

SN 2017dio: A type-Ic SN showing early interactions with H-rich circumstellar medium

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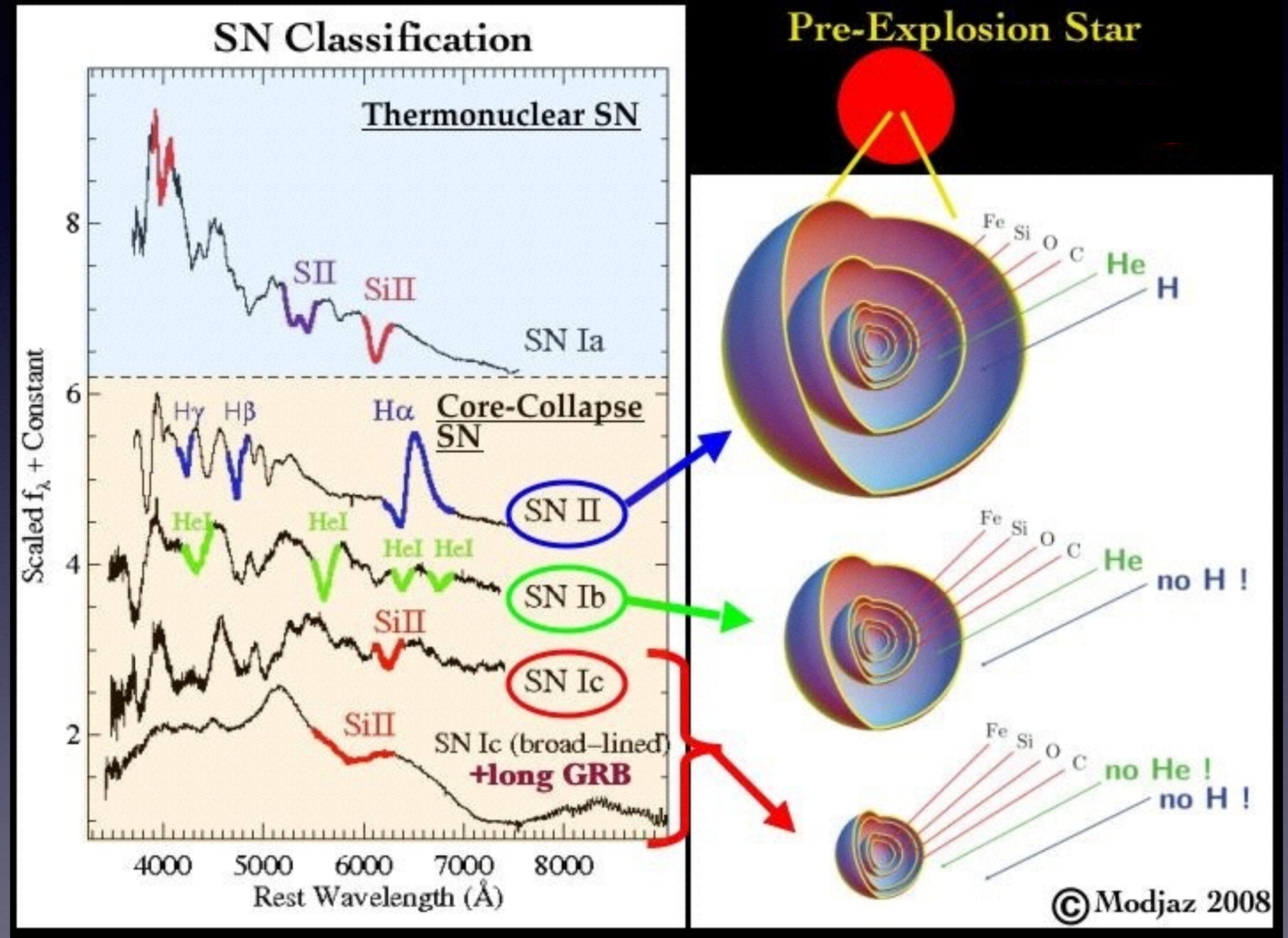
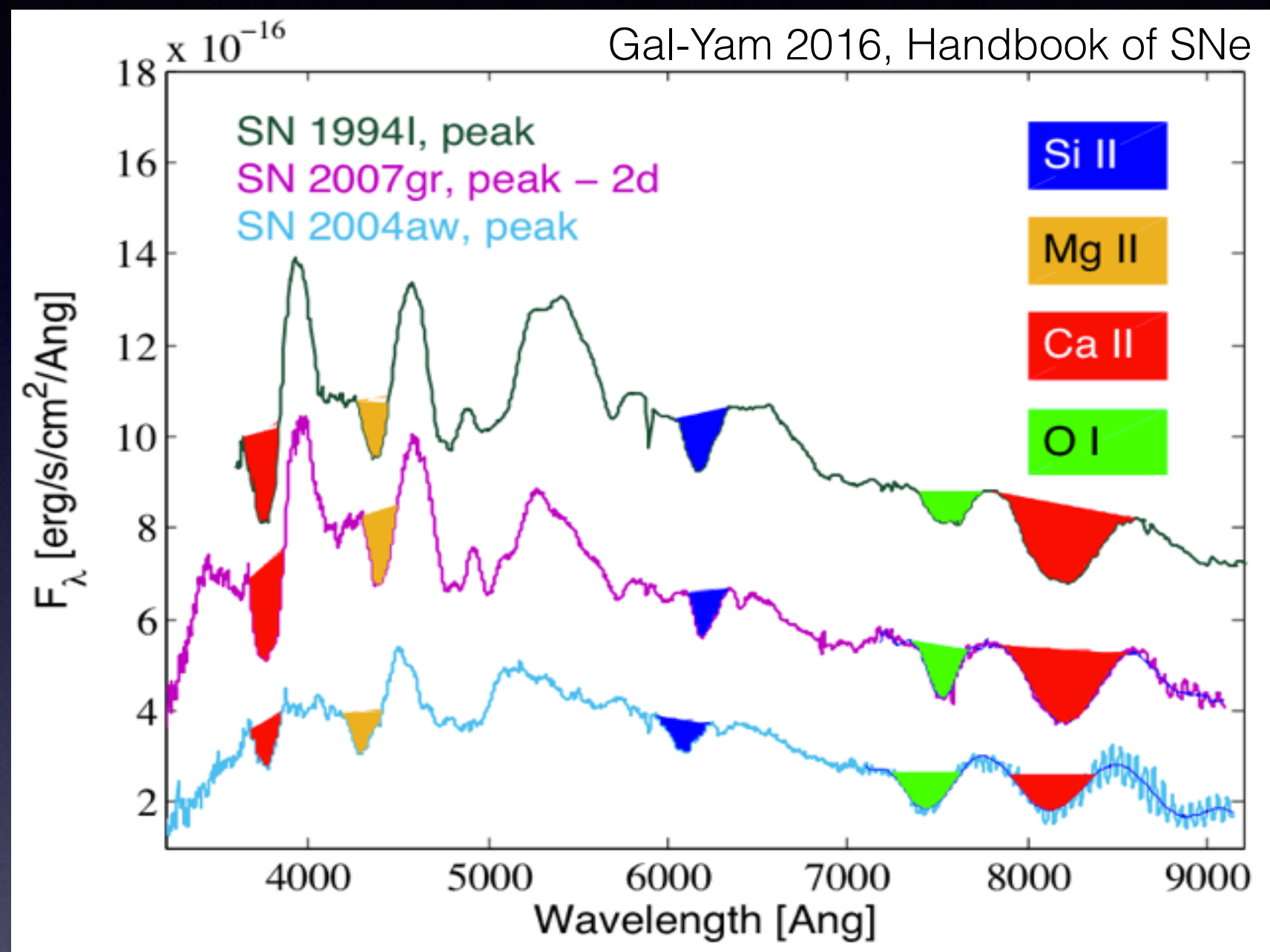
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SNe Ic: no H & He

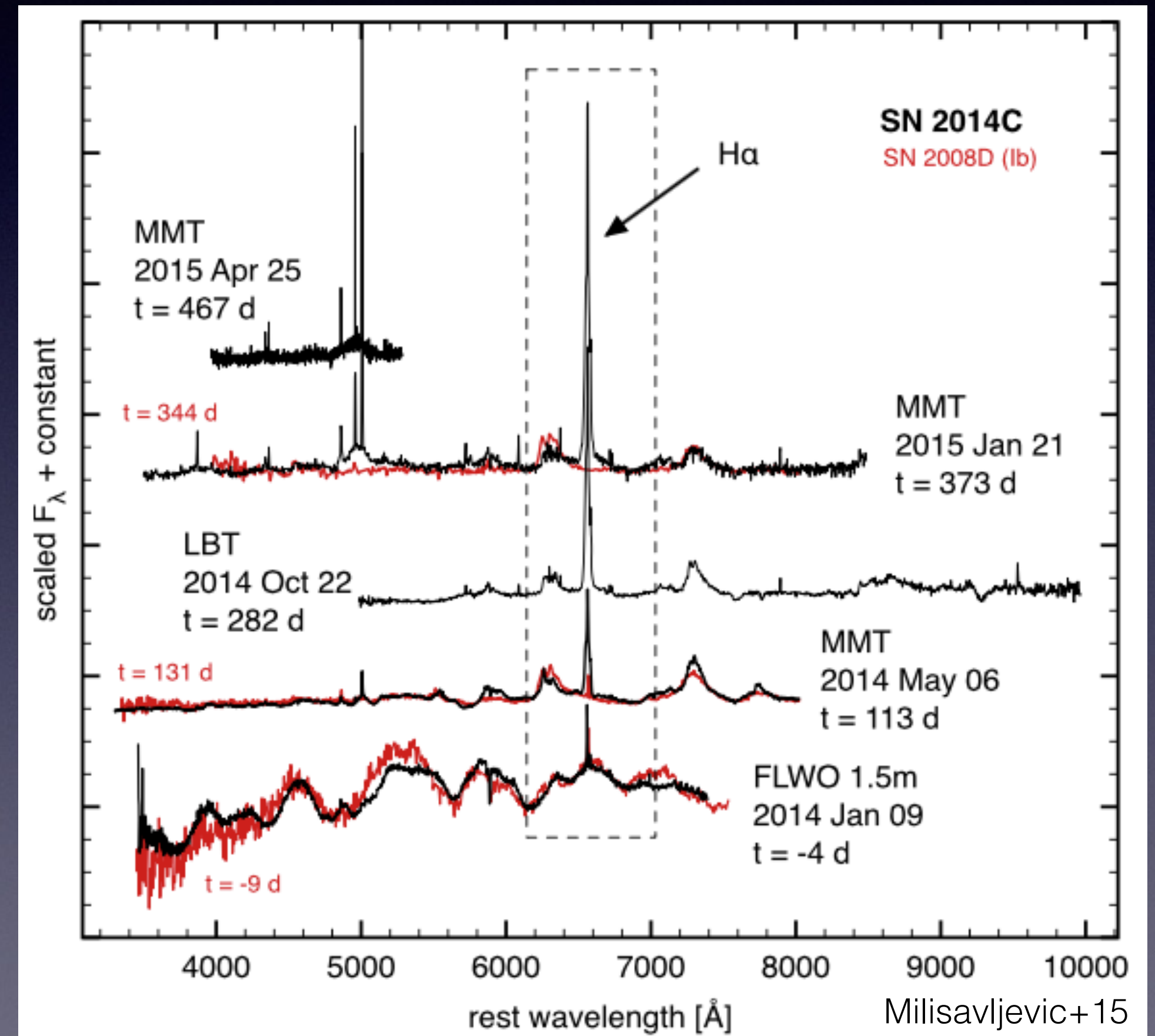
(see Keiichi Maeda's talk)



- WR star progenitors?
- The progenitors must have lost the envelope somehow
- Heavy mass loss → CSM?

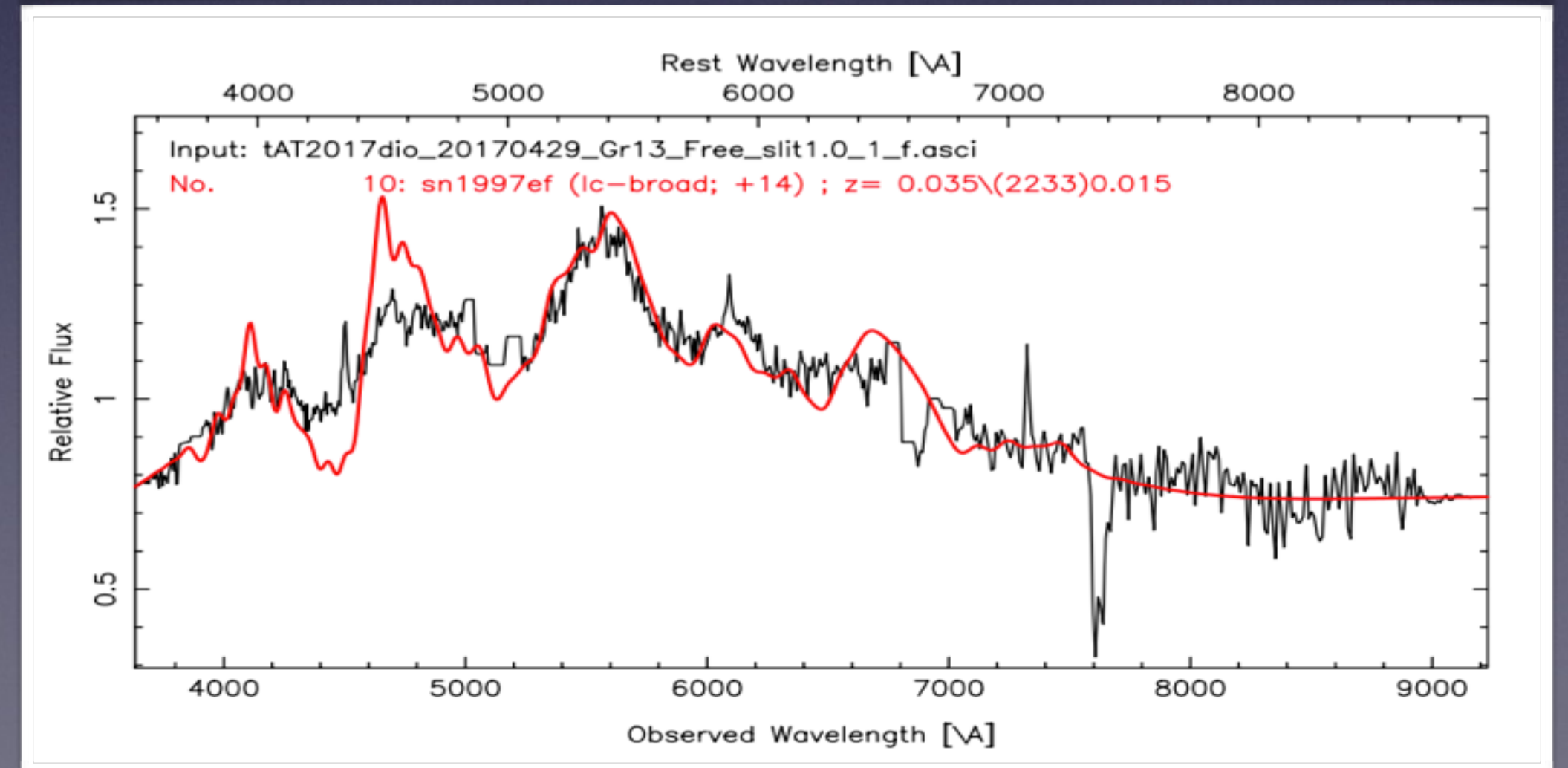
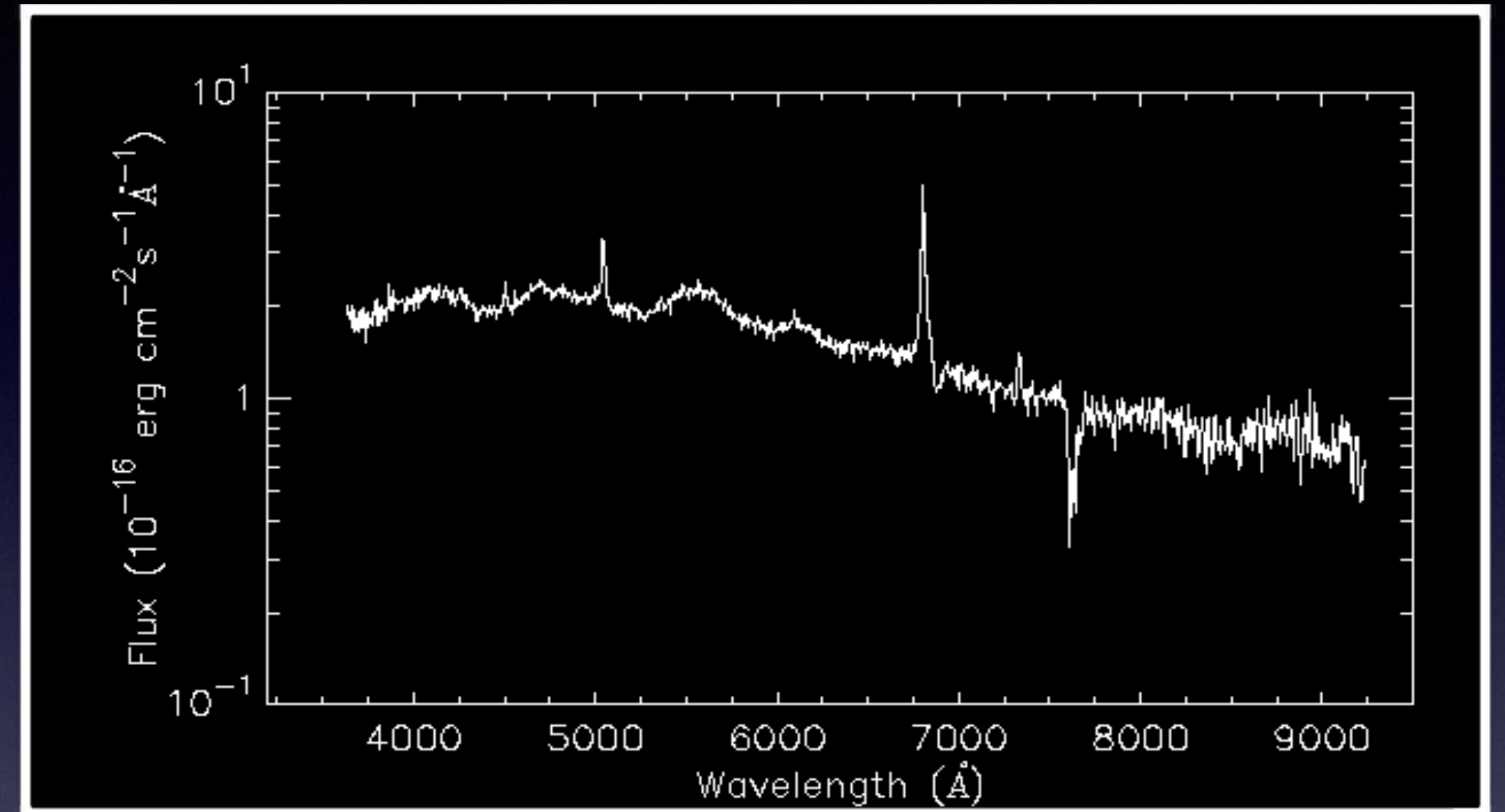
Some SNe Ib/c do show signs of CSM interactions

- SNe Ibn (see *Andrea Pastorello's talk*)
- Radio/X-ray detections, also see *Maria Drout's talk*
- SN 2014C (Ib, Milisavljevic+15); SN 2001em (Ib/c, Chugai & Chevalier 06), 2004dk (Ib, Mauerhan+18): *late-time H α emission* ... see *talk by Dan Milisavljevic*
- A number of Ib/c's in *late-time H α photometry* (Vinko+16)
- SLSNe Ic with *late-time H α emission* (Yan+15,17)
- SN 2010mb: Ic with *H/He free CSM* (Ben-Ami+14), also see PS17brq (*poster by Sebastian Gomez*)
- SN 2017ens (*talk by Janet Chen*)



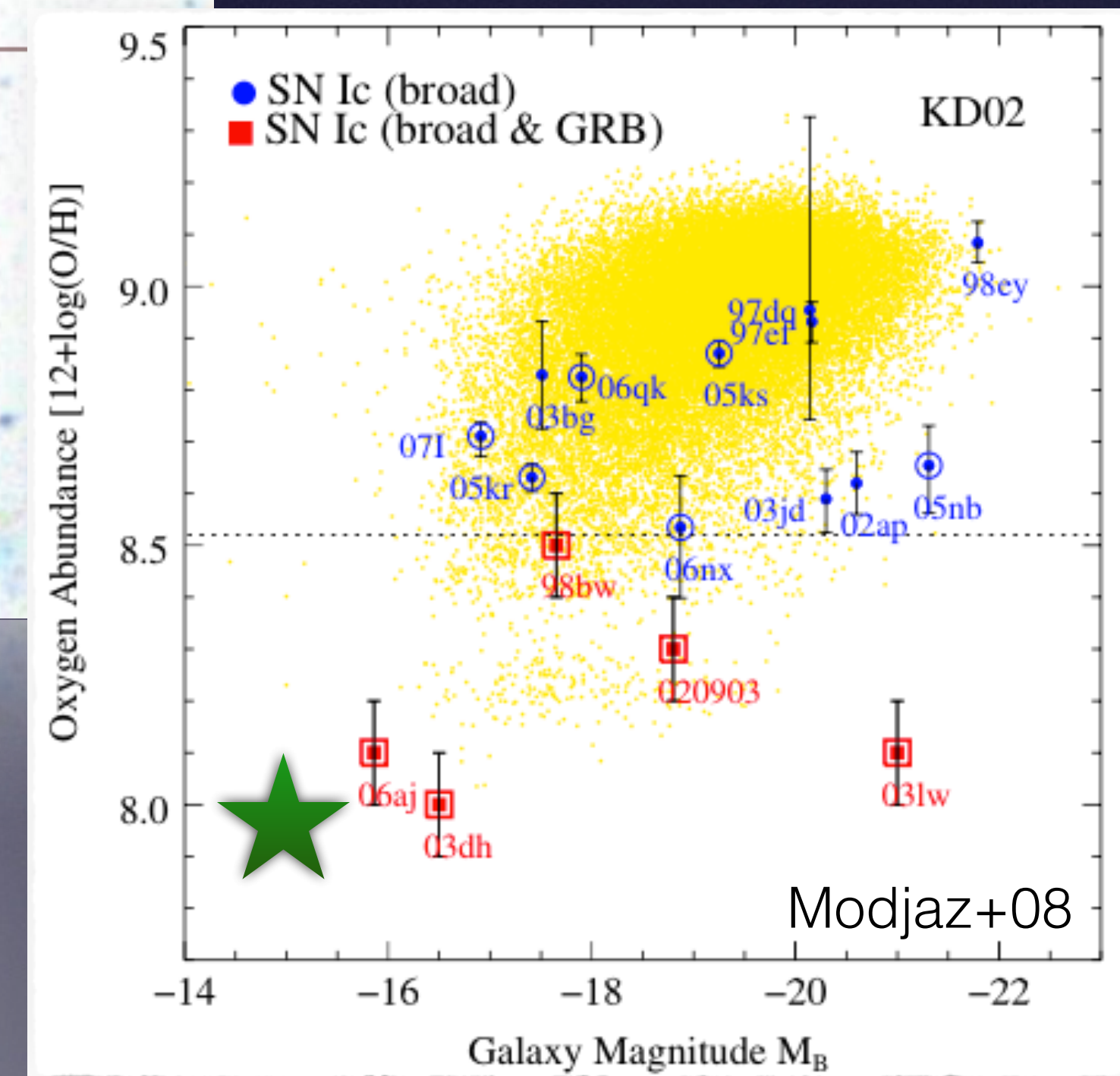
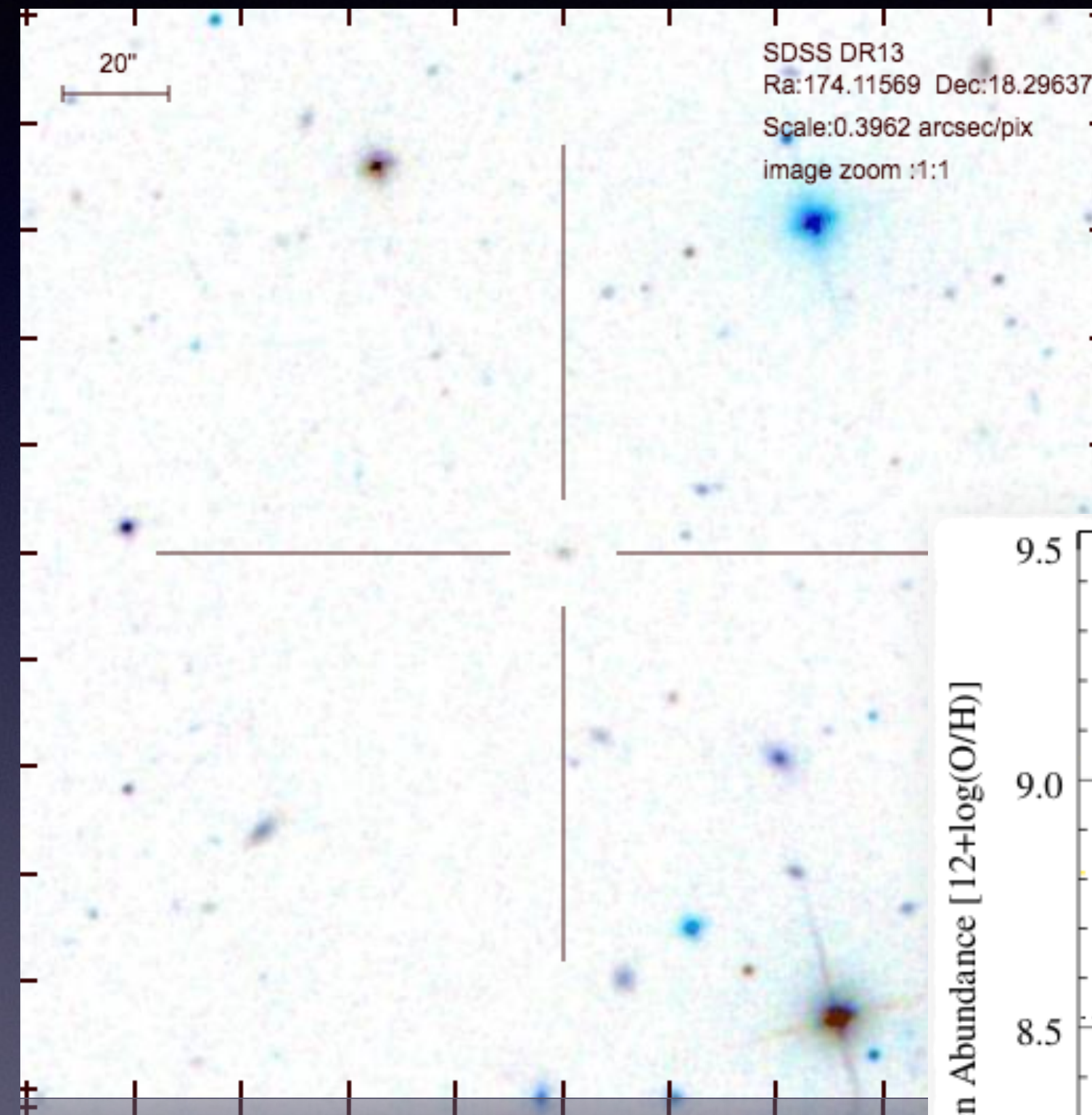
Enter SN 2017dio

- ATLAS discovery at 18.3 mag (cyan band)
- ePESSTO classification \rightarrow SN Ic(BL)
 - emission lines clipped for spectral fitting (SNID/Gelato)
- Follow-up by NUTS & ePESSTO



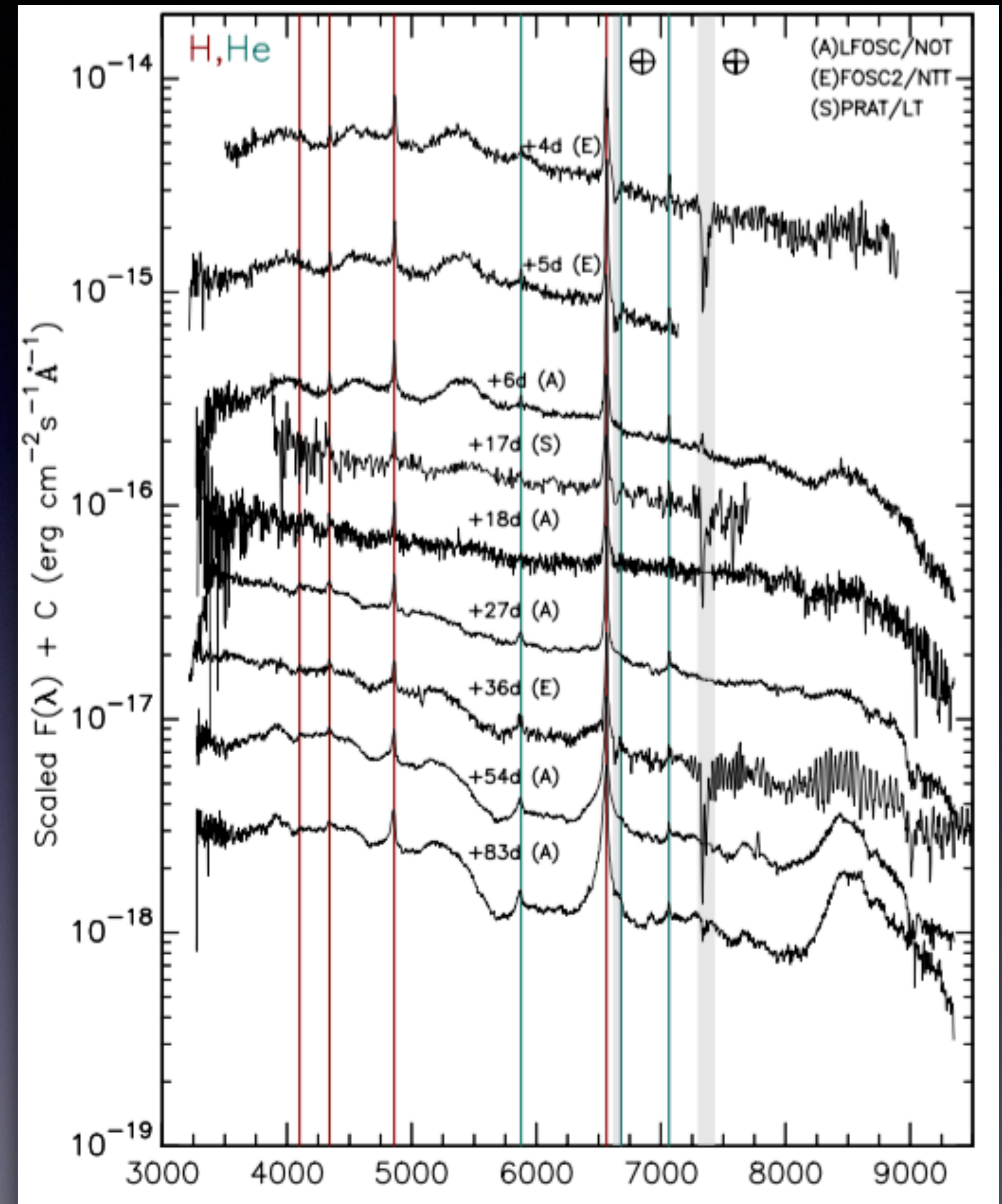
The host galaxy

- In SDSS field
- $z = 0.037$ (SN lines)
- $DM = 36.0$ mag
- at $d = 160$ Mpc, 2-3 kpc size
- $E(B-V)_{MW} = 0.028$
- $M_g \sim -15 \rightarrow$ **fainter than SMC**
- $12+\log(O/H) \sim 8.0$ dex? (L-Z relation, Tremonti+04)



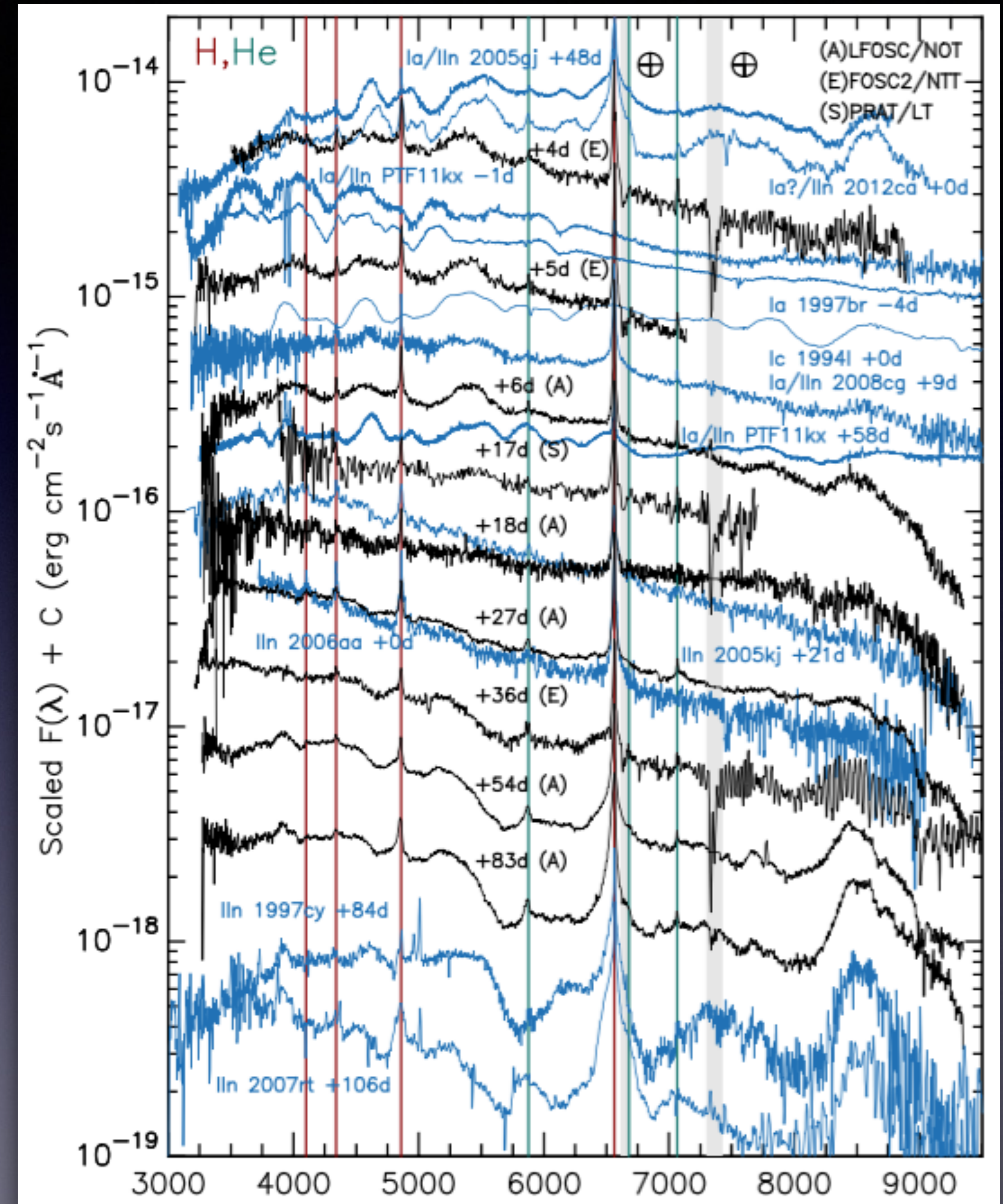
Spectral sequence

- First 3 spectra very similar
- Evolving into blue featureless continuum, typical to SNe IIn
- **H, He I emission lines** always present (resolved; >500 km/s) \rightarrow CSM



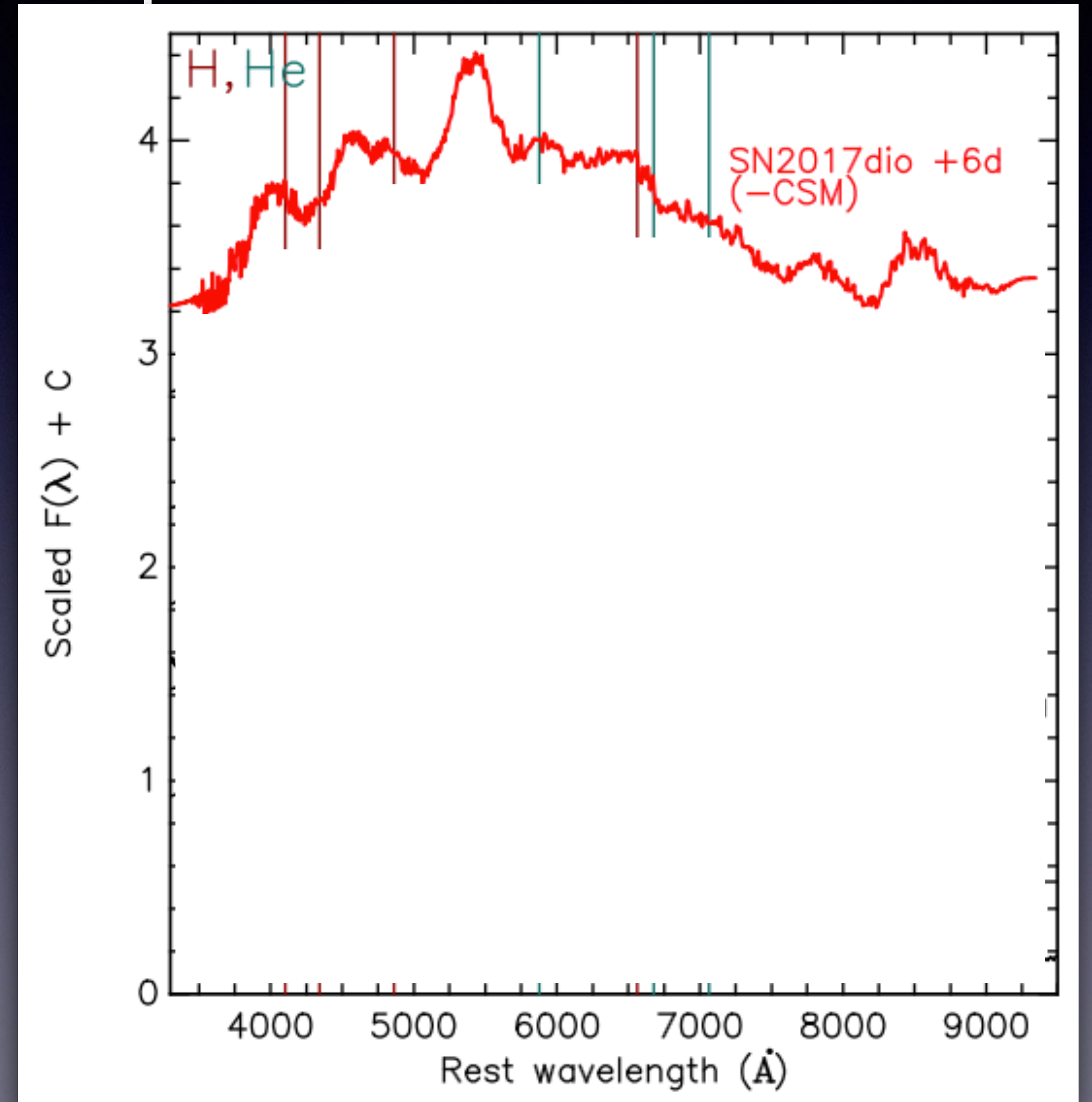
Spectral sequence

- Early spectra bear some resemblance with SNe Ia-CSM, but also to Ic
- Note: SN type-I spectral difference not always obvious
- Later evolution similar to SNe II_n
- Could it be a Ia+CSM instead? c.f. SNe 2002ic, 2012ca (Ia vs. Ic)



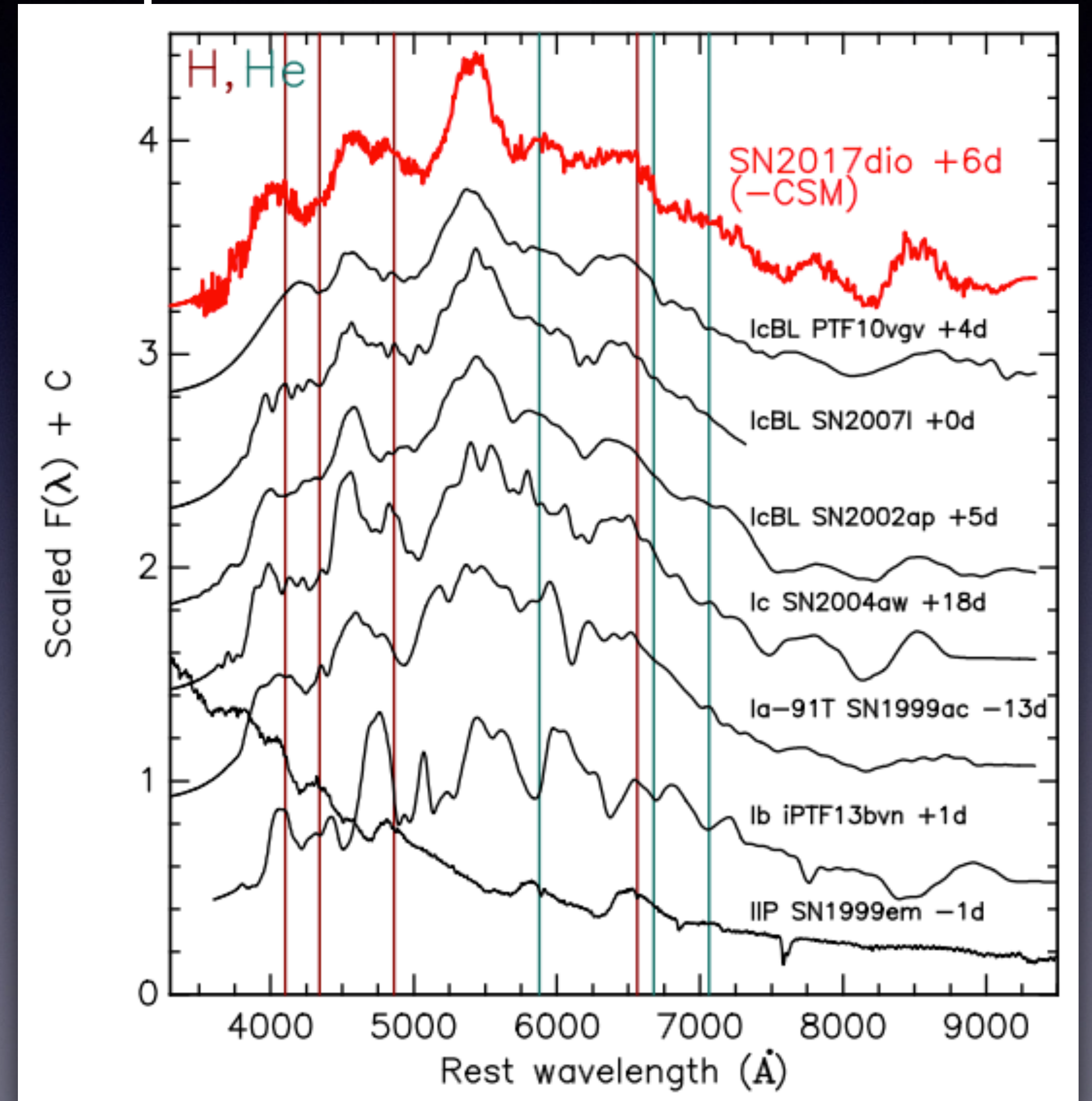
Spectrum decomposition: removing interaction component

- Subtract +6d (early phase) with +18d (featureless)
- Cross-correlate with template library (SNID, Gelato)



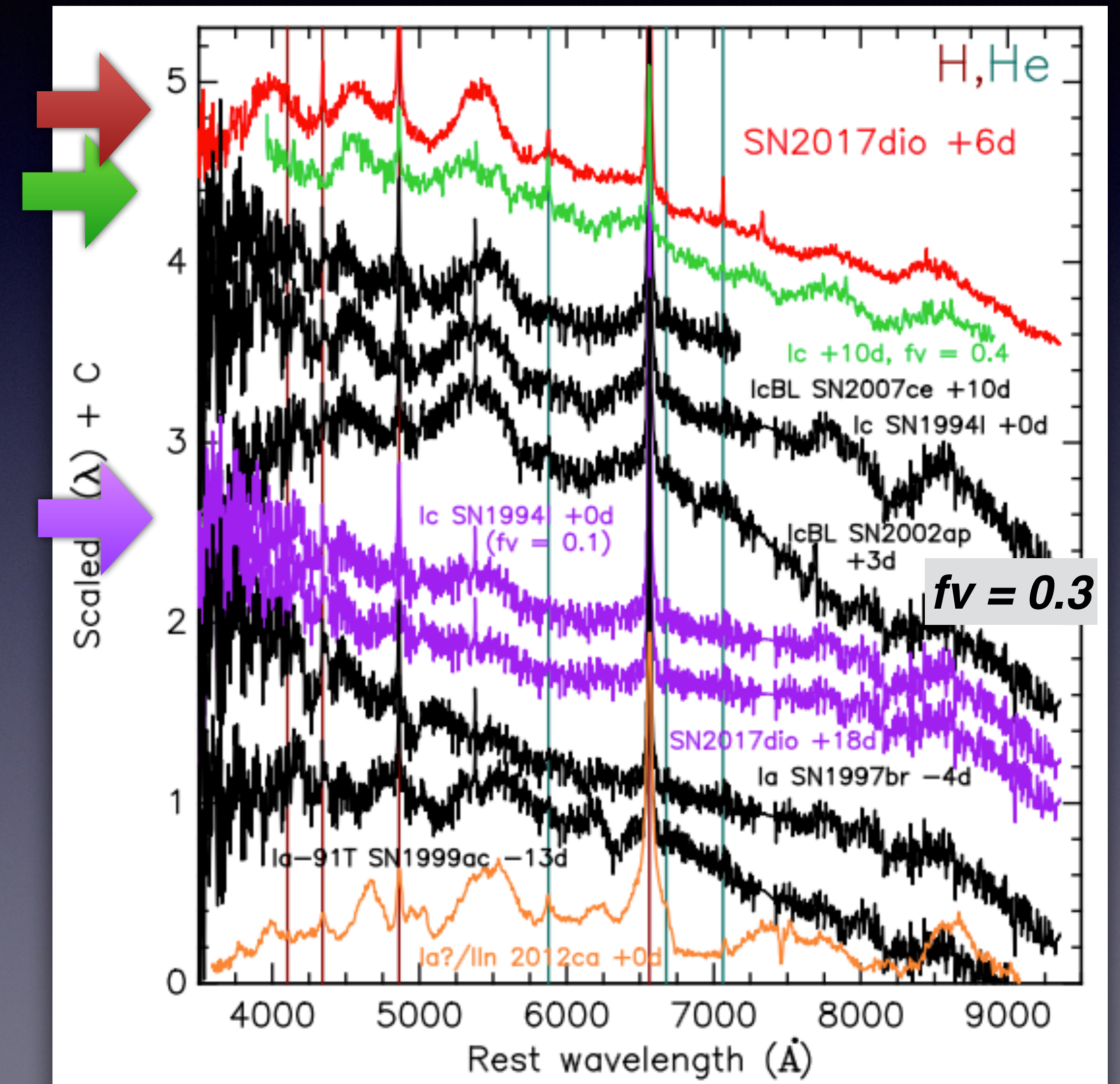
Spectrum decomposition: removing interaction component

- Subtract +6d (early phase) with +18d (featureless)
- Cross-correlate with template library (SNID, Gelato)
- **Best match with SN Ic (BL)**



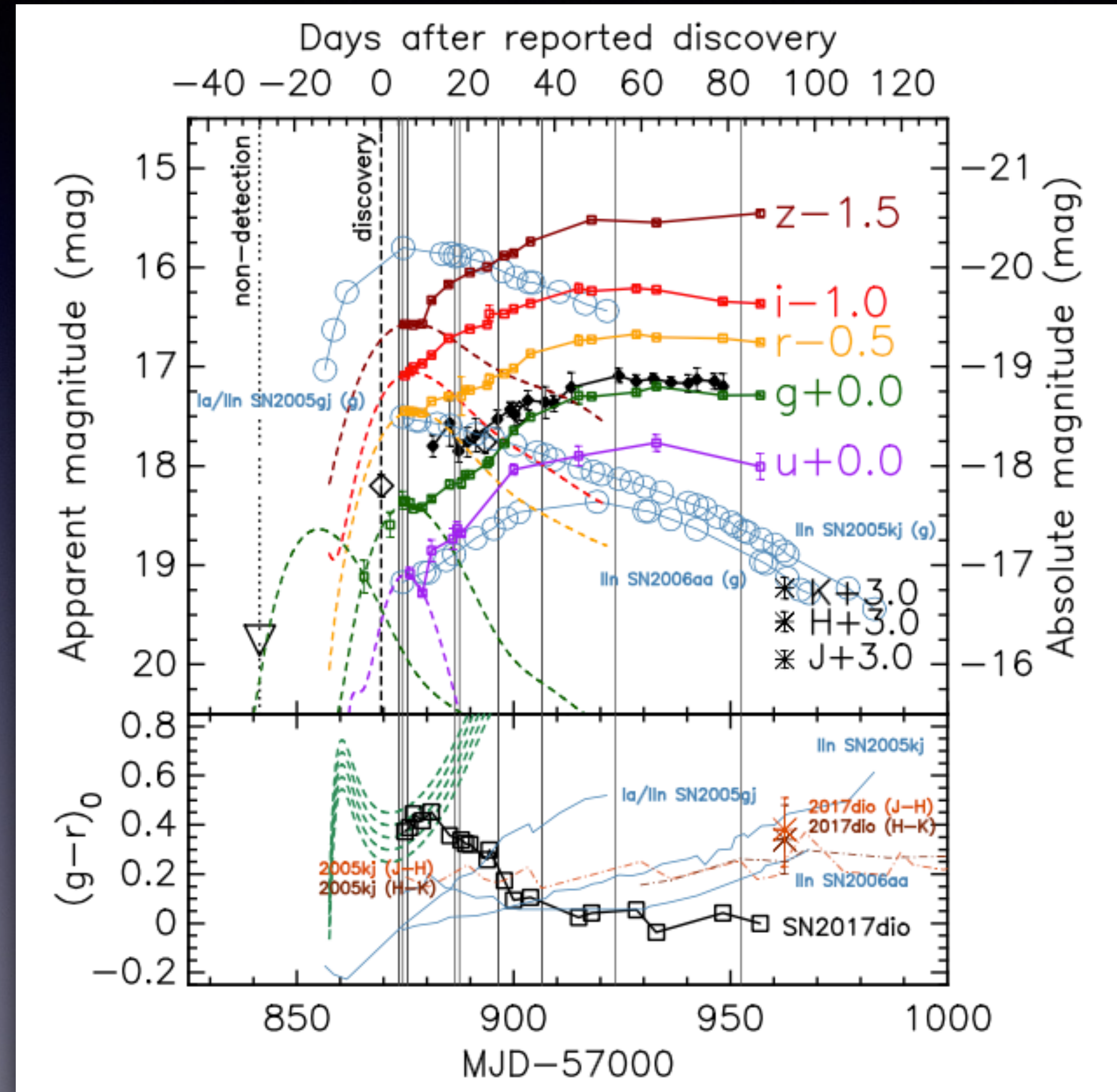
Reverse method of adding CSI confirms Ic classification

- < to double check! >
- Adding CSI to various comparison spectra, varying SN/continuum flux ratio (f_v , Leloudas+15)
- Previous method confirmed: striking similarity with SNe Ic



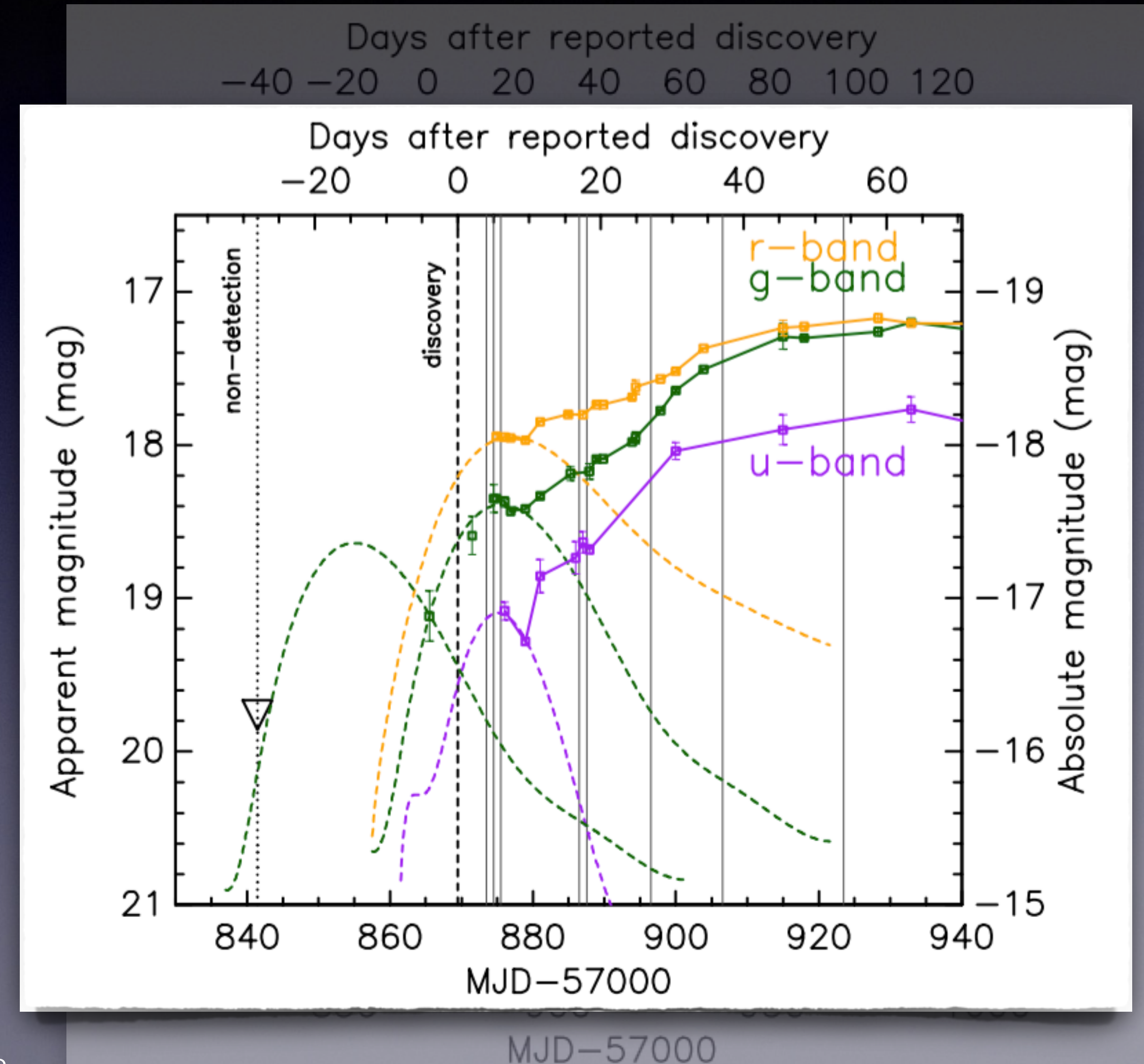
Light curve

- Early phase can be fitted with SN Ic template (Taddia+15)
- Constraint of $M_g \sim -17.5$ mag at photospheric (Ic LC) peak \rightarrow within typical Ic/IcBL distribution
- Peak $M_g \sim -18.8$ mag (CSI dominated)
- No sign of high extinction
- Cannot hide a SN Ia below CSI!



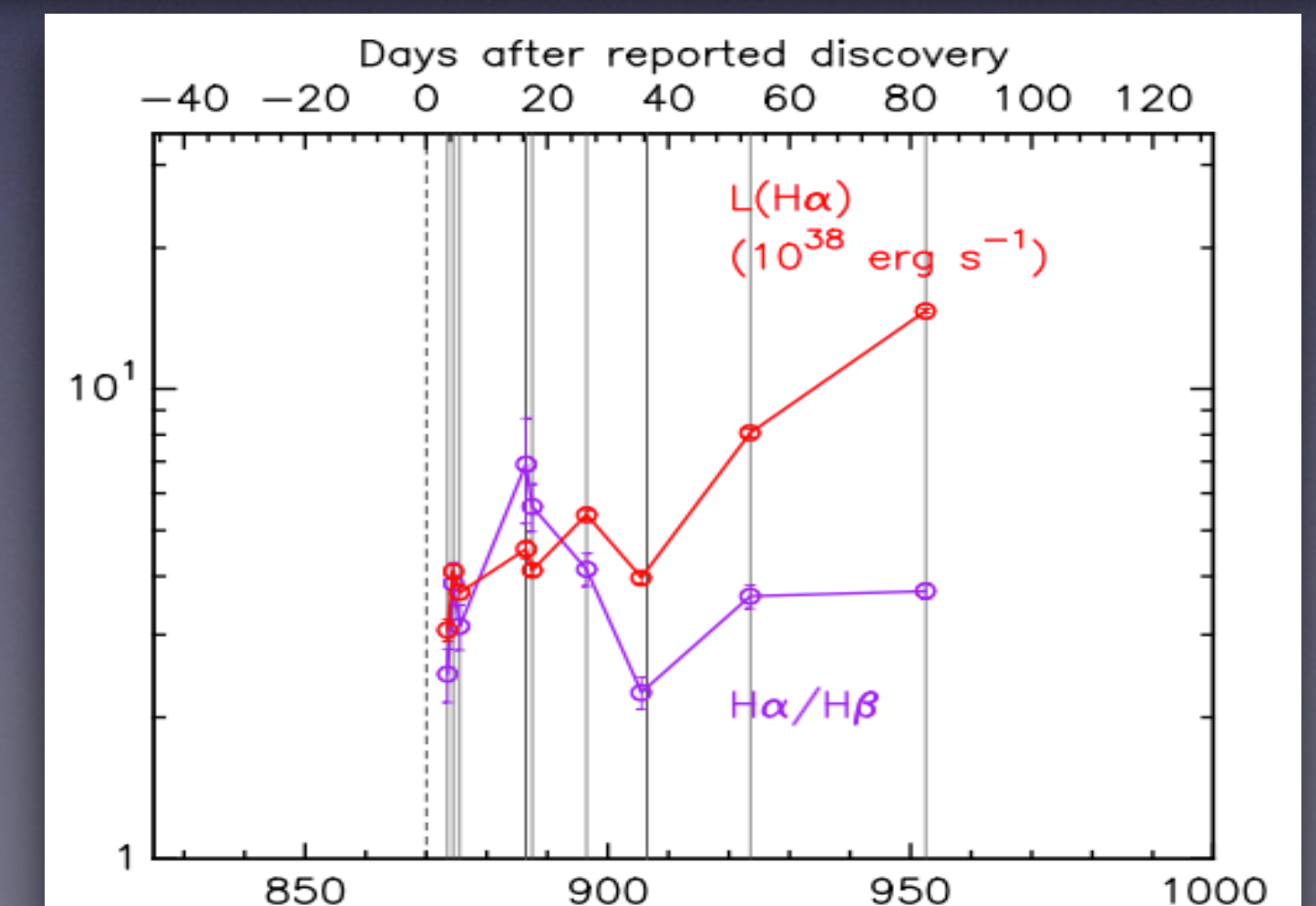
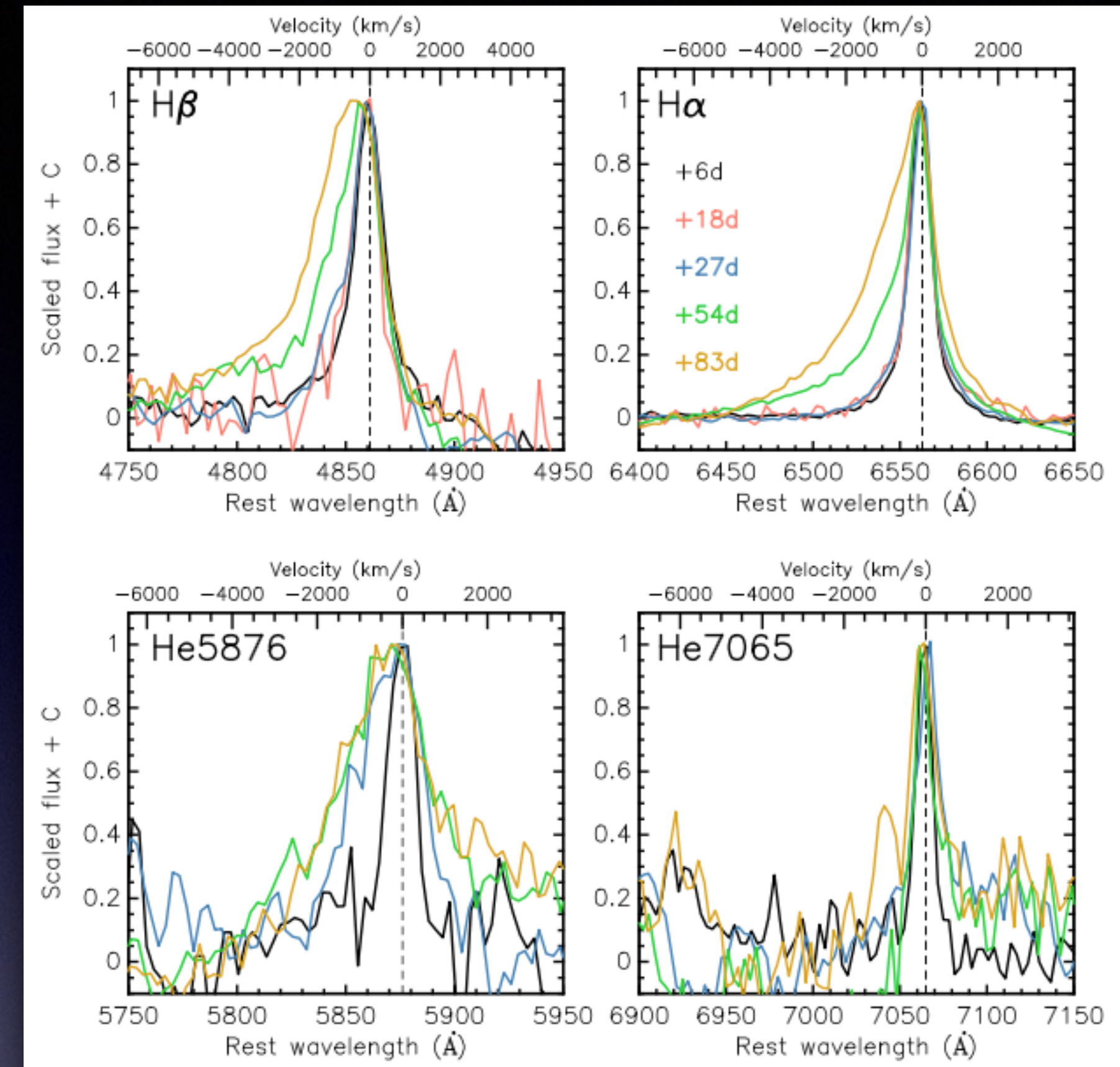
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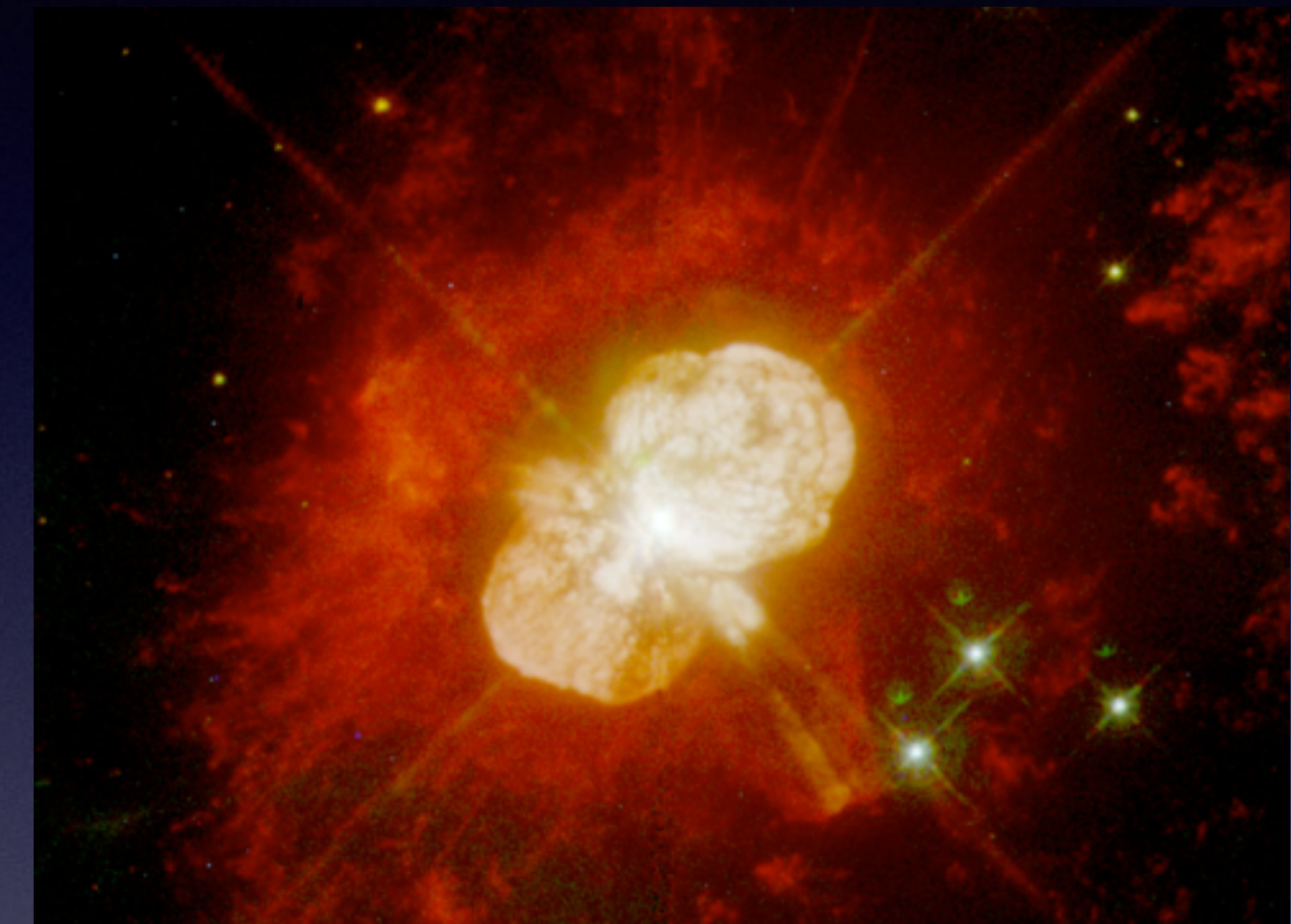
CSM & progenitor system

- Interaction was not dominant at early times
- Asymmetric line profile: occultation by ejecta on the far (red) side as ejecta expands and accelerate CSM
- The bulk of the CSM is somewhat detached (peak density at $\sim 10^{16}$ cm, if $v_{\text{ejecta}} = 10000$ km/s)
- Not spherically symmetric ($\rho \sim r^{-2}$) wind CSM
- Major mass loss in decades preceding the SN ($\sim 10^{-2} M_{\odot}/\text{yr}$)

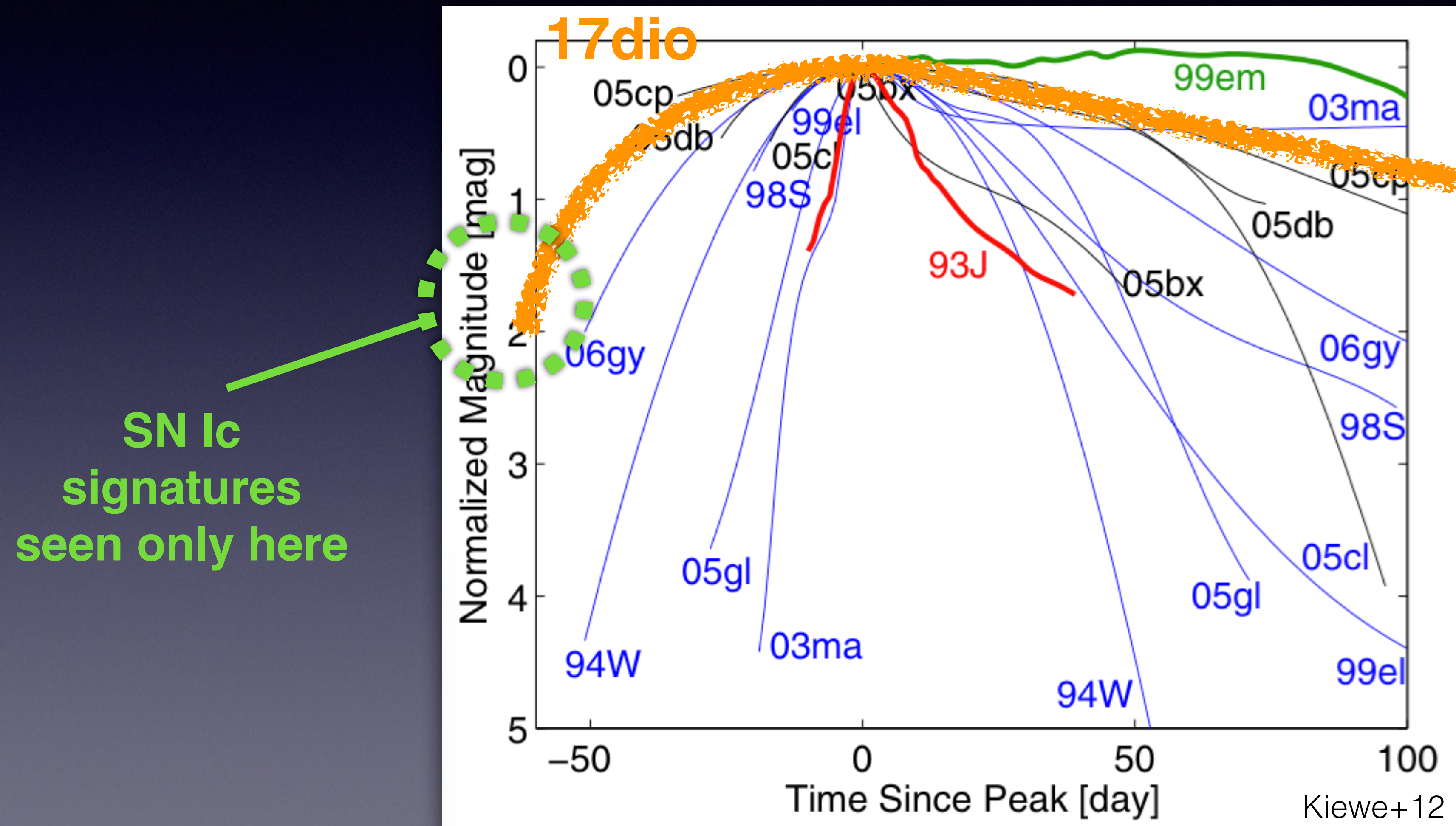


CSM: from previous eruption, or companion

- **How come a H/He-free progenitor still has H-rich CSM?**
- —> CSM from a **binary companion**, or **pre-SN major eruption** (c.f. SN 2006jc)
- Possible binary scenario:
 1. Primary evolves, RLOF, becomes C+O star
 2. Secondary evolution accelerated, becomes LBV or giant, 2nd RLOF —> source of H-rich CSM
 3. Primary explodes at this point



Are some IIn's like this and we are just missing the early evolution?



Summary

- First firm case of a SN Ic (BL?) with prompt interaction with a nearby H-rich CSM
- Progenitor experienced major eruption before the SN, or was in a close binary system
- Challenge for progenitor modeling
- Need to find IIn's at very early phase! —> future surveys may help

Tack!