V1405 Cas – slow nova evolution

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with: D. Chochol

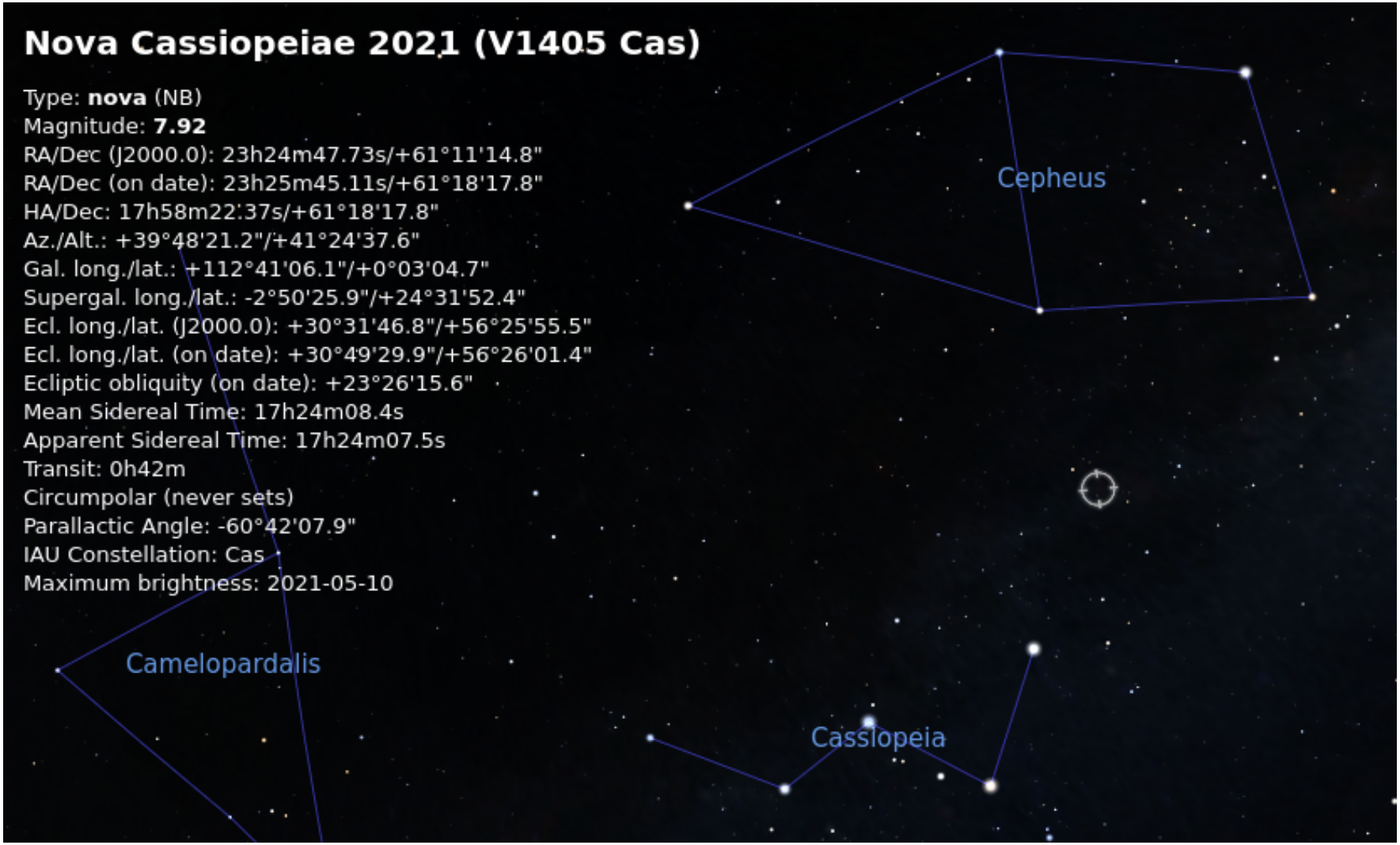
Bezovec, Sep 11, 2021

Outline

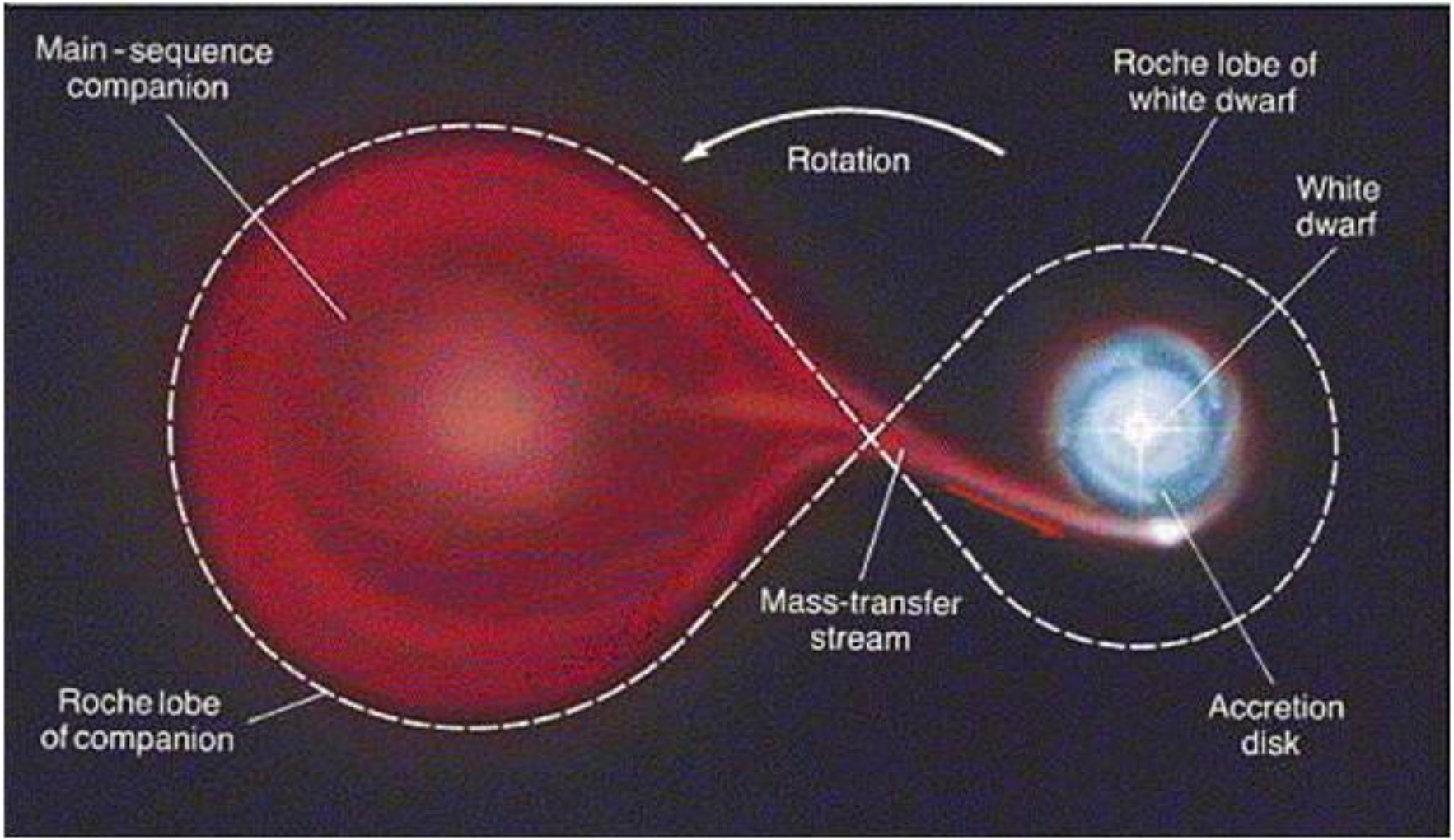
V1405 Cassiopeiae

Discovered: March 17-18, 2021 (Yuji Nakamura) @ $V = 9.6$ mag

V1405 Cassiopeiae

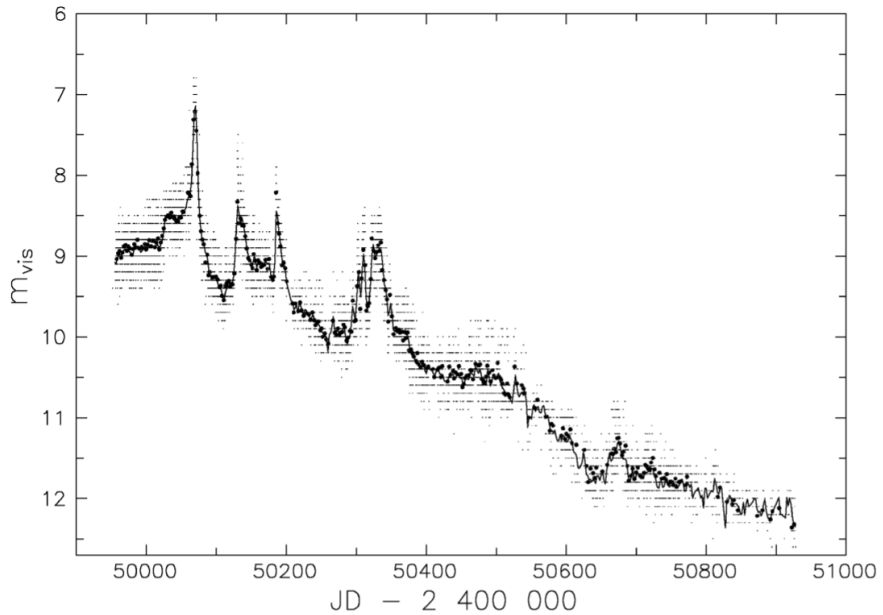


Novae


Main - sequence companion
Roche lobe of white dwarf
Rotation
White dwarf
Mass-transfer stream
Roche lobe of companion
Accretion disk

Nova outburst

$10^{-4}\,M_\odot$ ejected with $RV \sim (1-4)\times 10^3$ km.s^{-1}
Classification by Downes & Duerbeck (2000) uses t_2 and t_3 - days from peak brightness until decreased by 2 or 3 mag
"fast": $t_2 < 13$ d, $t_3 < 30$ d vs. "slow": $t_2 > 13$ d, $t_3 > 30$ d

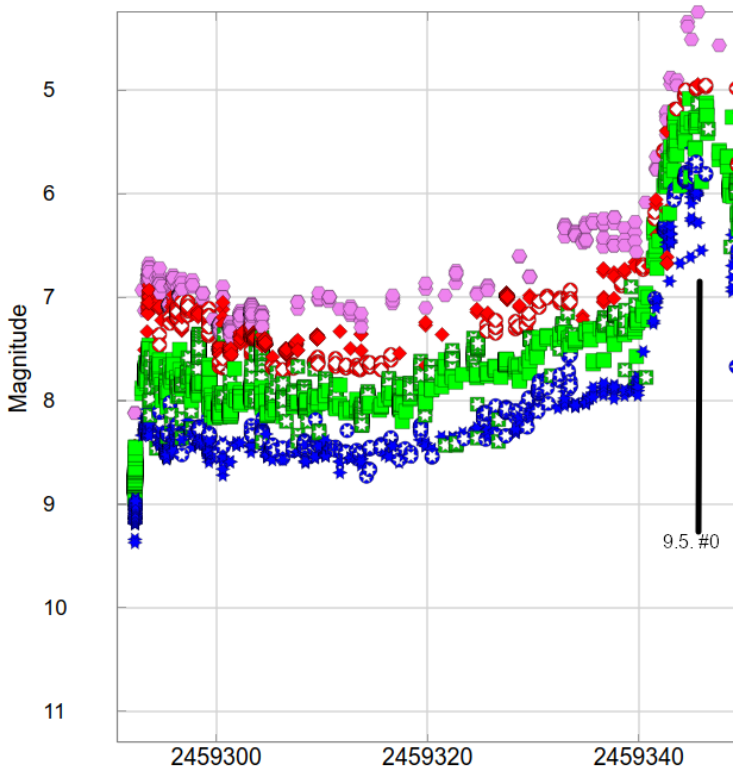


Very slow nova V723 Cas (Chochol & Pribulla, 1998):

$t_3 = 173$ d
transformed $t_2 = 102 \pm 3$ d
calculated using relation of Capacciolli et al. (1990)

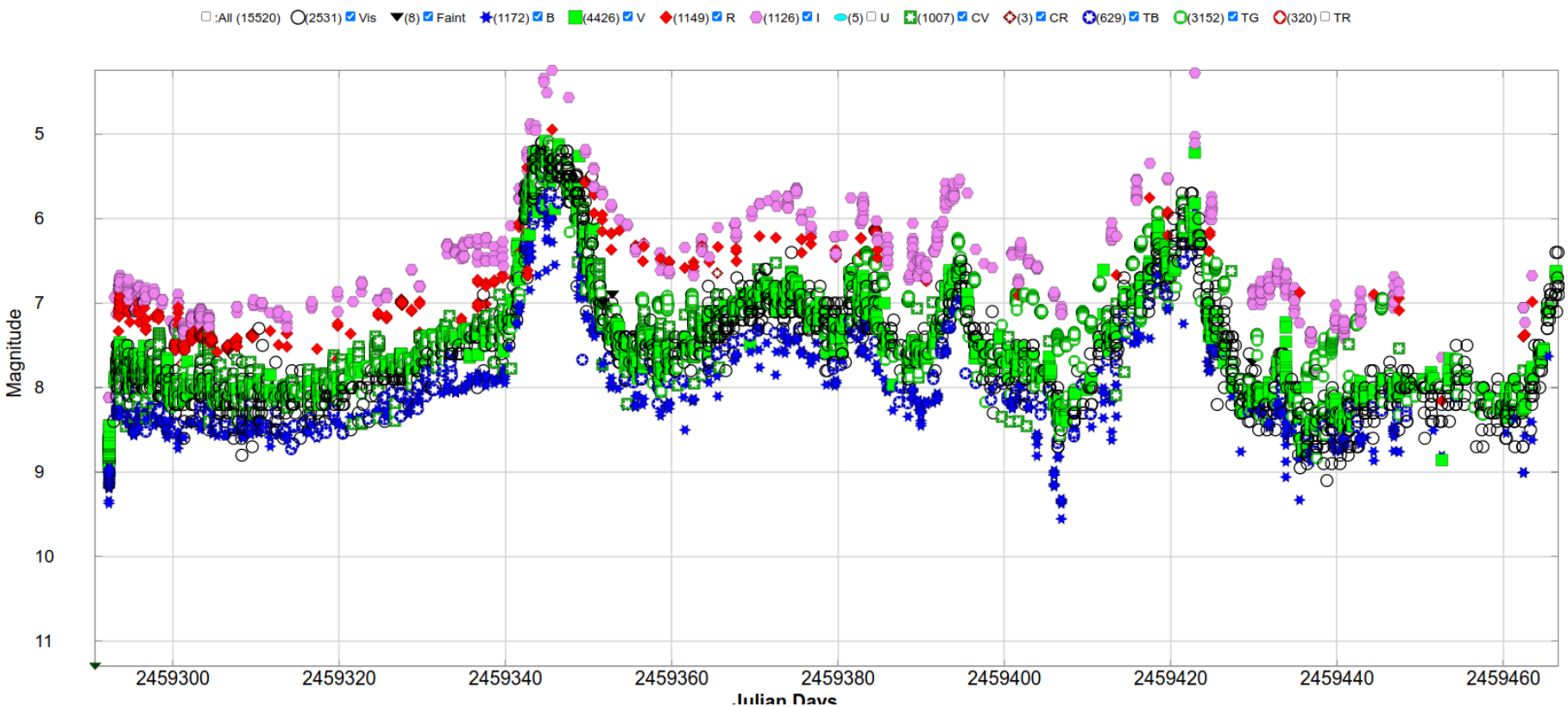
AAVSO photometry

Max brightness: May 9-10



AAVSO photometry

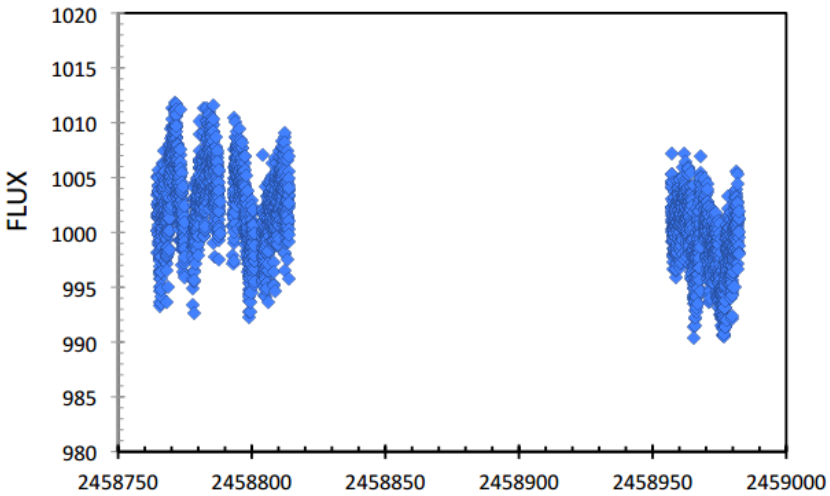
Total $\sim 150+$ days, $V_{max} = 5.08$, $t_2 = 7$ days, $t_3 = 61$ days

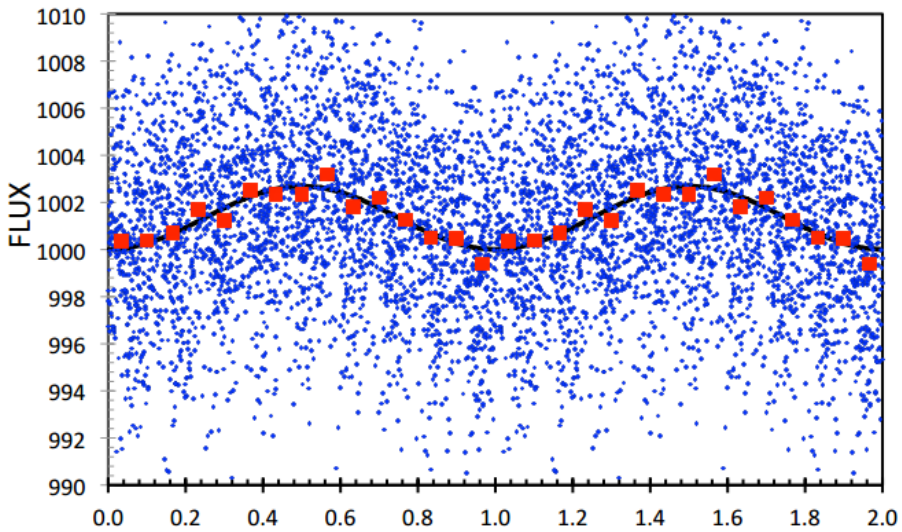


$t_{2,trans} = (t_3 - 2.3 \pm 1.6)/(1.68 \pm 0.04) \sim 35 \pm 2$ days
(Capacciolli et al., 1990)

TESS pre-outburst

B. Schaefer (April 20, 2021) - irradiation (e.g. orbital) variability in TESS data from sectors 17, 18, and 24 (Oct 8, 2019 – May 12, 2020) with $P_{orb} = 0.1883907 \pm 0.000048$ d





Spectroscopy

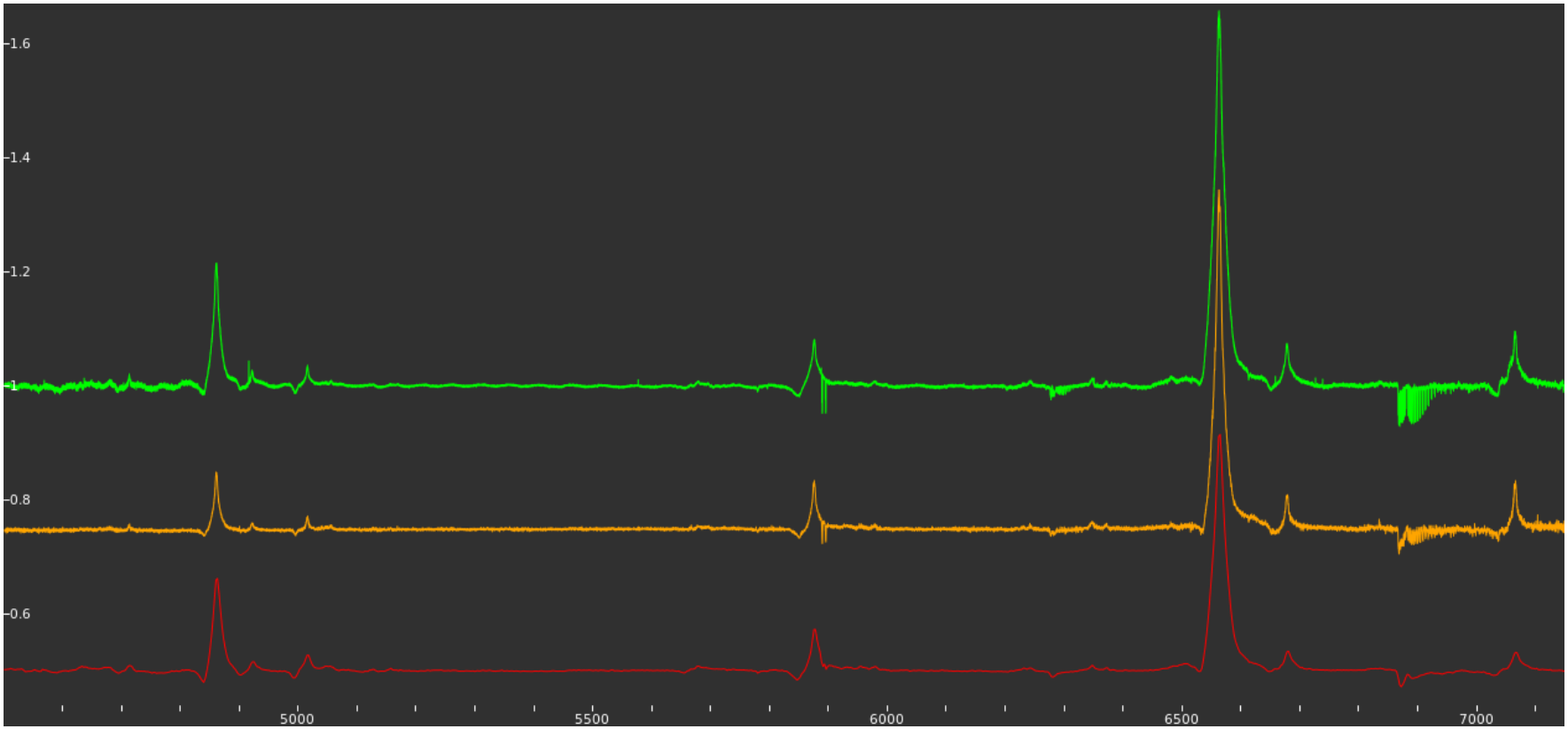
Up to Sep 3, 2021:

- $24\times$ with $R \sim 38000$ on 1.3m @ Skalnaté Pleso
- $232\times$ with $R \sim 500 - 5000$ ARAS spectra
- $61\times$ with $R \sim 10000 - 20000$ ARAS spectra (H_α region)

and counting...

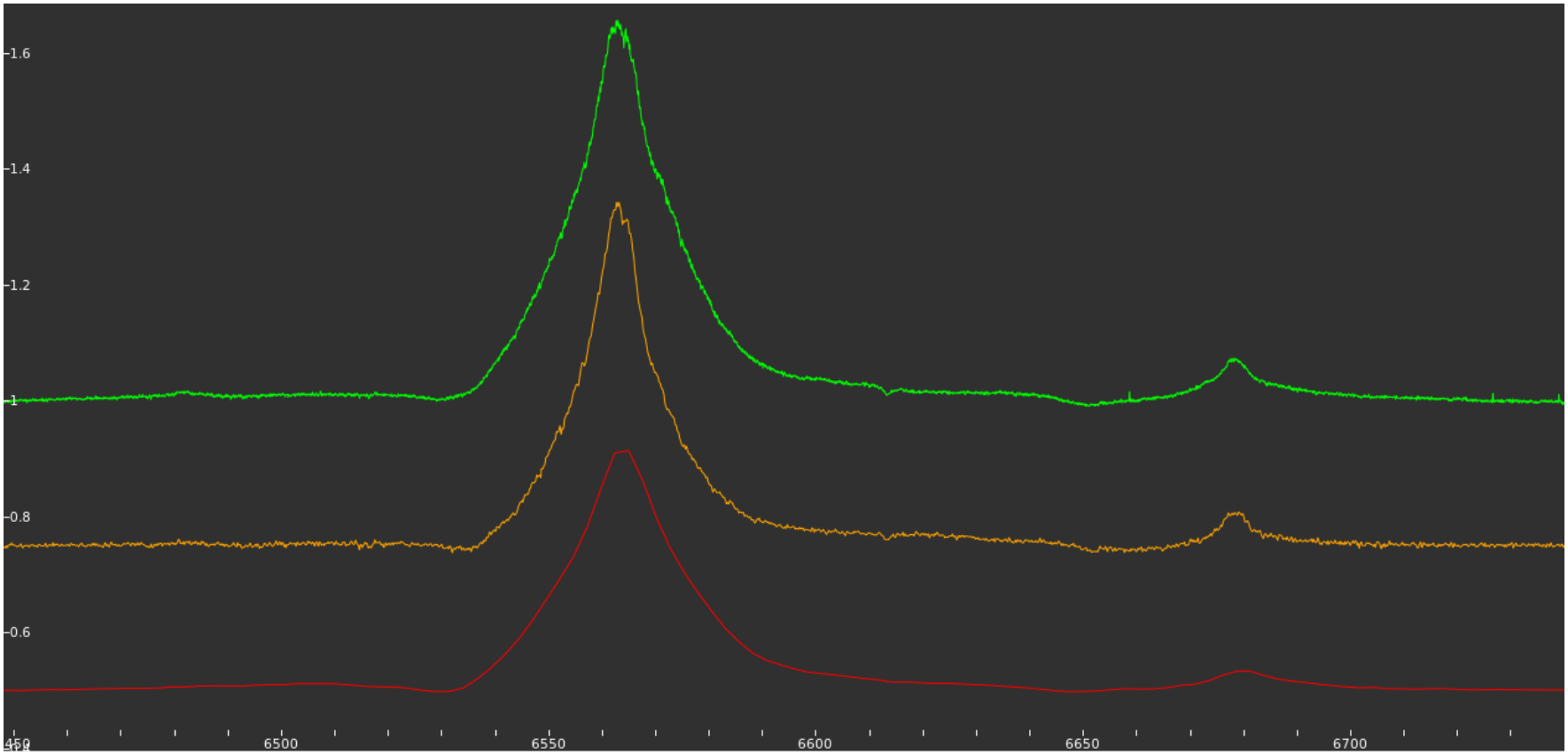
Classification vs Characterization

Compare spectra from Mar 20, 2021: R=38000, R=11000, R=1000



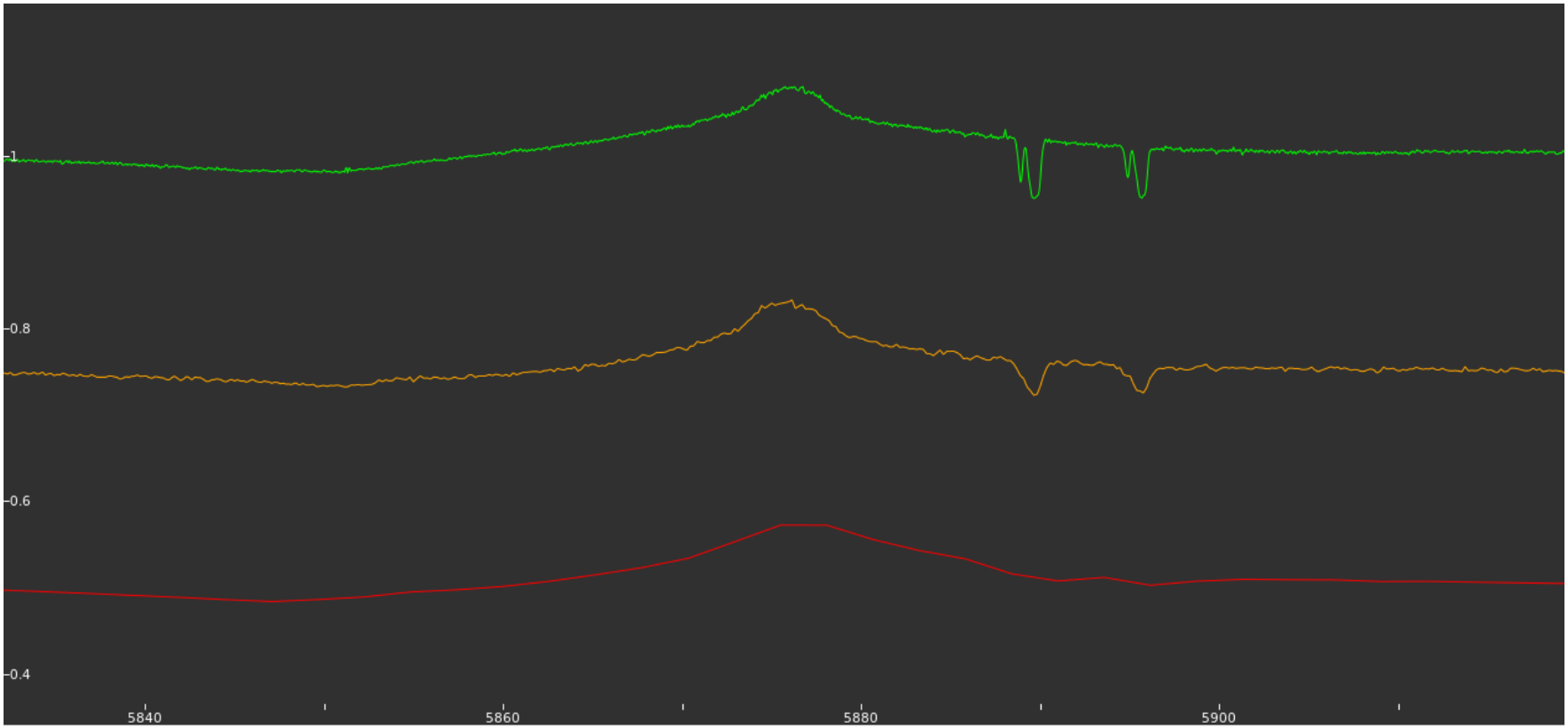
Classification vs Characterization

Zoom to H_α region: R=38000, R=11000, R=1000



Classification vs Characterization

Zoom to Na doublet region: R=38000, R=11000, R=1000



ARAS difficulties

- **different instruments (spectral regions)**
- usually not flux calibrated (exposure, gain, throughput...)
- unknown dispersion (wavelength calibration)
- unknown barycentric correction (or missing site location)

Date	Time (UT)	JD	Observer	Site	Resolution	λ_{min}	λ_{max}
2021-03-19	20:11	59292.842	DBO	WCO-UK	1030	3900	7380
2021-03-19	20:13	59292.843	MCLHVBSVA	ALI-BE	212	3922	7171
2021-03-20	01:49	59293.076	MLA	LOR-FR	600	3900	7400
2021-03-20	02:26	59293.101	PAD	KOL-SK	751	3800	7590
2021-03-20	04:56	59293.206	PLD	KER-FR	508	3751	7500
2021-03-20	11:01	59293.459	KSH	CAR-US	1000	3950	7333
2021-03-20	18:04	59293.753	PAD	KOL-SK	775	3800	7590
2021-03-20	18:36	59293.775	MBA	MIE-PL	1000	3899	8002
2021-03-20	18:54	59293.788	OGA	OTO-FR	11000	4300	7605
2021-03-20	19:21	59293.807	EBE	SSO-FR	13881	6501	6612
2021-03-20	19:39	59293.819	JMV	RON-FR	554	3700	7300
2021-03-20	19:54	59293.830	CBO	OCT-FR	528	3550	7400
2021-03-20	20:01	59293.834	JGF	SMM-SP	9500	3739	8938
2021-03-20	20:02	59293.835	FBO	SJI-FR	9500	4001	7451
2021-03-21	19:39	59294.819	JGFFMT	SMM-SP	9500	4500	7300

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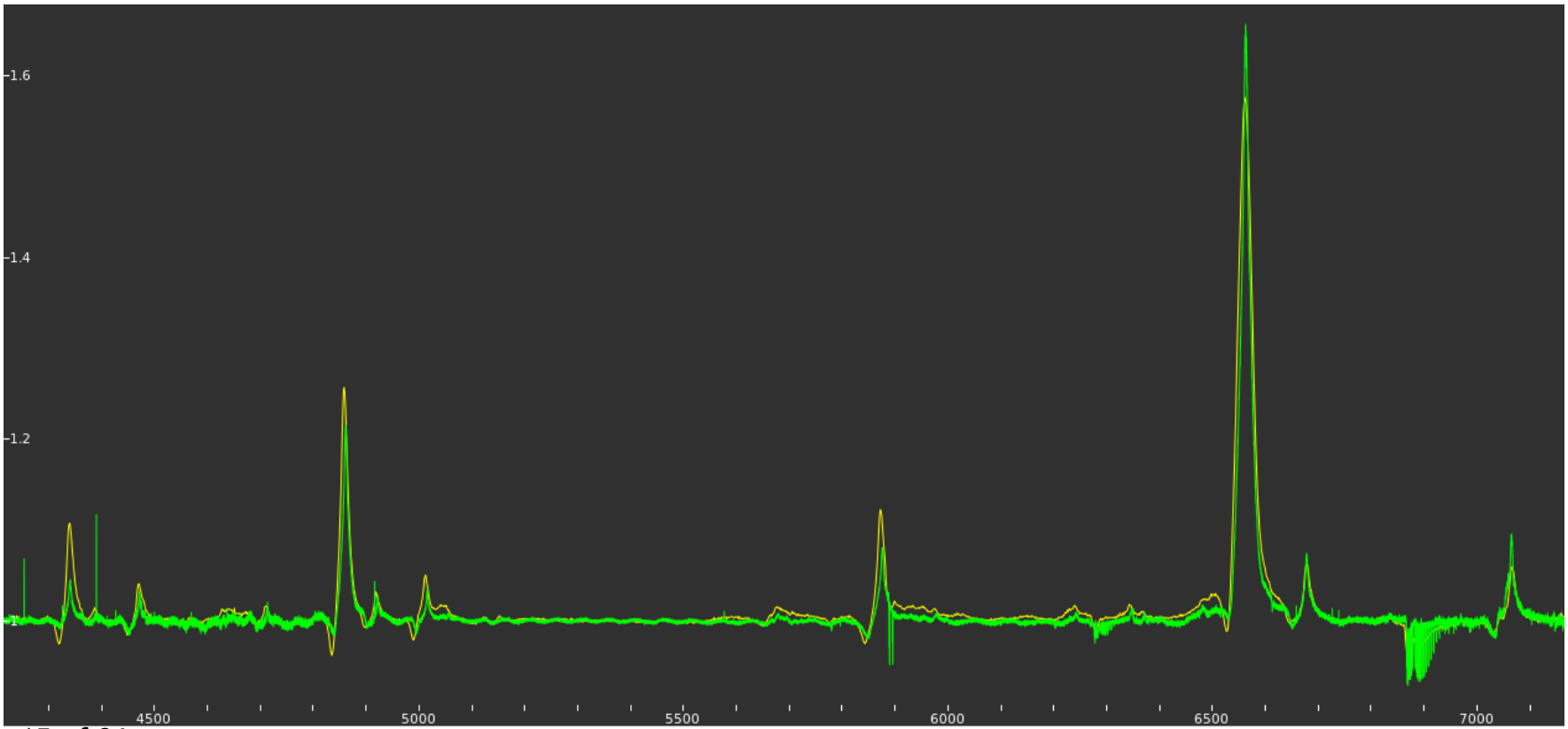

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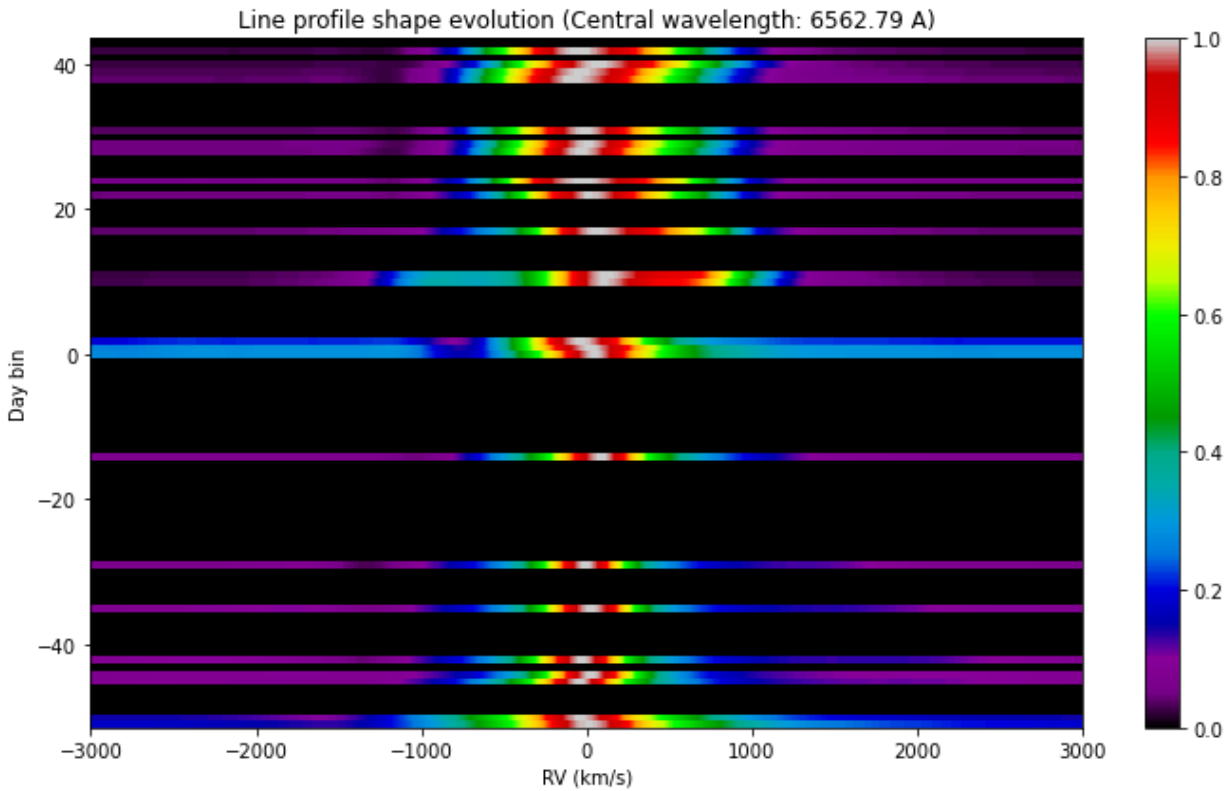

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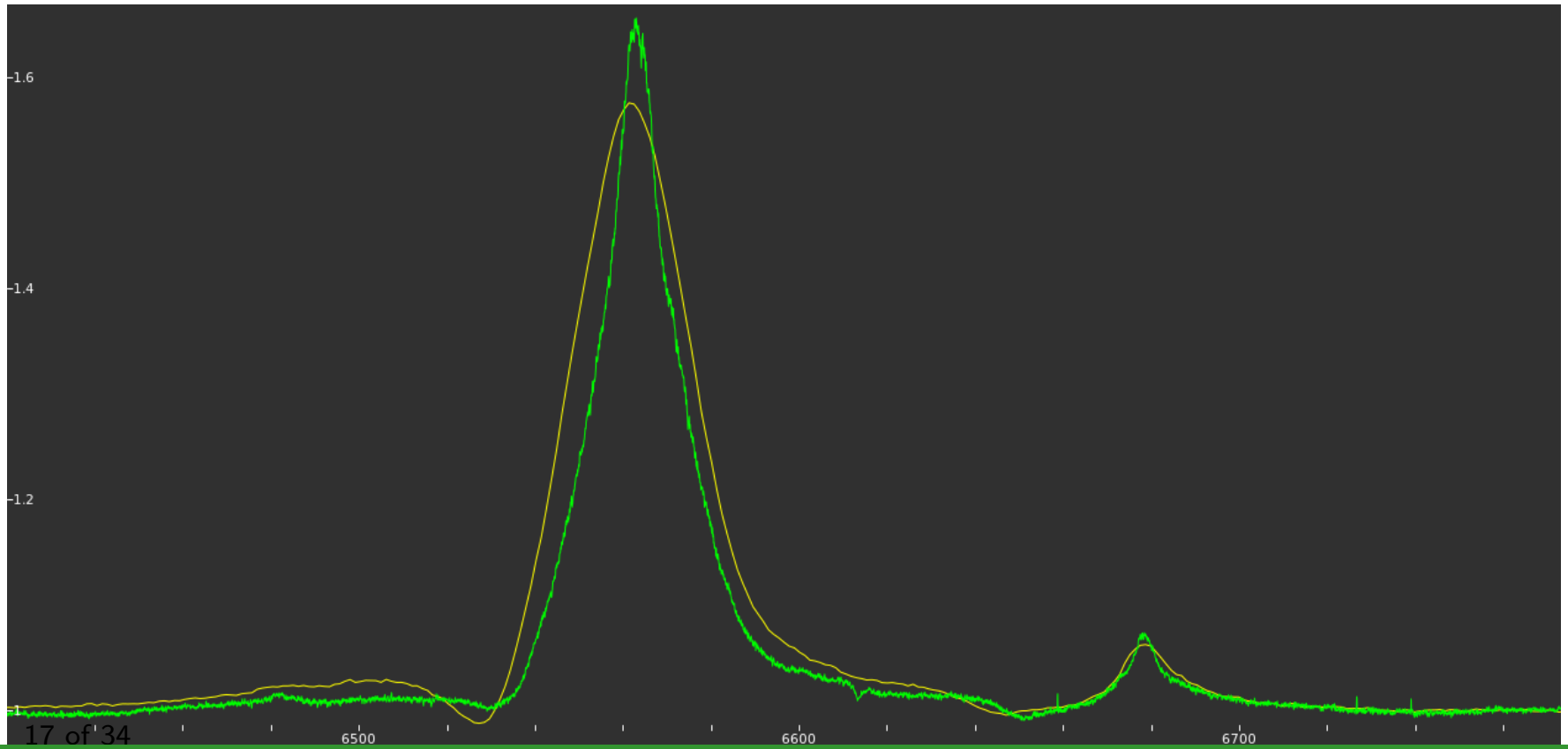
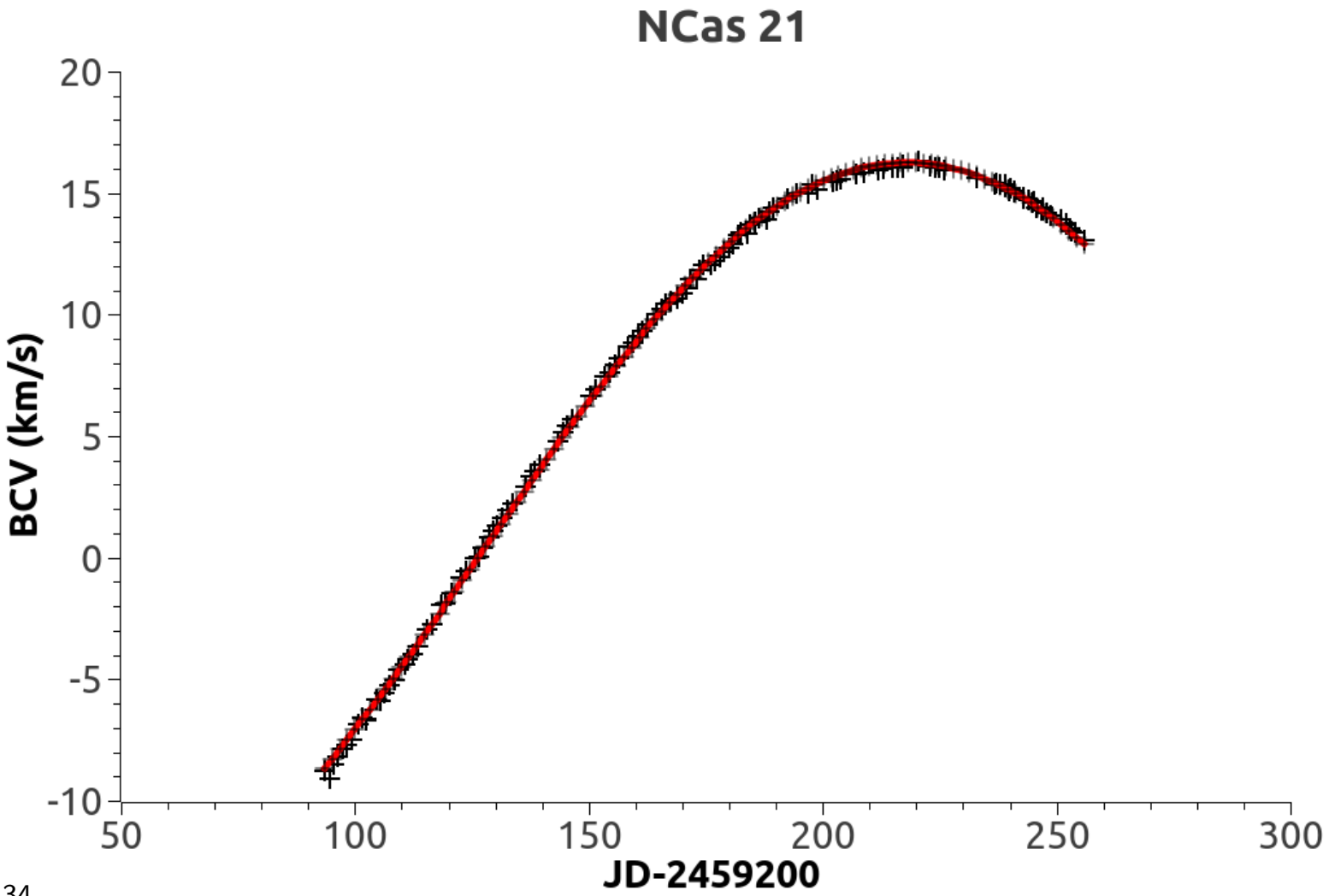


Workaround

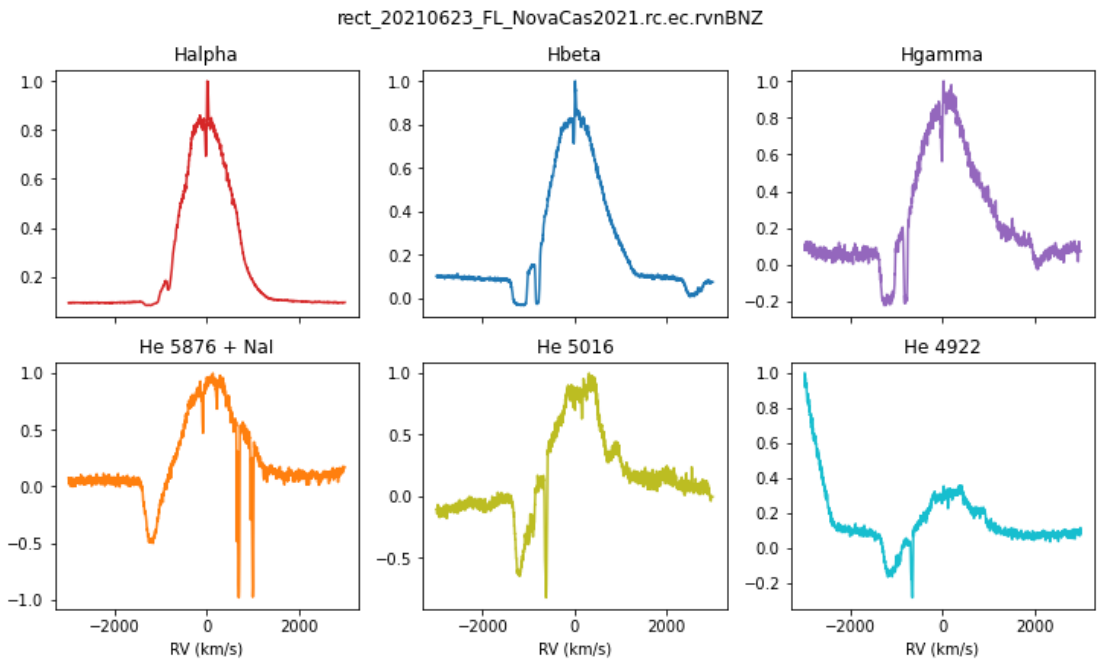
Recalculate BCV where available (+) use **model** for all other



Workaround

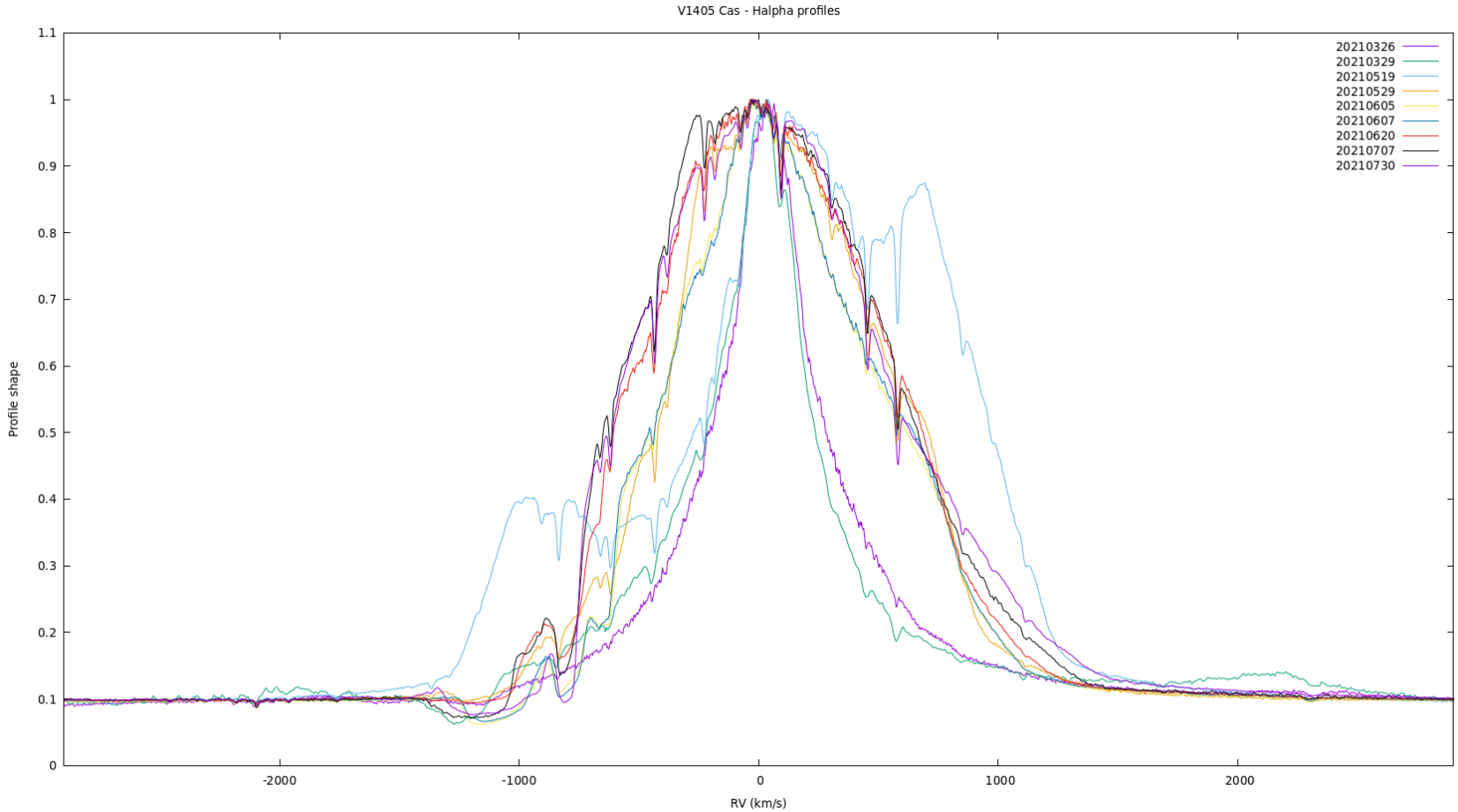
Work in discrete intervals (e.g.$\sim$ 100 Å) in Doppler velocity space

6562.79Å	H_α	4861.33Å	H_β	4340.46Å	H_γ
5875.97Å	He I + Na I	5015.68Å	He I	4921.93Å	He I
6678.15Å	He I	7065.71Å	He I	4101.74Å	H_δ



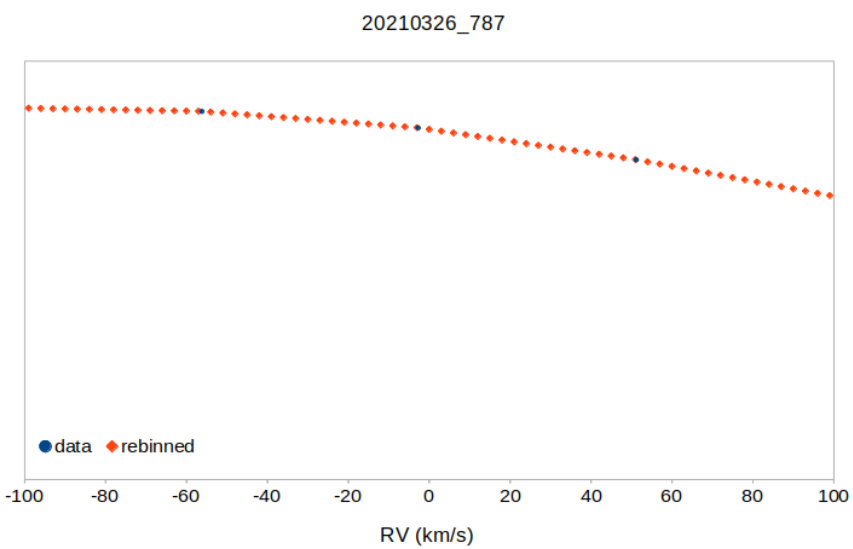
Workaround

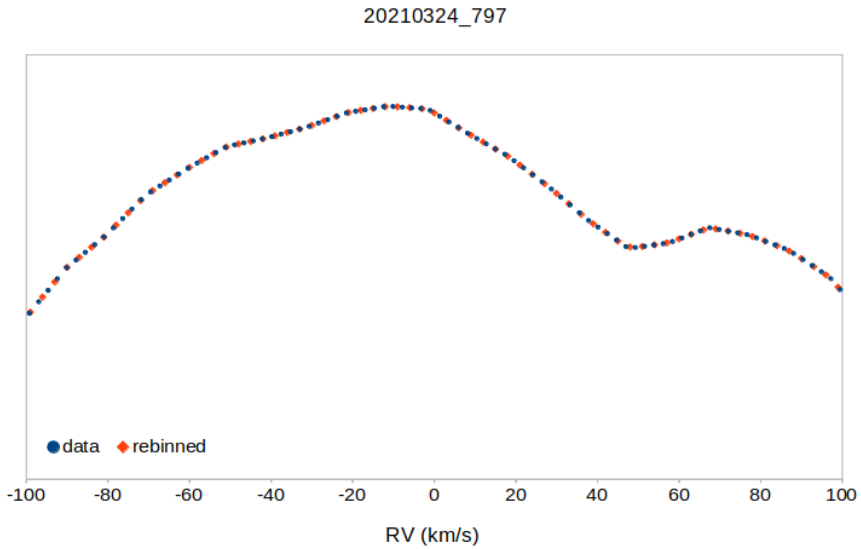
Remove instrumental offset by aligning water absorption lines present in e.g. H_α, then apply calculated BCV



Workaround

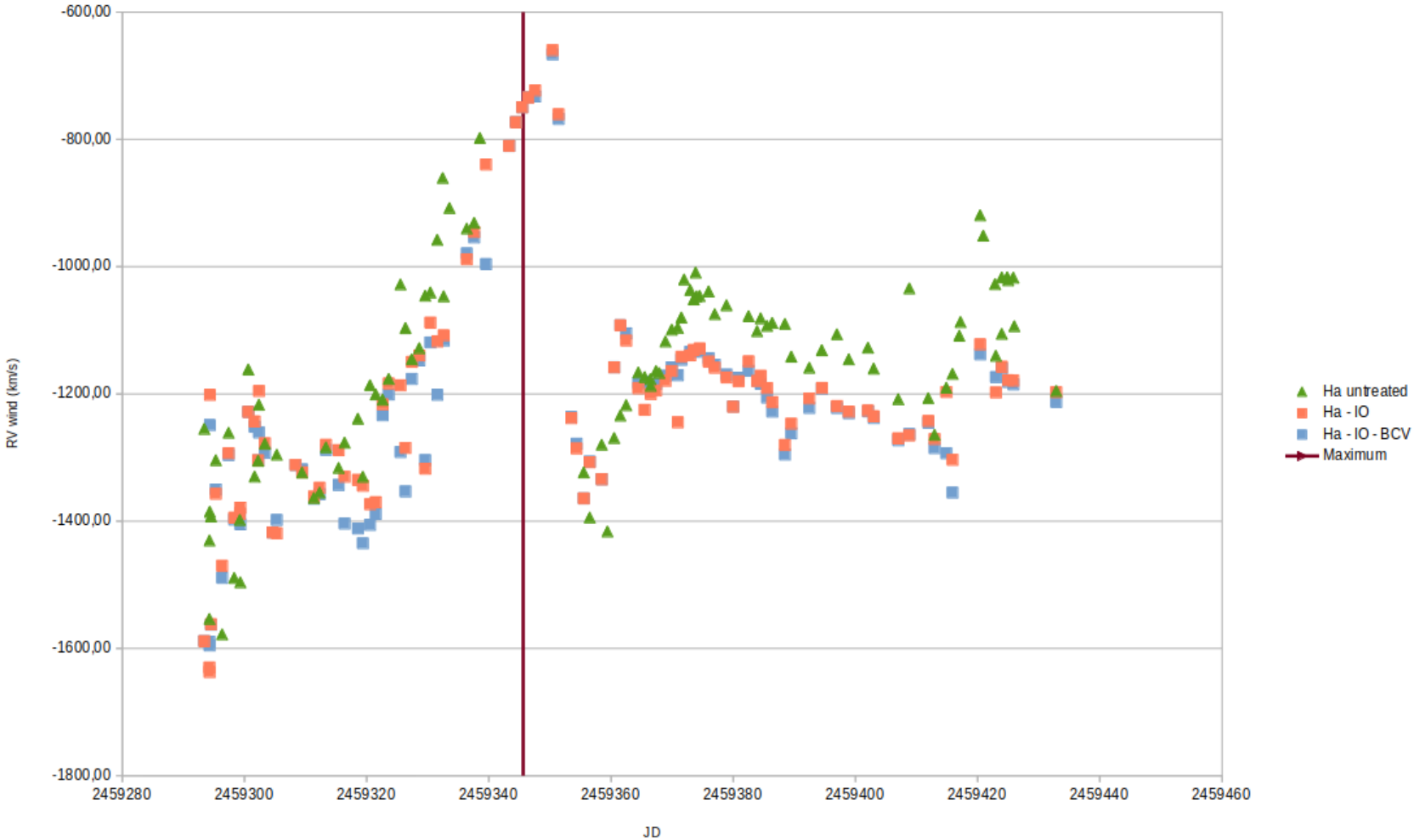
Rebin region data to $\Delta RV = 3$ km.s^{-1}& construct normalized profile with fixed continuum level and unit maximum intensity





Workaround

Measure RV: untreated, IO removed, BCV applied



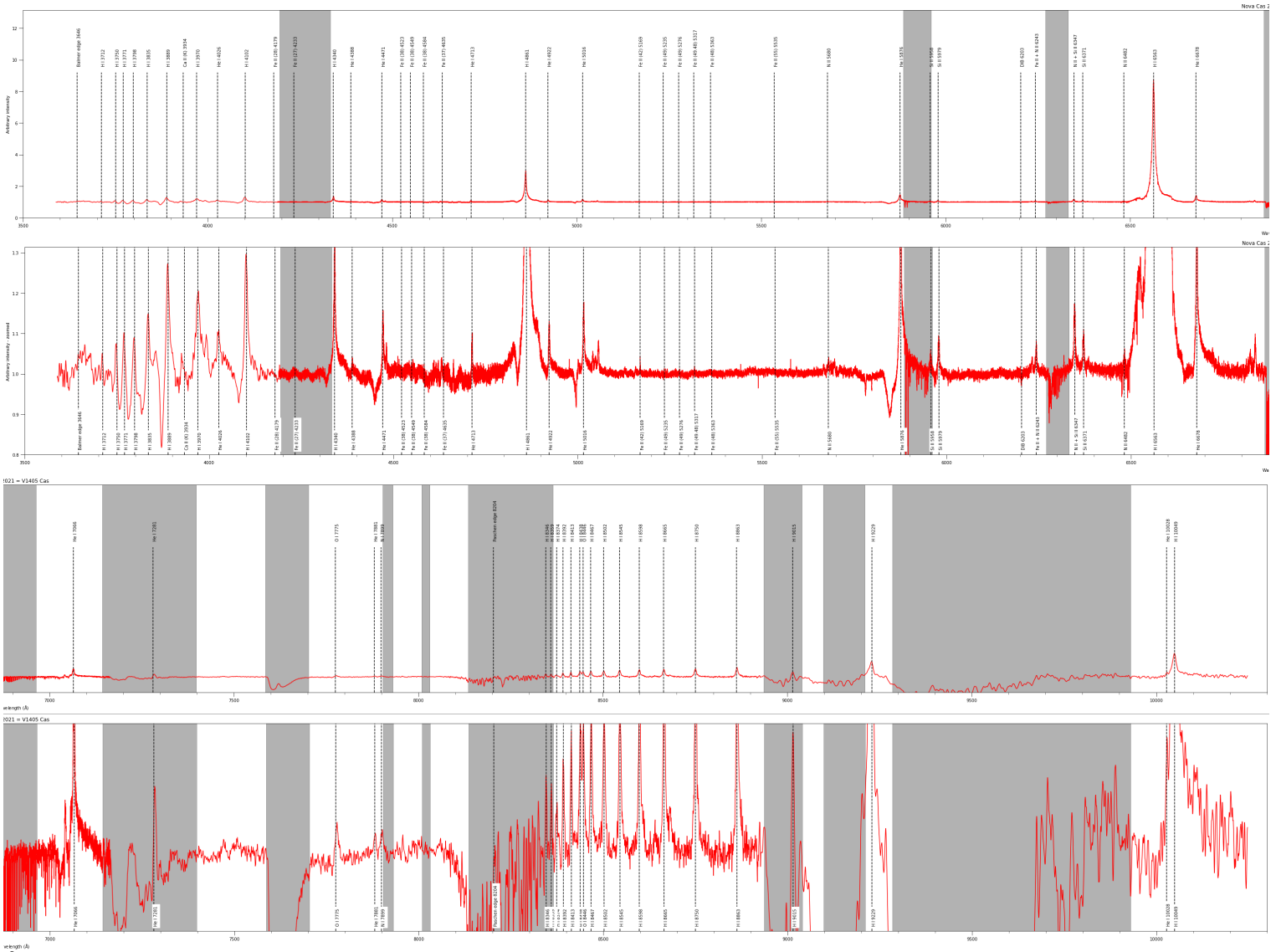
Preliminary results

Pre-maximum line ID: Balmer (3-15), Paschen (7-23), He I, Fe II, Ca II (K), N II, O I, Si II

Added spectra (May 29 – Apr 7):

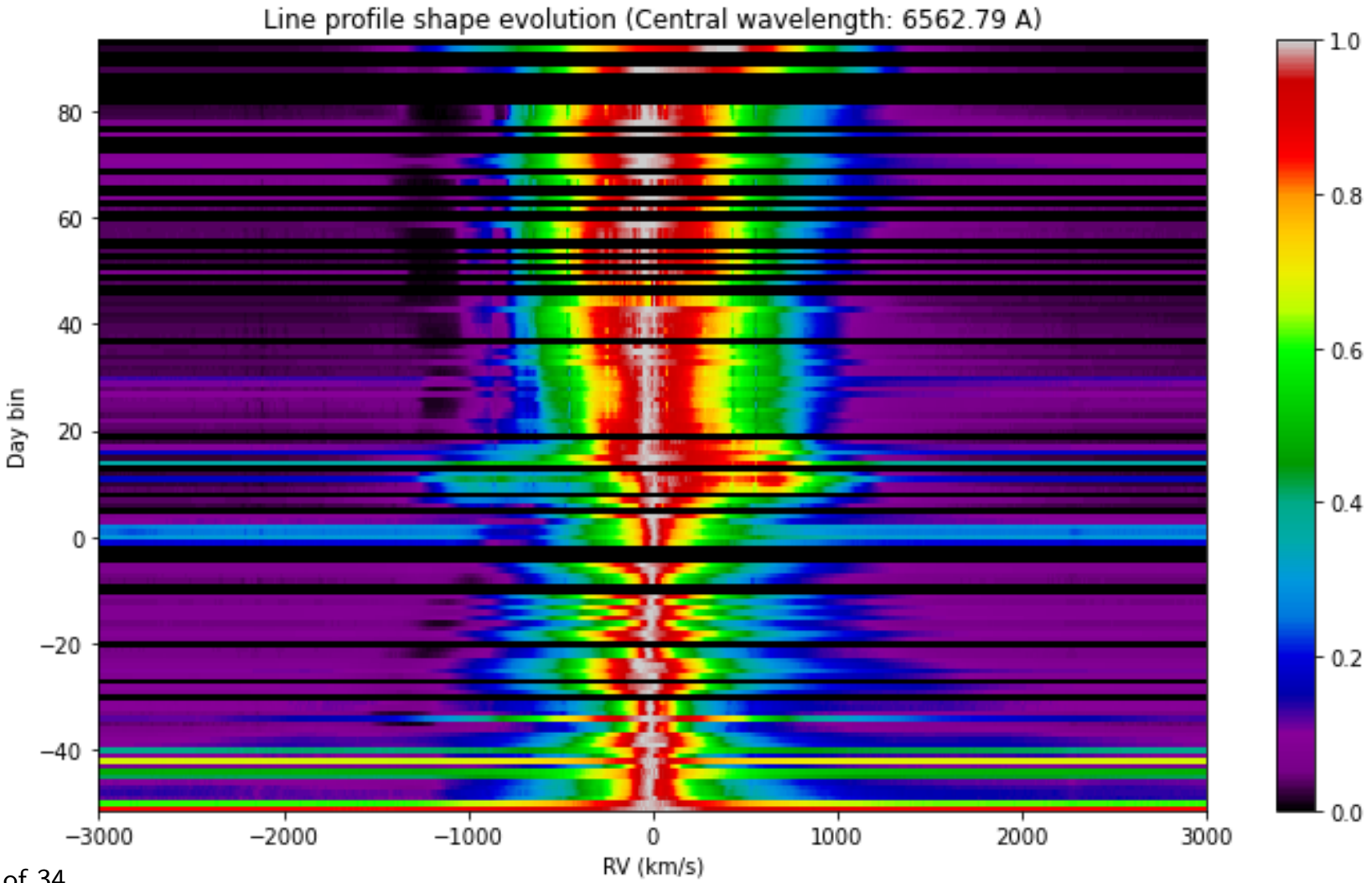
from	to	R	bin
3588	3909	600	-32
3909	4189	1000	-37
4189	7164	38000	-40
7164	8072	1000	-37
8072	8930	3500	-41
8930	10247	900	-38

Preliminary results



Preliminary results

Wind velocity evolution (V_{max} @ bin #0)



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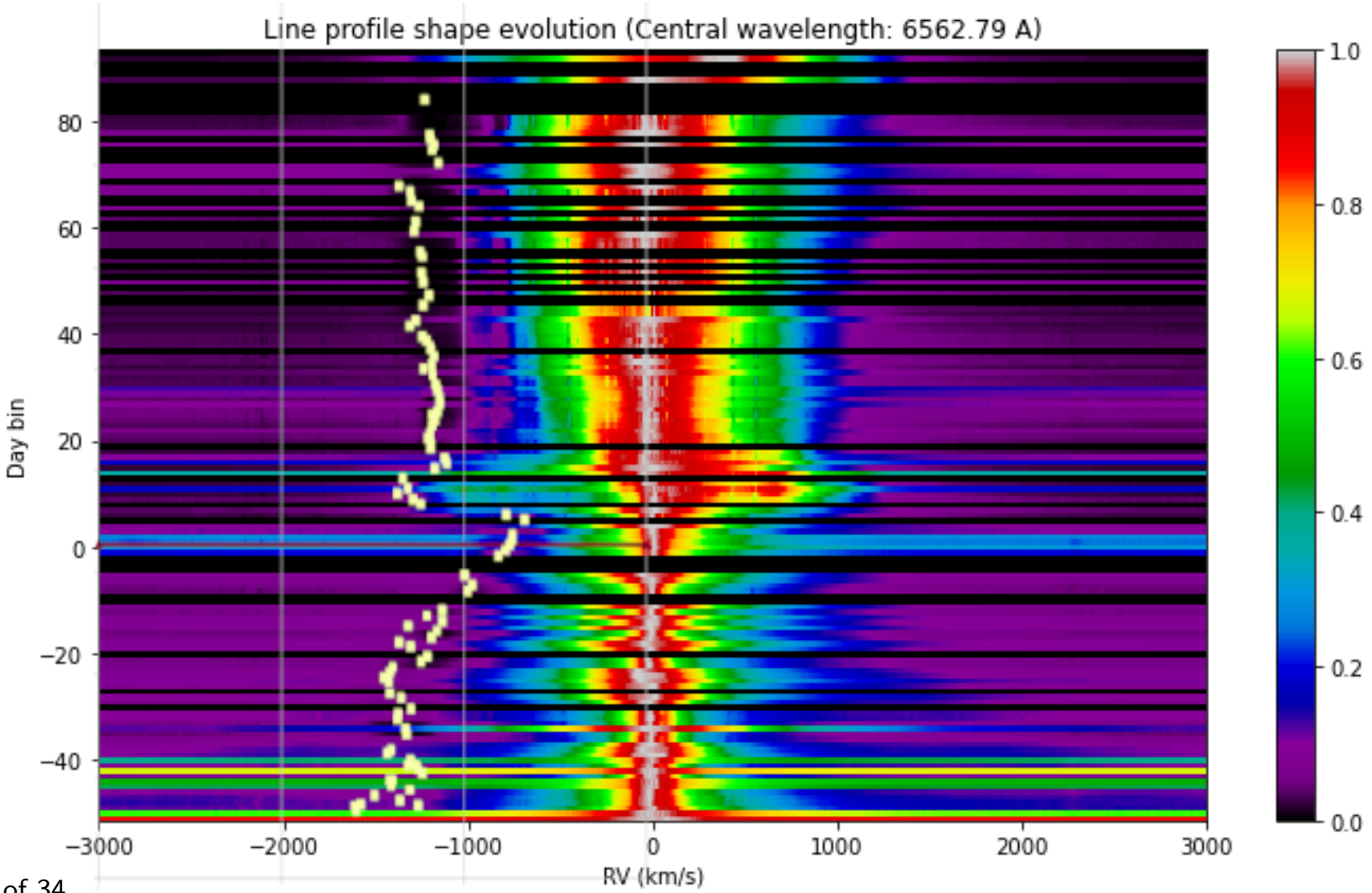

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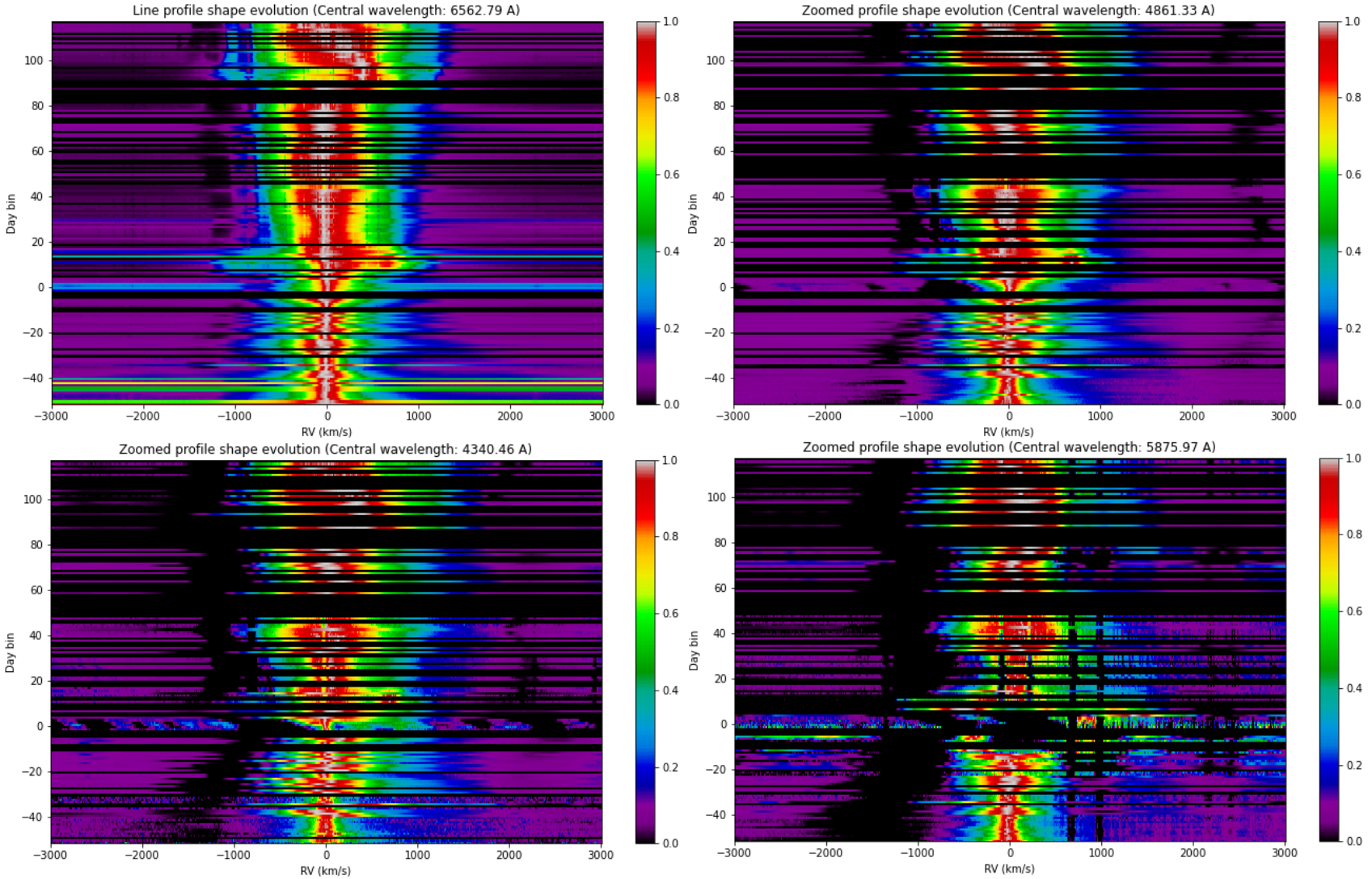
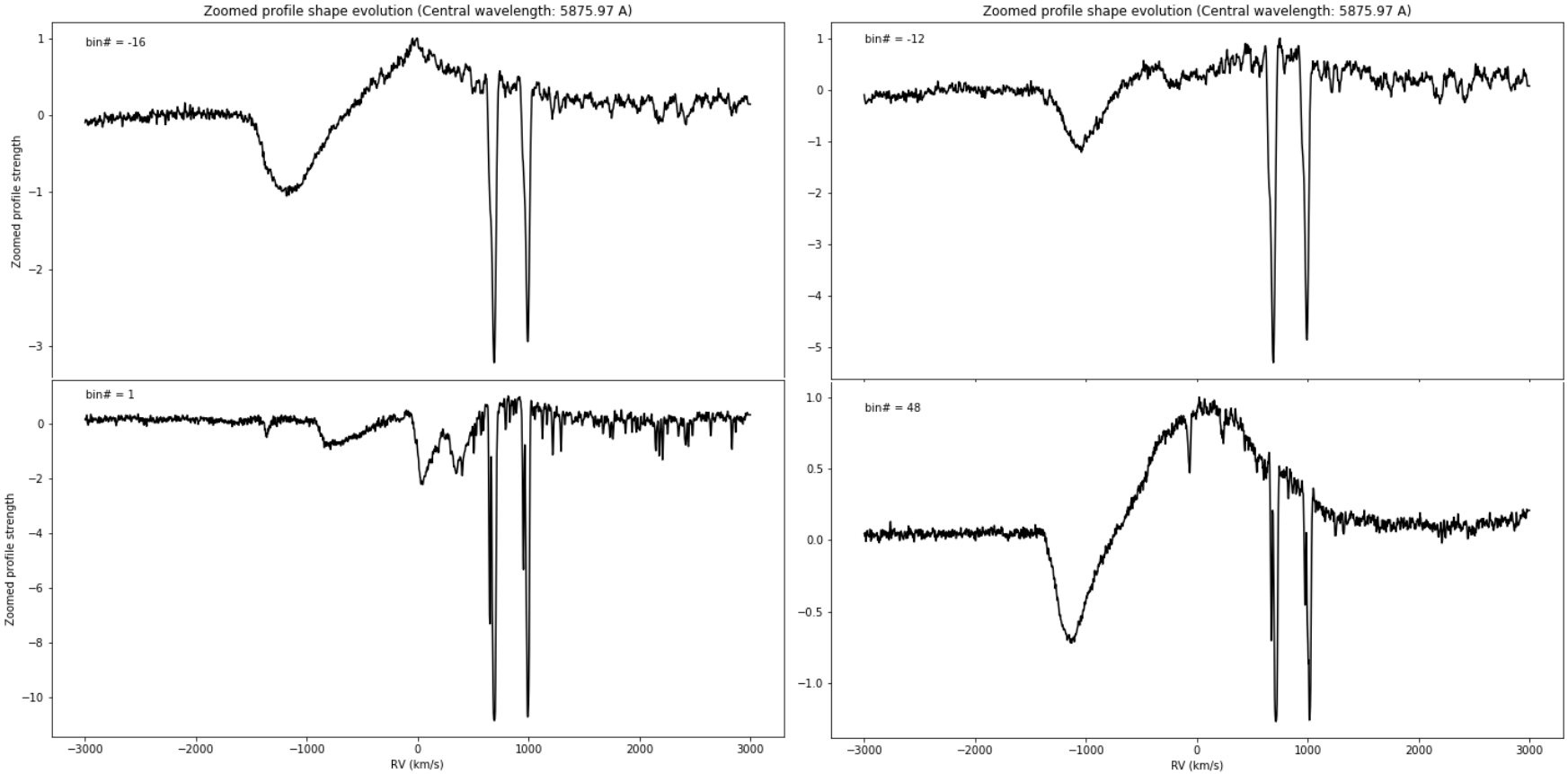


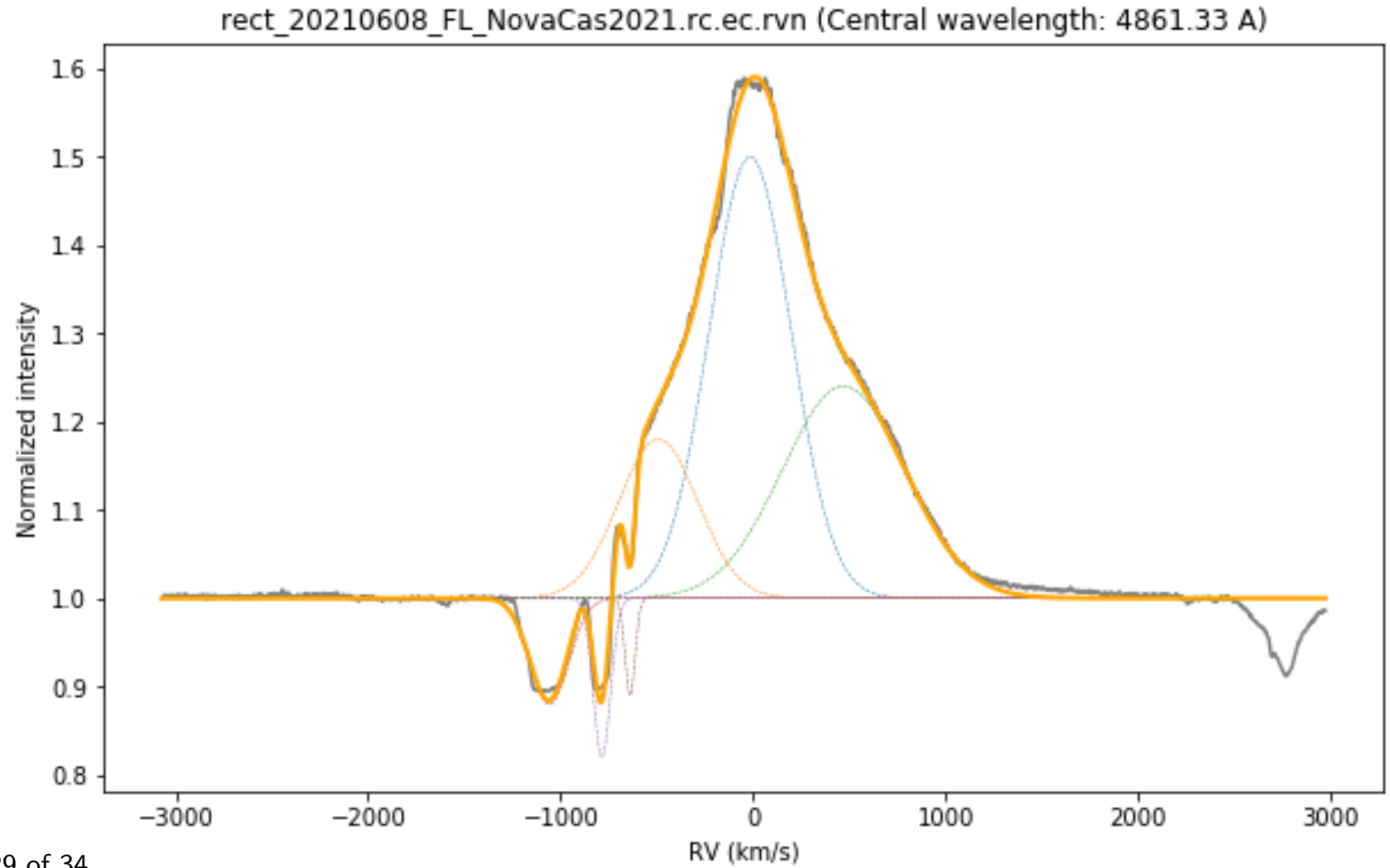
Preliminary results

Double set of Na I lines shifted by ~ -800 km.s^{-1}



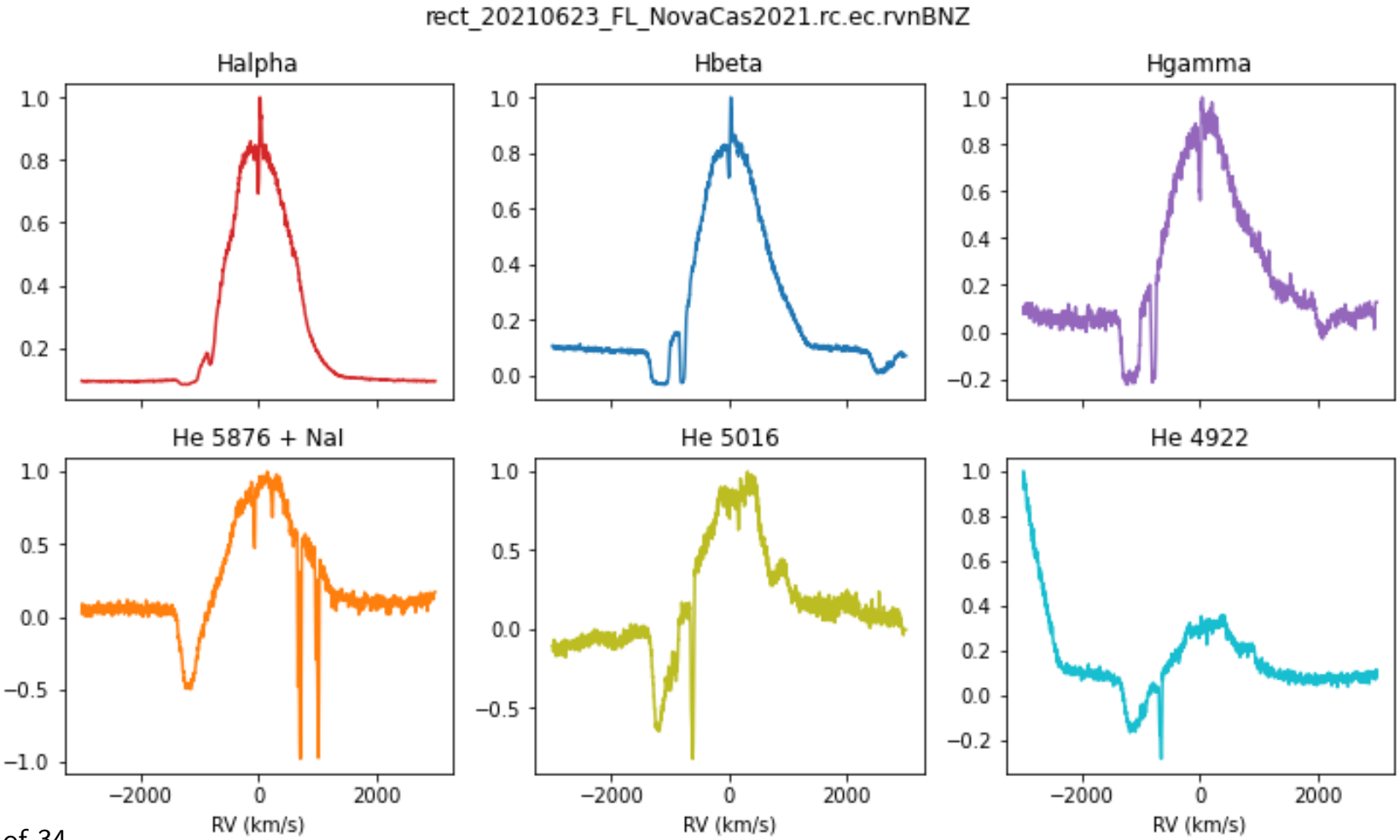
Preliminary results

Spectra with R=38000 for profile deconstruction, usually H_α with H_β



Preliminary results

Sharp PCyg feature in H! Present only during Jun 22 – 26. Visible ONLY in R> 30000



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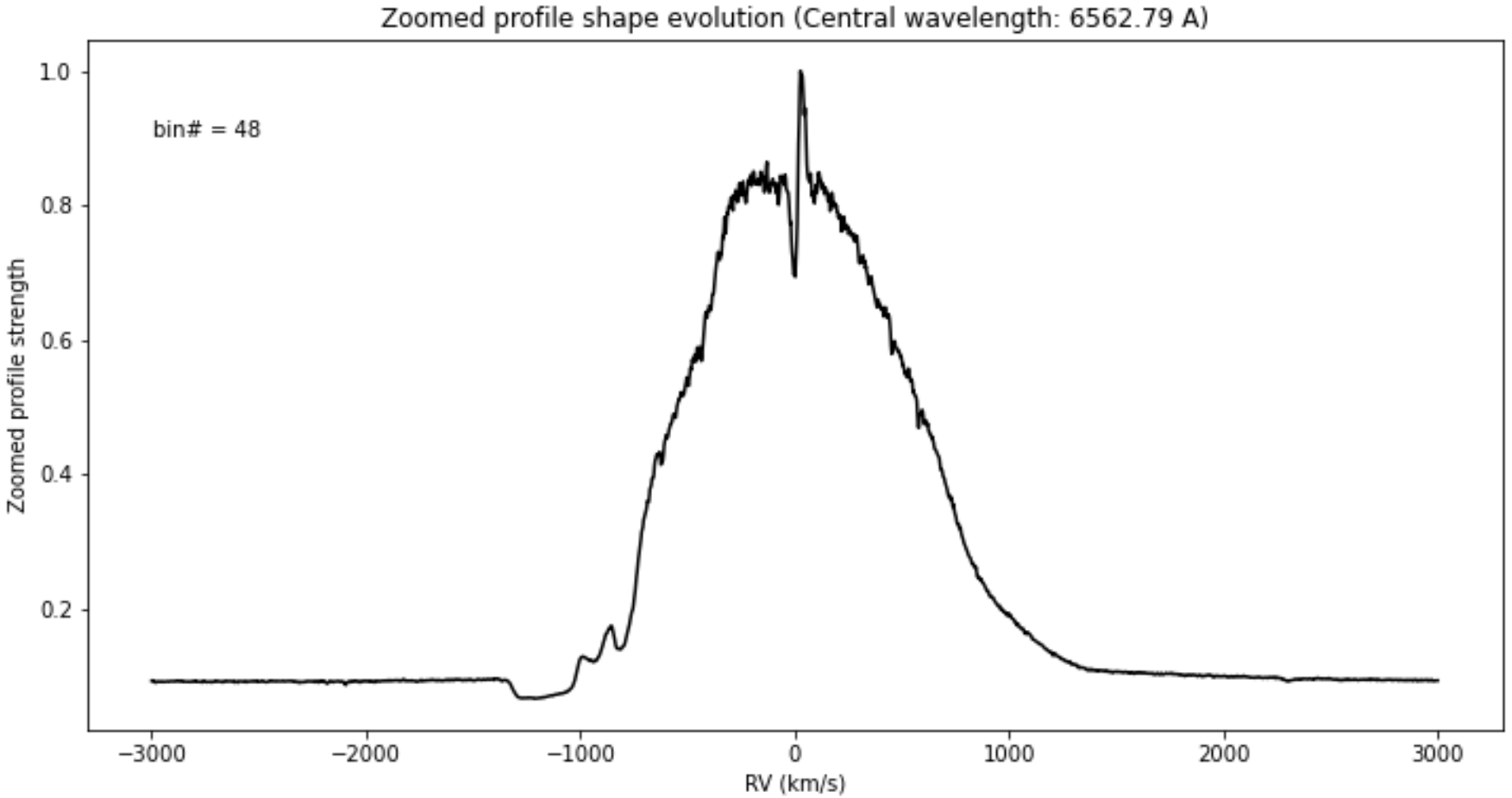
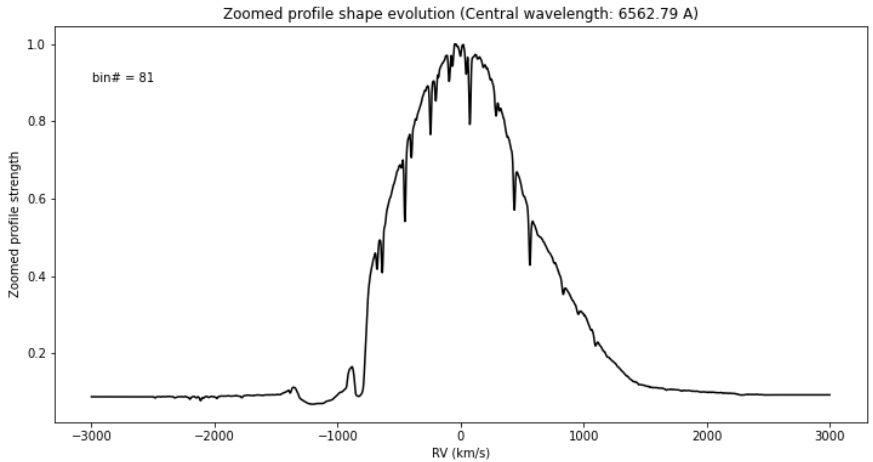
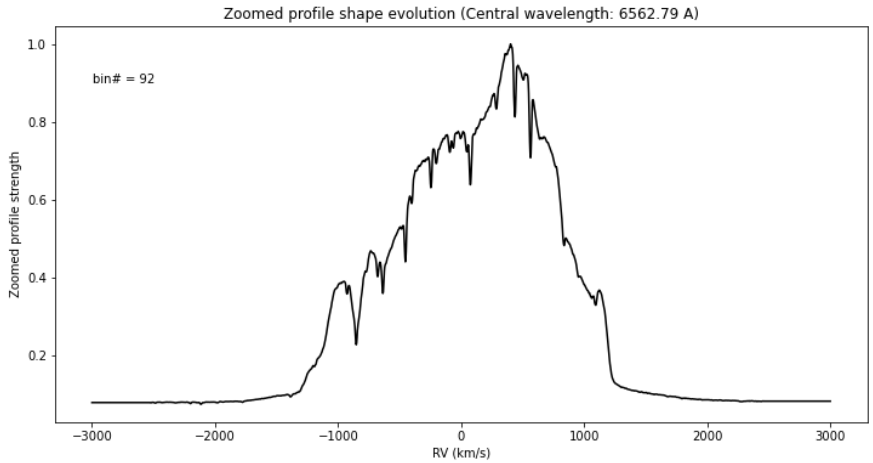
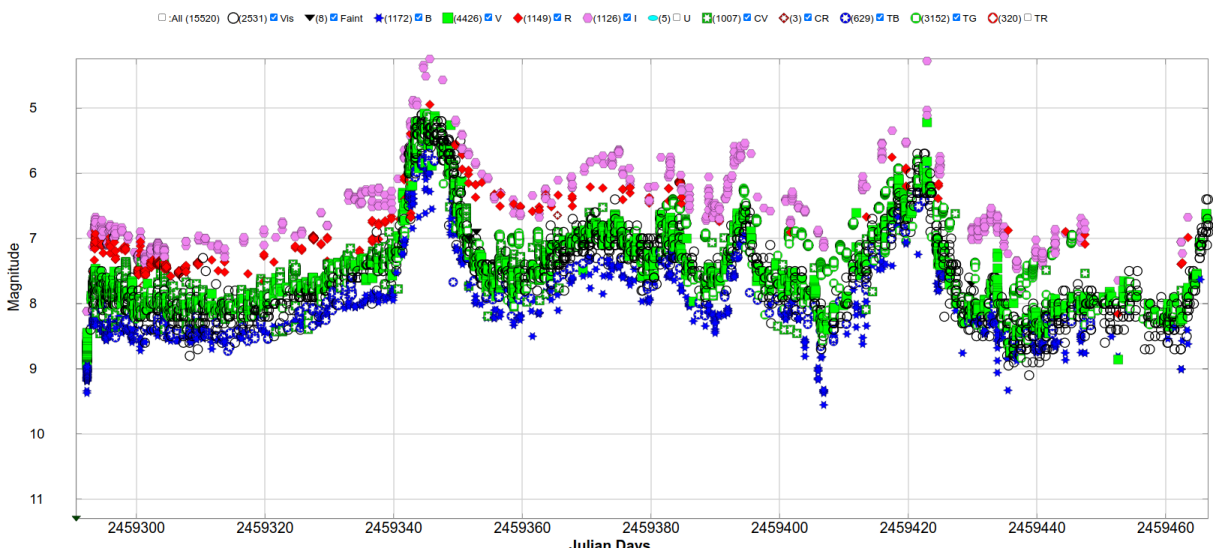


Preliminary

Re-brightening and another shell (Jul 30 – Aug 10)

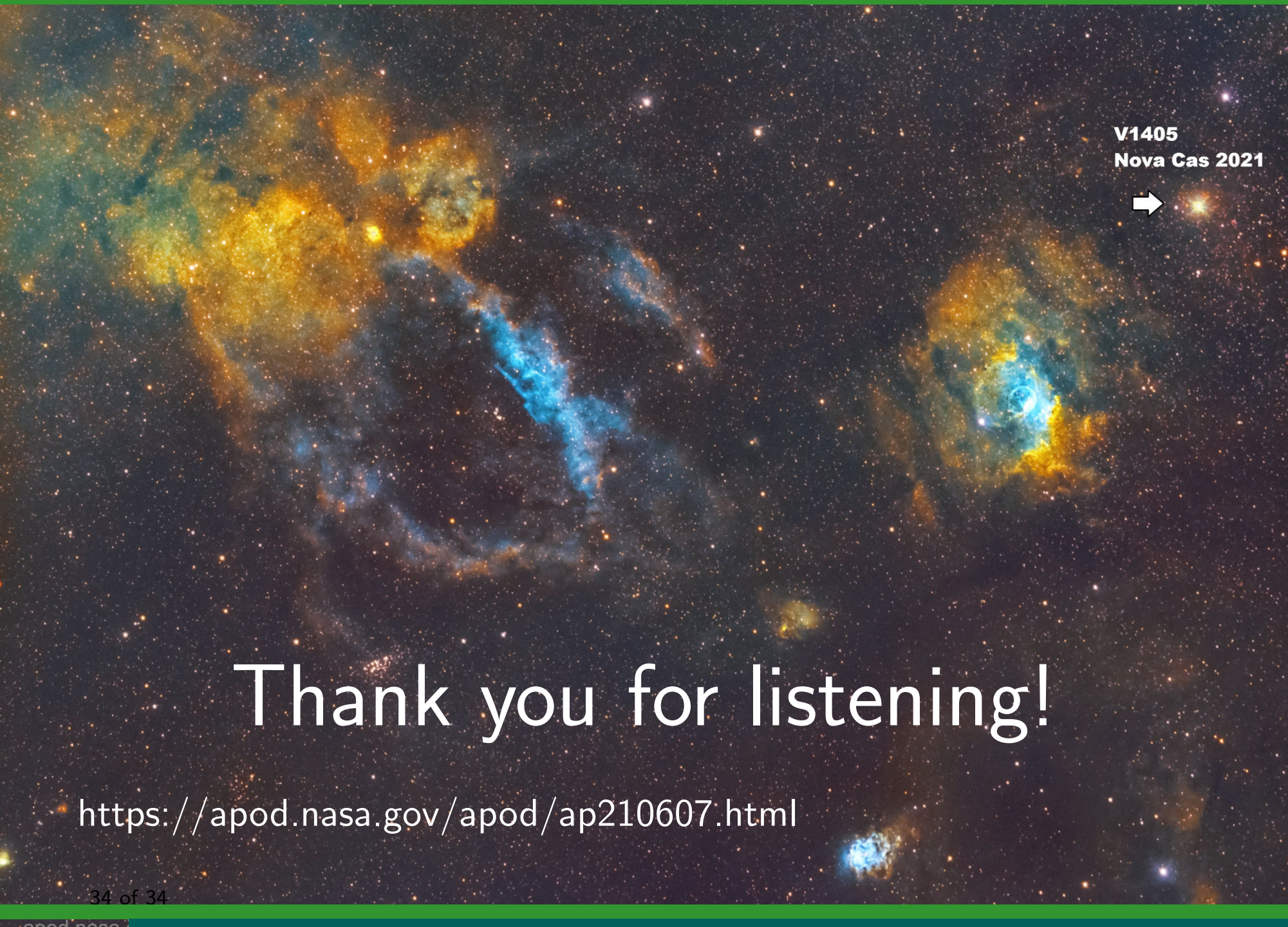






Summary

- slow He-nova with re-brightenings
- wind speeds accelerating with re-brightenings
- multiple absorptions – envelope shells
- still not in nebular stage



Thank you for listening!

https://apod.nasa.gov/apod/ap210607.html