

Some Type Ibc supernovae are not from massive stars

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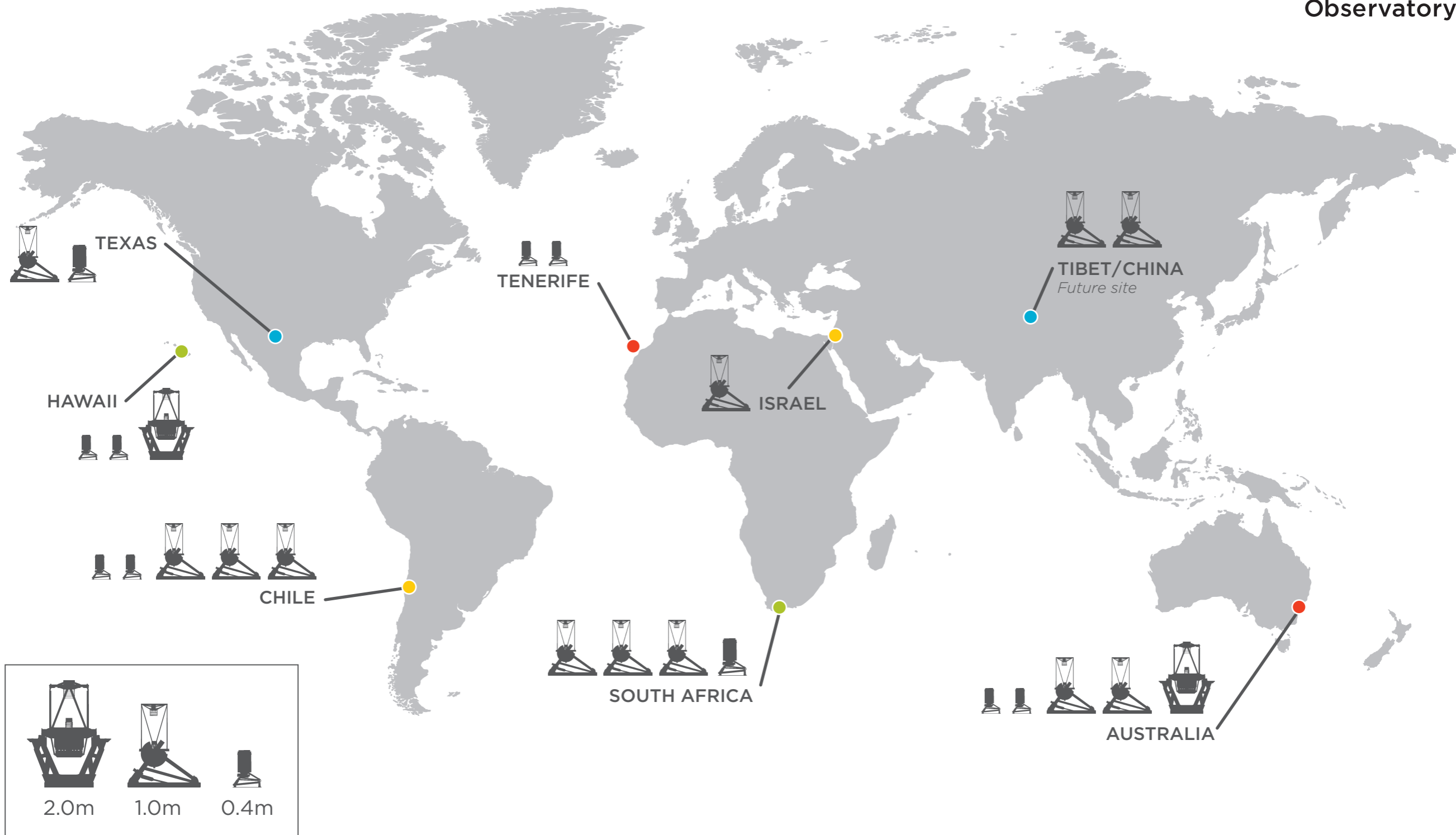
Previously, Las Cumbres / UCSB
Now at Harvard / CfA



@BrunoLetarte



GLOBAL TELESCOPE NETWORK



Global Supernova Project

Led by LCO - PI: Howell

150+ members of the worldwide SN community working together. Members from every continent.

More than halfway to goal of getting unprecedented data on 900+ SNe with well sampled light curves and spectra over 6 years.

Creating tools and incentives for scientists to work together, share data.

Feeder surveys

PTF/iPTF/ZTF

Pan-STARRS

(e)PESSTO

La Silla-Quest

ASAS-SN

Catalina Sky Survey

MASTER

OGLE

KAIT

ATLAS

Gaia

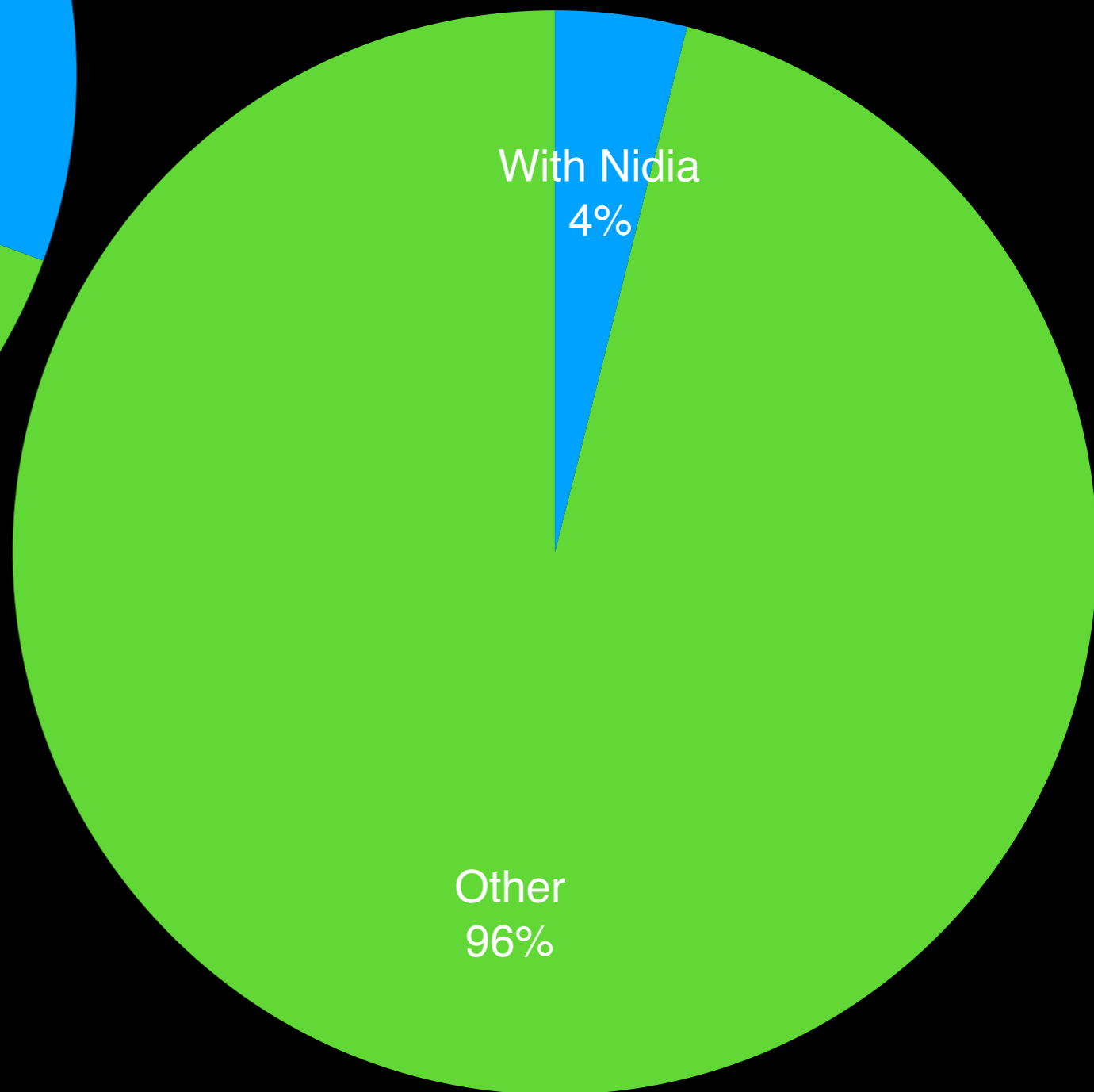
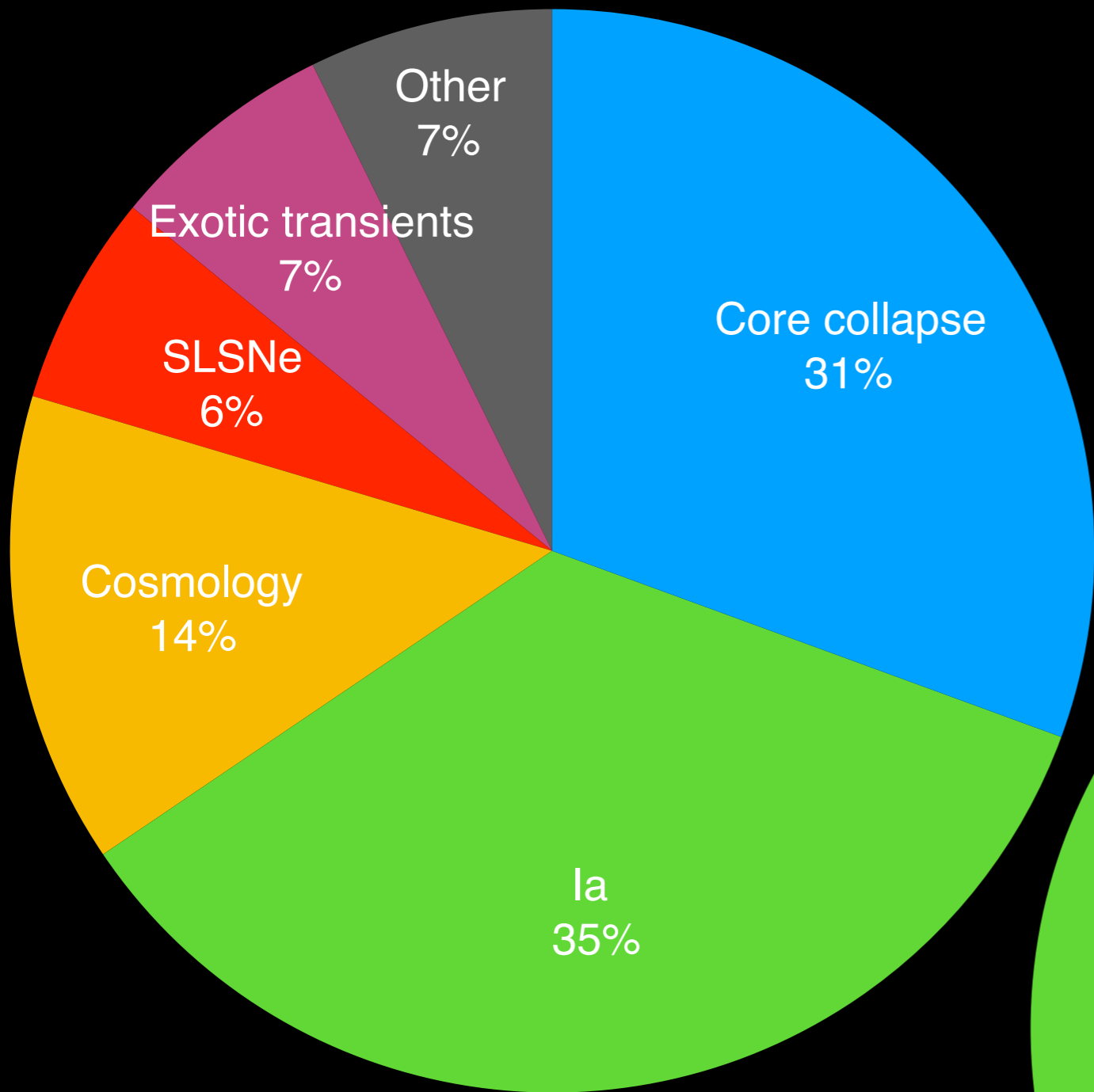
KMTNet

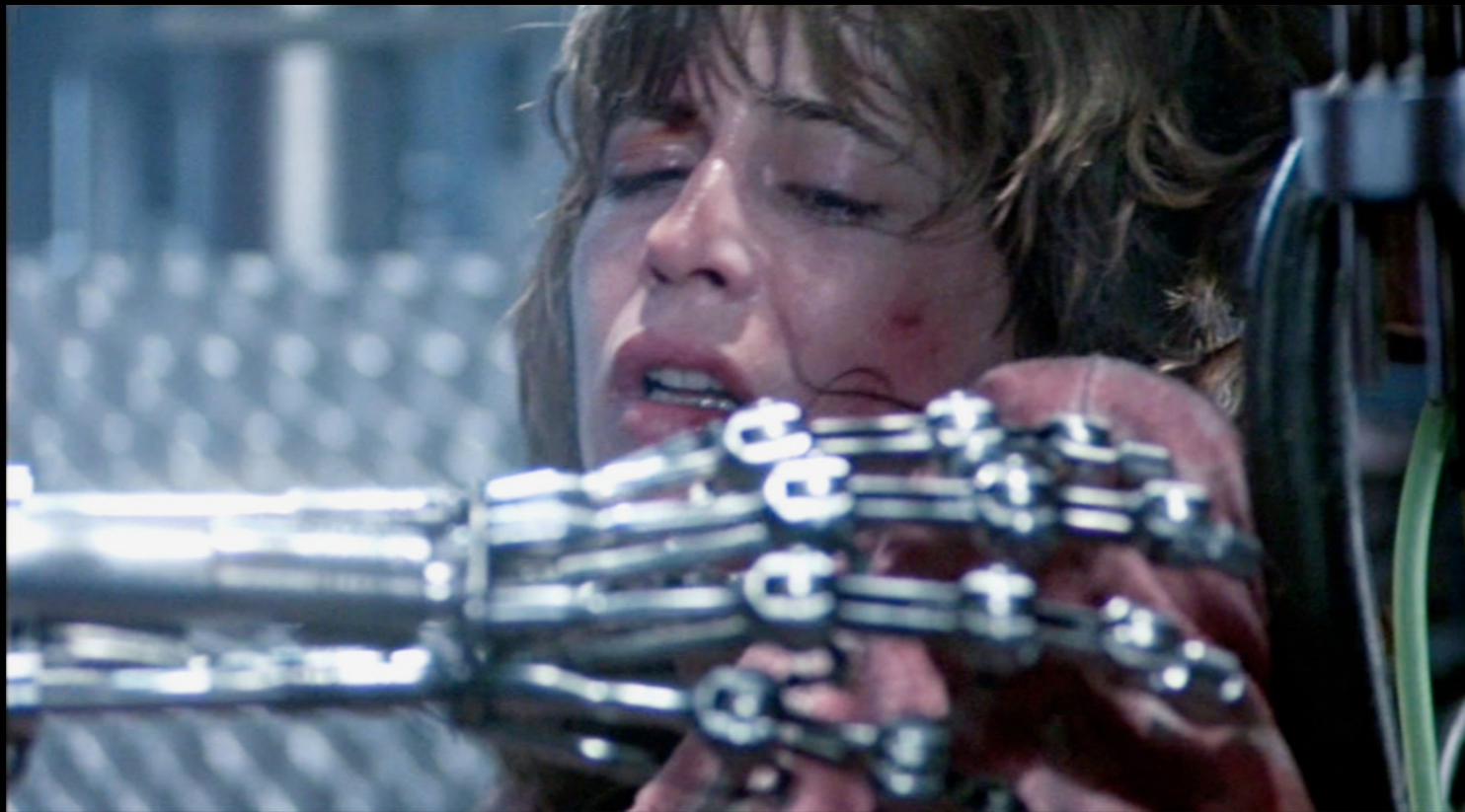
Sky mapper

DLT40

KMTNet

BlackGEM

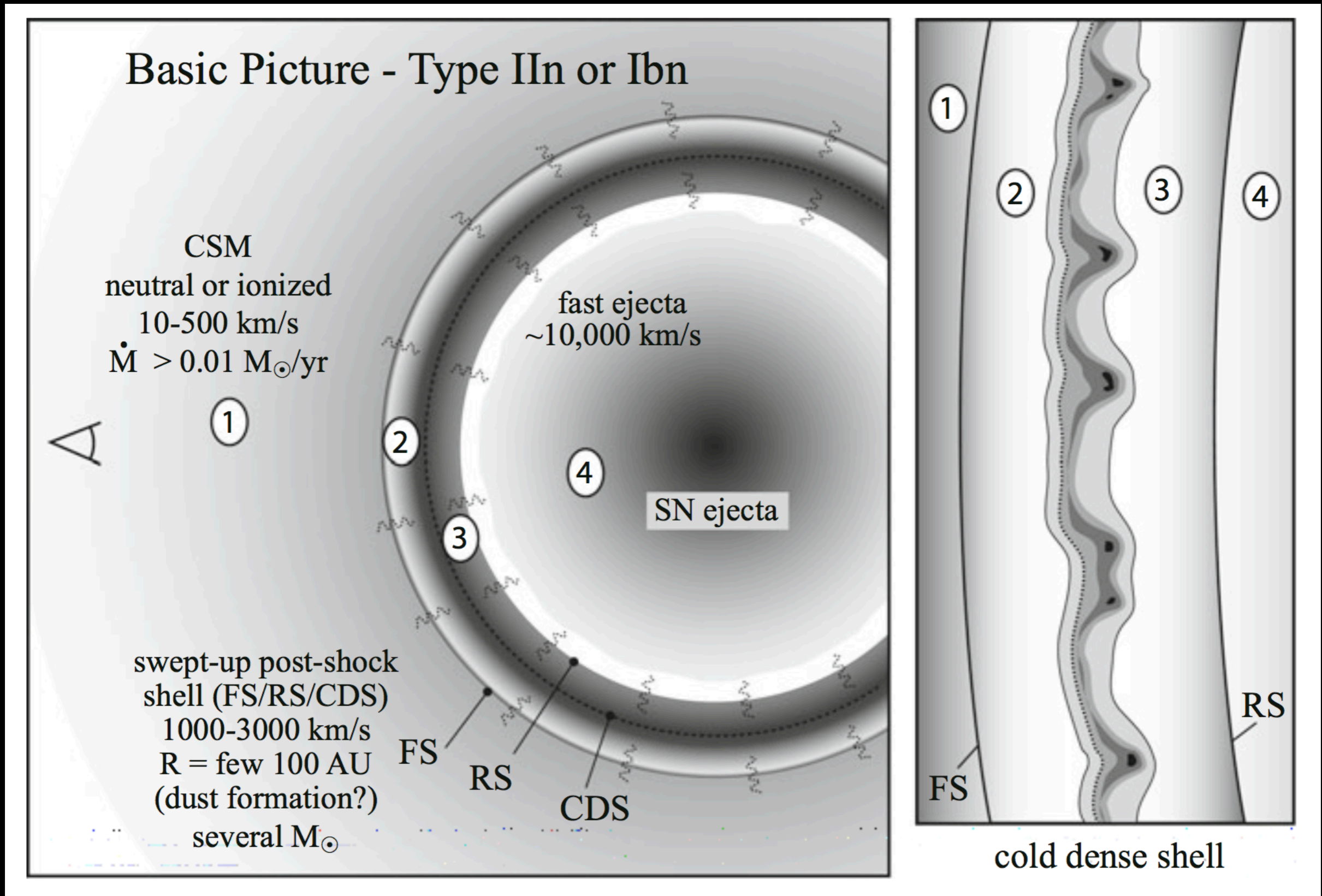






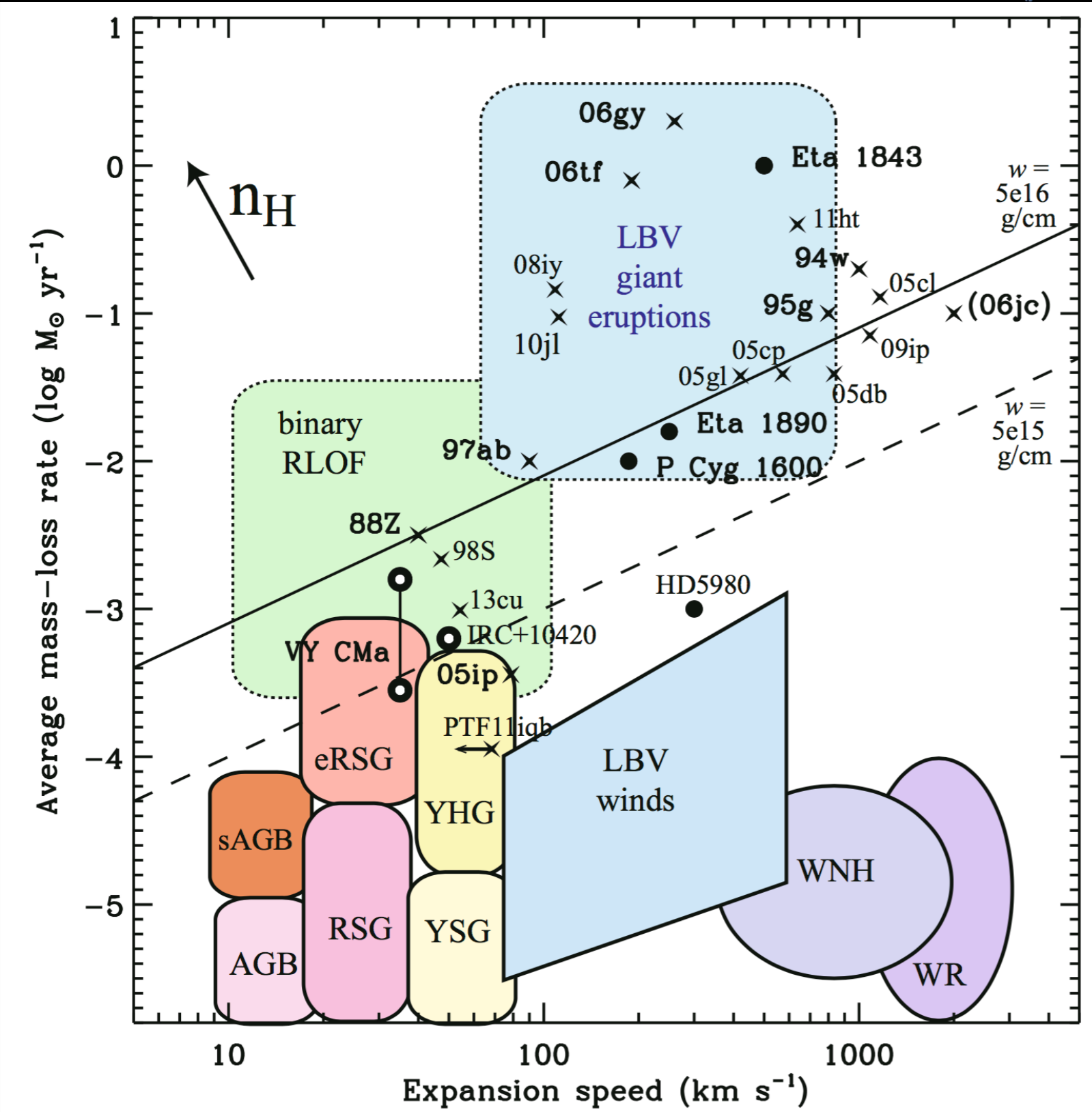
**COME WITH ME IF
YOU WANT TO LIVE**

SNe IIn have narrow lines of hydrogen, SNe Ibn have no hydrogen, but have narrow lines of helium.

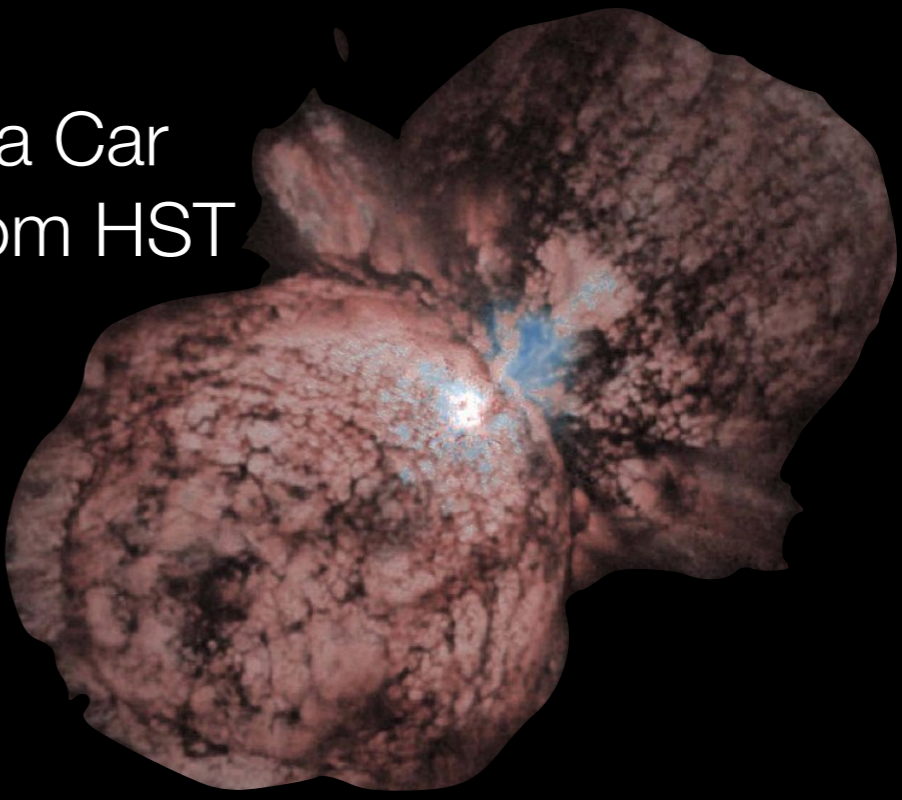


From Nathan Smith's IIn/Ibn article in the Handbook of Supernovae

Inferred circumstellar material parameters around SNe II_n/I_{bn}.
 From Nathan Smith's II_n/I_{bn} article in the Handbook of Supernovae



Eta Car from HST

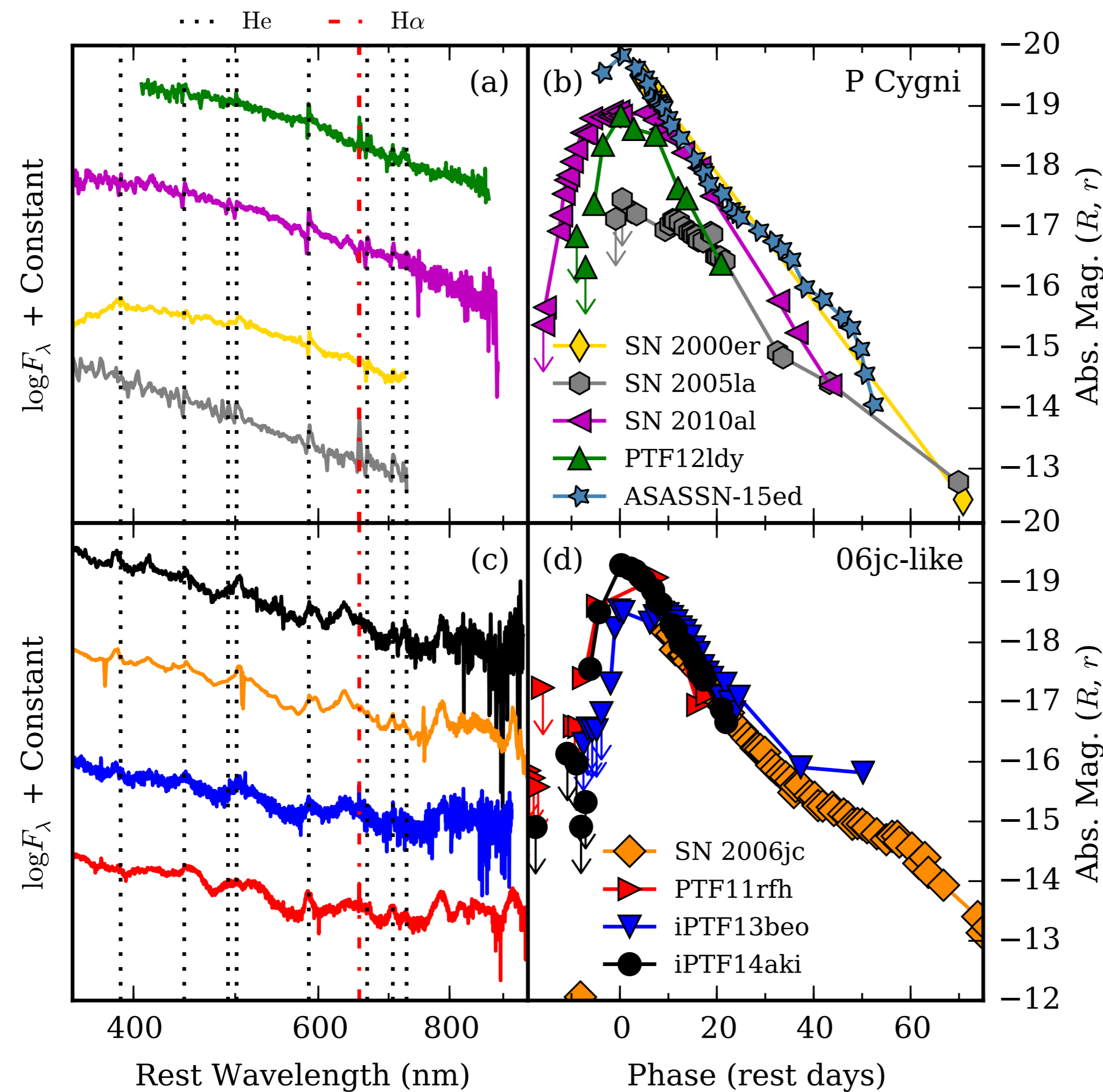


Wider view of Eta Car in X-rays



Added 6 SNe
Ibc to bring
total known to
22.

SNe Ibc fall into
two classes
based on early
spectra: those
with narrow He
P-Cygni
profiles, and
those with
narrow He
emission.



PS1-12sk is a Ibn that looks like SN 2006jc, the prototype Ibn.
 SN 2006jc was seen in outburst at $M_r \sim -14$ pre-explosion, modeled as
 a Wolf-Rayet star with 40 M_{sun} ZAMS, 6.9 M_{sun} at explosion
 (Tominaga et al. 2008).

Sanders et al. 2013

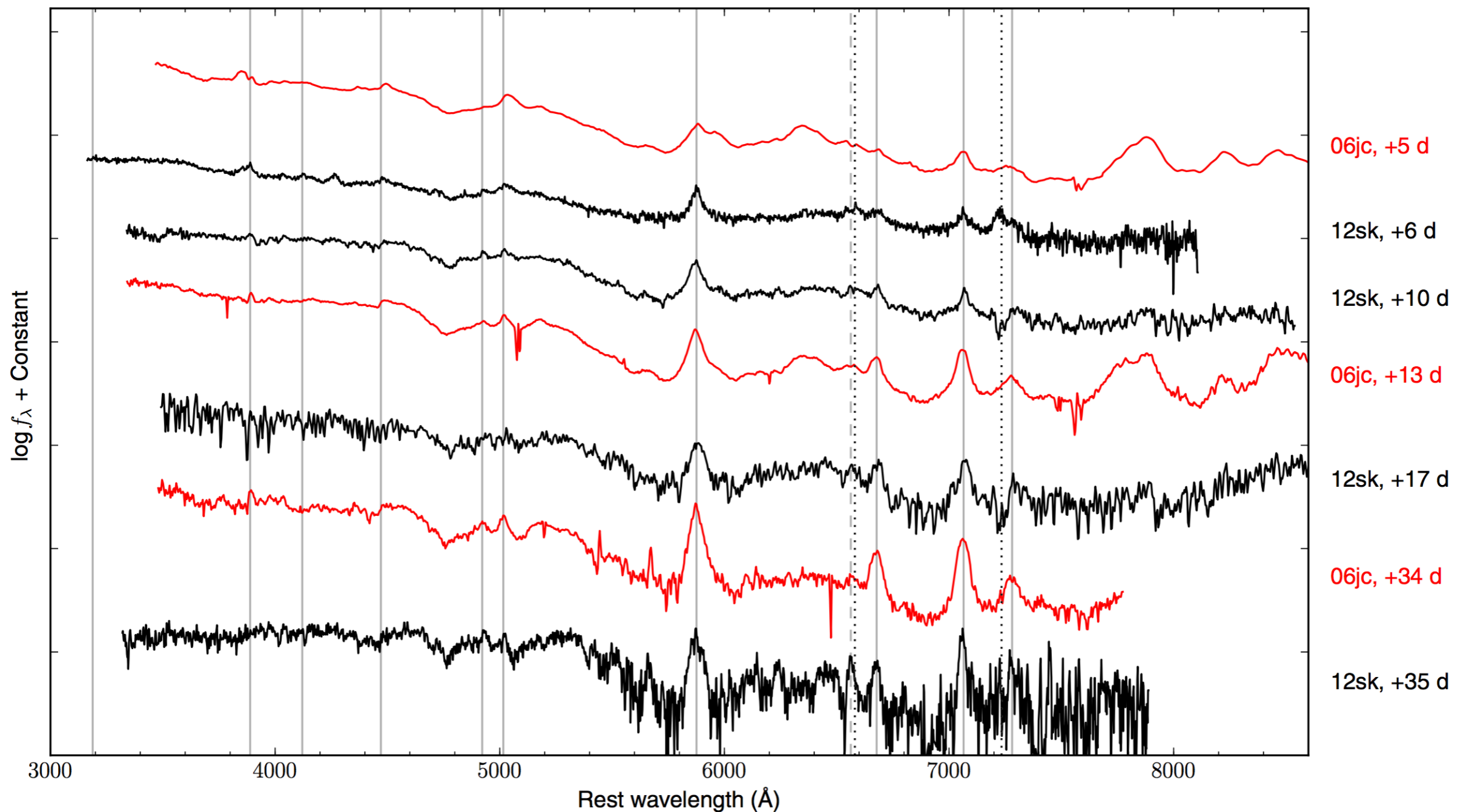
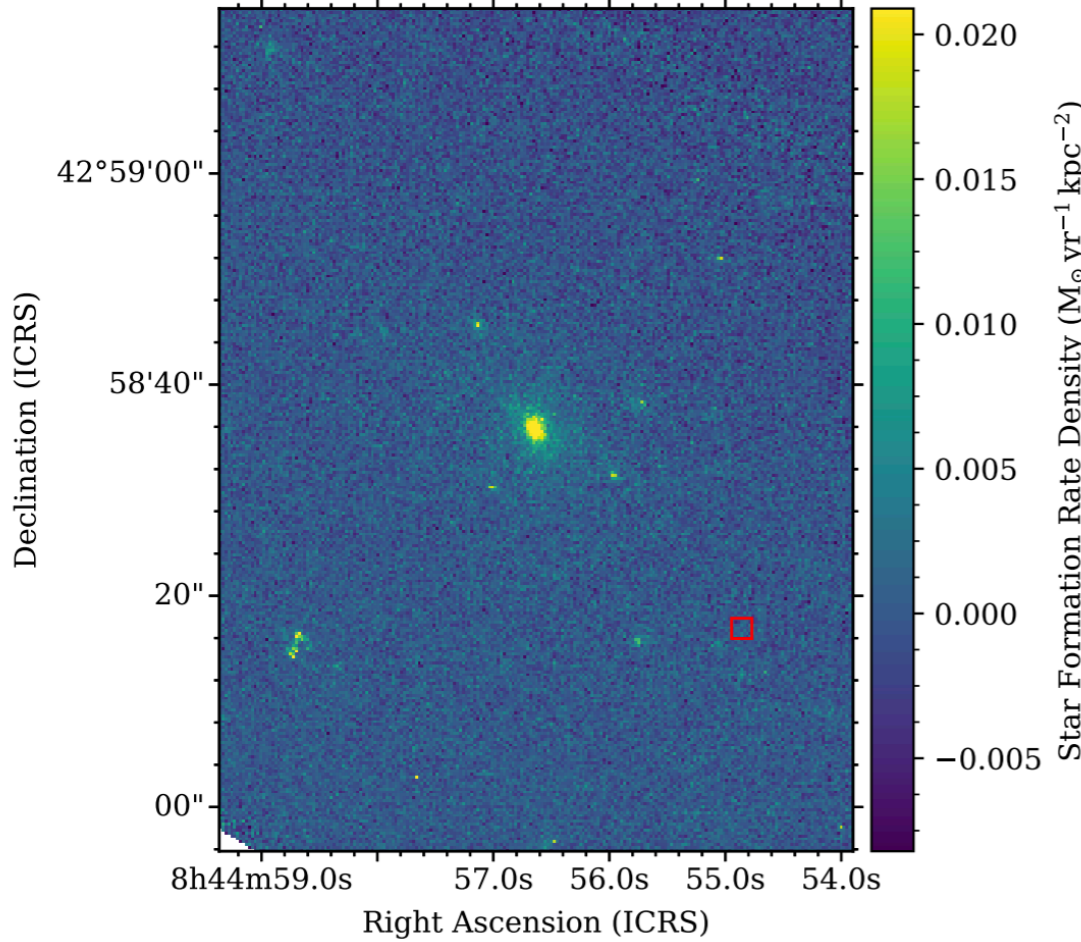
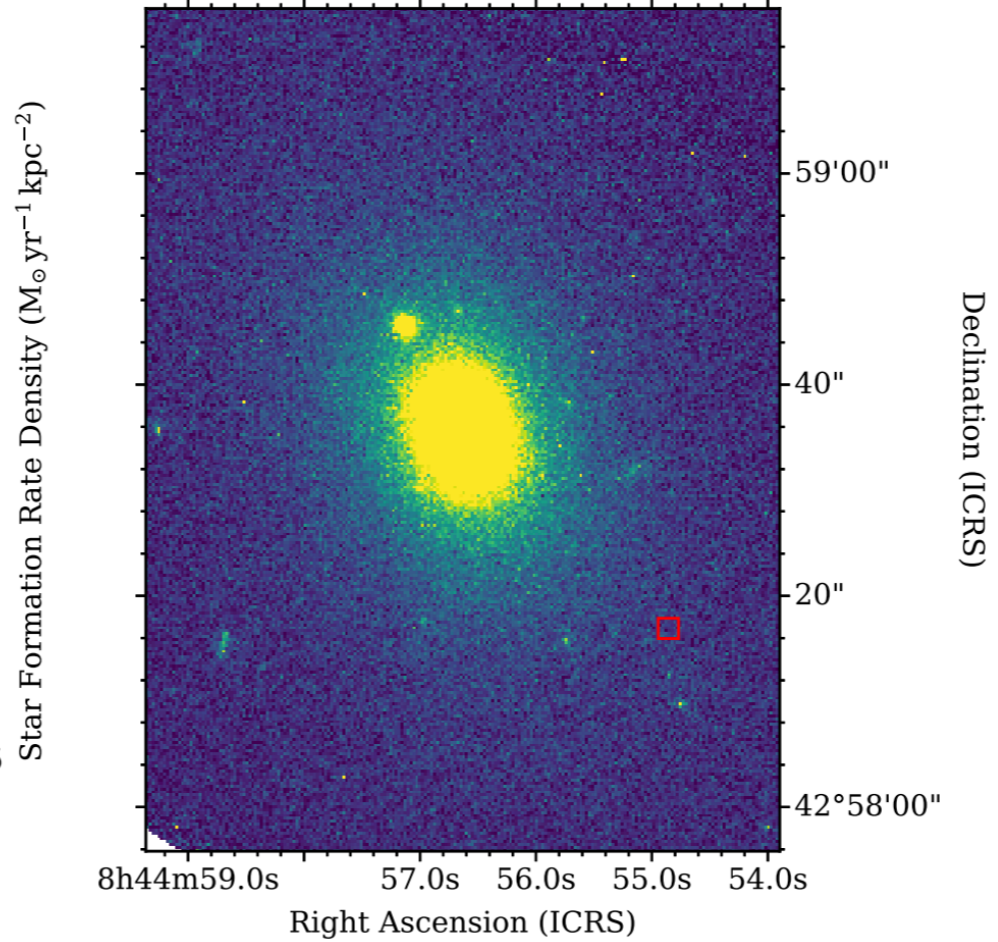


Figure 2. Low-resolution spectroscopic sequence of PS1-12sk, with time since z -band peak noted at right. See Table 2 for observing details. The moderate resolution MMT/BC spectrum is shown separately in Figure 5. The locations of the He I features $\lambda\lambda 3188, 3889, 4121, 4471, 4922, 5016, 5876, 6678, 7065, 7281$ are marked with solid lines; H α with a dashed line; and C II $\lambda\lambda 6580, 7234$ with dotted lines. Spectra of SN 2006jc at representative epochs (Pastorello et al. 2008a) are shown in red.

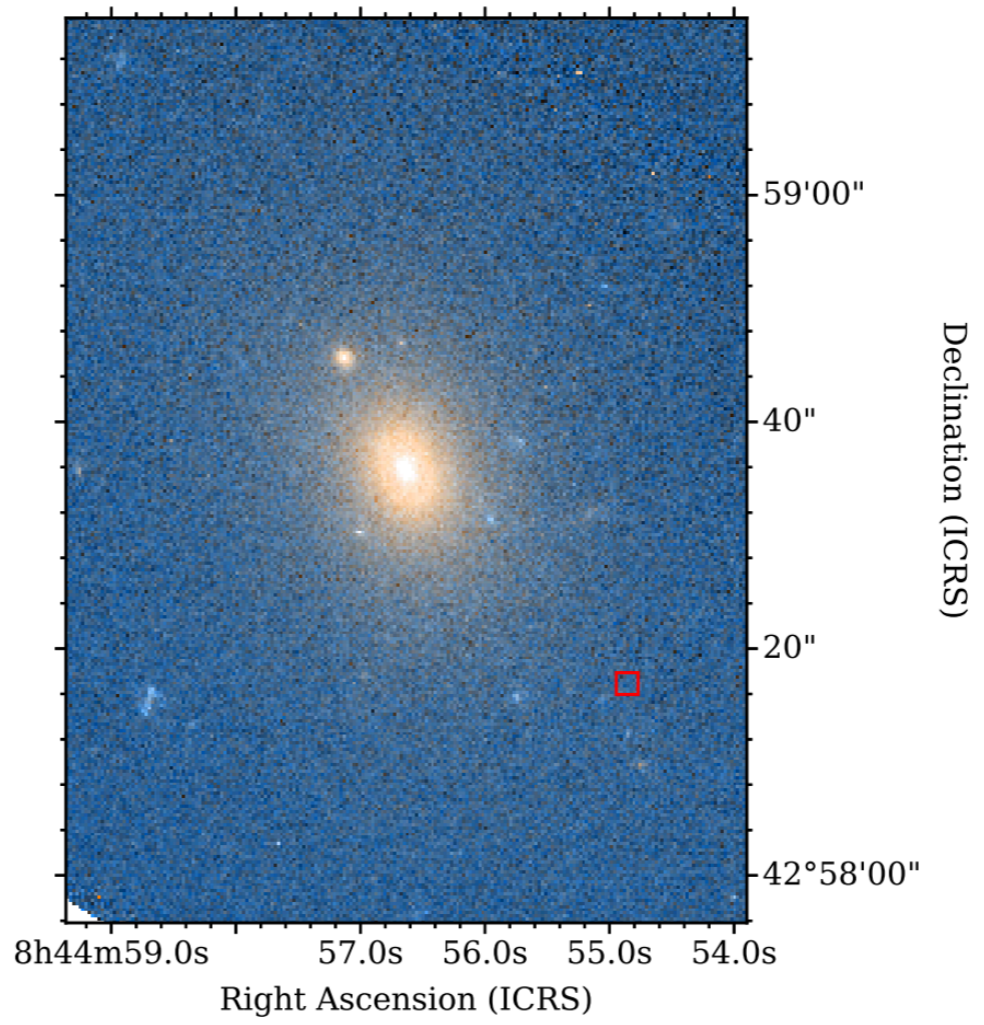
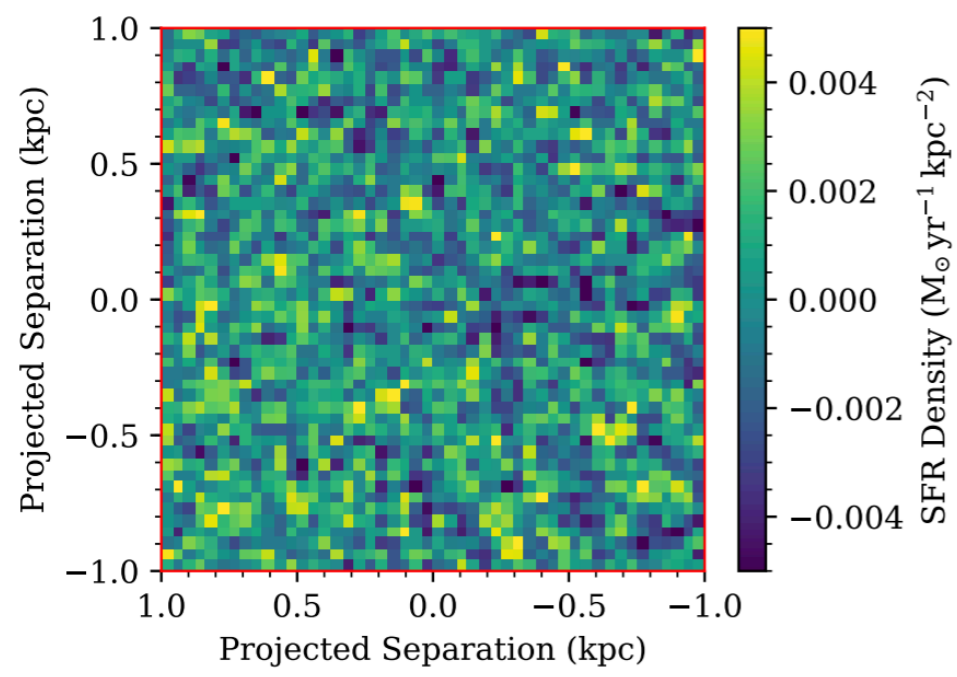
F300X, 3.4 h exposure



F625W, 17.5 min exposure



PS1-12sk is at 28 kpc projected separation from a Brightest Cluster (Elliptical) Galaxy

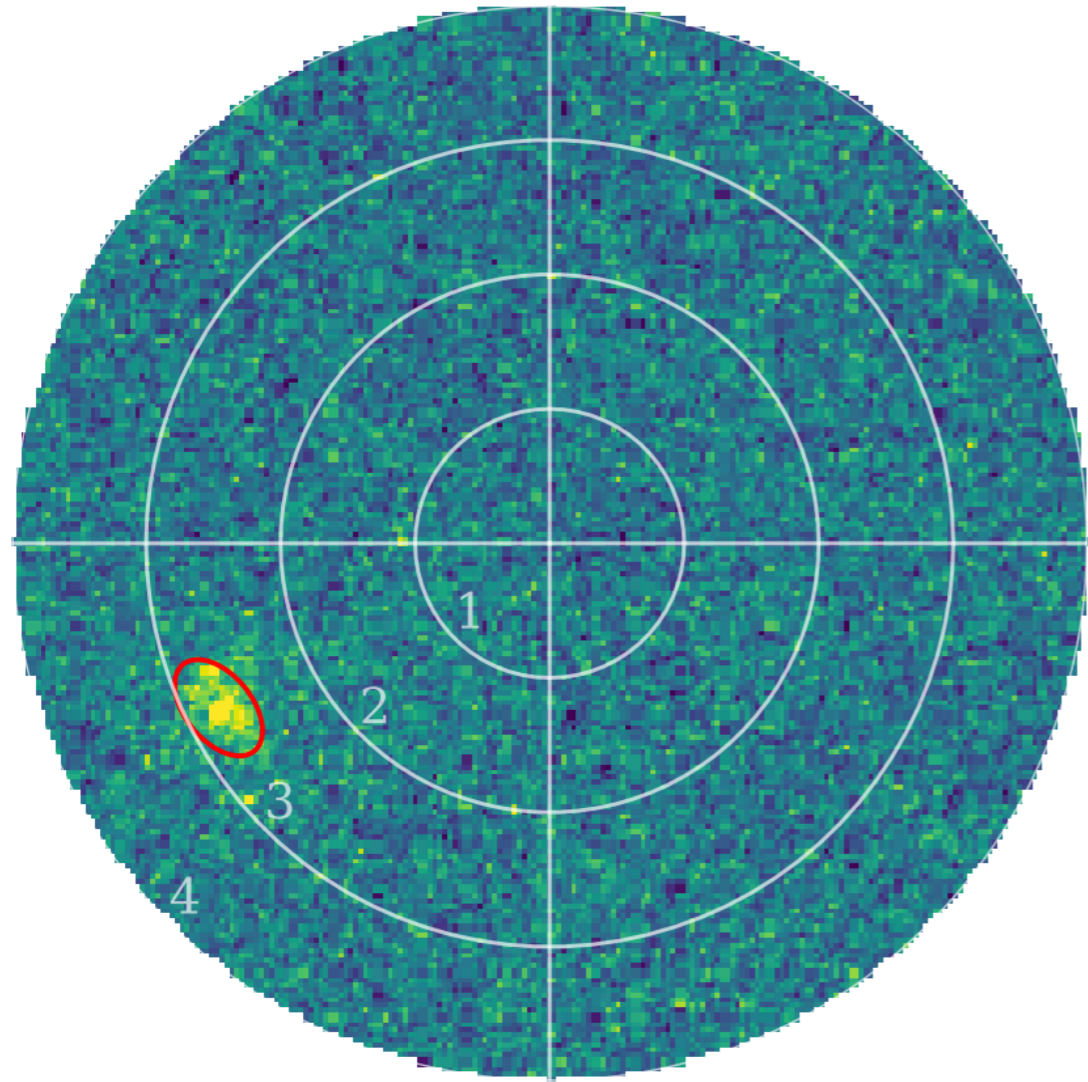


HST UV observations show no apparent star formation — see 2kpc x 2kpc region in bottom left.

F300X

N

E



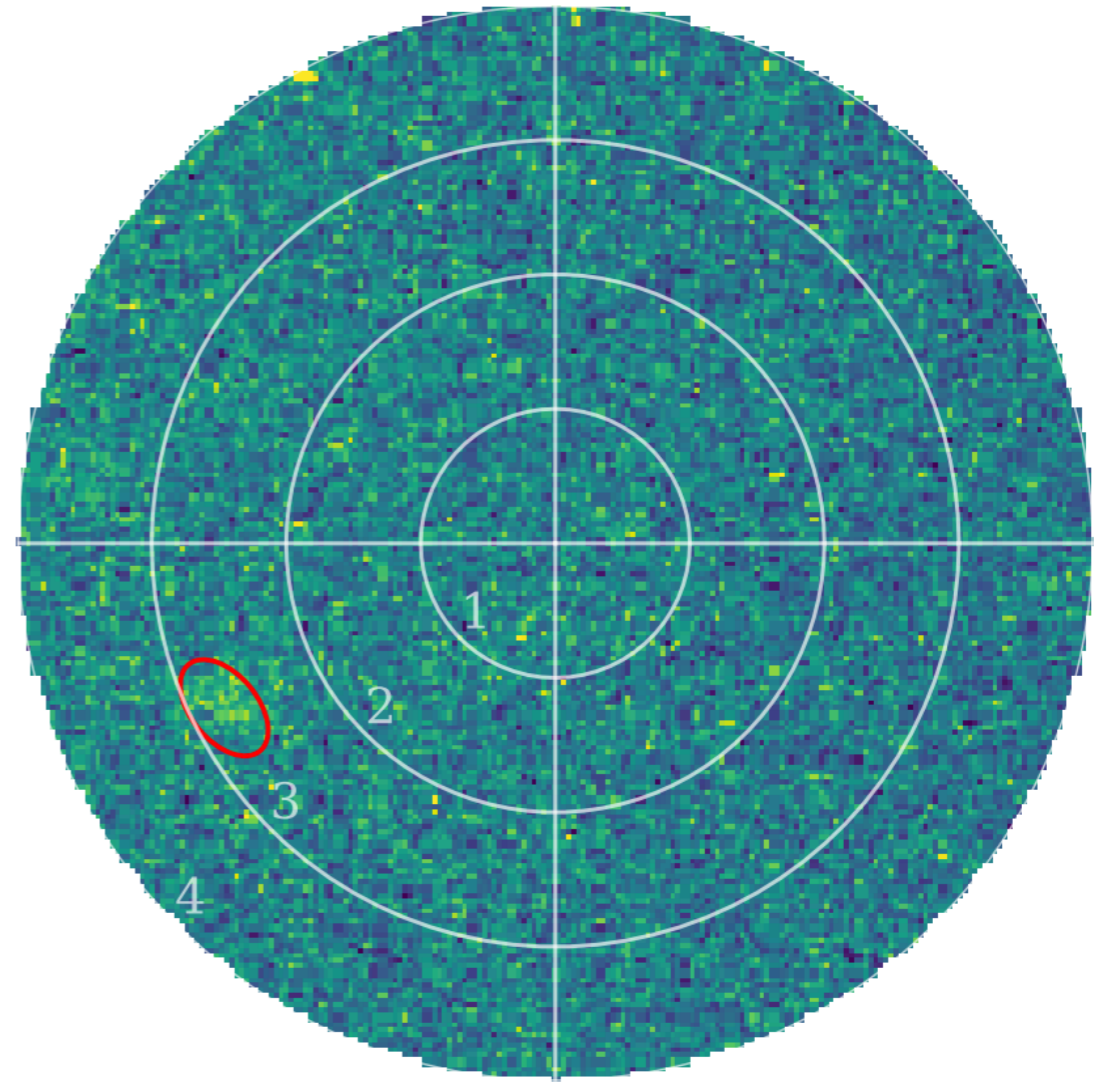
S

W

F625W

N

E



S

W

Rings are in kpc. Nearest source may be ultra-compact dwarf 2.7 kpc away.

28

26

24

22

20

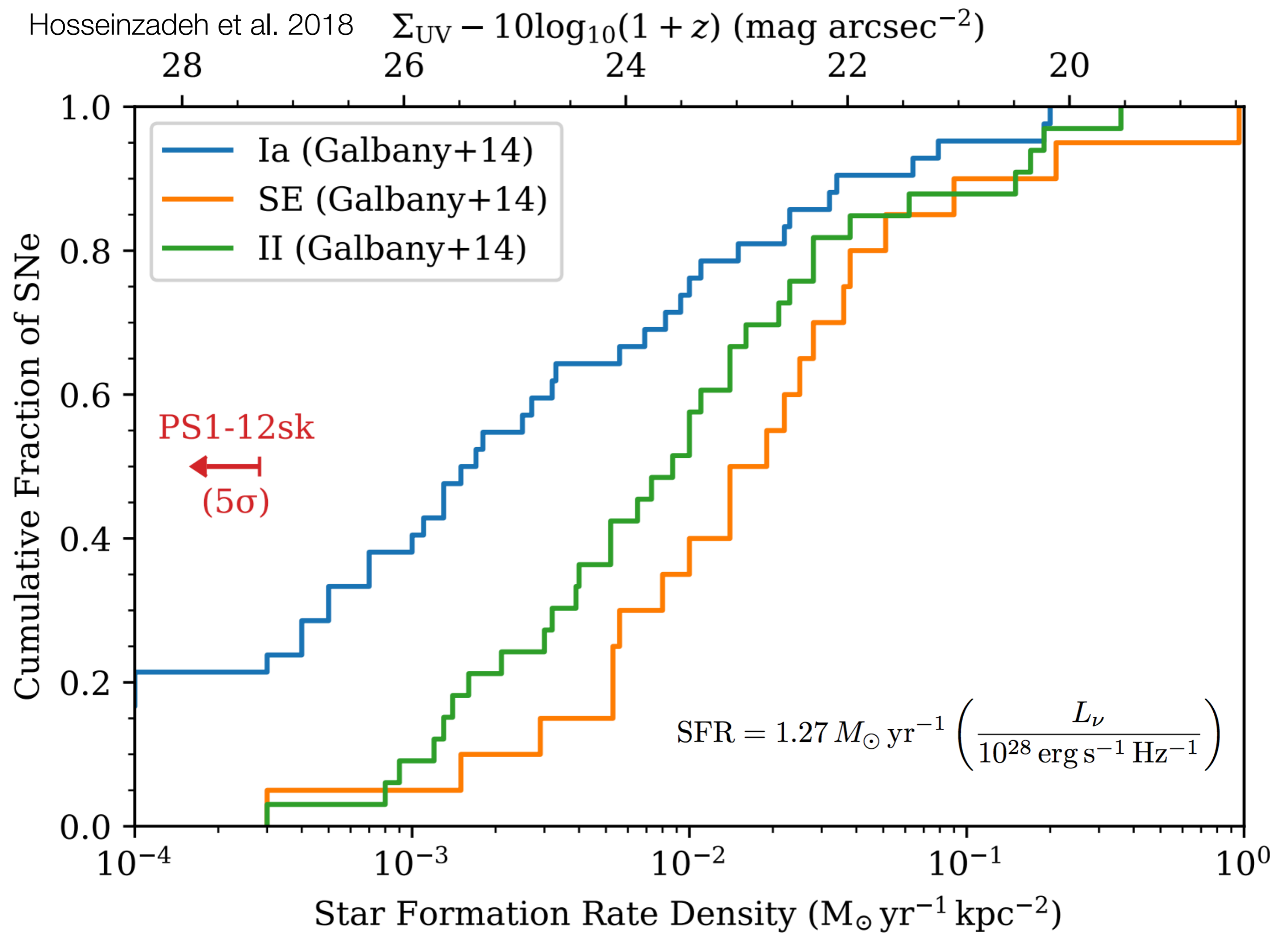
Cumulative Fraction of SNe

- Ia (Galbany+14)
- SE (Galbany+14)
- II (Galbany+14)

PS1-12sk

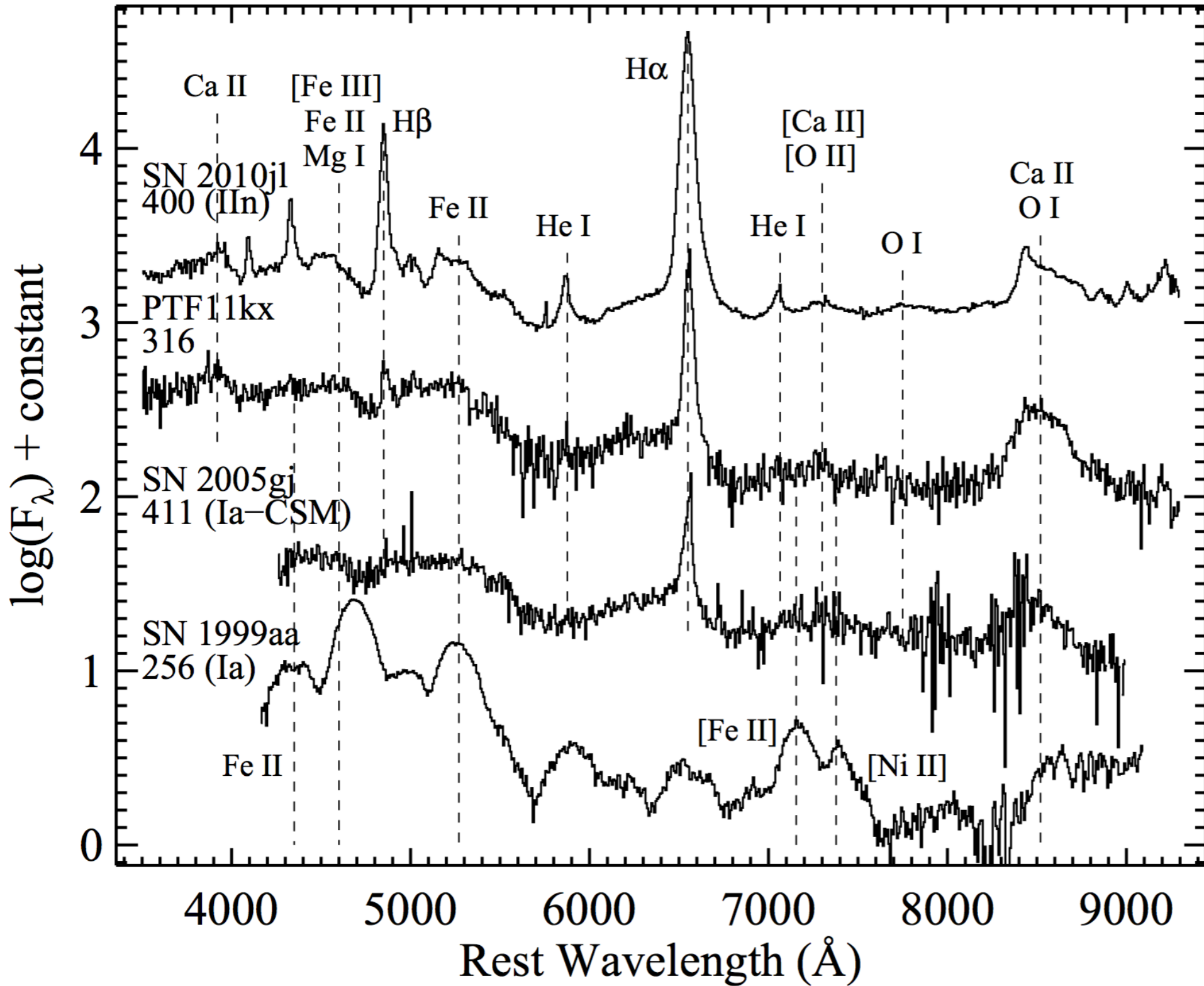
 (5σ)

$$\text{SFR} = 1.27 M_{\odot} \text{ yr}^{-1} \left(\frac{L_{\nu}}{10^{28} \text{ erg s}^{-1} \text{ Hz}^{-1}} \right)$$

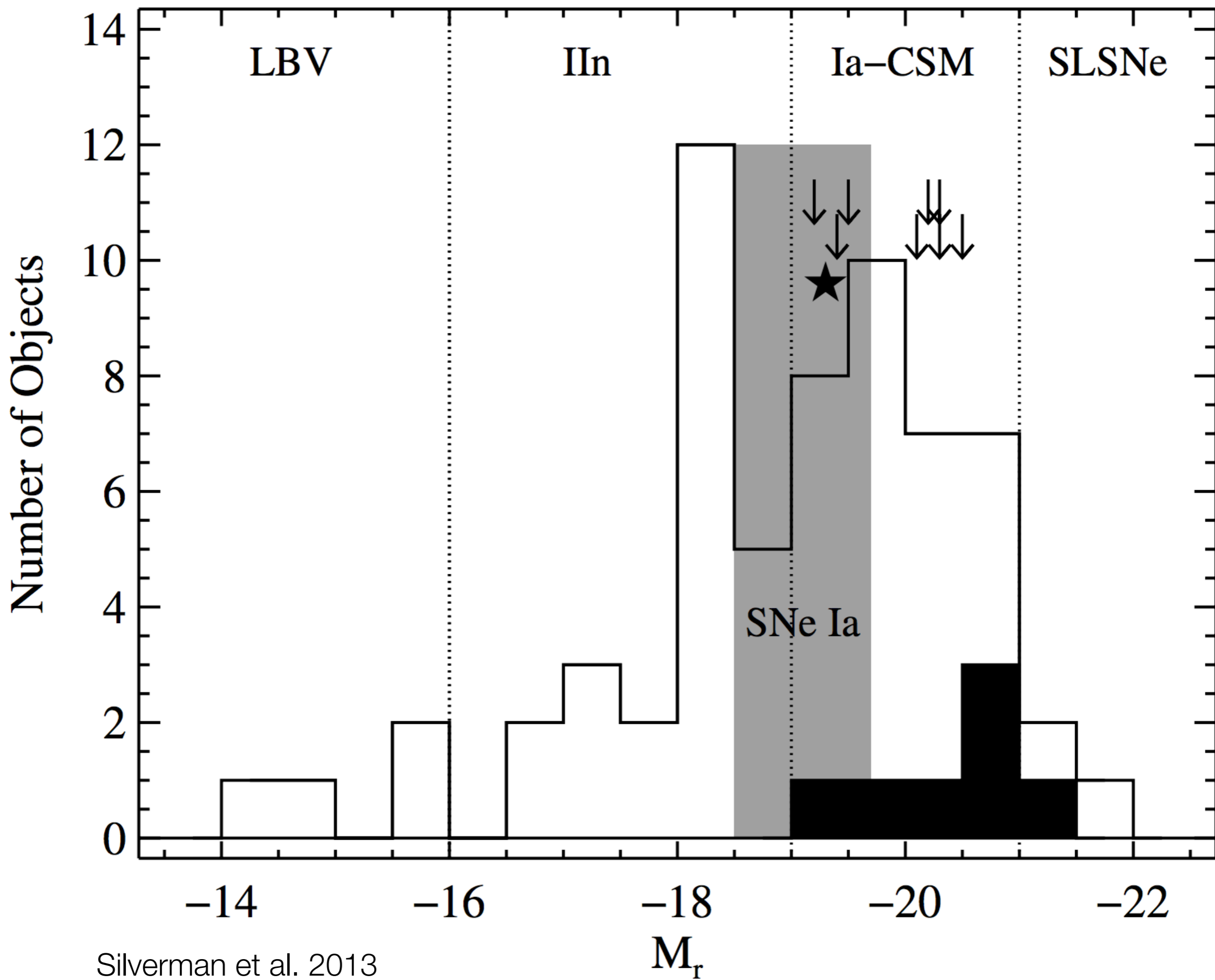
 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^0 Star Formation Rate Density ($M_{\odot} \text{ yr}^{-1} \text{ kpc}^{-2}$)

Possibilities

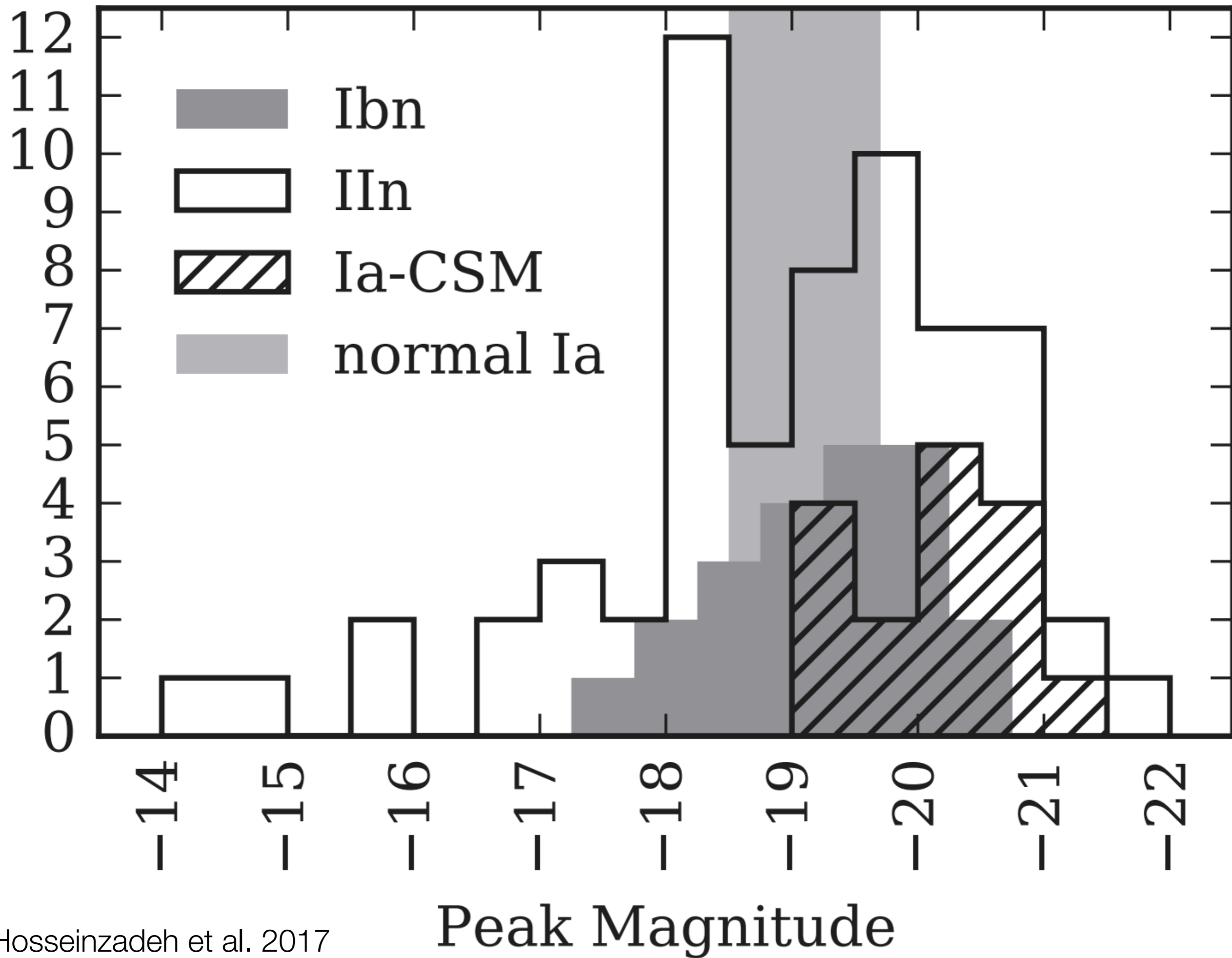
1. Hypervelocity Star (>2.7 kpc in 5M yrs, >530 km/s).
2. Luck - star formation just shut off in the last 5 million years. But this would be the first time this has been seen. “We would expect this a few times per 100 million years per kpc².”
3. Some SNe Ibn do not come from massive stars



Not all SNe IIn are core collapse! Some are SNe Ia exploding in H-rich environment.



Observed Number



What is the progenitor?

Could a white dwarf be exploding in a He-rich environment?

He nova?

.Ia supernovae? He shell detonations on CO white dwarfs accreting from He white dwarfs (AM CVn systems; Bildsten et al. 2007, Shen et al. 2010). But doesn't match theoretical predictions.

Are all SNe Ibn the same?

Are SNe Ib...

Ib or not Ib, that is the question (Shakespeare, 1603)