BADGRS

Submillimeter galaxies in the local universe

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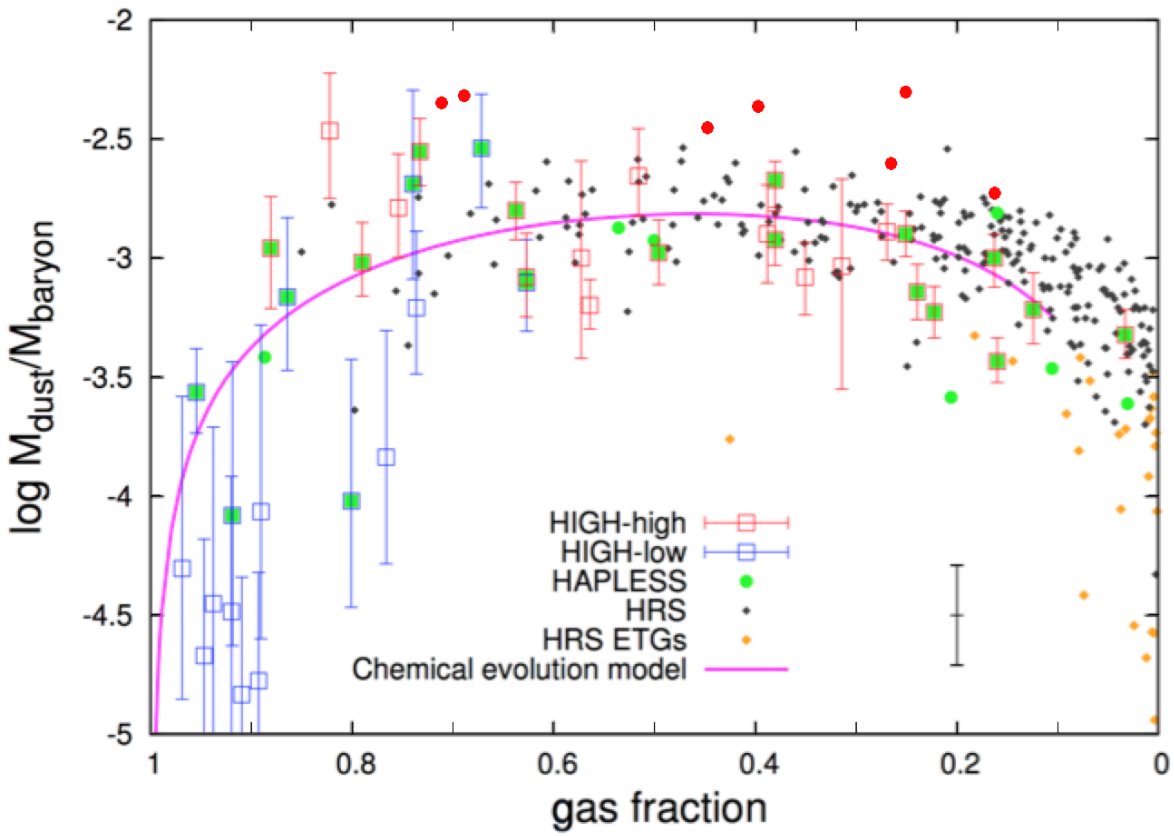
Sub-mm selection of local galaxies

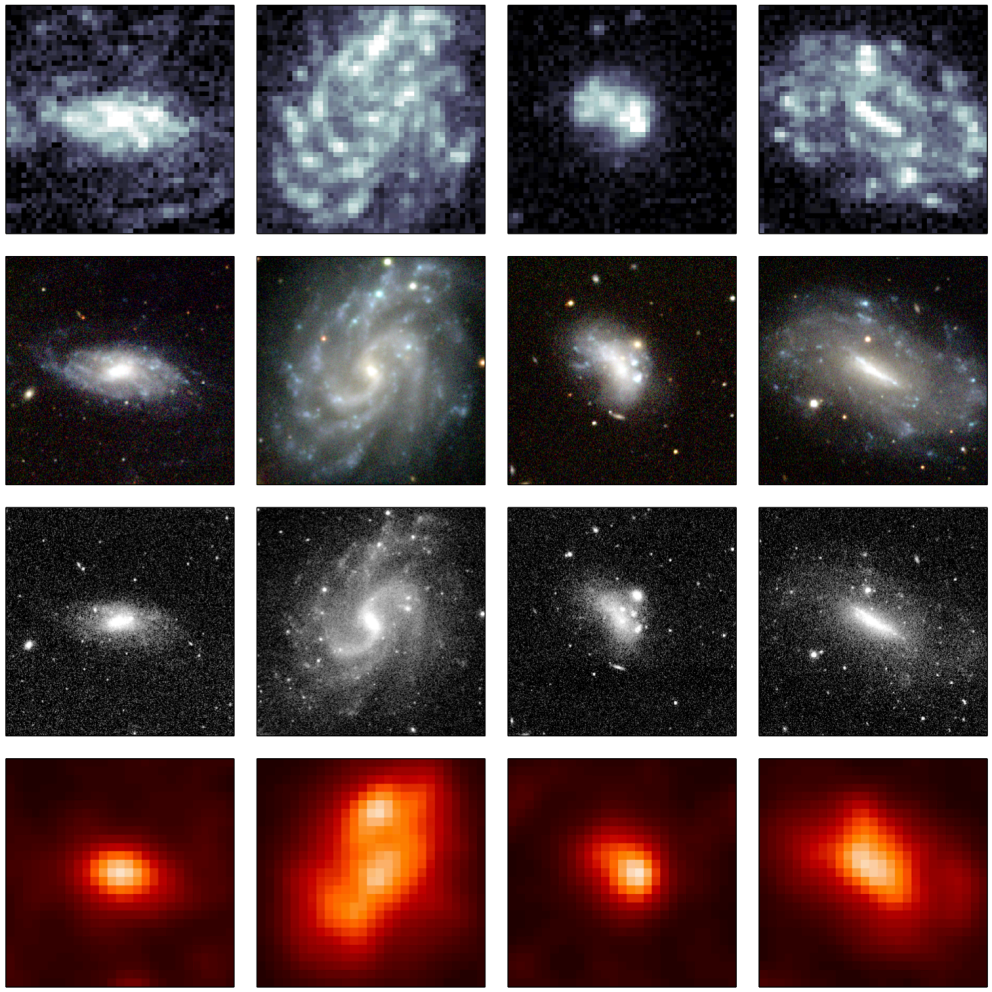


de Vis et al 2017

- dust fraction increases rapidly as stars form
- then declines as star-formation stops
- different selections favour different stages

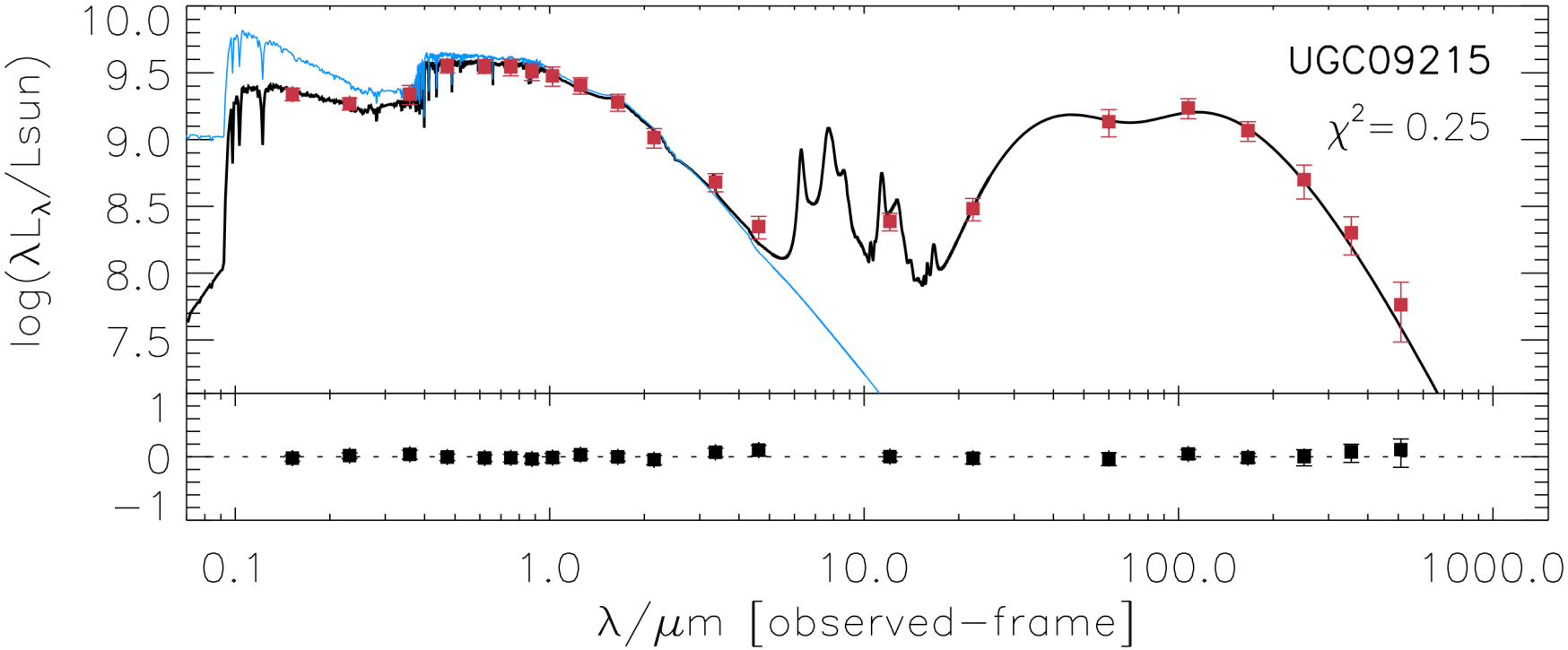
HAPLESS and BADGRS

- Local volume-limited sample from phase 1 H-ATLAS, 15<D<46Mpc
- found >50% of galaxies were:
  - very blue (FUV-K)<3.5
  - intermediate mass ($10^8 < M_* < 10^{10}\ M_\odot$)
  - flocculent or irregular morphologies
  - high gas fractions in terms of HI.
- Blue And Dusty Gas Rich Sources – BADGRS
- only 6% of stellar mass, 30% of dust mass density 20% of the star formation rate



Clark et al 2015

Dust Temperatures and Radiation field

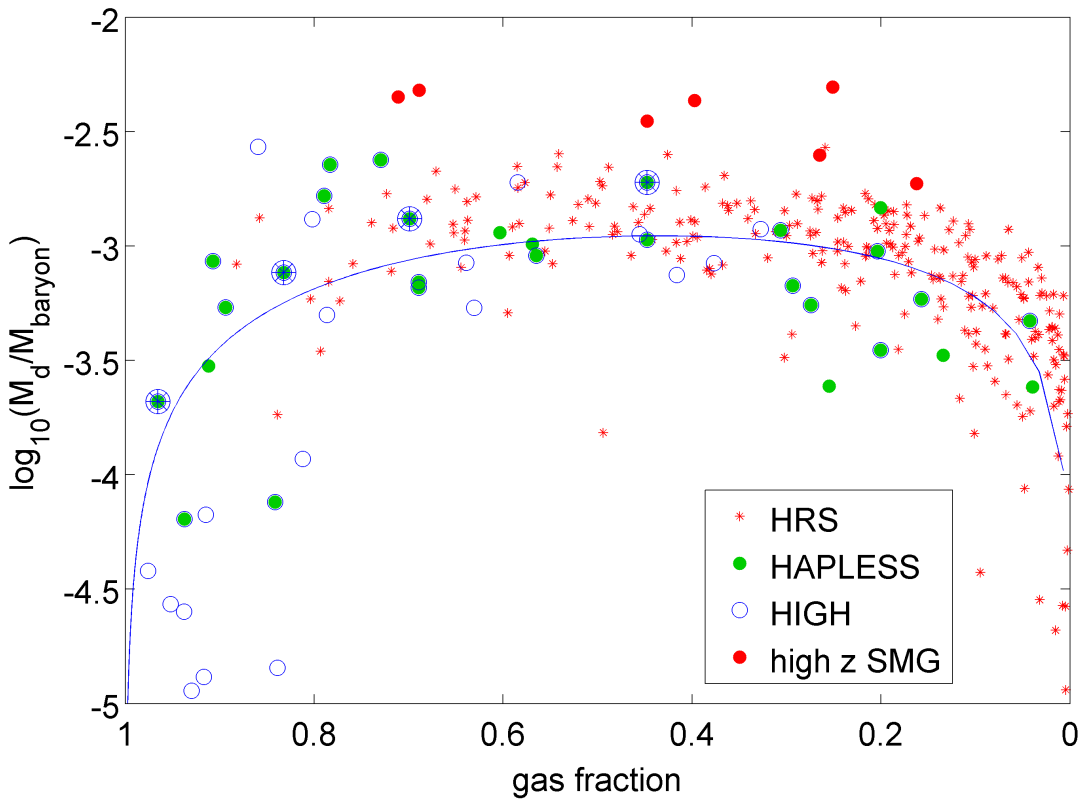


- Diffuse dust temperature in the BADGRS is 13–14 K (cf 18–31 K for normal spirals)
- For the same dust properties, this would require an ISRF 10–20 times lower than the local Galactic value.
- The measured radiation surface densities are similar to local Galactic value
- Need either
  - different dust geometry (clumpier)
  - different dust properties (size distribution, composition, opacity)

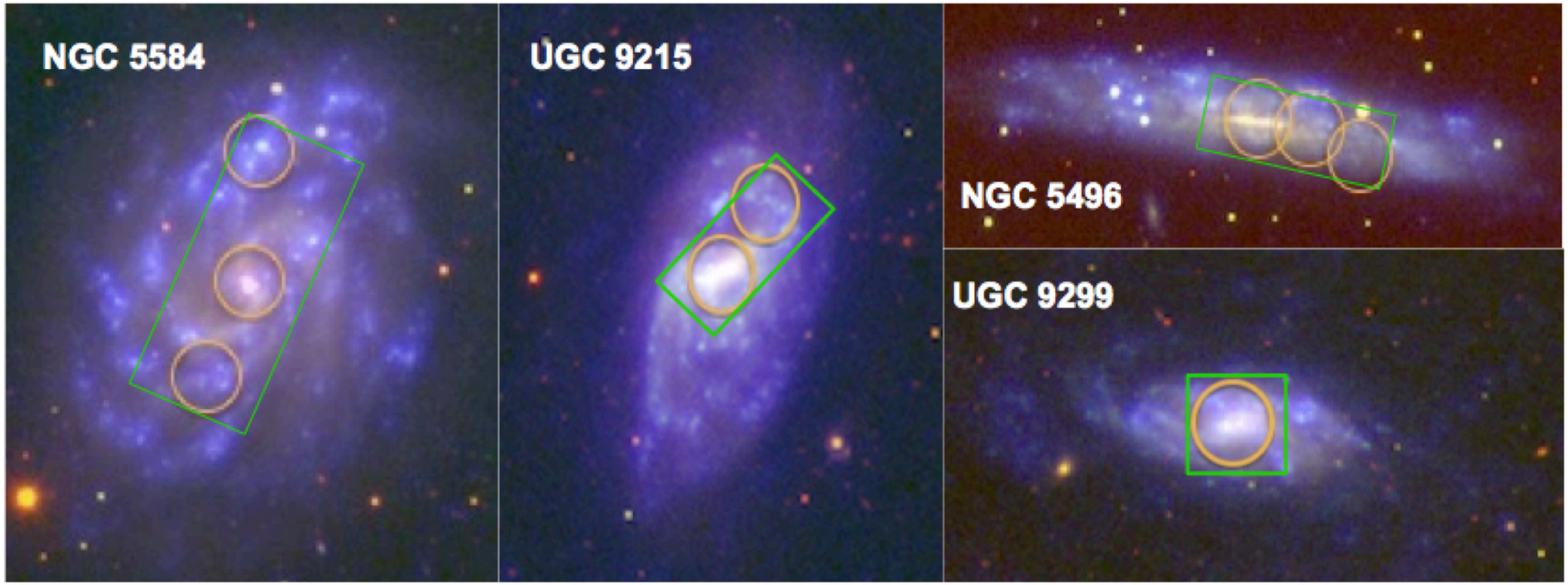
Sample of 4 BADGRS for detailed follow-up

- Range of gas fractions
- Higher dust mass per stellar mass
- Very blue: FUV-K < 2.7

- Follow-up observations
  - CO lines (IRAM + APEX)
  - HI maps (VLA + GMRT)
  - optical IFU spectra (AAT)
  - CO maps (ALMA)

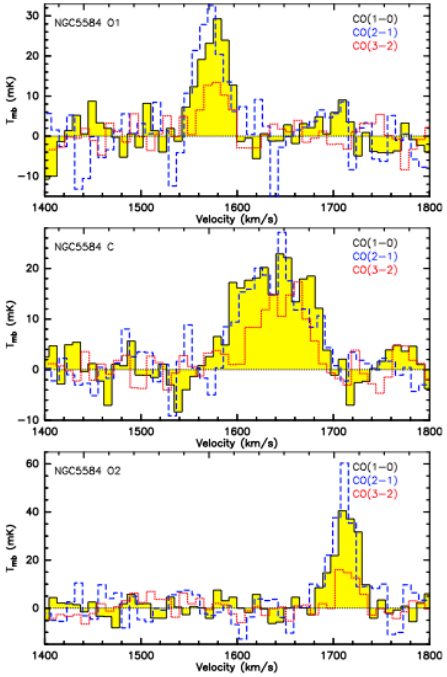


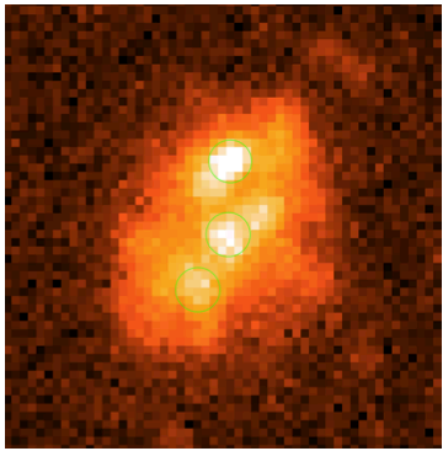
4 BADGRS

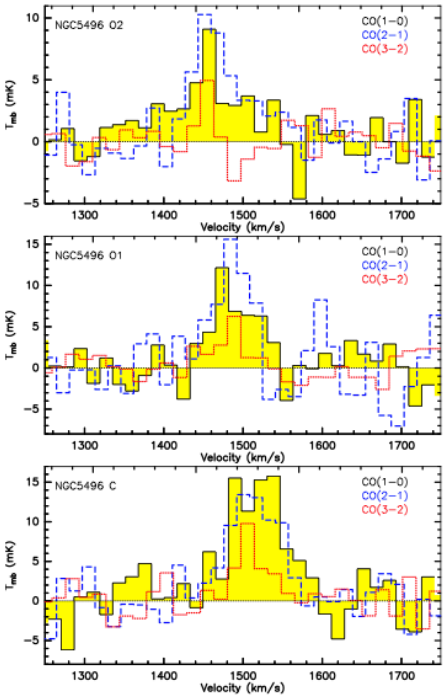


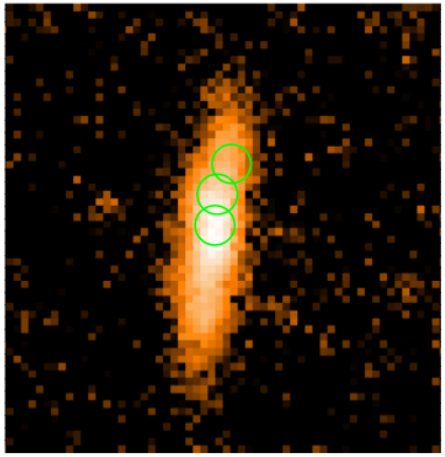
- yellow – IRAM CO pointings
- green – KOALA IFU and ALMA coverage

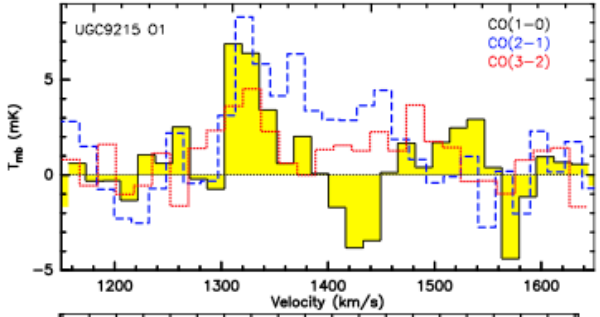
CO in BADGRS

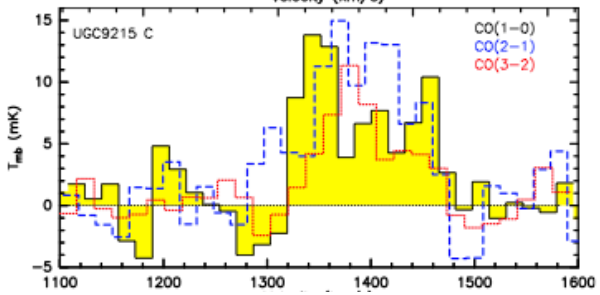

NGC5584 O1
NGC5584 C
NGC5584 O2
CO(1−0)
CO(2−1)
CO(3−2)
T_{mb} (mK)
Velocity (km/s)

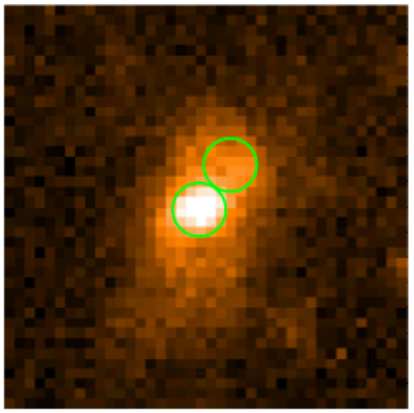


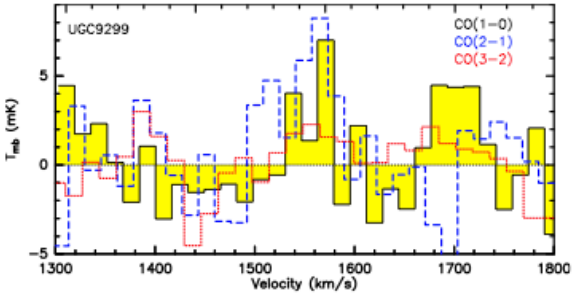

NGC5496 O2
NGC5496 O1
NGC5496 C
CO(1−0)
CO(2−1)
CO(3−2)
T_{mb} (mK)
Velocity (km/s)

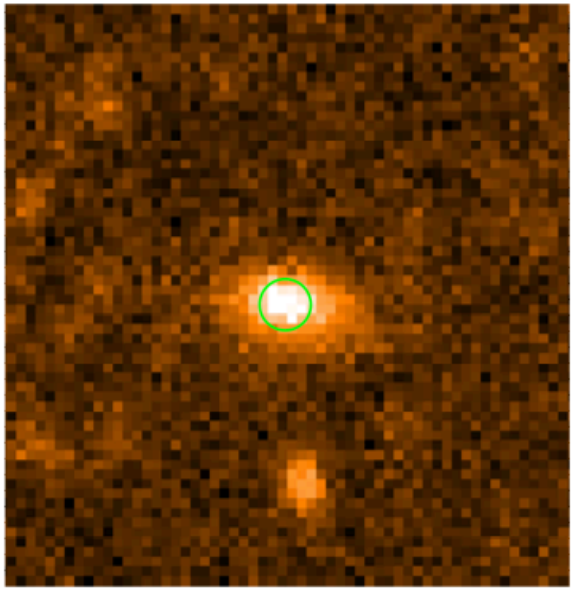



UGC9215 O1
CO(1−0)
CO(2−1)
CO(3−2)
T_{mb} (mK)
Velocity (km/s)


UGC9215 C
CO(1−0)
CO(2−1)
CO(3−2)
T_{mb} (mK)




UGC9299
CO(1−0)
CO(2−1)
CO(3−2)
T_{mb} (mK)
Velocity (km/s)



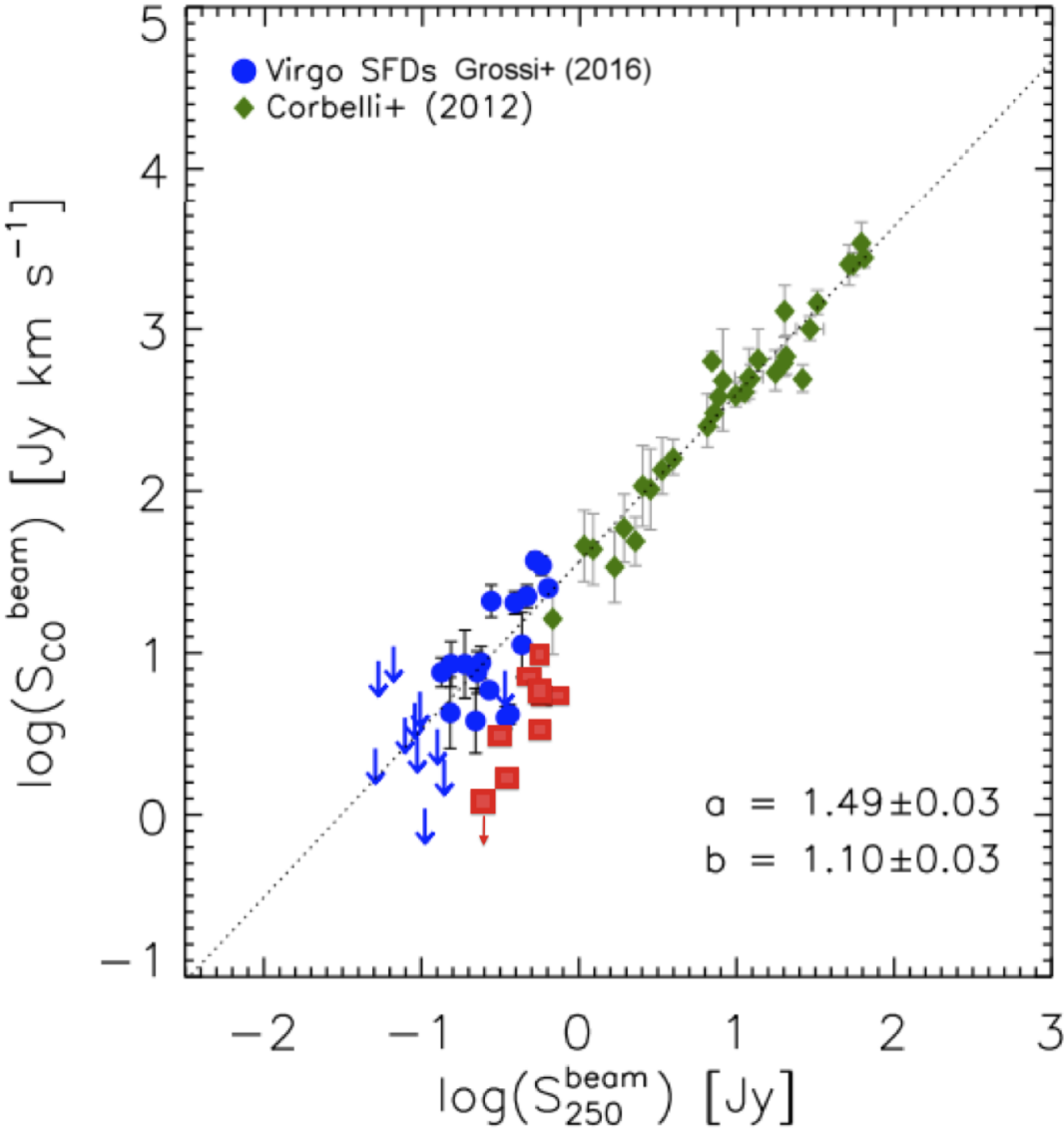
CO in BADGRS

- Low CO flux (Peak $T_{MB} \sim 5 - 30$ mK)
- Narrow Line widths (FWHM 30 – 100 km/s)
- Wide range of excitations ($r_{31} = 0.25 - 0.6$)

A lack of molecular gas?

- Deficient in CO emission cf 250 flux by factor 2 to 7 (average 4.2)

- $M_{H2}/M_{dust} \sim 10$ times lower than seen in local spirals ($M_{H2}/M_{dust} \sim 10$ vs ~ 100)



Grossi et al 2016

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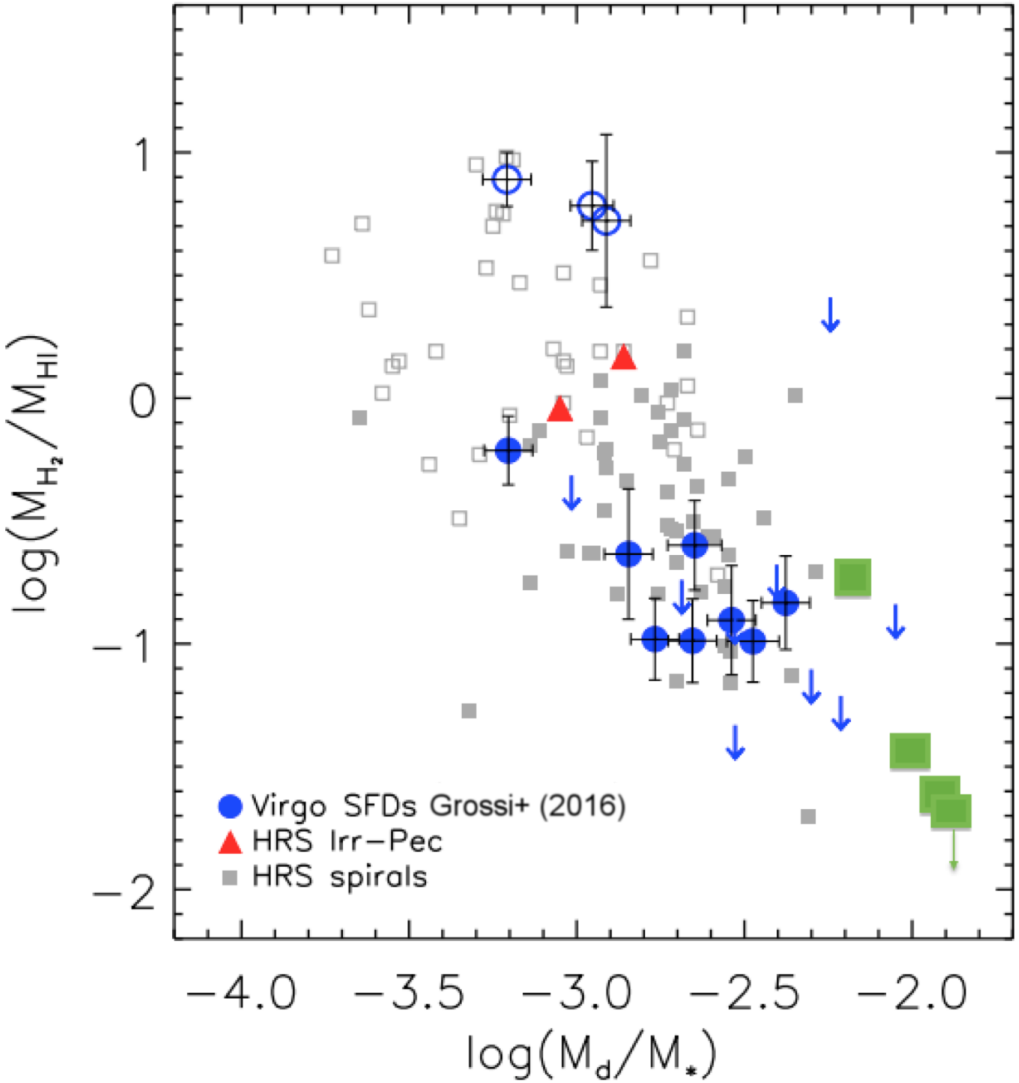


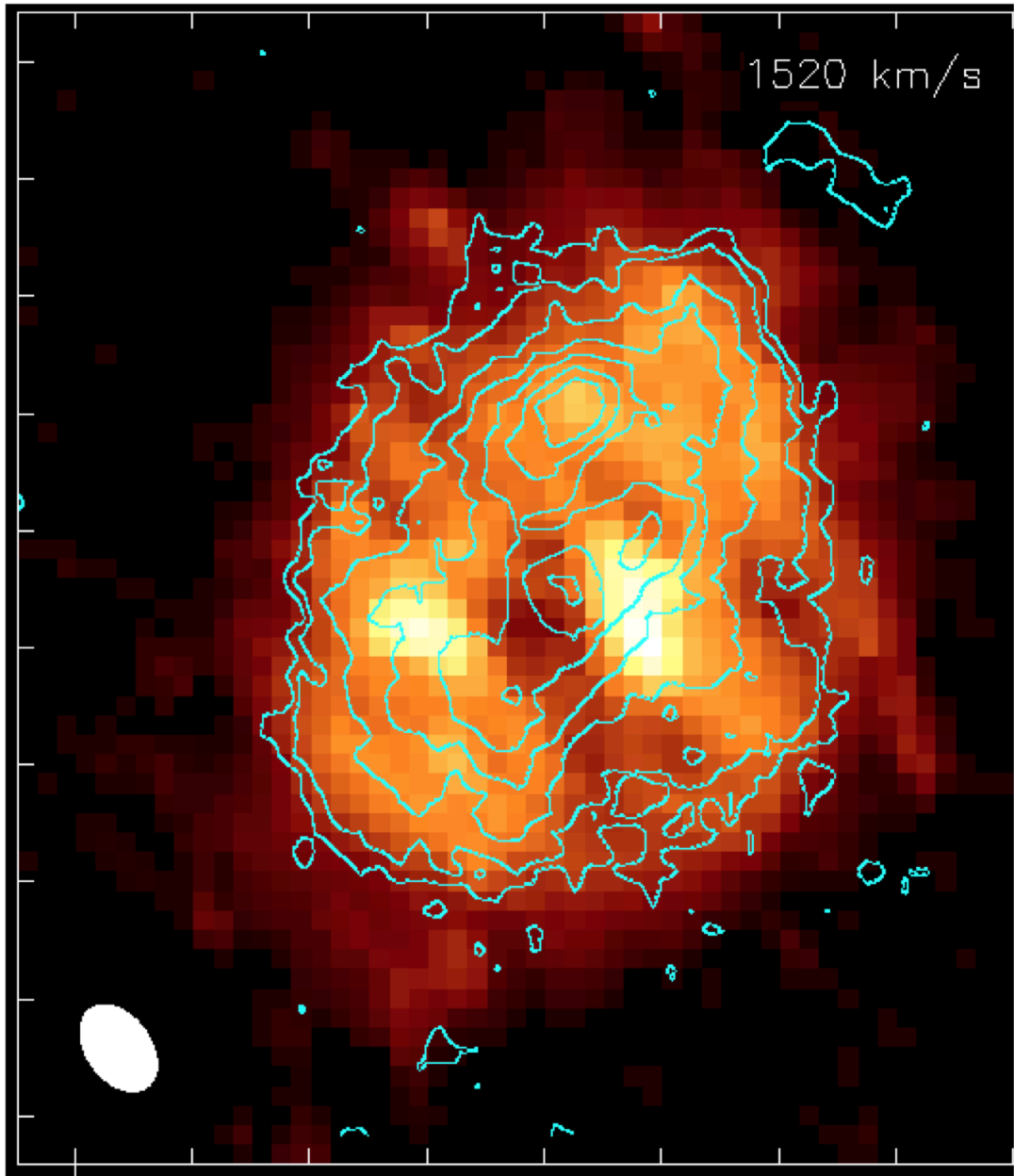
Grossi et al 2016

Reasons CO may be low

- ISM conditions unfavourable for HI ➔ H_2 conversion, so very little molecular gas.
- Low metallicity, so CO is destroyed.
- Is either possibility correct?

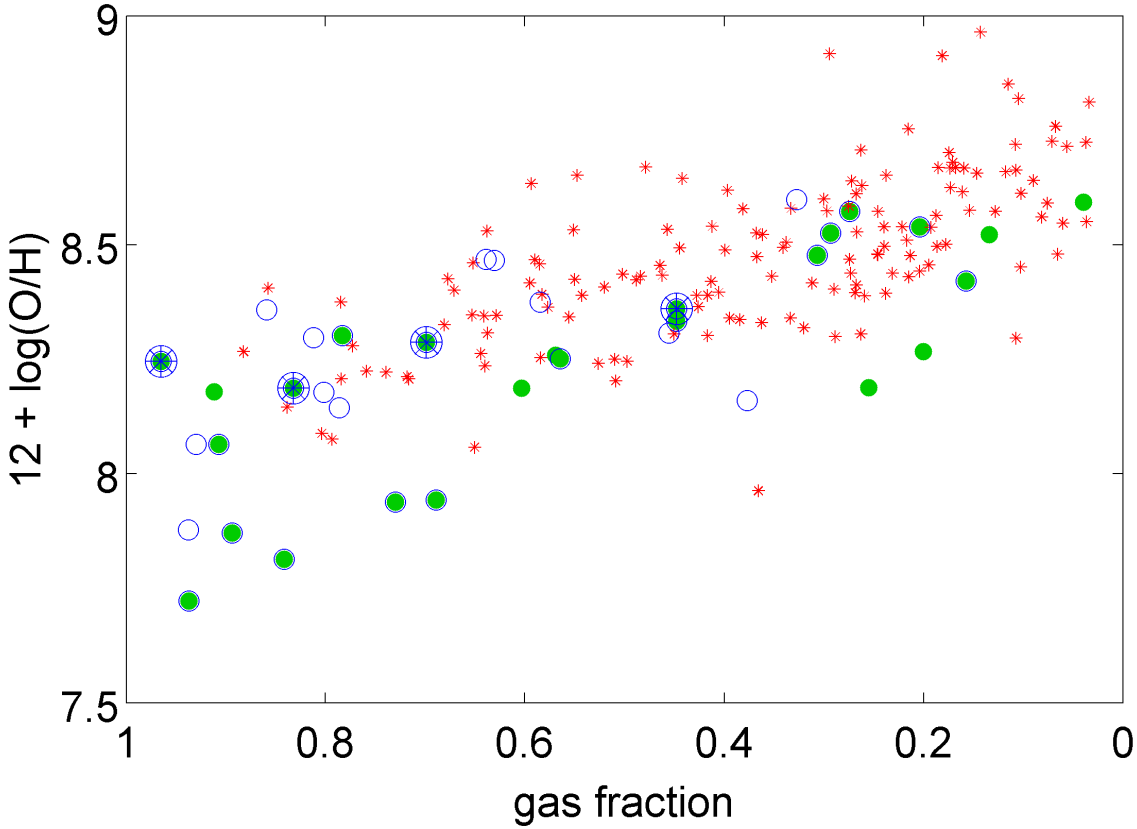
Low Molecular gas

- If most gas is HI, then dust would trace HI
- Compare HI to dust distribution
- HI peaks don't trace dust
- The deficiency in CO does not appear to be due to a lack of H_2
- Also estimates of the ISM pressure suggest that >50%of the gas should be molecular



Metallicity

- Low metallicity can lead to low CO:
  - low Z➔ low dust ➔ reduces the shielding of CO in molecular clouds
  - CO is strongly photo-dissociated at $Z < 0.5\ Z_{\odot}$



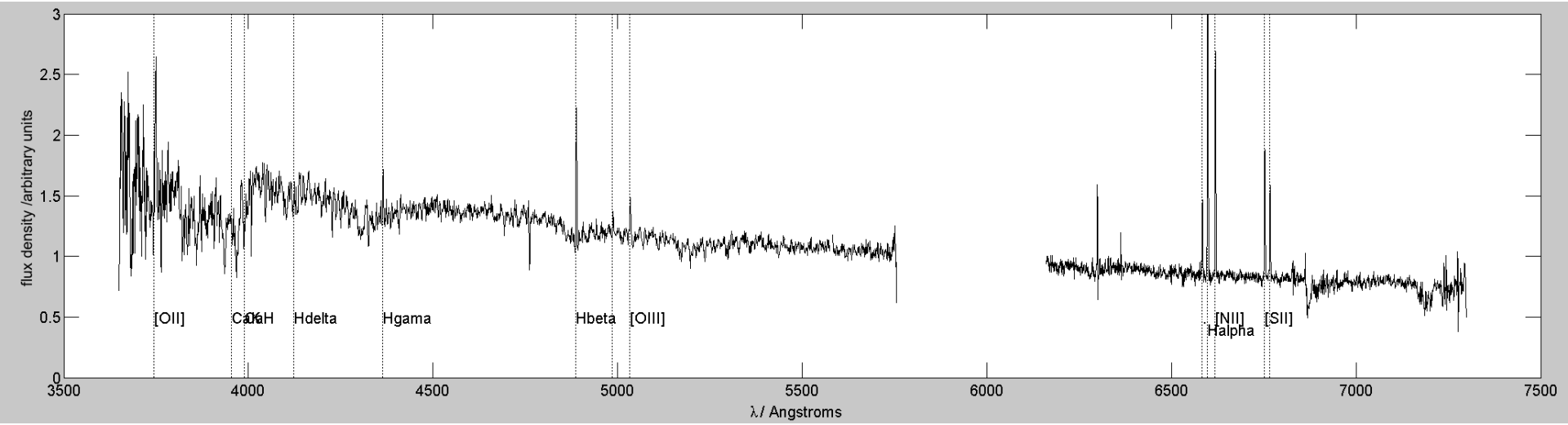
- But measured metallicities are ***not*** low (O/H abundance ~8.4)
- And we can see plenty of dust

Paradoxical properties

- Very dusty, but very blue
- Low temperature dust, but strong ISRF
- Low CO but metal rich

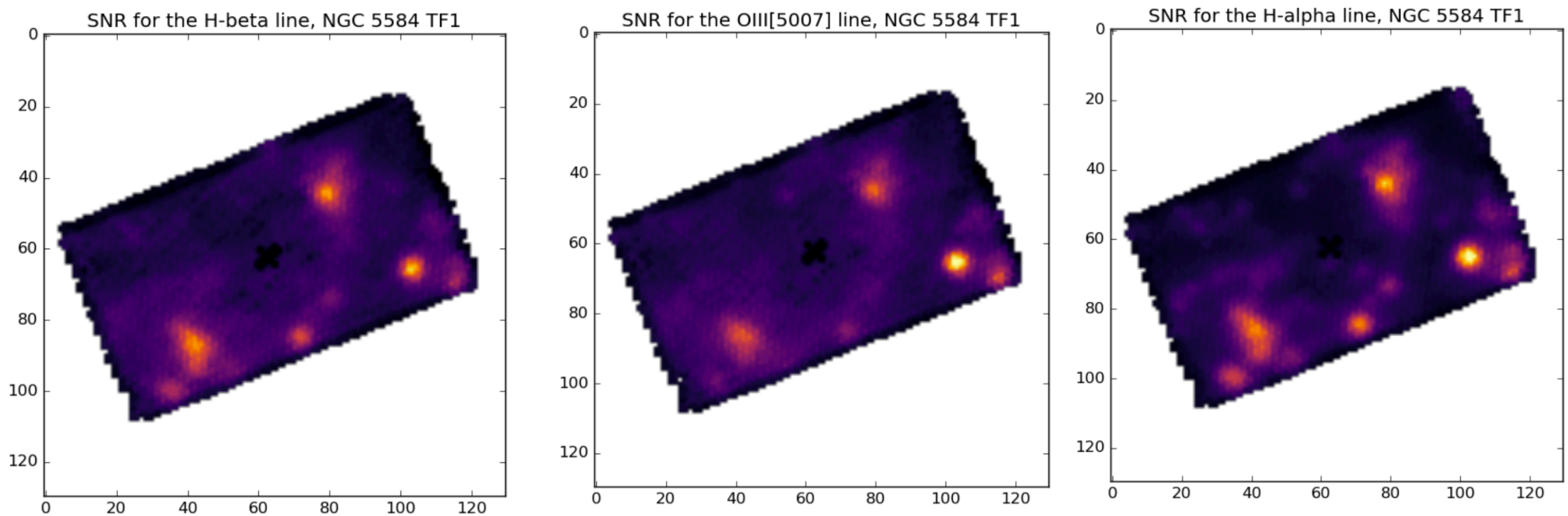
- to make progress need
  - high resolution CO and dust measurements from ALMA
  - optical IFU data to measure gas surface densities, kinematics, line ratios, metallicities, star formation histories, and dust attenuation
  - resolved SED fitting (including radiative transfer modelling)

IFU Koala Observations



- optical spectra
  - blue 3600A to 5700 with 1A resolution
  - red 6100A to 7300A with 0.6 A resolution
- O[I], O[II], O[III], N[II], S[II], Hα, Hβ, Hγ, Hδ

Koala IFU Observations



- Analysis of line strengths from spectral cubes underway
- Measure kinematics of both gas and stars
  - rotation
  - velocity dispersion
  - Toomre Q value
- Spatially resolved measurements of:
  - dust reddening
  - O and N abundances
  - excitation temperatures

Summary

- Dust selection favours high gas fraction galaxies
- About half are very blue, flocculent, intermediate mass galaxies
- BADGRS – contain only 6% of stellar mass, but have 30% of dust mass density and 20% of the star formation rate

- Unusual ISM properties:
  - low T_{dust} but high IS radiation field
  - should be H_2 rich but are found to be CO poor

- In order to explain this discrepancy there must be either:
  - a radically different dust geometry (clumpier)
  - different dust properties (size distribution, composition, opacity) compared to the Milky Way and other local galaxies