A. Durkalec [1]; O. Le Fevre [2]; A. Pollo [1] and VUDS team

Connecting light and dark side of the Universe:

Relation between galaxy stellar and dark matter halo mass at z~3

[1] National Centre for Nuclear Research, Warsaw, Poland
[2] Laboratoire d'Astrophysique de Marseille, France

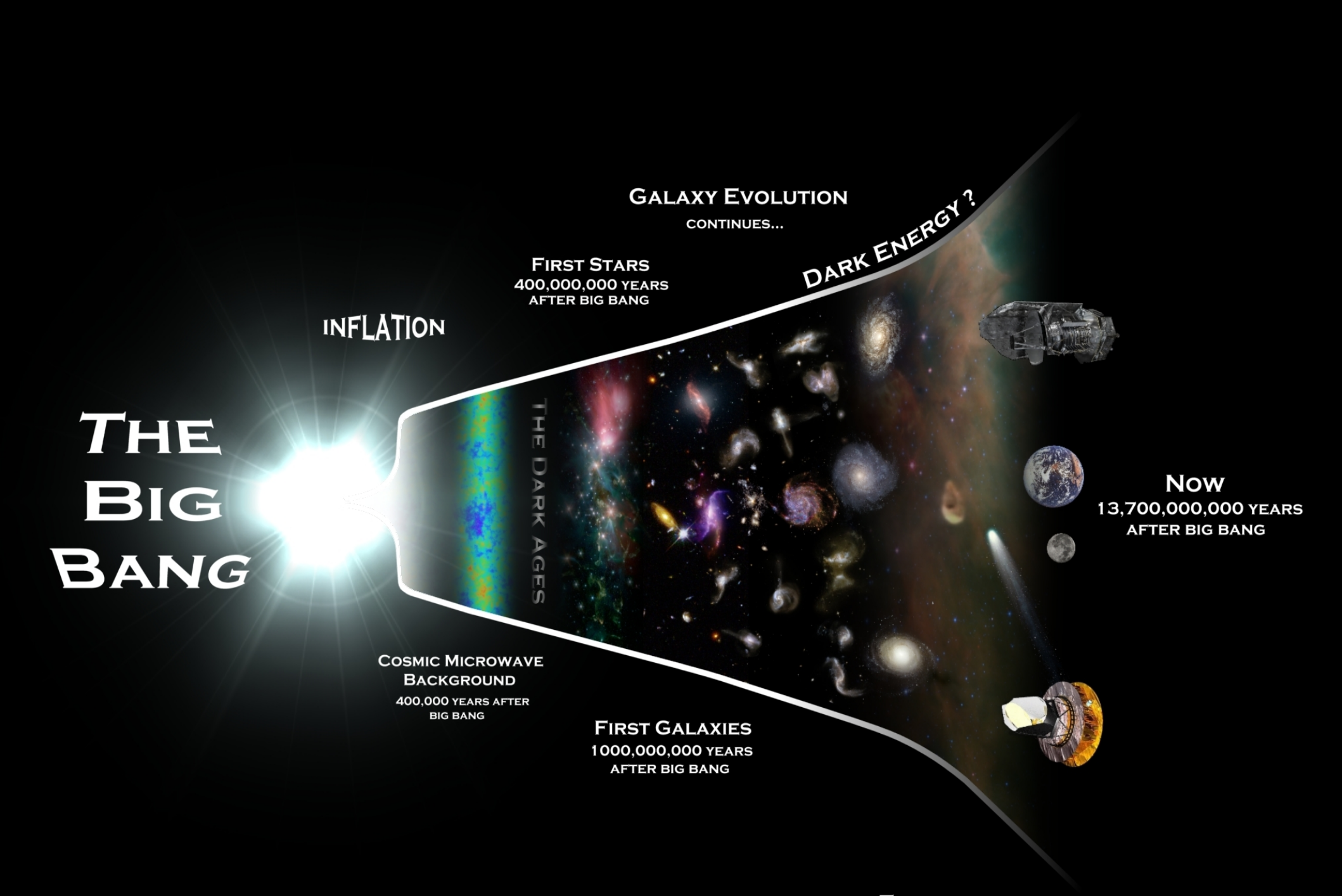
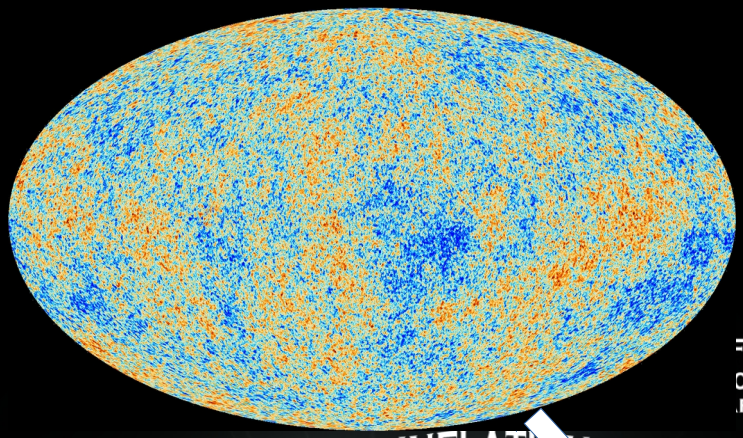


Image credit : Rhys Taylor, Cardiff University

Cosmic microwave background seen by Planck



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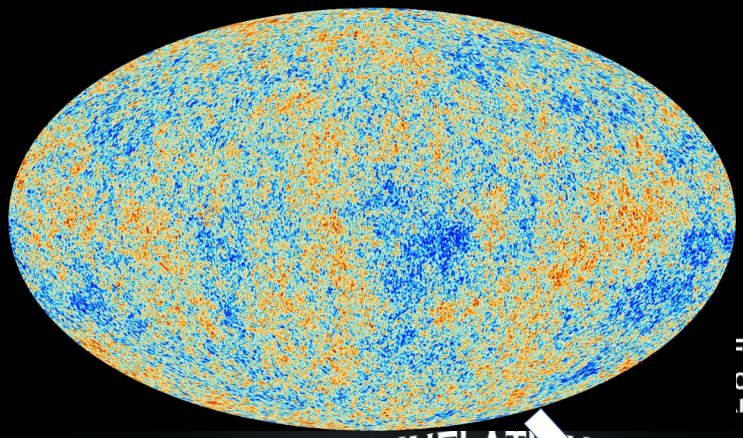


(credit: Suvendra Dutta)

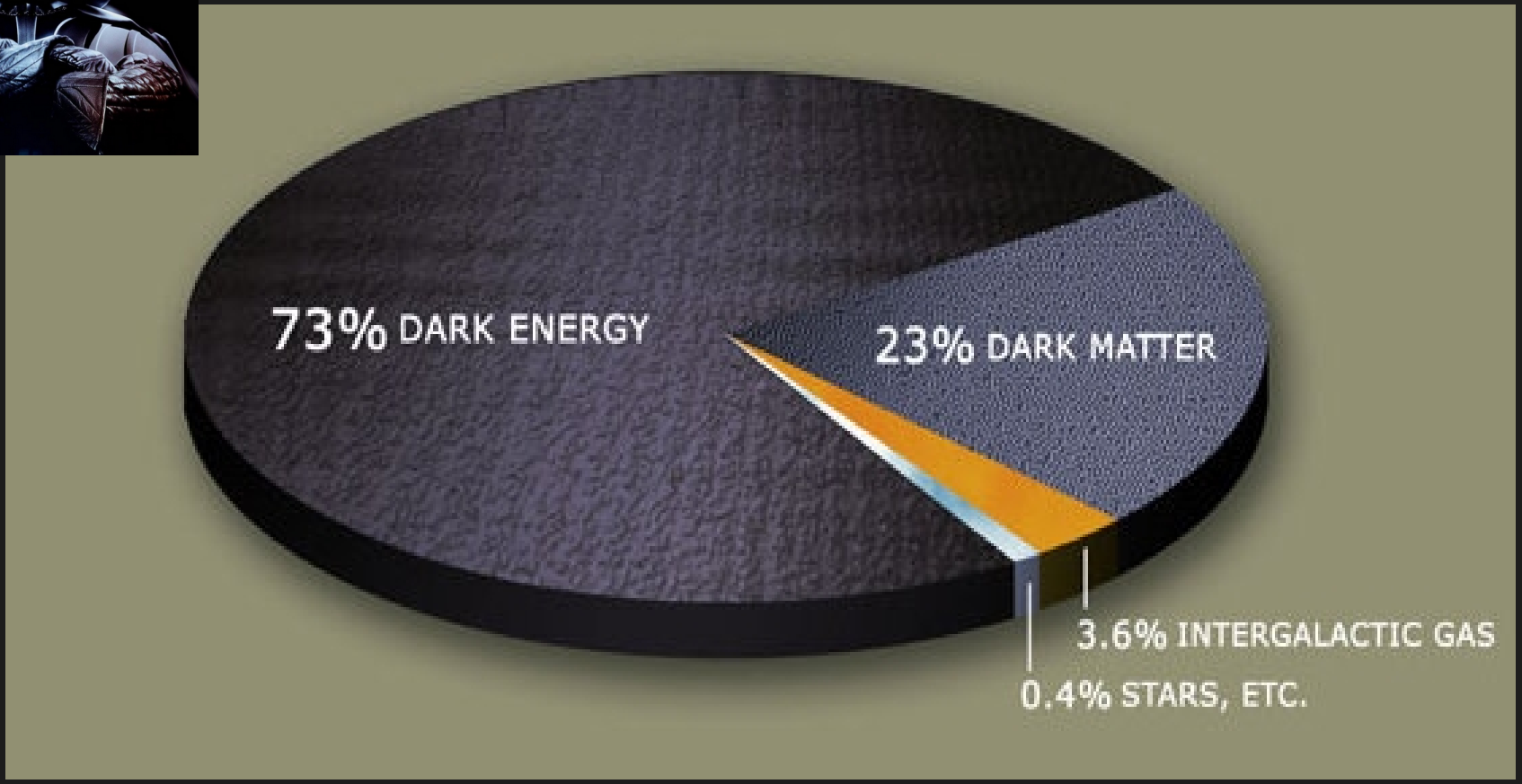
Image credit : Rhys Taylor, Cardiff University

Well…

Well... not quite :(

Because of the Dark Side of the Universe

Deal with it



"Understanding the relationship between galaxies (baryonic matter) and the underlying dark matter is one of the key elements and the biggest questions of modern cosmology."

“Understanding the relationship between galaxies (baryonic matter) and the underlying dark matter is one of the key elements and the biggest questions of modern cosmology.”

… especially at z > 2

All you need...

All you need... is ~~love~~ DATA!

Galaxy sample – VIMOS Ultra Deep Survey (VUDS)

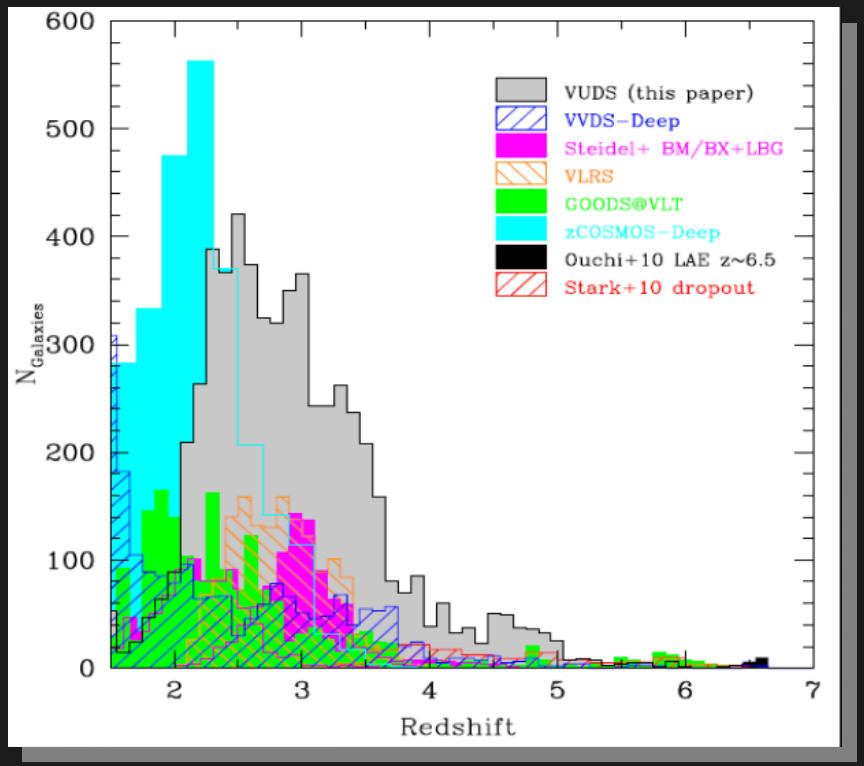


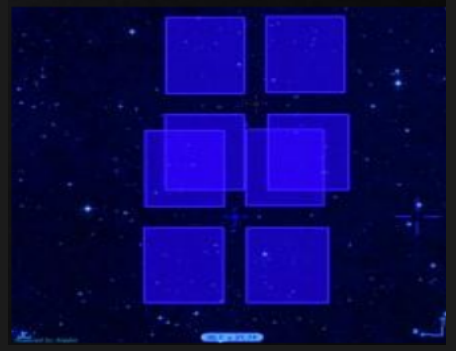
Fig. from LeFevre+15

- ESO Large Program: 640h
- Focused on $2 < z < 6.5$
- 1 deg^2
- 10,000 targets
- 3 fields: mitigate cosmic variance
- Selection: phot-z + SED + color
- 14hr integration over 3600-9300 Å
- 8,000 galaxies with $2 < z_{spec} < 6.5$

VVDS02h

COSMOS

ECDFS



All you need... is clever idea

Correlation function

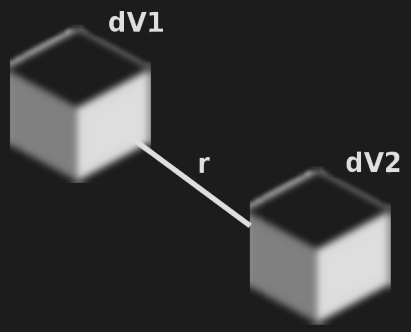
Excess number of pairs separated by *r* over the random distribution

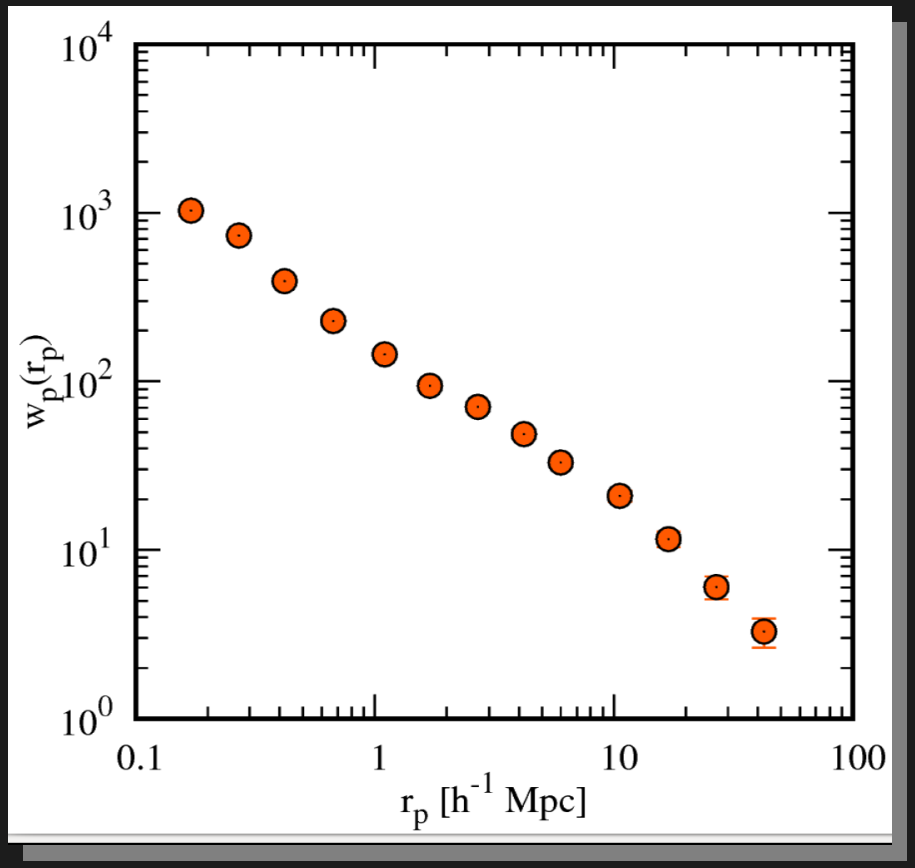
Benefits :

- Allows us to measure the distribution of galaxies in the matter field.
- Indicates how galaxies trace the overall dark matter distribution.

Requirements :

- Sufficiently big volume and number of galaxies.
- Spectroscopic redshift to get robust measurement.



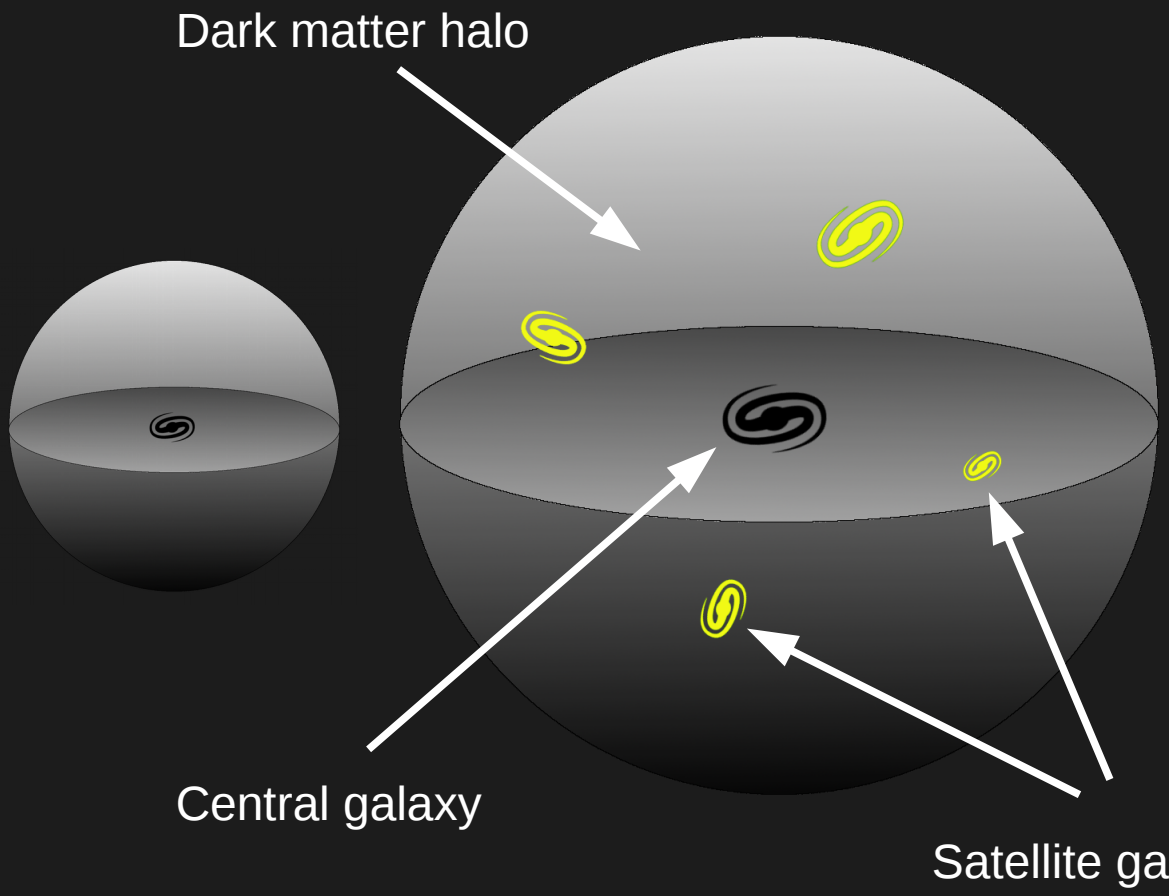


Data from Zehavi+11

The HOD framework

Assumptions:

- Galaxies reside in dark matter halos.
- Number of galaxies inside halo is the function of the mass of the halo.



Two-point real-space Correlation Function

HOD

5 HOD parameters

M_{min} M_1 M_0

$\sigma_{\log M}$ α

Halo mass M_h

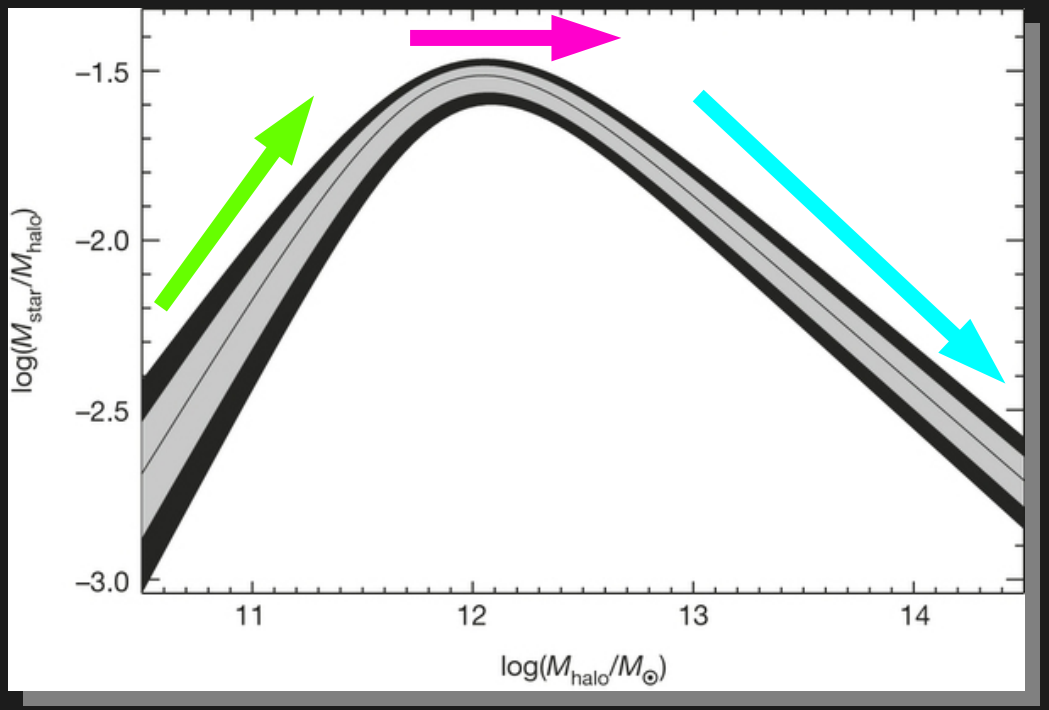
Galaxy bias b_{gal}

Satellite fraction f_s

The Stellar-to-Halo Mass Relation (SHMR)

2. Quenching* – star formation stops slowly in galaxies while DM haloes still increase their mass

1. Effective star formation – increasing of stellar mass of galaxies and growth of DM haloes



3. No star formation – galaxies are cold and dead, but DM haloes slowly grows

Figure from Moster+10, see also Behroozi+13

***QUENCHING - shutting off star formation in galaxies**

All right...

Show me what you got!

SHMR for massive galaxies in VIMOS Ultra Deep Survey (VUDS)

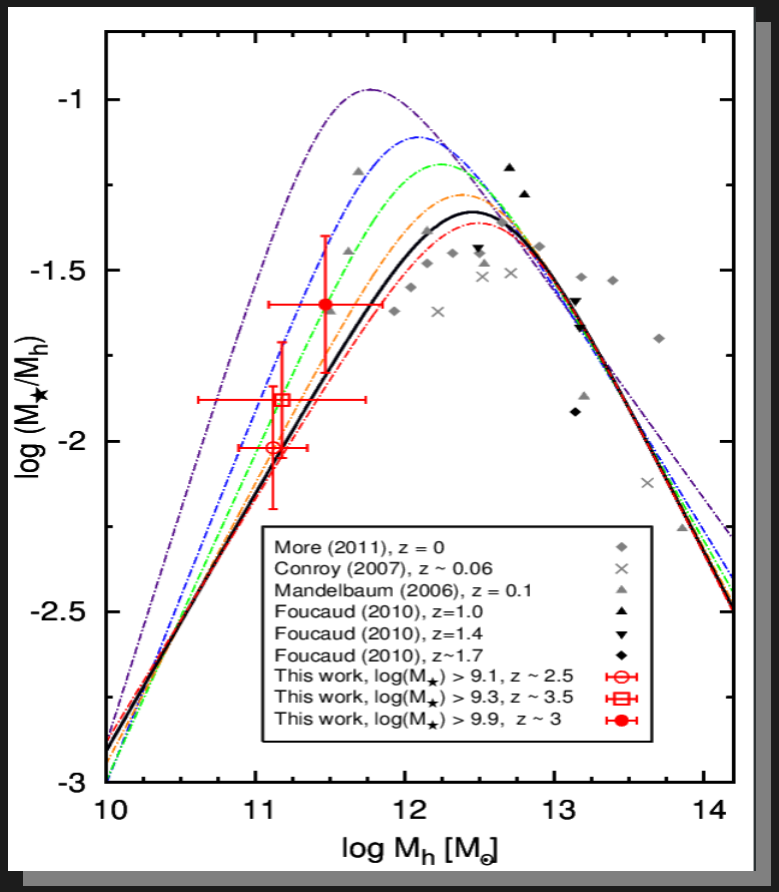
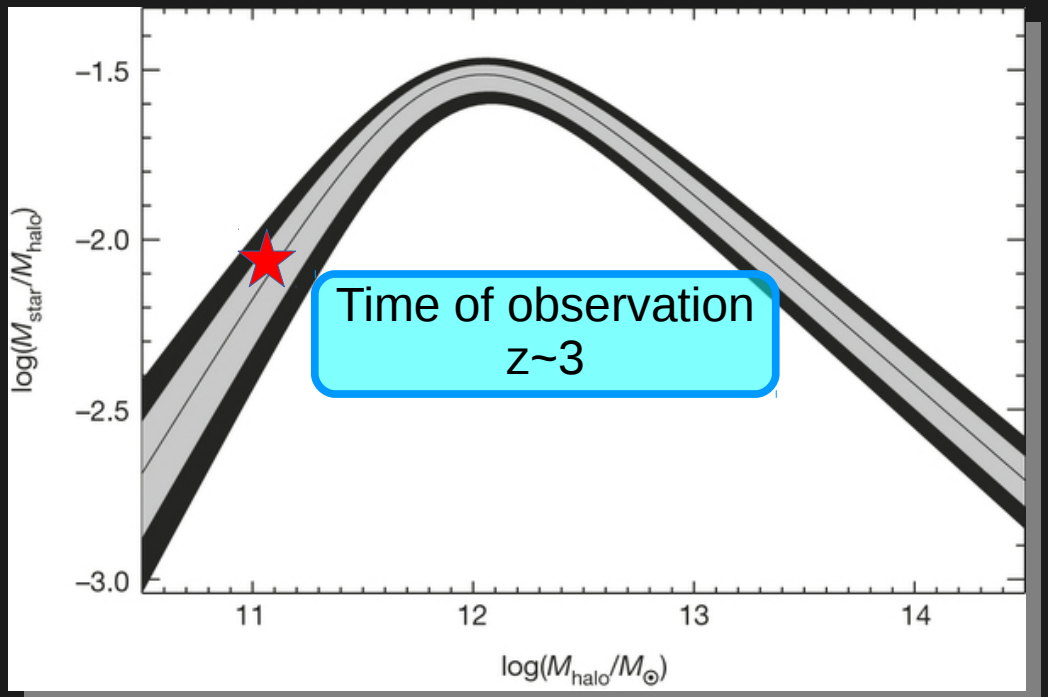


Figure from Durkalec+15

SHMR measured for massive galaxies follows theoretical model predictions

Assuming theoretical model by Behroozi+13 we can estimate the time scales for specific stages of star formation of a 'typical' massive galaxy observed in VUDS.



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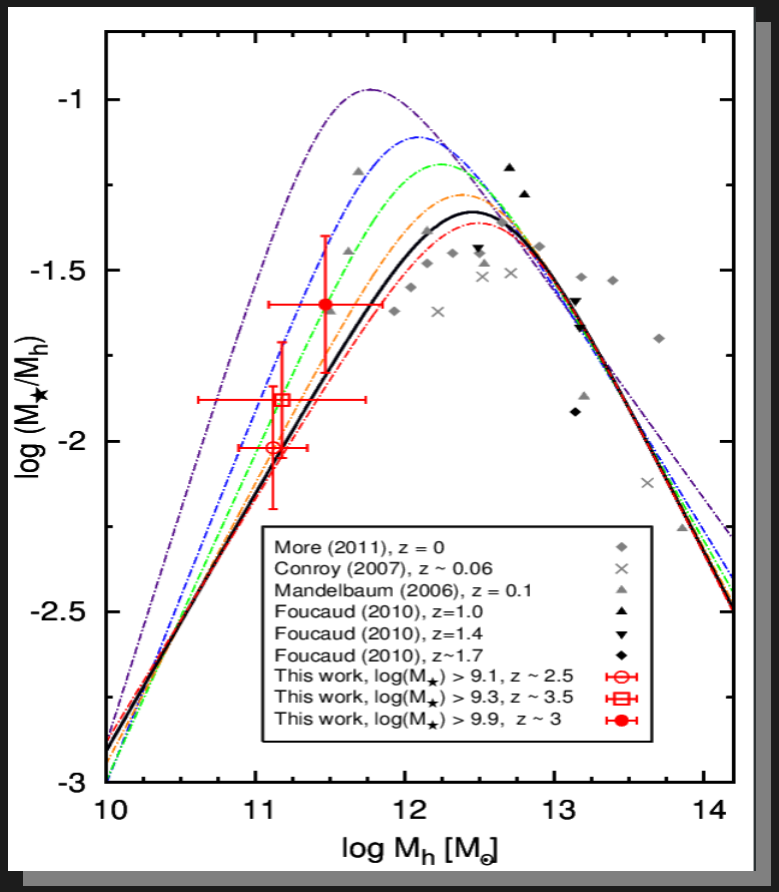

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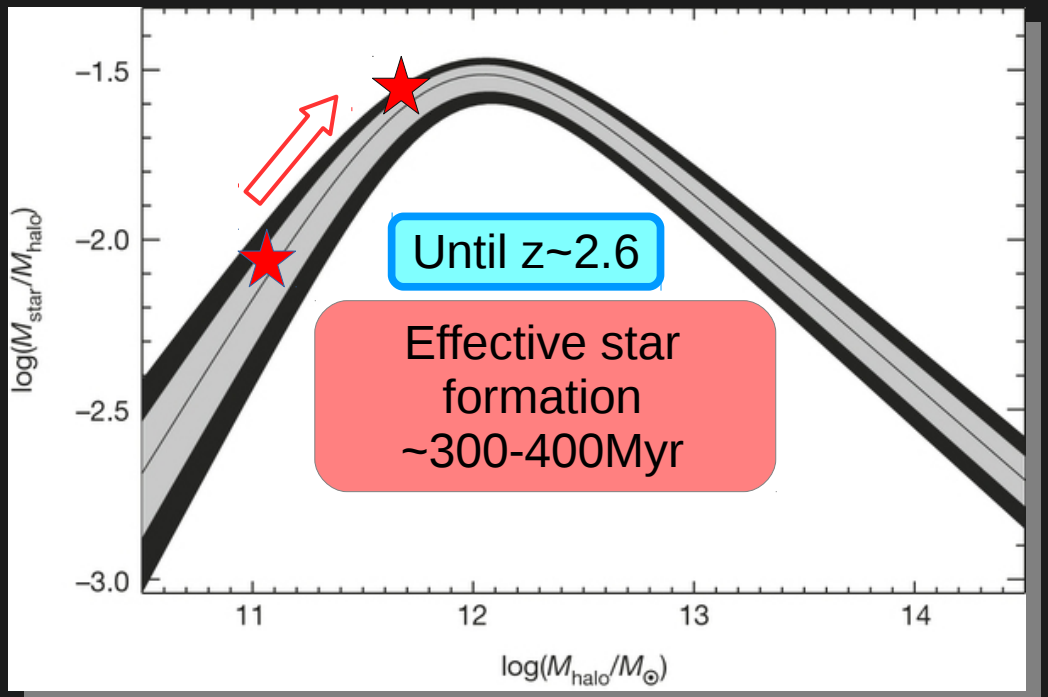

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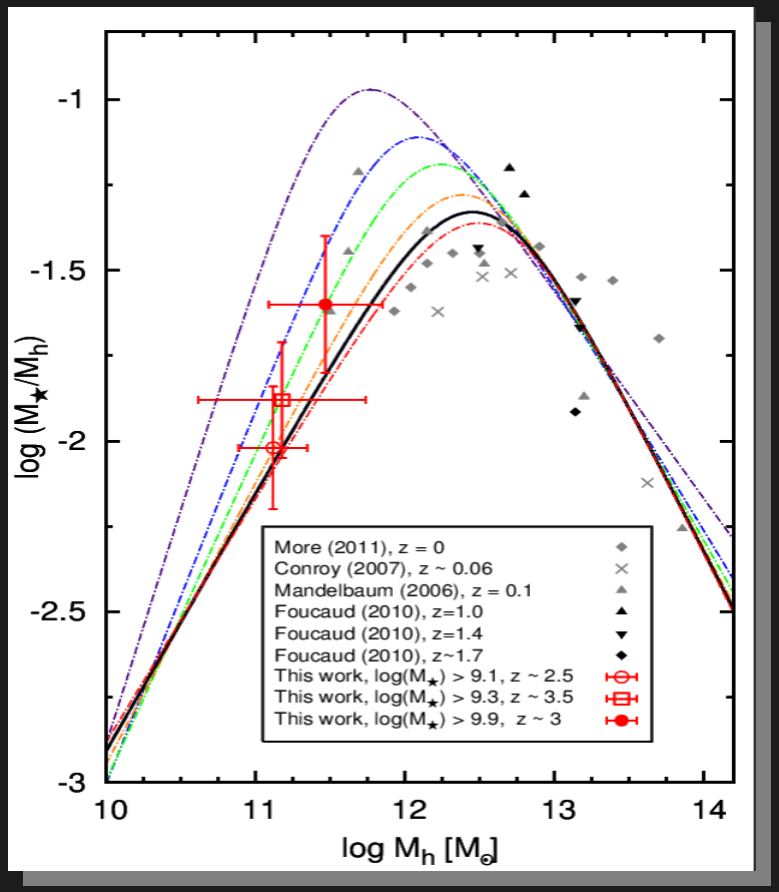

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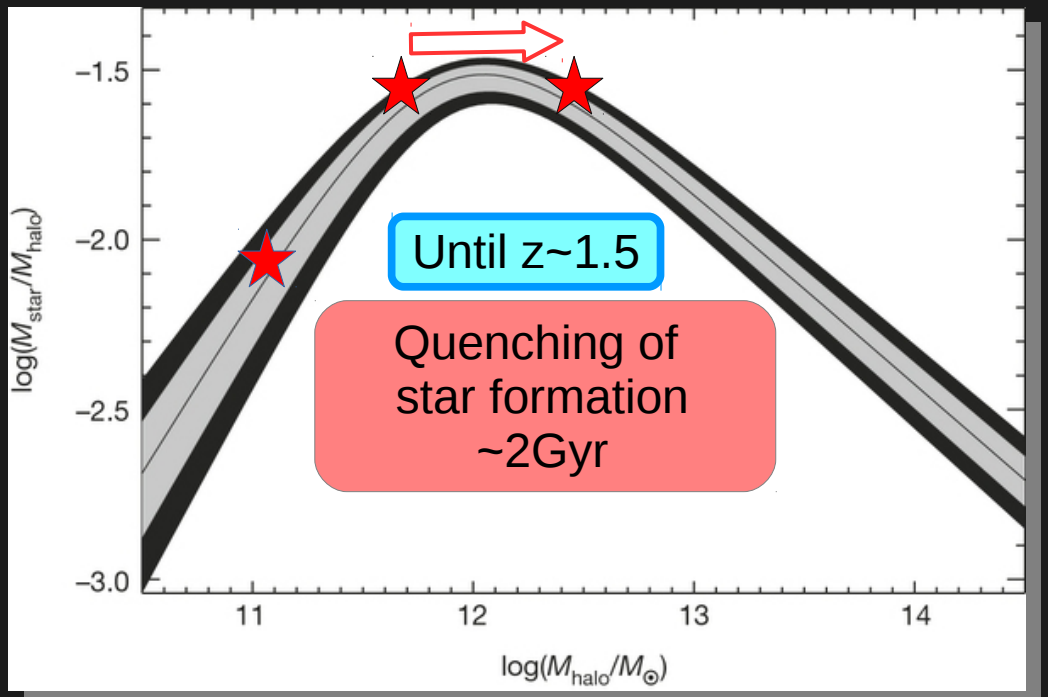

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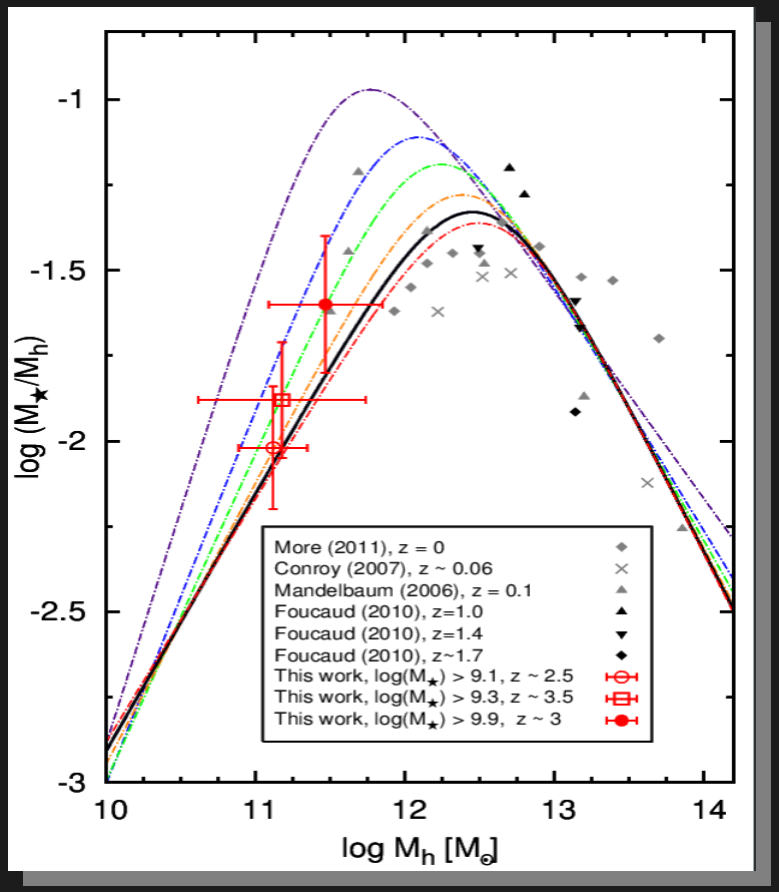

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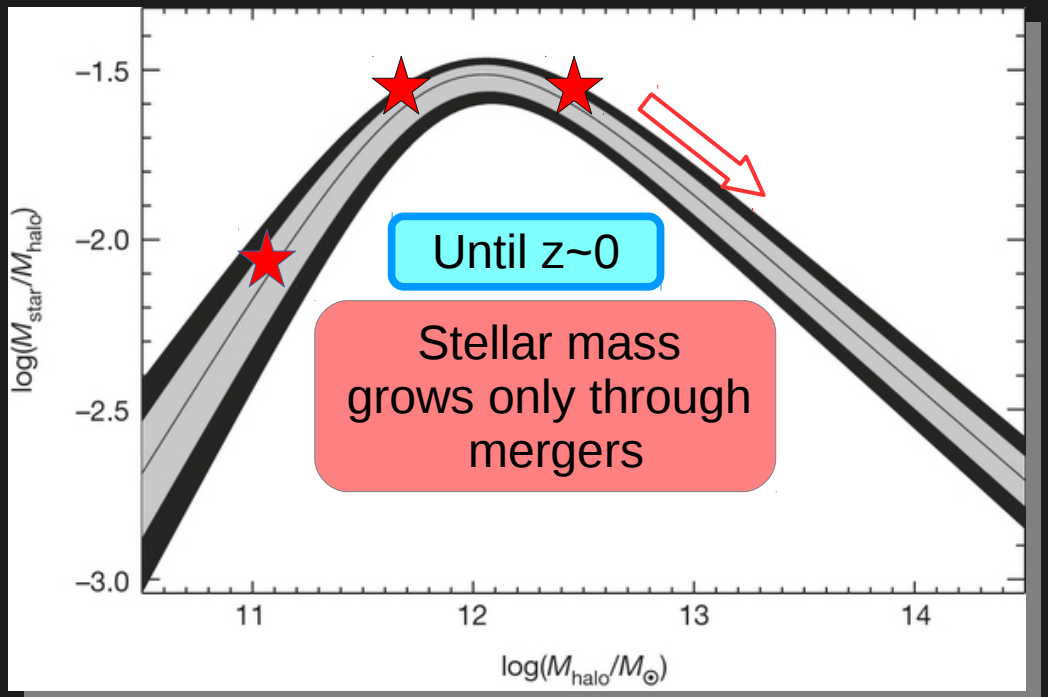

What about low mass galaxies?

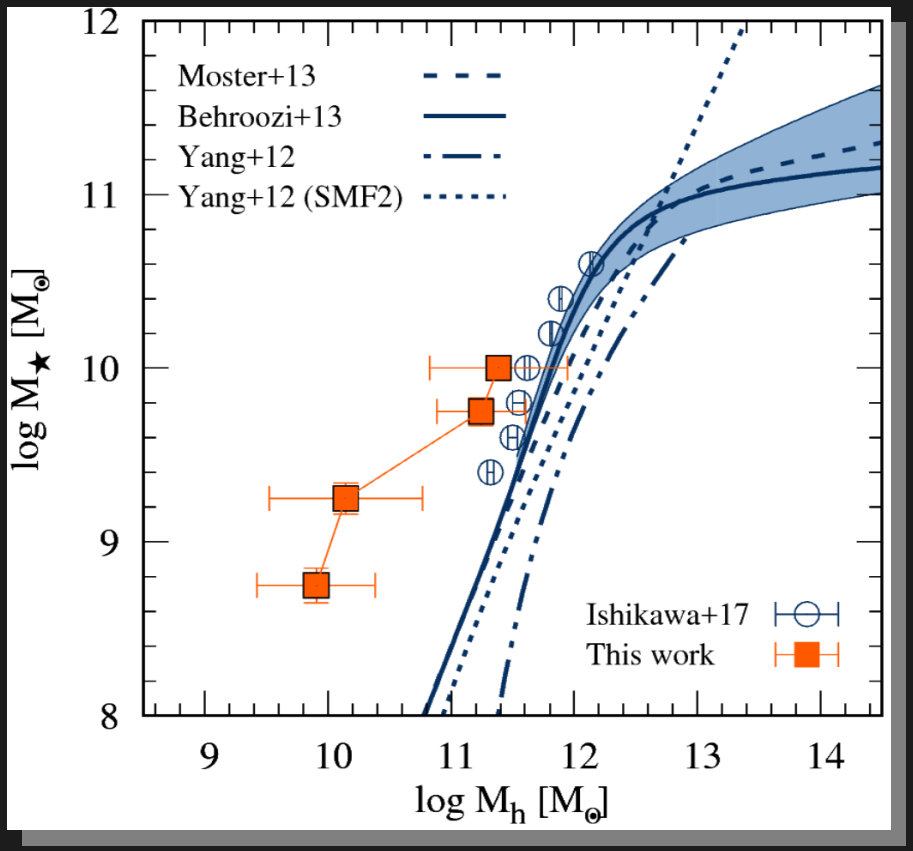

Figure from Durkalec+17 (submitted)

We observe a significant model-observation discrepancy for low-mass galaxies, suggesting a higher than expected star formation efficiency

Possible explanations (who to blame?):

1. Feedback effects – or rather our poor understanding of their influence on not only baryonic component of the galaxies, but also on their dark matter haloes.

Might not be enough...

2. We might need to account for the possible existence of 'dark haloes', i.e., haloes that are completely devoid of stars.

Thank you !

Special thanks to :

Olivier Le Fèvre
Agnieszka Pollo
Sylvain de la Torre
Martin Kilbinger
and the VUDS team