Big Data applications for Black hole Evolution Studies

Shaping galaxies via DREAM
The DiscRete statistical sEmi-empiricAl Model

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From galaxies to cosmology with deep spectroscopic surverys

A tribute to Olivier Le Fèvre. 4-8 July 2022 Marseille

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Background image by C. Marsden from the Astera project (Marsden & Shankar 2020).

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- Motivations
- Methodology
- Main goals
- Results

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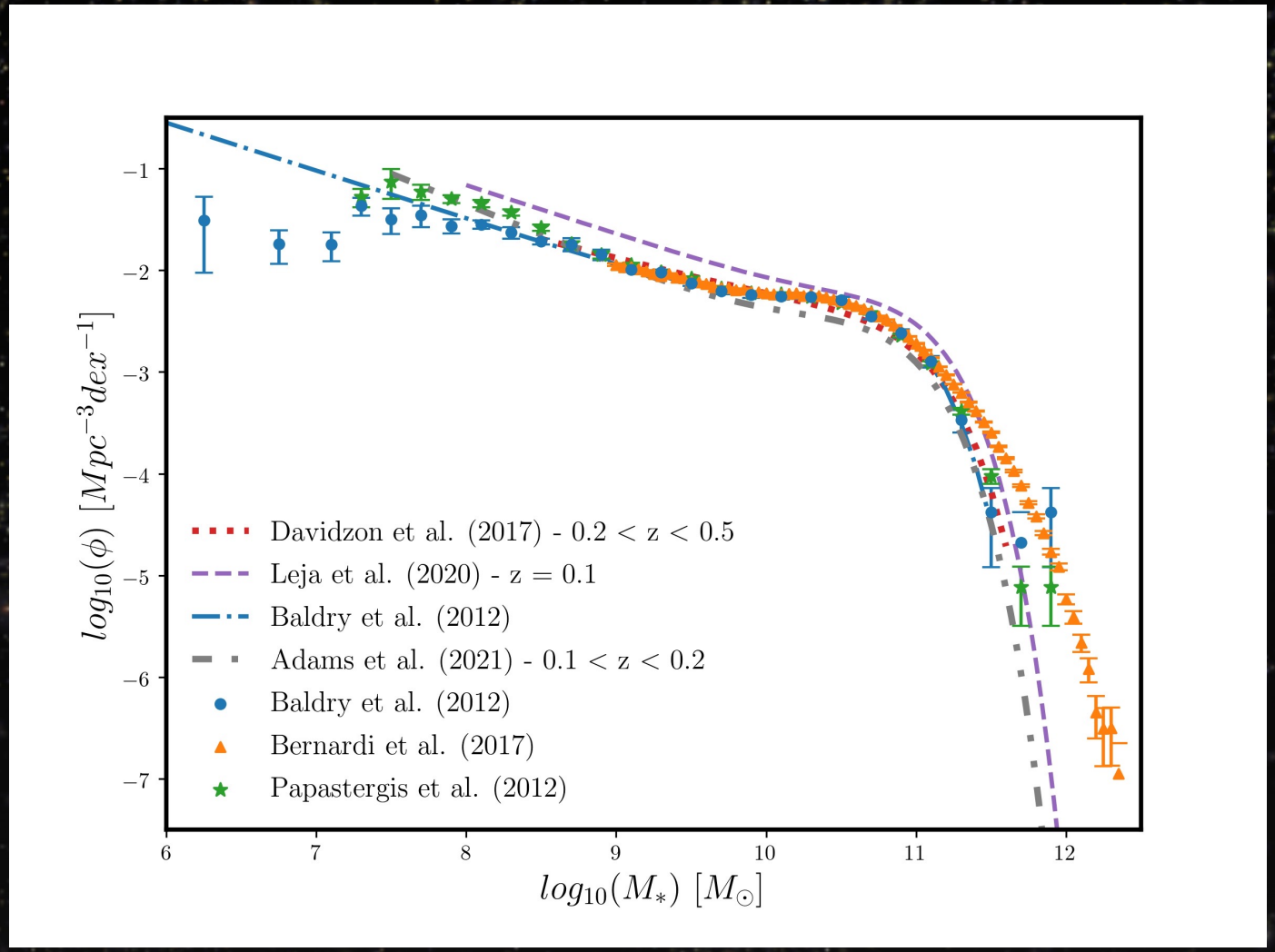
Motivations

The galaxy stellar mass function

- Systematics in stellar mass measurements
- Different works/observations suggest different shapes and evolutions for the galaxy stellar mass function (SMF)
- Especially the high-mass end of the SMF is poorly constrained



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Methodology

Time

Discs grow between mergers

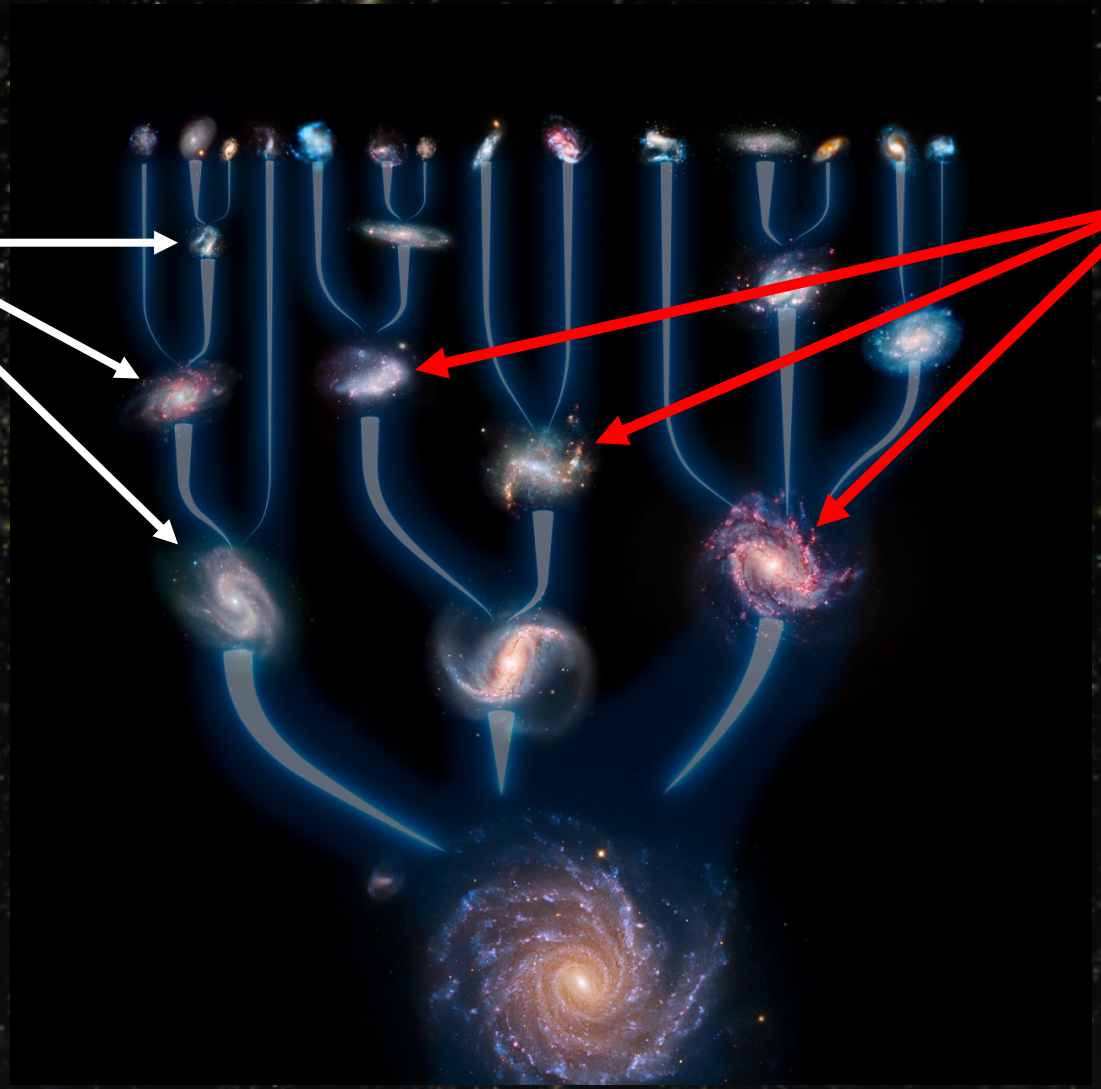
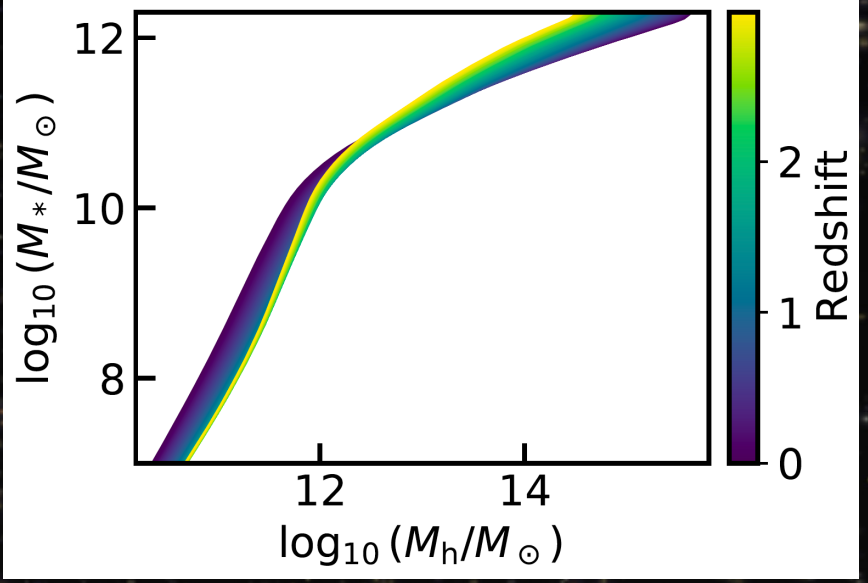


Image credit: ESO/L. Calçada

Stellar Mass-Halo Mass (SMHM) relation to assign galaxy stellar masses to host dark matter haloes at each cosmic time



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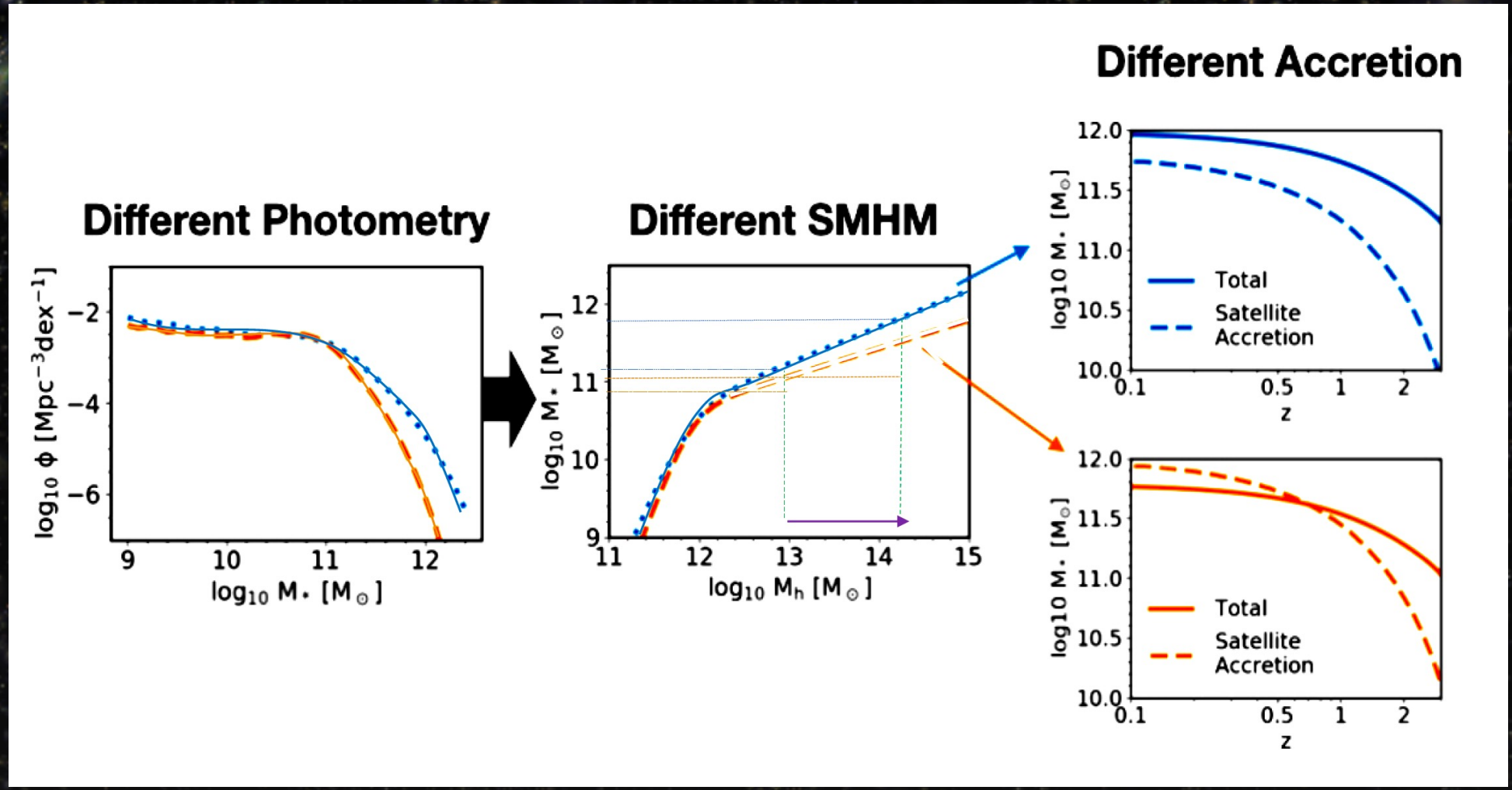
Methodology

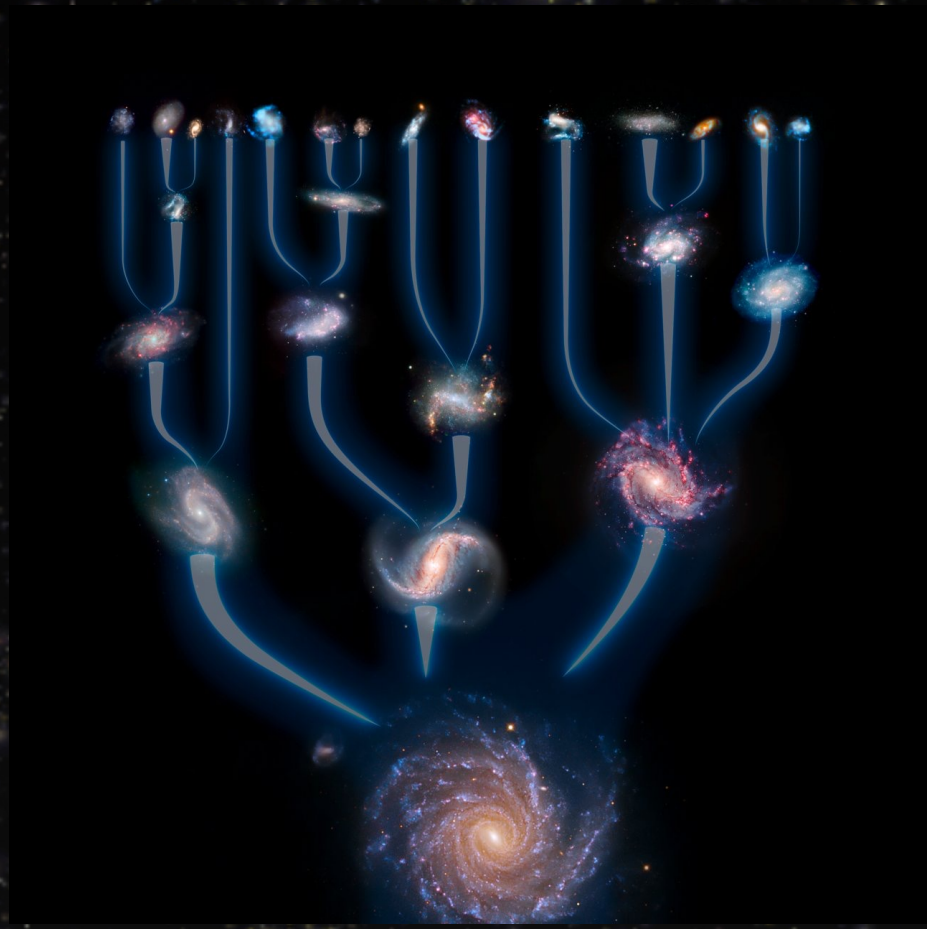
The role of the SMHM relation



Methodology

DREAM (DiscRete statistical sEmi-empiricAl Model)
(Fu H., Shankar F., et al. 2022, MNRAS, resubmitted)

- Generation of dark matter (sub)halo population.
- Populating haloes with galaxies.
- Evolution of subhaloes/satellites after infall.



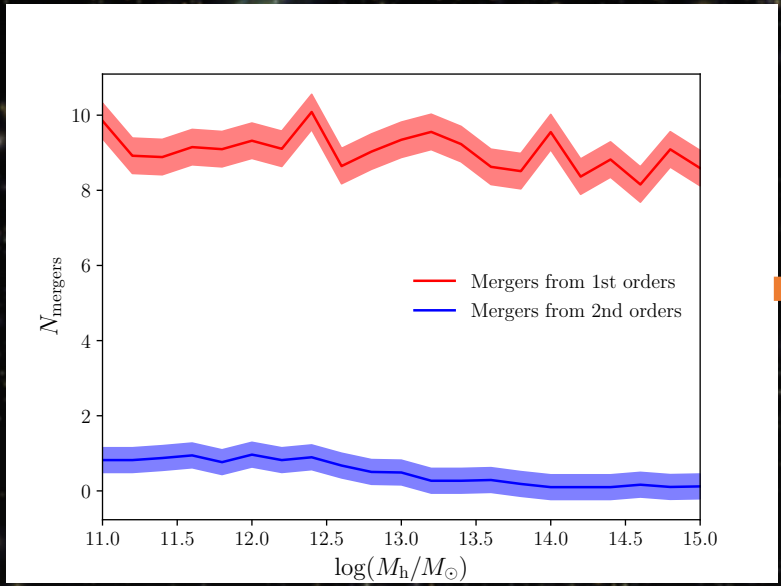
Main goals

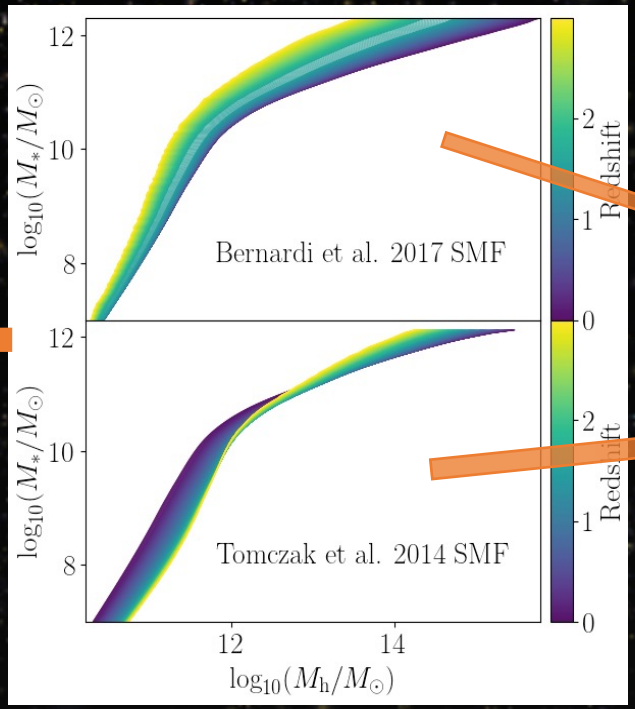
DREAM can rapidly probe the impact of the SMHM relation on:

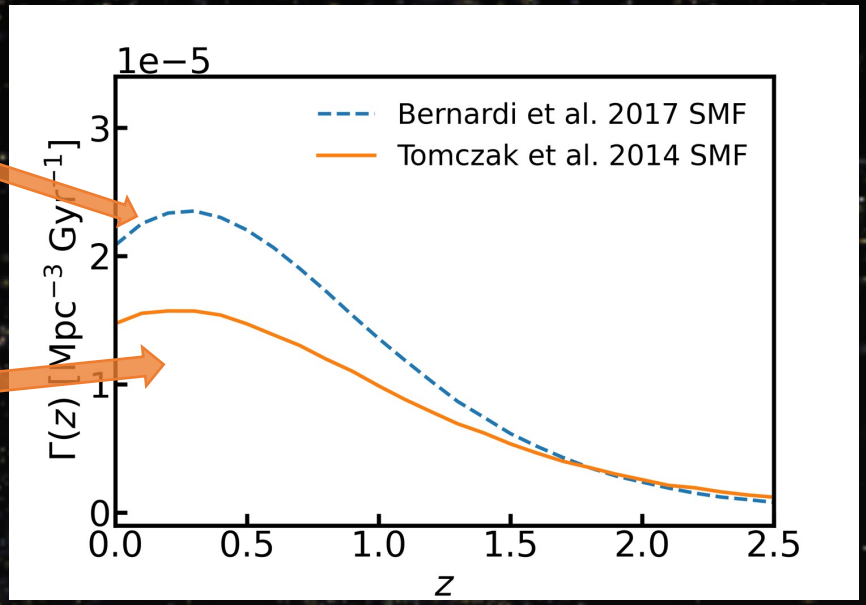
- Galaxy-galaxy mergers.
- Satellite galaxy abundances.
- Star formation histories.
- Morphologies and B/T ratios.

Results

Galaxy-galaxy major mergers







- We follow galaxy-galaxy mergers from redshift $z = 4$.
- **Different SMHM relations lead to different galaxy merger histories.**

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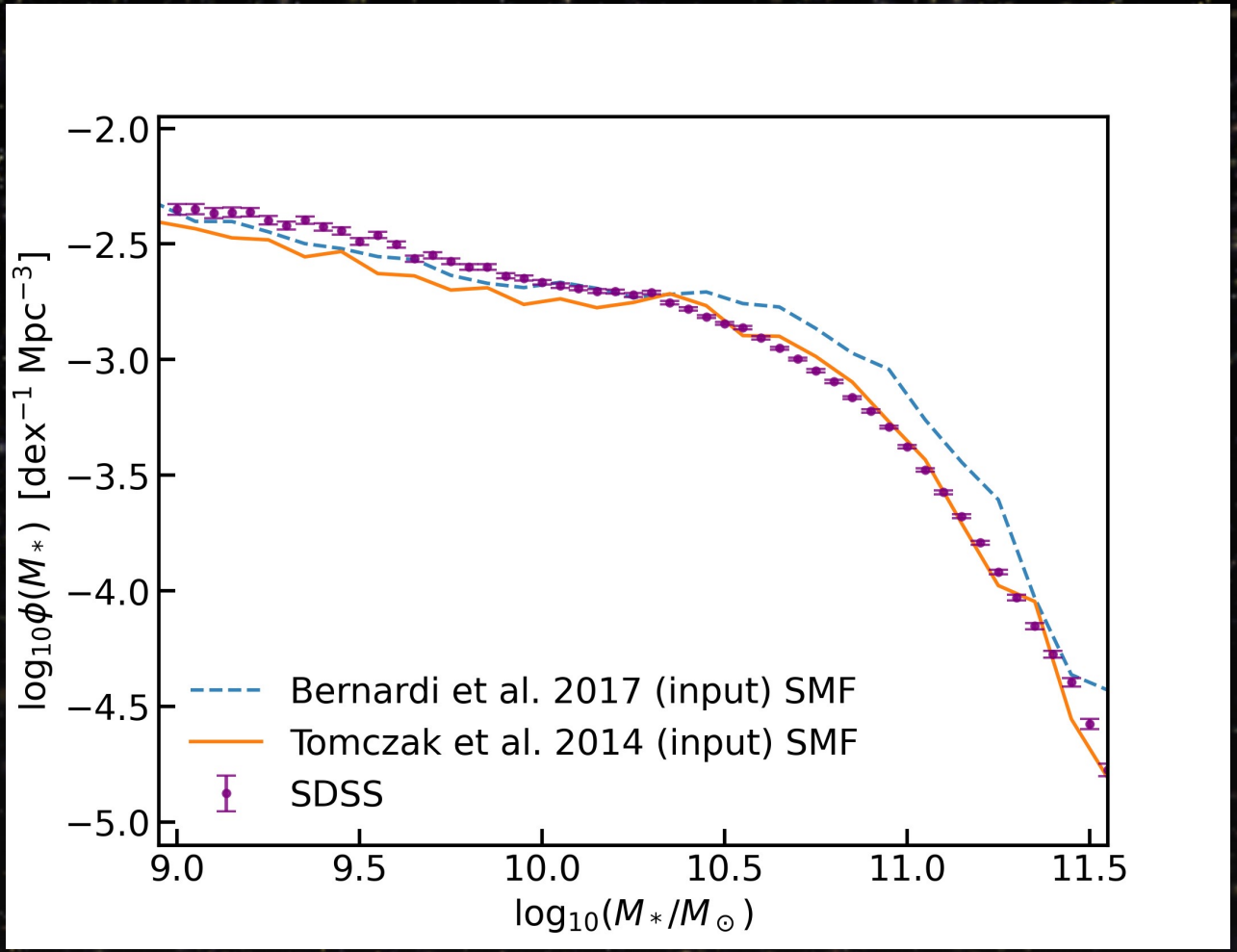
Results

Satellite galaxy abundances

The rate of mergers impacts the numbers of satellites!

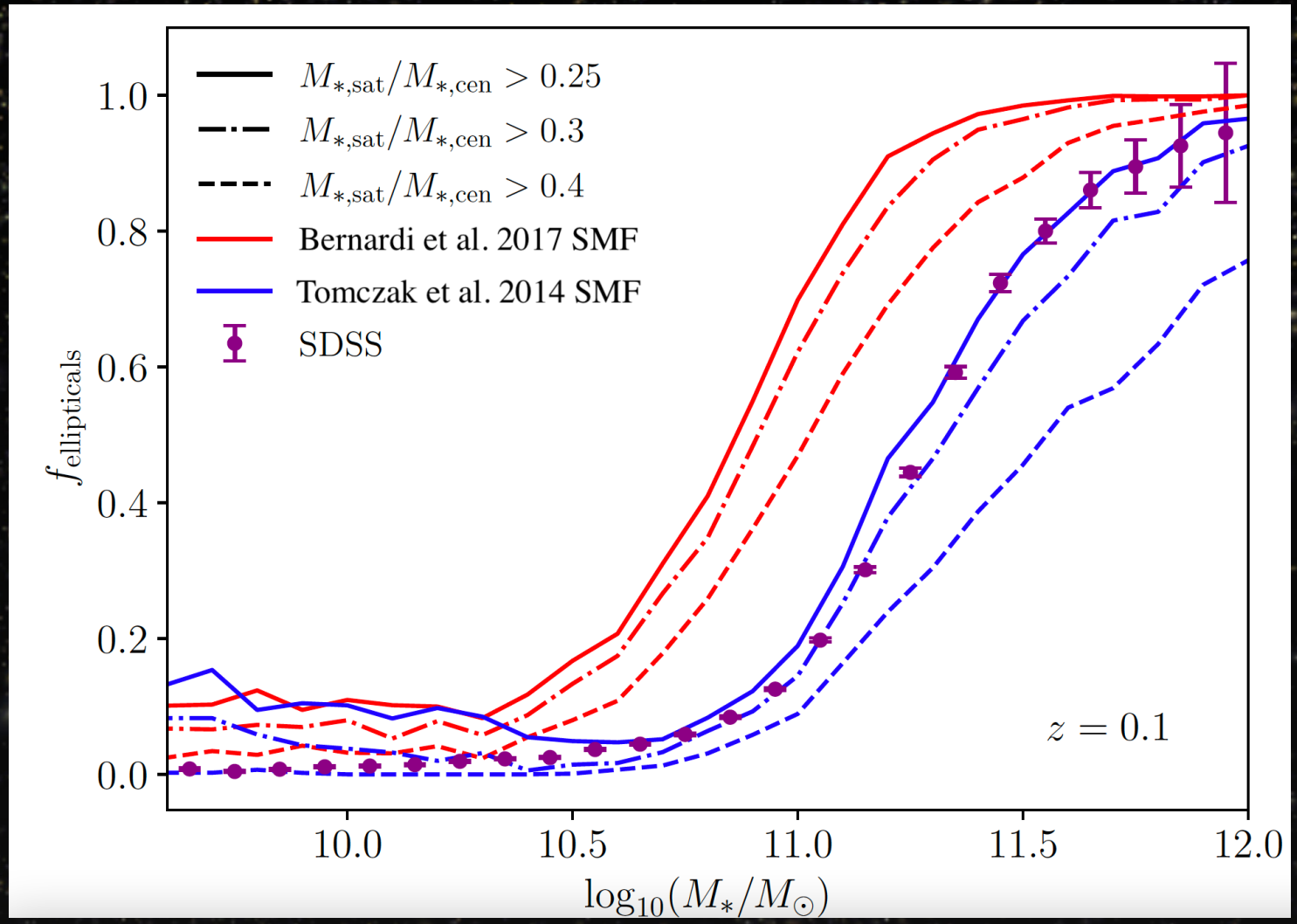


Results

Elliptical type galaxies

Ellipticals in DREAM:

- Can major mergers generate the right fraction of ellipticals?
- It depends on the SMHM relation and the major merger mass ratio threshold.
- Only a redshift-evolving SMHM relation can reproduce the observational local fraction of ellipticals.



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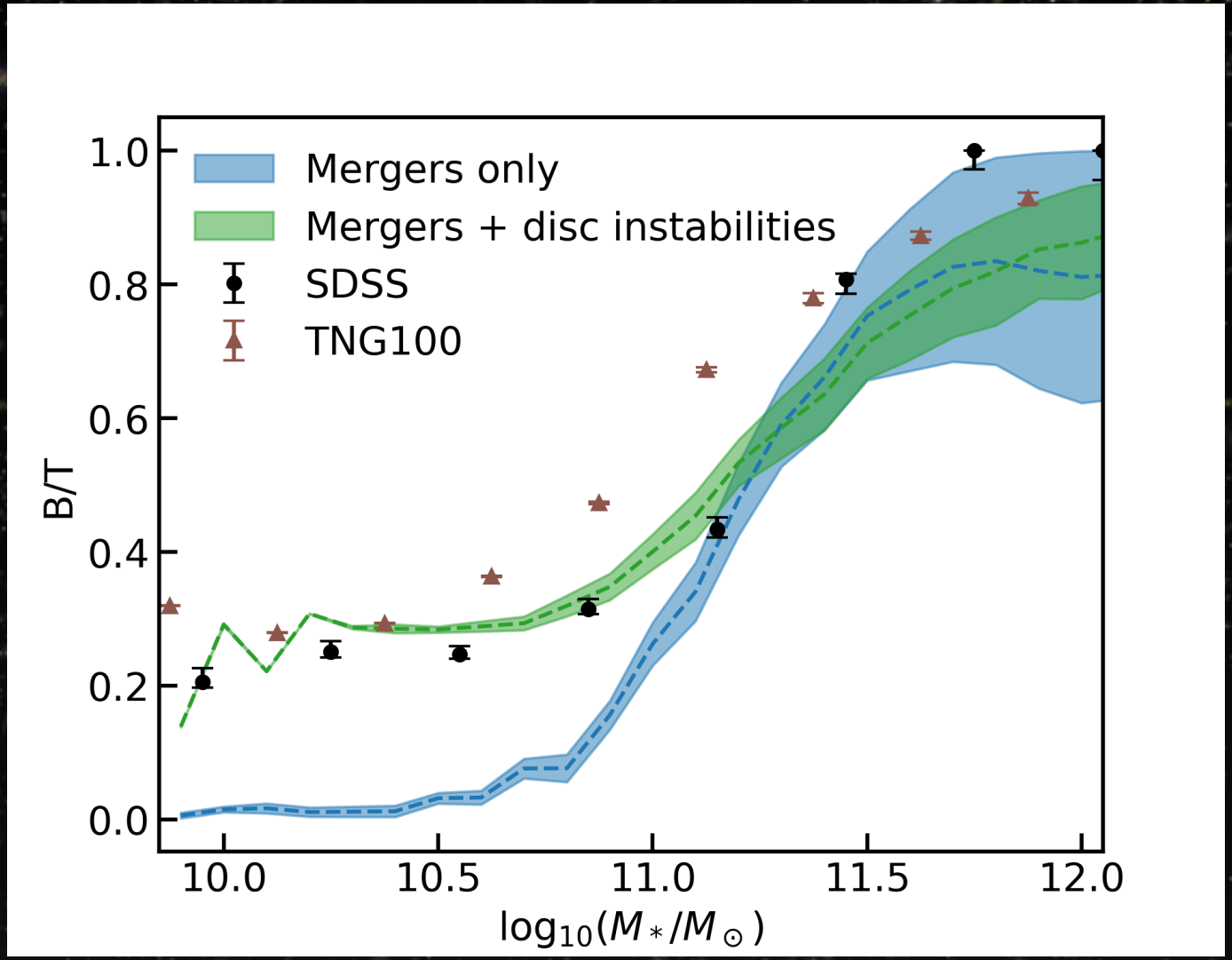
Results

Fraction of Bulge-to-Total ratios

Modelling galaxy bulges in DREAM:

- Can mergers build the right B/T ratio?
- Need disc instabilities?

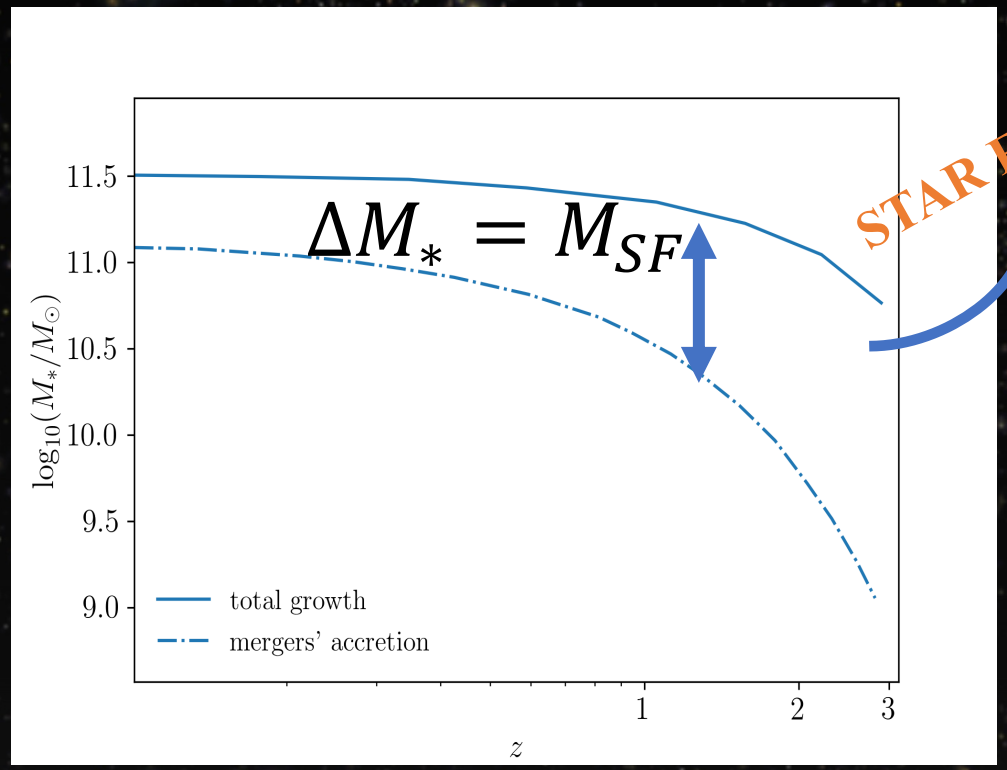


Results

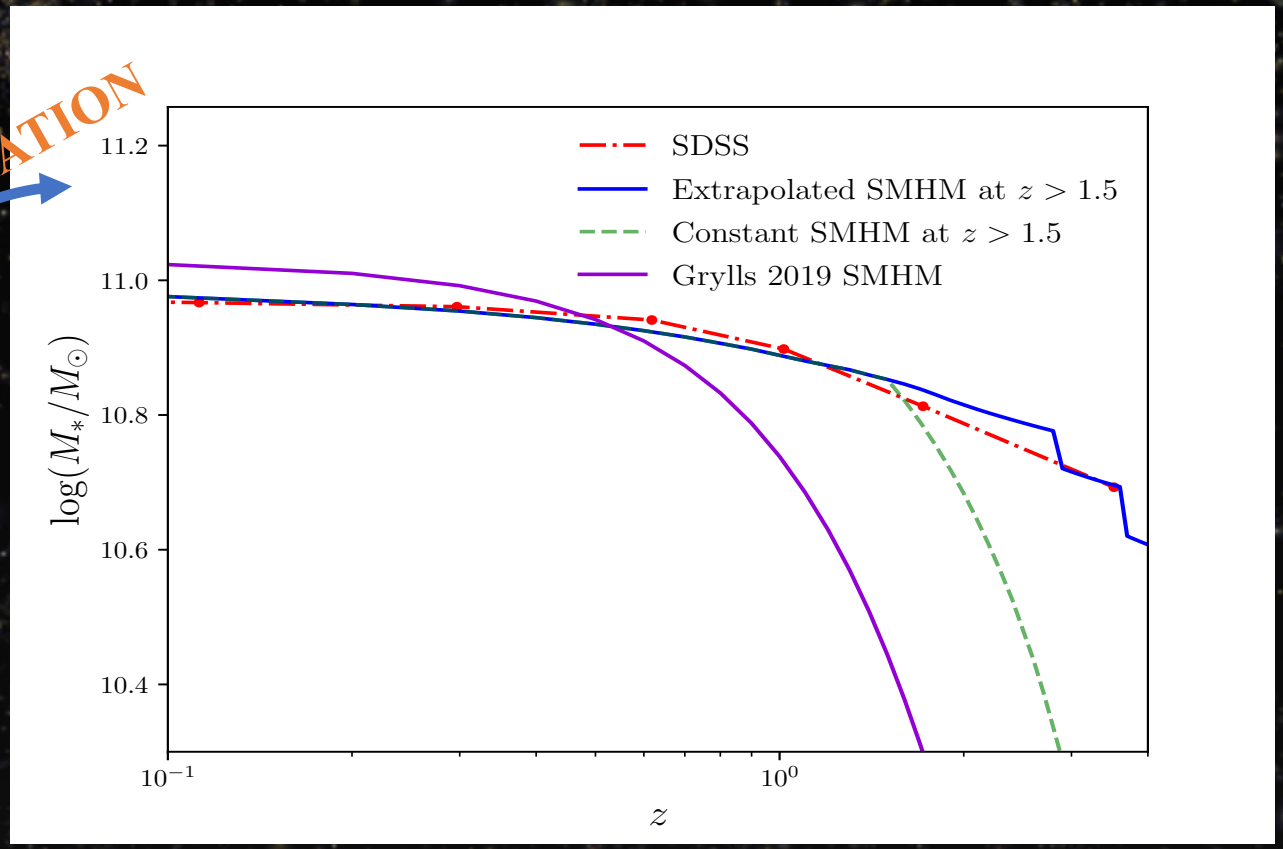
Star formation histories

Galaxies grow their mass via both *in-situ* (e.g., star formation) and *ex-situ* processes (e.g., mergers)

$$M_{tot} = M_{SF} + M_{mergers} + minor\ effects$$



STAR FORMATION



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Summary

Our main results are summarized as below:

- Galaxy major merger rates, satellite abundances, elliptical fractions, B/T ratios and SFHs are highly sensitive to the input SMHM relation.
- A SMHM relation implied by a SMF with larger number or massive galaxies and significant evolution in redshift, is more suitable to reproduce simultaneously the **satellite abundances** in the local Universe as inferred by observations.
- The same SMHM relation can also reproduce the **fraction of local elliptical galaxies** on the assumption that they are formed by major mergers with mass ratio > 0.25, and the **mean B/T ratio** with contribution from disc instabilities at low stellar masses.