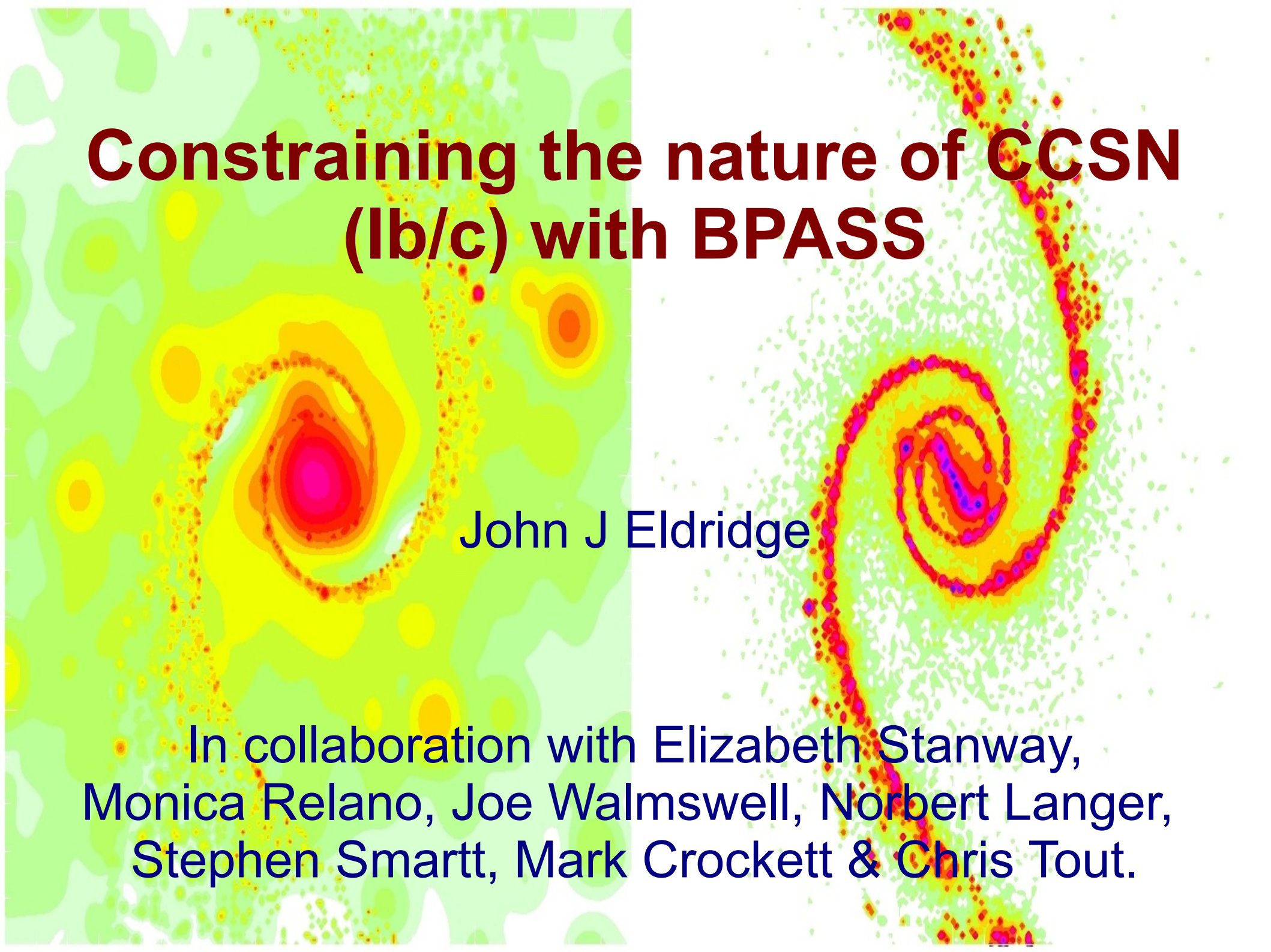


Constraining the nature of CCSN (Ib/c) with BPASS

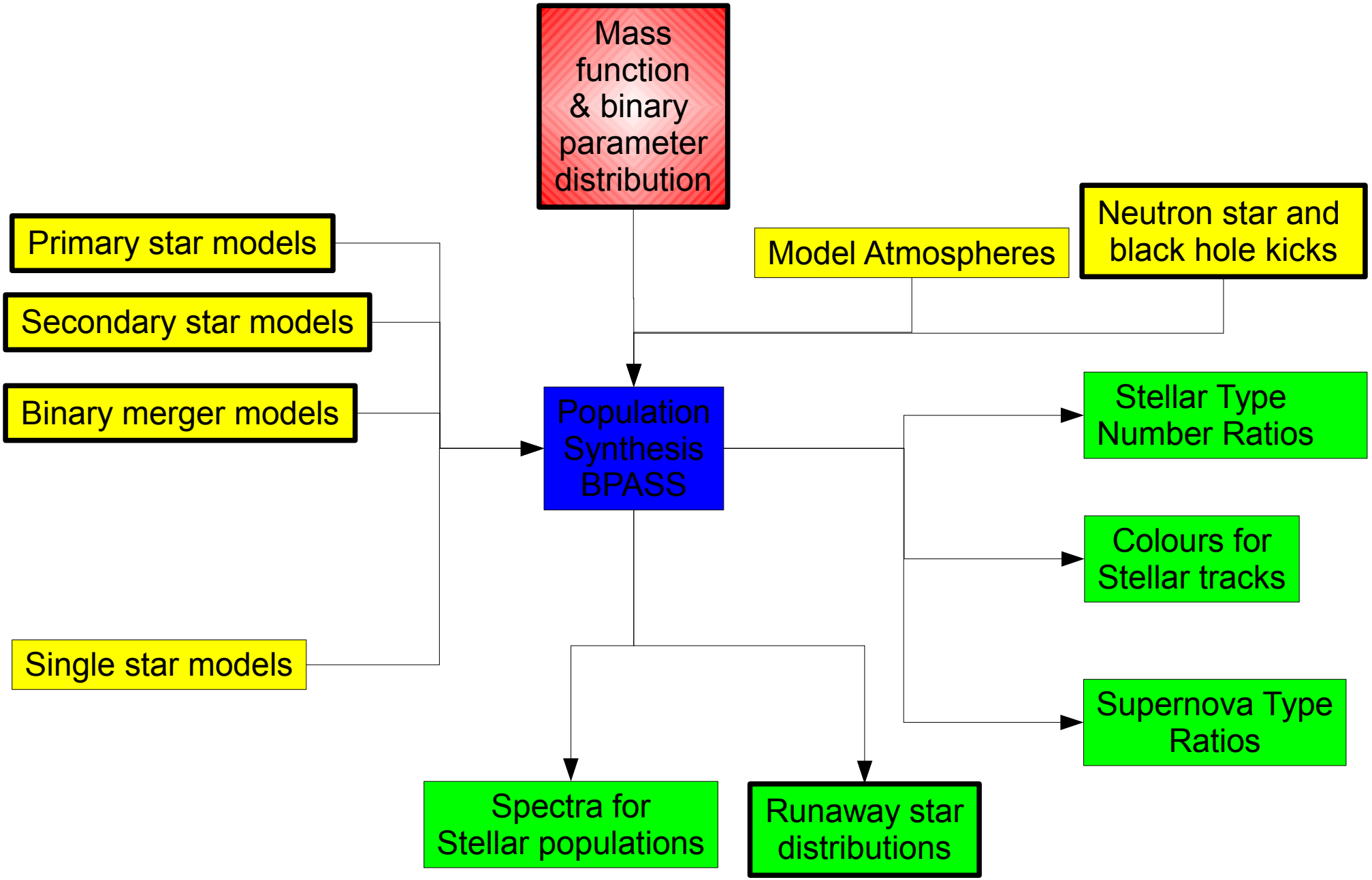
John J Eldridge

In collaboration with Elizabeth Stanway, Monica Relano, Joe Walmswell, Norbert Langer, Stephen Smartt, Mark Crockett & Chris Tout.

BPASS?

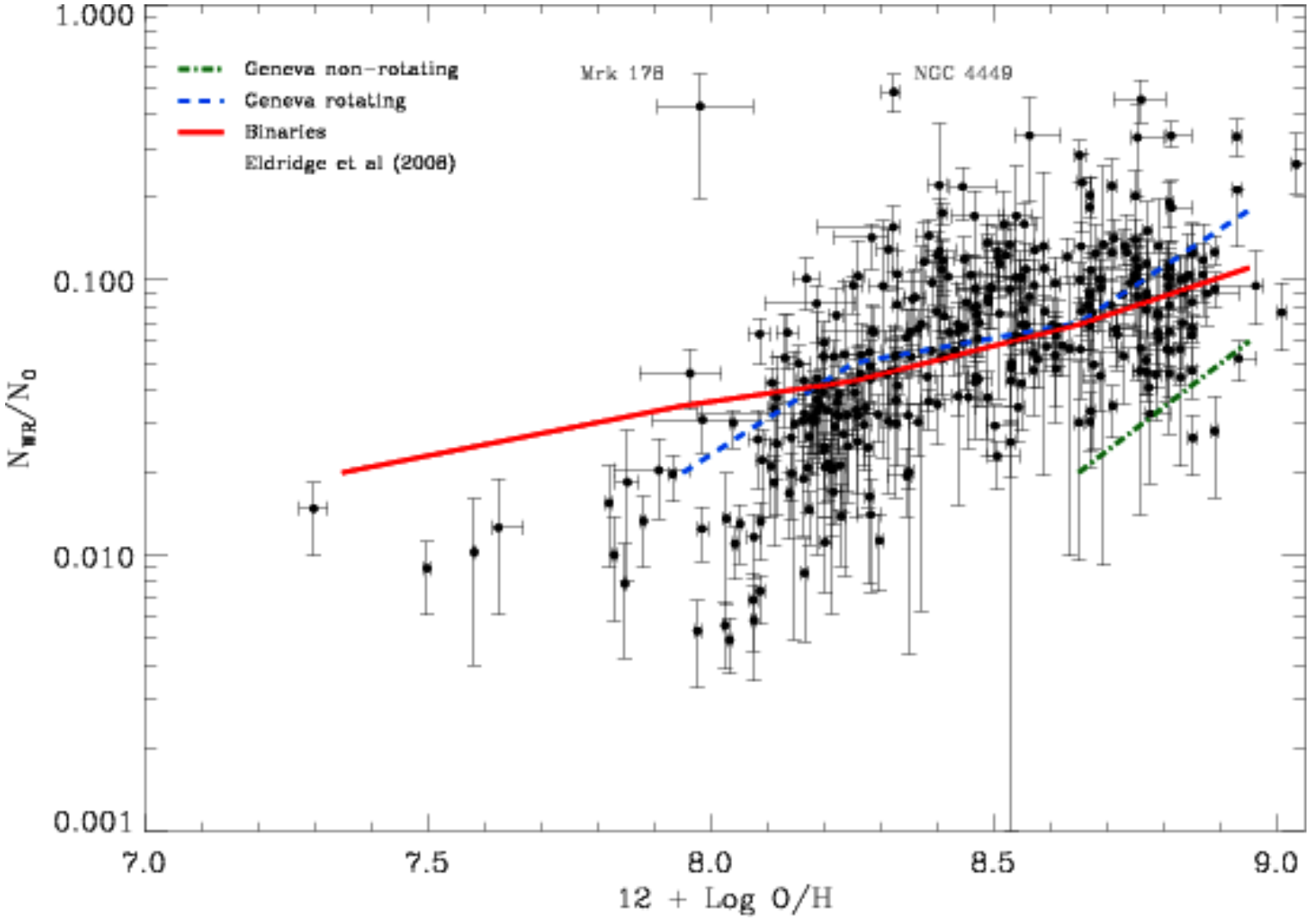
- **B**inary **P**opulation **a**nd **S**pectral **S**ynthesis
- Why unique?
- 15,000 detailed stellar evolution models.
- *Almost* all theoretical inputs.
- Use of Cloudy (Ferland et al.) for nebular emission.
- Note: we use a flat mass ratio distribution and flat in log separation distribution for binary parameters.
- Our motto? “If you need a number and no one else can help, maybe you can ask the BPASS-team.”

BPASS


Mass function & binary parameter distribution
Primary star models
Secondary star models
Binary merger models
Single star models
Model Atmospheres
Neutron star and black hole kicks
Population Synthesis BPASS
Stellar Type Number Ratios
Colours for Stellar tracks
Supernova Type Ratios
Spectra for Stellar populations
Runaway star distributions

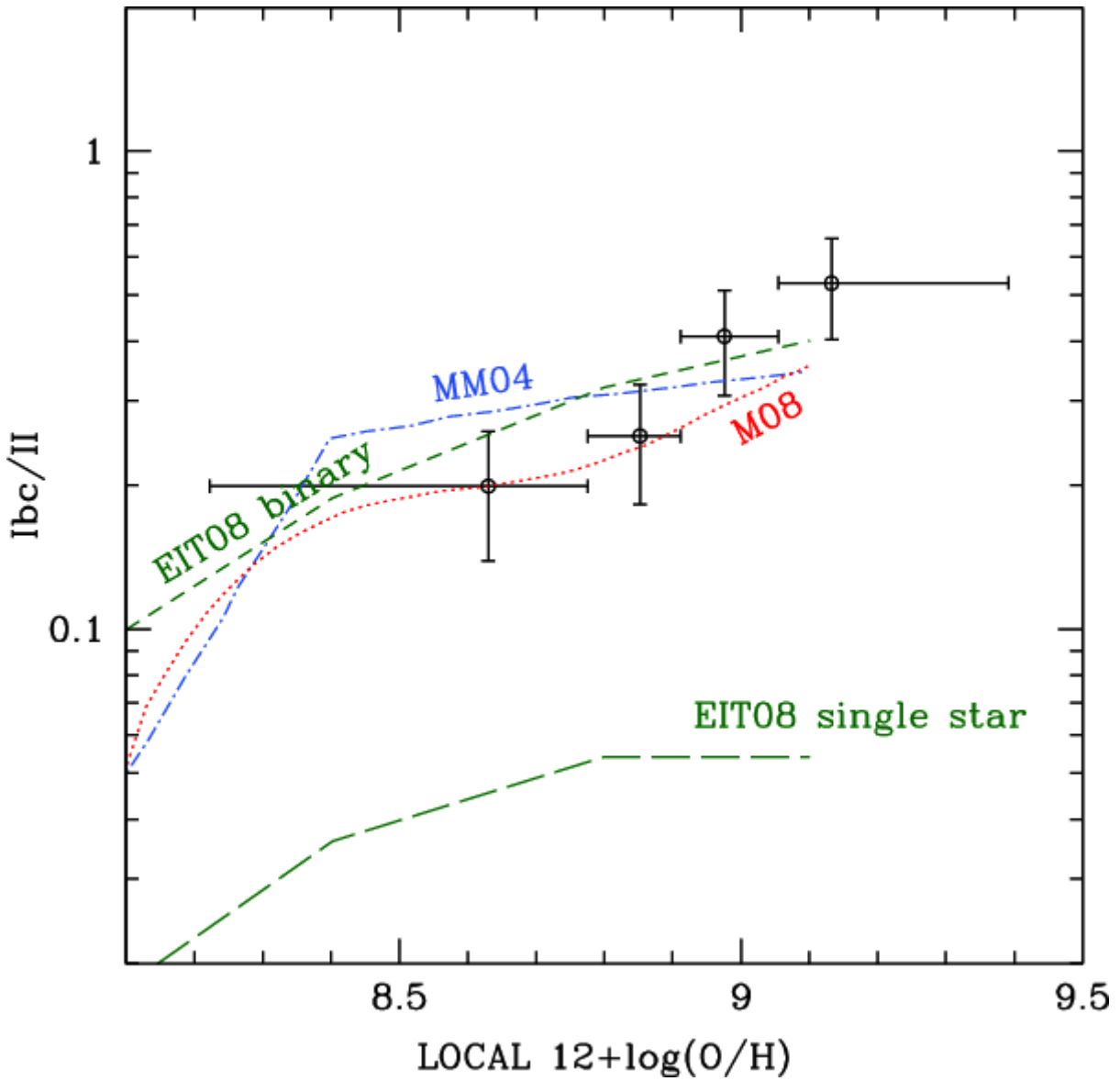
For more details:

- Eldridge, Izzard & Tout (2008) – BSG/RSG, WR/O, RSG/WR?, WC/WN, N(Ib/c)/N(II).
- Eldridge & Stanway (2009) – Colours of massive clusters, He(II) UV, Blue & Red WR bumps and spectra of H(II) regions.
- Coming soon, runaway stars, resolved/unresolved stellar populations, more on supernova progenitors and rotation in binaries....
- And don't take my word for it....



Brinchmann et al. (2008)

Note: both rotation and binaries are important.



Boissier & Prantzos (2009)

Note: both rotation and binaries are important.

Direct (non) detections?

Predicted WR magnitude distribution

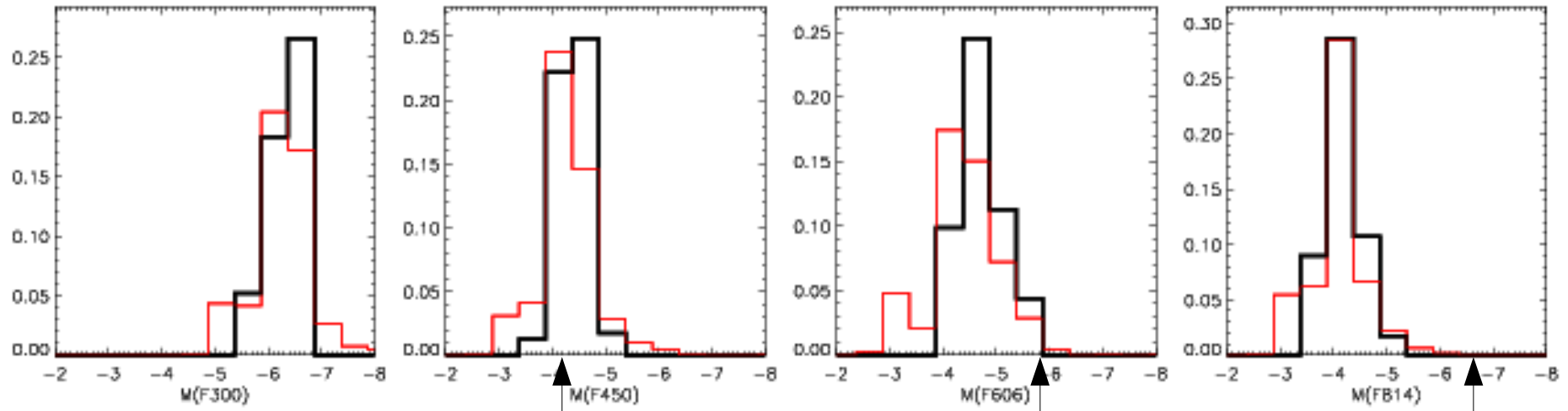


Figure 2. Predicted HST magnitude distribution for synthetic progenitor populations, Single stars - black, binaries -red

2002ap

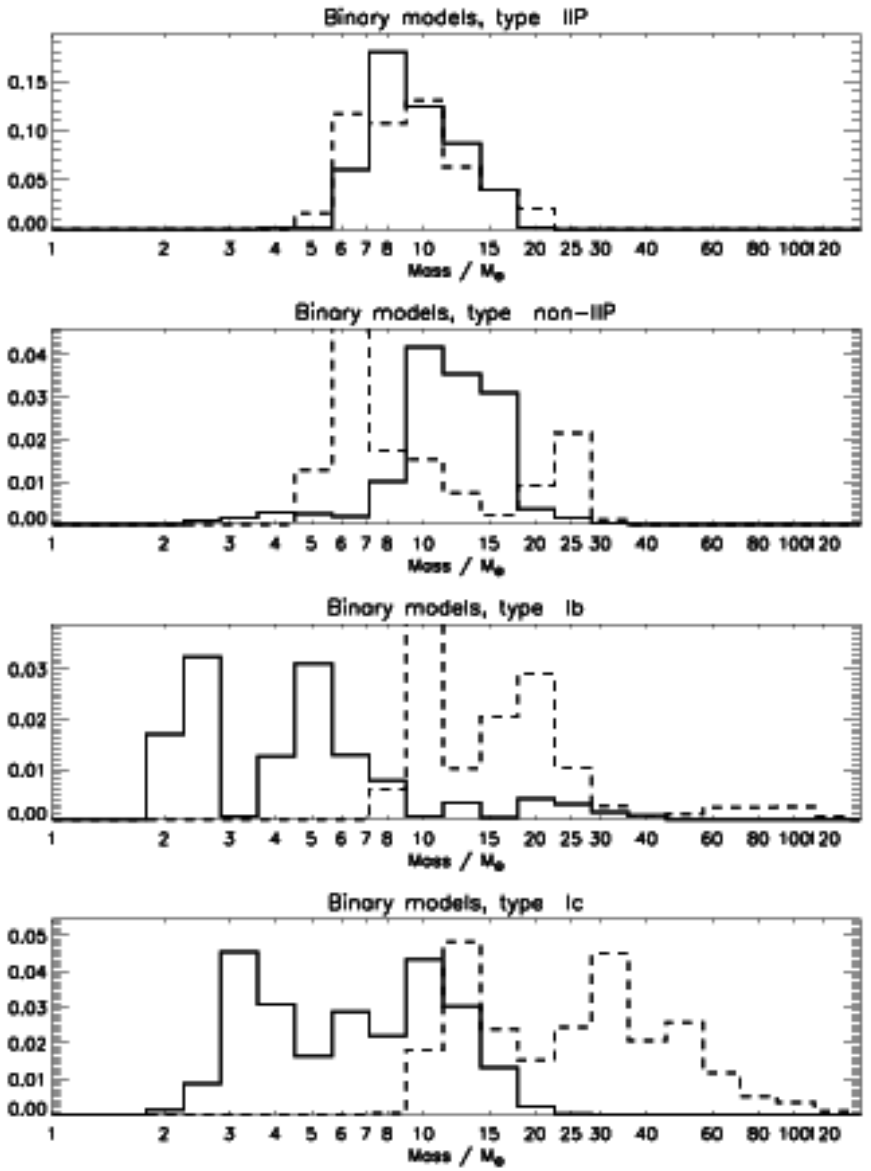
2004gt

2000ds

Non-detection limits from Mark Crockett's thesis
Eldridge, Crockett, Maund & Smart (in prep)

Relative Rates?

Z	IIP	non-IIP	Ib	Ic
Single				
0.008	0.761	0.095	0.064	0.081
0.020	0.742	0.096	0.017	0.145
0.040	0.609	0.209	0.010	0.172
Mix				
0.008	0.584	0.120	0.134	0.162
0.020	0.593	0.119	0.057	0.231
0.040	0.444	0.240	0.024	0.293
Binaries				
0.008	0.488	0.134	0.173	0.206
0.020	0.505	0.133	0.080	0.282
0.040	0.348	0.257	0.031	0.363
0.008 & 0.020	0.588	0.120	0.097	0.195
Smartt et al.	0.587	0.120	0.098	0.195

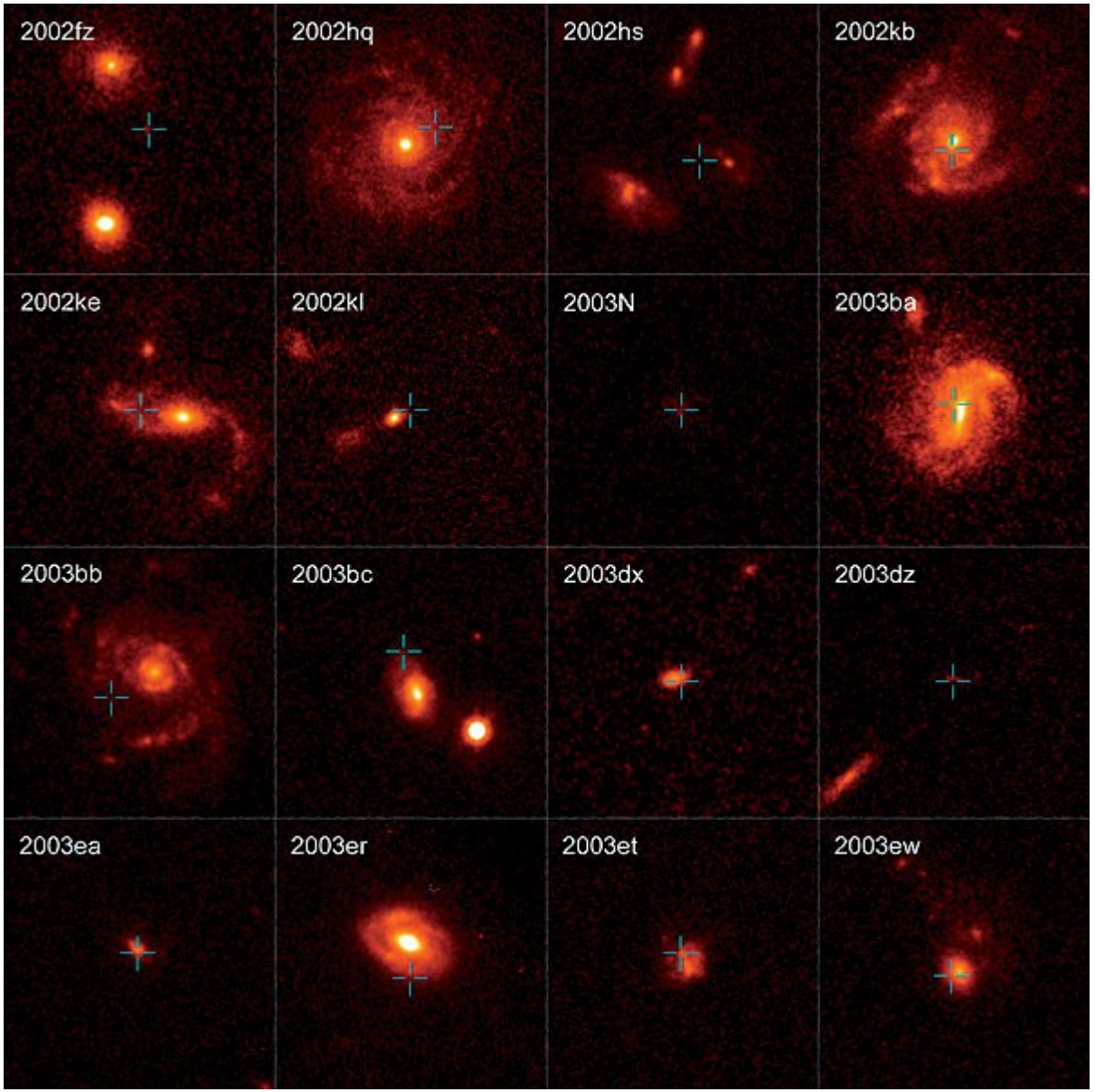


Eldridge, Crockett, Maund & Smartt (in prep) or Eldridge, Langer & Tout (in prep)
Note: approx 30% of stripped SNe come from binaries, if massive WR stars produce no SNe display then need more binaries.

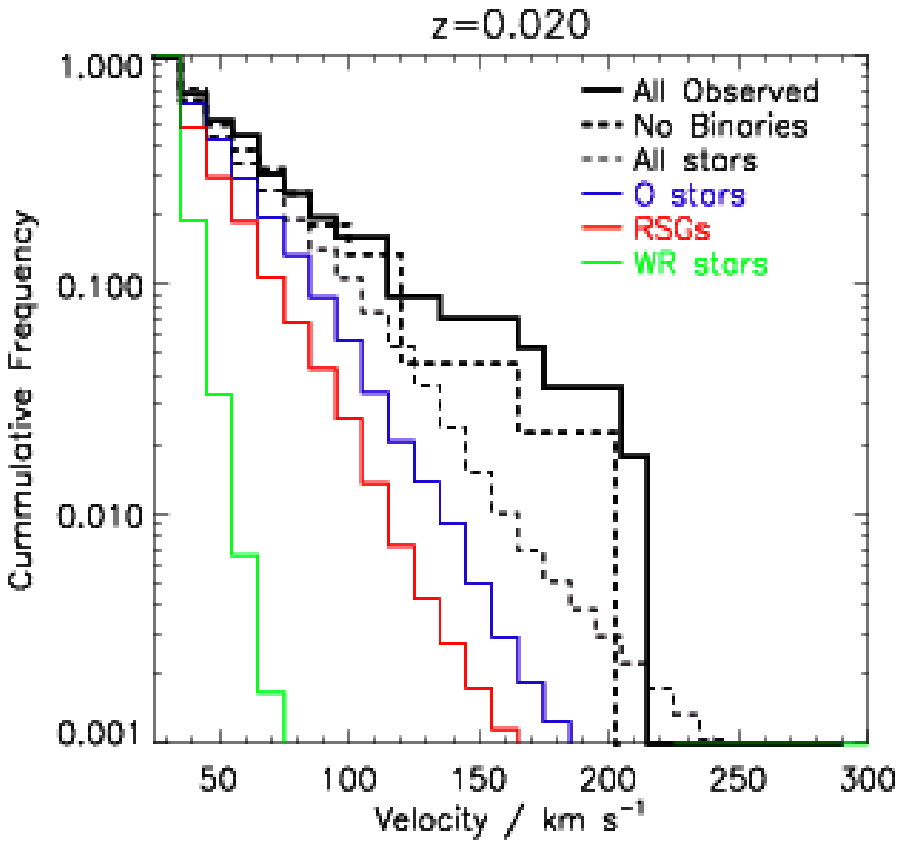
What about where a supernova goes off?

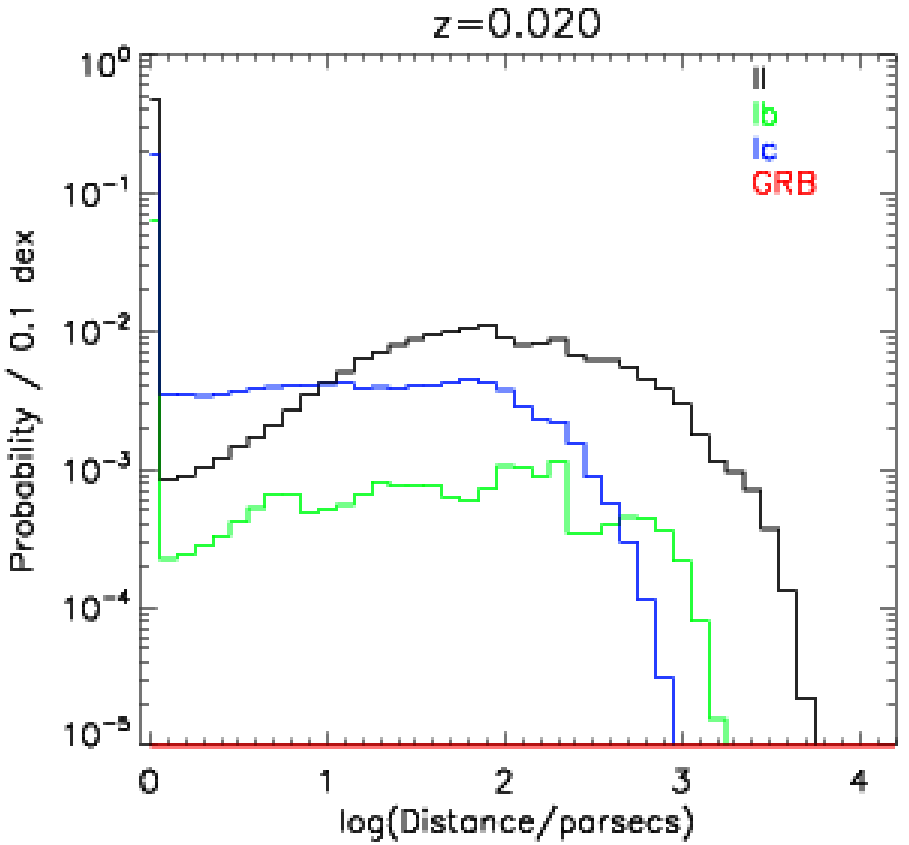
Observed supernova locations

Fruchter et al. (2006)



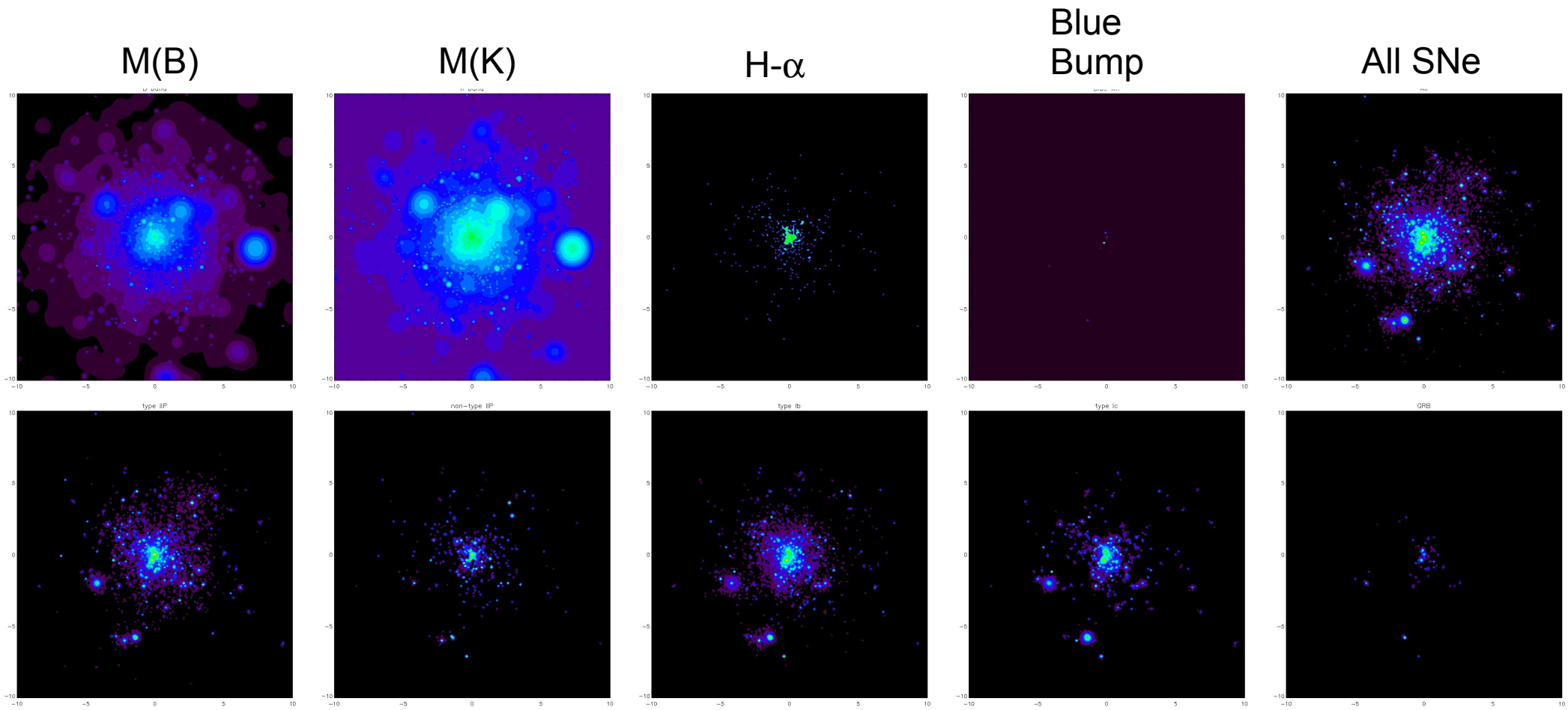
Runaways as Supernova Progenitors





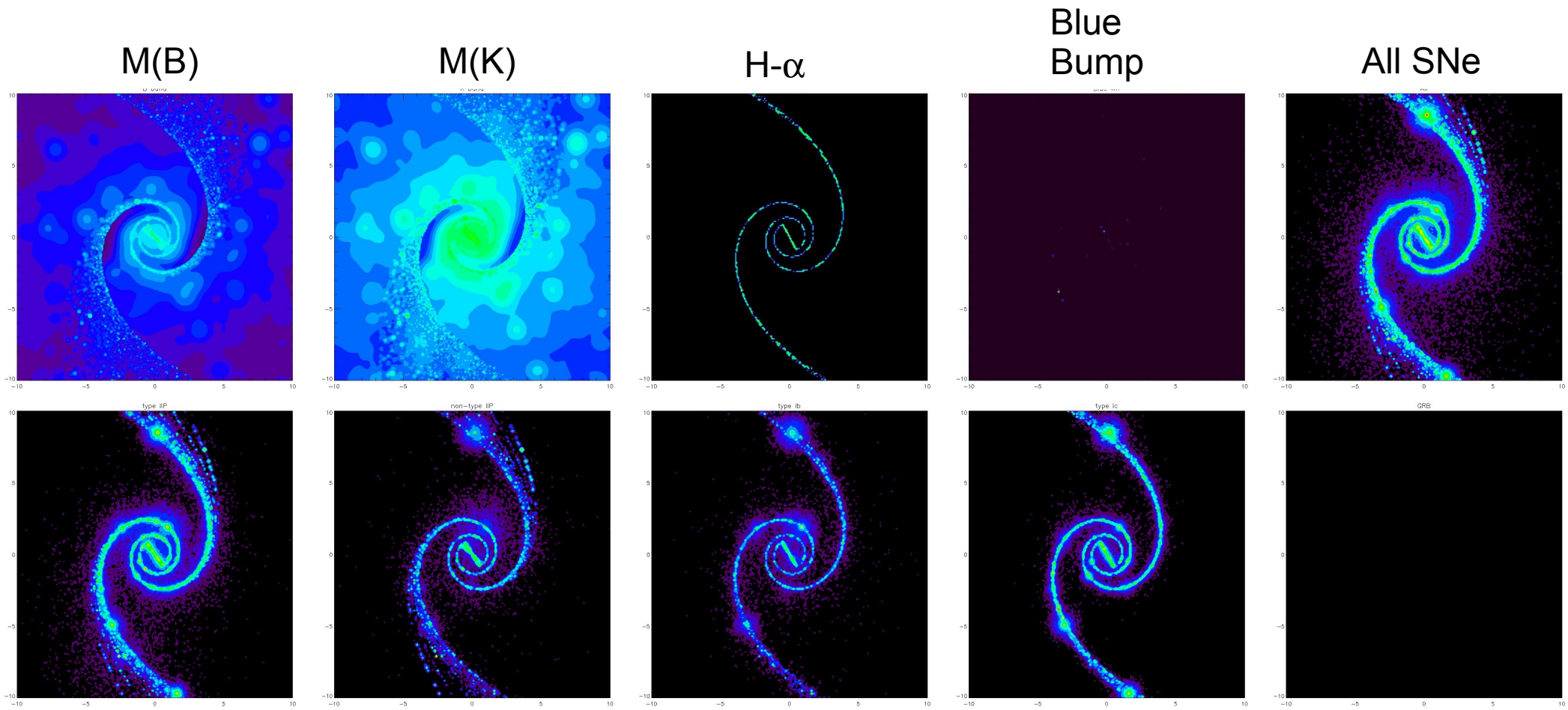
Eldridge, Langer & Tout (in prep)

Model dwarf galaxy



Eldridge (in prep)

Model spiral galaxy



Eldridge (in prep)

Supernova and Hα flux

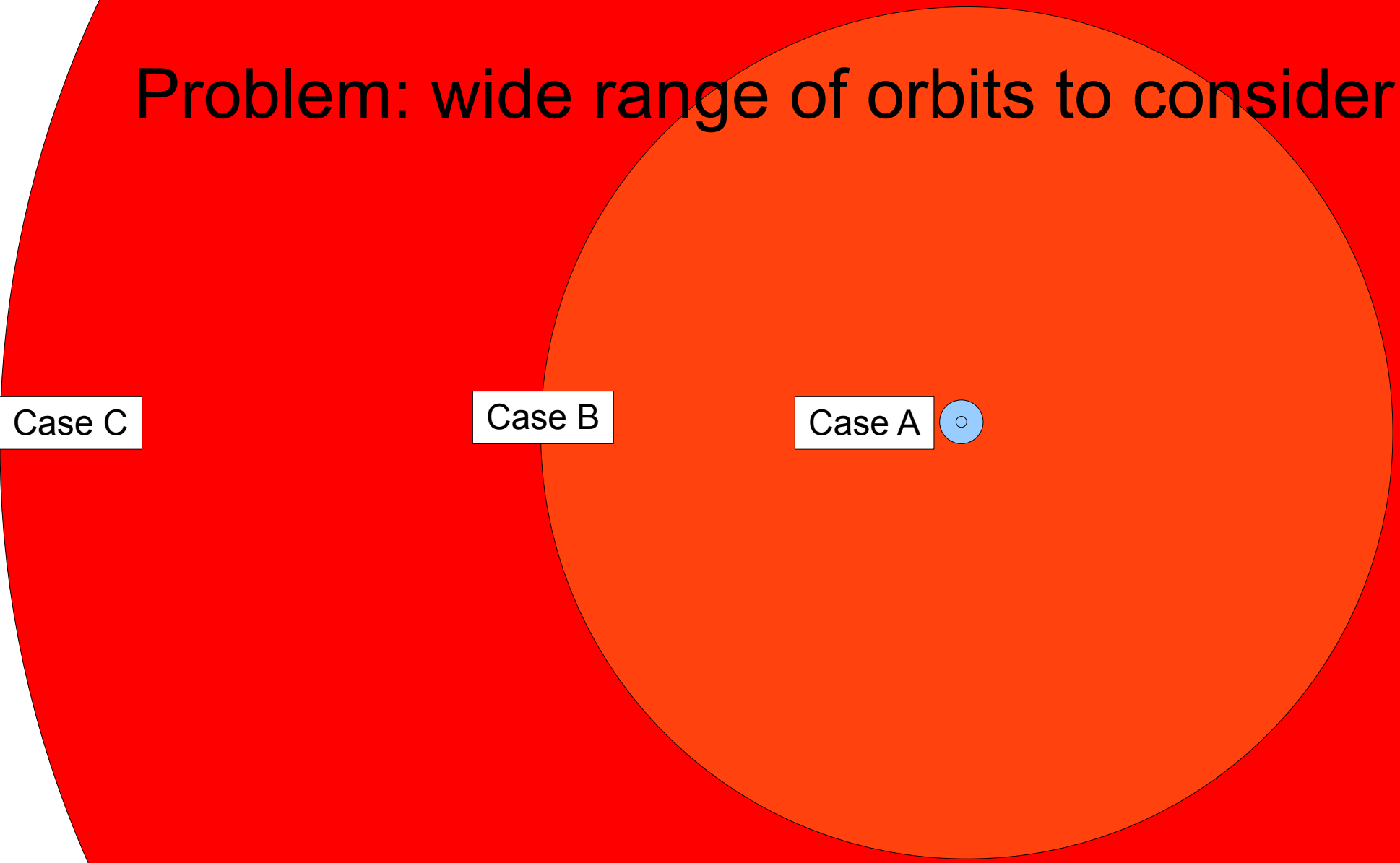
	IIP	II-o	Ib	Ic	GRB
BPASS	0.36	0.48	0.56	0.75	0.92
Observed	0.54	0.44	0.62	0.74	

Data from James & Anderson (2006)

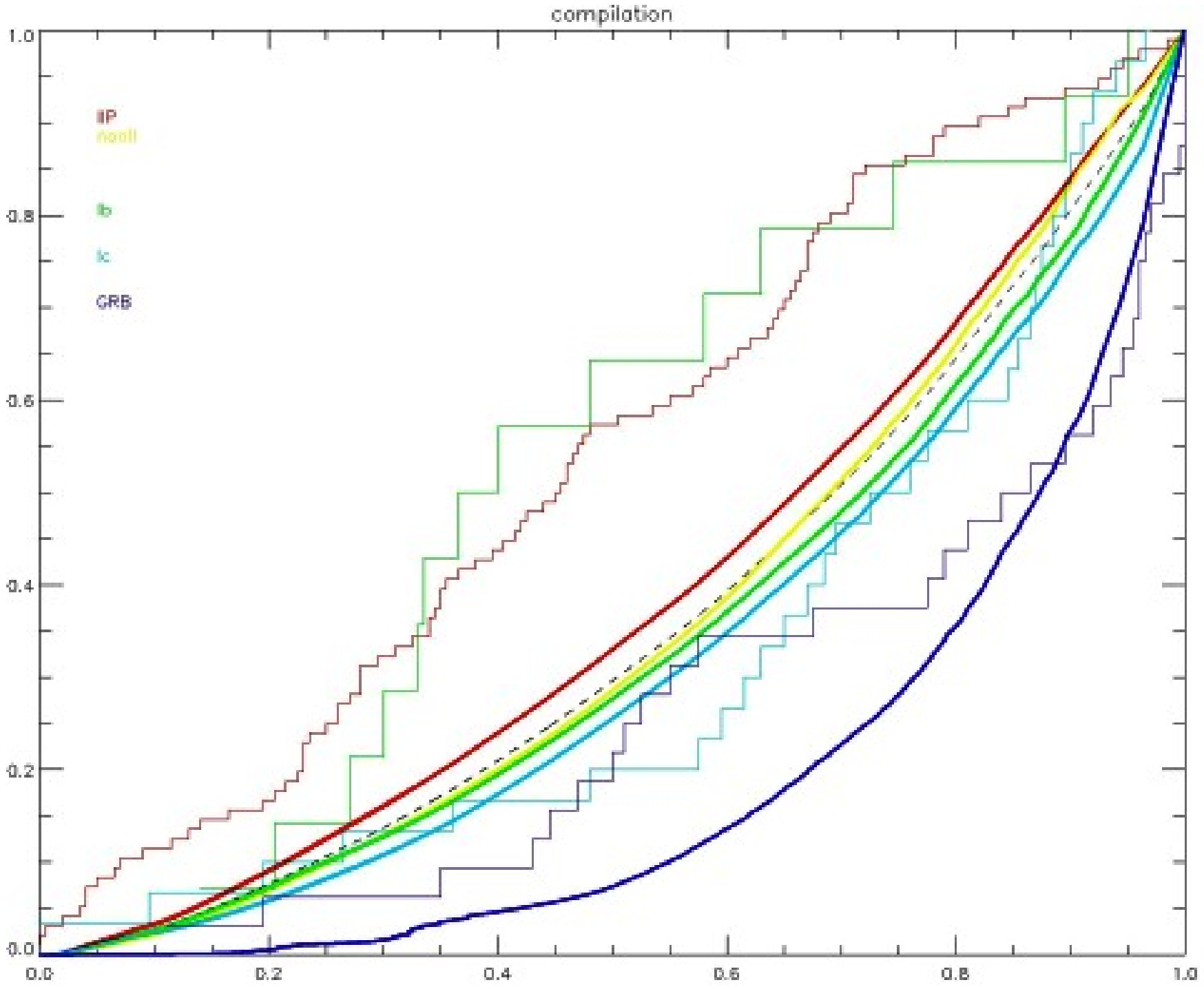
Summary

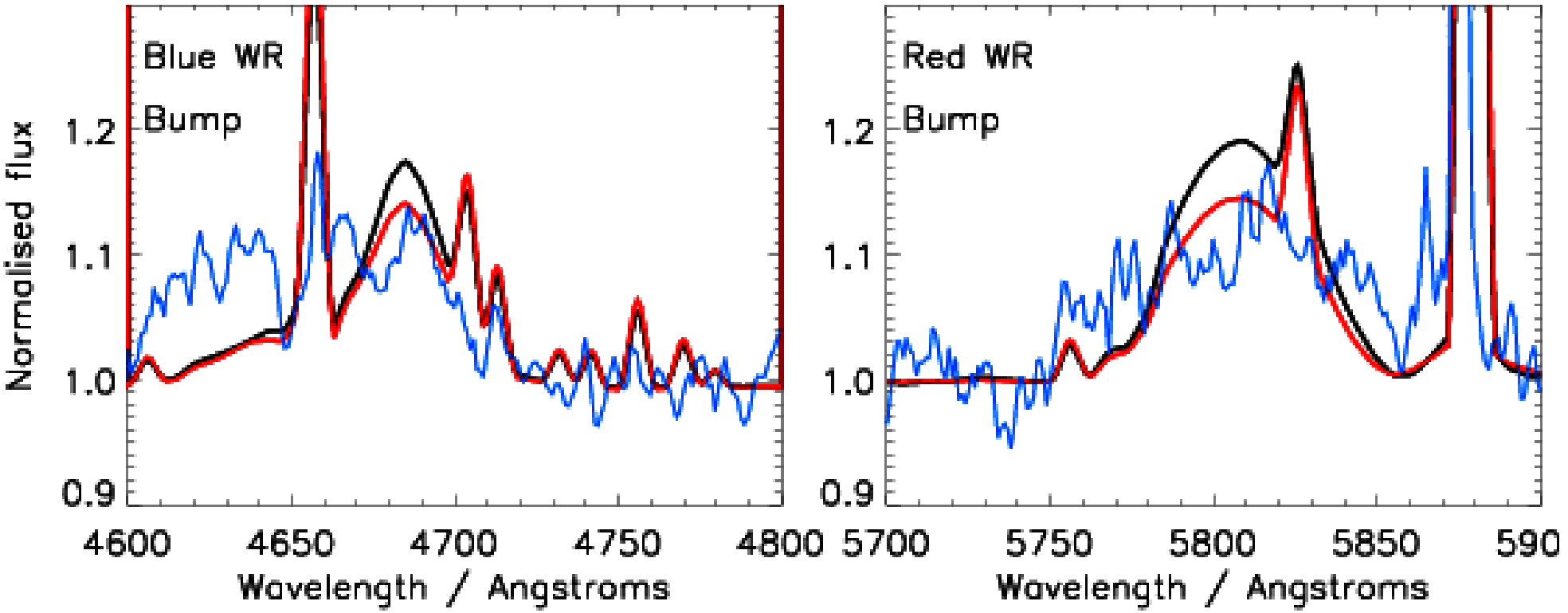
- Populations including binaries and/or rotation problematic due to diversity of possible evolution!
- Binaries are vital to consider when modelling a number of observables.
- Work in progress, this is only a first attempt, new improved models including rotation are planned.
- If you want a number/ spectrum email: jje@ast.cam.ac.uk
- But I know people are always shy to ask so data release is coming soon to **bpass.org.uk**

Problem: wide range of orbits to consider



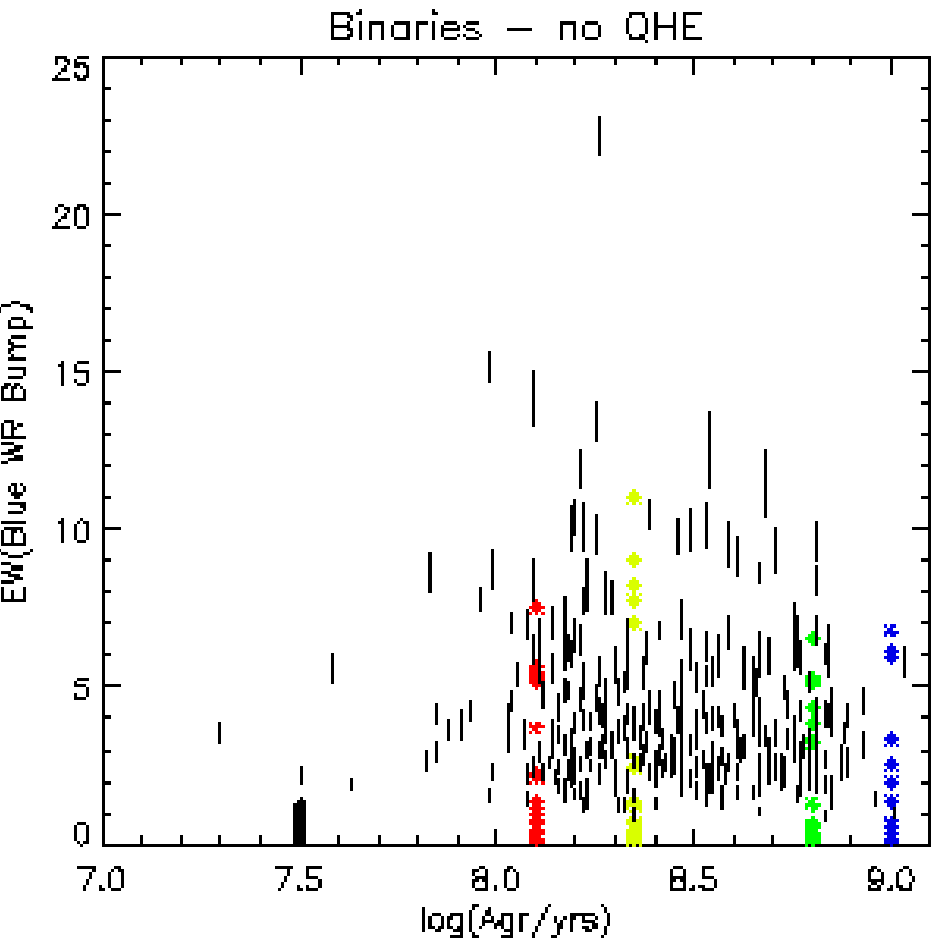
It's not just an effect to switch on/off, need to consider a wide range of possible initial separations & mass ratios, any difference evolutionary paths are possible.
Note – rotation is also the same as needs a range of rotation periods.

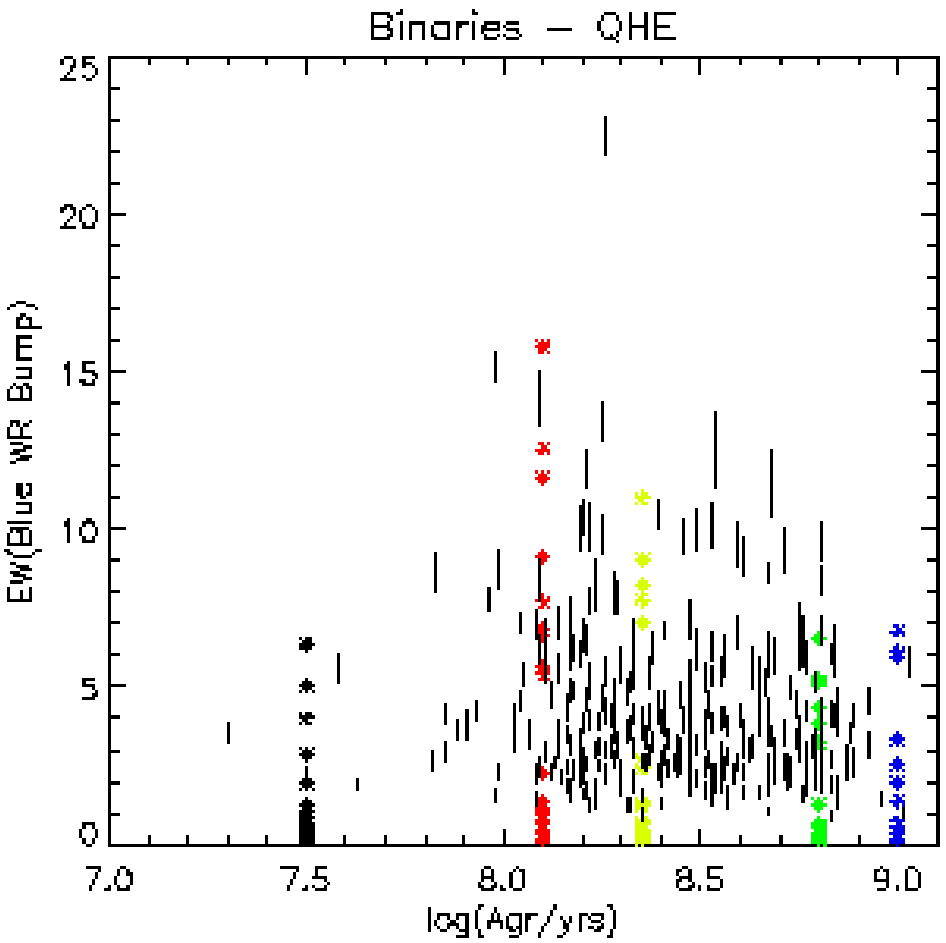

compilation
IP
nonII
Ib
Ic
GRB
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0



Single star population
Binary population
Observations of TolAB

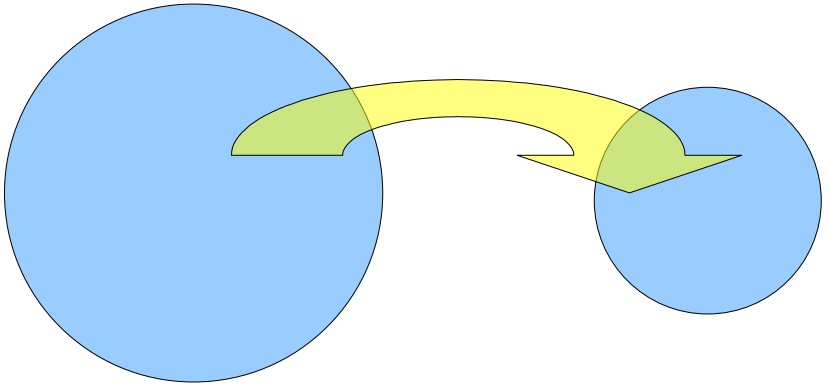
What can a galaxy spectrum tell us?


Binaries – no QHE
EW(Blue WR Bump)
log(Agr/yrs)
0
5
10
15
20
25
7.0
7.5
8.0
8.5
9.0

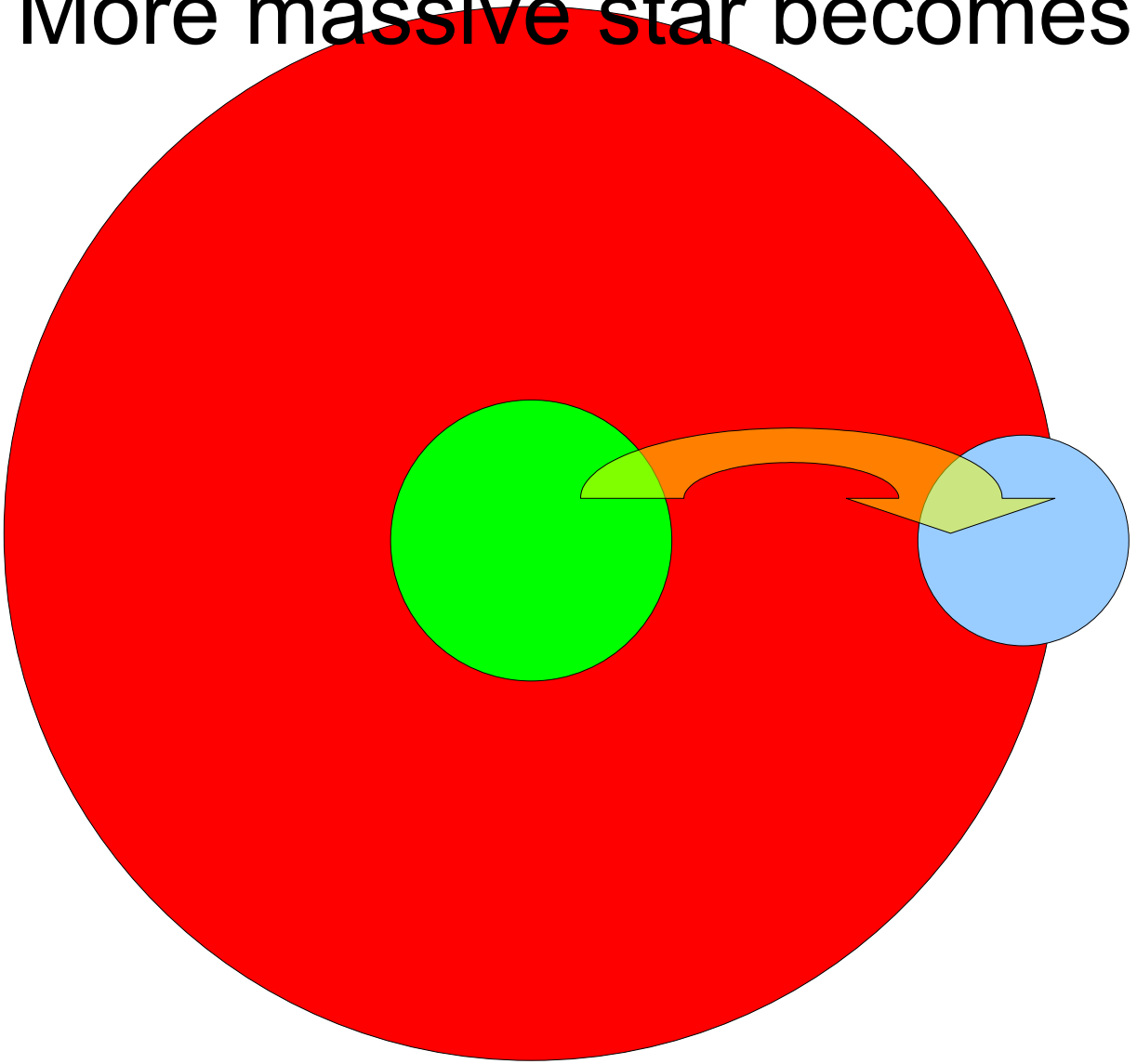

Binaries – QHE
EW(Blue WR Bump)
log(Agr/yrs)
0
5
10
15
20
25
7.0
7.5
8.0
8.5
9.0

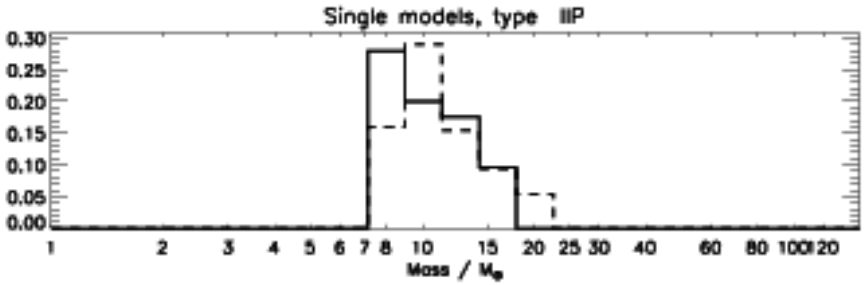
What's so important about binaries?

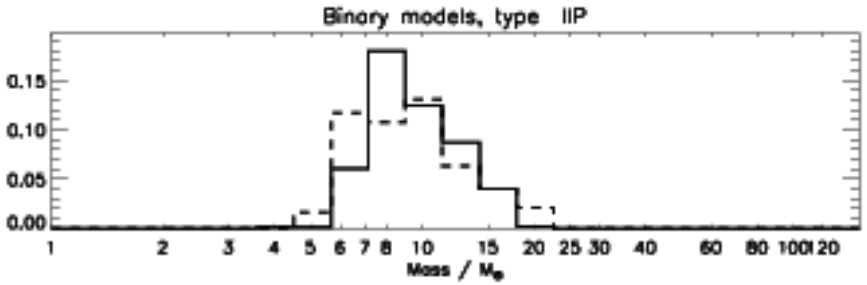
Consider two stars in a binary...

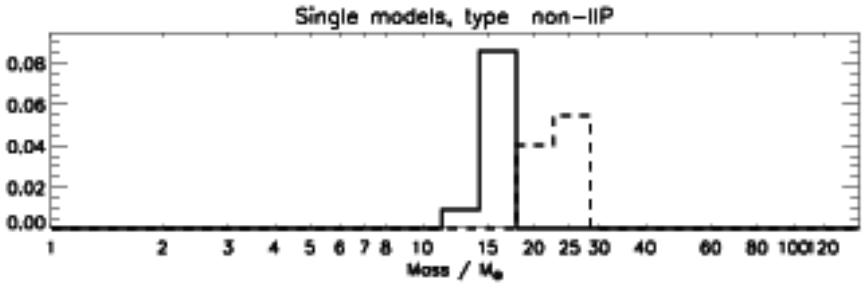


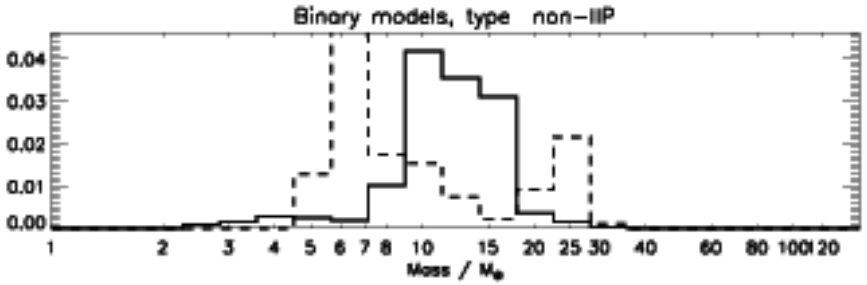
More massive star becomes a RSG

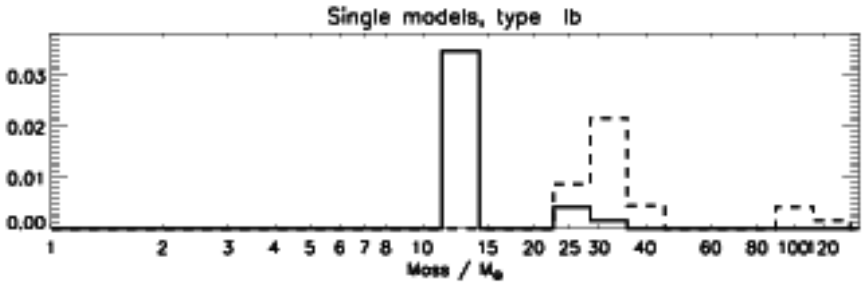


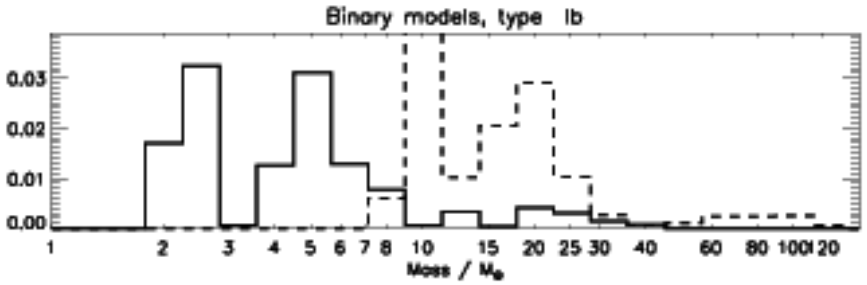

Single models, type IIP
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙

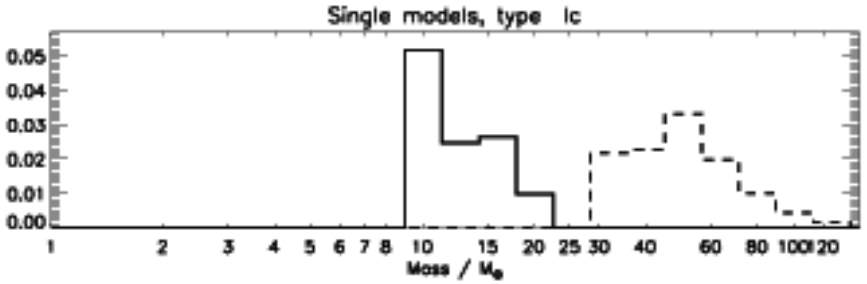

Binary models, type IIP
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙

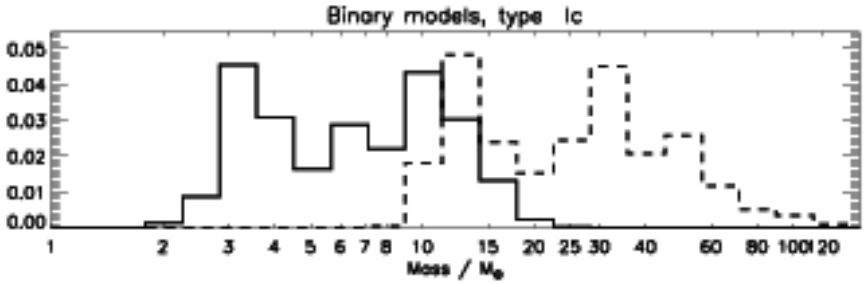

Single models, type non−IIP
0.08
0.06
0.04
0.02
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙


Binary models, type non−IIP
0.04
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙

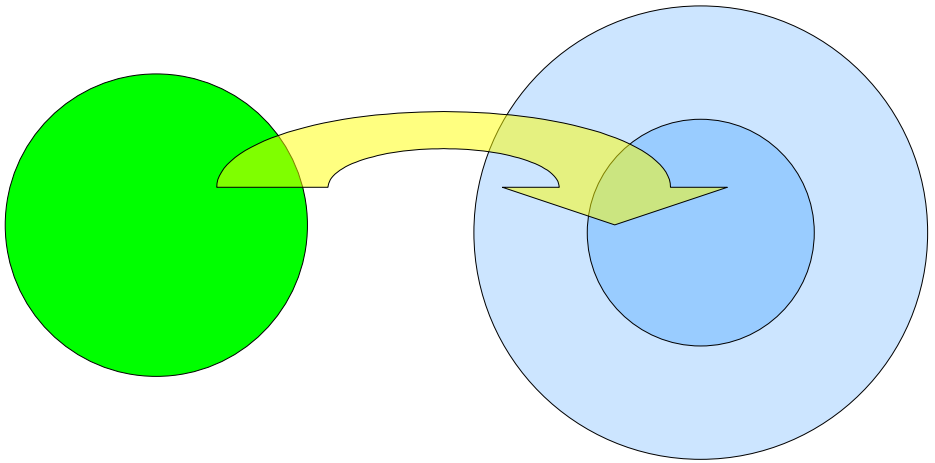

Single models, type Ib
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙


Binary models, type Ib
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙

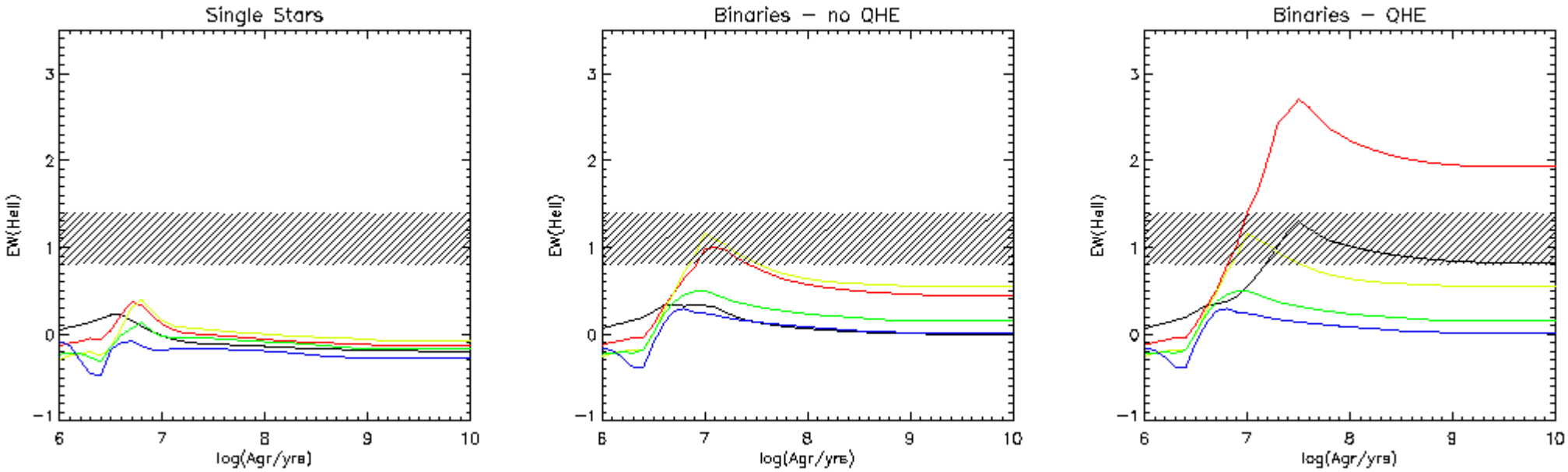

Single models, type Ic
0.05
0.04
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙


Binary models, type Ic
0.05
0.04
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 10 15 20 25 30 40 60 80 100 120
Mass / M⊙

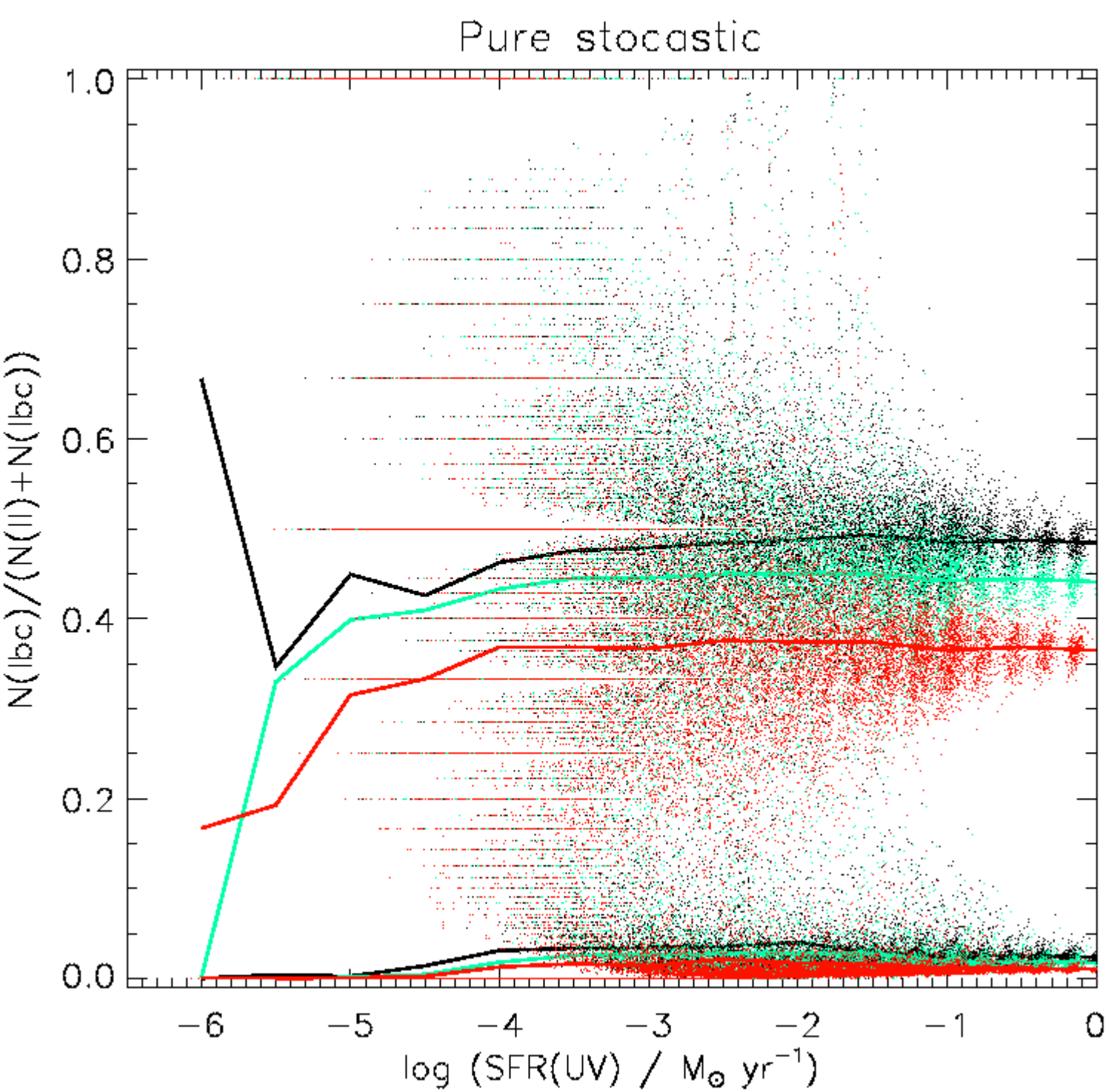
H-envelope lost! Also secondary ***may*** accrete some mass



Bottom line – more hot stars either from removal of hydrogen envelope or from Secondary stars accretting material and becoming more massive & luminous.



WR galaxies from SDSS DR6 Brinchmann et al. (2008)
Models from Eldridge & Stanway (2009)
“+” Single star Population & **“X”** Binary Population


Pure stocastic
1.0
0.8
0.6
0.4
0.2
0.0
N(Ibc)/(N(II)+N(Ibc))
−6
−5
−4
−3
−2
−1
0
log (SFR(UV) / M⊙ yr−1)