# Splashback radius of clusters in the HSC survey

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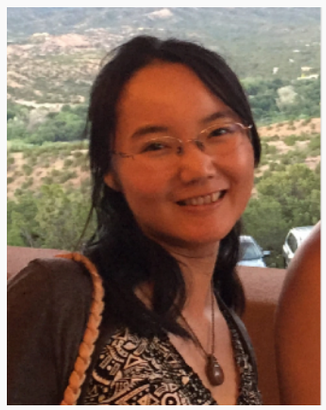
# Reference

- “The Splashback Radius of Optically Selected Clusters with Subaru HSC Second Public Data Release” **arXiv:2001.01160**

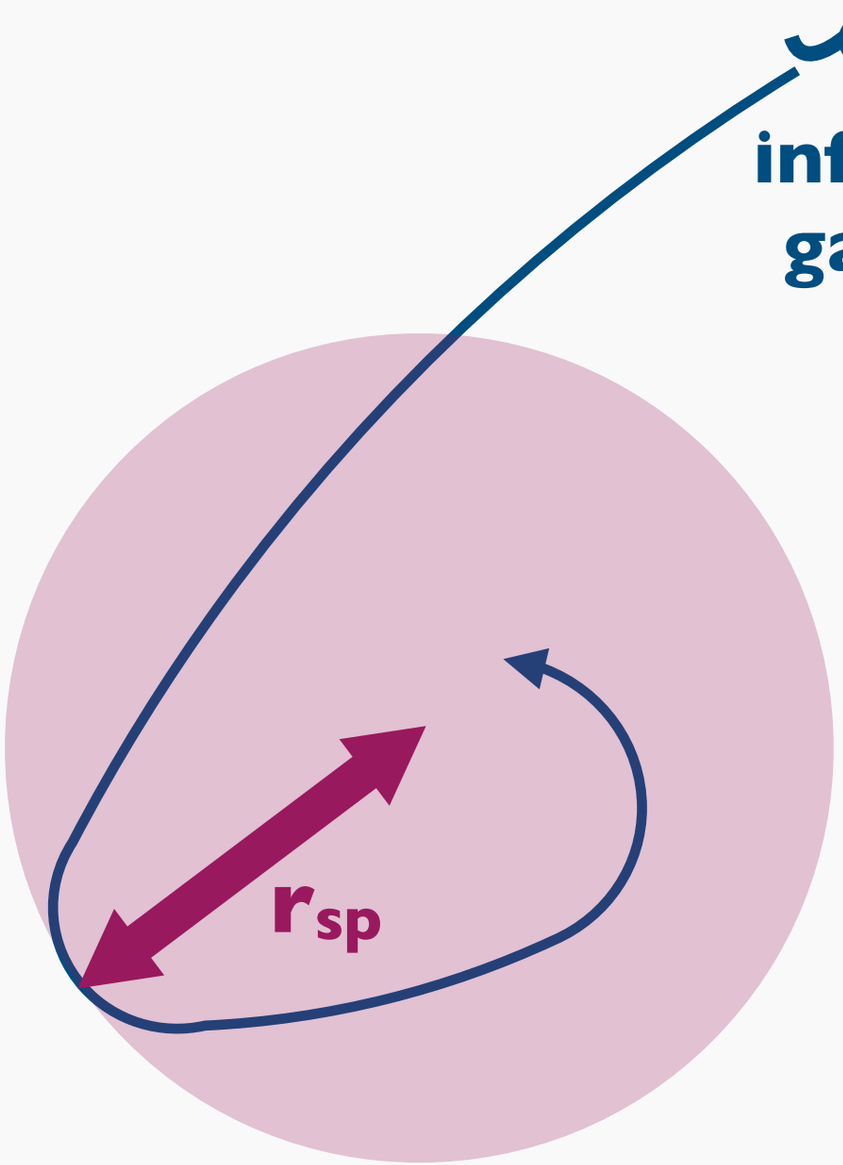
  R. Murata, T. Sunayama, MO, S. More, A. J. Nishizawa, T. Nishimichi, & K. Osato

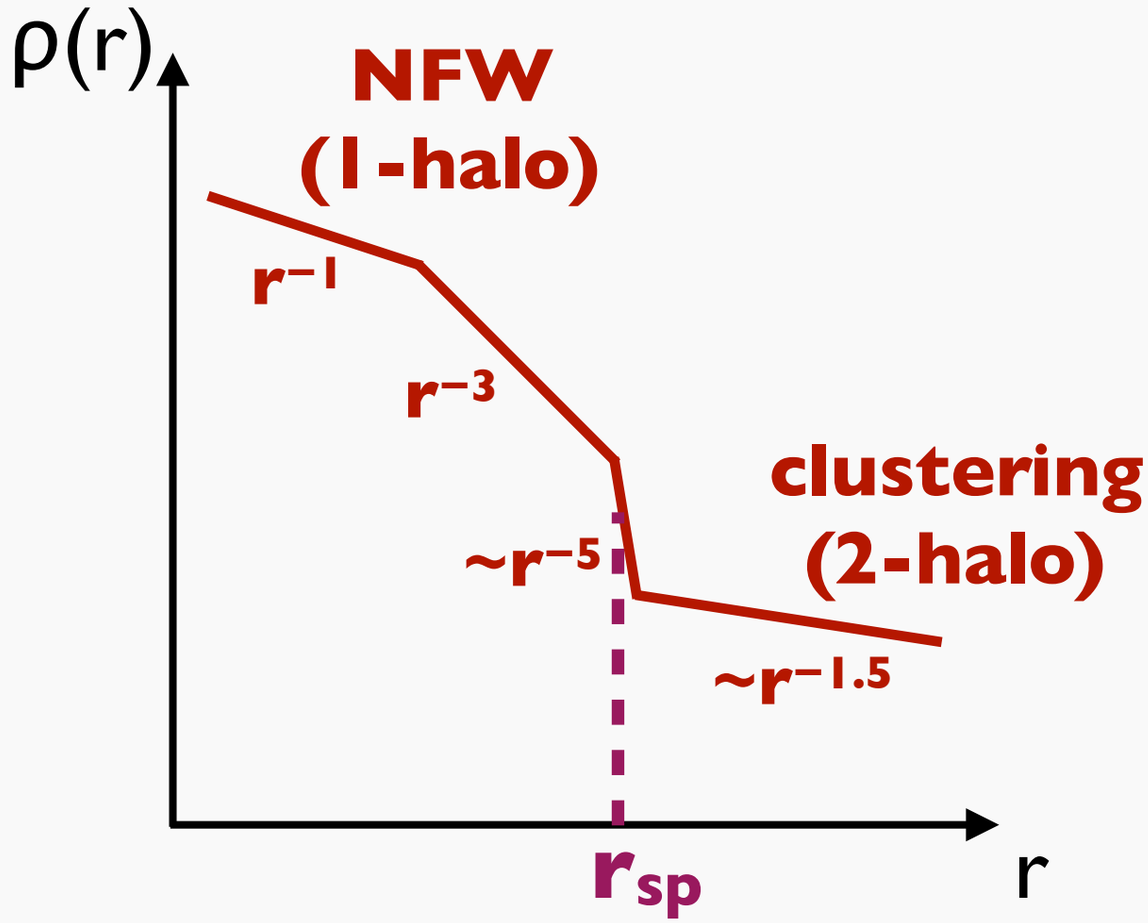
  [**Ph.D. student**] [**B03**] [**B02**] [**B03**]



e.g., Diemer & Kravtsov 2014; Adhikari+2014; More+2015

# Splashback radius ($r_{sp}$)

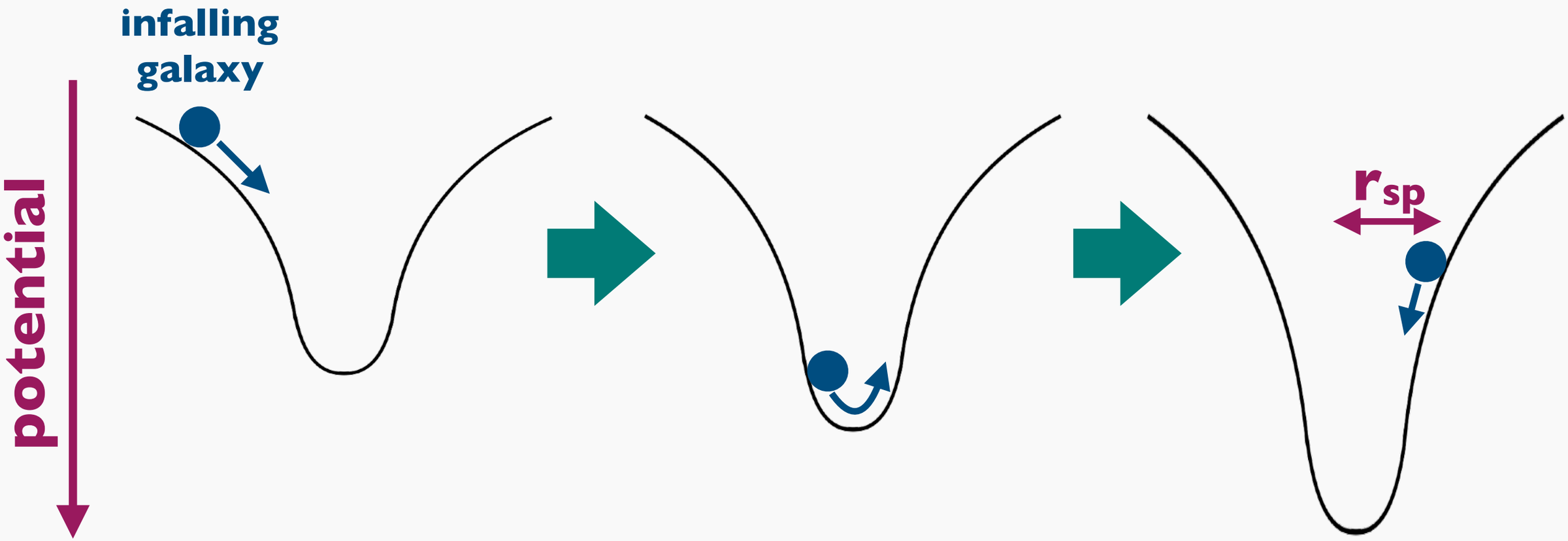



- first apocenter after infall
- sharp drop of ρ(r)
- physical halo boundary

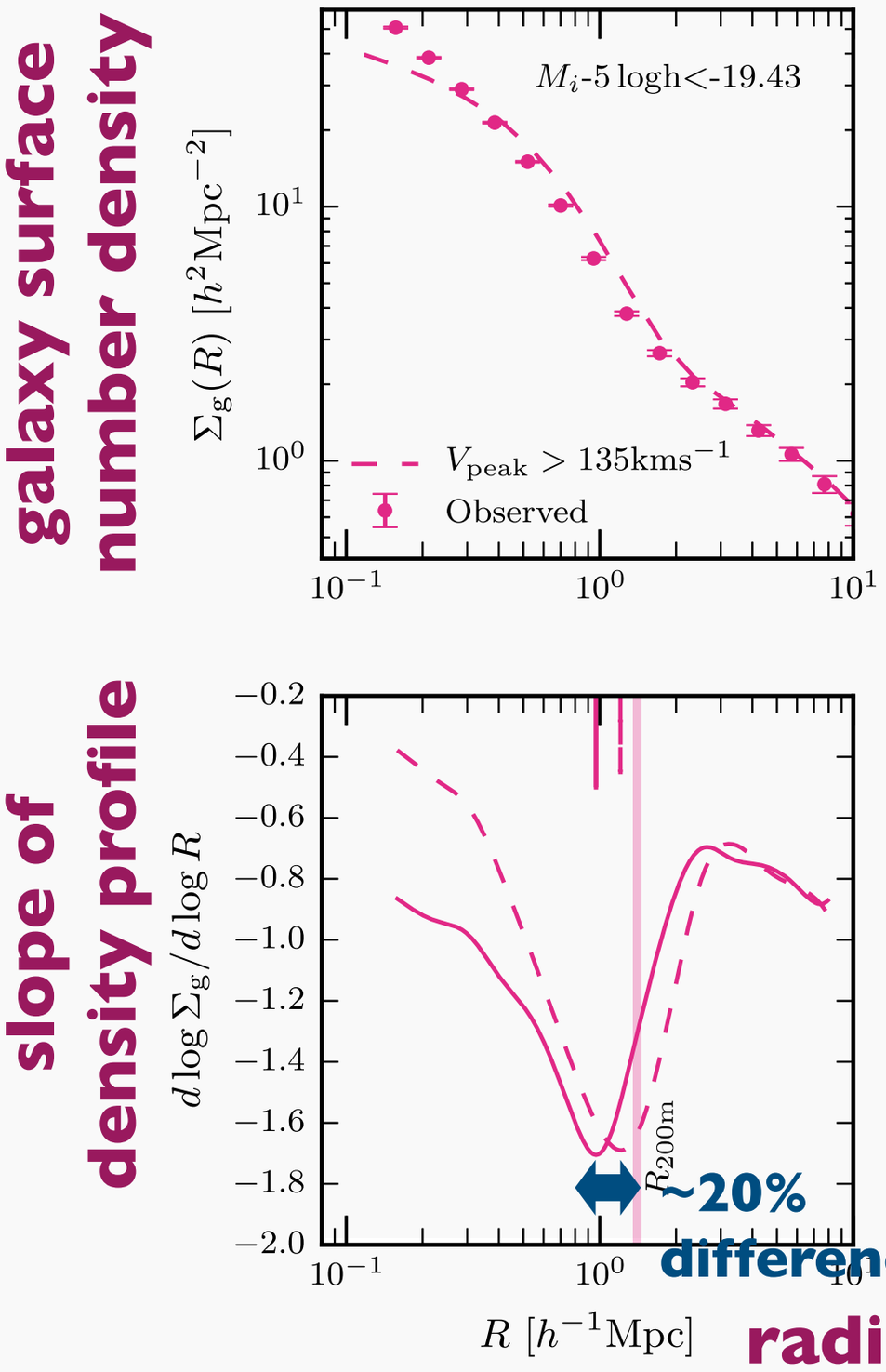
e.g., Fillmore & Goldreich 1984

# Basic physics




- "splashback" due to change of the potential
- **$r_{sp}$ smaller for higher accretion rate**

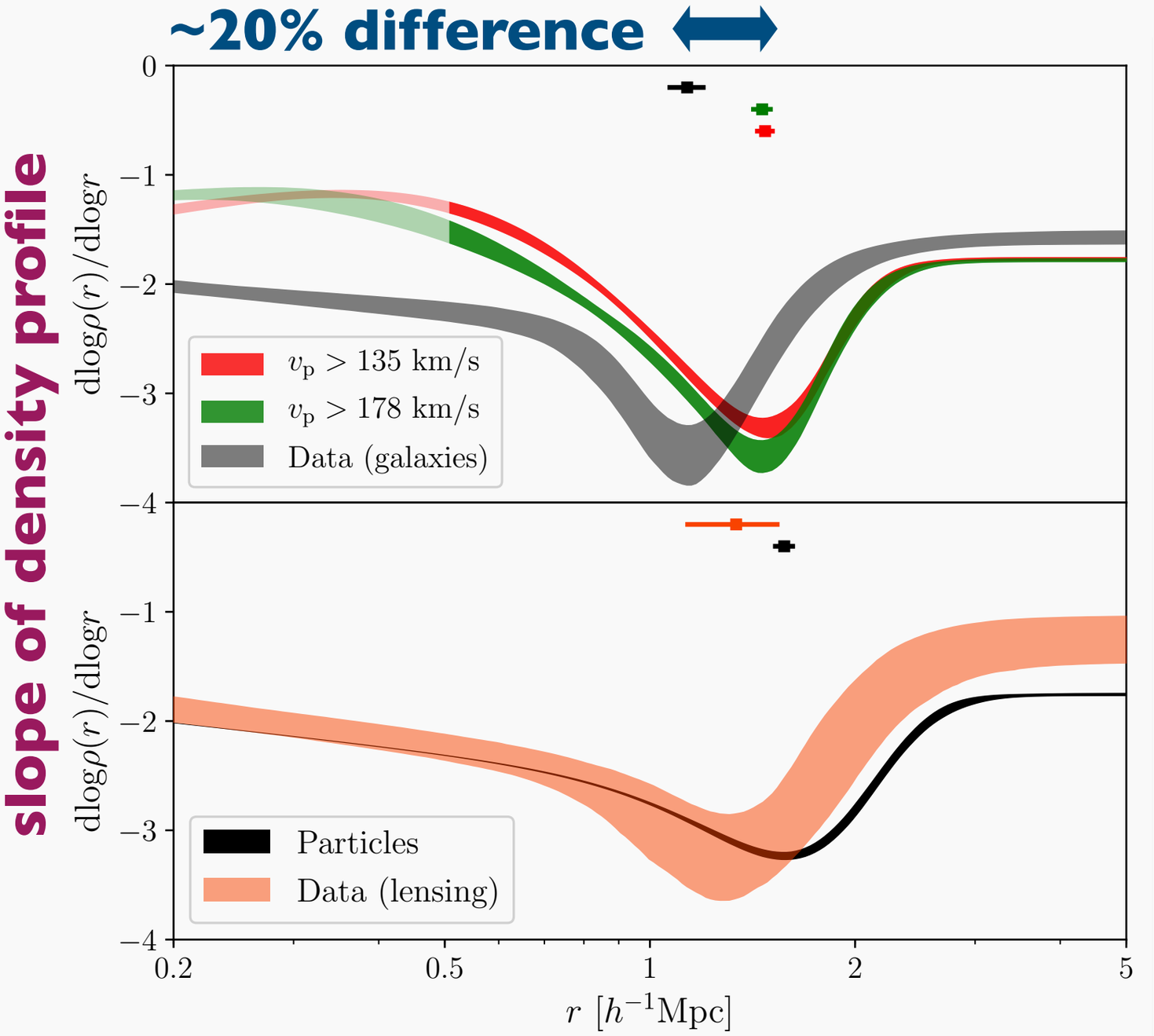
# First (high S/N) detection




- using SDSS data and redMaPPer cluster catalog
- ρ(r) from number density of galaxies around clusters
- $r_{sp}$ **smaller** than theoretical expectation by **~20%**

Chang+2018; see also Baxter+2017, Shin+2019

# More measurements



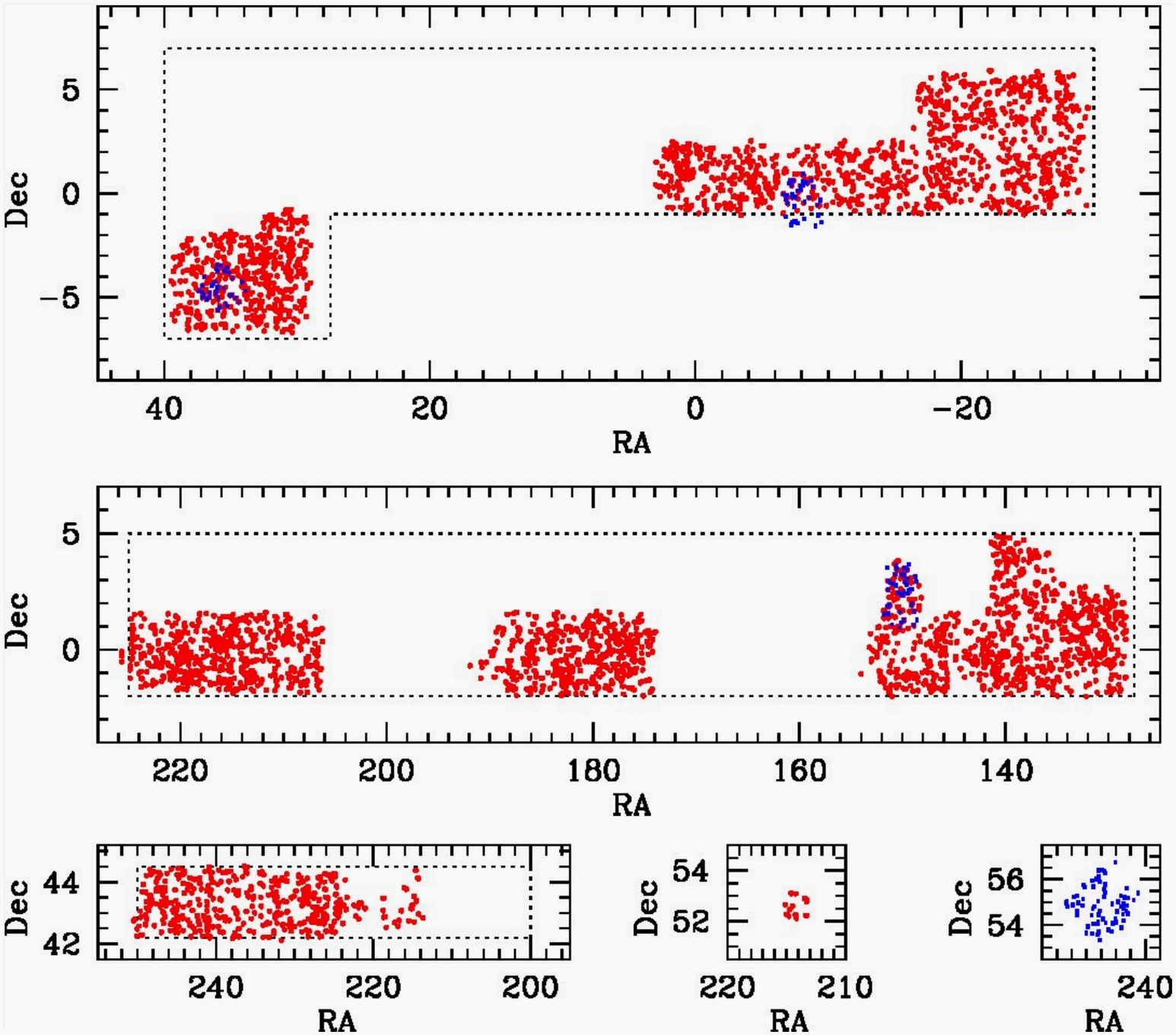

- using DES data and redMaPPer cluster catalog
- $r_{sp}$ **smaller** than theoretical expectation by **~20%**
- detected also by lensing

# Why $r_{sp}$ smaller than expected?

- **new physics?**
  self-interacting dark matter? (Banerjee+2019)
  dark energy? (Adhikari+2018)

- **systematics?**
  optical cluster selections from overdensity of galaxies may cause selection effects

# Measurements in the HSC survey

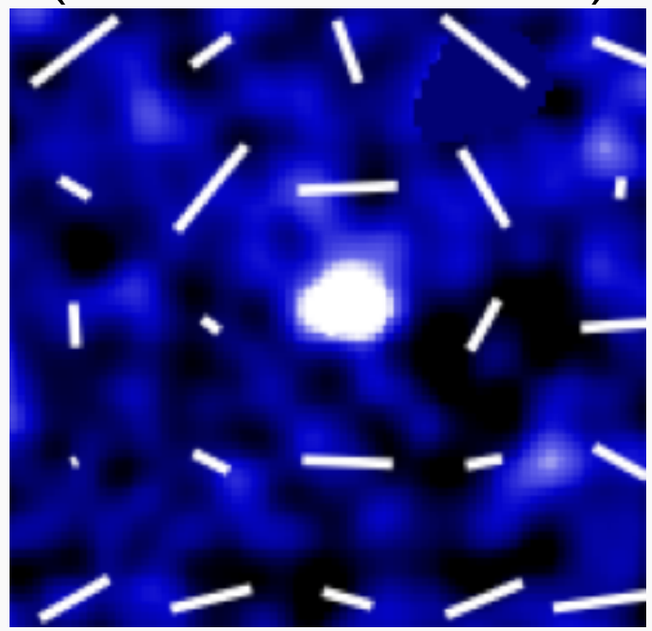



- **3316** clusters at **0.1<z<1** selected by **CAMIRA** (MO 2014; MO+2018)
- area ~427 deg$^2$

# Analysis procedure

**stacked weak lensing**

(Murata, MO+2019)



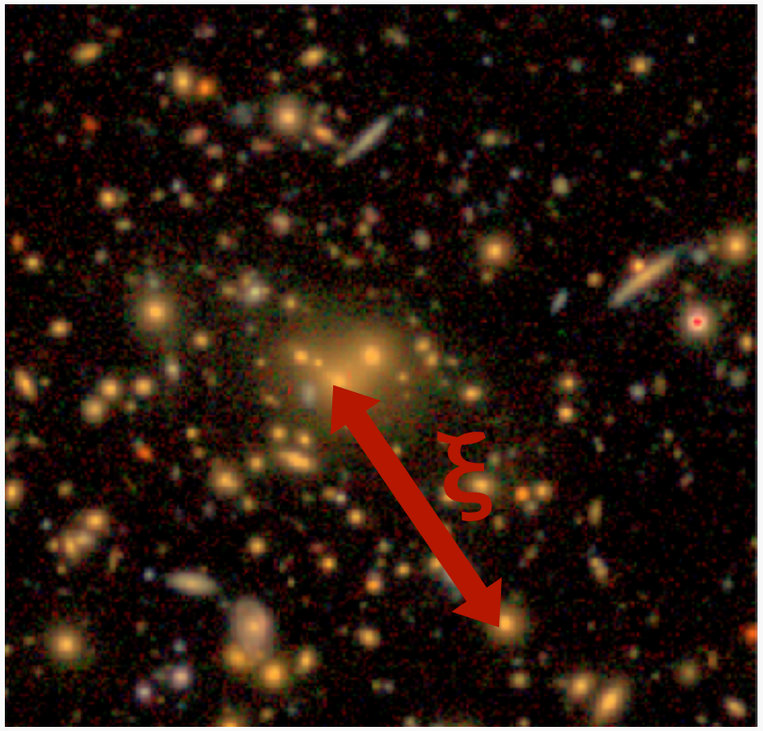
**compare**

$r_{sp,obs}$ ⟷ $r_{sp,model}$

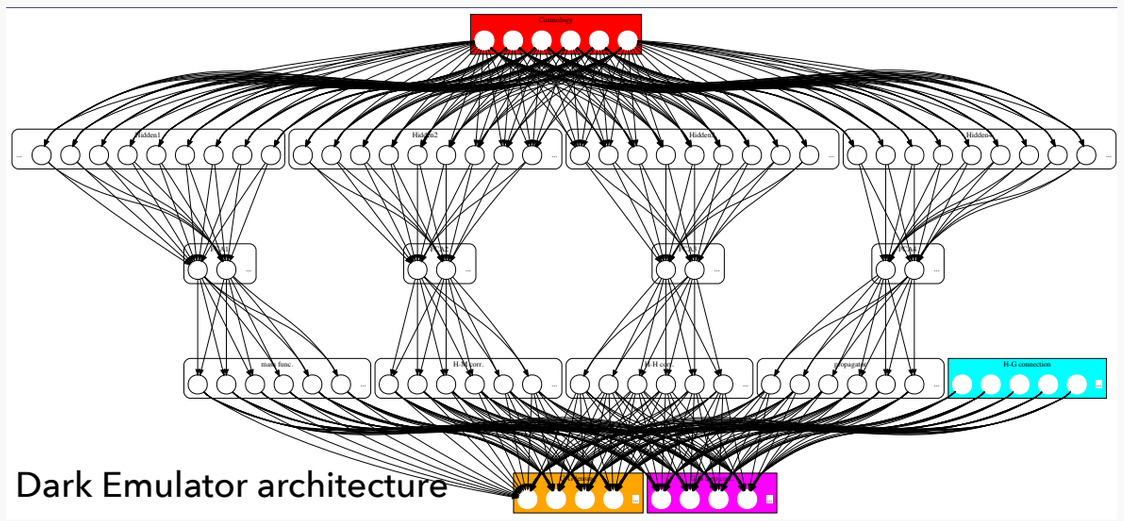
$\xi_{obs}$

$\xi_{model}$

**P(N|M)**




**cluster-galaxy 2-point correlation function**

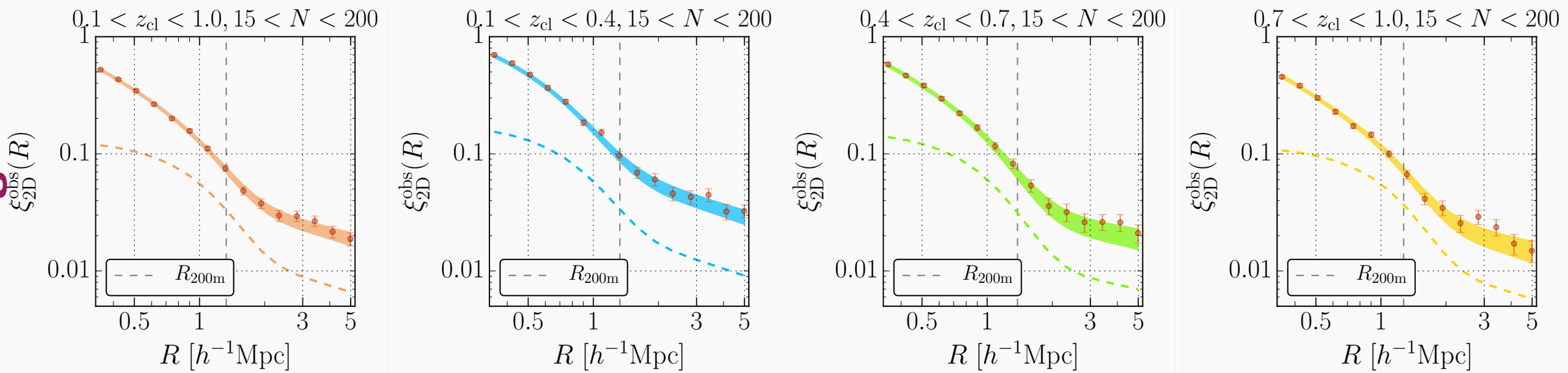



**Dark Emulator** (Nishimichi+2019)

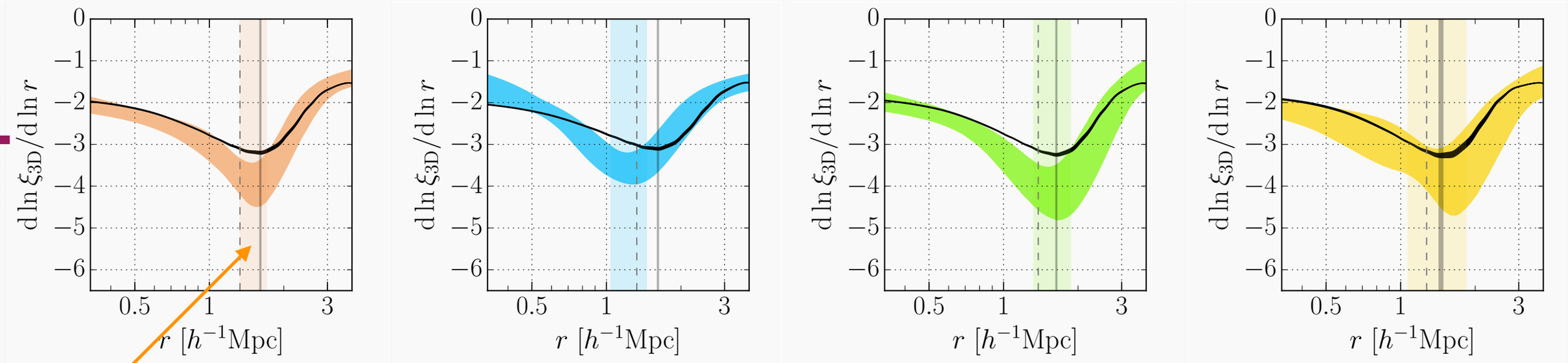
# Measurement of $r_{sp,obs}$

**all z** | **low-z** | **mid-z** | **high-z**

**cluster-gal 2PCF**




**slope**




**$r_{sp,obs}$**

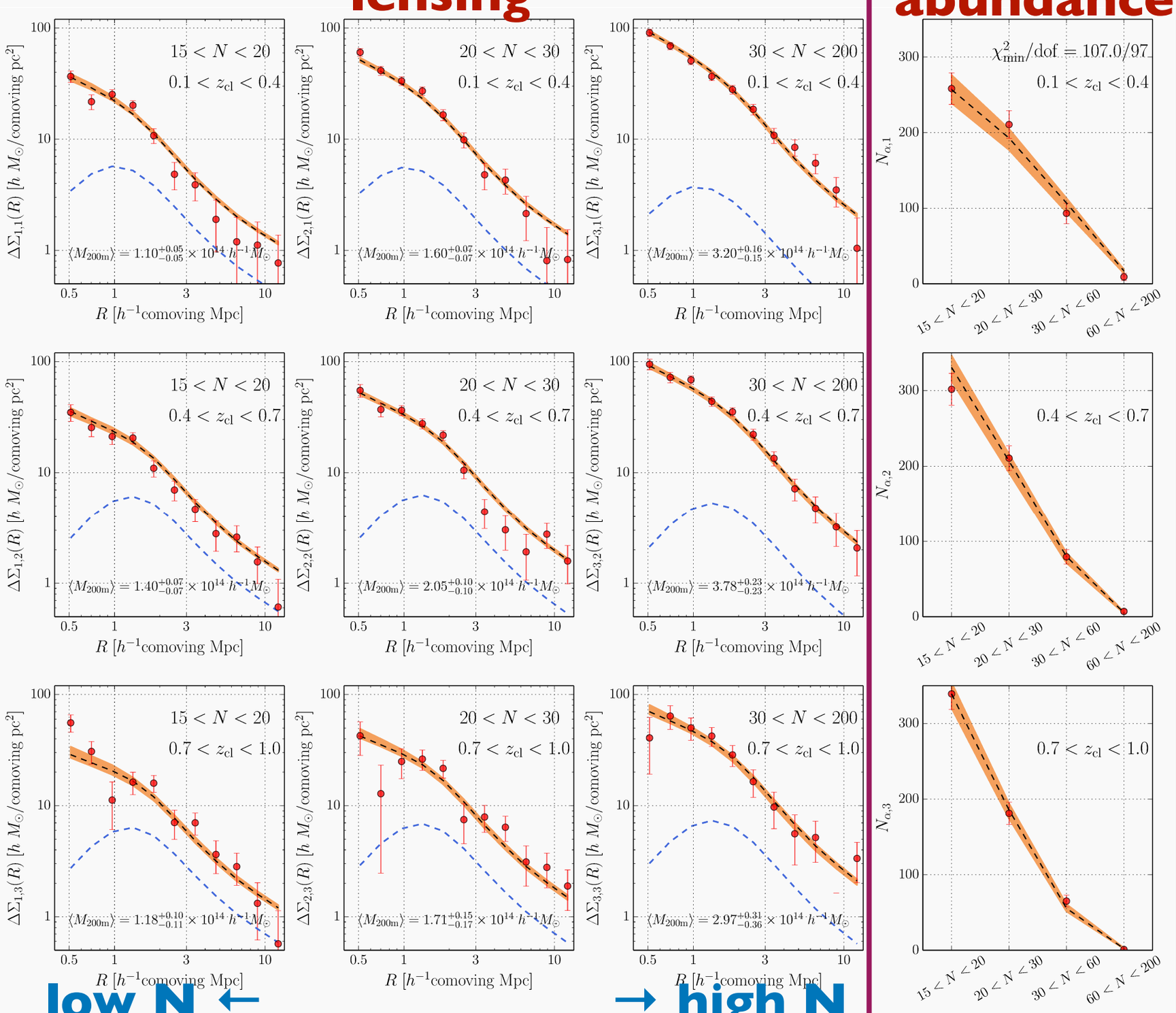
**detection at high-z!**

Murata, MO+ PASJ **71**(2019)107

# Mass calibration w/ weak lensing

**lensing** | **abundance**

→ low z



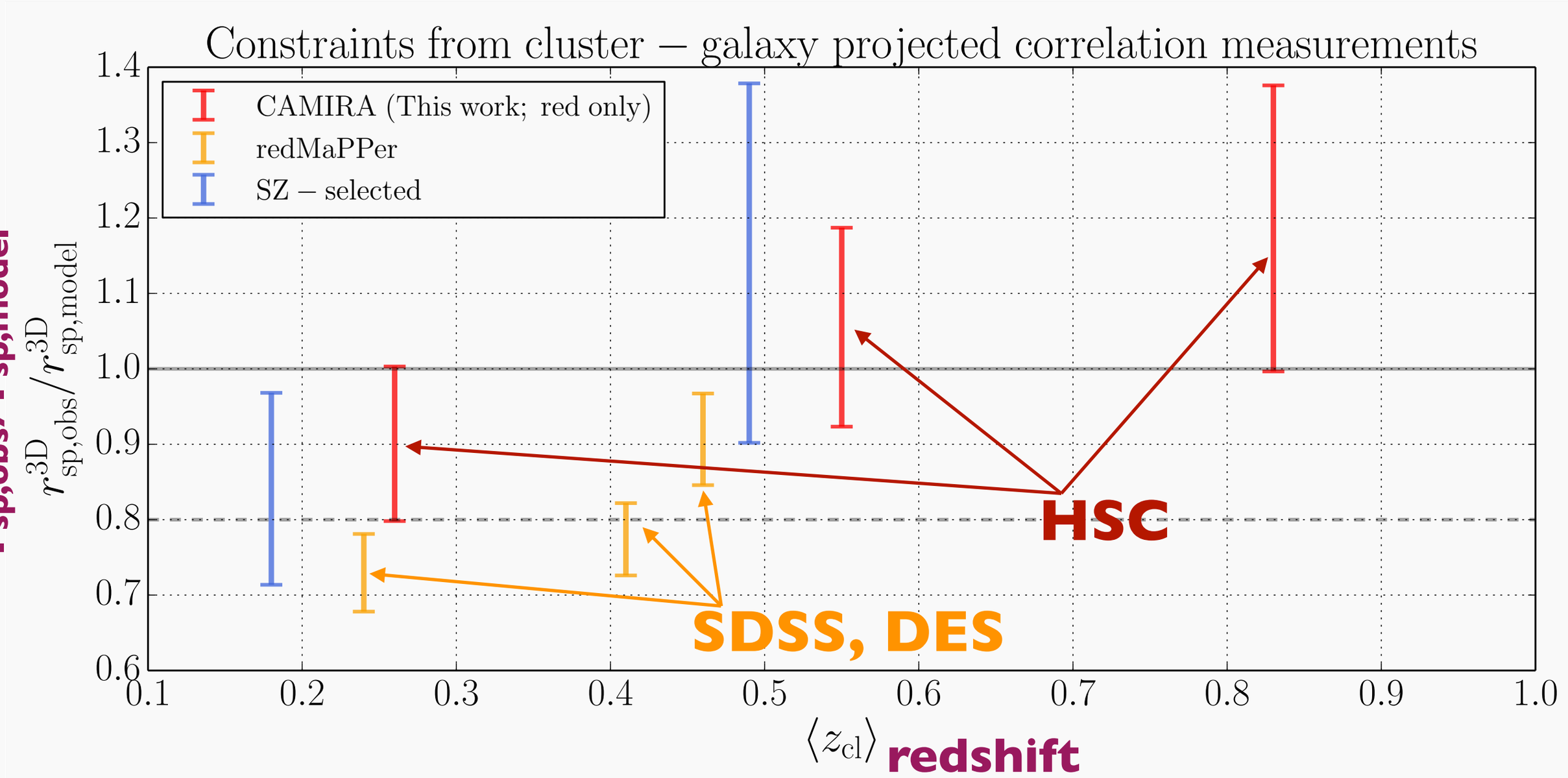

high z ←

low N ←

→ high N

richness (N) – mass (M) relation **P(N|M)** for a wide redshift range

# Result




- highest redshift detection
- $r_{sp}$ **consistent** between observation and theory

# Why?

## SDSS/DES

**redMaPPer** (Rykoff+2014)

red-sequence method

**N-depend.** filter size

(**$R_c$~0.7Mpc/h** for N=20)

**global** background subt.

## HSC

**CAMIRA** (MO 2014)

red-sequence method

**N-independ.** filter size

(**$R_c$~1Mpc/h**)

**local** background subt.

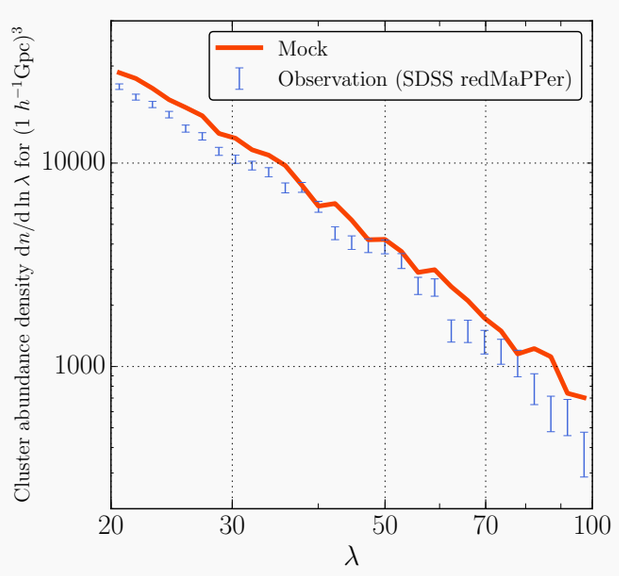
different systematics due to
different cluster finding method??

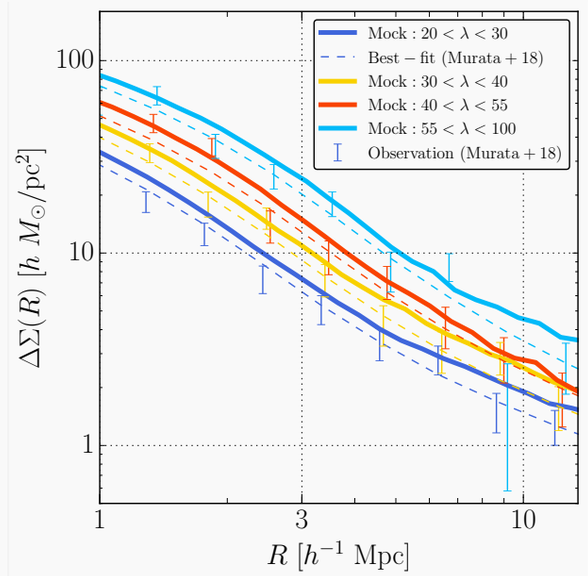
see also Sunayama & More 2019; Sunayama+2020

# Mock analysis

N-body simulations → populate galaxies (HOD) → **CAMIRA** or **redMaPPer** "cluster finding" in mock → mock obs. of $r_{sp}$

**abundance** and **lensing** consistent with obs.

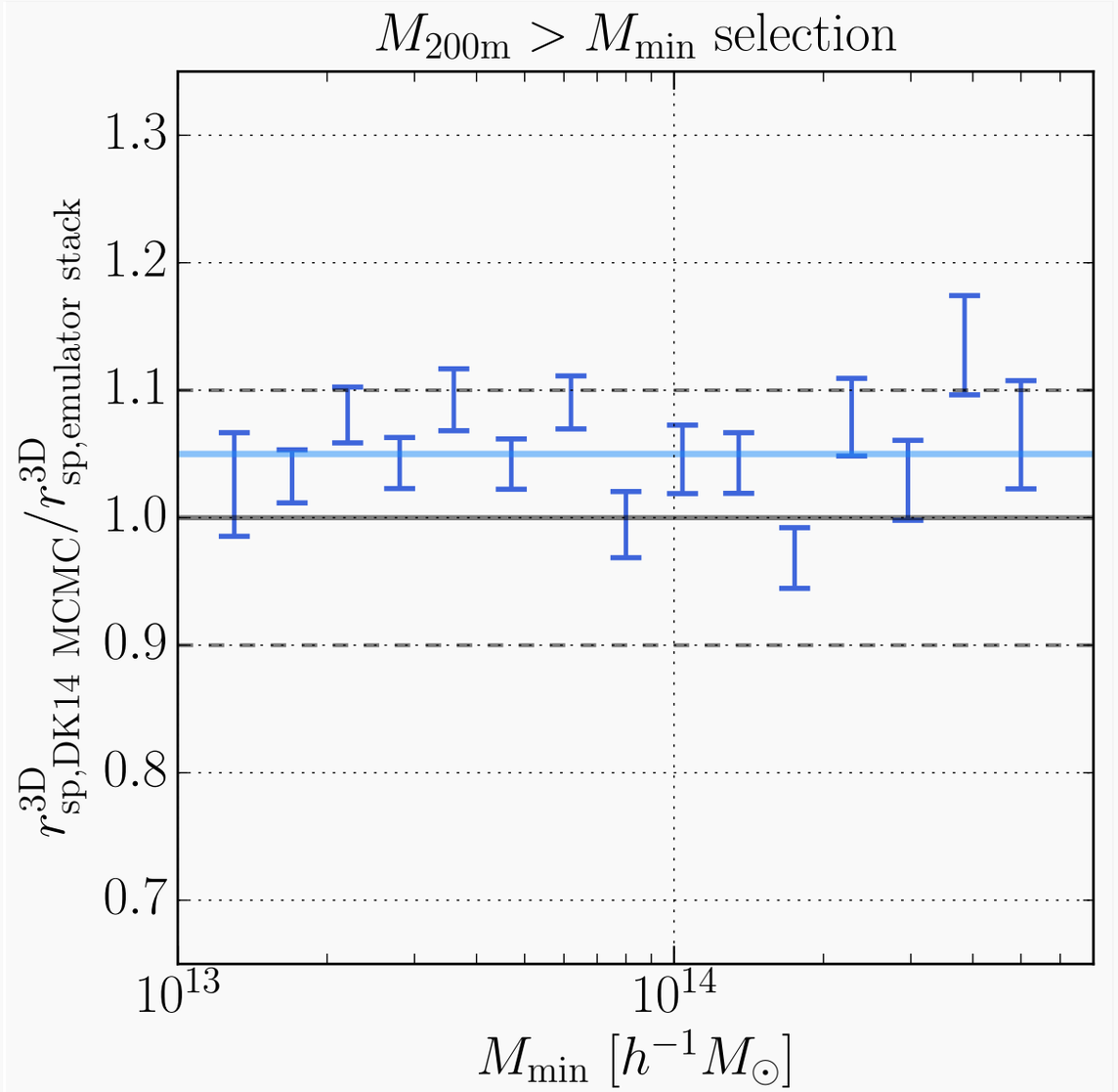


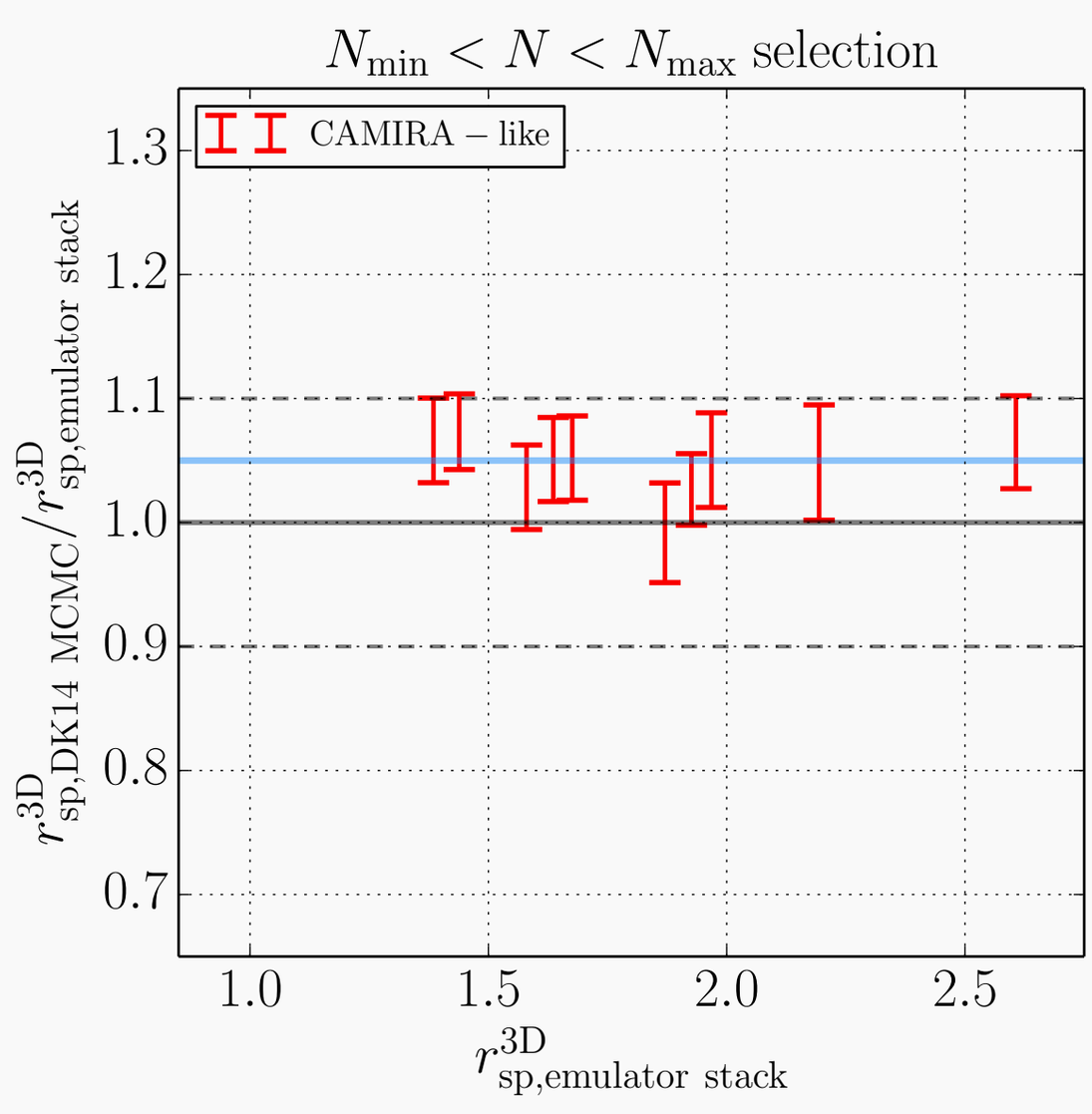
# Mock result: CAMIRA

**$r_{sp,obs}/r_{sp,model}$**

## mass selection



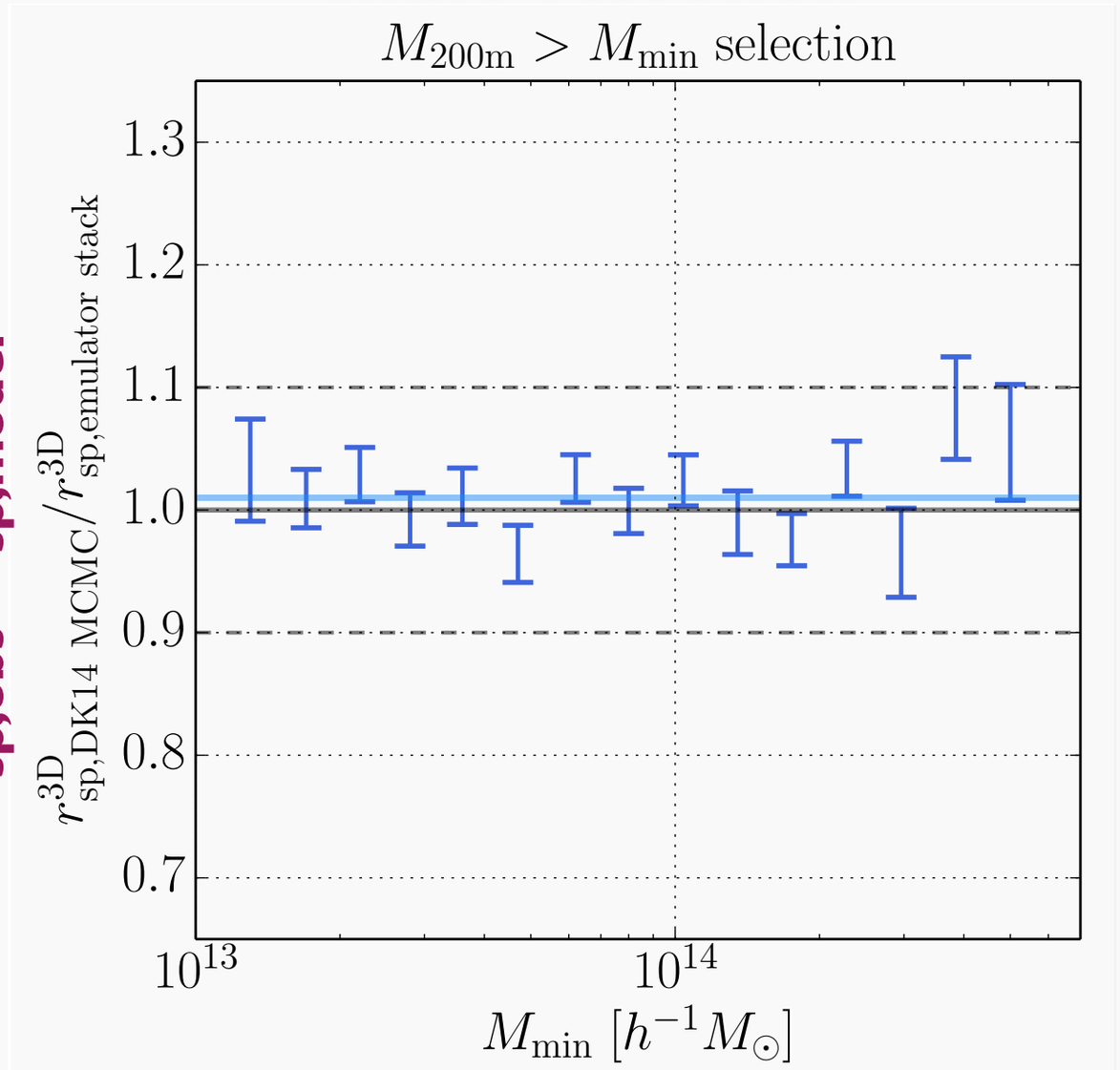

## richness selection



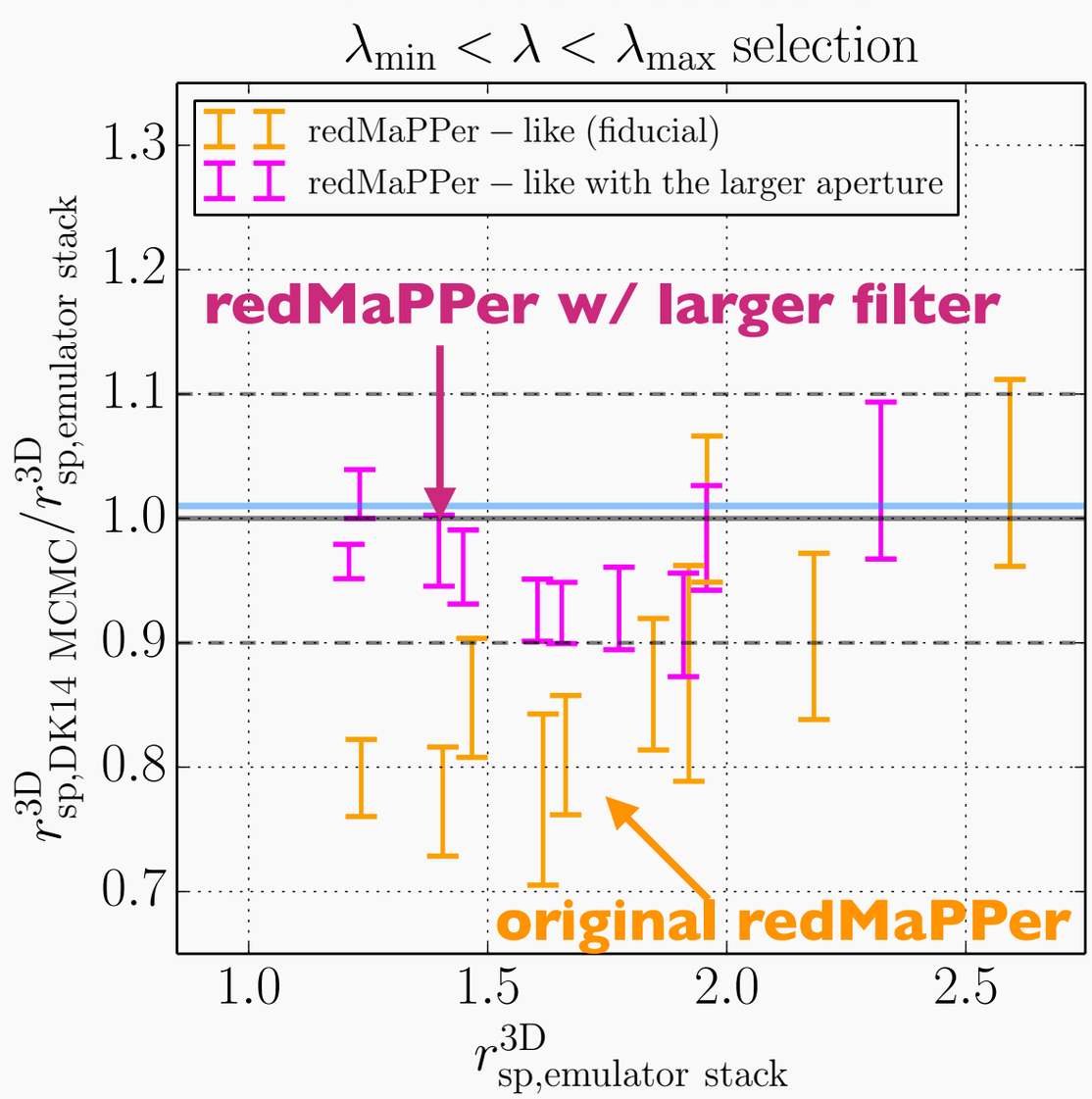

- systematics on $r_{sp}$ **negligibly small**

# Mock result: redMaPPer

**mass selection**




**richness selection**




- **~20%** bias (similar to obs!) on $r_{sp}$ for original setup
- bias reduced for larger radial filter size

Murata, Sunayama, MO, More+ arXiv:2001.01160

# Summary

- HSC measurements of splashback radius $r_{sp}$ out to z~1 using CAMIRA clusters
- consistent with theoretical expectation
- mock analysis indicates that ~20% smaller $r_{sp}$ previously found was due to systematics associated with redMaPPer cluster finder
- with better understanding of systematics, we can use $r_{sp}$ as a useful cosmological probe in the future!