The [CI]/dust ratio in star forming galaxies at z=1

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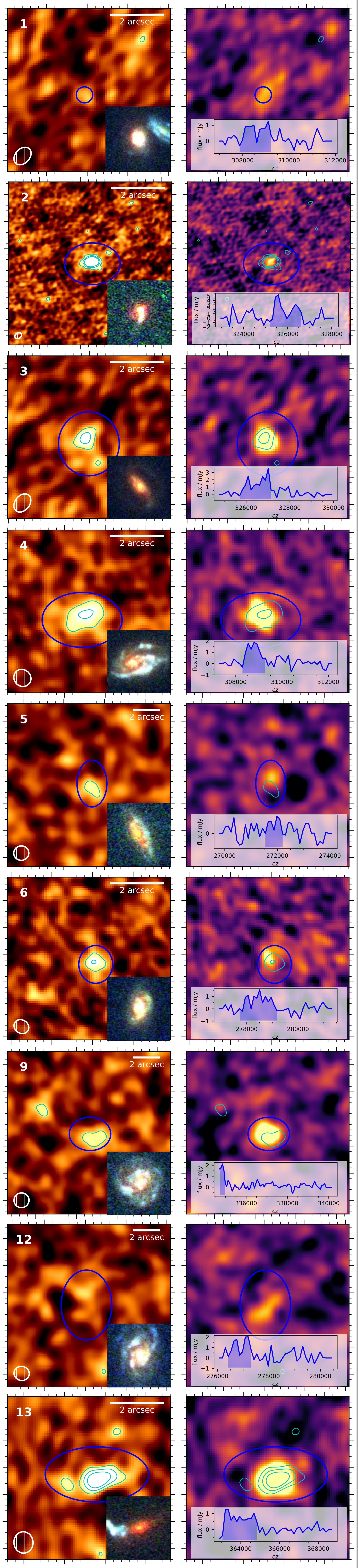
Figure 2: continuum & CI moment-0 maps



Abstract: Analysis of the cold molecular gas content in high-z galaxies is hampered by systematic uncertainties in the calibration of H_2 mass from the standard tracer, CO emission lines. One alternative tracer is the dust continuum, which shows promise for large samples but still requires accurate calibration on a direct gas tracer at high redshift. We use ALMA to investigate the correlation between dust emission and a third tracer, the 492 GHz [CI] emission line, in a sample of star-forming galaxies at z=1. We aim to determine whether [CI] can provide an alternative to CO with reduced systematics.

Why [CI]? The [CI] line has several potential advantages. Unlike CO, it is optically thin, so flux is directly linked to the amount of emitting material. The line has similar excitation conditions to CO(1-0), but its higher frequency is accessible over a wider redshift range without recourse to higher-excitation transitions such as CO(3-2), which introduce another unknown conversion factor. Predictions from PDR modelling suggest that the [CI]/H_2 conversion is valid over a wider range of metallicity and gas density than CO(1-0) (Geach & Papadopoulos 2012). As yet, there are relatively few extragalactic CI measurements in the literature, all for luminous SMGs and quasar hosts (Walter +11; Alaghband-Zadeh+13; Bothwell+17). Such systems are not typical of the majority of galaxies or the conditions under which most star formation in the Universe occurs.

Figure 1: SFR vs. stellar mass

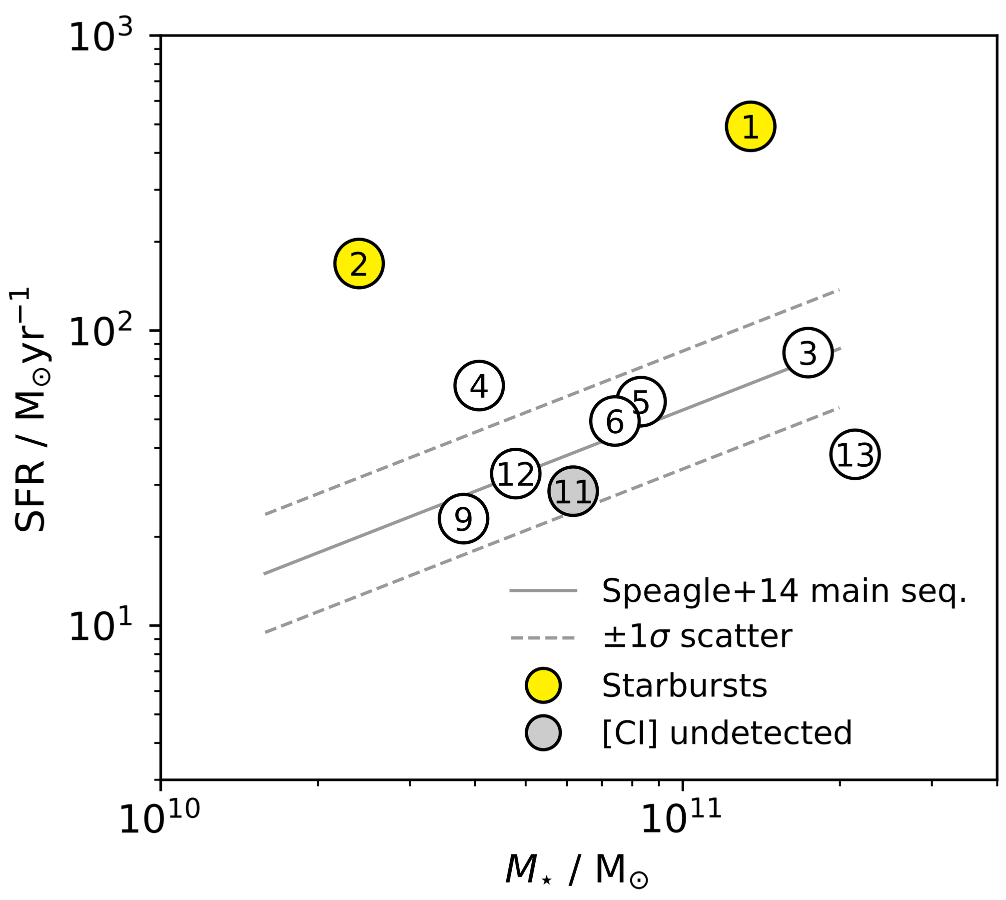
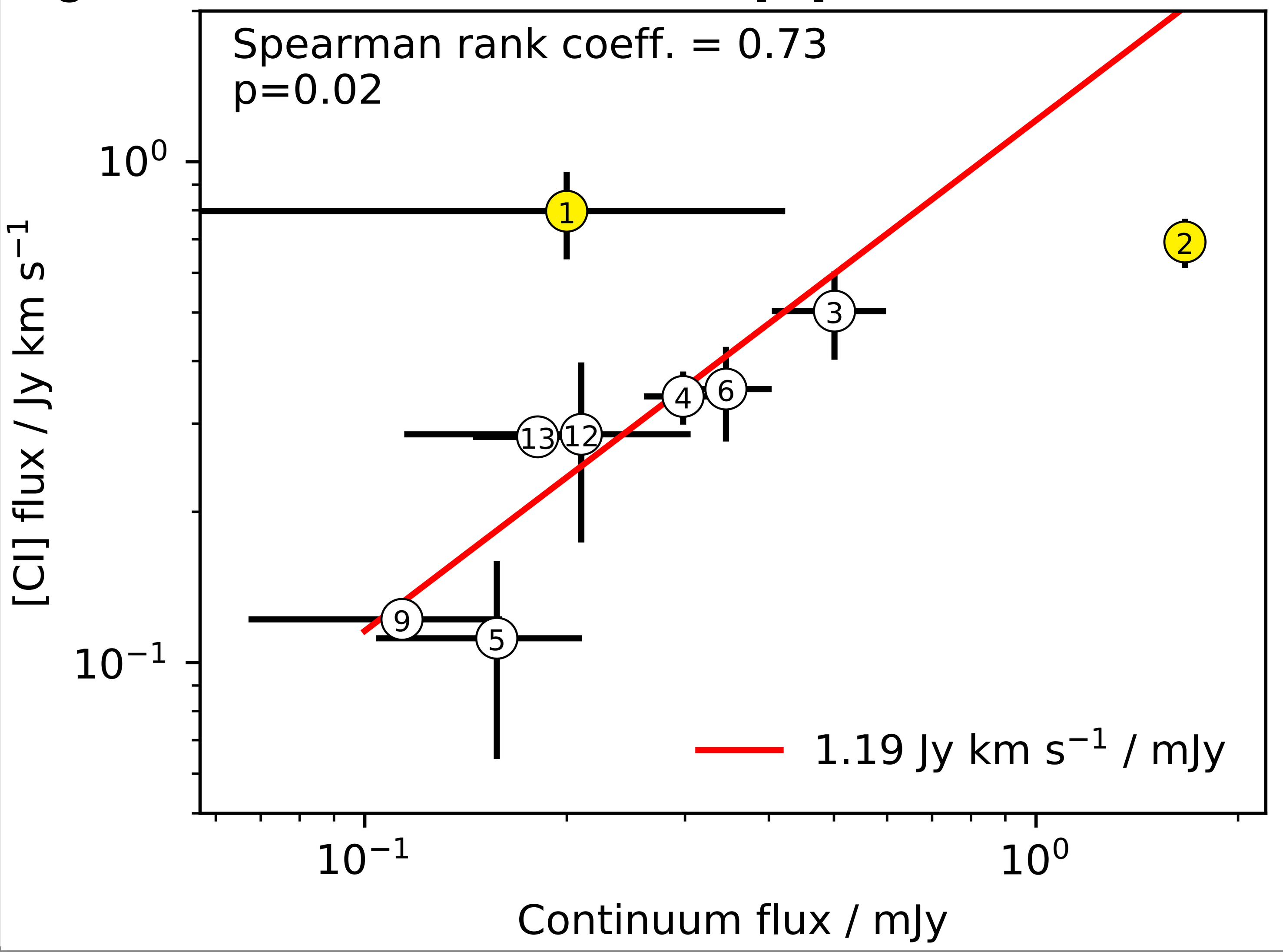


Figure 3: Correlation between total [CI] and continuum fluxes

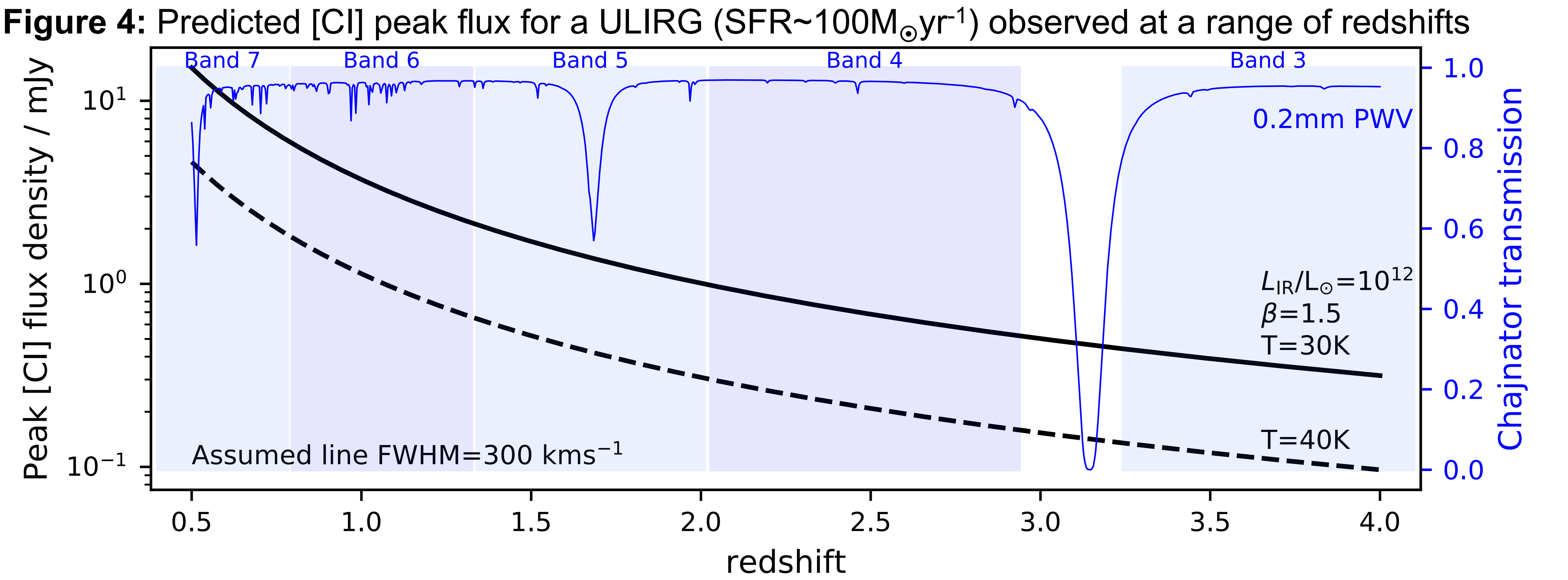


Sample & Data: To conduct a first analysis of [CI] in a representative sample of high-redshift star-forming galaxies, we selected galaxies from 3DHST (Skelton+14) that we detected with SCUBA-2 at 450μm (see Bourne +17). At z=1, [CI] is observable in Band 6, and the sample spans a wide range in the mass-SFR plane (**Fig 1**), including the typical SFR/mass at that redshift (given by the main sequence). Ten targets were observed in Cycles 4 & 5 with rms 0.08-0.60 mJy, and [CI] was detected in 9/10 (**Fig 2**). We extracted continuum and [CI] fluxes in matched apertures (blue ellipses, fig 2), revealing a strong correlation, but also two significant outliers (**Fig 3**).

Preliminary Conclusions: We measured the [CI]/continuum correlation in a sample of z=1 galaxies that, unlike previous samples of luminous SMGs and quasar hosts, represent a broad range of star-forming galaxies including the typical disk-dominated galaxies described by the main sequence. Seven galaxies are consistent with a common flux ratio of 1.19 Jy km s^{-1} mJy^{-1}, but intriguingly there are two outliers which are both starbursts (**Fig 1, 3**). However, these do not suggest a systematically lower or higher [CI]/continuum flux ratio in starbursts. Further investigation of kinematics, gas excitation, full dust SED modelling, and upcoming CO data may provide an explanation for their anomalous flux ratios.

Predictions: Based on a fixed [CI]/continuum flux ratio 1.19 Jy km s^{-1} mJy^{-1}, and typical values for line width and SED parameters, we can predict the peak [CI] flux for a putative star forming galaxy observed at any redshift. **Fig 4** indicates the sensitivity required to detect this in various ALMA bands.

Figure 4: Predicted [CI] peak flux for a ULIRG (SFR~100$M_\odot yr^{-1}$) observed at a range of redshifts



References: • Alaghband-Zadeh et al. 2013 MNRAS 435, 1493 • Bothwell et al. 2017 MNRAS 466, 2825 • Bourne et al. 2017 MNRAS 467, 1360 • Geach & Papadopoulos 2012 ApJ, 757, 156 • Skelton et al. 2014 ApJS 214, 24 • Speagle et al. 2014 ApJS 214, 15 • Walter et al. 2011 ApJ 730, 18

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