Hyper Massive Galaxies with Euclid

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& Euclid Flagship2.0

Introduction

Massive (passive) galaxies are important to test galaxy formation and evolution models

➔ **Unexpected massive passive galaxies at high-z**

In LCDM formation models (SAM & idro) massive galaxies form and assembly their mass late in cosmic time

➔ **Densities & comparison with models**

→ Mass assembly, SF and merging/quenching history

➔ **Properties**

Colors, SF, morphology, Halo Mass, local and global environment → physical processes (merging, AGN, gas consuming/stripping)

How many hyper massive galaxies?

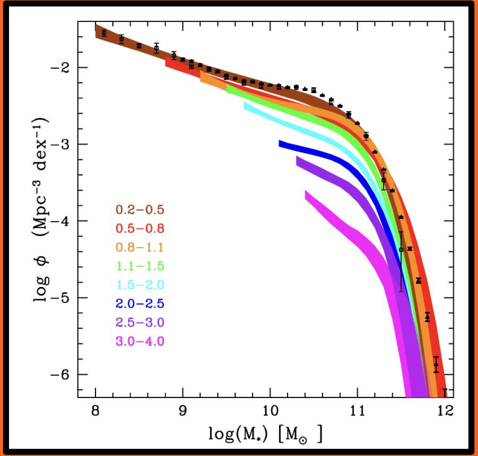
where, when they form?
when they stop SF?

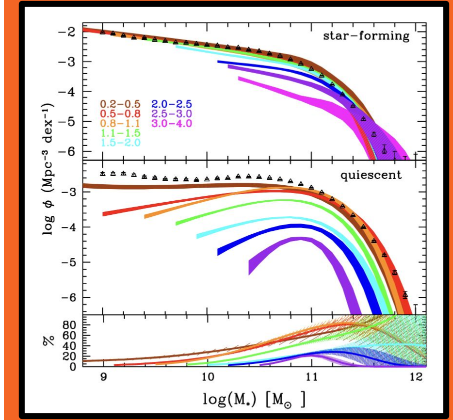
The number density and passive fraction of high-redshift massive galaxies are key constraints on galaxy formation models

Galaxy Stellar Mass Function (GSMF)

Spectrophotometric surveys gave constrain to GSMF from low to high redshift, **from 10^8 to ~10^{11} M_{sun}**, and of different galaxy types (Passive vs. SF. disk vs. ellipticals, low vs. high density environments)

→ Euclid WIDE survey (**50 deg² @Q1, 2500 deg² @ DR1 to 15000 deg²**) will allow to reconstruct also its hyper massive part (>2x10^{11} M_{sun})





Hyper Massive galaxies

are rare due to limited survey areas

COSMOS15 (1.4 deg²):

- only ~45/10 more massive than >4/5x10^{11} M_{sun} (z<3)
- only 2 more massive than 10^{12} M_{sun} (z<3)

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Euclid FLAGSHIP (2.0) galaxy mock simulation

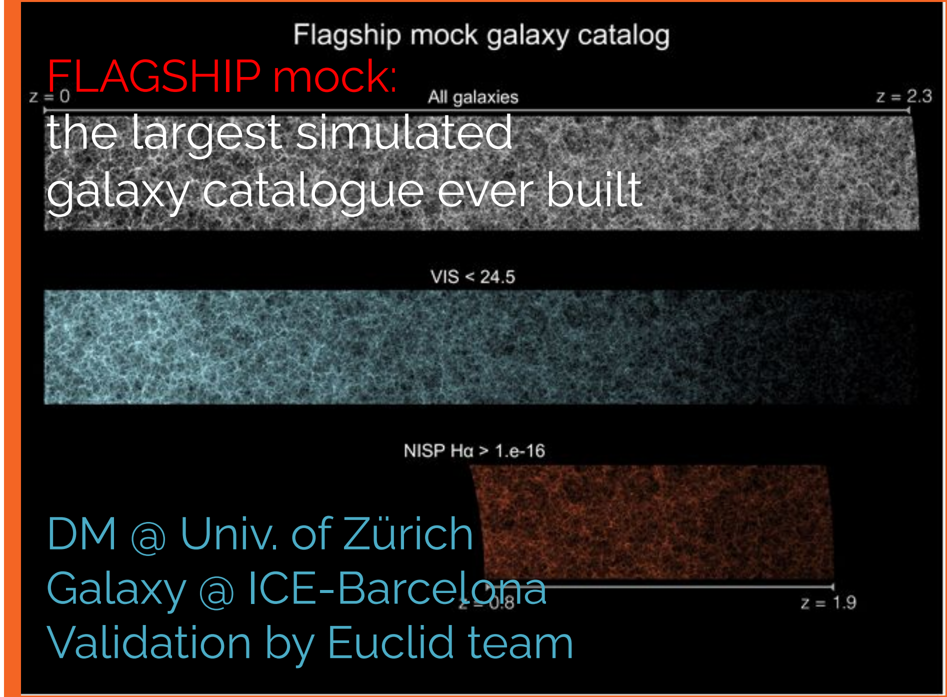
F. Castander et al. PLKP-CS2-paper3

Flagship 1

- 4 trillion dark matter particles
- L_{box} = 3780 Mpc/h
- DM particle mass = $2.4x10^9$ M_{sun}/h
- lightcone up to z=2.3

Flagship 2

- 4.1 trillion dark matter particles
- L_{box} = 3600 Mpc/h
- DM particle mass = 10^9 M_{sun}/h
- All-sky 3D lightcone up to z=3



FLAGSHIP mock:
the largest simulated
galaxy catalogue ever built

DM @ Univ. of Zürich
Galaxy @ ICE-Barcelona
Validation by Euclid team

Euclid FLAGSHIP (2.0) galaxy mock simulation

F. Castander et al. PLKP-CS2-paper3

FS2 mock team

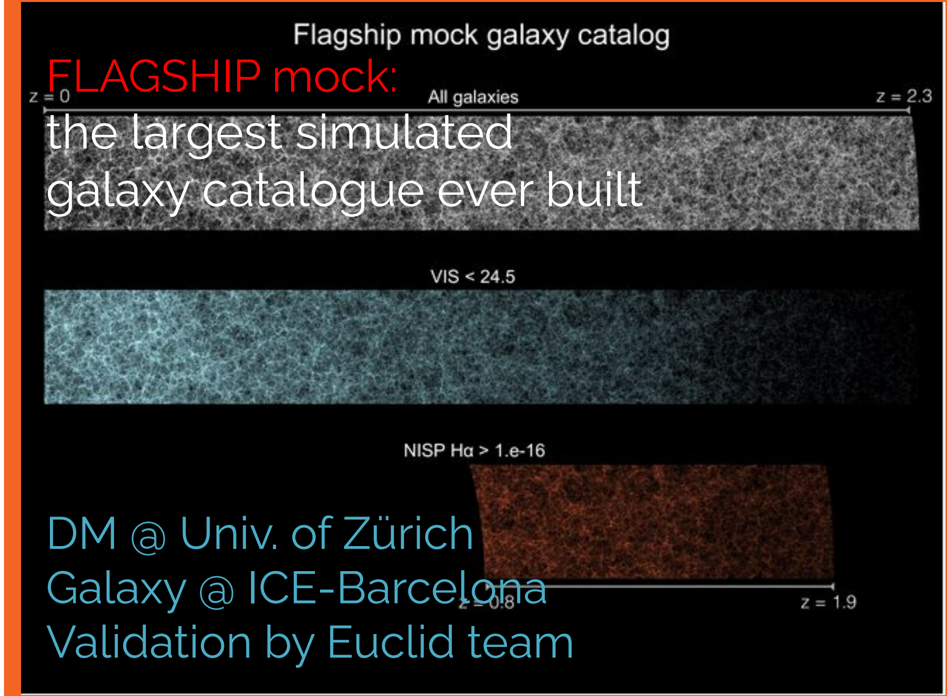
Production team (@ PIC, spanish SDC)

- Jorge Carretero
- Pau Tallada
- Christian Neissner
- Francisco Castander

Big team effort!

Validation team (SWGs/SGS)

- Lucia Pozzetti (GEV/CSWG)
- Micol Bolzonella (GEV/SGS)
- Gabriella de Lucia (GEV/SGS)
- Marc Huertas Company (GEV/SGS)
- Francisco Castander (CSWG/SGS)
- Jorge Carretero (CSWG/SGS)
- Pau Tallada (CSWG/SGS)
- Christian Neissner (CSWG/SGS)
- Zonghxu Zhai (GC)
- Pierluigi Monaco (GC/SGS)
- Shun-Sheng Li (WL)
- Gary Mamon (CL)
- Tim Schrabback (CL)
- Michel-Andres Breton (IST:NL/CSWG)
- Martin Crocce (IST:NL)
- Joachim Stadel (CSWG)
- Cristian Viglione (CSWG)



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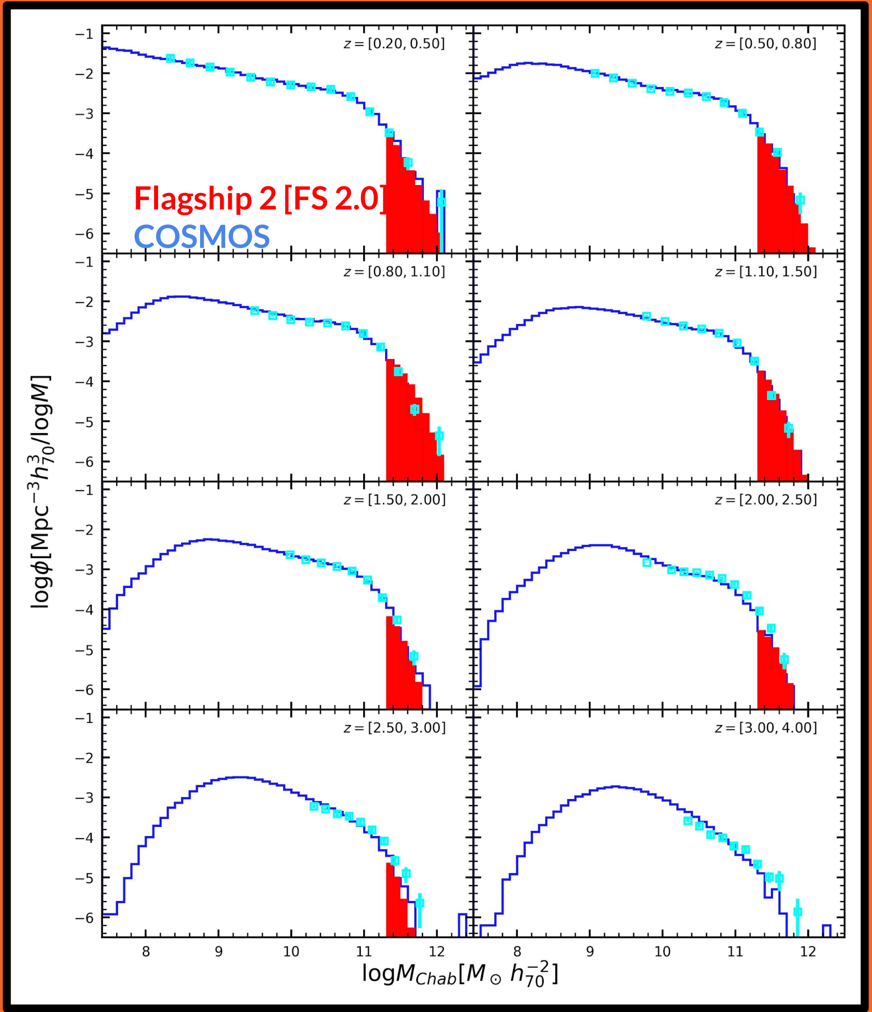
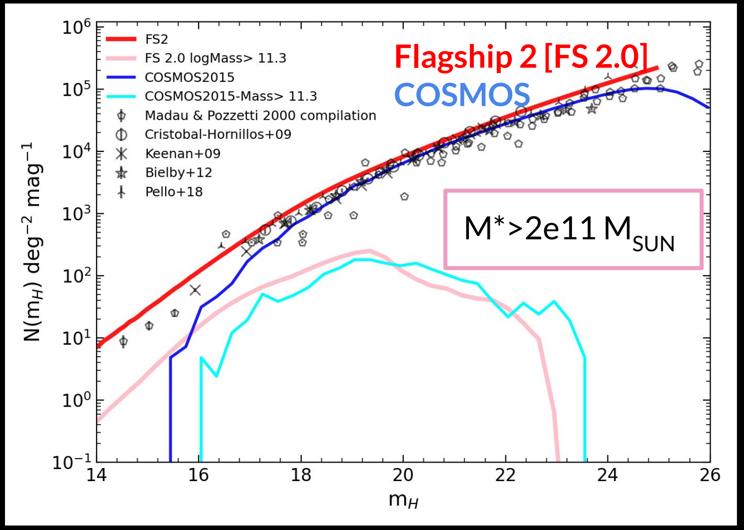
→ I explored galaxies >2e11 M_{sun} in **Flagship2** from z=0 to z=3 in a octant (~5000 deg^2)

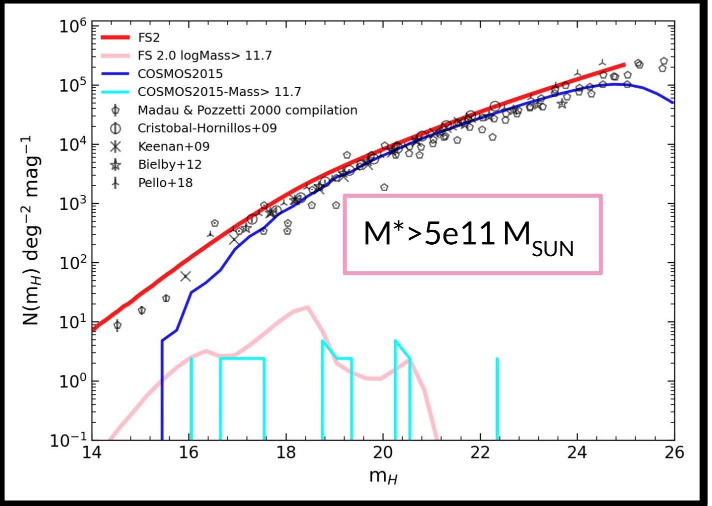
FS2.0 Galaxy Stellar Mass Function

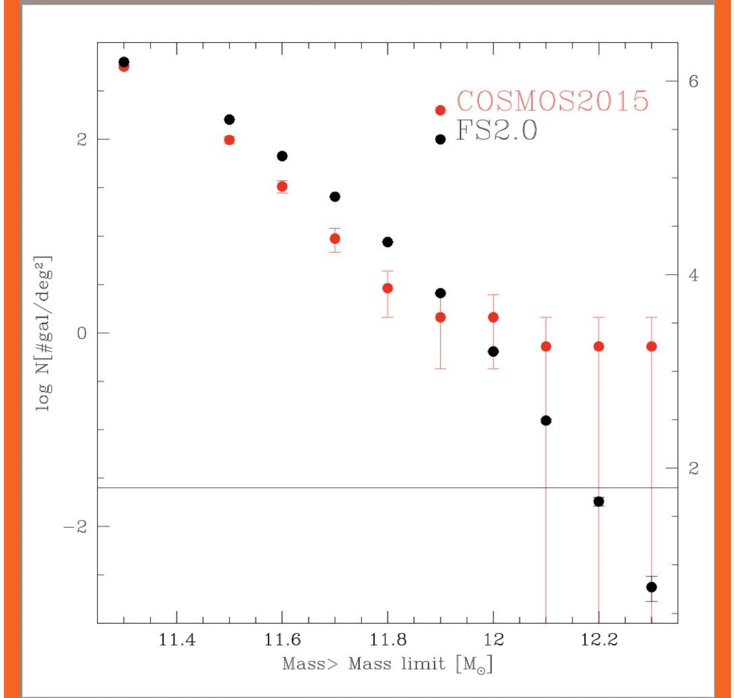
→ **Flagship2** from **z=0 to 3** in a octant (~5000 deg^2) consistent with **COSMOS15 MF** (used to calibrate FS2)



Number densities



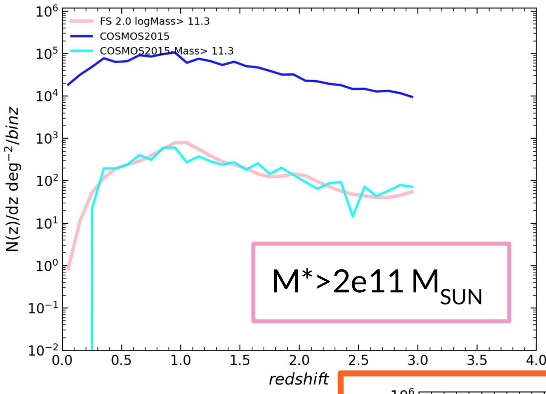


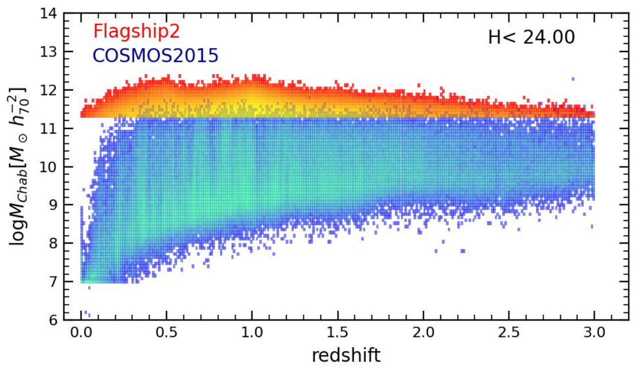


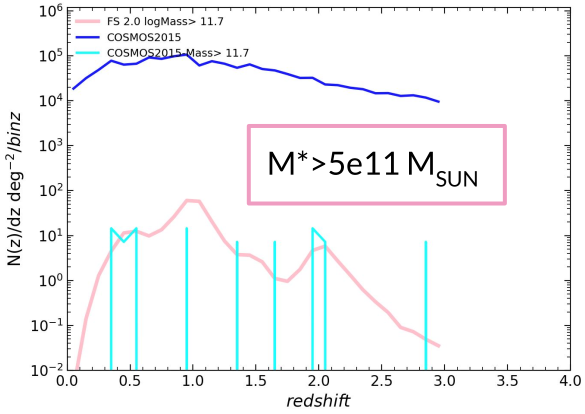
The number densities are roughly consistent with COSMOS15 but extended to higher stellar masses

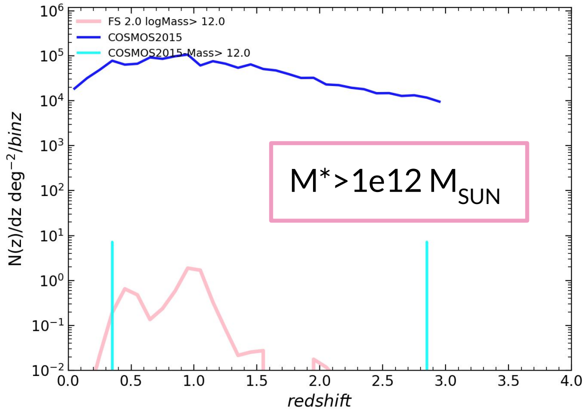
>log(Mass) Msun (z<3)	**COSMOS (z<3) (1.38 deg^2)**	**Euclid Q1 or DEEP 50deg^2**	**Euclid DR1 2500 deg^2 [Halpha]**	**Euclid Total 15000 deg^2 [Halpha]**
2e11	779	32k	**1.5M [92k]**	**9.5M [0.5M]**
3e11	136	8k	0.4M	2.4M
4e11	45	3.3k	0.17M [10k]	**1.0M [59k]**
5e11	13	**1.3k**	63k	0.4M
6e11	4	0.4k	22k	0.13M
8e11	2	128	6.4k	39k
1e12	2	32	**1.6k [170]**	**9.6k [1k]**
1.3e12	1	6	311	1.9k
1.6e12	1	0.9	45	271
2e12	1	0.1	6	35

Redshift distributions









The redshift range is roughly consistent with COSMOS15 → z=0 to z=2-3

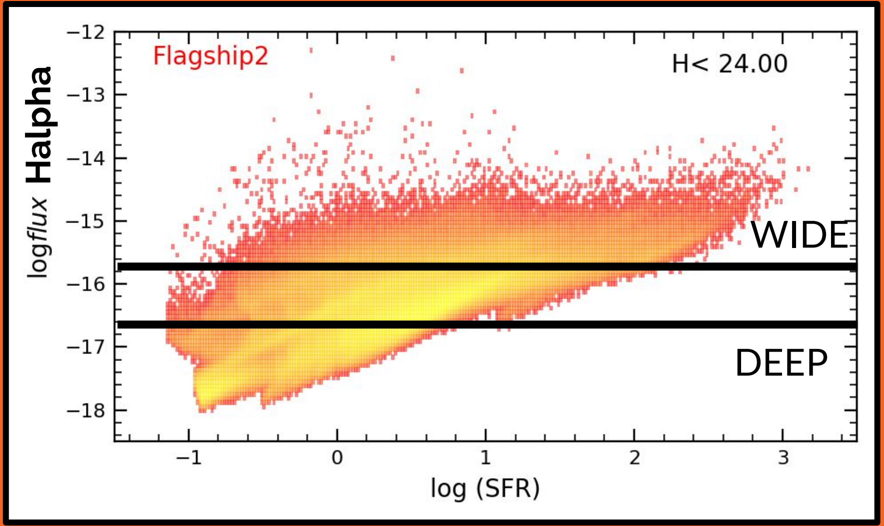
Euclid surveys will allow to explore the massive tail of:

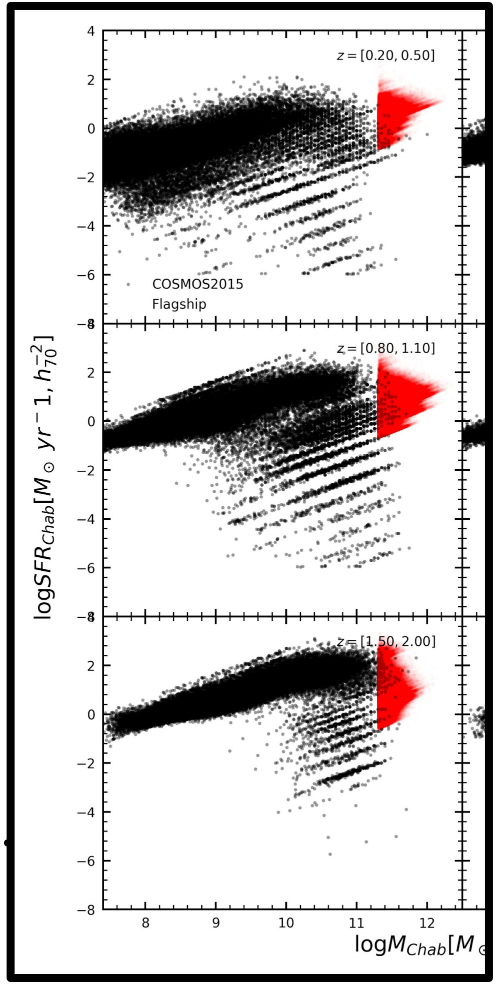
- ➔ SFR-Mass relation
- ➔ Mass-Metallicity relation
- ➔ SIze-Mass relation
- ➔ Passive vs. Star forming fraction
- ➔ Environment: group, filaments, clusters?
- ➔ Halo Masses vs. Stellar Mass

SFR-Mass

Mass-SFR extended to higher stellar masses

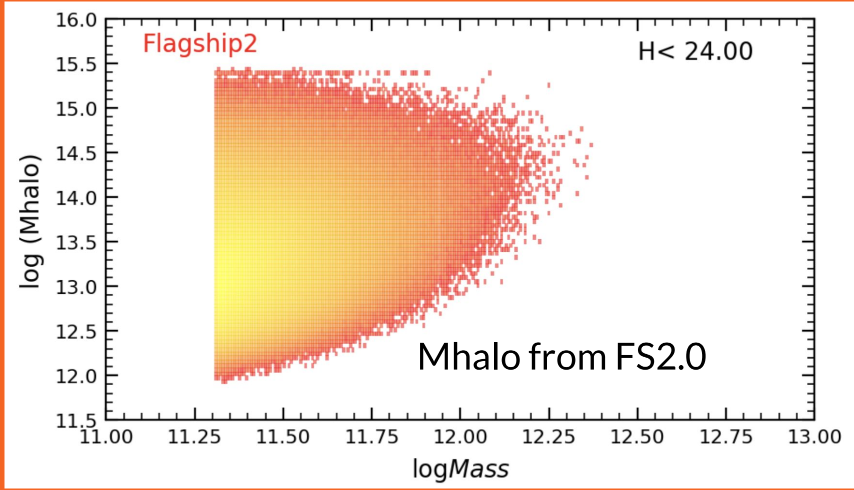
→ SF or passive ?
→ MS flattening at high-Mass ?
→ From NISP spectra: redshift & SFR from Halpha emission @ 0.9<z<1.8

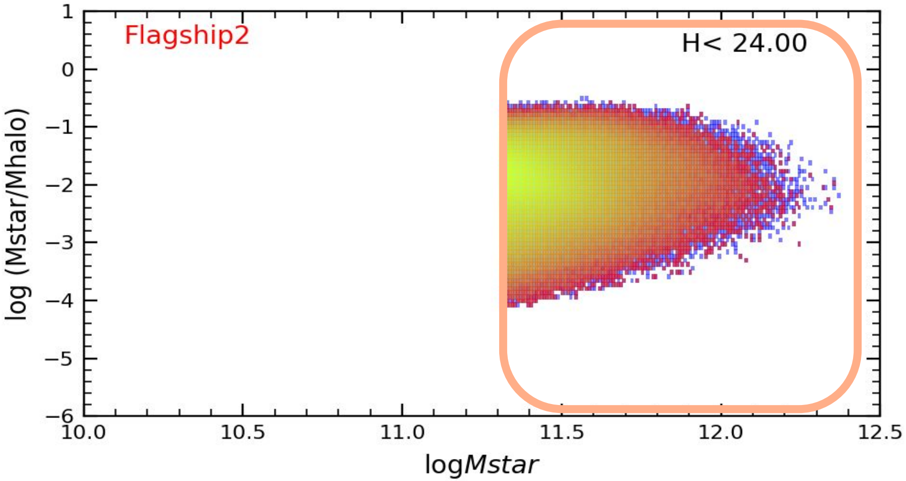


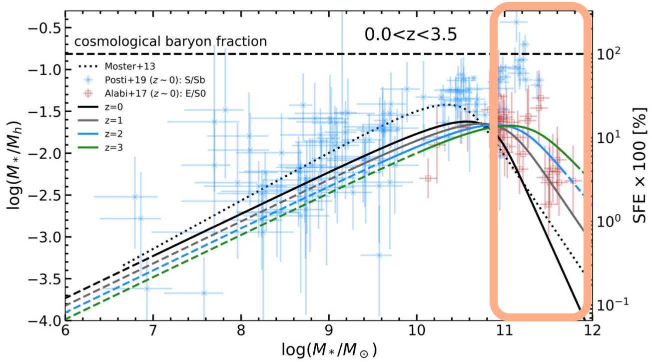


Mhalo-Mstar relation

Euclid lensing will probe Mhalo



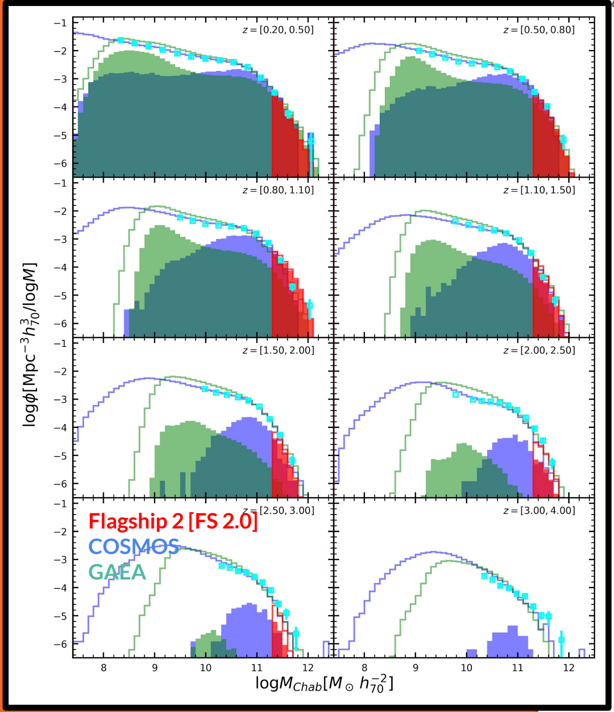




Mstar/Mhalo vs. Mstar

Different relations for SF/quescient galaxies ??

SAMs (GAEA, Henriques+15)



Total Mass Function

well reproduced COSMOS to z=3

Passive Mass Function

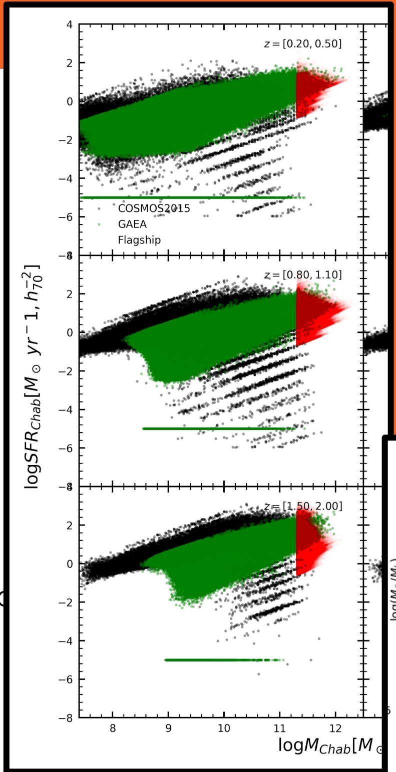
Underestimate Massive passive populatio
z>0.8

SFR vs. Mass

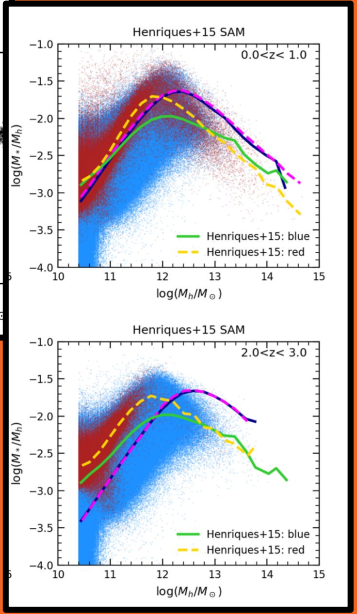
SFR-Mass relation lower than COSMOS
and mainly dominated by SF massive galaxies

Mstar/Mhalo vs. Mhalo

Different relations for SF/quescient galaxies



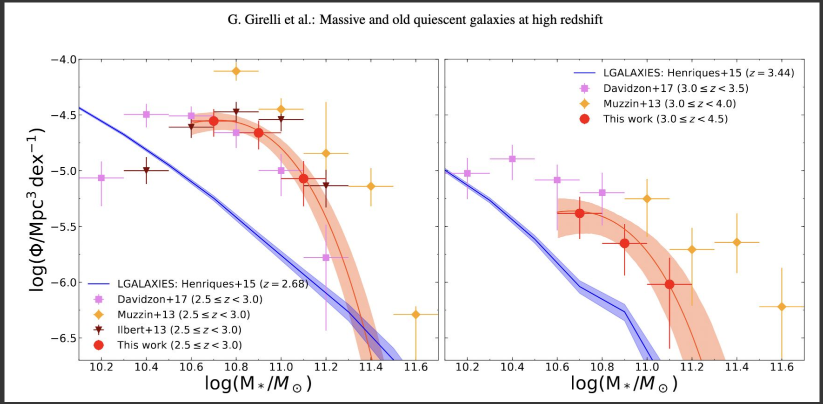
Girelli PhD thesis



At z>3 ?

few logM>11.3

SAMs not able to reproduce

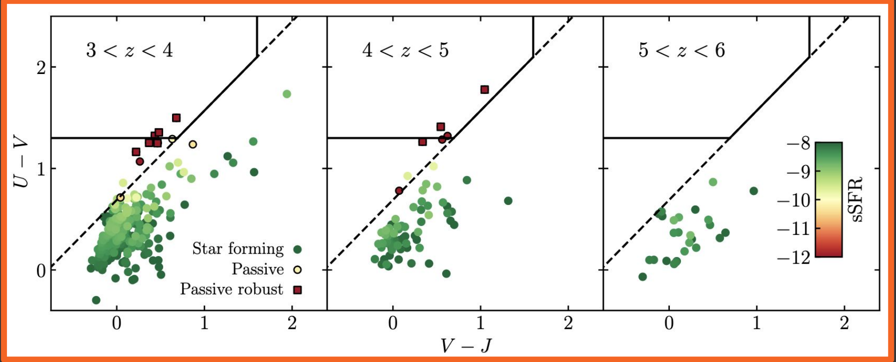


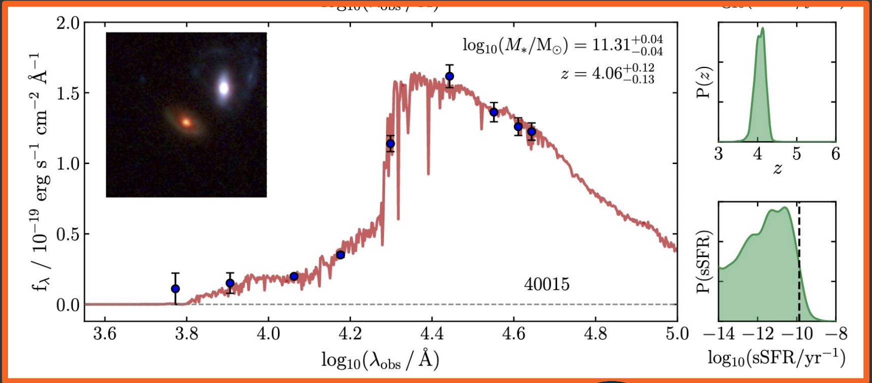
Mass Function of quiescent galaxy at z>3

Muzzin+13
Davidzon+17
Girelli+19

Carnall+22

A first look at JWST CEERS: massive quiescent galaxies from 3 < z < 5 [Carnall+22]





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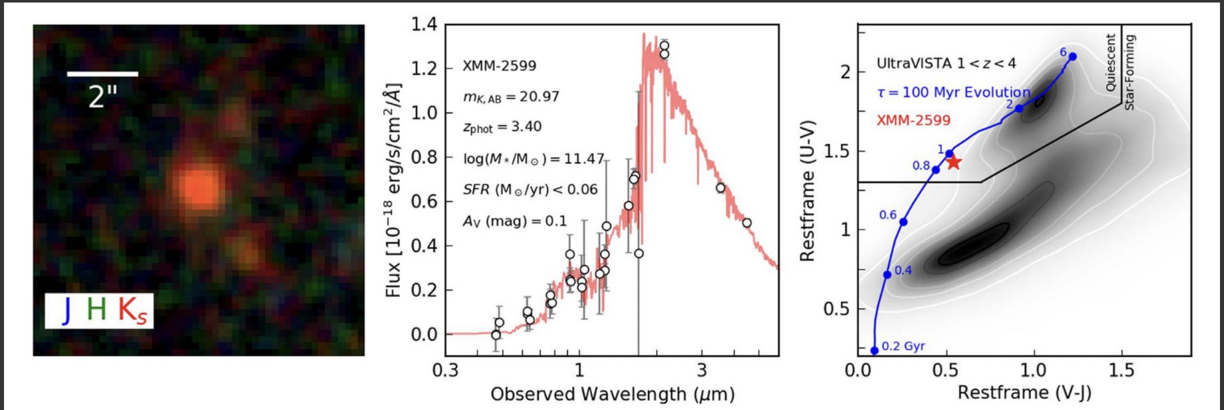
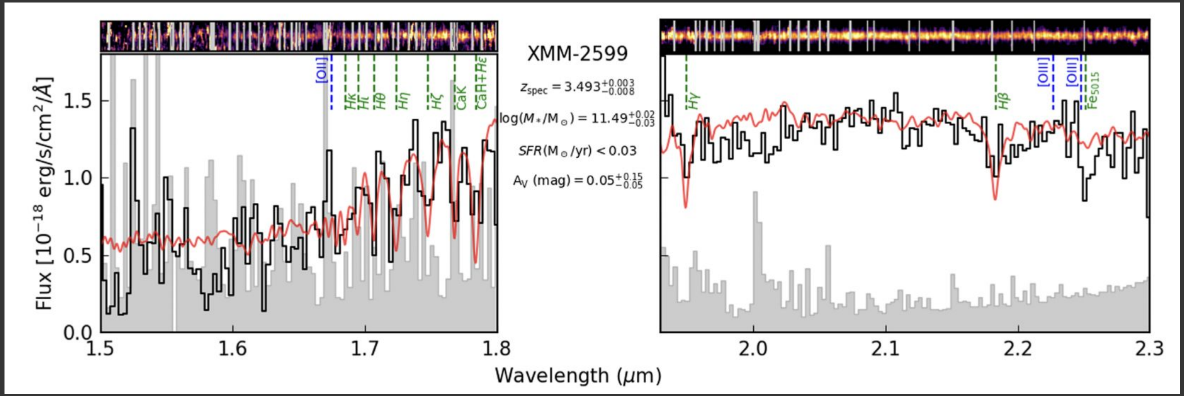
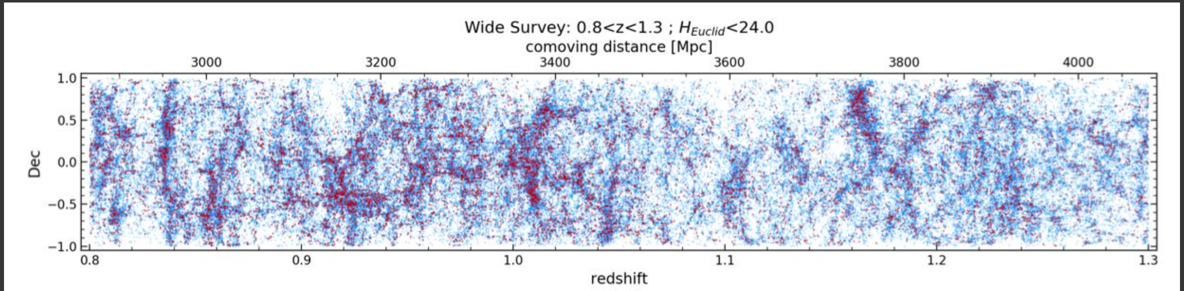
Spectra at z>3 ?

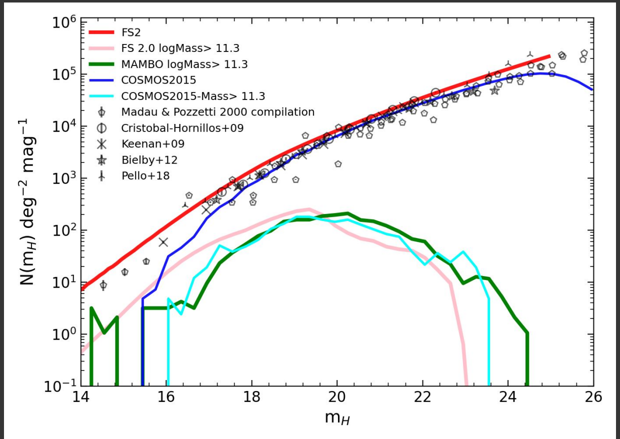


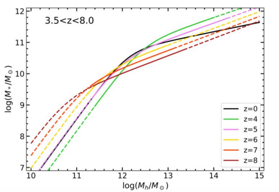


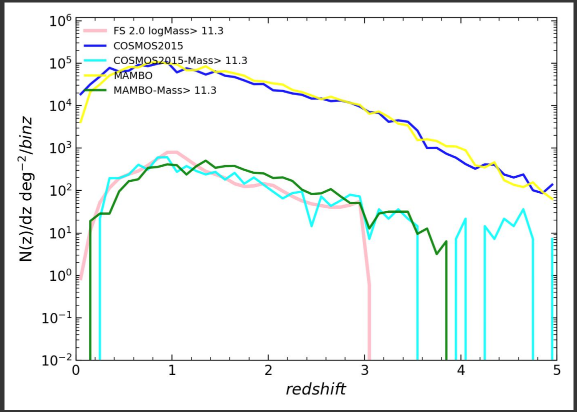
Spectra of the most massive ($3.1\mathrm{x}10^{11} M_{sun}$) quiescent galaxy confirmed at z=3.493 (Forrest+20) with Keck/MOSFIRE

Euclid at z>3 ?









MAMBO = Mocks with Abundance Matching in Bologna (Bolzonella, Pozzetti, Girelli, Lopez-Lopez)

SHAM (Girelli+20) + EGG (Schreiber+17) applied to Millenium Herinques+ 15 lightcones up to z=8

logM>$2\times10^{11}M_{sun}$ & H<24 & z>3 COSMOS 38/deg^2 vs. MAMBO 17/deg^2 → 95-43k in DR1

logM>$5\times10^{11}M_{sun}$ & H<24 & z>3 COSMOS 4/deg^2 → 10k in DR1

logM>$8\times10^{11}M_{sun}$ & H<24 & z>3 COSMOS 0.7/deg^2 → 2k in DR1

follow-up

- Spectroscopic targets for JWST, MOONS, ALMA, ELT, MSE, ...
- Environment studies using MOONS
- ISM and stellar populations using JWST, MOONS
- Gas content using ALMA

Conclusions

Euclid will detect k-to-M hyper-massive galaxies up to z=4-5

➔ **Mstar, SFR, morphologies, profile & size (VIS), halo mass, environment, SF/Passive/AGN fractions**

→ test for galaxy formation and evolution models and indication on merging and quenching history and physical processes involved

➔ **Challenge with Real Euclid data:**

derive the stellar mass and properties for rare (unconventional?) objects→ test to be done with ML.
Additional NIR data are important to trust on Mstar, FIR for SFR and SF/Passive classification, MIR for AGN component.

➔ **Need follow-up observations to confirm redshift, SFR, environment ...**

L. POZZETTI

THANKS