A panchromatic view of the Herschel Virgo Cluster Survey (HeViCS) background sources

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Introduction

Galaxy evolution is set by a complex mechanism of recycling between stellar and gaseous component.

DUST

Is a catalyst for the transformation of HI into H_2 from which stars form

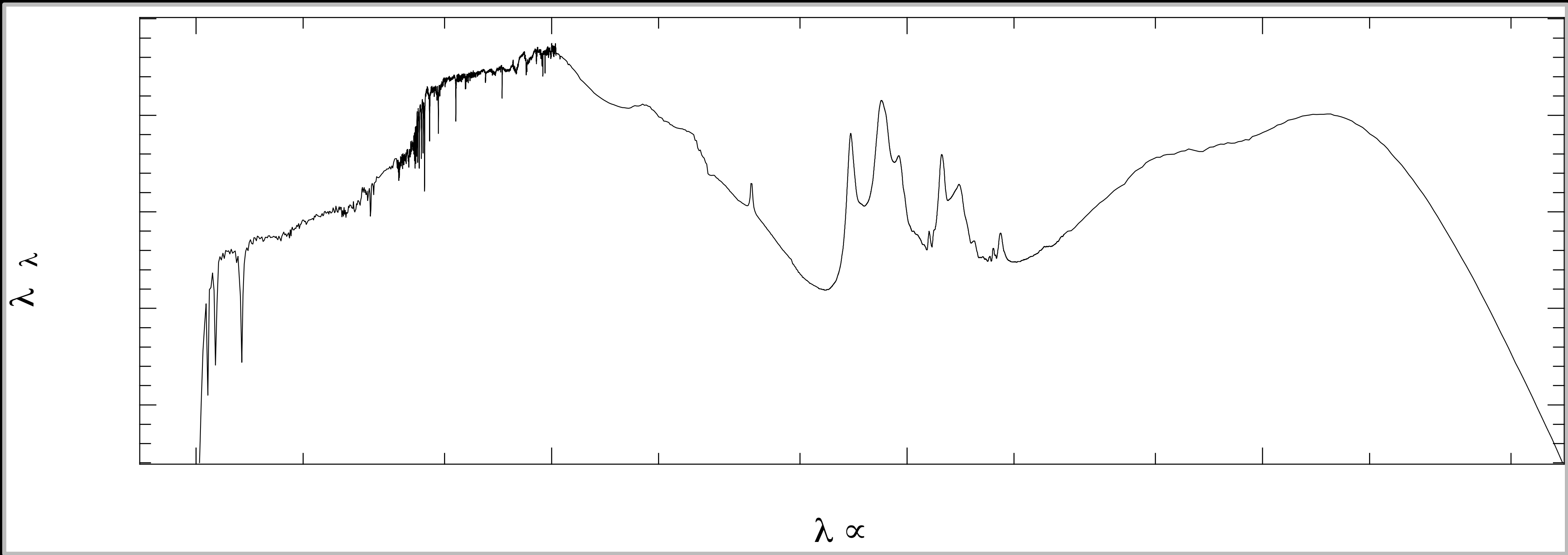
Absorbs the UV from young star allowing to the gas to cool and form new stars (Wolfire 95)

reemits the absorbed energy in the IR, dominating the SED of galaxies between 10-1000 micron (Draine 78)

dust is very important in order to understand galaxy evolution

Introduction

In the past decades an huge effort has been done to cover MIR and FIR wavelengths pushing towards multiwavelengths approach.



Introduction

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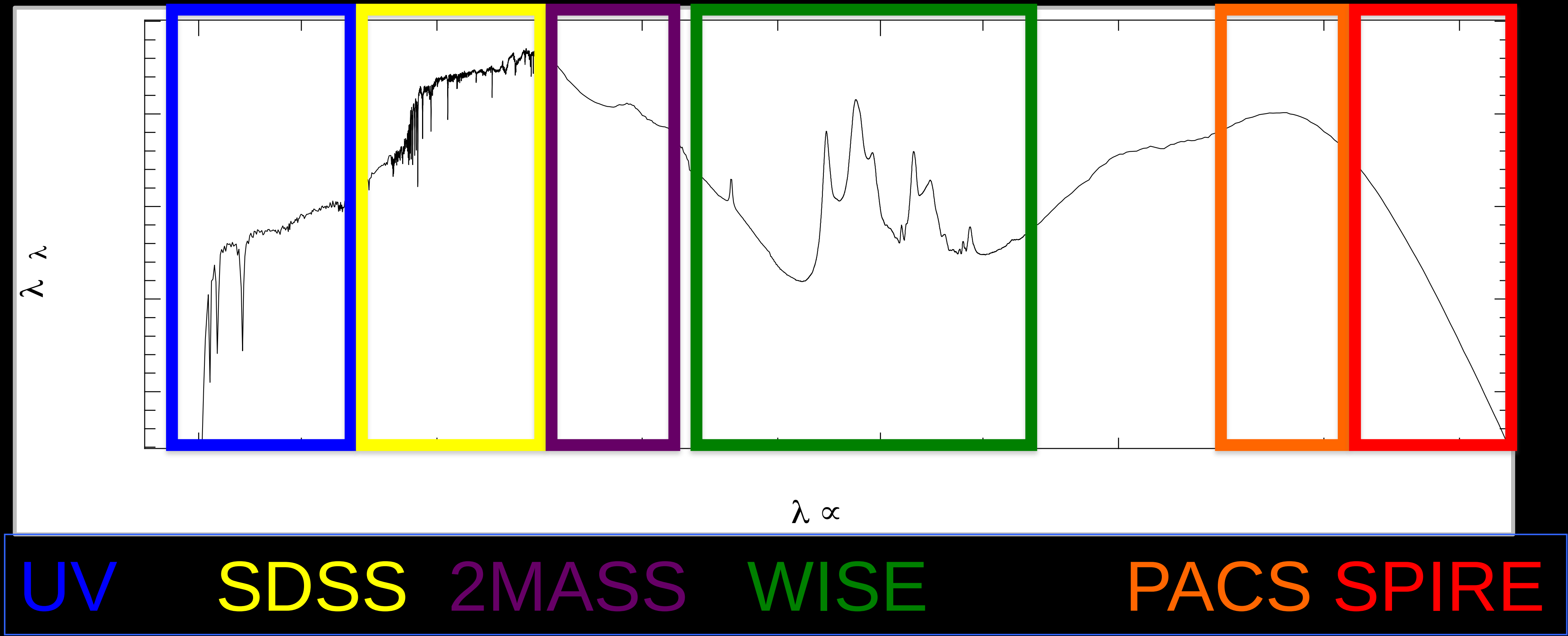


Introduction

Understanding the heating processes of the dust is fundamental.
Multiwavelengths radiative transfer modeling is a powerful tool to analyze galaxy dust (e.g., Xilouris et al. 1999; Popescu et al. 2000, 2011; de Looze et al. 2012; Alton et al. 2004; Bianchi 2008; Baes et al. 2010; MacLachlan et al. 2011),
BUT THEY REQUIRE:

- assumptions on the dust geometry (Viaene et al. in prep)
- large computational resources

Another method is to select a sample representative of a particular population of galaxies and built an SED template

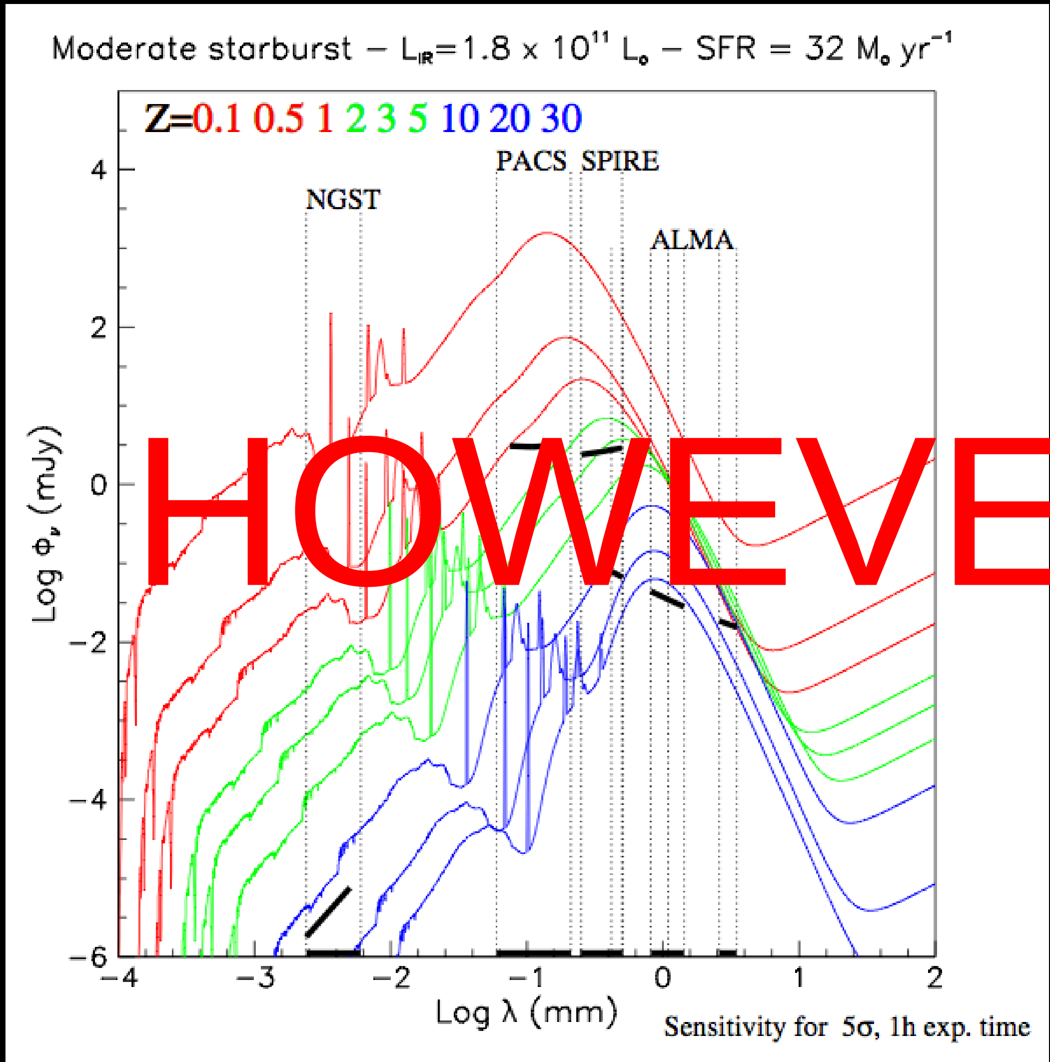
Pre-Herschel templates (Chary & Elbaz 01, Dale & Helou 02) were calibrated on data up to 200 micron

Post-Herschel data, provided new IR templates for low- and high-redshift objects (Elbaz et al. 2011; Smith et al. 2012; Magdis et al. 2012).

However there is a lack of templates representative of the broad variety of nearby normal galaxies, reference of the z=0 Universe:
This is indirectly useful also for high-z galaxies

Introduction

ALMA can detect flux densities below 1 mJy up to z>5 and can shed light on the evolution of SEDs in “normal” galaxies (normal means with SFR ≈ 10−100 M_{sol} yr^{-1})

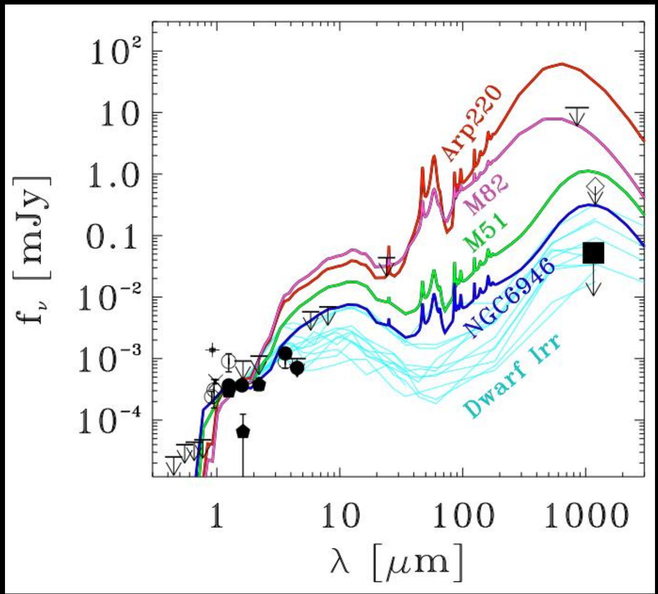


HOWEVER

Melchior et al. 01

Introduction

Ouchi et al.13



Ouchi et al. 13

z = 6.59

SFR = 100 M_{sol}/yr

no AGN - no 1.2 mm

Ota et al. 14

z = 6.96

SFR < 10 M_{sol}/yr

no FIR continuum

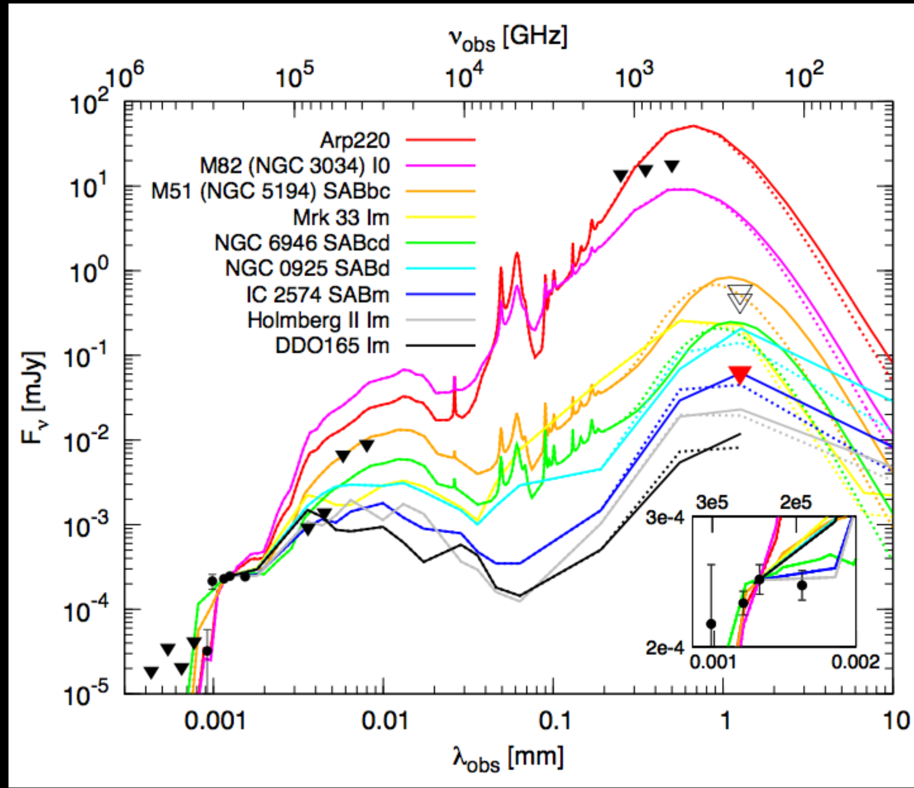
Riechers et al. 14

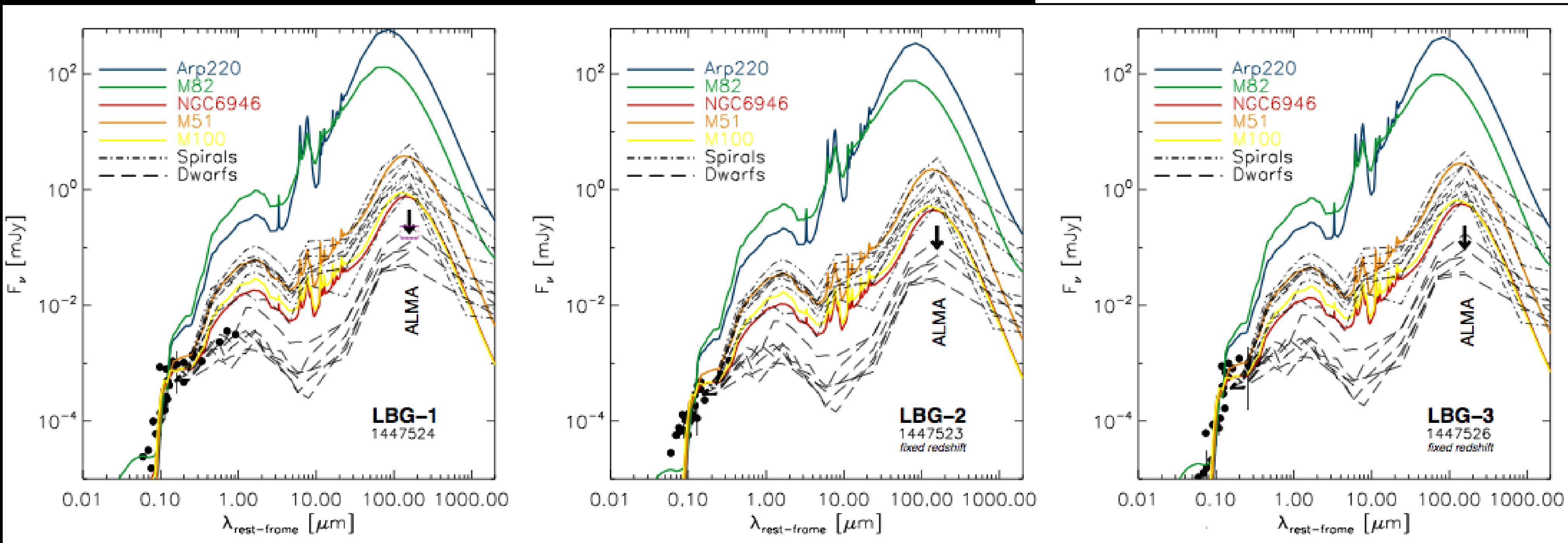
z < 5.3

SFR = 18-54 M_{sol}/yr

no 1.26 mm

Ota et al. 14





Riechers et al. 14

Motivation

Then we need to provide a template selected at FIR, representative of dusty “normal” high redshift galaxies. To do this we need to have big sensitivity in order to investigate lower luminosities and we need a sample of LOW REDSHIFT and LOW SFR galaxies

GOAL:
the characterization of the SED of a 250 mic selected sample and its comparison with other nearby and high-z samples.

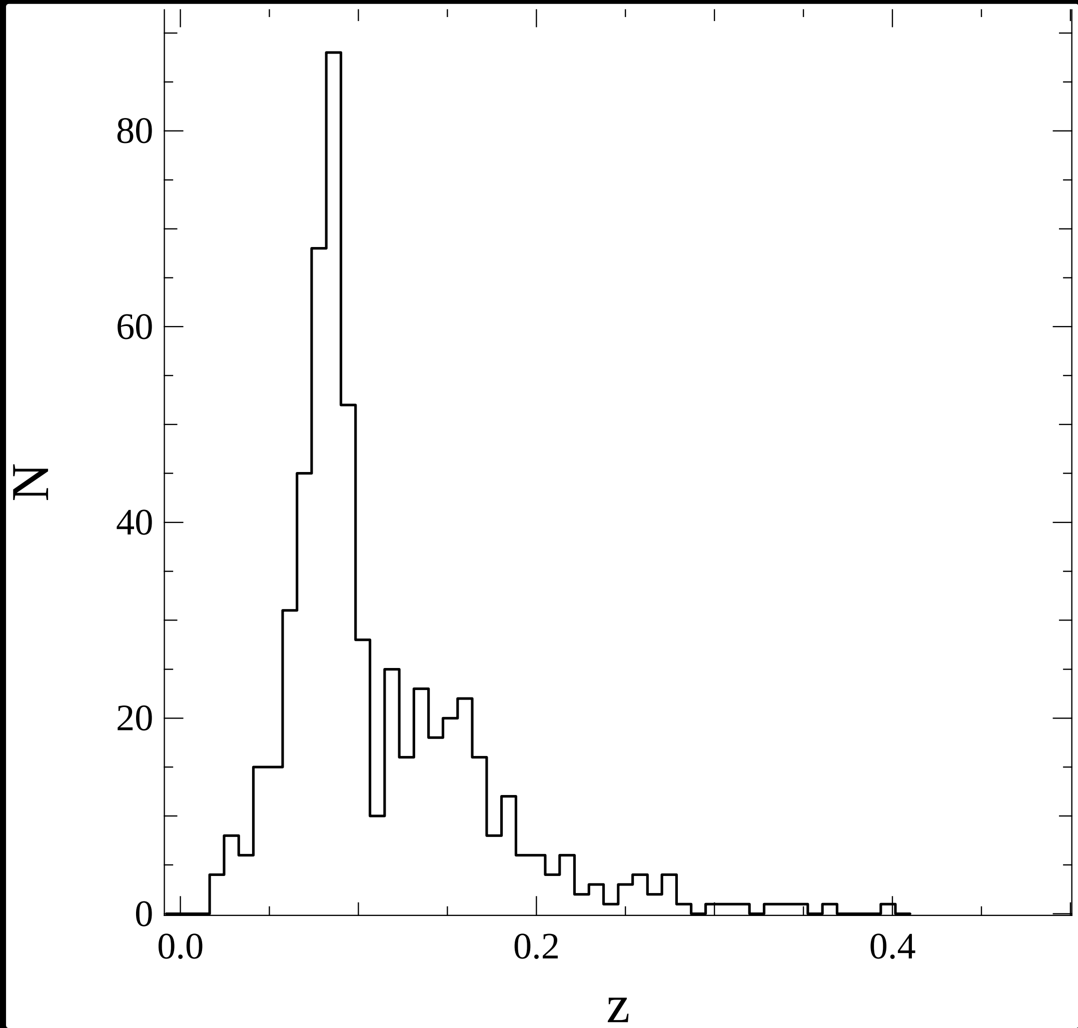
WITH RESPECT TO PREVIOUS WORKS WE HAVE TWO ADVANTAGES:
- Deep Herschel data -> up to 20 mJy, then we can probe lower dust luminosities
- The introduction of WISE data, a region important to discriminate warm and col dust temperature

Sample

- Starting point: 250 µm selected point source catalogue of Pappalardo et al. (2014) from the Herschel Virgo Cluster Survey (HeViCS, Davies et al. 2010) -> PACS – SPIRE

– FUV and NUV: GUViCS, Boselli et al. 11
– Optical data: u, g, r, i, z bands from SDSS DR10
– NIR: J – H – K -> 2MASS
– MIR: 3.4, 4.6, 12, 22 µm -> WISE

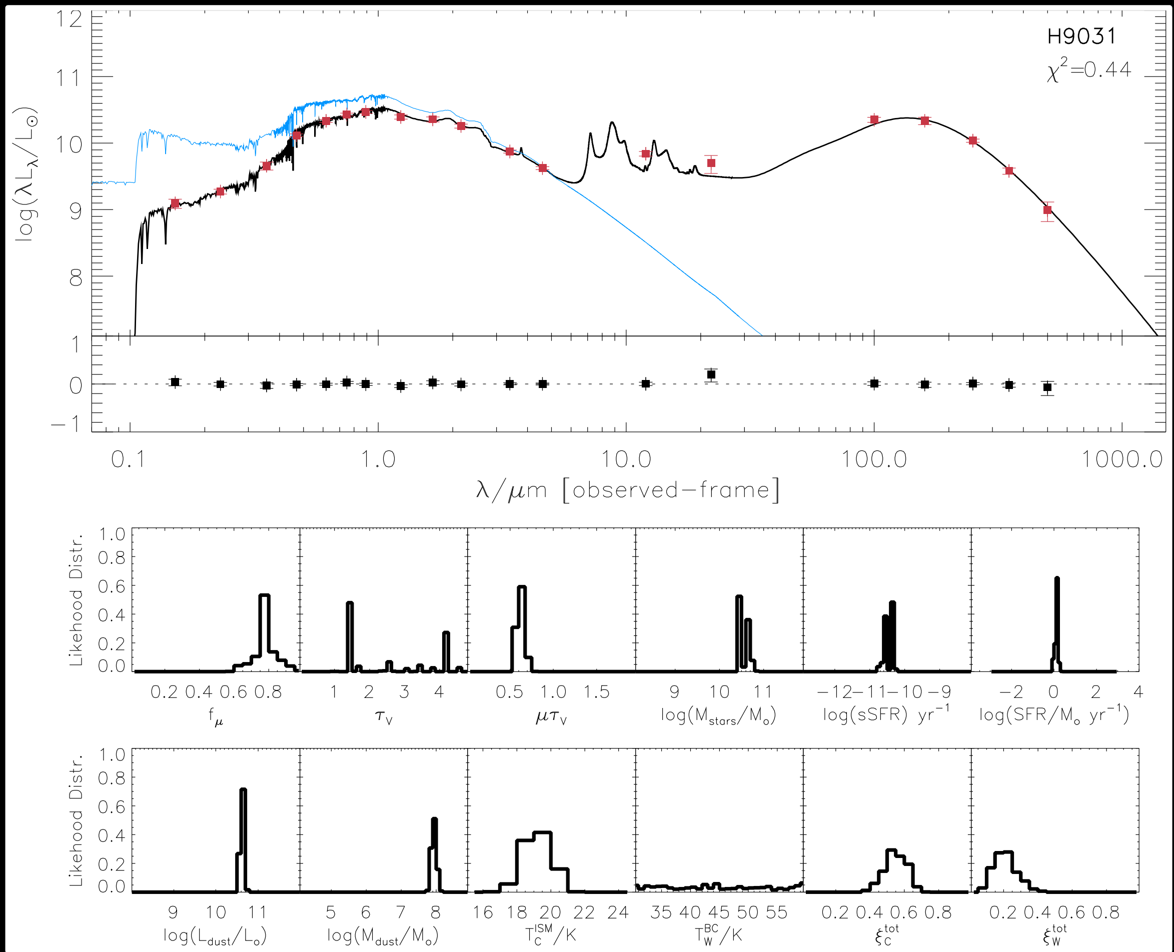
Consistent choice of counterparts with likelihood methods, F_{250} > 20 mJy and SNR_{250} > 3, and no AGN (WISE criterion)
About 600 sources with a spectral coverage in 19 different photometric bands, with average:
z = 0.11 ± 0.06 -> LOW REDSHIFT



Method

MAGPHYS (da Cunha et al. 2008), a method that interprets the SED of a galaxy in terms of its reproducibility as a combination of different simple stellar population libraries and dust emission.

A main feature of the method is the energy balance technique to consistently constraint both the stellar and dust emission. The fraction of stellar radiation absorbed by dust in the stellar birth clouds and in the ambient ISM is redistributed at FIR wavelengths, assuming that the starlight is the only source of heating.



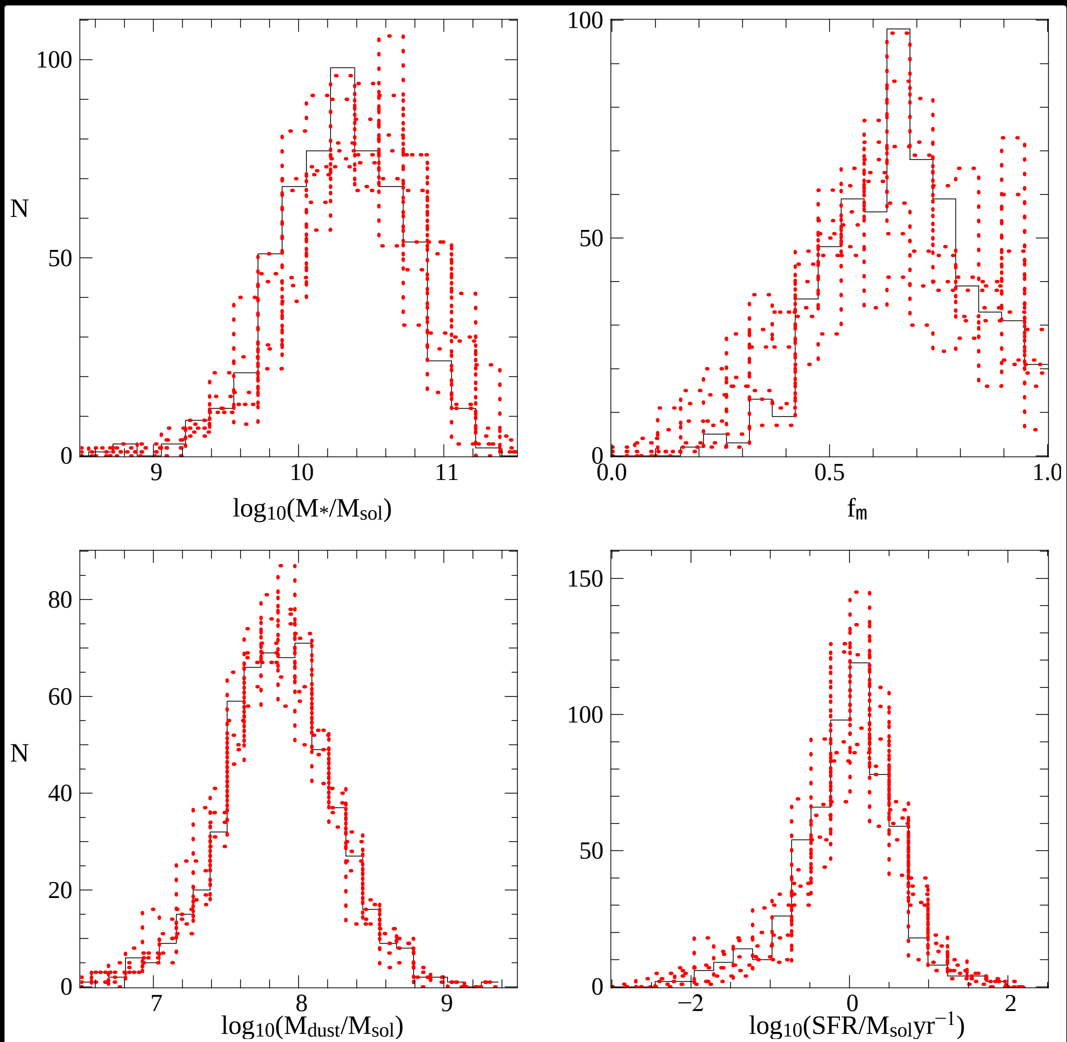
Results

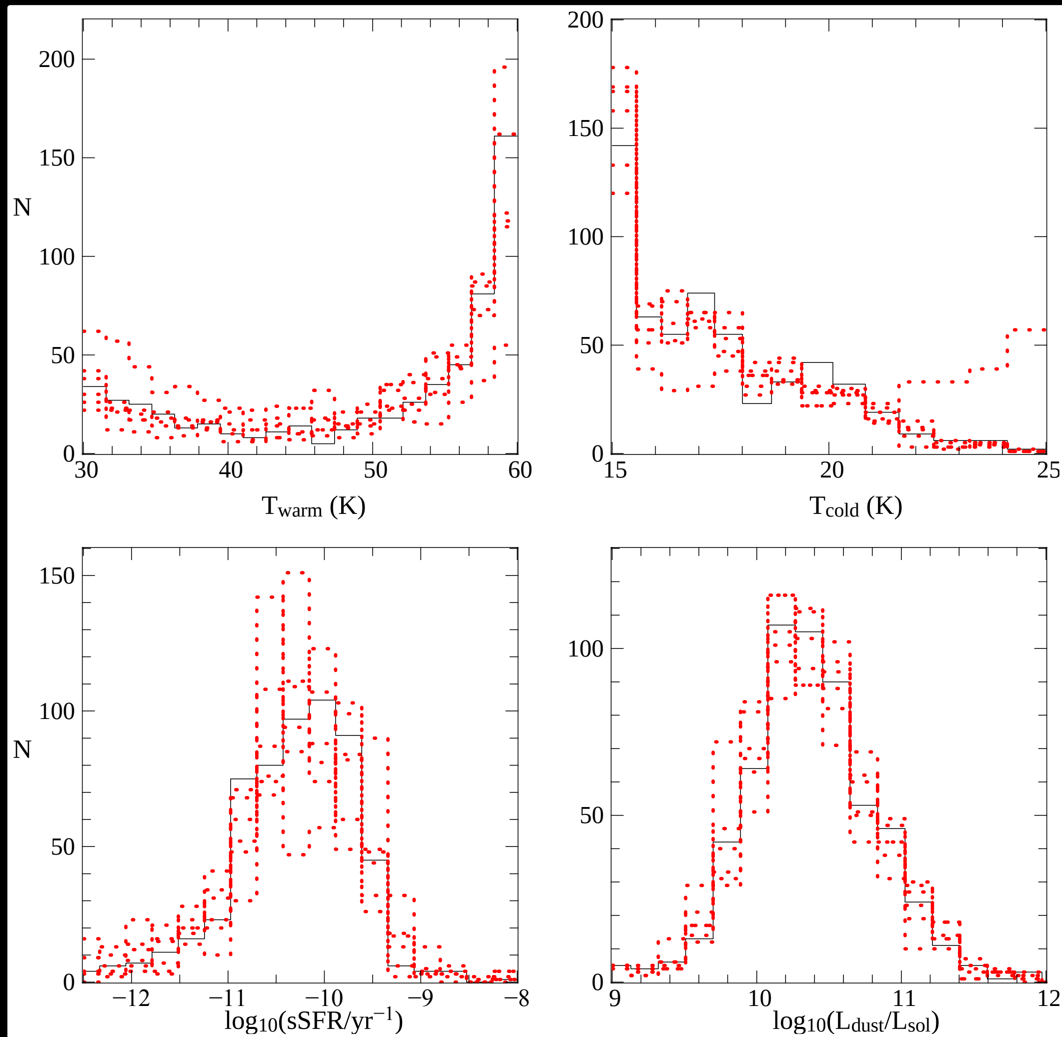
High stability M_{dust} and L_{dust}

Parameter (1)	Mean (2)	σ(mean) (3)
$\log_{10} M_{dust}$ ($M_\odot$)	7.85	6.77
SFR ($M_\odot$ yr^{-1})	1.08	0.22
f_μ	0.65	0.03
$\log_{10} M_{star}$ ($M_\odot$)	10.38	9.75
$\log_{10}$ sSFR (yr^{-1})	-10.28	-10.86
$\log_{10} L_{dust}$ ($L_\odot$)	10.32	9.41
T_c (K)	16.91	0.58
T_w (K)	52.39	4.64

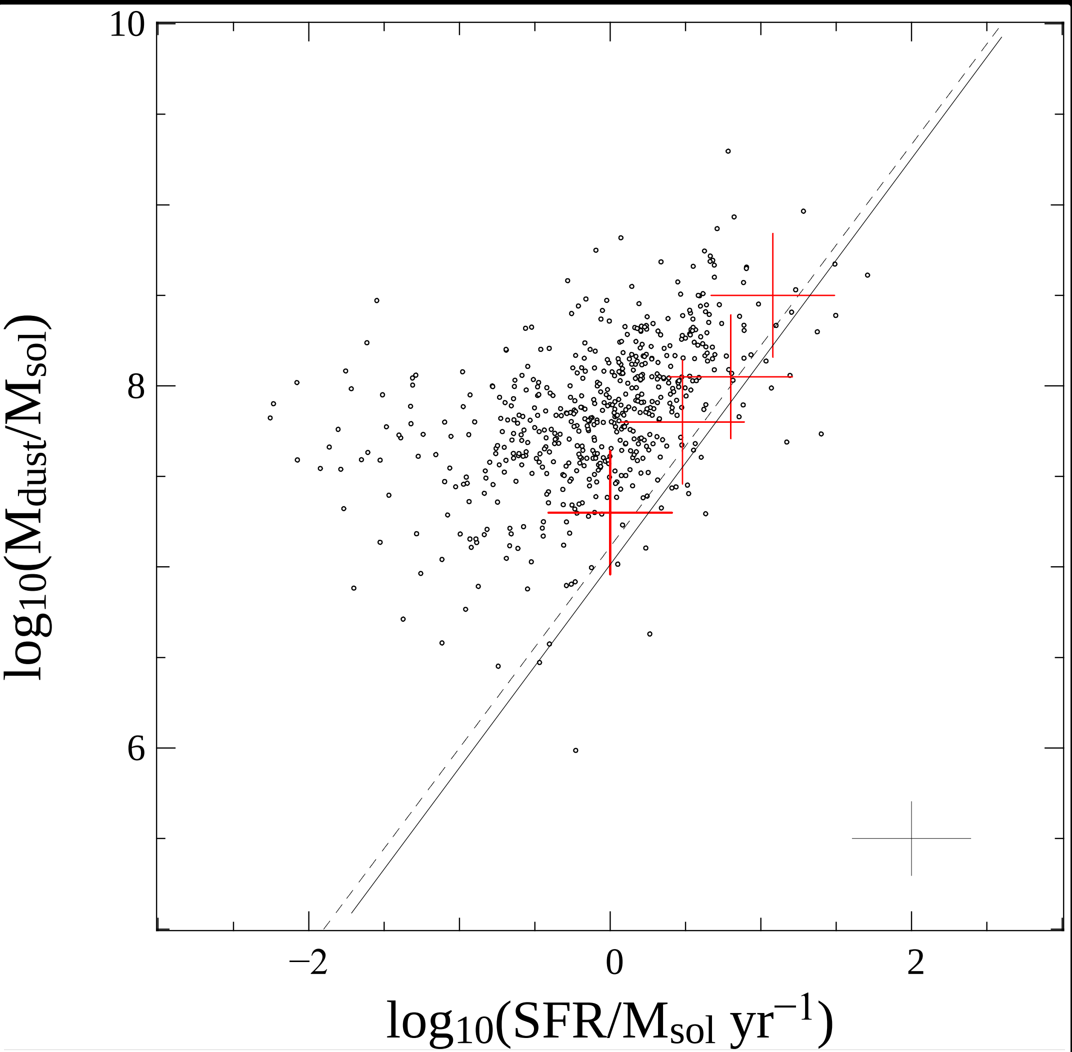
LOW SFR

LOW LUM (LIRG)





M_{dust} vs M_{star}



Median $L_{dust} \sim 10^{10} L_{sol}$ -> LIRG
Median SFR ~ 1 M_{sol}/yr -> "normal"

RED CROSSES: Smith et al. 12 (H-ATLAS)
M_{dust} are comparable -> SFRs lower

Due to a different redshift range (z~0.35), which investigates galaxies at a different stage of its evolution, i.e. more dusty (Dunnet et al. 11).

At fixed SFR our M_{dust} is systematically higher than both samples.

SOLID LINE: DA Cunha et al. 08 (IRAS sel)
Selection criteria. IRAS selects galaxies with lower dust content

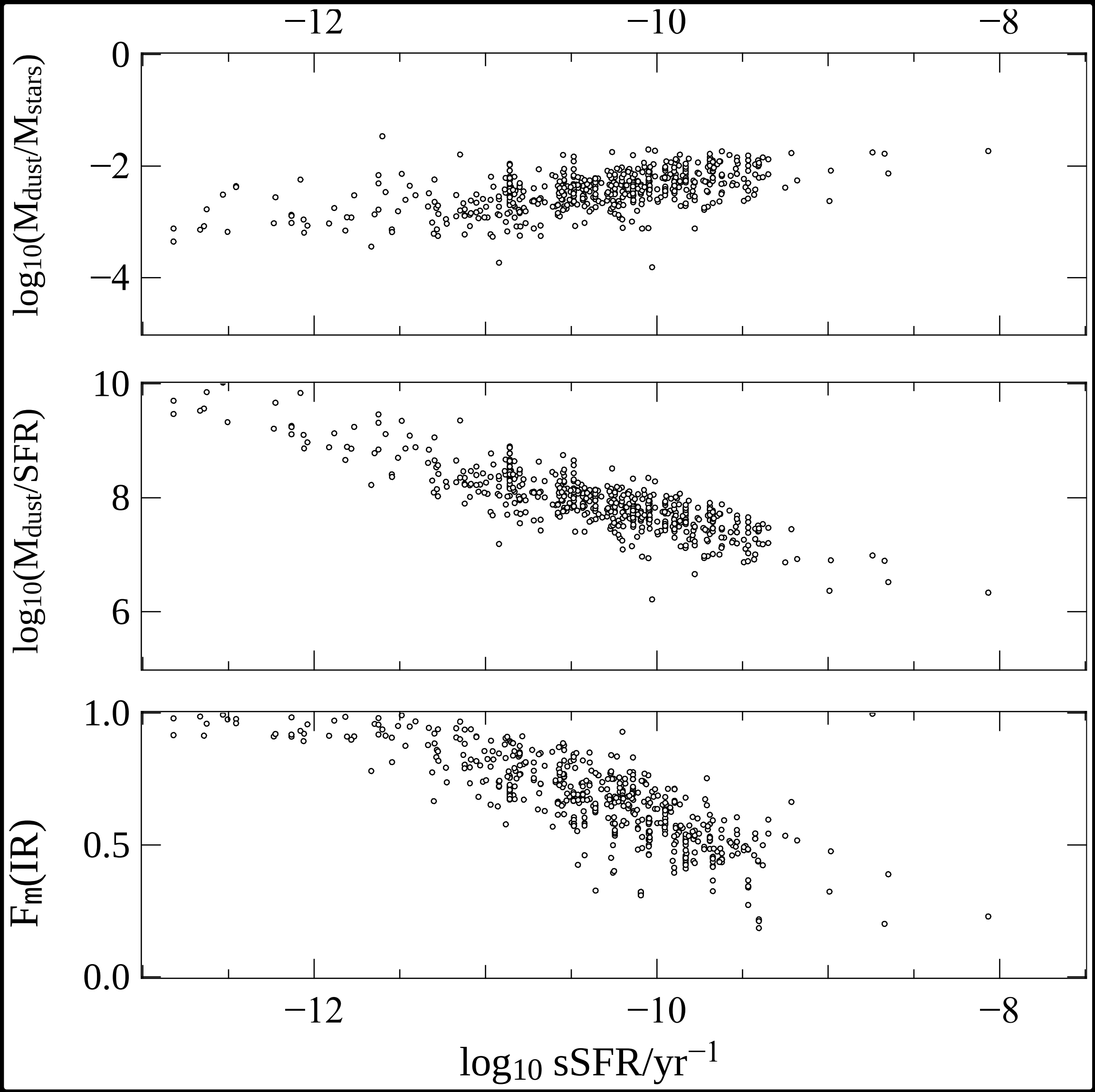
RED CROSSES. Due to the deepness of our data.

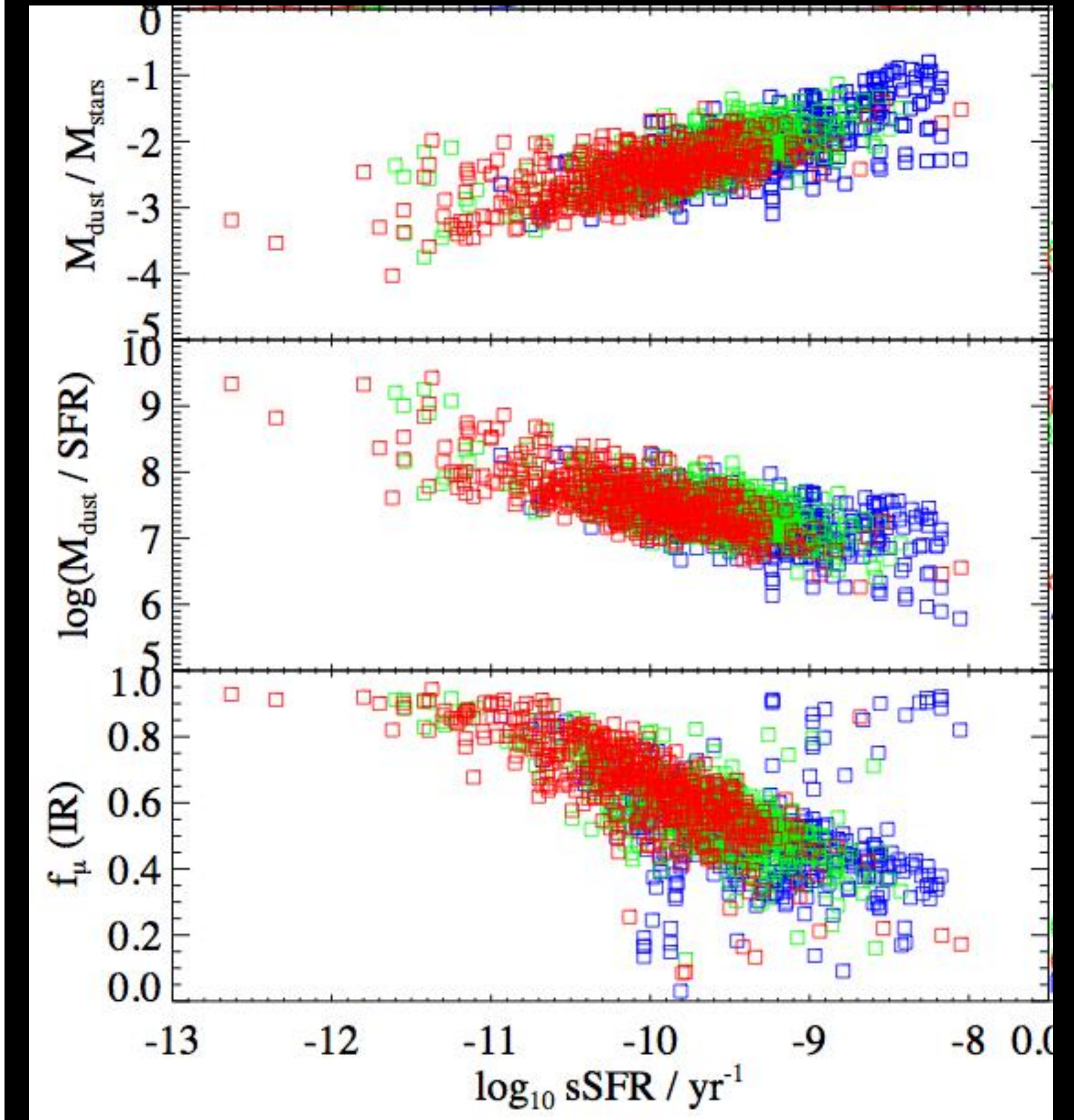
Lower L_{dust} (10.81 vs 10.32)

Physical properties

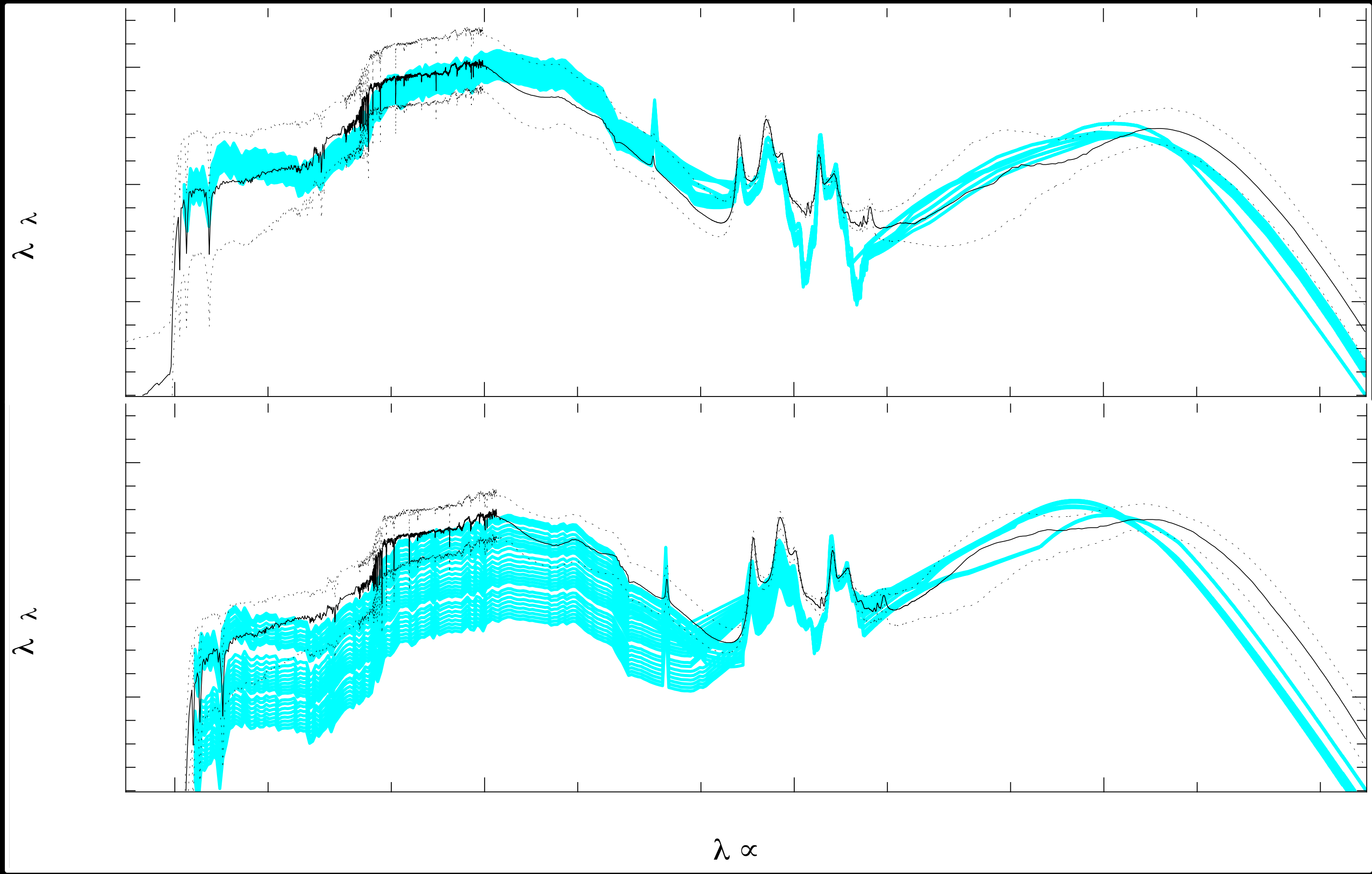
High fμ values indicate that dust in the diffuse ISM heated ISRF dominates the far-infrared emission in these sources, but the high sSFR suggests that these sources have very recent star formation activity.

Smith et al. 12





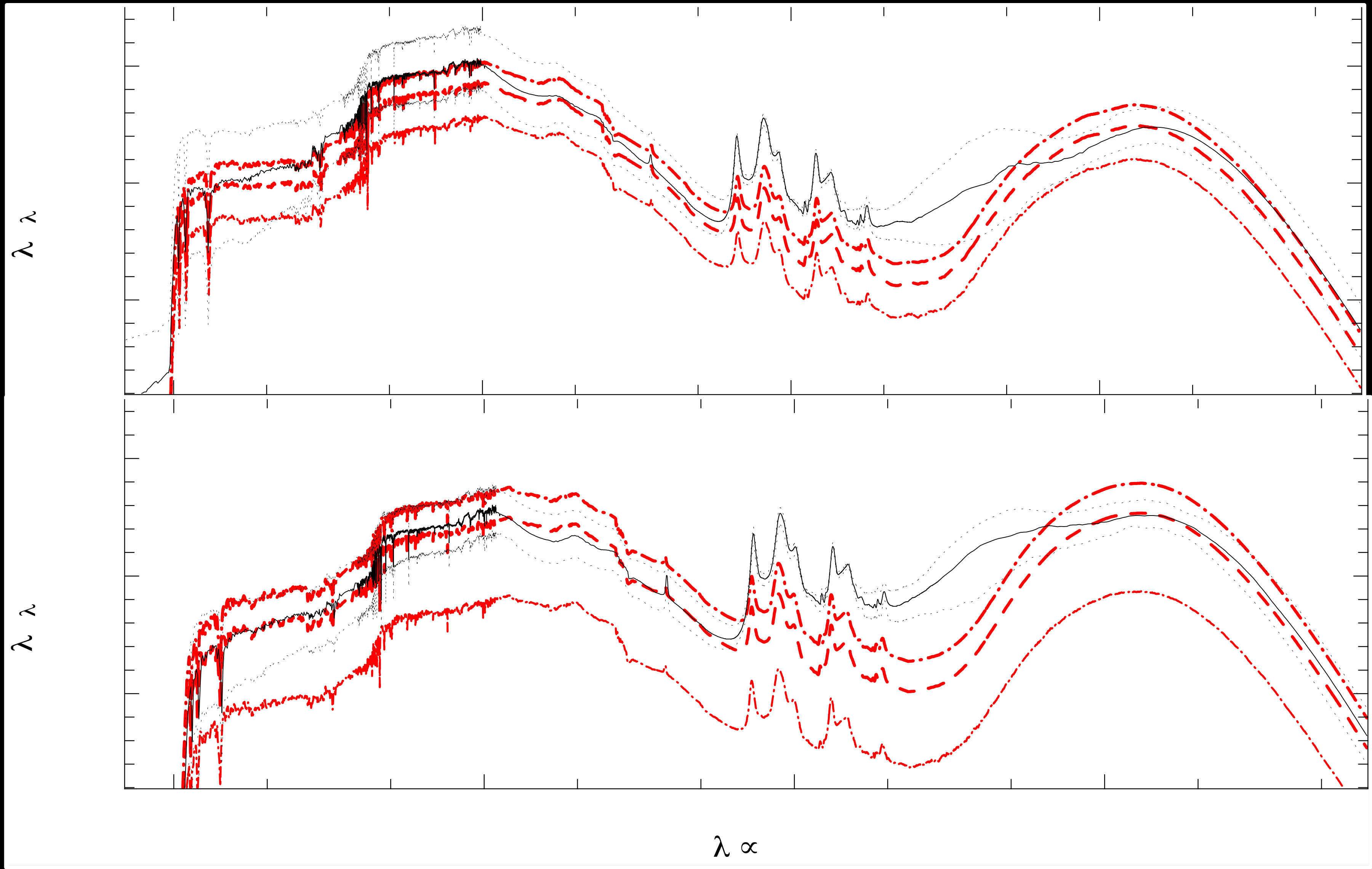
SED template: pre-Herschel (Chary Elbaz 01)



- Where the emission is dominated by stellar component the shape of the spectra are similar.
- Above 10 micron the discrepancies increase, and in average the peak of the dust thermal component is at lower wavelengths, implying hotter temperature.

Differences are relevant in the range of WISE data, where we have a better coverage. The comparison in FIR bands confirms the importance of Herschel in characterizing the evolution of galaxies, where templates selected at a different wavelength tend to underestimate the Rayleigh-Taylor emission of the thermal component of the dust.

SED template: post-Herschel (Smith, private comm)



Except the region between 9-200 micron the spectra are almost identical, despite the differences in star formations, stellar masses, and different redshift range.
The main differences are the spectral bands covered by WISE, where Smith et al do not have constraints. This evidence confirms the importance of these bands in order to build a SED template for galaxies.

Conclusions

We selected about 600 sources with 19 photometric bands with average redshift z~0.11 and we investigate the physical properties of this sample using a SED fitting technique

- Our sample has SFRs and dust luminosities typical of star forming LIRG.
- We have compared our results with a sample of H-ATLAS galaxies selected at 250 micron with average z~0.35 (Smith et al. 12), and the IRAS selected sample of da Cunha et al. 08. The range of dust masses are comparable, but at fixed M_{dust} we found lower SFRs, implying larger dust masses at higher redsfhit (Dunne et al. 01). Galaxies selected with IRAS show lower dust masses, as a combination of lower redshift and selection effects.

- At fixed SFR we have higher M_{dust}. The discrepancies between are a consequence of selection criteria for Da cunha et al 08 and deeper data for Smith et al 12.

- We built SEDs template representative of low redshift LIRG and we compare it to previous examples:

The comparison with the pre-Herschel templates shows, in the range where the stellar emission is dominant, a good agreement. Above 10 micron the discrepancies increase, and the peak of the dust thermal component shifts to lower wavelengths, implying hotter temperature.
The main differences with post-Herschel templates are in the spectral bands covered by WISE. The emission at MIR are in average lower than our sample when we have constraints in Herschel bands, and lower when there are no constraints in FIR