Does the Stellar Initial Mass Function Vary With Redshift?

PHY 689 Final Presentation:

Amruta Deshpande

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Initial Mass Function

- Power law slope, -x, at high mass, turnover at low mass
- Difficult to measure:
  - Resolution
  - Assume a conversion from luminosity to initial mass

Overview

- Why it matters
- Why we think it might evolve
- 3 independent suggestions for evolution
- Summary

Why Do We Care?

- History: monolithic collapse suggests a statistical distribution of stellar masses
- Environment should effect IMF (P, P_{rad}, Φ_g)
  - Cluster vs. field: metallicity, feedback, density
- IMF Variation?
  - Through redshift
  - Through different galactic regions
- Issues in understanding:
  - Can we assume a single IMF, related law?
  - What does it mean for SFR observations/Models?

Image credit: http://www.galaxyphoto.com/high_res/hst_galaxy.JPG

Early Measurements

Salpeter

At high mass end:

M^{-X} $X \sim 1.35$

Chabrier

$$\frac{dN_*}{d\ln m_*} \propto \exp\left[-\left(\ln m_* - \ln m_c\right)^2 / \left(2\sigma^2\right)\right]$$

-a log-normal (smooth) representation with characteristic Mass

m_c ~ .2 Solar masses

Kroupa

Three part broken power law:

$$dN_*/d\ln m_* \propto m_*^{-\alpha}$$

$$\alpha = -0.70.01 < m_*/M_\odot < .08$$

$$\alpha = +0.30.08 < m_*/M_\odot < .50$$

$$\alpha = +1.30.50 < m_*/M_\odot < 50$$

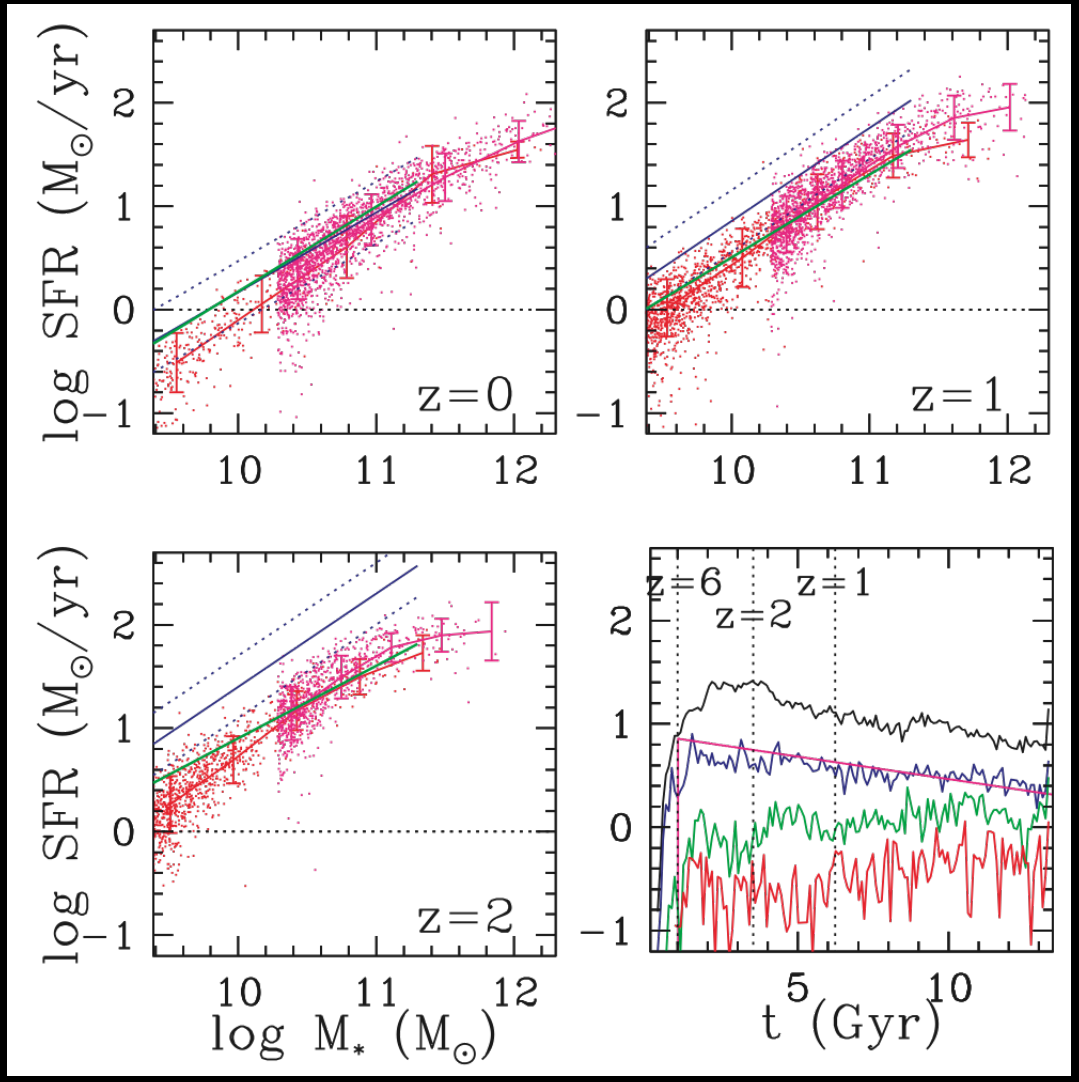
All measurements are galactic disc measurements

Early Indications of IMF Variation

- Galactic variations
  - Arches Cluster, and others near galactic center: TOP HEAVY (older stars?) - stay tuned for CMF discussion
- Implications for Galaxy Formation?
  - Did these form differently from rest of galaxy? How?
- Later, inconsistencies between observed and predicted SFR as well as some other scaling relations

SFR: Arguments

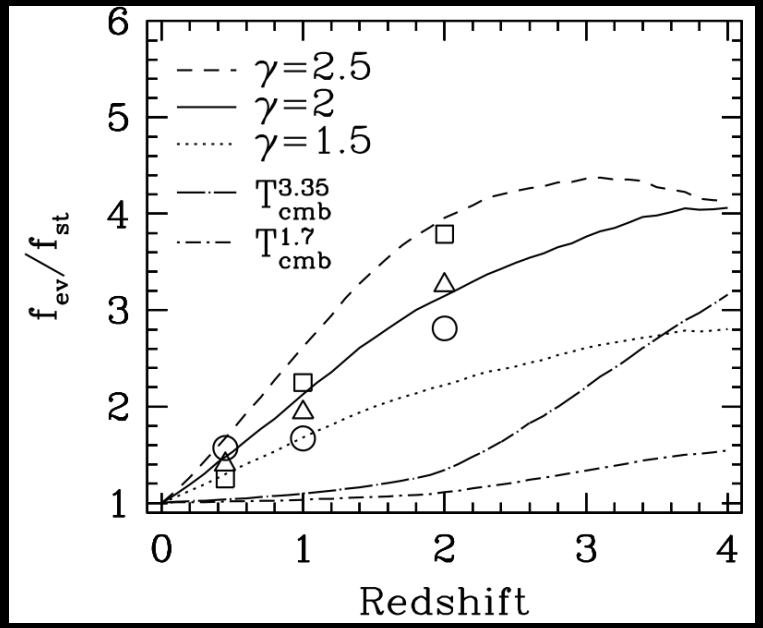
- Cannot reconcile observed and predicted SFR's
- Discrepency independent of only free parameter of models: **FEEDBACK**.

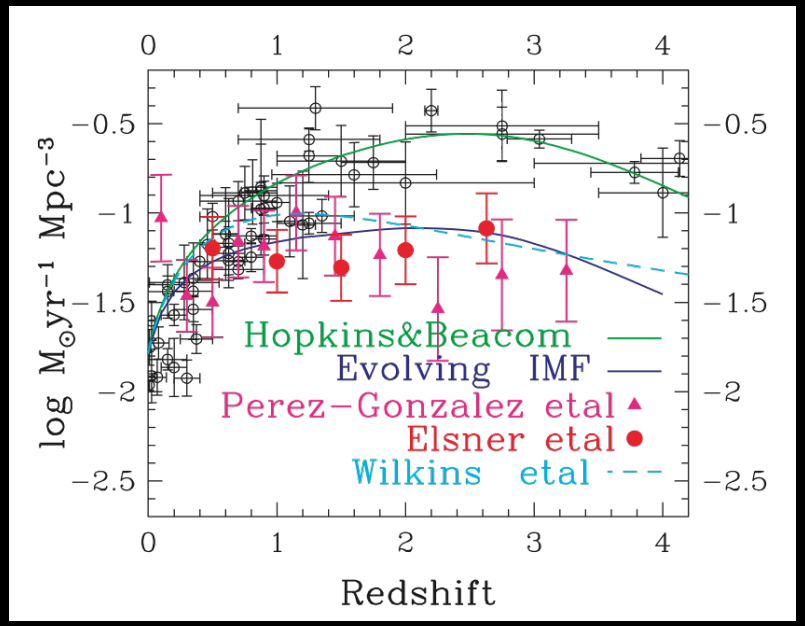


SFR Constraints

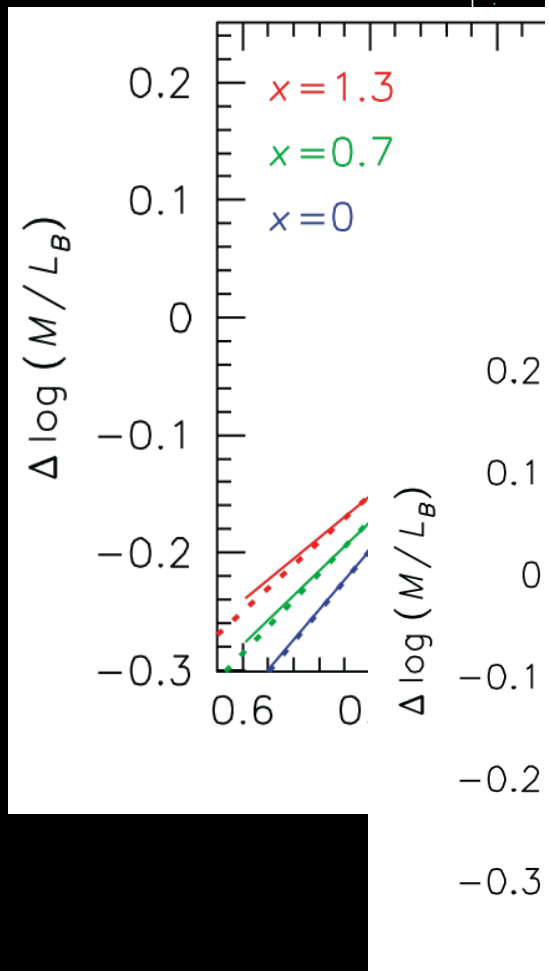
- Evolving Kroupa IMF is good fit
- More direct measures of stellar mass are also consistent with evolving IMF

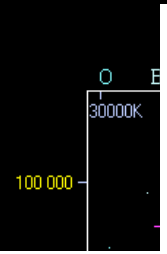
$$m_* = 0.5\,(1+z)^2\,M_\odot$$





Mid-z Efforts: Luminosity & Color Evolution Method





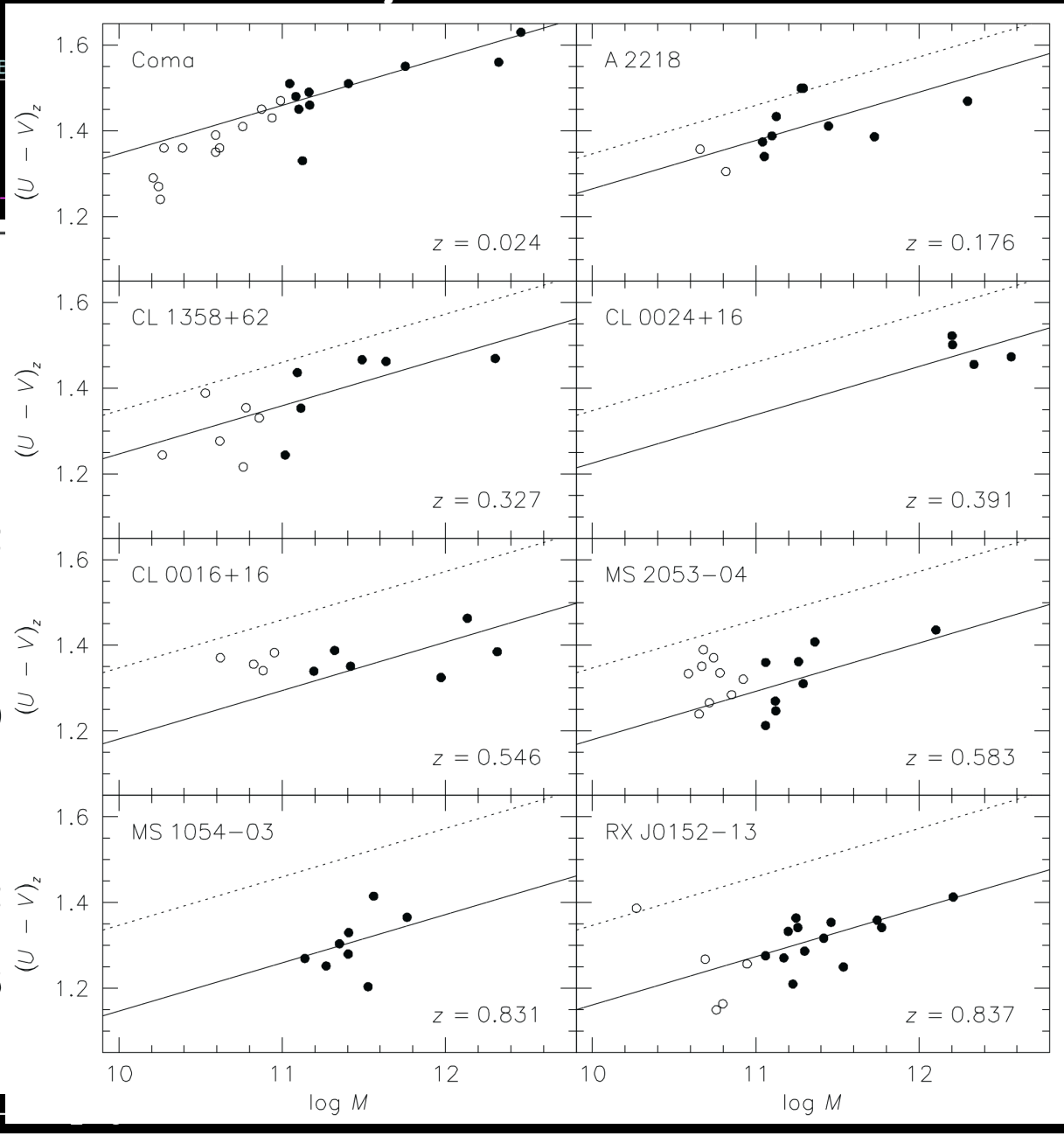


image credit: http://en.wikipedia.org/wiki/Hertzsprung–

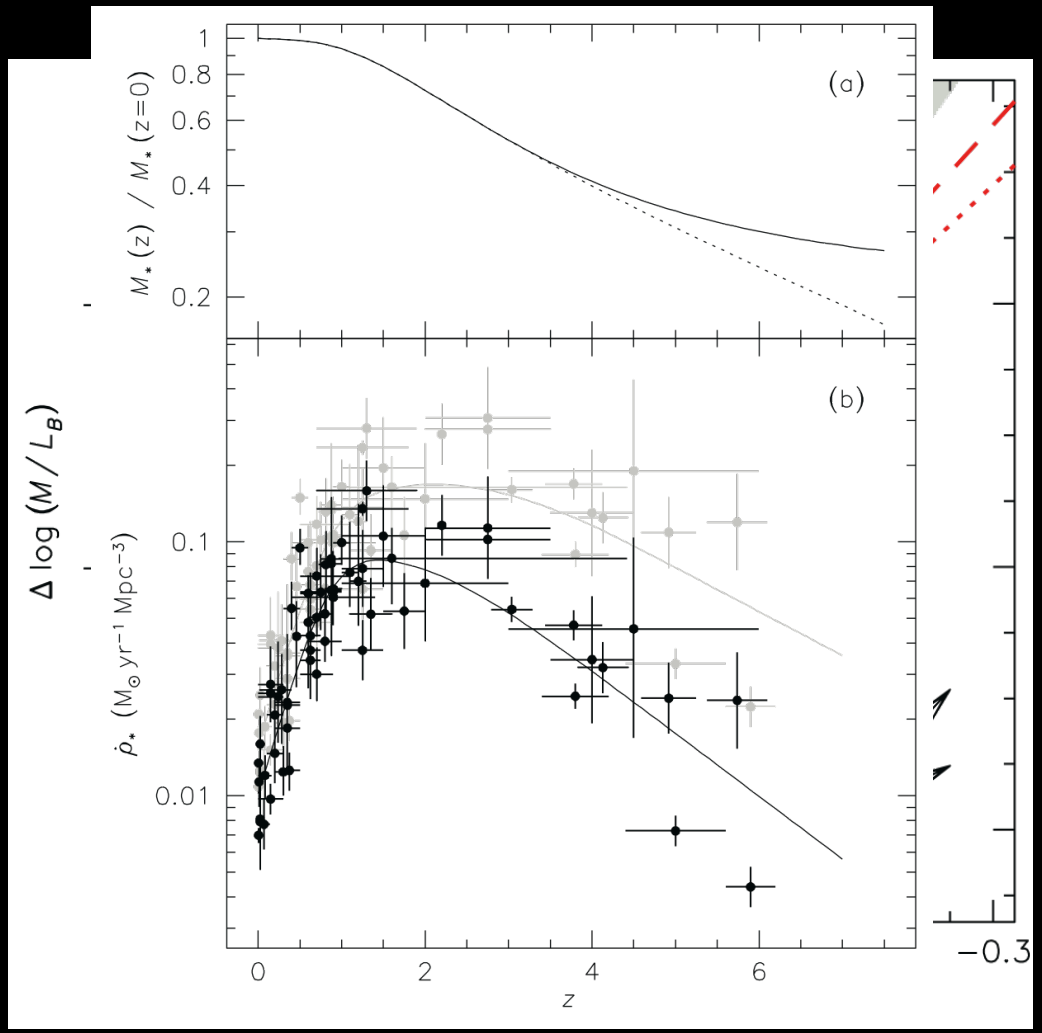
Mid-z Efforts:

dN/dln(M) ~ M^-x

$x < 0.9$

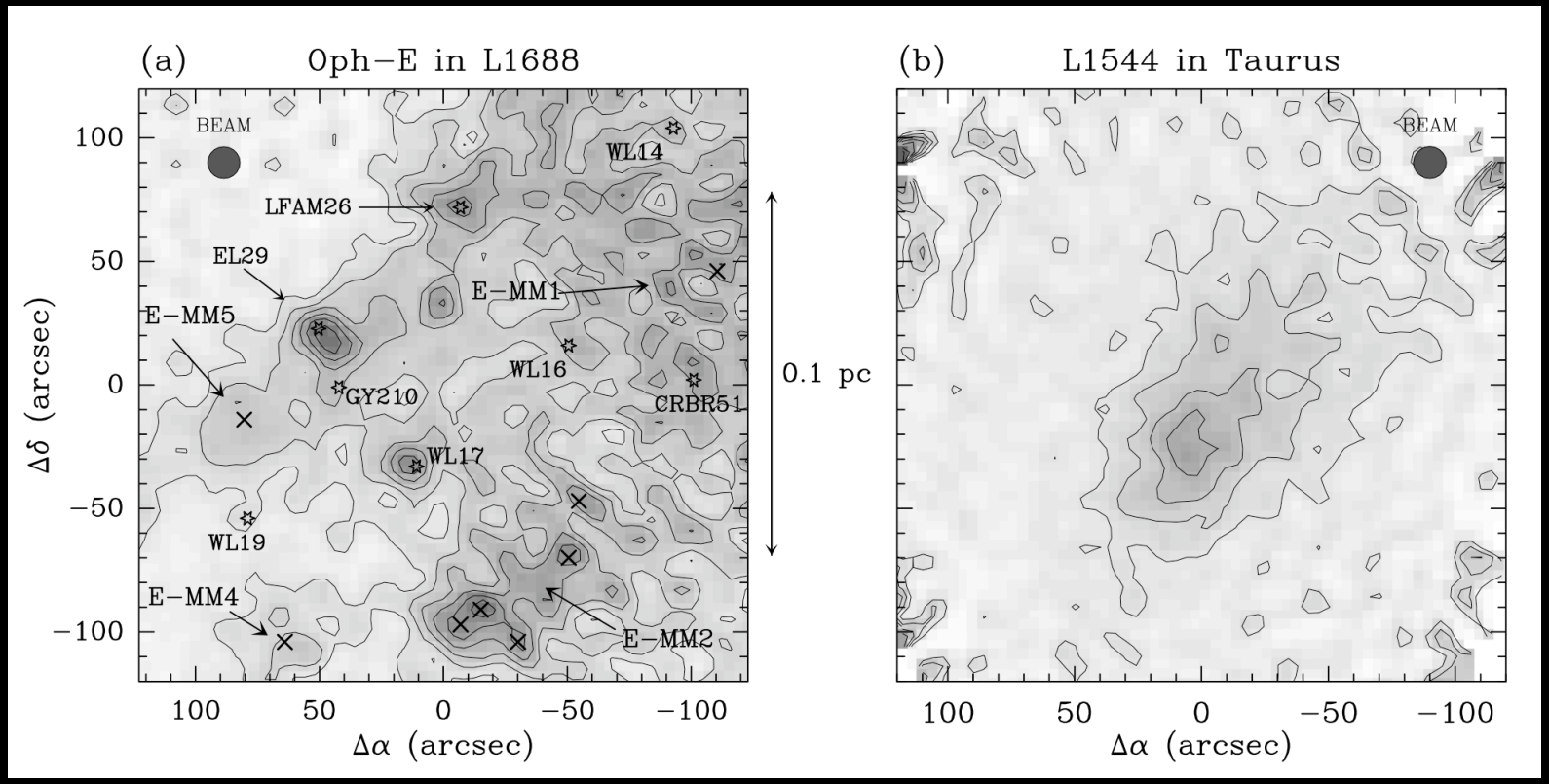
Salpeter: $x = 1.3$ Ruled out at > 98% confidence

Bias in IMF extrapolation, overpredicts observed star-formation rate density



At Highest z's? Core Mass Function

Mm and sub-mm observations

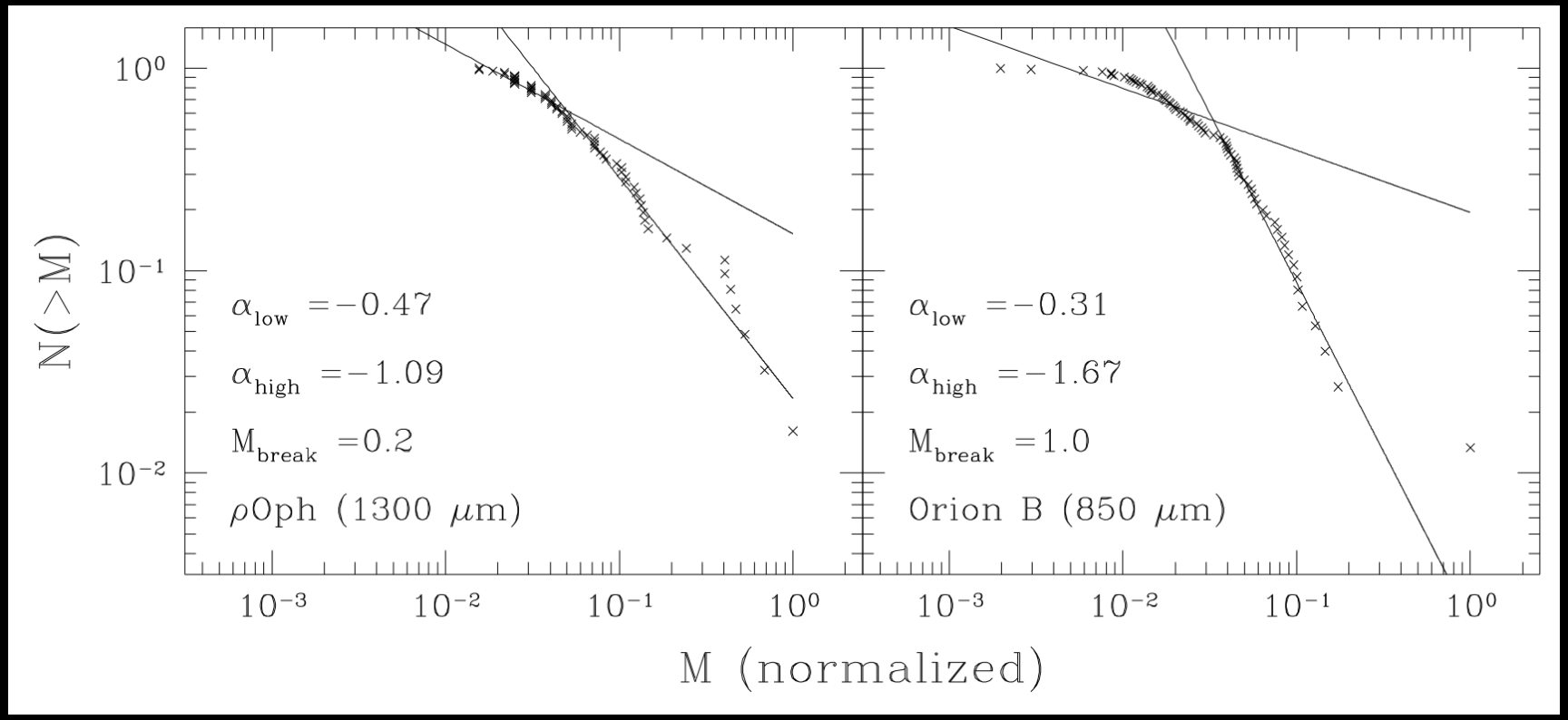


Dense core system
Motte et al 1998

Low density core system
Ward-Thompson et al 1999

Core Mass Function

CMF's for Ophiucus molecular cloud and Orion for comparison



Striking resemblance to Kroupa IMF

Shallower slope at low mass: - suggests larger ratio of higher mass objects to low mass objects

Summary

- Measuring the IMF is difficult, and the exact form cannot be constrained, but qualitative statements can be made.
- Most attempts at constraining IMF at high redshift seem to suggest a flatter IMF, or a larger fraction of higher mass stars produced