SCUBA and Sub-millimetre galaxies
SCUBA

- It stands for Submillimetre Common-User Bolometer Array.
- ‘First light’ was in 1997, mounted on the James Clerk Maxwell Telescope (JCMT) 15m sub-mm telescope at Mauna Kea, Hawaii.
- It consists of 2 bolometer arrays operating at 450μm and 850 μm, plus 3 photometric pixels operating at 1.1, 1.3 and 2.0 mm.
Sub-mm Astronomy

- Sub-mm astronomy from the ground can only be performed from very dry sites, in select windows.
- The transparency of the sky is low, and the sky temperature is high.
Sub-mm Astronomy

- It traces cold dust (3-30K) in the local universe (molecular clouds, dense pre-stellar cores, debris discs etc).
- It traces FIR emission from heated dust at high redshift (star formation at high-z, AGN activity).
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2 bolometer arrays:
- The Short Wave Array, operating at the 450μm (or 350μm) window.
- The Long Wave Array, operating at the 850μm (or 750μm) window.

3 photometric pixels, operating at 1.1, 1.3 and 2.0 mm.
Observing strategies

- There are 3 available observing strategies:
  - Photometry
  - Jiggle-mapping
  - Scan mapping
Sky subtraction

• The dominant source of noise is the sky and so chopping and nodding are used to subtract the sky noise.
• However variability of the sky with time and position, makes SCUBA a sky noise limited instrument.
Science with SCUBA

White et al. 1999

Holland et al. 1998a

Smail et al. 1999
Finding Star-Forming Galaxies at High Z

- Actively star-forming galaxies have young, massive stars that produce high E photons
- Many z~2-4 galaxies identified using Lyman-dropout technique:
But this doesn't always work...

- But high star-formation rates correlate with high amounts of dust!
- The dust extincts these high-energy photons and dump their energy into the IR
- Lyman is suppressed

- Obvious solution: look in the IR spectrum for these galaxies instead
Submillimeter Galaxies

- Star-Forming
- High Amounts of Dust
- Many may contain AGNs
- High Z counterparts of ULIRGs
Science from SCUBA (Early Results 1998)

Points: Data with errors, selection bias not accounted for
Solid Line Models: No evolution (lowest), then $(1+z)^3$ out to increasing $z$
Dashed Line Models: Constant density of star formation, increasing density
Science from SCUBA
(from SHADES 2008)

“Shades IX” Serjeant et. al (2008)

Simulations by de Lucia et. al (2006)
Environment Distribution (from SHADES)

- Density field estimated by Spitzer 3.6um galaxies
- SMGs tend to be in overdense regions
- Opposite of $z = 0$

Summary

- SCUBA is an array on the JCMT operating mainly at the 450μm and 850μm bands with 3 “bonus” pixels for photometry
- Ground-based sub-mm Astronomy difficult because sky absorbs in this regime and is noisy
- SMGs difficult to detect/classify photometrically
- Optically selected samples miss SMGs
  - Significantly under-estimate SFRs at high z
  - Models agreeing with those results have some bias
- High-SFR galaxies in the early universe tended to be in overdense regions