Dark and luminous satellites of isolated LMC-mass galaxies in the FIRE simulations

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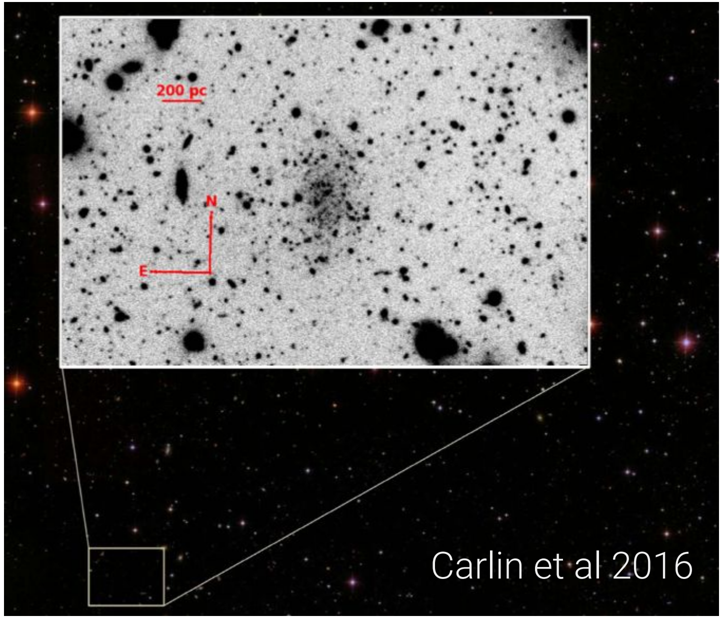
Laura Sales, Andrew Wetzel, FIRE Collaboration et al.

Science In Our Own Backyard: Exploring the Galaxy and the Local Group with WFIRST

June 19, 2019

Motivation: WFIRST and Satellites of LMC-analogs



- ΛCDM predicts **many** dwarf galaxies orbiting LMC-type galaxies (largest dwarfs)
- WFIRST can find satellites of isolated LMC's and **test predictions on the faint end of galaxy formation**
- Promising results from ground-based surveys, e.g. MADCASH

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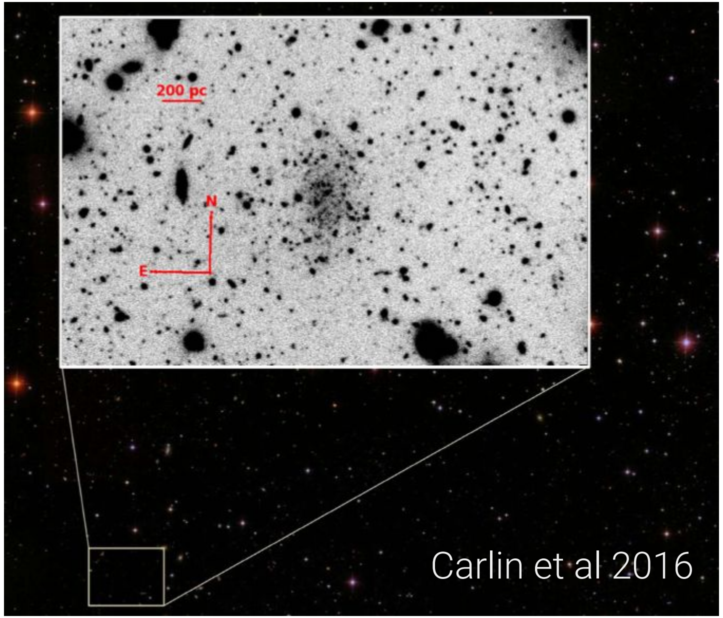


Carlin et al 2016

Satellites themselves also useful laboratories:

- **Ultrafaints** = limits of galaxy formation
  - Least massive, most abundant
  - Only observed near MW so far
  - Tools to study gal. form. processes, reionization, early universe (fossils)
  - Evolution in different environments
- Detection: **field vs. satellite** galaxies

FIRE Simulations: Our Sample

Jahn et al., in prep

Five isolated LMC-mass hosts

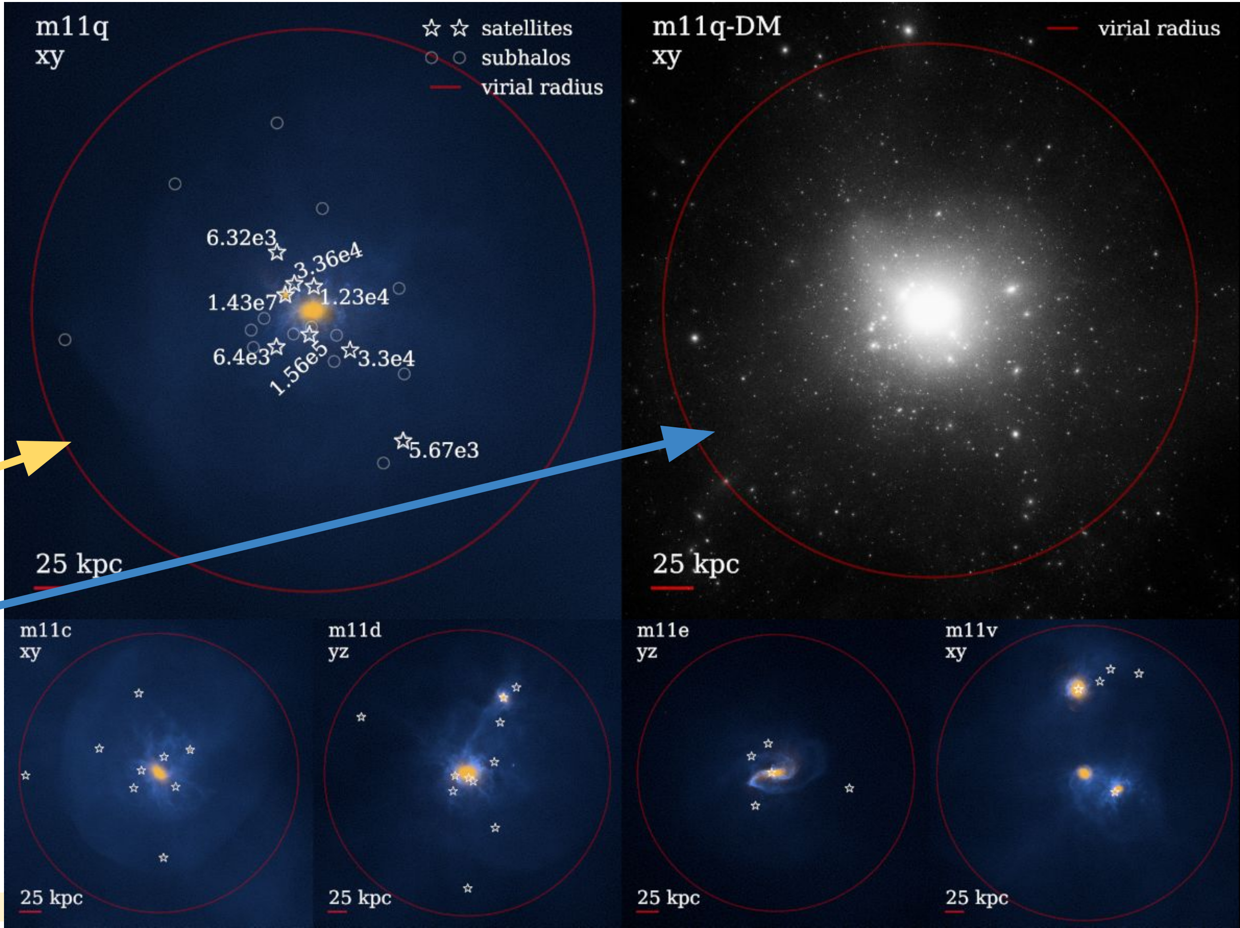
$M_{halo} = 1\text{-}3 \times 10^{11}\ M_{\odot}$

Compare to the *Latte* suite:
seven isolated MW-mass hosts

$M_{halo} = 1\text{-}2 \times 10^{12}\ M_{\odot}$

Hydro versus **DMO**

stars, gas, etc — dark matter only

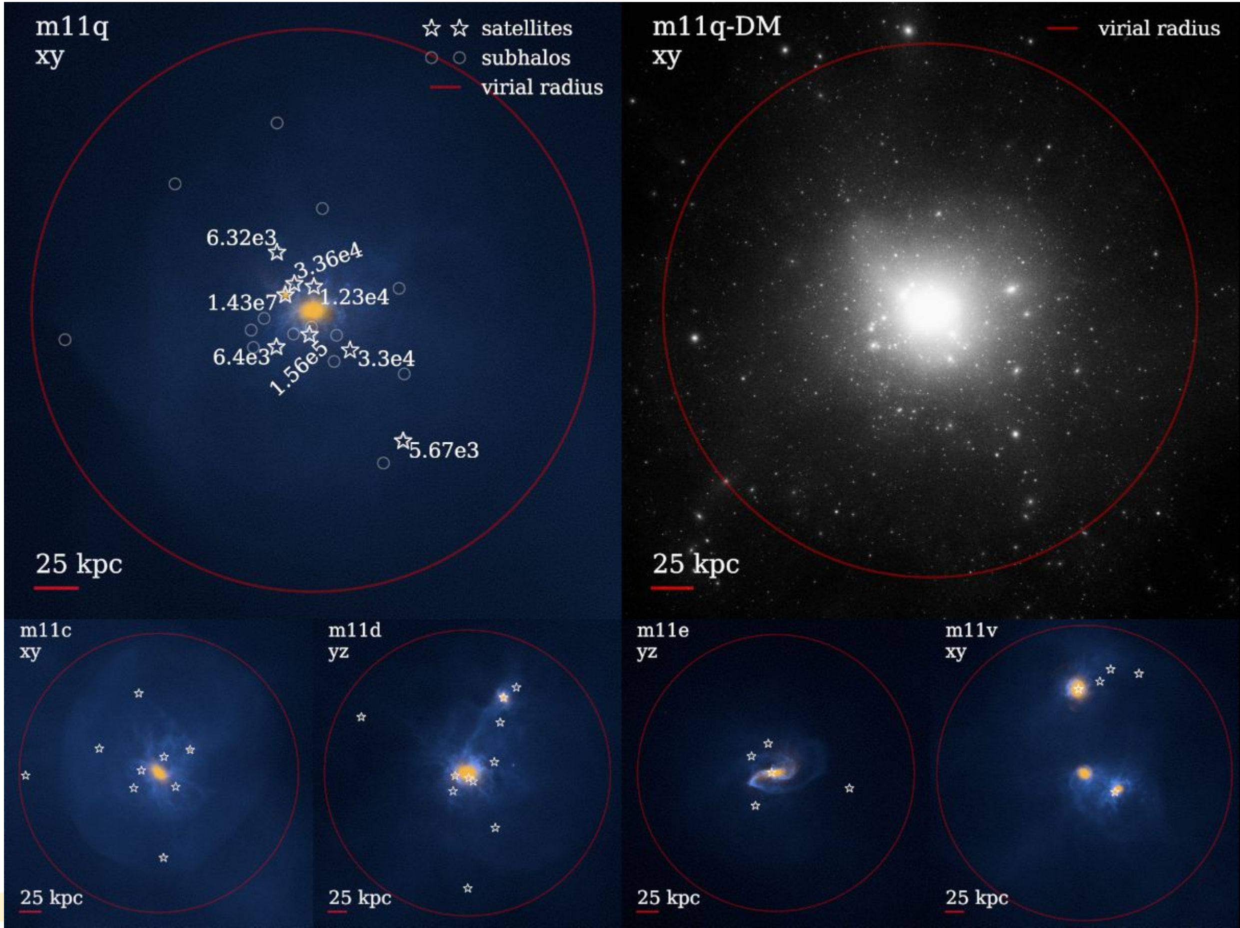


FIRE Simulations: Our Sample

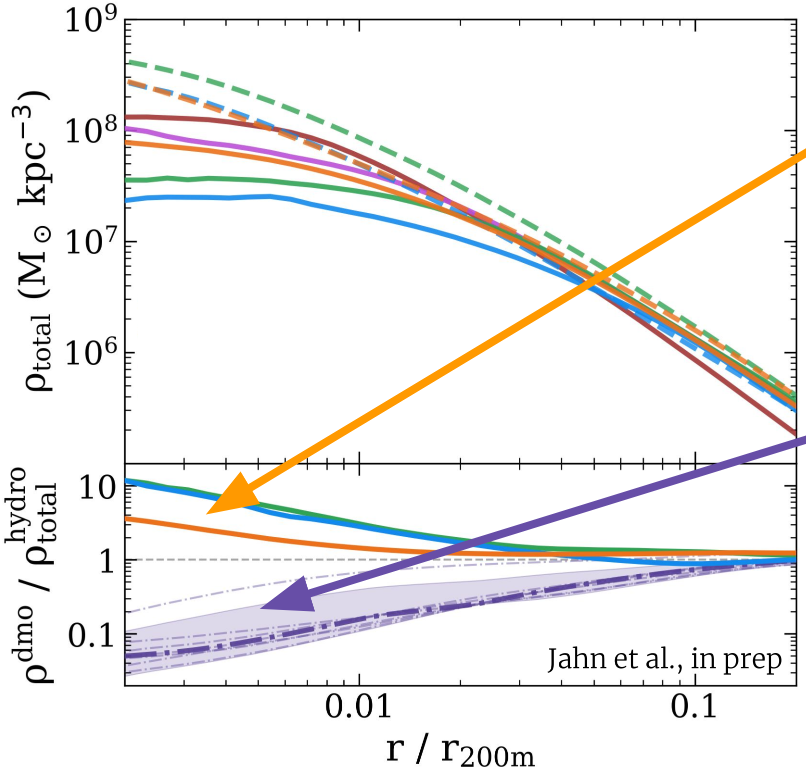
Jahn et al., in prep

Plan:

1. Count DM subhalos
2. Count satellite galaxies



FIRE Simulations: Our Sample

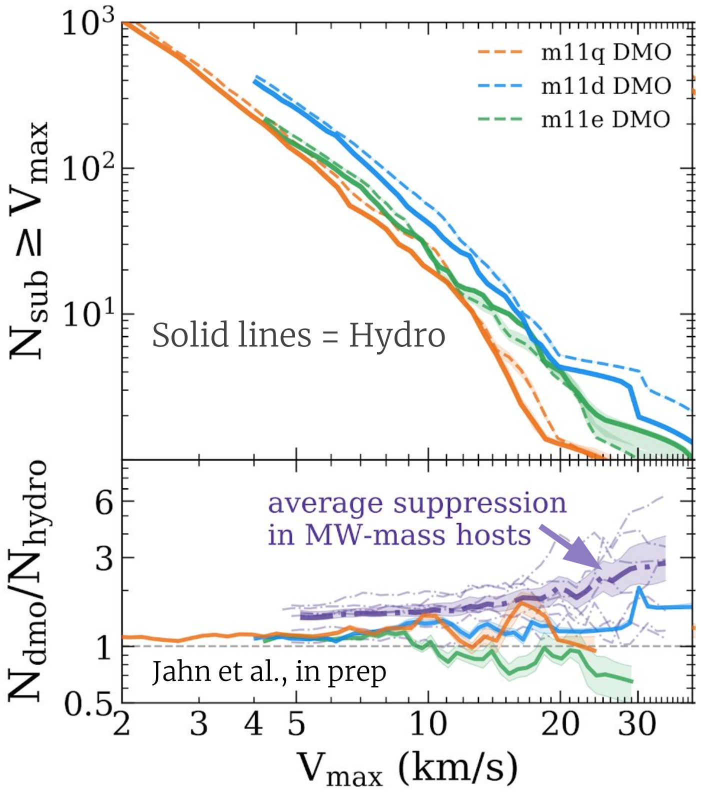


LMC-mass halos show inner regions with **low density** (cores)

While **MW**-mass halos have **high density** inner regions

Why is host density relevant to counting subhalos?

Substructure Depletion



Satellite Velocity Function

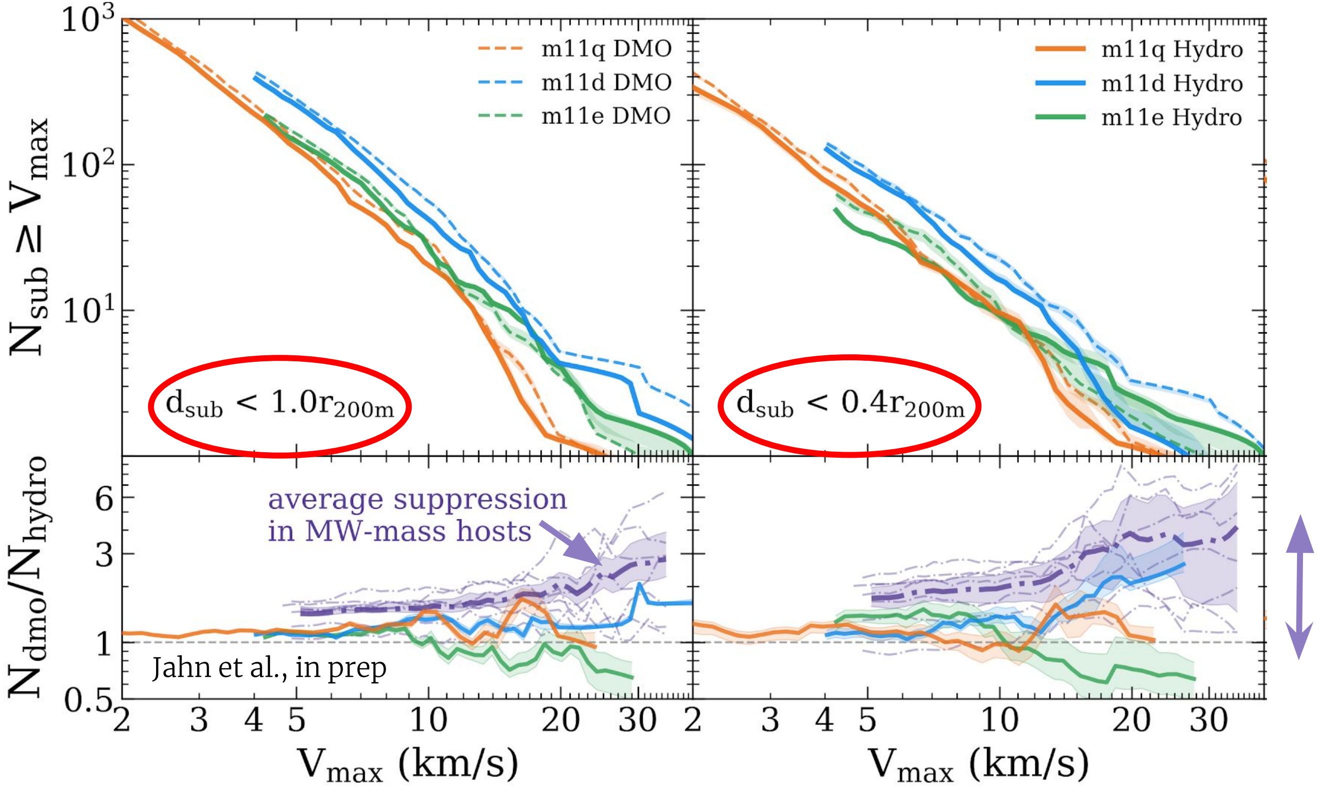
How many subhalos are hosted by LMC-mass centrals in ***DMO*** versus ***Hydro*** simulations?

Subhalo counts are time-averaged for z<0.1, or 1.3Gyr

Suppression/Depletion

Tidal interactions with central galaxy **reduce the number of subhalos** at a given V_{max}

Substructure Depletion



Increase in suppression for **MW**-mass hosts

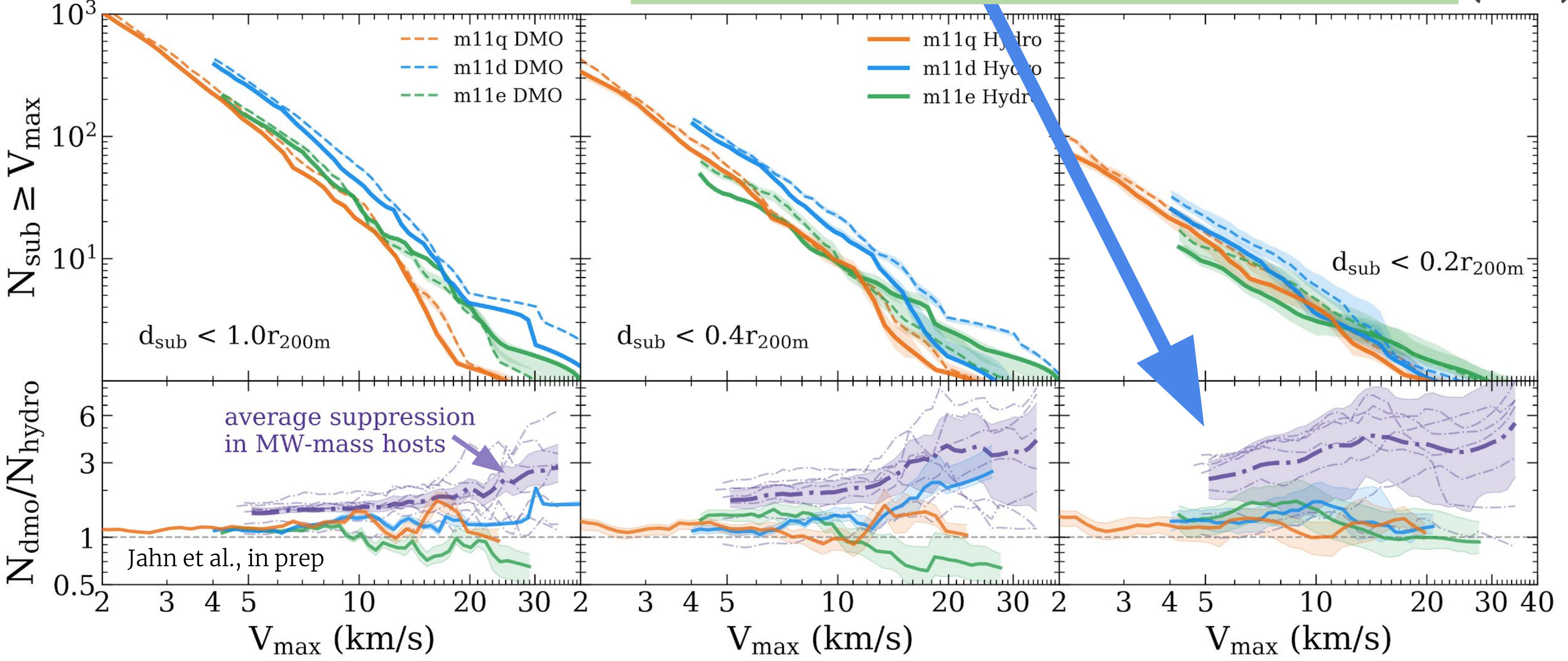
→ fewer surviving subhalos

Not much change for **LMC**-mass hosts (scatter)

Substructure Depletion

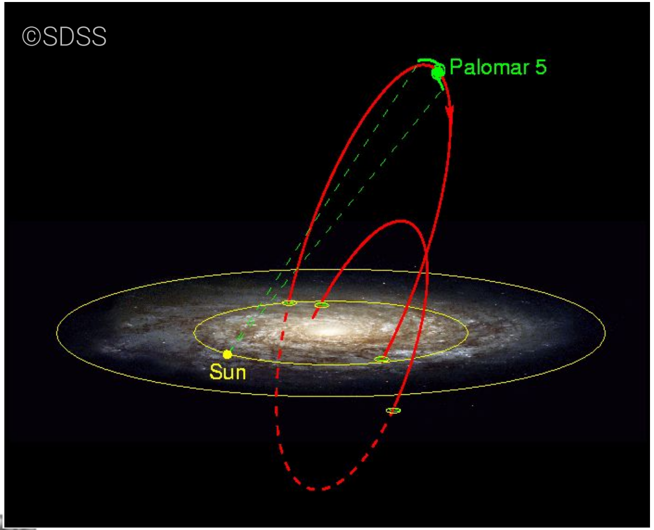
Strong depletion from MW at inner regions (~3)

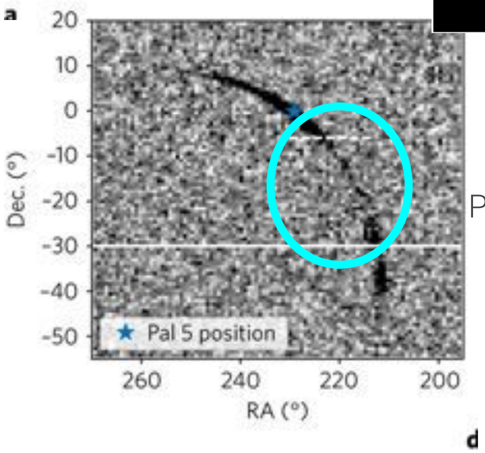
LMC-mass hosts retain much more substructure (~1.5)



Substructure Detection with WFIRST

- Isolated LMC-like hosts are **less destructive** to their substructure than MW's
- **Stronger relative dynamical impact** from dark halos for LMC-host system versus MW-host system
- WFIRST detects individual stars, so **disturbances in tidal streams** are possible to detect, which point to interactions with dark subhalos

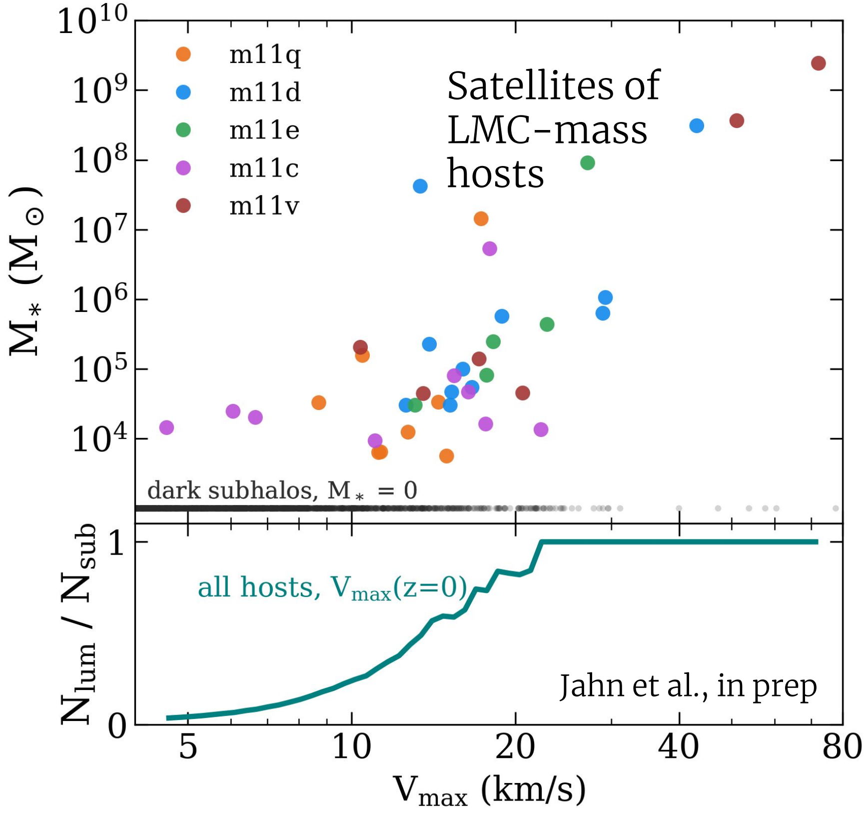




Pearson et al. 2017

Pearson, et al. 2019
arXiv:1906.03264

Substructure: Dark and Luminous



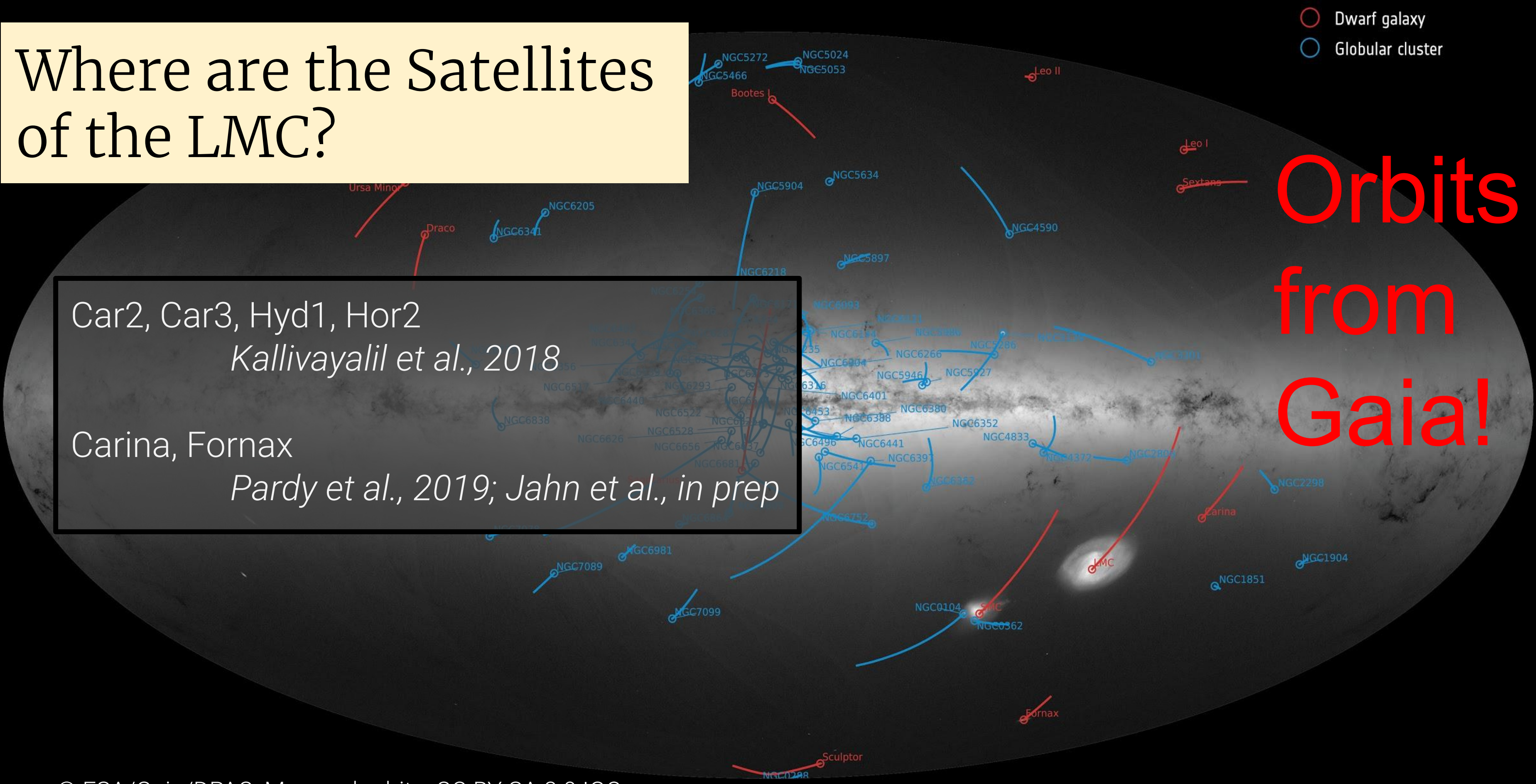
Subhalos act as **sites of galaxy formation**

All subhalos with V_{max} > 20 km/s host a stellar component

Occupation fraction drops off for smaller subhalos

➢ Suppression of star formation by **reionization**

Where are the Satellites of the LMC?



Orbits from Gaia!

Car2, Car3, Hyd1, Hor2

Kallivayalil et al., 2018

Carina, Fornax

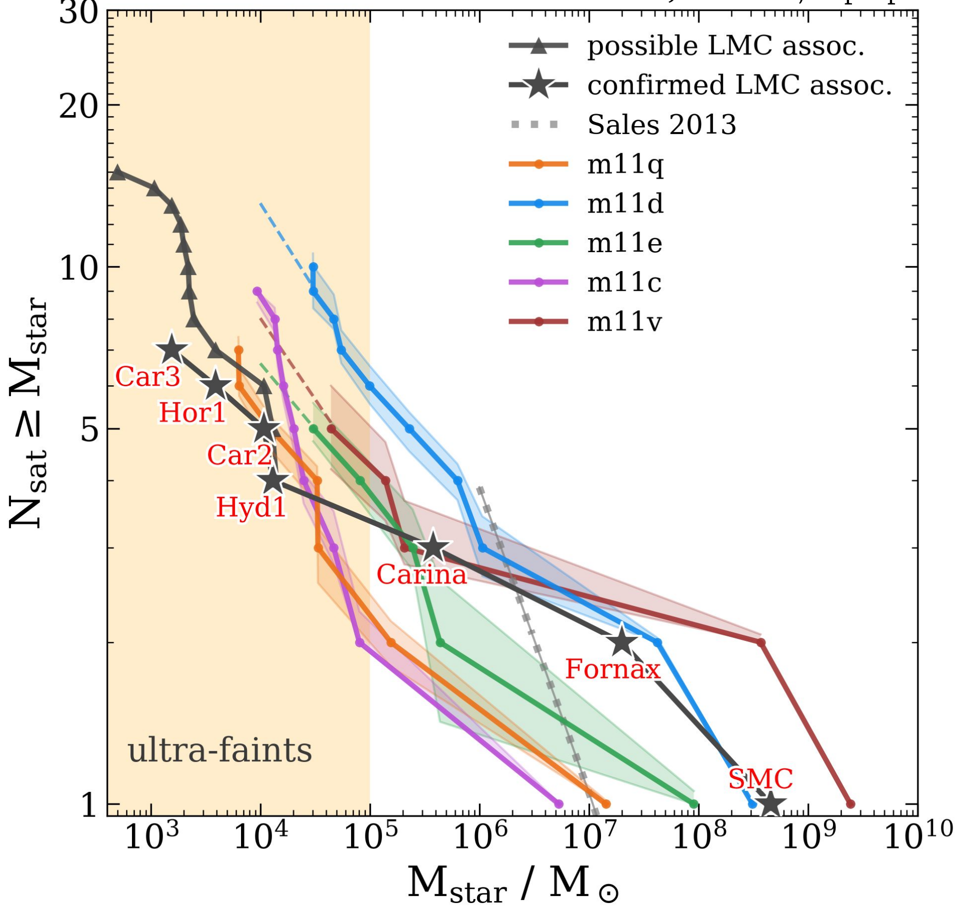
Pardy et al., 2019; Jahn et al., in prep

Where are the Satellites of the LMC?

- Agreement on bright end favors **large LMC halo**
- Is the LMC **missing** a few **ultrafaint** companions?
- Triangles = likely candidates awaiting full proper motions

Ultrafaints in FIRE:
Wheeler et al. 2015, 2018

Jahn et al., in prep



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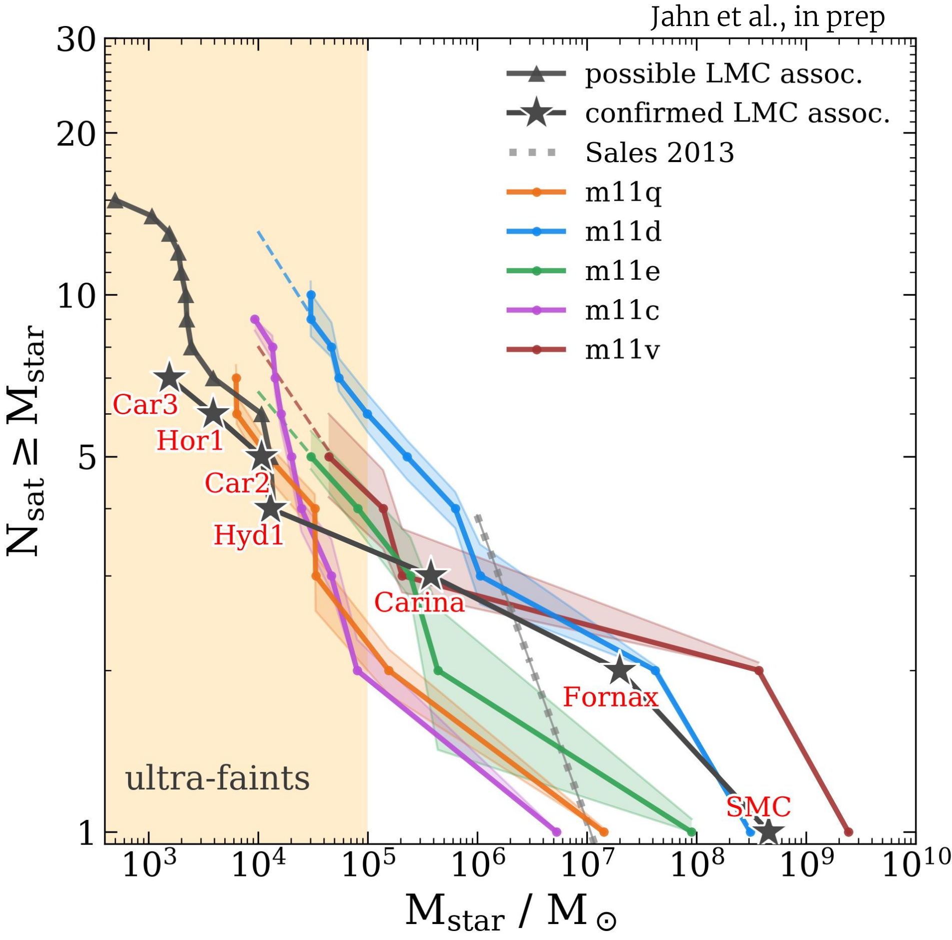
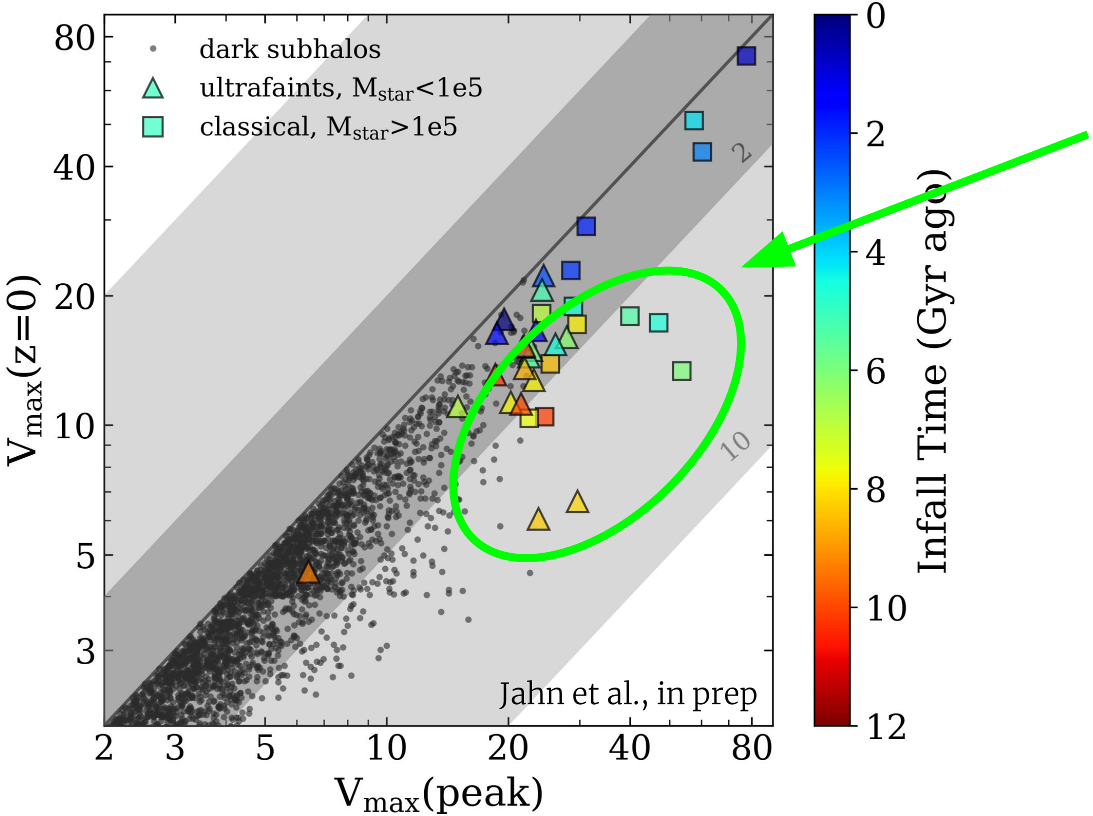
Satellite counts: good agreement

What about other properties?



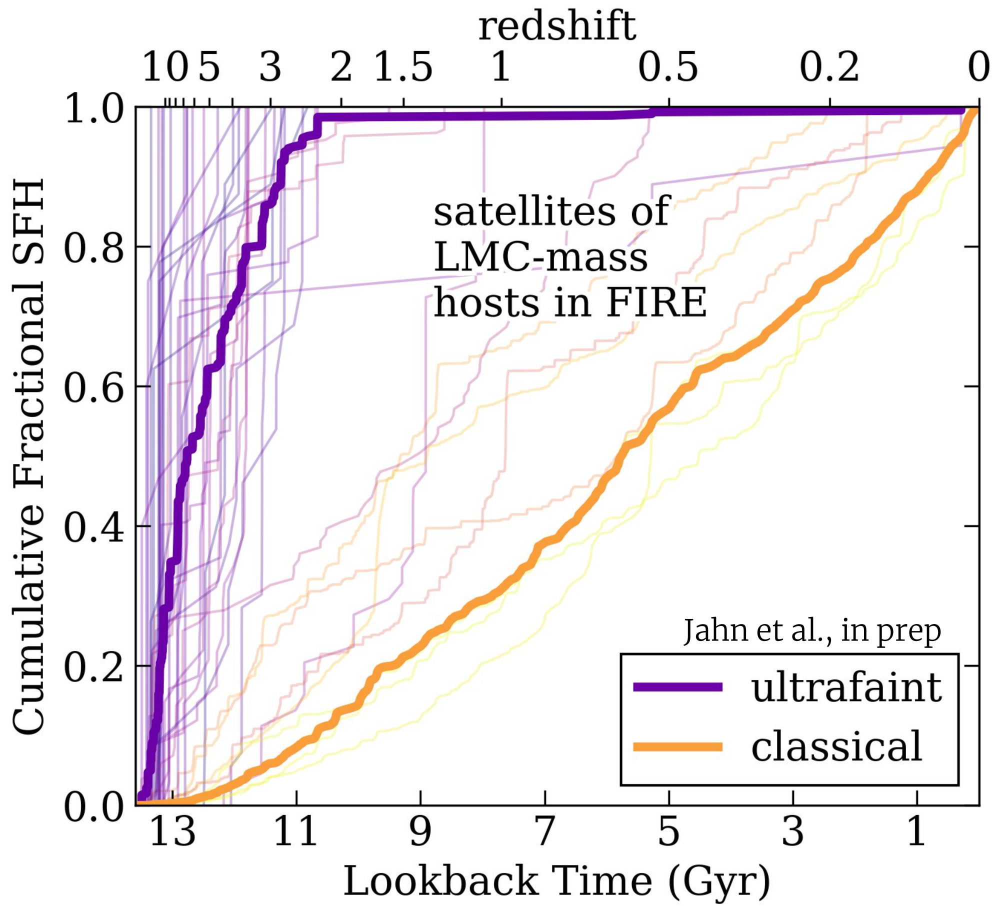
Effect of the LMC Environment on Satellites



Tidal stripping seems to be important, even at LMC scale

Reduction in V_{max} points to a **lowering of satellite density**

Star formation histories of LMC Satellites



Low mass → early forming

High mass → late forming

High impact from reionization

Fillingham et al.2019

Fitts et al. 2016

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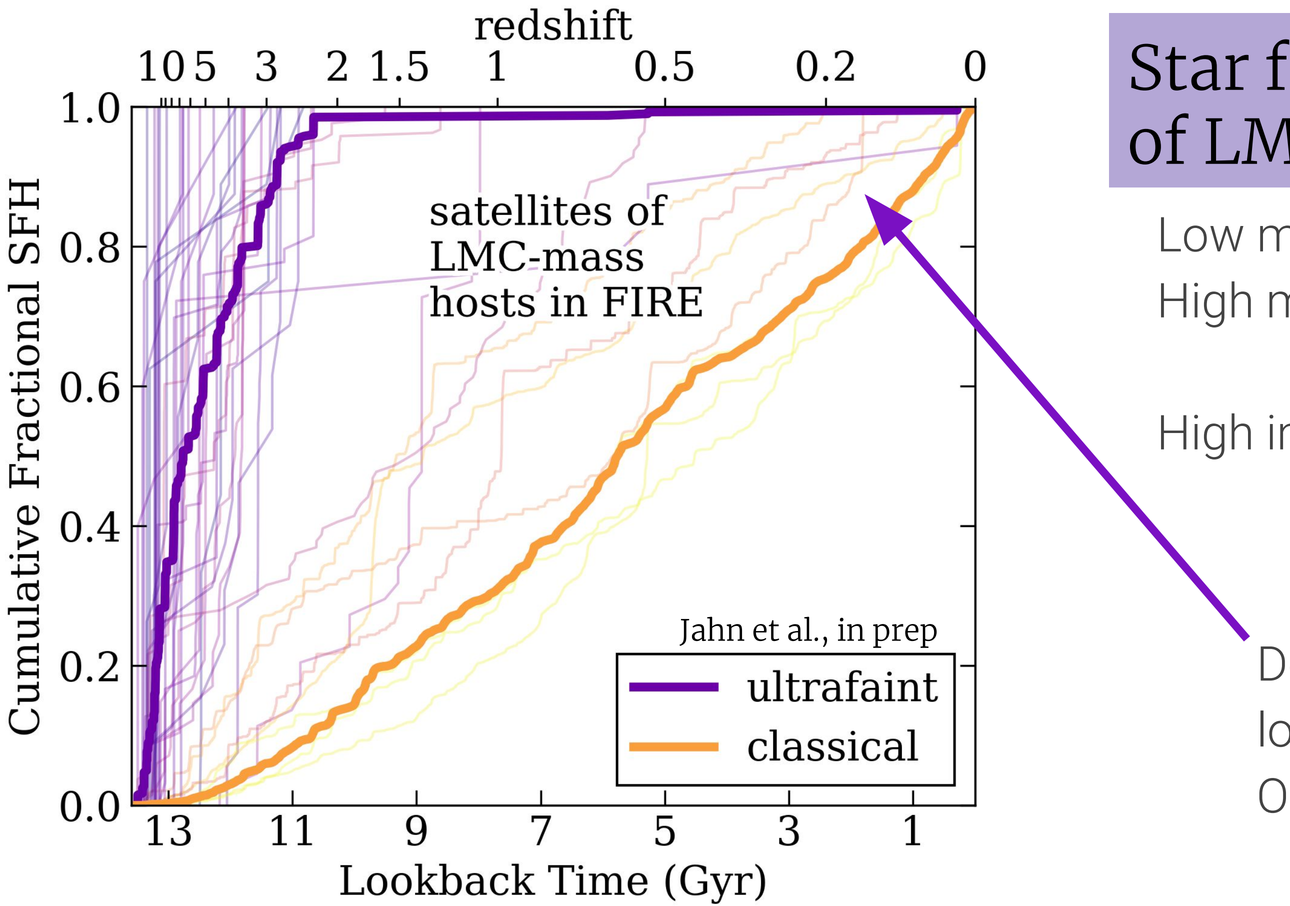

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Do we see late-forming low-mass satellites?

Ongoing investigation...

Summary of Predictions for WFIRST

- **Gaps in stellar streams** around LMC-mass galaxies from subhalo interactions

- In a 10 Mpc volume, expect ~dozen LMC's
  - 60-84 satellites > $10^5\ M_{\odot}$ (5-7 per host)
  - Many more ultrafaints as well
  - **WFIRST should find numerous dwarf satellites of Magellanic-type galaxies**

- **Tidally stripped**, low-density satellite galaxies

- Many reionization fossils
  - Some faint satellites may still be forming stars?
  - **Stellar photometry allows WFIRST to measure Star Formation Histories!**