

# Probing reionization with streams in external galaxies using Roman

**Aritra Kundu**

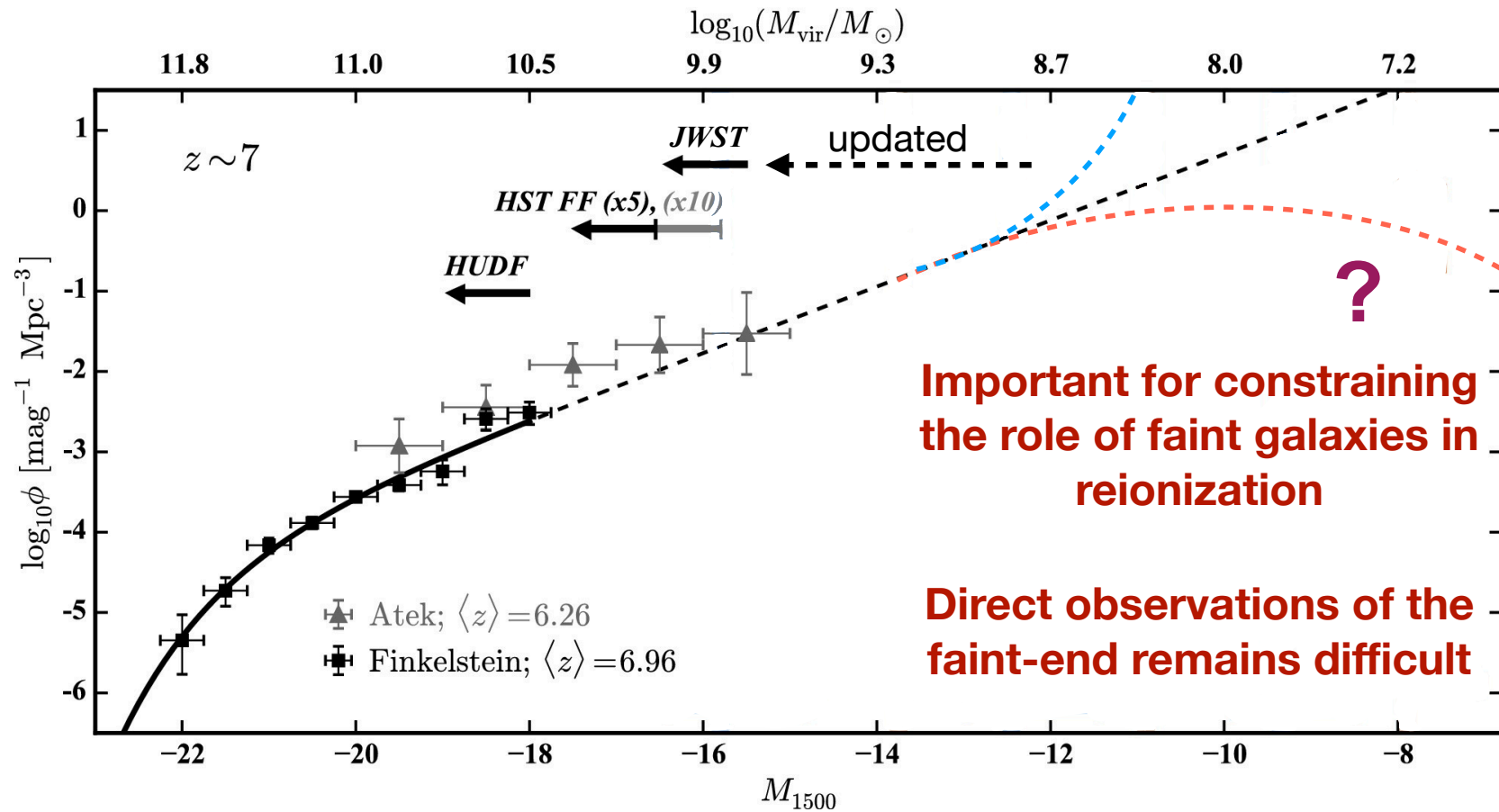
***University of Pennsylvania***

*Robyn Sanderson, Benjamin Williams, Adrien Thob, Adam Lidz*

Shifting Landscapes in Astrophysics  
July 2026



# The key question - What is the shape of high- $z$ UVLFs at faint-end?

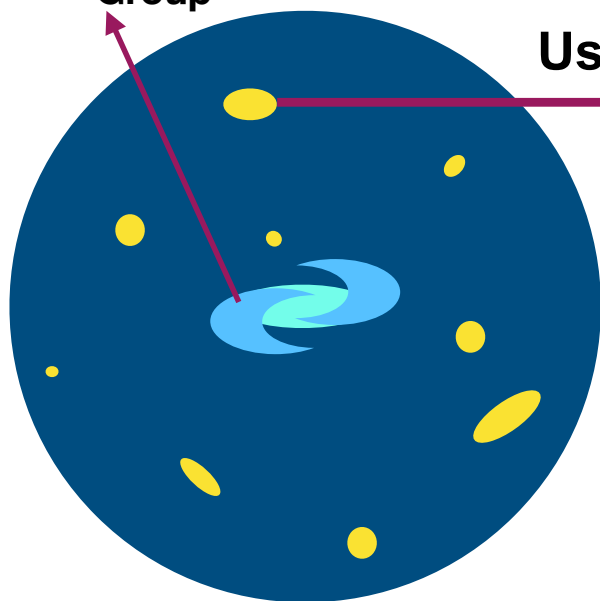


Adapted from Boylan-Kolchin et al. 2015

# From low- $z$ galaxies to their high- $z$ progenitors

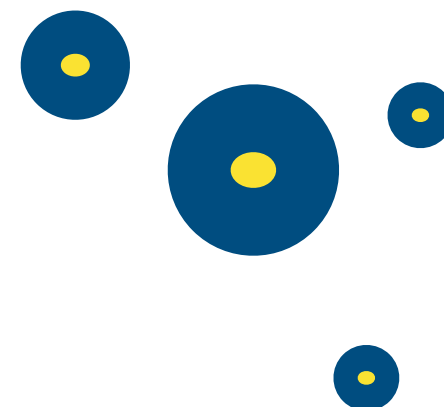
(near) (far)

Milky Way / Local  
Group



$z = 0$

Using SFHs from resolved CMDs

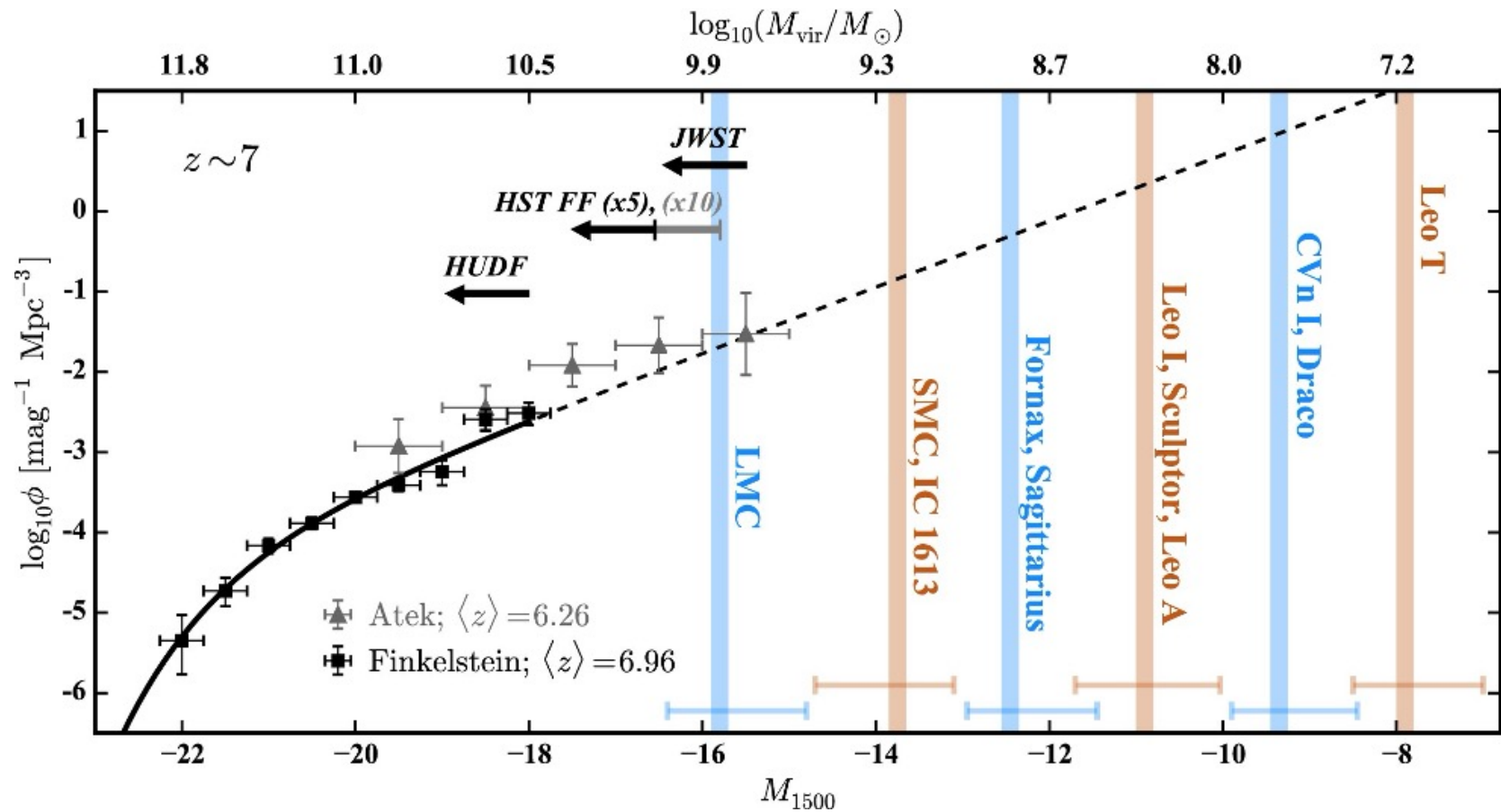


Stellar mass / UV luminosity  
at  $z \gtrsim 6$



- Dwarf galaxy

# Near-far technique using LG dwarfs can probe the faint end



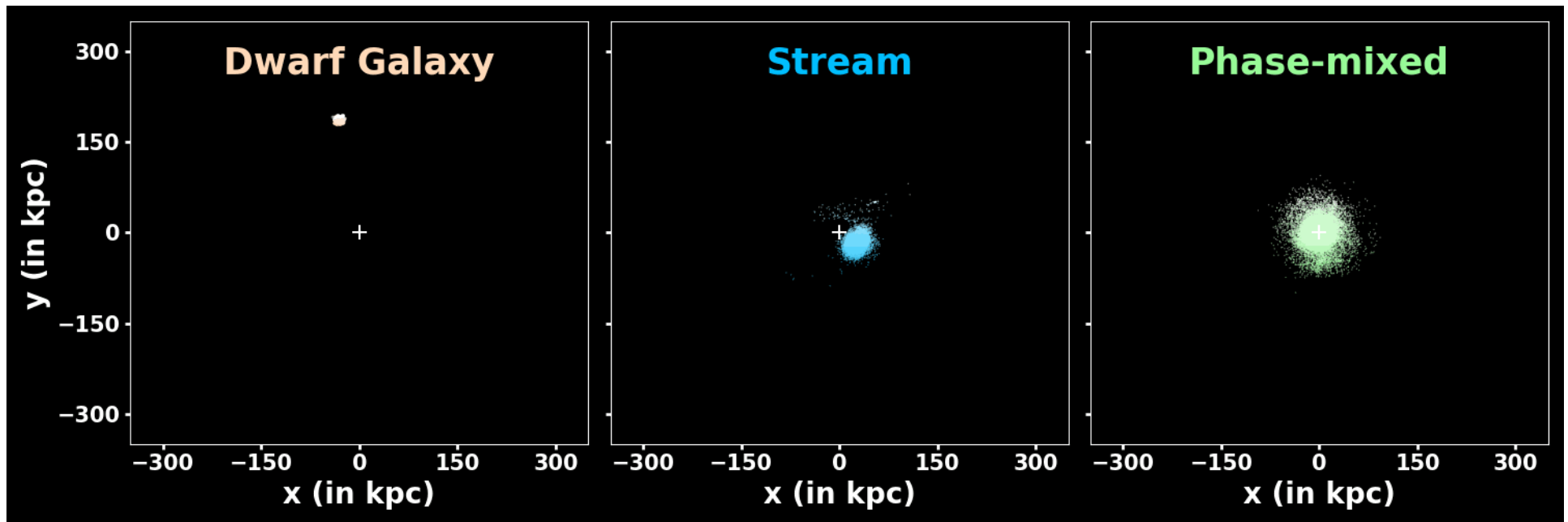
Boylan-Kolchin et al. 2015



# But what about disrupted galaxies?

Intact

Tidally disrupted



**From the FIRE simulations**

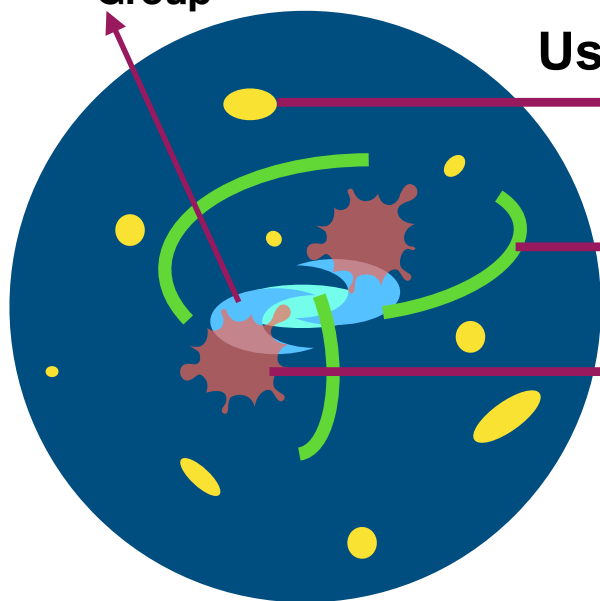
Cosmological zoom-in baryonic simulations with  
mass resolution of 4000-7000  $M_{\odot}$



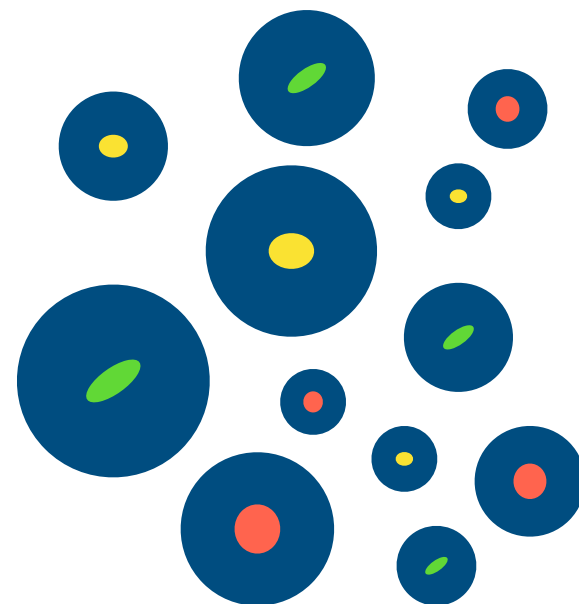
# From low- $z$ galaxies to their high- $z$ progenitors

Now with present-day disrupted galaxies

Milky Way / Local  
Group



Using SFHs from resolved CMDs



$z = 0$

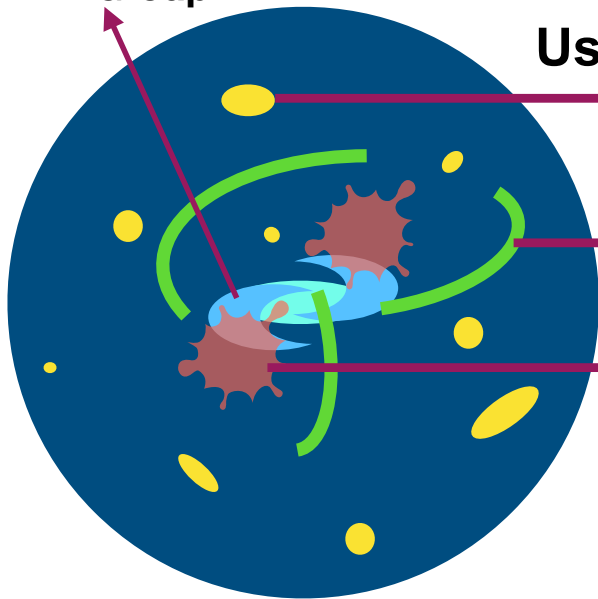
- Dwarf galaxy
- Stellar stream
- Phase-mixed object

UV luminosity  
at  $z \gtrsim 6$

# From low- $z$ galaxies to their high- $z$ progenitors

Now with present-day disrupted galaxies

Milky Way / Local  
Group



$z = 0$

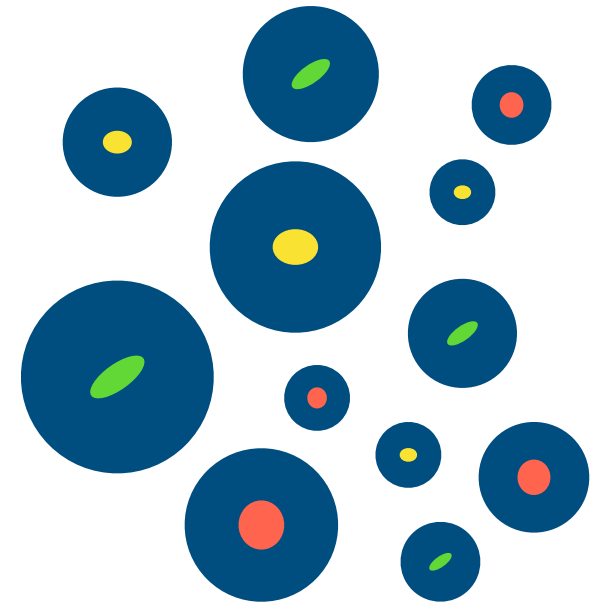
Using SFHs from resolved CMDs

(observations)

(simulations)

Track star particles to their  
progenitors in FIRE

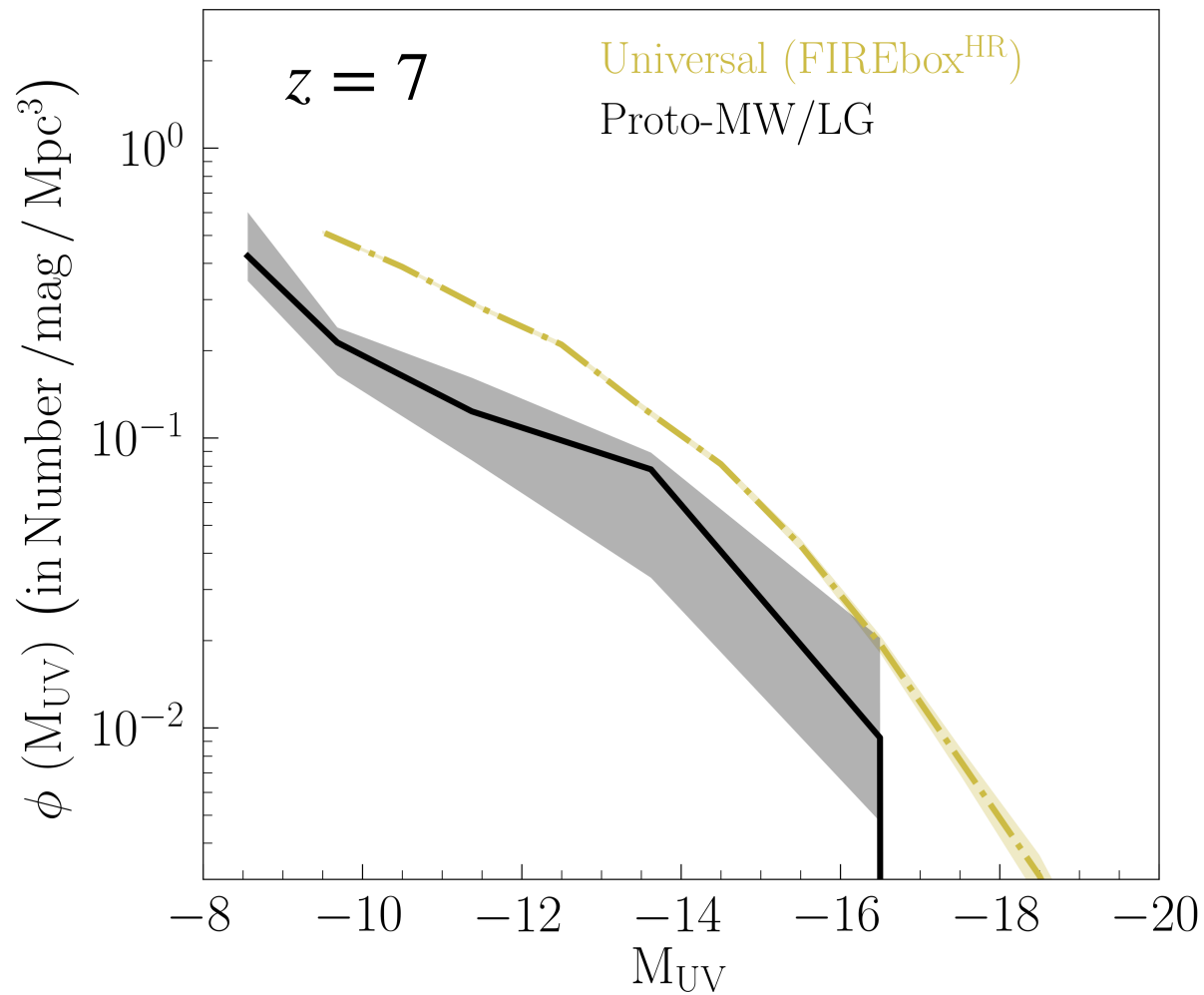
- Dwarf galaxy
- Stellar stream
- Phase-mixed object



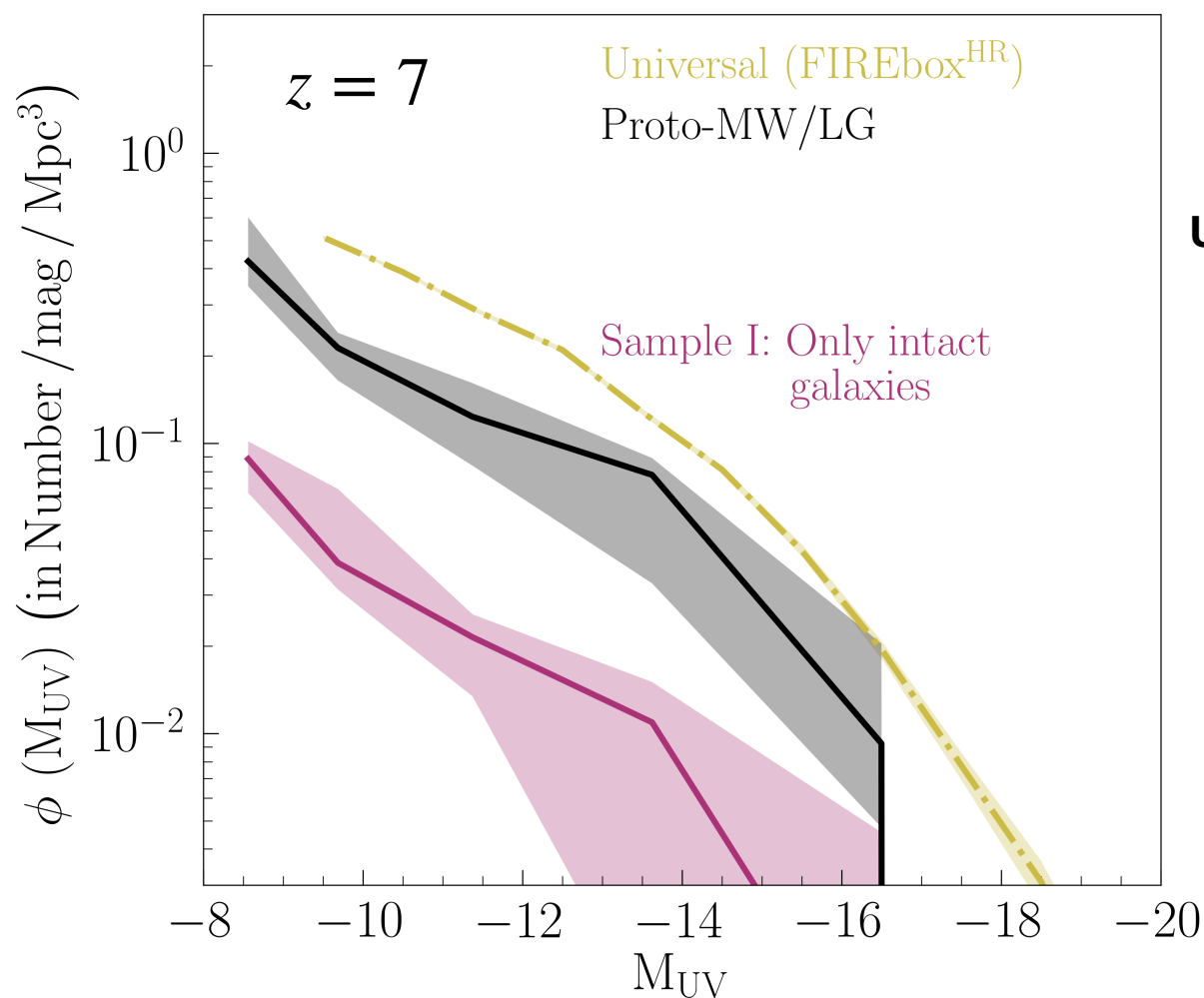
UV luminosity  
at  $z \gtrsim 6$



# UVLFs through the near-far technique



# Using only intact galaxies misses the normalization



**UVLFs of the samples**

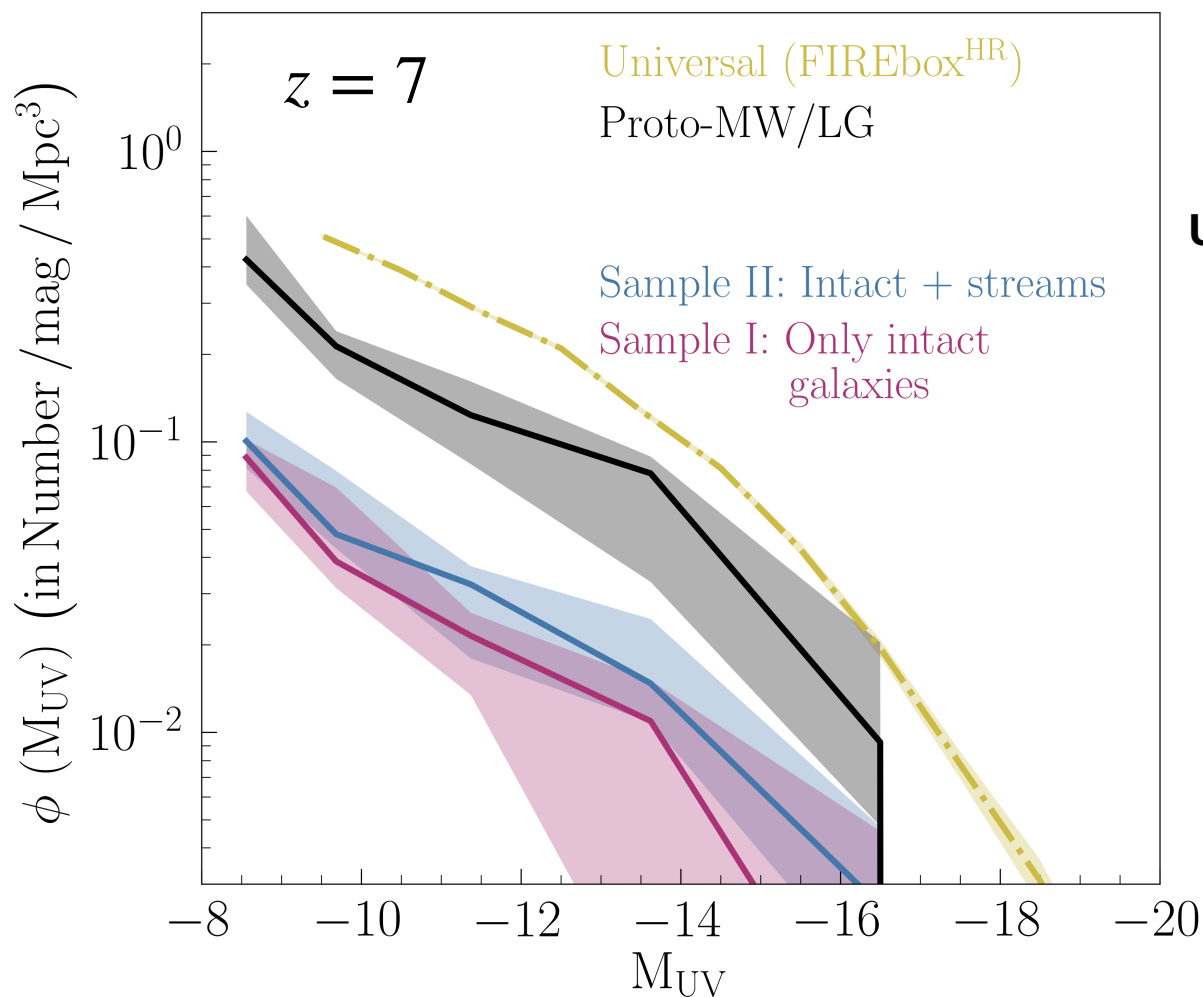
Reconstructed using  
the progenitors of  
present-day “fossil  
records”

*Kundu et al. 2026*

Median and 68%  
scatter across all  
the FIRE halos



# Better UVLFs by adding disrupted galaxies

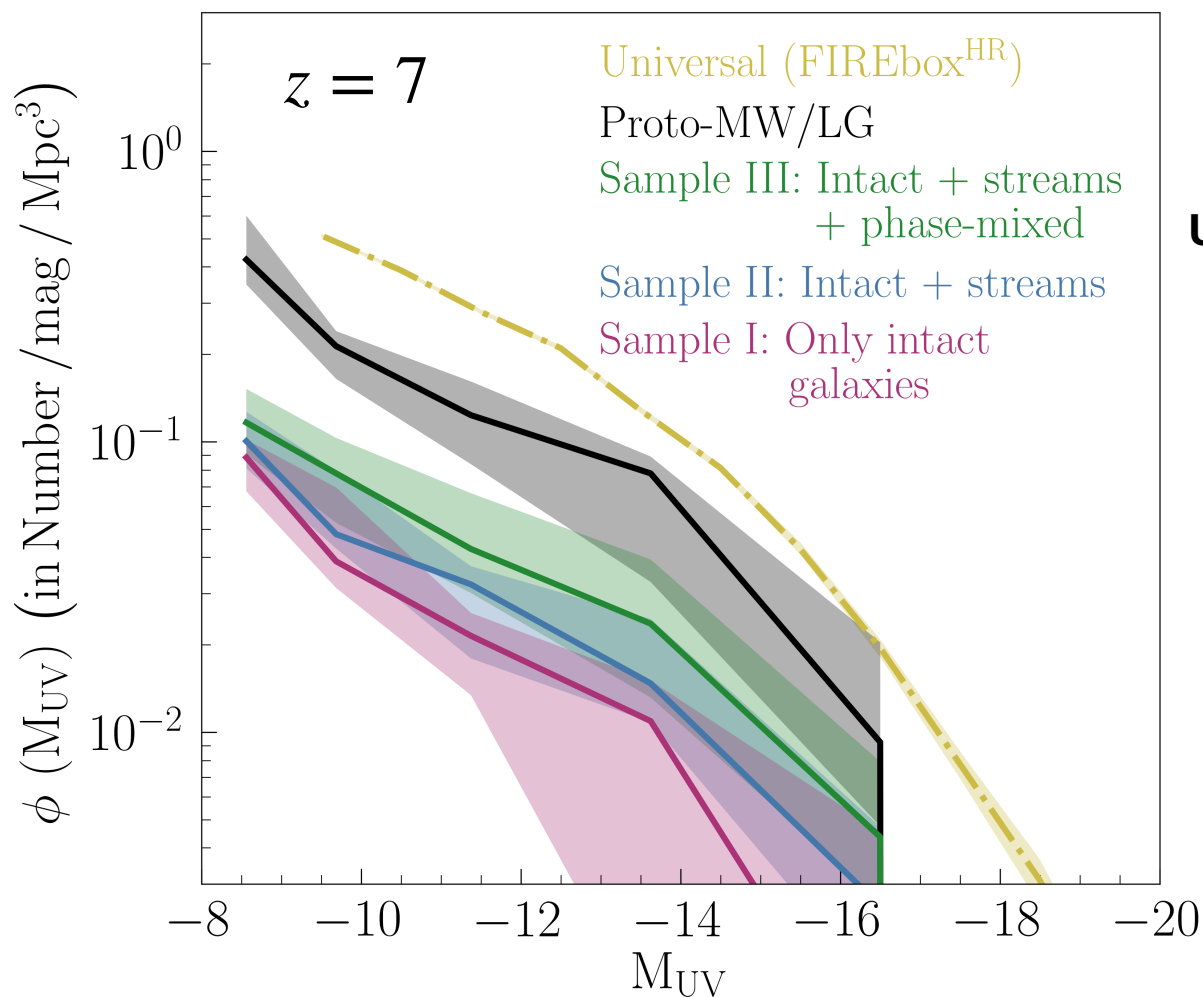


## UVLFs of the samples

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Median and 68%  
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# Better UVLFs by adding disrupted galaxies



## UVLFs of the samples

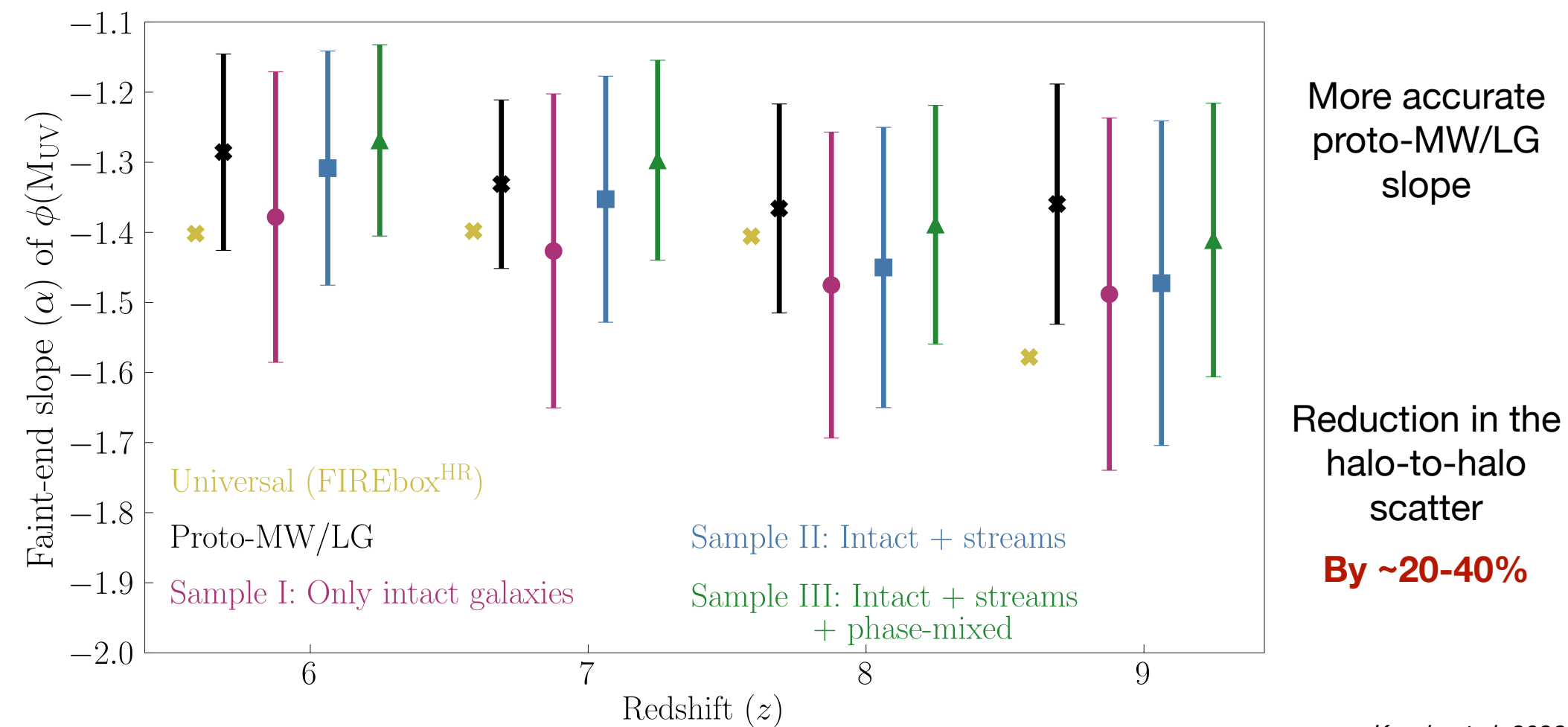
Reconstructed using  
the progenitors of  
present-day “fossil  
records”

**Improves the  
normalization  
~2-3x**

*Kundu et al. 2026*

Median and 68%  
scatter across all  
the FIRE halos

# More accurate and precise faint-end slopes



## **A big question**

**But will it be observationally feasible to use the disrupted galaxies in the context of the near-far technique?**

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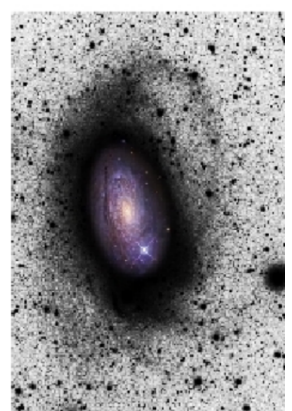
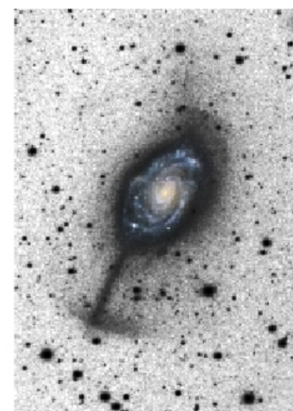
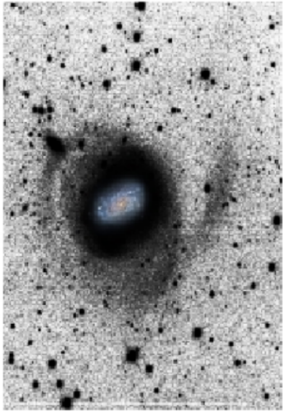
**LSST will observe more disrupted galaxies, particularly in the MW halo**

## A big question

**But will it be observationally feasible to use the disrupted galaxies in the context of the near-far technique?**

**LSST will observe more disrupted galaxies, particularly in the MW halo**

**Roman will go beyond! (Ana's talk)**



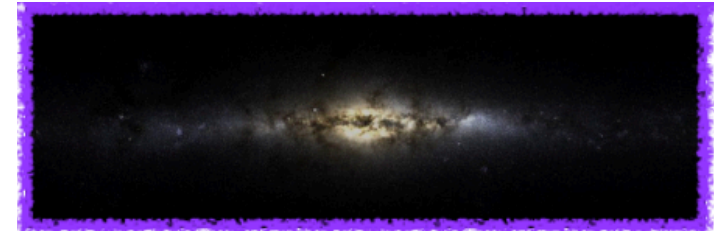
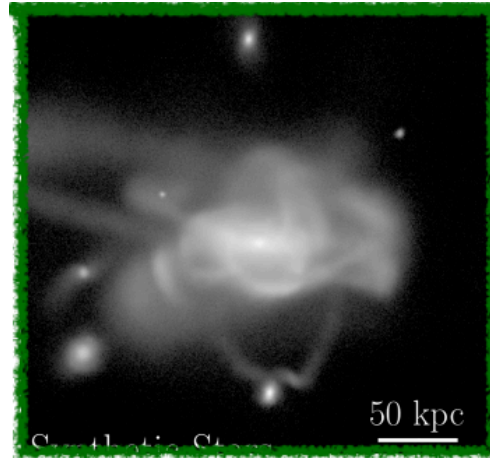
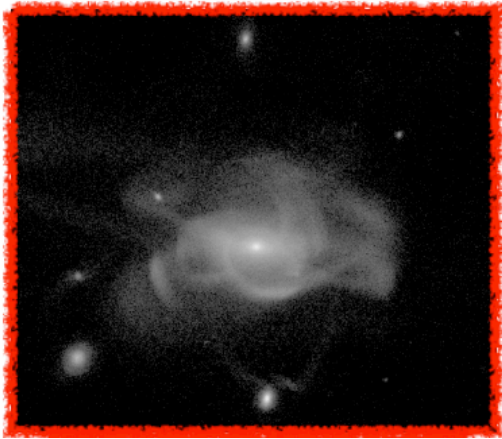
*Martínez-Delgado et al. 2008, 2010*

# From stars particles to stars

**Ananke / py-ananke**

`pip install ananke`

<https://github.com/athob/py-ananke>



**Simulated star particles**

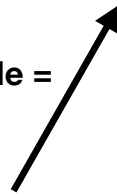
pos, vel, mass,  
age, Fe/H



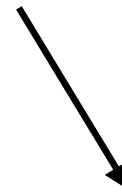
**Phase-space density,  
stellar population from IMF**

**Mock stars**

One star particle =  
many stars



One mock star =  
one star



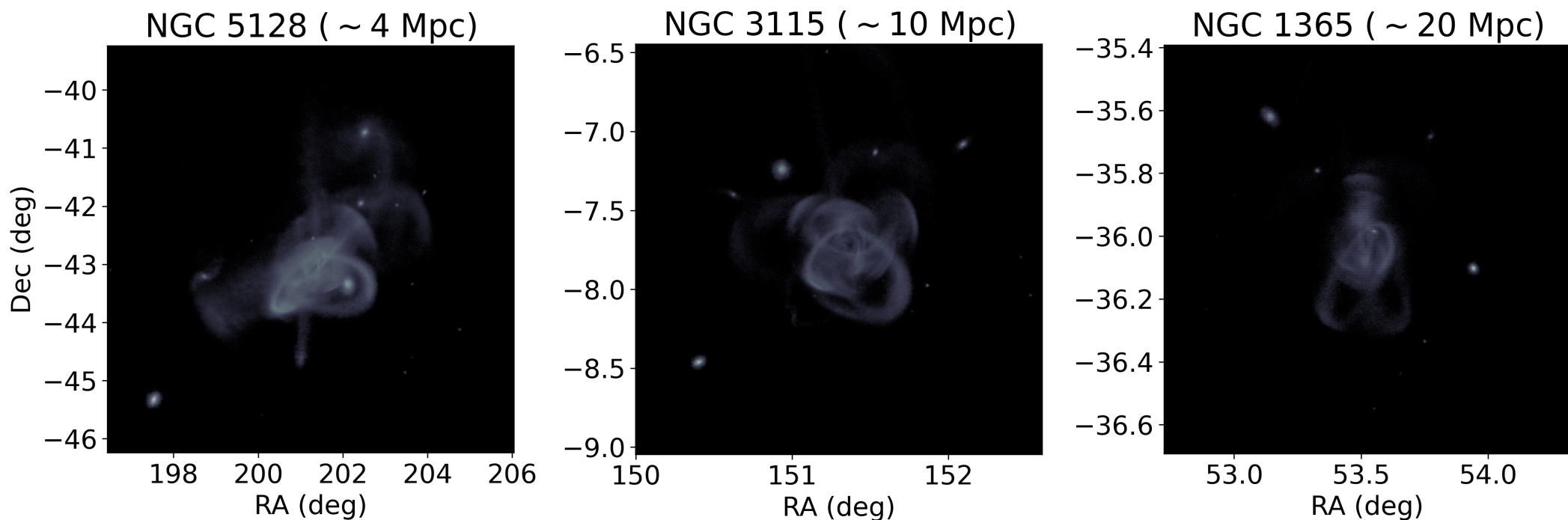
**Survey, sky position,  
magnitude limits, error and  
dust modeling**

**Synthetic  
observations**



Adrien Thob  
UPenn

# Mock Roman catalogs of external galaxies



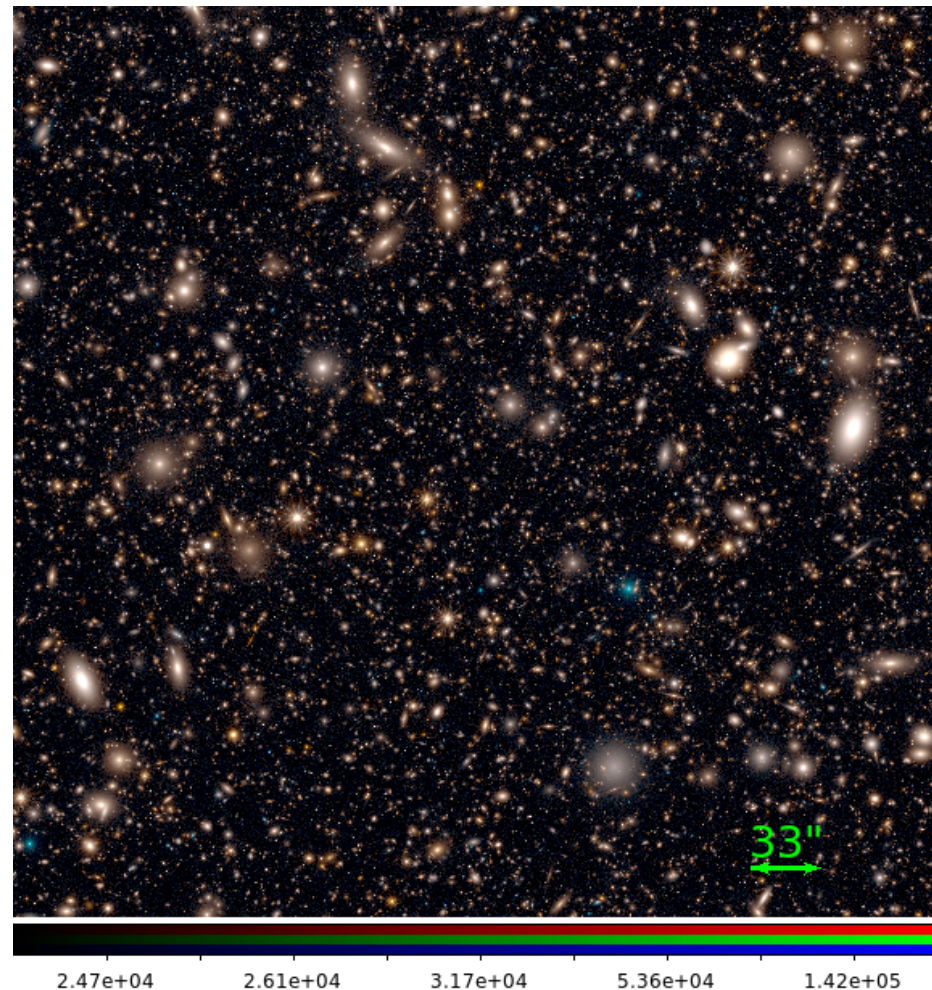
Mock streams and satellites of one of the FIRE halos placed at 3 different distances

Substructures become fainter with distance

But these include stars that may not be detectable using Roman



# Simulating images by adding background



Background:  
CANDELS-  
based catalogs

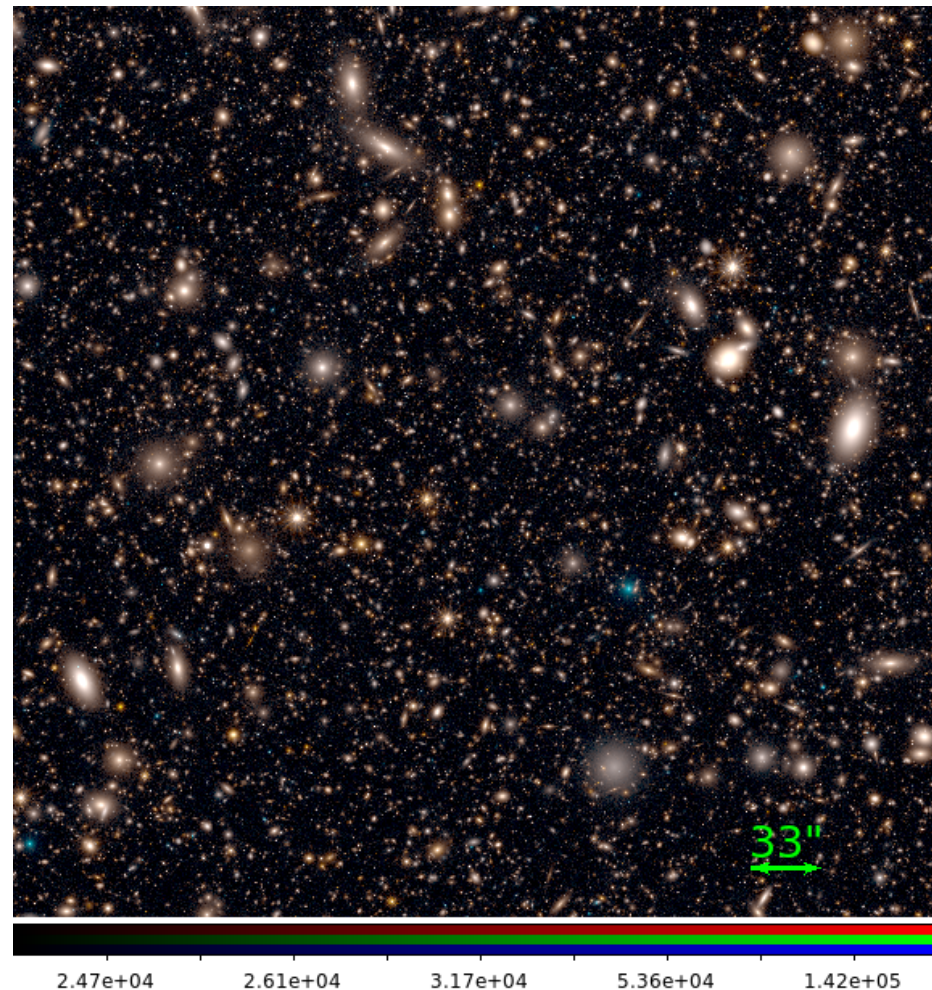
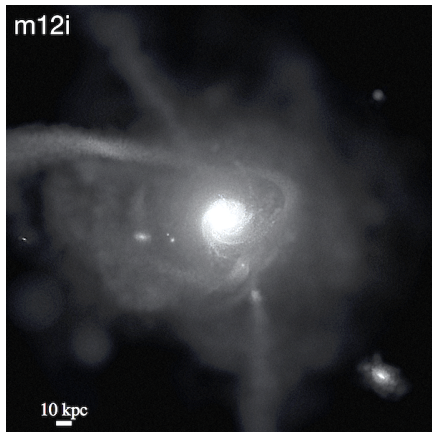
RINGS project

<https://github.com/benw1/WINGS>

*Benjamin Williams*  
*University of Washington*

*Thanks to Ben for the slides!*

# Simulating images by adding background



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CANDELS-  
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Stars: py-ananke mock  
stars from FIRE

RINGS project

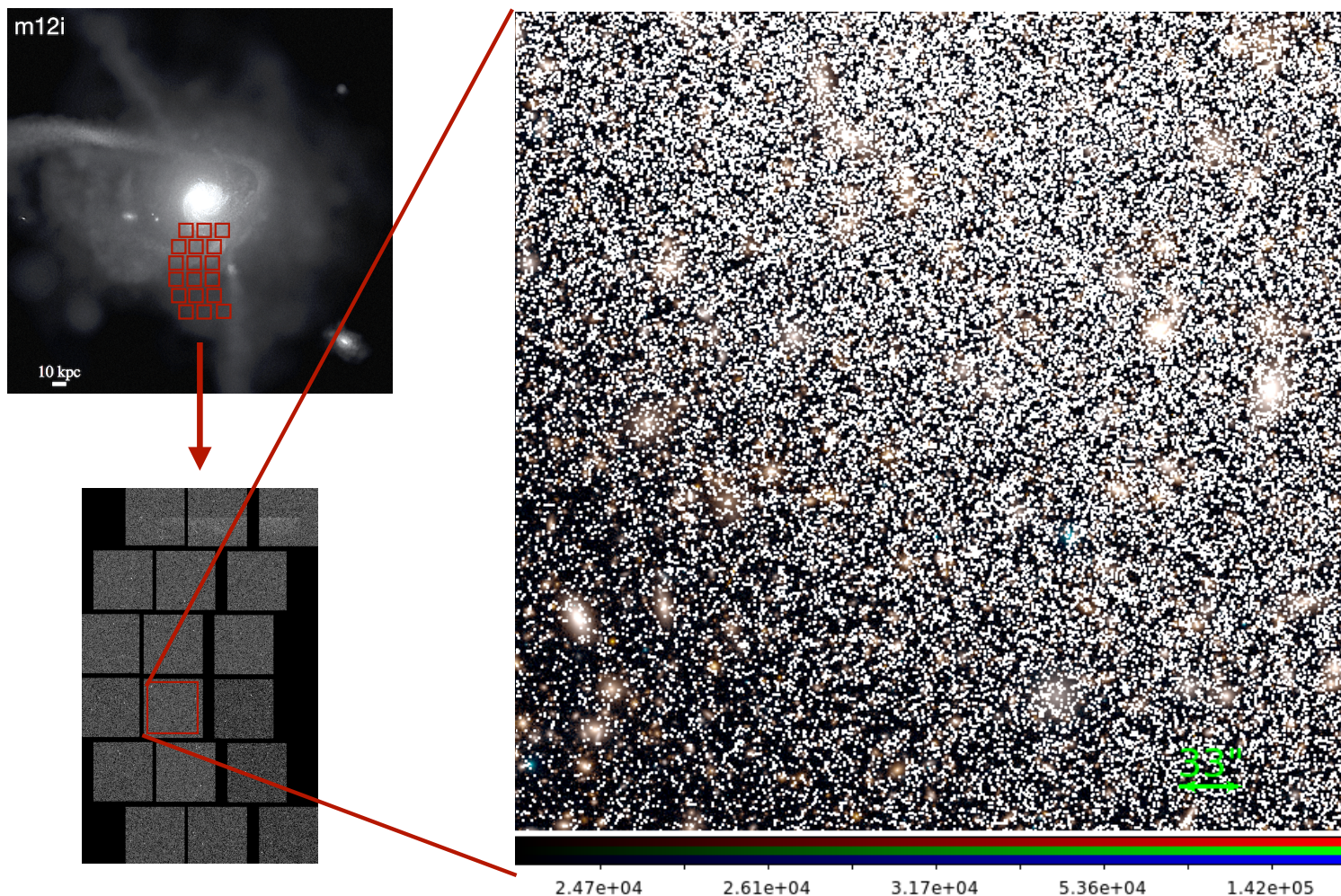
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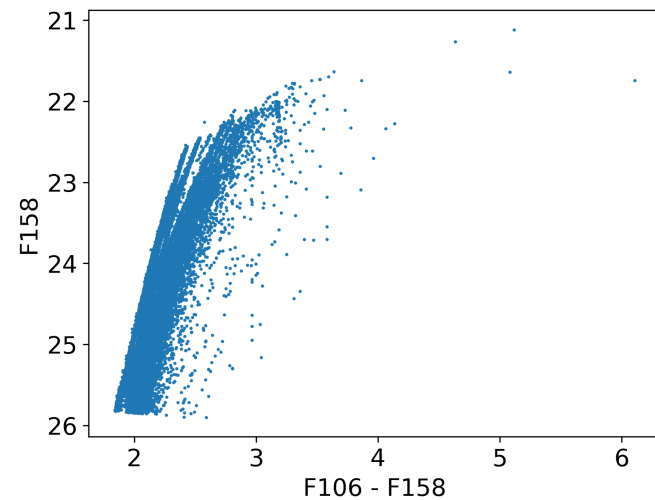
*Benjamin Williams*  
*University of Washington*

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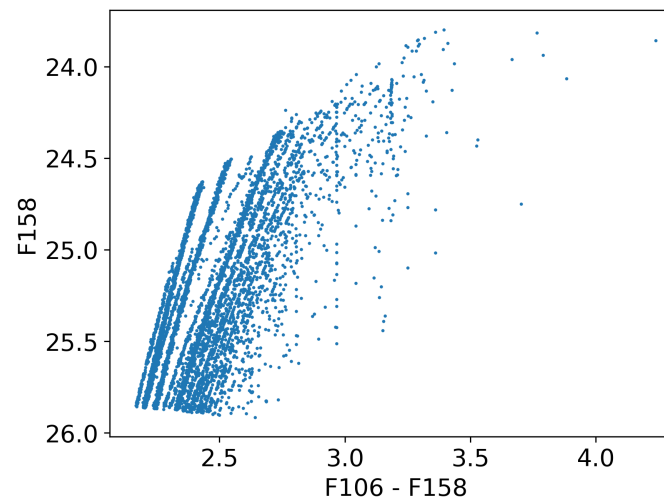
# Color-Magnitude Diagrams

We use DOLPHOT as our photometry pipeline and determine which mock stars are detectable in Roman

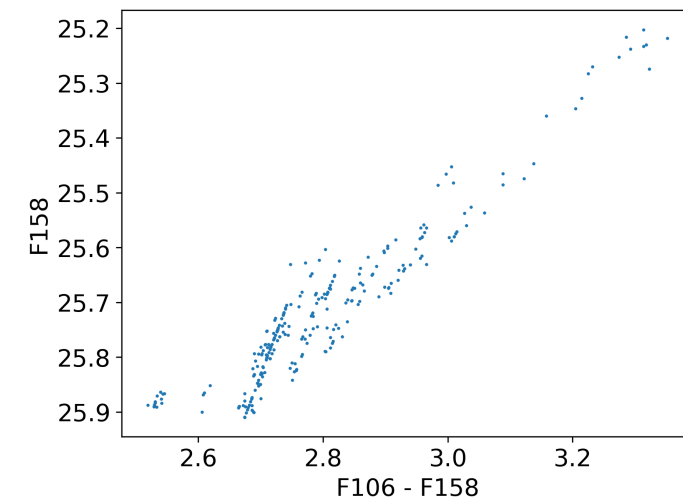
4 Mpc



10 Mpc



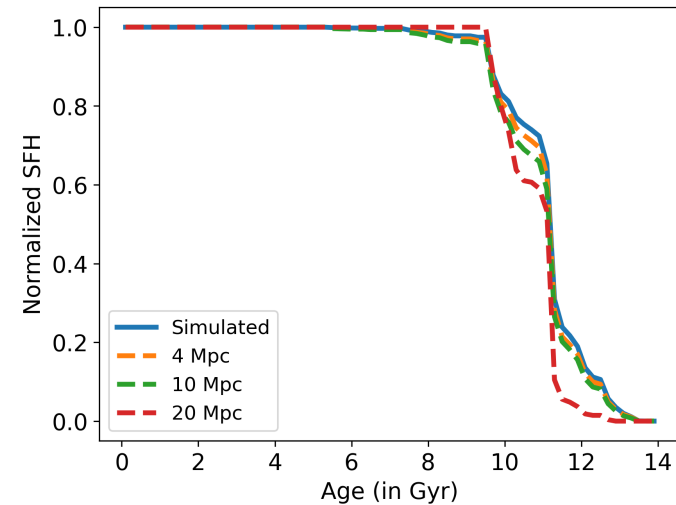
20 Mpc



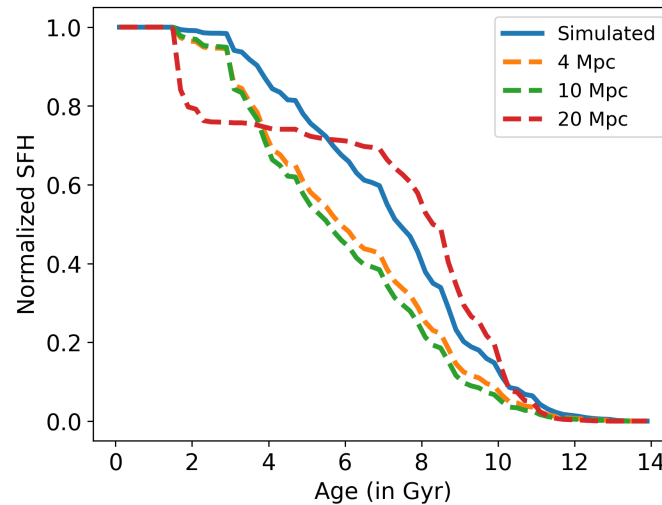
CMDs of a stream using only detectable stars

# Star formation histories

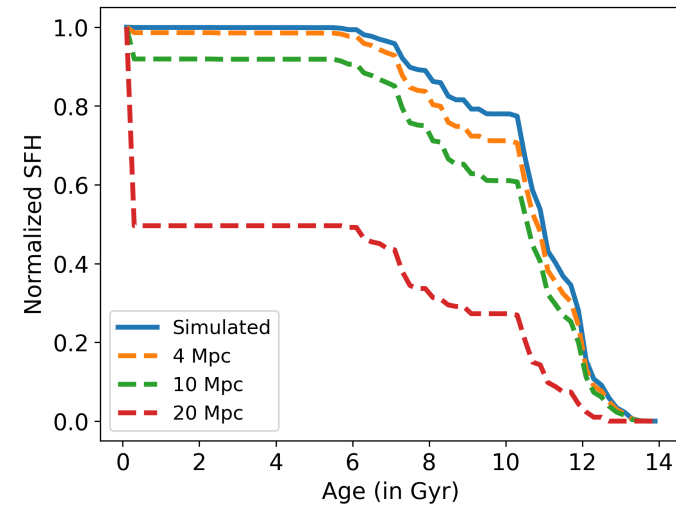
Stream 1



Stream 2

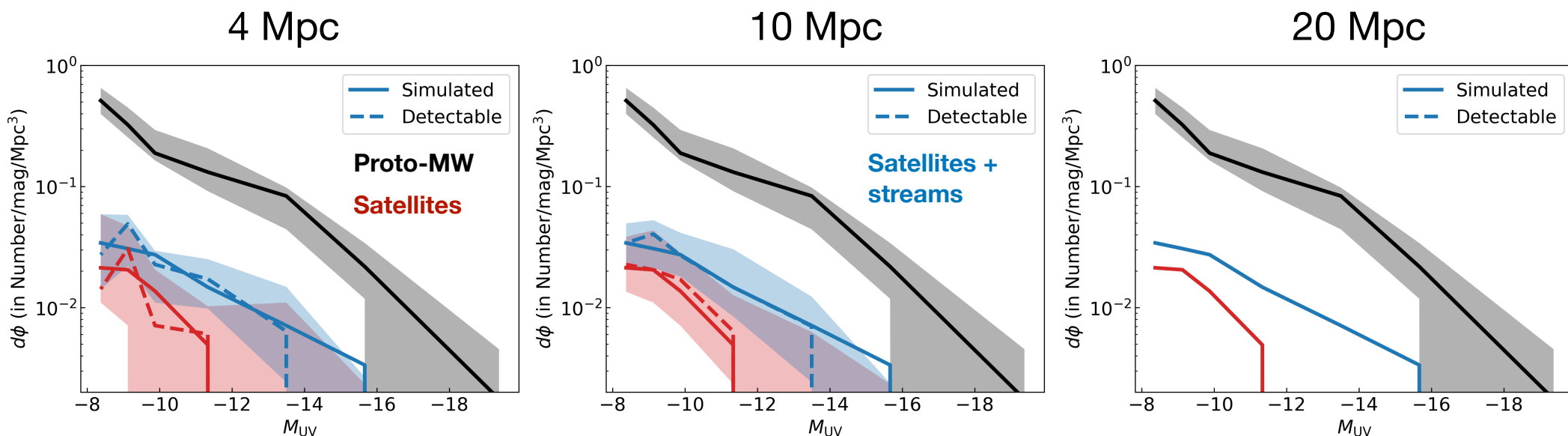


Stream 3



We can recover the simulated SFH to a good extent, but **maybe** not at super-far distances

# High- $z$ UVLFs can be reconstructed

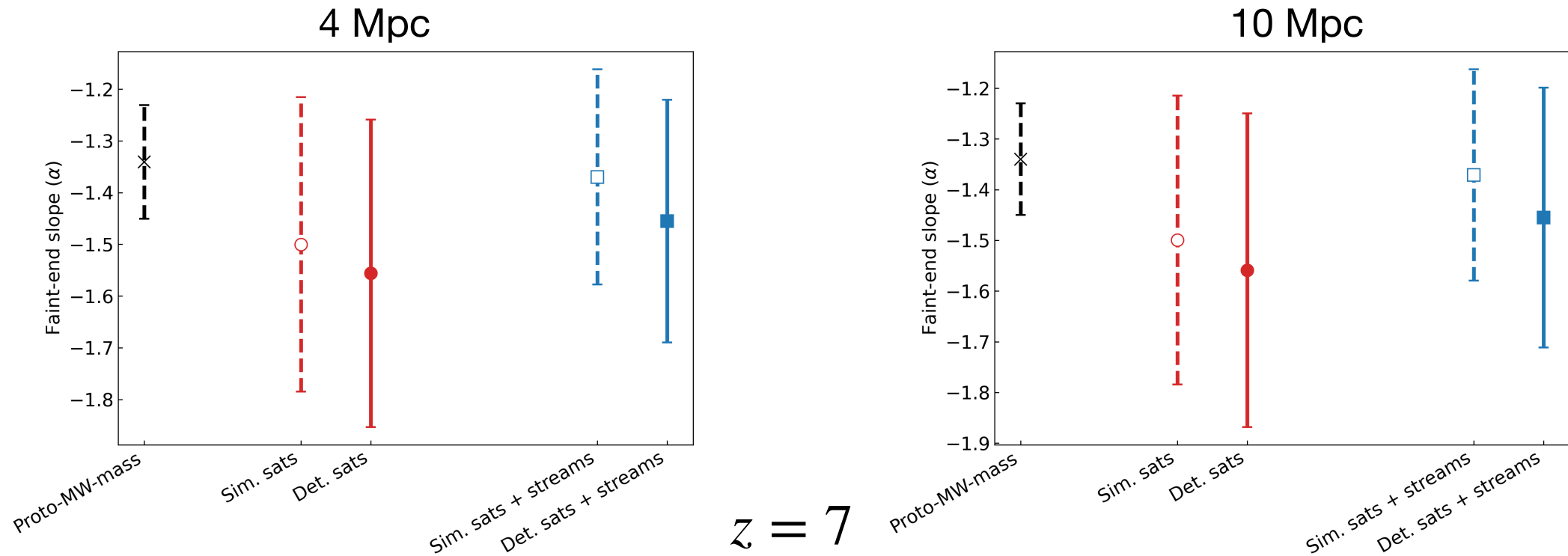


$$z = 7$$

Reconstructed UVLFs from detectable stars agrees well with the simulations

Preliminarily this might not be possible at super-large distances, but yet to confirm

# Adding detectable streams gives better slopes



Faint-end slopes are well-reproduced by detectable stars

Adding the streams provides more accurate and precise slopes

# Key takeaways

- Near-far technique is a great alternative way to estimate the shape of the UVLFs at the faint-end during EoR.
- Including present-day disrupted galaxies such as stellar streams can improve the constraints on the faint-end slope.
- Roman will detect streams in external galaxies, increasing the sample for the (not so) near-far technique. We find using our mock catalogs that this will be plausible.
- Our (soon to be released) mock catalogs can be useful for many other science cases.



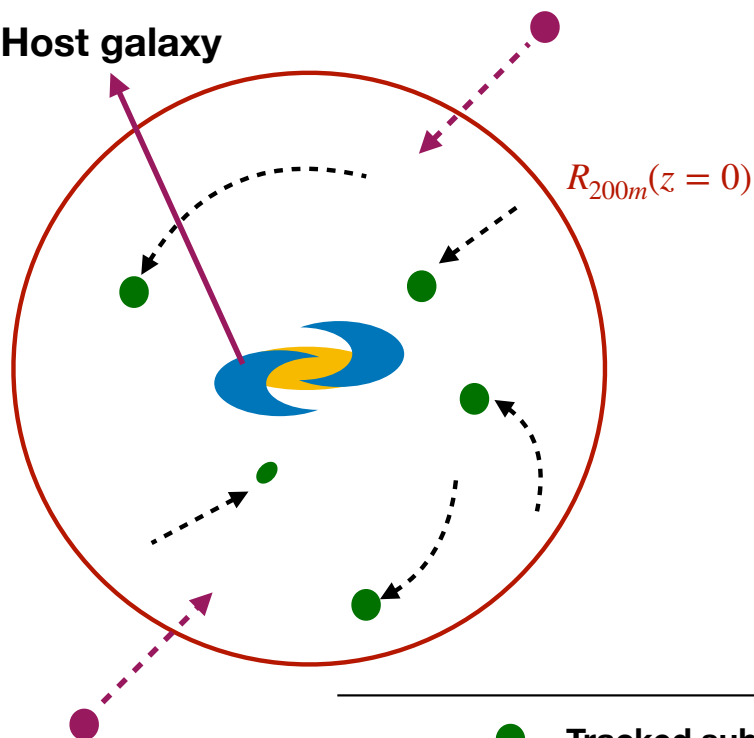
**Thank you!**

**Backup slides**

# Tracking and classification pipeline

$t_{\text{start}} = z_{MR_{3:1}}$    $t_{\text{end}} = z = 0$

Host galaxy



Satellite

Stream

Phase-mixed

1.  $M_{\star} \geq 5 \times 10^5 M_{\odot}$  and within  $R_{200m}$

2. Maximum pairwise separation between star particles  $> 120$  kpc

3. Velocity dispersion above a certain mass-dependent value

*Panithanpaisal et al. 2021*

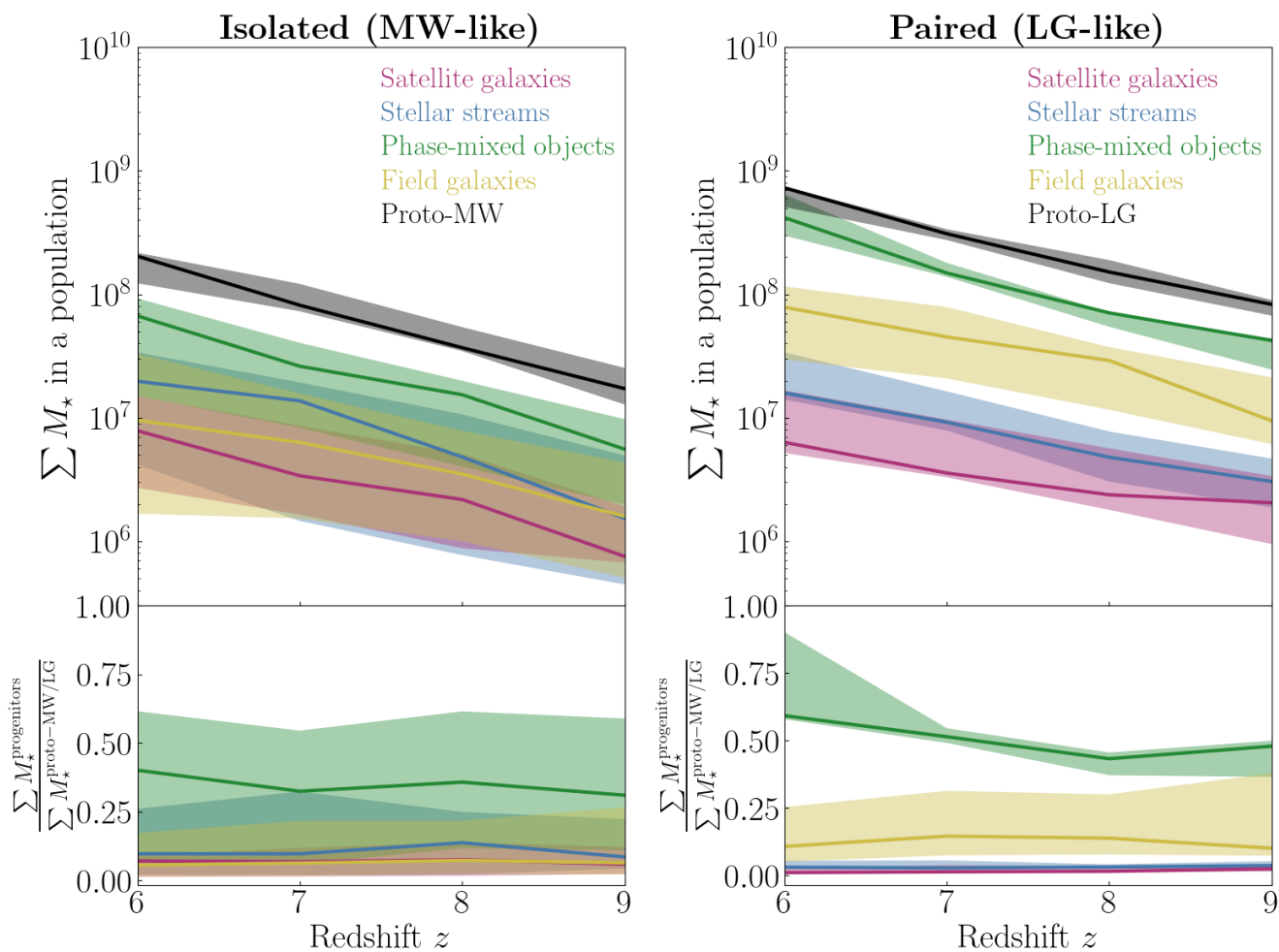
● - Tracked subhalos

● - Subhalos that fall in later and are then tracked

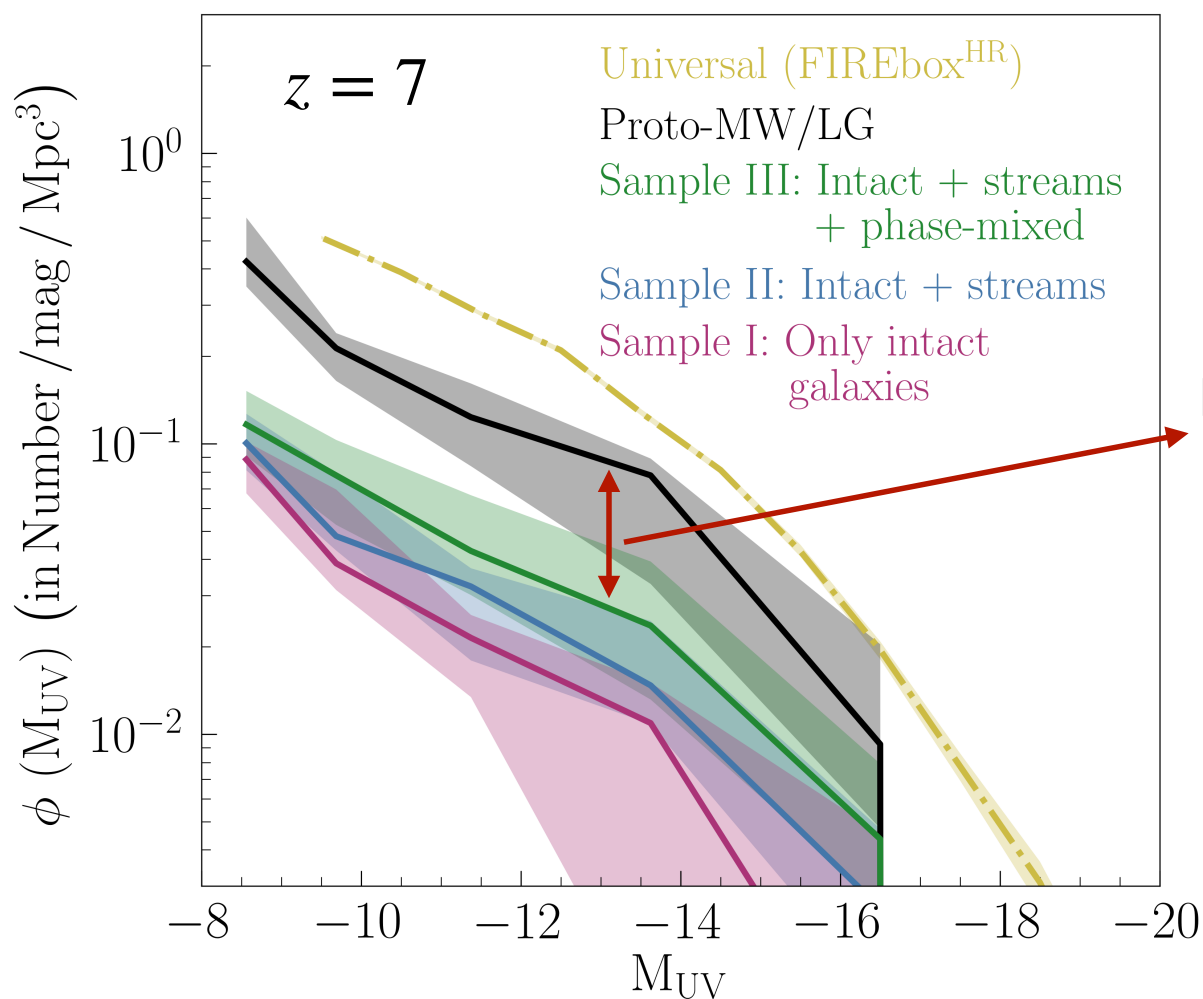
$z_{MR_{3:1}}$  - Time when the host galaxy emerges

$M_{\star} \geq 10^{4.5} M_{\odot}$  for intact galaxies

# Disrupted galaxies matter!



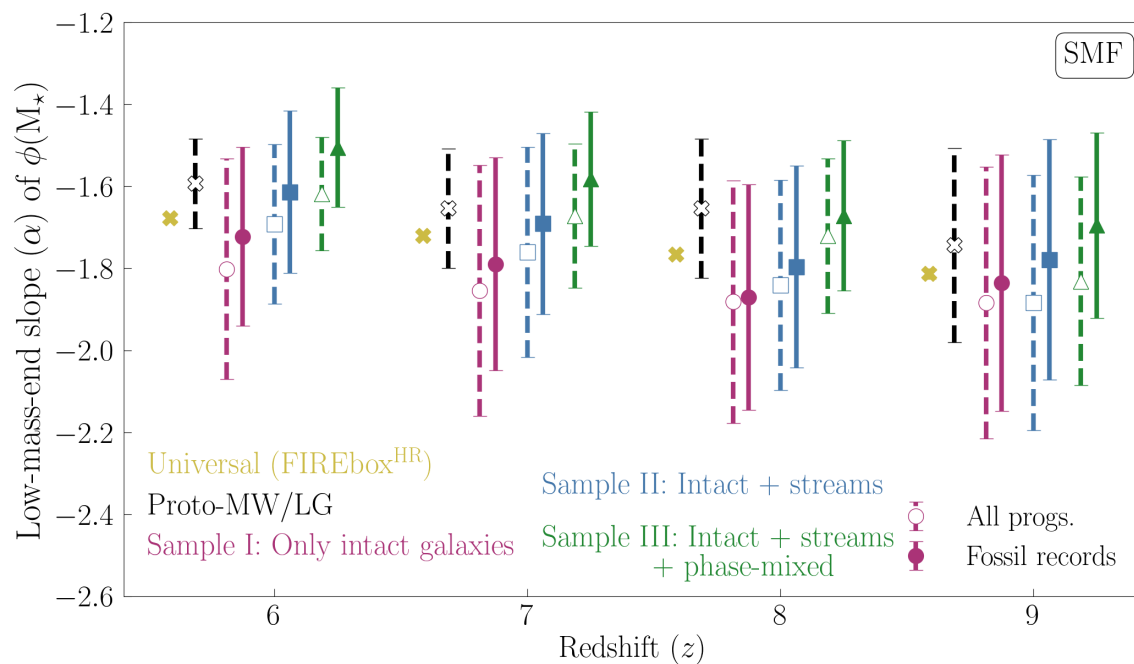
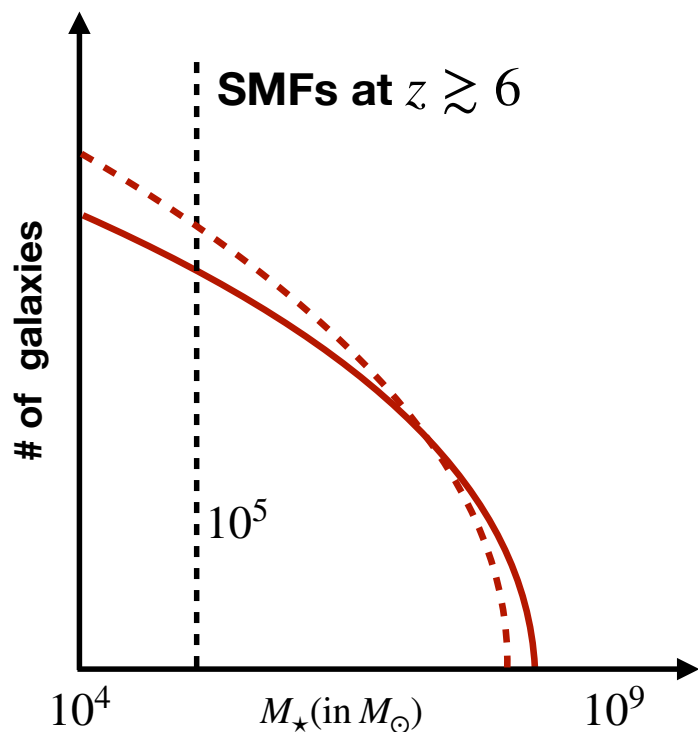
# Better UVLFs by adding disrupted galaxies



From the  
progenitors of the  
main host galaxy  
(*which we ignore*)

Median and 68%  
scatter across all  
the FIRE halos

# Slope depends on your sample of galaxies

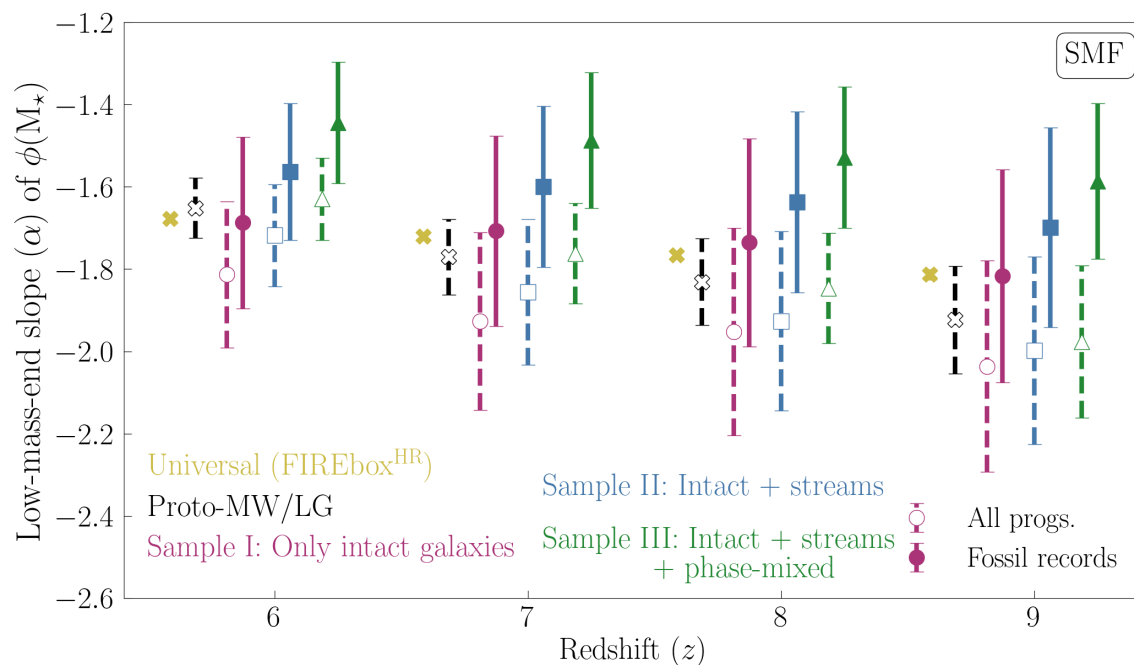
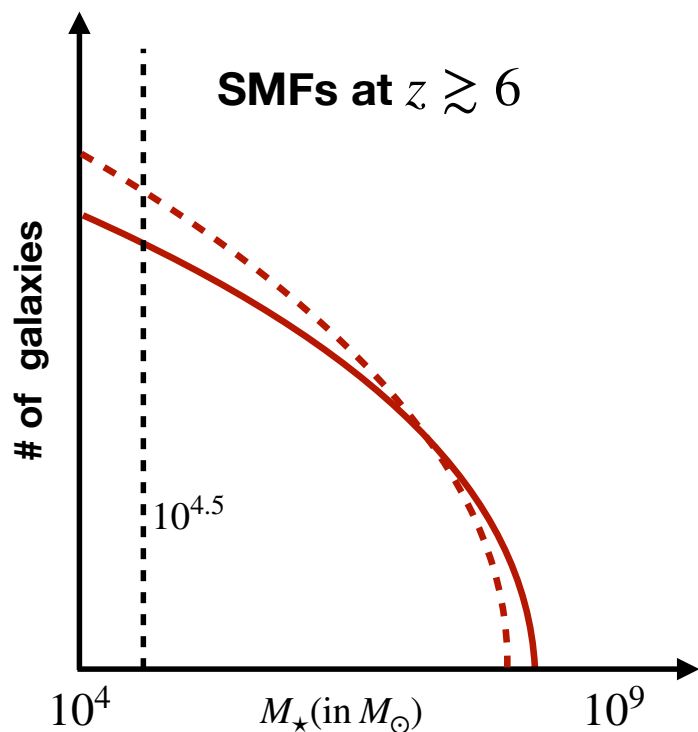


Intact galaxies  $M_\star \geq 10^{4.5} M_\odot$  at  $z = 0$

Disrupted galaxies  $M_\star \geq 10^6 M_\odot$  at  $z = 0$



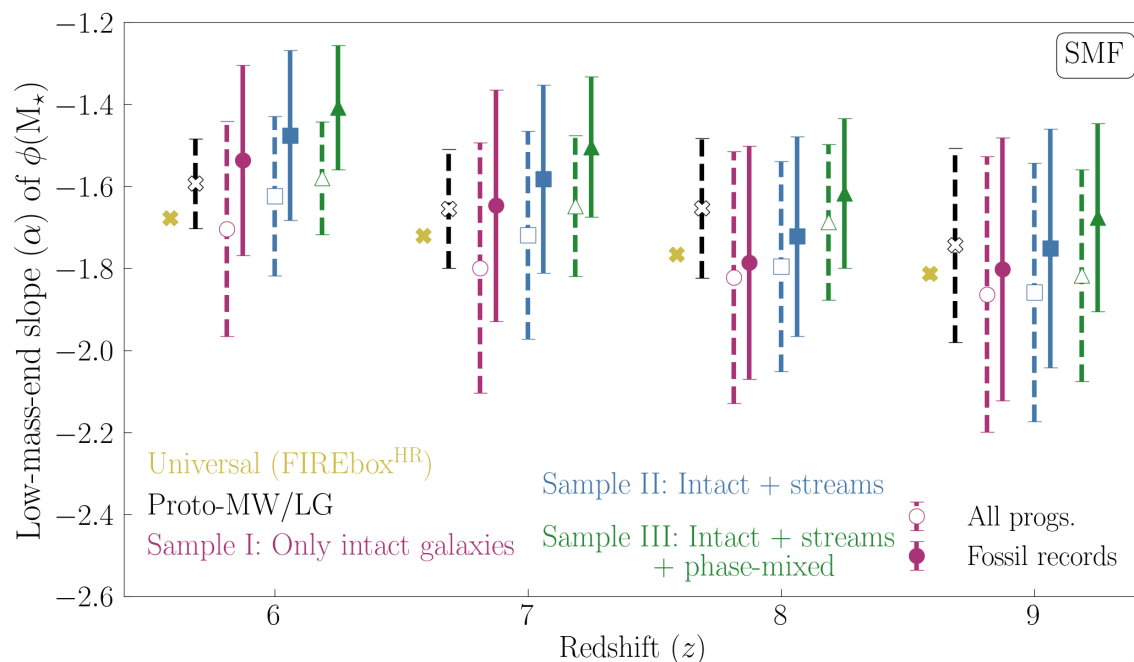
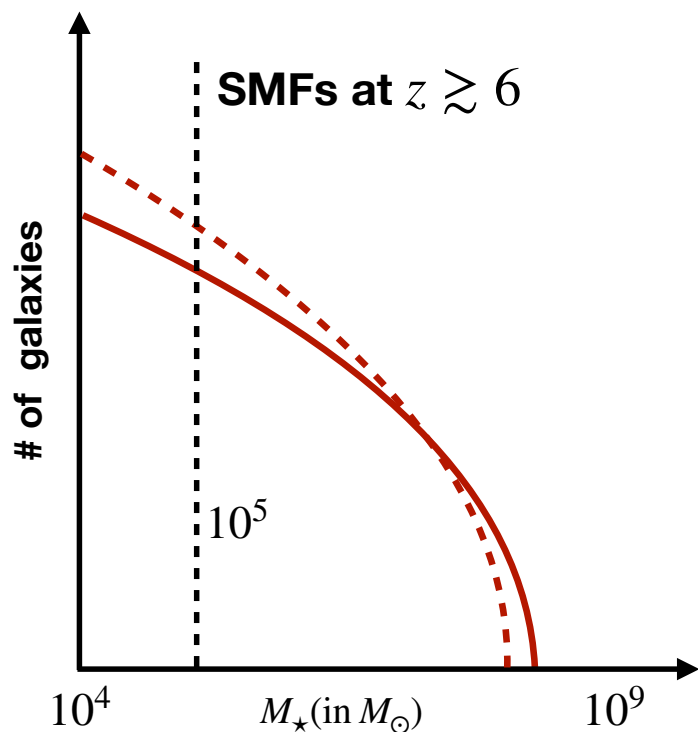
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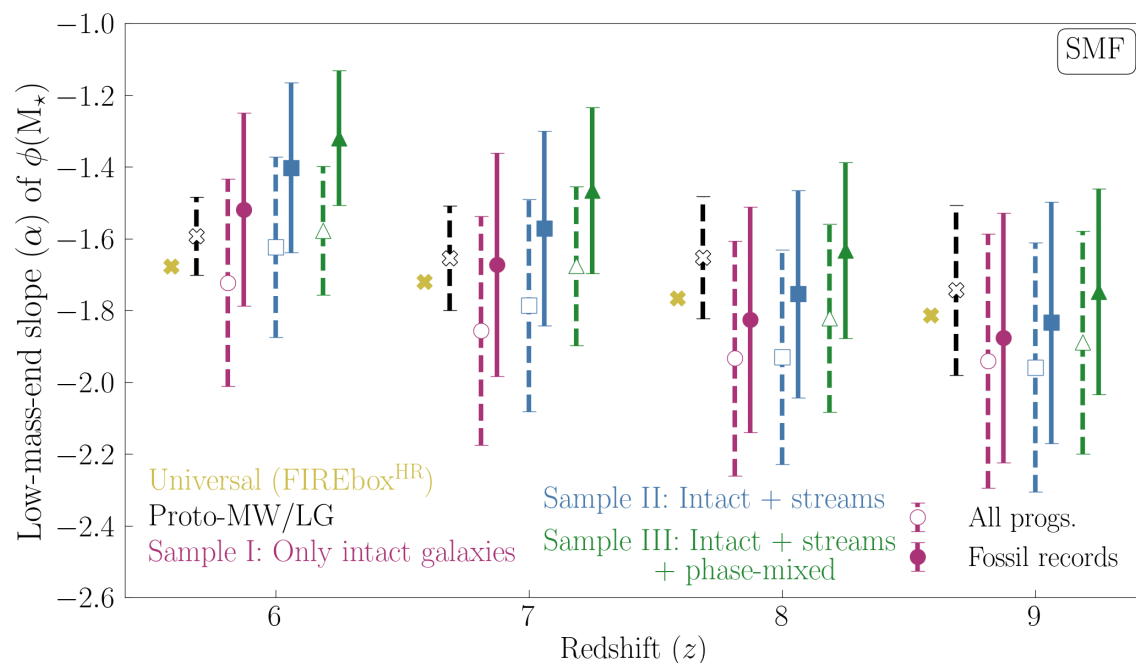
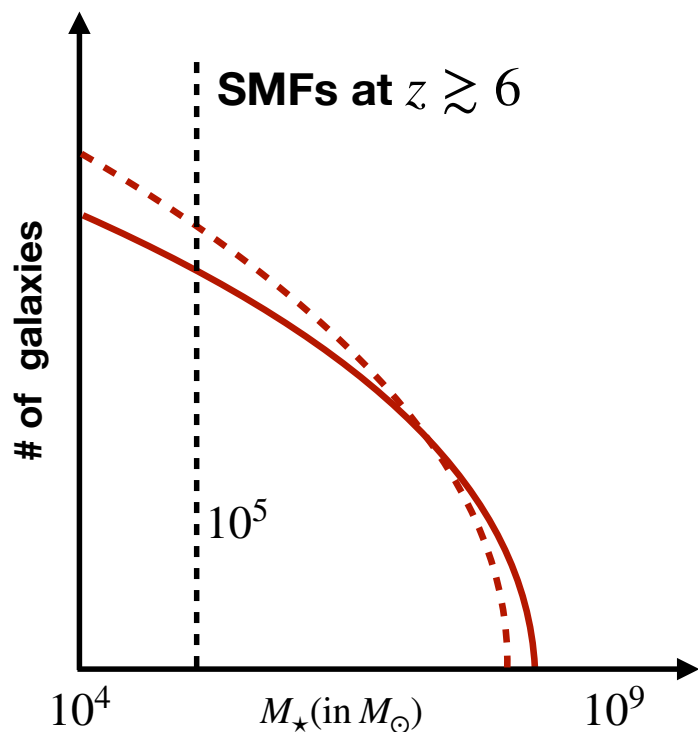
# Slope depends on your sample of galaxies



Intact galaxies  $M_\star \geq 10^6 M_\odot$  at  $z = 0$

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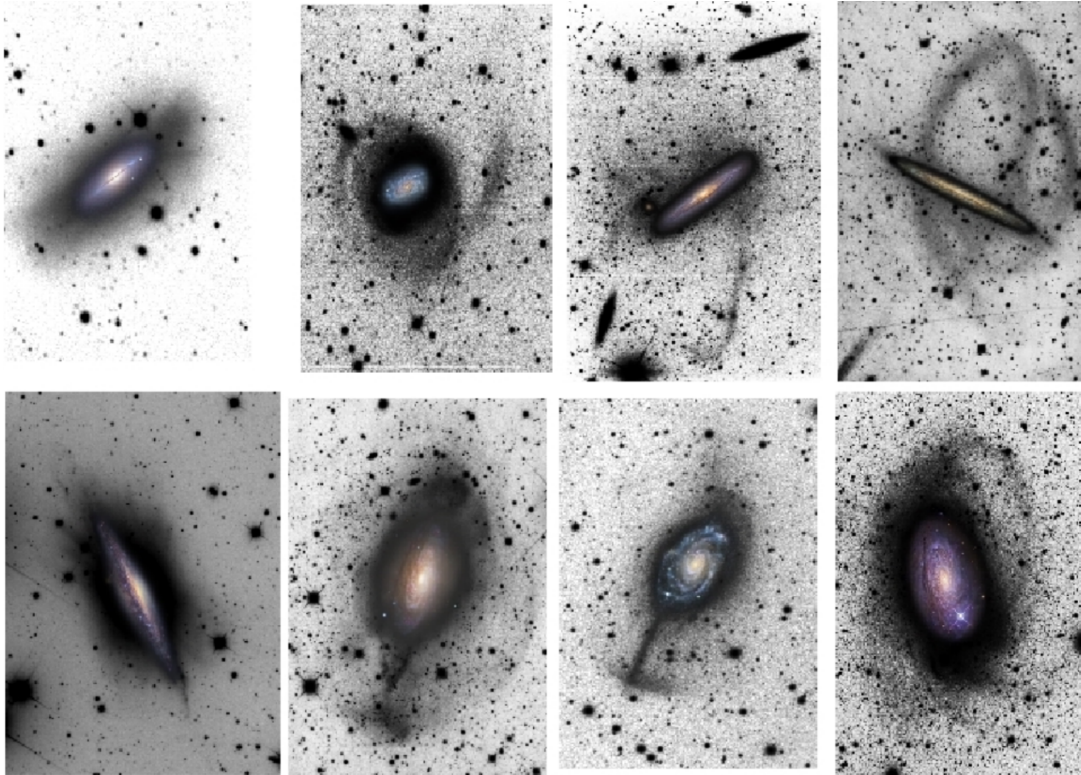
# Slope depends on your sample of galaxies



Intact galaxies  $10^6 \leq M_\star \leq 10^9 M_\odot$  at  $z = 0$

Disrupted galaxies  $10^6 \leq M_\star \leq 10^9 M_\odot$  at  $z = 0$

# Streams in external galaxies



**Roman will observe resolved stellar populations of satellites and streams in external galaxies**

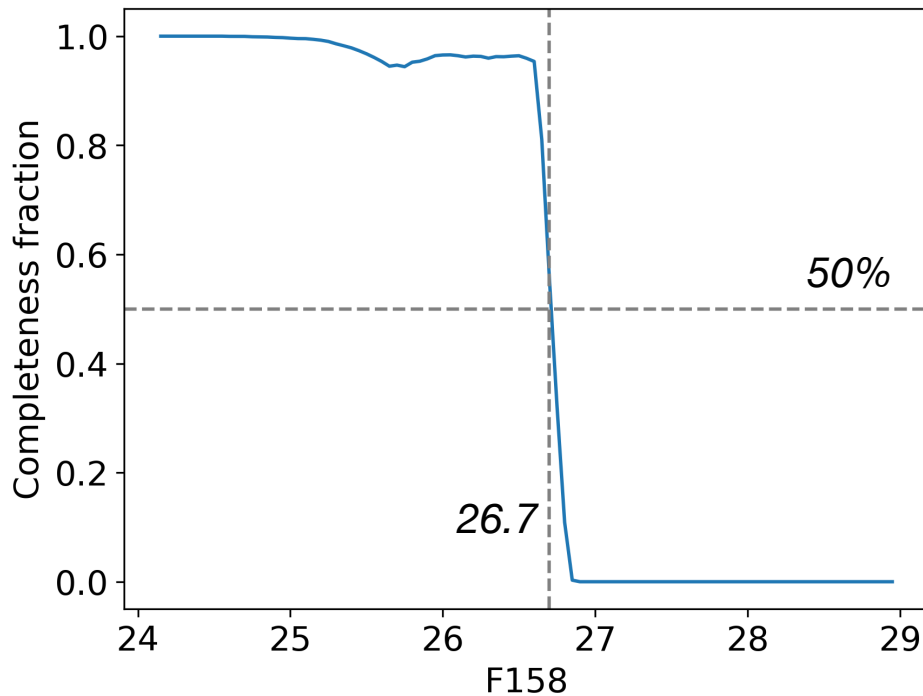
**This can allow using the near-far technique in external galaxies**

*Martínez-Delgado et al. 2008, 2010*

# Detectable stars in the mock catalogs

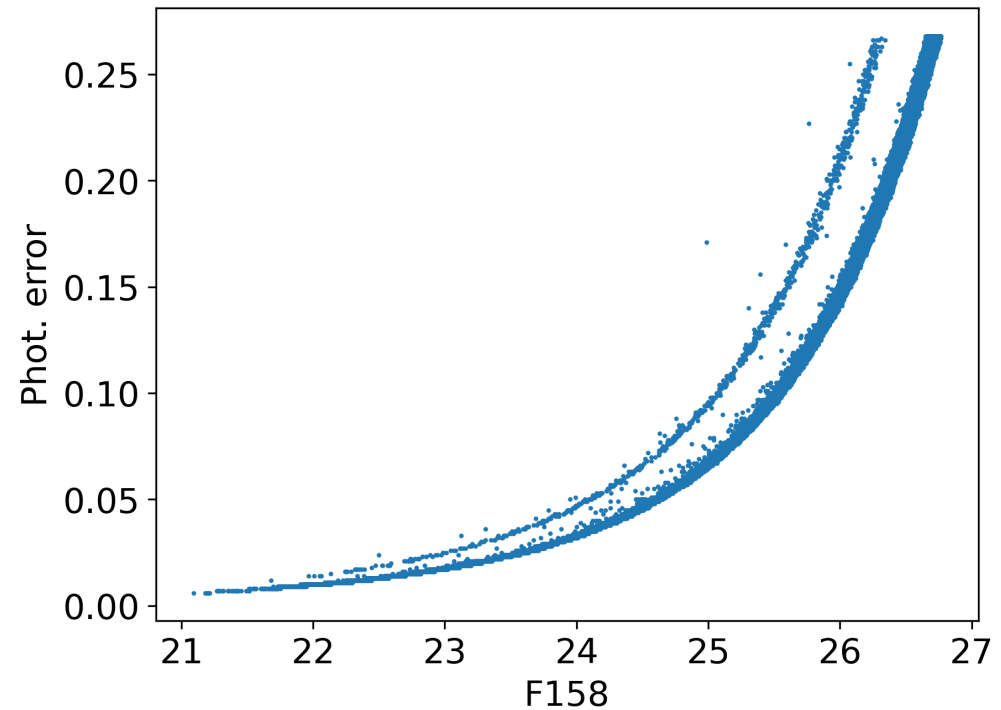
From DOLPHOT

By using the “good” stars



Preliminary and approximate

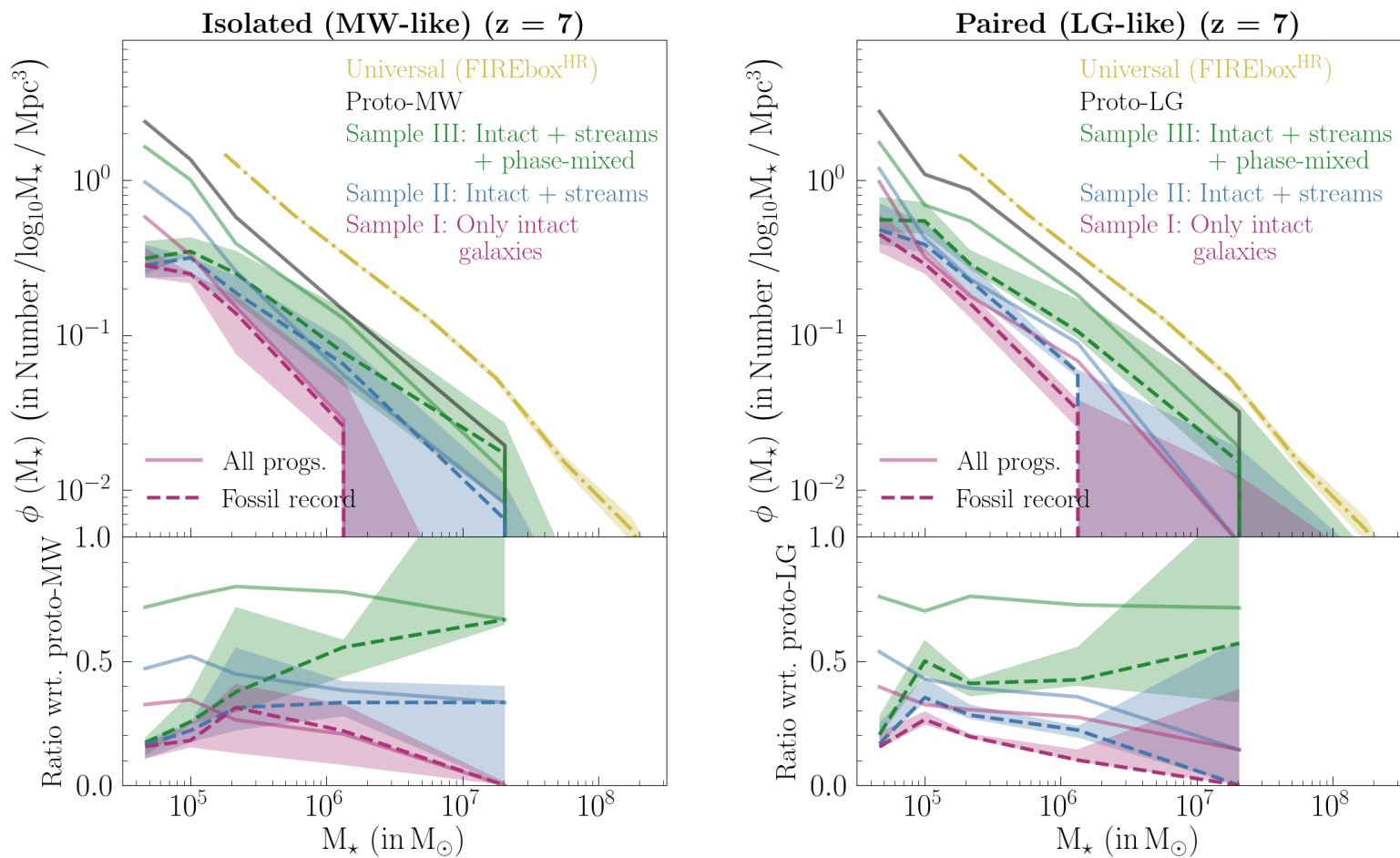
Photometric error modeling



This is what we will do

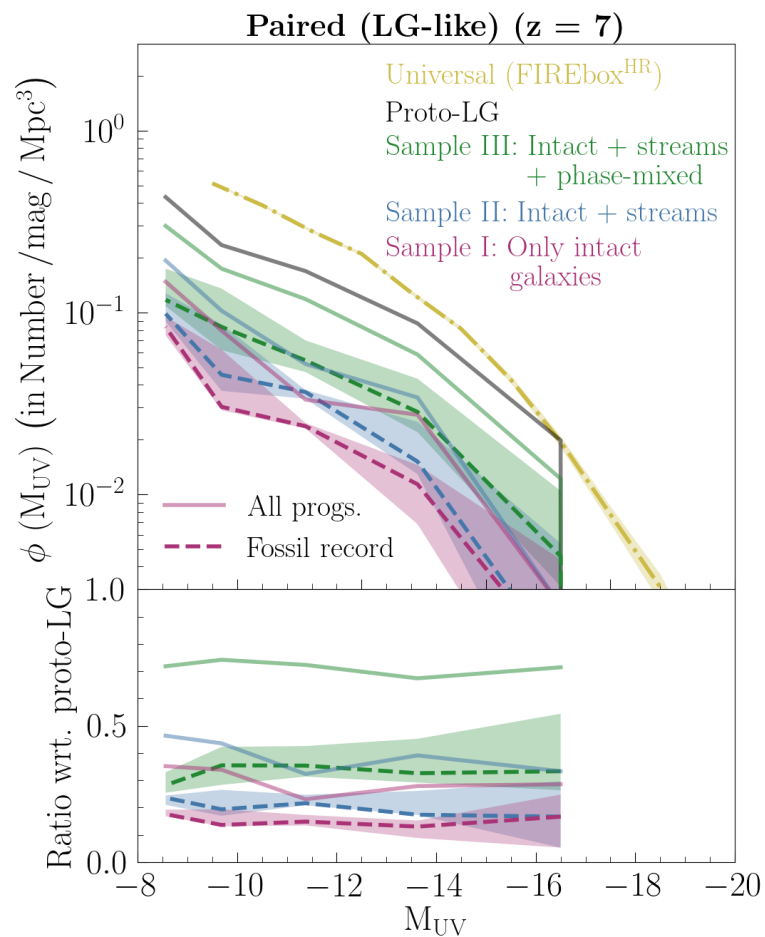
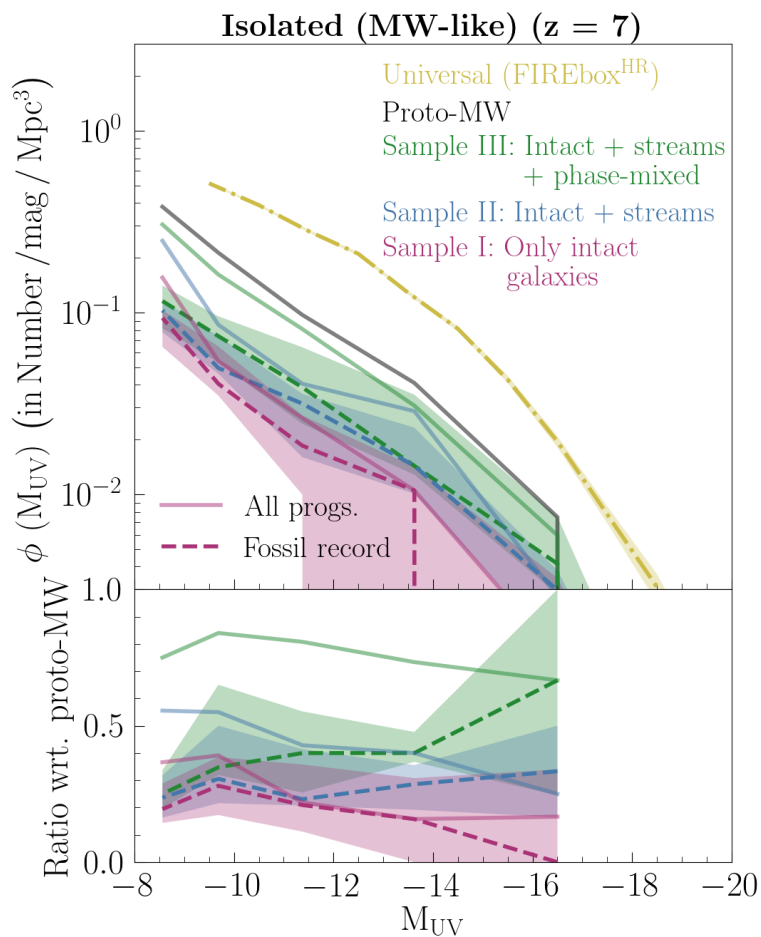
# Differential SMFs (MW vs LG)

## Fossil record scenario



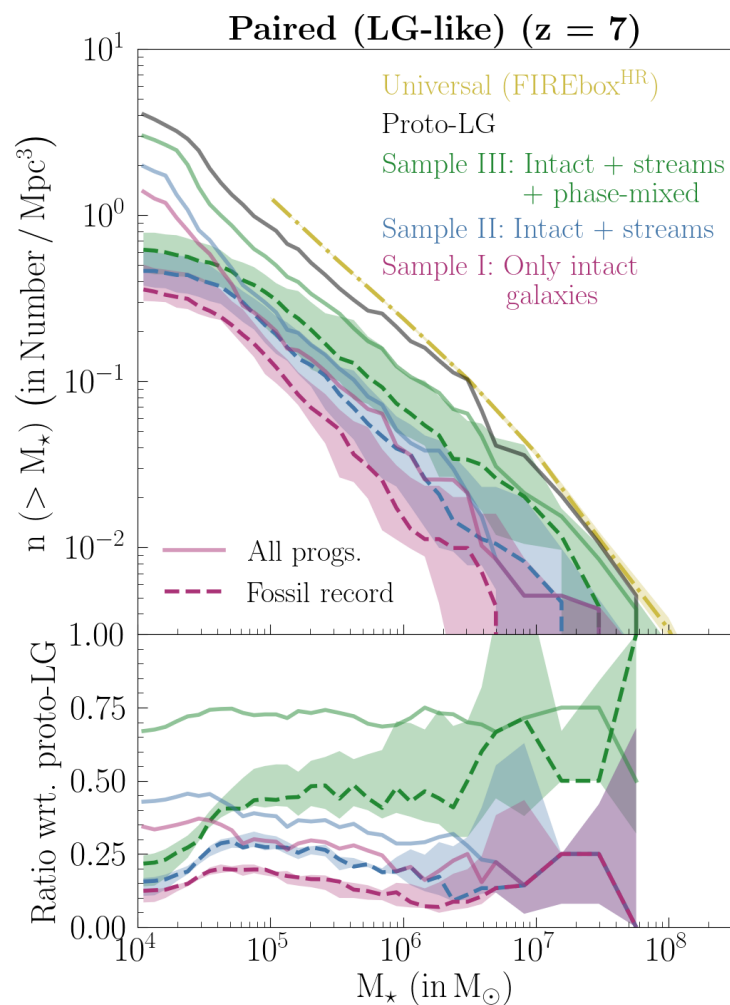
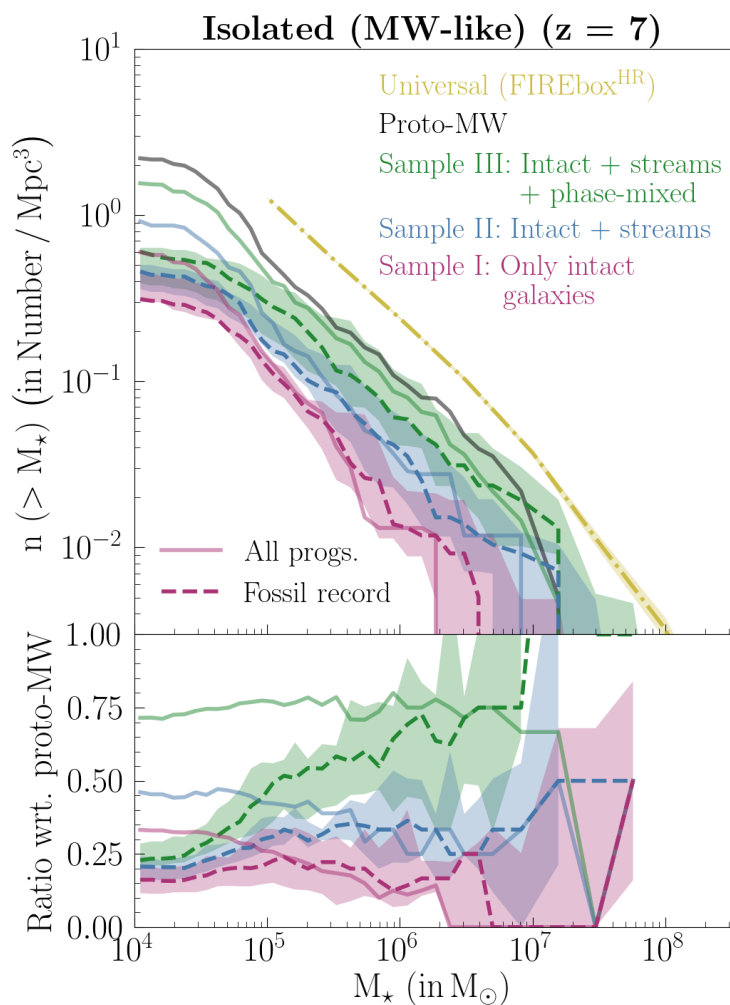
# Differential UVLFs (MW vs LG)

## Fossil record scenario

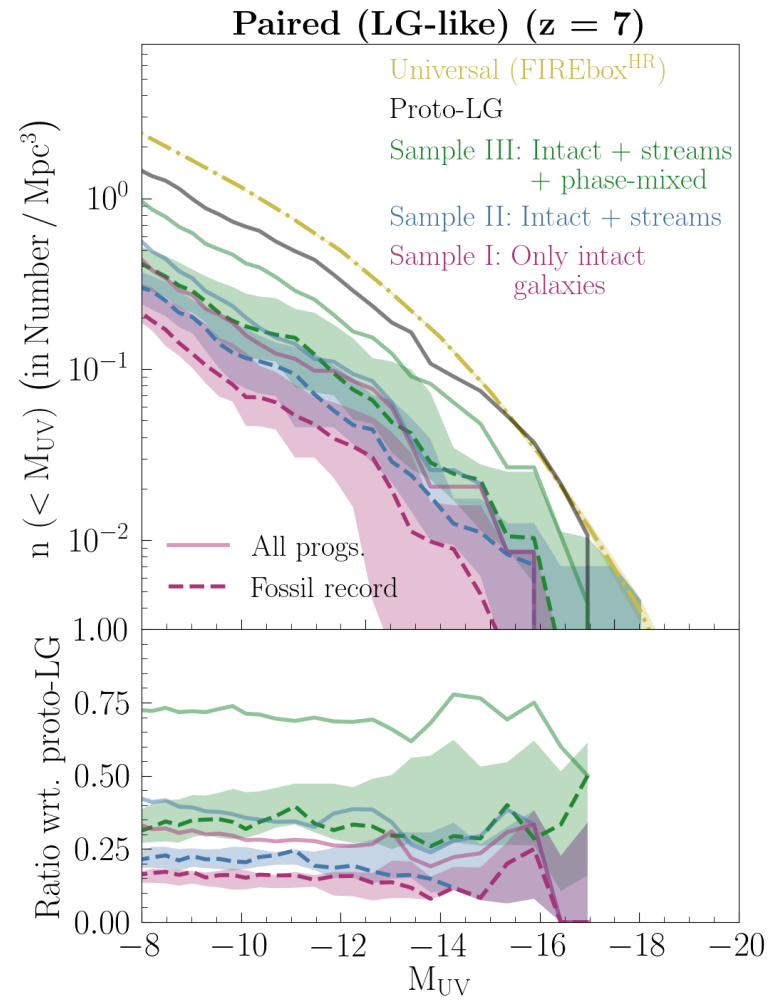
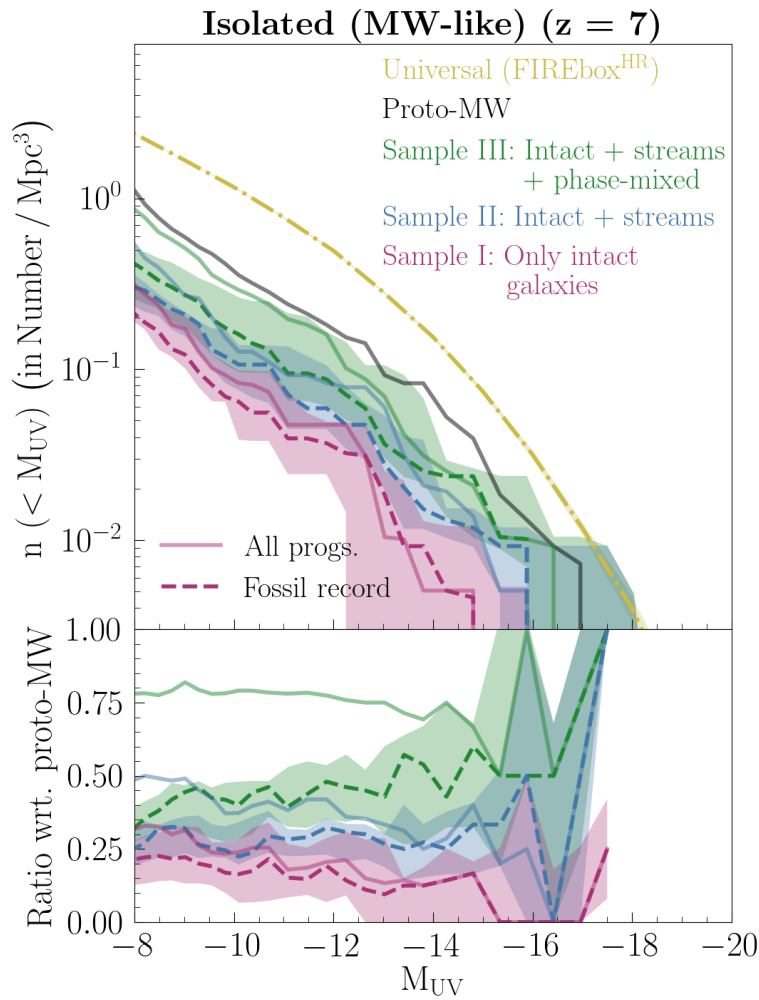




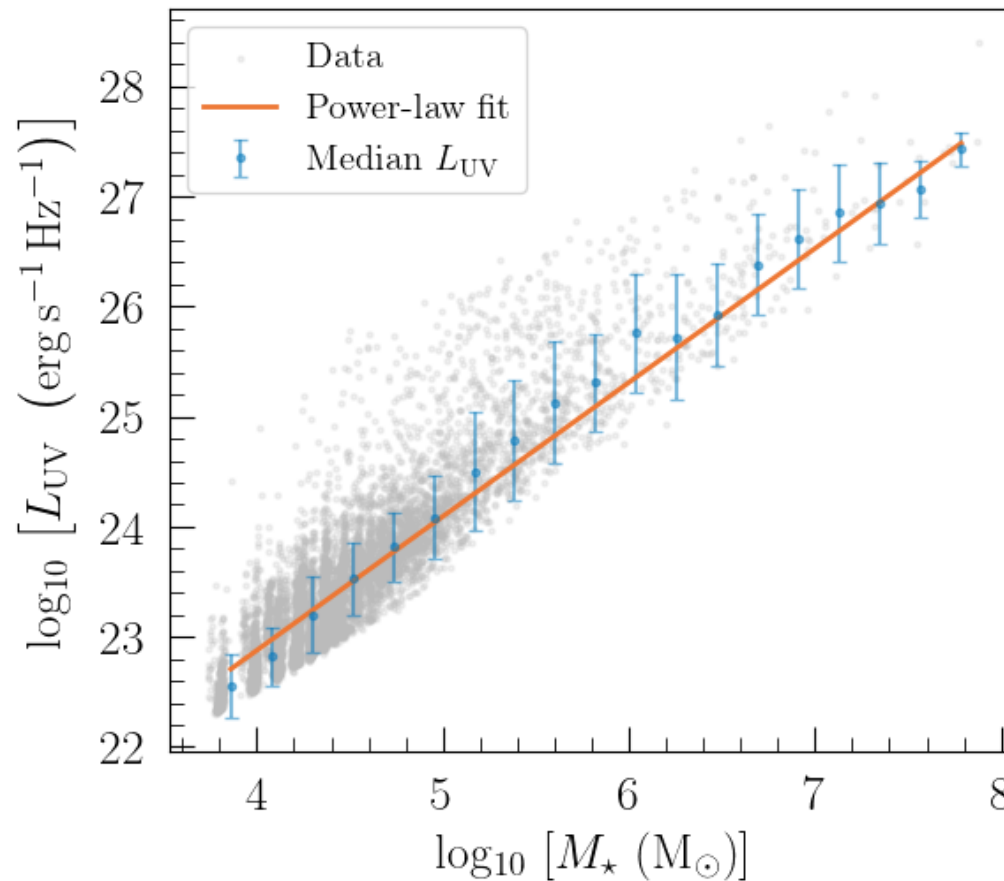
# Cumulative SMFs (MW vs LG)



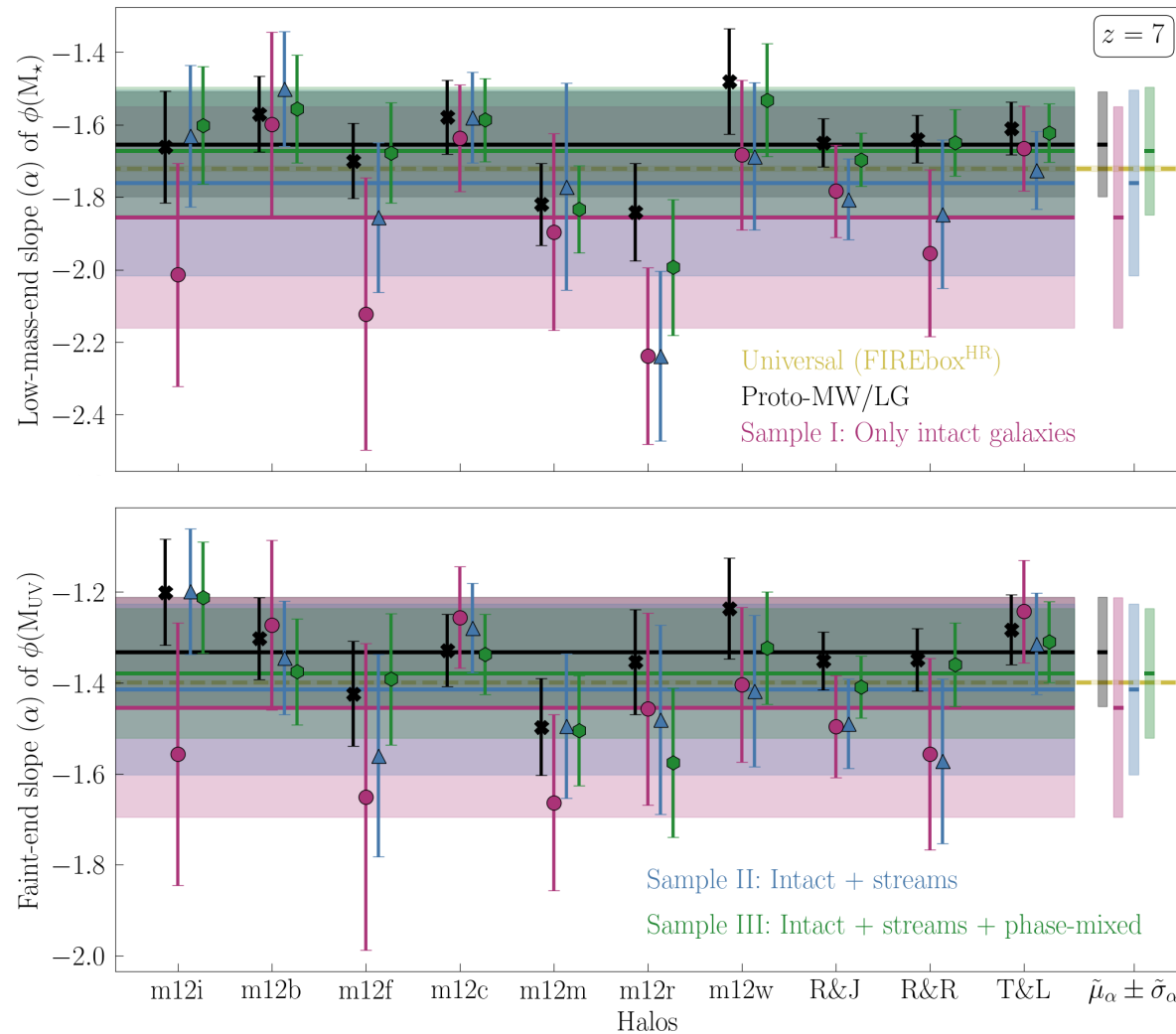
# Cumulative UVLFs (MW vs LG)



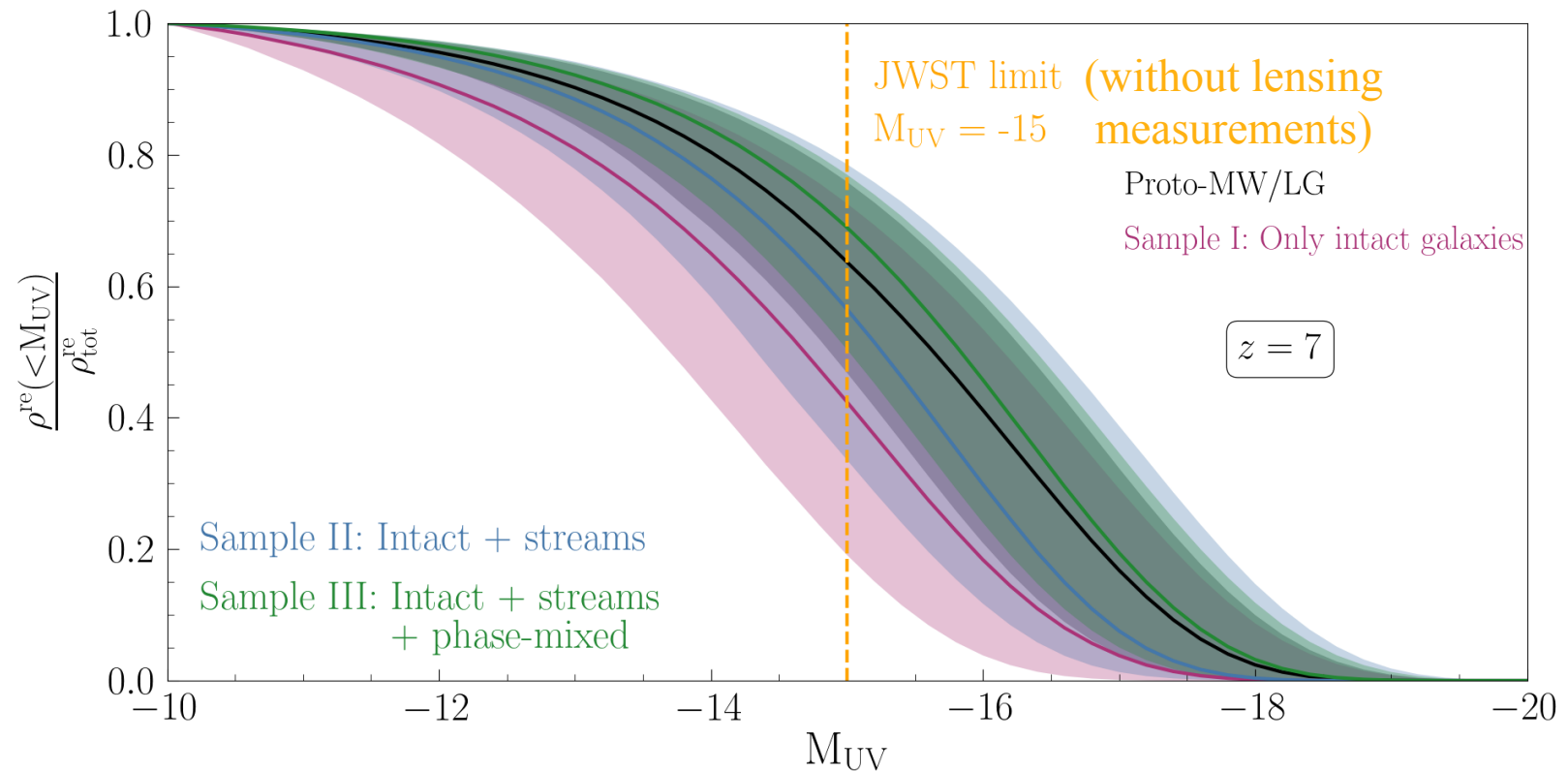
# Mass to light relation is superlinear



# More accurate and precise slopes



# More contribution from brighter galaxies



**Adding disrupted galaxies in the near-far technique predicts larger contribution from relatively brighter galaxies within JWST limits**