The Infrared Properties of Sources in the H-ATLAS and WISE Surveys

Nicholas Bond (NASA Goddard)

Collaborators: Jonathan Gardner, Dominic Benford (Goddard), Andrew Blain (Leicester), Loretta Dunne (Nottingham), Simone Fleuren (Queen Mary, University of London), Dan Smith (Hertfordshire), Alexandre Amblard (NASA/Ames), Asantha Cooray (UC Irvine), H-ATLAS and WISE collaborations

Survey data

- Working in GAMA 15-hr field, ~36 deg^2

Wide-field Infrared Survey Explorer (WISE):

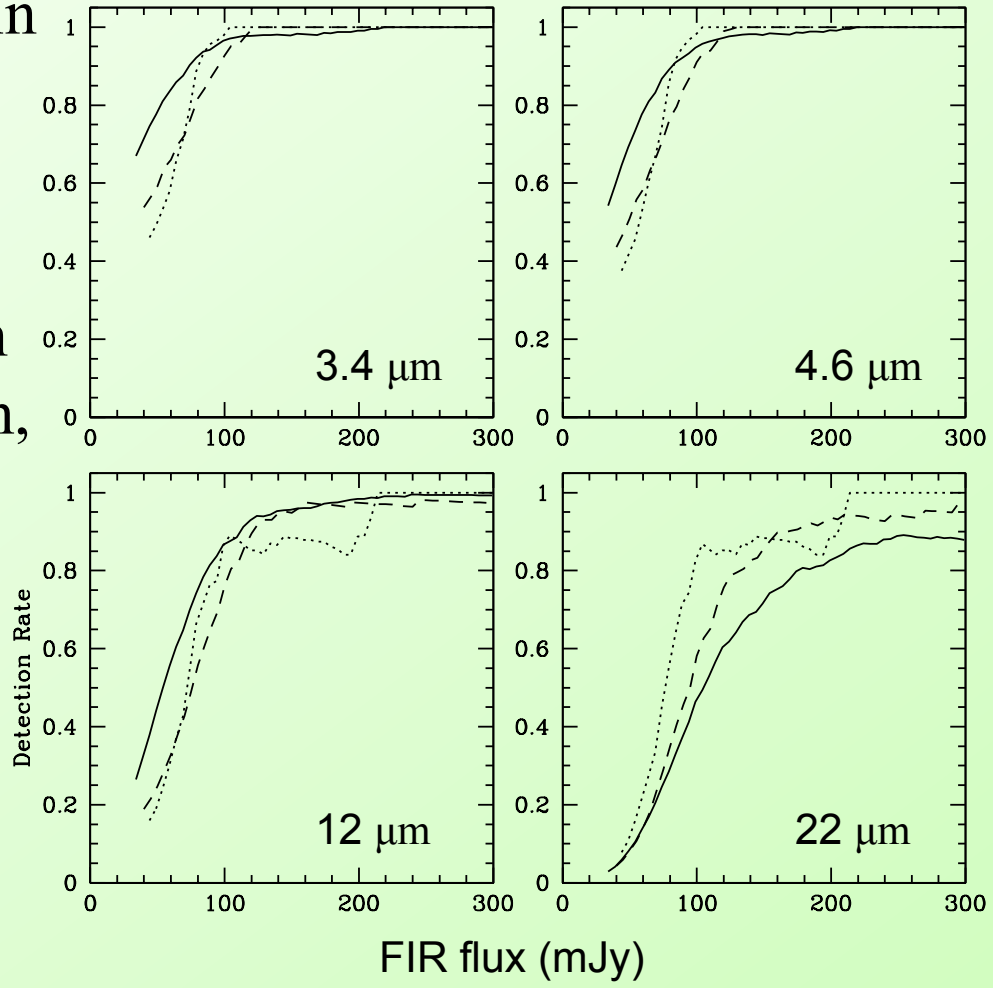
- 5σ point-source depths of 0.048, 0.10, 0.73, and 5.9 mJy at 3.4, 4.6, 12, and 22μm
- ~6" resolution at 3.4 μm

Herschel Astrophysical Terahertz Large-Area Survey (H-ATLAS):

- 5σ point-source depths of 34, 40, and 44 mJy at 250, 350, and 500 μm
- Final catalog will cover ~550 deg^2
- spec-z's from GAMA (r<19.5, Driver et al. 2011) and phot-z's from SDSS+UKIDSS
- ~18" resolution at 250 μm, astrometry good to ~2.4"

NIR/MIR detection rates for FIR flux-limited surveys

- Detection rates computed within 10” apertures, corrected for expected background/ foreground contamination rate
- > 95% for sources >100 mJy in any SPIRE band, 250 – 500 μm, dominated by low-z sources
- Toward fainter WISE fluxes, high-redshift sources make up increasing fraction of matches



Solid: 250 μm **Dashed**: 350 μm **Dotted**: 500 μm

Cross-identification and verification

- Remove likely stars ([3.4] - [4.6] > 0)
- Identify with a maximum likelihood algorithm (Sutherland & Sanders 1992, Smith et al. 2010)
- Likelihood given by

$$L = f(r)q(m)/n(m)$$

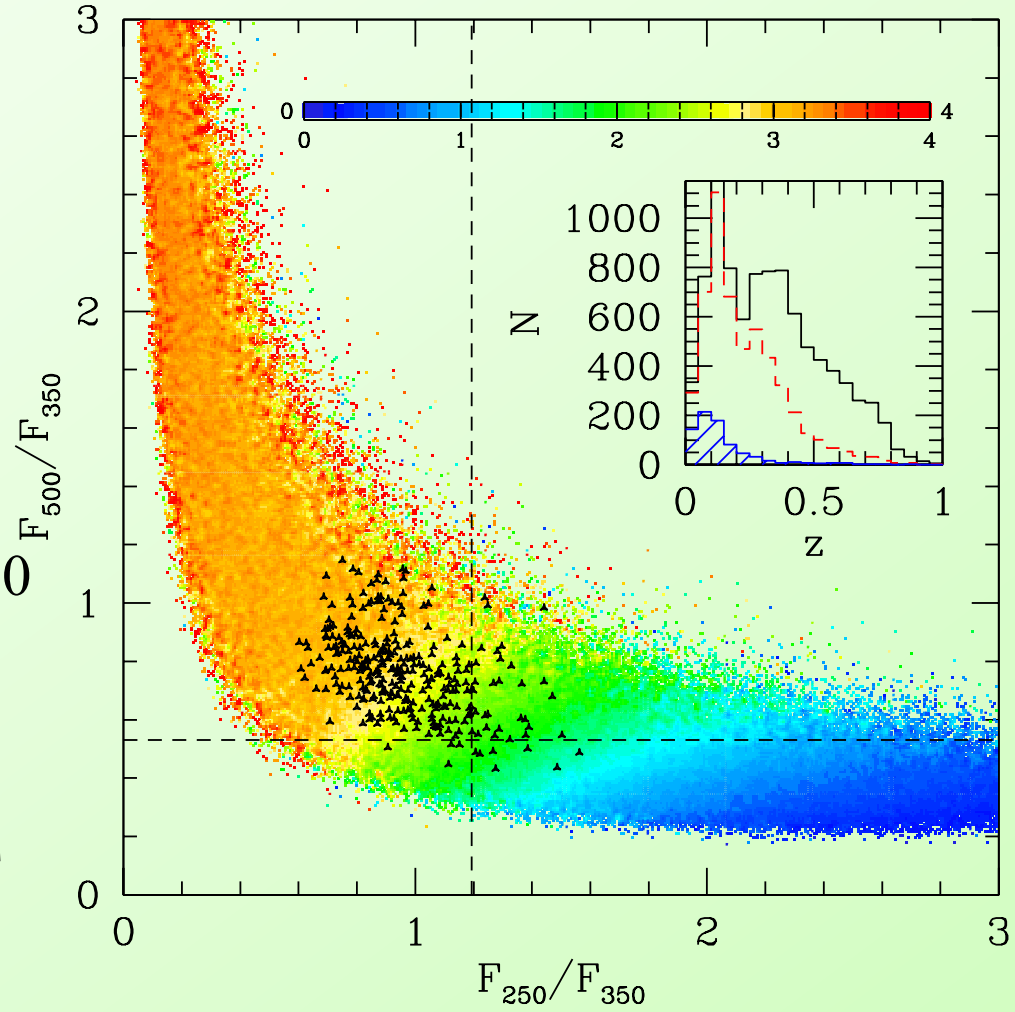
- Where f(r) is a Gaussian radial probability distribution, q (m) is the 3.4 μm magnitude distribution of IDed sources, and n(m) is the magnitude distribution of background/ foreground sources
- Successfully identify 50.4% of H-ATLAS sources in at least one WISE band (usually 3.4 μm), including 85.7% of sources with optical/NIR redshifts

FIR colors and redshift distribution

- H-ATLAS sources w/redshift have $0 < z < 0.8$ (see inset)

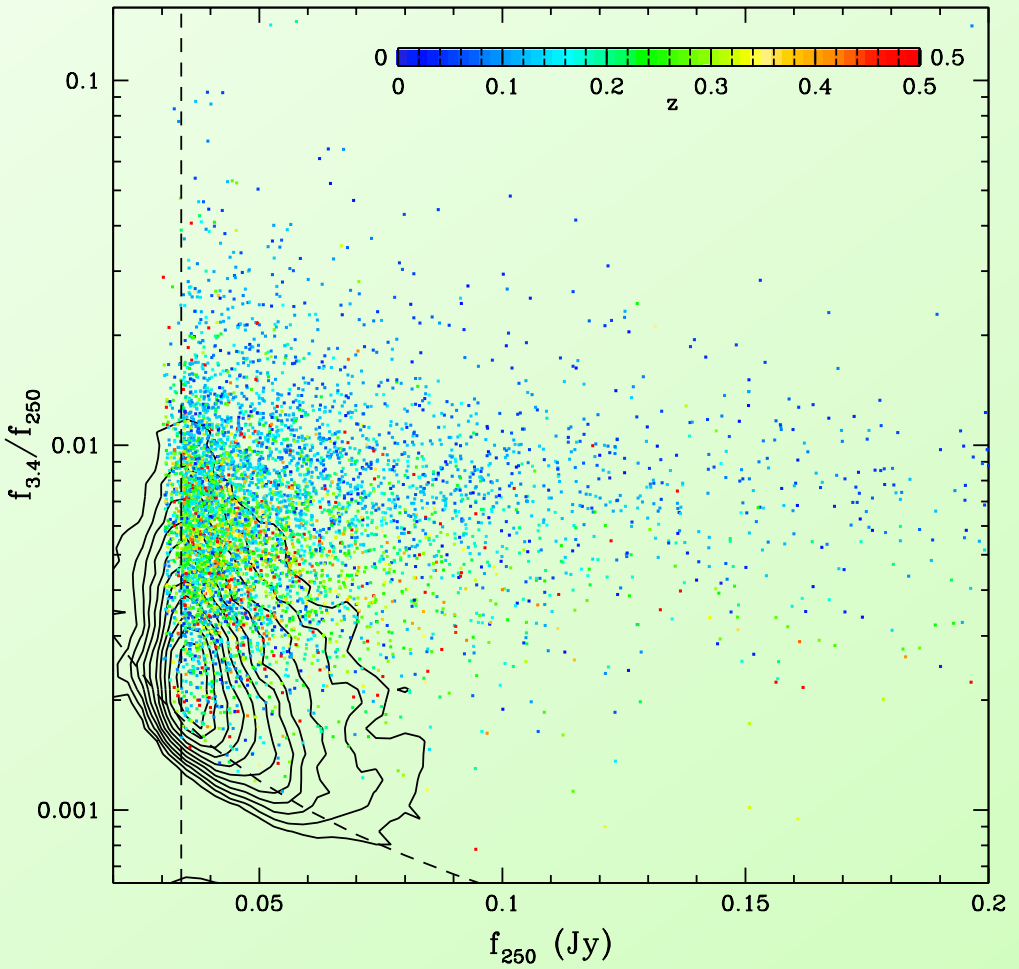
- For no-redshift sample, use Monte Carlo simulations from Amblard et al. 2010 to estimate redshift from FIR colors → range of modified blackbody spectra with $10 < T < 60$ K and $0 < \varepsilon < 2$

- Median flux ratios for no-redshift sample indicated by dashed lines, suggests $z \sim 2$ if $T \sim 35$ K ($z \sim 1$ if $T \sim 25$ K)

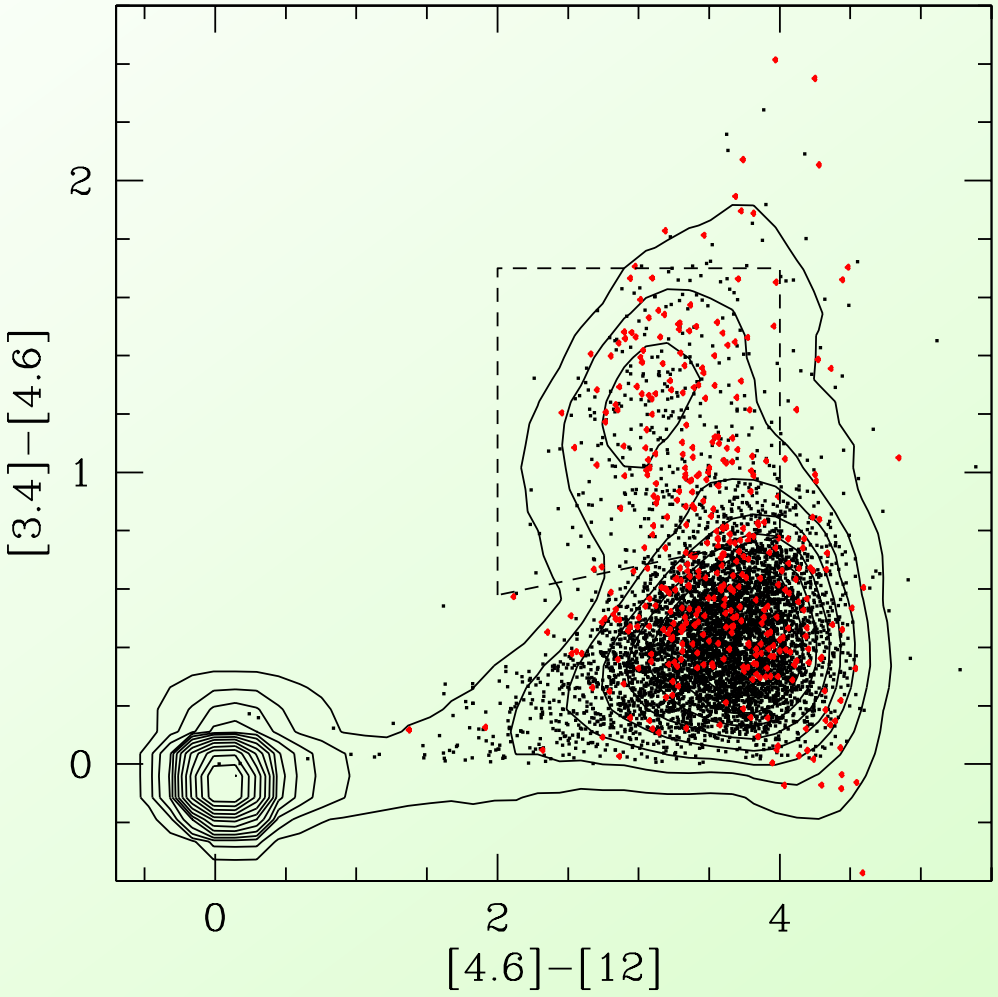


NIR-FIR colors for submm-selected galaxies

- Two flux-limited samples, $f_{3.4}$>0.07 mJy, f_{250}>34 mJy
- Majority of low-redshift sources (colored points) well detected at 3.4 μm
- Decrease in flux ratio w/ redshift due to k-correction and increasing specific star formatin rates
- Sources w/o measured redshifts indicated by contours, small flux ratio indicates high redshift or extreme intrinsic color (Arp 220-like)

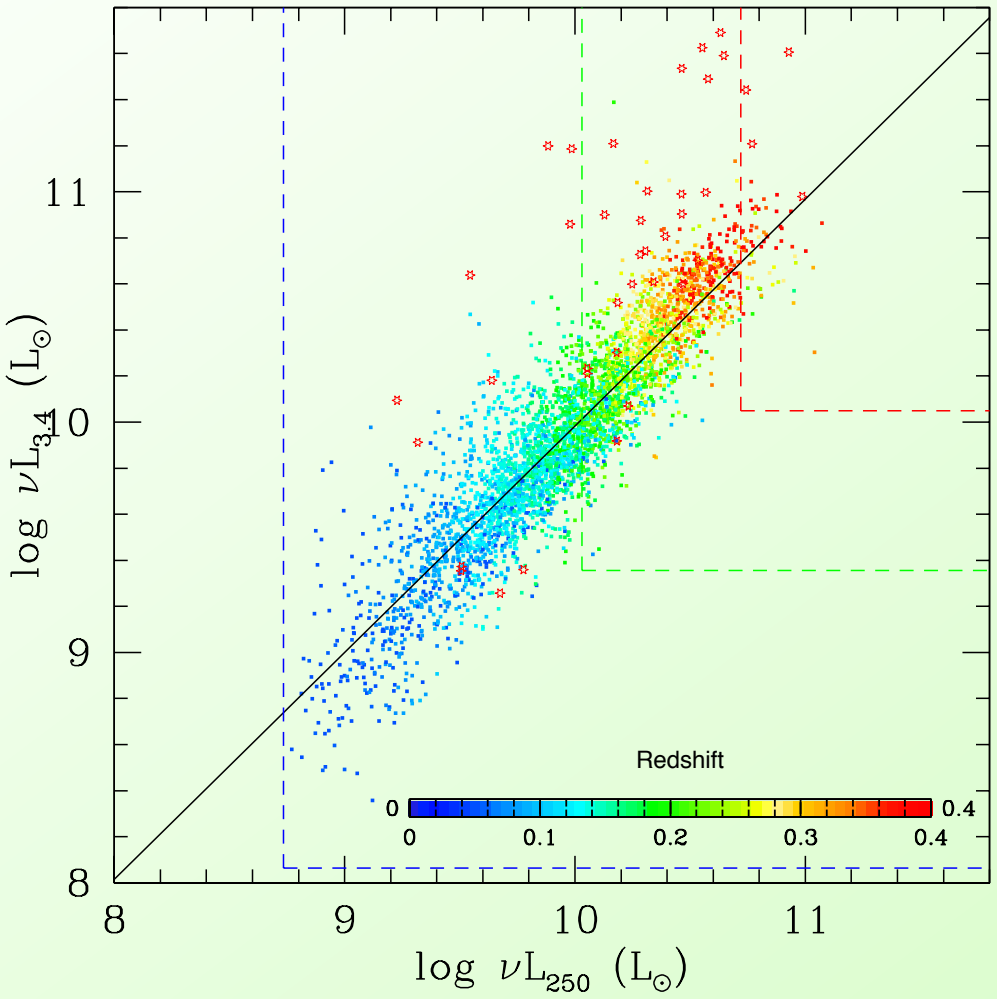


WISE color space – AGN selection



- WISE color space differentiates stars and early-type galaxies (lower left), star-forming galaxies (lower right), and AGNs (dashed box, Jarrett et al. 2011)
- Selection region looks for power-law continuum in NIR and MIR
- Of sources with IDs and WISE detections out to 12 μm, ~10% consistent with AGN, including ~25% of those in no-redshift sample
- Cruder AGN selection with [3.4]-[4.6] > 0.8 also gives 25% AGN fraction over larger fraction of sample

Rest-frame luminosities in the NIR and FIR



- Sources w/spectroscopic $0.05 < z < 0.4$, stars indicate AGNS, dashed lines approximate selection regions
- k-corrections performed in FIR assuming $T = 30$ K and $\varepsilon = 1.5$, NIR using power-law interpolation of the [3.4] − [4.6] color
- Best-fit power-law has $\alpha = 1.00 \pm 0.07$, ~50% scatter
- Correlation likely driven by linear relation between SFR and stellar mass (e.g., Daddi et al. 2007, Elbaz et al. 2010)

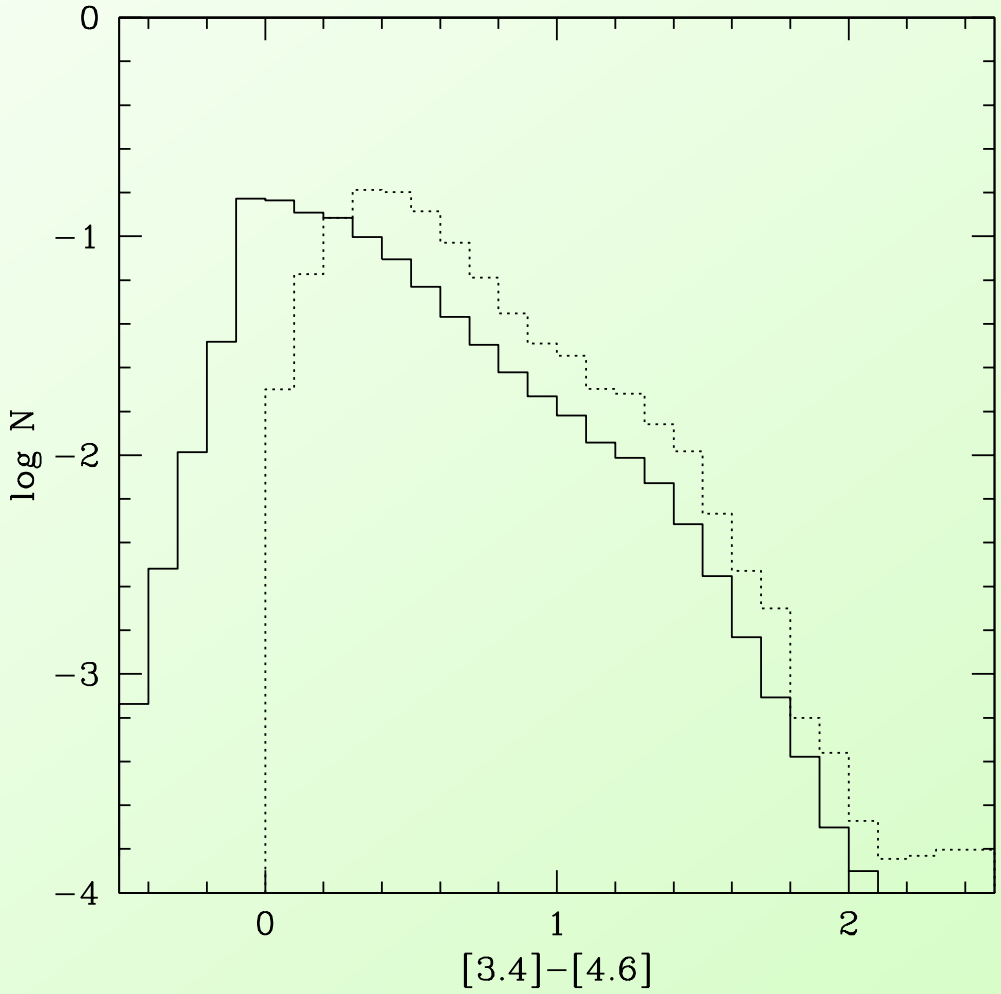
Future Work

- Create full matched catalog

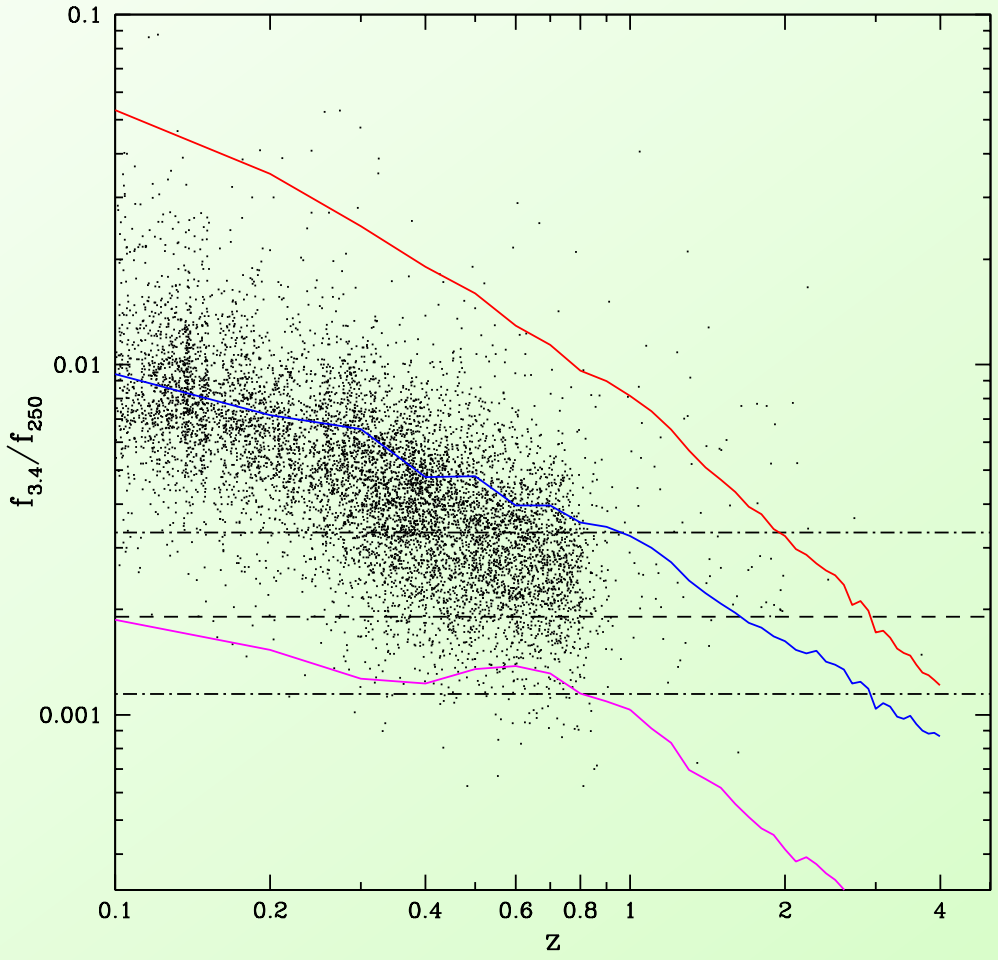
Results summary

- Successfully identify 50% of H-ATLAS 250 μm sources in WISE 3.4 μm, with flux limits of 34 mJy and 0.07 mJy, respectively
- Majority of H-ATLAS sources with pre-existing optical/NIR redshifts ($0 < z < 0.8$) are well detected at 3.4 μm, with an ID rate of ~85%
- Majority of no-redshift sample likely to be at high redshift ($z \sim 2$) because
  → FIR colors are consistent with either moderate temperatures ($T \sim 35$ K) at high-z ($z \sim 2$) or very low temperatures ($T \sim 17$ K) at low-z ($z \sim 0.5$)
  → FIR/NIR colors are ~3 times redder than typical low-z galaxies with measured redshifts and FIR detections (Arp 220-like if at low z)
  → AGN fraction of no-redshift sources is high (25%)
- Find linear correlation between 3.4 μm and 250 μm luminosities over two decades in luminosity for H-ATLAS sources at $0.05 < z < 0.4$

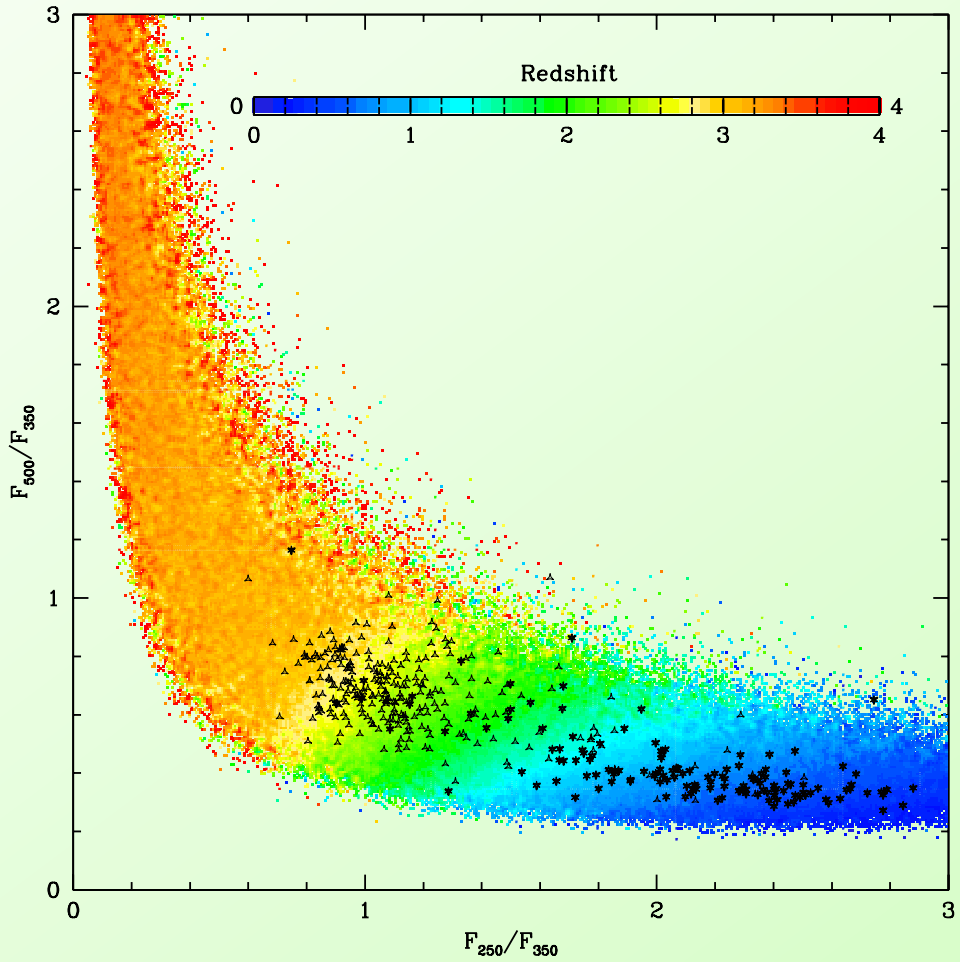
NIR magnitude and color distributions



NIR-FIR colors vs. redshift



FIR flux ratios for galaxies with spec-z



Sample SEDs