How Prevalent are Dust Obscured AGN at z=1-2?

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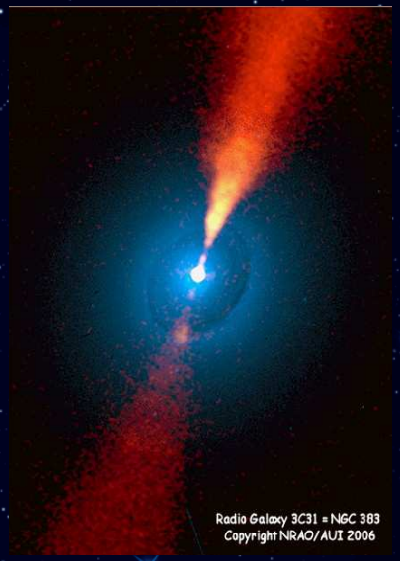
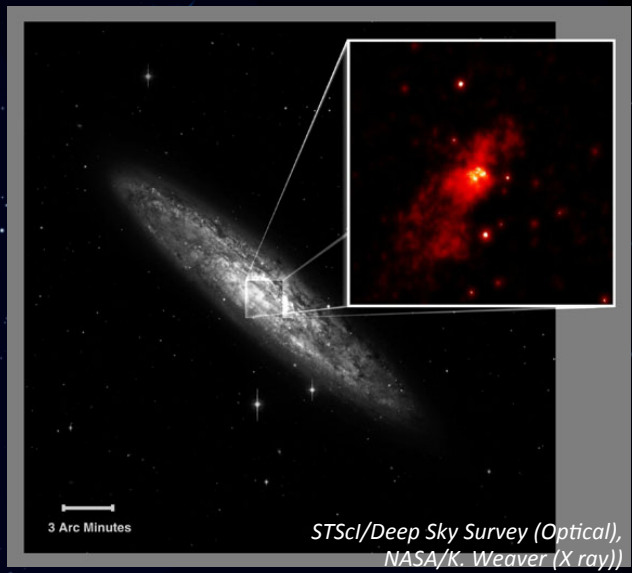
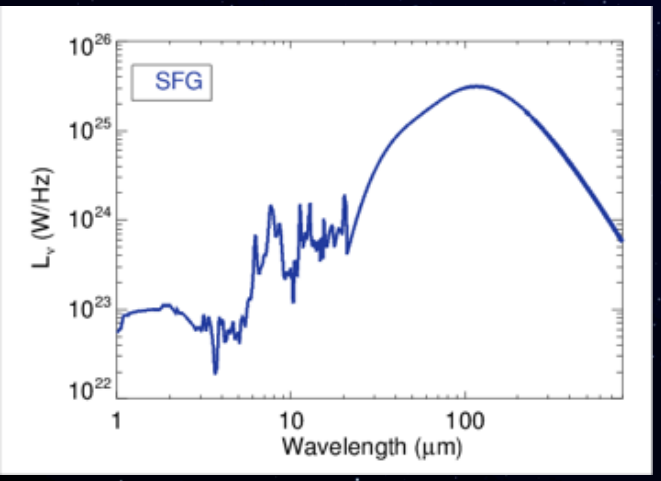
What is Dust Hiding?

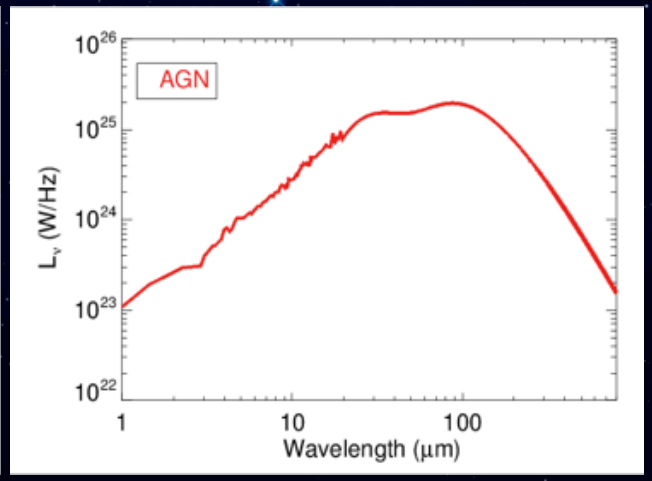
NASA/ESA/Hubble

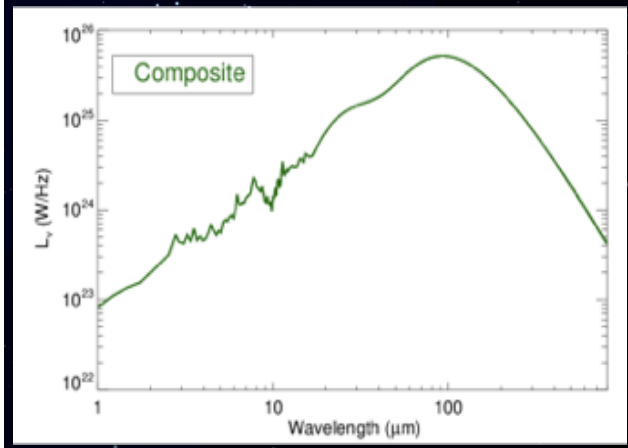




STScI/Deep Sky Survey (Optical), NASA/K. Weaver (X ray))

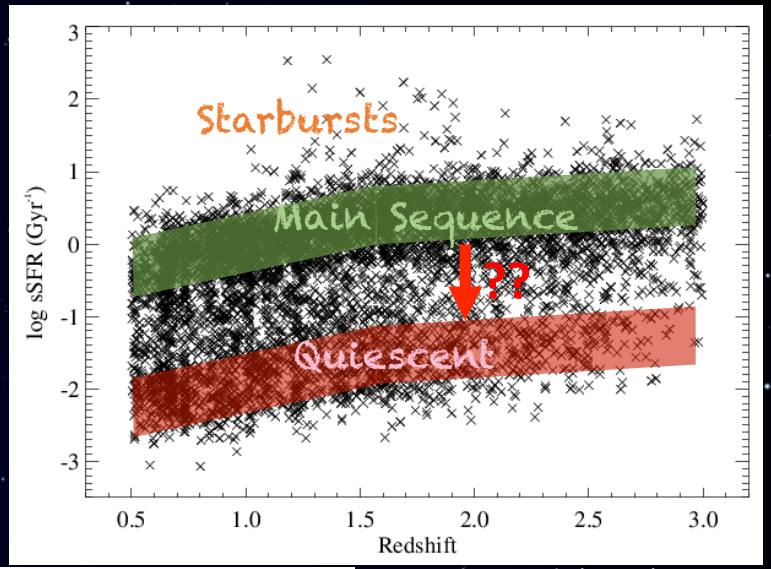




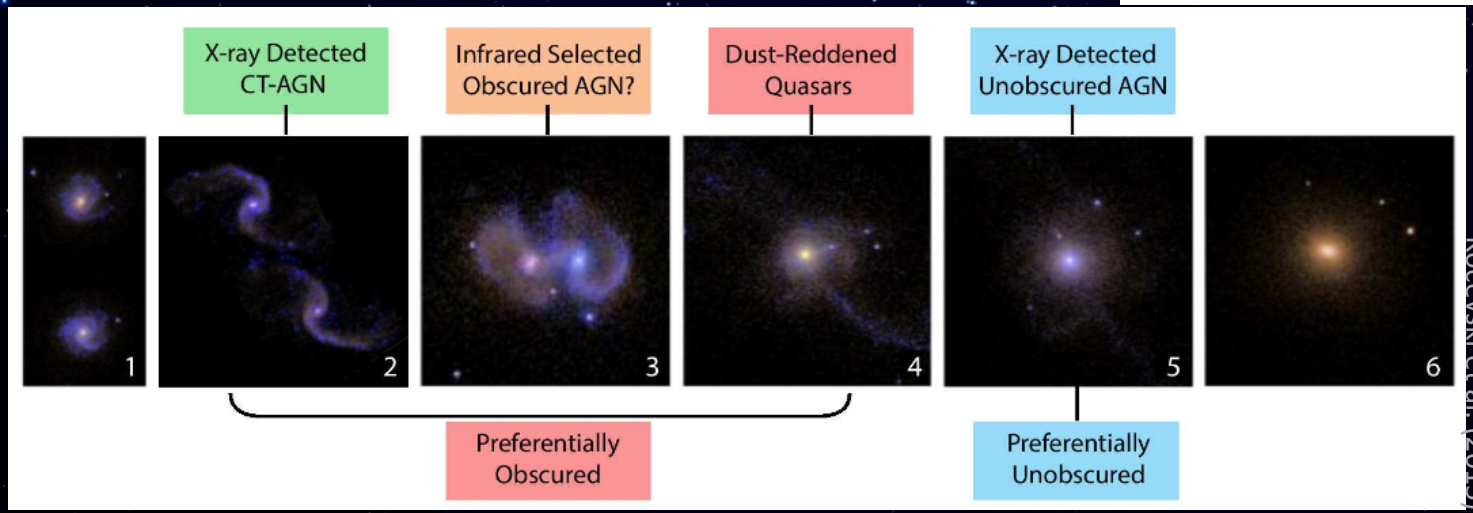


The Importance of IR AGN

1. IR AGN may be a distinct phase of galaxy evolution
2. AGN may cause quenching in massive galaxies
3. Composites could be “early” AGN



Pandya et al. (2016), in prep

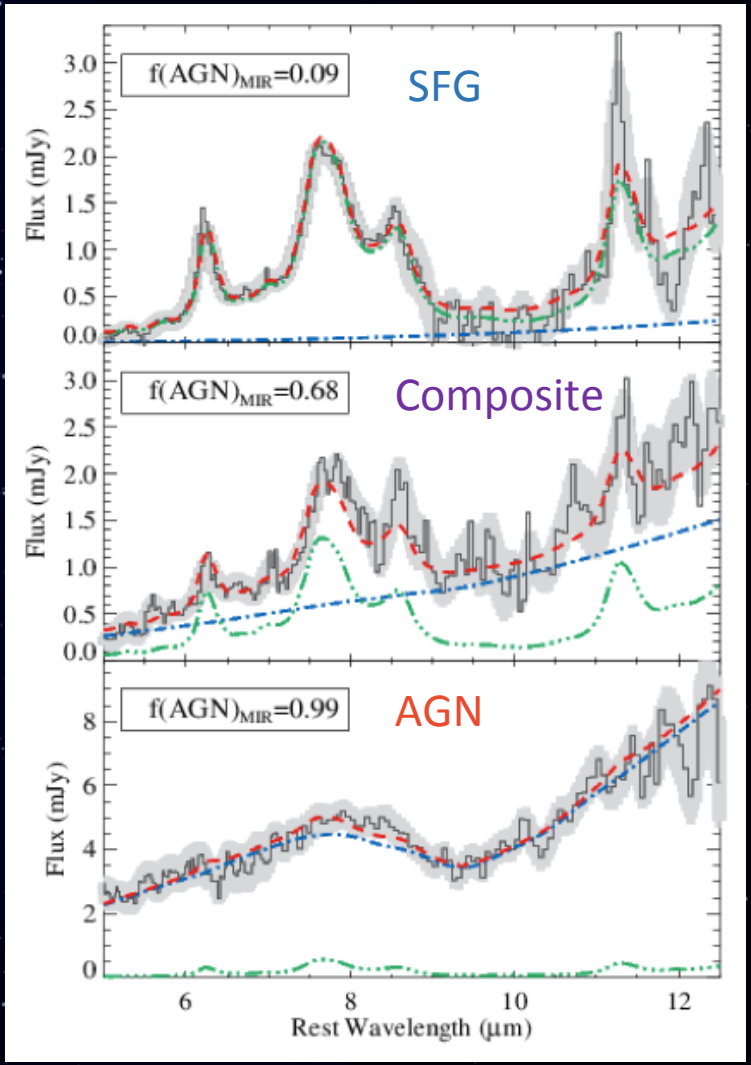


Kocevski et al. (2015)

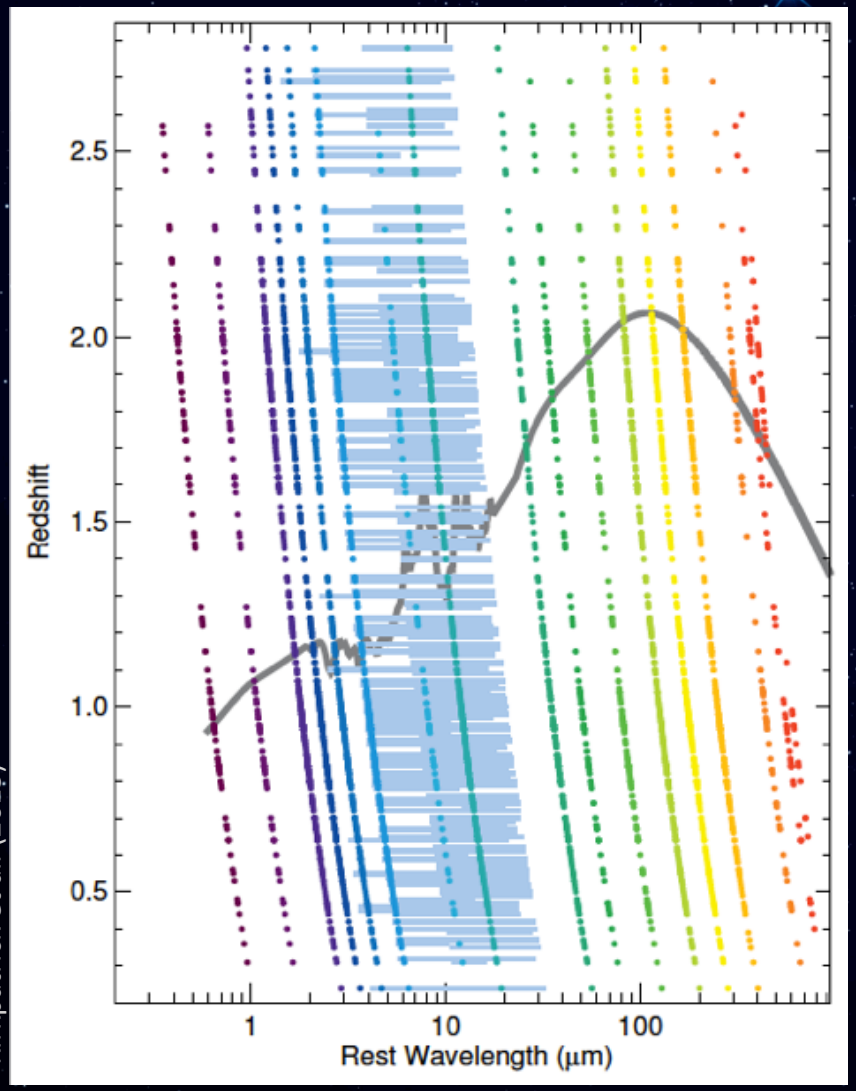
Measuring Mid-IR AGN Emission

- Fit spectra with a model:
  - PAH emission (M82): Star Formation
  - Power law continuum: AGN Torus
  - Extinction (Draine 2003)
- Spectral decomposition can identify composites
- Decomposition can *quantify* amount of luminosity due to AGN heating

$f(AGN)_{MIR}$ = Power Law / MIR luminosity



Creating a Toolkit for finding Composites

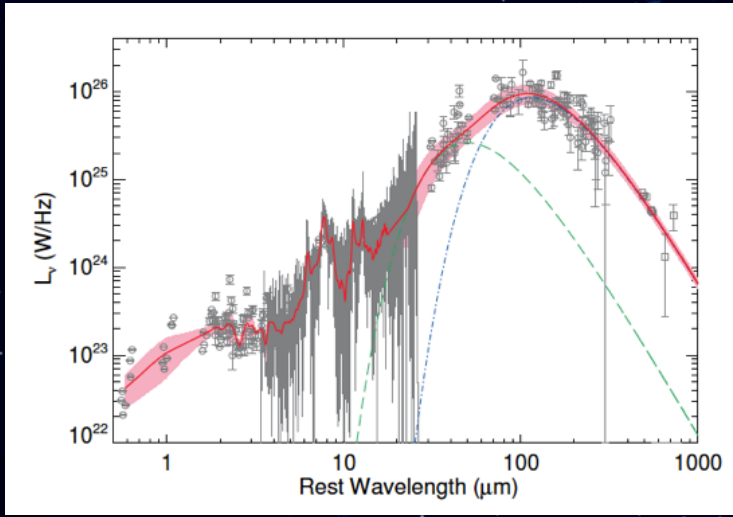


Kirkpatrick et al. (2015)

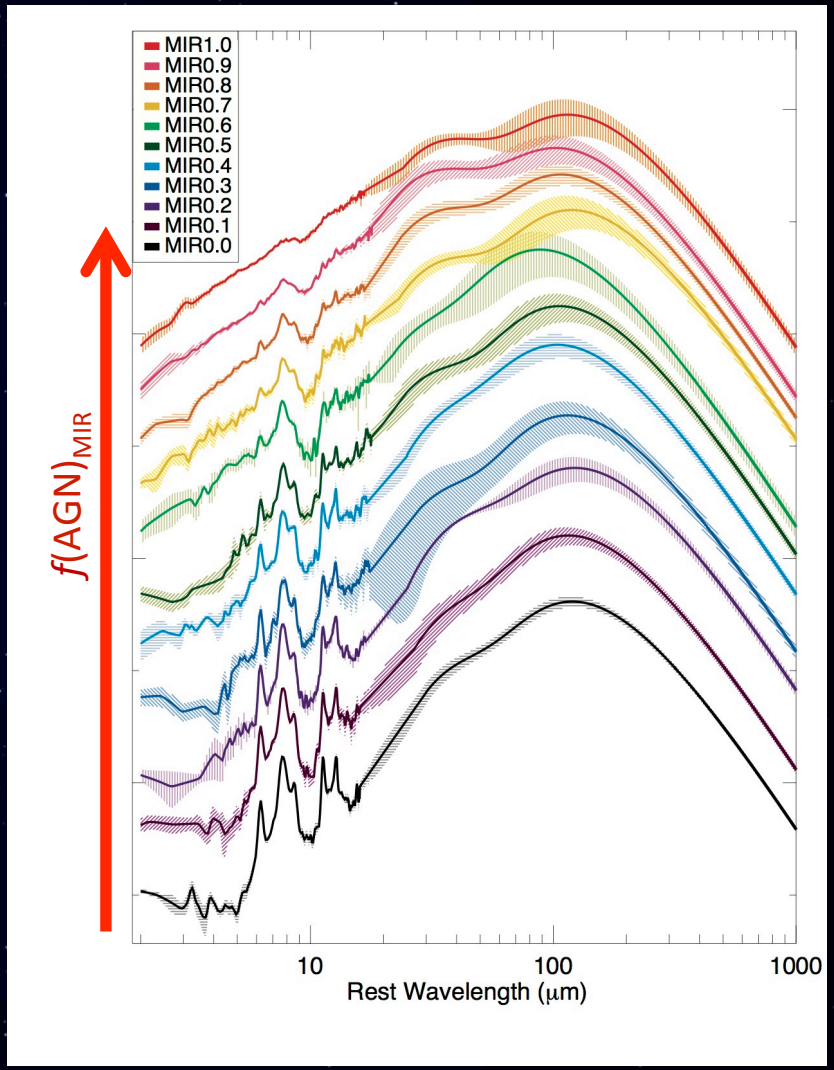
GOAL: Identify Composites without spectroscopy

- 342 24 μm selected sources
  - S_{24} > 0.9 mJy (xFLS)
  - S_{24} > 0.1 mJy (GOODS)
- z = 0.2-4
- $L_{IR} = 10^{11} – 10^{13}$ L_{sun}
- All sources have mid-IR spectroscopy
- Multiwavelength photometry: *Herschel*, *HST*, *Chandra*, submm

Template Libraries

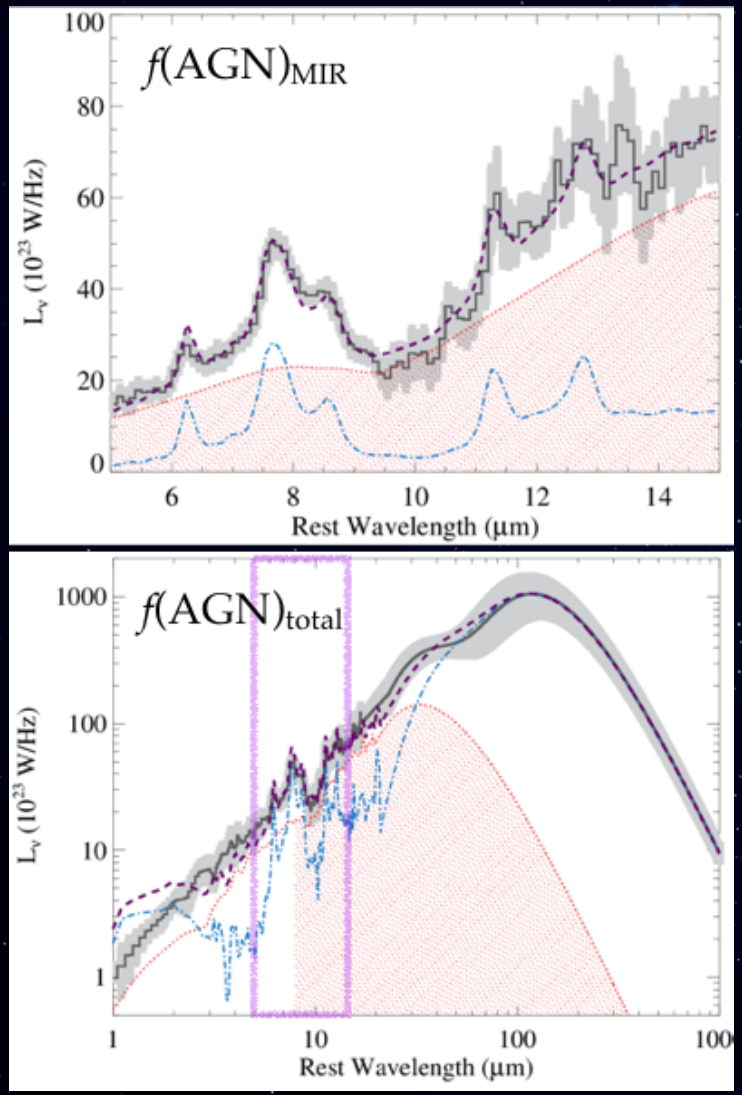


Kirkpatrick et al. (2015)

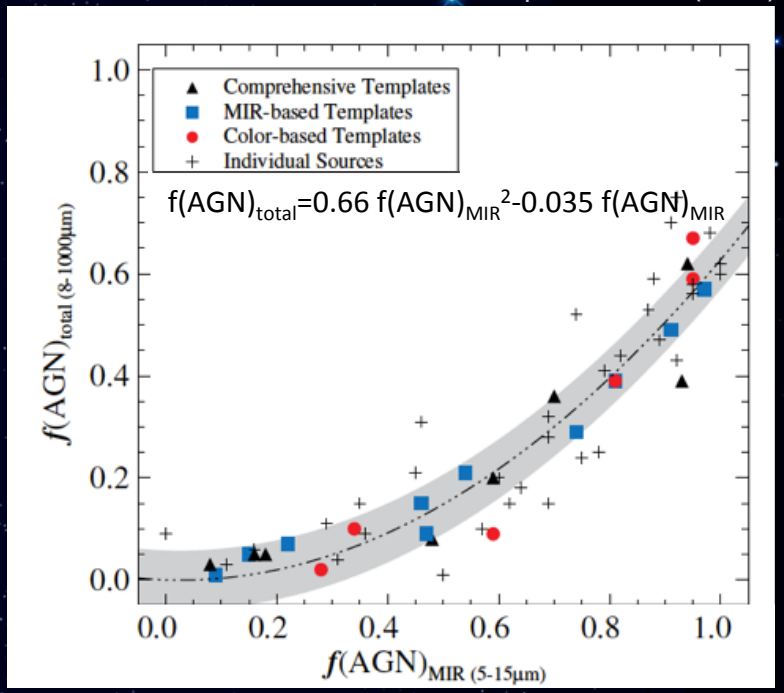


- Publicly available: www.astro.umass.edu/~pope/Kirkpatrick2015
- Group sources by $f(AGN)_{MIR}$, z, L_{IR}
- Normalize by Mid-IR luminosity
- Calculate median L_ν as function of λ
- Correct template is important for L_{IR}

Calculating Total IR AGN Emission

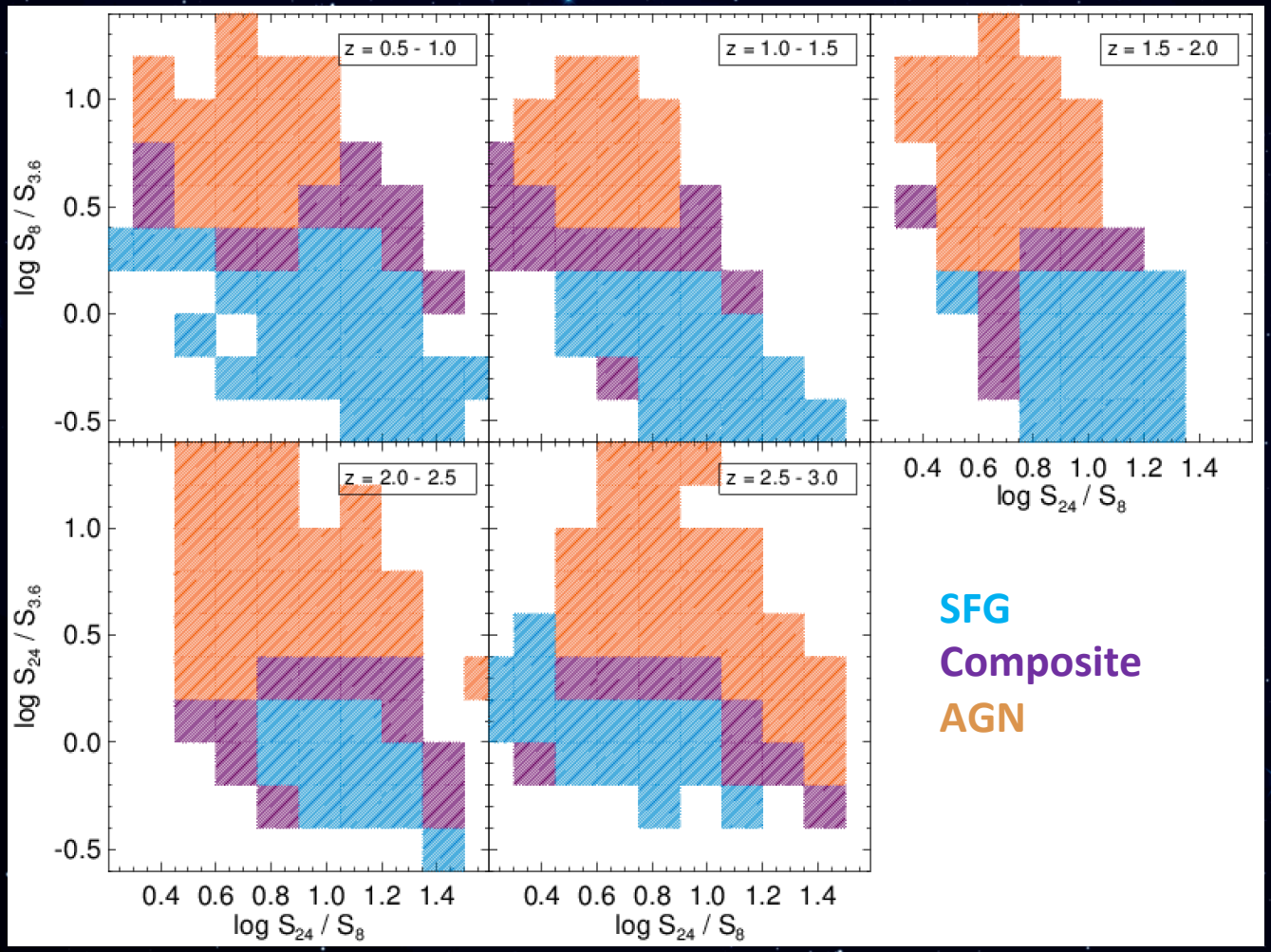


Kirkpatrick et al. (2015)

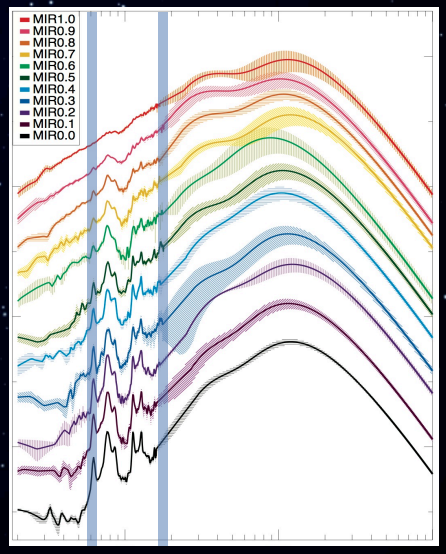


- Need to know how much L_{IR} is due to star formation and AGN
- $f(\mathrm{AGN})_{\mathrm{MIR}}$ is related to $f(\mathrm{AGN})_{\mathrm{total}}$ by quadratic equation
- Useful for calculating L_{IR}(AGN) with MIR spectra

Identification with Colors



- Use template library to simulate sources in different redshift slices
- Composite regions make diagnostic unique
- Redshift evolution is important for accurate classification
- Use color diagnostics to classify CANDELS galaxies

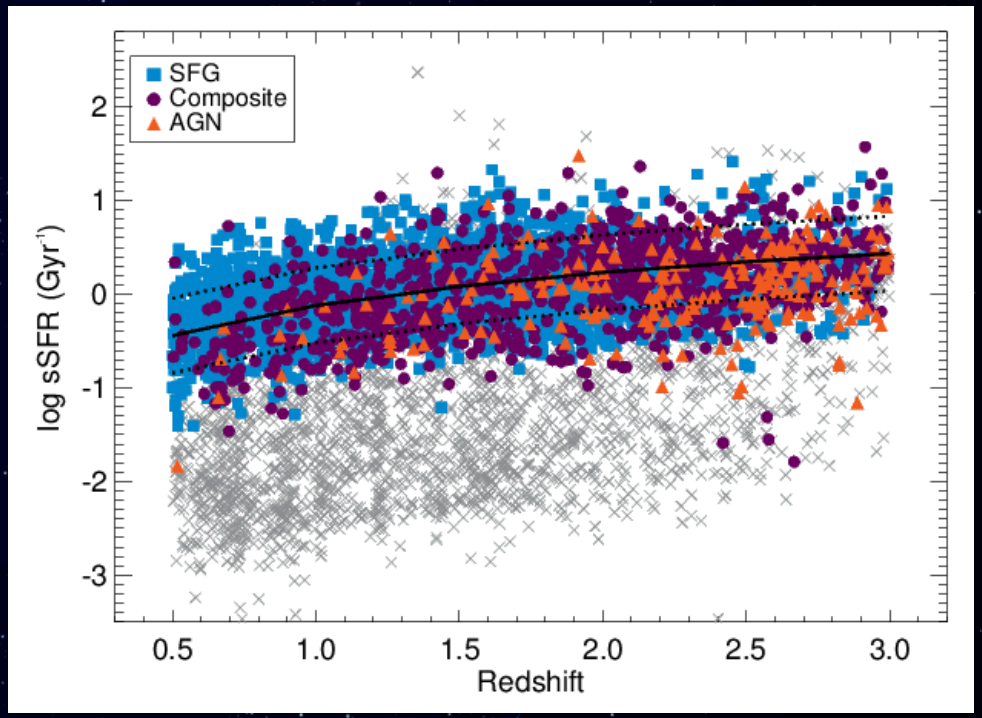


Dusty AGN on the Main Sequence

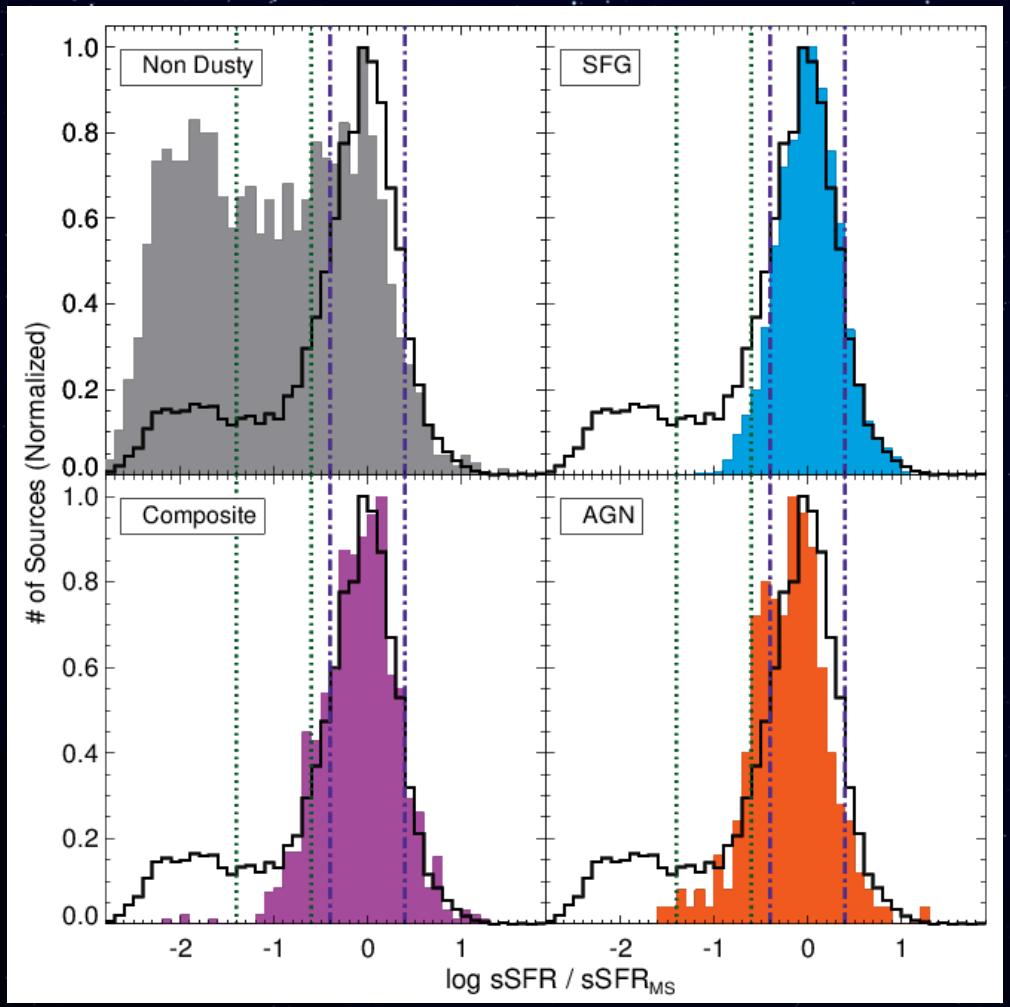
CANDELS Sample:

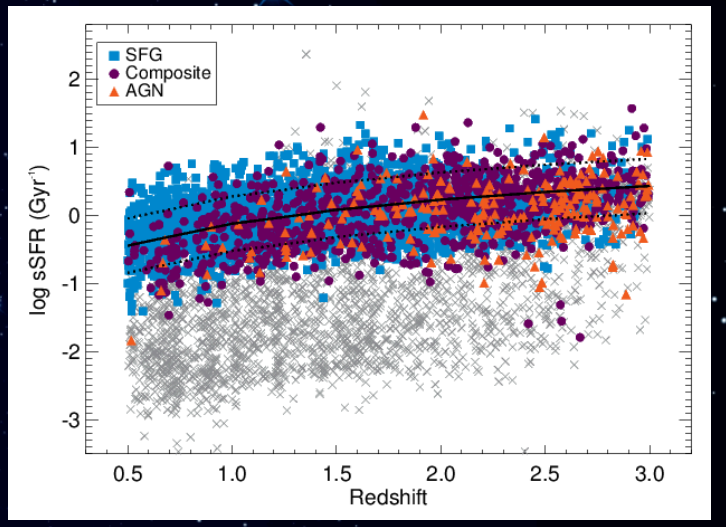
- $M_* > 10^{10}\ M_{sun}$
- $z = 0.5\text{-}3.0$
- $S_{24} > 70\ \mu m$

- Classify galaxies as SFG, Composite, AGN, and Non-dusty
- SFR calculated from IR or UV
- Dusty galaxies lie on the main sequence



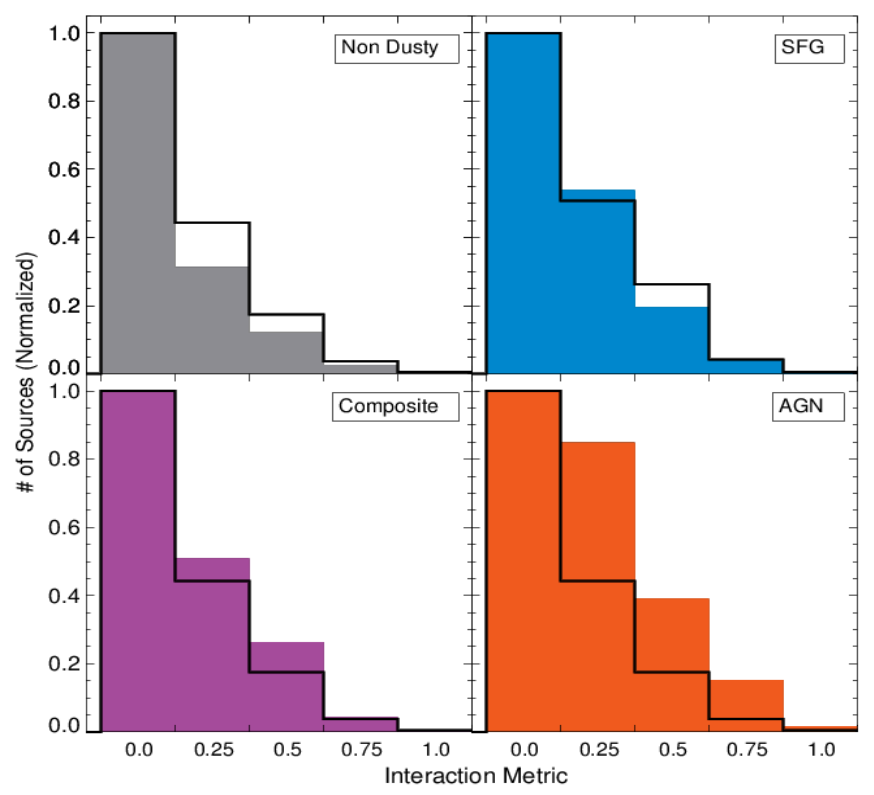
Distance from the Main Sequence



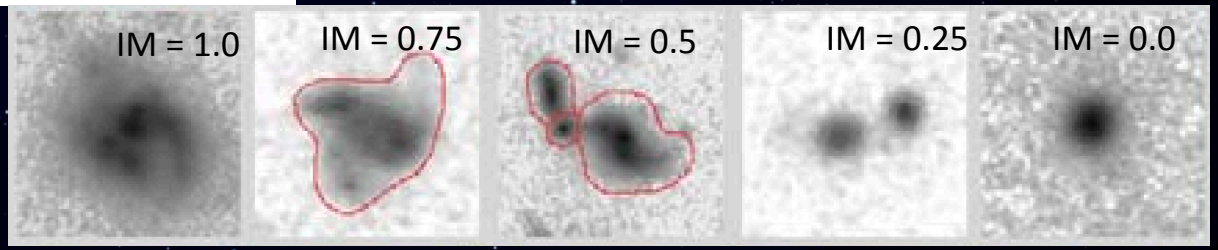


- Most quiescent and transition galaxies are not dusty
- Distance from the main sequence increases for composites and AGN
- Growth of AGN could be linked with quenching

Mergers and AGN

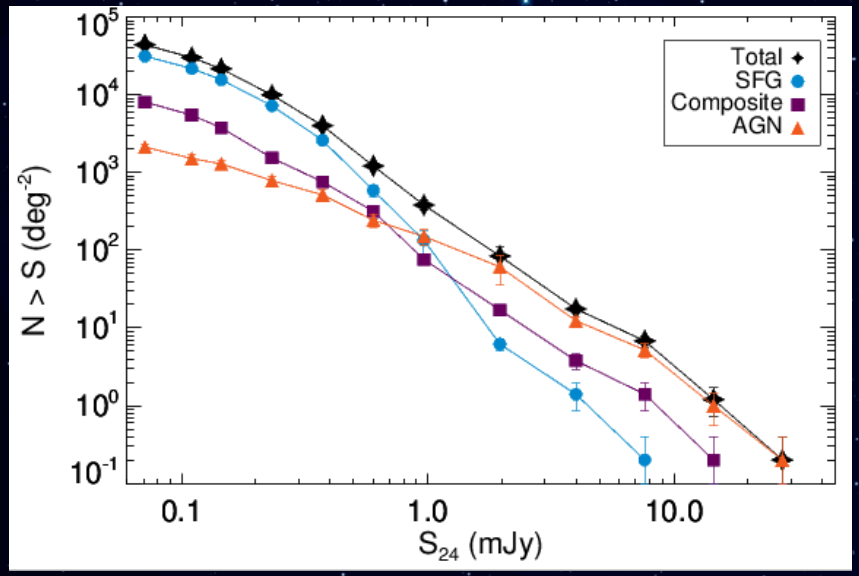


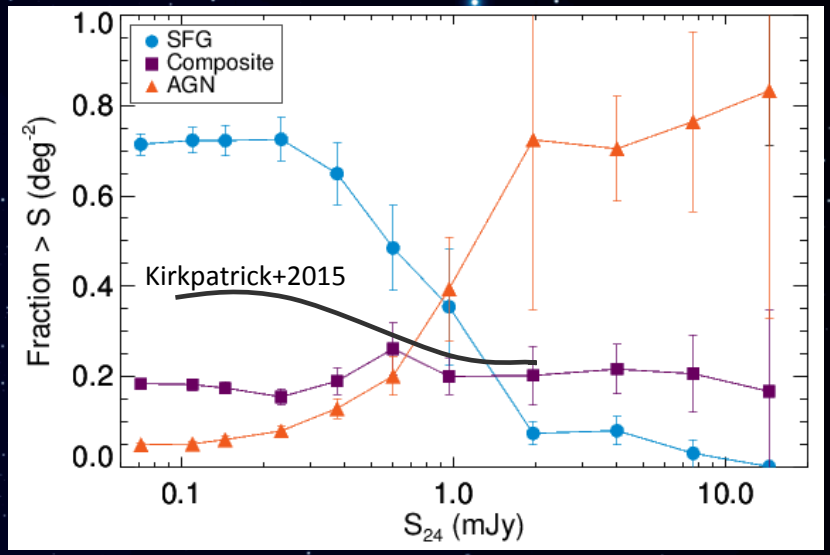
- Visually classify sources based on HST H-band images
- Interaction Metric combines individual classification and correlates with merger sequence
- Increase in merger stage corresponds with growth of an AGN



Kartaltepe et al. (2015)

Number Counts and JWST



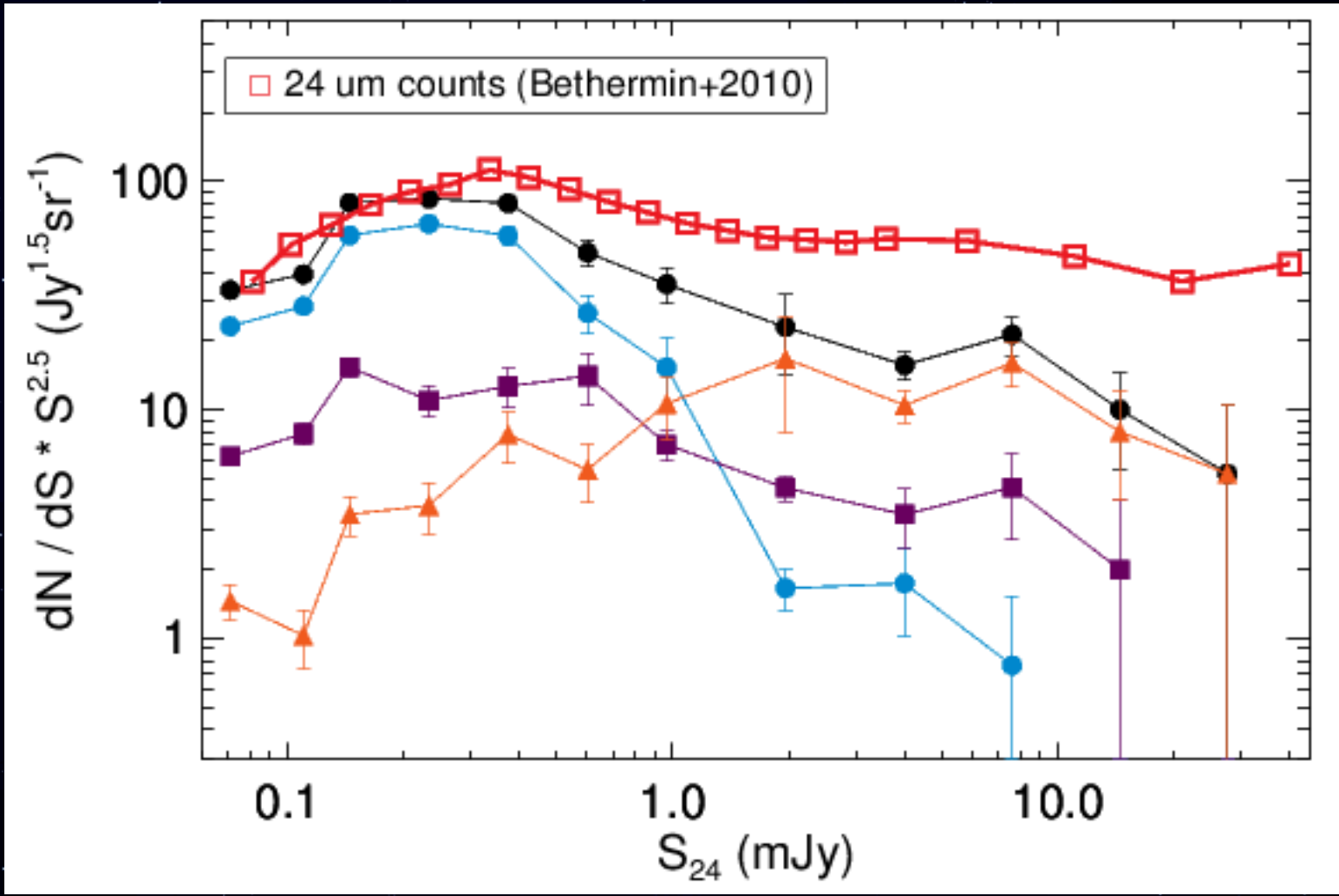


- For number counts, combine CANDELS (0.24 deg^2) with xFLS (5.0 deg^2)
- Classify xFLS sources using S_{24}/S_8, $S_8/S_{3.6}$
- At S_{24} >1.0 mJy, AGN and composites dominate

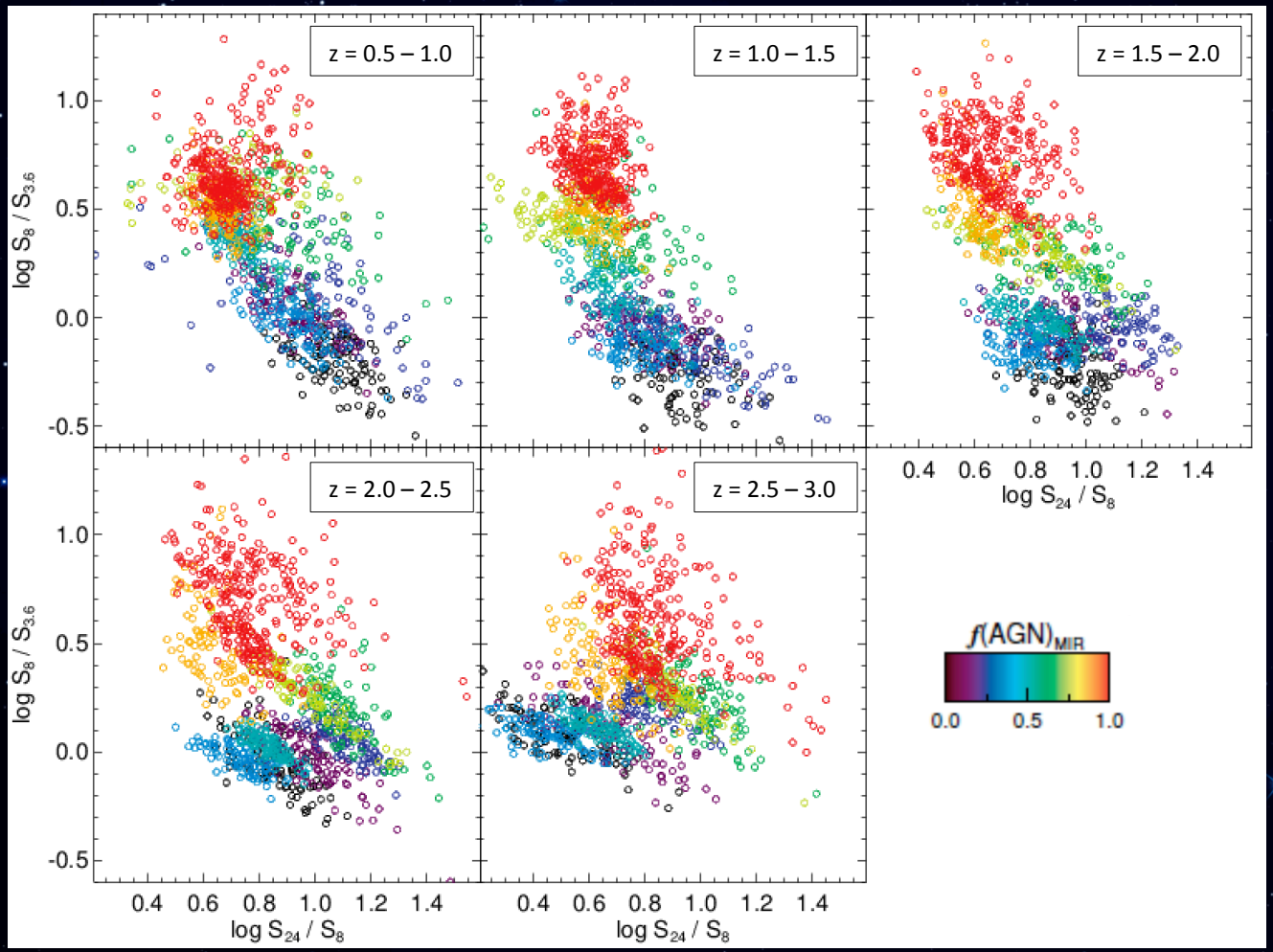
- Fraction of sources in a given population
- Solid line is # of composites based on spectroscopic sample (Kirkpatrick+2015)
- Spectroscopy is more sensitive—MIRI samples will improve our numbers of composites

Summary

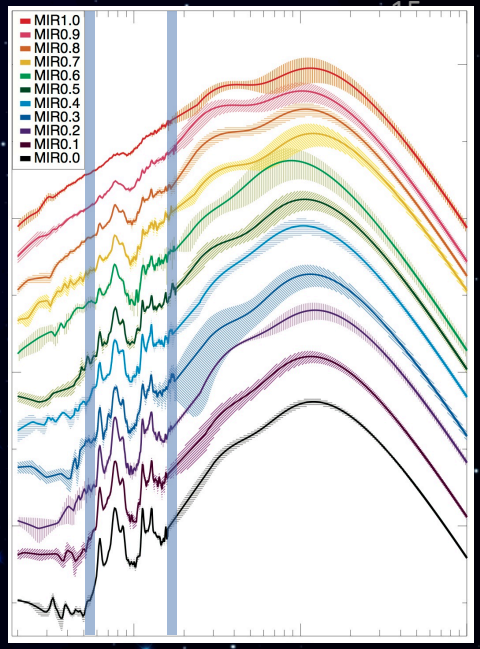
- Quantify AGN emission by decomposing mid-IR spectra to calculate $f(\mathrm{AGN})_{\mathrm{MIR}}$
- Create publicly available empirical IR SEDs (2-1000 μm)
- $f(\mathrm{AGN})_{\mathrm{MIR}}$ relates to $f(\mathrm{AGN})_{\mathrm{total}}$, which is the contribution of AGN heating to L_{IR}
- Use template library to create redshift dependent IR diagnostic to quantify $f(\mathrm{AGN})_{\mathrm{MIR}}$ in large samples
- After correcting SFR for AGN contribution, AGN on average lie below the main sequence, compared with SFGs and composites
- Composites will comprise at least 20% of JWST samples


24 um counts (Bethermin+2010)
dN / dS * S^2.5 (Jy^1.5sr^-1)
100
10
1
0.1
1.0
10.0
S24 (mJy)

Identification with Colors



- Identify SFGs, Composites, AGN using just photometry
- Use template library to simulate sources in different redshift slices



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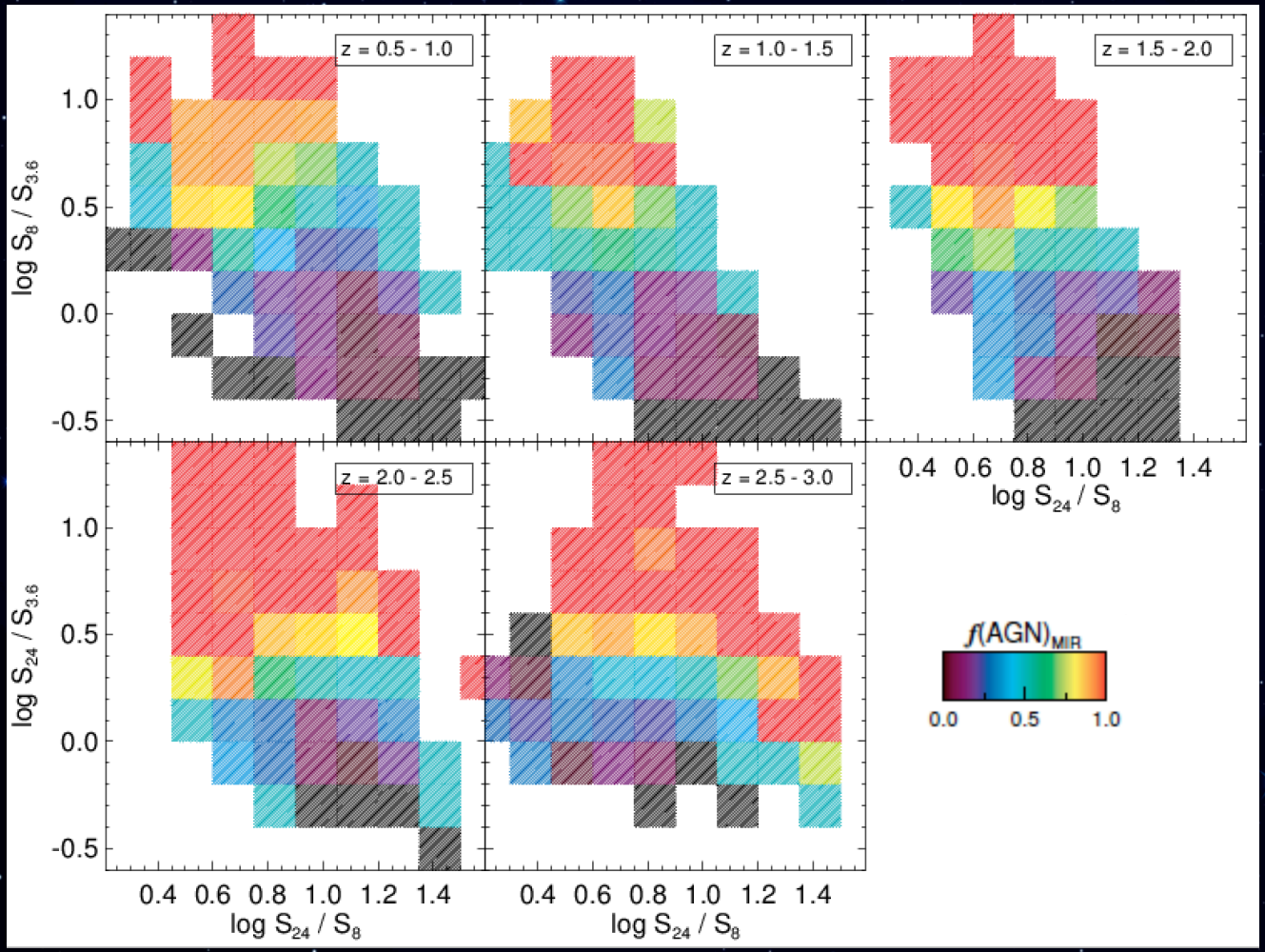

- Calculate average $f(\mathrm{AGN})_{\mathrm{MIR}}$ in different regions
- Assess reliability by comparing with other color diagnostics
- Scatter: $\sigma_{\mathrm{AGN}} = 0.32$

SFG: 0.0-0.32

Comp: 0.32-0.64

AGN: 0.64-1.0