Revealing a nearby interacting SuperLuminous SuperNova using X-Shooter

Seán Brennan

(Seán Ó Braonáin)

Postdoctoral researcher

Oskar Klein Centre,Stockholm University, Sweden

Stockholm University

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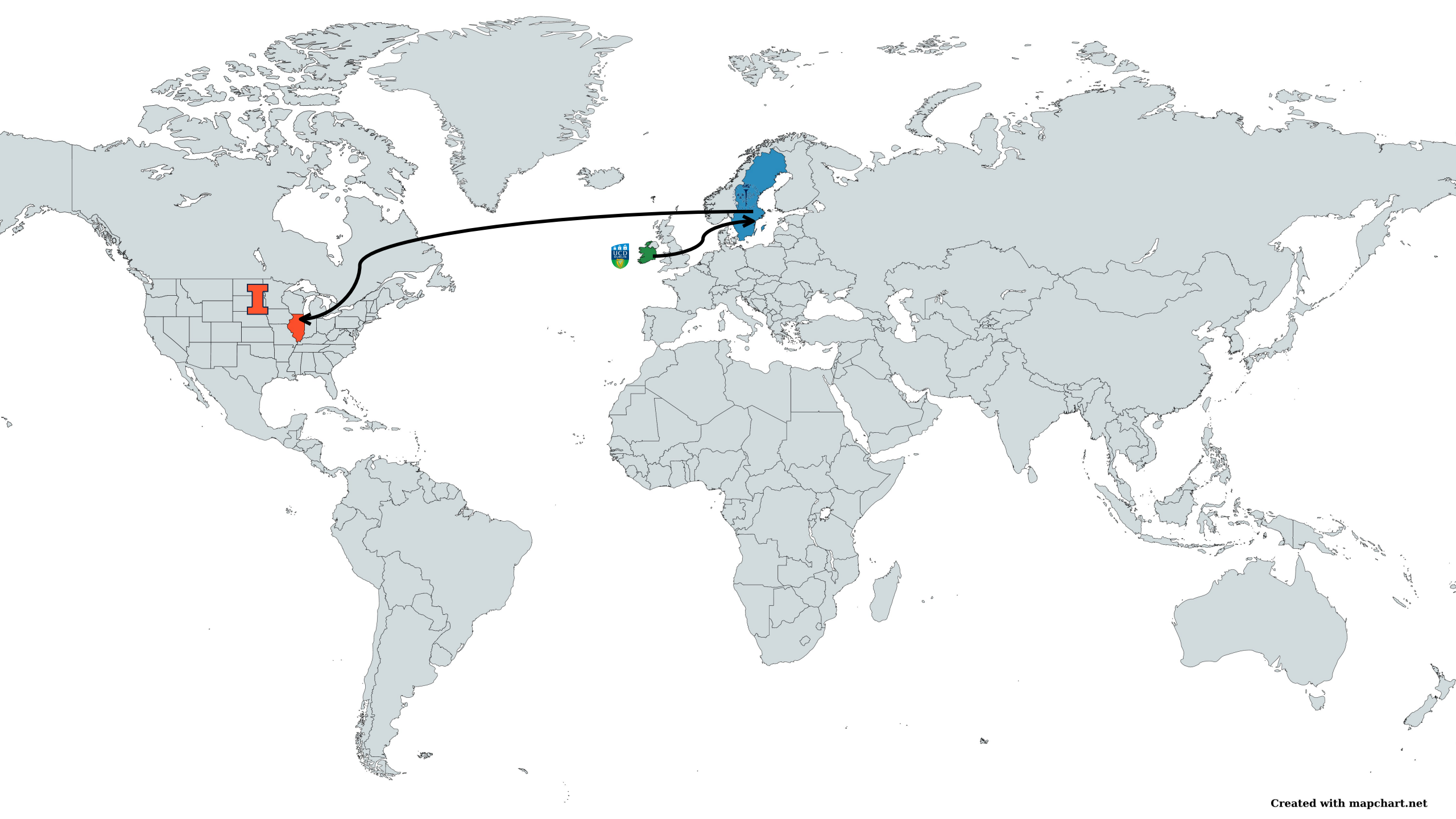
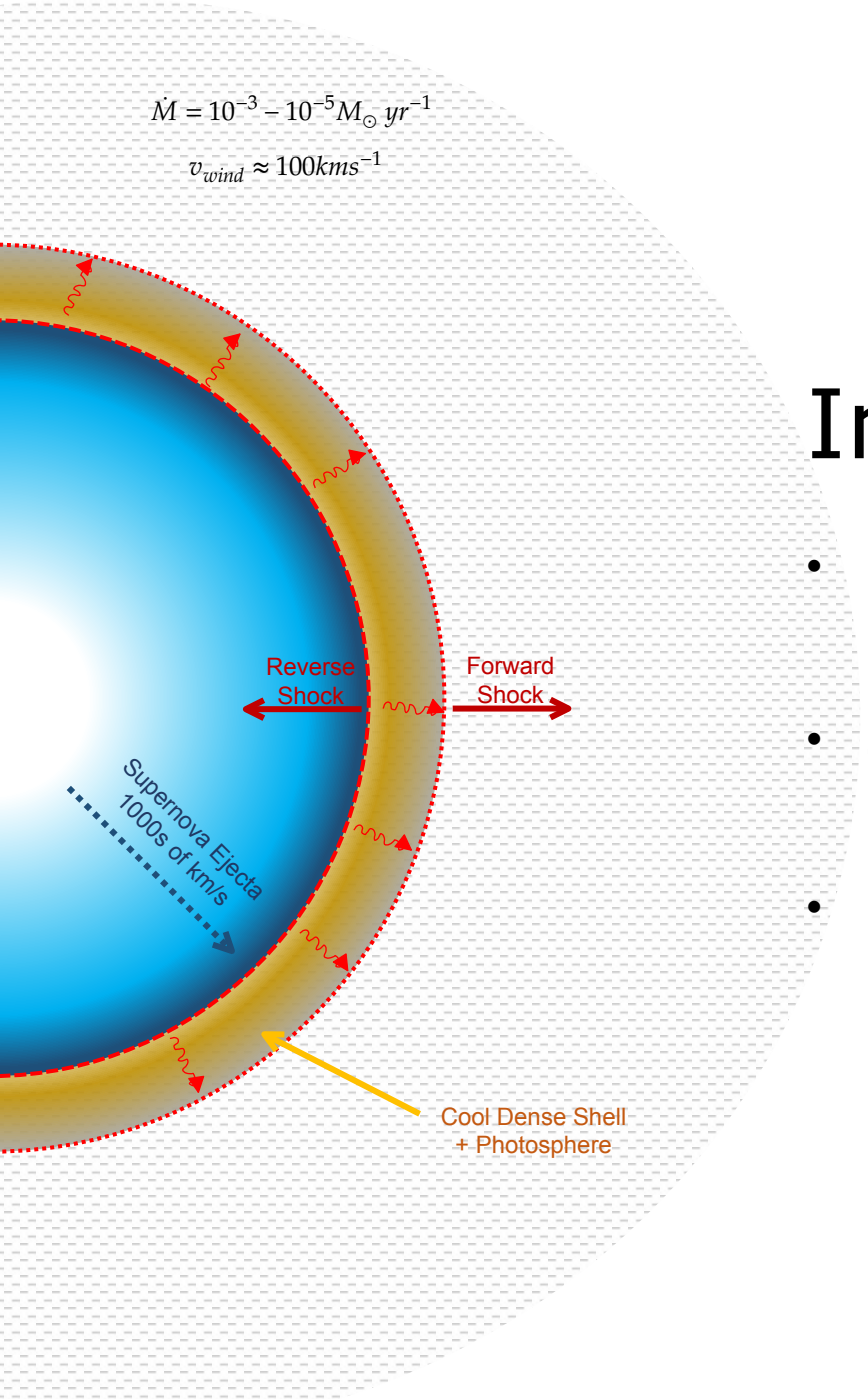


Created with mapchart.net



Interacting core-collapse supernova

- Hydrogen rich transient
- SN ejecta collides with dense circumstellar material
- $E_{kinetic} \rightarrow E_{Radiation}$

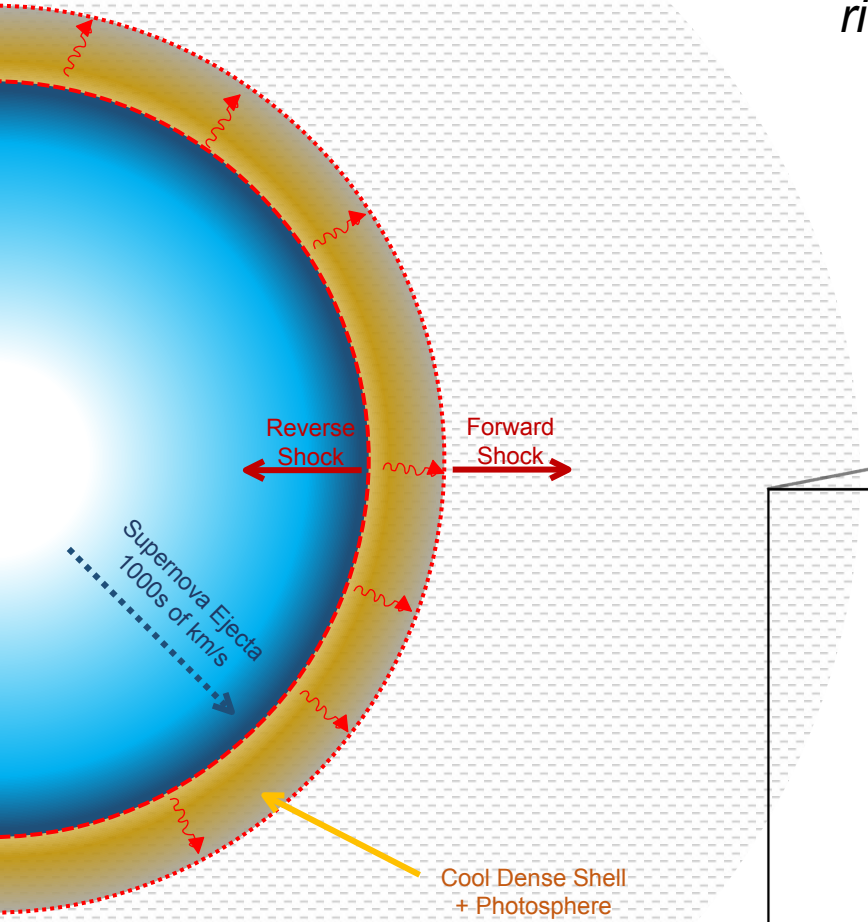
Usually easy to identify a type IIn SN

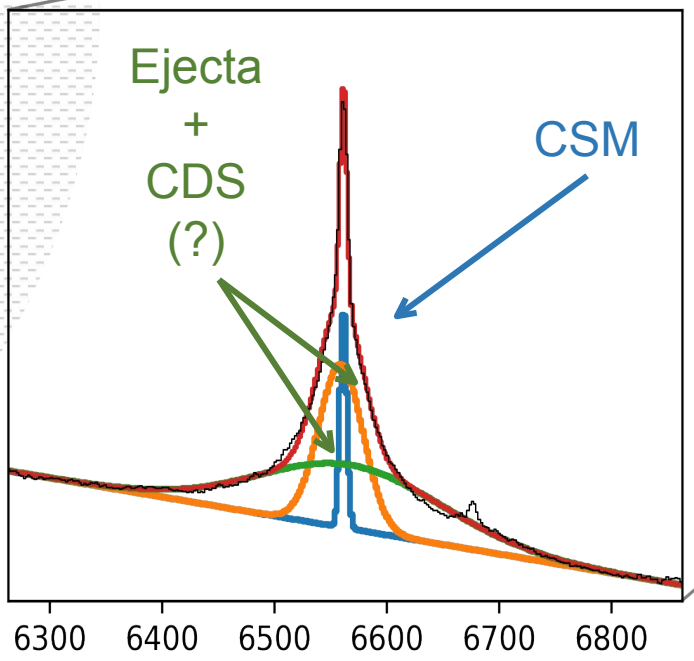
Hydrogen rich

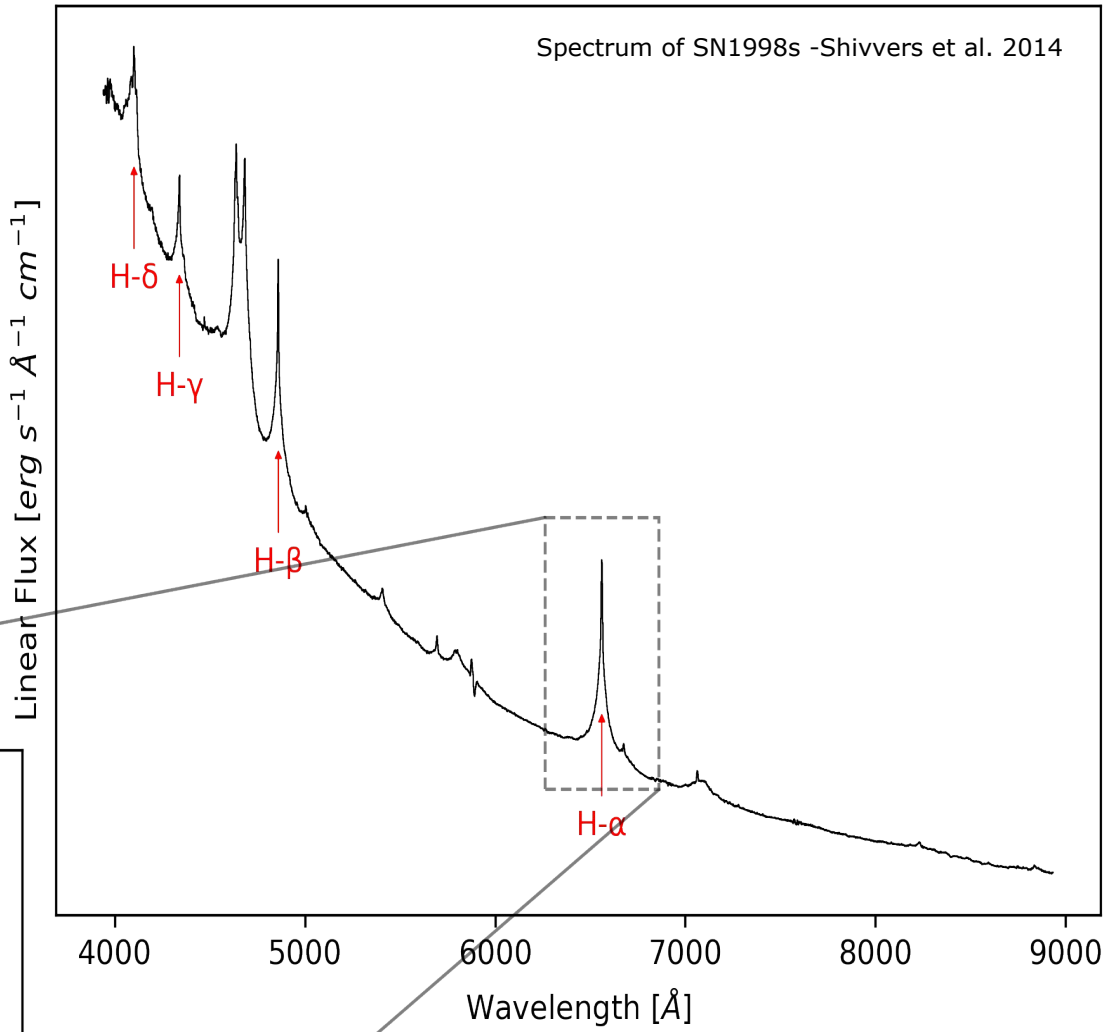
"narrow"

$\dot{M} = 10^{-3} - 10^{-5} M_{\odot}\ yr^{-1}$

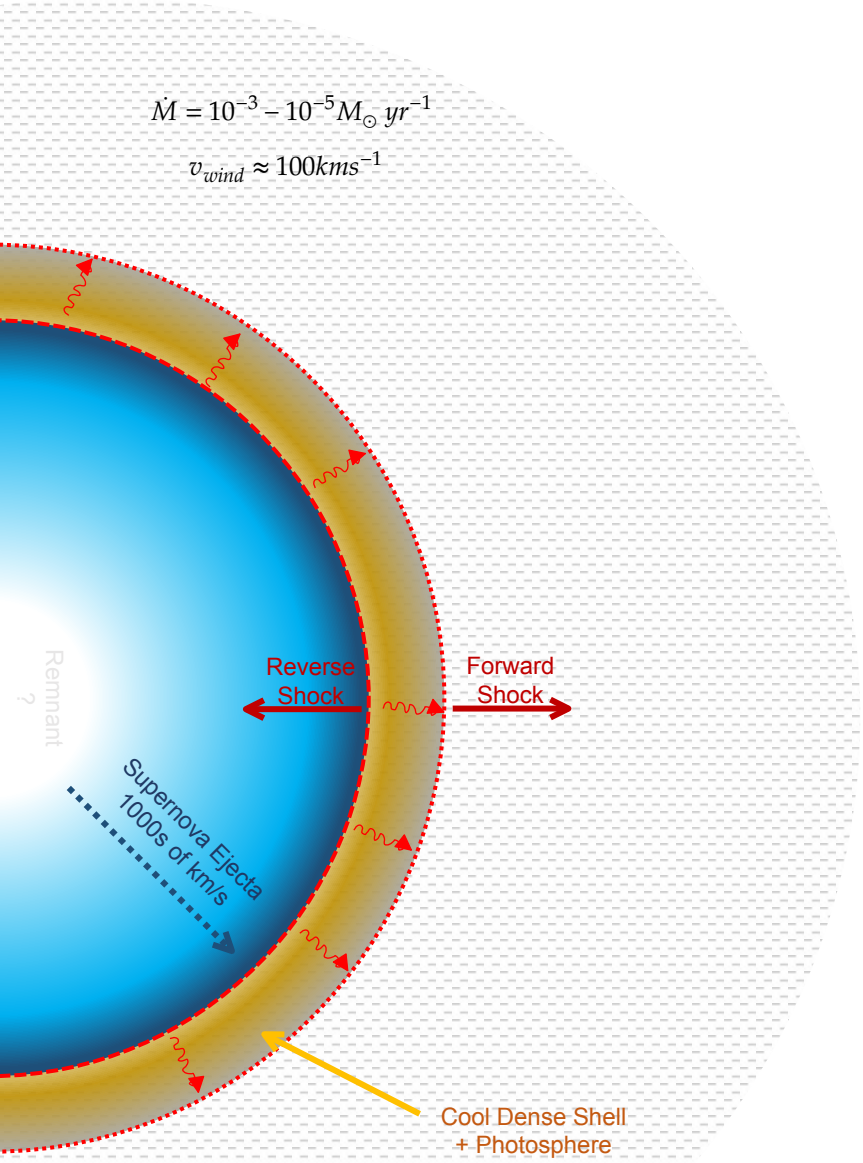
$v_{wind} \approx 100 kms^{-1}$







Li et al. 2011,. Schlegel 1990



Progenitors (?)

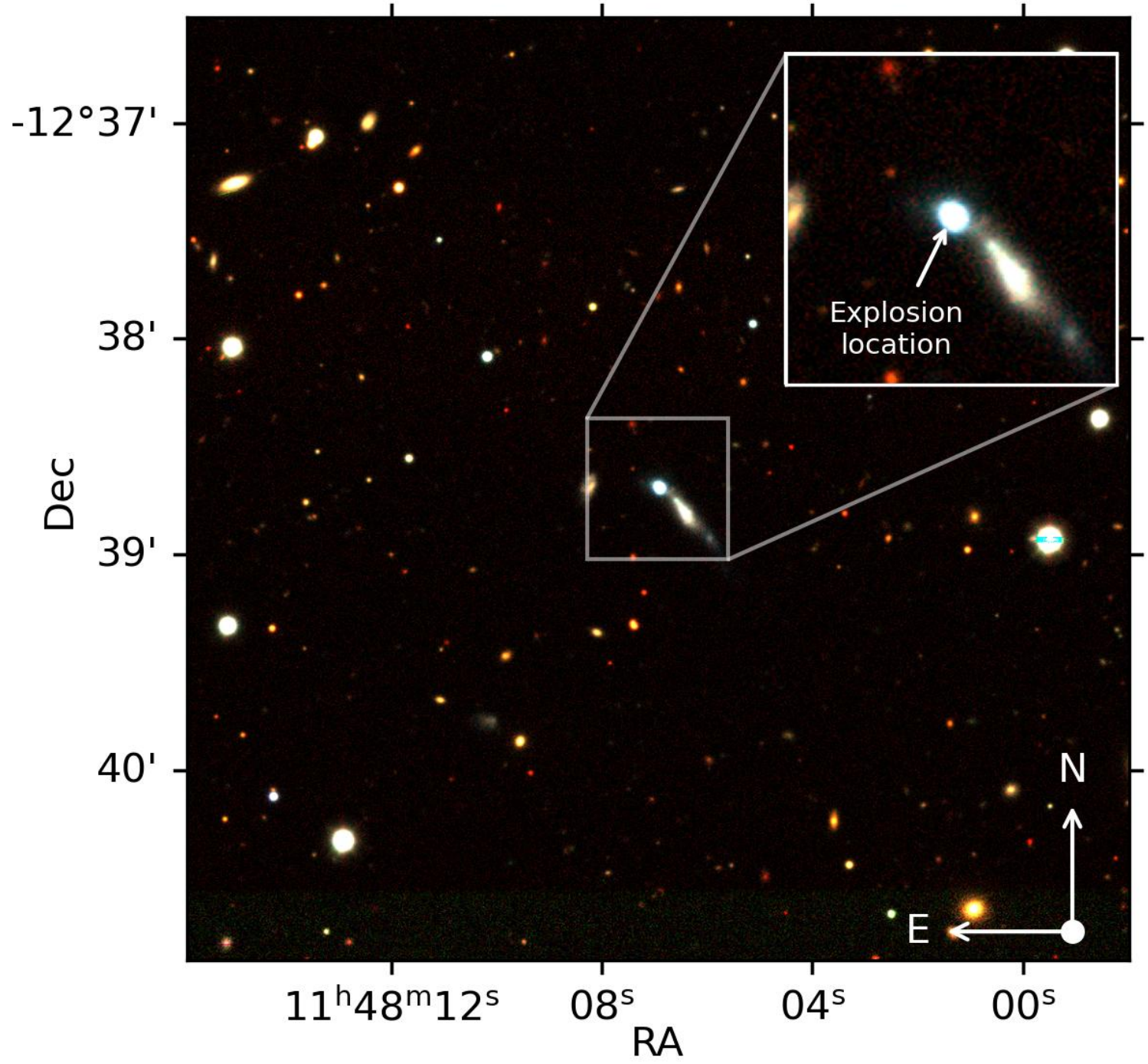
- Require very high mass loss rate shortly (months - decades) before core-collapse
- Interaction dominates, difficult to see explosion
- Rare - Type IIn SNe account for ~3% in Bright Transient Survey (Perley et al. 2020)
- LBVs exploding != Stellar Theory

ZTF21ackxdos

(SN 2021adxl)

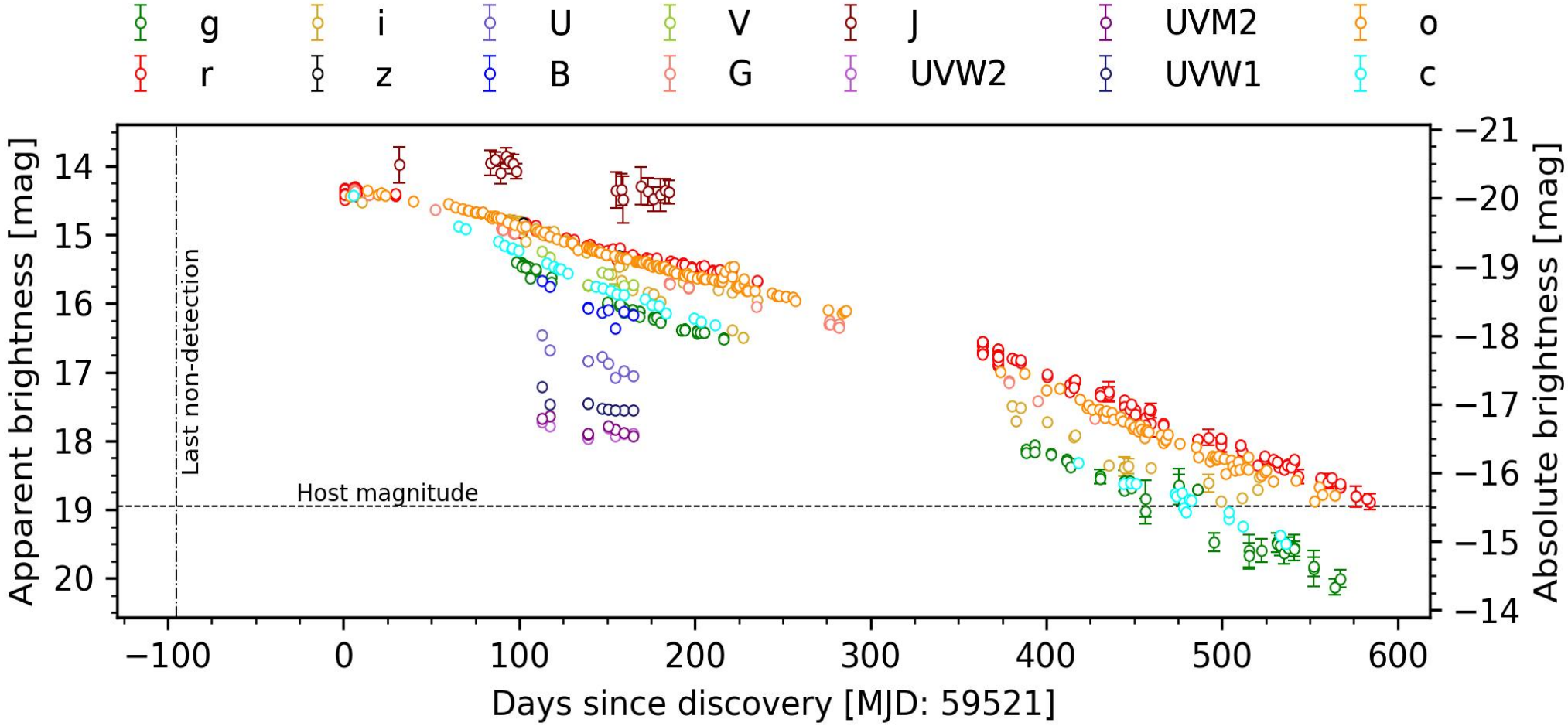
(referred to as XDOS)

- Very nearby at 80Mpc
- Strange host environment
- Head of high star formation rate
- Bright + nearby == Long followup



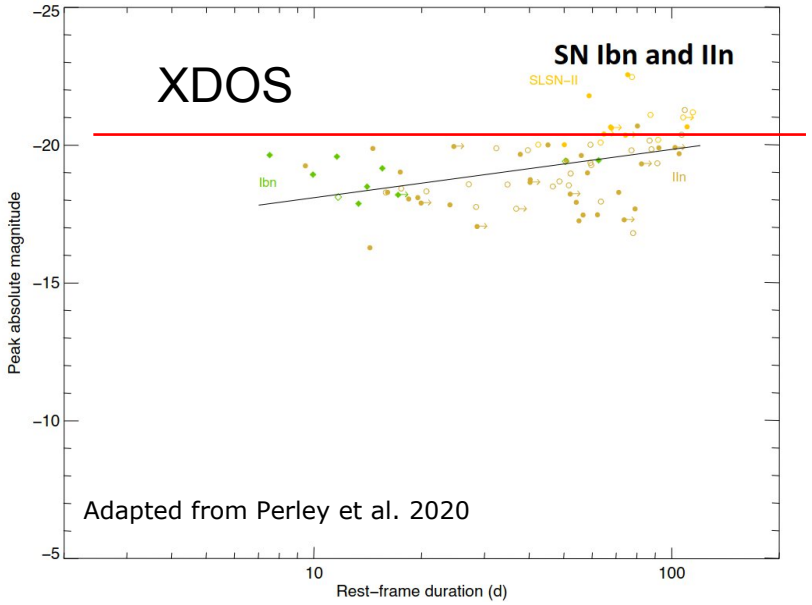
Bright, long lived & nearby

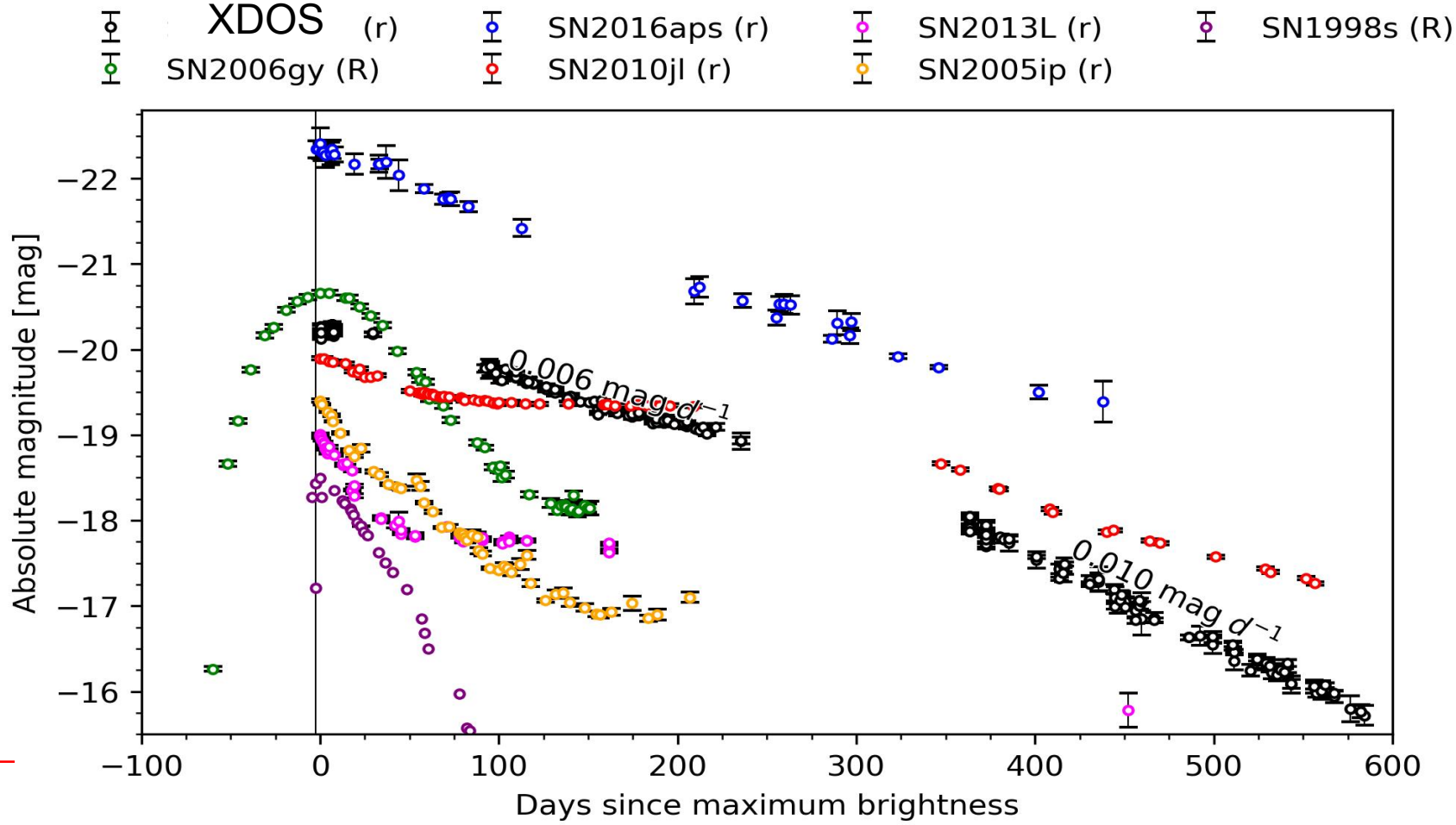
- Observations of ~600 days and on-going
- $r_{peak,0} \approx -20.2\ mag$



Heterogeneous transients

- Wide spread in peak magnitude
- Various explosion mechanism or mass loss rates





Rise time not observed

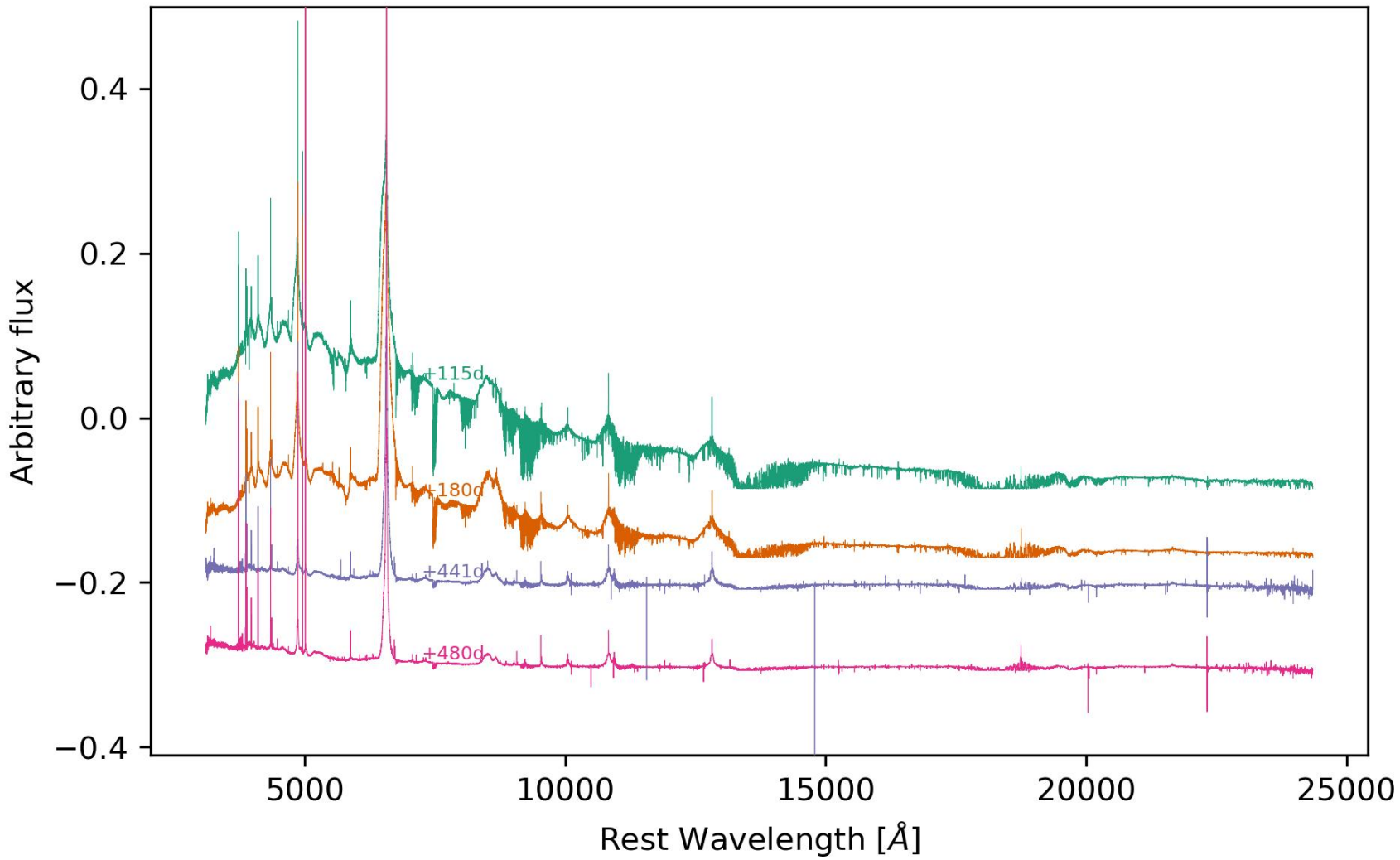
Nichol+20, Fransson+13, Taddia+20, Fox+20, Smith+07

VLT + XSHOOTER

Medium resolution spectrograph covering 3000-25000A

- Dominated by transient flux
- Narrow lines from underlying H II region = host analysis

(work in progress)



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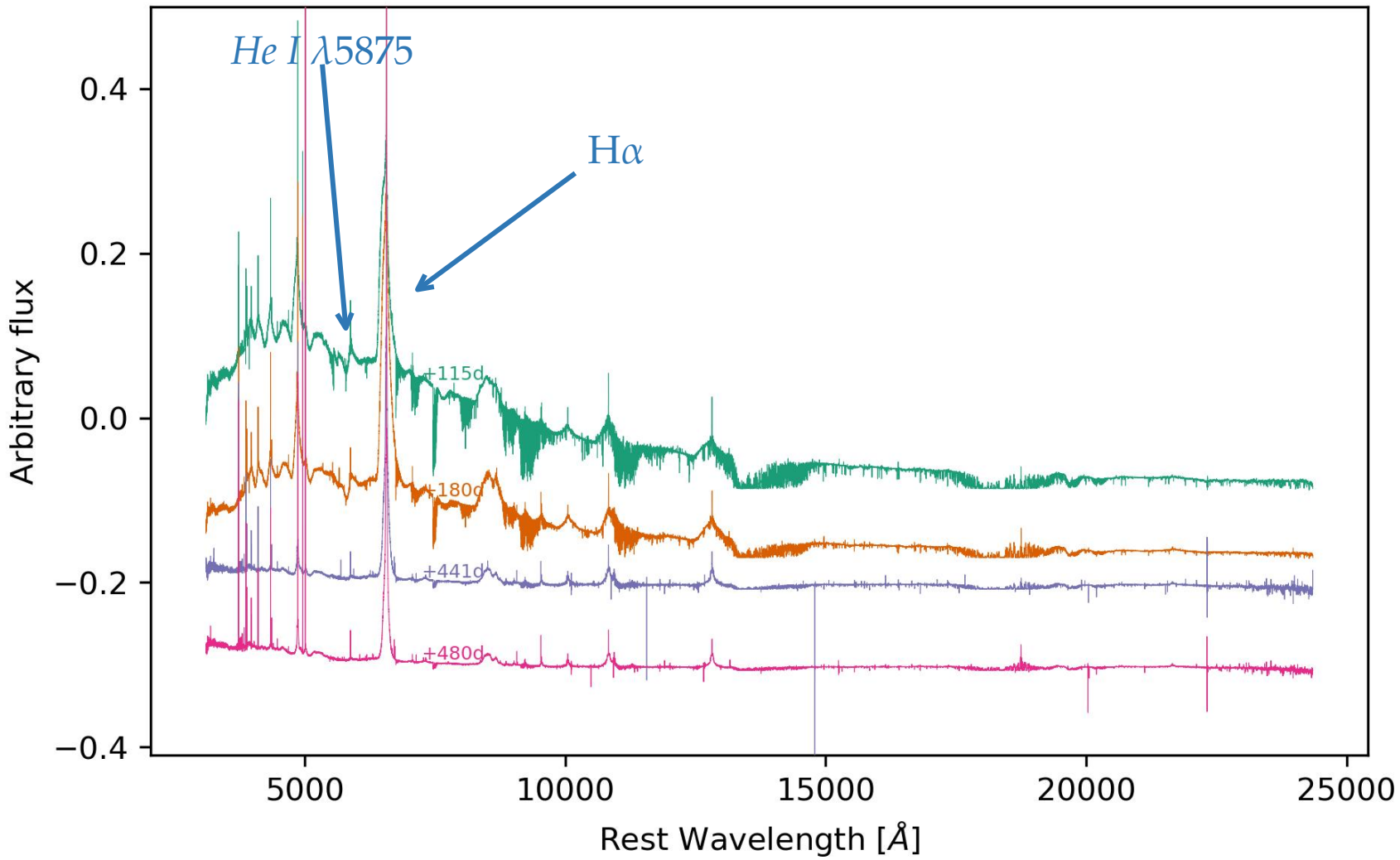
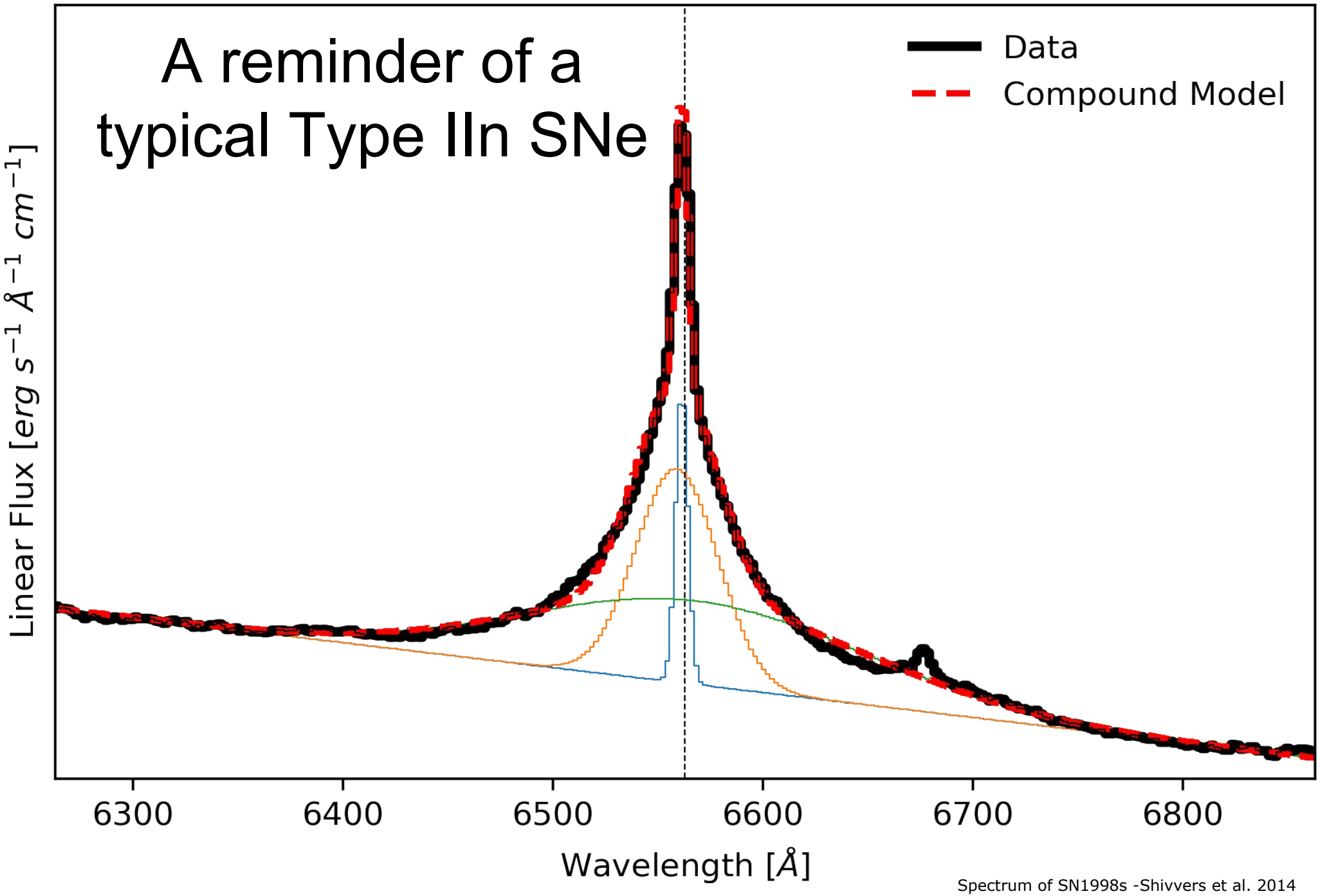
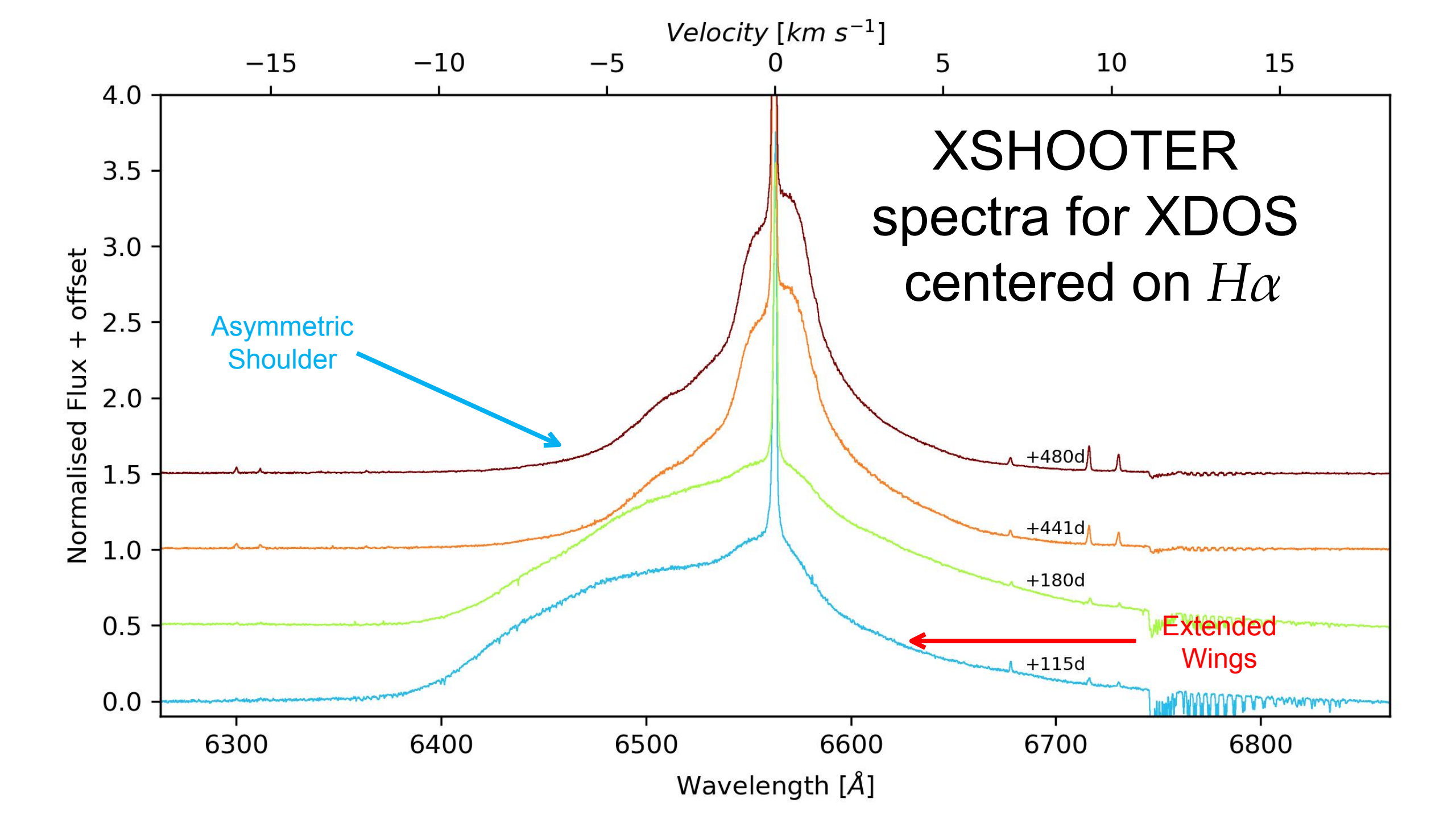
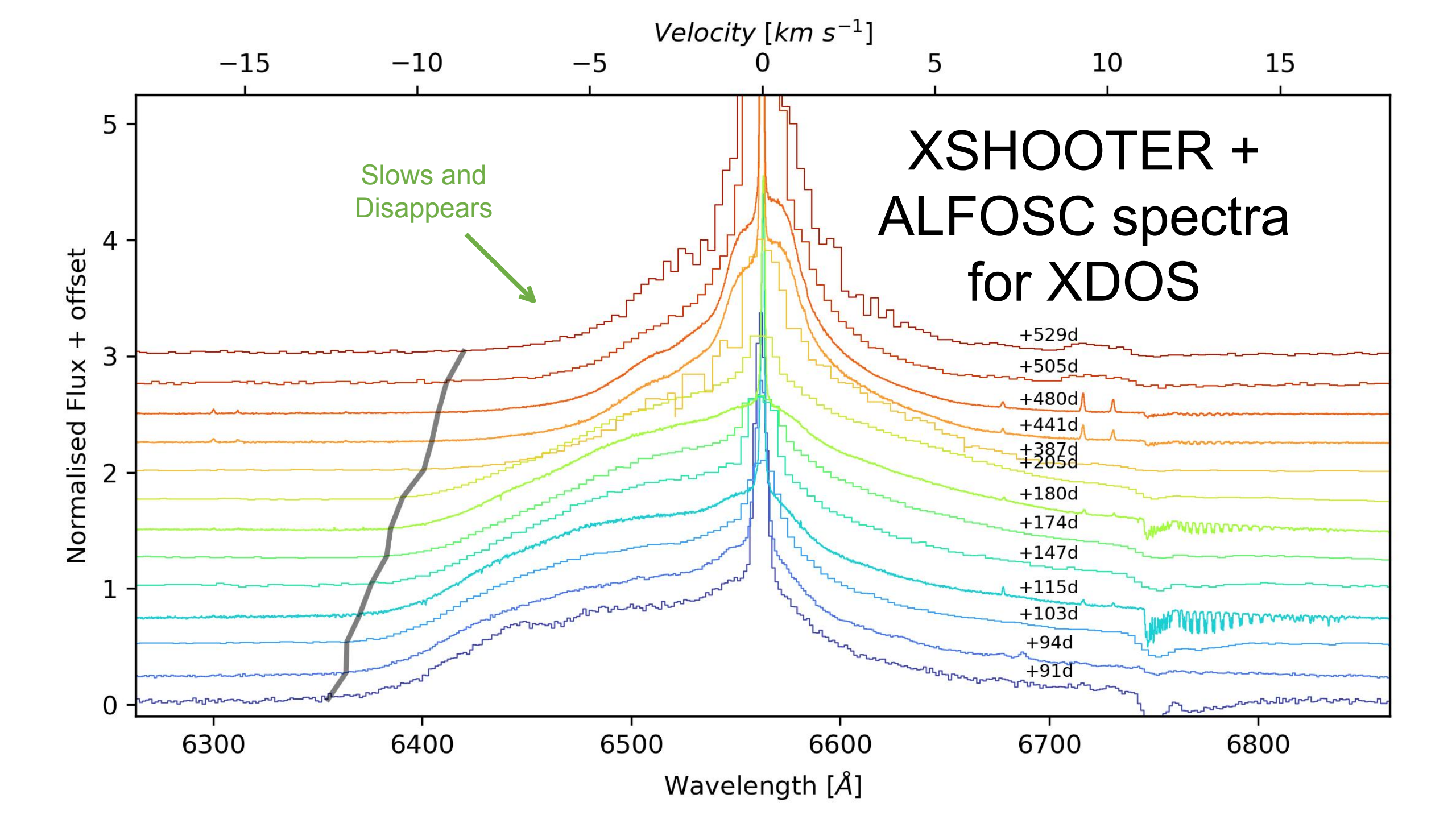




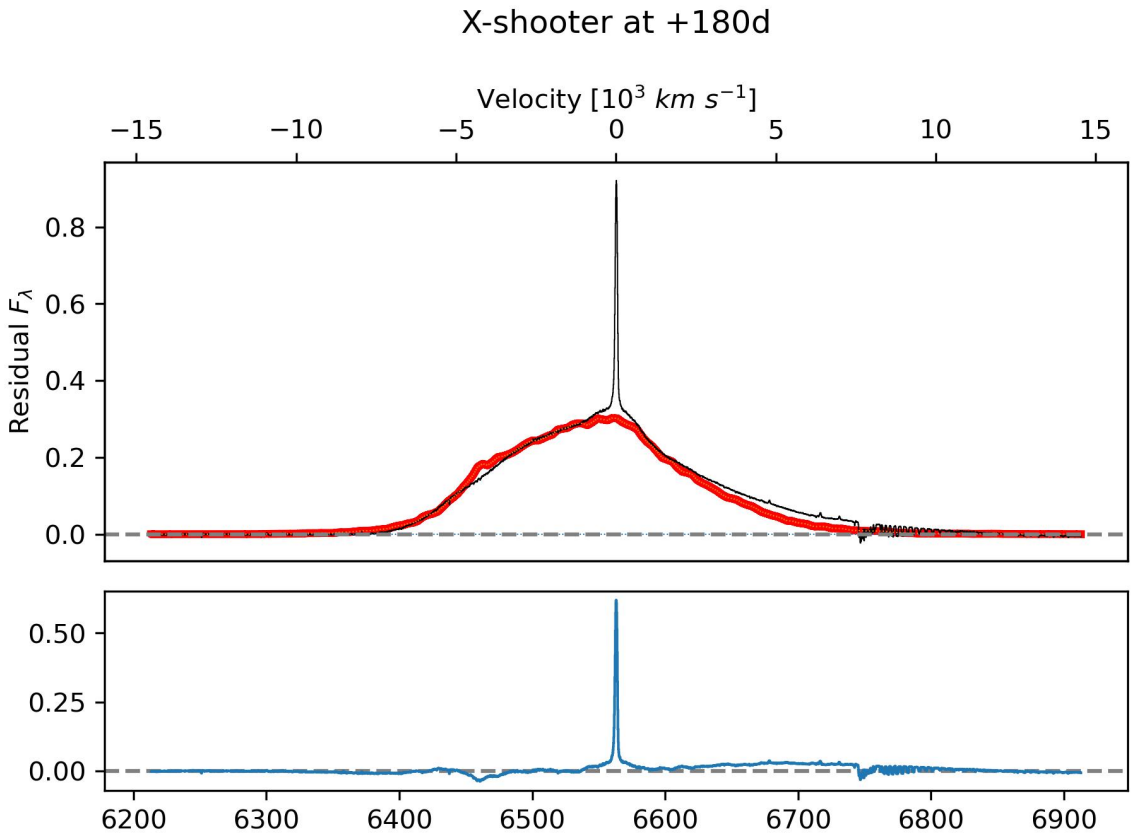
Spectrum of SN1998s -Shivvers et al. 2014

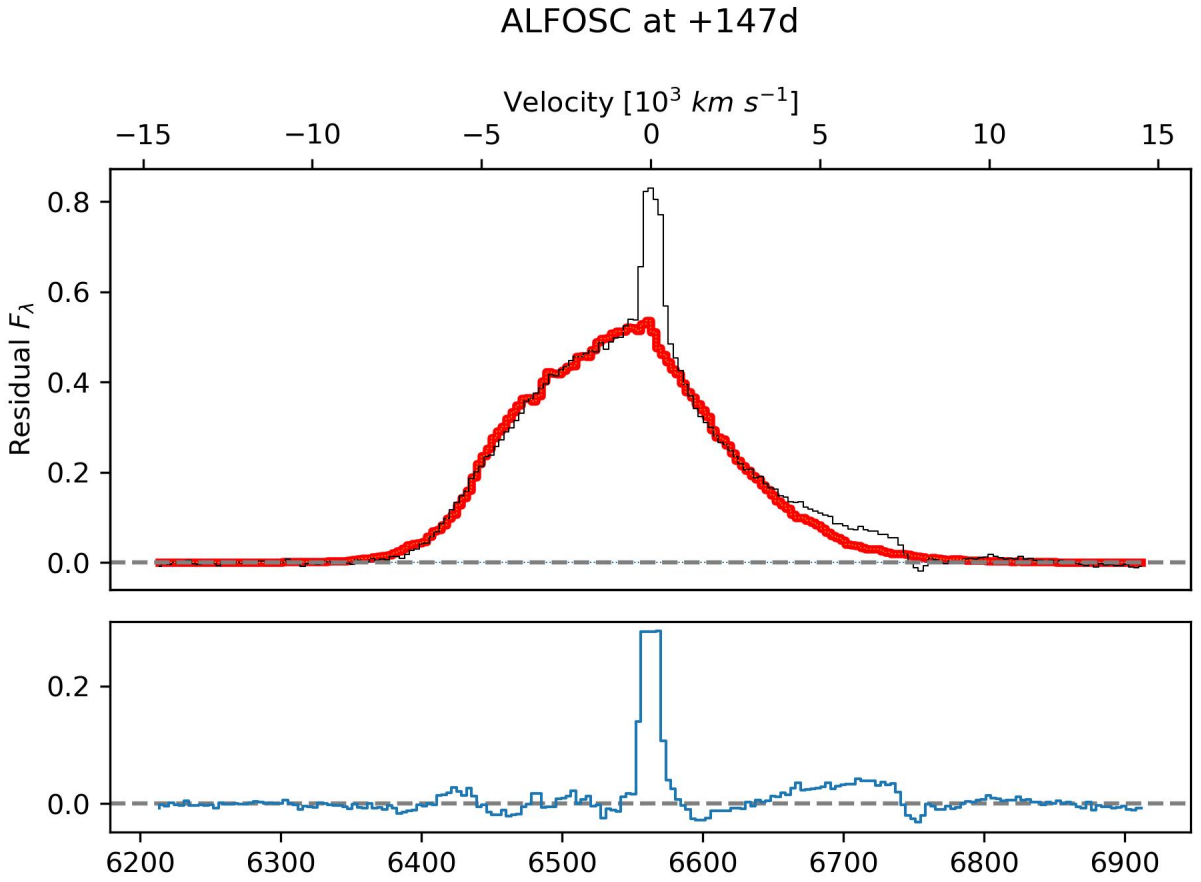

Velocity [km s^{-1}]
−15
−10
−5
0
5
10
15
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Normalised Flux + offset
XSHOOTER spectra for XDOS centered on $H\alpha$
Asymmetric Shoulder
+480d
+441d
+180d
+115d
Extended Wings
6300
6400
6500
6600
6700
6800
Wavelength [Å]


Velocity [km s^{-1}]
−15
−10
−5
0
5
10
15
Slows and
Disappears
XSHOOTER +
ALFOSC spectra
for XDOS
+529d
+505d
+480d
+441d
+387d
+205d
+180d
+174d
+147d
+115d
+103d
+94d
+91d
Normalised Flux + offset
0
1
2
3
4
5
6300
6400
6500
6600
6700
6800
Wavelength [Å]

Line profiles well fit by electron scattering

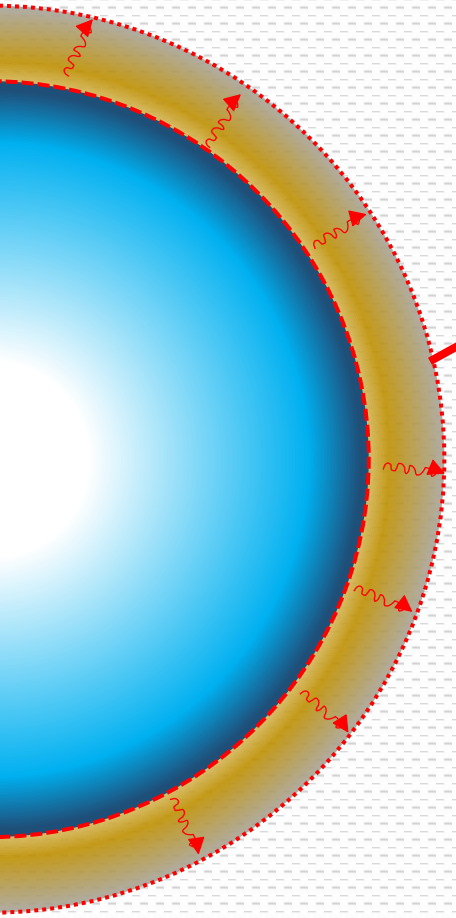
- Hα profile scatter as they diffuse outwards
- No need for model asymmetries - require occultation from photosphere.

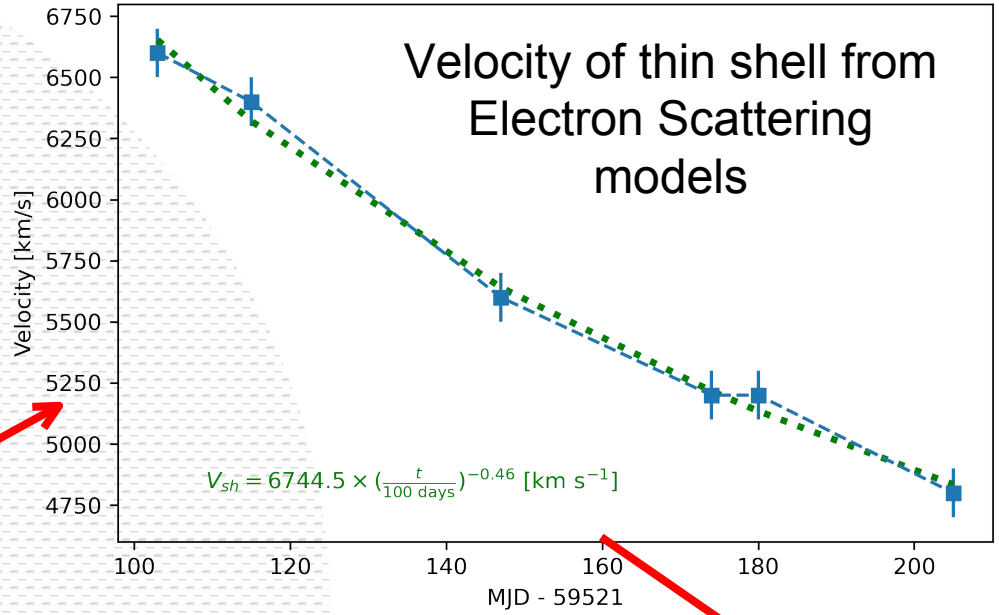


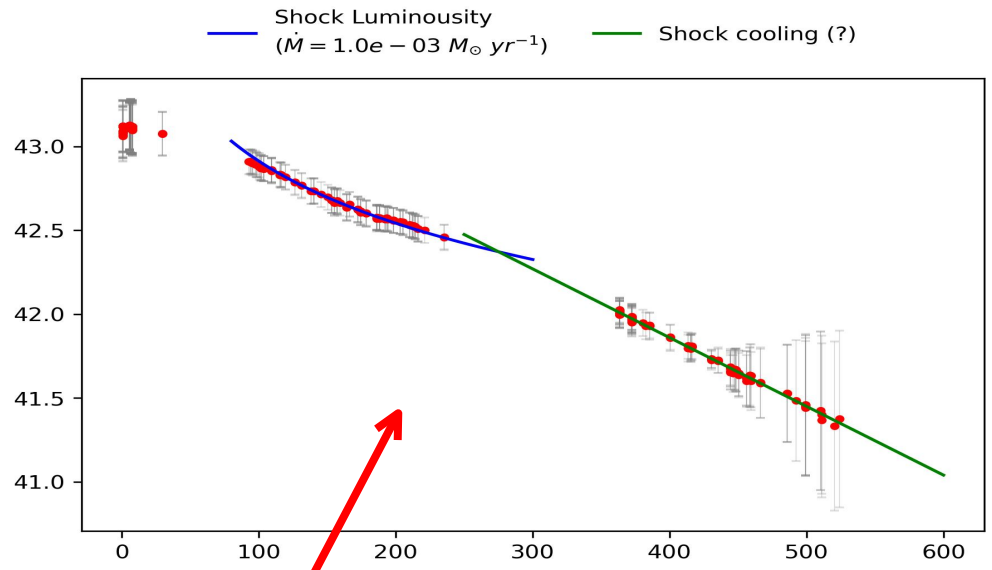


Custom pipeline based on Pozdnyakov et al.1983

Light curve + spectral modeling implies high mass loss rate







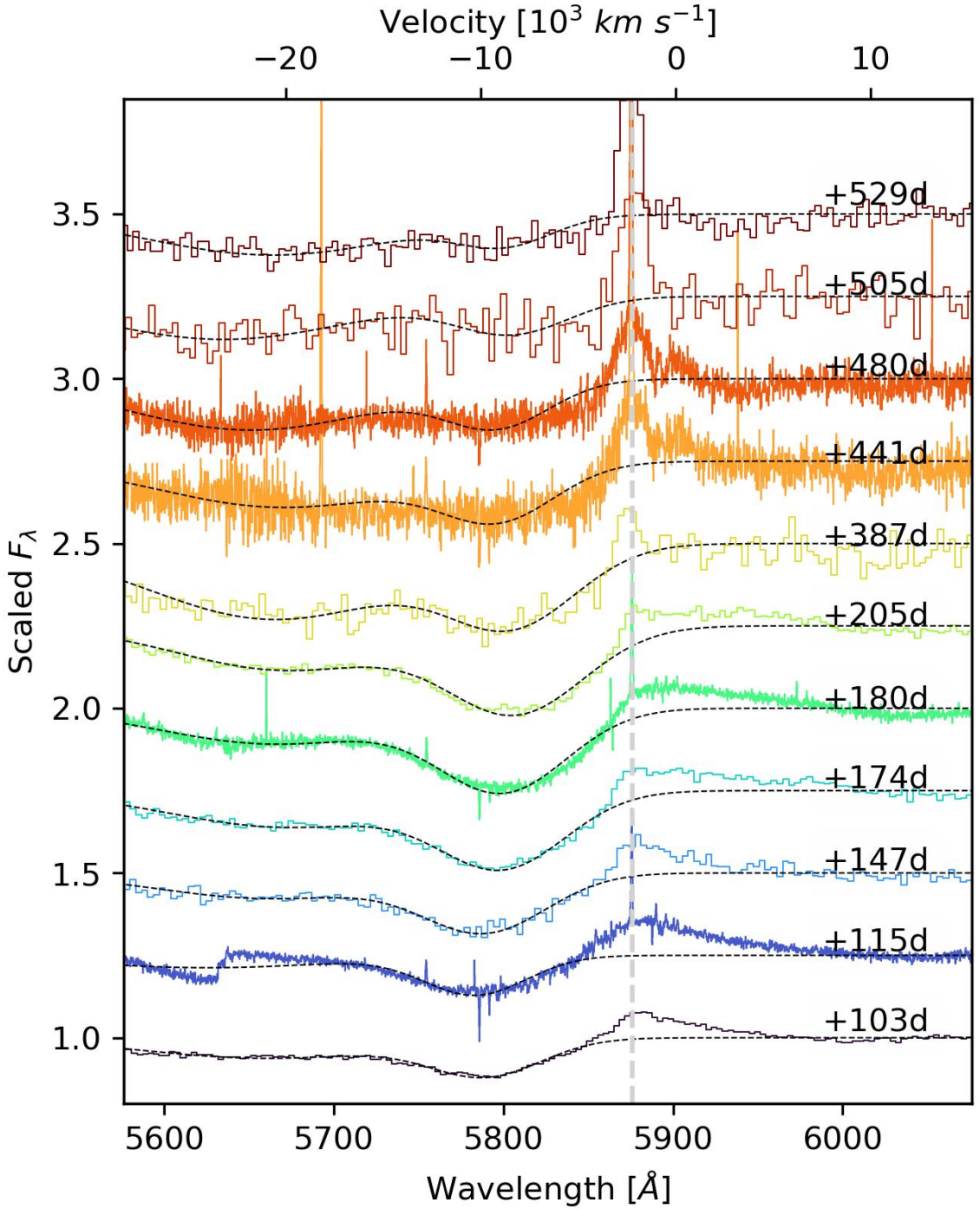
$$L_{shock} = \frac{1}{2}\frac{\dot{M}}{v_{wind}} V_{shock}^{\ 3}$$

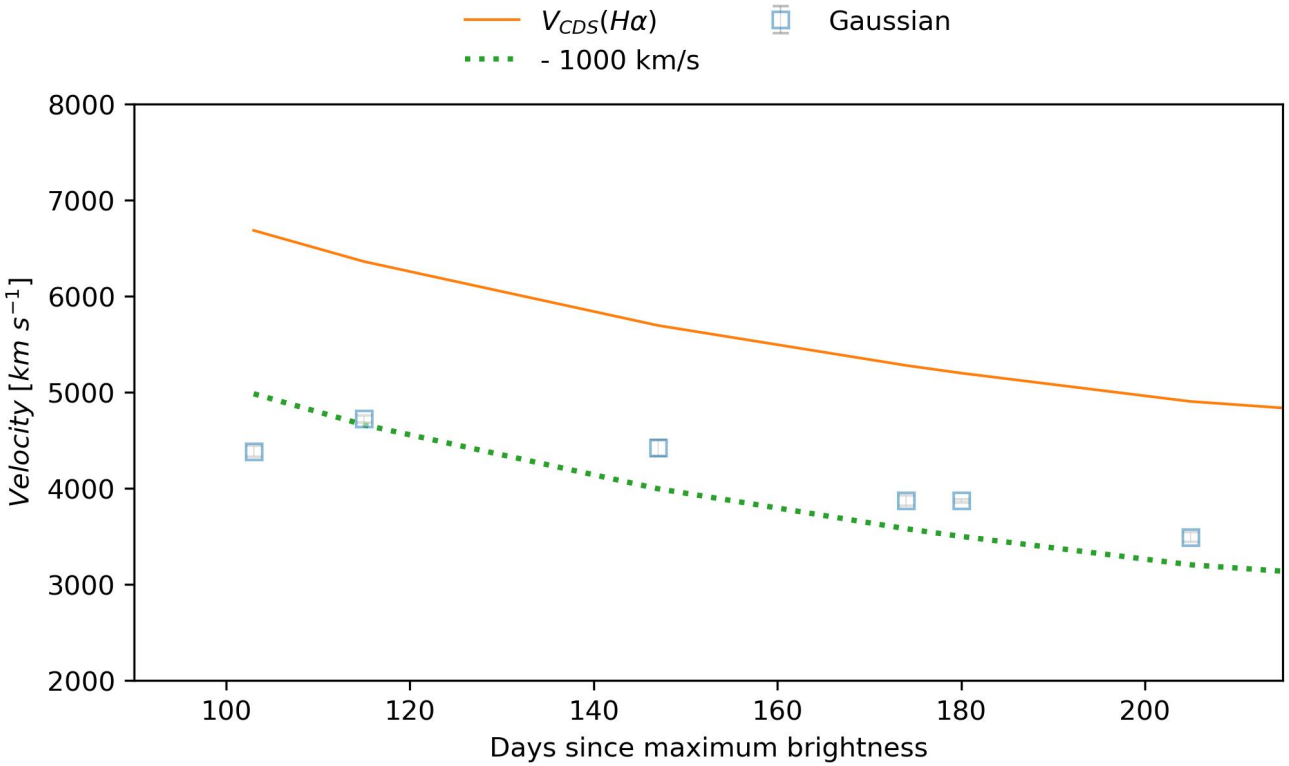
Type	$T_{\rm eff}$ (kK)	M ($M_\odot$)	v_∞ (km/s)	$\dot{M}$ ($M_\odot \mathrm{yr}^{-1}$)
O	30-45	20-60	2000-3500	$10^{-7} - 10^{-5}$
WNh	35-50	80-300	1500-3000	10^{-4}
BSG	15-25	15-30	500-1500	$10^{-7} - 10^{-5}$
YSG	5-10	10-25	50-200	$10^{-6} - 10^{-4}$
RSG	3-5	10-25	10-30	$10^{-7} - 10^{-4}$
LBV low-L	10-15	15-25	100-200	10^{-5}
LBV high-L	10-30	40-	200-500	$10^{-4} - 10^{-3}$
cWR	90-200	10-30	1500-6000	$10^{-5} - 10^{-4}$
Stripped He	50-80	1-5	1000	10^{-8}

Table from J. Vink 21

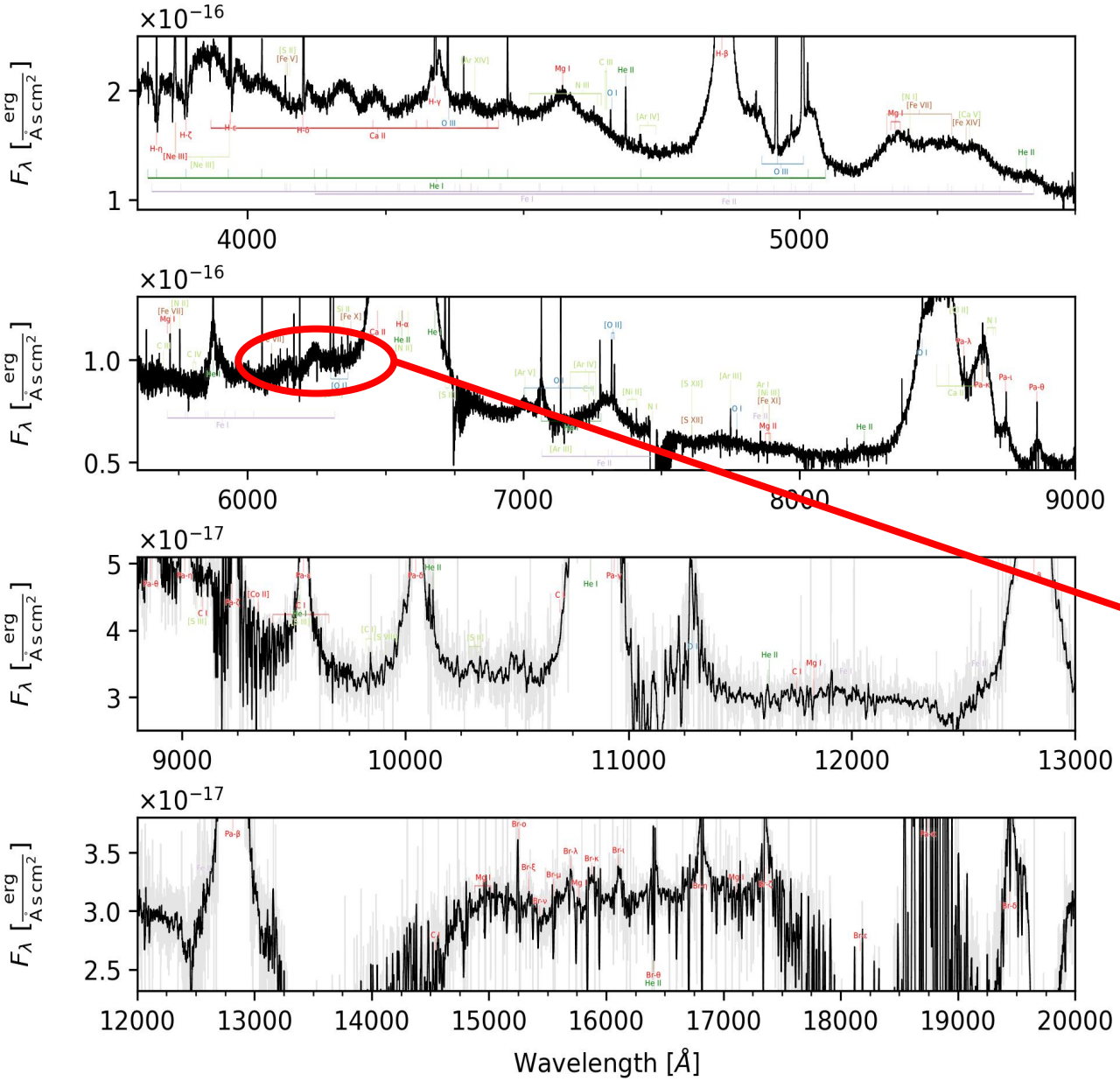
Unique profile seen in Helium $\lambda 5876$

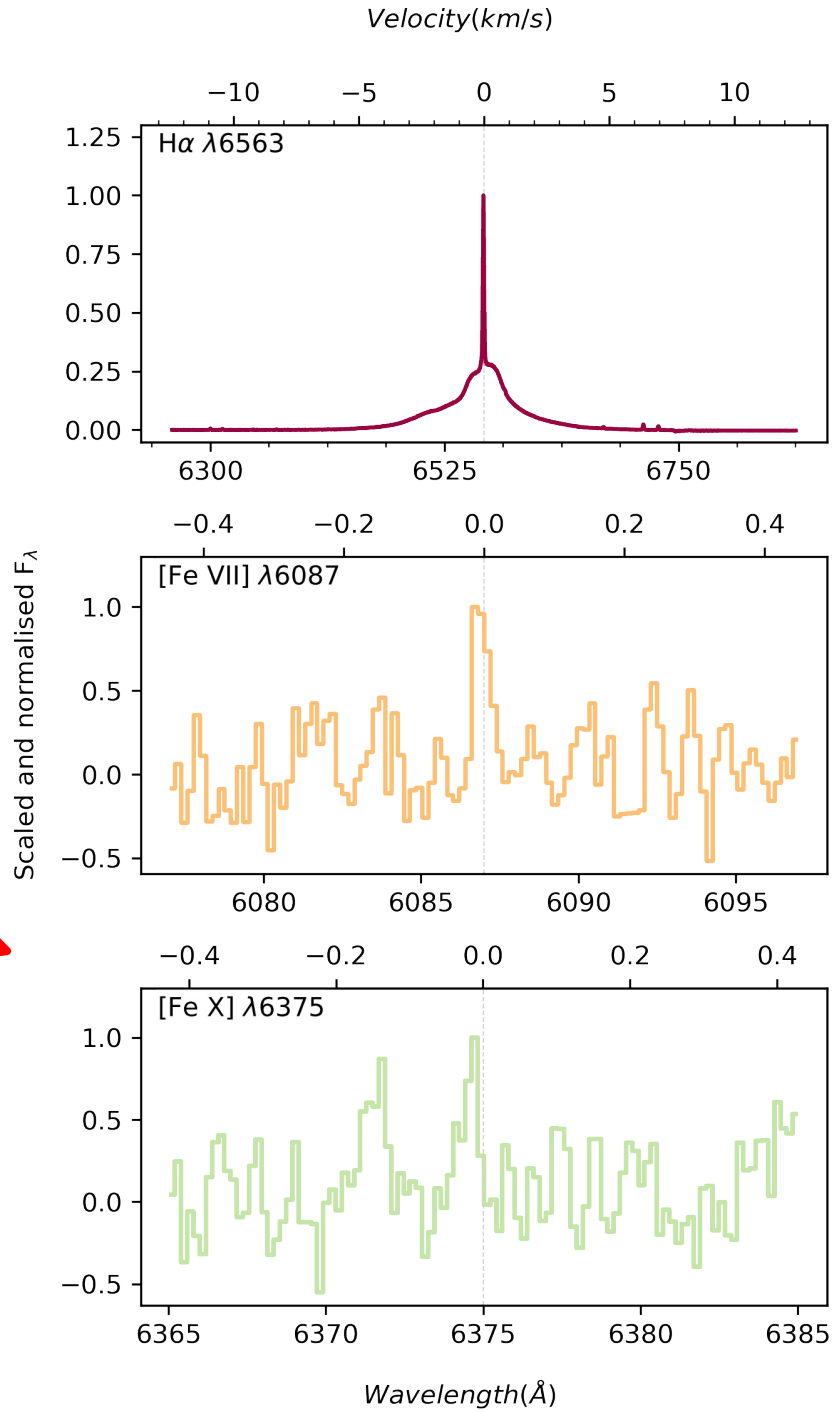
Helium absorption evolves similar to $H\alpha$

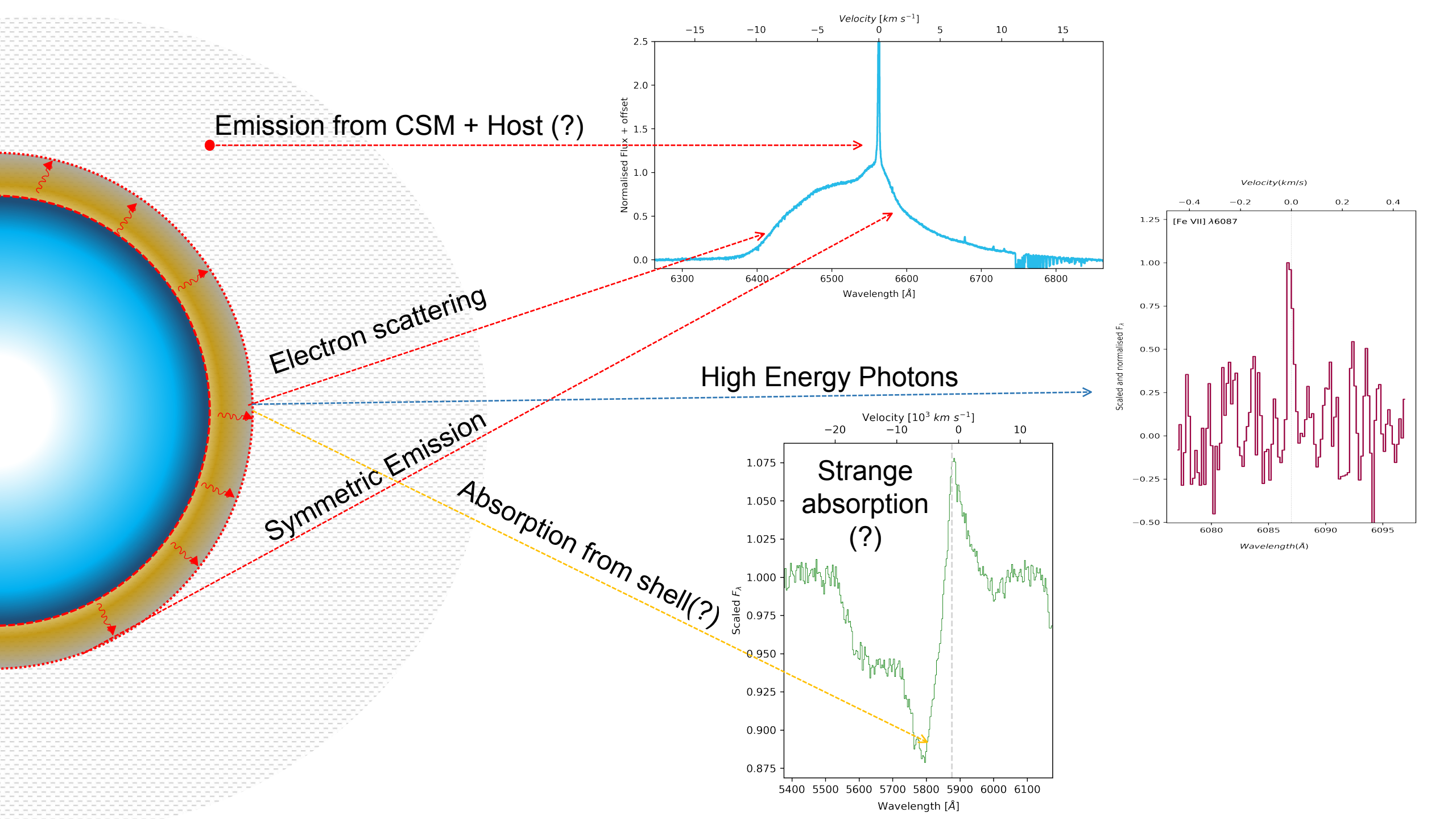




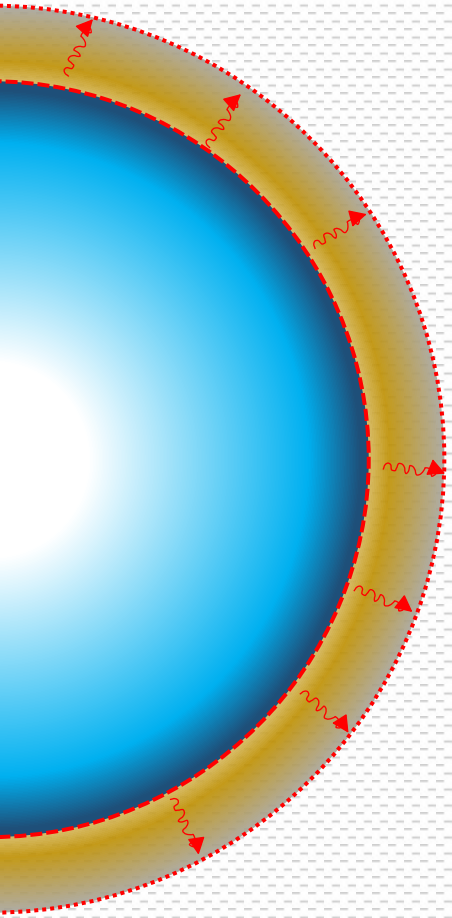
Coronal emission lines at +480 days - Preliminary!






Emission from CSM + Host (?)
Electron scattering
Symmetric Emission
High Energy Photons
Absorption from shell(?)
Strange absorption (?)
Velocity [km s^{-1}]
Normalised Flux + offset
Wavelength [Å]
Velocity [10^3 km s^{-1}]
Scaled F_λ
Wavelength [Å]
Velocity(km/s)
[Fe VII] λ6087
Scaled and normalised F_λ
Wavelength(Å)

Take away points



- SN2021adxl is a luminous, long lived Type IIn Supernova.
- At only 80 Mpc it's the closest such SN since SN2010jl, allowing for studying the emission line profiles, geometry and explosion in detail.
- One of the rare Type IIn SNe to show coronal emission lines - thanks to high resolution spectra and high S\N.
- Possible LBV progenitor**

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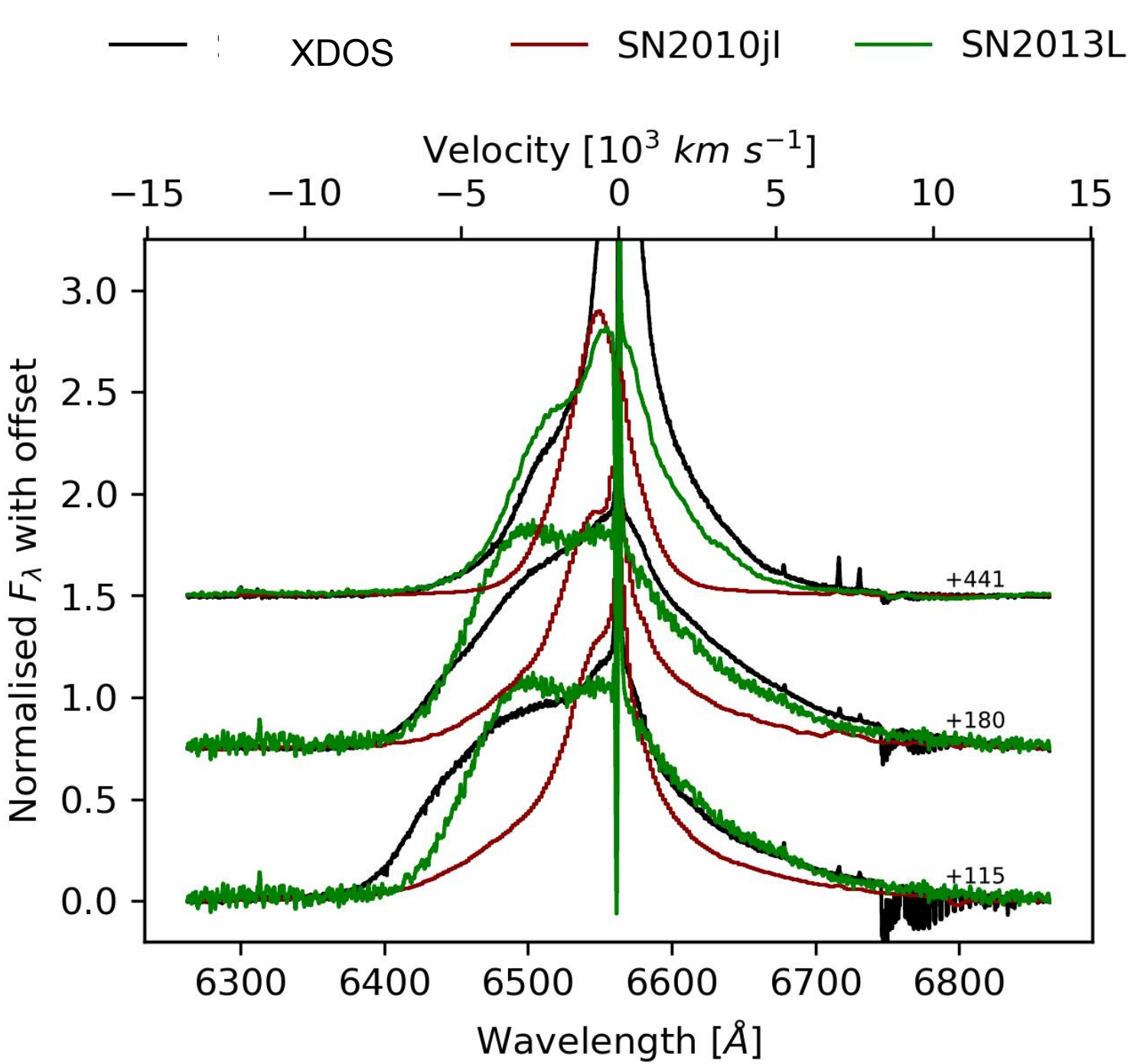
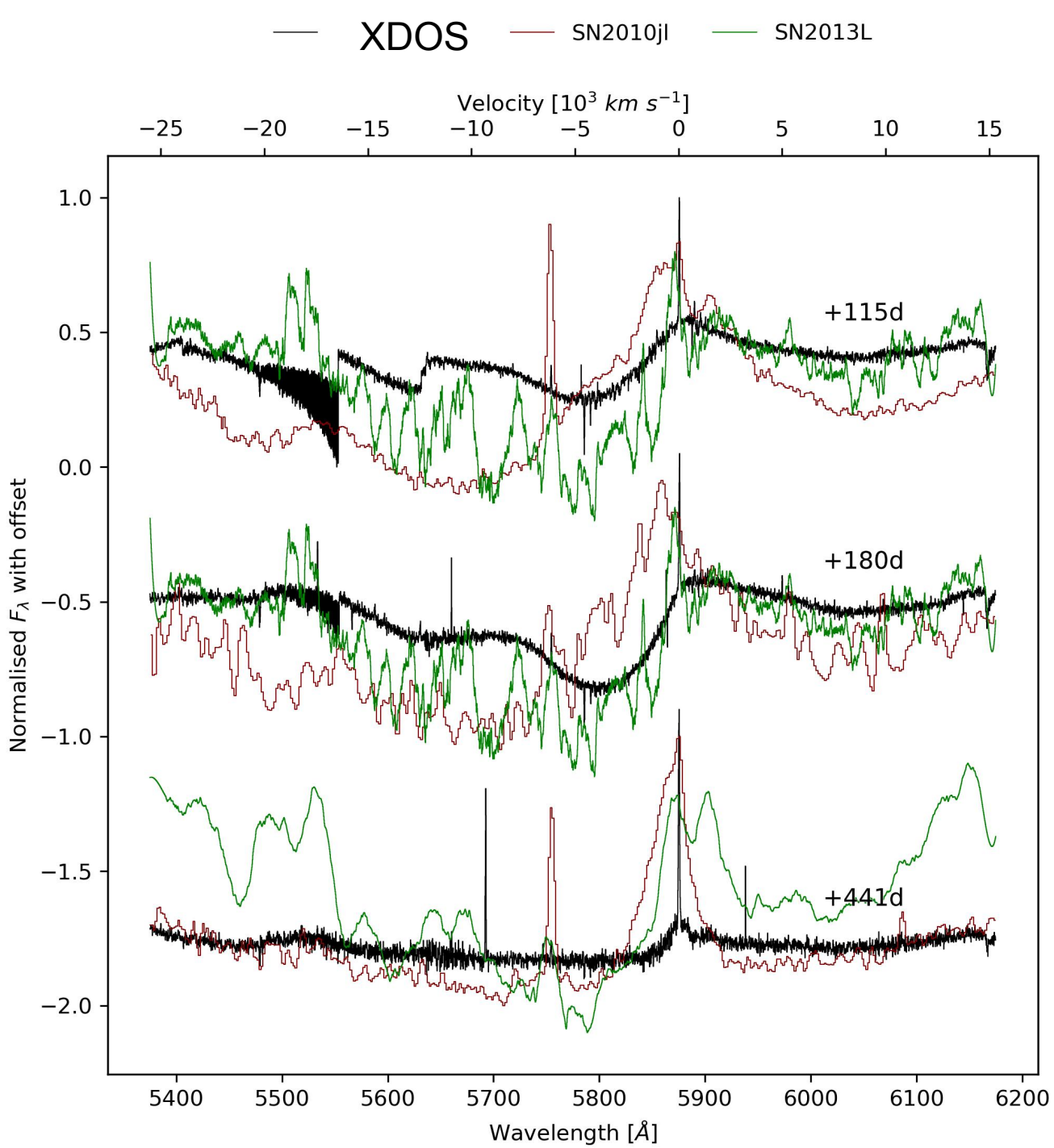
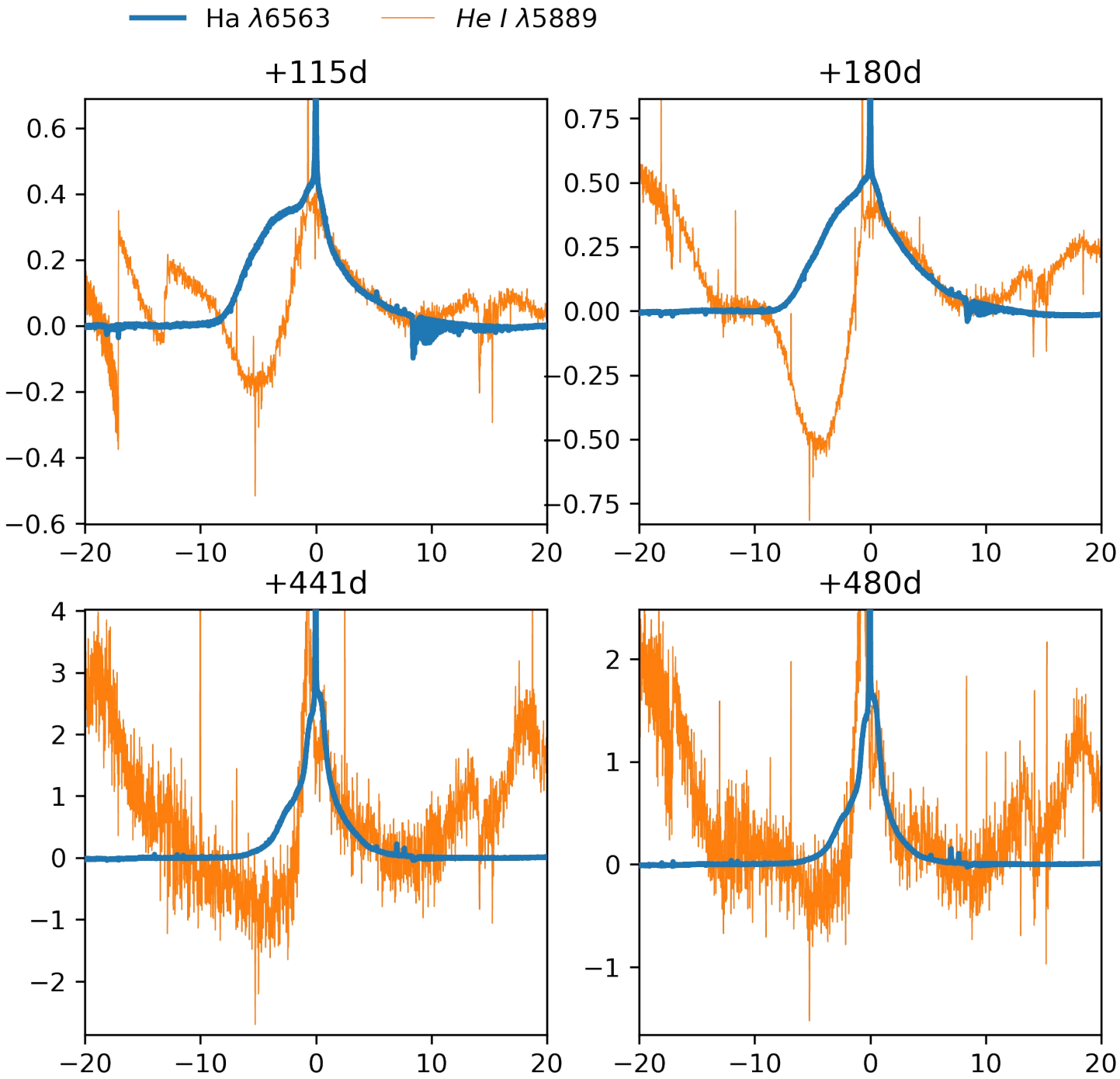
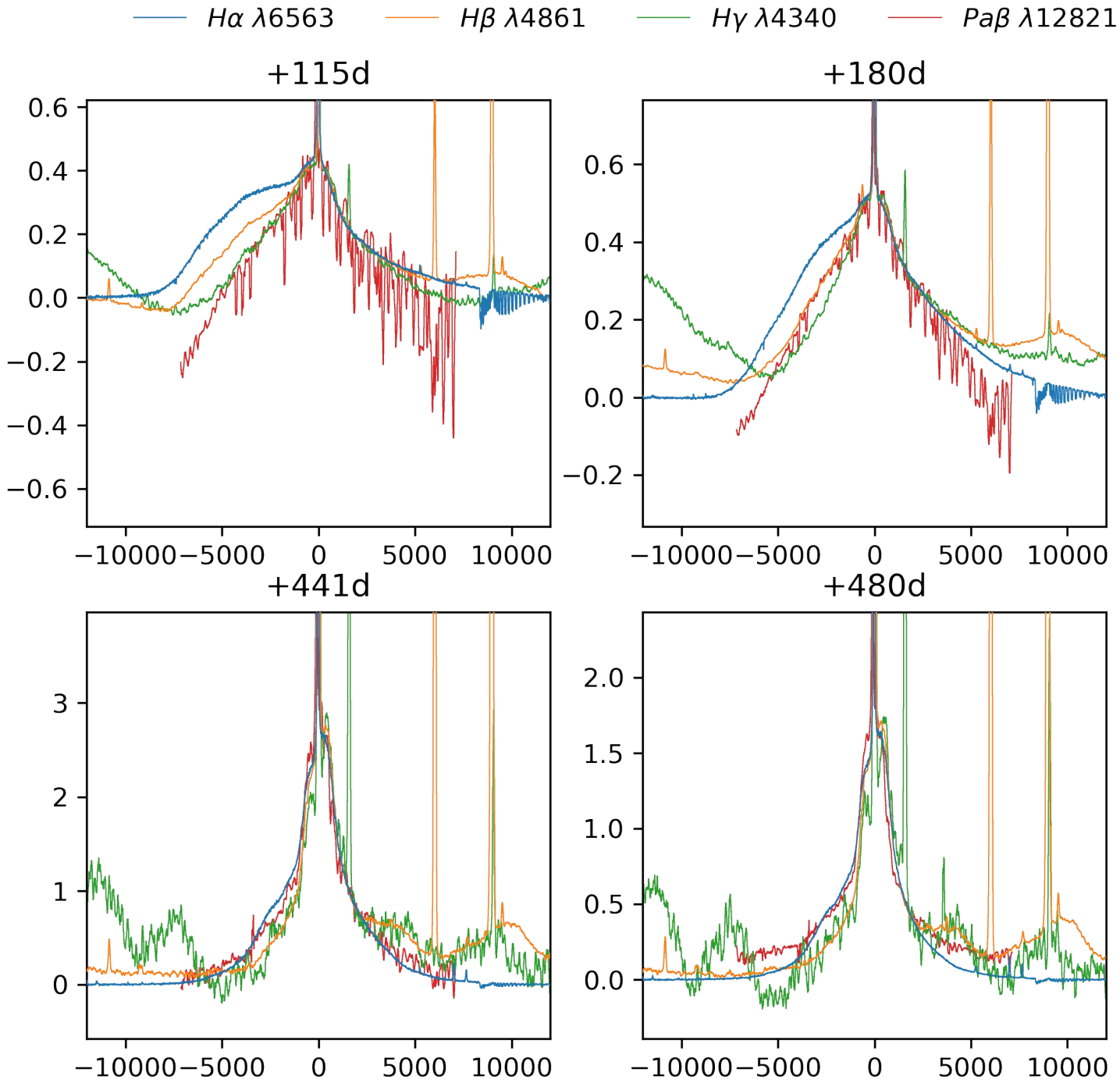
EXTRA SLIDES


XDOS
SN2010jl
SN2013L
Velocity [10^3 km s^{-1}]
−15
−10
−5
0
5
10
15
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Normalised F_λ with offset
+441
+180
+115
6300
6400
6500
6600
6700
6800
Wavelength [$Å$]


XDOS
SN2010jl
SN2013L
Velocity [10^3 km s^{-1}]
−25
−20
−15
−10
−5
0
5
10
15
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
Normalised F_λ with offset
+115d
+180d
+441d
5400
5500
5600
5700
5800
5900
6000
6100
6200
Wavelength [$Å$]


Ha λ6563
He I λ5889
+115d
+180d
+441d
+480d


Hα λ6563
Hβ λ4861
Hγ λ4340
Paβ λ12821
+115d
+180d
+441d
+480d