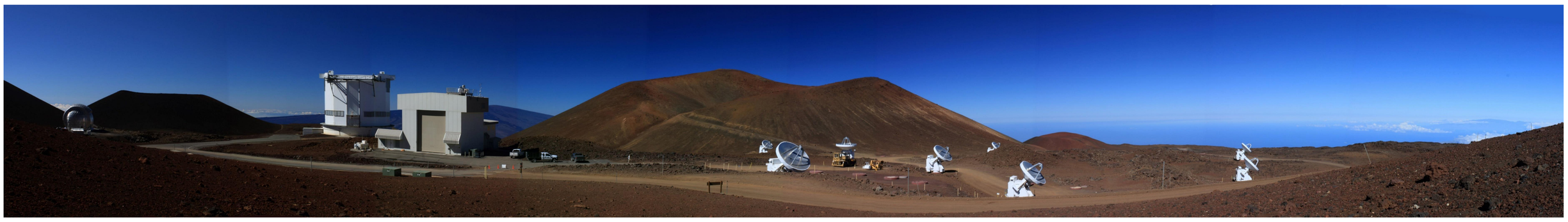


High Redshift Galaxy Observations with the Submillimeter Array

Glen Petitpas, Mark Gurwell, and the SMA Team

Planck's Dusty GEMS

(Canameras, R., et al. 2015, A&A, 581, 105)

Goal: use the SMA to image a variety of dusty Gravitationally Enhanced subMillimeter Sources (GEMS) initially detected using the Planck all-sky survey and follow-up Herschel SPIRE 250 um imaging. All sources appear as point sources in the 18" SPIRE beam, with apparent far-infrared luminosities up to 3 x 10^{14} L_{sun}.

Results: - the global dust-to-gas ratios and star formation efficiencies are predominantly in the range expected from massive, metal-rich, intense, high-redshift starbursts.

- All galaxies have gas-to-dust ratios of 40-140, consistent with a low CO-to-H_2 conversion factor, as expected for a sample of galaxies with these properties.

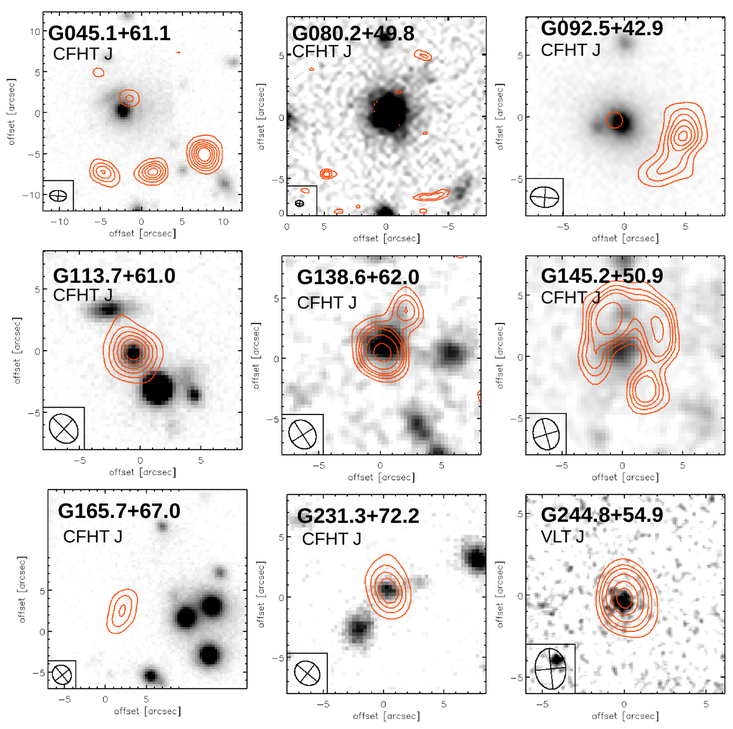


Figure 1: NIR J-band images of part of the sample taken using the CFHT. The red coutours are the SMA 850um continuum images at the resolution of the primary beam shown in the lower left corner. These were detected using the 18" FWHM 250 um SPIRE beam, which clearly does not have the resolution to identify the lens morphology.

A Candidate High-z Protocluster

(Clements, D., et al., 2016, MNRAS, 461, 1719)

Goal: investigate the region around the Planck detected z=3.26 gravitationally lensed galaxy HATLAS J114637.9-001132 (hereafter H12-00). The lensed source is found to be surrounded by an over-density of sources in both LABOCA and SCUBA2 maps.

Results: - the SMA data provided higher precision positions for some of the candidate cluster members, allowing detailed follow-up observations and better redshift determinations.

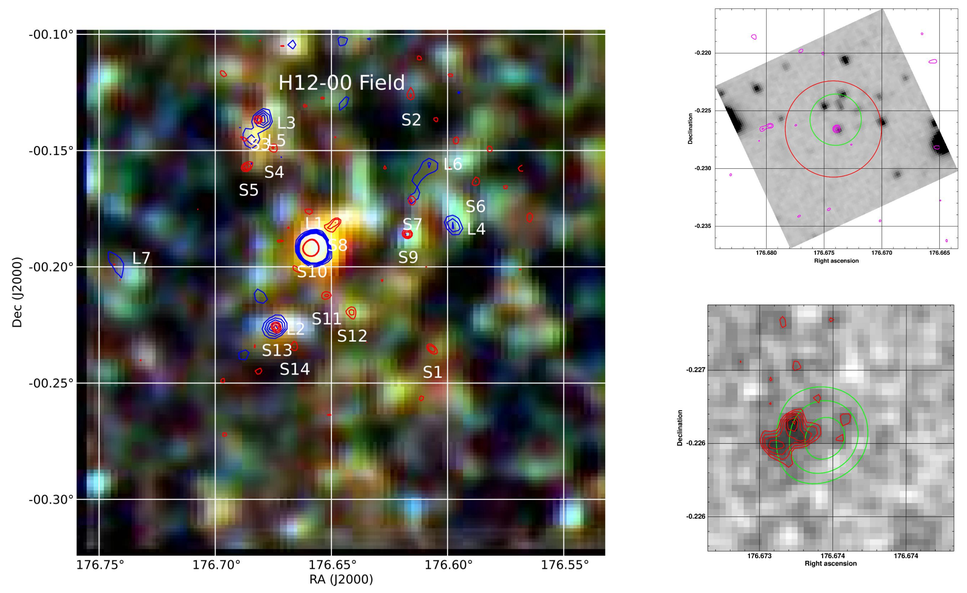


Figure 2a (left): Three-color SPIRE image of the 400"x400" region around H12-00. LABOCA detections are shown in blue contours, while SCUBA2 contours are shown in red (3,4,5 sigma). **Figure 2b (top right)** shows magenta SMA contours for "L2" on the IRAC 3.6 um image. The red circle is the LABOCA beam; green is SCUBA2. Figure 2c (bottom right) shows the green SMA contours for "L2" overlaid on K' band VLT image and red contours with a pixels size of 0.15" and a f.o.v. of 6"x6".

A Survey of Bright SCUBA-2 Sources

(Hill, R., et al., 2018, accepted MNRAS)

Goal: observe the brightest of the SCUBA2 Cosmology Legacy Survey (S2CLS) at 860 um with the goal to construct a statistically significant sample of these rare sources.

Results: - observed 70 S2CLS sources with an average beam of 2.4" and rms of 1.8 mJy/beam.

- detected 62 galaxies including 3 pairs, and added a further 35 targets to their sample using archival SMA data.
- they derive a volume density of ~ 3 x 10^{-7} Mpc^{-3} for these sources with star formation rates > 400 M_{sun}/yr between z=2-3.
- Descendants of these galaxies could be > 4 x $10^{11}M_{sun}$ local quiescent galaxies with about 10 percent of their total stellar mass forming during these short busts of star formation.

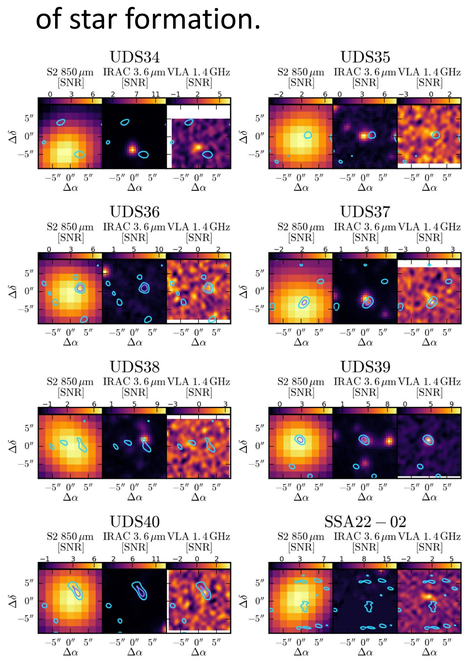
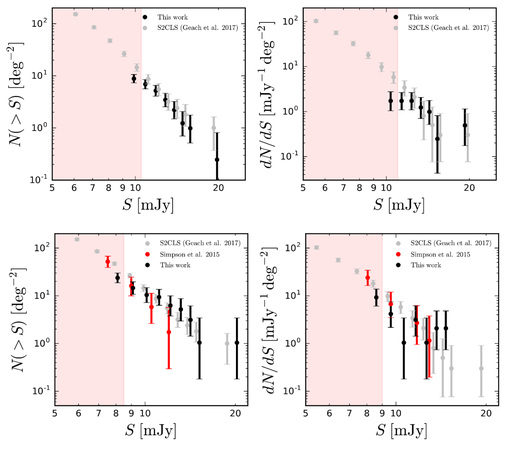


Figure 3a: Blue SMA 860 u contours overlaid on SCUBA, IRAC, and VLA images for a small part of the sample.

Figure 3b (top): Cumulative (left) and differential (right) number counts for galaxies observe with SMA (black) and SCUBA2 (grey). **(bottom)** same, but only including the UDS field. The red dots are a less complete study of this field and the shaded area shows where the sample is not 100% complete.



A Dusty Star Forming Galaxy at z=6

(Zavala, J., et al., 2018, NatAs, 2, 56)

Goal: use the SMA in conjunction with the LMT to measure a variety of spectral lines in the z=6.027 lensed galaxy HATLAS J090045.4+004125 which was discovered as part of the "500 um risers" sample from the H-ATLAS survey. The source was imaged with ALMA and using lens models an amplification factor of 9.3 was calculated.

Results: - detected the [CII] line of ionized carbon (rest frequency 1900.5 GHz) redshifted down to 270.4 GHz, while the LMT detected the CO J=6-5, J=5-4 and H_2O (2_{11}-2_{02}) lines.

- derive a modest star formation rate of 380 M_{sun}/yr (lens corrected)
- gas and dust properties are similar to those measured for local ULIRGs. The star formation efficiency is also similar to local galaxies, despite a difference of ~12 Gyr in cosmic time.

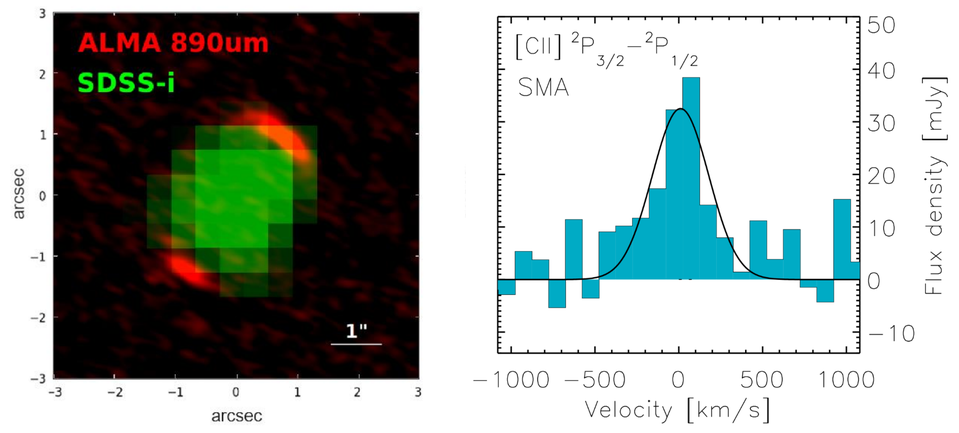


Figure 4 a (left): ALMA 890 um imaging of HATLAS J090045.4+004125 at 0.2"x0.1" resolution overlaid on the i-band SDSS image of the foreground lens (z=0.776). The Einstein-like ring has a radius of 1.4". **Figure 4 b (right):** SMA spectrum of the [CII] line redshifted to a local frequency of 270.4 GHz. The best fit Gaussian used to derive line properties is shown.