Ultra-stripped Type Ic Supernovae from Close Binary Evolution

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Thomas Tauris
Norbert Langer
Takashi Moriya
Philipp Podsiadlowski
Sung-Chul Yoon
Sergei Blinnikov

Florence
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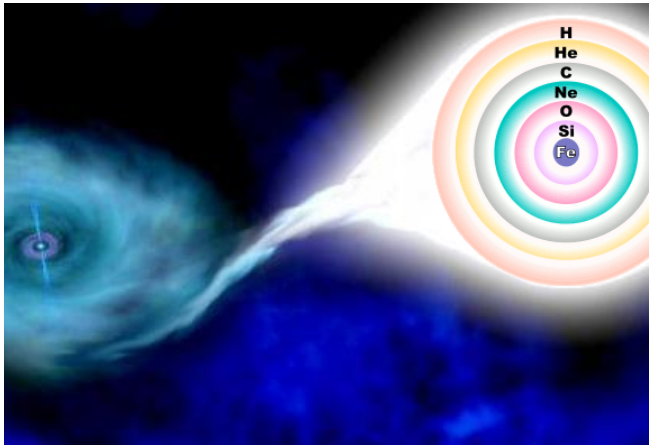
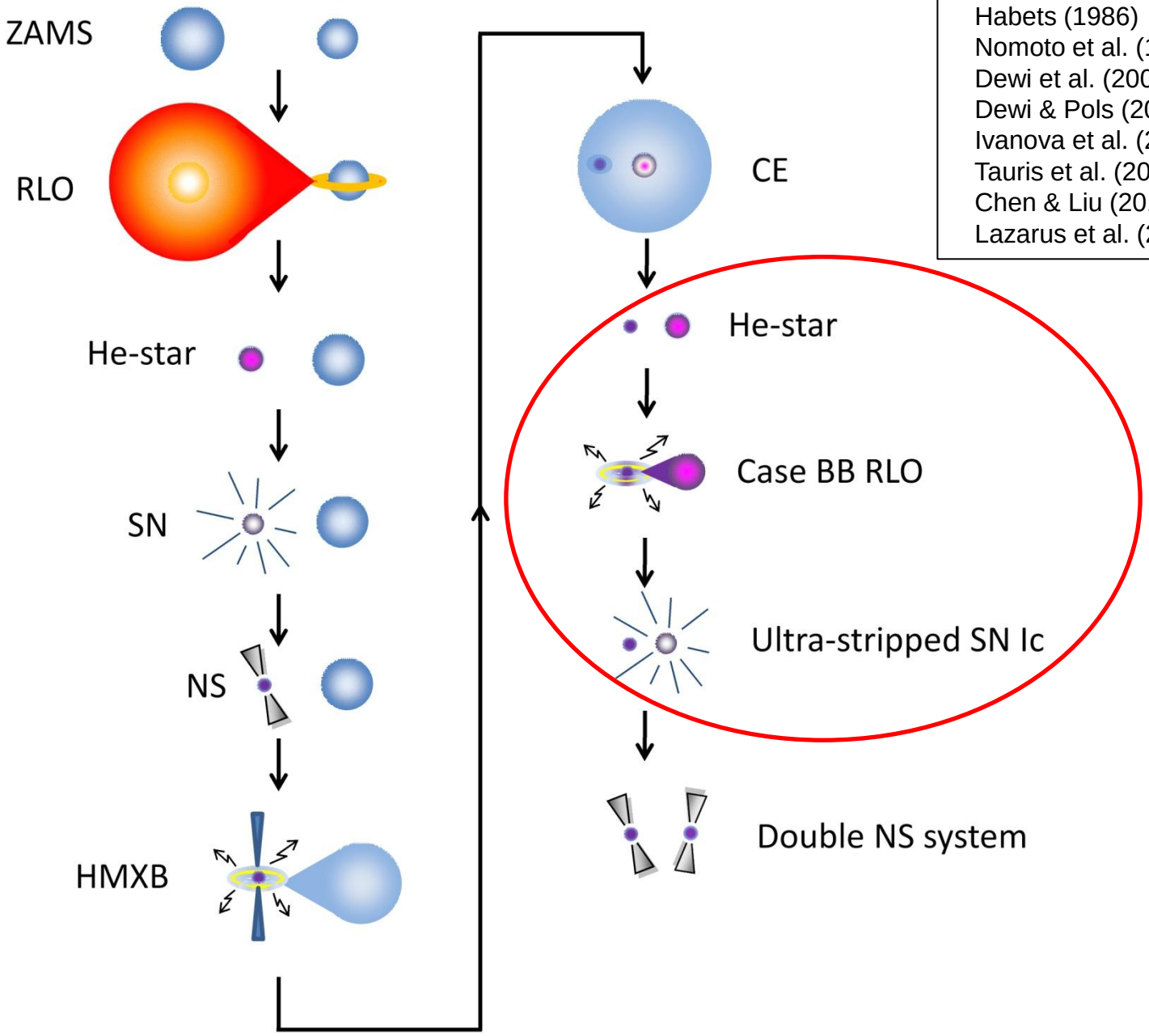
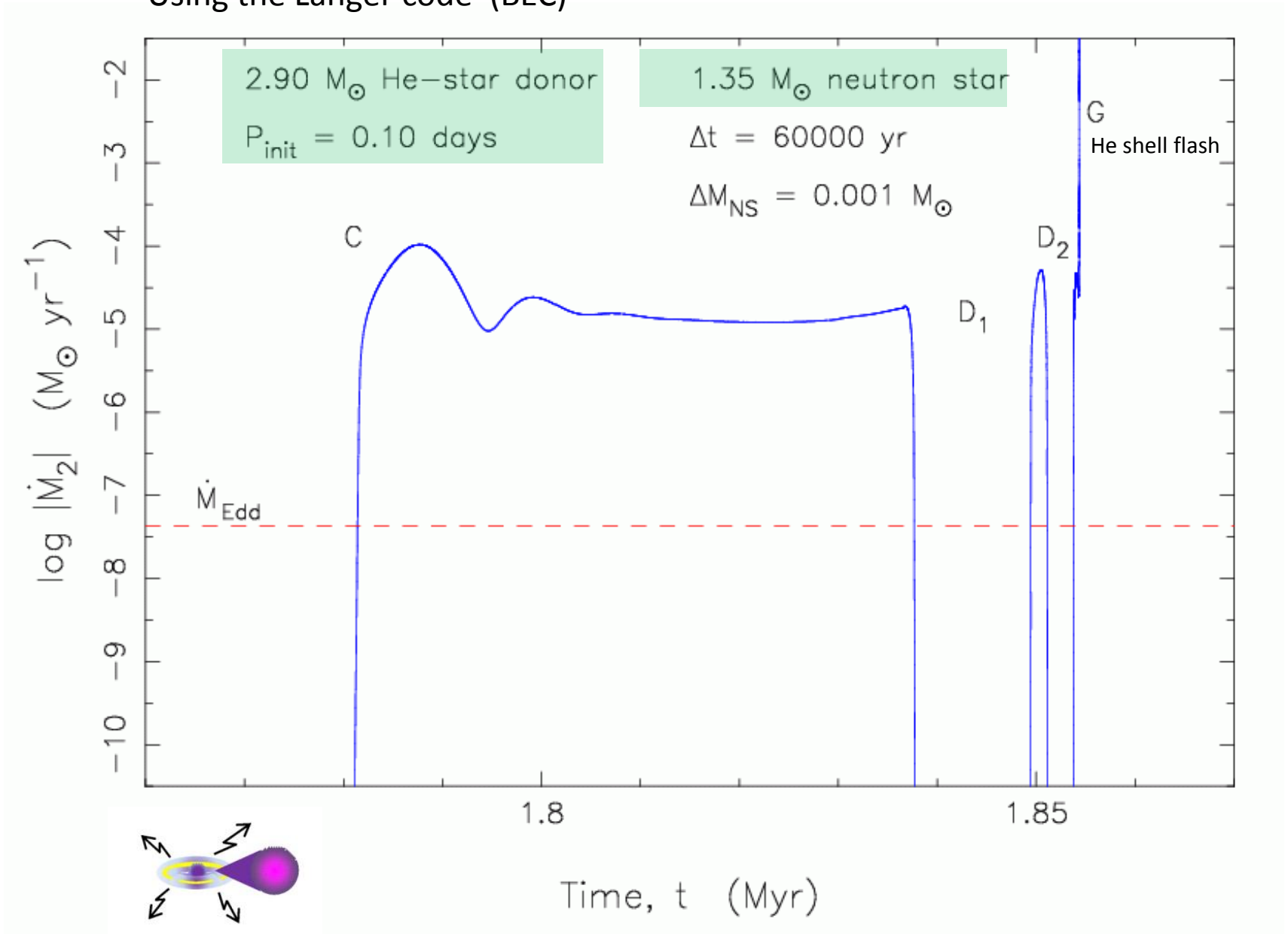


see also:

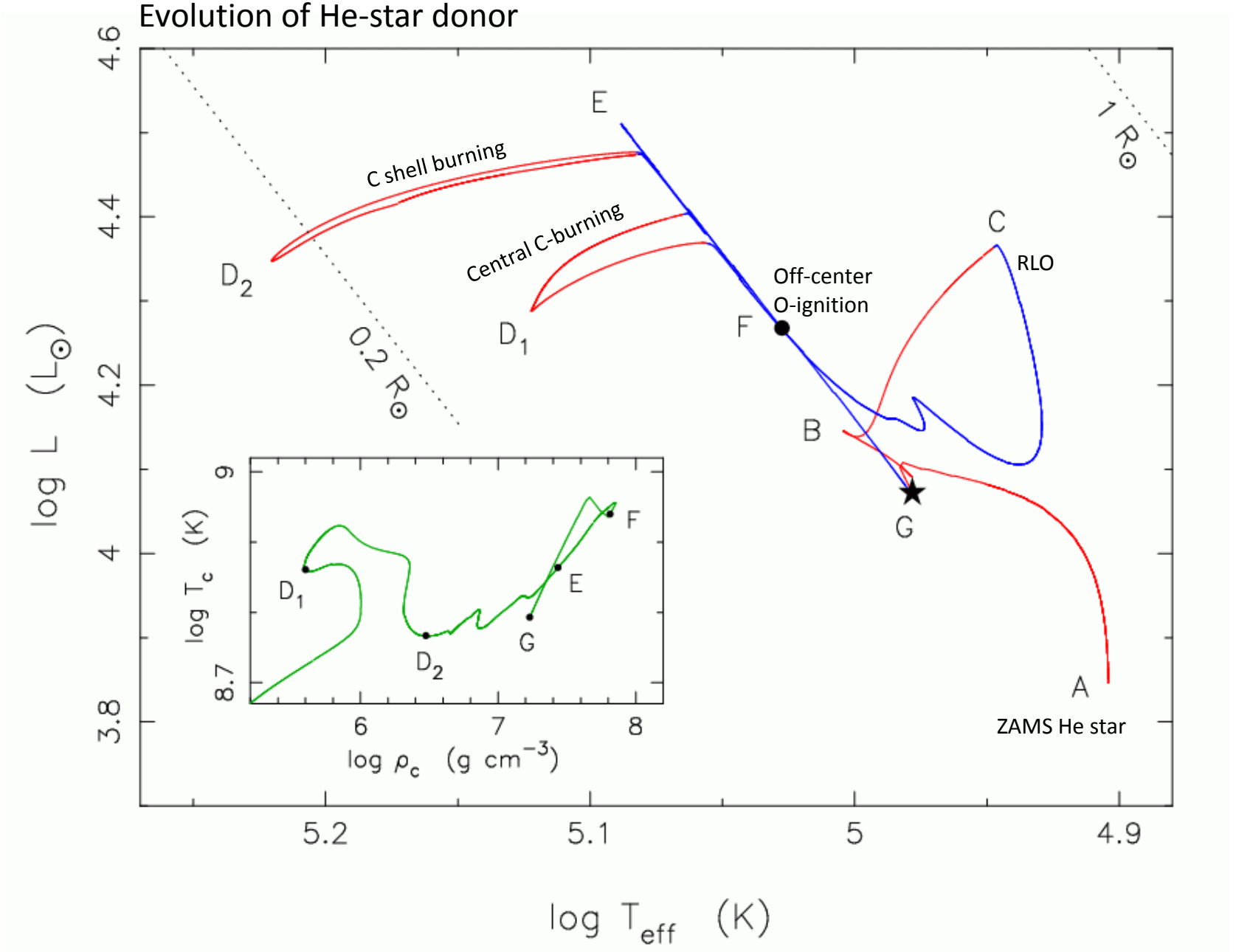
Habets (1986)
Nomoto et al. (1994)
Dewi et al. (2002)
Dewi & Pols (2003)
Ivanova et al. (2003)
Tauris et al. (2012)
Chen & Liu (2013)
Lazarus et al. (2014)

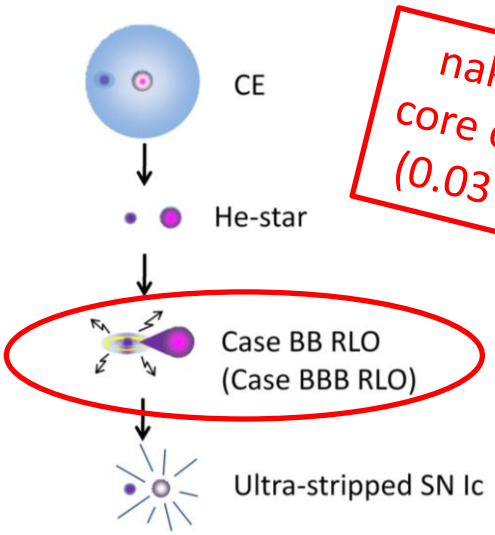


Using the Langer code (BEC)

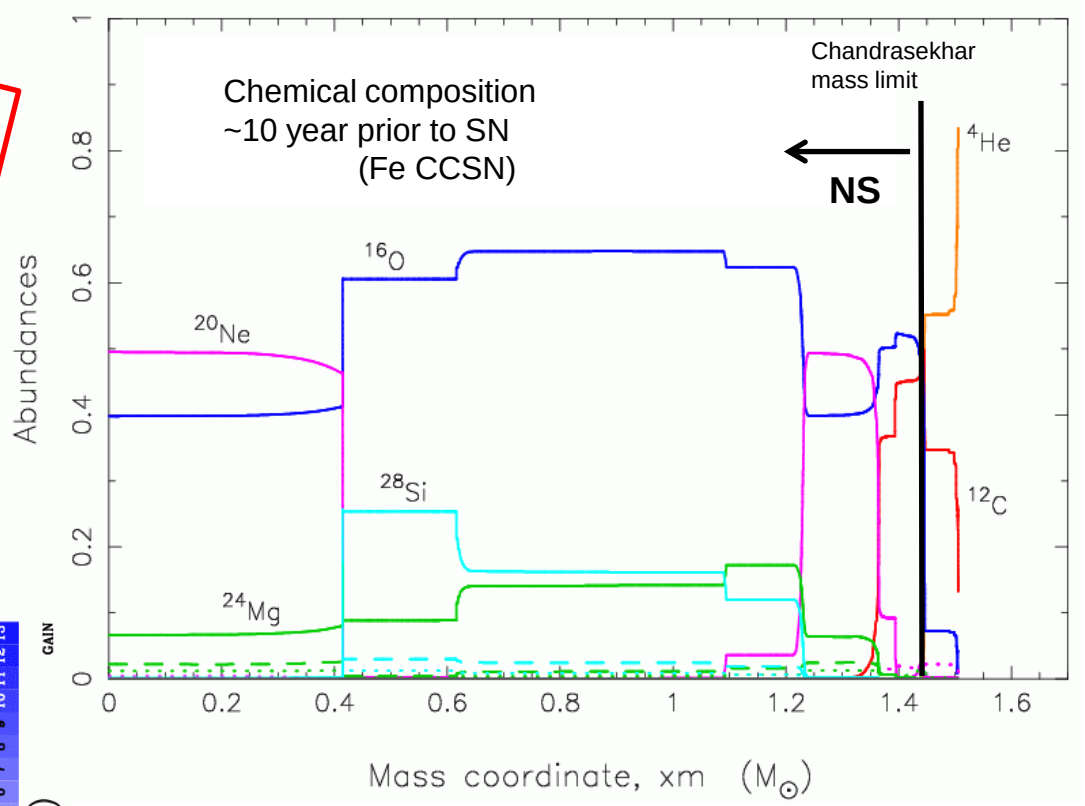


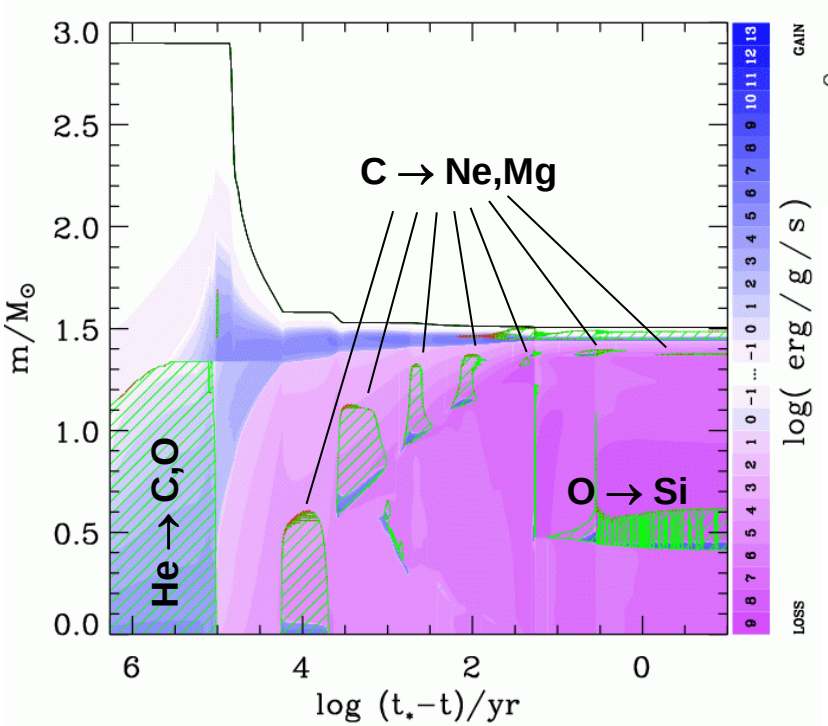
Evolution of He-star donor

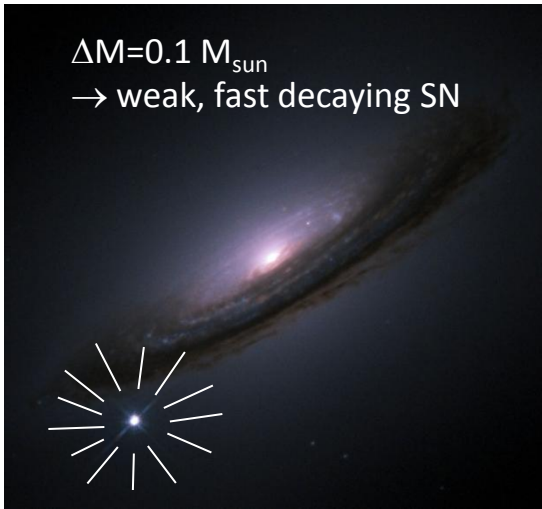




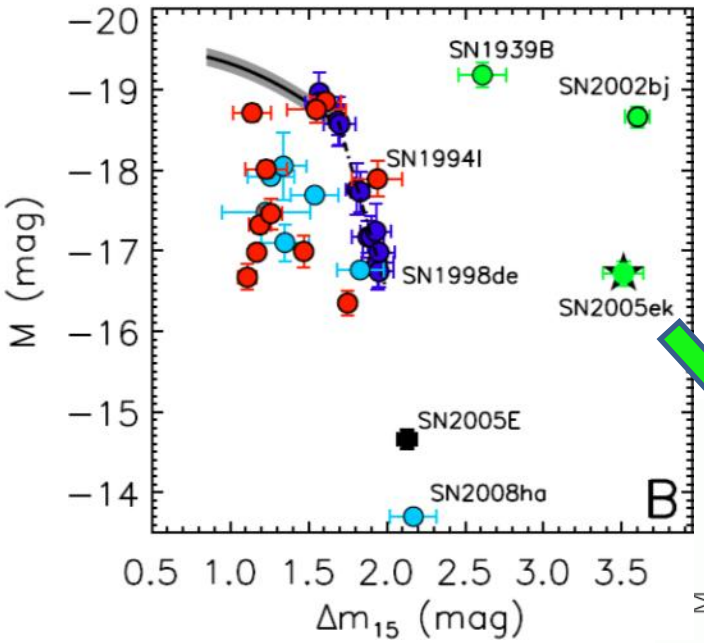
naked metal core exploding! (0.03 M_{sun} He)





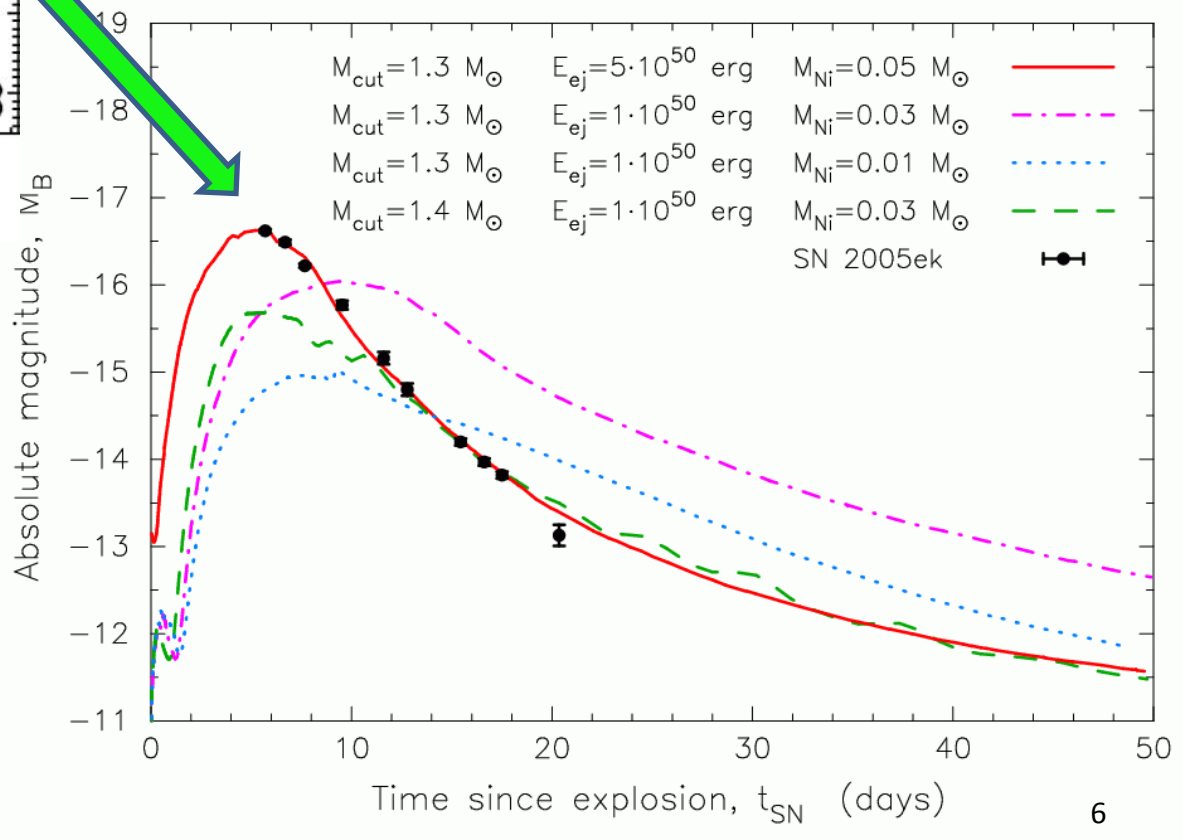


Drout et al. (2013)



observational evidence?

Tauris et al. (2013)



We estimate that roughly **0.1-1% of all SNe** are ultra-stripped SNe

Ultra-stripped Fe CCSN might form NSs with a mass as low as 1.10 M_{sun}

Future Work on Ultra-stripped SNe:

1) Systematic grid of M_{He} and P_{orb} (using BEC) to probe the conditions leading to:

Done!

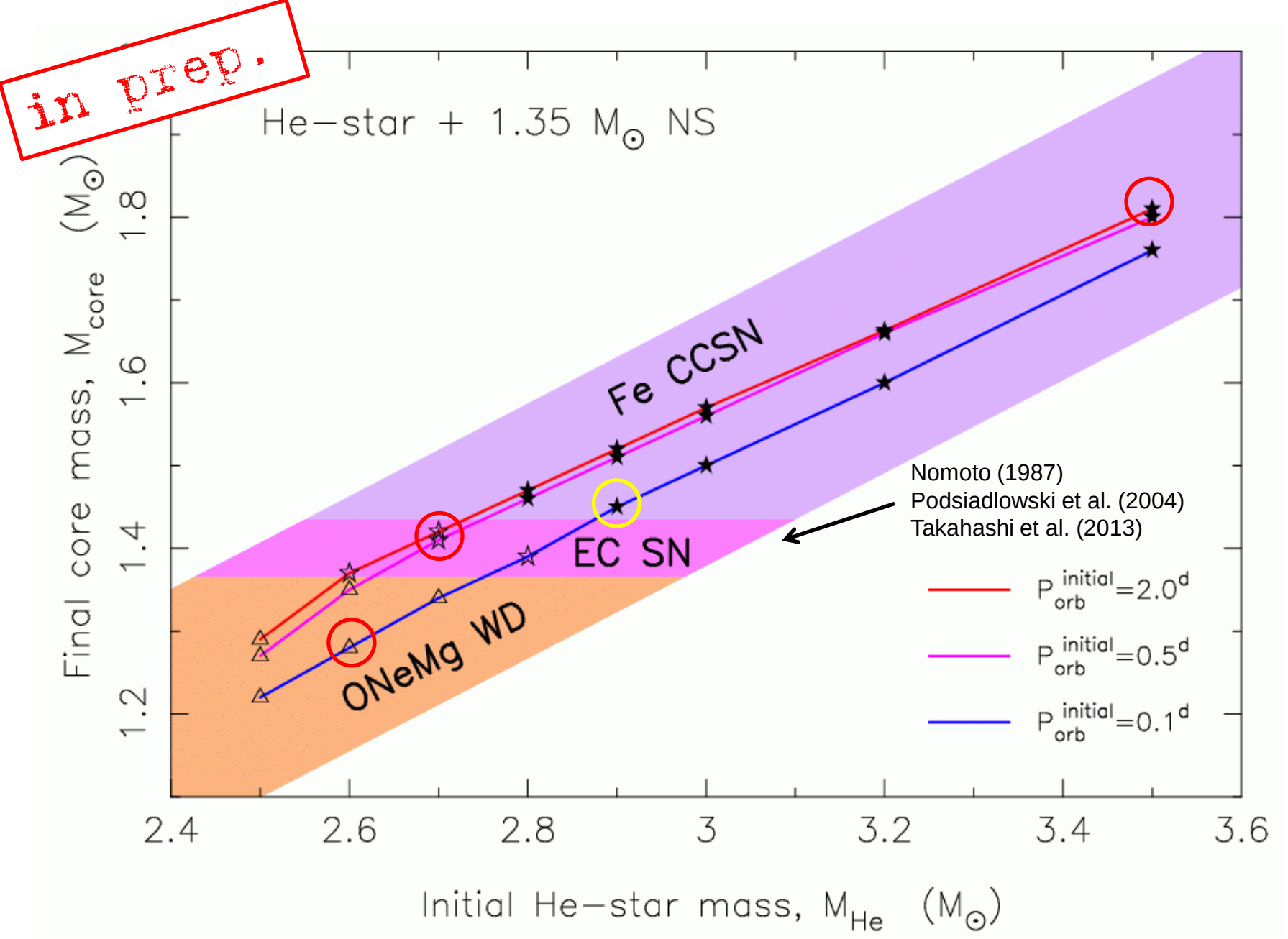
- ONeMg WD
- (ultra-stripped) electron capture SNe
- (ultra-stripped) iron core-collapse SNe

2) The properties of double NS systems (kicks!)

e.g. can the double pulsar originate from a low-kick ultra-stripped Fe CCSN?

3) SN light curves of the ultra-stripped EC and Fe CCSNe

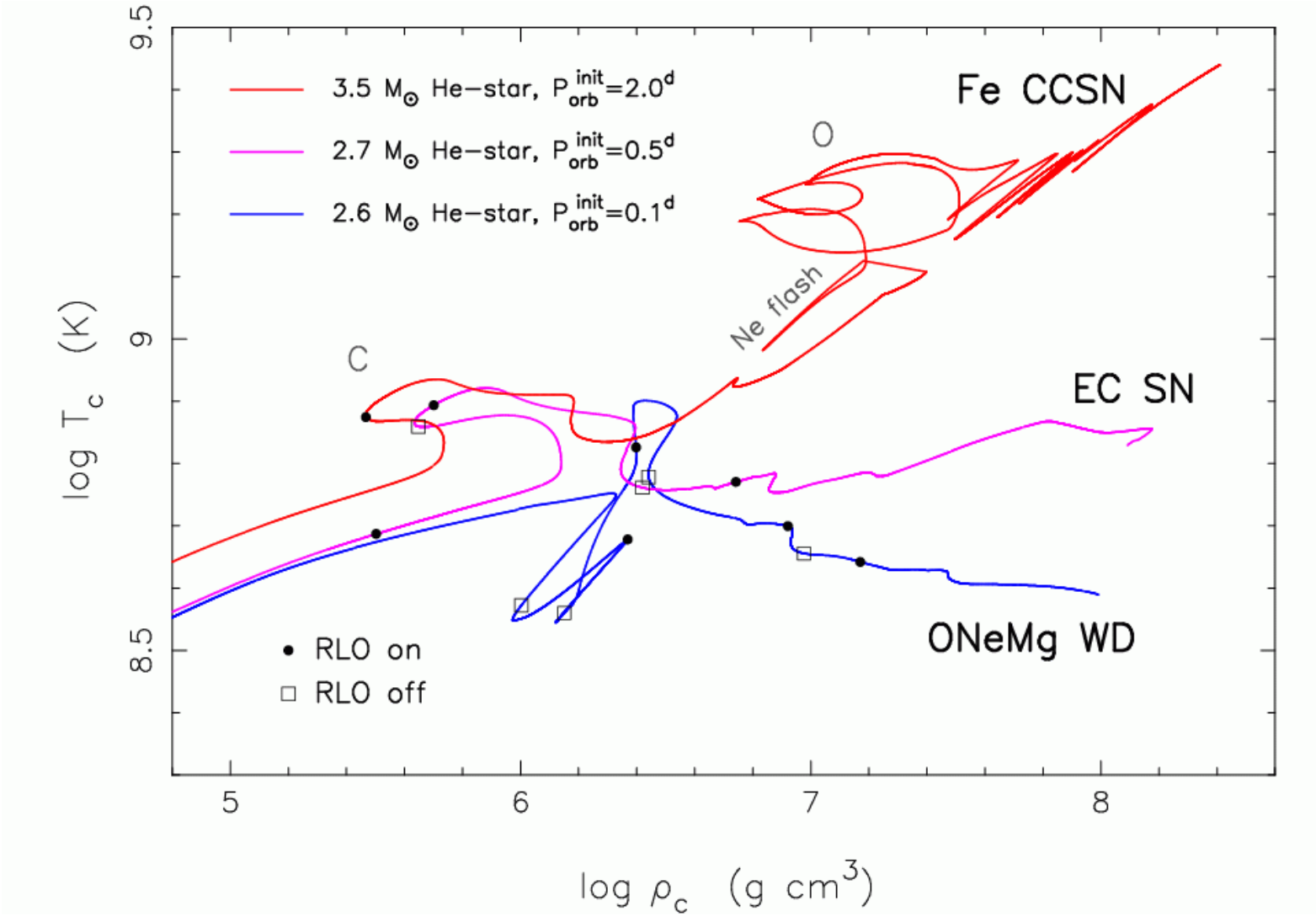
4) The spin evolution of accreting NS!

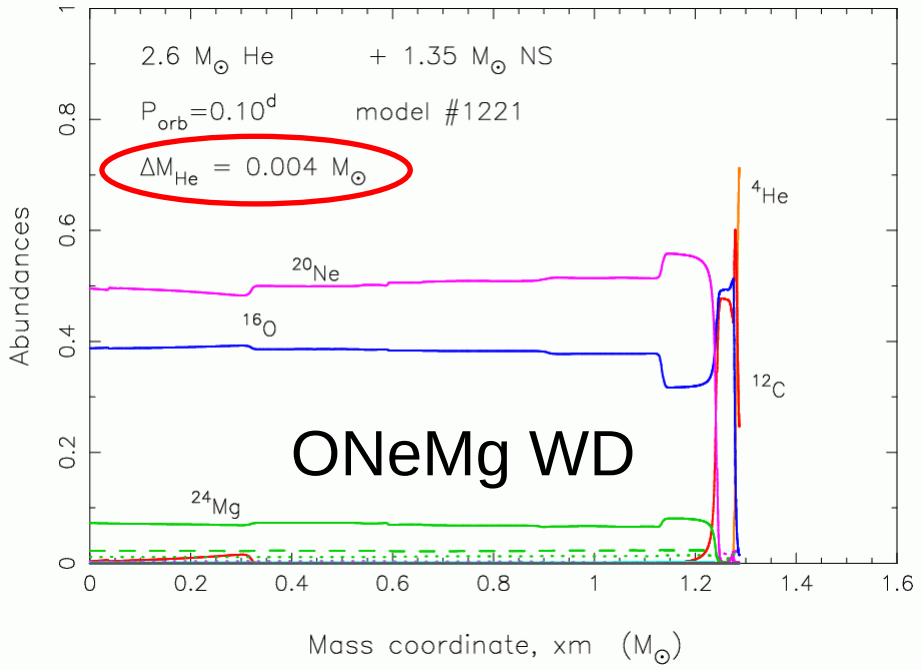

in prep.
He−star + 1.35 M⊙ NS
Final core mass, M_core (M⊙)
1.2
1.4
1.6
1.8
Fe CCSN
EC SN
ONeMg WD
Nomoto (1987)
Podsiadlowski et al. (2004)
Takahashi et al. (2013)
P_orb^initial=2.0^d
P_orb^initial=0.5^d
P_orb^initial=0.1^d
2.4
2.6
2.8
3
3.2
3.4
3.6
Initial He−star mass, M_He (M⊙)

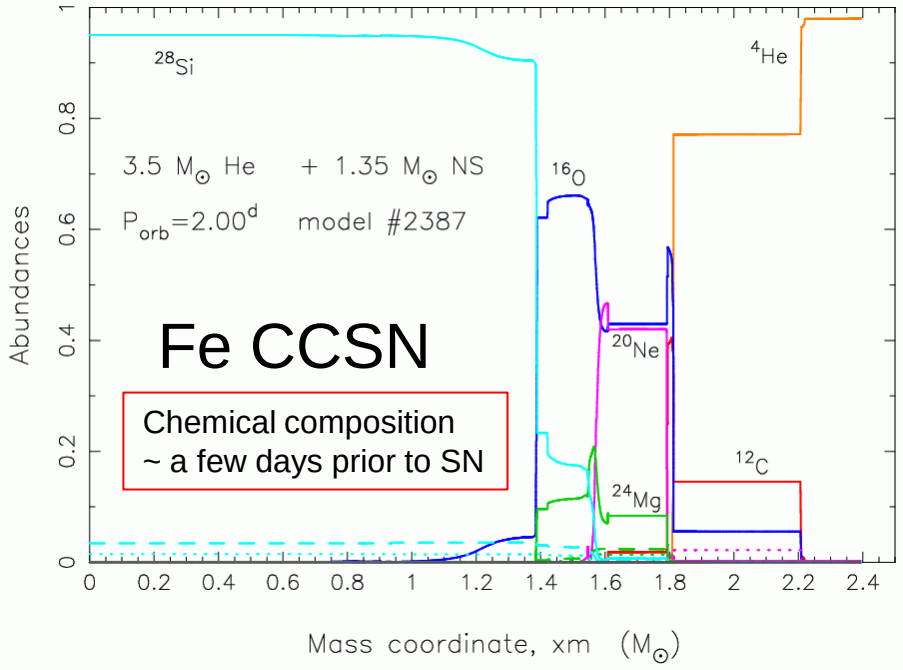
in prep.

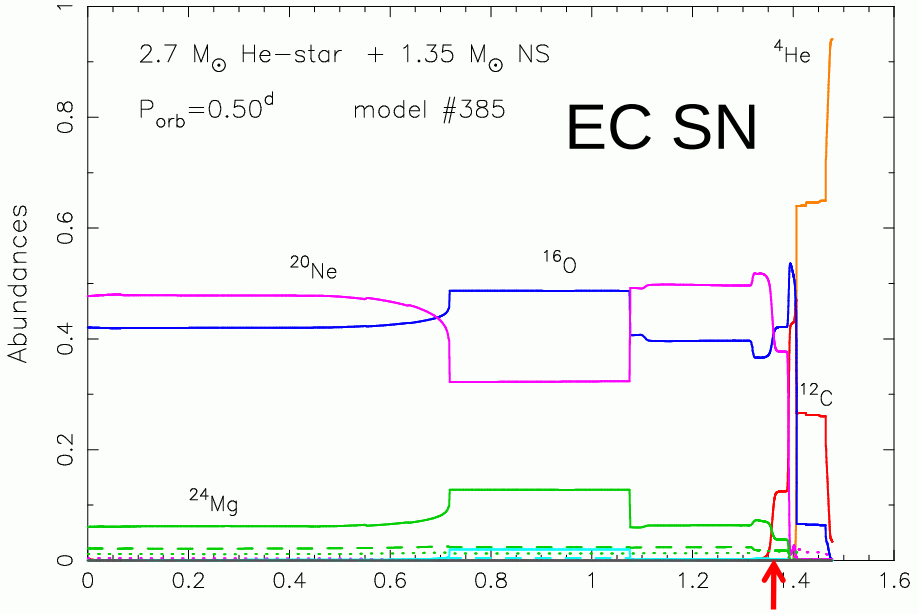
Fe CCSN versus EC SN

Takahashi et al. (2013)
Umeda et al. (2012)
Jones et al. (2013)









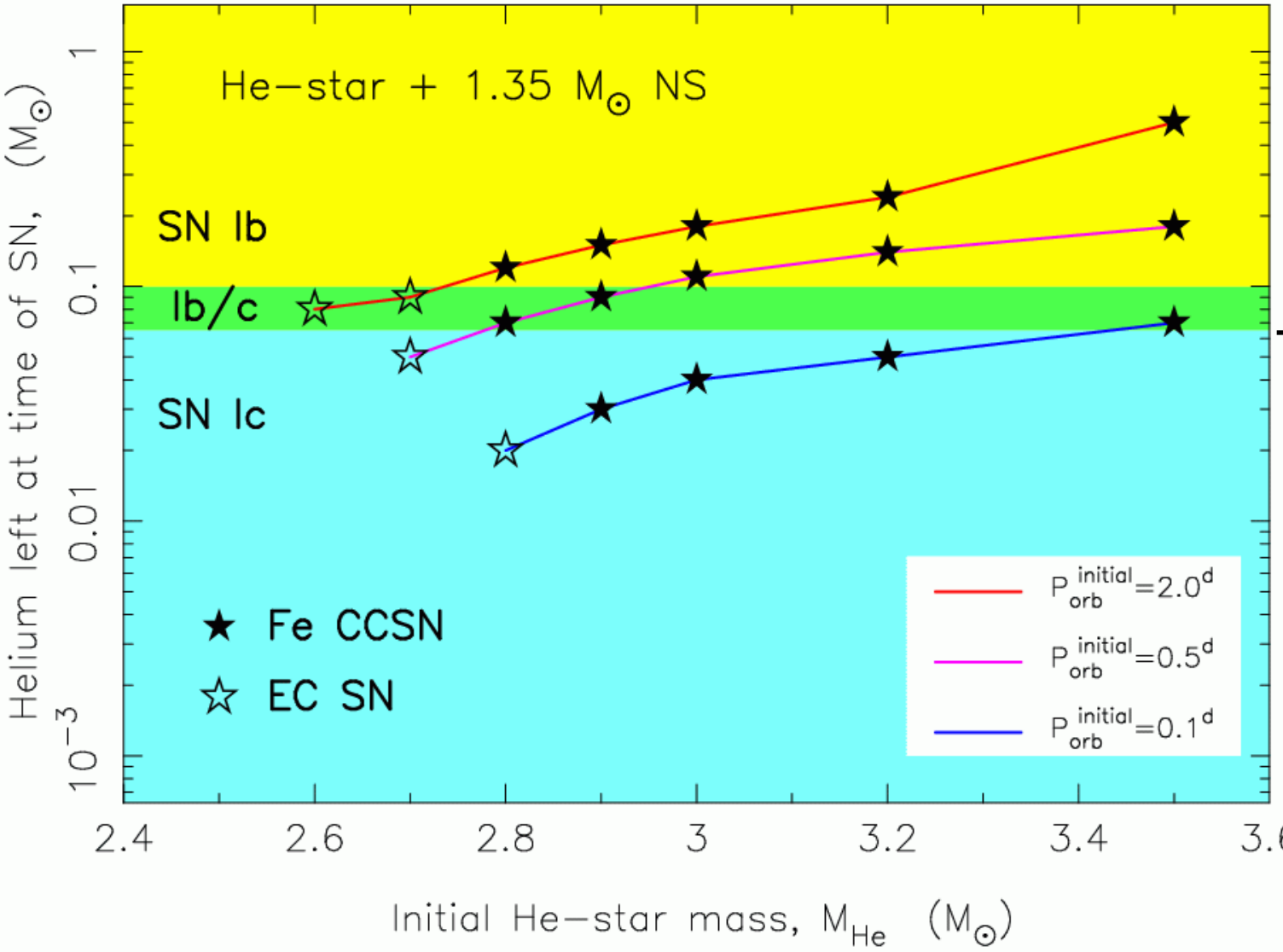
in prep.

Future:
Calculate these models until core collapse to obtain density profiles → **SN kicks!**

> 1.37 M_{sun} (Nomoto 1987, Takahashi et al. 2013)

in prep.

Spectral type of ultra-stripped SNe



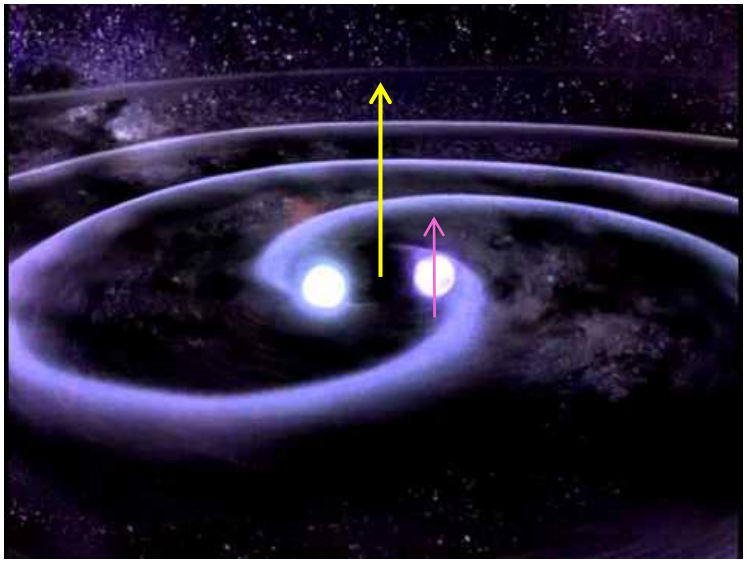
He limit: 0.06 M_{sun} (Hachinger et al. 2012)

ultra-stripped SNe Ic

Double Neutron Star Systems:

Evidence for NSs born with a small kick

- small eccentricities (e.g. Schwab, Podsiadlowski & Rappaport 2010)
- small systemic velocities (e.g. Wex, Kalogera & Kramer 2000)
- small misalignment between recycled pulsar spin axis and orbital ang.mom. vector (Ferdman et al. 2013)



Usually explained by EC SNe.
But… they might also originate from ultra-stripped FeCC SNe.

Double Neutron Star Systems

= ultra-stripped EC / Fe CCSN candidates

		P (ms)	P_{dot} (10^{-18})	P_{orb} (d)	ecc	M_{psr} / M_{comp}	M_{total}
recycled	New Martinez et al.	45.8	0.19	4.07	0.11	?	2.77
recycled	J0737-3039 A	22.7	1.8	0.10	0.09	1.34	2.59
young	B	2773.5	892			1.25	
recycled	J1518+4904	40.9	0.022	8.63	0.25	<1.17 / >1.55	2.72
recycled	B1534+12	37.9	2.4	0.42	0.27	1.33 / 1.35	2.68
recycled	J1753-2240	95.1	0.79	13.64	0.30	?	?
recycled	J1756-2251	28.5	1.0	0.32	0.18	1.34 / 1.23	2.57
recycled	J1811-1736	104.2	0.90	18.78	0.83	<1.64 / >0.93	2.60
recycled	J1829+2456	41.0	0.053	1.18	0.14	<1.38 / >1.22	2.59
young	J1906+0746	144.1	20300	0.17	0.09	1.29 / 1.32	2.61
recycled	New **PALFA** Lazarus et al.	27.3	0.15	0.20	0.09	?	2.86
recycled	B1913+16	59.0	8.6	0.32	0.62	1.44 / 1.39	2.83
GC	J1807-2500B	4.2	8.2*	9.96	0.75	1.37 / 1.21	2.57
GC	B2127+11C	30.5	5.0	0.34	0.68	1.36 / 1.35	2.71

Summary - Ultra-stripped SNe Ic:

1) Mass-transfer in post-CE HMXBs can significantly **strip** a helium star all the way to the Chandrasekhar limit, leaving a **naked metal core** undergoing a SN explosion with **very little ejecta**.

2) Ultra-stripped SNe are *possibly* already observed (SN2005ek)

3) Ultra-stripped SNe can be ***electron capture*** or ***iron core-collapse*** *SNe*

4) Up to 1% of *all* SNe are ultra-stripped SNe

5) Ultra-stripped SNe are **important** for the **formation of double NS systems** ($\rightarrow$ small NS masses, small kicks, small eccentricities)

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Thank you!