Modeling Low-mass Galaxy Star Formation Histories in the Local Universe

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Modeling SAGA Satellites with updated UniverseMachine-SAGA

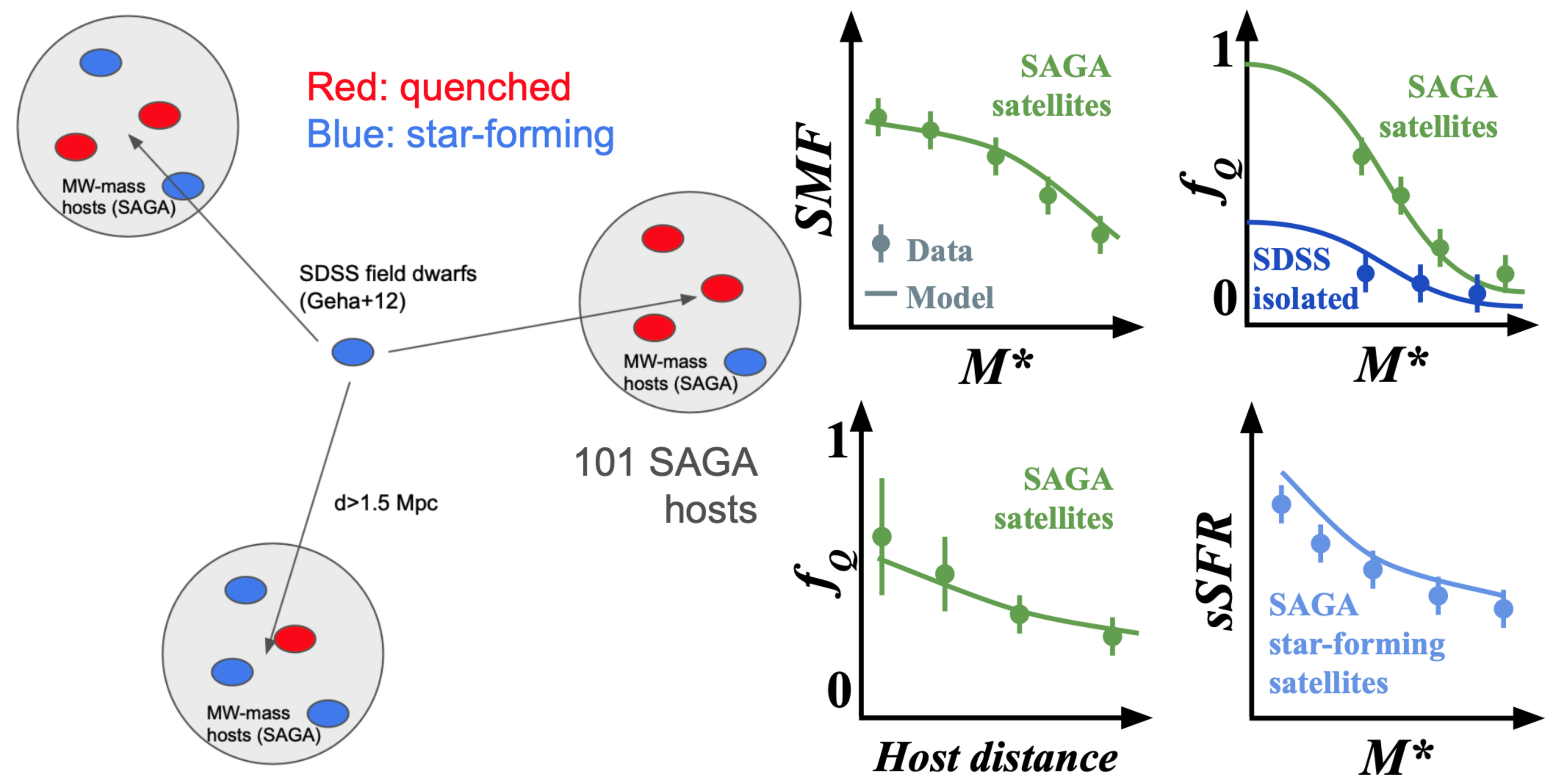

Figure 1. Illustration of the environment (left) and data statistics (right) of the SAGA satellites within Milky-Way (MW) mass hosts and the SDSS isolated galaxies that are > 1.5 Mpc away from any more massive neighbors.

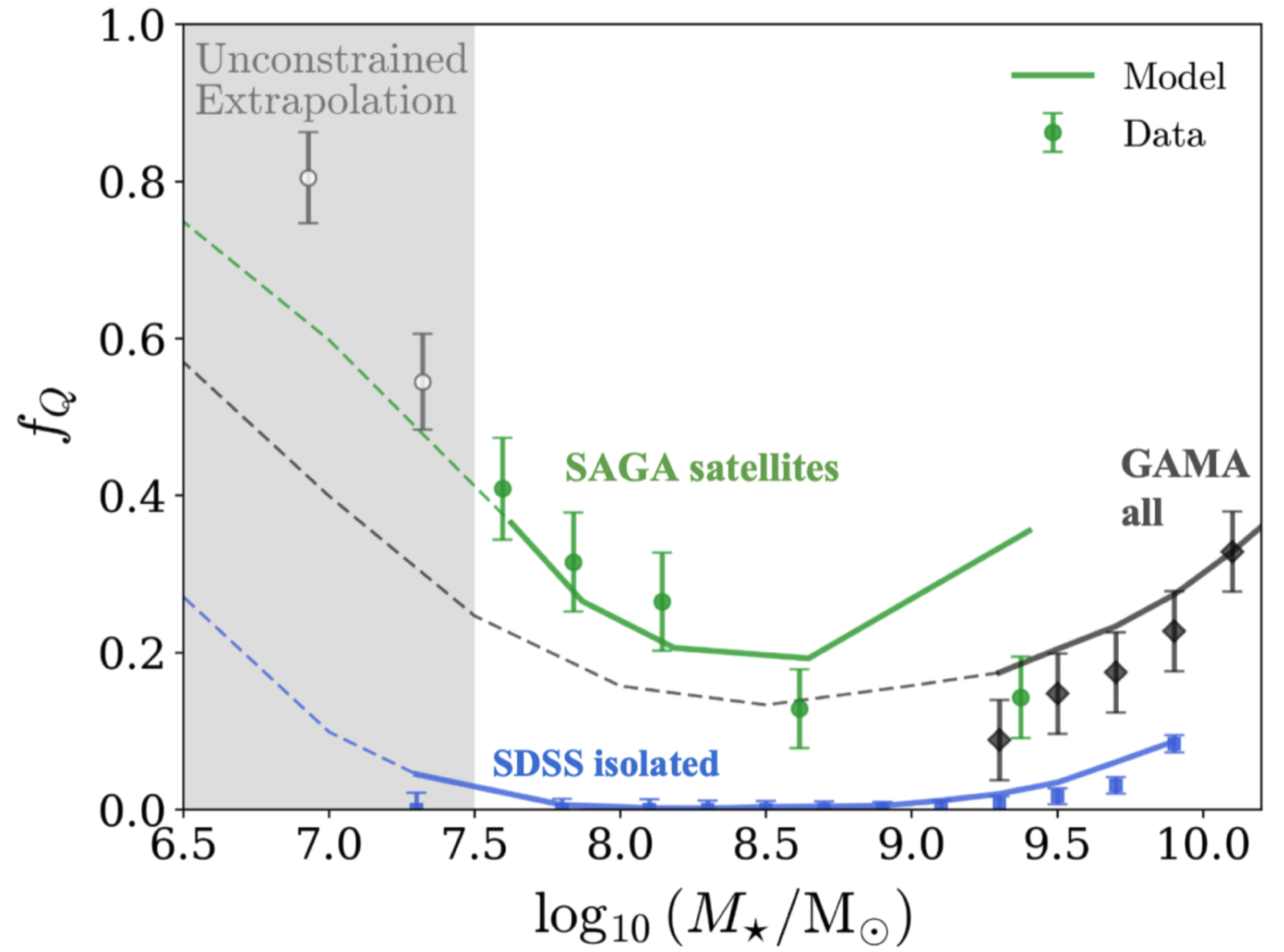

Figure 2. The quenched fractions as a function of stellar mass for the SAGA satellites (green), SDSS isolated galaxies (blue), and GAMA Survey (black) galaxies in diverse environments. Solid curves are predictions from the new UM-SAGA model jointly constrained by SAGA, SDSS, and GAMA low-mass galaxies.

Goal: Better understand the cosmological context of environmental quenching by **empirically forward modelling star formation histories** of low-mass galaxies ($M_* < 10^9 \mathrm{M}_\odot$) using **updated UniverseMachine**. New constraints from **SAGA satellites** and **SDSS isolated** galaxies (Fig 1.).

Key assumptions of UniverseMachine

- **Star formation** is dependent on **halo mass** dependence and **halo assembly** at fixed halo mass: $P(\mathrm{SFR}|\text{halo mass, assembly history, redshift})$.
- **Paint SFR** onto halo merger trees from simulations, integrate to obtain galaxy catalogs.
- **New low-mass quenching model:** enable non-monotonic $fQ(v_{\mathrm{Mpeak}})$ that accounts for low-mass galaxy quenching. This new combined model is named as **UM-SAGA**.

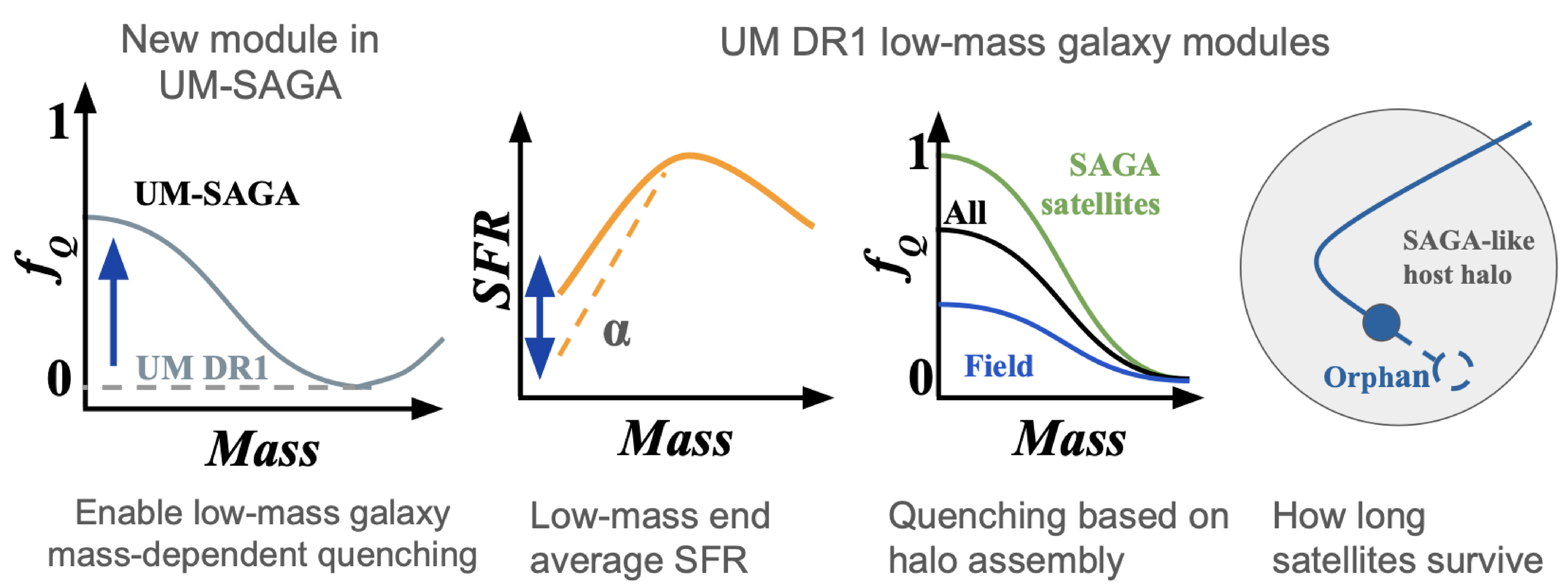

Figure 3. New low-mass quenching model (left) and UM DR1 low-mass galaxy-related modules in UM-SAGA.

Key results

- **Halo mass and assembly history largely describes** dwarf galaxy formation including number densities, mass trend and radial trends of satellite quenching for $M_* \geqslant 10^{7.5}\mathrm{M}_\odot$ (Fig.2).
- A **strong correlation between halo assembly history and SFR** is required to consistently model the huge difference in satellite and field dwarf galaxy quenched fractions (Fig.3).

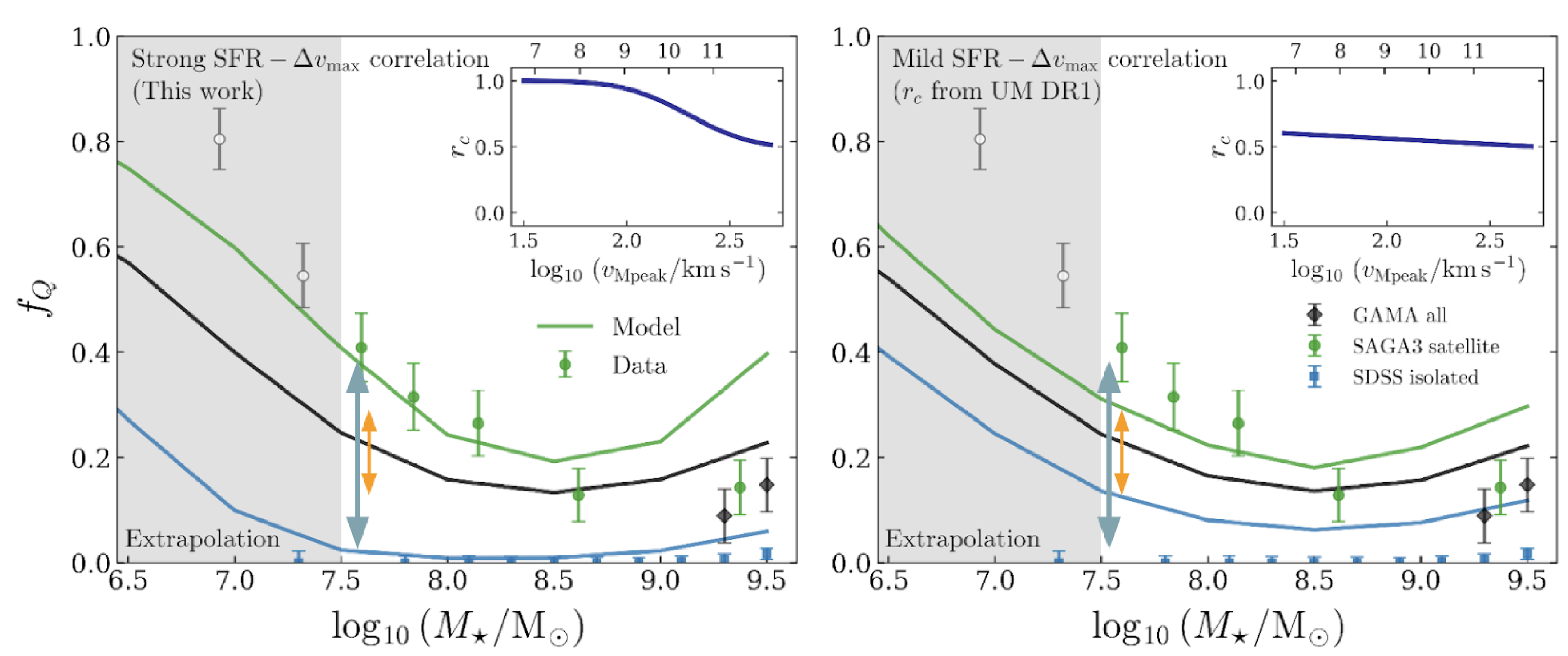

Figure 4. Left: UM-SAGA best-fit model, strong correlation ($r_c \longrightarrow 1$) between SFR and halo assembly history, well-describes the SAGA-satellite and SDSS isolated low-mass galaxies. Right: Mild (UM DR1) correlation of SFR and halo assembly history; produces smaller-than-observed differences in satellite and isolated quenching.

EDEN: Exploring Disks Embedded in N-body simulations

- **Goal:** Establish the cosmological context for baryons impact on subhalos over a wide range of host galaxy **disk masses and growth histories.**
- **EDEN: Symphony MilkyWay simulations (45)+Symfind particle-tracking halo finder.** Analytic disk potentials **grow** self-consistently **according to UniverseMachine** predictions.

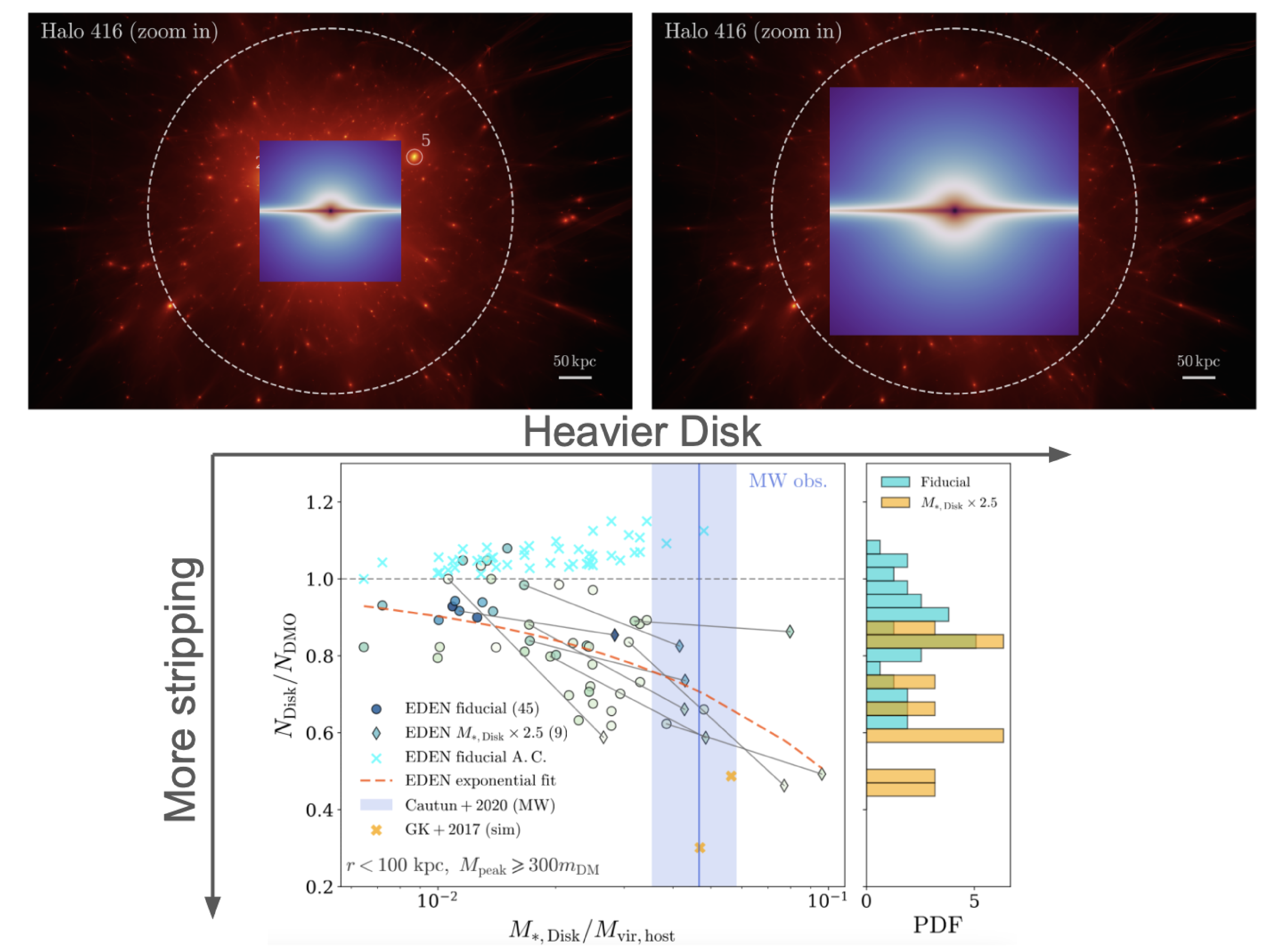

Figure 5. Subhalo abundance suppression due to disk-enhanced mass loss versus disk-to-halo mass ratio. From left to right, heavier disks are embedded into the MW host halos and fewer subhalos survive.

Key results

- **Larger disks leads to fewer subhalos** in a MW-mass ($M_{\mathrm{vir}} \sim 10^{12}\mathrm{M}_\odot$) halo.
- Re-simulating 9 halos with $2.5\times$ **heavier disks** causes **more subhalo mass loss.**
- Subhalo abundance is **most suppressed in heavy MW-like stellar disks.**

Next steps: reionization modeling for local group dwarfs

- Incorporate **reionization quenching** into UniverseMachine.
- New constraint from HST-CMD star formation histories of **MW ultra-faint-dwarfs**.
- Constrain new model on **MWest** simulations with tailored LMC and GSE mergers.