(A Better) Intro to Measuring the Stellar IMF

Astro 250: Spring 2026

Jan 27, 2026

The “Original” mass function

Salpeter (1955)

THE LUMINOSITY FUNCTION AND STELLAR EVOLUTION

GCs were “missing” massive stars at that time

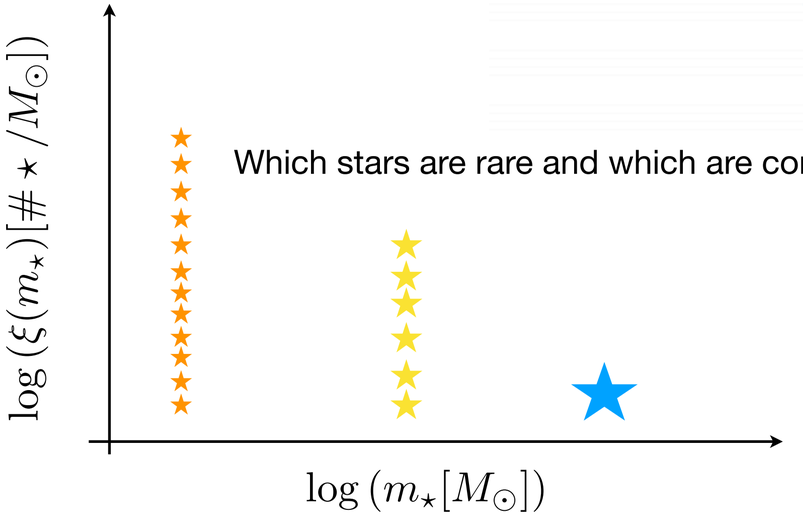
EDWIN E. SALPETER*
Australian National University, Canberra, and Cornell University
Received July 29, 1954

We defined the “original mass function,” $\xi(\mathfrak{M})$, by

★ ↓ Mass bin

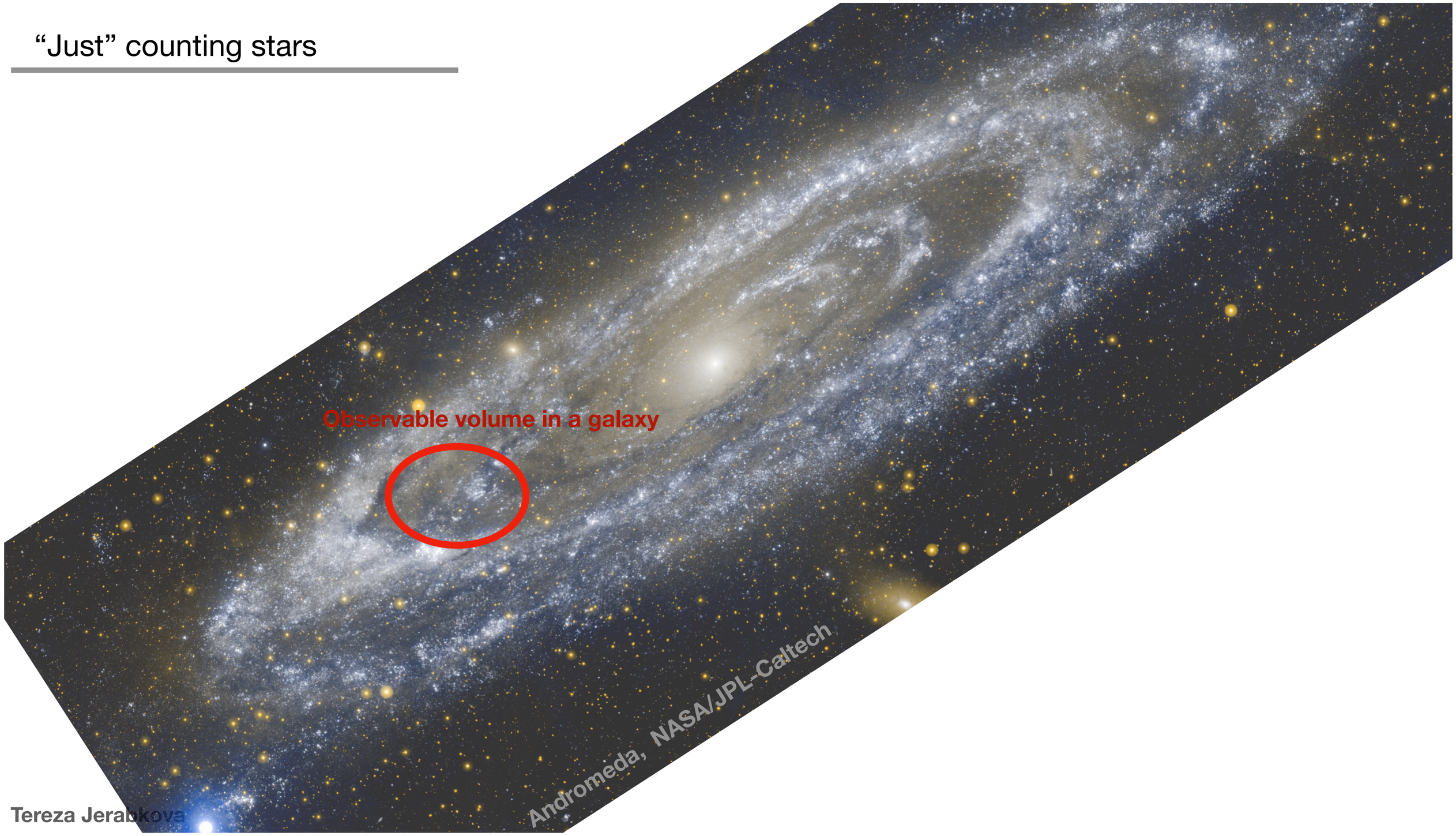
$$d\,N = \xi\,(\mathfrak{M})\;d\,(\log_{10}\,\mathfrak{M})\,\frac{dt}{T_0},$$

Stars form over T_0

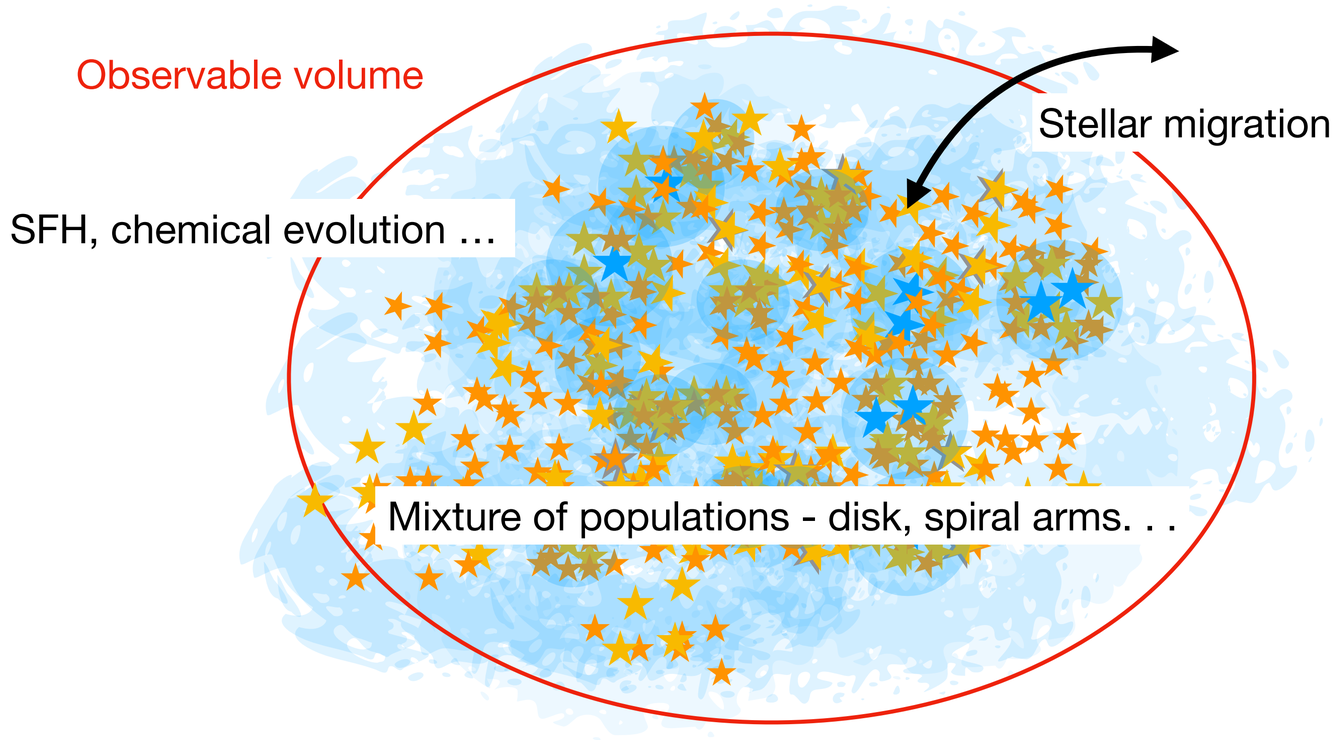


Which stars are rare and which are common?

“Just” counting stars



“Just” counting stars



“Just” counting stars

The measured quantity

1) Present day luminosity function

need to correct for biases!

2) Salpeter (1955) Scalo(1986)
Miller & Scalo(1979) Kroupa, Tout, Gilmore(1990-93)

Stellar mass-luminosity relation (its derivative)

Scale height distribution as a function luminosity (age)

Main sequence brightening

Correction for evolved (still alive stars)

Metallicity variations

Unresolved binaries (important issue by itself!)

Embedded stars , extinction

~~?The stellar Initial Mass Function?~~

Present day mass function

$$\Phi_m(\log_{10} m_\star) = \Phi(M_V)\left|\frac{\mathrm{d}M_V}{\mathrm{d}\log_{10} m_\star}\right| 2H(M_V) f_{ms}(M_V)$$

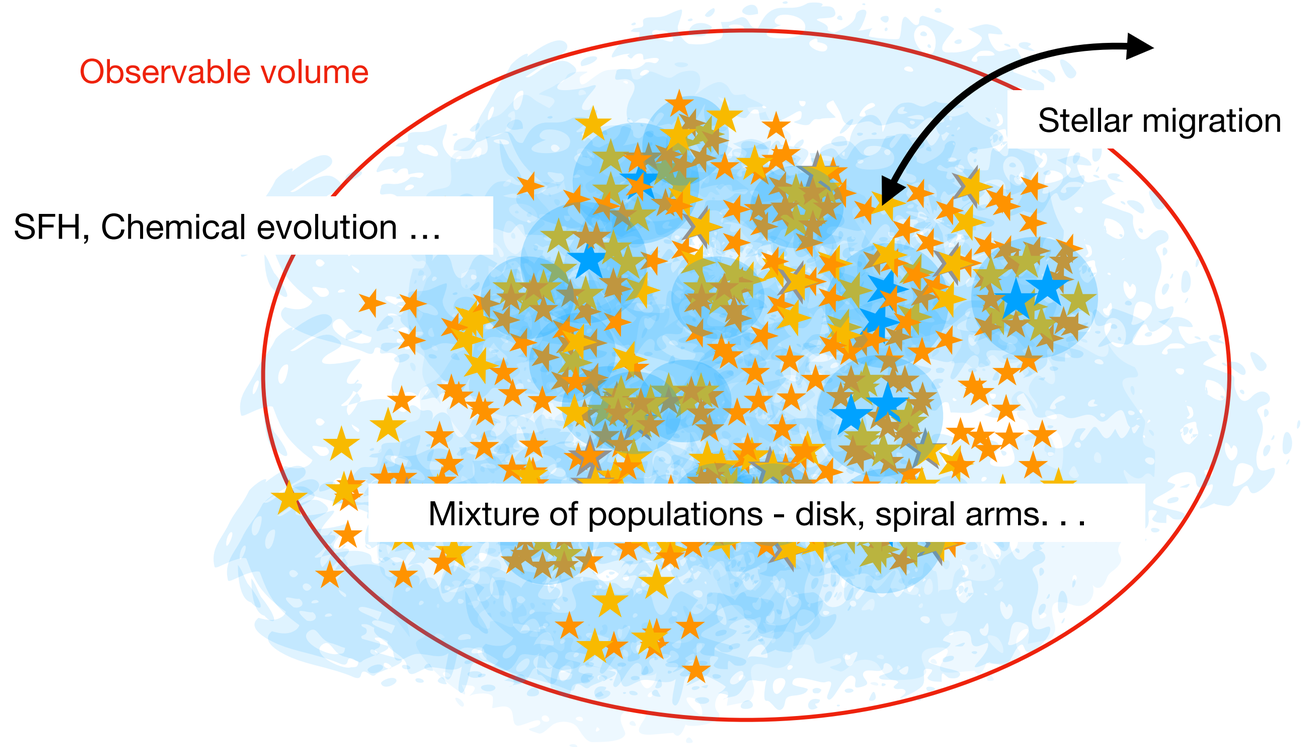
By counting stars one looks into the internal structure of stars!

Kroupa, Tout & Gilmore (1990)

Correction for finite stellar lives, SFH → **Empirical stellar Initial Mass Function**

Salpeter (1955)

(with all the issues connected to the SHF, stellar migration, …)



Kroupa & Jerabkova (2017)

IMF does not exist in nature (it's a Hilfskonstrukt),
we need to *infer* the IMF to interpret measurements and make calculations

“Just” counting stars

What about star clusters?

- *Small number statistics*
- *dynamical effects, mass segregation —> initial conditions!*
(ejections, mergers) Kroupa (1995), De Marchi, Paresce, Portegies Zwart (2010)
- *binary stars* Oh & Kroupa (2016, 2018)
- *field contamination*
- *cluster’s SFH* Elmegreen & Scalo (2005), Beccari+2017, Jerabkova+2017

observer: IMF?
Cluster: not, yet

observer: IMF?
Cluster: too late

1) MW & nearby clusters: consistent with no variations within (large) uncertainties

Massey+1995ab, Weisz+2015 —> see also Oh & Kroupa (2016)

Scalo (1986): Average over star clusters is well defined if IMF is universal

What variations of the IMF are consistent with the data?

See Dib (2014), and use KDE as Prisinzano+ (2001)

2) Variations detected in extreme environments - high densities, low metallicity

Dabringhausen+2008,2012, Bartko+2010, Marks+2012, Schneider+2018, Kalari+2018, Hosek+2019

More massive stars relative to the canonical IMF

+ more evidence from unresolved stellar populations, stellar population synthesis and chemical evolution

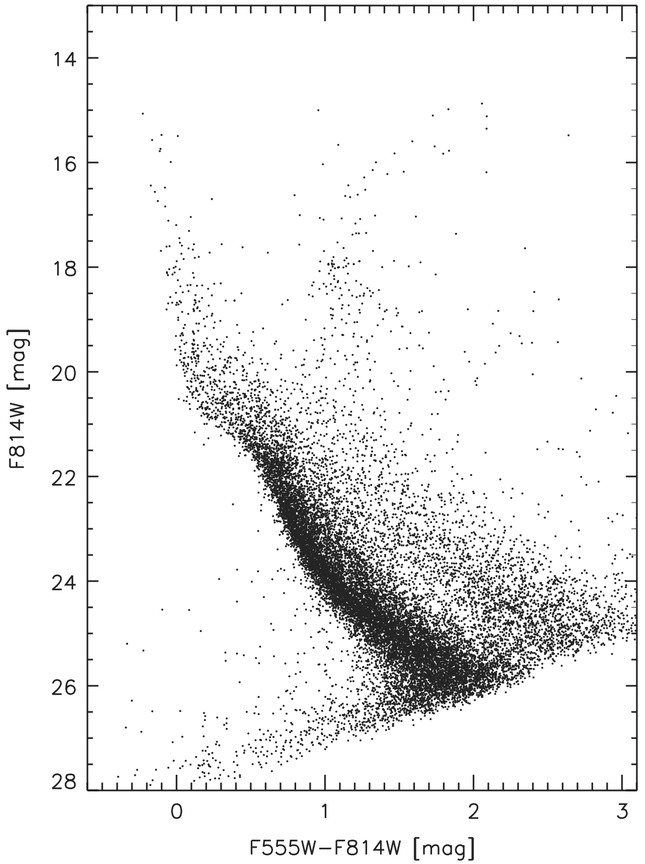
3) Low density environments

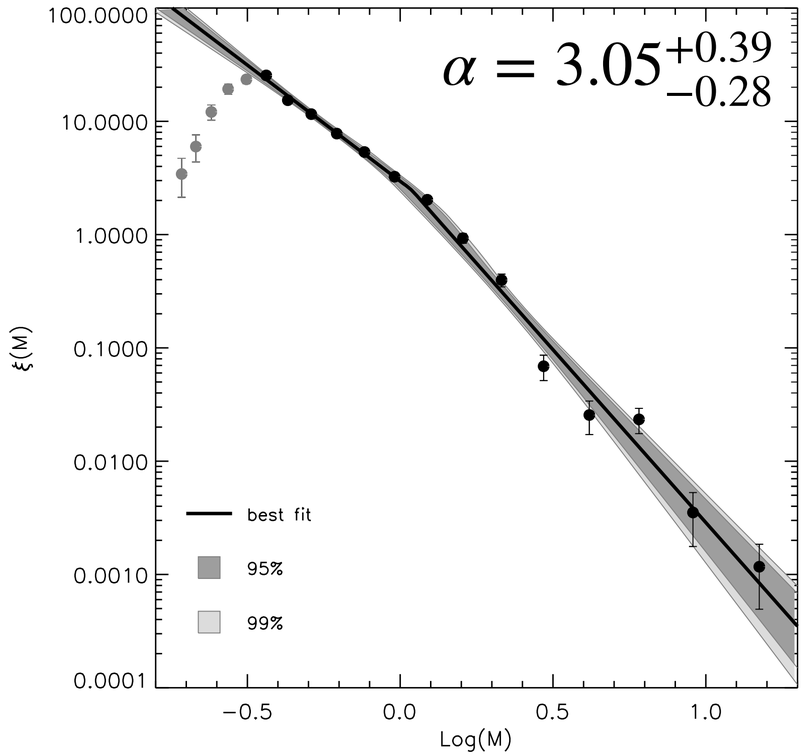
Hsu, Hartmann+2012,2013, Megeath+2012, Watts+2017

Lack of massive stars relative to the canonical IMF

IMF in Star Cluster LH 90 in the Large Magellanic Cloud

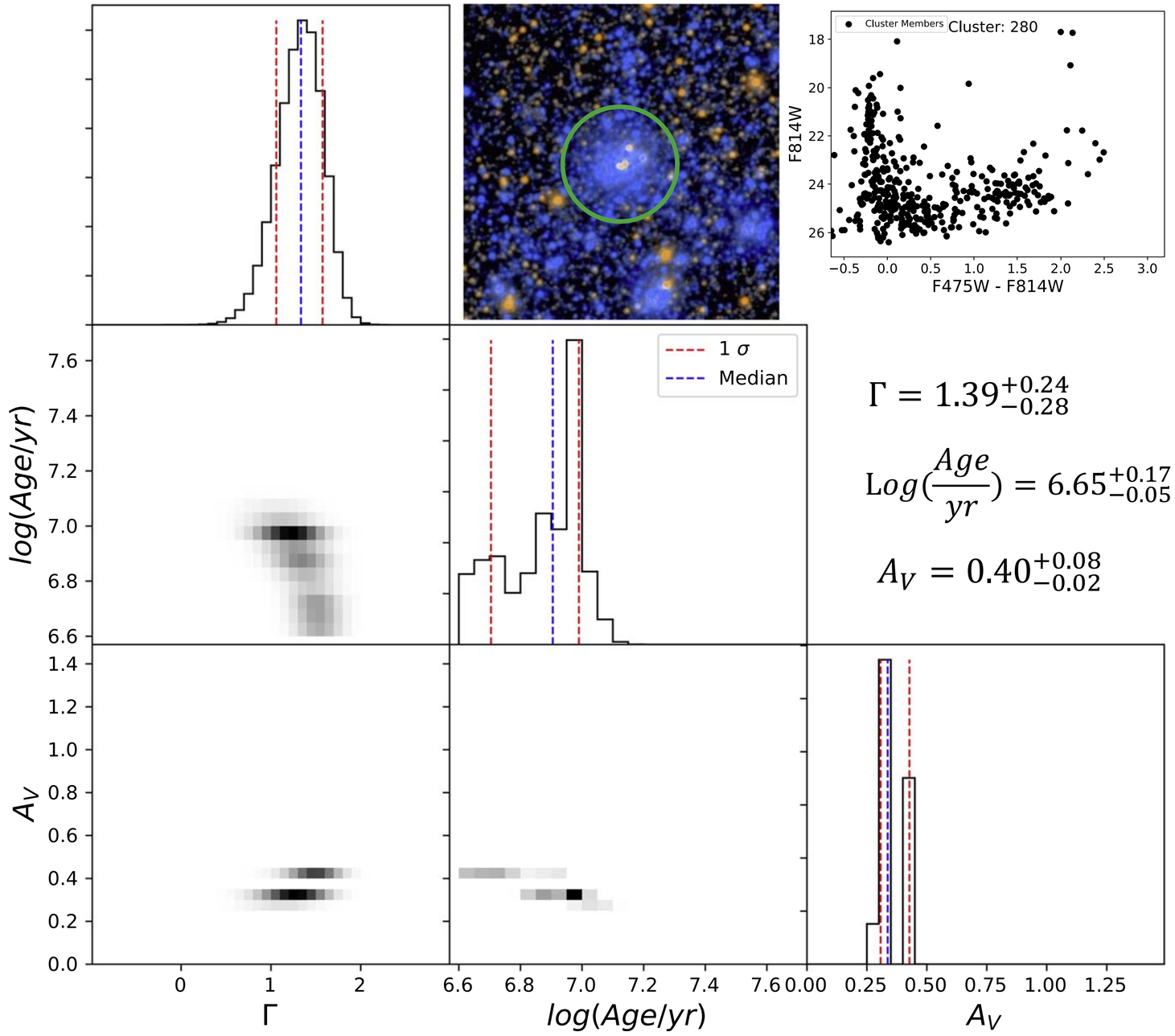
$$\alpha_{\mathrm{MW}} = 2.35$$





Da Rio+ (2009)

IMF in Star Cluster AP 280 in M33



$$\Gamma = 1.39^{+0.24}_{-0.28}$$

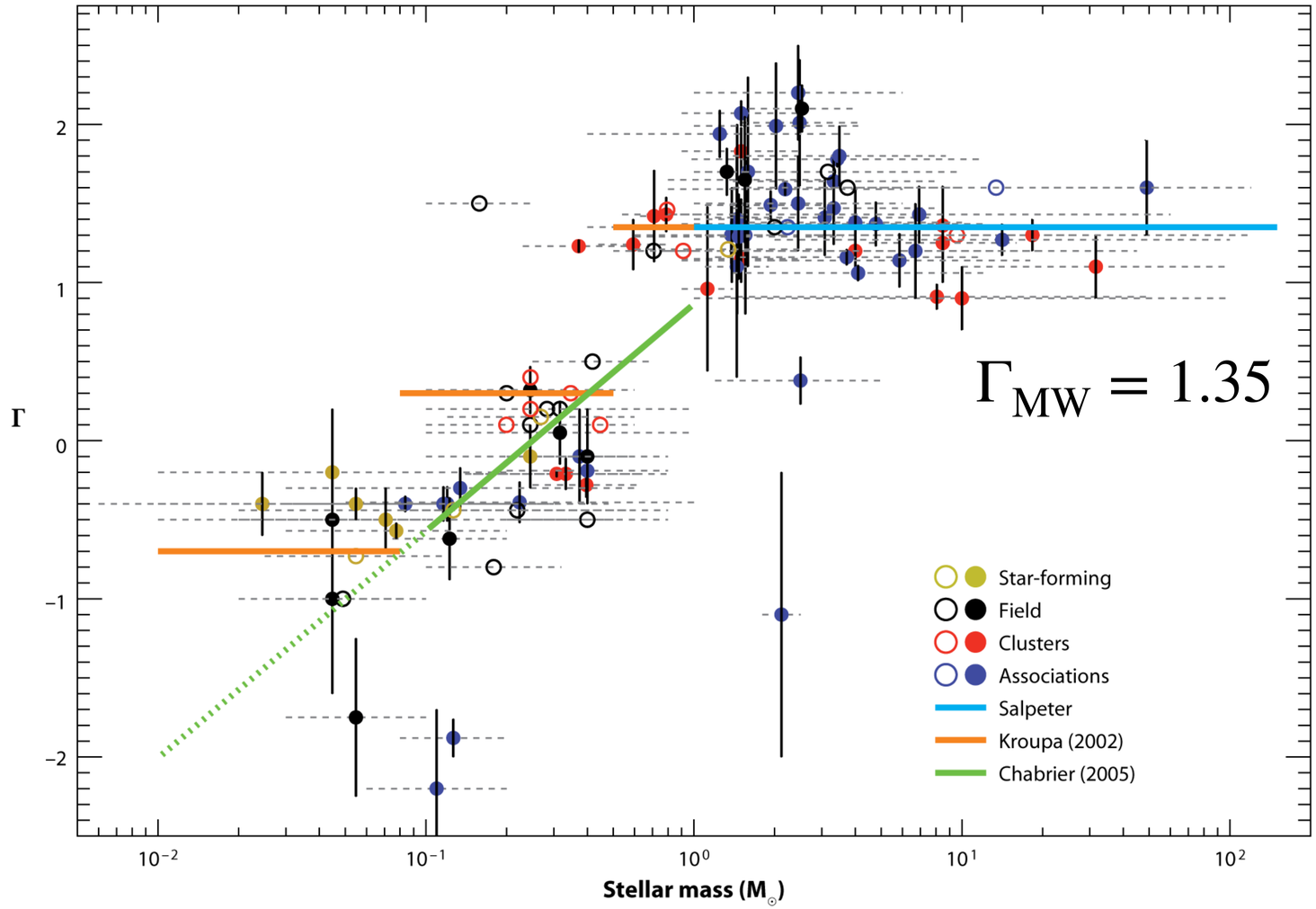
$$Log(\frac{Age}{yr}) = 6.65^{+0.17}_{-0.05}$$

$$A_V = 0.40^{+0.08}_{-0.02}$$

$$\Gamma_{\mathrm{MW}} = 1.35$$

Wainer+ (2024)

Aggregate of IMF Measurements from Resolved Star Counts



Bastian N, et al. 2010.
Annu. Rev. Astron. Astrophys. 48:339–89

Motivation for our in-class exercise

- Resolved star counts are the gold-standard for IMF measurements.
- But many studies, even of the same object, show conflicting results, often to high-levels of formal significance?
- How can we assess the reliability of these results without entirely re-doing the studies?
- Can we at least assess whether their claims are plausible given the most optimistic assumptions?
  - The exact number of how many stars were used
  - The exact masses of the stars
  - All other complications were perfectly dealt with