Chasing eruptive mass loss prior to superluminous supernovae

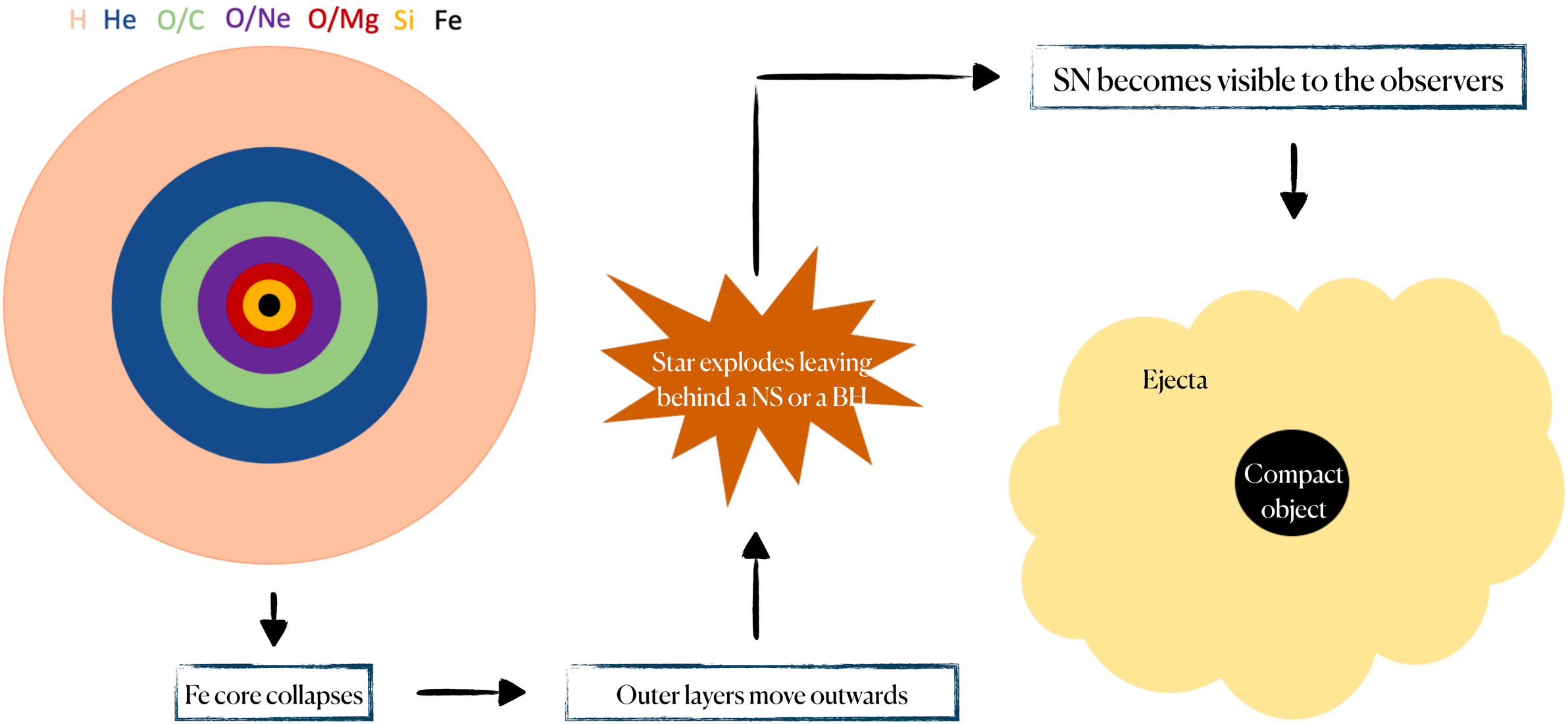
Anamaria Gkini

Supervisor: Ragnhild Lunnan

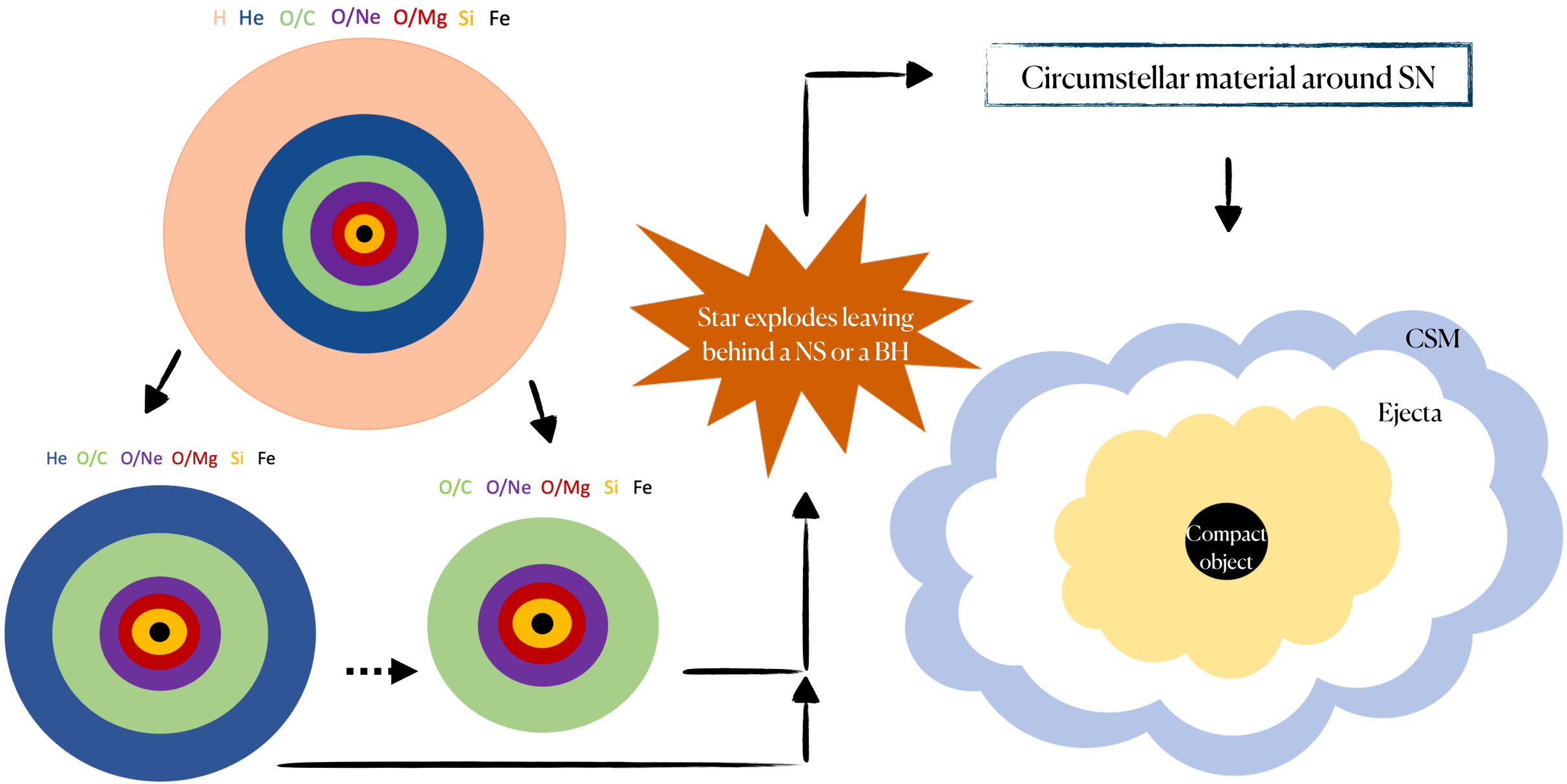
Co-supervisor: Jesper Sollerman

Credits image to NASA

Massive stars will collapse and explode as CCSNe

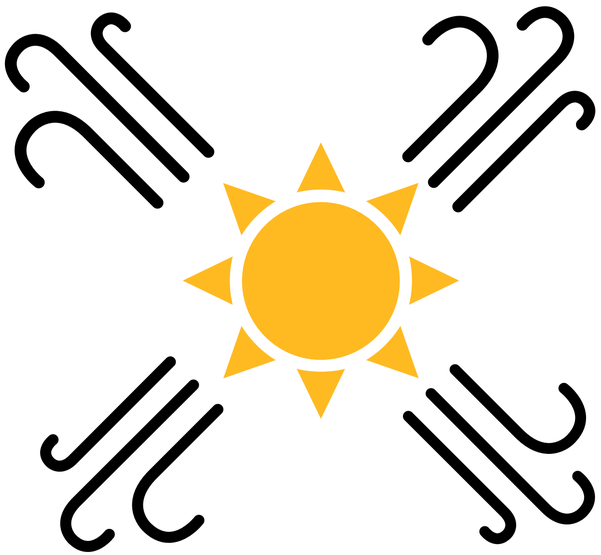


Stars lose significant mass during their life

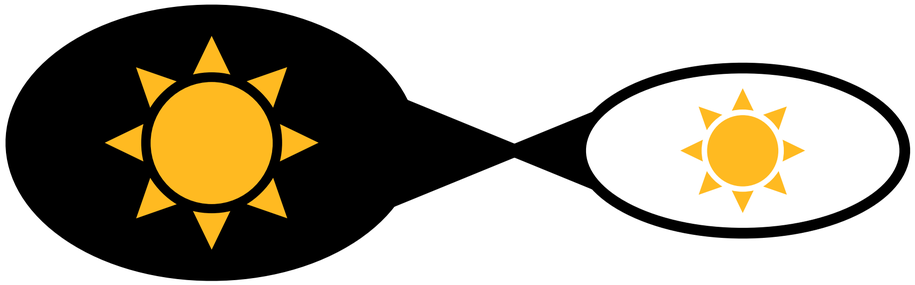


Stars can lose mass through various mechanisms

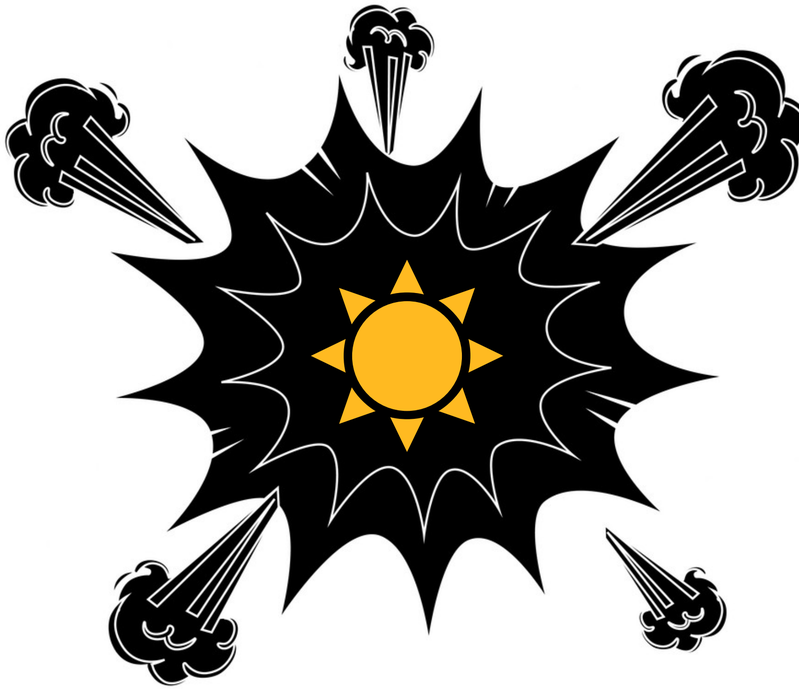
Stellar winds



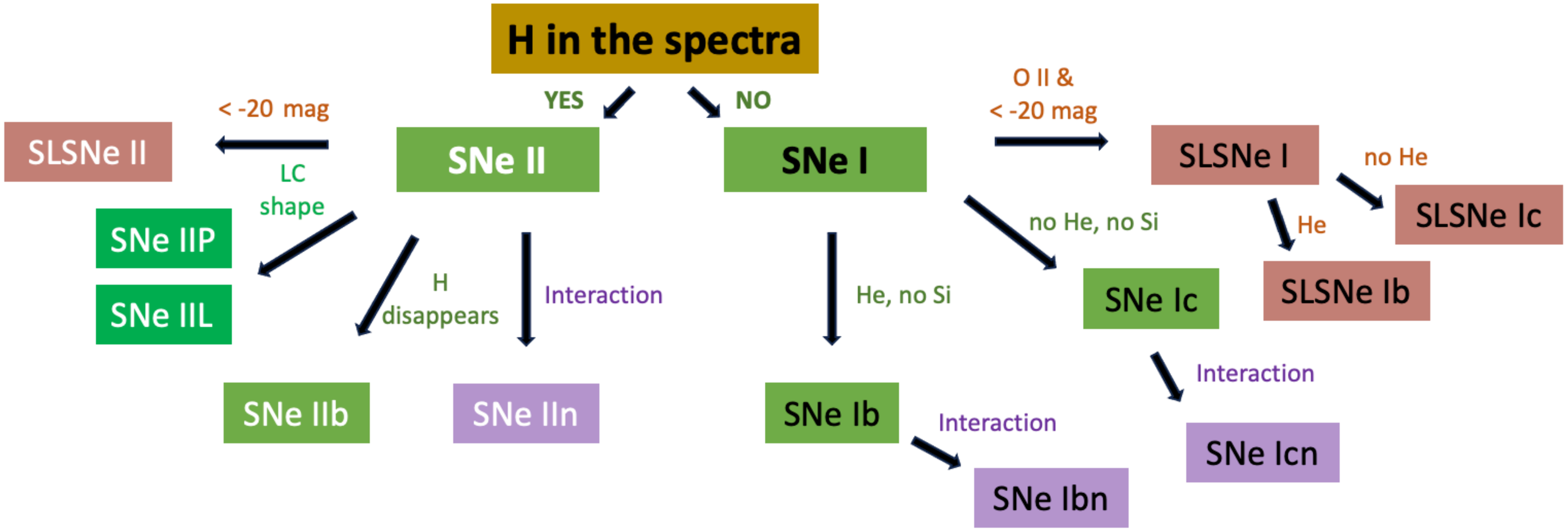
Binary interaction



Eruptive mass-loss



CCSNe come in different flavours



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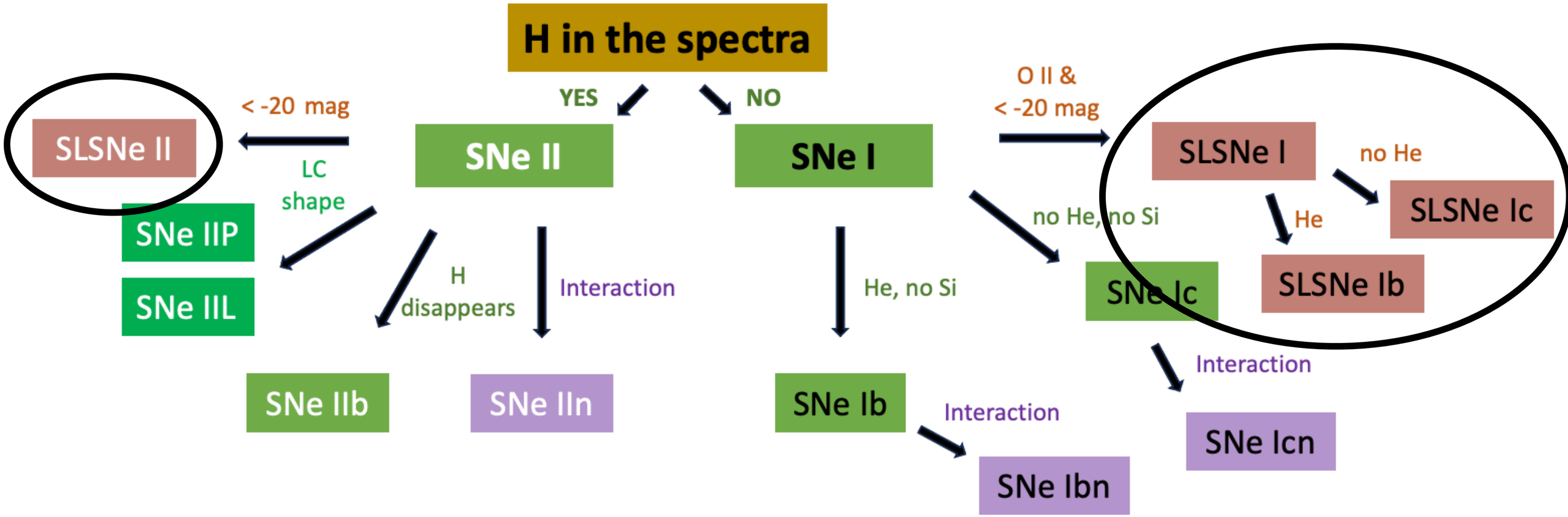
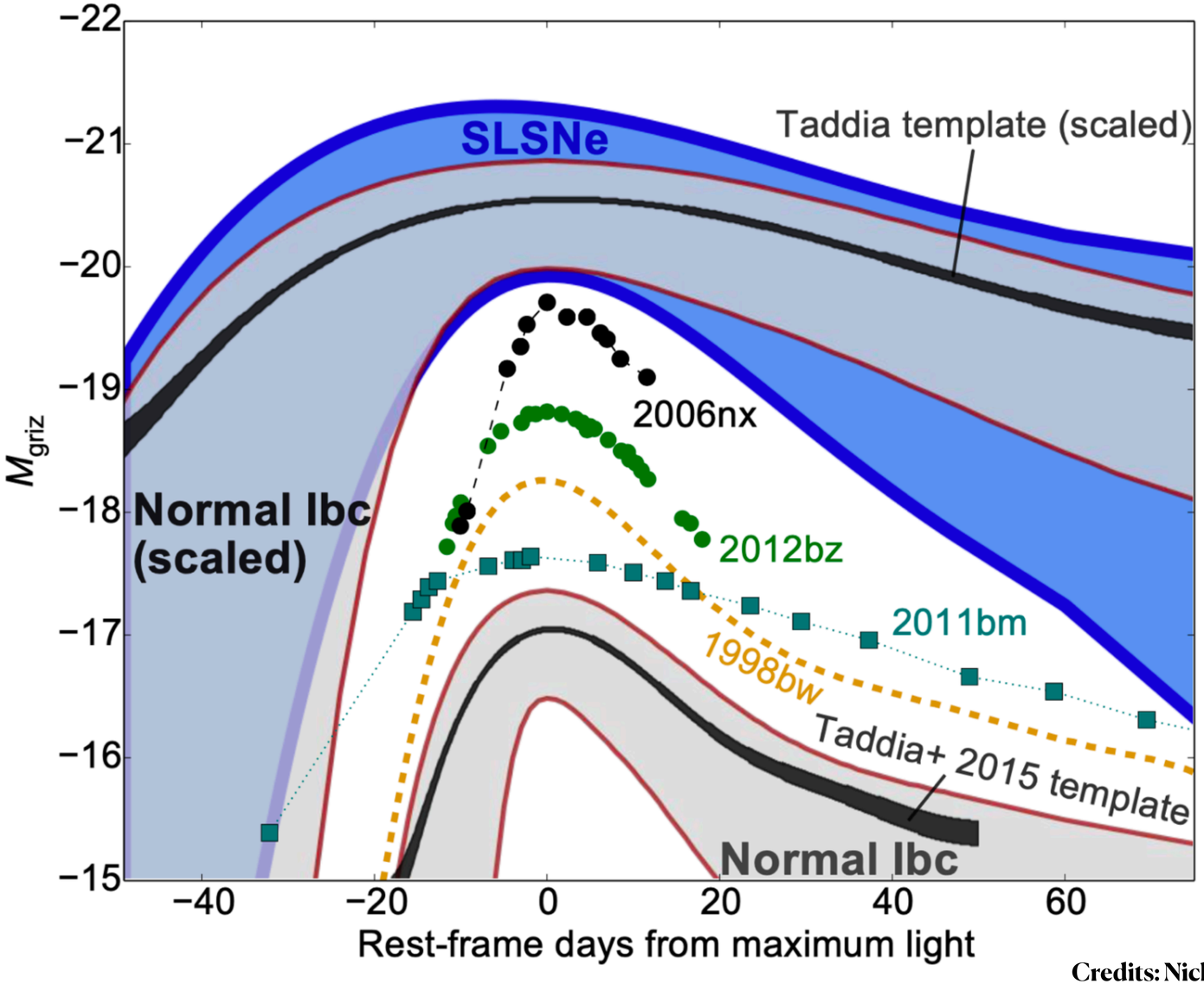


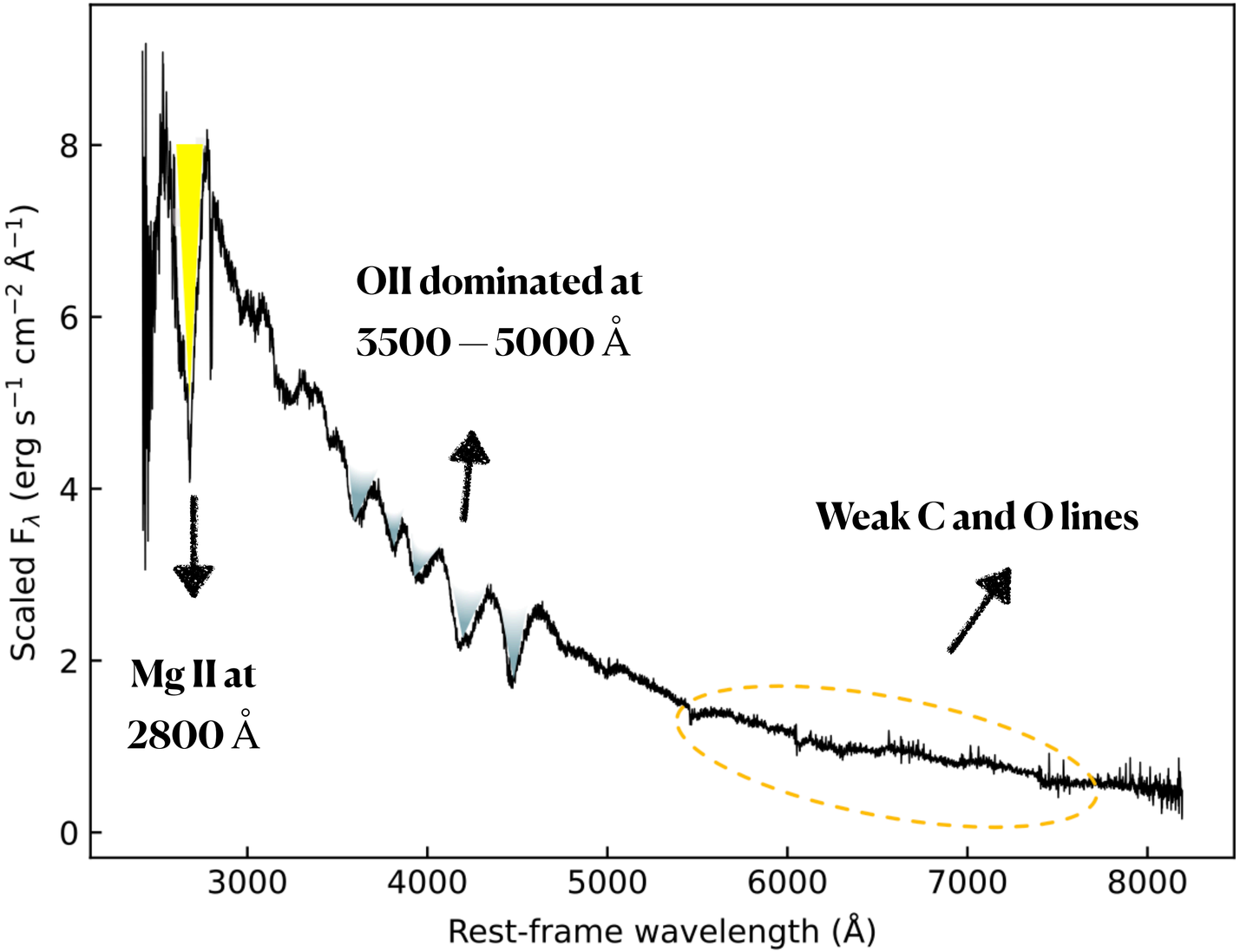
What are superluminous supernovae?

- Transient events **10 — 100** times more luminous than normal CCSNe
- Rare events
  - 0.001% of CCSNe
- SLSNe-I are brighter than ~ - **20 mag**
- Their rise times range between **10 — 125 days**

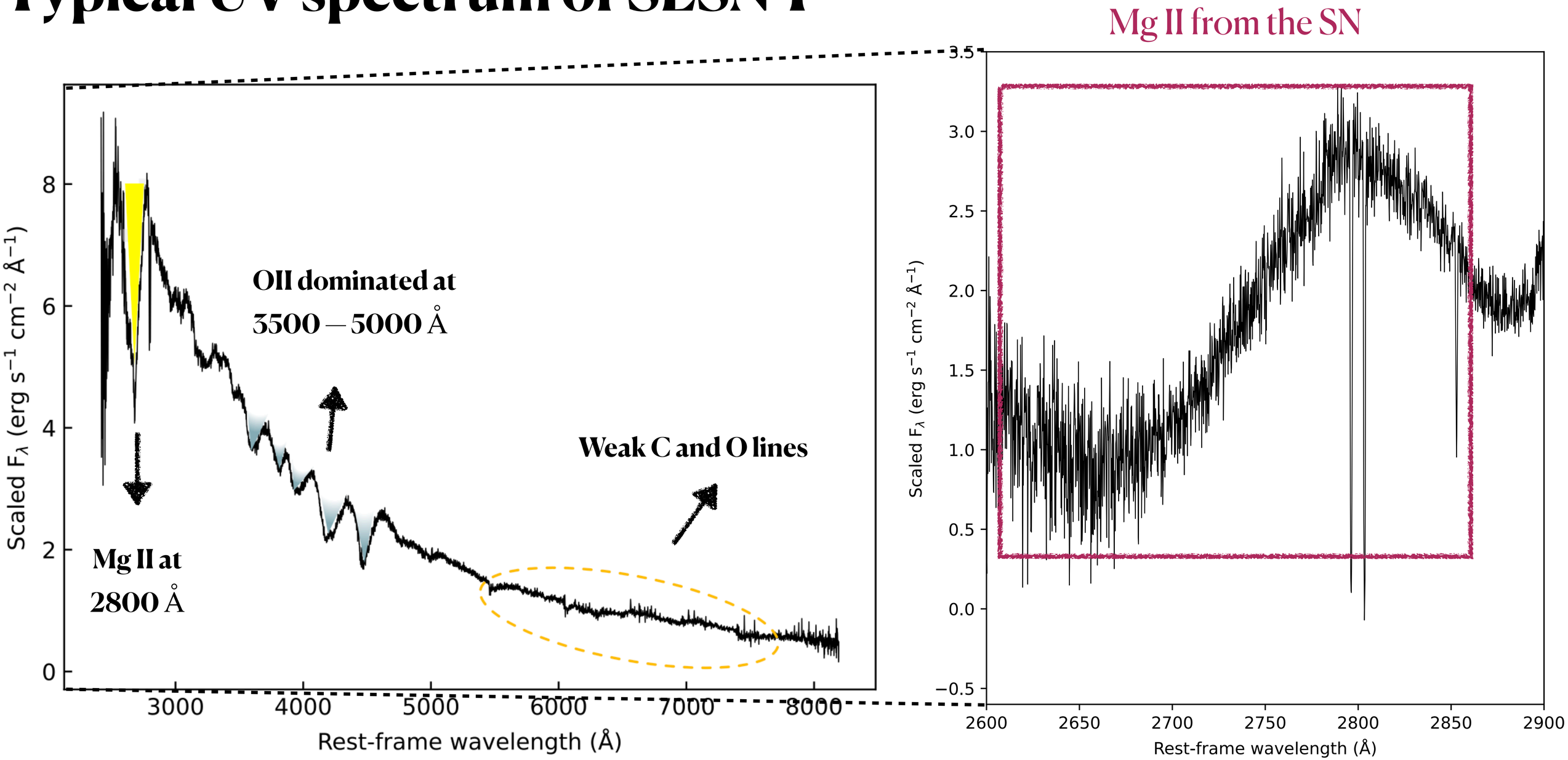


Credits: Nicholl + 2015

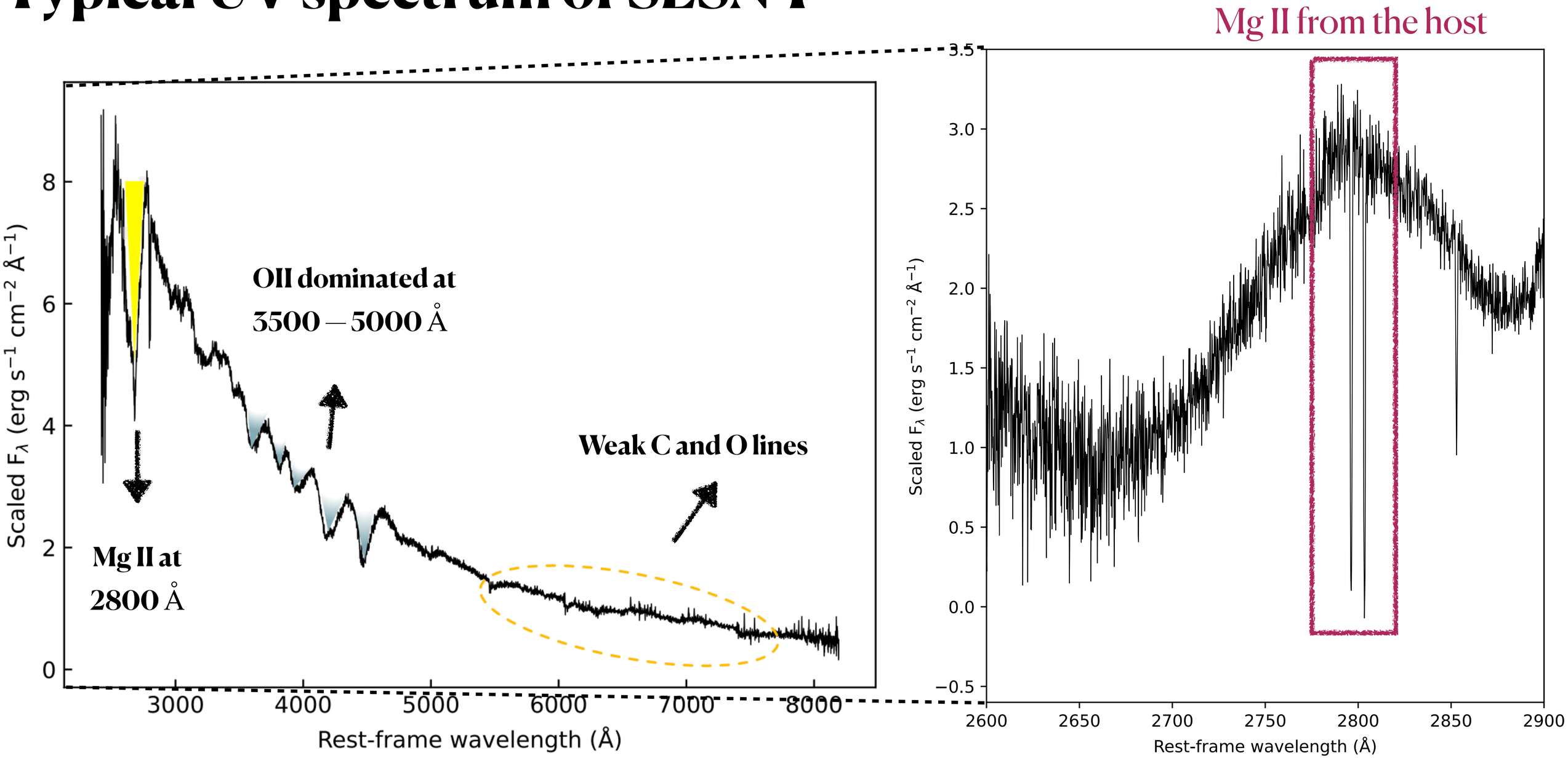
Spectra can give insight into the SLSNe



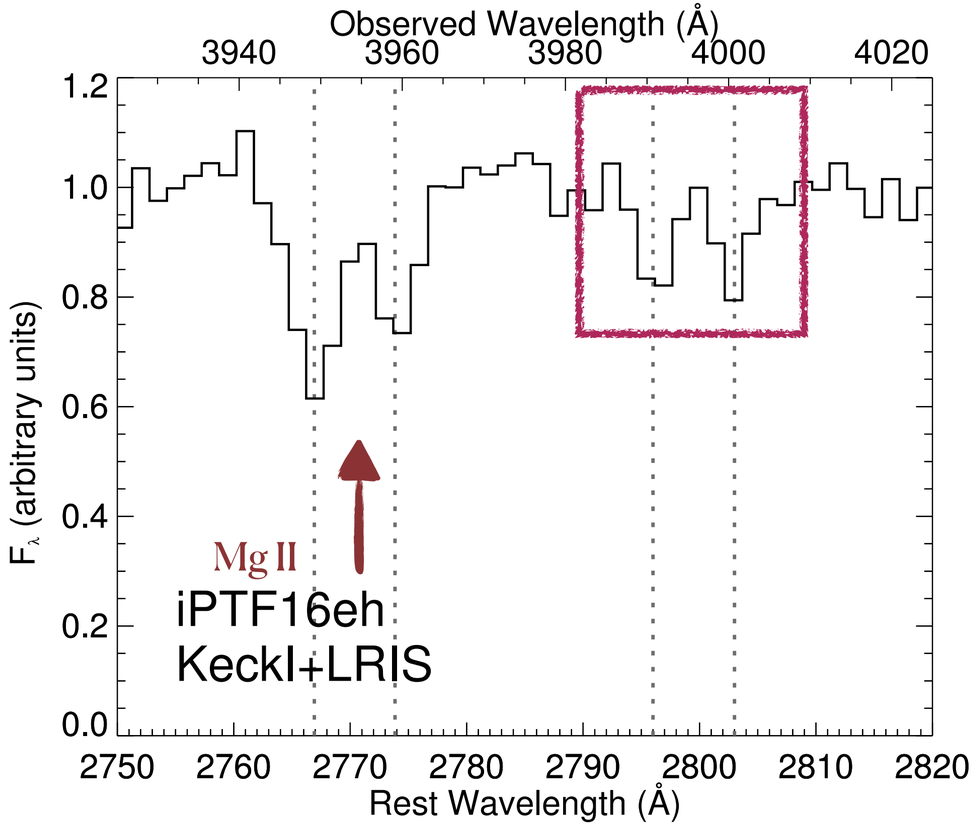
Typical UV spectrum of SLSN-I

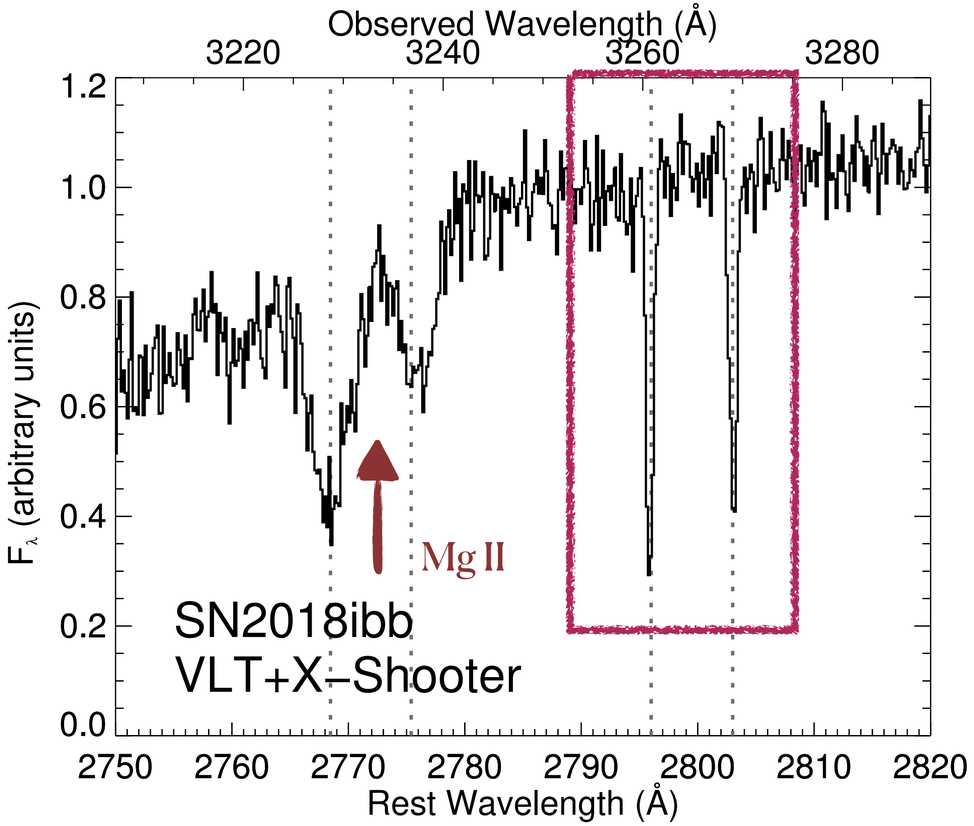


Typical UV spectrum of SLSN-I



Motivation

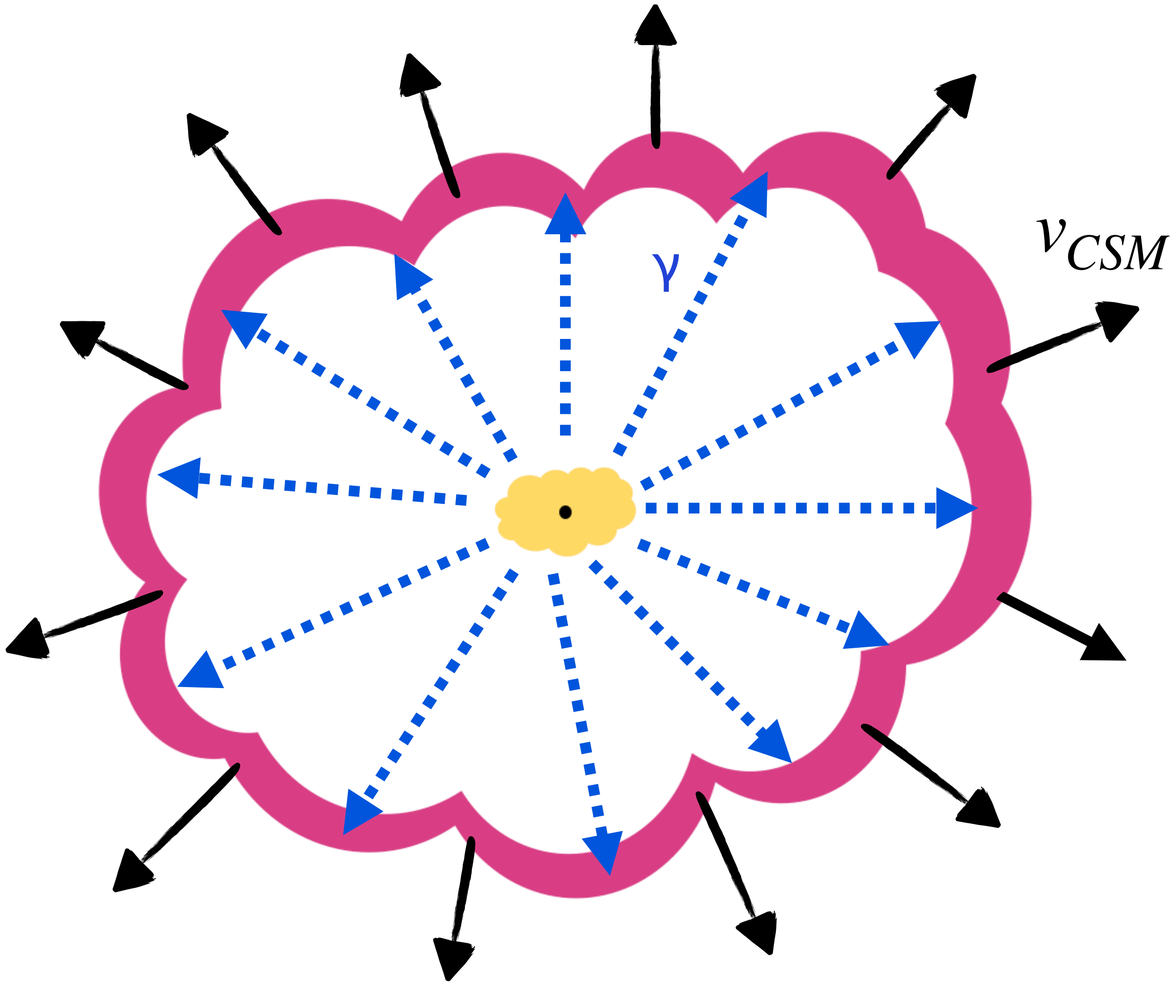


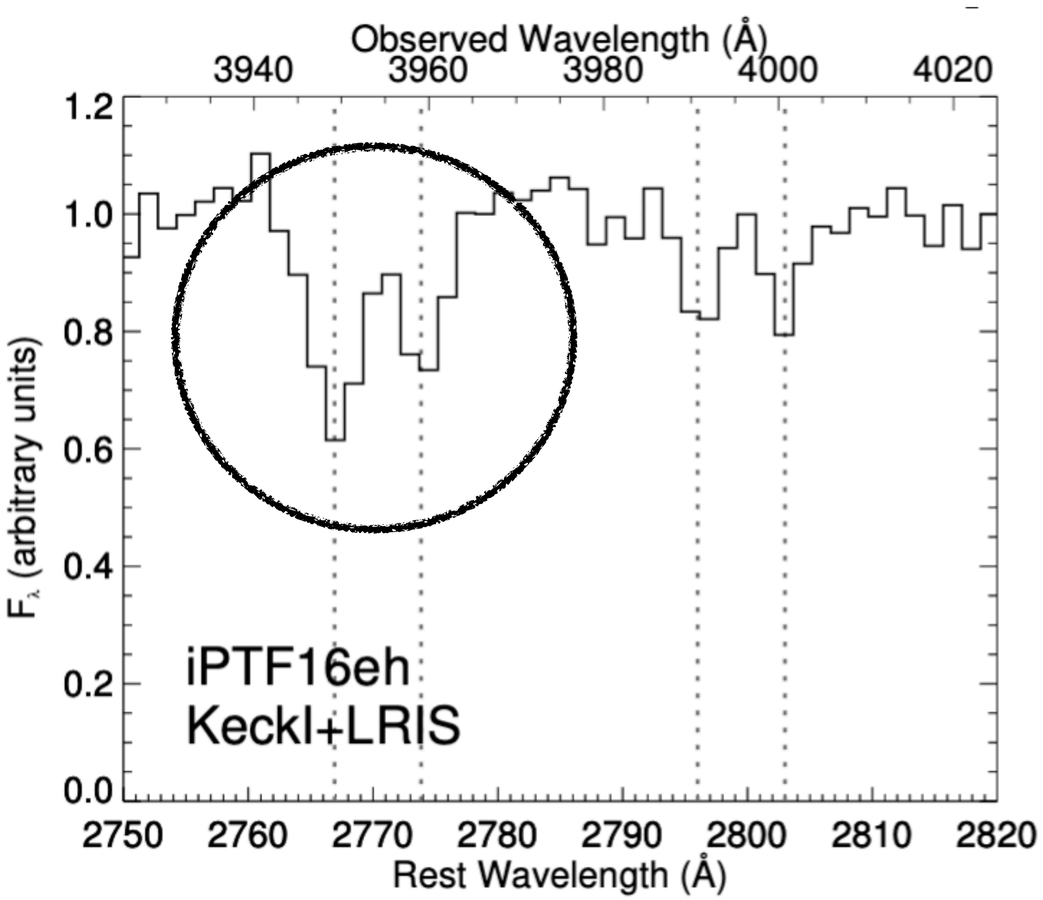


Credits: Lunnan +2018

Credits: Schulze +2024

Fast-moving CSM shell around SLSNe-I





Credits: Lunnan +2018

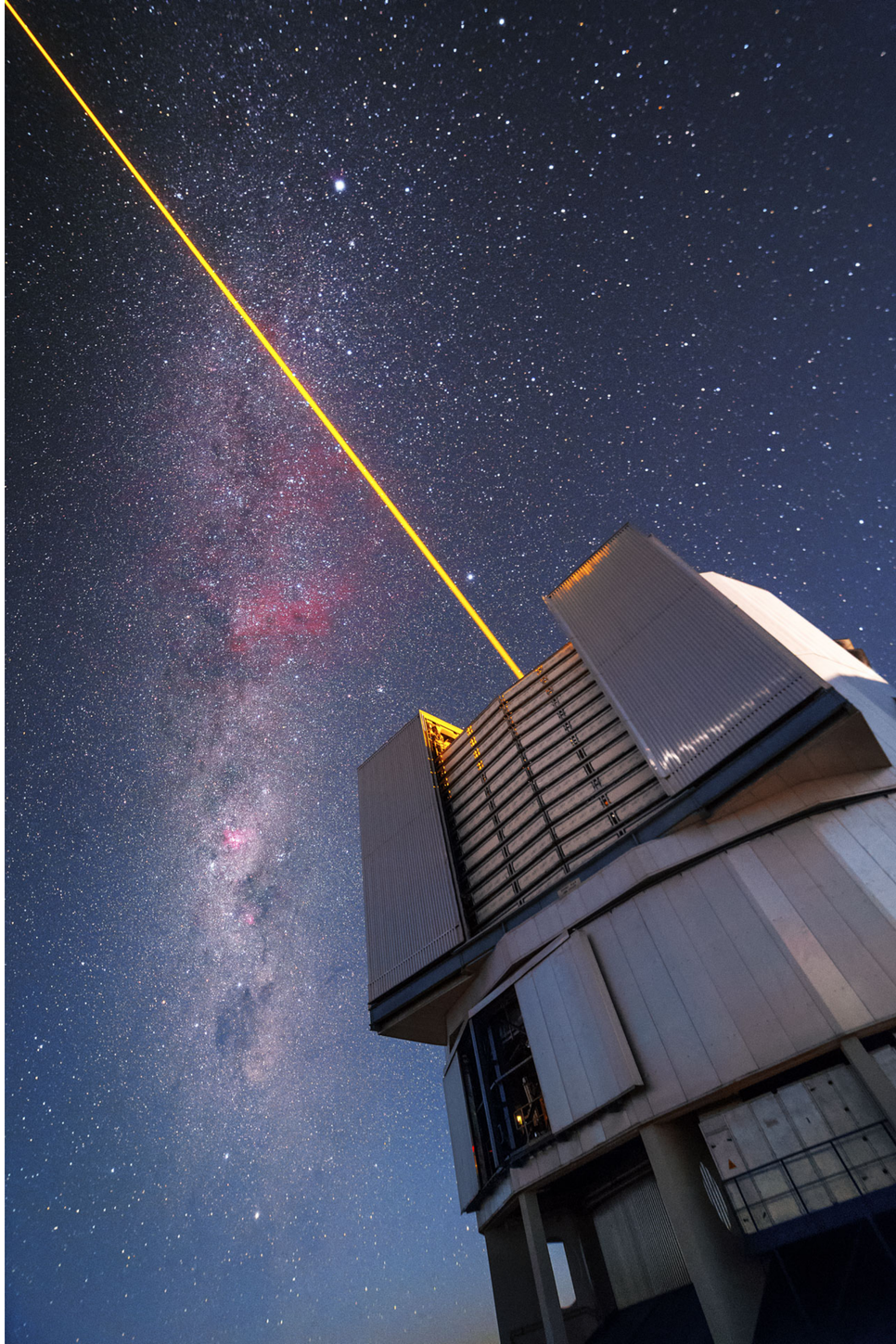
Fast-moving CSM shell around SLSNe

We collected X-shooter spectra of SLSNe

We observed 19 SLSNe with z>0.1

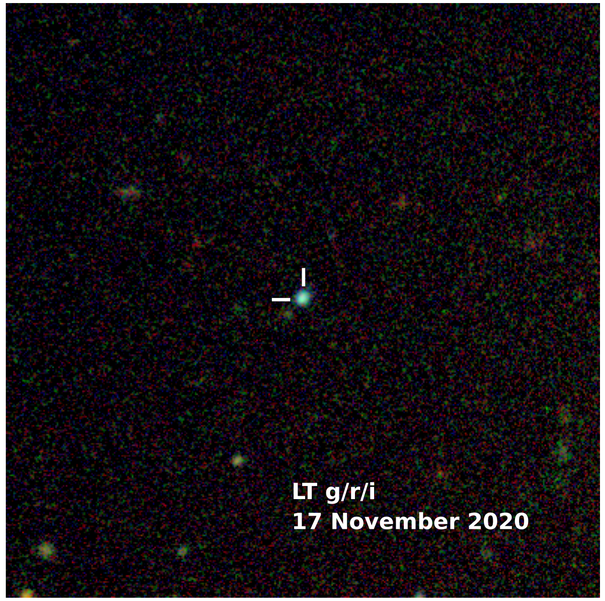
Dedicated analysis of one objects in Gkini+2024 →

Analysis of the sample in Gkini+ (in prep)

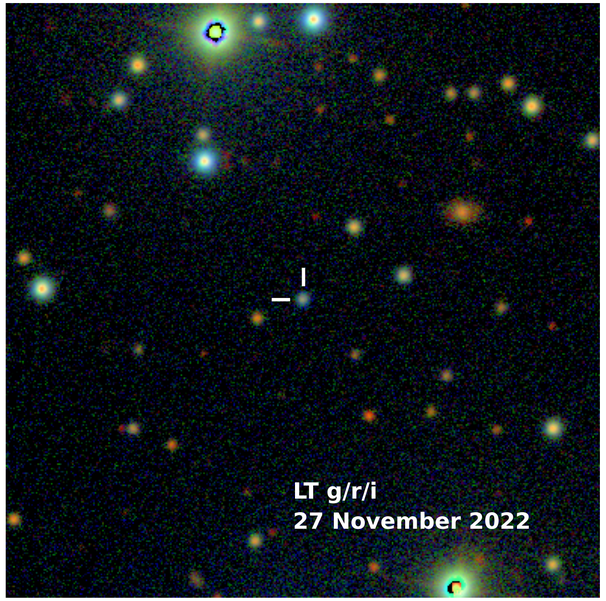


Two more SLSNe-I with Mg II signature

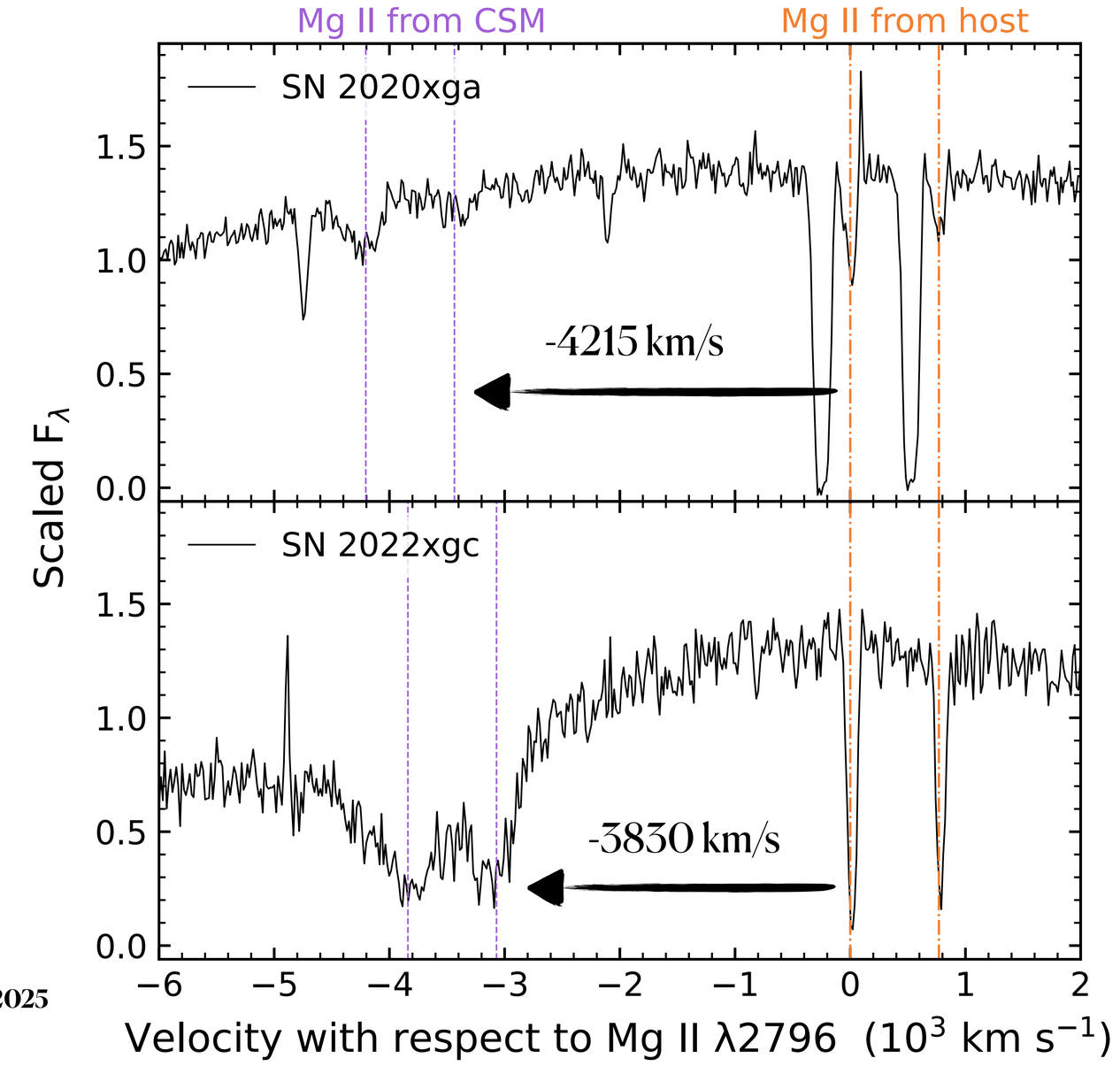
SN 2020xga



SN 2022xgc

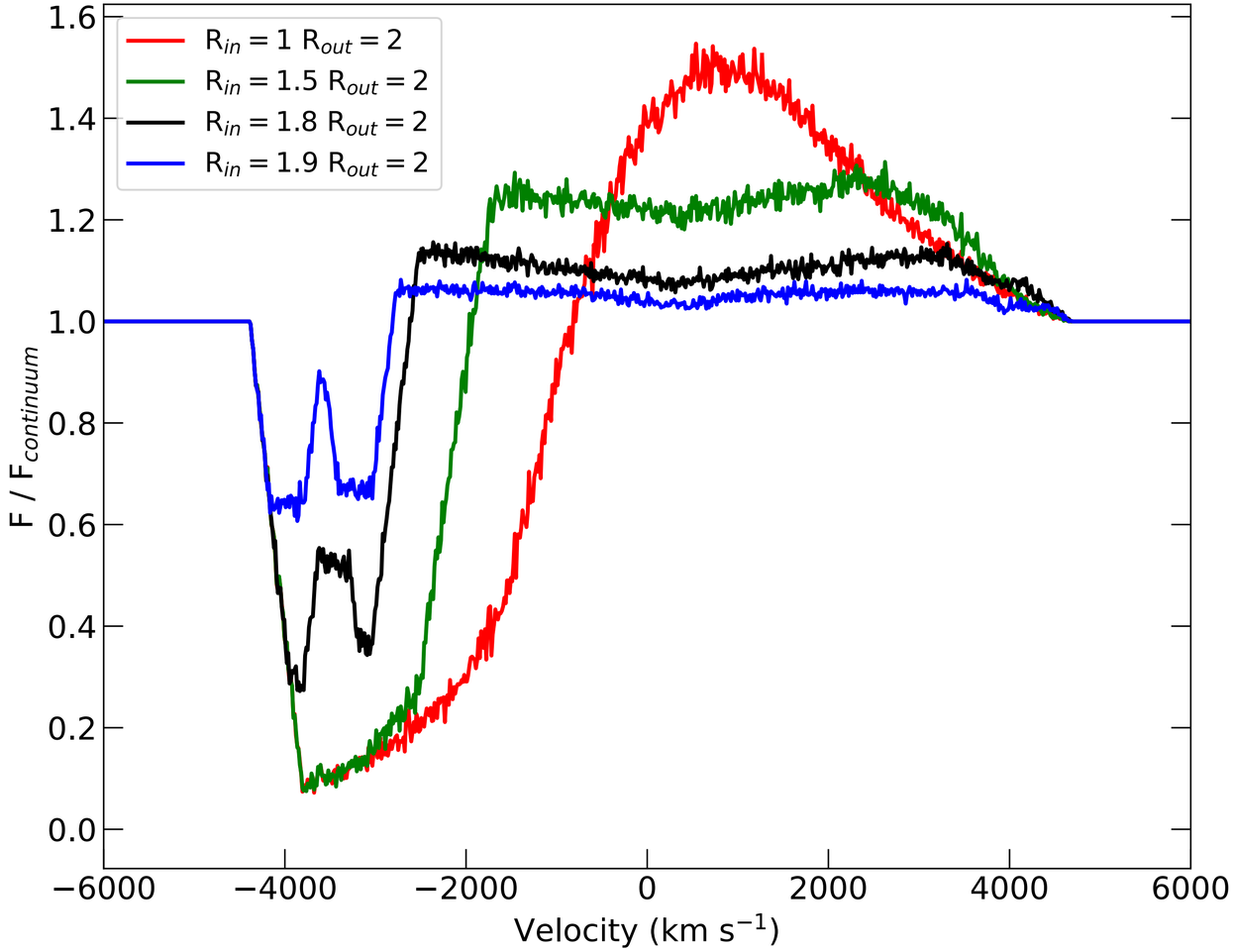


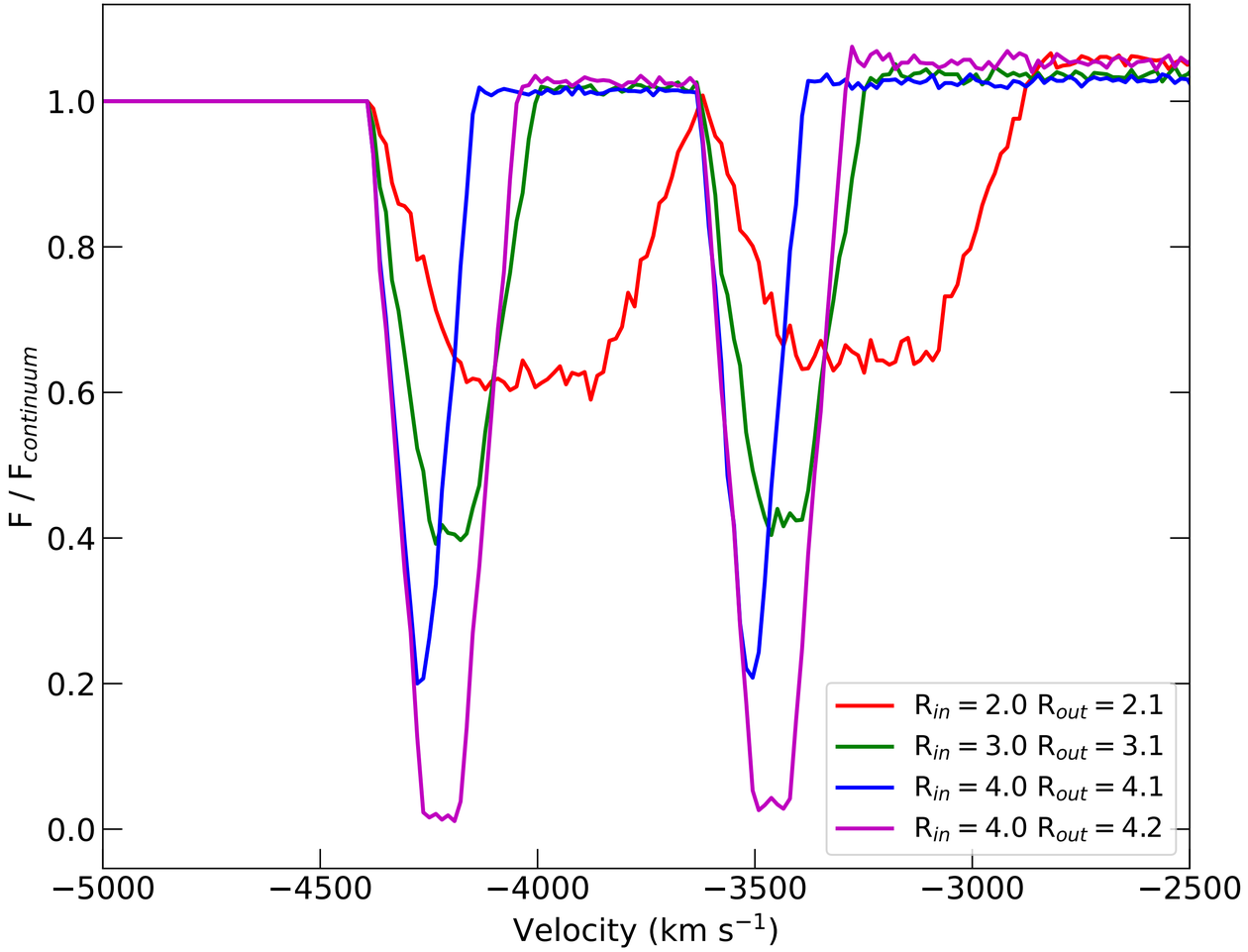
Credits: Gkini+2025



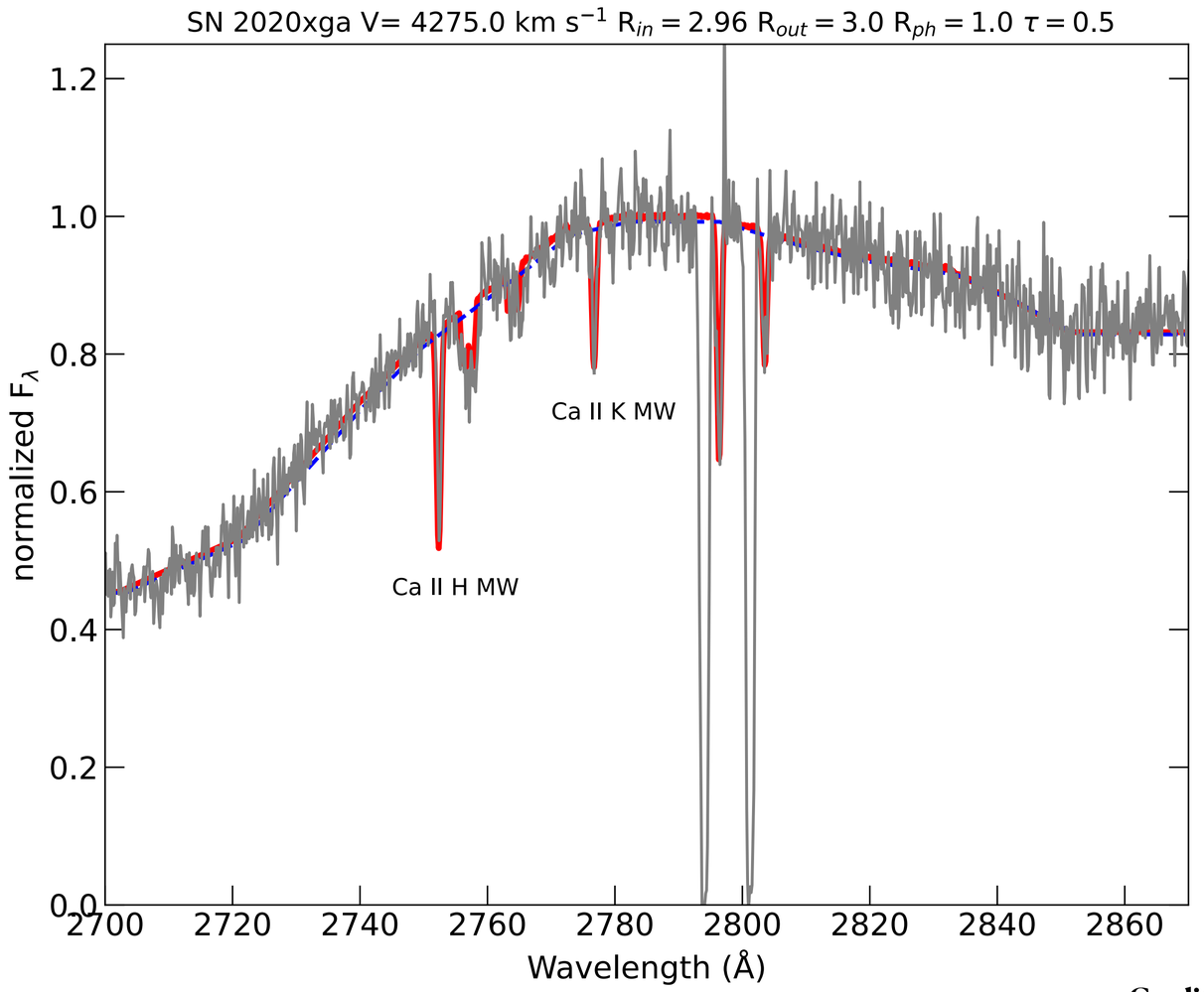
Credits: Gkini+2025

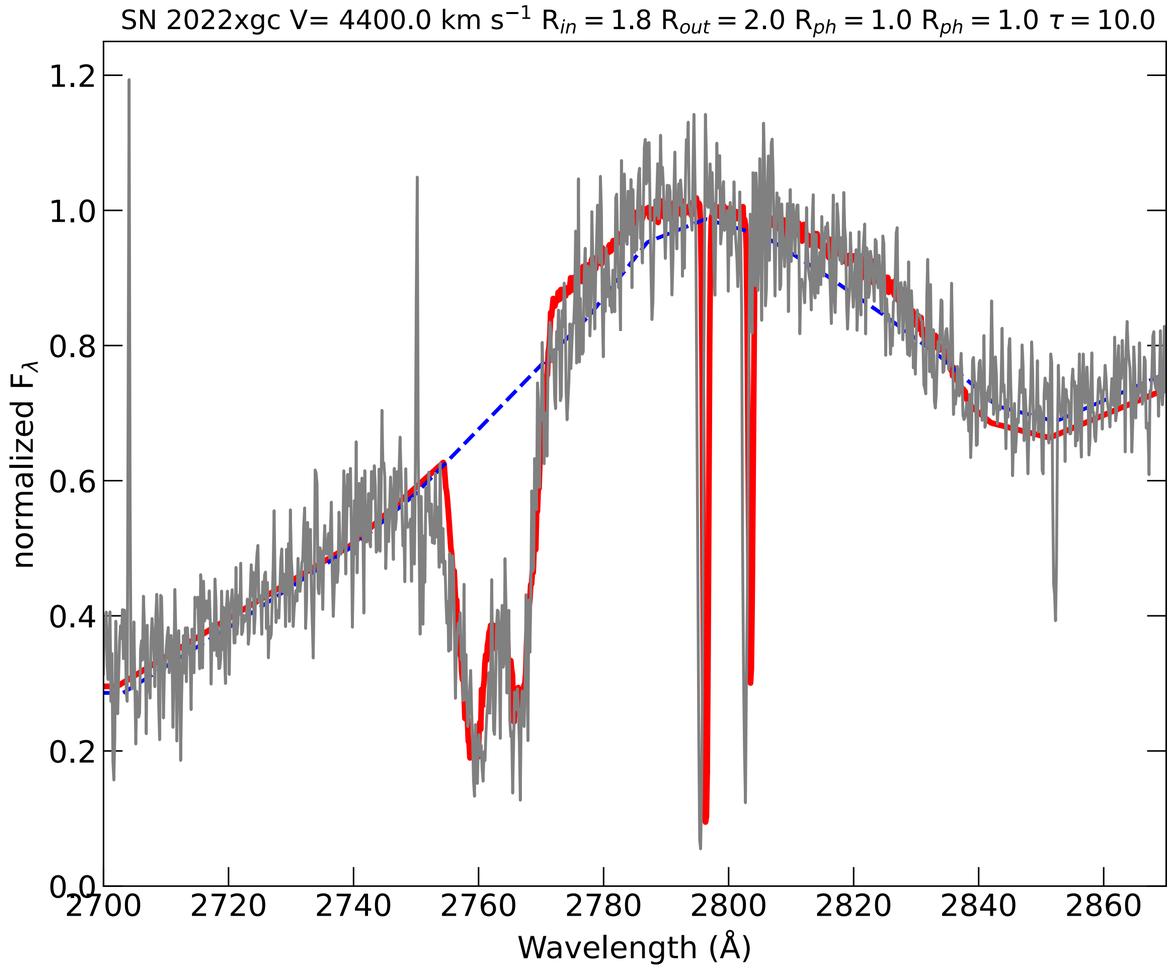
We can extract CSM properties from the absorption lines





CSM shells expelled less than a year before CC



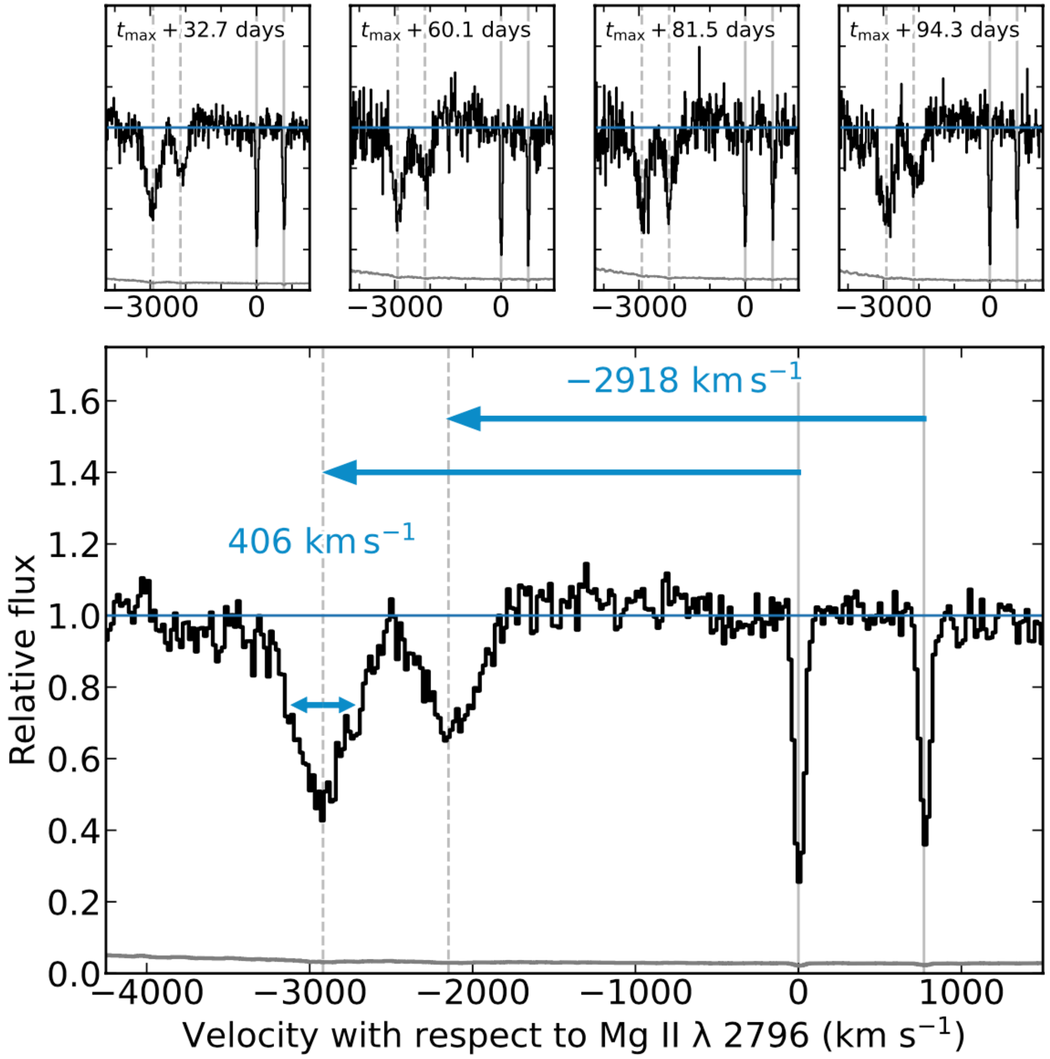


Credits: Gkini+2025

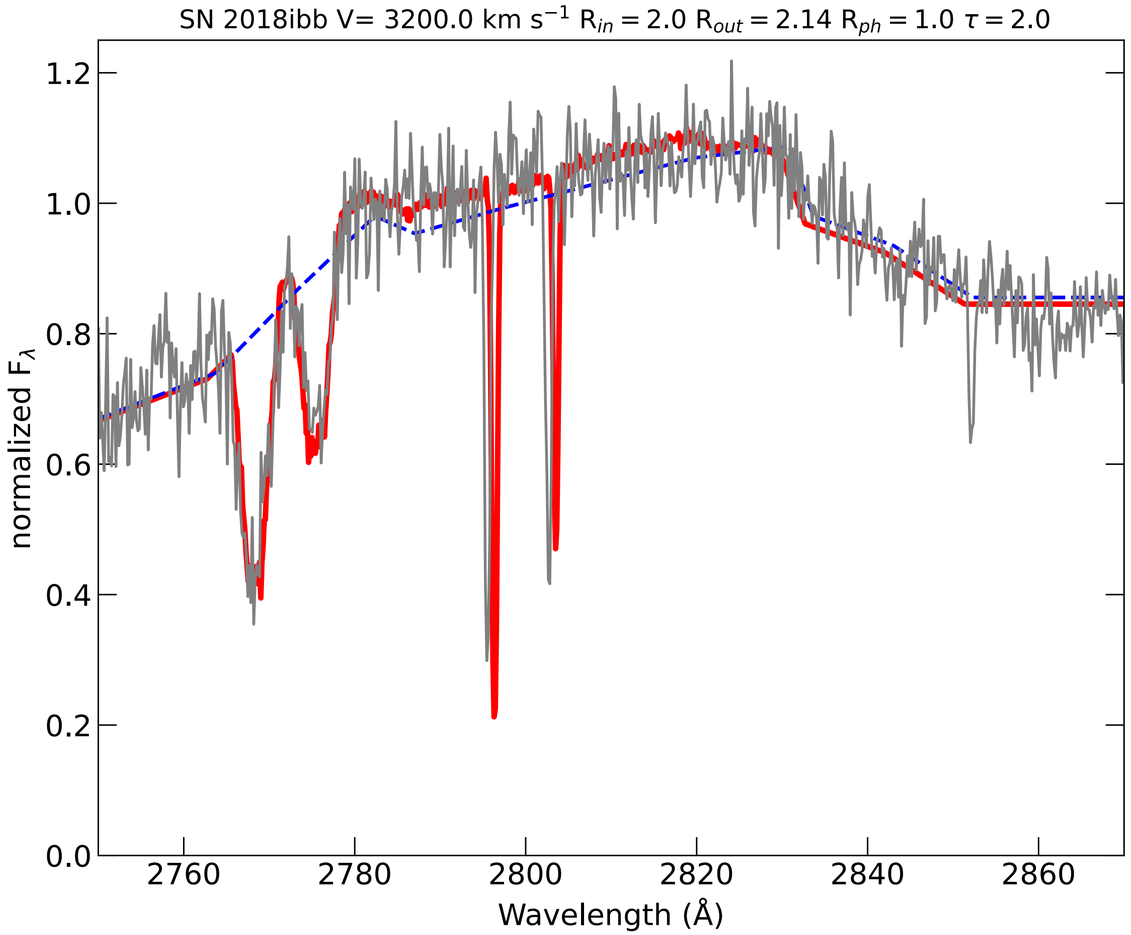
Expelled ~ 11 months before CC

Expelled ~ 5 months before CC

SN2018ibb the ejecta interacted with the CSM



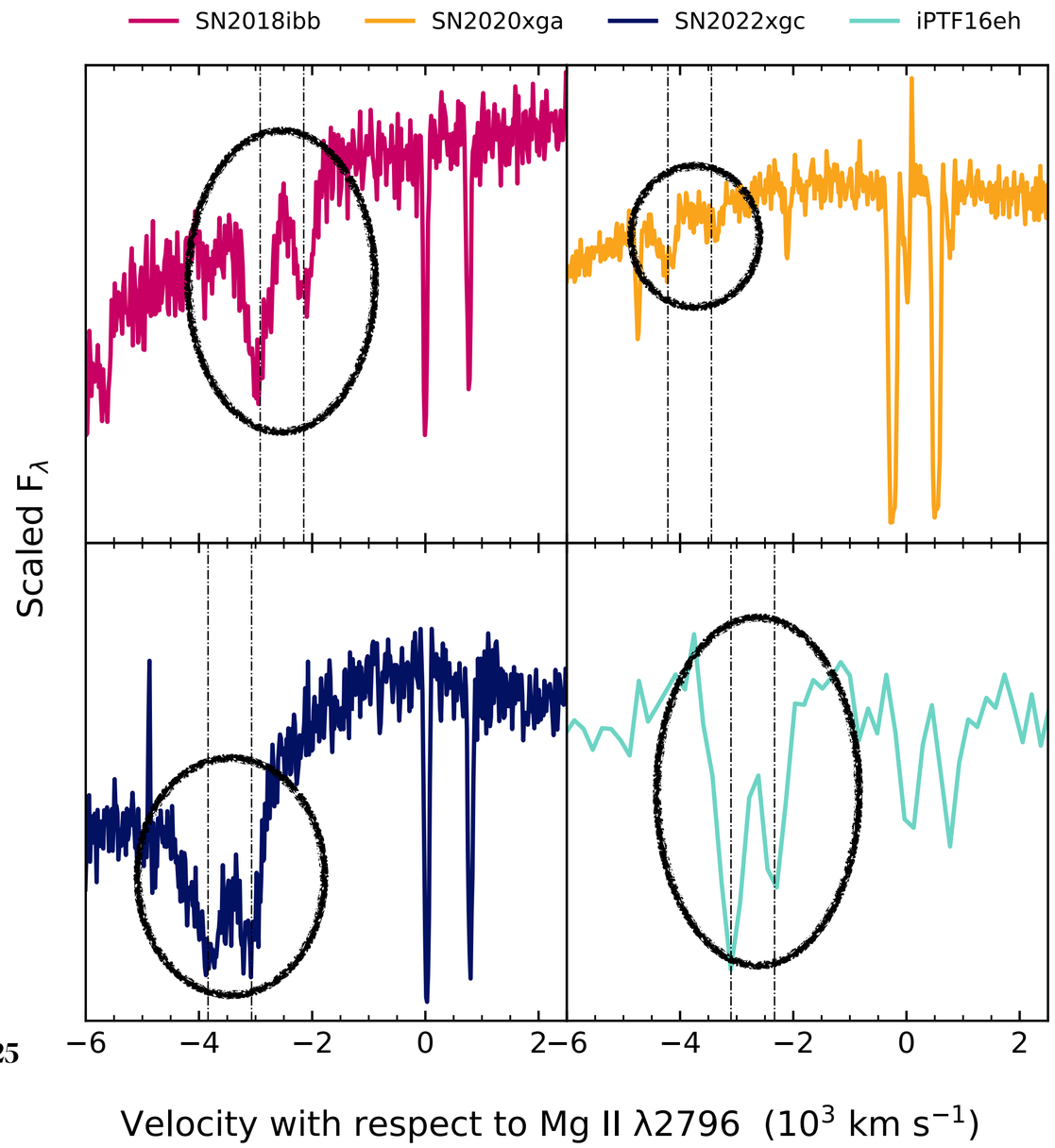
Credits: Schulze+2024



Credits: Gkini+2025

Expelled ~ 9 months before CC

The Mg II system differs

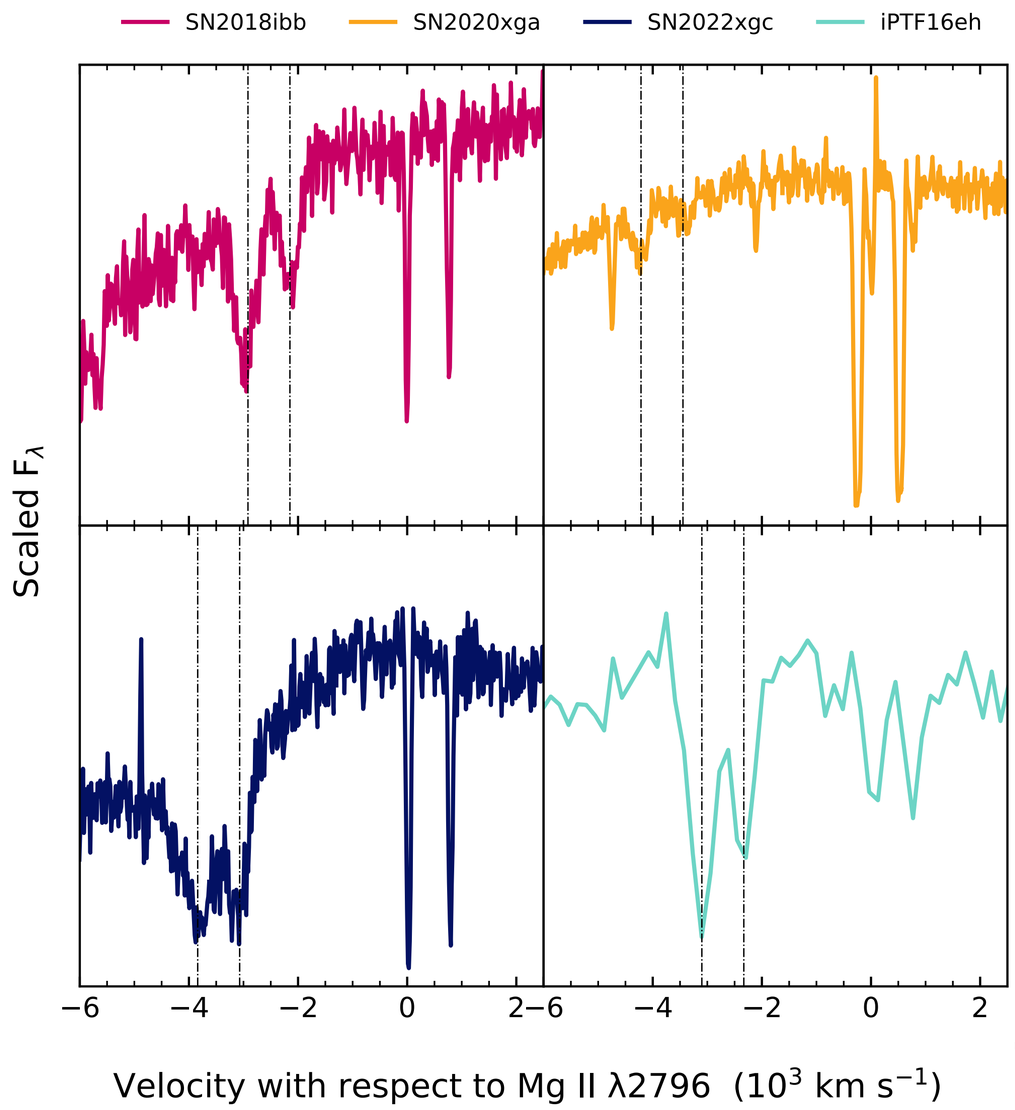


Credits: Gkini+2025

Different line profiles

Various CSM properties

Eruptive mass loss is required to form CSM at this distances

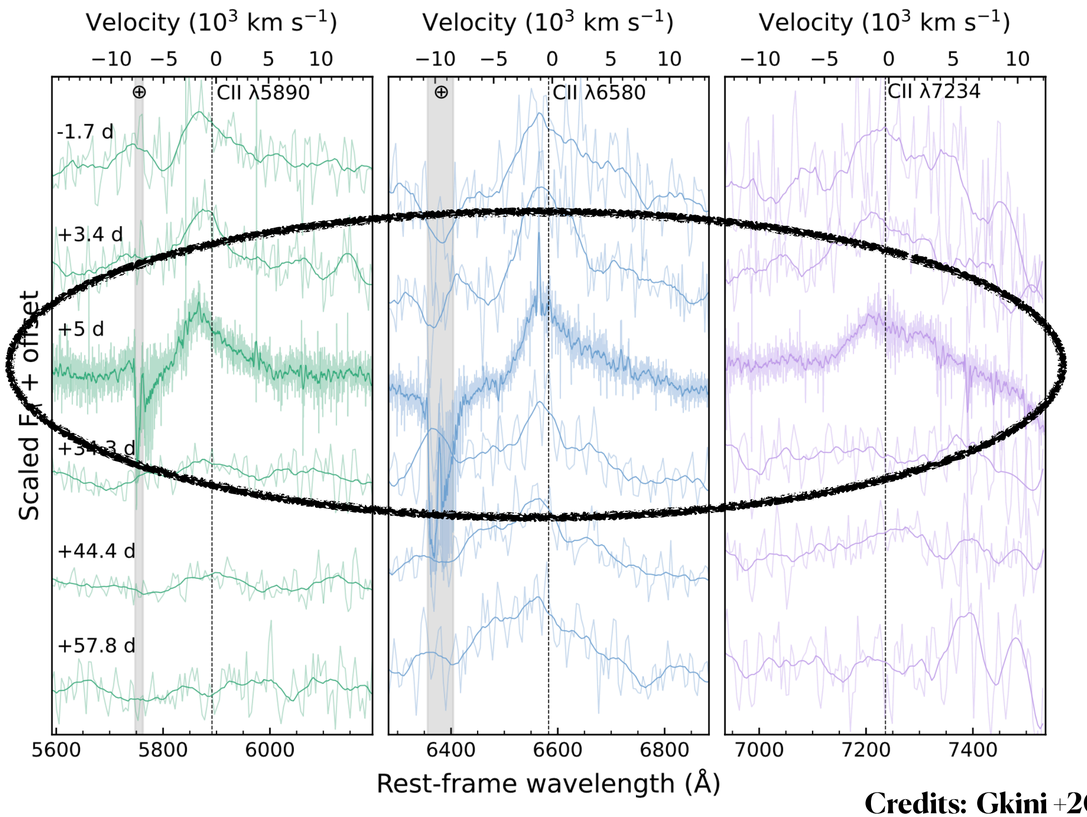


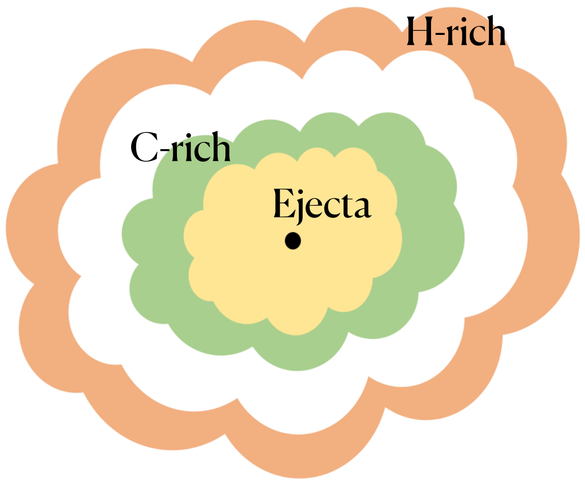
Credits: Gkini+2025

Pulsational Pair Instability?

- The estimated ejection time put a limit on the He-core progenitor mass of > 46-50 $M_\odot$
- Geometry could perhaps give a hint of the expelling mechanism

Not all SLSNe show this signature





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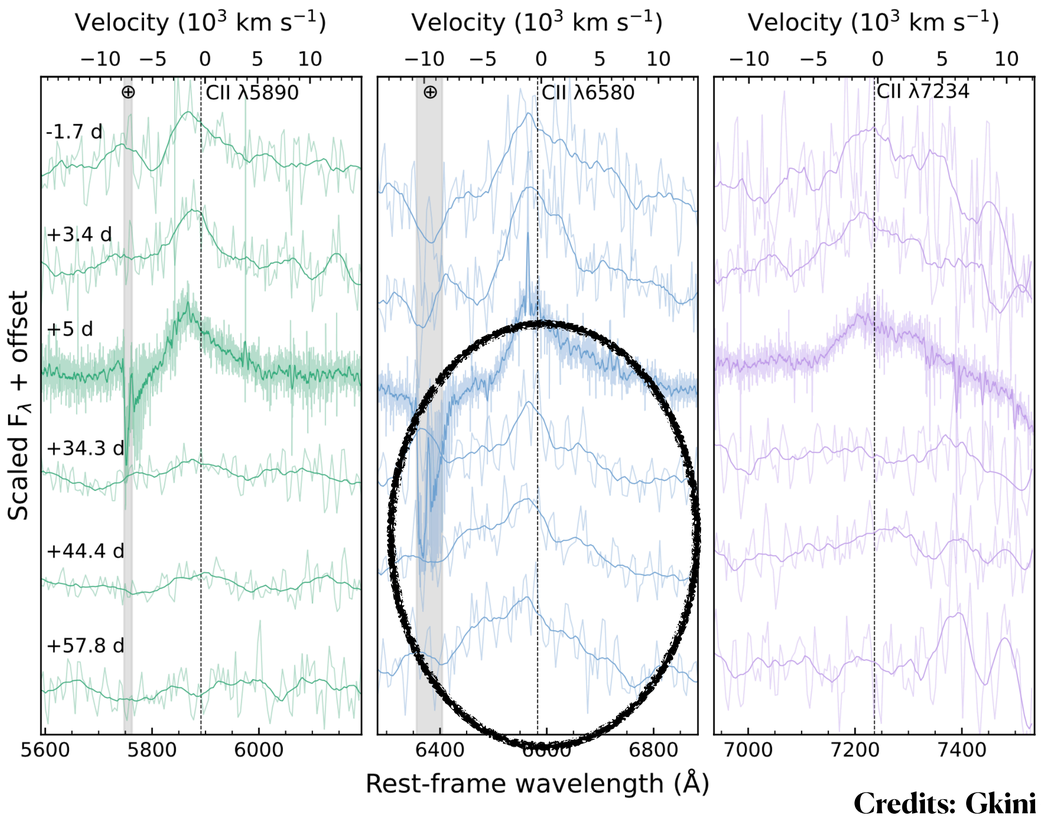
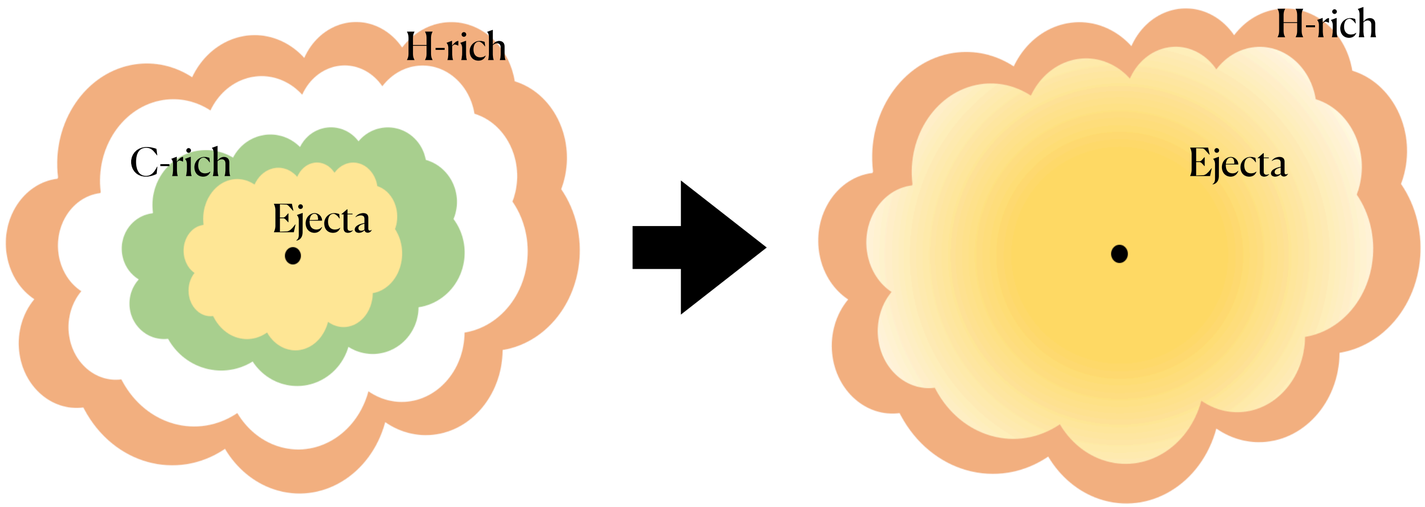
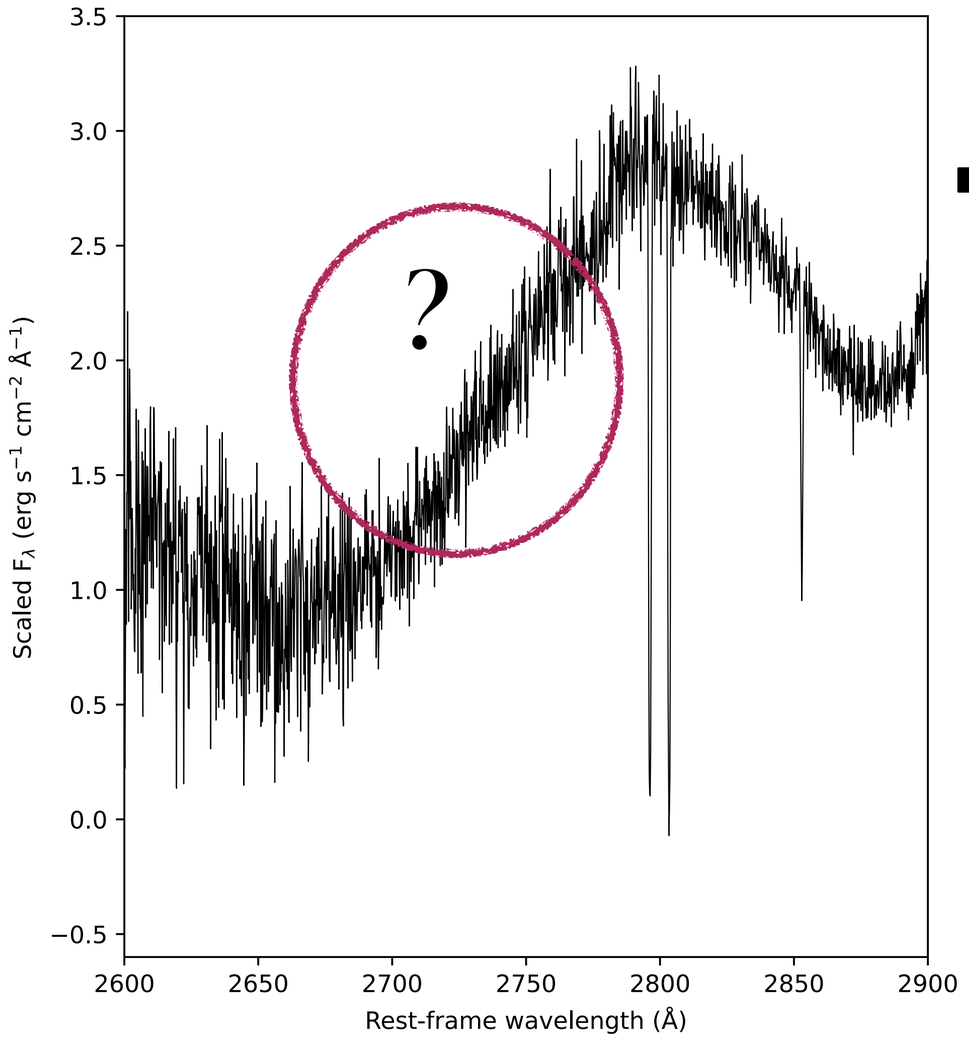


Credits: Gkini +2024



Searching for eruptive mass loss...



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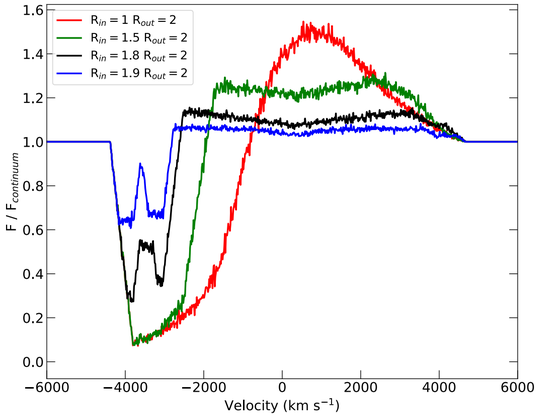

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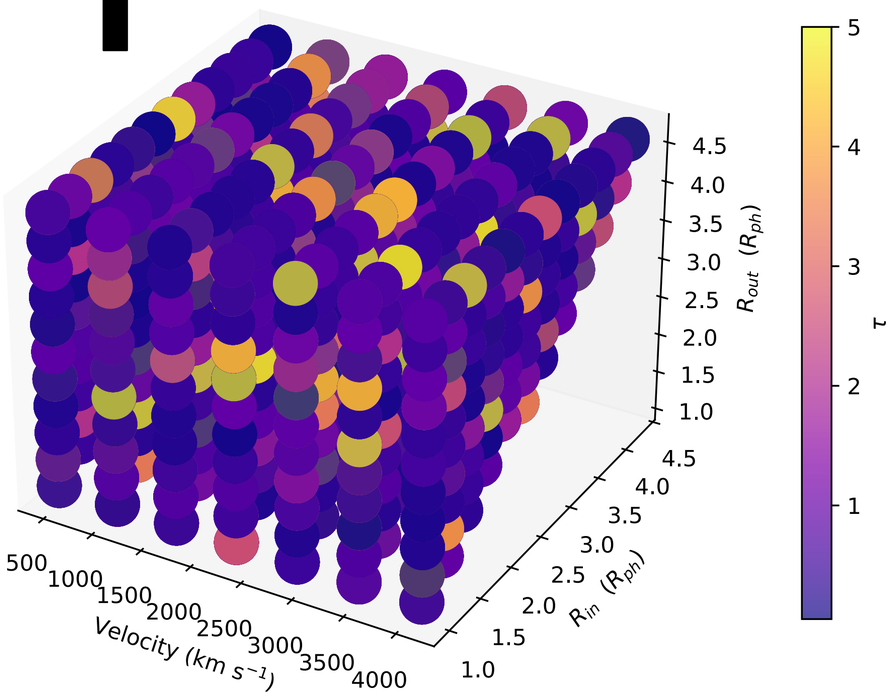
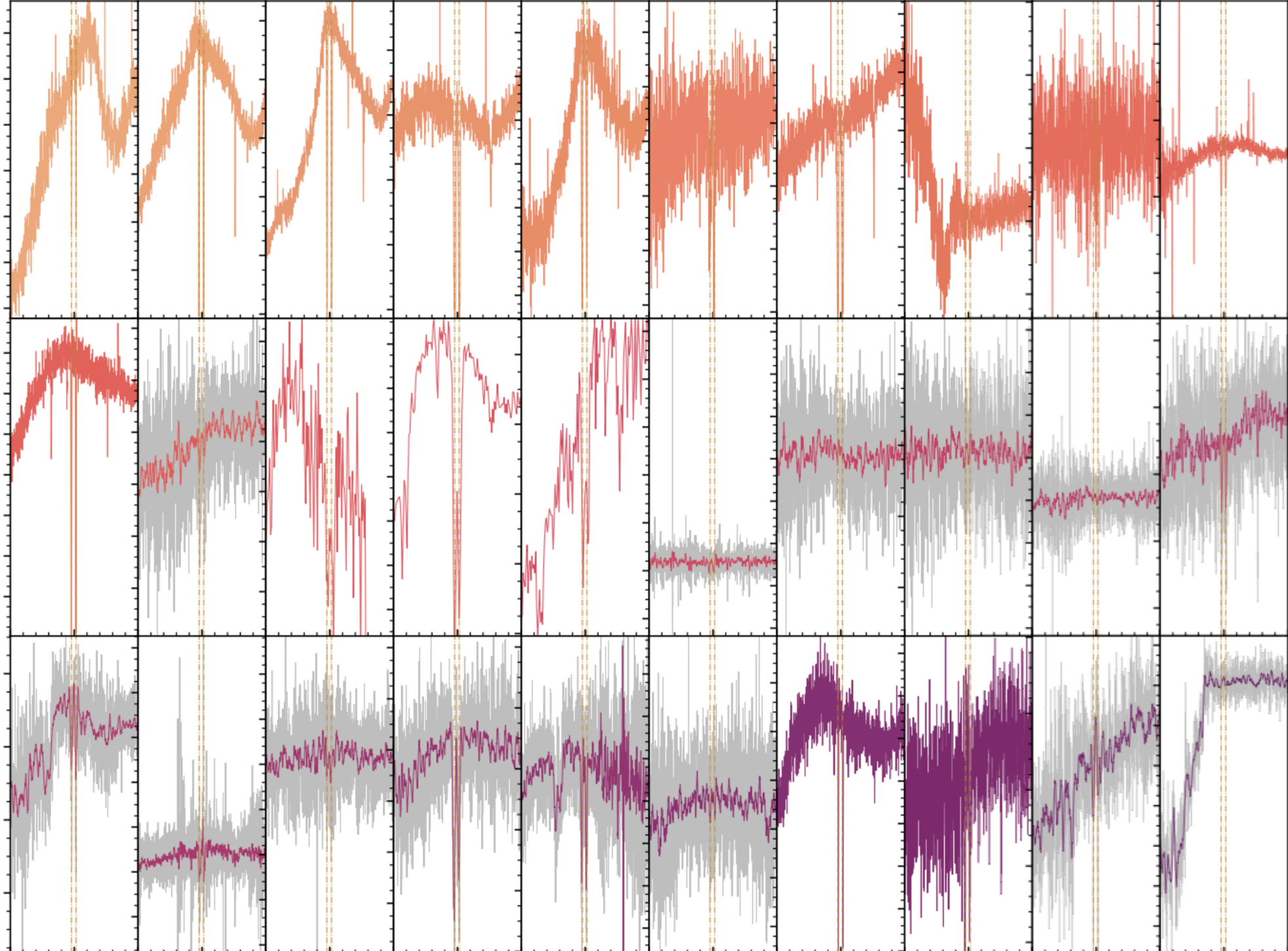
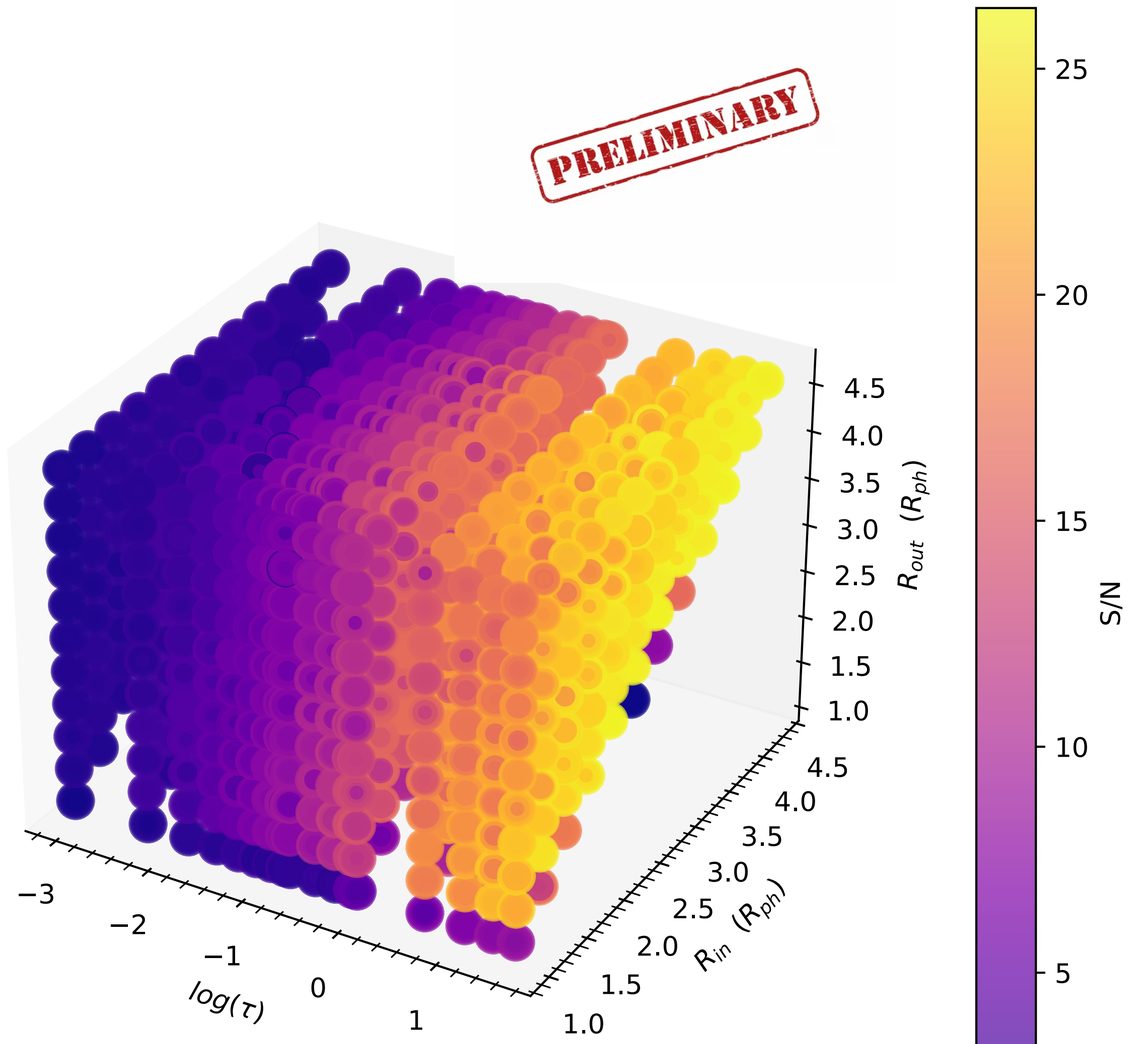
CSM parameters

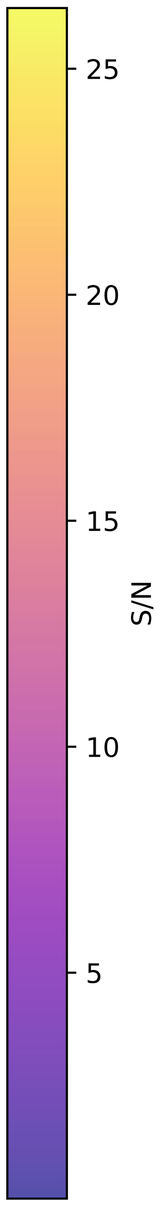


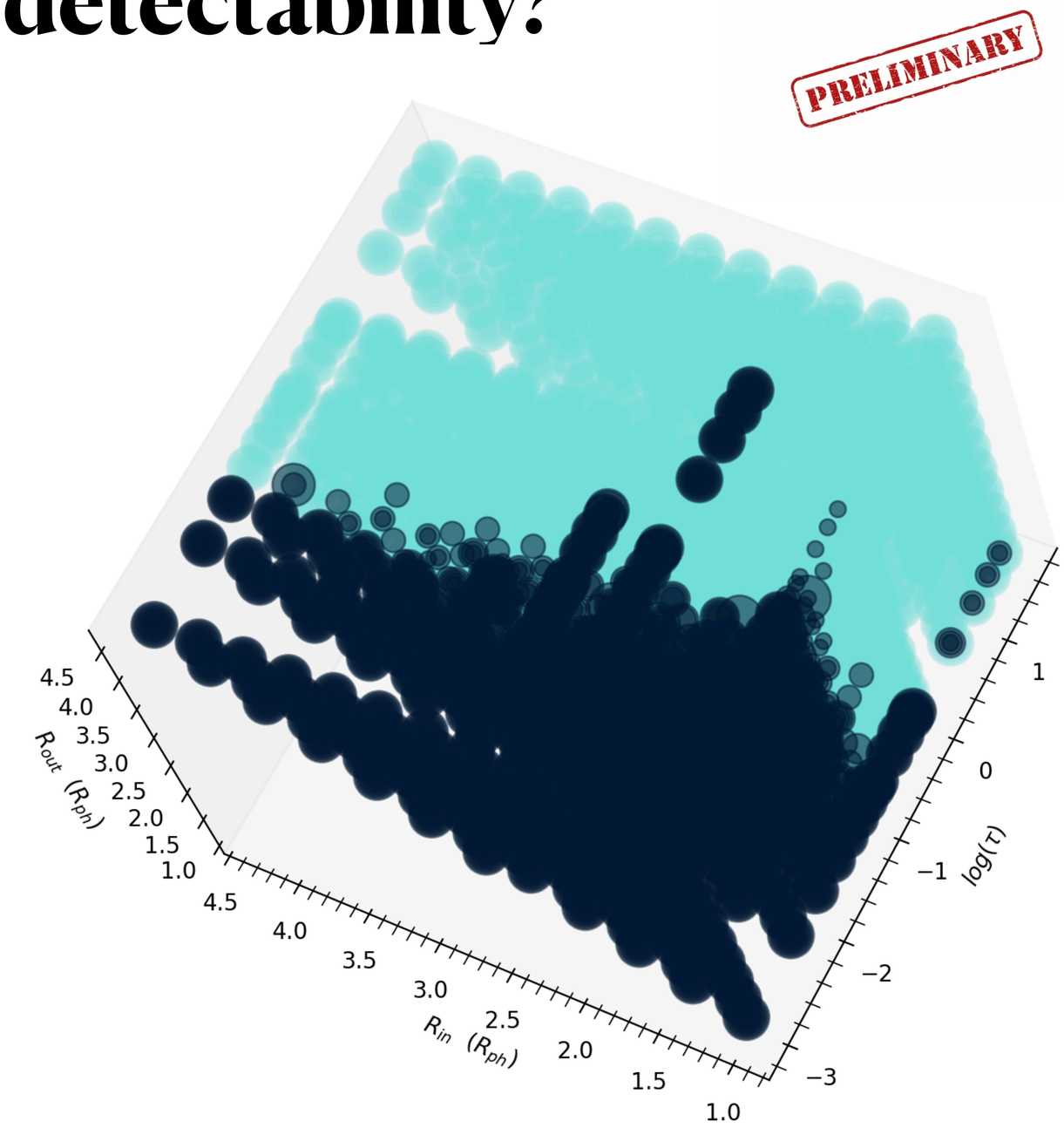
Our sample



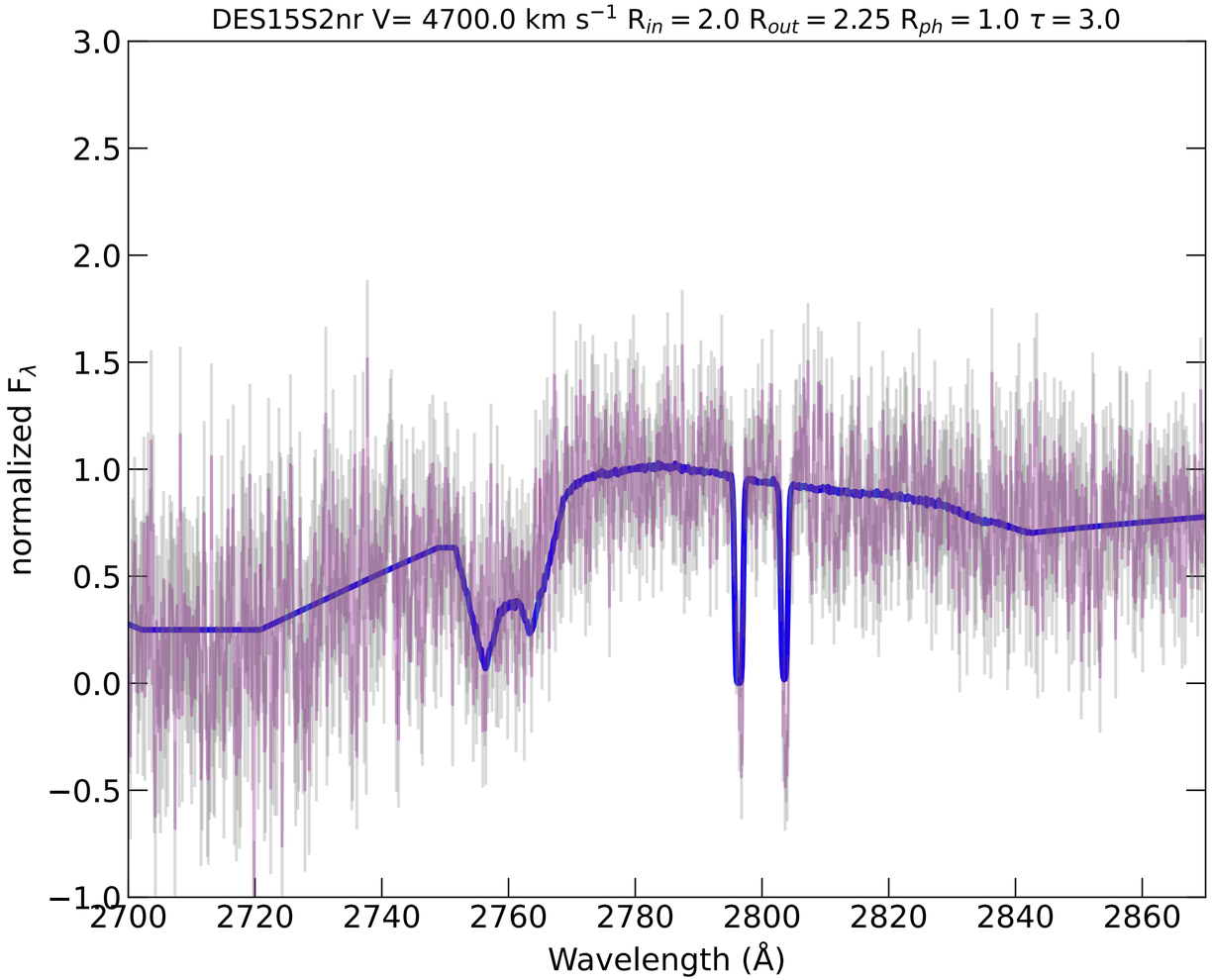
Is optical depth the key to detectability?

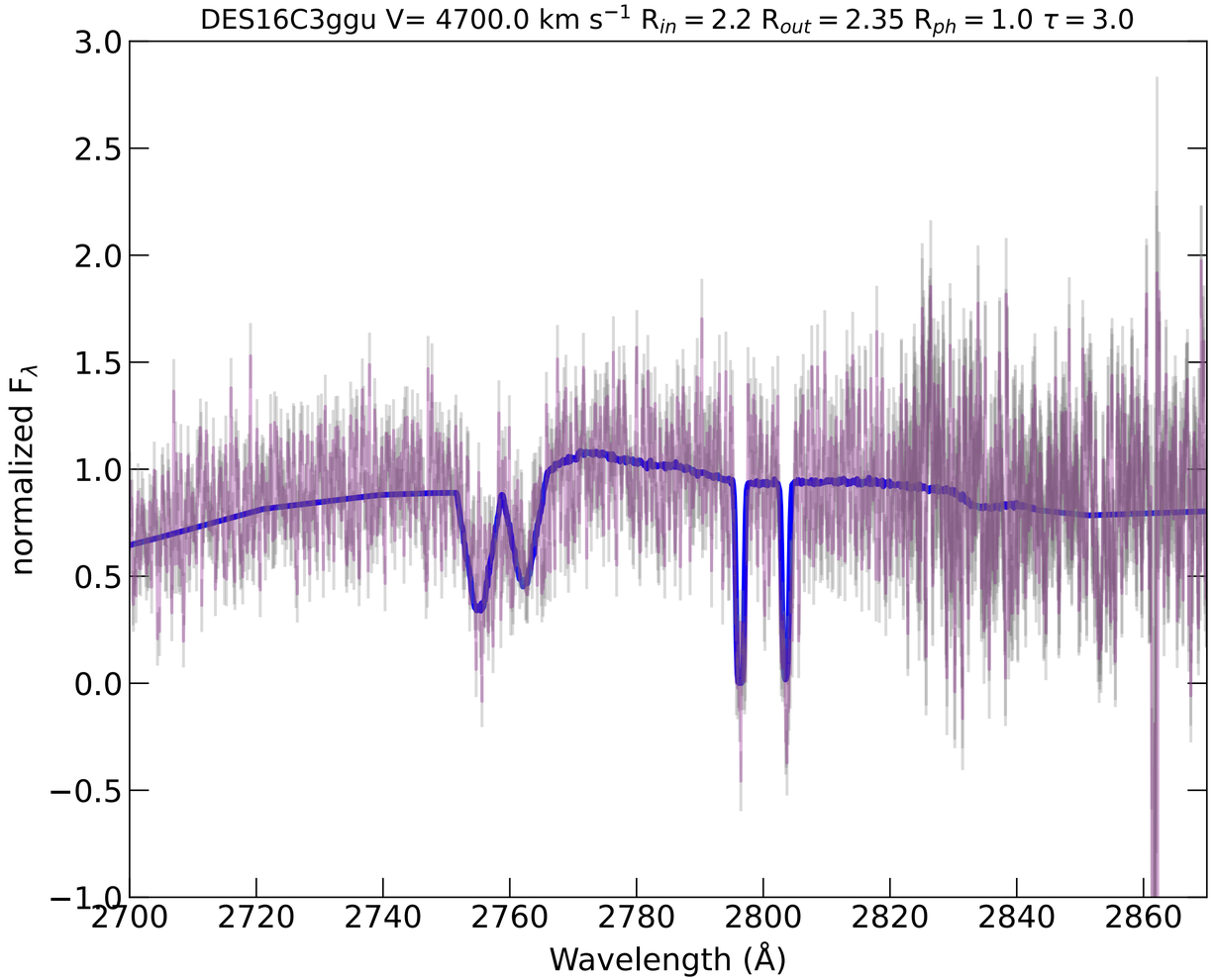






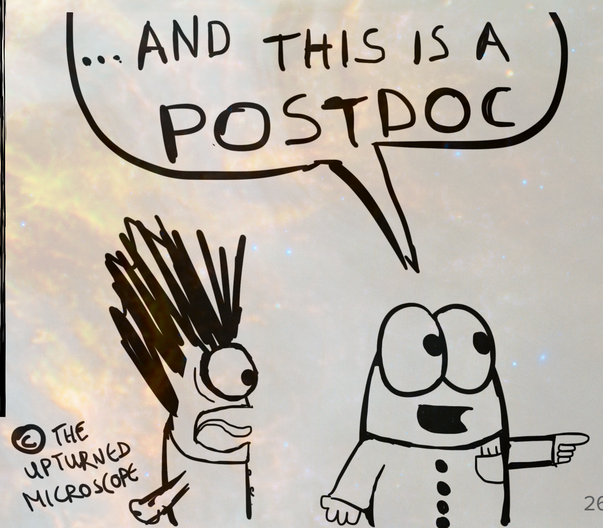
Two more objects !!!

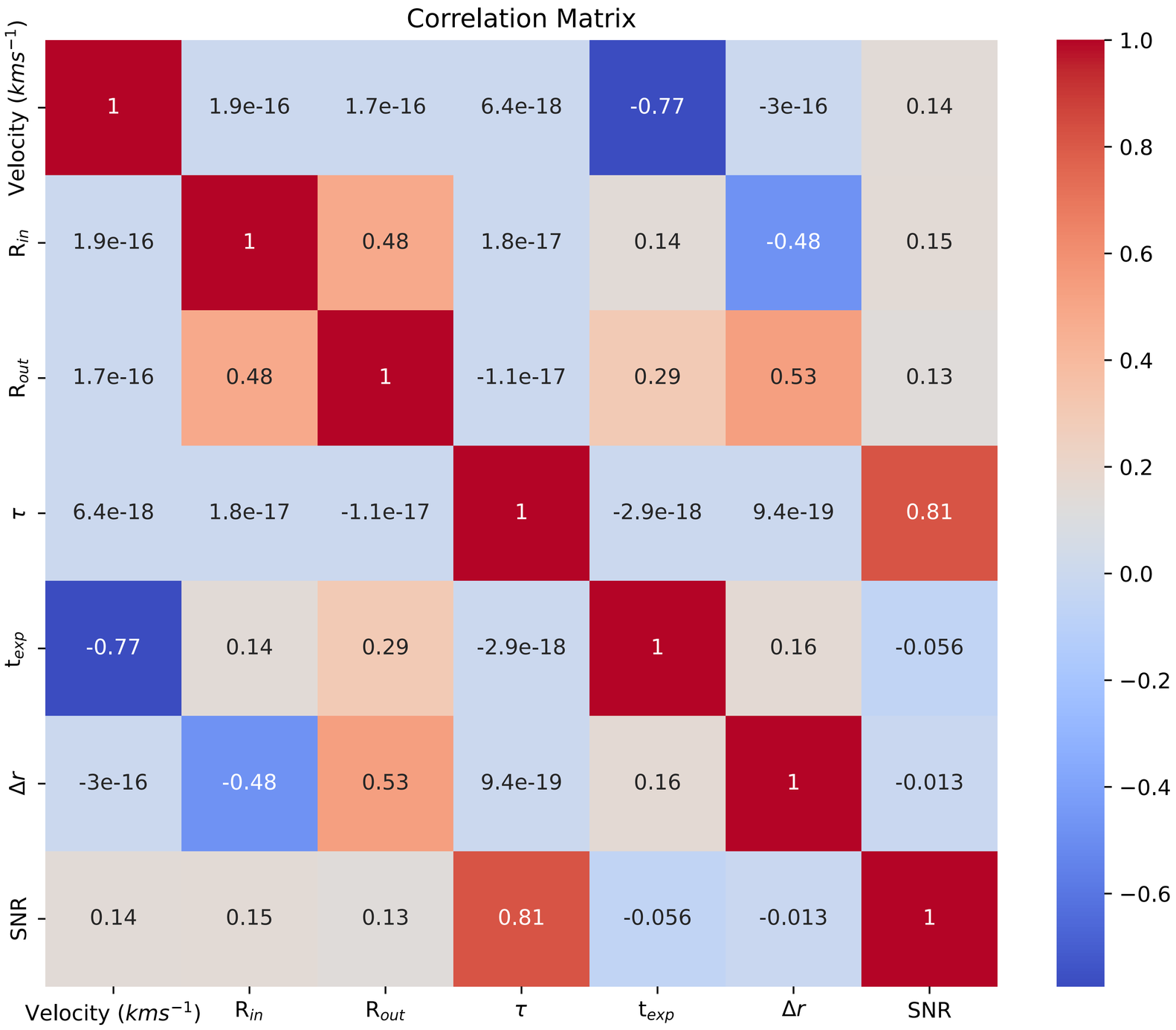




Takeaways

- SN2020xga and SN2022xgc are SLSNe-I with Mg II absorption lines which indicate CSM shell around the SNe
  - The shells were expelled < 1 year before the explosion
- Pulsational Pair Instability of >50 $M_\odot$ of He-core progenitors?
- **Six** objects have shown this feature. Rare events?
- Ongoing analysis could give insight into the mass loss before the explosion...




Correlation Matrix
Velocity (kms^{-1})
R_{in}
R_{out}
τ
t_{exp}
Δr
SNR
1 1.9e-16 1.7e-16 6.4e-18 -0.77 -3e-16 0.14
1.9e-16 1 0.48 1.8e-17 0.14 -0.48 0.15
1.7e-16 0.48 1 -1.1e-17 0.29 0.53 0.13
6.4e-18 1.8e-17 -1.1e-17 1 -2.9e-18 9.4e-19 0.81
-0.77 0.14 0.29 -2.9e-18 1 0.16 -0.056
-3e-16 -0.48 0.53 9.4e-19 0.16 1 -0.013
0.14 0.15 0.13 0.81 -0.056 -0.013 1
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6