Dust attenuation in the universe: the UV and the IR points of view

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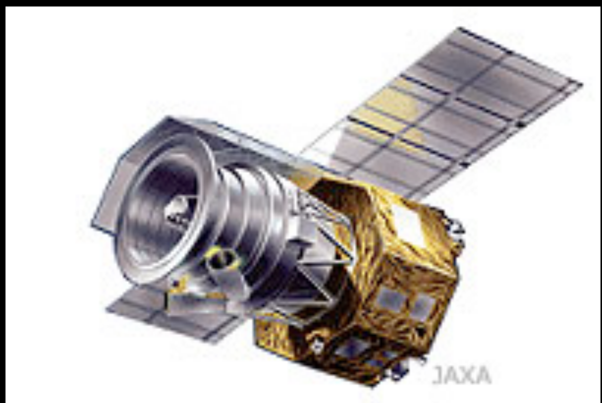
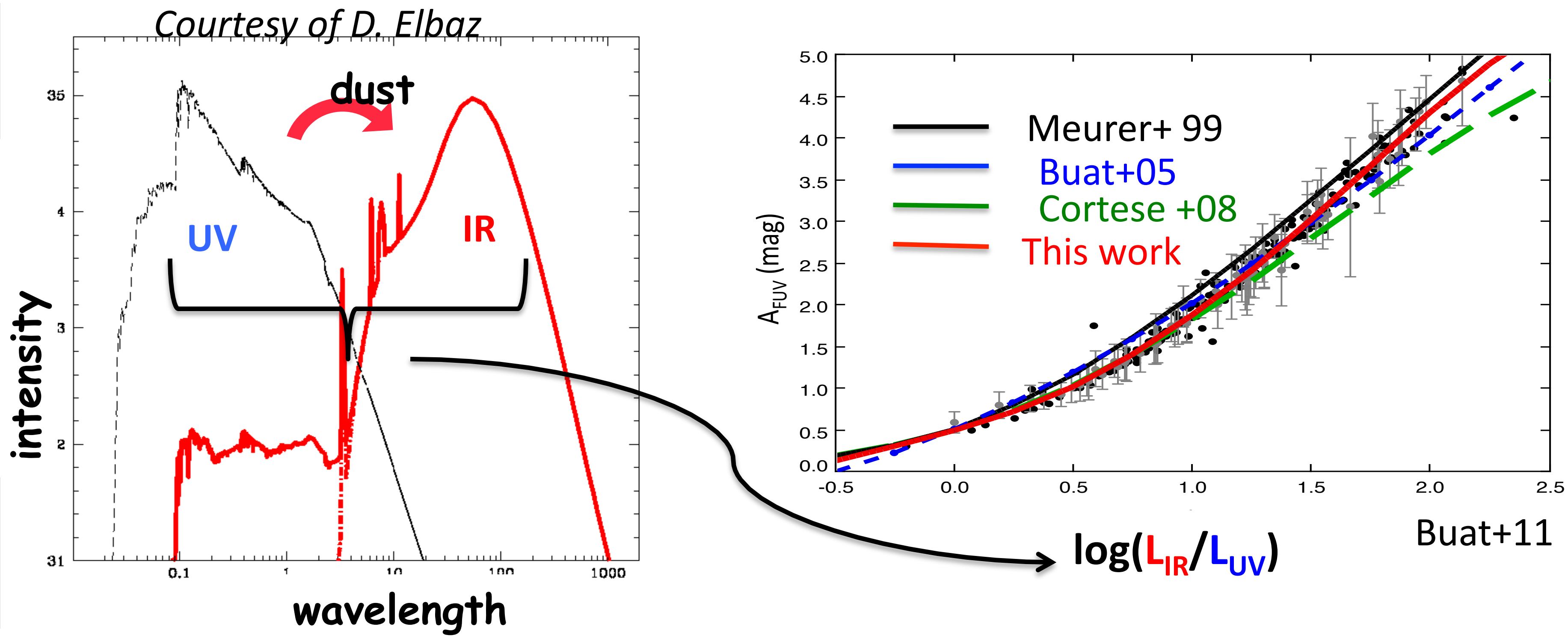
Nagisa Oi (ISAS),
Denis Burgarella (LAM, France)
And many other collaborators from Herschel and AKARI surveys teams



Sendai-november 7th 2014

General context



Both UV and IR emissions are related to recent star formation and to dust attenuation

Three different measurements of dust attenuation in the universe

- **A global point of view:**

UV and IR luminosity densities

- **UV emitting galaxies:**

Z=1.5, 3 & 4 COSMOS field with Herschel (HERMeS data)

- **IR selected galaxies**

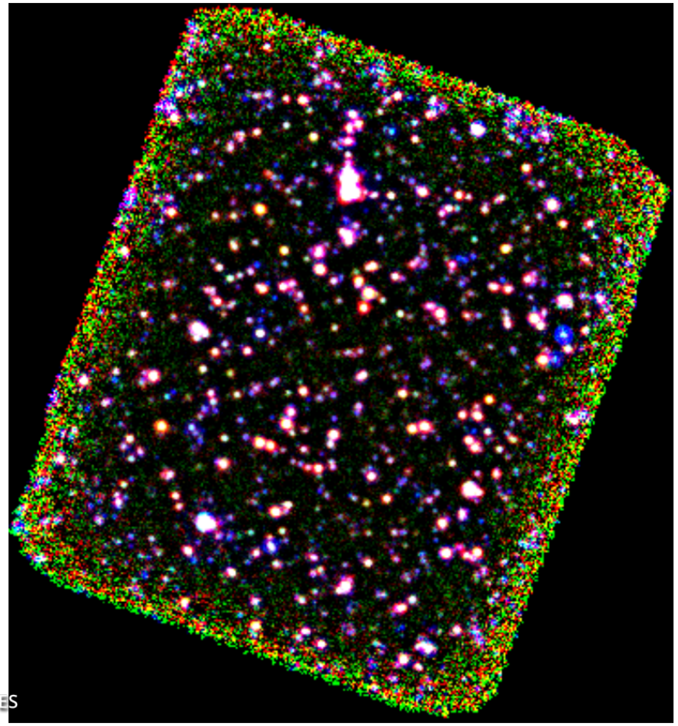
NEP-AKARI field, 0<z<2

A work based on several Herschel surveys

- HerMES (P.I.: S. Oliver),
- GOODS-Herschel (P.I.:D. Elbaz)

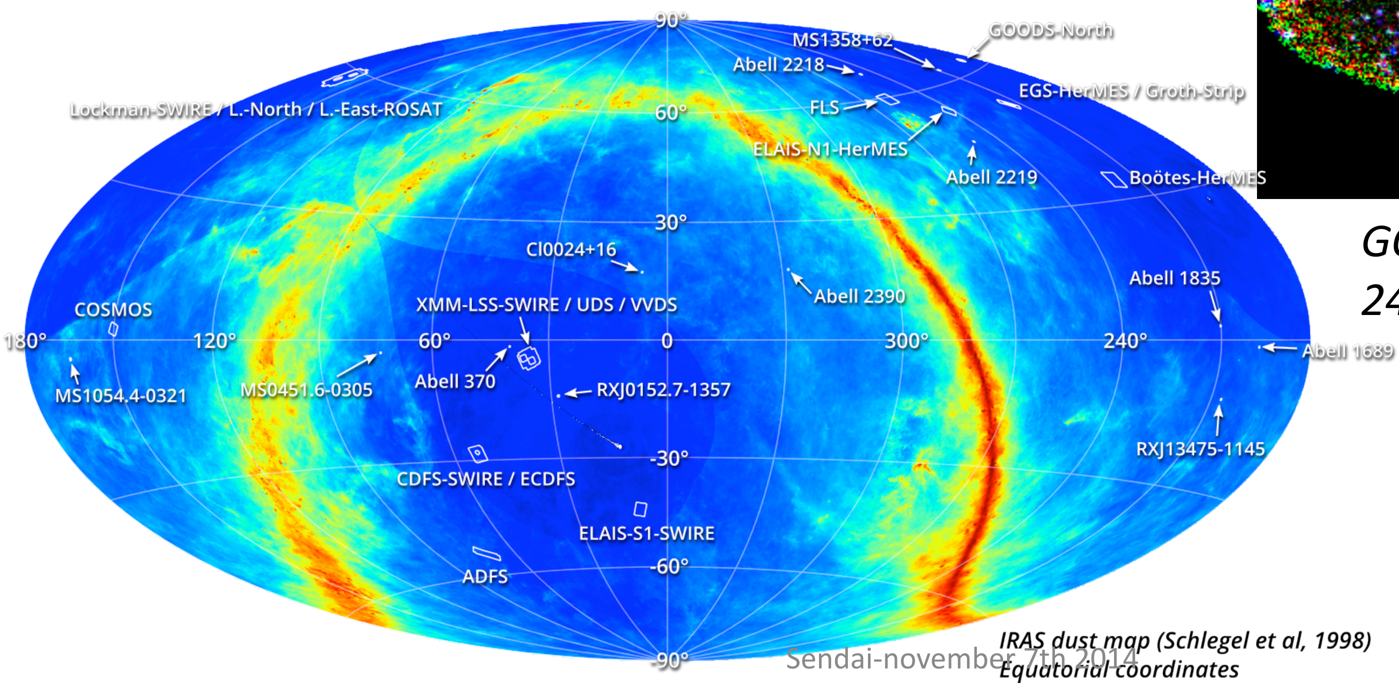
  + PEP (P.I.: D. Lutz)

COSMOS and CDFS fields

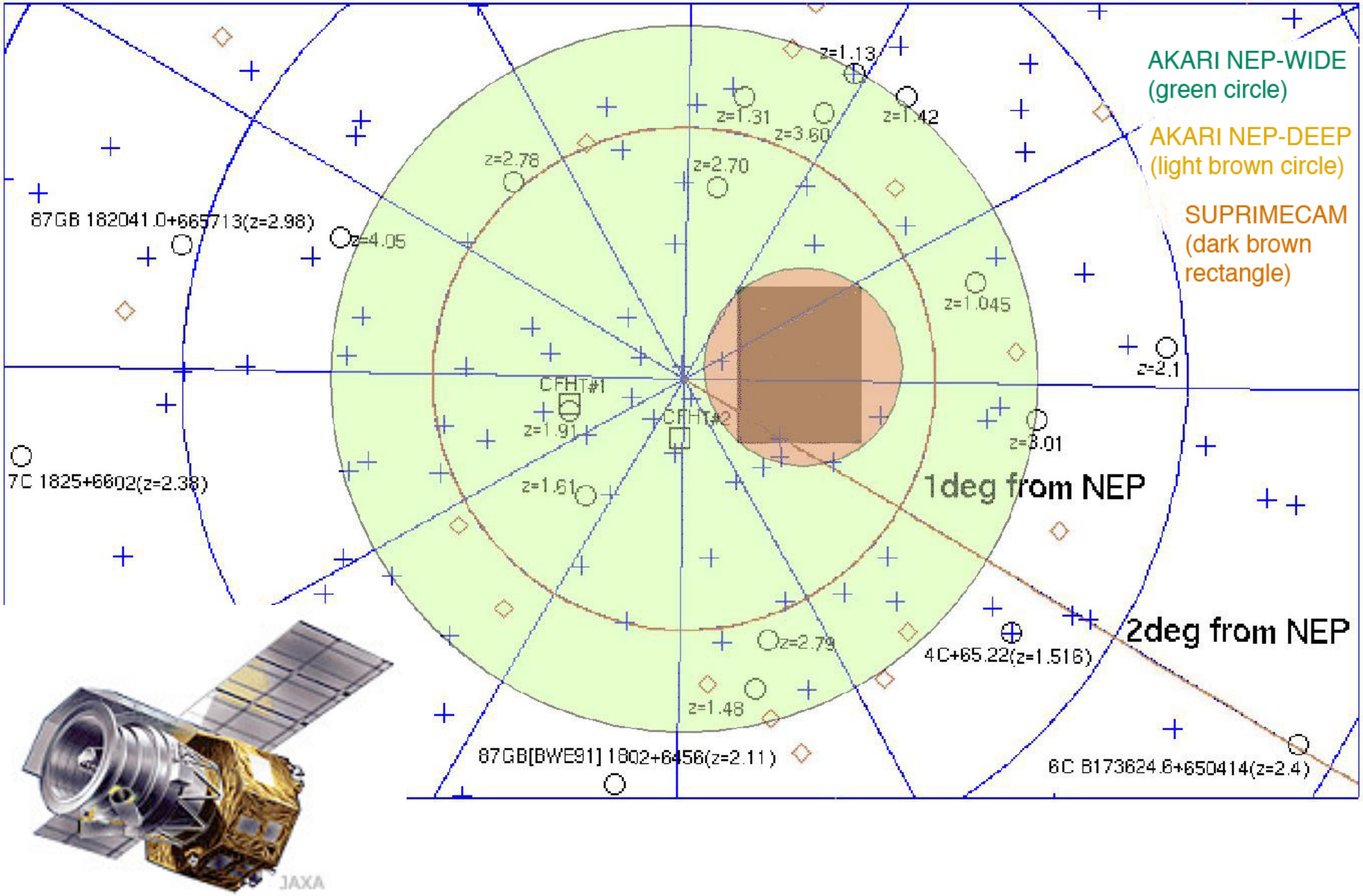


GOODS-H-CDFS field at 24-100-160 µm

HerMES Data Release 2 Field Positions



The NEP-AKARI deep survey

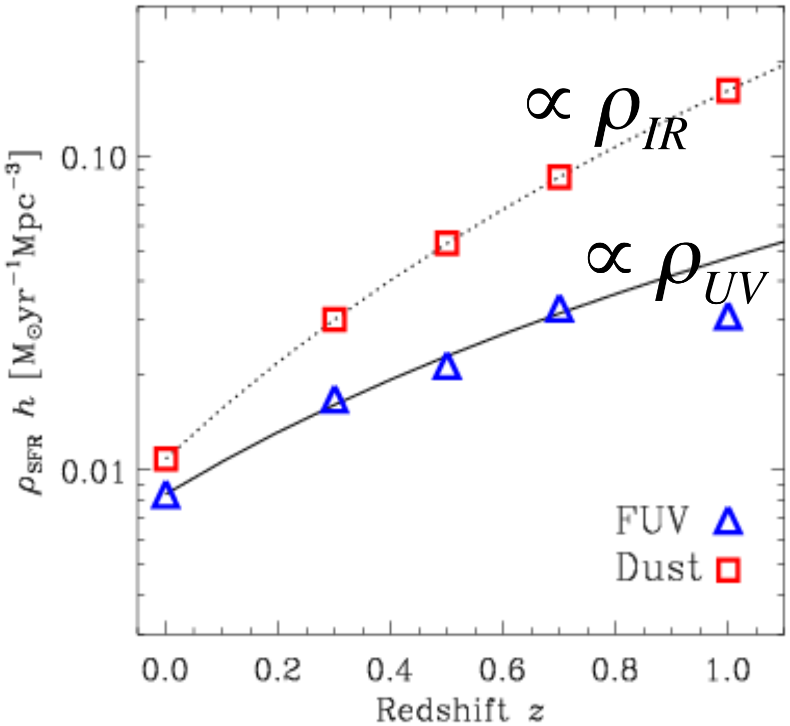


Three different measurements to be compared

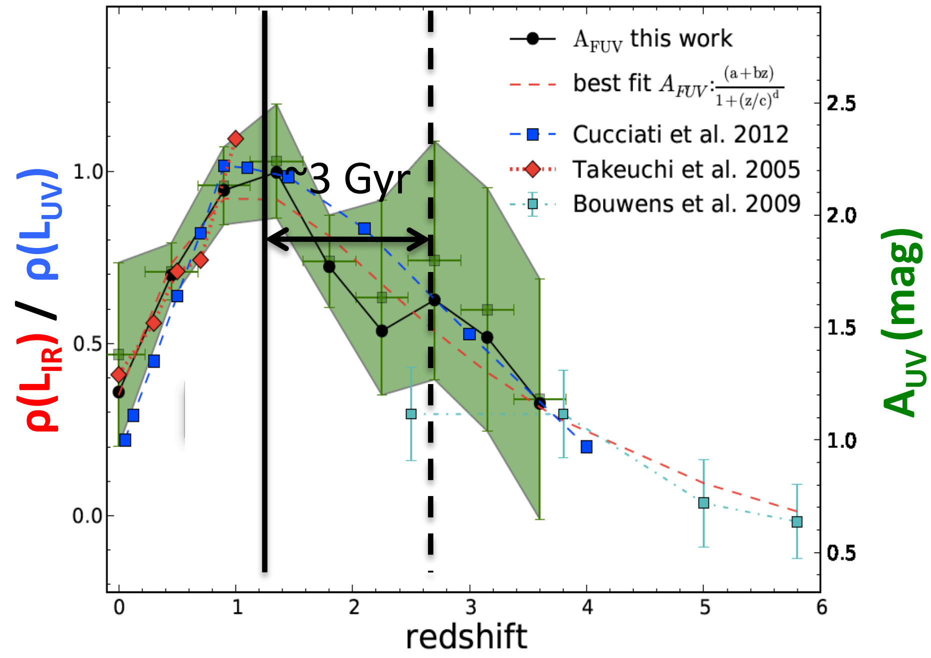
- **A global point of view:**

UV and IR luminosity densities

Takeuchi, Buat & Burgarella+06
GALEX & SPITZER



Burgarella, Buat +13
Herschel and optical surveys



Attenuation increases up to z=1 and then decreases **$A_{UV}(z=0) \sim A_{UV}(z=4)$**

Three different measurements to be compared

- **A global point of view**:

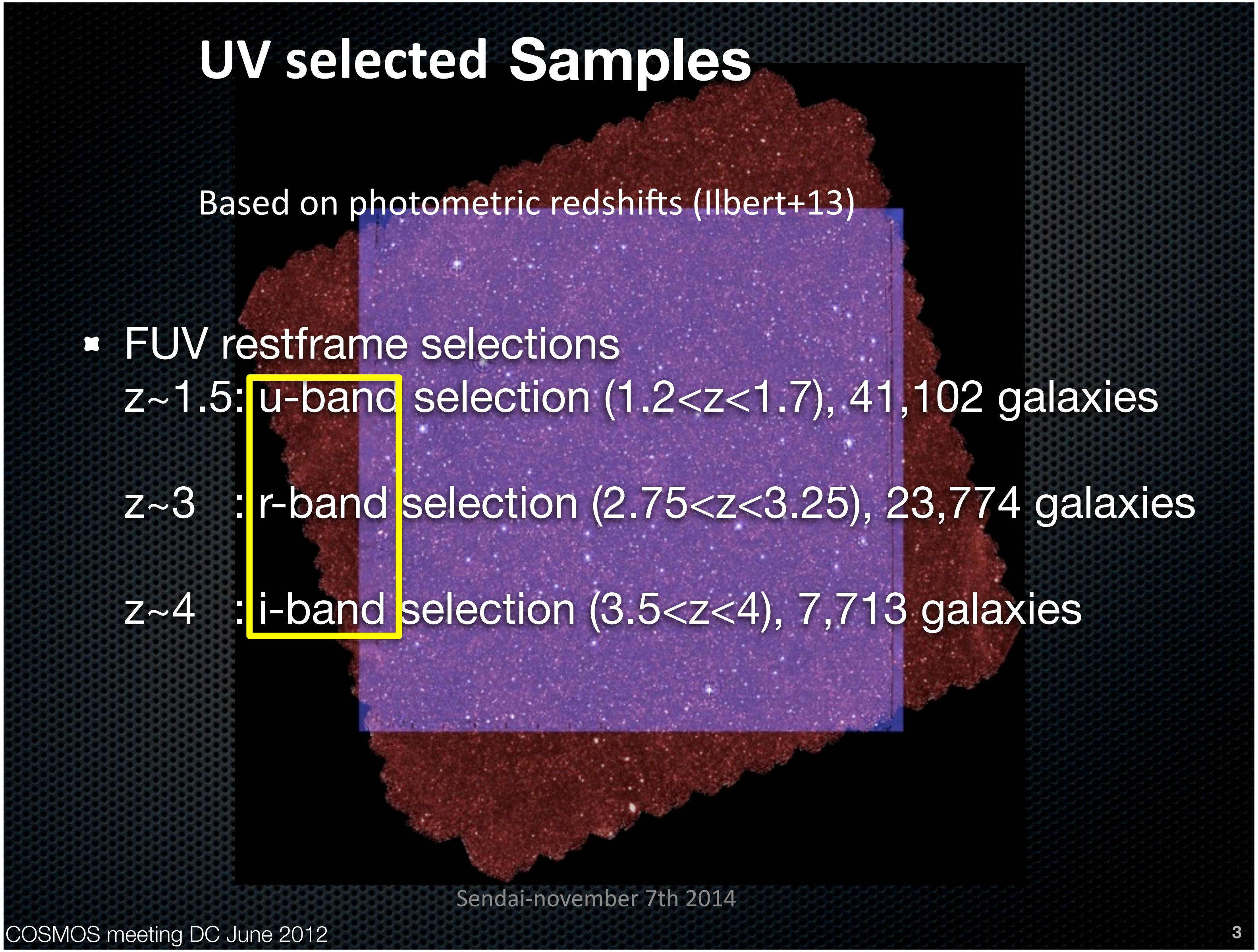
UV and IR luminosity densities

- **UV emitting galaxies:**

Z=1.5, 3 & 4 COSMOS field with Herschel (HERMeS data)

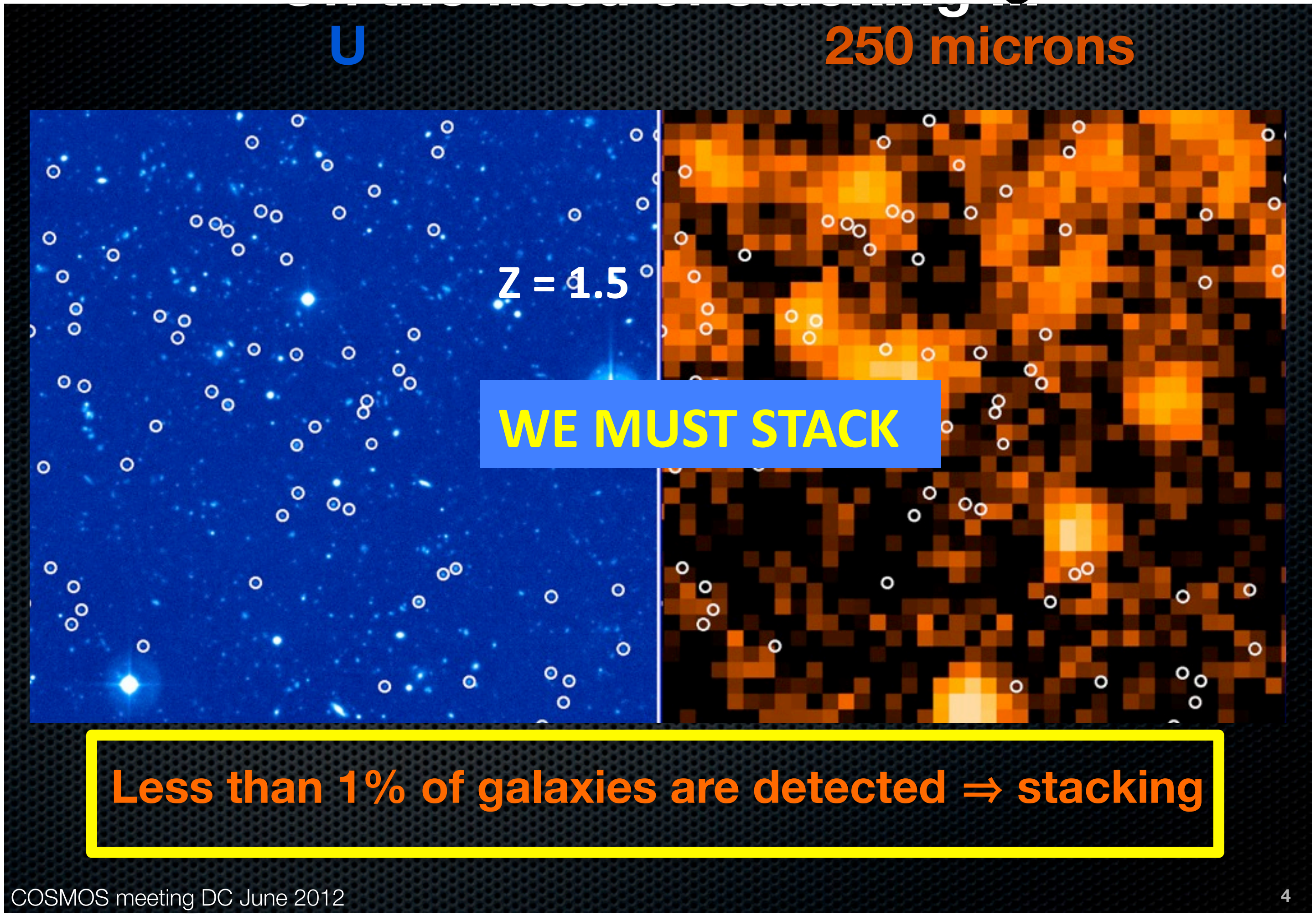
Study of UV selected galaxies in the COSMOS field @ z=1.5, 3 & 4

Heinis+13,+14

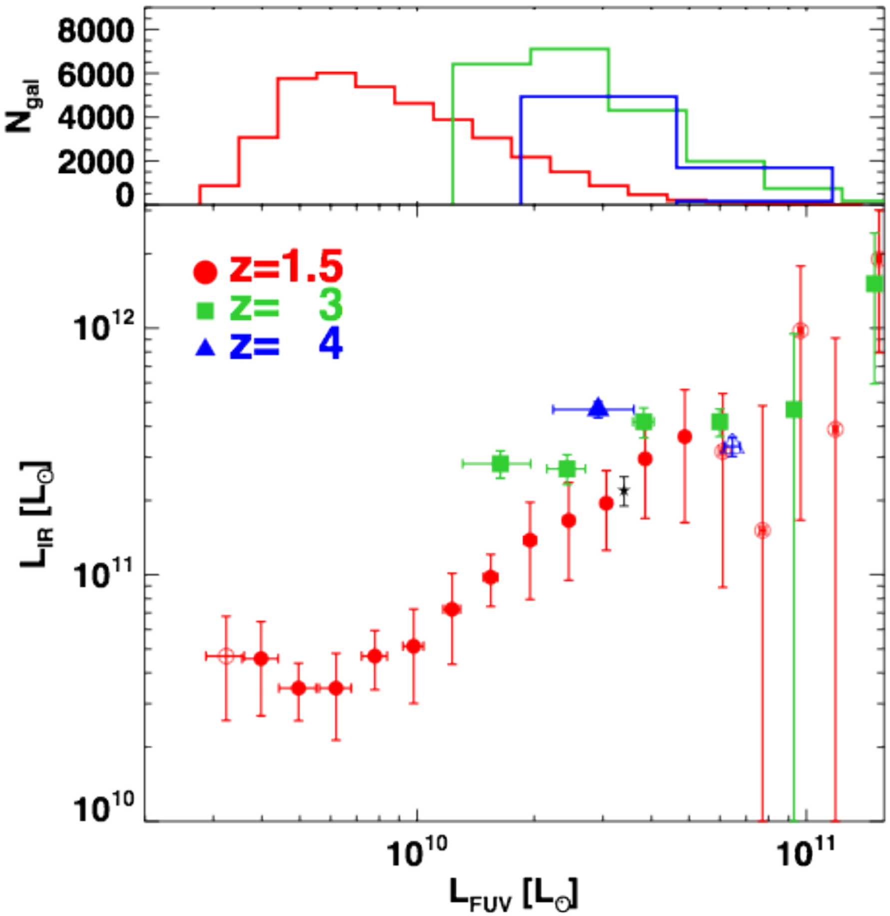


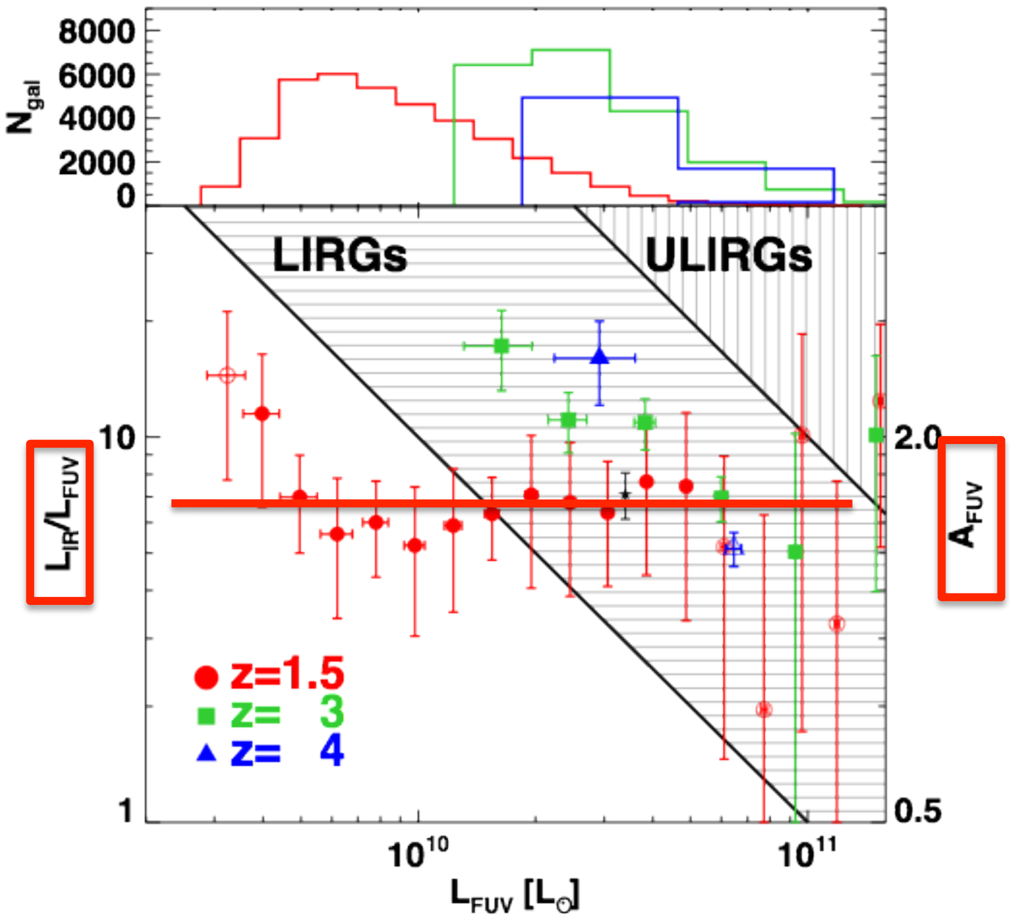
Adding the IR to the UV:

Almost no counterpart of UV selected sources in Herschel images!!



Stacking per bin of L_{FUV}





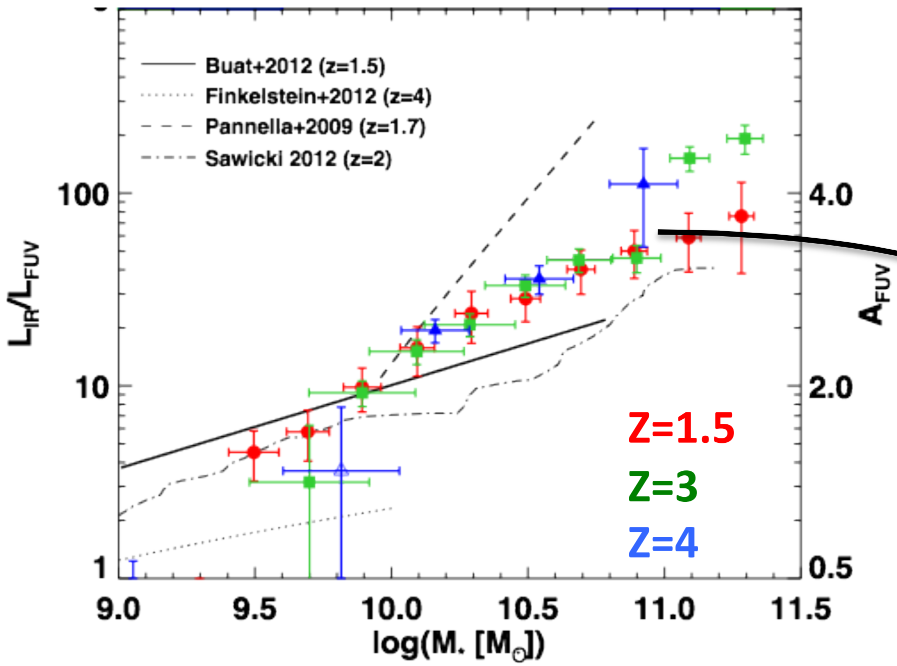
L_{IR} measured by fitting Dale & Helou (2002) templates on SPIRE data

$A_{FUV} = f(L_{IR}/L_{FUV})$ (Buat+05)

→ **LIRGs and sub-LIRGs**

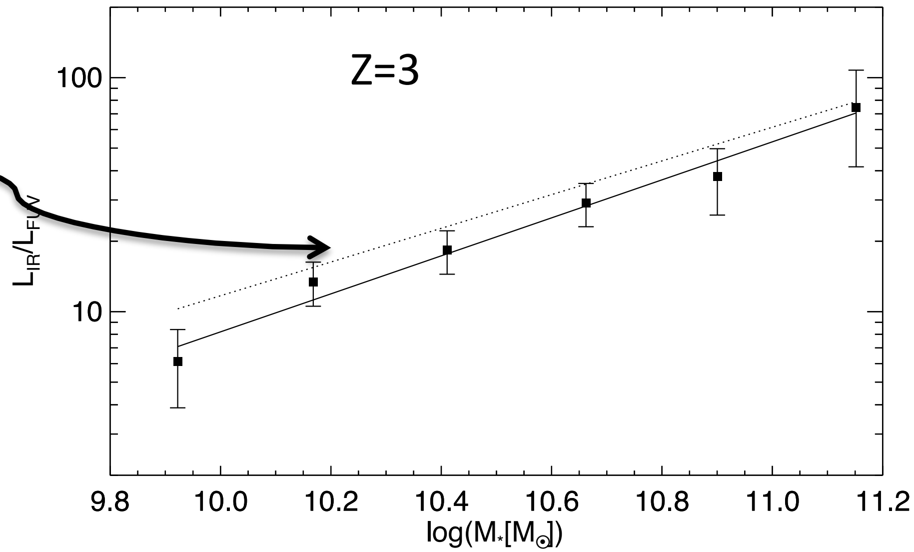
Dust attenuation L_{IR}/L_{FUV}=IRX versus M_* for UV selected galaxies and LBGs

Heinis+14



Lyman-Break Galaxies

Alvarez-Marquez et al. in prep



L_{IR} measured by fitting Dale & Helou (2002) templates on SPIRE data

$A_{FUV} = f(L_{IR}/L_{FUV})$ (Buat+05)

Consistent results found by Panella+14 for a mass selection

Three different measurements to be compared

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- **UV emitting galaxies:**

Z=1.5, 3 & 4 COSMOS field with Herschel (HERMeS data)

- **<u>IR selected galaxies:</u>**

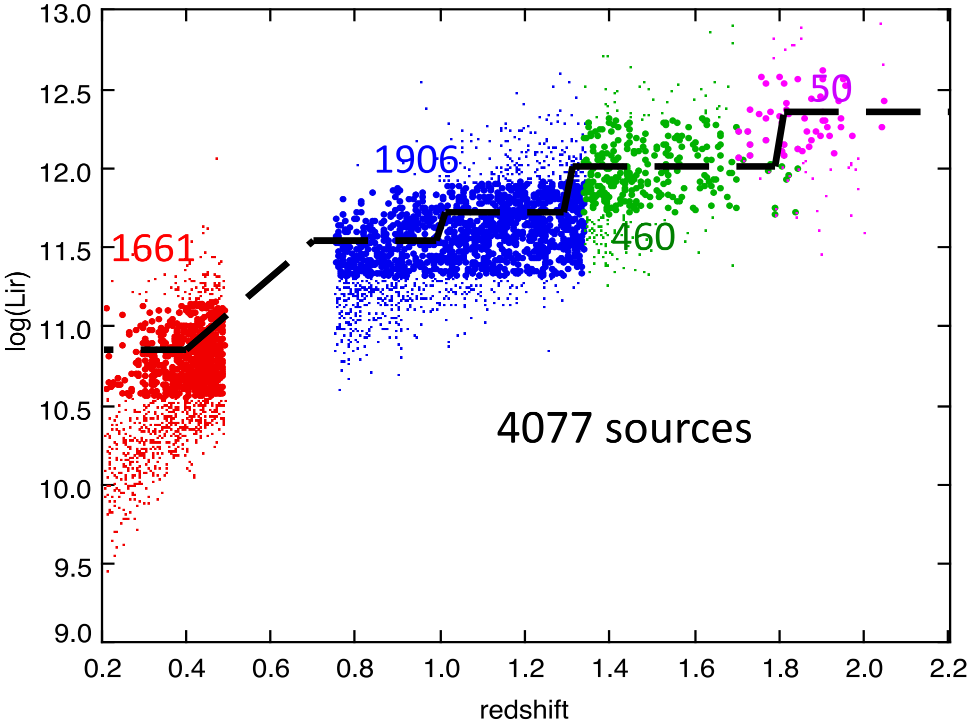
<u>NEP-AKARI field, 0<z<2</u>

Buat et al. In prep (submitted end of nov)

Definition of the 8 µm rest-frame selection in the NEP-AKARI deep field

PAH Feature @ 7.7 µm

- **S11** λ(cent) -→ z=0.38
  With trans> 0.8 (right) & 0.9 (left) **0.15<z<0.49**
- **L15** λ(cent) -→ z=1.08
  With trans > 0.8 **0.75<z<1.34**
- **L18** λ(cent) -→ z=1.55
  With trans > 0.8 **1.34<z<1.85**
- **L24** λ(cent) -→ z=2
  With trans > 0.8 **1.7<z<2.05**



Similar selection as in Goto+10

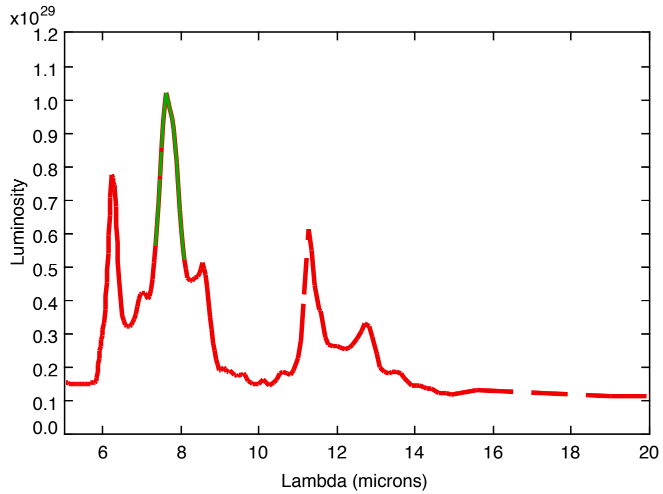


Photo-z from Oi+14
AKARI sources from Murata+13
PACS data for 599 sources

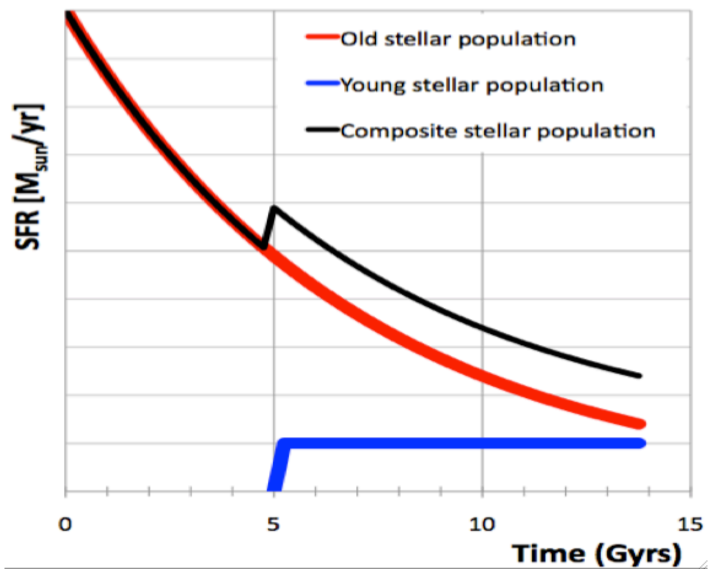
Fitting the full SED with Cigale

Parameter	Range
Amount of dust attenuation $E(B-V)$[1]	0.1-1 mag
Attenuation curve	B12,C00, SMC-like
IR templates, α	1-3
AGN fraction,$frac_{AGN}$	0-0.5
Stellar populations[2]	
age (old stellar population) t_f	2-11 Gyr
e-folding rate (old stellar population) τ	1-5 Gyr
age (young stellar population) t_{ySP}	50-500 Myr
stellar mass fraction[3] f_{ySP}	0.01-0.2

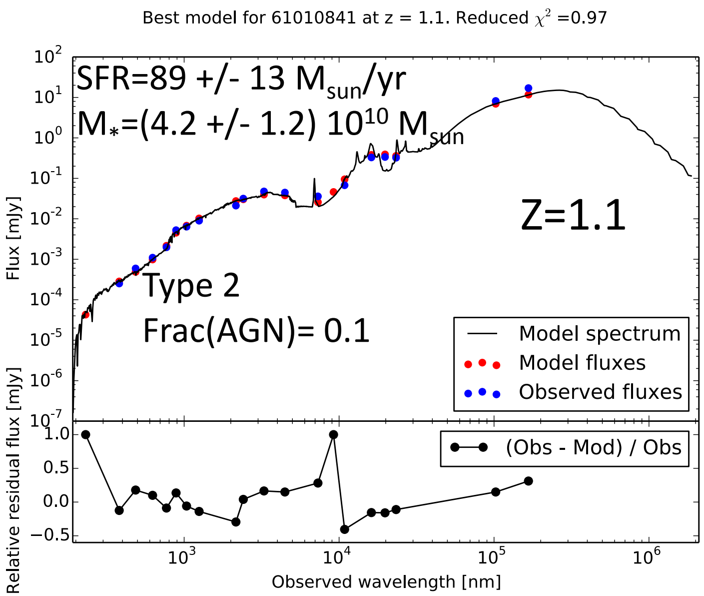
Dale+14 templates
Fritz+06 templates

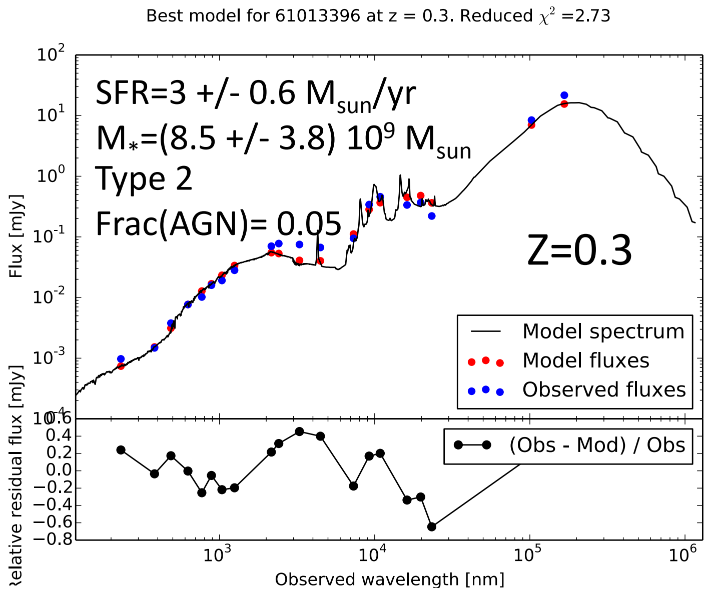
2 stellar populations

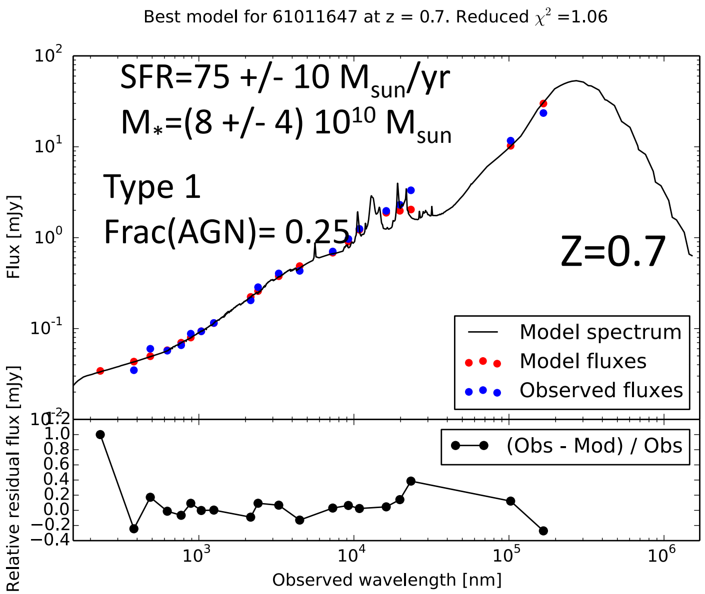
One output parameter: A_{UV}
Mainly constrained by L_{IR}/L_{UV}

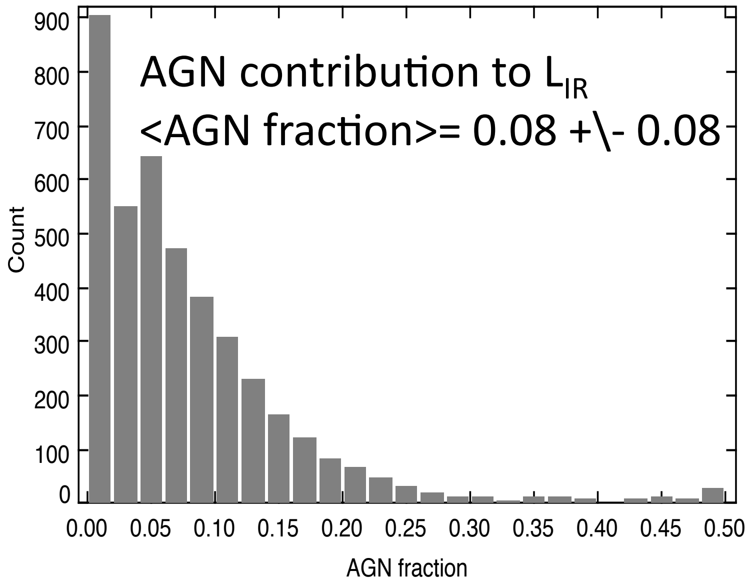


Examples of best fits

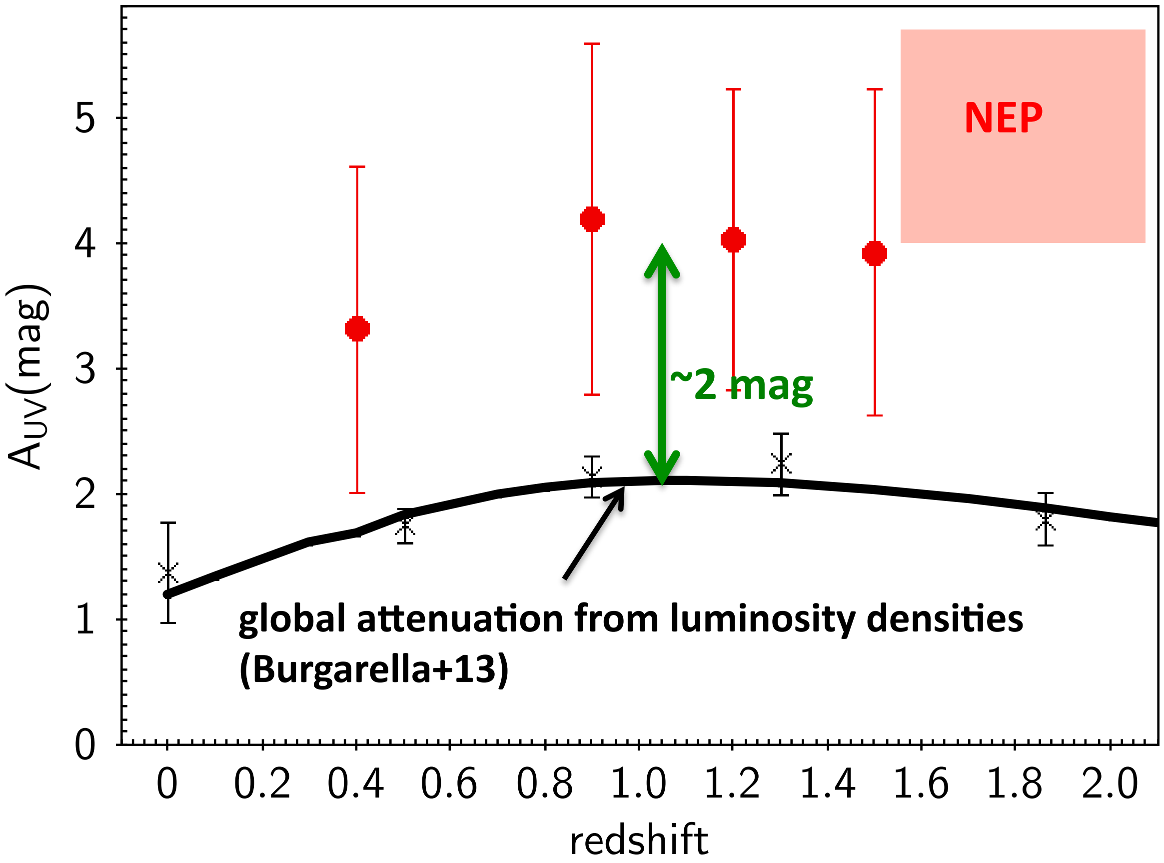






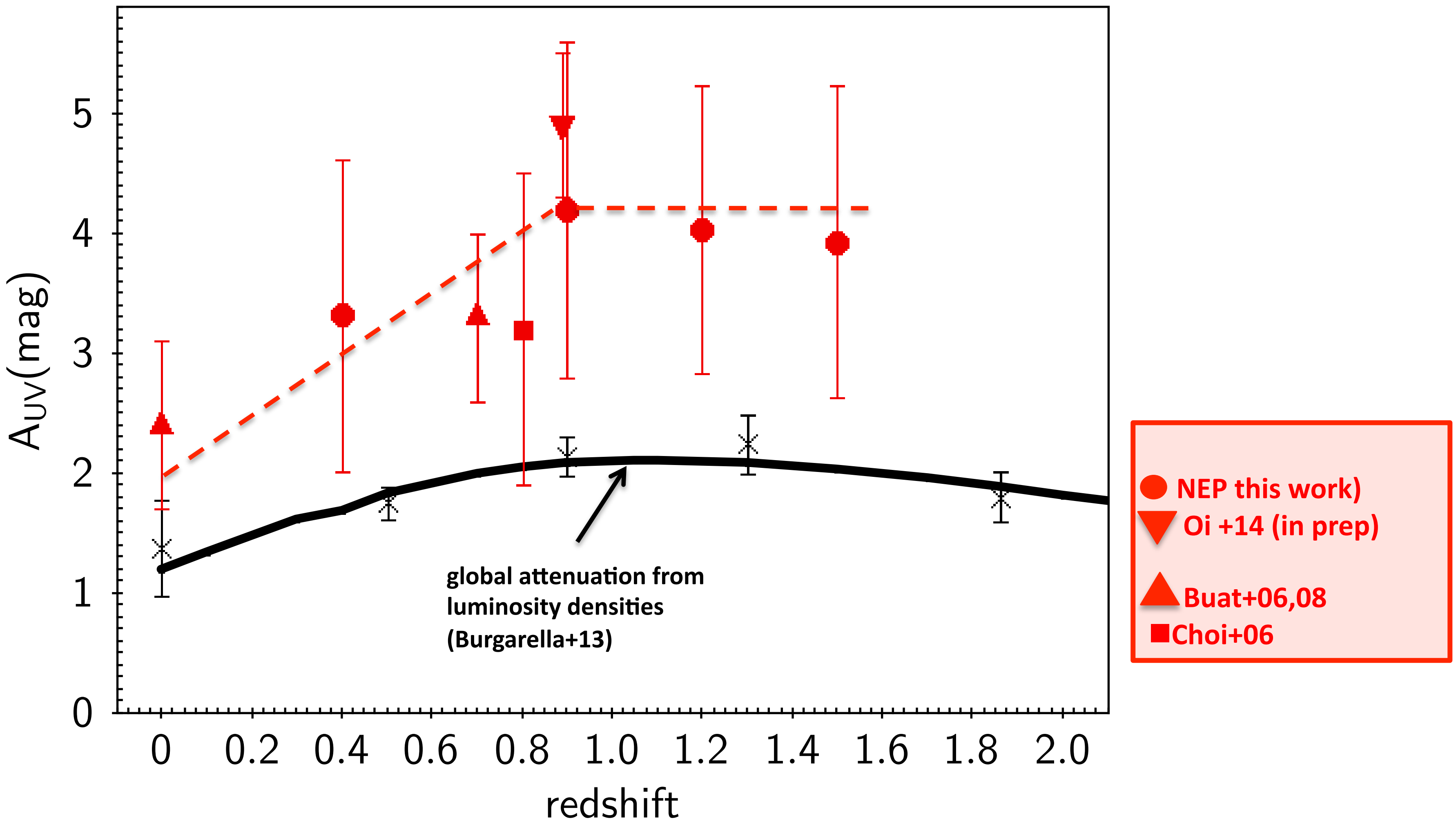


Evolution of dust attenuation A_{UV} (@ 150 nm) with z



Attenuation in IR selected galaxies ~2 mag higher than the average of the universe

Evolution of dust attenuation with z

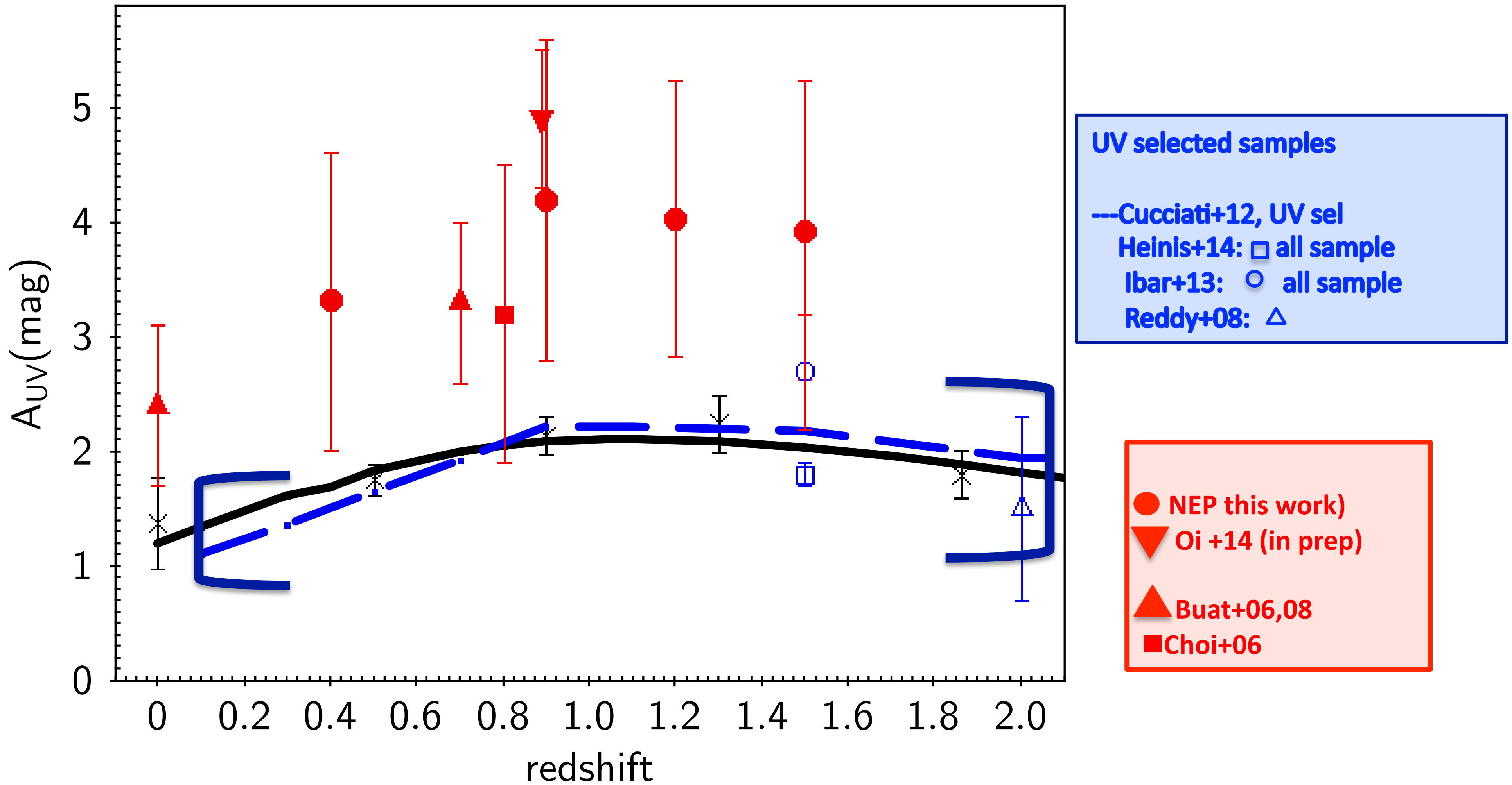


IR selected samples: **this work and literature**

Good agreement in the measurements:

→ Dust attenuation increases up to z~1 and then remains ~constant

Evolution of dust attenuation with z

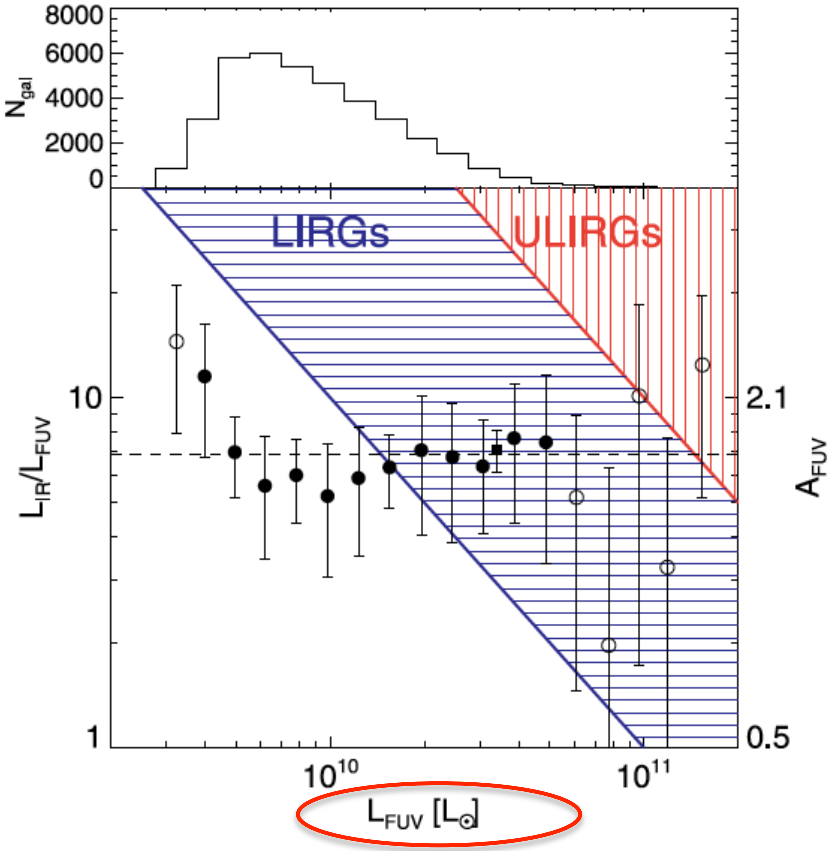


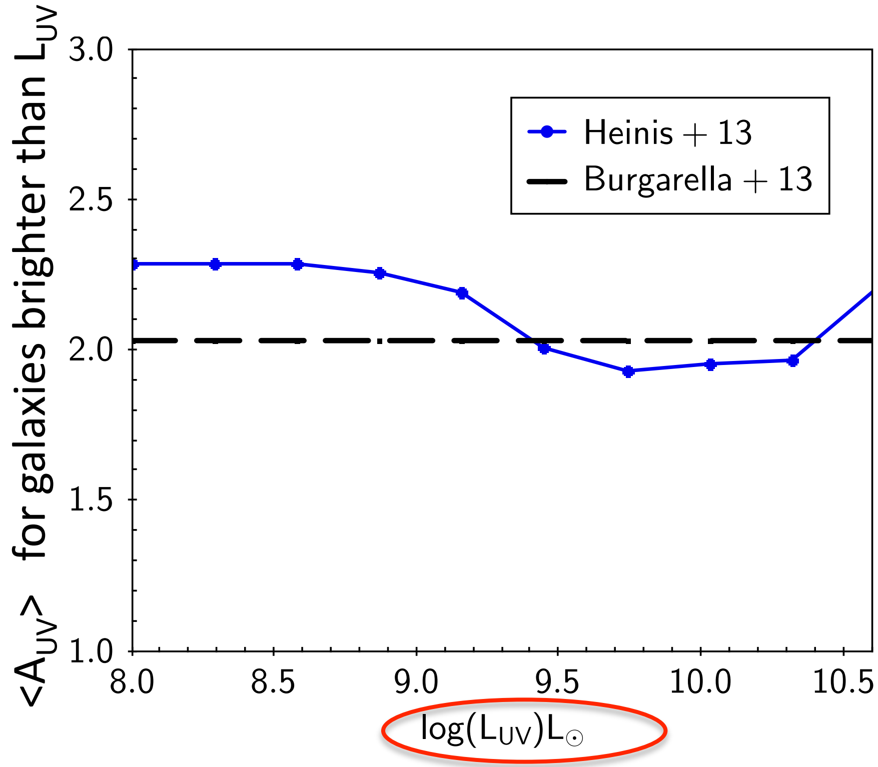
IR selected samples (this work and literature:

Slight increase of the attenuation with redshift for galaxies producing the bulk of the IR energy (L_{IR}^* galaxies)

UV selected samples: much lower attenuation, similar to the global one measured with ρ_{IR}/ρ_{UV}

Heinis+13

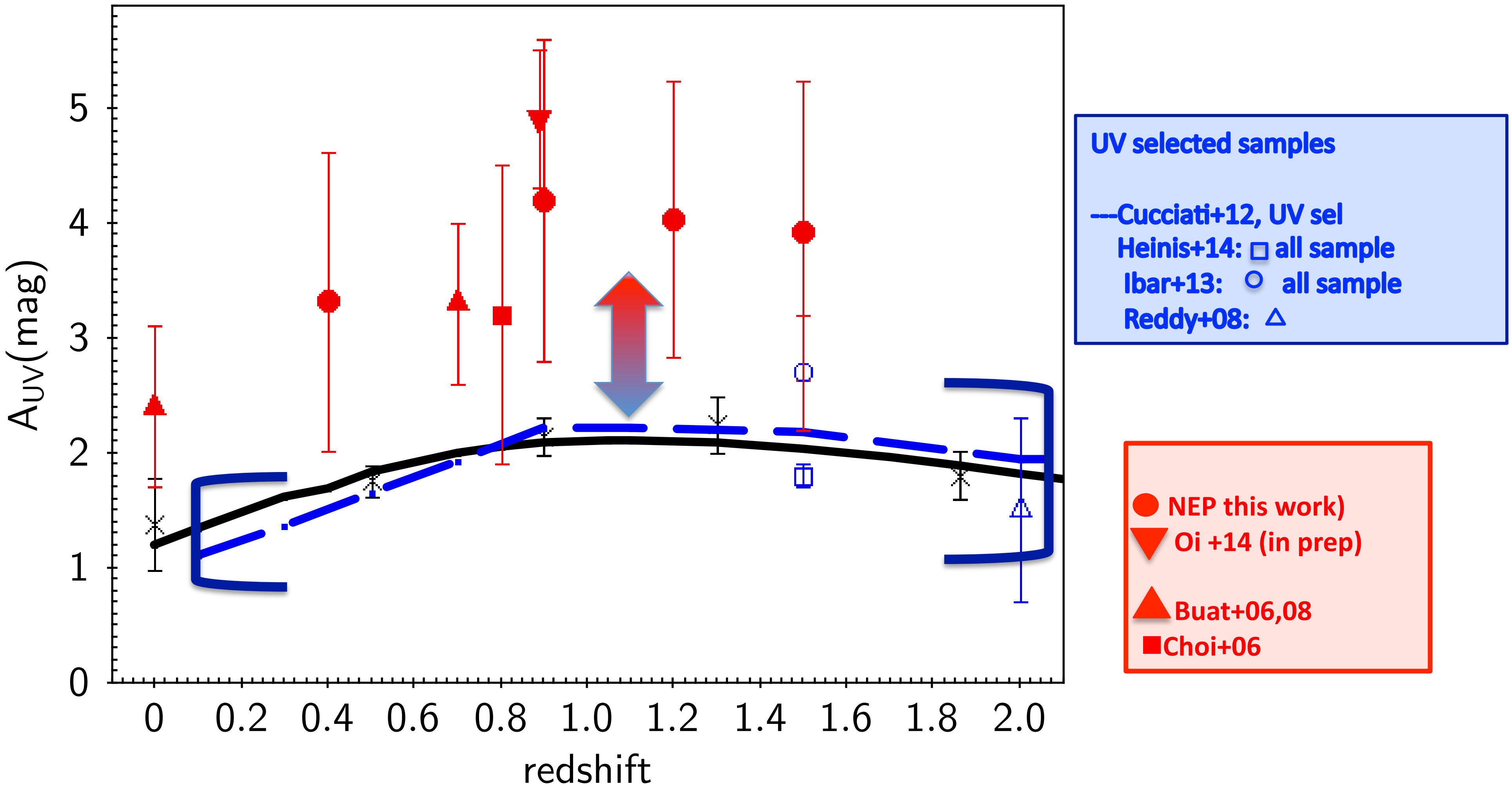




No trend of L_{IR}/L_{UV} with L_{UV}
→The same average L_{IR}/L_{UV}
is measured for any cut in L_{IR}

<A_{UV}> in a UV selection is similar to the average attenuation

Evolution of dust attenuation with z



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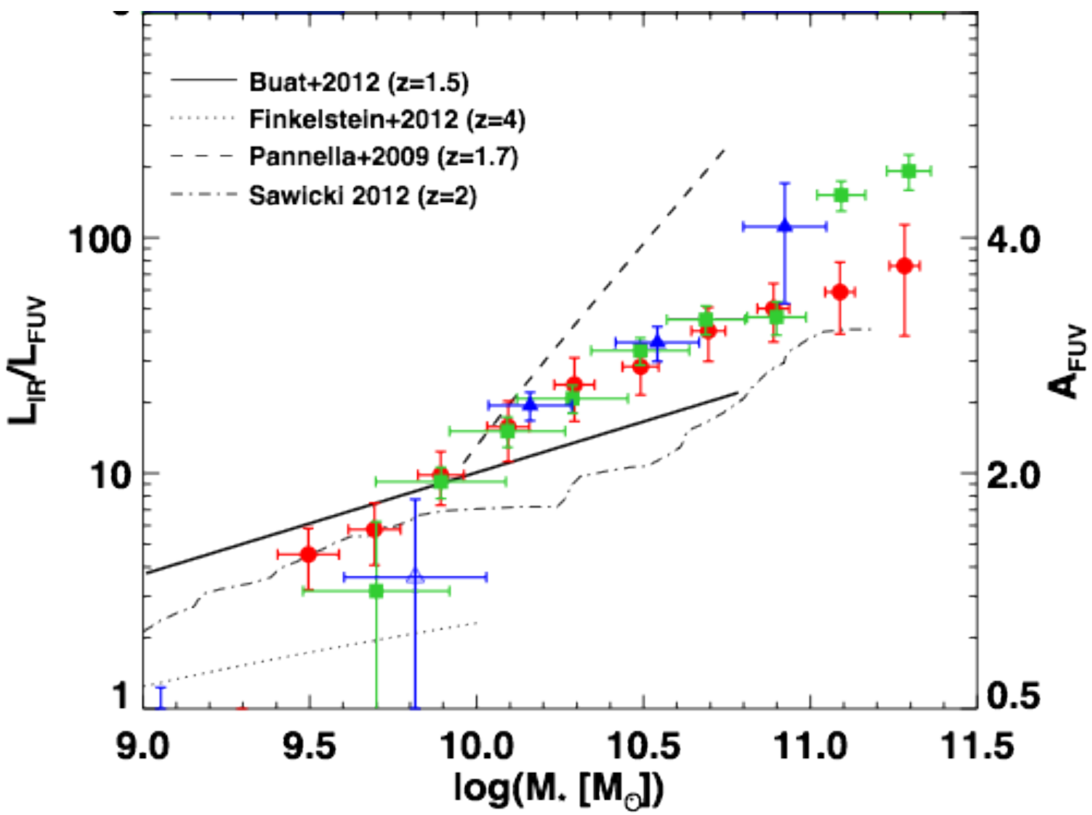
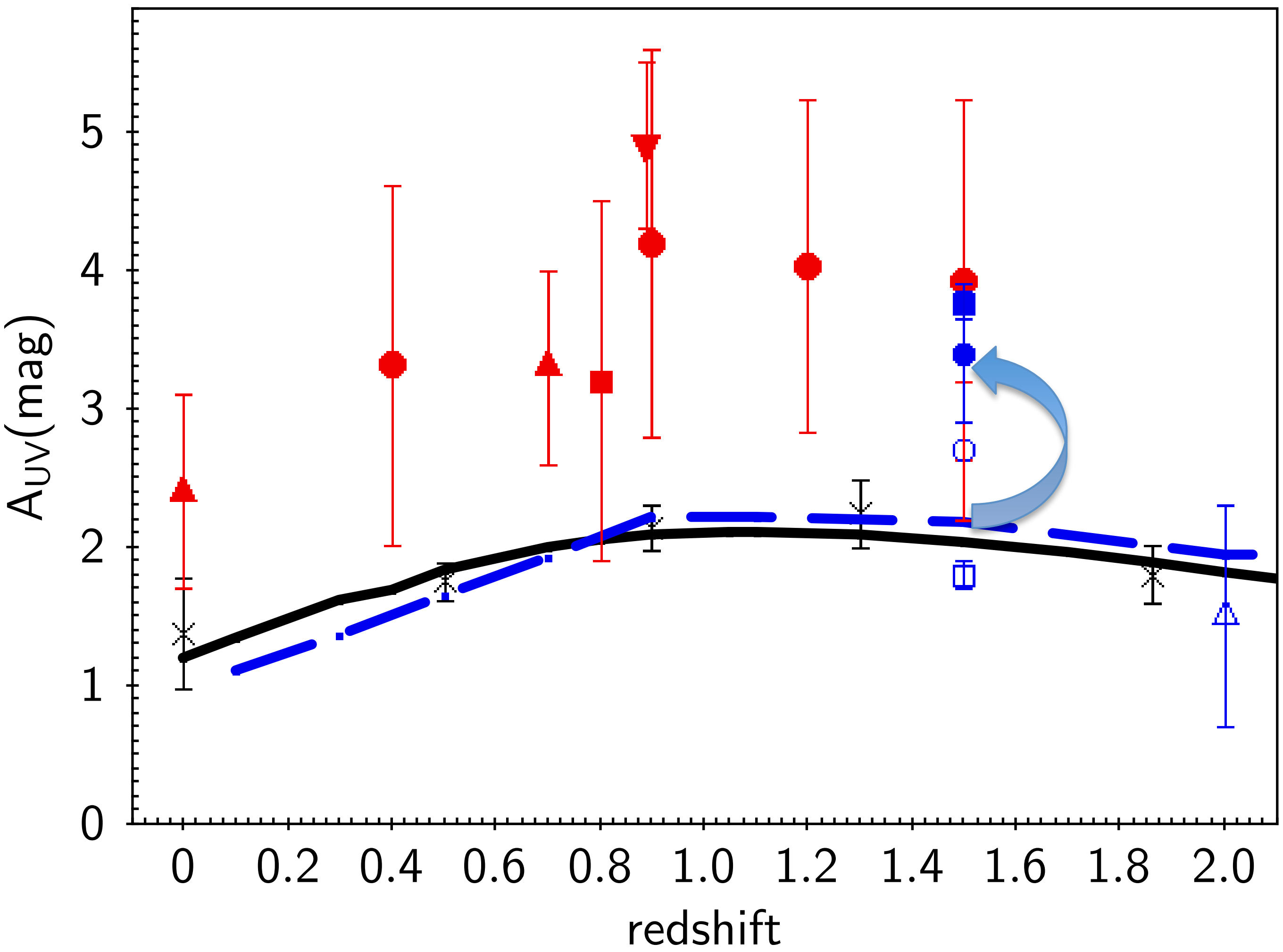


Dust attenuation increases with M_* in a UV selected sample

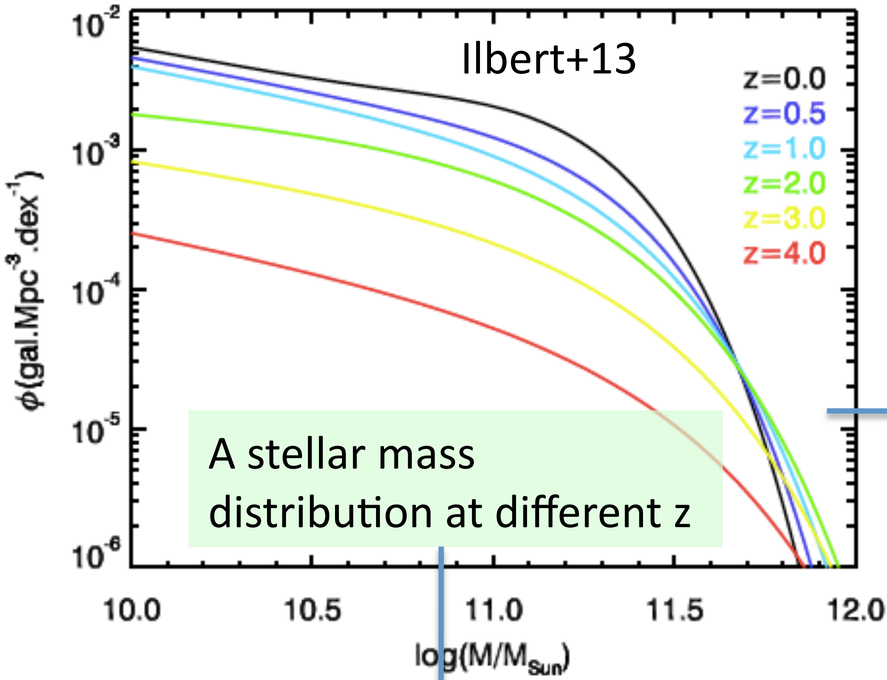
Heinis+14

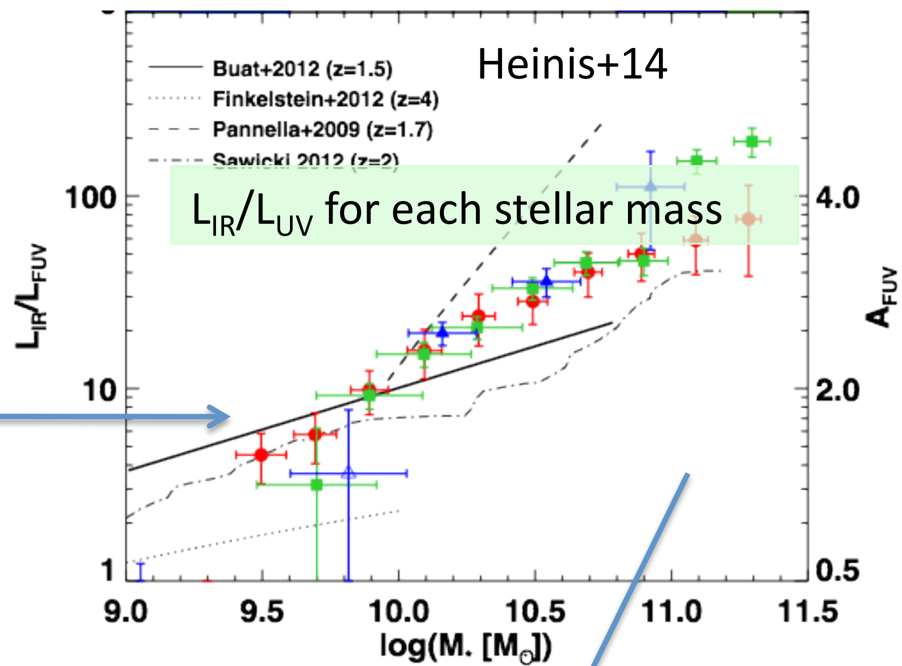
Evolution of dust attenuation with z

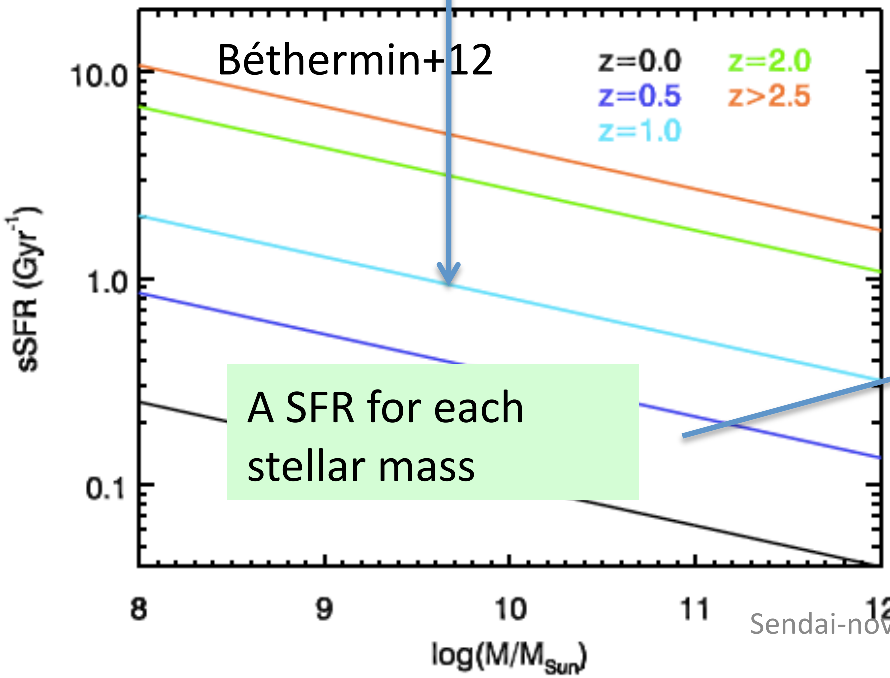


If we select galaxies with the same stellar mass as in the IR selection
→ Similar attenuation

Towards a consistent model?
Bernhard, Béthermin et al. 2014







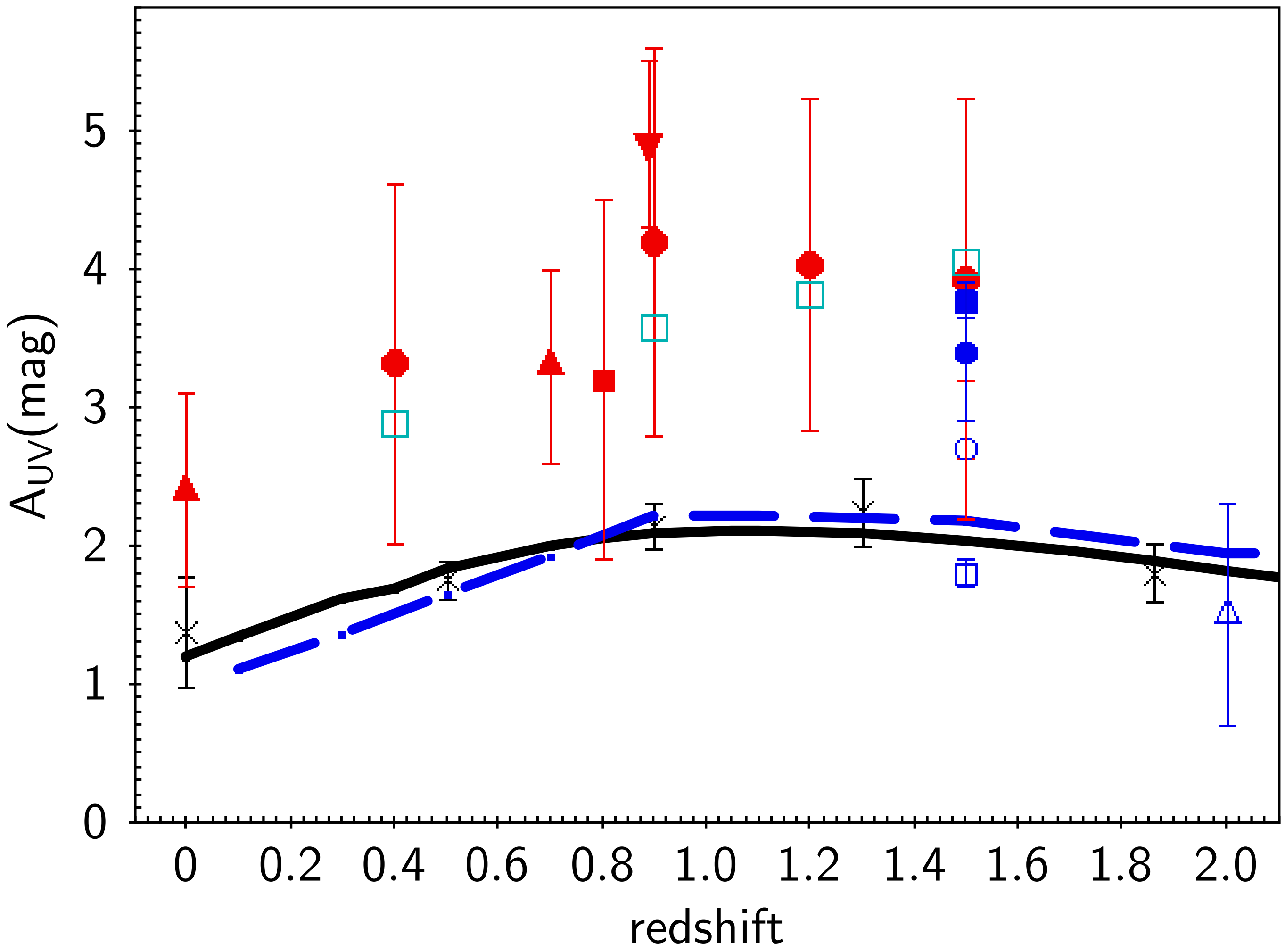
MOCK CATALOGUE

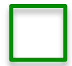
For each $\mathbf{M_{star}}$ at any z

- SFR = SFR(IR)+SFR(UV)
  $= k_{IR}\, \mathbf{L_{IR}} + K_{UV}\, \mathbf{L_{UV}}$
- $\mathbf{L_{IR}/L_{UV}}$

$\rightarrow \mathbf{L_{IR}}$ **&** $\mathbf{L_{UV}}$

Evolution of dust attenuation with z





Model of Bernhard+14

To (quickly) conclude:

We have compared the evolution of dust attenuation globally in the universe, in UV and IR selected samples from z=0 to z~2

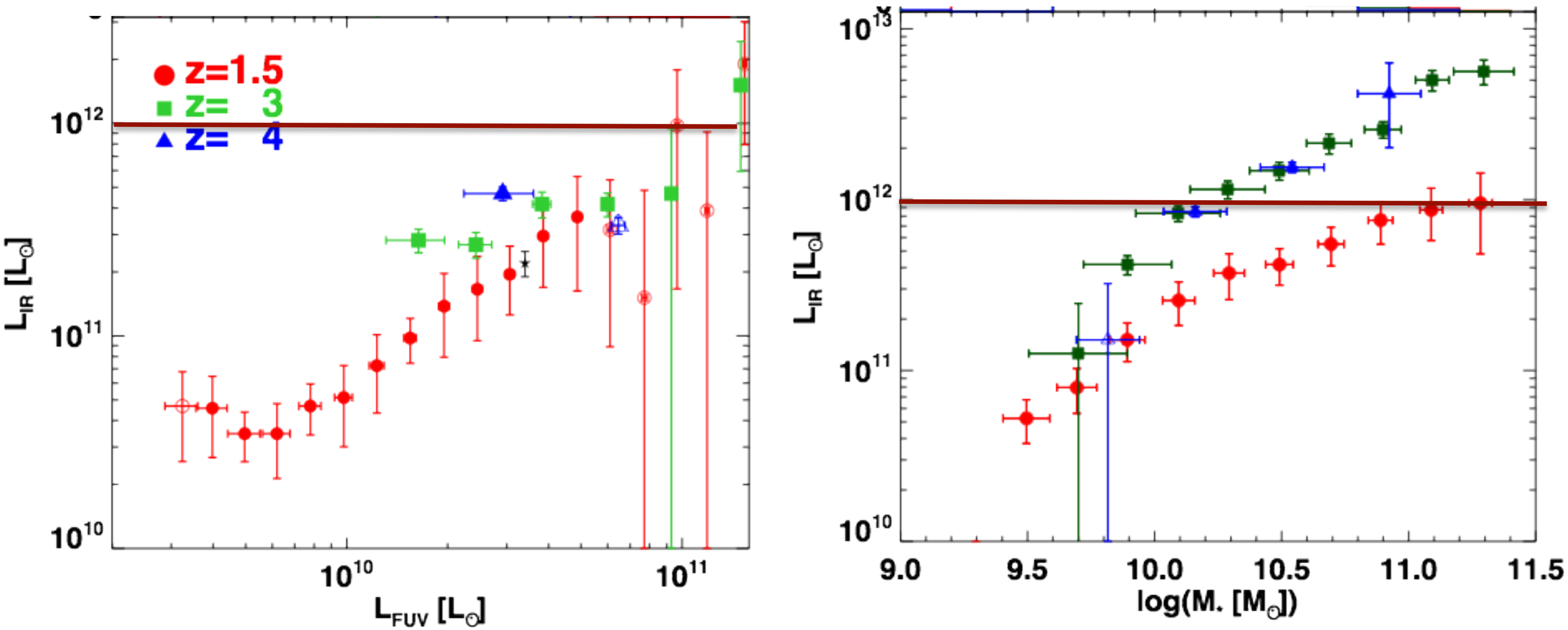
→ Dust attenuation is ~2 mag higher in IR selected galaxies than in average or in a UV selection

→ The stellar mass appears as the main driver for dust attenuation: universal relation between attenuation and stellar mass

IR selected galaxies, dominate the SFR density, they are massive galaxies & more attenuated than the average universe

UV selected galaxies exhibit a large range in stellar mass and exhibit an attenuation similar to that found in average for the universe

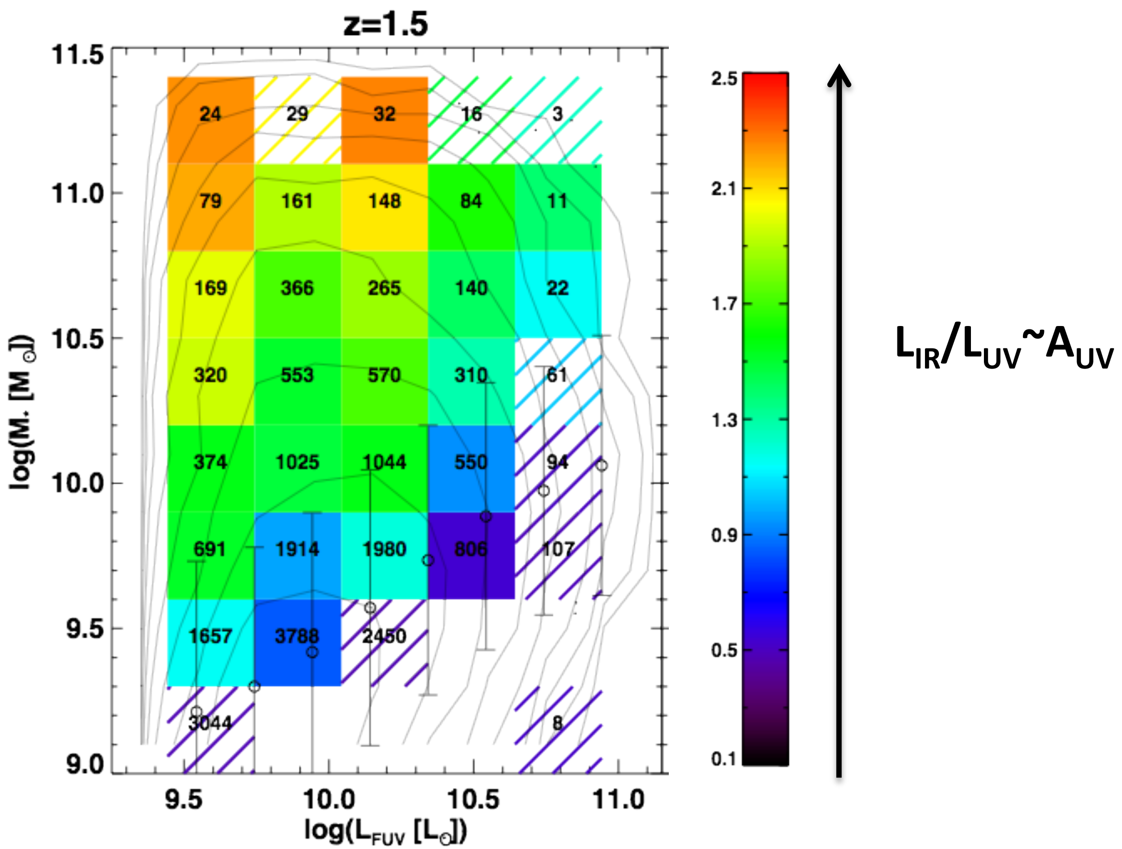
ありがとうございます



Higher IR luminosities are reached when the stacking is performed by bins of M_*

→ **M_* crucial parameter:**

→ **Stacking per bin of (L_{FUV},M_*)**



- **In a bin of L_{UV}: large range of M_***
- **Dust attenuation increases with M_* for a given L_{FUV}**
- **Dust attenuation decreases with L_{FUV} for a given M_***

Heinis+14