Star formation and feedback in massive galaxies at cosmic noon

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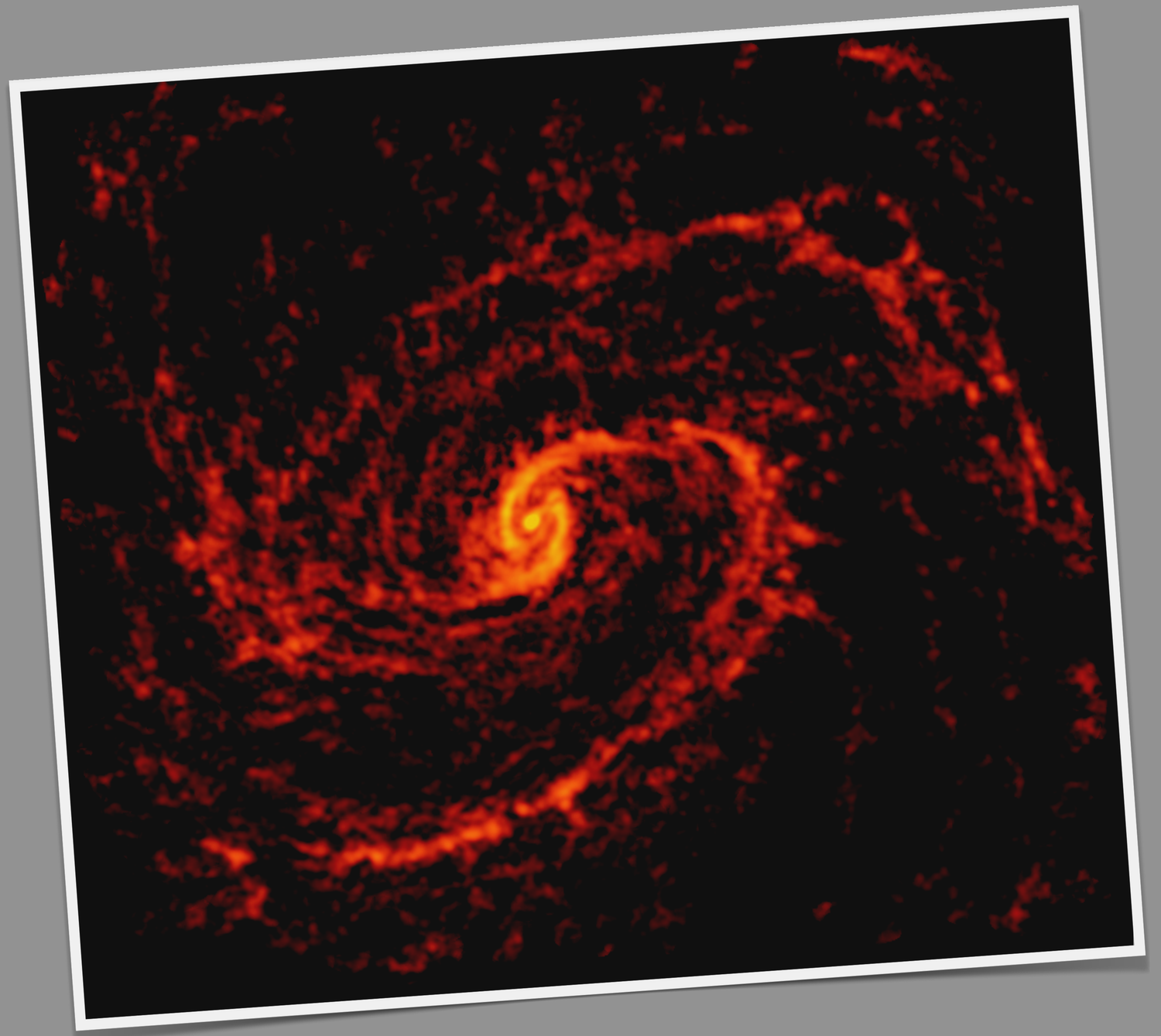
(she/her)

Anniversary Fellow @ UoS

University of Southampton

Southampton, 7th February 2024



Credit:
ALMA (ESO/NAOJ/NRAO); NRAO/AUI/NSF, B. Saxton

Molecular gas properties of star-forming galaxies at cosmic noon

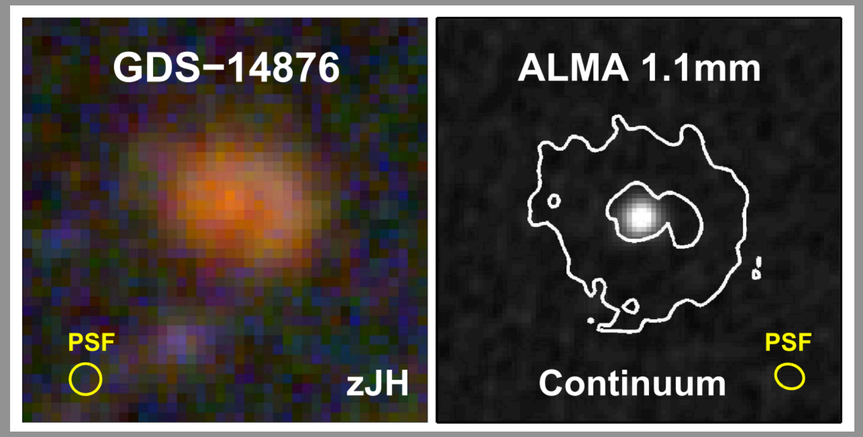
- Very high gas fractions (e.g. Tacconi et al. 2020; Decarli et al. 2020)

- Higher molecular gas excitation in z~2 main-sequence galaxies than MW disks (e.g., Daddi et al. 2015), but lower than starbursts (e.g., Bothwell+13)

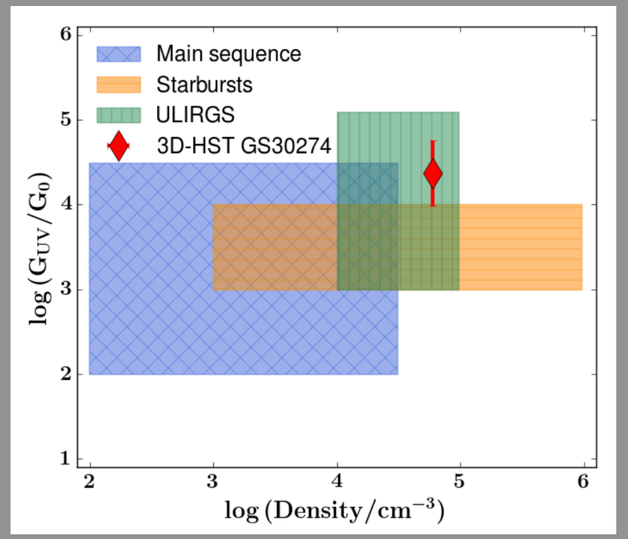
- Starbursts more efficient than main-sequence galaxies in converting gas into stars (SFE = SFR / M_{gas}, e.g., Sargent+14, Silverman+15)

Starbursting galaxies within the Main Sequence

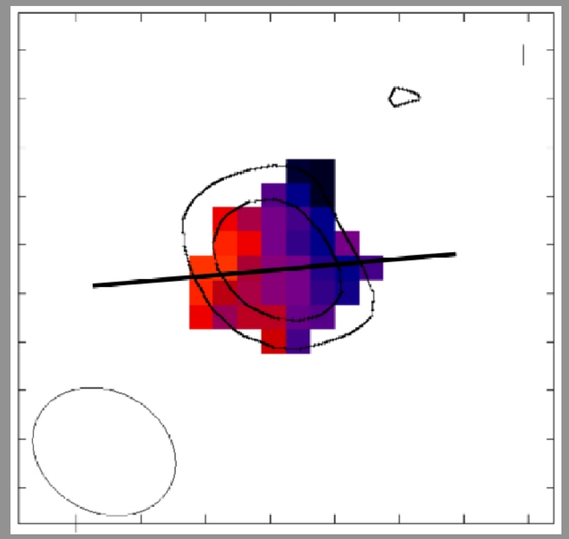
Main-sequence galaxies with starbursting properties (compact dust/gas/star formation; high ISM density, very short $t_{depl,}$ e.g. Barro+17; Popping+17; Tadaki+17; Elbaz+18; Brusa+18), gas poor, some with rotating disks (but very compact!!!, e.g., Talia+18)



Barro+17



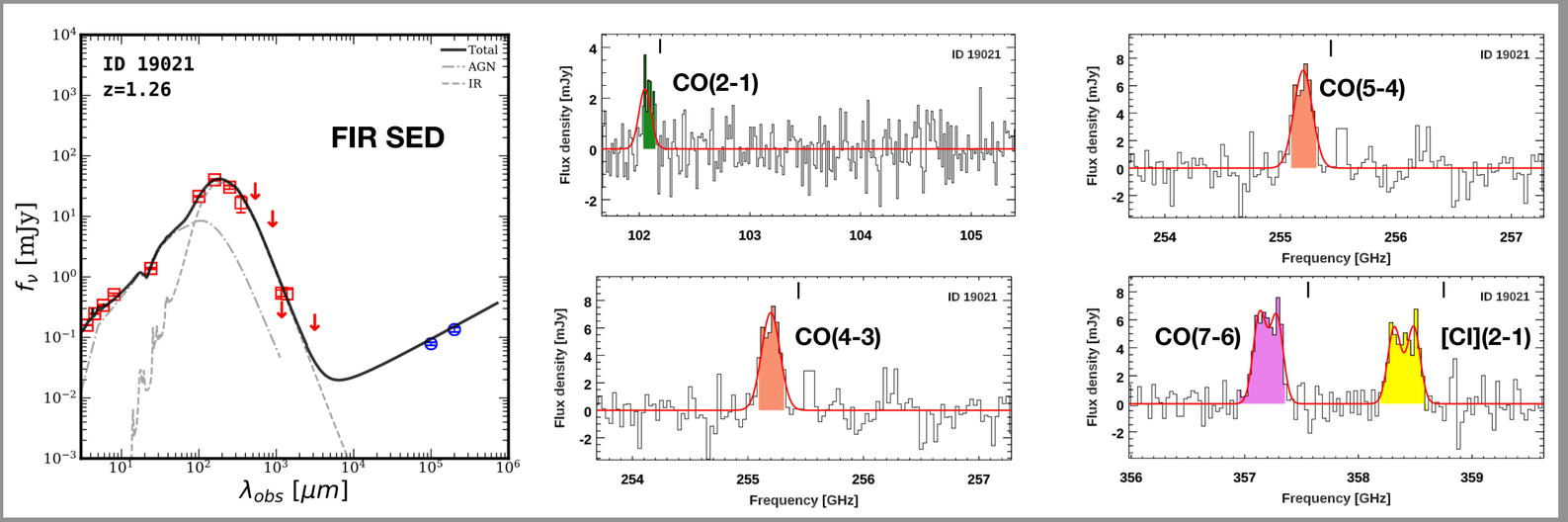
Popping+17



Talia+18

Molecular gas in massive galaxies at cosmic noon

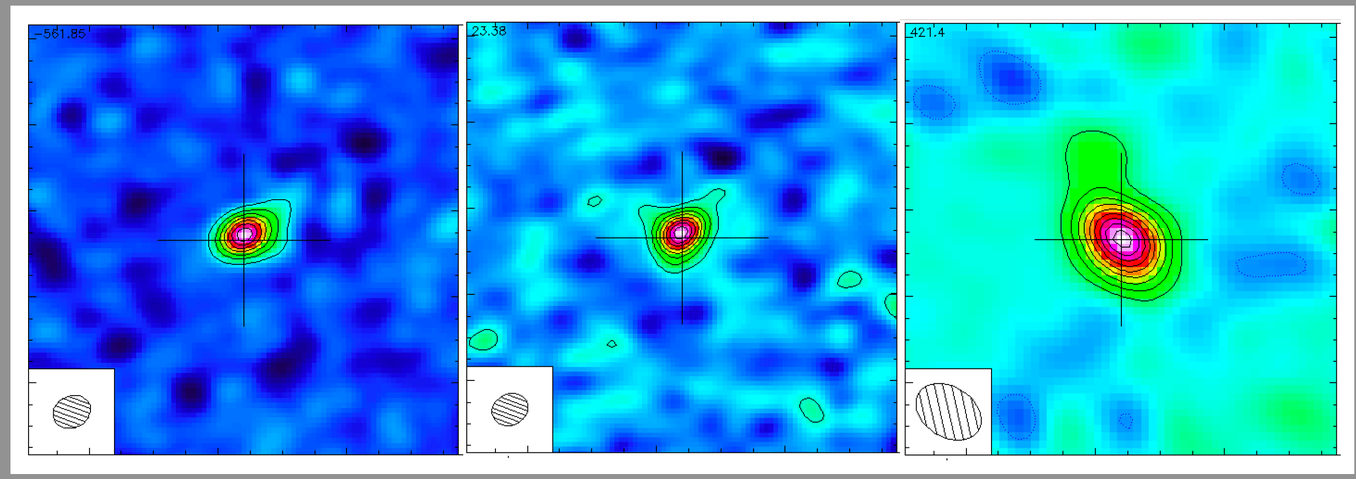
Molecular gas physics



Valentino, Daddi, Puglisi+20

- Large statistics (~100 z~1.3 galaxies on/off MS)
- Multiple CO/[CI] lines
- Moderate resolution (0.9'')
- COSMOS multi-wavelength information

Molecular gas sizes

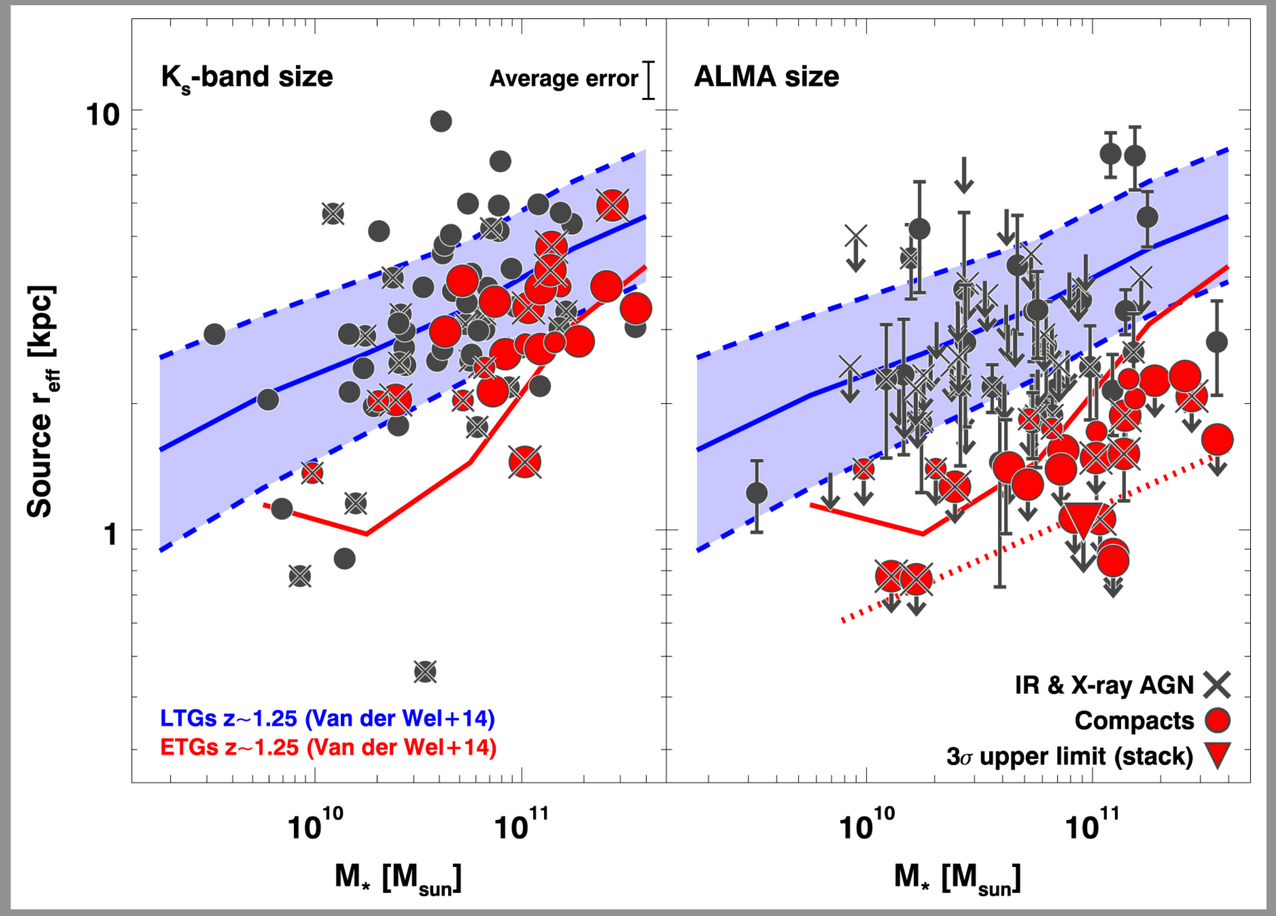


Puglisi+19; +21b

Stellar vs molecular gas sizes

- Compact sub-millimetre sizes in **~30%** of “typical main-sequence disks”

- These “sub millimetre” compact galaxies have **molecular gas sizes ~3.4x smaller** than the stellar size.

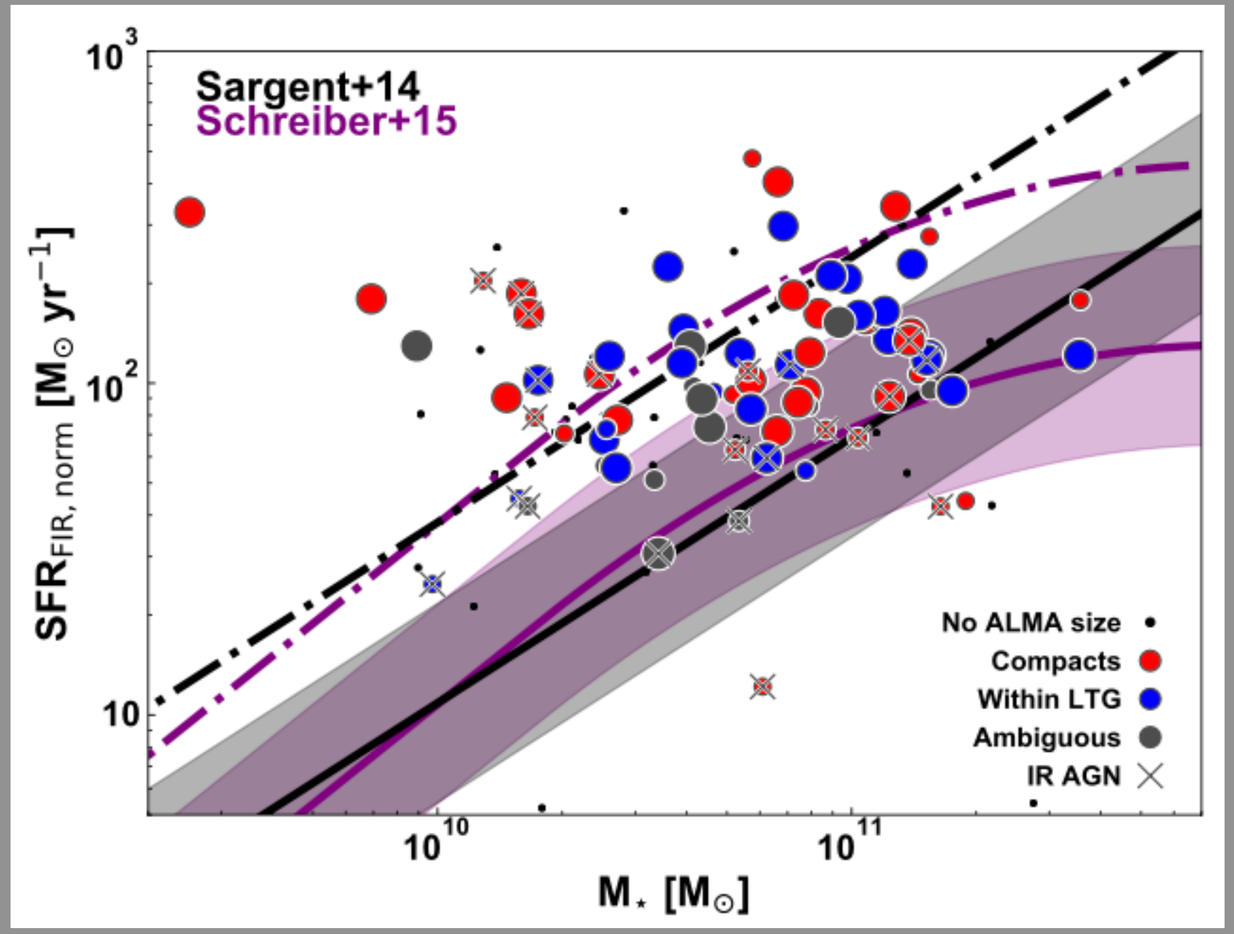


Puglisi+19

Sub-millimetre compact galaxies on and above the MS

- No clear dependence of sub-millimetre compactness on main-sequence position.

- More than **50% sub-mm/CO compact within the main-sequence scatter** above M*~10^{11} $M_\odot$, similar to continuum (Elbaz+18, Franco+20, Tadaki+20, Gomez-Gujiarro+22, Gullberg+19) and radio (but ~10%, Jiménez-Andrade+19).

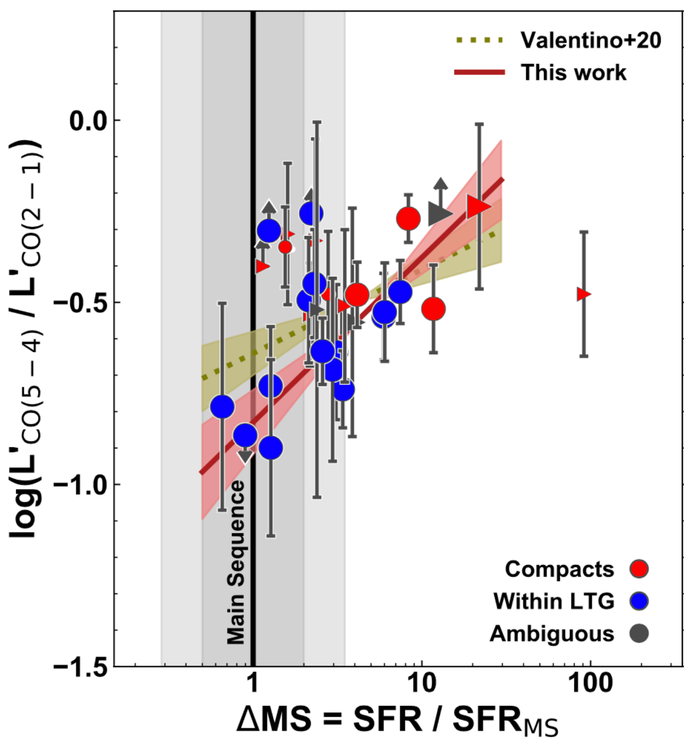


Puglisi+19; 21b

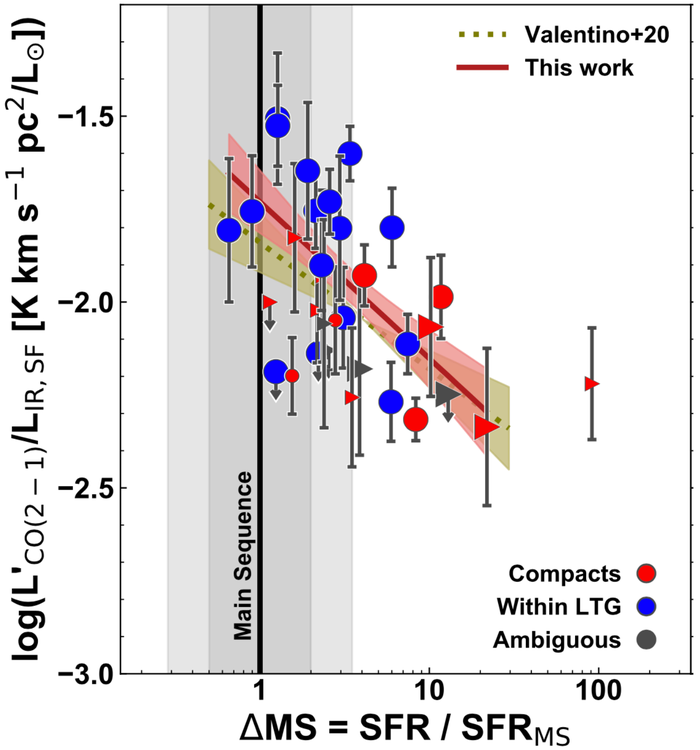
A diversity of molecular gas properties within the MS

Sub-millimetre compact galaxies on the main sequence have **enhanced excitation**, and **lower t_{depl} / enhanced SFE** than main sequence galaxies.

Molecular gas excitation



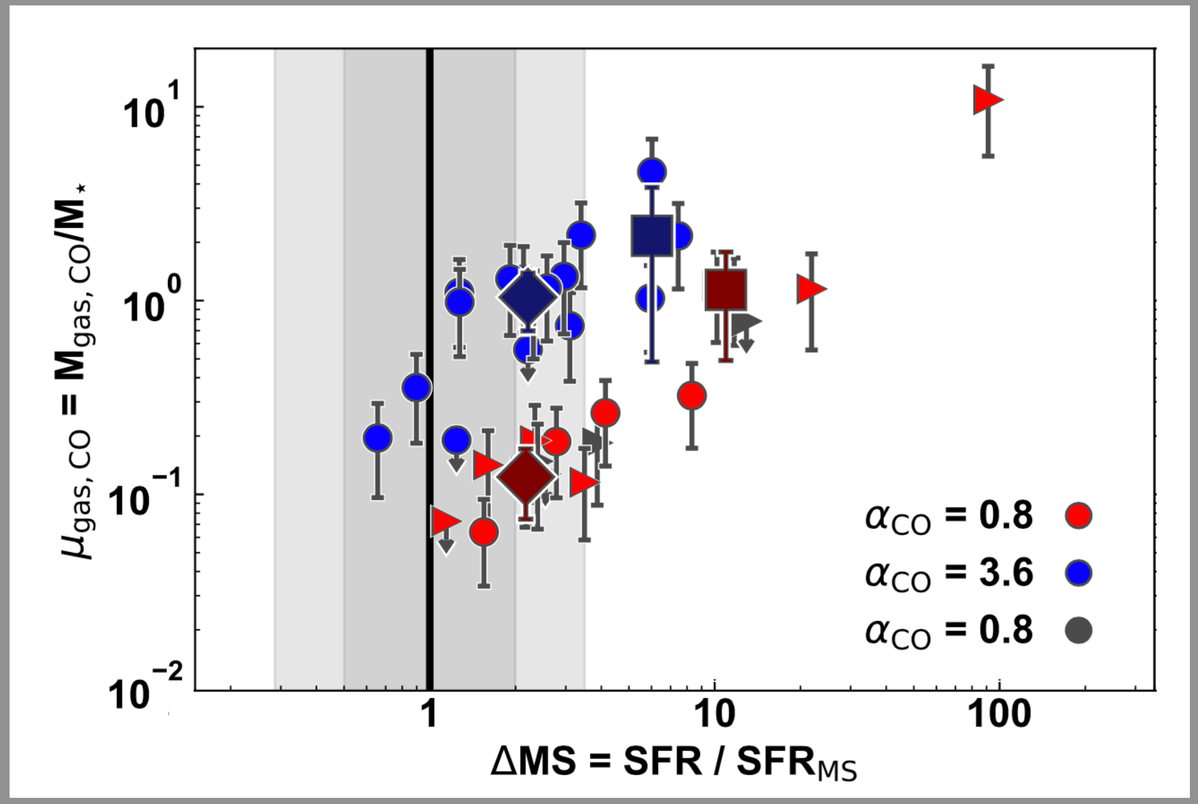
Depletion time/SFE



Puglisi+21b

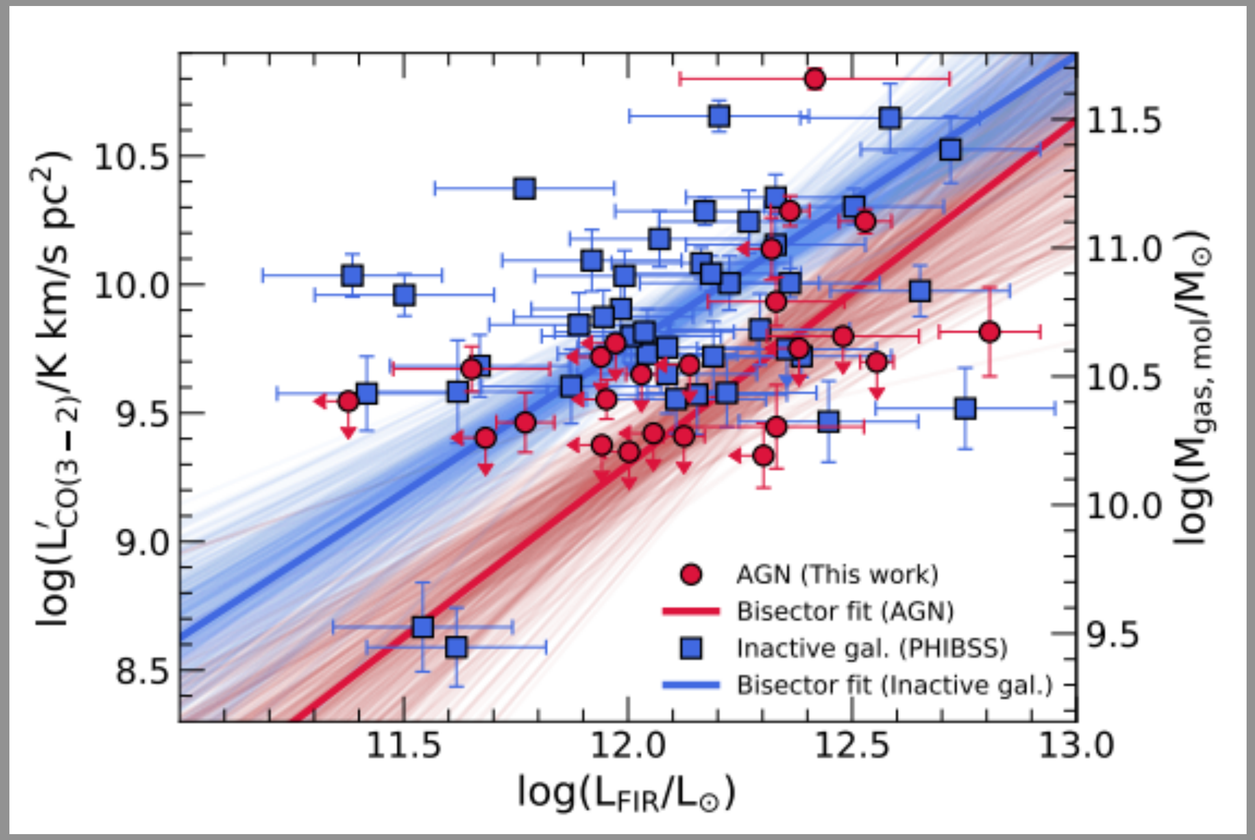
A diversity of molecular gas properties within the MS

Sub-mm compact galaxies on the main sequence have **lower gas fractions** than their extended counterparts (see also Franco+20; Gomez-Gujiarro+22)



Puglisi+21b

Star formation and AGN activity

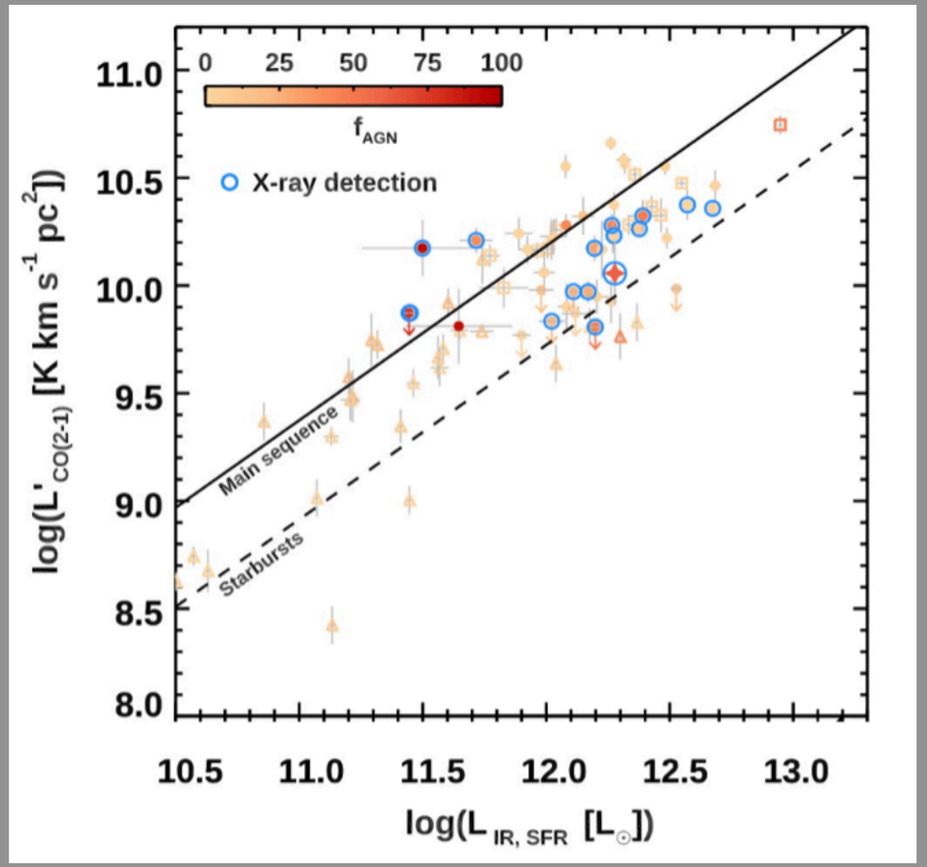


Circosta+21, incl. Puglisi
See also Bertola+ in prep, incl. Puglisi

Star formation and AGN activity

- ~40% of galaxies in our survey host an AGN (X-ray and/or mid-IR)

- The position of galaxies in the integrated Schmidt-Kennicutt plane correlates with the AGN fraction, suggesting **lower CO luminosities / SFE enhancement in AGN hosts.**

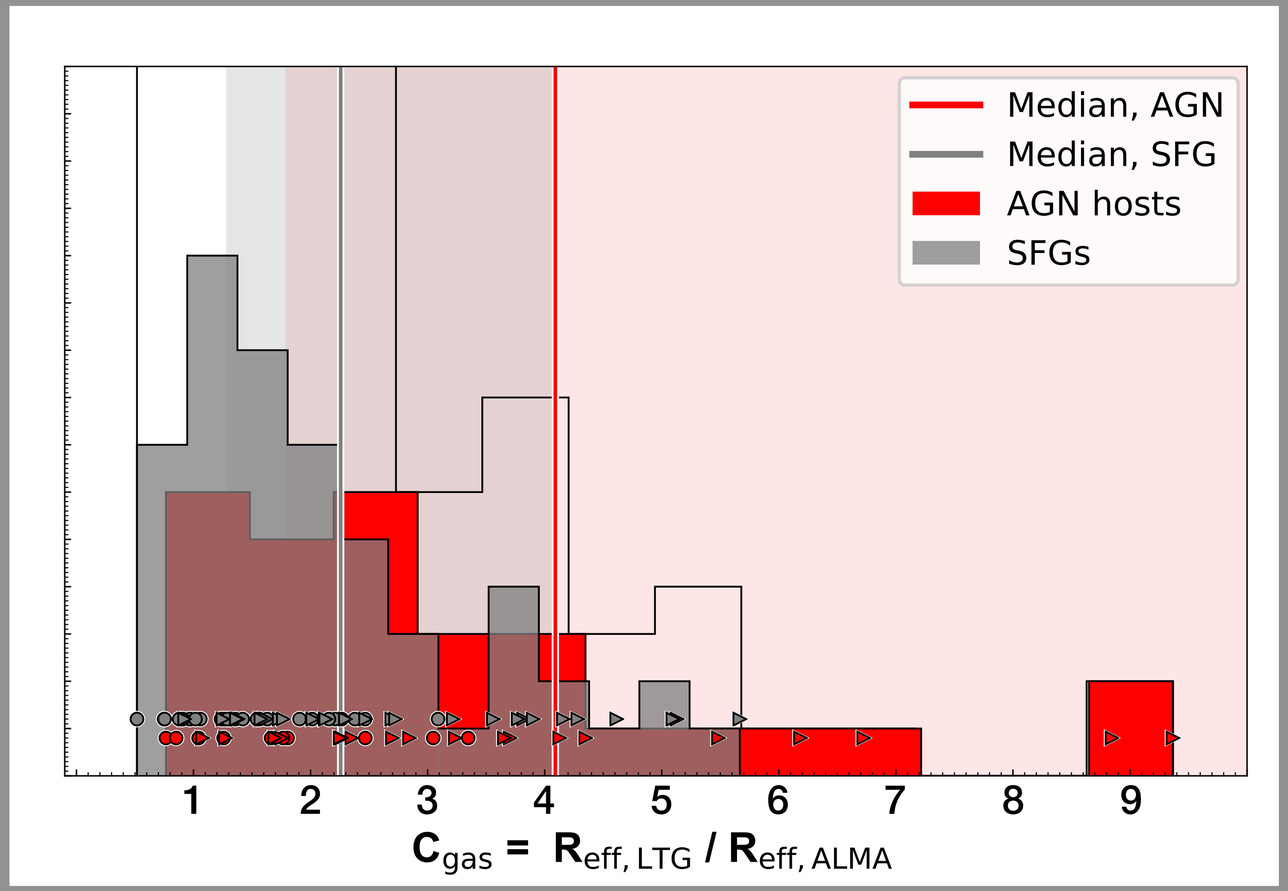


Valentino, Daddi, Puglisi+21

Sub-mm compact galaxies and AGN

- Signatures of **AGN** in **45 ± 13% of sub-millimetre compact galaxies** as oppsed to 25 ± 11% of the extended galaxies.

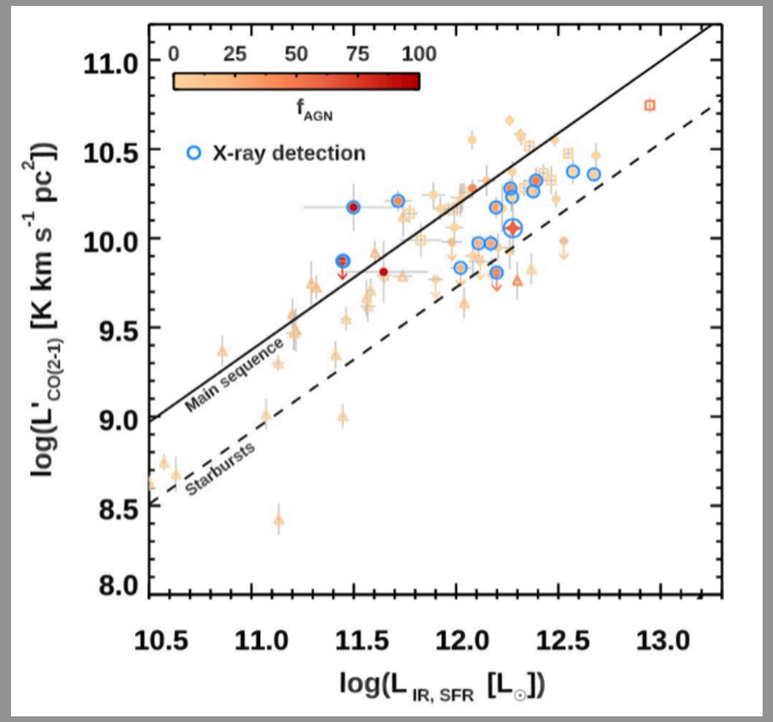
- Sub-mm compactness distribution of galaxies with/ without AGN are different at **~2σ level**



Puglisi+21b

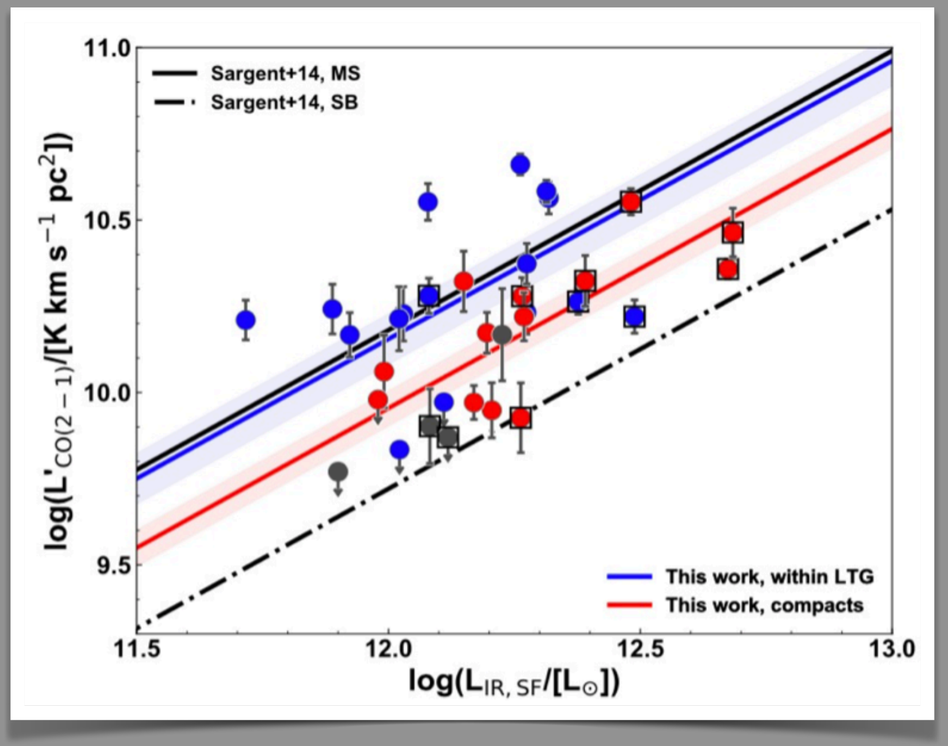
Sub-mm compact galaxies and AGN

AGN “effect” on SFE



Valentino, Daddi, Puglisi+21

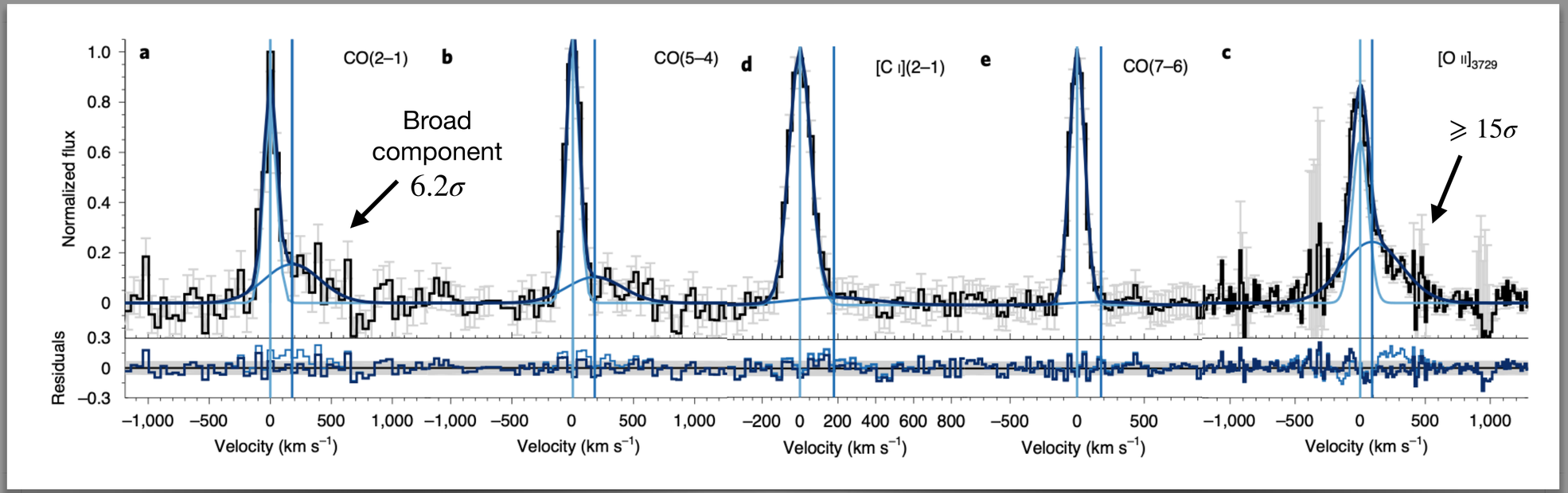
Sub-mm size “effect” on SFE



Puglisi+21b

A fundamental connection between bulge growth and AGN feeding?

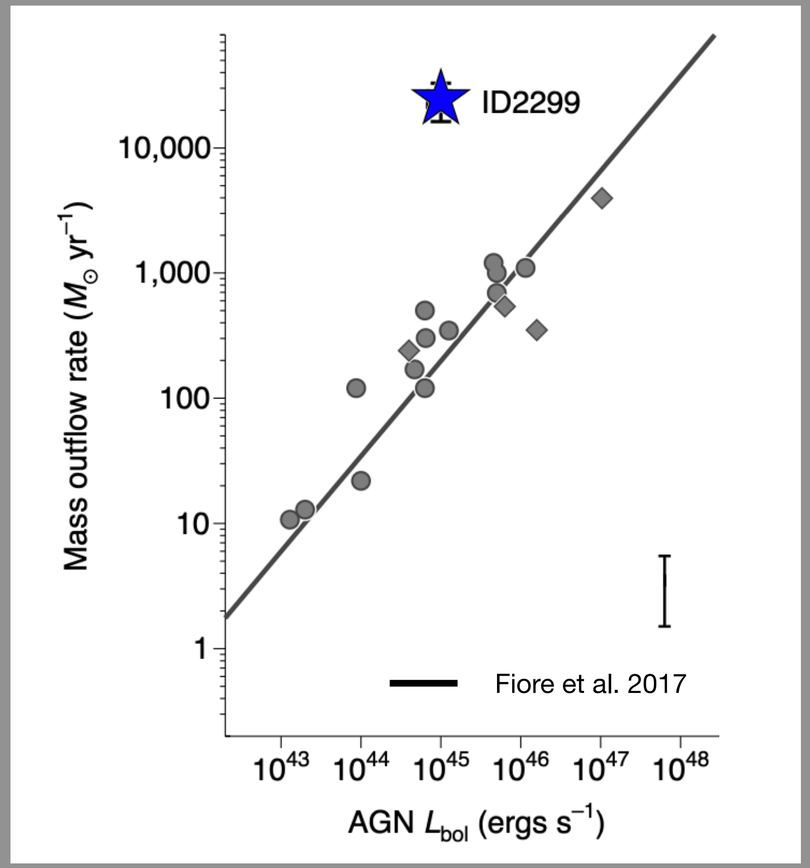
What causes low gas fractions in galaxies?



- Massive starburst galaxy at z~1.4
- 46 ± 13% of the total molecular gas mass expelled
- $t_{depl,\ host} = M_{mol,n} / SFR \sim 40$ Myr

Puglisi+21a

What causes low gas fractions in galaxies?



Puglisi+21a

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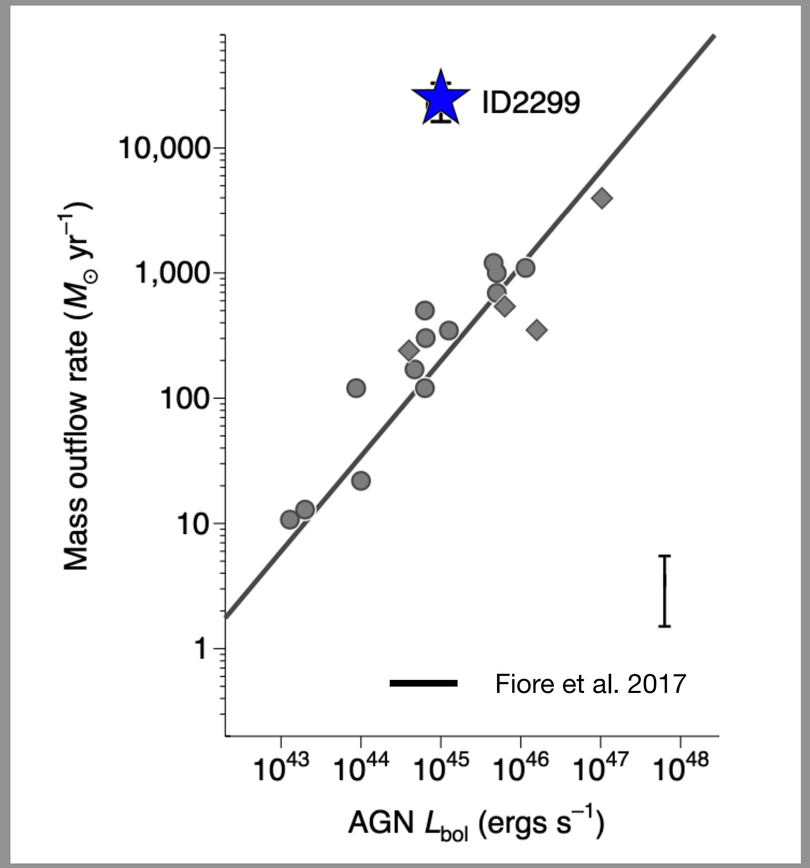

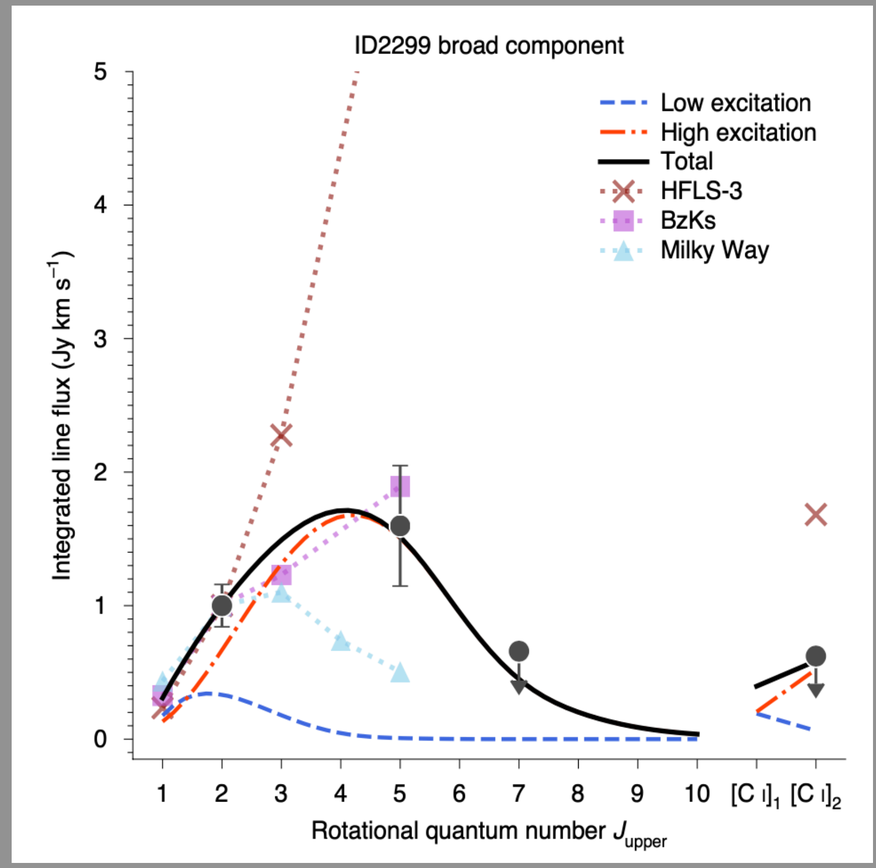

It is **challenging** to explain the extreme energetics and low excitation conditions of the expelled molecular gas with an **outflow scenario**

Puglisi+21a

AGN-driven winds and merger-driven tidal tails

- The gas conditions and merging nature of the galaxy suggest that the broad component is likely tidally-ejected material

- Winds and tidally-ejected gas can present similar observational signatures (see also Spilker+22; Baron+24)

Puglisi+21a

- ALMA revealed a **sizable population** of **sub-mm compact galaxies** within the scatter of the **main sequence** at cosmic noon with ISM properties similar to starbursts and low gas fractions.

- Sub-mm compact galaxies are more likely to host an AGN, and both sub-mm compact galaxies and AGN hosts have low depletion times and enhanced star formation efficiencies. This might suggest **a fundamental connection between bulge growth and AGN feeding.**

- AGN and major mergers can both eject gas from galaxies via **winds and tidal tails**, with similar observational features in 1D spectra. This stresses the importance of spatially-resolved IFU spectroscopy to study gas ejection mechanisms.