

Very late-time observations of stripped envelope SNe

GIACOMO TERRERAN

Margutti, Coppejans, Milisavljevic,
Alexander, Bersier, Dong, Chornock,
Caprioli, Cartier, Patnaude



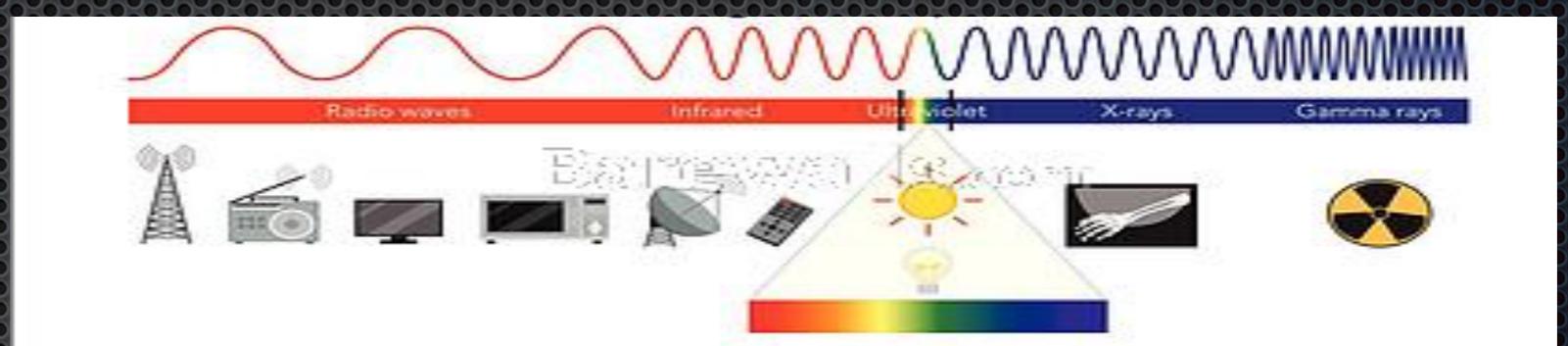
SUPERNOVA REMNANTS
AN ODYSSEY IN SPACE AFTER STELLAR DEATH
6 - 11 JUNE 2016, CHANIA, CRETE, GREECE



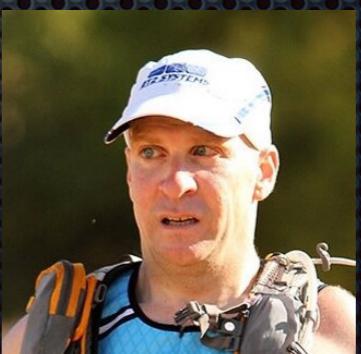
Northwestern
University

C I E R A

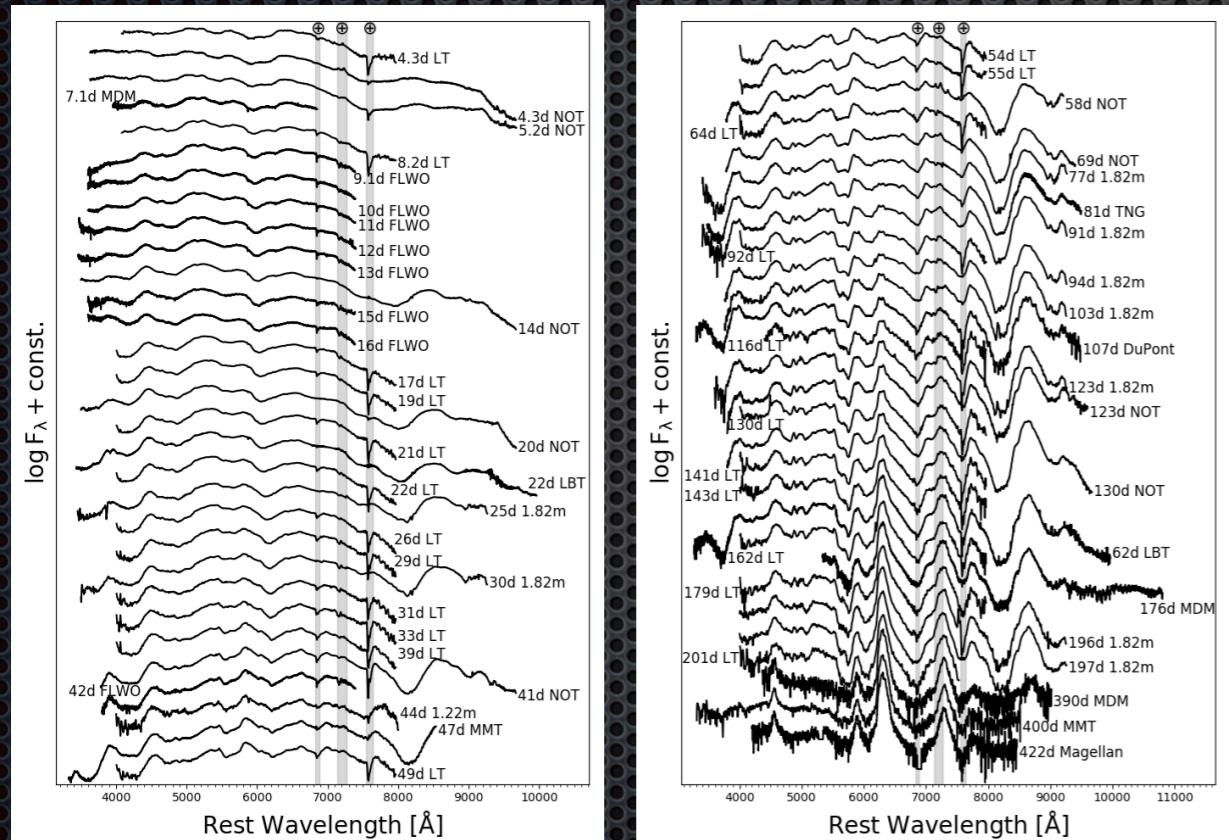
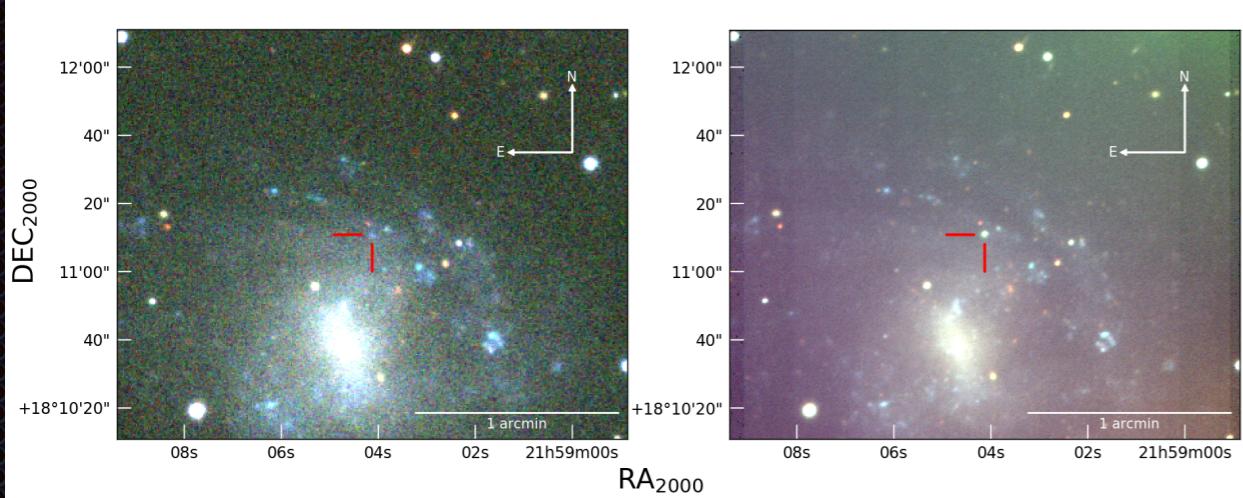
Margutti's group at CIERA



and collaborators

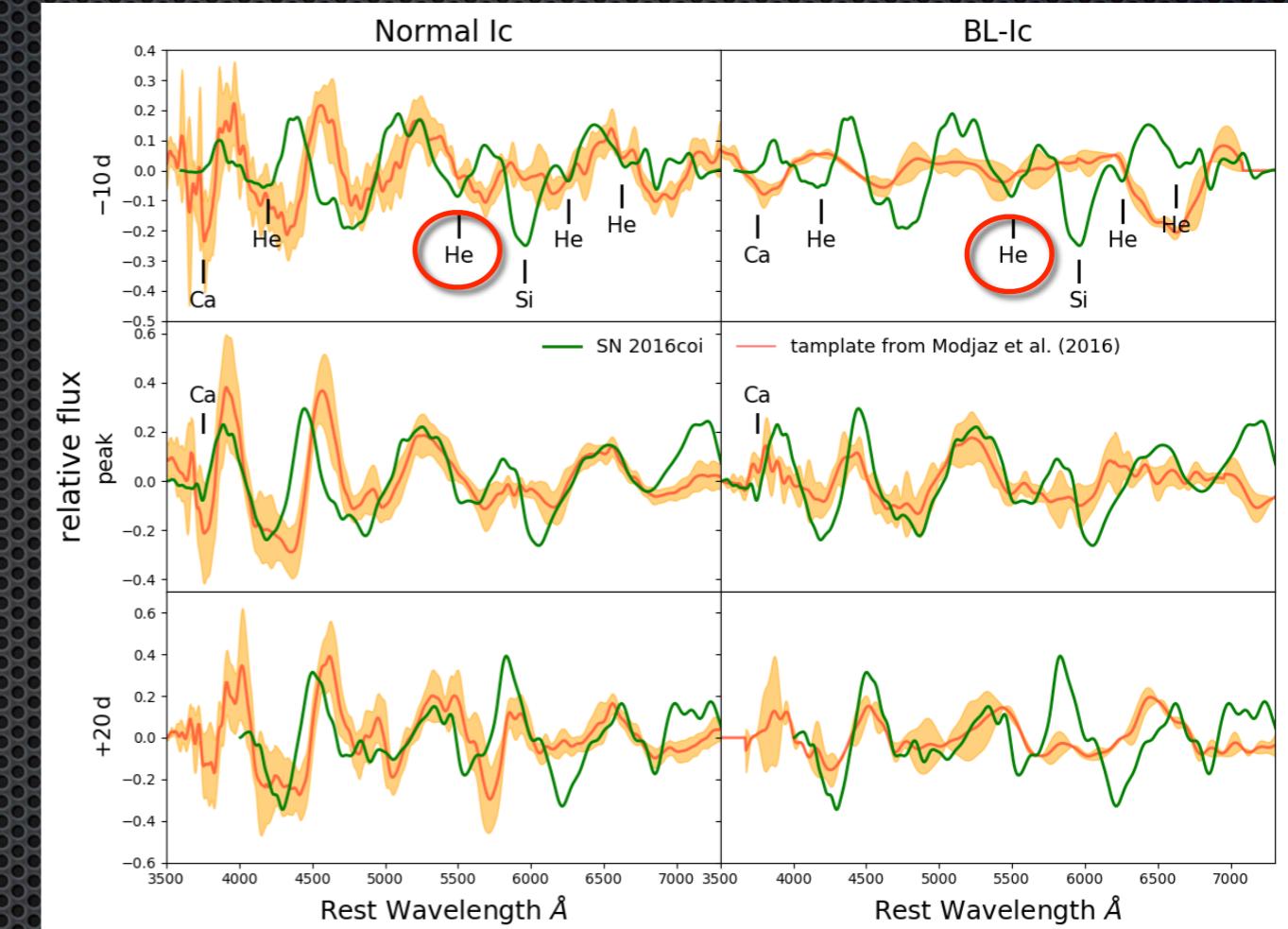


SN 2016coi / ASASSN-16fp



Terreran et al. 2019, arXiv:1905.02226

03 Jun 2019



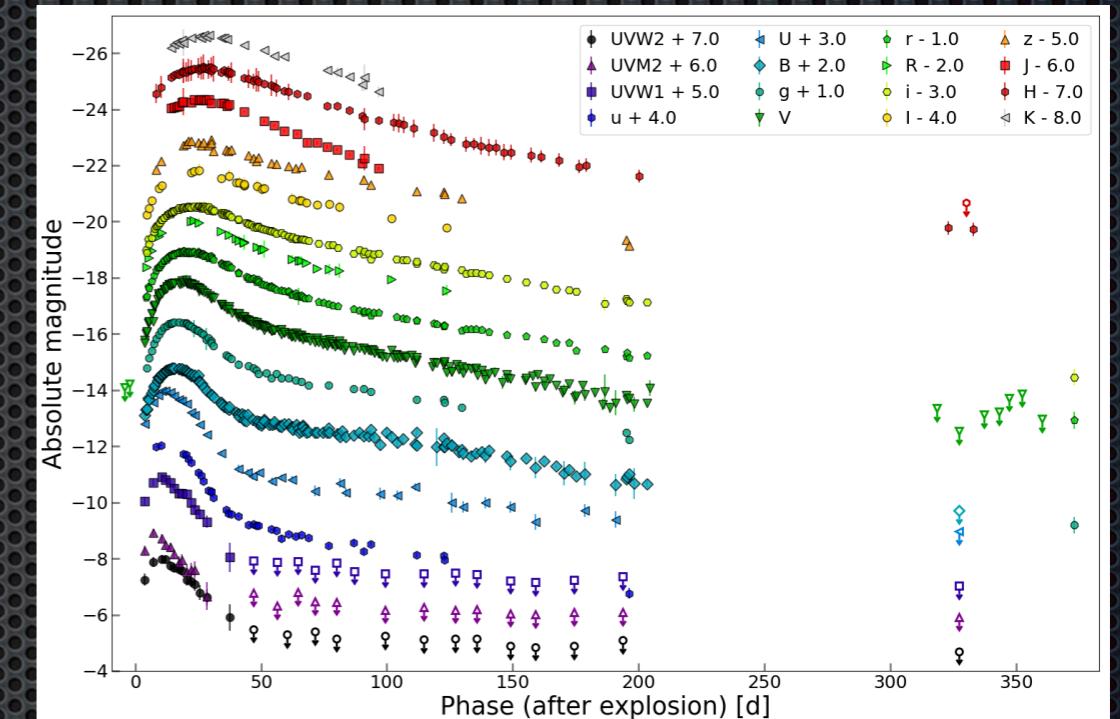
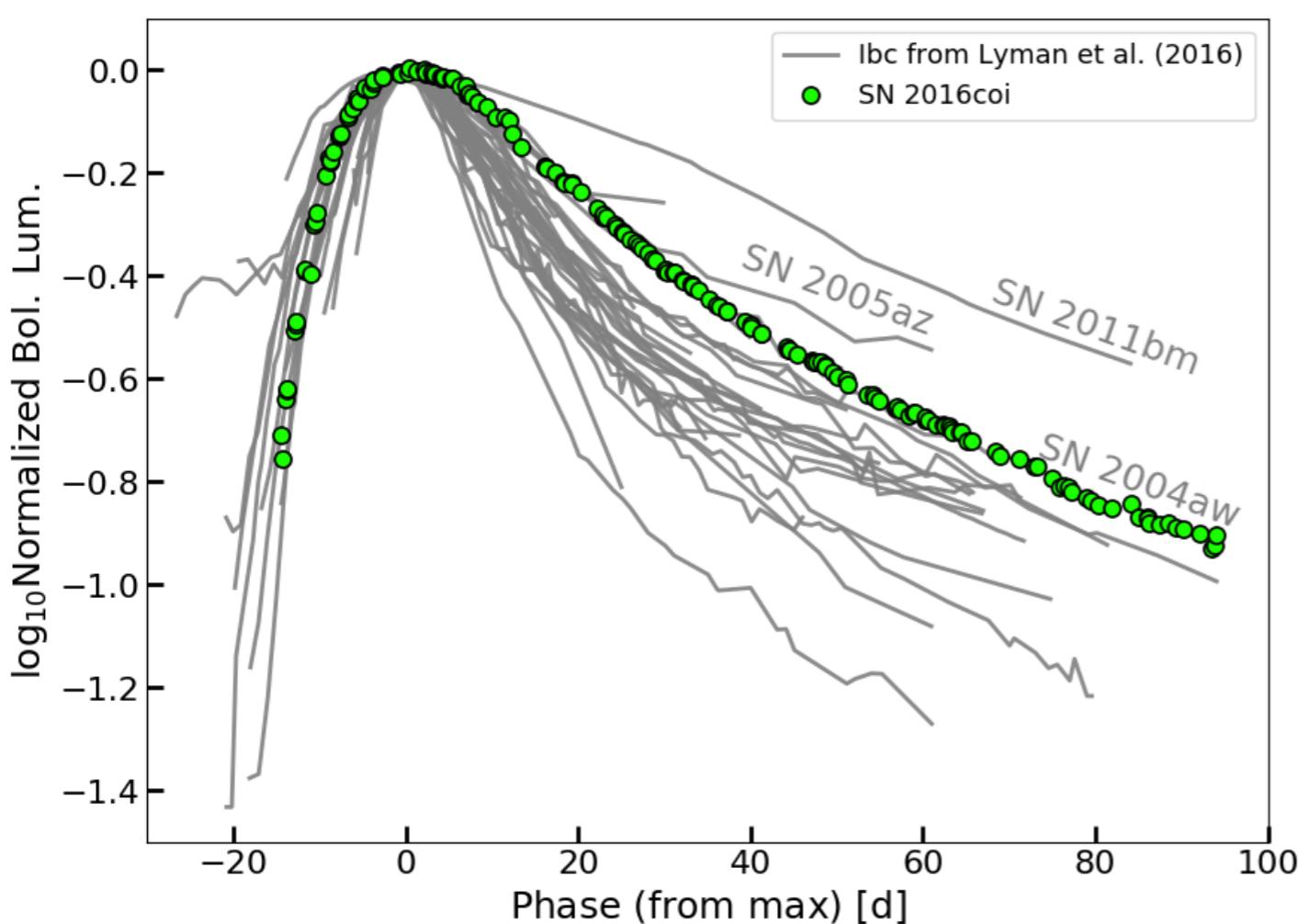
Templates from Modjaz et al., 2016, ApJ, 832, 108

Similarities with both
Ic and Ic-BL SN
But with He!!

Chania

G. Terreran

Bolometric light curve

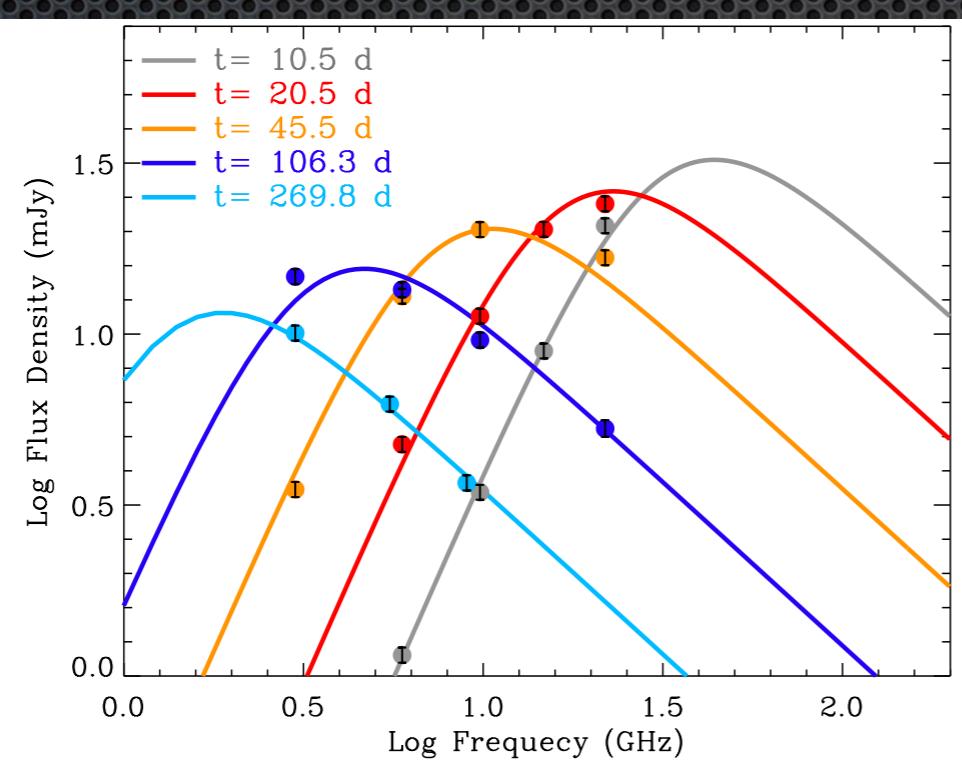
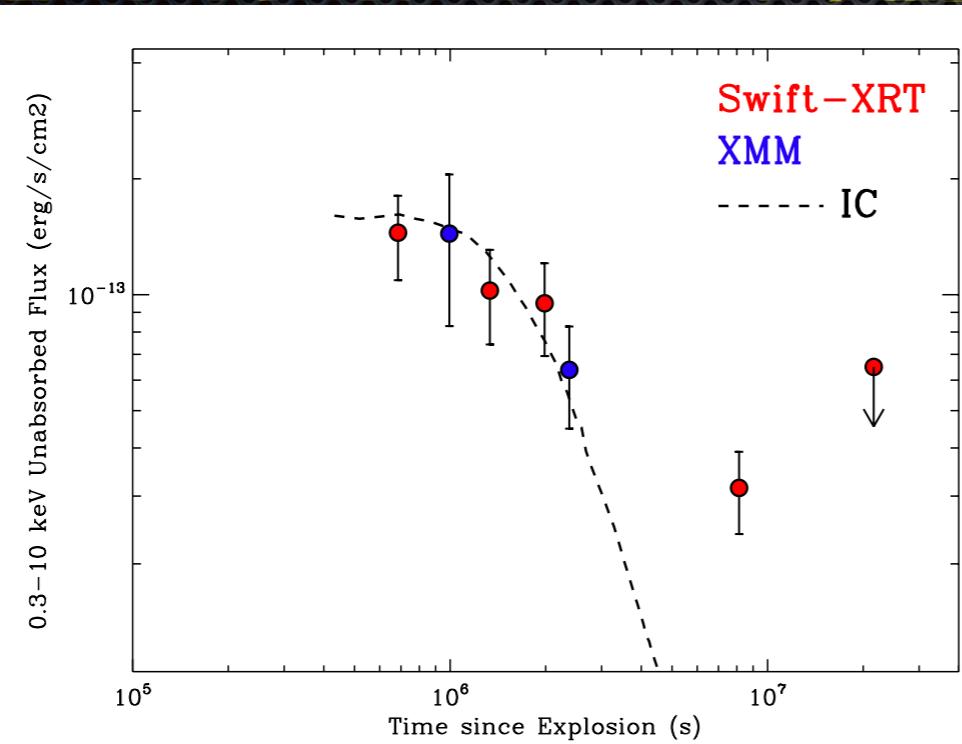


$M_{ej} \sim 4-7 M_{\odot}$
 $E_k \sim 7-8 \times 10^{51} \text{ erg}$
 $M_{Ni} \sim 0.15 M_{\odot}$

Massive ejecta!

Multi-wavelength follow-up

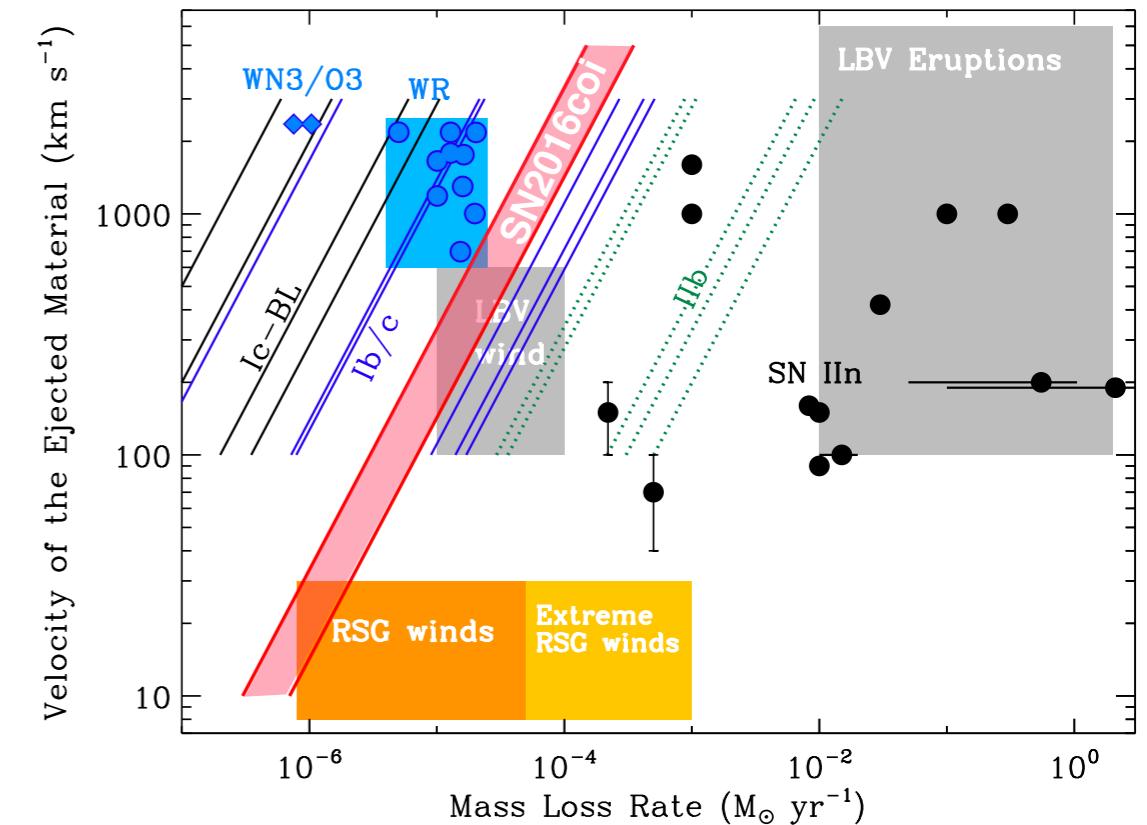
X-rays



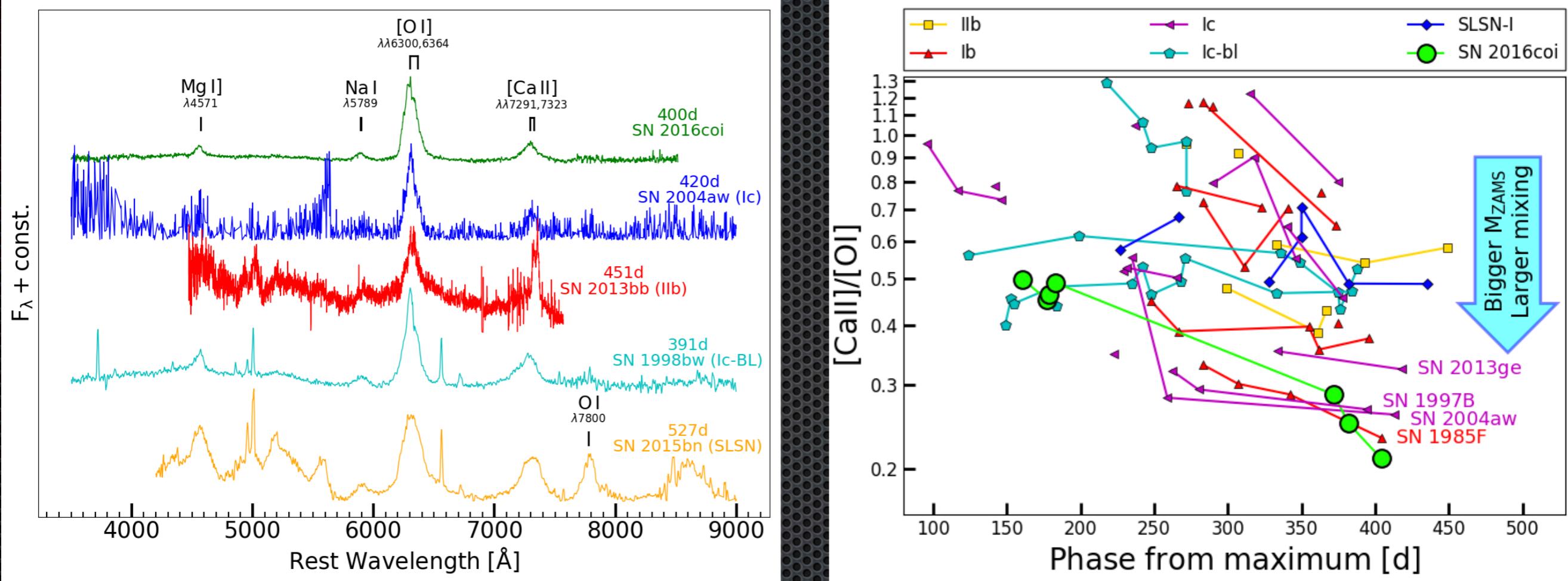
Radio

$$\dot{M} \sim (3 - 7) 10^{-5} M_{\odot} \text{ yr}^{-1}$$

$$v_{\text{sh}} \sim 0.25 c$$



[Ca II]/[O I] ratio



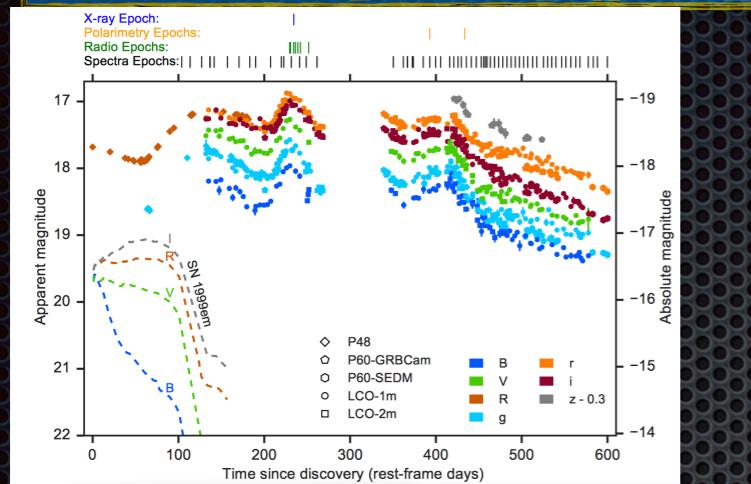
Massive ZAMS progenitor

Northwestern @ Keck & MMT



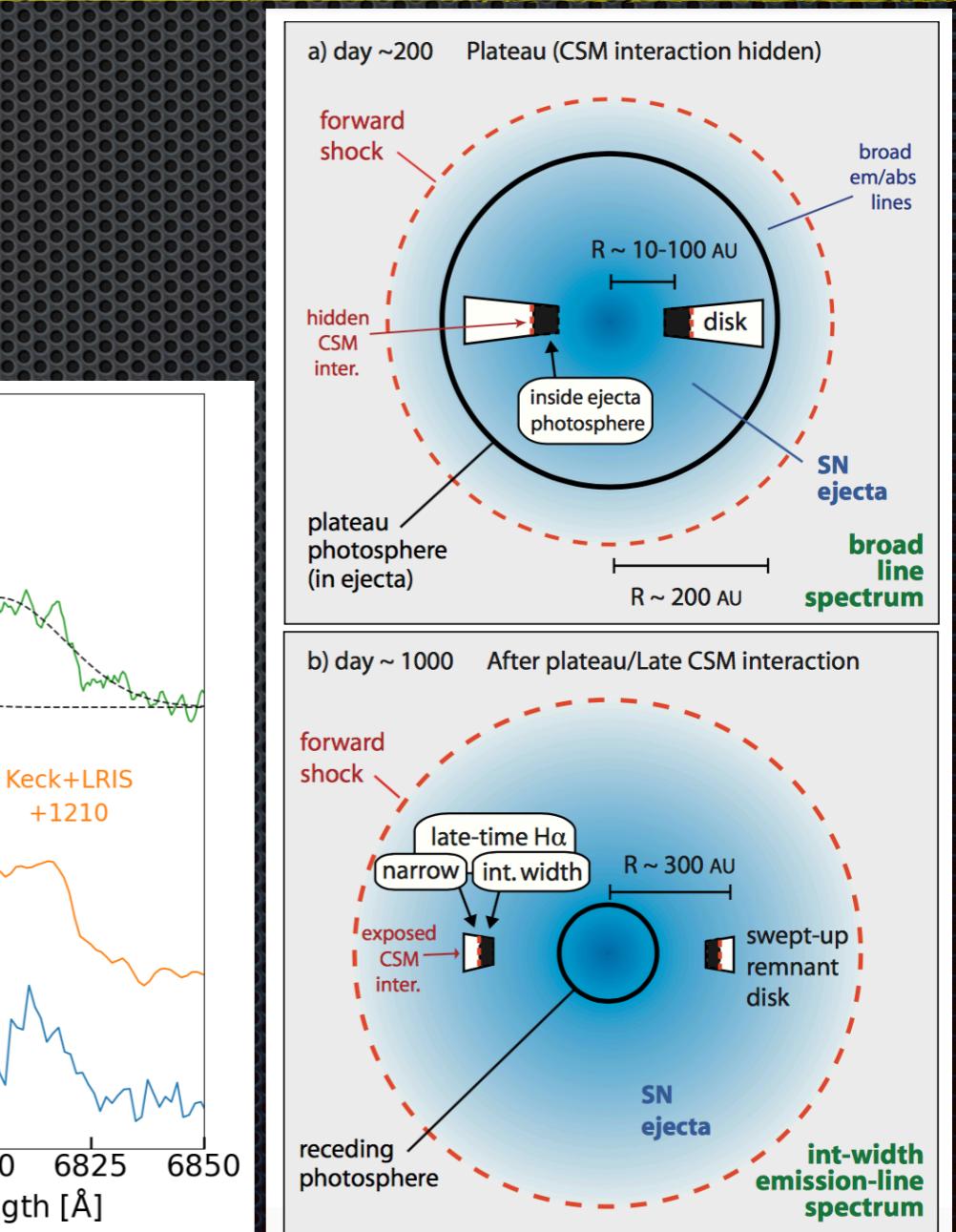
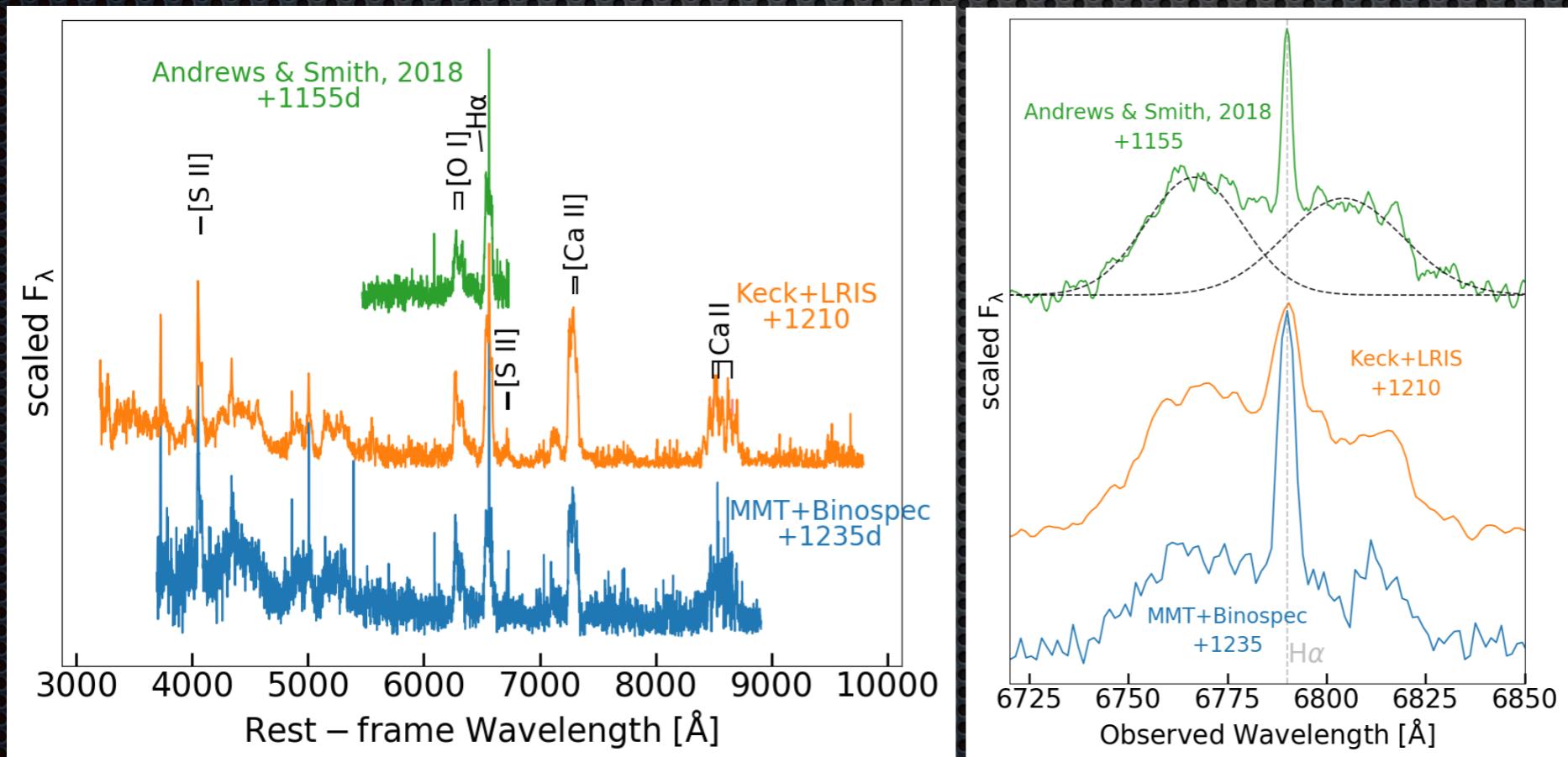
Optical follow-up!

iPTF14hls: the “impossible” SN

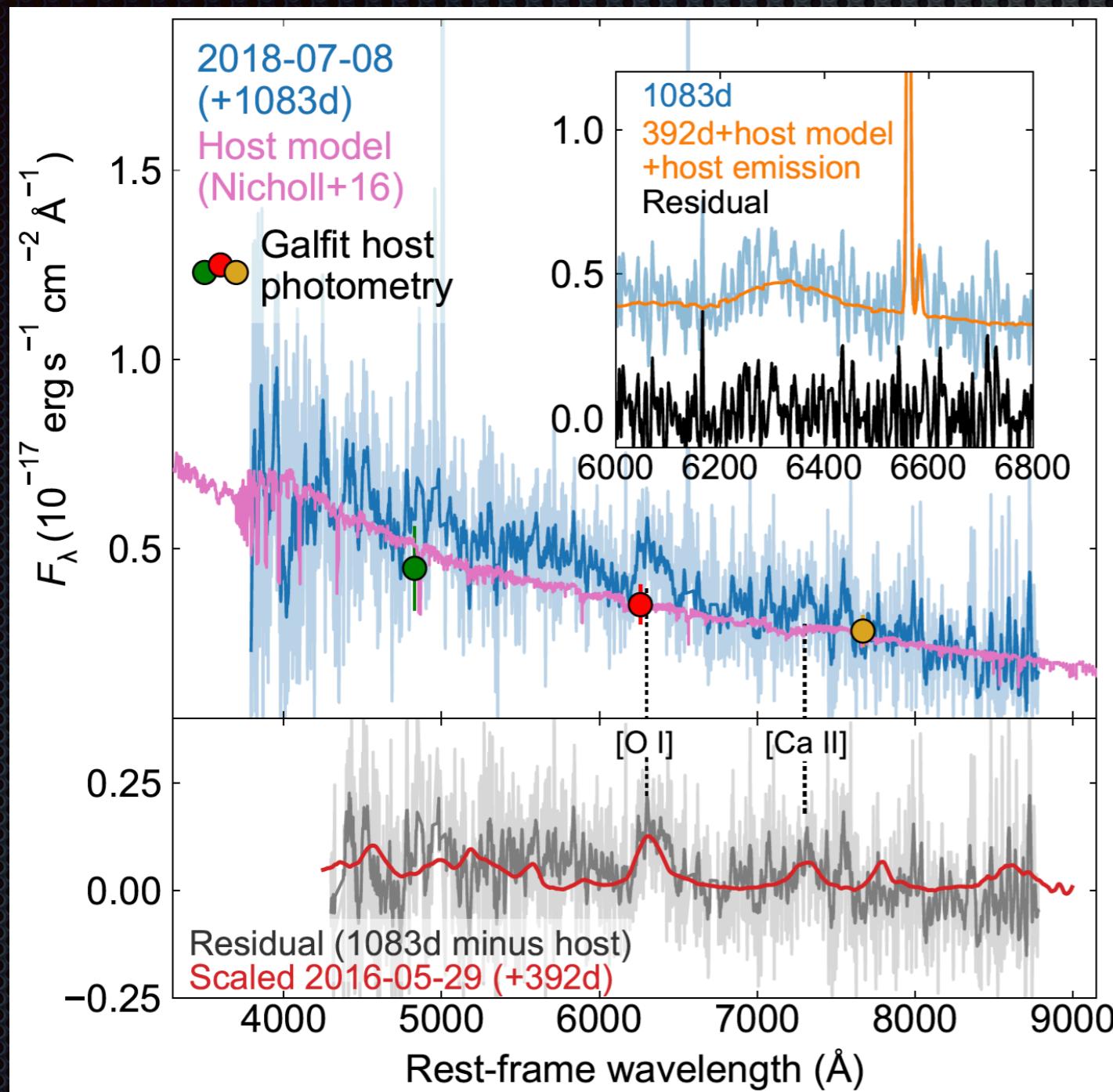


Arcavi et al. 2017, Nature, 551, 2104

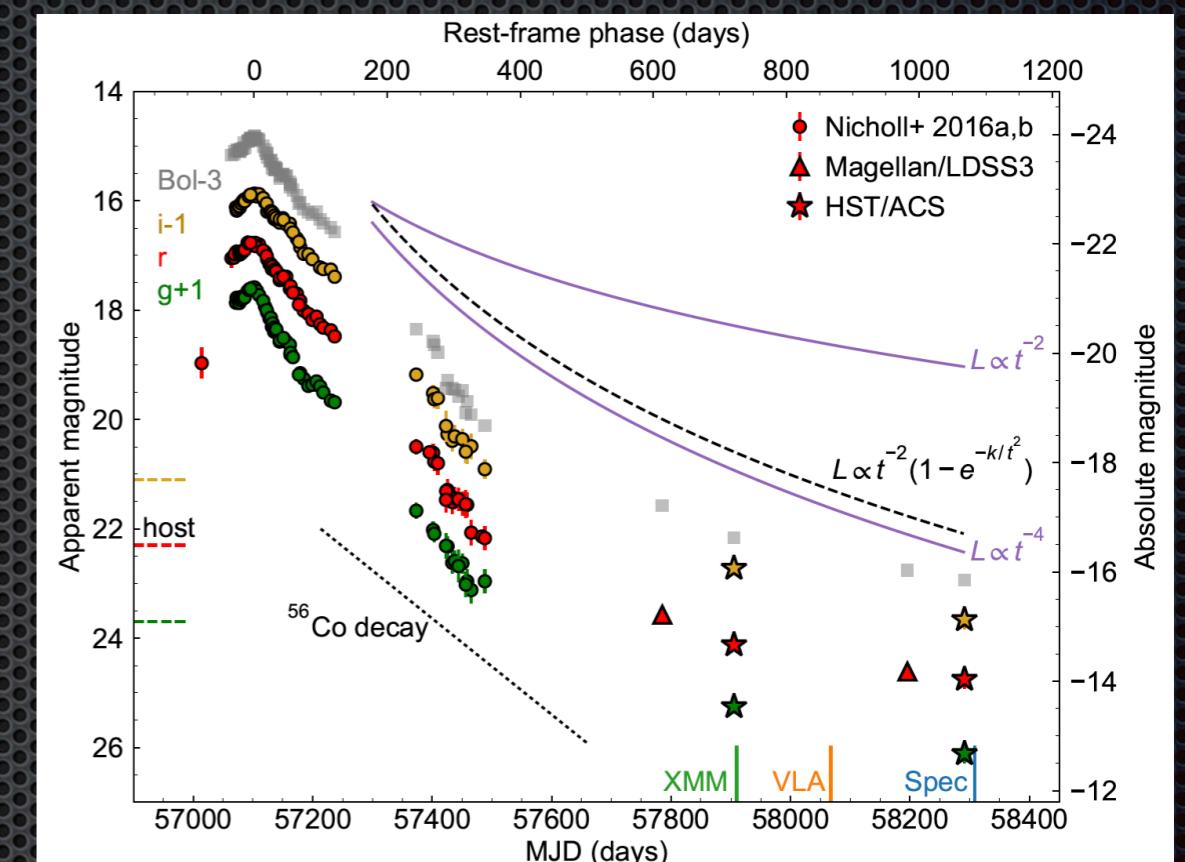
Andrews & Smith 2018, MNRAS, 477, 74



2015bn



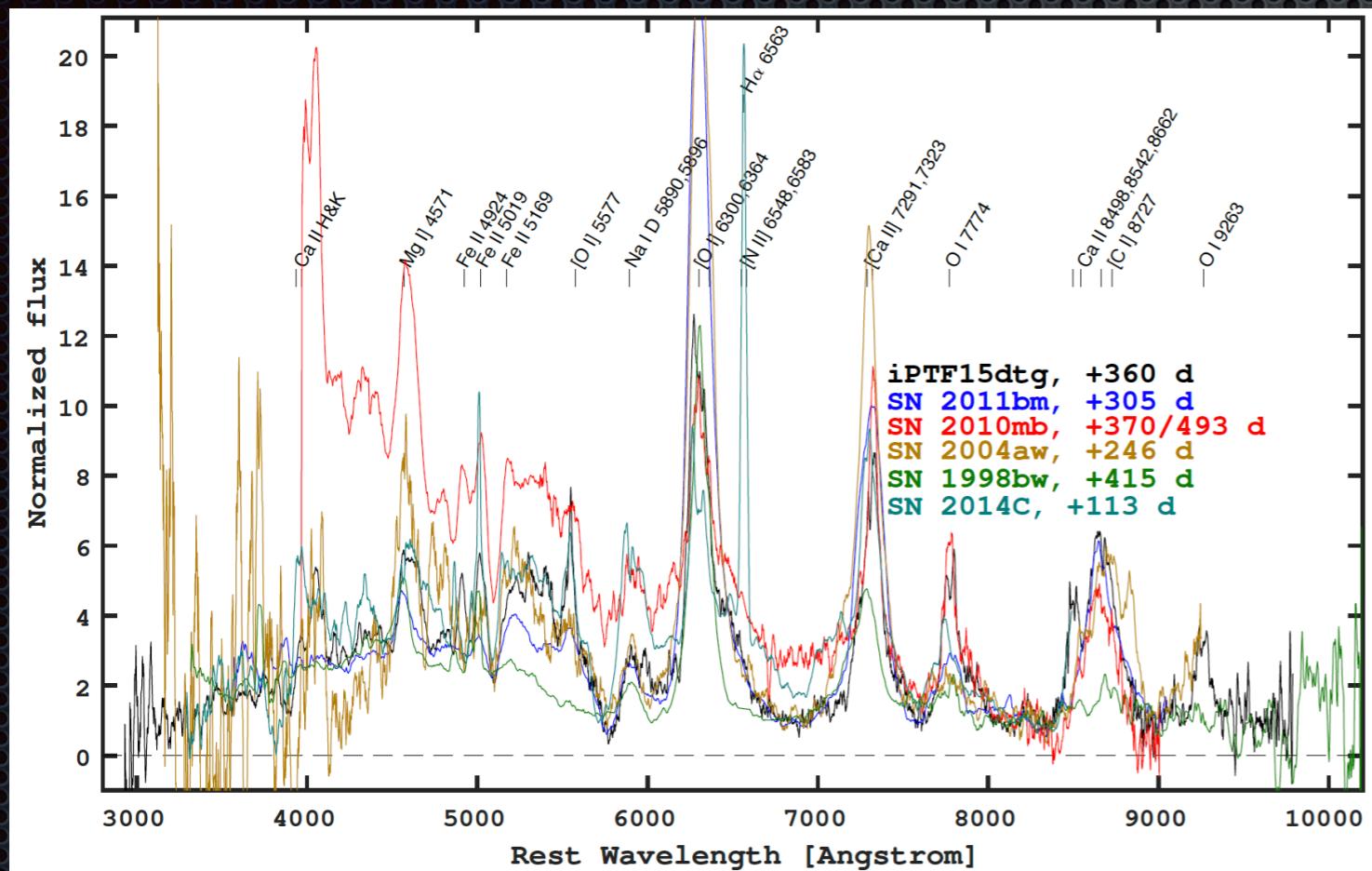
Nicholl et al. 2018, ApJ, 866, L24



Decays slower than ^{56}Co

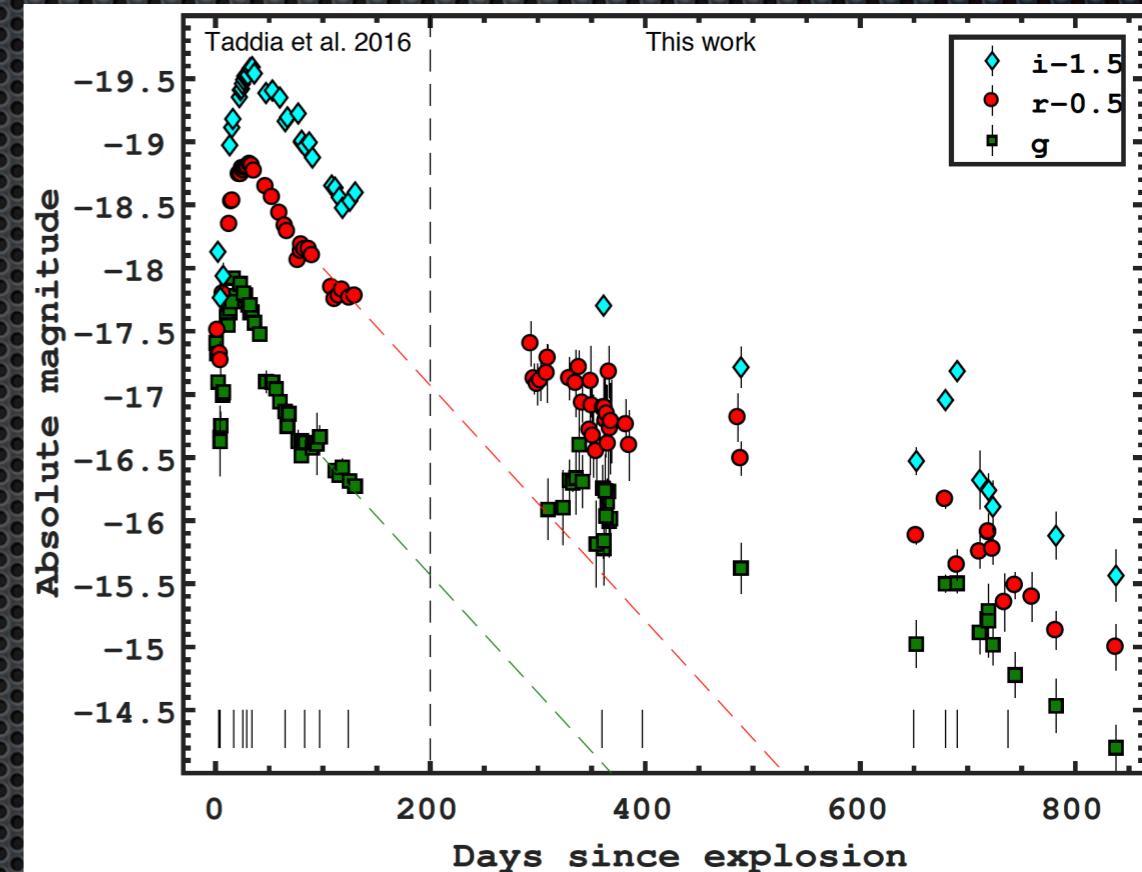
EVIDENCE FOR A MAGNETAR?

iPTF15dtg



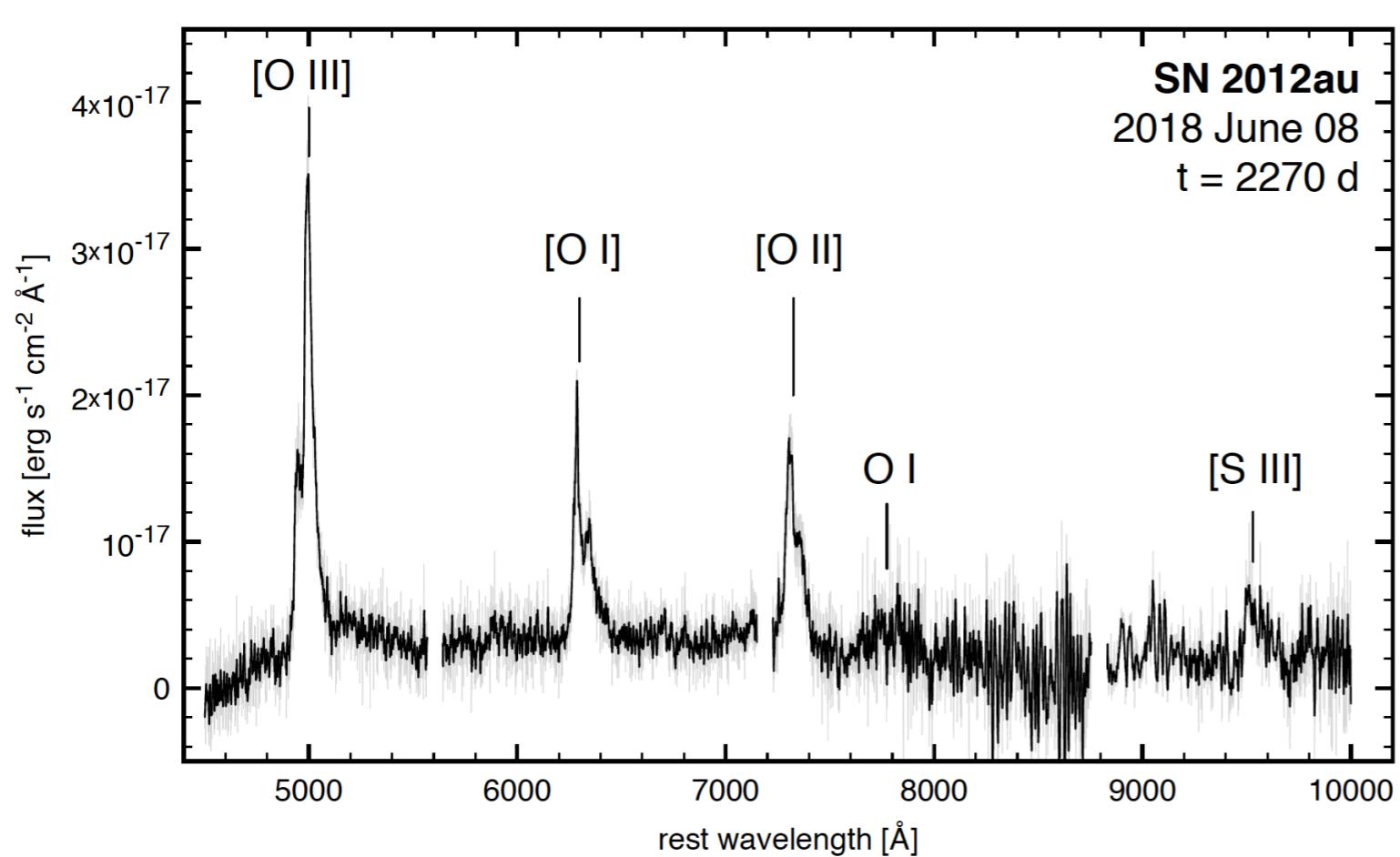
Taddia et al. 2019, A&A, 621, A64

NO EVIDENCE FOR
INTERACTION



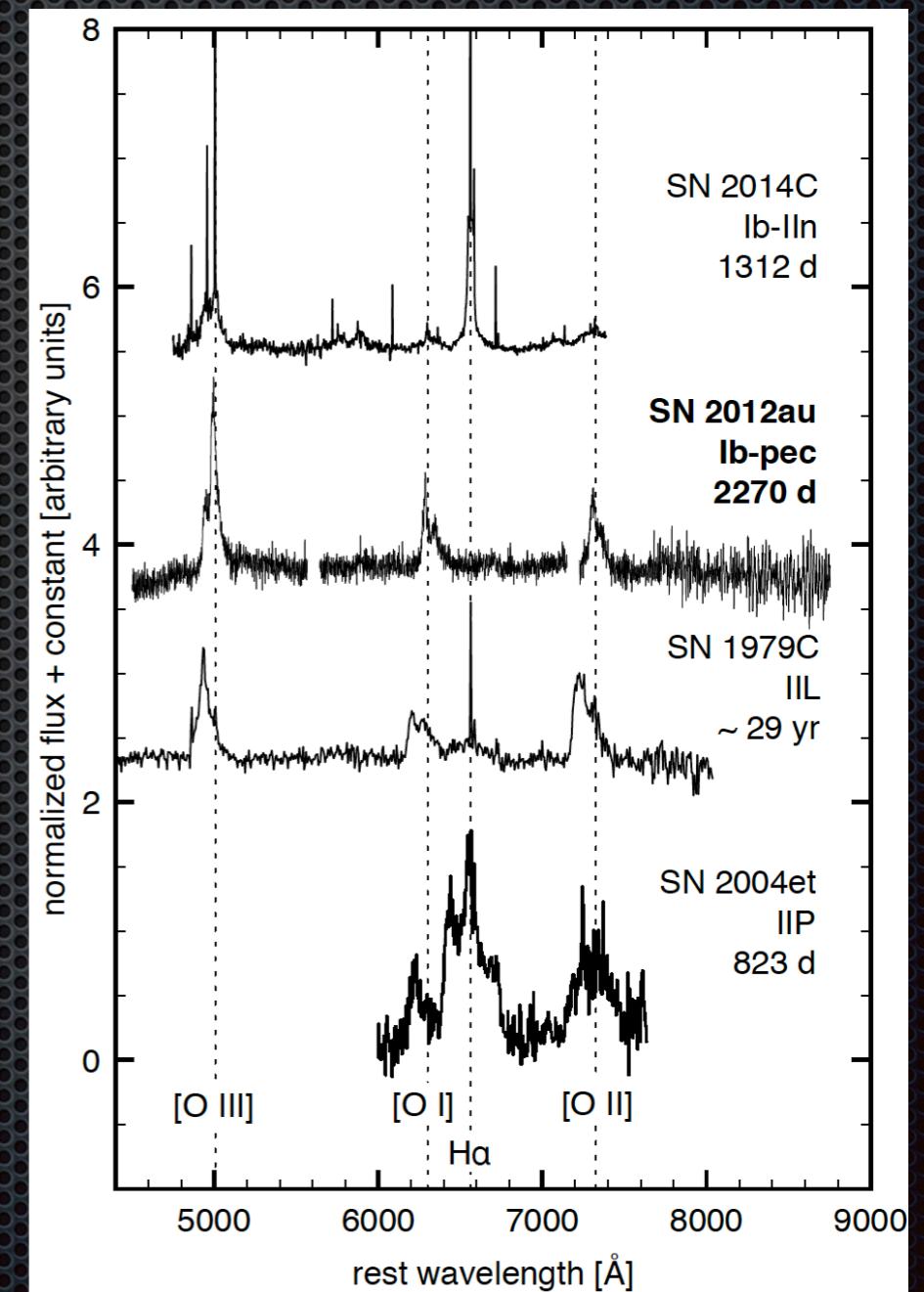
Decays slower than ^{56}Co

2012ap



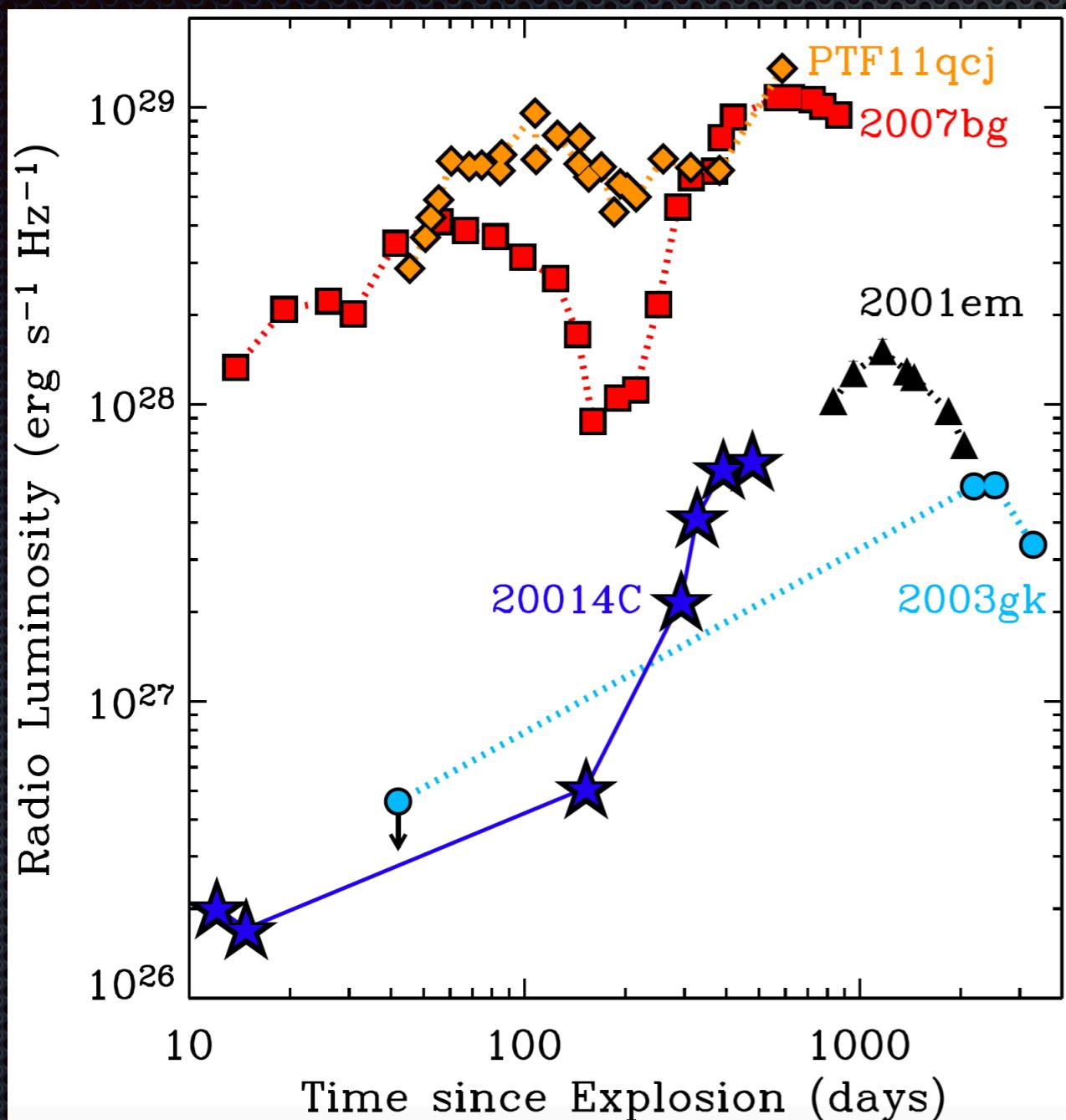
**NO STRONG EVIDENCE
FOR INTERACTION**

PHOTOIONIZATION FROM A PSW?

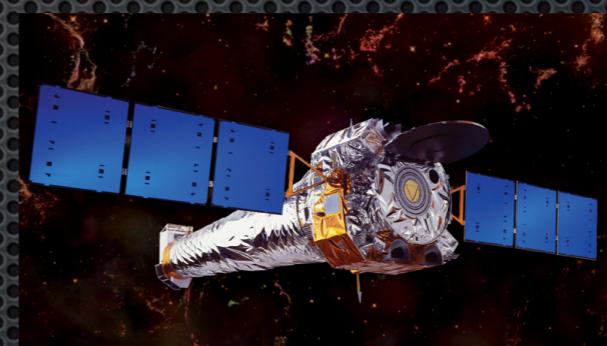


Milisavljevic et al. 2018, ApJ, 864, L36

Late-time monitoring of SESNe

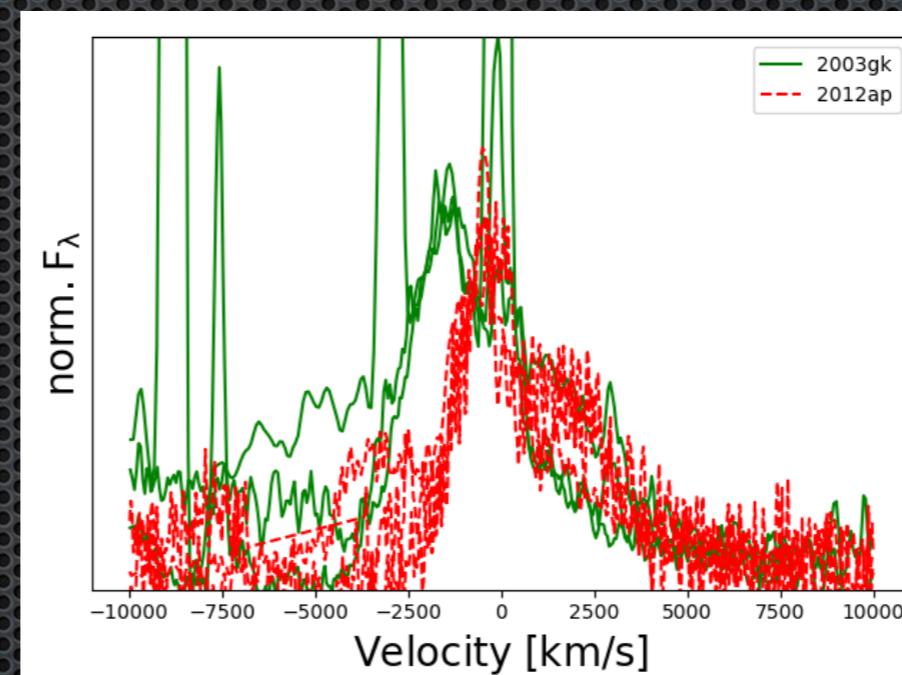
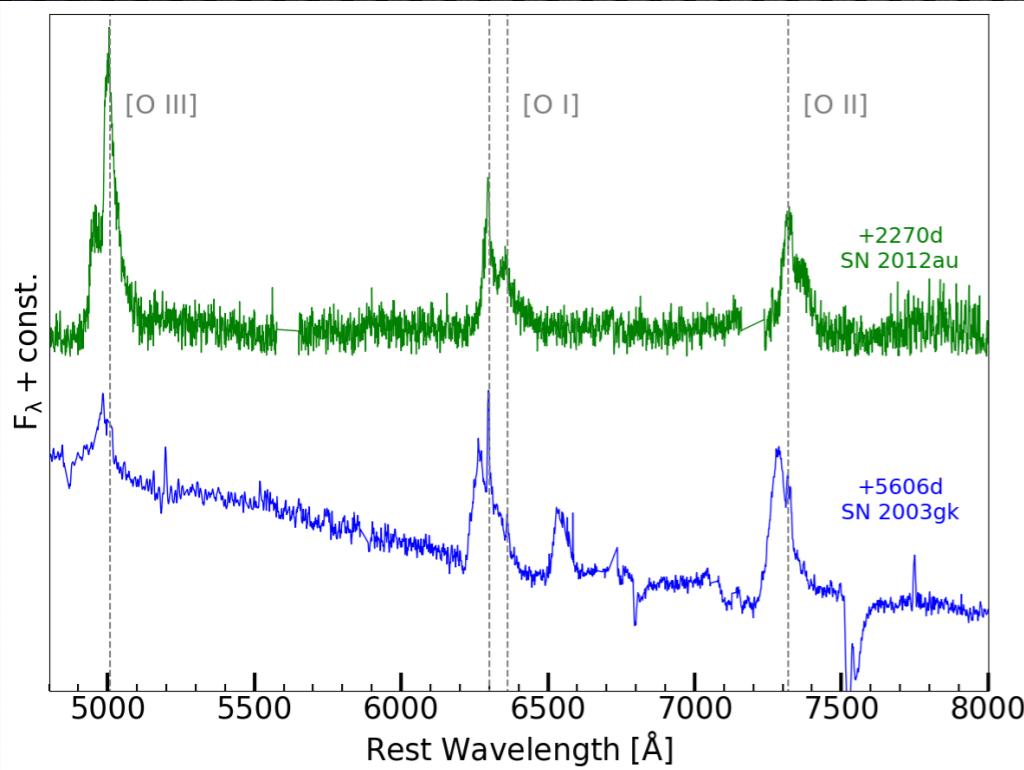
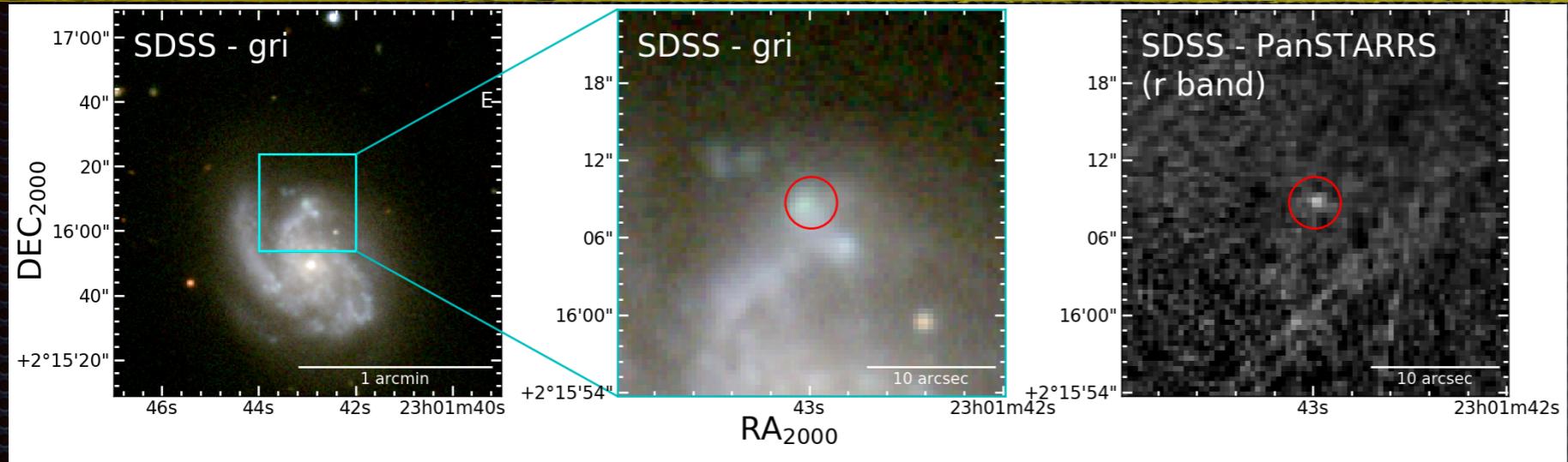


Margutti et al. 2017, ApJ, 835, 140



See Daniel Patnaude's talk

2003gk



Accelerated material from the PSW?



WE HAVE THE X-RAY AND RADIO!!

Terreran et al. 2019, in prep.

Conclusions

- Nebular spectra are very informative, both on the nature of the progenitor and the energy powering the SN at late time
- Multiwavelength observation solve each other's problem
- Exploring the [Ca II]/[O I] ratio in nebular spectroscopy, suggestive of a large progenitor core mass
- We can indirectly infer the presence of a PSW with late observation

SEE YOU IN CHICAGO!!



Northwestern
C I E R A
CENTER FOR INTERDISCIPLINARY EXPLORATION
AND RESEARCH IN ASTROPHYSICS

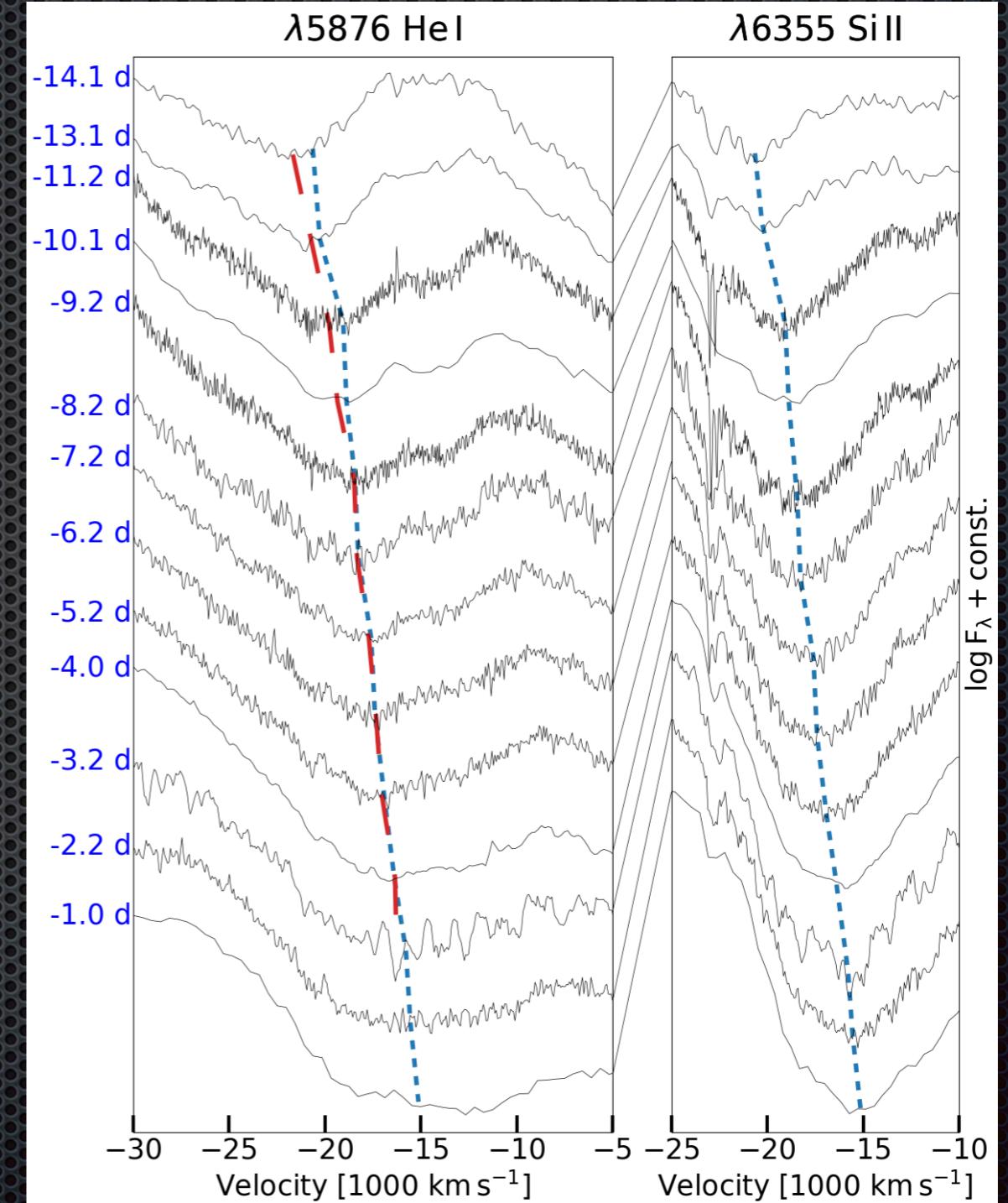
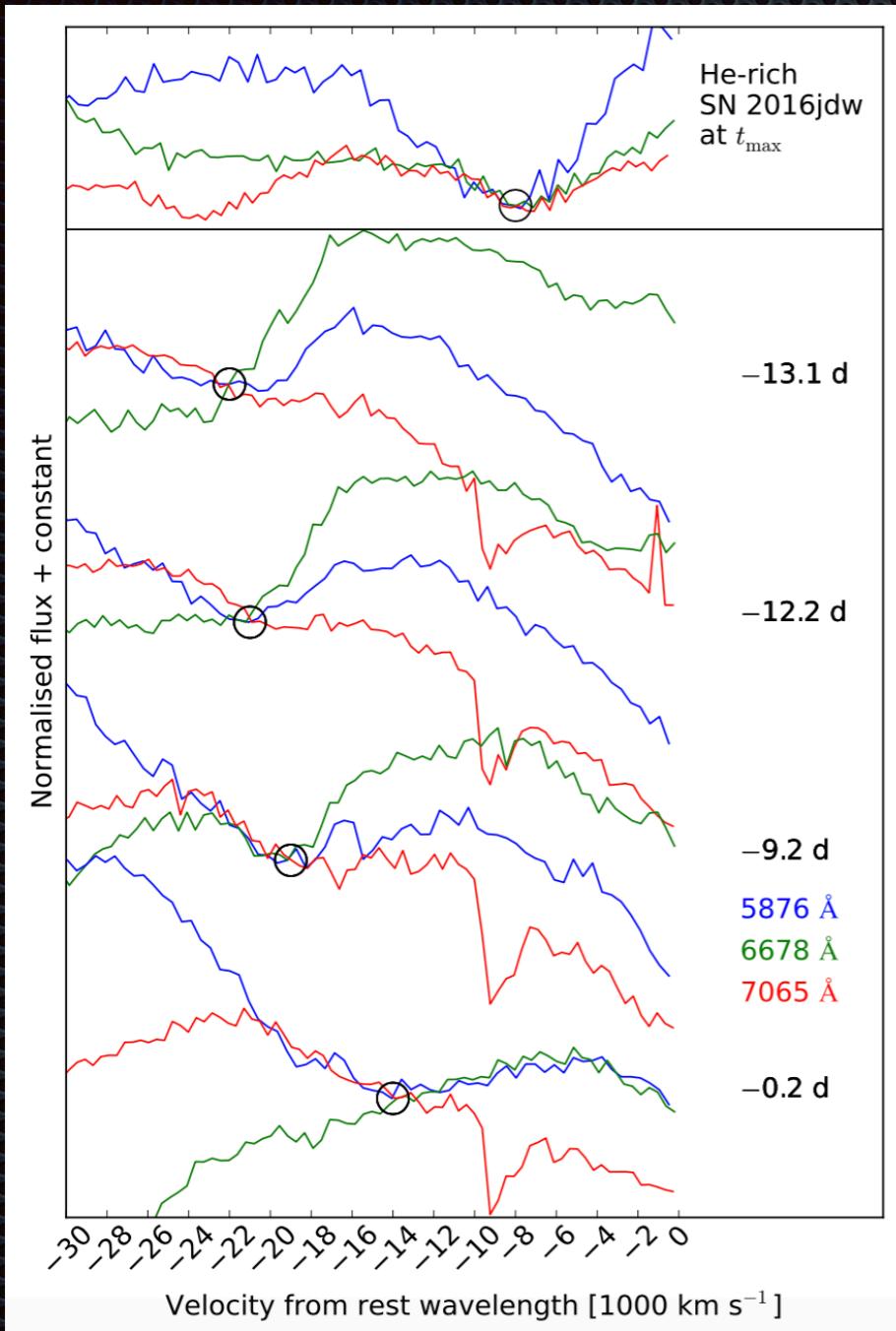
HOT-WIRING THE TRANSIENT UNIVERSE

August 19 - 22, 2019 | #HOTWIREDVI
Northwestern University, Evanston, Illinois, USA

Register by June 17th
<https://sites.northwestern.edu/hotwired6>

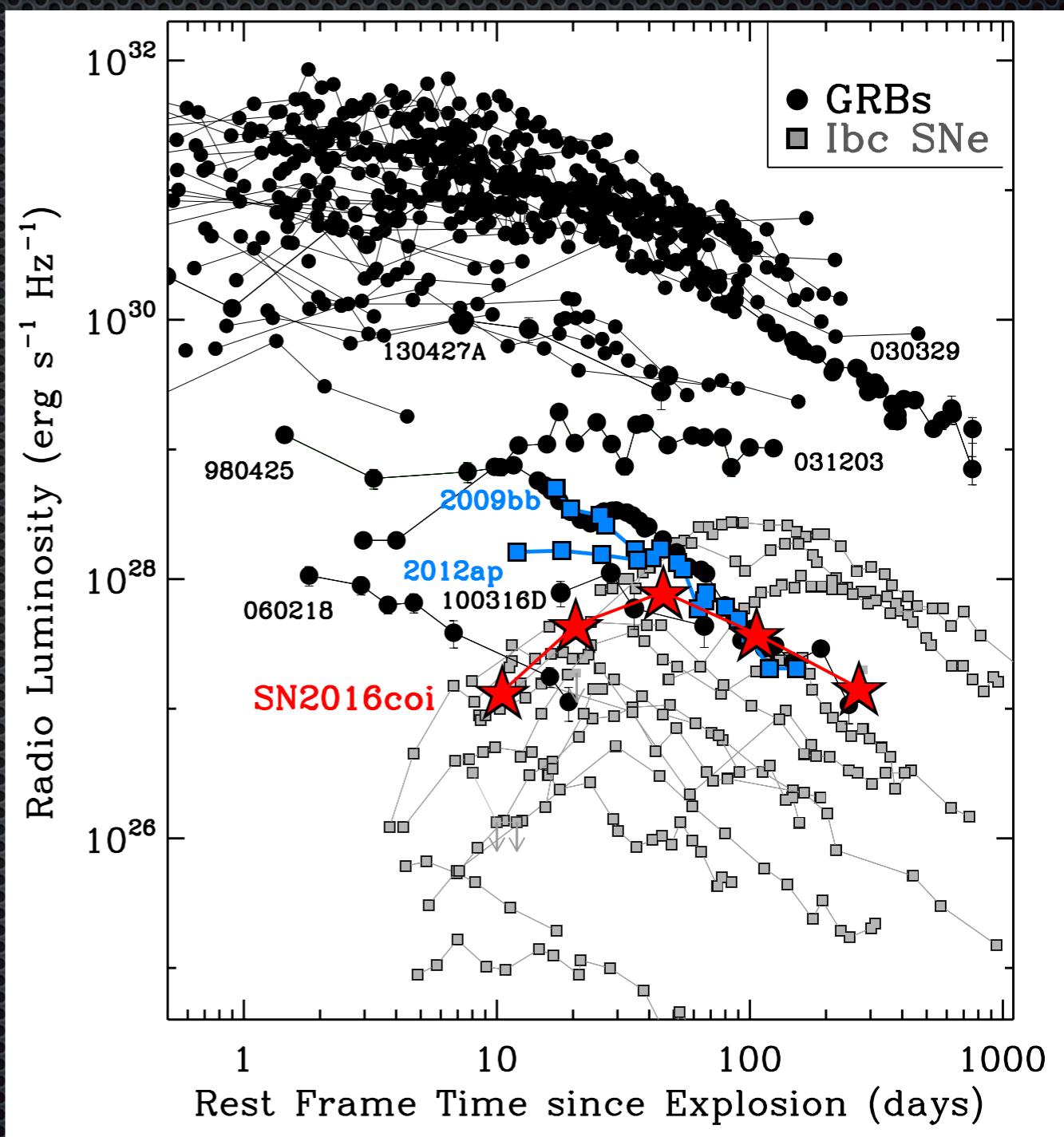
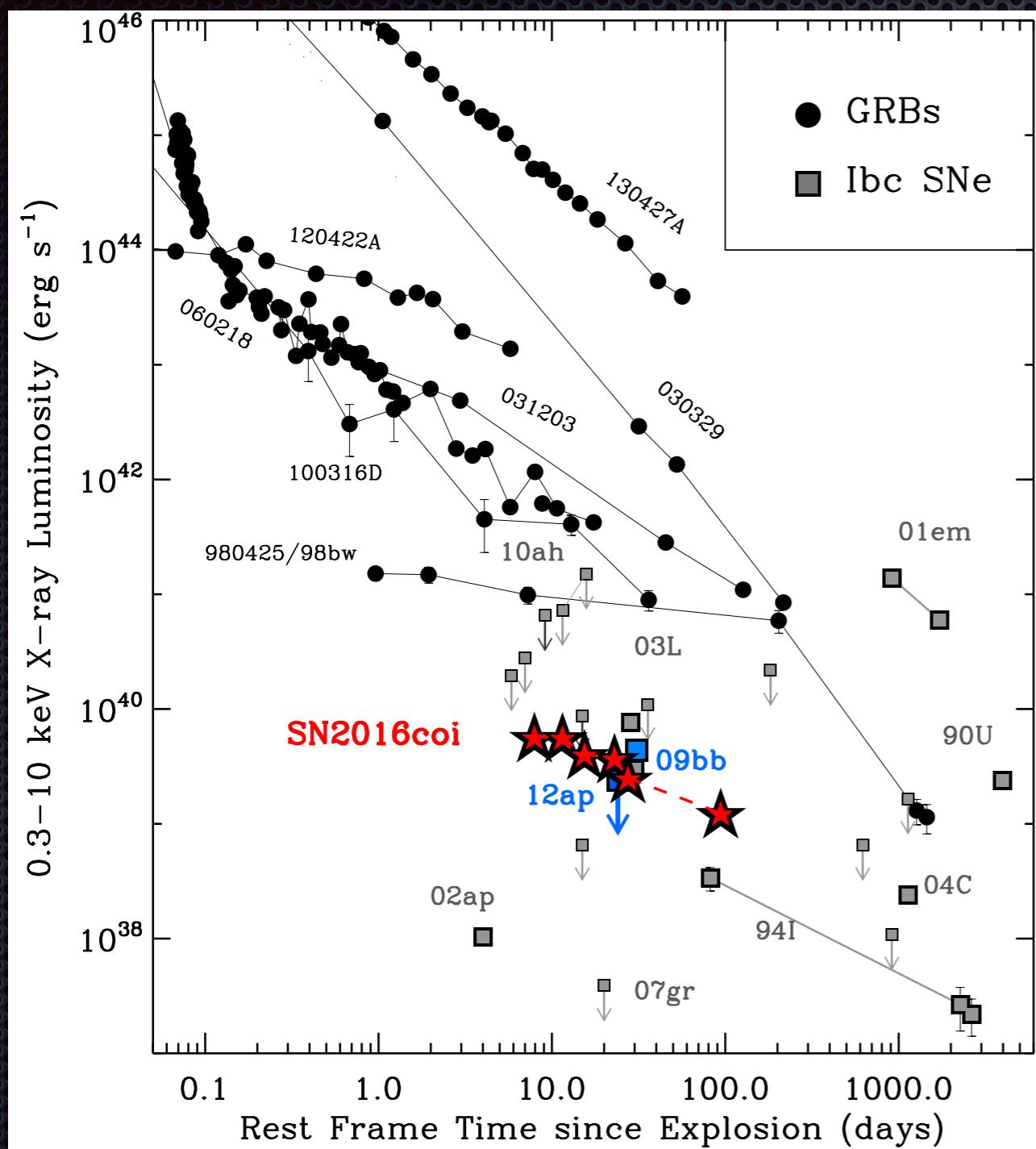
EXTRA SLIDES

He evolution

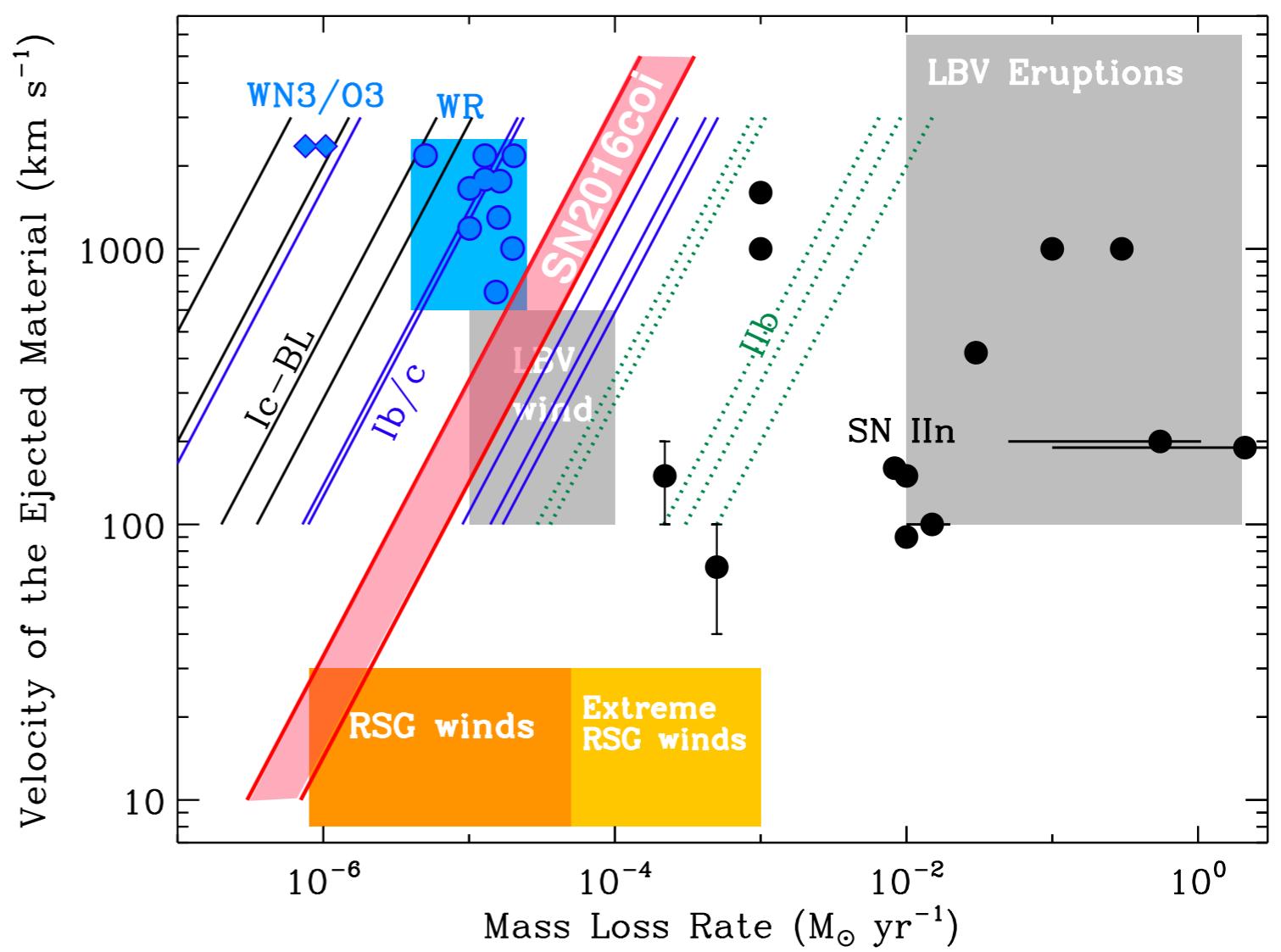
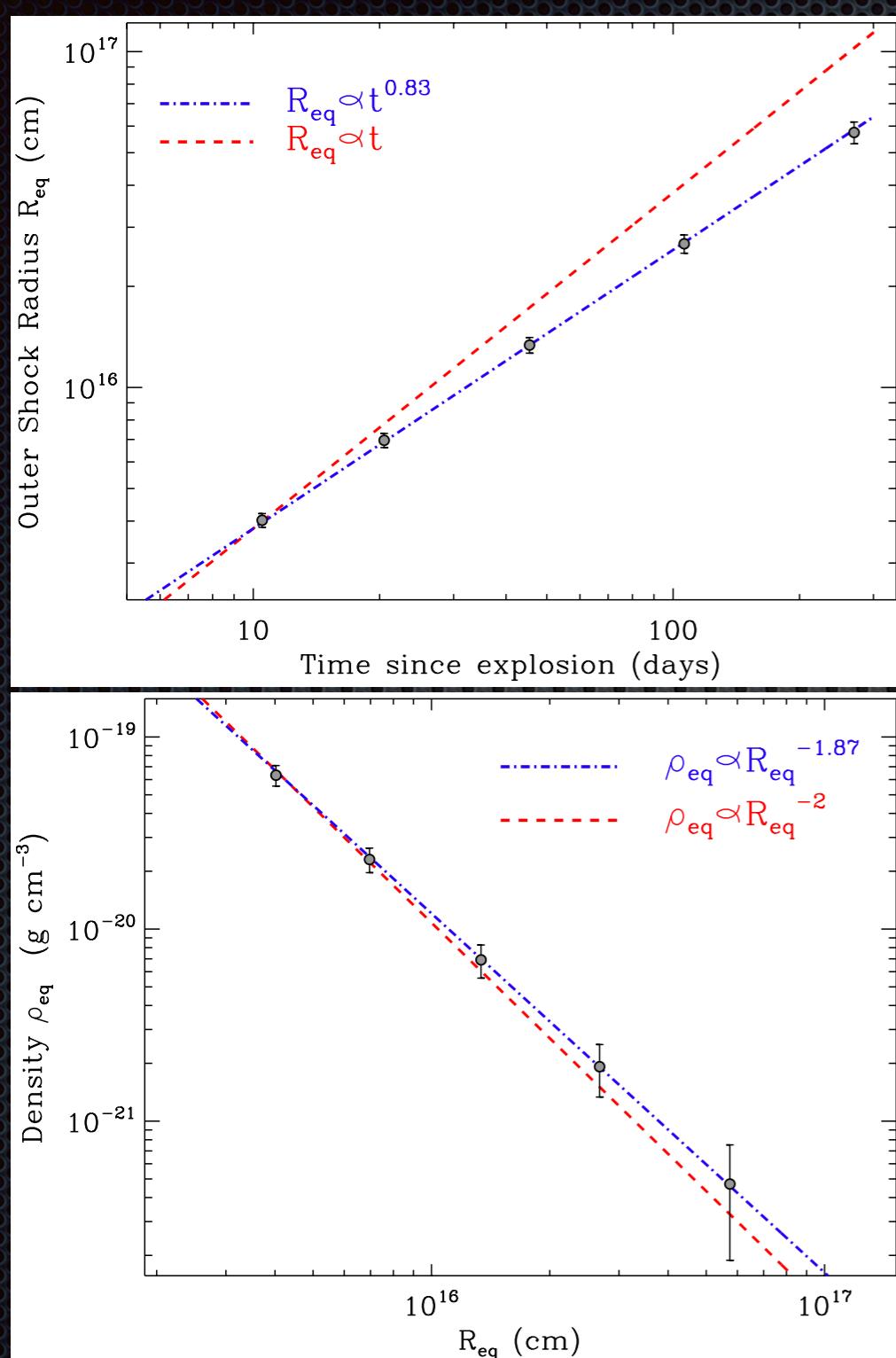


Prentice, et al. 2018, MNRAS, 478, 4162

Comparison with other objects



Dense environment



Massive progenitor