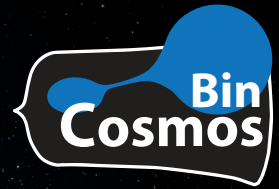




UNIVERSITEIT VAN AMSTERDAM



ANTON PANNEKOEK
INSTITUTE



Impact of binarity on core-collapse supernovae

E. (Manos) Zapartas

(Some of the) collaborators:

S.E. de Mink, R.G. Izzard, S.-C. Yoon, C. Badenes, S. van Dyk, O. Fox, N. Smith,
A. de Koter, M. Renzo, Y. Gotberg, C.J. Neijssel, S. Ryder, A. Schootemeijer

Importance of ccSupernovae

Cosmic rays,
neutrinos

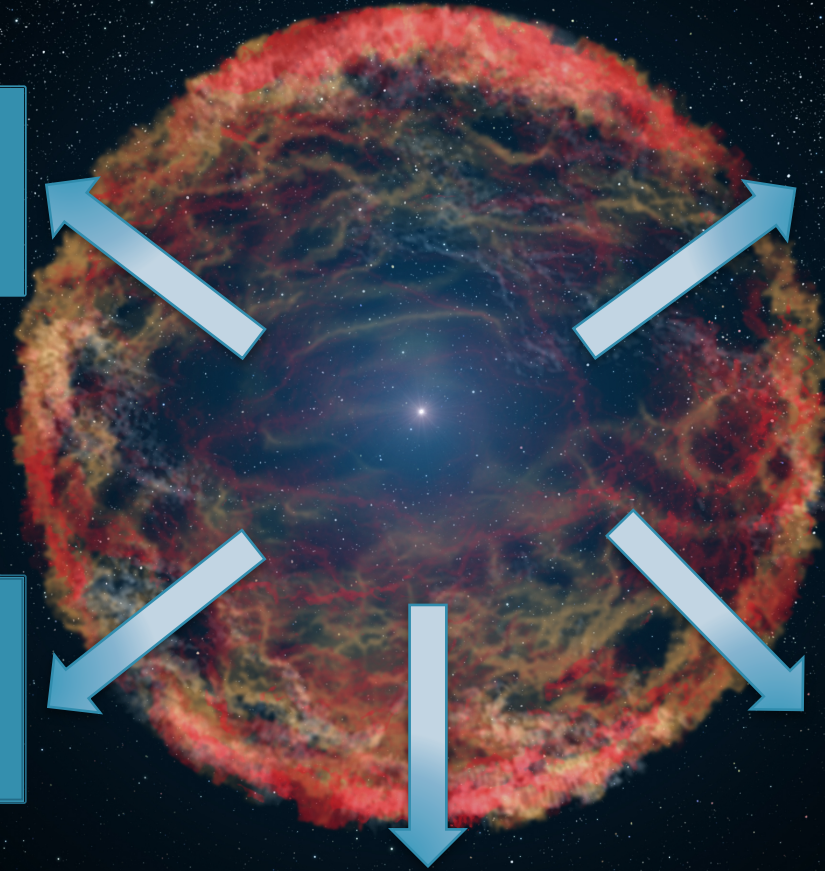
Chemical
enrichment

Neutron stars,
black holes,
gravitational wave
sources

Mechanical and
radiative feedback

Evolution of
massive stars and
their explosion

"Artist's impression of
supernova 1993J" by NASA,
ESA, and G. Bacon (STScI)



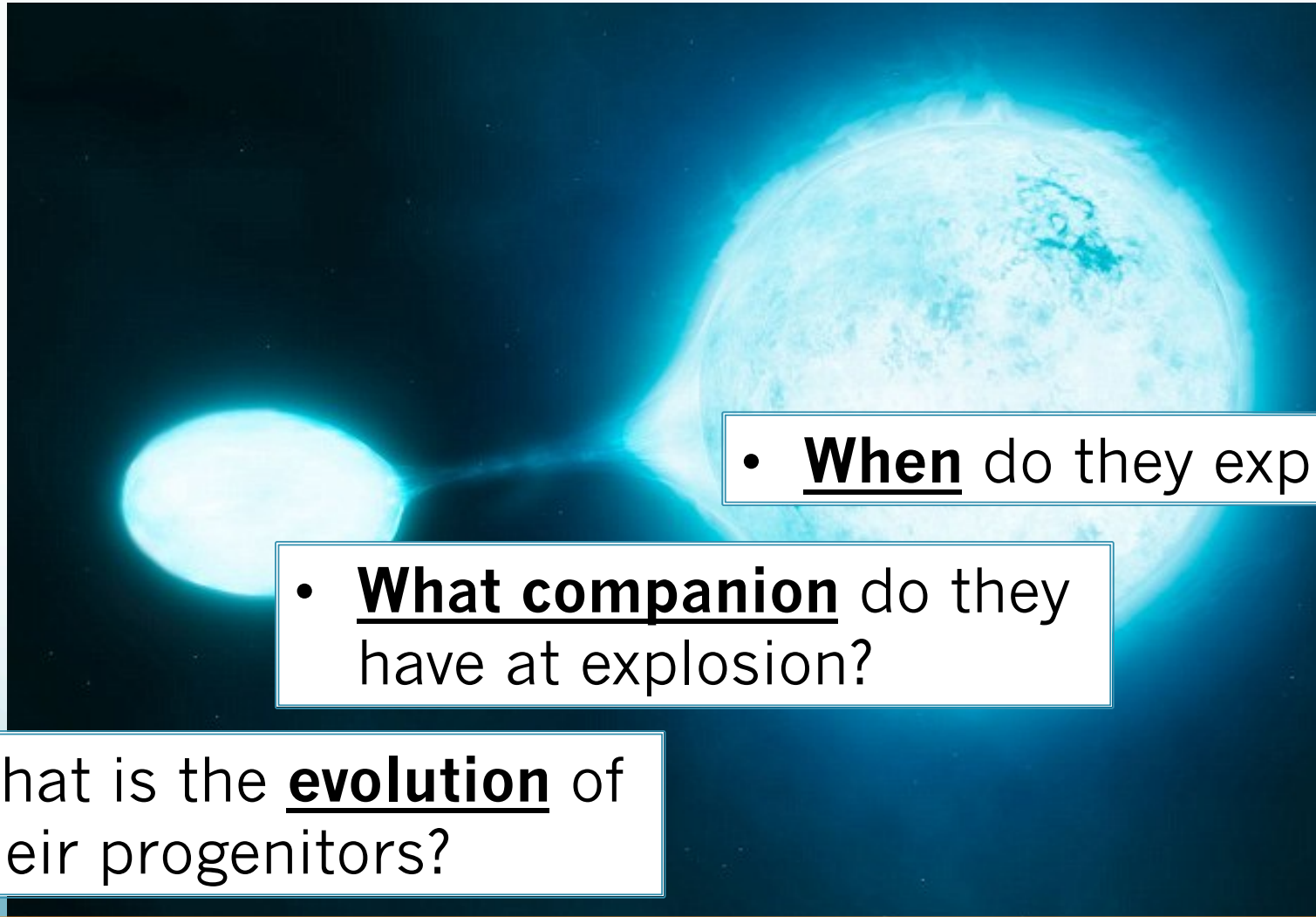
Most young massive stars are found in binaries...



... and will probably interact

(Mason+'09, Sana+Evans'12, Sana+'12, Kiminki+Kobulnicky+'12)

How binarity affects ccSNe?



- When do they explode?
- What companion do they have at explosion?
- What is the evolution of their progenitors?

e.g. Podsiadlowski+ '92, De Donder+Vanbeveren'03, Eldridge+'04,'07,'08, Izzard+'04

Why population synthesis?

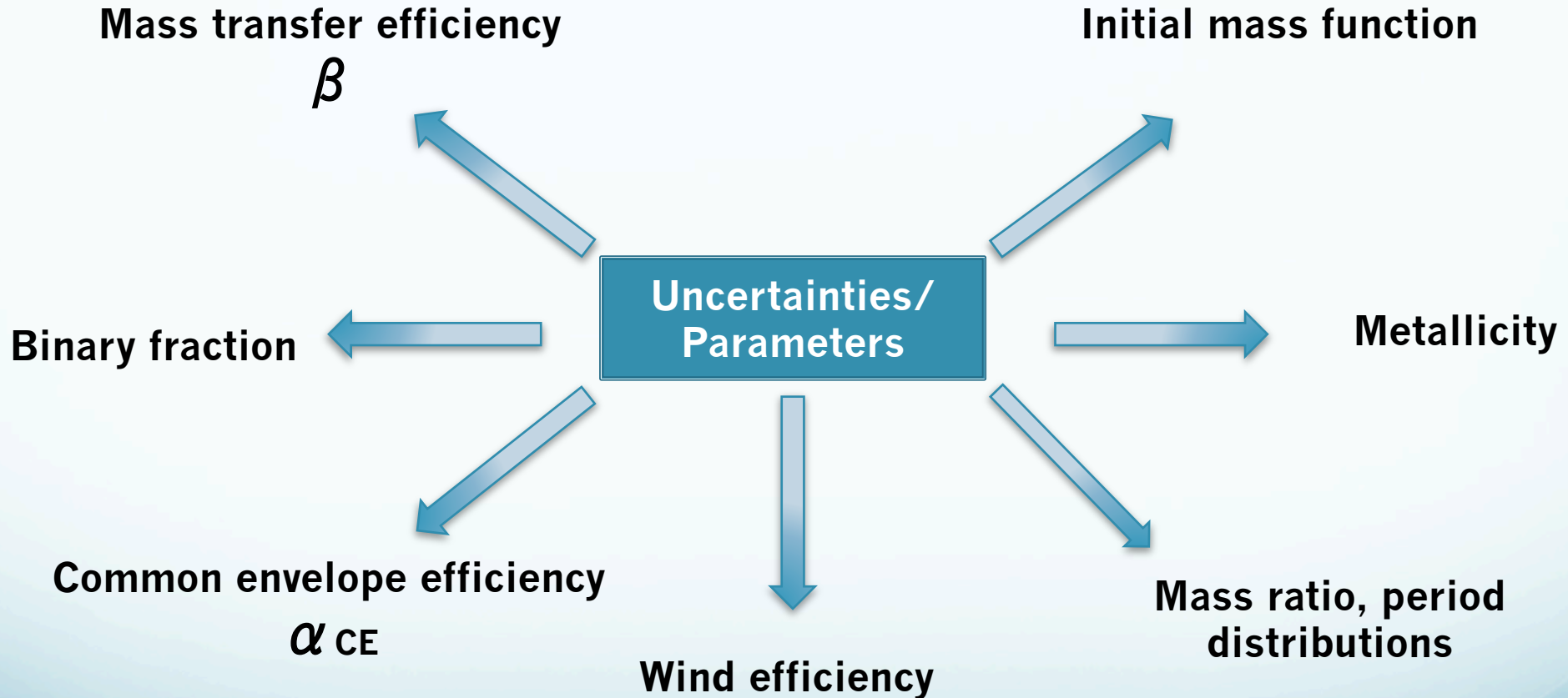
Binary_c: a rapid stellar evolutionary code

(Izzard+ '04, '06, '09, Hurley+ '00, '02, de Mink+ '13, Schneider+ '15)

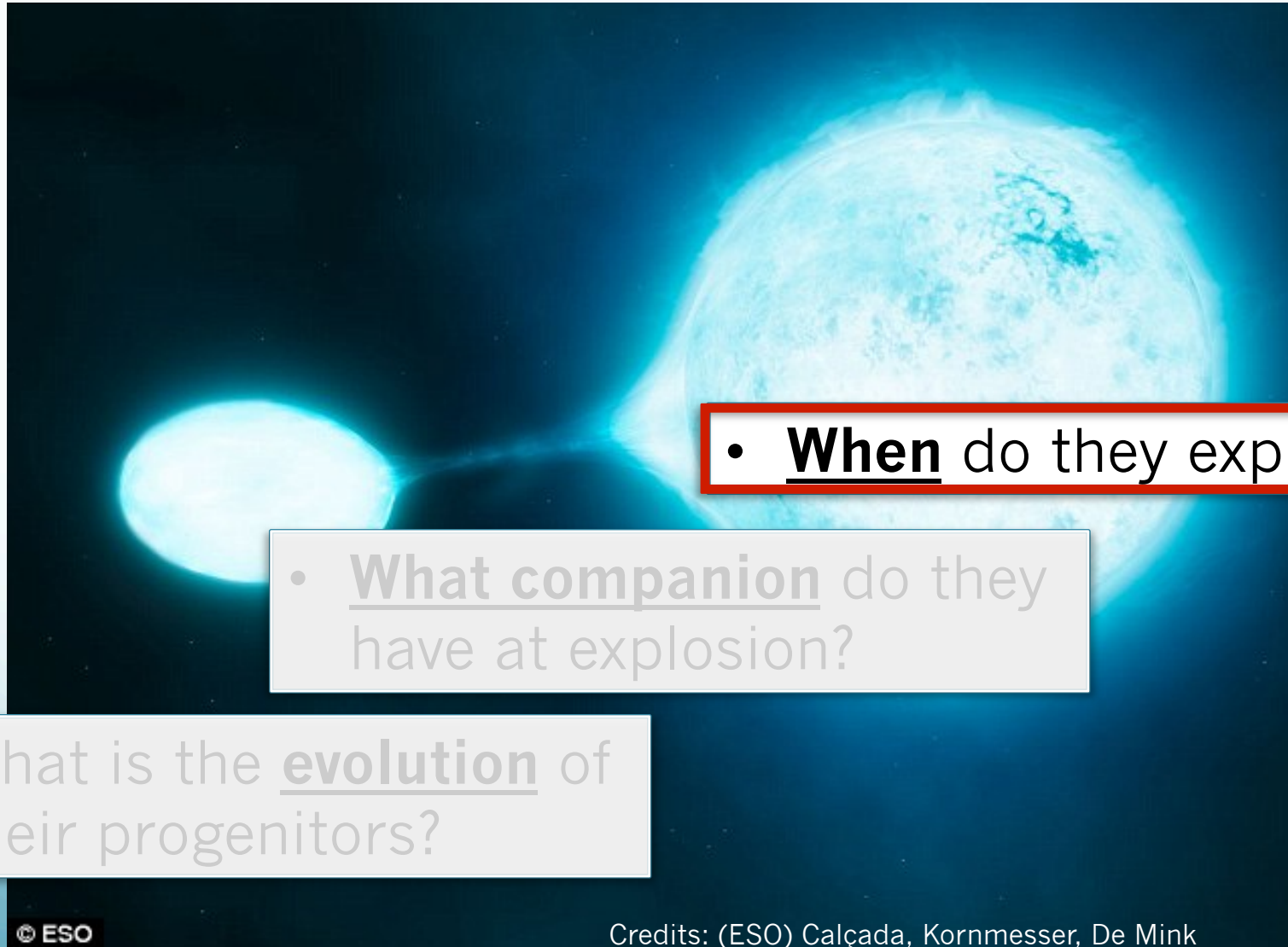
Upcoming/Existing Automated **Transient Surveys**



How robust are our predictions?



How binaries affect ccSNe?



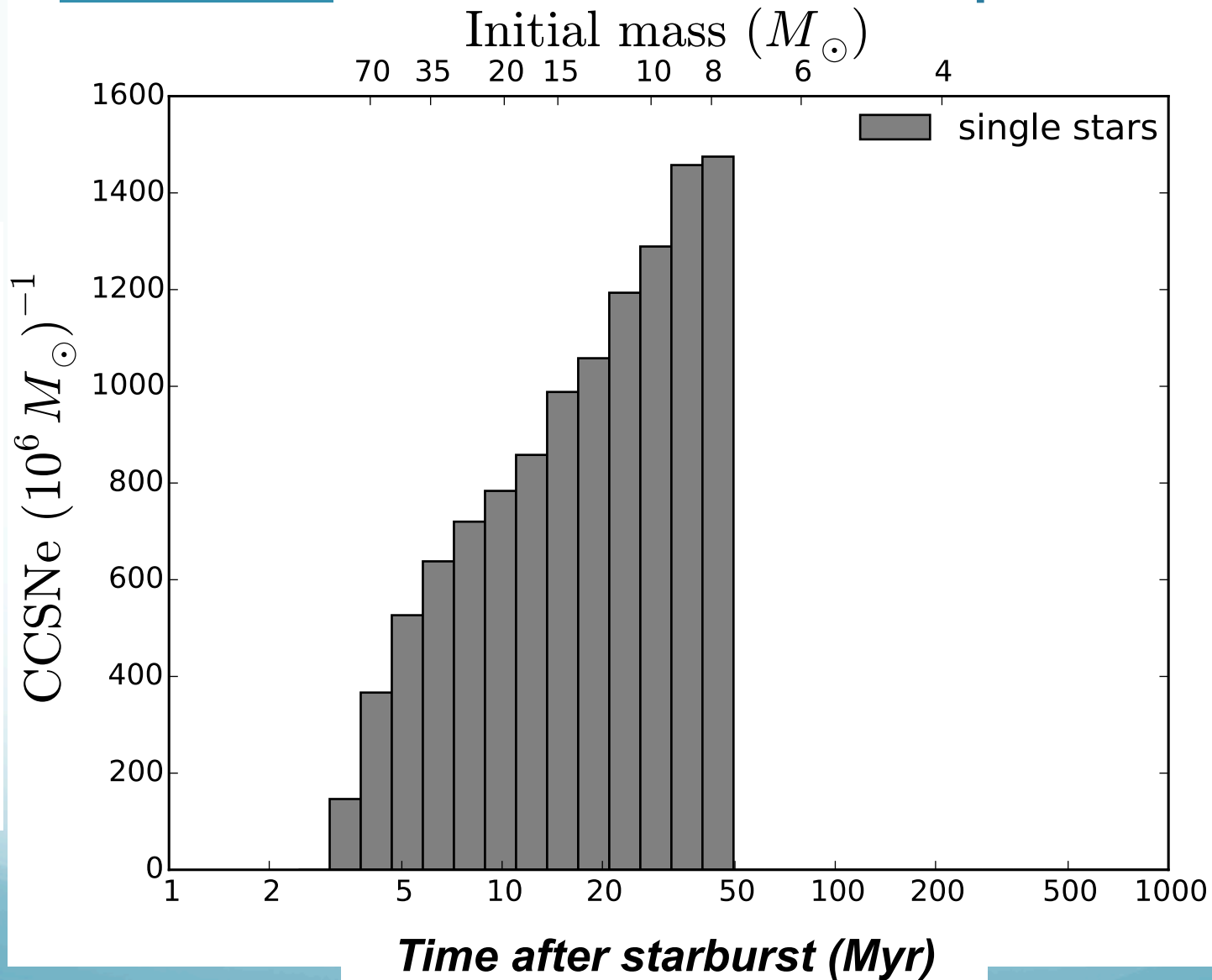
• **When** do they explode?

• What companion do they have at explosion?

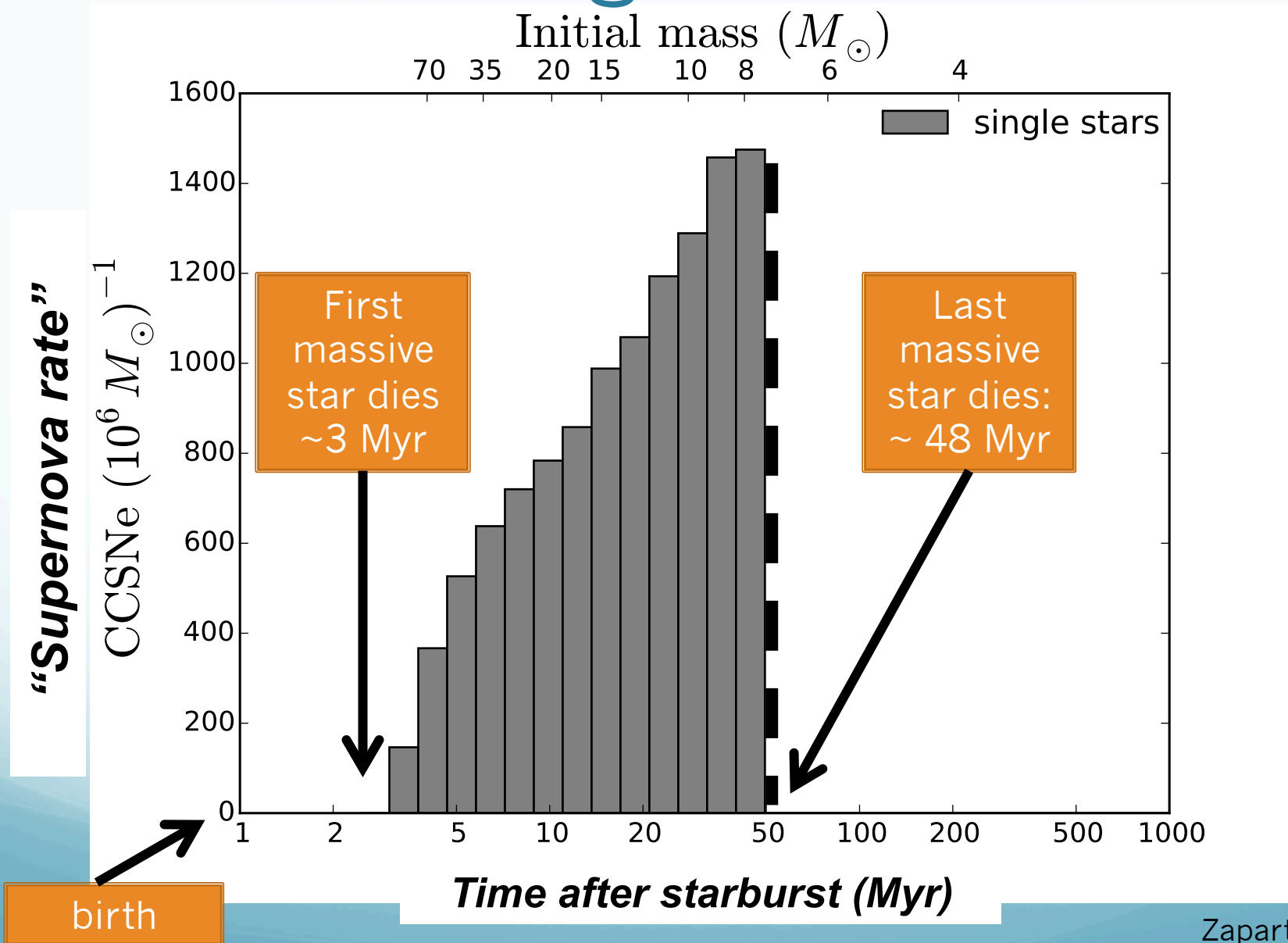
• What is the evolution of their progenitors?

When do ccSNe explode?

“Supernova rate”

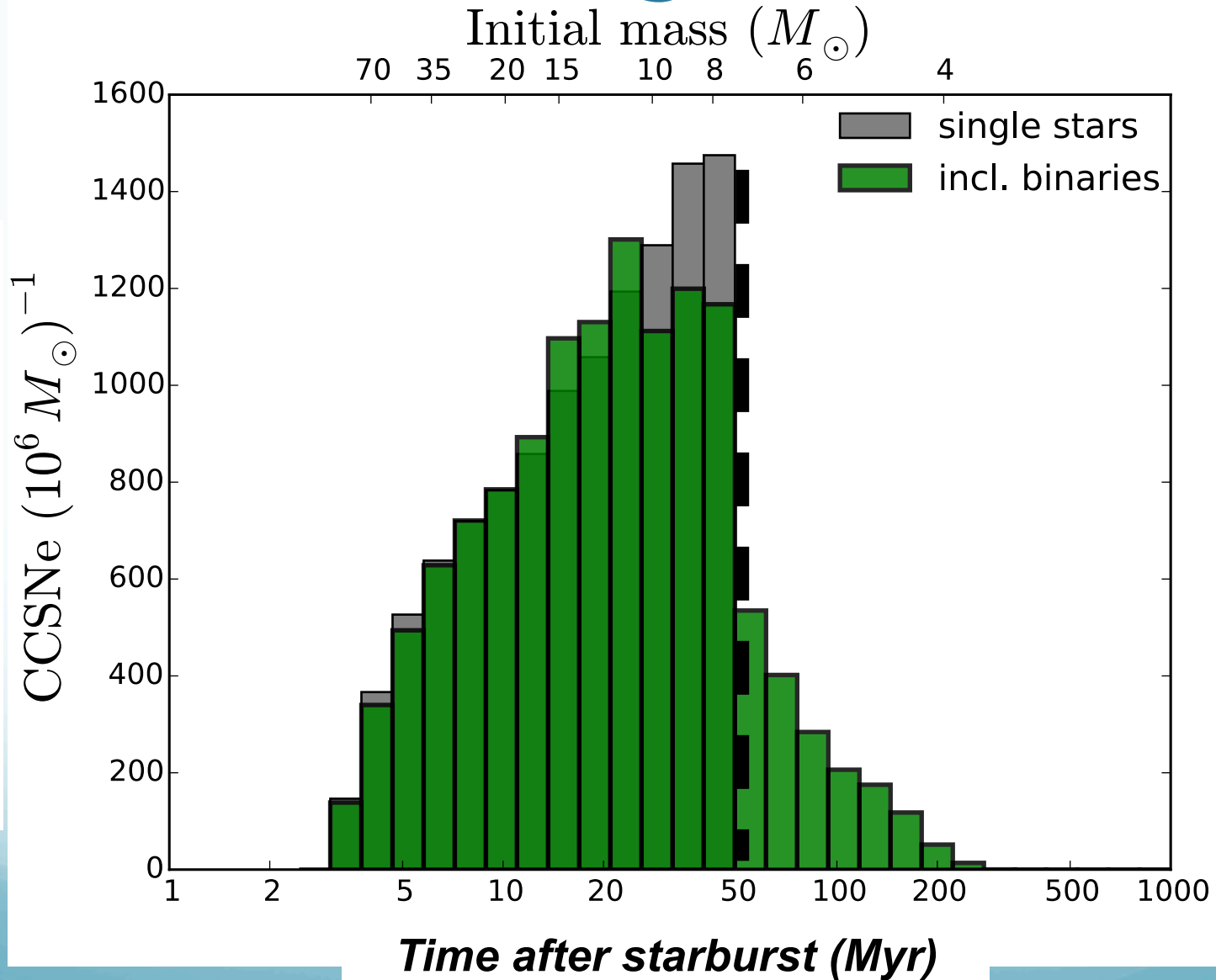


Single stars



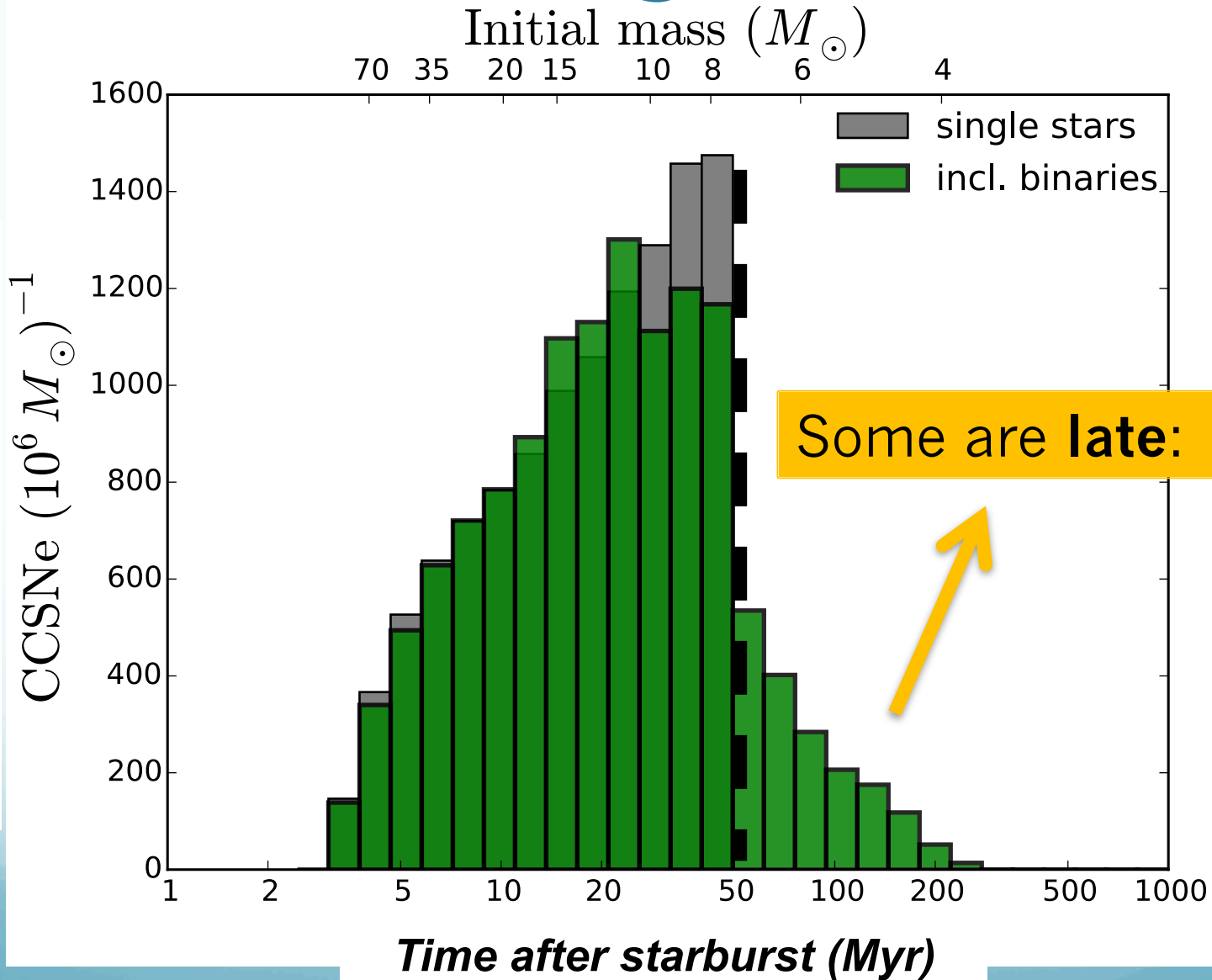
Including binaries

“Supernova rate”



Including binaries

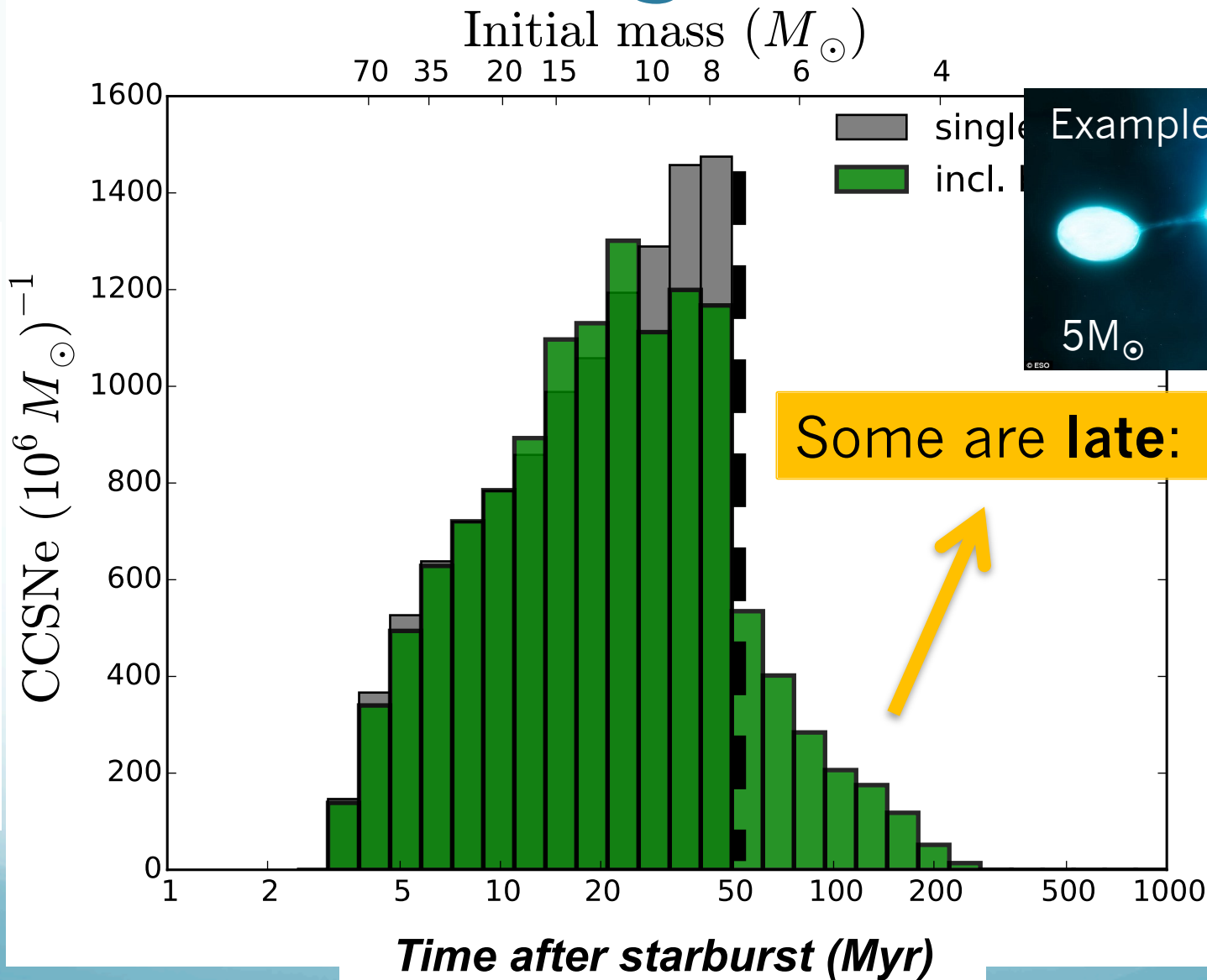
“Supernova rate”



Some are late: ~7-24%

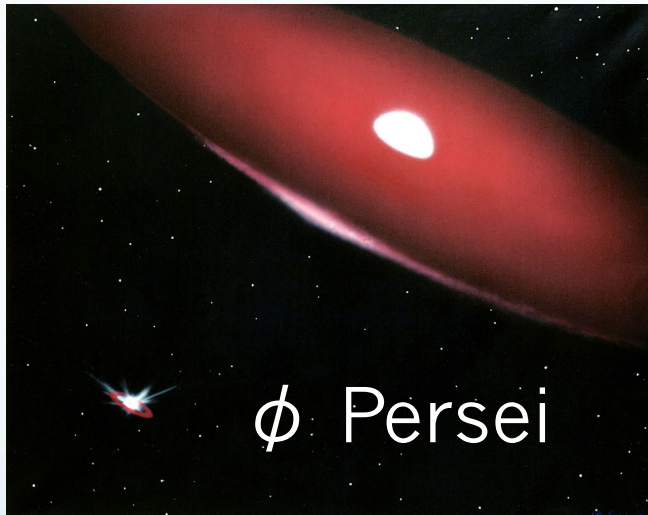
Including binaries

“Supernova rate”



Possible observational signature of late ccSNe

Progenitor?



e.g. Mourard+'15
Schootemeijer+(in prep.)
Pols '07
Vanbeveren+'98

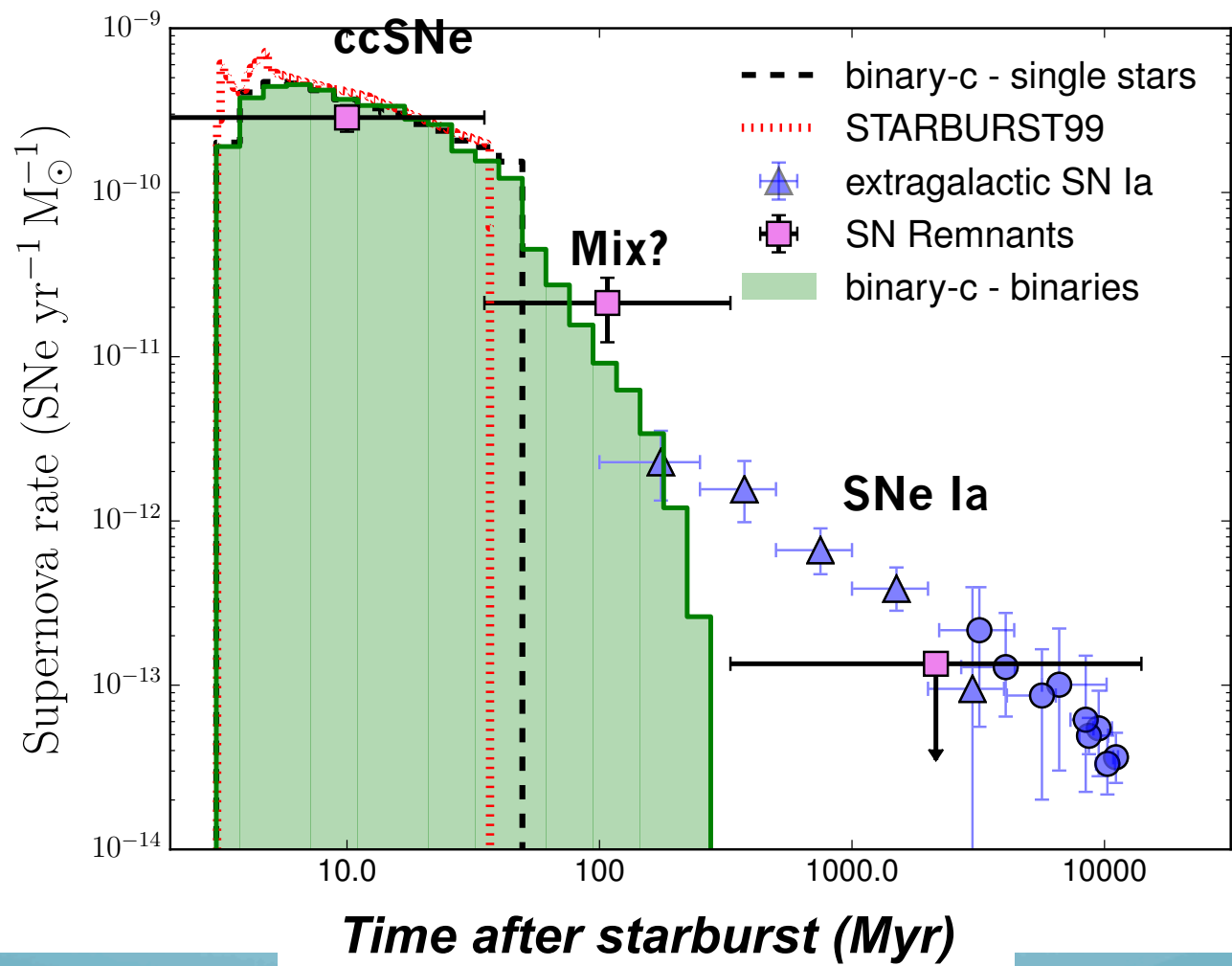
Descendant?



e.g. Portegies Zwart+Yungelson '99
Tauris+Sennels'00
Davies+Ritter+King'02
Kalogera+'05
Church+'06

Possible observational signature of late ccSNe

“Supernova rate”



Leitherer+'99, Schaller+92
Totani+'08, Maoz+'10
Maoz+Badenes'10

How binaries affect ccSNe?

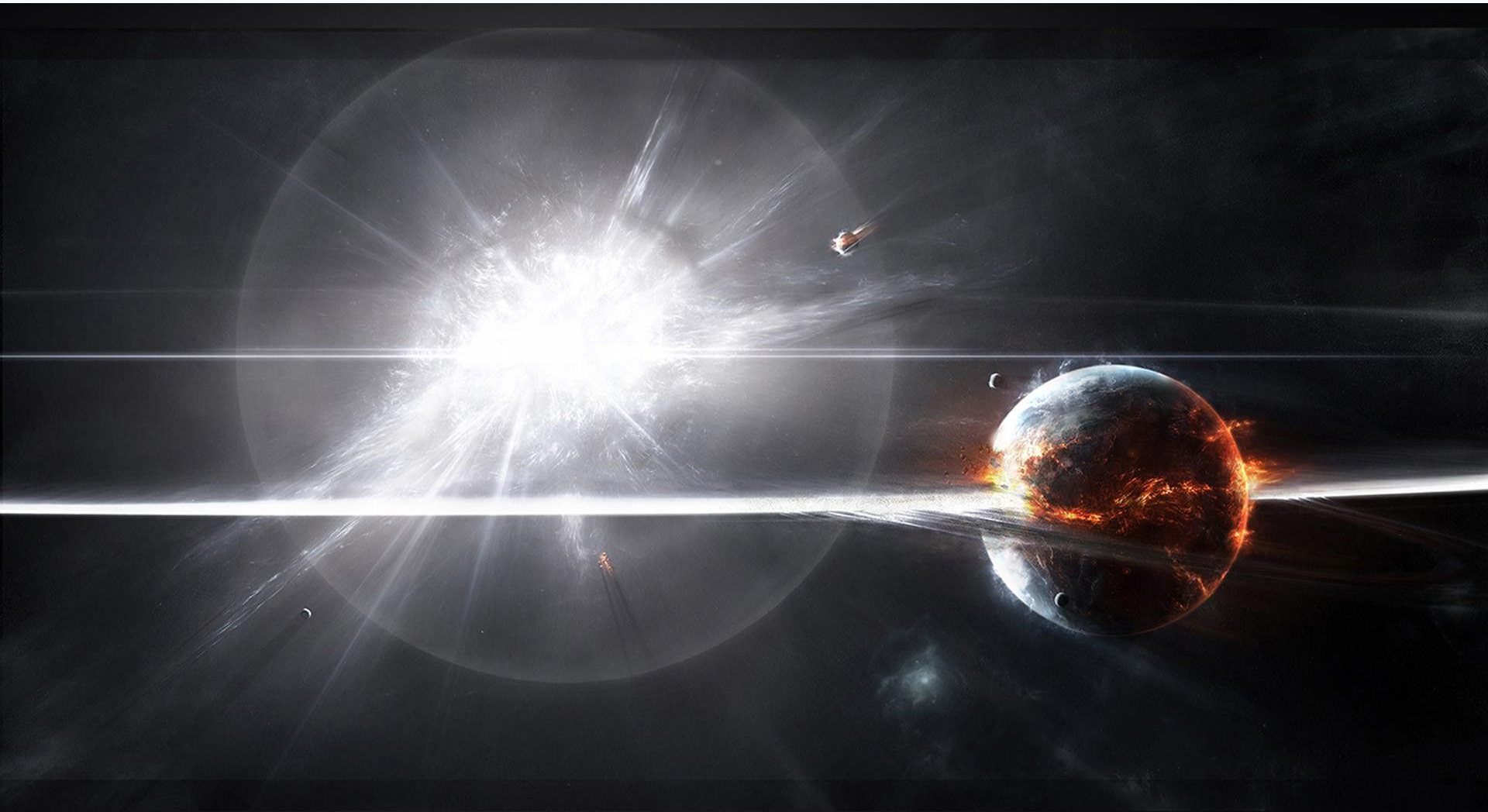


- When do they explode?

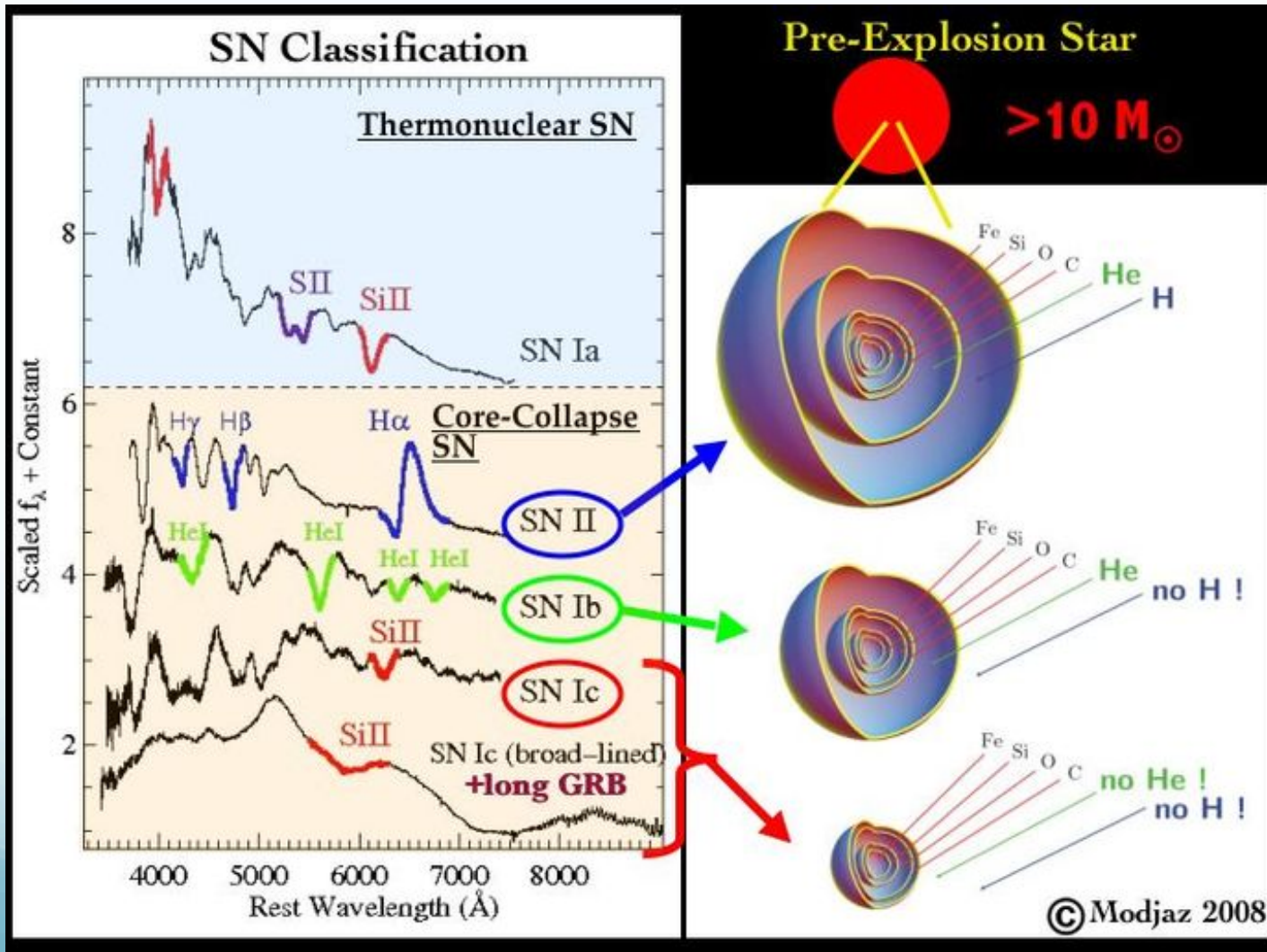
- **What companion** do they have at explosion?

- What is the evolution of their progenitors?

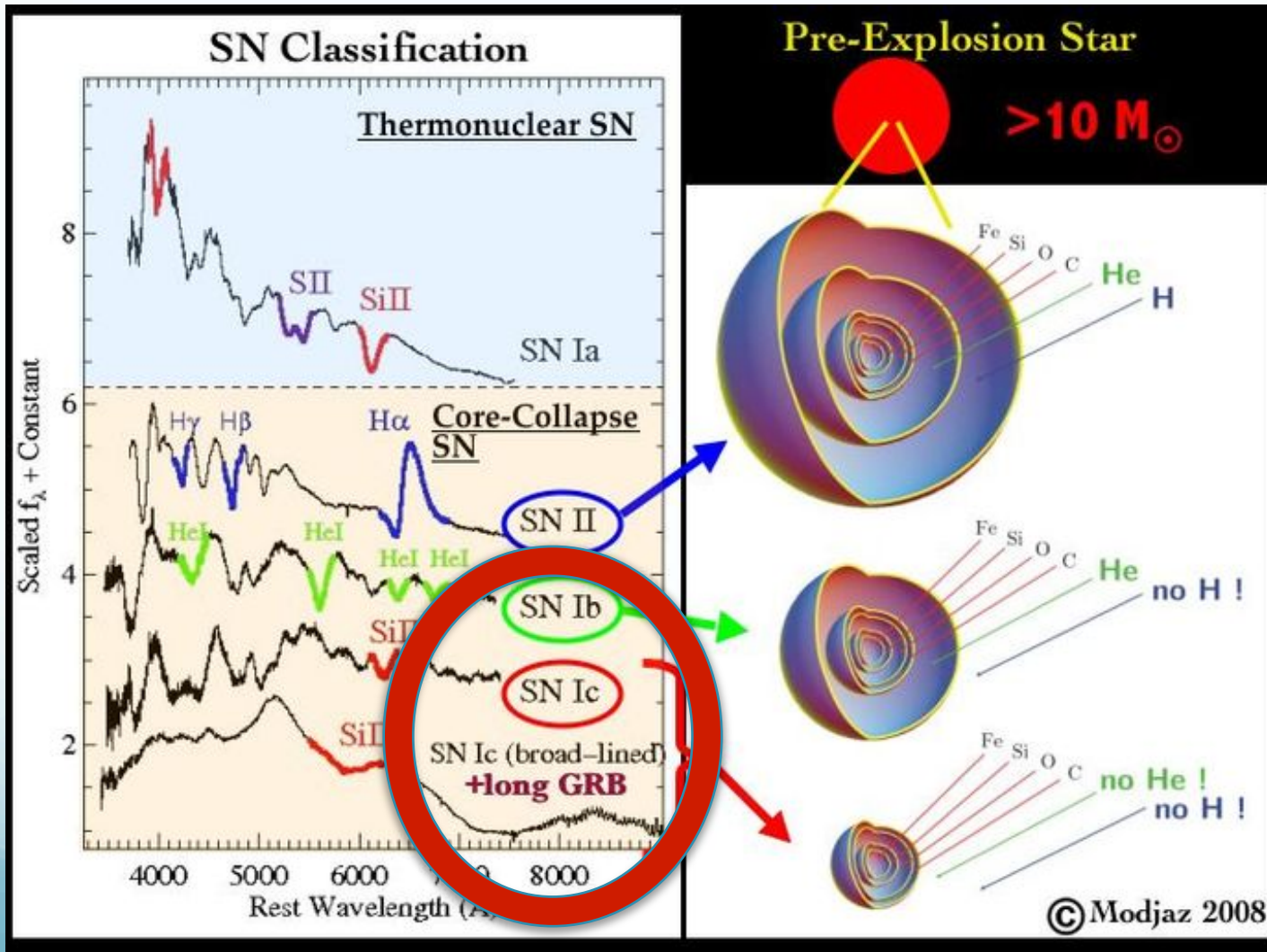
Companions of stripped ccSNe



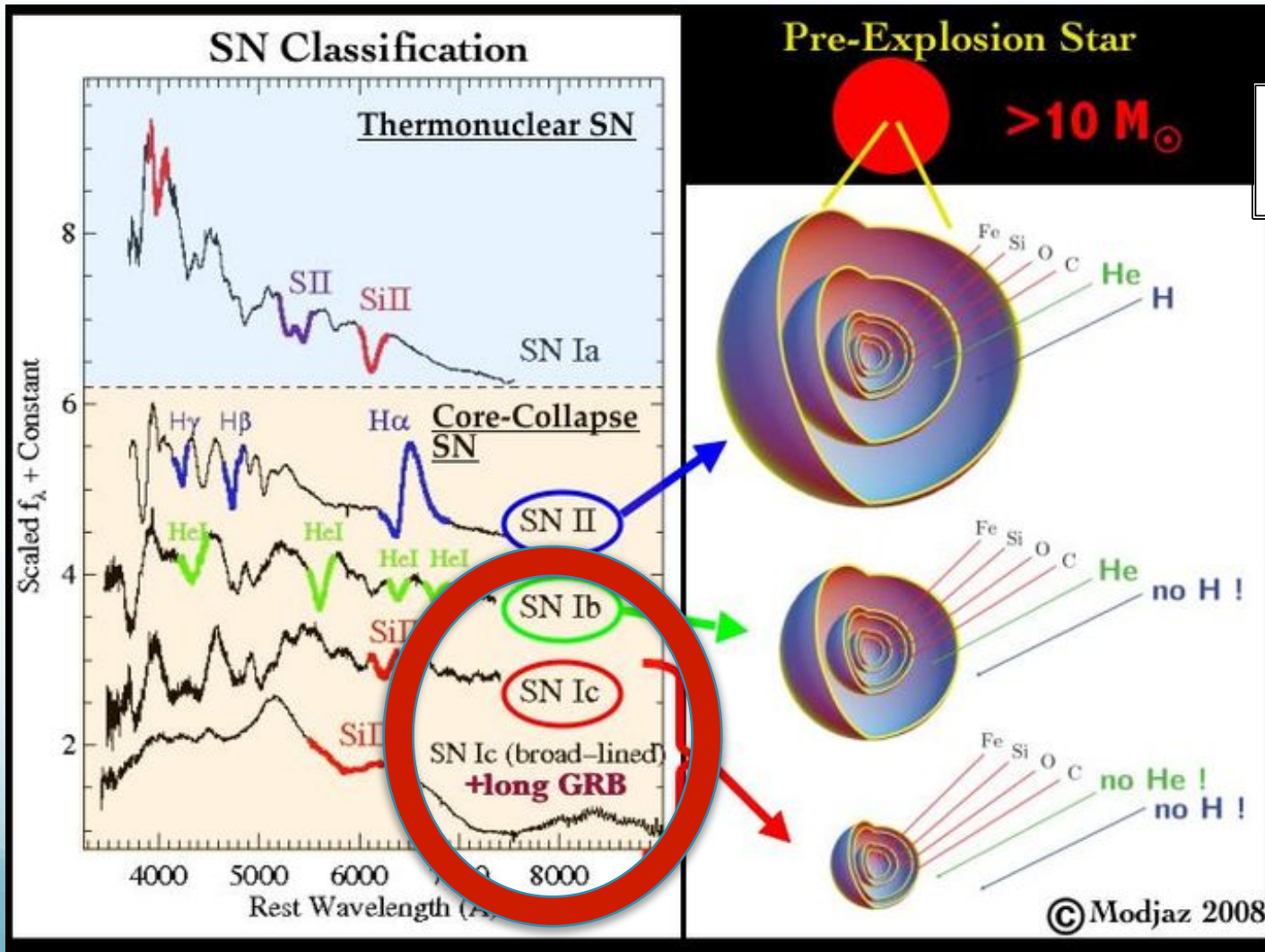
Types of supernovae



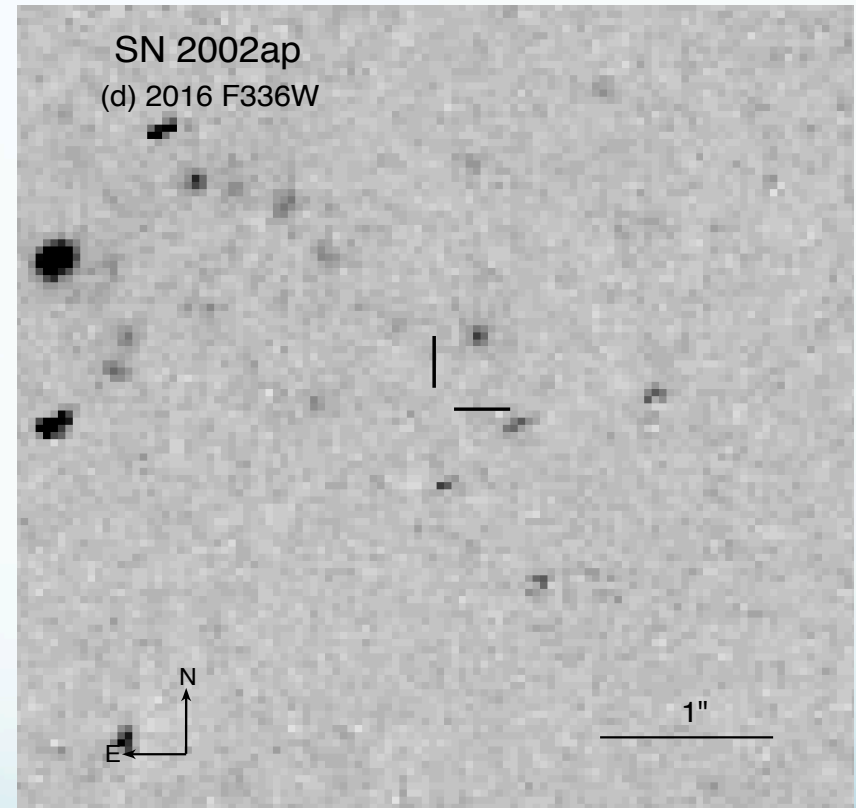
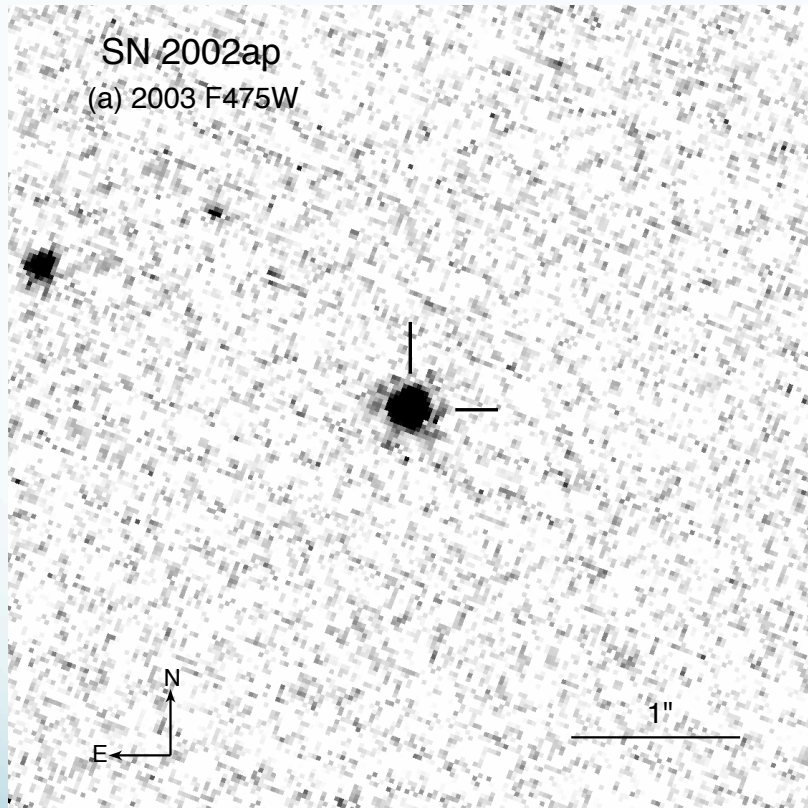
Types of supernovae



Types of supernovae

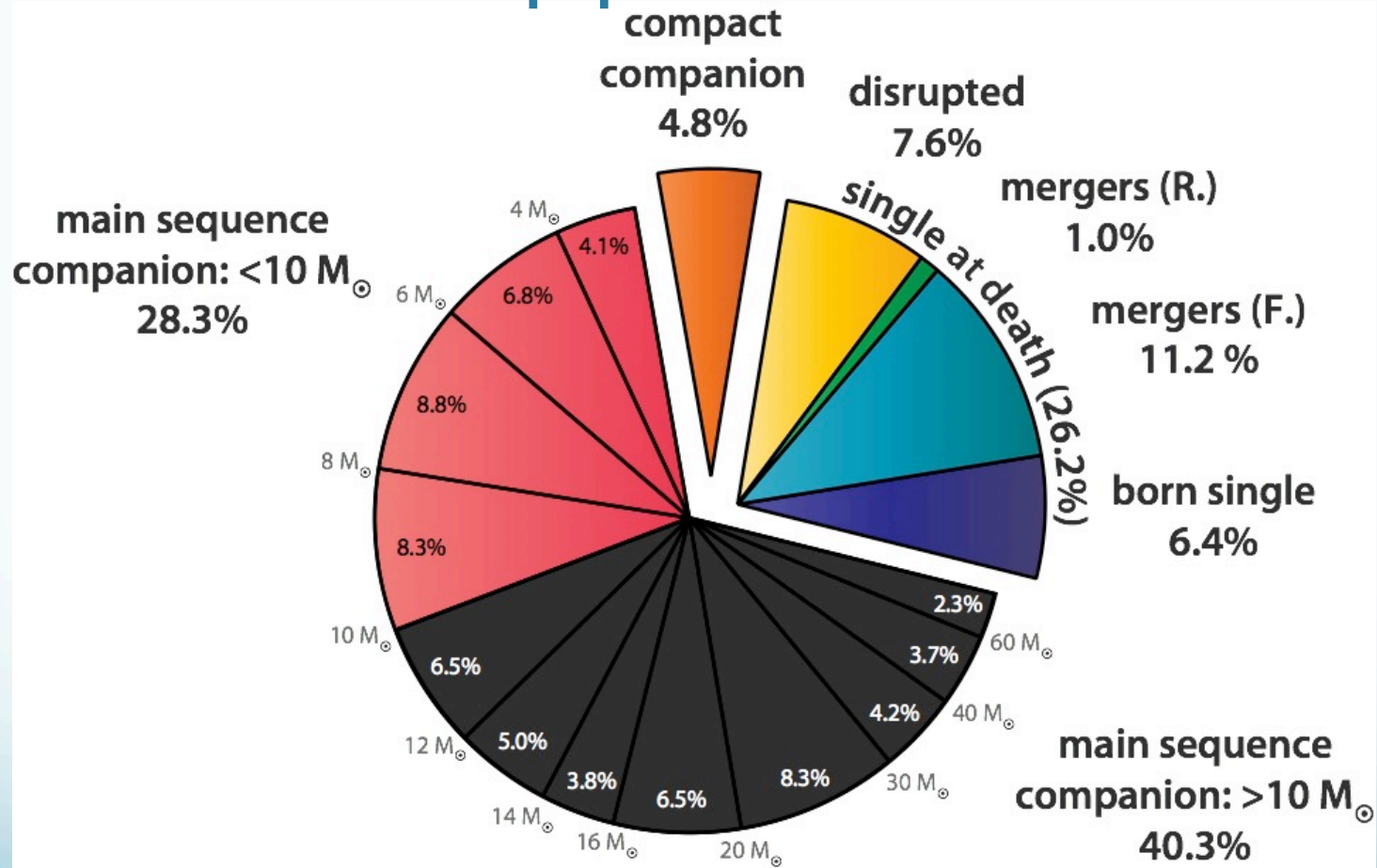


Companion search



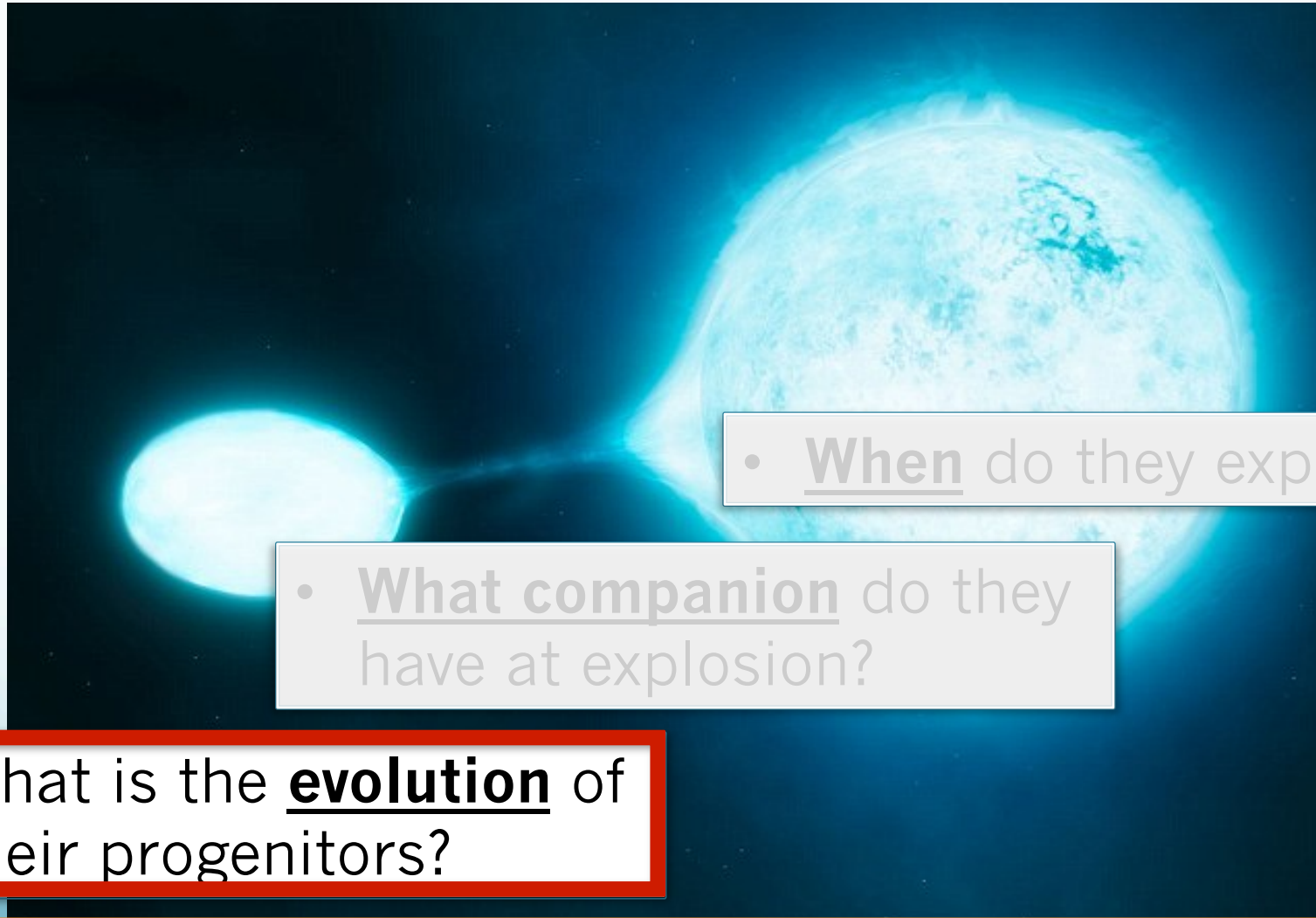
Zapartas+2017b, VanDyk+2016

Companions of stripped ccSNe



Stripped-envelope SNe (Z = 0.0055)

How binaries affect ccSNe?



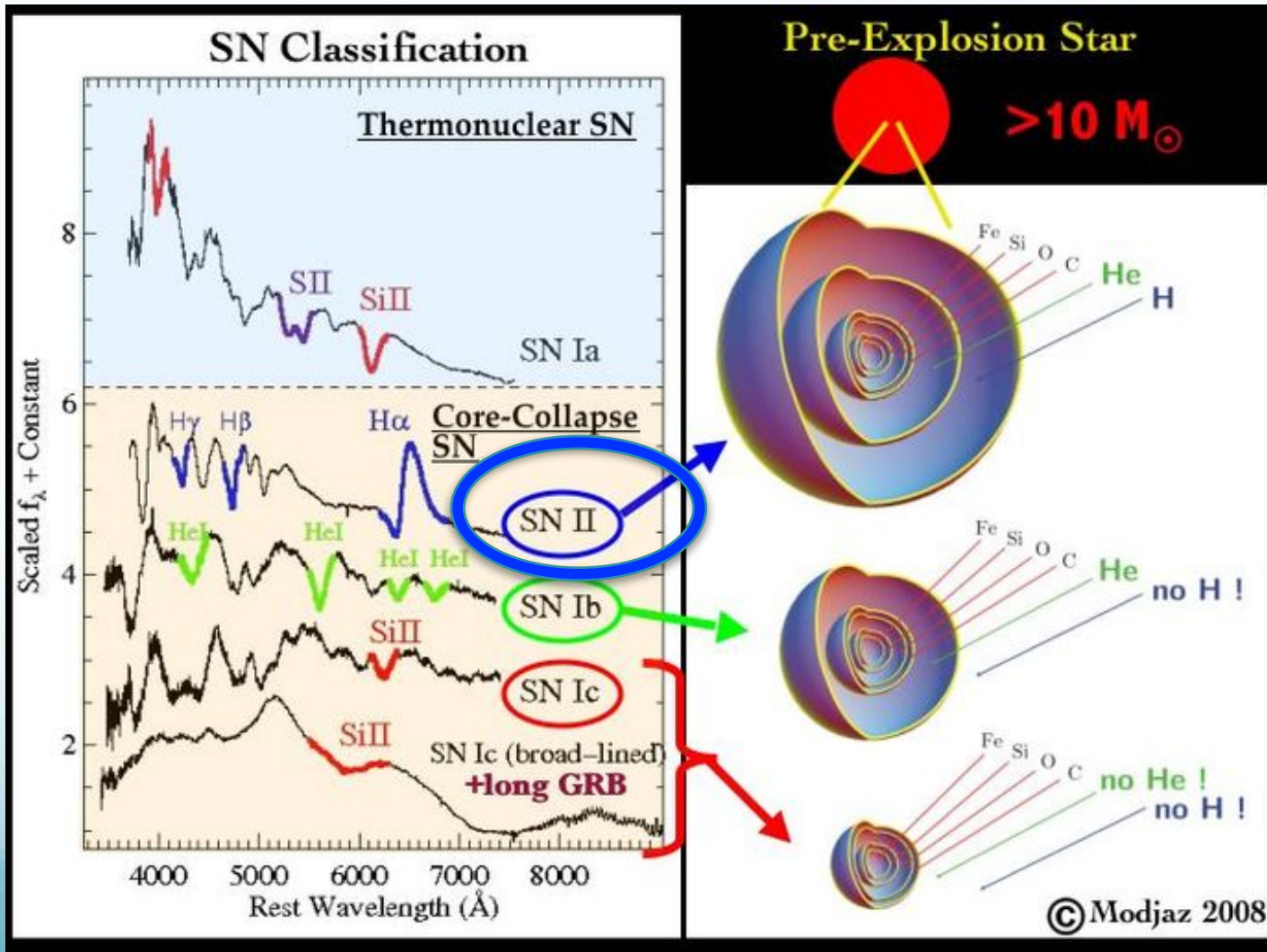
- When do they explode?

- What companion do they have at explosion?

- What is the evolution of their progenitors?

e.g. Podsiadlowski+ '92, De Donder+Vanbeveren'03, Eldridge+'04,'07,'08, Izzard+'04

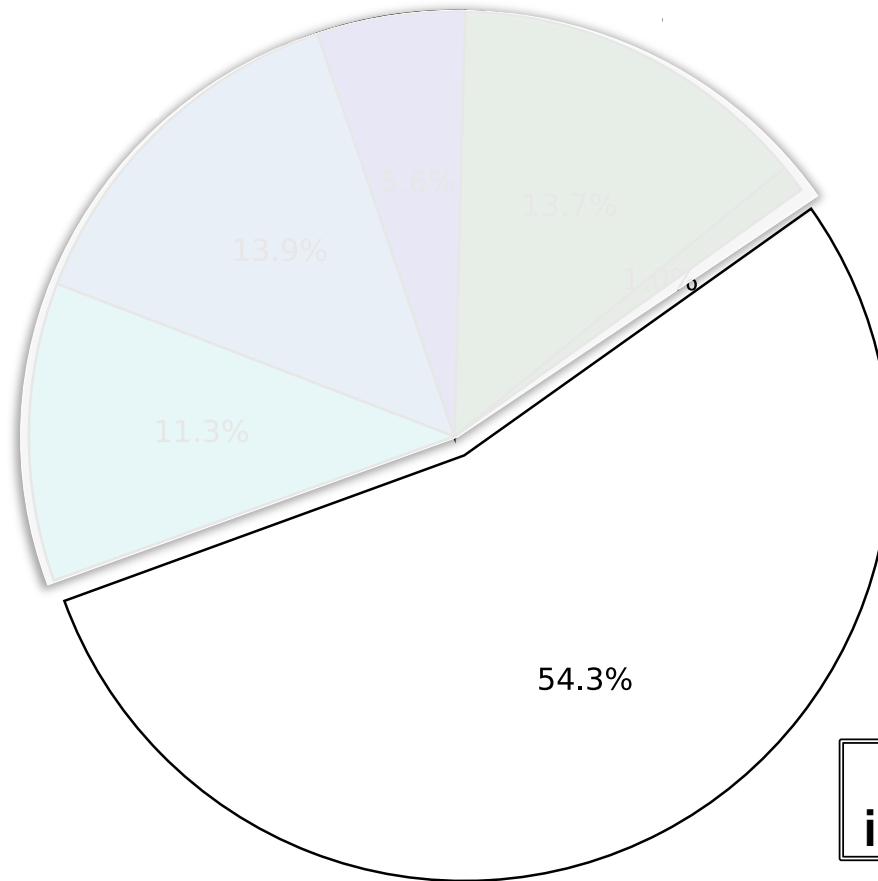
Types of supernovae



Progenitor evolution of SN type II

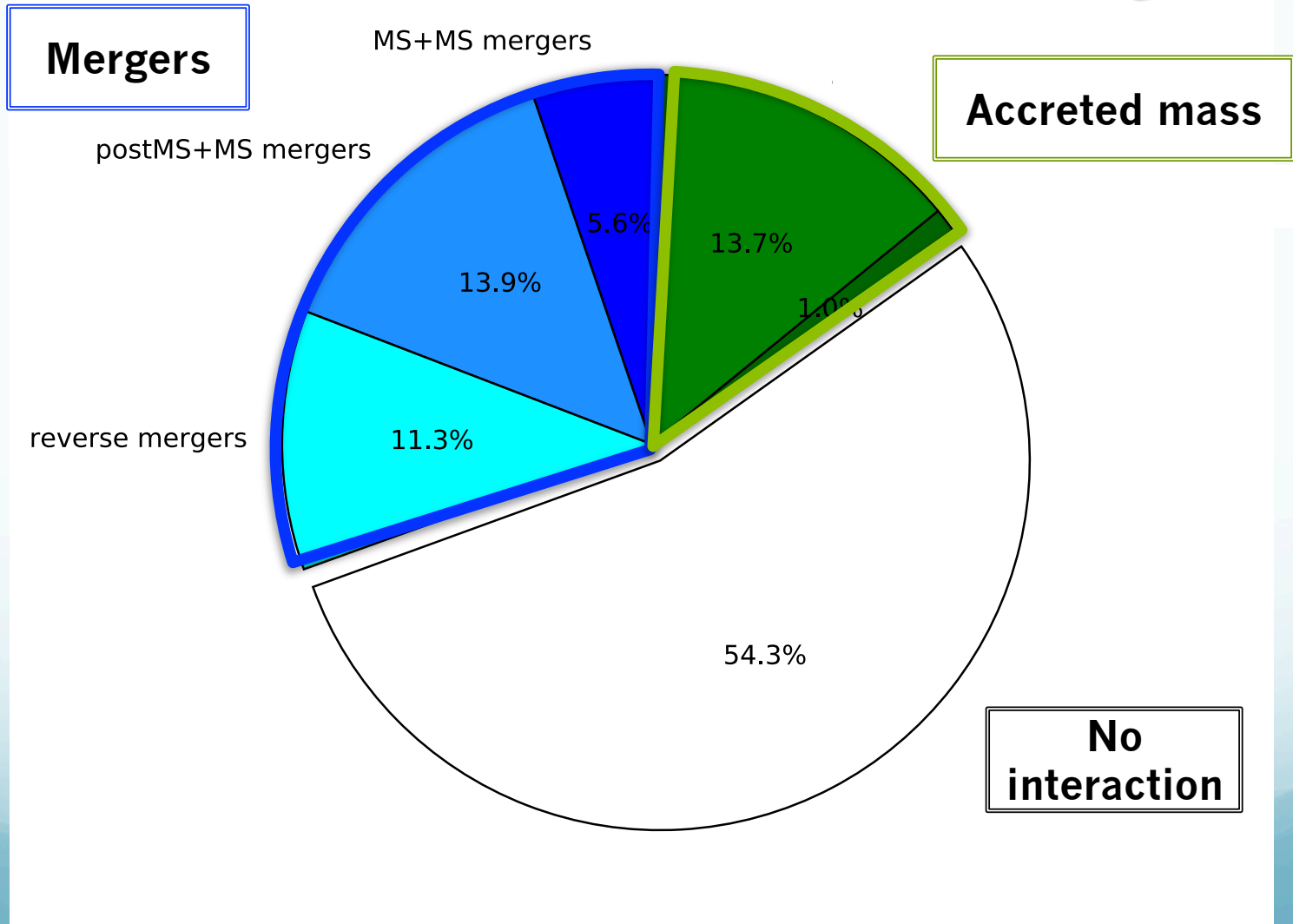


Progenitor evolution of SN type II



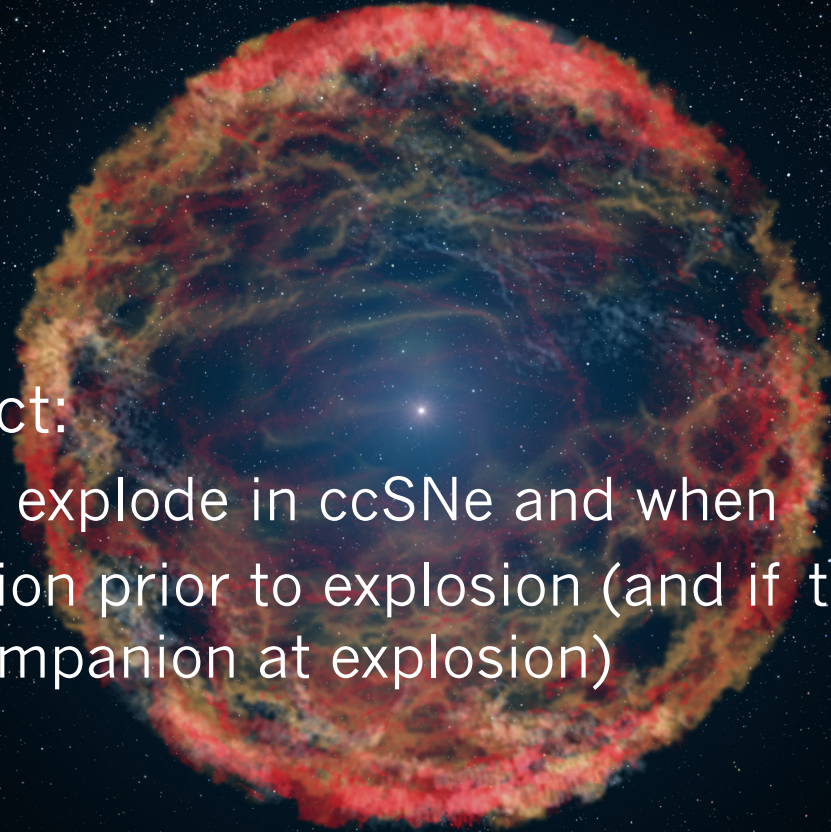
**No
interaction**

Progenitor evolution of SN type II

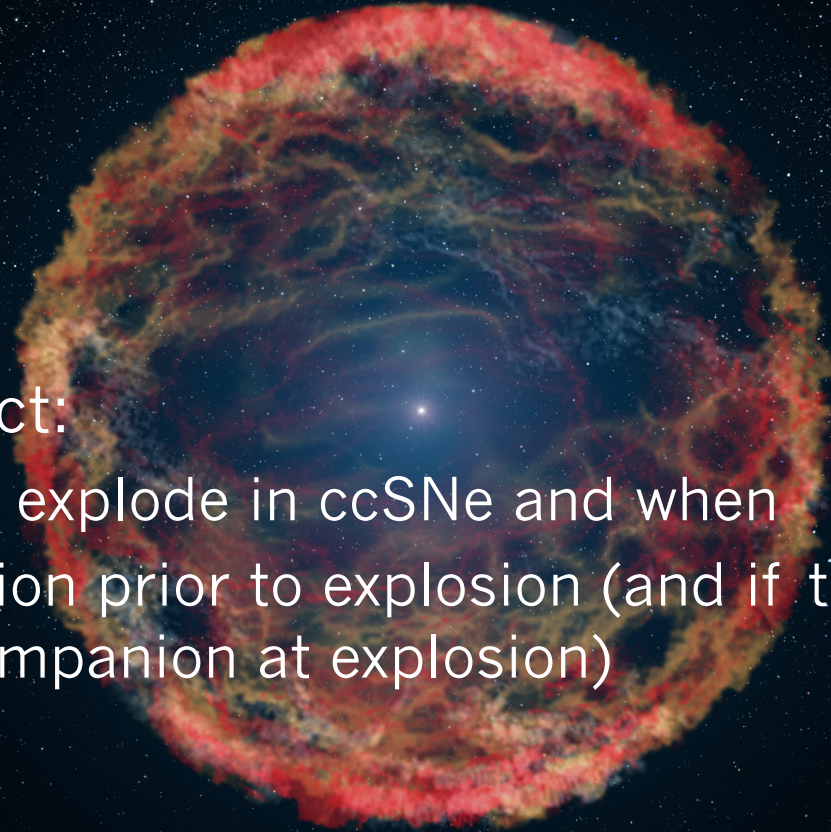


Take home message

- Binaries affect:
 - which stars explode in ccSNe and when
 - their evolution prior to explosion (and if they have a possibly companion at explosion)



Take home message



- Binaries affect:
 - which stars explode in ccSNe and when
 - their evolution prior to explosion (and if they have a possibly companion at explosion)

Thank you!