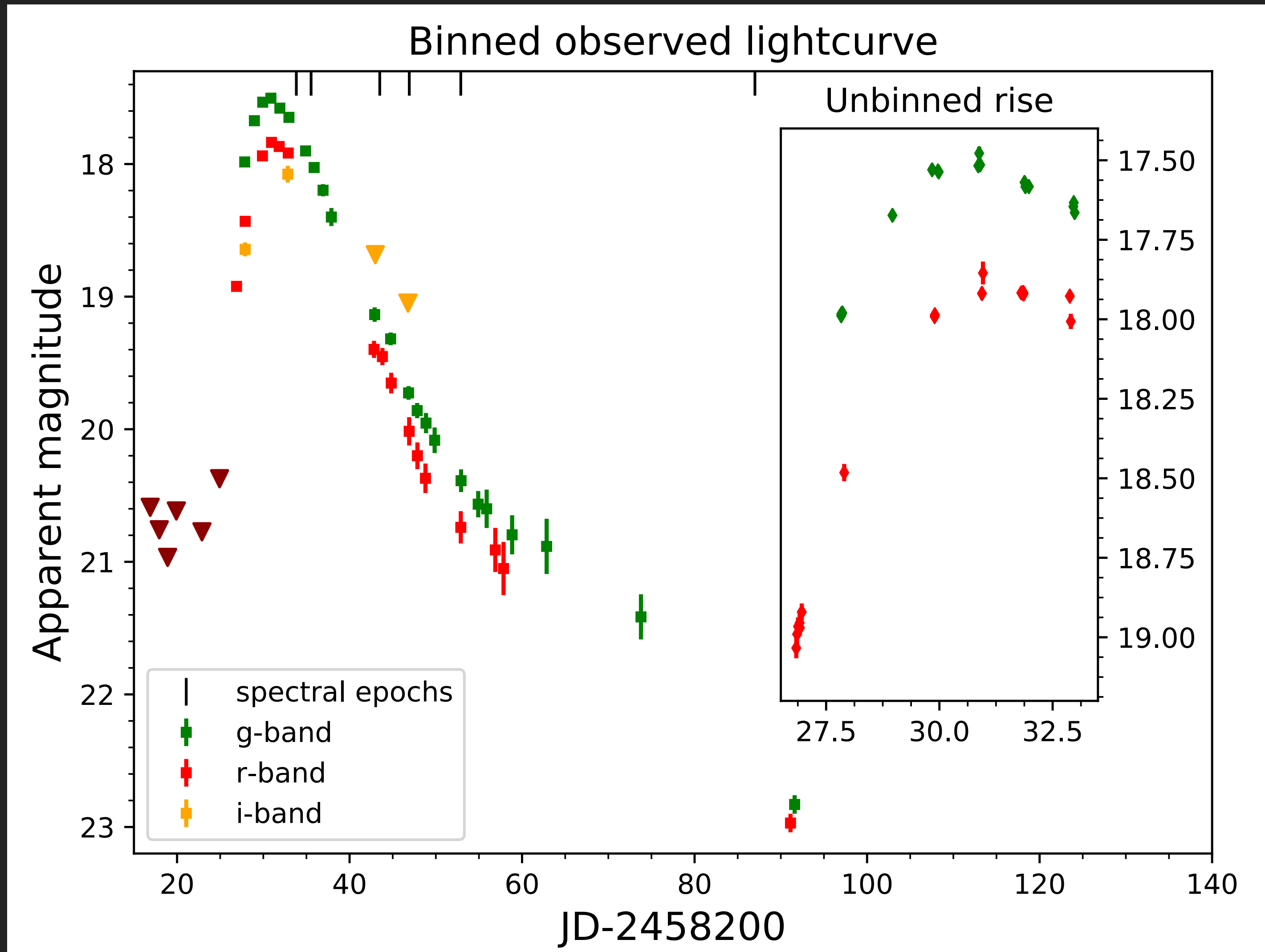


Oskar Klein centre


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Stockholm University,
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Phd. thesis work

## SN 2018BCC: A FAST-RISING TYPE IBN SN

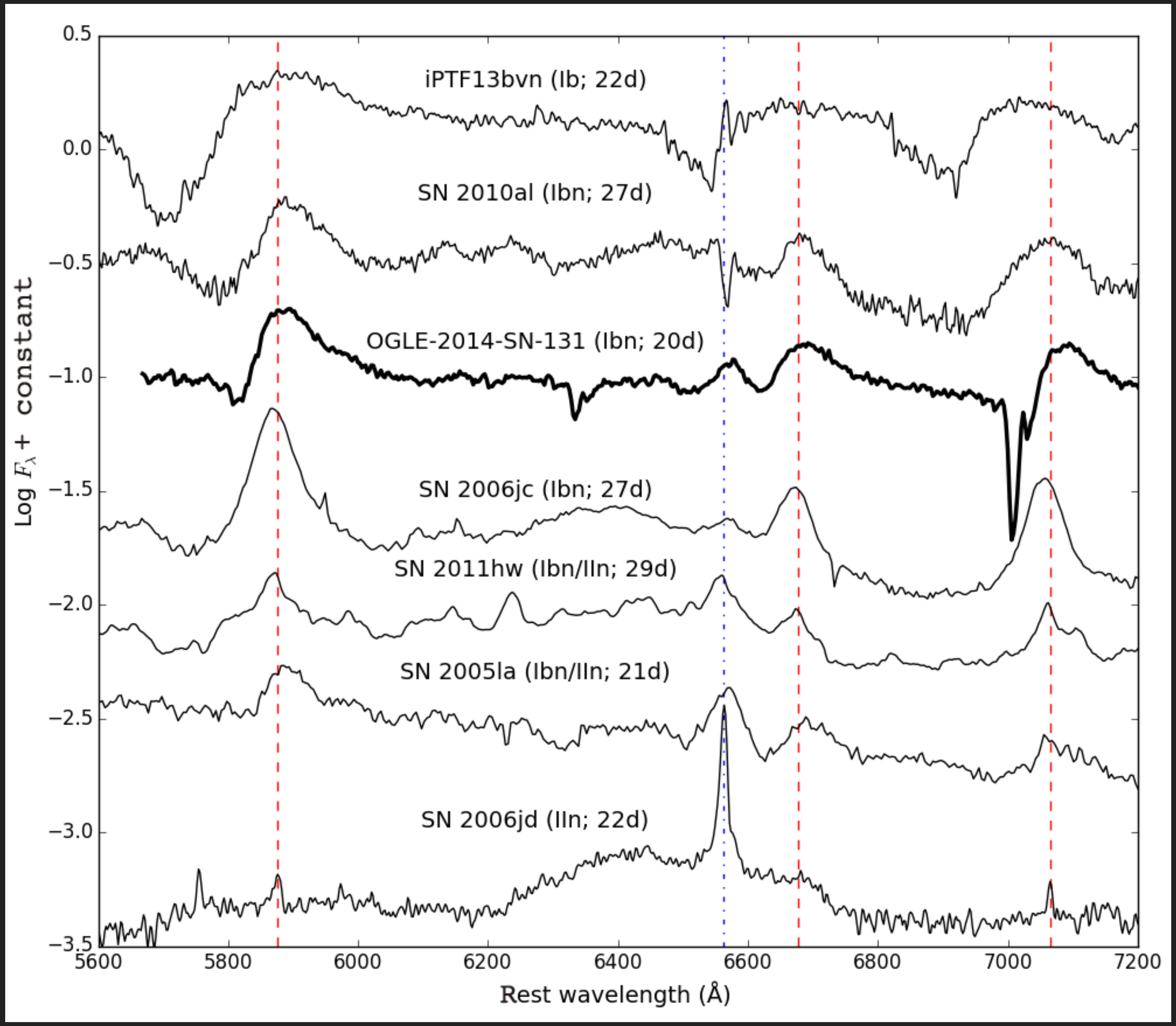
# CLUES TOWARD THE MYSTERIOUS ORIGINS OF TYPE IBN SNE

# TALK OUTLINE

- "Fast" Type Ibn SNe
- SN2018bcc (ZTF18aakuewf)
- Literature comparison
- Unique analysis (Rising-shape, He I lines)
- Open discussion on progenitors of Type Ibn SNe

# TYPE IBN SNE

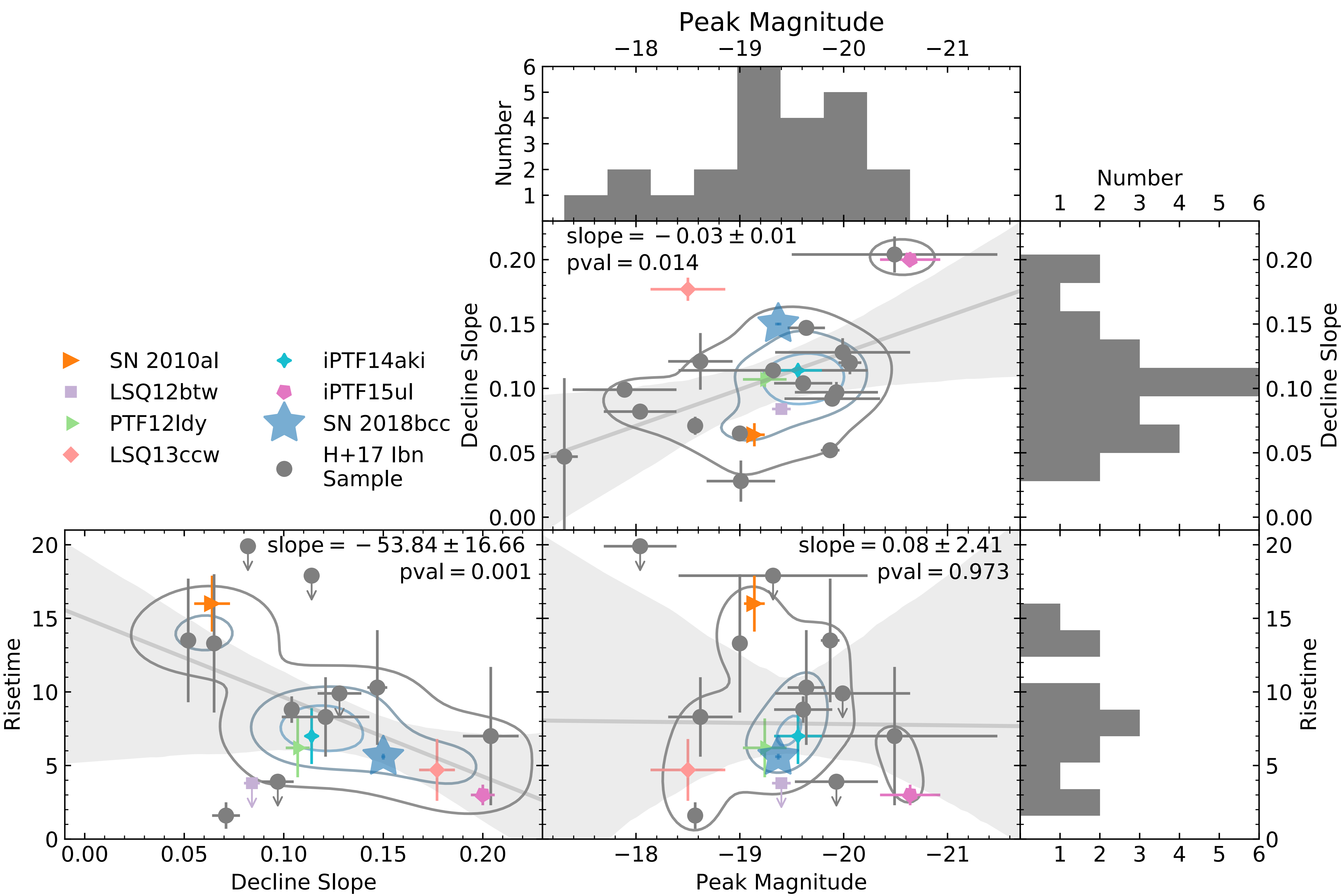
- Narrow to Intermediate-width He emission features ($V_{FWHM}$ ~1000-3000 km/s)
- Blue SED
- $M_R$ >~ -18
- He stronger than H
- Thought to be WR stars exploding in He-rich CSM.*




Karamehmetoglu et al. (2017)

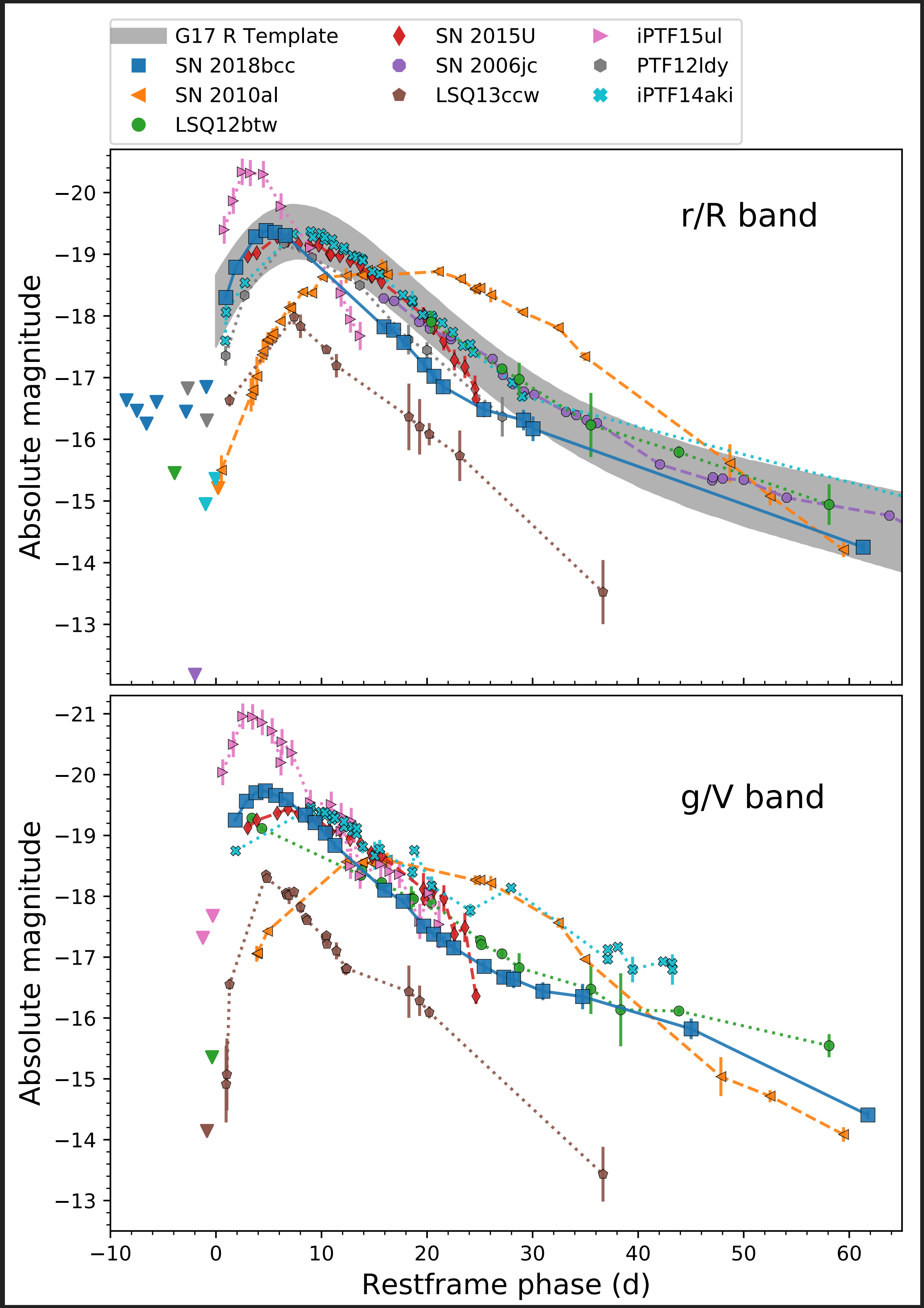
# LIGHTCURVES PROPERTIES & "FAST" TYPE IBN SNE

Karamehmetoglu et al. (in prep.)



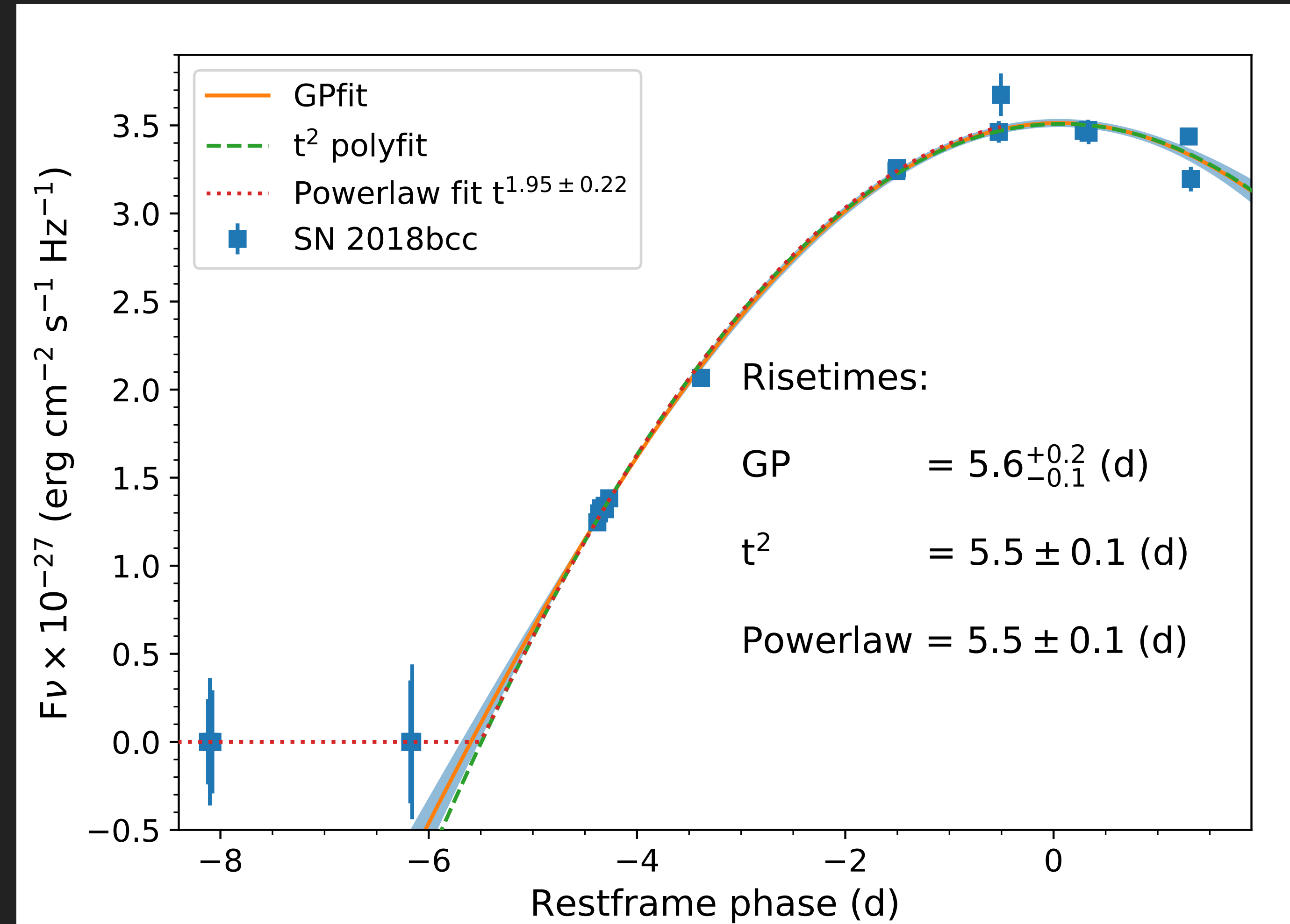
# SN2018BCC (BLUE SQUARES)

- "Fast":
  - Short rise-time
  - Rapid decay
- Well-covered in g & r at rise and peak.
- Only other (lesser) example in iPTF15ul (in pink)



# RISETIME & RISING SHAPE

- 5.6 day risetime (rest)
- Well fit by a t~2 powerlaw.
- Expanding Fireball model…

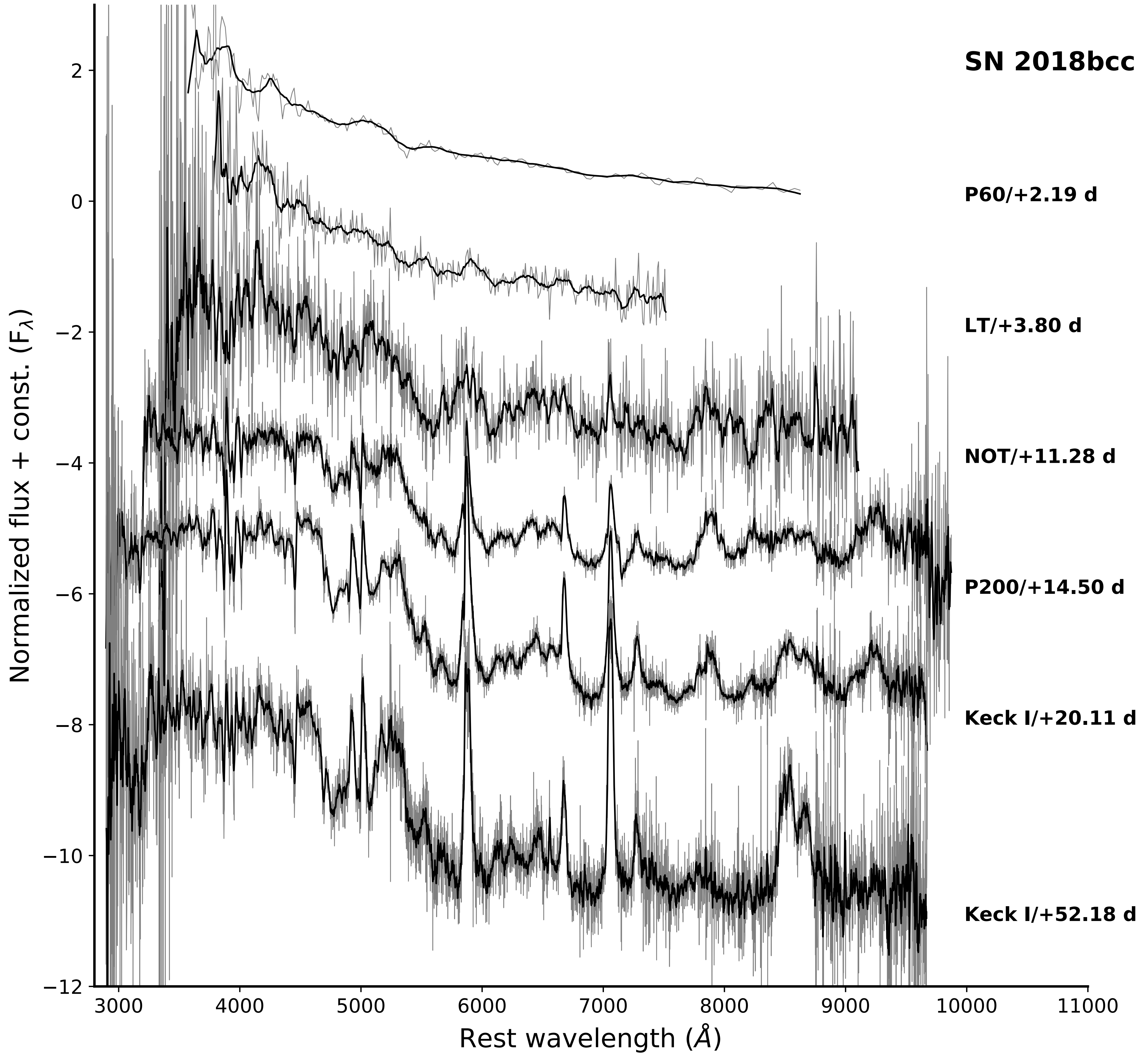



| SN | Rise (restframe d) | Uncertainty (d) | Powerlaw $\alpha$ |
|---|---|---|---|
| **SN 2018bcc** | 5.6 | $^{+0.2}_{-0.1}$ | 1.95 ± 0.22 |
| iPTF15ul | 4.0 [3.0] | ±0.6 [0.7] | 1.8 ± 0.4 |
| LSQ13ccw | [4.7] | ±[2.1] | - |
| LSQ12btw | [< 3.8][a] | - | - |
| PTF12ldy | [6.2] | ±[2.0] | - |

[a]Peak cannot be determined.

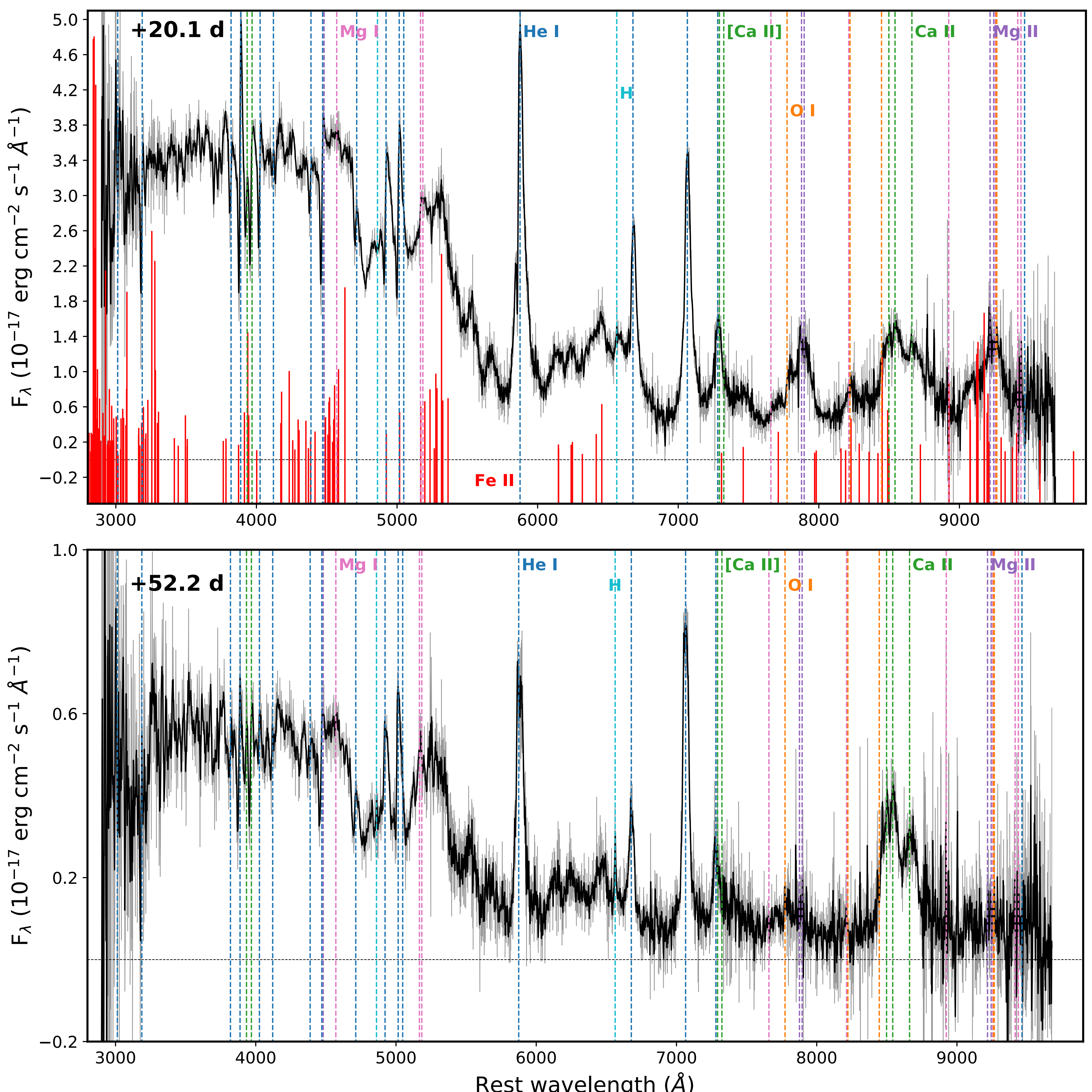
# SPECTRA

- Early spectra well-fit by a BB.
- He I after 10d



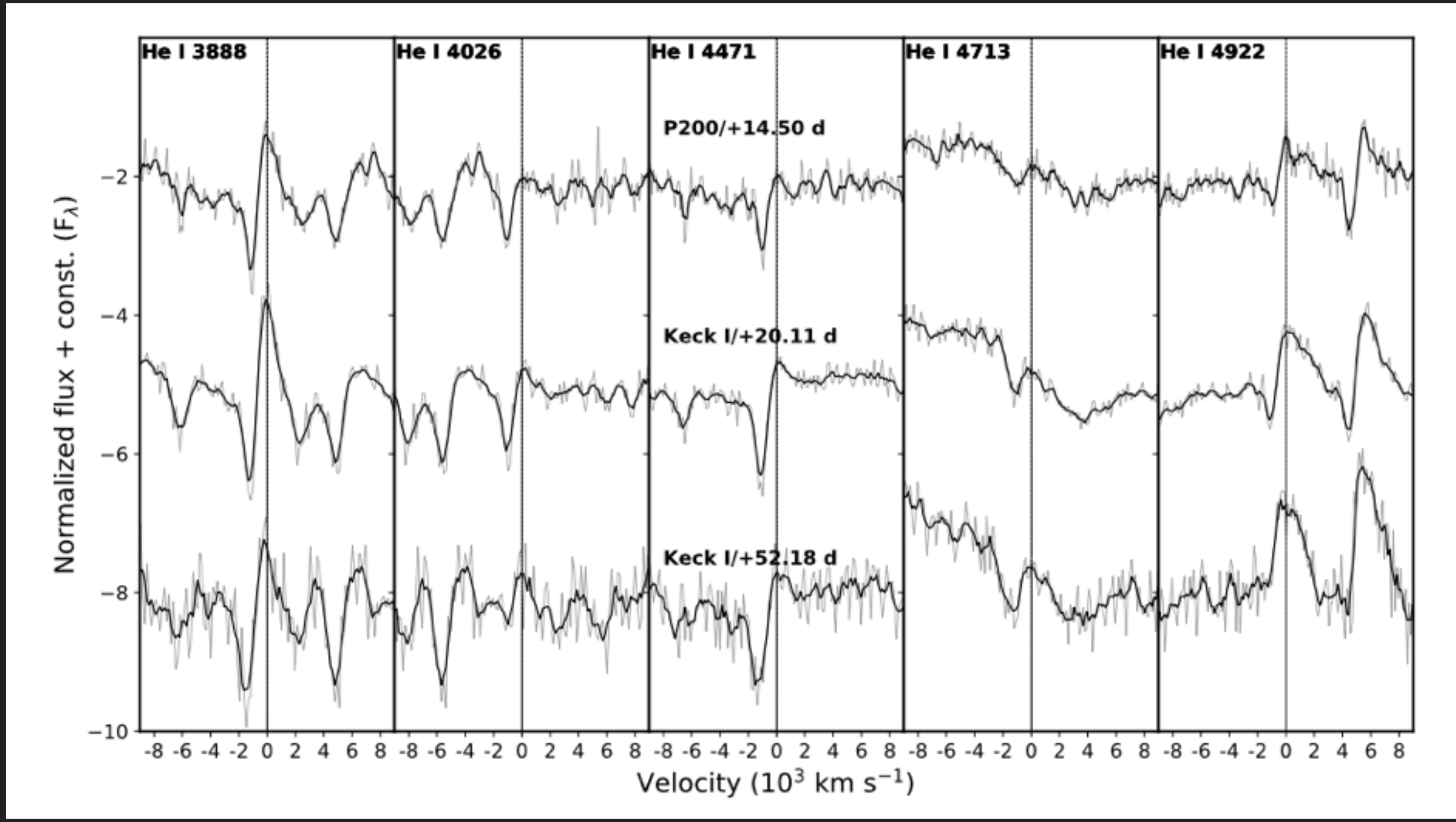
# SPECTRA

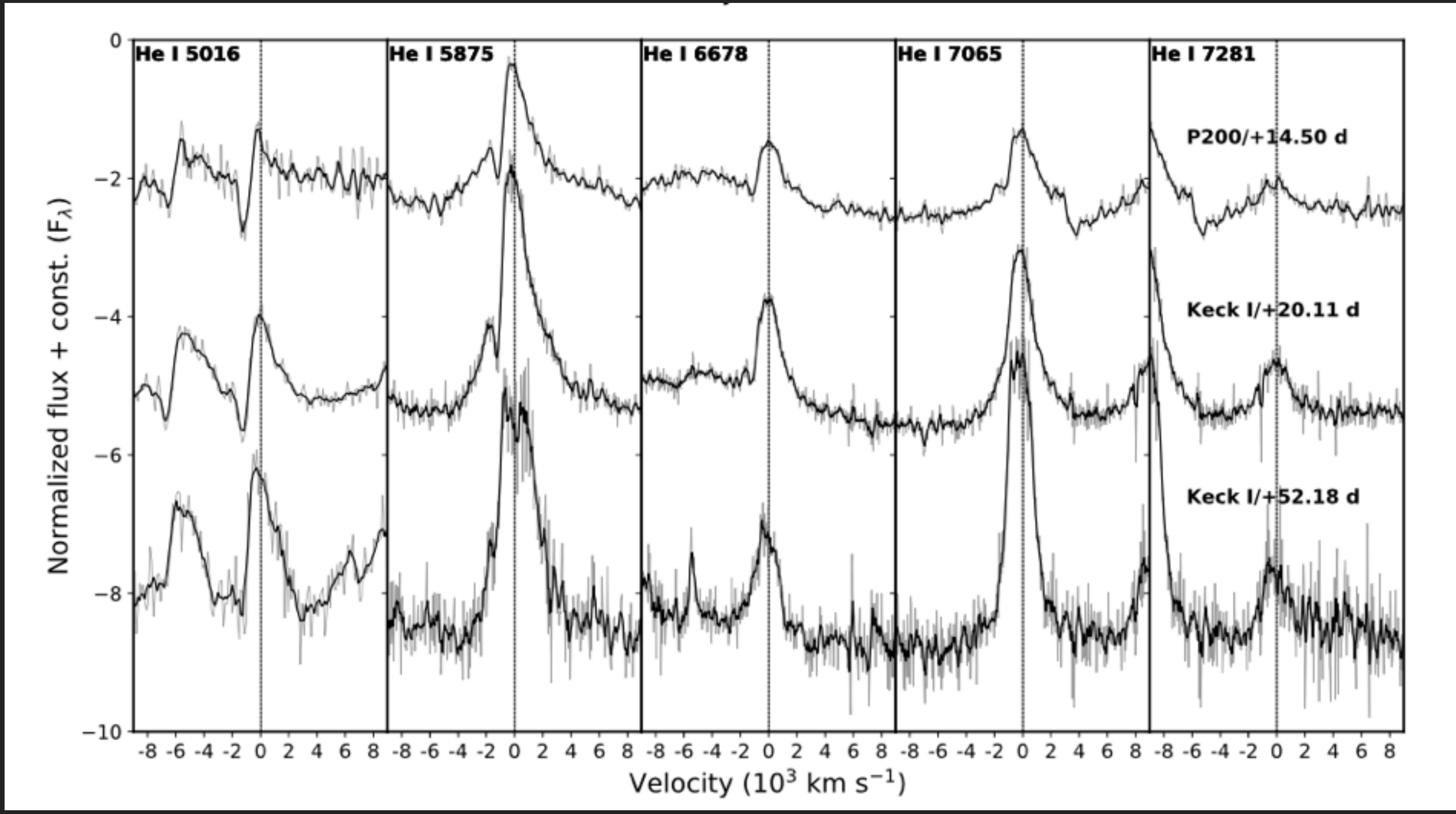
- Prominent He I
- Mg, Ca
- Weak O (if there)
- Narrow (resolved) H at +52d



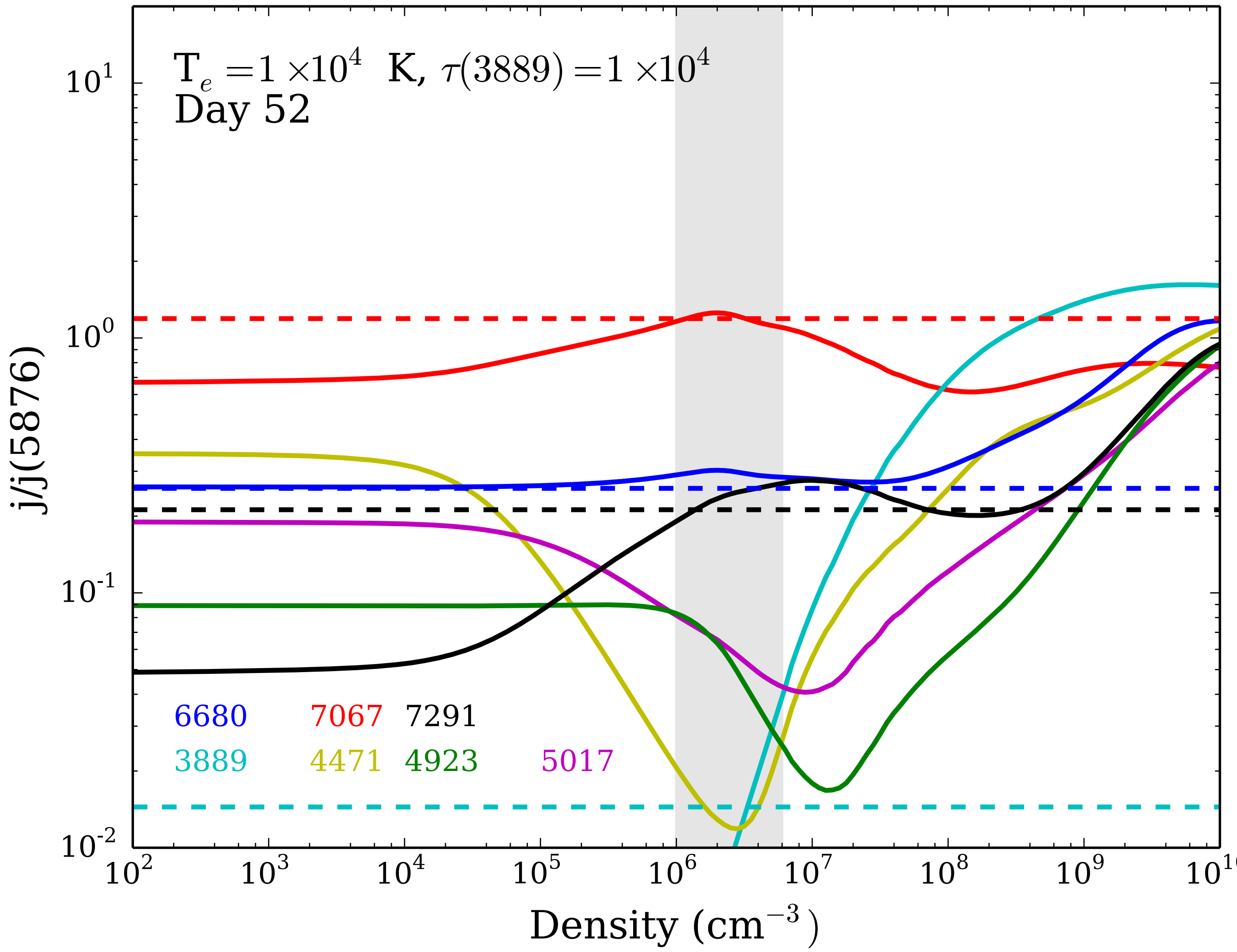
# P-CYGNI PROFILES

- P-Cygni profiles present in some lines but missing in others in the same spectra.
- P-Cygni profiles in "blue" lines stronger.
- Disappears for "red" lines.
- Collisional ionization can help explain.
- Does not fit with proposed division.



# He I lines




Solid lines: Model ratio relative to 5876

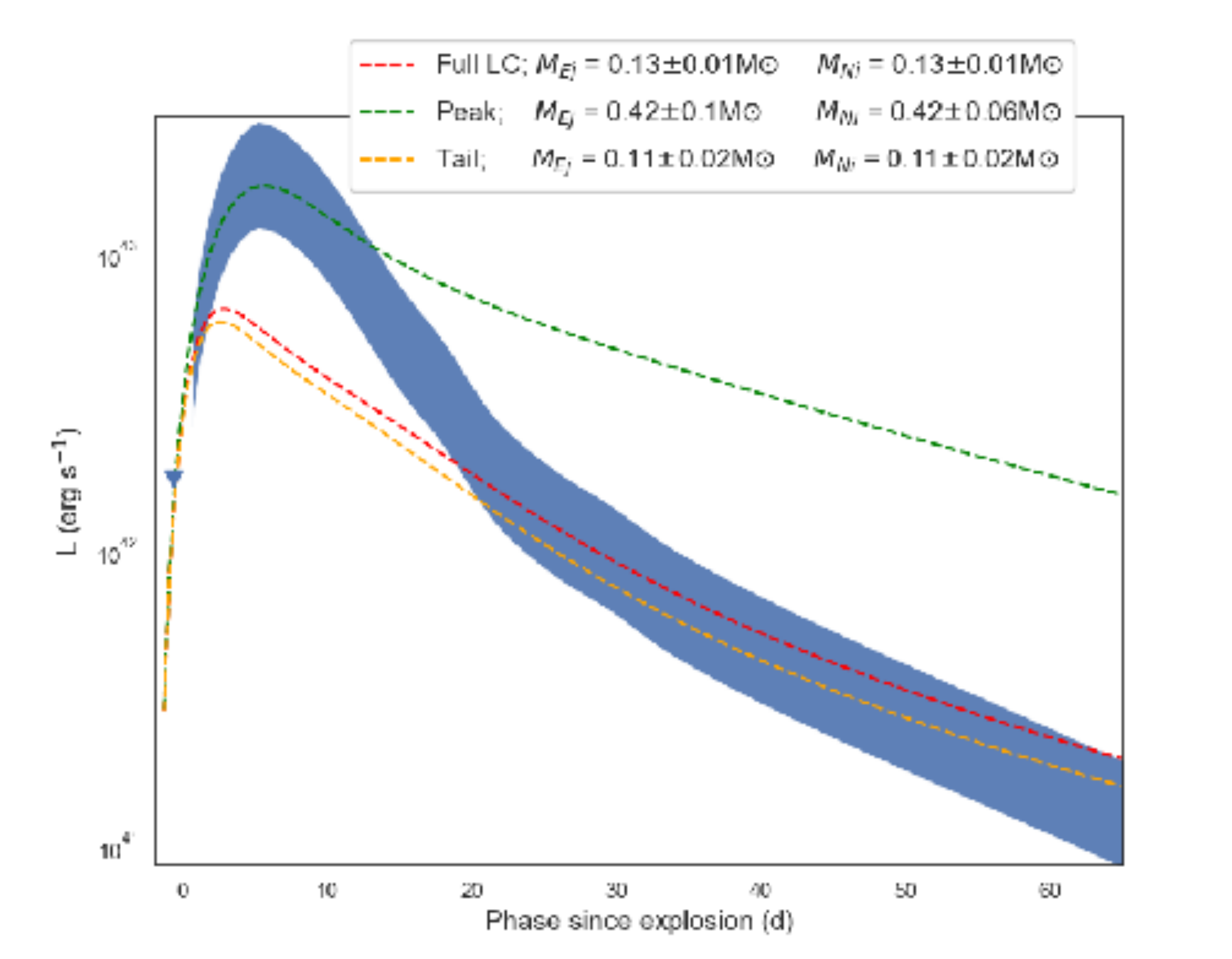
Dashed lines: Observed ratio

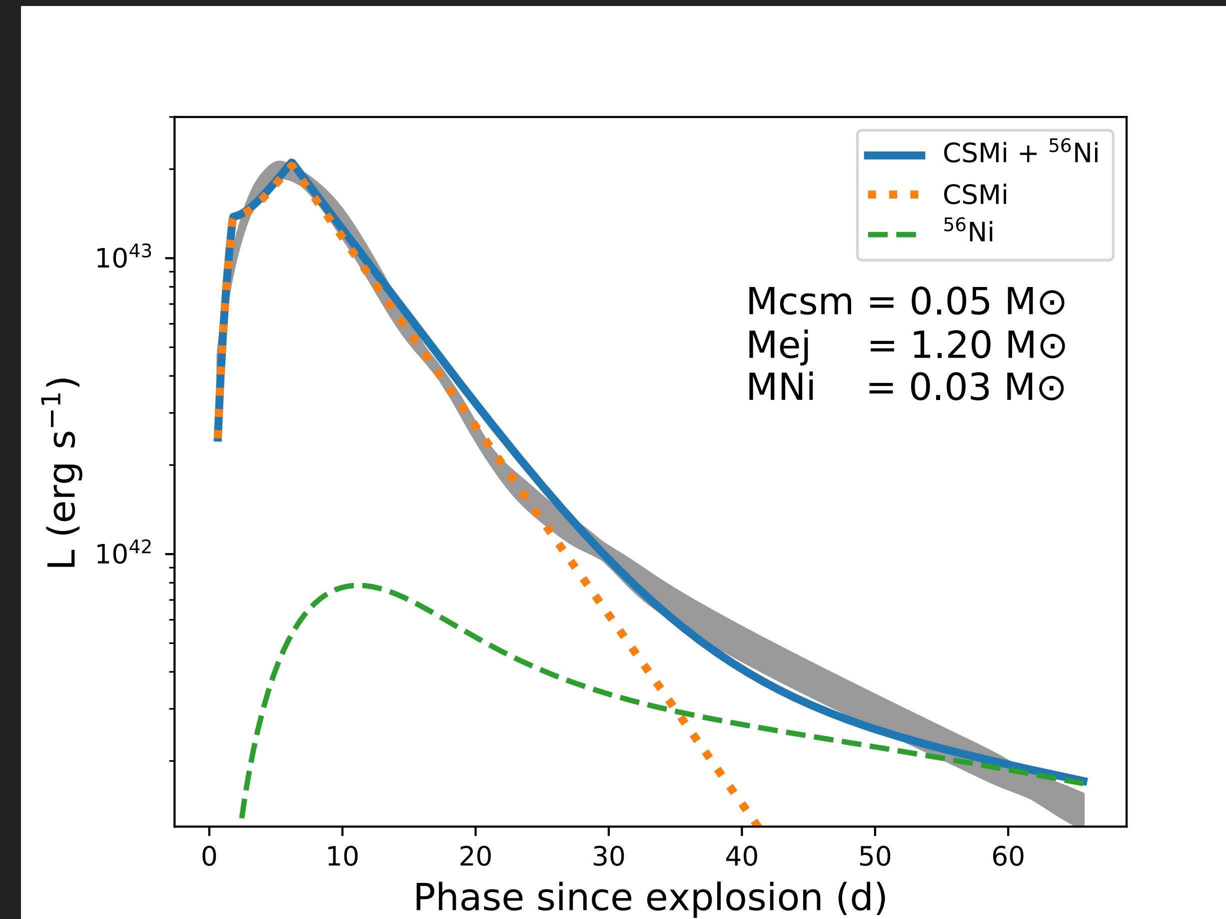
SN2018bcc:

- Line ratios very different from low density recombination (e.g. 7067/5876 = 0.17 at $10^2$ $cm^{-3}$, observed ~ 1)
- Blue lines only P-Cygni absorptions, weak emission component

Requires densities > $10^6$ $cm^{-3}$ and high optical depths: ‘Blue’ lines weak, (only abs.). ‘Red’ strong, emission dominates absorption.

# LIGHTCURVE MODELING



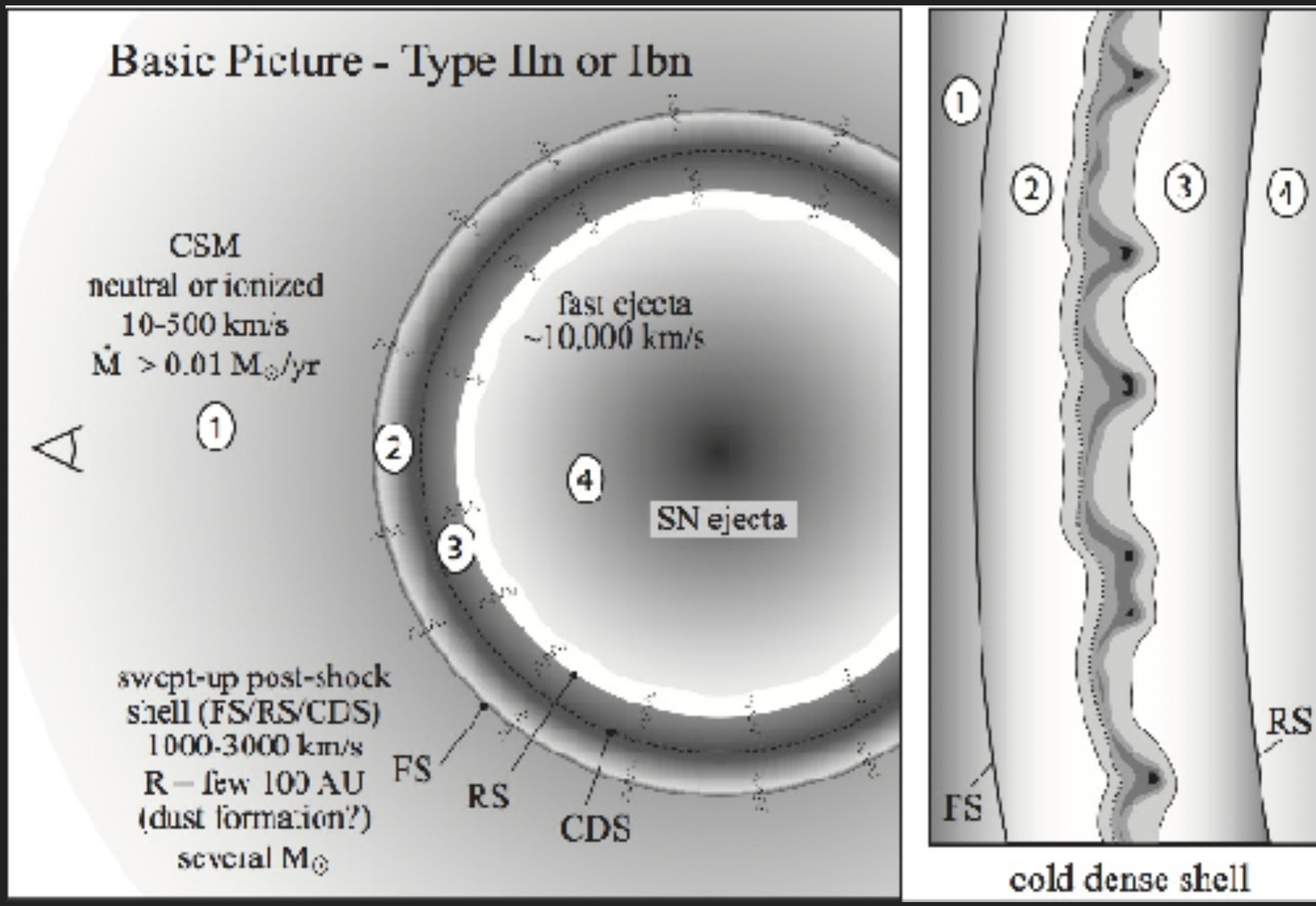




- Too bright, evolves too rapidly, for Ni56.
- Circumstellar-interaction powered models can produce such lightcurves.
- Late-time limit on Ni56 mass <0.1$M_{\odot}$ assuming 100% of ejecta is Nickel. Reasonable upper limit: < 0.02 $M_{\odot}$.

# PROGENITOR IMPLICATIONS

- Lack strong evidence for late-time Ni tail and Ni powered LC.
- Don't see ejecta in spectra nor enriched abundances (e.g.: O).
- CSM interaction powered LC.
- $V_{FWHM}$ ~ 2000-3000 km/s.
- Low-metallicity environment**.
- Late-time narrow H**. [** Not shown]

Perhaps not the CC of a WR star? CSM interacting transients can come from collision of CSM shells.

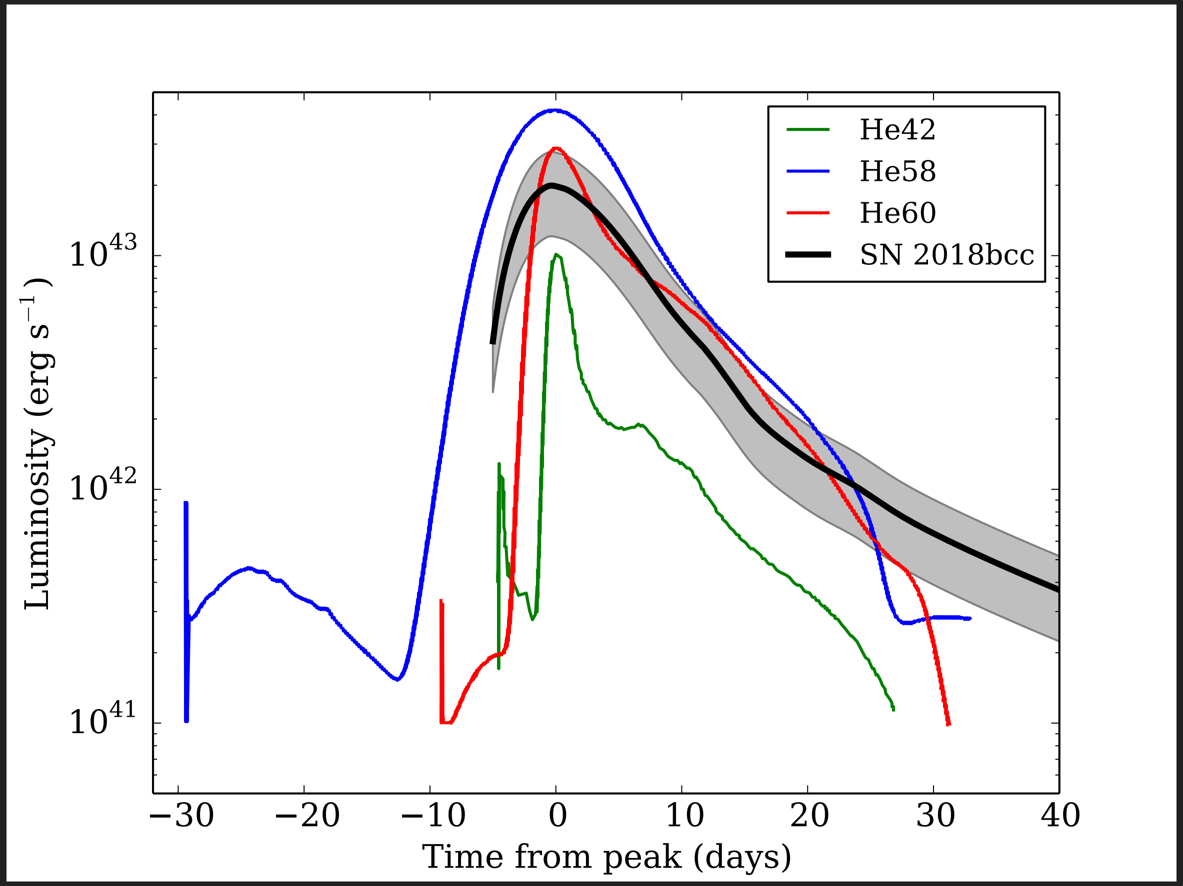



"Any type of core collapse or thermonuclear SN (or for that matter, any non-SN explosive outflow) can appear as a SN IIn or SN Ibn. All that is required is fast ejecta with sufficient energy crashing into slower ejecta with sufficient density. This is a cause of much confusion and uncertainty."

Smith (2016), SN Handbook

# COMPARISON TO PPISN MODELS

- Discussed previously by e.g., Woosley (2016).
- Good match to risetime, radiated energy, peak luminosity, LC shape, spectral velocities.
- Can naturally explain late-time narrow (but resolved) H-alpha.
- Get matches to very high-mass PPISN. (He-core mass ~60 $M_\odot$)
- Fast Type-Ibn SNe w/o evidence of SN ejecta are viable PPISN candidates.




## CAVEATS

- Model LCs highly uncertain.
- Bolometric correction uncertainties.
- Evidence of SN ejecta would disprove.

# CONCLUSIONS

- PPISN viable progenitor scenario, alongside CC of WR star.
- LC peak not Ni powered, CS-interaction obvious answer.
- He I lines profiles argue for dense CSM. Also do not fit suggestion of 2 spectral sub-classes based on P-Cygni.
- Otherwise an ordinary fast Type Ibn SN.
- Rising shape matches the simple fireball model ($t^2$).
- ZTF can find and *is* finding fast transients.