ZTF and Determining the Progenitors of Type Ia Supernova

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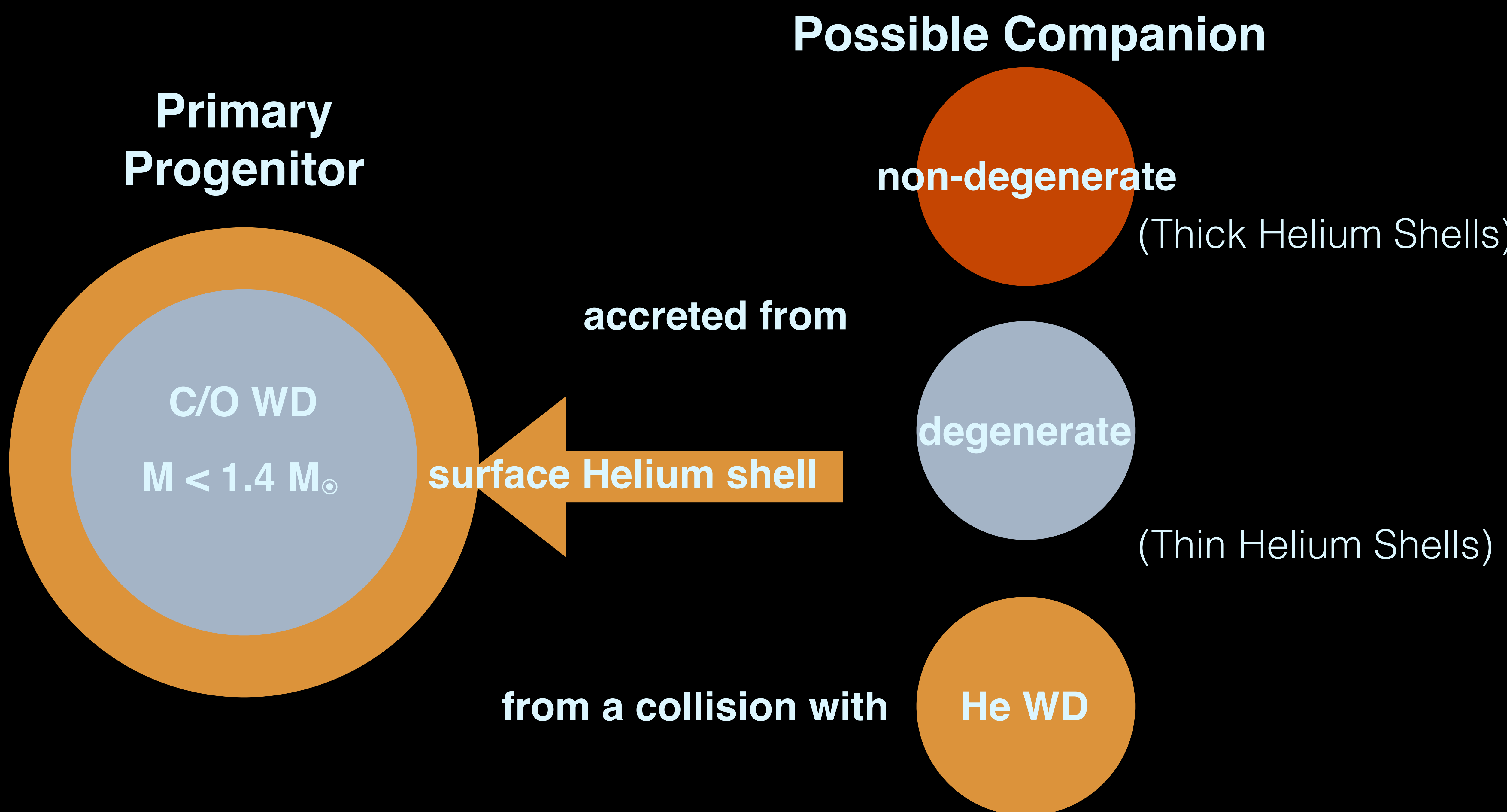
The Sub-Chandrasekhar Model



Double Detonation Scenario: detonation of the surface helium leads to a detonation of the carbon-oxygen core

Sub-Chandra’s: Why look at them?

THE ASTROPHYSICAL JOURNAL, 485:812–819, 1997 August 20

SYNTHETIC SPECTRA OF HYDRODYNAMIC MODELS OF TYPE Ia SUPERNOVAE

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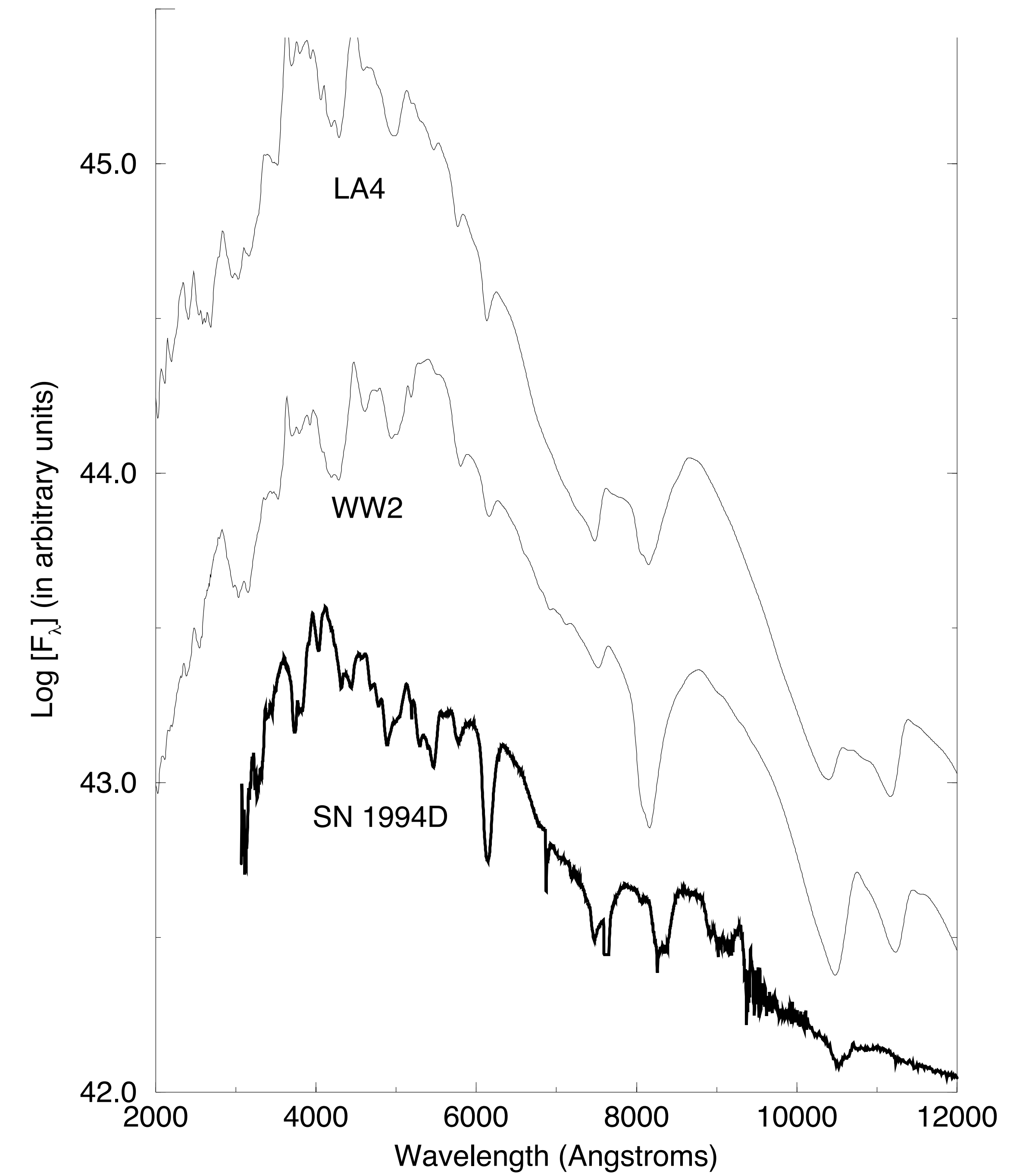
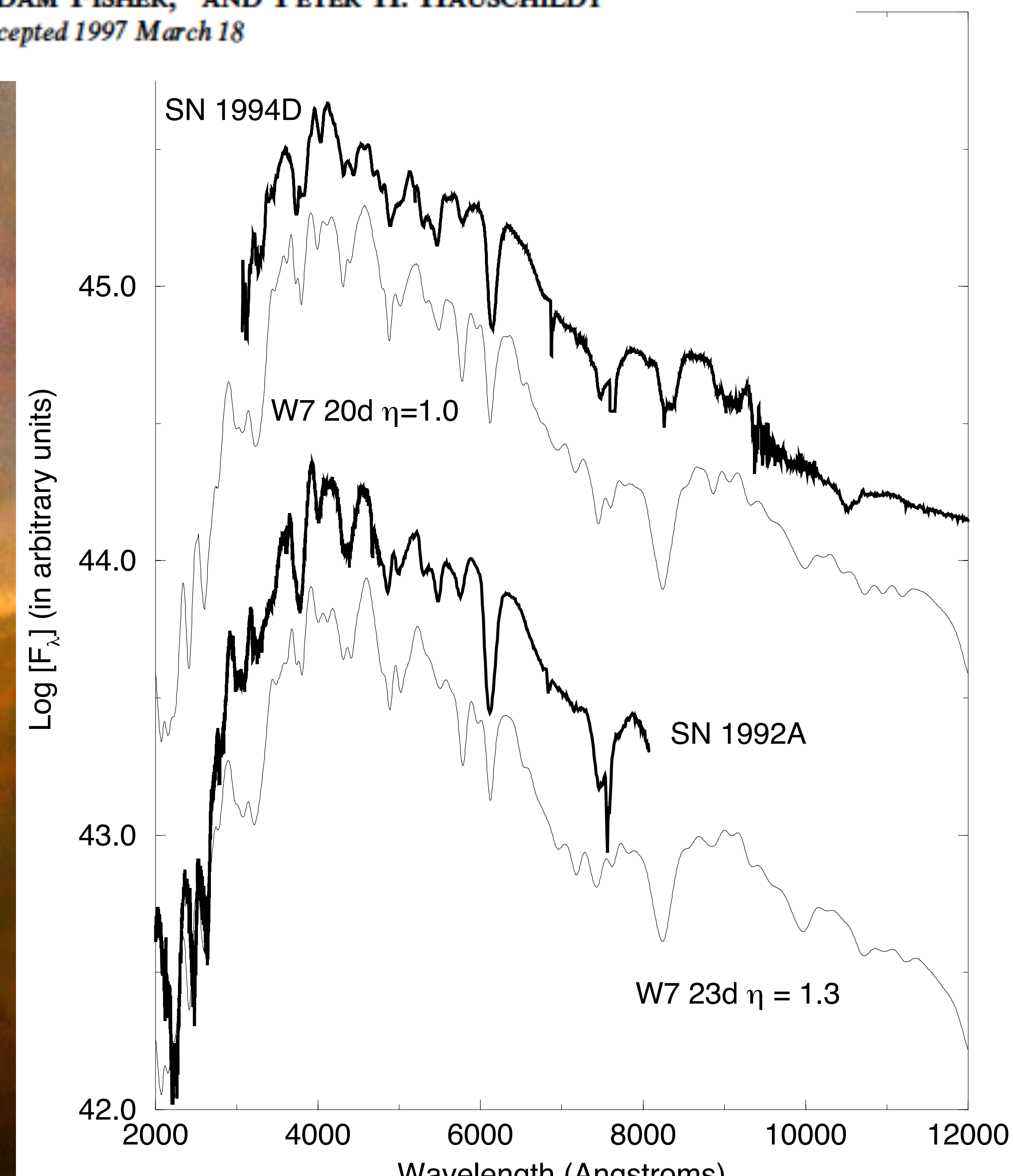




Sub-Chandra's: Why look at them?

THE ASTROPHYSICAL JOURNAL

THE IGNITION OF CARBON DETONATIONS VIA CONVERGING SHOCK WAVES IN WHITE DWARFS

Ken J. Shen[1,3] and Lars Bildsten[2]

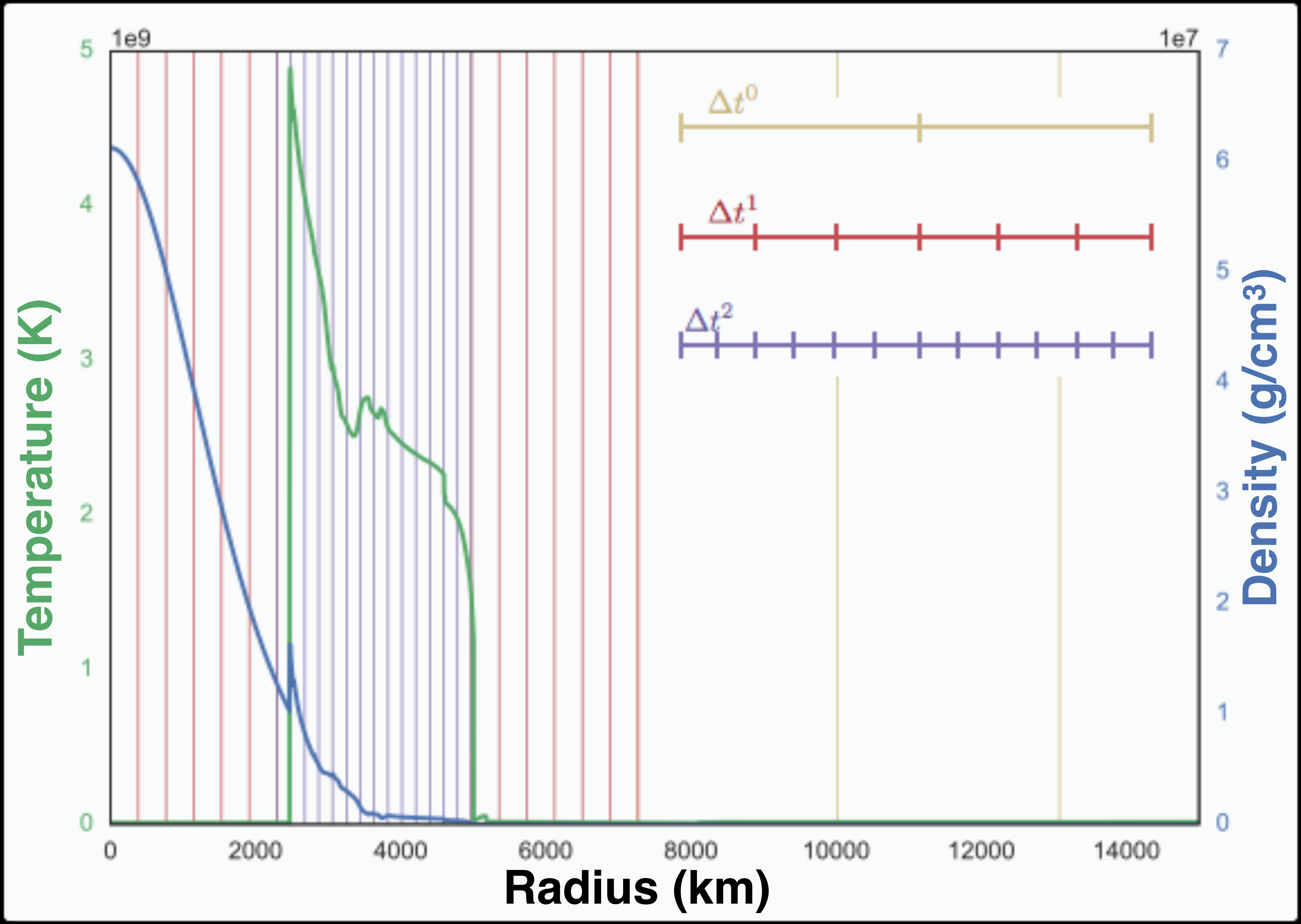
Published 2014 March 26 •

The Astrophysical Journal, Volume 785, Number 1

In more recent years, the possibility of He shell detonations in systems with dynamically stable mass transfer from a He WD donor was considered (Bildsten et al. 2007; Shen & Bildsten 2009; Shen et al. 2010; Kaplan et al. 2012). Because the resulting accretion rates are higher, the accumulated He shells at the onset of He-burning are 10–100 times less massive than in the non-degenerate He donor scenario. While subsequent work on double detonations predicted that even these small He shells would adversely affect observations (Fink et al. 2007, 2010; Kromer et al. 2010; Sim et al. 2010; Woosley & Kasen 2011), more recent multi-dimensional work allowing for post-shock radial expansion in the He layer suggests that He-burning will be truncated before significant production of IGEs (Townsley et al. 2012; Holcomb et al. 2013; Moll & Woosley 2013; Moore et al. 2013). A large amount of C/O pollution in the He layer, either dredged up from the core or produced during a phase of convective He-burning, may also prevent overproduction of IGEs (Kromer et al. 2010; Waldman et al. 2011).

Numerical Methods — Castro

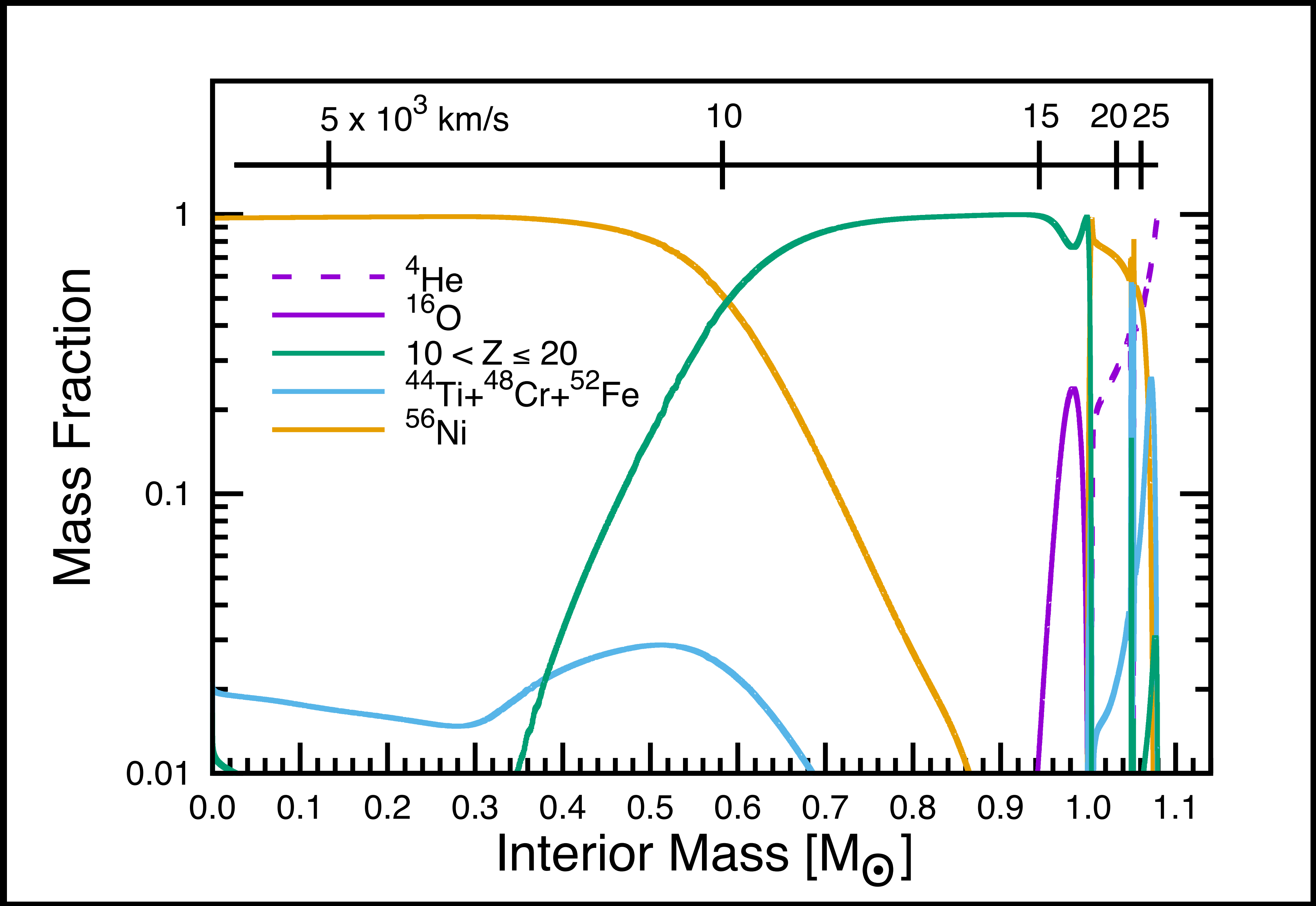
Castro: an adaptive mesh, astrophysical radiation hydrodynamics code



example adaptive grid designed to tag areas of nuclear burning for refinement

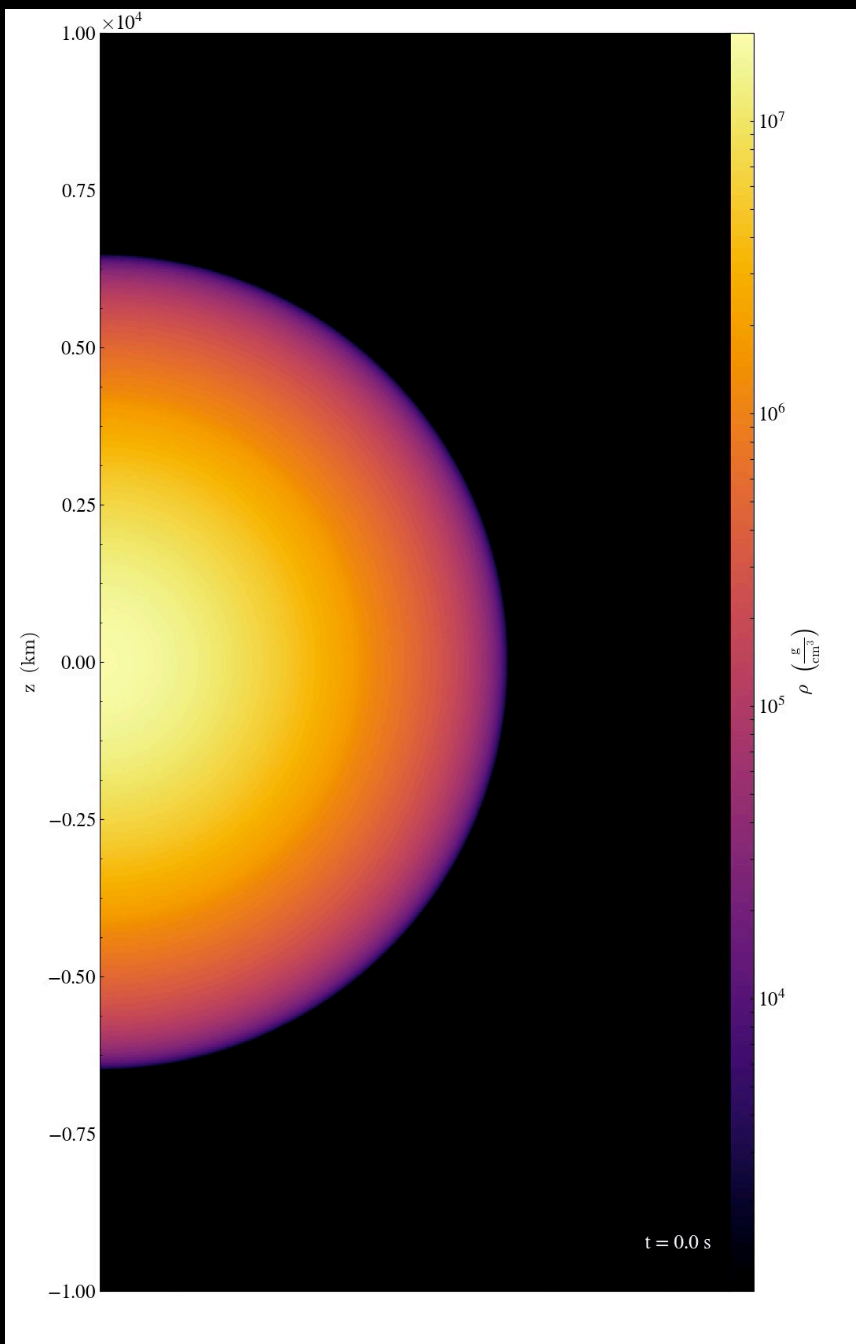
Example Ejecta Composition

1.0 M⊙ WD w/ 0.08 M⊙ He

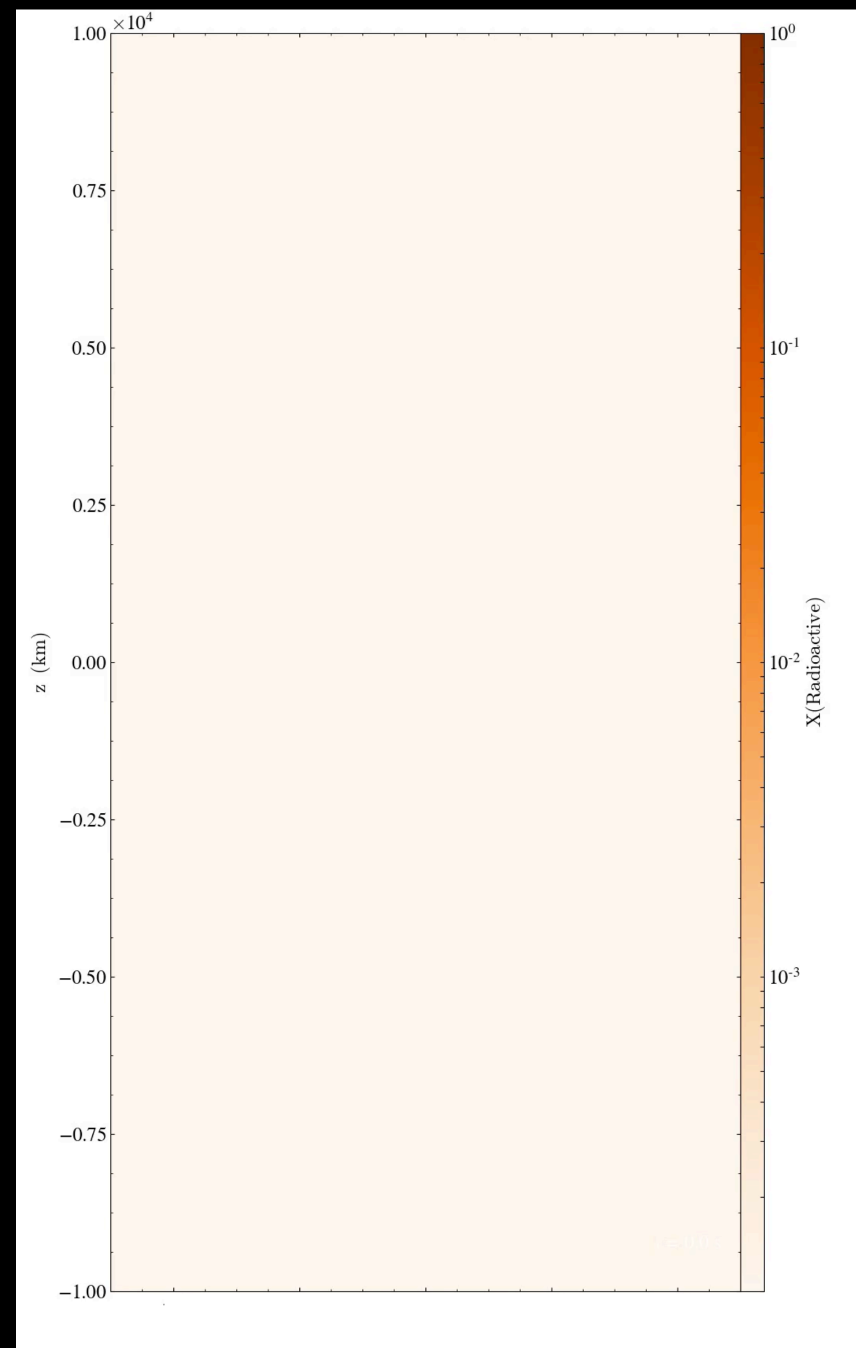


Double Detonation - 0.76 $M_\odot$ WD w/ 0.15 $M_\odot$ He

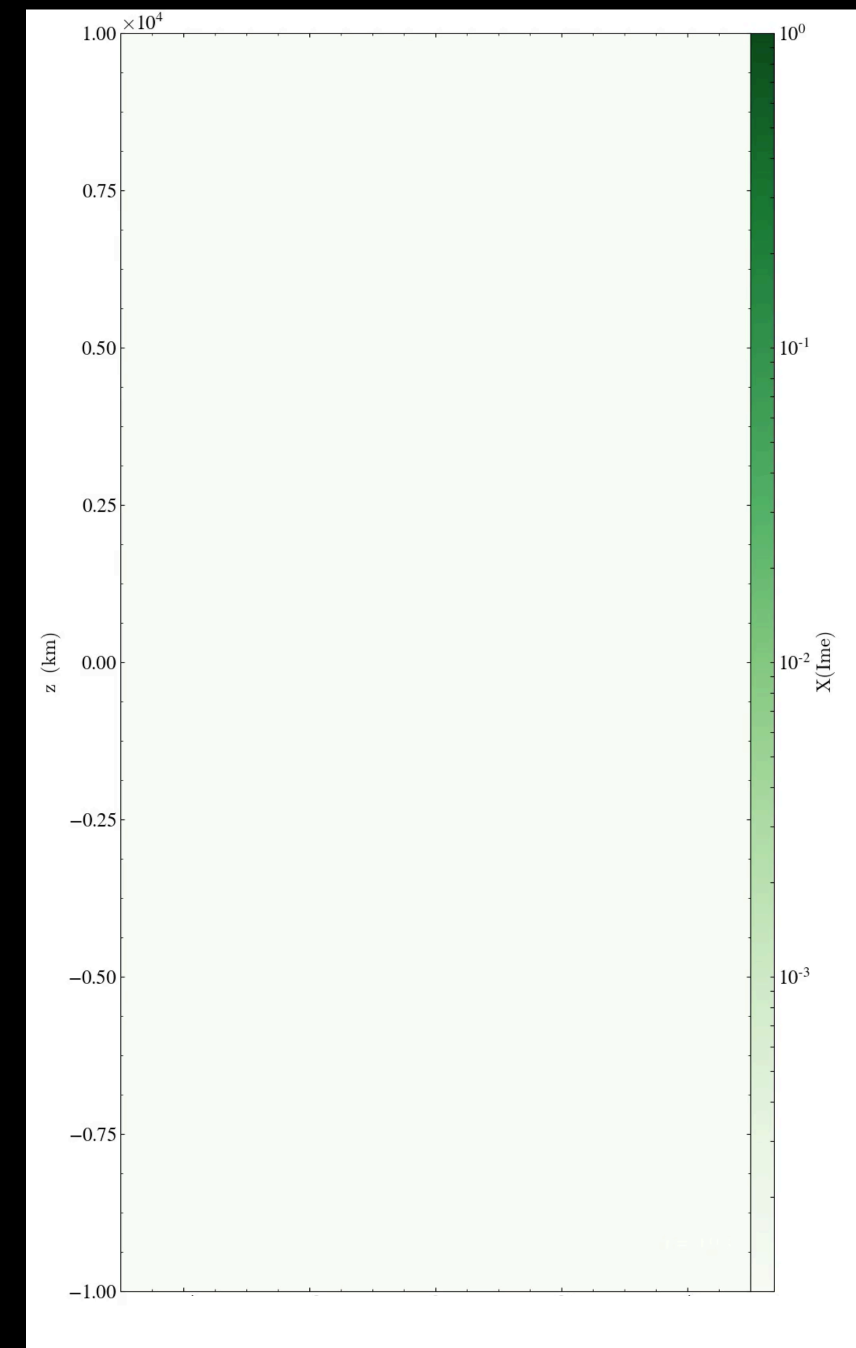
Density



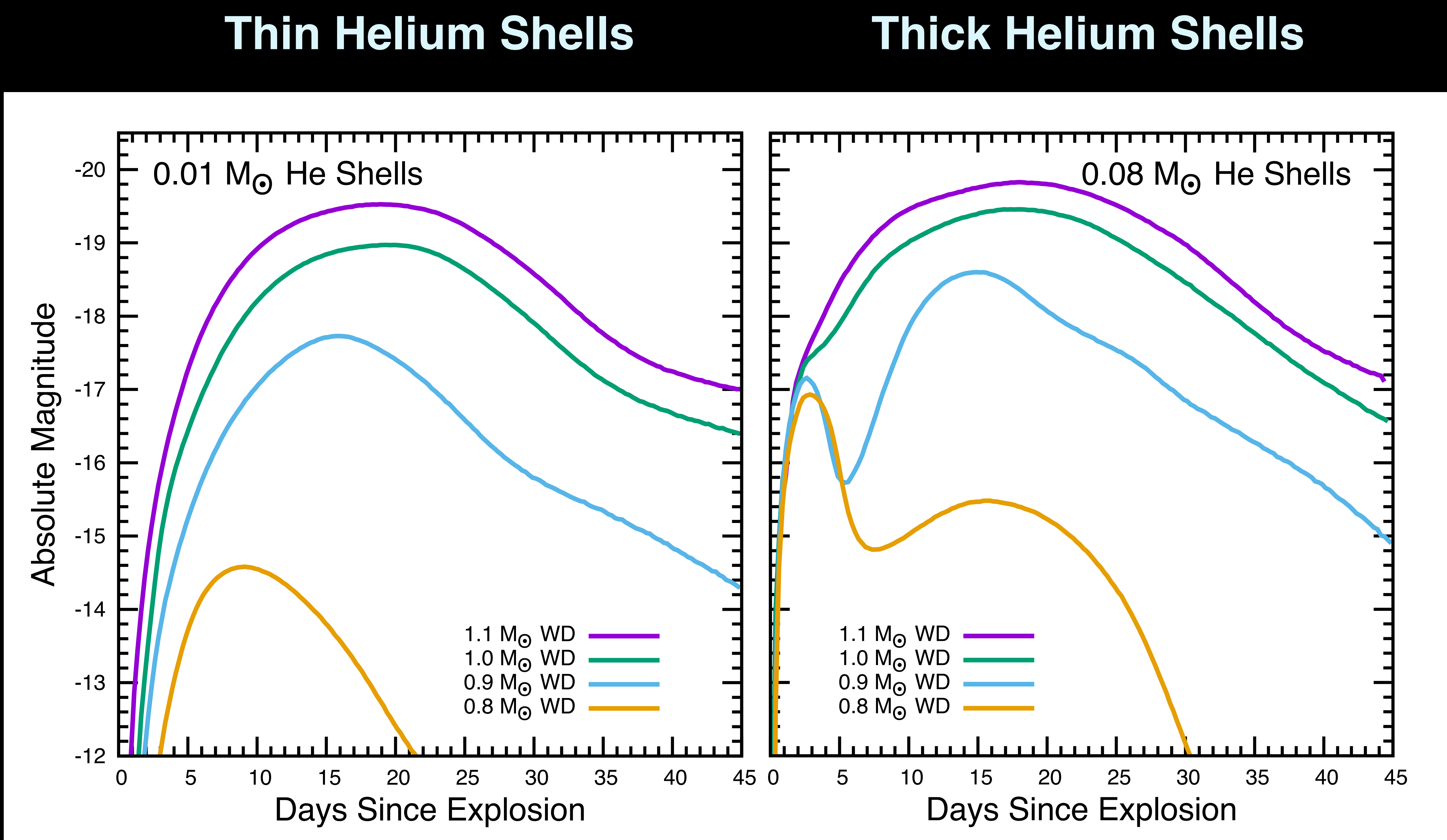
radioactive elements



IMEs (10<Z<40)



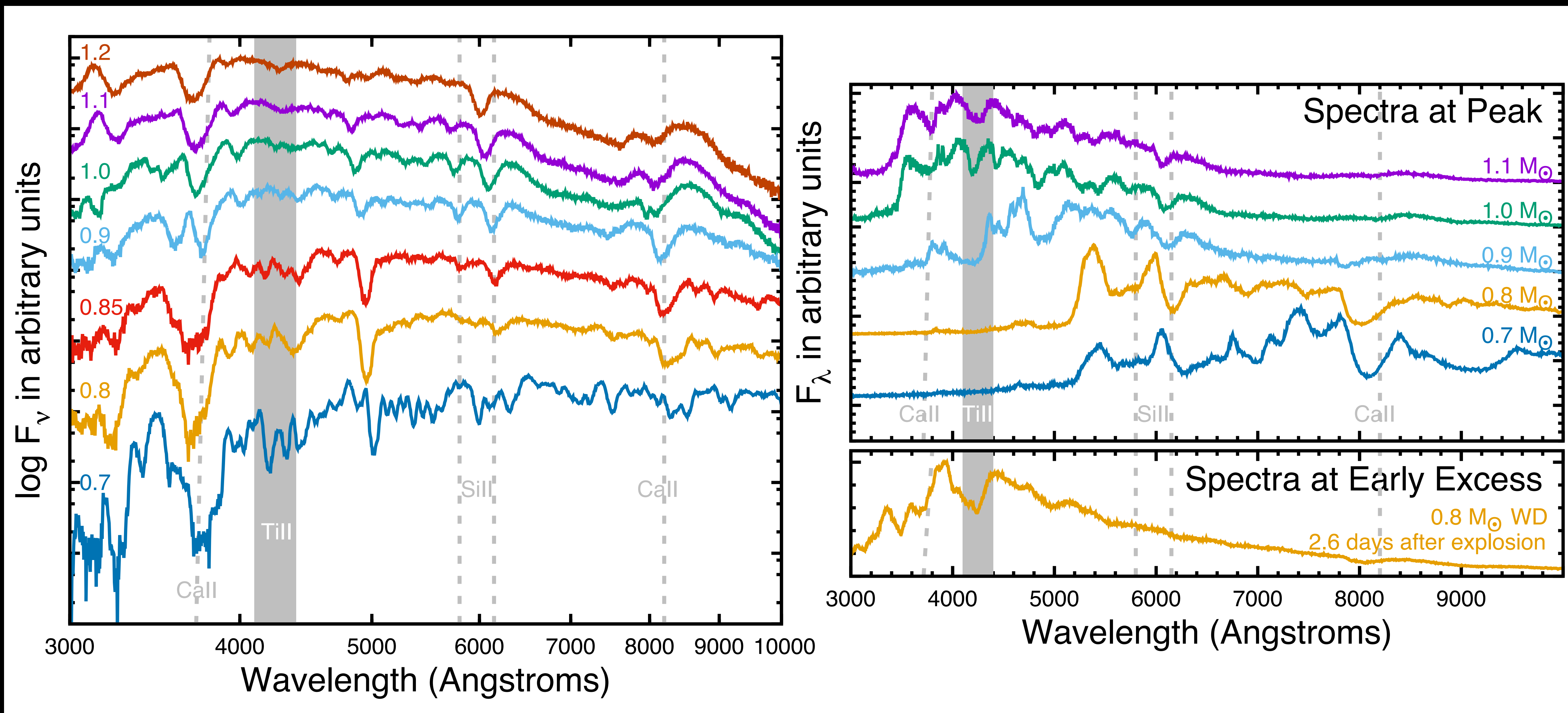
Light Curves - (g-band)



Spectra - (at peak g-band)

Thin Helium Shells

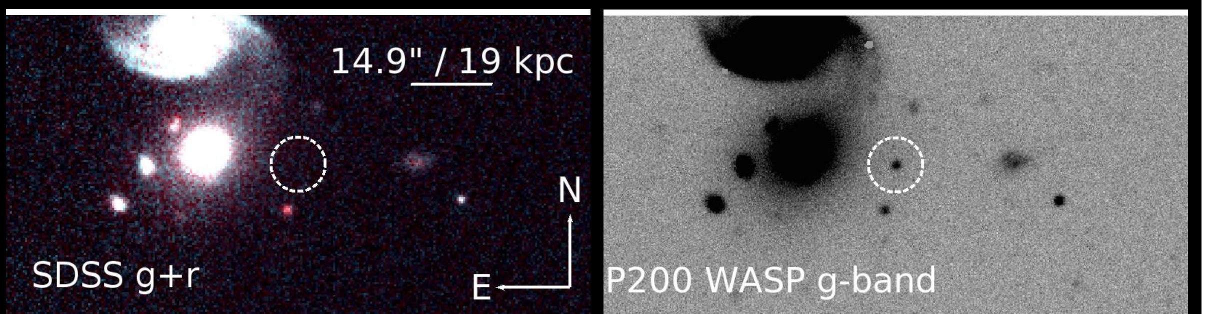
Thick Helium Shells

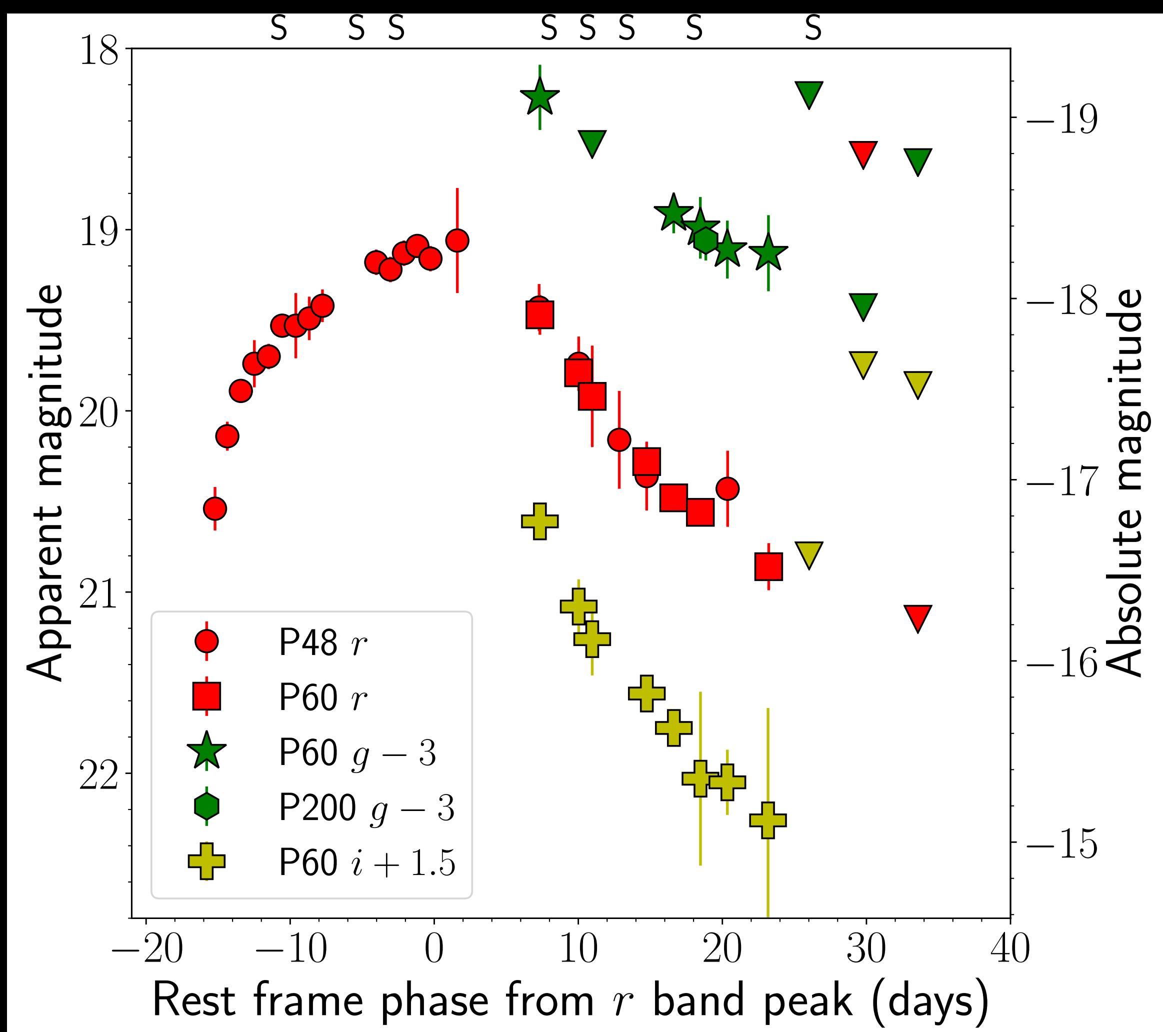


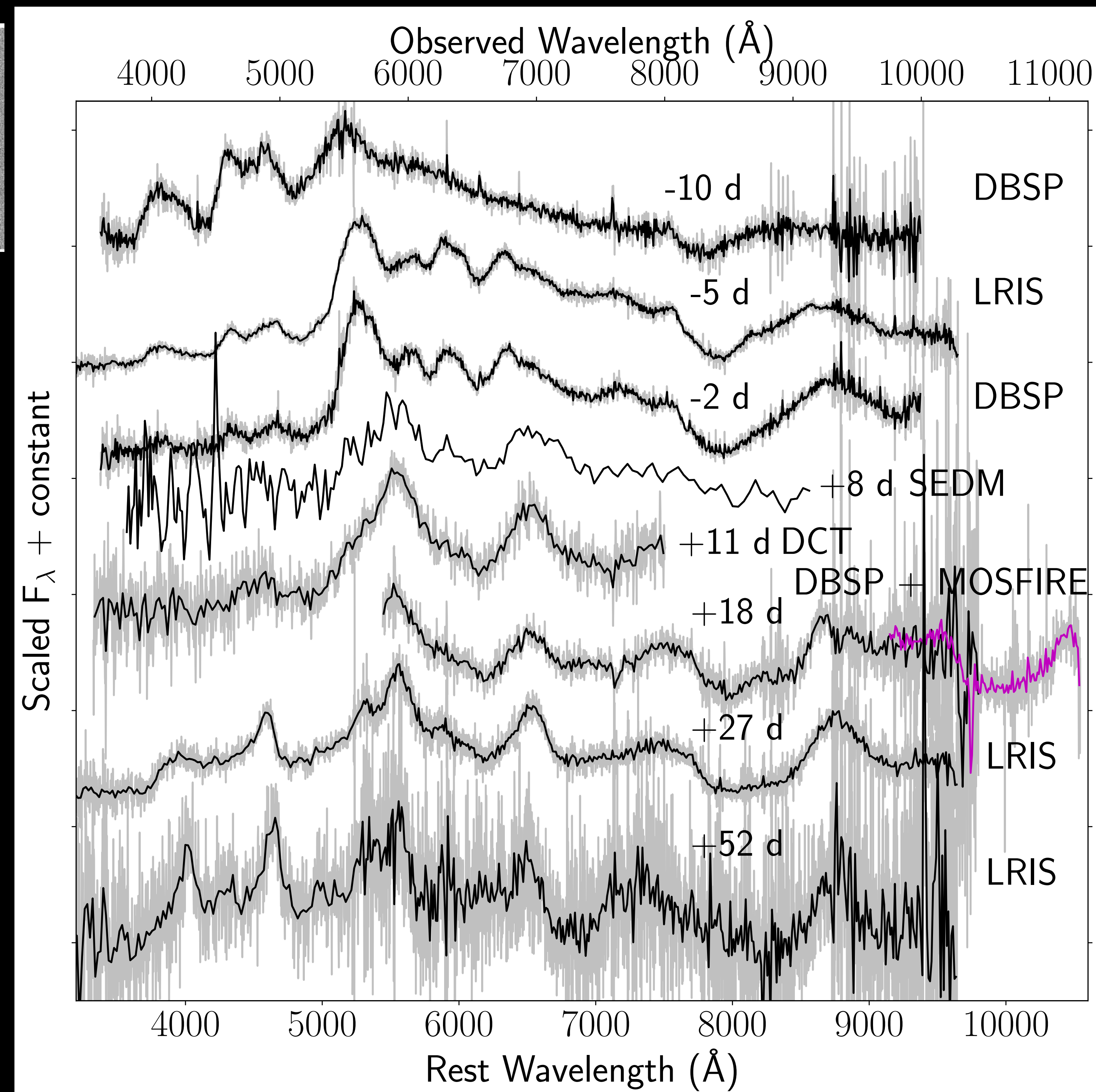
SN2018byg (ZTF18aaqeasu)

A Massive Helium-shell Double Detonation on a Sub-Chandrasekhar Mass White Dwarf

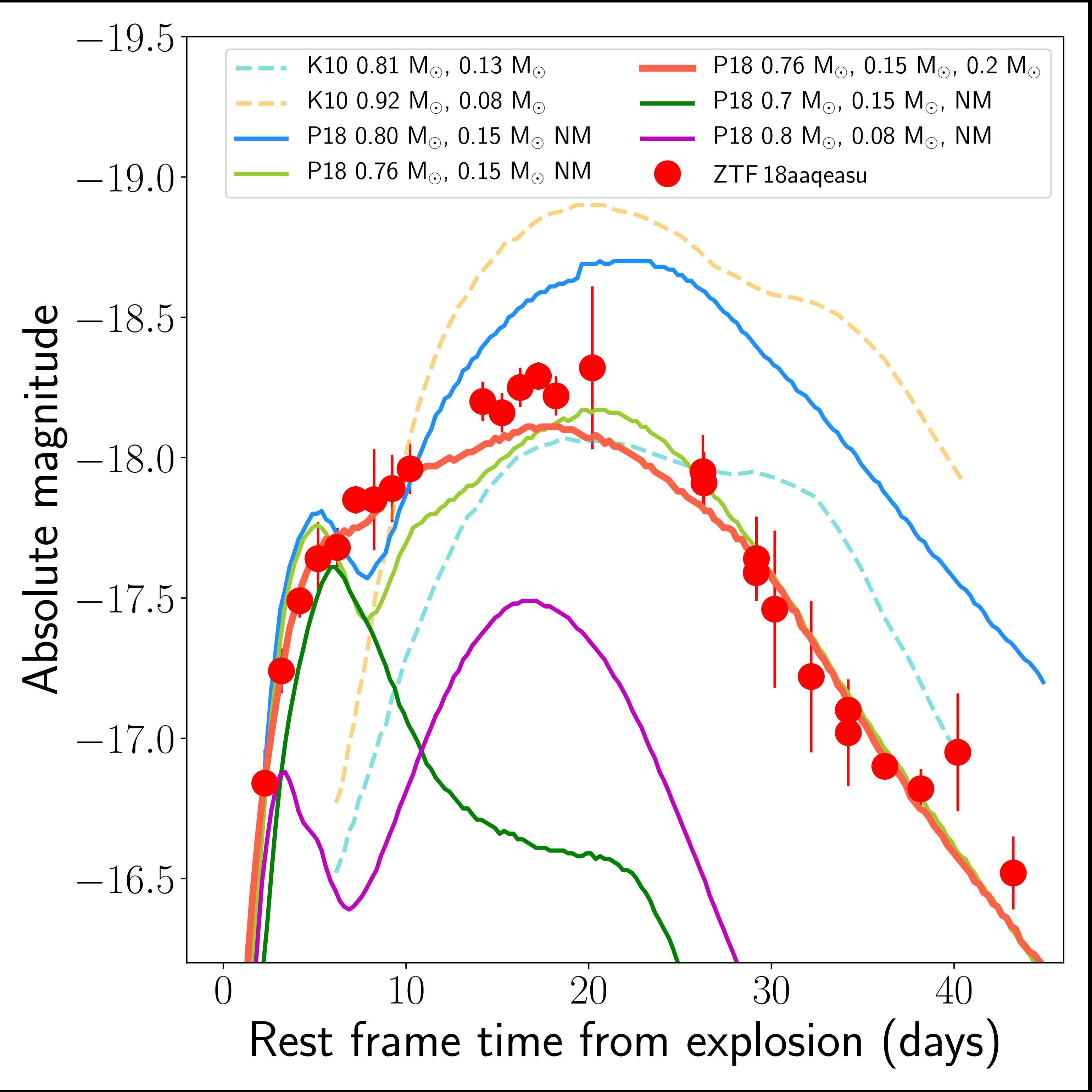
De et al. 2019







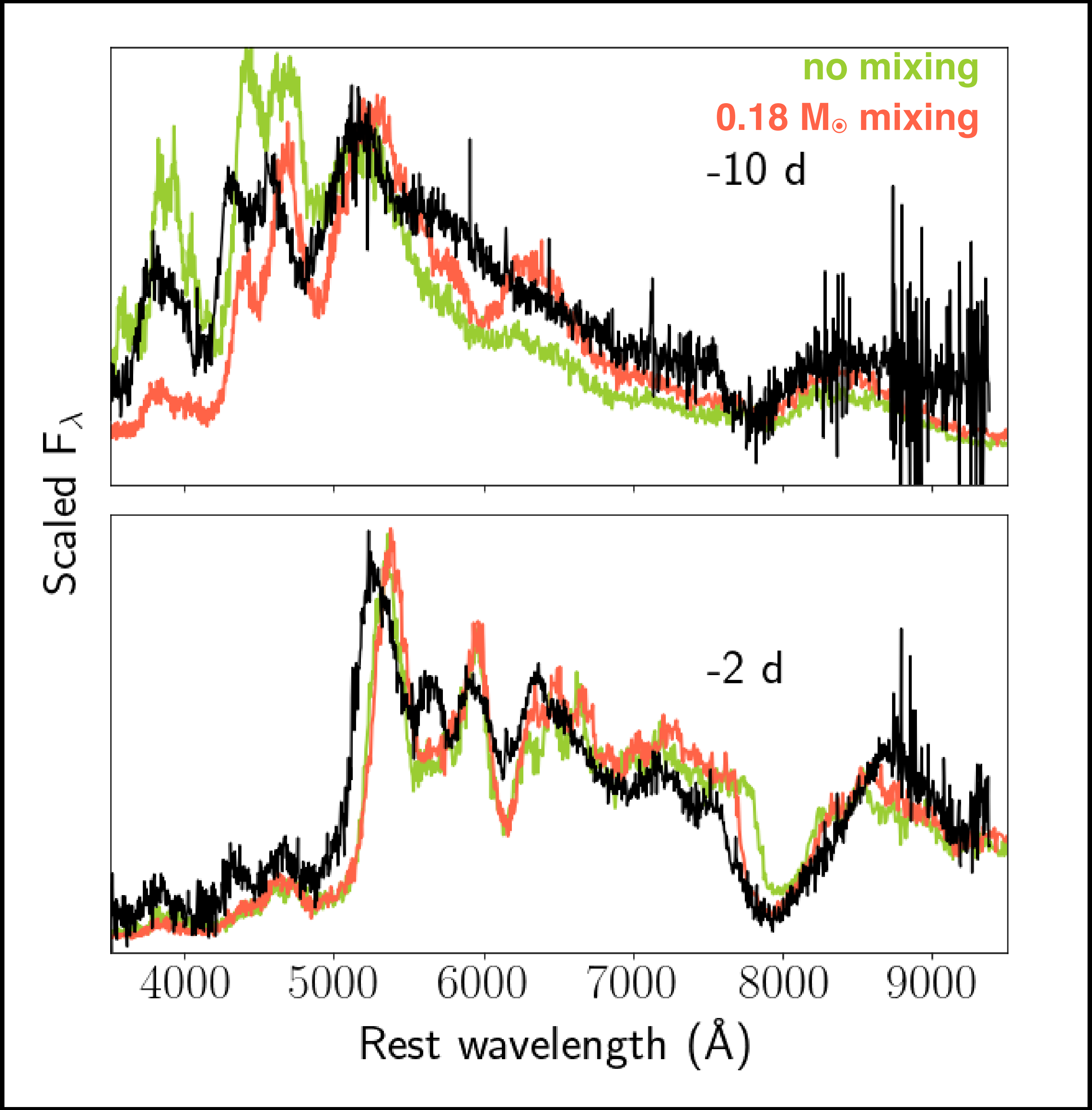
SN2018byg (ZTF18aaqeasu)



De et al. 2018

SN2018byg (ZTF18aaqeasu)

0.76 $M_\odot$ WD w/ 0.15 $M_\odot$ Shell

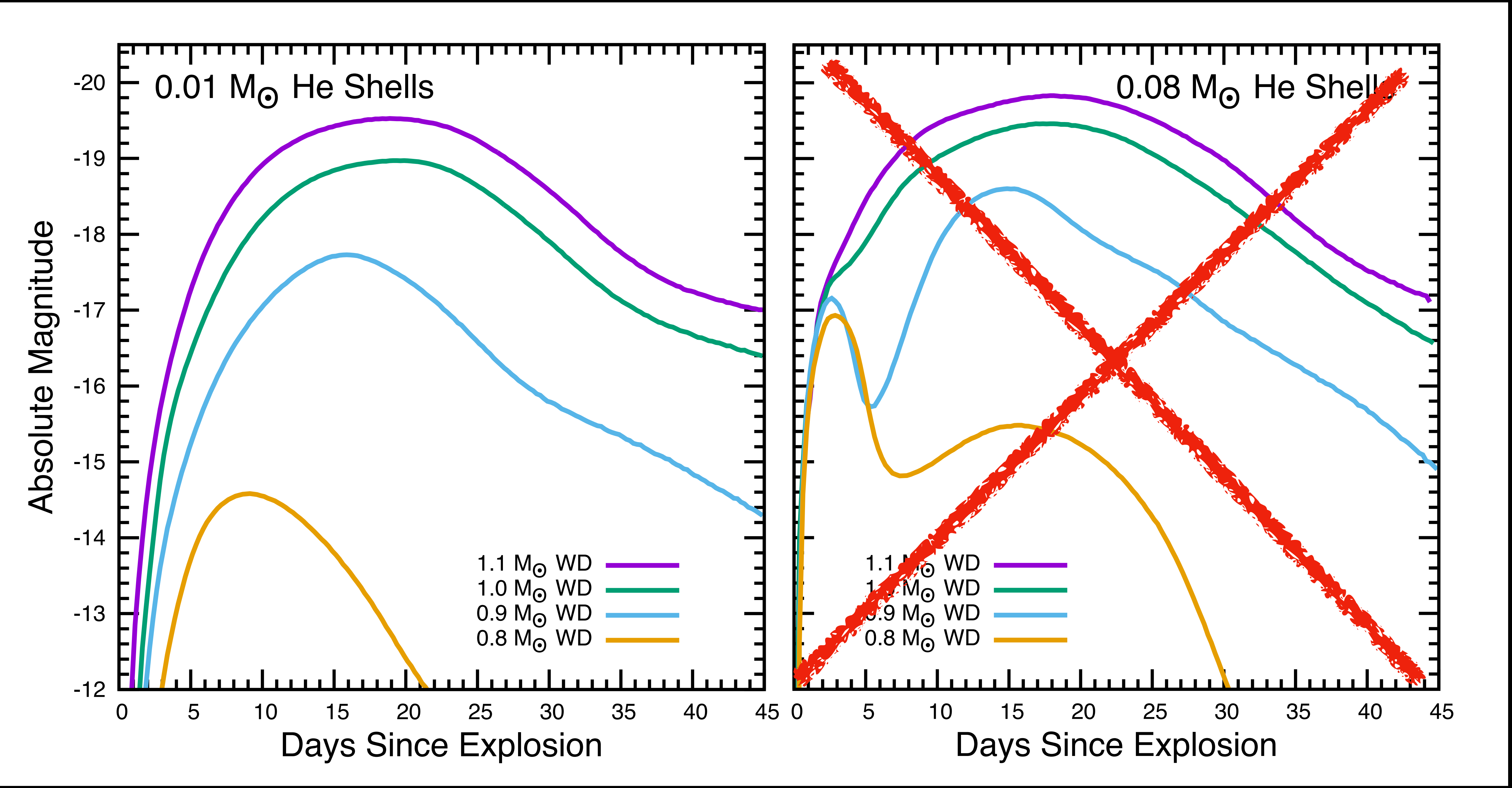


De et al. 2018

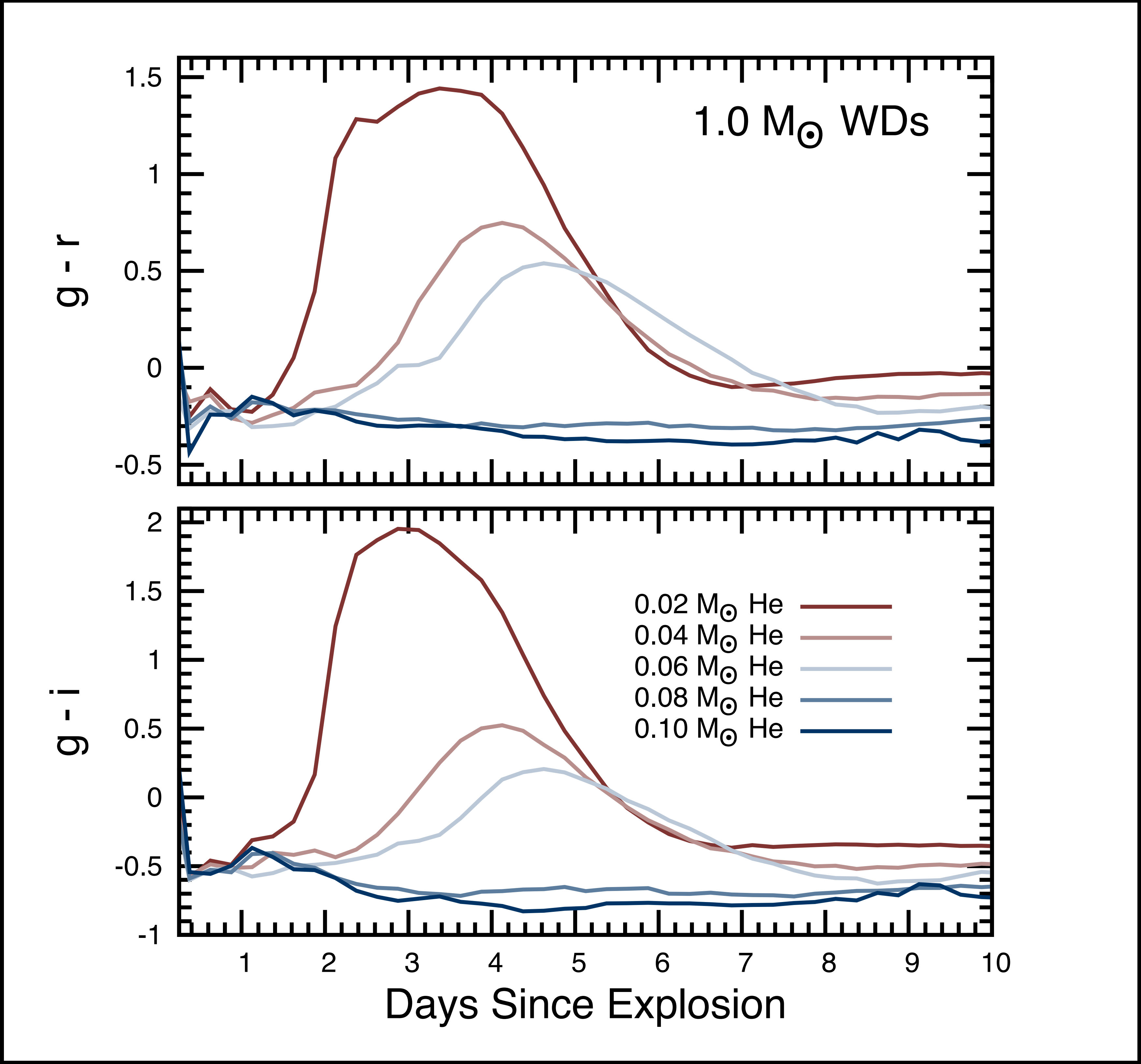
Light Curves - (g-band)

Thin Helium Shells

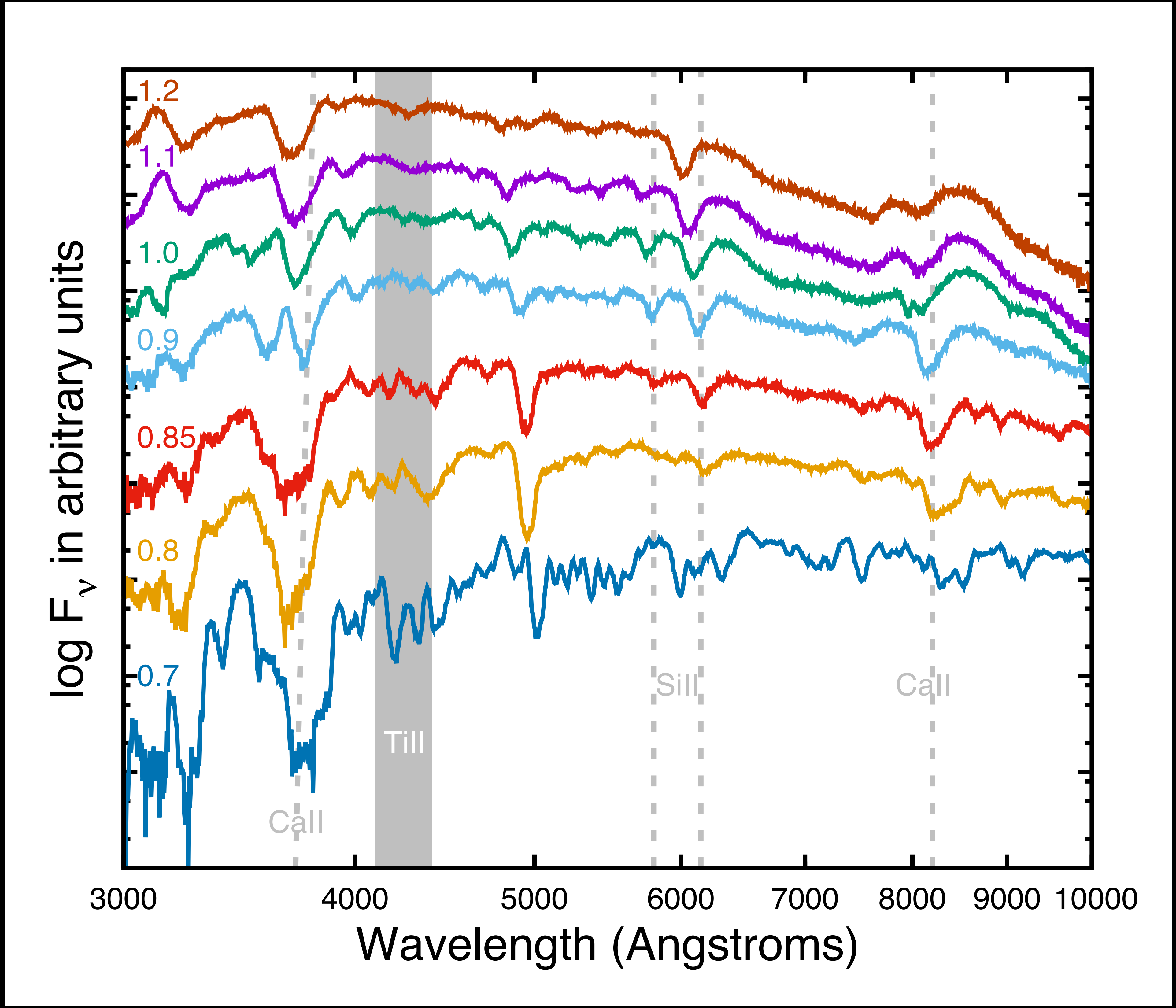
Thick Helium Shells



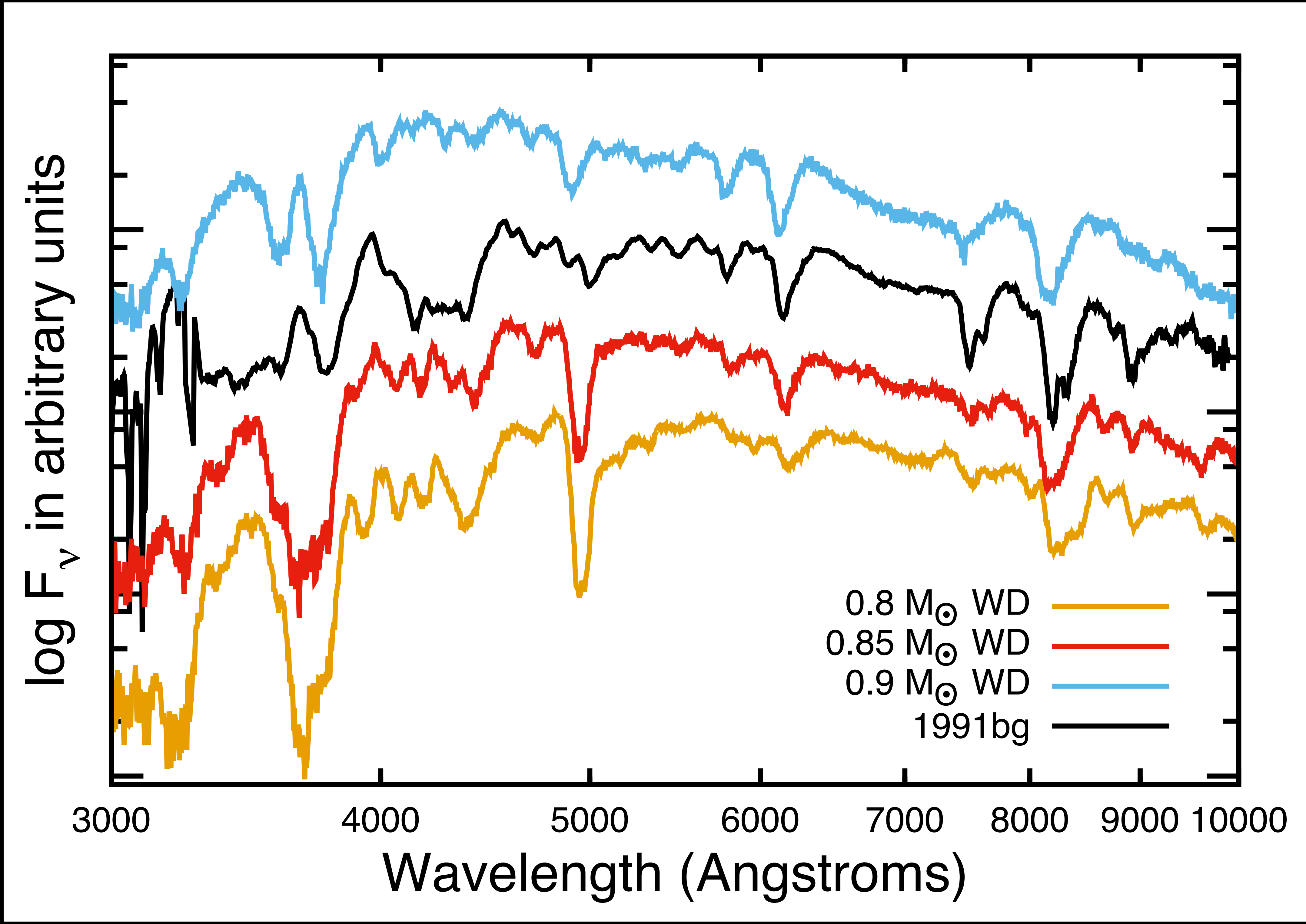
Thin Shells — Early Red Colors



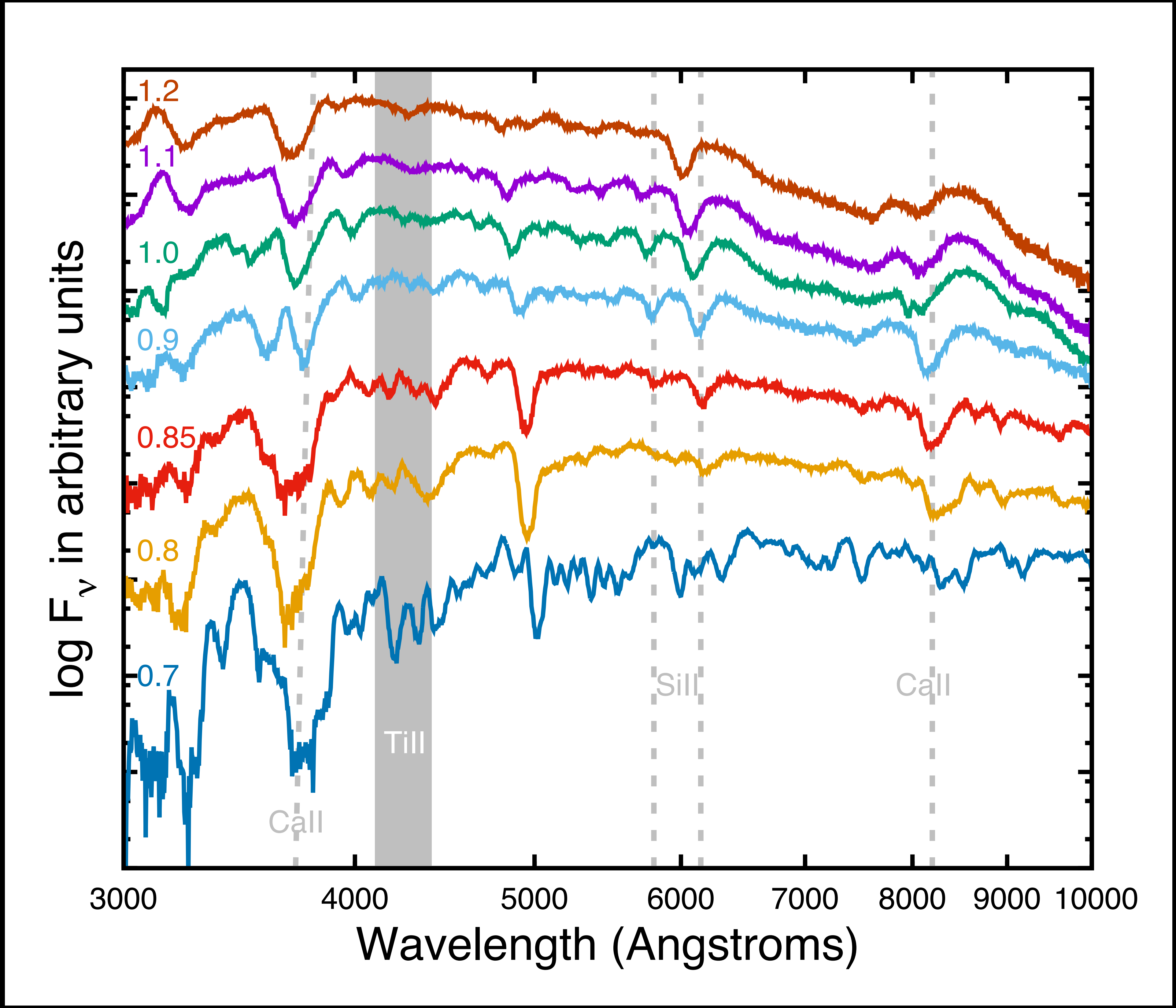
Thin Shells - Peak Spectra - 0.01 $M_\odot$ He



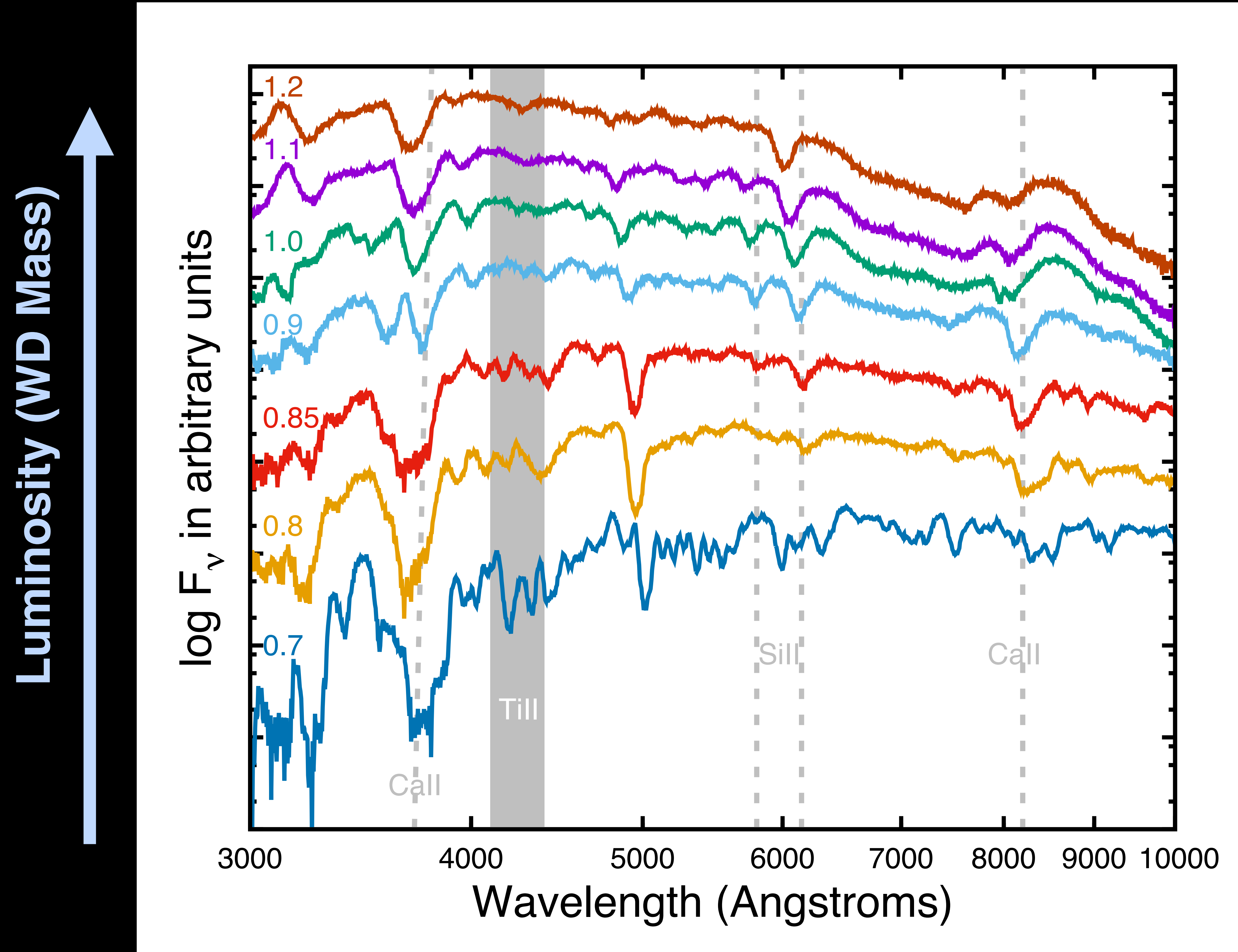
Subluminous (91bg-like) SNe Ia



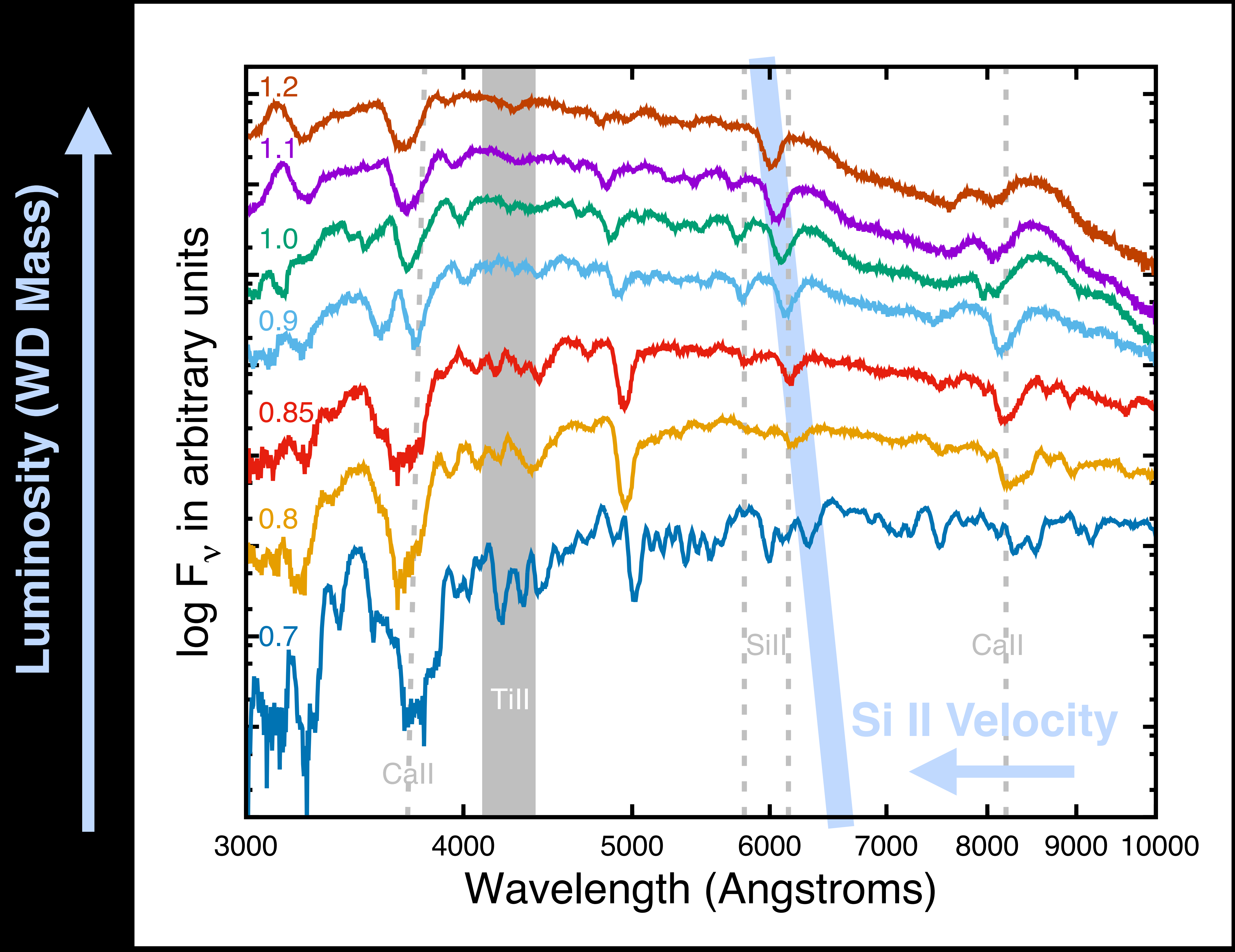
Thin Shells — 0.01 M⊙ He



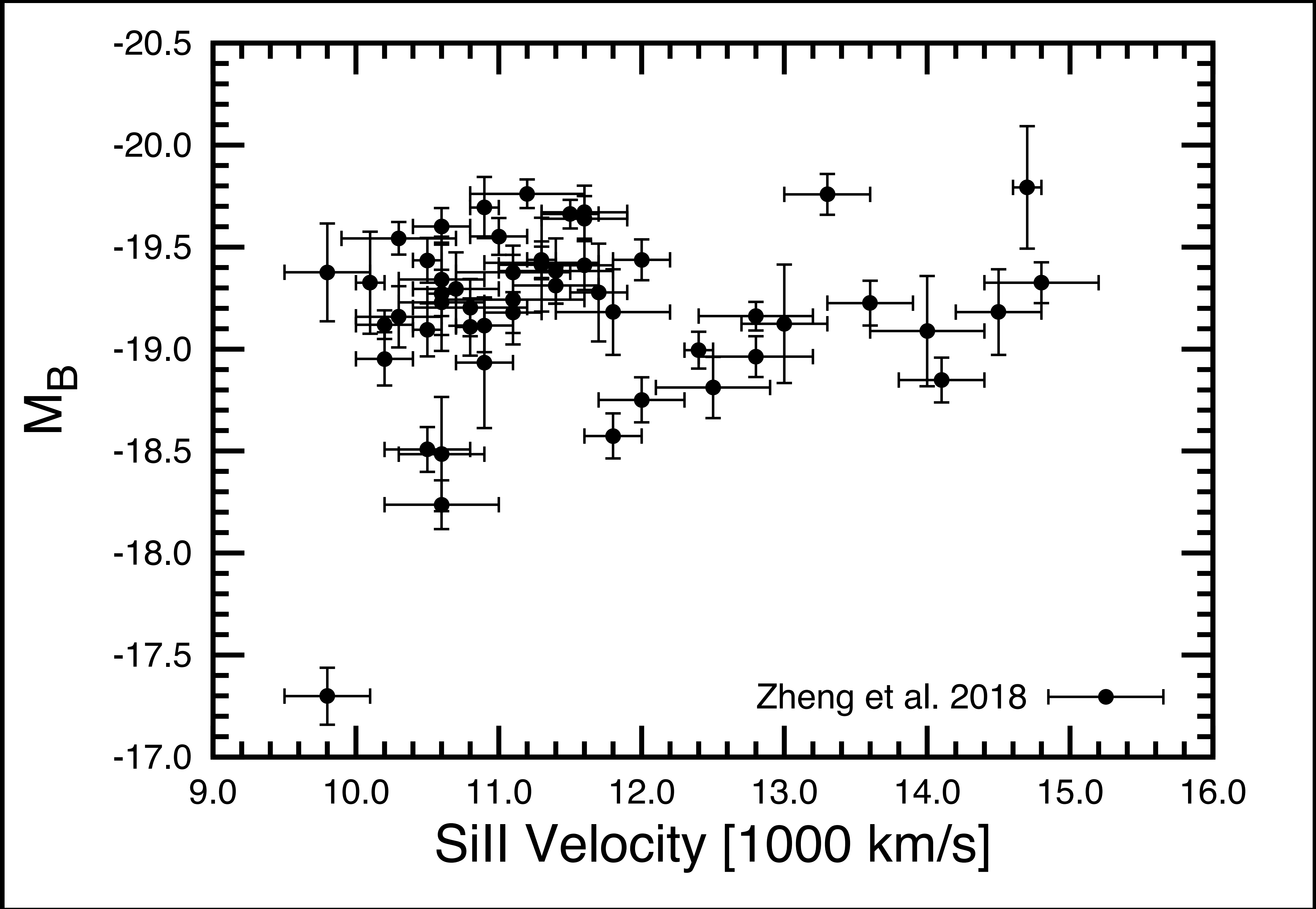
Thin Shells — 0.01 $M_{\odot}$ He



Thin Shells — 0.01 M☉ He

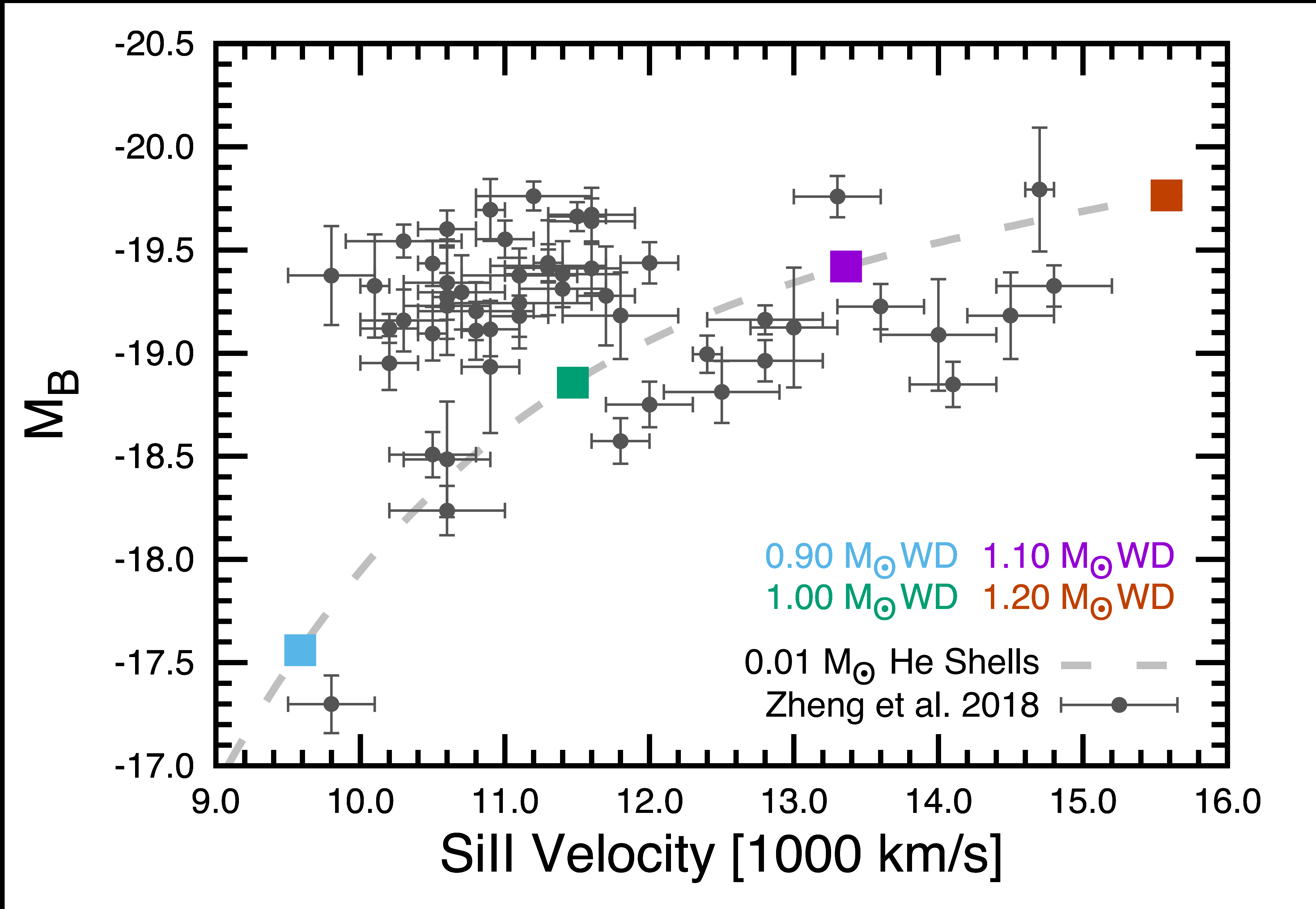


Thin Shells — 0.01 M☉ He



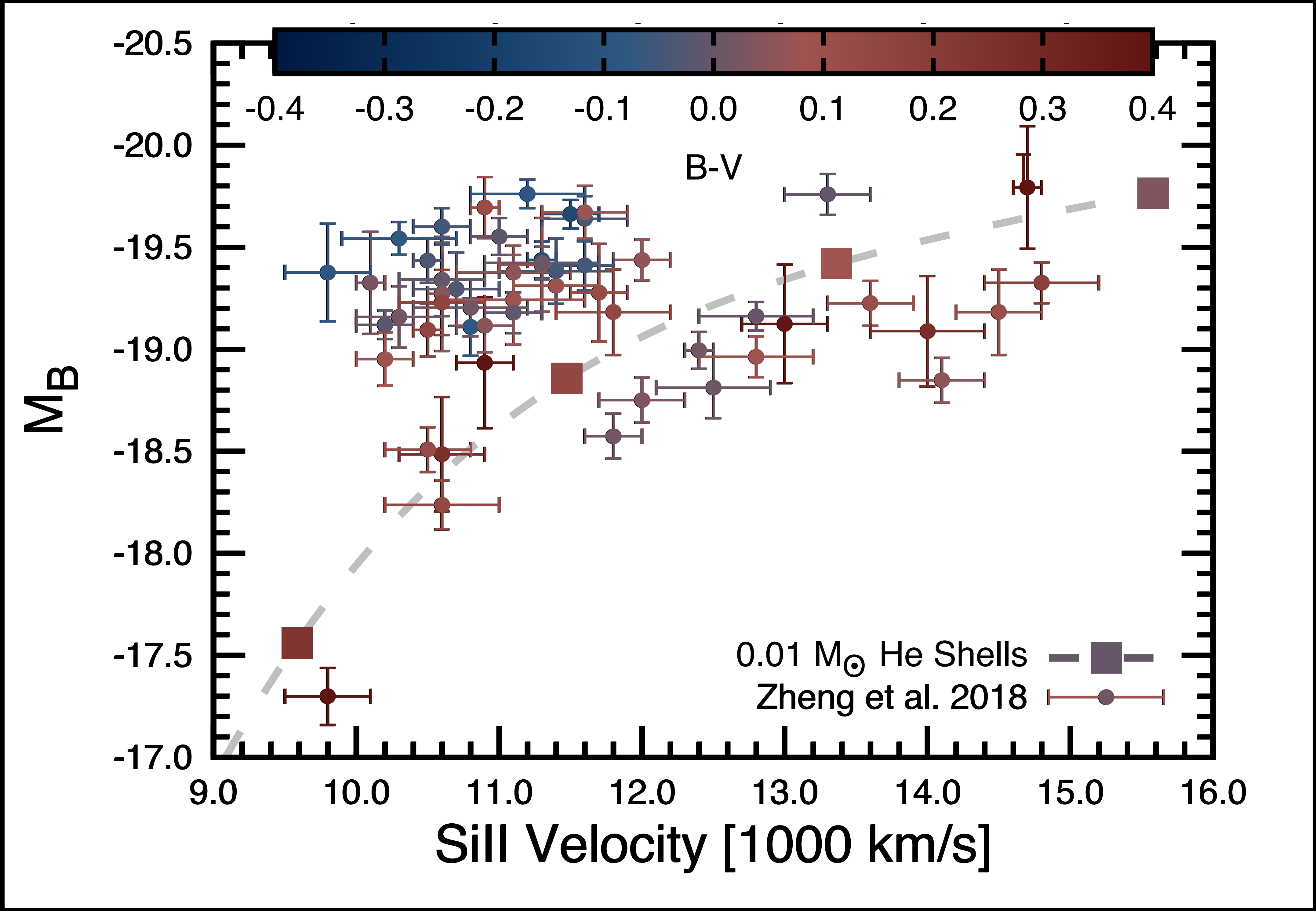
Polin et al. 2018

Thin Shells — 0.01 M⊙ He



Polin et al. 2018

Thin Shells — 0.01 $M_\odot$ He

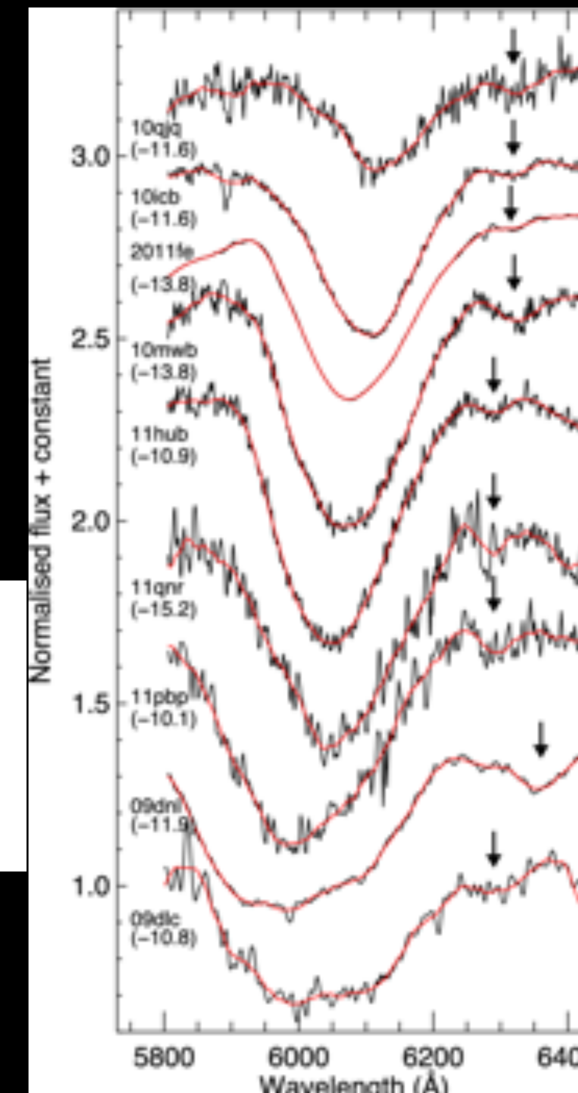


Polin et al. 2018

Carbon II in SNe Ia

Polin et al. (2019) - Carbon burns really well:
1991bg-like models yield 0.001 M$_\odot$
Normals: it is 10^-5 M$_\odot$ or lower.

A greater frequency of C II λ6580 absorption features appears in the LVG subtypes compared to HVG events. This is in line with the interpretation of Maeda et al. (2010b), supporting the idea that part of SN Ia diversity can be accounted for by viewing angle and off-center ignition effects.

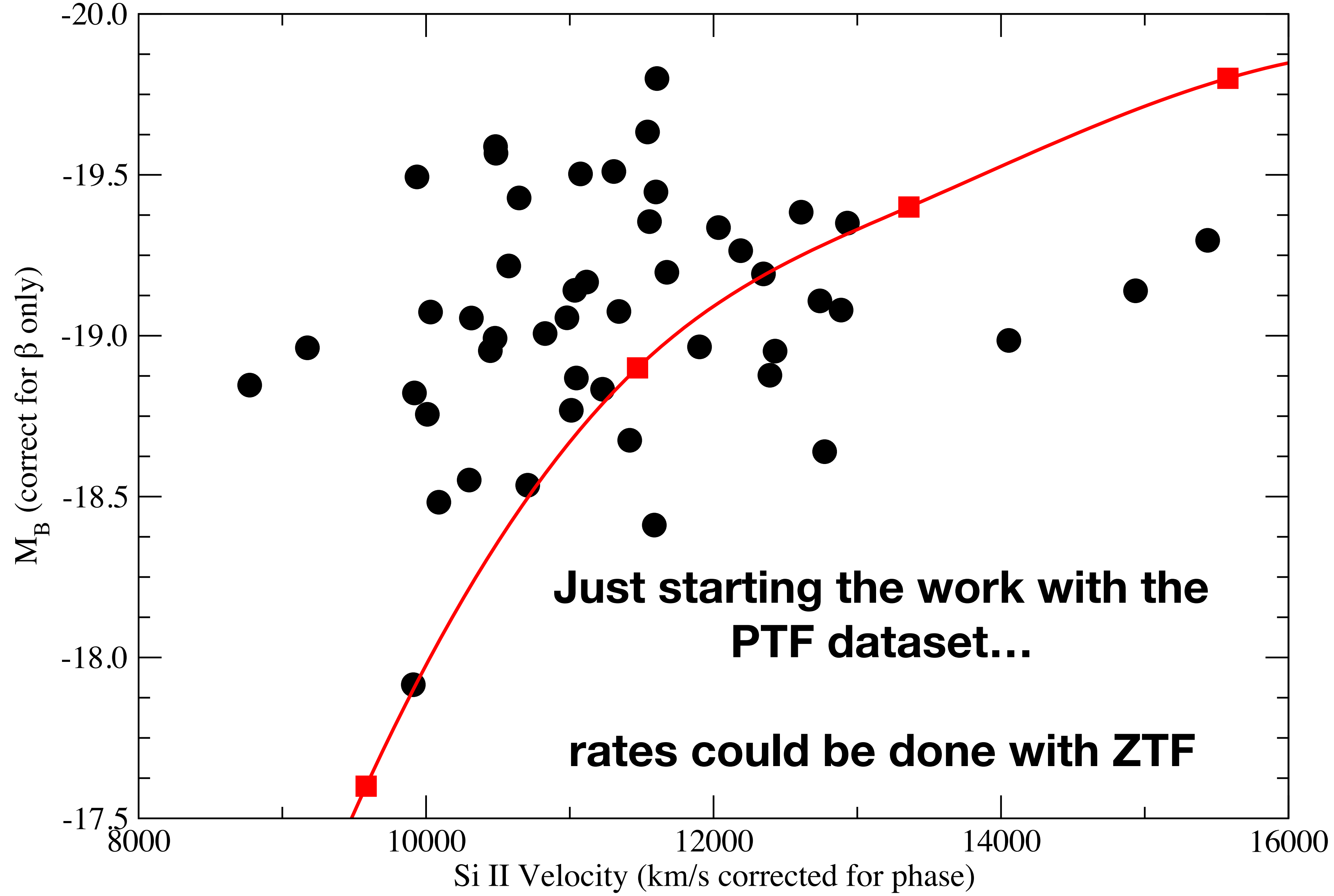


Parrent et al. 2011

Using a new sample of 24 SNe Ia obtained by PTF with at least one spectrum before −10 d with respect to maximum, we find that ~40 per cent of SNe Ia at these early phases have a clear detection of C II 6580 Å in their spectra. If we include 'absorption?' detections and 'flat' profiles, we find that as much as ~55 per cent may have C present. However, ~25 per cent of SNe Ia show no clear detection of C II in their spectra when observed at these early phases.

Maguire et al. 2014

PTF - iPTF - ZTF


-20.0
-19.5
-19.0
-18.5
-18.0
-17.5
M_B (correct for β only)
8000
10000
12000
14000
16000
Si II Velocity (km/s corrected for phase)
Just starting the work with the PTF dataset...
rates could be done with ZTF