



清华大学天文系
Department of Astronomy, Tsinghua University

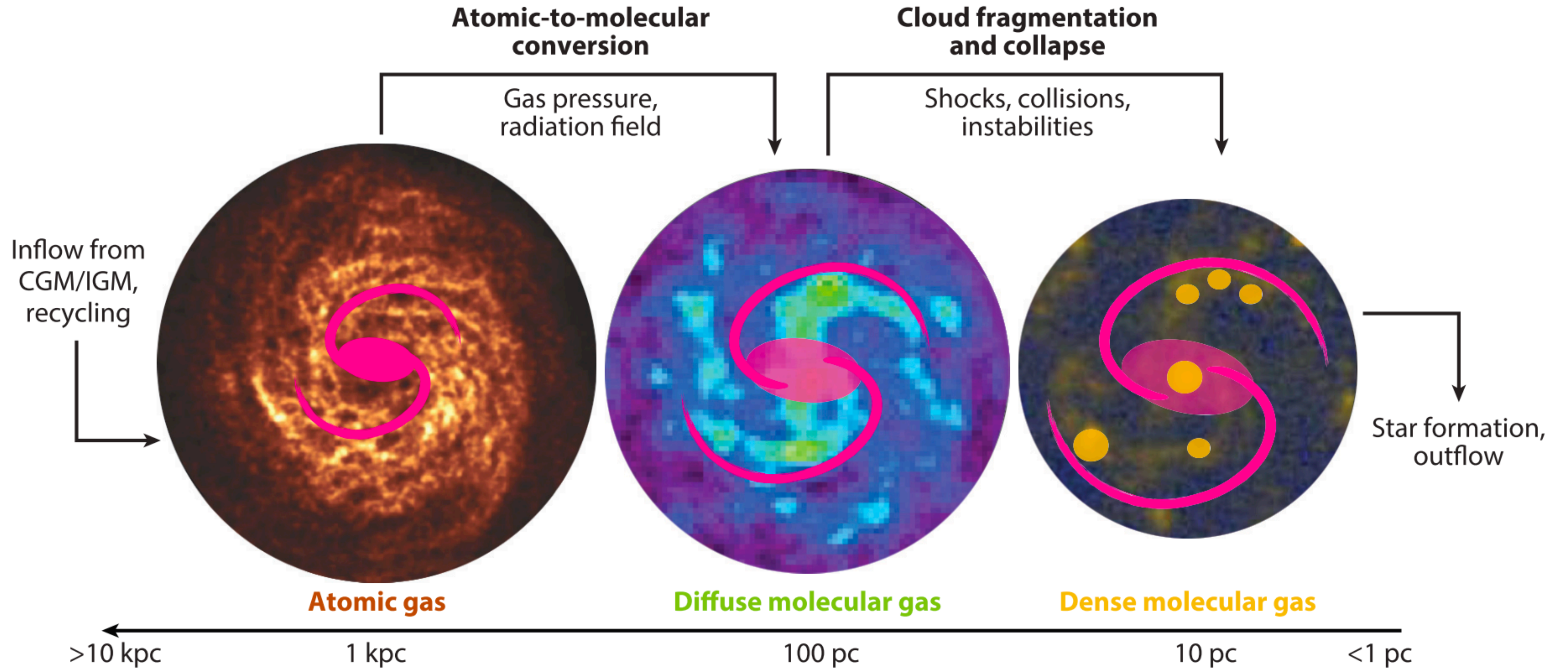
On the origin of red but HI-rich galaxies in the local universe

Xiao Li (李霄)

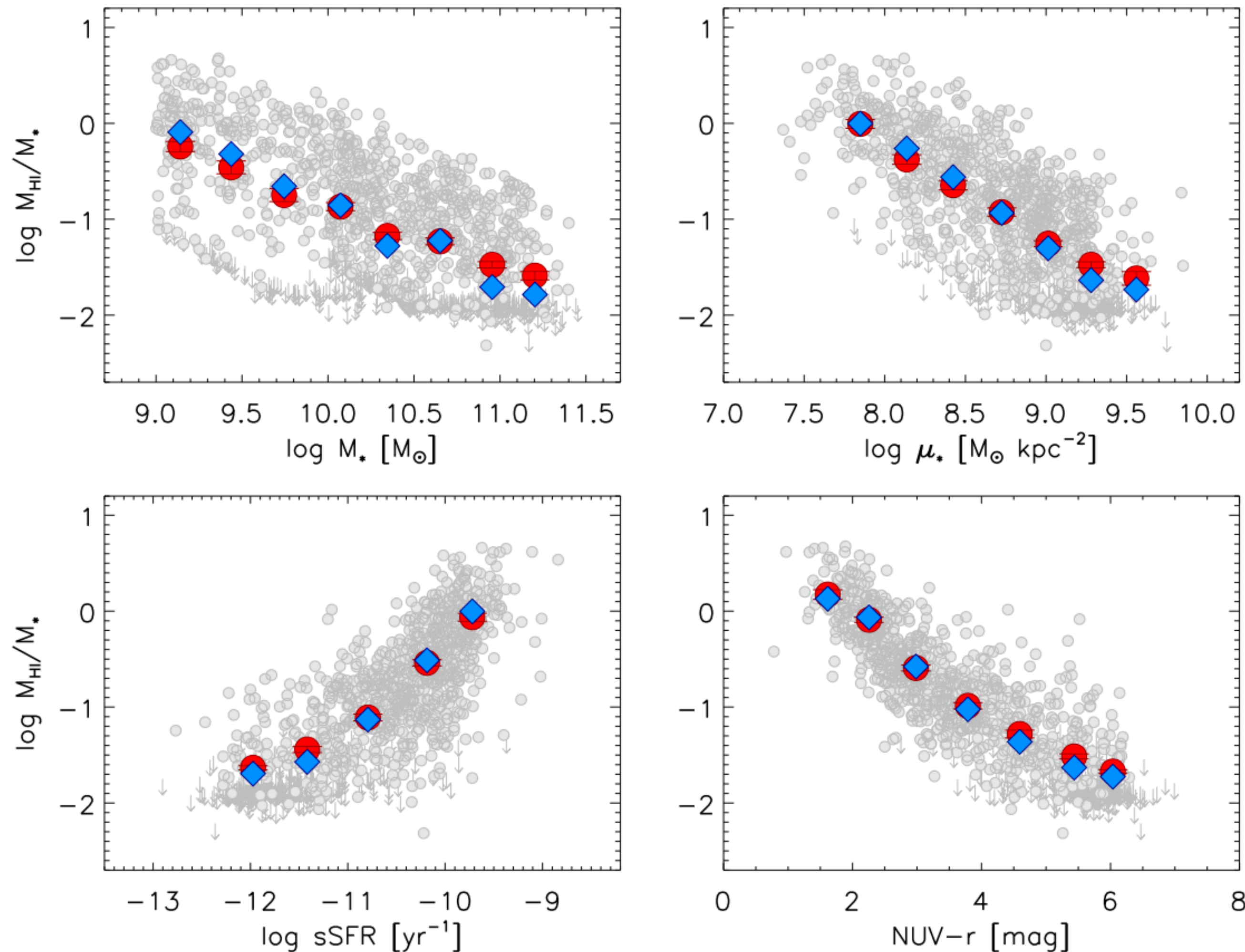
Collaborators: Cheng Li , Houjun Mo , Jianhong Hu , Jing Wang , Ting Xiao

Oct 30 - Nov 3, The 2nd Shanghai Assembly on Cosmology and Structure Formation

Atomic hydrogen (HI) fuels star formation



HI gas is correlated with galaxy optical properties



Catinella et al 2018

These HI scaling relations can be used to estimate the HI mass of galaxies (HI estimator)

Kannappan 2004; Zhang et al. 2009; Catinella et al. 2010; Huang et al. 2012; Li et al. 2012; Eckert et al. 2015; Teimoorinia et al. 2017; Rafieferantsoa et al. 2018; Ying Zu 2020;

a new HI estimator that can give unbiased prediction of HI gas content to the general galaxy population (Li et al 2022, ApJ, 941, 48)

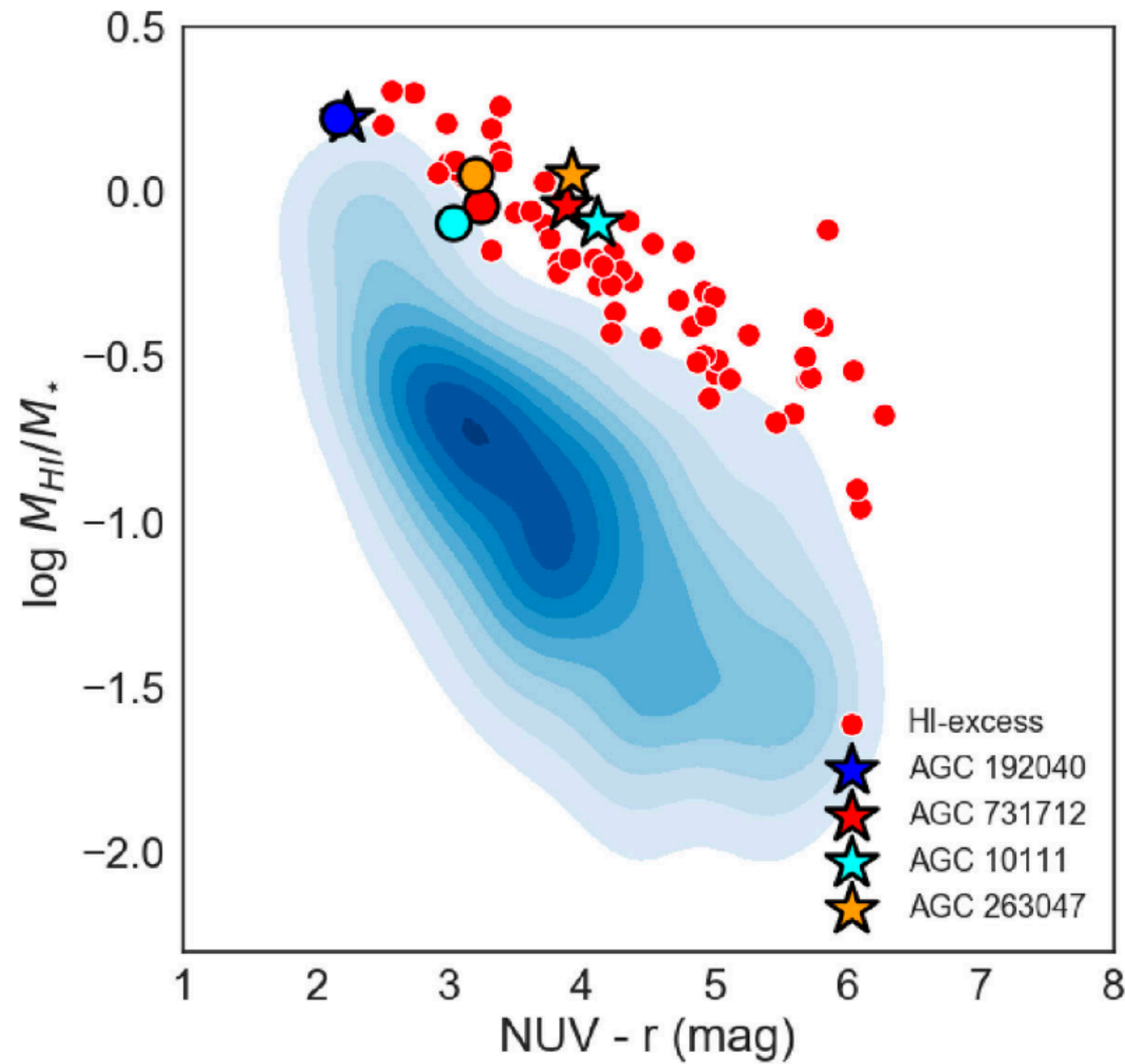
Not all galaxies tightly follow the average HI scaling relations

HI-excess star-forming galaxies

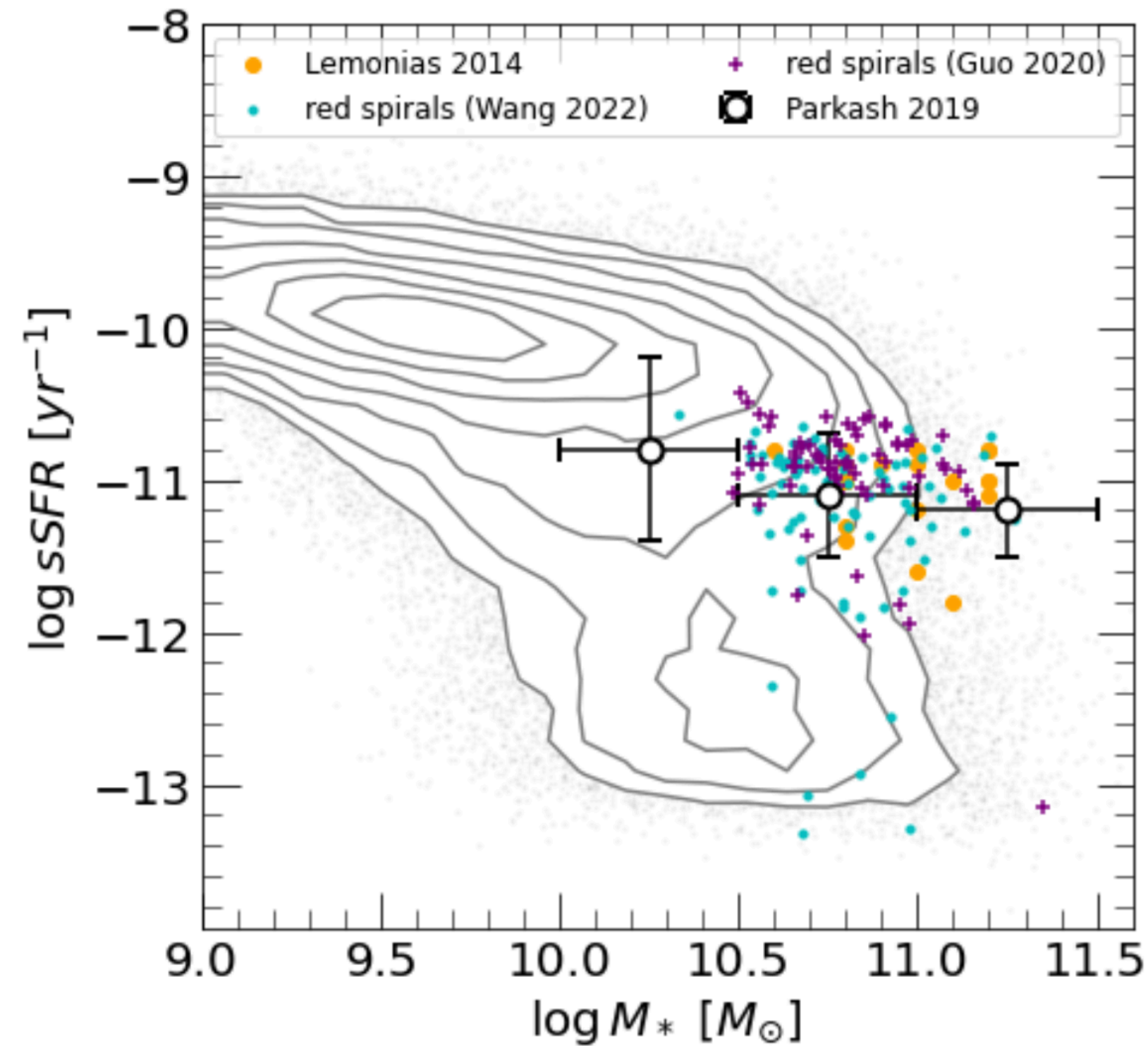
Huang et al. 2014; Catinella & Cortese 2015; Lutz et al. 2017, 2018, 2020; Geréb et al 2017; Zasov & Zaitseva 2022;

HI-rich but low-SFR galaxies

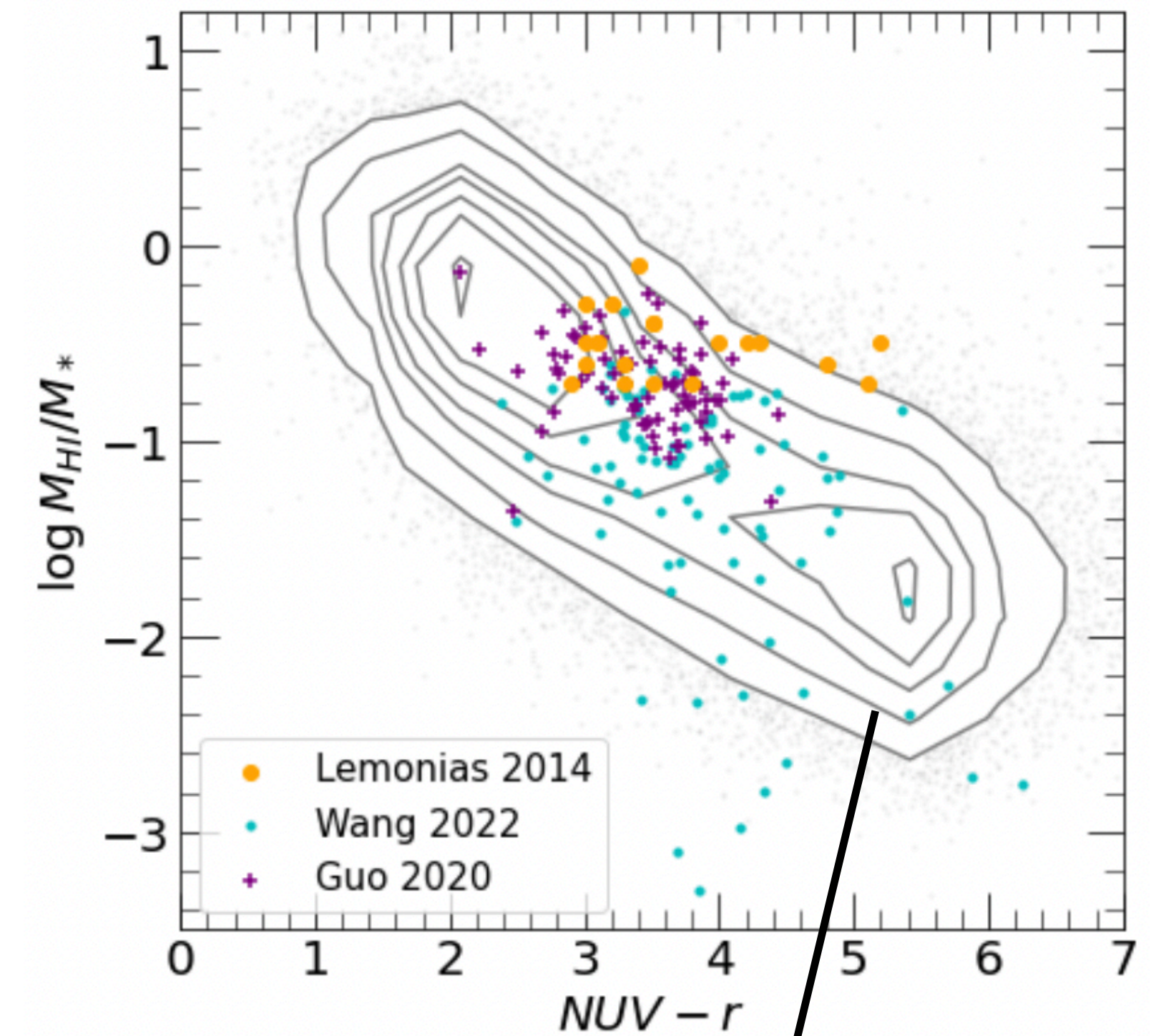
Lemonias et al. 2014; Geréb et al 2016; Parkash et al 2019; Zhang et al. 2019; Guo et al. 2020; Wang et al. 2022; Sharma et al. 2023



Geréb et al 2017



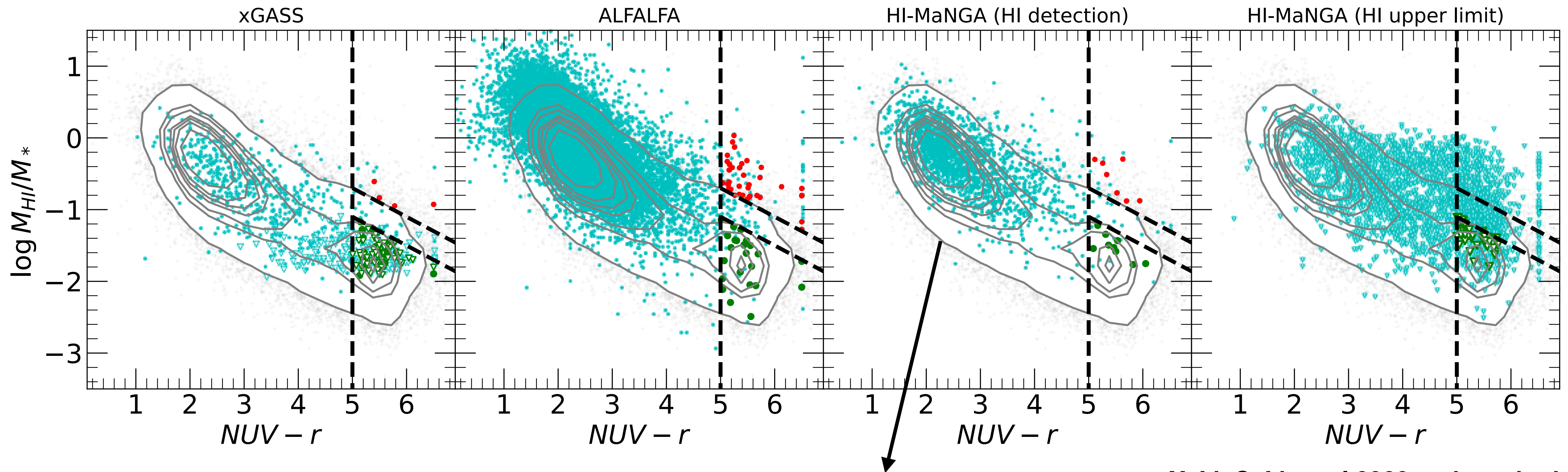
X. Li, C. Li, et al 2023, to be submitted



contours represent an SDSS volume-limited sample, of which each galaxy is assigned an HI mass using the HI estimator in Li et al 2022, ApJ, 941, 48

Select fully quenched but HI-rich galaxies based on the $\log M_{\text{HI}}/M_*$ vs $NUV - r$ diagram

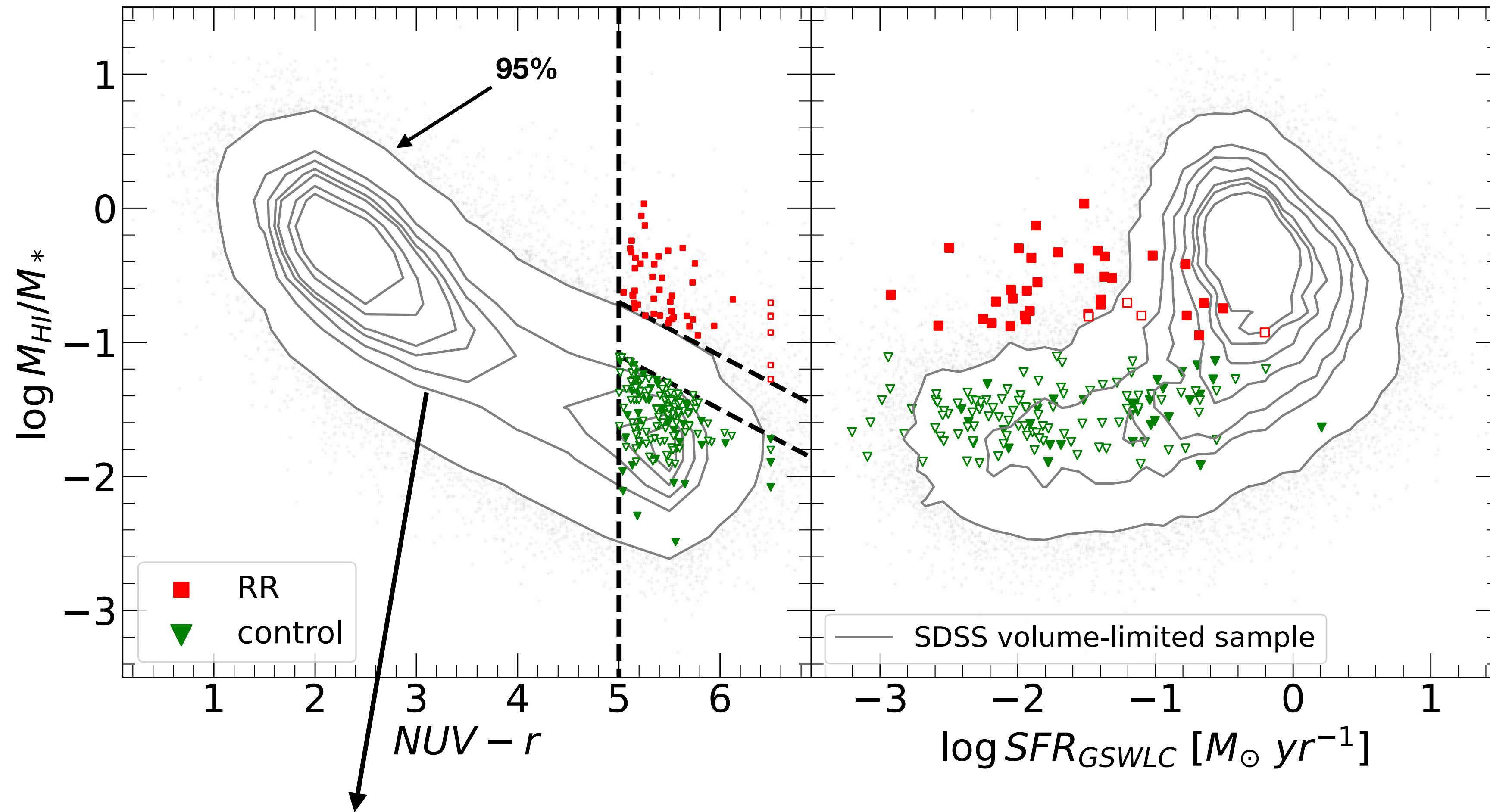
- 49 red but HI-rich galaxies (**RR**)
- 154 red and HI-normal galaxies (**control**) with the same stellar mass distribution as RR



contours represent an SDSS volume-limited sample, of which each galaxy is assigned an HI mass using the HI estimator in Li et al 2022, ApJ, 941, 48

X. Li, C. Li, et al 2023, to be submitted

RR galaxies are very rare and unique



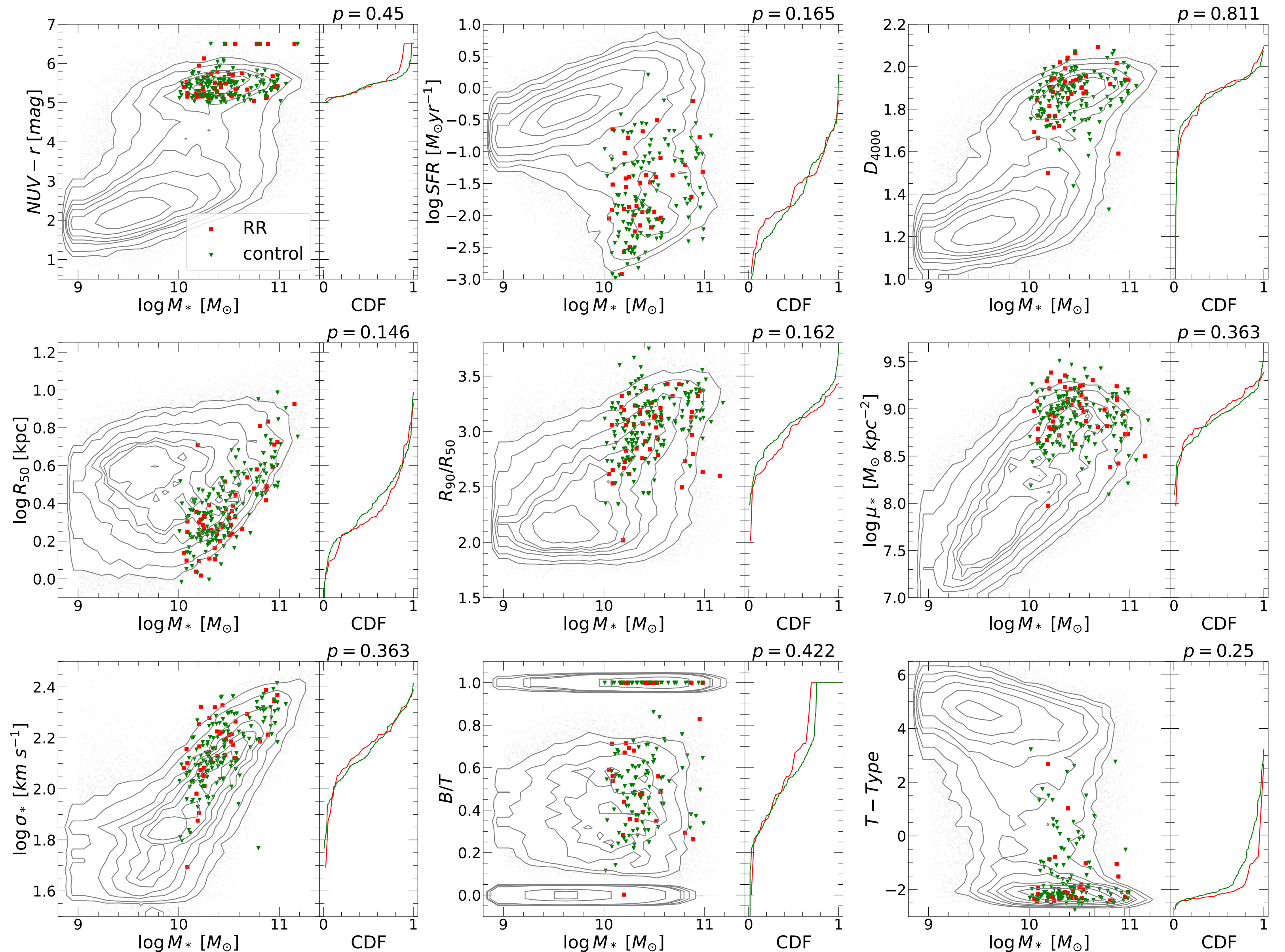
contours represent an SDSS volume-limited sample, of which each galaxy is assigned an HI mass using the HI estimator in Li et al 2022, ApJ, 941, 48

X. Li, C. Li, et al 2023, to be submitted

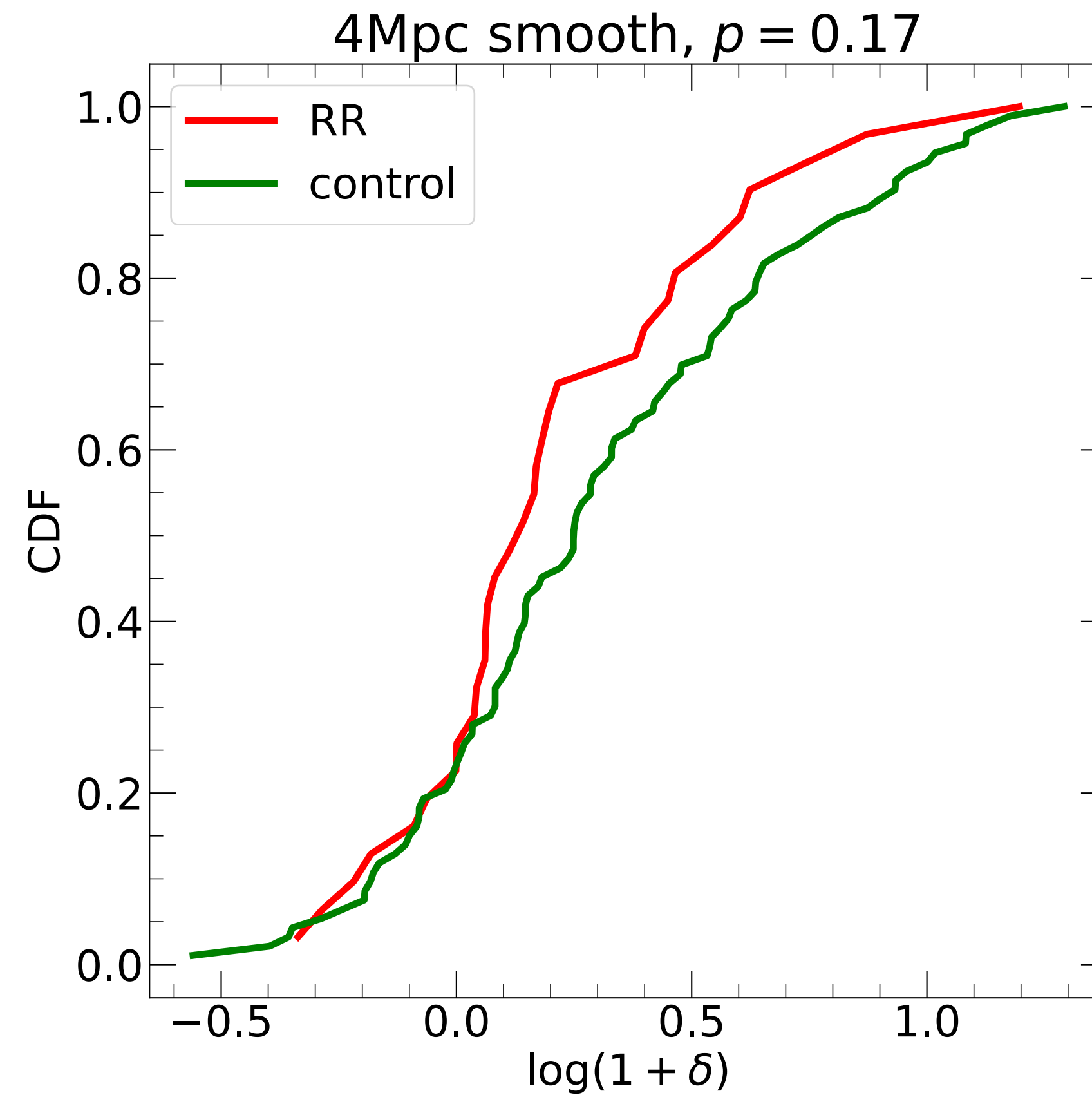
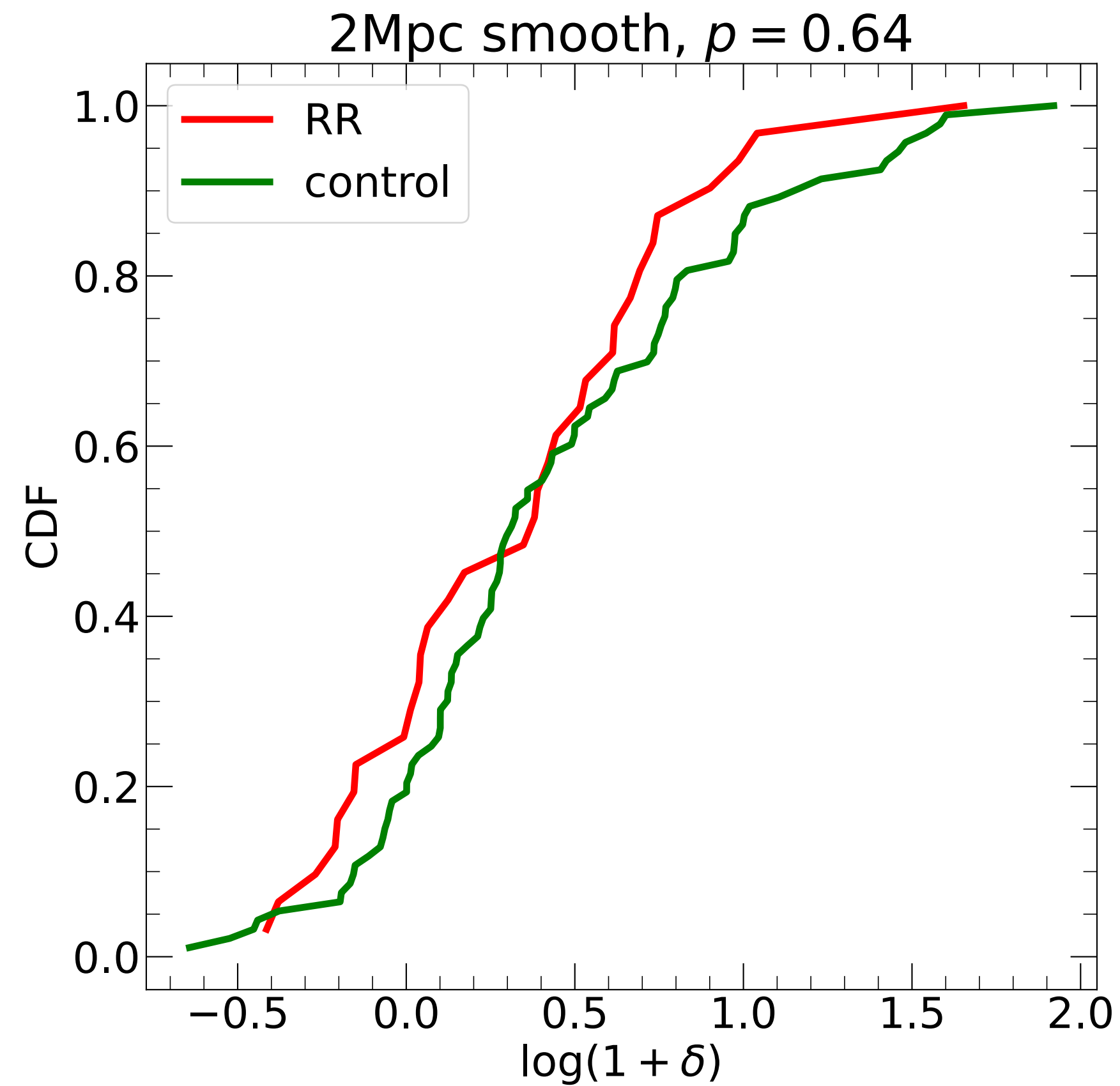
RR galaxies have similar optical properties as control galaxies

We checked enormous galaxy properties:

- star formation rate
- D_{4000} break
- Petrosian 90% radius R_{90}
- concentration R_{90}/R_{50}
- stellar surface mass density μ_*
- central stellar velocity dispersion σ_*
- bulge-to-total ratio B/T
- morphology T-Type
- color gradient Δ_{g-r}
- probability of being a merger
- probability of having a bar



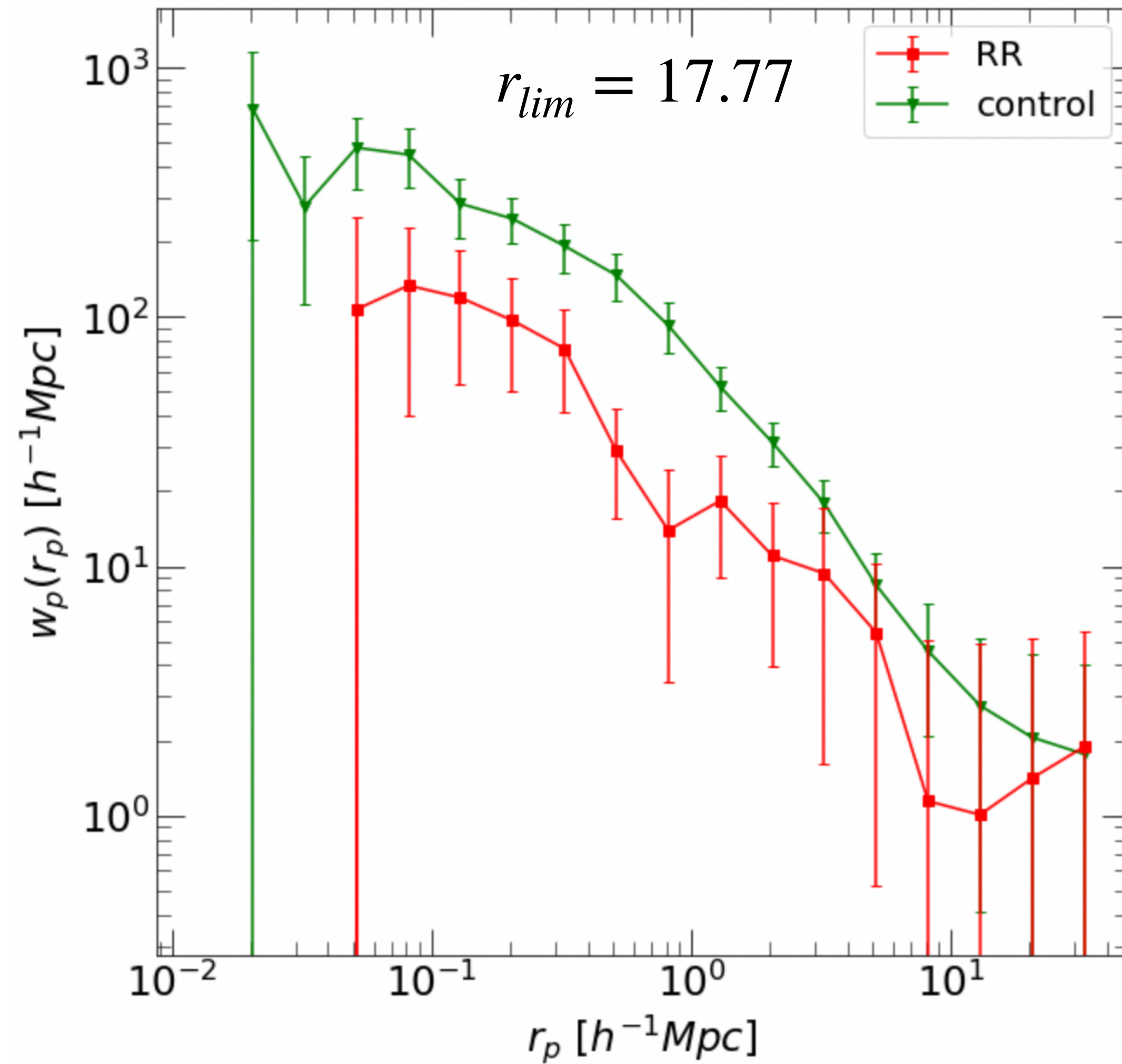
RR galaxies tend to locate in lower density environments



X. Li, C. Li, et al 2023, to be submitted

overdensity data are taken from ELUCID simulation (Wang et al 2014)

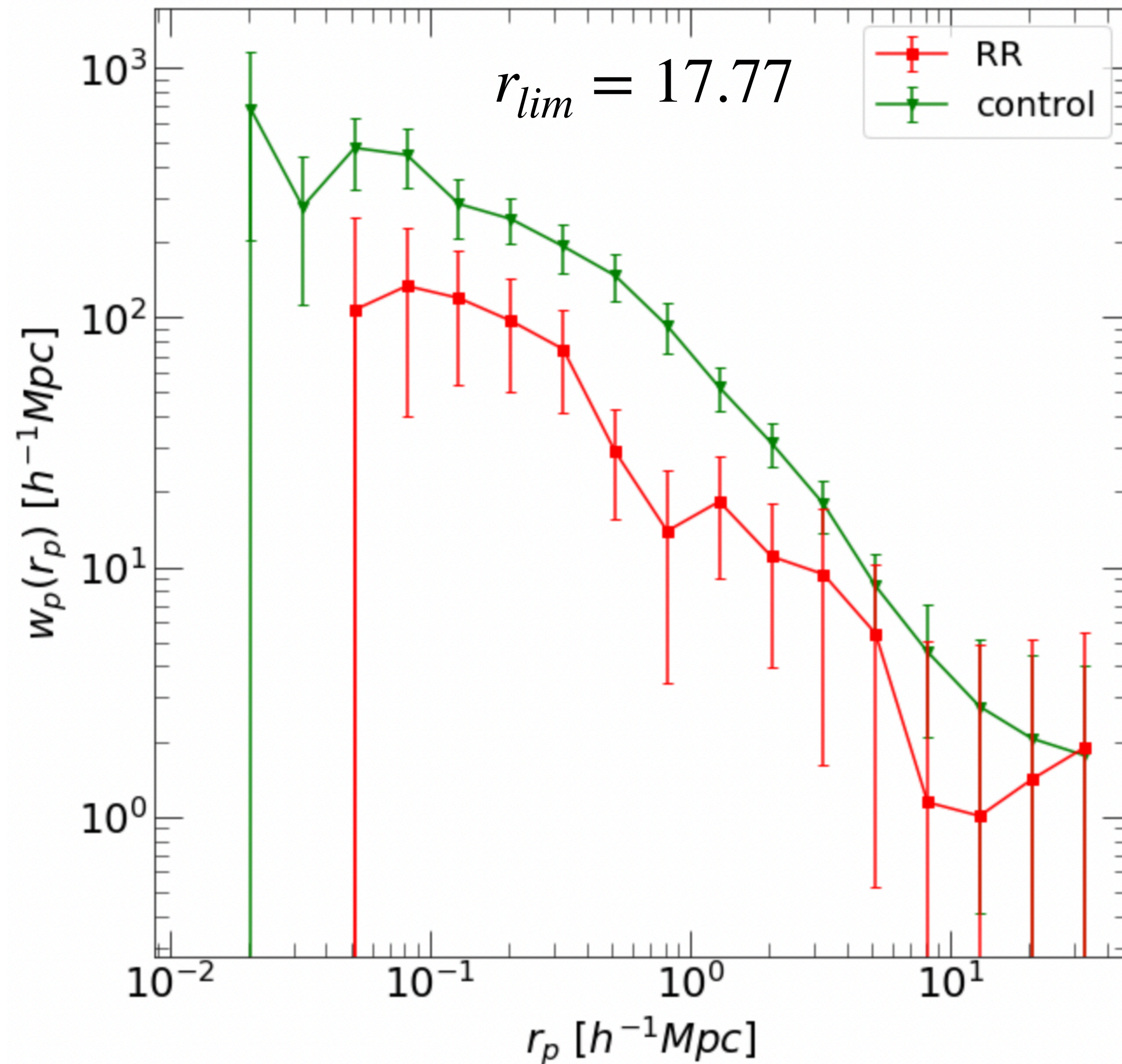
The projected cross-correlation function of RR is lower than the control sample



Especially at intermediate scale
($0.1 \sim 1 h^{-1}Mpc$)

→ higher central fraction of RR sample

The projected cross-correlation function of RR is lower than the control sample



X. Li, C. Li, et al 2023, to be submitted

Especially at intermediate scale
 ($0.1 \sim 1 h^{-1}Mpc$)

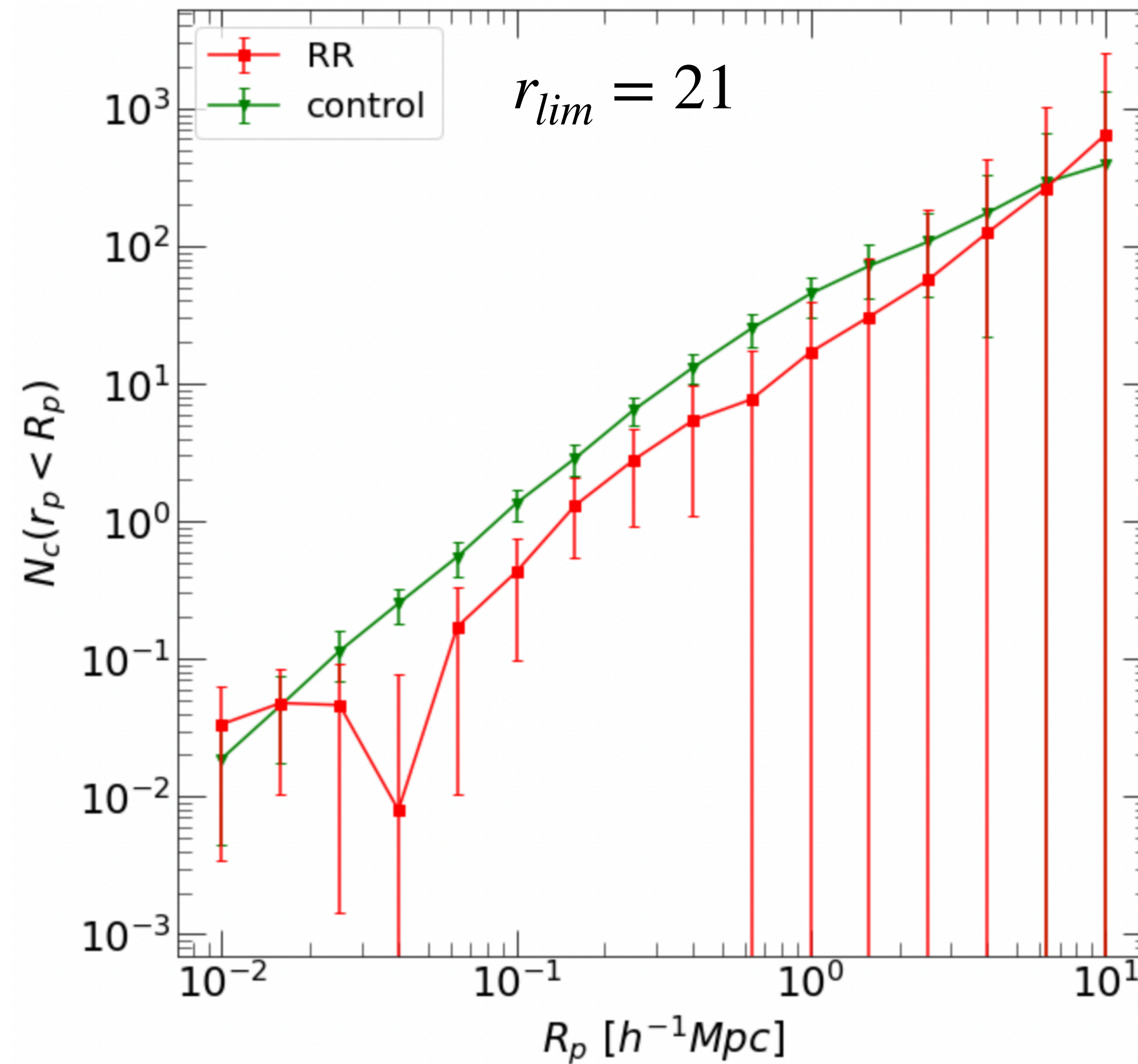
→ higher **central fraction** of RR sample

SDSS group catalog
 Yang et al. 2007

RR:	$90\% \pm 18\%$
control:	$64\% \pm 8\%$

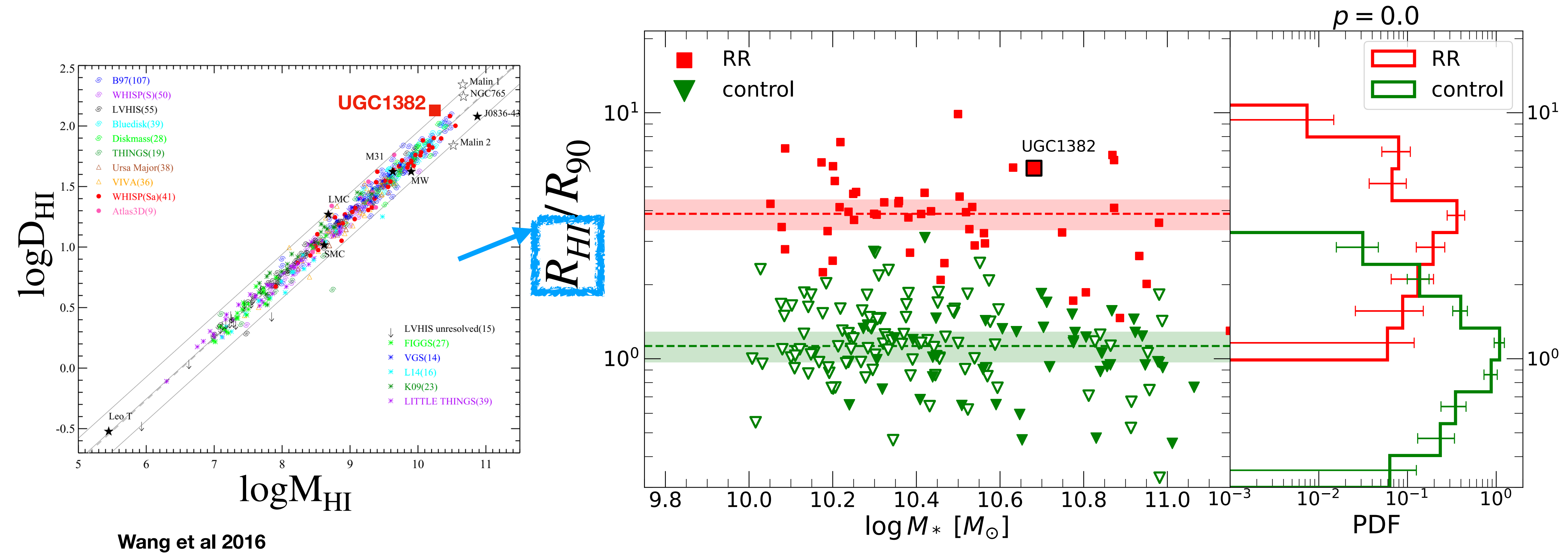


The neighbour counts of RR galaxies is less than the control sample



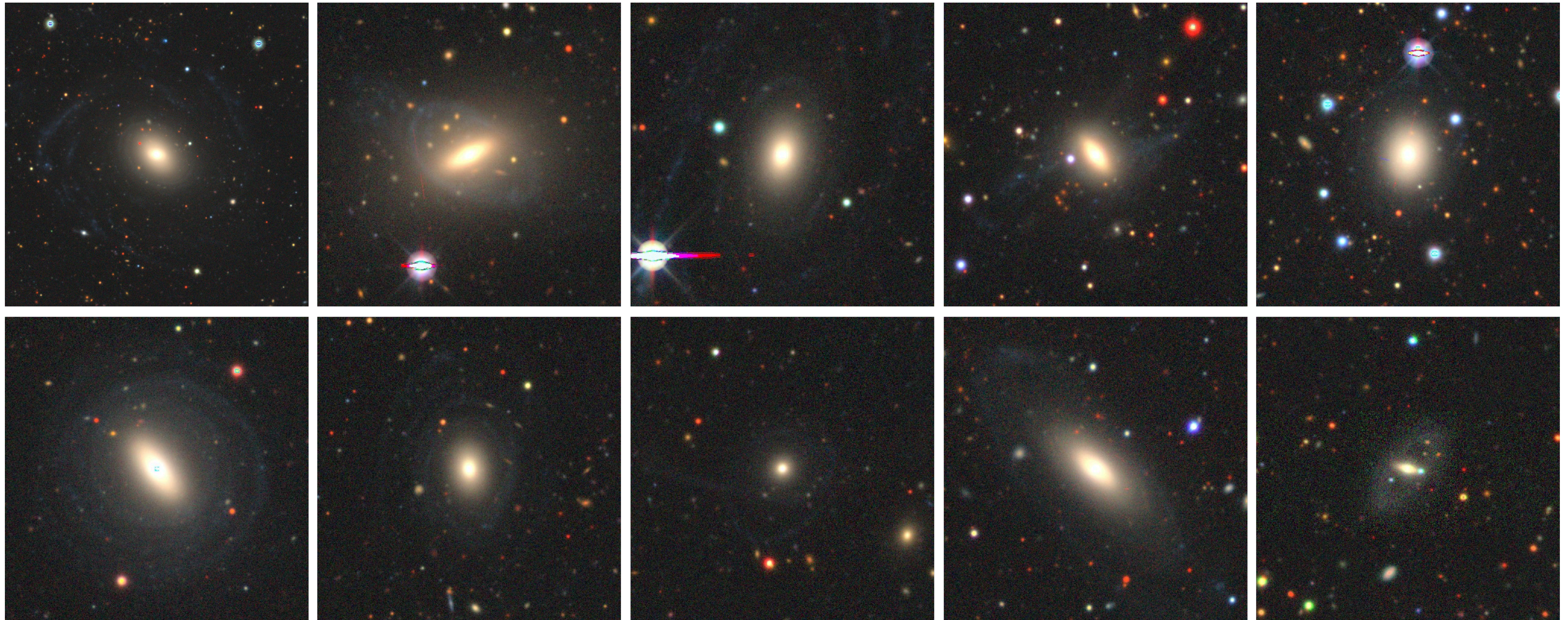
The HI-to-optical radius ratio

RR galaxies have HI disk radius much larger than the optical radius



Wang et al 2016

20% of RR galaxies show faint extended structures in their optical images



Images taken from <https://www.legacysurvey.org>

Summary

- Quenched but HI-rich (RR) galaxies do exist. They are rare and unique.
- RR galaxies have very **similar optical properties** as control galaxies. The main differences are that they have a very **high central fraction (~90%)** and tend to locate in **lower density environment** compared to control galaxies.
- The HI radius of RR galaxies is about 4 times of their optical radius on average
- 20% of RR galaxies show faint **extended structures**, implying an extended rotating HI disk

Backup

20% of RR galaxies s

Images

