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The spatially-segregated stellar metallicity populations in simulated Local Group dwarfs

Anna Genina

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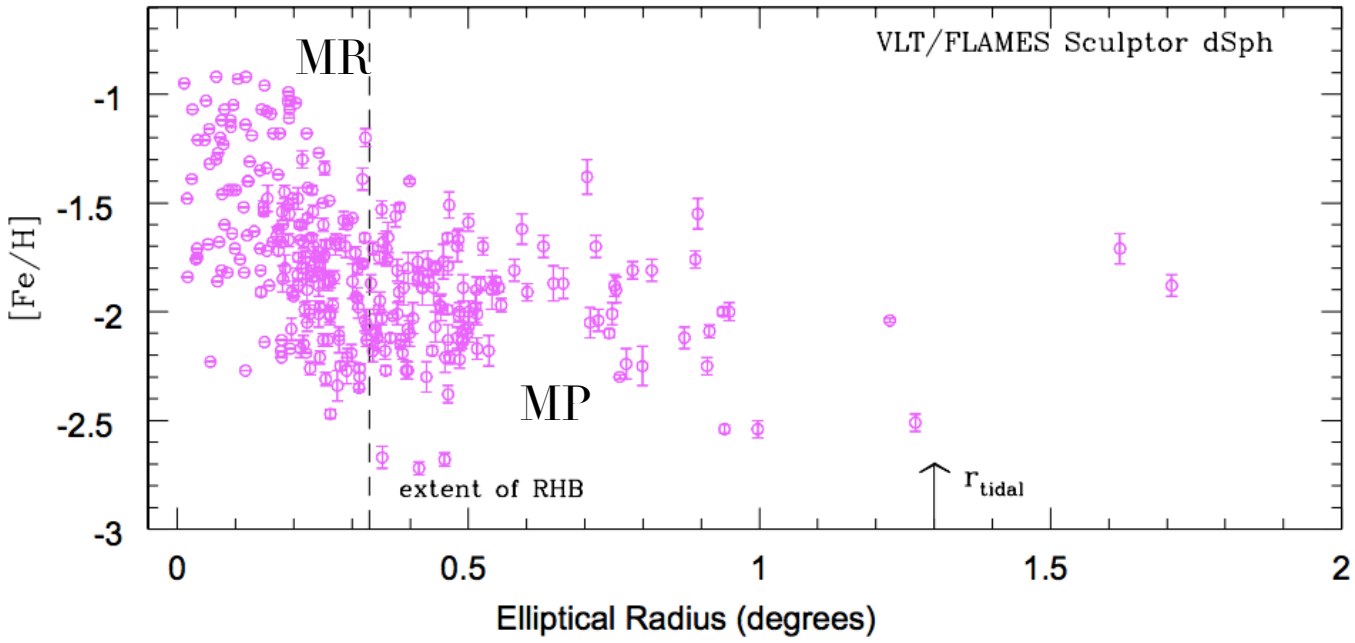
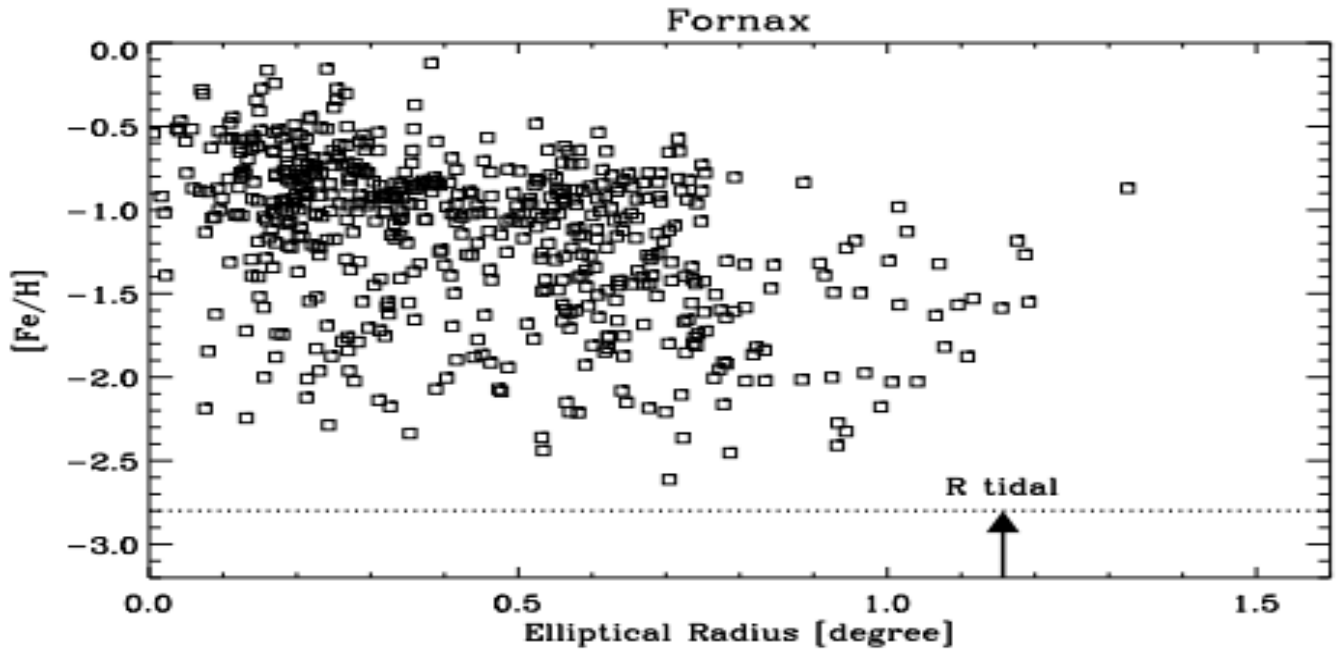
Genina et al. (2019) MNRAS 488,2
Genina eta l. (2018) MNRAS 474,1





Two populations in Sculptor and Fornax:

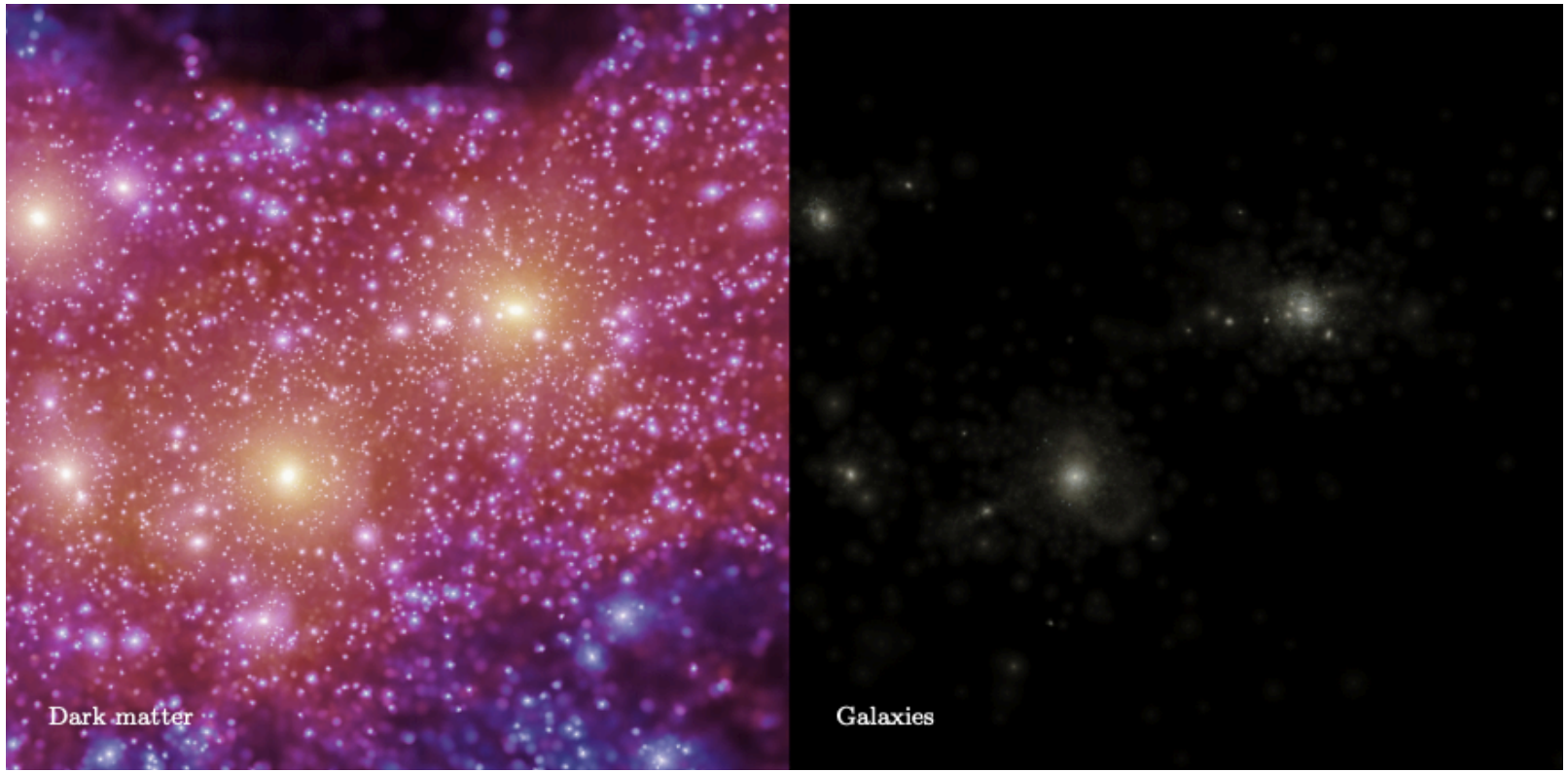
- A centrally-concentrated metal-rich population
- An extended metal-poor population
- Can exhibit different kinematics

E.Tolstoy et al. arXiv:0411029 (2004)
G.Battaglia et al. arXiv:0608370(2006)
G.Battaglia et al. arXiv:0802.4220 (2007)

but also see D.Kawata et al (2006) arXiv: 0509402

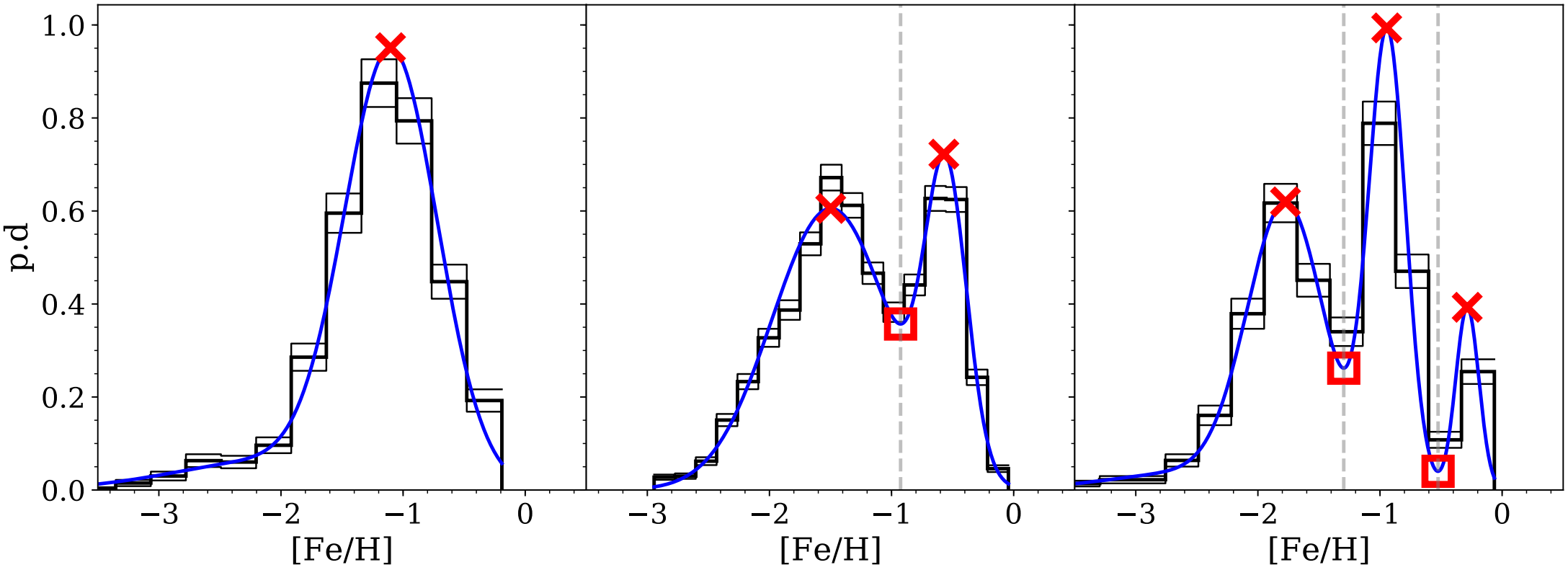
APOSTLE simulations

- EAGLE model
- 5 high-resolution volumes (m_{gas} = 0.5-0.8×10^4 Msol)
- Milky-Way and Andromeda analogues selected to fit Local Group constraints



Sawala T. et al. (2016) arXiv:1511.01098
Fattahi A. et al. (2016) arXiv:1507.03643

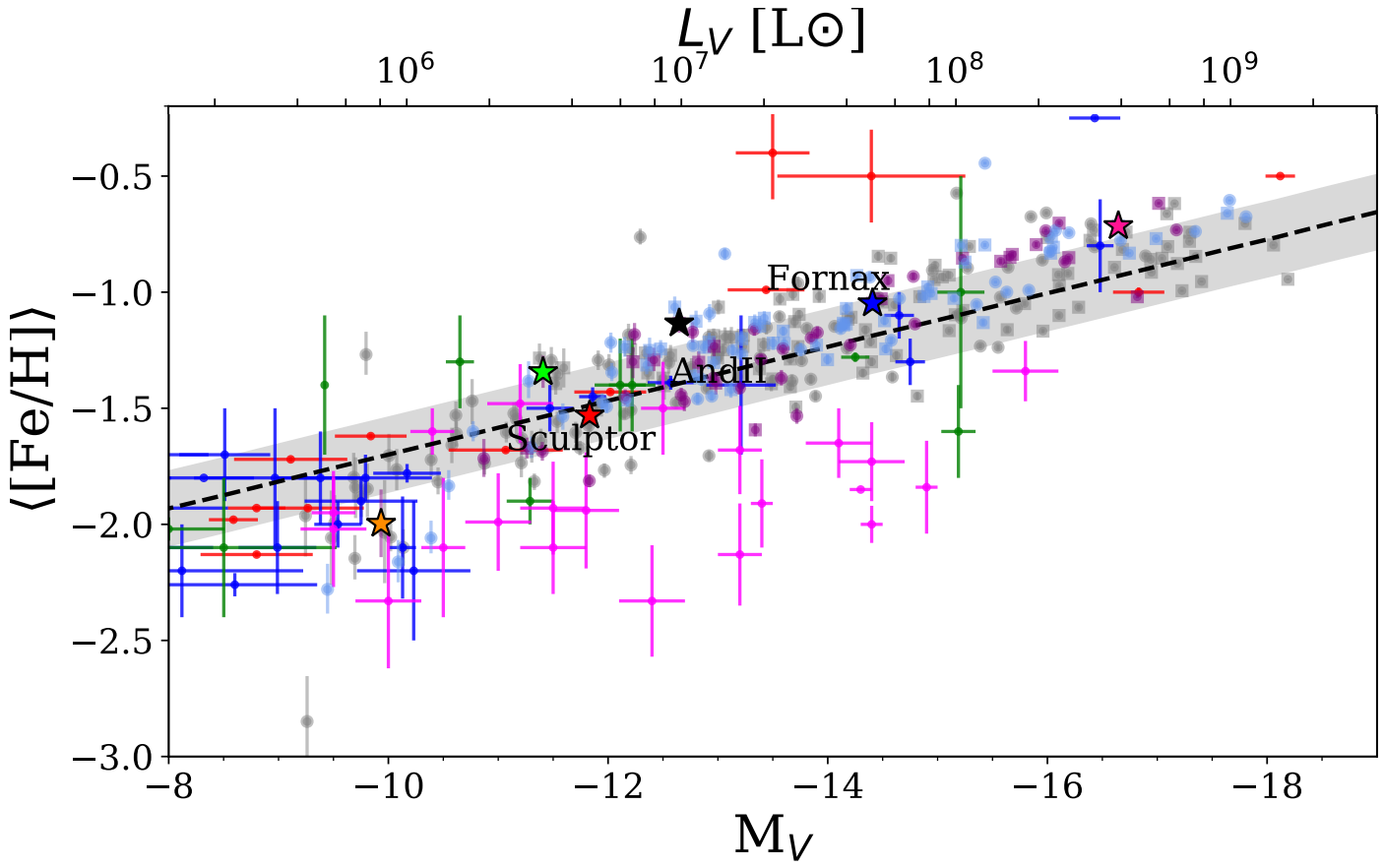
Defining the number of populations



1. Fit metallicity histograms with a Gaussian Mixture Model + calculate AIC
2. Count the number of peaks
3. Number of peaks = Number of populations

Genina et al. (2019) arXiv:1812.04839

The Sample

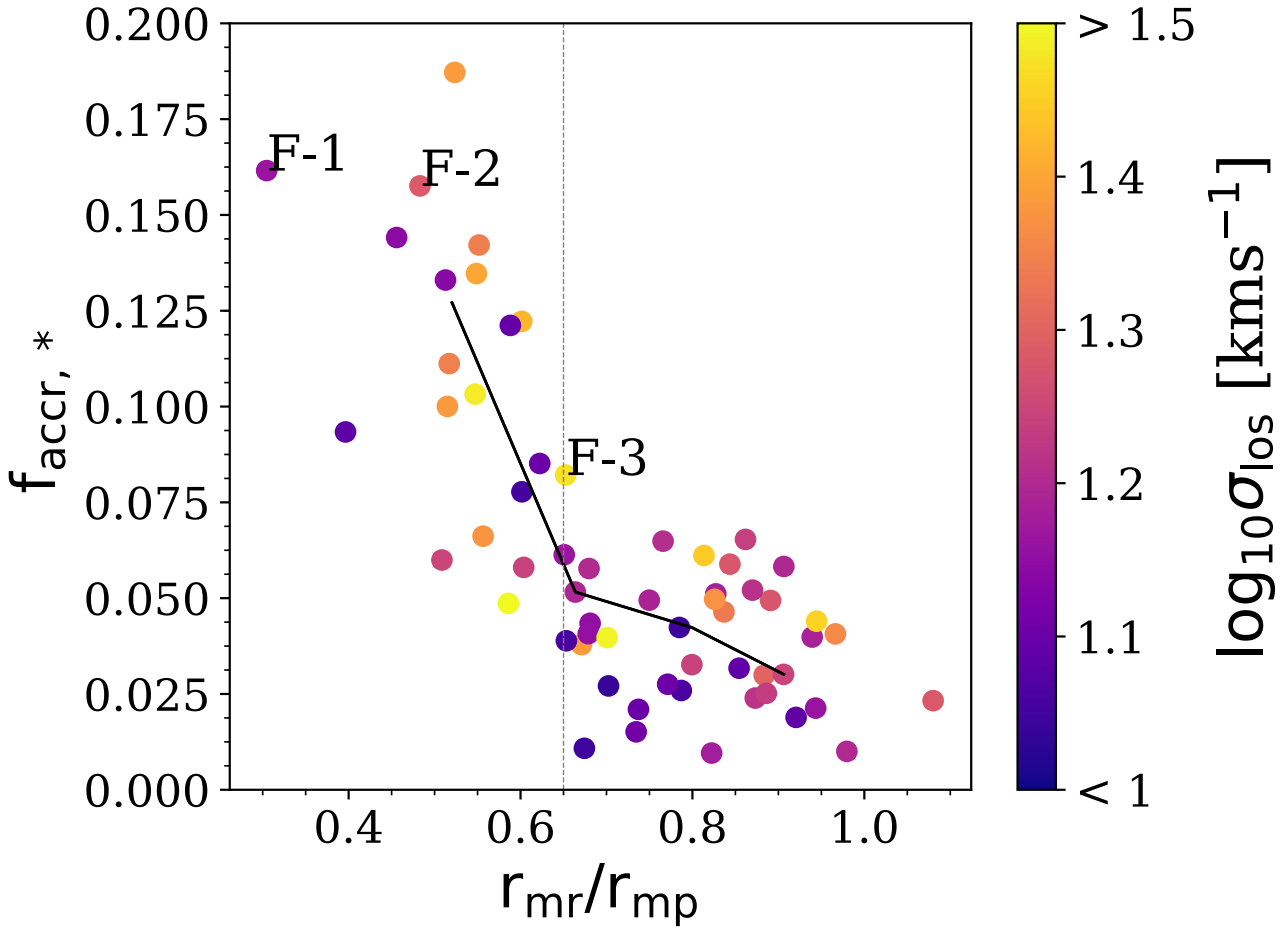


- APOSTLE does well on the mass-metallicity relation
- We find two populations along the entire mass range
- Dwarfs with two populations make up nearly half of all dwarfs and this fraction is approximately the same across all mass bins

Genina et al. (2019) arXiv:1812.04839

A.McConnachie (2012) arXiv:1204.1562
E.N.Kirby et al. (2013) arXiv:1310.0814

Isolated dwarfs



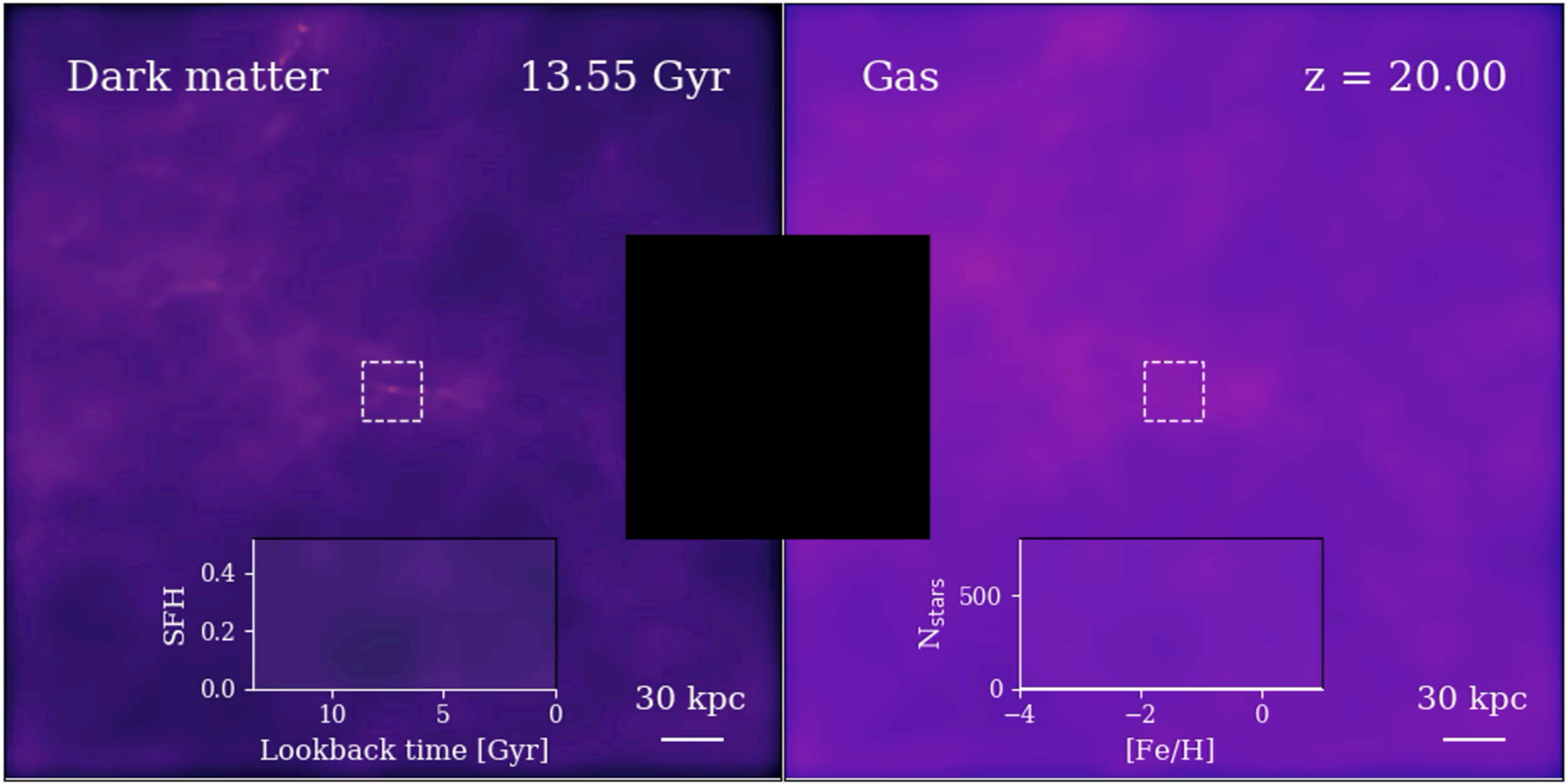
Genina et al. (2019) arXiv:1812.04839

Spatial segregation is related to mergers

See also Benitez-Llambay et al. (2015) arXiv:1405.5540
Benitez-Llambay et al. (2016) arXiv:1511.06188
Revaz & Jablonka (2018) arXiv:1801.0622

Mergers can be the cause of the formation of two populations in low and high mass dwarfs. Signs of a merger have been seen in Fornax and Andromeda II.

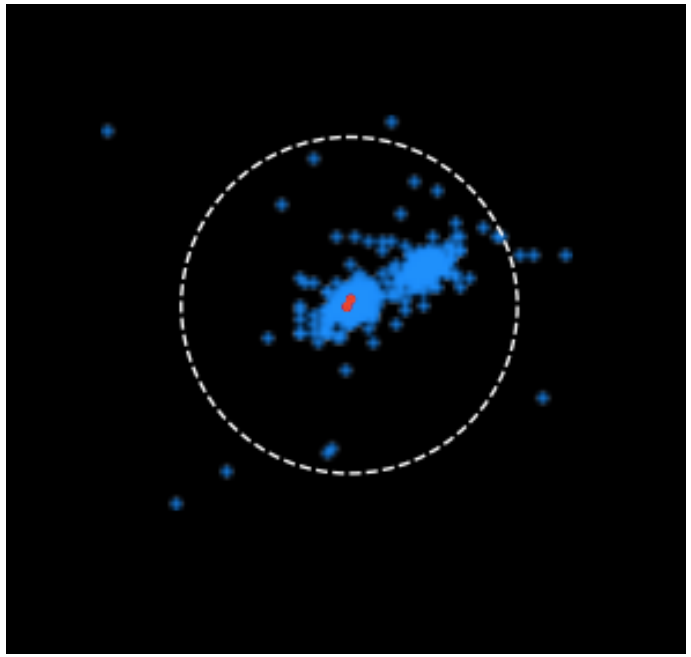
Amorisco et al. (2014) arXiv: 1402.5142
del Pino et al. (2015) arXiv: 1509.05336
del Pino et al. (2017) arXiv: 1611.08446



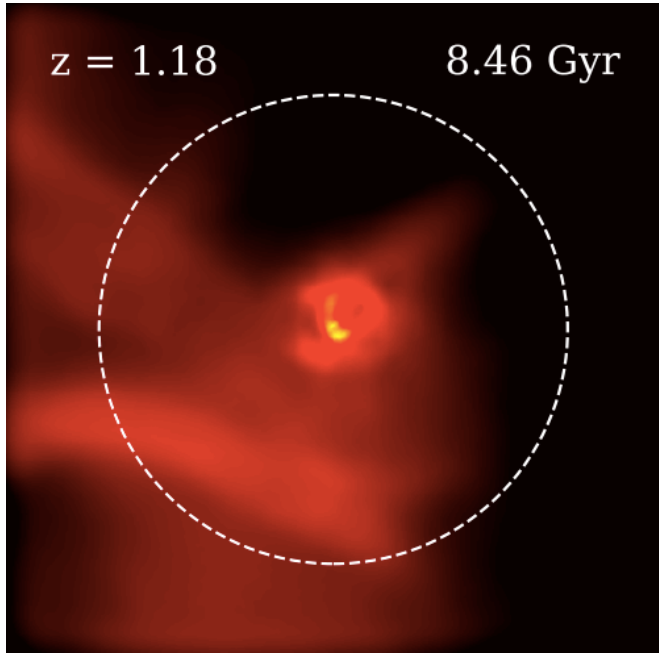
Genina et al. (2019) arXiv:1812.04839

https://youtu.be/obgdLxd3vq0

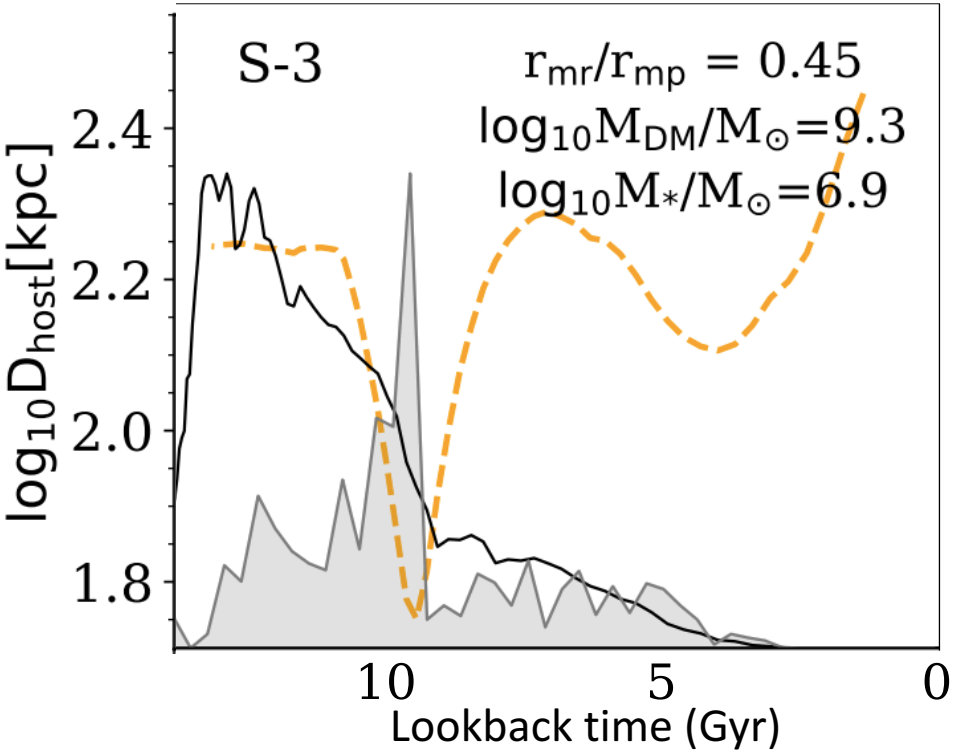
Satellite dwarfs



1. Mergers



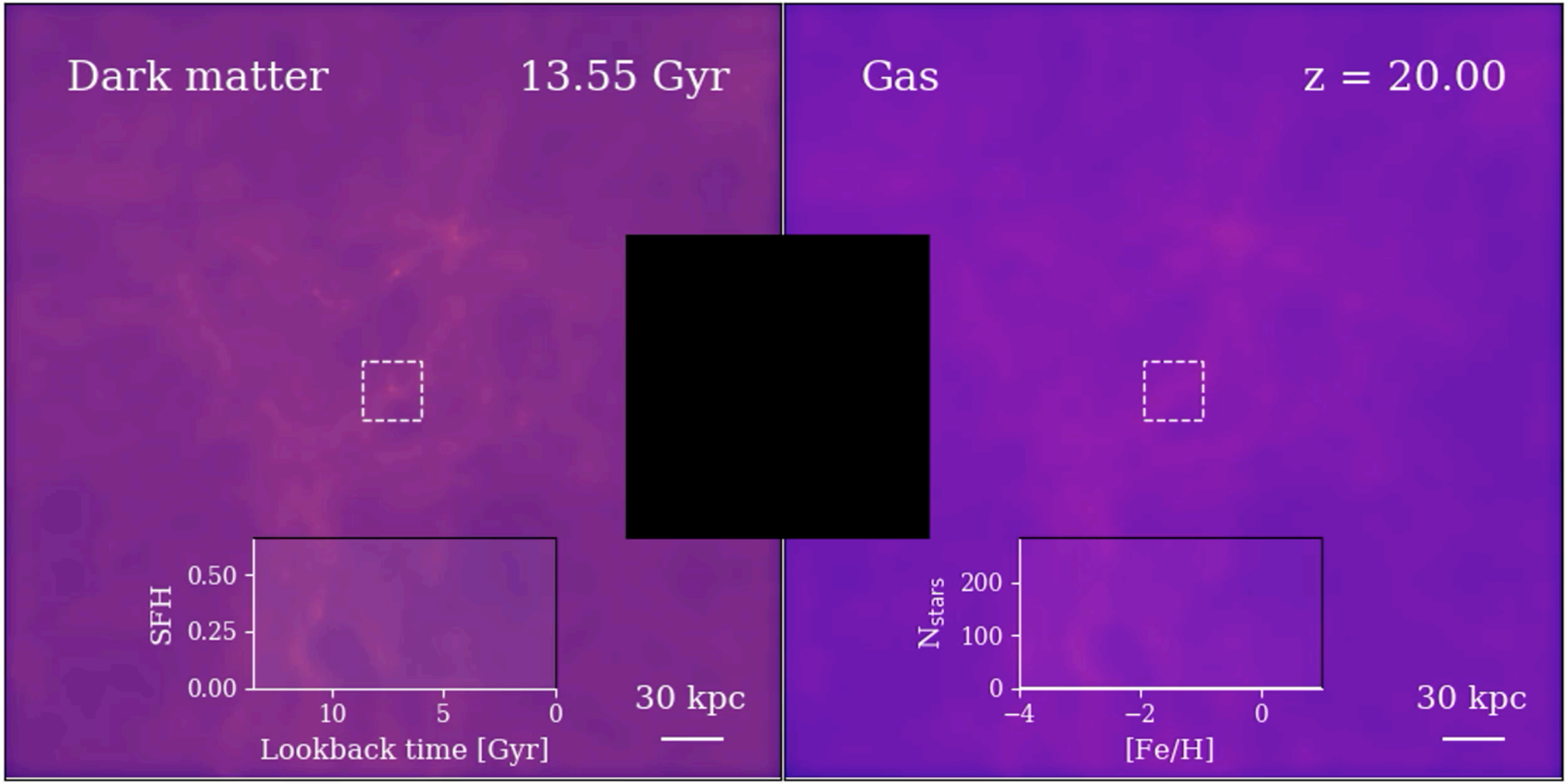
2. Interactions with filaments



3. At pericentre

Genina et al. (2019) arXiv:1812.04839

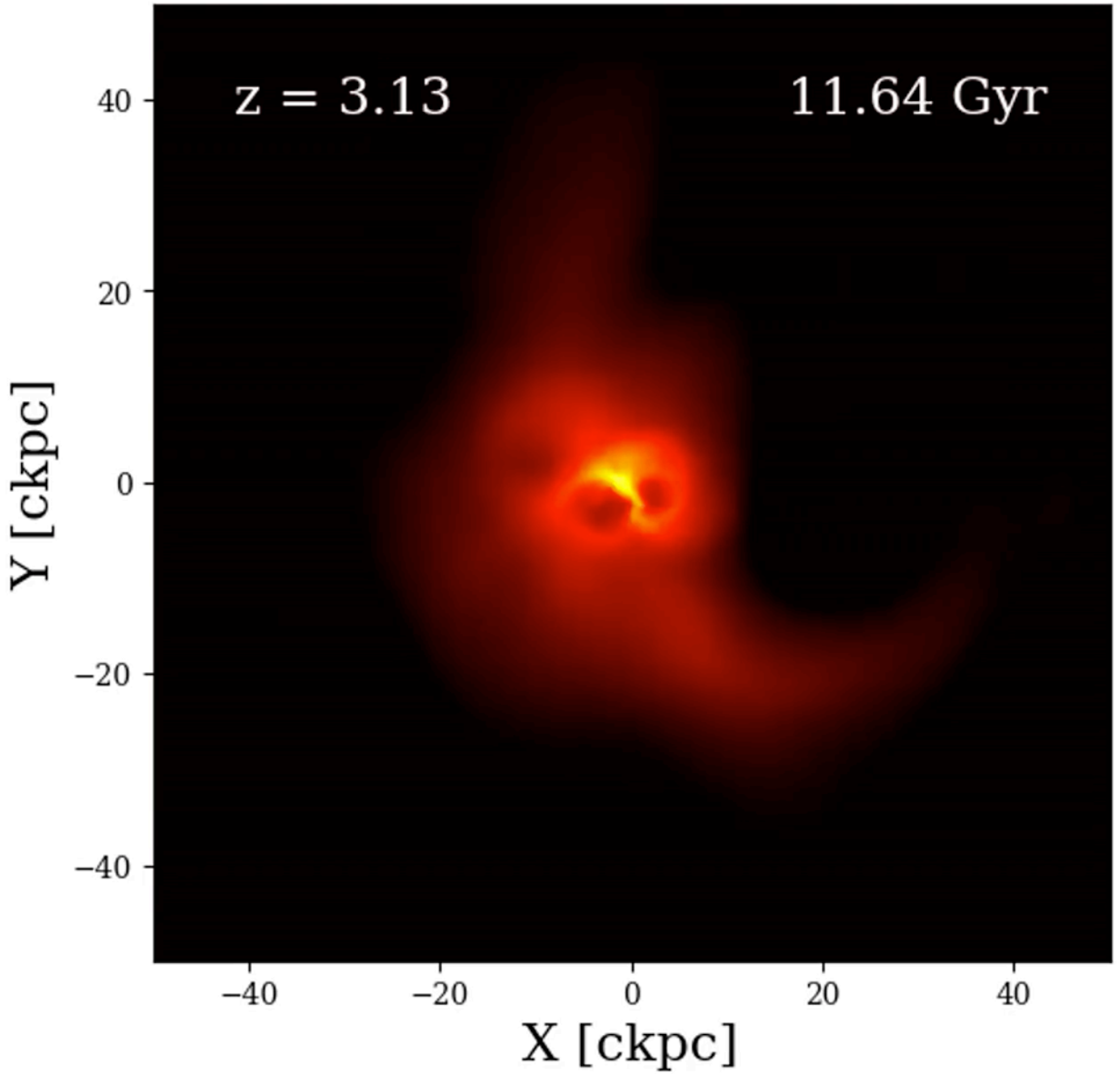
Star formation near pericentre

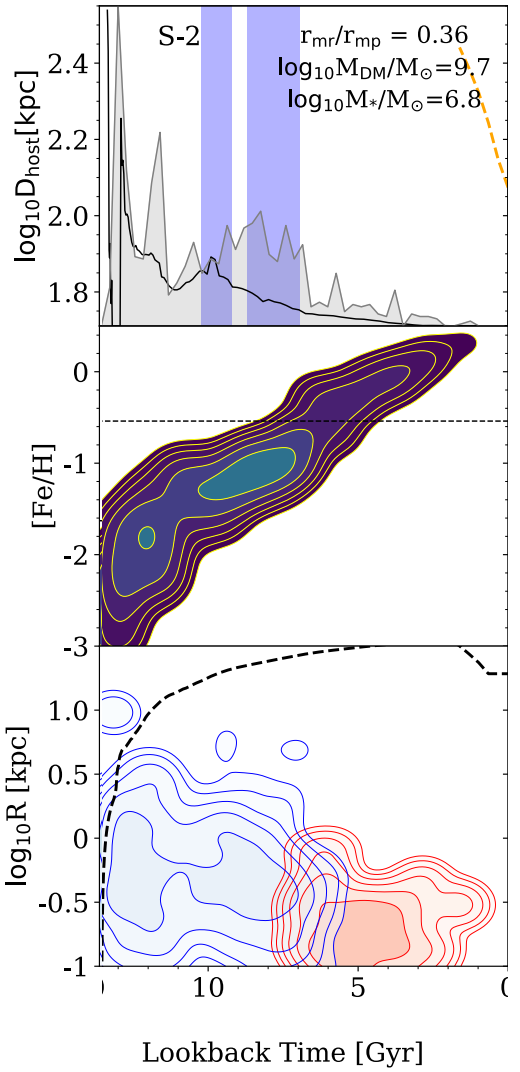


Genina et al. (2019) arXiv:1812.04839

https://youtu.be/TmRwi6iaPls

Ram pressure induced star formation

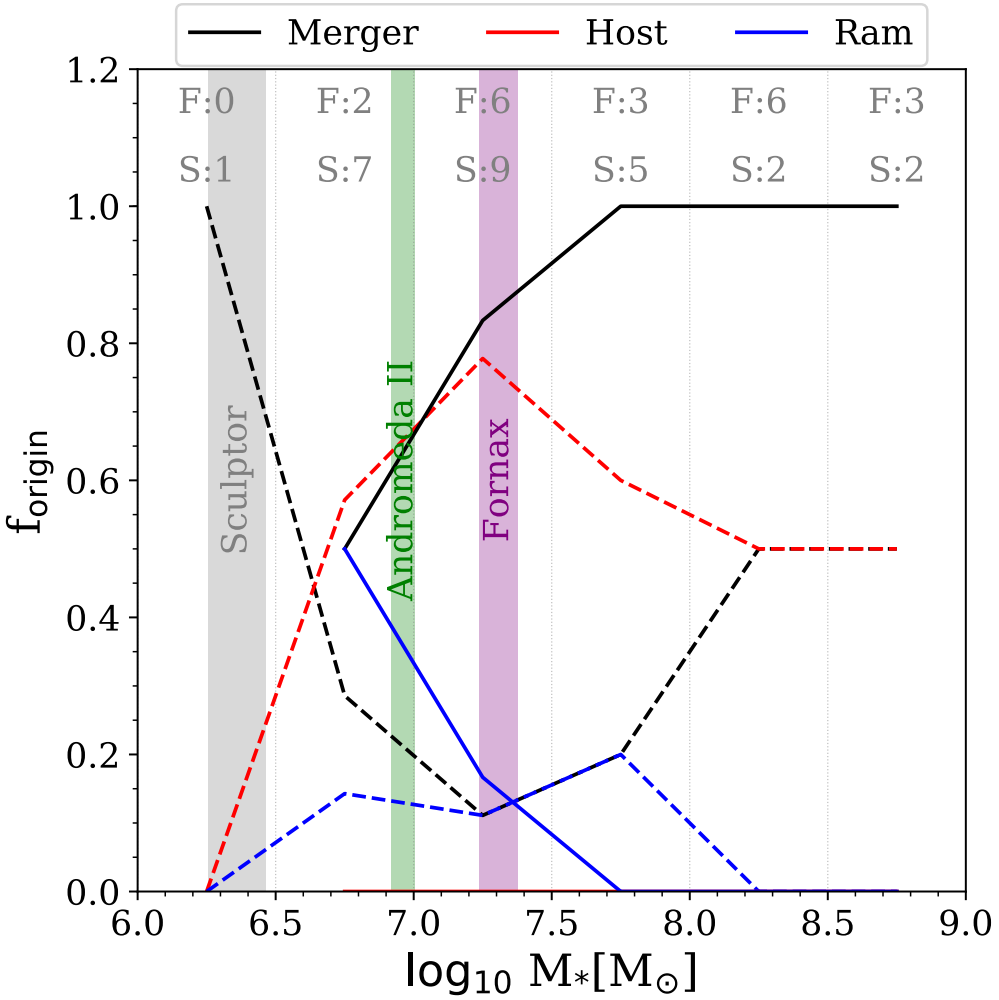




Genina et al. (2019) arXiv:1812.04839 https://youtu.be/HAU_kcjrgGw

See also Wright et al.(2019) arXiv: 1802.03019

Mass dependence of the mechanisms



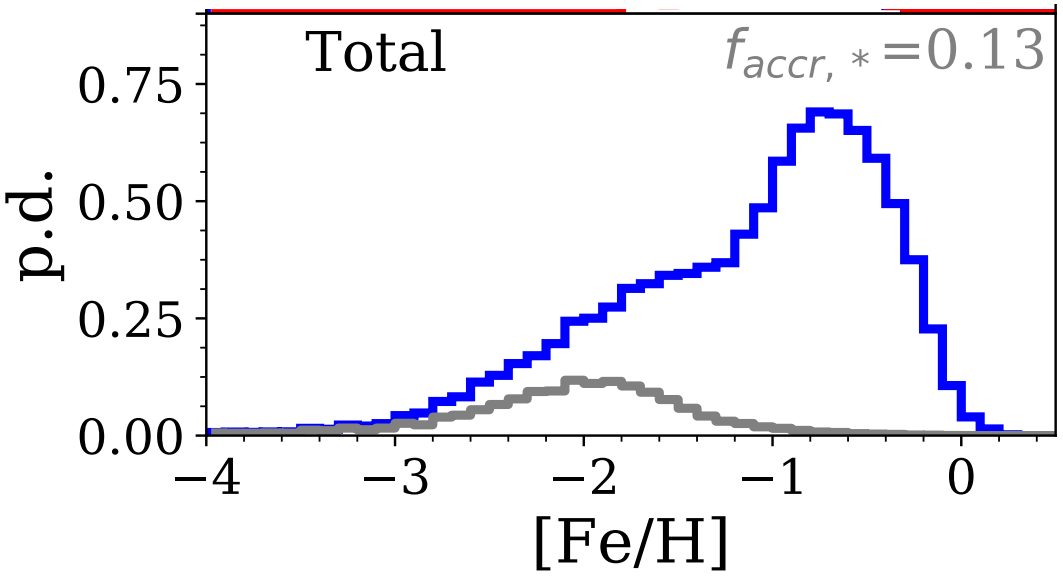
Genina et al. (2019) arXiv:1812.04839

- The prevalence of the merger scenario dependent on mass and is the most common mechanism in isolated dwarfs
- Forming a metal-rich population by passing through pericentre is the dominant mechanism in satellites.
- Fornax-mass galaxies likely formed their metal-rich stars by passing through pericenter, unless never reached that stage
- Best Sculptor analogue formed through a merger, but sample is small in this mass range

Can we tell the mechanisms apart?

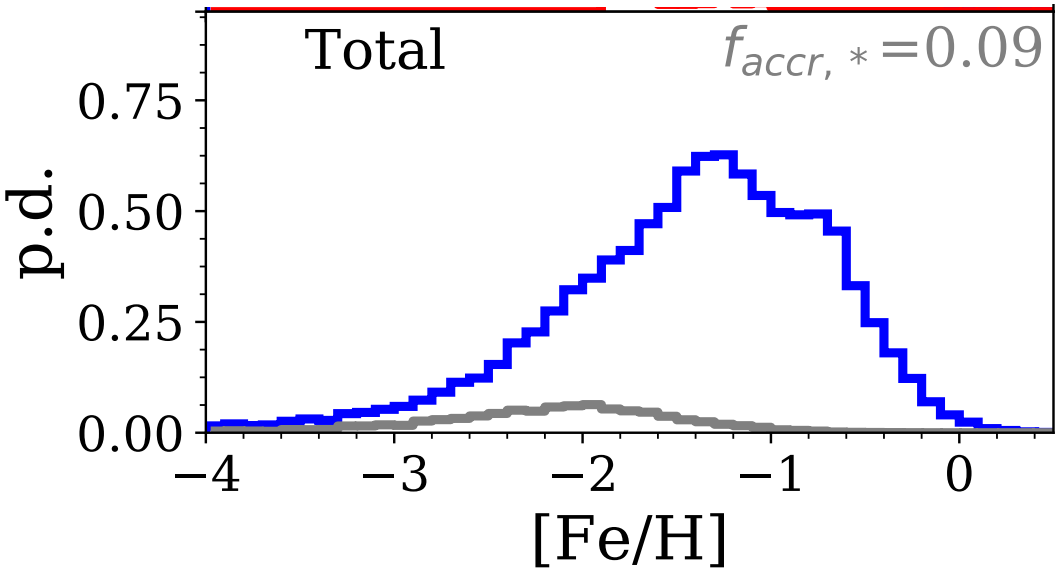
Mostly not! But metallicity distributions can be telling…

Isolated (mostly mergers)



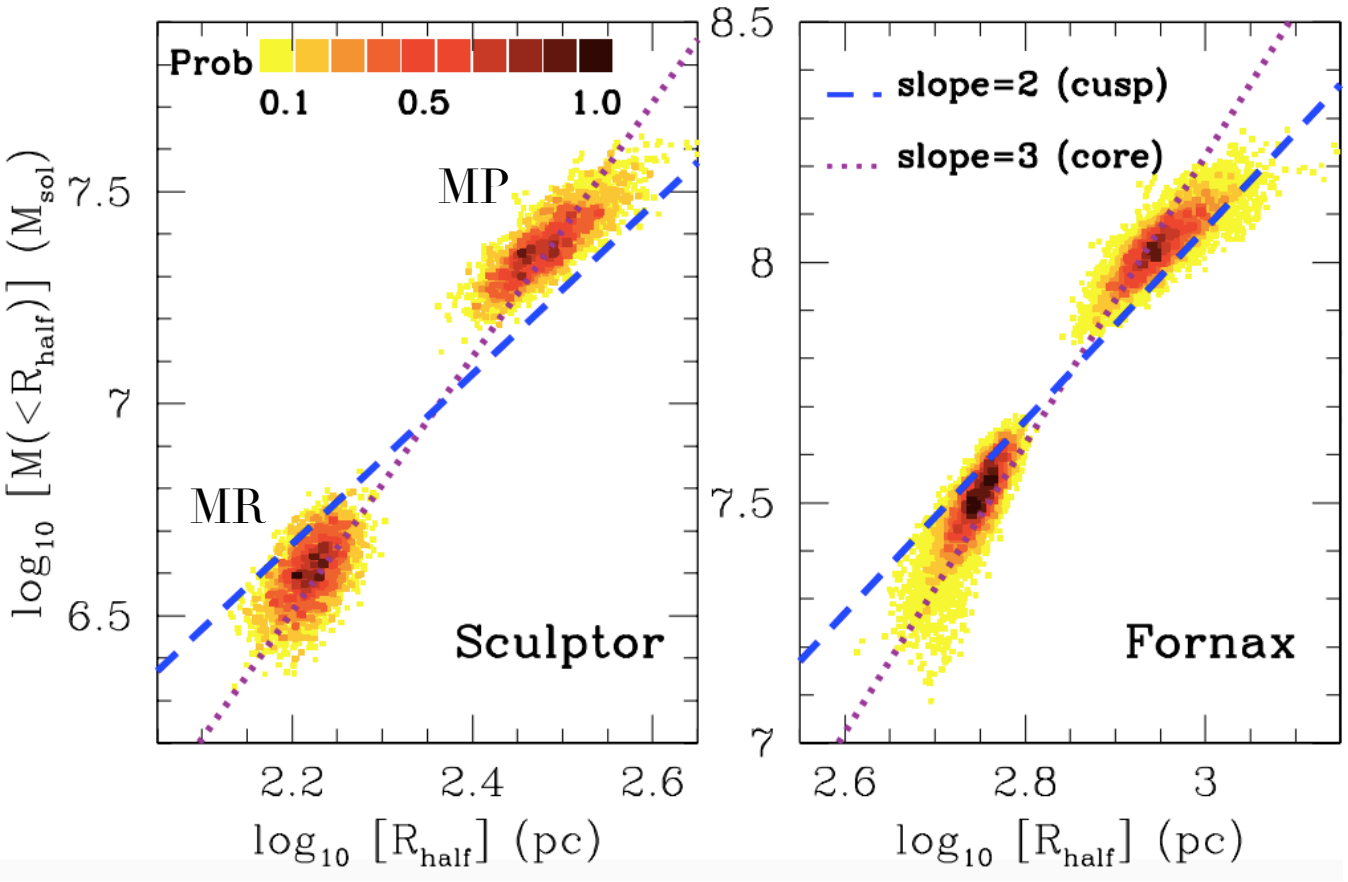
More abundant metal-rich population

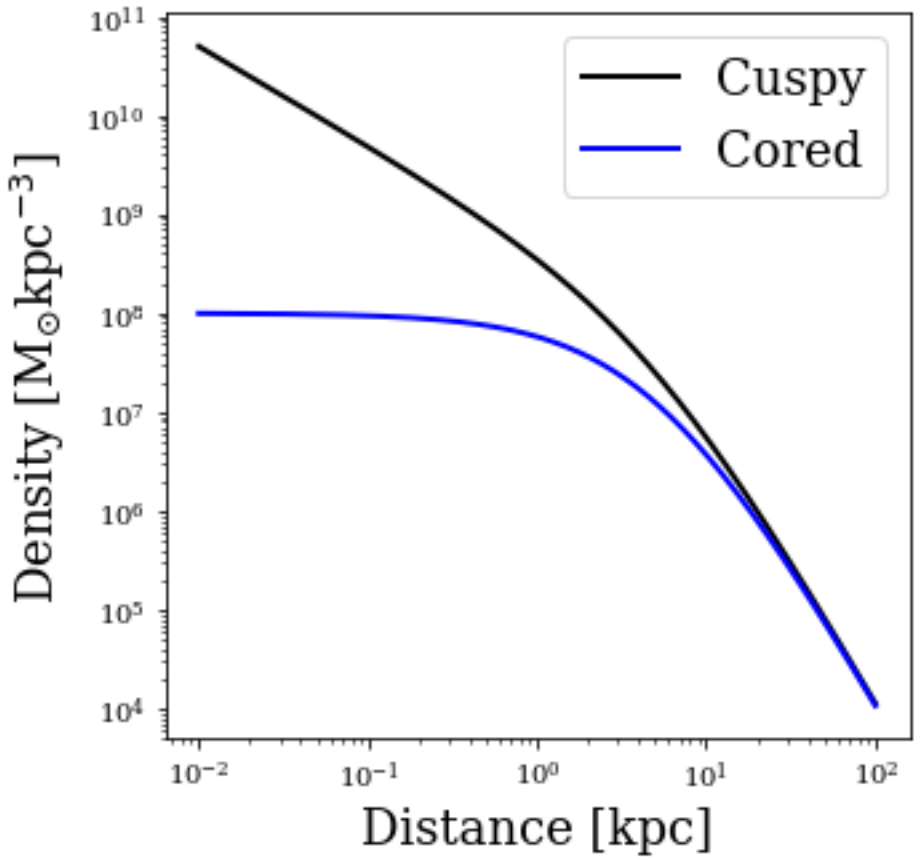
Satellite (mostly host influence)



More abundant metal-poor population because gas is stripped at late times

What can we learn from two populations?





Define the mass slope:

$$\Gamma \equiv \Delta \log M / \Delta \log r$$

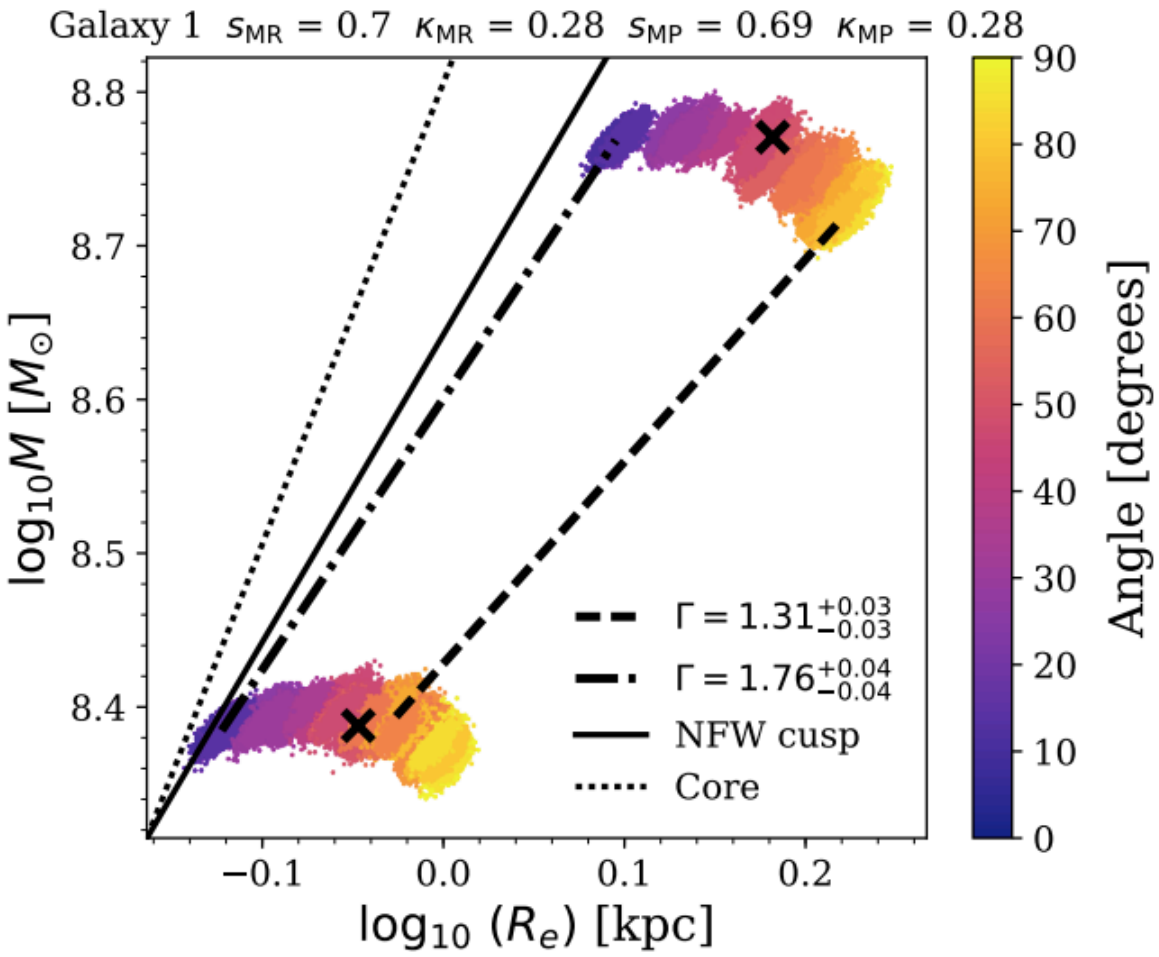
$$\begin{aligned} M_{1/2} &\equiv M(r_{1/2}) \simeq 3 G^{-1} \langle \sigma^2_{los} \rangle r_{1/2} , \\ &\simeq 4 G^{-1} \langle \sigma^2_{los} \rangle R_e , \end{aligned}$$

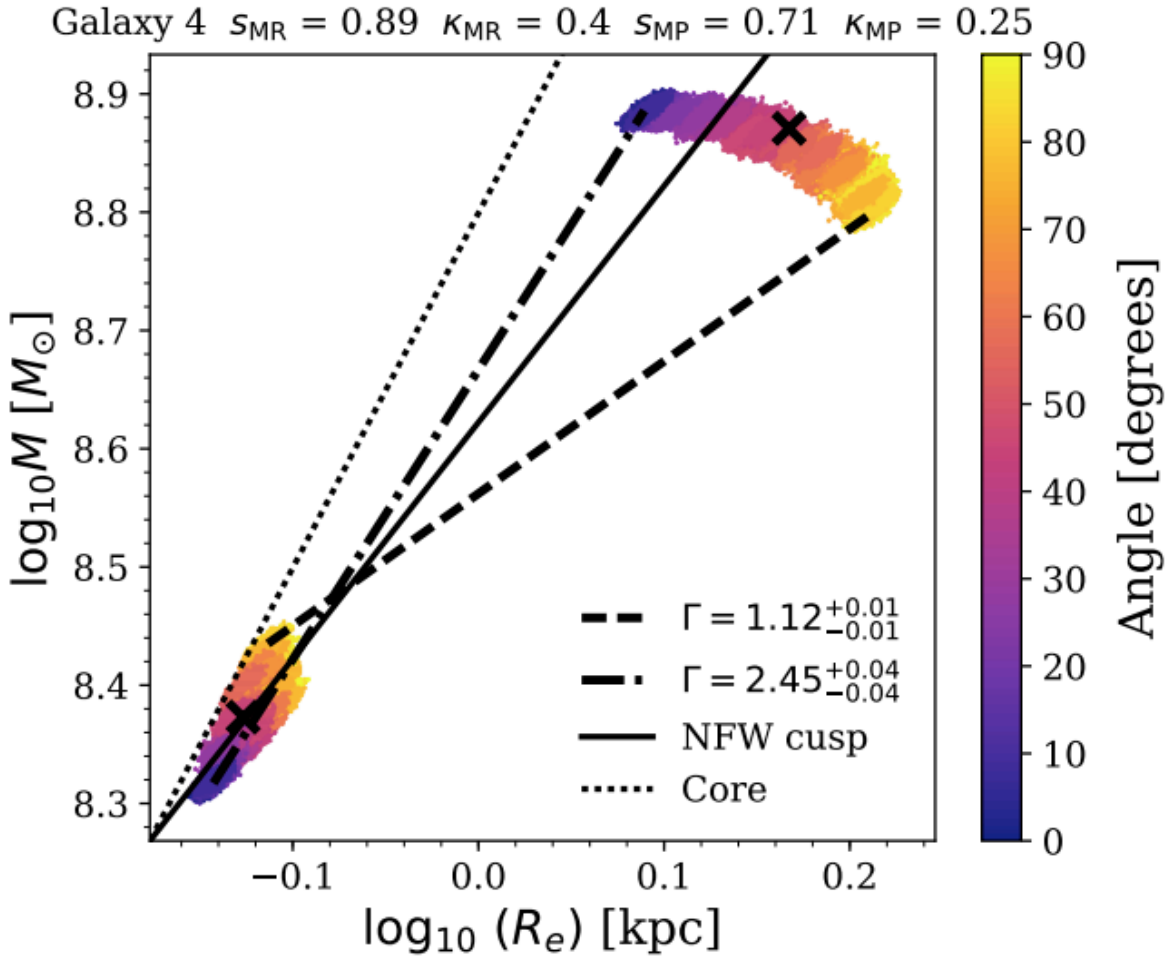
Wolf et al. (2010) arXiv: 0908.2995

M.Walker & J.Penarrubia (2011) arXiv:1108.2404

The core - cusp problem: a matter of perspective

Genina et al. (2018) arXiv:1707.06303

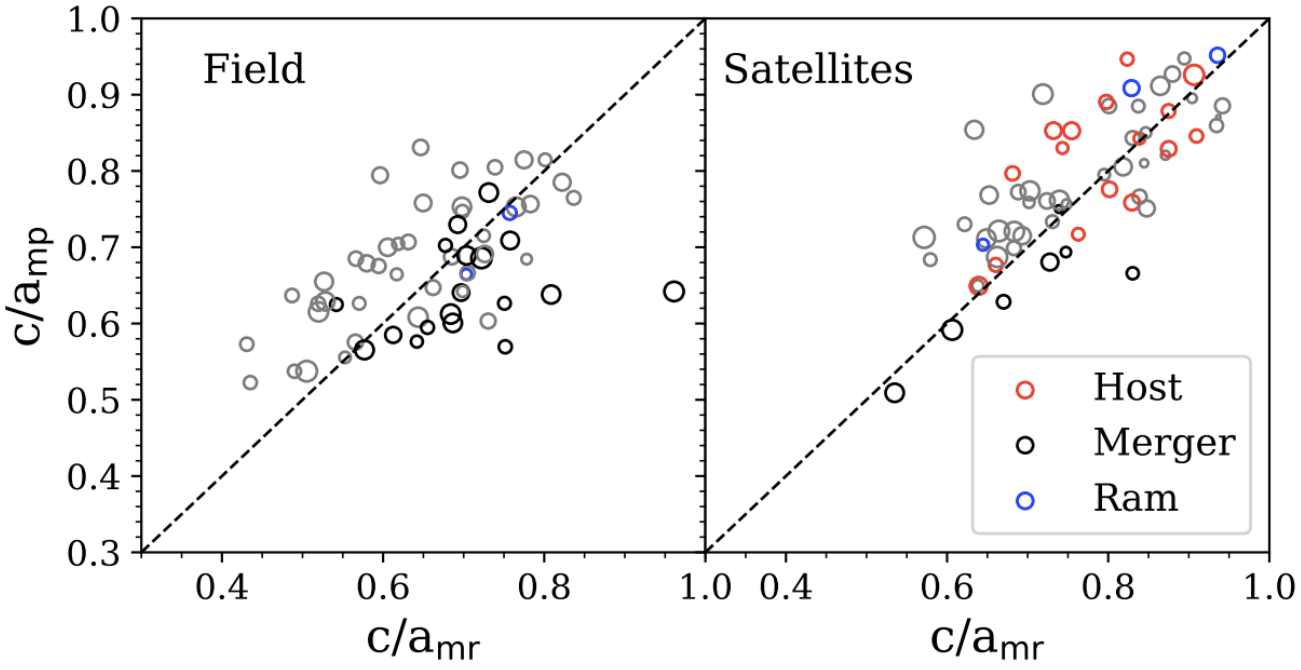


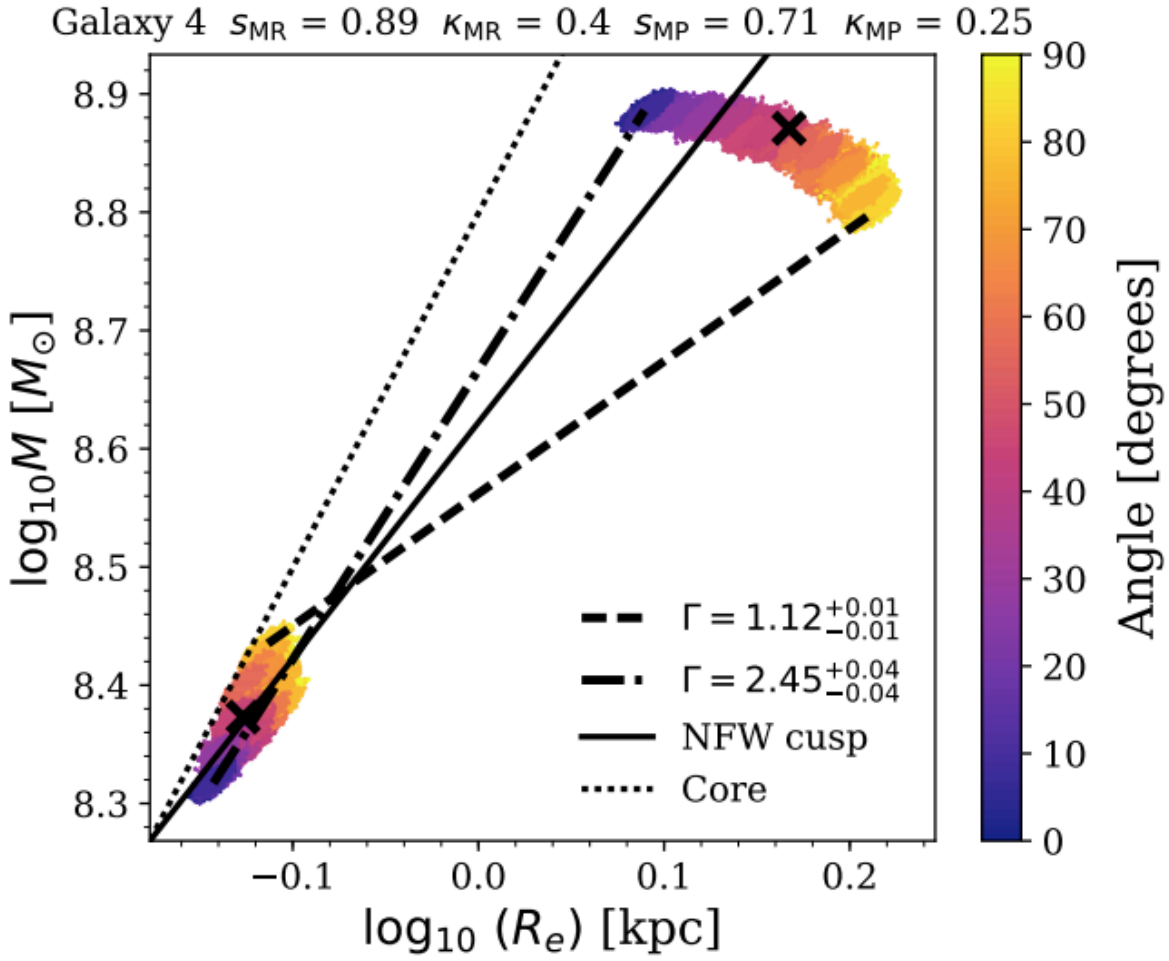


see also Kowalczyk et al. (2013) arXiv: 1212.3438

The core - cusp problem: a matter of perspective

Genina et al. (2018) arXiv:1707.06303

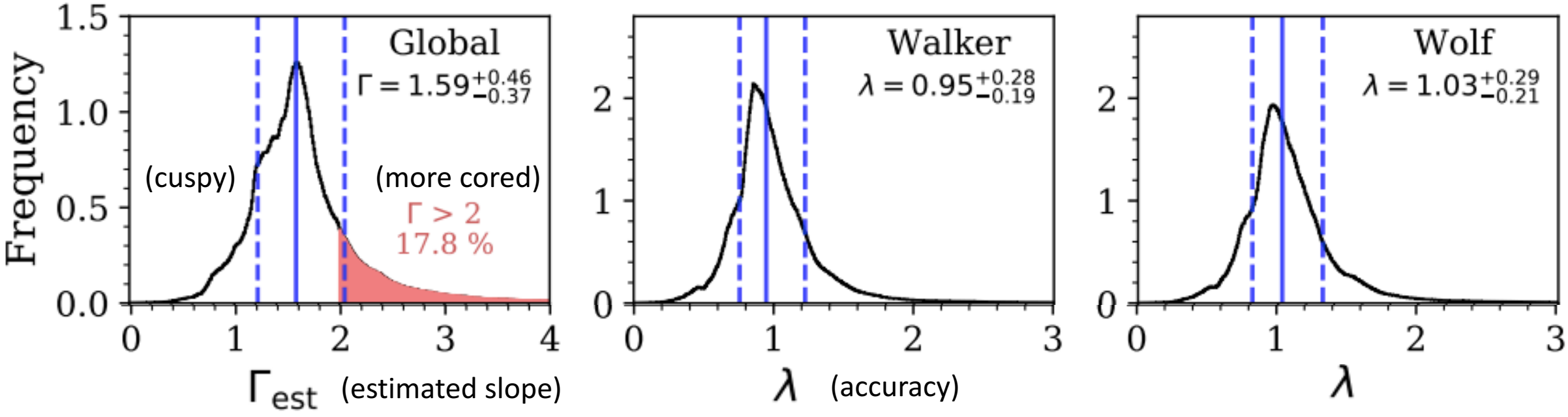




We find satellites and fields with different ellipticities of the metal-rich and the metal-poor populations. This difference occurs across the entire range of masses explored.

The core - cusp problem: a matter of perspective

Genina et al. (2018) arXiv:1707.06303



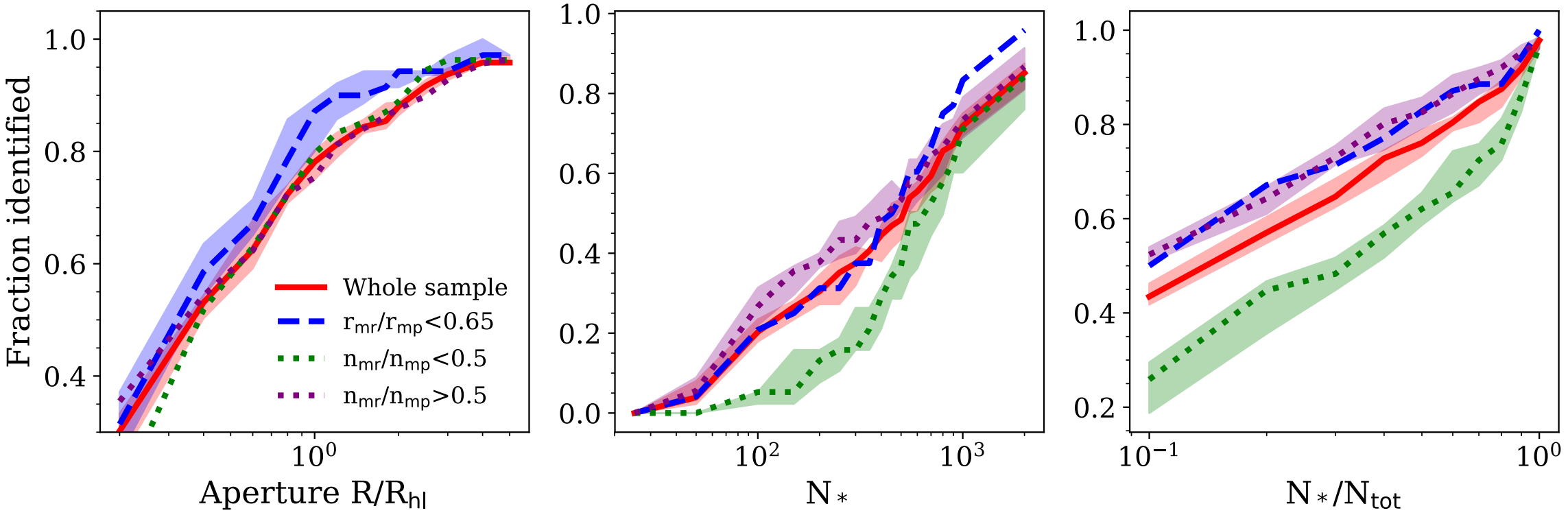
- The estimators do well on average, but ~20% of the time we infer a core-like profile, when in reality there is a cusp.

- Problematic dwarfs are ones where the the two populations have different ellipticity and/or are misaligned

Questions?

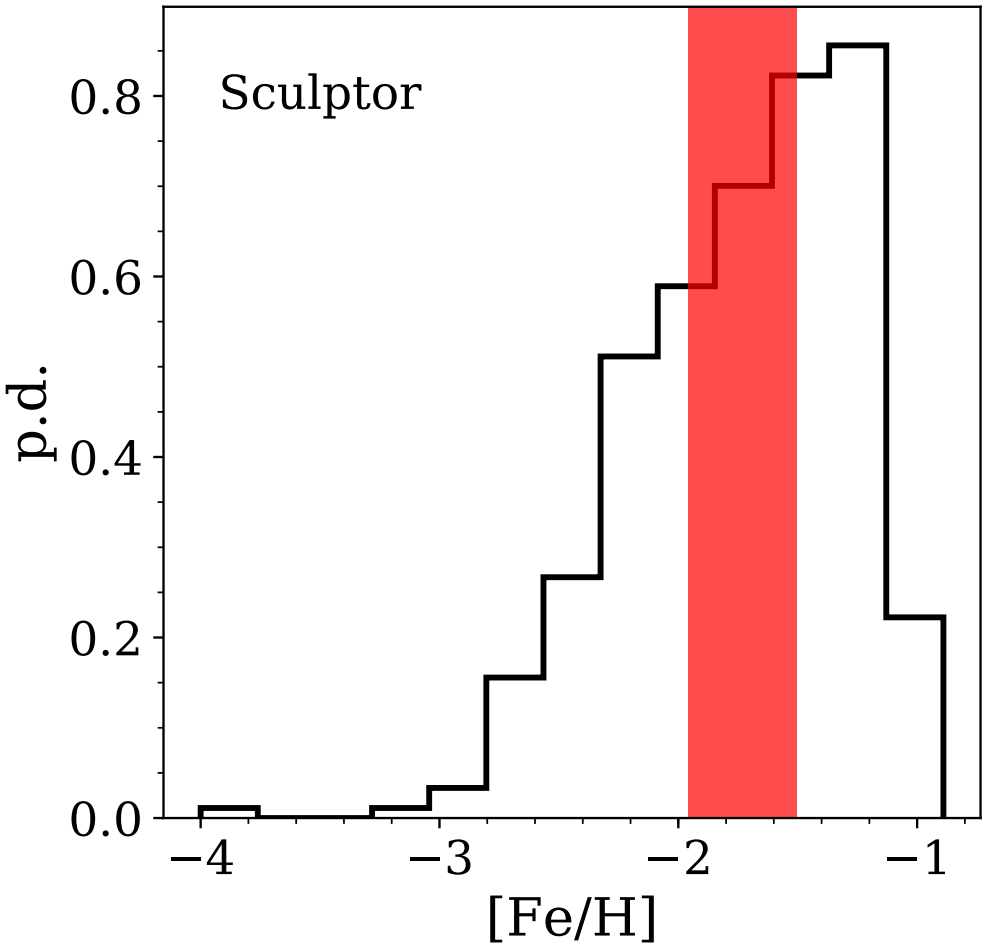
And thanks
for listening!

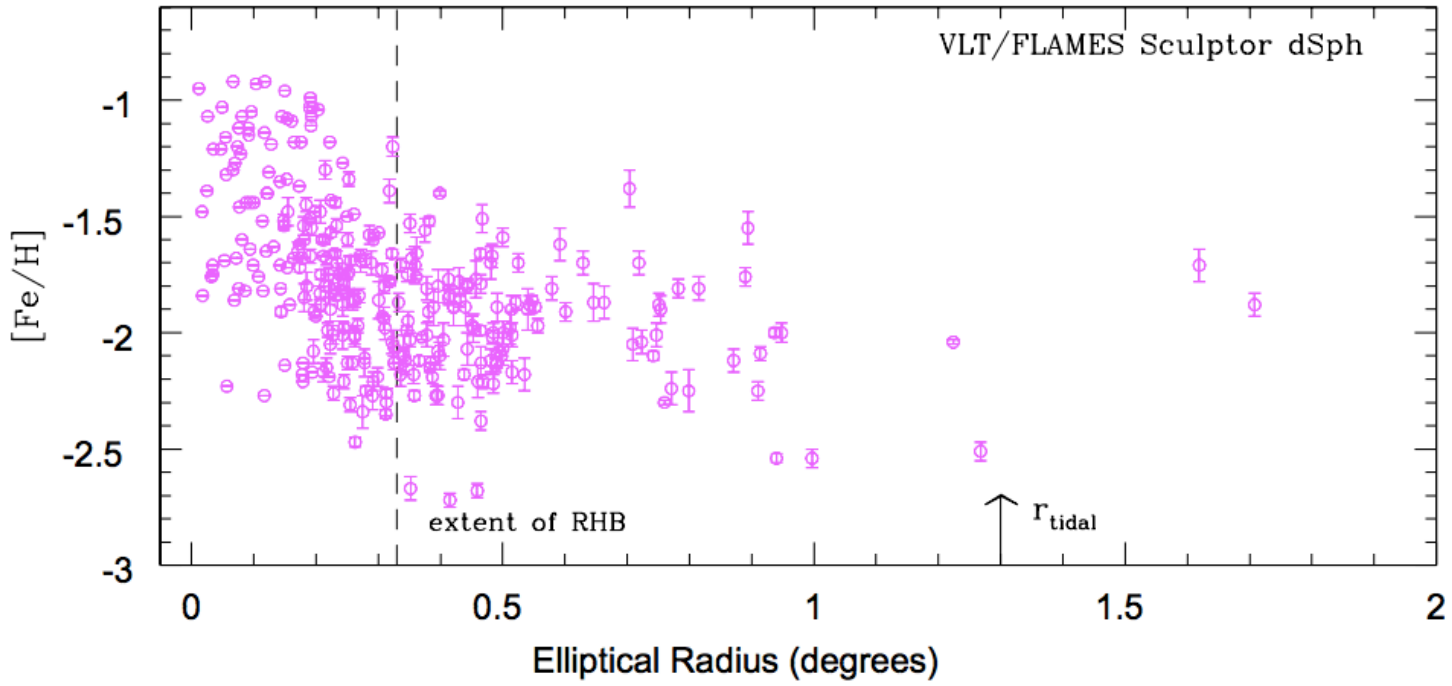
Need more stars and data beyond ~3Rh (difficult to achieve though)



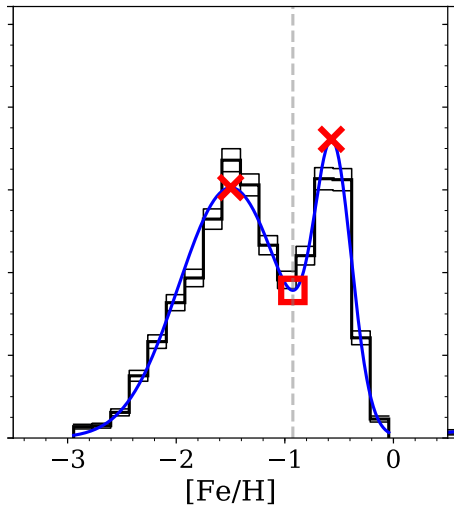
Fraction of galaxies correctly identified as having two populations
Expect 1-3 galaxies within the mass range explored

We apply our method to find two populations in Sculptor





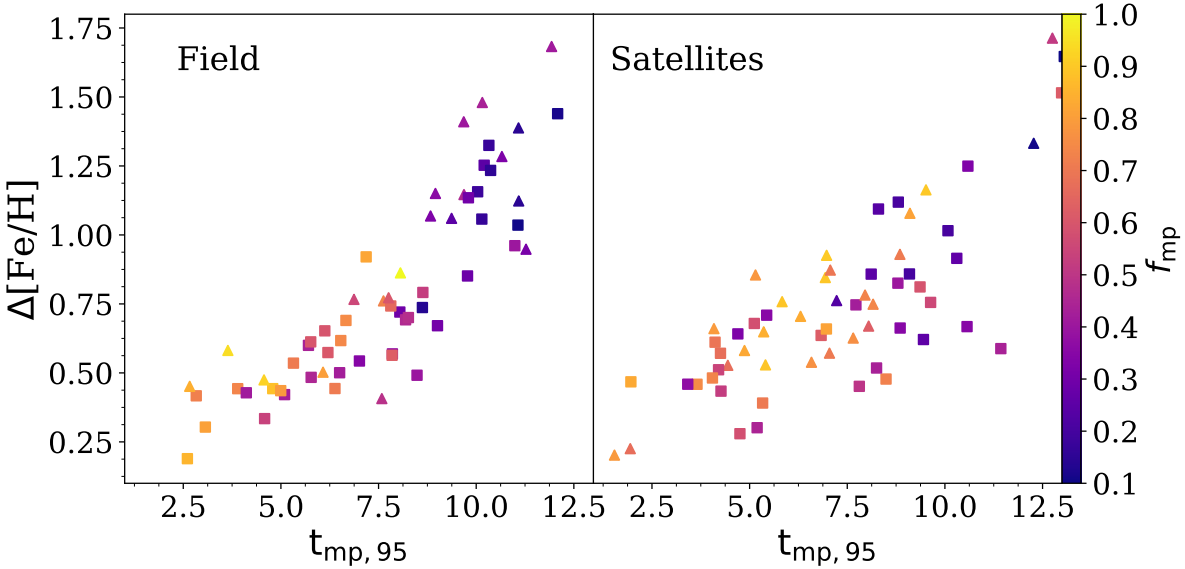
The origin of metallicity distribution bimodality

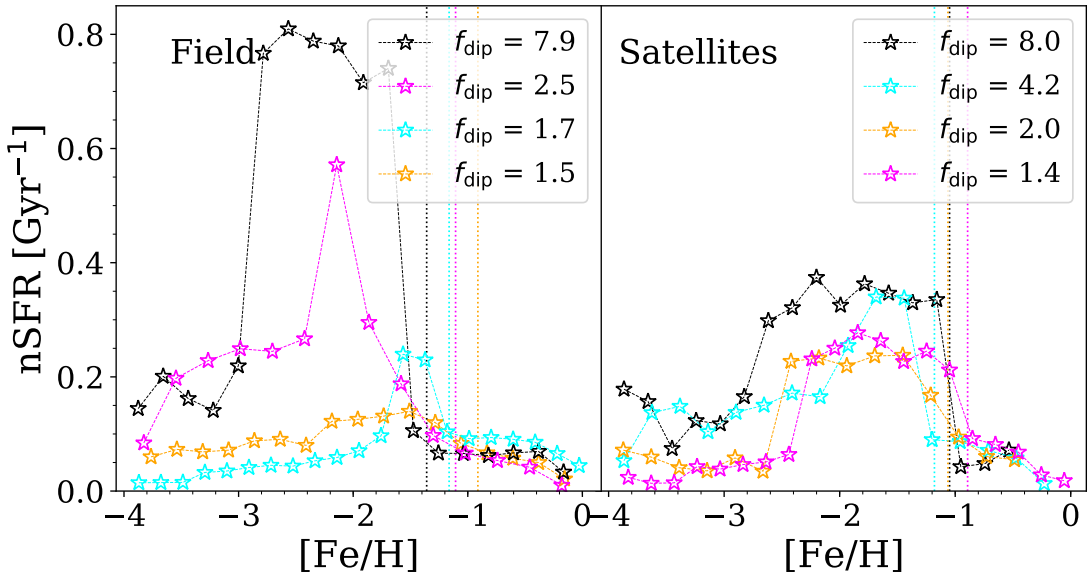


The separation of the metallicity peaks depends on how long the galaxy had to form its stars

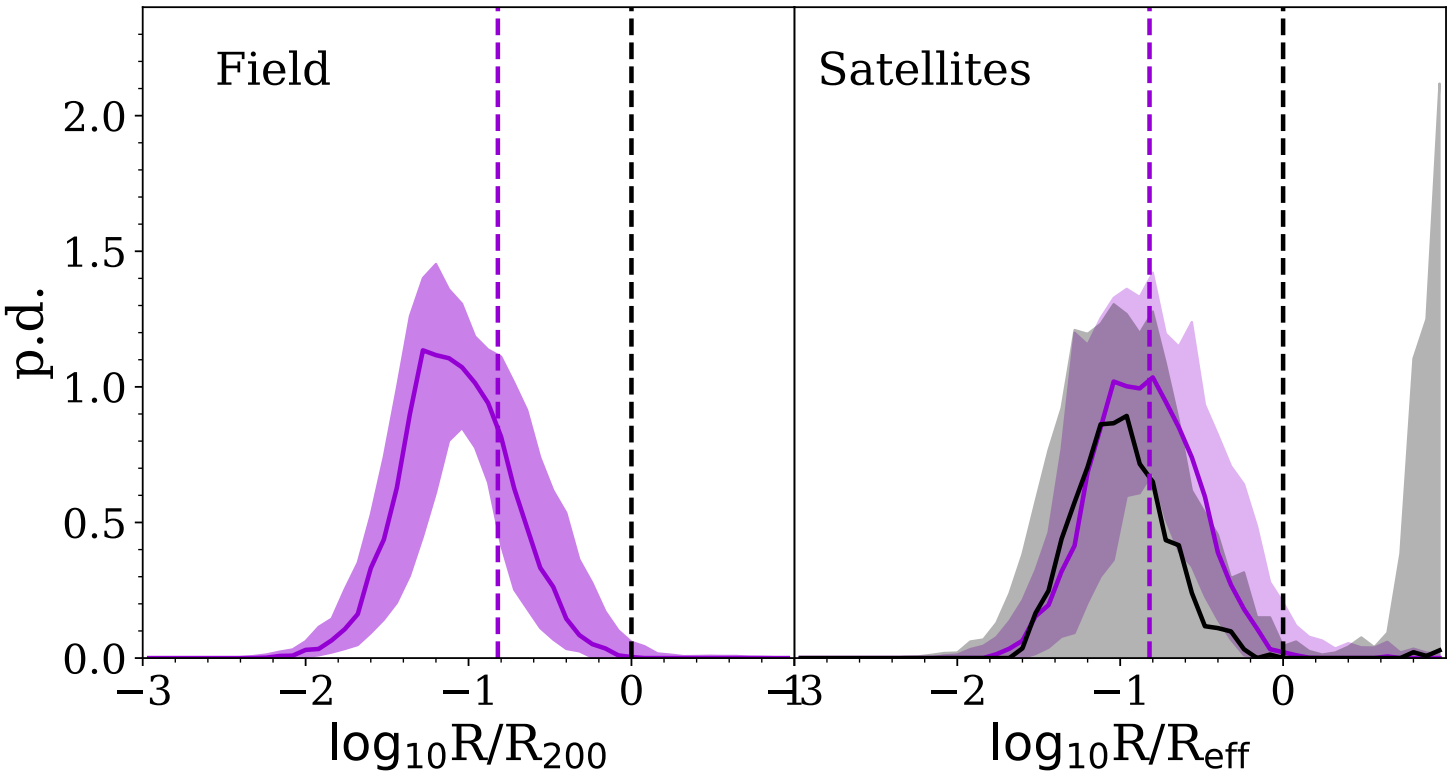
How quickly do stars form in each metallicity bin.

Split of two populations (dip in the distribution) happens after an intense episode of star formation



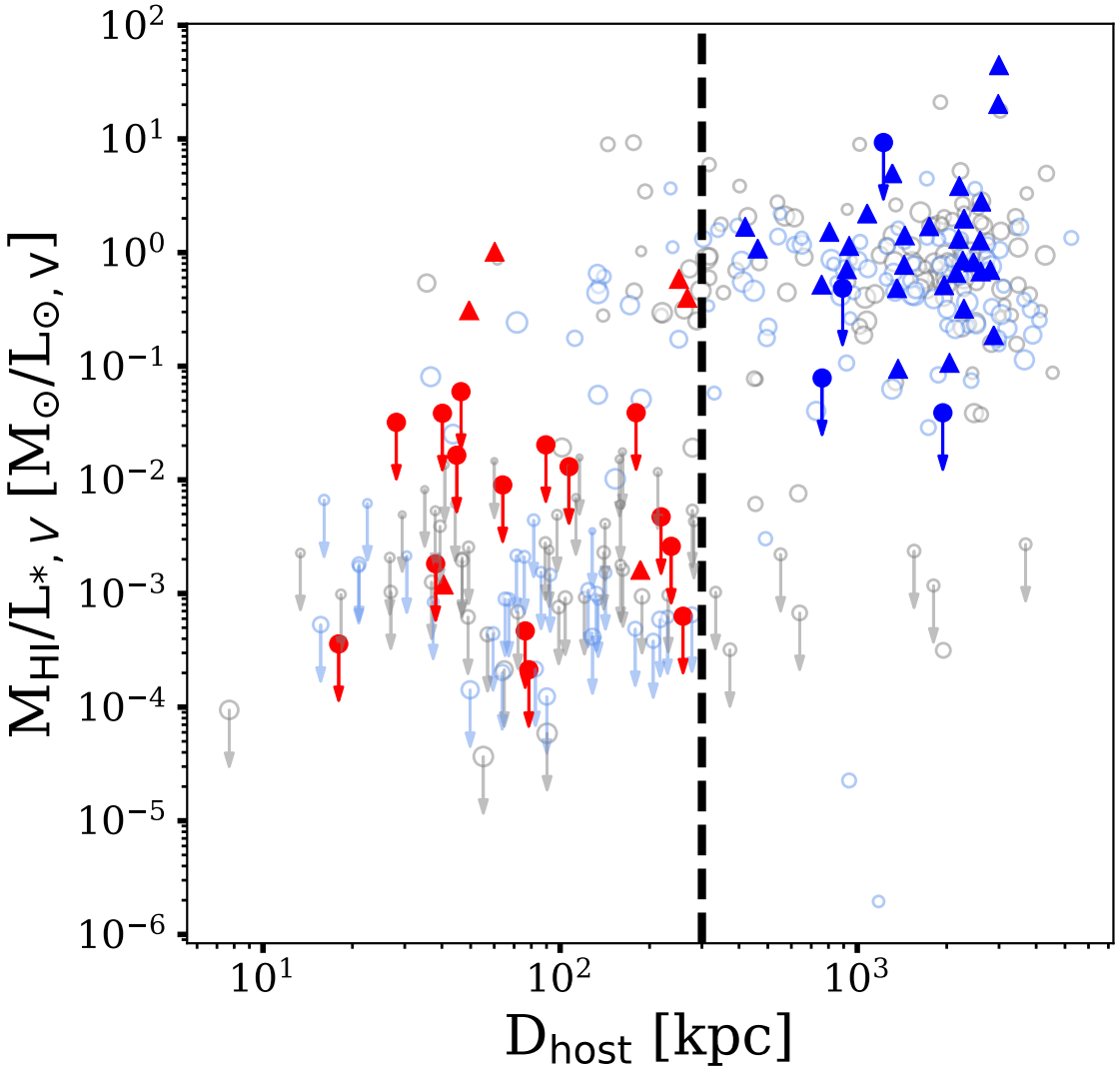


The gas is enriched within the galaxy!



Position of gas particles when they were sufficiently enriched to form a metal-rich stellar particle

We replicate the z=0 HI masses in APOSTLE



Accretion matters for satellites too!