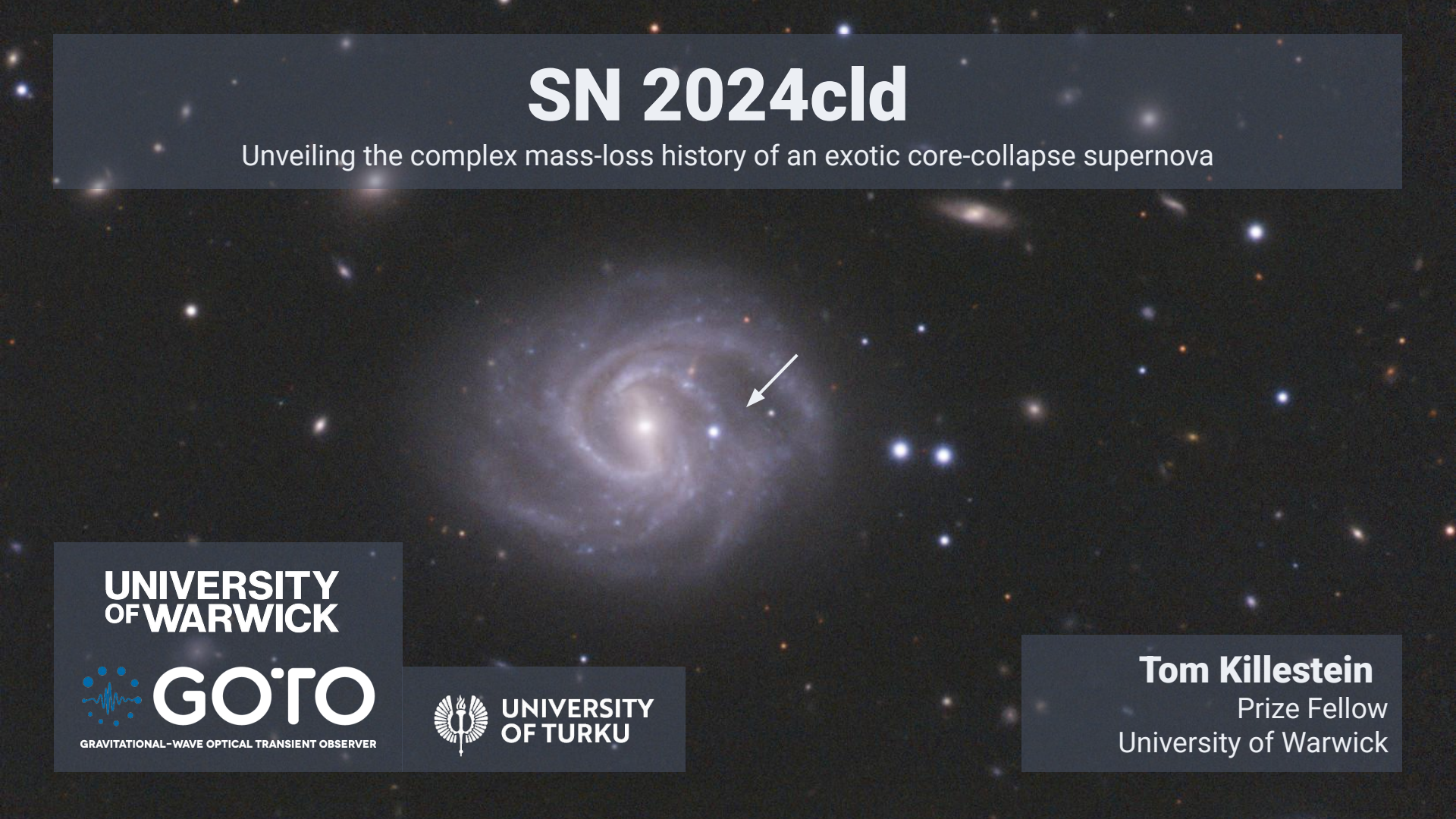
SN 2024cld

Unveiling the complex mass-loss history of an exotic core-collapse supernova



UNIVERSITY OF WARWICK

GOTO
GRAVITATIONAL-WAVE OPTICAL TRANSIENT OBSERVER

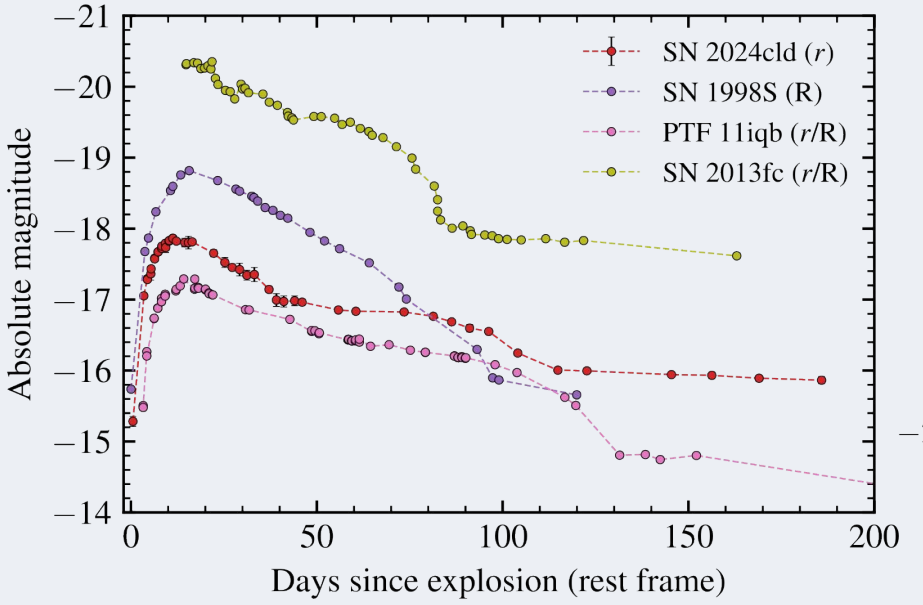
UNIVERSITY OF TURKU

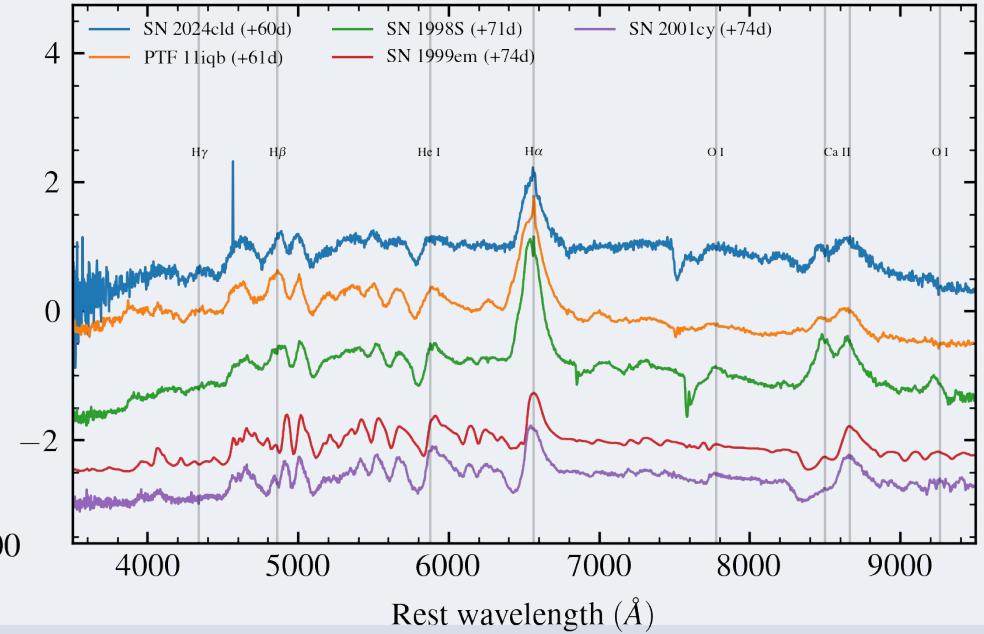
Tom Killestein
Prize Fellow
University of Warwick

SN 1998S-like supernovae

Transitional between SNe IIn (interaction-dominated spectra) and SNe II (ejecta-dominated spectra) - show interaction-driven LCs and narrow H emission throughout

Are 98S-likes just SNe II with the interaction turned up to 11? Or is there something more subtle driving their behaviour? (Smith+2015)

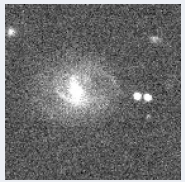


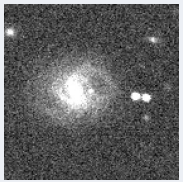


SN2024cld: discovered 11h post-explosion

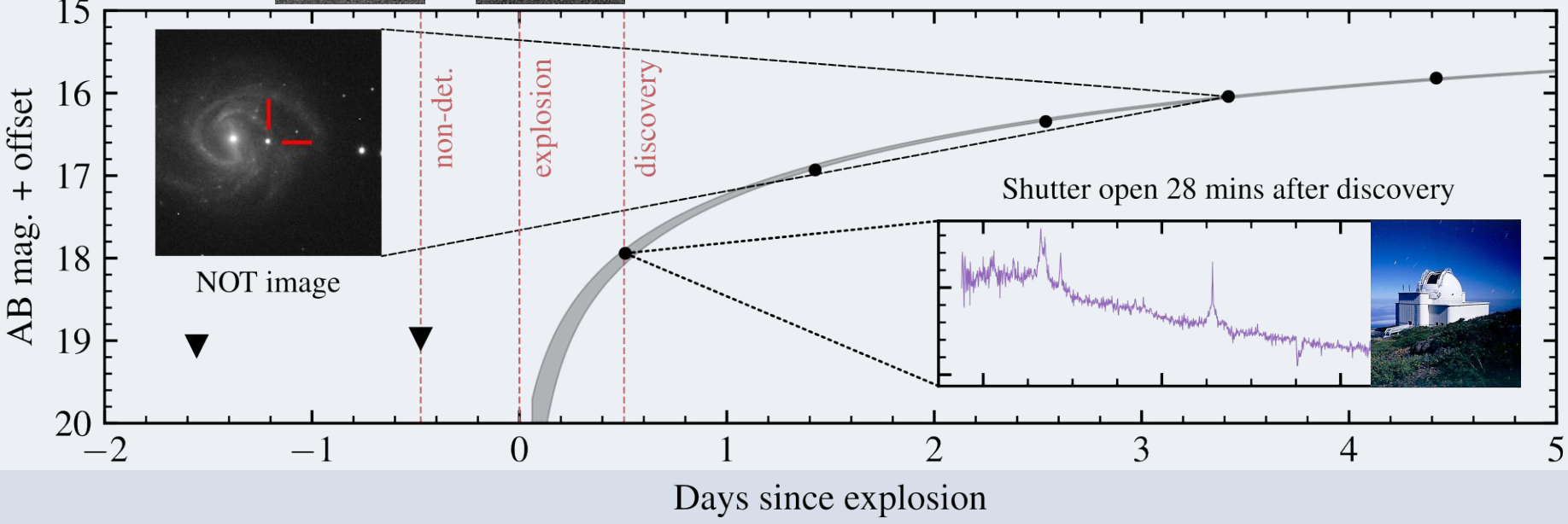
GOTO-FAST critical target identified mid-night by the team - bright, in ~40 Mpc galaxy, real-time classification *(AstroNote 2024-48, Warwick+)*

GOTO:



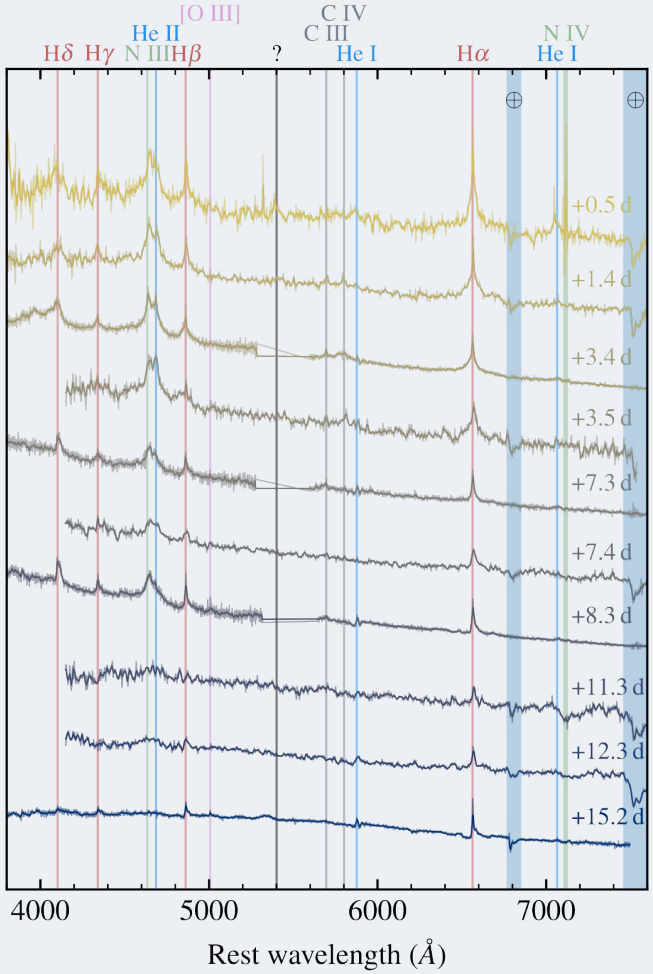


Follow-up with LT, NOT via **NUTS2**, Swift, ANU2.3m, GTC, REM,

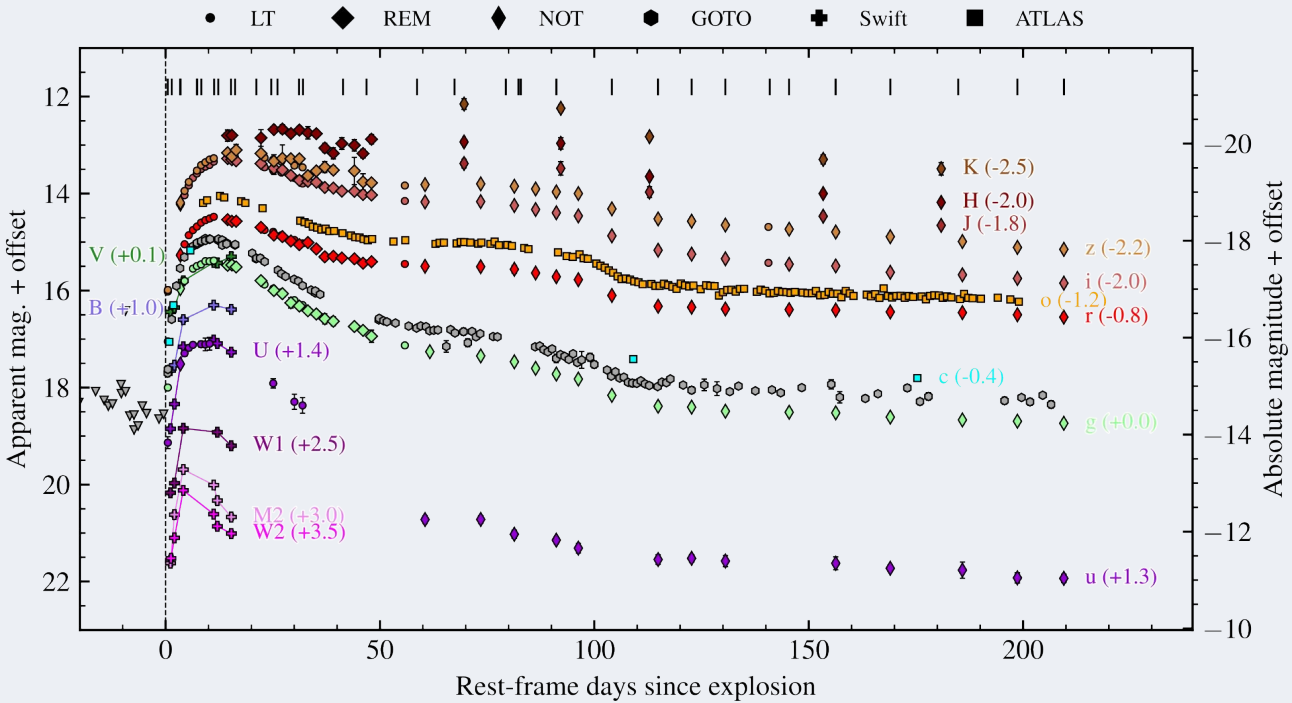


Early-phase: flash features

- At discovery: narrow H, He II, C III/IV, N III. High ionisation initially but low temperature -> ejecta-CSM interaction.
- Narrow Ha emission suggests 0.06-0.1 solar mass/year
- Disappearance of flash features around day 14: long-lived! But no broad Ha/P Cyg like SNe IIP.
- No photospheric features (e.g. Fe II) until ~day 30. Veiled by interaction.



Lightcurve and energetics

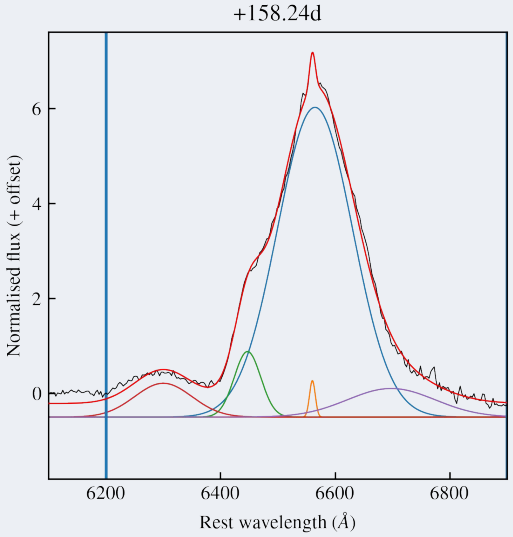


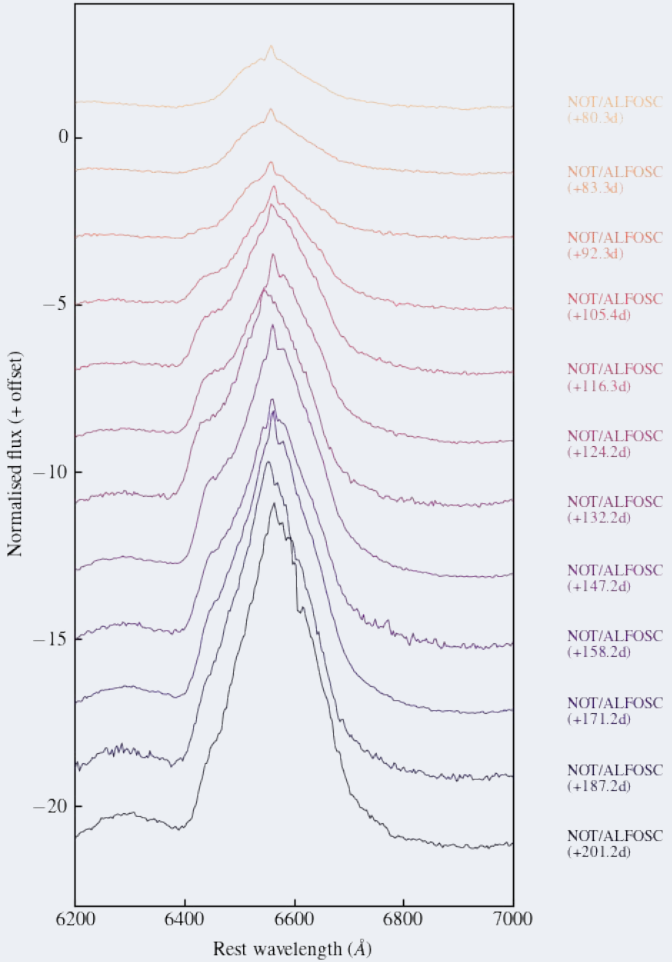
- 2-week rise to peak, absolute mag of g=-17.6 - driven by interaction
- Shows IIP-like plateau after around +50d, followed by a drop onto a secondary plateau that lasts til +200d

Enduring interaction

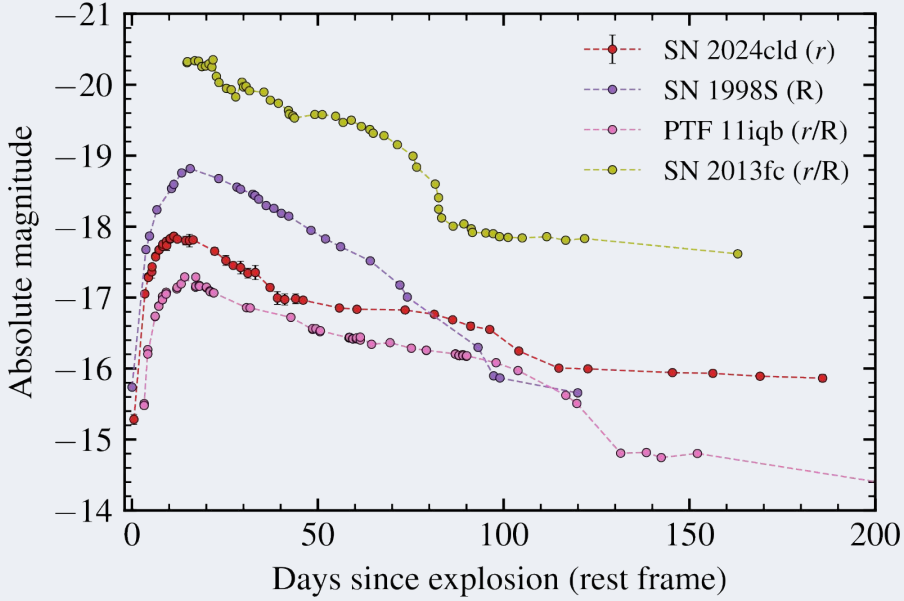
At late times, marked asymmetry in Ha, with multiple profiles:

- Narrow Ha: unresolved CSM interaction line
- Broad Ha at rest: largely ejecta-driven
- Ha @ -6000 km/s: strong CSM asymmetry
- Luminosity on second plateau (with CSM velocity and shell velocity) suggests mass loss rate of 10^{-3} solar mass/year (following Smith+2015)

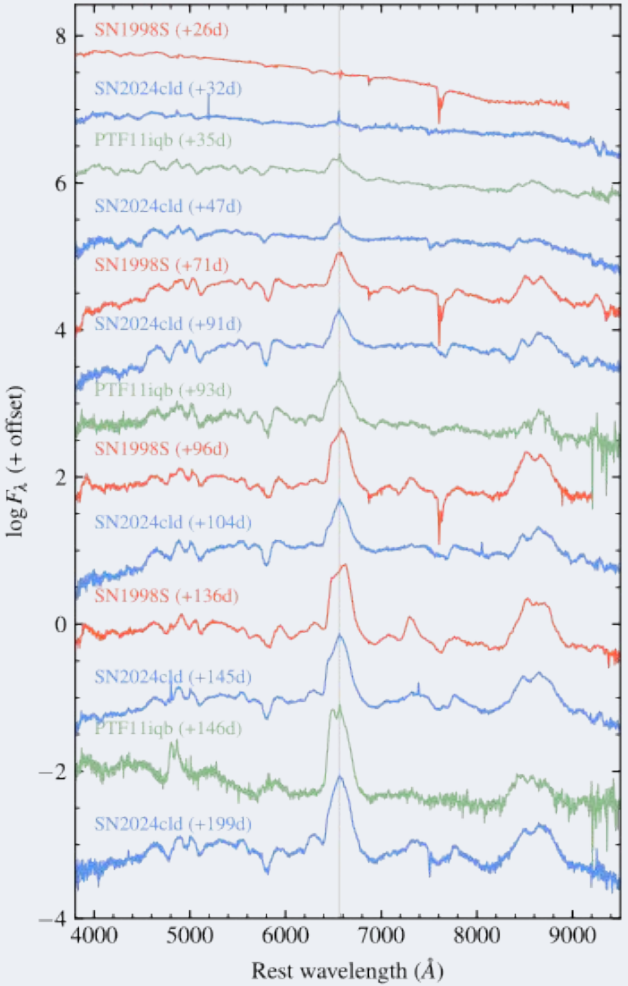




Comparison to other 98S-likes

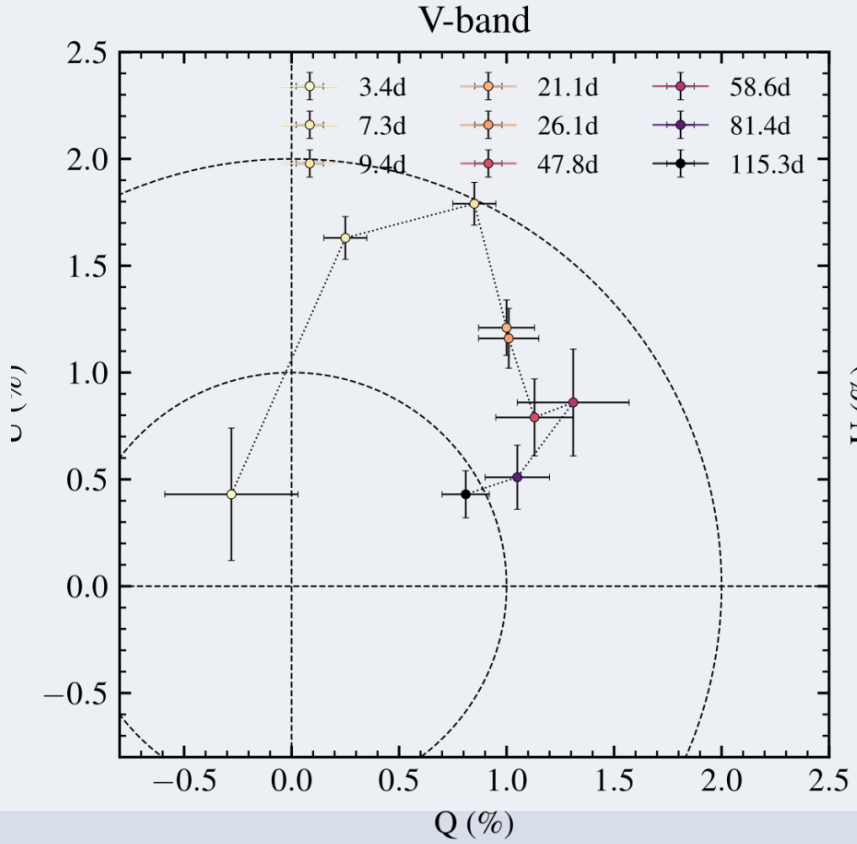


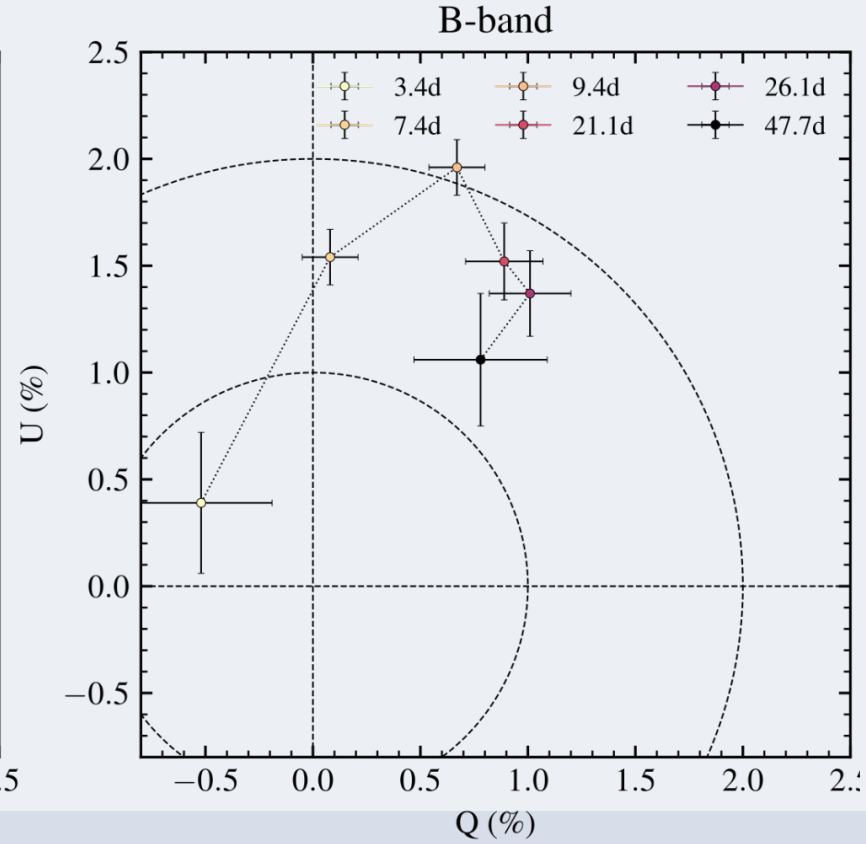
SN1998S (Fassia+1998), PTF11iqb (Smith+2014) are primary comparison objects



Evolving polarisation

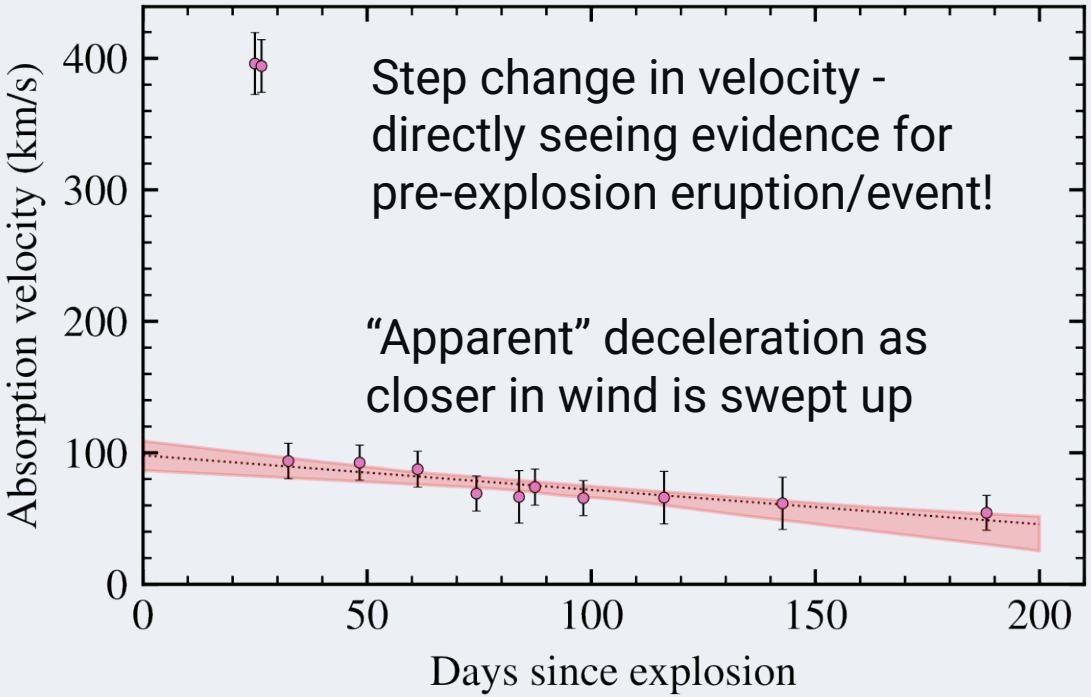
Most comprehensive polarimetric series for a 98S-like to date

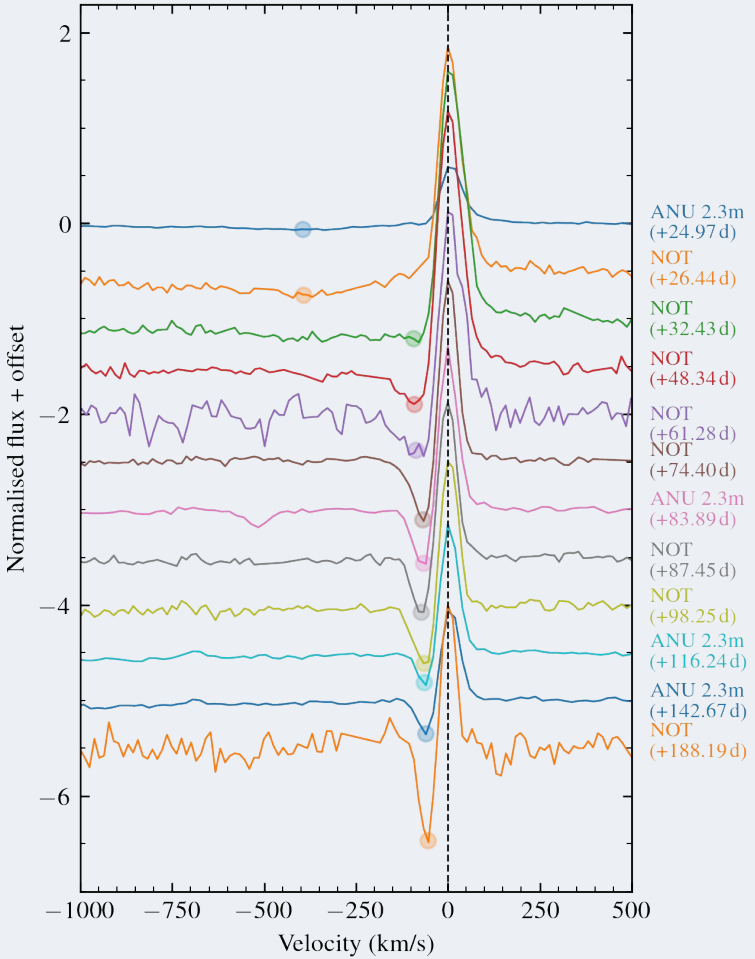




Probing the pre-shock CSM

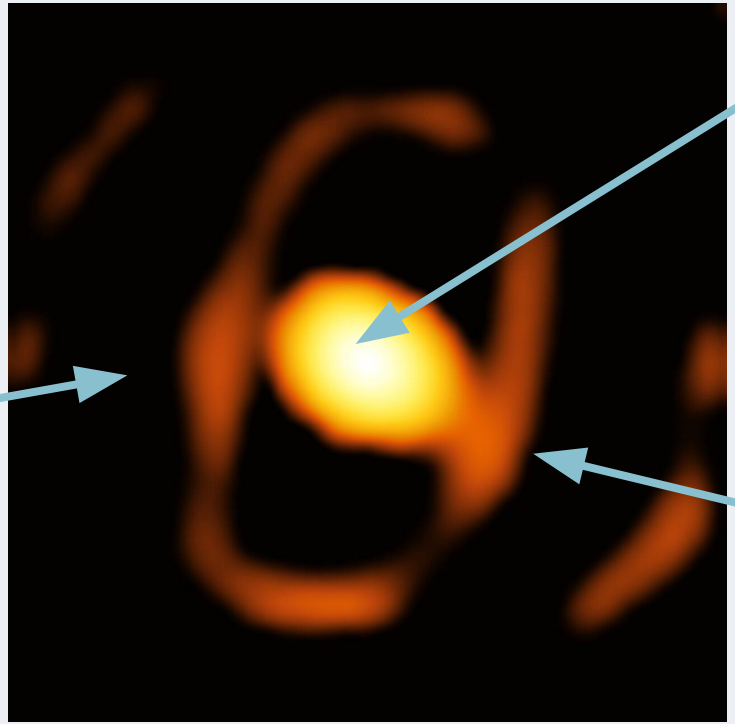
High-resolution ALFOSC + WiFeS spectra reveal narrow P Cygni at rest H-alpha - progenitor wind!





Scenario

Tenuous wind-driven CSM ahead of shock along line of sight, visible as very narrow P Cyg at rest

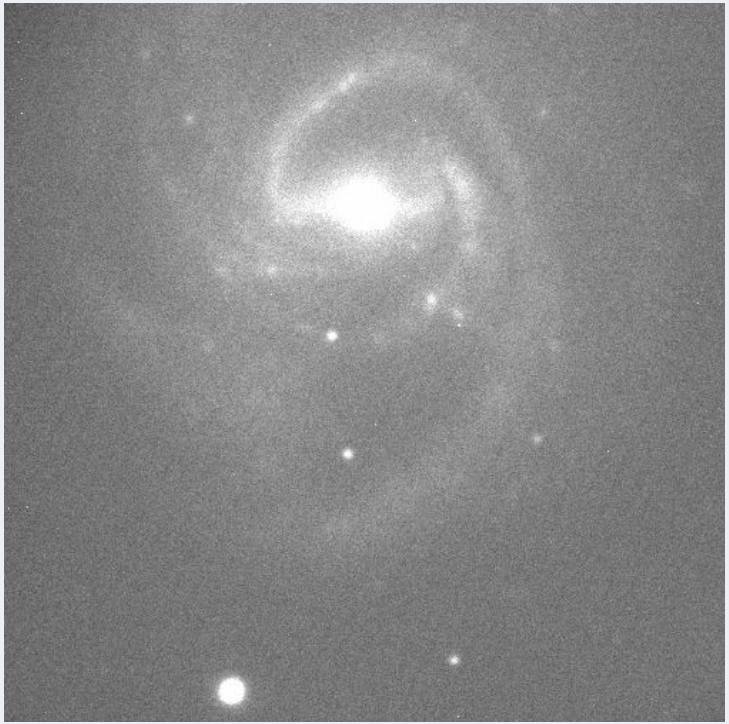


FI from aspherical extended envelope/CSM ~4000 solar radii across - powers early rise

Asymmetric CSM shell/torus - drives Ha shoulders seen later and polarisation rotation.

Ohnaka+24: VLTI imaging of WOH G64

Still going!



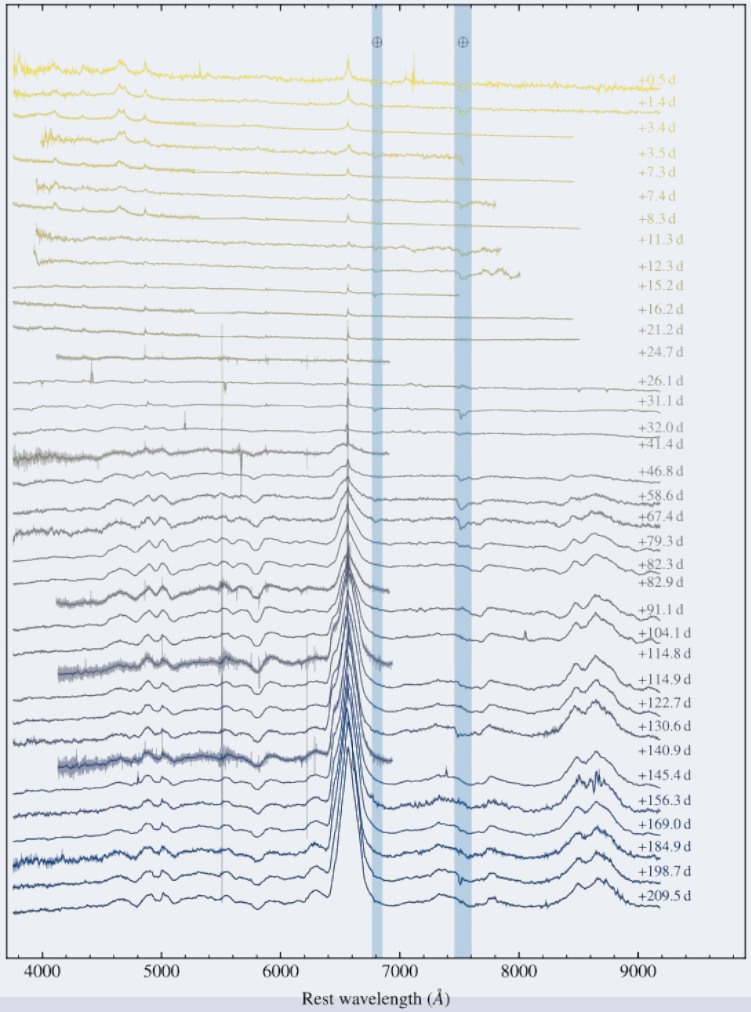
SN 2024cld still photospheric at day 500+.

Awarded FORS2 + X-Shooter time for late-time spectra - trace far-out CSM, probe dust formation and evolution, and aim to constrain progenitor by nebular modelling*.

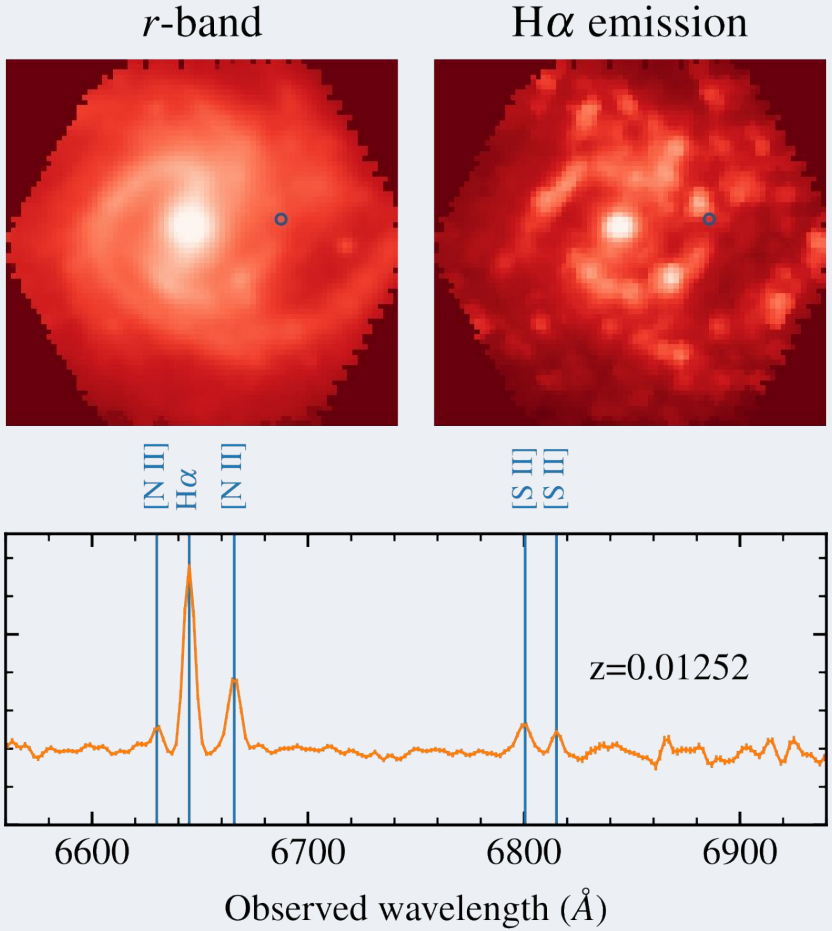
*If we could actually see the nebular lines!

thomas.killestein@warwick.ac.uk

UNIVERSITY OF WARWICK


+0.5 d
+1.4 d
+3.4 d
+3.5 d
+7.3 d
+7.4 d
+8.3 d
+11.3 d
+12.3 d
+15.2 d
+16.2 d
+21.2 d
+24.7 d
+26.1 d
+31.1 d
+32.0 d
+41.4 d
+46.8 d
+58.6 d
+67.4 d
+79.3 d
+82.3 d
+82.9 d
+91.1 d
+104.1 d
+114.8 d
+114.9 d
+122.7 d
+130.6 d
+140.9 d
+145.4 d
+156.3 d
+169.0 d
+184.9 d
+198.7 d
+209.5 d
4000
5000
6000
7000
8000
9000
Rest wavelength (Å)

BONUS


r-band
Hα emission
[N II]
Hα
[N II]
[S II]
[S II]
z=0.01252
6600
6700
6800
6900
Observed wavelength (Å)