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R. A, CRAIN, J. SCHAYE, .Y. M. BAHÉ, T. VAN DER HULST, T. THEUNS, R. G. BOWER

ENVIRONMENTAL HI STRIPPING IN THE EAGLE SIMULATIONS

MNRAS, 461, 2630

The HI Story of the Nearby Universe, 10-12 Sept 2018, Groninegn

THE ENVIRONMENT

DEFINITION (in this contest)

It's a local property related to the matter density
at a given location of the Universe

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EMPIRICAL IMPORTANCE

- Morphology-density relation (Oemler 1974, Dressler 1980)
- affects the sSFR of galaxies (e.g. Kauffmann et al 2004)
- affect the HI morphology (e.g. Chung et al. 2009)
- affects the average HI content of galaxies (e.g. Fabello et al. 2012)

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PHYSICS

Gravitational and hydrodynamical forces

⬇

Prediction can be given by large-scale hydrodynamical cosmological simulations

THE EAGLE SIMULATIONS

Why hydro?.....................Gravitational and hydrodynamical forces are followed self-consistently

Why cosmological?.........The formation of structures (and environments) is followed self-consistently

Why large scale?...................The larger the box, the wider the dynamical range of environments

CALIBRATED TO THE GALAXY MASS FUNCTION AT Z=0 AND TO THE MASS-SIZE RELATION

↓

TULLY-FISHER
FUNDAMENTAL PLANE
MASS-METALLICITY
CGM PROPERTIES
...

COMPARISON WITH OBSERVATIONS

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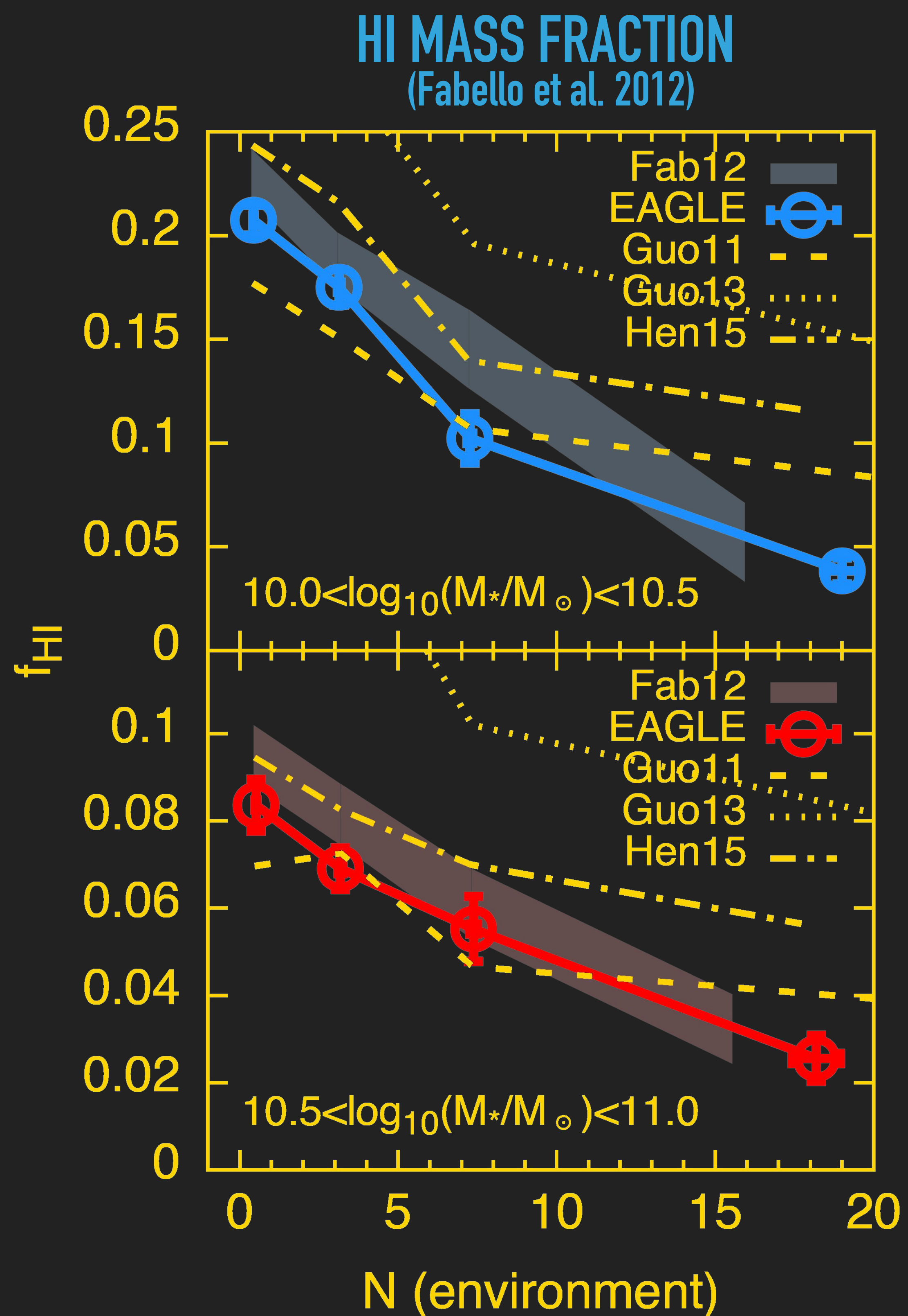
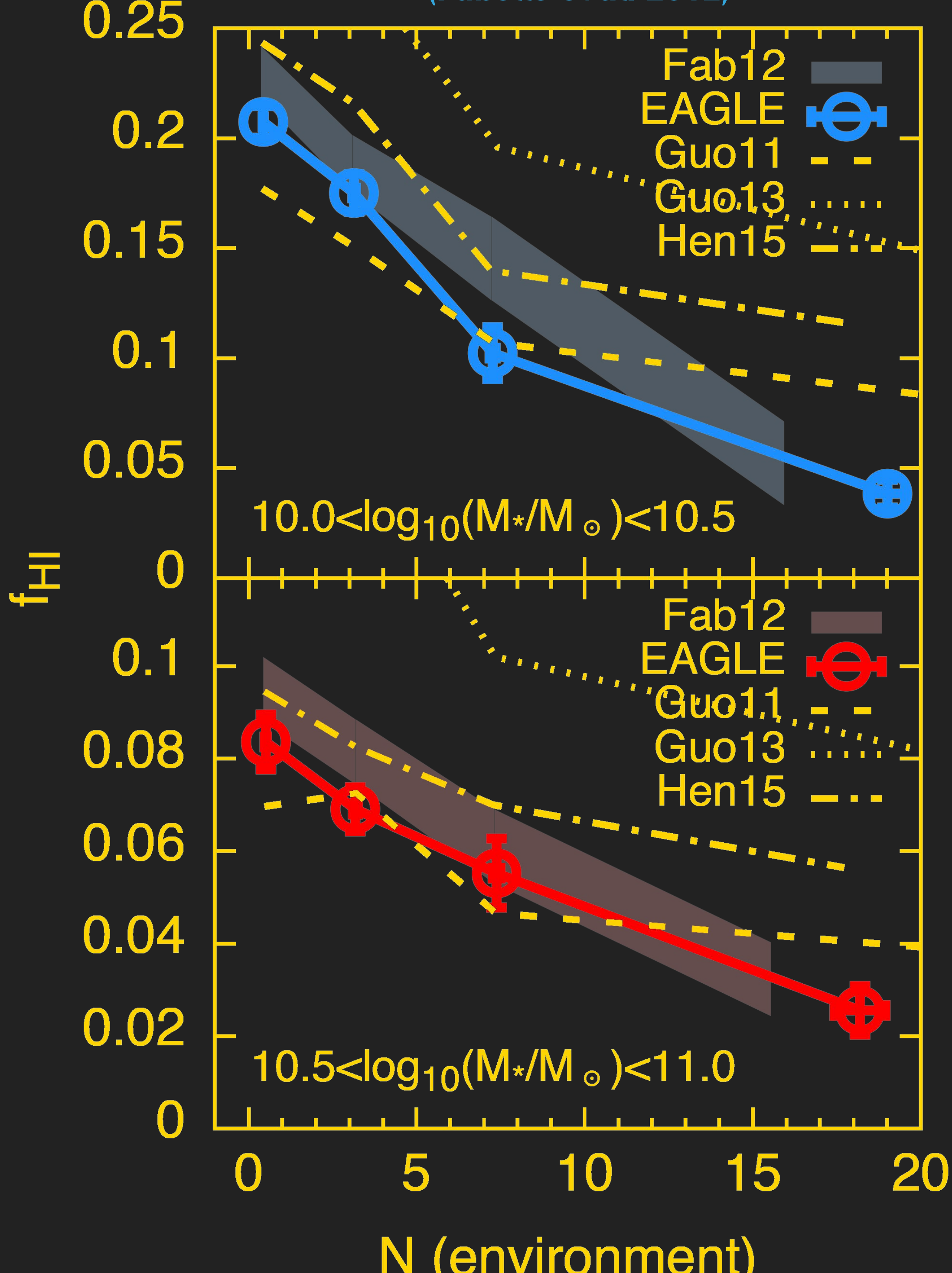


COMPARISON WITH OBSERVATIONS

HI MASS FRACTION
(Fabello et al. 2012)



HI DETECTION FRACTION
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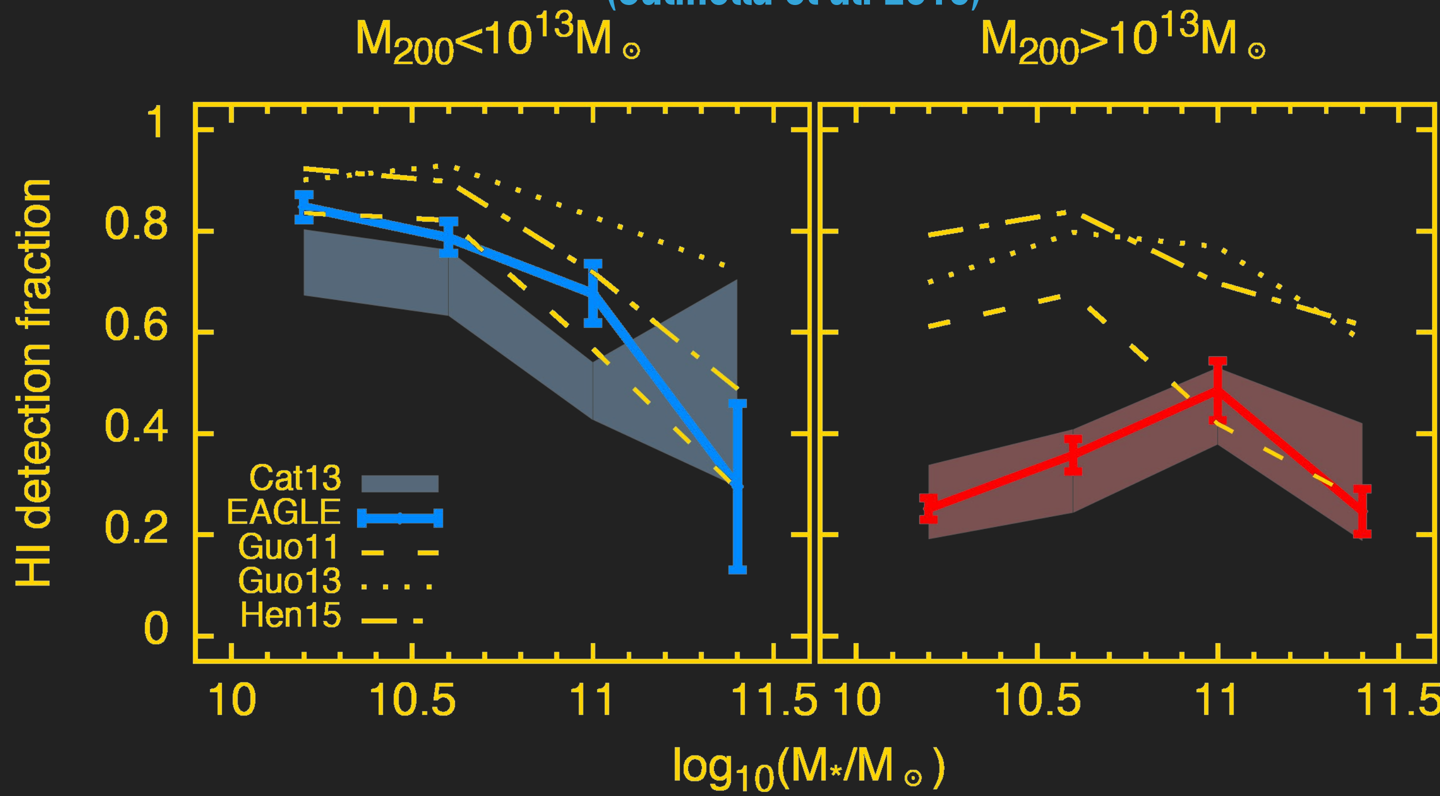

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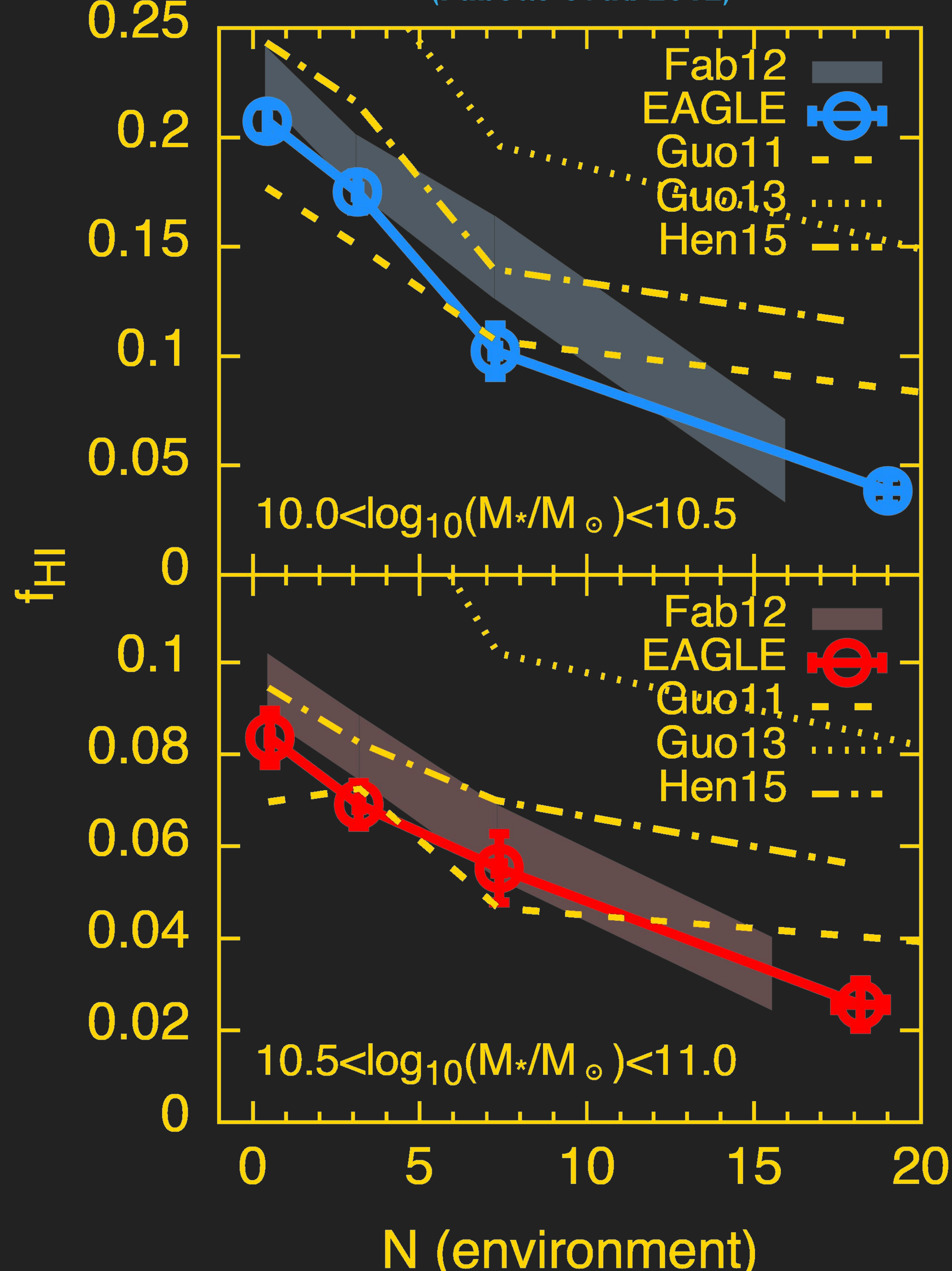

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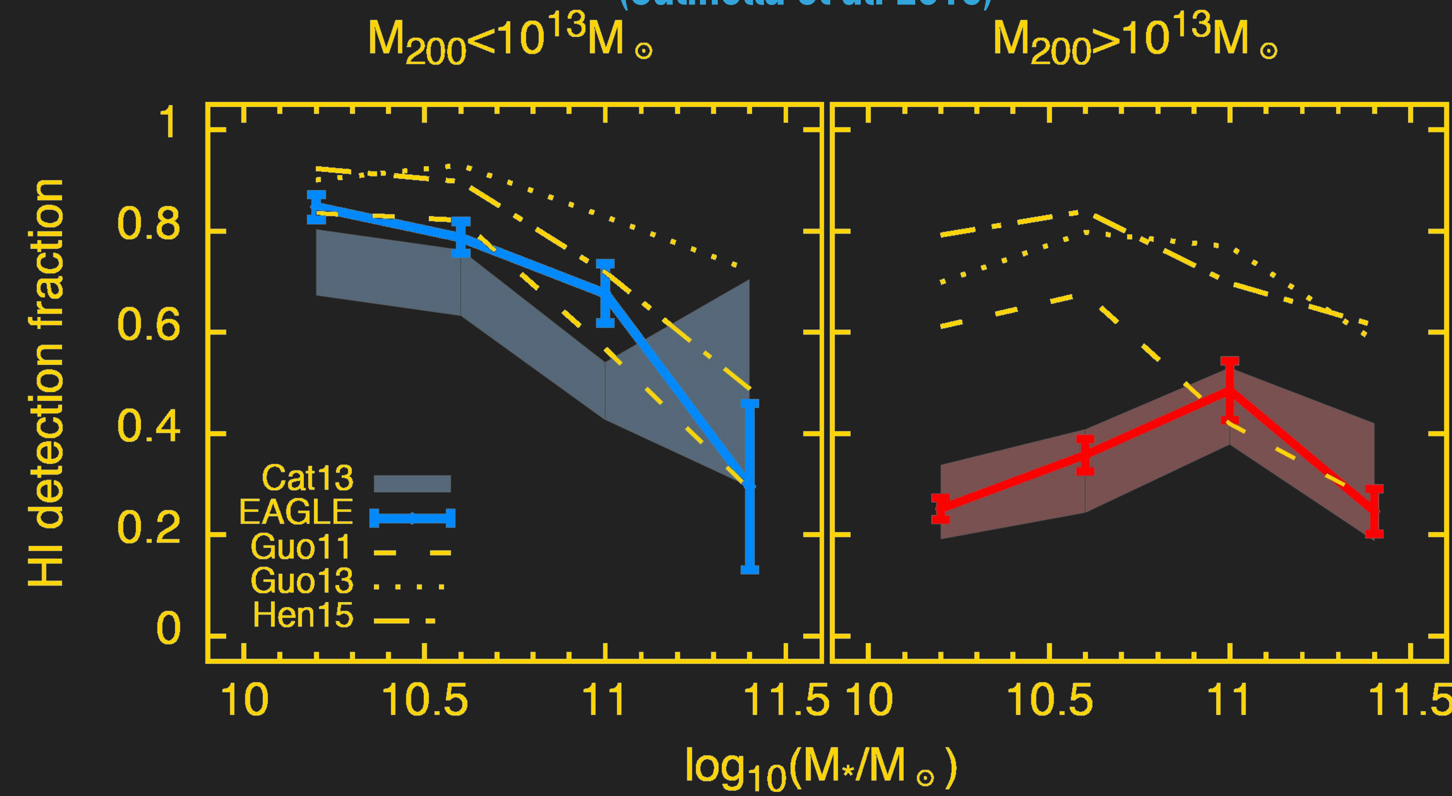

HI DEFICIENCY

(Solanes et al. 2001; Gavazzi et al. 2006)

COMPARISON WITH OBSERVATIONS

HI MASS FRACTION
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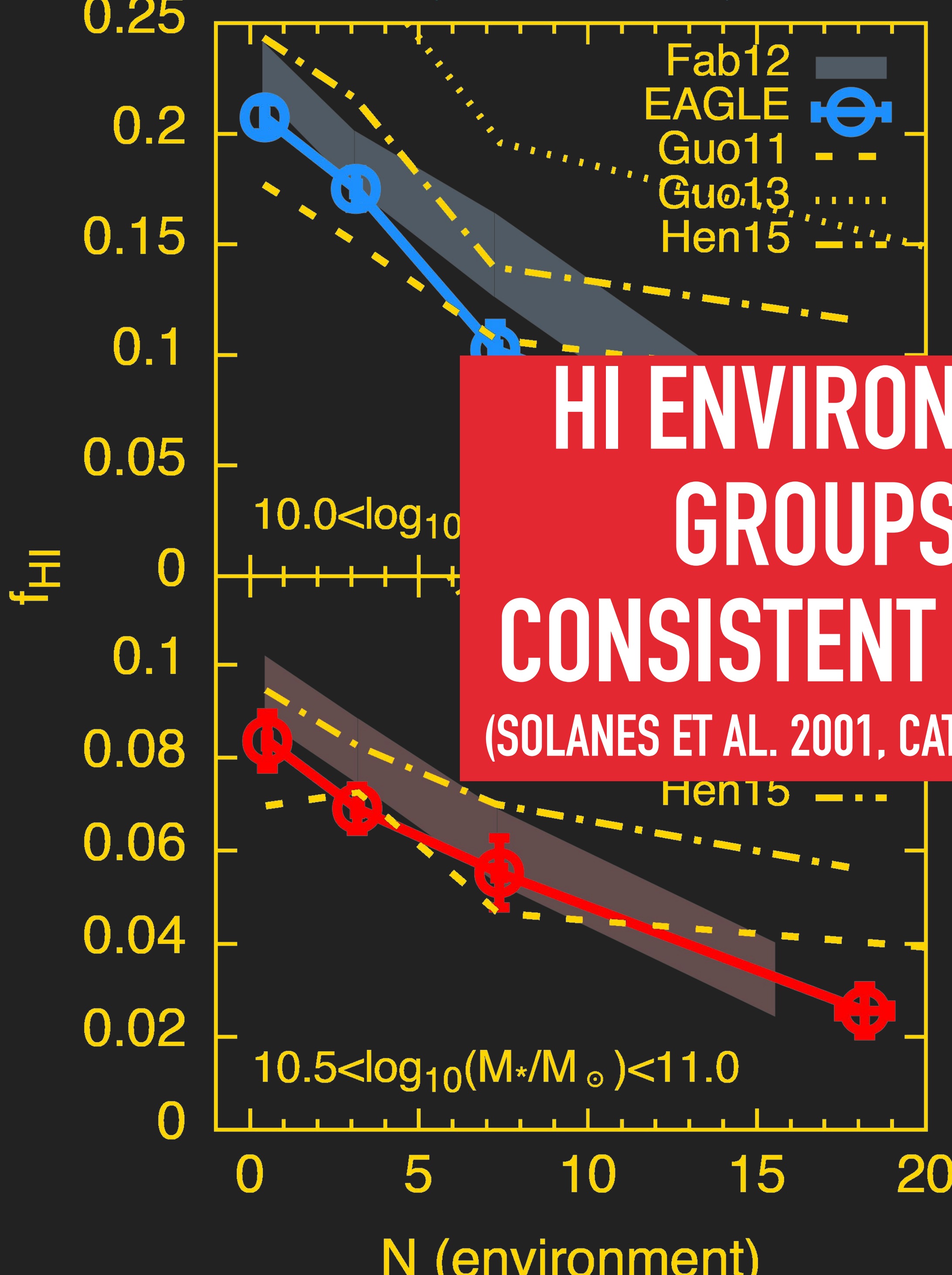

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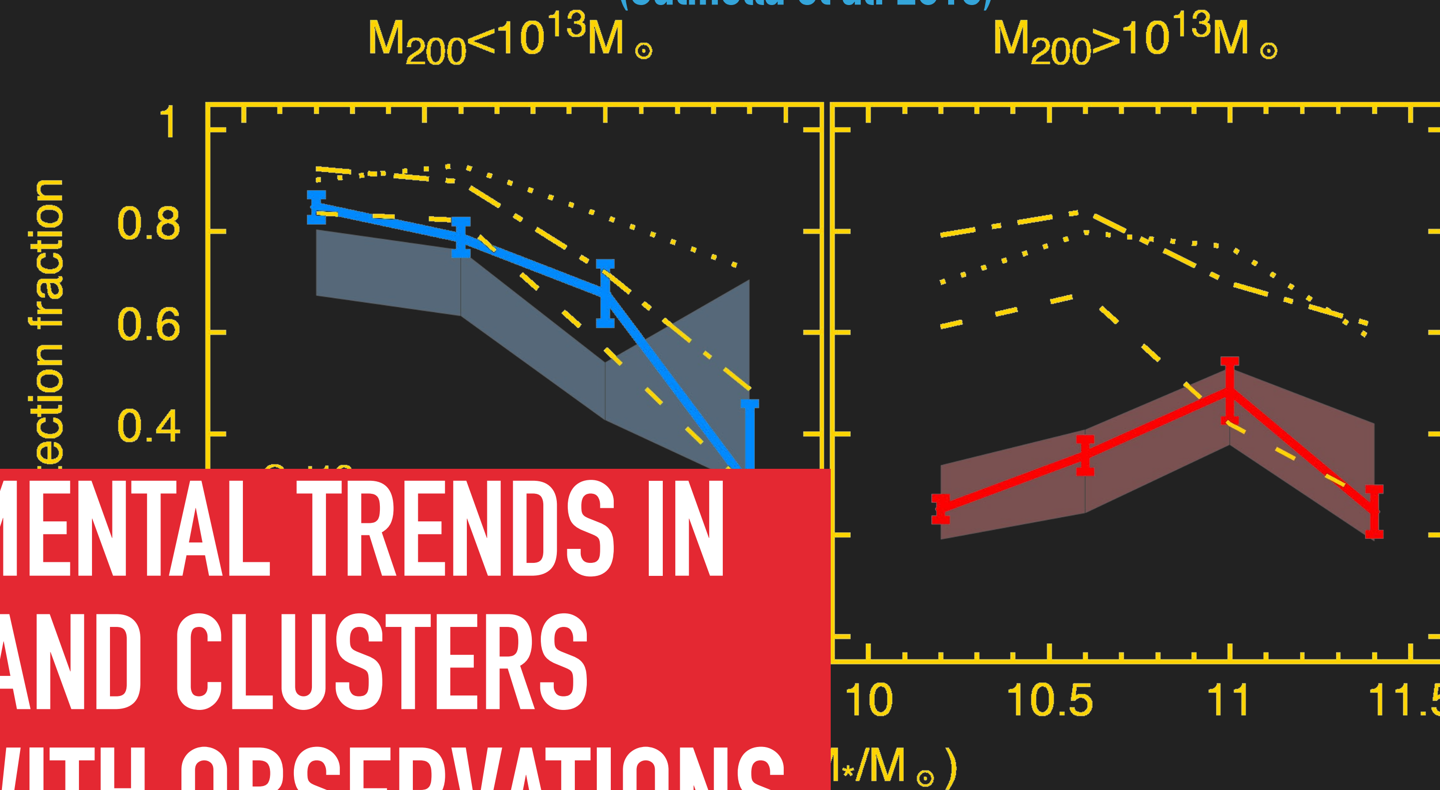
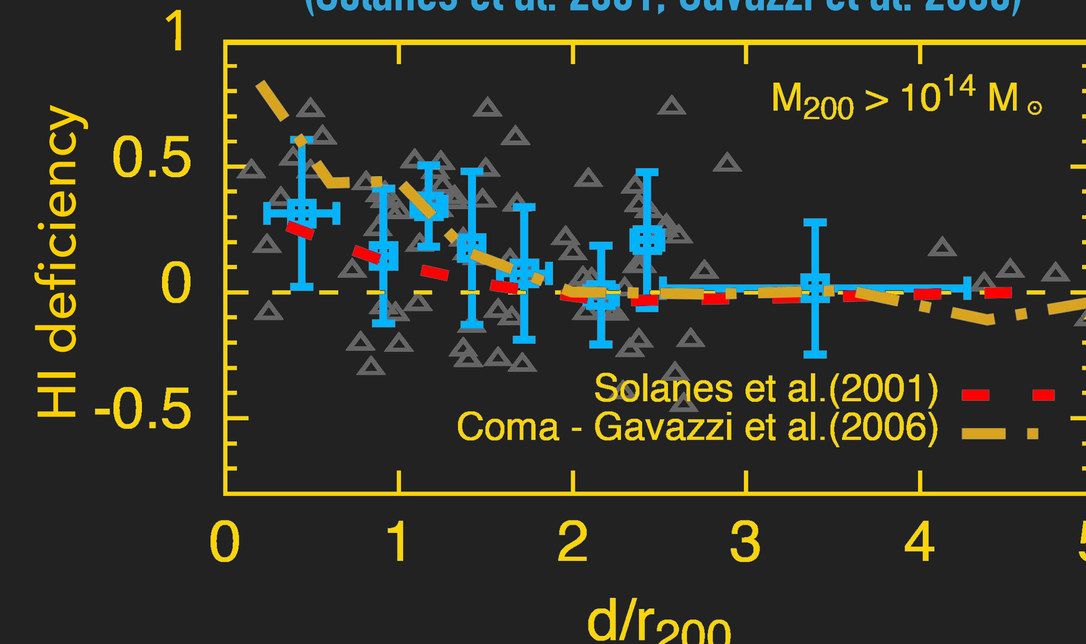


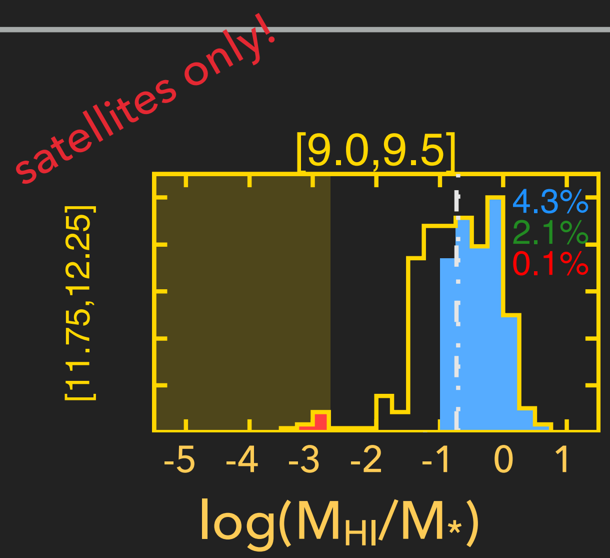
HI ENVIRONMENTAL TRENDS IN GROUPS AND CLUSTERS CONSISTENT WITH OBSERVATIONS

(SOLANES ET AL. 2001, CATINELLA ET AL. 2013, FABELLO ET AL. 2012)

CIENCY
(Solanes et al. 2001; Gavazzi et al. 2006)

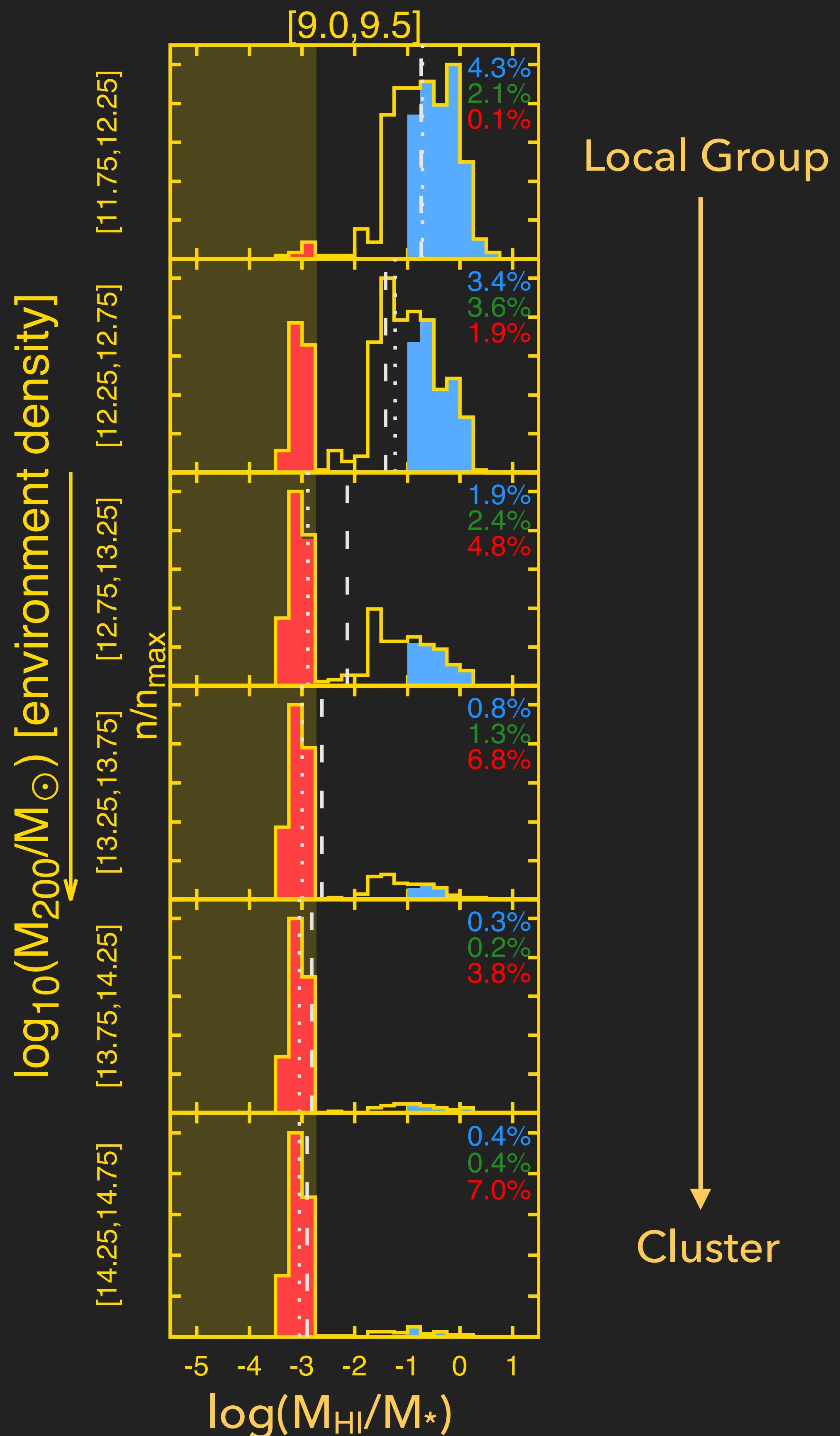


STELLAR MASS VS ENVIRONMENT (NATURE VS NURTURE)



Local Group

STELLAR MASS VS ENVIRONMENT (NATURE VS NURTURE)



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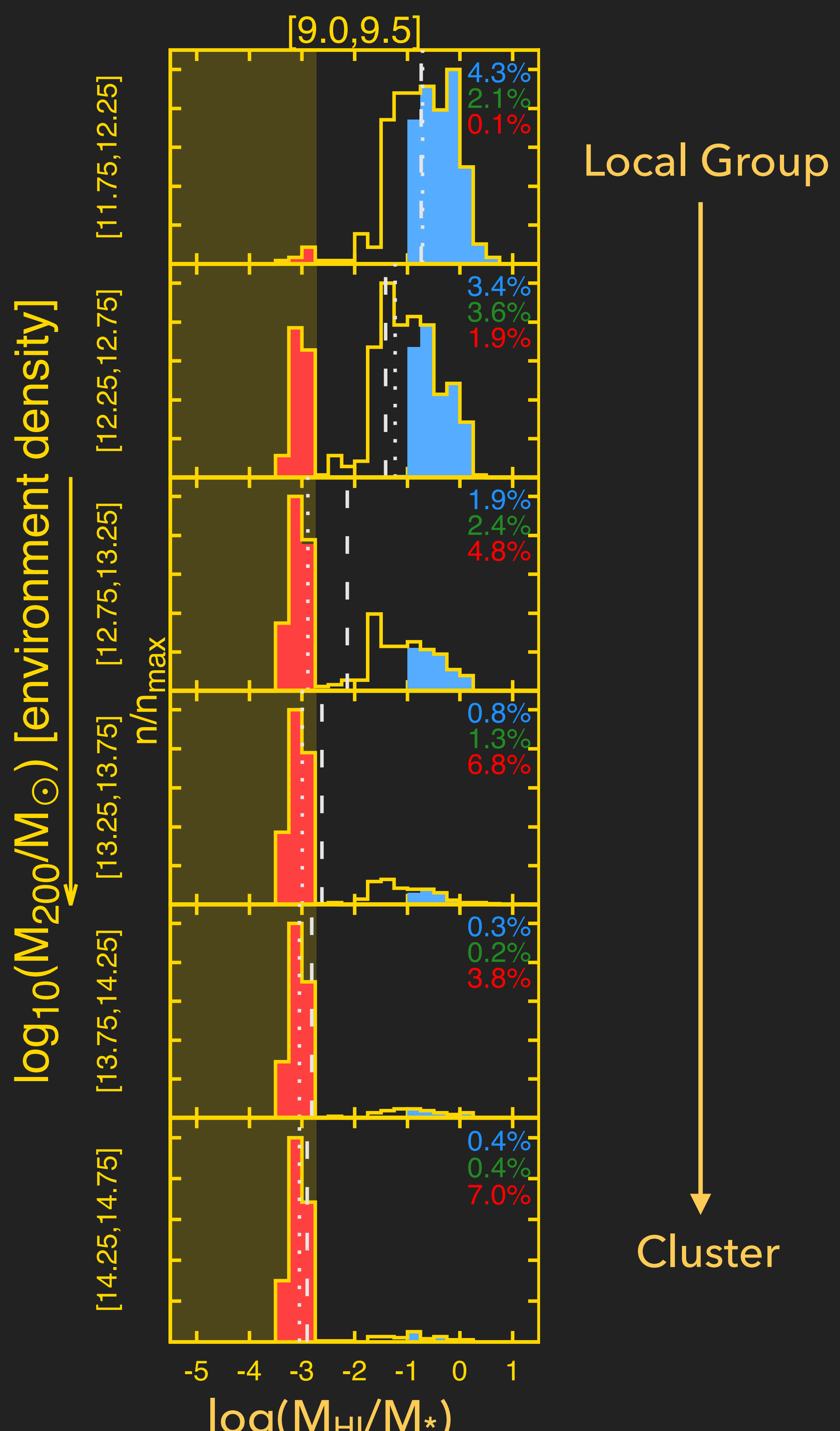

THE ENVIRONMENT ACTS AS AN ON–OFF SWITCH TO THE HI CONTENT OF SATELLITES

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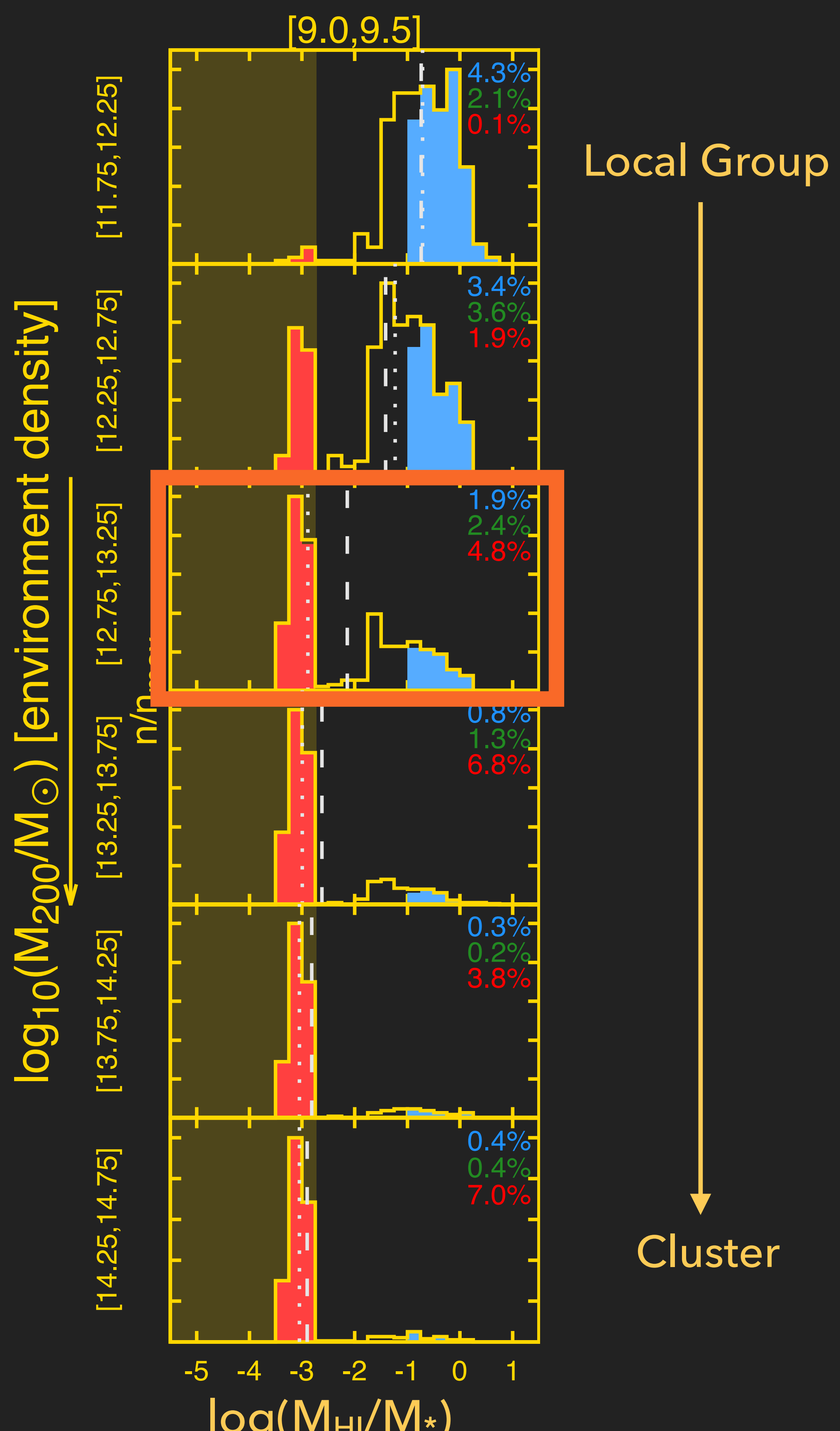

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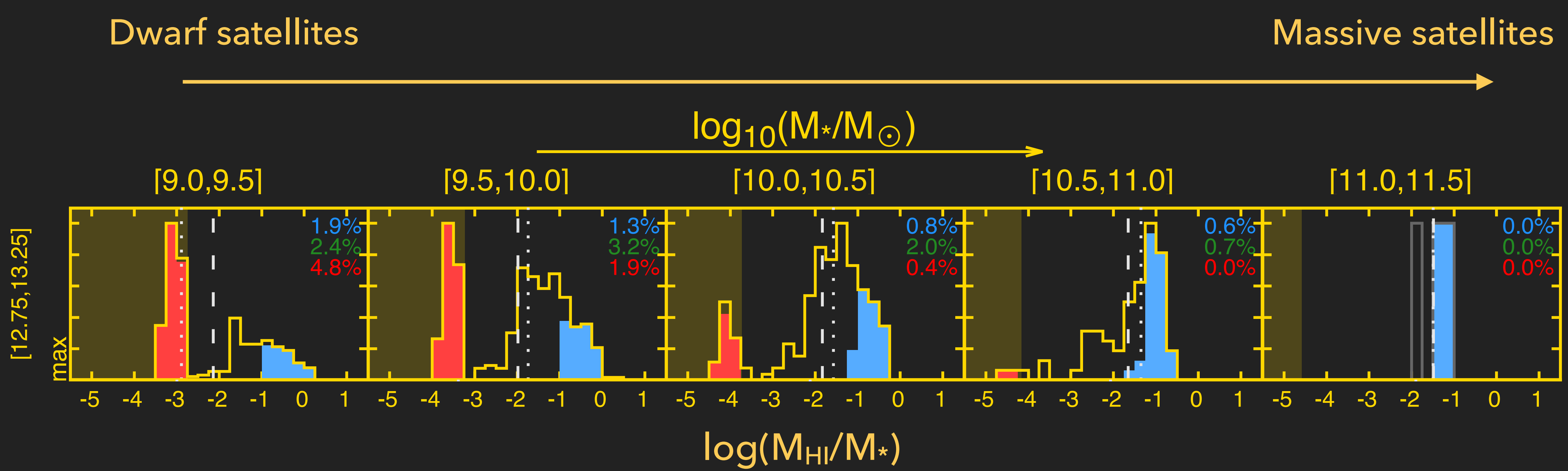

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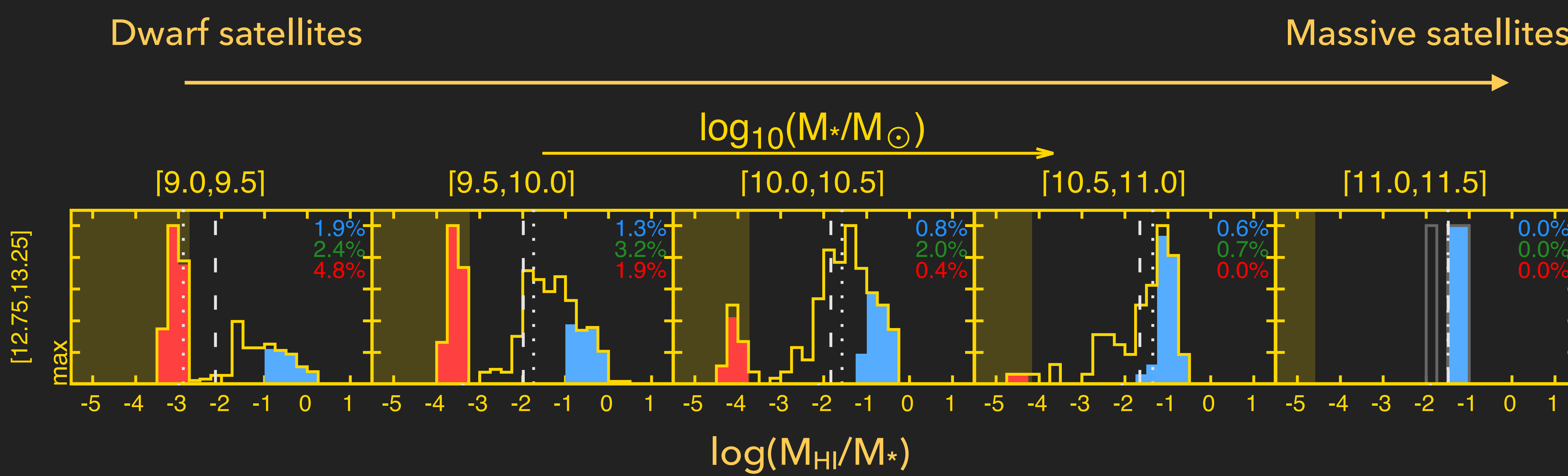
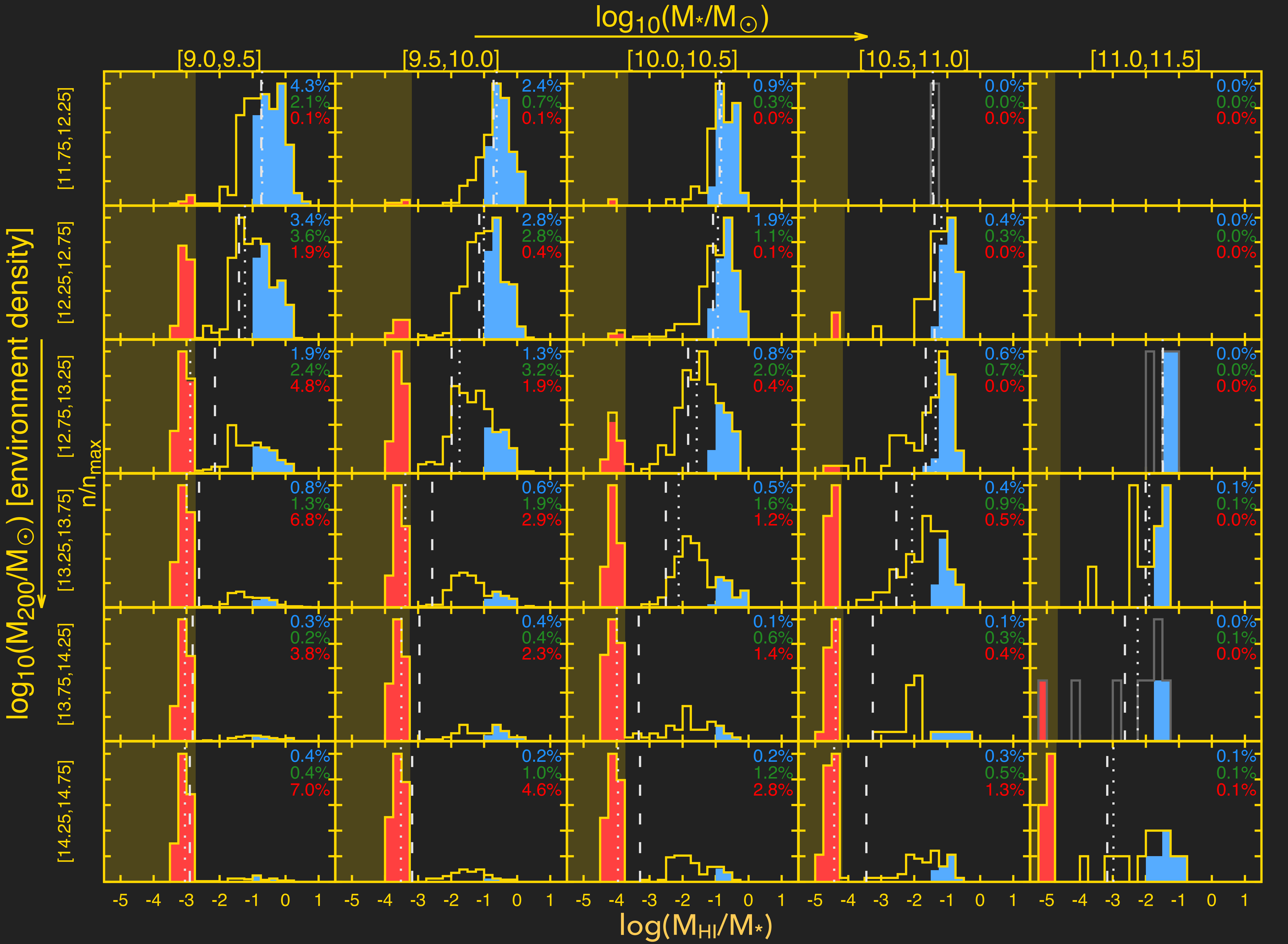


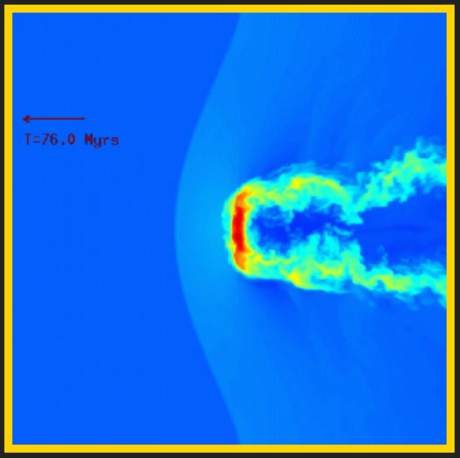
MORE MASSIVE GALAXIES ARE MORE STABLE AGAINST THE ENVIRONMENT

STELLAR MASS VS ENVIRONMENT (NATURE VS NURTURE)

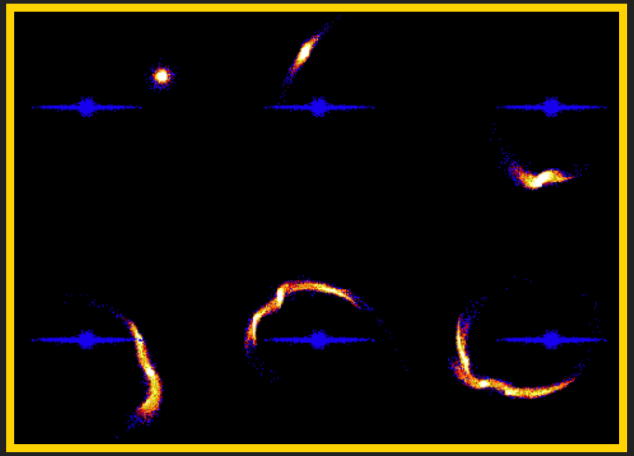


ENVIRONMENTAL PROCESSES FOR DIRECT STRIPPING

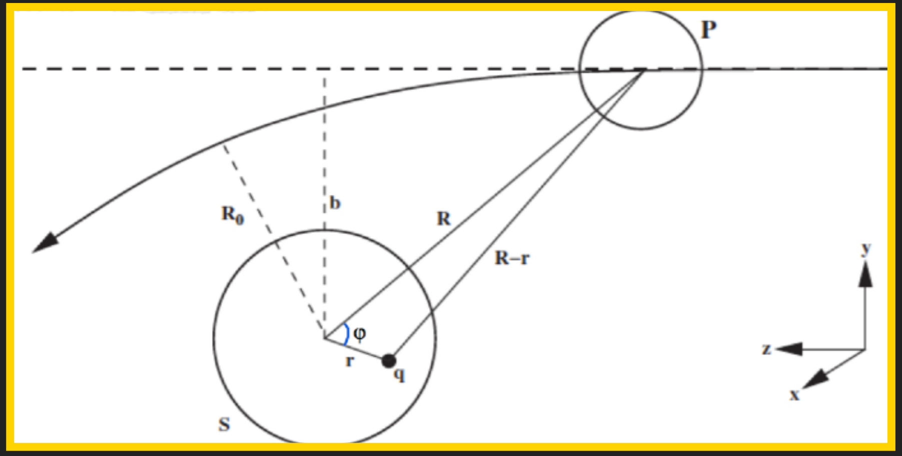
Ram pressure by intra-group medium



Tidal stripping by the host halo



Satellite-satellite encounters



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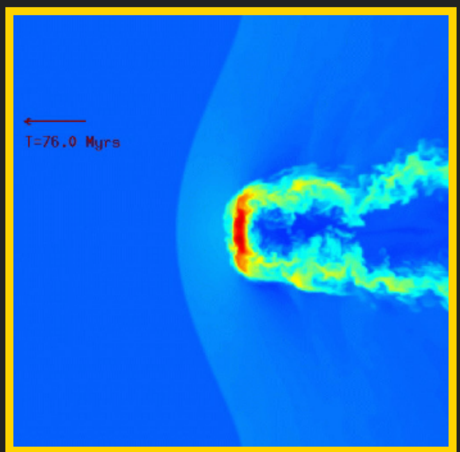
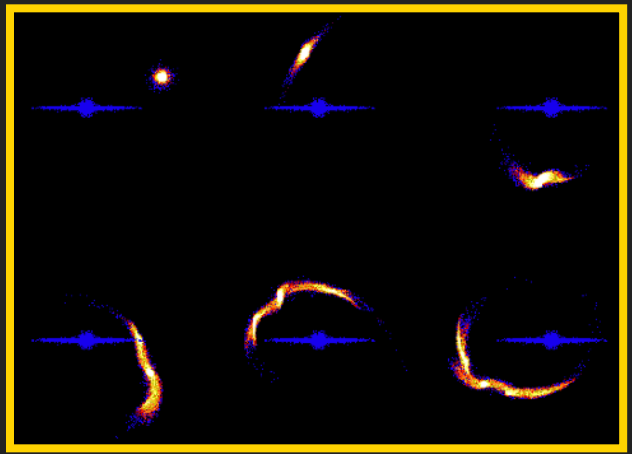


$$\frac{P_{\mathrm{IGM}}}{P_{\mathrm{GRAV}}}$$

$$\rho v^2$$

$$2\pi G \Sigma_{\mathrm{tot}} \Sigma_{\mathrm{HI}}$$

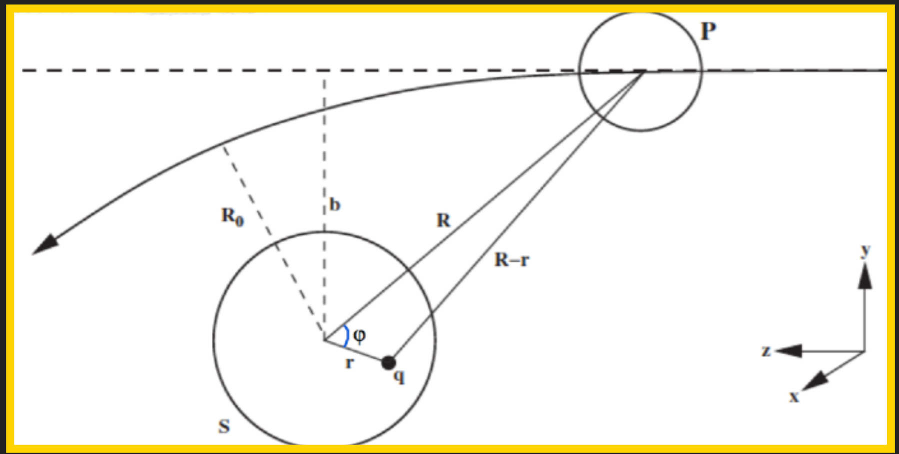
Tidal stripping by the host halo



$$\frac{R_{50}}{R_{\mathrm{TID}}}$$

$$\approx \left(\frac{m}{3M(r)} \right)^{\frac{1}{3}} r$$

Satellite-satellite encounters

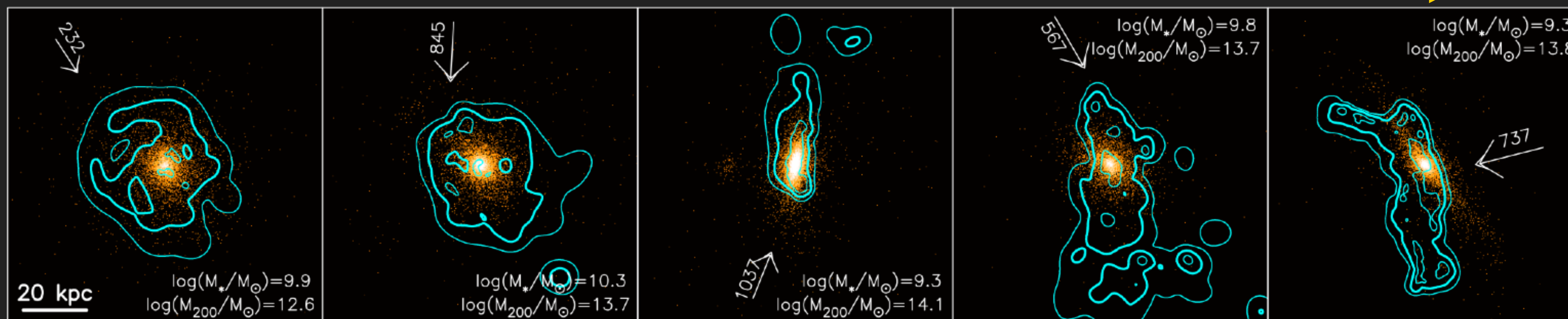


$$\frac{E_{\mathrm{S}}}{E_{\mathrm{TOT}}}$$

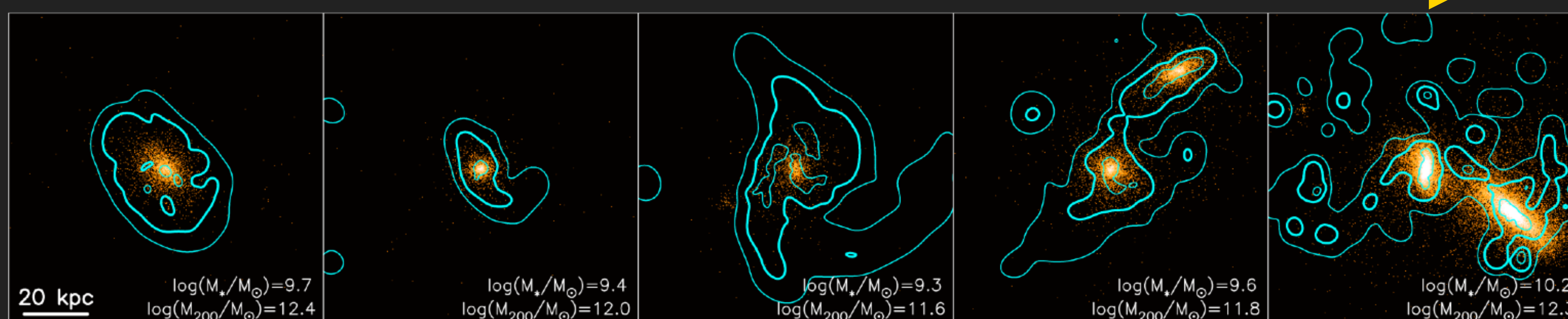
$$\approx \frac{4}{3} G^2 M_{\mathrm{s}} \left(\frac{M_{\mathrm{p}}}{v} \right)^2 \frac{\langle r^2 \rangle}{b^4}$$

ENVIRONMENTAL PROCESSES FOR DIRECT STRIPPING

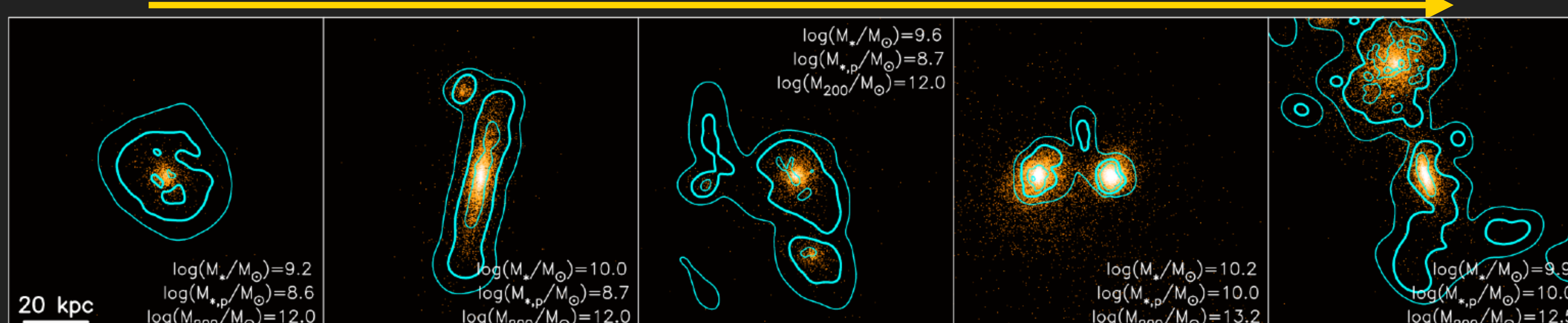
low Ram pressure by intra-group medium high



low Tidal stripping by the host halo high



low Satellite-satellite encounters high



ENVIRONMENTAL PROCESSES FOR DIRECT STRIPPING

~1600 HI-depleted satellites
with $M_* > 10^9\ M_\odot$

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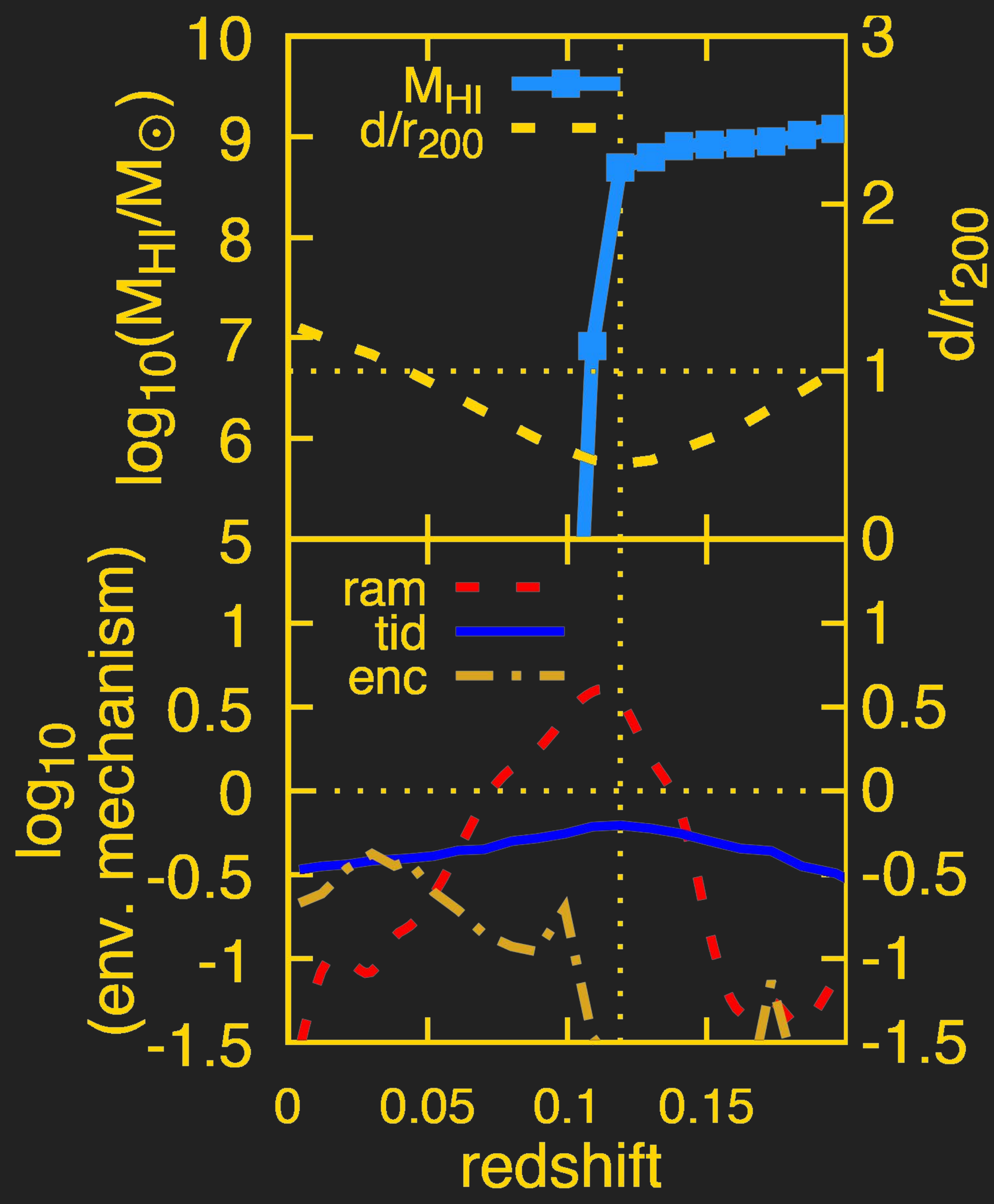

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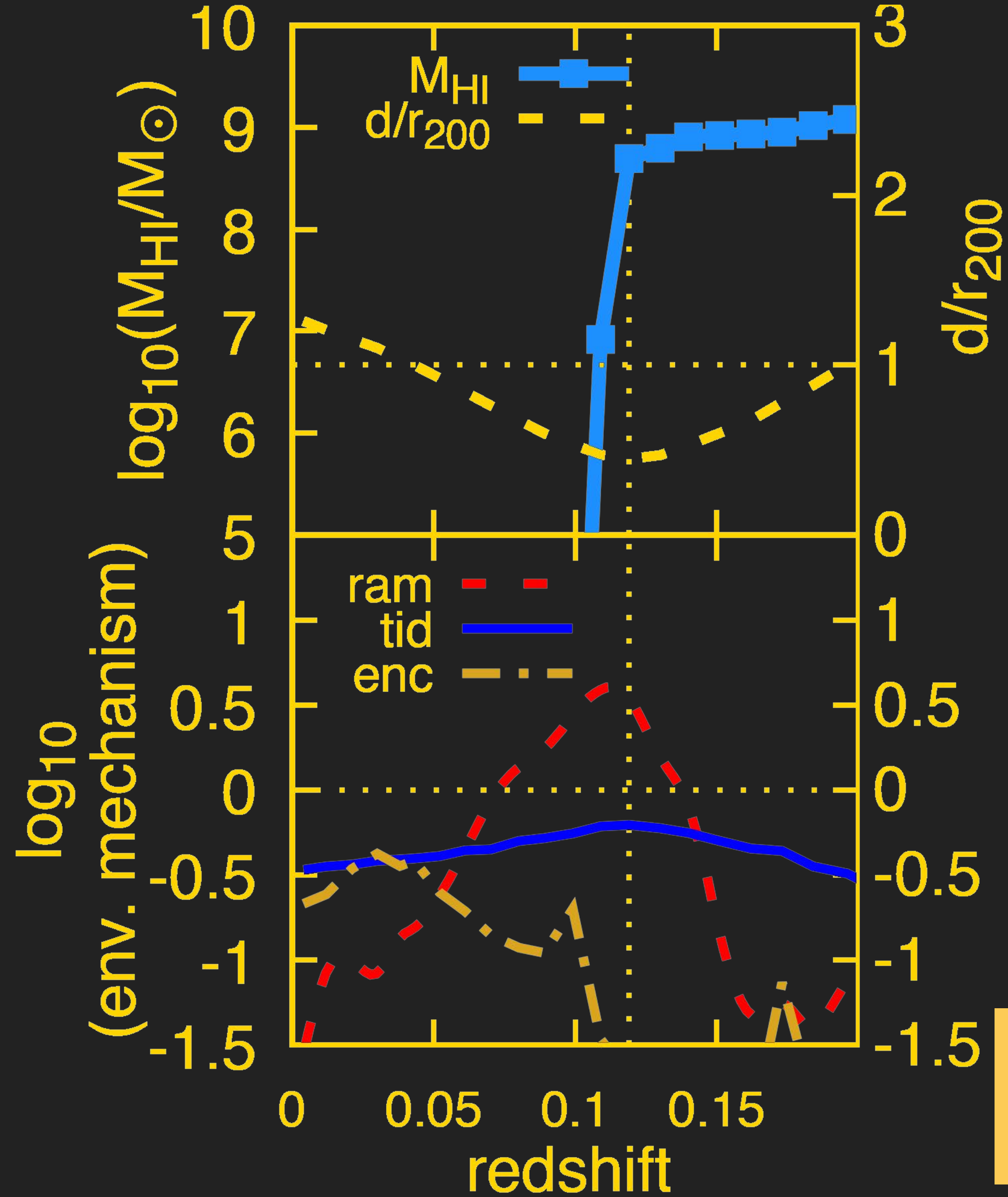

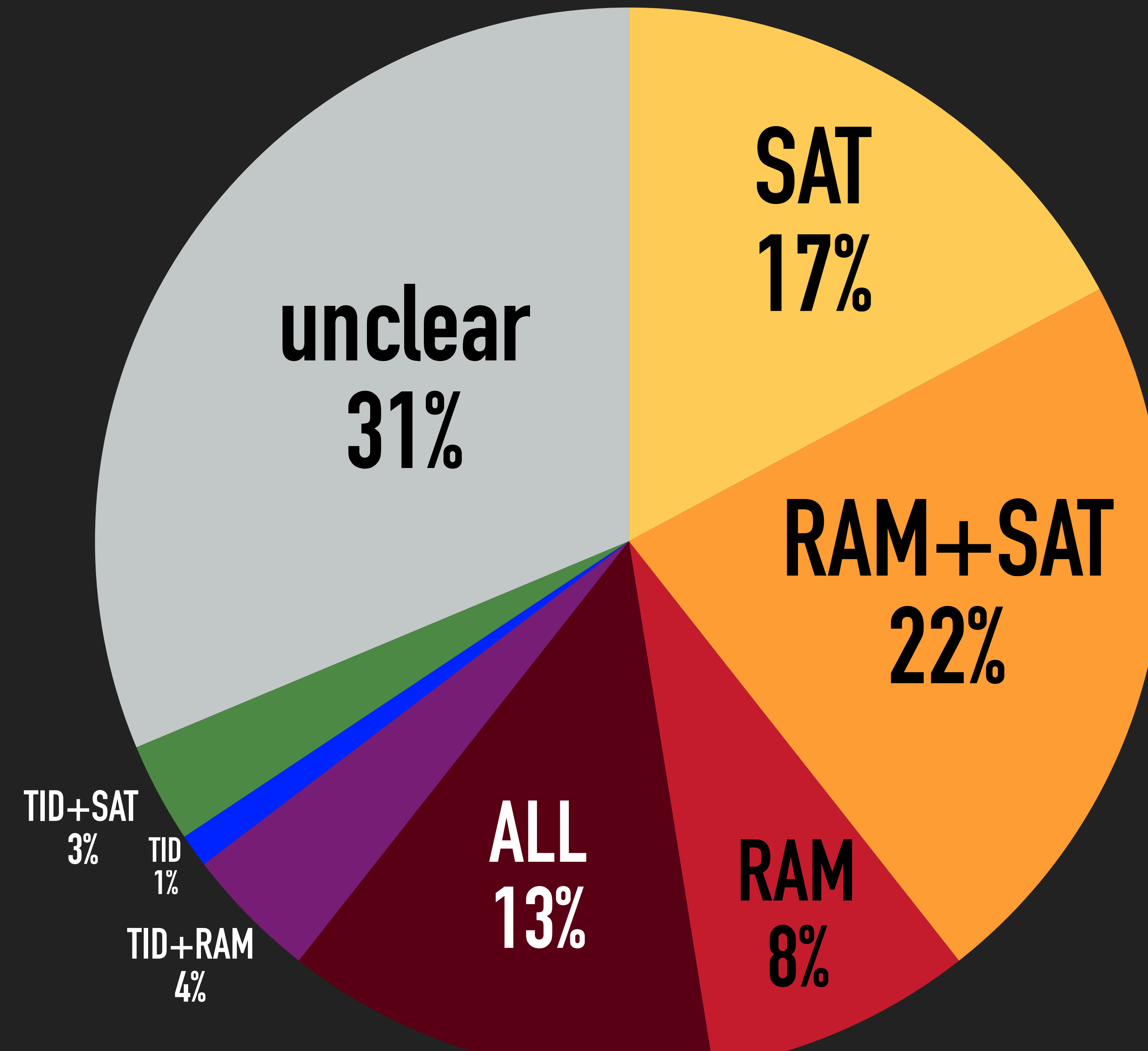

$T_{STRIPPING} < 0.5$ GYR

Satellite encounters..........55%
Ram pressure stripping...47%
Tidal str. by host halo........21%
Unclear..31%

CONCLUSIONS

- EAGLE reproduces very well the observed HI mass-environment trends
- Environmental processes act primarily as an on-off switch to the HI content of satellites
- The fraction of HI-depleted satellites increases with the environment density and decreases with the stellar mass
- Satellite encounters and ram pressure stripping dominate the processes of HI removal from the discs
- HI removal timescales typically < 0.5 Gyr