# Which theories of star formation fit the observations?

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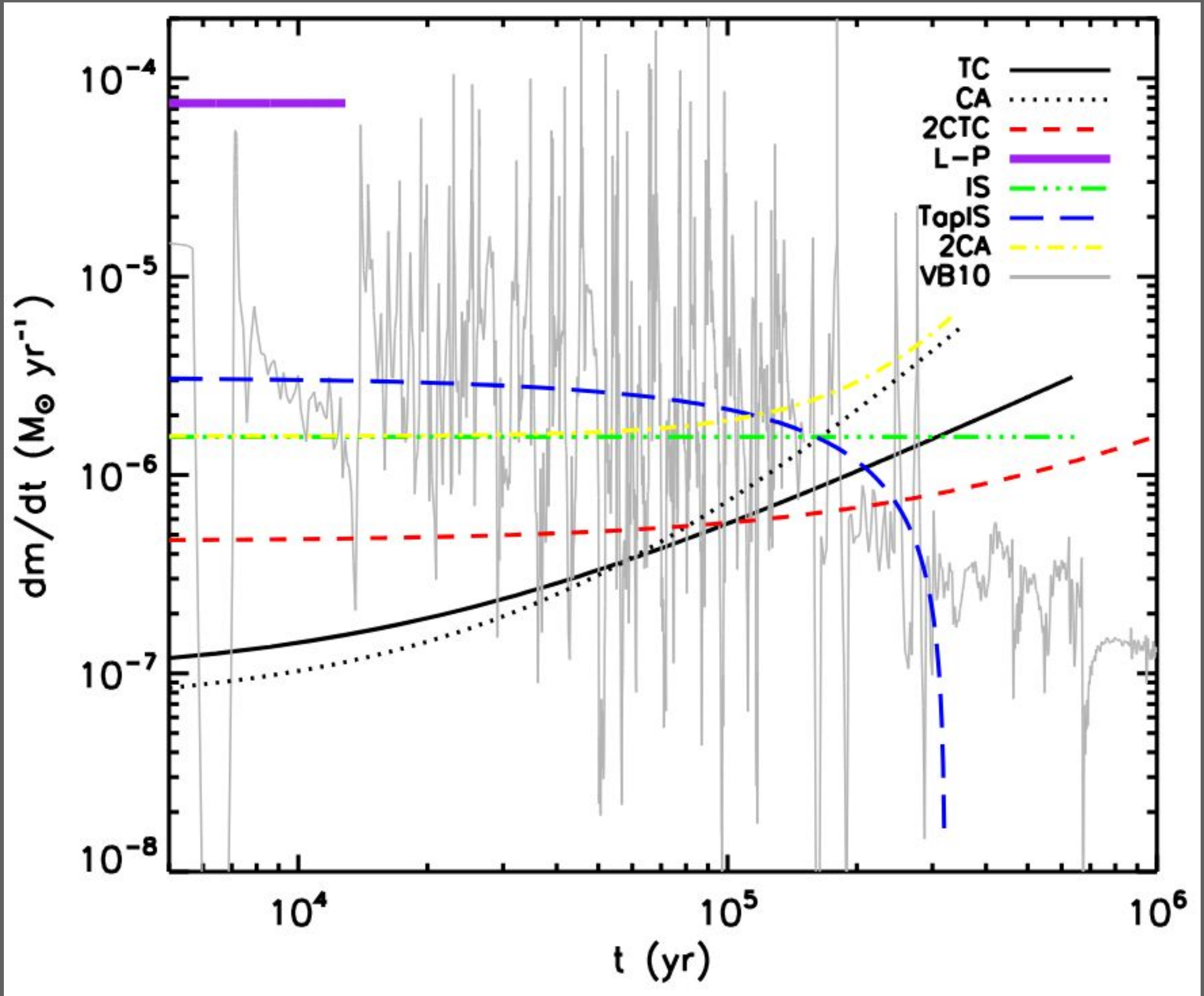
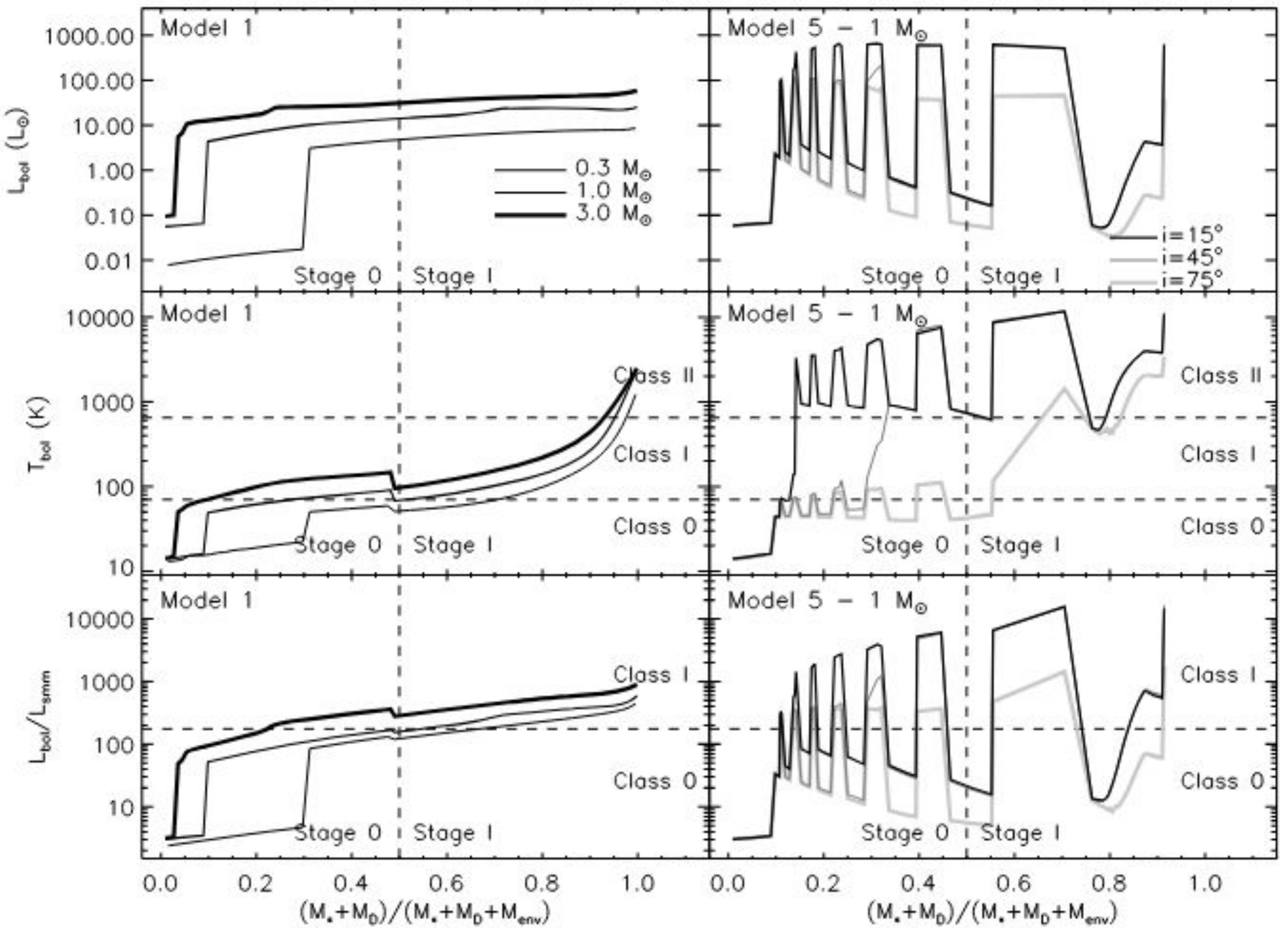
# The Theory Space of Mass Accretion



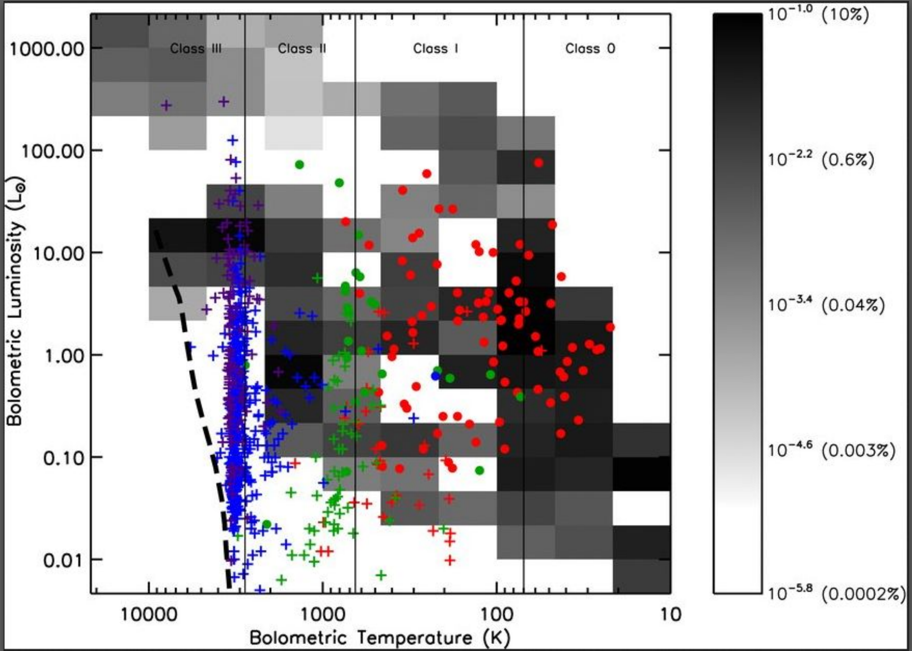

Predicted accretion rates as a function of time for a solar-mass star, according to multiple different theories. (Dunham+ 2014)

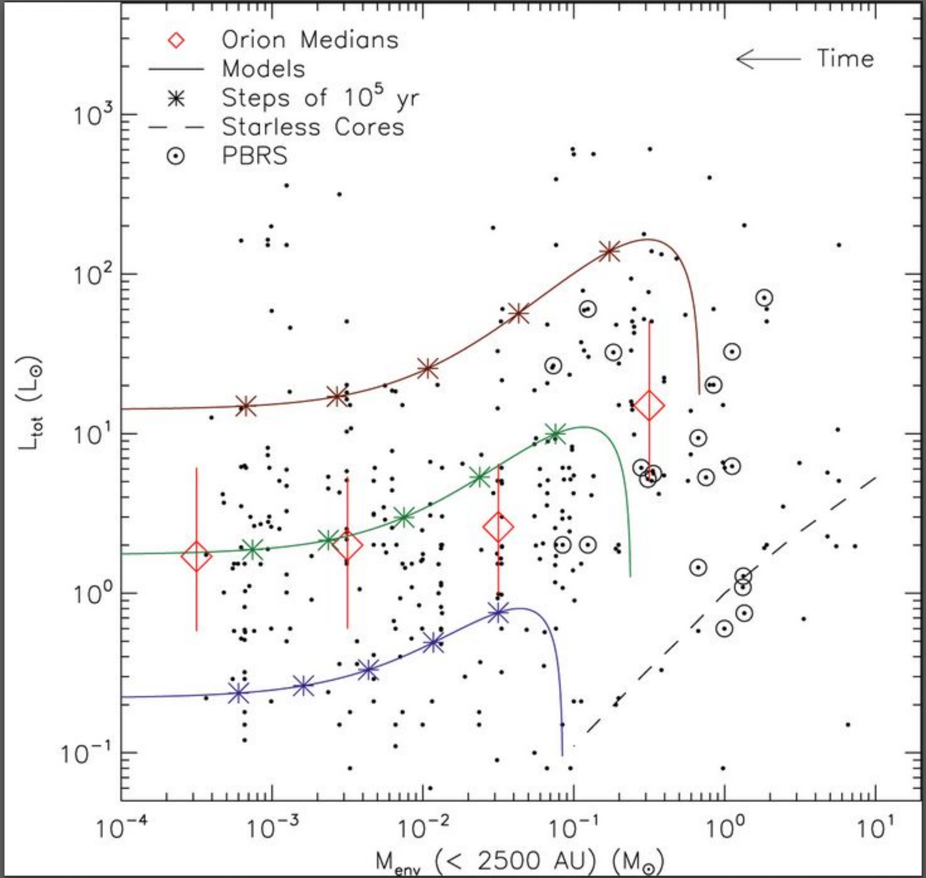
# Theory Vs. Observed YSO Properties




Comparing the evolution of commonly tracked YSO properties for a traditional core collapse model (*left*) and a case where accretion is episodic (*right*) (from Dunham+ 2010).

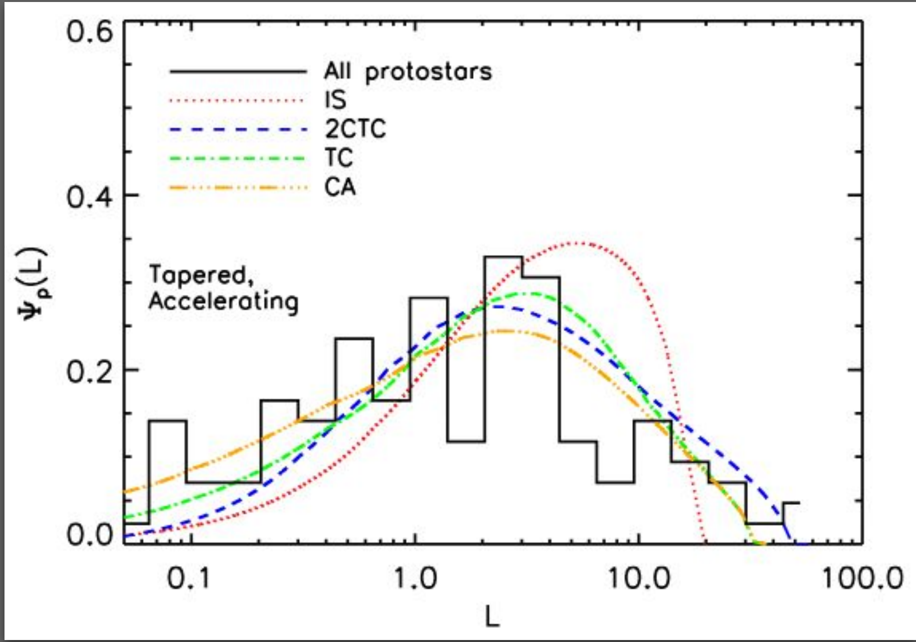
# Ensemble Comparisons

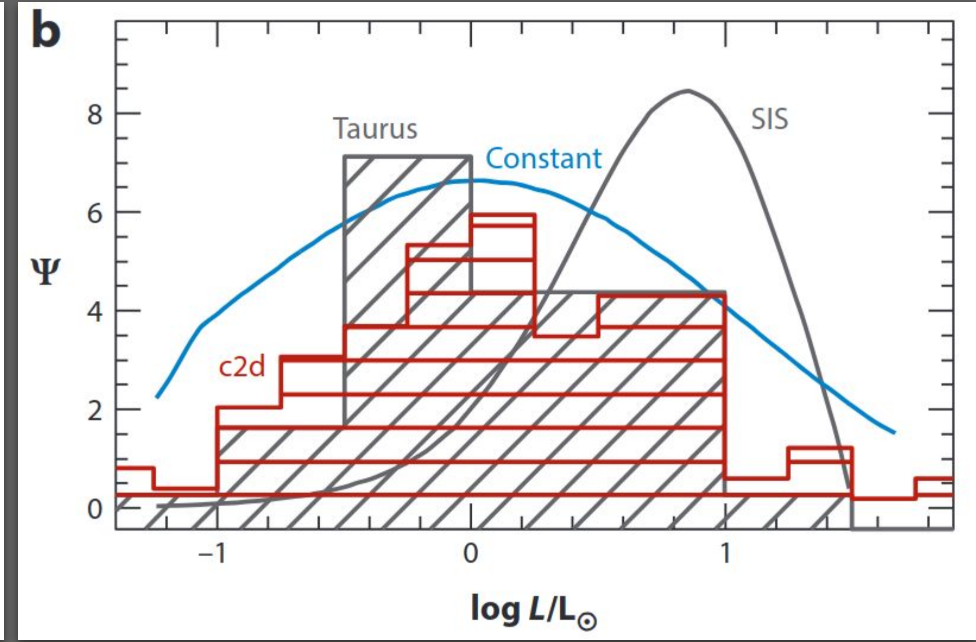



Examples of methods often used to compare star formation theory and observation (from Dunham+ 2010, *left* / Fischer+ 2017, *right*).

# More Ensemble Comparisons




Calculated protostellar luminosity functions for various accretion history models from Offner/McKee (2011, *left*) and Hartmann+ (2016, *right*) compared to the measured bolometric luminosities of Galactic YSOs.

## What is *possible?*

- Constant-rate SIS formation
- Turbulent core collapse
- Competitive accretion
- Tapered accretion (exp./lin.)
- Episodic accretion
- Multi-component accretion
- Constant SFR
- Accelerating SFR

## What is *favored?*

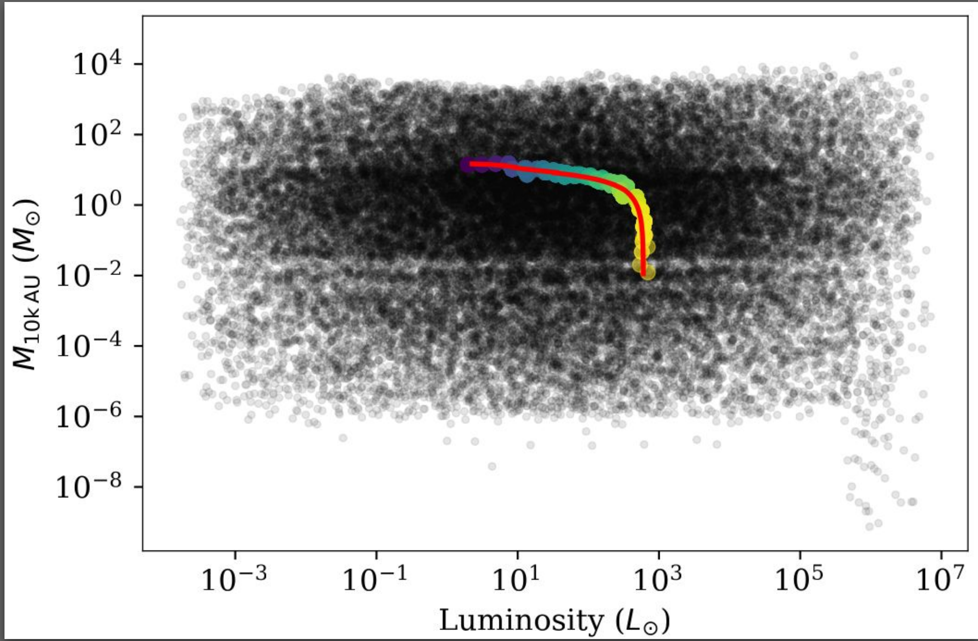
- Episodic accretion?
- Roughly “constant-time” formation?

## What is *disfavored?*

- (Simplified) Constant-rate SIS formation

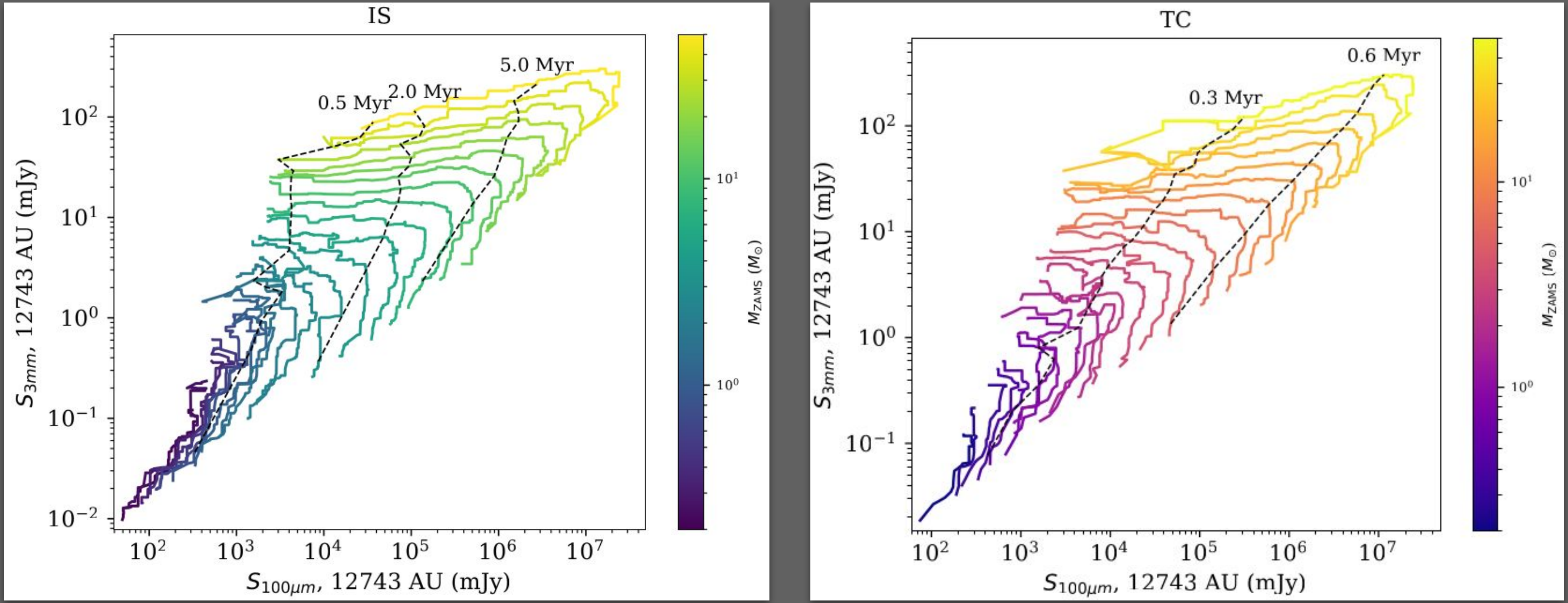
# One Possible Path to Connection

1. Use a radiative transfer model grid with minimal foundational assumptions. (Richardson+ 2024)
2. Generate a protostellar evolutionary track based on some theory.
3. Pick models from the grid consistent with the track.
    a. Match on $T_{star}$, $L_{star}$, $M_{core}$
4. Average over these nearest-neighbor models to produce SEDs.




An example of model selection in a subset of models from Richardson+ (submitted). The nearest models (*dots*) to an isothermal-sphere protostellar evolutionary track (*red line*) are colored by time.

# The Output




Time evolution of flux at 3 mm vs. 100 μm for YSOs, colored by corresponding zero-age stellar mass. Generated for isothermal-sphere *(left)* and turbulent-core *(right)* accretion histories. Isochrones *(dashed)* are overplotted. (Richardson+, submitted)

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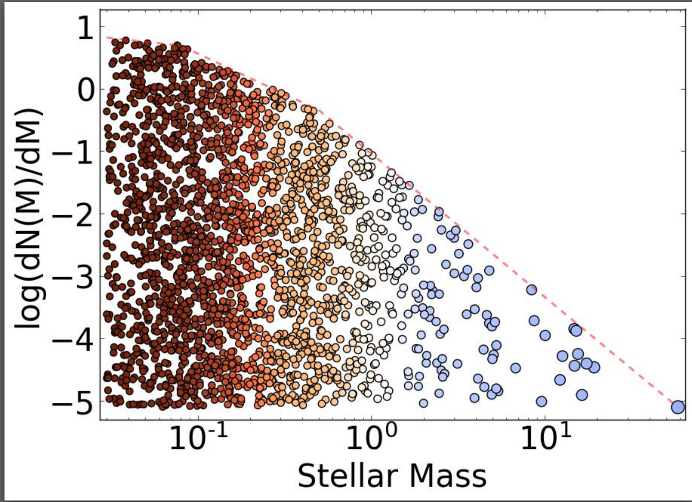


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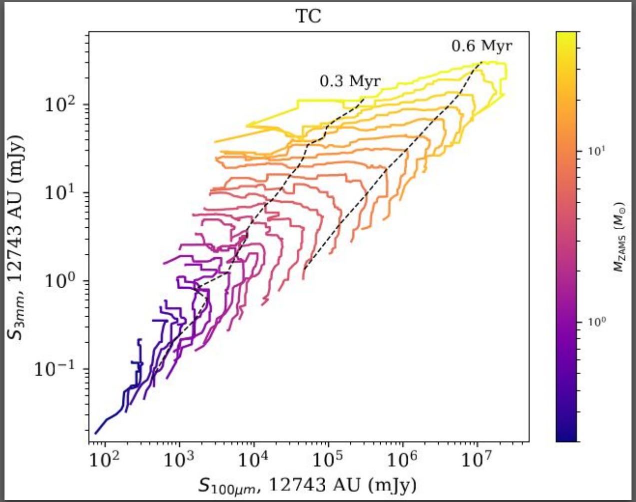
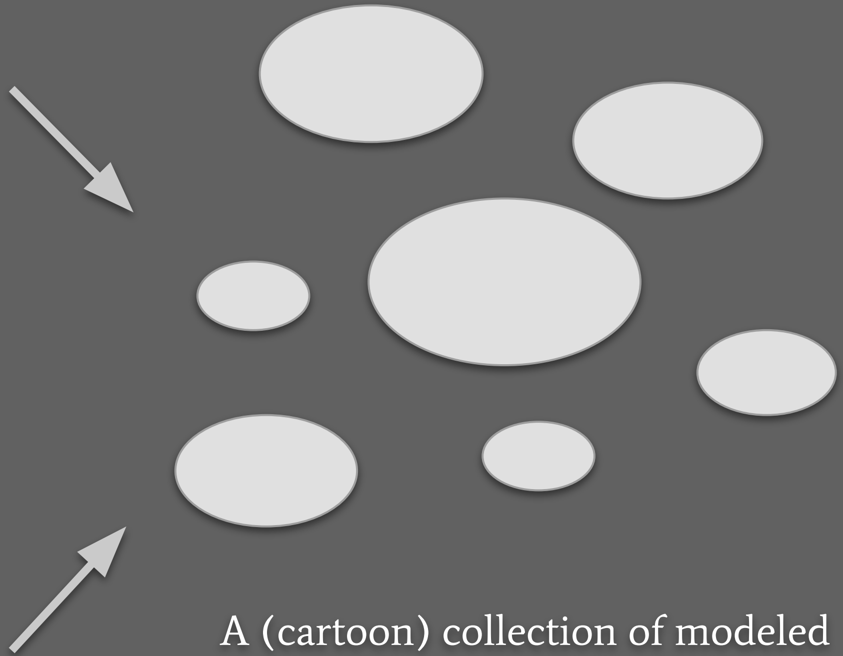
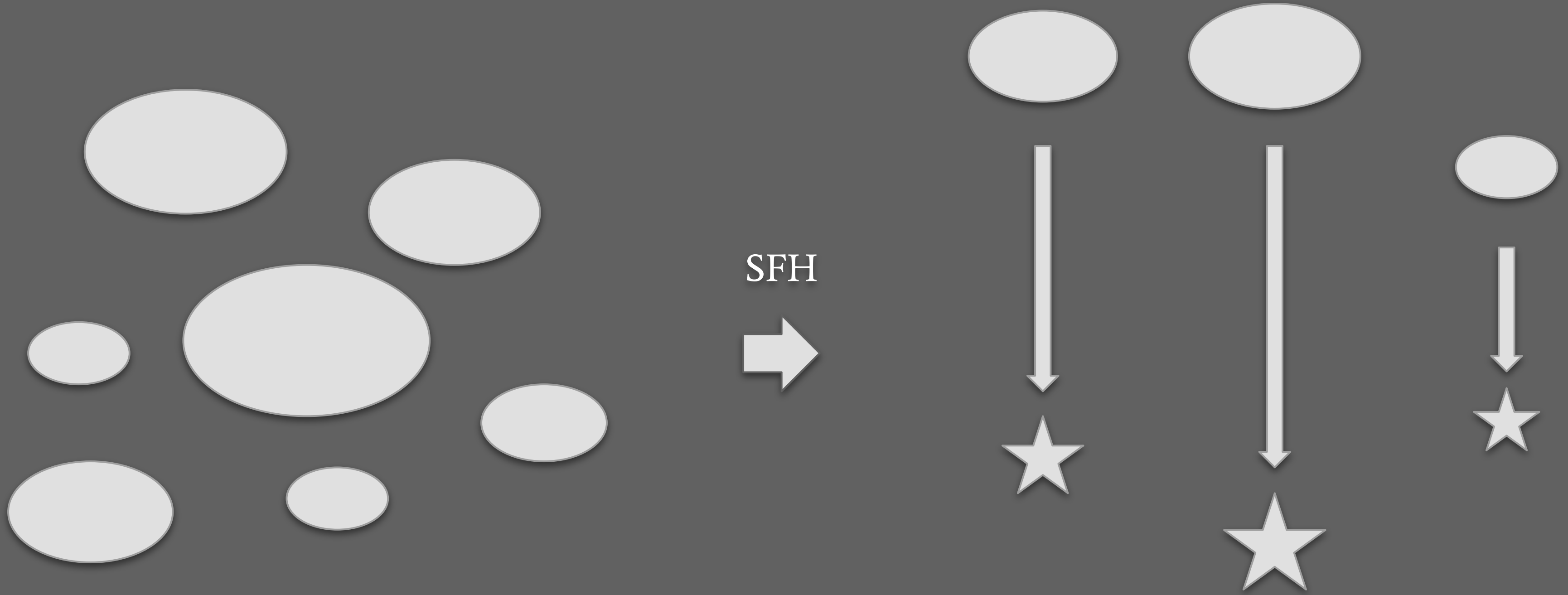


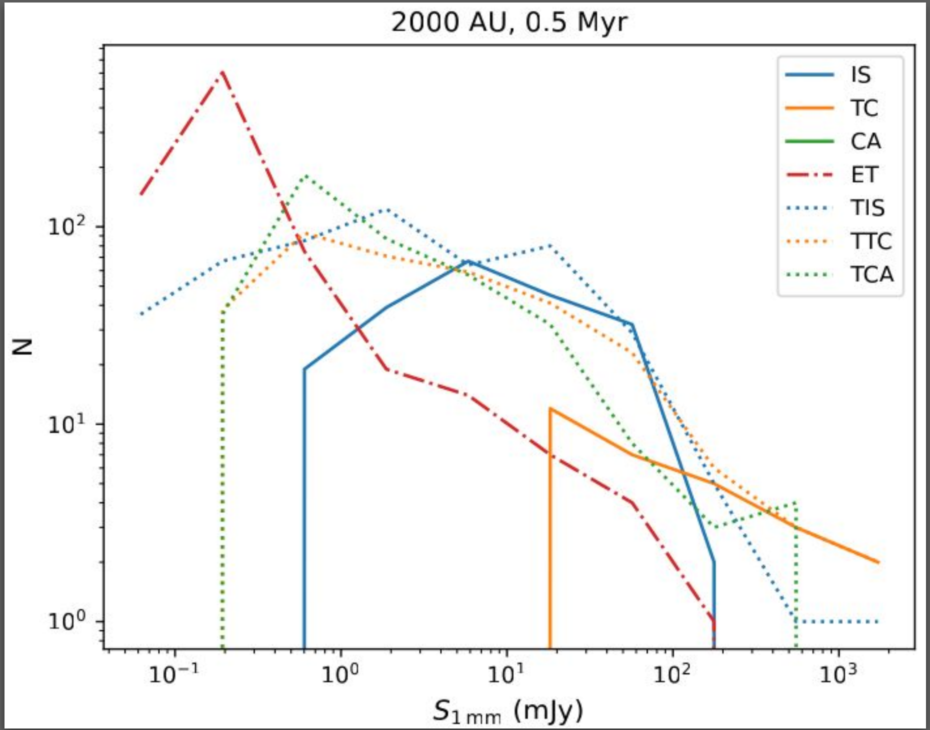
A (cartoon) collection of modeled YSOs.

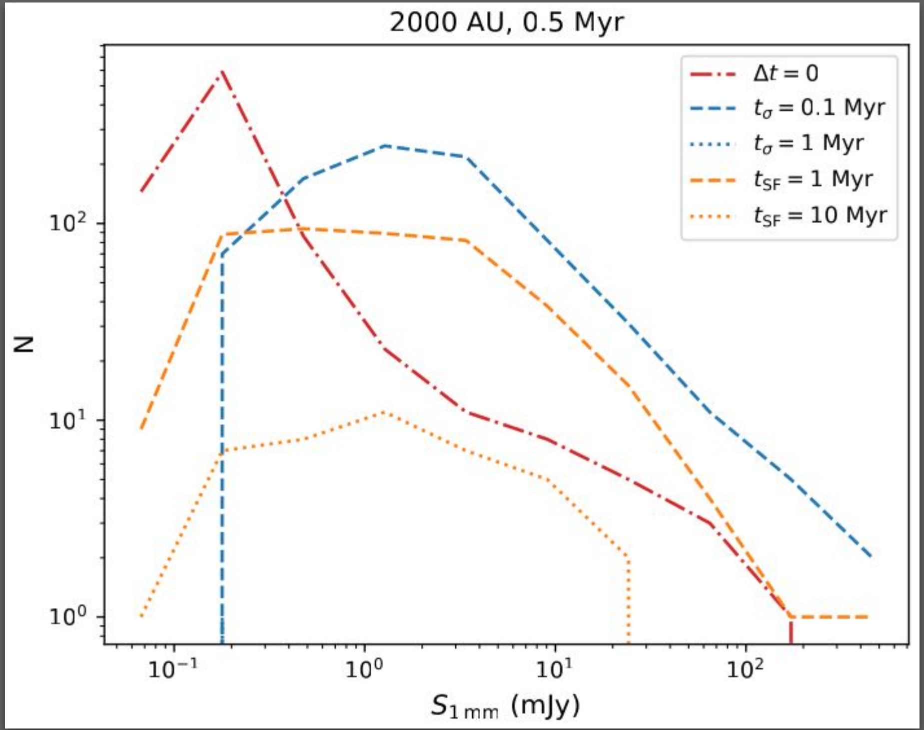



A (cartoon) collection of modeled YSOs.

A collection of modeled YSOs, aligned according to some star formation history.

# How Does Varying Theory Manifest In Flux Predictions?



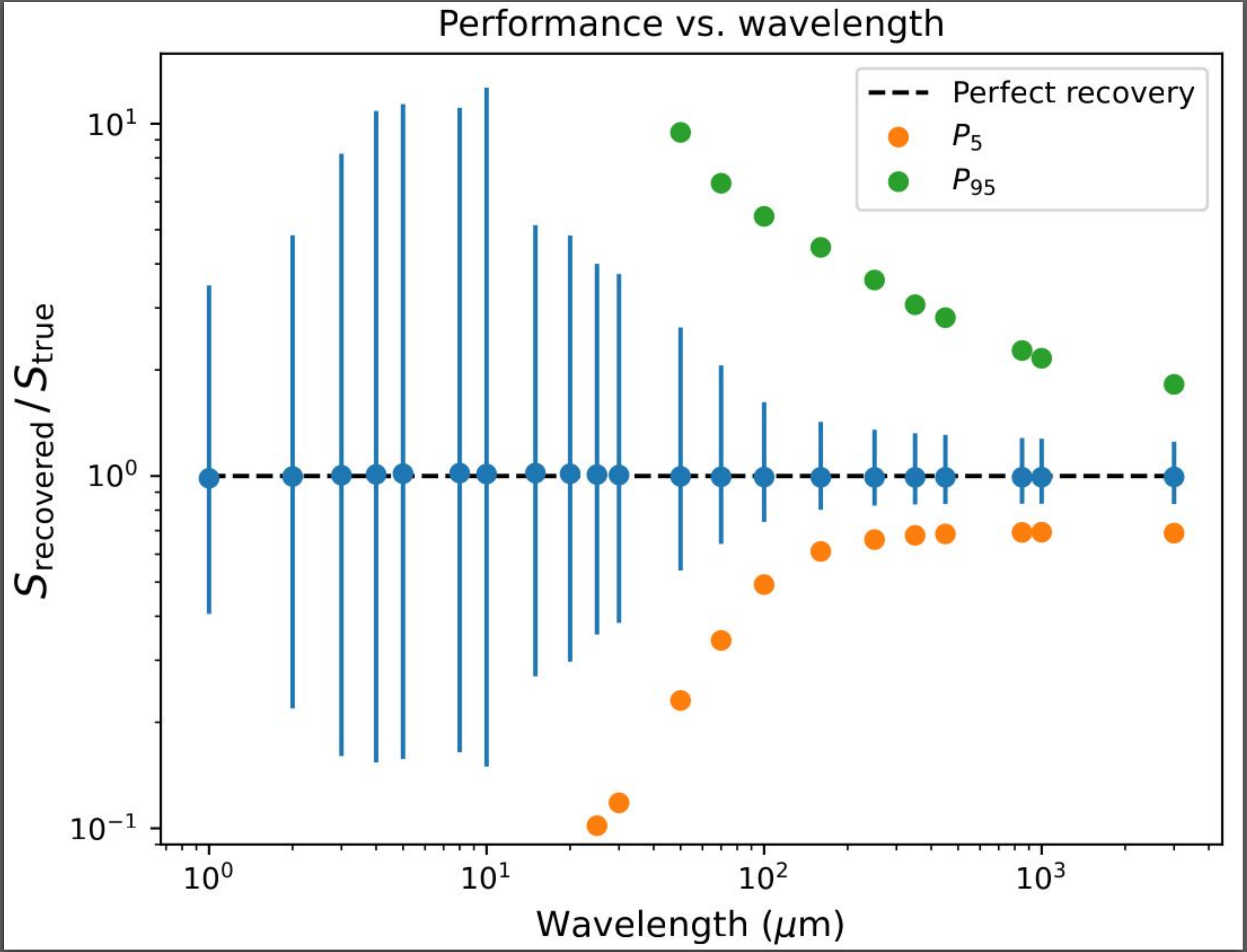

The distributions of 1-millimeter fluxes for the members of model protoclusters. The left panel shows clusters which vary by accretion history, and the right panel shows clusters which vary by star formation history (assuming exponentially tapered accretion). All clusters are optimally sampled from a Kroupa IMF and have a total final mass of 1000 $M_{sun}$. (Richardson+, in prep)

# Some Things to Think About

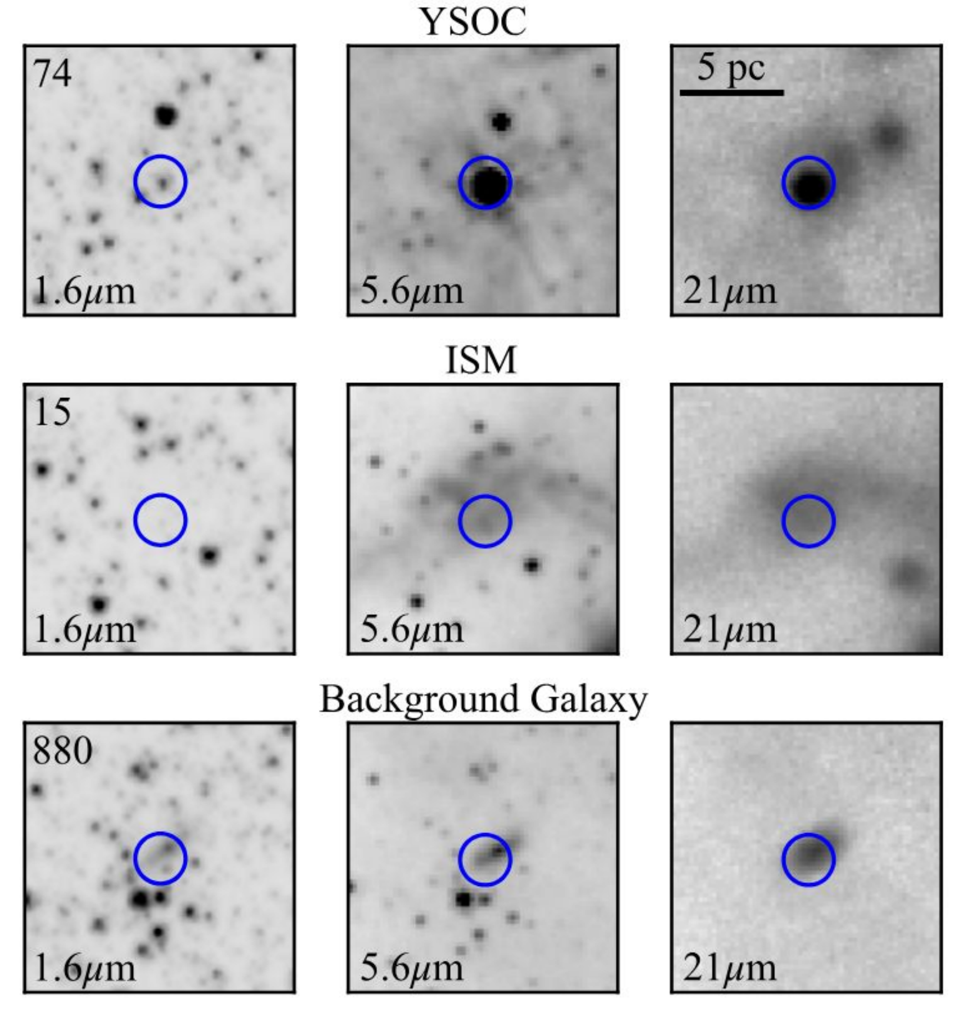
- Which quantities actually connect theory and observations?
  - How much does that differ between low- and high-mass star formation?
  - Are there particular wavelength regimes which are useful probes of theory?
- What kinds of predictions can be tested against resolved/unresolved star formation?

# Theory vs. Wavelength

Mean recovered flux divided by true flux for the entire set of R24 models used for model construction at different wavelengths. Means are the 50th percentile of the distribution of flux ratios at each wavelength. Error bars represent the 16th and 84th percentiles of the flux ratio distribution. The 5th- and 95th-percentile values are also plotted. (Richardson+, submitted)



# Observations of Extragalactic Star Formation




An example of YSO candidate (YSOC) identification in M33 from Peltonen+ (2024). Sources are identified using DOLPHOT (Dolphin 2000/2016) and classified through a combination of color cuts in F560W and F2100W and visual inspection.