[OII] ELGs in MultiDark-Galaxies and DEEP2

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Motivations/Goals

- Study [OII] ELG properties in MultiDark-Galaxies and qualitatively compare with DEEP2 data processed with Firefly (Wilkinson et al. 2017)

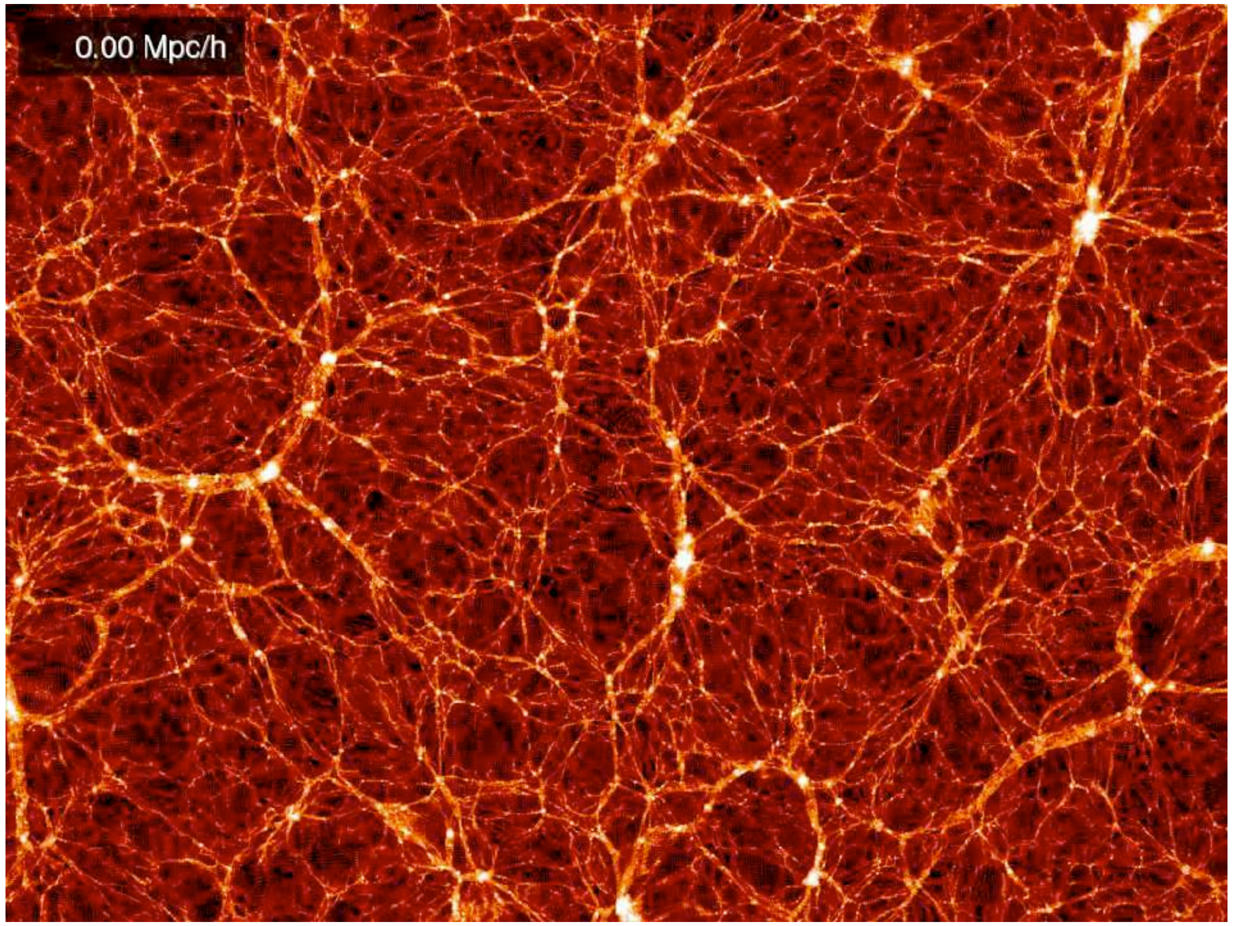
- Study the feasibility of computing model [OII] luminosities in post-processing using the GET_EMLINES code (Orsi et al. 2014) with different SFRs and metallicity as inputs

- Establish reliable L[OII] proxies to be used in SAMs that lack ELG properties

MultiDark-Galaxies

Knebe et al. 2018

MultiDark Planck2



L_{box} = 1000 Mpc/h, M_{DM} = 1.5 x $10^9 M_{sun}$, N_P = 3840^3

Ω_m = 0.6929, Ω_Λ = 0.3071, h=0.6777

cosmosim.org & skiesanduniverses.org

+

SAMs: approximate, analytic prescriptions to populate DM haloes with galaxies

similar format: modular, customisable, with updated physics (e.g., feedback, cooling,…)

SAG

Cora et al. 2018

Includes ELG line properties computed with GET_EMLINES in pre-processing

SAGE

Croton et al. 2016

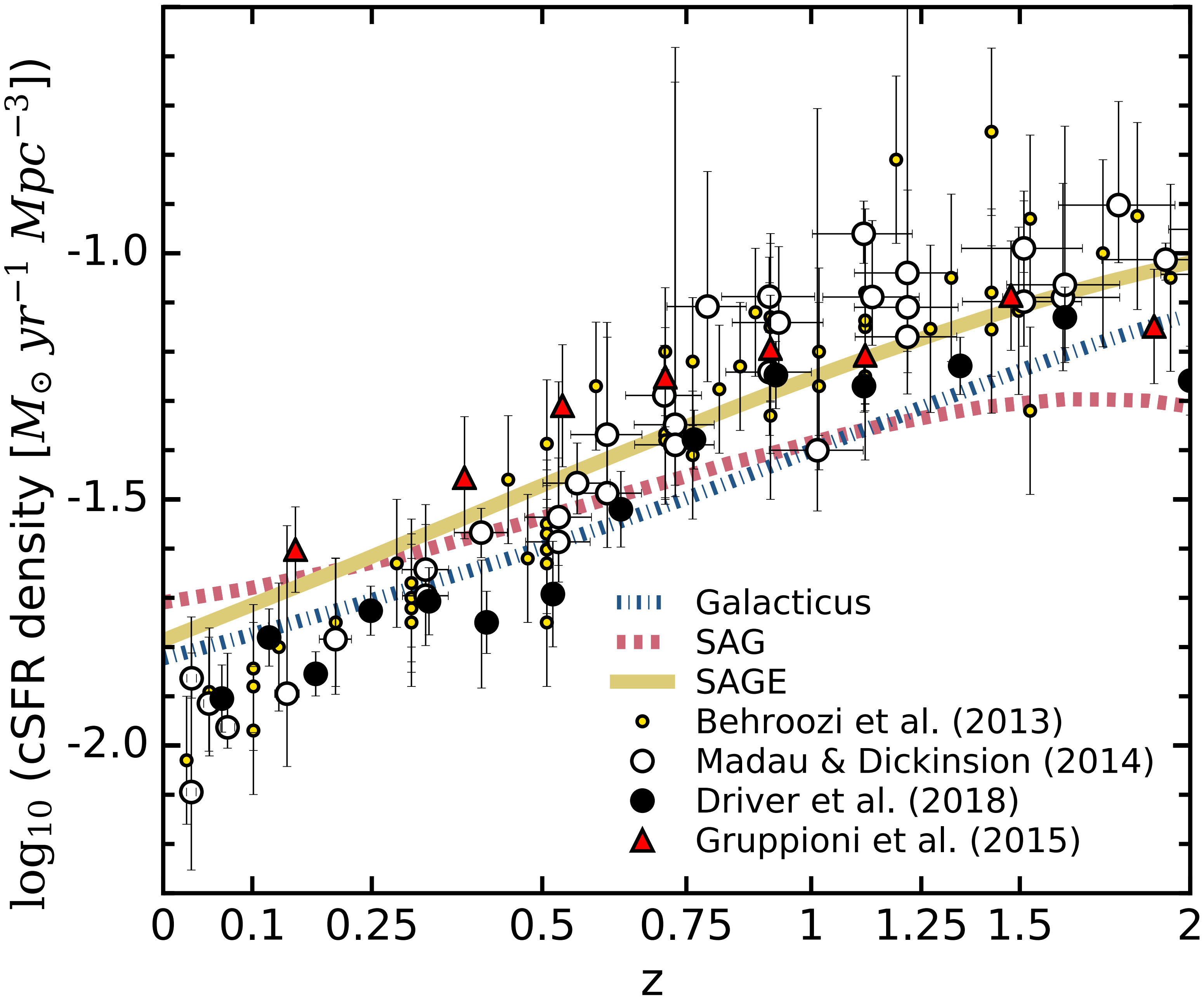
No ELG properties

Galacticus

Benson et al. 2012

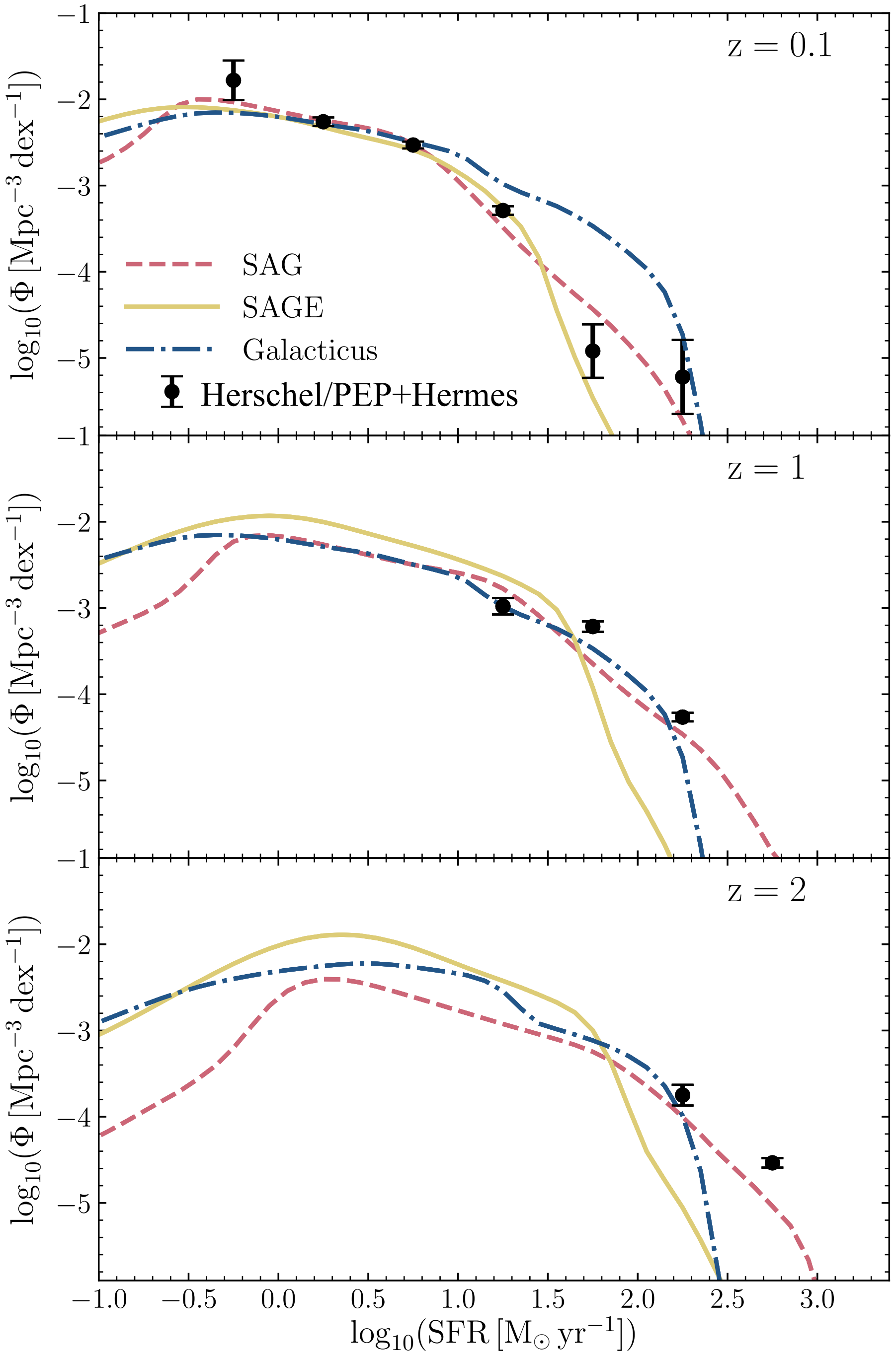
No ELG properties

Model overview

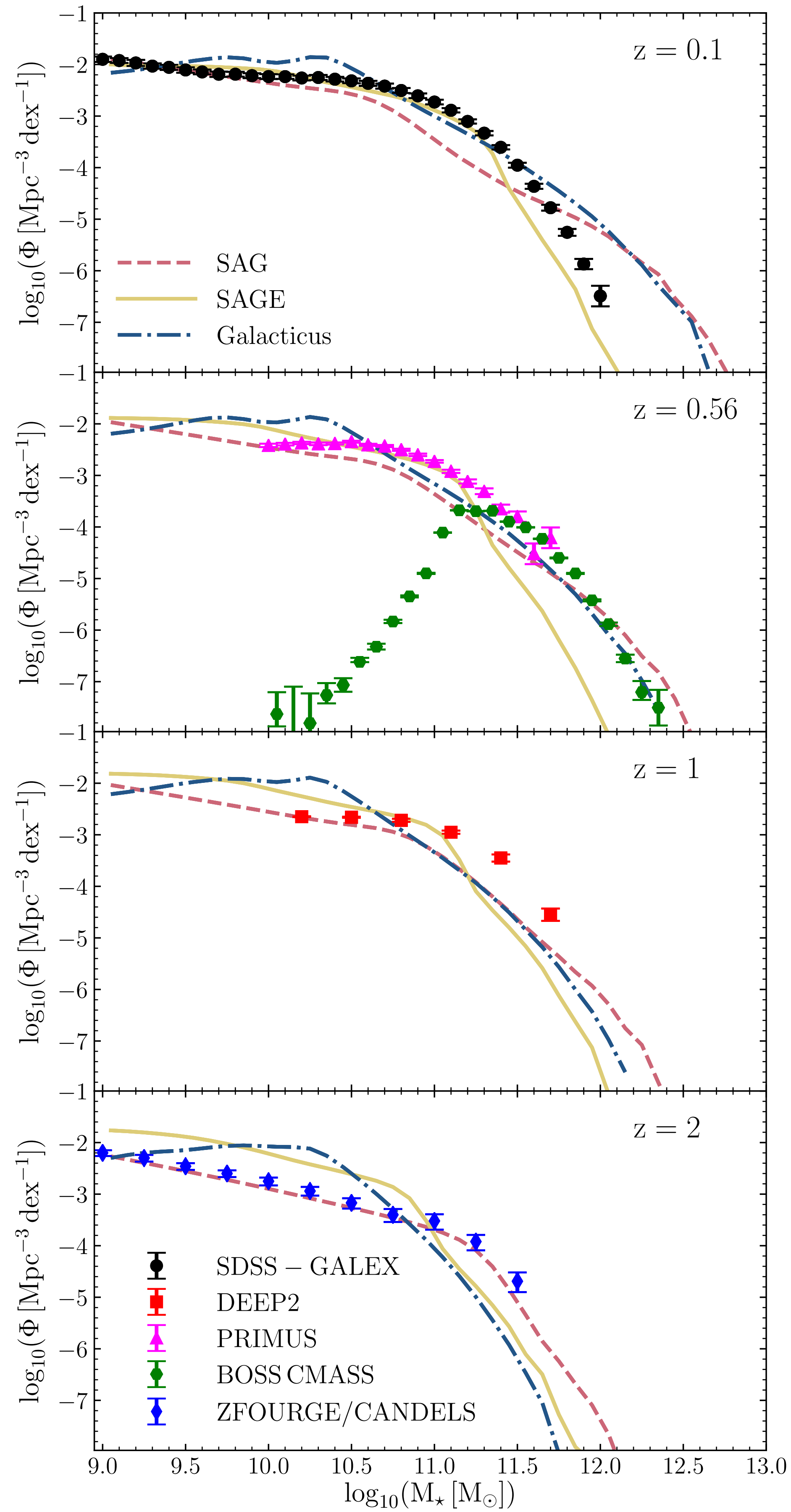


All the SAMs reproduce well the cosmic SFR density at z<2

Average SFR



Stellar mass



Computing [OII] luminosities

GET_EMLINES (Orsi et al. 2014)
https://github.com/aaorsi

MAPPINGS-III
photoionisation code

Ionisation parameter of gas:

$$q(Z) = q_0 \left(\frac{Z_{\rm cold}}{Z_0} \right)^{-\gamma}$$

q_0 =2.8e7 cm/s
Z_0 =0.012

Levesque et al. 2010
pre-computed model grid

Galaxy metallicity:

$$Z_{\rm cold} = \frac{M_{Z\rm cold}}{M_{\rm cold}}$$

Hydrogen ionising photon rate:

$$Q_{\rm H^0} = \log_{10} 1.35 + \log_{10}({\rm SFR}/{\rm M_\odot\,yr^{-1}}) + 53.0.$$

Instantaneous SFR

$$L(\lambda_j) = 1.37 \times 10^{-12} Q_{\rm H^0} \frac{F(\lambda_j, q, Z_{\rm cold})}{F(H\alpha, q, Z_{\rm cold})}$$

MAPPINGS-III prediction for the desired ELG flux and Hα normalisation flux

Dust extinction

We implement interstellar dust extinction on [OII] ELG luminosities:

$$L(\lambda_j)^{\rm att} = L(\lambda_j) 10^{-0.4 A_\lambda(\tau_\lambda^z, \theta)}$$

Attenuation coefficient:

$$A_\lambda(\tau_\lambda^z, \theta) = -2.5 \log_{10} \frac{1 - \exp(-a_\lambda \sec\theta)}{a_\lambda \sec\theta}$$

Izquierdo-Villalba 2019

Draine 2003

θ: dust scattering angle

$$a_\lambda = \sqrt{1 - \omega_\lambda} \tau_\lambda^z$$

ω_λ:dust albedo

galaxy optical depth:

$$\tau_\lambda^z = \left(\frac{A_\lambda}{A_V}\right)_{Z_\odot} \left(\frac{Z_{\rm cold}}{Z_\odot}\right)^s \left(\frac{\langle N_H \rangle}{2.1 \times 10^{21} {\rm atoms\ cm^{-2}}}\right)$$

Cardelli et al. 1989 extinction curve

Mean Hydrogen column density $f(M_{\rm cold}^{\rm disc}, R_{1/2}^{\rm disc})$

De Lucia & Blazot 2007

https://github.com/gfavole/dust

Instantaneous vs average SFR

Instantaneous SFR

Mstar formed during the last time step (SAG: snap/25, ~10-25Myrs at z=1)

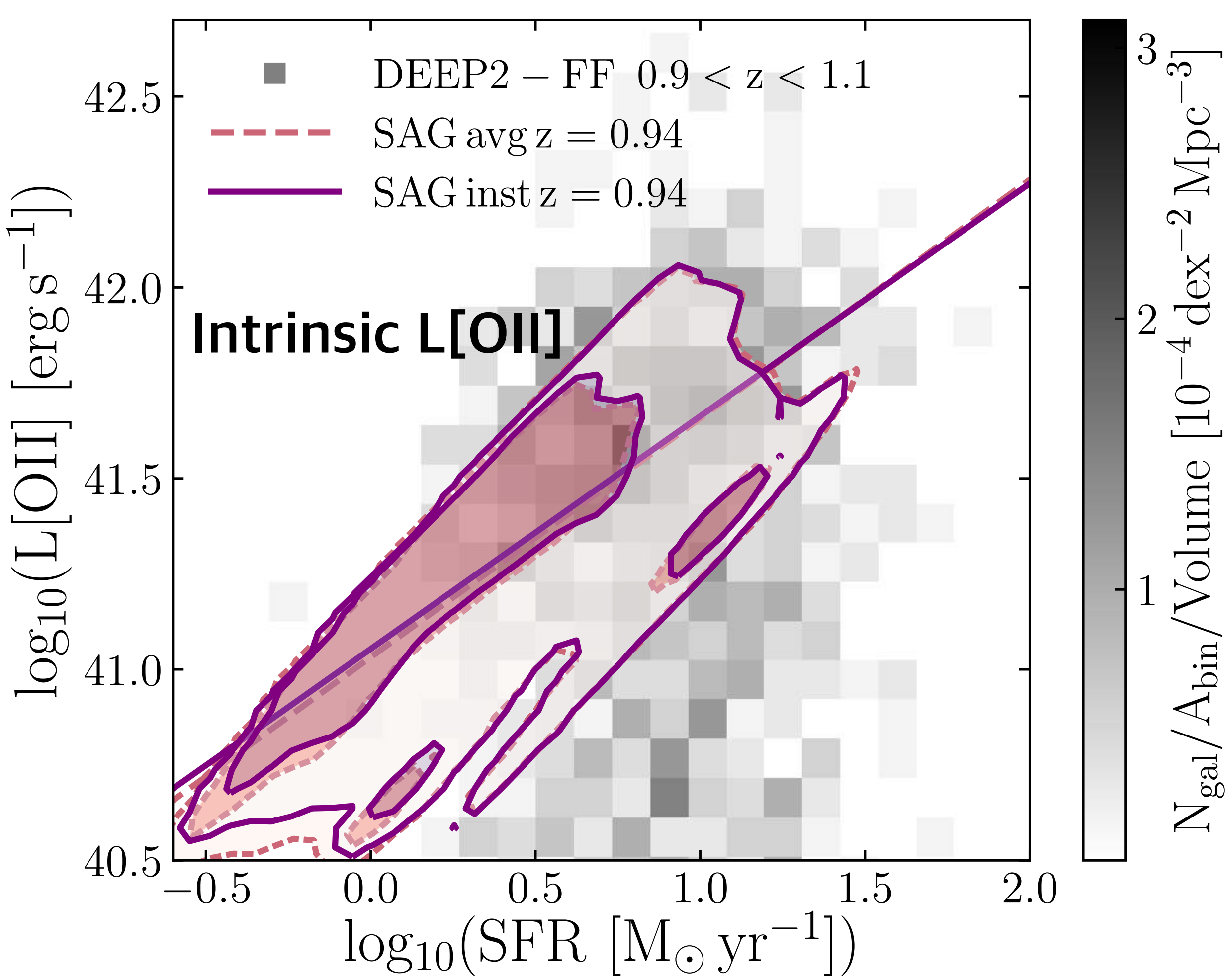
Average SFR

average contribution of all the steps

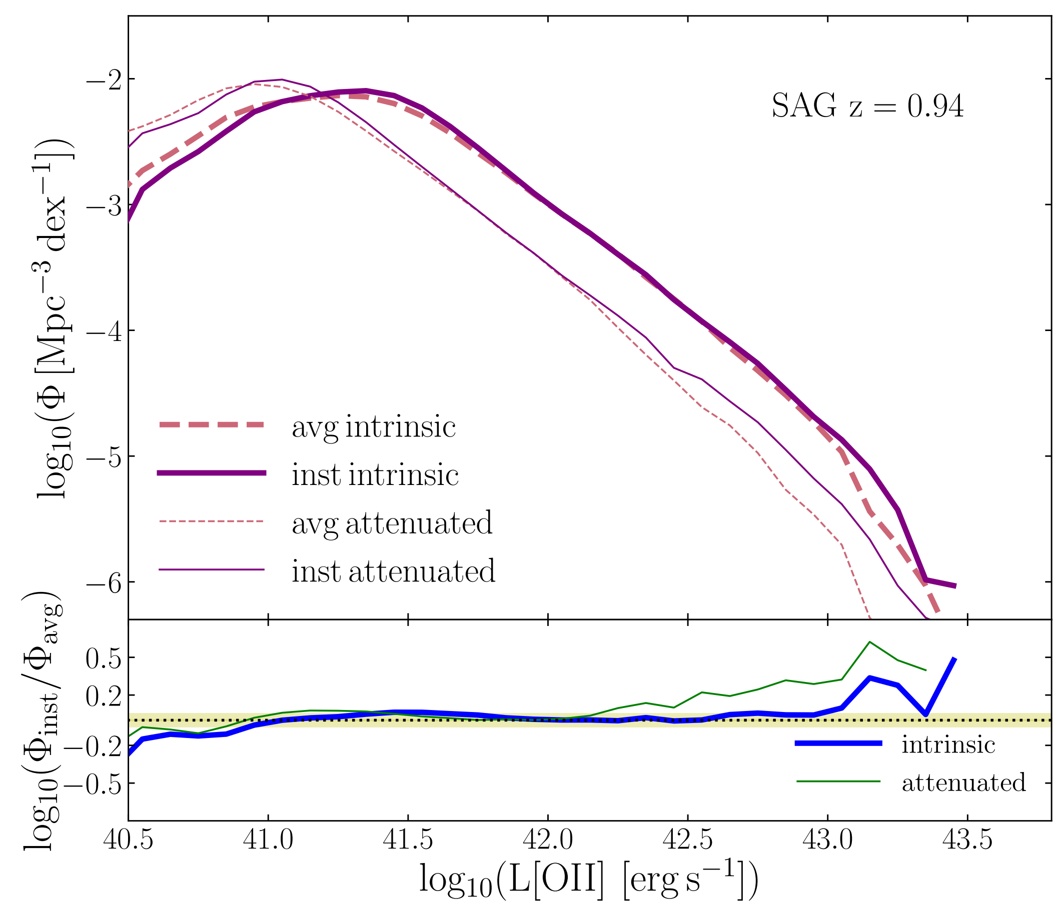
Traces recent SF episodes, relevant for nebular emission

SAG is the only model providing both SFRs; most of the available SAMs have only average SFR

We check the feasibility of calculating **L[OII] using average SFRs**:



Good qualitative overlap with DEEP2

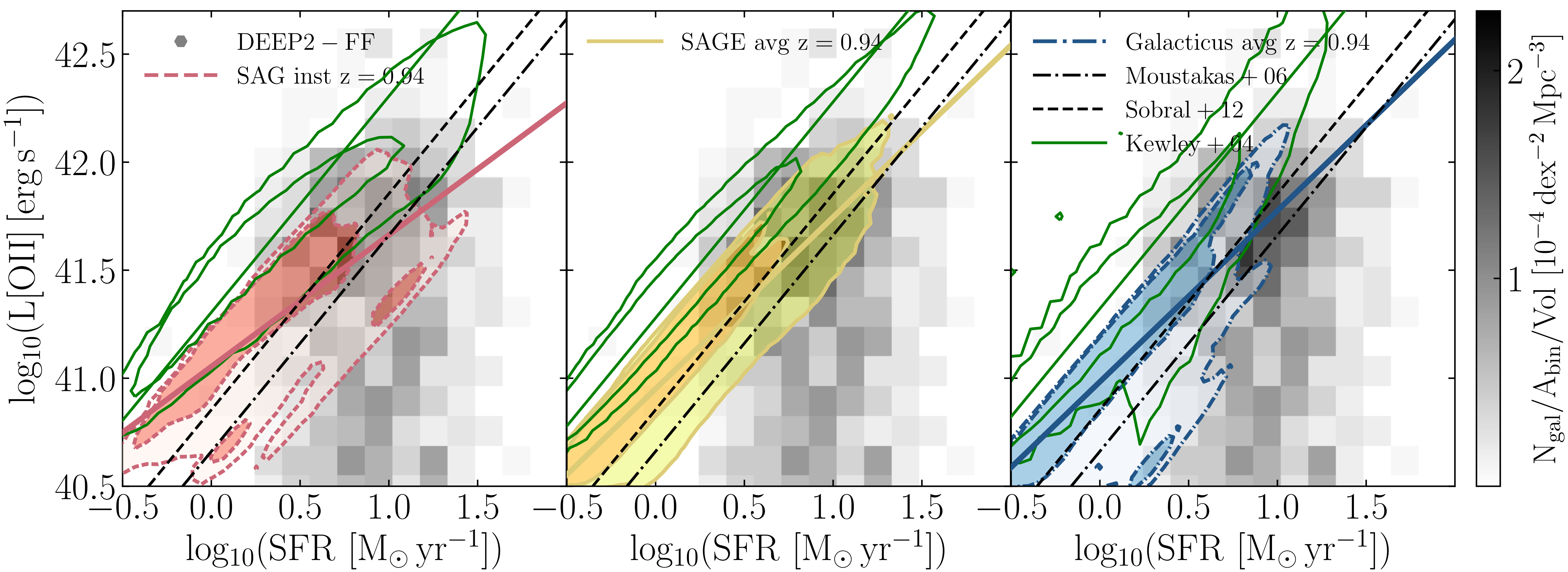


<5% discrepancy at logL[OII]att<42.2

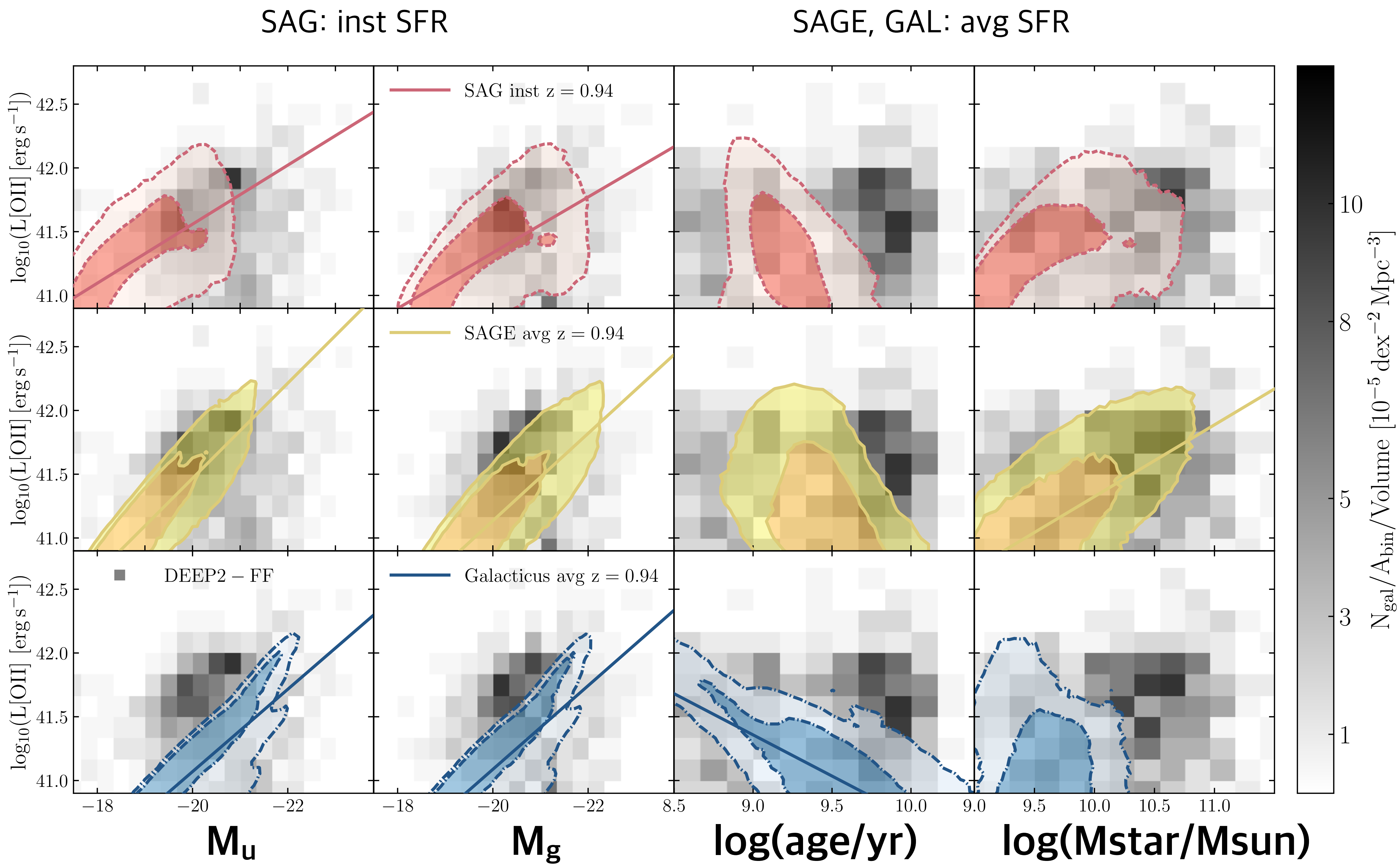
Qualitatively compare the L[OII] - SFR dependence against 3 published relations calibrated on different data sets:

- Moustakas et al. 2006, z=0.1: $$L^{\rm Moust}_{\rm [OII]}({\rm erg\ s^{-1}}) = \frac{\rm SFR(M_\odot\ yr^{-1})}{2.18\times10^{-41}}$$
- Sobral et al. 2012, z=1.47: $$L^{\rm Sob}_{\rm [OII]}({\rm erg\ s^{-1}}) = \frac{\rm SFR(M_\odot\ yr^{-1})}{1.4\times10^{-41}},$$
- Kewley et al. 2004, z=1: $$L^{\rm Kew}_{\rm [OII]}({\rm erg\,s^{-1}}) = \frac{\rm SFR(M_\odot\ yr^{-1})}{7.9\times10^{-42}}\times(a[12+\log_{10}({\rm O/H})_{\rm cold}]+b).$$

[OII] ELG gas-phase Oxygen abundance, which we proxy with $Z_{\rm cold}$



L[OII] correlations with other galactic properties



SFR and magnitudes are the galaxy properties that correlate the most with L[OII], so we use them as L[OII] proxies

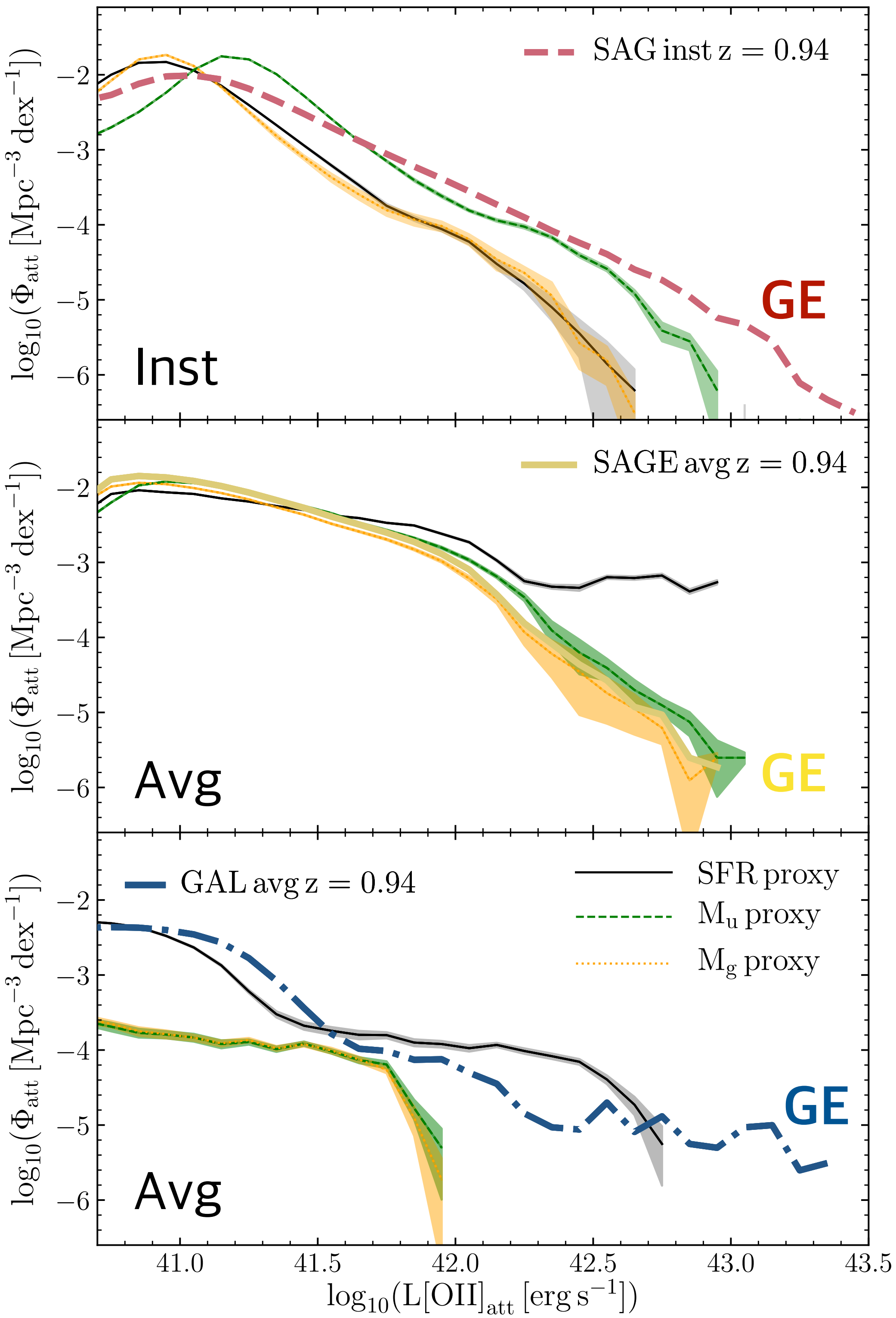
Fit these correlations and use them as proxies for L[OII] in SAMs that lack L[OII]:

z=1			SAG	SAGE	GALACTICUS
$\log_{10}(L[\mathrm{O\,II}]\,/\mathrm{erg\,s^{-1}})$	$= A\log_{10}(\mathrm{SFR/M_\odot\,yr^{-1}}) + B$	A	0.609±0.001	0.792±0.001	0.795±0.001
		B	41.05±0.01	40.98±0.01	40.95±0.01
		$\sigma_{\log(\mathrm{SFR})}$	0.50	0.53	0.48
		$\sigma_{\log(\mathrm{L[OII]})}$	0.38	0.45	0.46
		r	0.80	0.92	0.83
$\log_{10}(L[\mathrm{O\,II}]\,/\mathrm{erg\,s^{-1}})$	$= A\,M_u + B$	A	-0.231±0.001	-0.373±0.001	-0.323±0.001
		B	36.93±0.01	34.01±0.01	34.61±0.01
		$\sigma_{\mathrm{M_u}}$	1.07	1.05	1.18
		$\sigma_{\log(\mathrm{L[OII]})}$	0.38	0.45	0.46
		r	0.65	0.86	0.83
$\log_{10}(L[\mathrm{O\,II}]\,/\mathrm{erg\,s^{-1}})$	$= A\,M_g + B$	A	-0.218±0.001	-0.342±0.001	-0.328±0.001
		B	36.97±0.01	34.29±0.01	34.53±0.01
		$\sigma_{\mathrm{M_g}}$	1.11	1.08	1.15
		$\sigma_{\log(\mathrm{L[OII]})}$	0.38	0.45	0.46
		r	0.64	0.81	0.82

Proxy performance against GET_EMLINES estimates

I) L[OII] functions

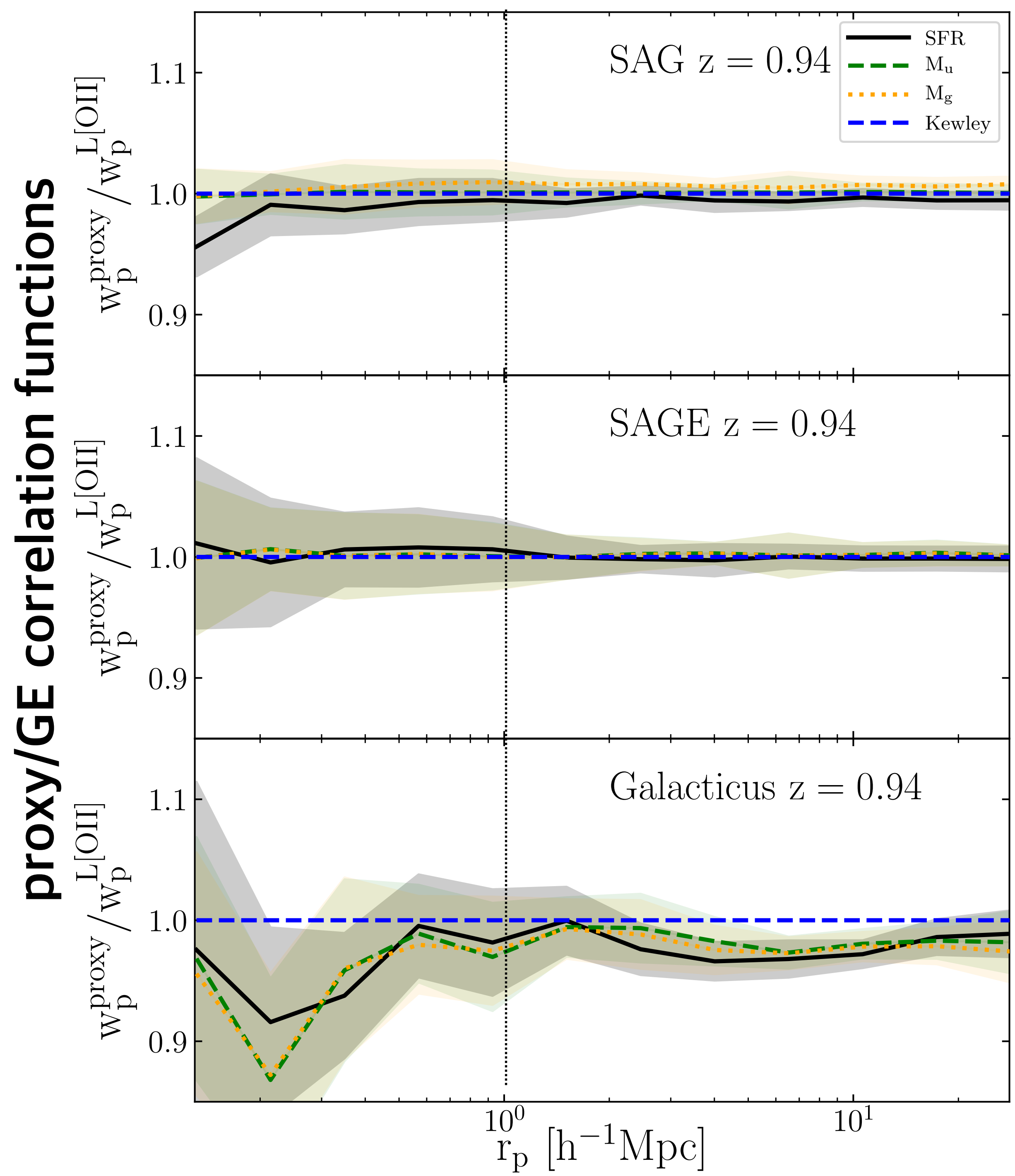
attenuated



Proxies overall result in a lack of bright emitters

Very model and proxy dependent

II) Clustering of SAM galaxies selected at log(L[OII]/erg s-1)>40.4



Clustering remains unchanged beyond 1Mpc/h independently from the model/proxy

Summary

- The **average SFR** used as input for L[OII] computation using GET_EMLINES returns accurate (**<5% discrepancy**) results at log(L[OII]/erg s-1)**<42.2** (dust attenuated)

- **SFR** and the **broad-band u,g magnitudes** are the quantities that correlate the most with L[OII], so **best proxies**. They result in L[OII] functions which are in **reasonable agreement** with the **GET_EMLINES** estimates, although very model/proxy dependent. Overall, the proxies result in a lack of bright emitters.

- The **clustering** of galaxies selected at log(L[OII]/erg s-1)>40.4 remains **unchanged** beyond 1Mpc/h, independently of the L[OII] computation method.

Our results show that ELGs are different from SFR-selected samples and their L[OII] estimation needs a **more complex modelling than** assuming a **linear relation with SFR**. Simple L[OII] estimates are **not accurate enough to predict direct statistics** of L[OII], as the luminosity functions, **but** they are **sufficient to model the large-scale clustering** of [OII] emitters.