A new analytic profile to model RP in galaxy groups and clusters

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Ram pressure stripping in galaxies

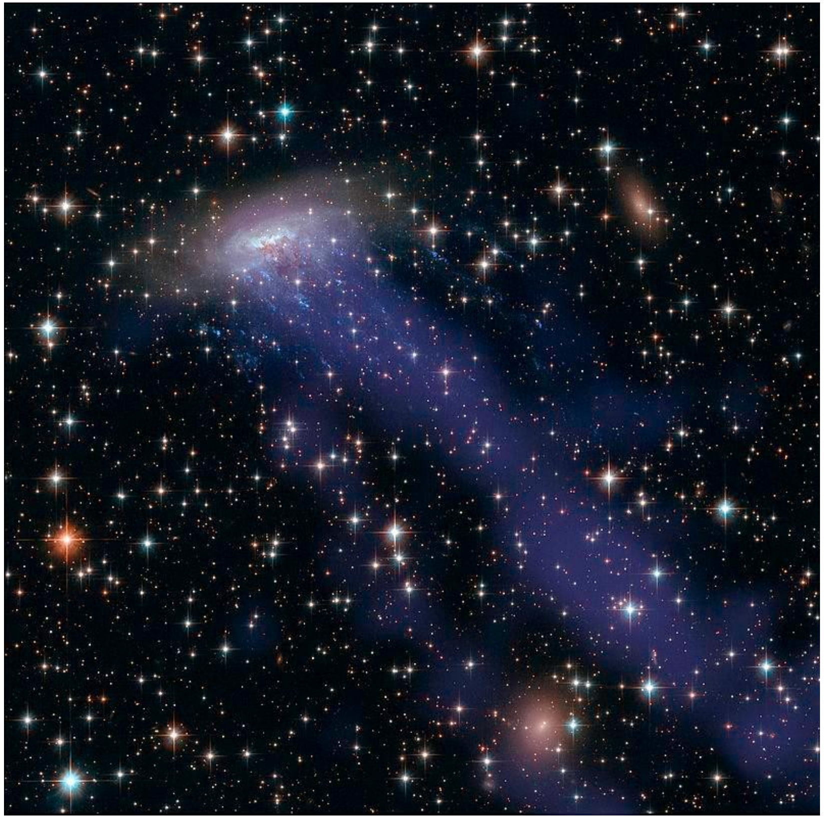
Stripping modeling compares the exerted pressure with the galaxy anchoring self-gravity

$$P_{\rm ram} \equiv \rho_{\rm icm} v^2 > 2\pi G \Sigma_{\rm disc}(R) \Sigma_{\rm cold}(R)$$

Analytic profiles of $P_{\rm ram}$ can be obtained by analyzing hydrodynamical simulations.

Here we revisit the Tecce+11* (T11) analytic RP profile, analyze its (missed) predictions and **introduce a new universal profile**.

(*) 2011/MNRAS/416/3170



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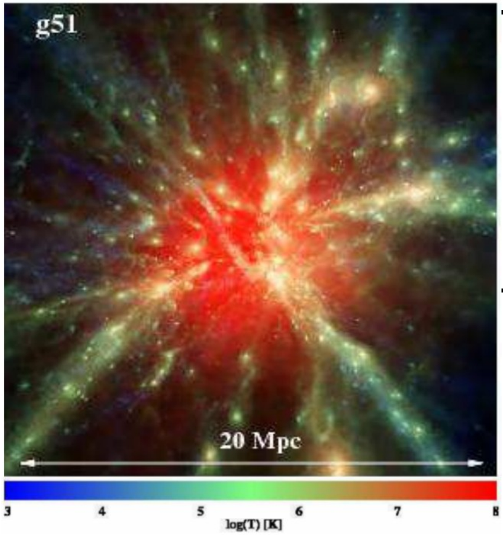
Numerical simulations

- Cosmological hydrodynamical (re)simulated regions: galaxy groups and clusters

  $M_{DM} \sim 1.13 \times 10^9\ h^{-1}\ M_\odot$

  $M_{gas} \sim 1.69 \times 10^8\ h^{-1}\ M_\odot$

- 3 massive clusters ($\sim 10^{15} M_\odot$)
  12 low-mass clusters ($\sim 10^{14} M_\odot$)
  and a set of galaxy groups



Cluster	R_{200} Mpc	M_{200} $10^{14} M_\odot$	R_{500} Mpc	M_{500} $10^{14} M_\odot$
g676.a	1.06	1.33	0.71	1.03
g914.a	1.09	1.43	0.71	1.06
g1542.a	1.043	1.30	0.69	0.94
g3344.a	1.07	1.39	0.73	1.07
g6212.a	1.06	1.31	0.70	1.00
g51.a	2.37	15.30	1.57	11.16
g1.a	2.50	17.80	1.69	13.59
g1.b	1.67	5.36	1.06	3.43
g1.c	1.23	2.09	0.79	1.41
g1.d	1.07	1.40	0.61	0.66
g1.e	0.93	0.93	0.63	0.70
g1.f	0.77	0.53	0.50	0.34
g8.a	2.89	27.56	1.93	20.60
g8.b	1.14	1.70	0.74	1.20
g8.c	1.03	1.24	0.61	0.66
g8.d	1.00	1.14	0.66	0.81
g8.e	0.96	1.00	0.63	0.69
g8.f	0.87	0.76	0.54	0.47
g8.g	0.76	0.49	0.50	0.36

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Problem: T11 (MNRAS/416/3170) ram pressure profile

- P_{ram} in halos can be described with a ***β*–profile**

$$P_{\mathrm{ram}}(M,z) = P_0(M,z)\left[1+\left(\frac{r}{r_{\mathrm{s}}(M,z)}\right)^2\right]^{-\frac{3}{2}\beta(M,z)}$$

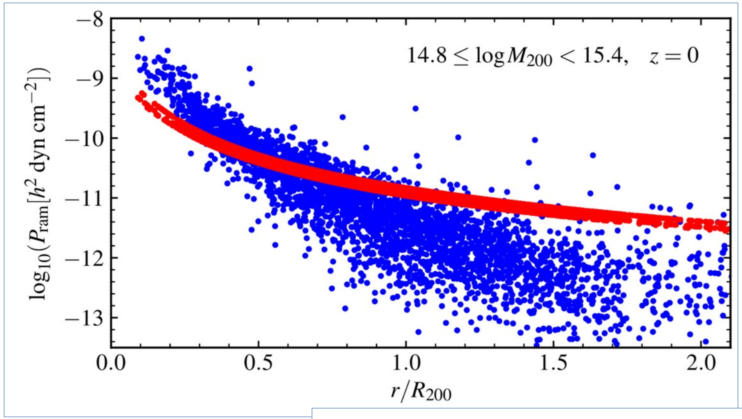
where

$$\log\left(\frac{P_0}{10^{-12}h^2\,\mathrm{dyn\,cm^{-2}}}\right) = A_P + B_P(a-0.25),$$
$$\frac{r_{\mathrm{s}}}{R_{200}} = A_r + B_r(a-0.25),$$
$$\beta = A_\beta + B_\beta(a-0.25),$$

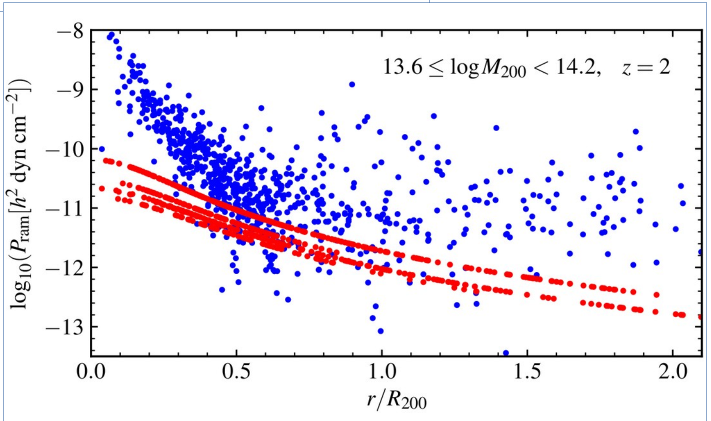
- Using **Tecce+10** (MNRAS/408/2008) technique to measure P_{ram} using the gas particles around each satellite, the *β*–profile fit gave:

$$A_P = (-0.8\pm0.1) + (1.2\pm0.1)(\log M_{200} - 12),$$
$$B_P = (1.2\pm0.2) + (-0.4\pm0.1)(\log M_{200} - 12),$$
$$A_r = (0.59\pm0.03) + (-0.14\pm0.02)(\log M_{200} - 12),$$
$$B_r = (-0.44\pm0.06) + (0.12\pm0.04)(\log M_{200} - 12),$$
$$A_\beta = 0.92\pm0.08,$$
$$B_\beta = -0.4\pm0.1.$$

- We applied the same method to measure RP in each satellite location for different distances, epochs and halo masses.



Inconsistent modeling



New ram pressure profile

- RP profile is better described with a damped power-low, and only the power is dependent on host halo mass

$$P_{\rm ram}(M, z) = P_0(z)\left[\frac{1}{\xi(z)}\left(\frac{r}{R_{200}}\right)\right]^{-\frac{3}{2}\alpha(M_{200},z)}$$

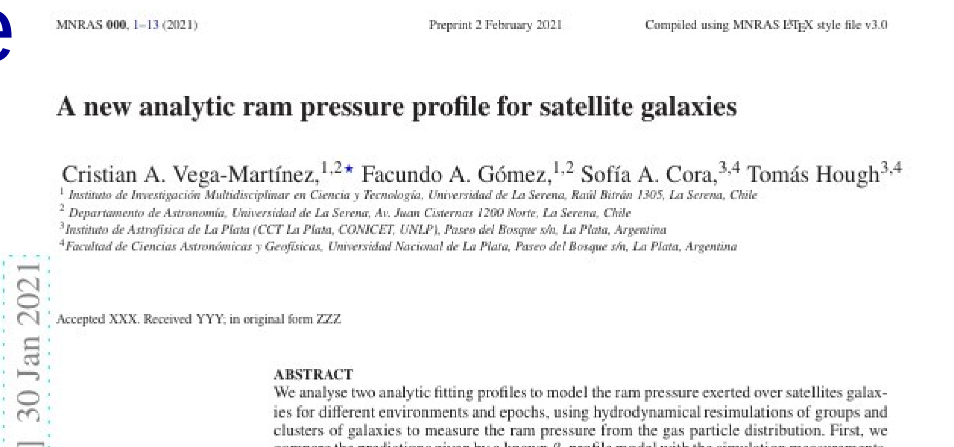
where

$$\alpha(M, z) = \alpha_{\rm M}(z)\log\left(M_{200}\ h^{-1}[{\rm M}_\odot]\right) + \alpha_{\rm N}$$

and to avoid degeneracies:

$$\alpha_{\rm N} = -5.5$$

arXiv: 2102.00132


MNRAS 000, 1–13 (2021) Preprint 2 February 2021 Compiled using MNRAS LaTeX style file v3.0

A new analytic ram pressure profile for satellite galaxies

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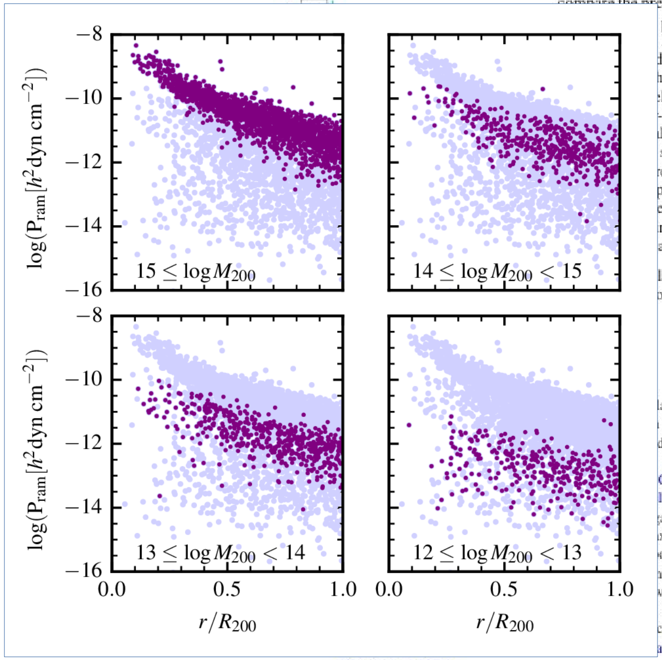
Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT
We analyse two analytic fitting profiles to model the ram pressure exerted over satellites galaxies for different environments and epochs, using hydrodynamical resimulations of groups and clusters of galaxies to measure the ram pressure from the gas particle distribution. First, we ... profile is not in agreement with the expected behaviour by missing the depen- ... halo mass and halocentric distance. It features a systematic underestimation ... ram pressure at high redshifts ($z > 1.5$), which increases toward the central ... halos and it is independent of halo mass, reaching differences larger than two ... llites at $r < 0.4R_{\rm vir}$. This behaviour reverses as redshift decreases, featuring an ... -estimation with halocentric distance at $z = 0$. As an alternative, we introduce ... analytic model for the profiles consisting in a damped power law, and we ... set of fitted parameters which can recover the ram pressure dependence on ... edshifts. Finally, we analyse the impact of these analytic profiles in the galaxy ... pplying a semi-analytic model of galaxy formation and evolution on top of the ... find the number of galaxies experiencing large amounts of accumulated ram ... ng have low stellar mass ($M_\star \leq 10^9{\rm M}_\odot$), and their specific star formation rates ... antly on the pressure modelling, particularly at high redshifts ($z > 1.5$).

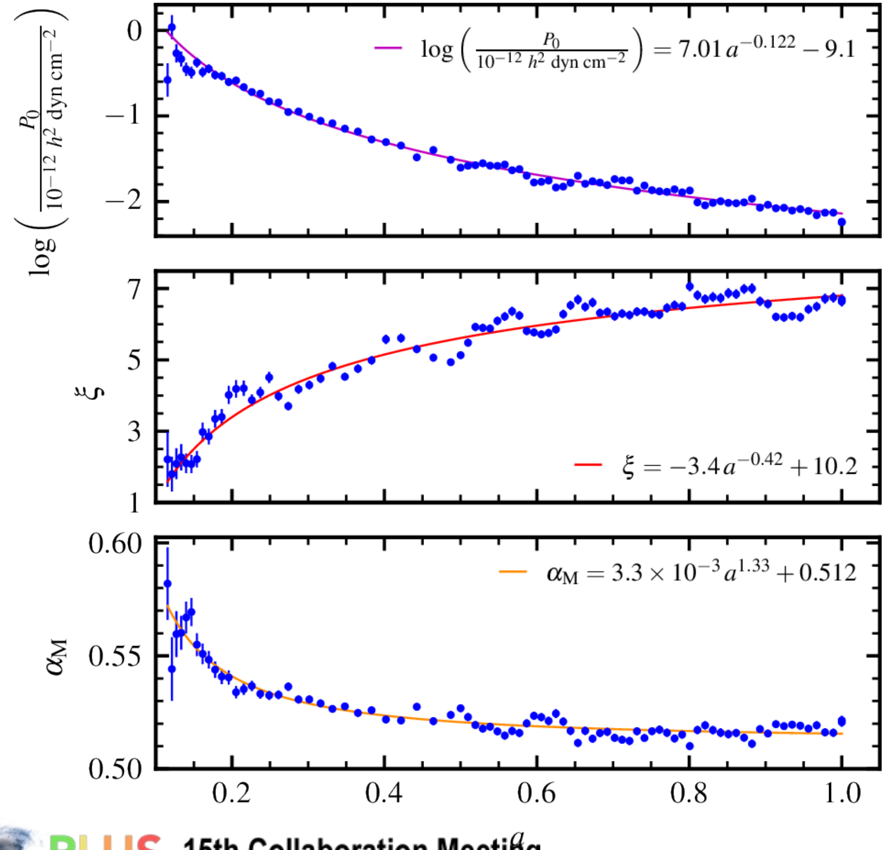
... laxies: general – galaxies: interactions – galaxies: evolution – galaxies: clusters: ... ods: numerical

of debate (see Somerville & Davé 2015, for a review on physical models on galaxy formation). Two different types of processes have been invoked in the suppression of the star formation: mass- and environmental- quenching (Peng et al. 2010). This characterisation of the quenching processes gave rise to the known *nature* versus *nurture* discussion to disentangle the main drivers of the evolution of galaxy properties. Comparisons between the properties of populations of star-forming (active) and quiescent (passive) galaxies have shown that, up to $z \sim 1$, it is possible to identify the main mechanism driving them to the quenching state (e.g. Baldry et al. 2006; Peng et al. 2010; Muzzin et al. 2012; Kovač et al. 2014; Guglielmo et al. 2015; van der Burg et al. 2018, 2020). This, however, does not necessarily mean that they are physically unrelated. At higher redshifts, the picture is more intriguing. The median star formation rate (SFR) of galaxies and the quenched fraction (i.e. the ratio between the number of quenched galaxies

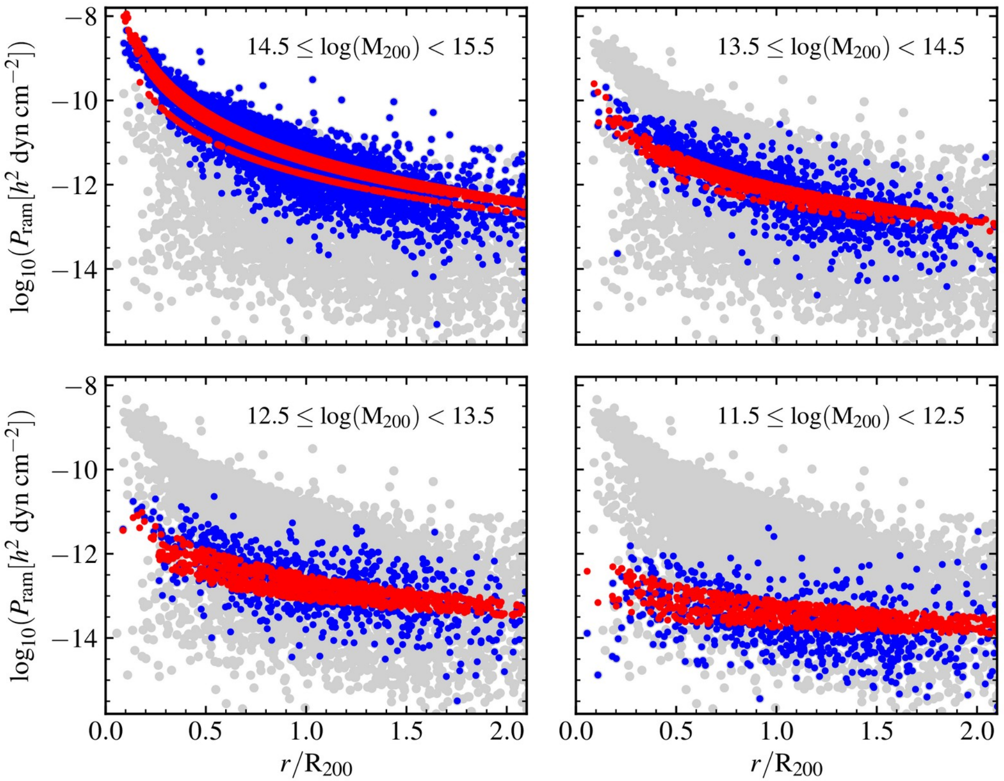


New ram pressure profile

- Temporal evolution of the parameters



- Profile predictions



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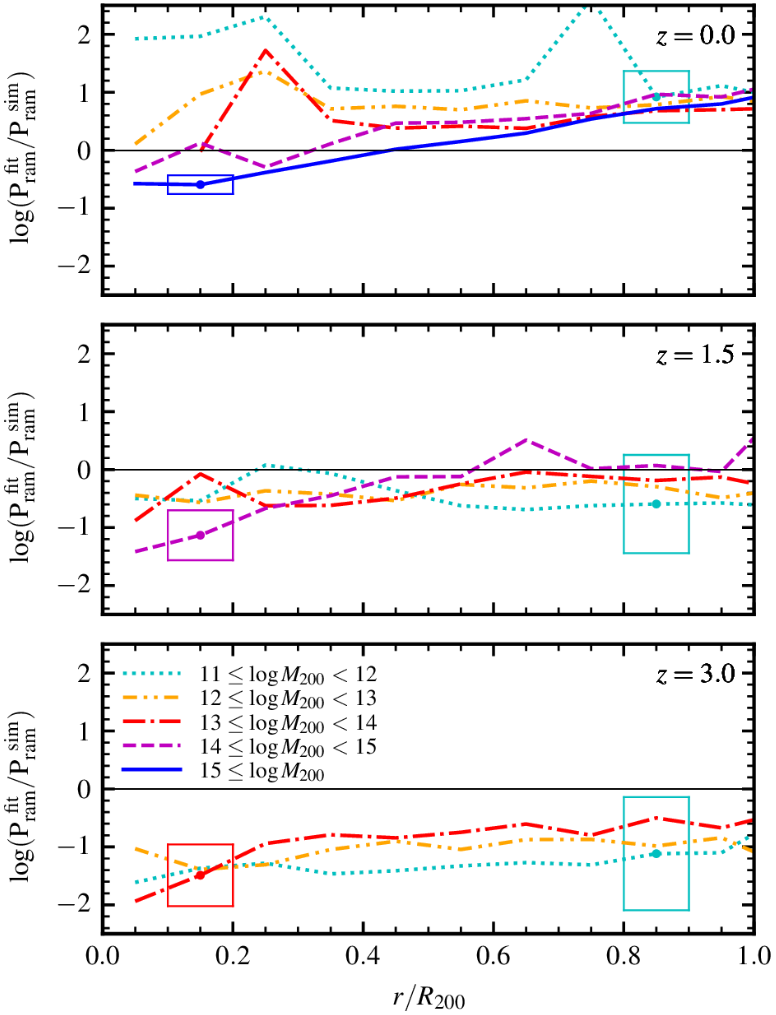
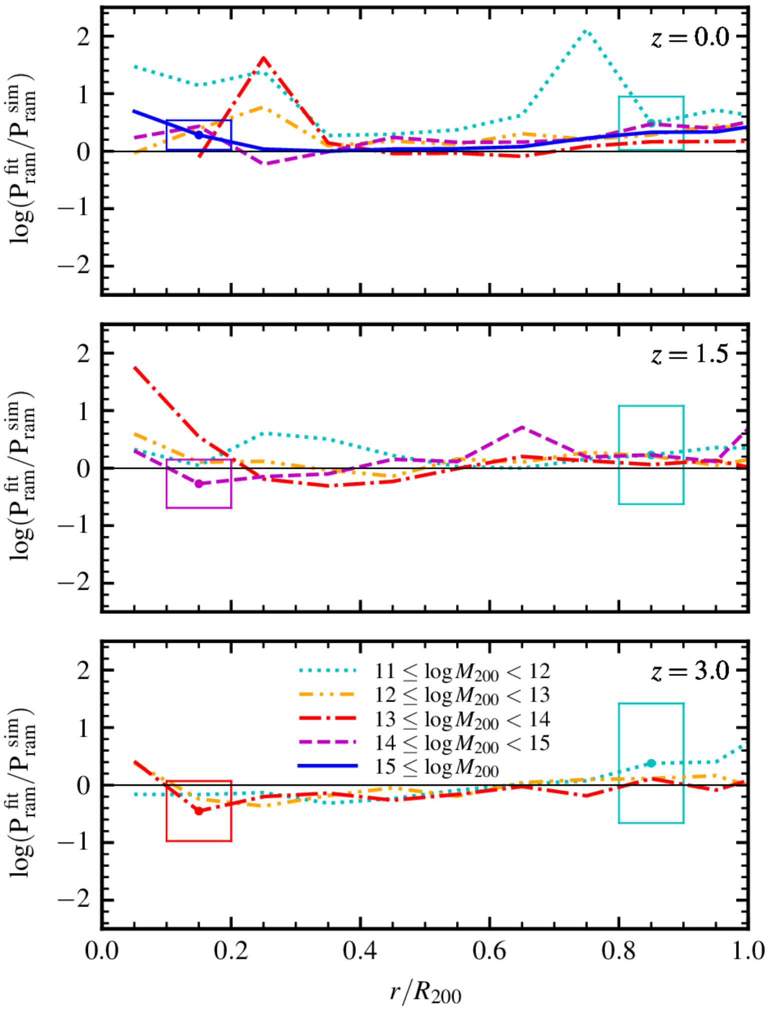
T11 profile



New profile



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Effect in the galaxy properties

- We applied the semi-analytic model of galaxy formation SAG on these simulations. Among the included processes, we highlight: SAG retains the hot gas of satellites after infall, and it applies RPS/~~TS~~.

- Three model variants were considered:

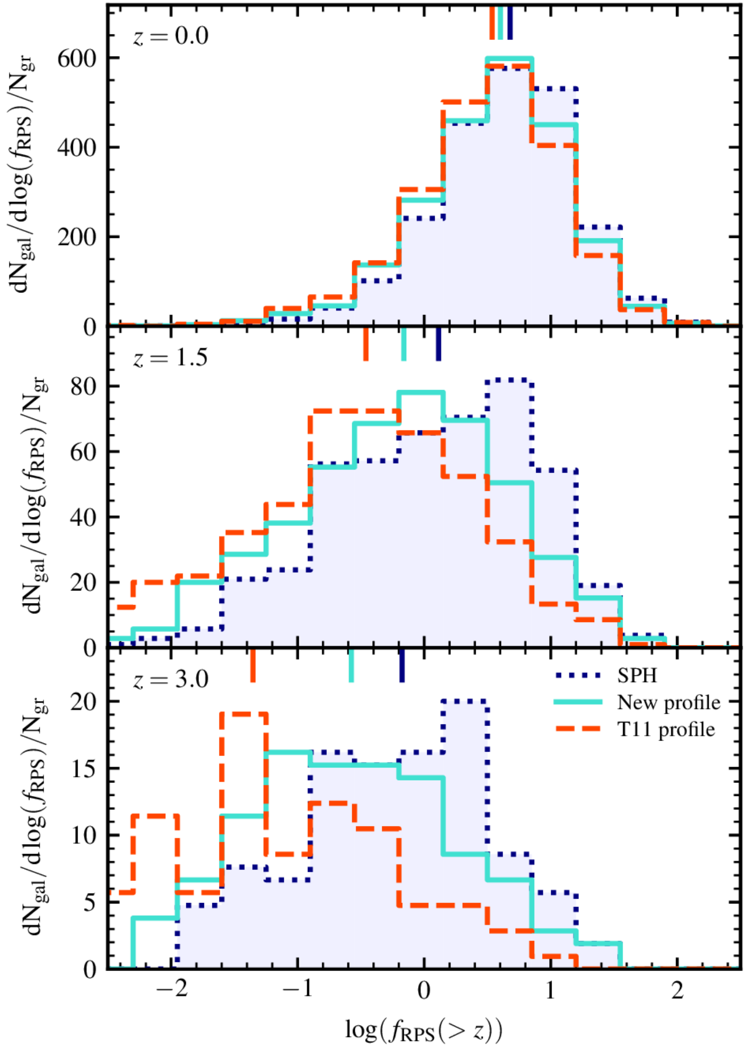
  1) a fiducial model using measured $P_{\rm ram}$,

  2) one using T11 RP profile

  3) one using the new profile

- We focus on the massive clusters. The current fraction of the total stripped mass is calculated for each satellite:

$$f_{\rm RPS}(z) \equiv \frac{M_{\rm RPS}(> z)}{M_\star(z)}$$



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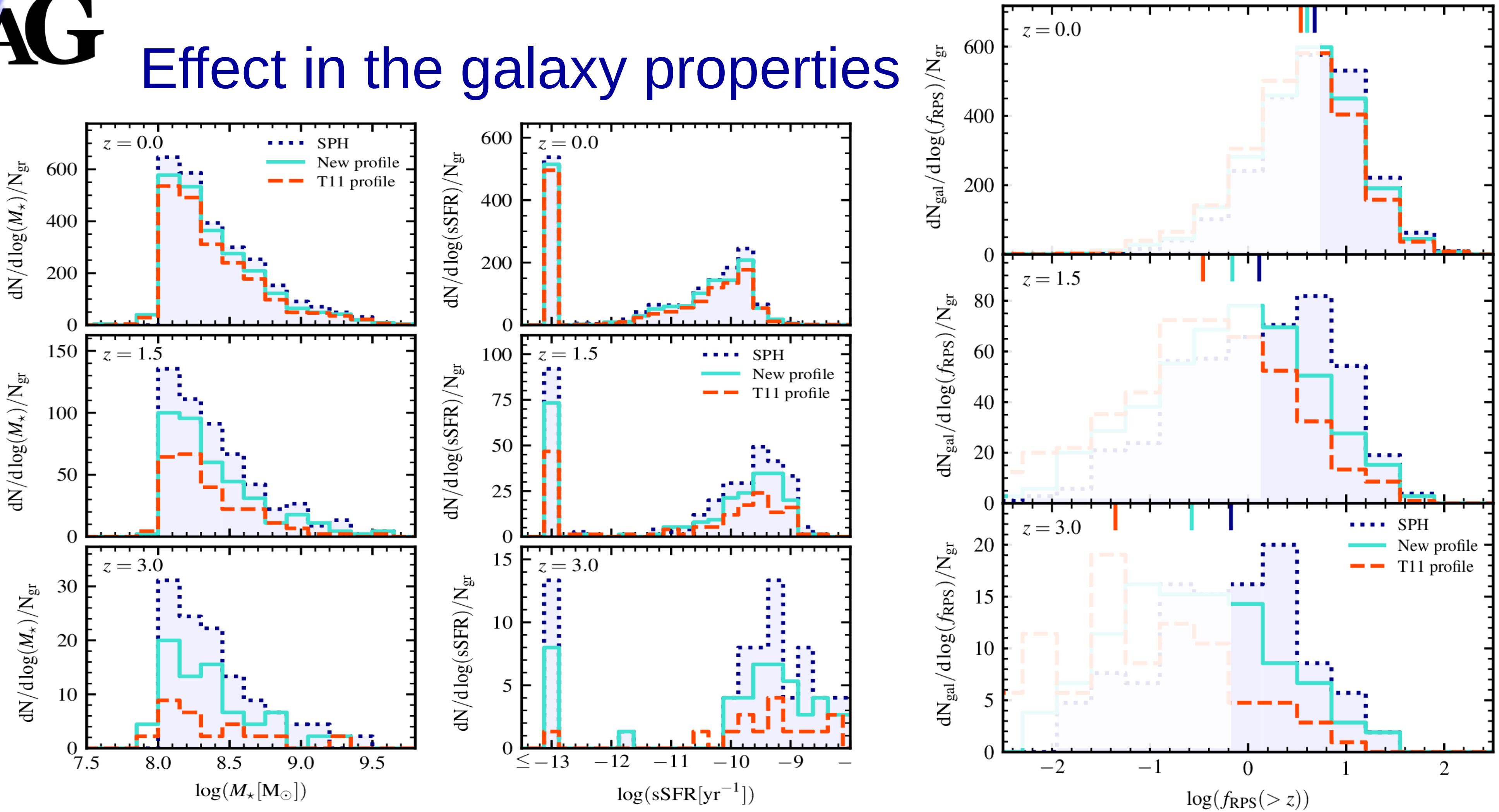
Effect in the galaxy properties



SAG

S-PLUS survey
15th Collaboration Meeting
Southern Photometric Local Universe Survey

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Conclusions

- T11 analytic fit (*β*–profile) is disproved as a predictive RP profile
- We introduced a new universal profile to describe RP in galaxy groups and clusters:

$$P_{\rm ram}(M,z) = P_0(z)\left[\frac{1}{\xi(z)}\left(\frac{r}{R_{200}}\right)\right]^{-\frac{3}{2}\,\alpha(M_{200},z)}$$

$$\alpha(M,z) = \alpha_{\rm M}(z)\log\left(M_{200}\ h^{-1}\,[{\rm M}_\odot]\right) - 5.5$$

- Present-day galaxy properties calculated with SAMs are independent of the RP modeling applied. However, it has an strong impact on low-mass ($M_* < 10^9$ M$_\odot$) high redshift ($z > 1$) satellite galaxies, particularly on their sSFR.

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