

# **Cosmic Explosions: Observations Of Infant Hydrogen-Free Supernovae Towards An Understanding Of Their Parent Systems**

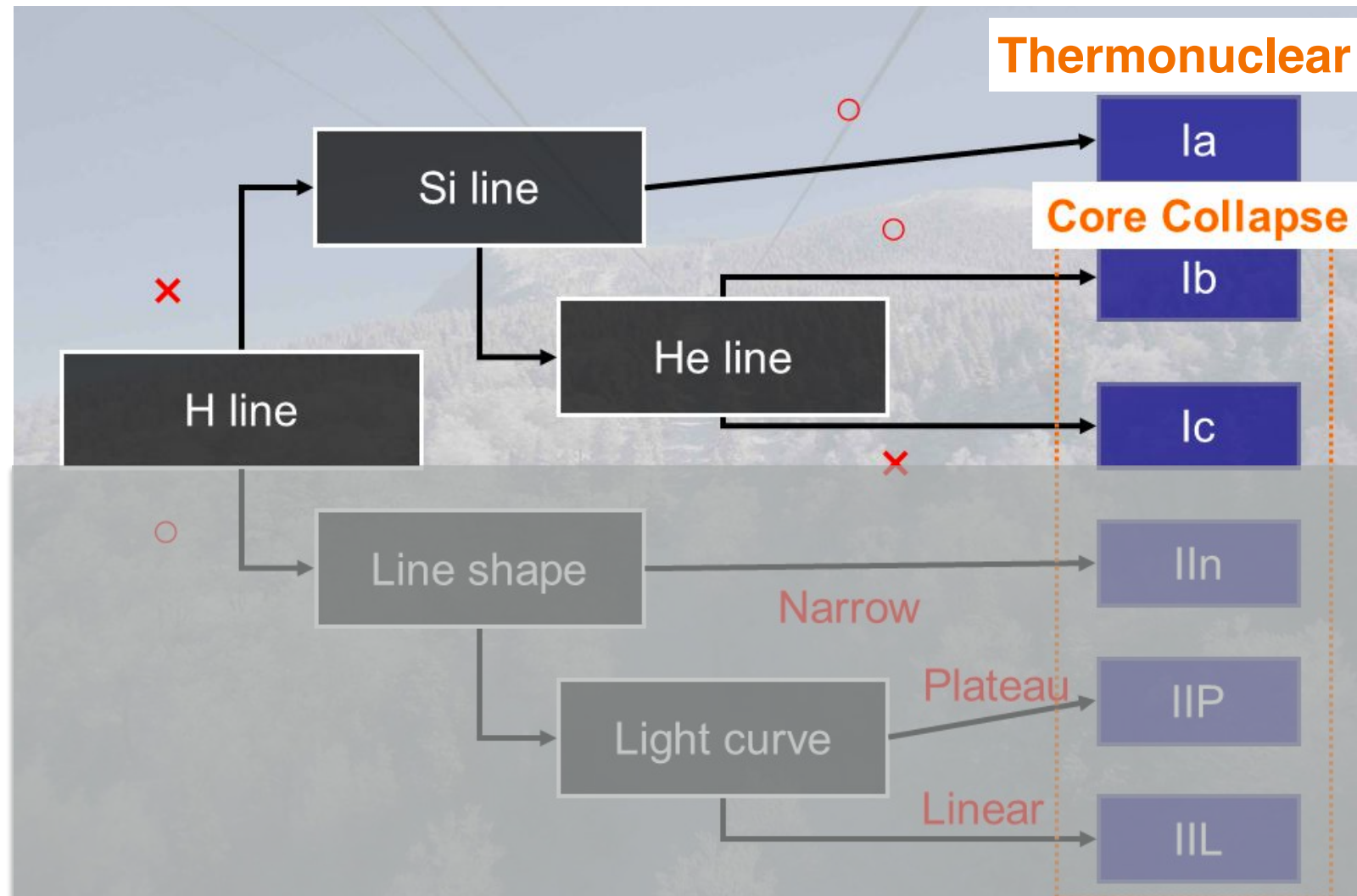
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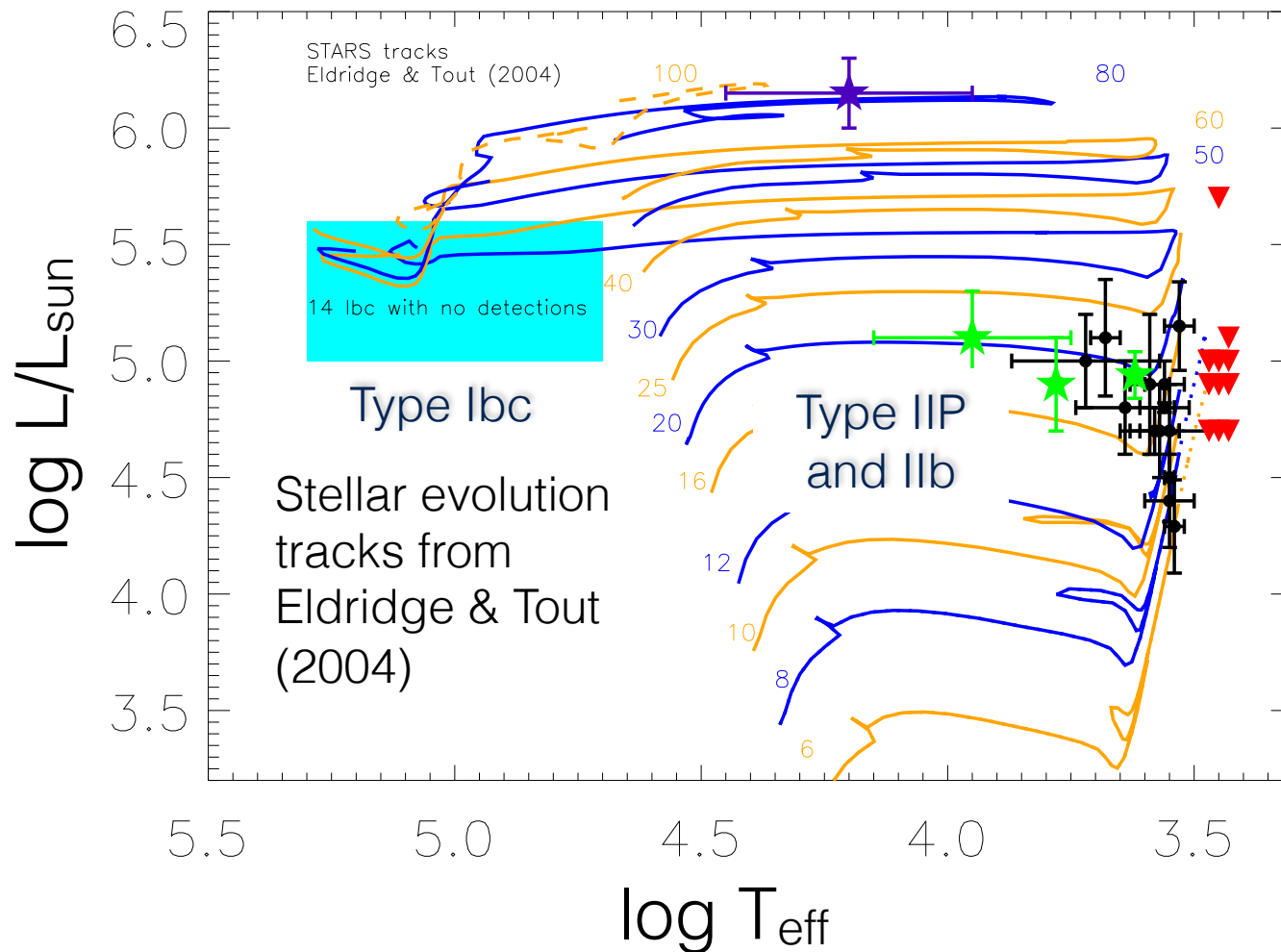
<http://www.astro.caltech.edu/~ycao>

(Advisor: S. R. Kulkarni)

# Supernova classification



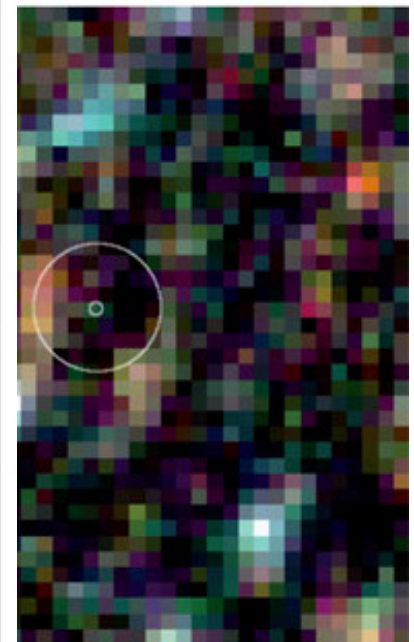
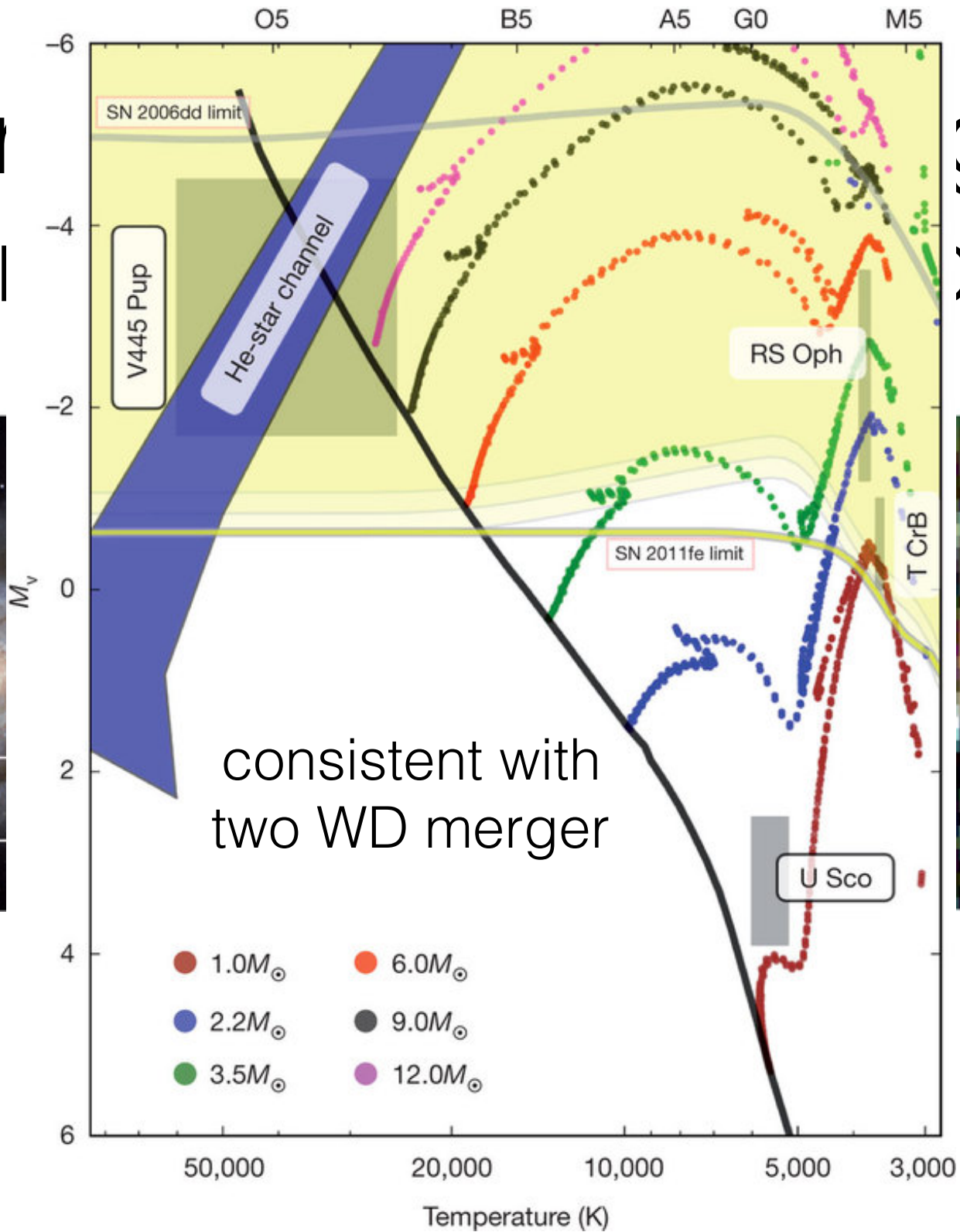
# Pre-Explosion Imaging: Core-Collapse Supernovae



(Smartt et al. 2015)

Pr  
Thei

g:  
ovae



(Li et al. 2011)



# Obs. of a SN within a few days of its explosion are important.

- Simple physics: free expansion + adiabatic cooling -> the size of the pre-explosion star
- New signature: SN ejecta hits a companion star.

# Fast, Faster, Fastest

48-inch Telescope at Palomar Observatory monitors the sky on a nightly cadence.



Supercomputer delivers transient candidates within 10 minutes of images being taken.

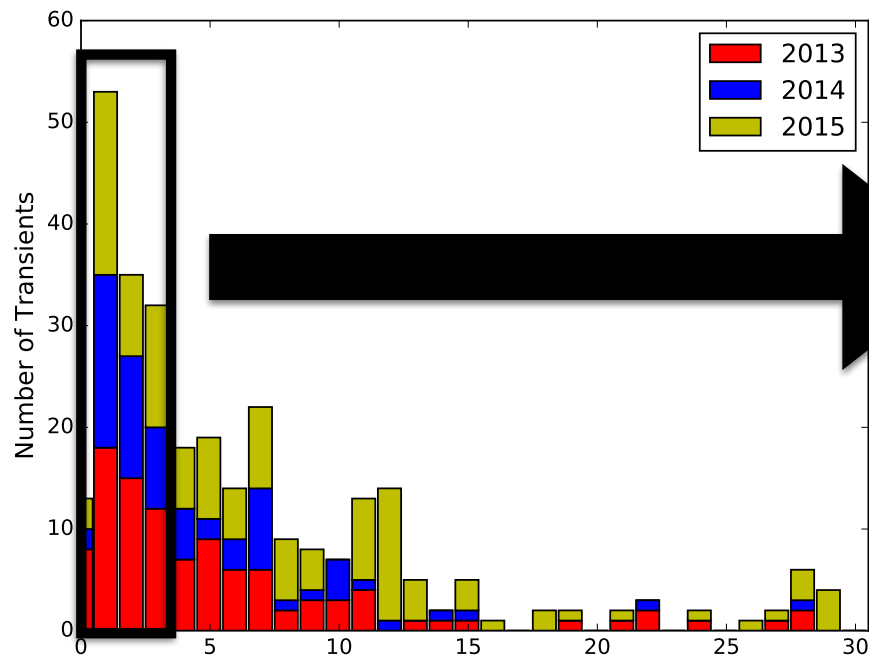


Telescopes around the world perform immediate follow-up observations.

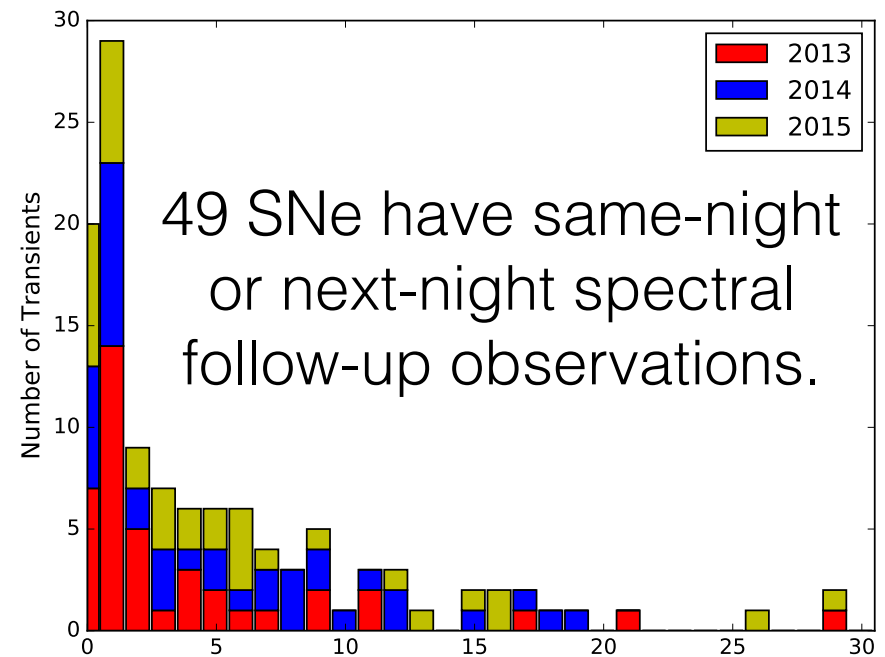
**GROWTH**

(Cao 2016 PhDT; Cao et al. submitted to PASP)

# iPTF Transient Surveys Science Performance



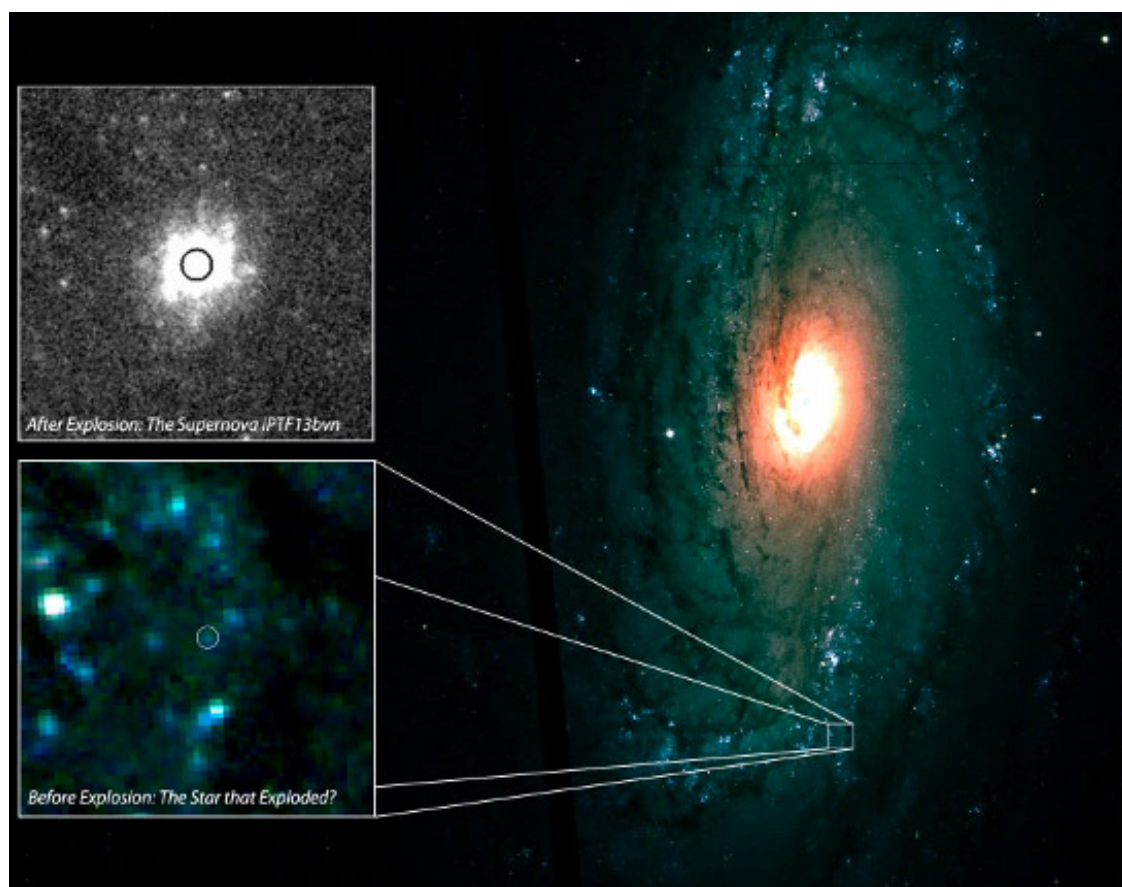
Discovery — Last  
Upper Limit (days)



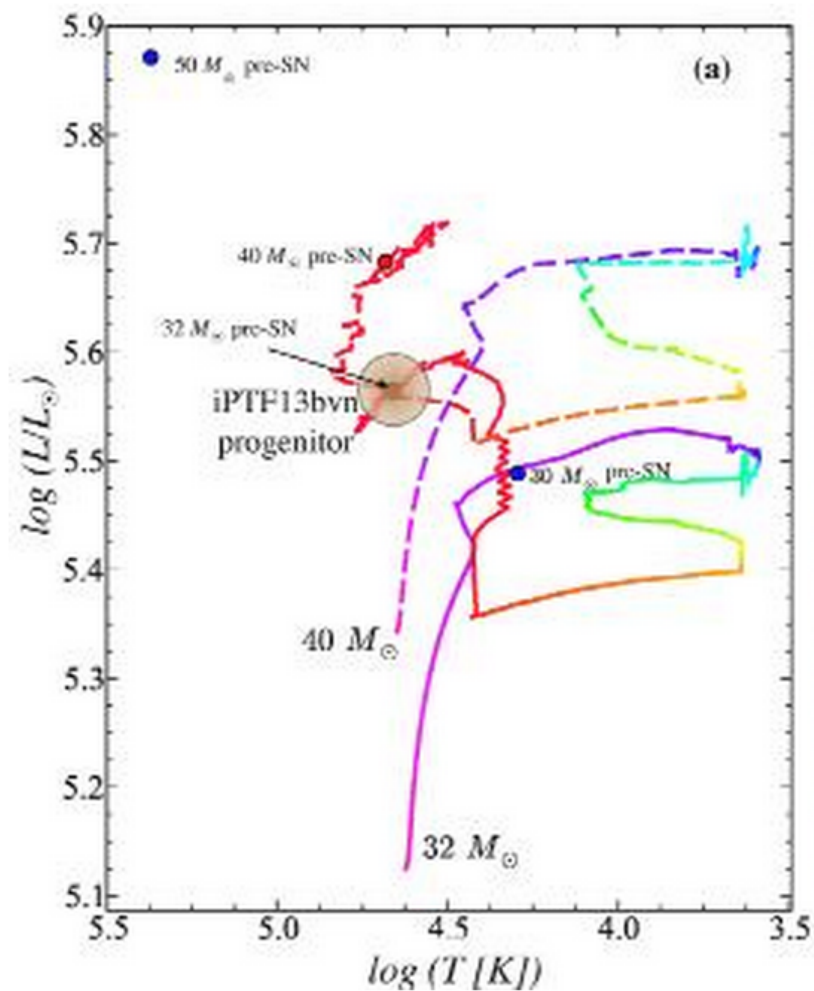
49 SNe have same-night  
or next-night spectral  
follow-up observations.

1st Spec.Obs.  
— Discovery (days)

# Progenitor of Type Ib SN iPTF13bvn: a blue star

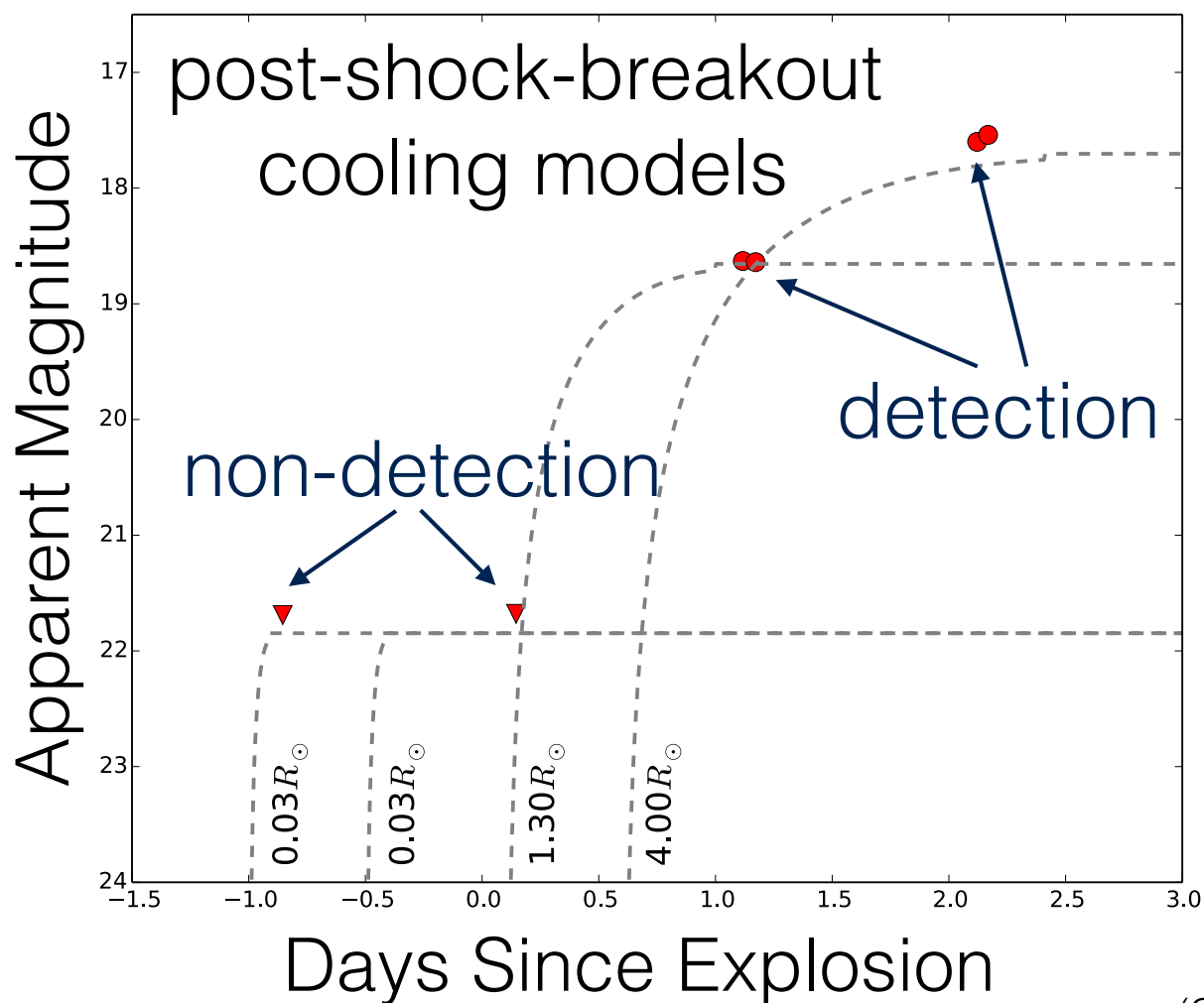


(Cao et al. 2013)



(Groh et al. 2013)

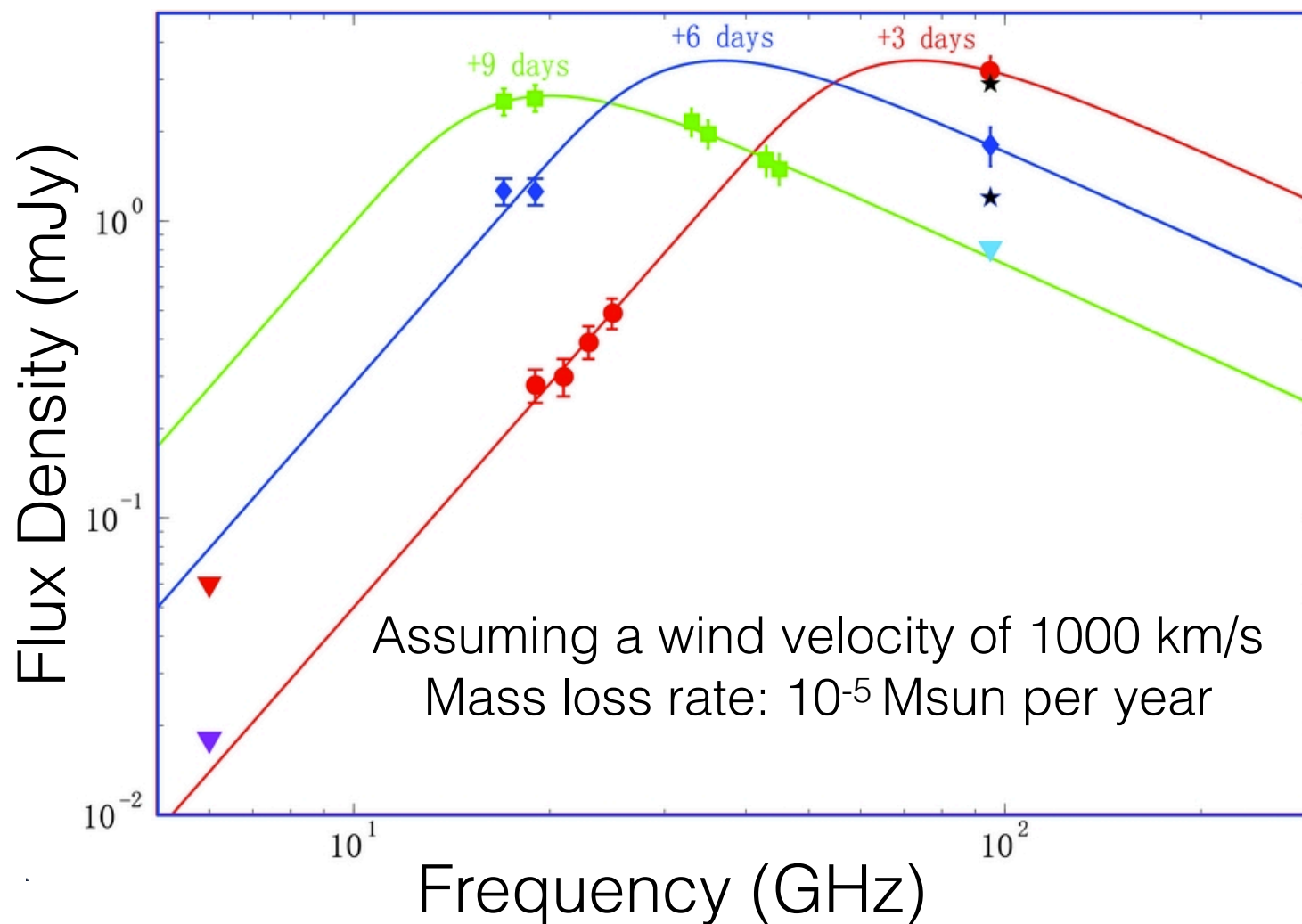
# Progenitor of Type Ib SN iPTF13bvn: a compact star



(Cao et al. 2013)

YC - GROWTH 2016

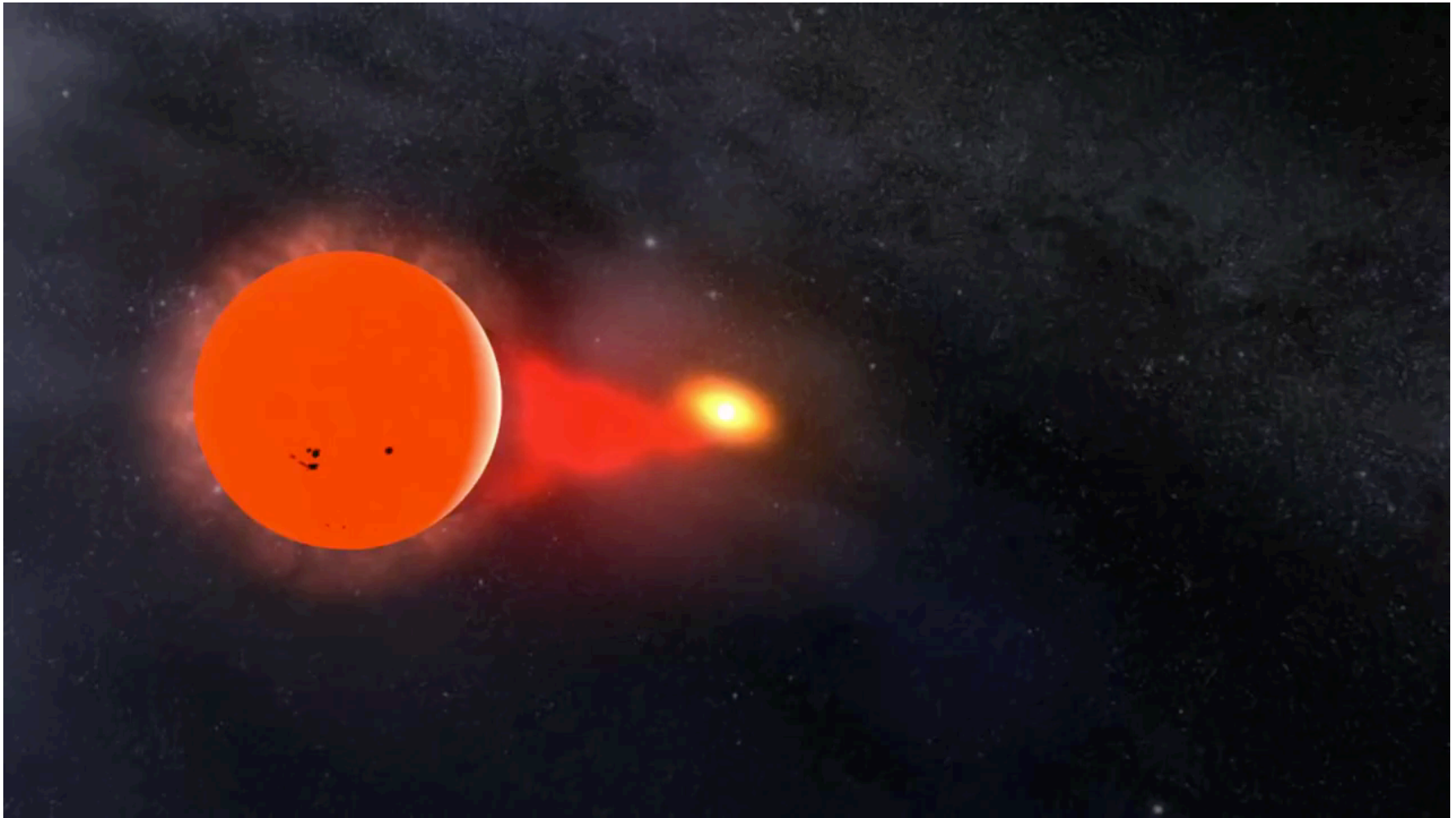
# Progenitor of Type Ib SN iPTF13bvn: a star with strong mass loss



(Cao et al. 2013)

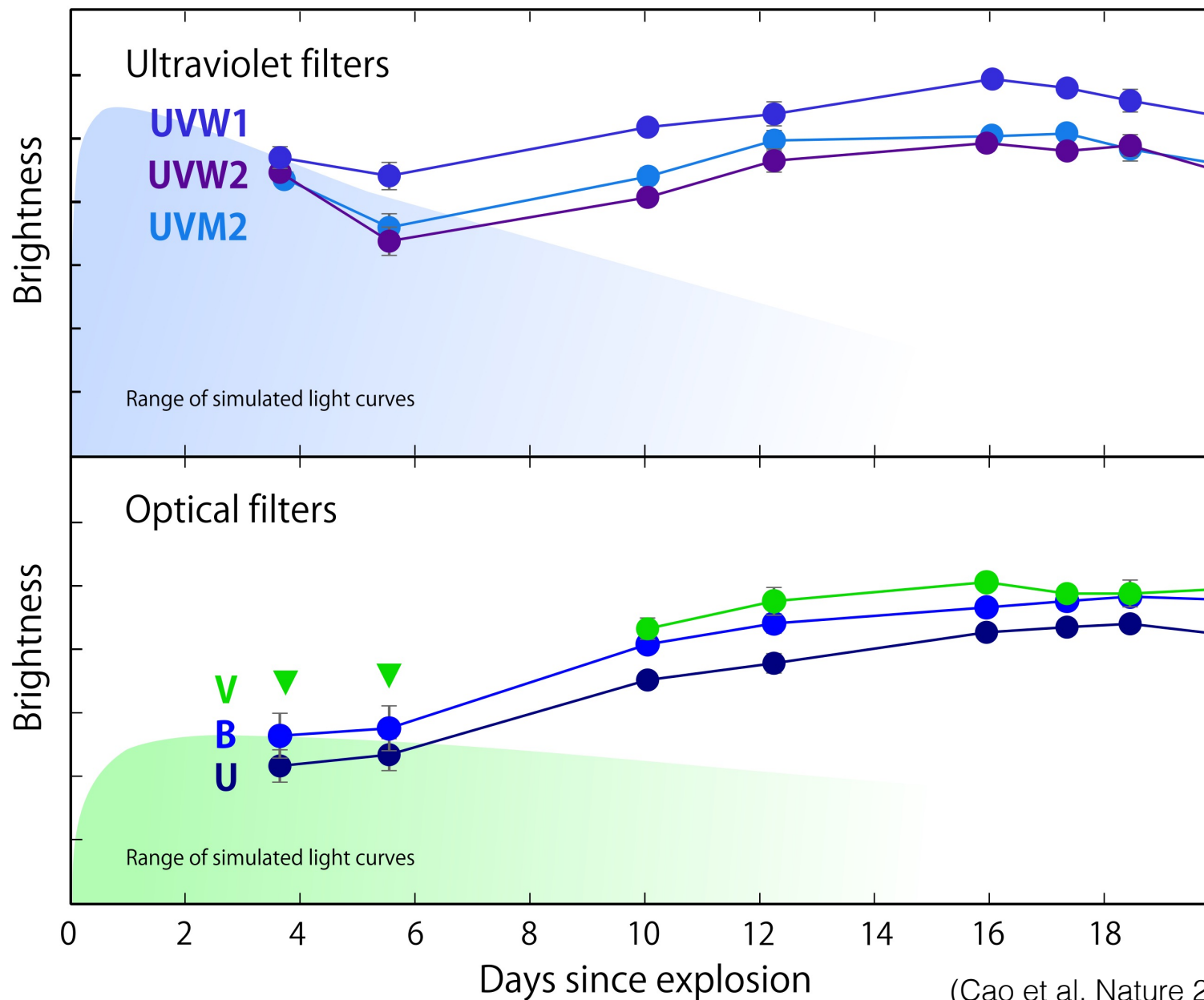


# Thermonuclear Supernovae: Single Degenerate Progenitors



(Credits: NASA's Goddard Space Flight Center/Walt Feimer)

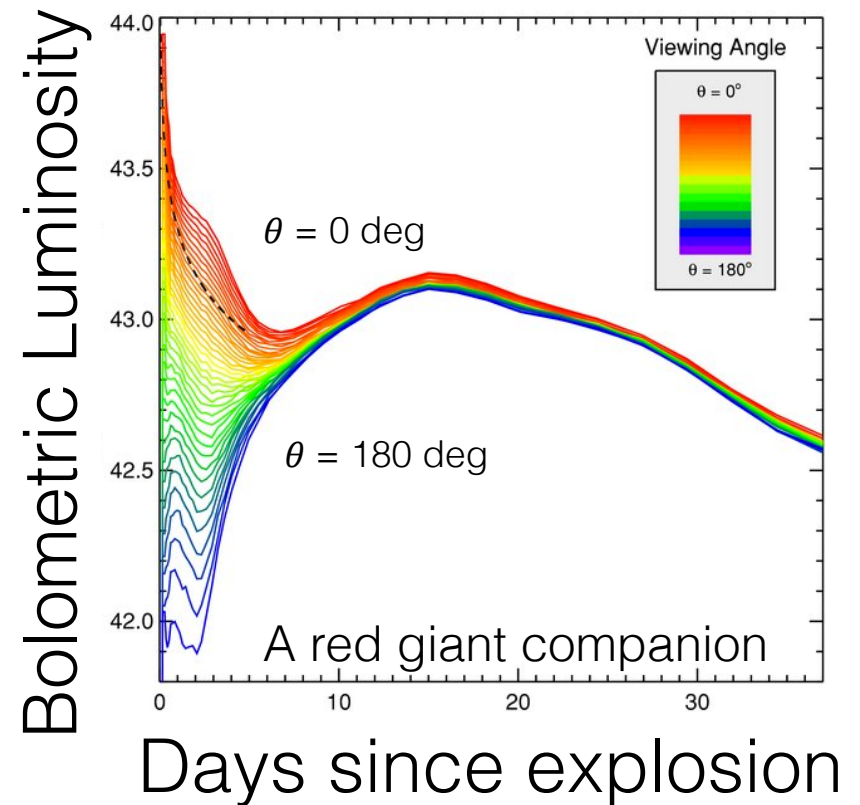
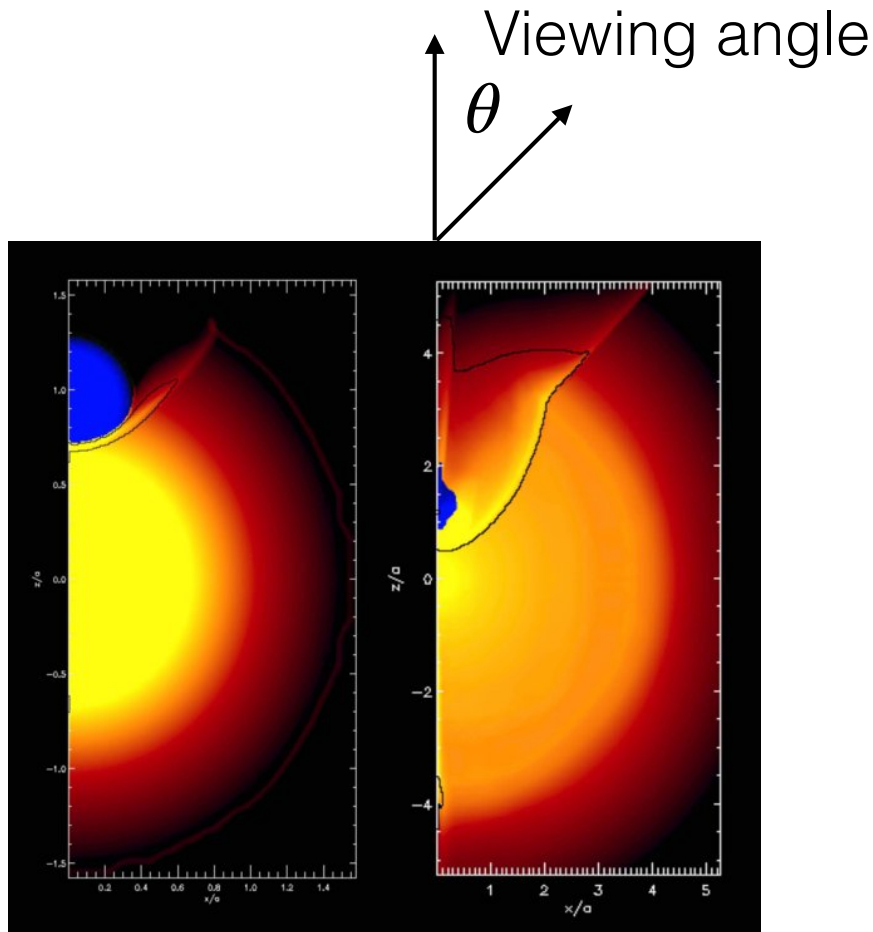
# Swift Observations of Supernova iPTF14atg



(Cao et al. Nature 2015)

Image Credit: F. Reddy (NASA/Goddard)

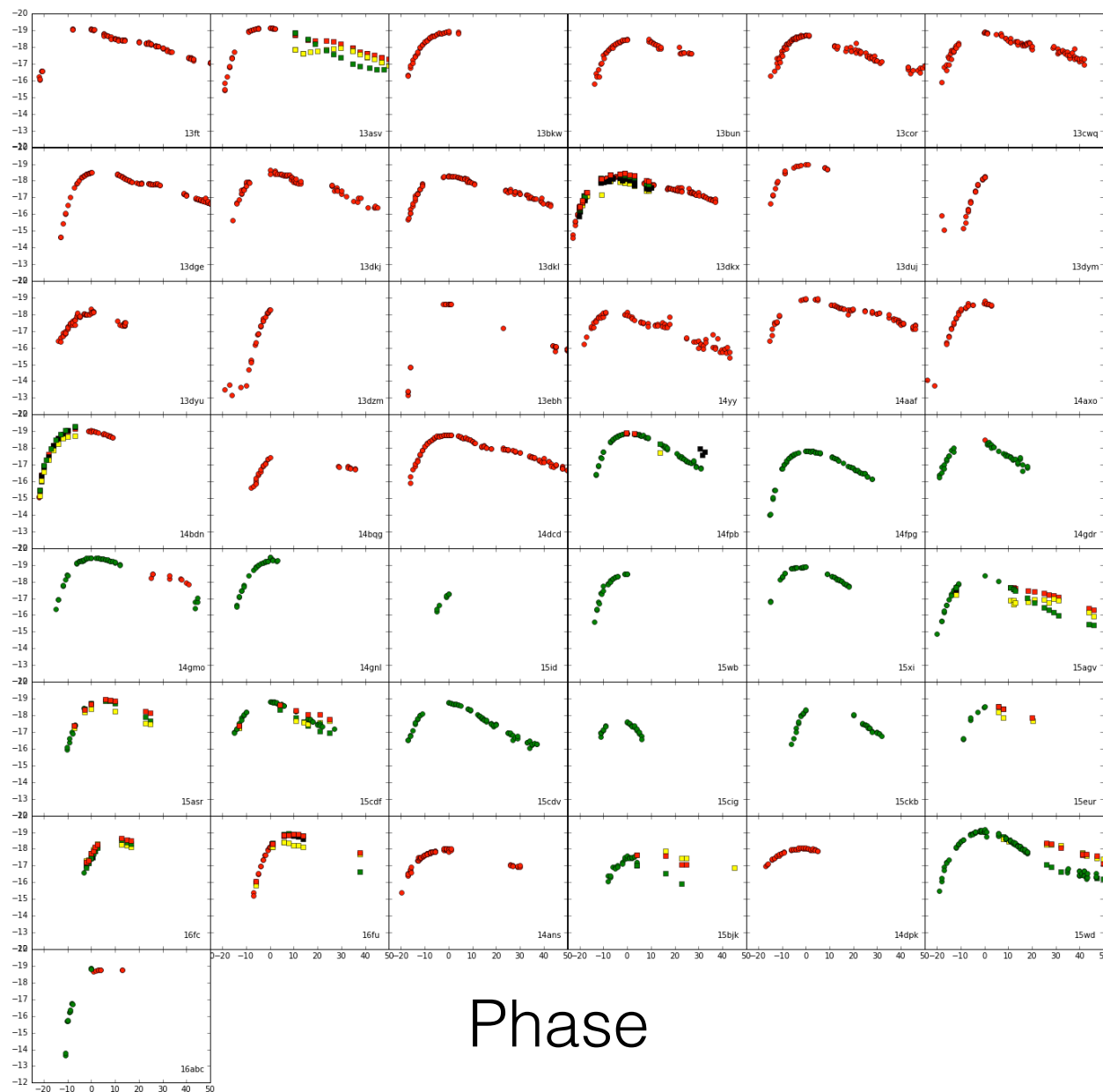
# SN-companion interaction is expected to be seen in the UV



(Kasen 2010)

# Young Type Ia sample

Absolute Magnitudes



iPTF will continue operating until Feb 2017.

Current sample:  
43 Young Type Ia SNe  
( $z < 0.07$ ), 10 of them with  
early Swift data

Science questions:  
Fraction of SN-companion  
collision -> Fraction of  
SNe Ia from the single-  
degenerate channel

(Cao et al. in prep.)

# Conclusions

- Our fast-cadence transient surveys equipped with fast-turnaround data processing software have pushed the latency time between occurrence of a transient and detailed observations of the transient to a few hours.
- We identified the first Type Ib SN progenitor in the pre-explosion images and constrained its progenitor radius and mass loss history from the early-phase optical and radio observations.
- We observed a strong and declining UV pulse from a low-velocity Type Ia SN. The UV pulse probably arises from the SN-companion collision, providing evidence for the single-degenerate progenitor hypothesis.