The SFR Cookbook at 1<z<3

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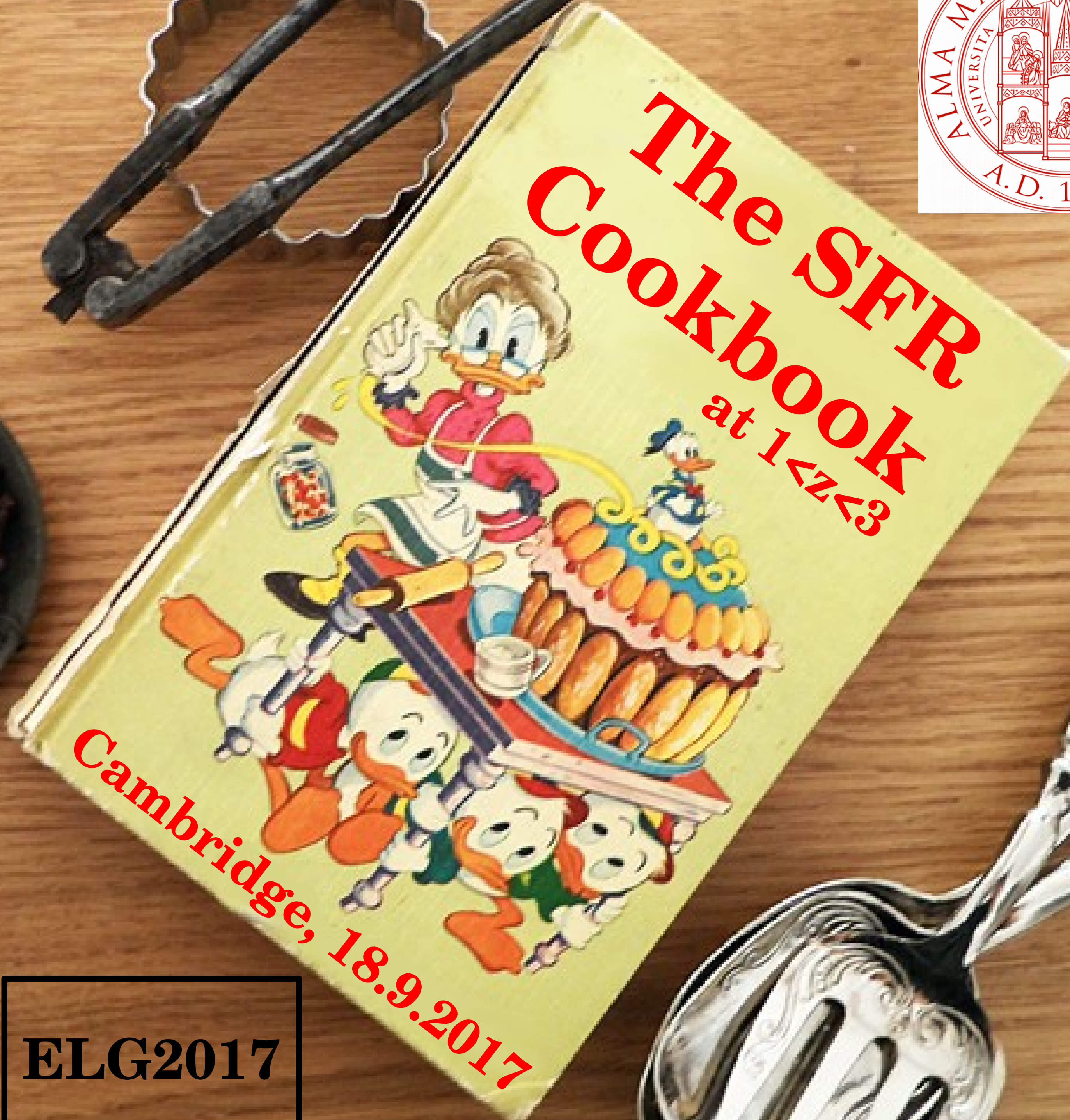
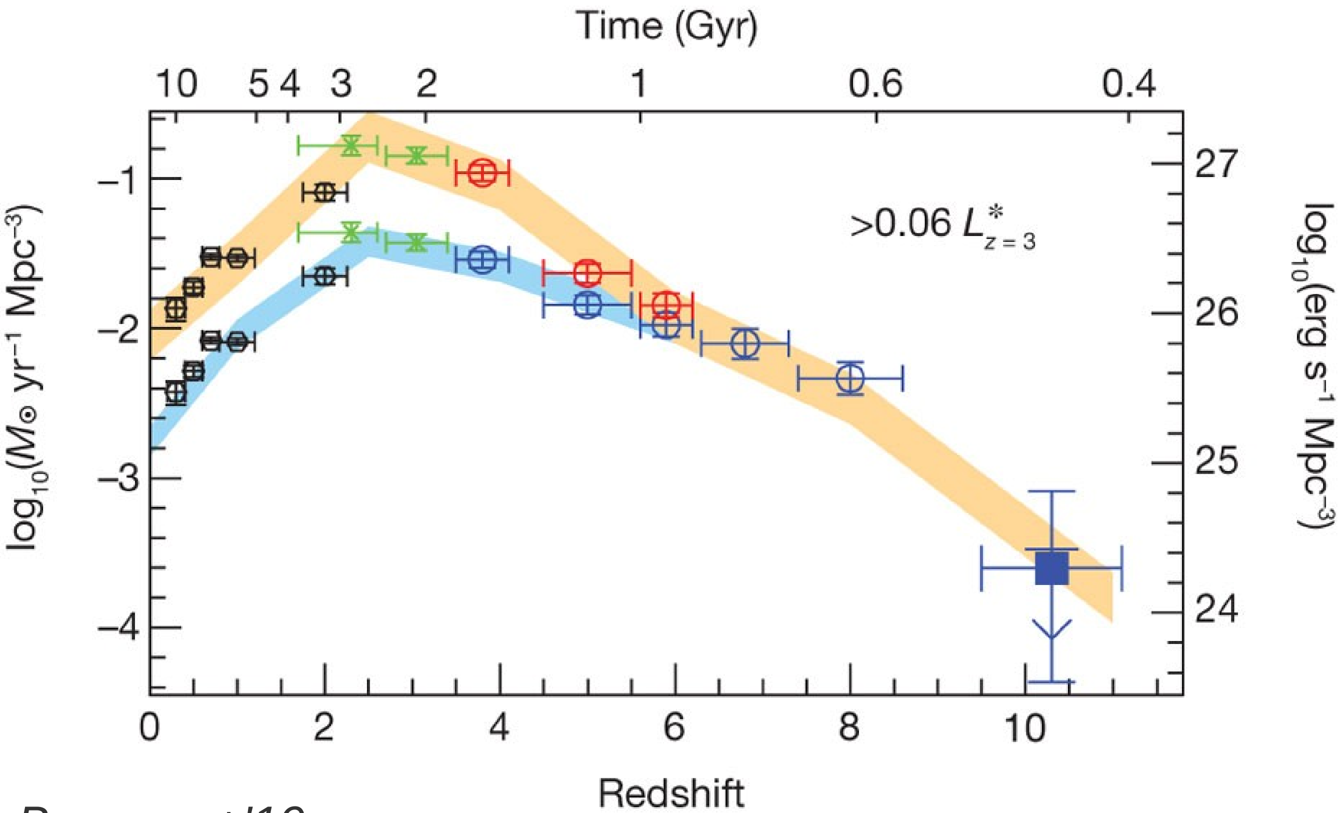
2015
A&A, 582, 80



ELG2017

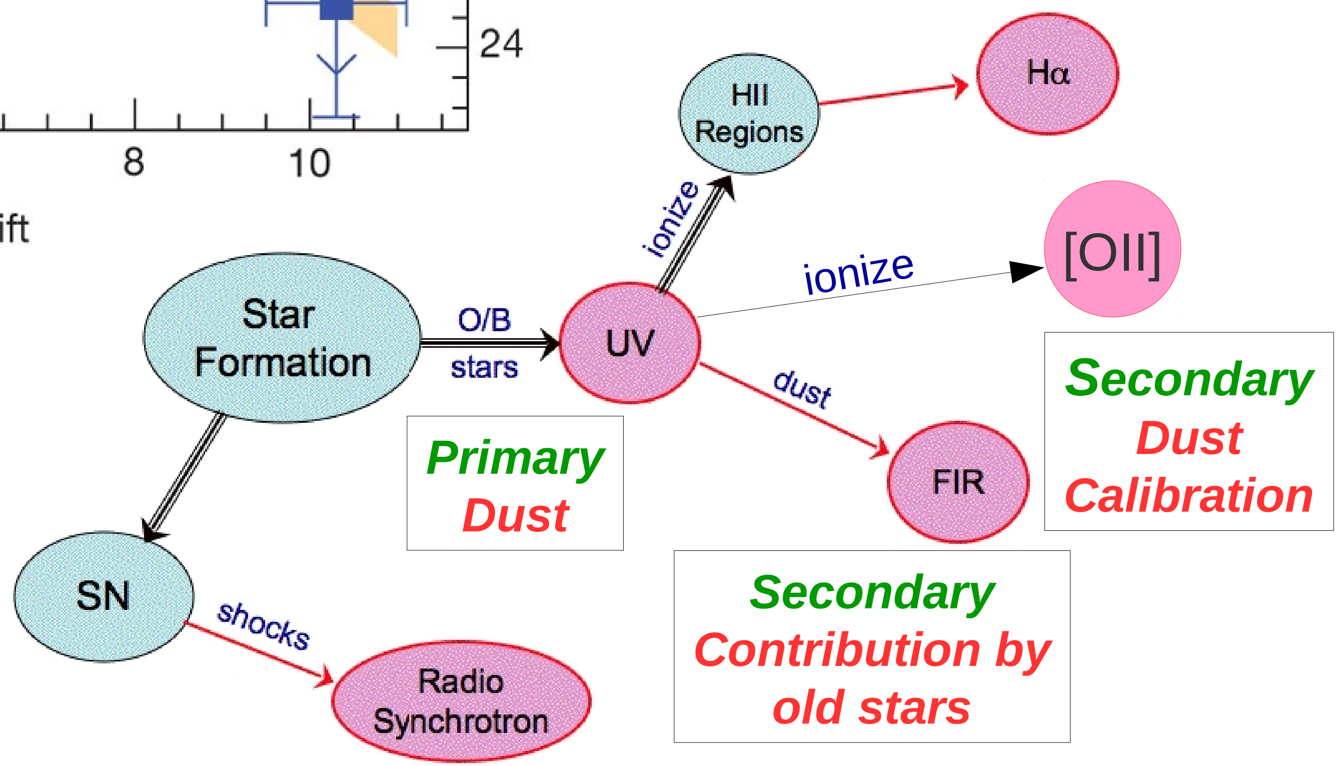
Cambridge, 18.9.2017

Introduction

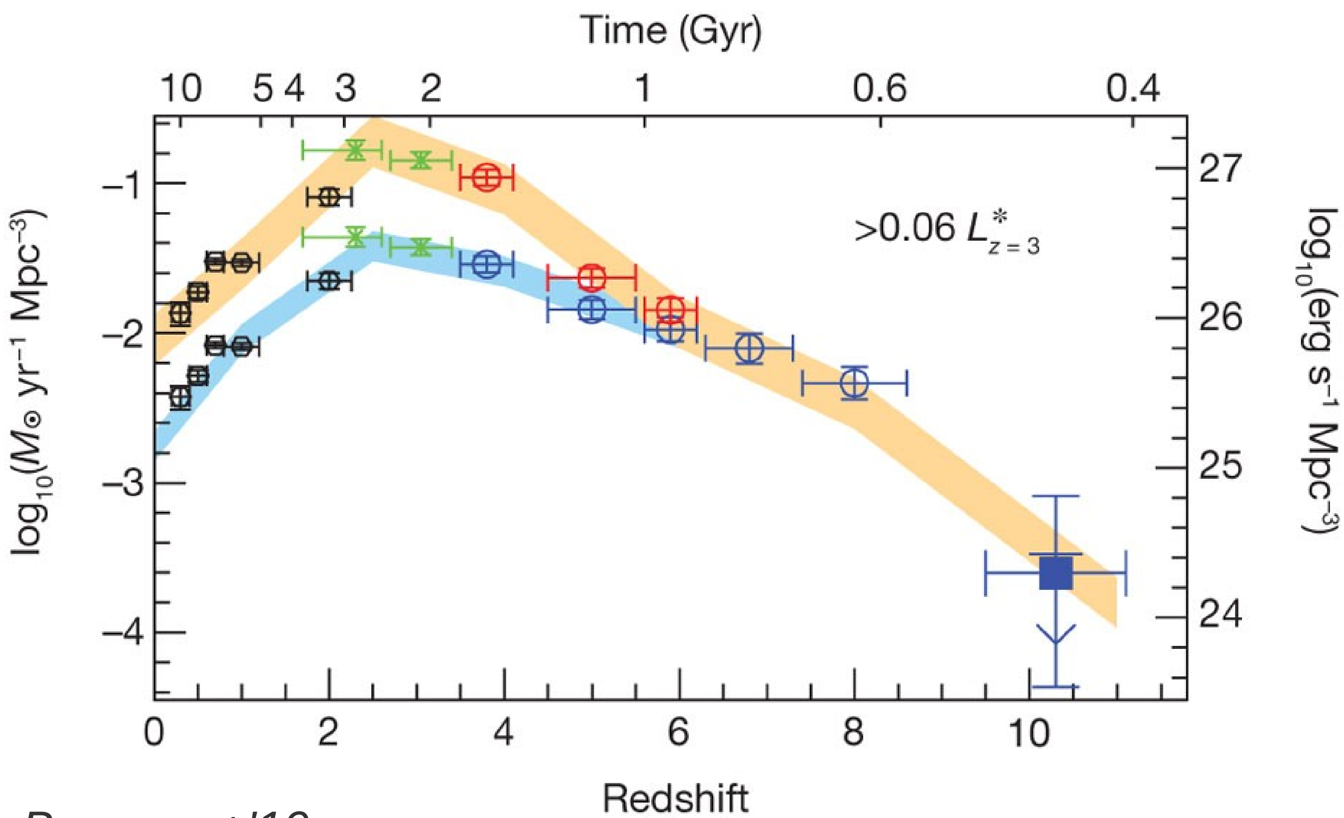


Bouwens+'10

(Lilly+'96; Madau+'96)



Introduction



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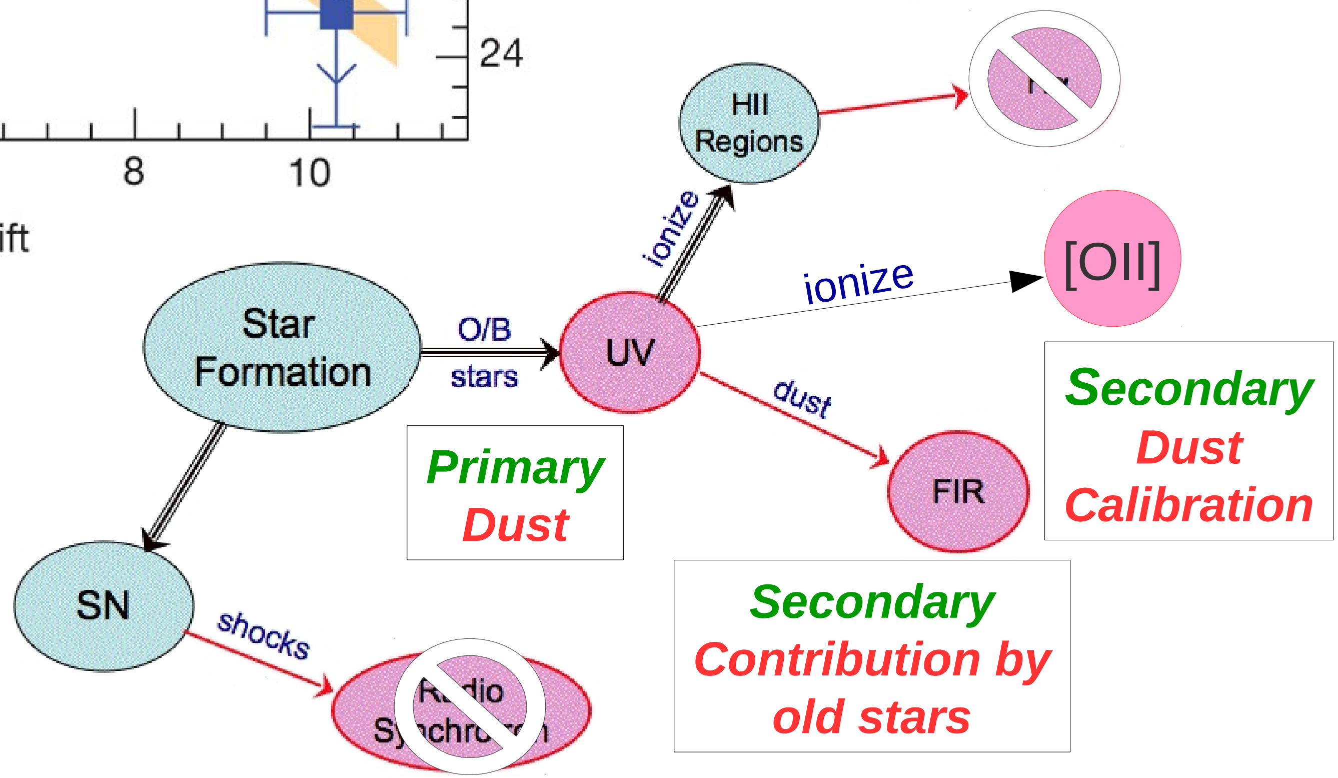
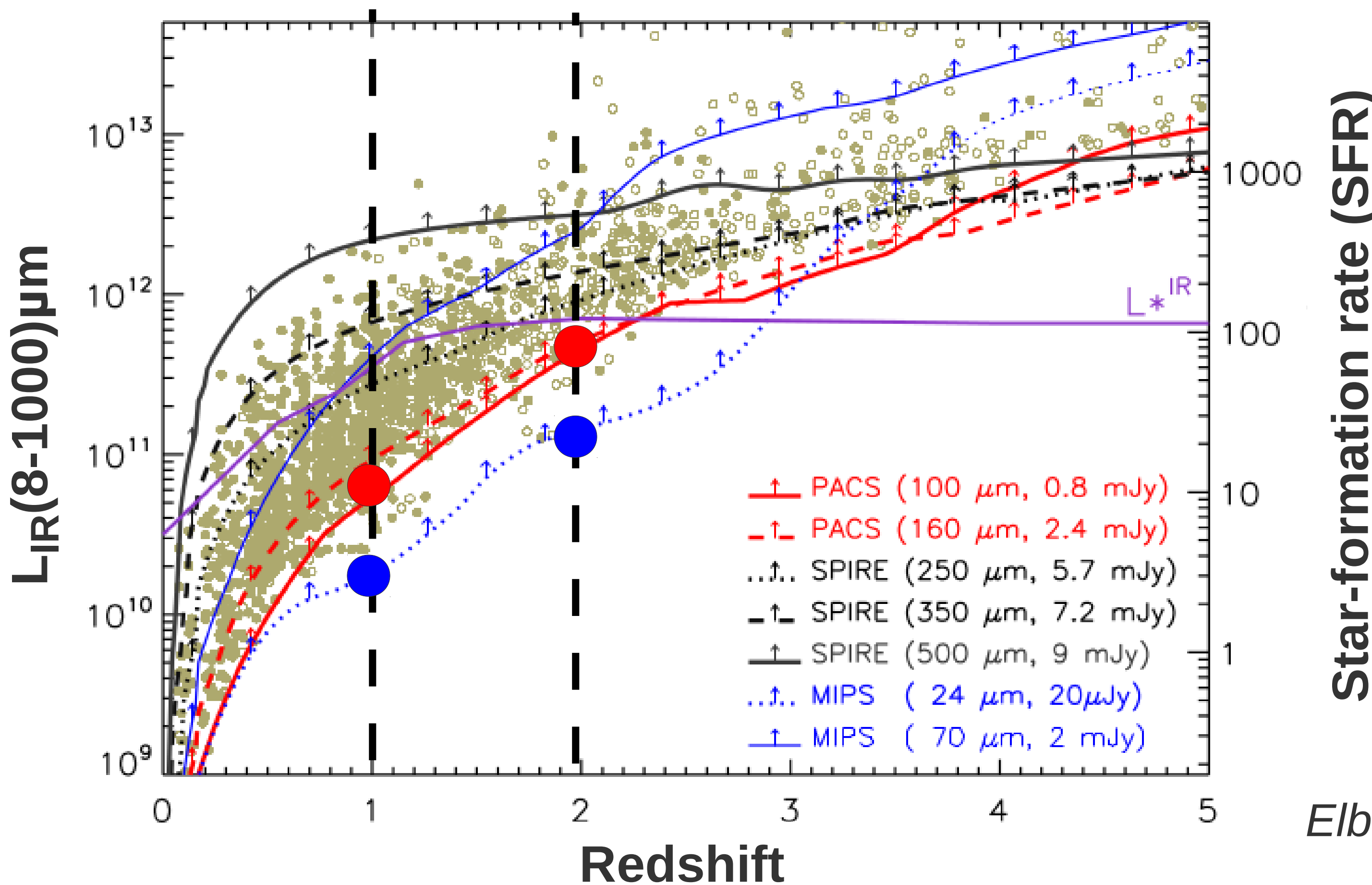


Introduction



Elbaz+'11

Dust-unbiased tracers: sensitivity limits at high redshift

Dust-biased tracers still of fundamental importance

<u>IR luminosity can be used to calibrate relations to correct dust-biased tracers</u>

The data sample

GMASS

Galaxy Mass Assembly
ultra-deep Spectroscopic Survey
(P.I. A. Cimatti; Kurk+'13)

Chandra Deep Field South

Pure flux-limited sample:
mag (4.5μm) < 23.0

Ultra-deep spectroscopy with FORS2
(intergrations up to 30 h)

Multi-wavelength photometric coverage
(from U band to **SPITZER-MIPS 24μm**)

PLUS

Spectra from public ESO surveys
(Vanzella+'08; Balestra+'10; Le Fèvre+'05; Mignoli+'05)

Photometric IR data from
HERSCHEL PACS
(PEP + GOODS-H)
(Lutz+'11; Elbaz+'11; Magnelli+'13)

The sample selection

1 < z < 3

Peak of SFRD
and AGN activity

Spectroscopy

Secure redshift
Spectral features

Star-forming
galaxies

Preliminary selection:
NO quiescent/passive
NO AGNs

Two sub-samples

Consistency of
Spectral features

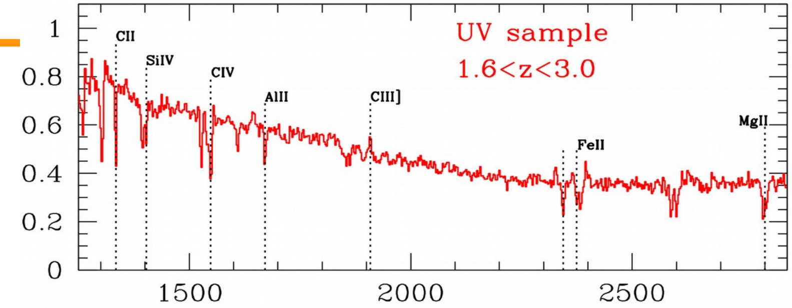
[OII]-sample

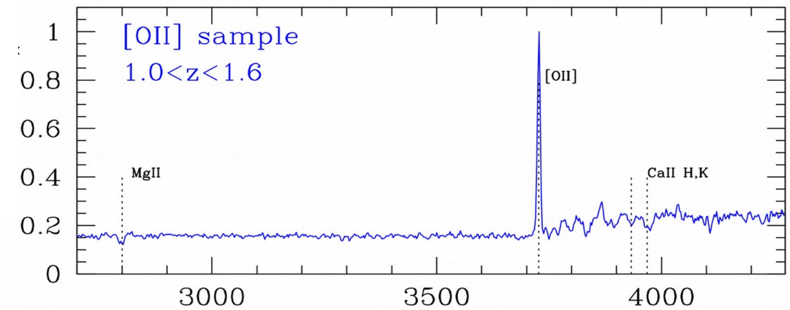
- 1.0 < z < 1.6
- 2700−4300Å
- [OII]λ3727 em. line

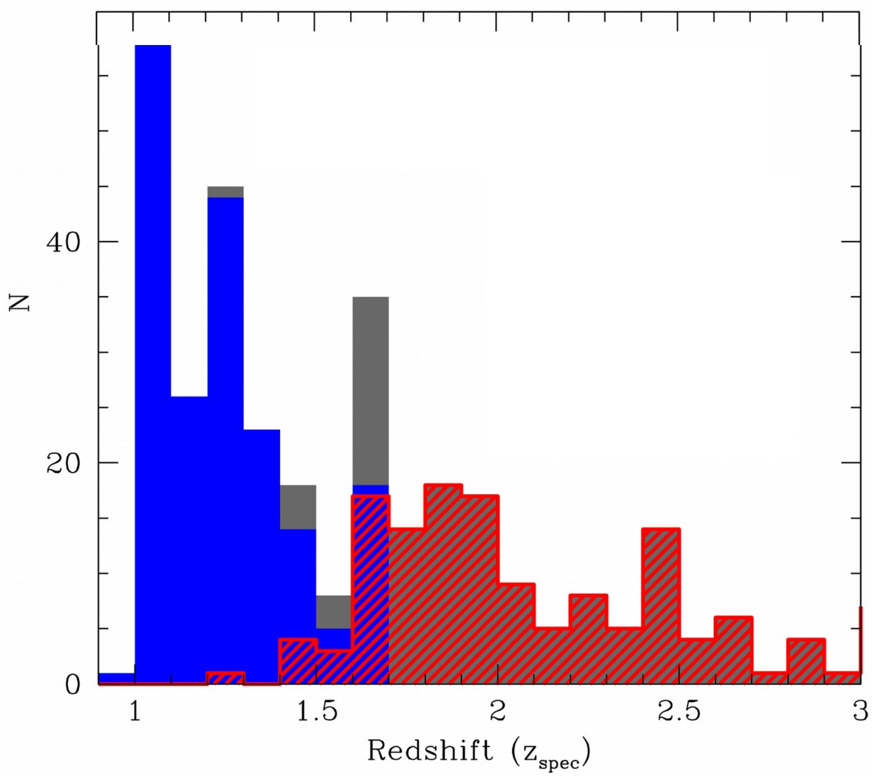
UV-sample

- 1.6 < z < 3.0
- 1100 – 2800Å
- UV continuum
- ISM abs. lines

FINAL SAMPLE
~ 300 SFGs



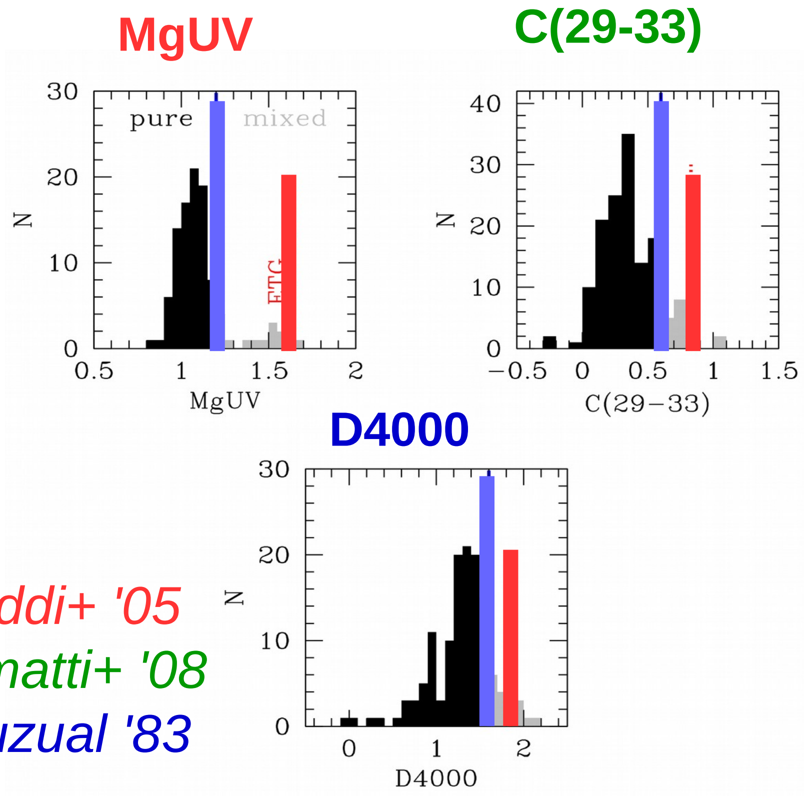




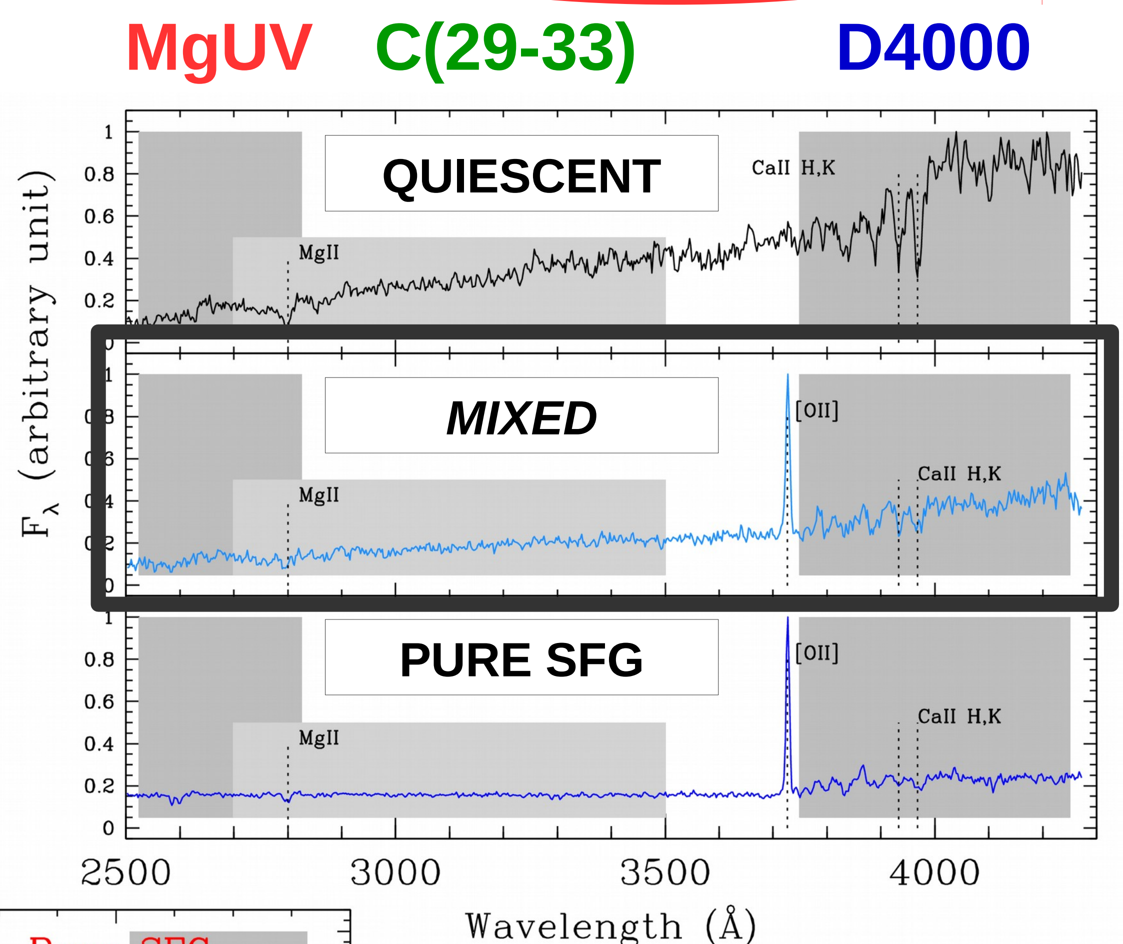
Spotting the presence of old stellar populations

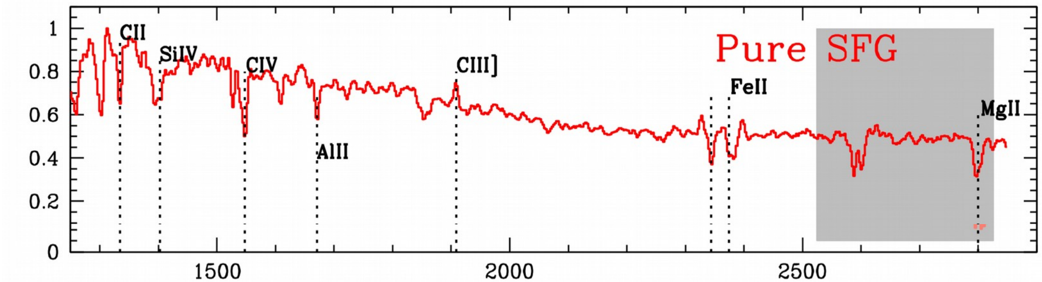
- Possible contribution to UV continuum reddening
- Non-negligible contribution to dust heating

Overestimate of total SFR!

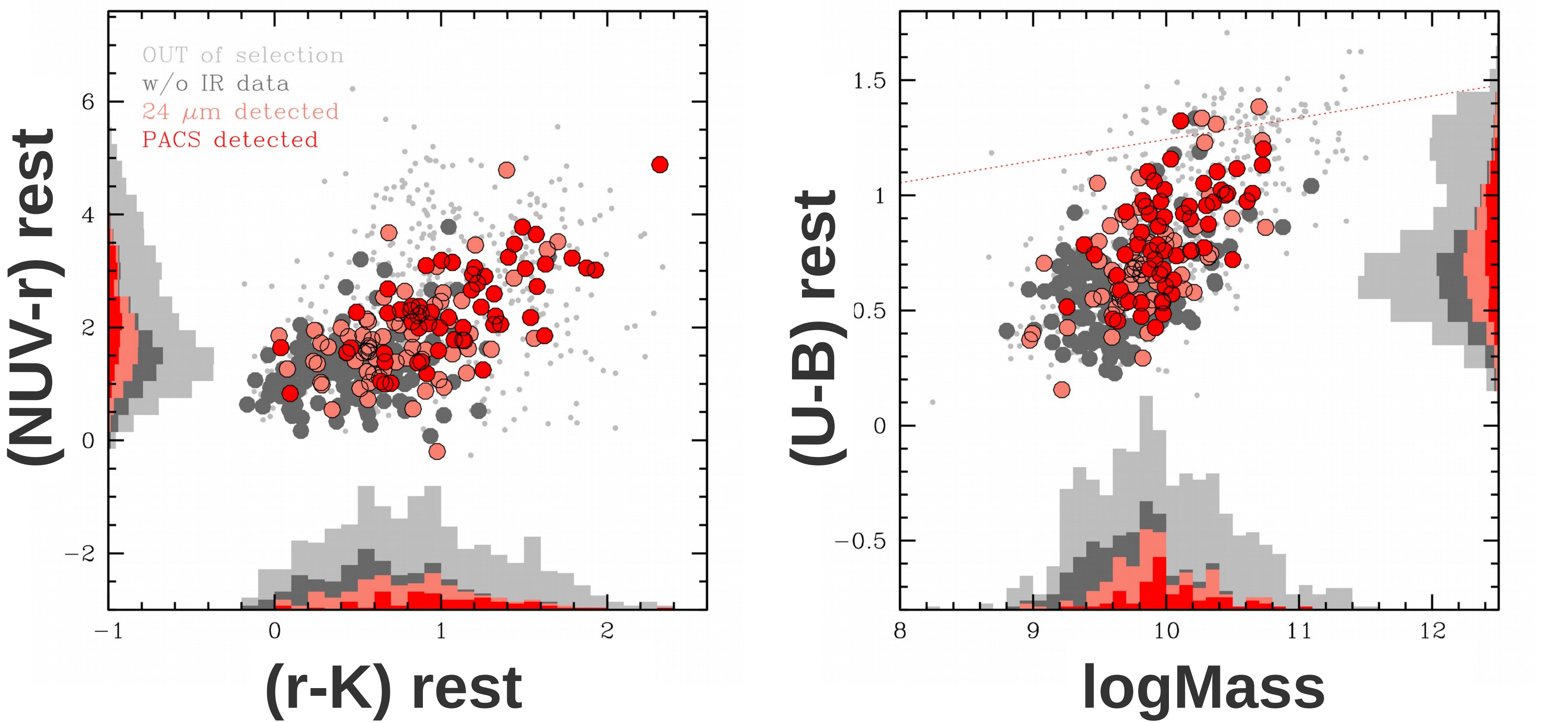


Daddi+ '05
Cimatti+ '08
Bruzual '83





Properties of the final sample

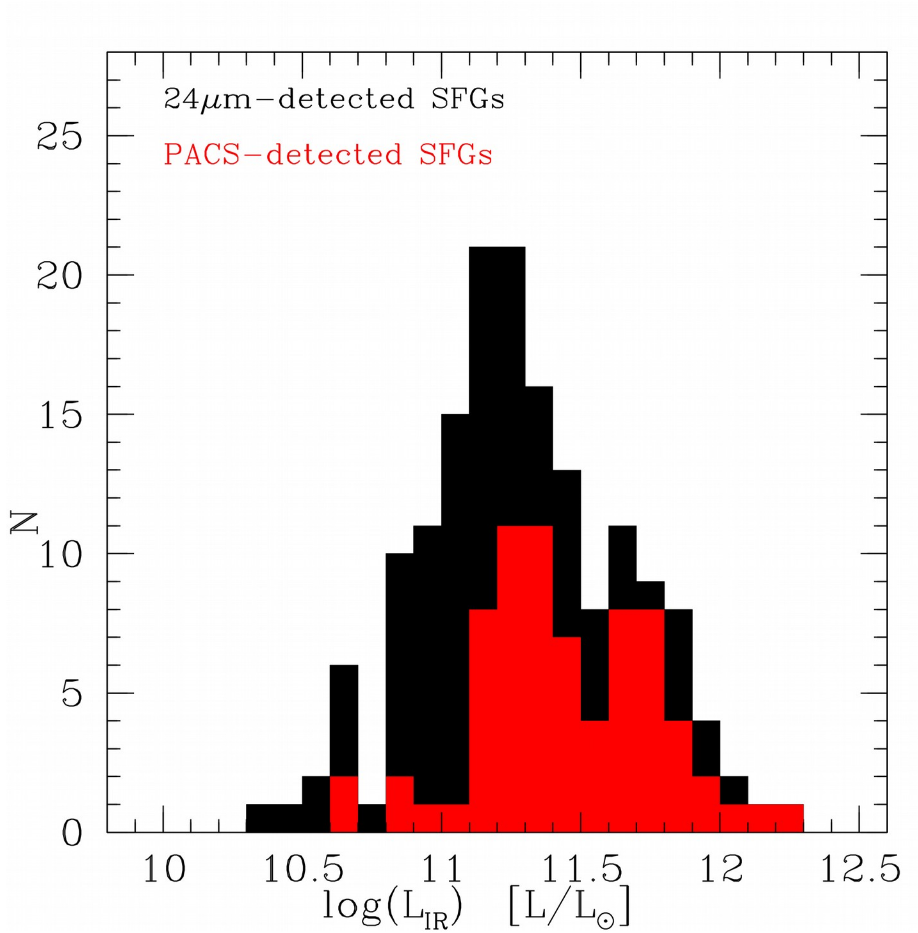


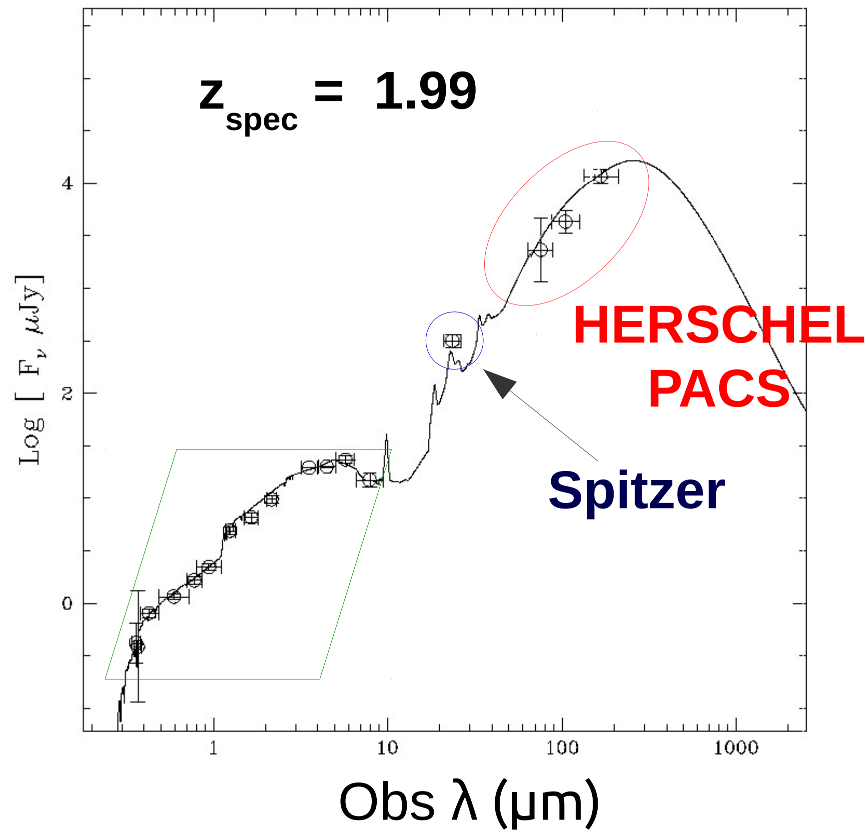
- 1 < z < 3
- Intermediate stellar mass ($10^{9.2} < M/M_{\odot} < 10^{10.2}$) [*completess limit = $M/M_{\odot} \sim 10^{10.5}$*]
- Blue rest-frame colours
- Blue continuum indices (MgUV<1.2, C(29−33)<0.6, D4000<1.6)

The benchmark: SFR_{IR} + $SFR_{UV(uncorr)}$

$$SFR_{TOT} = SFR_{IR+UV} = SFR_{IR} + SFR_{UV(uncorr)}$$

(e.g. Papovich+'07; Rodighiero+'10)





- **24μm + PACS detected (~ 100 gals):**
  `MAGPHYS` code
  da Cunha+'08
- **Only 24μm (~ 100 gals):**
  Main sequence SED templates
  Magdis+'12

Dust extinction correction: SFR from UV continuum luminosity

UV-sample

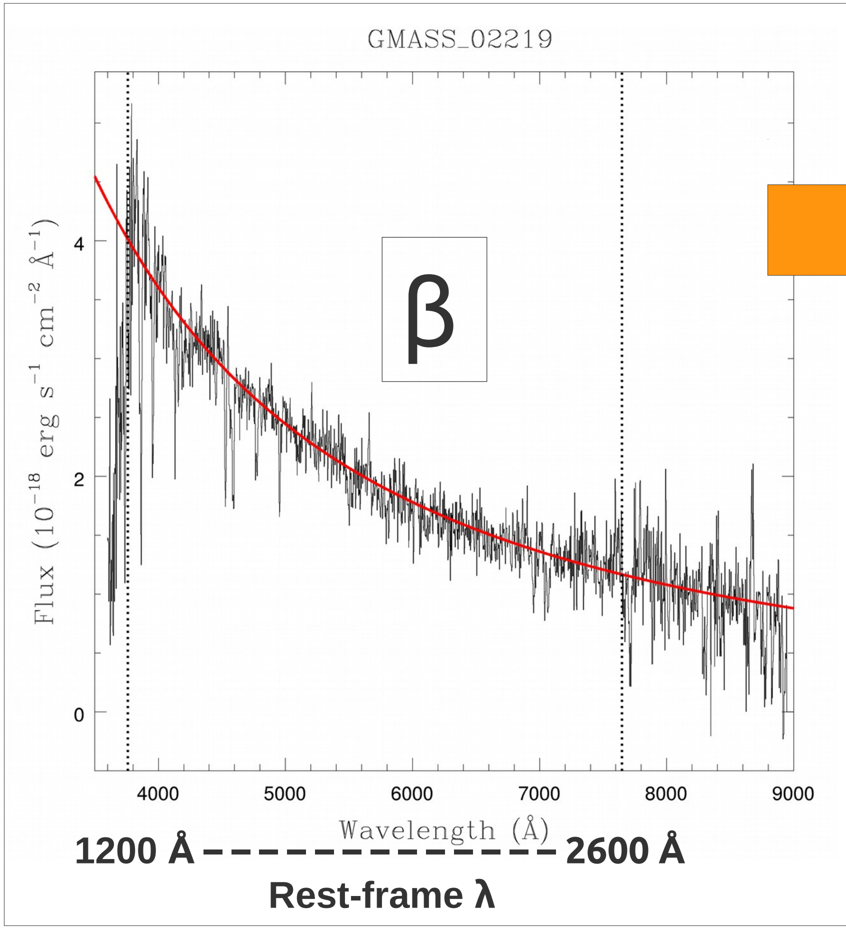
$$SFR_{UV\_0} \propto L_{UV\_0} = \nu L_\nu\,(1500\text{Å})$$

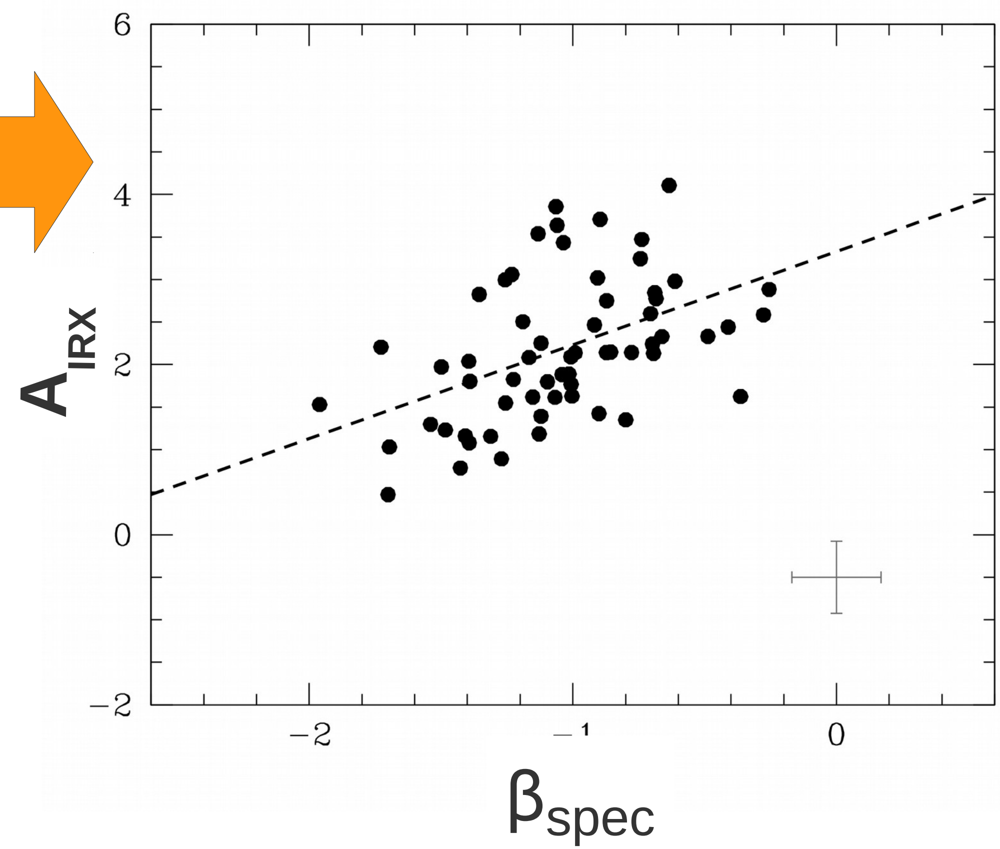
(Kennicutt+'98)

z ~ 2.3

$$A_{IRX} = 2.5\log(SFR_{IR}/SFR_{UV} + 1)$$

Talia et al. 2012





$$A_{IRX} = (1.10 \pm 0.23) \times \beta_{spec} + (3.33 \pm 0.24)$$

Dust extinction correction: SFR from UV continuum luminosity

UV-sample

$SFR_{UV\_0} \propto L_{UV\_0} = \nu L_\nu$ (1500Å) *(Kennicutt+'98)*

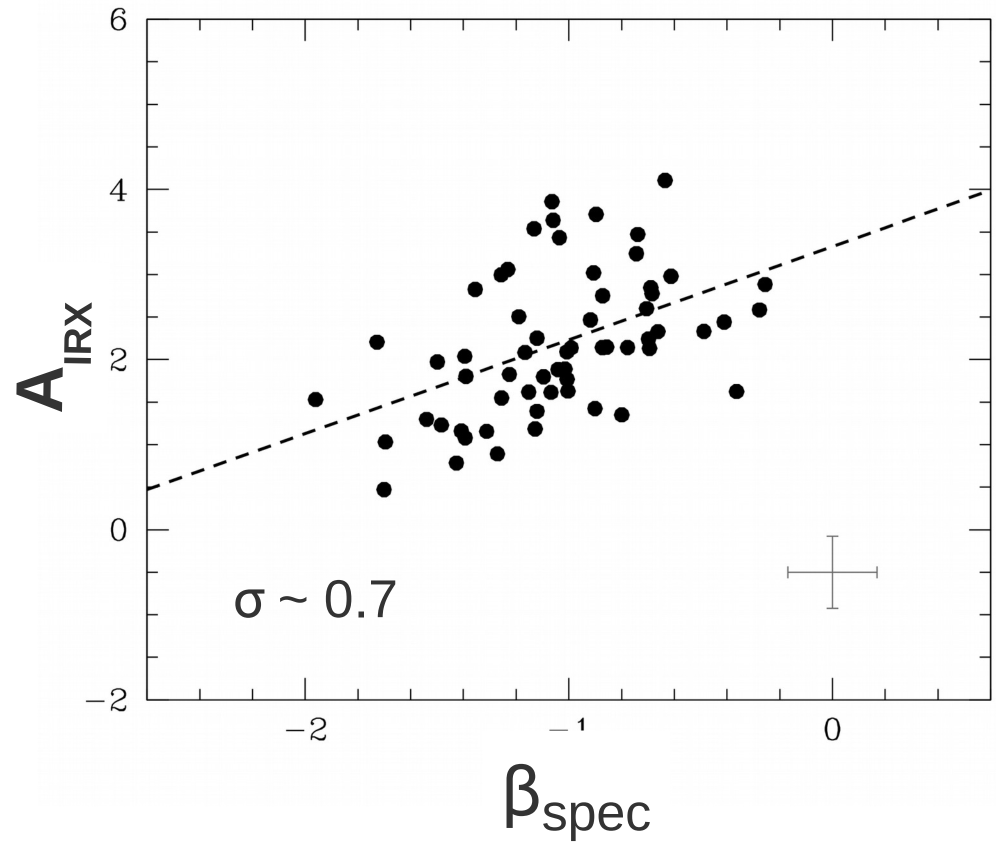
z ~ 2.3

$A_{IRX} = 2.5\log(SFR_{IR}/SFR_{UV} + 1)$

$$A_{IRX} = C_0 \times \beta + C_1$$

This work
(4.5μm-selected)
σ ~ 0.7 dex

UV-selected samples
σ ~ 0.3 dex



$$A_{IRX} = (1.10 \pm 0.23) \times \beta_{spec} + (3.33 \pm 0.24)$$

Dust extinction correction: SFR from UV continuum luminosity

[OII]-sample

$SFR_{UV\_0} \propto L_{UV\_0} = \nu L_\nu$ (1500Å)

(Kennicutt+'98)

z ~ 1.3

$A_{IRX} = 2.5\log(SFR_{IR}/SFR_{UV} + 1)$

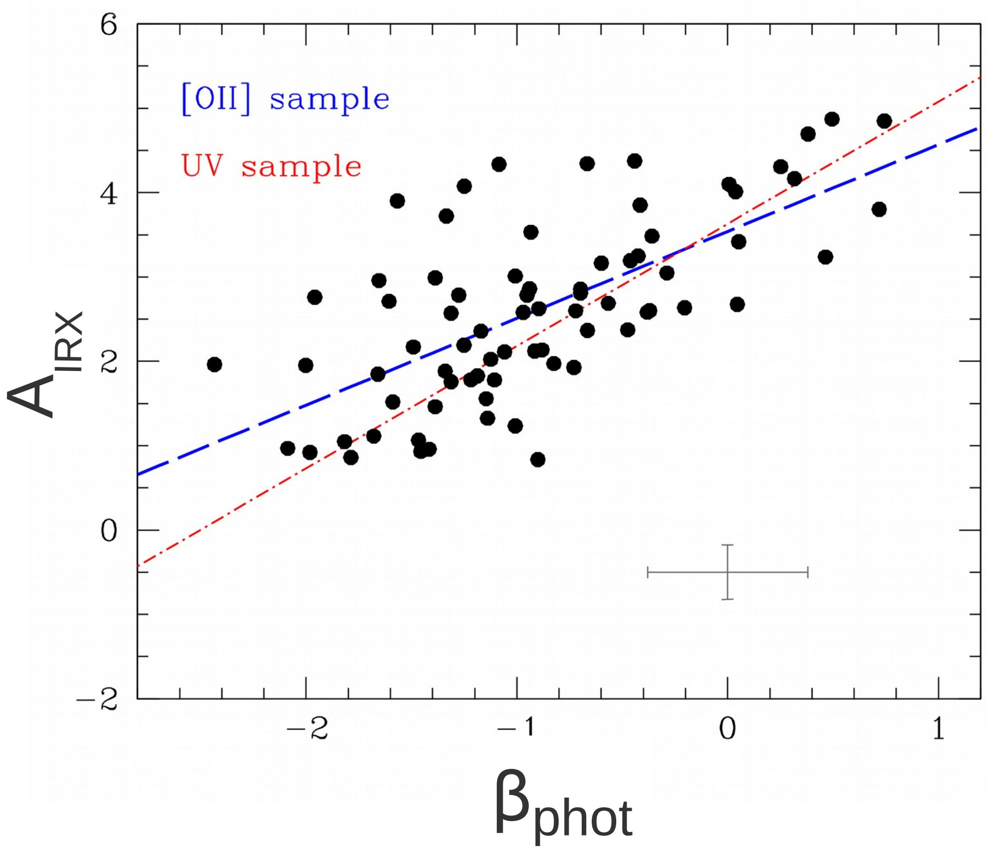
β must be derived from photometry

In the [OII] sample relation is slightly flatter than in the UV sample, but the difference is not highly significant

No evolution of the A_{IRX} vs. β relation between z~1.3 and z~2.3

Both samples broadly follow the prediction of the Calzetti law

See also Pannella+'14



$$A_{IRX} = (1.03 \pm 0.26) \times \beta_{phot} + (3.54 \pm 0.25)$$

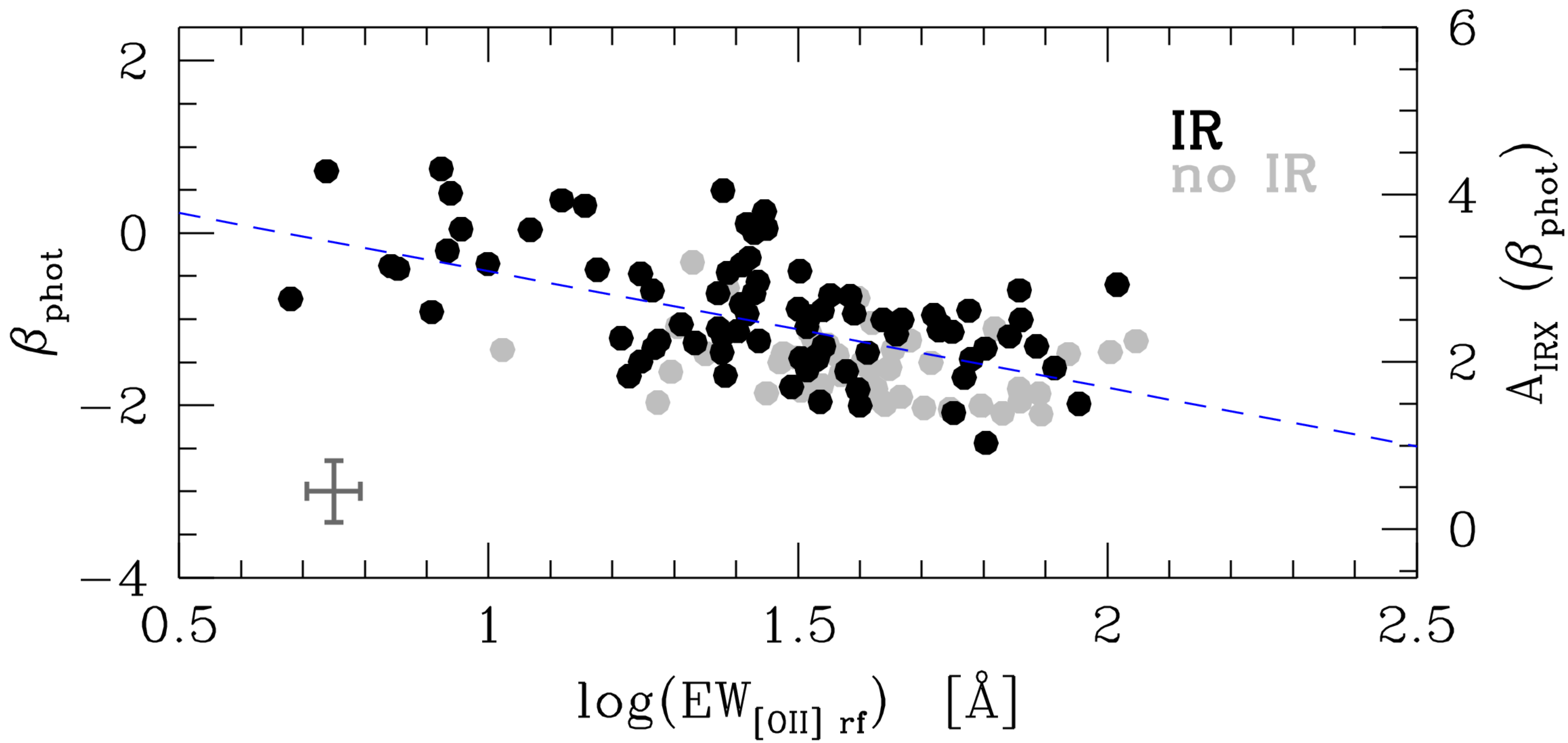
Dust extinction correction: SFR from [OII]λ3727 line luminosity

[OII]-sample

$SFR_{[OII]\_0} \propto L_{[OII]\_0}$ *(Kennicutt+'98)*

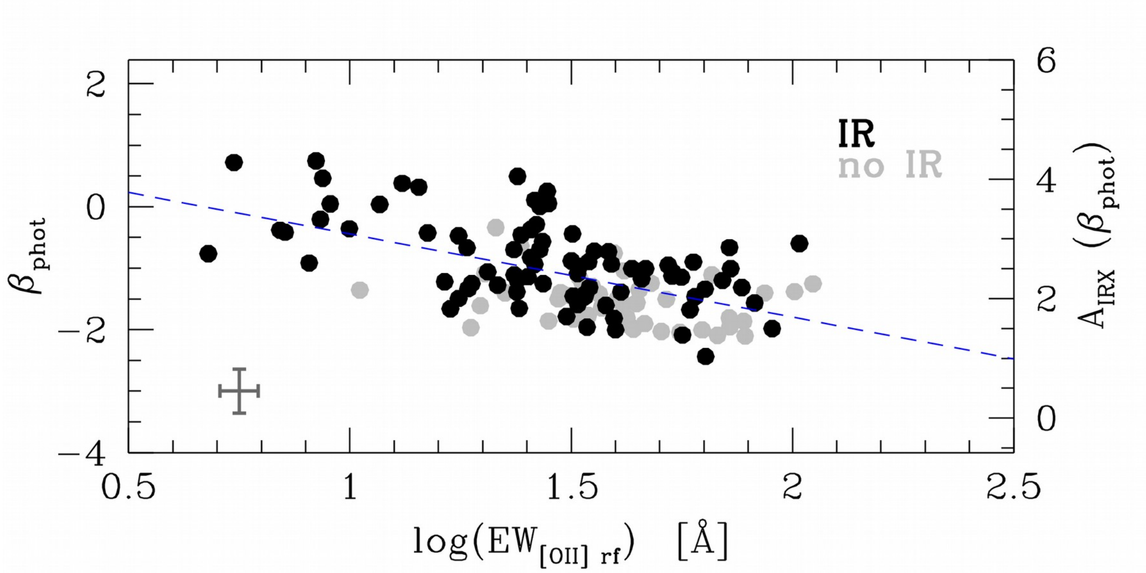
z ~ 1.3

See also Kewley+'04, Moustakas+'06



$$\beta_{phot} = (-1.35 \pm 0.20) \times \log EW_{rest} + (0.91 \pm 0.30)$$

Dust extinction correction: Continuum vs. nebular attenuation



$$A_{IRX} \xrightarrow[\text{Differential attenuation}]{\text{Extinction curve}} A_{[OII]}$$

$$\mathbf{E(B-V)_{neb} = E(B-V)_{cont} \,/\, \mathit{f}}$$

$$A_{[OII]} = A_{IRX} \times (\kappa_{H\alpha} / \kappa_{1500Å}) \times f^{-1}$$

Calzetti+'97

$$\mathbf{SFR_{[OII]\_0} \propto L_{[OII]\_0}}$$

(*Kennicutt+'98*)

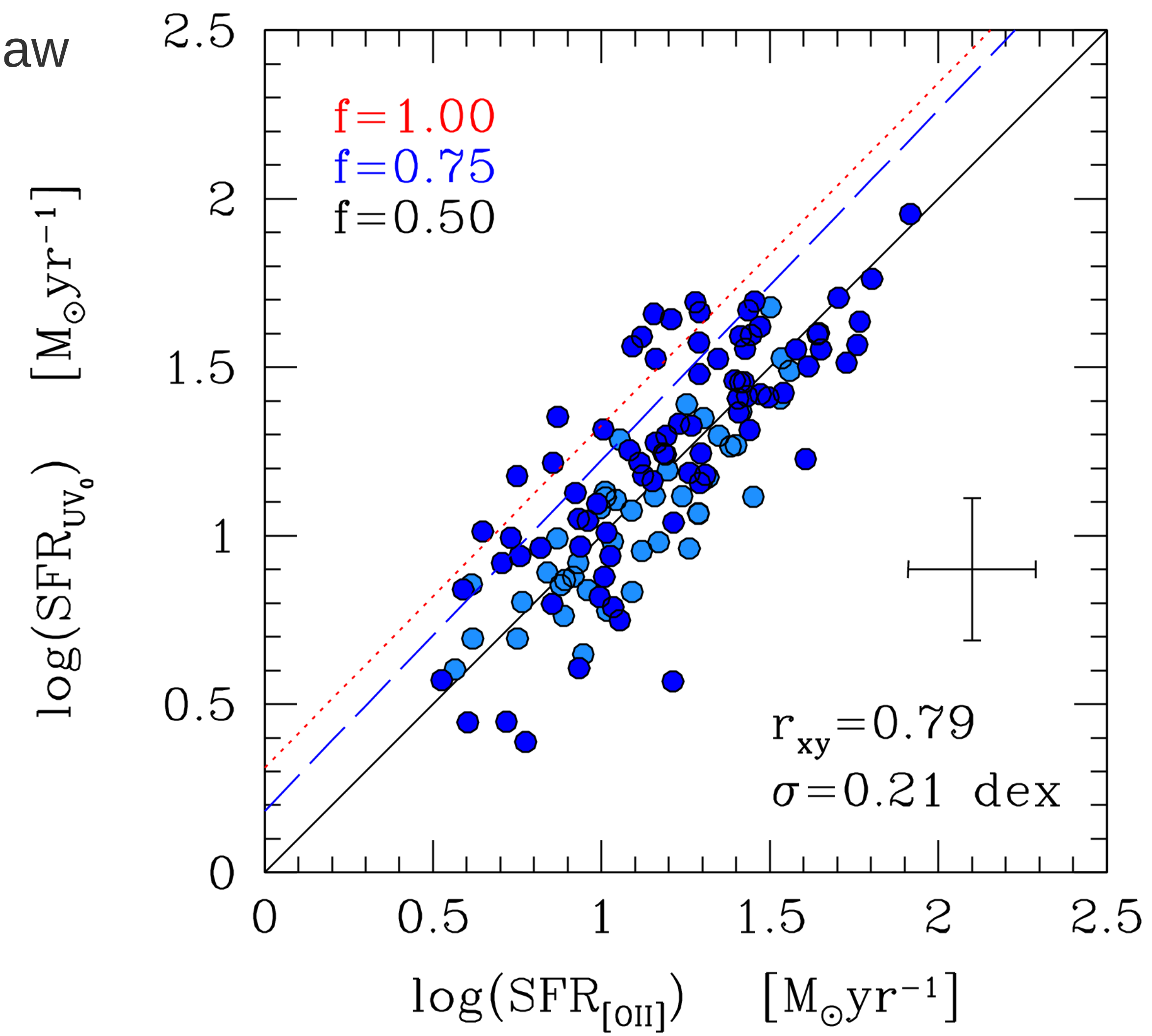
Dust extinction correction: **Continuum vs. nebular attenuation**

$$E(B-V)_{neb} = E(B-V)_{cont} \,/\, 0.50$$ *This work*

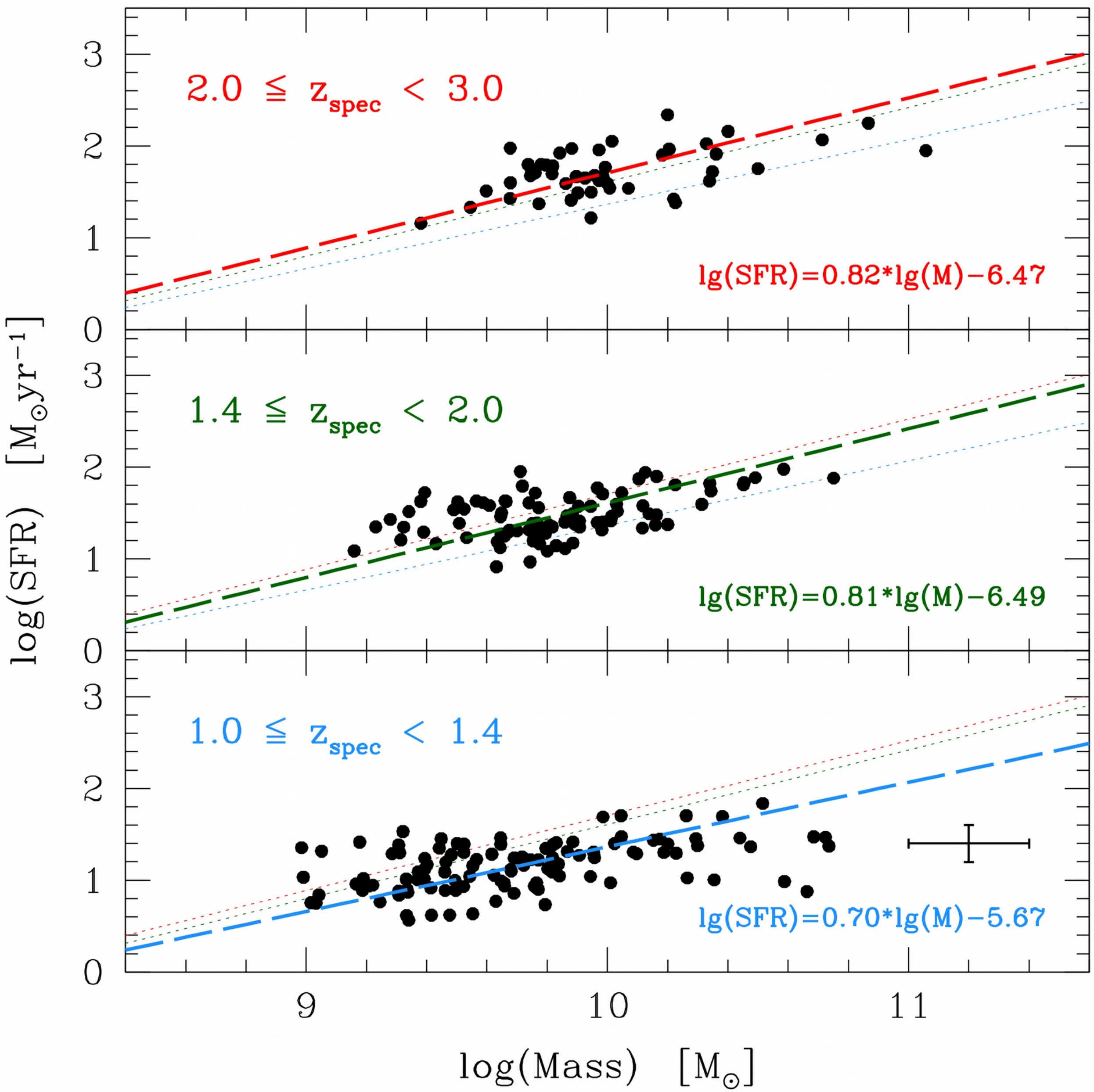
Calzetti law   Calzetti law

f ~ 0.5
e.g.
Forster-Schreiber+'09
Wuyts+'11

f ~ 1.0
e.g.
Kashino+'13
Puglisi+'15



An application: the SFR vs. Mass relation



Close linear relation
σ ~ 0.3 dex

Slope = ~ [0.7 , 0.9]

Weak trends of slope and normalization with redshift

See also e.g.
Daddi+'07; Noeske+'07;
Wuyts+'11; Kashino+'13;
Rodighiero+'11; Rodighiero+'14

ON-GOING

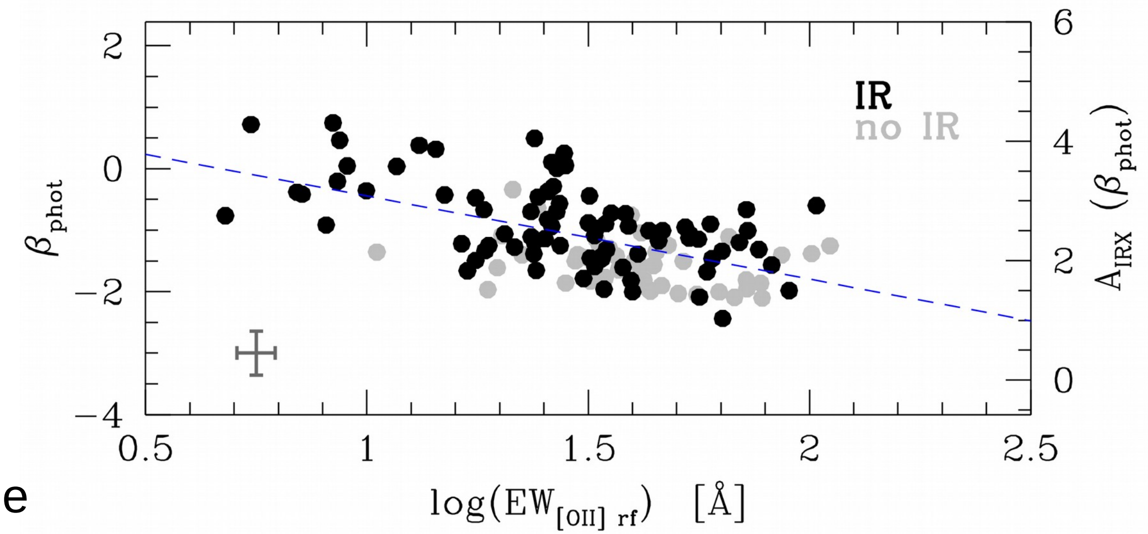
Look at larger samples, especially on the [OII] side (e.g. zCOSMOS-Bright)

Study dependences of AIRX vs. beta and [OII] EW vs. beta relations

Model the stellar populations of “mixed” galaxies

SUMMARY

We use **IR data** to derive empirical calibrations to correct UV and [OII]λ3727 luminosities for dust extinction, and dust-corrected estimates of SFR in a sample of **SFGs at 1<z<3**



We find a correlation between the rest-frame EW of the [OII]λ3727 line and β and we use A_{IRX} to calibrate $EW_{[OII]\lambda3727}$ as a dust attenuation probe

Talia et al. 2015, A&A, 582, 80

Thank you!