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The Obscured History of Galaxy Evolution

with the SCUBA-2 Cosmology Legacy Survey

arXiv:1607.04283

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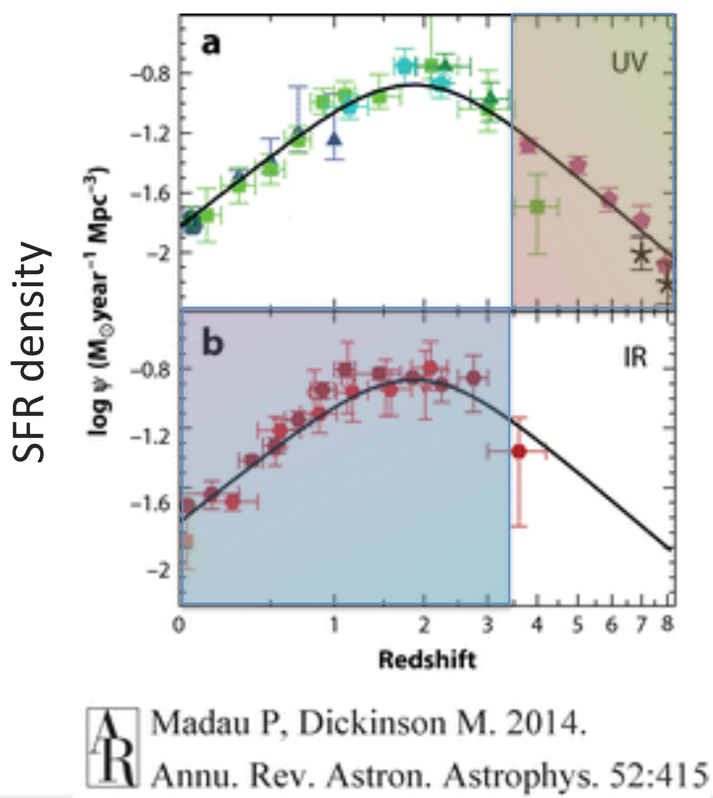
INTRODUCTION

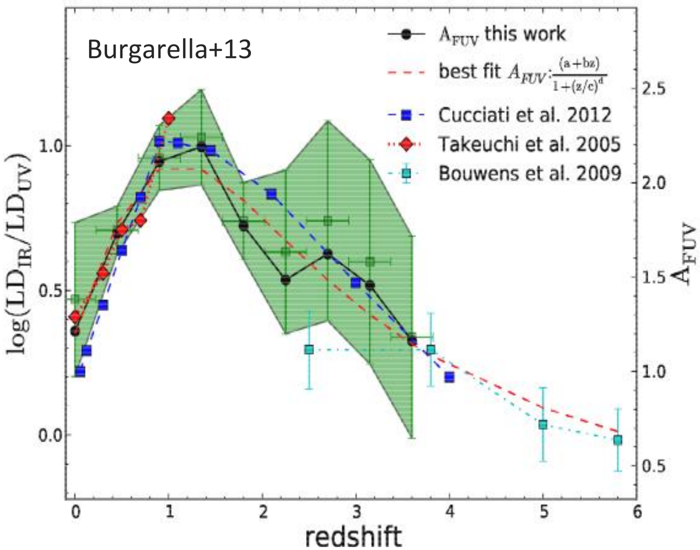
Motivation

The cosmic star formation history: Building up the galaxy population

evolution of SFR density of the Universe   evolution of SFRs in the galaxy population

The most widely available tracers of SFR at high redshift are FUV and FIR





Beating the confusion limit

How can existing datasets help us with our problems?

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Deep sub-mm imaging with low confusion and instrumental noise:

The SCUBA-2 Cosmology Legacy Survey

450+850μm imaging with beam = 7.5, 14 arcsec; Inst. Rms ~ 1.0, 0.2mJy/bm

Geach et al. 2013; 2016

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Deep & complete NIR-selected prior catalogues:

CANDELS/3D-HST

Spec+grism+photo-z

UV-MIR photometry

Derived stellar pop. params

Brammer et al. 2012; Skelton et al. 2014; Momcheva et al. 2015

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Photometric de-confusion algorithm:

T-PHOT

Measure faint confused sources by fitting the map with positional priors

Merlin et al. 2015; 2016

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How can existing datasets help us with our problems?

S2CLS deep fields: ~230 $arcmin^2$ in UDS, COSMOS, AEGIS

Deep sub-mm imaging with low confusion and instrumental noise:

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450+850μm imaging with beam = 7.5, 14 arcsec; Inst. Rms ~ 1.0, 0.2mJy/bm

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Obtain flux measurements and covariance matrix for all priors

Photometric de-confusion algorithm:

T-PHOT

Measure faint confused sources by fitting the map with positional priors

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Sample: K<24 or [3.6]<24; 0<z<6; logM>9

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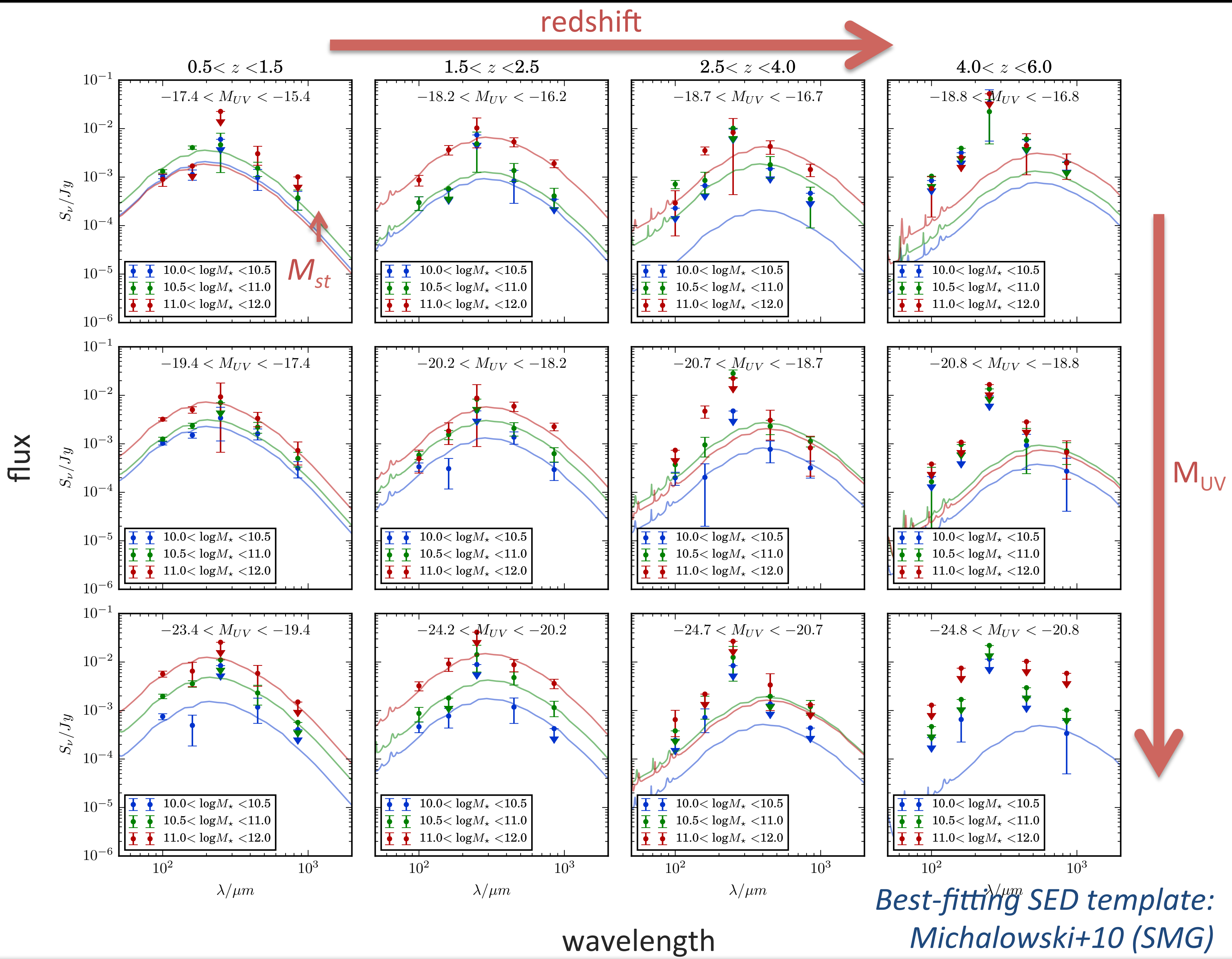
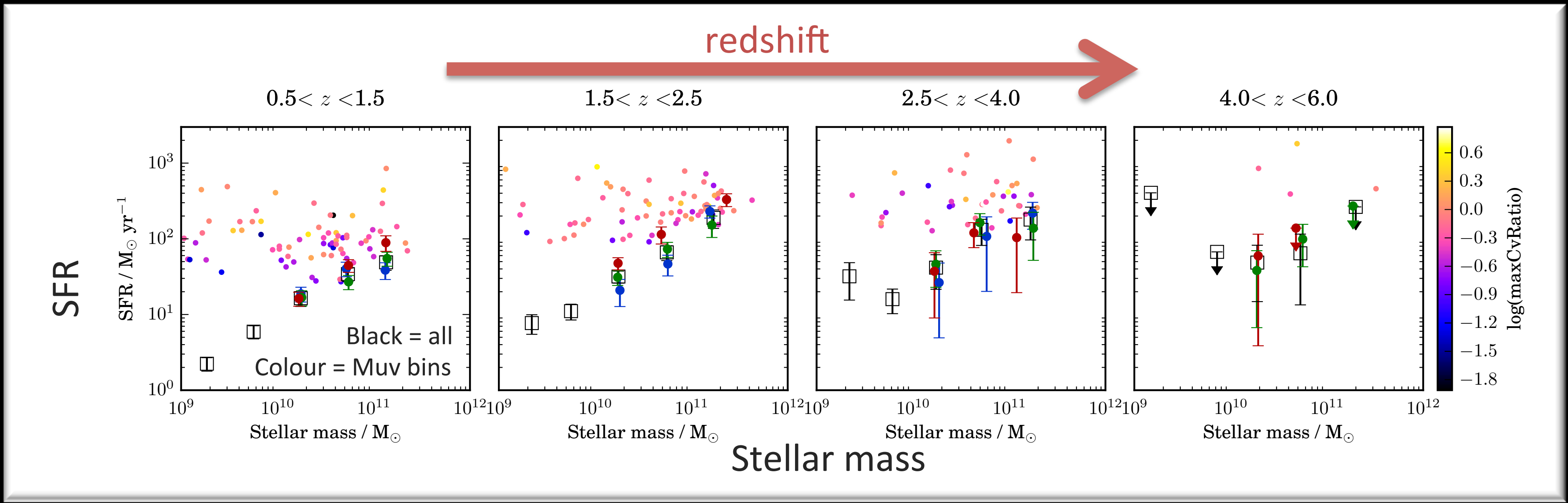


Best-fitting SED template: Michalowski+10 (SMG)

STAR FORMATION AND OBSCURATION

SFR

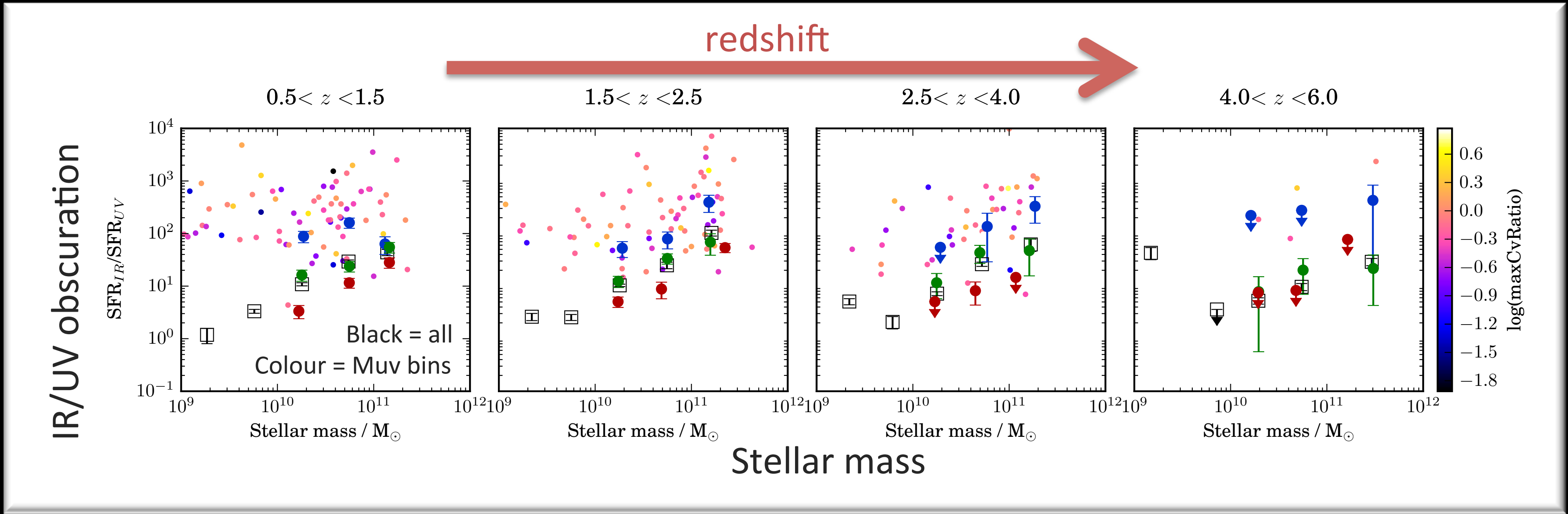
comparing FIR, UV, and mass-selected samples:



SFR_tot = SFR_IR + SFR_UV

SFR Obscuration

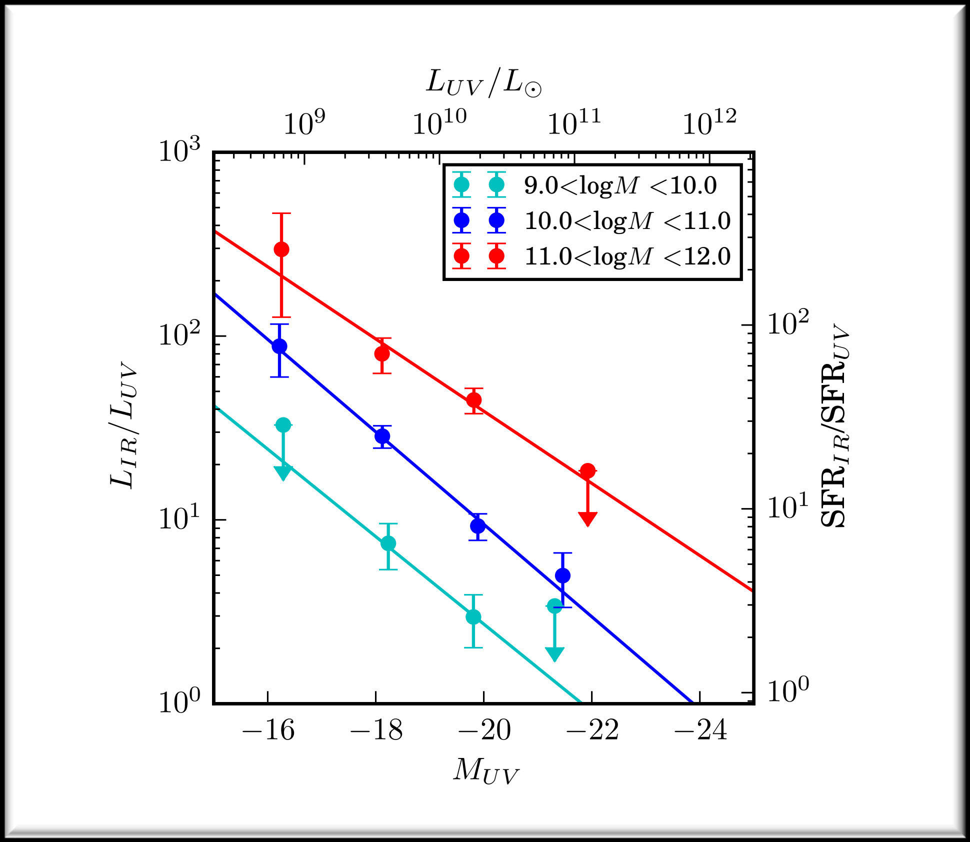
L_{IR}/L_{UV} strongly correlated with mass and M_{UV}



- More massive galaxies have higher SFR, and more of their star formation is obscured
- High FIR luminosities trace galaxies with the highest SFRs
- High UV luminosities trace the most unobscured star-forming galaxies

Obscuration as f(M,L_{UV})

$L_{IR}/L_{UV} \sim M_{star}^{0.7} L_{UV}^{-0.6}$ – independent of z



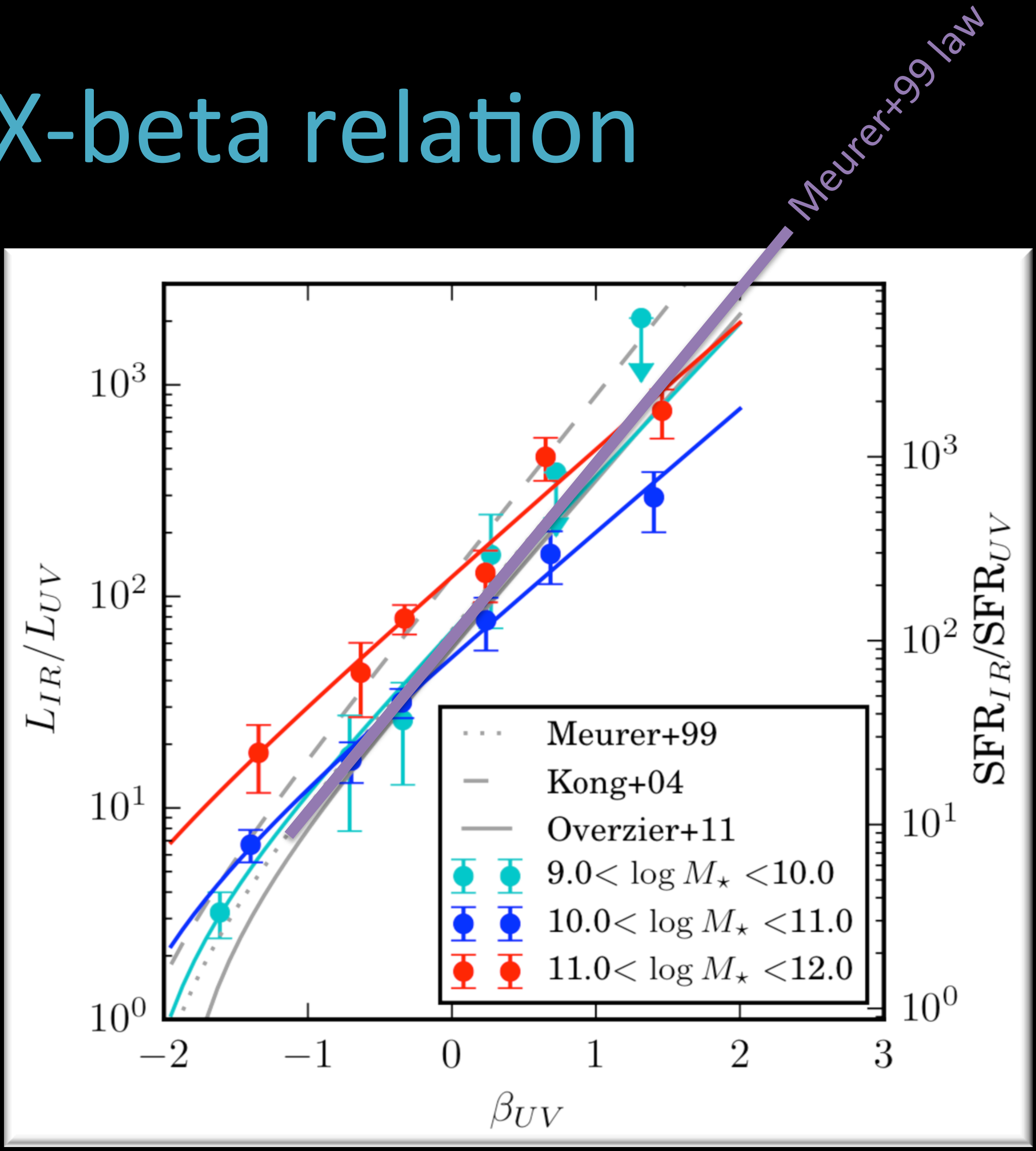
See also previous Herschel work – Buat+12, Hilton+12, Heinis+14, etc

UV DUST CORRECTIONS

The IRX-beta relation

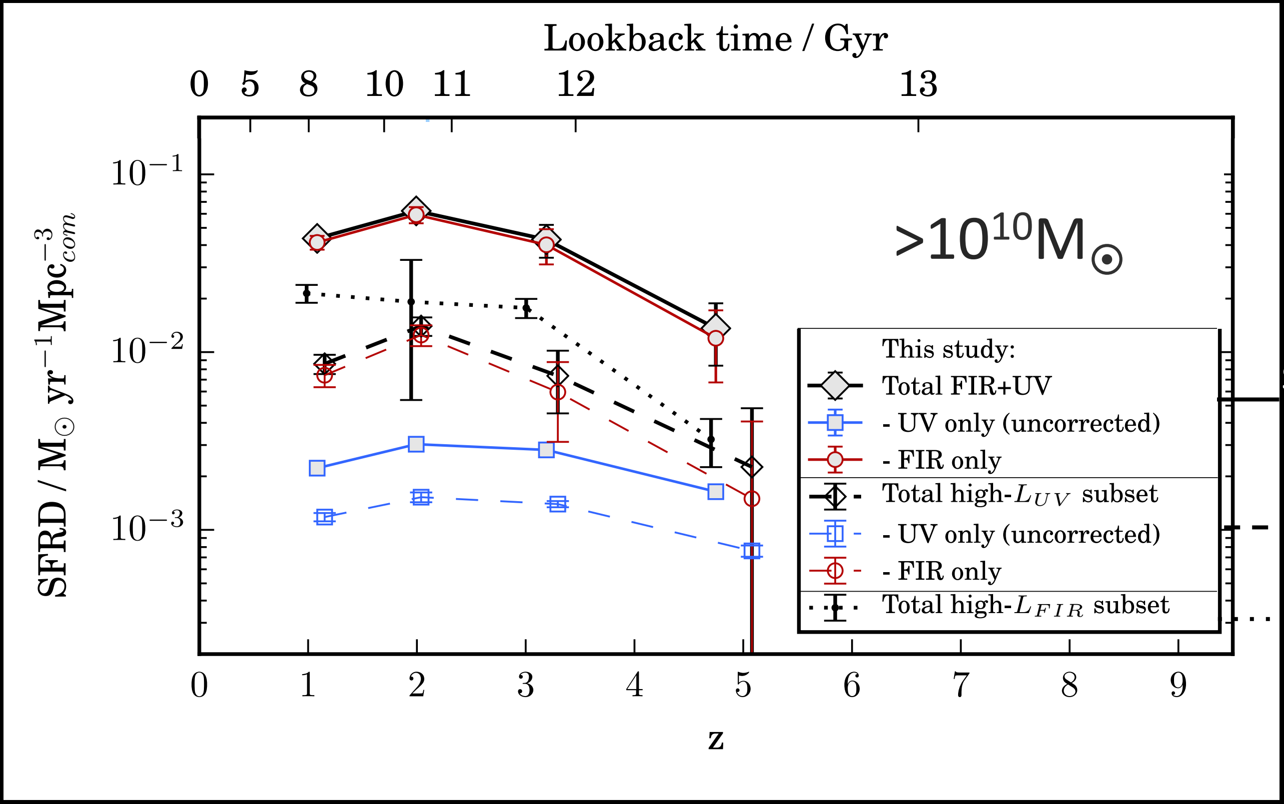
- Excluding passive galaxies based on UVJ colours
- $M<10^{11}M_{\odot}$ galaxies close to Meurer law
- $M>10^{11}M_{\odot}$ galaxies have higher extinction for given UV slope

See also Coppin+15; Alvarez-Marquez+16; Bouwens+16 (studies of z~3 LBGs)



COSMIC STAR FORMATION DENSITY AT Z<6

Cosmic SFR density in massive galaxies



Black=total
Blue=unobscured
Red=obscured

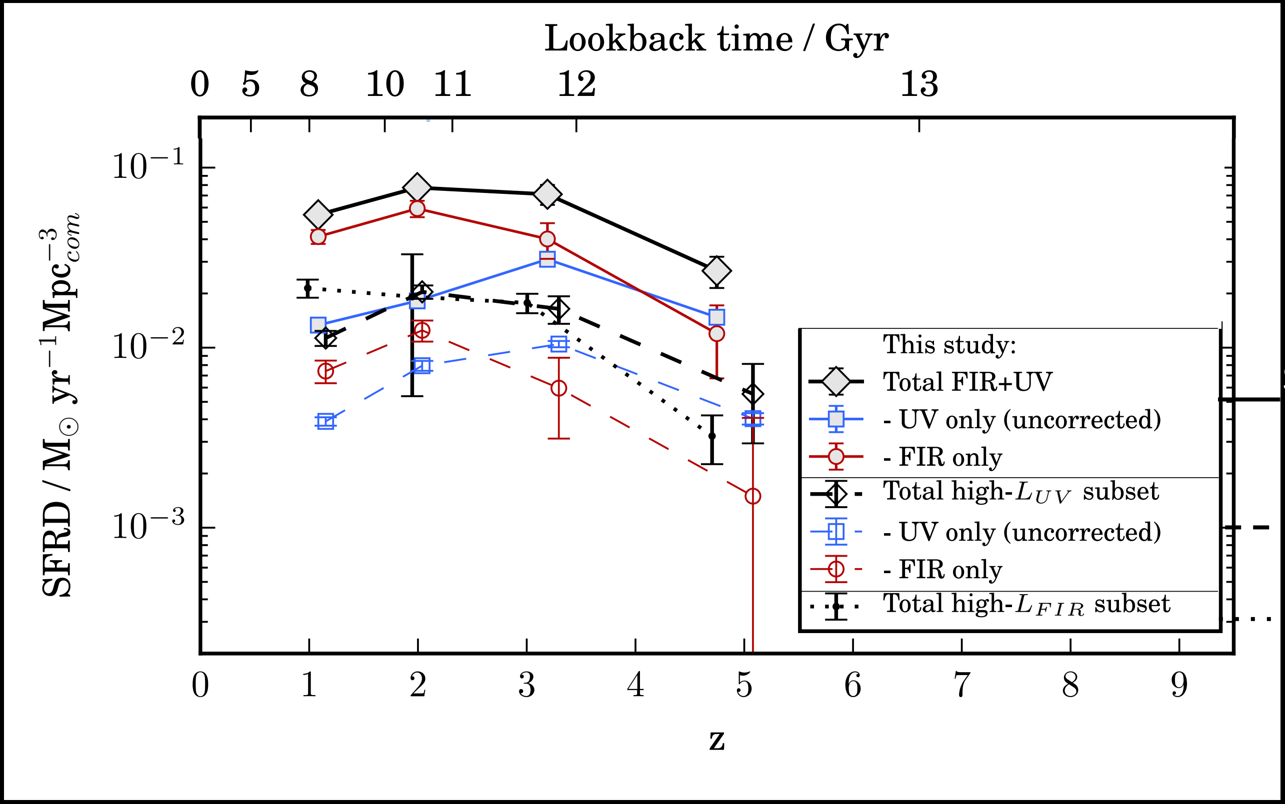
Solid lines = all galaxies

Dashed lines = L_{UV}>L*

Dotted=450-det

- SFRD peak at z~2
- Massive galaxies dominated by obscured SFR
- 1/5 of SFRD from L_{UV}>L* galaxies (also obscured)
- 1/3 of SFRD from 450μm-detected sources

Cosmic SFR density in *all* galaxies



Black=total
Blue=unobscured
Red=obscured

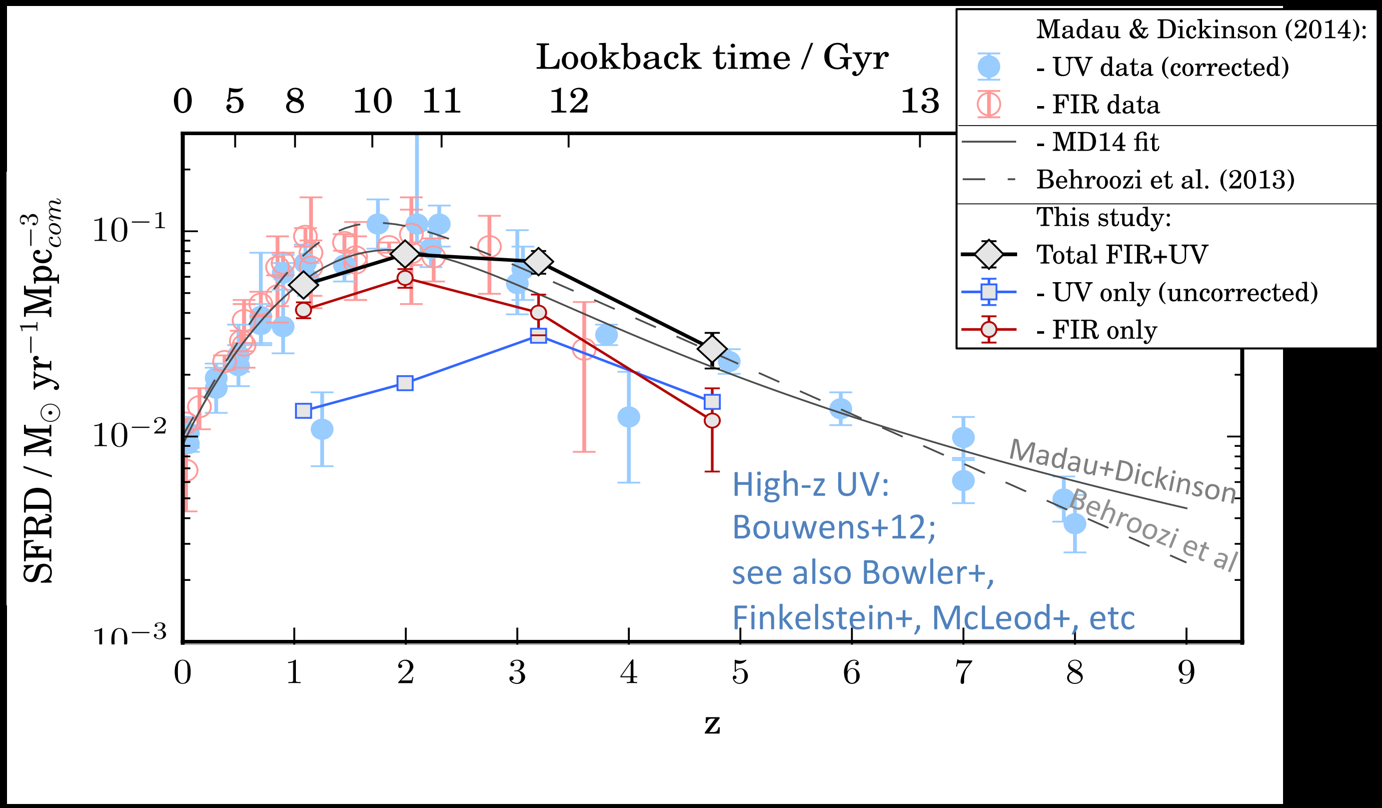
Solid lines = all galaxies

Dashed lines = L_{UV}>L*

Dotted=450-det

- Including UV emission from full LF integrated to -15 (Parsa+16)
- SFRD peak at z=2-2.5
- z<3: dominated by obscured SFRD (peaks at z=2)
- z>3: unobscured SFRD takes over (this peaks at z=3)

Cosmic SFR density in *all* galaxies



- SFRD at high-z broadly consistent with Behroozi+13, Madau & Dickinson14
- UV-corrected SFRD from the literature at z~5 is consistent with our IR+UV
- *The early universe (z>3) is increasingly dominated by unobscured SFRD*
- *But the peak epoch of SFRD (z=1-3) is dominated by obscured growth of high-mass galaxies – and in this regime, Meurer dust corrections are inadequate*

Take-home messages

- **Strong relationship between IR/UV, L_{UV} and M_*, independent of redshift:** $L_{IR}/L_{UV} \sim M_{star}^{0.7}\ L_{UV}^{-0.6}$
- UV luminosity traces obscuration rather than SFR
- More massive galaxies have higher SFR and higher IR/UV

- **The SFRD is mostly obscured at z=1-3, and is dominated by the growth of high-mass star-forming galaxies**
  - These galaxies are heavily obscured and Meurer dust corrections are insufficient

- **At z>4, the SFRD is predominantly *unobscured* and is dominated by lower-mass galaxies**
  - Because they have lower stellar mass, Meurer dust corrections appear to be successful

If you want to know more? → `arXiv:1607.04283`

Thank you for listening……..   any questions?