Dust properties of a complete sample of millimetre-selected galaxies in the SHADES fields

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From Dust to Galaxies
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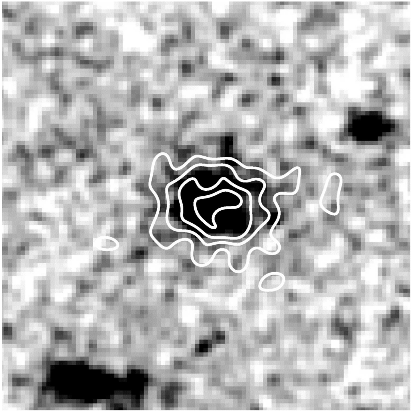
Outline

1. Introduction
2. AzTEC-SHADES survey
3. Properties of mm-selected galaxies

(Sub)millimeter Galaxies (SMGs)



(Chapman et al., ApJ, 2004, 611, 732)

- Selected at (sub)mm (850 μm or 1.1 mm)
- $z = 1.7 - 2.8$ (Chapman et al., 2005, ApJ, 622, 772)
- Luminous, massive, dusty galaxies
- A population missed by optical surveys
- ID problems, incompleteness, redshift distribution, SFRs, masses, . . .

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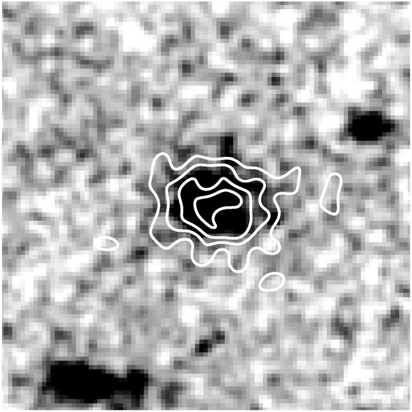

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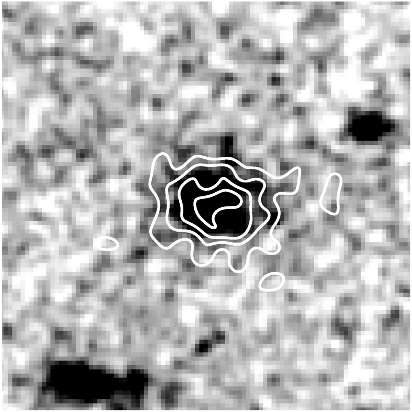

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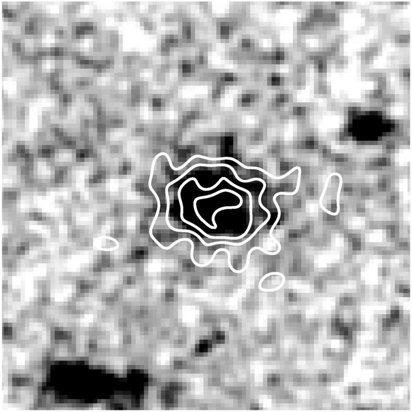

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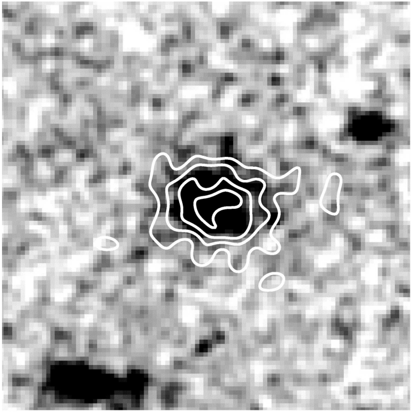

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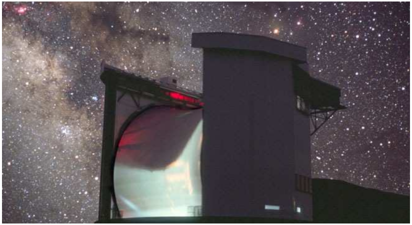
The AzTEC on JCMT

Astronomical Thermal Emission Camera

1.1 mm

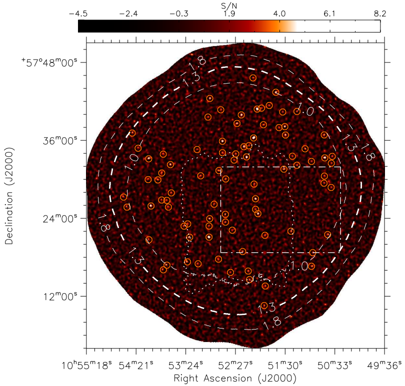
James Clerk Maxwell Telescope



15 m

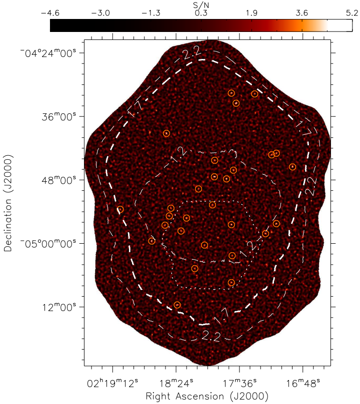
The AzTEC 1.1 mm survey of the SHADES fields

Lockman Hole



91 sources

Ultra Deep FIeld
Subaru/XMM-Newton Deep Field



57 sources

Austermann et al. 2010, MNRAS, 401, 160

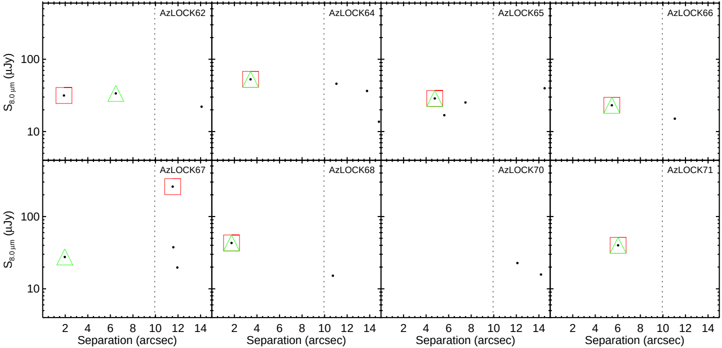
Excellent supporting data

Filter	LH	UDS	Unit
B	27.4	28.8	magAB
R	26.4	28.1	magAB
i	26.3	27.8	magAB
z	25.6	26.9	magAB
J	22.9	25.5	magAB
H	$\cdots$	24.8	magAB
K	23.5	25.2	magAB
3.6 μm	0.8	1.4	μJy
4.5 μm	1.6	1.5	μJy
5.6 μm	11	19	μJy
8.0 μm	13	12	μJy
24 μm	15	18	μJy
1.1 mm	0.9–1.3	1.0–1.7	mJy
1.4 GHz	18	27	μJy
0.6 GHz	45	$\cdots$	μJy

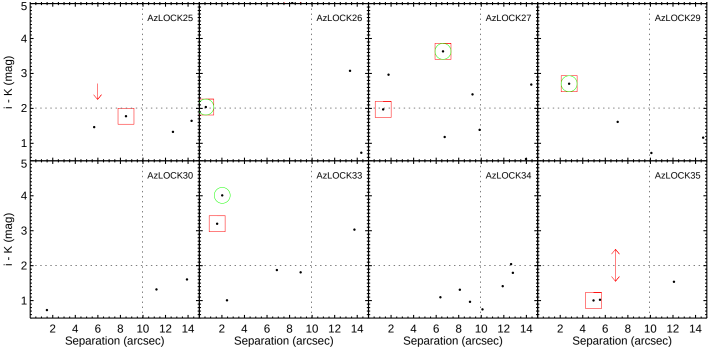
The identification of galaxy counterparts

- The probability of an object of a given flux to be found by chance a given distance away from the AzTEC position: *p*-value
- radio VLA 1.4 GHz and GMRT 0.6 GHz
- *Spitzer* MIPS 24 μm
- *Spitzer* IRAC 8 μm
- $i - K > 2$ color

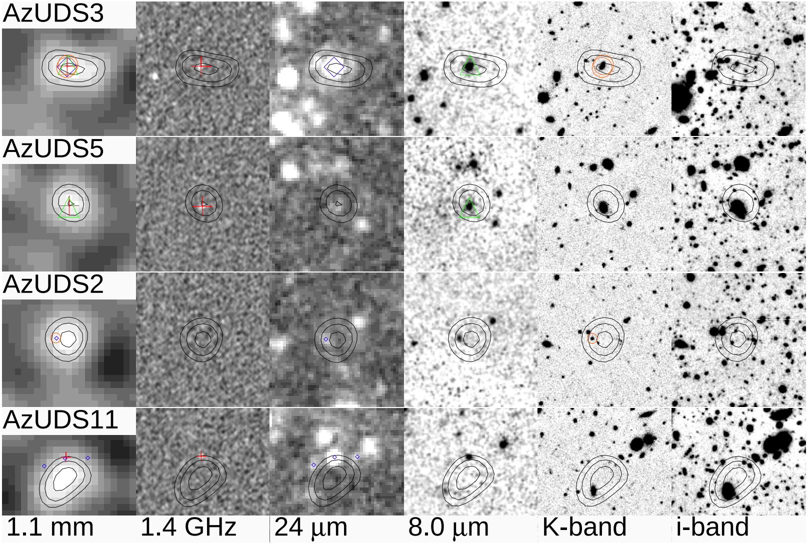
The brightest 8.0 μm object within 10″



The reddest $i - K > 2$ object within $10''$



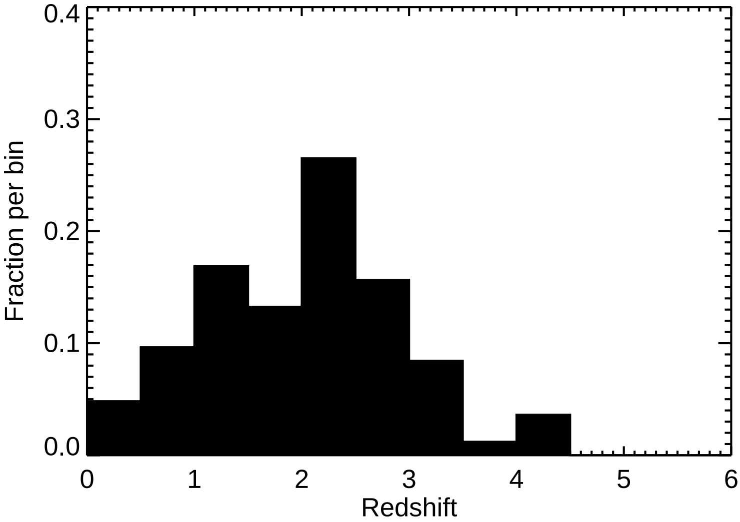
A few examples



Identification rate

Field	N	Cat 1	Cat 2	Cat 3	No ID	N_{opt}	z
LH	91	64 (70%)	7 (8%)	7 (8%)	13 (14%)	61	39 (64%)
UDS	57	31 (54%)	1 (2%)	8 (14%)	17 (30%)	44	31 (70%)
Both	148	95 (64%)	8 (5%)	15 (10%)	30 (20%)	105	70 (67%)

Redshift distribution



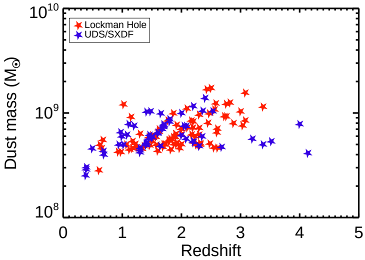
Dust masses

$$M_d = \frac{F_\nu D_L^2}{(1+z)\kappa(\nu_r)B(\nu_r, T_d)}$$

$$\kappa(\nu_r) = 0.067 \left[\frac{\nu_r\ (\mathrm{GHz})}{250}\right]^\beta \quad \mathrm{m^2\,kg^{-1}}$$

Dust masses

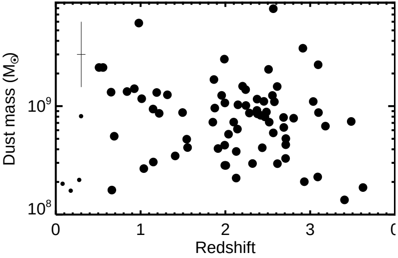
1.1 mm-selected



$\log M_d \sim 8.8\, M_\odot$

No T_d estimate!

850 μm-selected

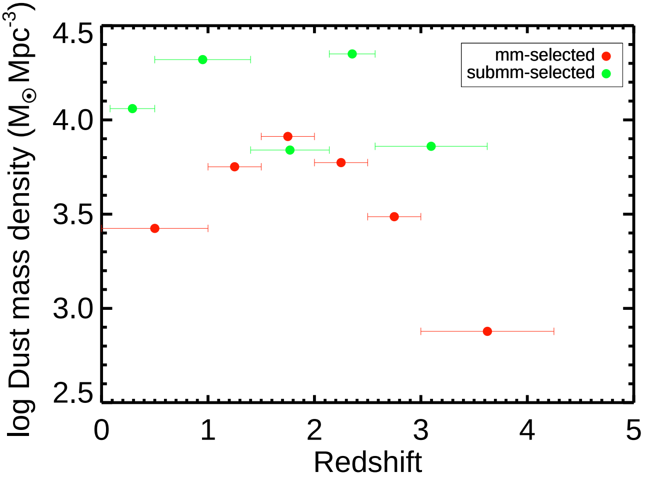


$\log M_d \sim 8.9\, M_\odot$

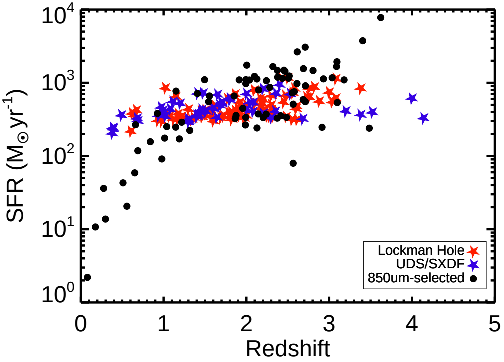
median $T_d \sim 40$ K

Michałowski et al. (2010, A&A, 514, 67)

Dust mass density



Star formation rate

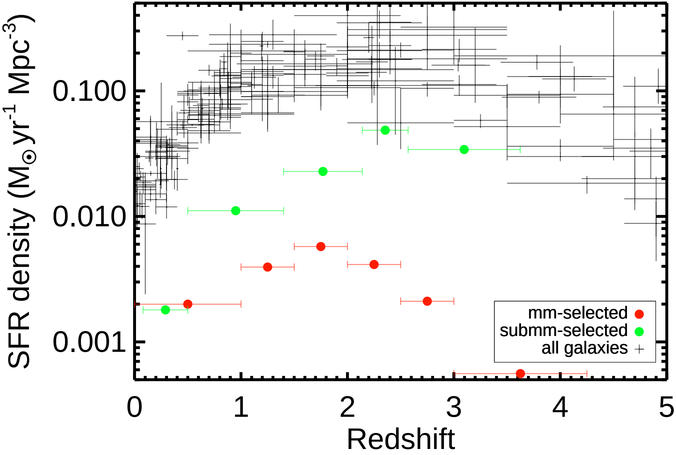


1.1 mm-selected
SFR $\sim 500\,M_\odot$ yr^{-1}

850 μm-selected
SFR $\sim 660\,M_\odot$ yr^{-1}

Michałowski et al. (2010, A&A, 514, 67)

Star formation rate density



Conclusions

1.1 mm-selected galaxies:

- Broad redshift distribution peaking at $z \sim 2$ with a significant low-z population and the high-z tail
- High dust masses $\sim 10^9\,M_\odot$ and SFRs $\sim 500 M_\odot$ yr^{-1} consistent with that of 850 μm-selected galaxies
- First handle on the dust mass density in the high-z Universe
- responsible for $\sim$ 5% of the cosmic star formation density at $z \sim$ 1–3.

Future:

- Use (existing) *Herschel* and (coming) SCUBA-2 data to constrain dust temperature.
- Use ALMA for finding the counterparts at other wavelengths.