Interplay between metallicity and properties of galaxies

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&

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Maud Galametz, Melanie Chevance,
Min-Young Lee

The plan

- *Describe a survey of a large variety of local universe galaxies*
  SF activity, metallicity, morphology….
- *Detailed SED model applied systematically to all galaxies*
- *SED model parameters -> physical properties of galaxies*
- *Gas-to-dust mass ratio (G/D) : a powerful tracer of evolutionay stage of a galaxy*

Local Universe -a zoo of galaxies, including low metallicity dwarf galaxies - convenient labs to study of the evolution of the dust and gas properties

Survey of Dust properties in galaxies: The Sample

DGS : Dwarf Galaxy Survey

Madden et al +13

Remy-Ruyer et al 2013; 2014

48 galaxies

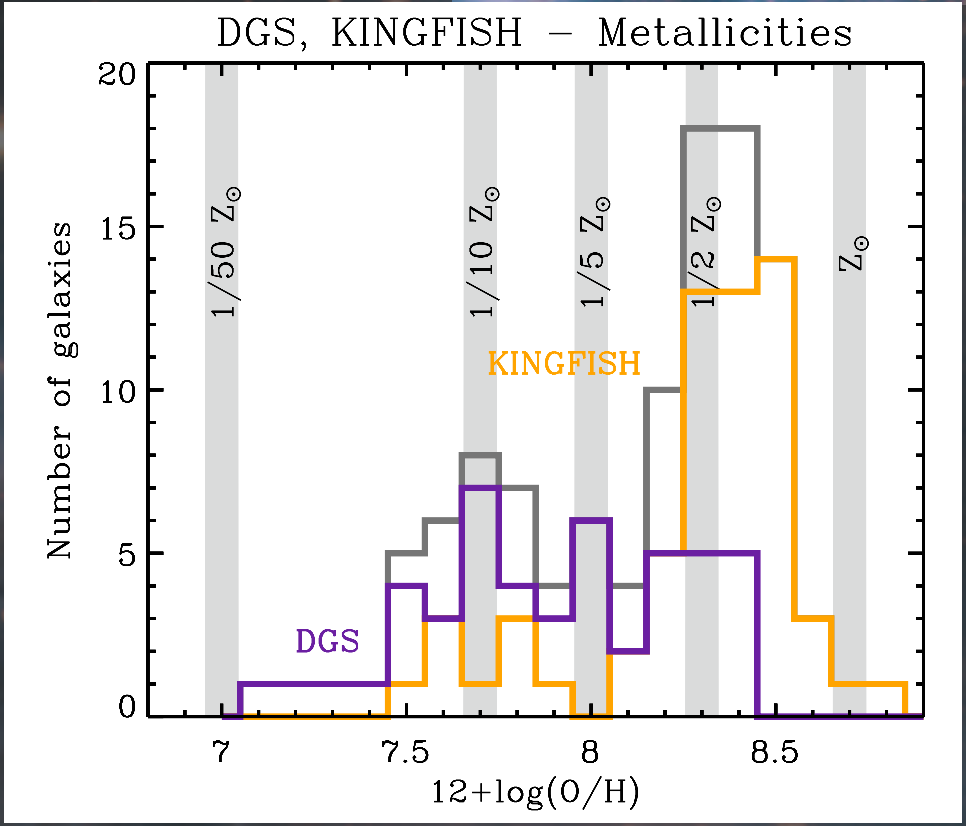
- Low metallicity, star forming, gas-rich dwarf galaxies

KINGFISH

Kennicutt+11, Dale+12

61 galaxies

- More metal-rich systems



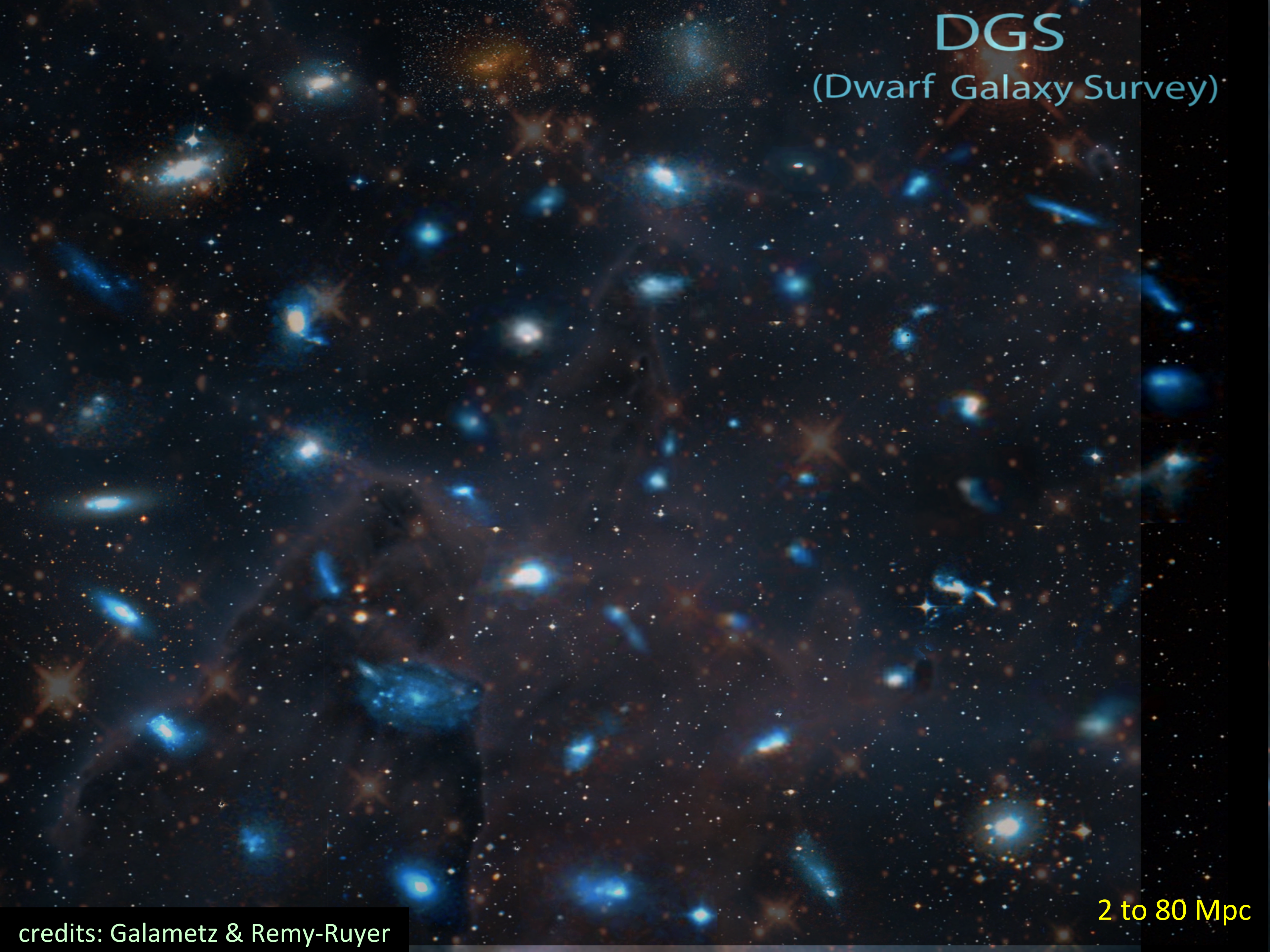
Observed with *Herschel & Spitzer*

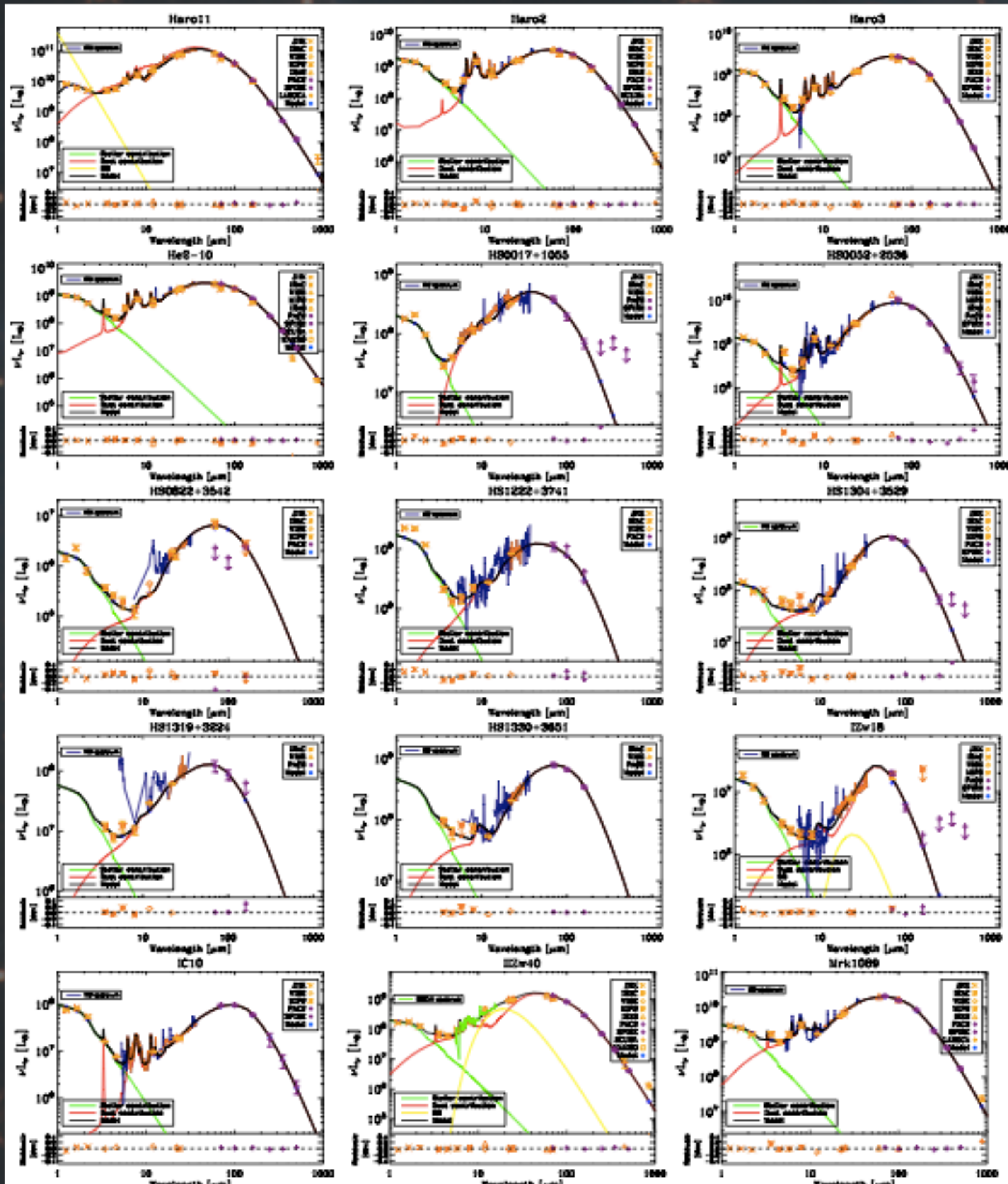
PACS : 70/100/160 µm + spectro

SPIRE : 250/350/500 µm

Diane Cormier's talk

Kingfish (Key Insights on Nearby Galaxies: a Far-Infrared Survey with Herschel)


DGS
(Dwarf Galaxy Survey)
2 to 80 Mpc
credits: Galametz & Remy-Ruyer



Detailed SED modeling of 109 galaxies - systematic.

full IR-submm wavelength range

- Dust SED Model of Galliano+11
- Grain size distribution Zubko+04
- MW dust: graphite, Silicate and PAHs

Rémy-Ruyer et al. in prep

SED characterization to galactic properties

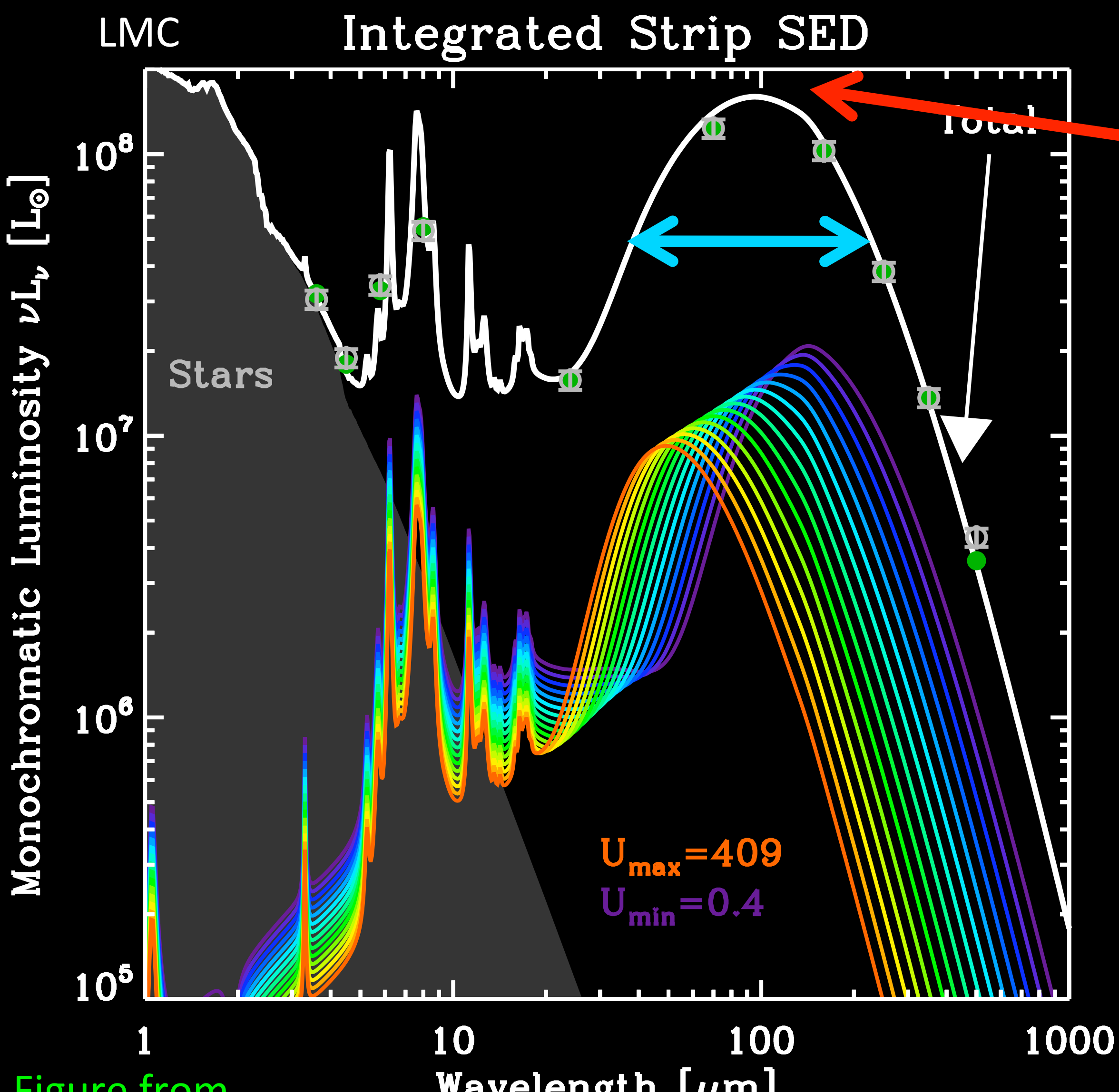


Figure from Galliano+11

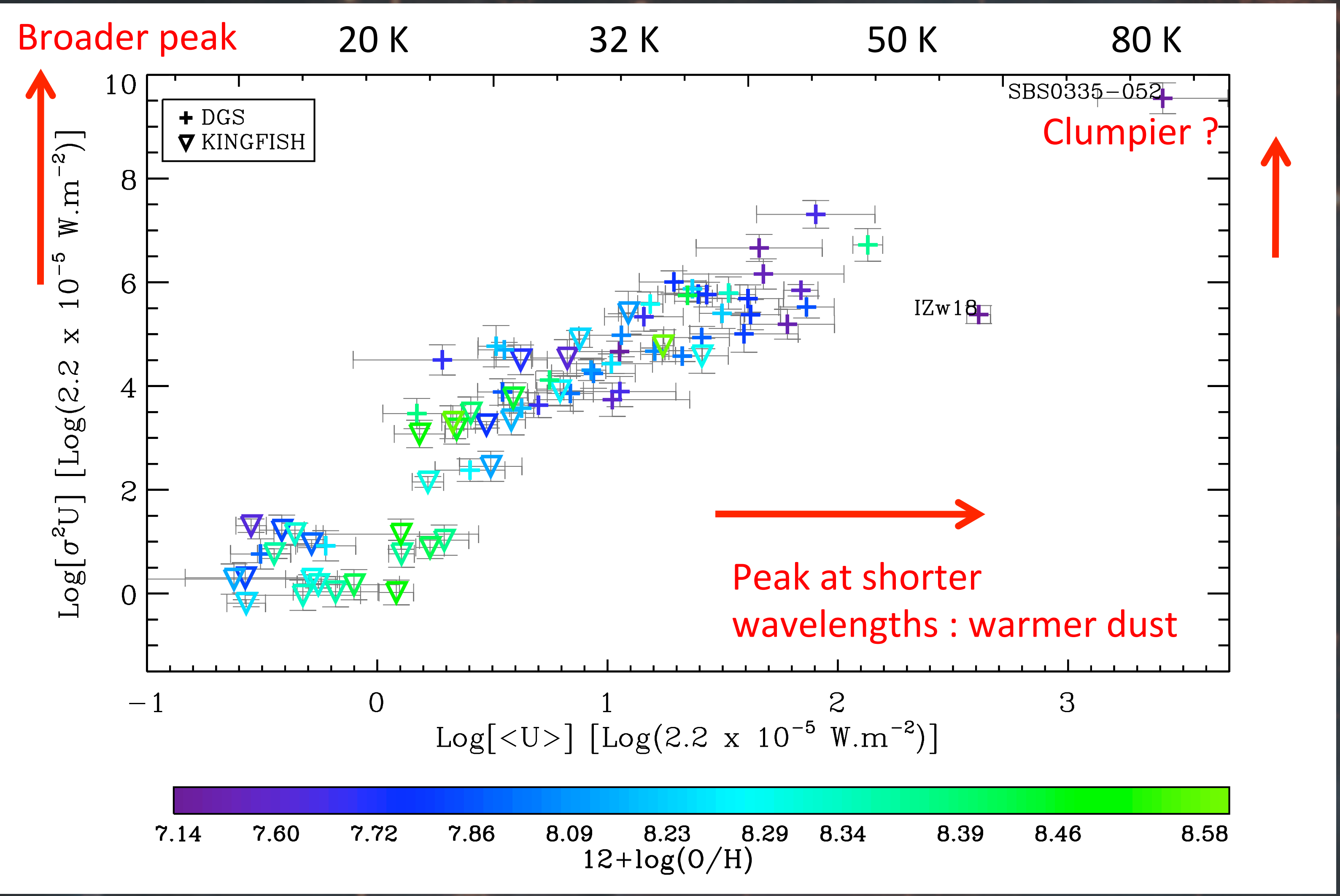
Position of the peak given by the average starlight intensity **<U>**

Width of the peak given by **σ^2U**

(dispersion in the staright intensity distribution)

*Can get high **σ^2U** With wide range of clumps in beam, for example*

Dust temperature distribution: Metallicity



<U> can be transformed into a characteristic dust grain temperature

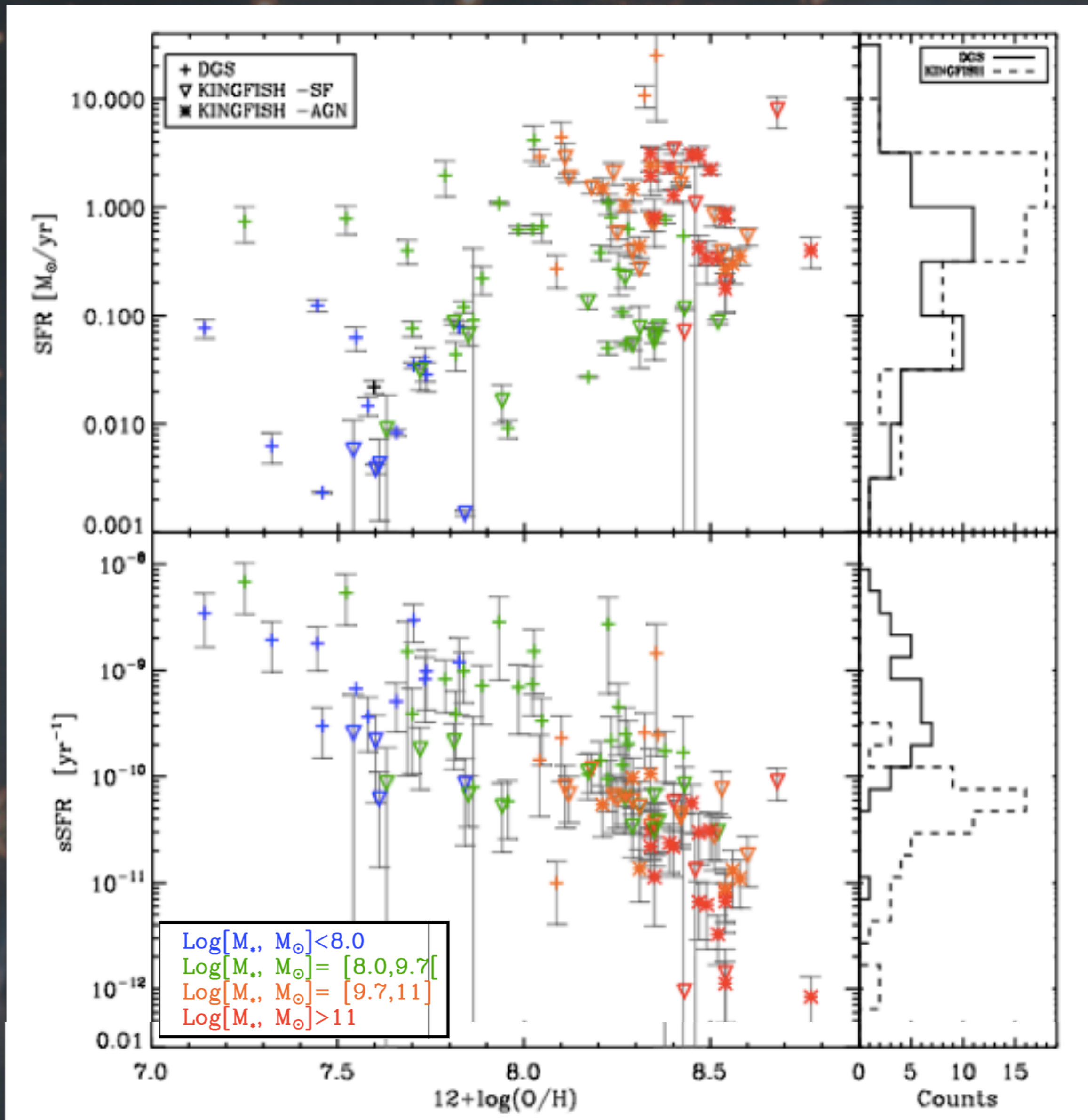
$\langle T_{DGS} \rangle \sim 30$ K

$\langle T_{KF} \rangle \sim 20$ K

- Dwarf galaxies have warmer dust and a broader range in dust temperature.
- KINFGISH galaxies have a colder and narrower SEDs

Rémy-Ruyer et al. in prep

SFR and sSFR and Metallicity



SFR
Composite:
Halpha corrected for attenuation with L_{TIR},
Kennicutt et al. (2009)

sSFR
M* Eskew +(2012)
irac 3.6 + 4.5 mu

Correlation sSFR & Z
Speafman rank c
Correlation coeff : -0.77

Rémy-Ruyer et al. in prep

What is controlling the SED shape?

<U> (position of peak) and σ^2U (peak width)

Spearman Rank Correlation Coefficients

Param	12+log(O/H)	$\langle U \rangle$	$\sigma^2 U$	sSFR	M_{star}
M_{dust}	0.76	-0.53	-0.56	-0.70	0.91
M_{dust}/M_{star}	-0.004	-0.60	-0.39	-0.03	-0.10
L_{TIR}	0.63	-0.02	-0.10	-0.40	0.86
f_{PAH}	0.61	-0.41	-0.50	-0.75	0.68
$\langle U \rangle$	-0.46	1.00	0.87	0.68	-0.34
$\sigma^2 U$	-0.54	0.87	1.00	0.76	-0.46
SFR	0.46	0.11	0.05	-0.14	0.70
sSFR	-0.77	0.68	0.76	1.00	-0.76
M_{star}	0.83	-0.34	-0.46	-0.76	1.00

Rémy-Ruyer et al. in prep

Z not strong correlation **<U>** (position of peak) and **σ^2U** (peak width)
sSFR correlates with **<U>** (position of peak) and **σ^2U** (peak width)

I.

The lowest metallicity galaxies in local universe

SBS0335-052

Z~ 2.3% Zsolar

D=58 Mpc
>10 000 stars in
6 (<50 pc) SSCs
n_e ~600 – 2000 cm-3
SFR~ 1 Mo/yr

Dense, compact,
More active SF regions

IZw18

Z~ 2% Zsolar

D=10 Mpc
1100 stars in 2 clusters
No SSCs
n_e ~100 cm-3
SFR ~ 0.4-0.1 Mo/yr

Diffuse, passive, low n
SF regions

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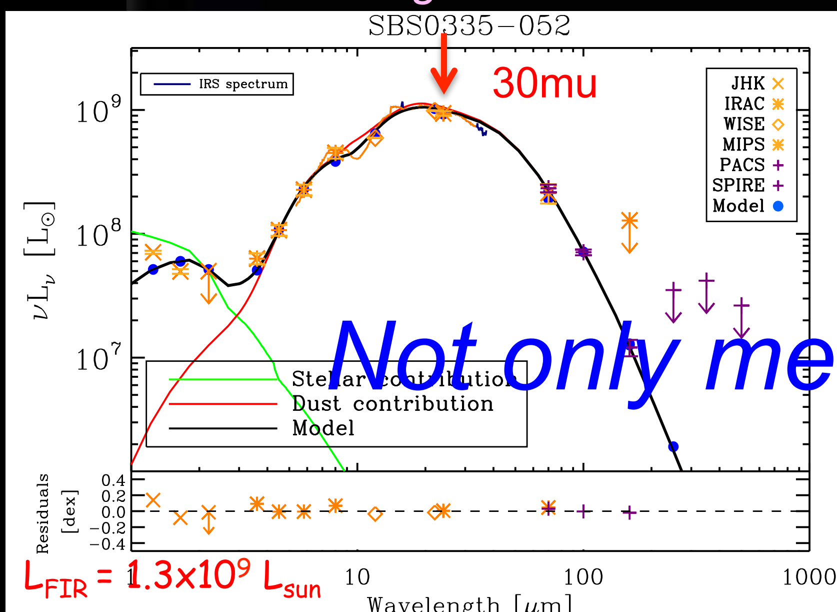
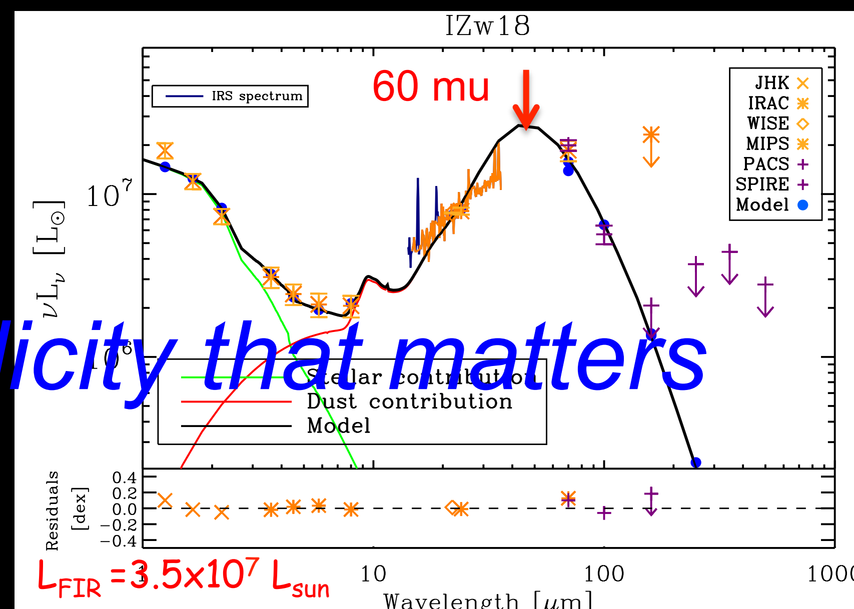
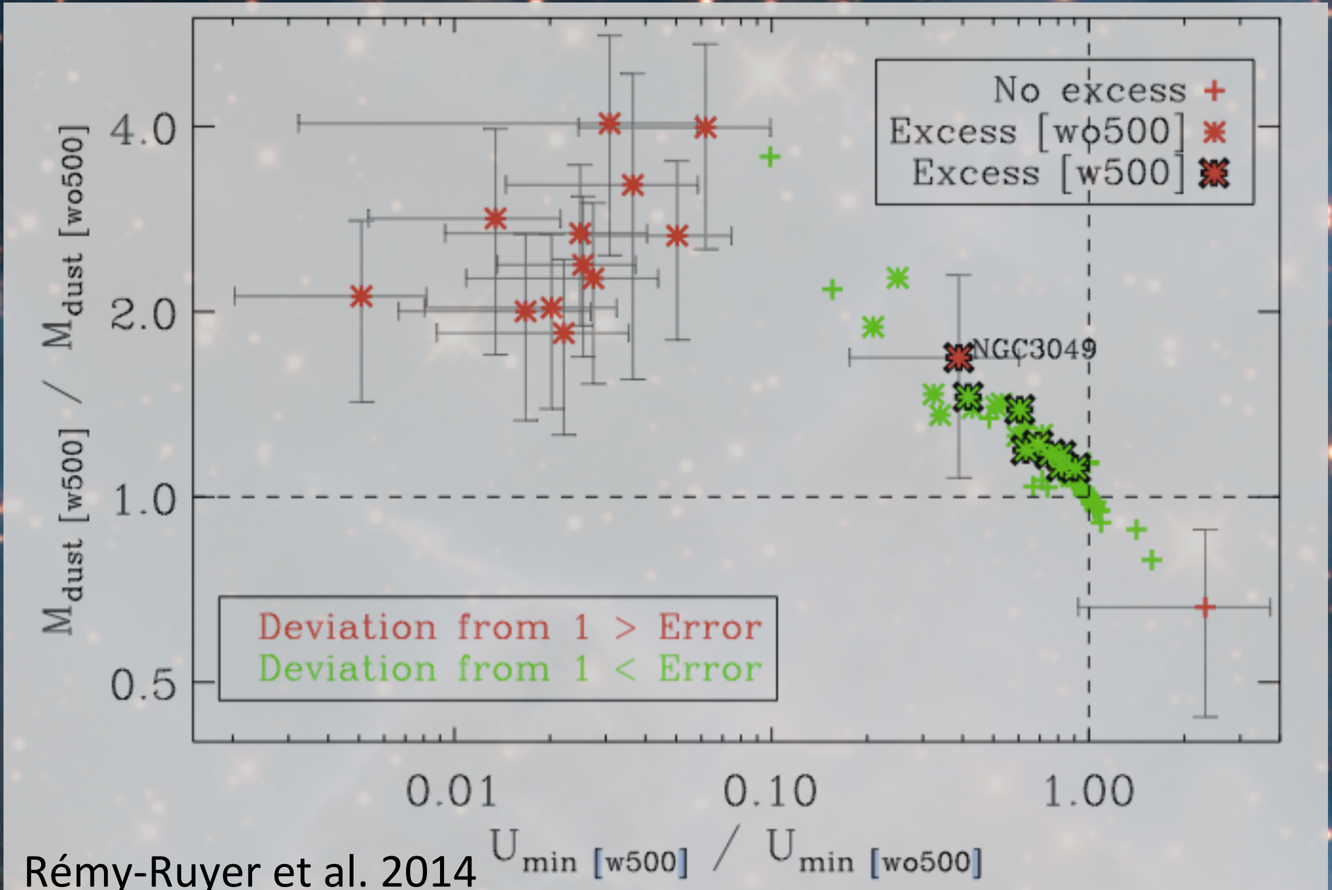




Not only metallicity that matters

Submmm excess ?



Rémy-Ruyer et al. 2014

- 500mu excess : the residual at 500 µm > its error bar
- Include (or not) 500mu point ?
- Conclusion:
- 8 galaxies show excess when using the 500mu point &
  dust masses are not effected with or without 500mu

G/D vs Z: Observed relation

Atomic gas mass : HI

Molecular gas mass : H2, use $X_{CO,Z}$ from Schruba+12

Same « strong line » method for the whole sample

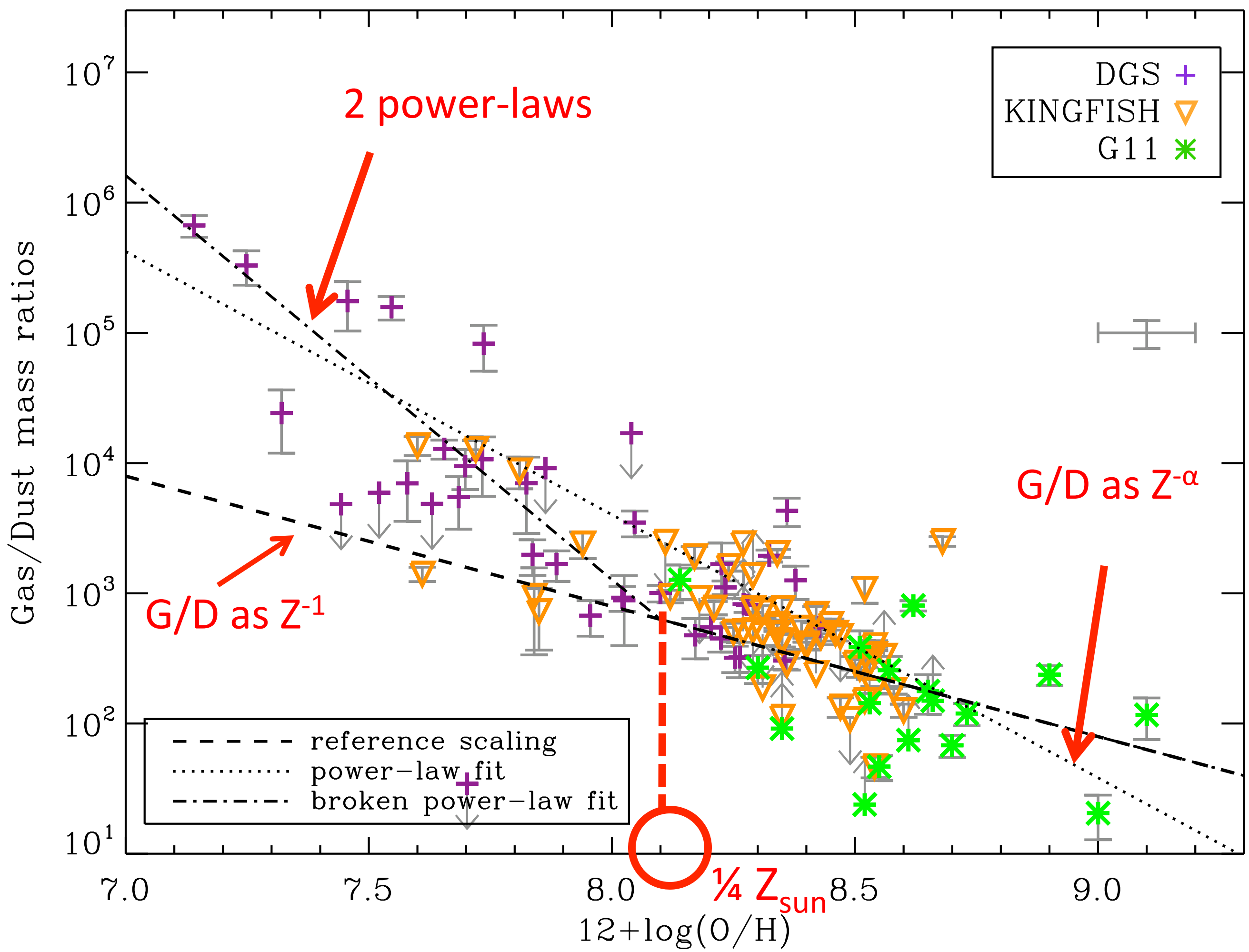
$\frac{G}{D}$ as a function of metallicity

From dust model

Sample : DGS, KINGFISH, and Galametz+11

G/D vs Z: Empirical relations

Rémy-Ruyer+14



- ➢ Trend with Z
- ➢ Large scatter

- Power law : G/D as $Z^{-\alpha}$
- ➢ Get α = 2.0 ± 0.3

- 2 power laws : G/D as $Z^{-\alpha L}$ at low metallicities
- ➢ Get αL = 3.1 ± 1.3
- ➢ Transition at 12+log(O/H) = 8.10

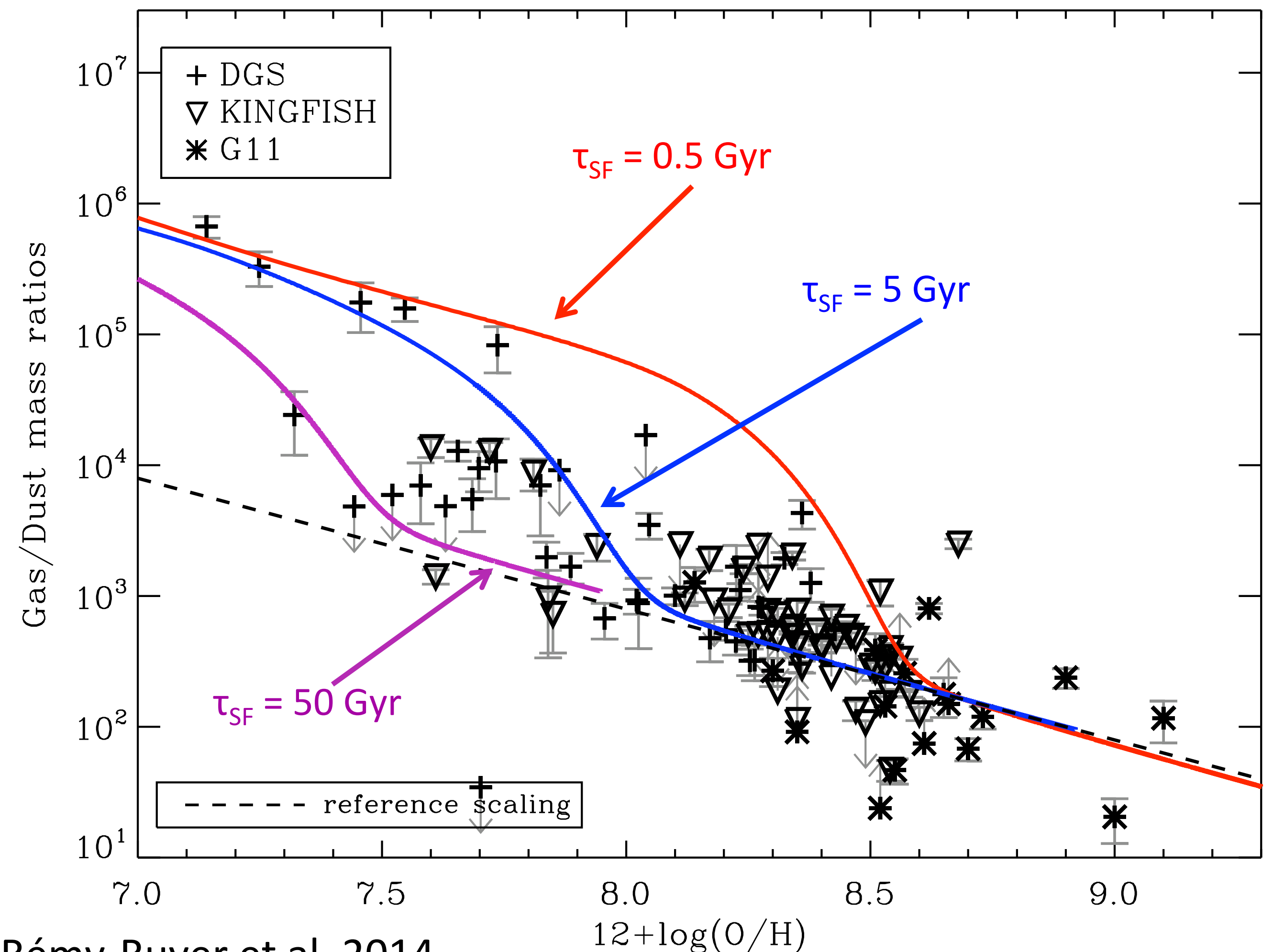
Less dust from the available metals in low-Z ISMs

➢ why is grain formation less efficient ?

Rémy-Ruyer et al. 2014

G/D vs Z: Chemical evolution models

Rémy-Ruyer+14



Rémy-Ruyer et al. 2014

- Chemical evolution model by Asano+13
- « Critical » metallicity over which dust growth is the main process in the dust mass evolution
- Depend on the star formation timescale

➢ Dust growth in the ISM is fundamental (also Zhukovska et al 2014)

➢ Scatter can be explained if you account for the different star formation histories of the sources

Summary

- Dust temperature, SF, metallicities:
  - Warmer dust, larger range of dust temperatures in low Z
  - Joint effect of low-metallicity and high star-formation activity
  - Wide spread in SFR but sSFR anticorrelated with Z - high in low metallicity galaxies
- Dust Mass and Gas/Dust mass ratios
  - Strong NON LINEAR metallicity evolution
  - Metals incororated into dust less efficiently until grain-growth has improved efficiency (Z~1/4)
  - Large scatter can be explained with different star formation histories
  - New empirical relation to estimate the G/D from metallicities

•*Caution going from dust mass to total gas mass – large variations.*