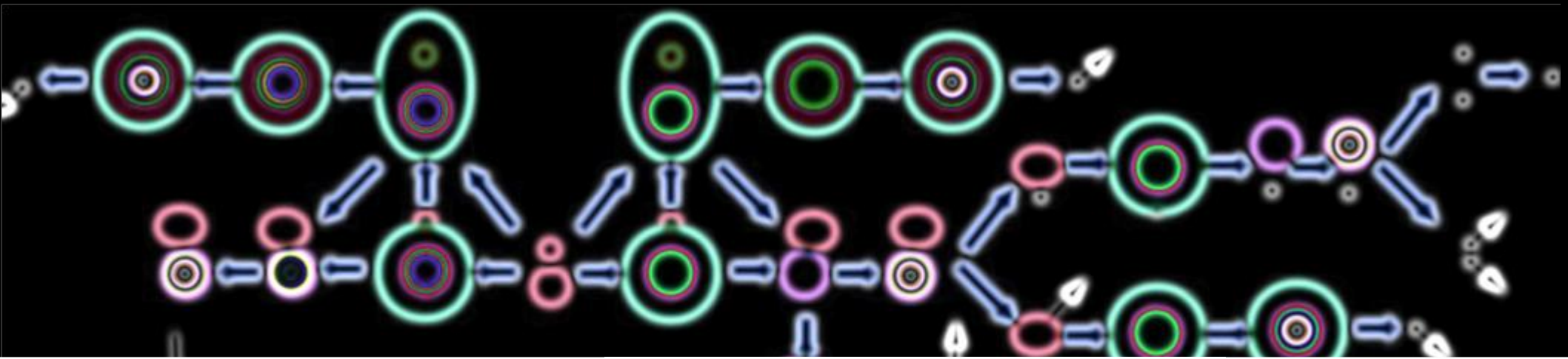
Exploding stars and the myth of a gender binary.

Jan J. Eldridge



MARSDEN FUND
TE PŪTEA RANGAHAU A MARSDEN

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NEW ZEALAND

WARWICK
THE UNIVERSITY OF WARWICK

Who am I?

A. Prof. JJ/Jan Eldridge

She/her/they pronouns.

Astro**physicist.**

“I study **exploding binary stars** while exploding the **myth of a gender binary**.”

Work on stars, galaxies, supernovae….

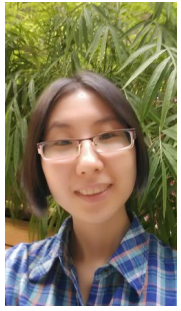
Twitter: **@astro_jje**

binary population and spectral synthesis

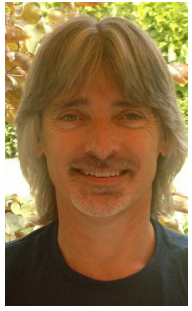
JJ Eldridge

Elizabeth Stanway

Héloïse Stevance



Lin Xiao



John Bray

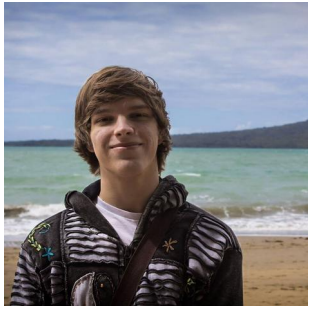
Max Briel

Petra Tang

Sohan Ghodla

Wouter van Zeist

Sean Richards



Gleb Geinke

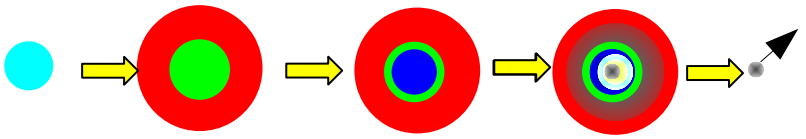
Adib Mowaz

Other Past Students: Ashley Chrimes, Liam McClelland, Georgie Taylor, Mason Ng, Lillian Guo, Nicole Rodrigues, Lucas Ostrowski, Itwinder Singh

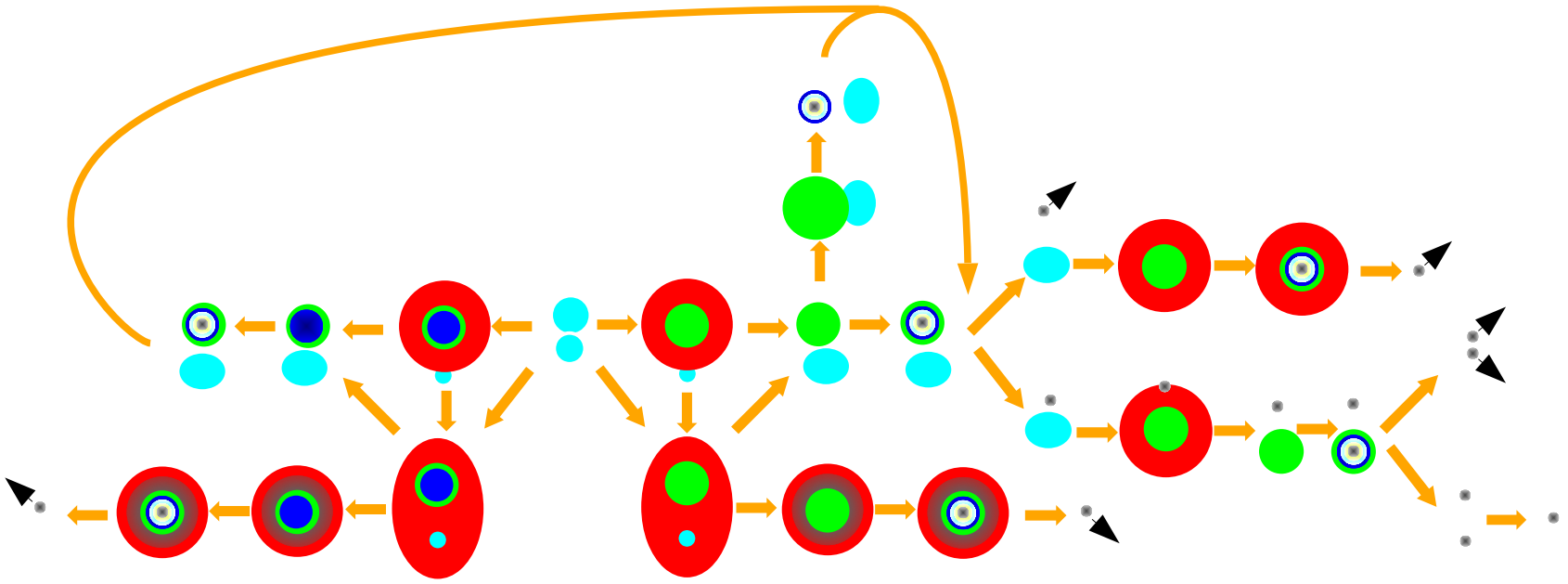
Why do I do astrophysics?

So how do single star and interacting binary star evolution compare?

The evolution of single stars....

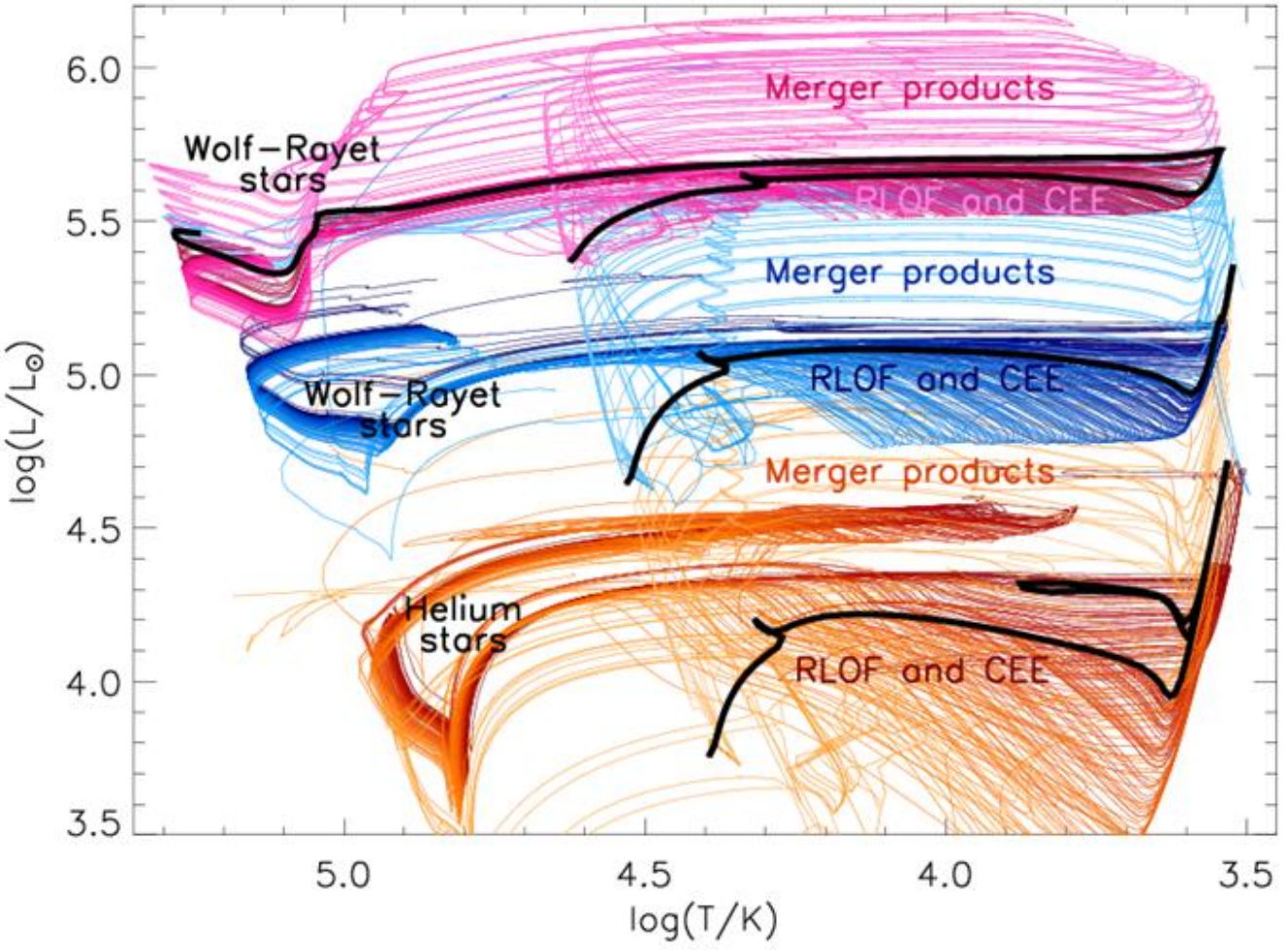


A few of the binary evolutionary pathways that must be included



Key point: a **new stellar type – helium stars** – occurs, at masses intermediate to Wolf-Rayet and sdB/sdO stars (see also Götberg et al., 2017; 2018).

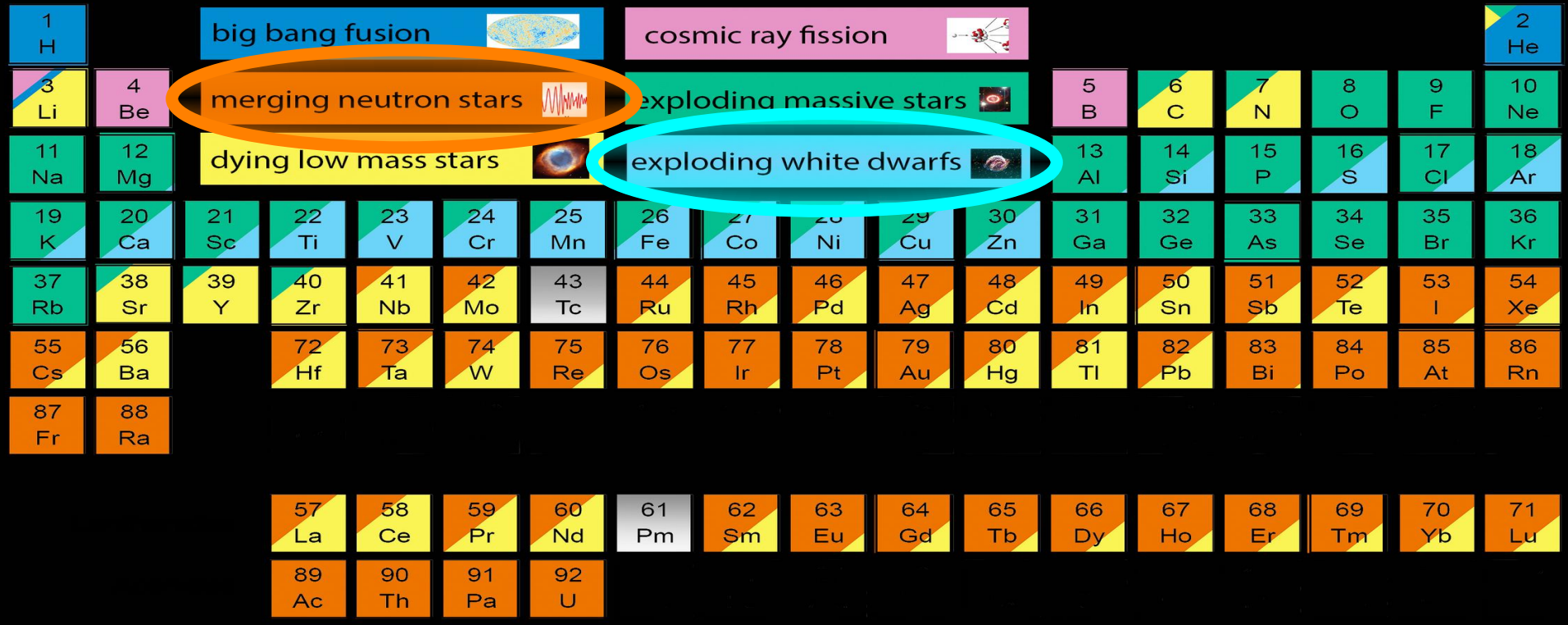
And on the HR diagram...



Eldridge (2020).

What about stellar explosions?

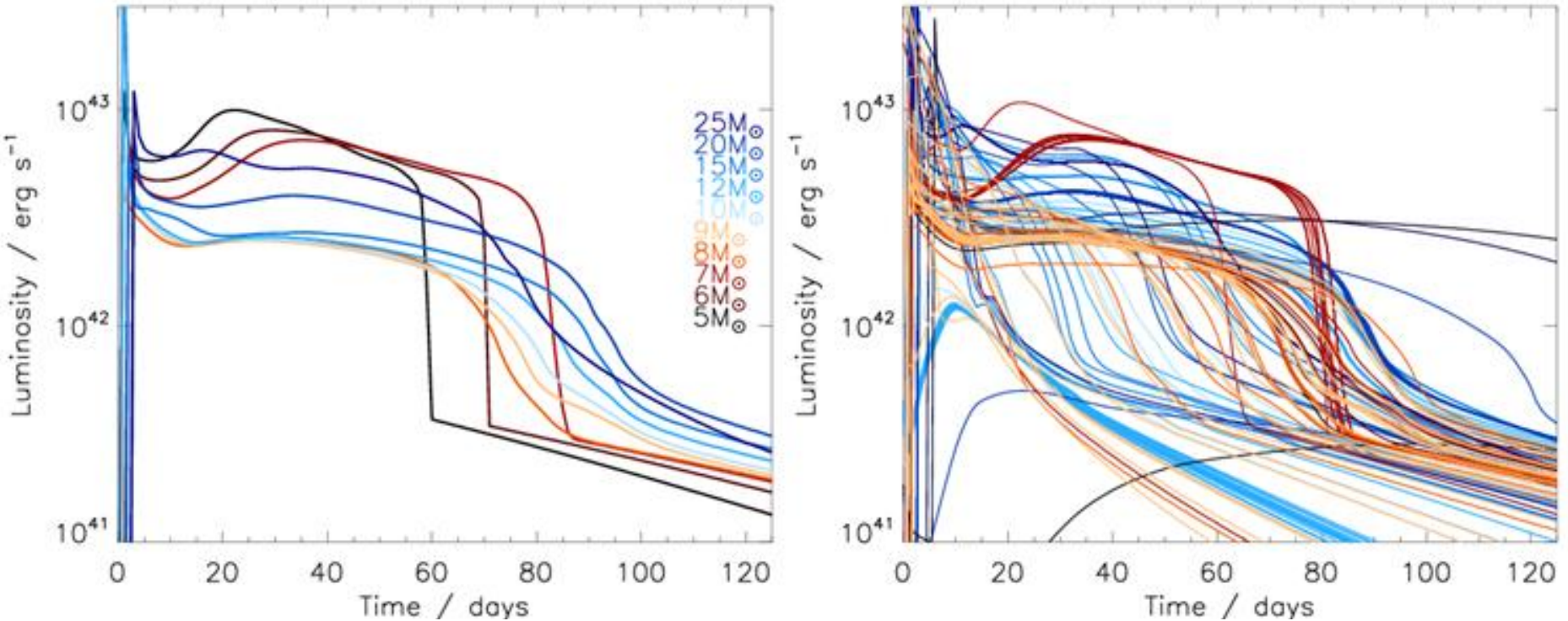
The Origin of the Solar System Elements



Graphic created by Jennifer Johnson

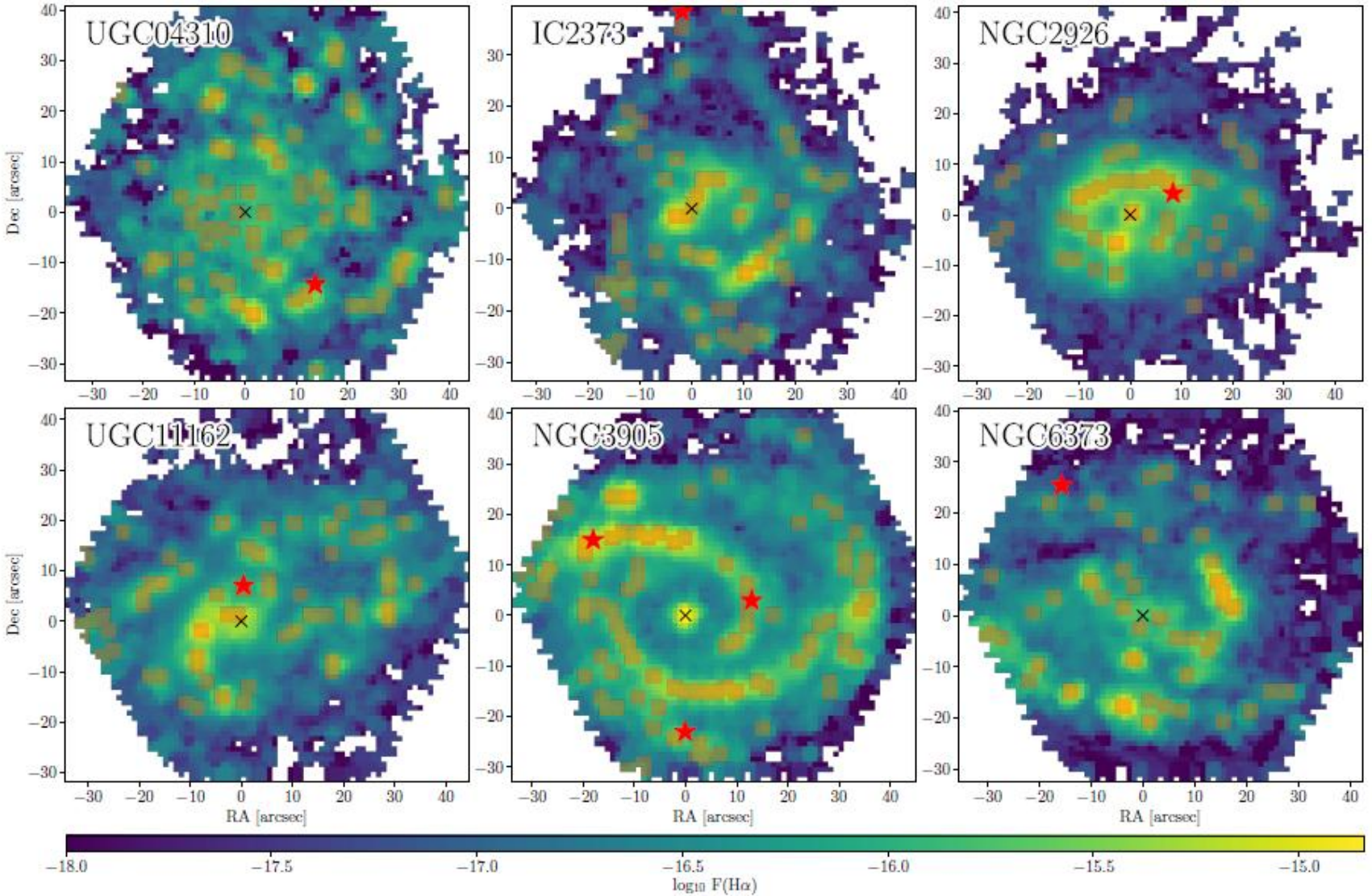
Astronomical Image Credits:
ESA/NASA/AASNova

Type II SN lightcruves from interacting binaries

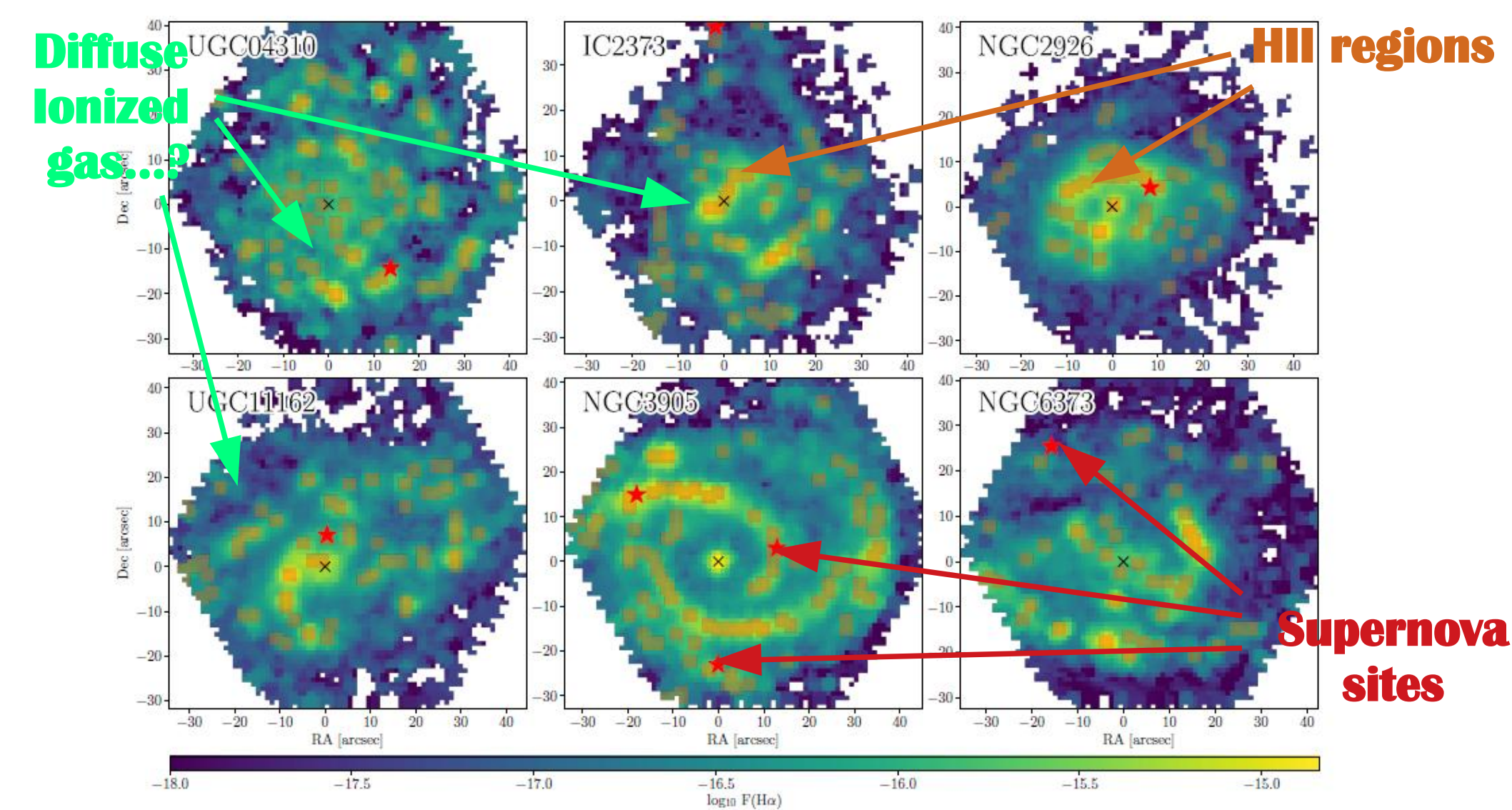


Eldridge et al. (2019).

Binaries cause more hydrogen-free supernovae and at the same time more hot stars can we see this in galaxies?

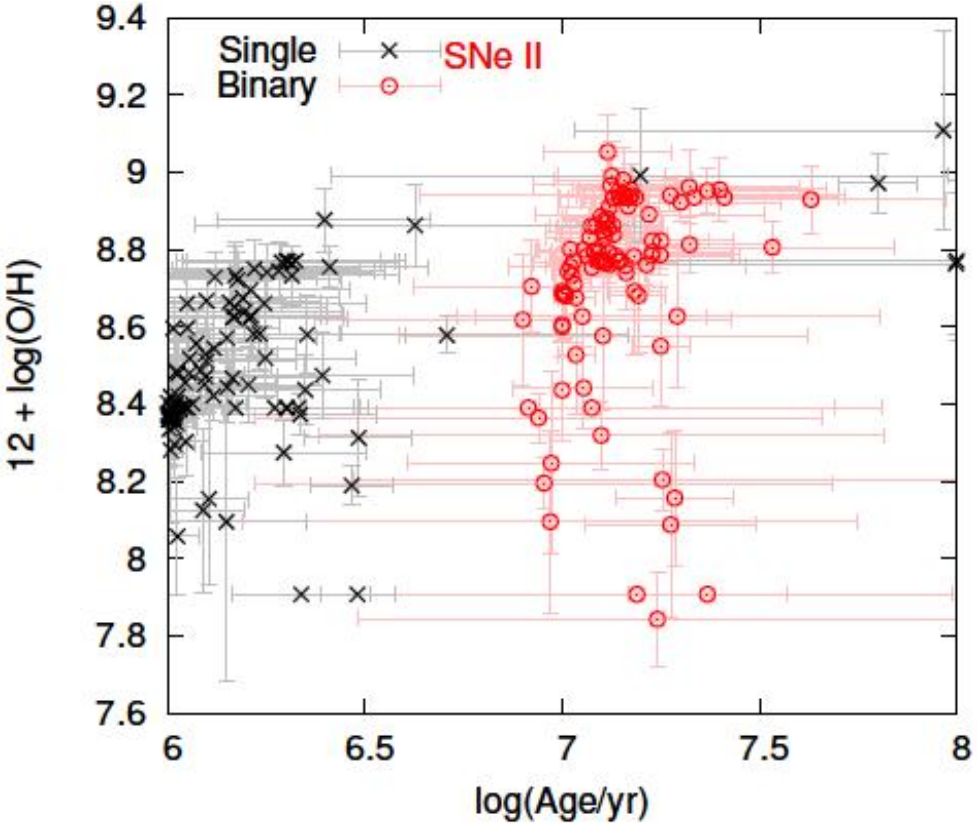


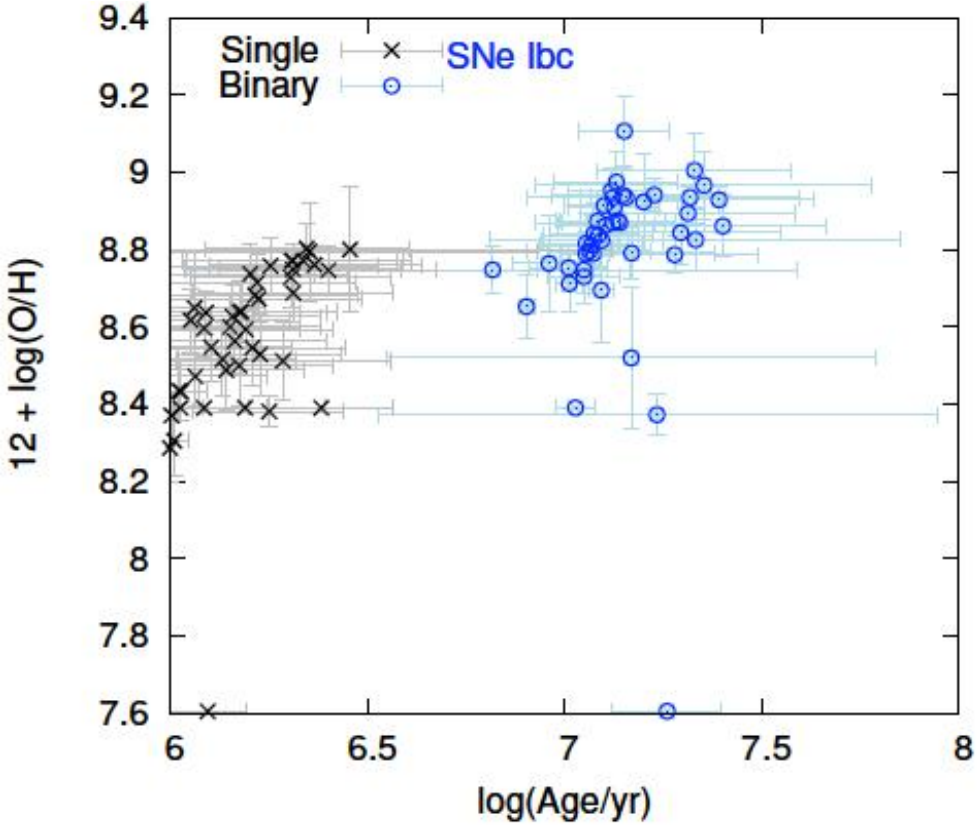
Galbany et al. (2018) - “PISCO: The PMAS/PPak Integral-field Supernova Hosts Compilation”.



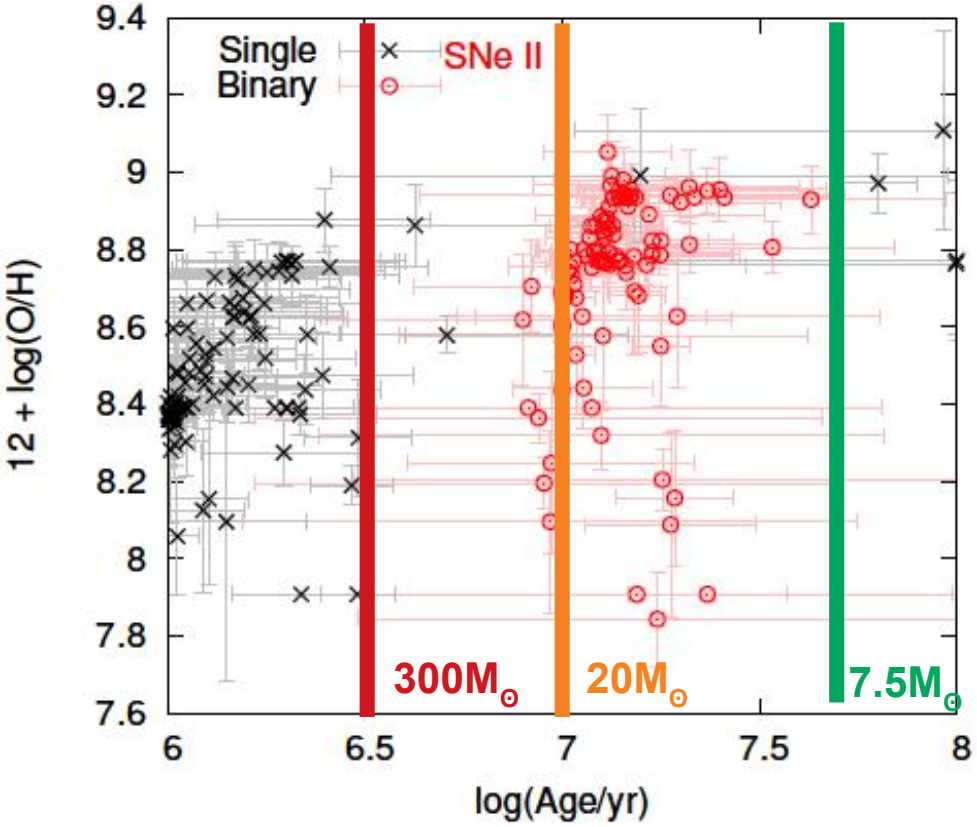
Galbany et al. (2018) - “PISCO: The PMAS/PPak Integral-field Supernova Hosts Compilation”.

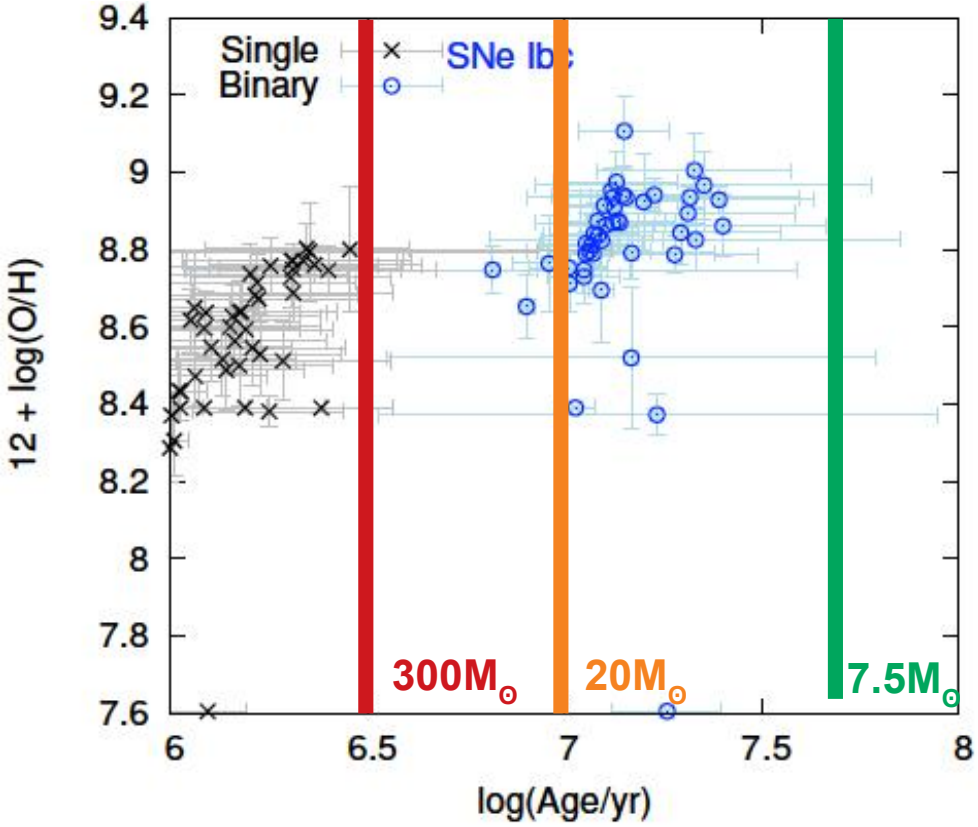
What happens when we attempt to age observed stellar populations at supernova sites with single star or interacting binary populations?





BPASSv2.1 **Xiao et al . (2018, 2019)** and see works by Götberg et al. and Zapartus et al..





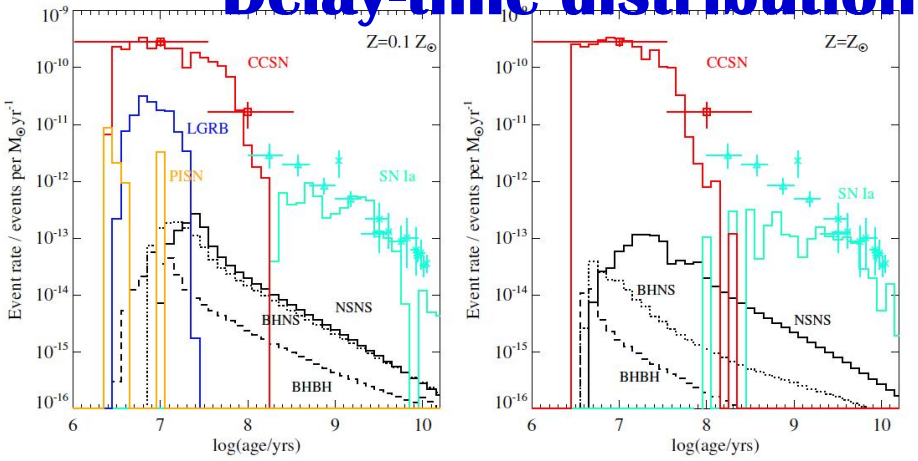
BPASSv2.1

Xiao et al . (2018, 2019) and see works by Götberg et al. and Zapartus et al..

But what about...

gravitational wave events?

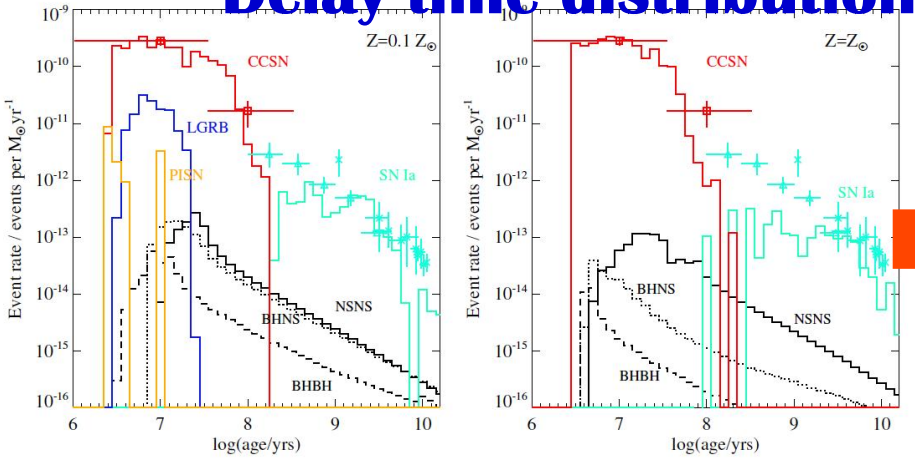
Delay-time distribution



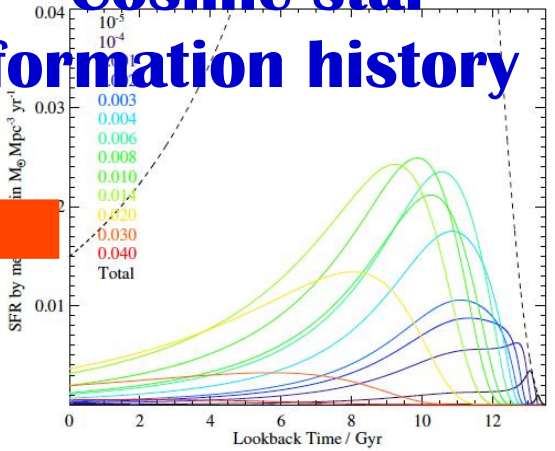
BPASSv2.2

Eldridge,
Stanway
& Tang (2019).

Delay-time distribution



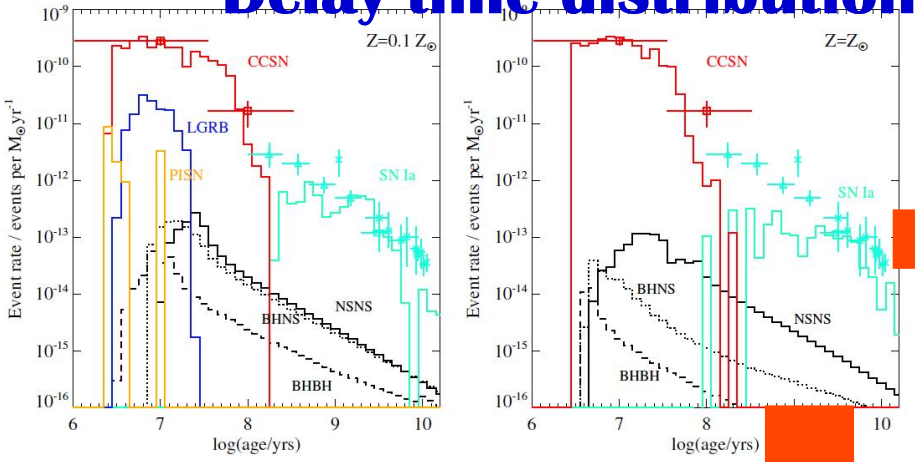
Cosmic star formation history



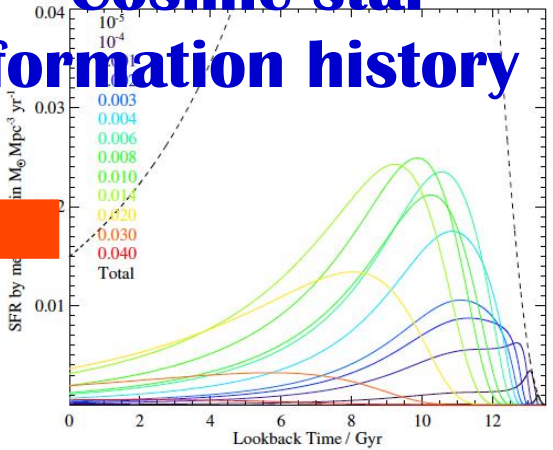
BPASSv2.2

Eldridge, Stanway & Tang (2019).

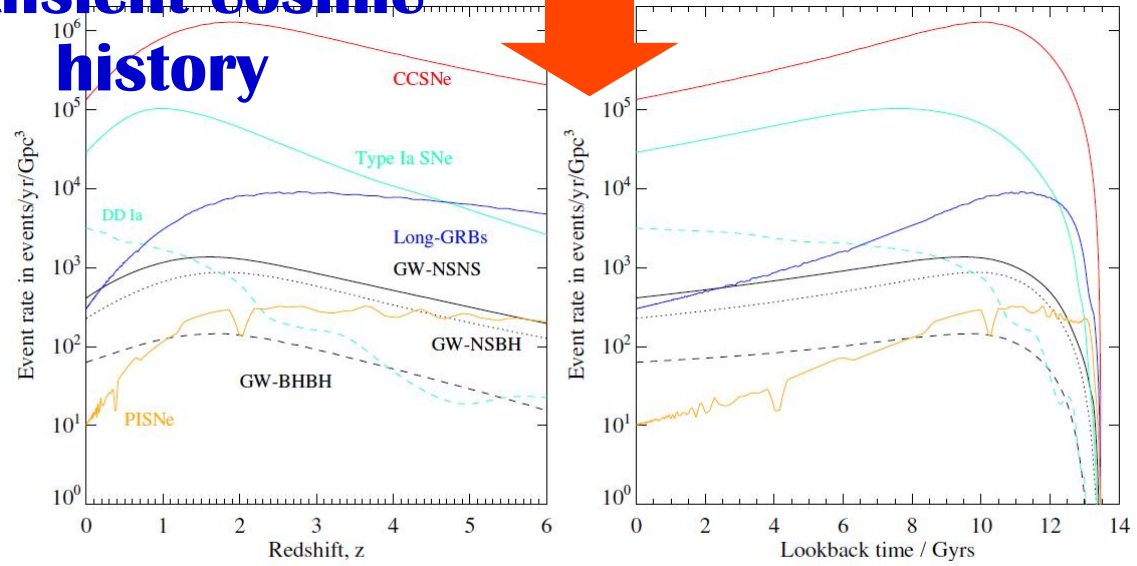
Delay-time distribution



Cosmic star formation history



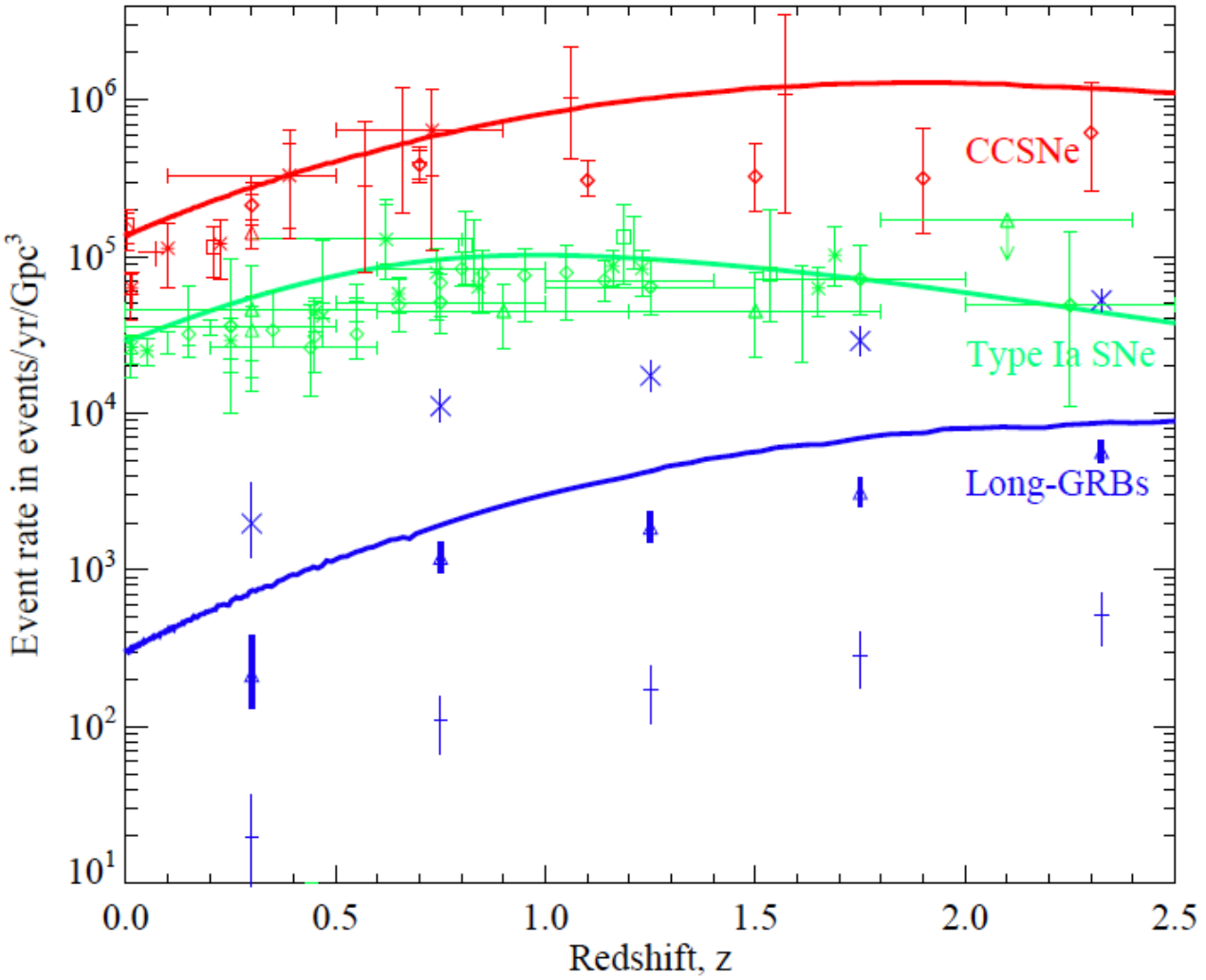
Transient cosmic history

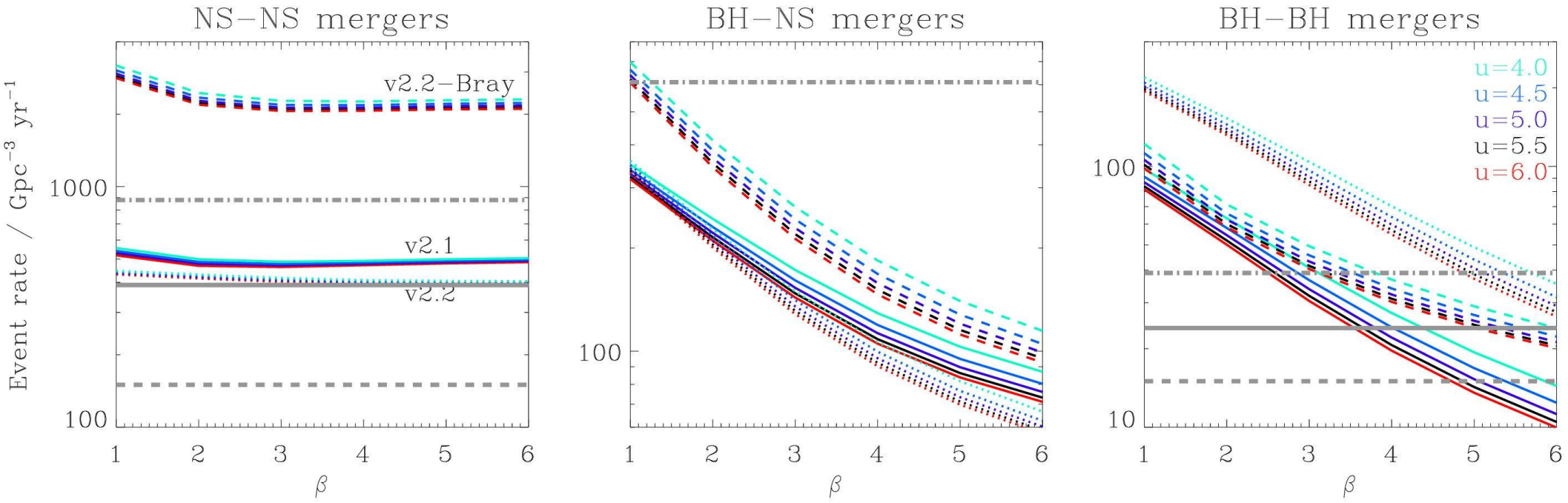


BPASSv2.2

Eldridge, Stanway & Tang (2019).

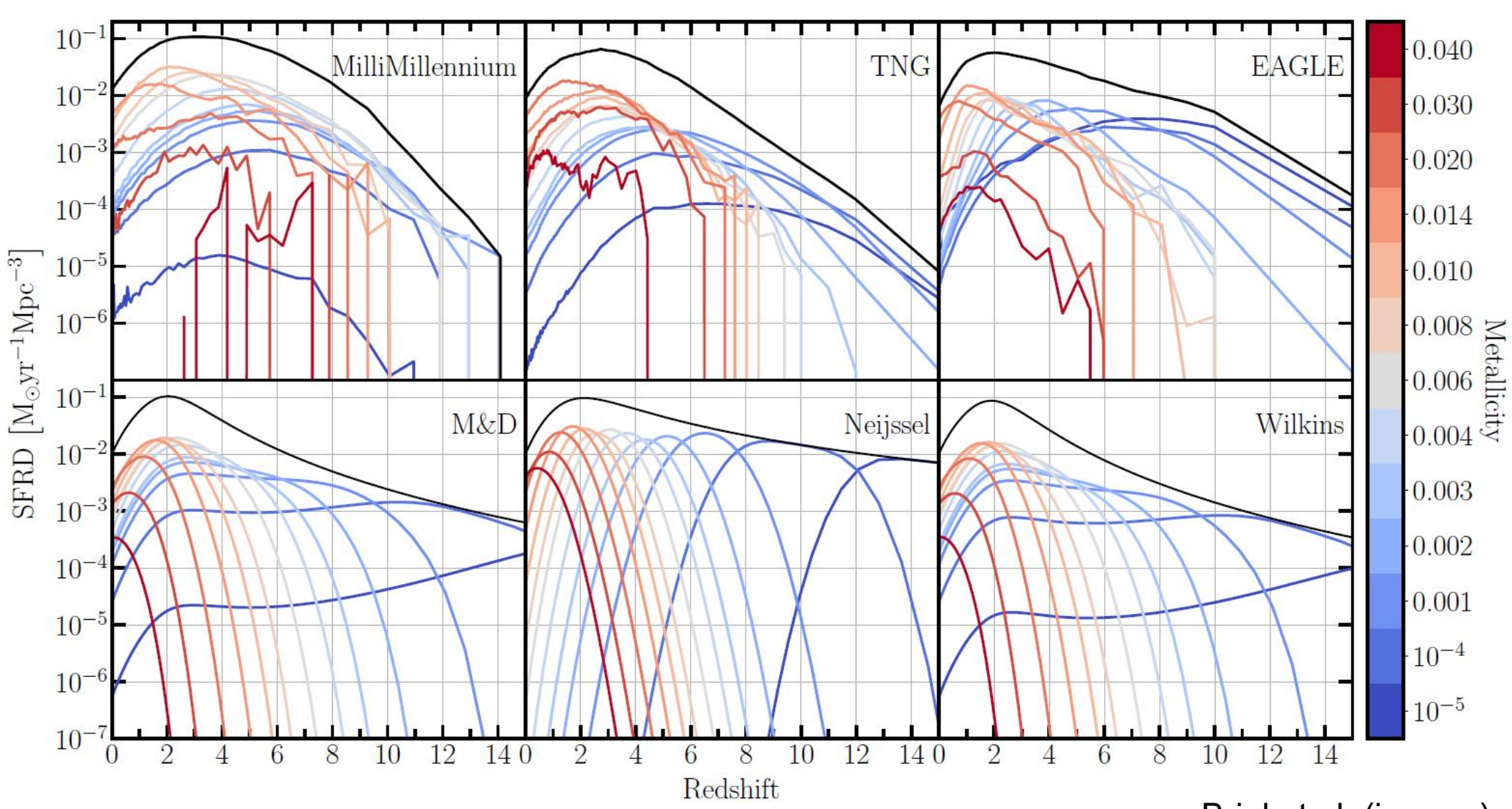
EM event rates (supernovae)



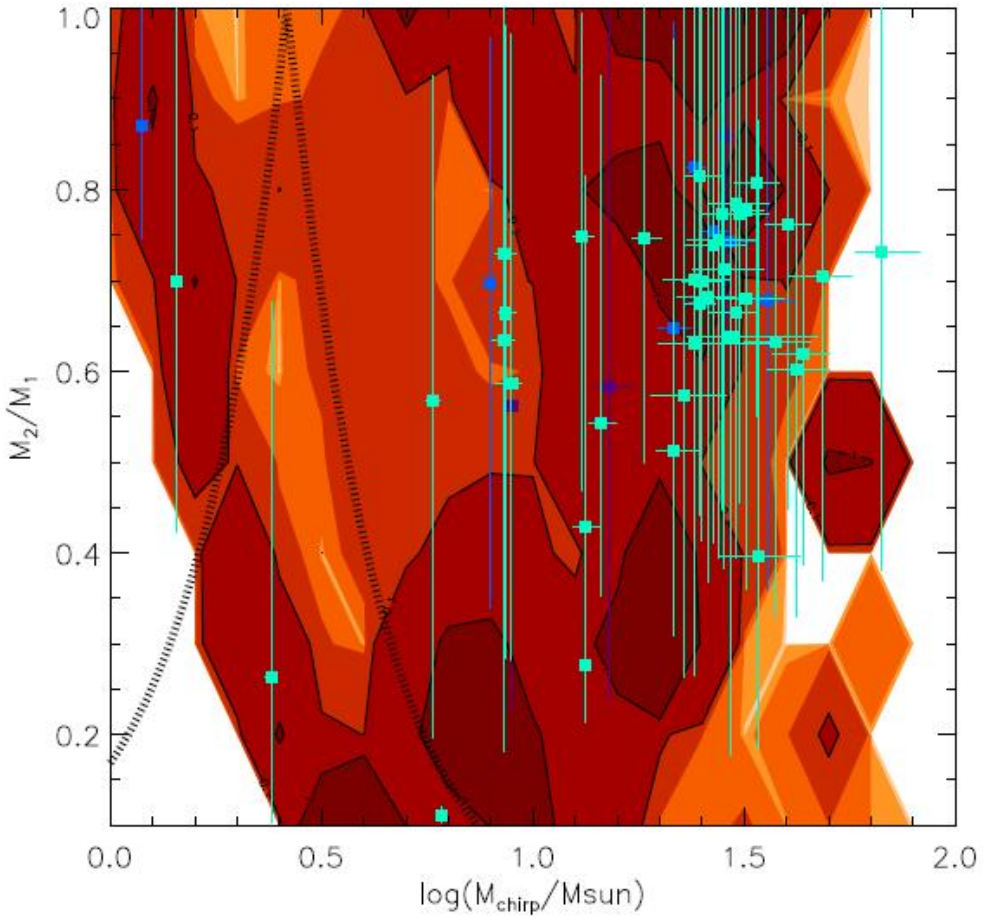


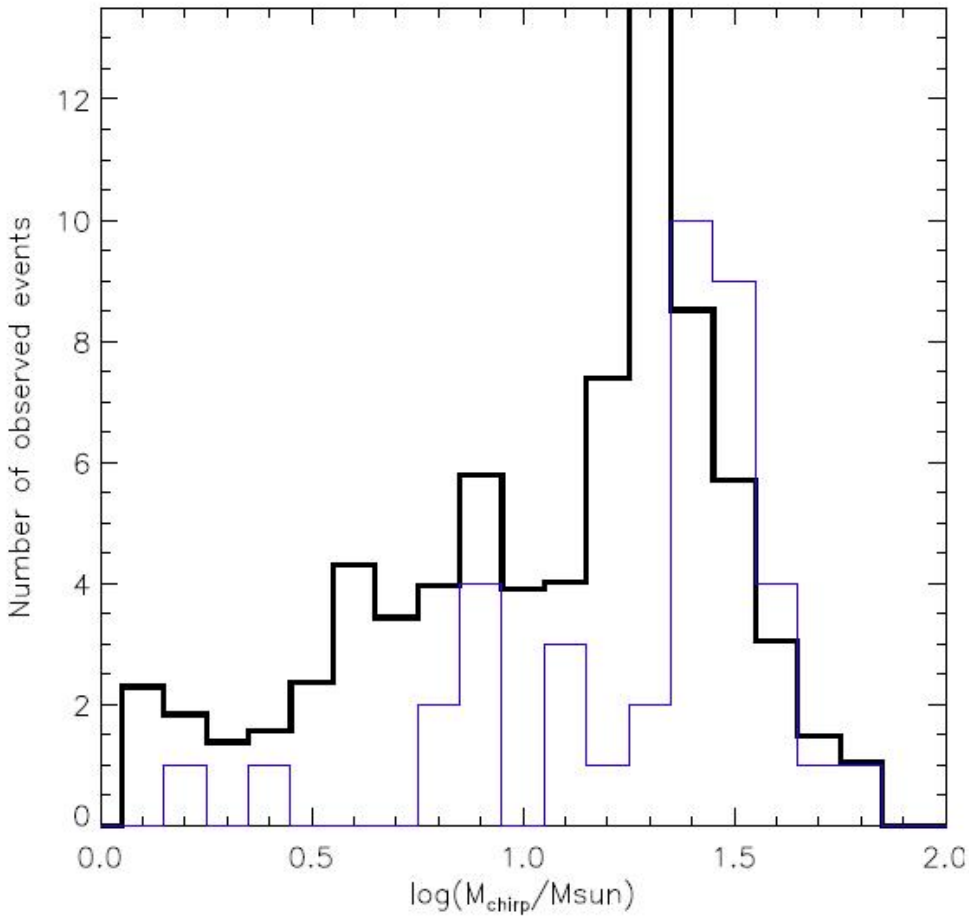
BPASS v2.1 and v2.2

Tang et al. (2020).



Briel et al. (in prep).





Ghodla, van Zeist et al. (in prep).

But Jan is it easy to include binaries myself?

binary population and spectral synthesis

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

Ethos:

1) "Yes there are uncertainties but let's take our best guess, no tuning, and see if we can be less wrong than single star populations".

2) "Be the theoretical equivalent of multi-messenger observations, make one model of stars in the Universe and observe in every way possible".

BPASS.AUCKLAND.AC.NZ

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

Version 2.2 based on **250,000 models DETAILED binary models**, Z=0.00001 to 0.040, binaries from 0.1 to 300$M_{\odot}$

binary population and spectral synthesis

The main papers:

- Stanway, Eldridge & Becker (16) – Reionization **v2.0**
- Eldridge & Stanway (16) – GW events
- Bray & Eldridge (16,18) – Supernova kicks
- **Eldridge, Stanway et al. (17)** – Instrument paper **v2.1 *Kiwi***
- Xiao, Stanway & Eldridge (18,19) – HII regions
- **Stanway & Eldridge (18)** – Old populations **v2.2 *Tuatara***
- Eldridge, Stanway & Tang (19) – GW & EM transients
- Eldridge, Tang, Bray & Stanway (18) – Chirp mass distribution of GW events
- Eldridge, Xiao et al. (18) – CURVEPOPS 1
- Stanway & Eldridge (19) – IMF and ionizing photons
- Eldridge & Xiao (19) – NGC 6946 distance & progenitors
- Eldridge, Guo, Rodriguez et al. (19) – CURVEPOPS 2
- Tang, Eldridge, Stanway & Bray (2020) - SFH & GW events
- **Stevance et al. (2020) – Hoki**
- Stevance et al. (2020) – HII region ages - **AgeWizard**
- Chrimes et al. (2020) – Tides in BPASS and long-GRBs
- Stanway et al. (2020) – Changing initial binary parameters effects
- Eldridge, Beasor & Britzvskiy (2020) – Using RSGs to estimate star cluster ages
- Eldridge et al. (2020) – LB1 doesn't contain a 70Msun black hole
- Stanway et al. (2020) – Binary fractions, stellar populations and supernova rates.
- Coming soon: X-ray binaries and more... I need more time....

What is Hoki?

Note

NEW FEATURES: Check out AgeWizard - A pipeline to systematically age any resolved stellar population!

Bridging the gap between theory and observations

Historically, theoretical models have been released to the community with the expectation that users would create their own data handling scripts as they perform the analysis. This was in line with a research culture where most people had their own code, resulting in a duplication of effort and creating the potential for a reproducibility crisis, as most personal scripts are not shared with the community.

In order to facilitate the application of BPASS to a wide range of scientific investigations, we have developped the tools necessary for observers to take full advantage of our models in a stream-lined, intuitive manner.

> **Hoki is a dedicated python package designed to provide a user friendly interface to the BPASS models in order to bridge the gap between theory and observations.**

The varsatility of **Hoki** allows you to focus on the science, and worry less about the technical nitty gritty that comes with using the varied outputs of a theoretical code.

What is BPASS?

The **Binary Populations And Spectral Synthesis (BPASS)** code simulates stellar populations and follows their evolution until death. Including binary evolution is **crucial to correctly interpreting** astronomical observations. The detailed follow-up of the stellar evolution within the code allows the retreival of important information such as supernova and gravitational wave event rates, giving us the ability to understand the properties of the stellar populations that are the precursors of these events.

Figure 1

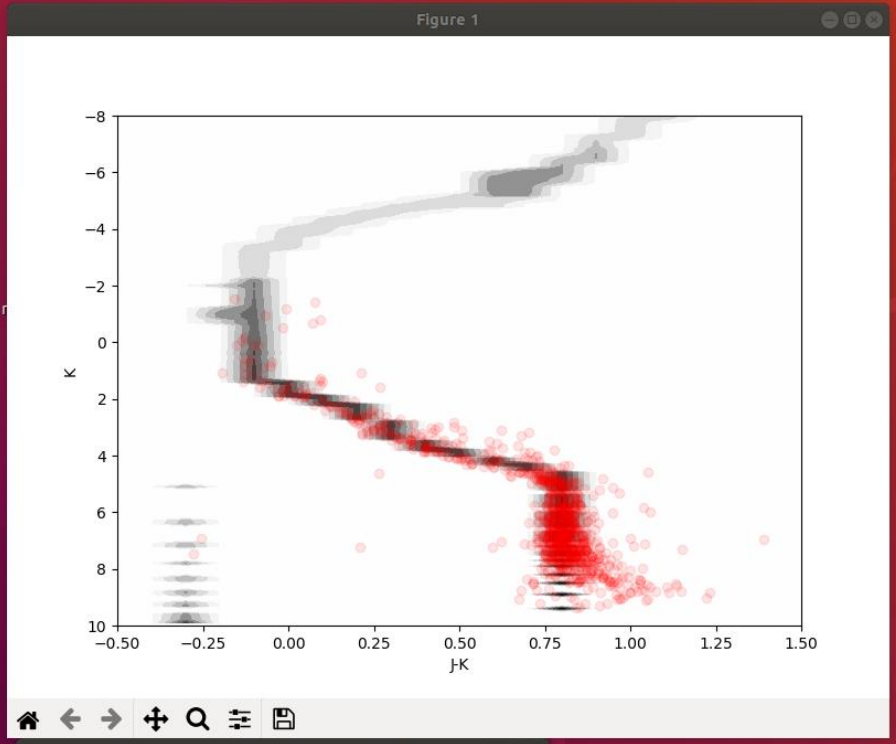
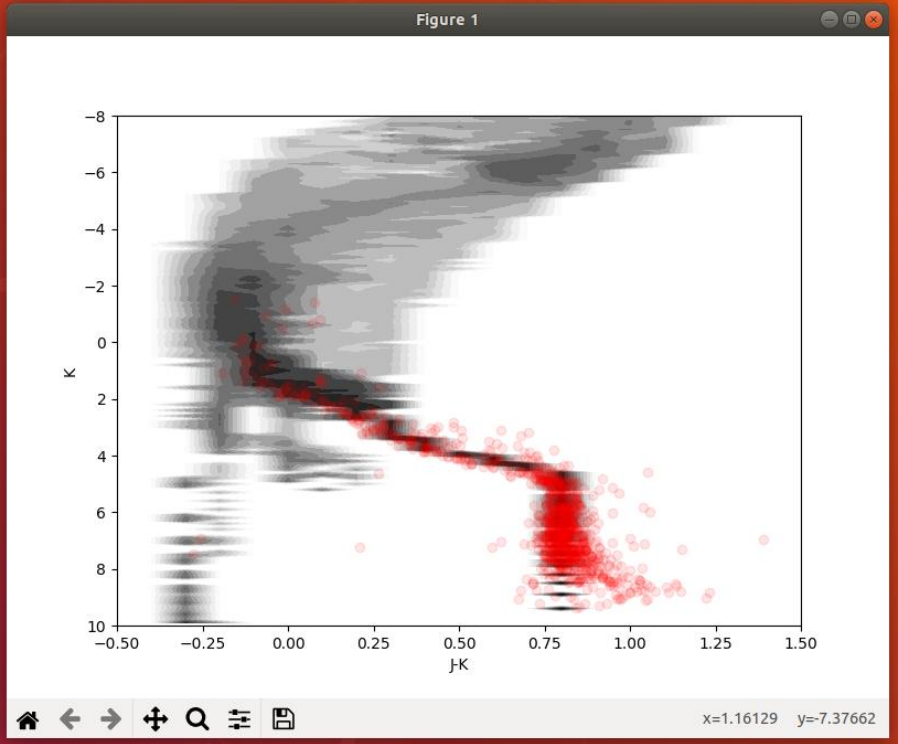


Figure 1



jan@jan-VirtualBox: ~/BPASS/hoki_test

```
jan@jan-VirtualBox:~$ cd BPASS/hoki_test/
jan@jan-VirtualBox:~/BPASS/hoki_test$ ls
cluster_gaia_binary.py   cluster_gaia.py~  cmdjjbin.py~  transients.py
cluster_gaia_binary.py~  cluster.py        cmdjj.py      transients.py~
cluster_gaia.py          cmdjjbin.py       cmdjj.py~
jan@jan-VirtualBox:~/BPASS/hoki_test$ python3 cluster_gaia.py
Created TAP+ (v1.2.1) - Connection:
        Host: gea.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
Created TAP+ (v1.2.1) - Connection:
        Host: geadata.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
INFO: Retrieving tables... [astroquery.utils.tap.core]
INFO: Parsing tables... [astroquery.utils.tap.core]
INFO: Done. [astroquery.utils.tap.core]
INFO: Query finished. [astroquery.utils.tap.core]
Looks like everything went well! You can check the path was correctly updated by
 looking at this file:
/home/jan/.local/lib/python3.6/site-packages/hoki/data/settings.yaml
```

jan@jan-VirtualBox: ~/BPASS/hoki_test

```
jan@jan-VirtualBox:~$ cd BPASS/hoki_test/
jan@jan-VirtualBox:~/BPASS/hoki_test$ python3 cluster_gaia_binary.py
Created TAP+ (v1.2.1) - Connection:
        Host: gea.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
Created TAP+ (v1.2.1) - Connection:
        Host: geadata.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
INFO: Retrieving tables... [astroquery.utils.tap.core]
INFO: Parsing tables... [astroquery.utils.tap.core]
INFO: Done. [astroquery.utils.tap.core]
INFO: Query finished. [astroquery.utils.tap.core]
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/home/jan/.local/lib/python3.6/site-packages/hoki/data/settings.yaml
```

That was some of the things binary stars do...