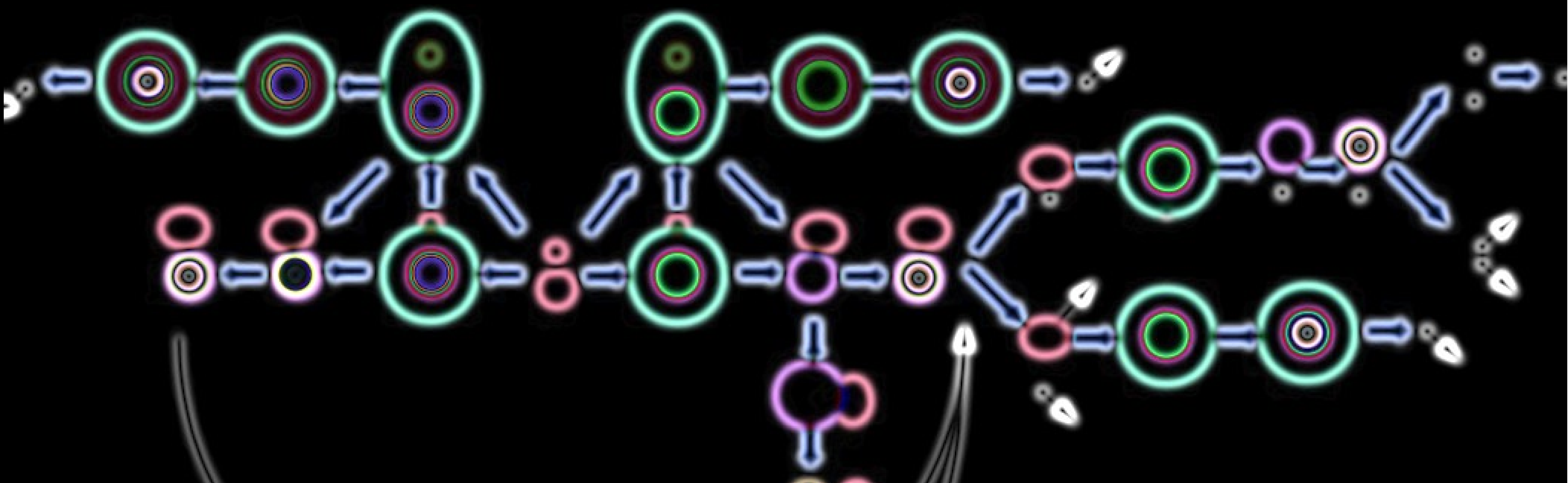
A double take on stellar population & spectral synthesis

JJ Eldridge

with Elizabeth Stanway & BPASS team



Motivation

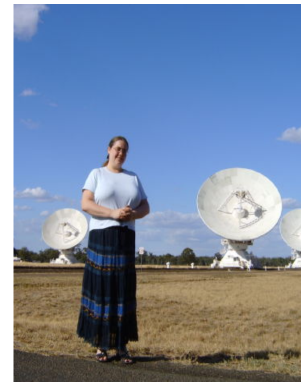
- Why are low mass galaxies interesting for stellar evolution ?
- Low metallicity – weaker winds, effects of rotation and binaries will become more important.
- Interest stellar objects found in low mass galaxies: long-GRBs, SLSNe, GW sources?, He(II) nebulae....
- What I hope to do today is highlight what binary stars do different to single stars, especially at lower metallcities.
- Questions: try socrative.com
  “student login”: ELDRIDGE8057

Outline

- BPASS team introductions.
- Reminder of stellar evolution and what is so different about binary evolution with supernova progenitors and resolved stellar populations.
- Implications of binary populations for ionizing radiation and BPT diagrams.
- **Required reading:** de Marco & Izzard (2017)

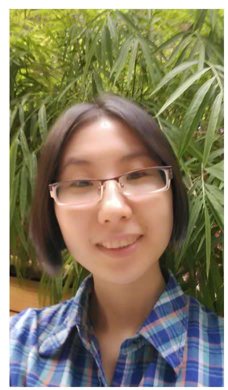
binary population & spectral synthesis

JJ Eldridge
Stellar models, population and spectral synthesis



Elizabeth Stanway
High-z, dust, IR, radio and unresolved population SED fitting
(University of Warwick)

Liam McClelland
Helium & Wolf-Rayet stars



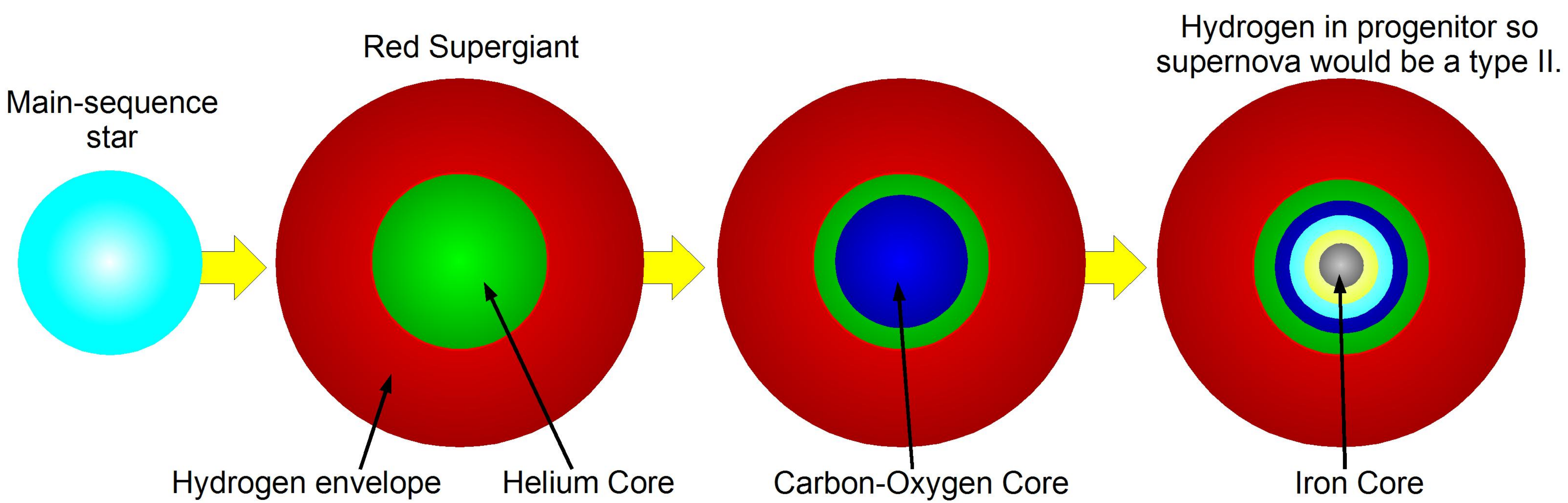
Lin Xiao
Spectral synthesis & supernovae

John Bray
Supernova kicks & binary population synthesis

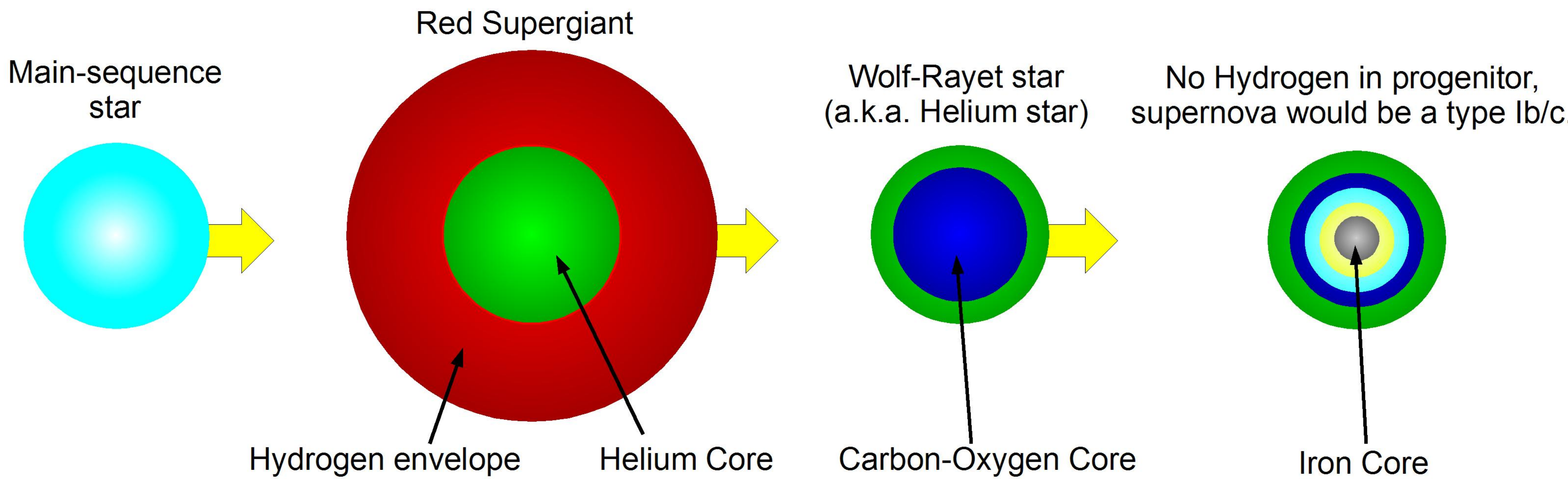
Undergrad Students: Georgie Taylor & Mason Ng

There are many past contributors to the physics and development of BPASS:
Aida Wofford, Monica Relano, Justyn Maund, Morgan Fraser,
Chris Tout, Stephen Smartt, Norbert Langer, Robert Izzard

The Stellar Lifecycle

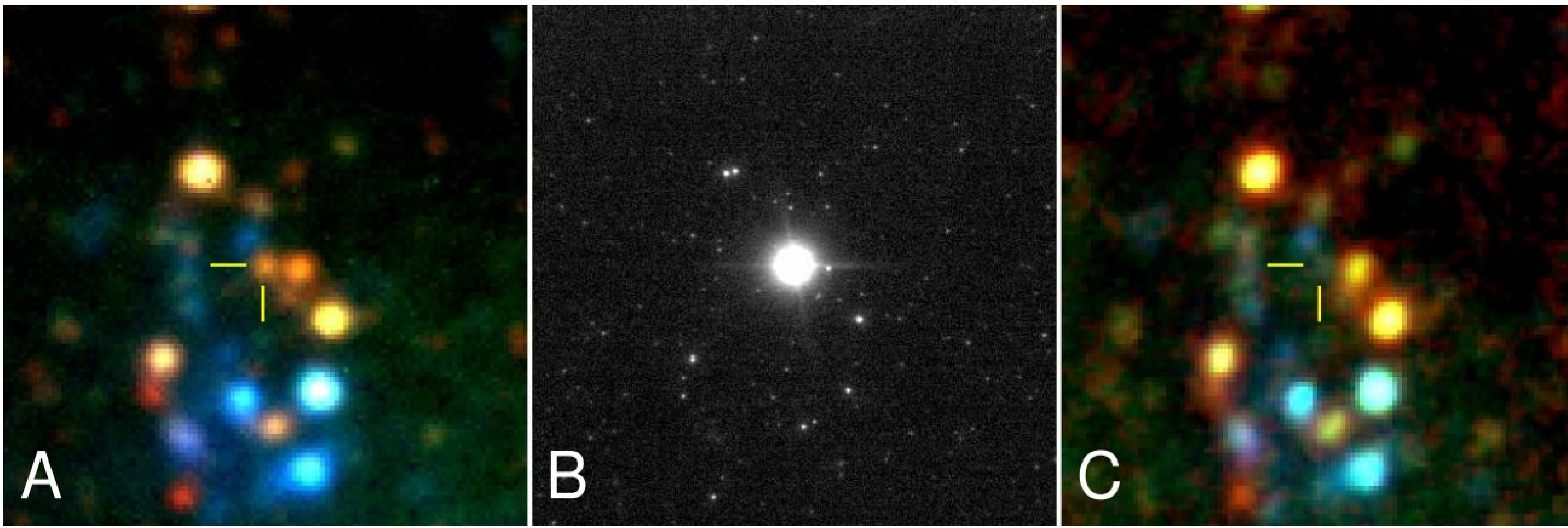


An Alternative Stellar Lifecycle



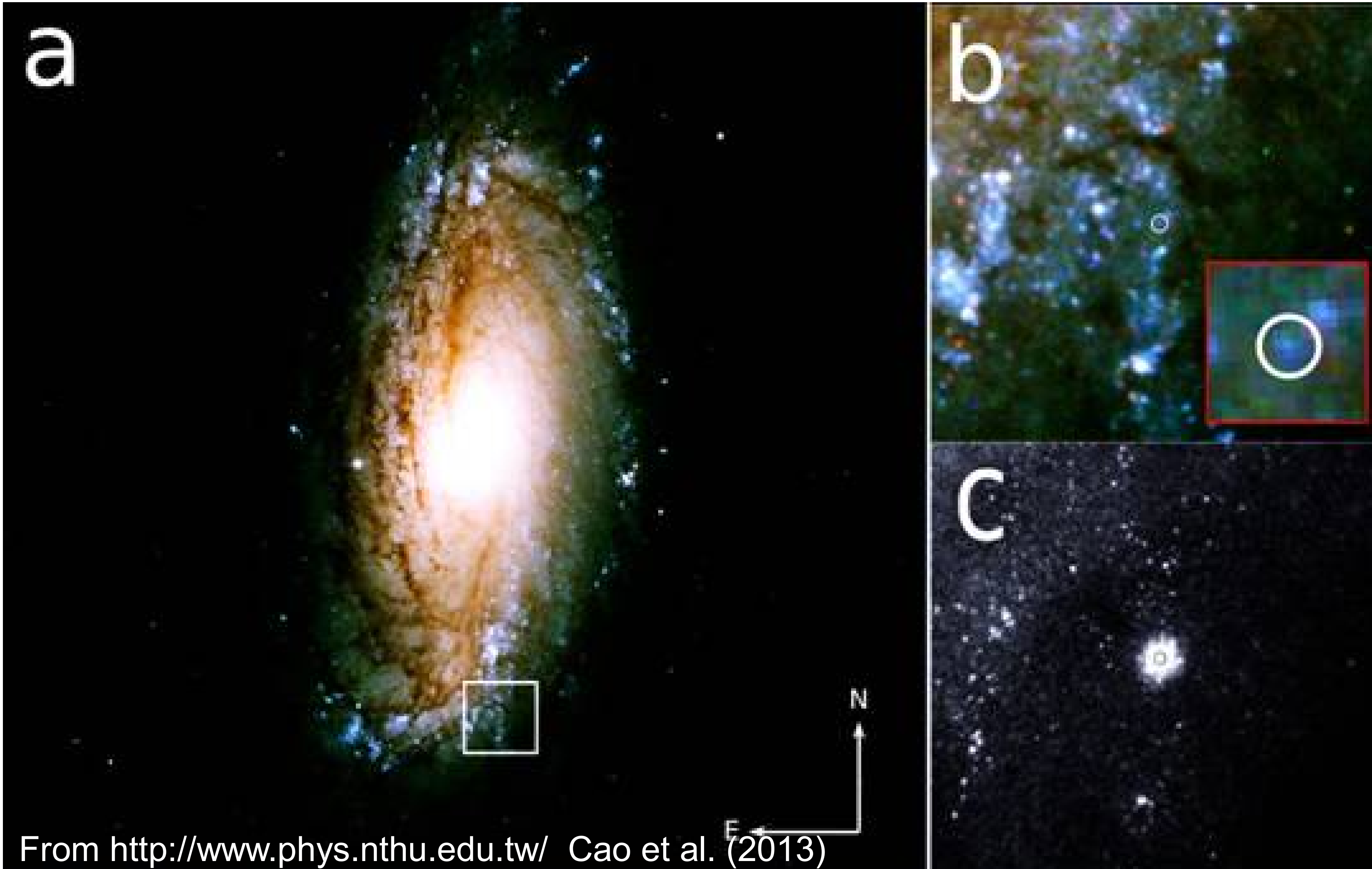
For stars more massive than 20 times the mass of the Sun
(Image not to scale).

Type IIP SN 2008bk



See Smartt (2015) for review.
Image from: Mattila et al. (2008)

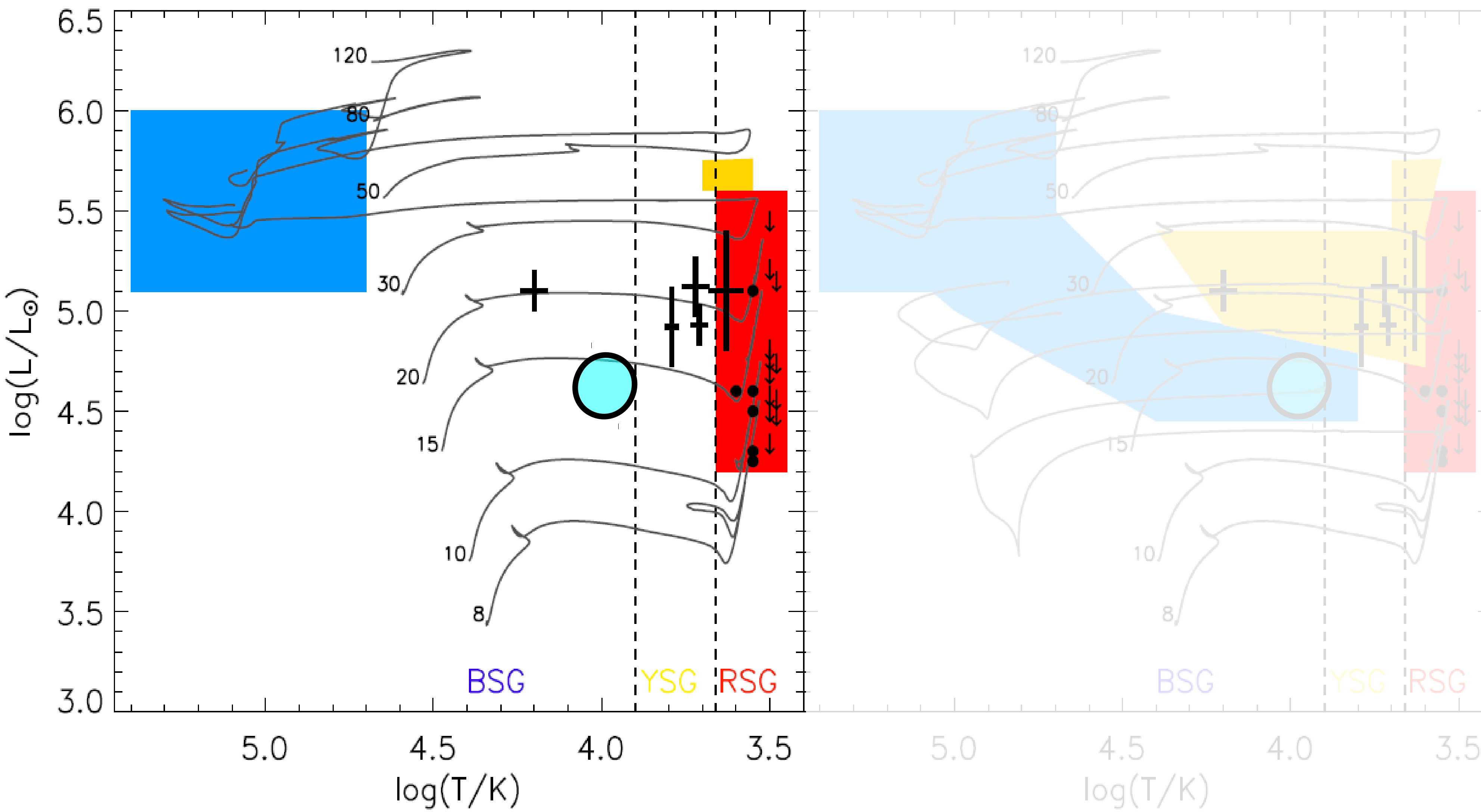
Type Ib SN iPTF13bvn



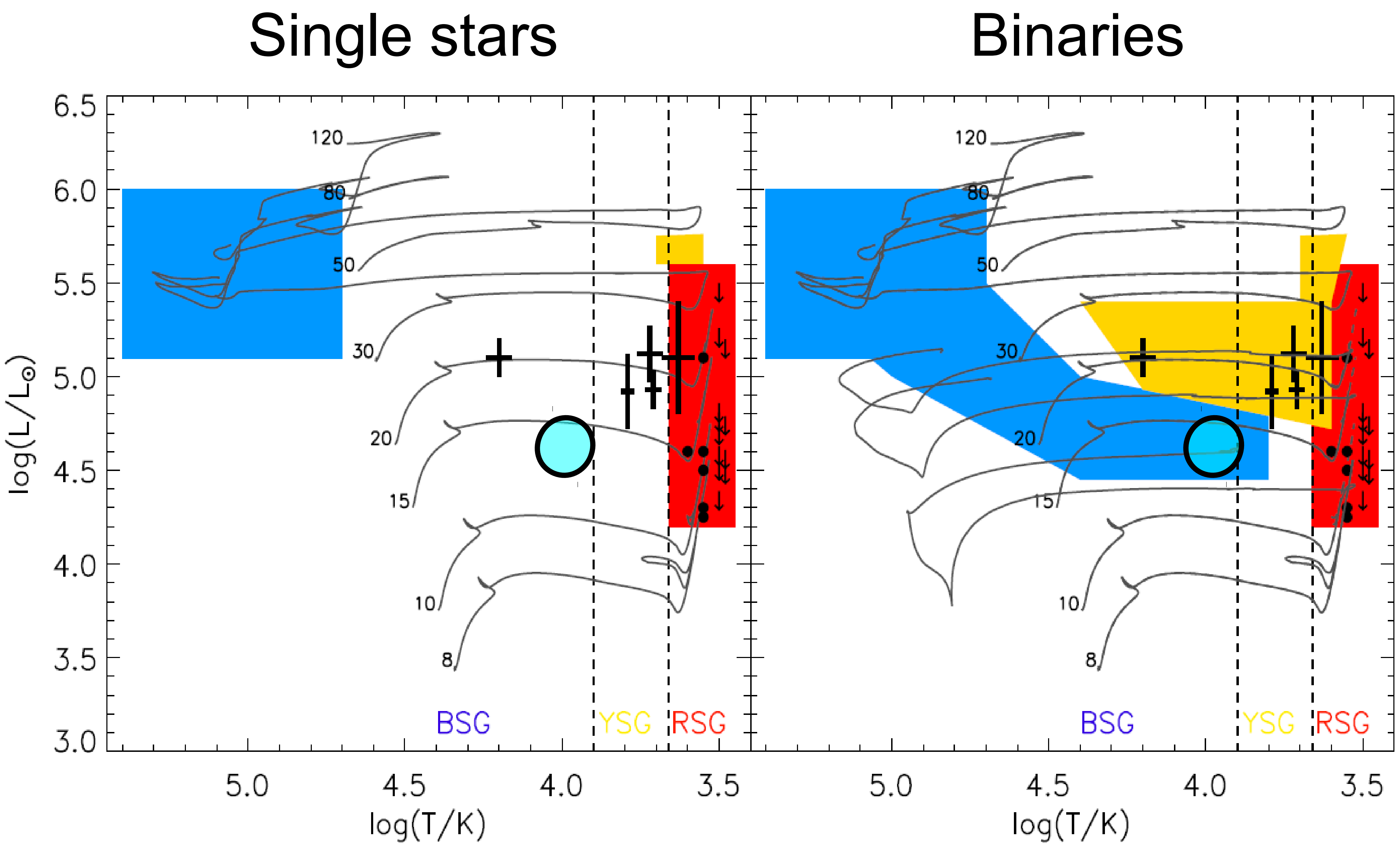
Bernsten et al. (2013); Eldridge et al . (2013, 2015, 2016)

What happens when we compare observed SN progenitors to model predictions?

Single stars | Binaries



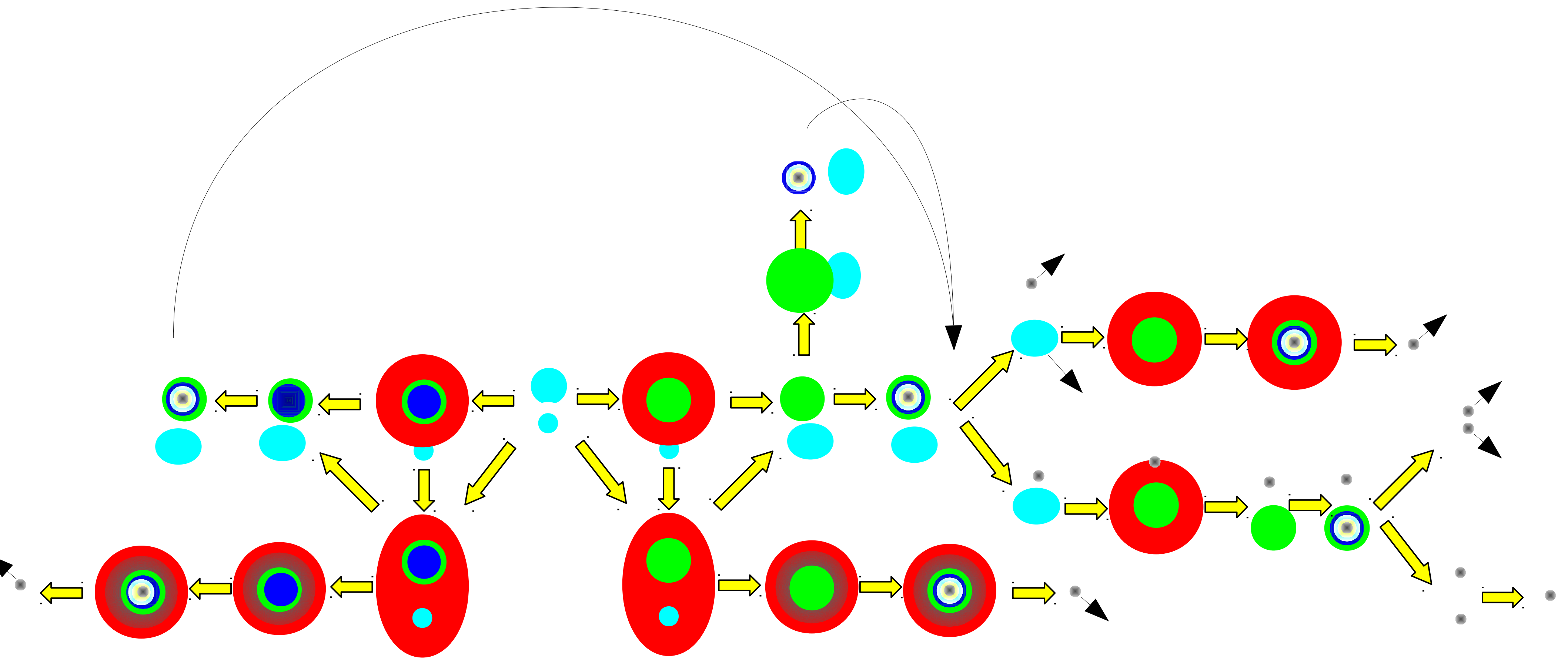
Eldridge et al . (2013, 2015, 2016)



Eldridge et al . (2013, 2015, 2016)

What's the main thing that happens in binaries to create this difference?

A few of the evolutionary pathways that must be included



Binary Population And Spectral Synthesis

Developed to study a broad range of astrophysical systems:
stars, supernovae, clusters, galaxies, compact remnant mergers

Ethos: "Yes there are uncertainties but let's take our best guess and see if we can be less wrong than single star populations".

BPASS.AUCKLAND.AC.NZ

Version 1.1 based on 15,000 detailed stellar models.
Eldridge et al. (2008, 2011), Eldridge & Stanway (2009, 2012)

Version 2 based on **250,000 models detailed stellar models**,
Z=0.00001 to 0.040, binaries from 0.1 to 300$M_{\odot}$

Instrument paper on the way: Eldridge, Stanway, Xiao, Taylor, Ng, McClelland & Bray

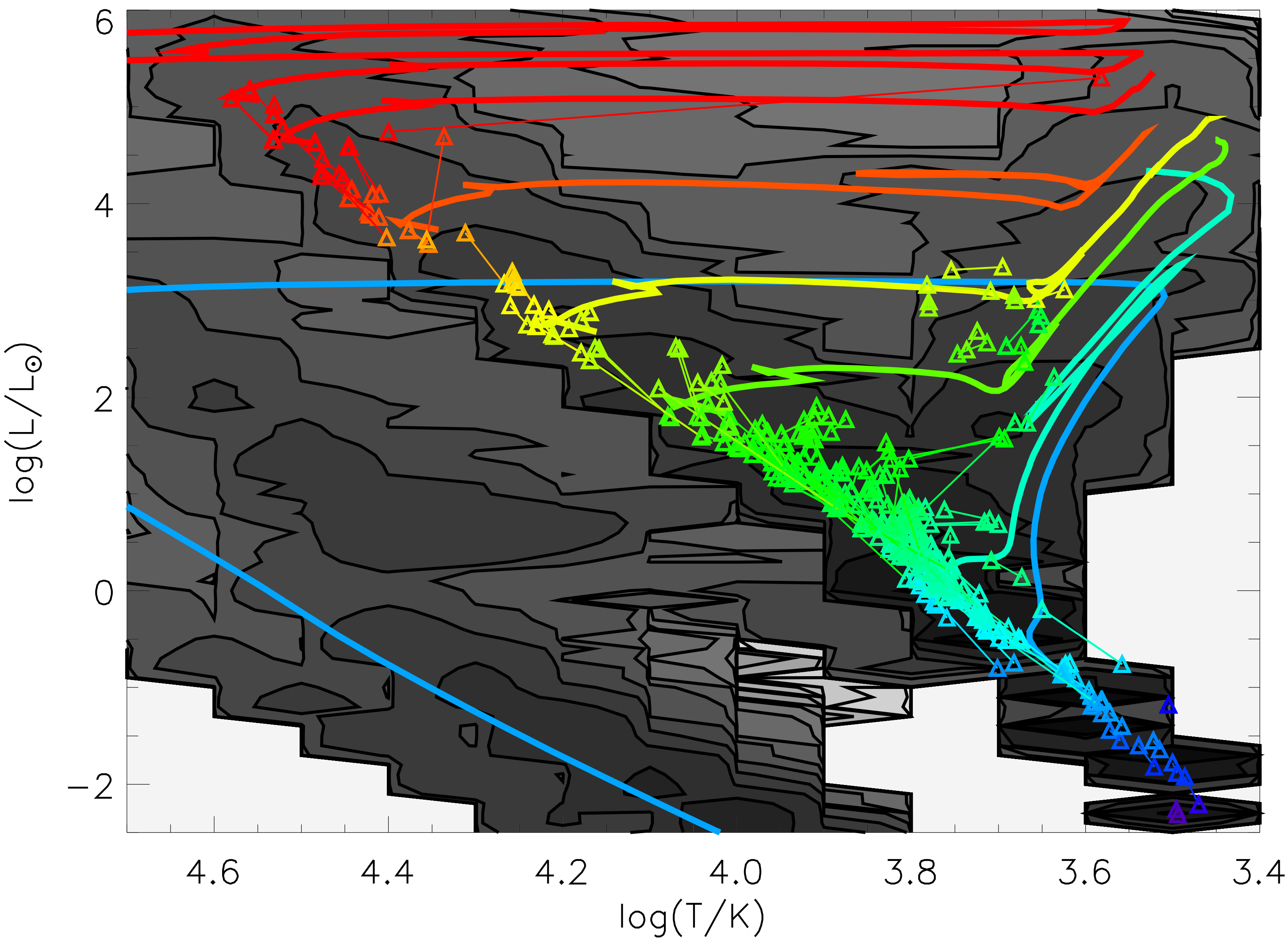
Papers by team already available using v2.0:
Stanway et al, Eldridge & Stanway, Bray & Eldridge, Eldridge & Maund

But don't take our word for it:

- Wofford et al., 2016 – Young massive LEGUS clusters
- Shenar et al., 2016 – Wolf-Rayet stars in the SMC
- Heikkila et al., 2016 – X-ray binaries as SN progenitors.
- Takashi & Eldridge, 2016 – ECSNe fast transients
- Steidel et al., 2016 – High-z galaxies rest frame UV and optical emission lines
- Wilkins et al. 2016 – Binaries key for reionization
- Ma et al., 2016 - Binaries key for reionization
- Graur et al., 2017 – SN rates versus metallicity

Note: I'm not the only person working on massive binaries, an incomplete list: de Mink, Yoon, Nomoto, Vanbeveren, Han, Belczynski, Langer, Podsiadlowski, Lipunov, Izzard, Hurley, Tout, Siess, Paczyński, Ivanova, Kalogera, de Marco, Gotberg...

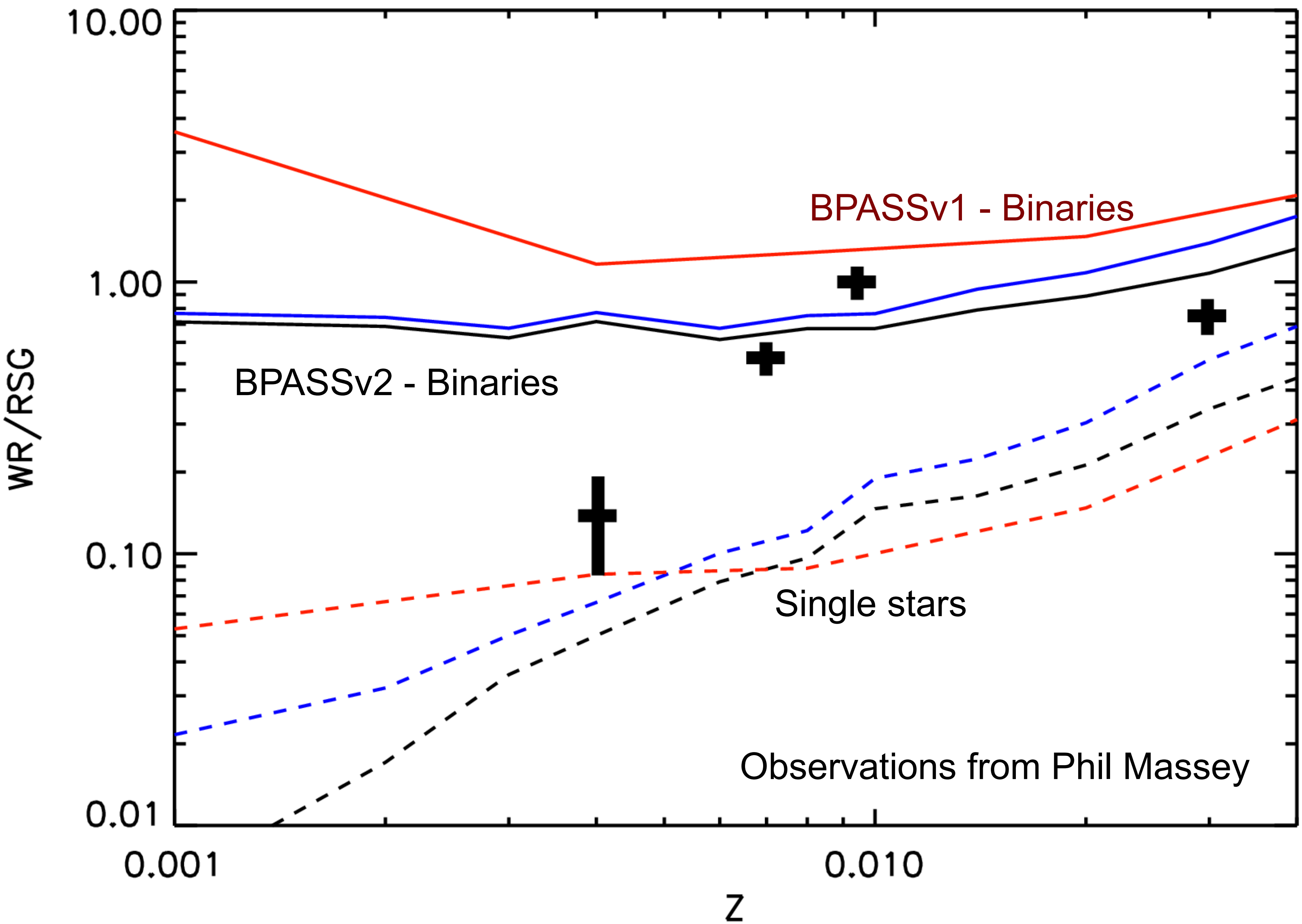
How accurate are the stellar models?



BPASSv2.1

Eldridge et al . (in prep)

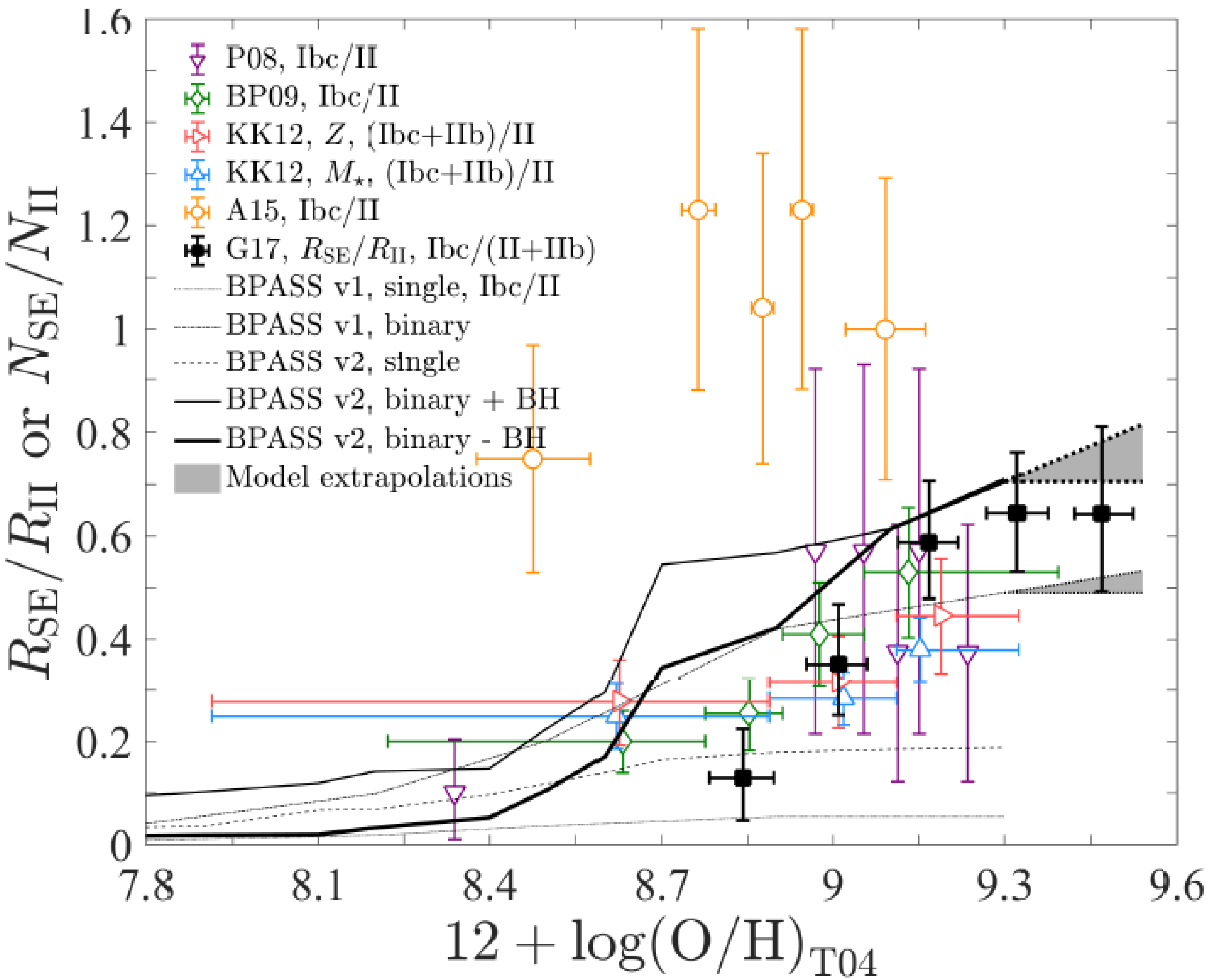
Predict RSG and WR population as well?



BPASSv2.1

Eldridge et al . (in prep)

But was does the SN rates look like with metallicity?



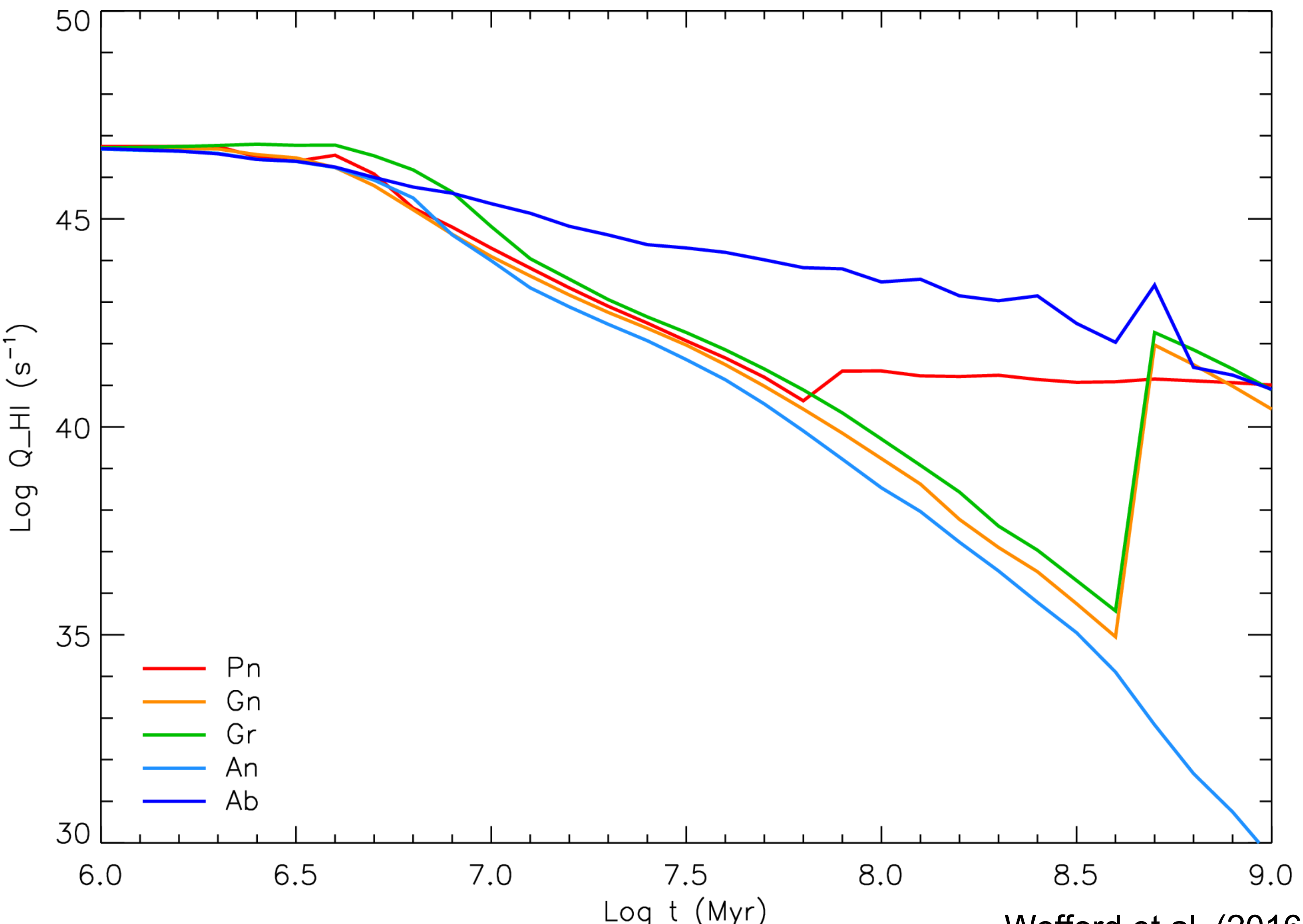
Graur et al . (2017)

BPASSv2.1

So what is the main important effect of binaries for low mass galaxies?

And which stars cause it?

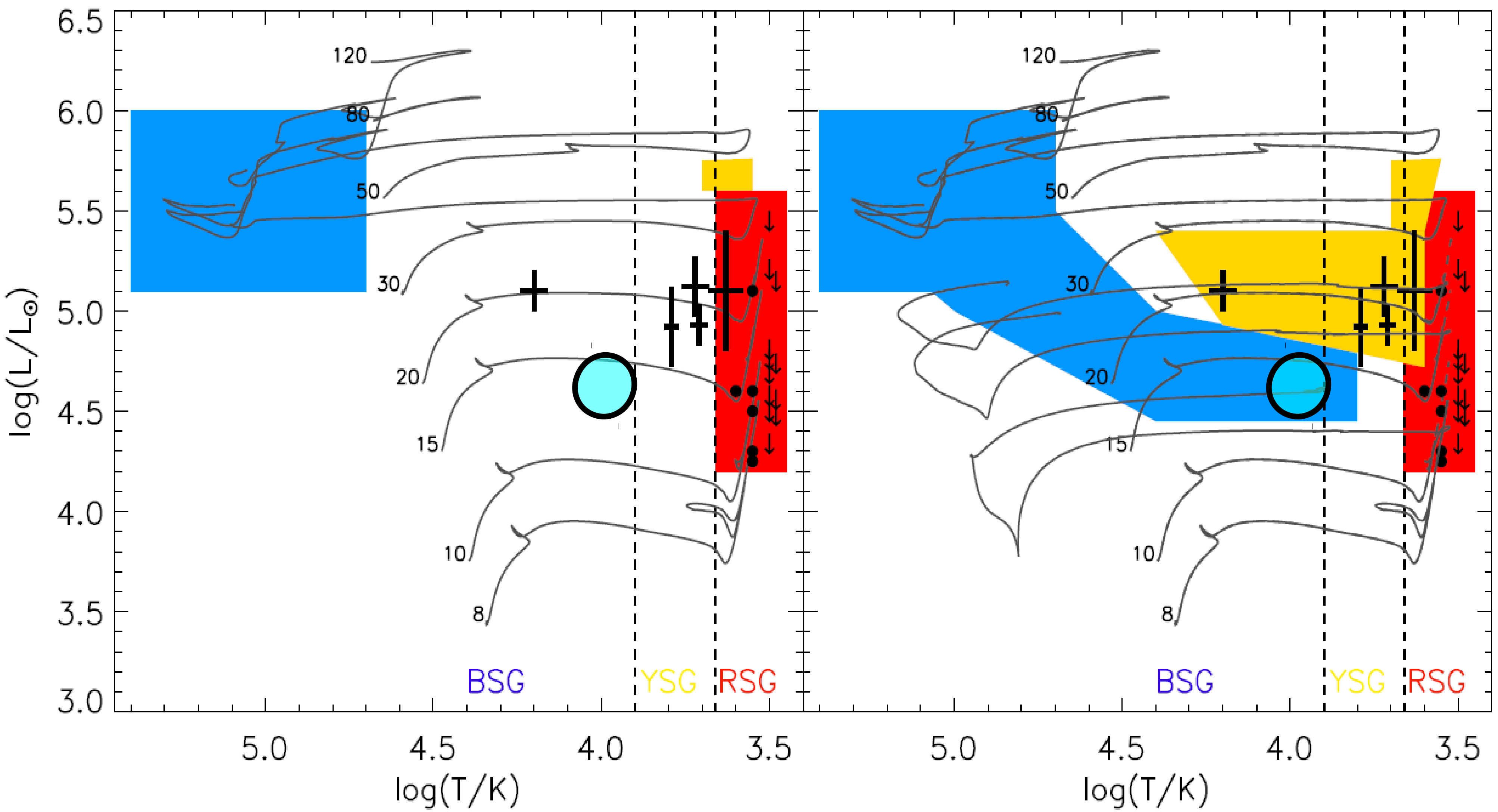
Number of ionizing photons?



BPASSv2.0

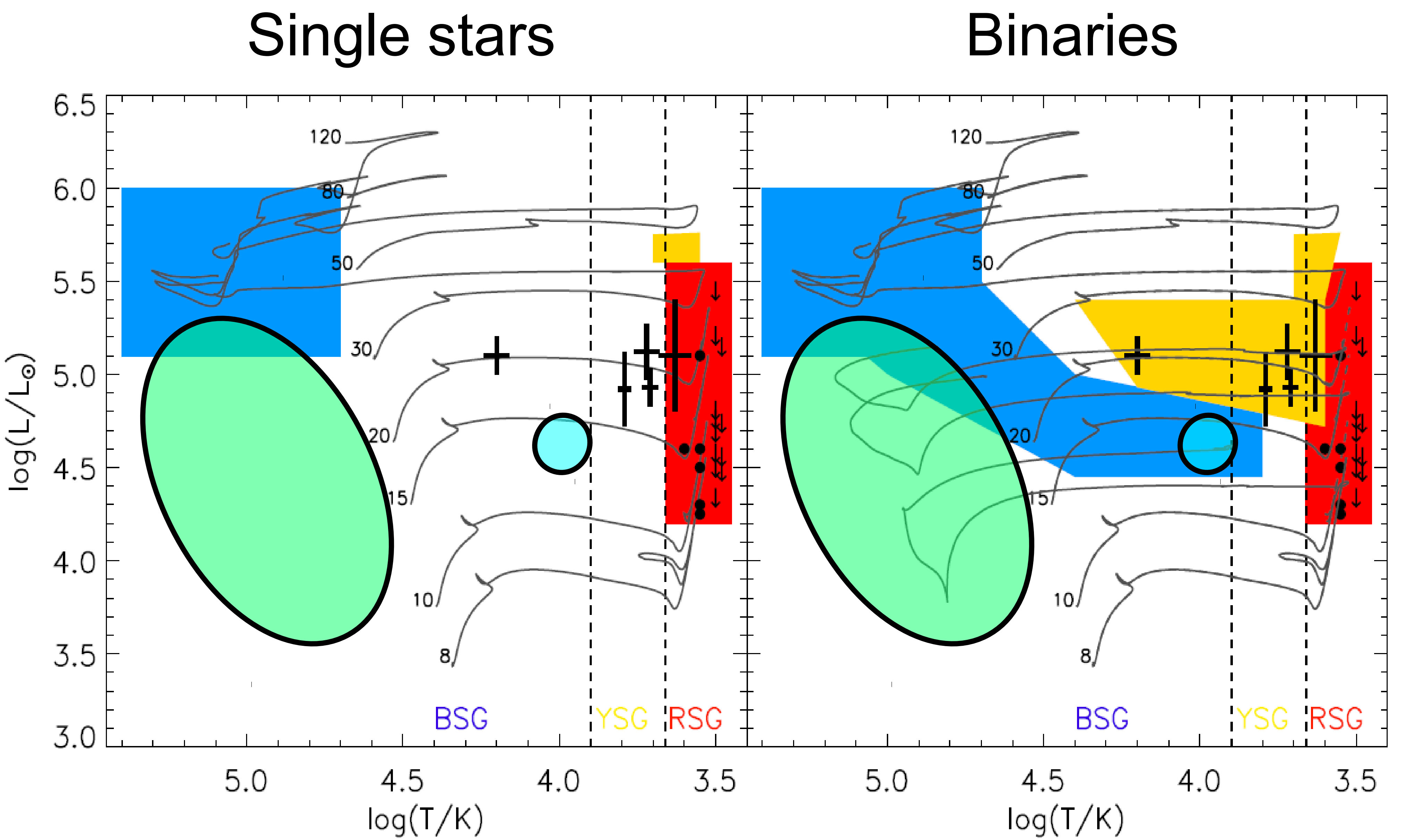
Wofford et al. (2016)

Single stars Binaries



BPASSv1.1 & 2.0

Eldridge et al . (2013, 2015, 2016)

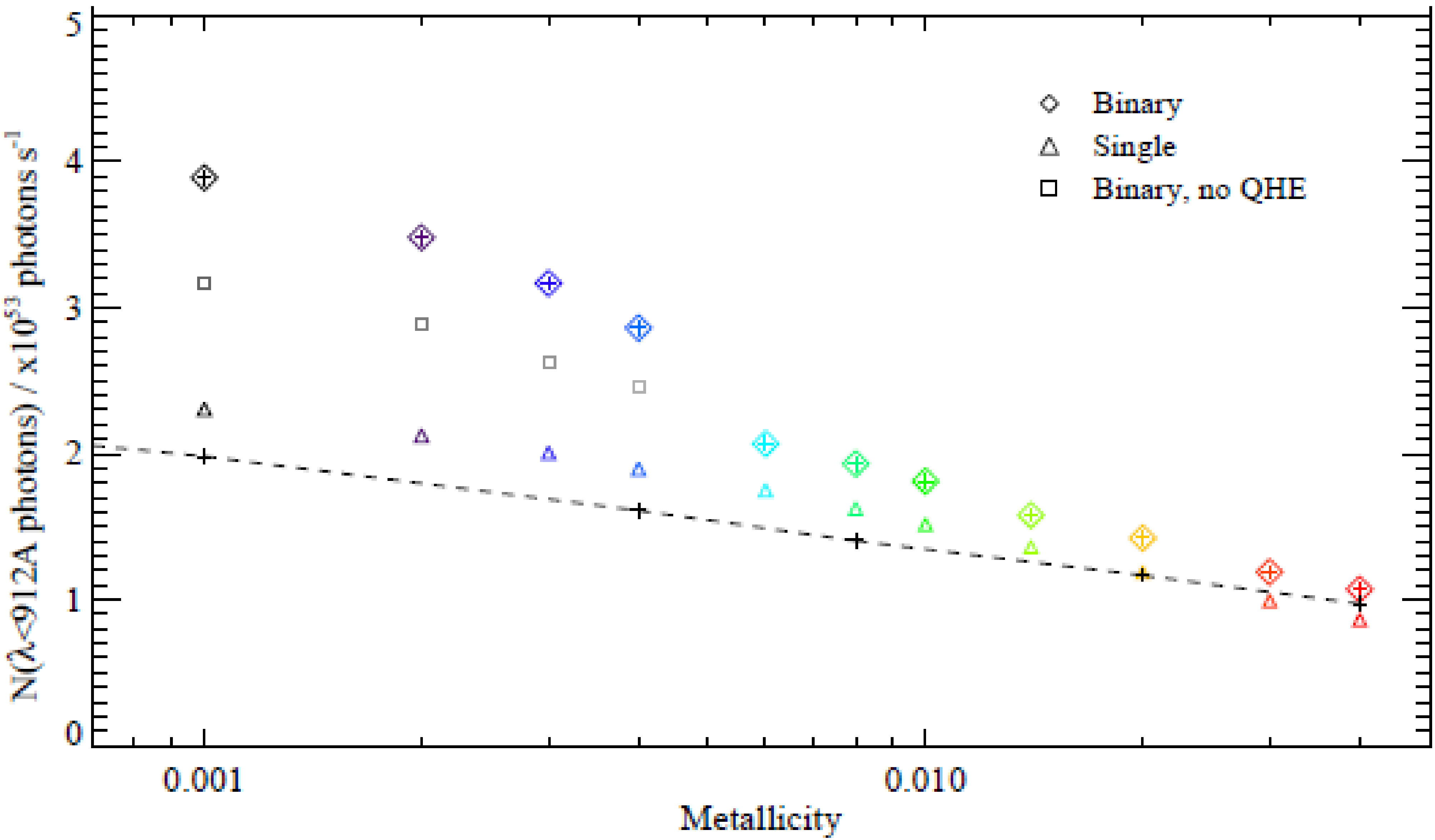


BPASSv1.1 & 2.0

Eldridge et al . (in prep) see also **Gotberg et al. (2017)**

What about when we go to low metallicity?

Number of ionizing photons during reionization?

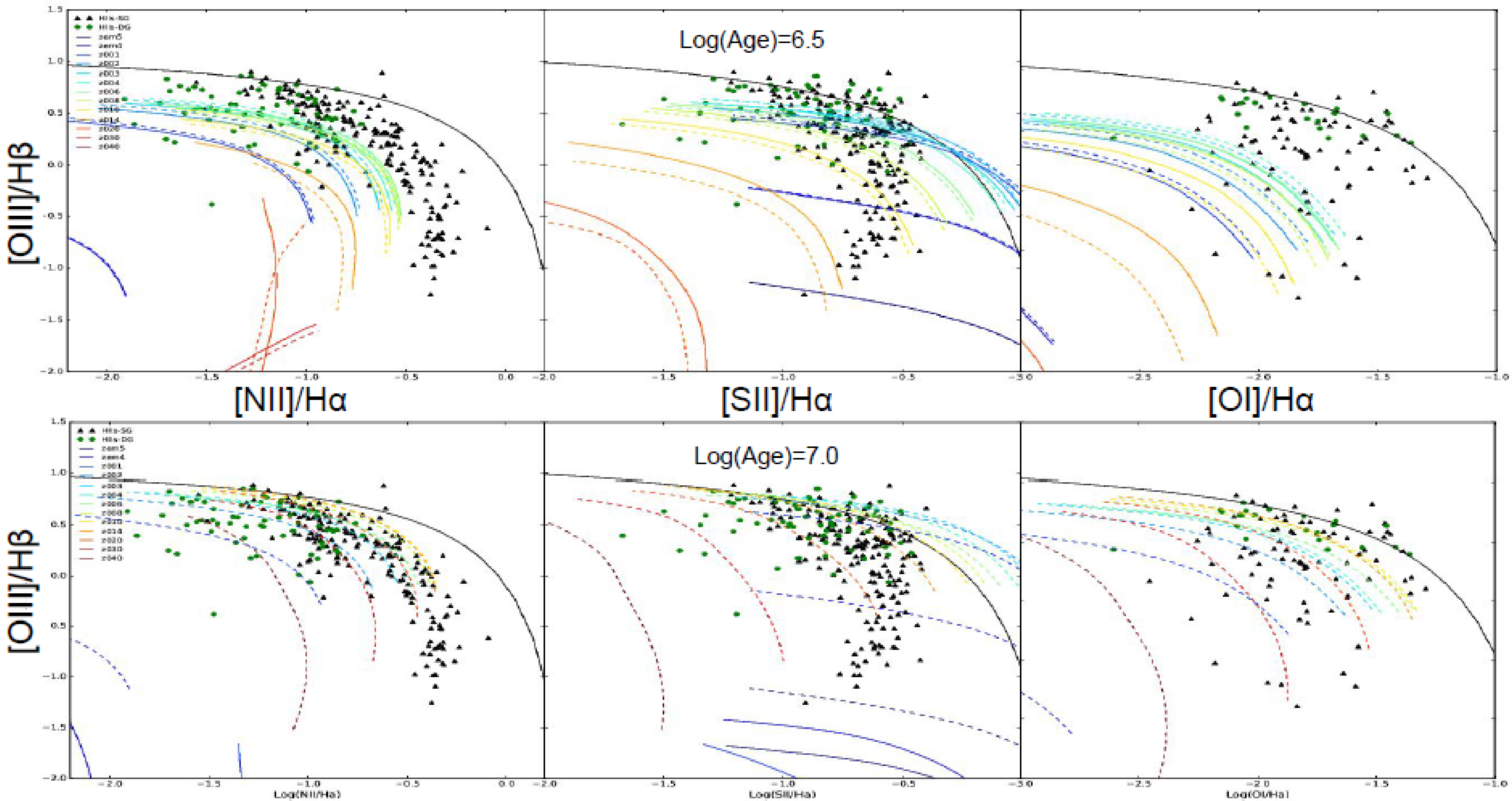


BPASSv2.0

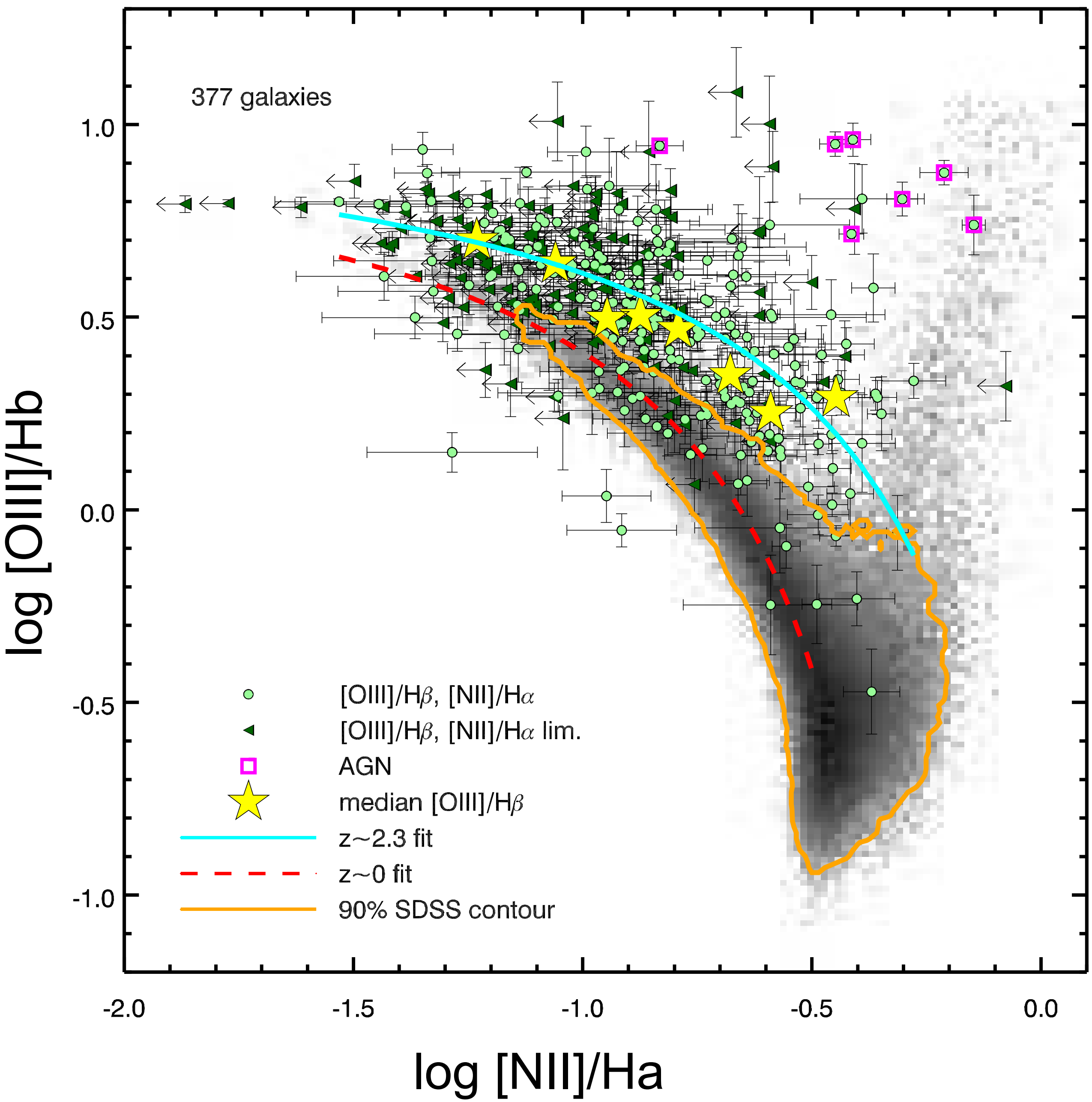
Stanway et al. (2014, 2016); Wilkins et al. (2016); Ma et al. (2016)

Finally the BPT diagram...

Xiao, Eldridge and Stanway. in prep

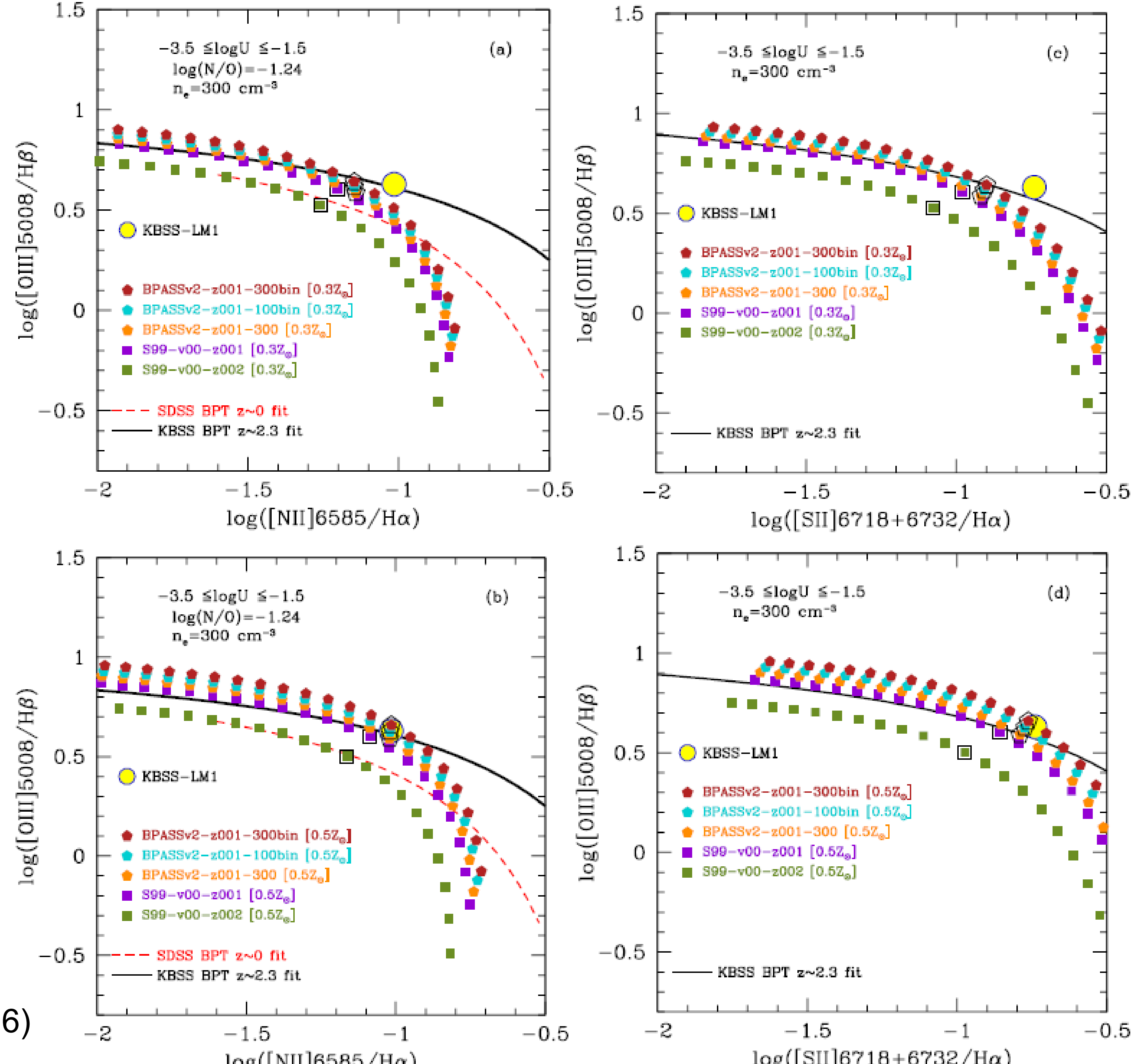


The Ionizing Spectrum at z~3

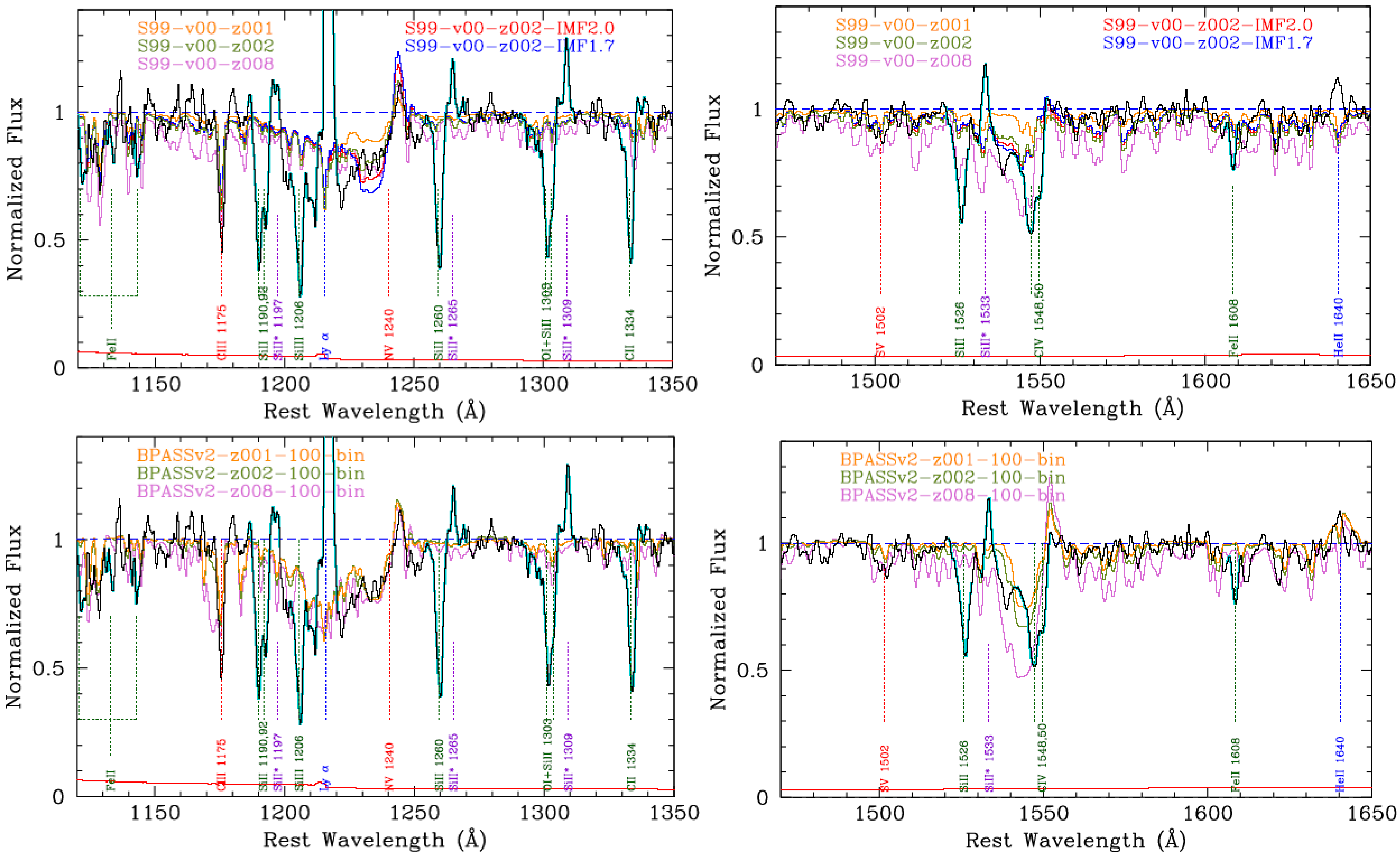


Multi-object near-IR spectrographs on 8-10m class telescopes (notably MOSFIRE on Keck) are making the high z rest-optical accessible for the first time.

(Strom et al 2016, see also Steidel et al 2016, Kriek et al 2016, Reddy et al 2016)



Steidel et al. (2016)



Steidel et al. (2016)
See also Eldridge & Stanway (2012)

BPASSv2.0

Summary

There is growing evidence we need reconstruct how we think about stellar populations, most massive stars have their lives dominated by binary interactions.

Key features for stellar populations is they provide s ource of hard ionizing photons at and age where single star models predict none. Should be “observable” in IFU surveys.

We haven’t discussed: CR7, stocasticity, X-ray binaries, gravitational wave sources, very massive stars, superluminous supernovae and GRBs will all link in with understanding low mass/metallicity galaxies.