Baby Elliptical Galaxies or Non-Universal IMFs?

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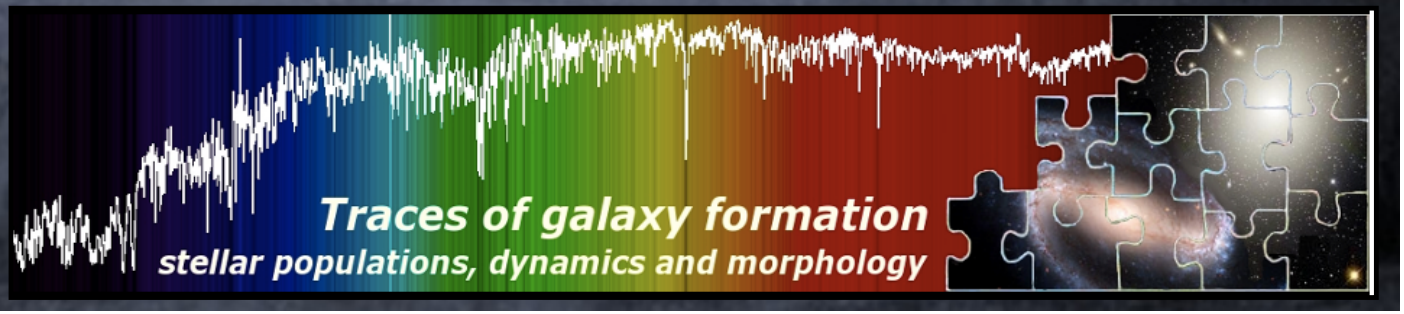
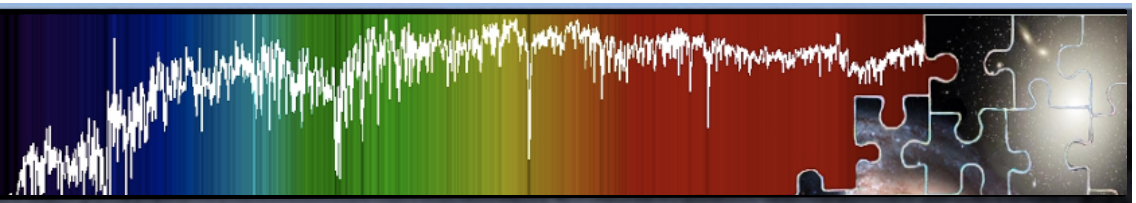
& A. Vazdekis & I. G. de la Rosa

"A fresh look into the stellar IMF" SpS12,
EWASS 2013, 12th July 2013

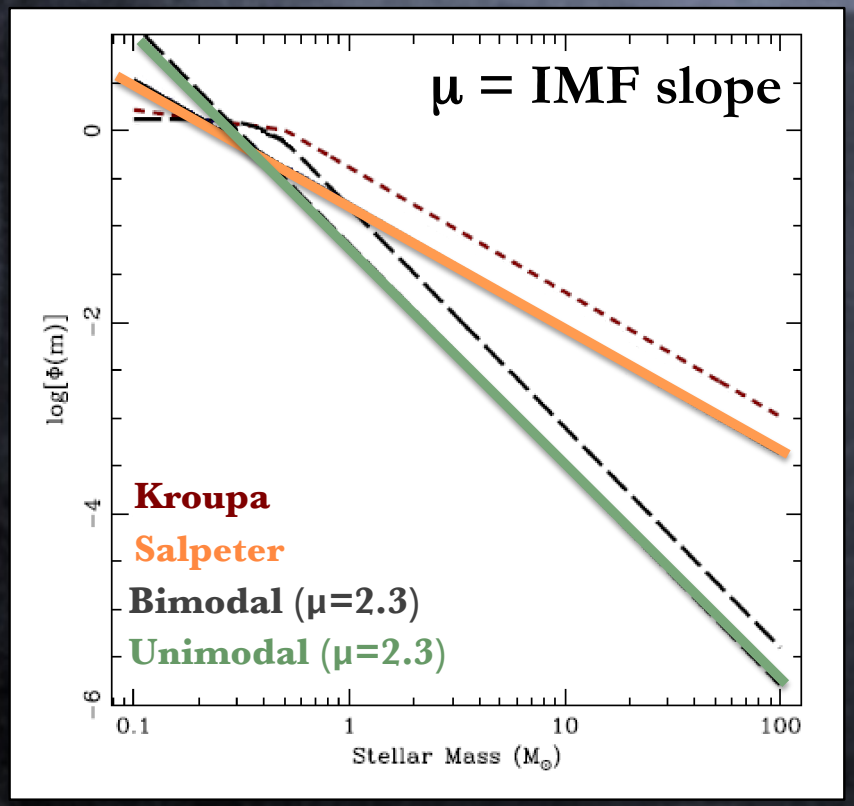


Does God play dice?



UNIVERSAL (e.h. Gilmore 2001, Bastian 2010, Renzini 2012, Narayanan 2012)

1) Single power-law: **SALPETER** (Salpeter 1955)
2) Multi-segmented power-law: **KROUPA** (Kroupa 2001)
3) Log-normal: CHABRIER (Chabrier 2003)



NON- UNIVERSAL

1) Spectral features (e.g. Vazdekis et al. 2003, Cenarro et al 2003, Falcón-Barroso et al. 2003, Conroy & van Dokkum 2012, Spiniello et al. 2012, Ferreras et al. 2013, La Barbera et al. 2013, Spiniello et al. 2013)

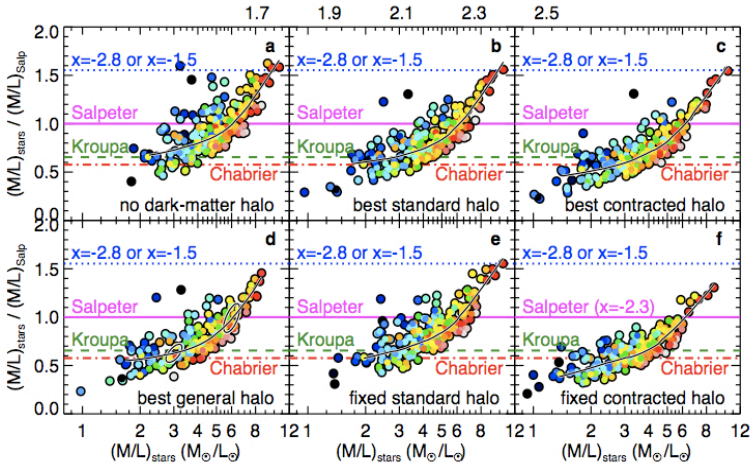
2) Colours (e.g. Dutton et al. 2012, Pforr et al. 2012, Ricciardelli et al. 2012, Vazdekis et al. 2012)

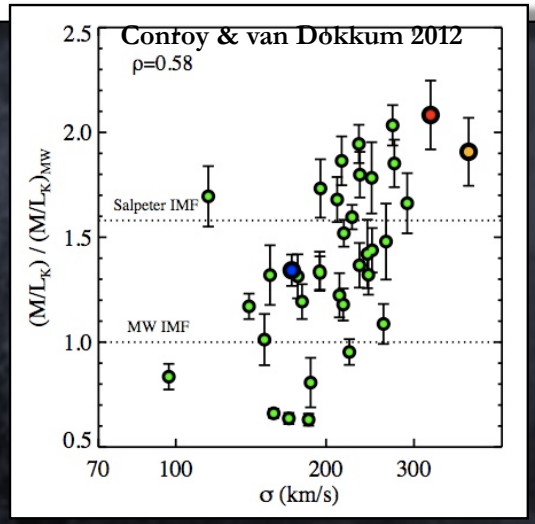
3) Dark matter (e.g. Auger et al. 2010, Treu et al. 2010, Cappellari et al. 2012, Dutton et al. 2012, Sonnenfeld et al. 2012, Tortora et al. 2013)

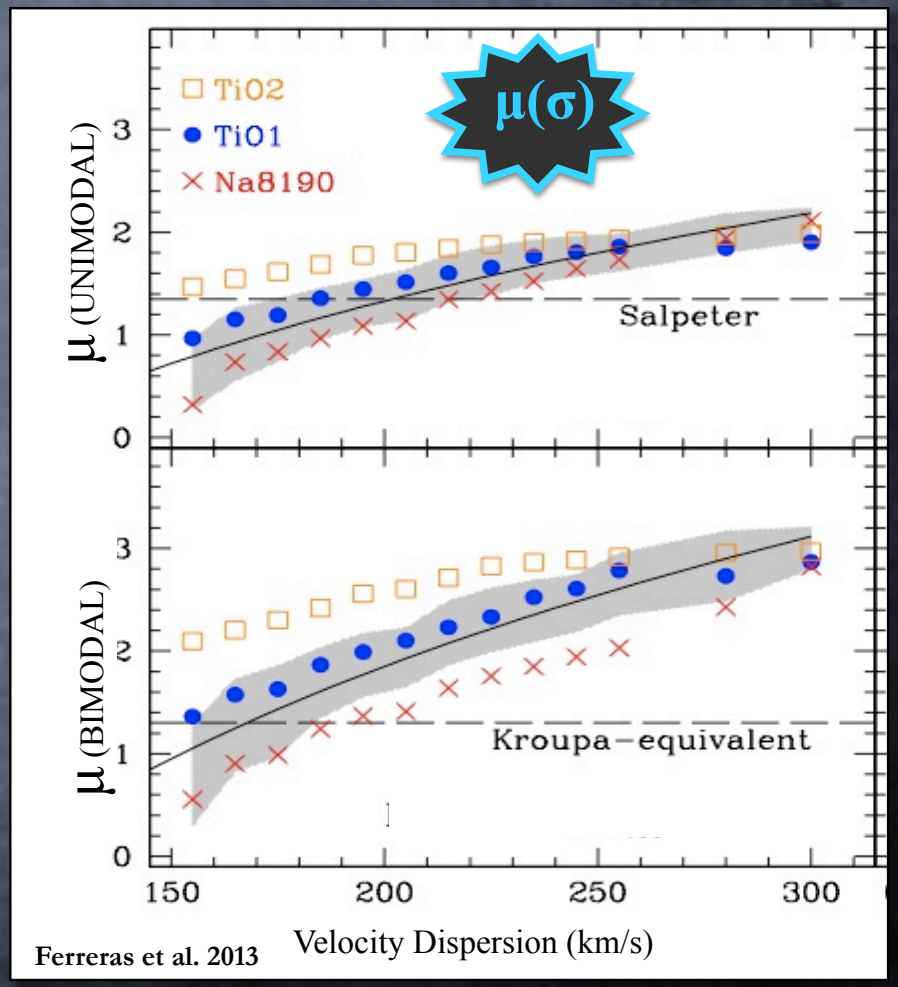
Evidences for a non-Universal IMF

Stellar IMF depends on galaxy velocity dispersion:
Massive galaxies → steeper IMFs than Salpeter

Cappellari et al. 2012



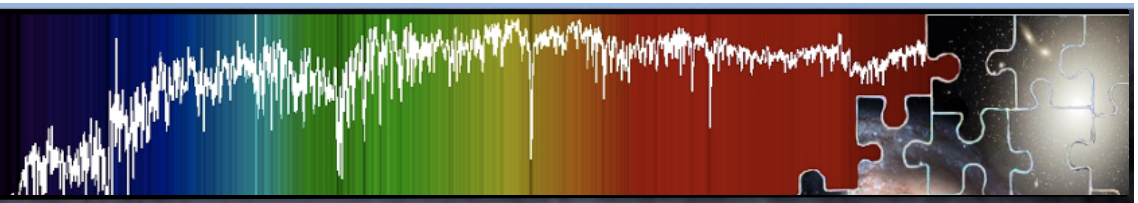




Ferreras et al. 2013

Ferreras et al. 2013

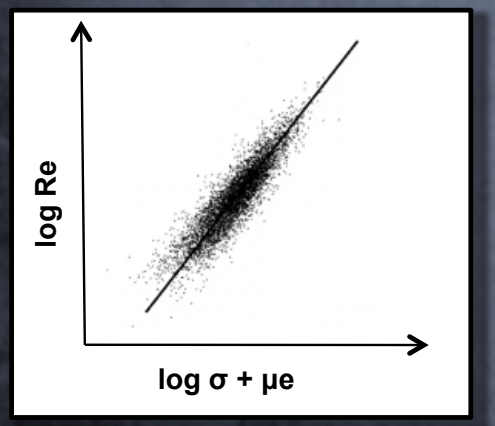
Do we really need to care?

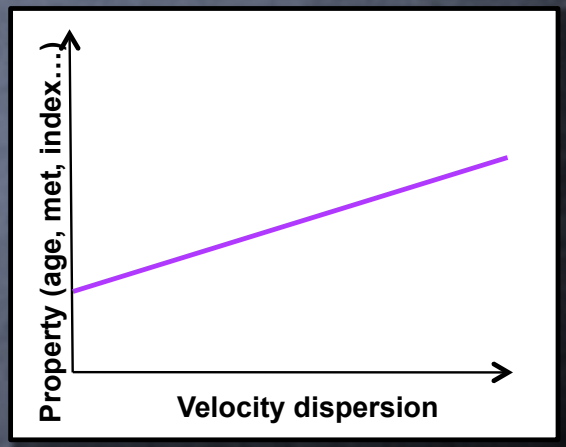


I'm just a humble observer that works in…

STELLAR POPULATION studies to test Galaxy evolution theories
→ with velocity dispersion e.g.:
the Fundamental Plane , scaling relations

(e.g. Bender et al. 1992, Kuntschner et al. 1998, Jorgensen et al. 1999, Poggianti et al. 2001, Terlevich et al. 2001, Kauffmann et al. 2003, Gallazzi et al. 2006)





Are our results biased by the assumption of a universal IMF?

Our Plan

MIUSCAT SSP models with μ=[0.8, 1.0, 1.3, 1.8, 2.3]

(Vazdekis et al. 2012 & Ricciardelli et al. 2012)

MILES Population Synthesis for the 21st Century

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Tune SSP model spectra

This tool should be use to obtain the spectra and line-strength predictions for a set of SSP models within a range of input parameters. It allows the adjustment of the resulting spectra to a particular instrumental setup and format. This tool is useful to be able to directly compare the models with data from the user.

INSTRUCTIONS:

Show/Hide Instructions

Input parameters

SSP models	Type of IMF	IMF slope	Mode	[M/H]	Age (Gyr)
MIUSCAT	ku	1.30	SAFE	-2.32 -1.71 -1.31 -0.71 -0.40 +0.00 +0.22	00.0631 00.0708 00.0794 00.0891 00.1000 00.1122 00.1259

ku
kb
un
bi

0.3
0.8
1.0
1.3
1.5
1.8
2.0
2.3
2.8
3.3

Output parameters (help)

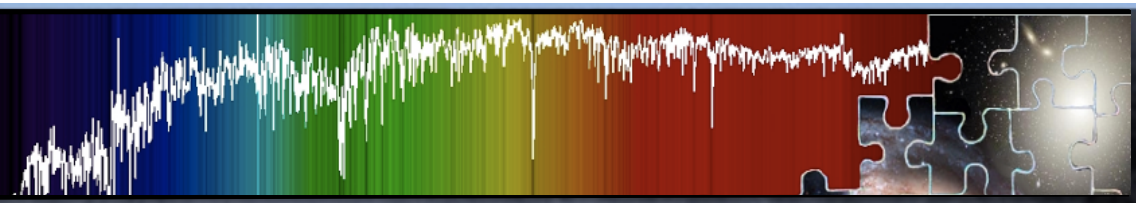
λInitial (Å)	λFinal (Å)	Δλ (Å/pix)	Sampling	Redshift (z)	Resolution	Format
3464.9	9468.8	0.9	Linear	0.0	2.51 FWHM (Å)	FITS

Enter the filename with the filter responses (Seleccionar archivo) ningún arc...leccionado (**Default:** filters_default.res)

Zeropoint: Vega (Hayes 1985)

Submit Query Reset

Our Plan



MIUSCAT SSP models with μ=[0.8, 1.0, **1.3**, 1.8, 2.3]
(Vazdekis et al. 2012 & Ricciardelli et al. 2012)

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\+

≅ Salpeter in the UNIMODAL case

≅ Kroupa universal in the BIMODAL case

STARLIGHT (Cid Fernandes et al. 2005) : full-spectrum-fitting code to recover the SFHs of a sample of ETGs covering a range in velocity dispersions:

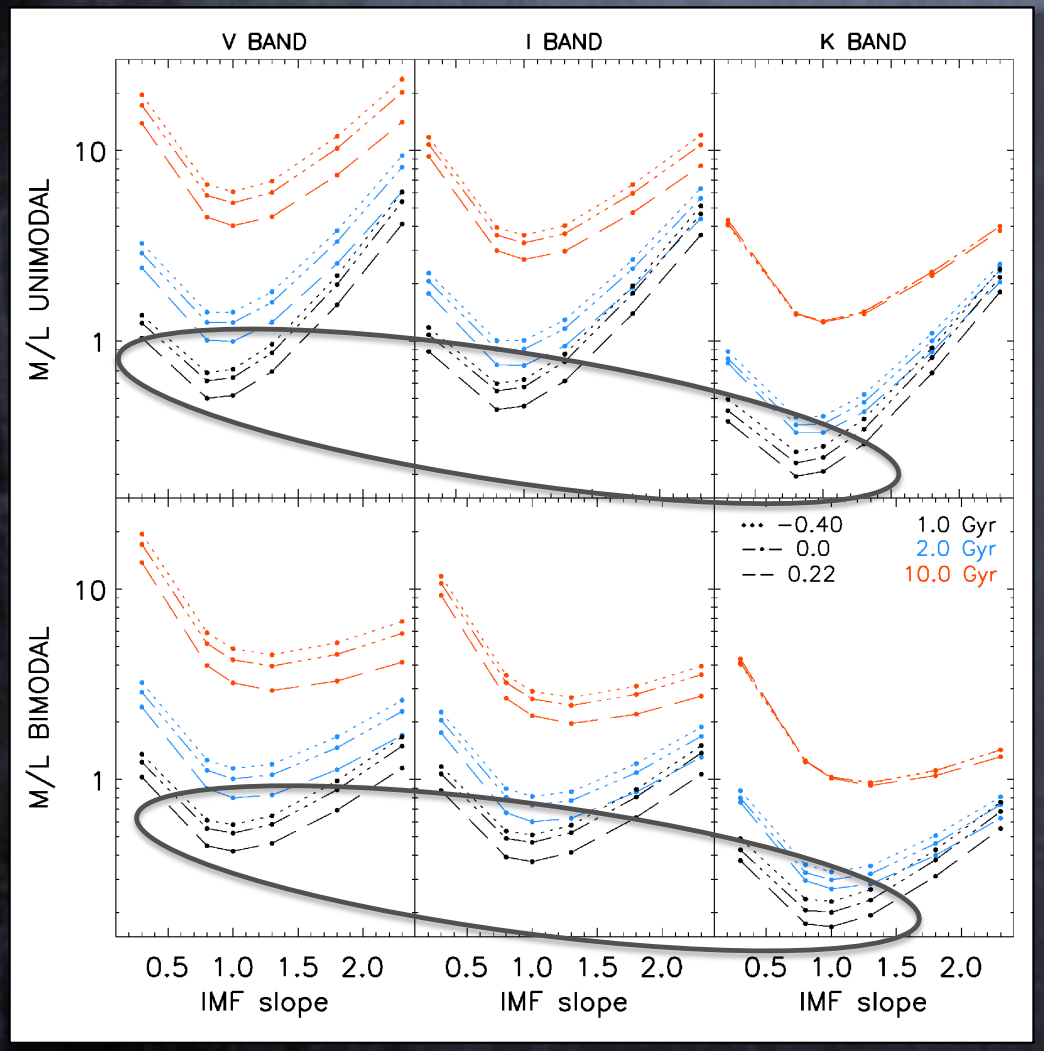
Very Massive Ellipticals (VME; 250-300 km/s) Yamada 2006, Sánchez-Blázquez et al. 2006
Massive Ellipticals (ME; 180-250 km/s) Yamada 2006, Sánchez-Blázquez et al. 2006
Low Mass Elliptical (LME; < 180km/s) Yamada 2006, Sánchez-Blázquez et al. 2006

=

Stellar population parameters as a function of the IMF: M/L, derived SFHs, mean (L/M-weigthed) ages, stellar masses, …

Ferré-Mateu, Vazdekis & de la Rosa 2013, MNRAS, 431, 440

Mass-to-light Ratios



Mass-to-light ratio from the models:

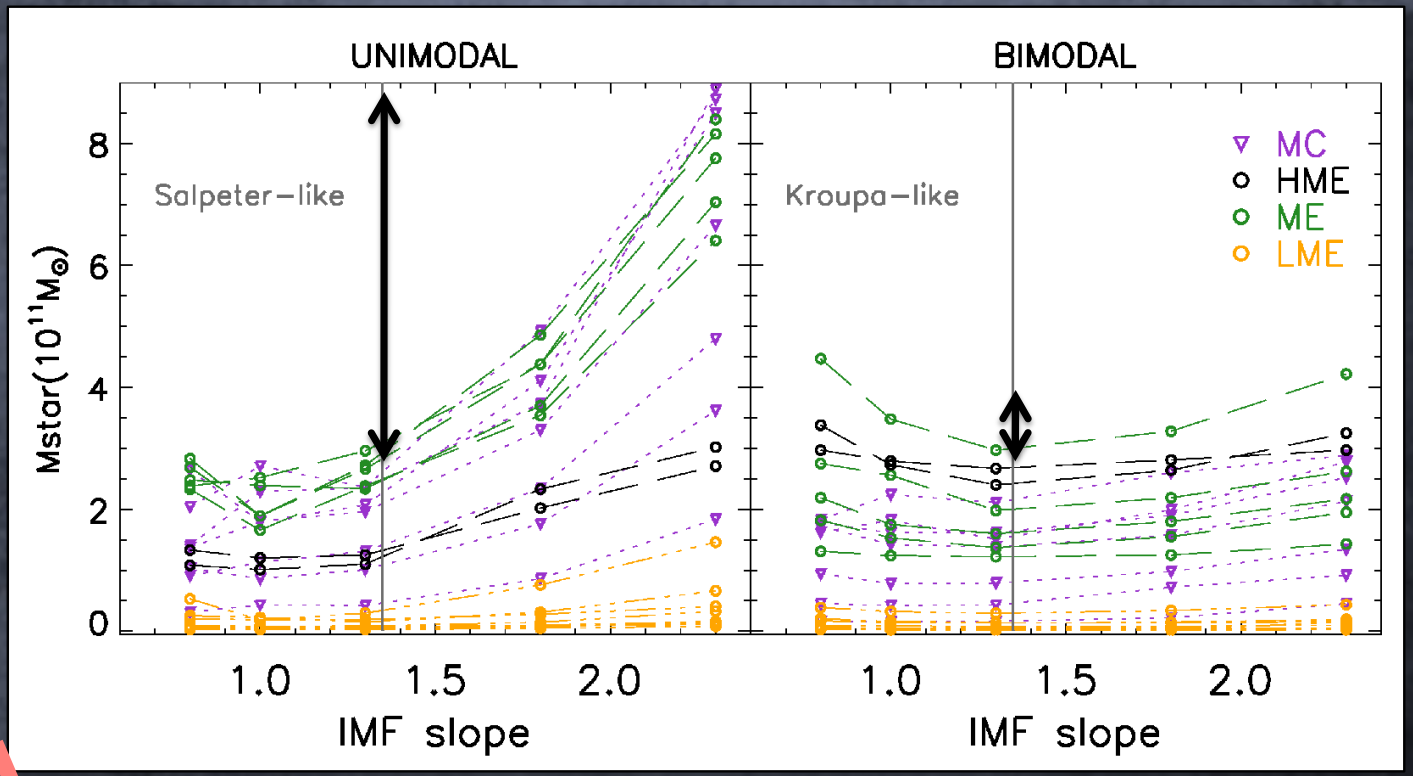
- Presents a minimum that depends on the age of the SSP → stellar remnants

- Depends on the broad-band filter

Emphasized in the UNIMODAL case

Quantifying the impact into …

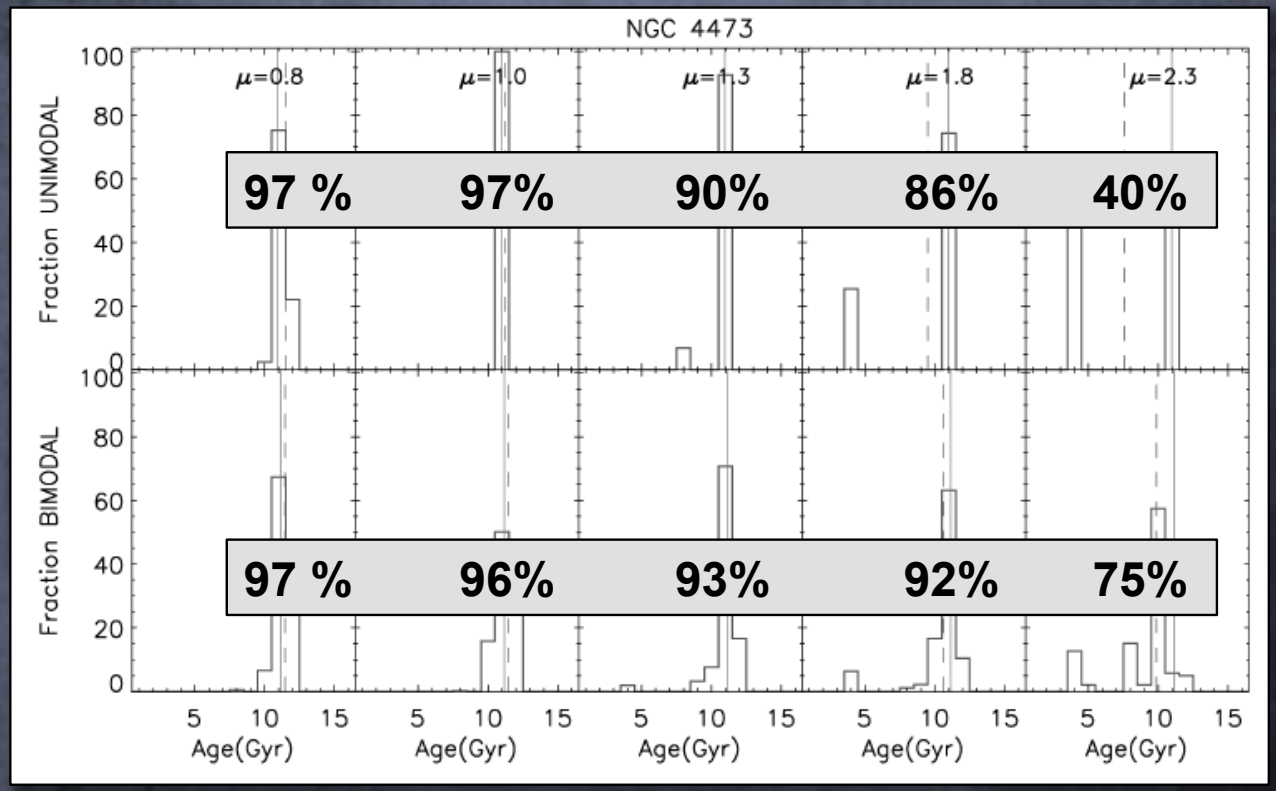
… stellar masses: steeper → more massive



Missing galaxies in samples if selected by their M*

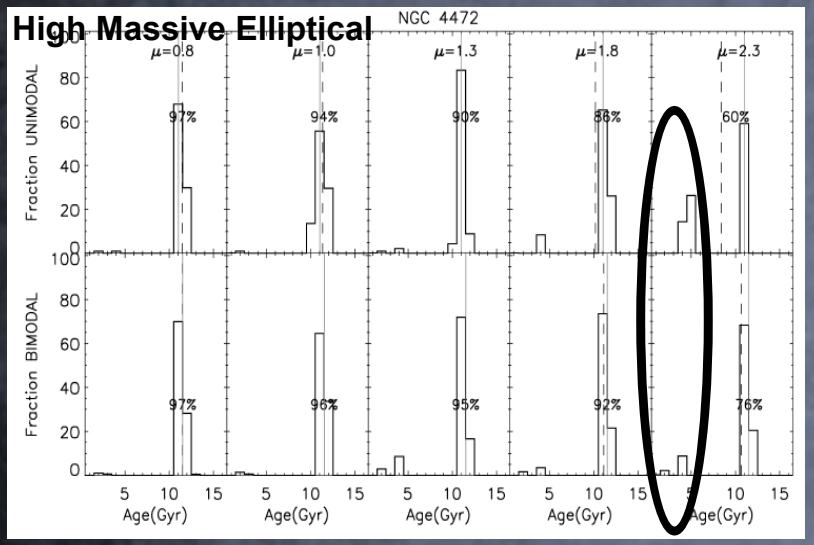
Quantifying the impact into …

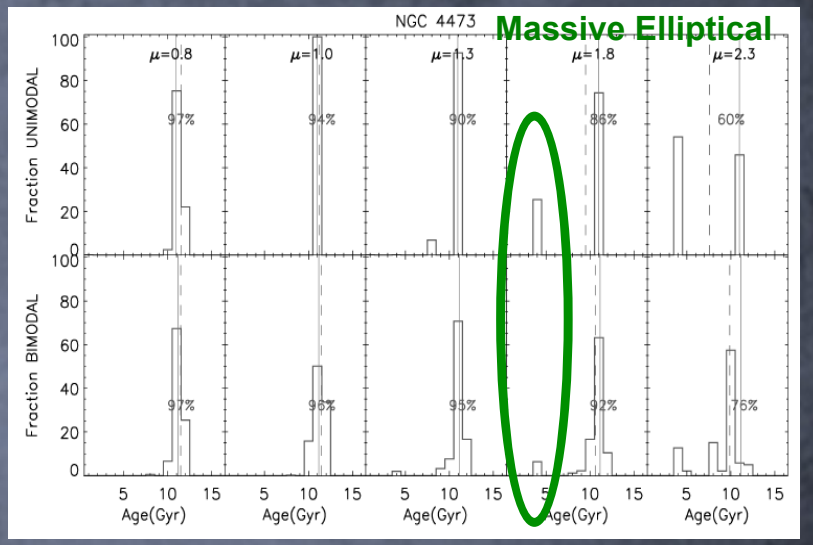
… mean ages: steeper → younger, young components appear while old components decrease/disappear

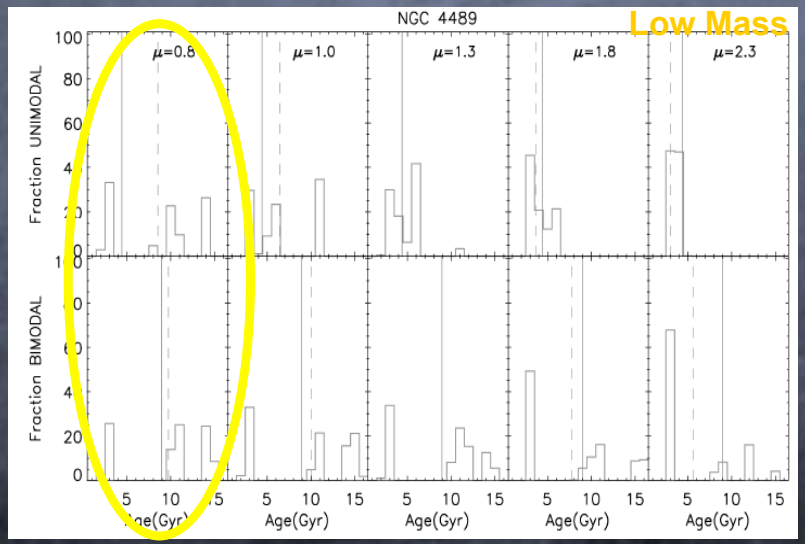


Missing galaxies in samples if selected by their ages and light IMFs will render OLD ages.

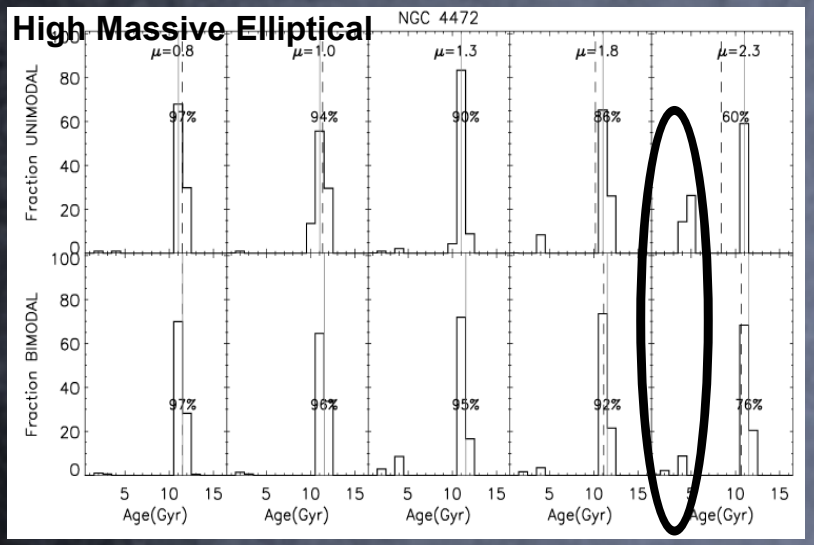
μ(σ) Star Formation Histories

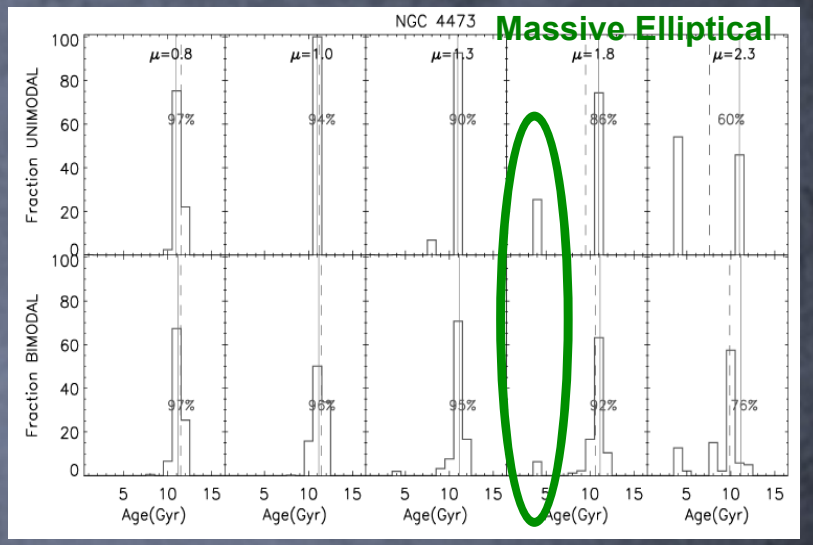






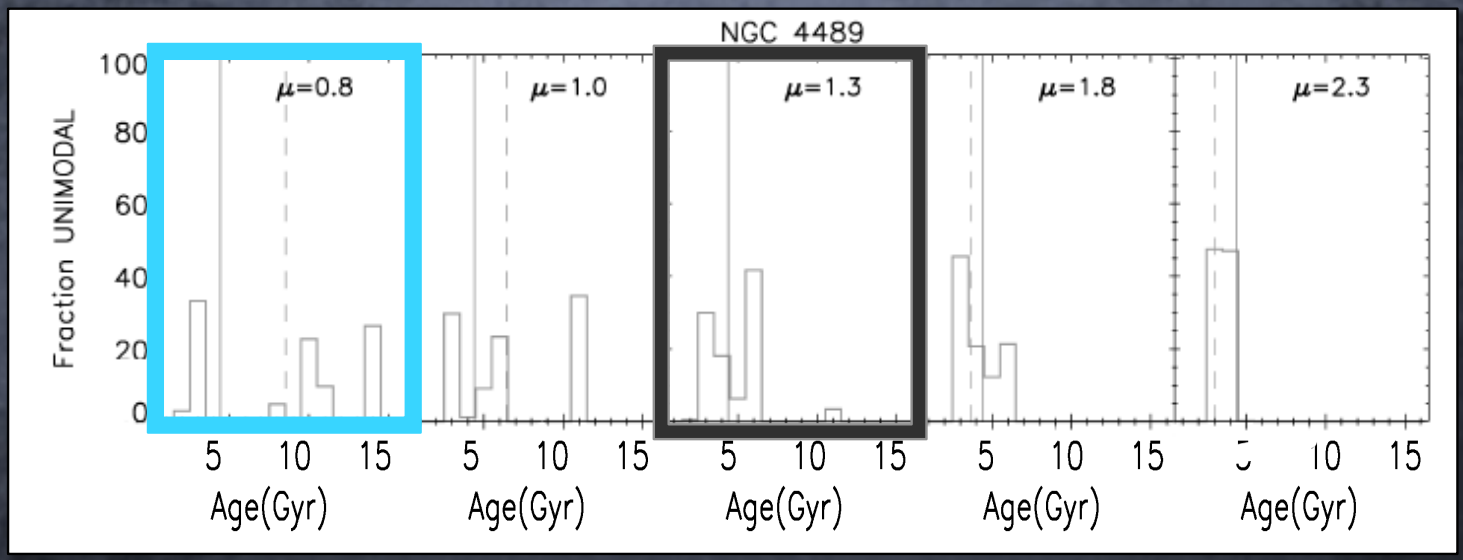
μ(σ) Star Formation Histories





NON-UNIVERSAL IMFs RENDER SIMILAR SFHs WITH A COMMON PATTERN FOR ALL ETGs: A VARYING AMOUNT OF RESIDUAL STAR FORMATION, WHICH DEPENDS ON THE MASS.

Baby Elliptical Galaxies?



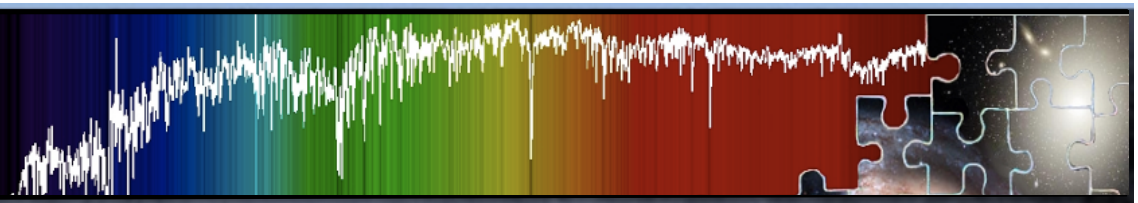
μ-σ relation IMFs

More similar to the SFHs of ellipticals

STANDARD IMFs

Completely young galaxies, *a.k.a* Baby Elliptical Galaxies

Conclusions



❖ New evidences towards a NON-UNIVERSAL IMF related to the VELOCITY DISPERSION of galaxies → need for new TUNABLE stellar populations synthesis models (MIUSCAT)

❖ BIASES→ To steepen the IMF slope implies…

- Younger ages (more contribution from the young SSPs)
- Desapearance/decrease of the OLD component
- More massive galaxies (higher Mstar)
- SFHs of ellipticals no longer fitted with a single old SSP

❖ By using a standard IMF we could claim the unexpected existence of Baby Elliptical galaxies, or missing galaxies in samples.

❖ The choice of an IMF slope according to the velocity dispersion of the galaxy provides comparable SFHs for all ETGs, involving a varying amount of recent residual star formation, which depends on the mass of the galaxy.

If you get an amazing result…first check your IMF

Thanks!