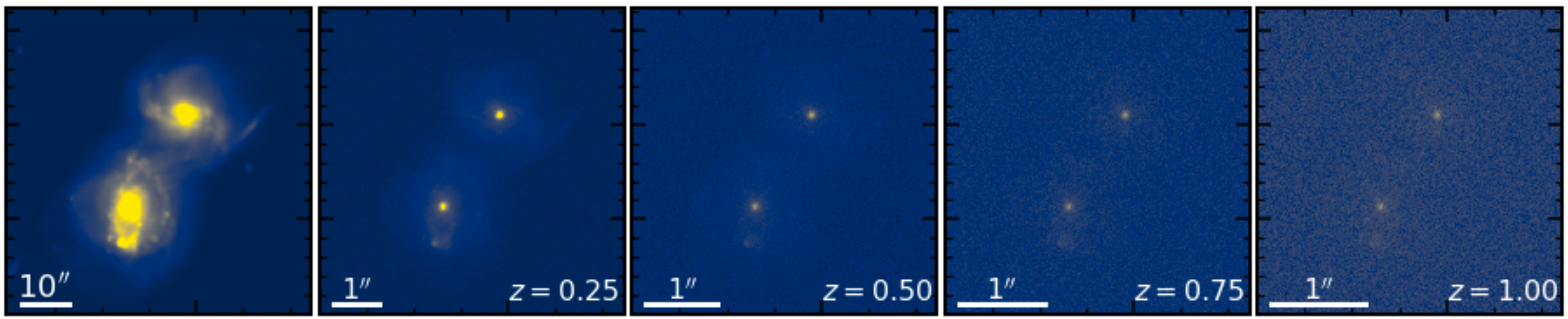
Bias and systematics in observational measurements of supernova hosts across cosmic time



Ana Paulino-Afonso

in collaboration with Ana Mourão, Santiago González-Gaitán, Lluís Galbany & the CRISP team

CRISP virtual Meeting 2020

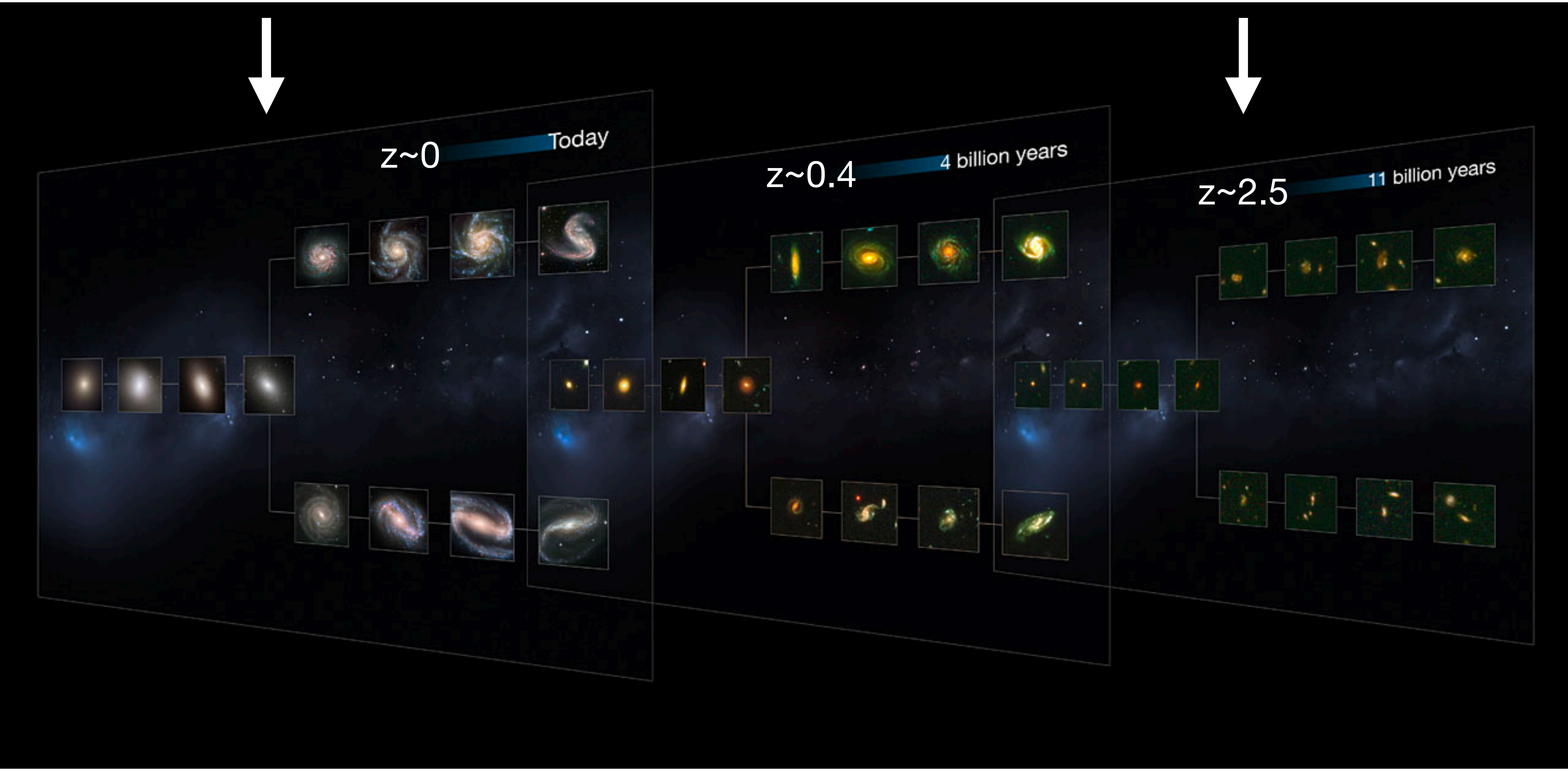
July 7, 2020

centra FCT Fundação para a Ciência e a Tecnologia TÉCNICO LISBOA

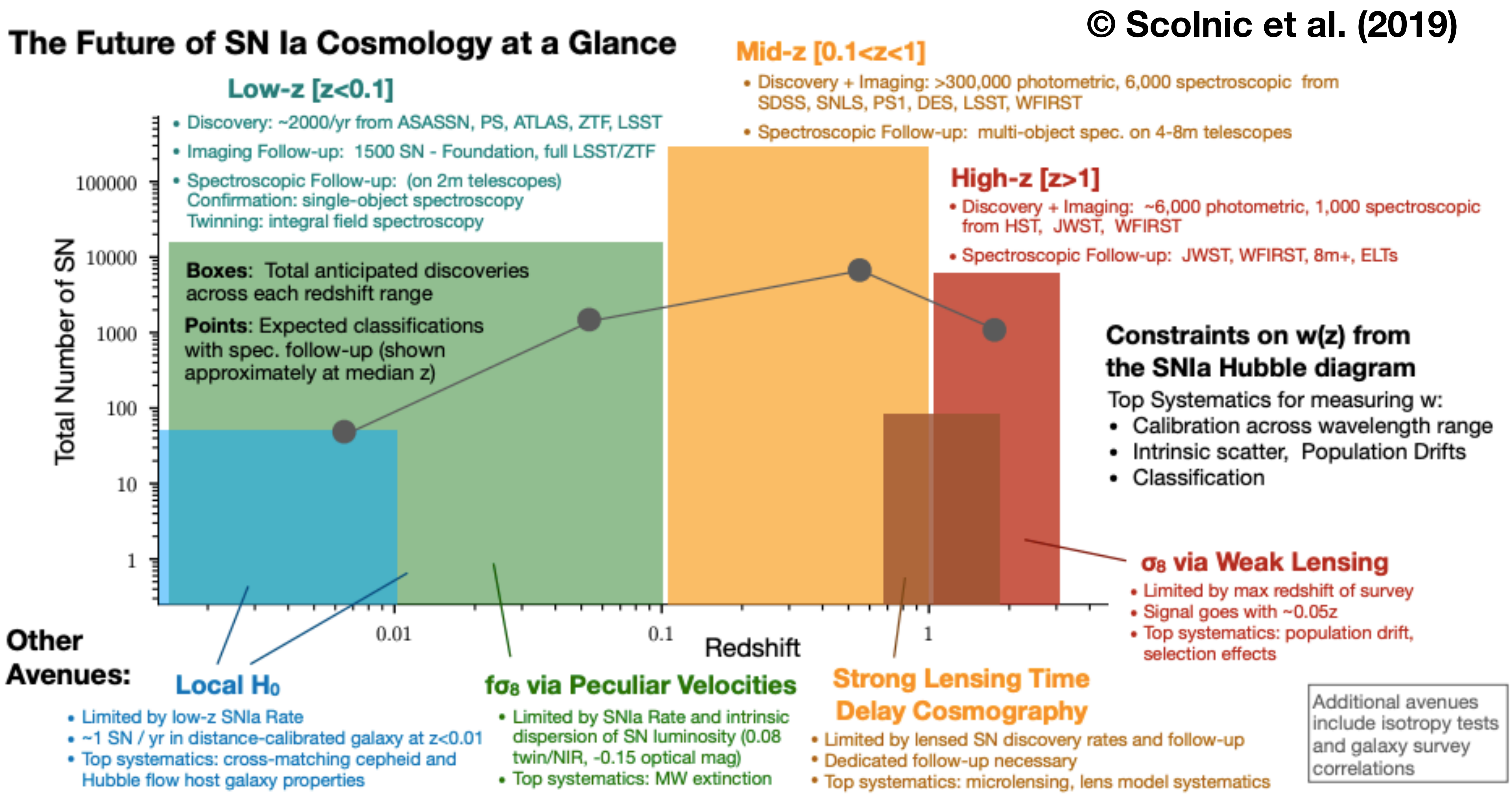
The Hubble Diagram throughout the Universe's history

big, fully formed and intricate shapes

smaller and less mature, difficult to distinguish between different visual types

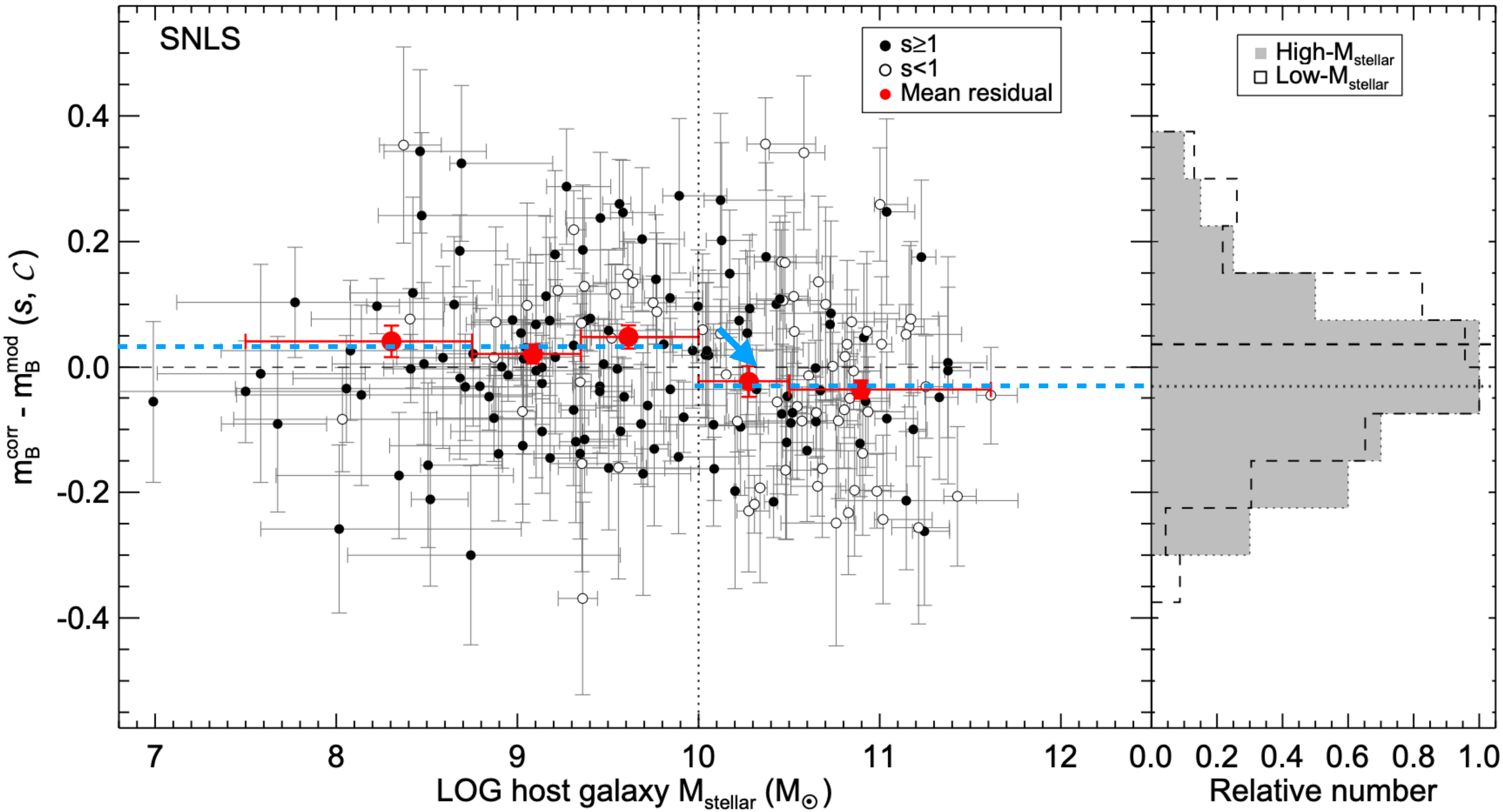


The future of SN Ia Cosmology

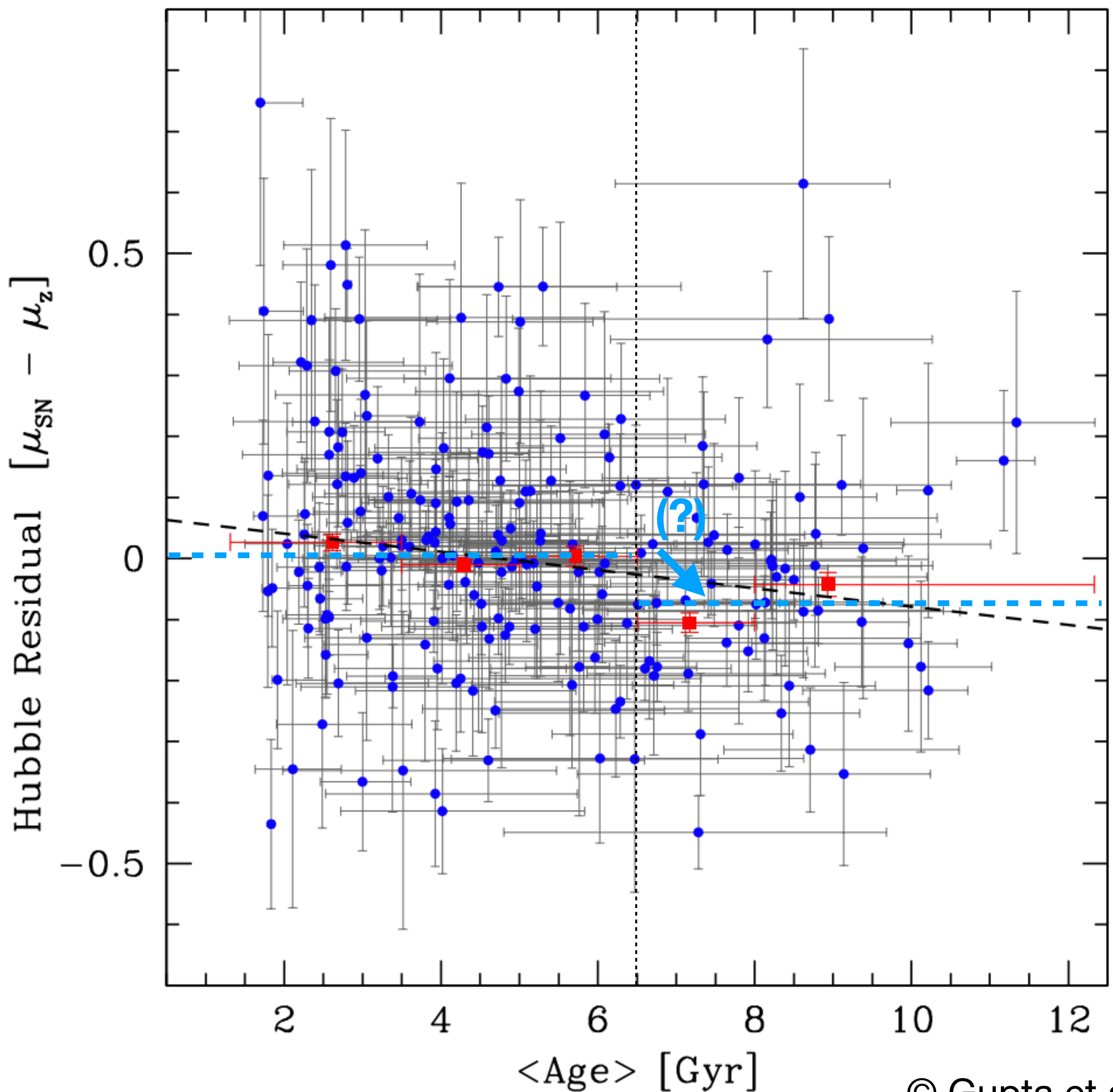


Local and Global properties of SN hosts

Mass-step



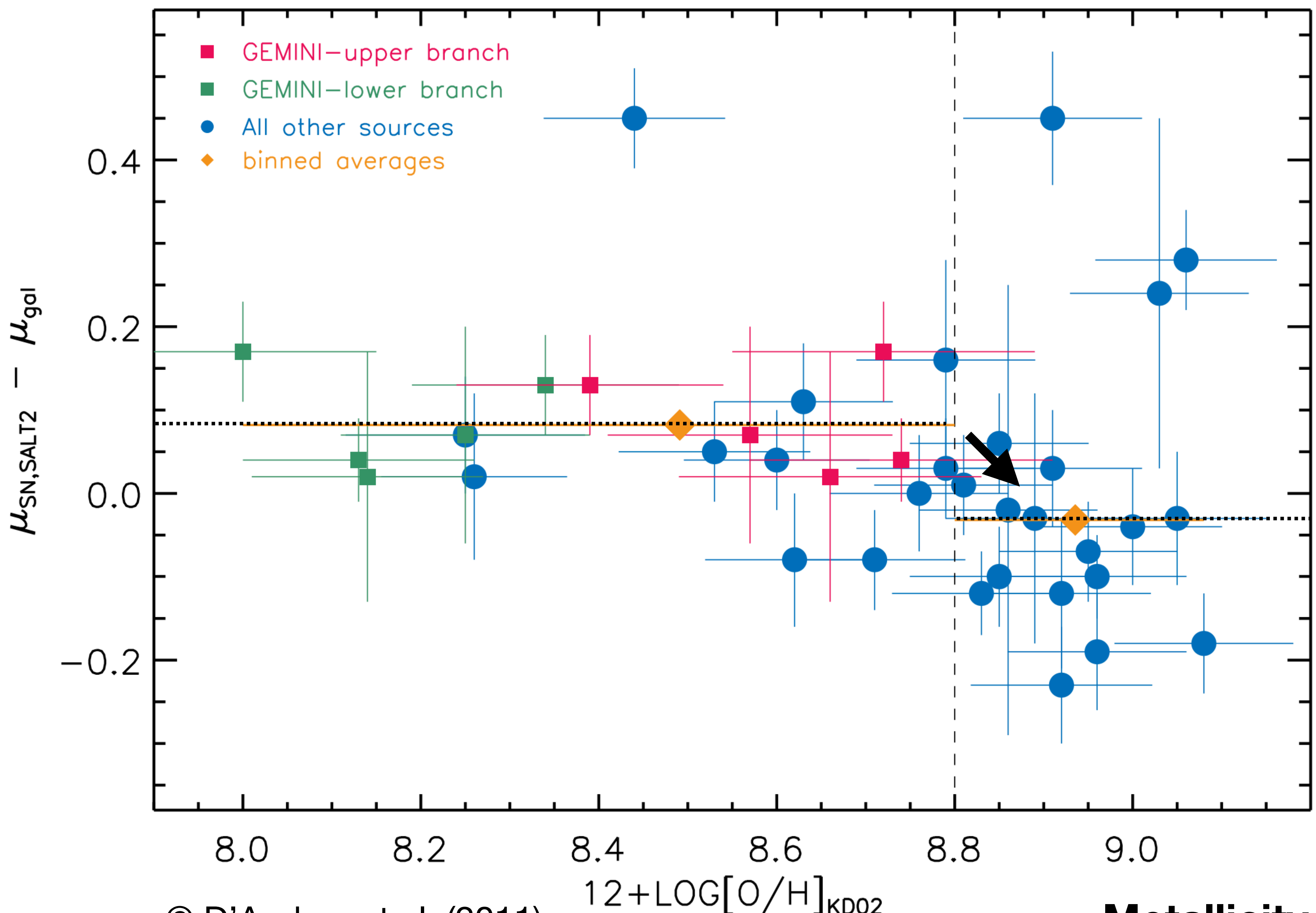
Local and Global properties of SN hosts



Age-step

© Gupta et al. (2011)

Local and Global properties of SN hosts



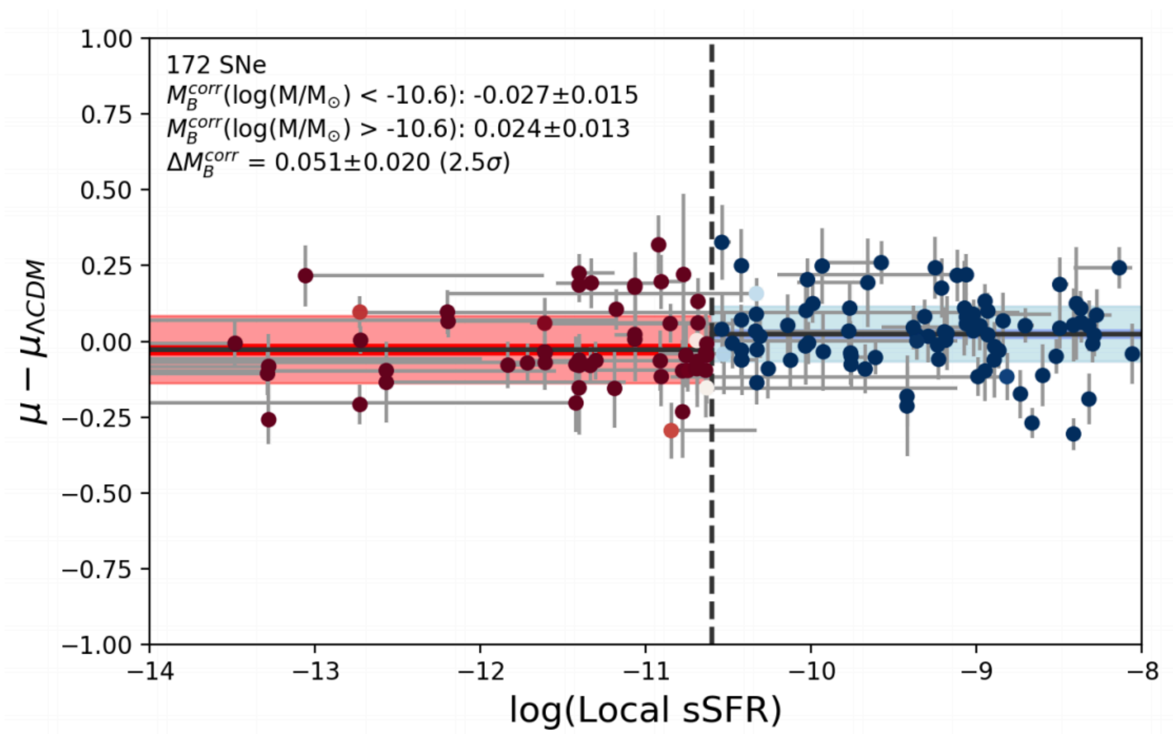
© D'Andrea et al. (2011)

Metallicity-step

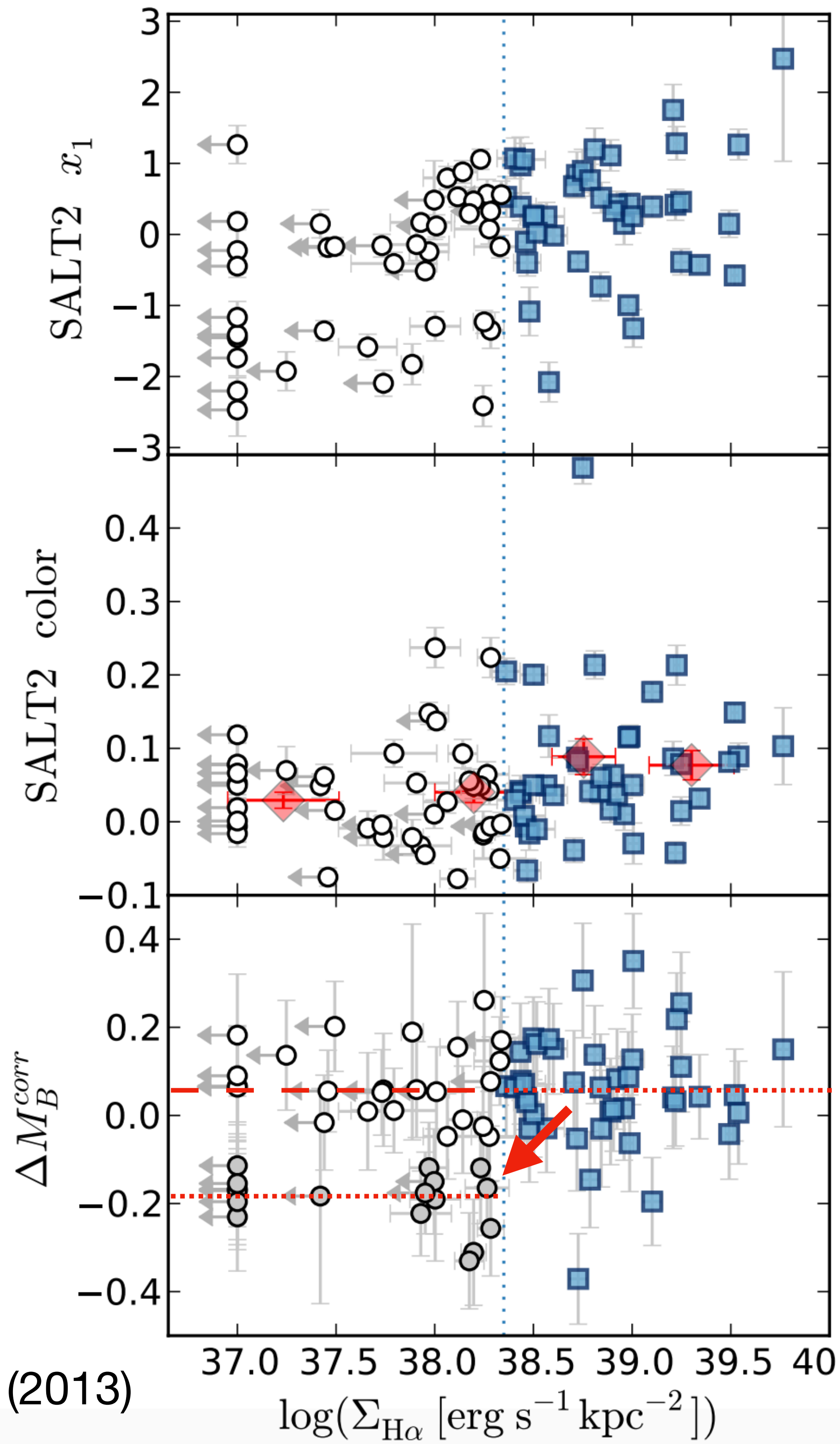
Local and Global properties of SN hosts

step or no step?

sSFR



© Jones et al. (2018b)

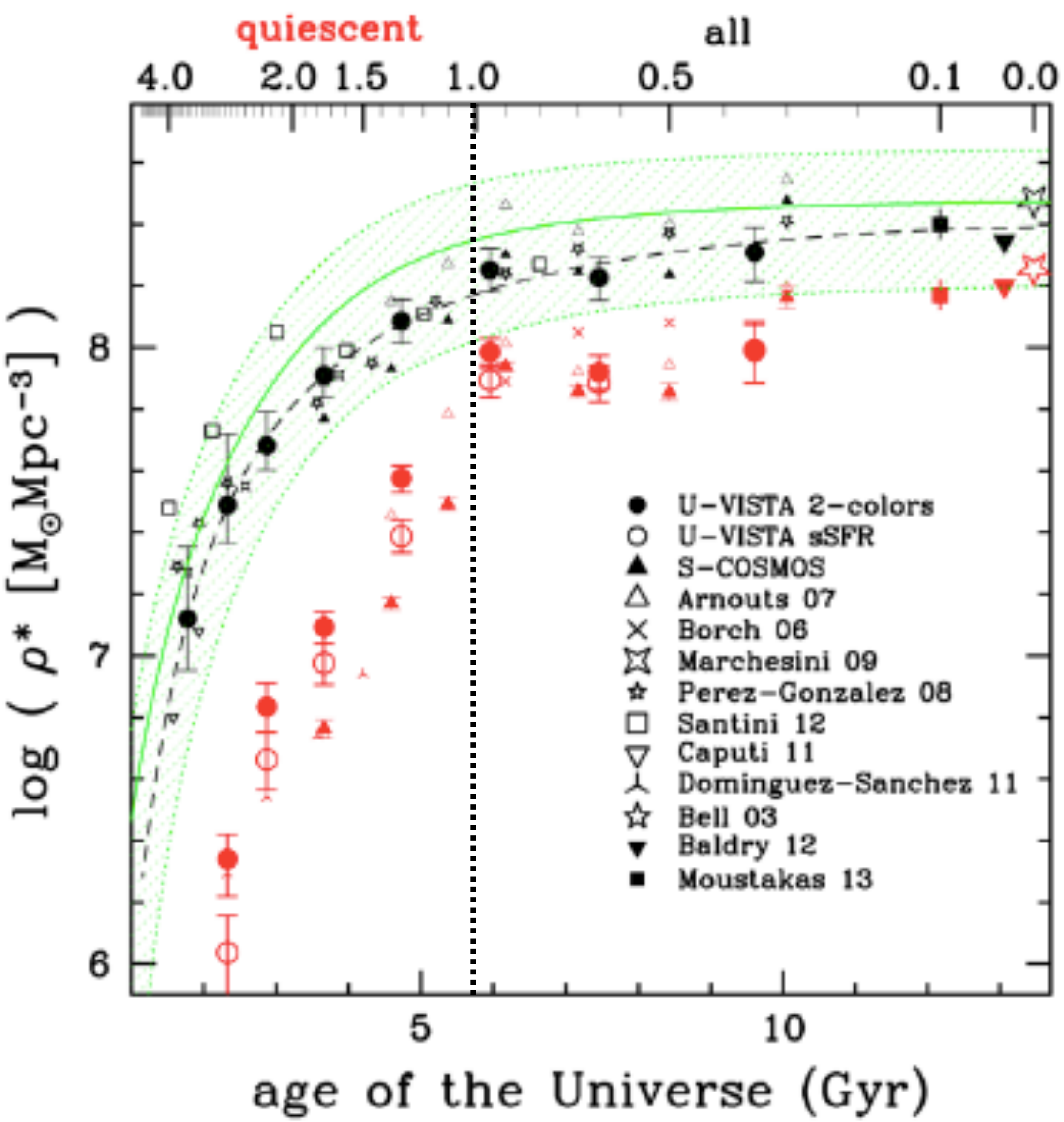


Proxy SFR Hα

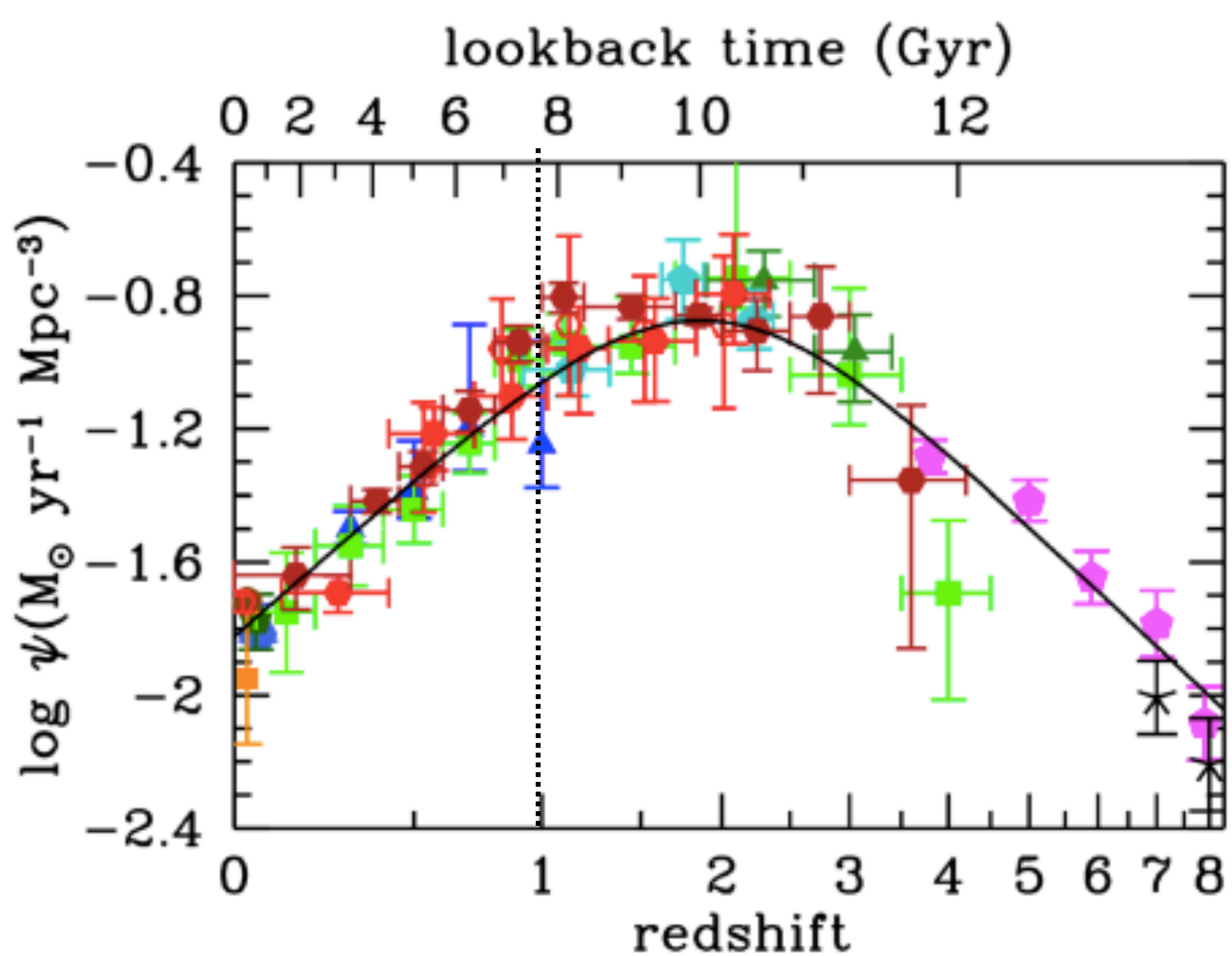
© Rigault et al. (2013)

Local and Global properties of SN hosts

Galaxy evolution across cosmic time



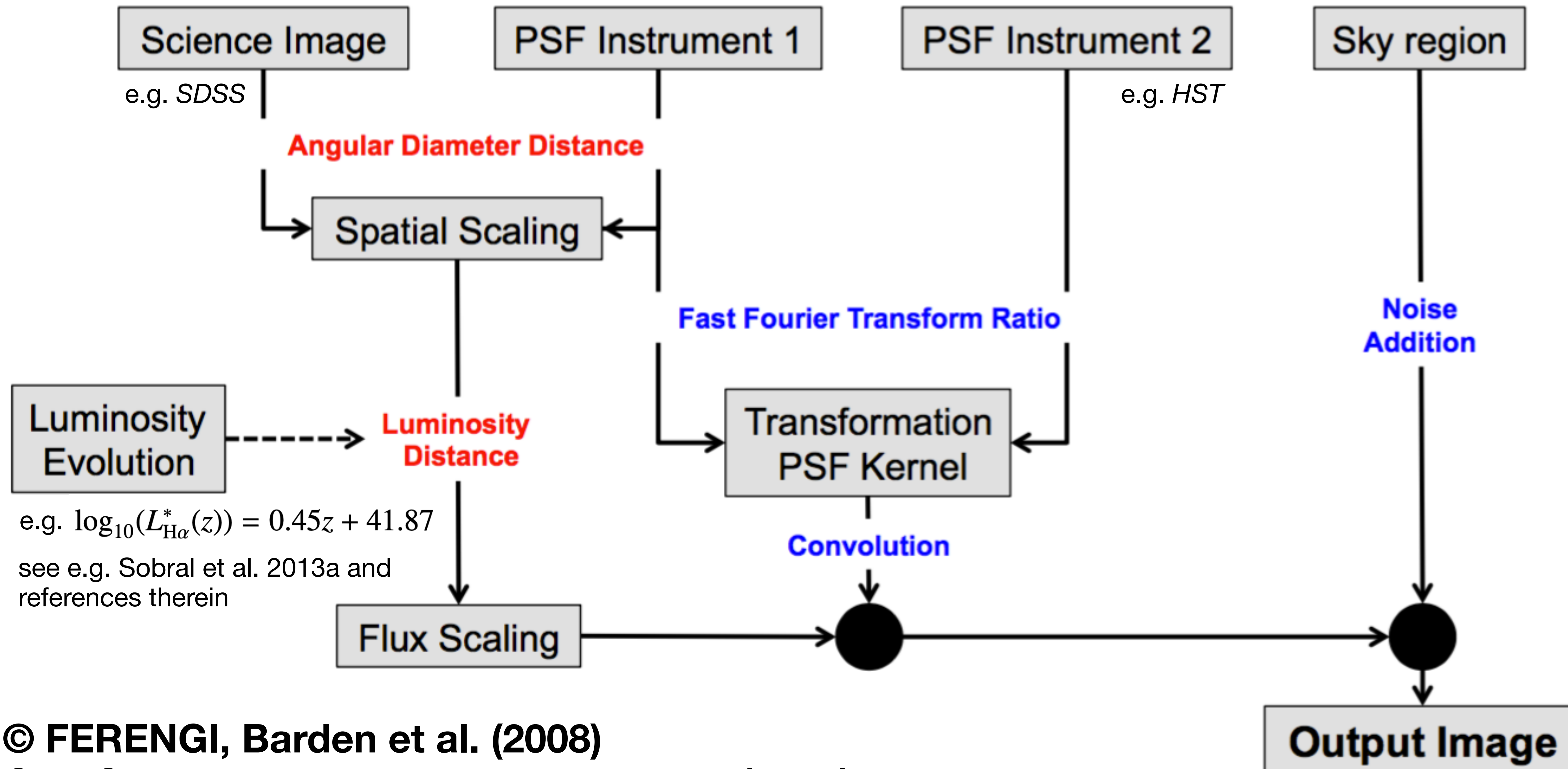
© Ilbert et al. (2013)



© Madau & Dickinson et al. (2014)

Artificial redshifting galaxies

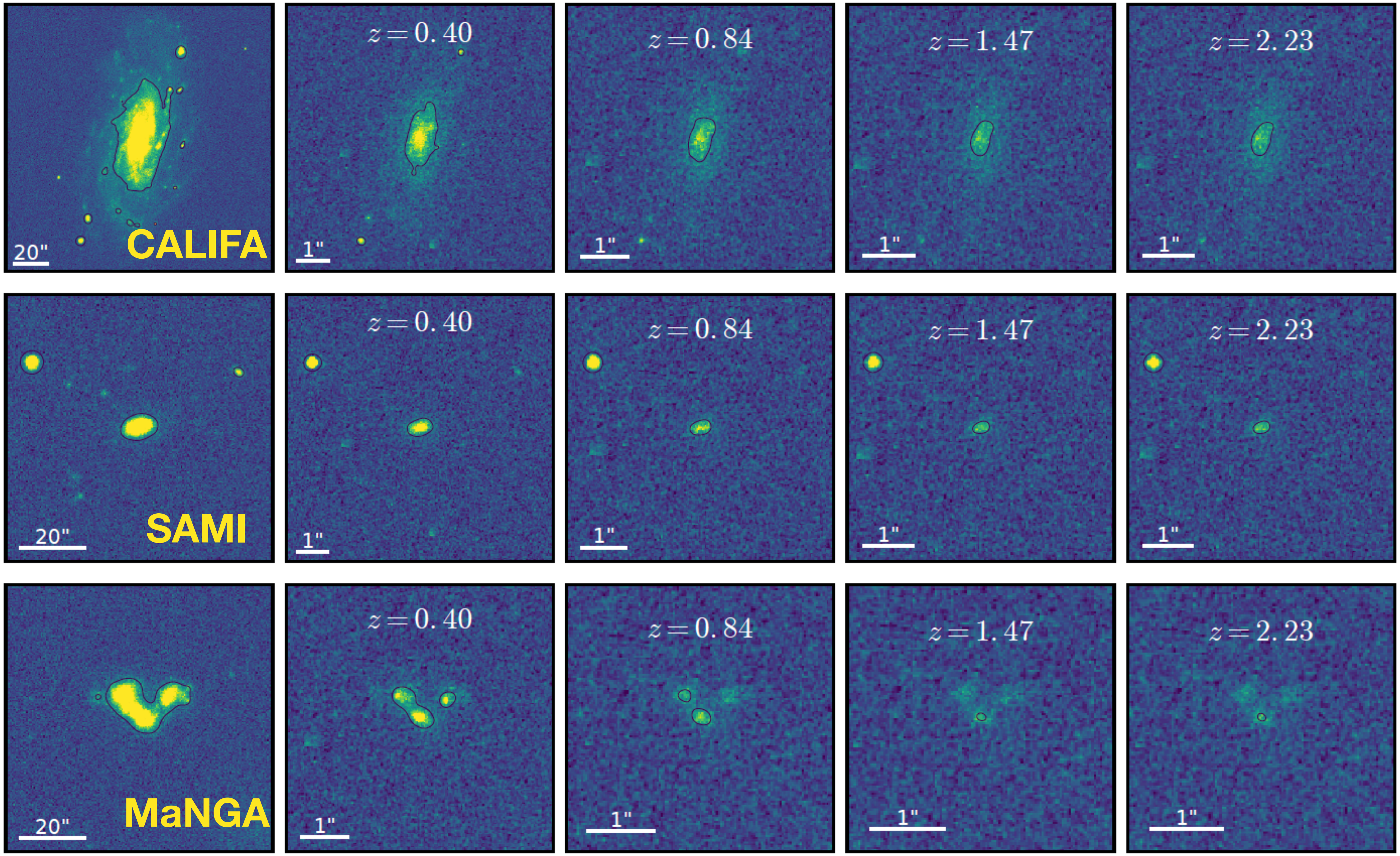
This is the general scheme that describes how to transform a source observed in one instrument into an higher redshift image observed with a different instrument.



© FERENGI, Barden et al. (2008)
© "DOPTERIAN", Paulino-Afonso et al. (2017)

Artificial redshifting galaxies

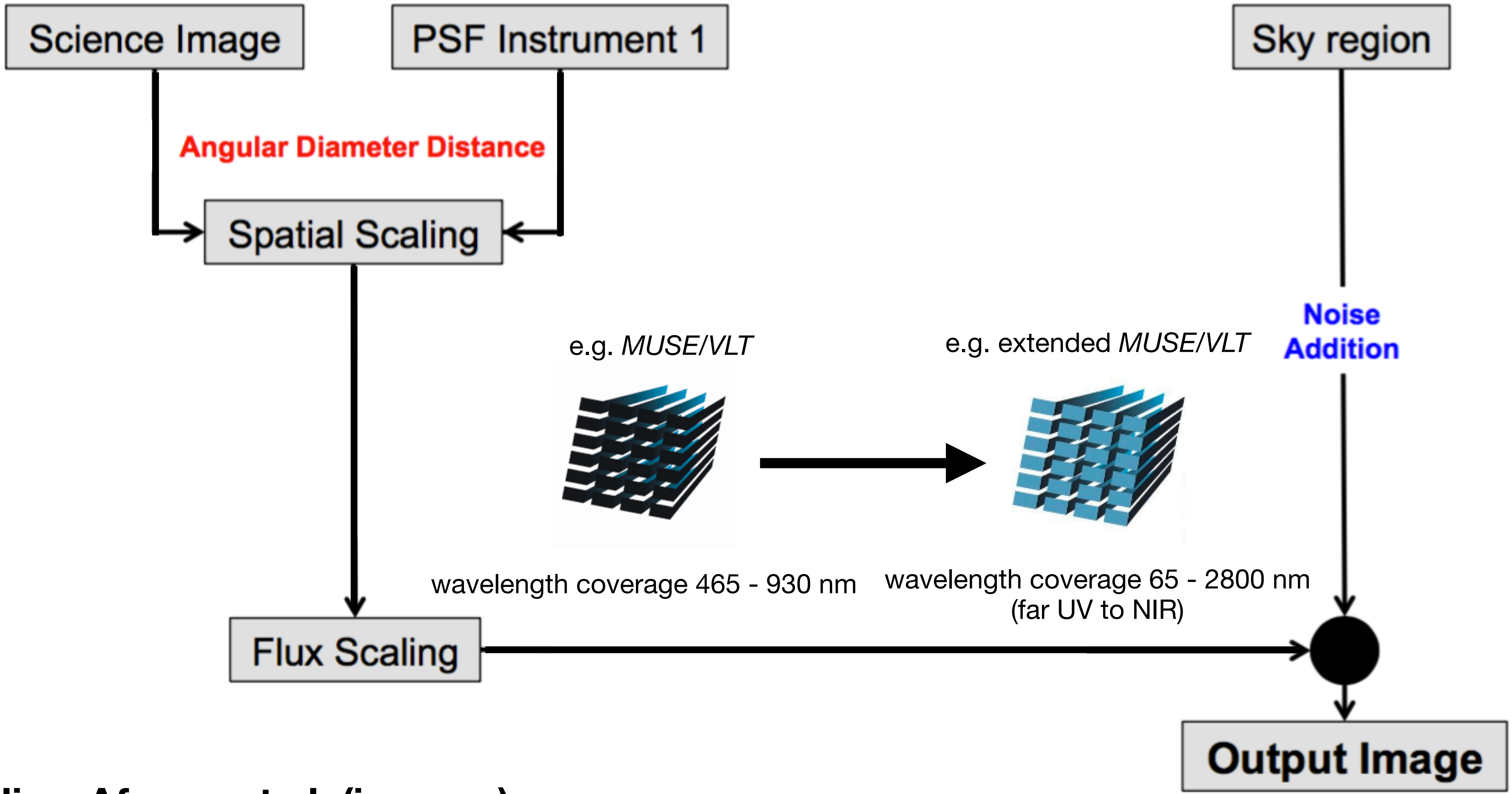
© Paulino-Afonso et al. (2017), code available at GitHub: *asofiafonso/Dopterian*



for the importance of SN host morphology in correctly interpreting SN observations see e.g. Lyman et al., 2017; Hill et al. 2018

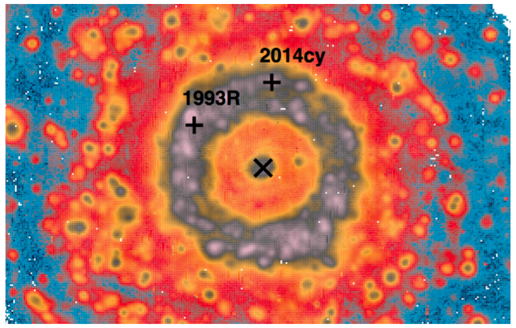
Artificial redshifting IFS data

This is the scheme that describes the test that we are performing. I.e. we assume that we can observe a local source at higher redshift using the same instrument.



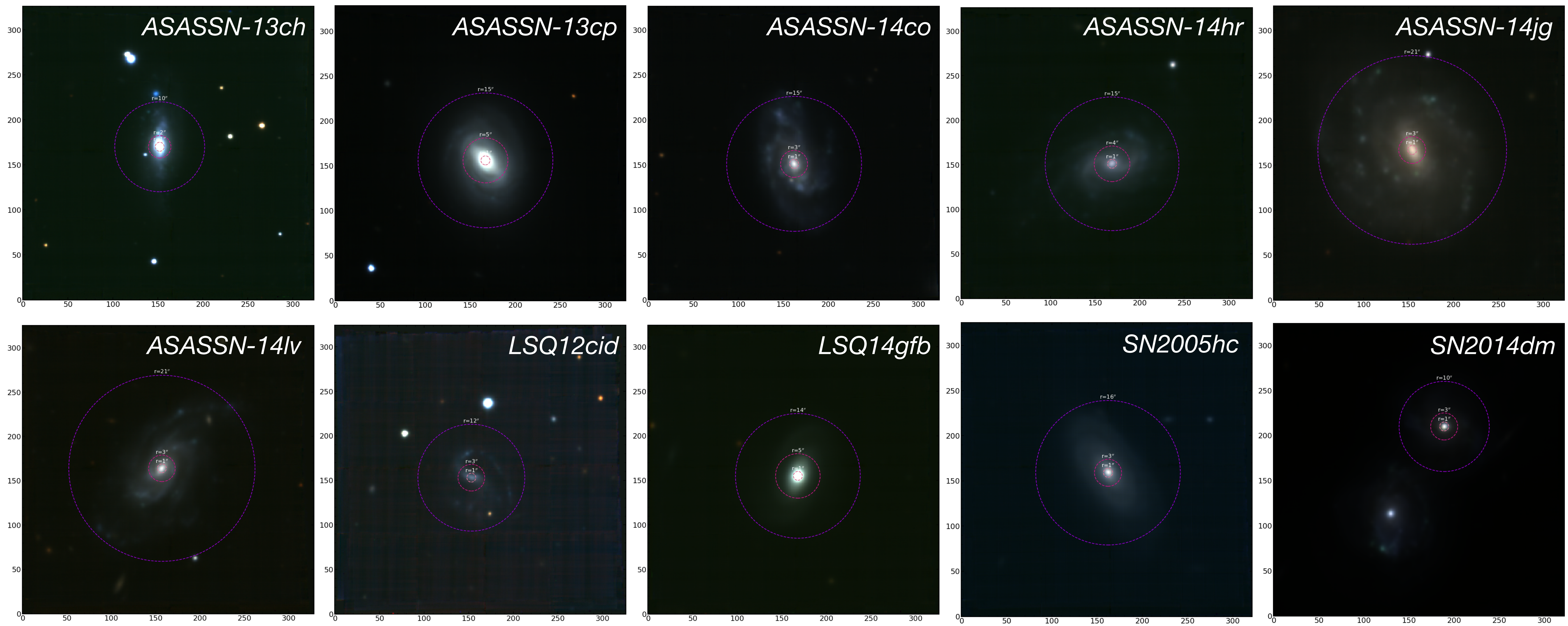
Data sample

started with a <u>non-representative test sample</u> of the All-weather MUse Supernova Integral field Nearby Galaxies (AMUSING) survey (PIs: J. Anderson & L. Galbany)



Now we are extending the sample to include the ~600 hosts!

RGB images made from the MUSE data cube



see https://amusing-muse.github.io/

see also eg. Galbany et al., MNRAS, 2016, 455, 4087-4099 (arXiv: 1511.01495)

Research approach

1) Object selection

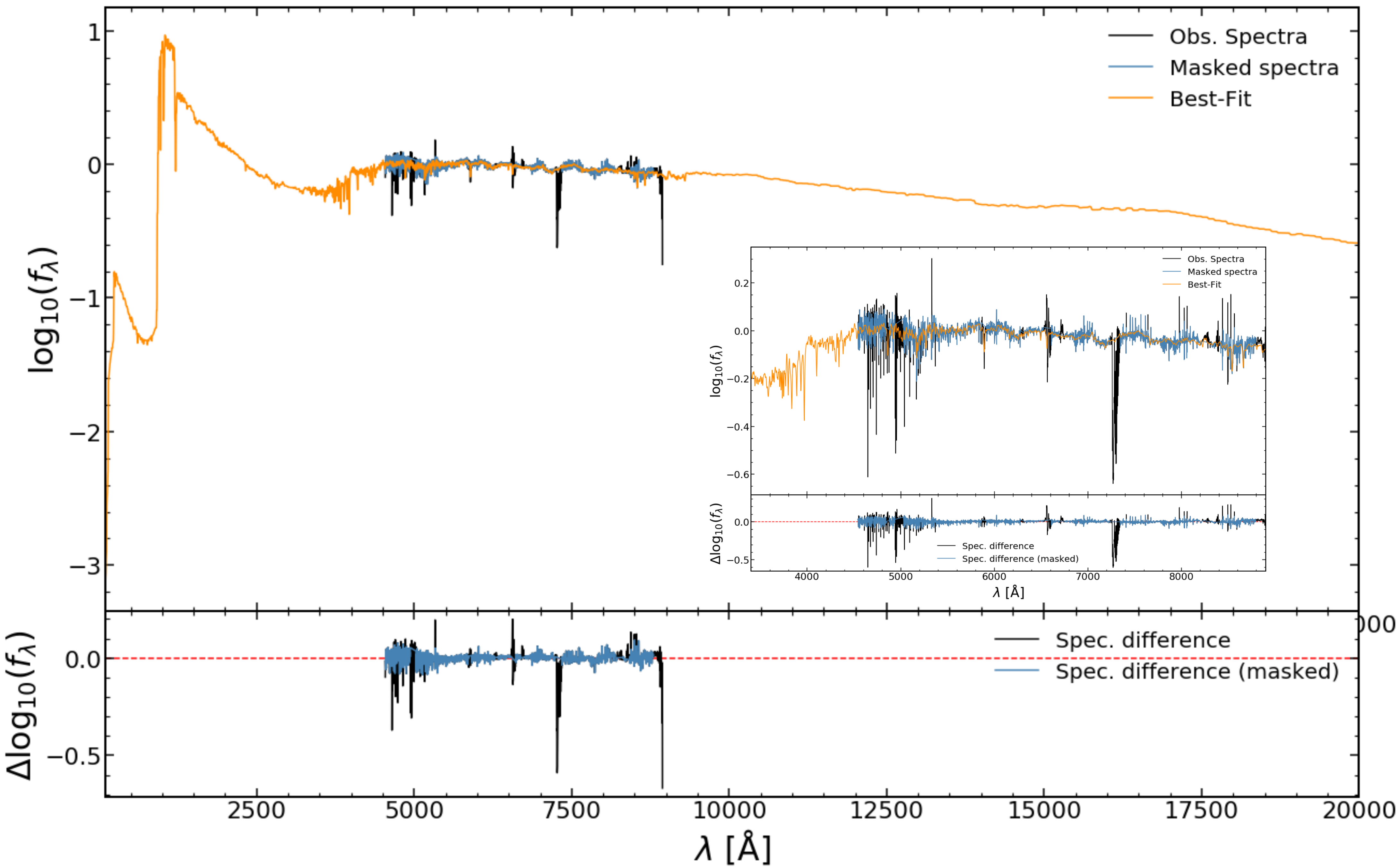
Collapsed MUSE data cubes. S/N > 5.

select pixels belonging to object for artificial redshifting

SExtractor-like (Bertin & Arnouts, 1996)

Research approach

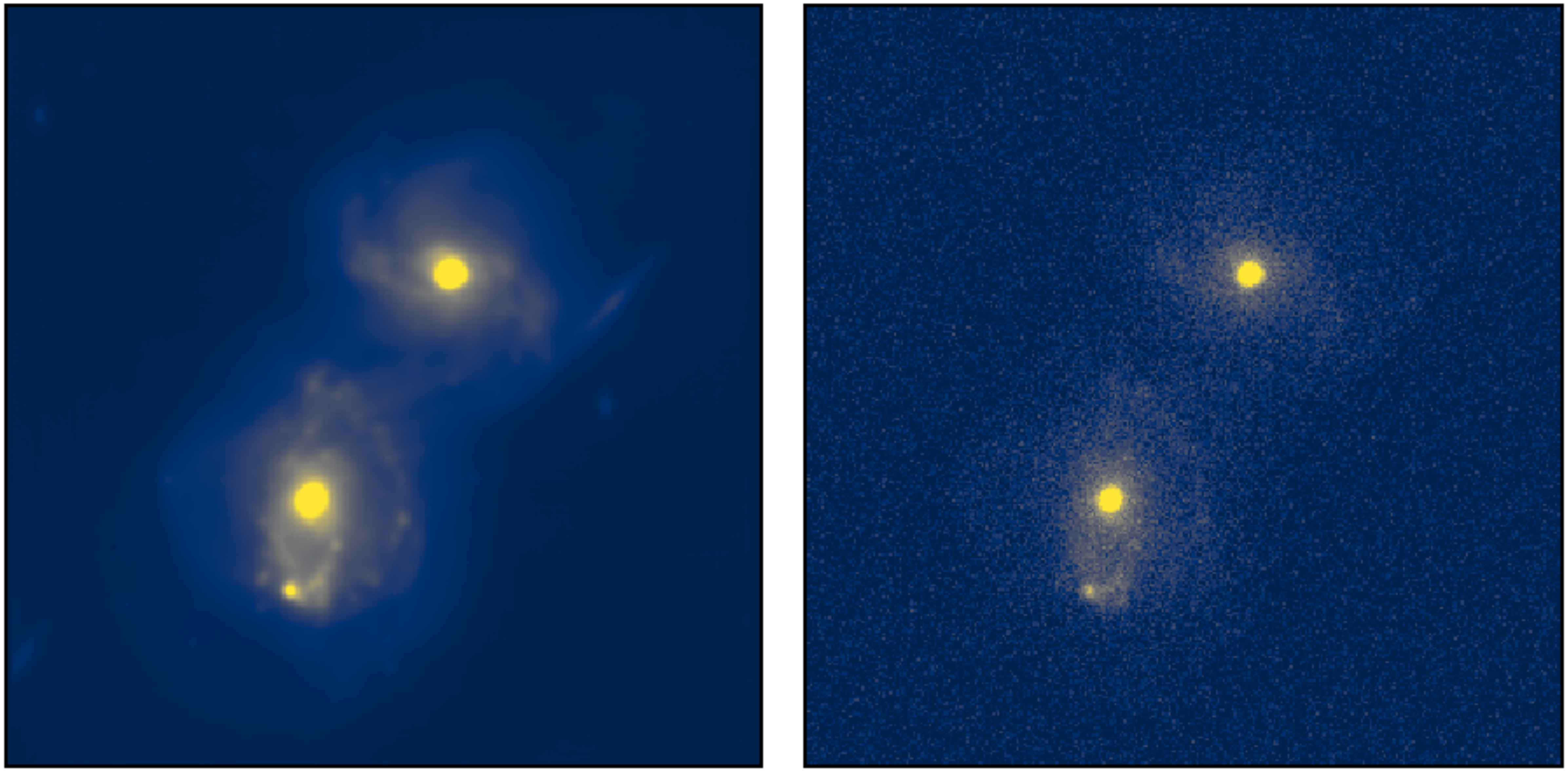
2) Fitting stellar populations to individual spaxels to generate a wavelength extended data cube



© Starlight, Cid Fernandes et al. (2005)

Research approach

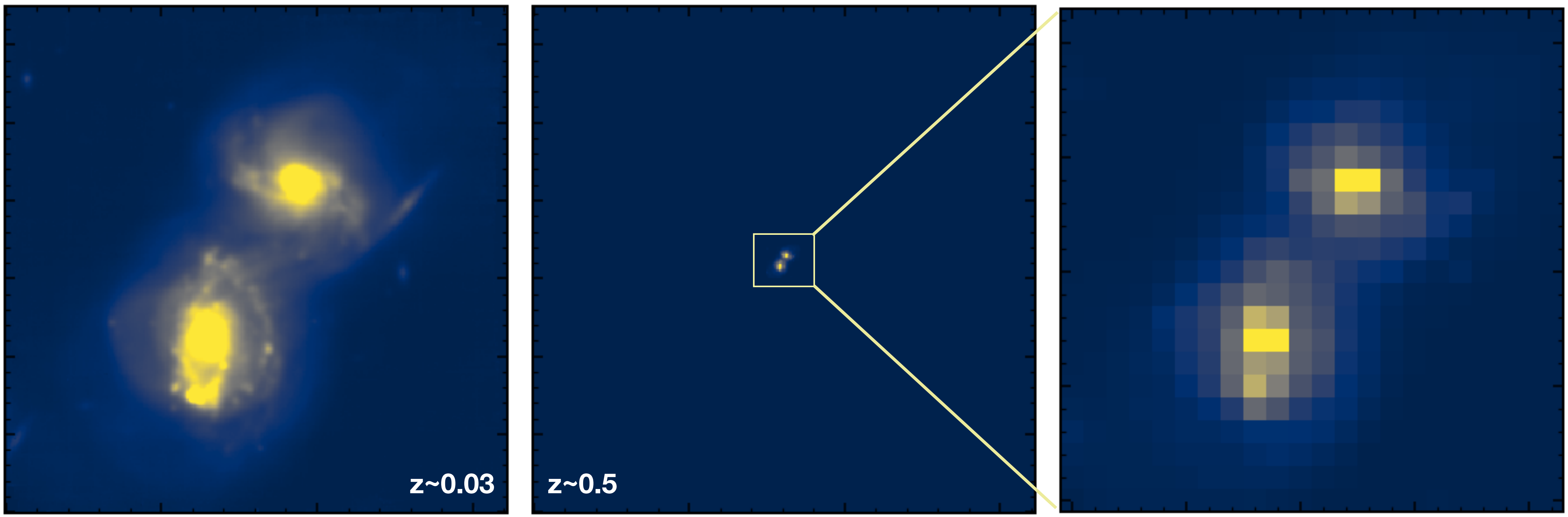
3) Applying dimming to each cube for each cosmic time slice



the flux in each pixel of the galaxy will diminish by a $(1+z)^3$ factor
due to cosmological surface brightness dimming.

Research approach

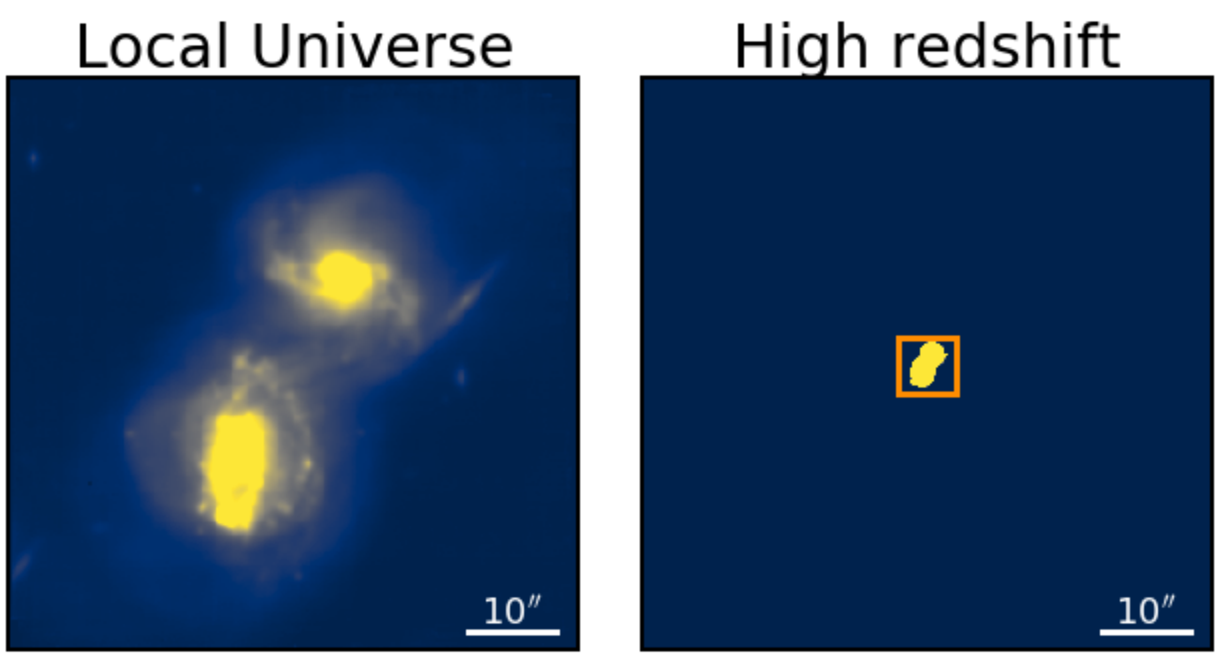
4) Rescaling the galaxy to match the spatial resolution at each cosmic slice

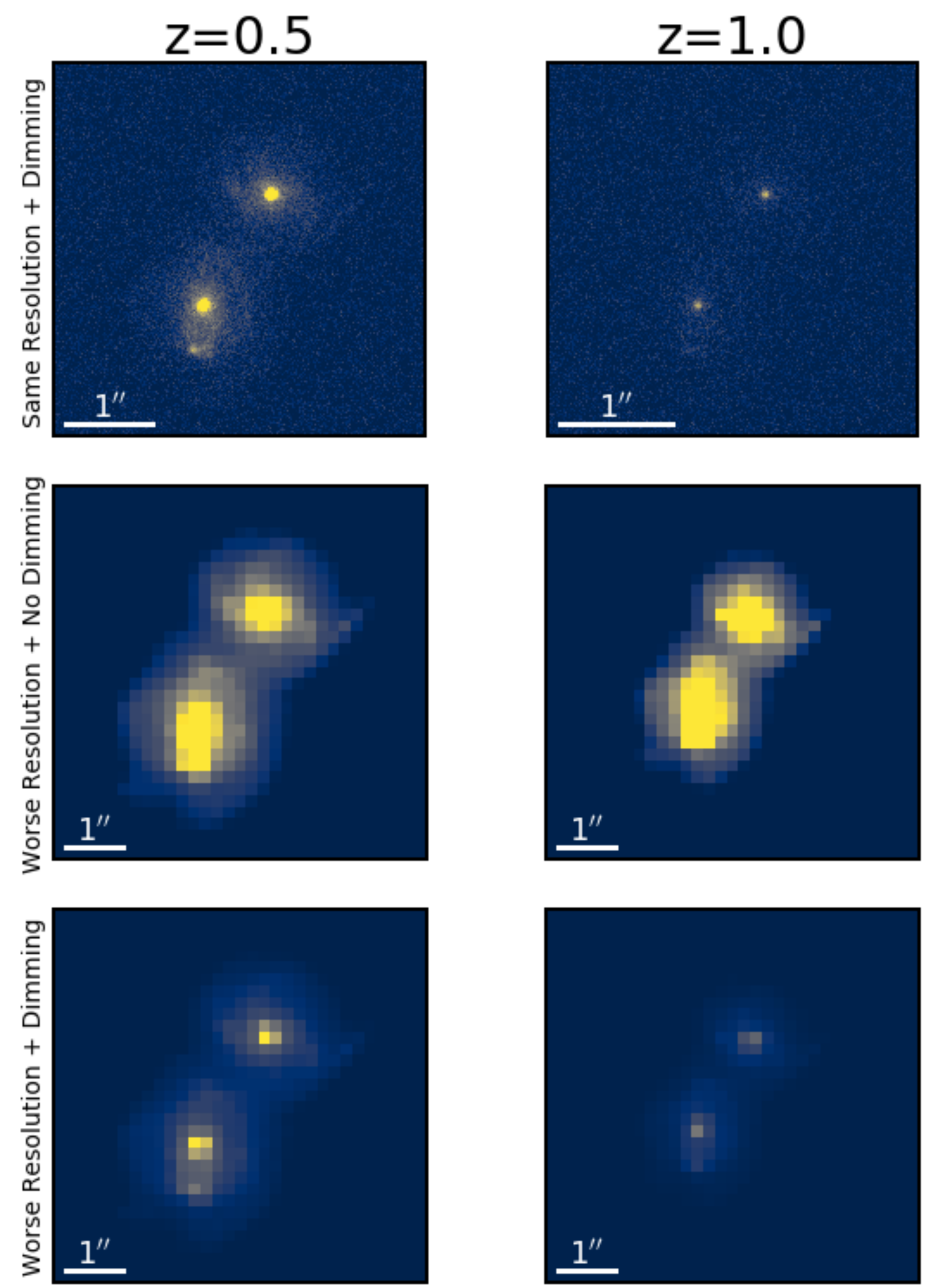


the galaxy being more distant will occupy a smaller angular section of the sky, which translates into a smaller number of pixels (as the pixel-scale is constant)

Research approach

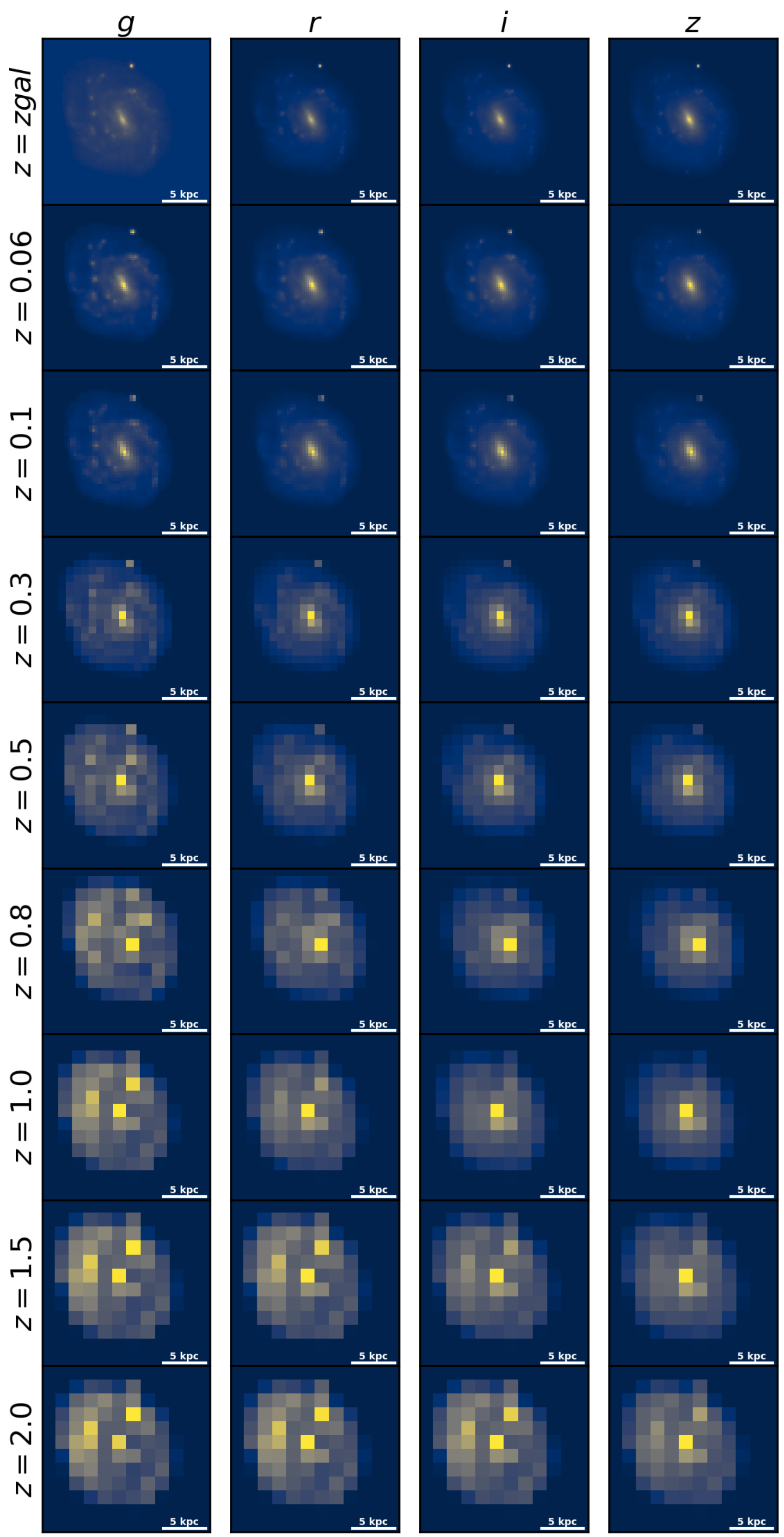
Summary





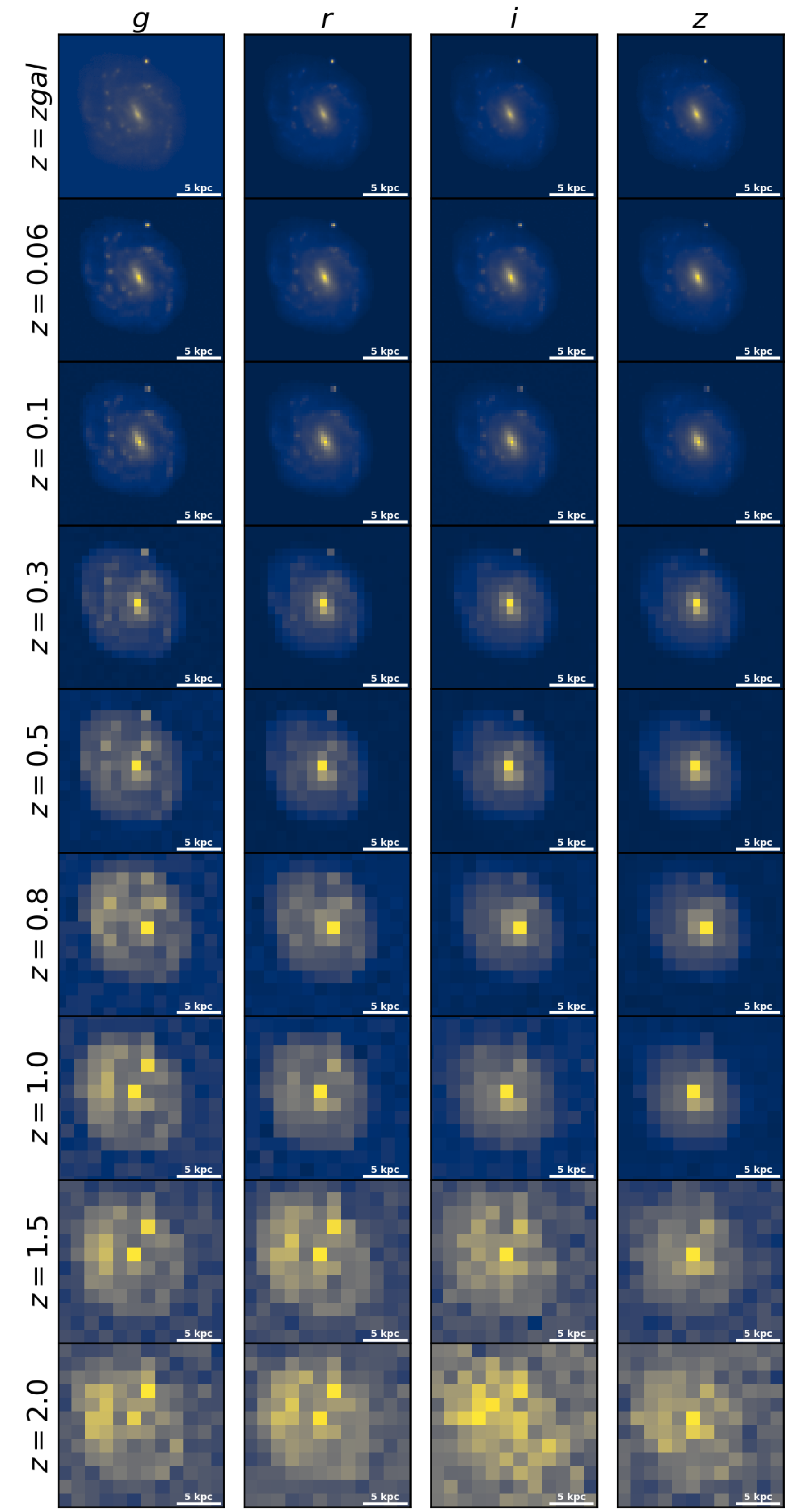
dimming tries to kill everything,
but scaling brings part back

Research approach



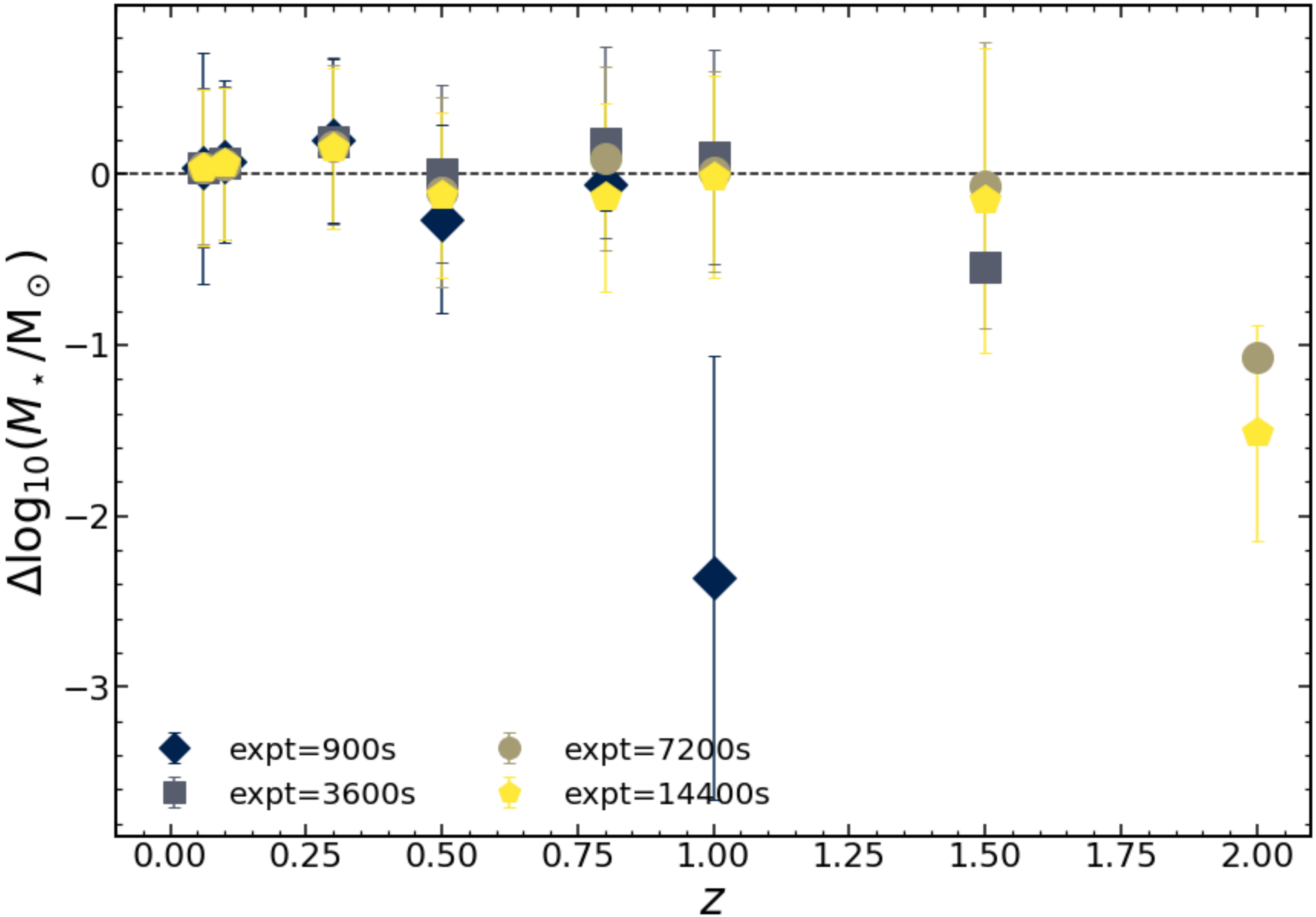
without noise

Noise impression

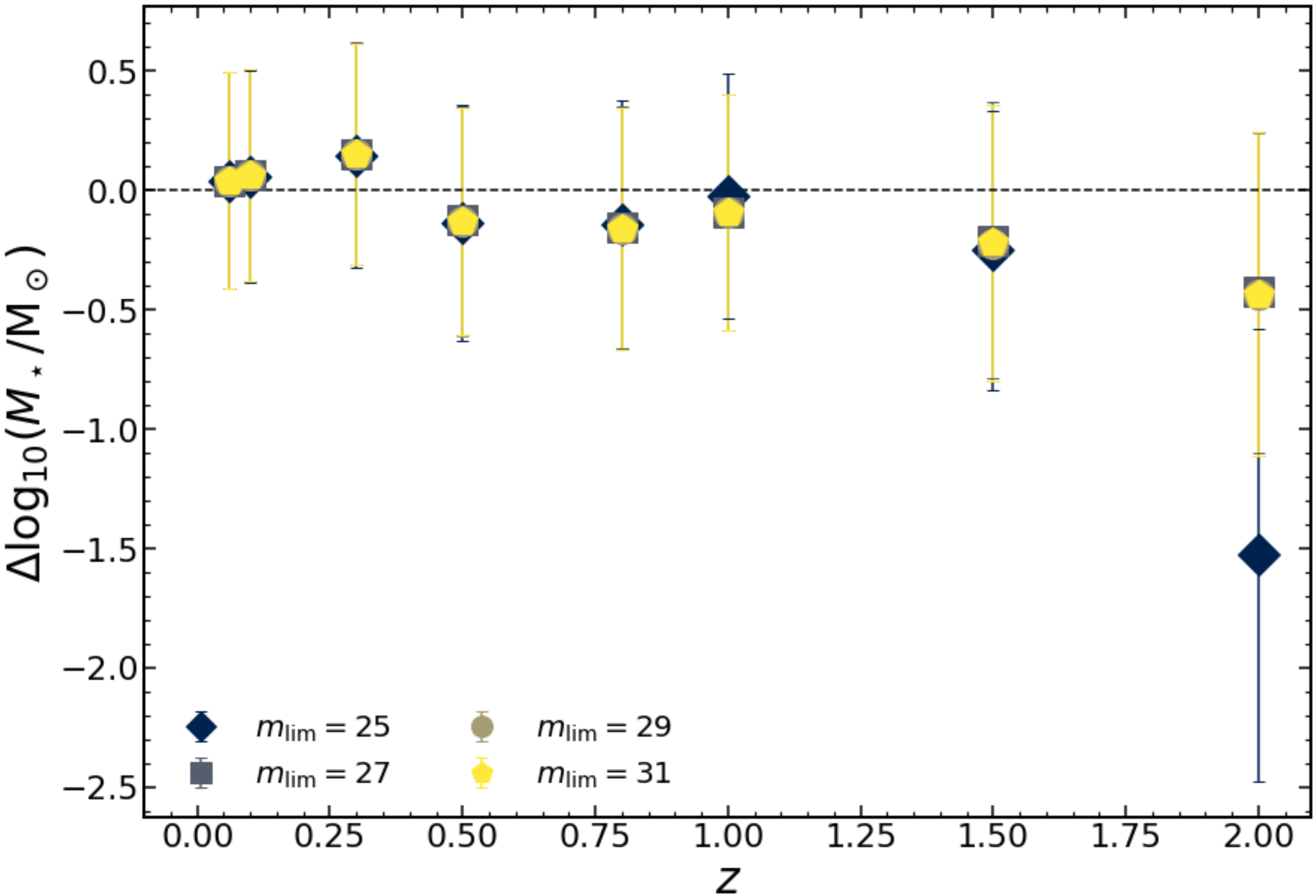


with noise

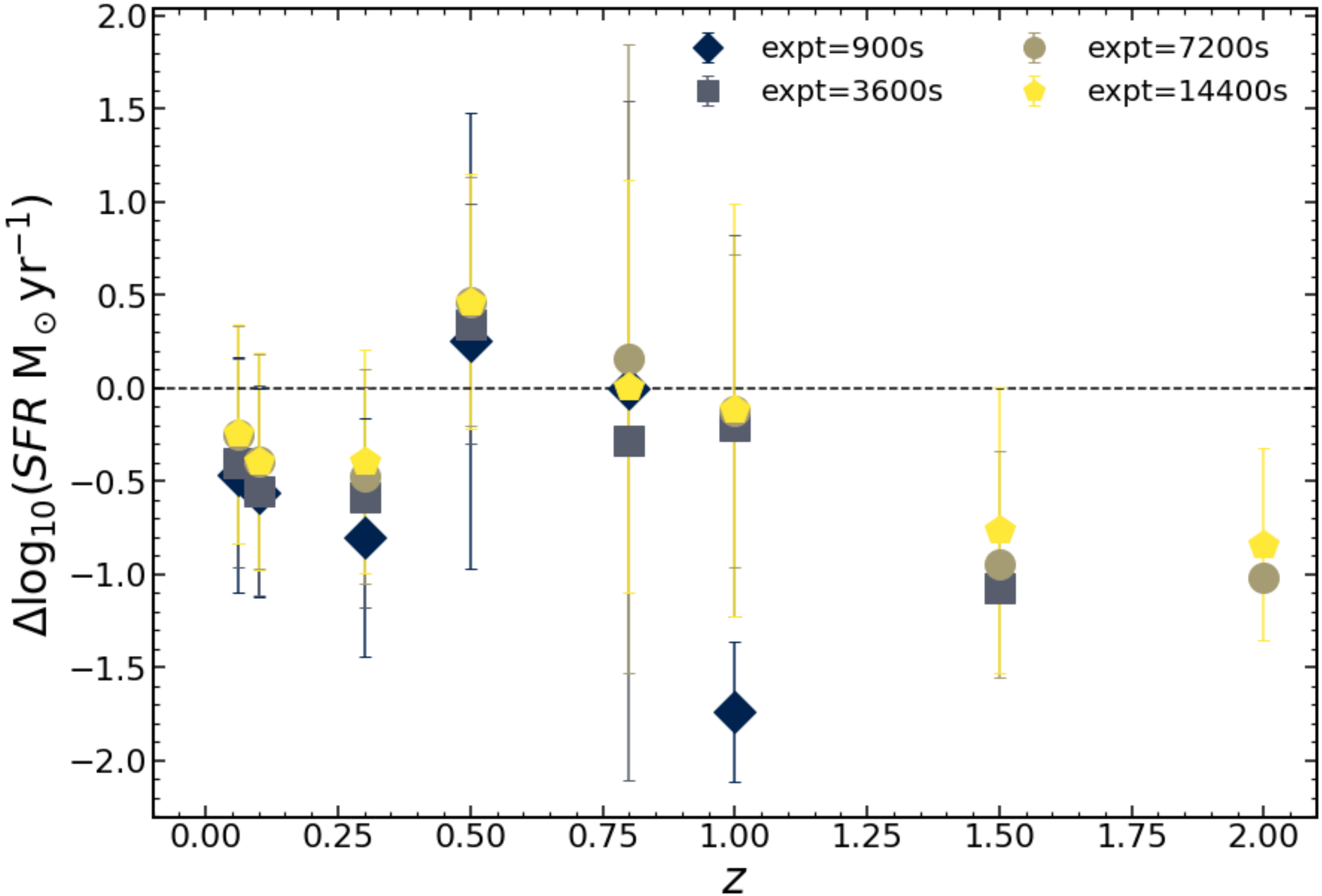
Preliminary results: SN host stellar mass



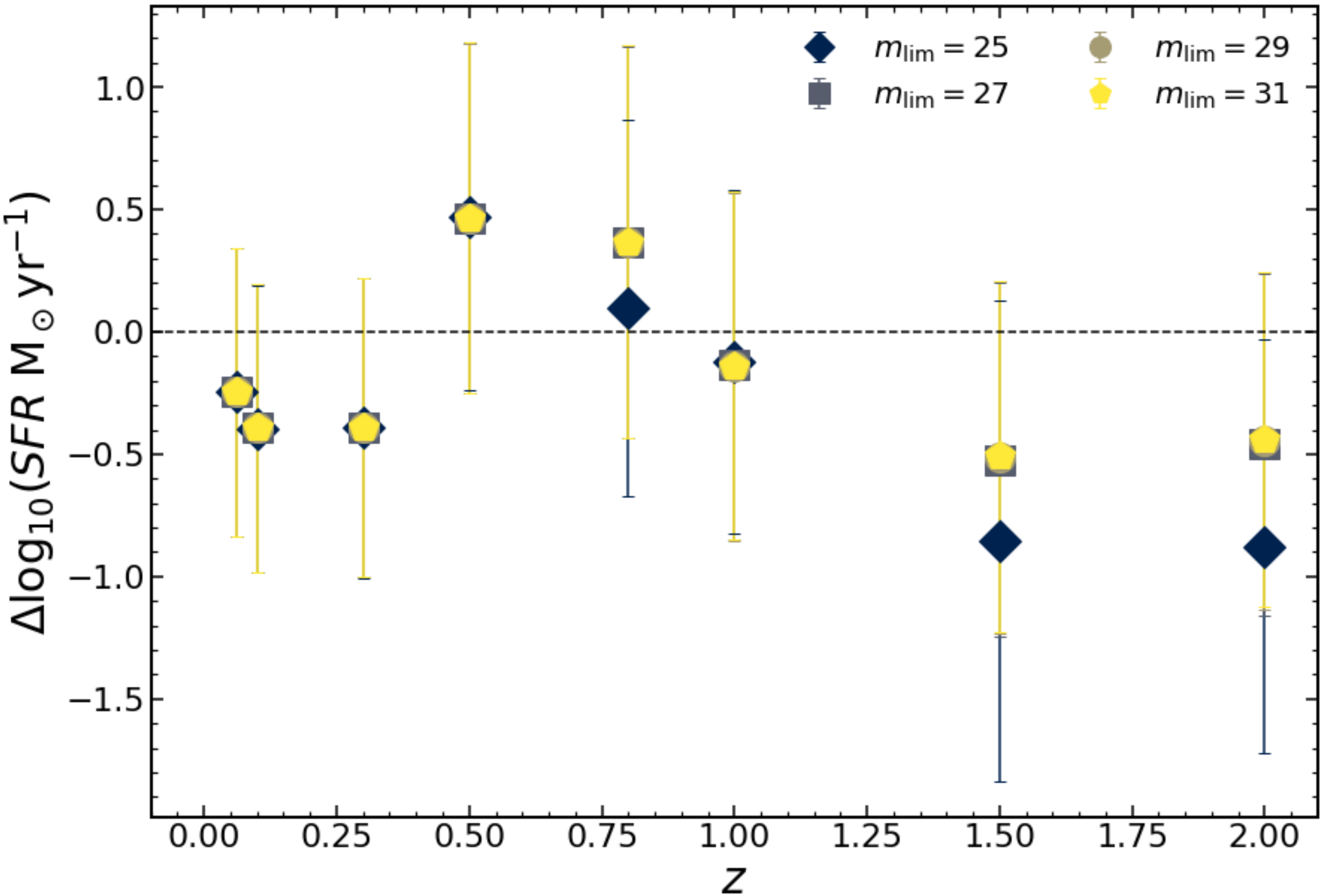
Preliminary results: SN host stellar mass



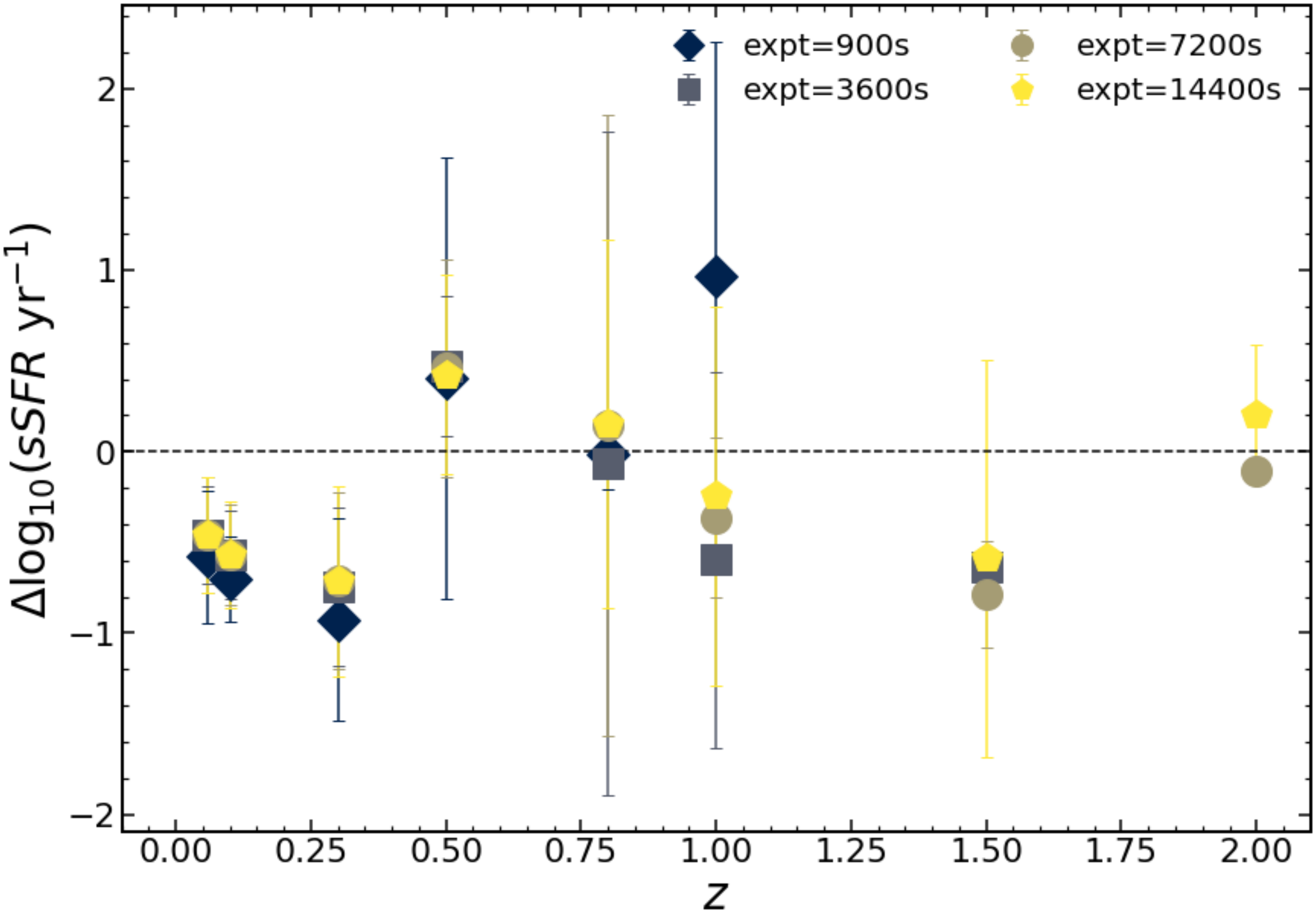
Preliminary results: SN host SFR



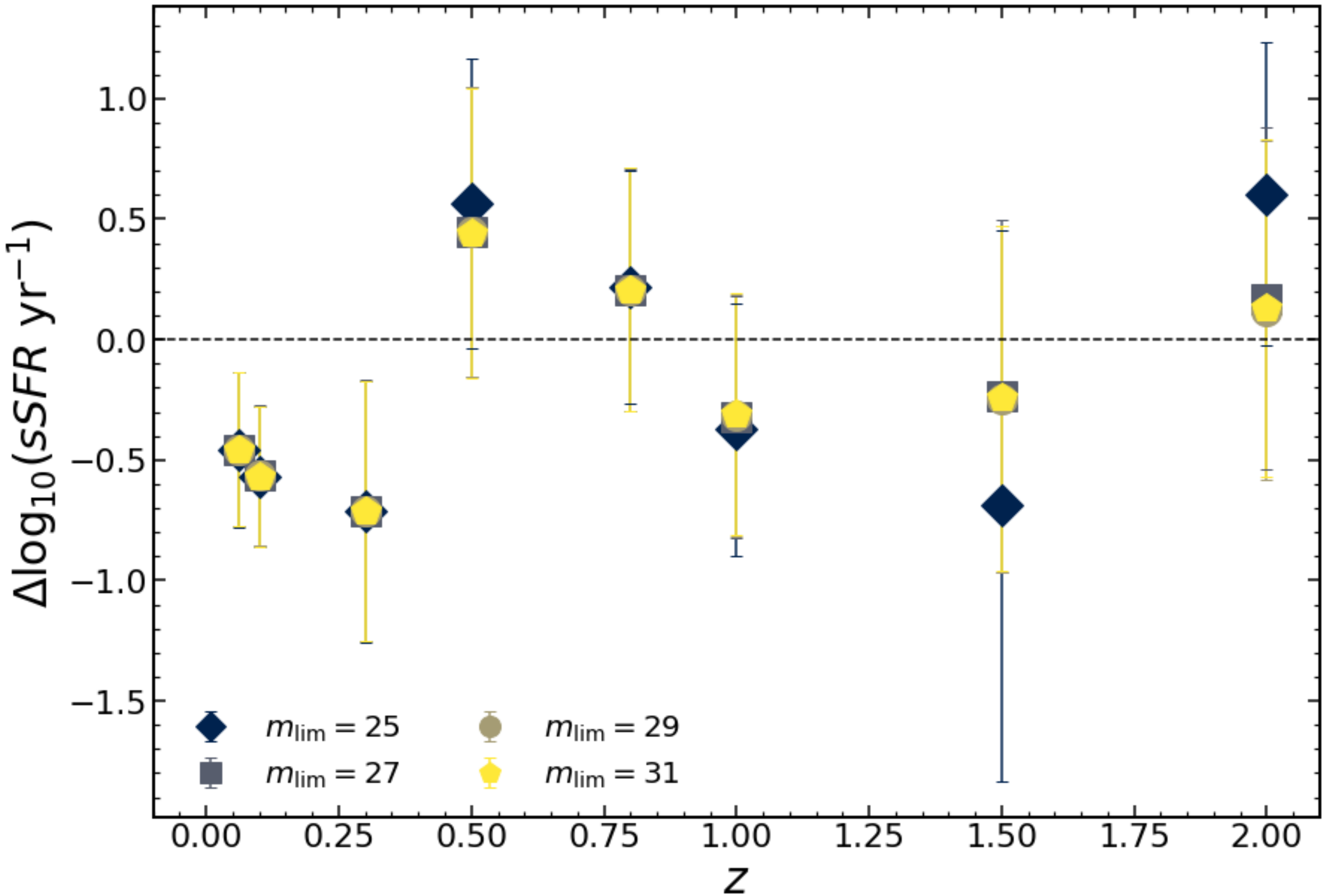
Preliminary results: SN host SFR



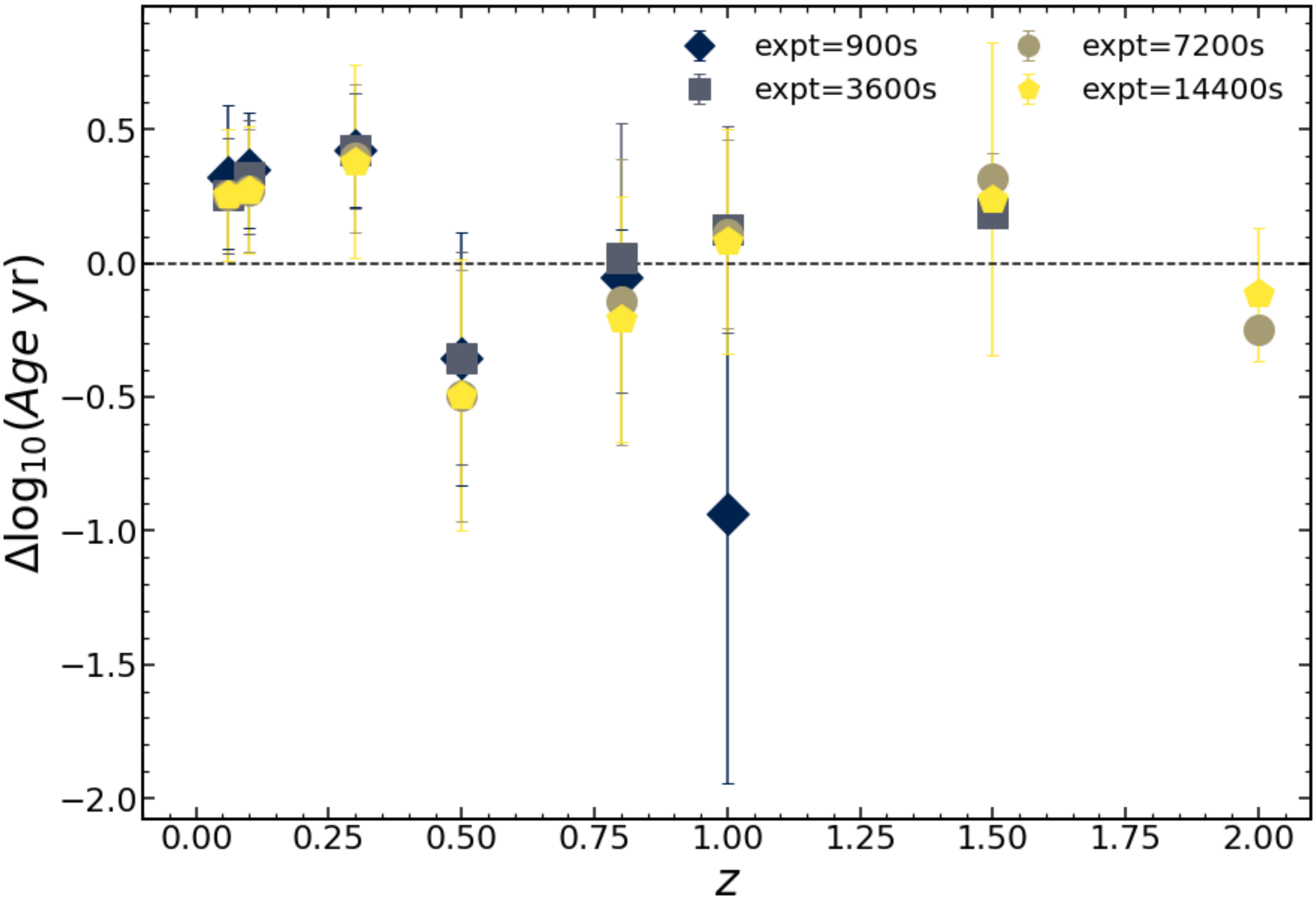
Preliminary results: SN host sSFR



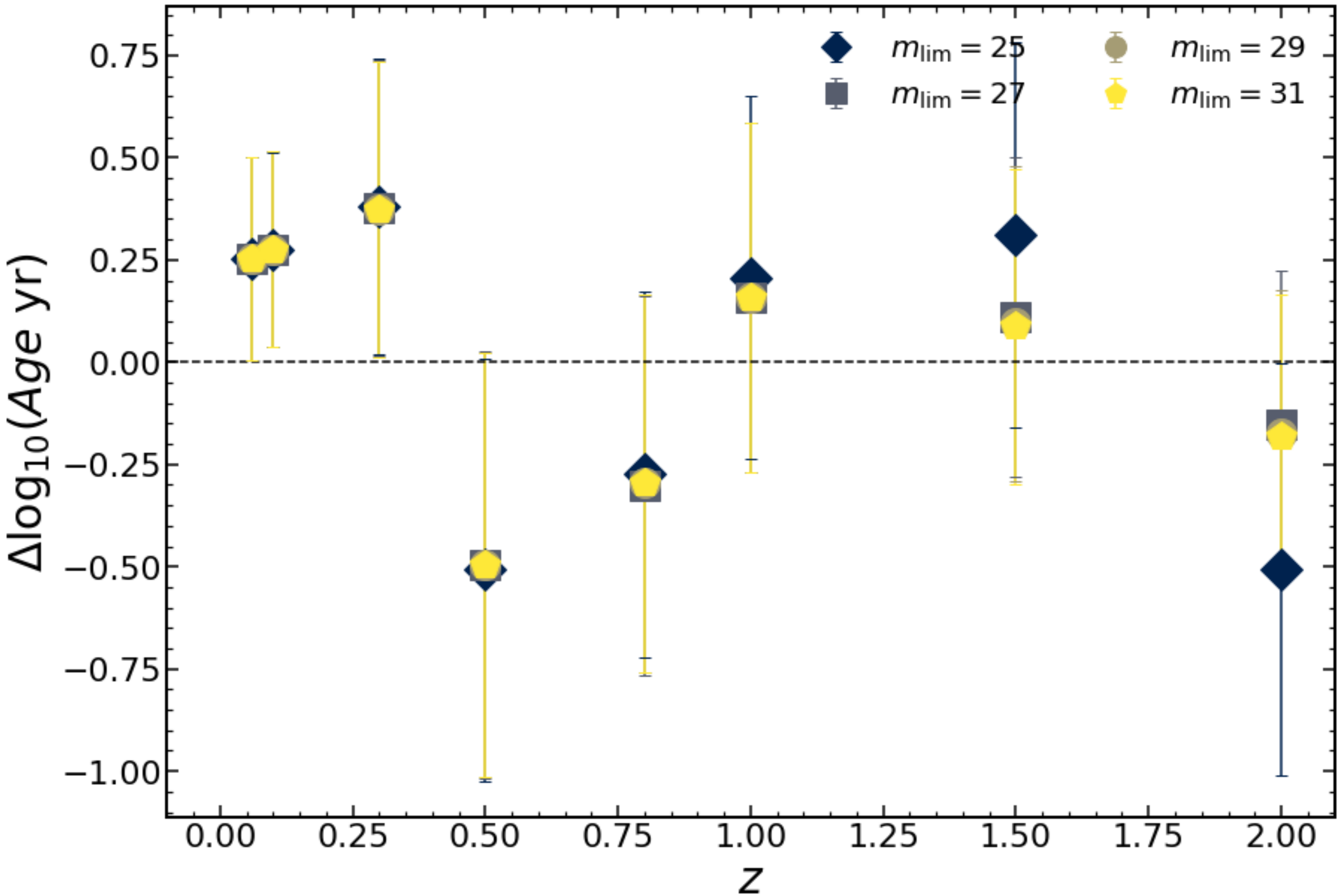
Preliminary results: SN host sSFR



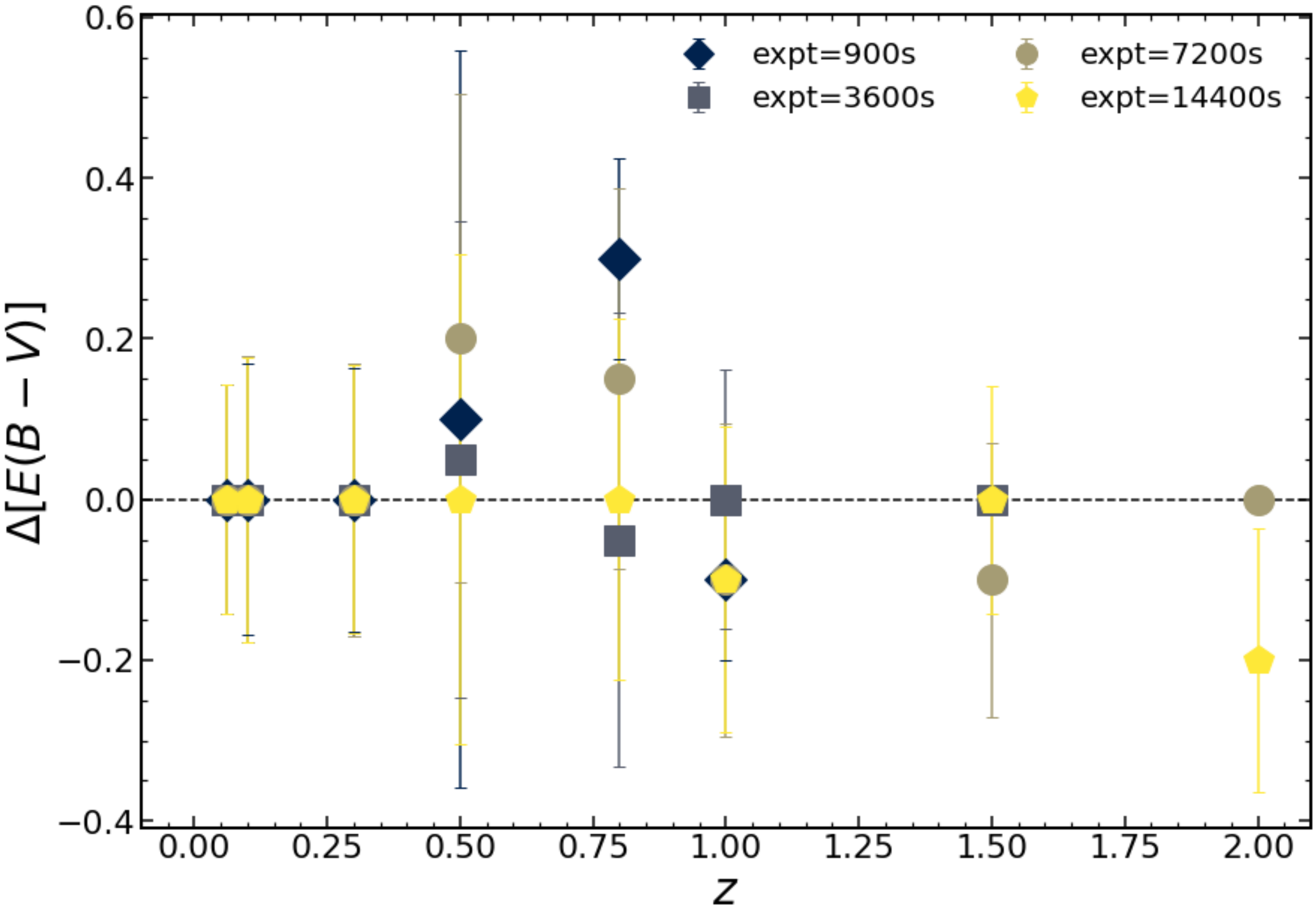
Preliminary results: SN host age



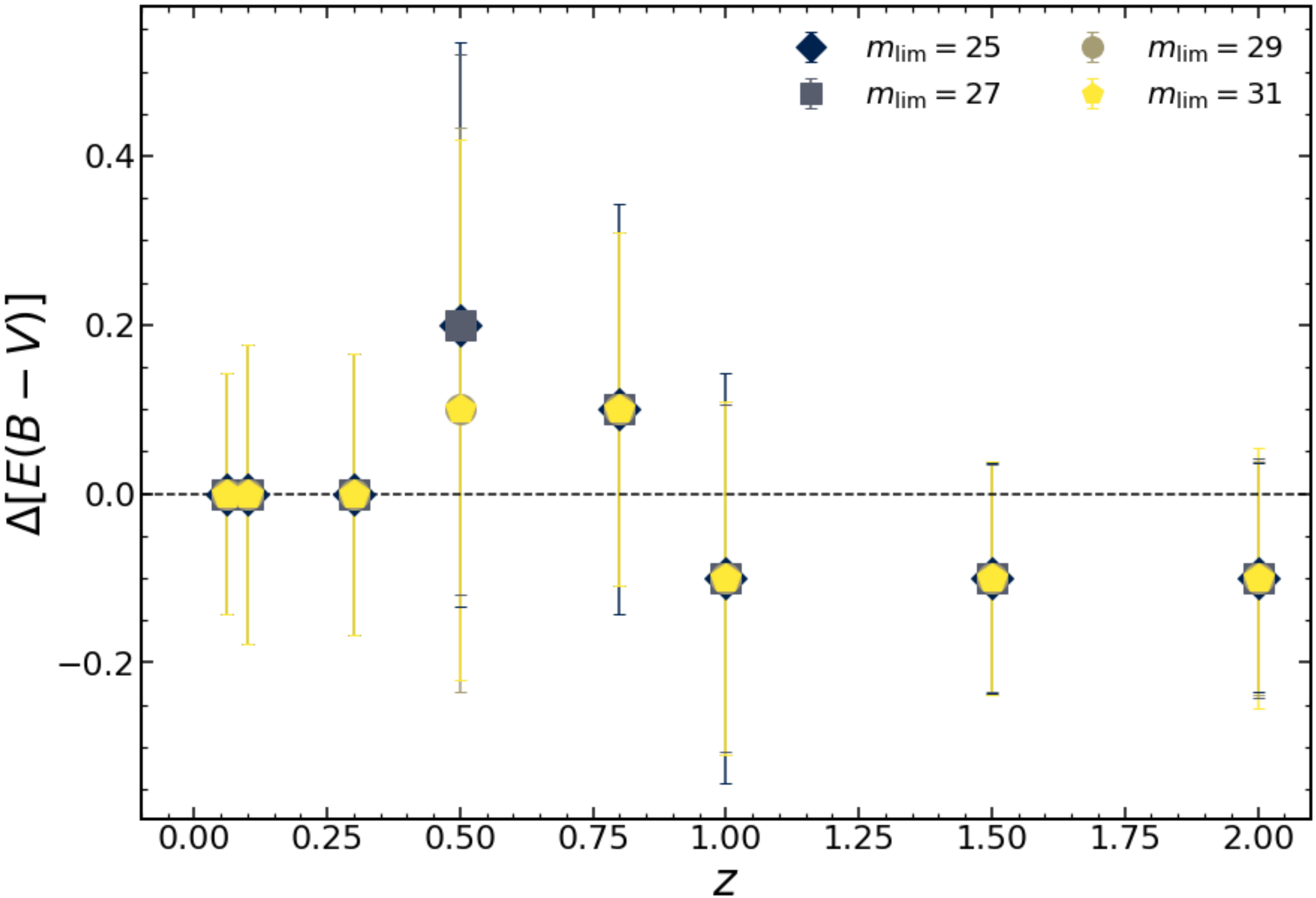
Preliminary results: SN host age



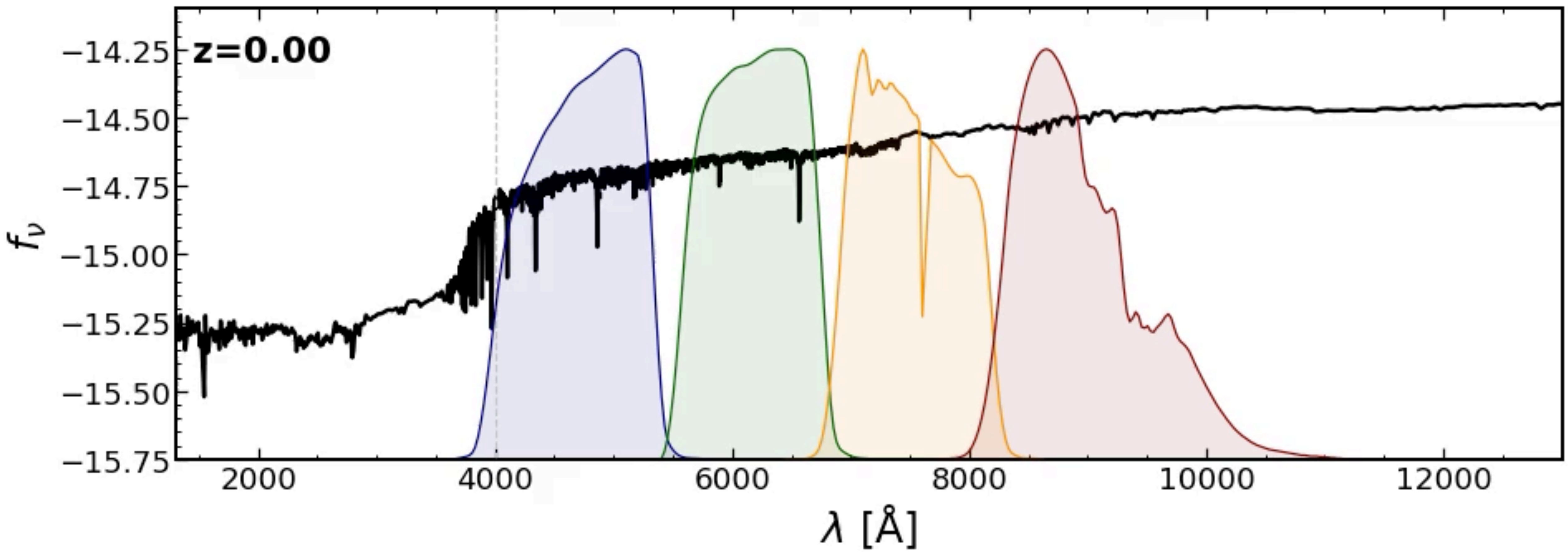
Preliminary results: SN host “dust”



Preliminary results: SN host “dust”

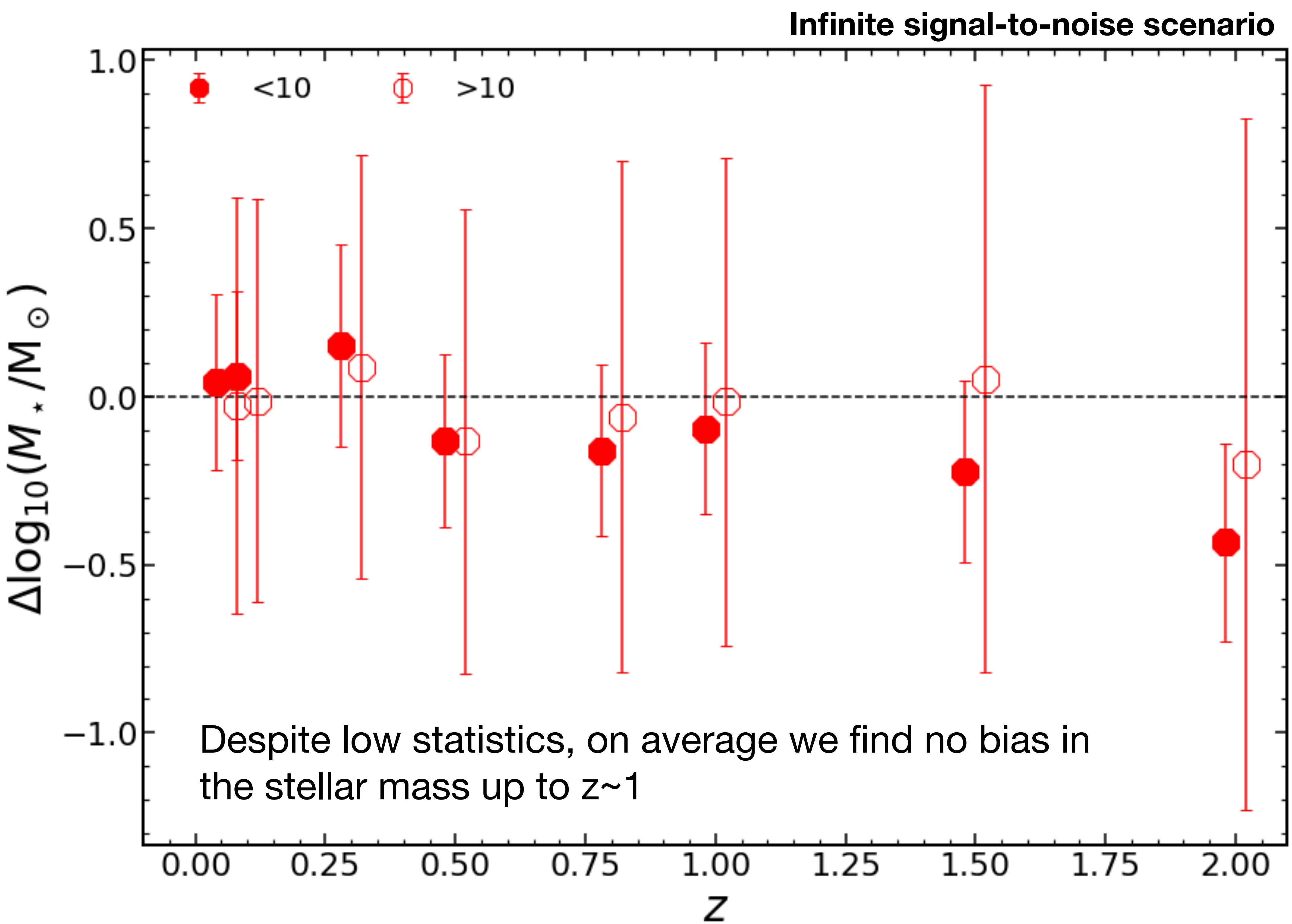


Take home message



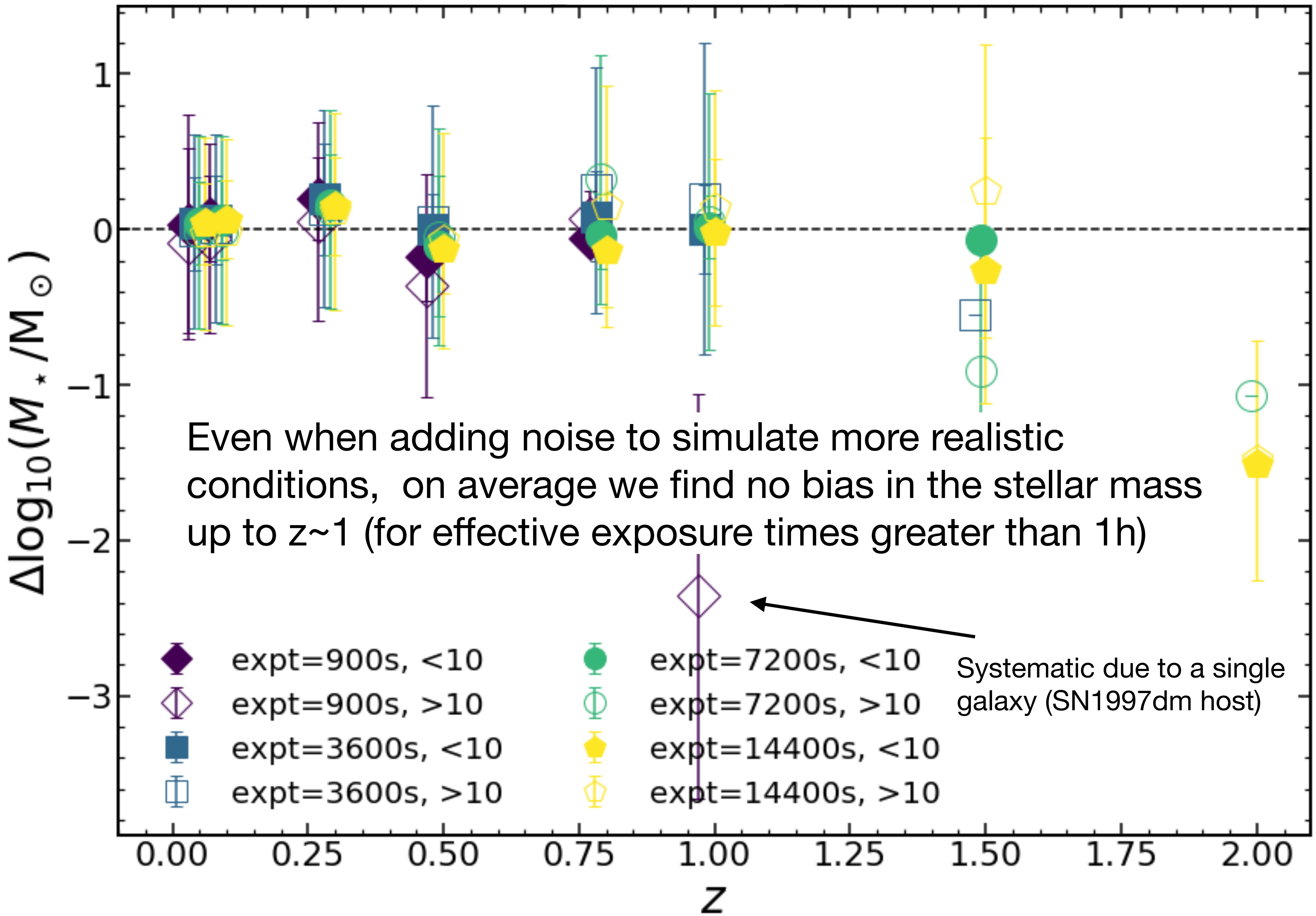
How well are we constraining the D4000Å?

Preliminary results: SN host stellar mass



Preliminary results: SN host stellar mass

Fixing the effective exposure time

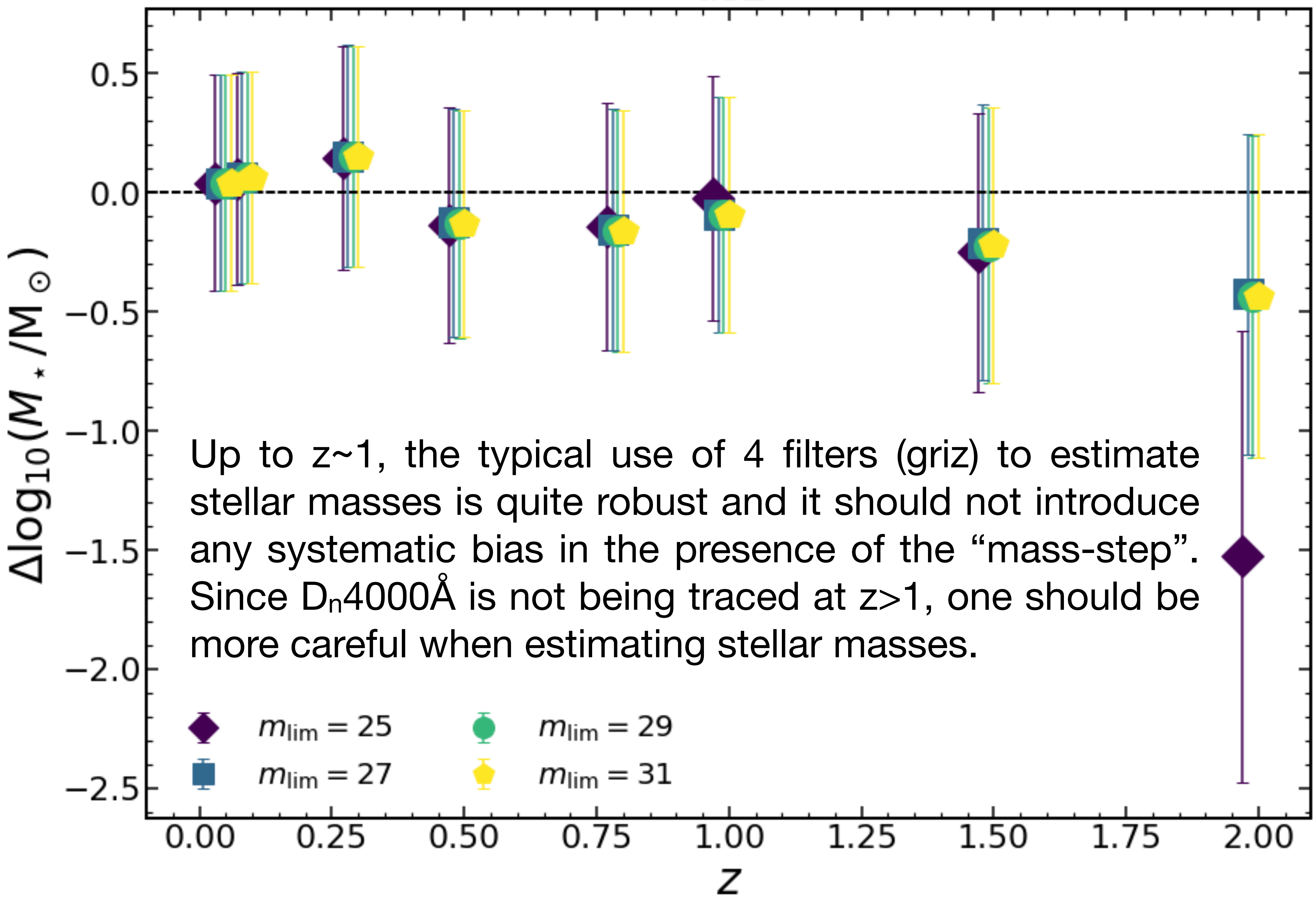


Even when adding noise to simulate more realistic conditions, on average we find no bias in the stellar mass up to z~1 (for effective exposure times greater than 1h)

Systematic due to a single galaxy (SN1997dm host)

Preliminary results: SN host stellar mass

Fixing the survey depth



Up to z~1, the typical use of 4 filters (griz) to estimate stellar masses is quite robust and it should not introduce any systematic bias in the presence of the "mass-step". Since D_n4000Å is not being traced at z>1, one should be more careful when estimating stellar masses.

Take home message

- In the era of precision cosmology, it is necessary to have a good control of the systematics.

- This work in progress to crucial to understand biases and systematics that one may have when compare low- and high-redshift results both on local or global properties.

- Stellar masses are robustly estimated up to z~1 using griz magnitudes. However, if one wants to go towards higher redshift, redder bands are needed (the D_n4000Å break should be well constrained).

- Feedback is more than welcome since we aim to develop a publicly available tool for the community to tackle different science cases.

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Thank you!