Identification of *z*>2 Herschel 500µm Sources in the GOODS-North Using Color-deconfusion

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Aim of the work: Bright high-redshift (z>2) Herschel 500µm Sources could play a significant role in the star formation history in the early Universe. However, due to source confusion issues, a significant fraction of them is missed and/or wrong misidentified in current surveys, whose properties are still not well characterized. We present a new method to systematically search for candidate z>2 Herschel 500µm sources in the GOODS-North field.

Method: (1) Select distant galaxies against the low-redshift ones based on their large S_{500um}/S_{24um} ratio, since redshift is more sensitive to produce the observed shift of IR SEDs (Fig 2 and Dowell et al. 2014); Thanks to the ultra-deep Herschel/500um and MIPS/24um imaging of GOODS-North field (Elbaz et al. 2011), this procedure raises the signal from candidate high-z sources considerably (Fig.1); (2) Objects are identified in the ratio map to have S/N>2 and counterparts at 24um and/or radio. The minimum S/N is determined to optimize the "purity" and completeness of the resulting sample, based on M-C simulations; (3) There are three 500µm sources with no 24µm counterparts, suggesting that they are likely extremely obscured dusty galaxies at z>4.

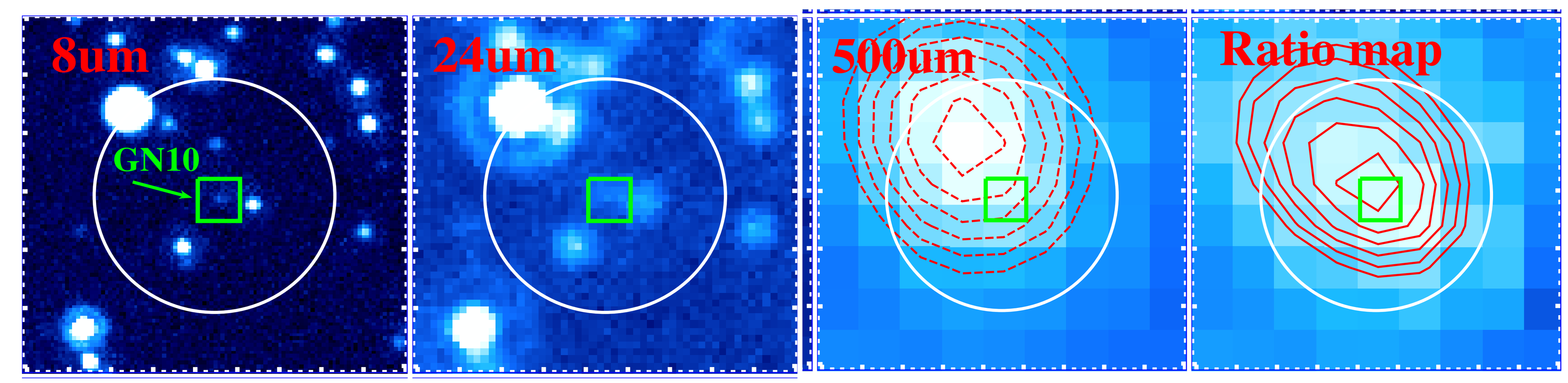
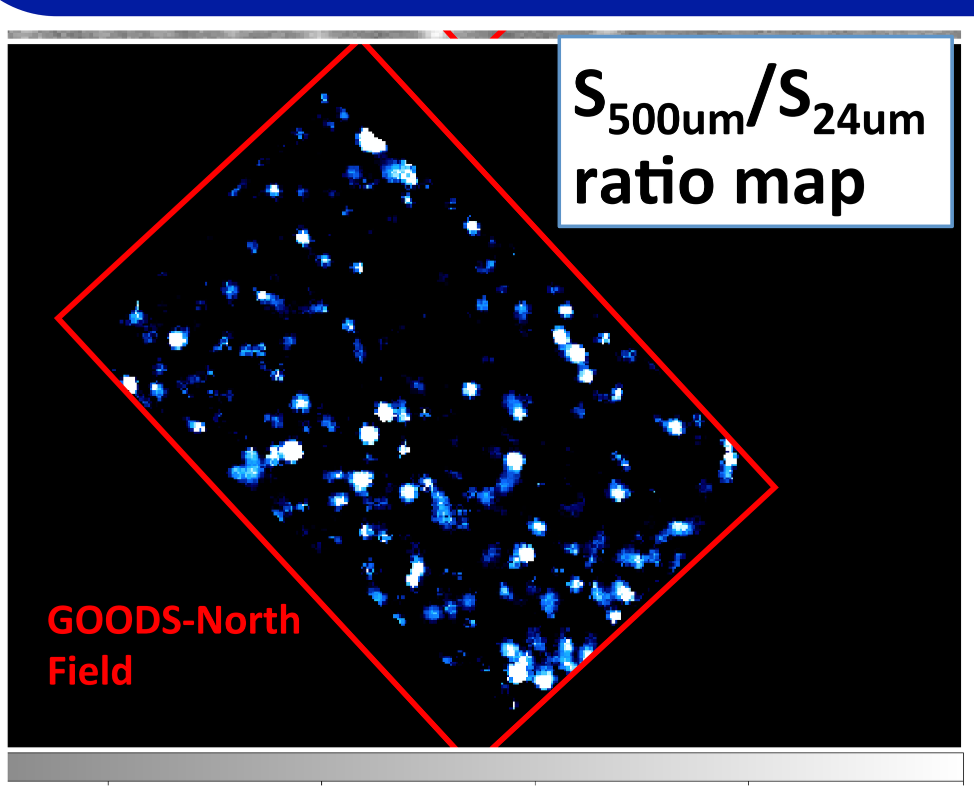
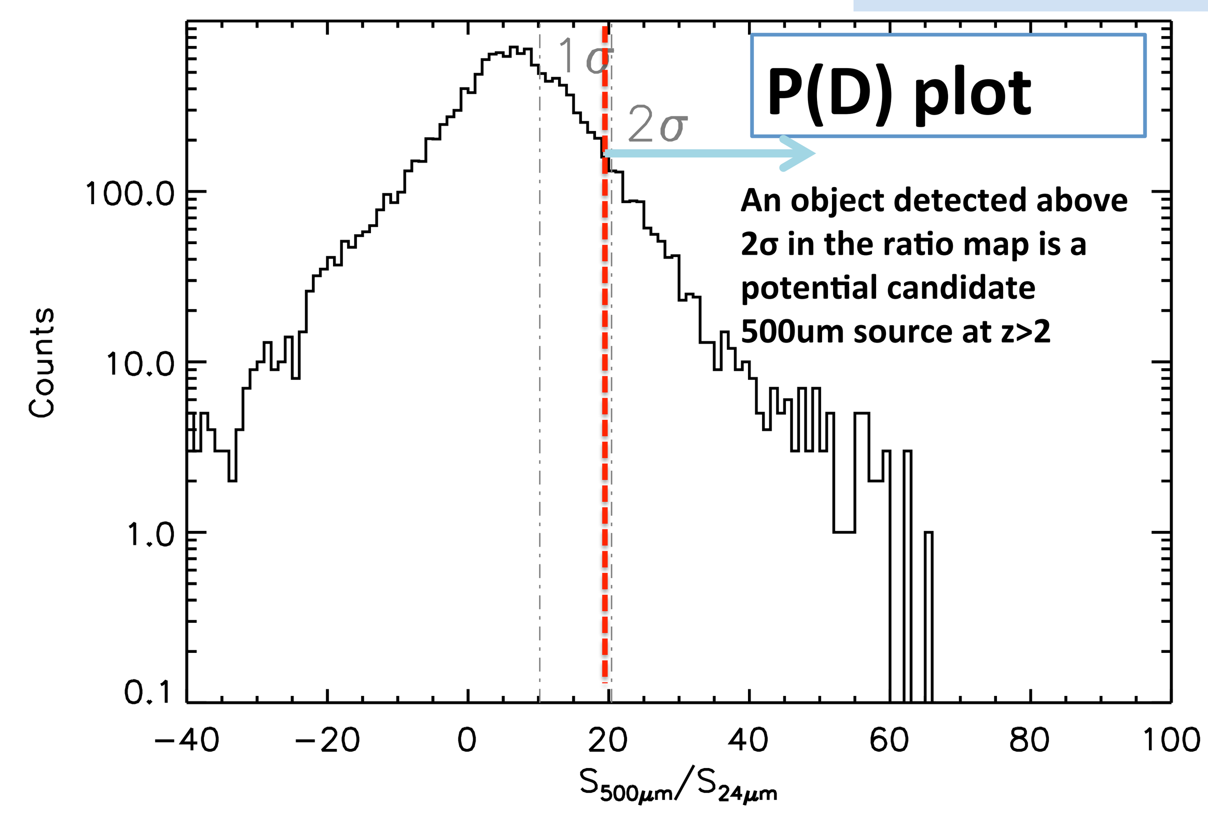
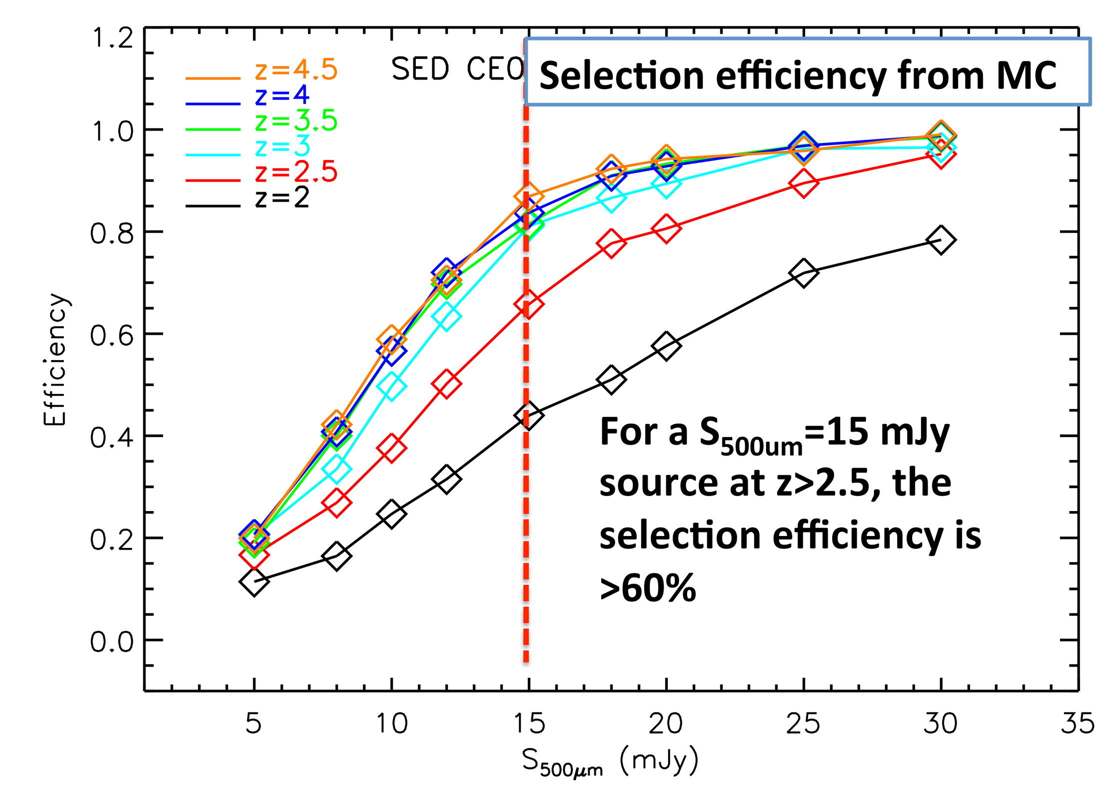


Figure 1: unambiguous identification of a z=4.05 galaxy (GN10, Daddi et al. 2009) based on the "color deconfusion", whose 500um flux is in fact wrongly associated to a nearby source due to strong source blending.







Results: redshift distribution, infrared luminosities and dust properties

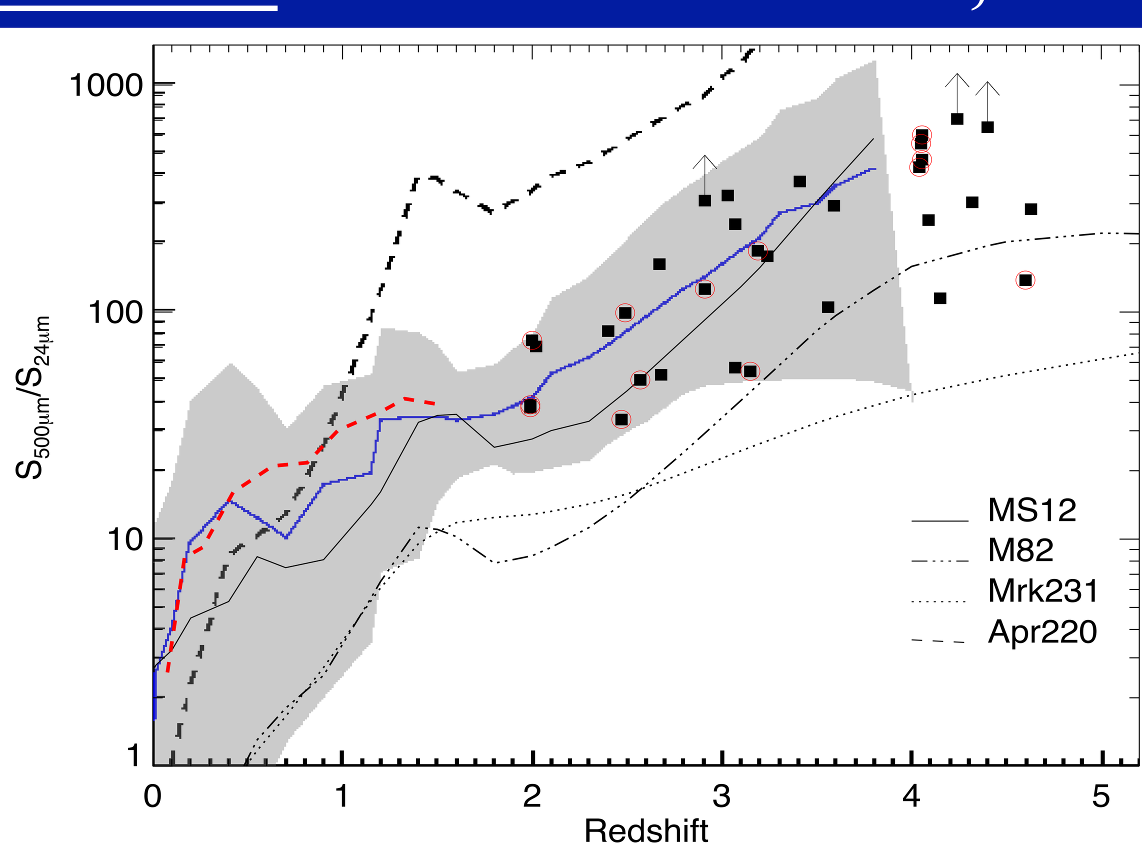


Figure2: S_{500um}/S_{24um} ratios of candidate distant 500µm sources follow the the trend for various SED models. The large ratios (>30) strongly suggest that they are indeed at z>2.

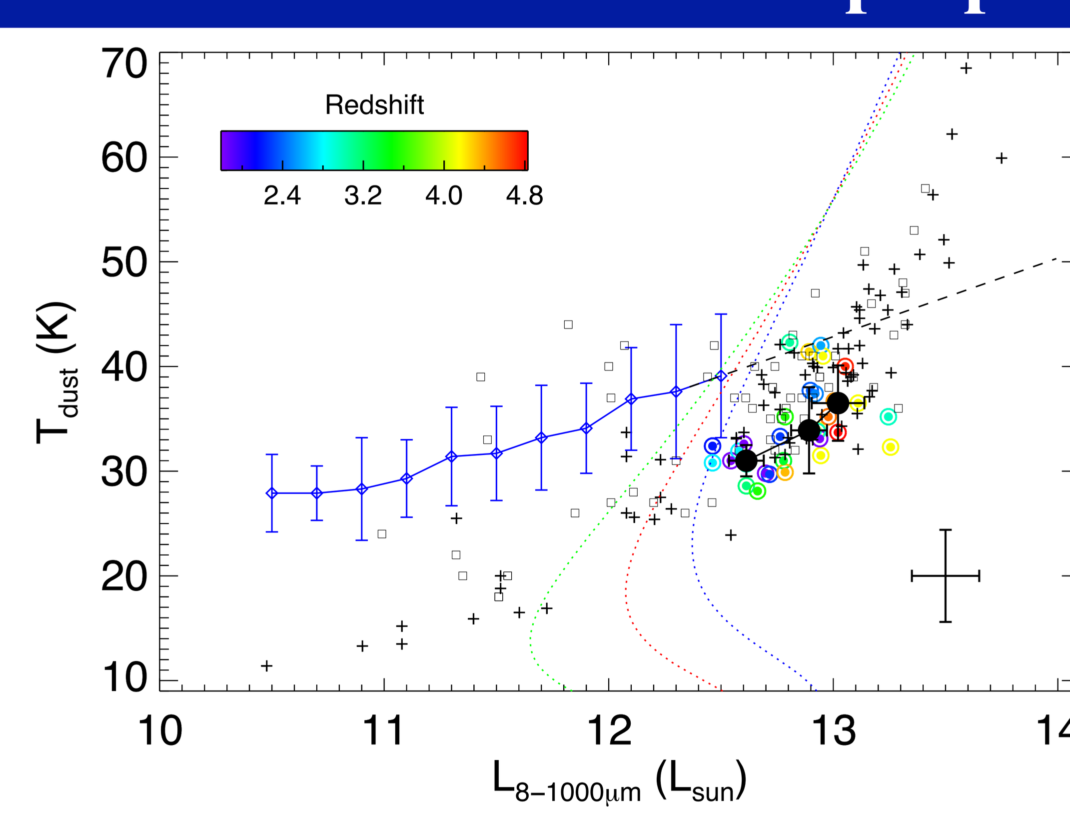


Figure3: high-z ULIRGs in our sample have cooler temperatures at fixed luminosity than the extrapolation of the T_d-L_{IR} relation at z=0-1, which may suggest more extended star formation at higher redshifts (e.g., Hwang et al. 2010; Swinbank et al. 2013).

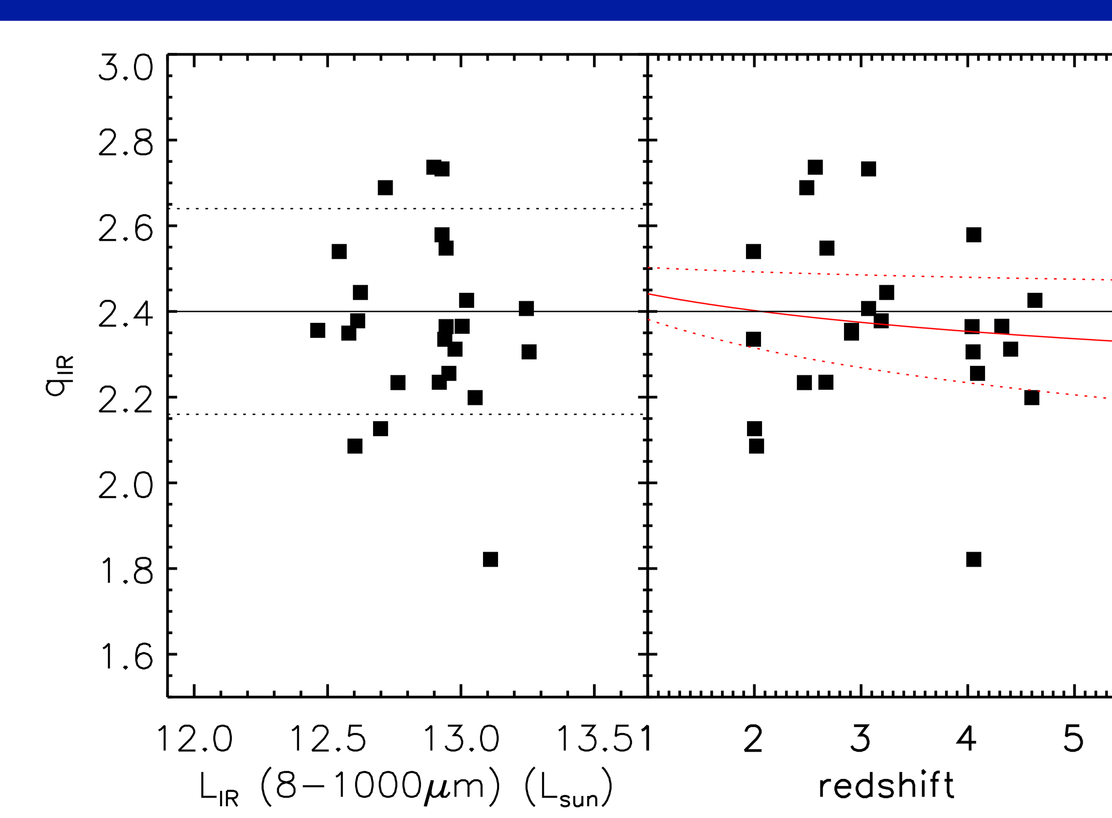


Figure4: high-z radio/FIR relation is consistent with that at z=0-2 (Ivison et al. 2010), and no evolution with redshift is observed. The result also suggests that the far-IR luminosity for high-z ULIRGs is dominated by star-forming process.

Results: Cosmic star formation rate density implications

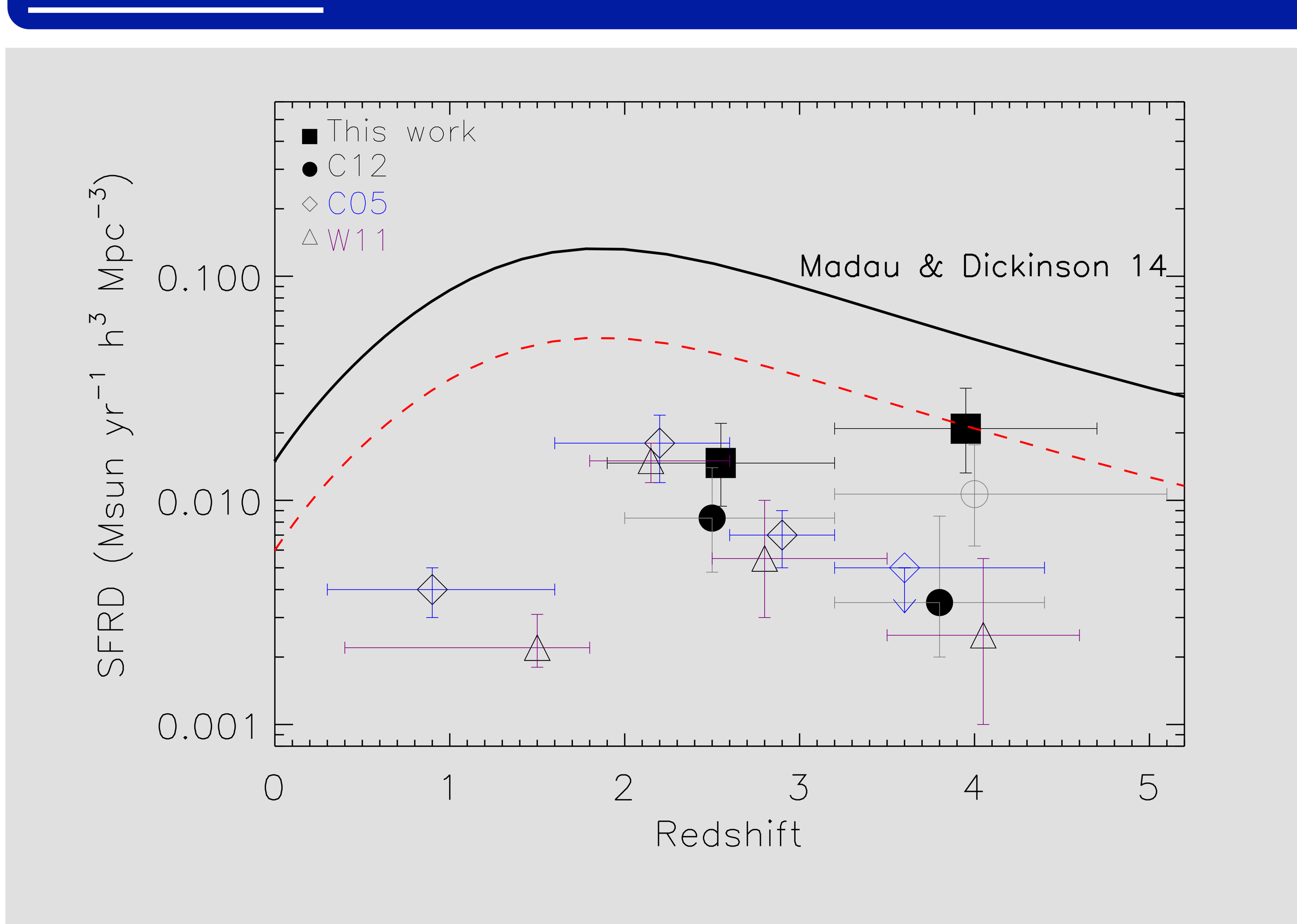


Figure5: (1) The contribution from our S_{500um}/S_{24um} ratio-selected sources to the star formation rate density is comparable to that measured from the 850um-selected sub-millimeter galaxies at z≈2 (Chapman et al. 2005; Wardlow et al. 2011); (2) We observed an increase in the ULIRGs contribution from z≈2.5 to z≈4, the latter making of ≈40% UV-selected samples (Madau & Dickinson 2014). (3) One has to keep in mind that this result maybe affected by cosmic variance in the GOODS-North field we probed.

Summary:

The map-based approach using the S_{500um}/S_{24um} "color deconfusion" is found to provide a more unbiased search for z≥2 ULIRGs. For the GOODS-North field we probed, this method recovers a fraction of 500um sources (≈30%) which would otherwise be misidentified and/or missed due to their wrong 24um counterpart associations. This is valuable for further investigations of the nature of high-z ULIRGs by extending to larger survey fields (CANDELS-Herschel, HerMES).

References: Casey, C. M., et al. 2012, ApJ, 761, 140; Chapman, S. C. et al. 2005, ApJ, 622, 772; Chapin, E. L. et al. 2011, MNRAS, 411, 505; Daddi, E., et al. 2009, ApJ, 695, L176; Dowell, C. D., et al. 2014, ApJ, 780, 75; Elbaz, D. et al. 2011, A&A, 533, A119; Hwang, H. S., et al. 2010, MNRAS, 409, 75; Ivison, R. J. et al. 2010, A&A, 518, L31; Madau, P., & Dickinson, M. 2014, ARA&A, 52, 415; Shu et al. 2014, to be submitted; Swinbank, A. M., et al. 2014, MNRAS, 438, 1267