Constraining the stochasticity of star formation at high redshifts with JWST

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date 22/09/17

Why do we care about the stochasticity of star formation?

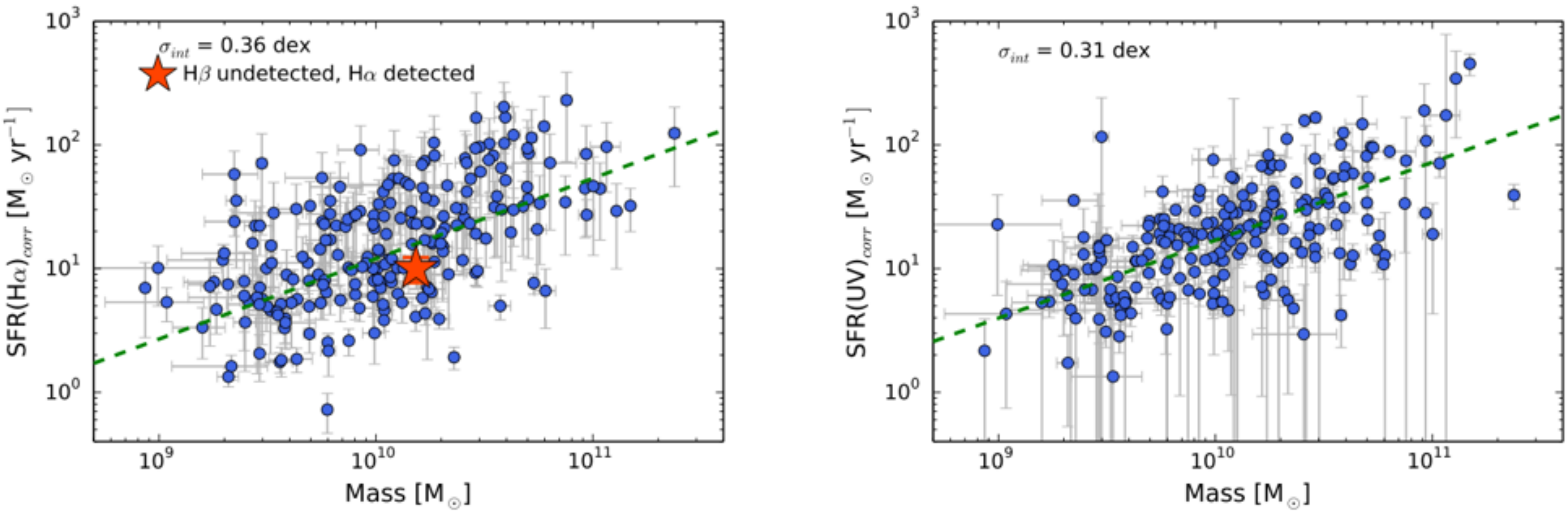
Astrophysical aspects:

- Strong feedback related to star formation.
- Stochastic infall of gas onto the galaxy.
- High gas fractions producing turbulent gas discs with clumpy star formation.

Technical aspects:

- Spectro-photometric fitting easier to interpret if smoothly varying, can get it very wrong if you fit with an analytical star formation history when there's been a recent burst of star formation.
- When do our simple assumptions break down?

Some interesting methods already used to assess stochasticity of star formation



Shivaei+ 2015

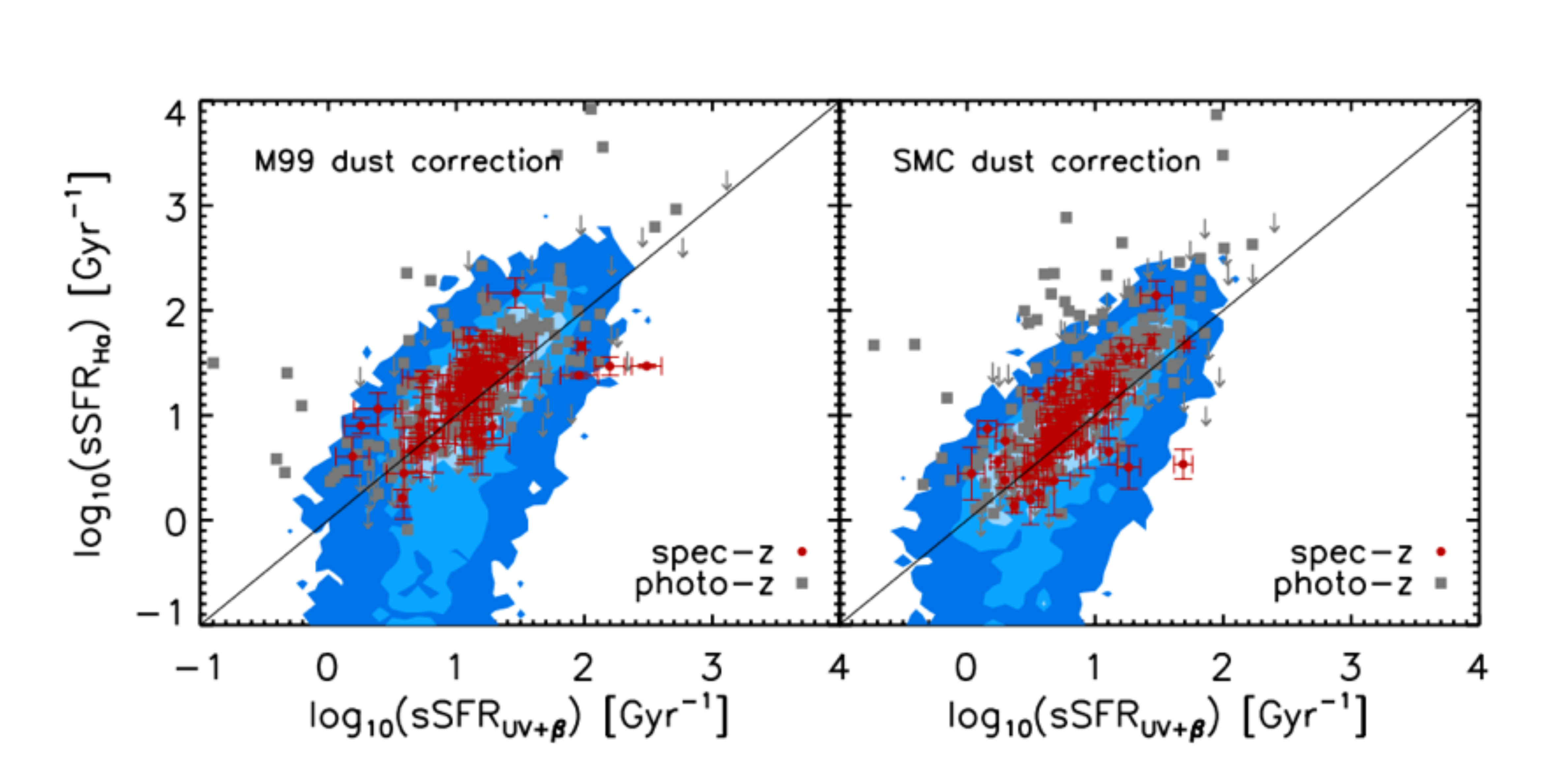
Exploiting the sensitivities of different observables on different timescales of star formation.

Hα sensitive to stars with ages ~10 Myr

Rest-frame UV sensitive to stars with ages ~100 Myr

Dust corrections - Case B, Meurer99

Some interesting methods already used to assess stochasticity of star formation



Smit+ 2015

This study

- Take SFHs from hydrodynamical simulation of galaxy formation and evolution with high resolution in time domain.
- Create mock spectra including nebular emission and dust attenuation using BEAGLE and stellar+nebular emission models of CB17 and Gutkin+16.
- Re-sample onto wavelength grid of NIRSpec and determine S/N required in different spectral features (Ha, UV, D4000), as well as optimum method to recover levels of stochasticity.
- Determine how many objects likely to satisfy these criteria.

BEAGLE

BayEsian Analysis of GaLaxy sEds

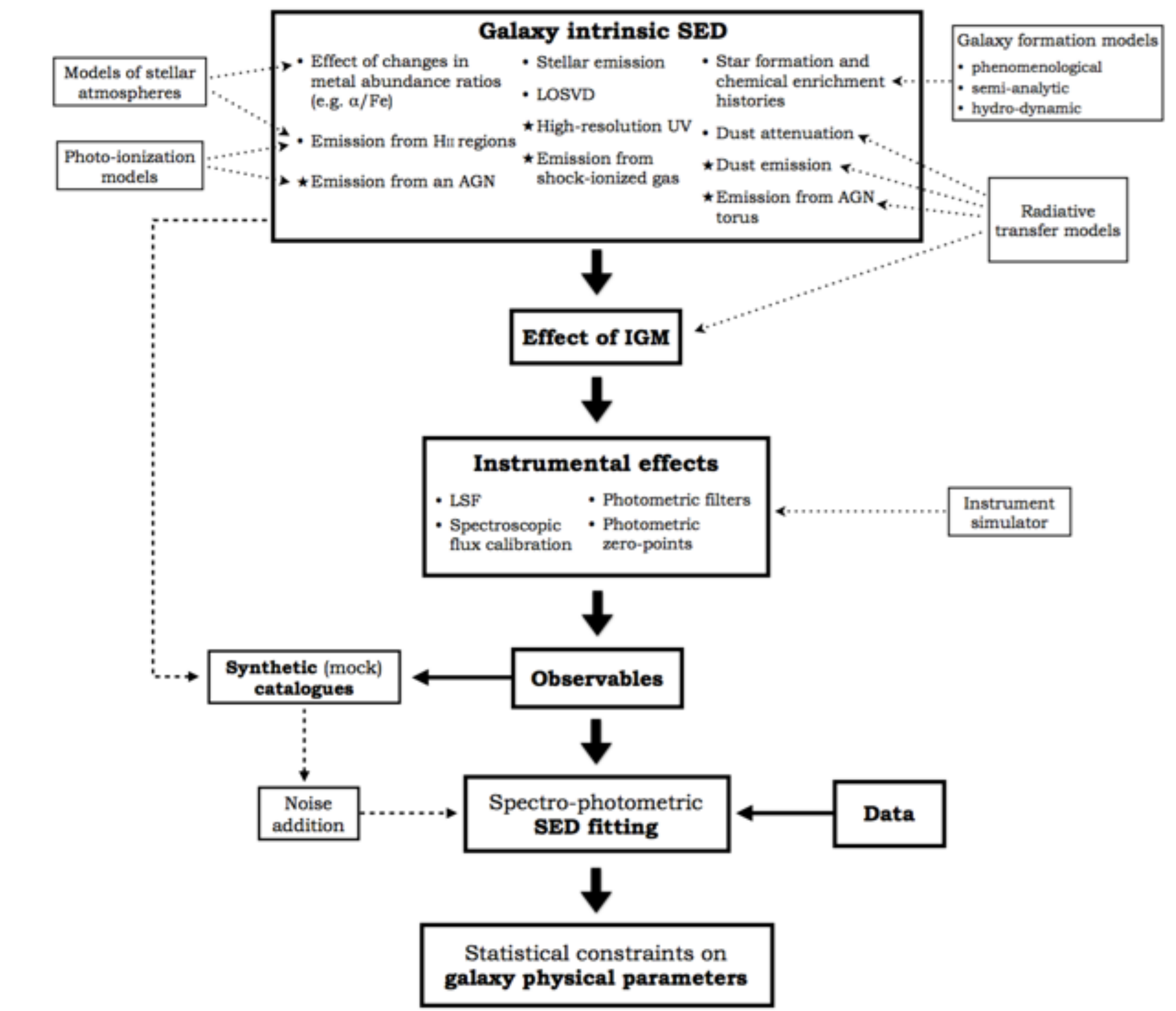
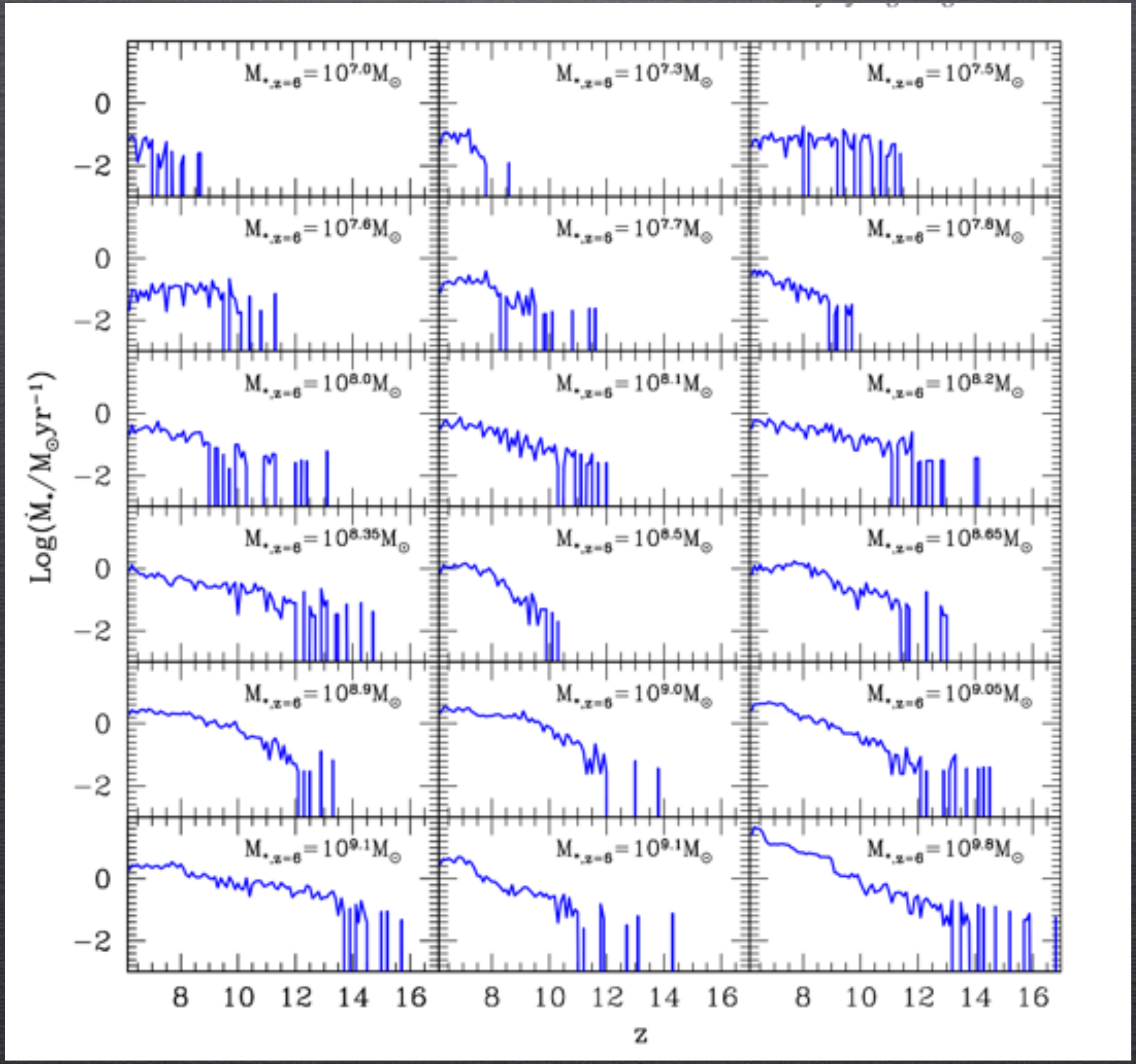


Figure 2. Workflow diagram showing the different building blocks of the BEAGLE tool. The astrophysical ingredients indicated with stars are currently being implemented and will soon be available. Dotted arrows indicate how external models can be incorporated into BEAGLE to inform the various ingredients. See Section 2 for details.

Chevallard+ 2016

The SFHs

Constant + SFHS



+ Delayed SFHS

Dayal+ 13

See Maio et al. (2007, 2009, 2010) and Campisi et al. (2011) for details of simulation

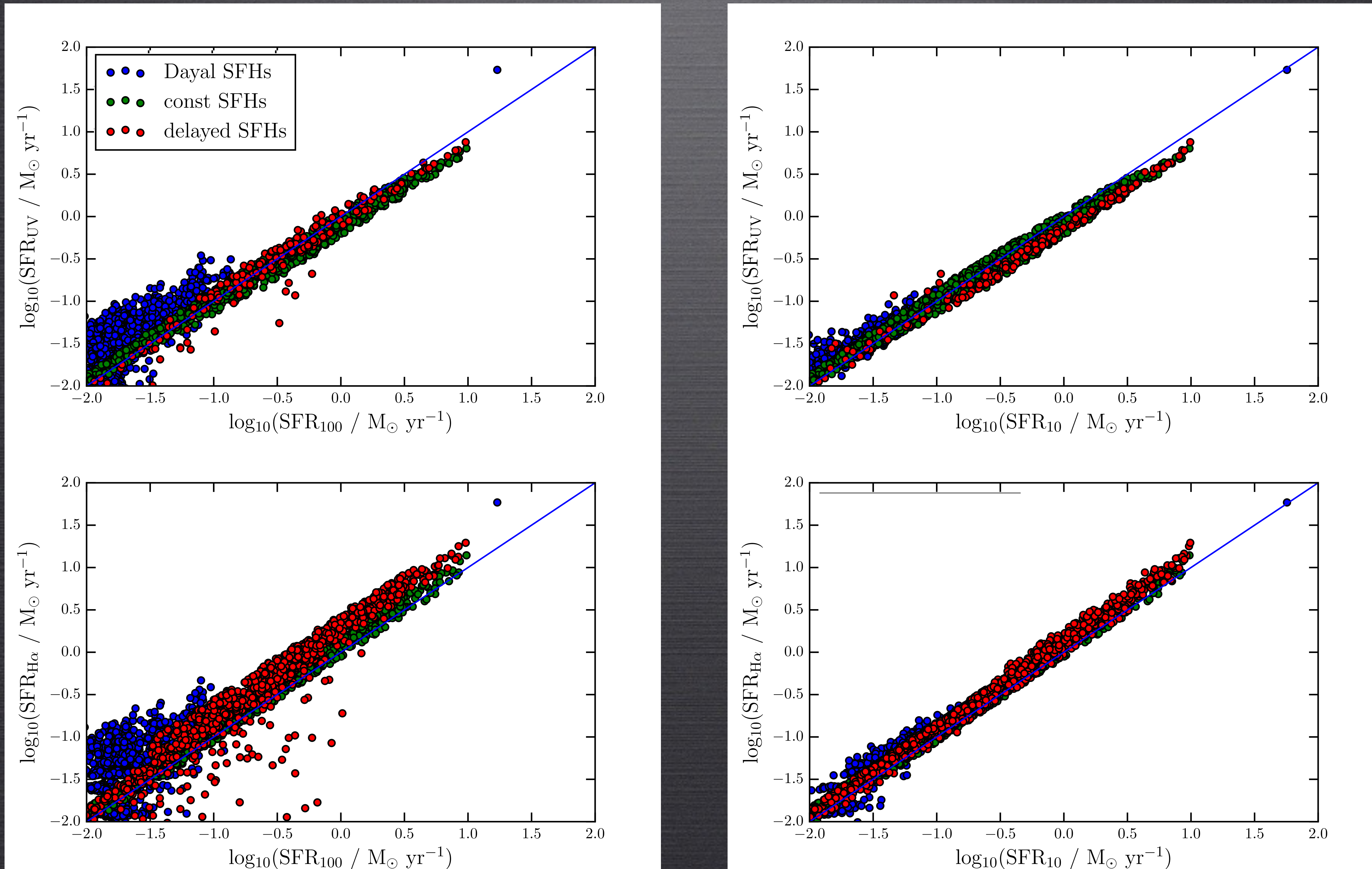
Assessing Hα and UV as SFR indicators on different timescales

SFR averaged over 100 Myrs

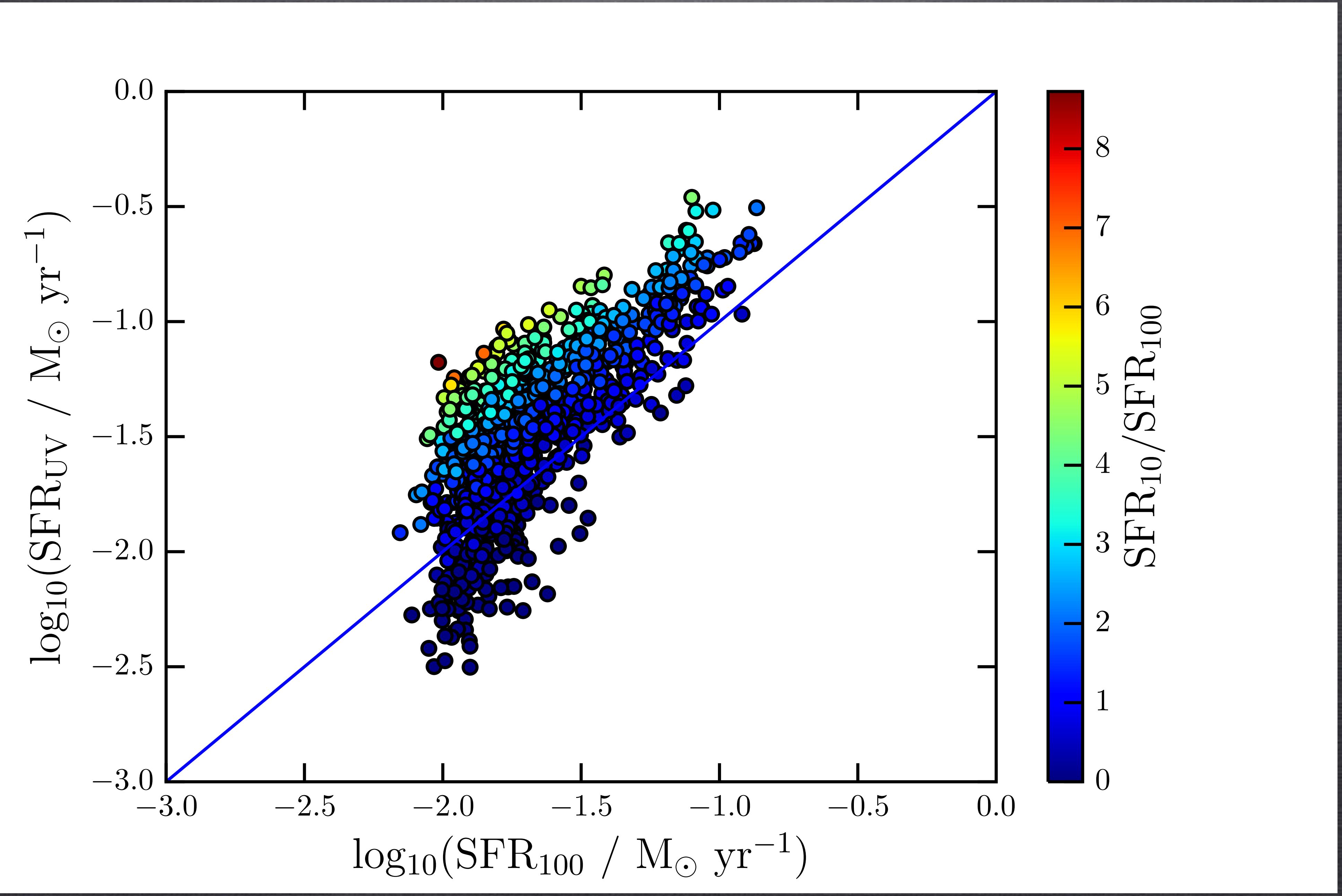
SFR averaged over 10 Myrs

UV-based SFR

Hα-based SFR



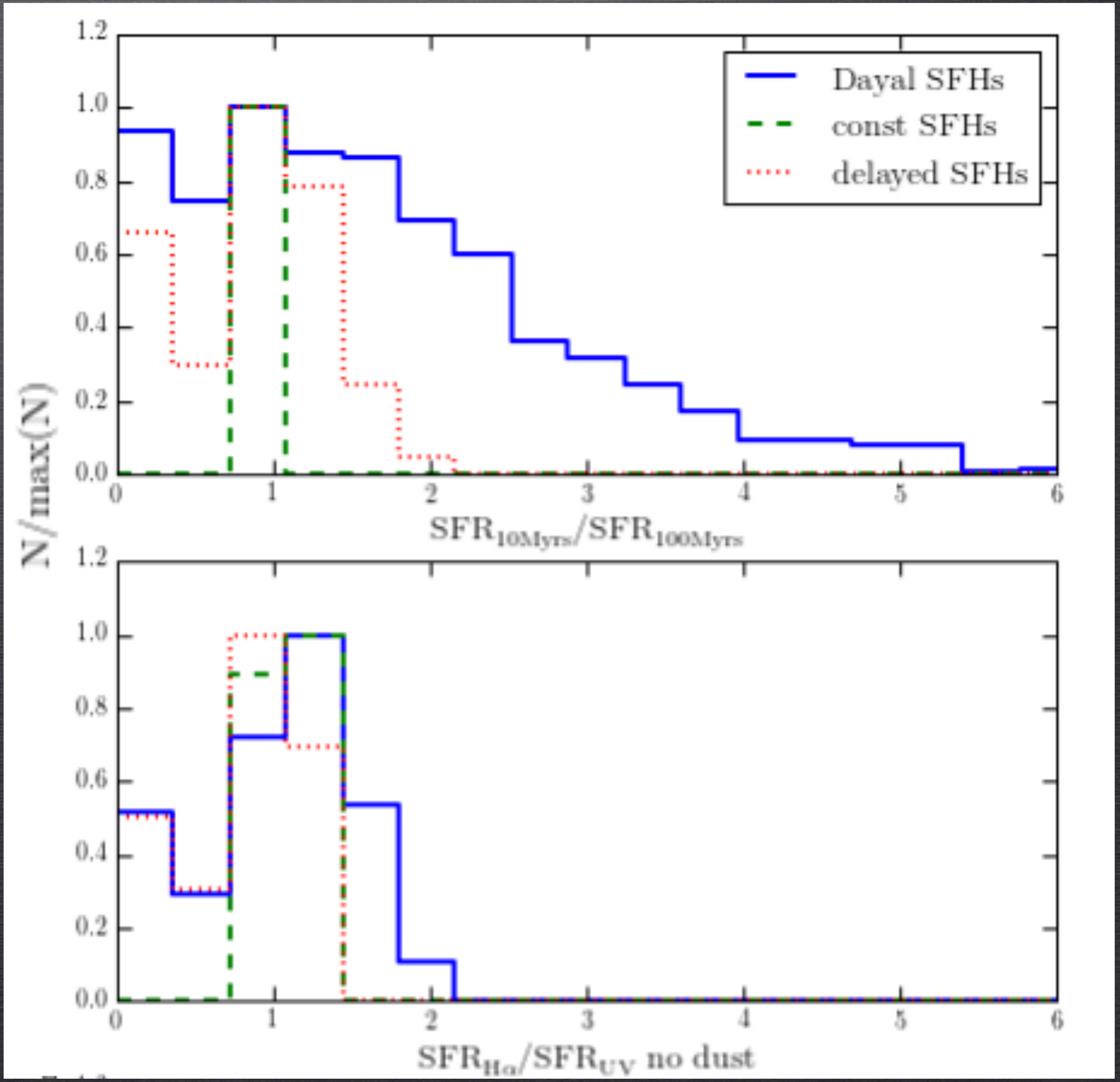
Assessing Ha and UV as SFR indicators on different timescales



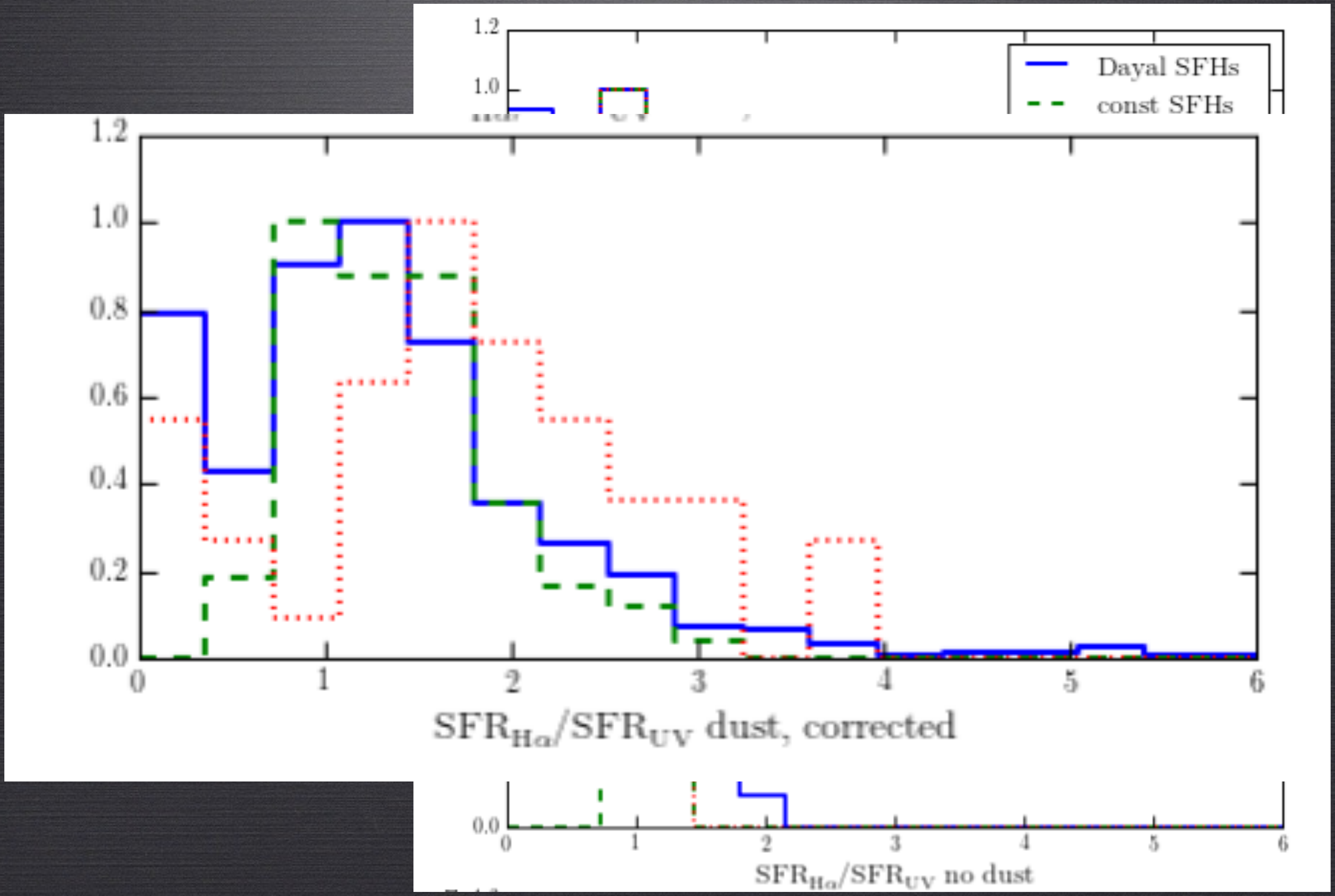
Assessing Ha and UV as SFR indicators on different timescales

SFR_10/SFR_100

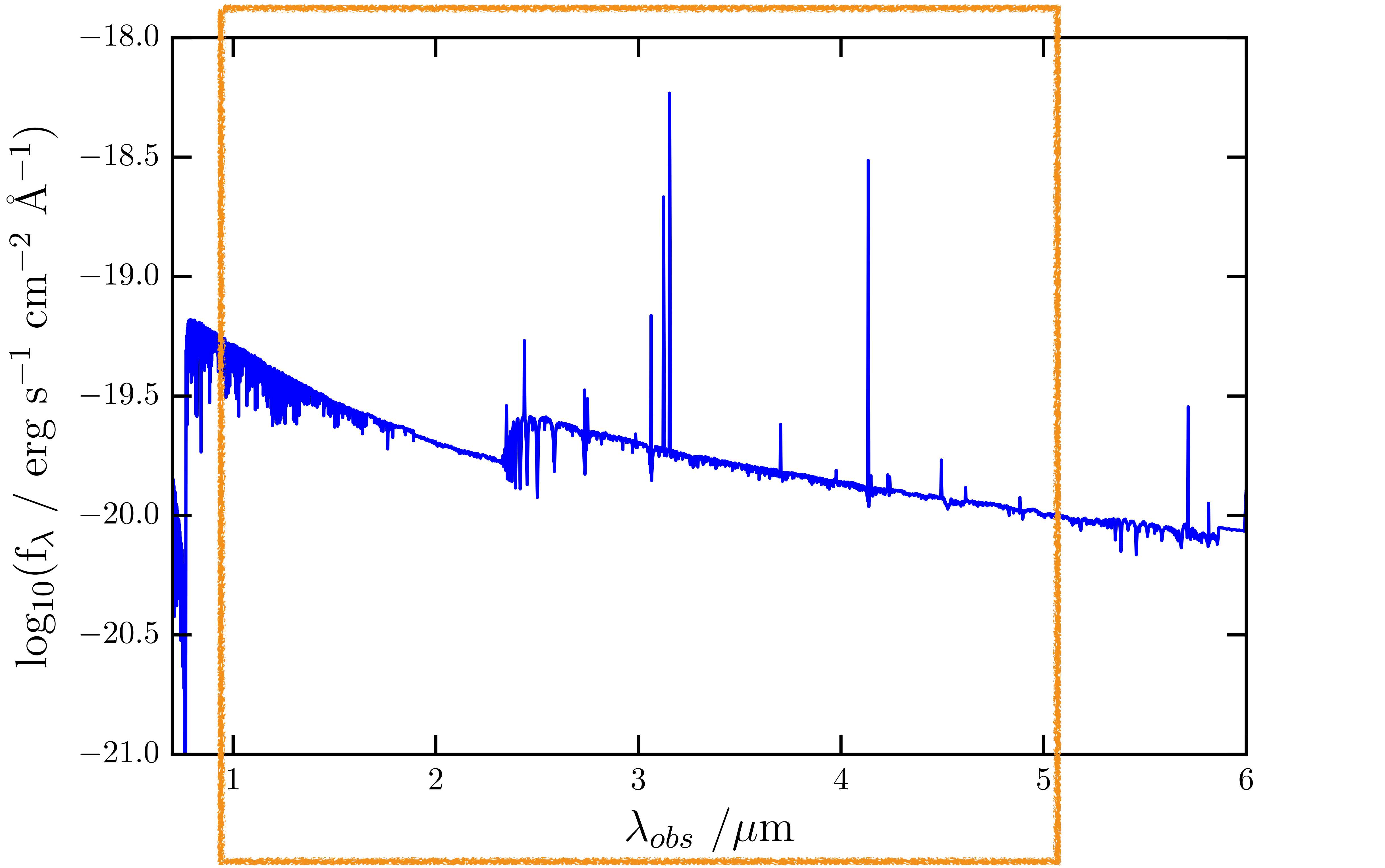
SFR_Hα/SFR_UV, no dust



Assessing Hα and UV as SFR indicators on different timescales



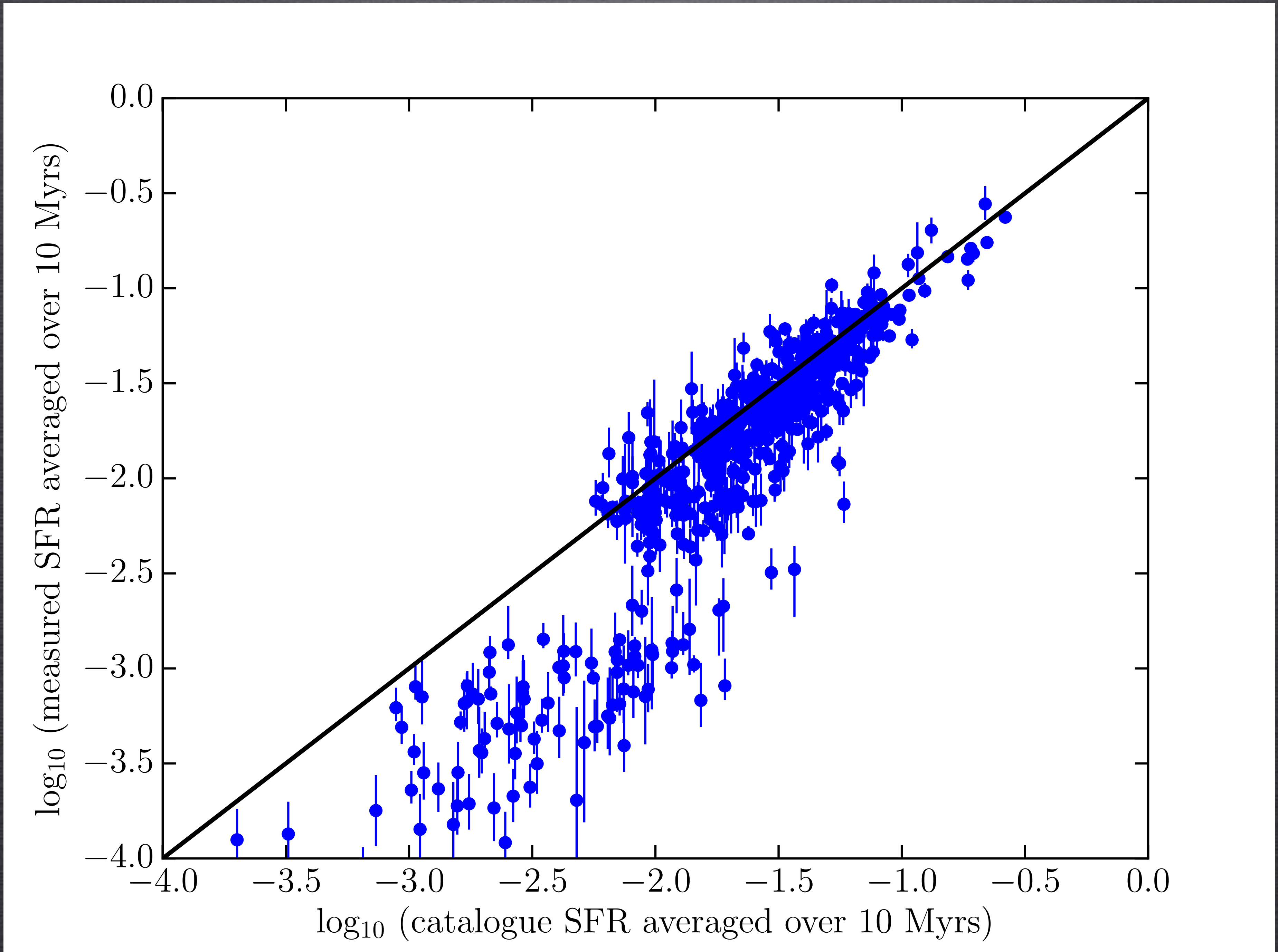
Fitting with BEAGLE
NIRSpec R=100 spectra



Fitting with BEAGLE NIRSpec R=100 spectra

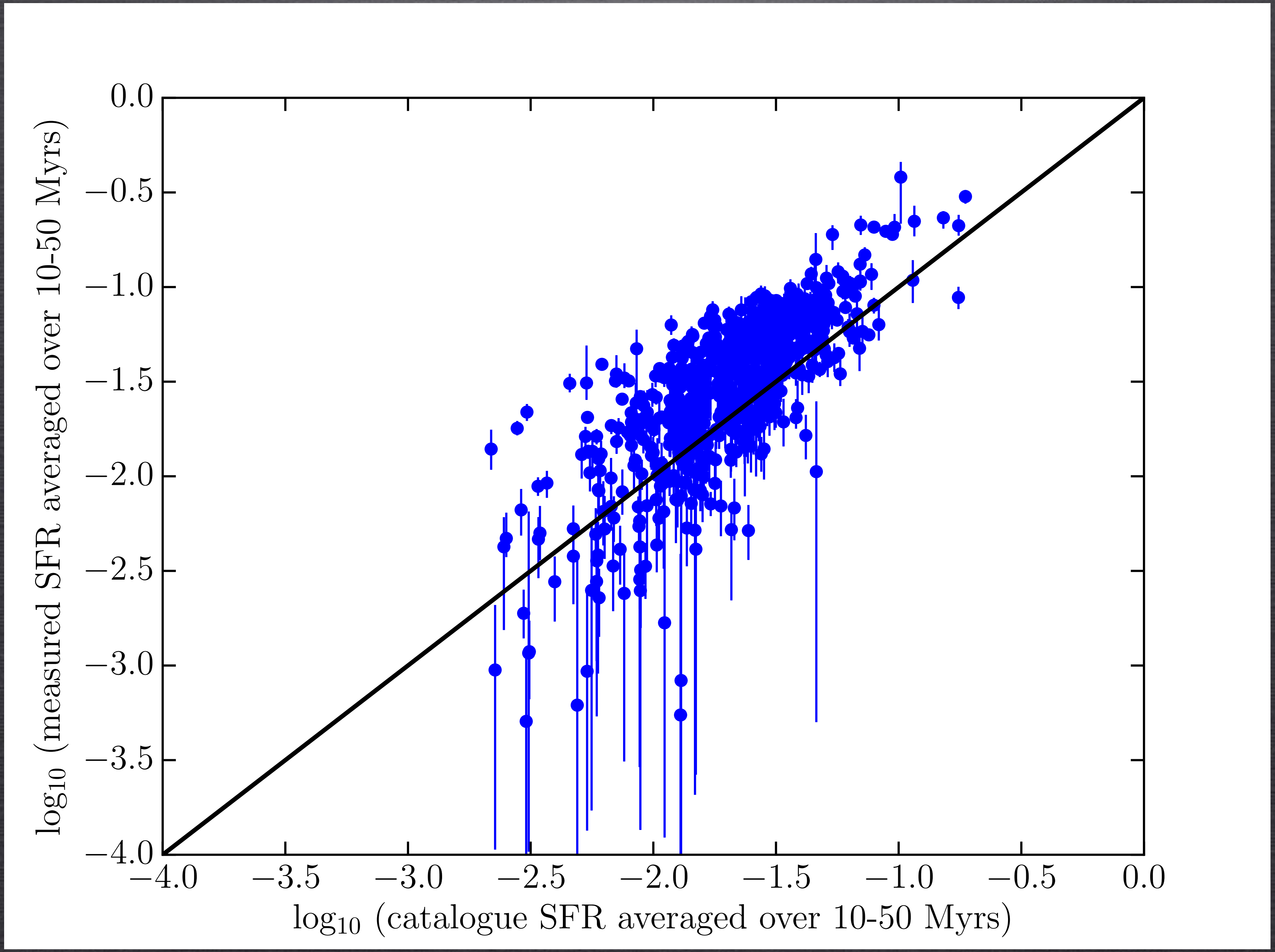
- Sampling mass formed in three bins of constant star formation -> 0<age<10 Myrs, 10<age<50 Myrs, 50<age<max_age
- Observables - UV, Ha *and* Balmer break visible in R~100 NIRSpec spectrum at 5<z<6.5
- Marginalise over dust attenuation/intrinsic galaxy properties employing CF00 dust prescription to give range of galaxy-wide attenuation curves.
- Fit objects with min S/N~10 in band 100A wide at 4050A (rest) - 1/3 of V-drops in Chevallard+17 (in prep) mock after slit losses.
- CAVEAT - fitting with same models as those that produced spectra!!

Results



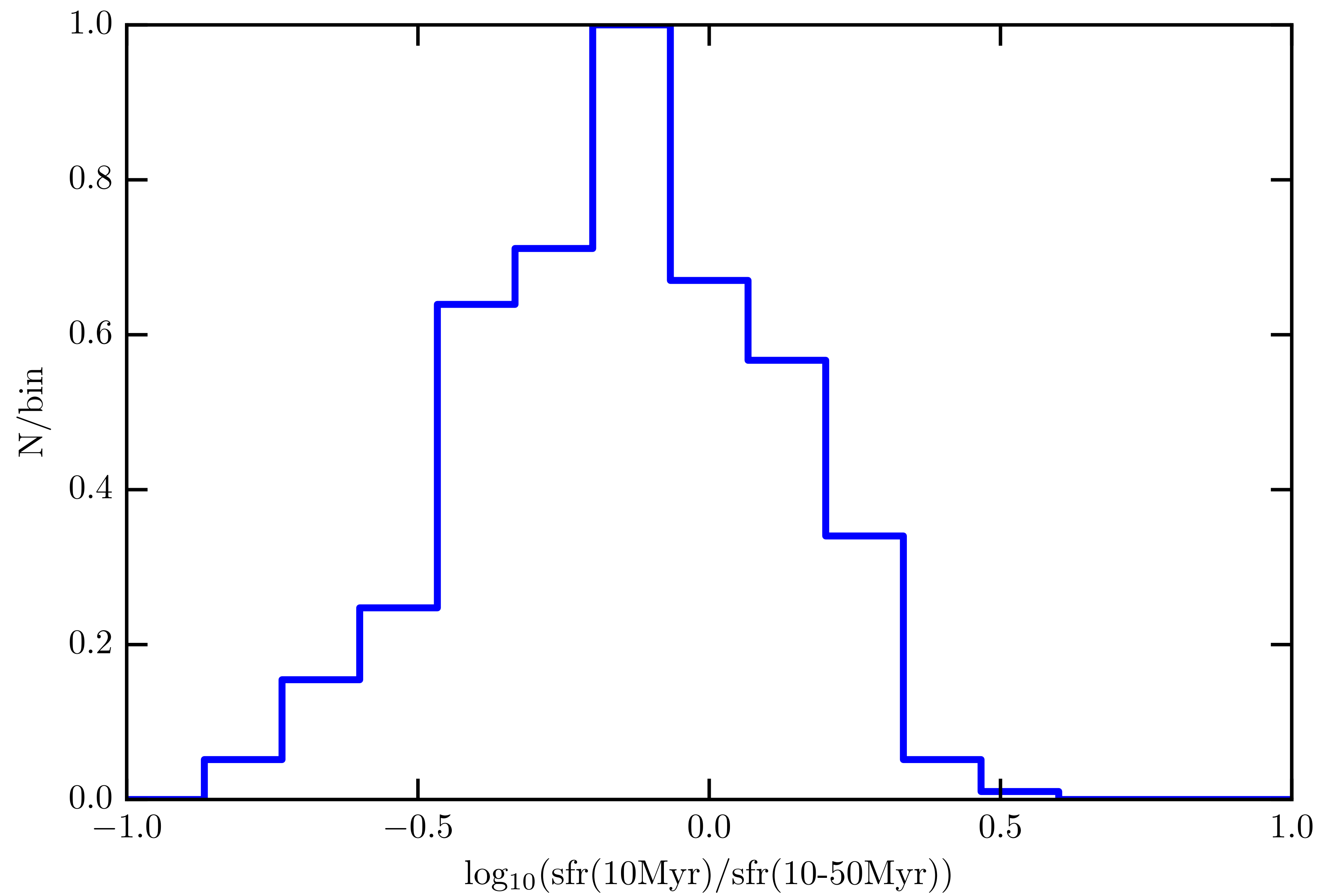
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0
$\log_{10}$ (measured SFR averaged over 10 Myrs)
−4.0
−3.5
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
$\log_{10}$ (catalogue SFR averaged over 10 Myrs)

Results

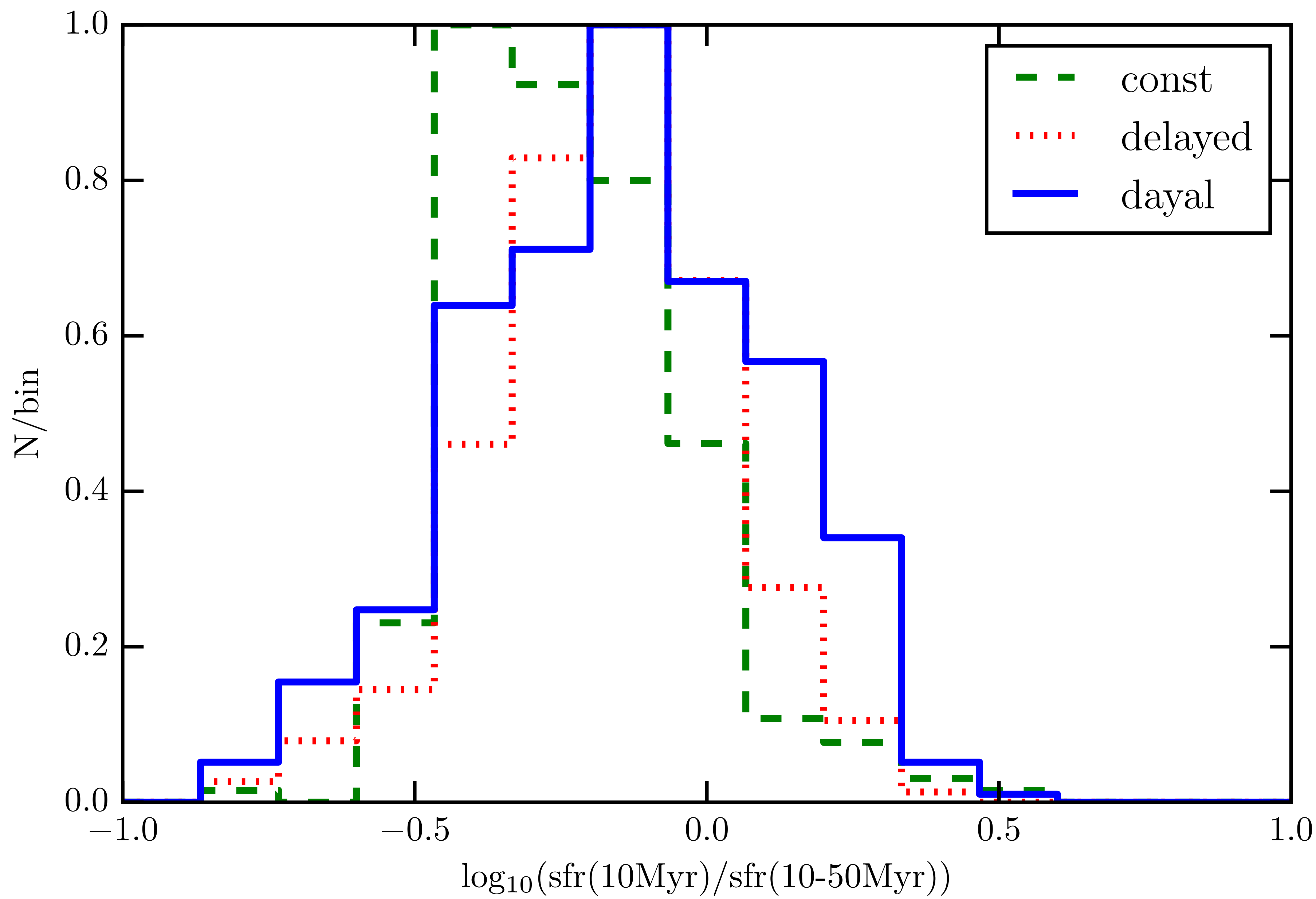


0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0
−4.0
−3.5
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
$\log_{10}$ (measured SFR averaged over 10-50 Myrs)
$\log_{10}$ (catalogue SFR averaged over 10-50 Myrs)

Results

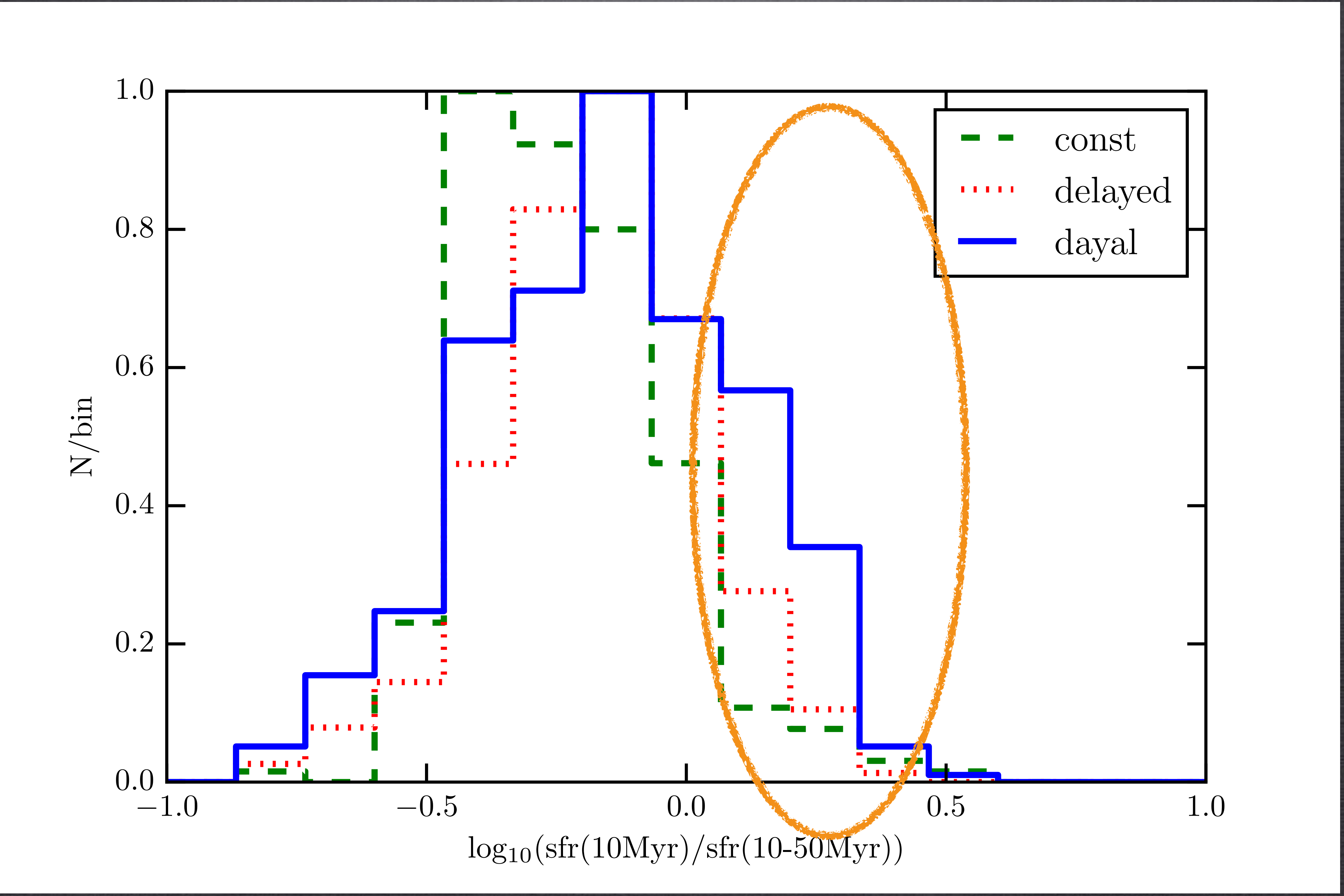


Results



const
delayed
dayal
1.0
0.8
0.6
0.4
0.2
0.0
N/bin
−1.0
−0.5
0.0
0.5
1.0
log10(sfr(10Myr)/sfr(10-50Myr))

Results



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log10(sfr(10Myr)/sfr(10-50Myr))
const
delayed
dayal

Takeaways

- It's hard….
- Steeply Rising/Stochastic histories - intrinsic UV dominated by shortest-lived stars -> poor tracer of SFR on longer timescales.
- Stochasticity distinguished from high SFR_10/SFR_10_50 ratios with this method.
- Marginalising over uncertainties in dust, logU, metallicity, intrinsic spectral slope etc. and we're still doing better than the UV/Ha SFR method!

Fitting with BEAGLE details - Dust