PEP/HERMES/COSMOS: WHAT ARE THE DUST PROPERTIES OF Z ∼ 3 LYMAN BREAK GALAXIES?

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INTRODUCTION

Lyman Break Galaxies (LBGs) are currently the largest population of star-forming galaxies known to be at high redshift, $z > 2.5$. This is due to the efficiency of the selection of LBGs in broad band colors (Steidel et al. 1996). From this, we have learned that they are massive ($M_* \sim 10^{9-10} M_\odot$), rapidly star-forming (10-100 $M_\odot yr^{-1}$) and numerous. However, the dust properties of these LBGs are still badly known due to their faintness in the far infrared (FIR) and sub-millimeter (submm) wavelength range, which is very likely related to the low dust content.

Only a few LBGs have been directly detected in the PACS (e.g. Oteo et al. 2013), IRAC and MIPS (e.g. Magdis et al. 2010) maps at z ∼ 3. Less than 0.5 % of our sample is detected in the SPIRE band, therefore, we focus on statistical (stacking) analysis of these LBGs to study their dust properties.

STACKING

The stacking is a technique that combine the signal of multiple sources, which are been selected previously in other wavelength observations (Dole et al. 2006). We use the IAS library (Bavouzet 2008 and Béthermin et al. 2010) to perform the stacking in PACS (100 μm and 160 μm images), SPIRE (250 μm, 350 μm and 500μm images) and AzTEC (1.1 mm image). **We apply a correction for the incompleteness in the priors and for the clustering of the stacked galaxies**.

The large sample allows us to split it in different bins as a function of **UV luminosity (L_{UV})**, **UV slope (β_{UV})** and **stellar mass (M_*)** to better catch their variety.

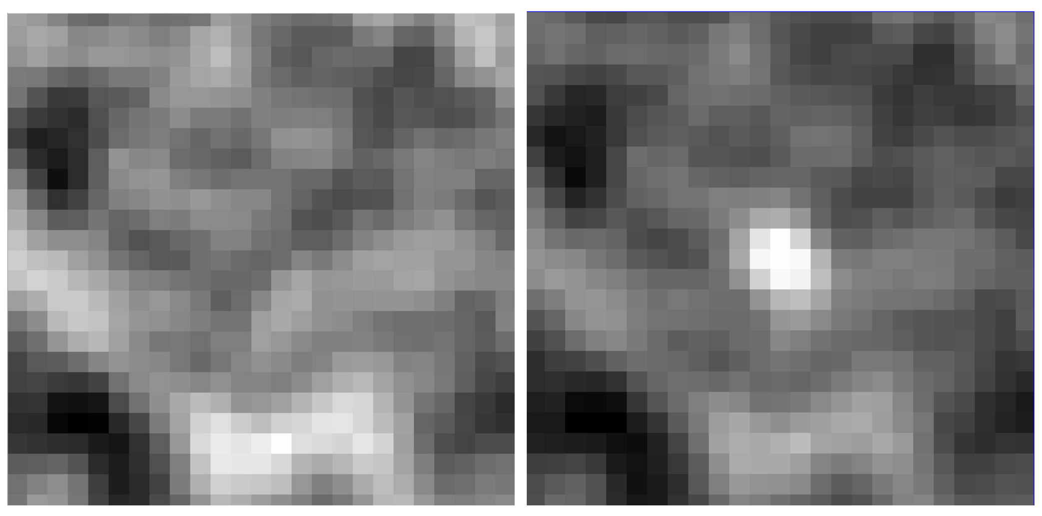

Fig 2. example of the residual map (left) and stacking map (right), which corresponds to the bin $10.8 < log(L_{FUV}[L_\odot]) < 11.10$ in the stacking as a function of L_{FUV}.

MAIN SEQUENCE

The "main sequence" of star-forming galaxies is the term coined to describe the relatively tight correlation between SFR and stellar mass, and the relation is known to evolve with redshift.

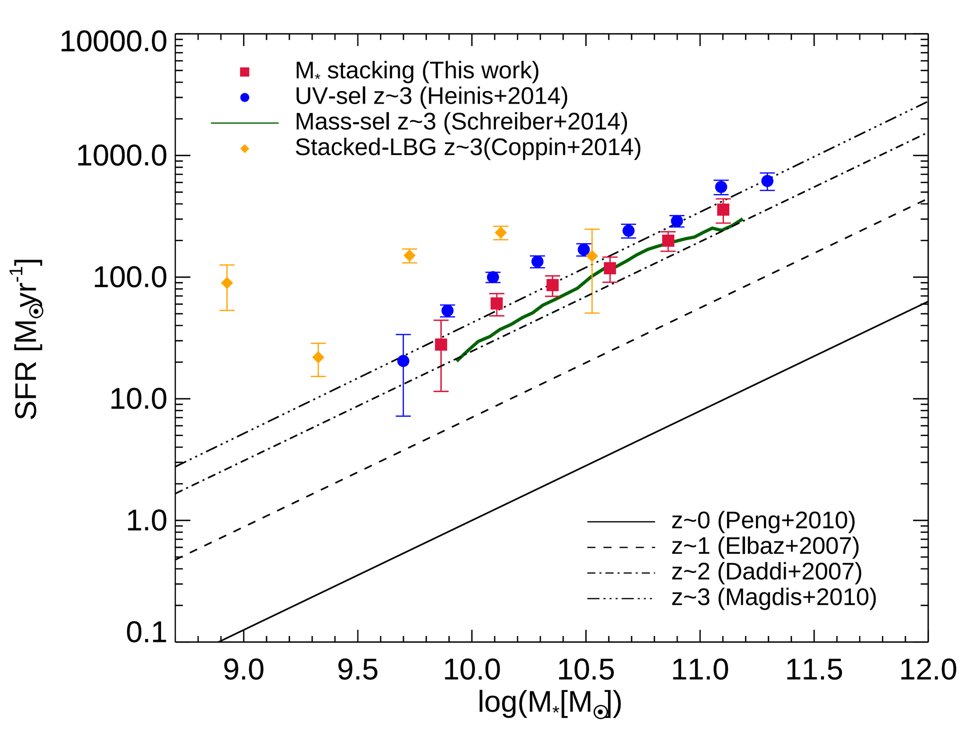

Fig 4. total star formation rate (unobscured + obscured) versus stellar mass for our stacking as a function of stellar mass.

DATA AND SAMPLE

We base this study on data from the **COSMOS** survey, which gathered deep multi-wavelength observations from X-ray to radio covering 2 sq. deg. We use optical data (images: Capak et al. 2007 and photometry: McCracken et al. 2012), Far-infrared data from **PACS** (PEP, Lutz et al. 2011) and **SPIRE** (HerMES, Oliver et al. 2011) bands and **AzTEC** (1.1 mm) data (Aretxaga et al. 2011).

Our LBGs at z ∼ 3 are selected by employing the classical dropout technique with the broad-band filters u, V and i (e.g. Steidel et al. 1996). We create synthetics spectra and SEDs with CIGALE code (v0.4, Burgarella et al. 2005 and Noll et al. 2009) to compute selection criterion (eq. 1) according to our broad-band filters. We simulate star-forming galaxies using constant SFH, stellar population of 100 Myr old, subsolar metallicity (0.2 $Z_\odot$) and three different V-band attenuation (Track in Fig.1).

The final sample contains ∼22.000 LBGs with mean redshift, <z> = 2.98 ± 0.25

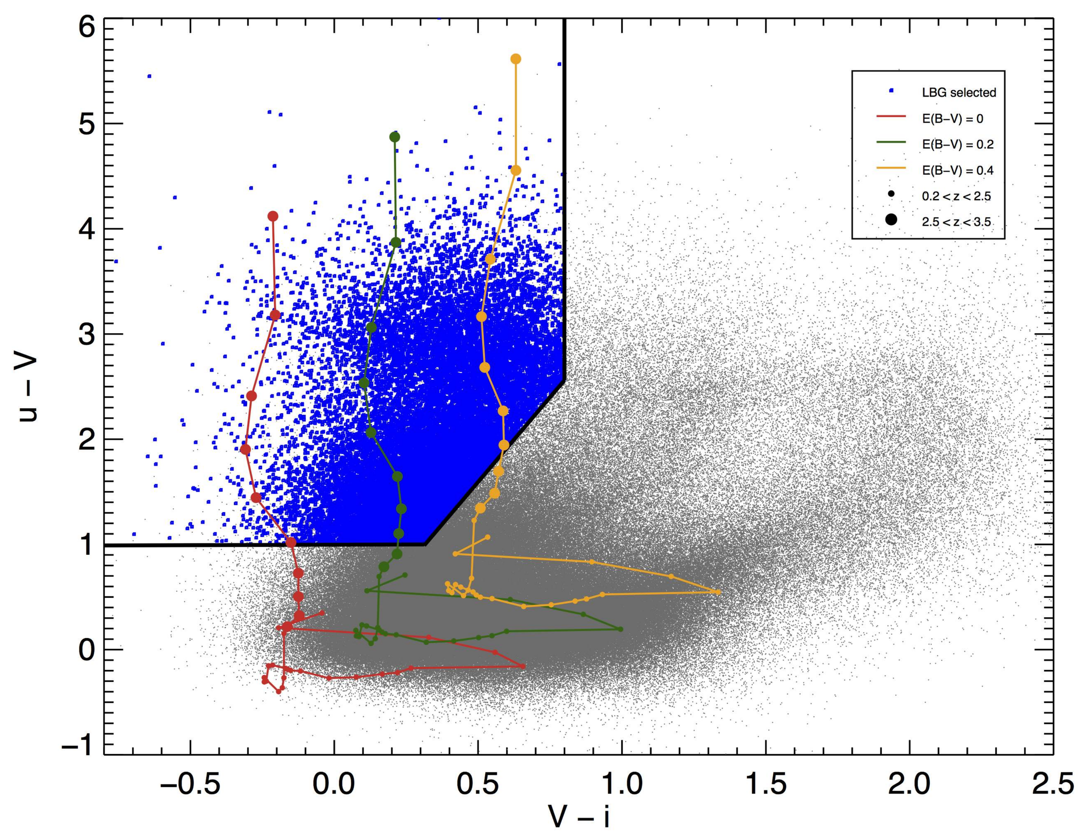

Fig 1. LBGs selection in a color-color diagram. The gray dots are the full sample from COSMOS field, the blue dots are the LBGs at $2.5 < z < 3.5$. The tracks are the star forming galaxies simulated ($0.2 < z < 3.5$).

$$\begin{aligned} u - V_J &> 1 \\ V_J - i^+ &< 0.8 \\ u - V_J &> 3.2(V_J - i^+) \end{aligned} \tag{1}$$

SED FITTING

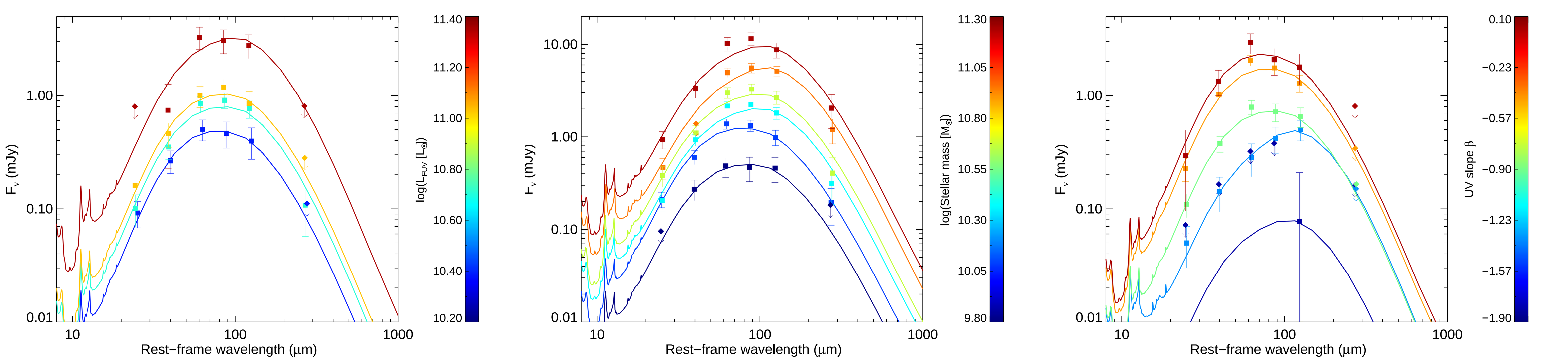

Fig 3. SEDs and models of our stacking as a function of L_{FUV} (left), stellar mass (center) and UV slope (right) using Dale et al. (2014) templates inside CIGALE. The square points are the measurements on stacked objects, and the upper-limits are the 3σ of the **bootstrap** resampling. The total IR luminosity (L_{IR}) is estimated by integrating the best model over the range $8 < \lambda < 1000$ μm.

DUST ATTENUATION

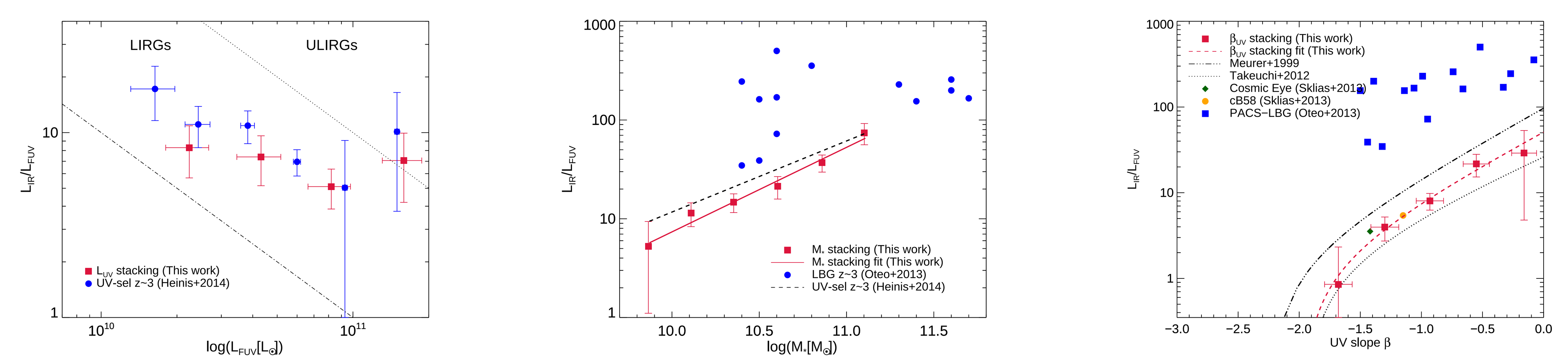

Fig 4. Dus attenuation obtained using the stacking as a function of L_{FUV} (left), stellar mass (center) and UV slope (right).

CONCLUSIONS

We perform a stacking analysis on a large (20.000) sample of LBGs to study their dust properties. We obtain the full infrared spectral energy distributions of our LBGs as a function of their ultraviolet luminosity L_{UV}, their UV slope β_{UV} and their stellar mass M_* and we can characterize them in terms of their dust attenuation, SFR and sSFR.

ACKNOWLEDGMENTS

Acknowledges for the CNRS, which is providing the funding to do my PhD in the mark of the international grant from the Instituto de astrofísica de Canarias (IAC).

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