SED modeling of galaxies in simulations

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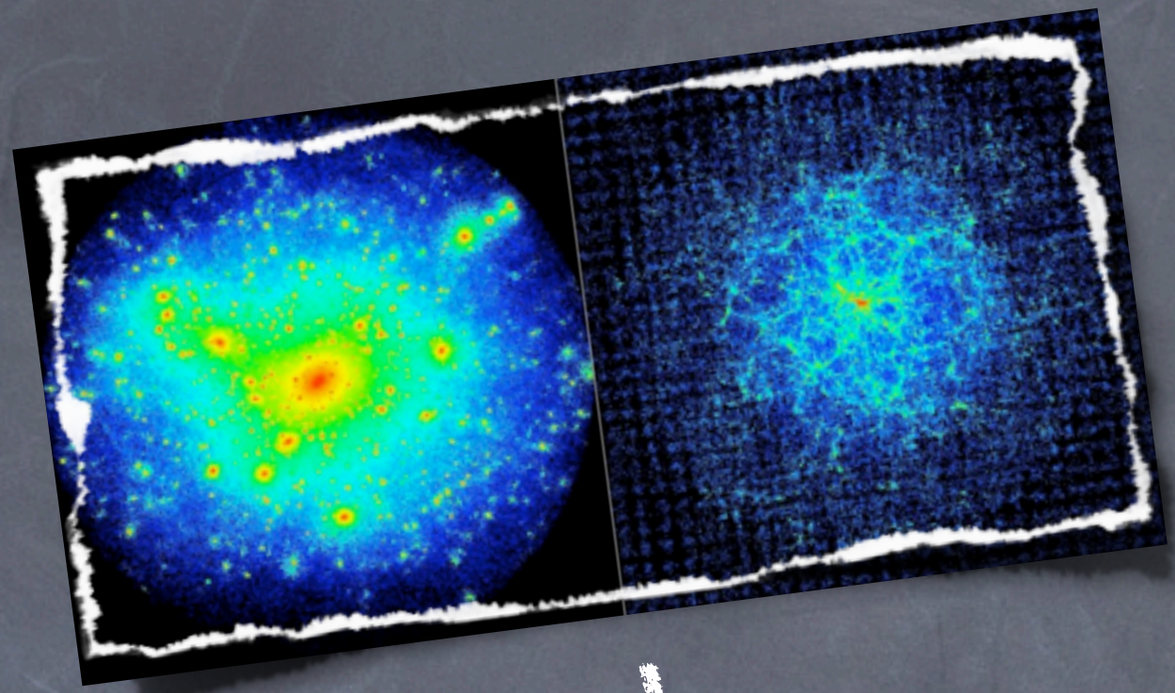
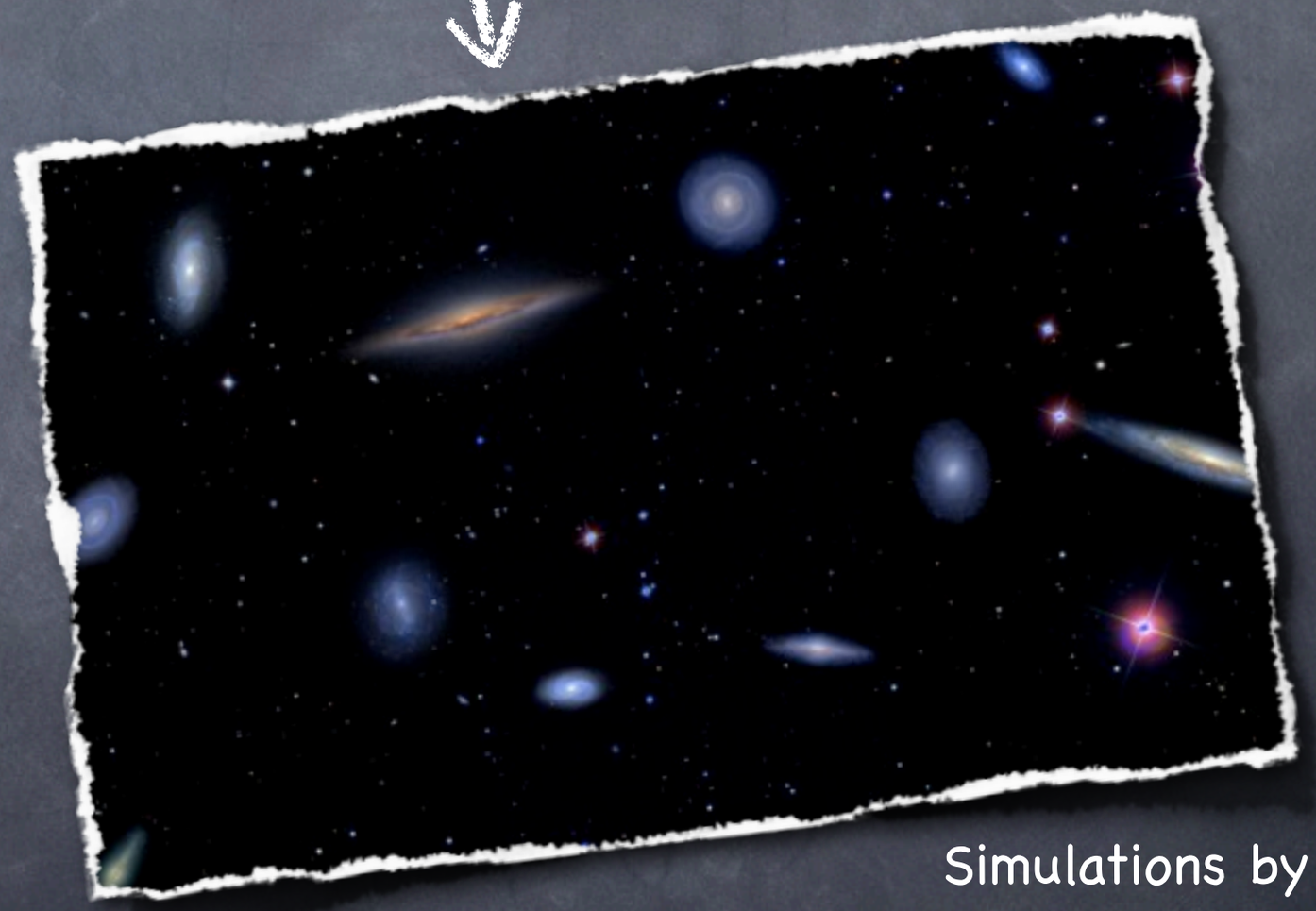
+Chris Hayward, Brent Groves, TJ Cox, Greg Snyder, Lars Hernquist

What controls the SEDs of galaxies?



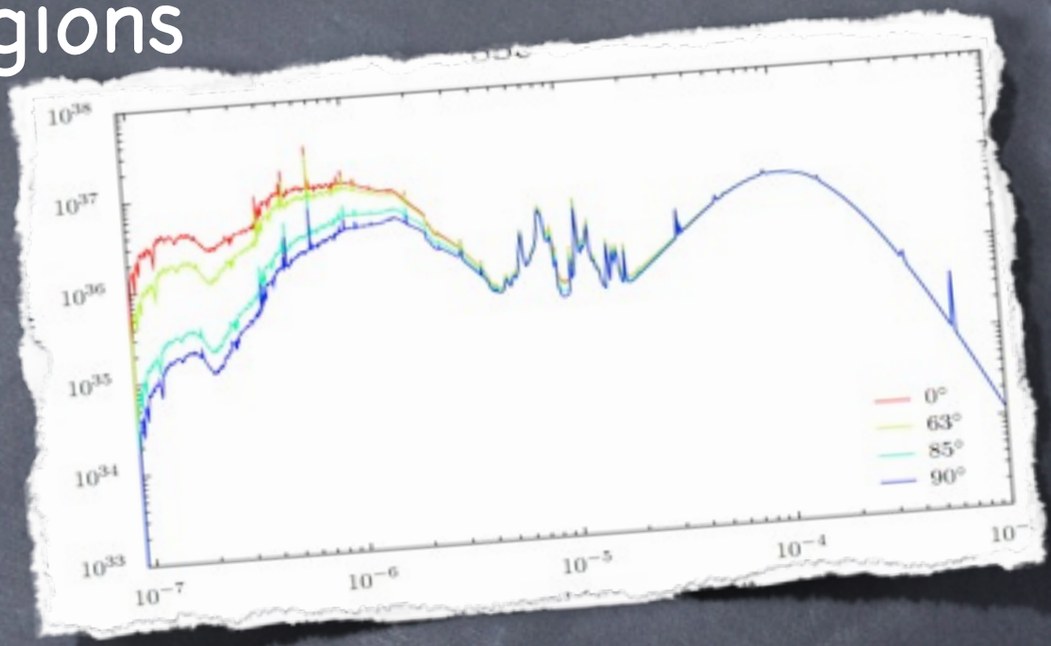


Use hydrodynamic simulations and radiation transfer to investigate

Simulations by the N-body Shop (U. Washington)

What goes into a galaxy spectrum?

- Stellar (continuum) emission
- Emission lines from HII regions
- Dust & PAH emission
- AGN emission

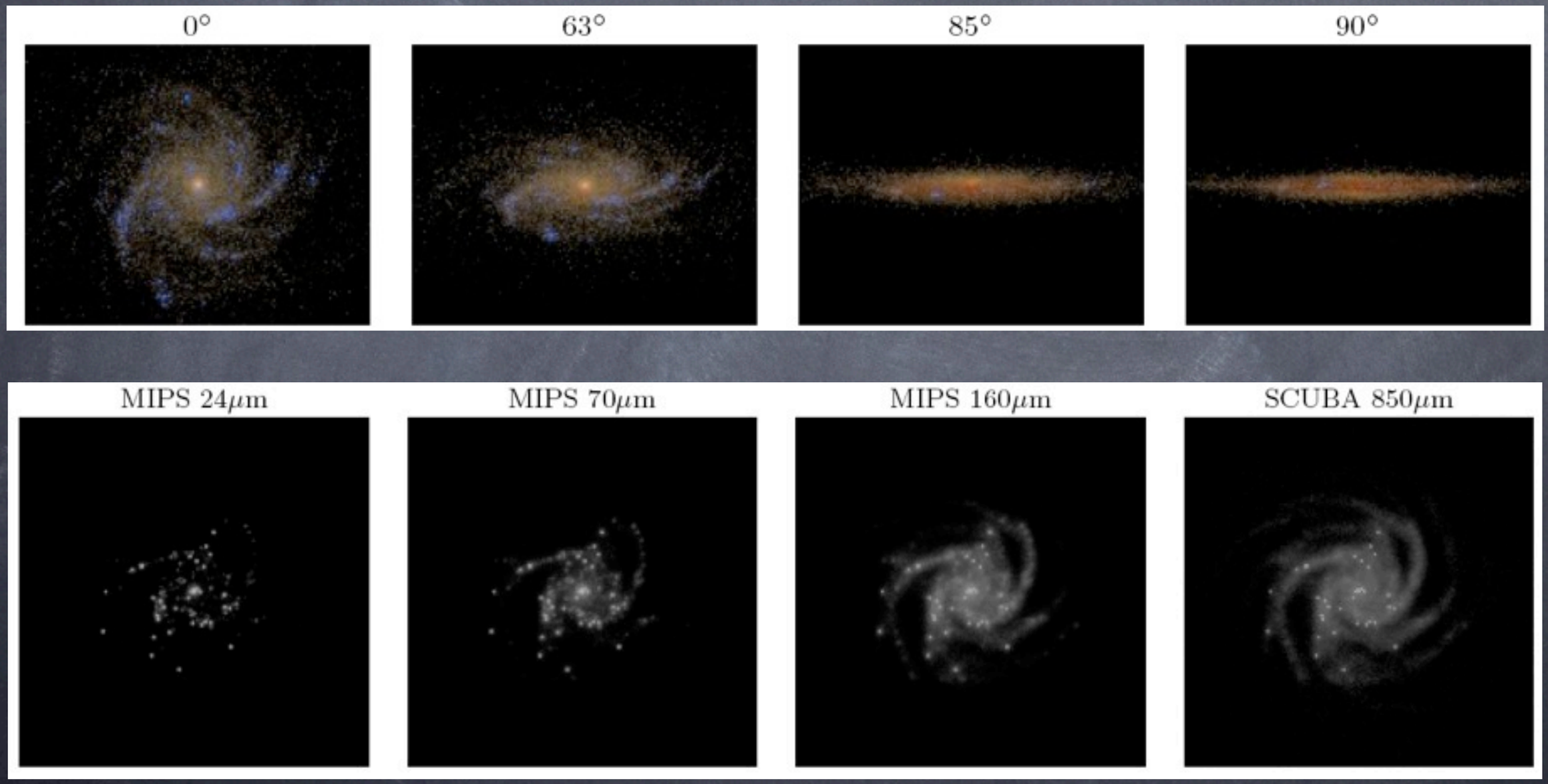


- Use radiation-transfer code **Sunrise** (PJ 06)

  Far-infrared emission is an interplay between dust emission and self-absorption, plus IR emission from AGN and SF regions

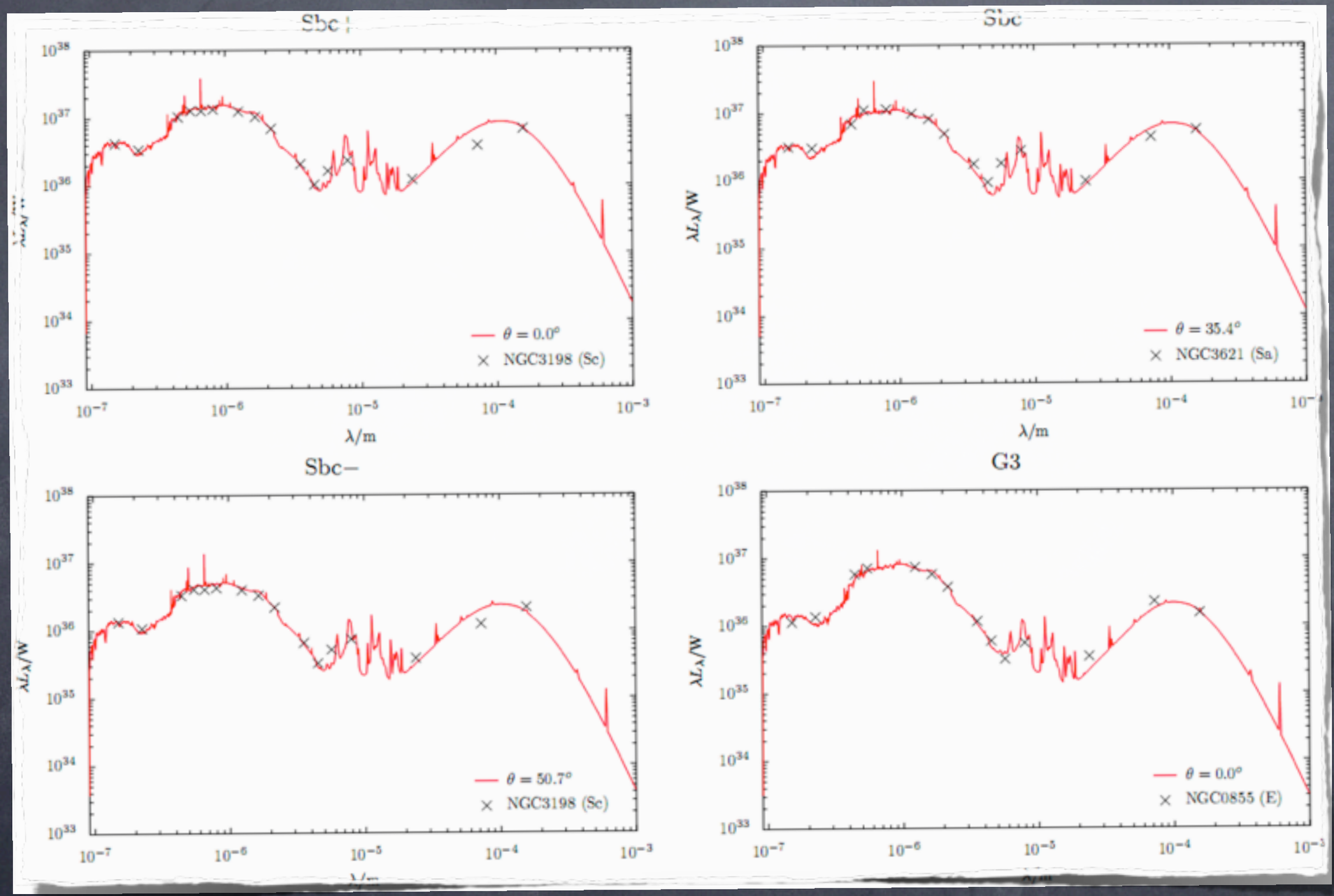
Sunrise outputs

Broadband photometry & images



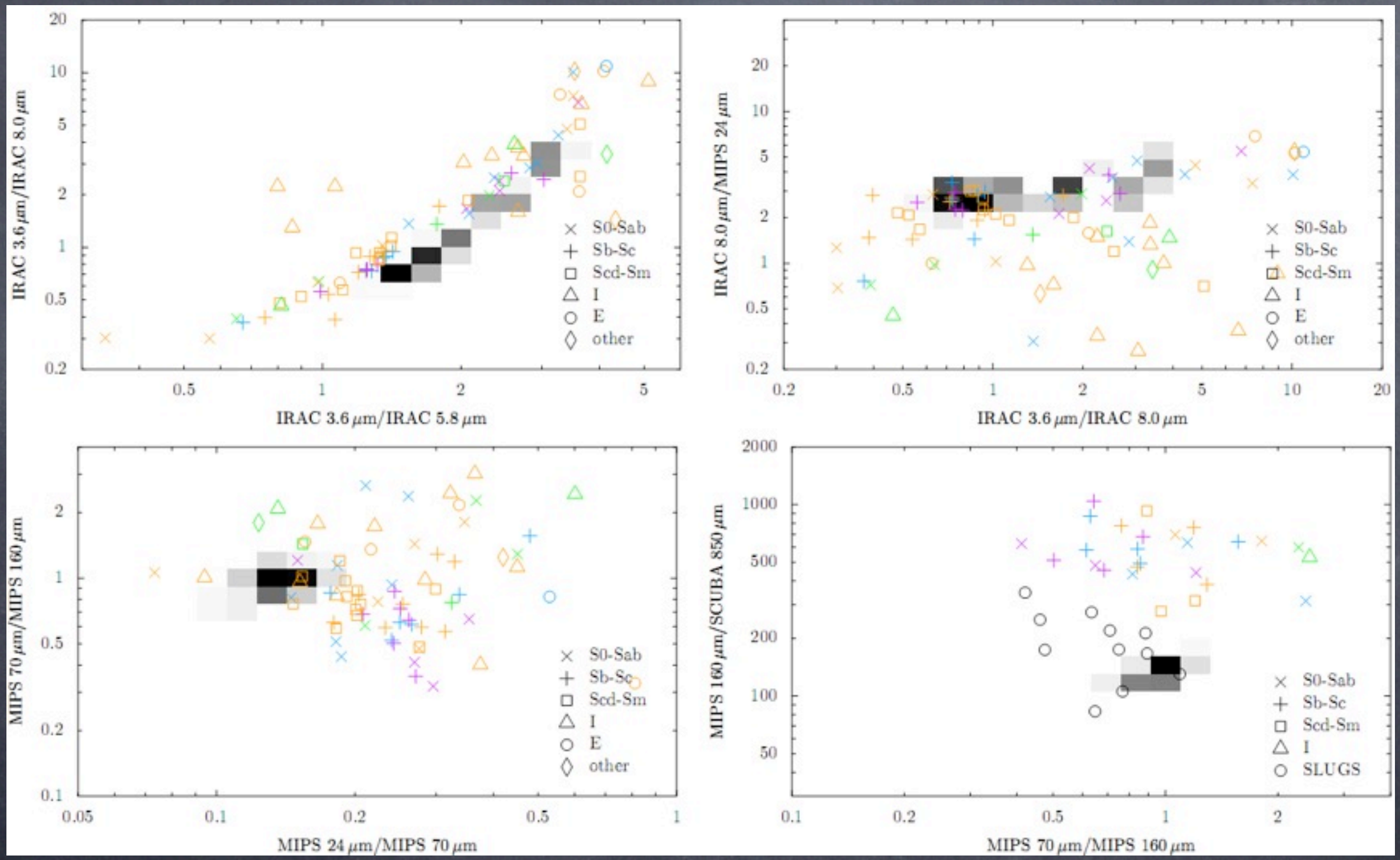
Jonsson, Groves, & Cox 10

Comparing local disk sims to SINGS



See PJ, Groves & Cox 10. Samples: SINGS (Dale et al. 07)

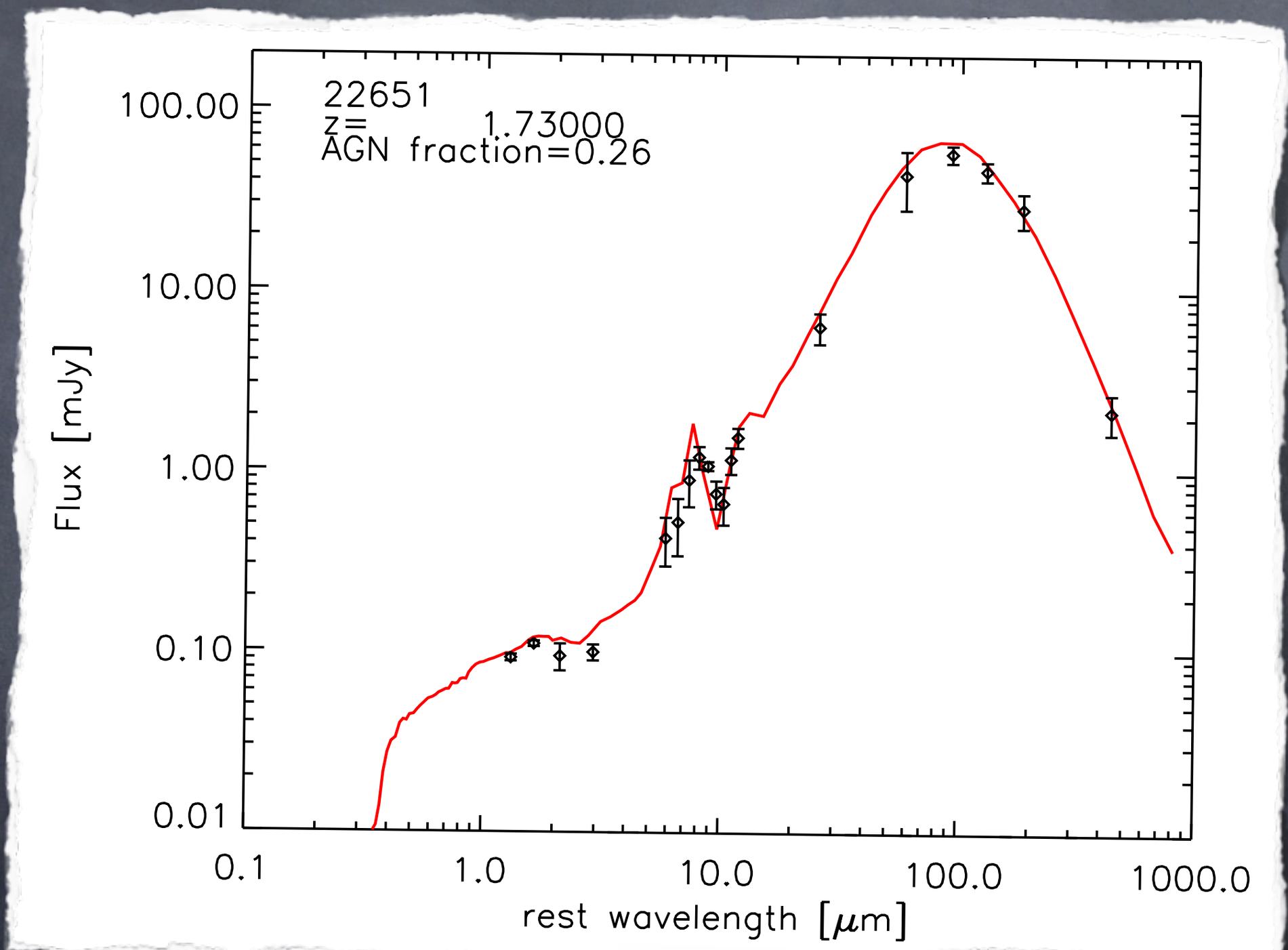
Comparing local disk sims to SINGS



See PJ, Groves & Cox 10. Samples: SINGS (Dale et al. 07), SLUGS (Willmer et al. 09)

In progress: Testing hi-z models against observations

(+ testing AGN indicators)



w/Anna Sajina, Lin Yan (Spitzer FLS sample)

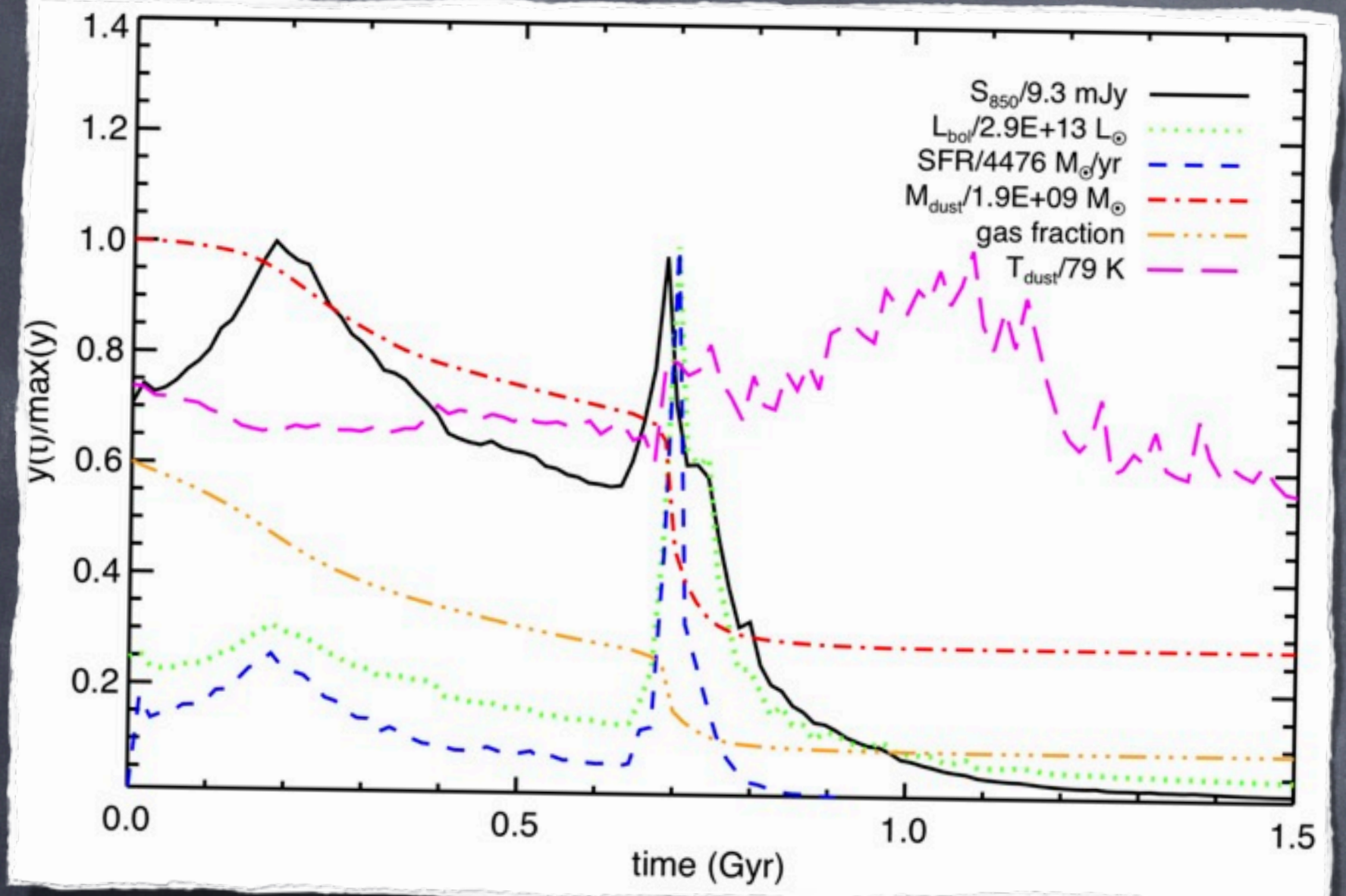
Sub-millimeter galaxies (SMGs)

Chris Hayward et al. (11)

- Population of optically faint sources detected in sub-mm (fiducial cut S_{850} > ~5 mJy)
- 99% of L is emitted in IR
- Powered by SF rather than AGN
- L_{IR} ~ 10^{12} - few x 10^{13} L_{sun} ⇒

  SFR ~ few x10^2-10^4 M_{sun}/yr
- Median z ~ 2.2, σ ~ 1.2 ⇒ sub-mm traces ~ 200-400 μm emission (longward of peak)

Merger evolution



Merger of two $z \sim 2$ disks:

M_{halo} = 9e12

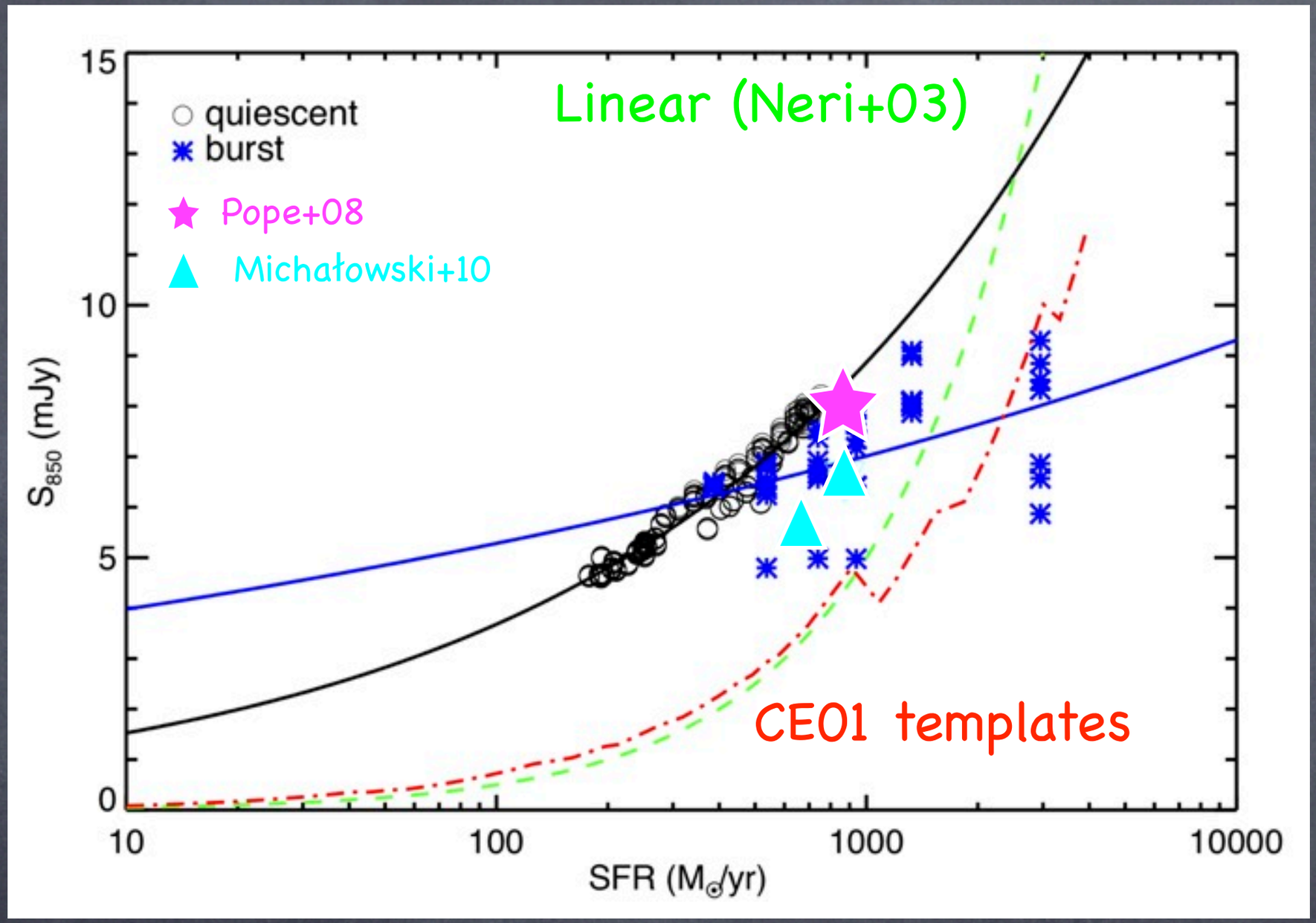
M_b = 4e11

initially 60% gas

Burst consumes gas, lowers dust mass, increases dust T

→ **Inefficient** at boosting submm flux (~15x in SFR but <2x in S_{850})

Merger evolution



Two SF regimes:

1. Quiescent disk (during infall)
2. Merger-driven burst

→ SMGs are not just the high-SFR tail of galaxy population

SMG bimodality

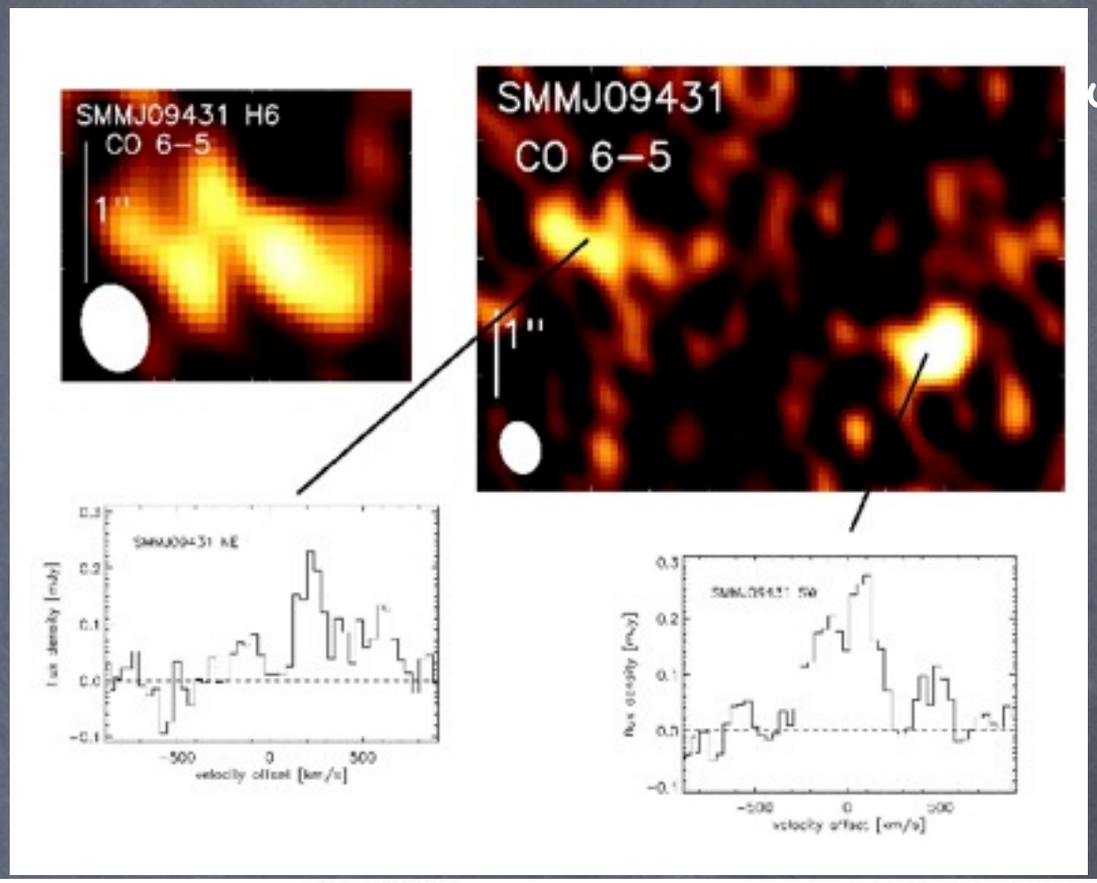
- SCUBA/AzTEC beams ~15" (~130 kpc at z = 2) ⇒

  easy to fit two disks in beam

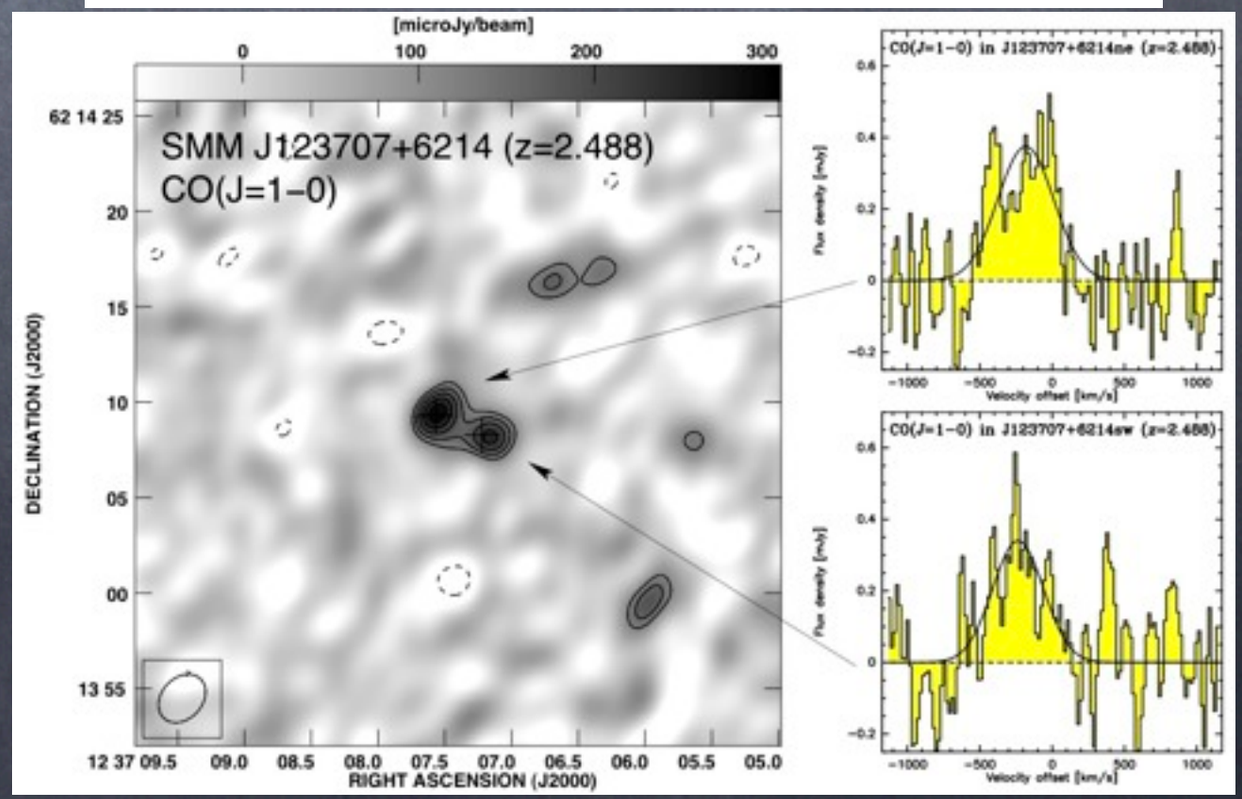
- Very efficient way to boost submm flux

- Early-stage merger; no strong interactions yet

- SMGs are a mix of merger-driven starbursts (near coalescence) and blended galaxy pairs (early-stage)



Engel+10



Riechers+11

Summary

- Simulations of local disks replicate local SEDs well, but real galaxies are a more diverse population
- (U)LIRG samples at low and high z are now beginning to cover FIR - will be able to test predictions of mergers
- Intense starbursts are an inefficient way of boosting submm flux
- Merger SMGs fall into two classes:

  1. Late-stage merger: starburst induced at coalescence
  2. Early-stage merger: two progenitor disks blended into one submm source

- Unlike local ULIRGs, SMGs are a mix of quiescent and bursting sources -- clear observational tests of this

Summary

- Intense starbursts are an inefficient way of boosting submm flux
- Merger SMGs fall into two classes:
  1. Late-stage merger: starburst induced at coalescence
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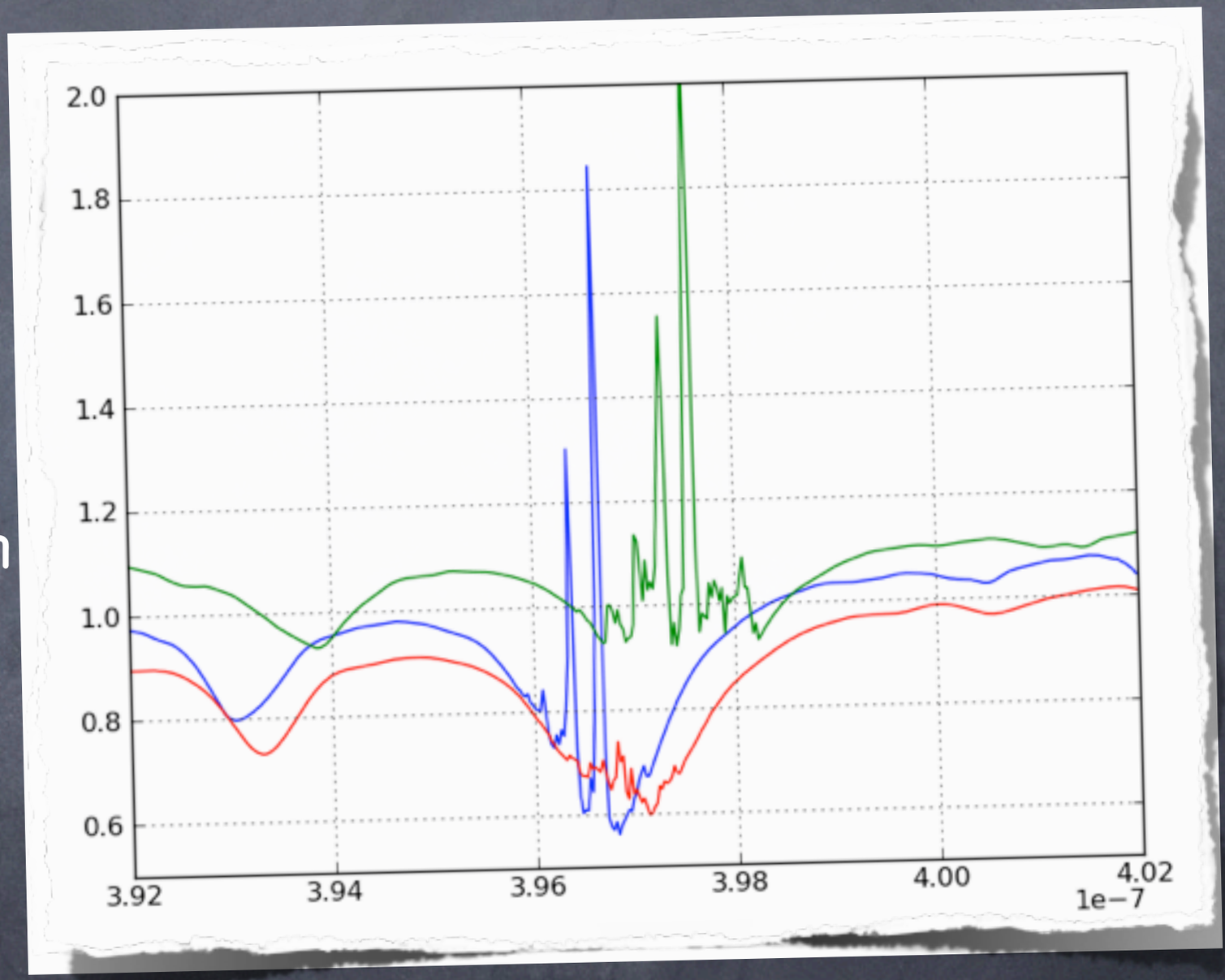
- Unlike local ULIRGs, SMGs are a mix of quiescent and bursting sources -- clear observational tests of this

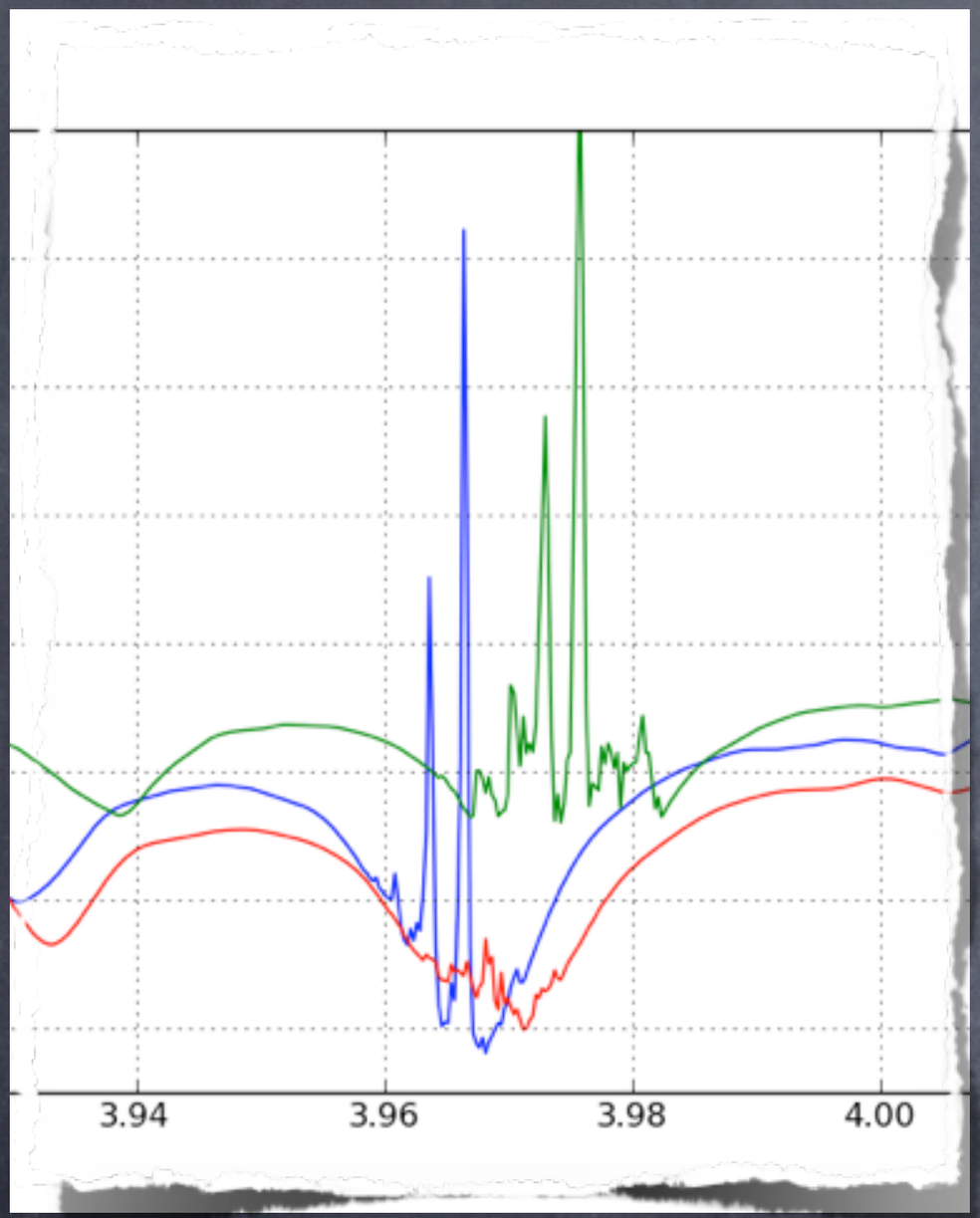
New: Kinematics

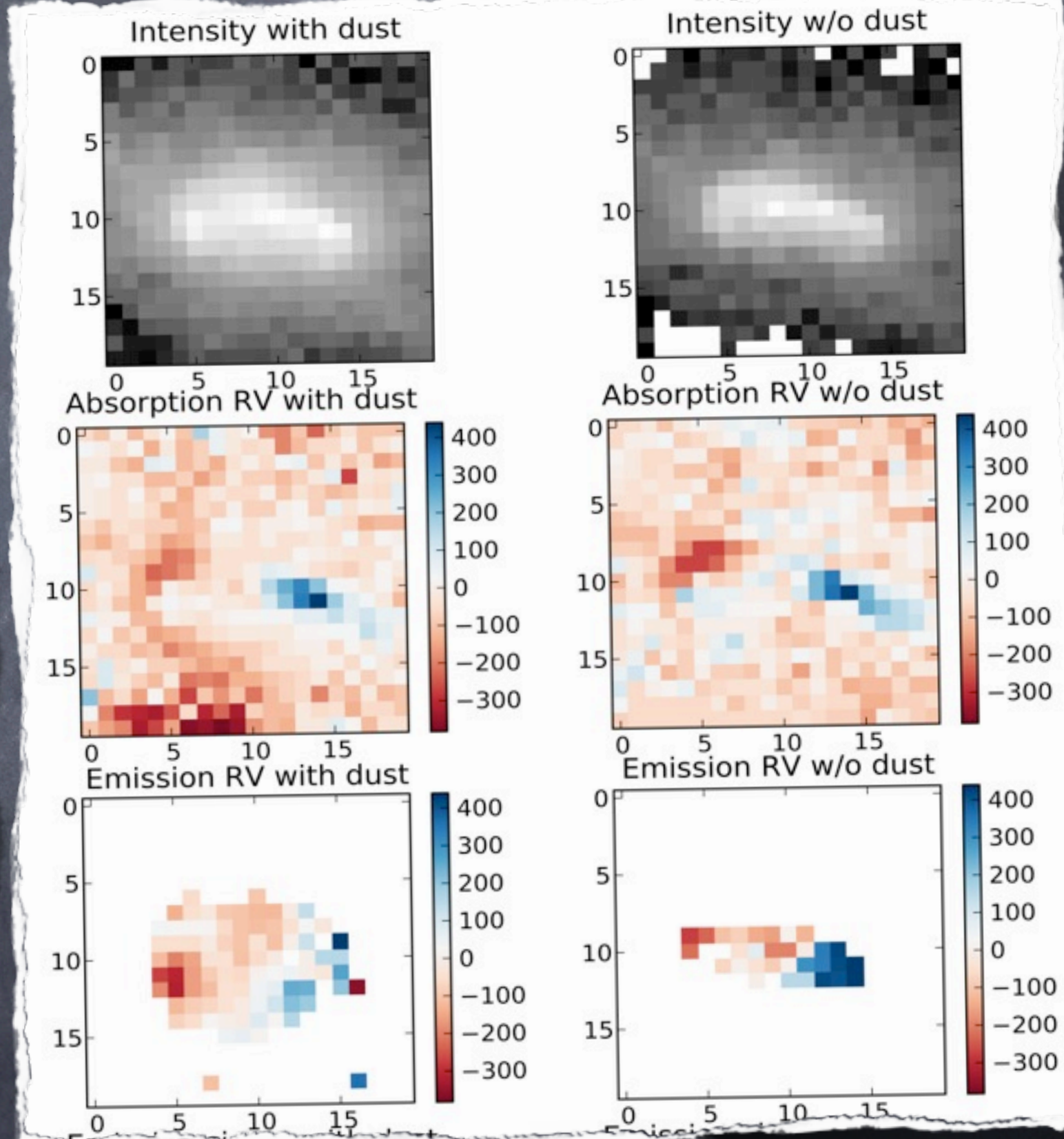
- Taking into account velocities of sources and scatterers
- Can generate emission and absorption line profiles at high resolution (R~16000)



(requires high-res SEDs; in the works...)

IFU-style outputs





Spectral Energy Distributions