Complete sample of millimetre-selected galaxies in the SHADES fields

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1 Introduction

Motivation for this work:

- Most of the (sub)millimeter blank-field surveys covered only < 0.1 deg^2.
- The identification rate of (sub)millimeter galaxies is usually $< 65\%$, so the samples are incomplete.

Data used:

- JCMT/AzTEC 0.7 deg^2 1.1 mm survey down to an rms of 0.9–1.7 mJy per beam (Austermann et al., 2010)
- Fields: the Lockman Hole East and the Subaru/*XMM-Newton* Deep Field (SXDF) aka Ultra Deep Field (UDS)
- Ultra-deep radio, mid-infrared, near-infrared and optical data

2 Identification of counterparts at other wavelengths

- The method involves calculation of a probability p that a chosen source could have been found by chance close to the AzTEC position (Downes et al., 1986; Dunlop et al., 1989; Ivison et al., 2007).
- We applied usual methods based on radio and 24 µm flux.
- We tested new methods of identification: we selected sources bright at 8.0 µm and red at $i-K$ and calculated the probability of their chance association with AzTEC sources.
- We present the most complete sample of millimeter-selected galaxies: counterparts identified for $\sim 80\%$ of the sample and redshifts measured for $\sim 70\%$ of the sample (Table 1).

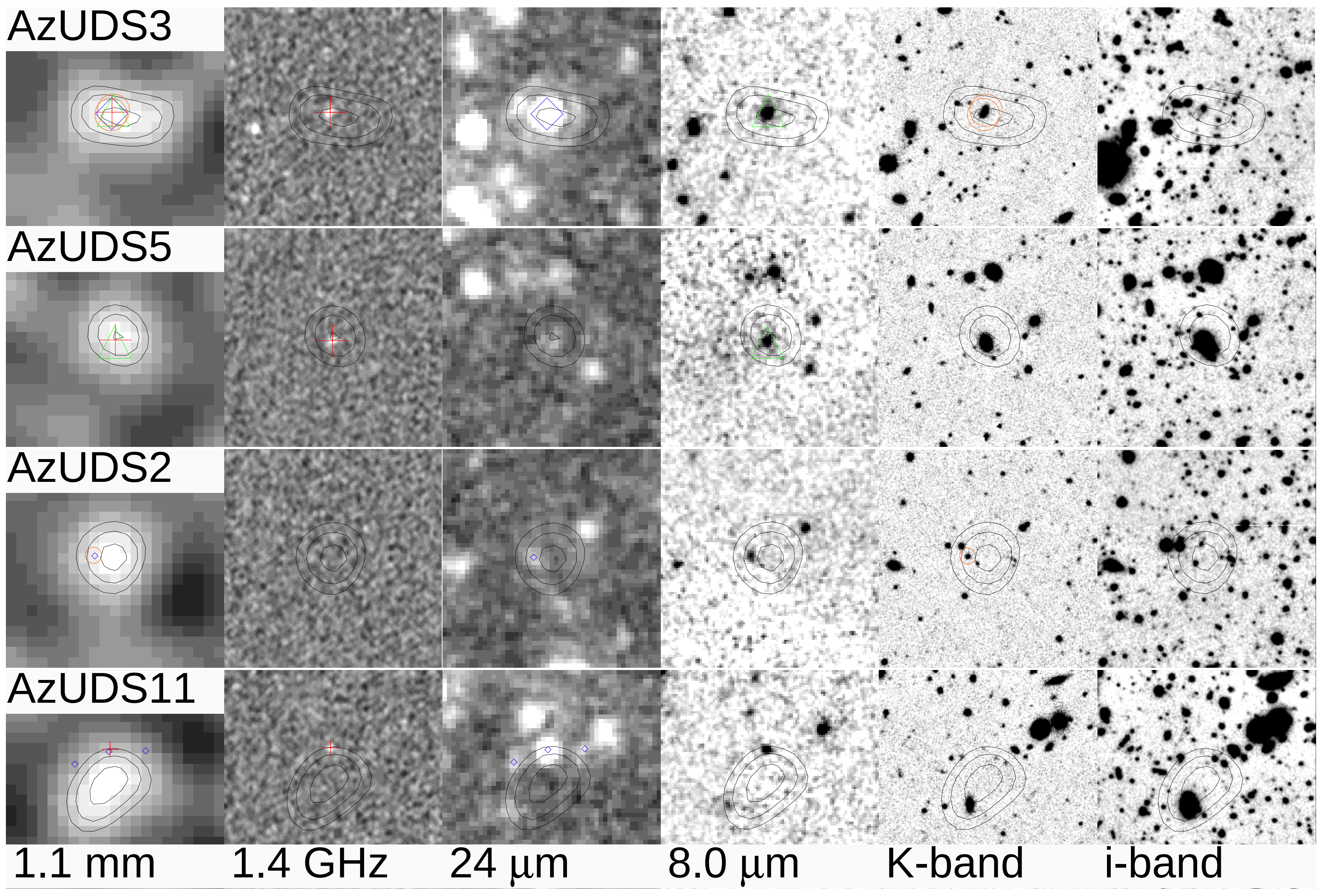

Figure 1: Thumbnail images of four representative targets selected from the AzTEC/UDS sources. Each panel is $60'' \times 60''$ and centered on the AzTEC position. The IDs are marked on the relevant images: *red pluses*: 1.4 GHz IDs, *blue diamonds*: 24 µm IDs, *green triangles*: the 8.0 µm IDs, *orange circles*: the $i-K > 2$ IDs. *Big symbols*: reliable IDs ($p < 0.05$), *medium symbols*: tentative IDs ($0.05 < p < 0.1$), *small symbols*: bad IDs ($p > 0.1$).

Field (1)	N (2)	Cat 1 (3)	Cat 2 (4)	Cat 3 (5)	No ID (6)	N_{opt} (7)	z (8)
Lockman Hole	91	64 (70%)	7 (8%)	7 (8%)	13 (14%)	61	42 (69%)
UDS	57	31 (54%)	1 (2%)	8 (14%)	17 (30%)	44	31 (70%)
Both	148	95 (64%)	8 (5%)	15 (10%)	30 (20%)	105	73 (70%)

Table 1: Success rate of the identification process. The columns show: (1) field name; (2) the total number of AzTEC sources, (3) the number of sources with IDs having at least one $p < 0.05$ at radio, 24 µm, 8.0 µm or $i-K$; (4) the number of sources with IDs having at least two $0.05 < p < 0.1$; (5), the number of sources with IDs having only one $0.05 < p < 0.1$ counterpart; (6) number of sources with no IDs; (7) number of sources covered by the optical map for which a photometric redshift can be reliably estimated (8) number of sources with an optical photometric redshift.

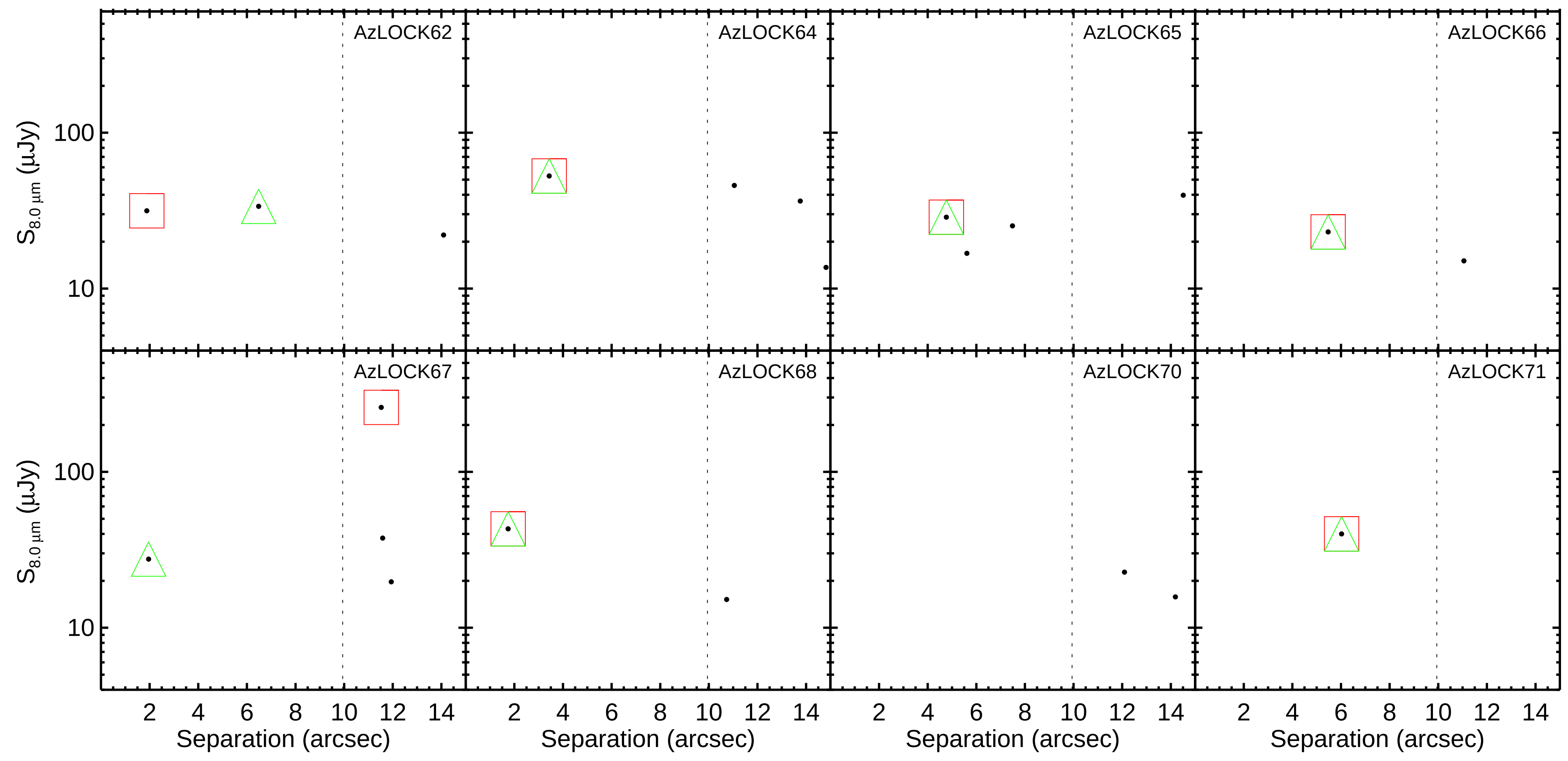

Figure 2: The 8.0 µm flux of all sources close to several AzTEC sources (*dots*) as a function of angular distance from the AzTEC position. *Red squares* correspond to robust radio IDs, whereas *green triangles* denote the brightest 8.0 µm objects within $10''$ from the AzTEC position. This is a motivation for exploring the 8.0 µm flux to identify the counterparts of millimeter-selected galaxies as the radio IDs are in many cases very bright at 8.0 µm.

3 Redshift distribution

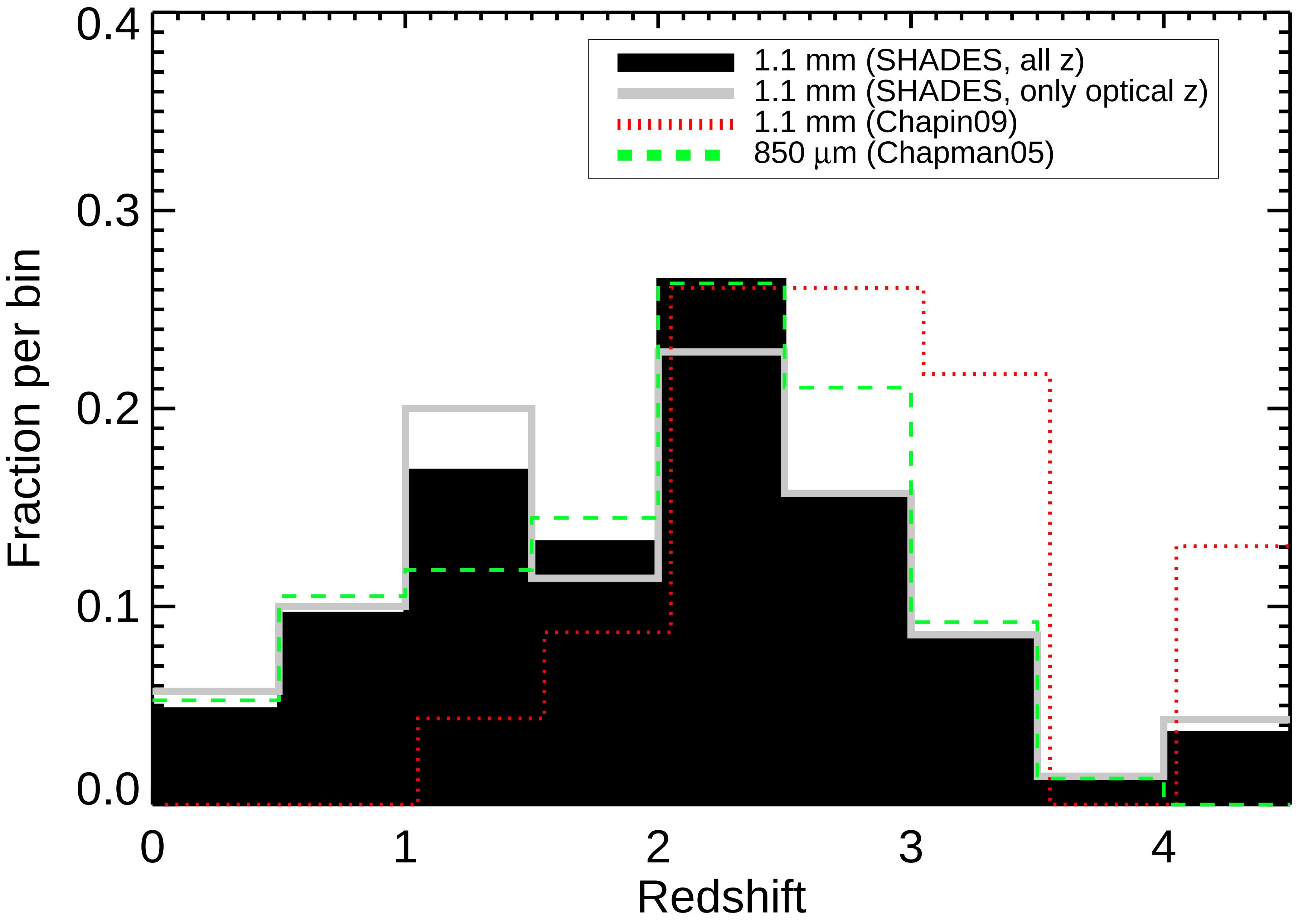

Figure 3: The redshift distribution of 1.1 mm-selected galaxies in the SHADES fields using optical and 1.1 mm / 1.4 GHz redshifts (*solid black histogram*) and only optical redshifts (*grey line*). Lower limits to redshift estimates were excluded. Also shown are the redshift distributions of the 1.1 mm-selected galaxies in GOODS-N (*dotted red line*; Chapin et al., 2009) and the 850 µm-selected galaxies (*dashed green line*; Chapman et al., 2005). The distributions peak at $z \sim 2$–3 and are broad containing objects at $z \sim 0$–4. The difference at low redshifts between the SHADES and GOODS-N can be explained by small survey area of the latter (see Fig. 4).

4 Impact of limited area coverage on the redshift distribution

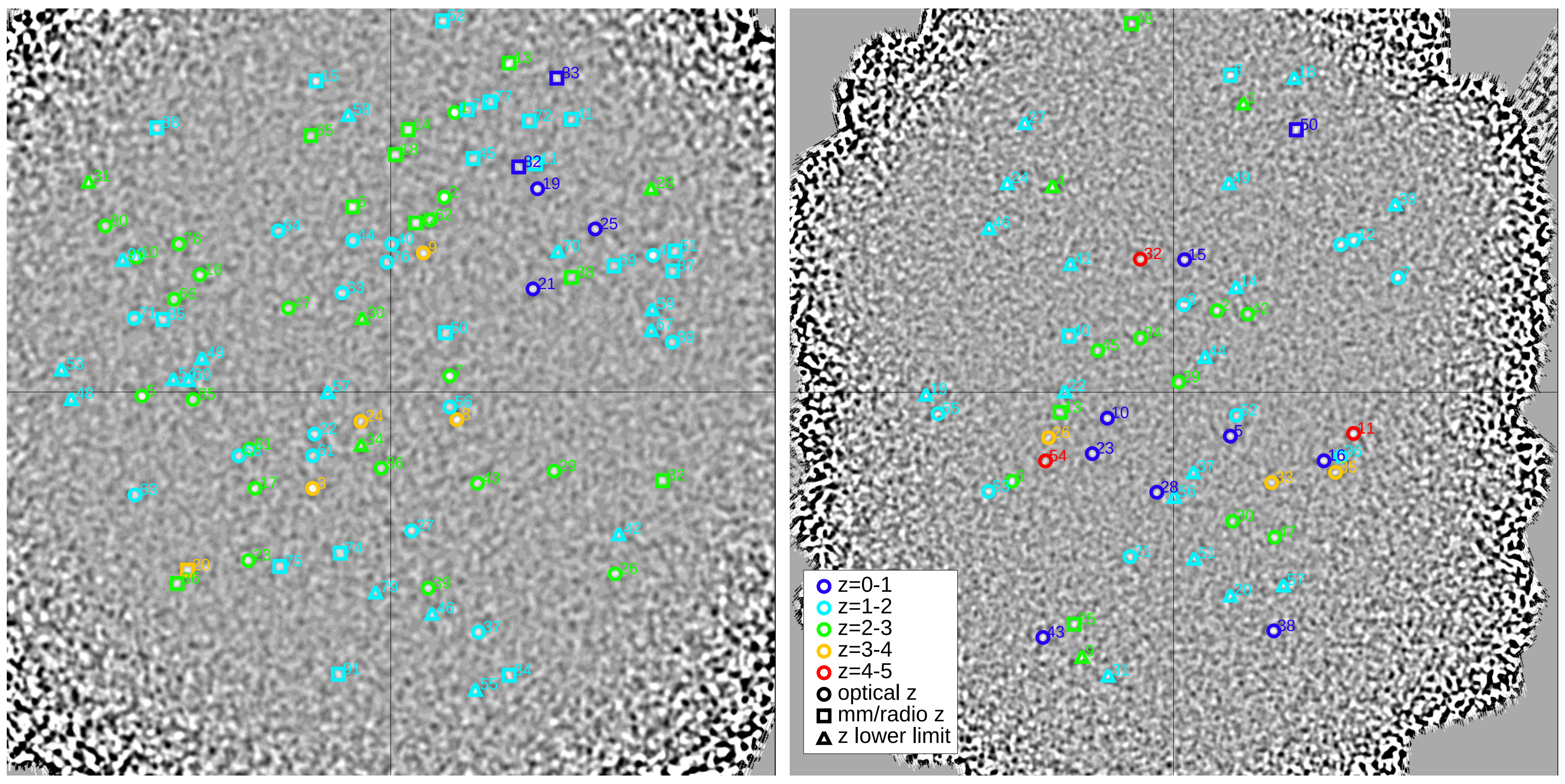

Figure 4: The AzTEC 1.1 mm maps of the Lockman Hole (*left*; 0.67 deg on a side) and the UDS field (*right*; 0.88 deg on a side) from Austermann et al. (2010). The sources analysed in this paper are marked and colour-coded according to their redshifts. *Circles* correspond to optical or PAH redshifts, whereas *squares* correspond to redshifts derived from the 1.1 mm / 1.4 GHz flux ratio based on the average SED model of SMGs (Michałowski et al., 2010). In case of radio non-detection this method provides only a lower limit to the redshift and such cases are marked as *triangles*. *Black lines* divide both fields into four equal parts each with the area similar to that used by Chapin et al. (2009). 50% (4/8) of these parts do not contain any reliable $z < 1$ source, so the fact that Chapin et al. (2009) did not detect any of such objects can be explain by their small survey area.

Summary:

- We tested new methods of identification of millimeter-selected galaxies based on 8.0 µm fluxes and $i-K$ colours.
- We found counterparts for $\sim 80\%$ and measured the redshift for $\sim 70\%$ of the sample.
- We found a broad redshift distribution of millimeter-selected galaxies containing objects at $z \sim 0$–4.
- The lack of millimeter-selected galaxies at $z < 1$ in previous surveys can be explained by their low area coverage.

References

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Contact

I will be happy to discuss your questions and comments during the meeting or by email: `mm@roe.ac.uk`.