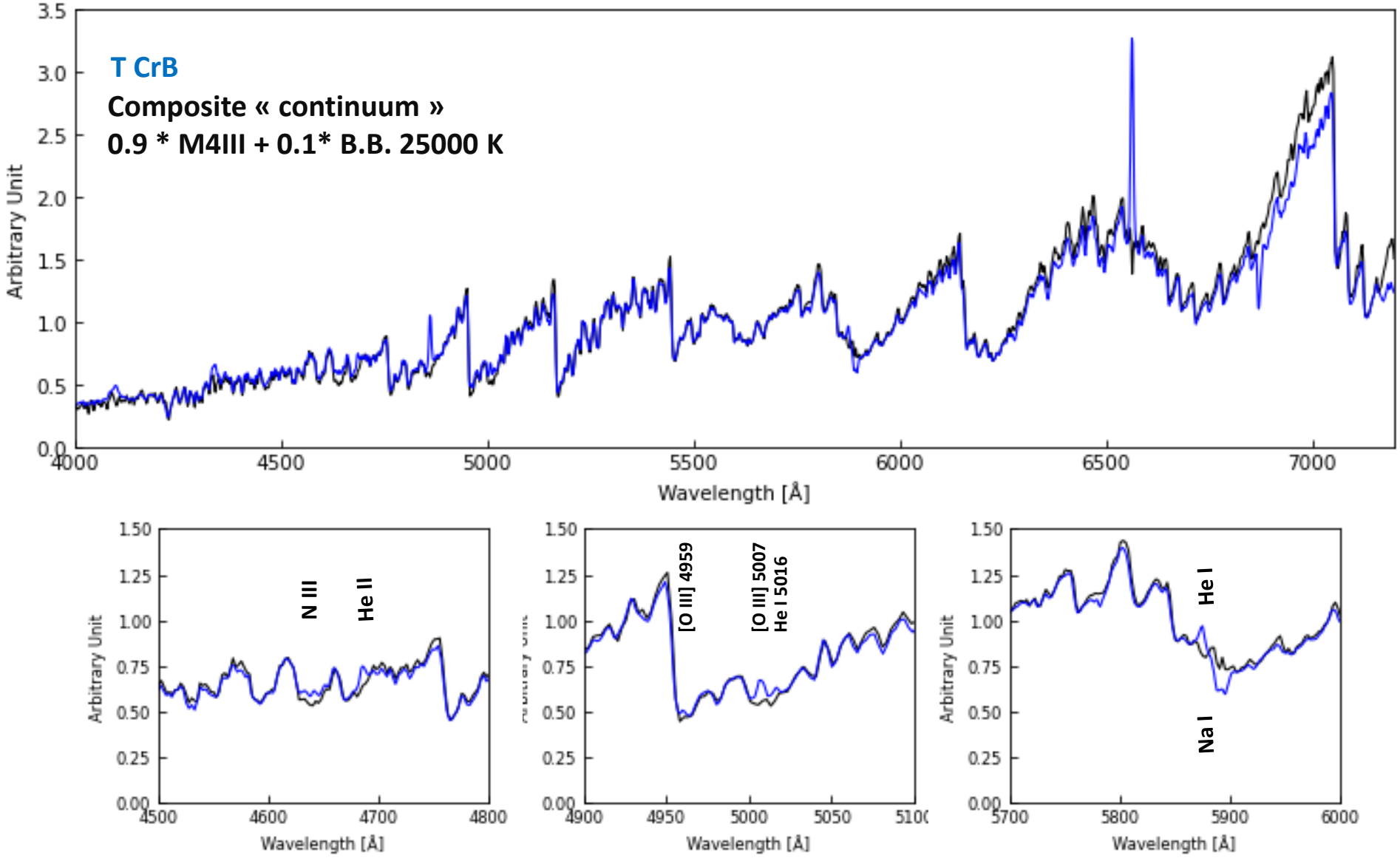
Observers:
F. Teyssier
D. Boyd
F. Sims
LISA R = 1000

He II 48.6 ev (50 000 K)
He I 24 ev (25 000 K)
H I 13.6 ev (10-15 000 K)

T CrB Last Active State, spectroscopy



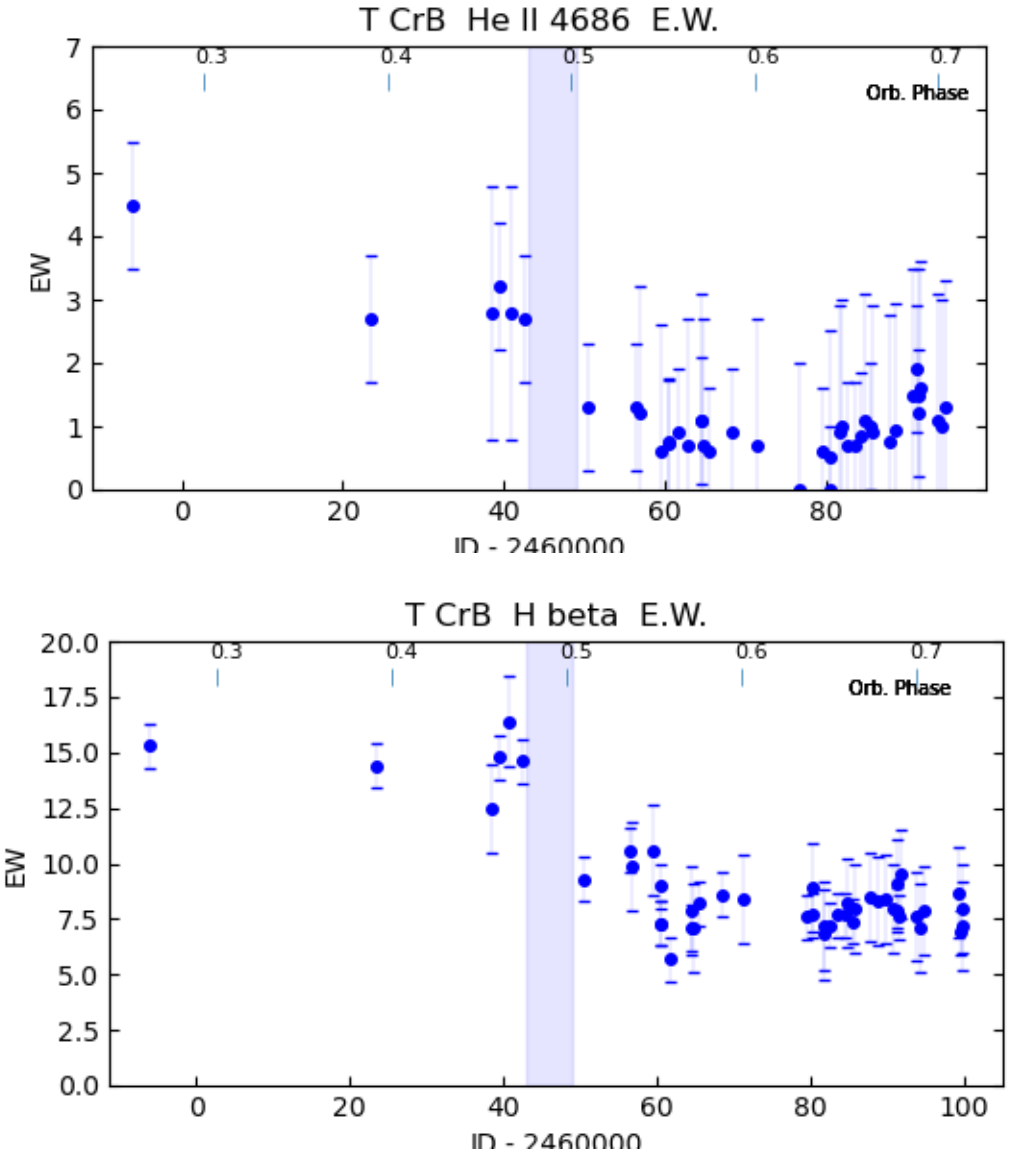
T CrB Last Active State, the turn-off*



Spectrum:
Forrest Sims
LISA R = 1000
2023-06-15

T CrB Last Active State, the turn-off

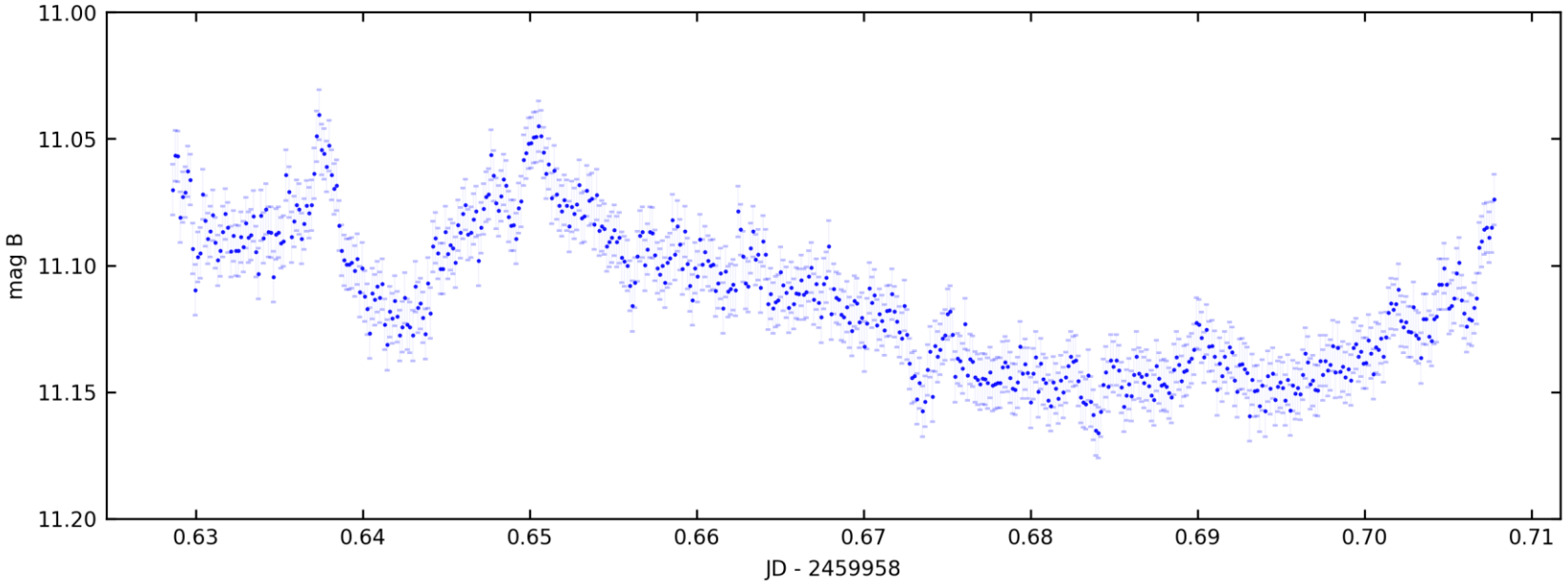
2023

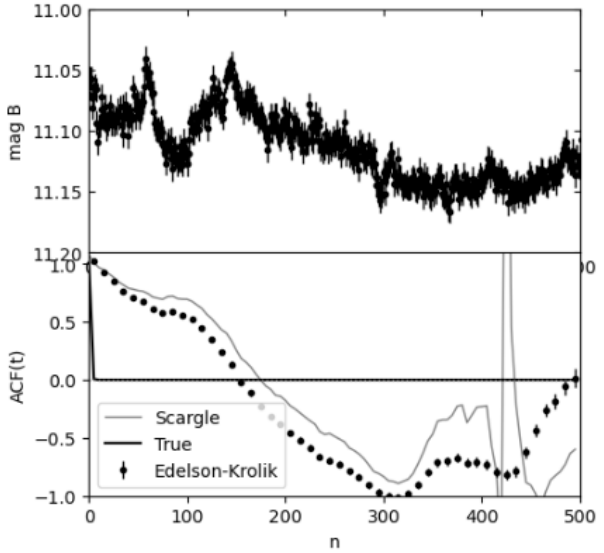


Spectra obtained by:

J.D. Hinnefeld
C. Boussin
I. Diabassoura
F. Sims
A. Leduc
F. Teyssier
S. Curry
D. Boyd,
D. Cujedo
J. Guarro Flo

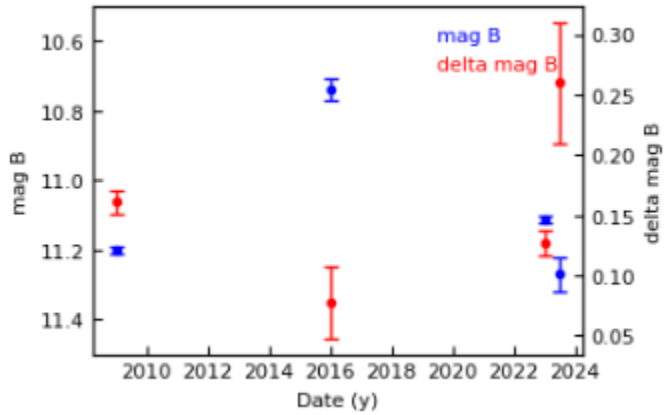
T CrB Active State: the turn-off - Flickering





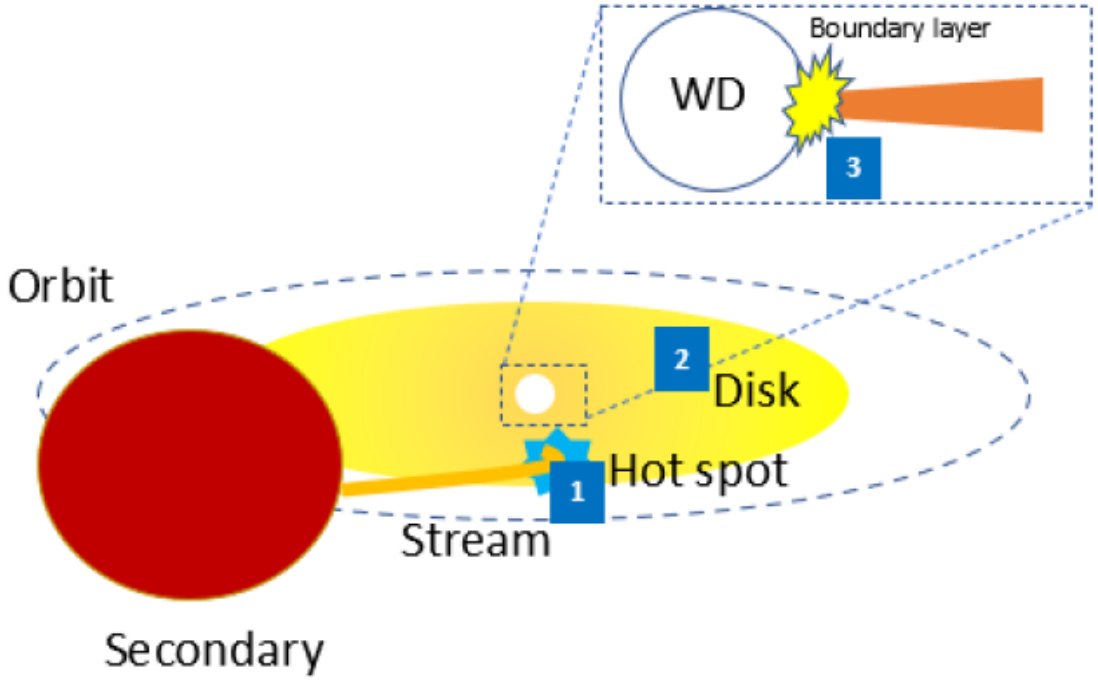
F. Teyssier T1M C2PU (FR) Omicron telescope
In the context of the DUAO 2022 (MAUCA Nice University – FR)
2023 January
Exposures: 10 seconds
https://www.astronomerstelegram.org/?read=15916

restore flickering to its original level
(Minev, Zamanov, Stoyanov)
2023 April
https://www.astronomerstelegram.org/?read=16023

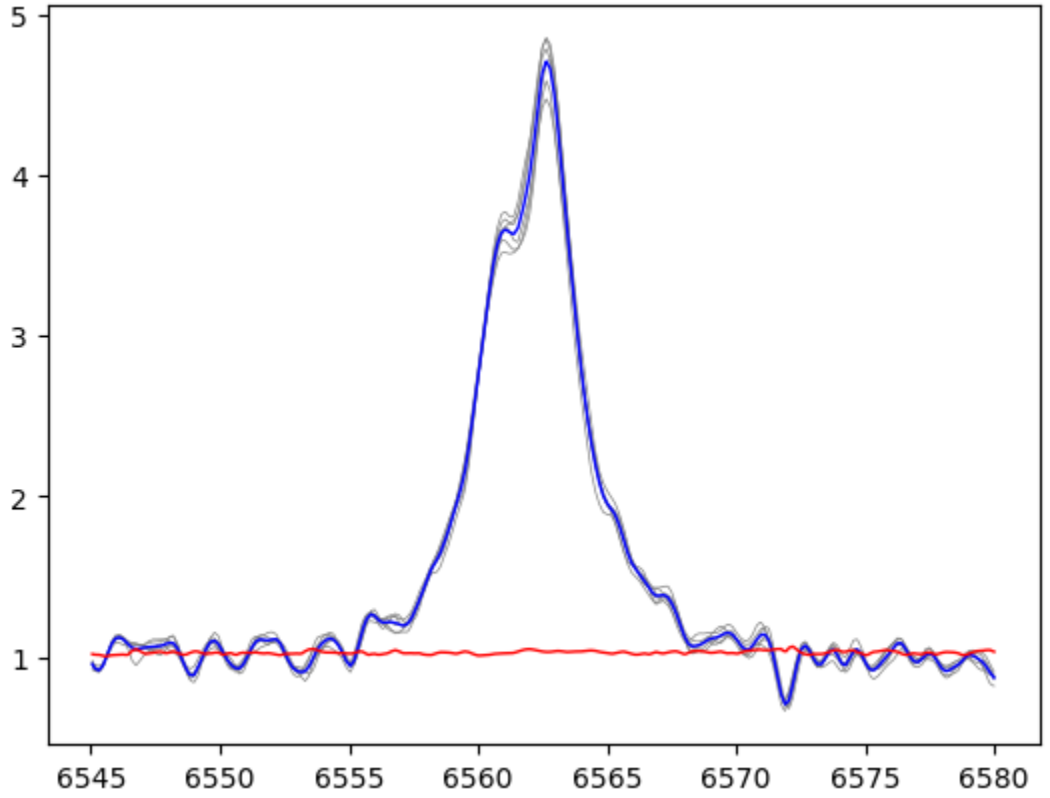


T CrB Flickering

Possible sources



T CrB Spectroscopy: search for flickering



$$\sigma_\lambda = \frac{1}{\bar{f}_\lambda}\left[\frac{1}{N-1}\sum_{i=1}^{N}(f_{i\lambda}-\bar{f}_\lambda)^2\right]^{1/2}$$

with

N = number of spectra
f_λ is the mean spectrum of the series
$f_{i\lambda}$ is the ith spectrum

H alpha line (**blue**)
and the series of 6 elementary spectra (exp. = 600 s) in **grey**
Variance in red (shifted by +1 for clarity)
24-04-2023 F. Teyssier
Spectrograph NOUT R = 9000

For each λ, the variance is under the threshold $3*\sigma_\lambda$ on the continuum.
The null hypothesis of variablity can be rejected

Agenda:

2012-2015	Low State
2015-2023	High State
2022-202X	Pre-outburst monitoring: current – 2/3 spectra a week
202X	Nova Outburst Very Short (a few days): **High Cadency & World wide coverage**
202X-202Y	Post Nova monitoring (secondary Bump)

Atmospheric correction

Flux calibrated spectra with V band photometry acquired *during* the run

- Spectra in asdb: https://aras-database.github.io/database/tcrb.html
- Web Page: astronomie-amateur.fr/EruptiveStars/TCrB0.html
- Forum: http://spectro-aras.com/forum/viewtopic.php?f=37&t=2902&start=10
- Whatsapp group for regular observers

Tribute

This work relies on the contribution of ARAS observers during more than 10 years (> 750 spectra)

F. Sims, P. Somogyi, J. Guarro Flo, F. Teyssier, I. Diabassoura, D. Boyd, C. Boussin, P.A. Dubovsky, T. Lester, F. Campos, A. Leduc, K. Shank, V. Lecoq, S. Curry, , J.R. Foster J. Montier, L. Franco, U. Sollecchia, C. Buil, K. Graham, V. Bouttard, T. Medulka, CDZ, J. Martin, J. Michelet, M. Rodriguez, R. Ehlert, P. Cazatto, O. Garde, F. Boubault, M. Verlinden, Y. Markus, P. Berardi, S. de Visscher, X. Dupont, G. Bertrand, J. Coffin, M. Le Lain, C. Laulhere, R Ehlert, J.D. Hinnefeld, J. Lecomte, S. Charbonnel, G. Martineau, Y. Buchet, J.P. Godard, T. Rodda, E. Bertrand, H. Boussier, J.B. Desrosiers, J.P. Masviel, D. Li, C. Revol, A.J. Wilson, C. Kreider

Aknowledgments to +++ AAVSO observers and their > 150 000 observations