

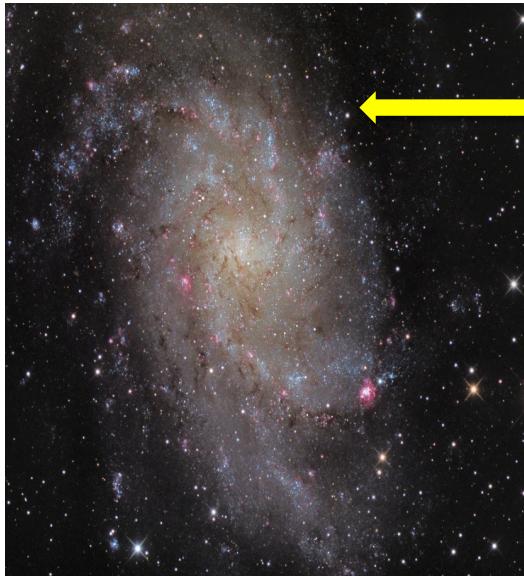
What is a Dwarf Galaxy?

MASS : $\sim 10^5 < M_* < 5 \times 10^9 M_\odot$; $M_v > -19$

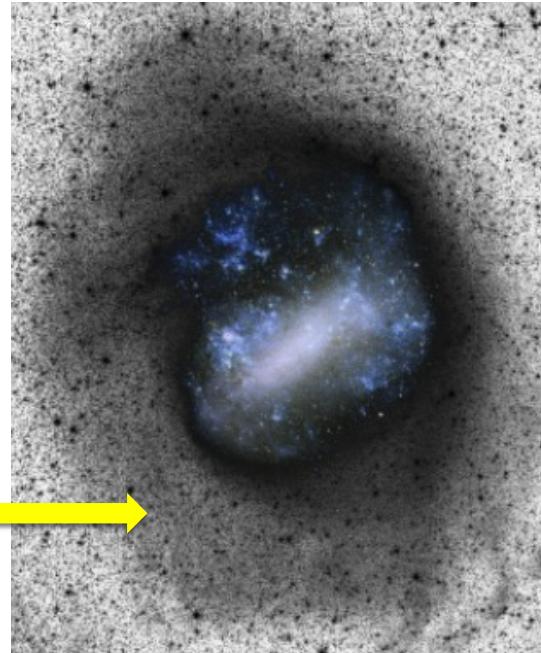
ROTATION CURVE : $V_{\text{rot}} < 100 \text{ km/s}$

METALLICITY : $[\text{Fe}/\text{H}] < -0.4 \sim 1/3 Z_\odot$

Evidence for a dark matter halo

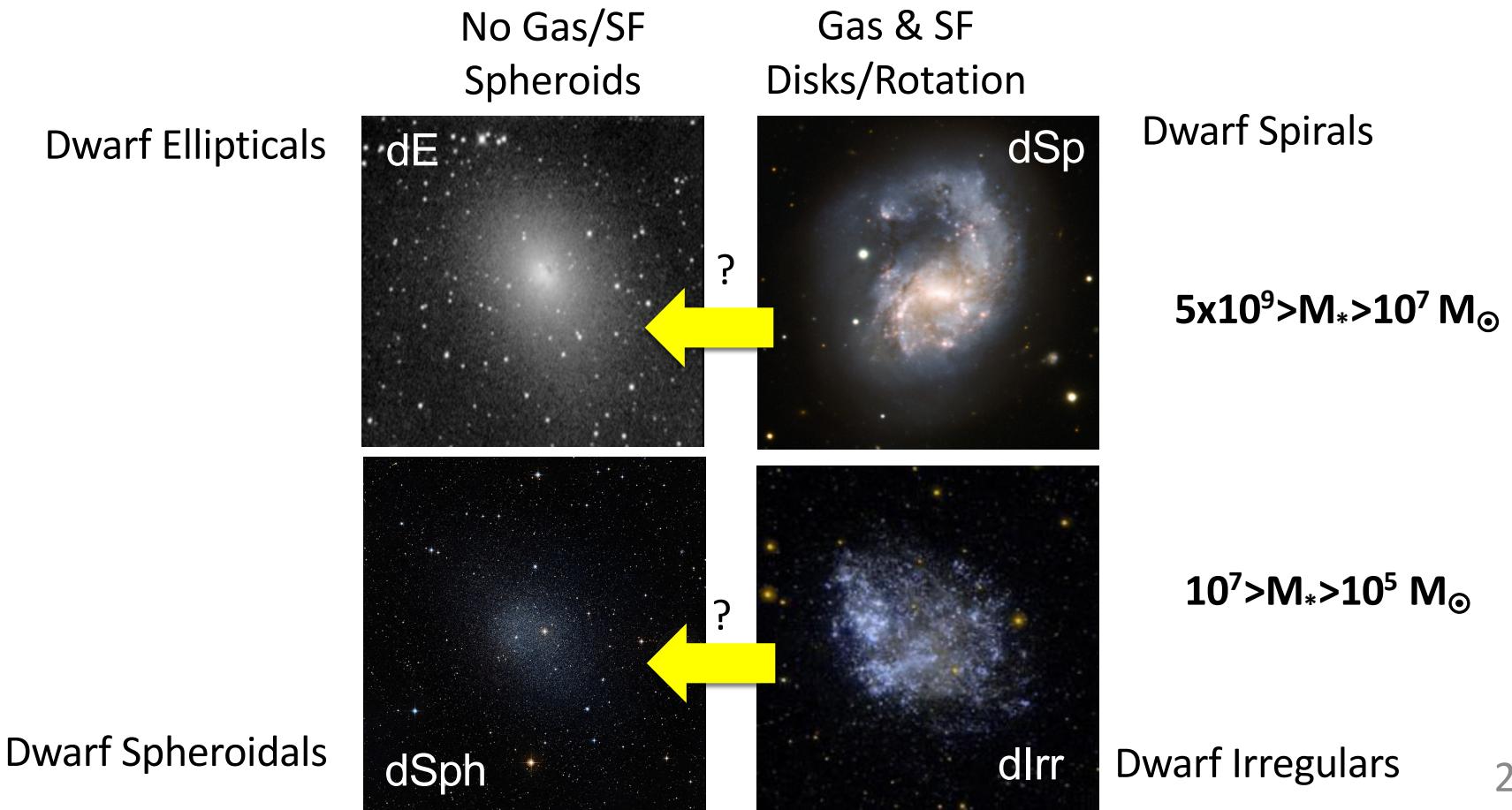


M33 is a satellite, but not a dwarf.

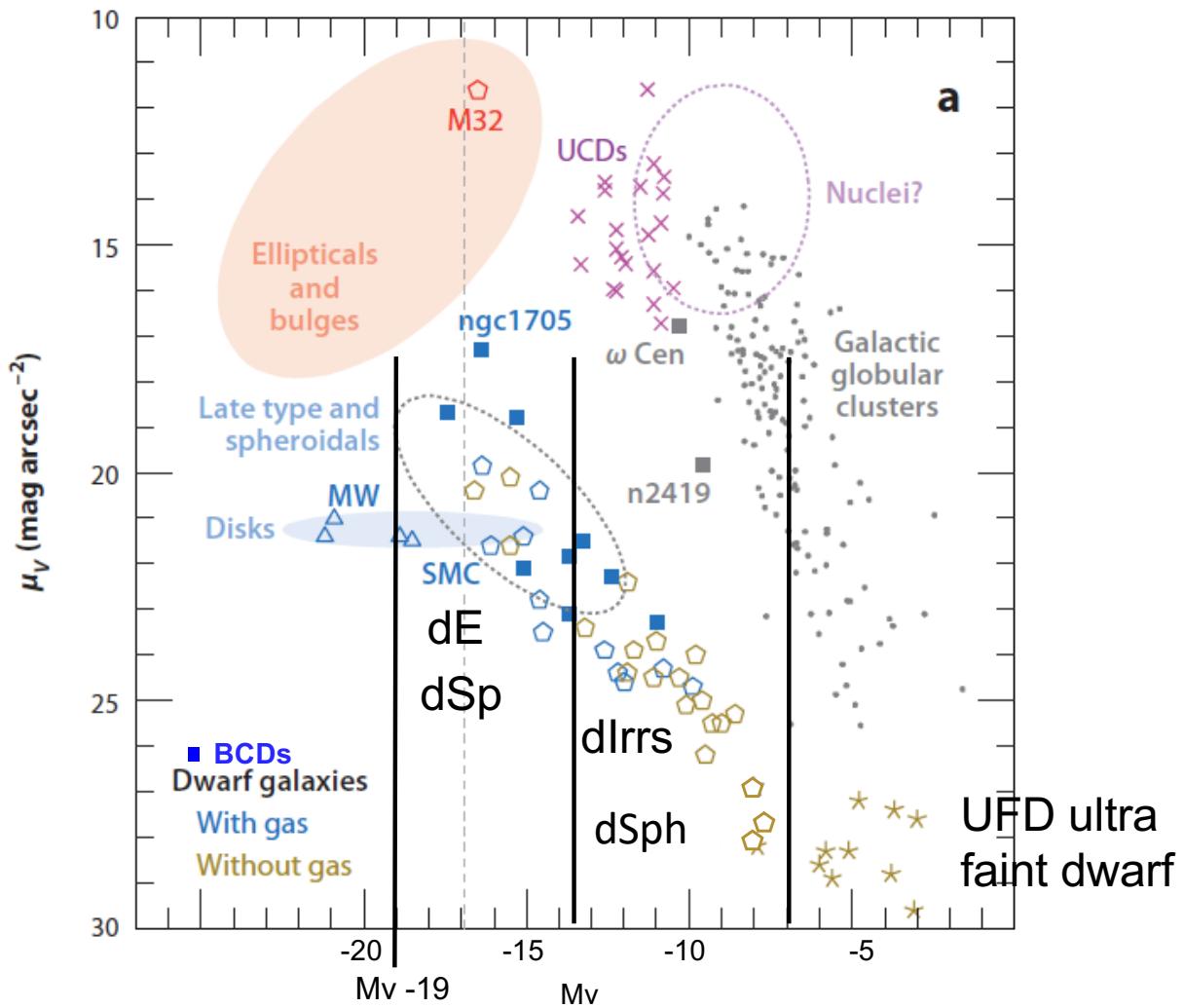


The LMC is both a satellite and a dwarf

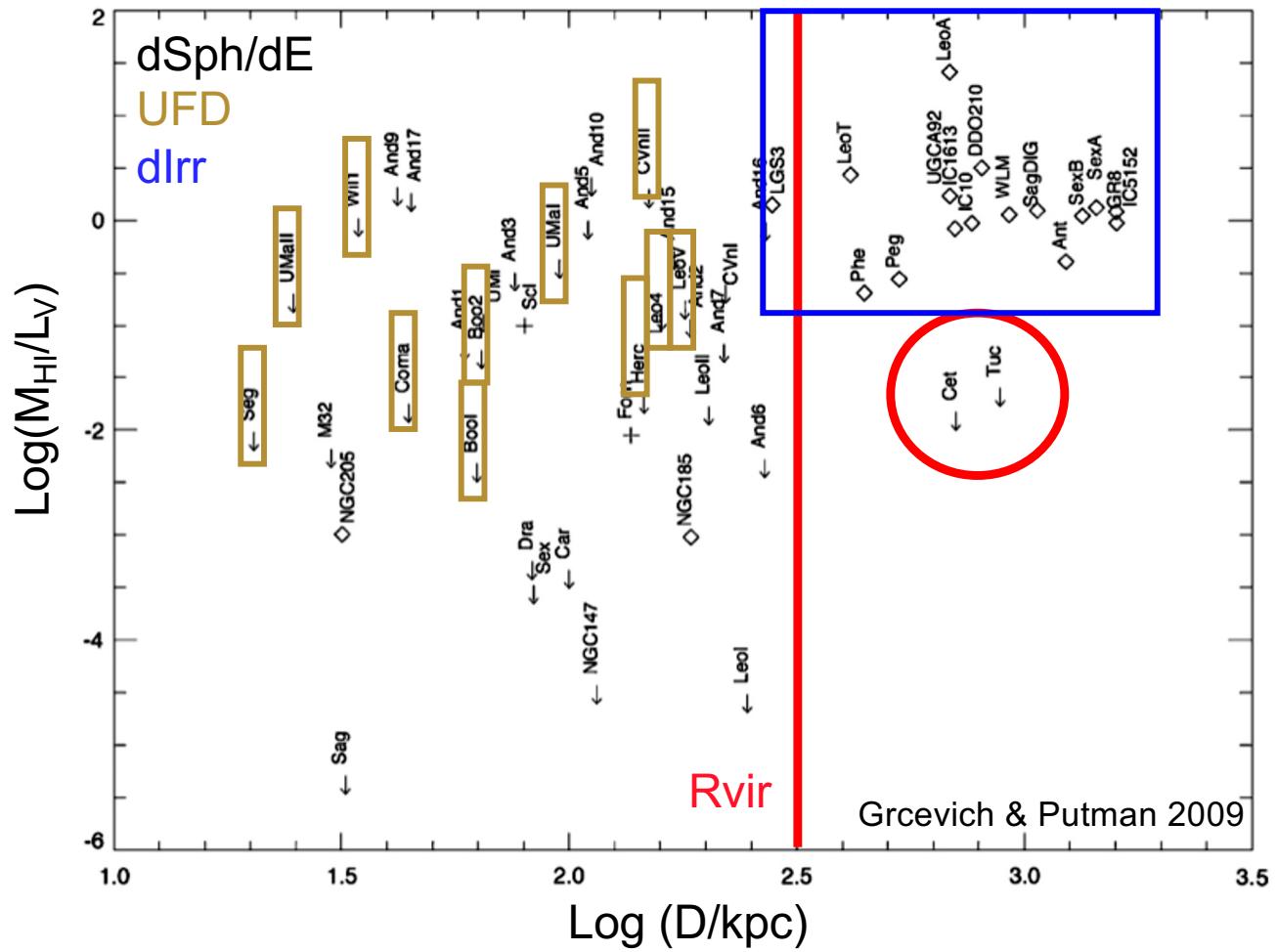
The Dwarf Galaxy Zoo: 2 Main Flavors at all mass scales



Tolstoy+ 2009

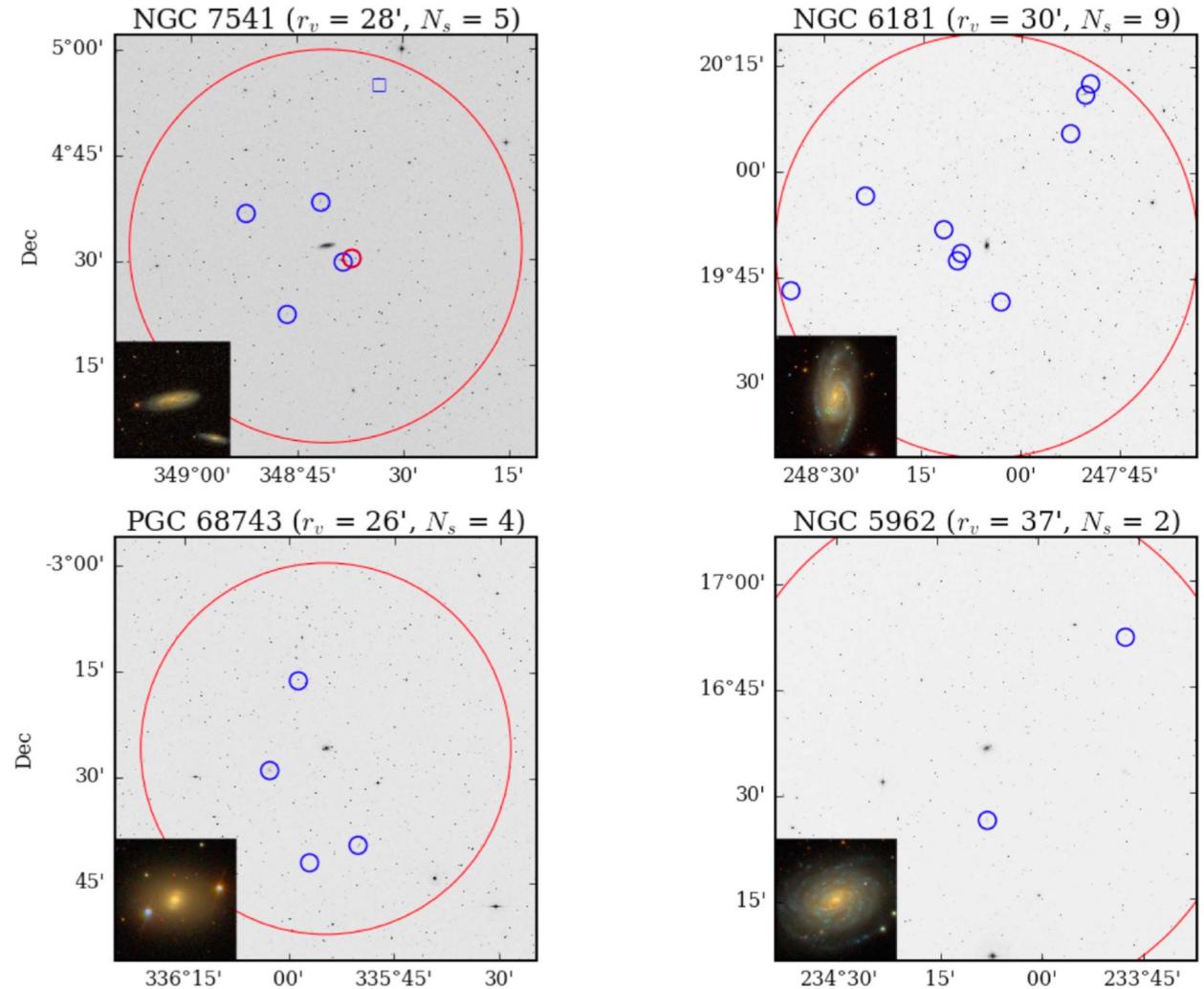


Distance Morphology Relationship



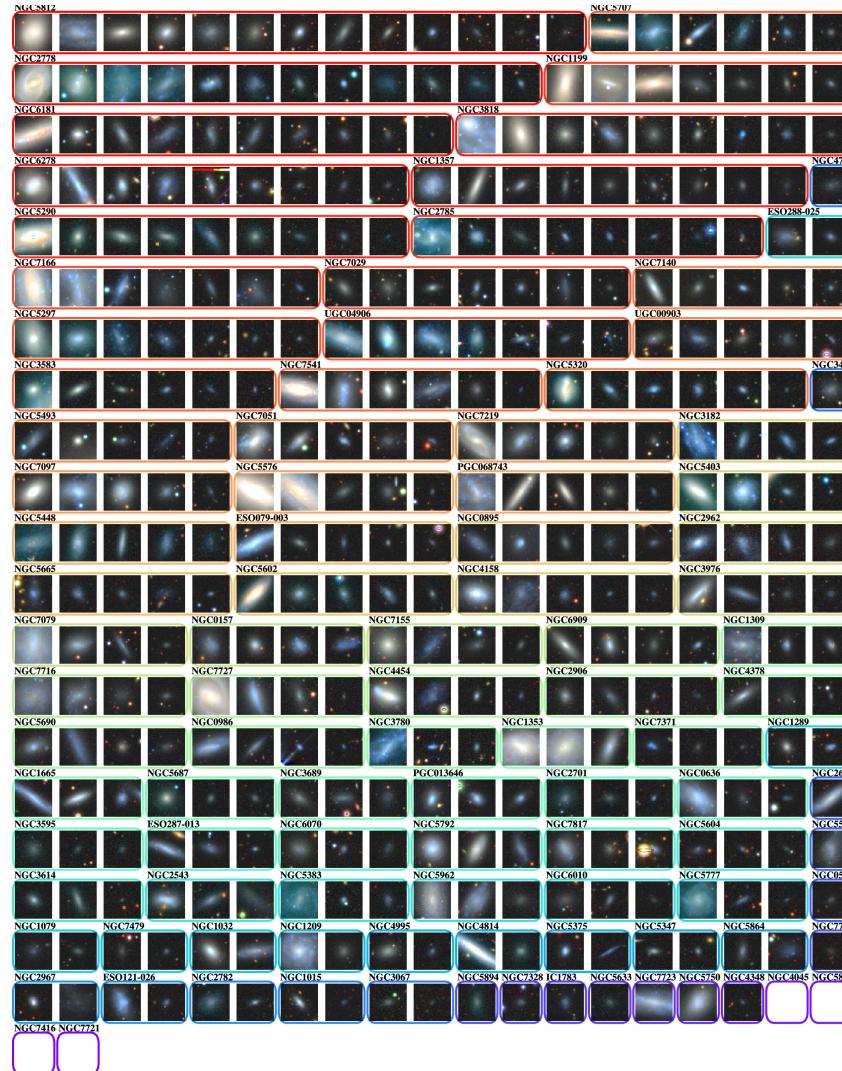
SAGA Survey: Placing the MW and M31 in context

Geha+2017, ApJ , 847
SAGA Survey I



The SAGA Survey DR3 includes **378 satellites** identified across **101 MW-mass systems** in the distance range of **25–40.75 Mpc**

SAGA Survey III
Yao-Yuan Mao et al 2024 *ApJ* **976**

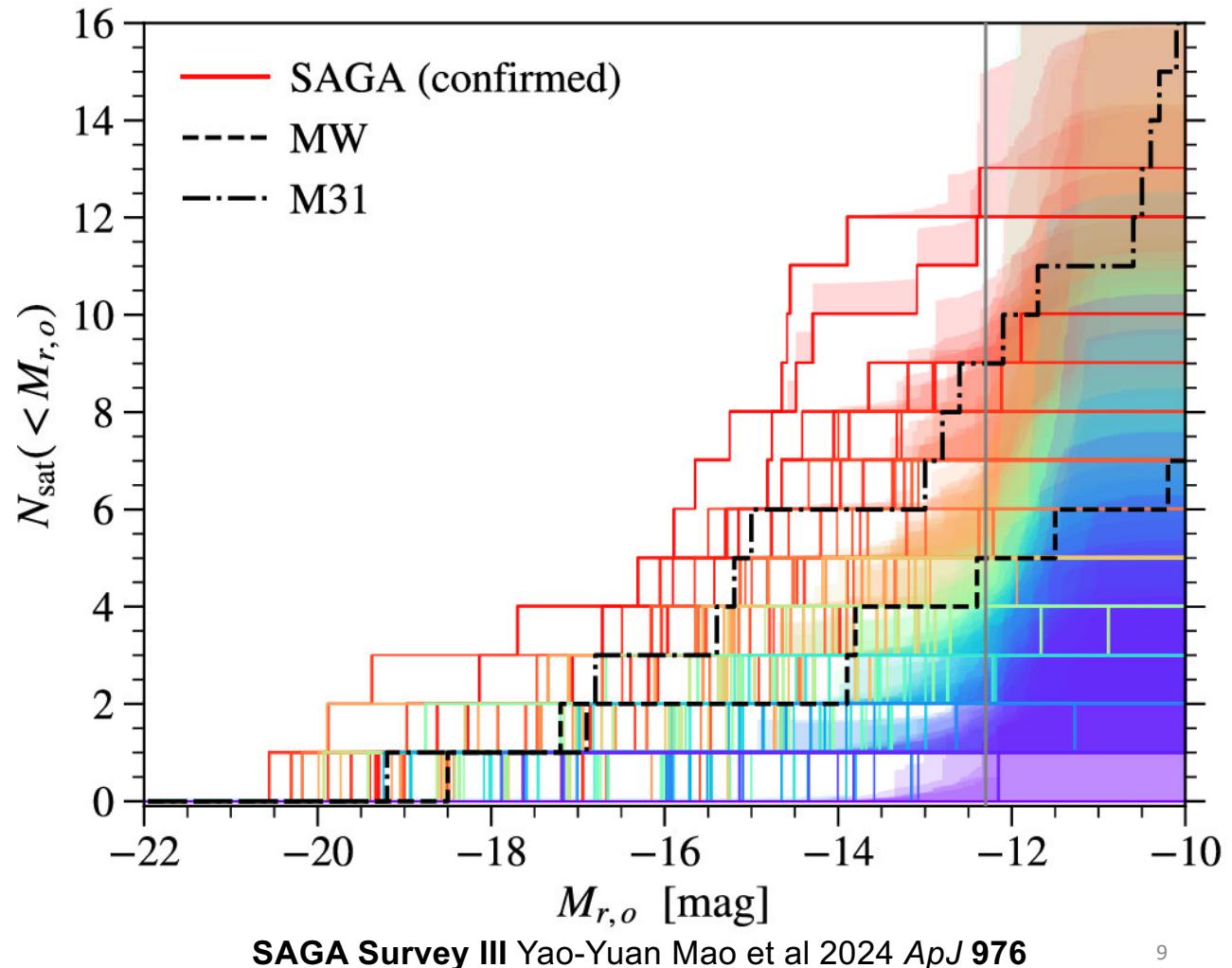


“Perhaps the most remarkable aspect of the SAGA results is how this exhibit satellite systems around MW analogs solidifies the idea that our very own satellite system of the MW is just one “realization” from a diverse distribution.”

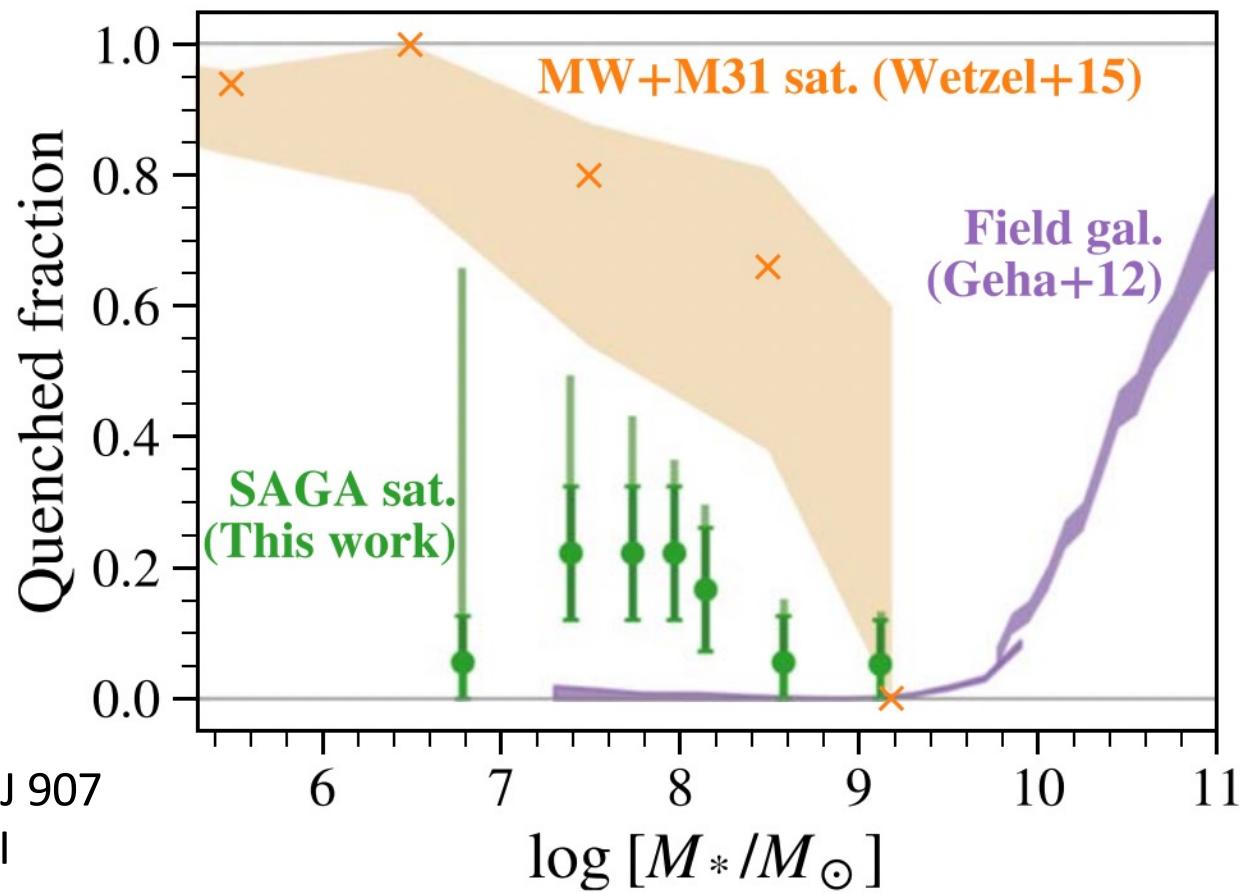
Mao+2021

ApJ 907

SAGA Survey II



SAGA Quenched Fraction (satellites galaxies of MW analogs)



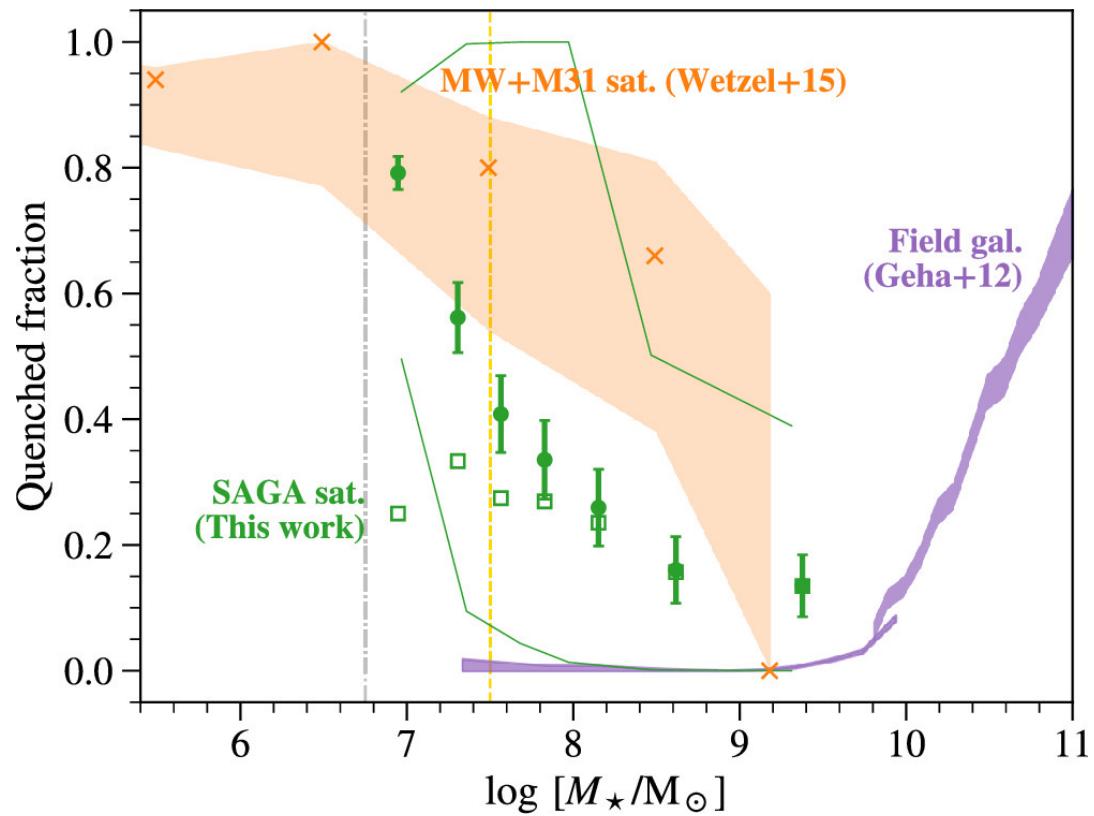
Mao+2021 ApJ 907

SAGA Survey II

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SAGA Quenched Fraction - Update

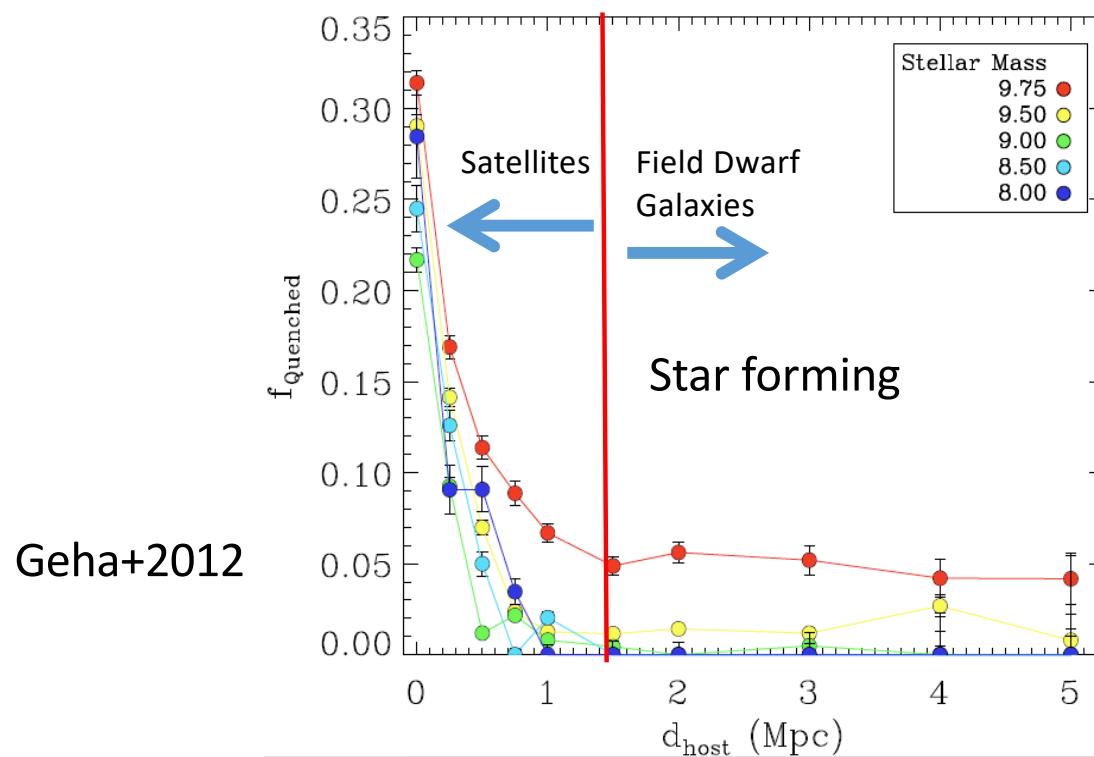
SAGA quenched fraction below $10^{8.5} M_{\odot}$ is lower than the MW's, but in both cases, the MW is within 1σ of SAGA system-to-system scatter



SAGA Survey III
Yao-Yuan Mao et al 2024 *ApJ* 976

Dwarf galaxies are gas rich & forming stars
UNLESS they are close to a massive galaxy

Dwarfs (10^8 - $10^9 M_{\odot}$) DON'T quench via secular processes



Quenched

No strong H α emission (EW < 2 Angstrom) [no star forming regions]
+ a strong 4000 Angstrom-break [spectrum dominated by old stars]

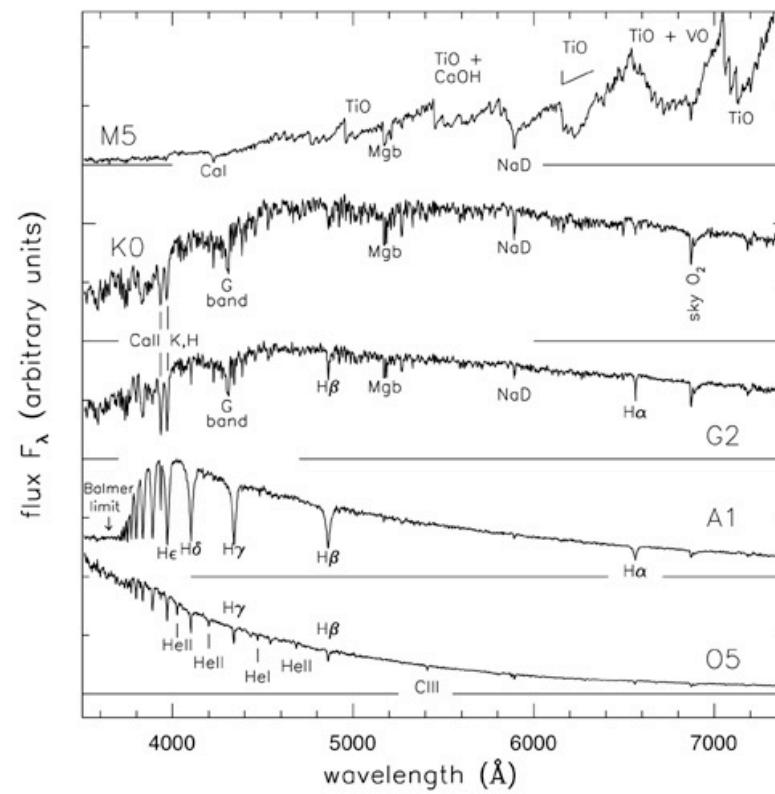
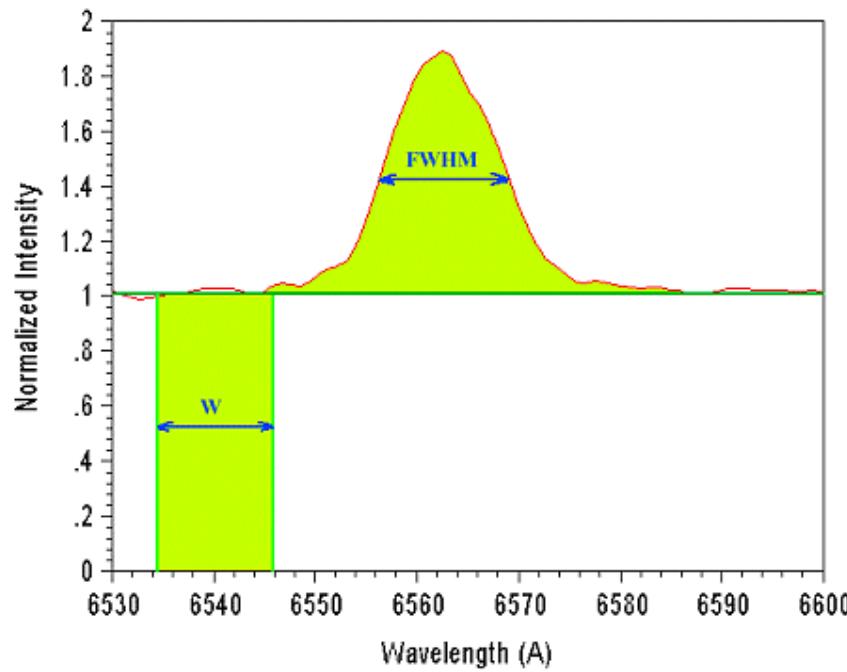
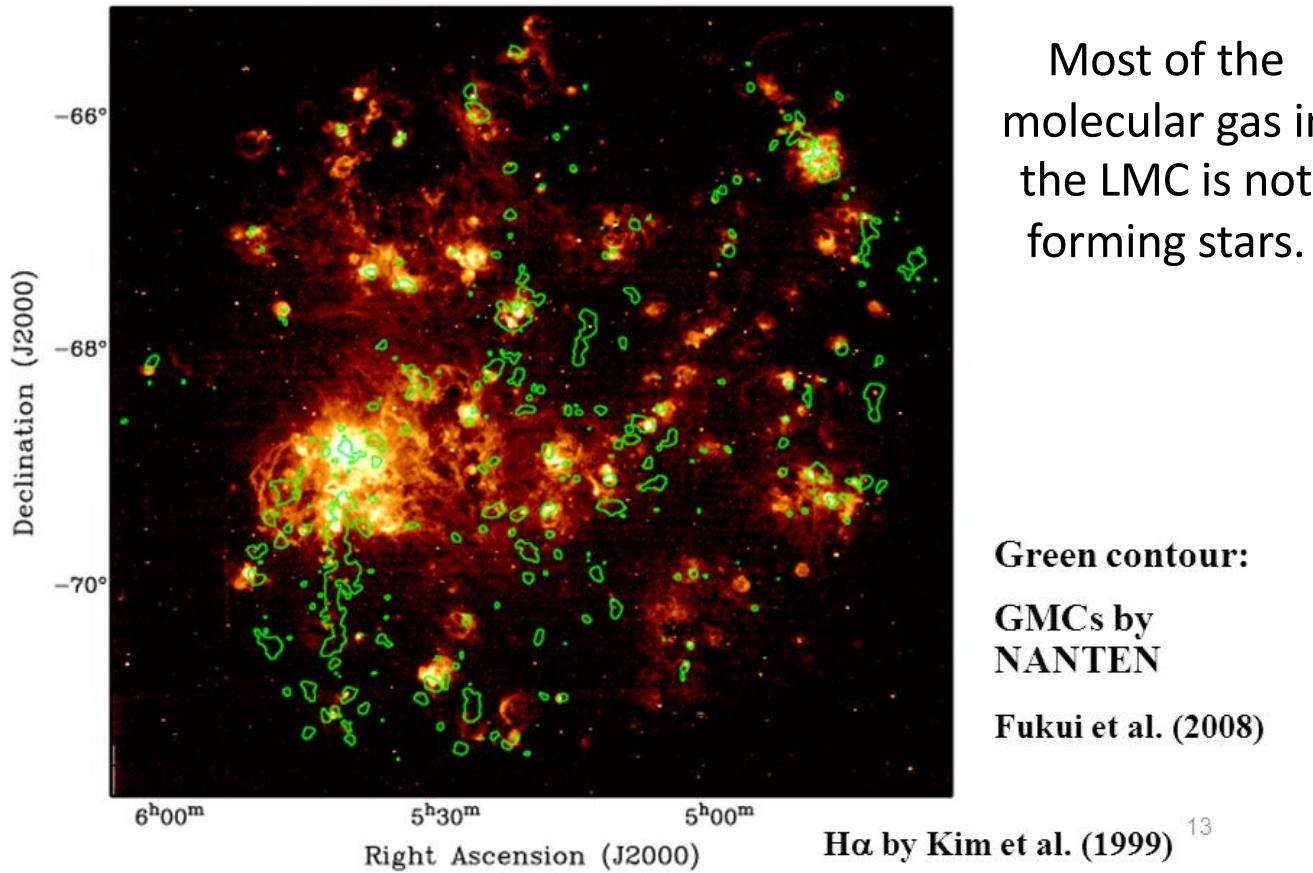


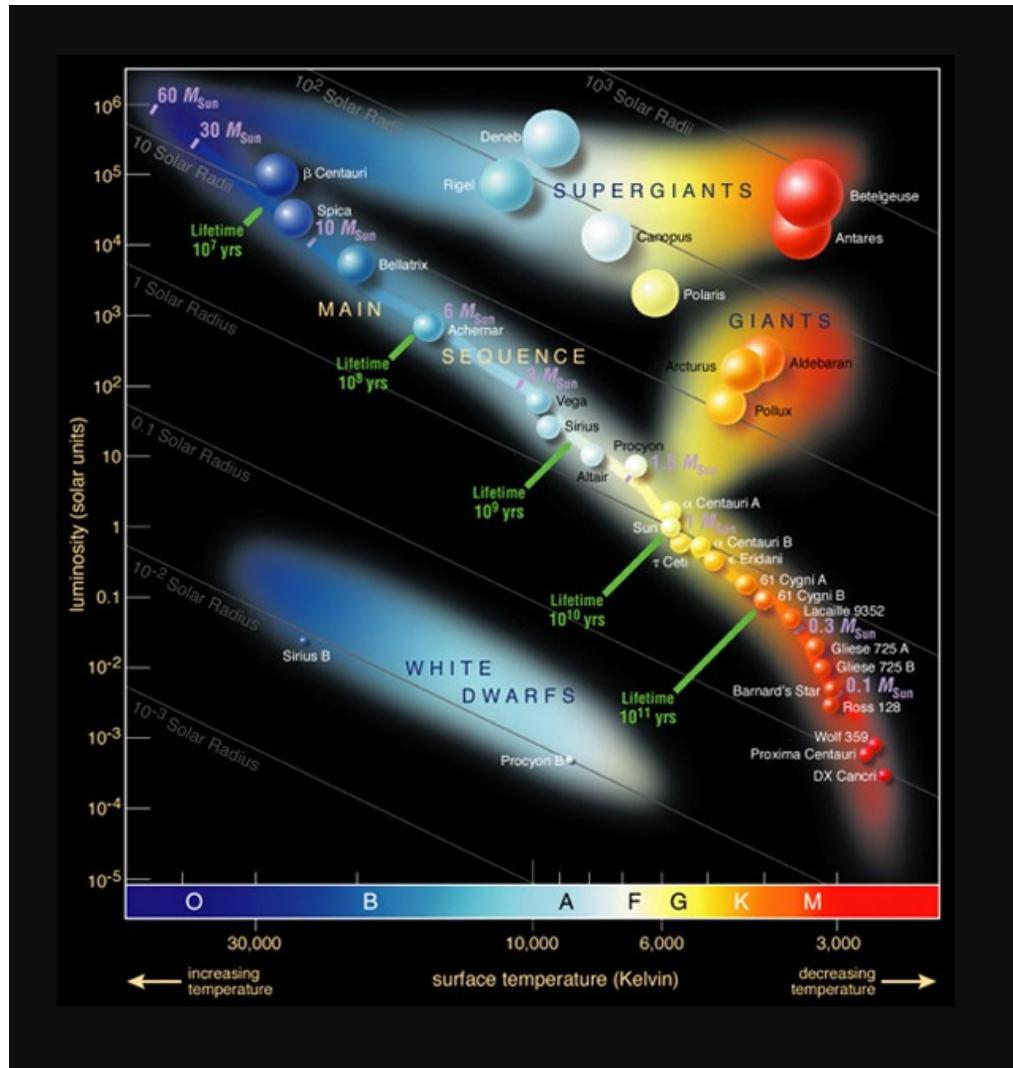
Fig 1.1 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

Star formation is inefficient at low metallicity
LMC: CO and H α

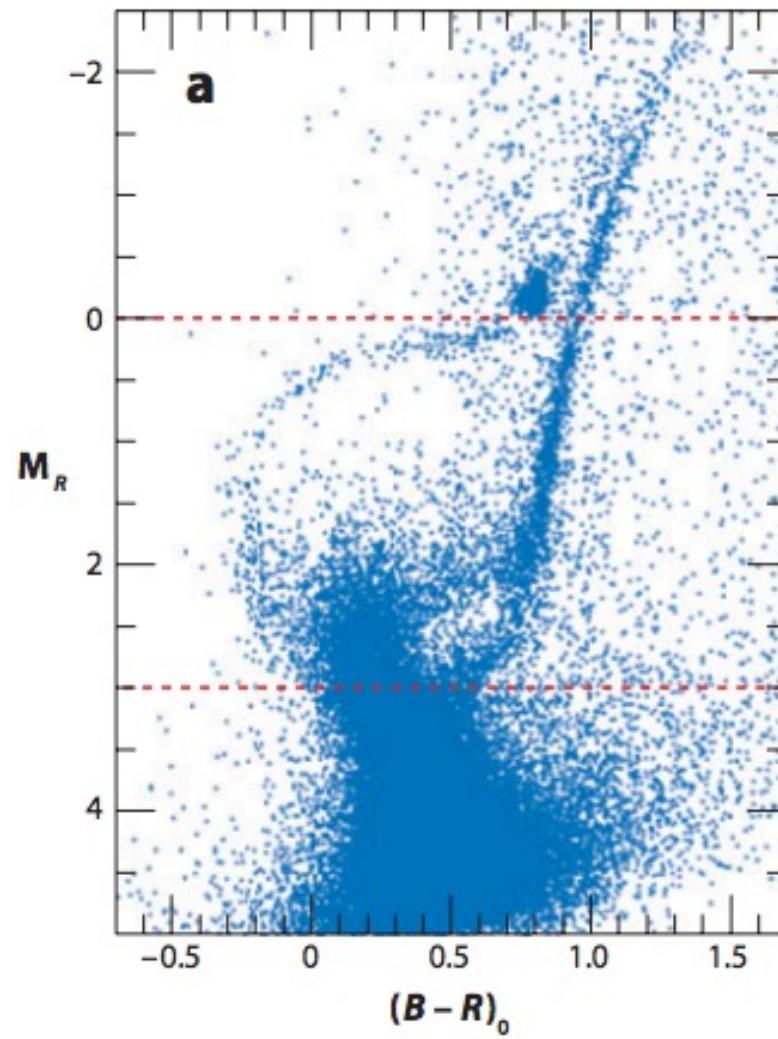
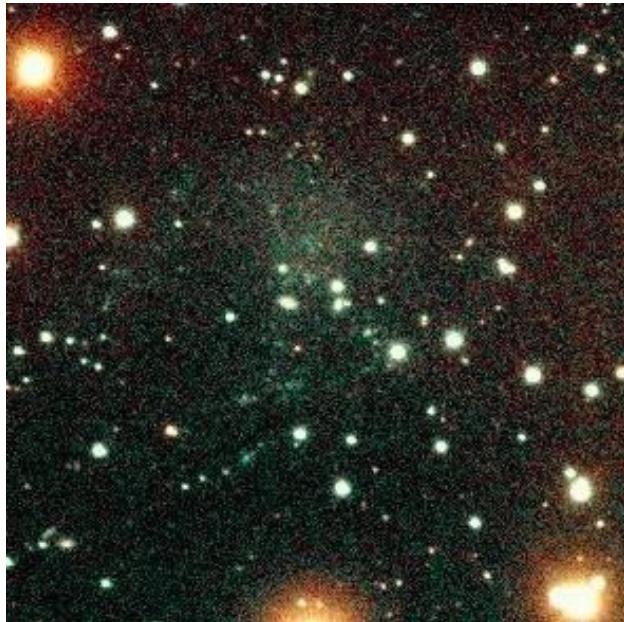


Hertzsprung Russell Diagram

the simple
version..



So what is this?



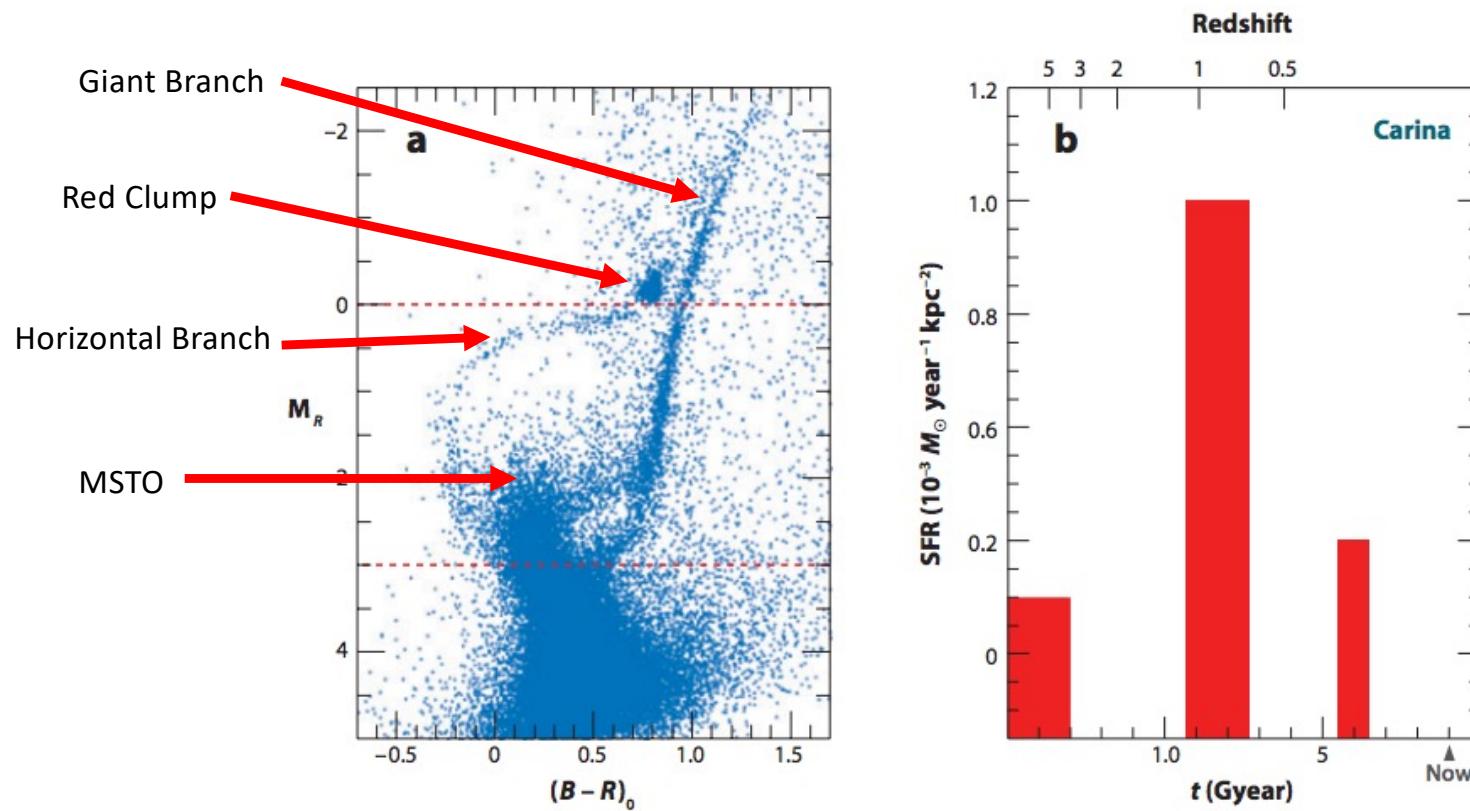
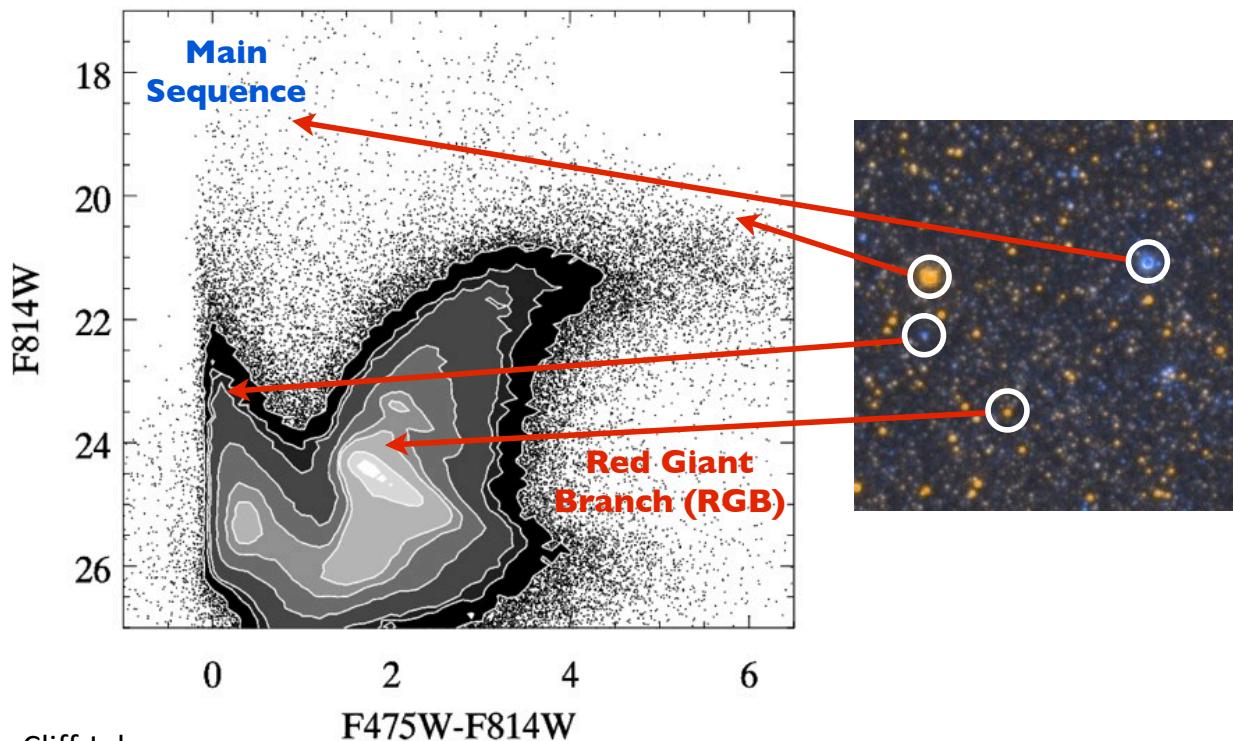


Figure 4

(a) A color-magnitude diagram of the Carina dwarf spheroidal (obtained by M. Mateo with the CTIO 4-m and MOSAIC camera, private communication) in the central 30' of the galaxy. This clearly shows the presence of at least three distinct MSTOs. (b) The star-formation history of the central region of Carina determined by Hurley-Keller, Mateo & Nemec (1998), showing the relative strength of the different bursts. The ages are also shown in terms of redshift.

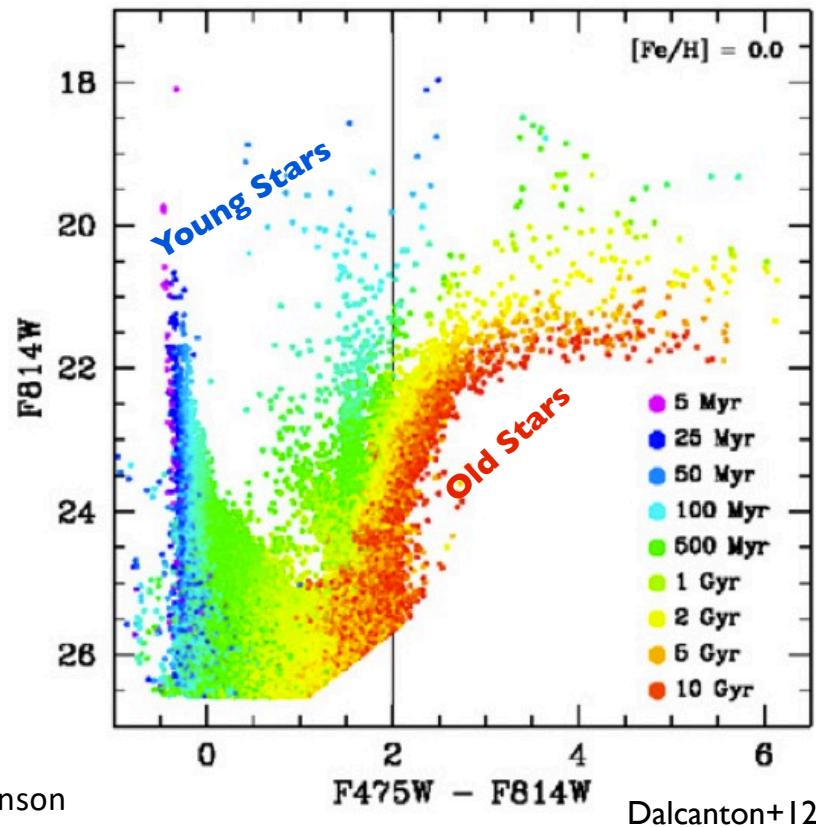
The Color-Magnitude Diagram (CMD)

Real galaxies



Courtesy Cliff Johnson

Age Dating with CMDs

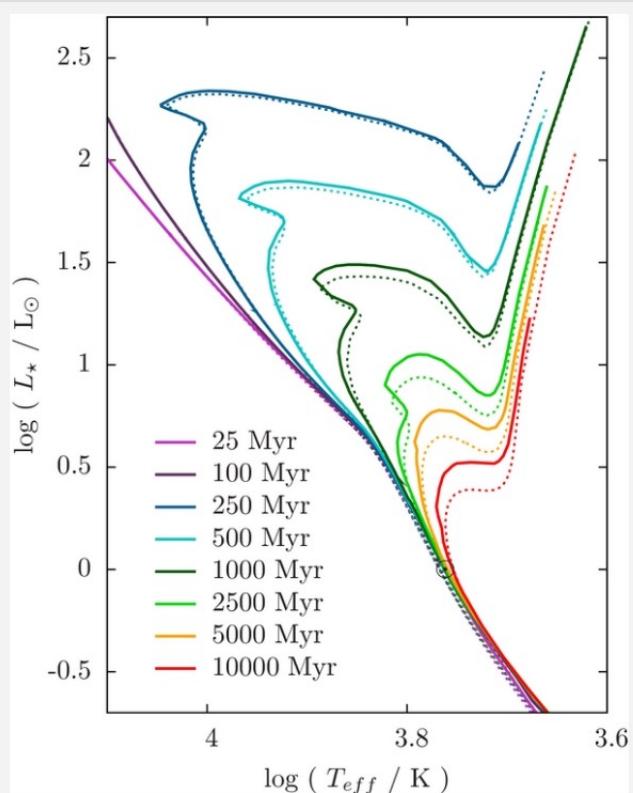


Courtesy Cliff Johnson

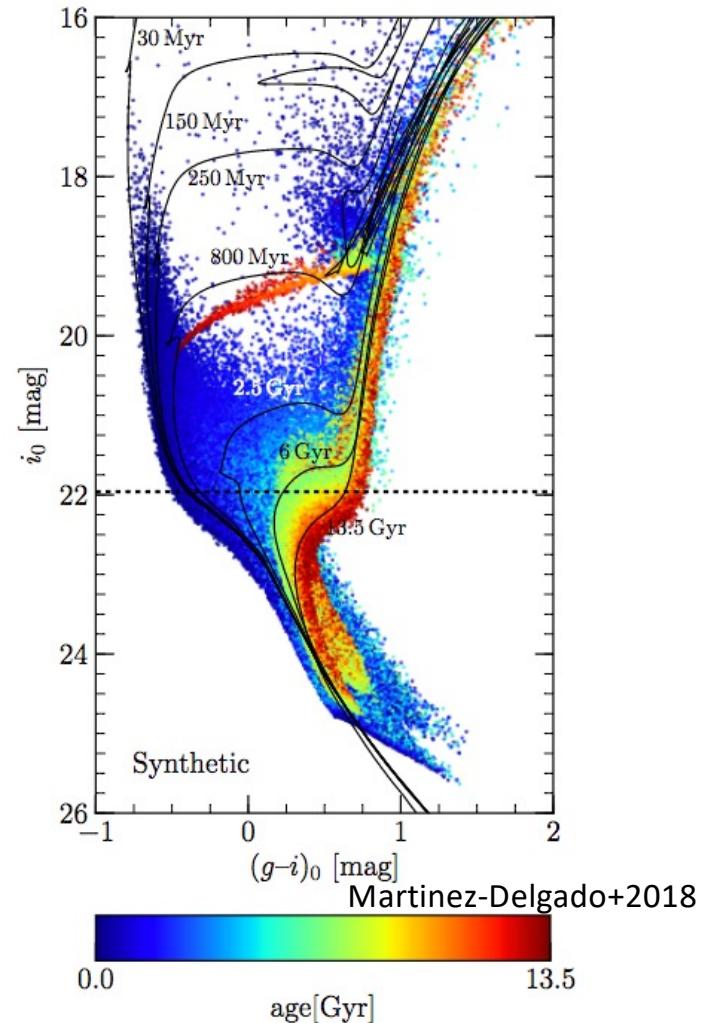
Dalcanton+12

Isochrones

Isochrones show the theoretical evolution of a single population of stars of the same metallicity but varying initial mass (according to some IMF), frozen at a certain instant in time.

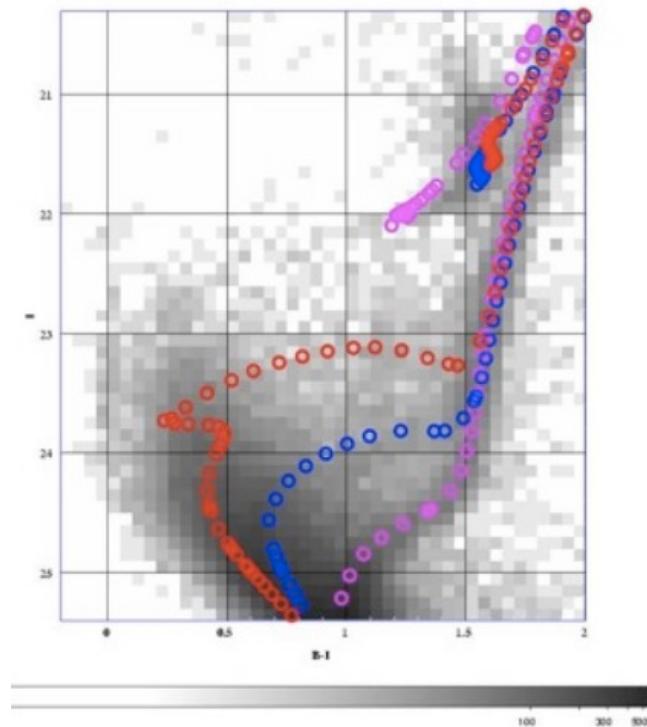


Source: Casanellas et al. 2011



Deriving SFH from CMDs: SFH of a quenched dwarf: Leo I

$M_* \sim 5 \times 10^6 M_\odot$

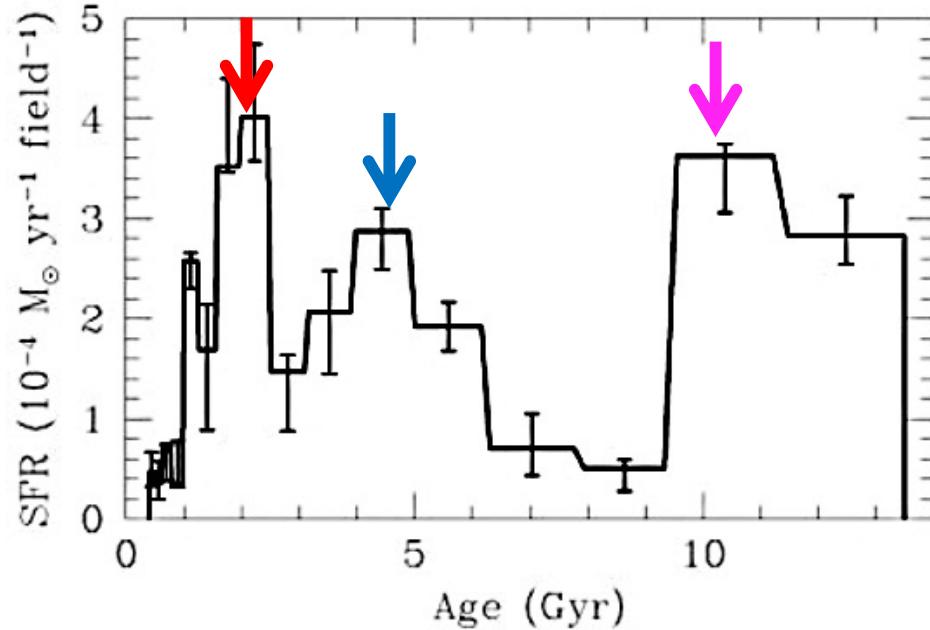


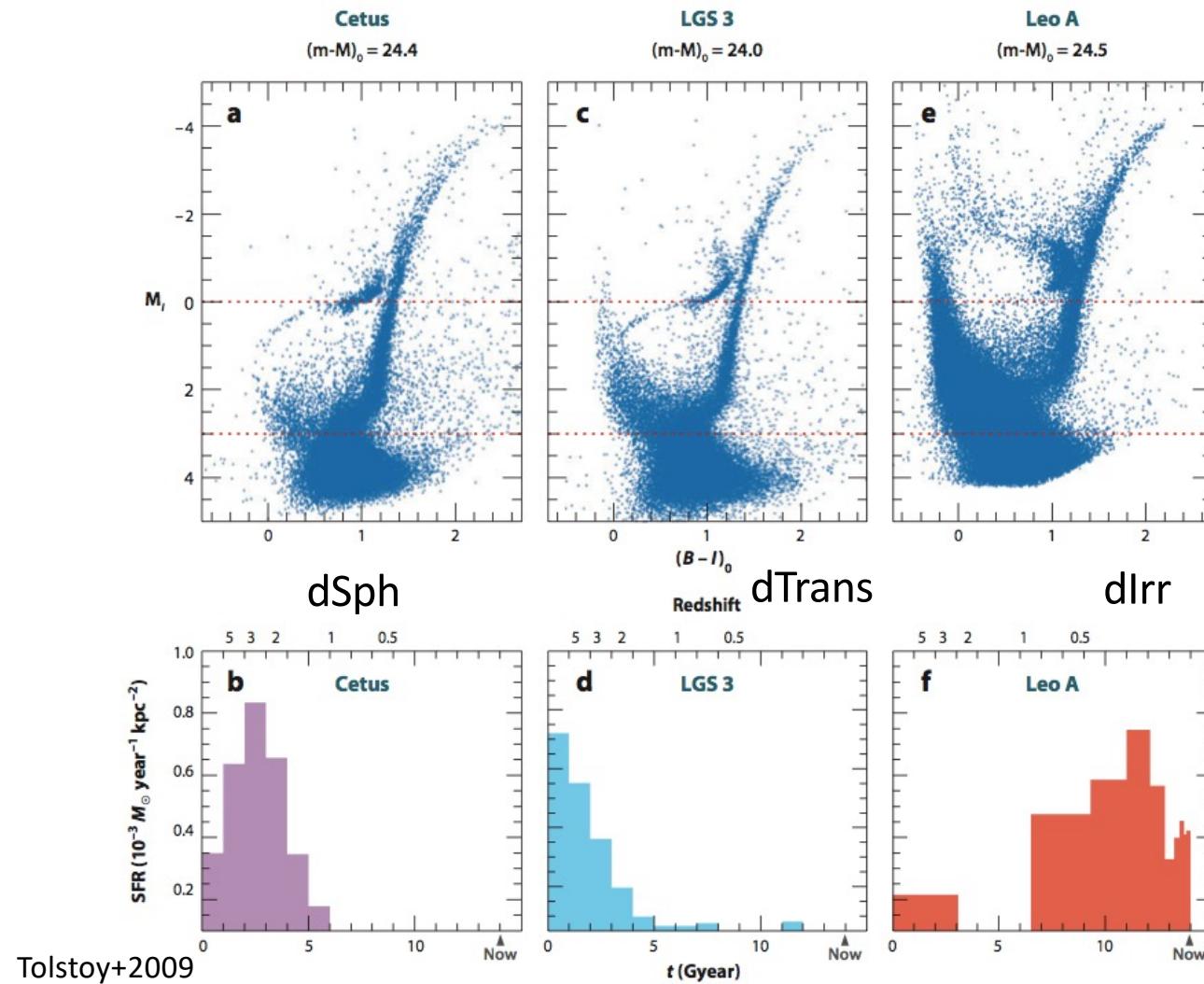
Gallart+1998

Orbits: HST Proper motions

Accretion by Milky Way
2 Gyr ago (Sohn, GB+2013)

Rapid quenching (Wetzel+2015)

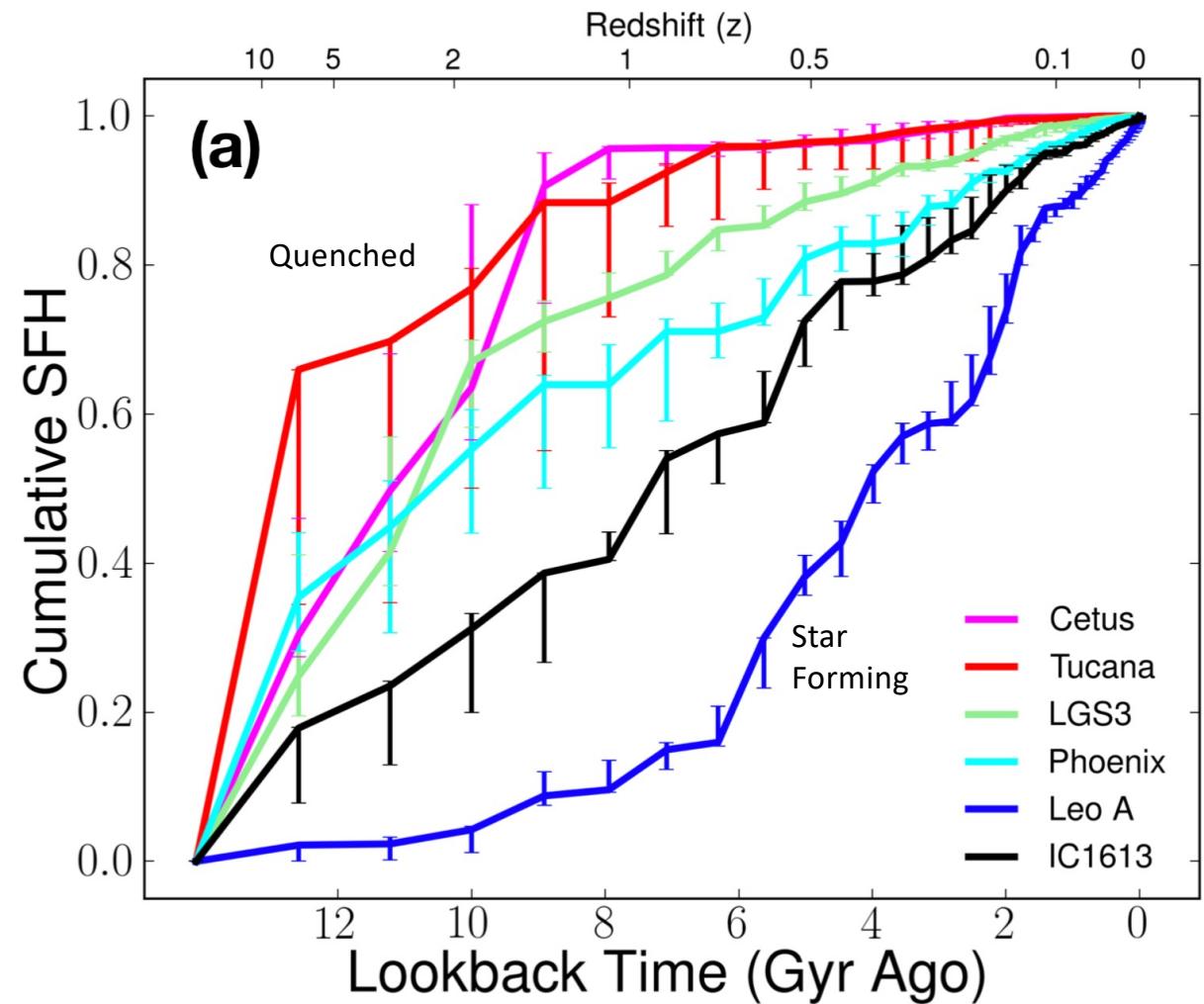




Cumulative SFHs

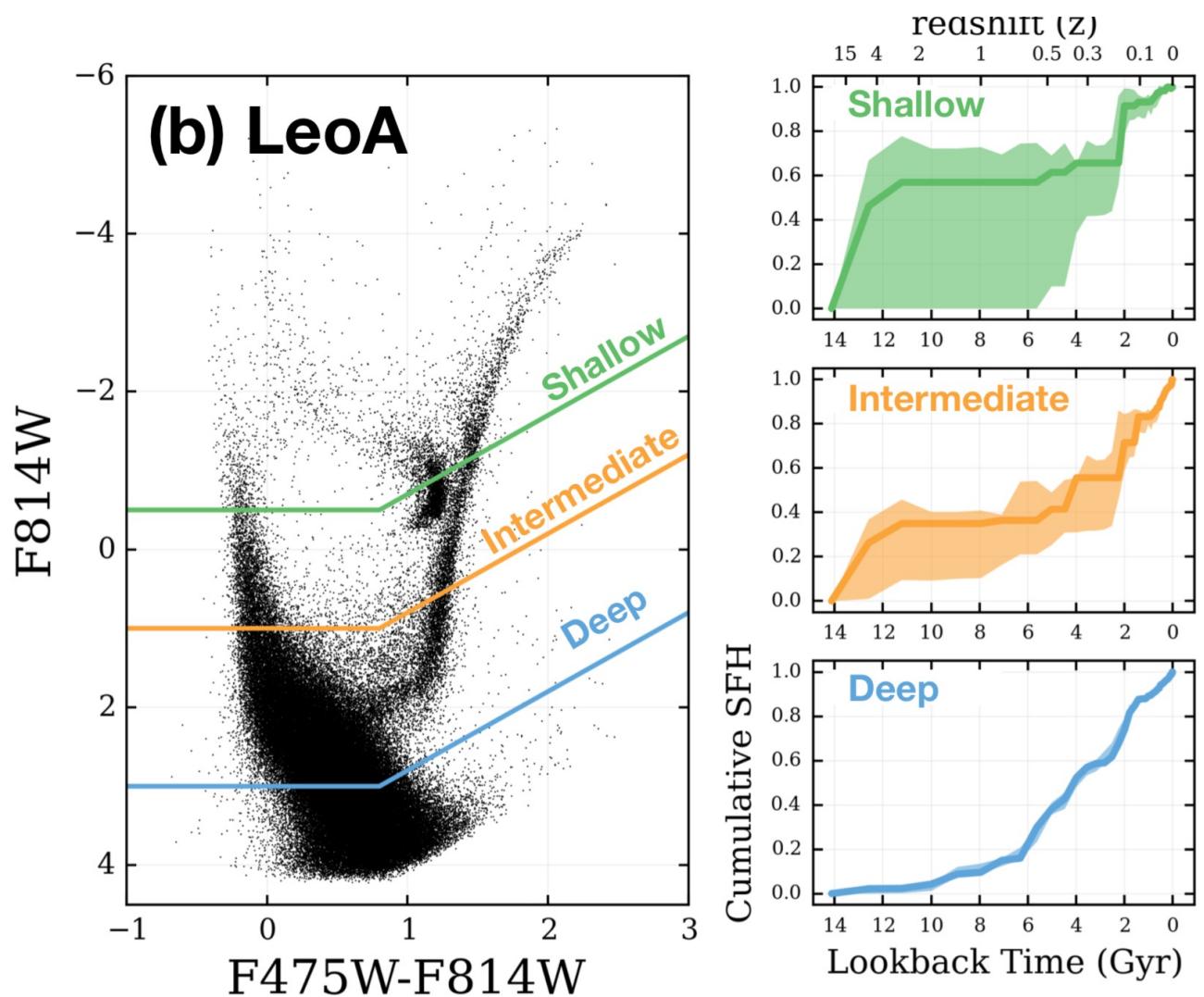
The SFHs of isolated (>300 kpc from the MW/M31) dwarf galaxies measured from deep CMDs (Skillman et al. 2014). The varied SFHs trace their diverse assembly history. *HST* can only provide deep CMDs for 9 isolated galaxies, while *JWST* can access hundreds.

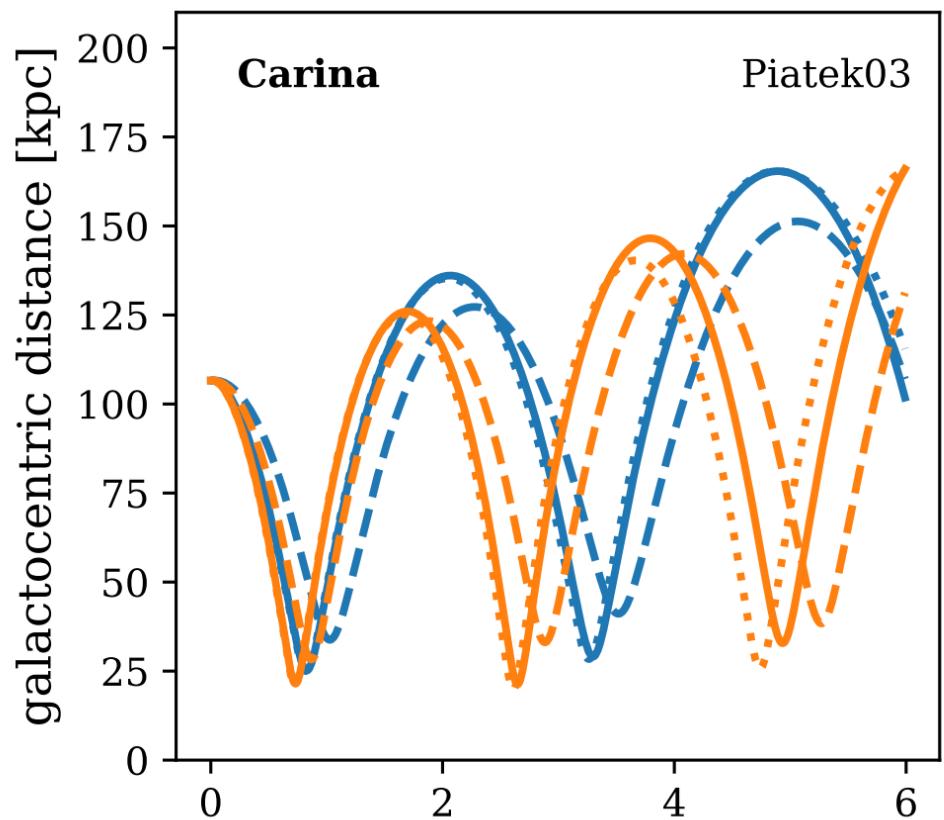
JWST ERS Proposal
PI Weisz



The Need for JWST

JWST ERS Proposal
PI Weisz





Patel + 2020

