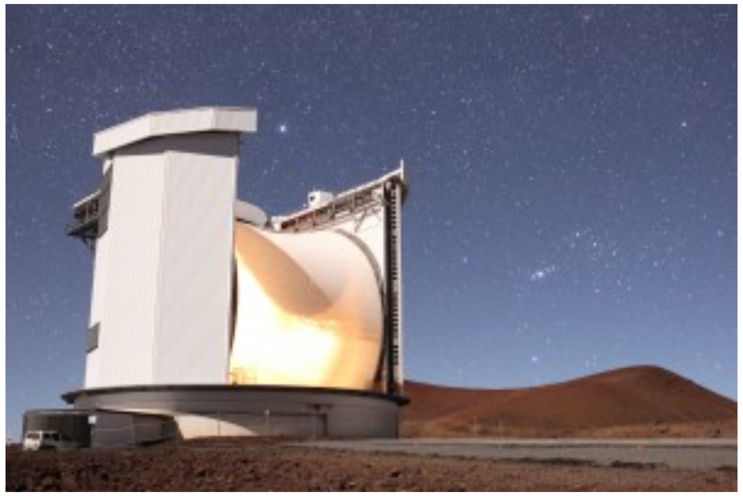

JINGLE: the JCMT dust and gas In Nearby Galaxies Legacy Exploration

a new JCMT legacy survey

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on behalf of
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JCMT Users Meeting@Mitaka, 2016/4/17-19

Outline

- Project Overview
- Survey Strategy
- Scientific Goals
- Survey Status
- First Preliminary Results

JINGLE: project overview

JINGLE

780h legacy survey

SCUBA-2

250 h, weather bands 2-4

850um observations of 195 galaxies

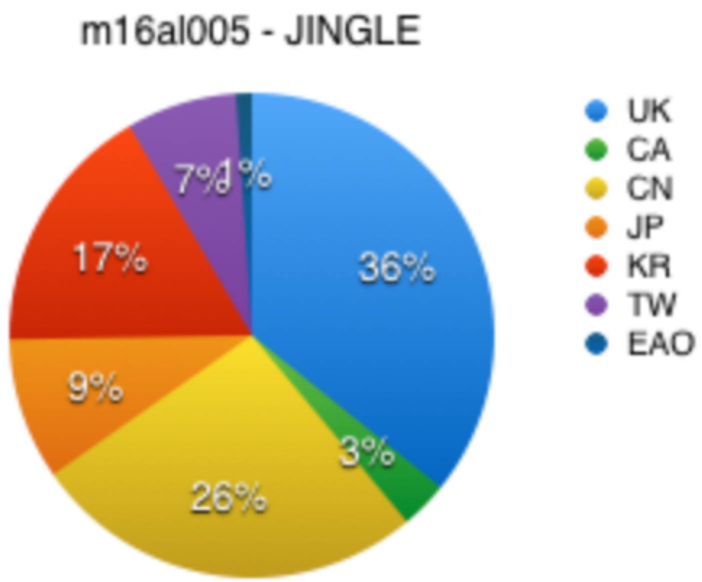
RxA

530 h, weather bands 4-5

CO(2-1) observations of 75 galaxies

JINGLE team

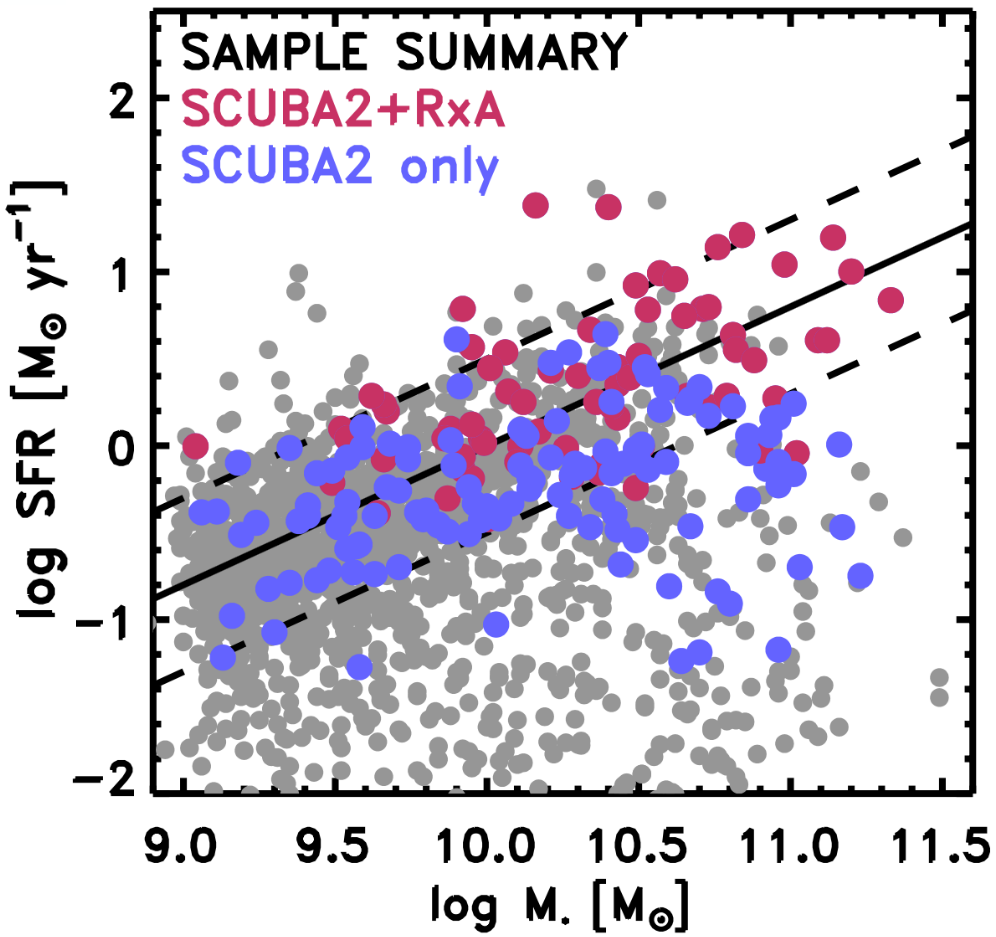
95 members from all the JCMT partner regions



Survey objectives

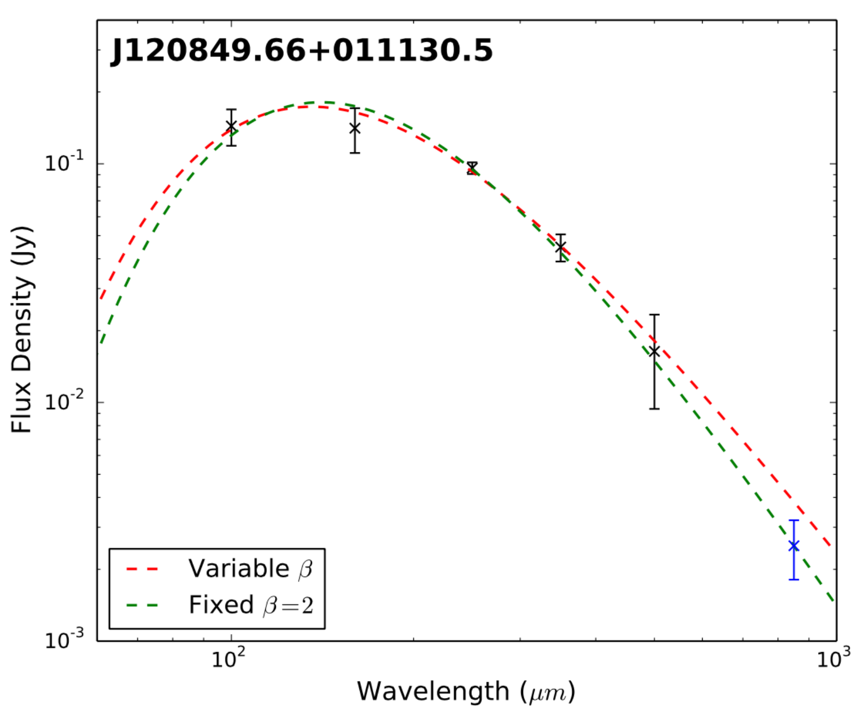
- deriving scaling relations between dust properties (mass, temperature, emissivity) and global galaxy observables.
- studying the dust-to-gas ratio and its variations across the galaxy population.
- benchmarking relations that can be used to infer gas masses for large samples of high-redshift galaxies.
- investigating the correlation between ISM properties and the dynamics of galaxies.

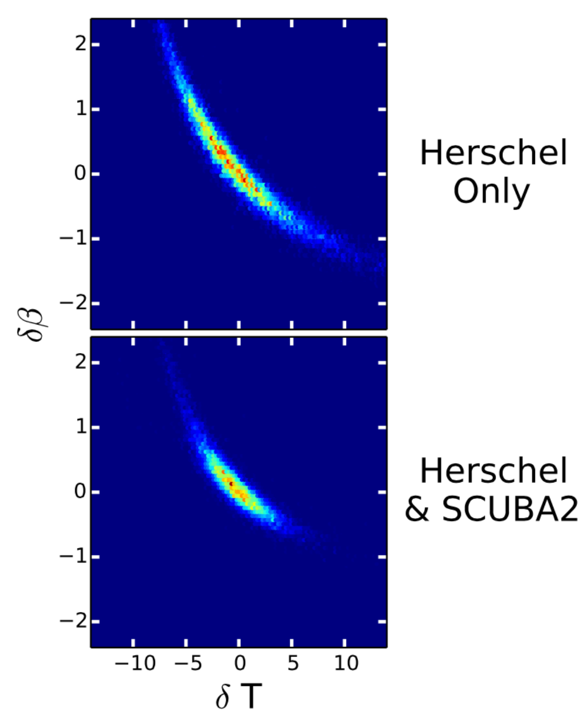
JINGLE: sample and survey strategy



Sample builds on multiple surveys

- H-ATLAS: Herschel PACS+SPIRE photometry
- GALEX/SDSS/WISE: UV-to-NIR photometry
- MaNGA/SAMI: optical IFU maps
- Apertif/ASKAP surveys: HI maps



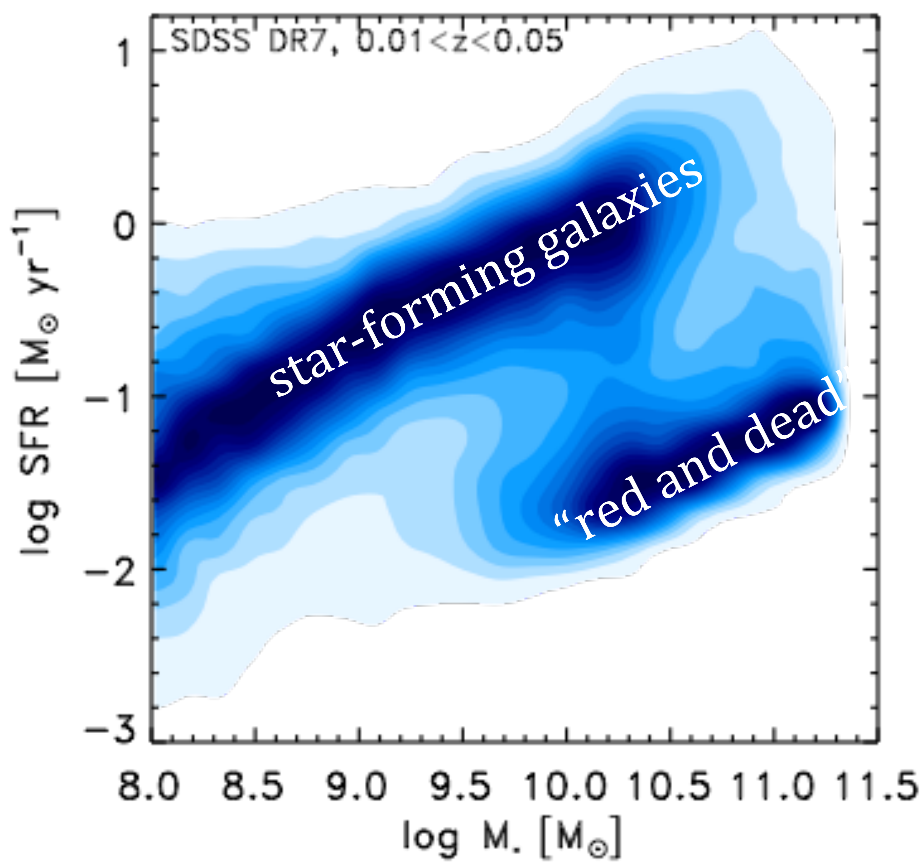


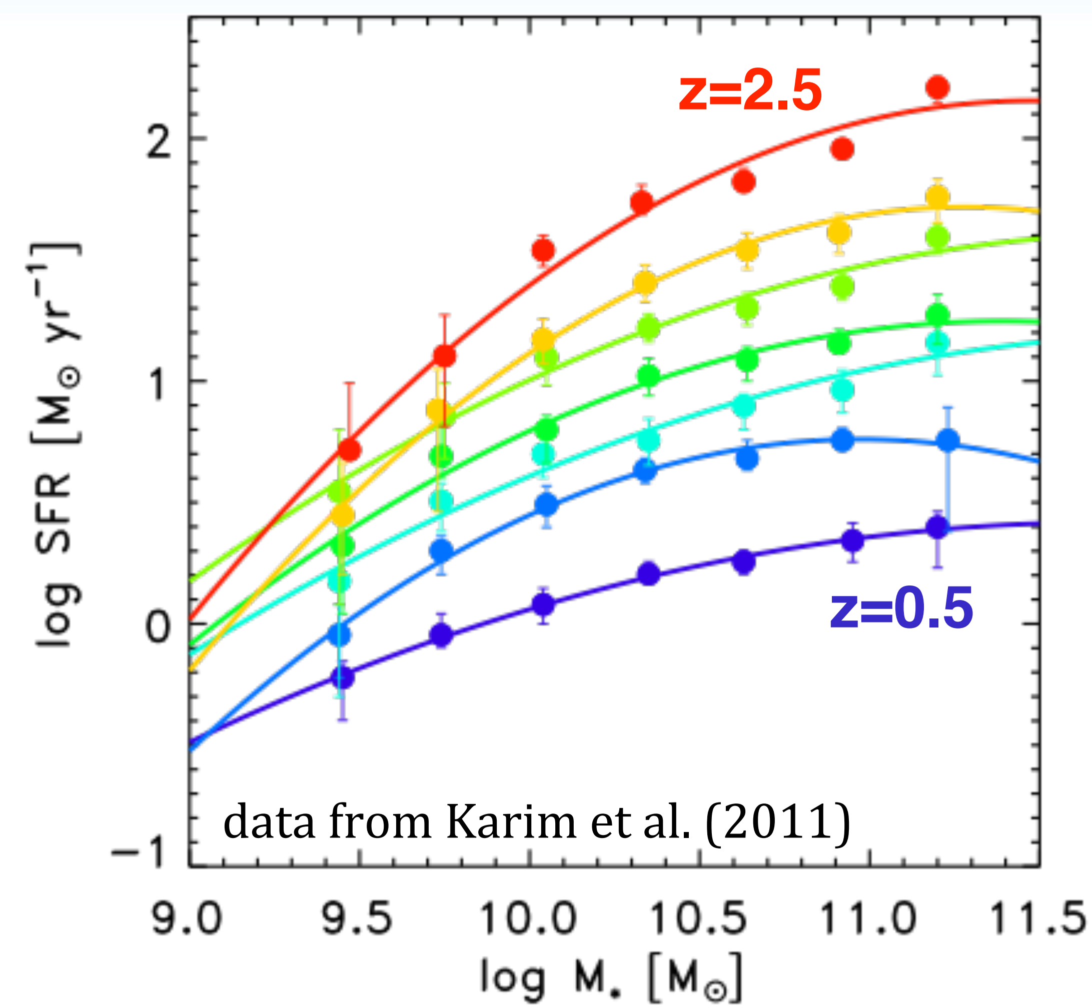
By adding SCUBA-2 data, can fit simultaneously for the temperature and emissivity of the dust.

Context: the current view on galaxy evolution

the star formation "main sequence"

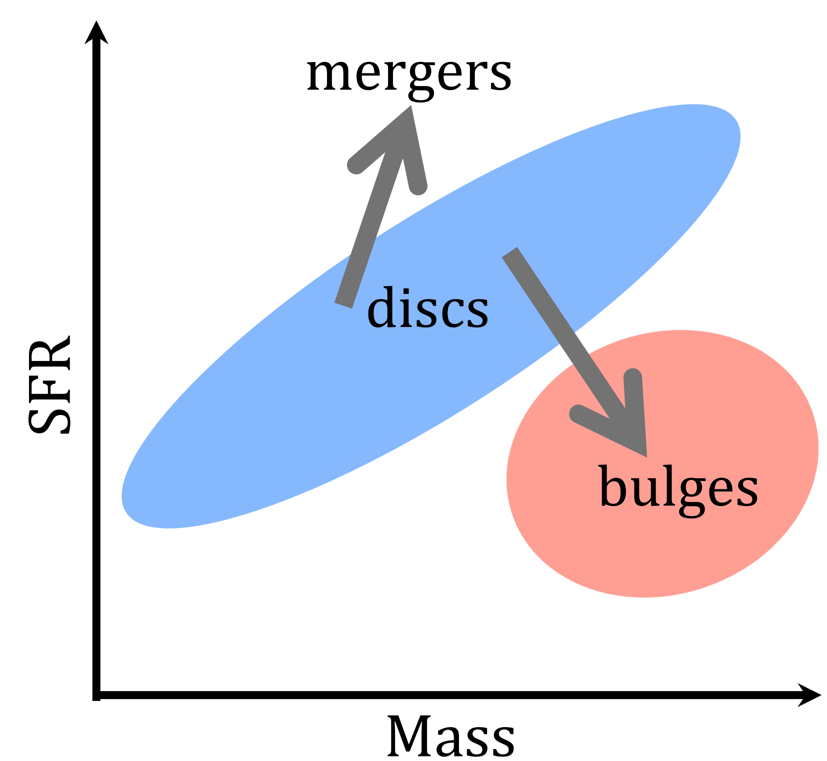
see e.g.: Schiminovich et al. (2007), Elbaz et al. (2007), Noeske et al. (2007), Daddi et al. (2007), Perez-Gonzalez et al. (2008), Peng et al. (2010)





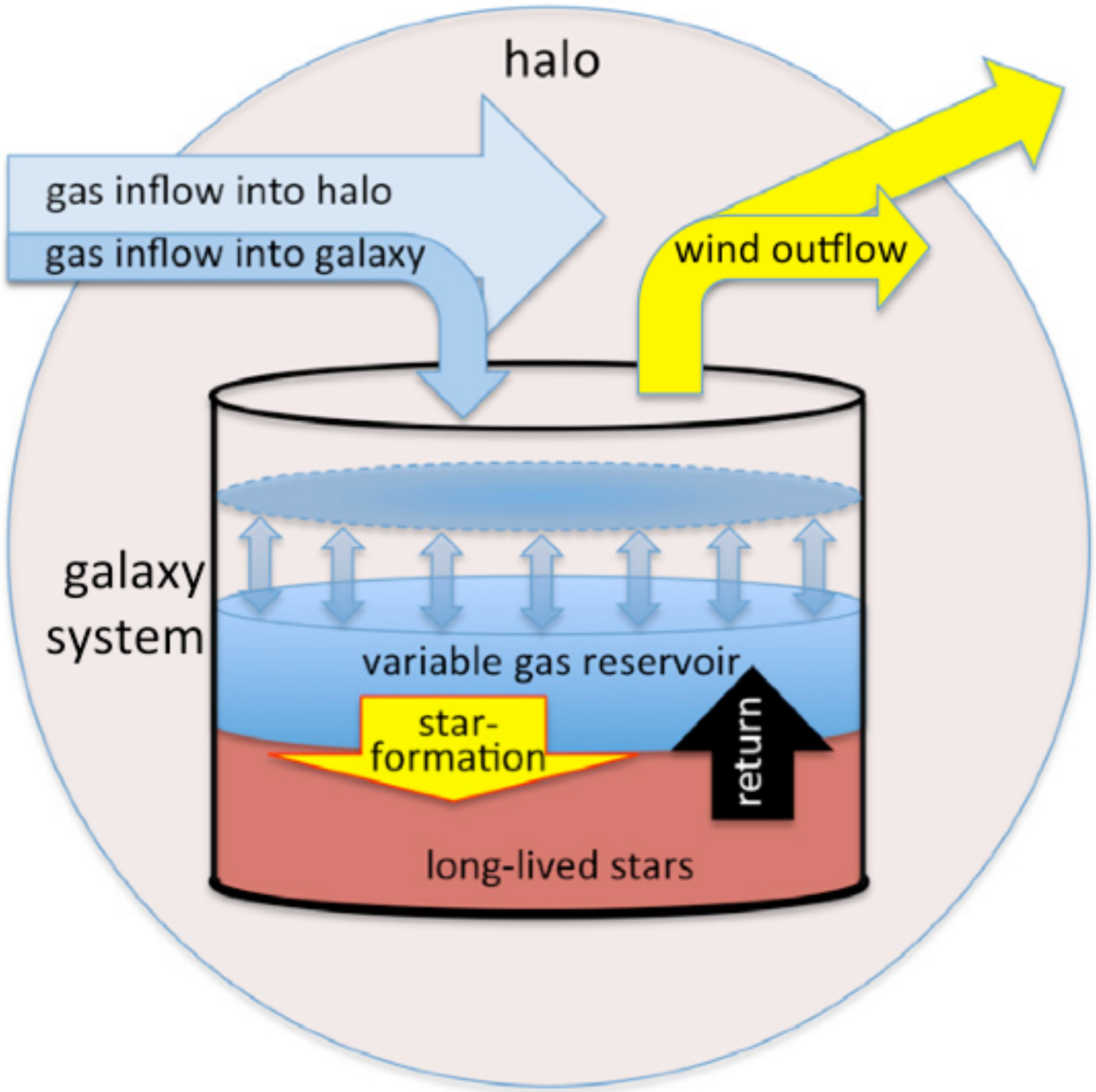
$SFR \sim M_*^a(1+z)^b$, where a~0.8, b~2.5

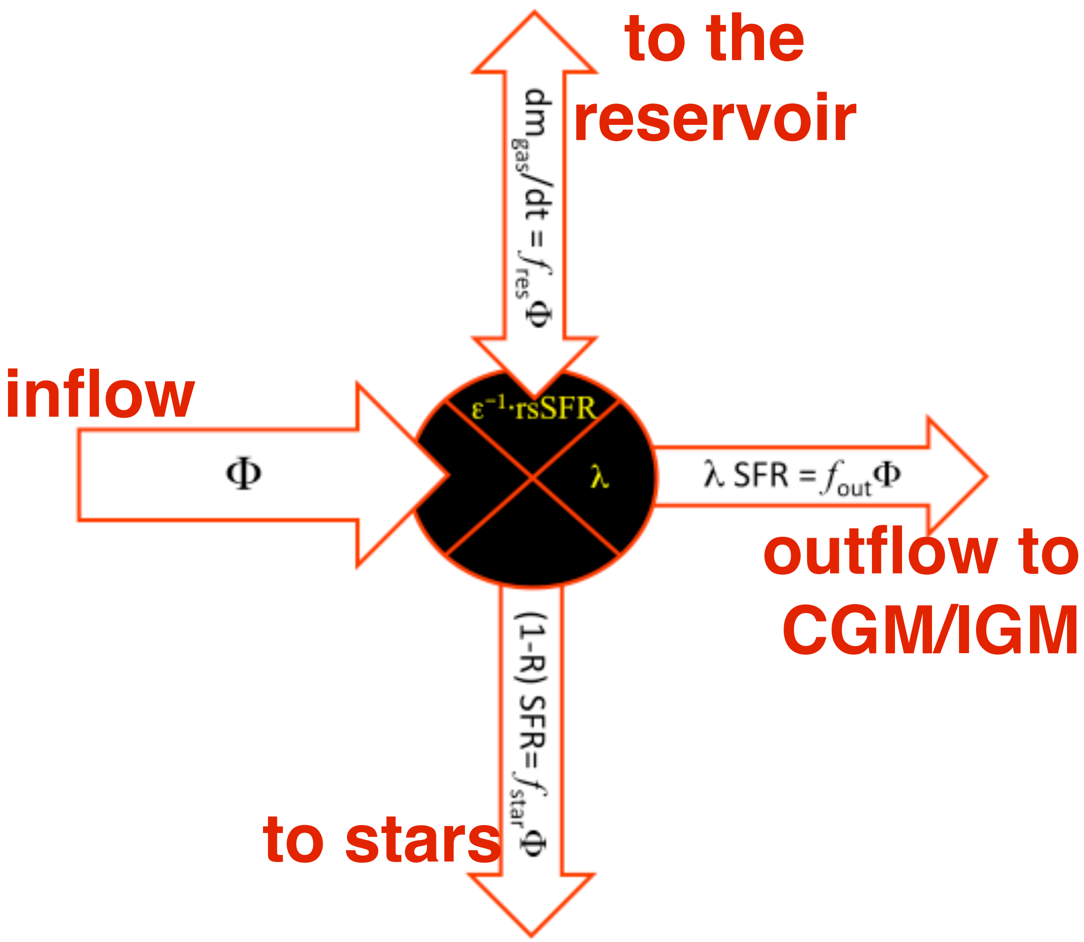
- Galaxies on the main sequence (MS) contribute ~90% of the star formation.
- Duty cycles on the MS are high at 40-70% implying that "catastrophic" events like **major mergers cannot be the main agent responsible for regulating star formation.**



Context: the current view on galaxy evolution

Illustration of the gas-regulated model





$$\Phi = (1 - R + \lambda) \cdot \mathrm{SFR} + \frac{dm_{\mathrm{gas}}}{dt}$$

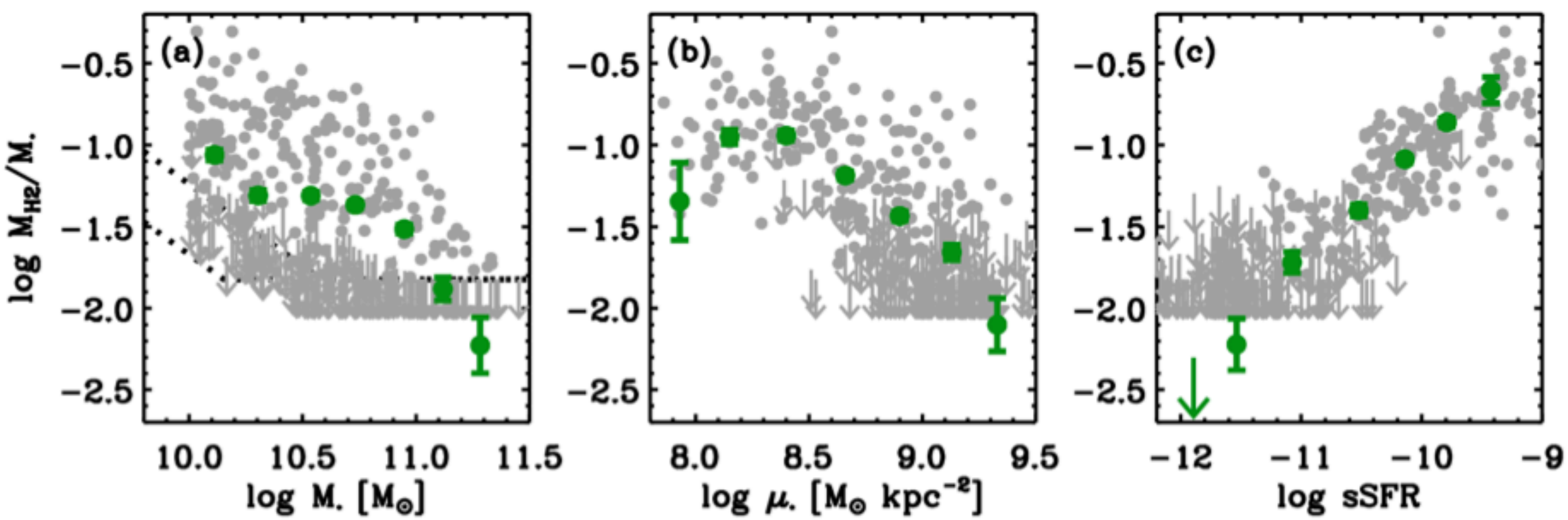
Star formation is regulated by the mass of gas in a reservoir, which itself is affected by the inflow rate, the star formation efficiency, and the mass loading factor of outflows.

Lilly et al. (2013), see also, e.g. Genel et al. (2008), Bouché et al. (2010), Davé et al. (2011,2012), Krumholz & Dekel (2012)

Science motivation #1: What is the link between the physics of star formation on small scales and the properties of entire galaxies?

Correlations of integrated gas content with spatially-resolved quantities:

- The molecular gas mass fraction correlates well with stellar mass, stellar mass surface density, and specific star formation rate, though with large scatter in a large complete sample.
- Drop in molecular gas content related to galaxy internal structure.
- Probe SF efficiency as a function of gradients in 2D galaxy properties (stellar / ionised-gas) measured from optical spatially-resolved spectroscopic data provided by MaNGA.

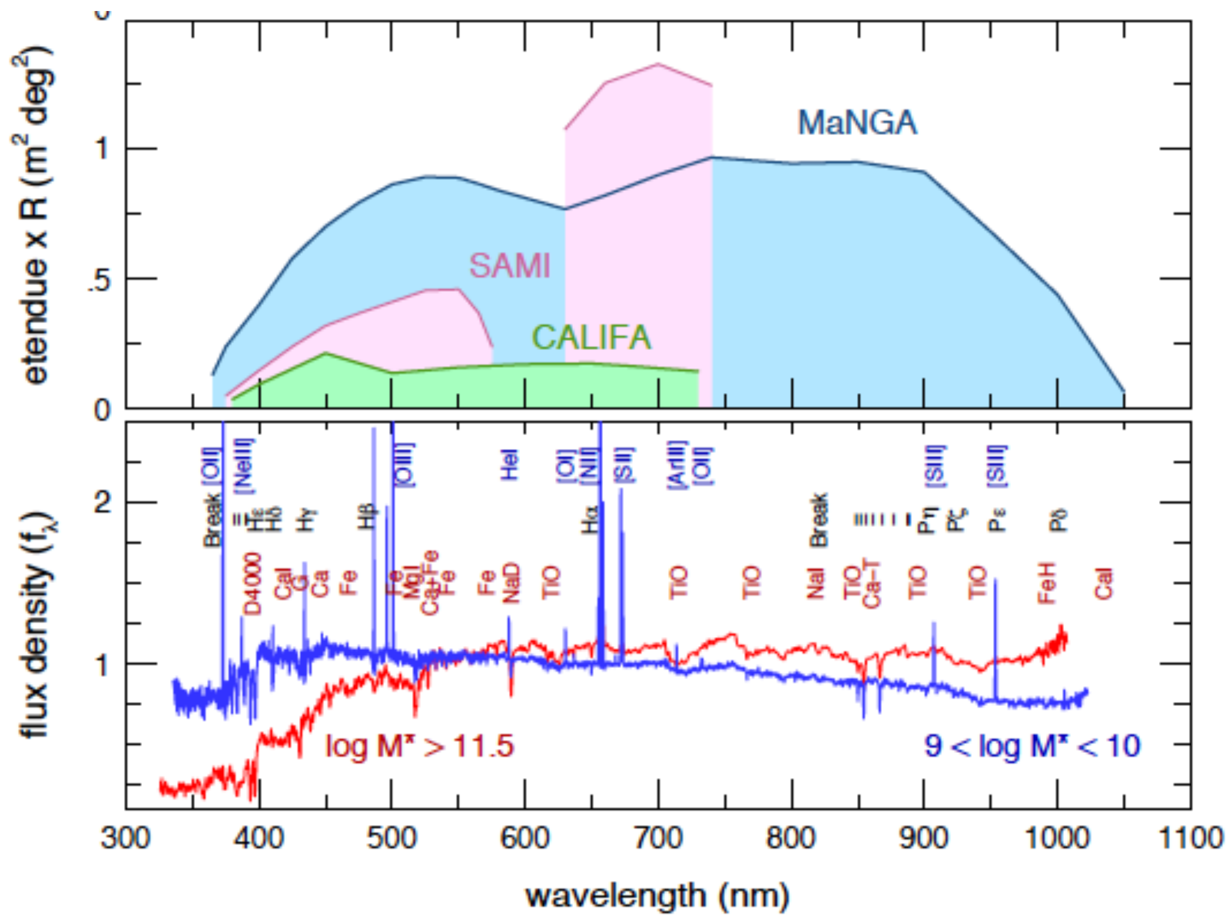


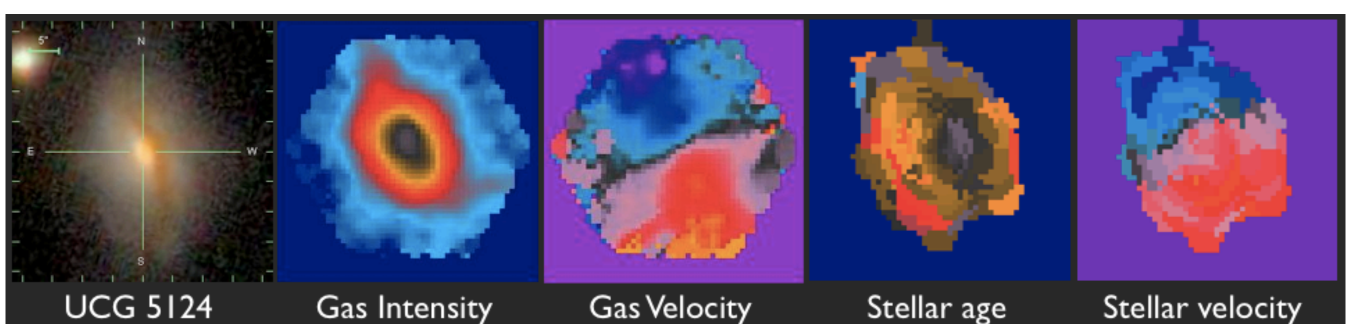
COLD GASS (Saintonge+ 2011)

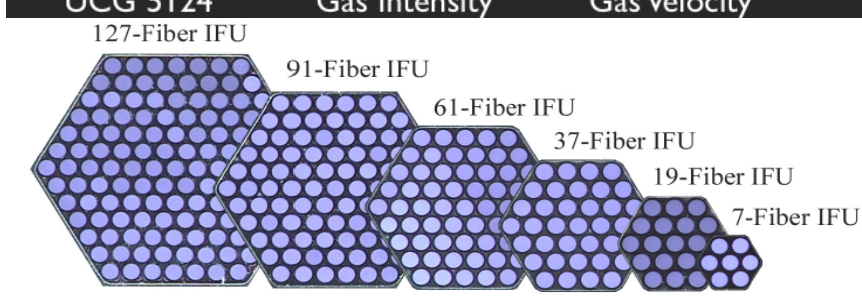
Science motivation #1: What is the link between the physics of star formation on small scales and the properties of entire galaxies?

Correlations of integrated gas content with spatially-resolved quantities:

MaNGA: Mapping Nearby Galaxies at Apache Point Observatory (Bundy et al. 2015)







- 10,000 SDSS galaxies at 0.01<z<0.15
- Mass-limited sample: lg(Mstar)>9.0
- Spatial resolution = 2” (1-2 kpc)
- Spectral resolution = 50-70 km/s
- Spectral coverage: 3600 - 10000 AA
- Spectral S/N = 4-8 at 1.5 Re

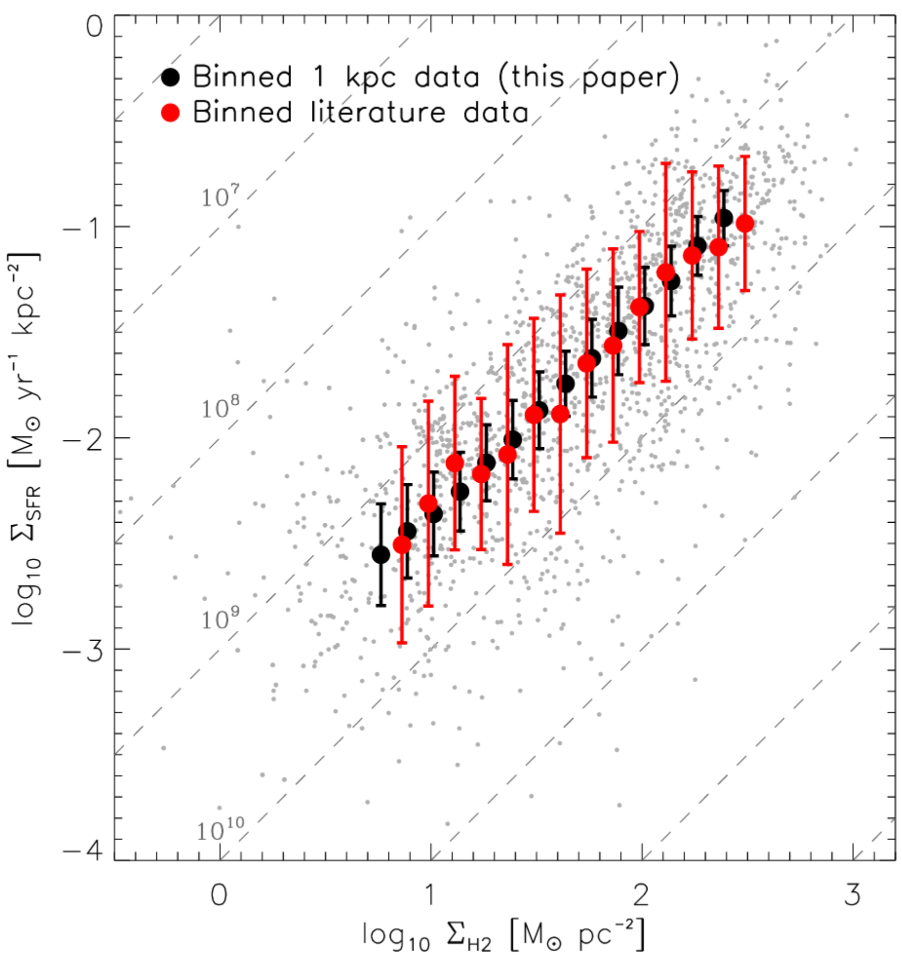
MaNGA key science goals:

- Growth of disk and bulge
- Staf formation quenching
- Kinematics of stars and gas
- Rotation curve and dark matter halo

Science motivation #1: What is the link between the physics of star formation on small scales and the properties of entire galaxies?

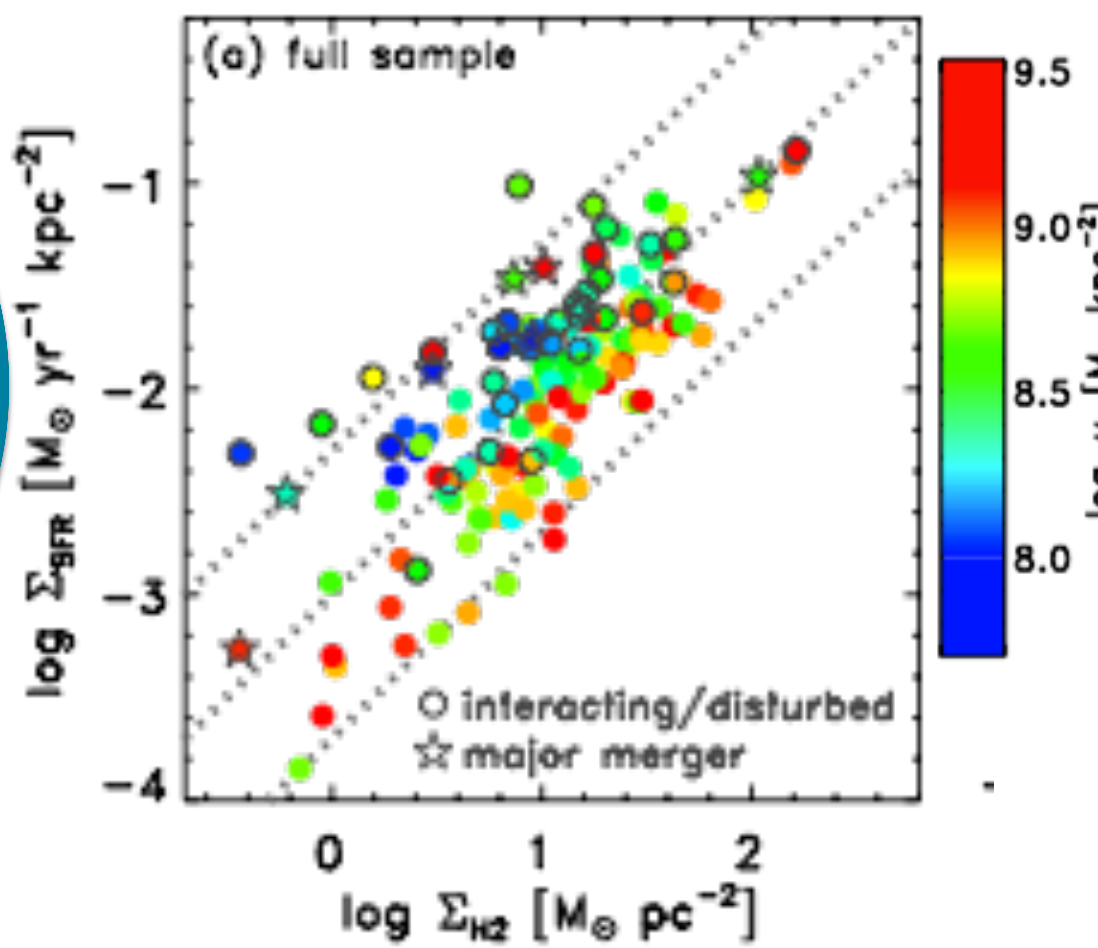
Some important questions:

- Do the properties of the GMC population of a galaxy depend on its global properties?
- How does the environment influence the formation of GMCs?
- Once GMCs are formed, does star formation occur with the same efficiency in all environments?



Bigiel et al. (2011)

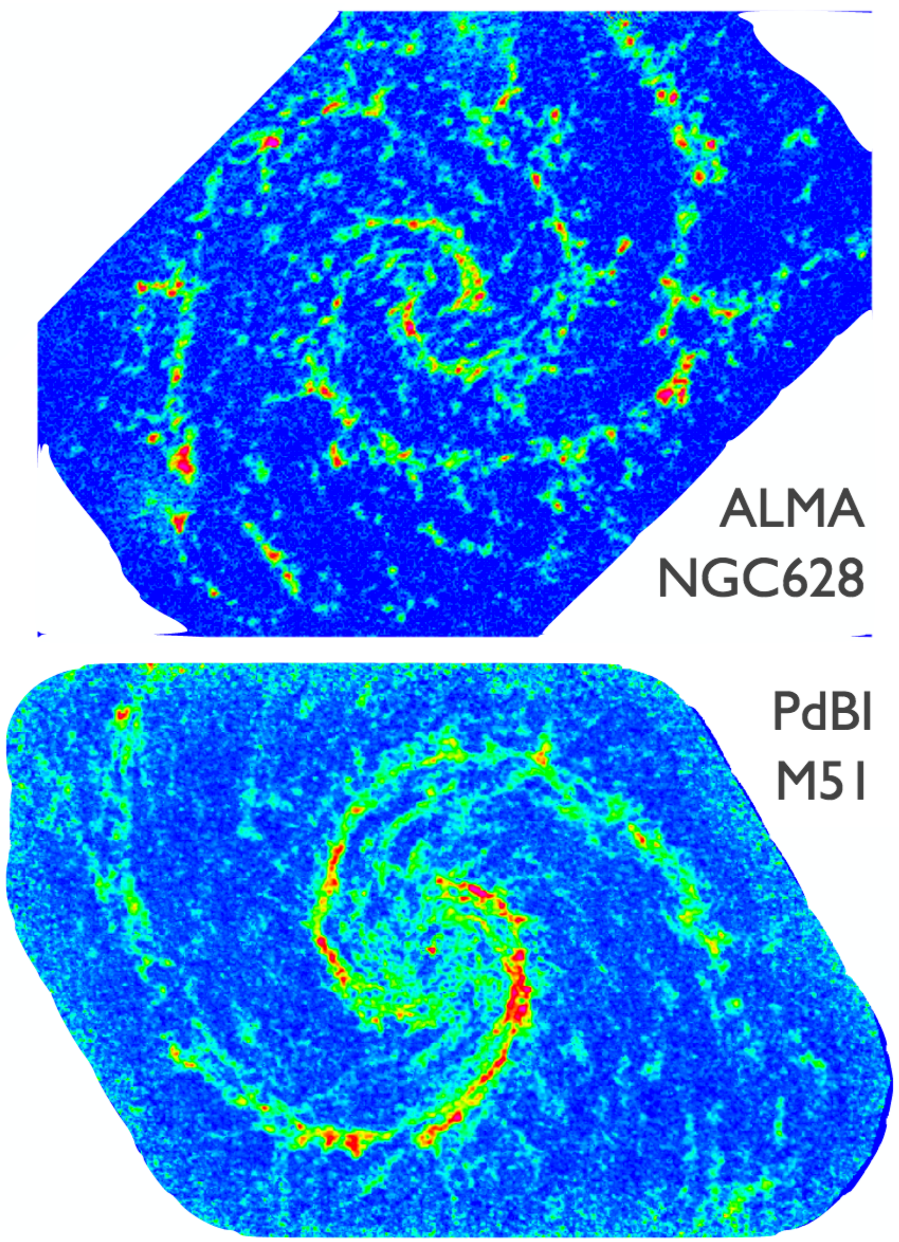
Universal SF law, or systematic variations with global environment ???

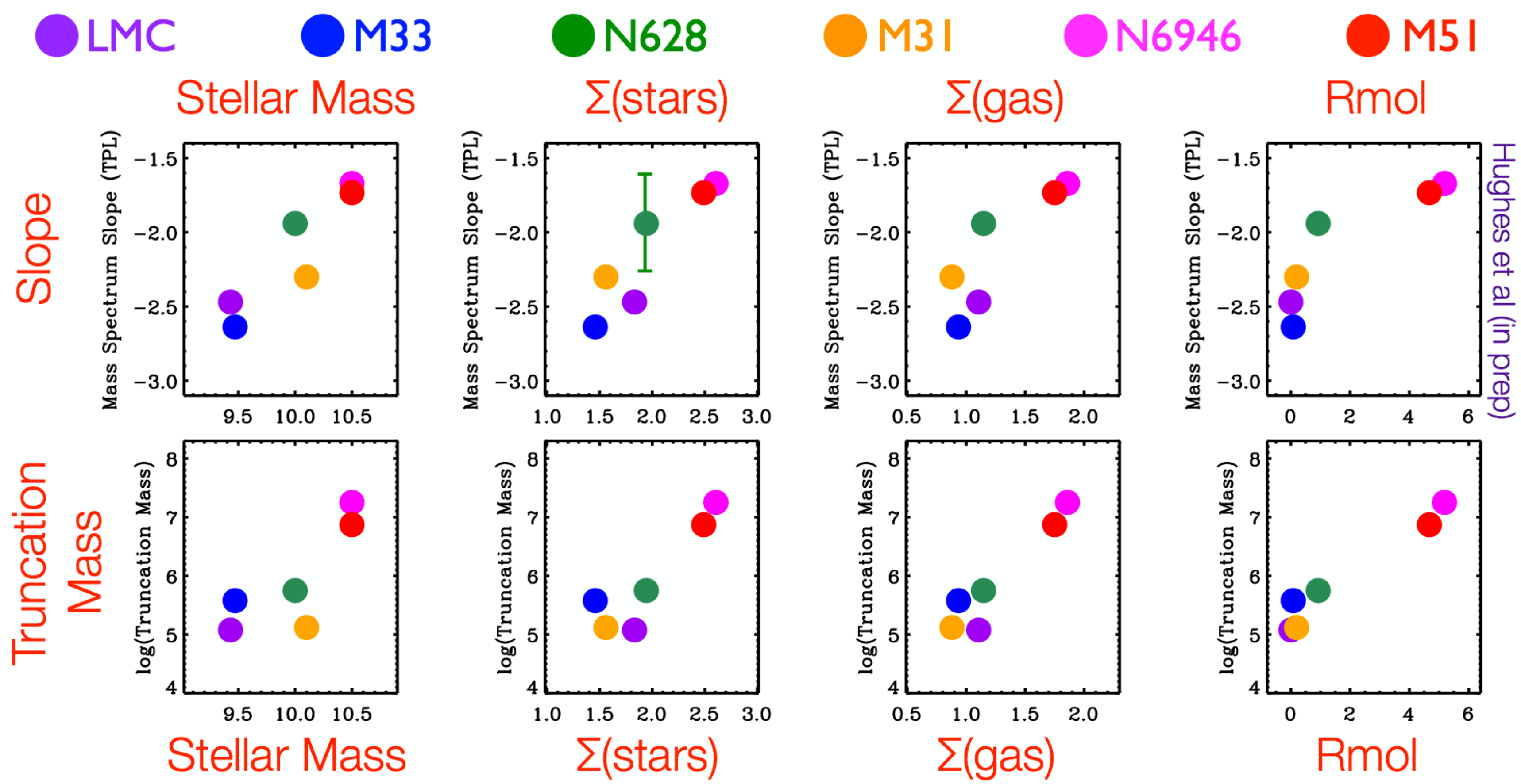


Saintonge et al. (2012)

Science motivation #1: What is the link between the physics of star formation on small scales and the properties of entire galaxies?

ALMA/NOEMA studies of the GMCs in a range of nearby galaxies:

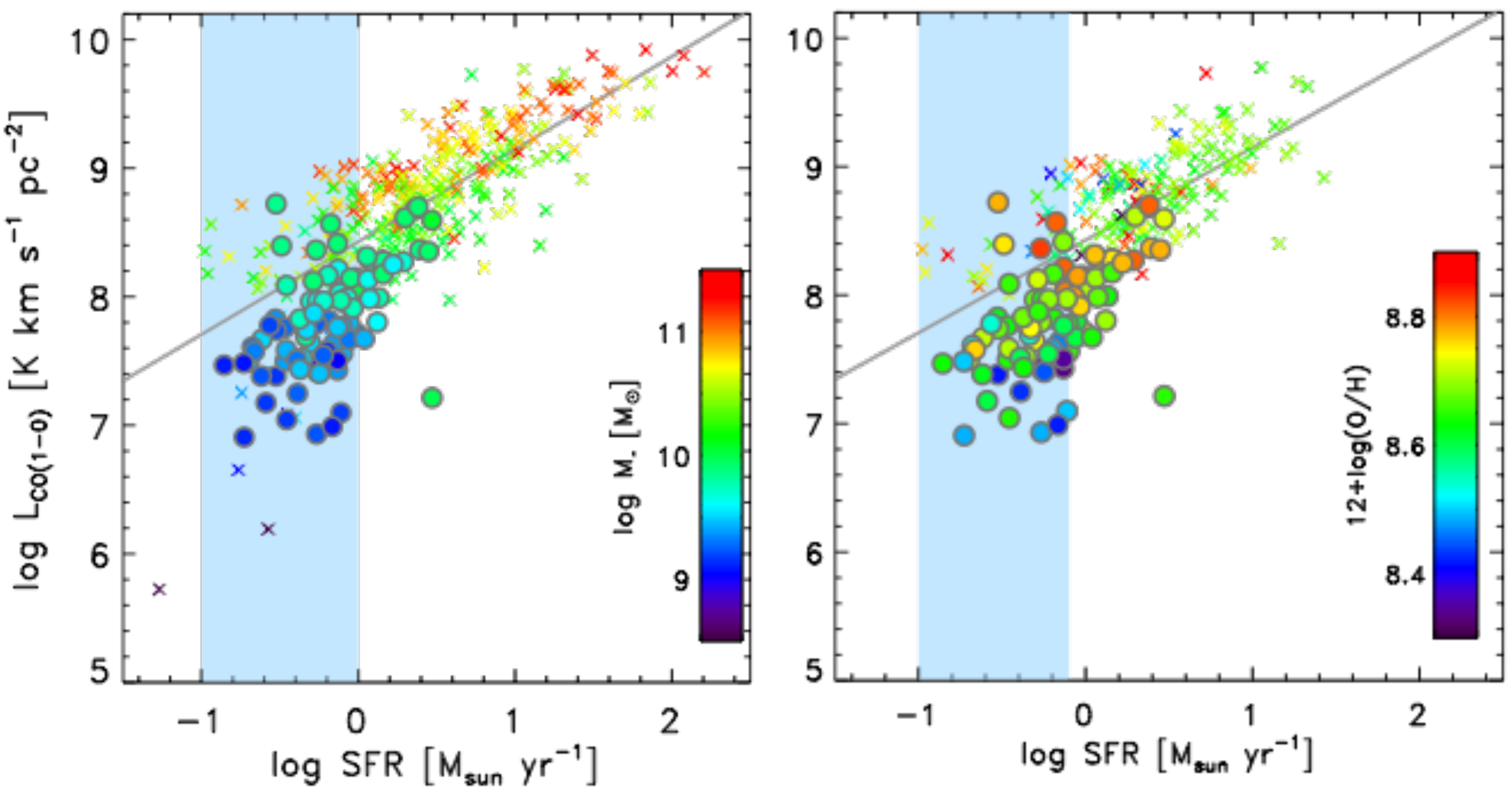




shape of GMC mass distribution is not universal: slope and turnover mass increase in more massive systems

Images from A. Hughes

Science motivation #2: How efficient is star formation in low mass galaxies and/or at high redshifts?

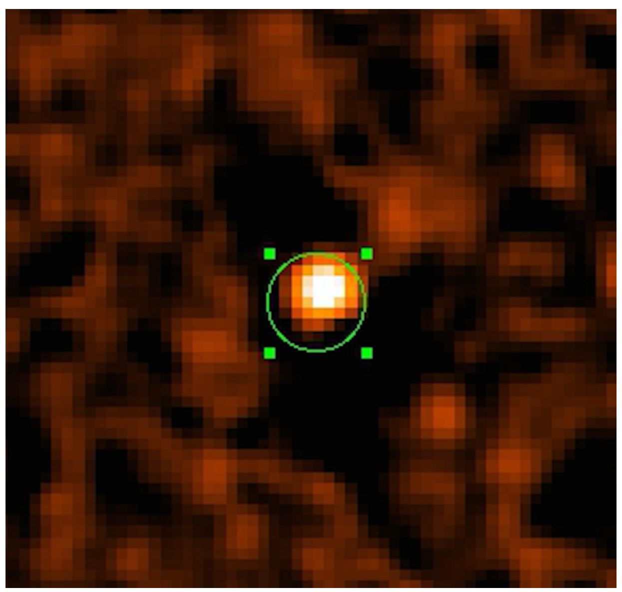


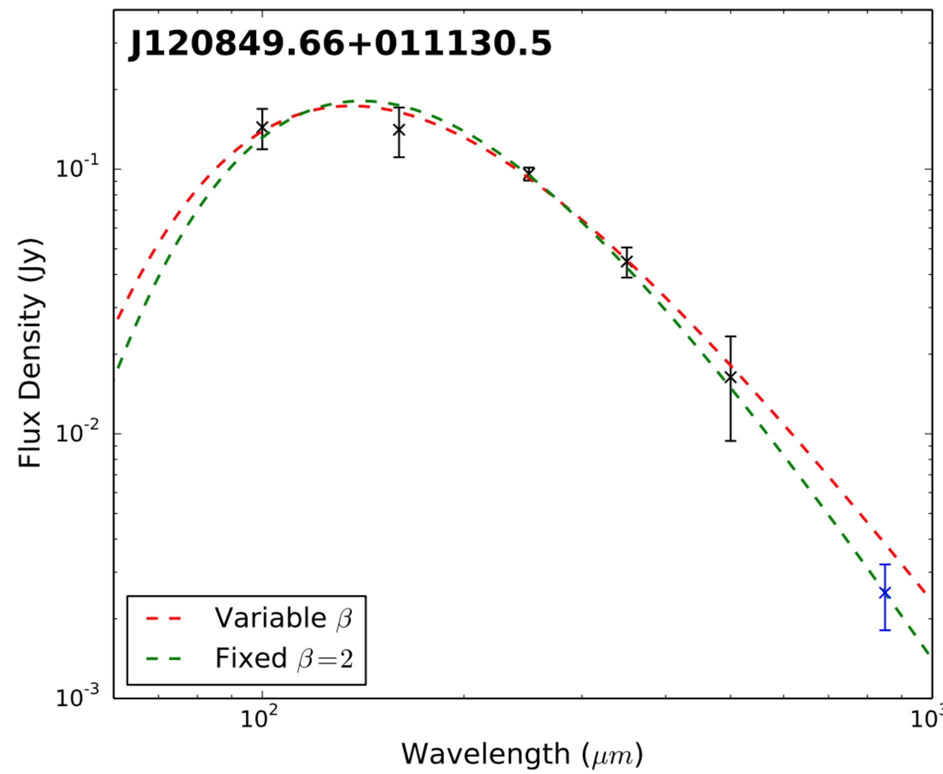
Are low mass galaxies under-luminous in CO at fixed SFR because they have high SF efficiency, or because CO is a poor tracer of total molecular gas?

Technical challenge How do we increase the accuracy of molecular gas measurements?

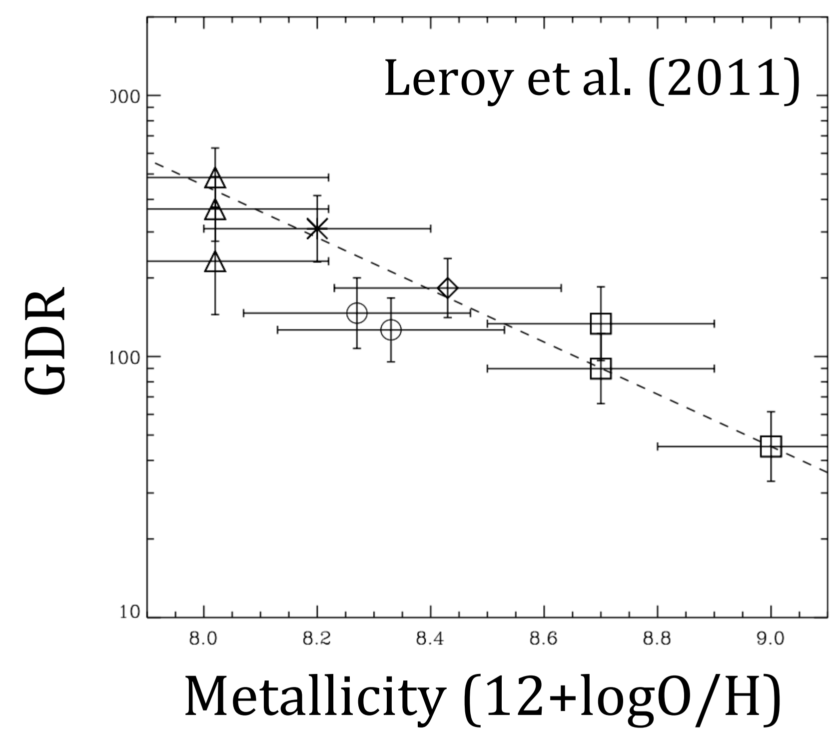
An alternative approach to CO line observations:

FIR/submm continuum observations → **dust mass measurements** → **gas mass estimations**





$$M_{gas} = M_{dust} \times GDR$$



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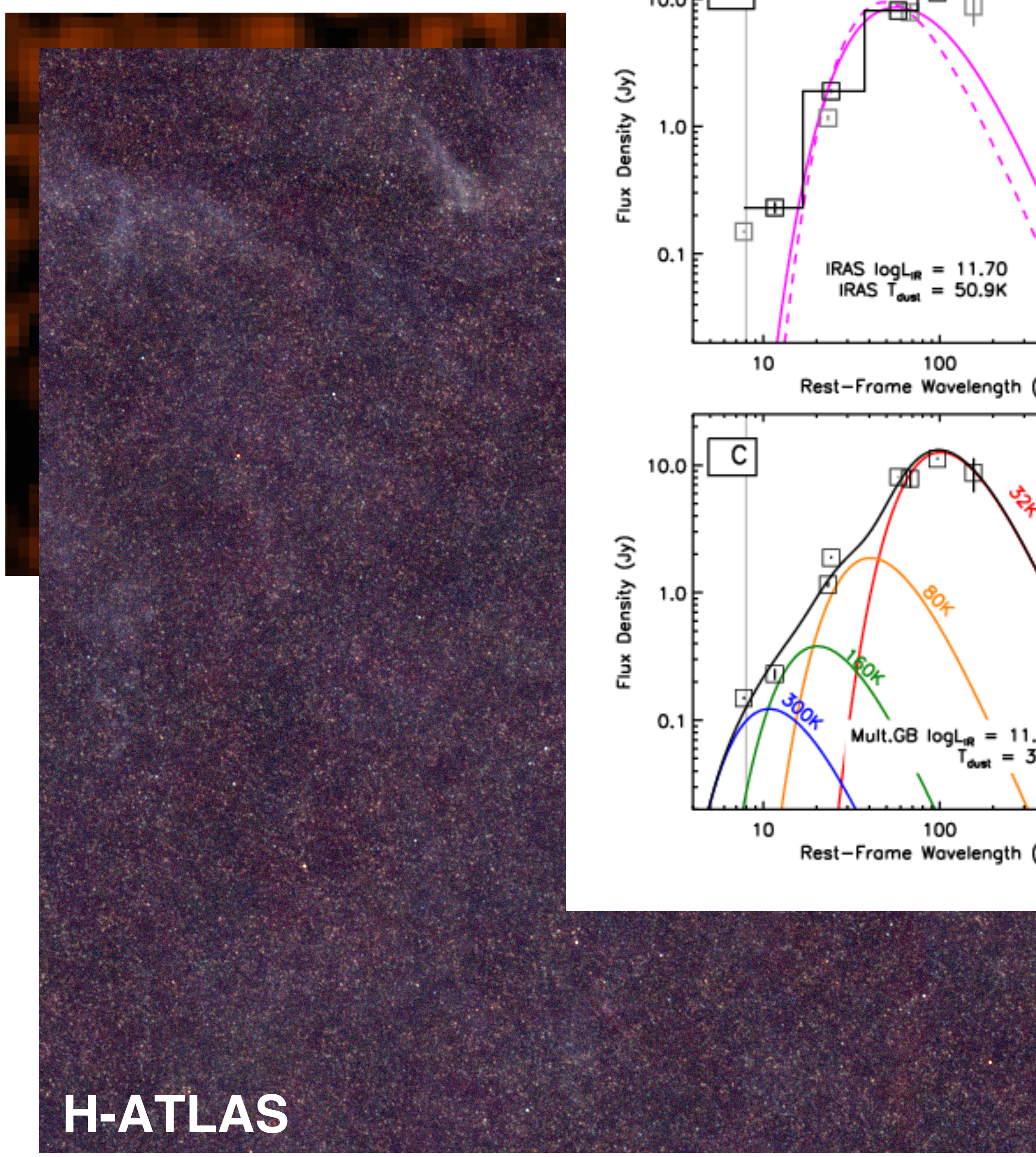
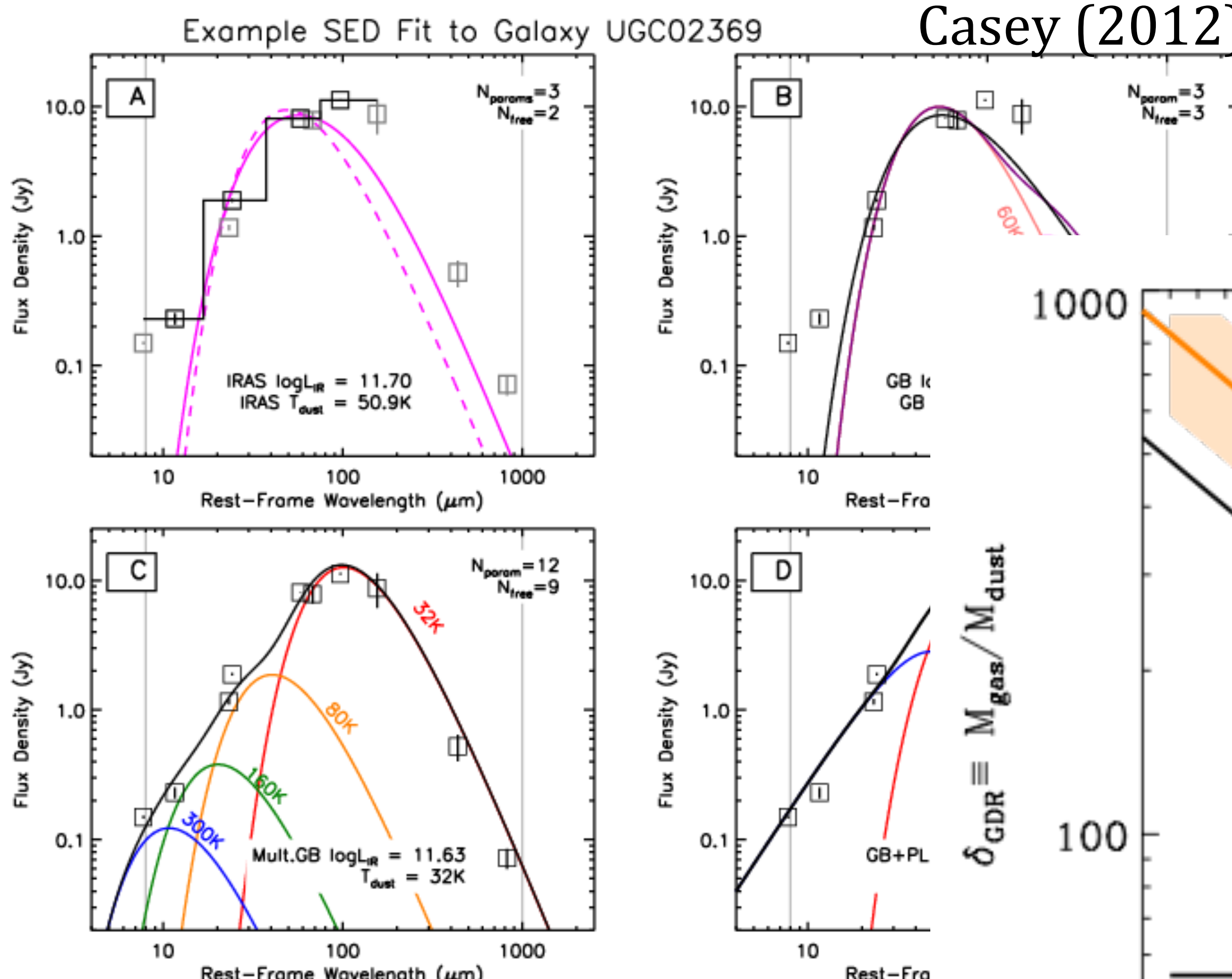
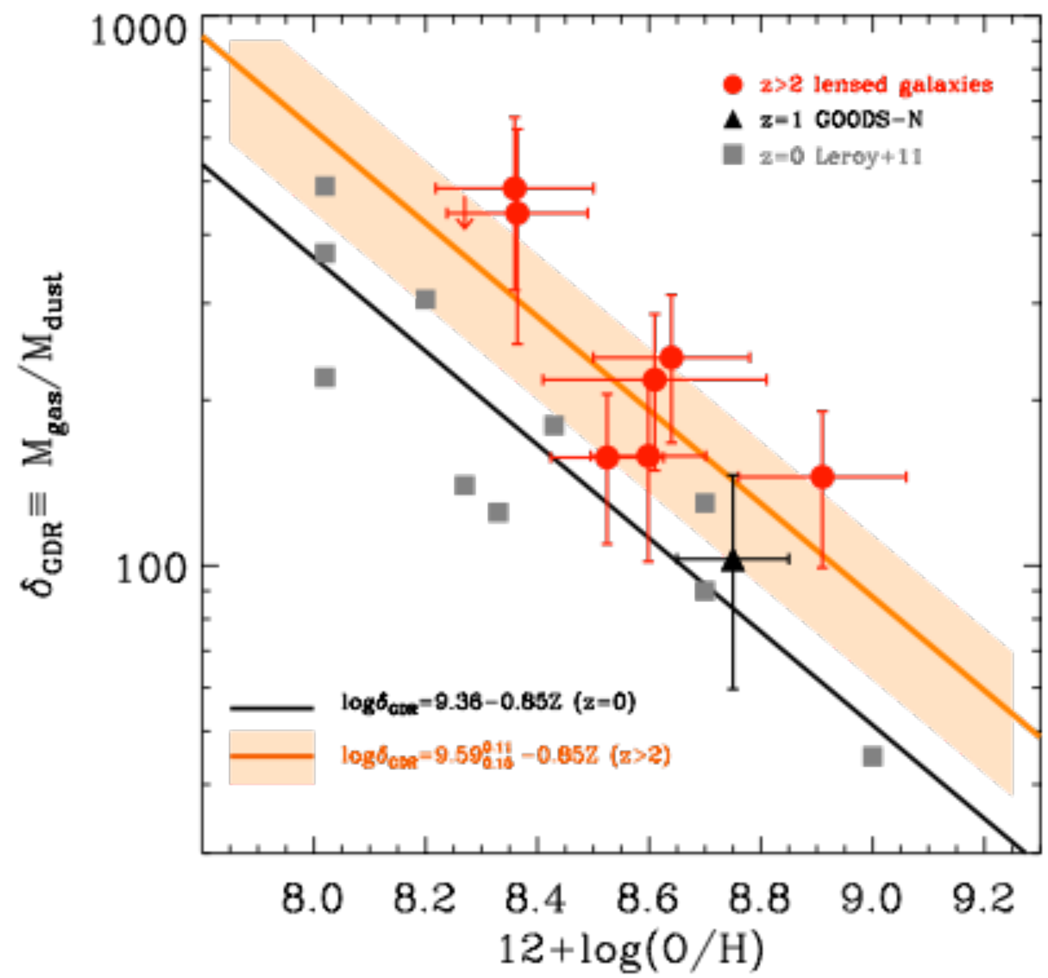




Casey (2012)

$$M_{gas} = M_{dust} \times GDR$$

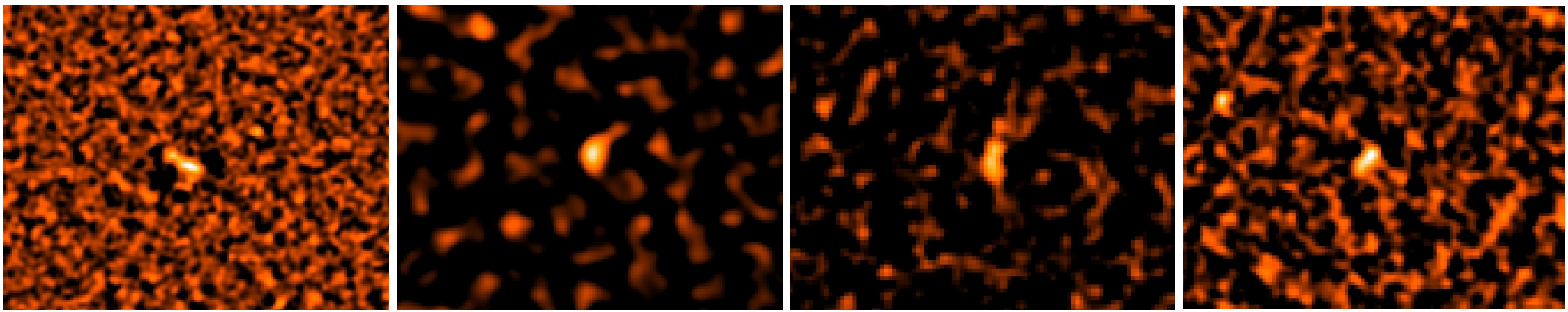


Saintonge et al. (2013)

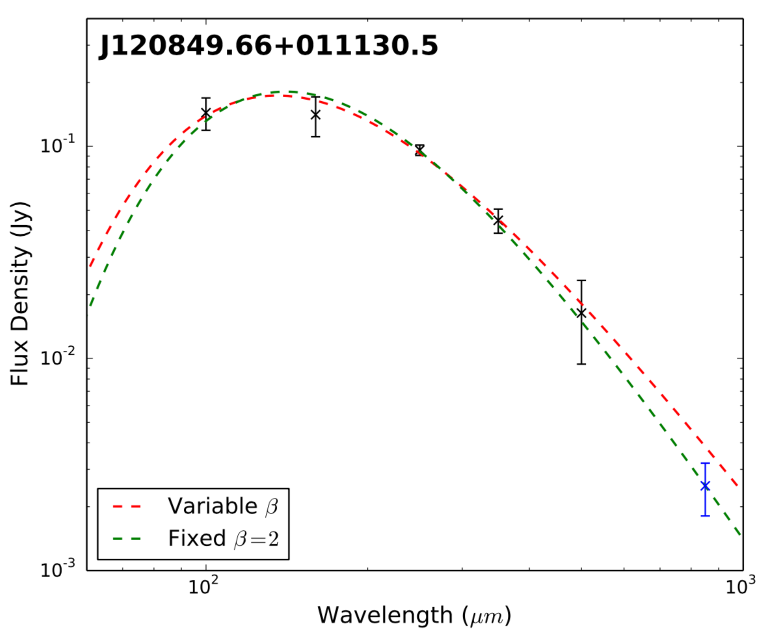
JINGLE: status of observations

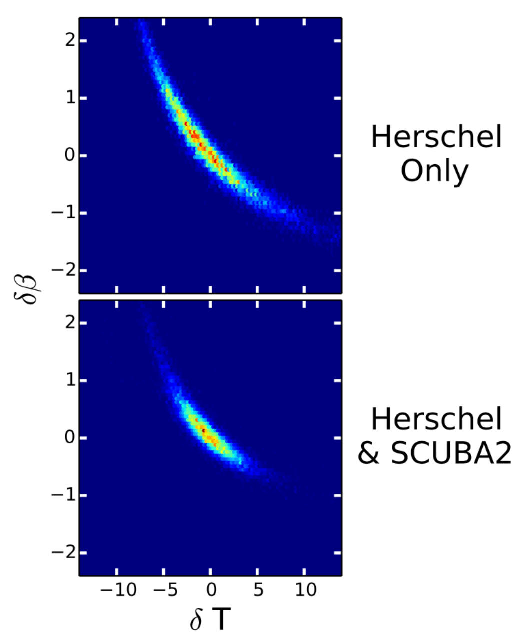
Survey is 13% complete!

- **70+1 galaxies with SCUBA-2 and 1 galaxy with RxA observations so far.**
- **Among the 70 galaxies, 42 galaxies are done; 28 galaxies will be observed by RxA.**



Credit: Matthew Smith

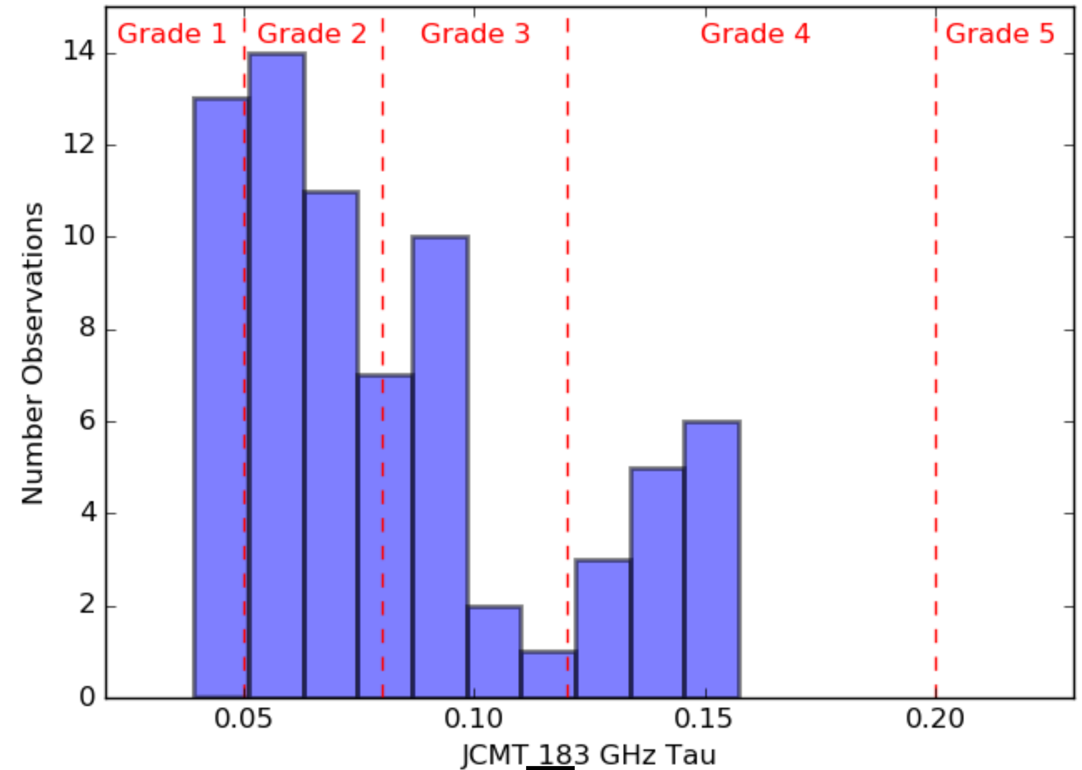




JINGLE: status of observations

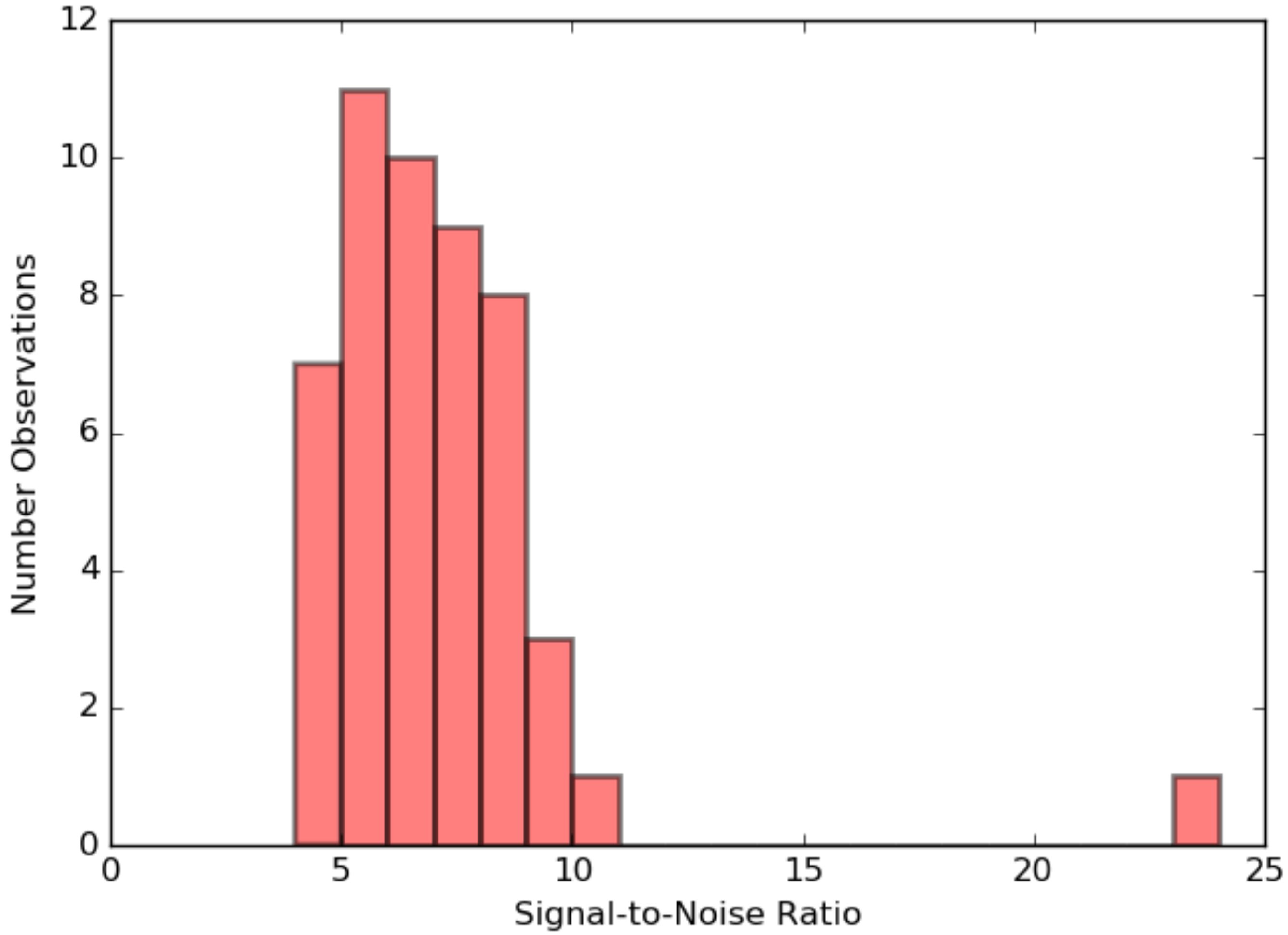
Observations in *Grade 2* weather finished.

More progress on our sample is being delayed by the extremely good weather in Hawaii this year!



Tau

	SCUBA2 Observations
Total Number Observed	71
Detection ($>5\sigma$)	62%
Probable Detection (4.5-5σ)	11%
Possible (3-4.5σ)	7%
Non-detection	20%



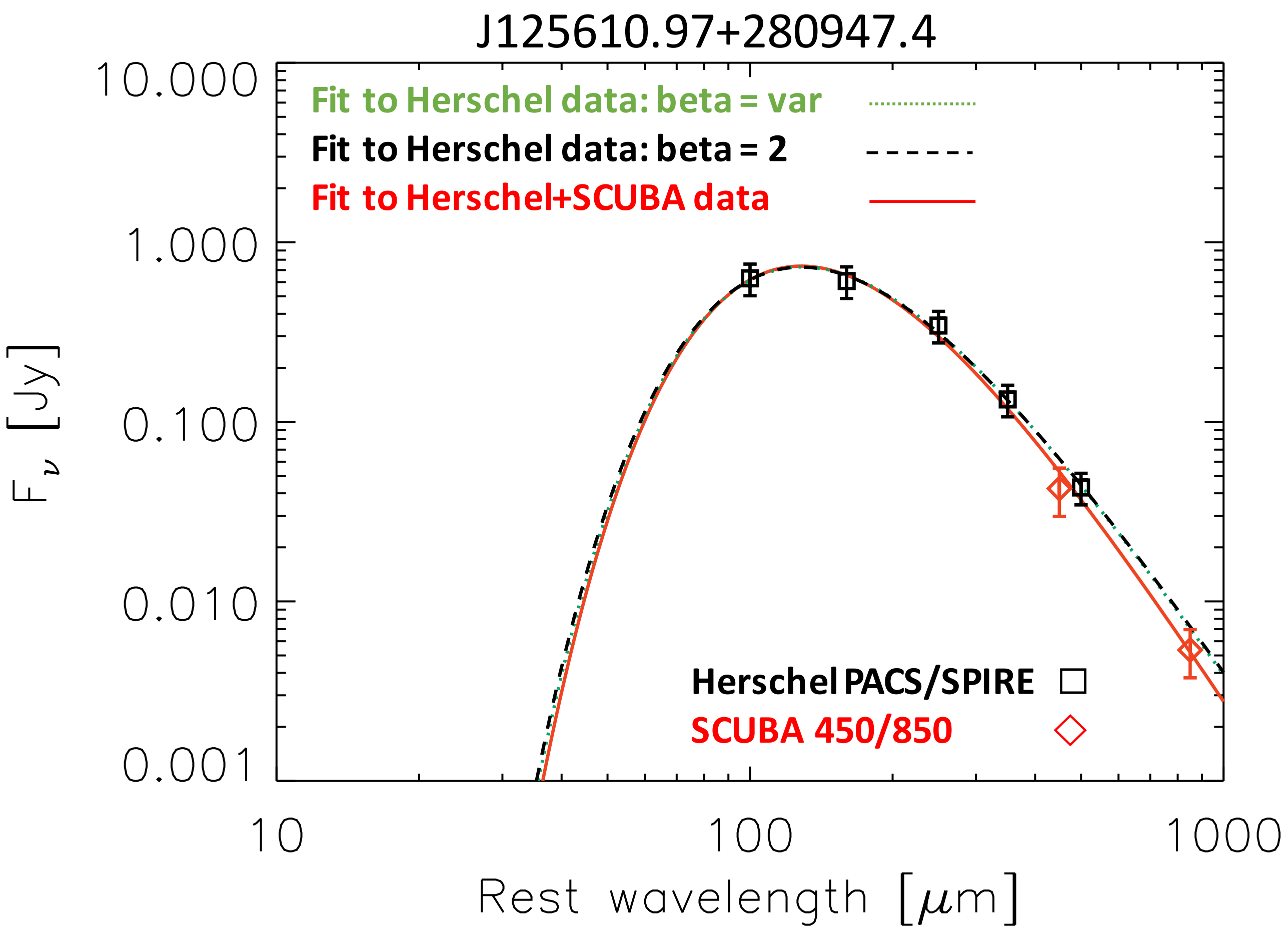
S/N

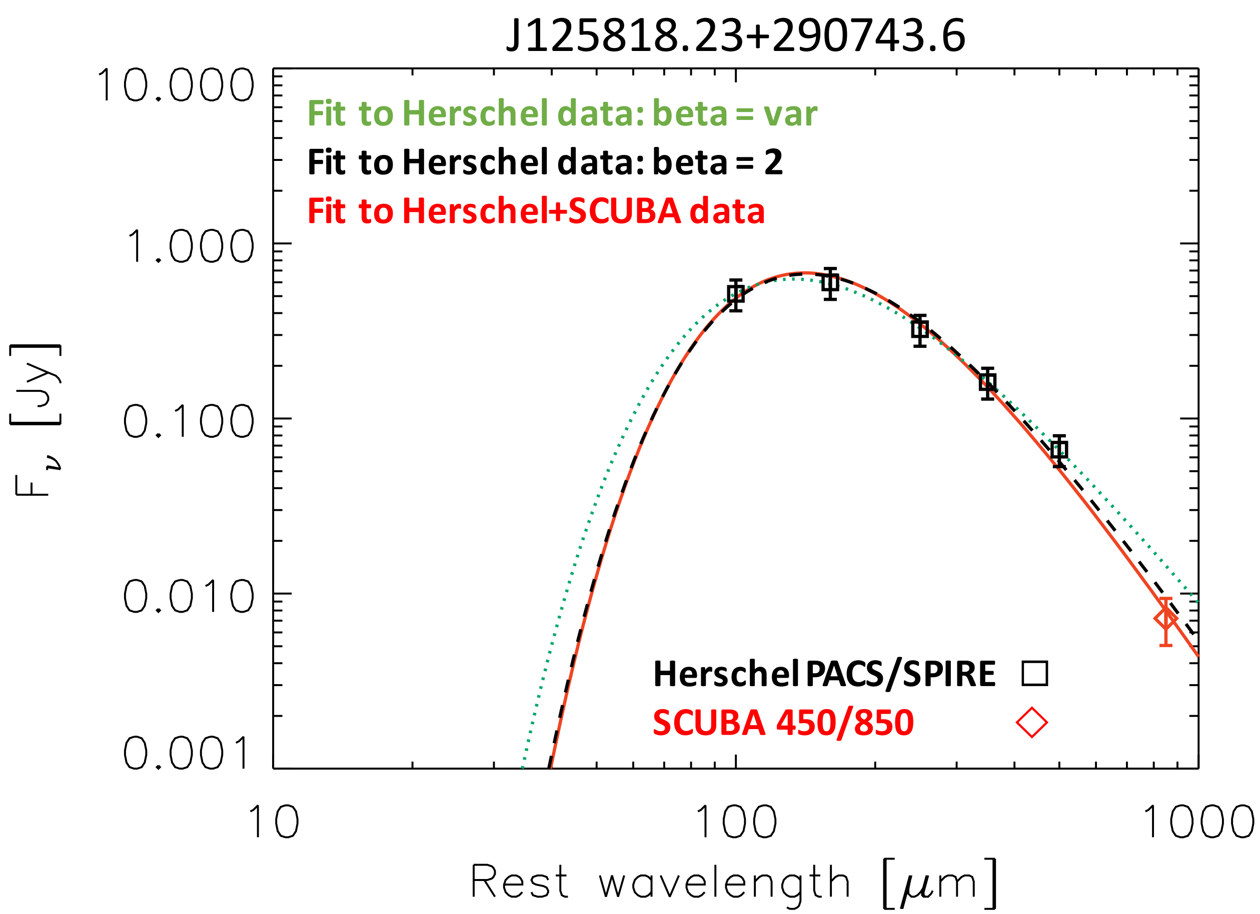
Credit: Matthew Smith

Some first SED modelling results

Our SCUBA 850 micron predictions were based on an extrapolation of modified blackbody fit (MBB) with dust emissivity index beta=2 to the Herschel data points.

In a first preliminary test cases, we find that most of the SCUBA850 micron fluxes agree with this beta=2 model, or are somewhat below are predictions.

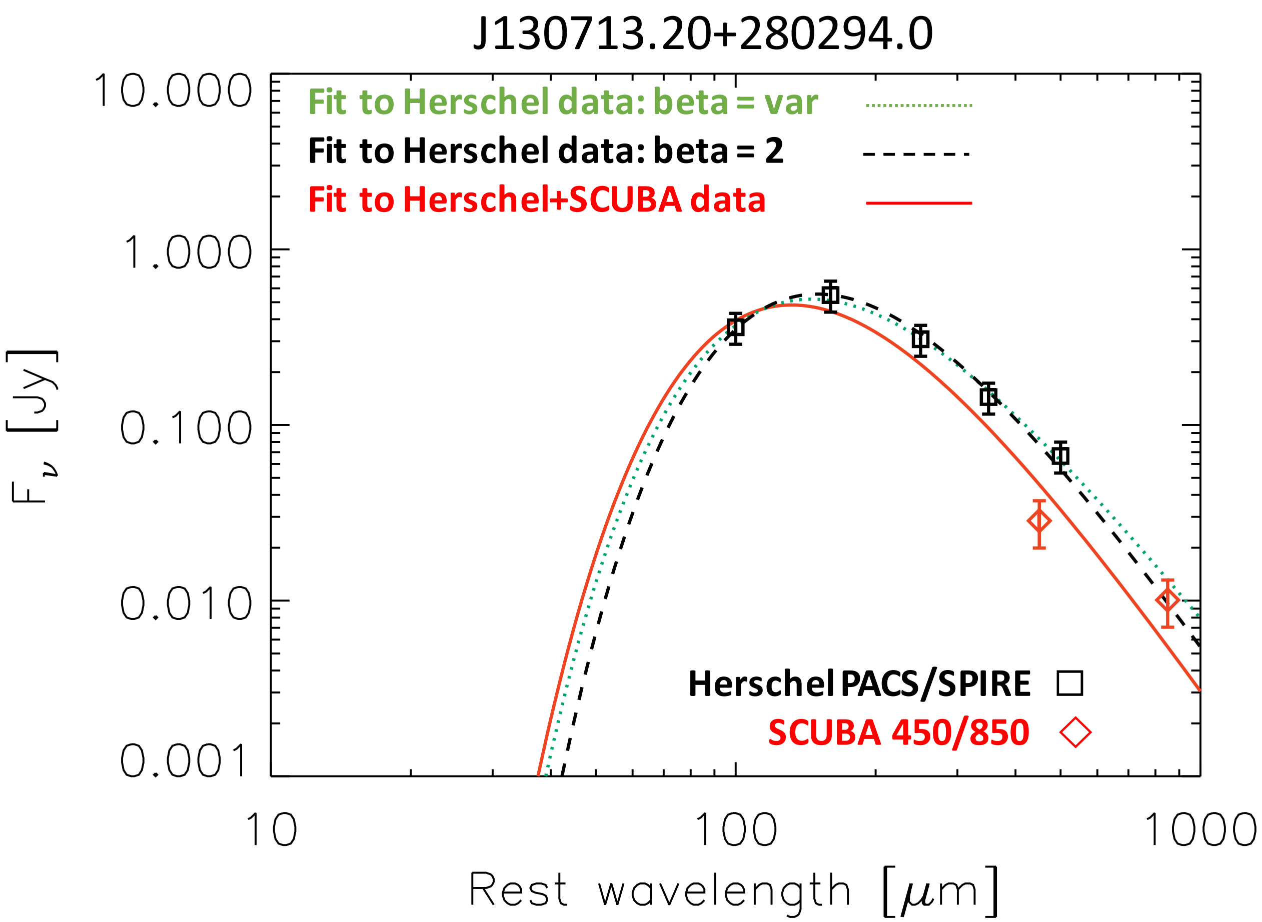


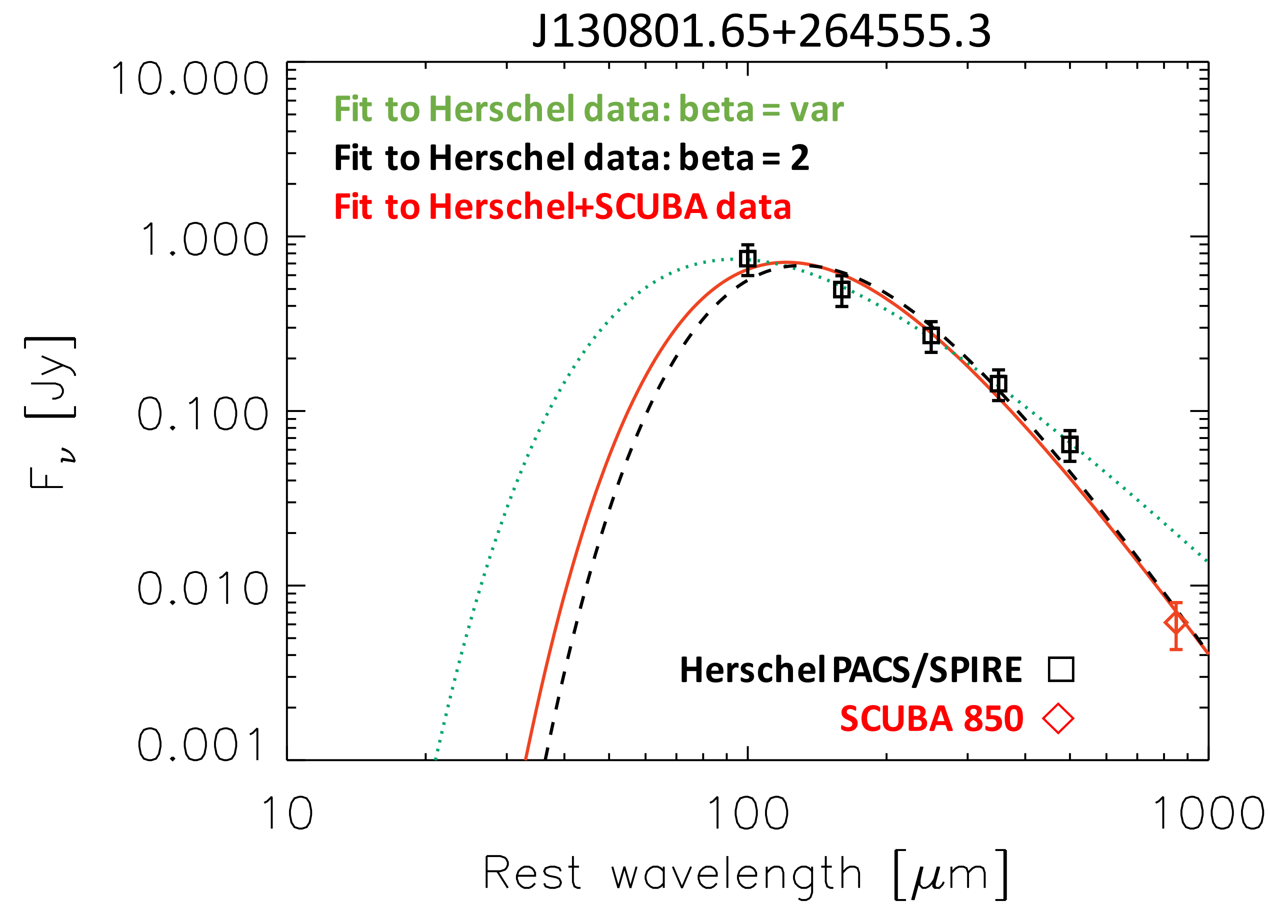


Some first SED modelling results

Based on the SCUBA data, we get more accurate dust masses. For the test cases presented here, dust masses are mostly consistent with the Herschel derived dust masses, but can be up to 0.3 dex higher due to the lower derived T_{dust}.

In the future, we will have more constraints on the variation of the dust emissivity index for a wide ranges of galaxies. We will be able to relate changes in the dust emissivity to galaxy properties, which will help us understand dust evolution processes.





Credit: Ilse De Looze

Thank You!

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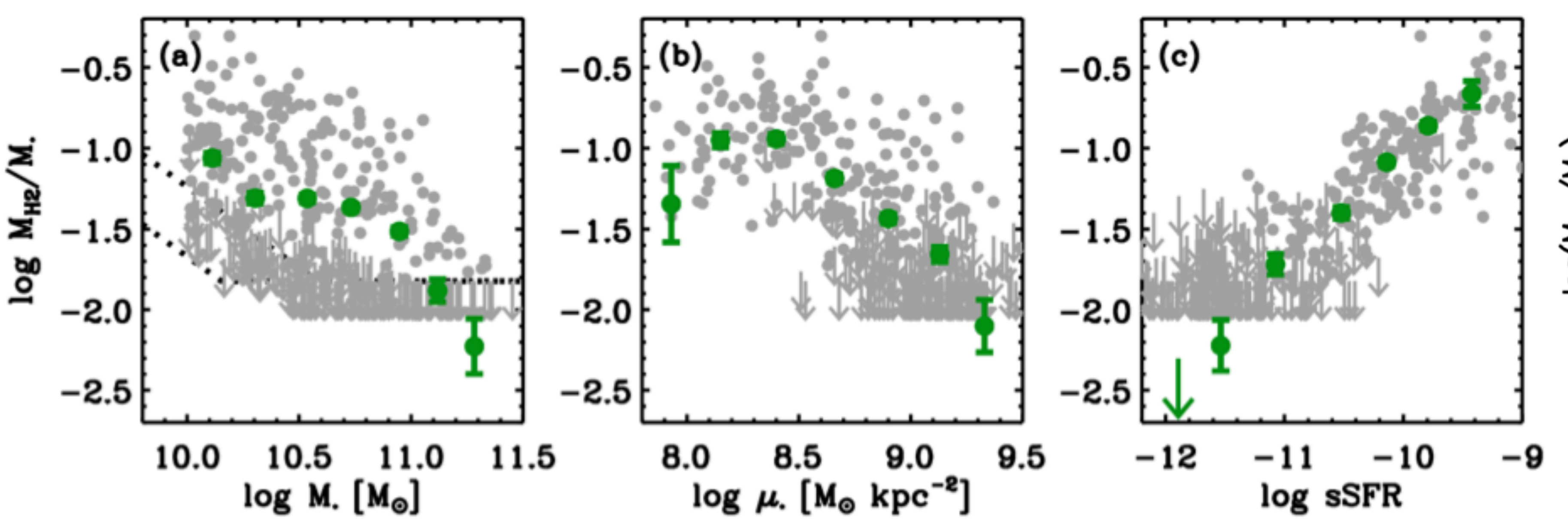
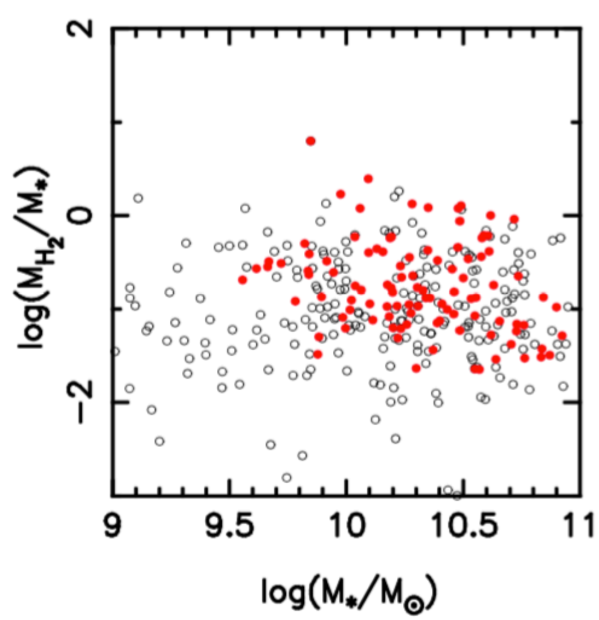
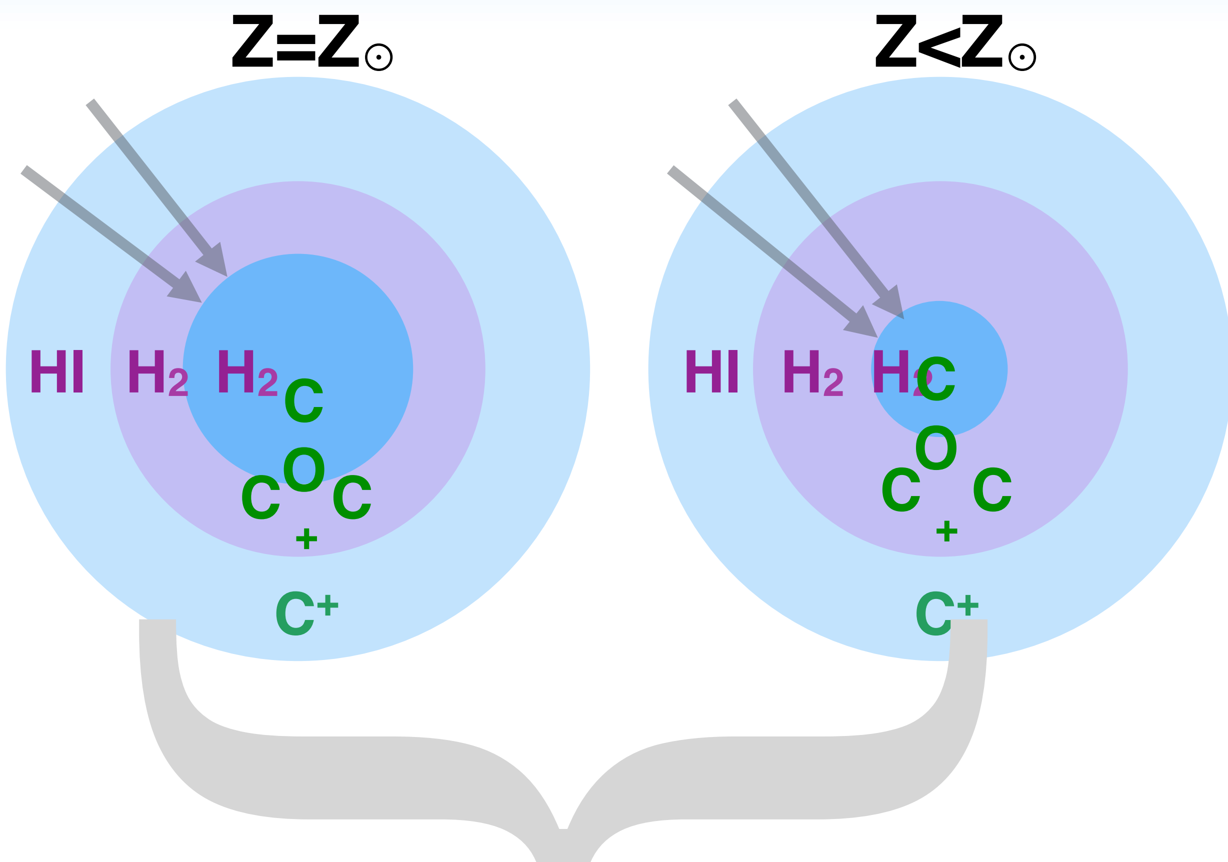
- Drop in molecular gas content related to galaxy internal structure.
- Probe SF efficiency as a function of gradients in 2D galaxy properties (stellar / ionised-gas) measured from optical spatially-resolved spectroscopic data provided by MaNGA.
- A large and systematic survey is necessary (right panel).



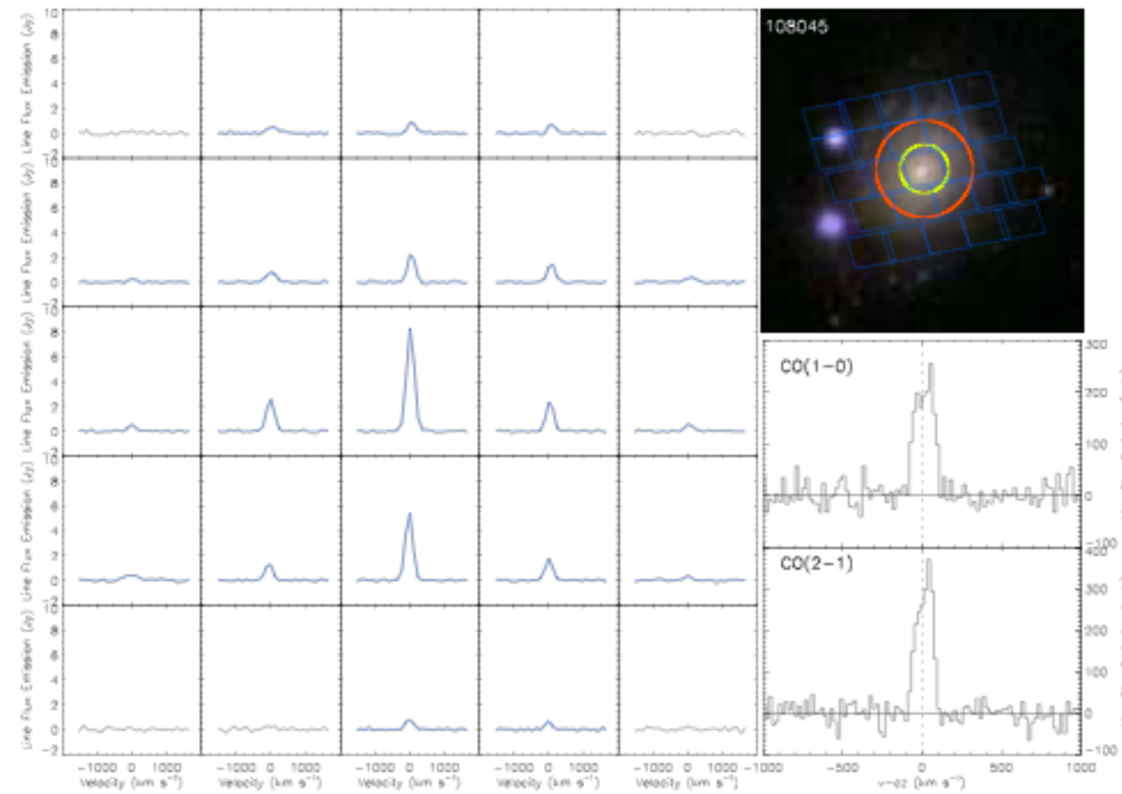


COLD GASS (Saintonge+ 2011)

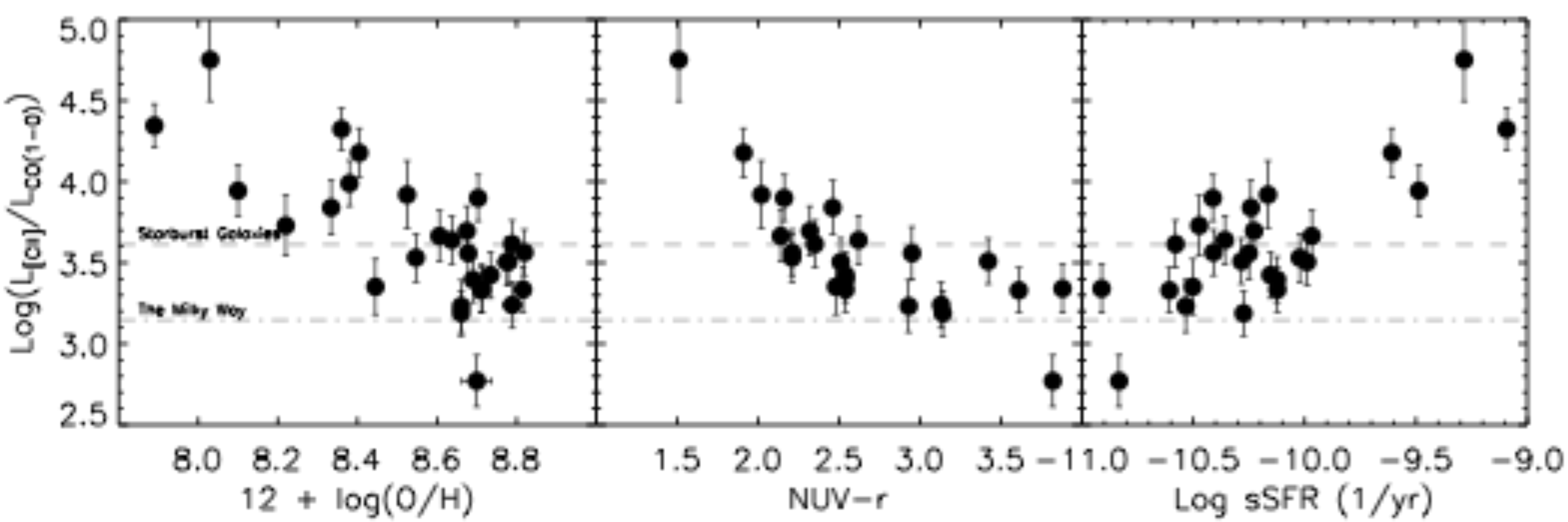
Technical challenge How do we increase the accuracy of molecular gas measurements?



the [CII]/CO ratio should track variations in the level of photodissociation of CO, and therefore give us a handle on X_{CO}



example galaxy: Herschel/PACS and IRAM-30m



work by UCL PhD student **Gio Accurso**