Interpreting Galaxies across Cosmic Time with Binary Population Synthesis Models

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Putting Warwick on the Map

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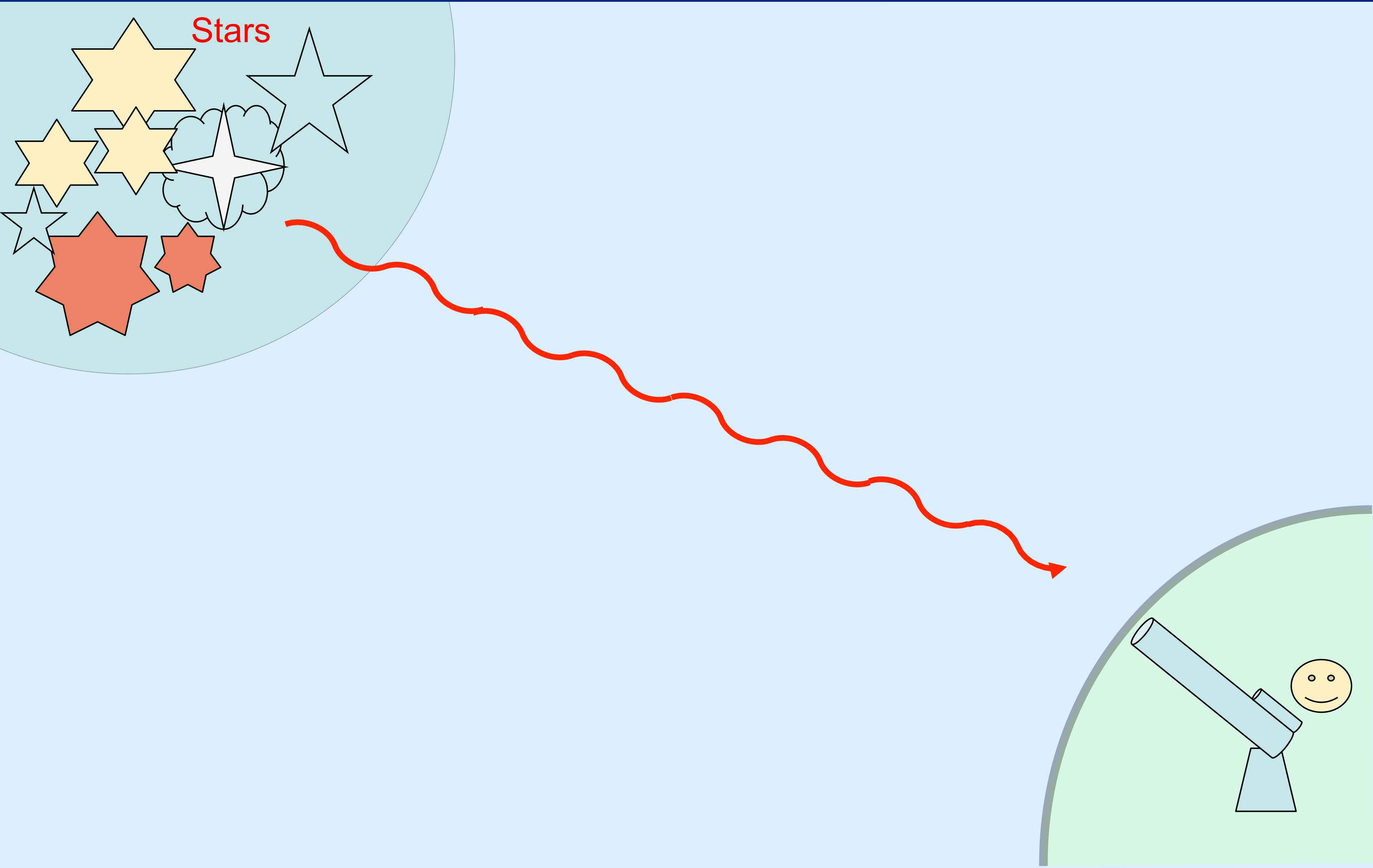
@WarwickAstro

London

Population Synthesis Models

- Studying distant, small or faint galaxies often means interpreting very incomplete data.
- We may only have broadband photometry, or a few strong emission lines.
- Interpreting these requires context from:
    - Comparison populations
    - Good theoretical models

Stellar Population Synthesis



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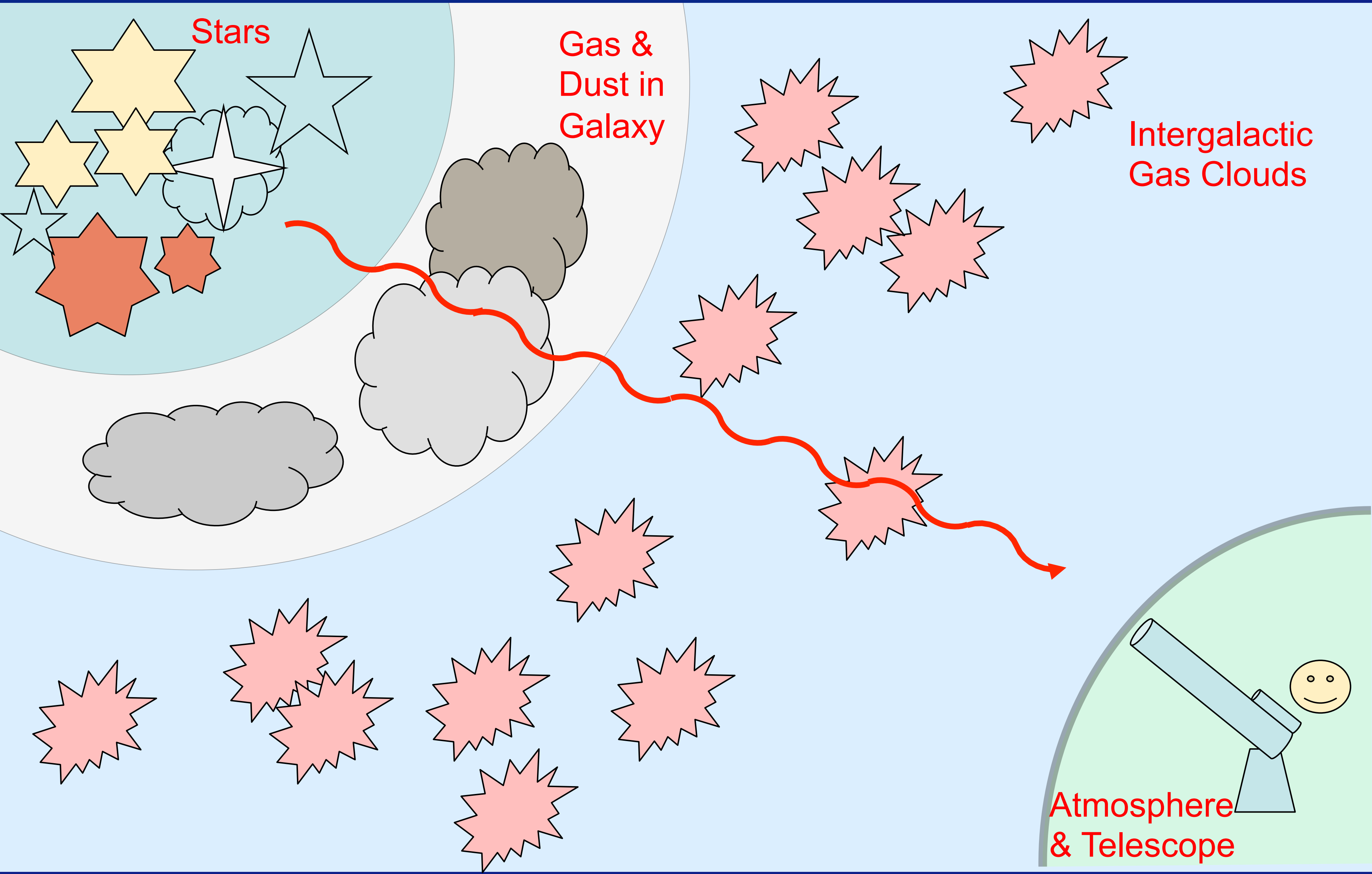

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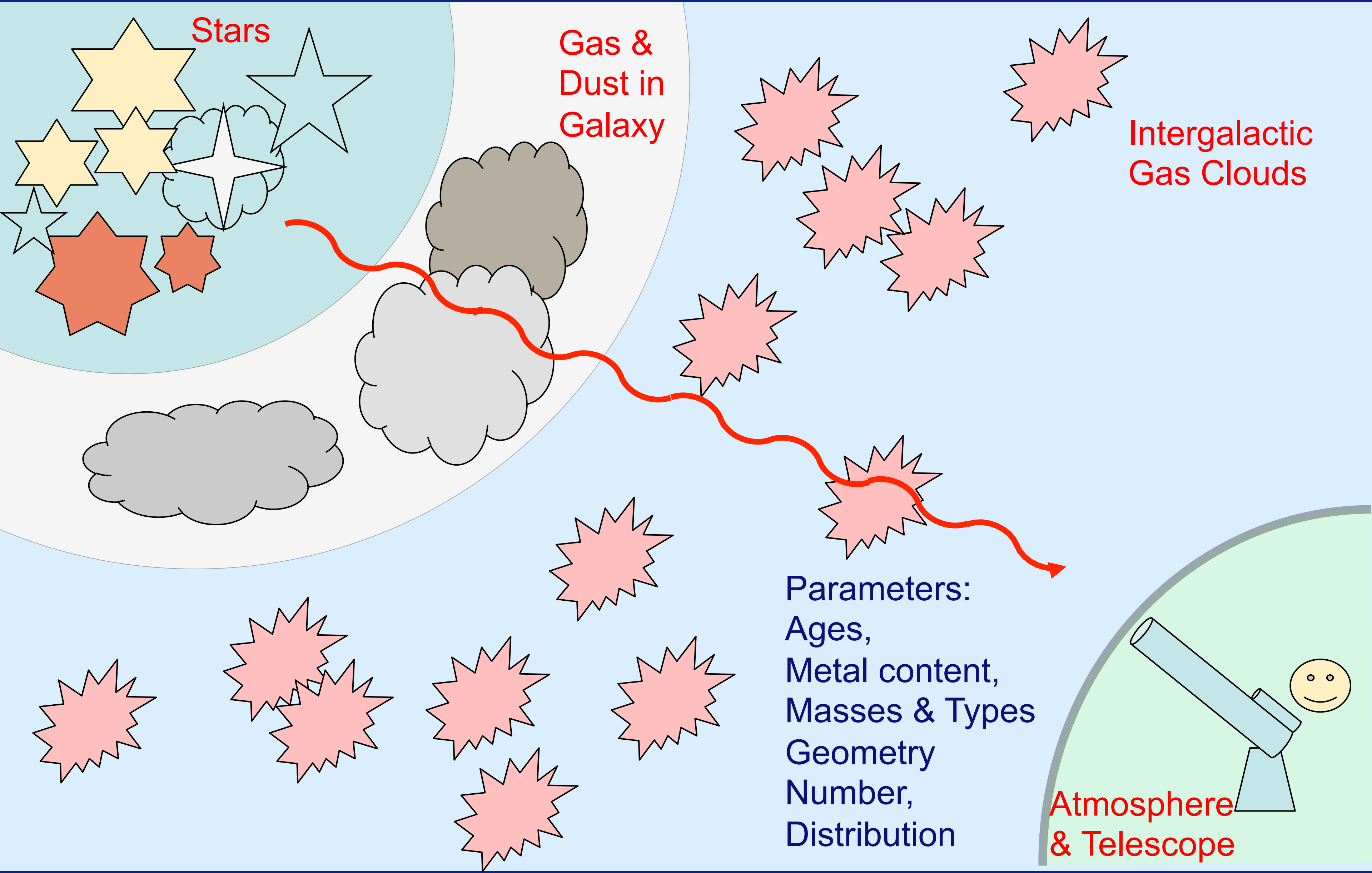

Parameters:
Ages,
Metal content,
Masses & Types
Geometry
Number,
Distribution

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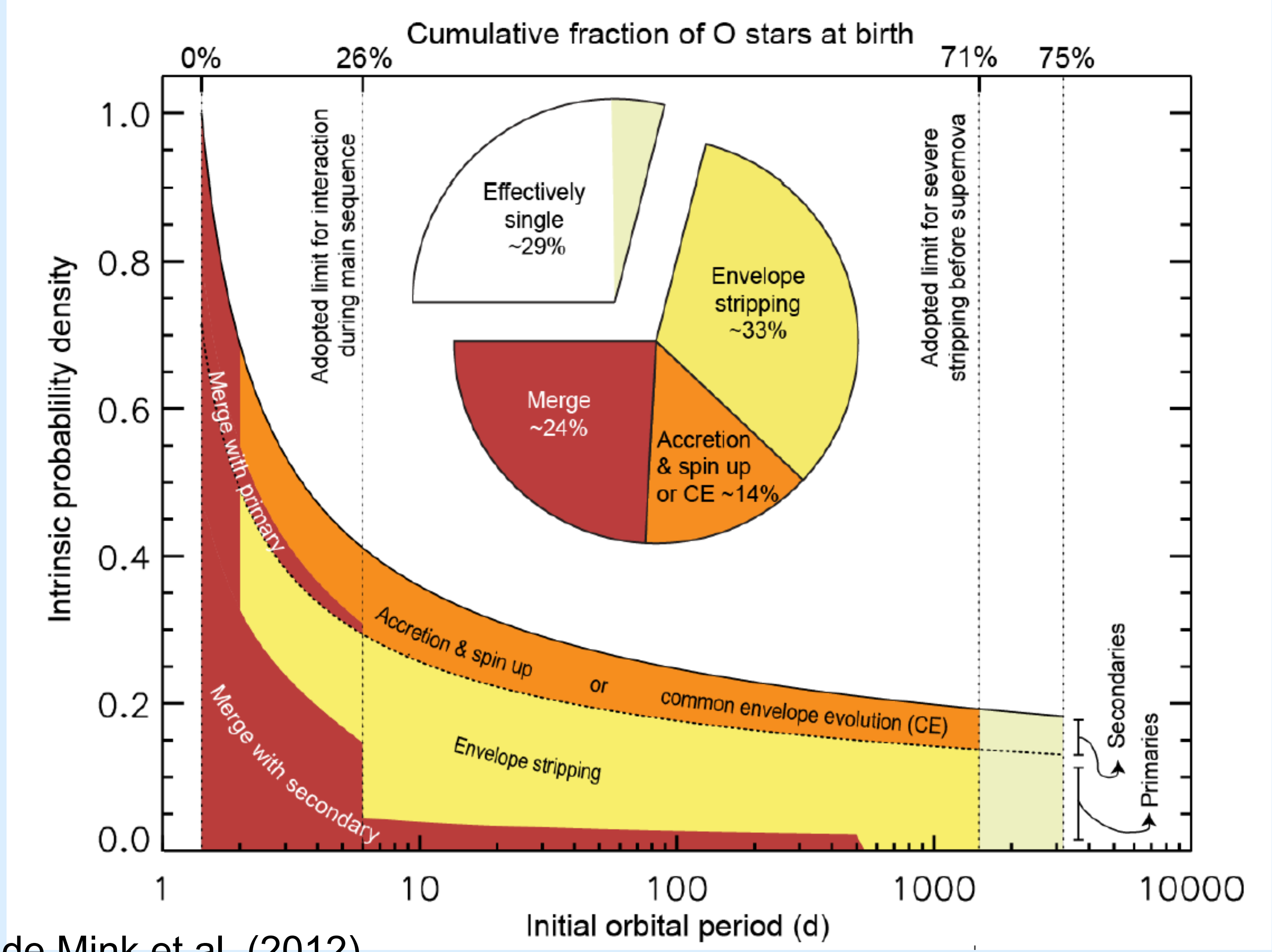
So what's missing…



Sana, de Mink et al. (2012)

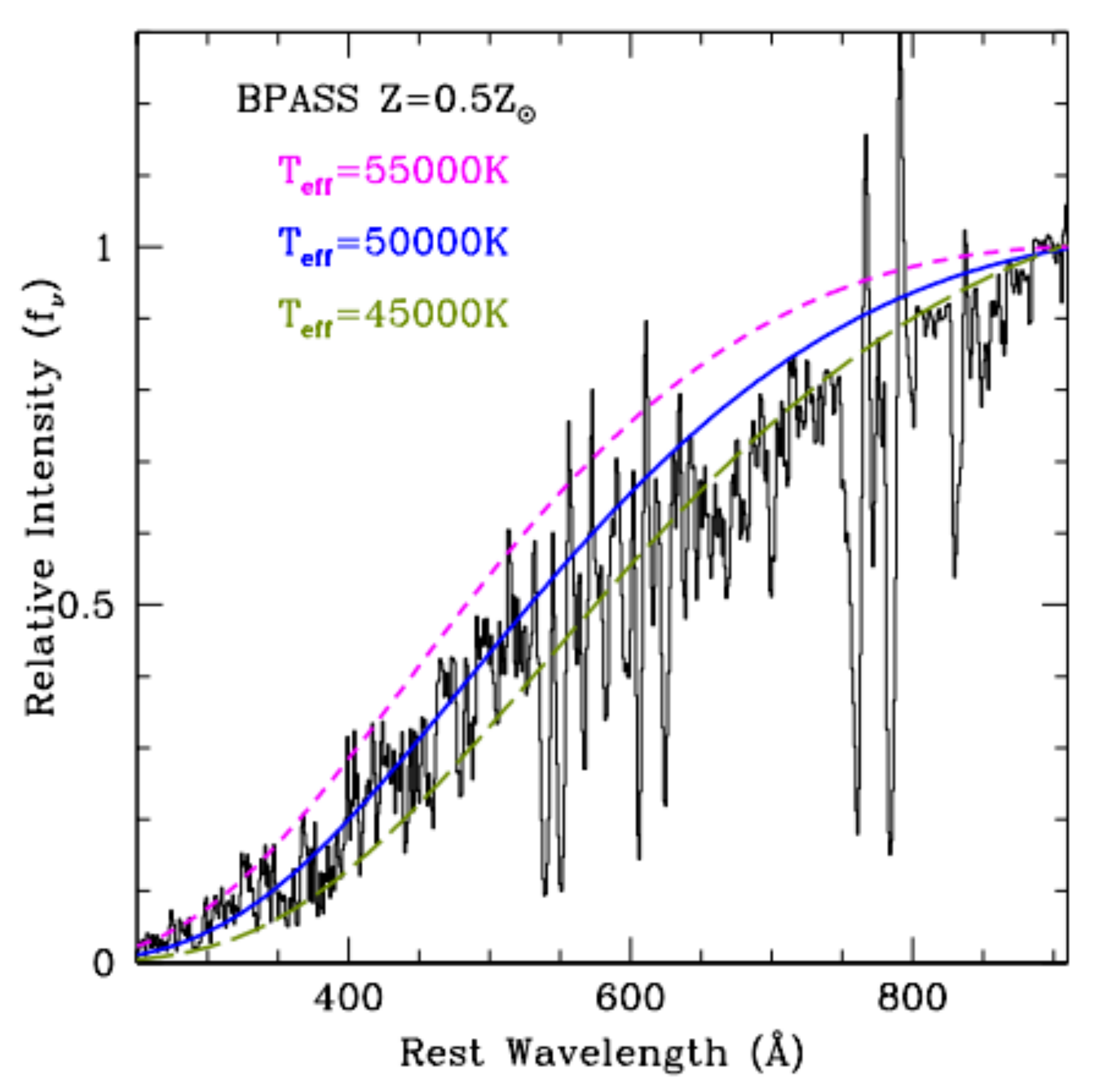
binary population & spectral synthesis

THE UNIVERSITY OF AUCKLAND
FACULTY OF SCIENCE

- Binary Population And Spectral Synthesis
- **15,000 detailed** stellar evolution models.
- Can be used to study a broad range of astrophysical systems: stars, **supernovae**, clusters and galaxies.
- **BPASS.AUCKLAND.AC.NZ**
- Next-gen models (**>100,000 models**, more masses, more metallicities, rotation?) hopefully 2015-2016ish...

(Eldridge & Stanway 2009, 2012)

Ionising Spectra

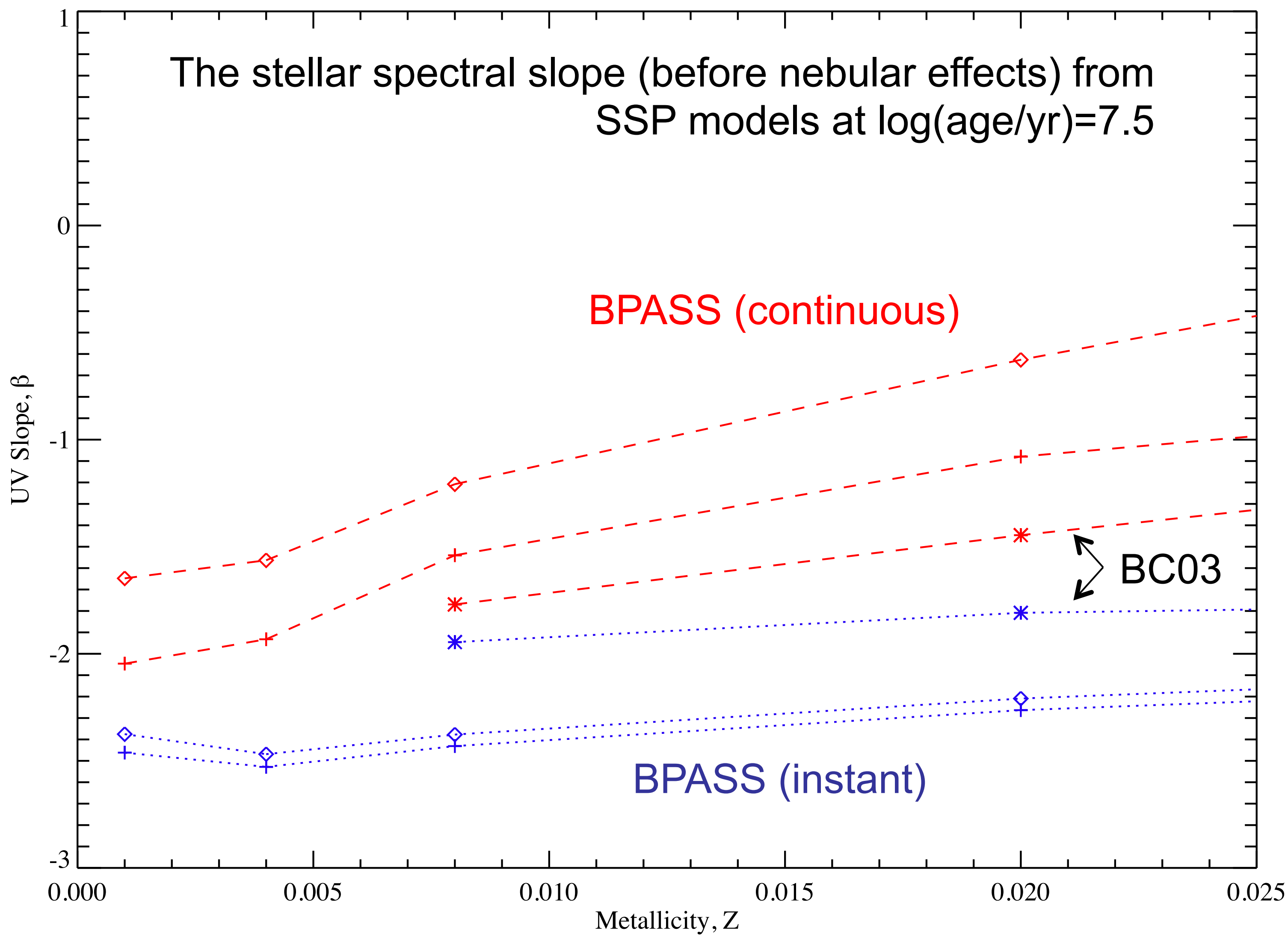


Binary pathways lead to more massive and WR stars in a stellar population at late times

The resulting spectrum is 'hotter' with a bluer ultraviolet spectrum

Plot from Steidel et al 2014

Ionising Spectra



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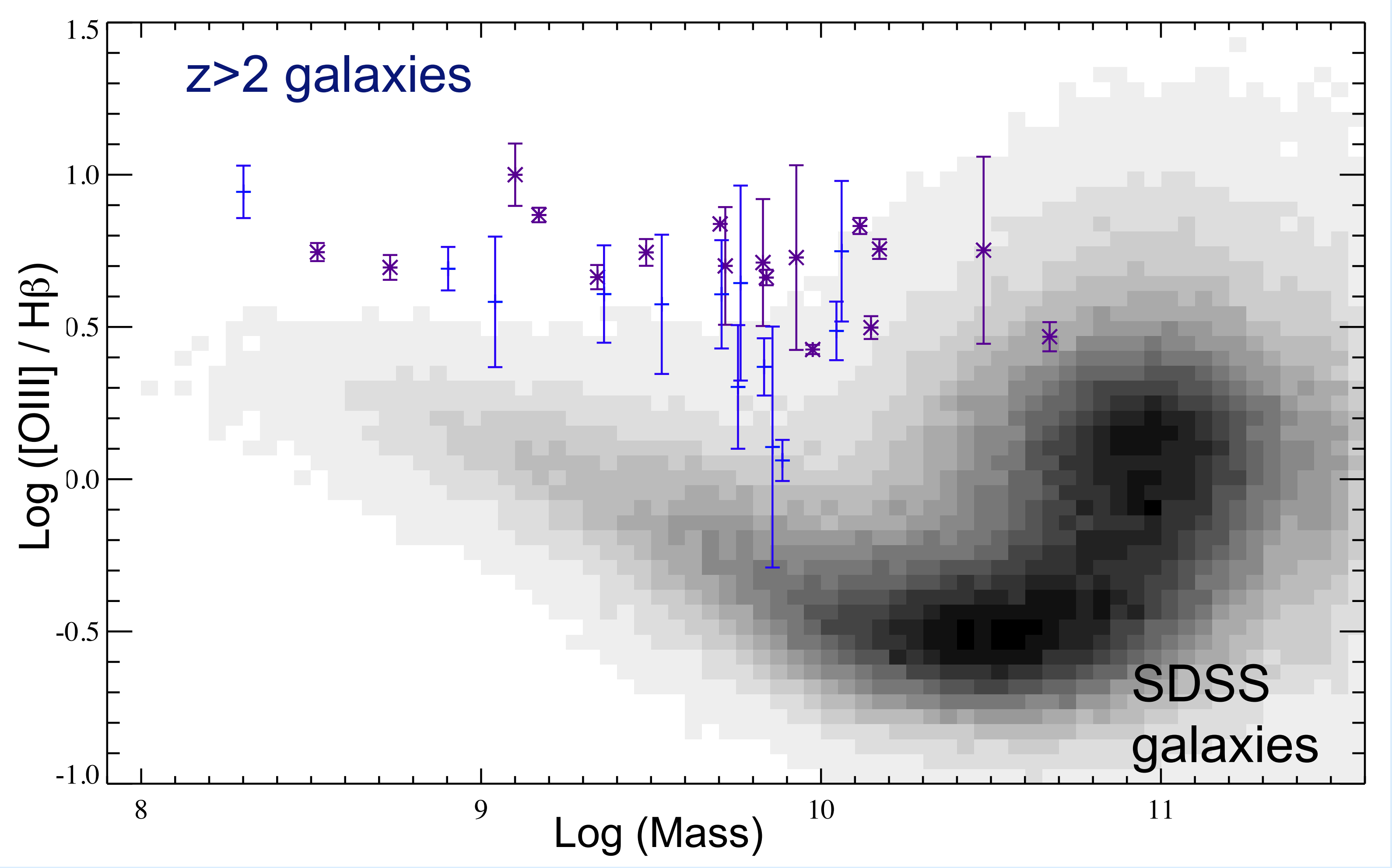
Emission Line Diagnostics

The ratio of optical emission line strengths provides information on the hardness of the ionizing radiation field



Masters et al 2014
Schenker et al 2013

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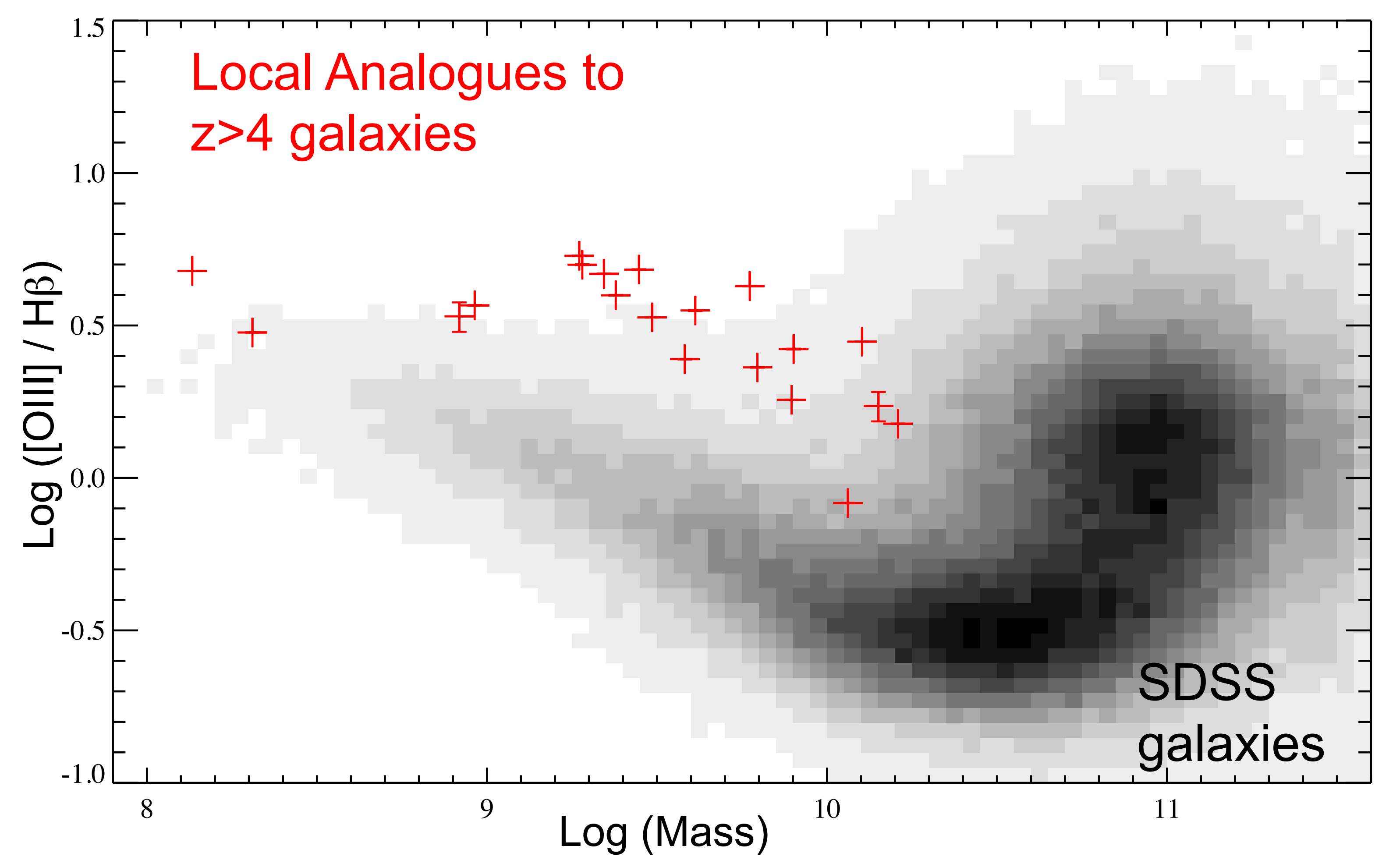

Stanway et al, 2014, MNRAS 444 3466

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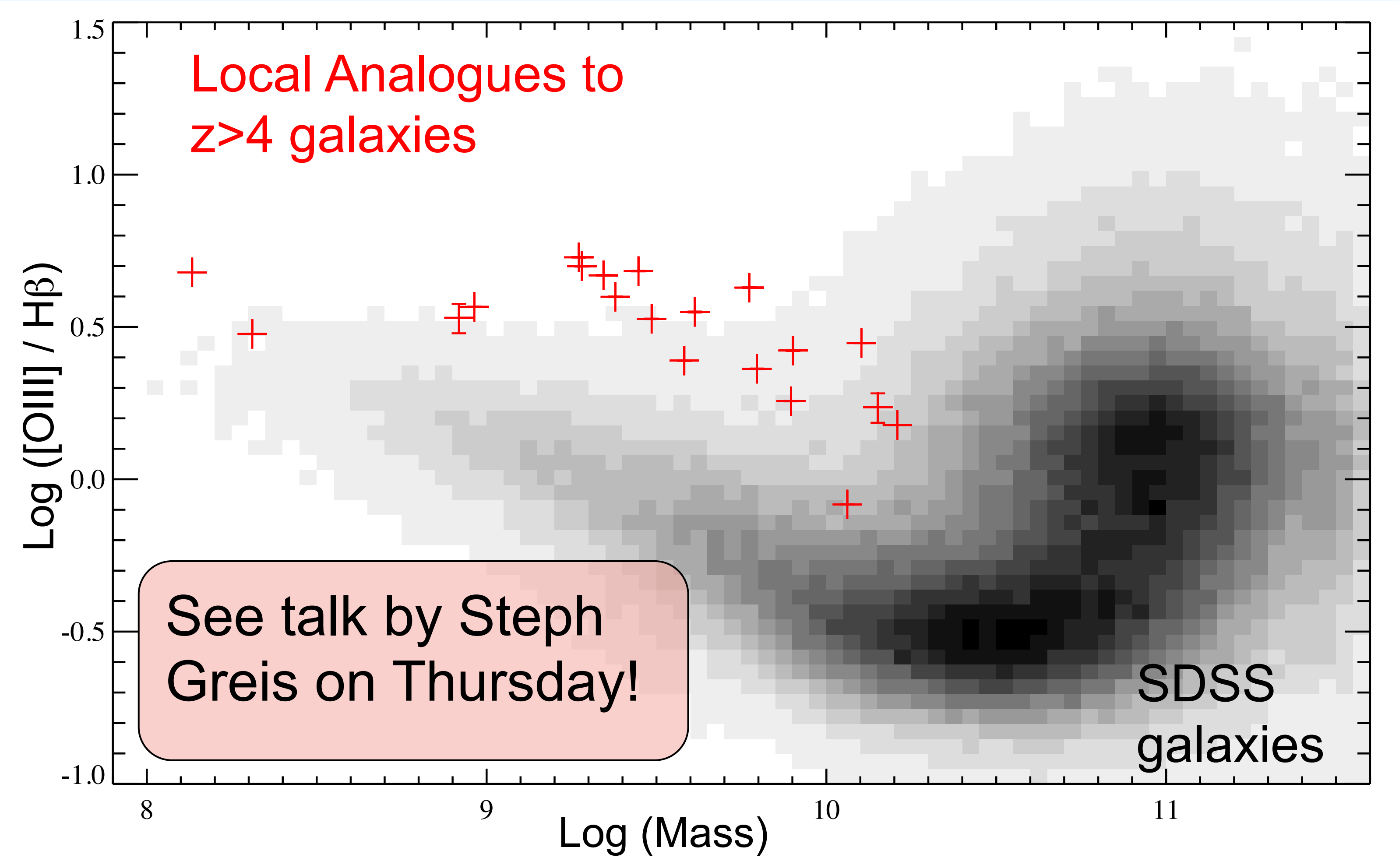

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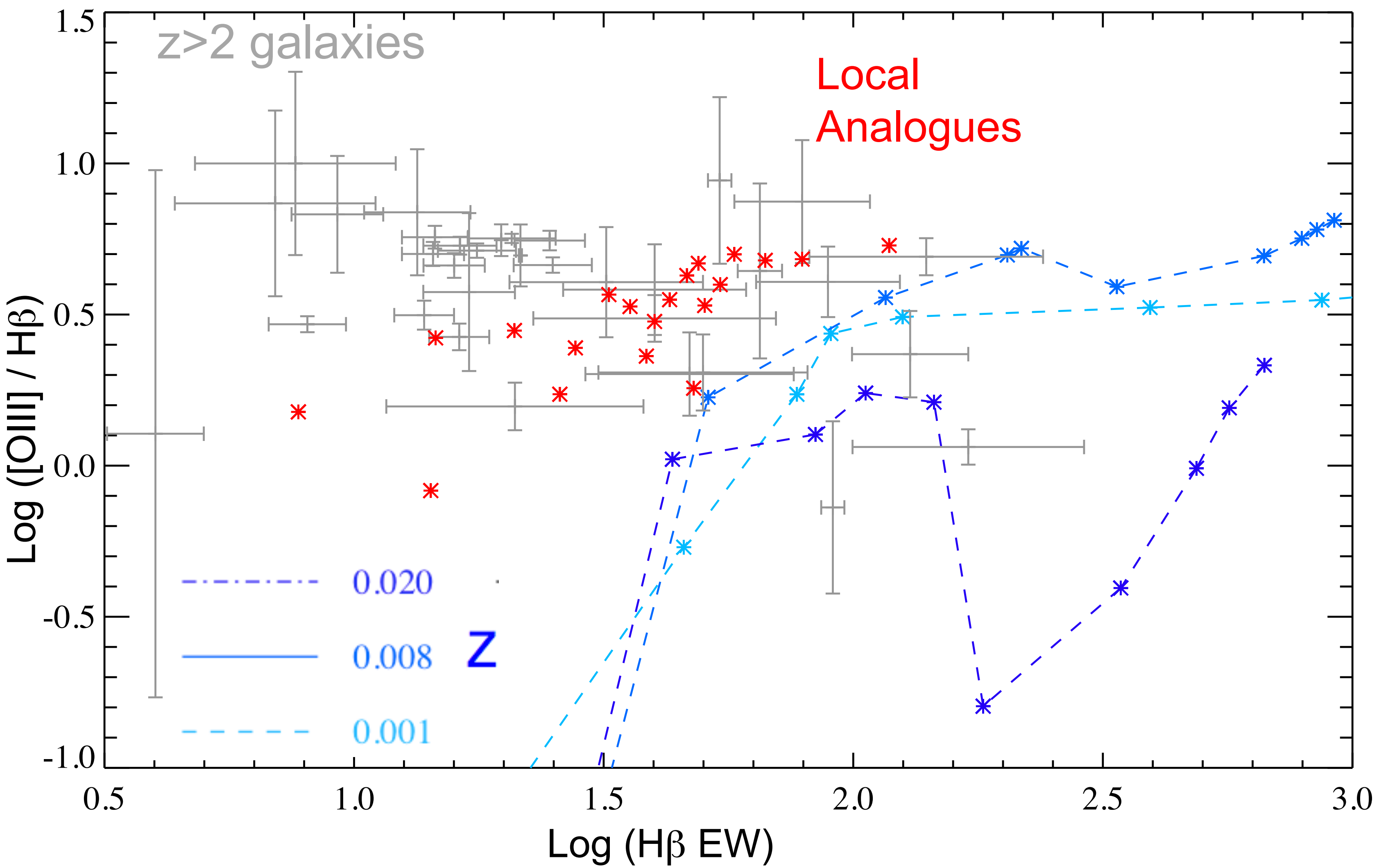

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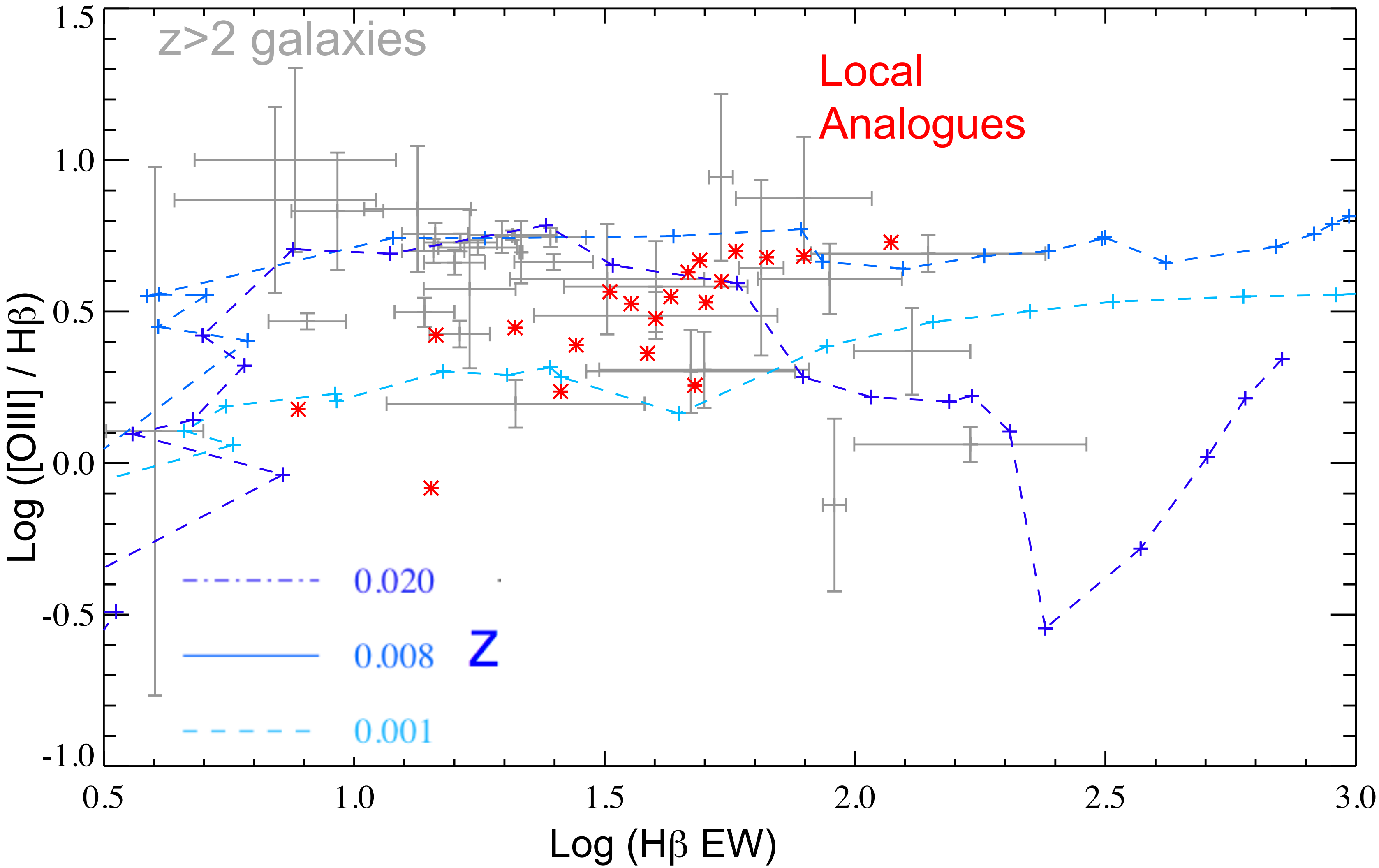

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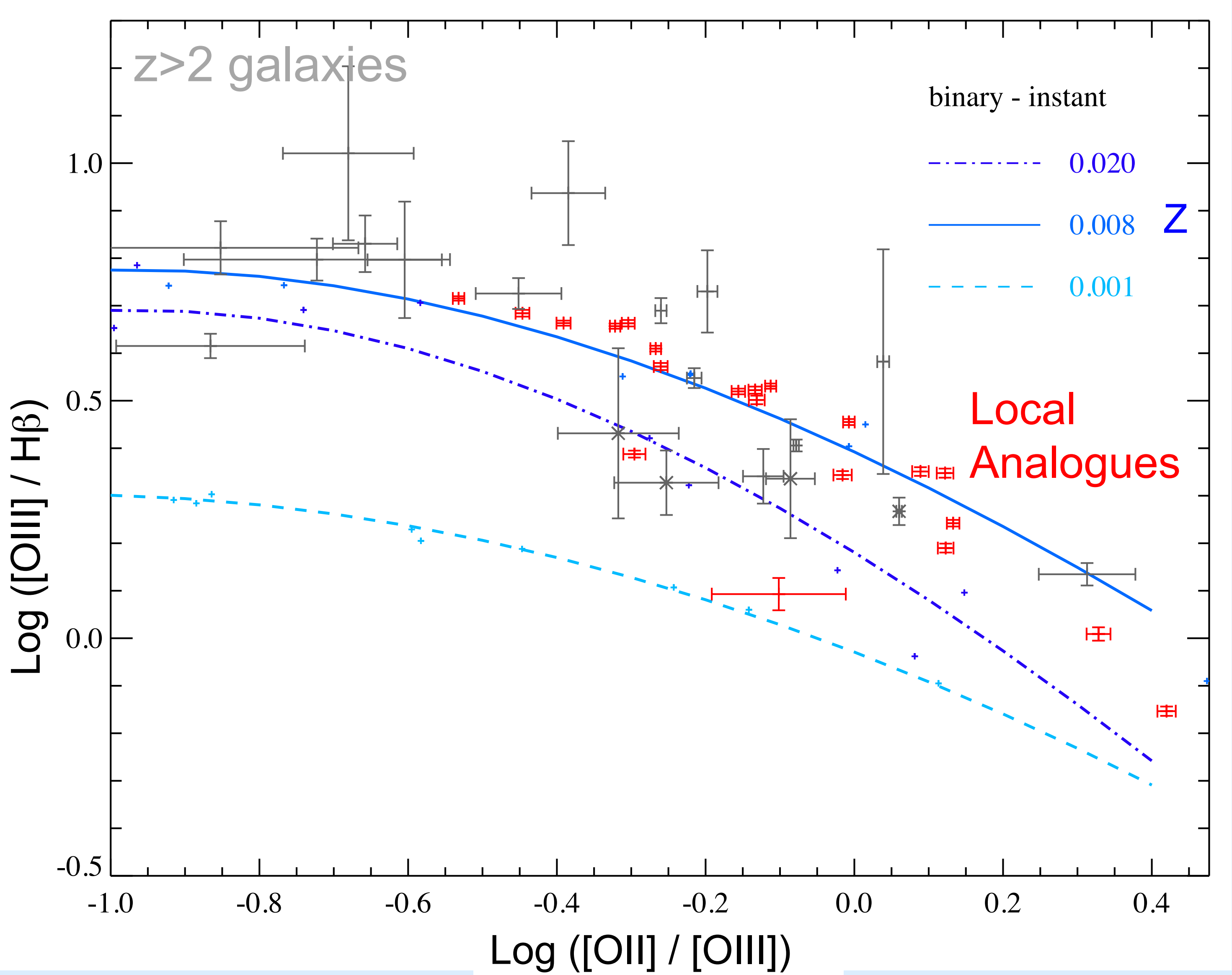

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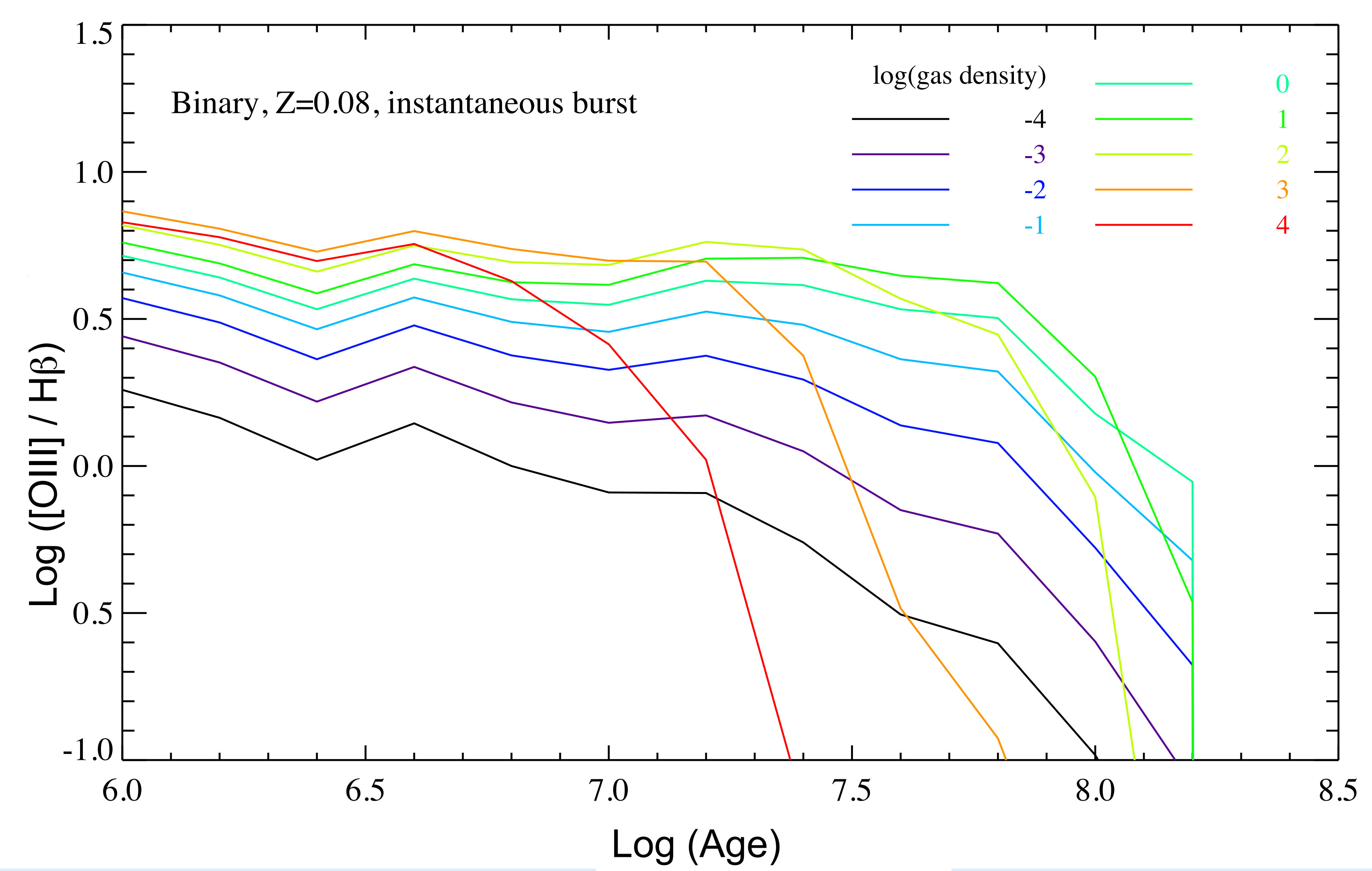

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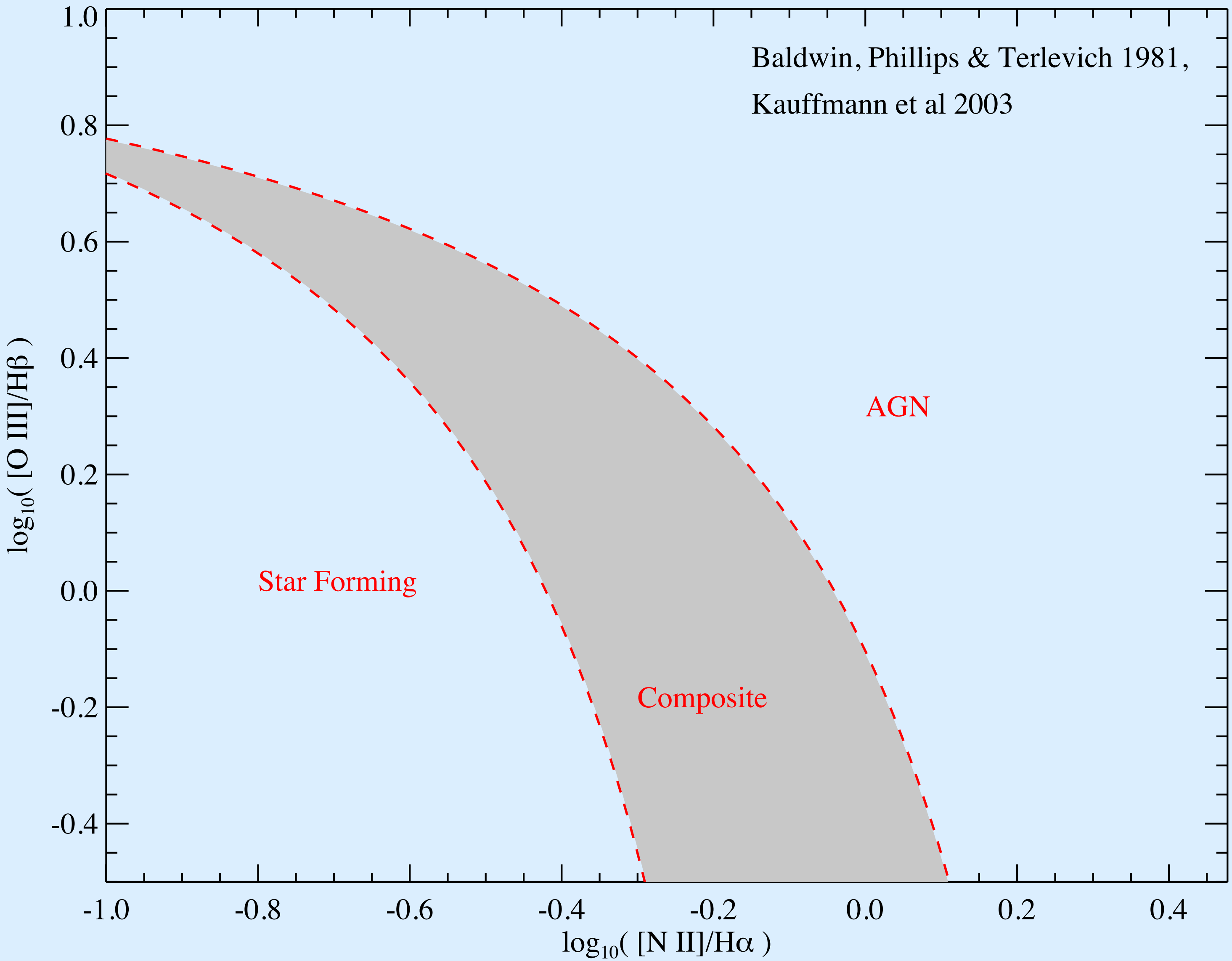
Reconsidering line classifications



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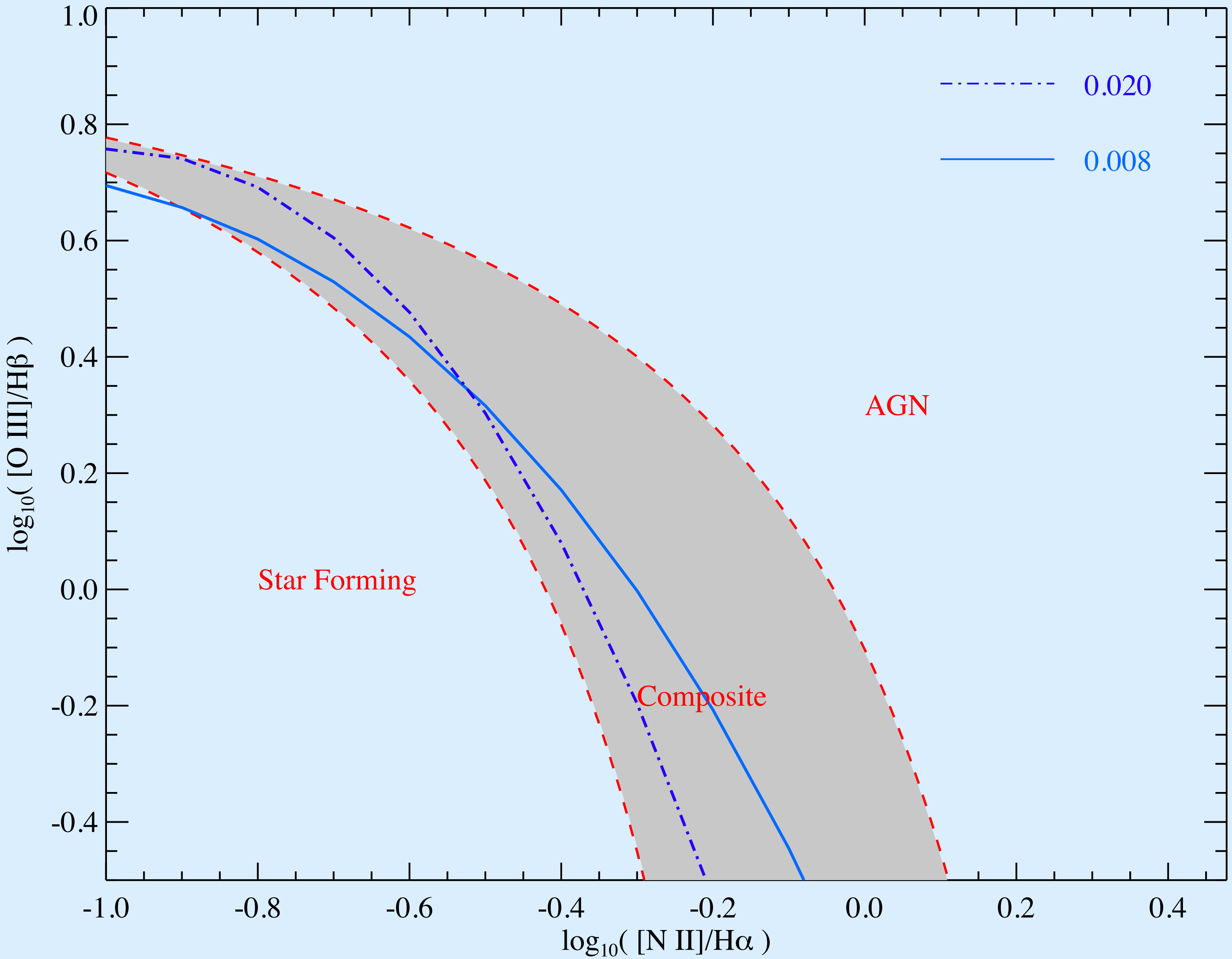


GRB Host 080517

GRBs are the most luminous explosions in the Universe

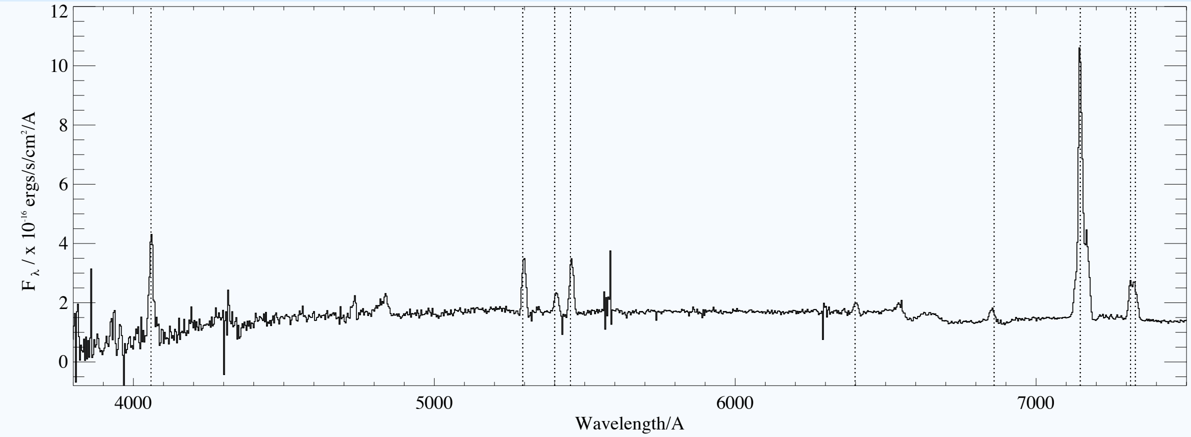
They (probably) end the lives of very massive stars

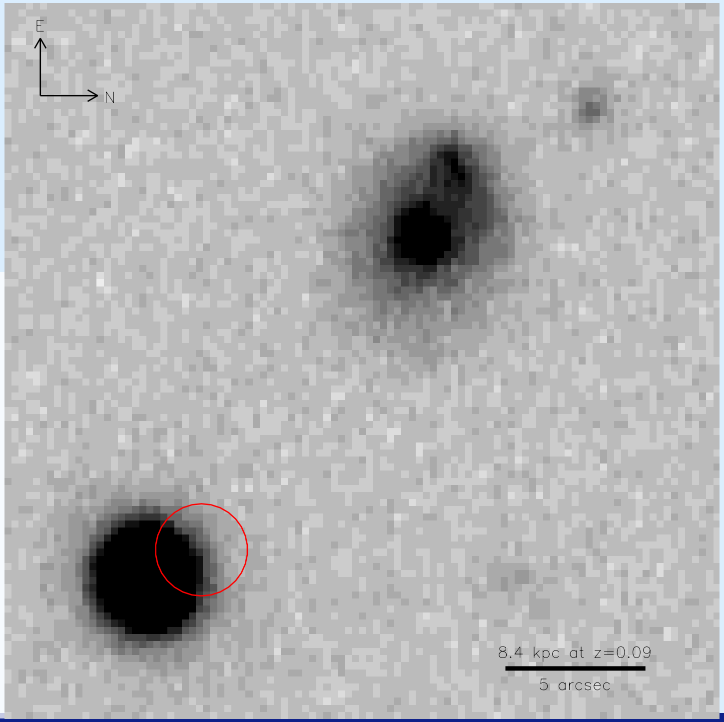
GRB 080517 occurred at unusually low redshift (z=0.09)

Its spectrum shows emission lines (i.e. recent star formation)

(Stanway et al 2015 MNRAS 446 3911
Stanway et al 2015 ApJ 798 L7)

This may be triggered by a neighbour at the same redshift





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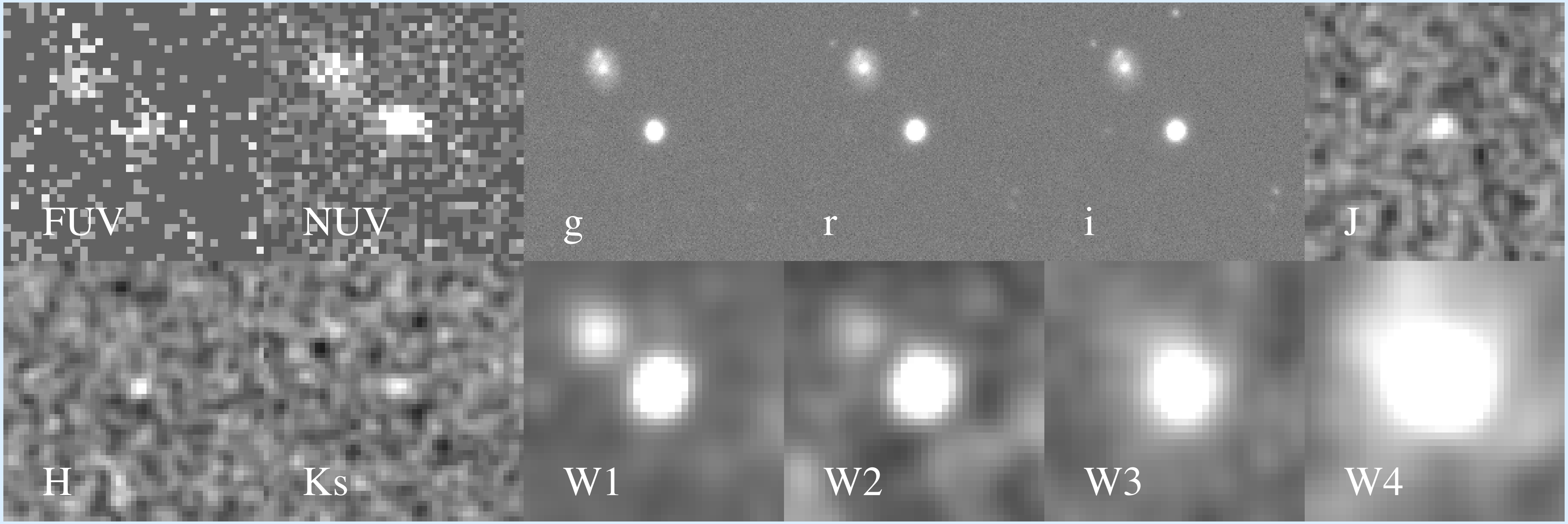
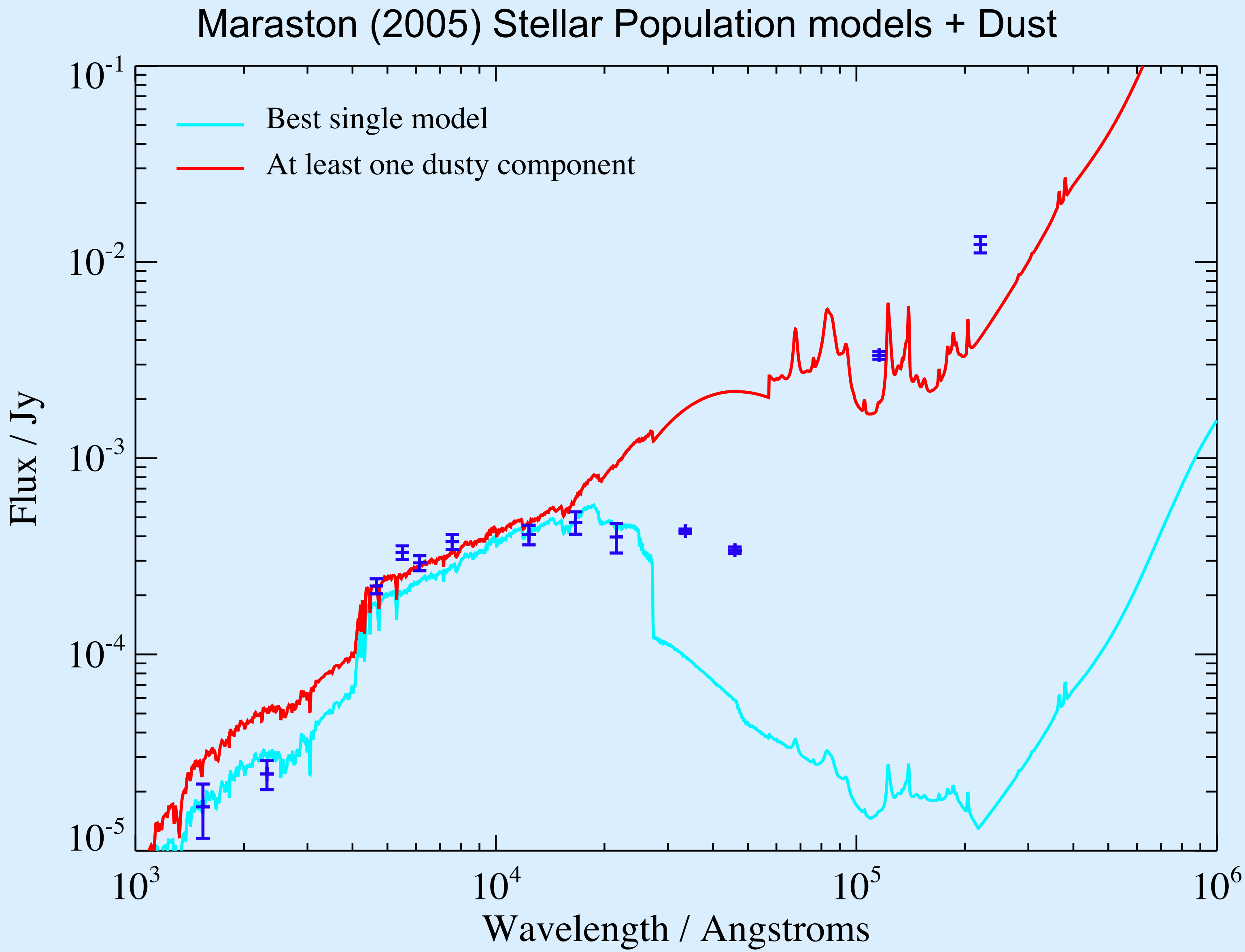


GRB 080517 occurred at unusually low redshift (z=0.09)…

It also appears to be extremely red in the infrared (out to 22μm)

Based on radio, emission lines, UV continuum and infrared, we estimate a star formation rate of ~16 $M_\odot$/yr

GRB Host 080517



Stanway et al 2015 MNRAS 446 3911

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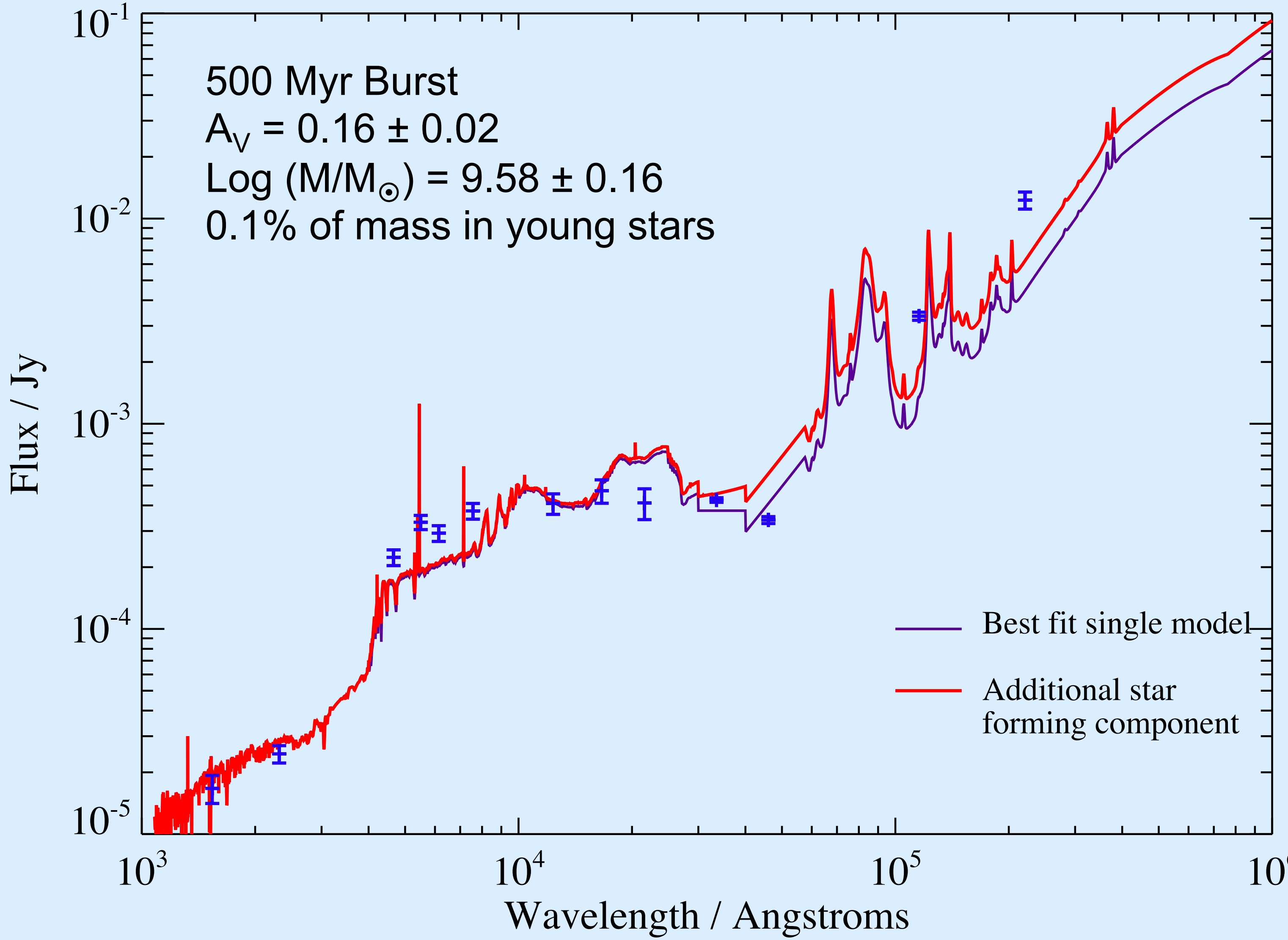
GRB Host 080517

BPASS Stellar Population models + Dust



Stanway et al 2015 MNRAS 446 3911

Plans for Development

- Modifications to stellar populations:
  - Secondary star treatment
  - White dwarfs and accretion
  - Building multiple stellar populations
  - Metallicity evolution

Plans for Development

- Modifications due to wider environment
  - – Gas geometries and densities
  - – Radio continuum from supernovae and their remnants
  - – Self-consistent treatment of dust emission in infrared
  - – Star formation histories and metallicities

Conclusions

- Binary evolution pathways are particularly important for massive stars and young starbursts, and for low metallicities
- These are particularly important at high redshift and in the rest-frame UV.
- Incorporating these in stellar population synthesis models can match observed properties of galaxy populations
- Our BPASS models include detailed binary models – bpass.auckland.ac.uk
- These are under ongoing development

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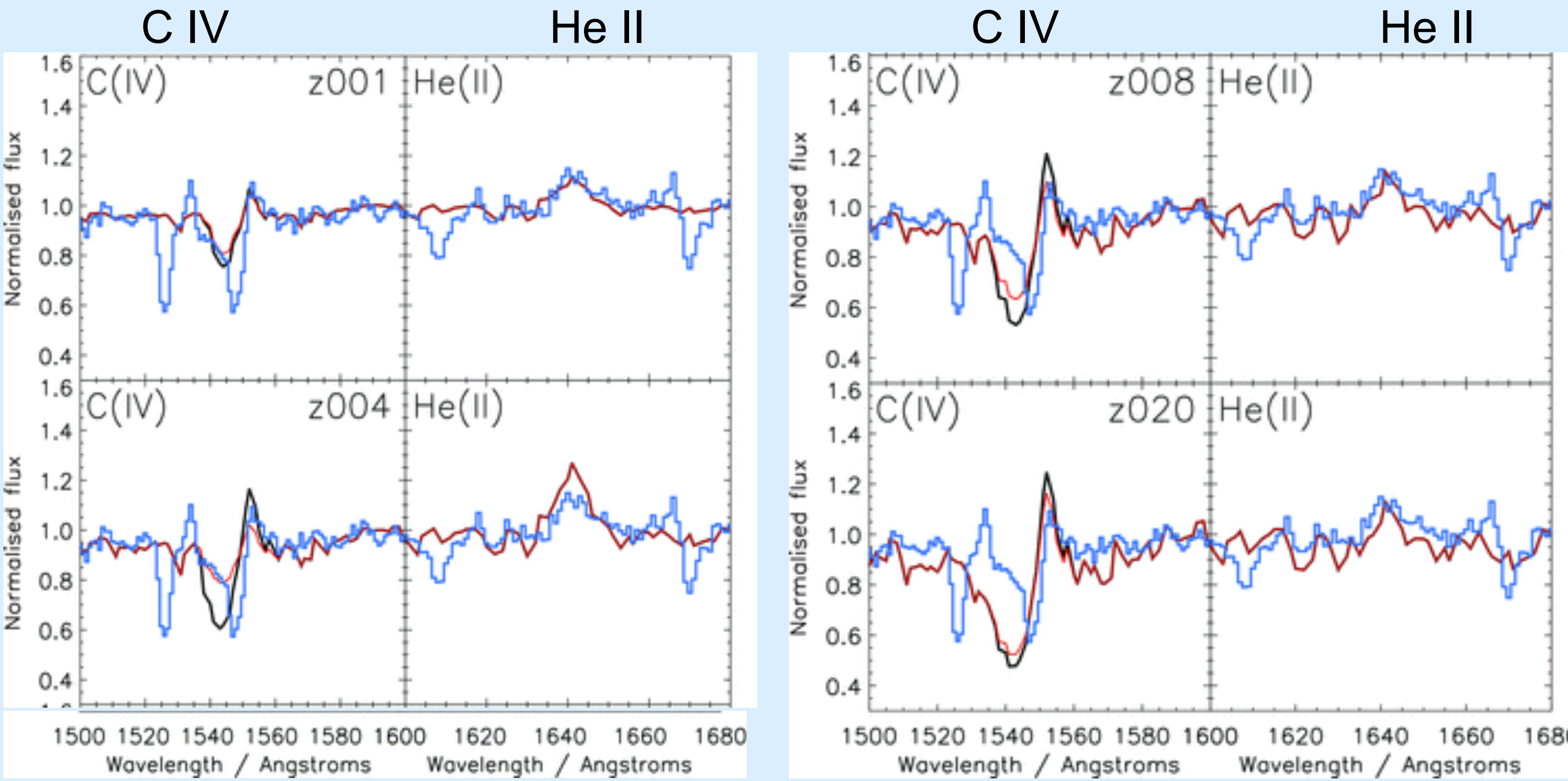
… watch this space!

Case Study: z=3 Spectra



Fitting the Shapley et al (2003) composite, we find good matches to the stellar component at low metallicities

(Eldridge & Stanway, 2012, MNRAS, 419, 479)

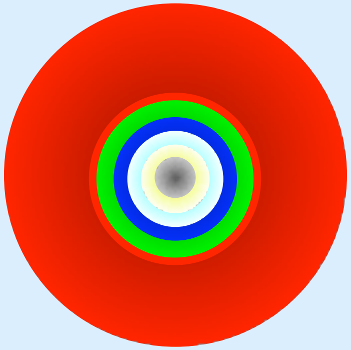
Case Study: z=3 Spectra

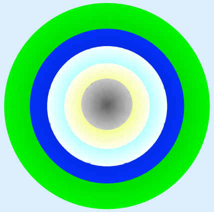
BPASS fitting reveals the variety of z~2-3 galaxies:

z=2-3 galaxy	BPASS metallicity	Reduced [C/O]?	Needs QHE?	Previous metallicity	Previous [C/O]
Composite	7.6-8.5	✔	✔	7.7-8.7	0.2
BX 418	7.6-8.2	✔	✔	7.7-8.1	0.2
8 o'clock arc	7.6-8.2	✔	✔	8.3-8.6	
Cosmic Eye	8.2-8.5	✔		~8.3	
cB58	8.2-8.5	✔		~8.4	
Cosmic Horseshoe	8.2-8.5	✔		~8.4	

(Eldridge & Stanway, 2012, MNRAS, 419, 479)

Case Study: Core-collapse supernovae

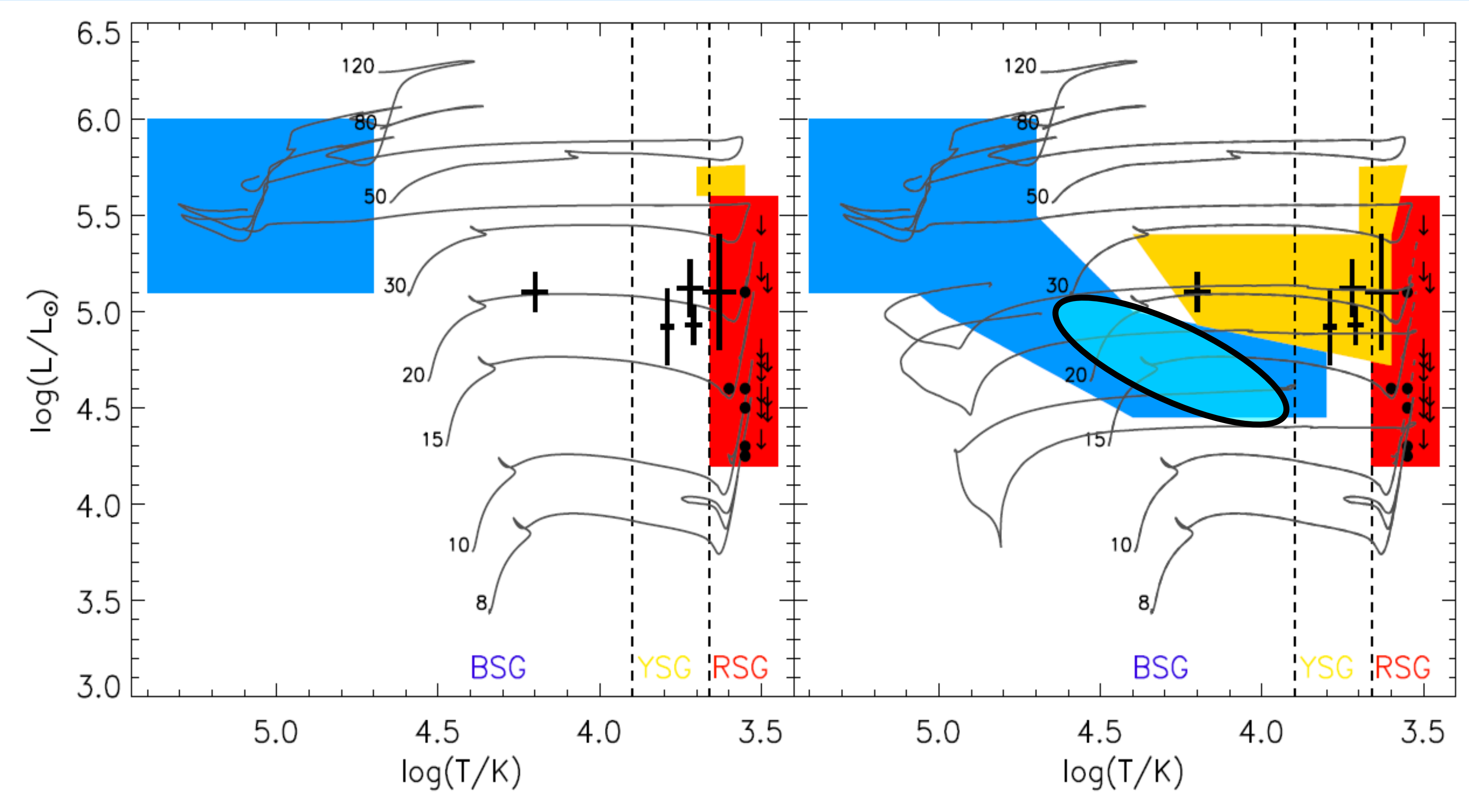




Supernova	Type II	Type Ib/c
Observations	71±9%	29±6%
Single stars	85%	15%
Mix	71%	29%
Binaries	63%	37%

Case Study: Core-collapse supernovae

Single stars | Binaries



Eldridge et al . (2013, 2014)

Extended LBA sample