A Model for [NII]/Hα(M,z)

Empirical Modeling of the Redshift Evolution of the [NII]/Hα ratio for Galaxy Redshift Surveys and Simulations

Andreas Faisst (Caltech/IPAC)
afaisst@caltech.edu
@astrofaisst

D. Masters *(JPL)*, Y. Wang *(Caltech/IPAC)*, A. Merson *(JPL)*, P. Capak *(Caltech/IPAC)*,
S. Malhotra *(Arizona SU)*, J. Rhoads *(Arizona SU)*

Simulated Skies, Madrid, April 25 2018

Why do we care about the [NII]/Hα ratio

- Hα is (likely) the strongest optical emission line: used to probe cosmology and astrophysical properties of galaxies
- Hα is blended with [NII] for $R < 800$ (*[NII] can be strong*)

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- Realistic **simulated observations** for future surveys (*Euclid* and *WFIRST*) *(A. Merson's talk)*
- Correct for systematic offset in **redshift measurement** from ([NII]+Hα) for *Euclid* *(many talks on Monday)*

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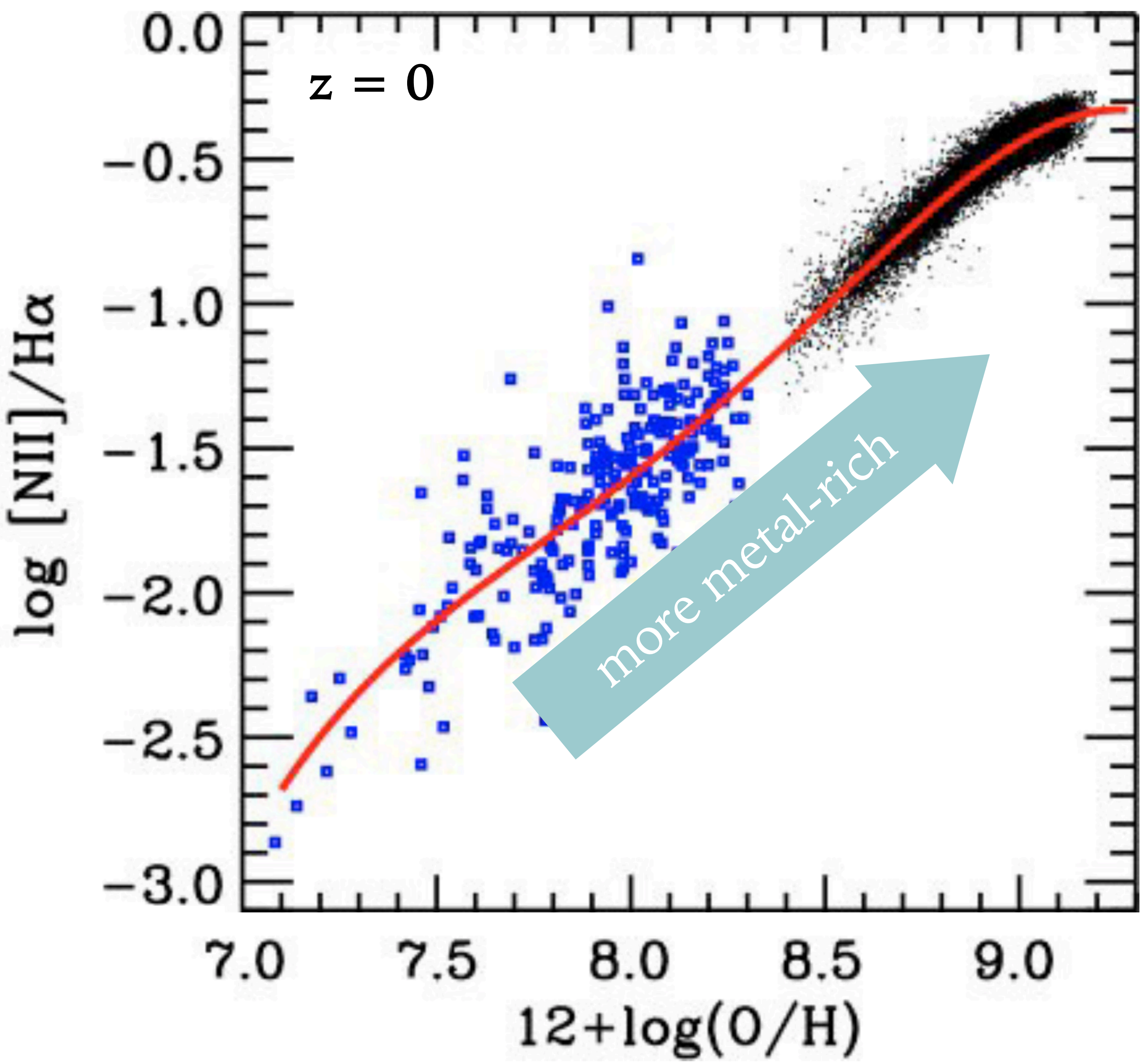
COSMOLOGY & SIMULATIONS	GENERAL ASTROPHYSICS
• Realistic **simulated observations** for future surveys (*Euclid* and *WFIRST*) *(A. Merson's talk)* • Correct for systematic offset in **redshift measurement** from ([NII]+Hα) for *Euclid* *(many talks on Monday)*	• Deblended intrinsic **Hα LF** from low-resolution spectroscopic (grism) and narrow-band surveys • Probe mass assembly with **accurate star-formation rates** from Hα • Plan future galaxy surveys

Dependencies of [NII]/Hα ratio

- Depends on various galaxy properties such as **metallicity**, **stellar mass, star-formation activity, …**



Maiolino+08

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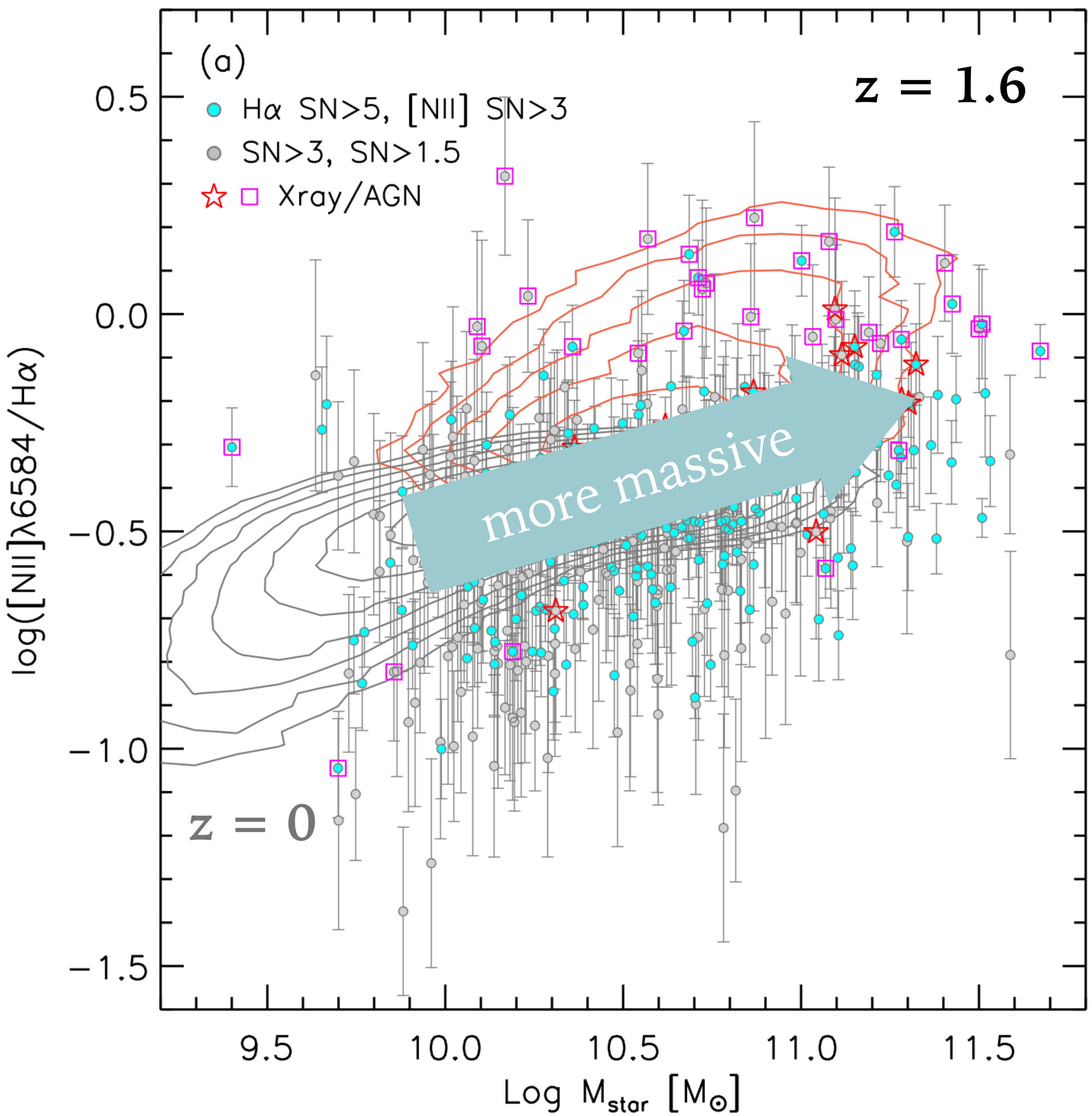

Masters+16
Kashino+16

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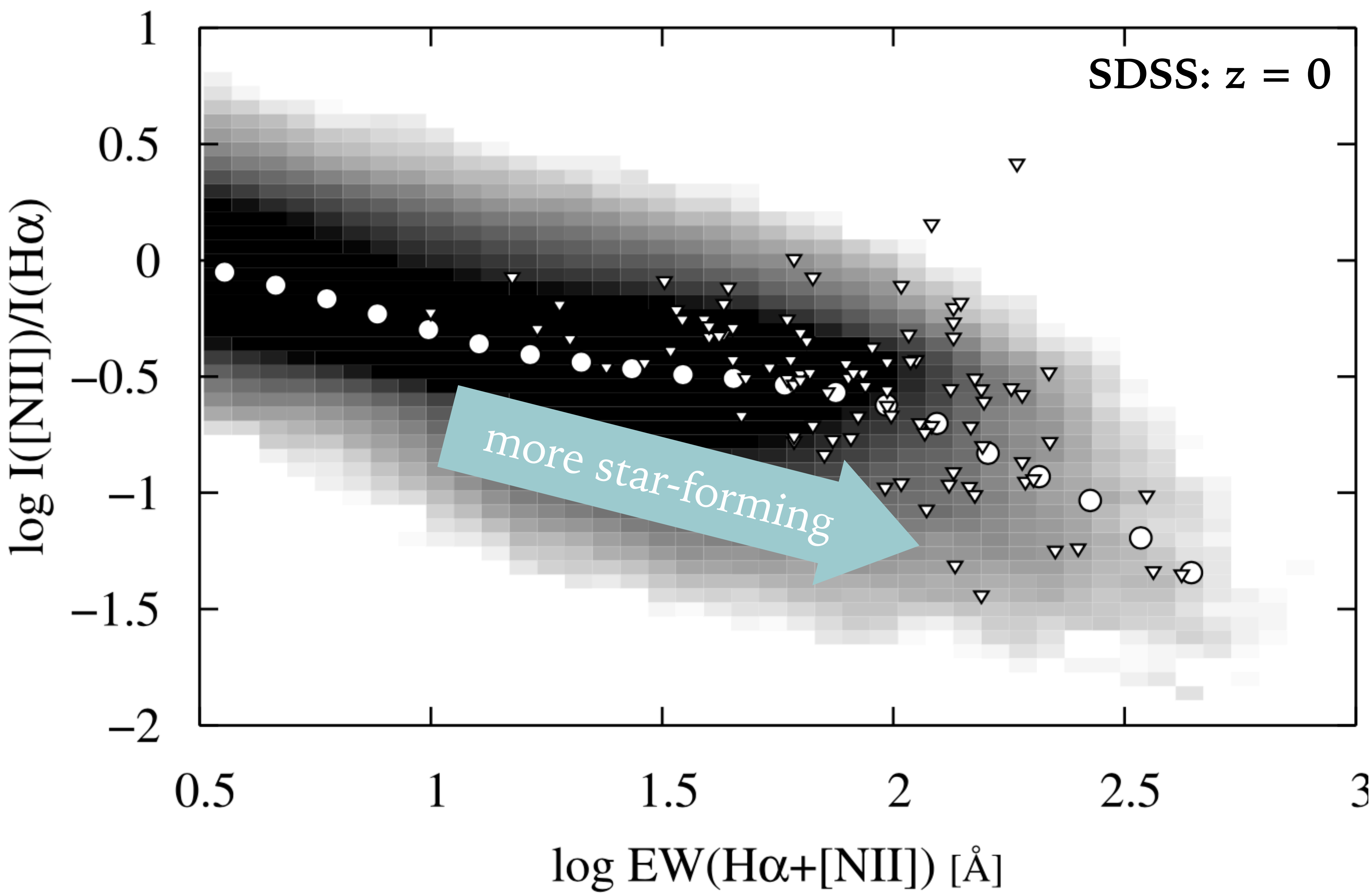

~ sSFR (=SFR/M)

Villar+08

Dependencies of [NII]/Hα ratio: the BPT-diagram

- The BPT-diagram combines dependencies of [NII]/Hα
- Strongest and perpendicular: stellar mass and sSFR!

Faisst+2018

see also: Shapley+15, Masters+16, Strom+17

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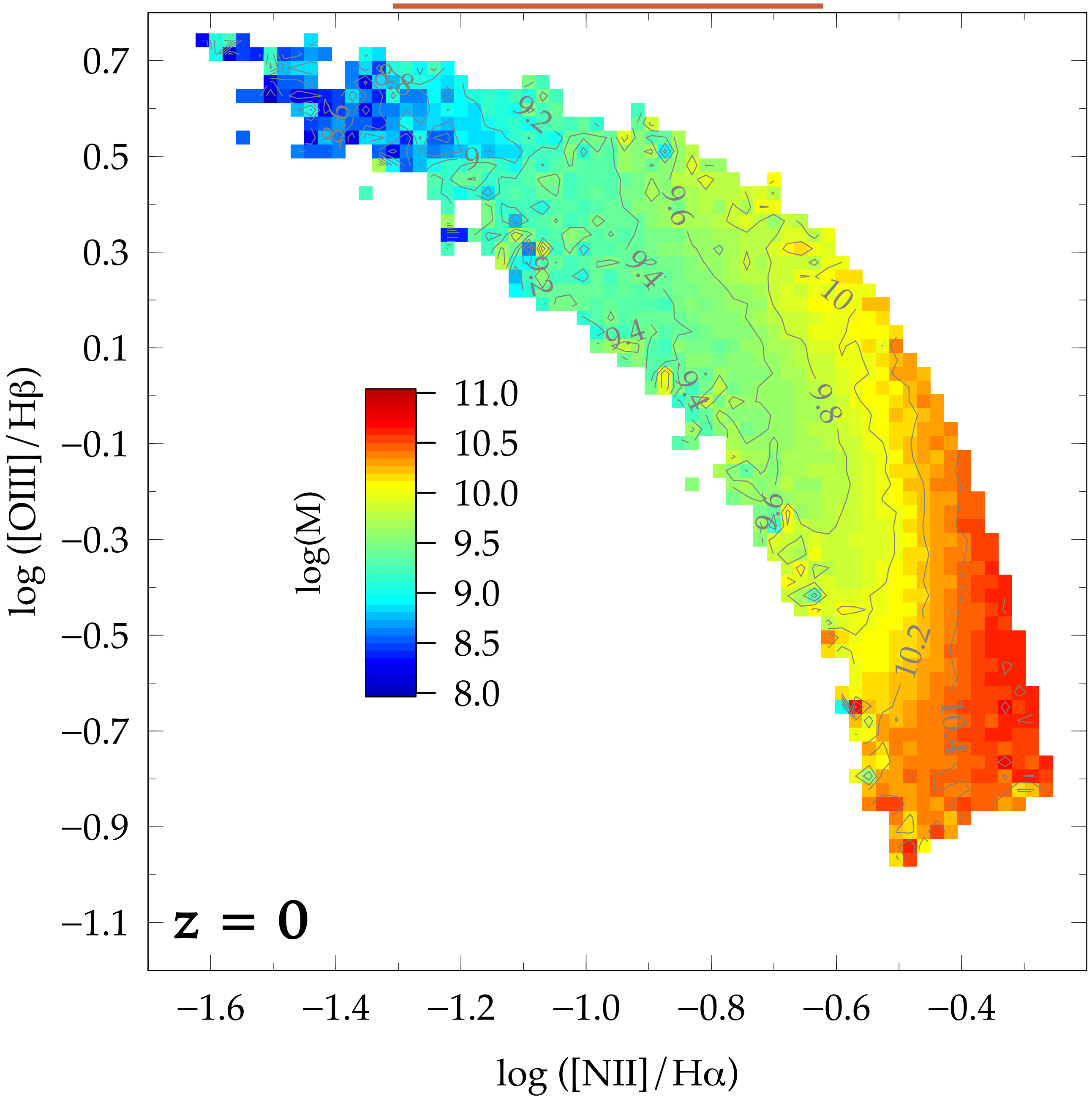
Stellar Mass



Faisst+2018

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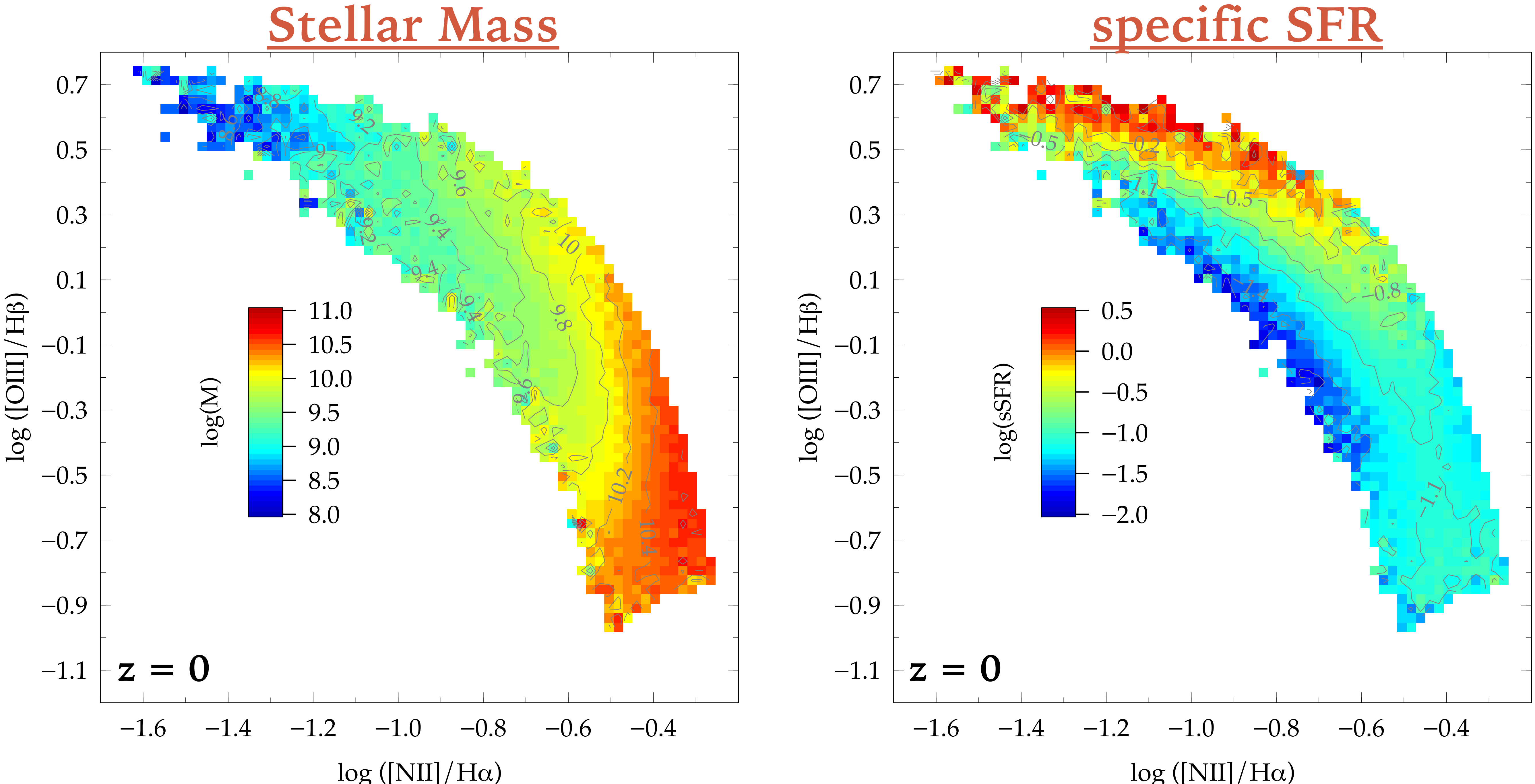

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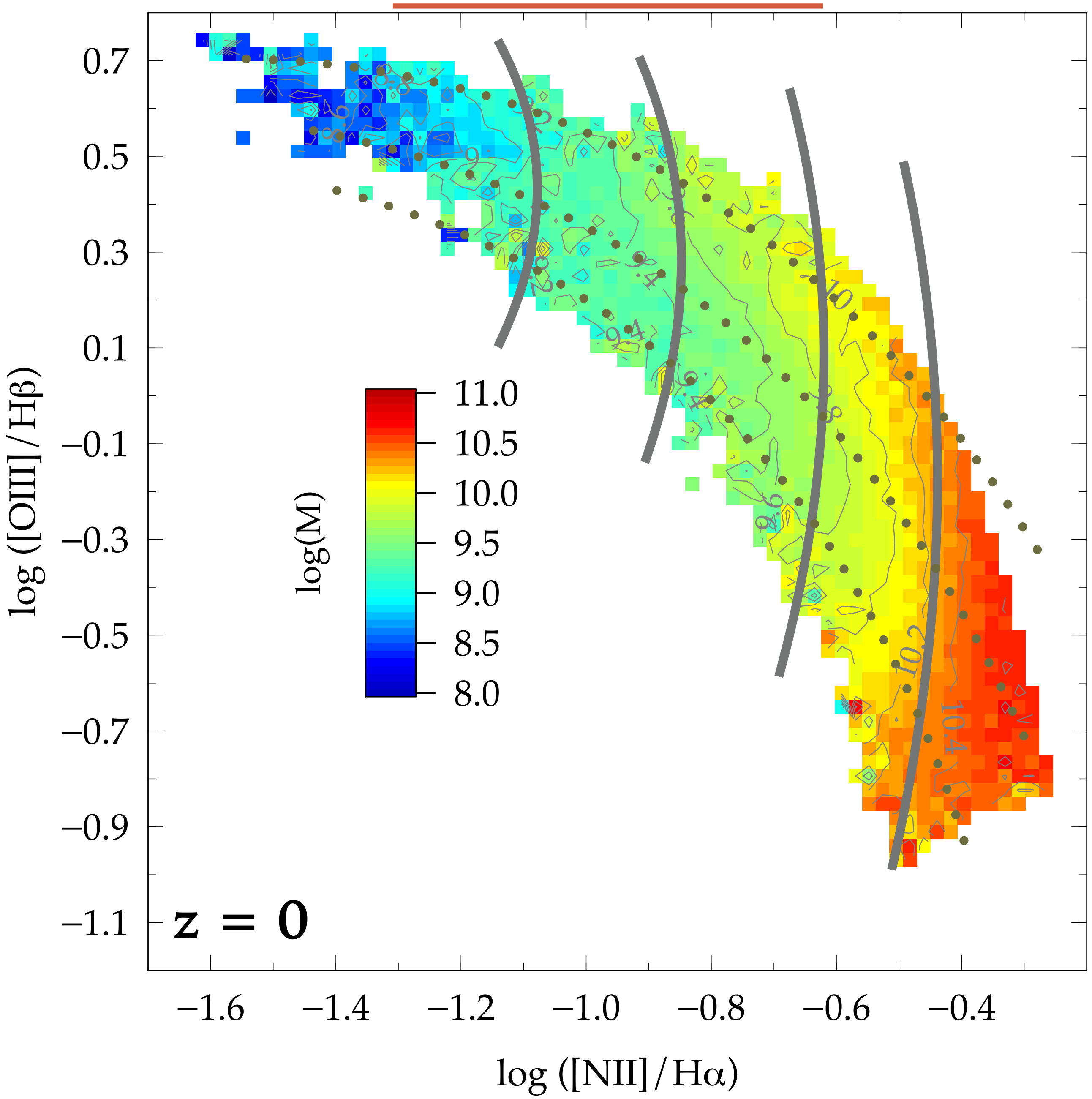
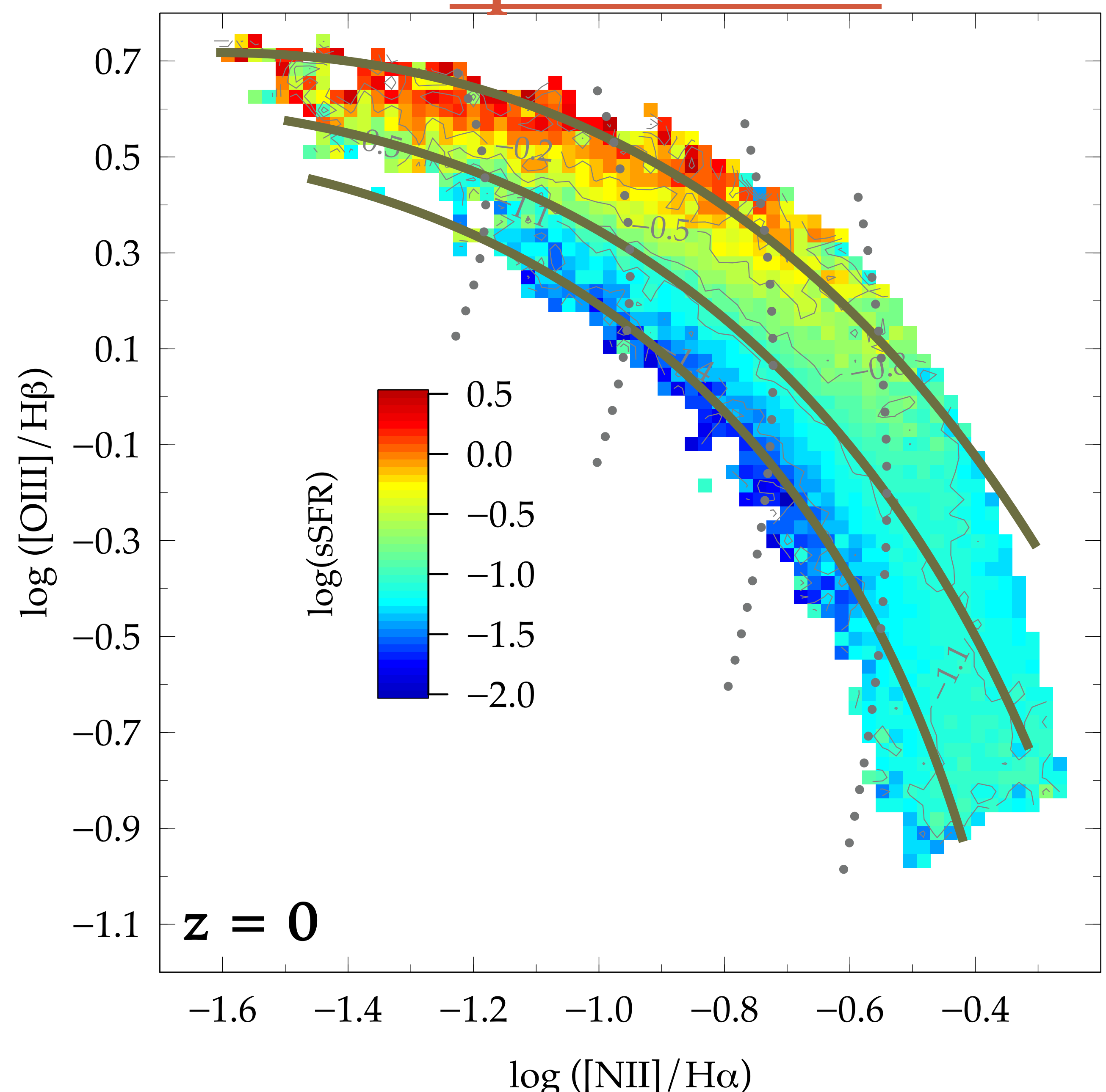


specific SFR



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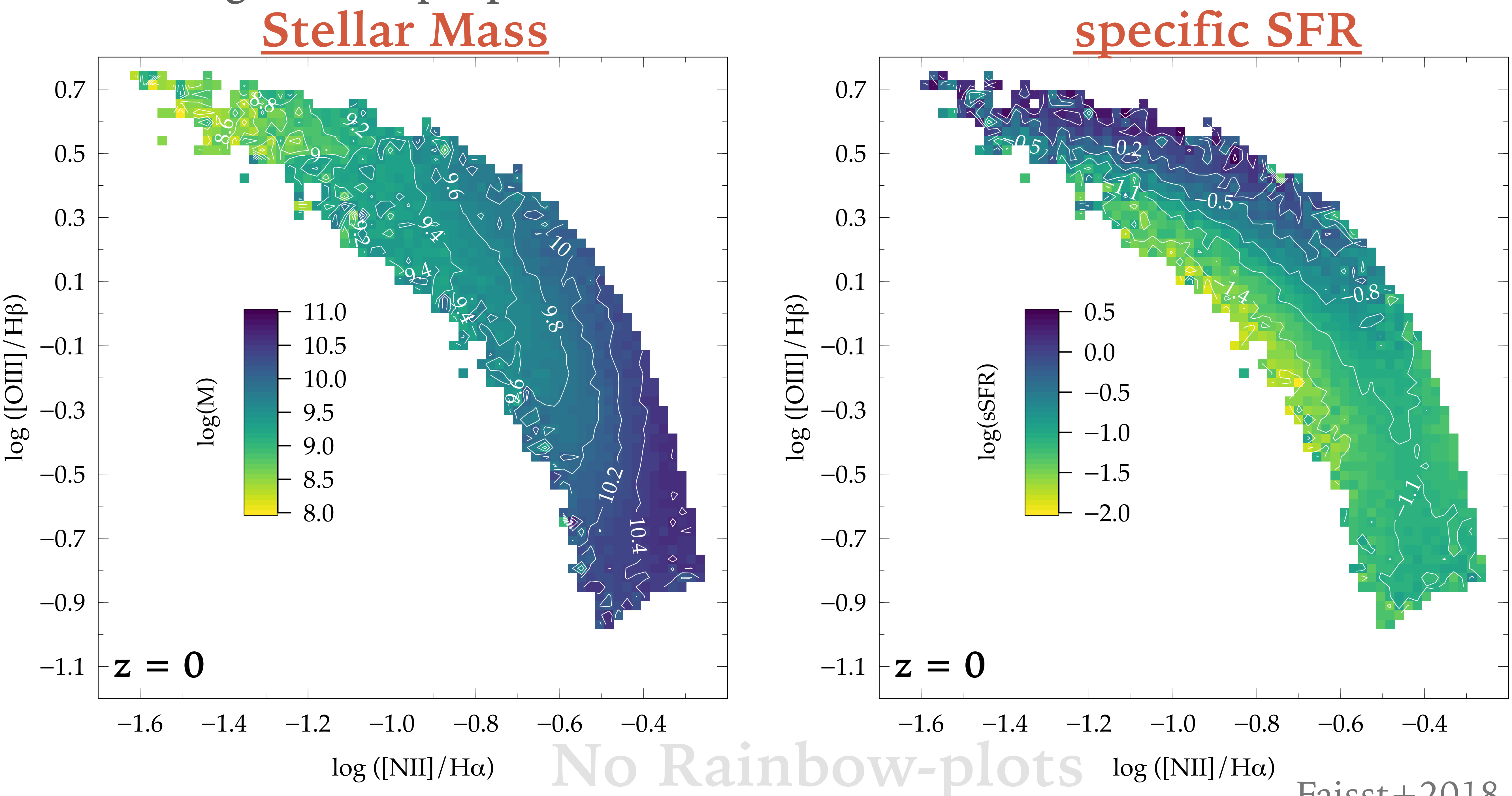

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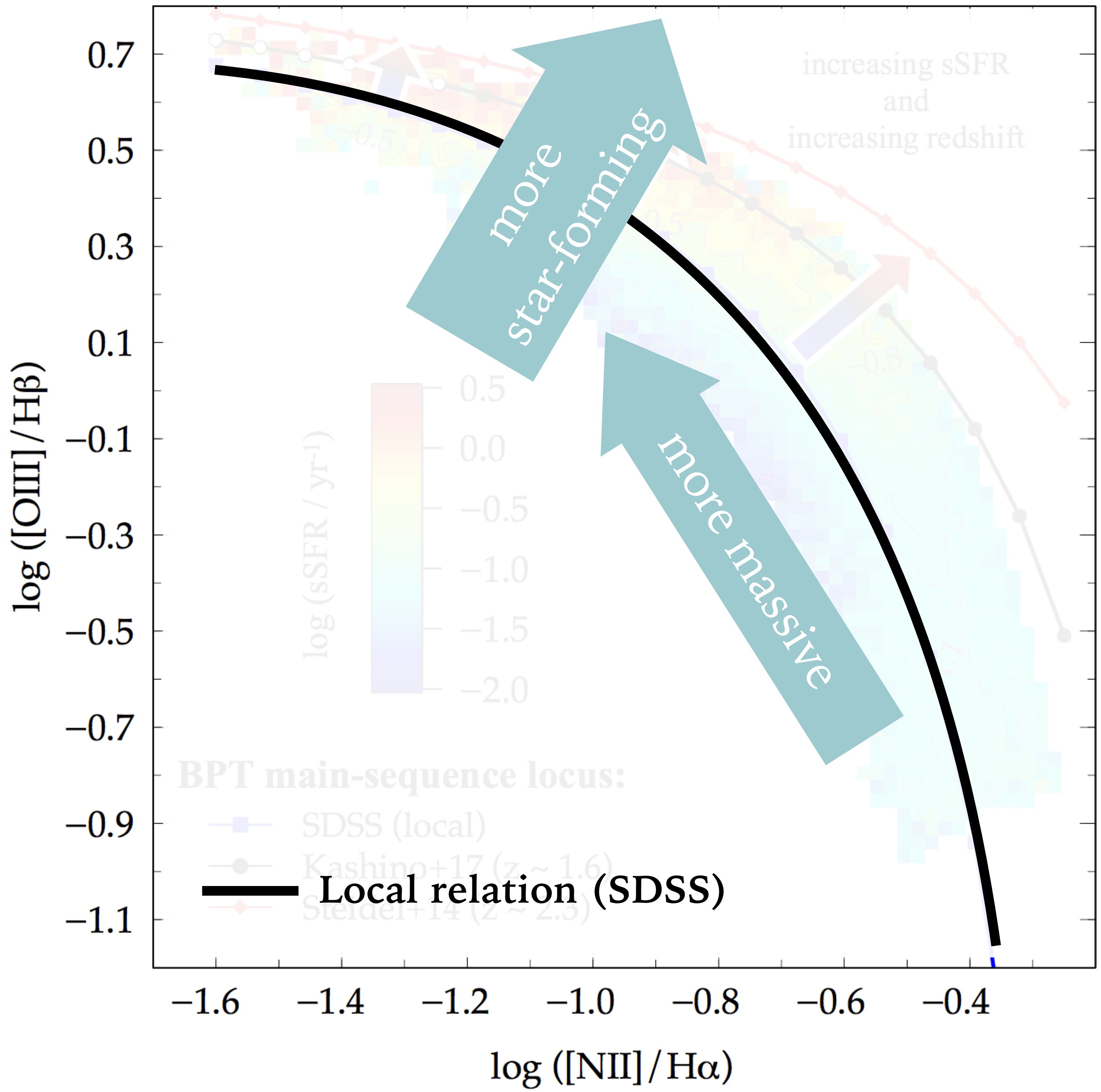

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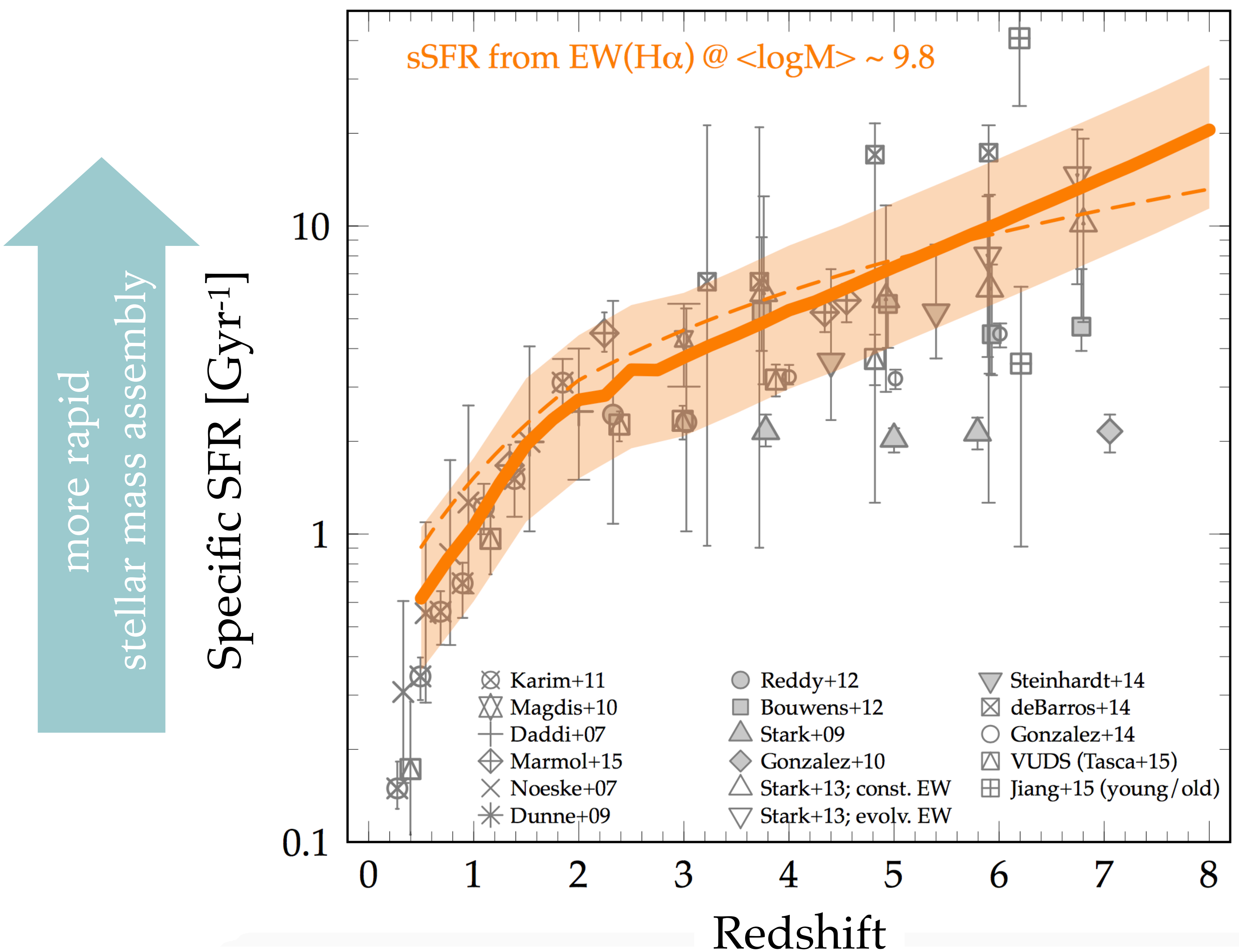
Redshift evolution of the specific SFR (sSFR)

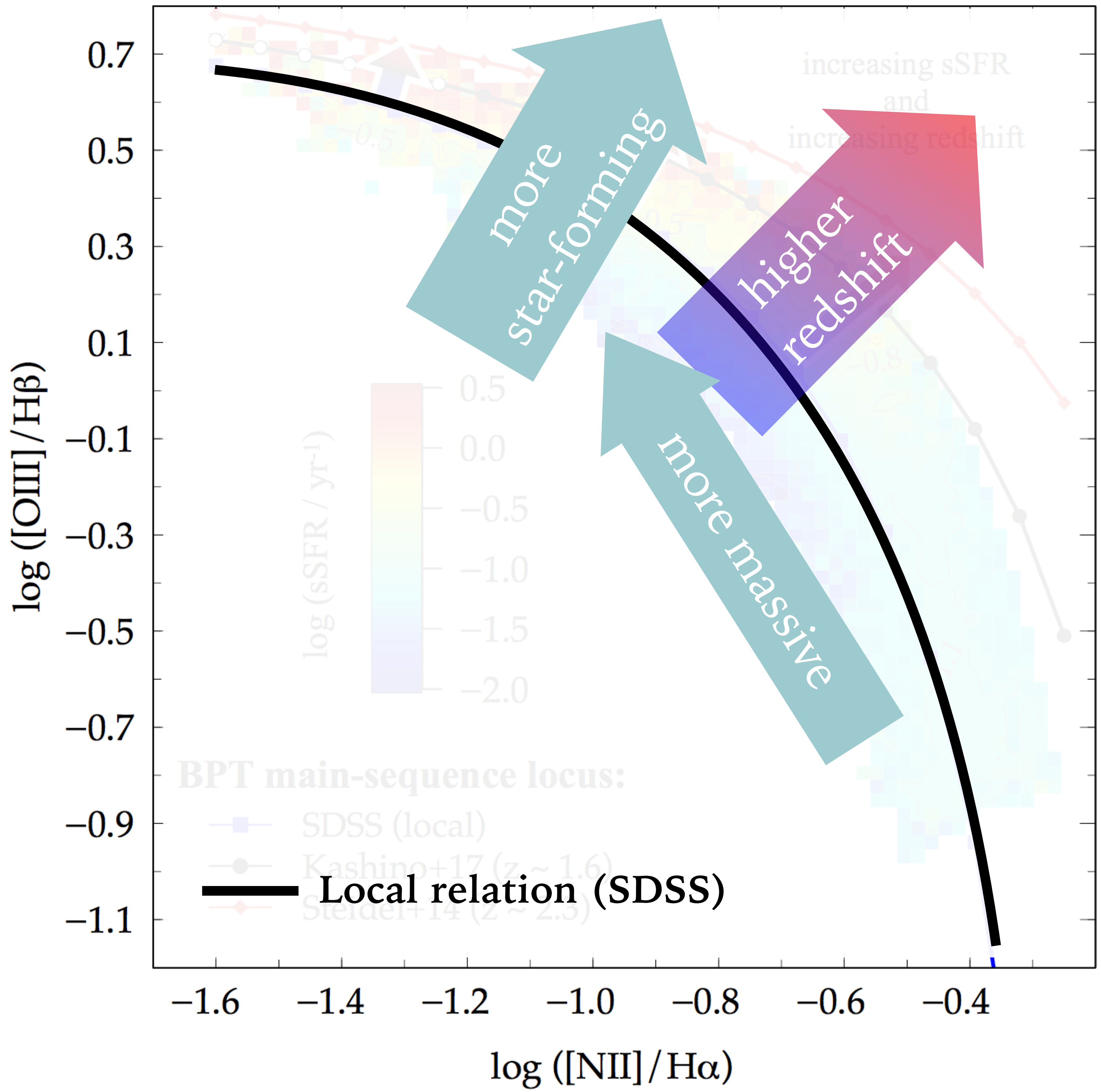
- Significantly higher sSFR at high redshifts



Faisst+2016

Dependencies of [NII]/Hα ratio: the BPT-diagram

➤ The BPT-diagram combines dependencies of [NII]/Hα



Faisst+2018

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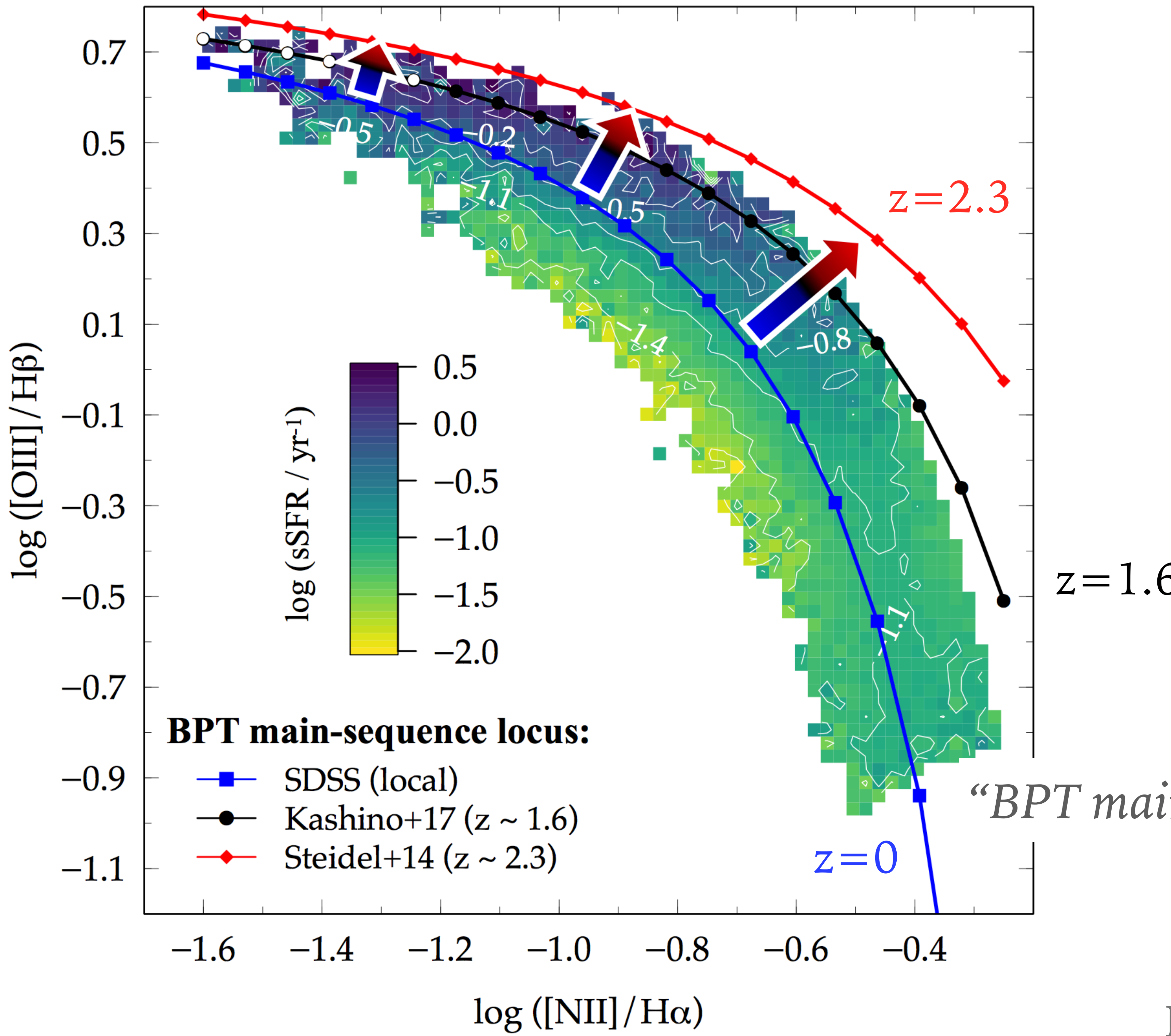

"BPT main-sequence"

see also: Shapley+15, Masters+16, Strom+17

Faisst+2018

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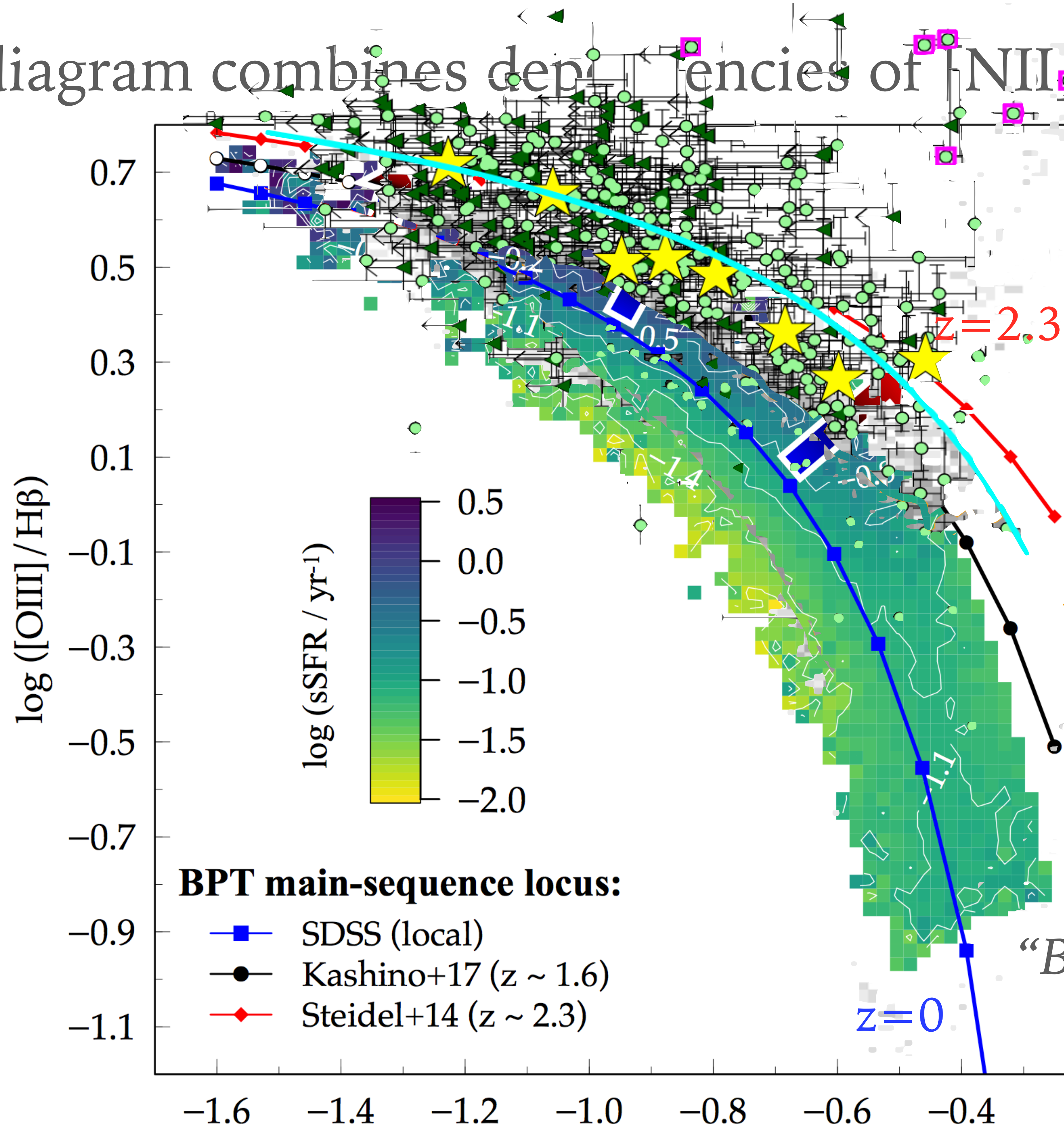

see also:
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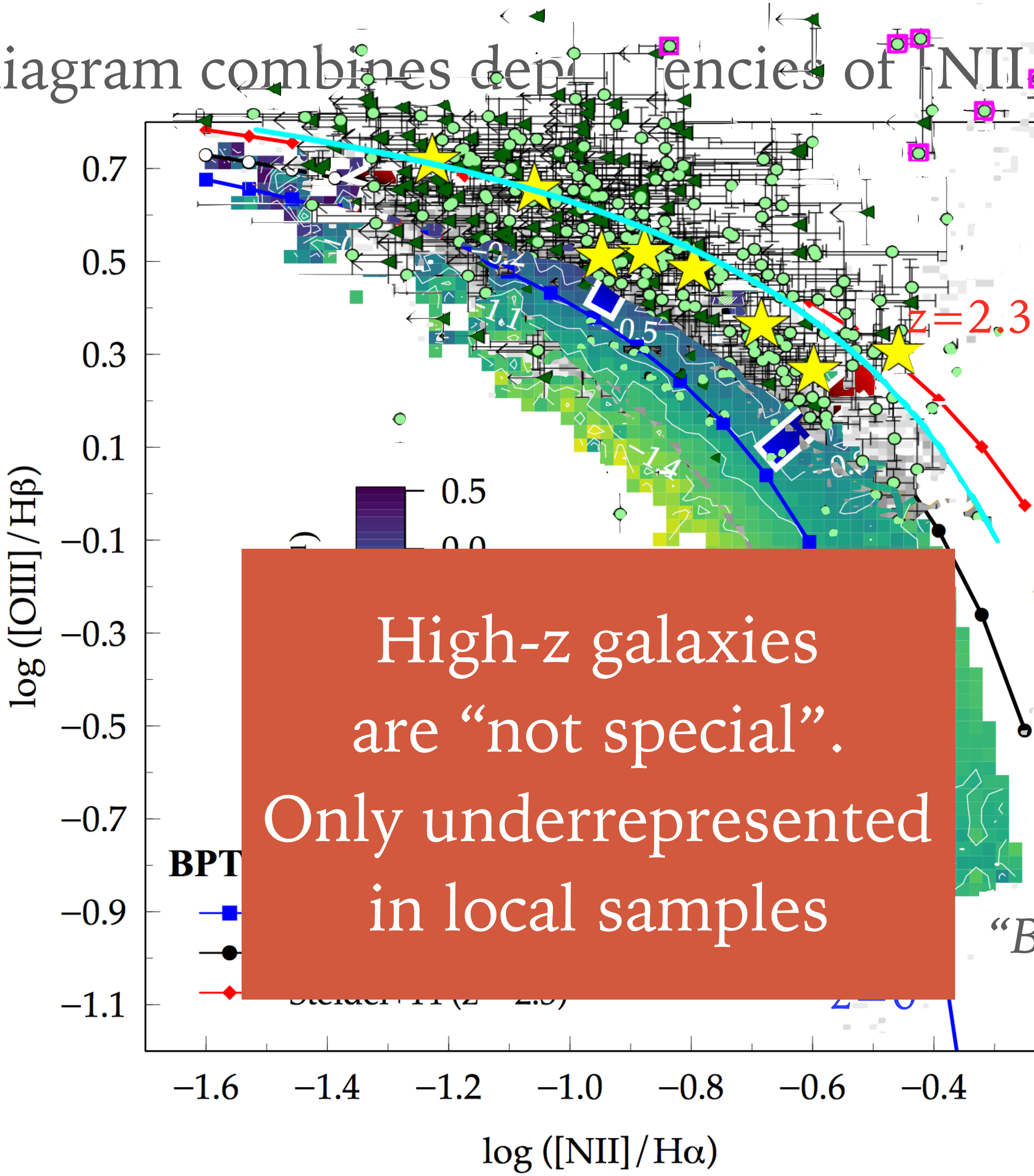

High-z galaxies are "not special". Only underrepresented in local samples

"BPT main-sequence"

Faisst+2018

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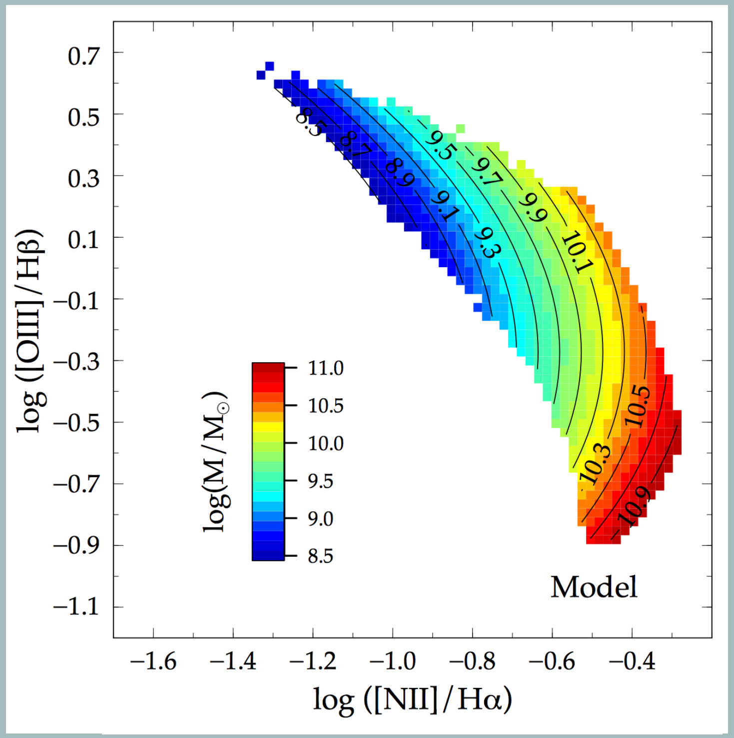
A Model for [NII]/Hα based on Local Galaxies



2-D fit of *M* dependence of BPT diagram at **z=0**

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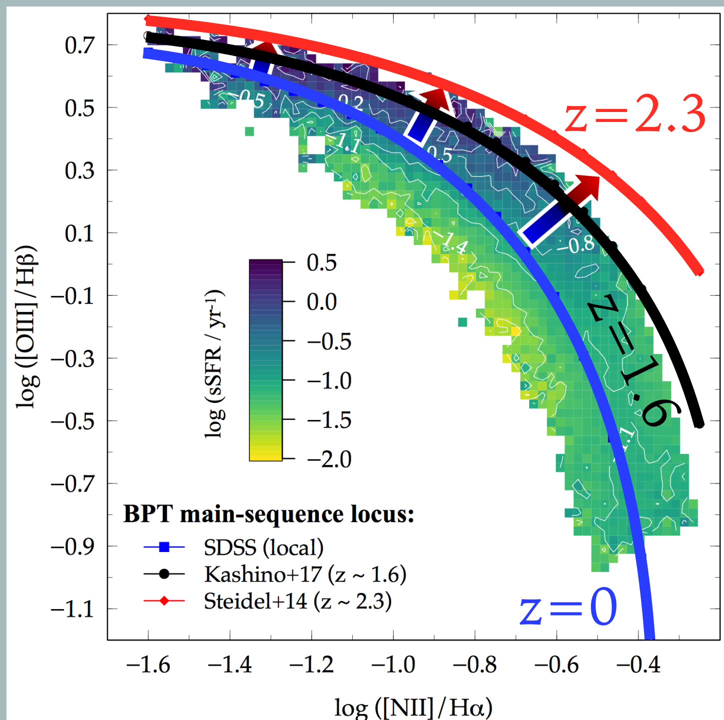
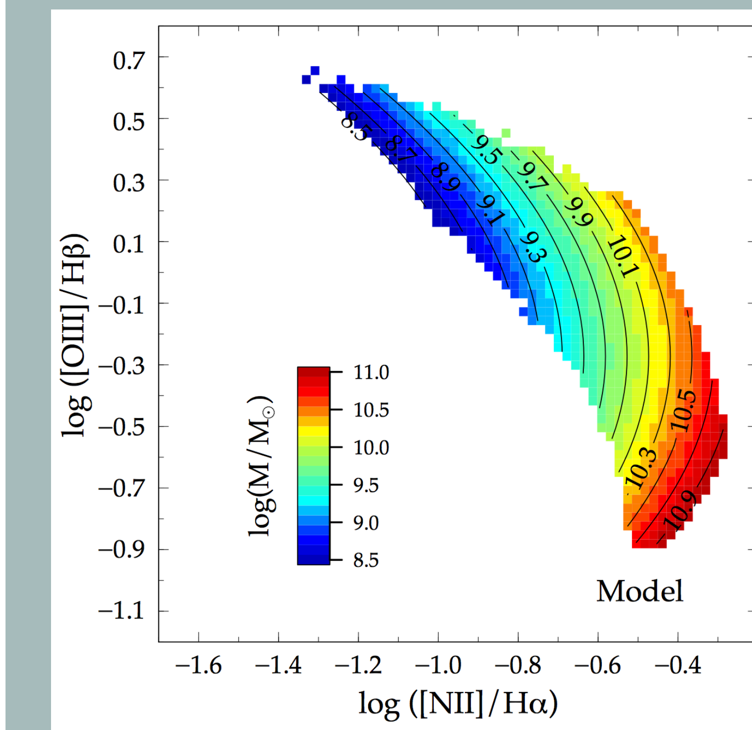


1-D fit of "BPT main-sequence" as function of z at 0<z<2.3



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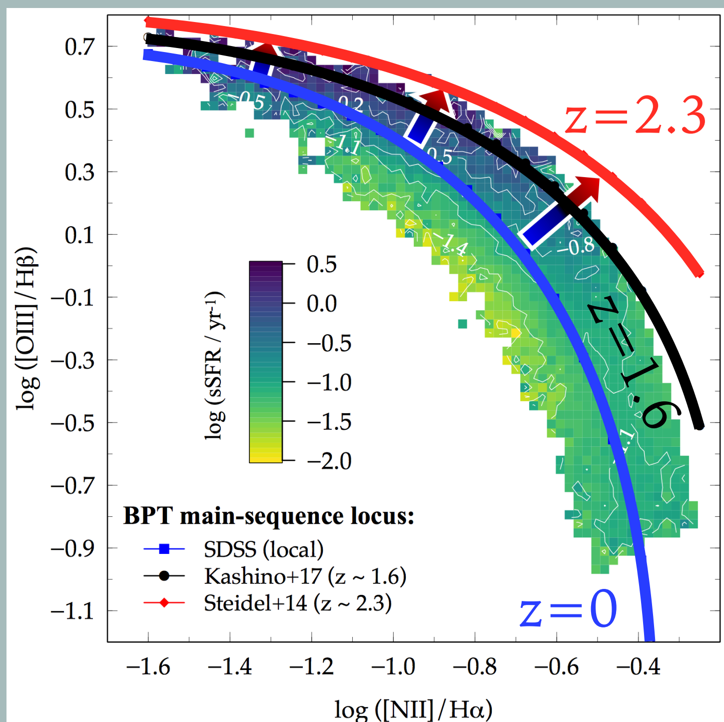

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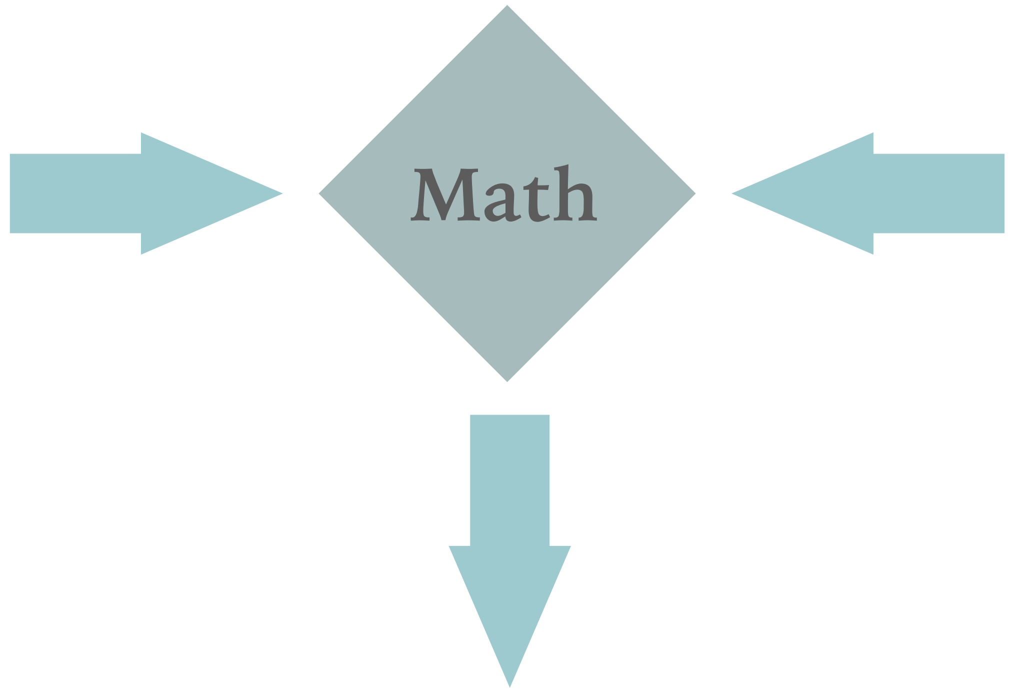

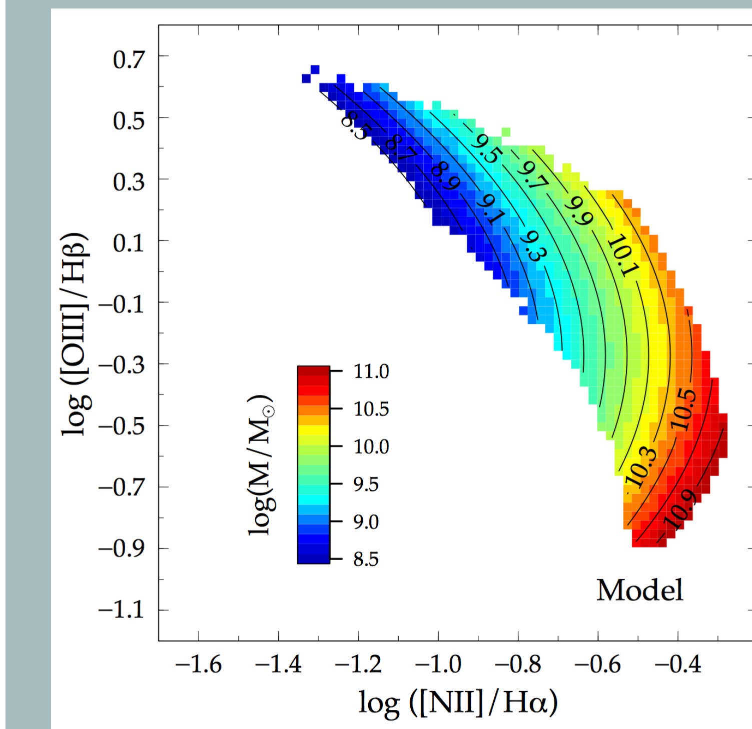

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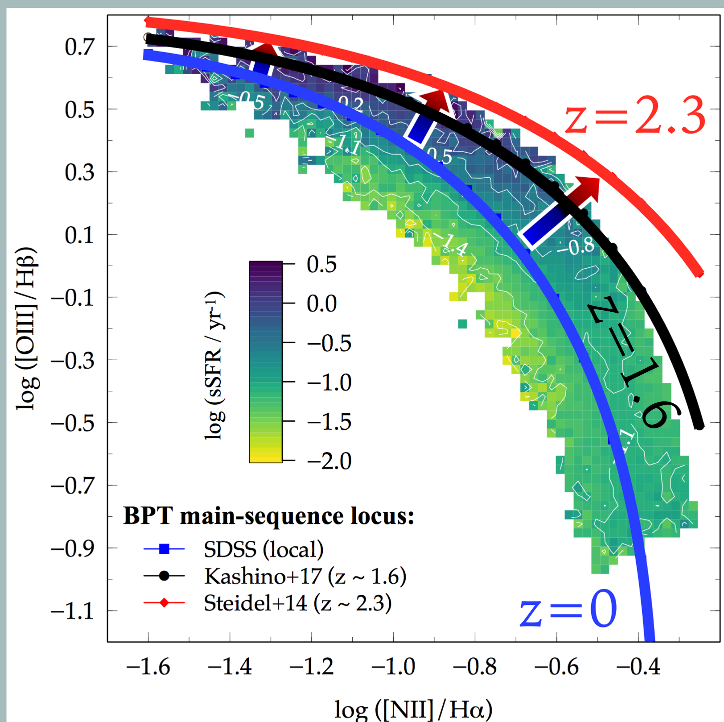

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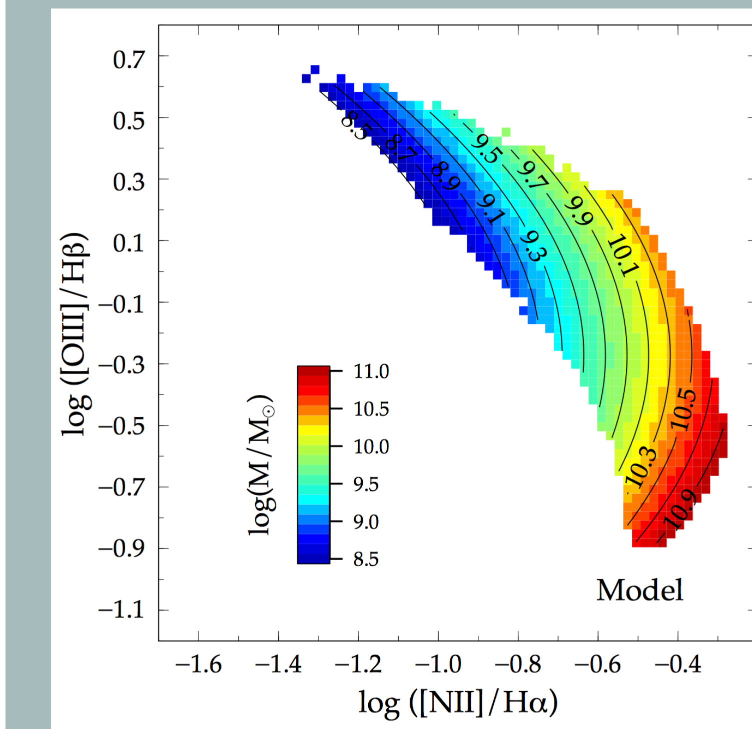

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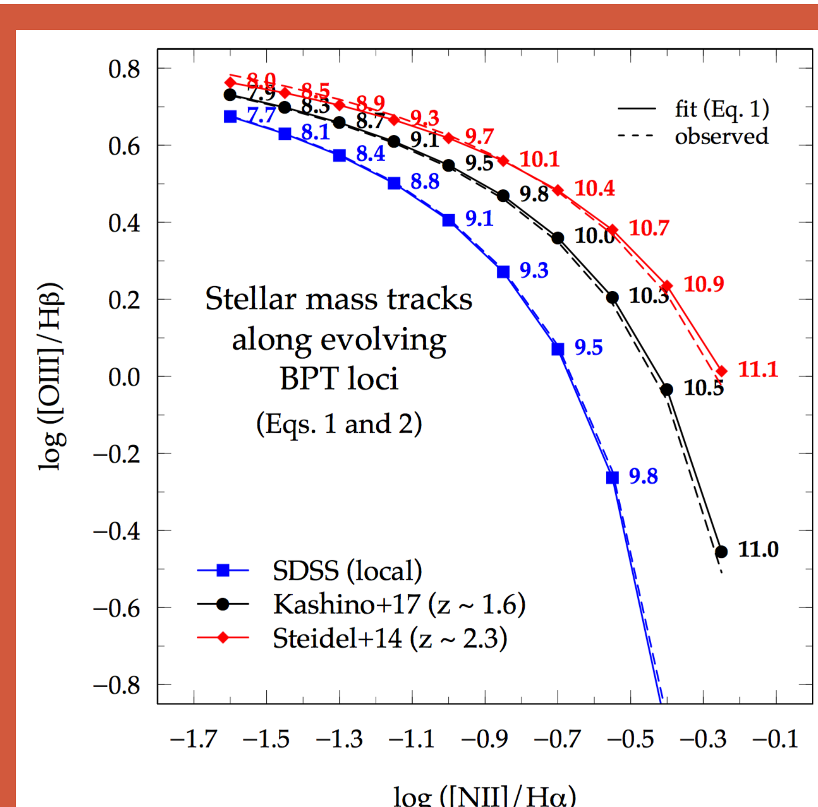
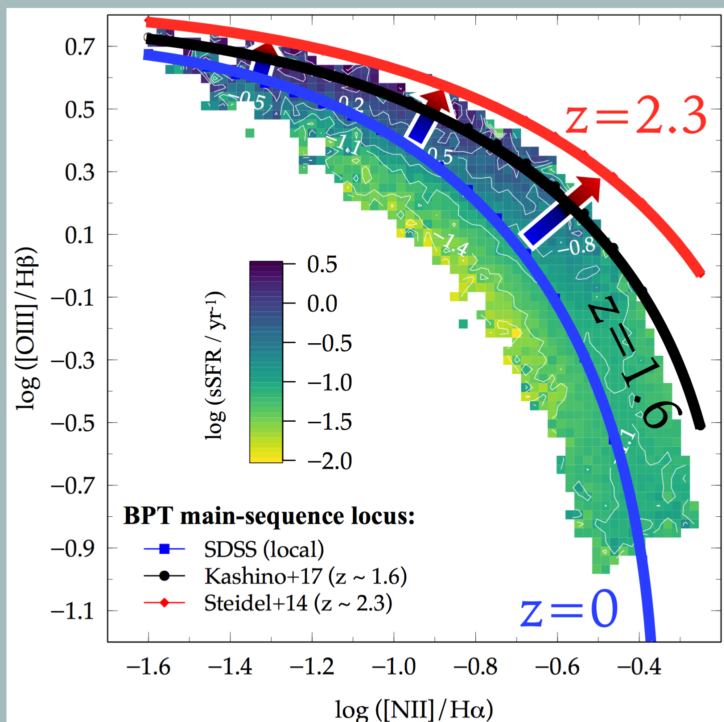


Empirical model for [NII]/Hα ratio as function of M and z.

$(0 < z < 2.5)$

$(9 < \log M < 11)$

A Model for [NII]/Hα based on Local Galaxies



1-D fit of "BPT main-sequence" as function of *z* at 0<z<2.3

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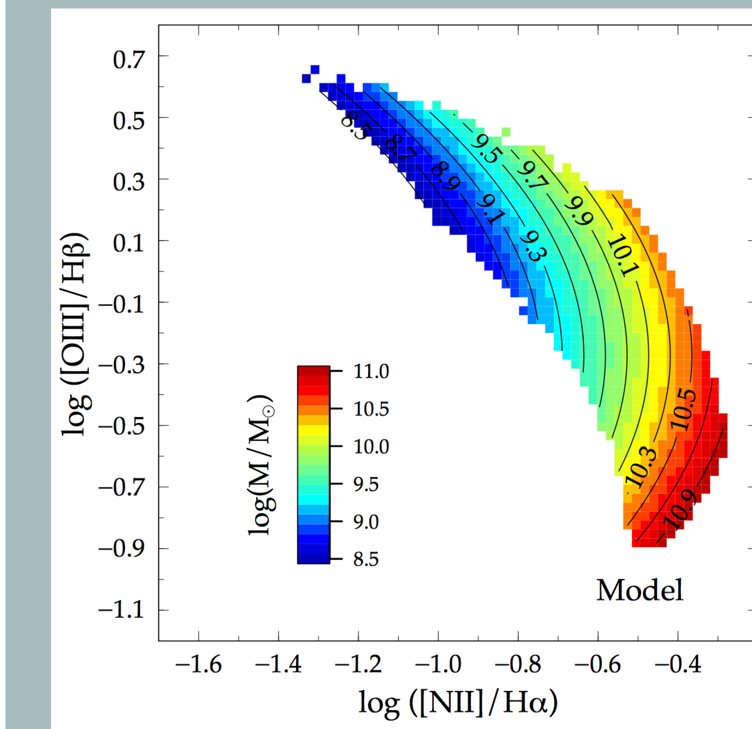
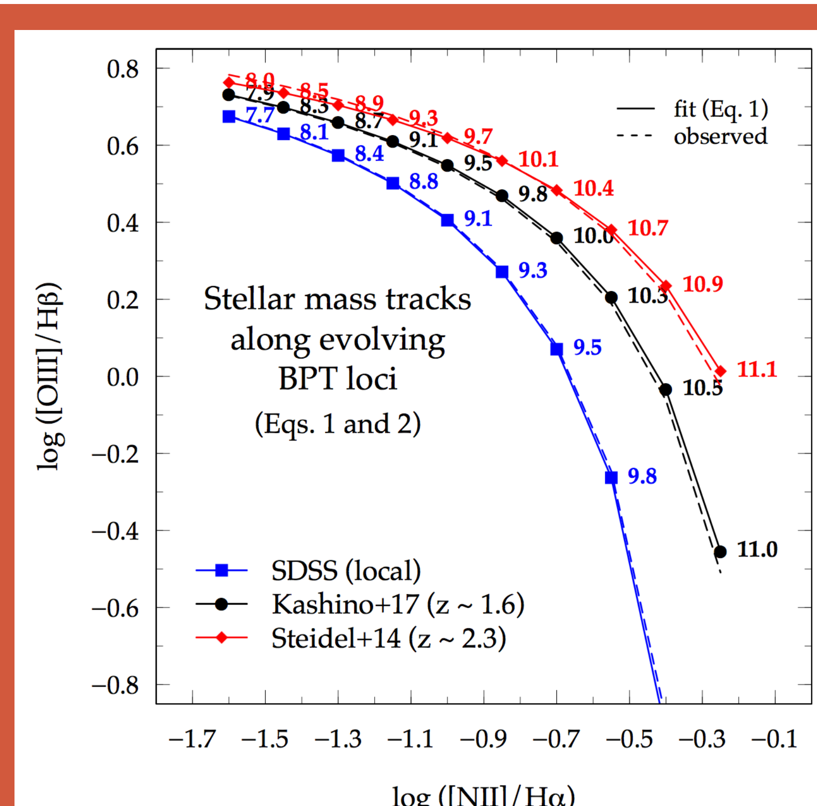


2-D fit of *M* dependence of BPT diagram at **z=0**

Also works for deriving [OIII]/Hβ



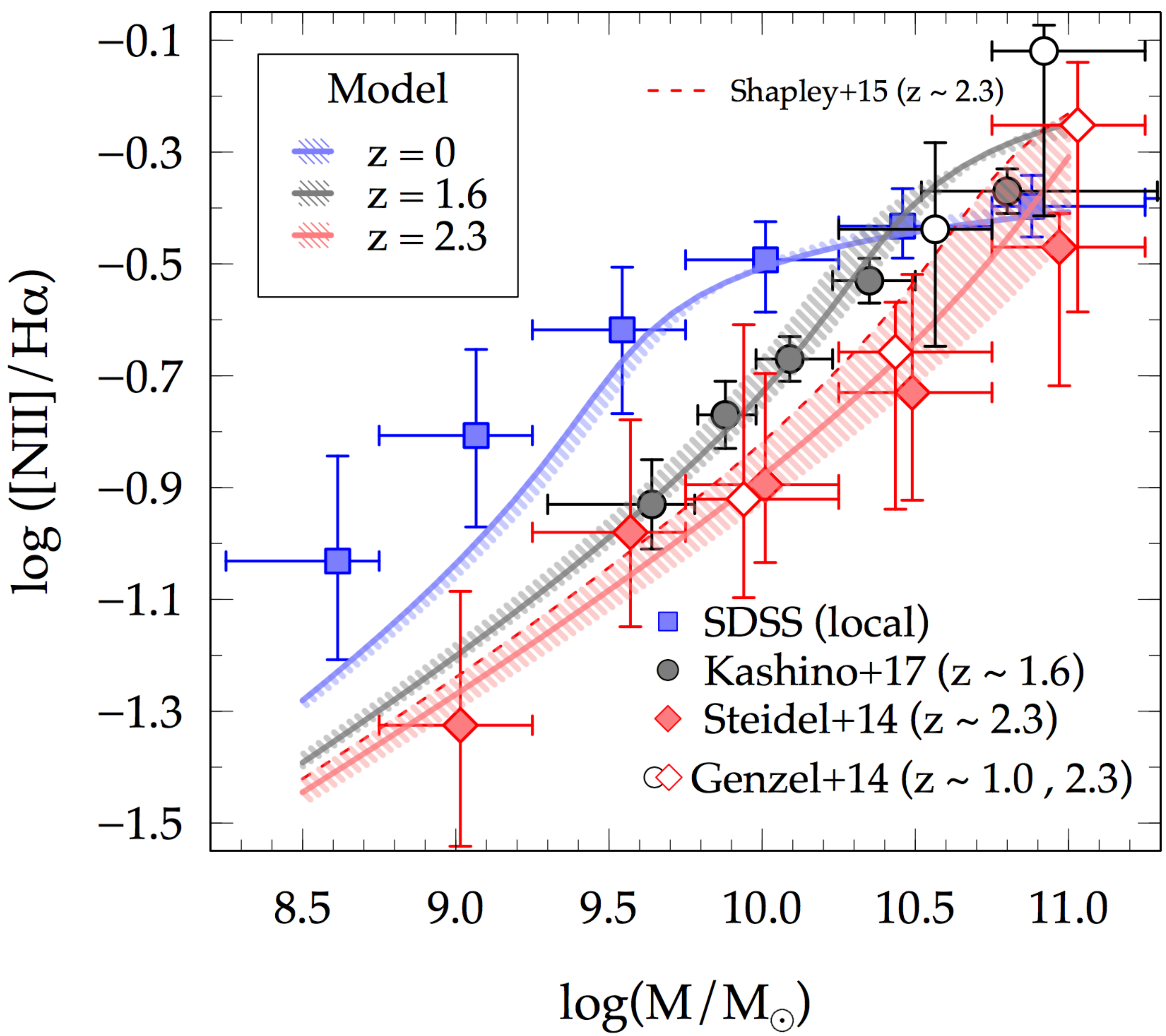
Empirical model for [NII]/Hα ratio as function of *M* and *z*.

(0 < z < 2.5)

(9 < logM < 11)

A Model for [NII]/Hα based on Local Galaxies

- Model for the (M,z) dependence of [NII]/Hα for $0 < z < 2.5$
- Recipe for **Simulators** and **Observers**



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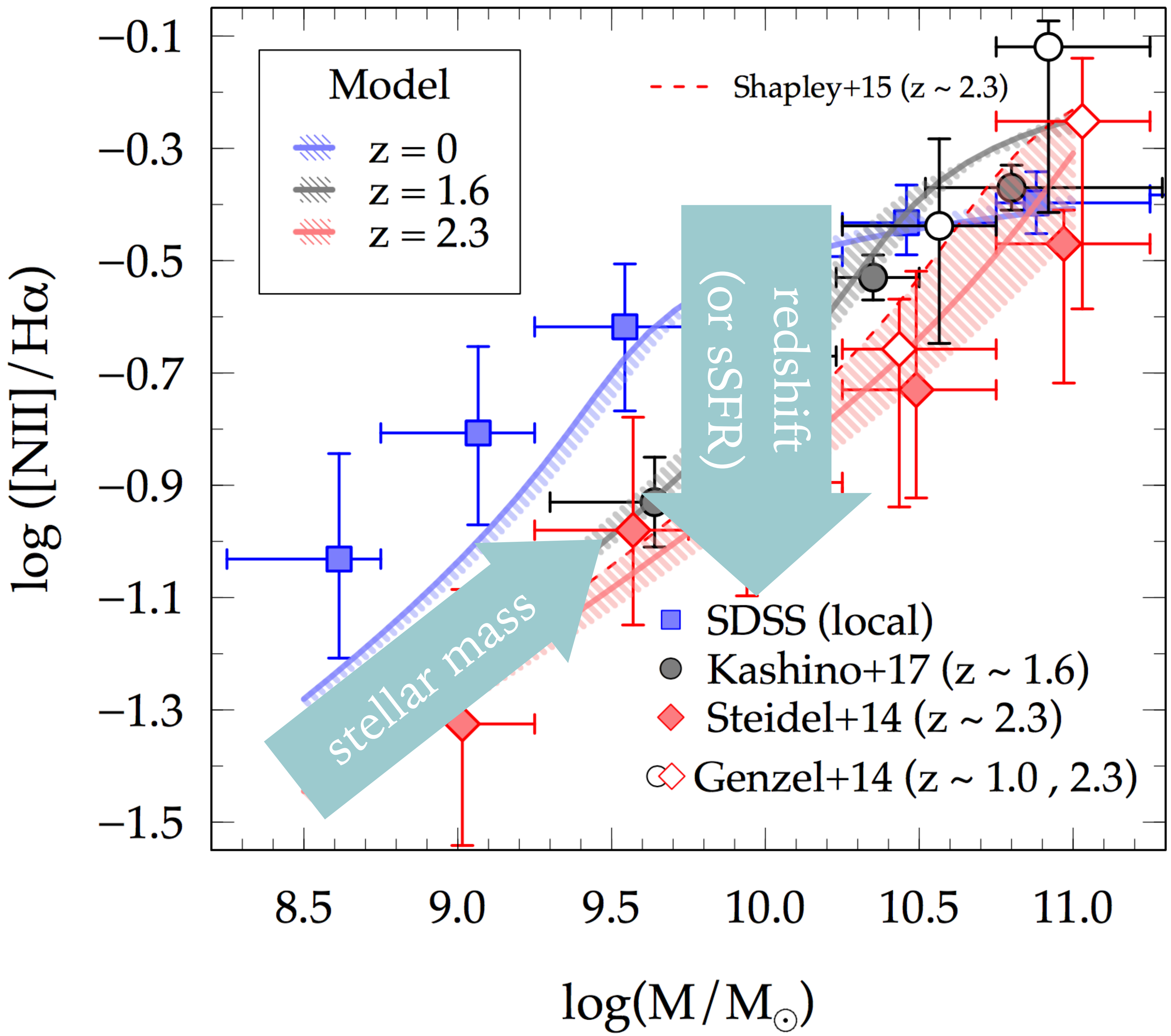

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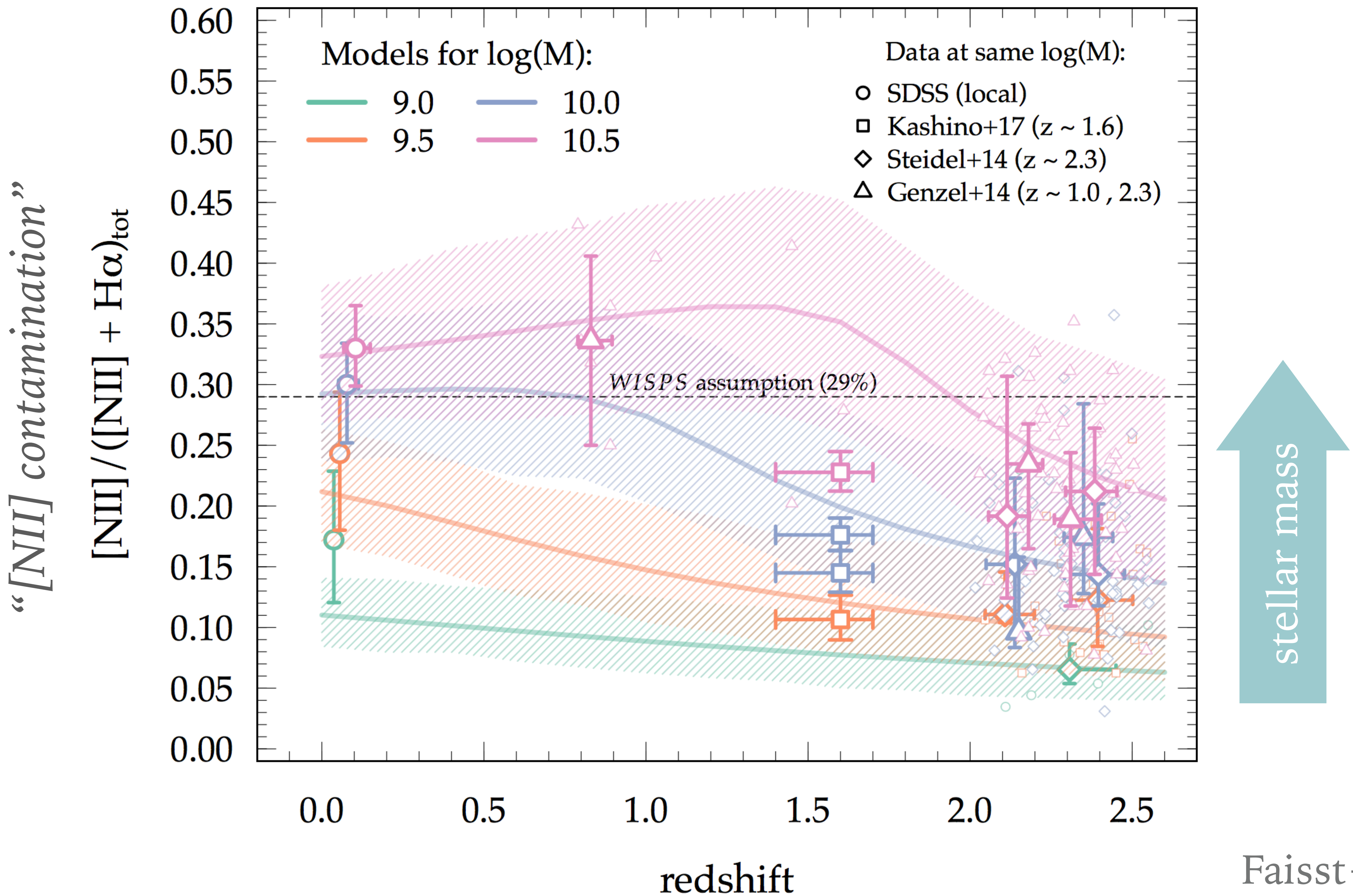

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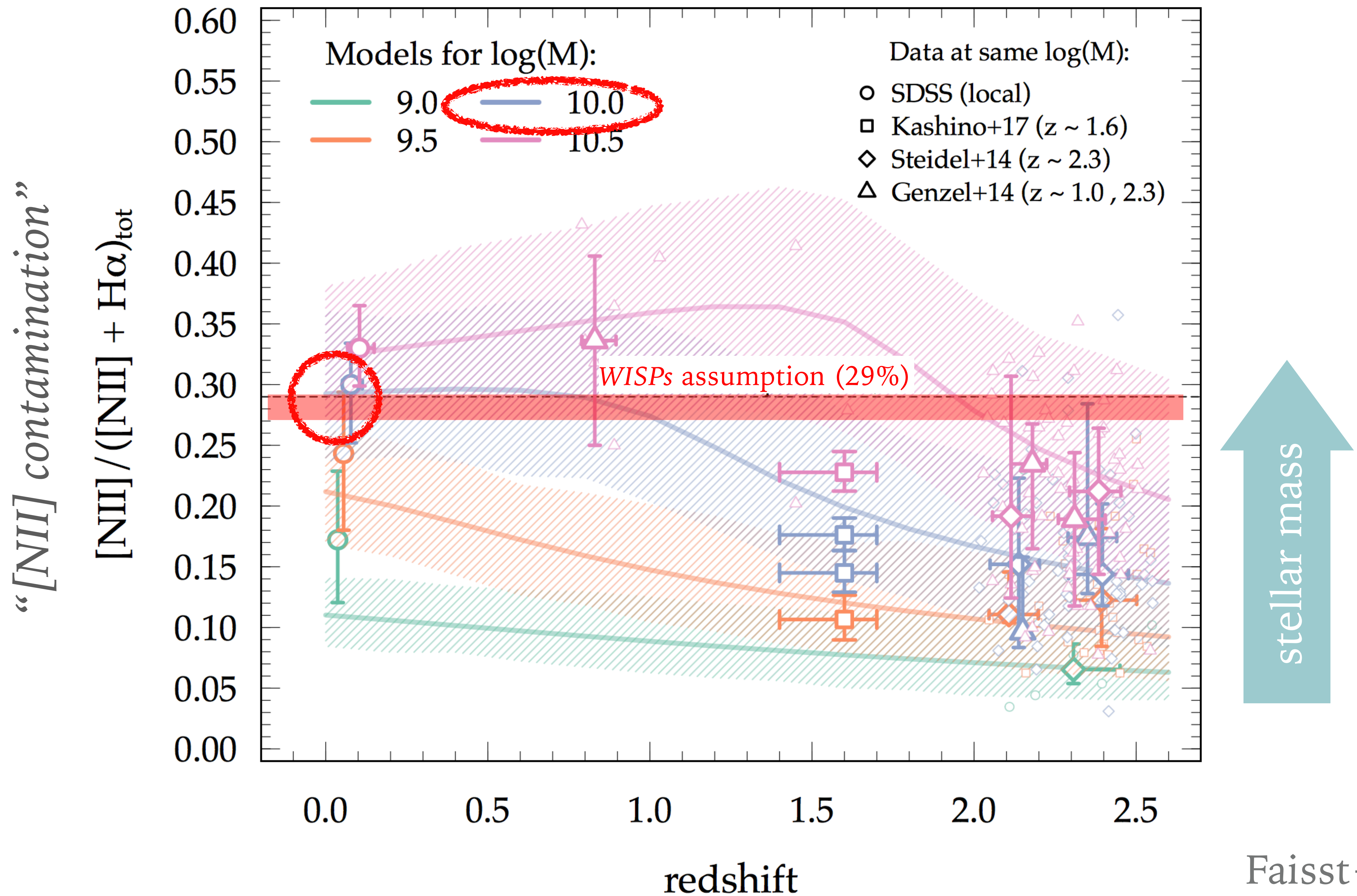

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$\log(M/M_\odot)$	Redshift													
	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
8.5	0.07	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
8.7	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05
8.9	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06
9.1	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07
9.3	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08
9.5	0.21	0.20	0.19	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.09
9.7	0.26	0.25	0.24	0.23	0.21	0.19	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11
9.9	0.28	0.28	0.28	0.28	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.14	0.13	0.13
10.1	0.30	0.30	0.31	0.31	0.31	0.30	0.28	0.25	0.22	0.20	0.18	0.17	0.16	0.15
10.3	0.31	0.32	0.32	0.33	0.33	0.34	0.33	0.32	0.29	0.25	0.22	0.20	0.19	0.17
10.5	0.32	0.33	0.34	0.34	0.35	0.36	0.36	0.36	0.35	0.32	0.28	0.25	0.22	0.21
10.7	0.33	0.34	0.35	0.36	0.36	0.37	0.38	0.39	0.39	0.38	0.35	0.31	0.27	0.24
10.9	0.34	0.35	0.35	0.36	0.37	0.39	0.40	0.41	0.42	0.42	0.42	0.38	0.33	0.29
11.1	0.34	0.35	0.36	0.37	0.38	0.40	0.41	0.42	0.44	0.45	0.46	0.45	0.41	0.36

[NII]/([NII]+Hα)

WISPs assumption (29%)

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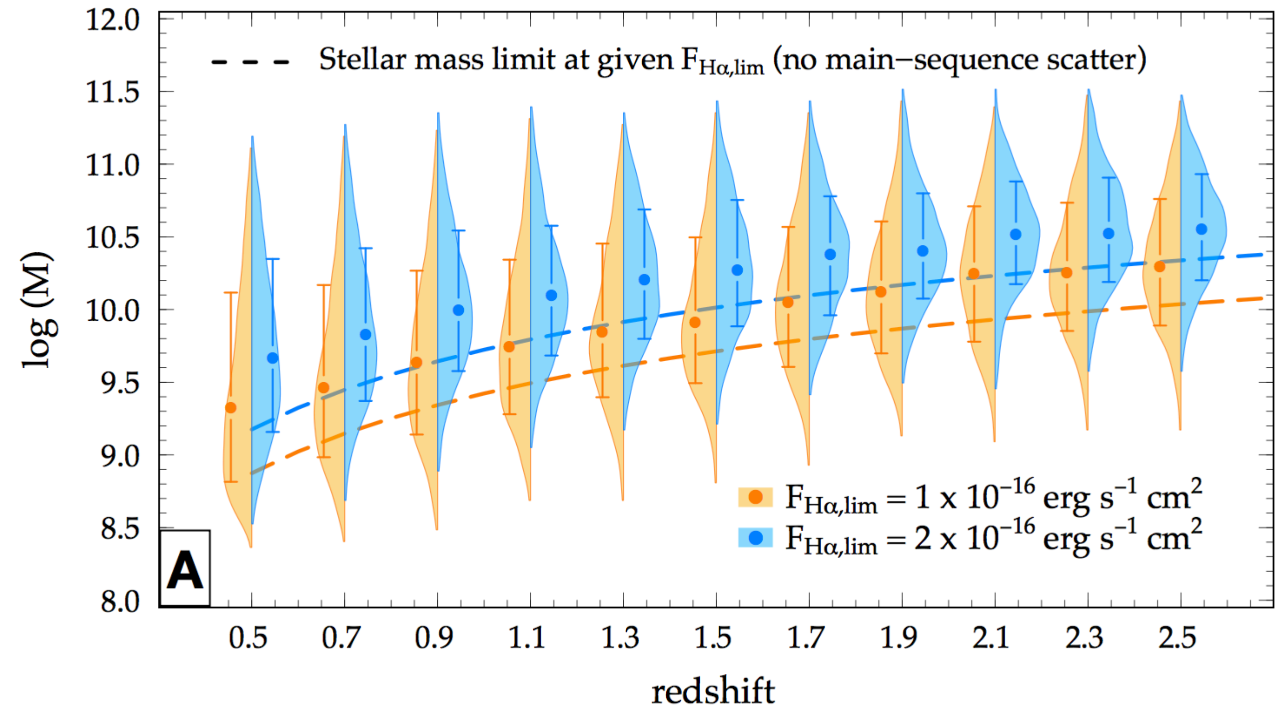
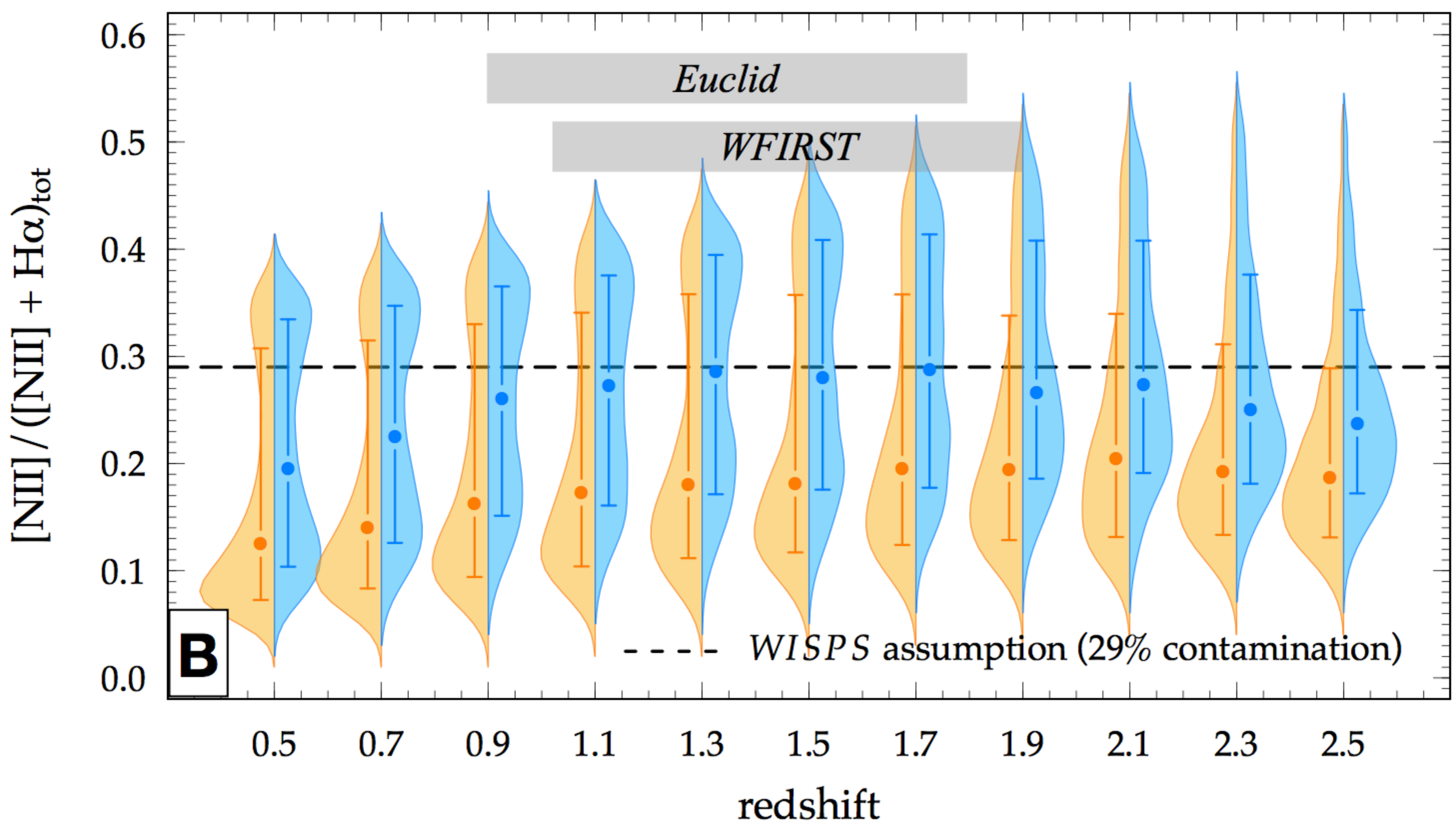
A Happy Swiss Cow

Almost Coffee time!

Use Case I: **[NII] Contamination Distribution**

- Based on realistic stellar mass distribution for *Euclid/WFIRST*
- On average 20% with large (factor 2) range
- Bimodal distribution!





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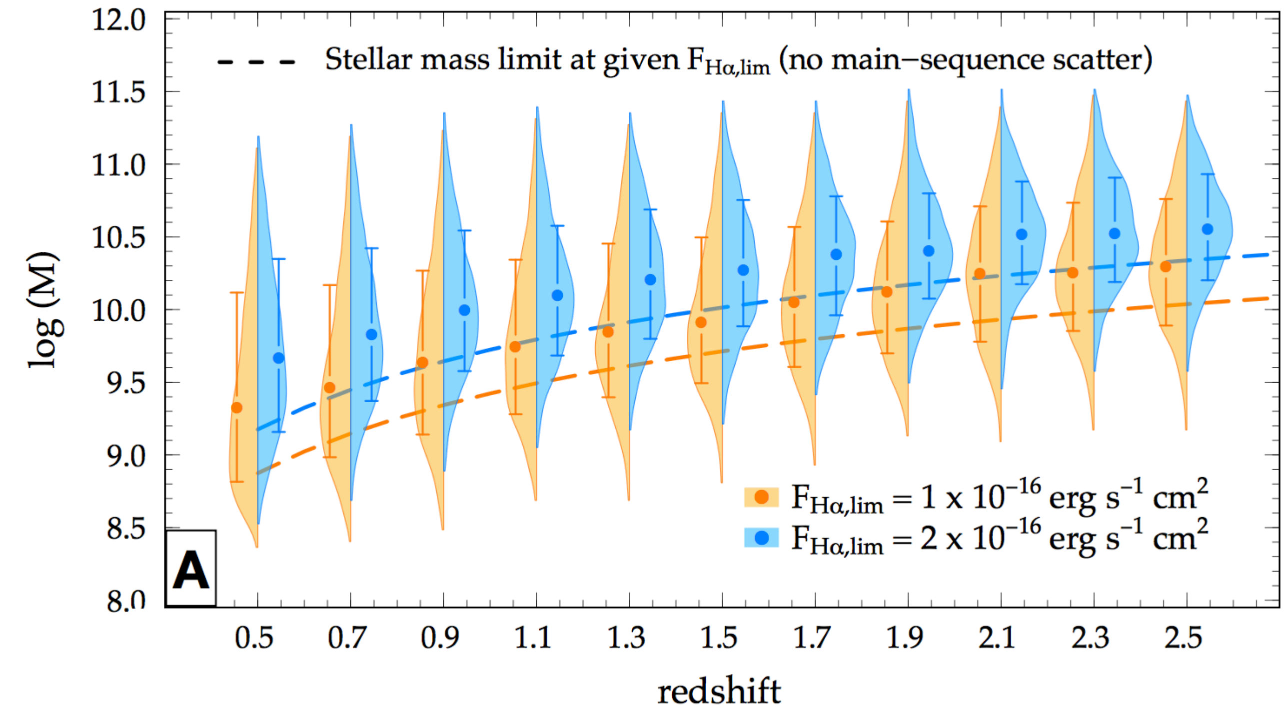

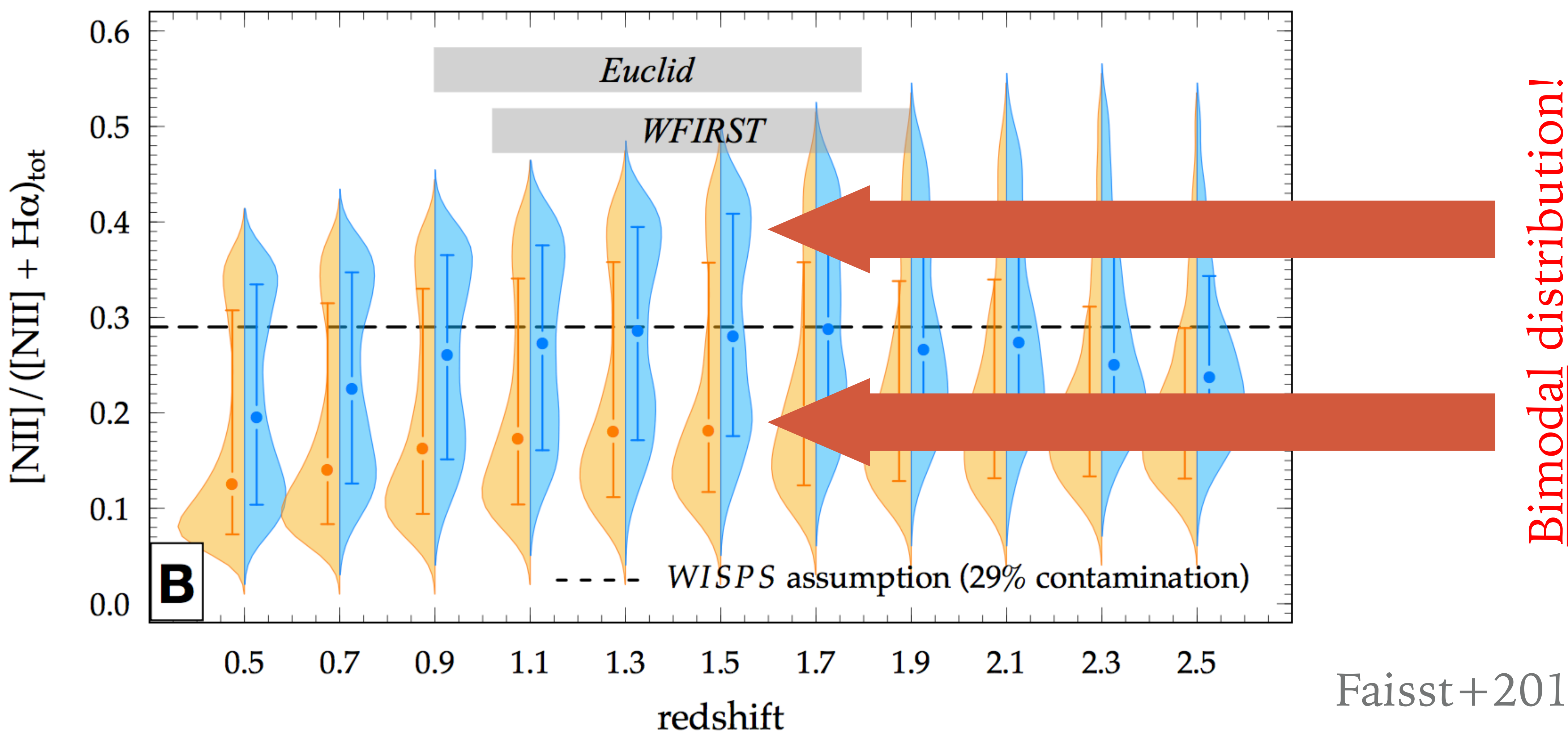

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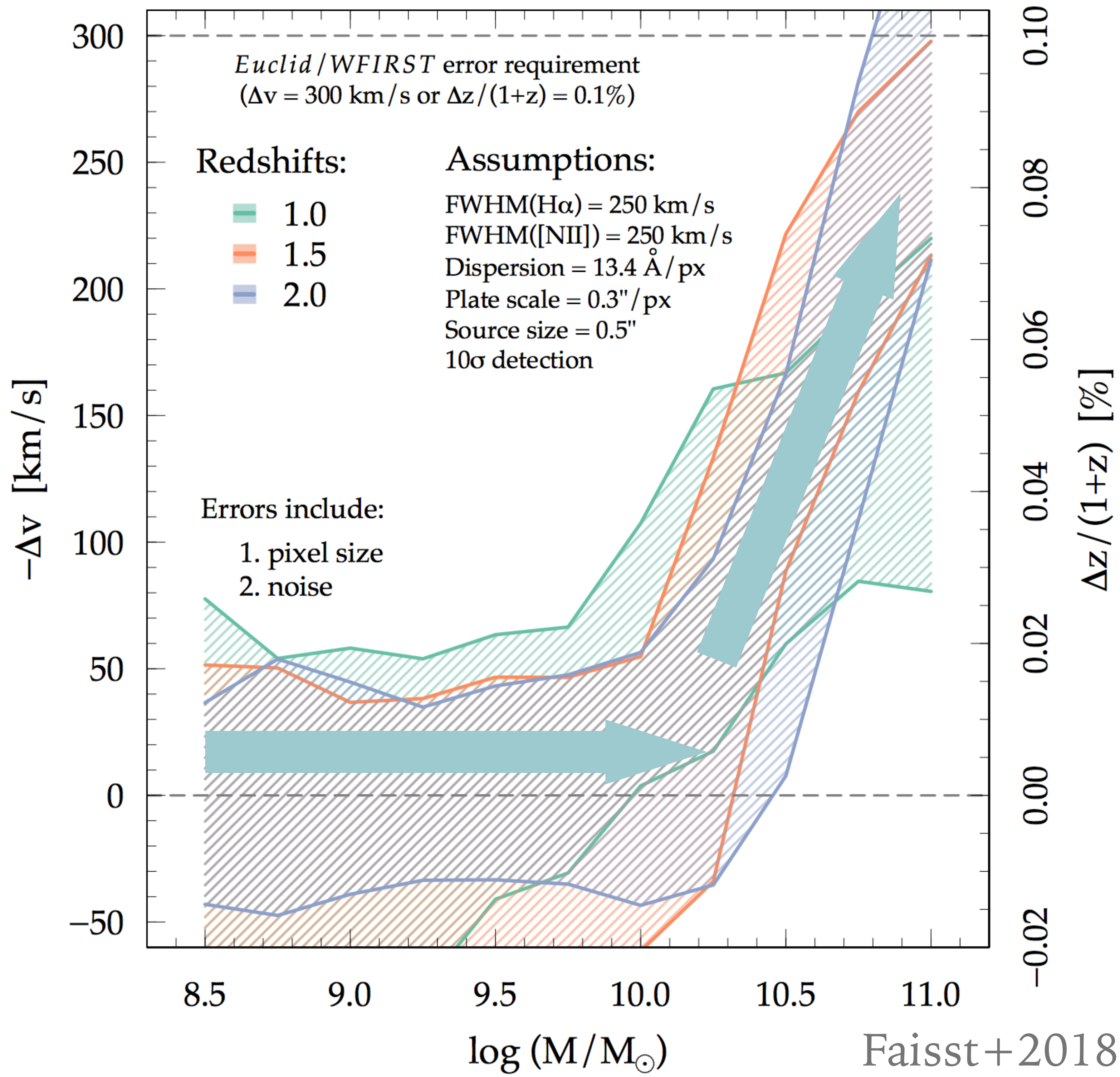
Use Case II: **Systematic Redshift Bias**

- Spectroscopic redshift bias from [NII] contamination
- Increasing with *M* and decreasing with z
- Becomes important at log(M) > 10.3
- Up to 300km/s (0.1%) for log(M)=11.0 (still better than required)



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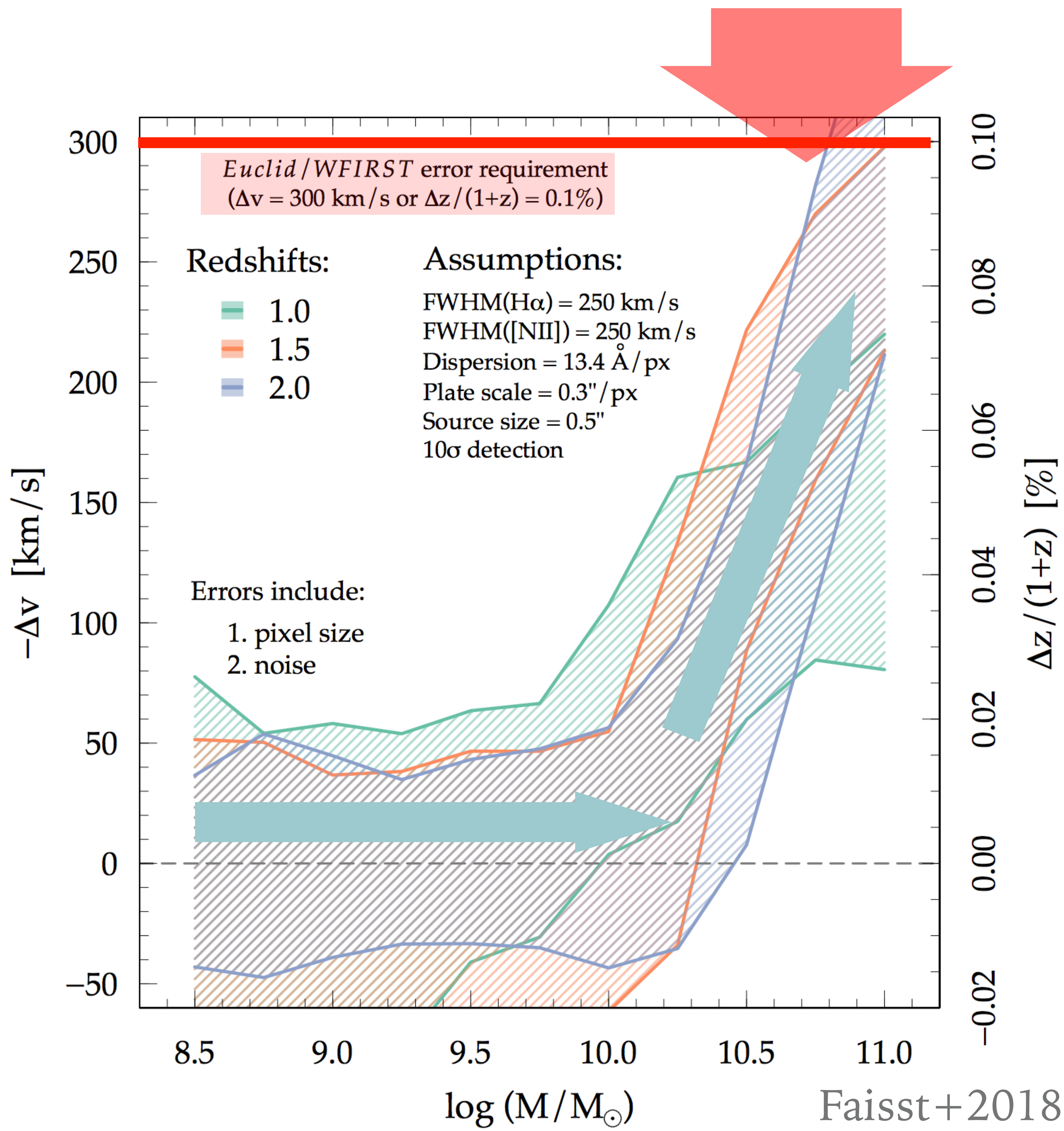
Euclid is sensitive here!



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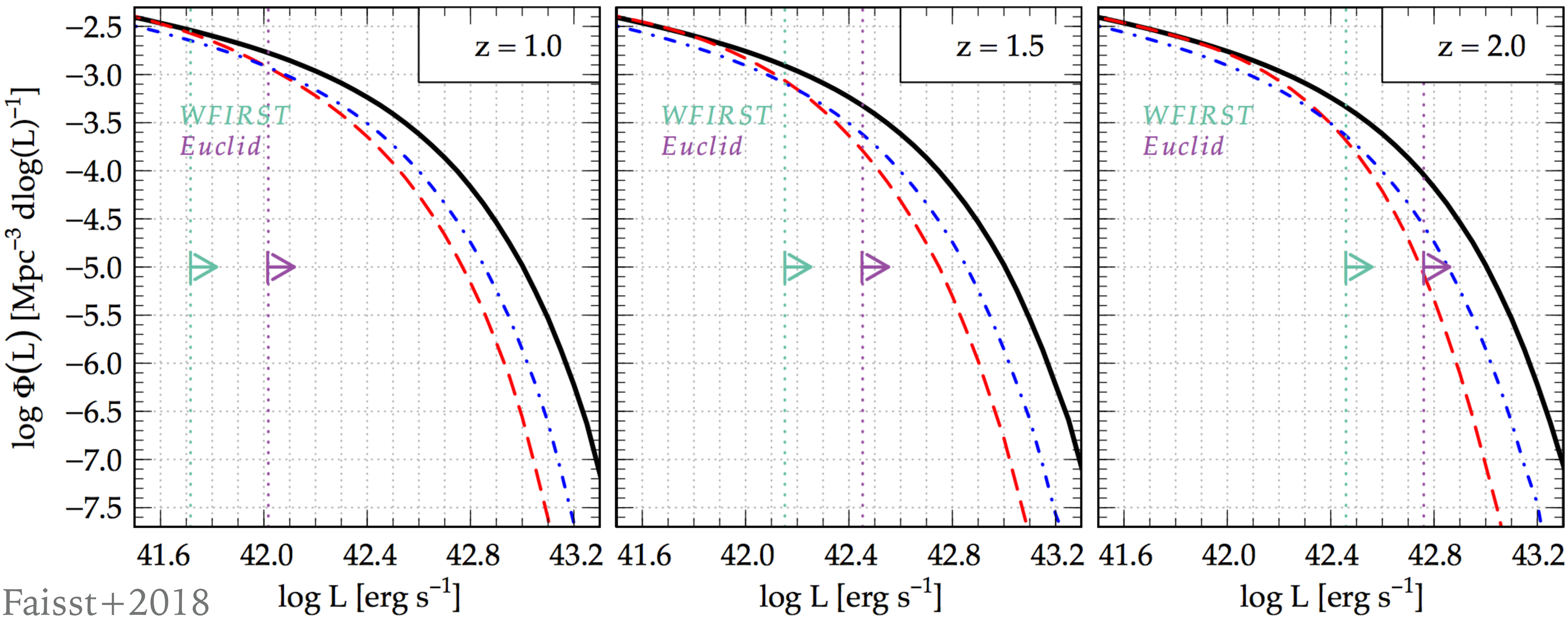
Use Case III: **Impact on Hα Luminosity Function**

- Large impact on steep bright (= massive) end of Hα LF
- Stronger [NII] in massive galaxies requires larger correction



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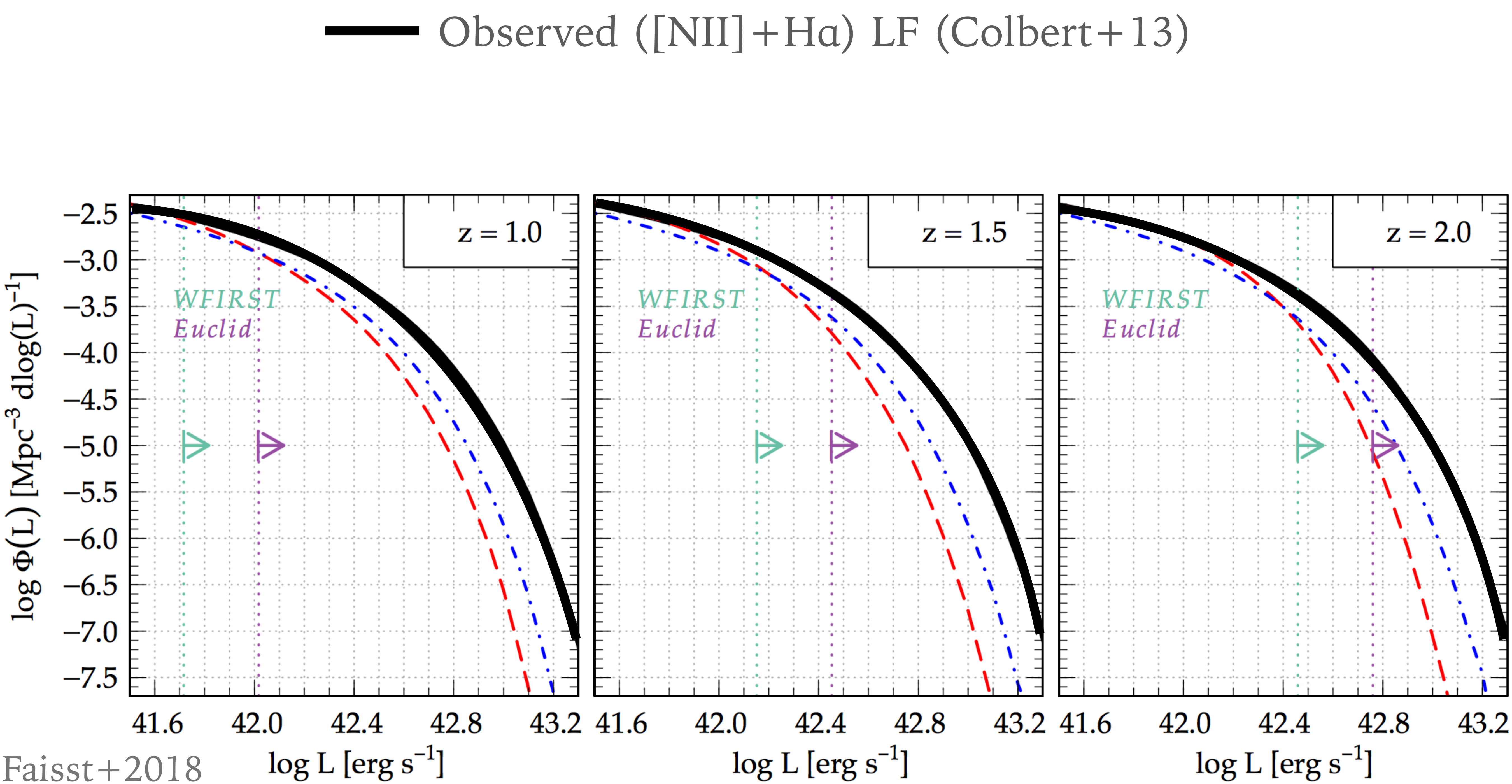

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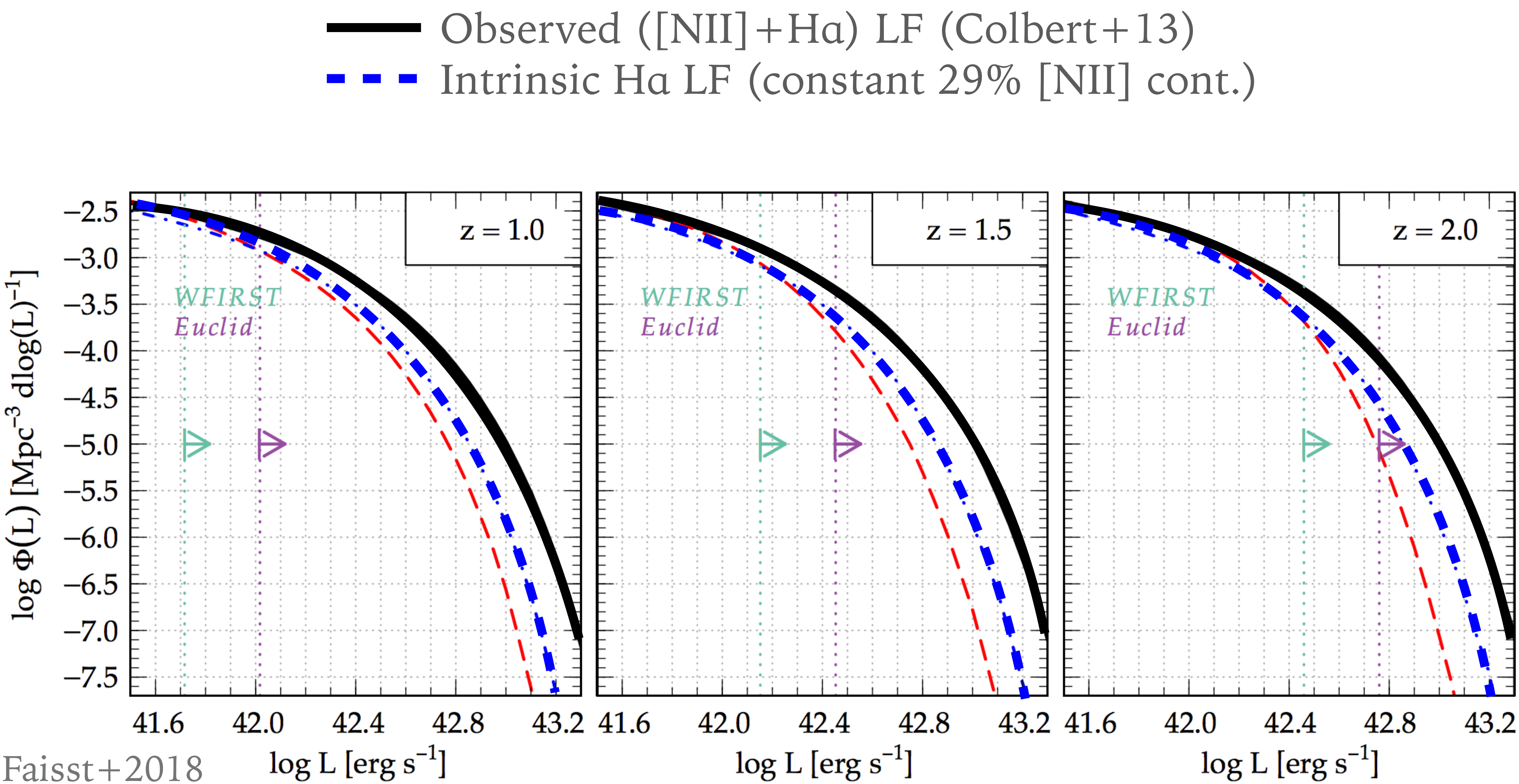

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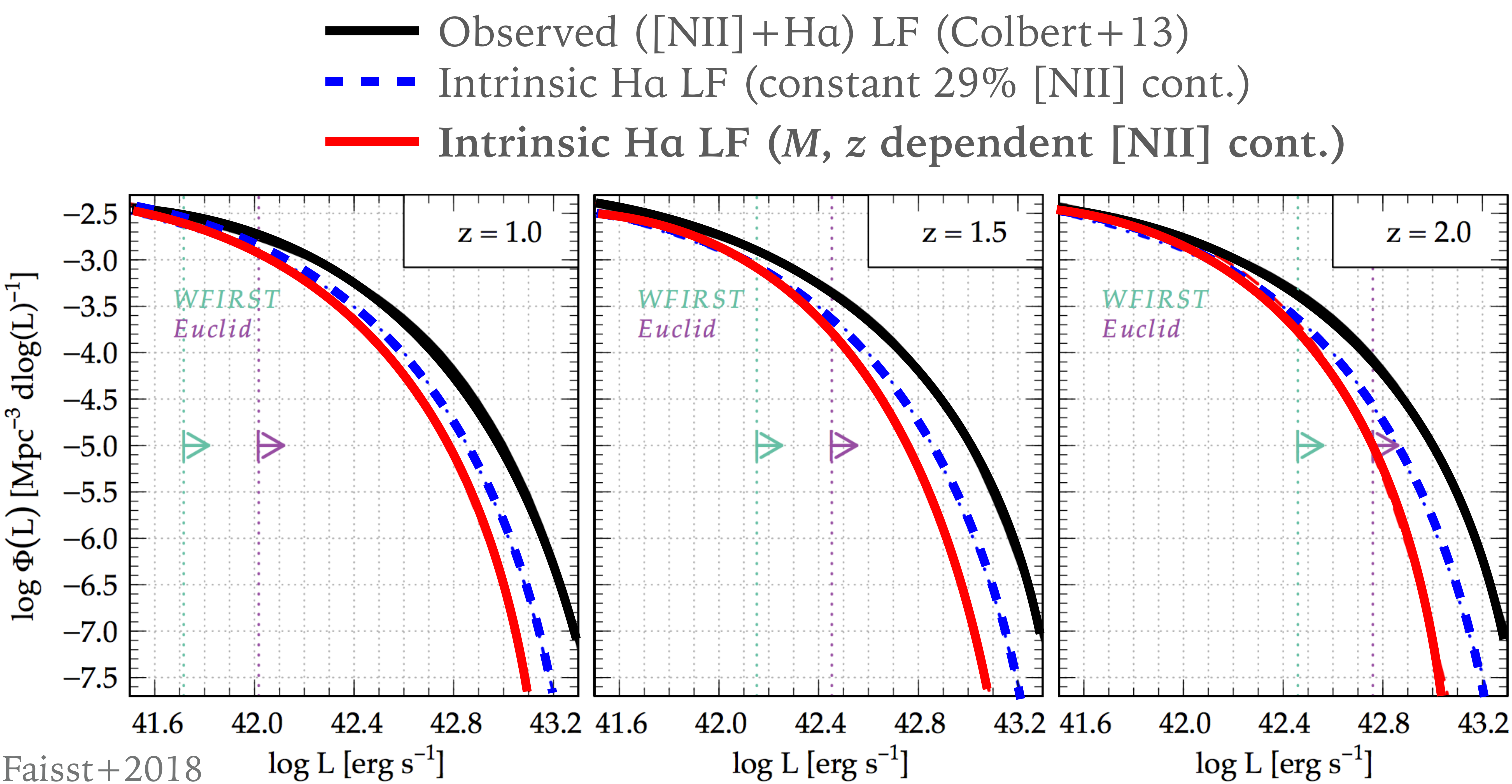

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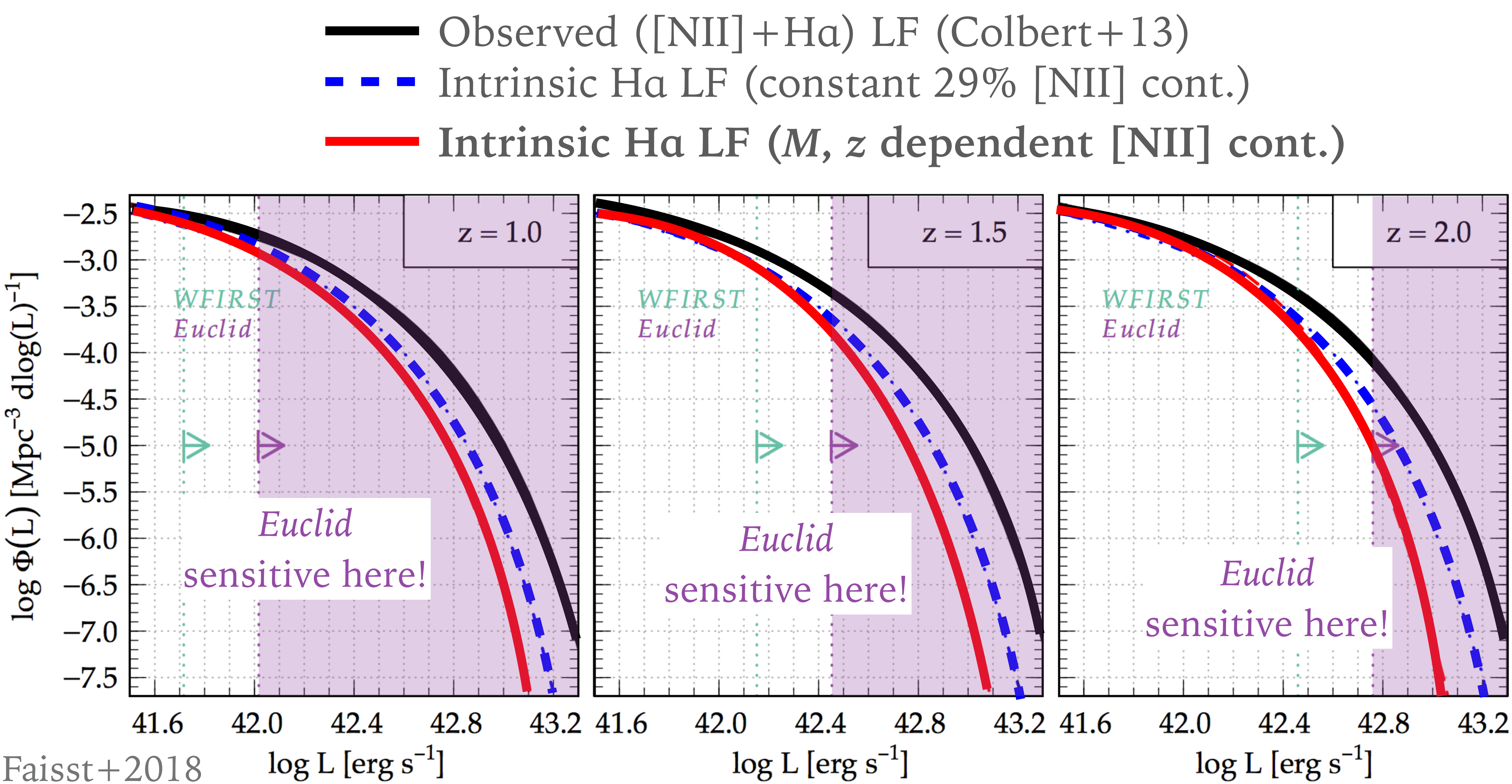

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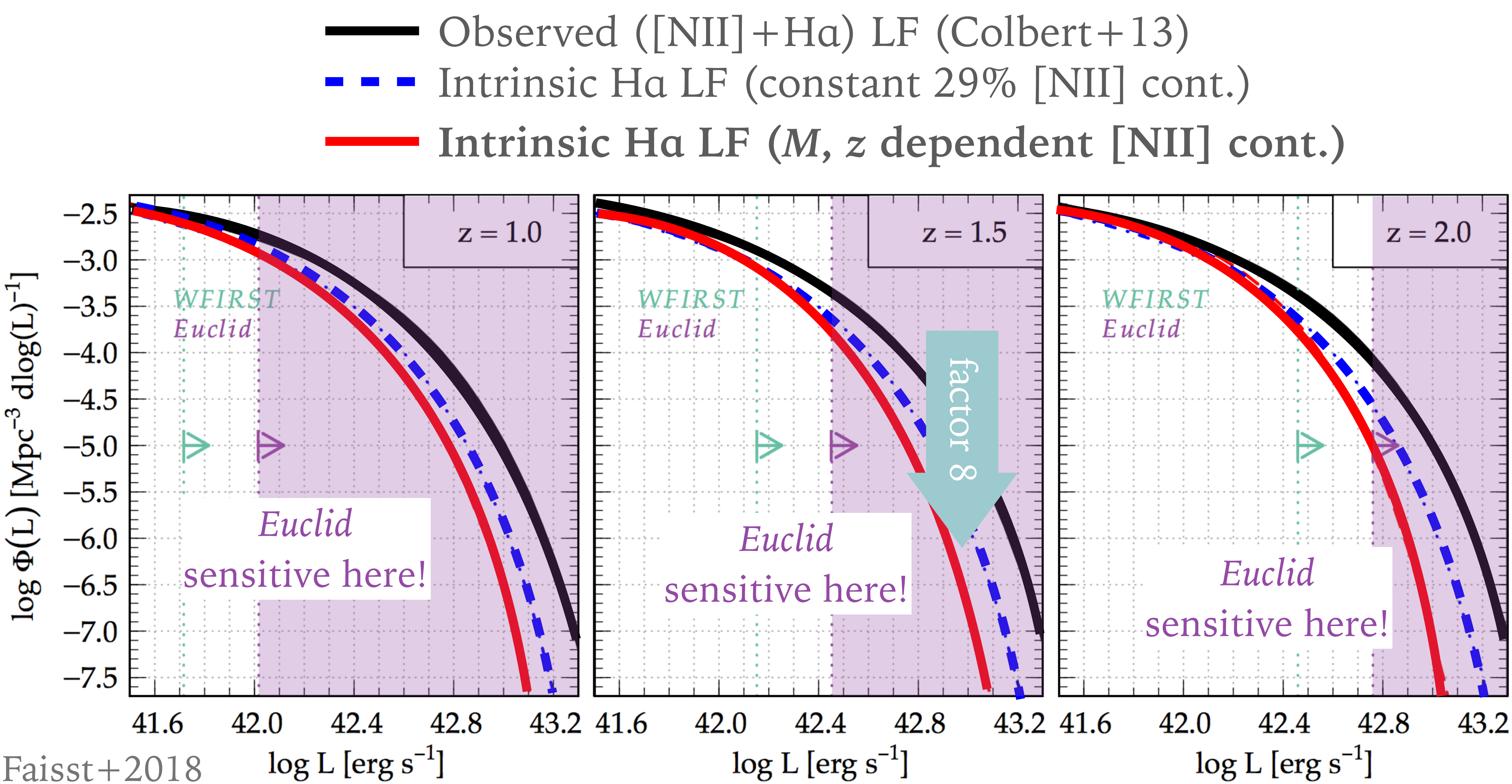

Faisst+2018

Summary

- Faisst et al. 2018: Empirical model for [NII]/Hα(M,z):
  Can be used by simulators and observers!
  - Simple to use (M and z straightforward to determine)
  - Accurate (incorporates many physical relations naturally)

- Redshift and stellar mass dependence of [NII]/Hα ratio has to be taken into account: For massive galaxies and low redshifts.
  - Correct **redshift bias** due to [NII] contamination
  - Use in **simulations** to derive ([NII]+Hα) number densities
  - Derive **deblended Hα LF** from observations