The Local Universe: From DustPedia with Herschel to PRIMA

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Dusting of the Secrets of the Cosmos with PRIMA Space IR Telescope
Marseille (France), 31 March – 2 April 2025

DustPedia - A Definitive Study of Cosmic Dust in the Local Universe (FP7-SPACE proj. 606847)

PI: Jon Davies. 6 European nodes

A legacy database of 875 galaxies observed by *Herschel* (HRS, KINGFISH, HeViCS…).

D_{25}> 1′, distance < 40 Mpc, multi-λ coverage from UV to submm (up to 42 bands/ galaxy)

DustPedia Database:
http://dustpedia.astro.noa.gr/

Davies et al. (2017)

Clark et al. (2018)

DustPedia selection criteria

- All galaxies observed by *Herschel*
- Distance < 40 Mpc
- D_{25} >1’
- WISE 3.4 μm S/N > 5

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  High stellar mass

The 875 DustPedia galaxies and other *Herschel* samples

- HeViCS: central ~84 deg^2 of the Virgo Cluster, Davies et al. 2010): 221 in DustPedia
- ~25% DustPedia galaxies in Virgo cluster, ~ 5% in Fornax
- 323 HRS galaxies (Boselli+2010): 288 in DustPedia
- 61 KINGFISH galaxies (Kennicutt+2011): 56 in DustPedia

DustPedia is a large sample of large local galaxies, including other samples

For DustPedia galaxies, there is a lot of information in other bands (including CO and HI, De Vis+19, Casasola+20,+22)

Table 2
Numbers of Galaxies of Different Morphological Types in the *Herschel* Sample

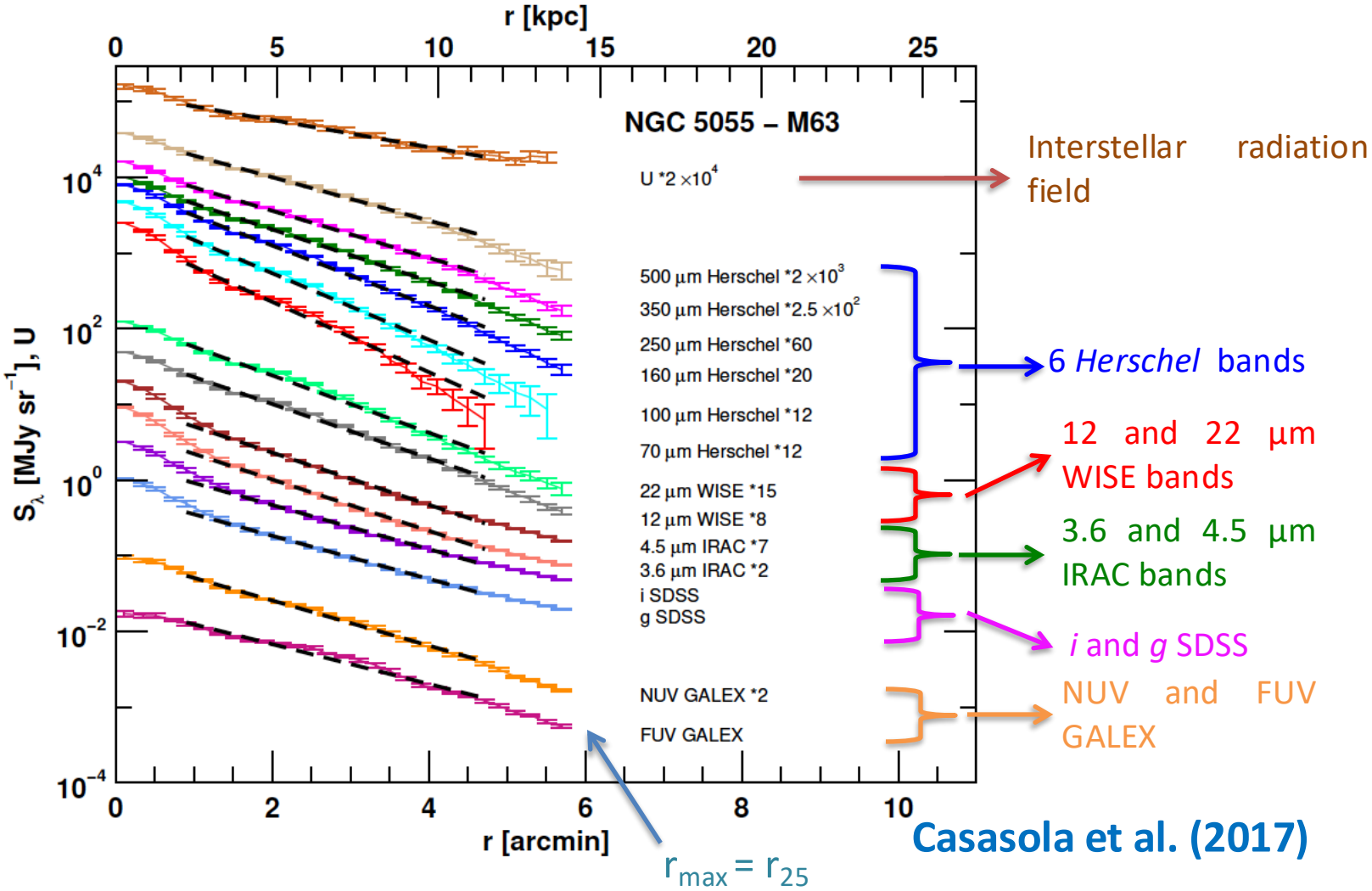
Type	Number
Early ($T \leqslant -4$)	72
S0 ($-4 < T \leqslant 0$)	203
Spiral ($0 < T \leqslant 7$)	433
Irr/dwarf ($7 < T$)	159

The DustPedia sample is dominated by late-type galaxies

Herschel traced the cold dust (T~15-30 K)
and the bulk of dust mass in DustPedia galaxies

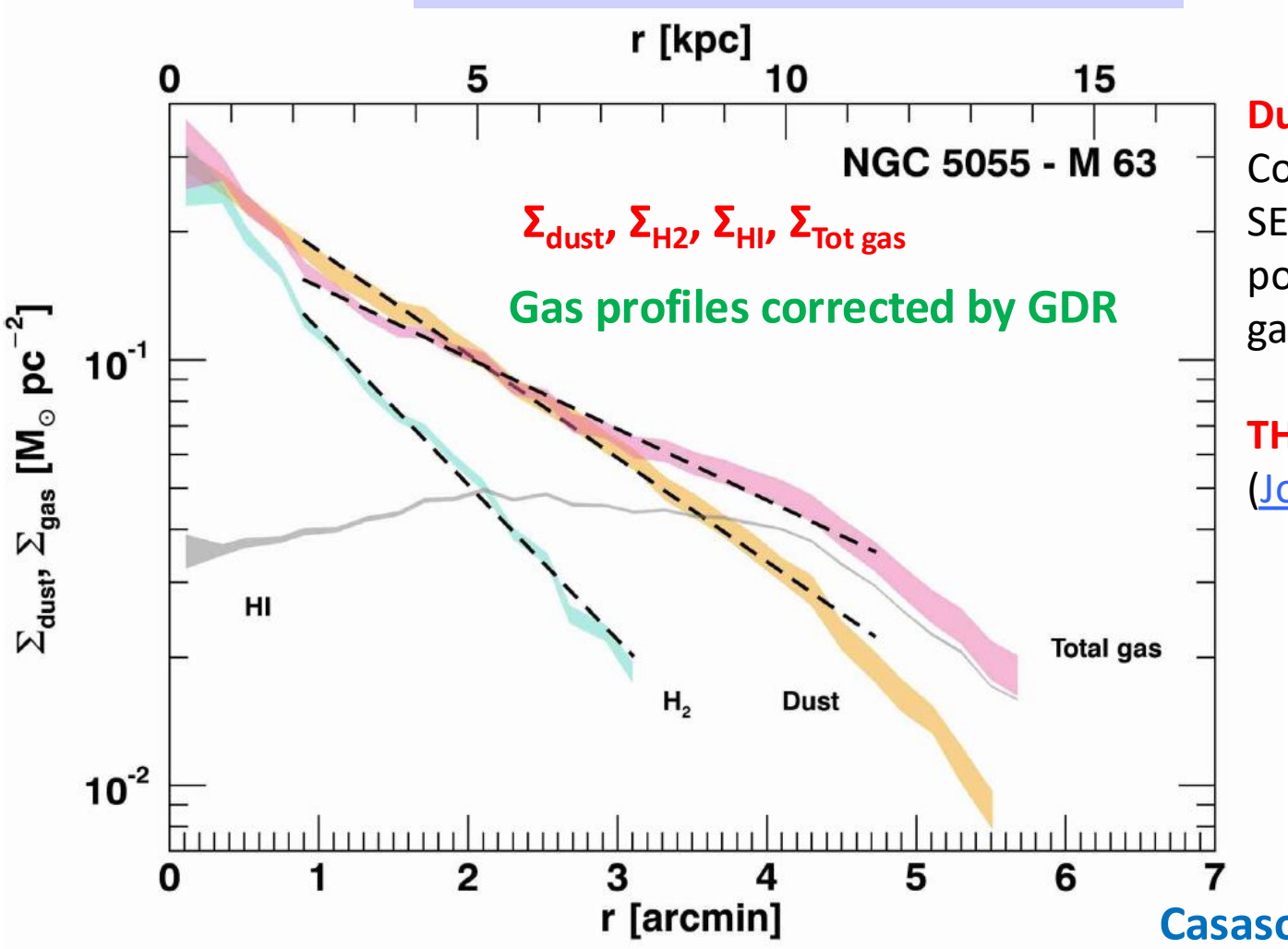
Radial distribution of dust, stars, gas and SFR in DustPedia face-on galaxies

Surface brightness and *U*: Typical plot



Radial distribution of dust, stars, gas and SFR in DustPedia face-on galaxies

Dust and Gas Masses: Typical plot



Dust mass:
Comparing a modelled SED with data at each position within a galaxy

THEMIS dust model (Jones+13, Jones+17)

Casasola et al. (2017)

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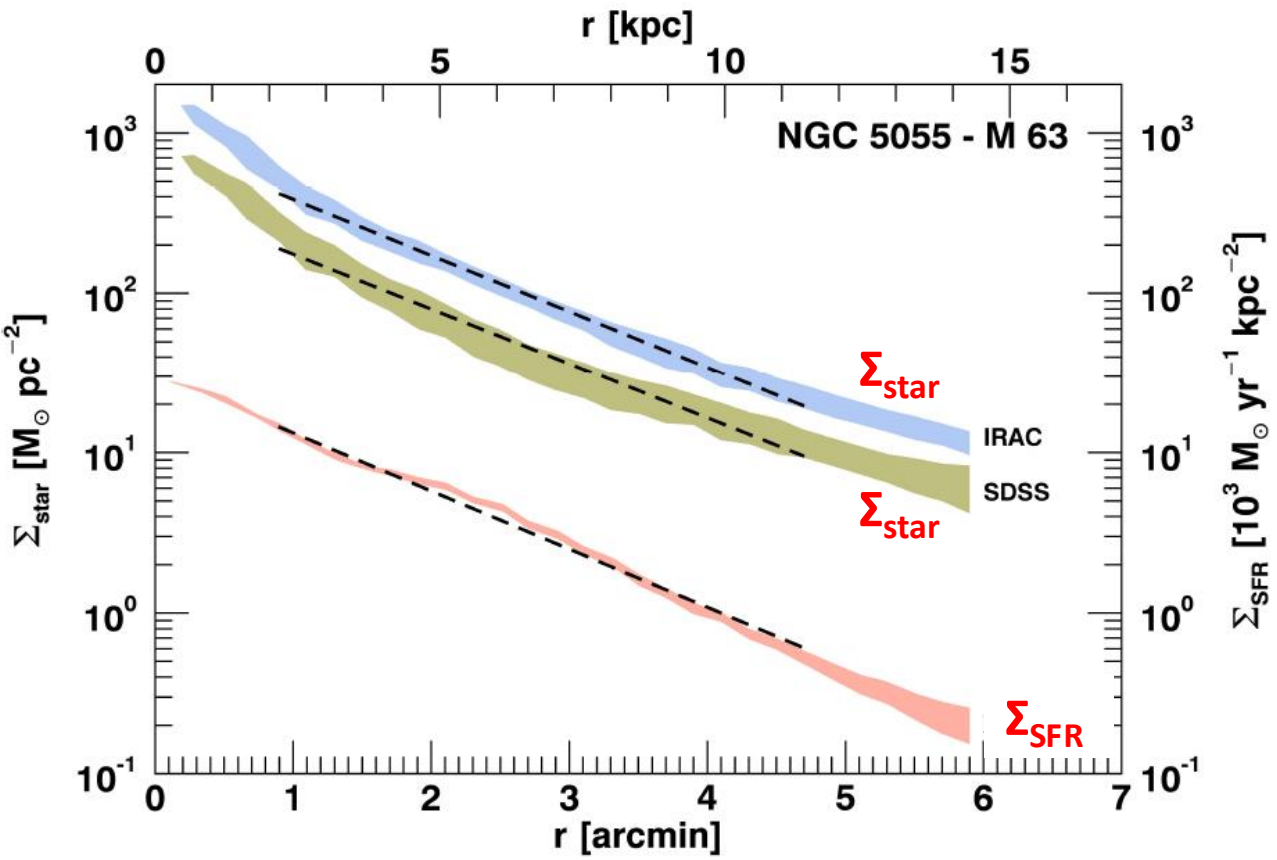
Stellar Mass and SFR: Typical plot



Stellar mass:

- IRAC 3.6 and 4.5 µm
- SDSS & SING optical

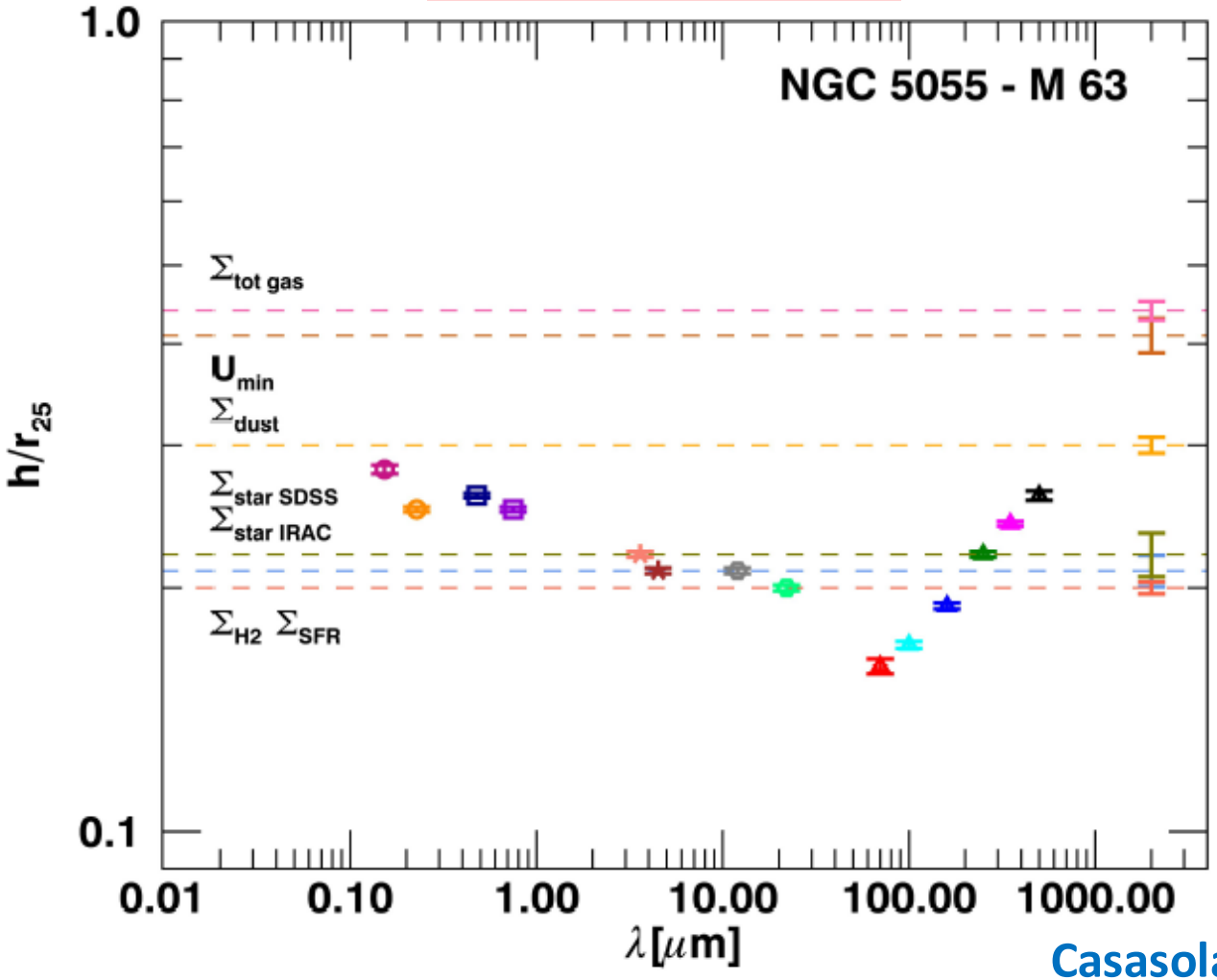
SFR:

GALEX-FUV + WISE-22 µm

Casasola et al. (2017)

Radial distribution of dust, stars, gas and SFR in DustPedia face-on galaxies

Scale-length vs. λ



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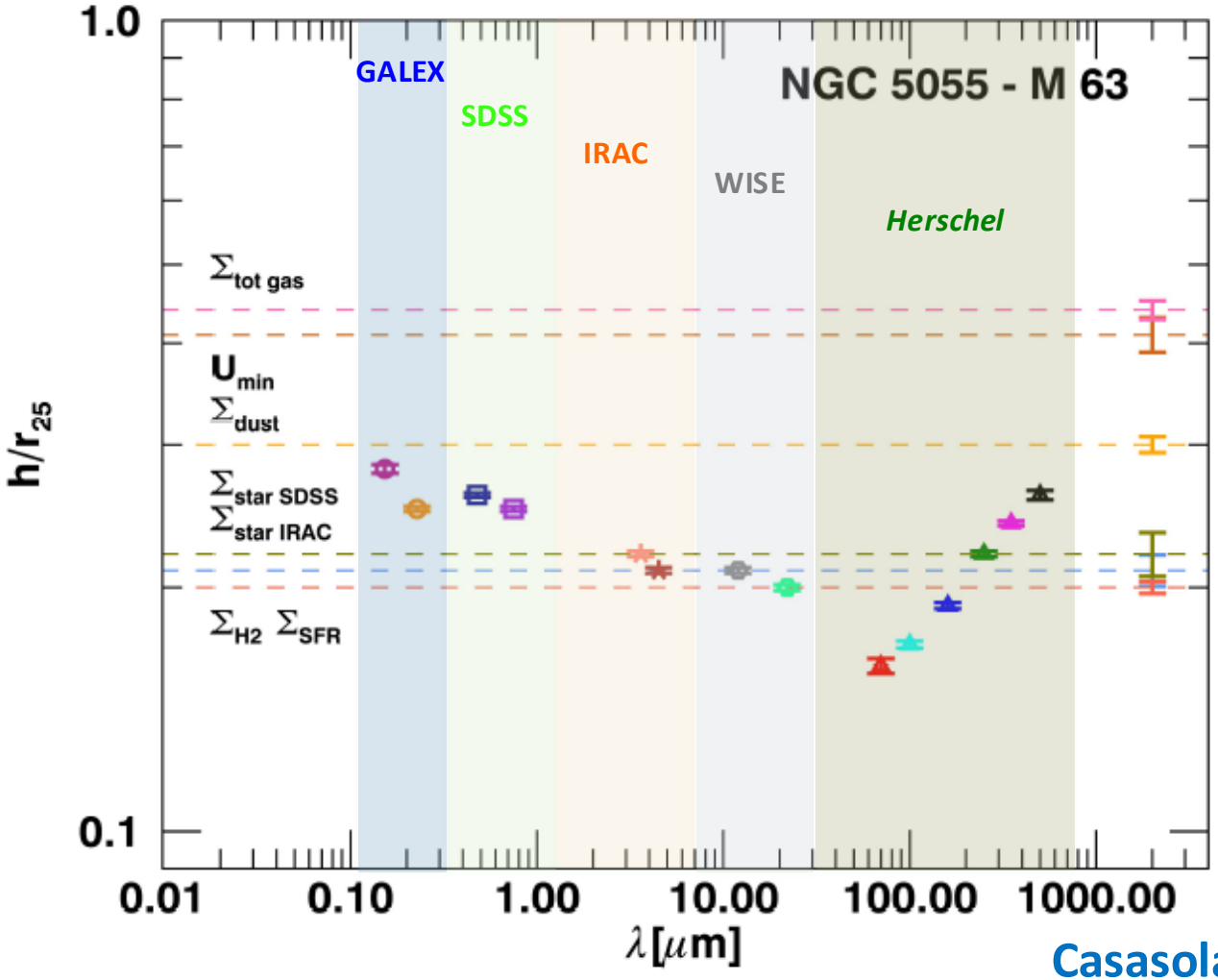

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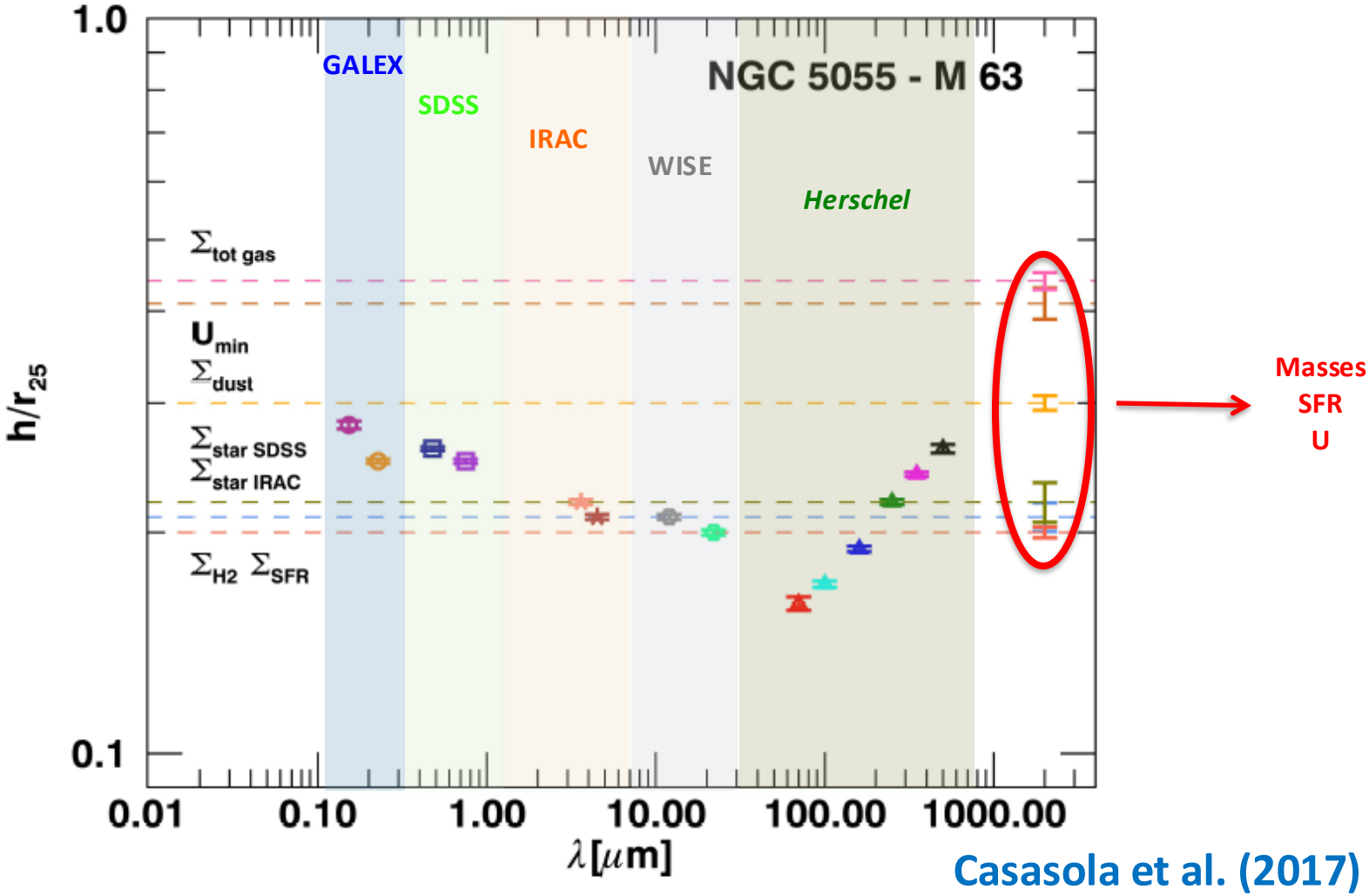

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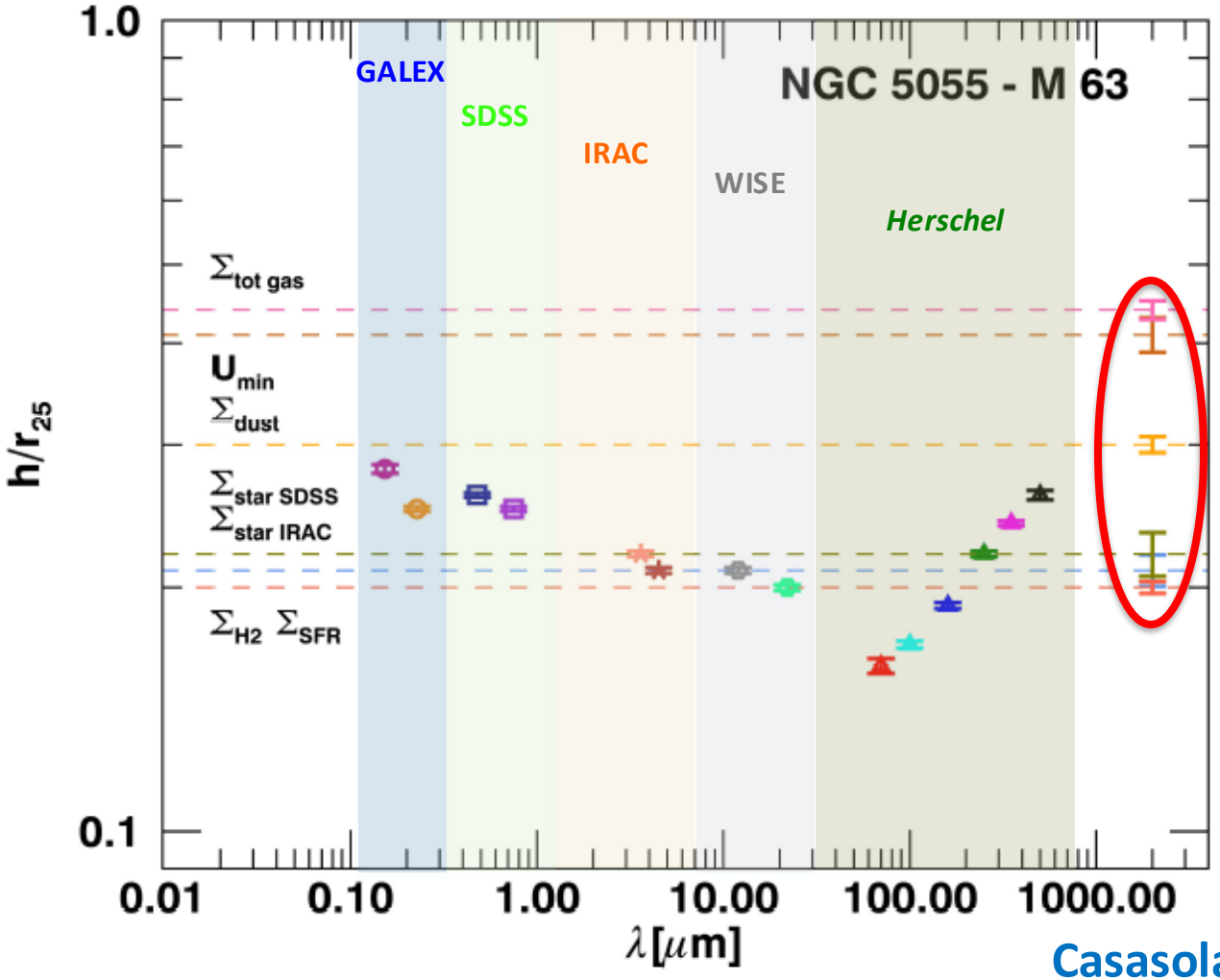

Each galaxy has its own peculiar behavior

Masses
SFR
U

Casasola et al. (2017)

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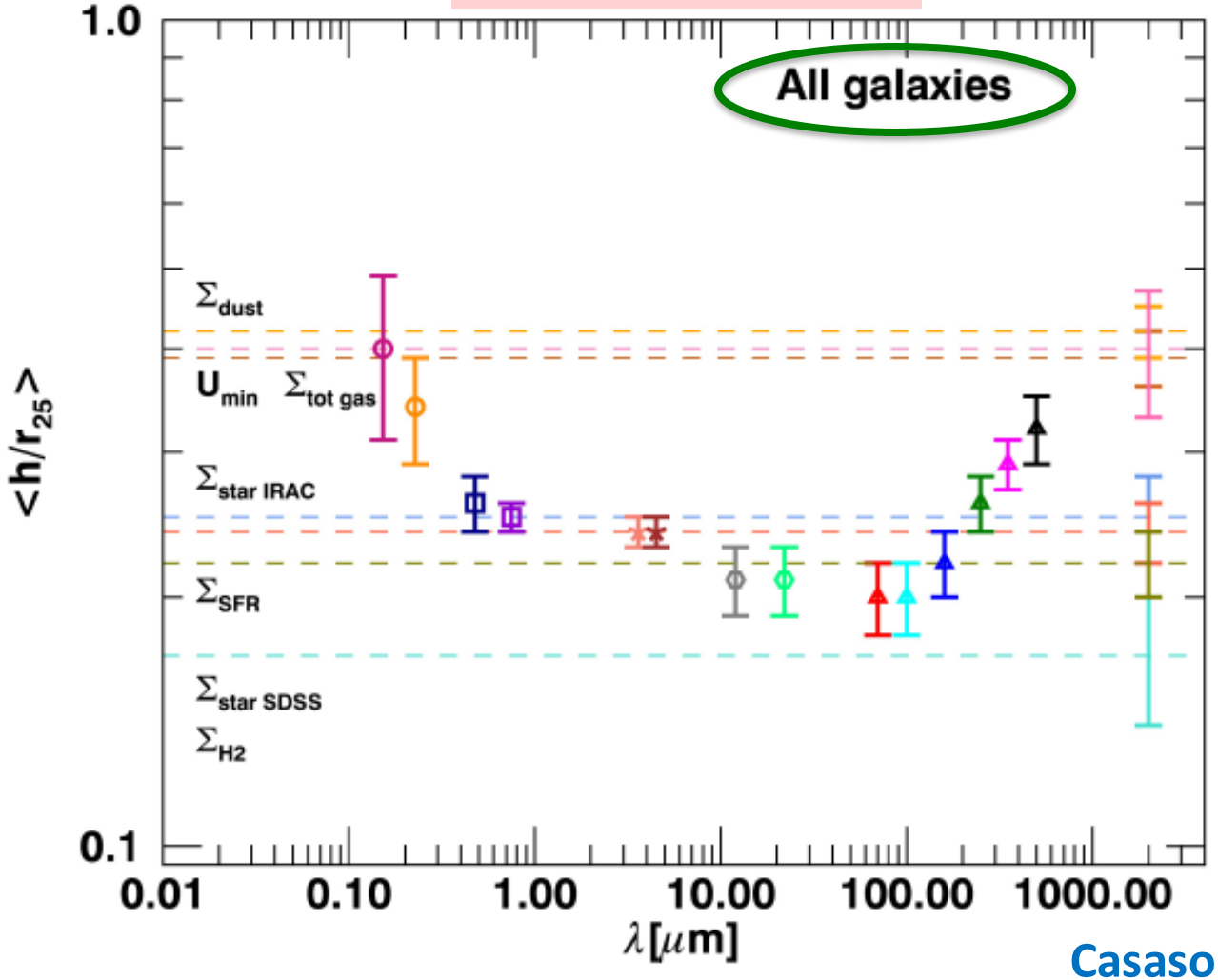

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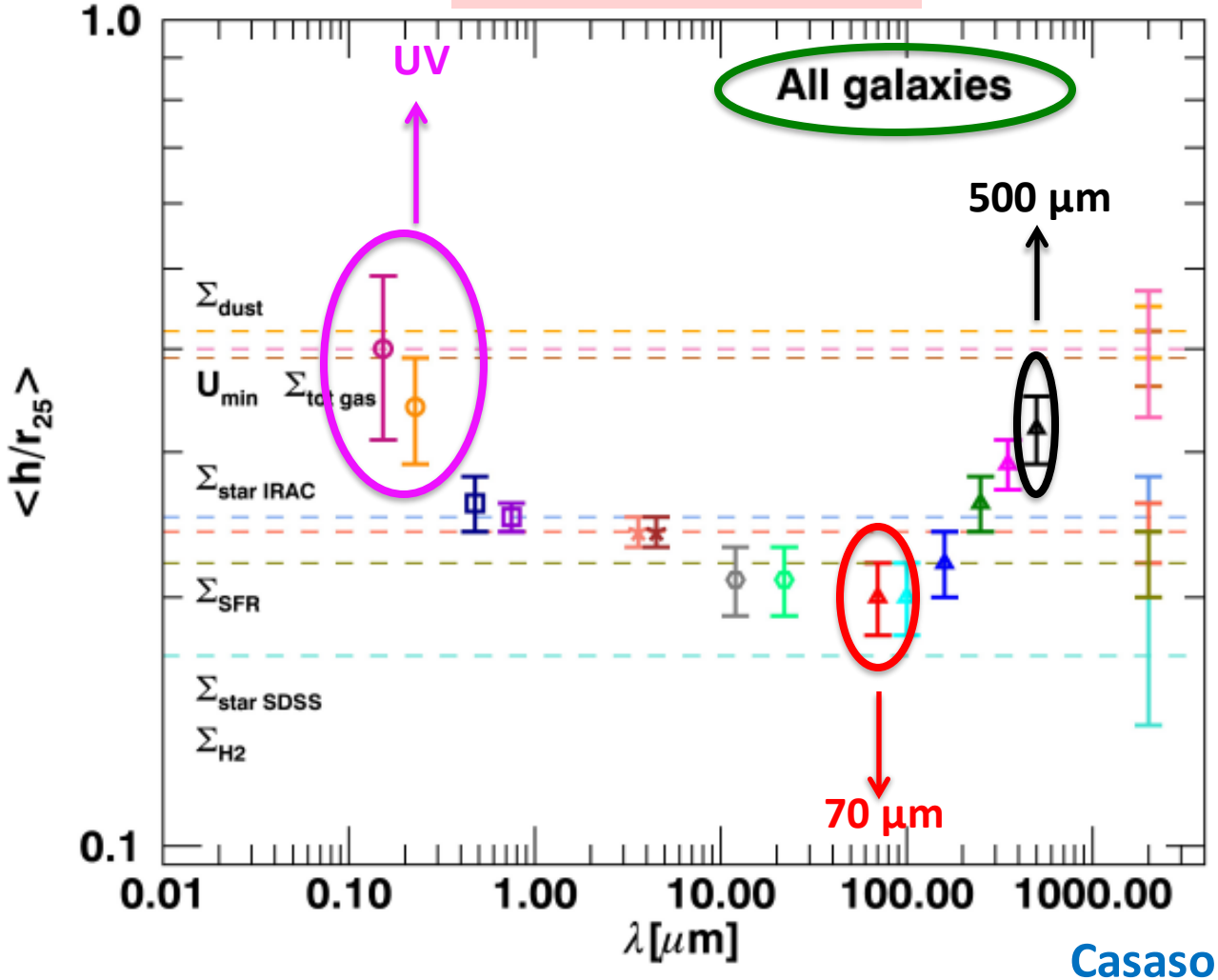

<h/r$_{25}$> decreases from UV to 70 μm and increases at 500 μm.

Casasola et al. (2017)

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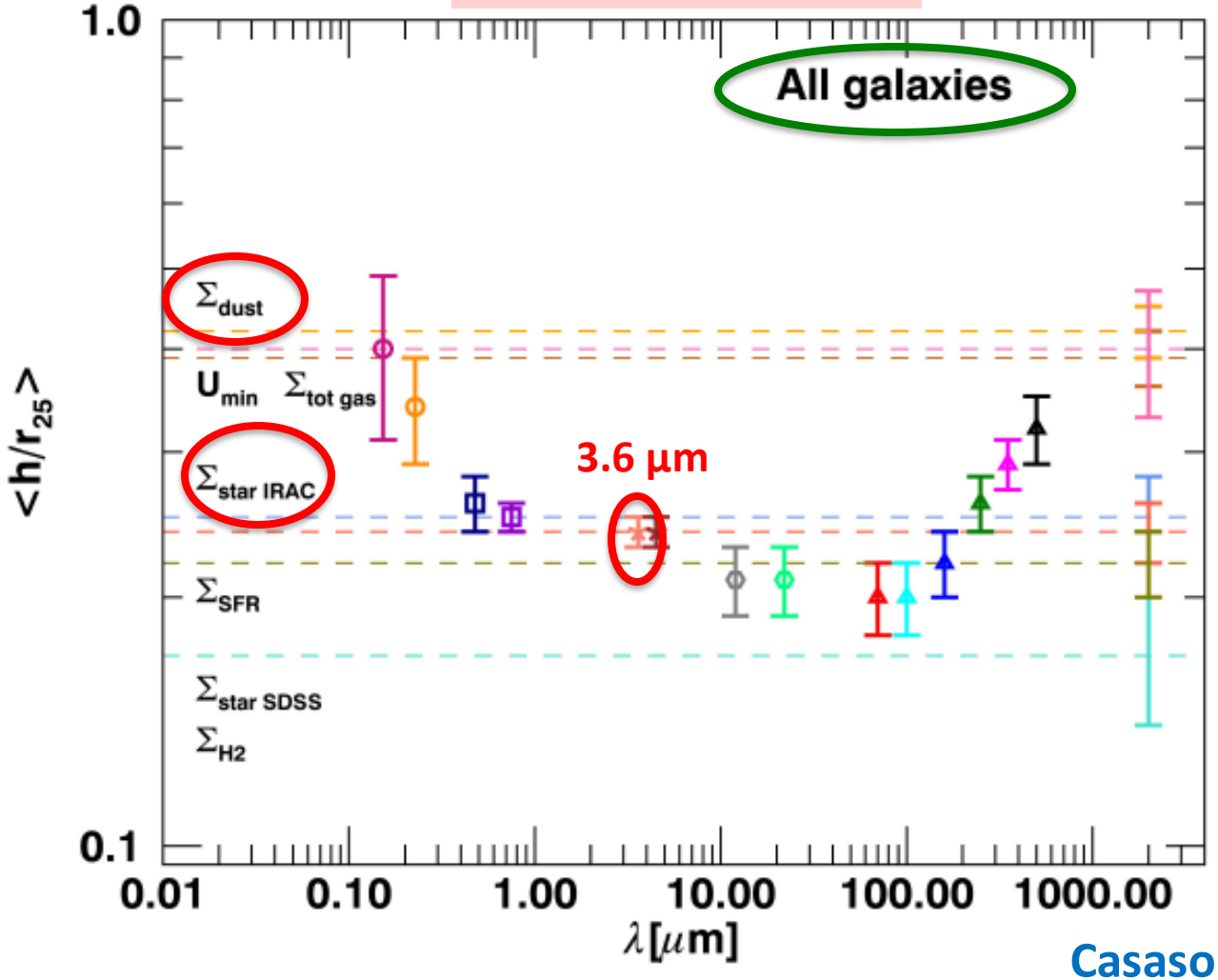

<h/r25> decreases from UV to 70 µm, and increases at 500 µm.

MAIN RESULT: Scale-length of **DUST is 1.8 times the stellar** one.

Casasola et al. (2017)

The global ISM scaling relations (SRs) in nearby late-type galaxies

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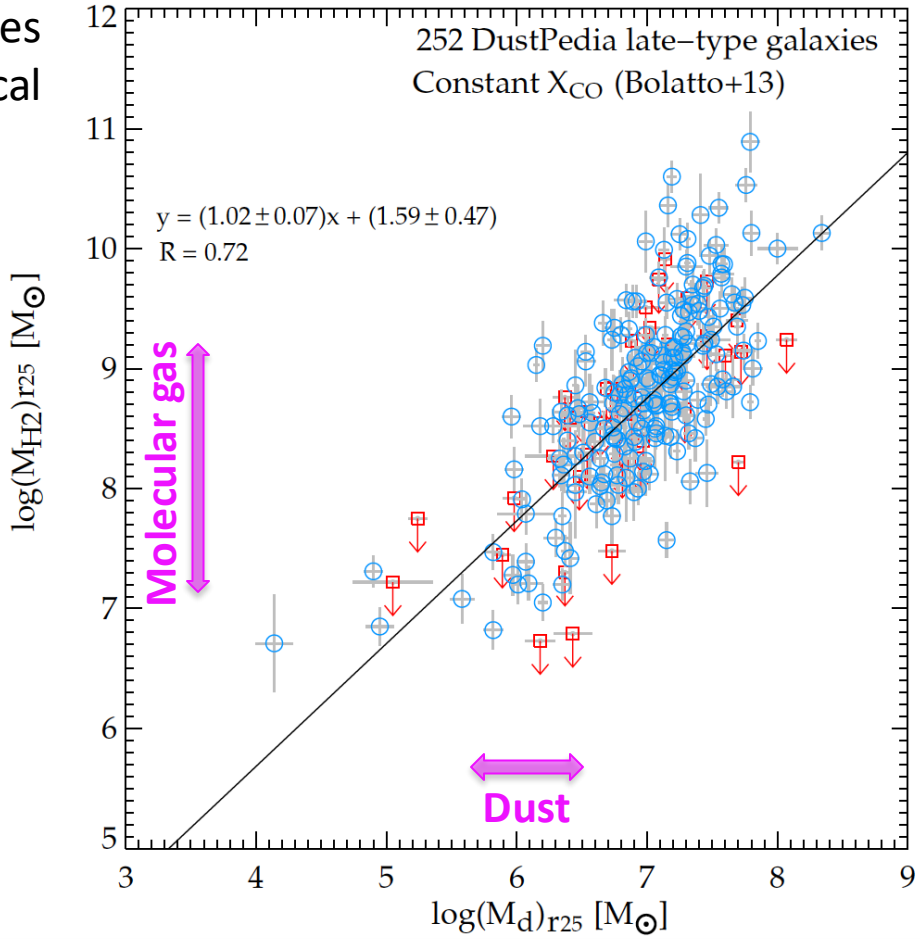
Dust and gas components (CO→H_2, HI, HI+H_2)

Both dust and gas masses are referred to the optical disk (r_{25})



Dust and molecular gas correlated

Consistent with SF process

No improvement with X_{CO} depending on metallicity (e.g., Sandstrom+13; Hunt+15; Amorin+16)

Casasola+20

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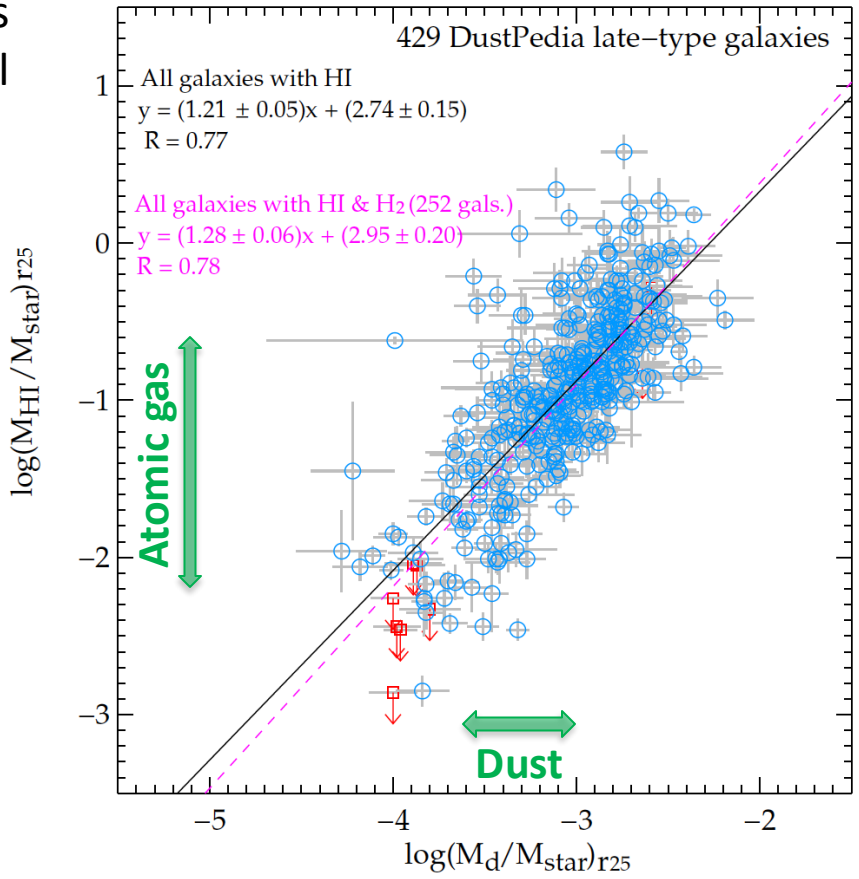

Dust and HI are better correlated than dust and molecular gas

Casasola+20

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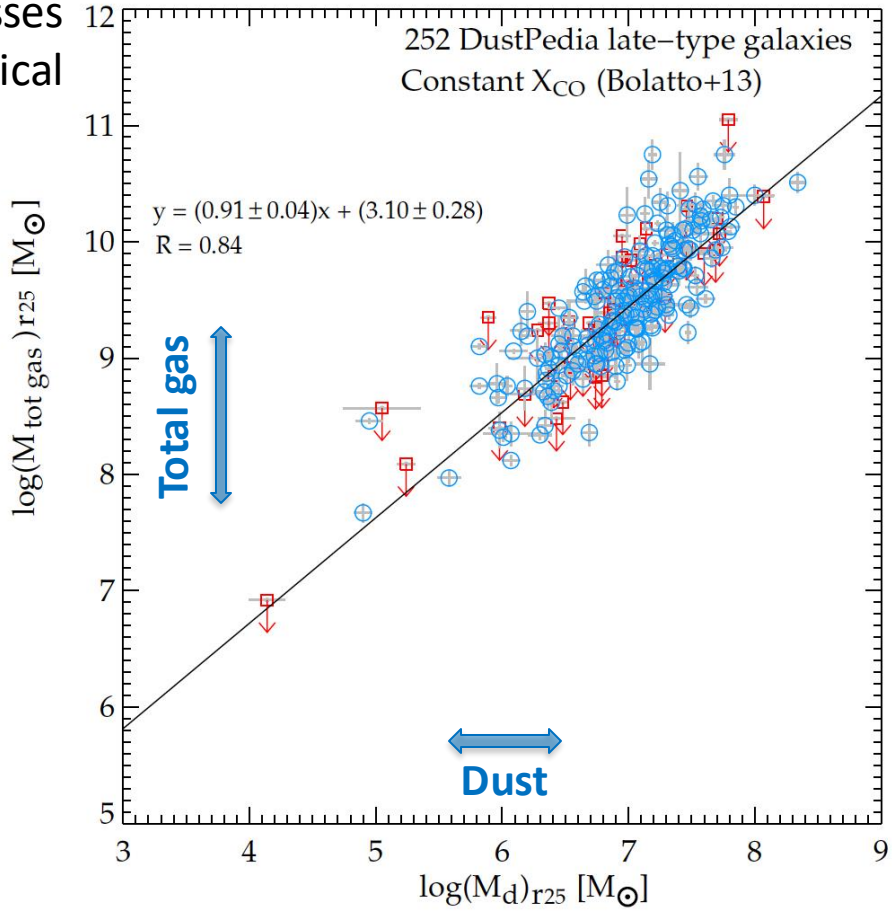


Dust and total gas is the best correlation

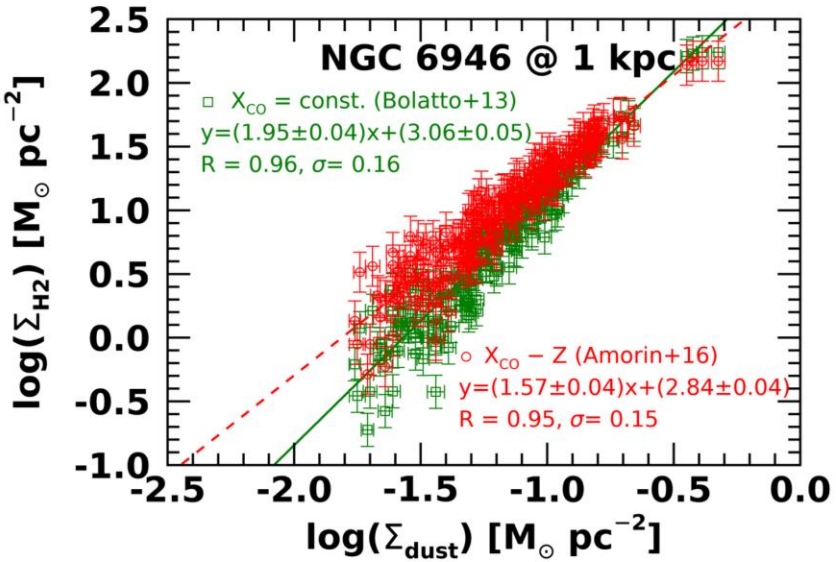
Scaling relations tested with a large and homogenous sample and under different physical assumptions.

Casasola+20

What happens at small scales?

What happens at small scales galaxy-by-galaxy?

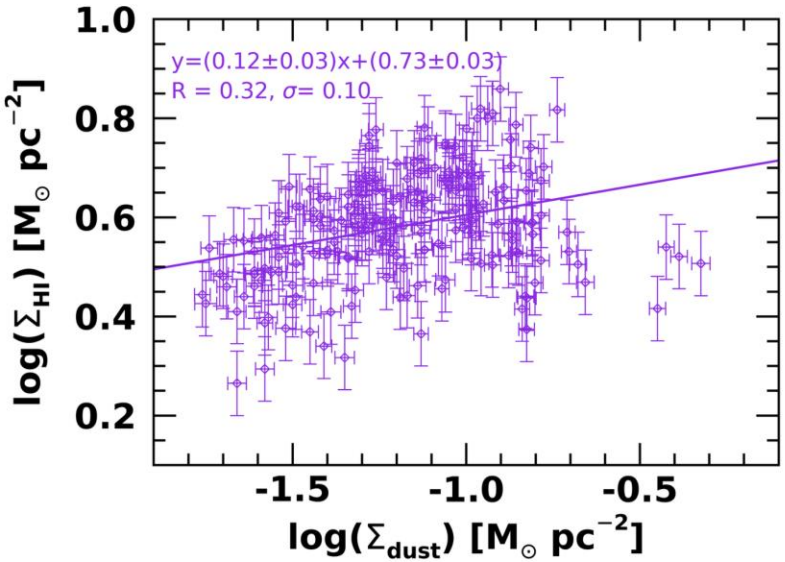
The spatially resolved ISM SRs in nearby late-type galaxies



Molecular gas

Dust

Consistent with SF



Atomic gas

Dust

Opposite to what happens globally (Casasola+20)

Casasola+22

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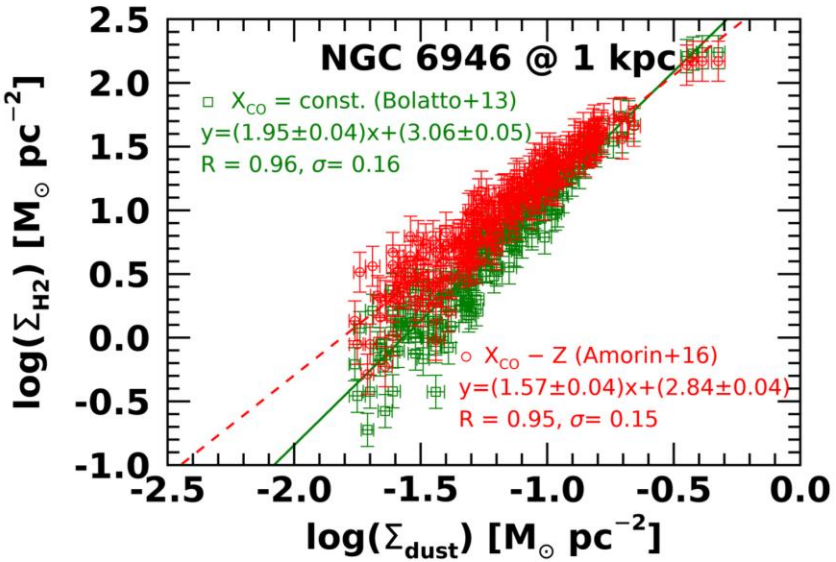
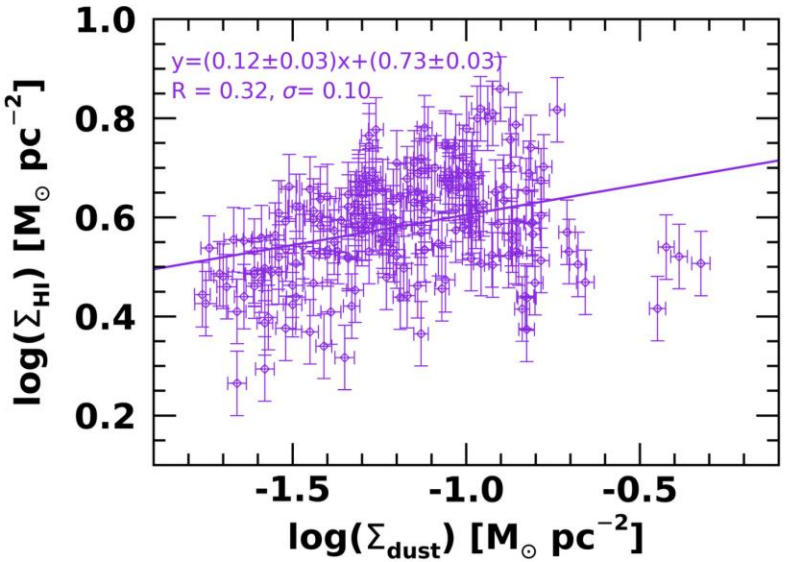
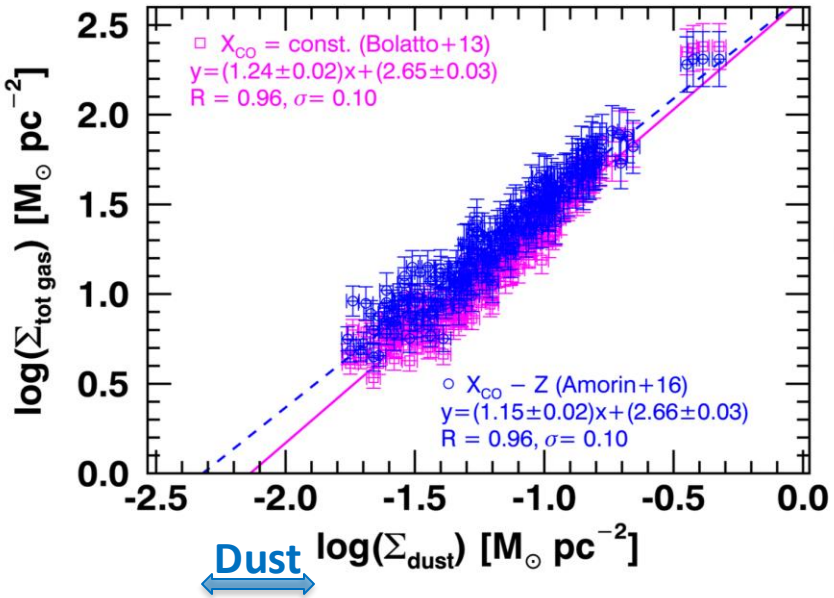


Molecular gas



Atomic gas

Dust



Total gas

Dust

Dust–total gas:
the best correlation @ SMALL and GLOBAL scales

Casasola+22

DustPedia profiles and scaling relations

Common trends but each galaxy has distinct behaviors
@ sub-kpc/kpc scales: Not universal rules!

Herschel has produced several important results on the cold dust (T~15-30 K) component in nearby galaxies

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PRIMA will allow the capture of the warm dust (T~30-120 K) and emissions from the smallest stochastically heated grains

This warm dust, which typically resides in birth clouds or mixed with the ISM, is likely more closely associated with molecular gas (traced by ALMA and JWST) than with cold dust

DustPedia with PRIMA

Required PRIMAger Sensitivity

	PRIMA Hyperspectral Imager		PRIMA Polarimetry Imager			
Source type	**PHI1**	**PHI2**	**PPI1**	**PPI2**	**PPI3**	**PPI4**
Wavelength [μm]	24–45	45–84	92	126	172	235
Point Source Flux Density (total, F_ν; mJy)	1.18–2.2	2.2–4.1	1.77	2.56	3.39	4.59
Point Source Flux Density (polarized, pF_ν; mJy)	–	–	2.50	3.62	4.65	6.49
Surface brightness (total, I_ν; MJy/sr)	1.64–0.66	0.74–0.58	0.46	0.34	0.25	0.18
Surface brightness (polarized, P_ν; MJy/sr)	–	–	0.65	0.47	0.35	0.25

The values above correspond to the 5σ background-subtracted flux density limit in a 1 degree^2 map observed for a total duration of 10h (overheads included). For PHI, the sensitivity is estimated for each of 6×2 sub-bands, individually spanning at 10% range in wavelength, under the assumption of R=10. Surface brightness sensitivity is measured per diffraction beam solid angle.

Estimations based on 875 DustPedia galaxies

In ~100 hrs, detections at 5σ for:

	PHI1 24-45 μm	PHI2 45-84 μm	PPI1 92 μm	PPI2 126 μm	PPI3 172 μm	PPI4 235 μm
N. gal.	772	109	501	-	583	652
Based on	22 μm WISE	70 μm PACS	100 μm PACS	-	160 μm PACS	250 μm SPIRE

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Possible Ideas:

- Select a subsample: more time/higher sensitivity for the largest galaxies to study the warm dust profiles

- Select a subsample, excluding the Virgo galaxies (PriViCS: the PRIMA Virgo Cluster Survey, see Baes+23 in PRIMA General Observer Science Book, Fritz+ submitted in JATIS), to study the warm dust in different environments

- Select a subsample varying in terms of morphology (KINGFISH), M_{star} (HRS), SFR, metallicity, AGN, environments, ..., excluding 100 low-metallicity disk galaxies proposed by Galliano+ in JATIS

PRIMA

PRIMA Hyperspectral Imager allow us to examine the warm dust in a representative and well-studied sample of nearby galaxies

The synergy between PRIMA and *Herschel* data will allow us to accurately characterize both warm and cold dust in the local Universe

Thanks for your attention!

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