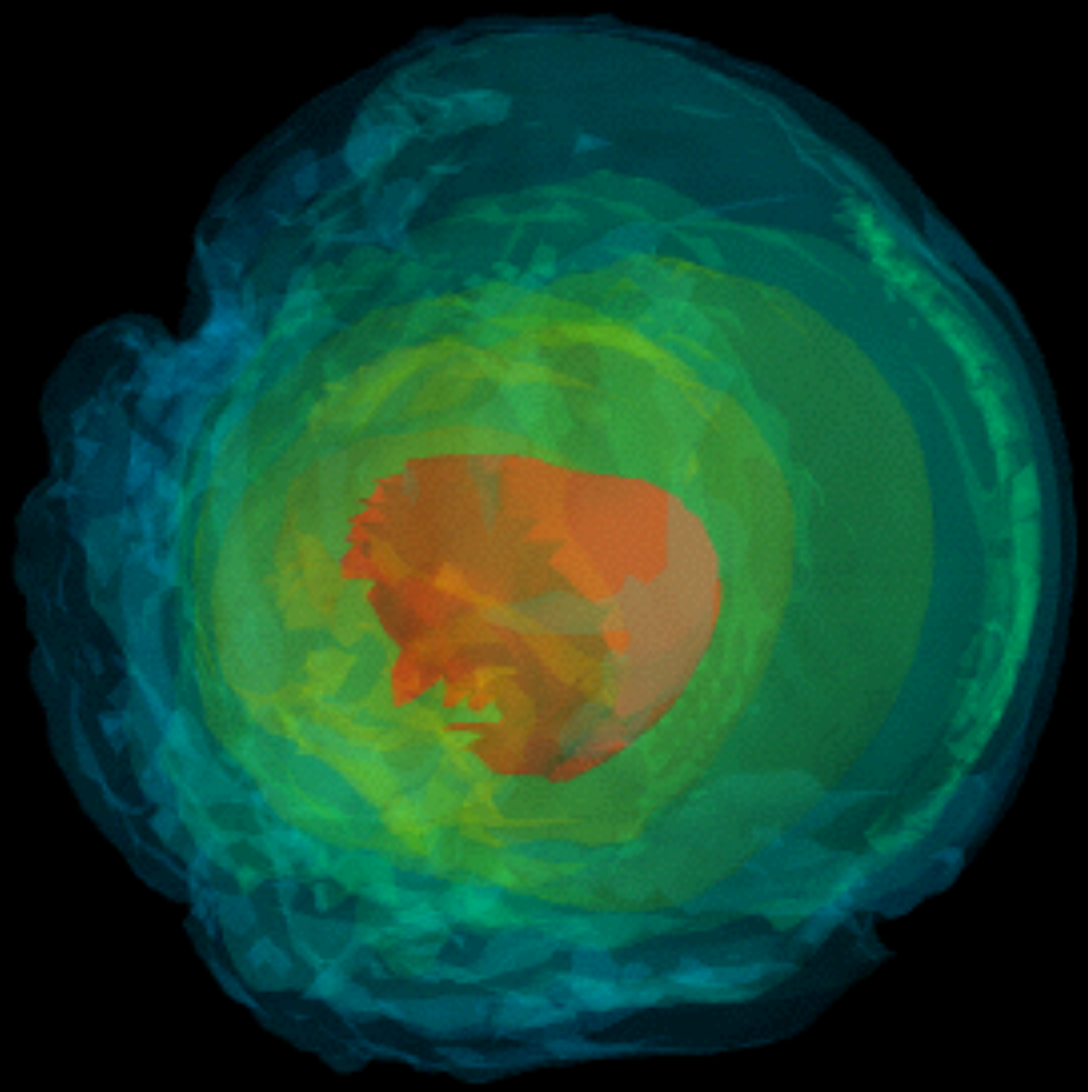
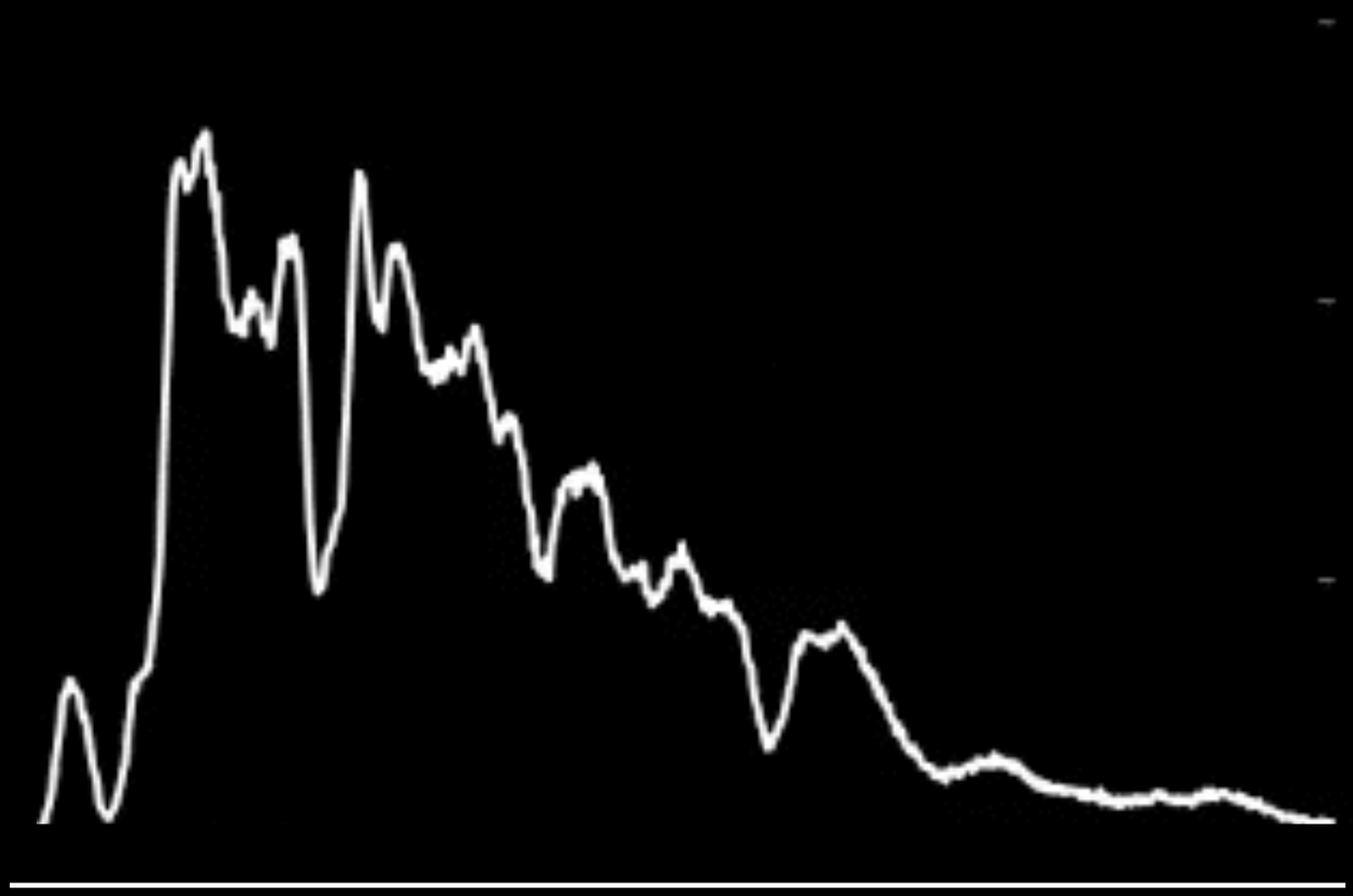




supernova Ia progenitors
overview of light curves and spectra

daniel kasen

zeroth order SNIa model

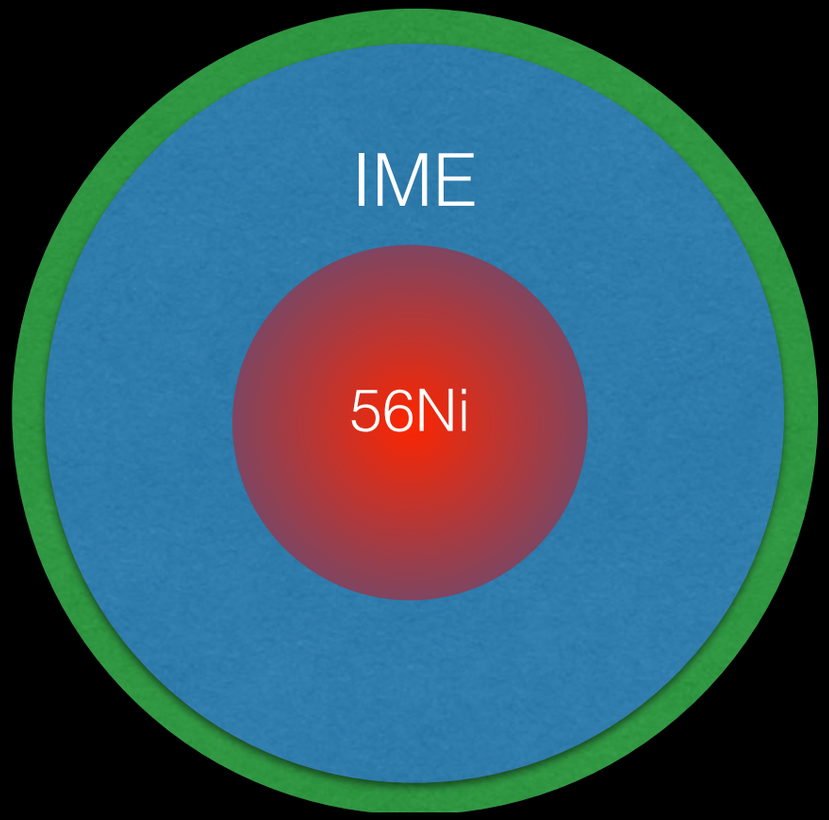
progenitor

explosion
t ~ secs

ejecta

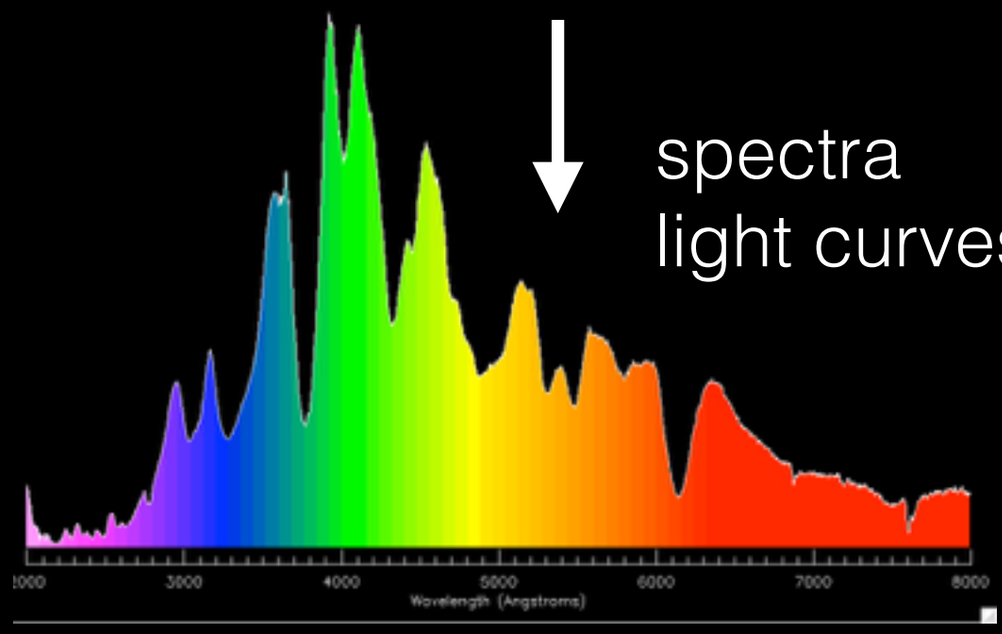
?

C/O

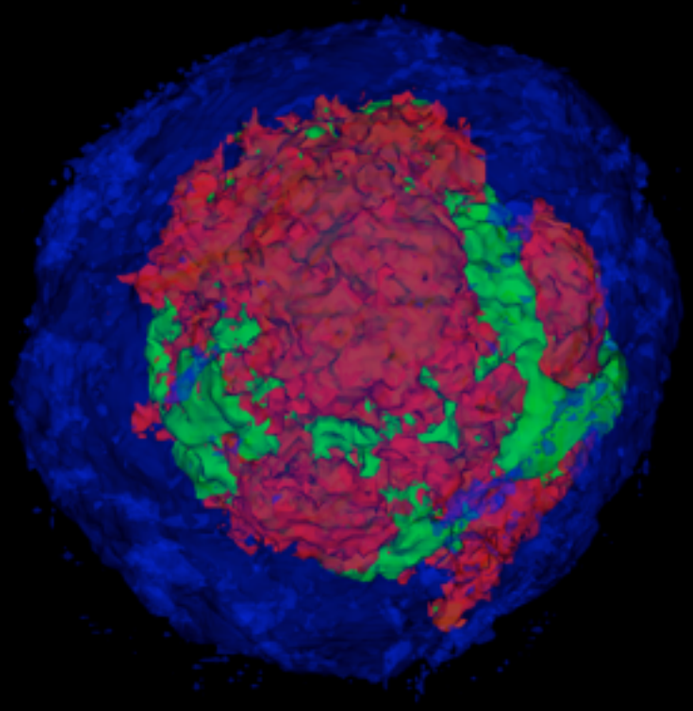


need to examine subtleties
(line features, asymmetry, CSM)
compare to imperfect models,
get mixed messages

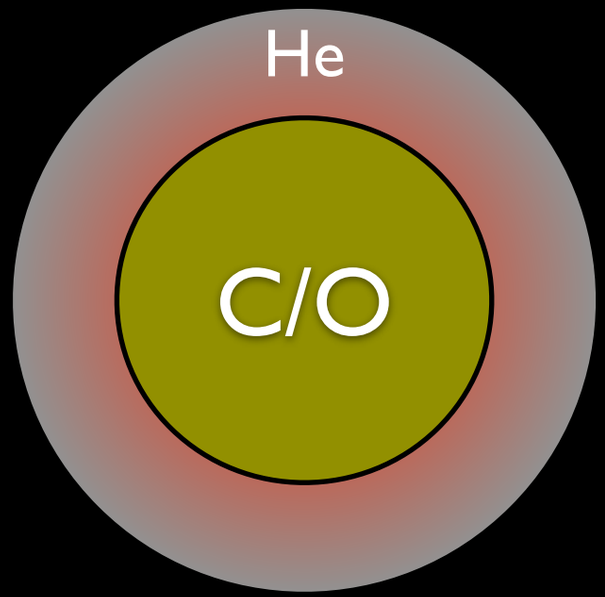
spectra
light curves



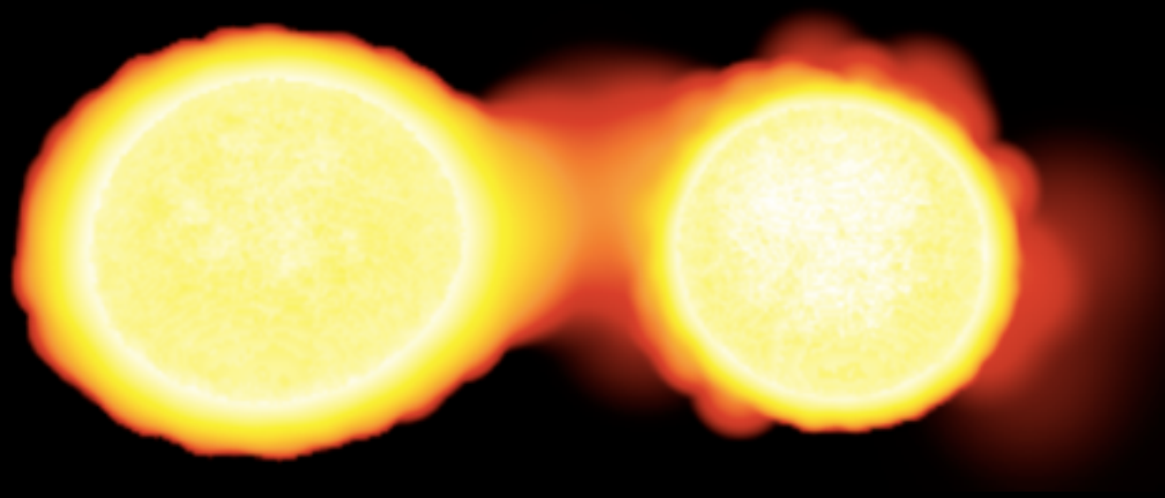
variety of progenitors/explosions



M_{ch} model
(central or off-center ignition)
C/O WD + H star

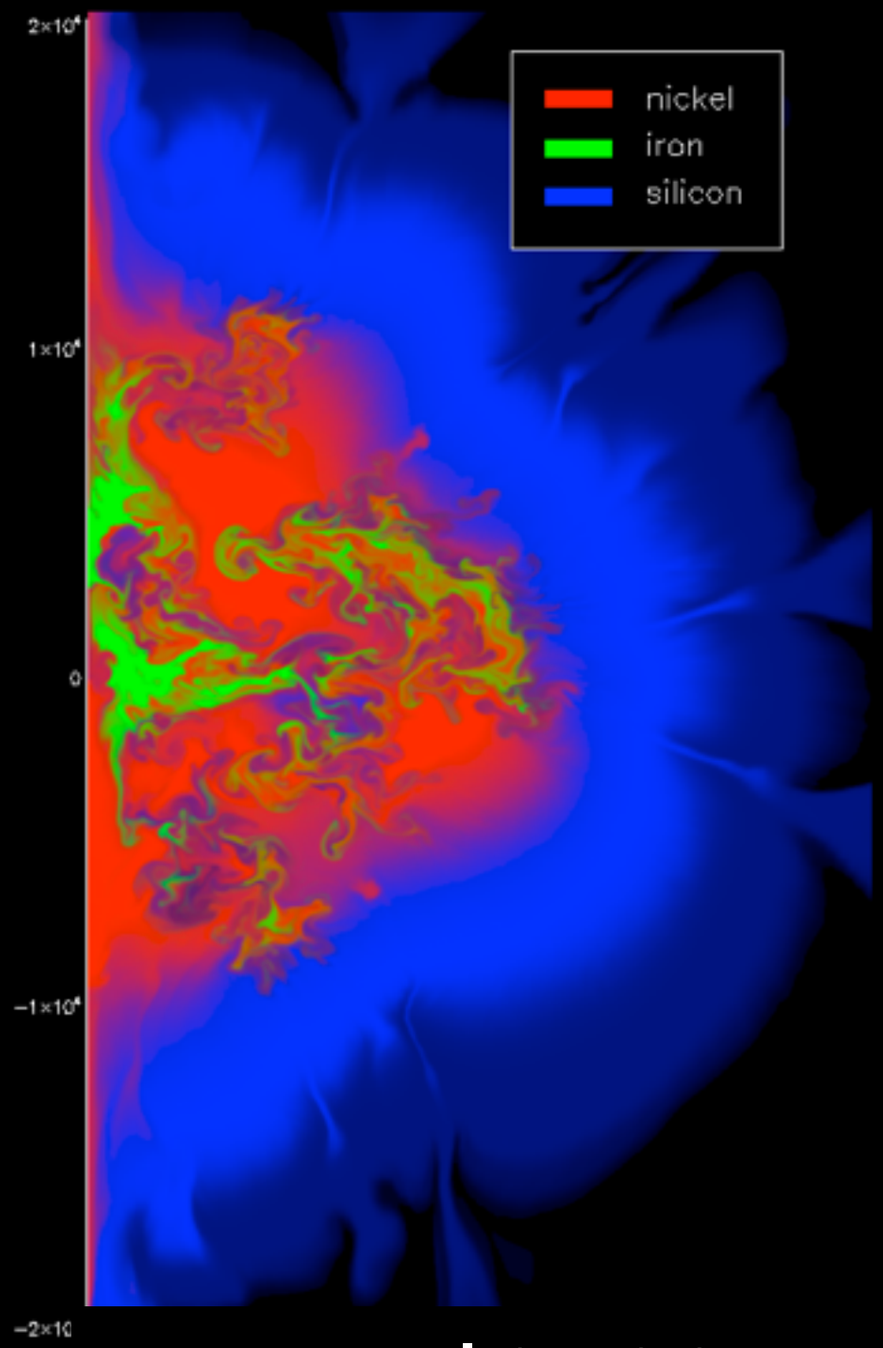


sub-M_{ch} model
(double detonation)
C/O WD + He star or WD

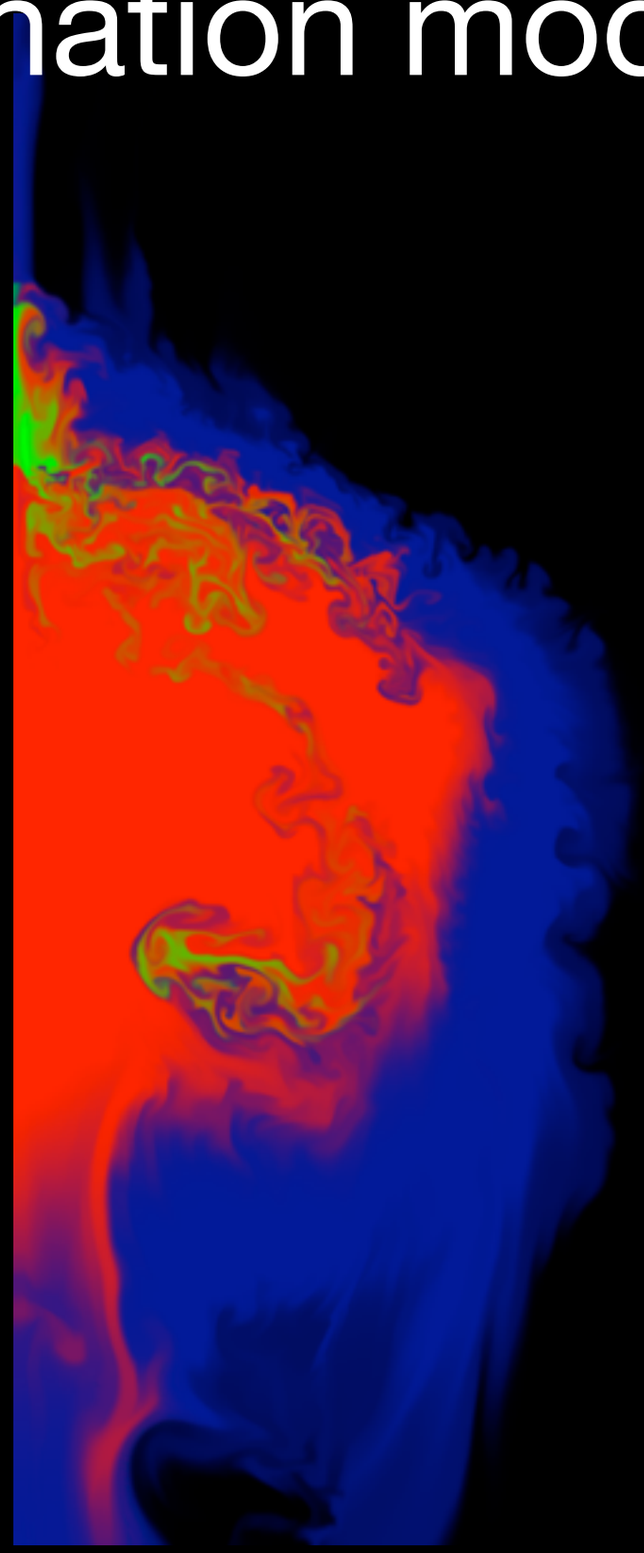


merger/collision of
two C/O white dwarfs

M_{ch} delayed detonation models



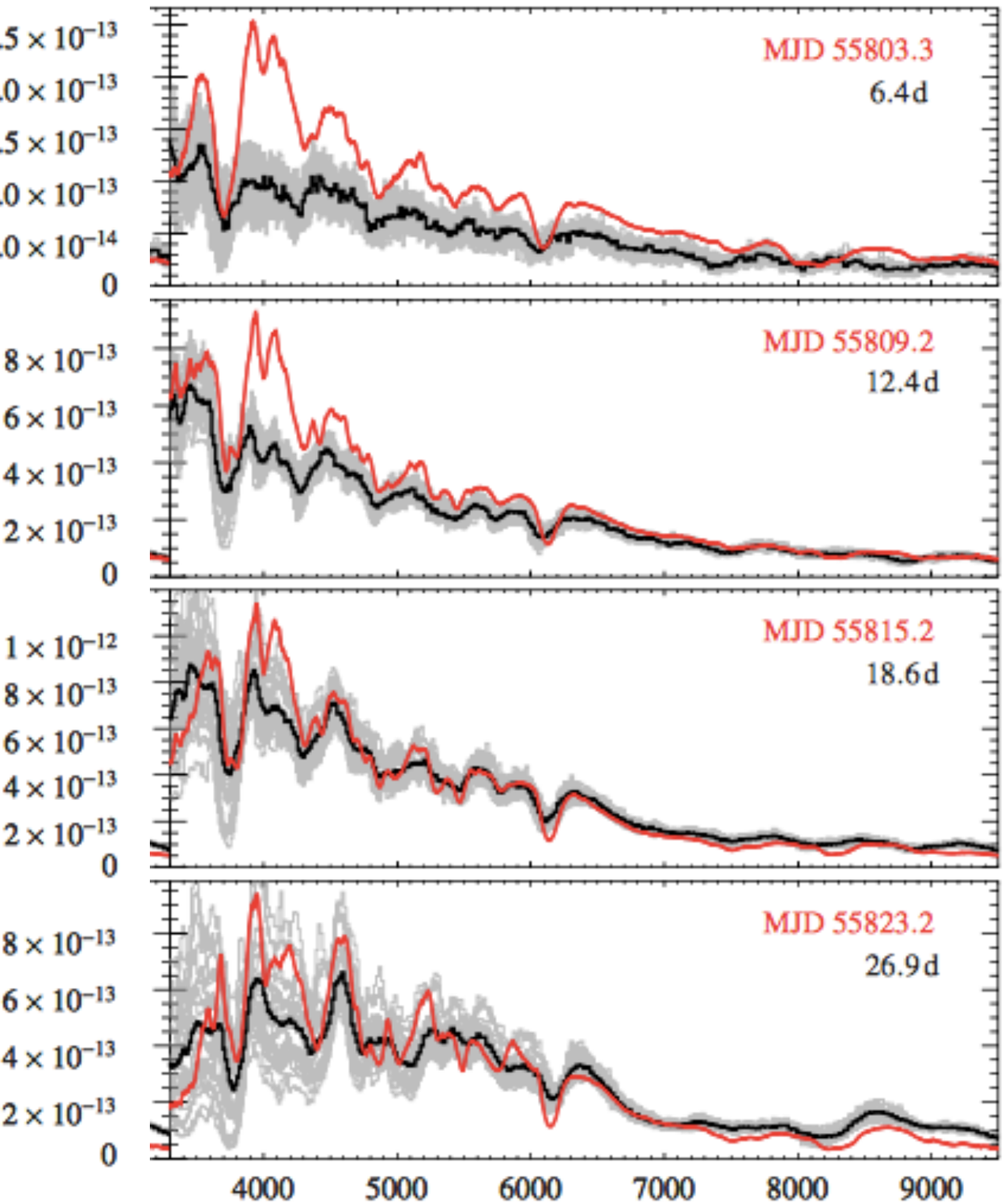
central ignition



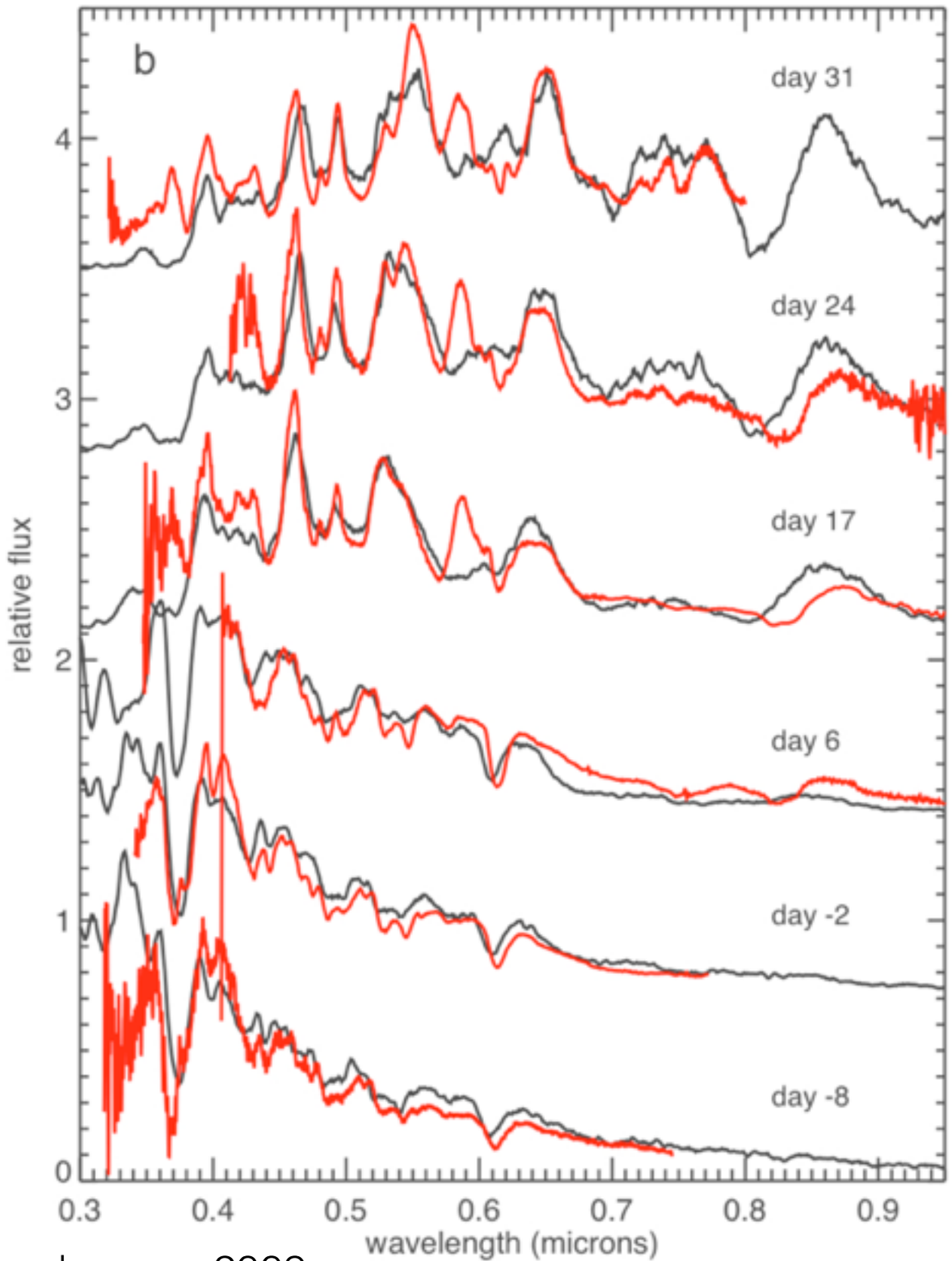
off-center ignition

delayed detonation models

hoeflich&Khokhlov 1995.6, nugent 1994, pinto&eastman 2000 kasen+ 2009, roepke+ 2012, sim+2013, dessart+ 2014

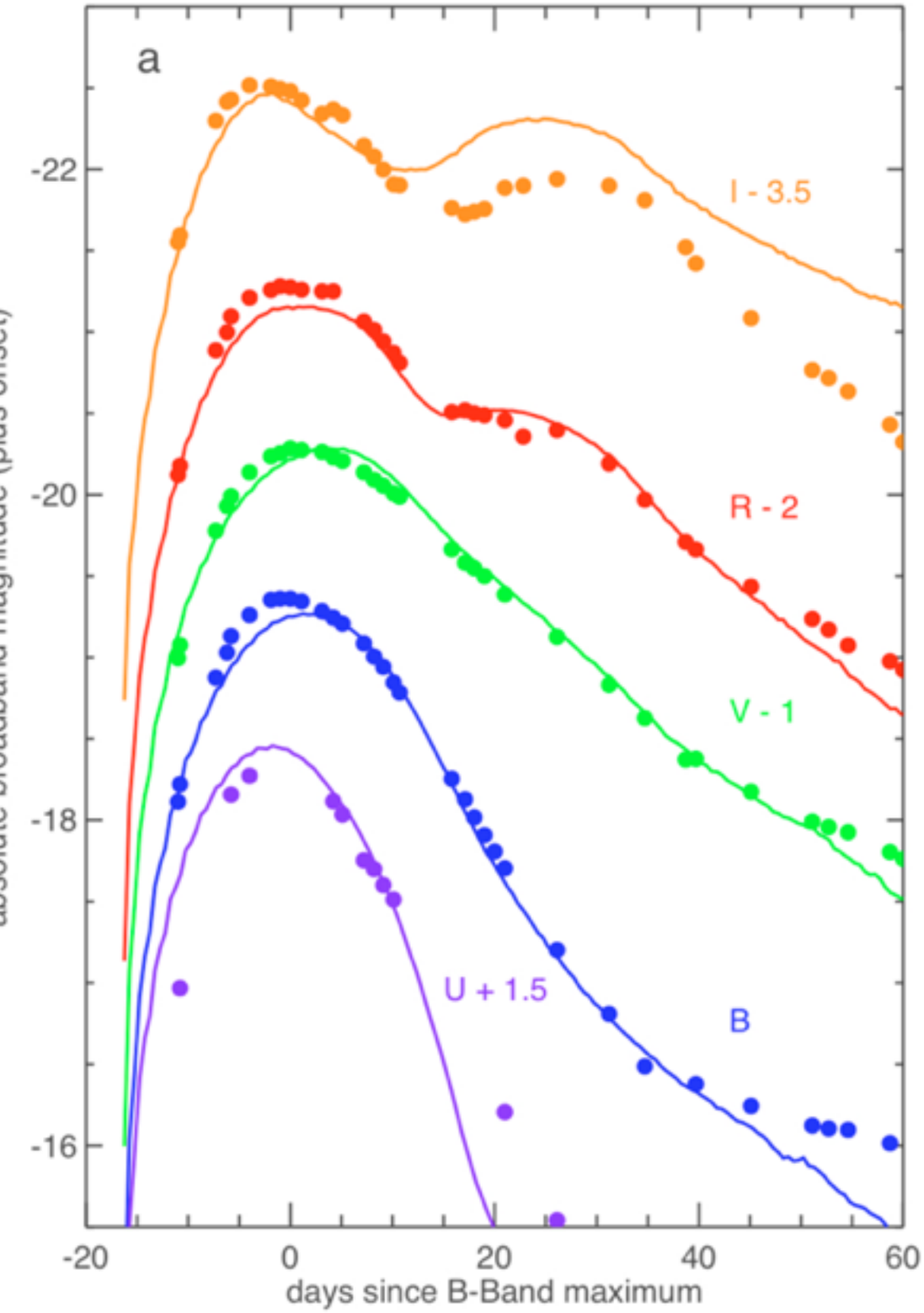


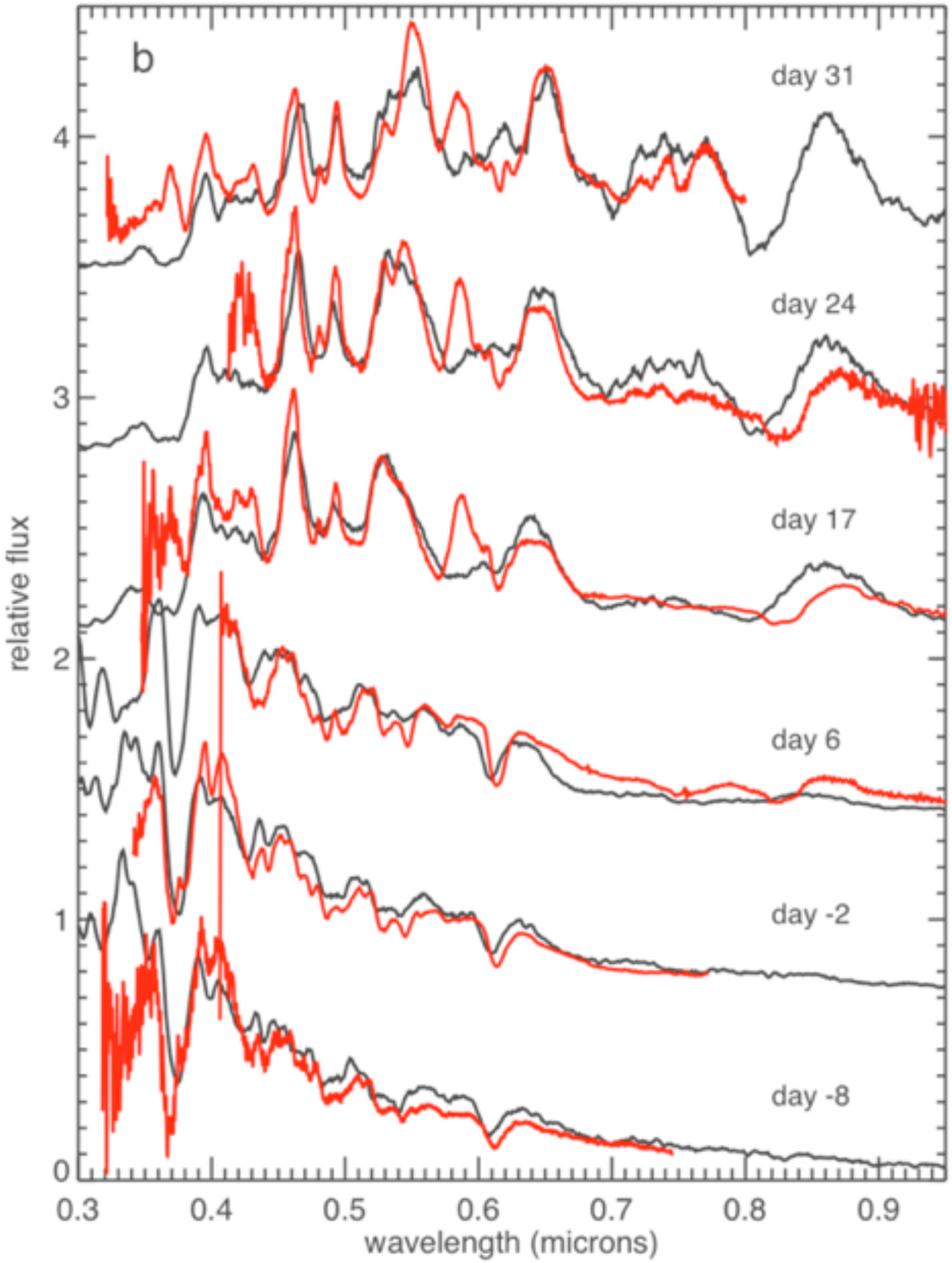
roepke+ 2012



kasen+ 2009

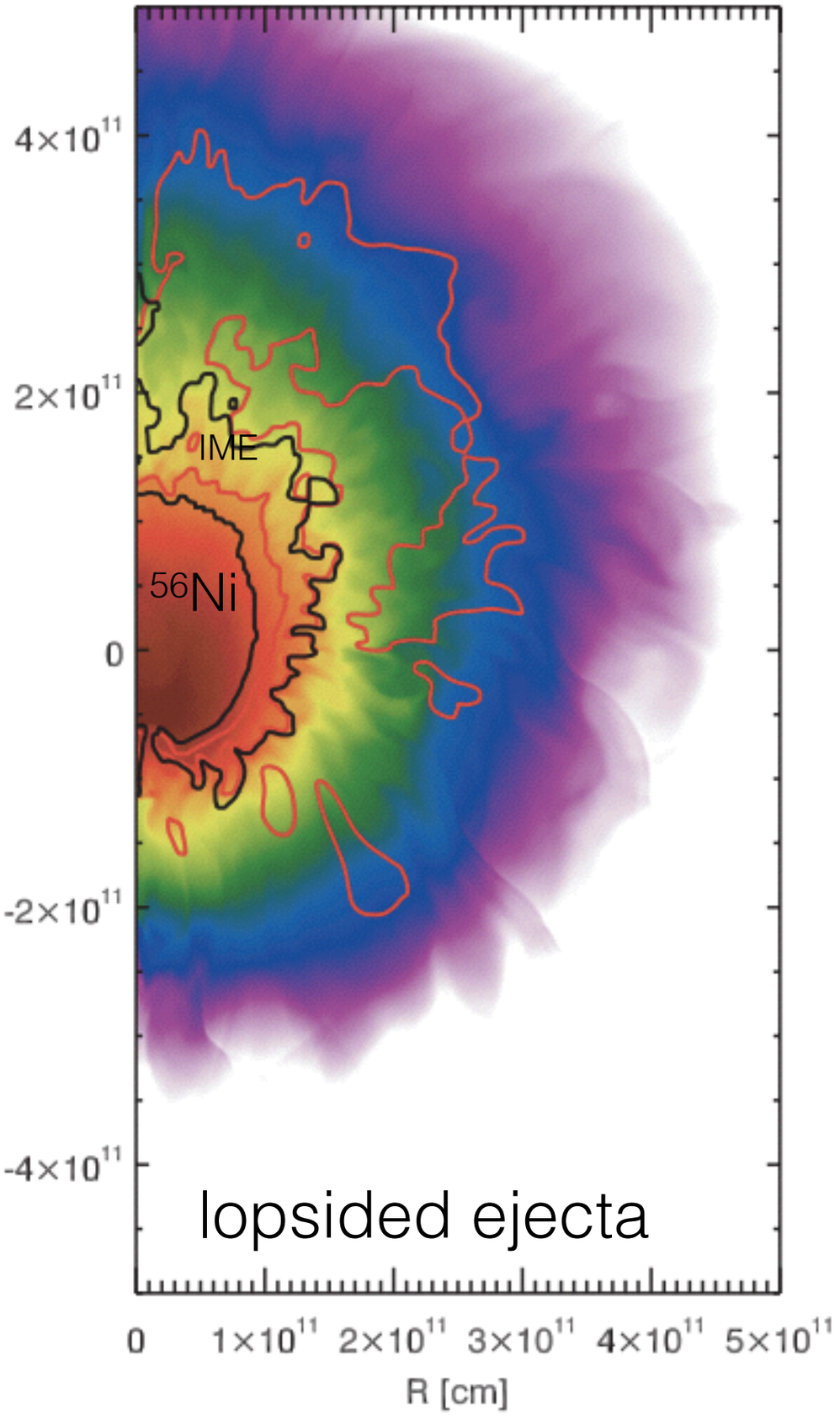
delayed detonation models
good fit to observed spectra/lightcurves



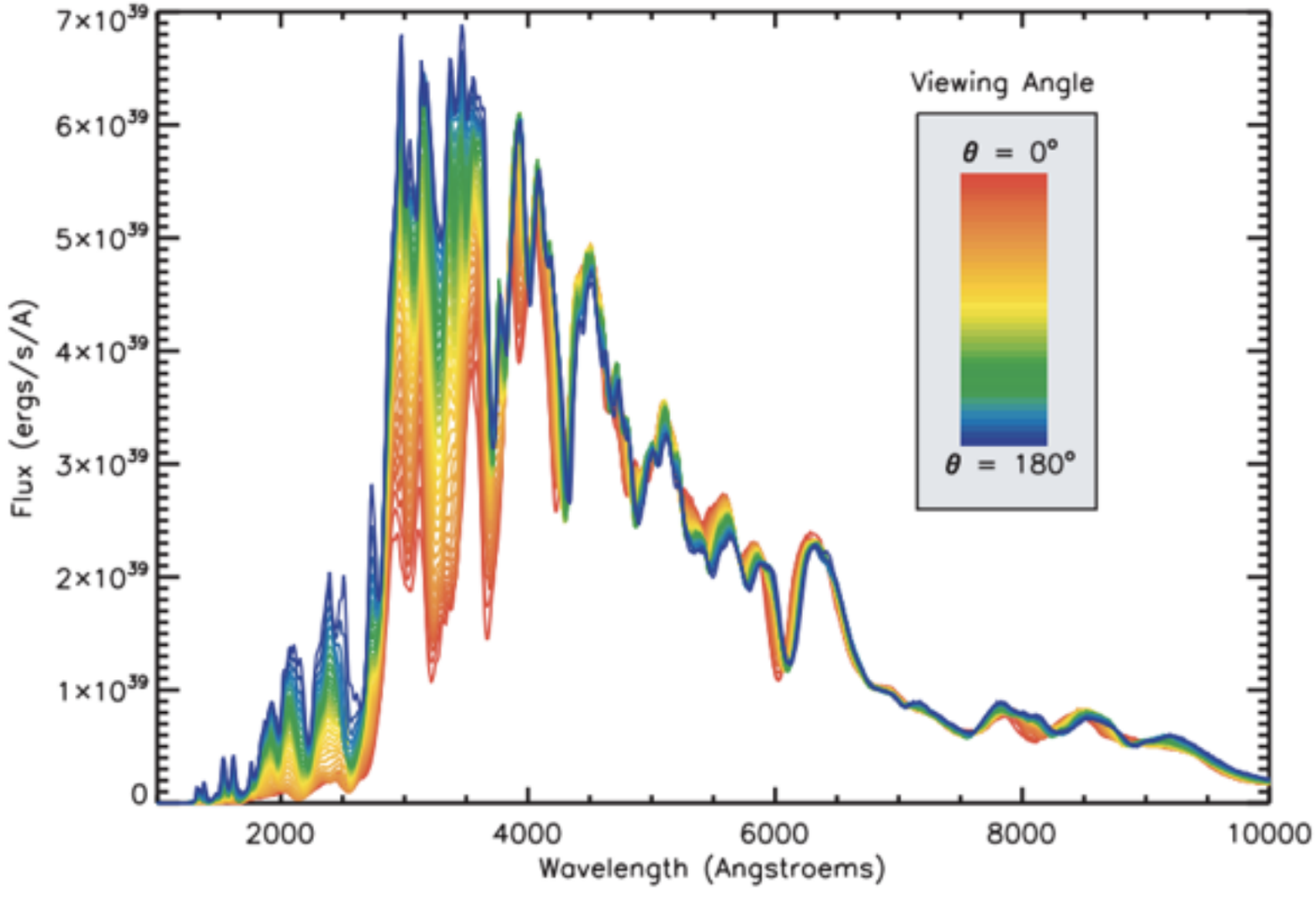


off-center ignition (GCD-like model)

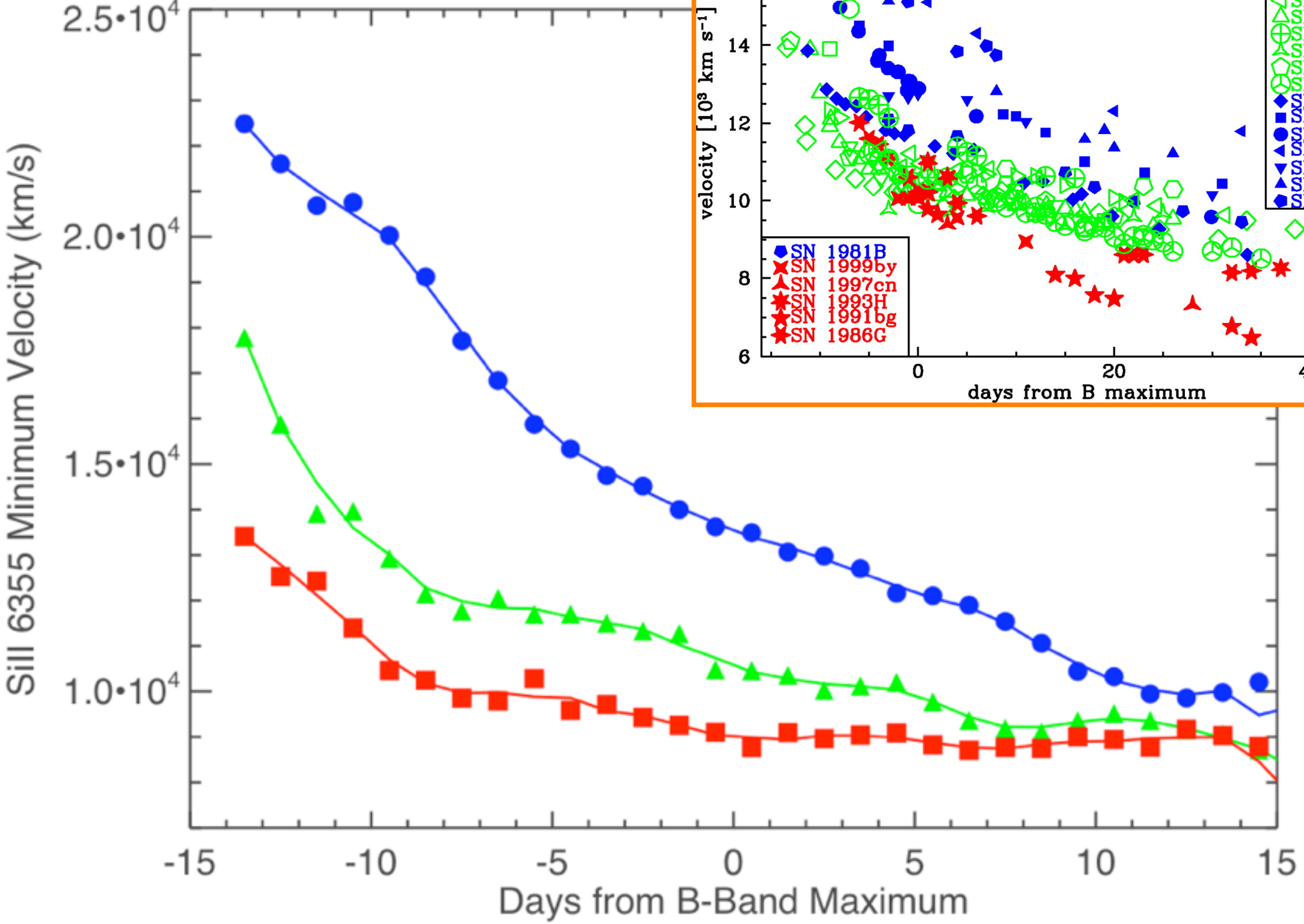
kasen & Plewa 2007
foley & kasen (2011)



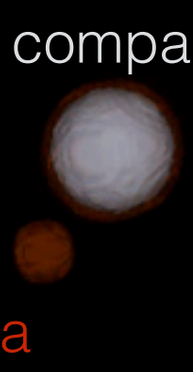
variations in Fe-group blanketing affect the UV brightness

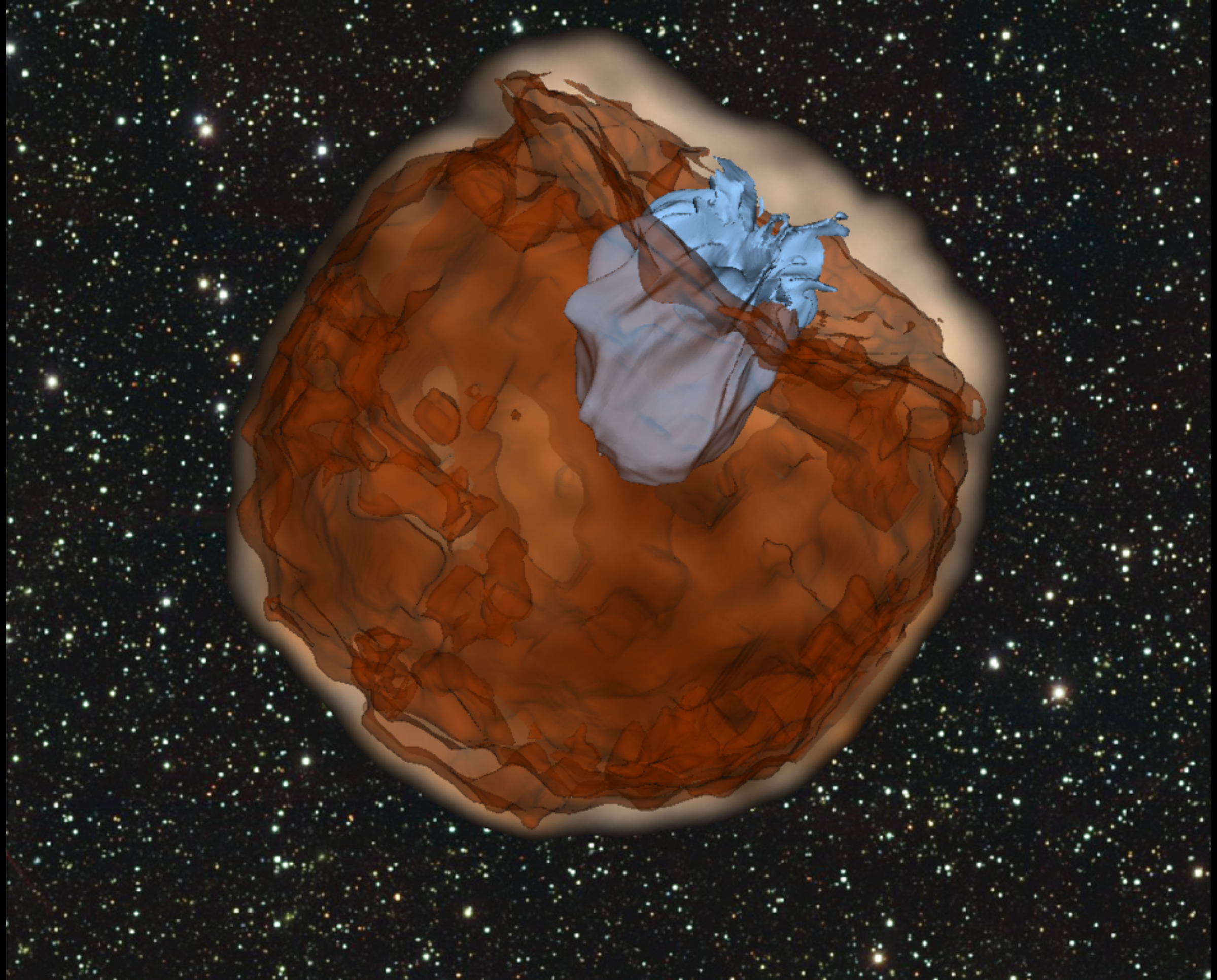


silicon velocity as a fun

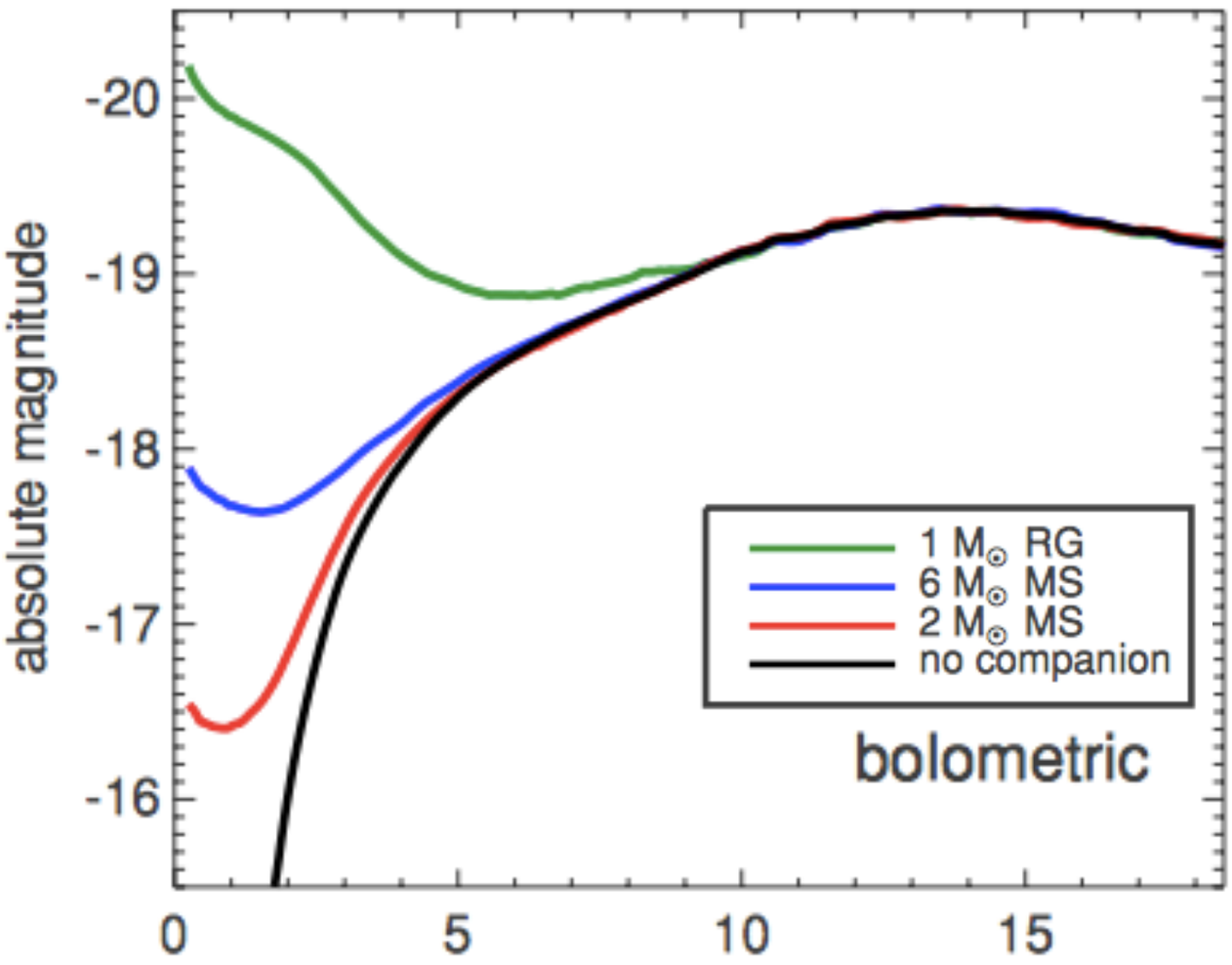


companion interaction and early light curves



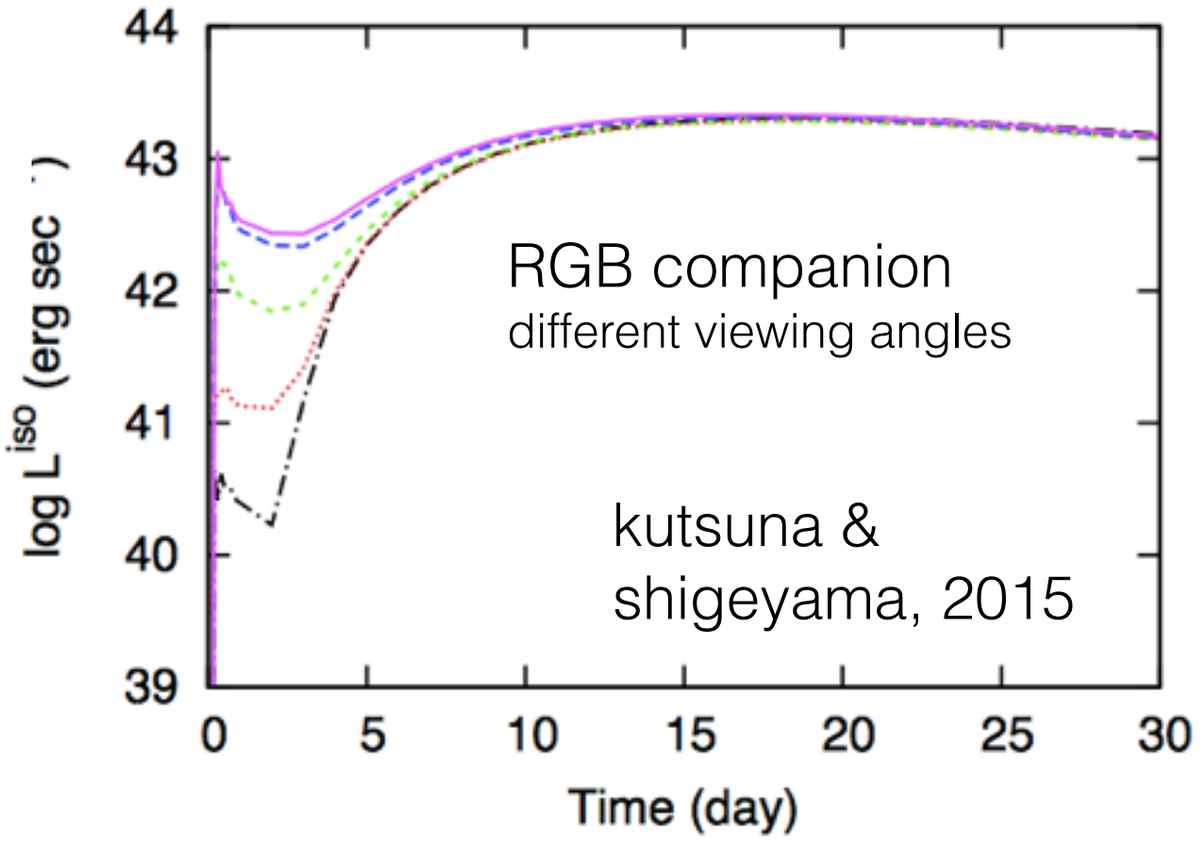


companion shock signatures



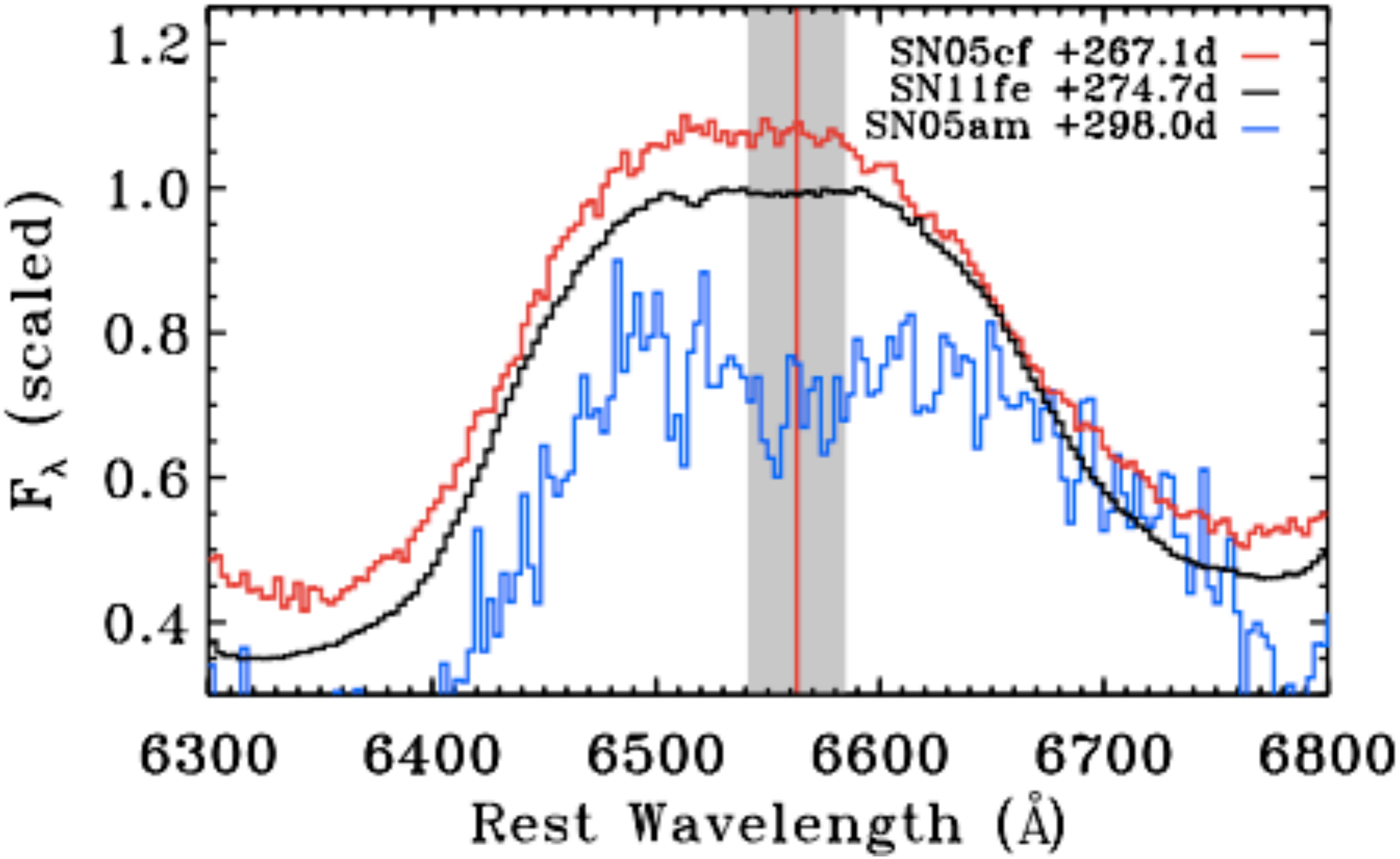
kasen 2010

Cao et al (2015) ~20 R_{sun}
Marion et al (2015) ~10 R_{sun}
Shappee (2015) no detection
Olling et al (2015) no detection
Nugent el al (2015) no detection
Bianco et al (2010) no detection
Hayden et al (2010) no detection
Brown et al (2011) no detection



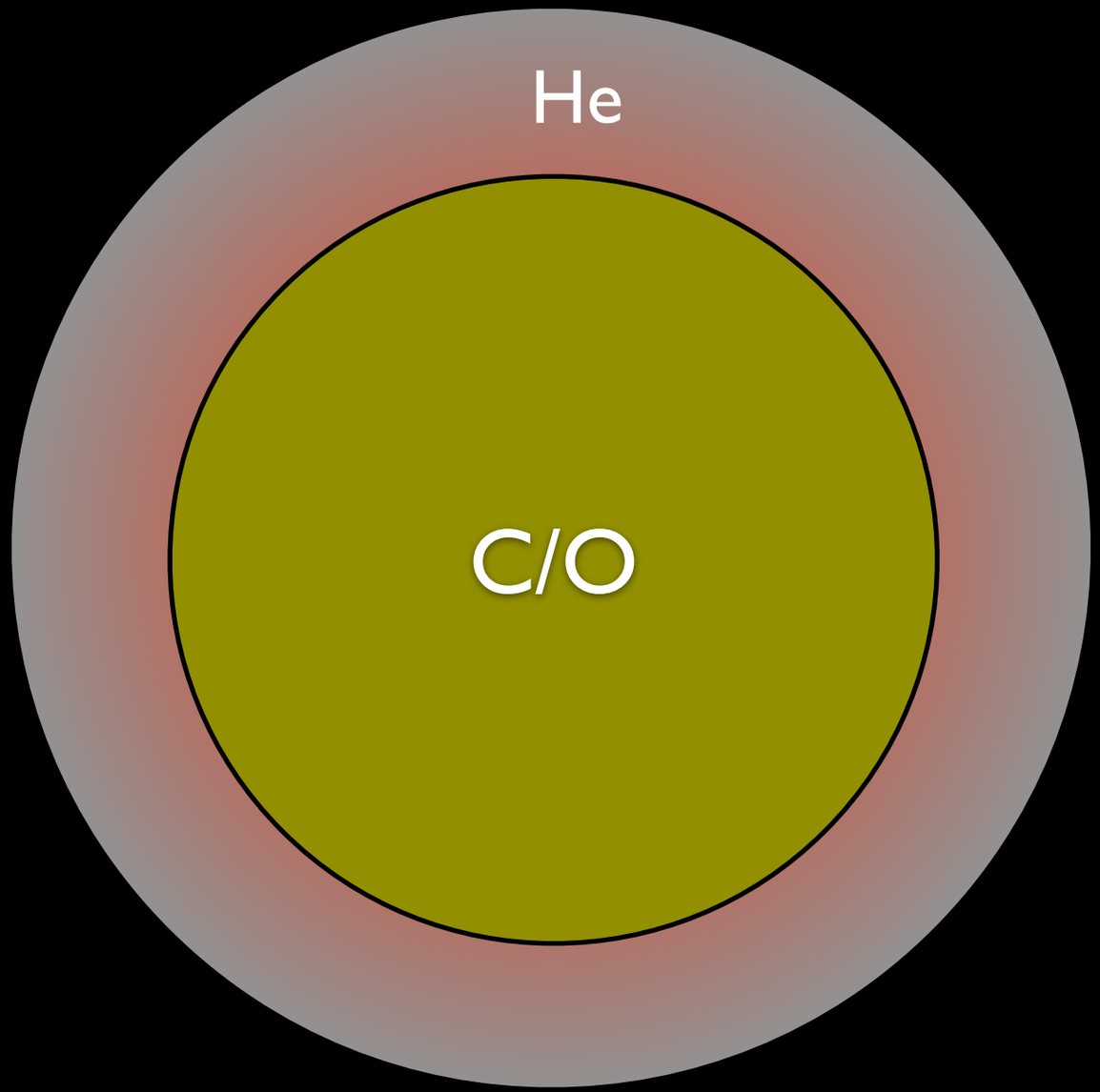
No sign of stripped hydrogen in spectra

but how robust our the theory predictions?



shappee+ 2013

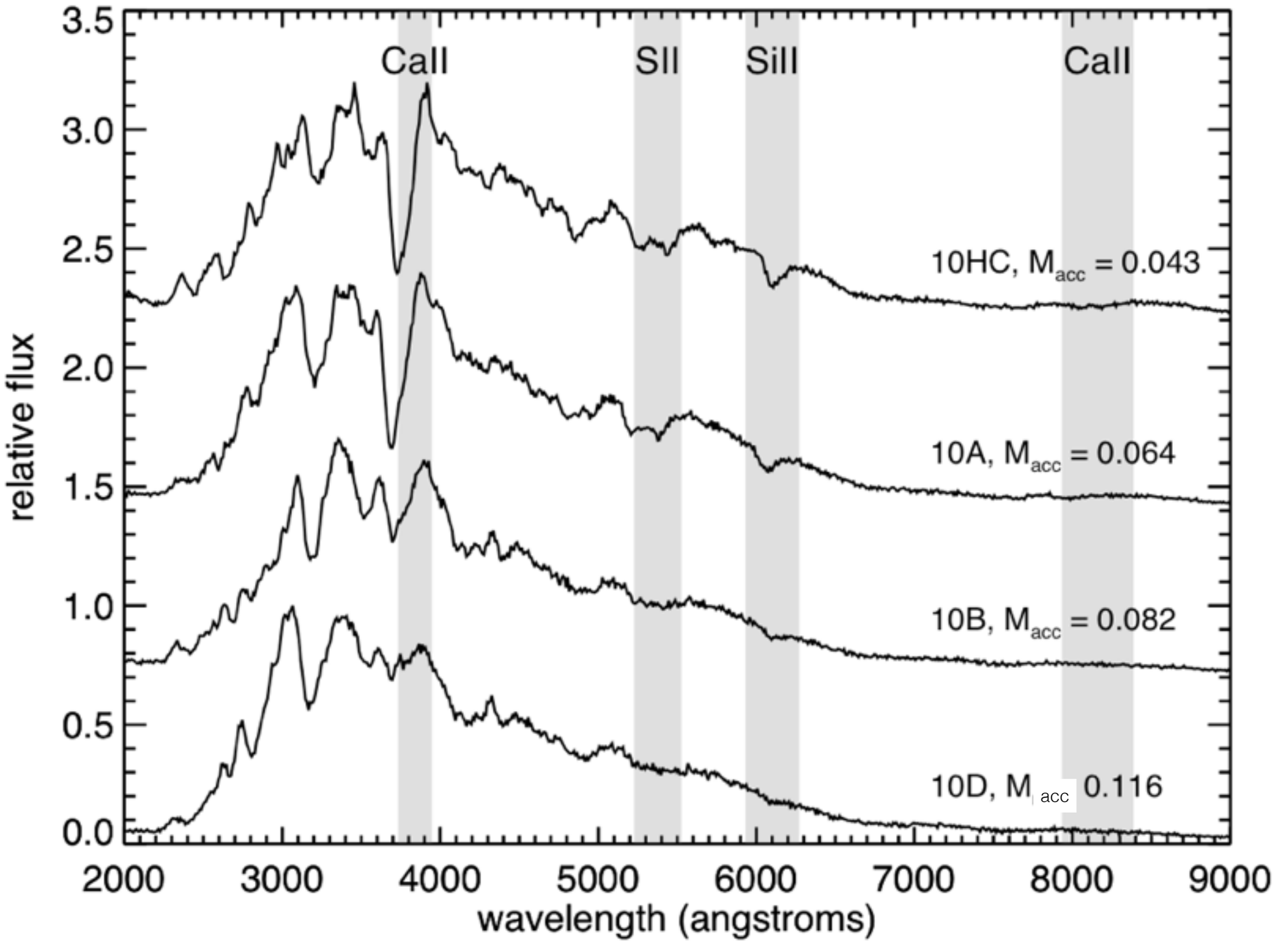
sub-chandrasekhar explosions (double-detonation)

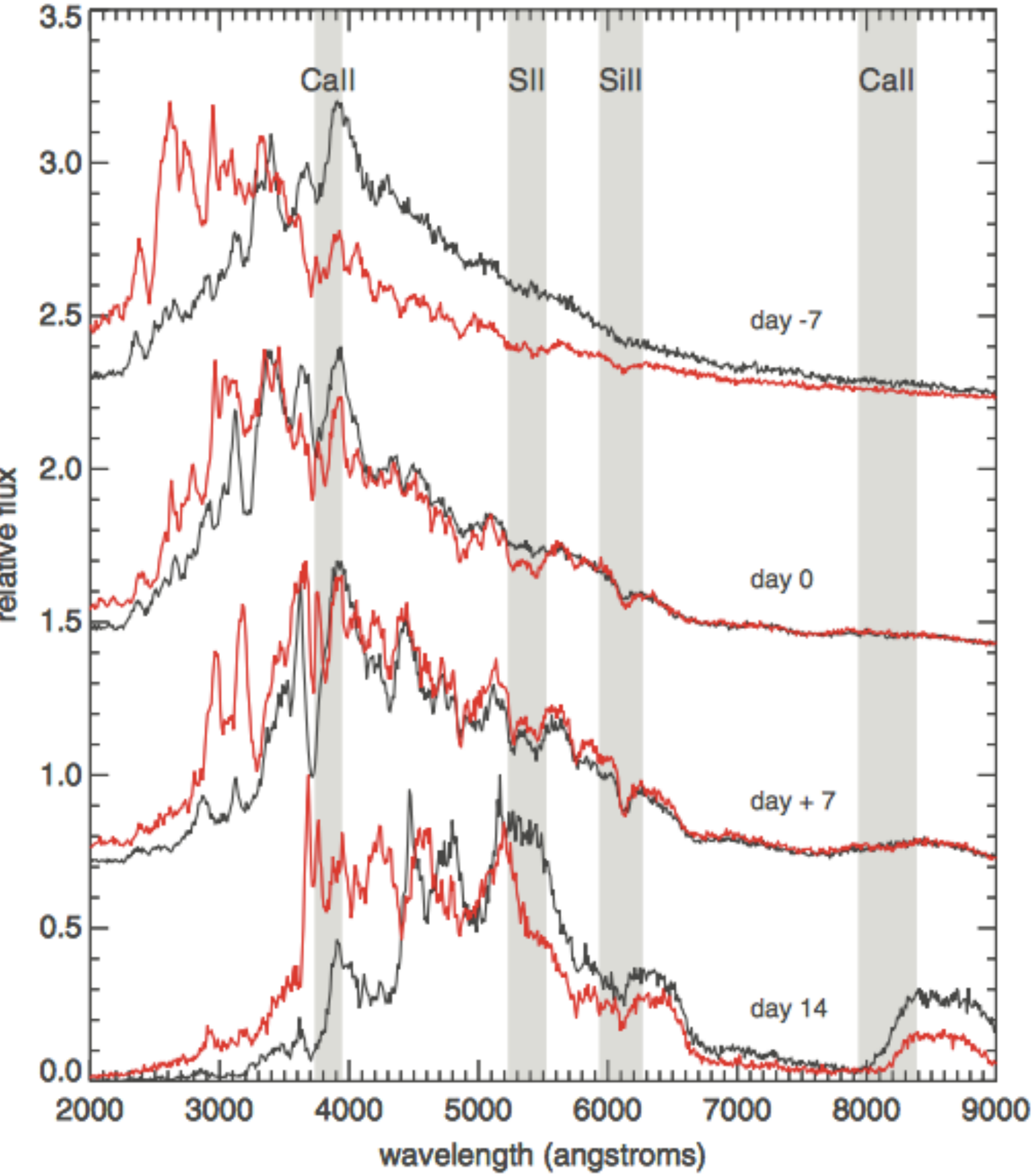


Nomoto+ 1980, Woosley+ 1980, Livne 1990
Woosley&Weaver 1994, Livne&Arnett 1994,
Bildsten+ 2007,Fink+ 2007, Sim+ 2010, Kromer+ 2010
Woosley&Kasen 2011

double detonation spectra (at maximum)

varying helium shell masses (woosley and kasen 2011)





spectral evolution

<u>double detonation</u>

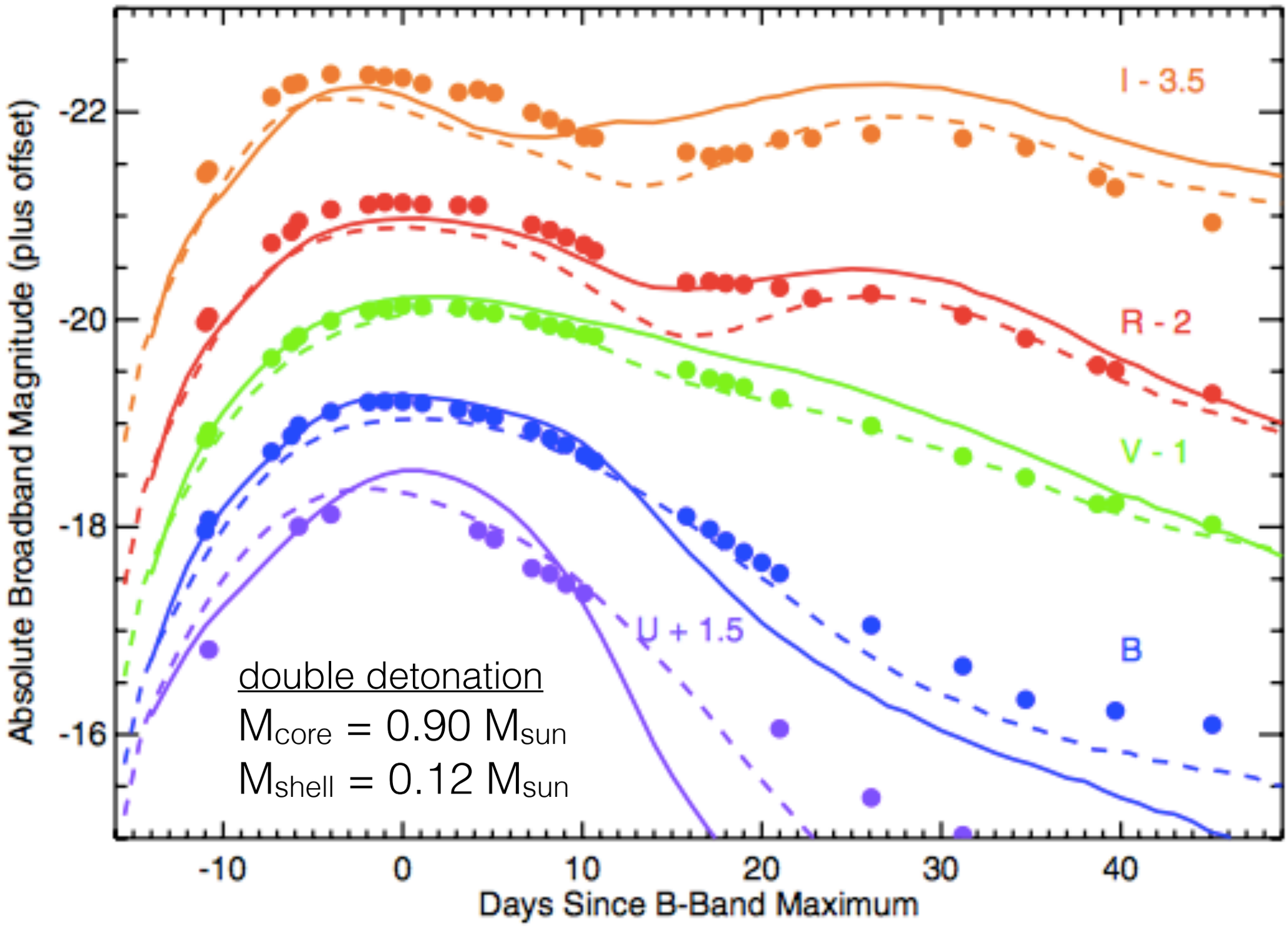
$M_{core} = 0.90\ M_{sun}$

$M_{shell} = 0.12\ M_{sun}$

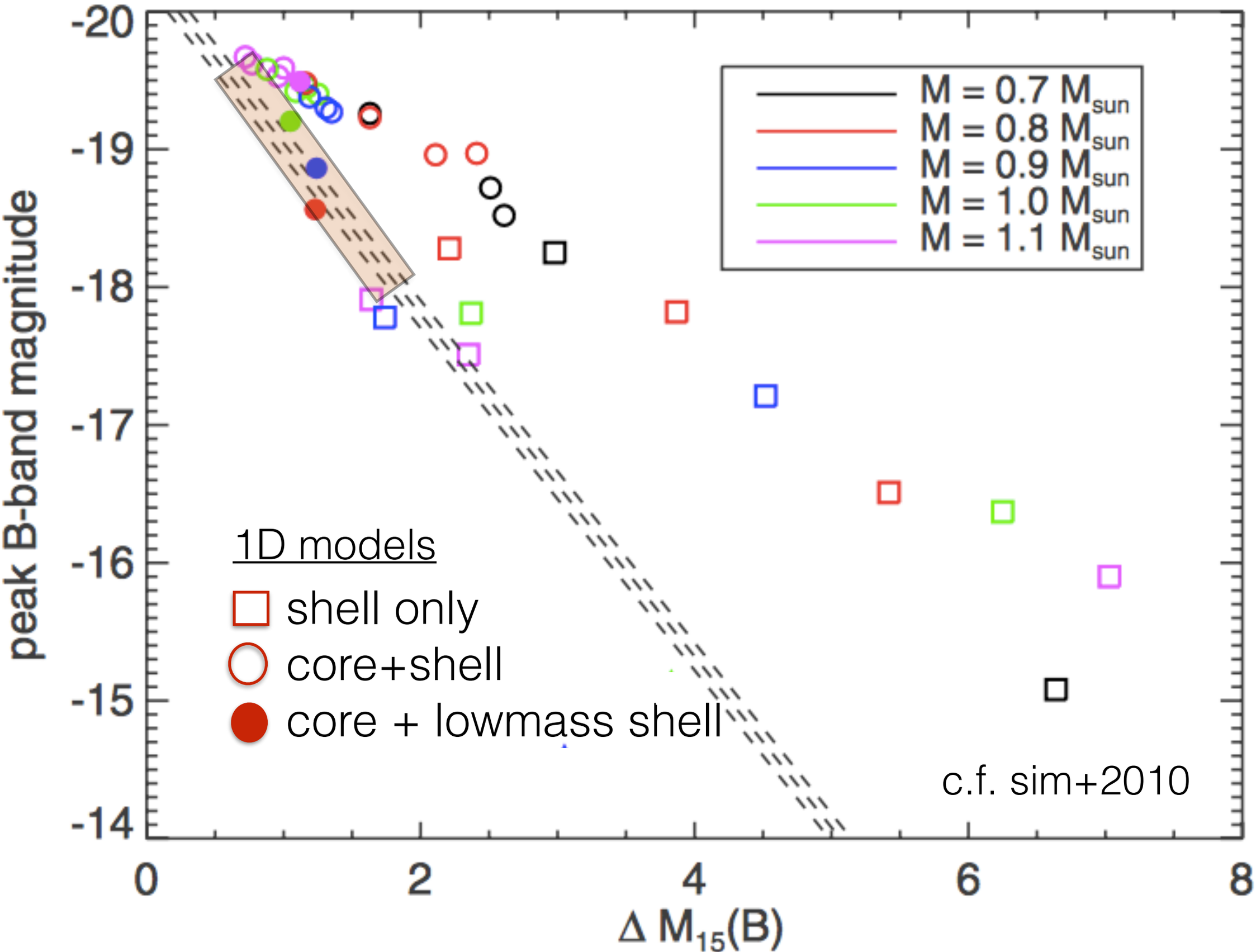
black: with burned shell
red: without burned shell

broadband light curves

solid (with shell), dashed (no shell), dots (SN2003du)



sub-chandrasekhar model width luminosity relation

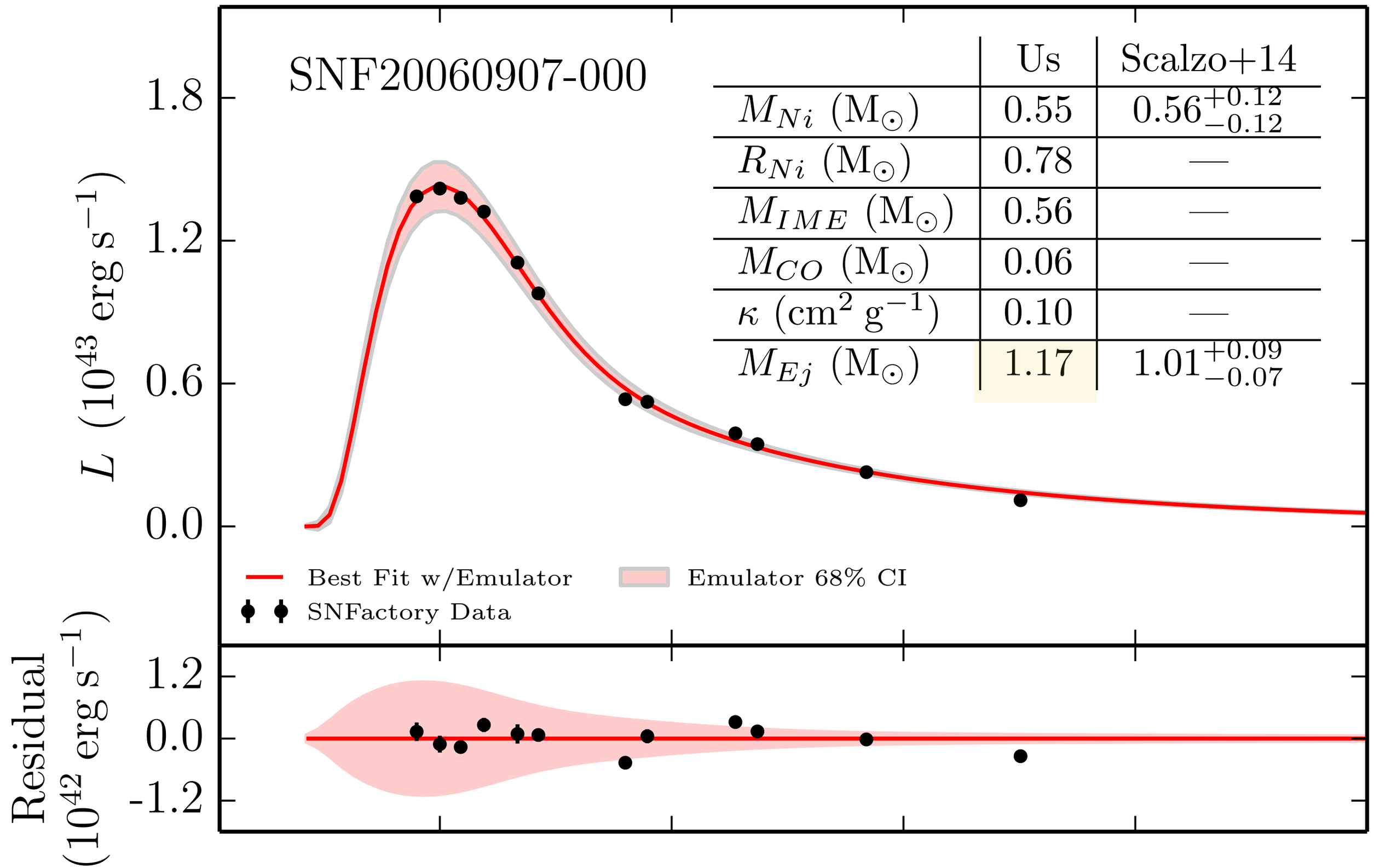


fits to observed SNF light curves

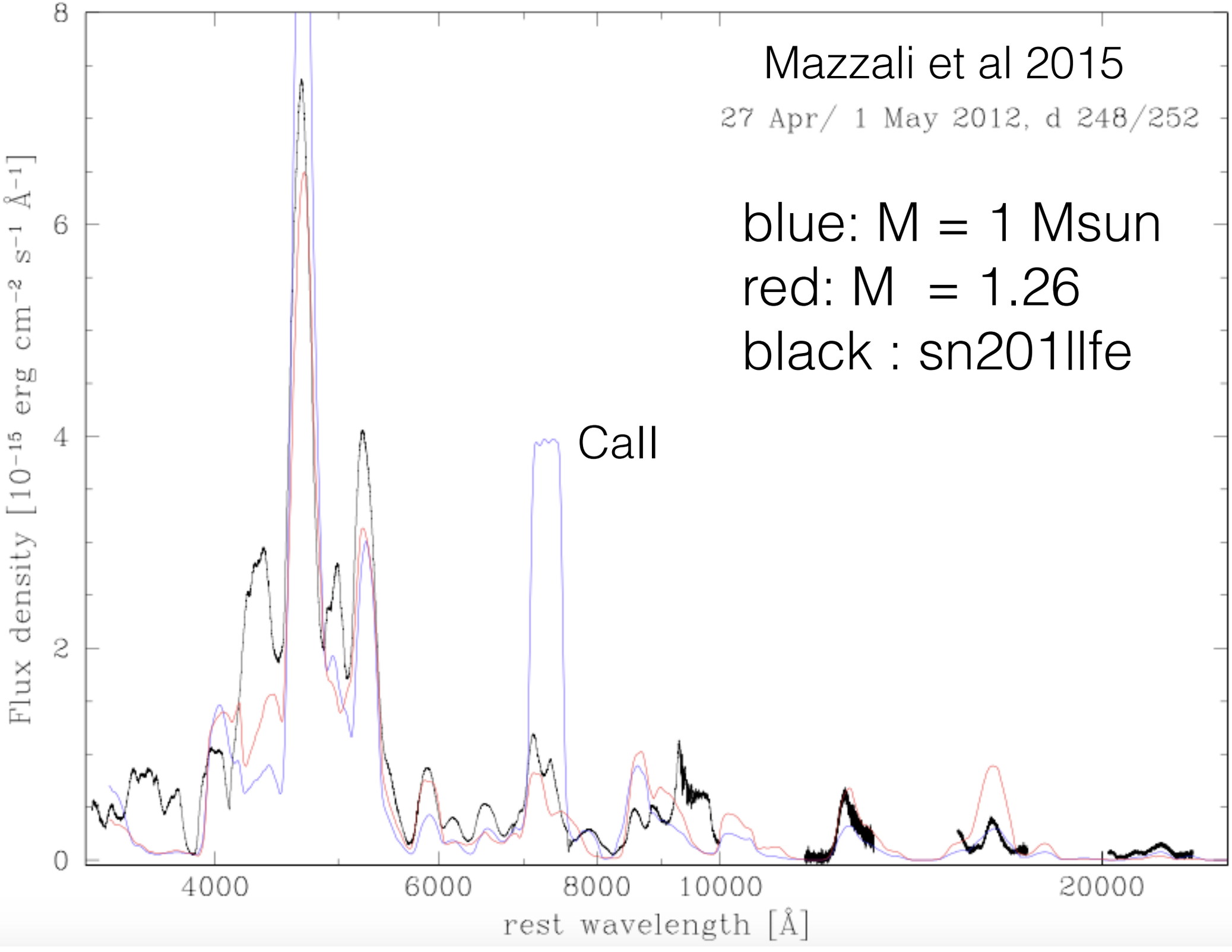
physical parameter estimation (danny goldstein, UCB)

SNF20060907-000

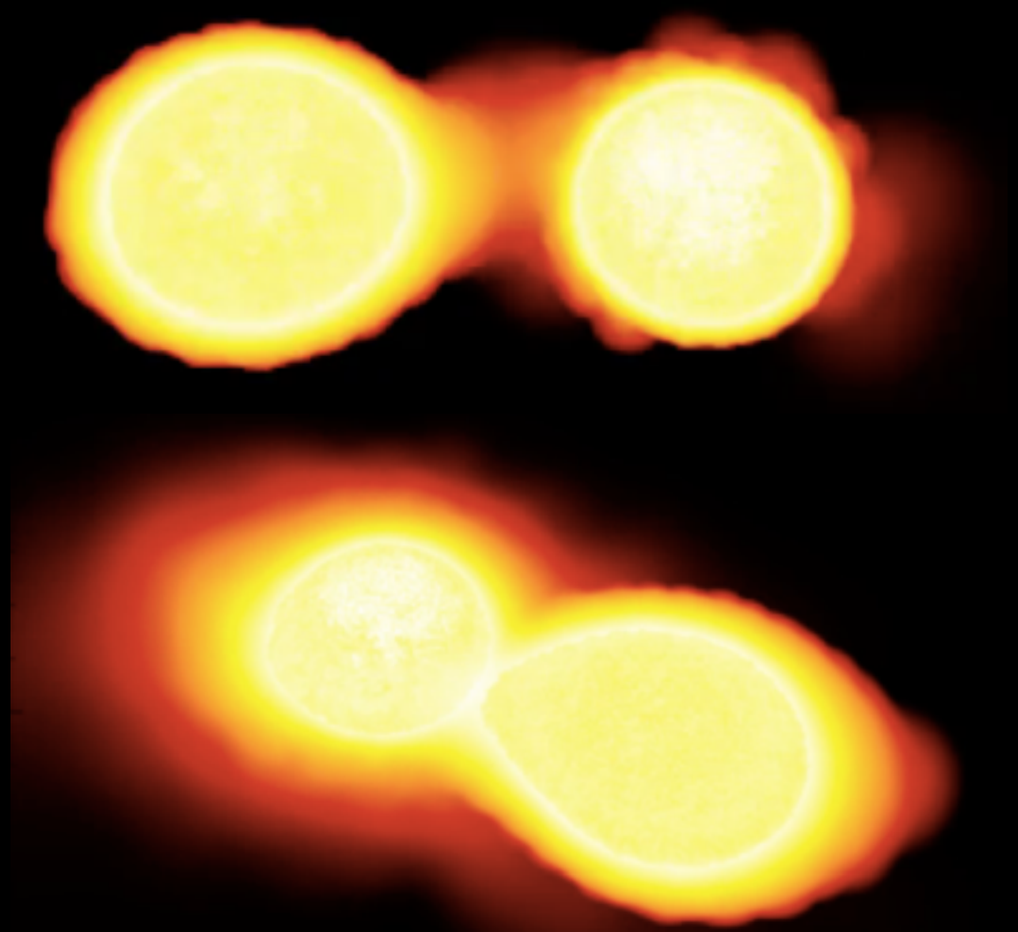
	Us	Scalzo+14
M_{Ni} ($M_\odot$)	0.55	$0.56^{+0.12}_{-0.12}$
R_{Ni} ($M_\odot$)	0.78	—
M_{IME} ($M_\odot$)	0.56	—
M_{CO} ($M_\odot$)	0.06	—
κ ($cm^2\ g^{-1}$)	0.10	—
M_{Ej} ($M_\odot$)	1.17	$1.01^{+0.09}_{-0.07}$

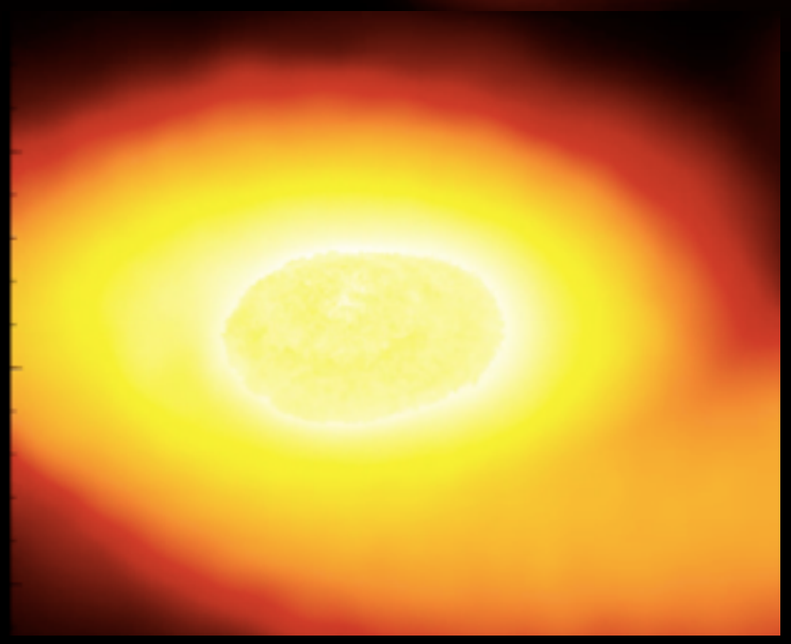


Lack of stable iron group elements in nebular spectra?



double white dwarf mergers as SNe Ia





“double” detonation

He shell explodes during mass transfer; secondary remains intact?
e.g. guillochon et al (2010)

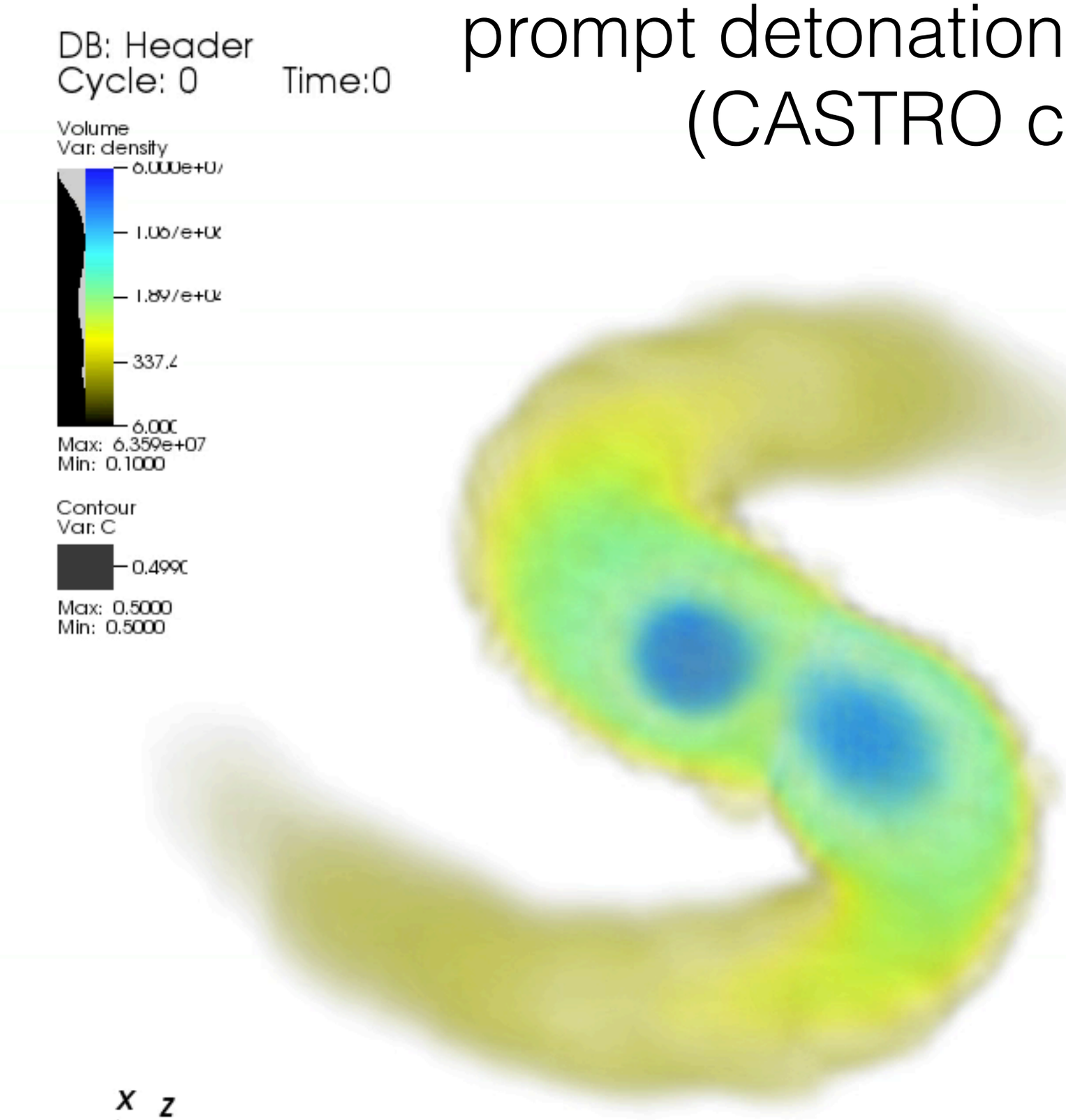
“prompt” (violent) detonation or collision

both stars explode
e.g. pakmor et al (2010)
raskin+2009, rosswog+2009

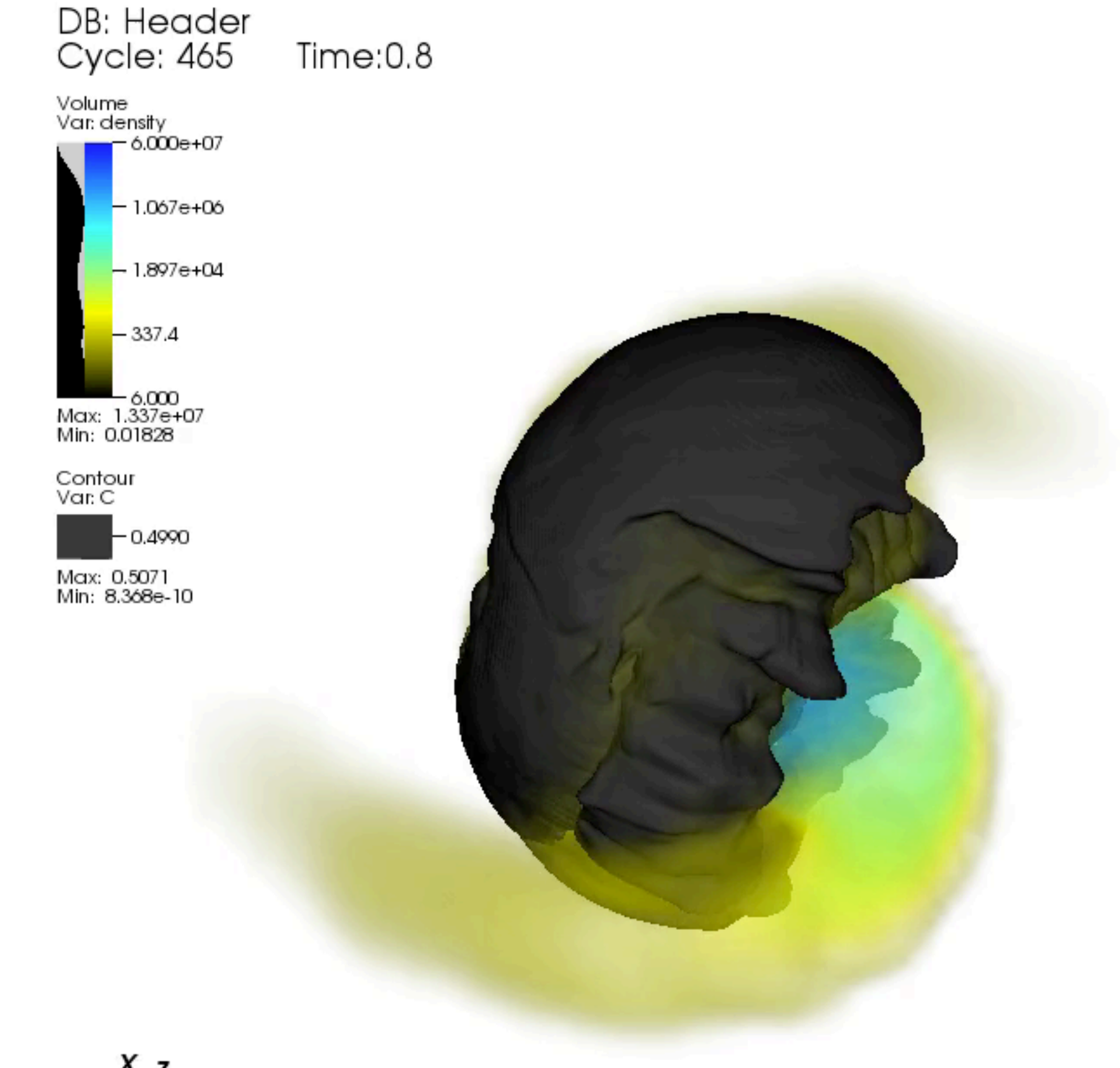
“late” detonation

secondary shredded to disk (“tamped” SNe Ia)
e.g., hoeflich and kokhlov (1996)
raskin+2014

prompt detonation calculation (CASTRO code)



moll, raskin, kasen, woosley (2014)
raskin, kasen, moll, schwab, woosley (2014)

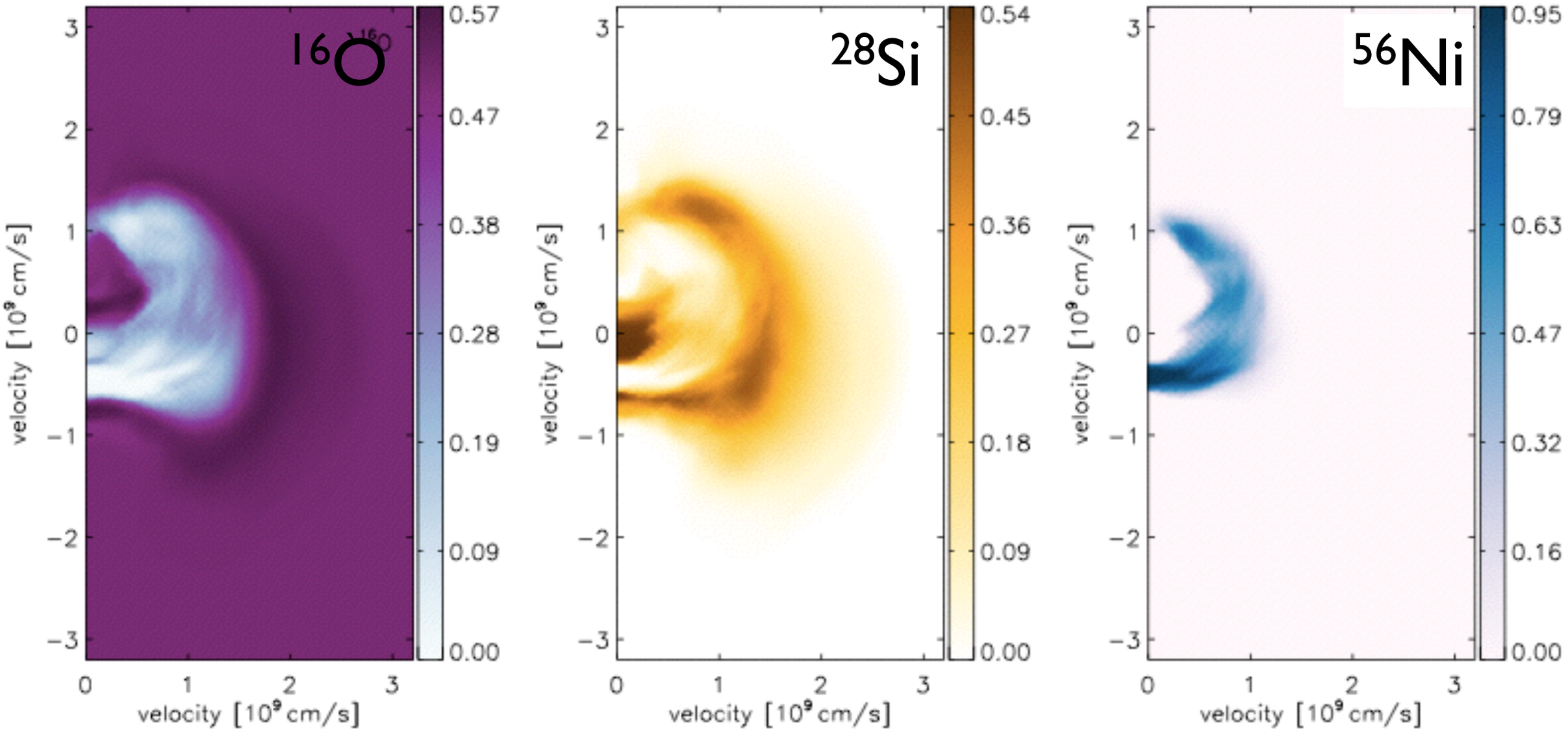


raskin and kasen (2013)
moll, raskin, kasen, woosley (2014)

white dwarf mergers as SNeIa

compositional structure of prompt explosions

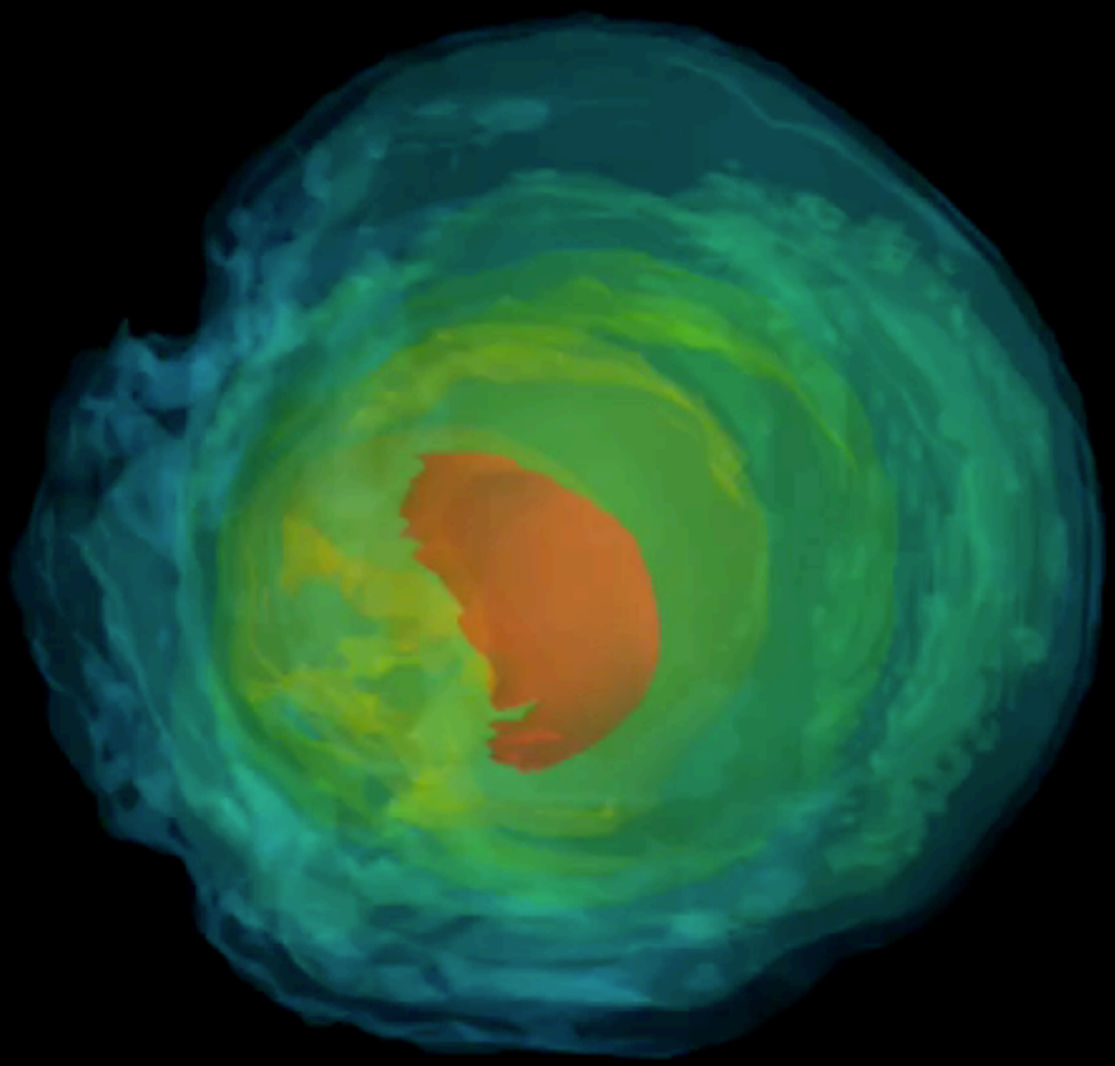
(azimuthal averages)



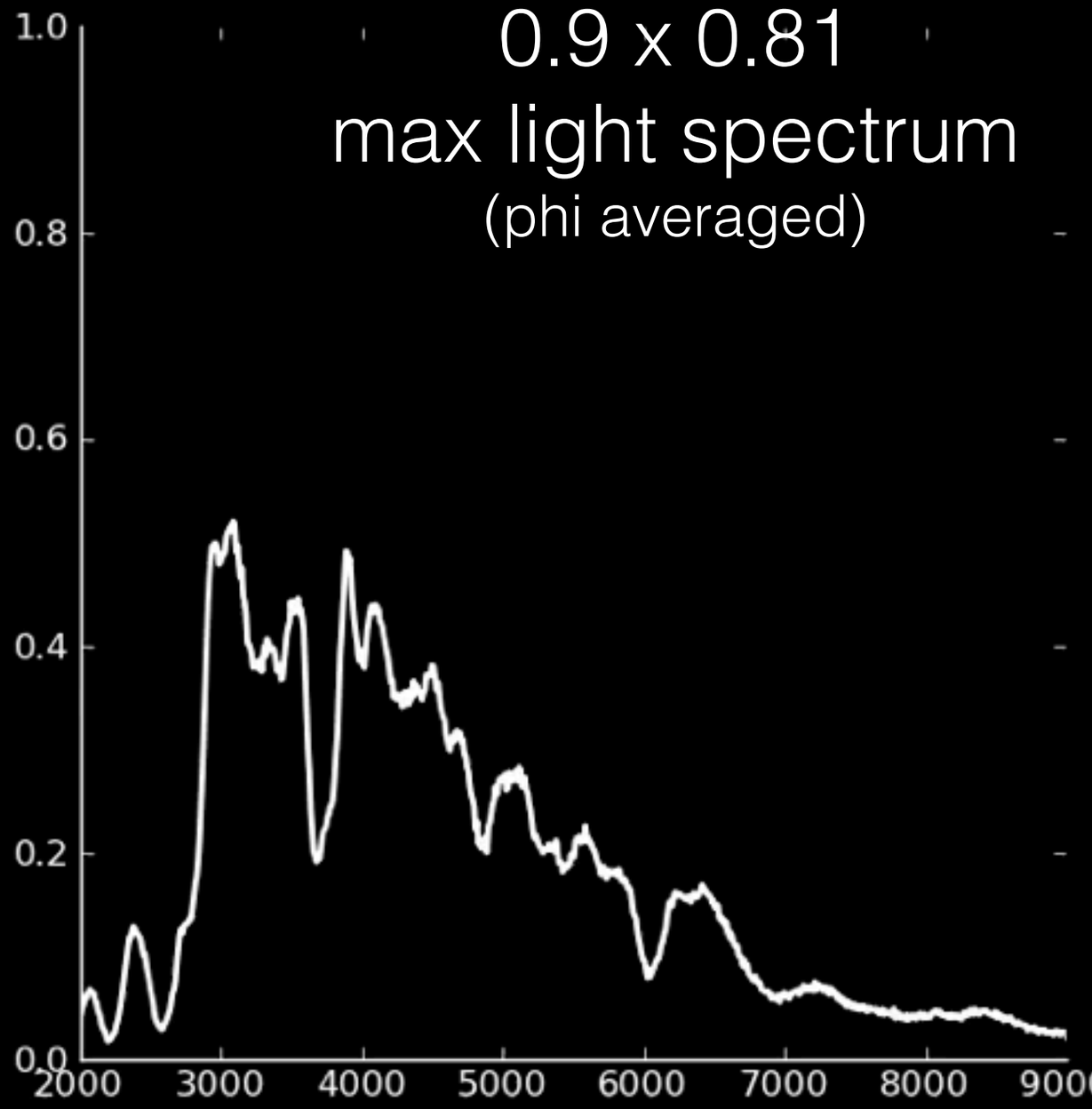
moll, raskin, kasen, woosley (2014)

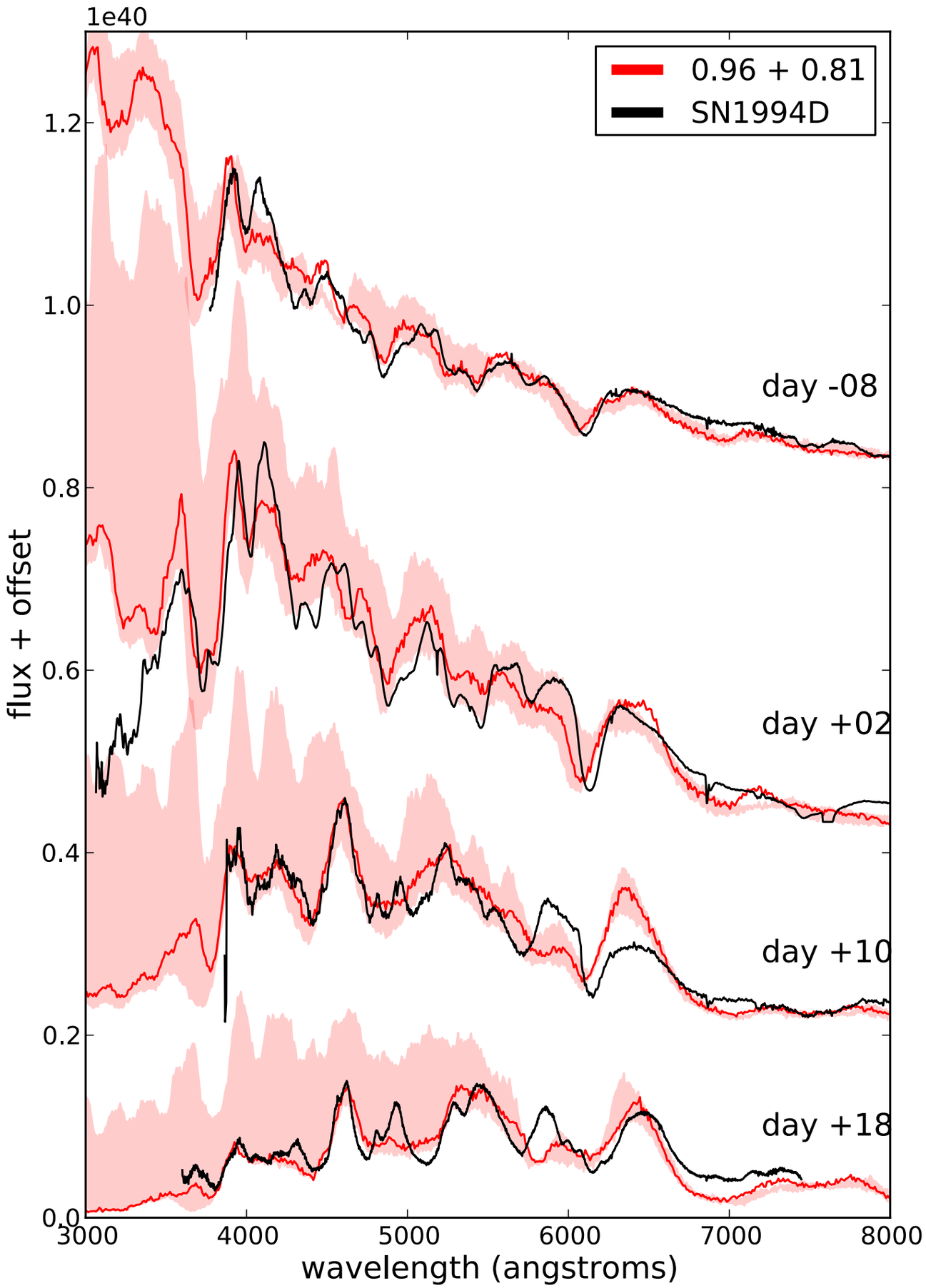
violent white dwarf merger

viewing angle dependence



0.9 x 0.81
max light spectrum
(phi averaged)





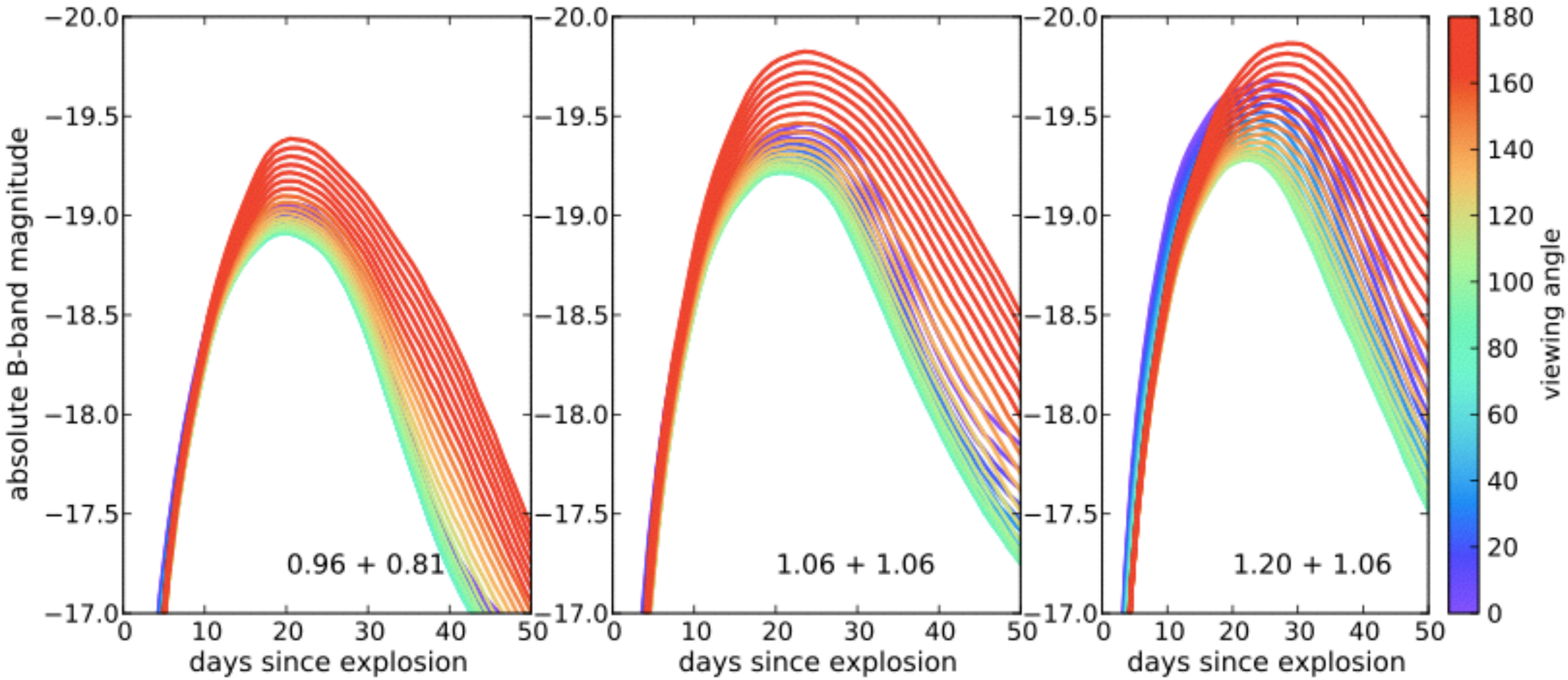
white dwarf mergers as SNeIa

prompt explosion comparison to observed spectra

moll, raskin, kasen, woosley (2014)
raskin, kasen, et al (2014)
c.f. roepke et al (2012)

prompt explosions of C/O WD mergers

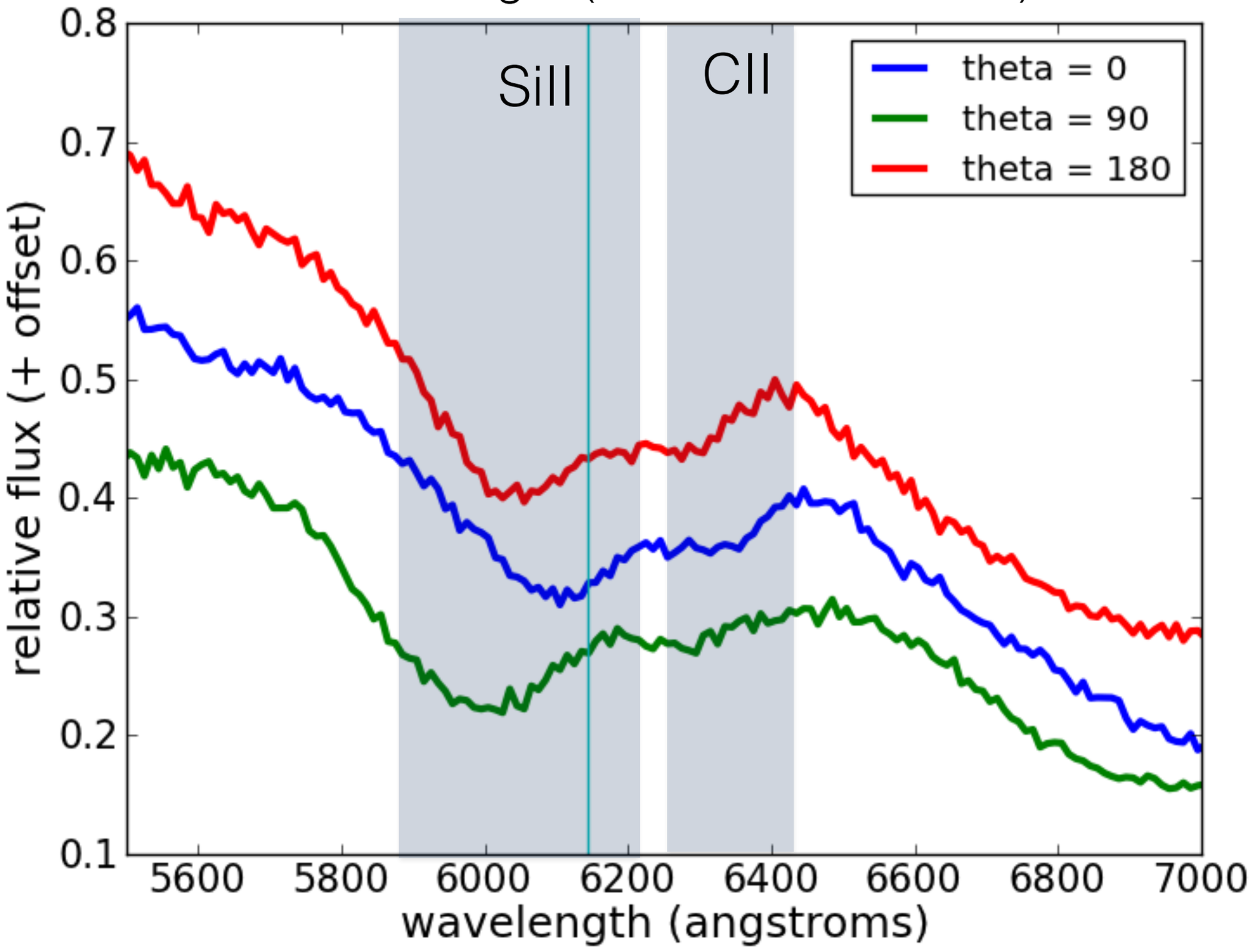
synthetic B-band light curves



moll, raskin, kasen, woosley (2014)

carbon features near maximum

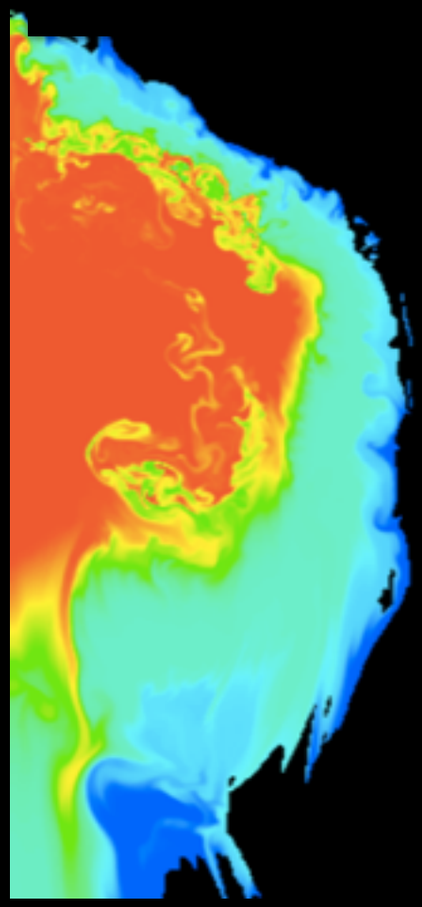
1.2 x 1.06 merger (~0.1 M_{sun} of carbon)



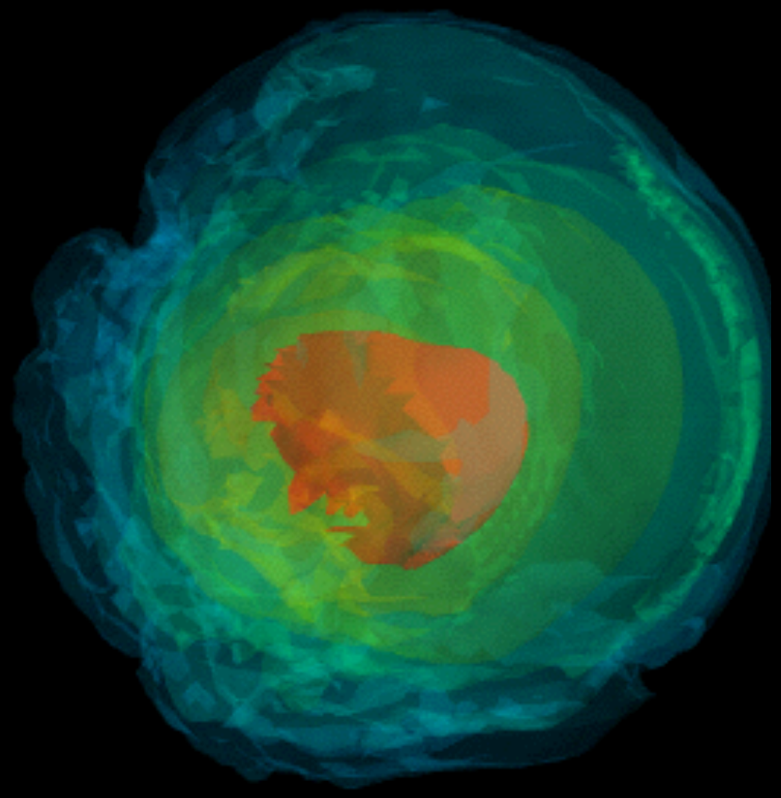
asymmetry and polarization

normal SNIa show low continuum polarization <~ 0.3%
(higher in SN1991bg-like ~ 0.6%)
(higher polarization in lines ~1-2%)

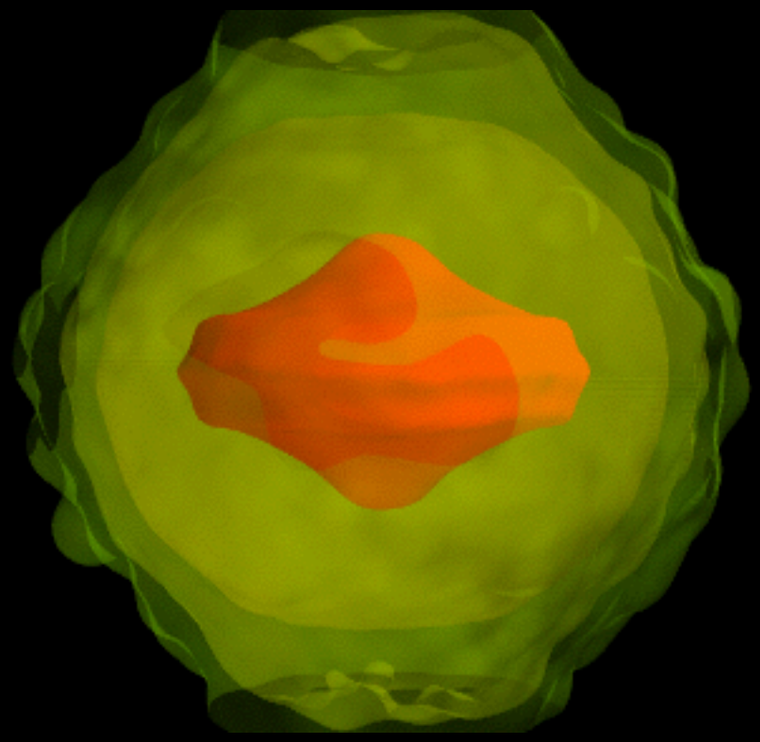
off-center M_{ch}



violent merger

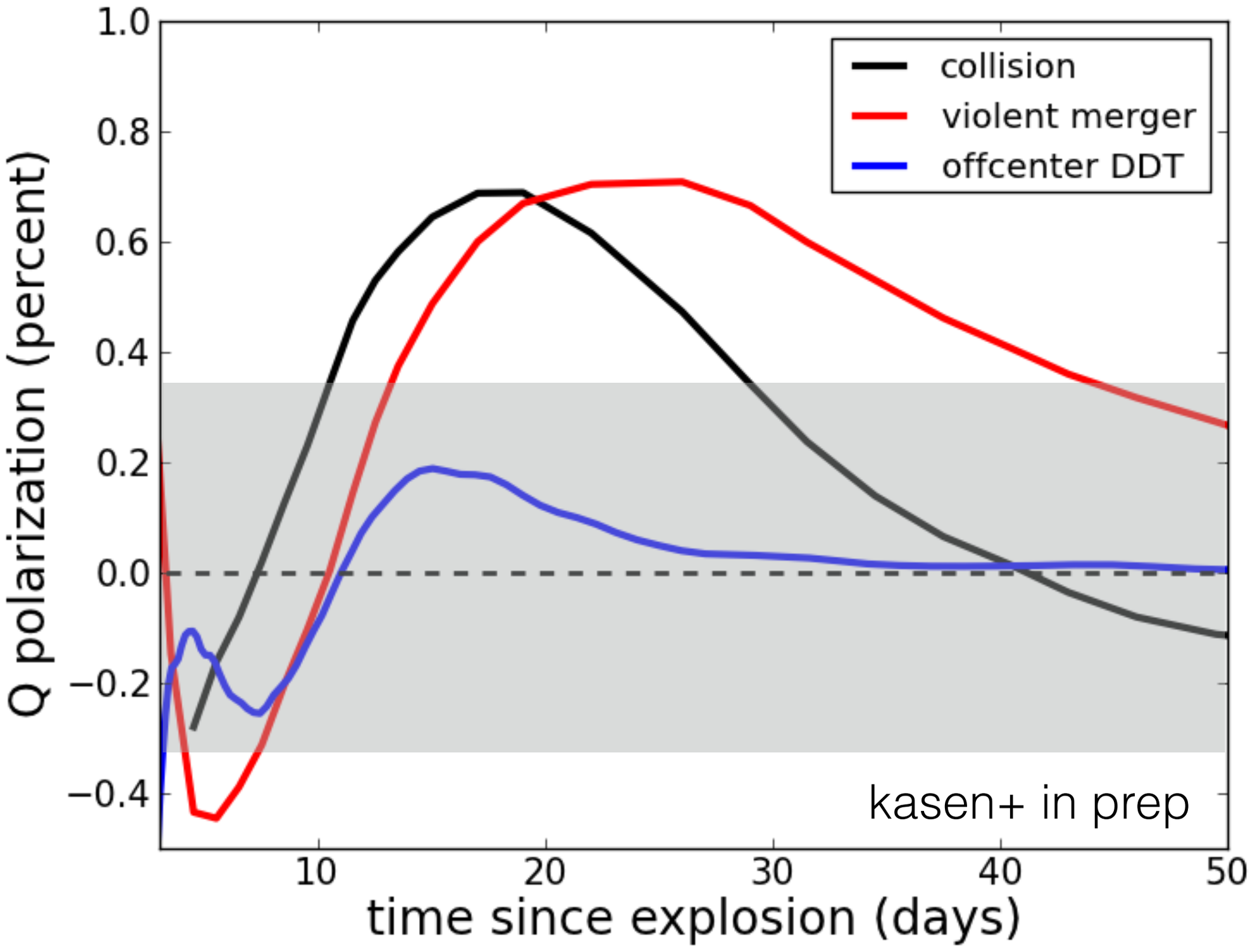


head on collision



continuum polarization curves

3-D models: pure e^- scattering, inclination = 90^o



M_{ch} models

Felicitous agreement with observed light curves/spectra (even the effects of asymmetry), tension with other indicators (e.g., no companion/CSM interaction).
Can they contribute at a significant rate?

sub-M_{ch} models

Can we ignite and propagate detonation in low shell masses (< 0.01 Msun) or in a WD merger leadup?
Do we need (can we get) stable iron group?

merger/collision models

Is the high-degree of asymmetry a deal breaker?
Are these (just) the “super-Chandrasekhar” events?