

# Mid-IR Bright, High-z Objects ----- From Spitzer to WISE

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# Outline

- What we learnt about bright 24 $\mu$ m galaxies (>1mJy) from Spitzer + Herschel
- Initial results on the WISE ULIRGs at  $z \sim 2$
- What does it all mean? -- modeling

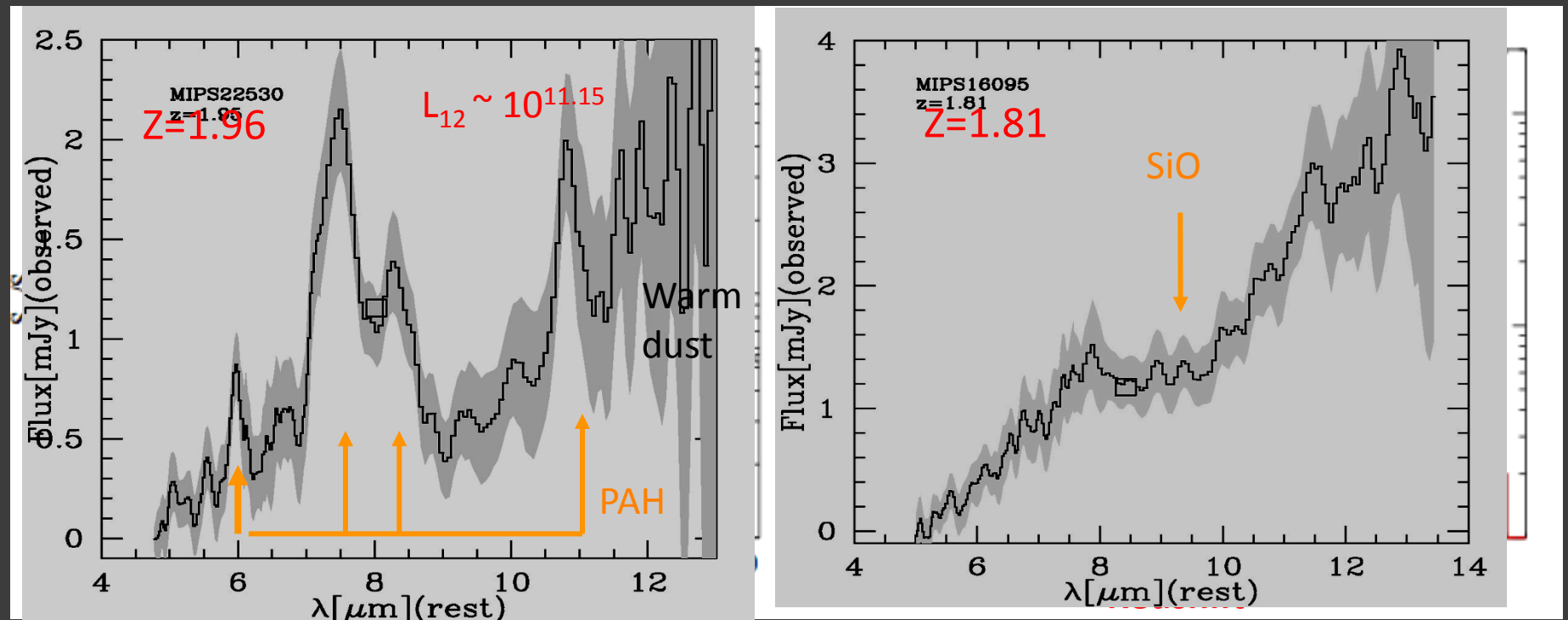
# Energetic Nature of Bright 24 $\mu$ m ( $>1\text{mJy}$ ), high- $z$ galaxies?

- (I) Mid-IR spectral diagnostics
- (II) Far-IR SED classification

Sample: A 24 $\mu$ m sample (191 obj.) with S(24)  
>1mJy & R>20 (combined from several programs)

Data: Complete Spitzer spectra,  $z: 0.3 - 2.8$ ,  $L(\text{IR}) \sim 10^{11-13}$ .

→ 64% are AGN based on mid-IR Spectra ( $\text{EW}_{7.7\text{PAH}} < 0.9\mu\text{m}$ )



Yan et al. 2005, 2007, ApJ, Sajina et al. 2008, 2009, Sajina, Yan et al. 2011, ApJ, submitted; Also see Melbourn talk yesterday

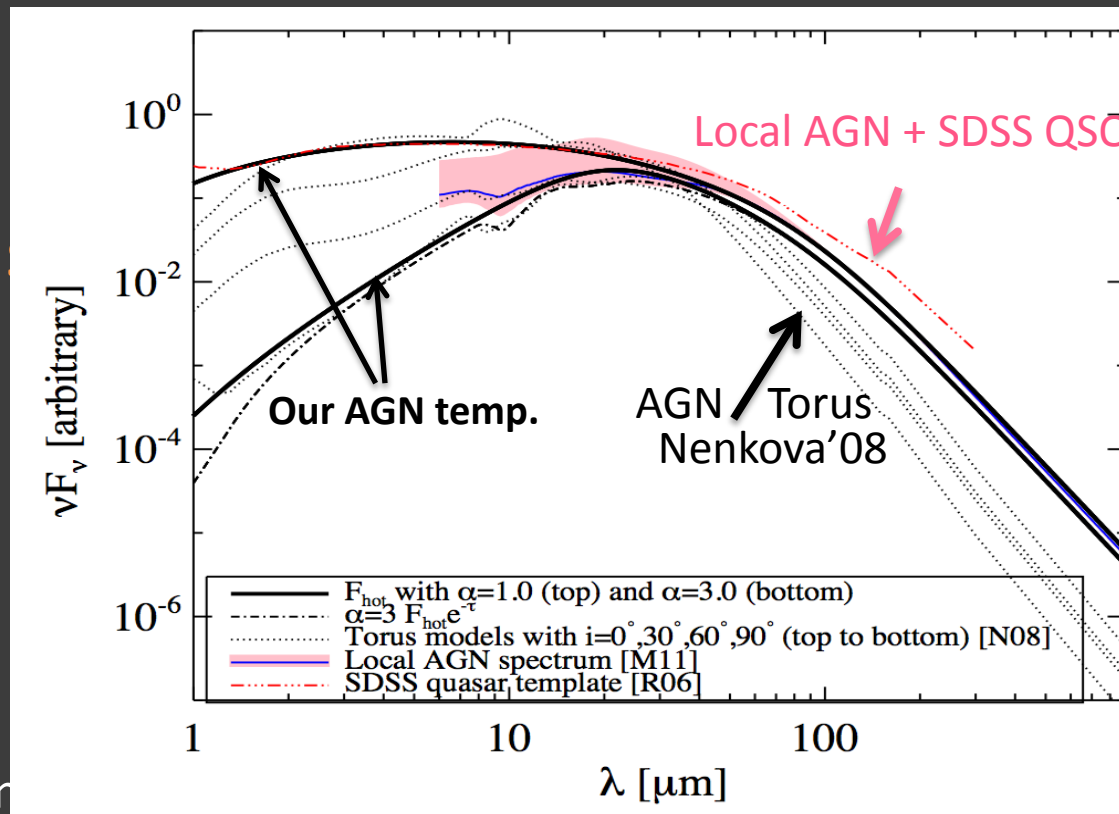
# Is a mid-IR classified AGN truly powered by AGN at L(IR)?

## 2). AGN/SB diagnostics --- Far-IR SED

**Data:** Spitzer spectra + Herschel far-IR (191 obj)

**Method:** Total IR SED =  $c_1 * SB \text{ SED} + c_2 * AGN \text{ SED}$

Class



$L(\text{IR})/L(\text{ir}) < 50\%$

We than

base dataset.

# Results: mid-IR spectral classification under-estimate star formation contribution to L(IR)

50%

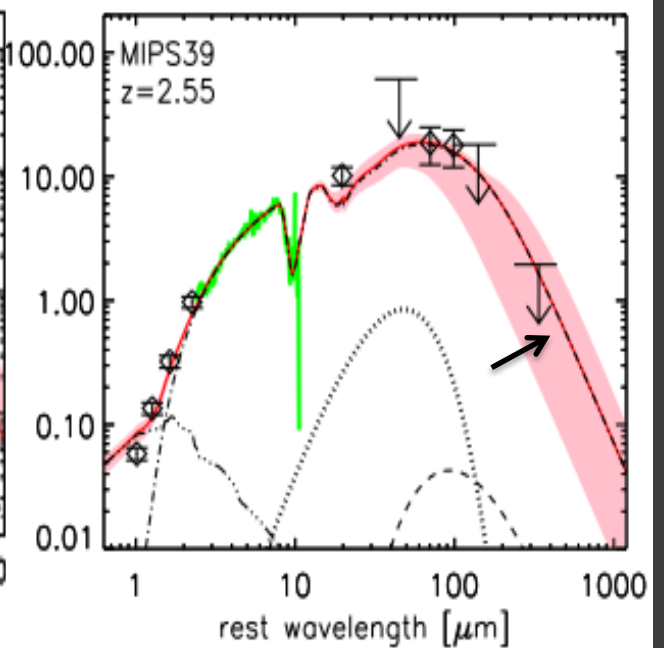
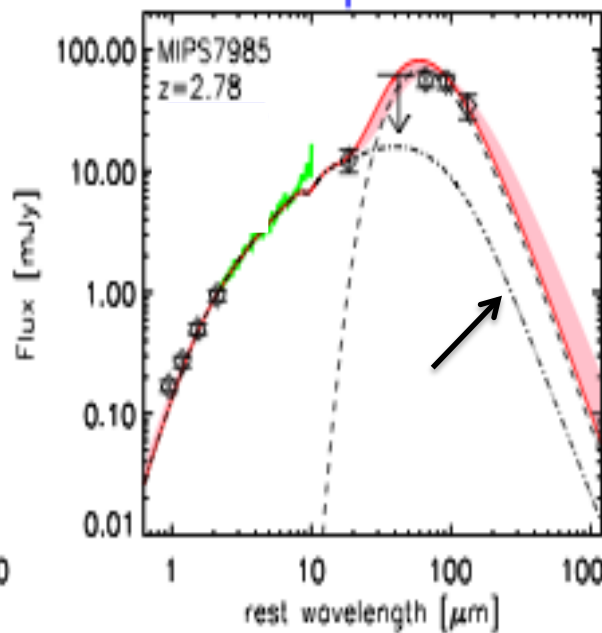
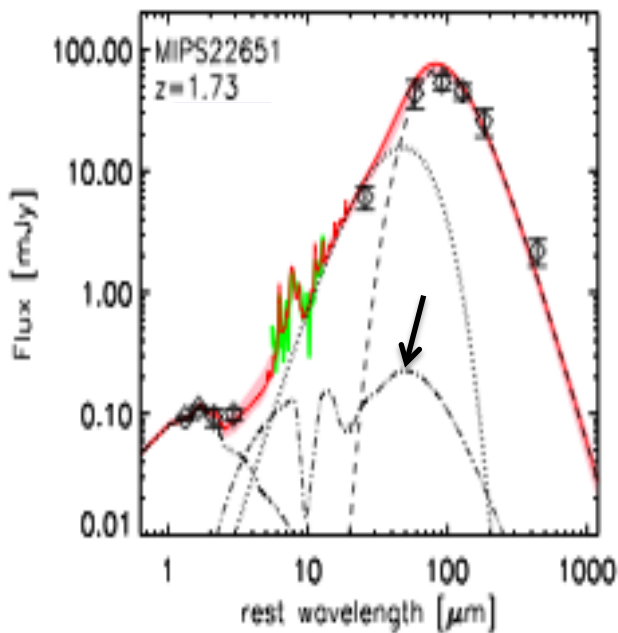
25%

25%

Starburst

Composite

AGN

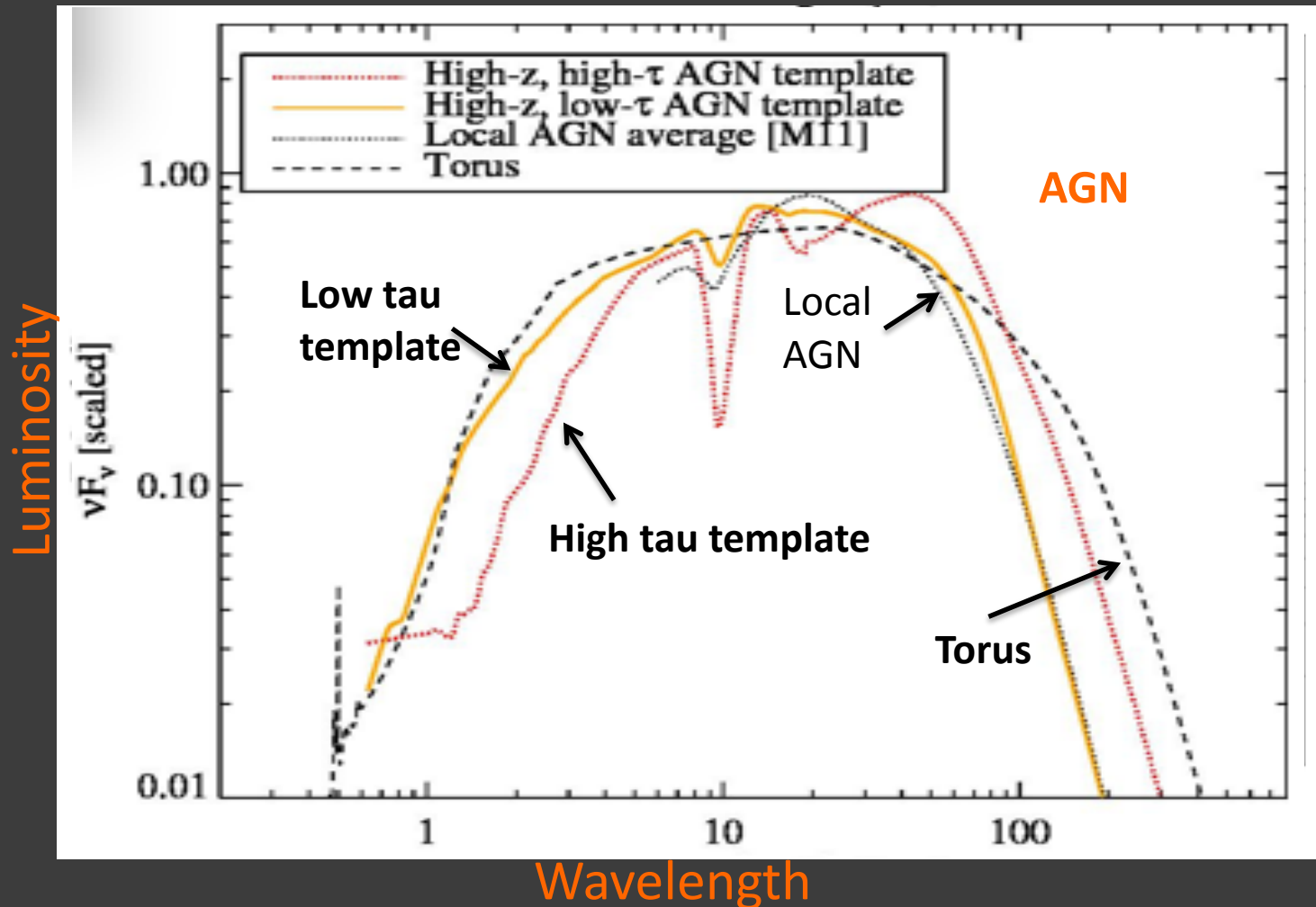


→ AGN component

# IR SED templates:

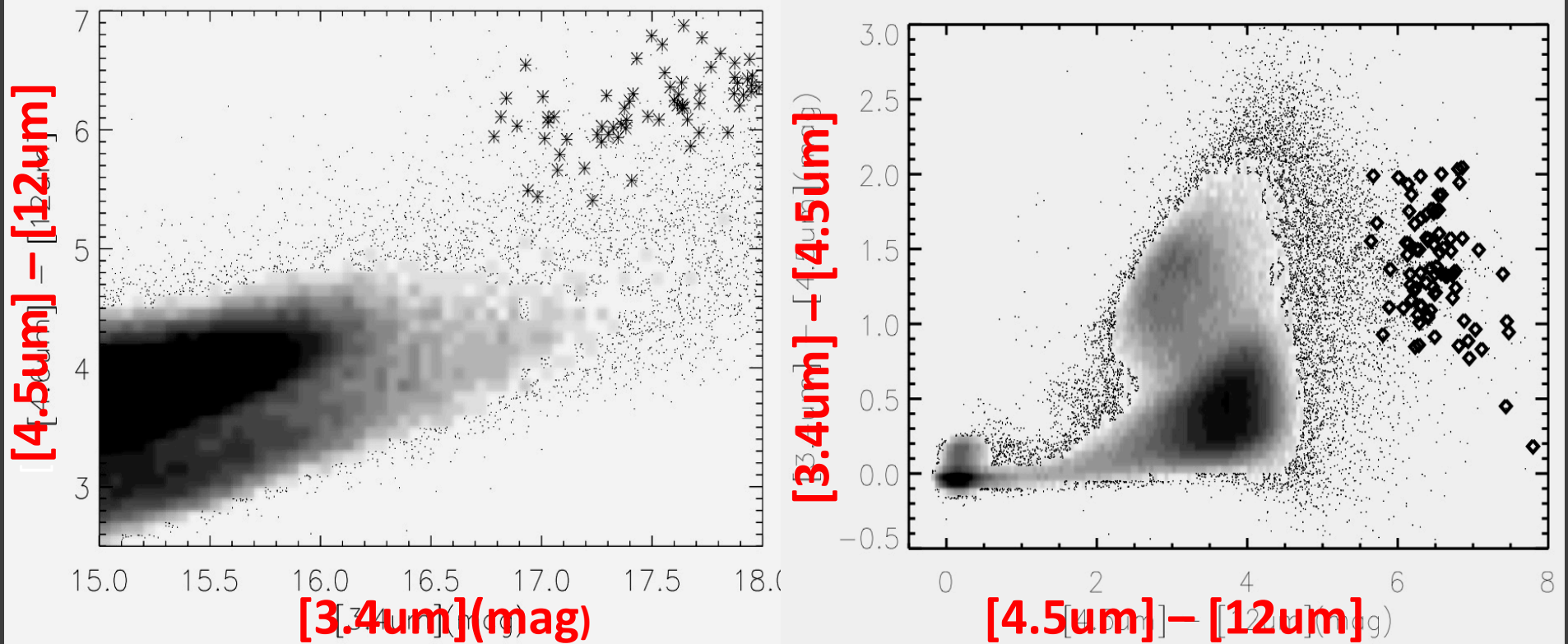
- Release to the public:

<http://cosmos2.phy.tufts.edu/~asajina/IRSsupersample.htm>



# WISE discovered bright ULIRGs @ $z \sim 2$

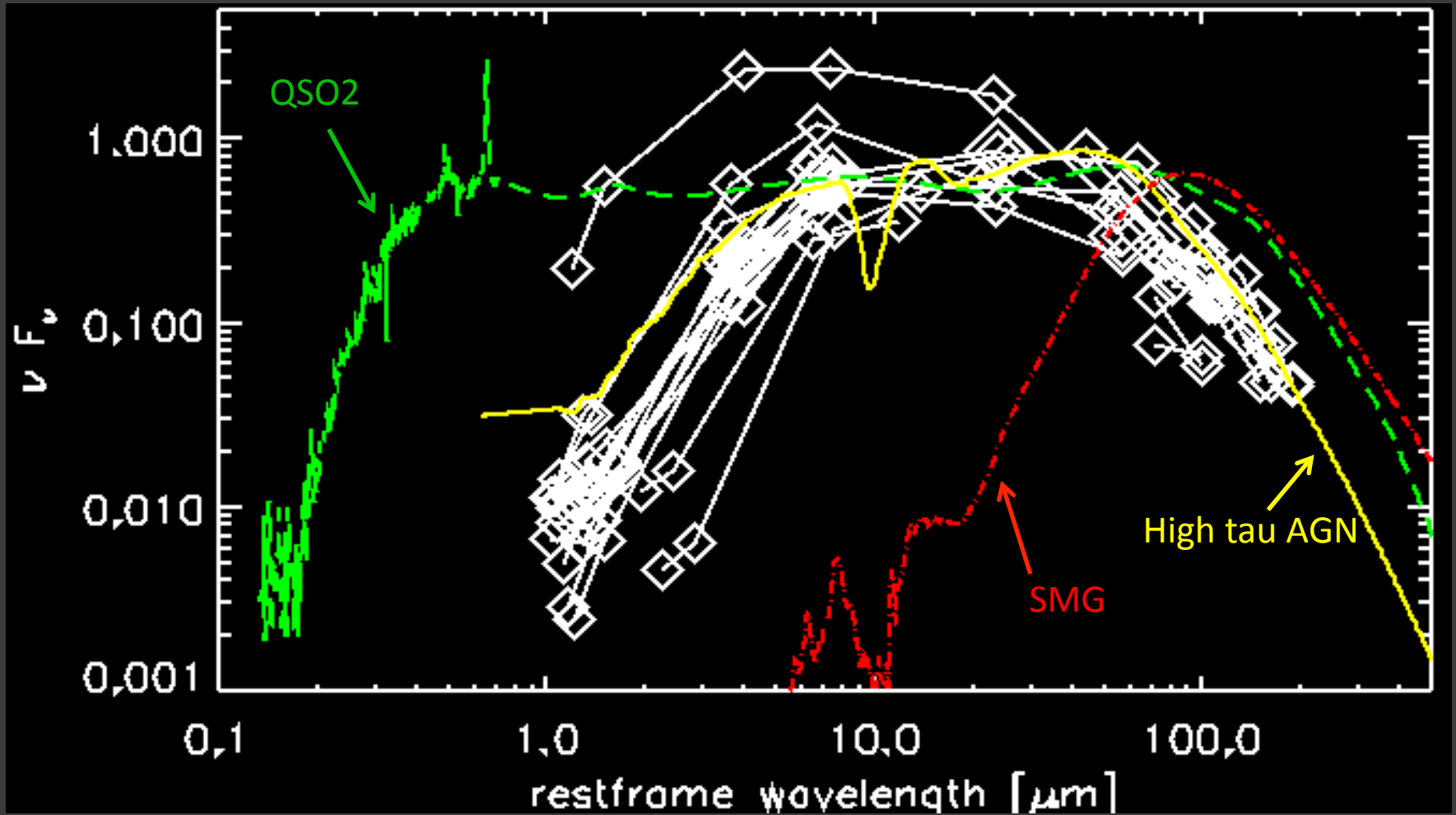
- **Very Red @3 – 22 $\mu$ m**: detected at 12/22 $\mu$ m & **not** at 3.4 & 4.5 $\mu$ m (w1w2 dropout, see Eisenhardt's talk). 5sigma limits (12 & 22 $\mu$ m) = 1, 6 mJy





# WISE $z \sim 2$ ULIRGs: Herschel far-IR data

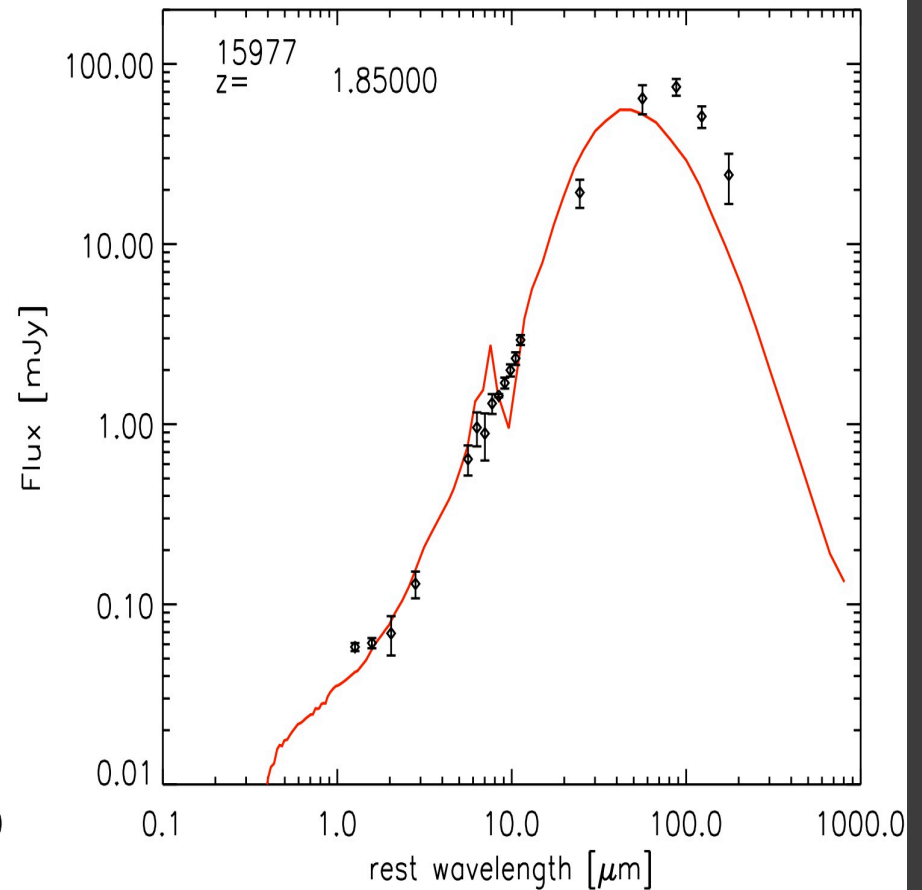
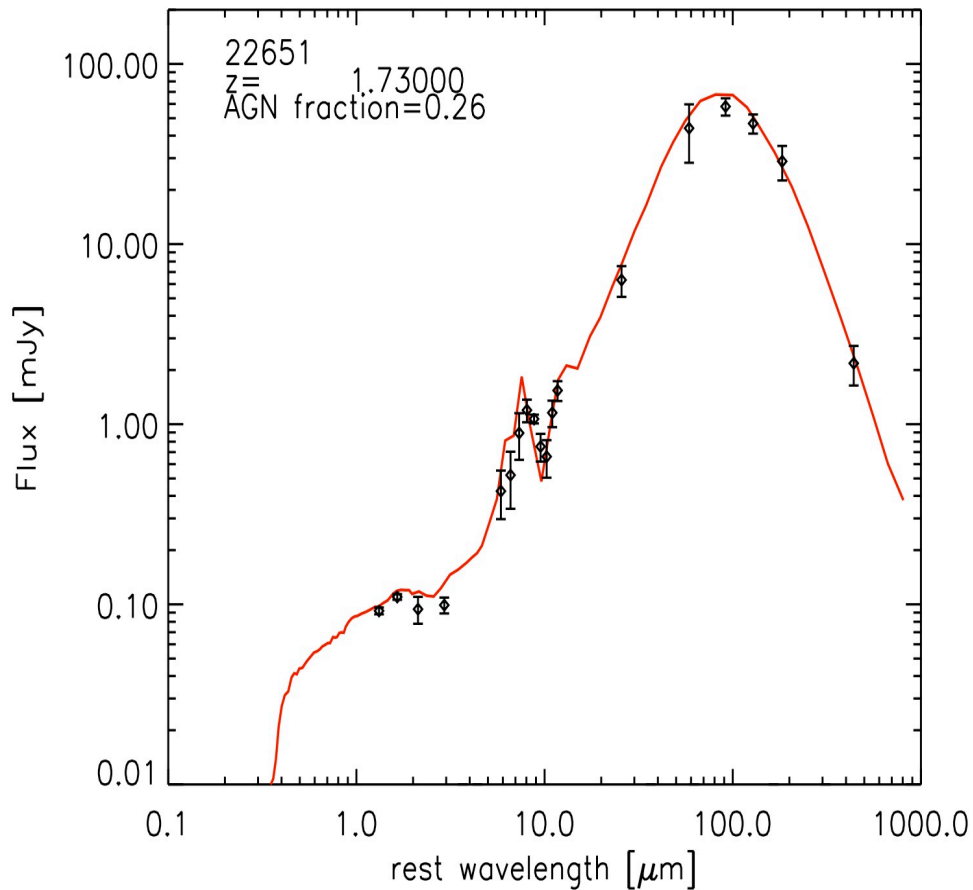
- PACS and SPIRE photometry --- initial look



## Question:

- For mid-IR AGN:  $L(\text{IR}) \sim L(\text{AGN}) \sim 10^{13}$  , does it probe bolometric AGN luminosity? What does it say about BH masses? ( $3 \cdot 10^8 M_{\text{sun}}$ )

# Modeling: Gadget + Sunrise (with Gadget input, full radiative transfer calculation)



In collaboration with C. Hayward, P. Jonsson, G. Snyder (cfa); Jonsson et al. 2008, MNRAS; SUNRISE website

# Summary

- 60-70% of 24 $\mu$ m mJy or brighter sources are strong mid-IR AGNs
- mid-IR spectra under-estimates the star formation contribution to L(IR)
- A significant fraction (50%) of AGN have moderate to strong far-IR excess  $\rightarrow$  co-existence of SF & BH
- WISE sources seem to have IR SED consistent with AGNs at  $z \sim 2$
- What does L(AGN) mean? --- modeling needed