# Definitive characterization of the ISM in the Local Universe: SKA and other facilities

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**The II National Workshop of SKA science and technology, Bologna, 3 – 5 December 2018**

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

PI: Jon Davies (Cardiff University). 6 European nodes.

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

$D_{25}$> 1′, v < 3000 km/s, multiwavelength coverage from UV to submm (up to 42 bands/ galaxy)


DustPedia Database:

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

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DustPedia

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 606874.

These are all 844 galaxies within 140 million light-years of us (that have angular sizes over $^{1}/_{60}{}^{th}$ a degree) that were observed by the *Herschel* Space Observatory's SPIRE camera. These images show how these galaxies appear at a wavelength of 250 μm (2000 times longer than what our eyes see). At this wavelength, we observe the thermal glow of the cosmic dust that floats between stars, and cocoons star-formation. In galaxies with no dust, we only see the even more distant galaxies behind.

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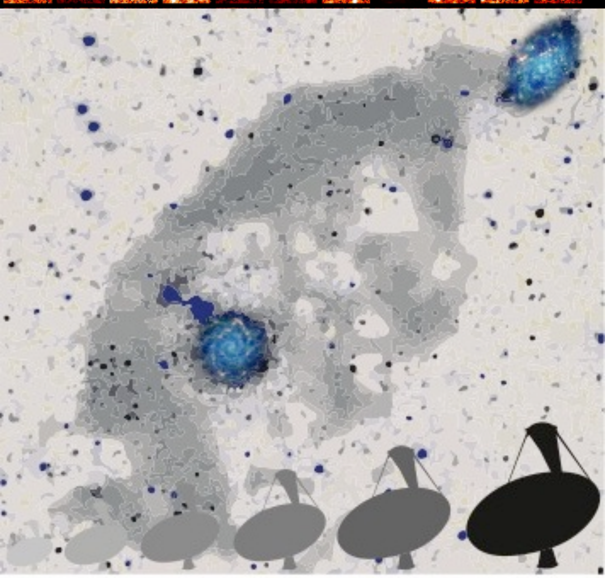

ESKAPE-HI

Empowering SKA as a Probe of galaxy Evolution with HI

PI: L. Hunt (INAF-Arcetri)

# Interstellar medium (ISM) & ISM scaling relations

**ISM: primary importance for the formation and evolution of galaxies since it is in the environment from which stars are formed**

- ✓ Mass of **ISM**: gas for ~99% (~74% of H, ~25% of He, ~1% of heavier elements, i.e. 'metals'), dust for ~1%
- ✓ Nearby galaxies: Intricate system of correlations between their global properties, called **scaling relations**
- ✓ Scaling relations: correlations between physical properties, internal physics, formation and evolutionary histories, different galaxy populations
- ✓ In the last years, the number of works on the ISM scaling relations has grown
- ✓ Dust often neglected, sometimes the molecular gas/ metallicity are neglected, …

# ISM scaling relations in the Local Universe (DustPedia)

## Sample and data:

- ✓ **436** late-type (T = 1 – 10, Sa – Irregular) **DustPedia** galaxies (Davies+17)
- ✓ **Dust mass** (THEMIS dust mass model, Jones+17) [IR data from **Herschel**]
- ✓ **CO** and **HI** (gas mass) data (Casasola+, in prep.) [mm and cm data from **radio telescopes (single-dish/interferometer)**]
- ✓ **Metallicity** data (De Vis+18, submitted) through multiple strong-line calibrations

**DustPedia sample + DustPedia data + DustPedia ancillary data: "ideal" project to characterize the ISM scaling relations in the Local Universe**

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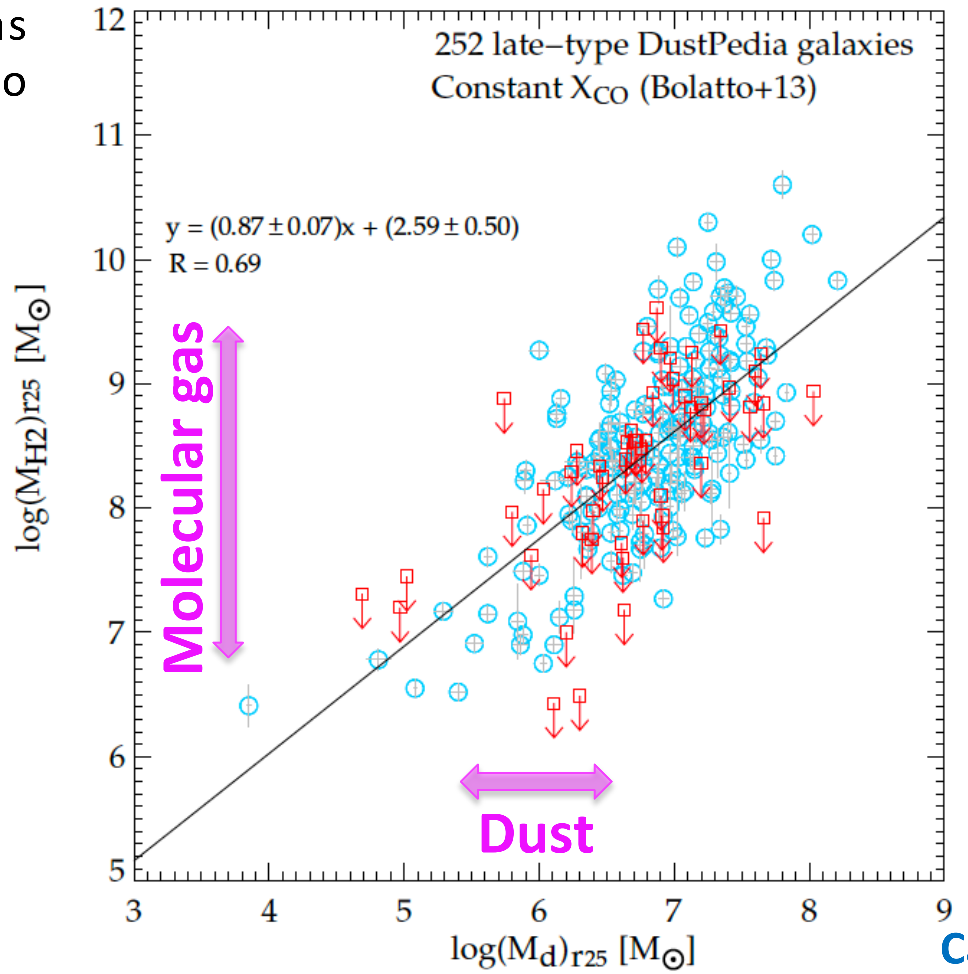


Casasola et al. in prep.

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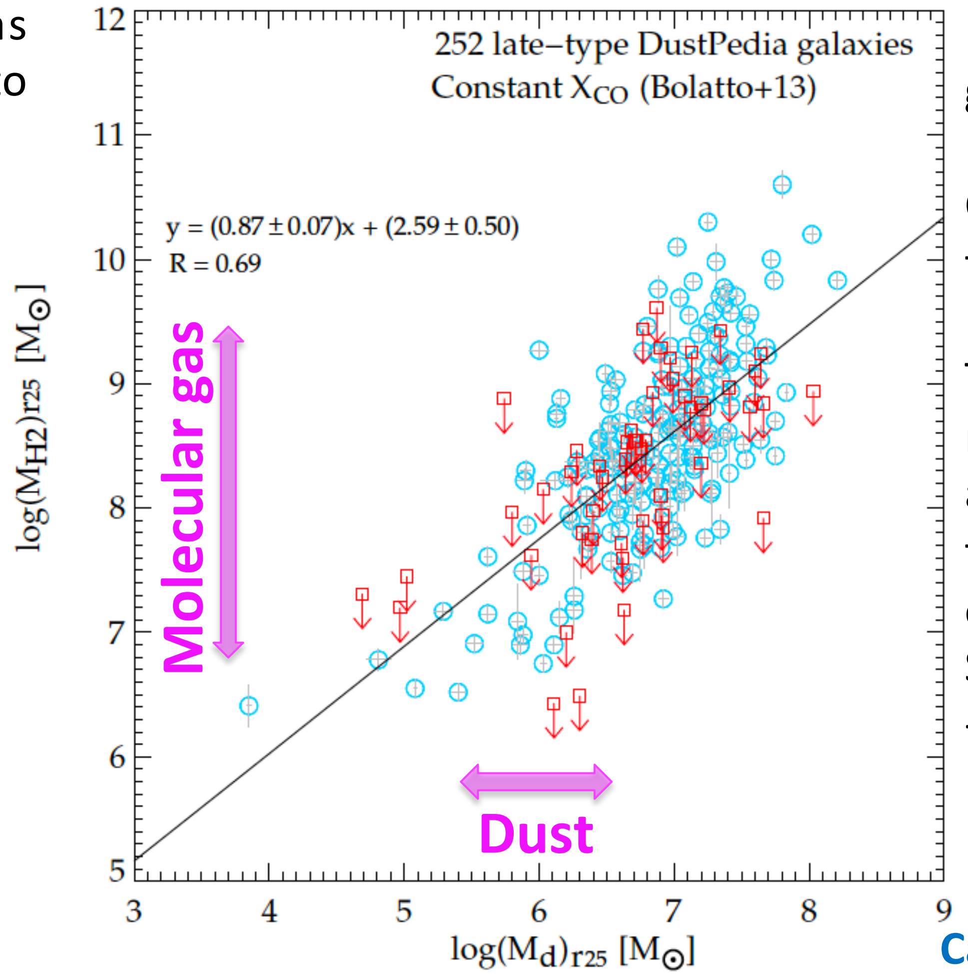


Dust and molecular gas are well correlated

Consistent with star formation process

The correlation does not improve assuming a CO → $H_2$ conversion factor ($X_{CO}$) depending on the metallicity (e.g., Sandstrom+13; Hunt +15; Amorin+16)

Casasola et al. in prep.

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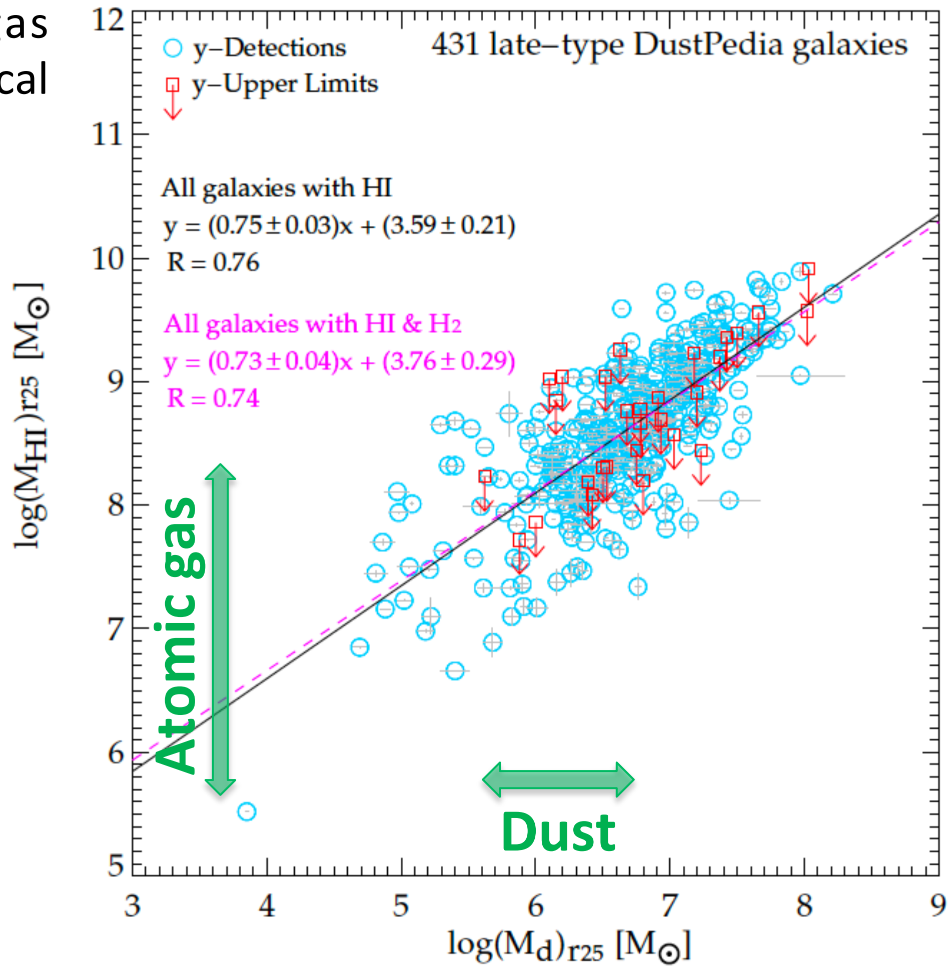


Dust and atomic gas (21cm-HI) are better correlated than dust and molecular gas

Opposite to what happens at small scale physics

Casasola et al. in prep.

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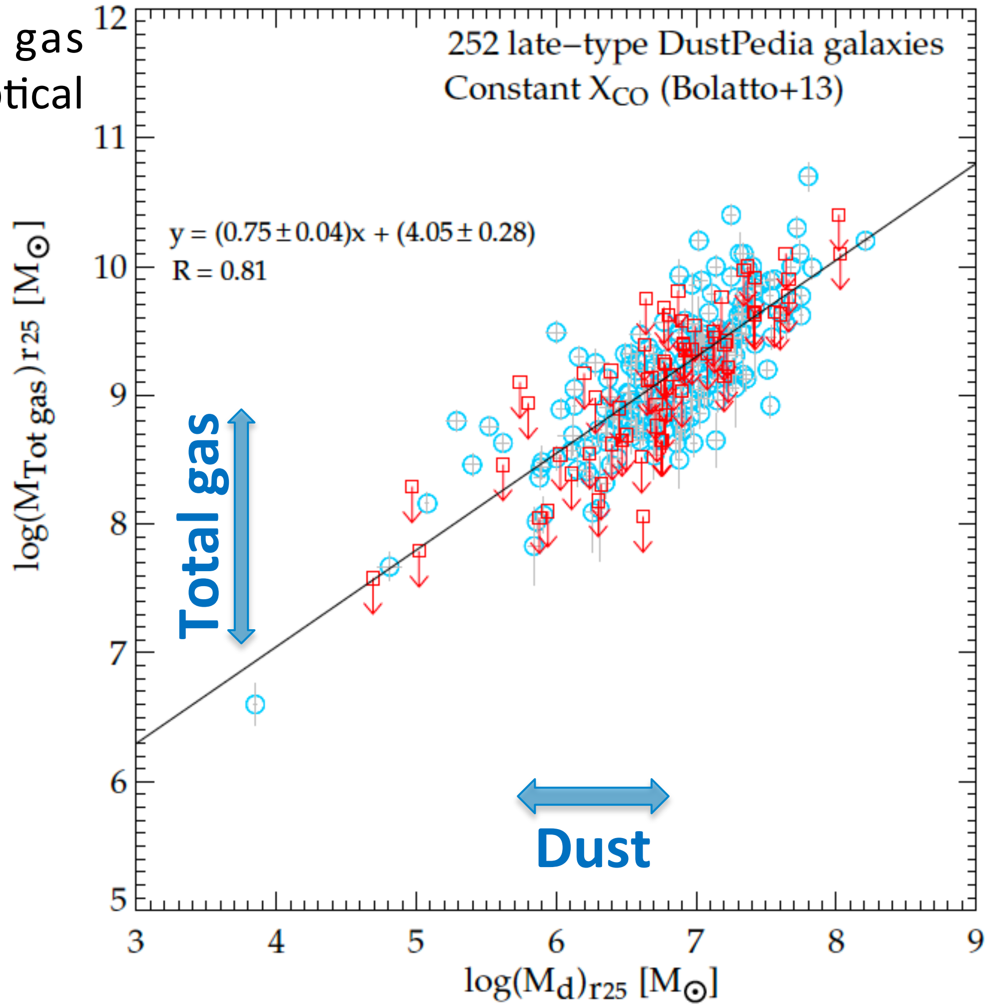
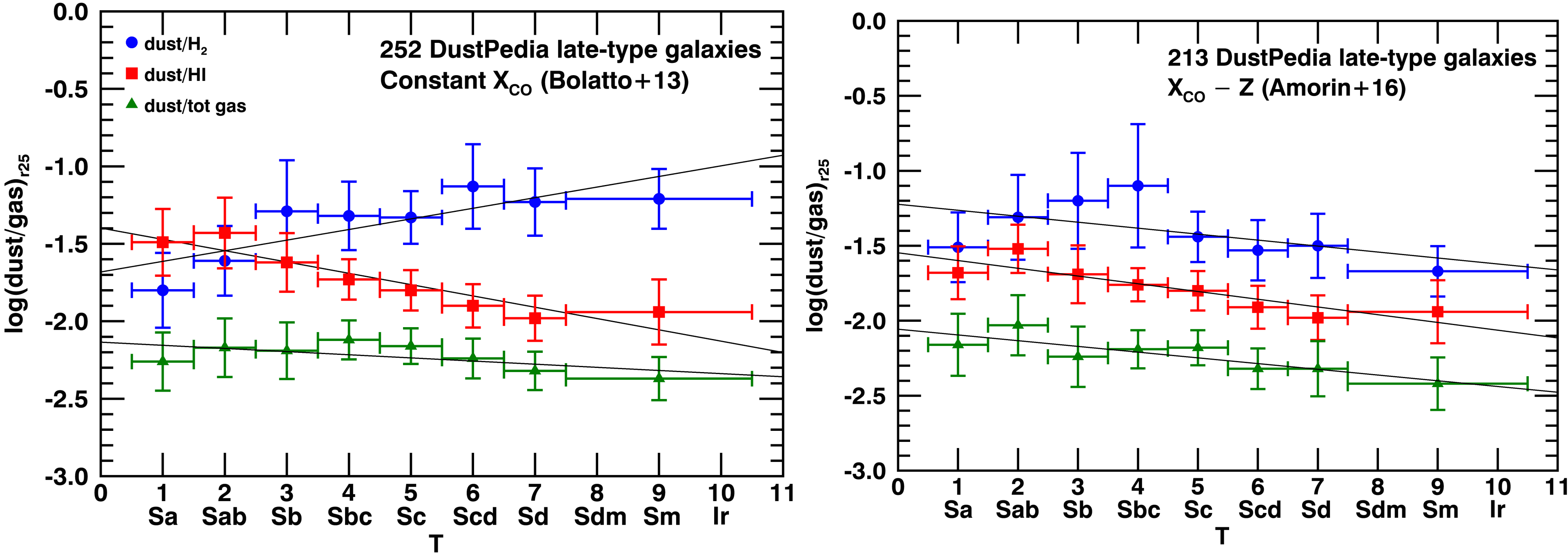



Dust and total gas are well correlated and the correlation is driven by HI in the galaxy disk

Scaling relations tested with a large and homogenous sample and under several assumptions: constant $X_{CO}$ (Bolatto+13), $X_{CO}$ depending on O/H (Amorin+16)

Casasola et al. in prep.

# Dust-to-gas mass ratio (DGR), metallicity, morphology

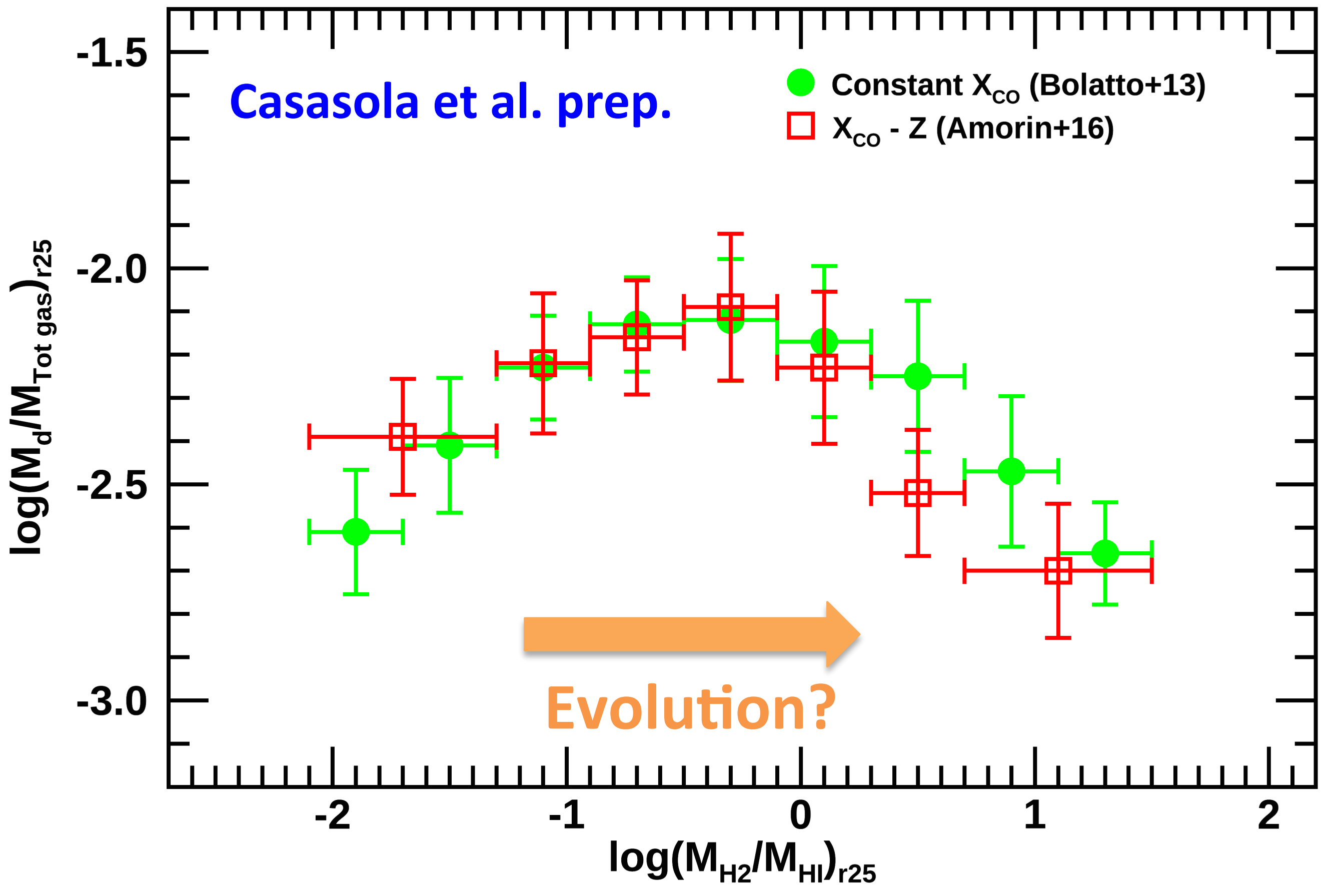



$X_{CO}$ depending on Z reproduces the expected decreasing of DGR with T
(see, e.g., Draine+07, Rémy-Ruyer+14, Hunt+15,Relano+18)

We characterize DGR at a given T for all gas phases

Casasola et al. in prep.

# Dust/Tot gas vs. $H_2$/HI




**Evolution:**

HI is dominant when dust is yet in small quantities wrt total gas

$H_2$ is dominant when dust is already destroyed

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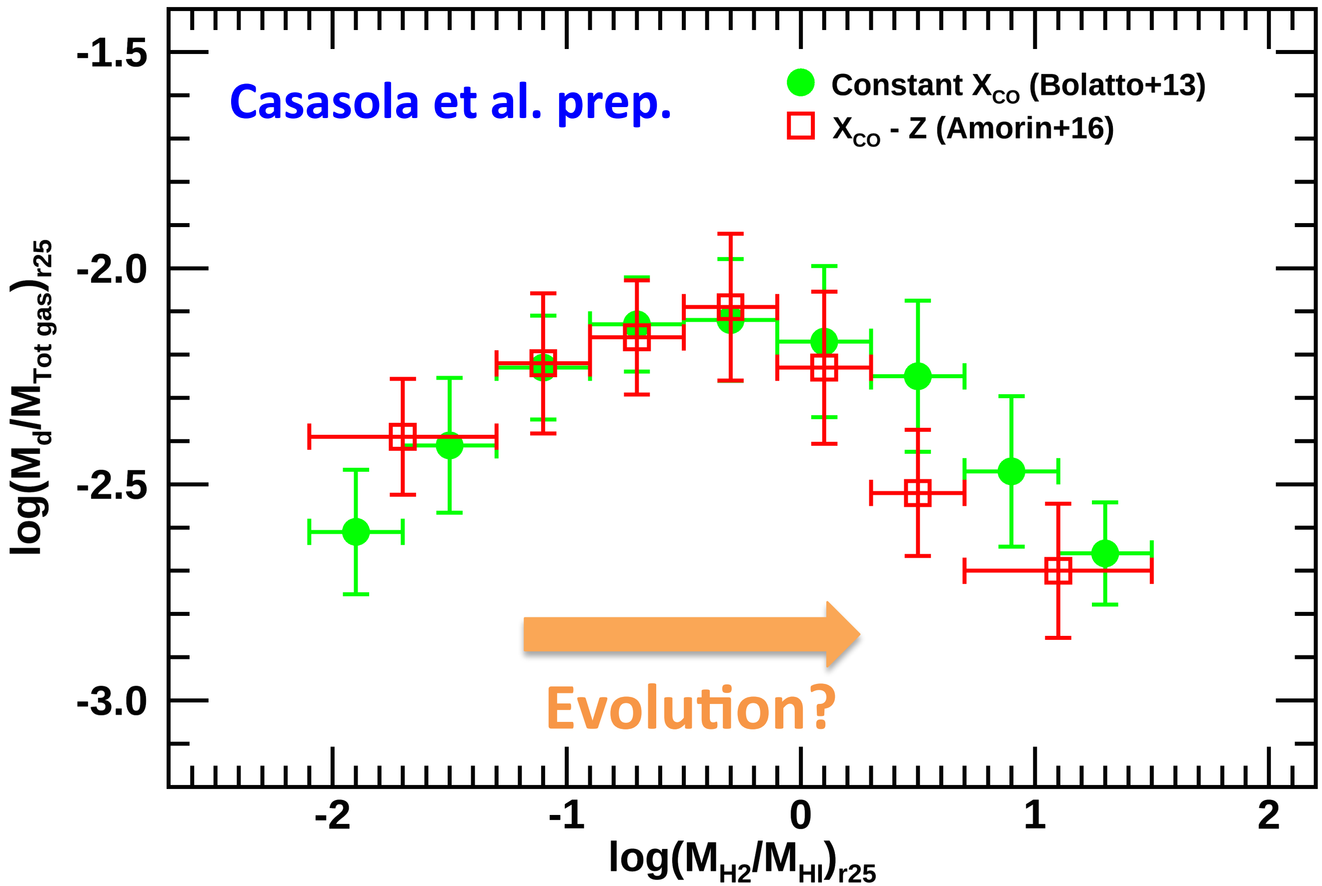


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The peak of DGR at intermediate ages.

The DGR is reduced for more evolved galaxies, possibly as an effect of differential consumption of dust and gas during astration.

**GALAXY EVOLUTION**: Science driver of **SKA**

ALMA, (*Herschel* →SPICA), DustPedia Project, PRIN SKA **ESKAPE-HI**

# ISM scaling relations in the Local Universe

## Conclusions

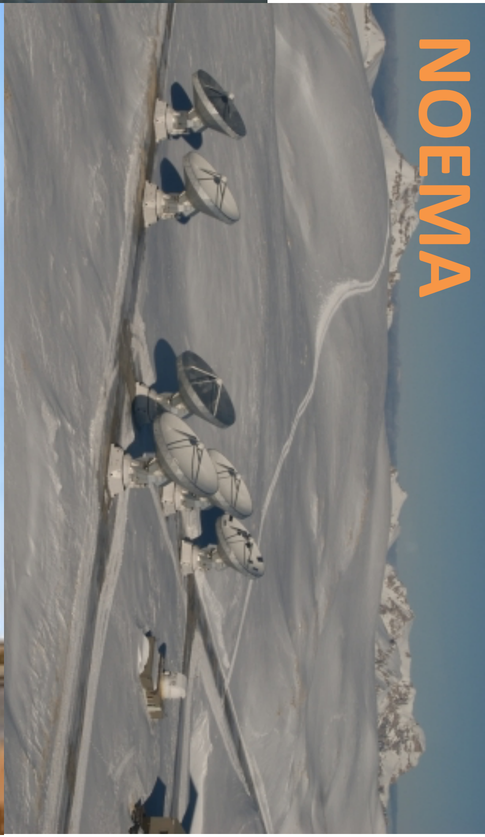
## in SKA perspective

## in perspective of synergies between SKA and other facilities

- ✓ HI @ 21cm (1.4 GHz): fundamental role to characterize the ISM in the disks of the Local Universe
- ✓ ALMA is revealing the molecular gas through several tracers (e.g., CO) at mm $\lambda$, telescopes as JVLA and, in future, **SKA** detect the HI gas component
- ✓ Our approach is an example of **synergy** between **SKA** pathfinder/precursors, ALMA (IRAM, Nobeyama), and *Herschel*, …
- ✓ Once characterized the ISM at $z = 0$: **What happens at $z > 0$? What happens at the small-scale physics?**

**SKA + other facilities will surely help us!**


\+ many others




# Thanks!

# 436 late-type DustPedia galaxies

- ✓ 50%: interacting galaxies, including pair and group members
- ✓ 12%: low-luminosity AGN ($L_X < 10^{42}$ erg $s^{-1}$) including Seyferts and LINERs
- ✓ 2%: starbursts