The KIAS Redshift Survey of Nearby Galaxy Groups and Clusters with MMT/Hectospec

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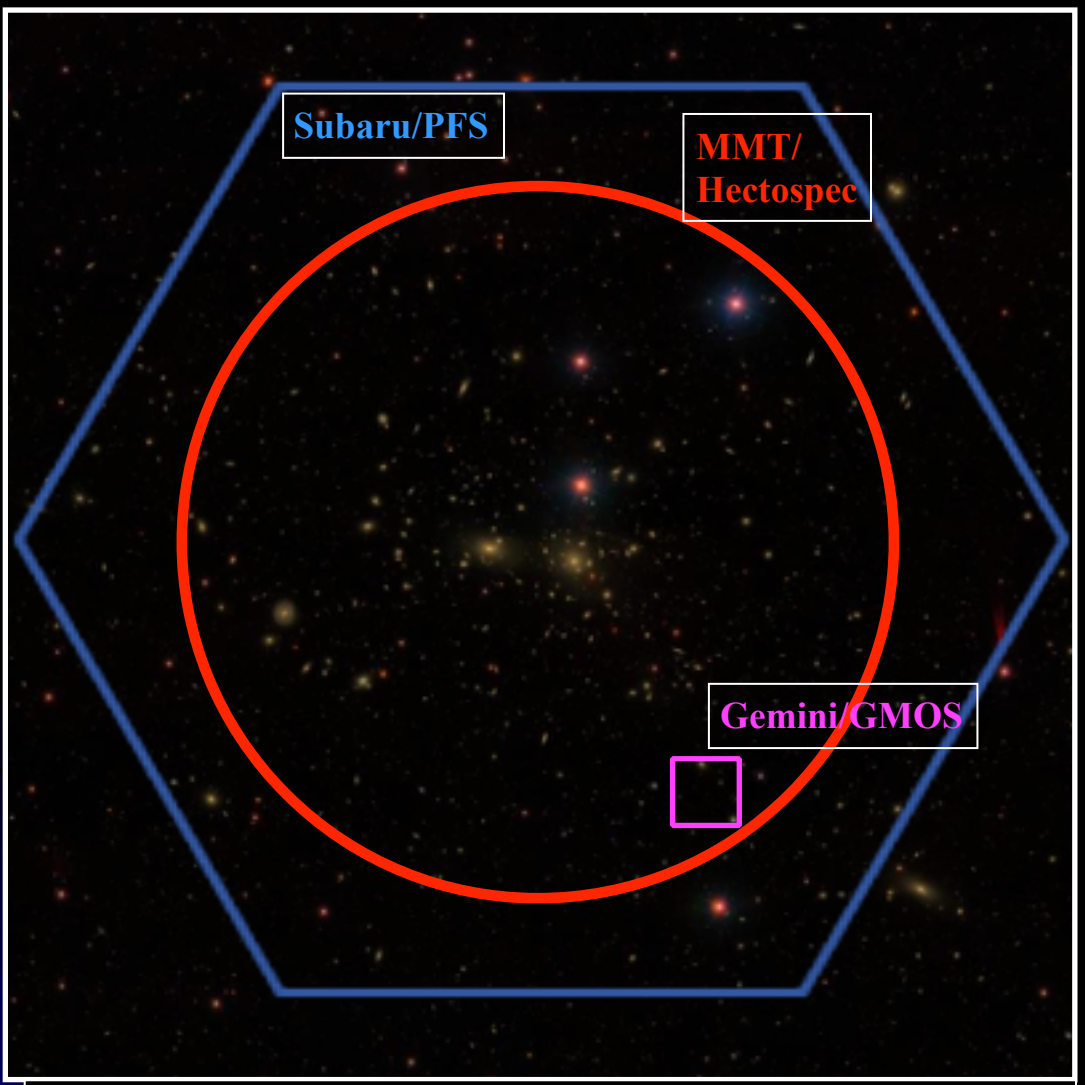
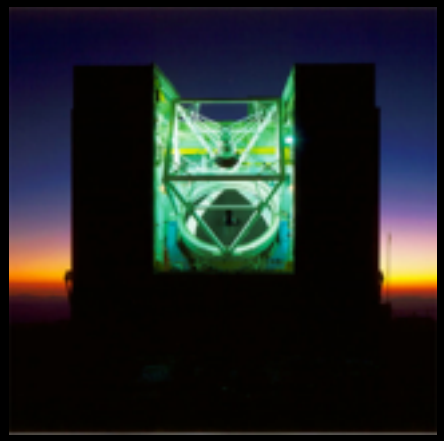
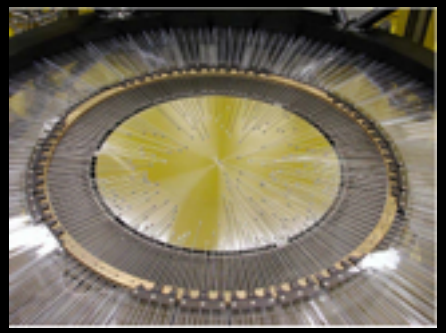
K-GMT Science Program Users Meeting 2019

KASI 한국천문연구원
Korea Astronomy & Space Science Institute



Coma Cluster 1.5 deg x 1.5 deg (r_{vir}=1.56 h^{-1}Mpc=1.3 deg, SDSS)





➢ 6.5m on Mount Hopkins, Arizona, USA

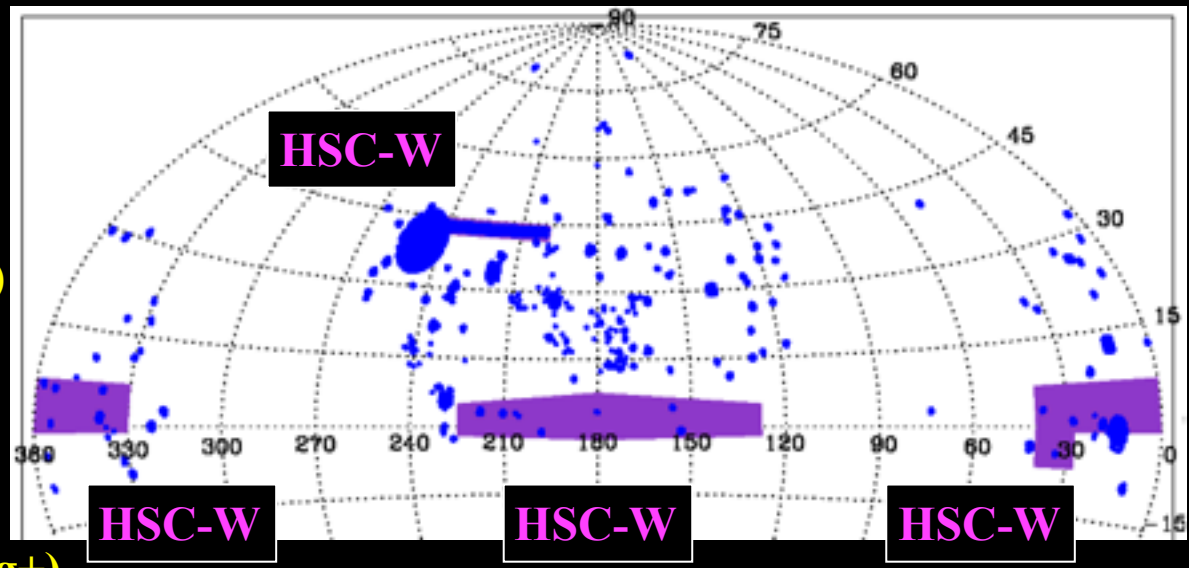
➢ 300 fibers (2" diameter) with 1 deg diameter FOV:
R ~ 6 Mpc at z~0.2;
ideal for studying the infall region of clusters

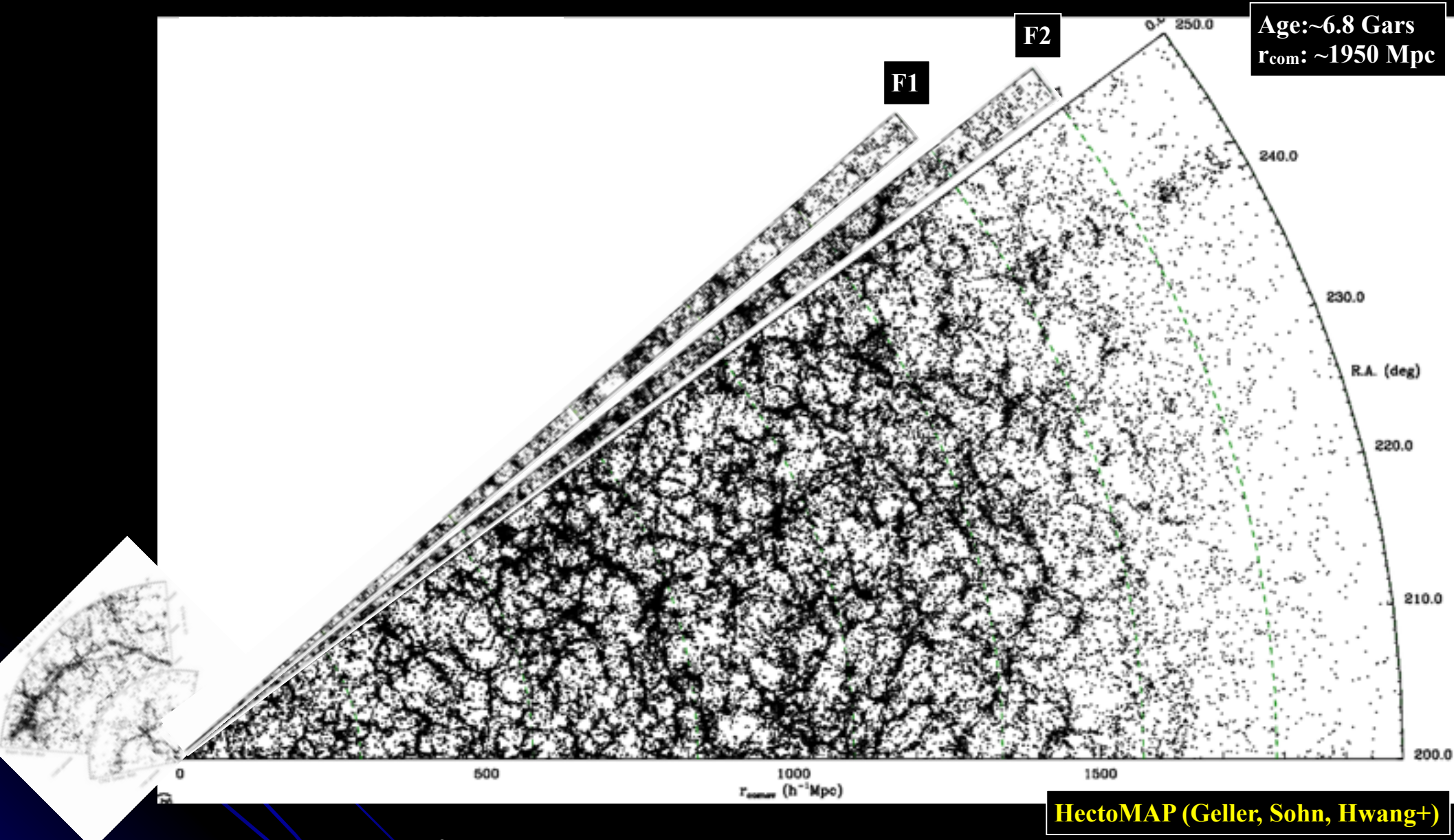
➢ Wavelength:
365 - 920nm with R~1000 (cz_{error}~30 km s^{-1})

➢ Observe galaxies at r<21.5 with 0.5-2 hour exp.:
Well combined with the SDSS photometric data

Redshift Surveys of Galaxy Clusters (CfA+KIAS+KASI)

- **CfA**
  - HeCS series
    - 0.1<z<0.3
    - 35,000 MMT redshifts for ~110 clusters + SDSS DR12
      - HeCS (Hectospec Cluster Survey, Rines+13)
      - HeCS_SZ (Rines+16)
      - HeCS_Red (Rines+17)
      - HeCS_WL (Hwang+14; Liu+18)
      - CIRS (~70 clusters at 0.003<z<0.1)
  - Clusters in F1/F2/HectoMAP
- **KIAS**
  - Galaxy Groups
    - 5+1 nearby ETG/LTG-host satellite systems (ParkC+2018)
  - Nearby Galaxy Clusters
    - A520 at z=0.20 (Deshev+2017)
    - A2199 at z=0.03 (SongH+2017)
    - A2107 at =0.04 (SongH+2018)
    - Coma Cluster at z=0.023 (Hwang+)
    - Perseus Cluster at z=0.018
- **KASI**
  - Galaxy clusters with diverse dynamical stages
    - A2261 at z=0.224 (KimH+)





- HectoMAP (53 deg^2, Geller+11, Geller & Hwang 15, Hwang+16)
  - ~62,000 redshifts: One of densest and complete survey of red galaxies at r<21.3 (~104,000 redshifts in total)
- F1 (Geller,Hwang+14): 4 deg^2, ~10,000 redshifts
- F2 (Geller,Hwang+16): 4 deg^2, ~16,000 redshifts (R<20.6 w/o color selection)

Redshift Surveys of Nearby Galaxy Systems

- Nearby Galaxy Groups
  - 5+1 nearby ETG/LTG-host satellite systems (ParkC+2018)
    - Demise of faint satellites around isolated early-type galaxies
- Nearby Galaxy Clusters
  - A520 at z=0.20 (Deshev+2017)
    - Galaxy Properties in Merging Clusters
  - A2199 at z=0.03
    - SongH+2017: Comparison of the Spatial and Kinematic distributions of Galaxies with the ICM
    - SongH, in prep.: Faint-end slope of cluster galaxy Luminosity Function
  - A2107 at =0.04 (SongH+2018)
    - Global Rotation of the Clusters and its Connection to Large-scale Structures in the Universe
  - Coma Cluster at z=0.023 (HwangHS, in prep.)
    - Comparison of Galaxy Distribution with Weak-lensing Maps
  - Perseus Cluster at z=0.018

1. Optical Luminosity Function in Galaxy Satellite Systems

1) Galaxy Satellite Systems

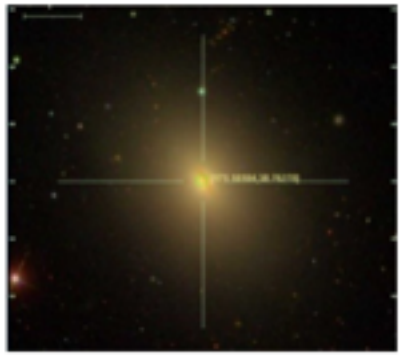
- ➢ **Radial Velocities of Satellites**
- ➢ **Derive Galaxy Halo Mass profile ⇒ Comparison with Simulations**

Table 1. Isolated early-type host galaxies selected in this work.

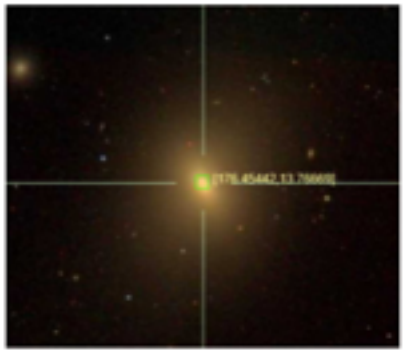
NGC	RA [deg]	DEC [deg]	z	D [Mpc][1]	m_r[2]	M_r	logM*/M⊙	T	r_{vir}[kpc]	$m_{r,lim}$[3]
2592	126.78354	25.97031	0.006825	26.3	12.205	-20.05	10.60	E2	346	20.38
3414	162.81754	27.97510	0.004903	25.7	10.918	-21.19	10.87	S0p	493	20.17
3665	171.18196	38.76279	0.006835	33.1	10.786	-21.85	11.22	S0	604	20.17
3872	176.45437	13.76668	0.010627	44.7	11.614	-21.77	11.30	E5	588	19.47
5363	209.02998	5.25503	0.003799	13.6	10.283	-20.45	11.22	E/S0p	393	17.77
5638	217.41823	3.23333	0.005591	26.5	11.178	-21.02	10.91	E1	468	20.09

NGC 2592
SDSS 1142165

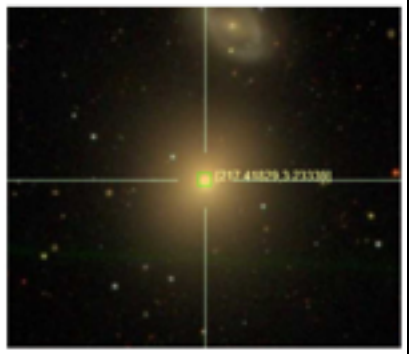
NGC 3414
SDSS 2204882



NGC 3665
SDSS 1317351



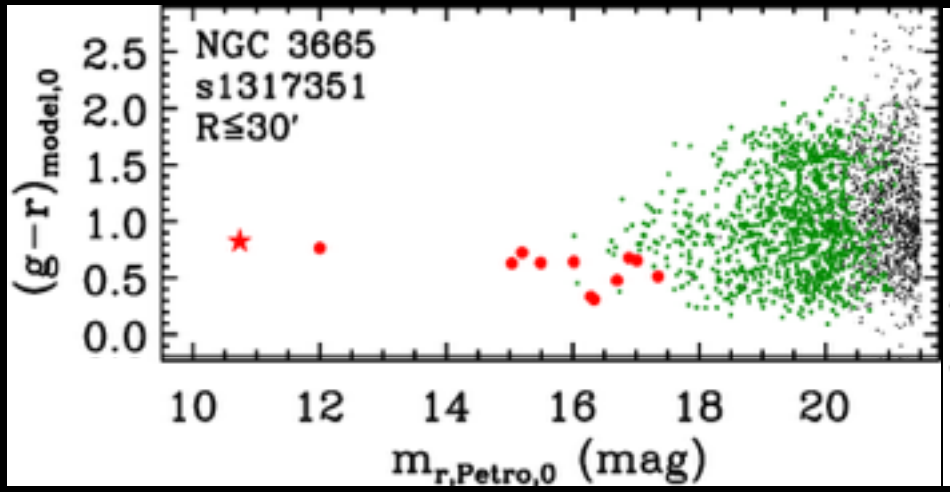
NGC 3872
SDSS 1122257

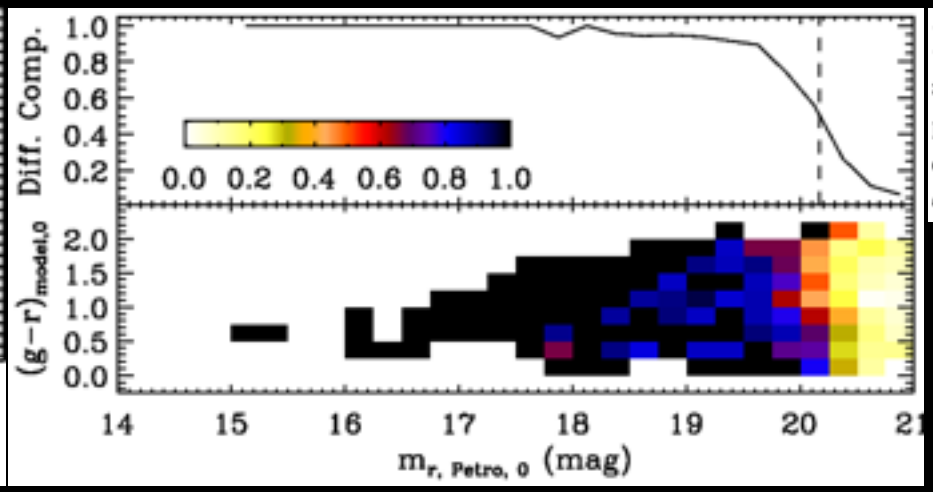


NGC 5638
SDSS 485766

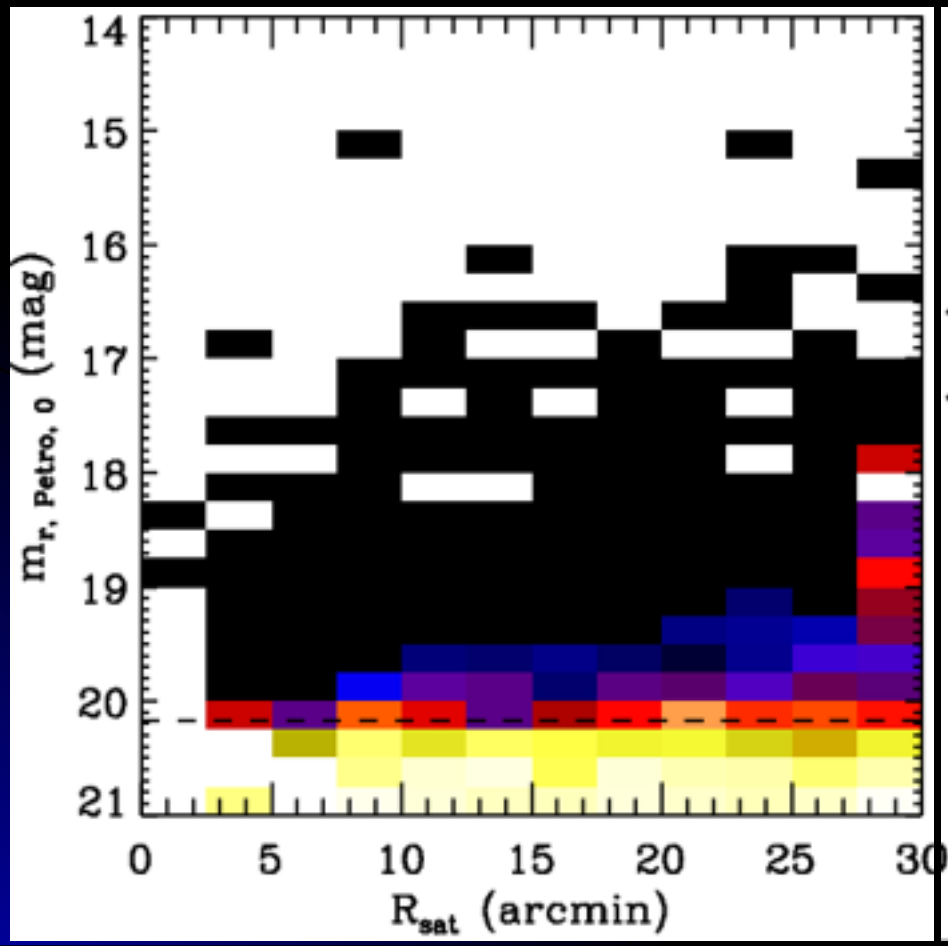
ParkC, HwangHS, ParkH, LeeJC+18

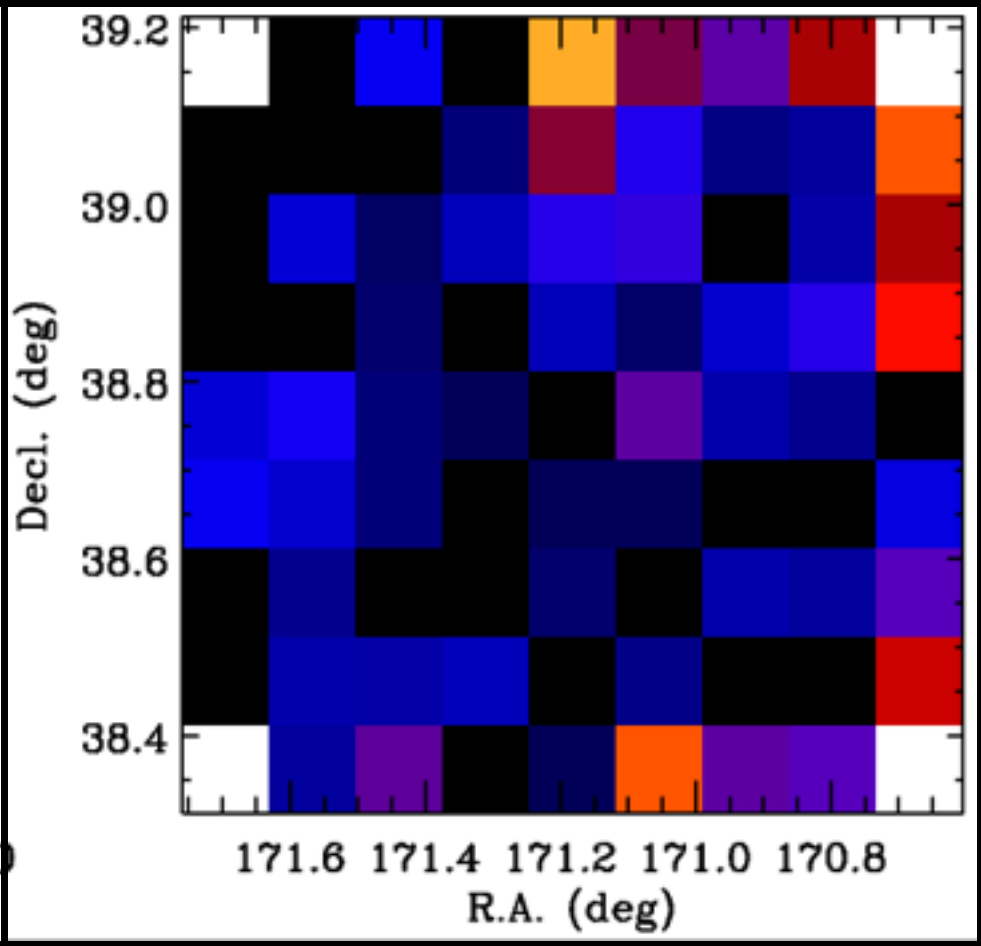
Galaxy Satellite Systems



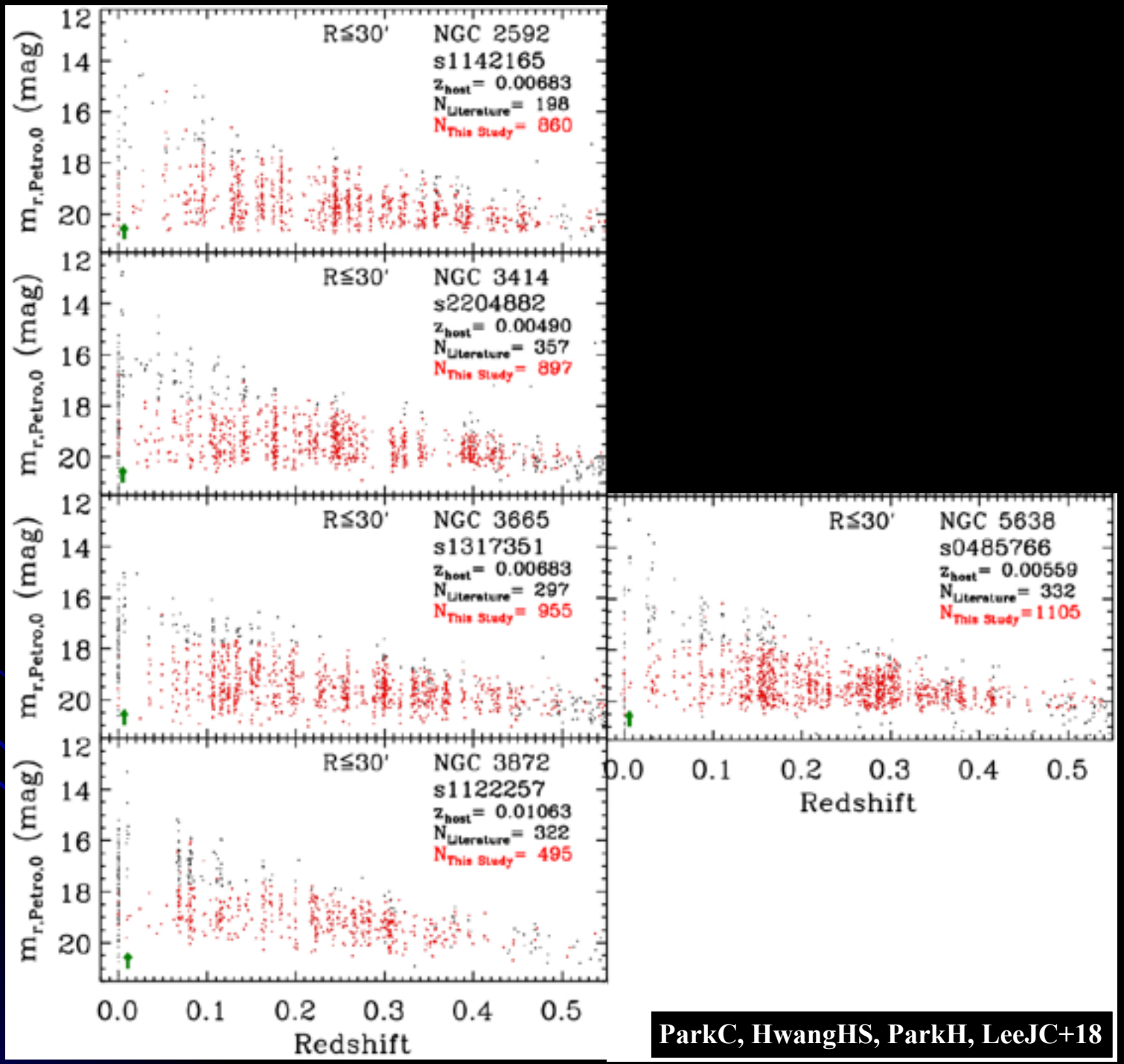


NGC 3665
s1317351
R≦30′
Cumulative Comp.=84%
at $m_{r,\ Petro,\ 0}$≦20.17





Galaxy Satellite Systems



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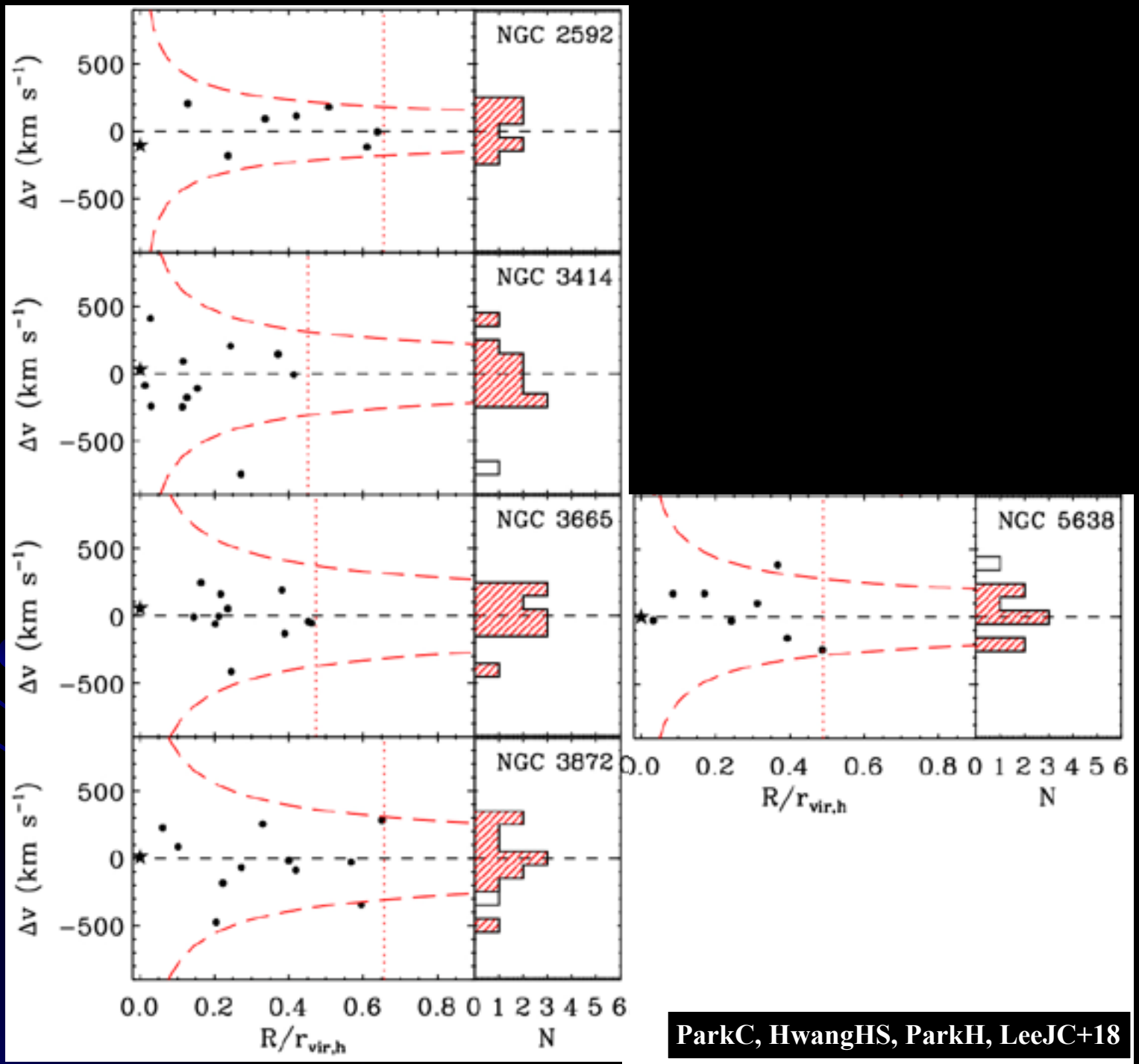
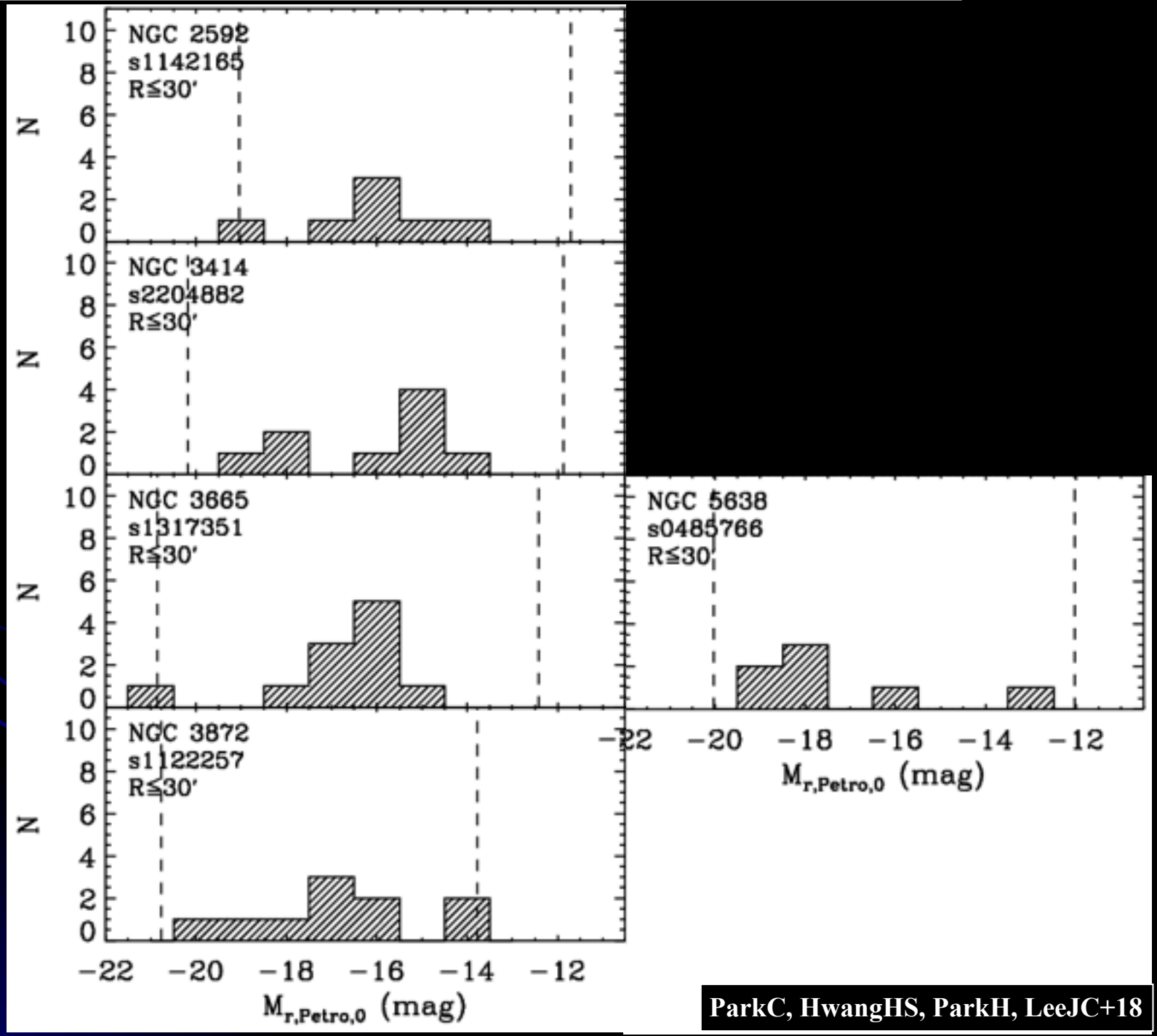
Galaxy Satellite Systems



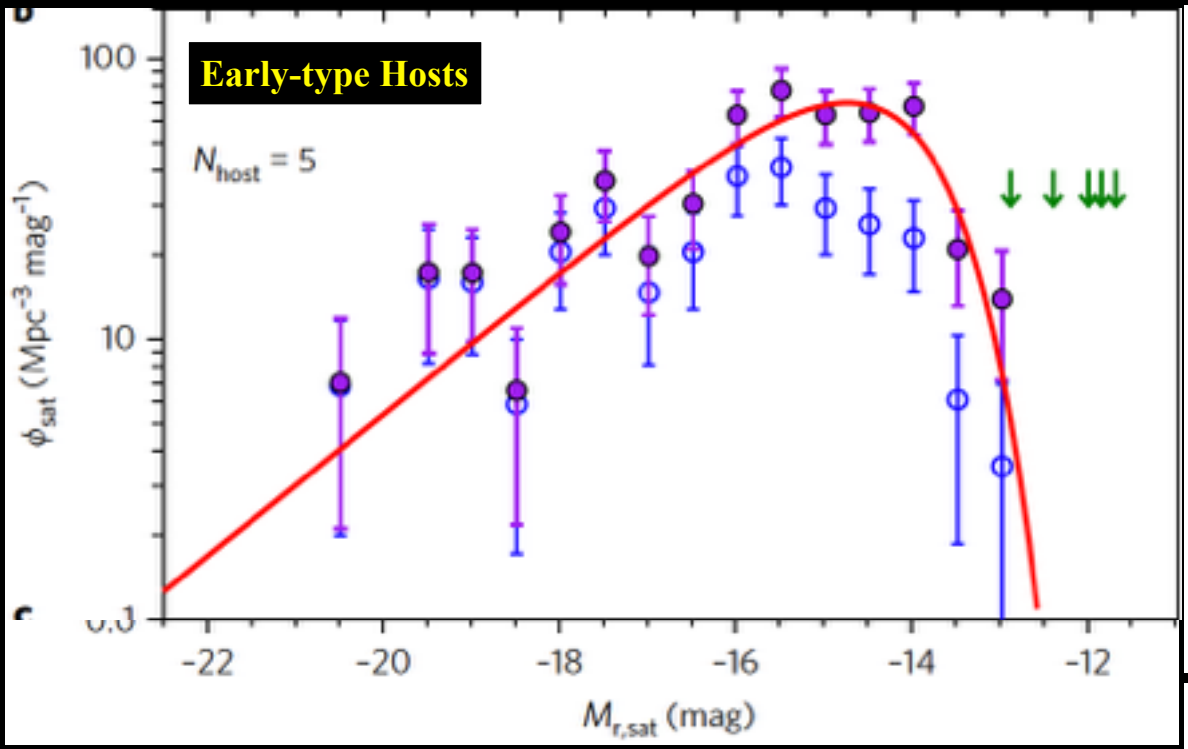
ParkC, HwangHS, ParkH, LeeJC+18

Galaxy Satellite Systems

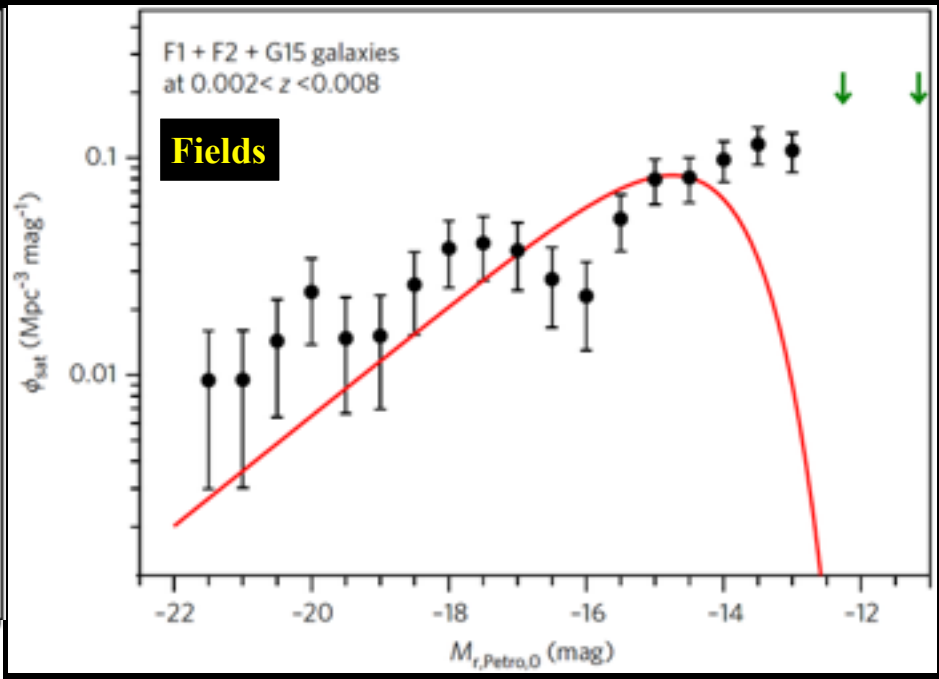


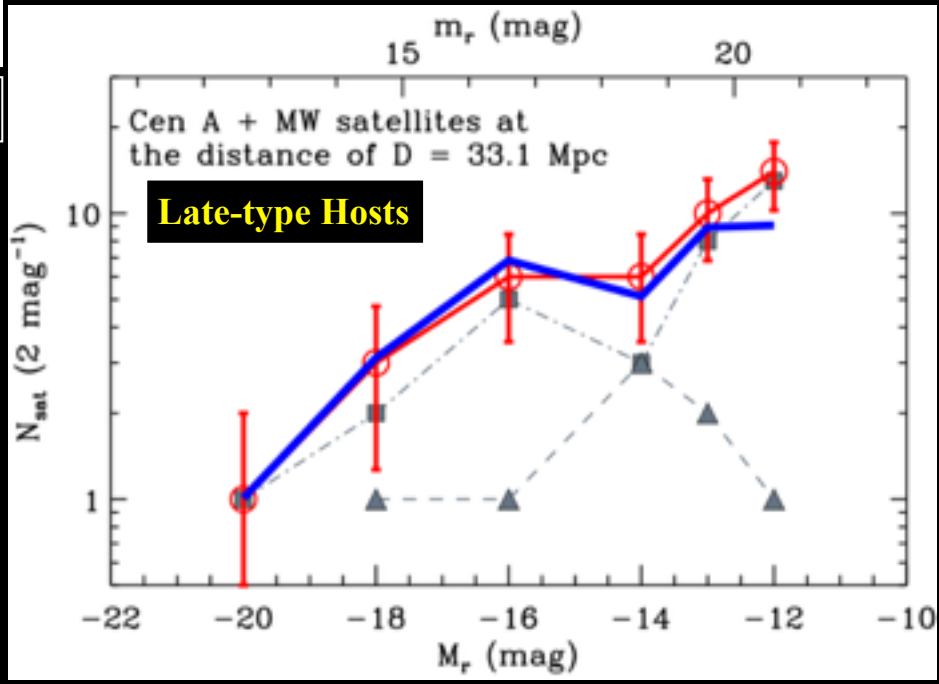
ParkC, HwangHS, ParkH, LeeJC+18

Galaxy Satellite Systems: Luminosity Function

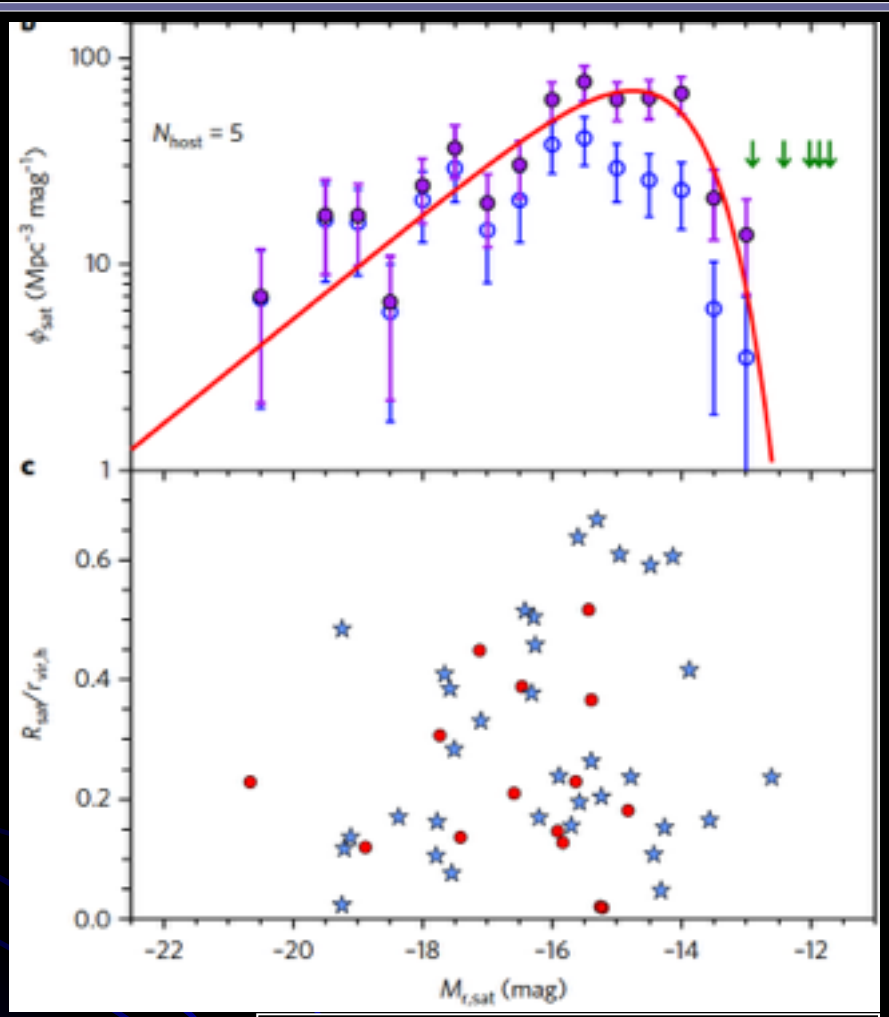


Cutoff at M_r~-14 (ParkC, HwangHS, ParkH, LeeJC+18)

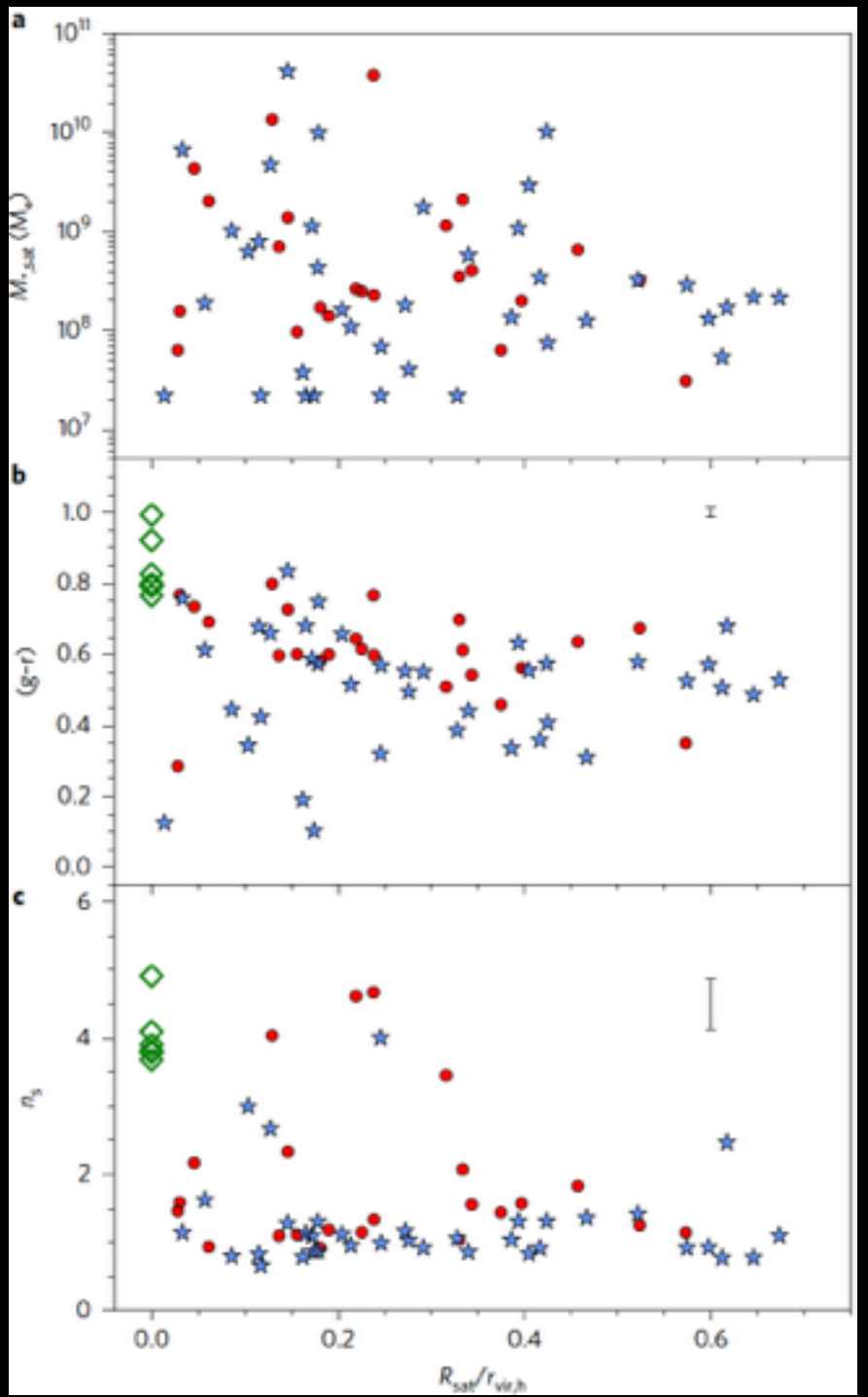




Luminosity Function Cutoff: Hydrodynamic Interaction with Hosts

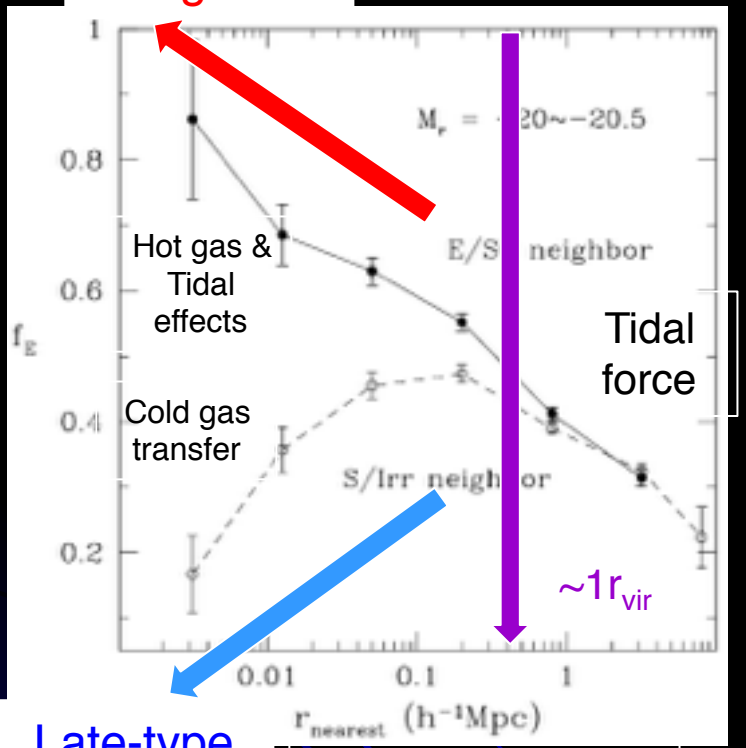


ParkC, HwangHS, ParkH, LeeJC+18



Hydrodynamic Effects on Galaxy Properties

Early-type neighbor

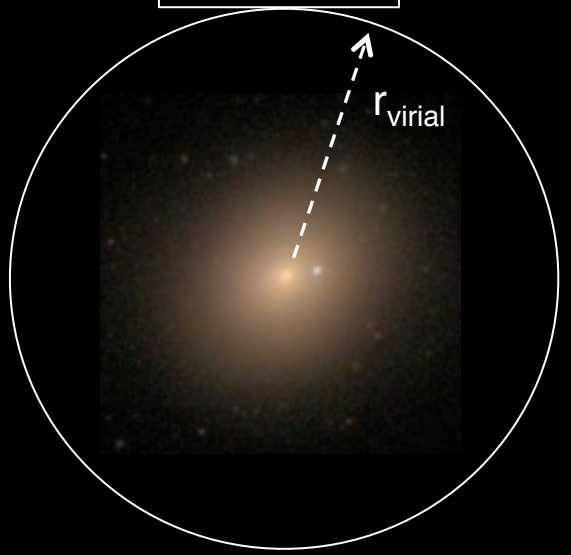


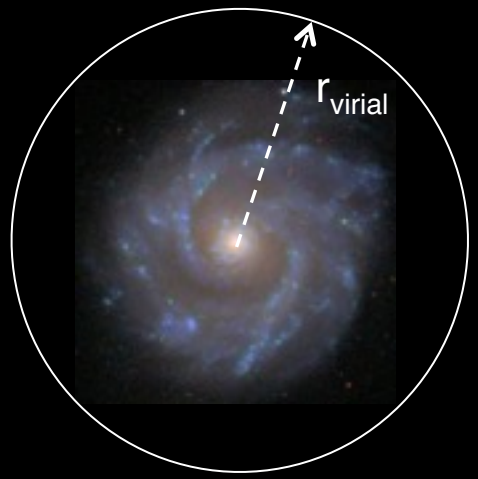
Late-type neighbor

Park, Gott & Choi 08

Galaxy

Neighbor Galaxy

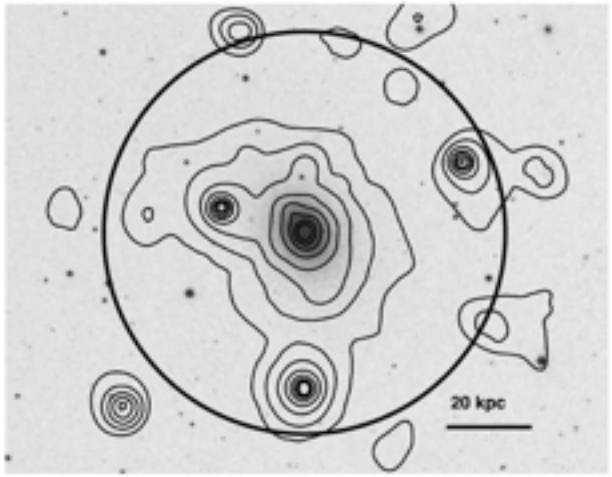




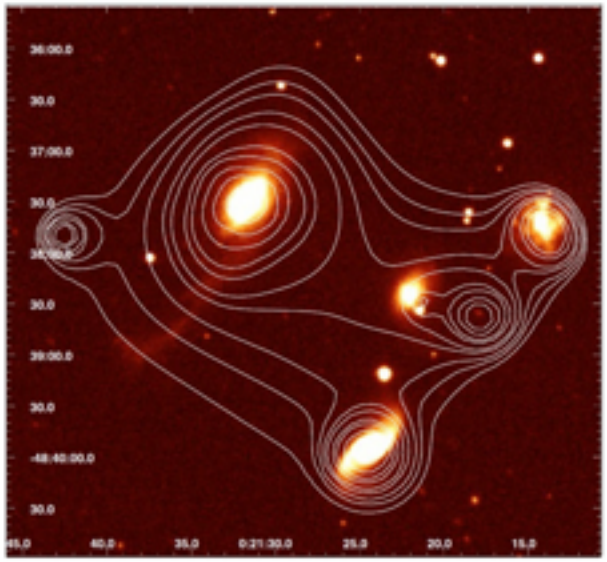
Luminosity Function Cutoff: Hydrodynamic Interaction with Hosts

Hot intra-group medium exists!

(ex) in early types
NGC3665(M_r=-20.6)
in 0.7-1.5keV band
(Helsdon et al. 2005)
r_{circle} = 5.8'



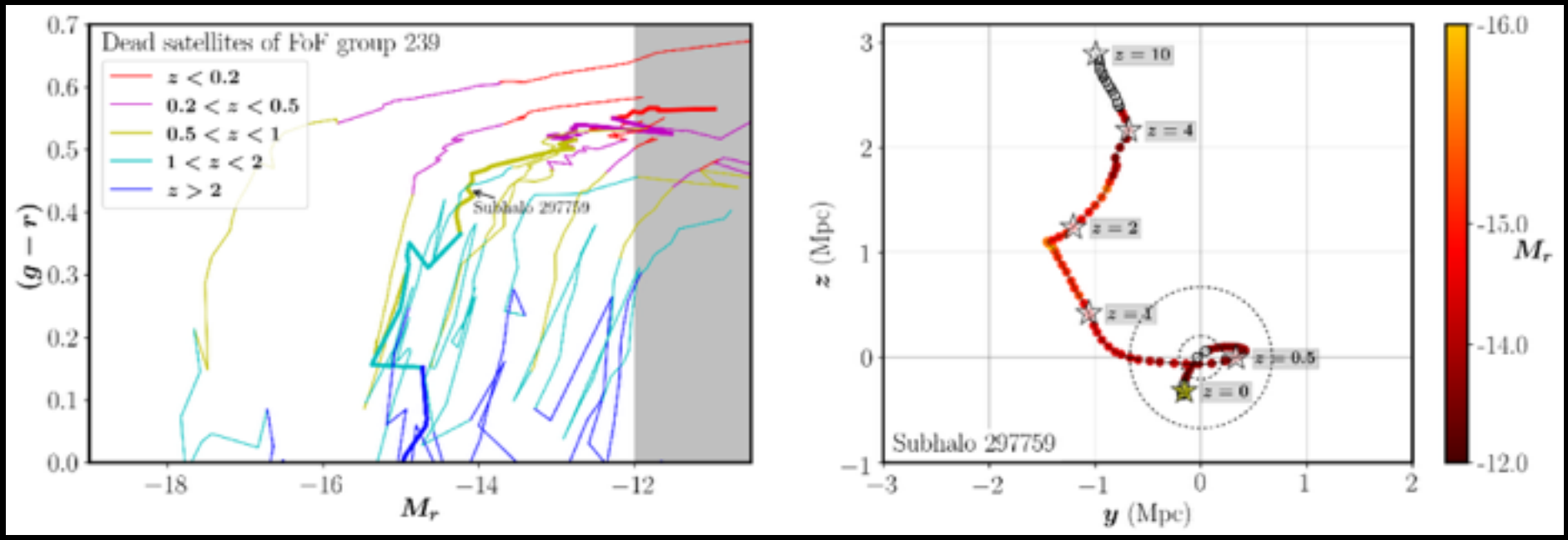
(ex) in late types
Hot intra-group medium in a spiral-only compact group SGC0018-4845. Emission in 0.3-2keV from XMM-Newton (Trinchieri 2008)

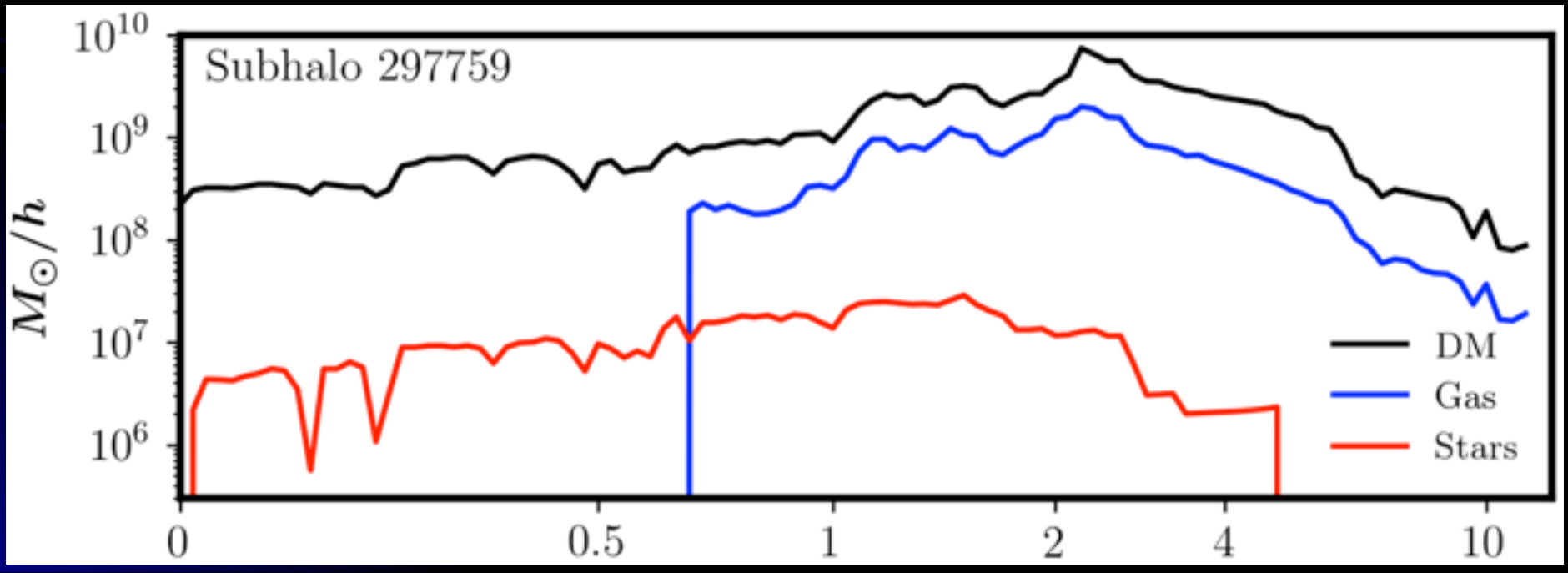


From CBP's slide

Luminosity Function Cutoff: in Cosmological Simulations?

➢We could not reproduce such a cutoff using the Illustris simulation, but





Luminosity Function Cutoff: in Cosmological Simulations?

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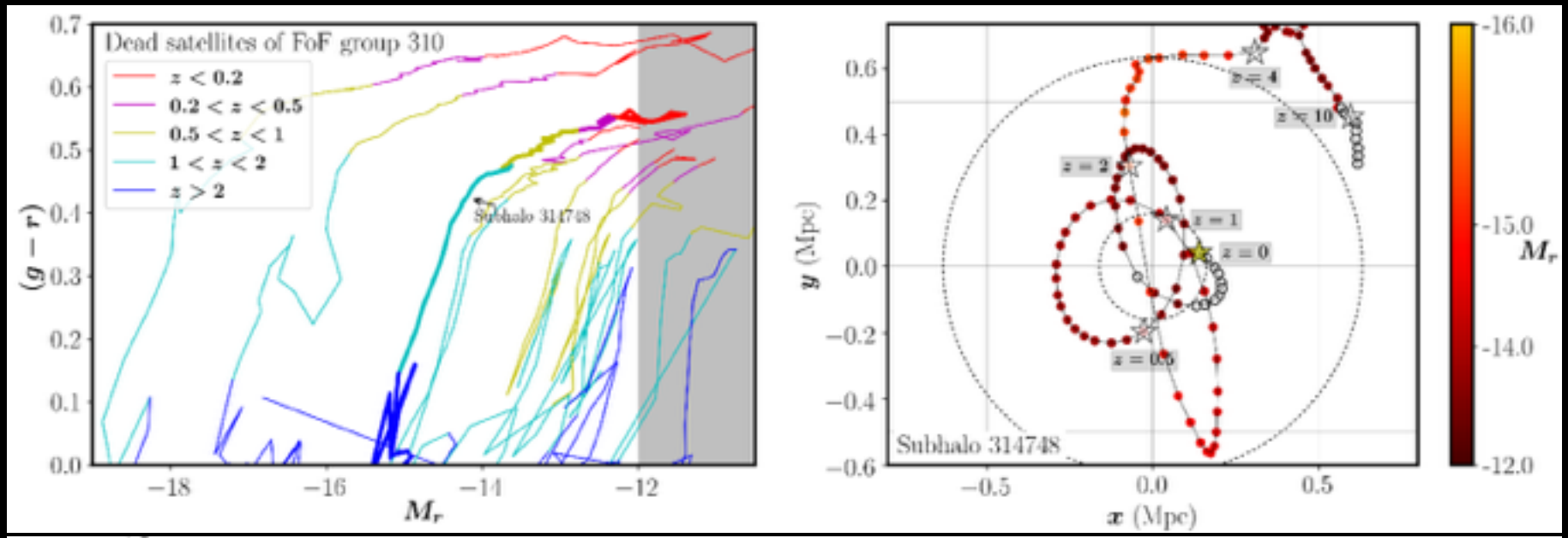

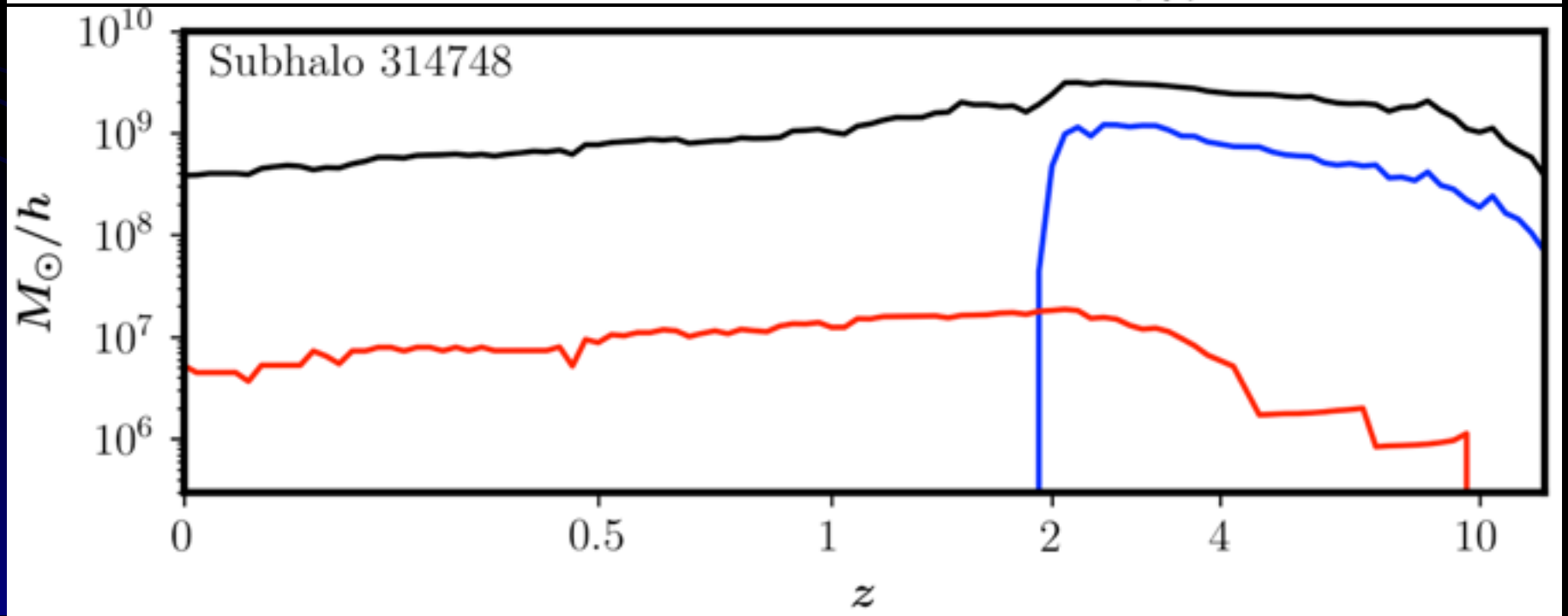

Luminosity Function Cutoff: in Cosmological Simulations?

➢ We could not reproduce such a cutoff using the Illustris simulation, but

➢ An improved treatment of baryonic physics associated with galaxy collision in the future simulations may be able to give results similar to the observation.

➢ The observed cutoff in the satellite galaxy LF of isolated bright ETGs is strong evidence for the critical role of baryonic physics in the evolution of satellite galaxies and can be a clue to resolve the missing satellite galaxy problem.

➢ Horizon Run 5 simulation of KIAS (coming this year!) will be helpful.

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CrossMark

The SAGA Survey. I. Satellite Galaxy Populations around Eight Milky Way Analogs

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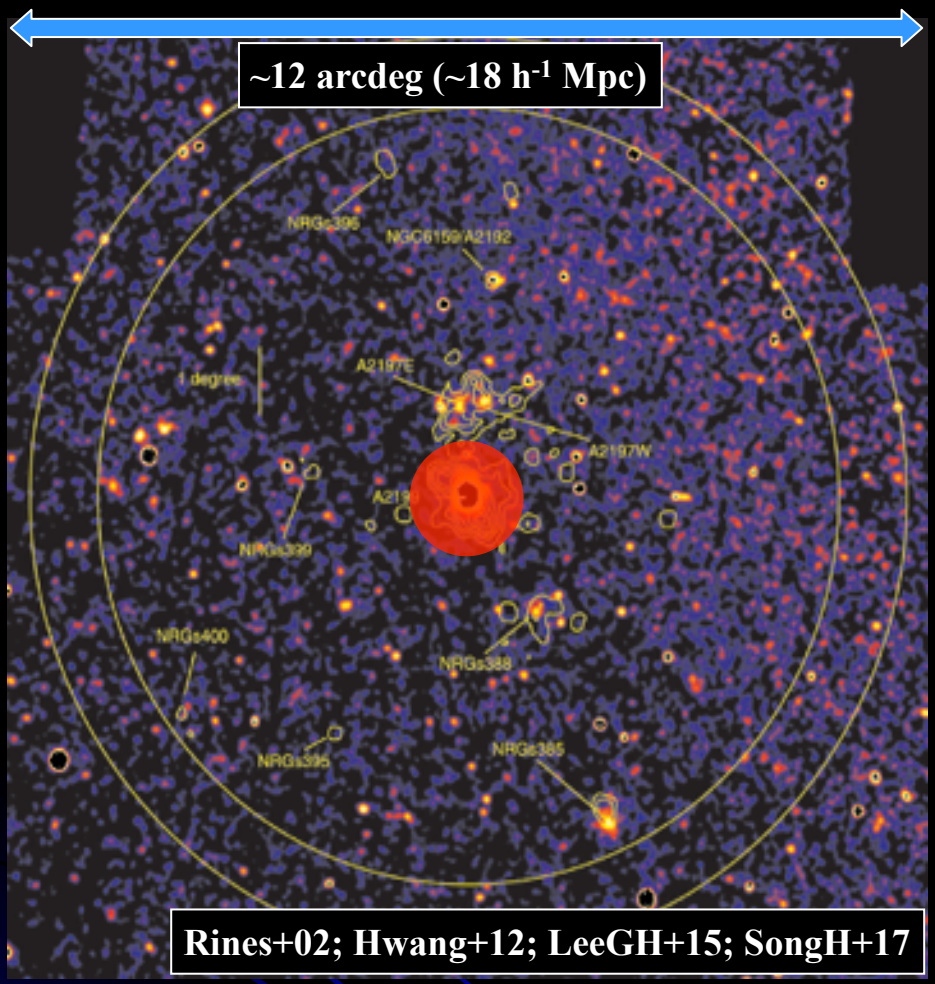
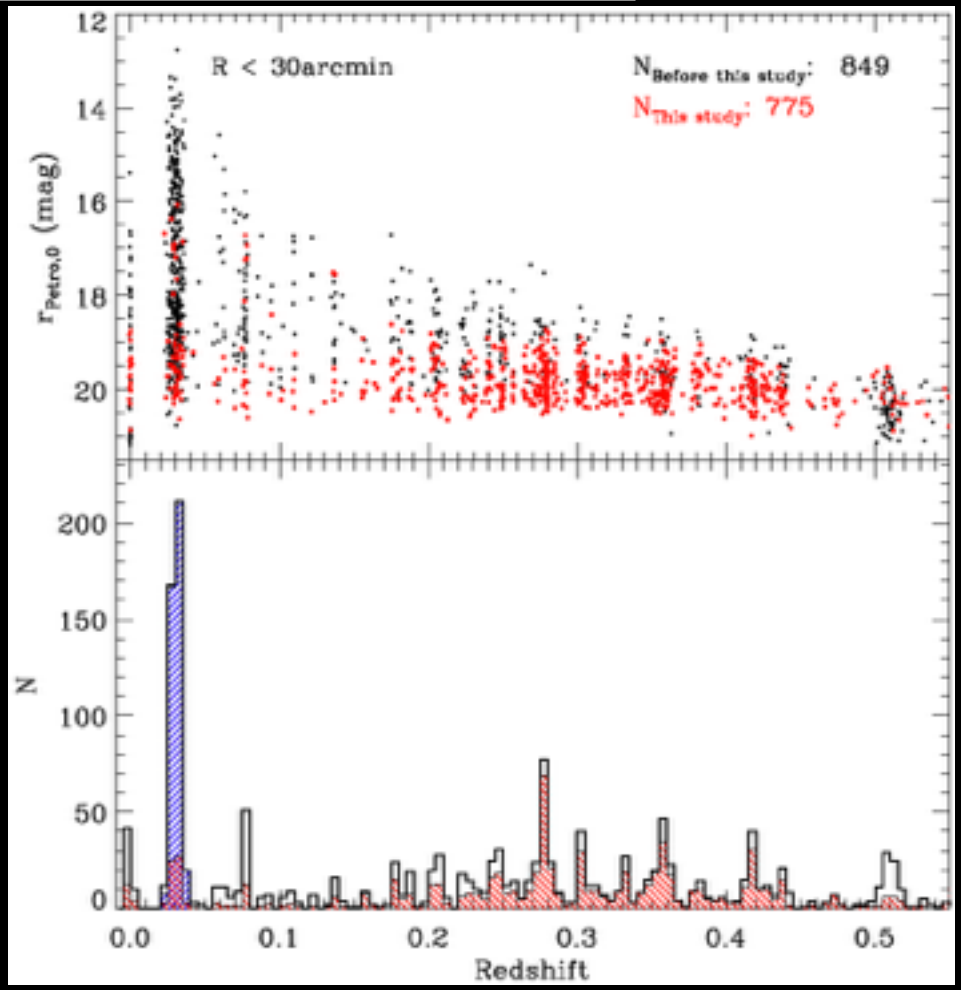
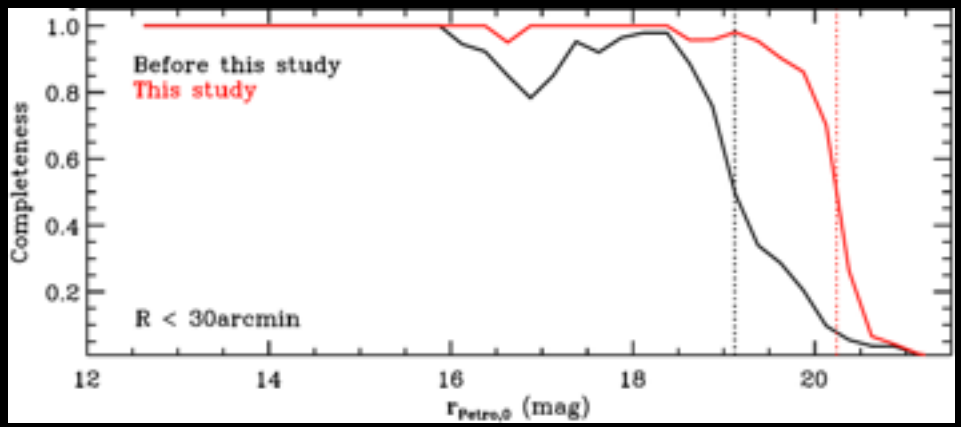
2. Optical Luminosity Function in a Galaxy Cluster (A2199)

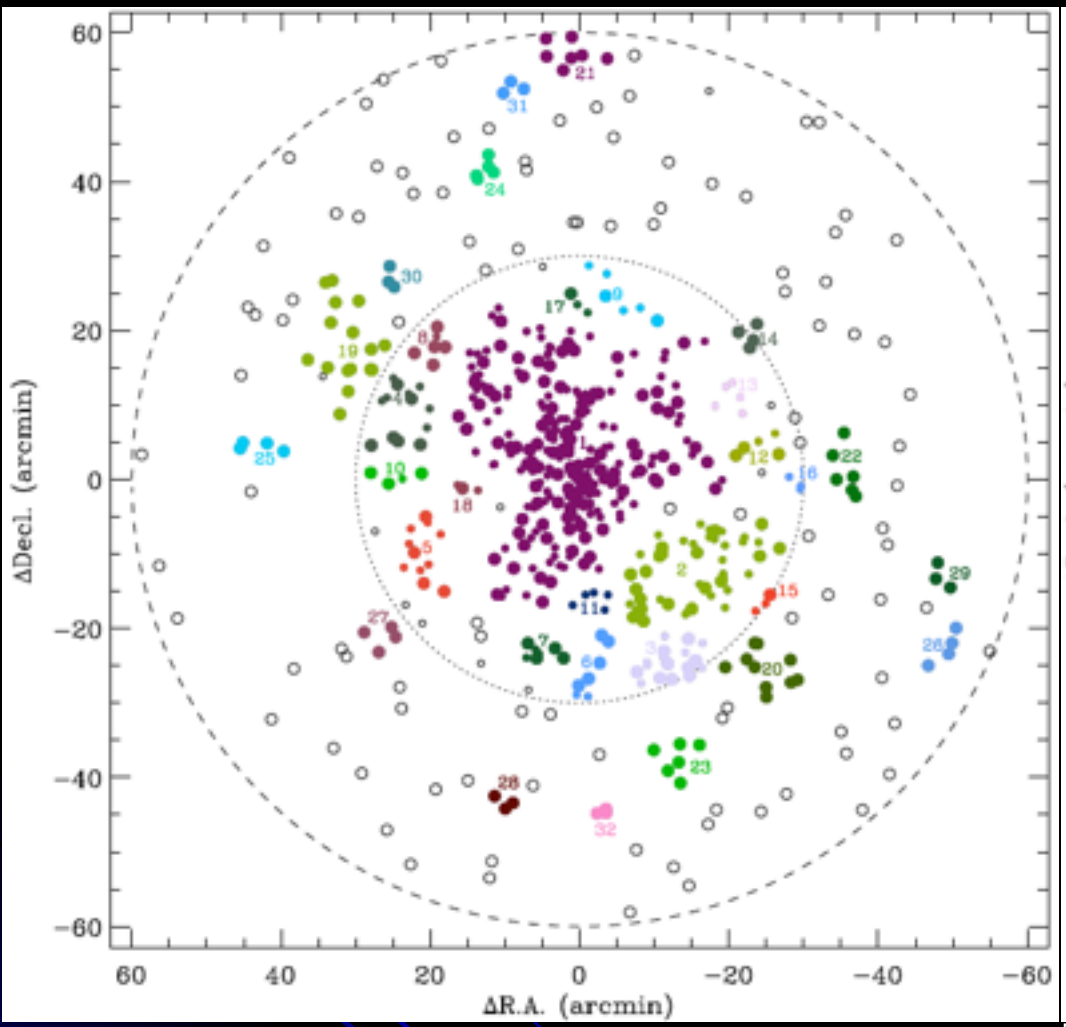
A2199 Supercluster: Very deep survey in the central region

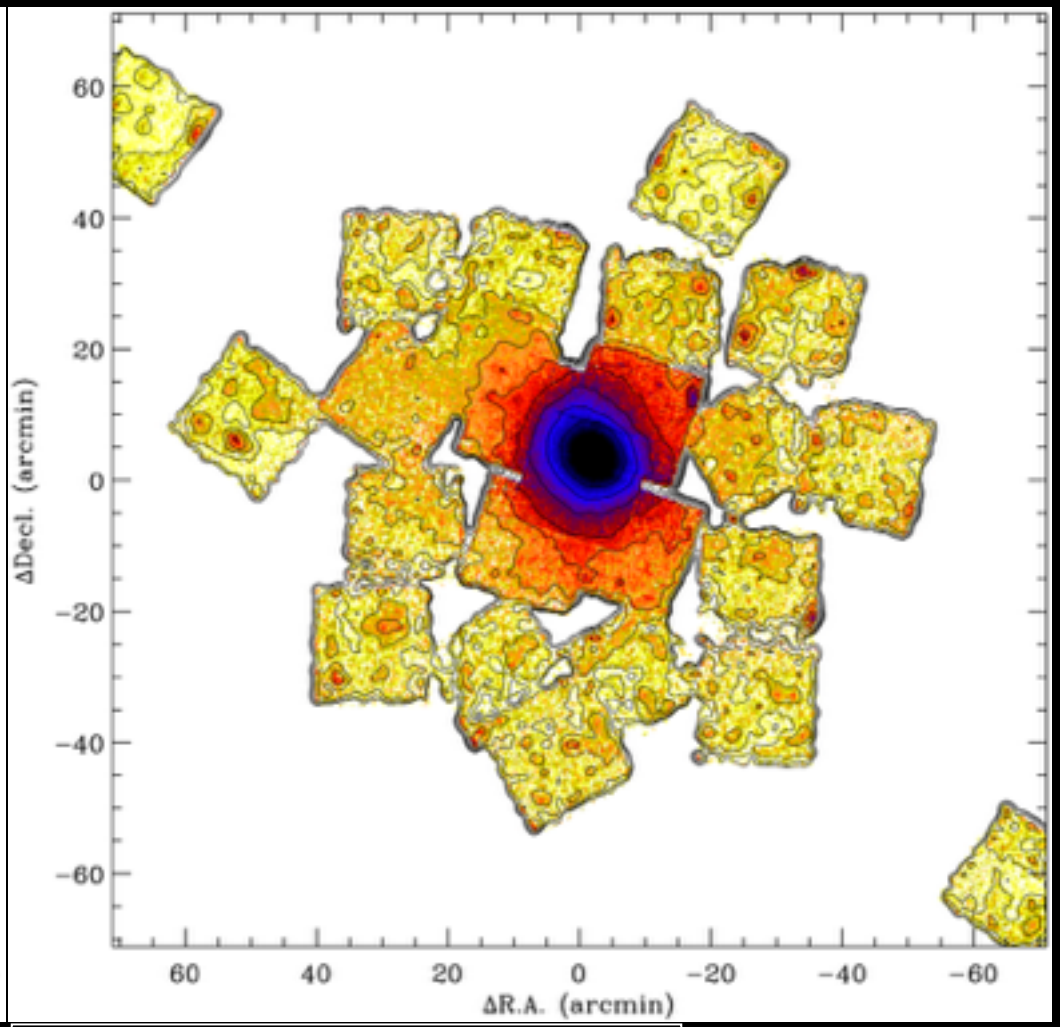






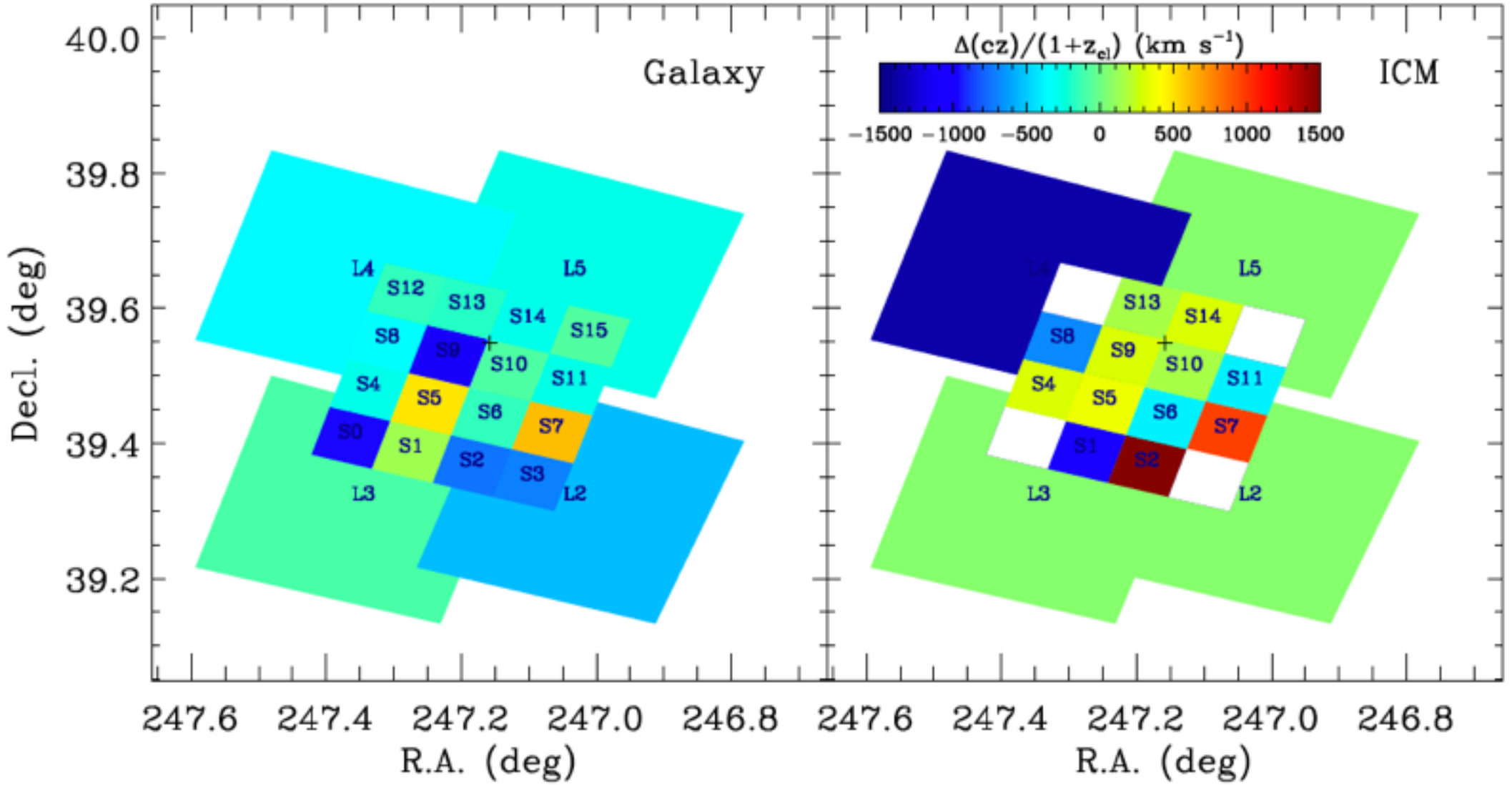
A2199: Spatial Distribution of Galaxies with ICM





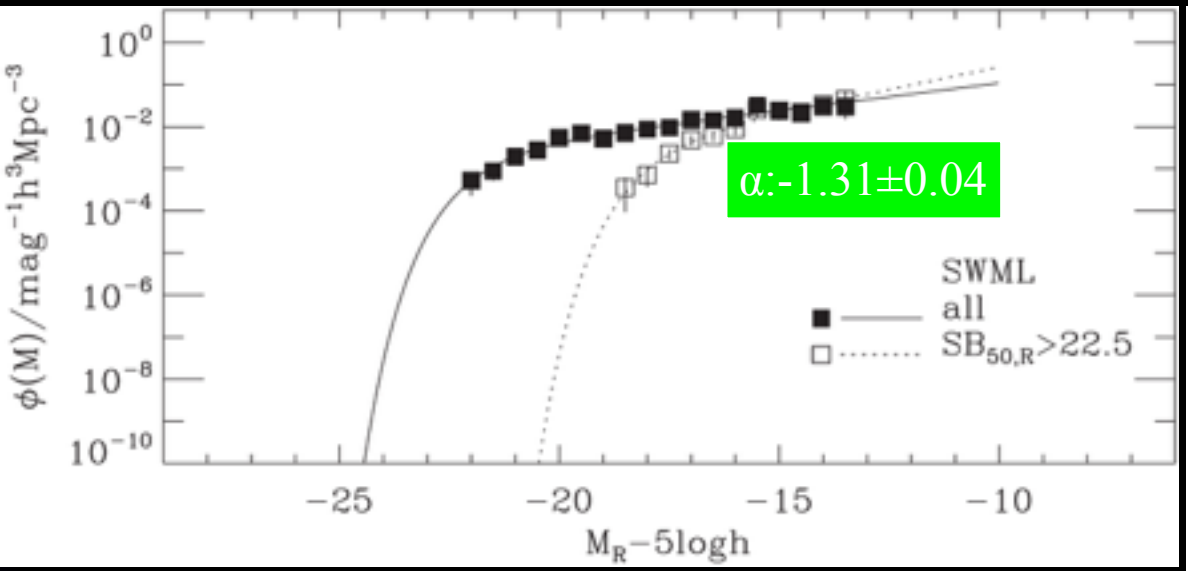
SongH, HwangHS, ParkC, TamuraT+17

A2199: Kinematics between Galaxies and ICM

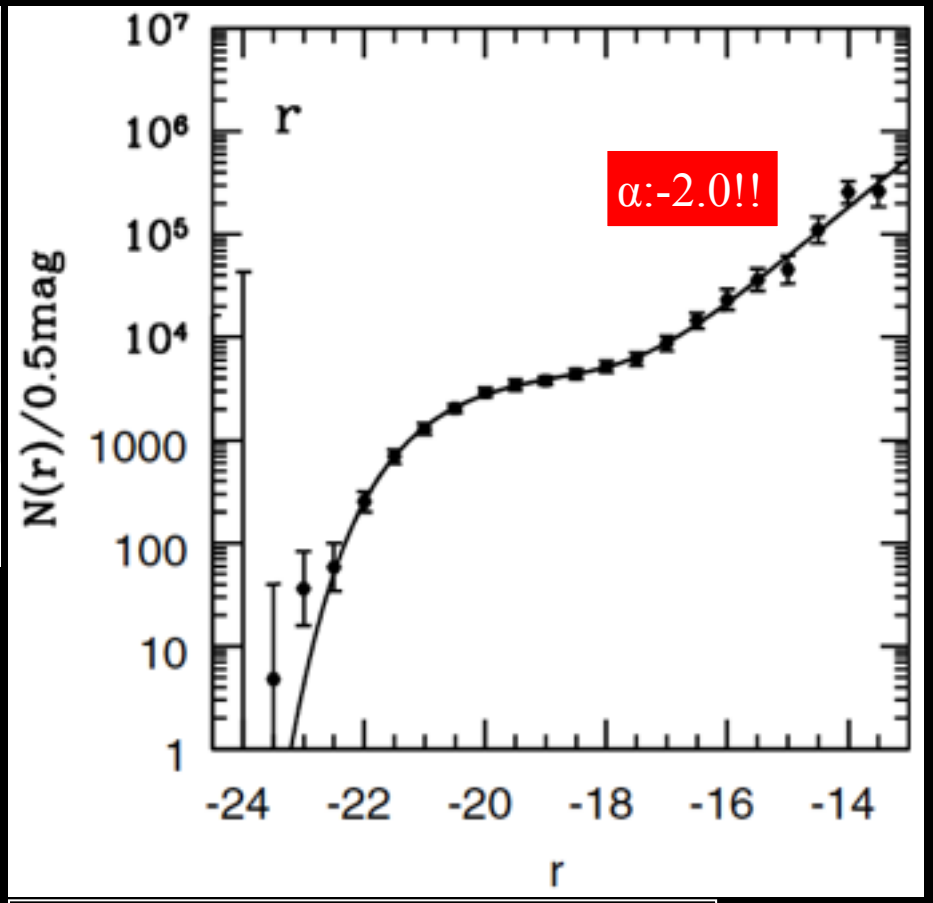


SongH, HwangHS, ParkC, TamuraT+17

A2199 Supercluster: Very deep survey in the central region



Field: F2 SHELS (Geller+12, Spectroscopy)

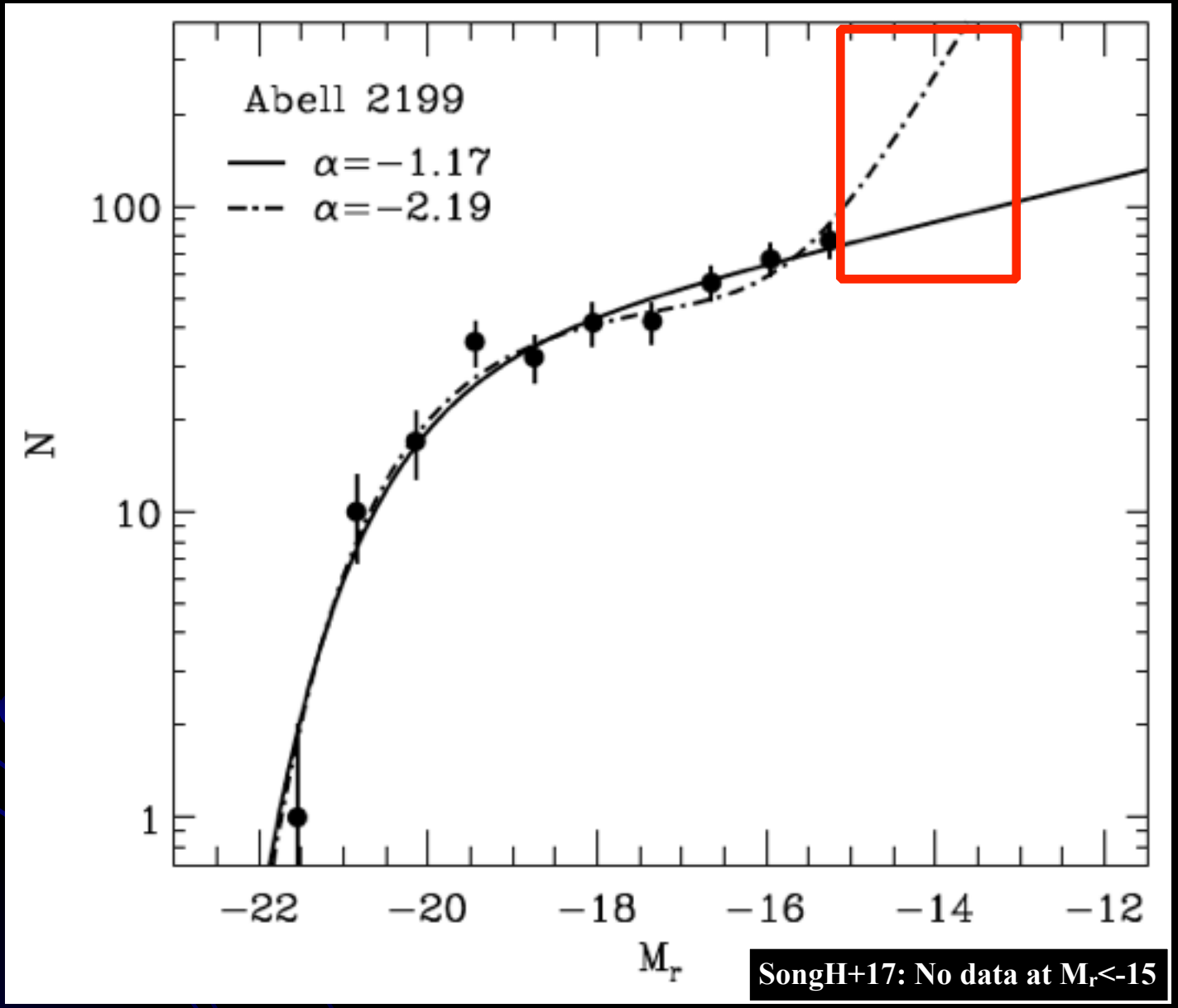


Cluster: SDSS (Popesso+06, Photometry)

Why more faint galaxies in clusters?

➢ We do not know well, but
physical processes of creating/protecting dwarf galaxies
(i.e. tidal interactions and shielding from ultraviolet radiation) are dominant
in cluster environment rather than those of destroying them.

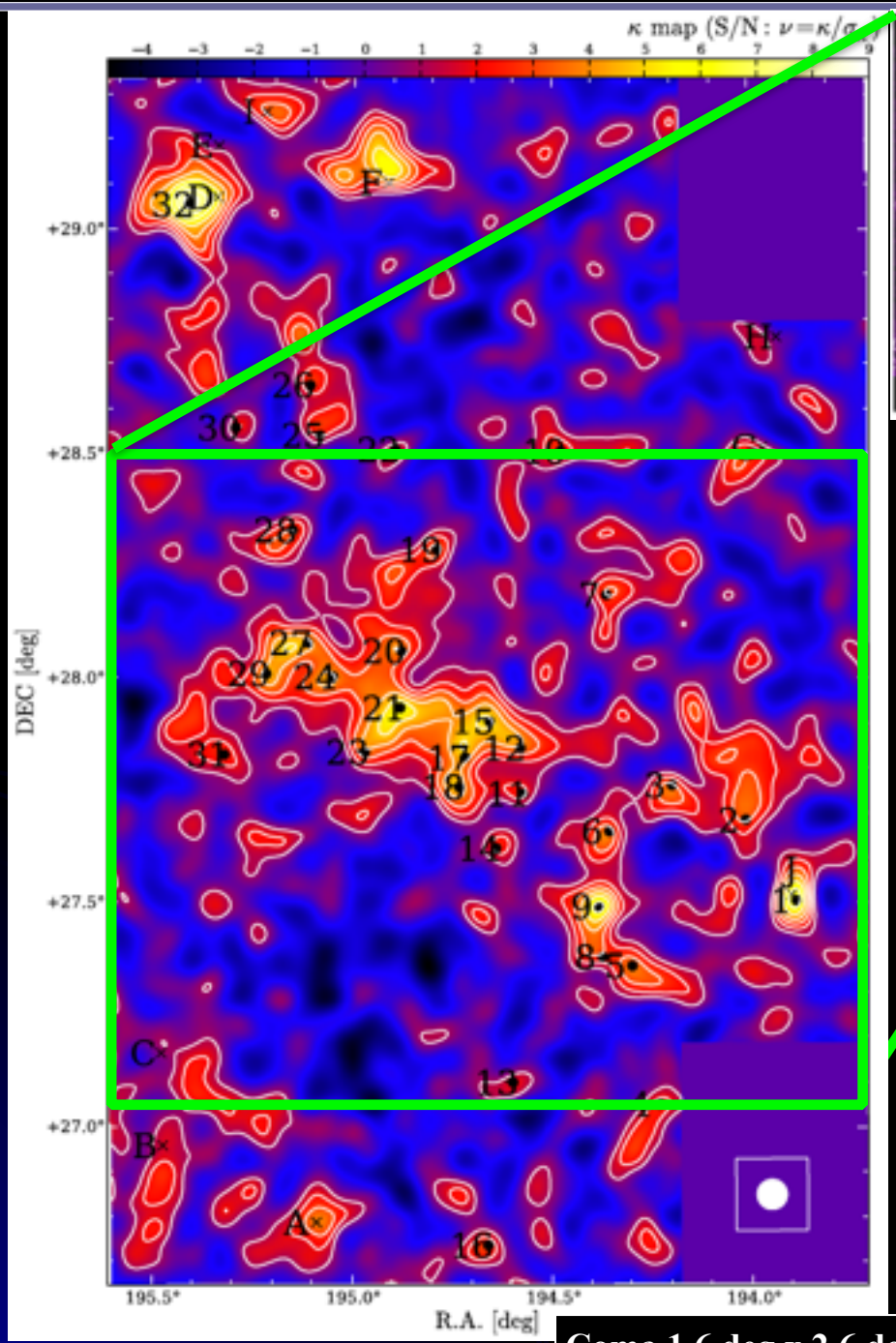
A2199: Luminosity Function

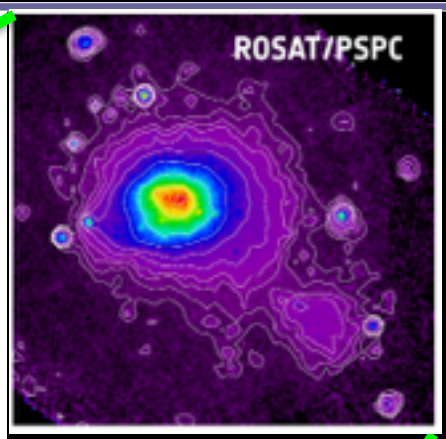


➢ **Not conclusive yet, so more data at faint ends are necessary - MMT observation in 2019A**

3. A Study of Dark Matter Subhalos in and around Galaxy Clusters

COMA Cluster: Subhalos!



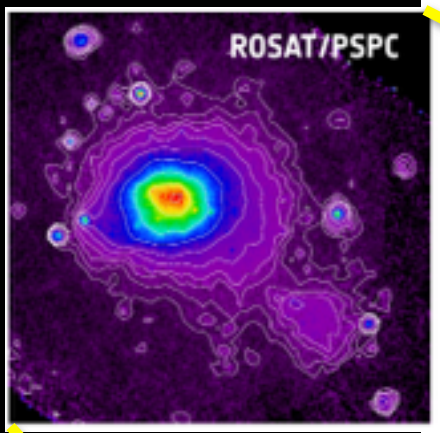


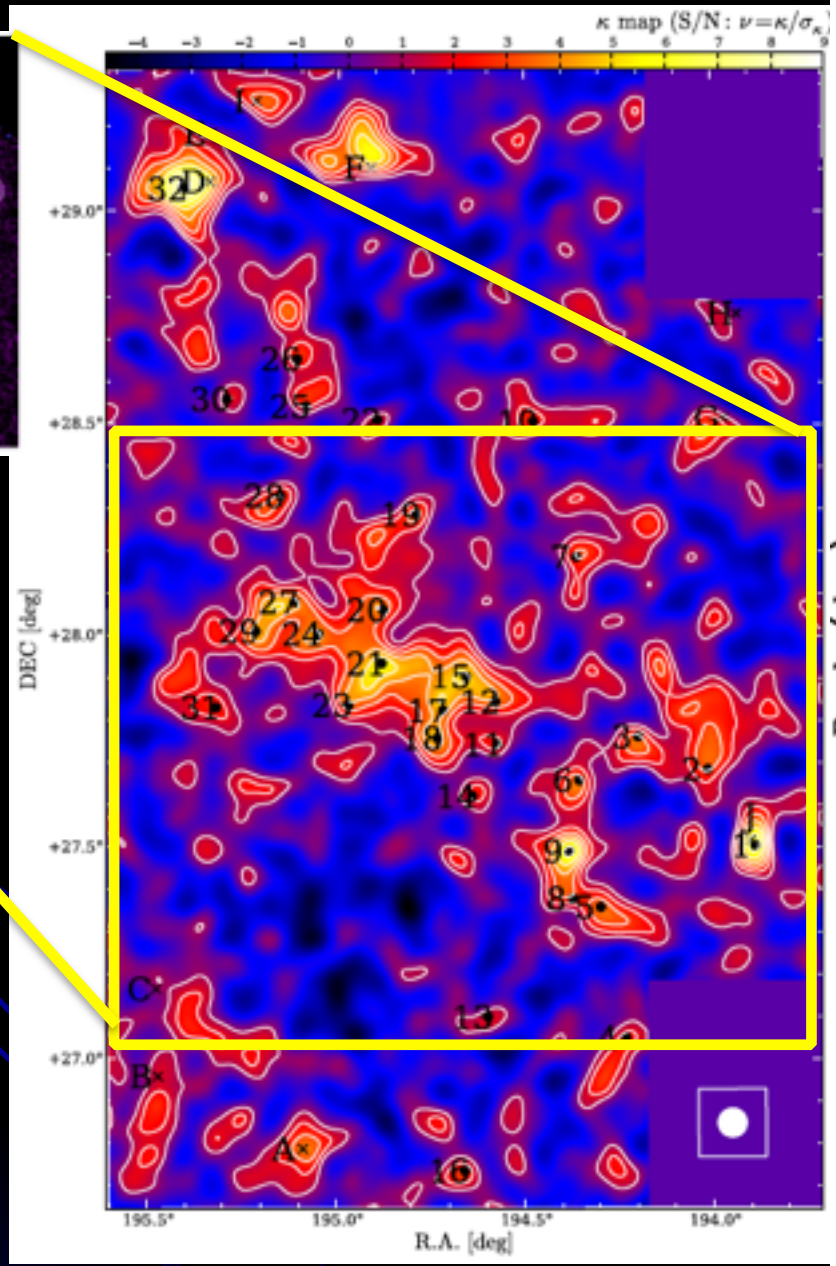
- Lensing peaks from subhalos!
  - Dark structure?
  - Subhalo mass function: Cosmological Test

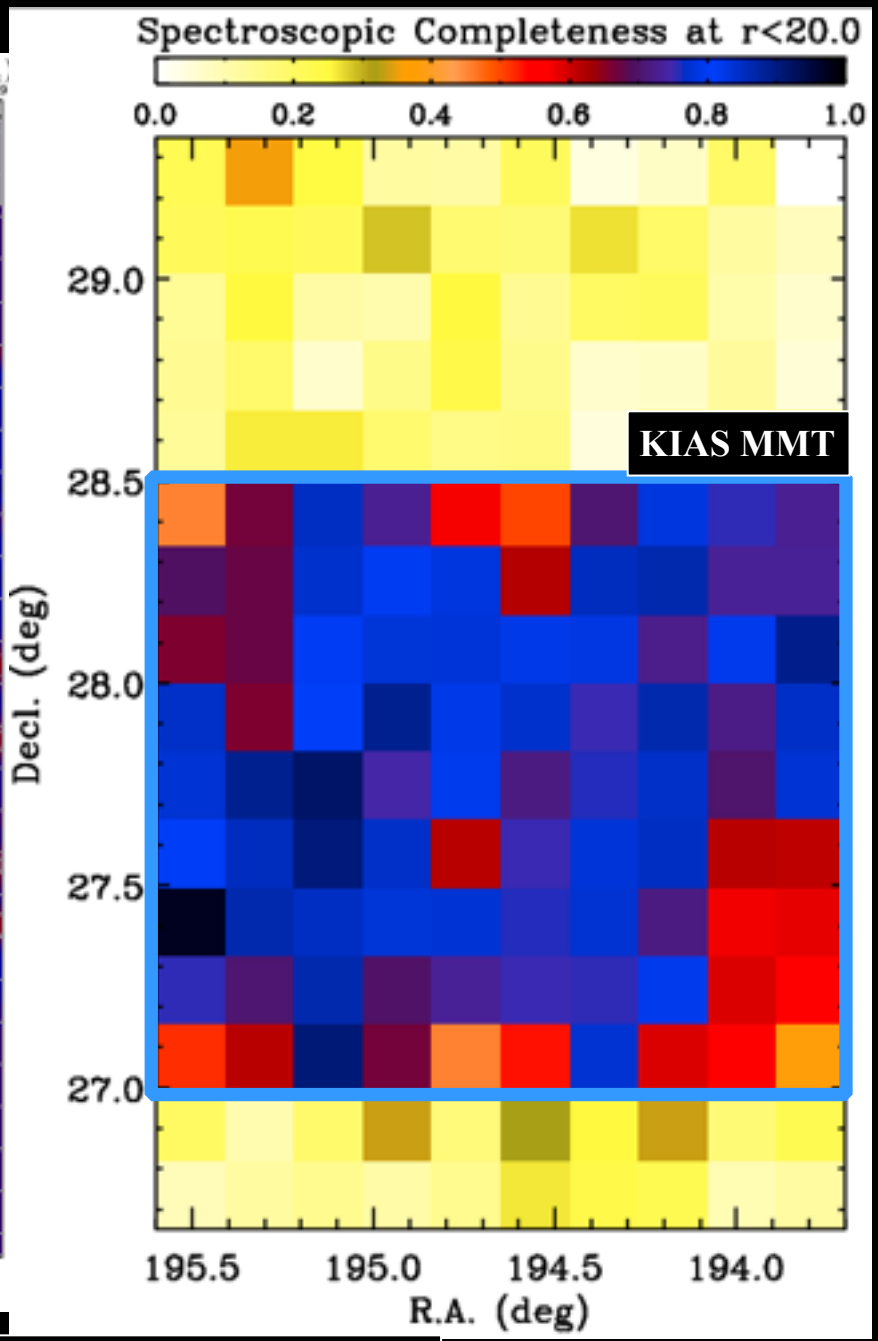
- Goals:
  - Nature of Subhalos? (cluster-related?)
  - Comparison of galaxy distribution with (subhalo) matter distribution from weak-lensing analysis

Coma 1.6 deg x 2.6 deg with i < 18 (Okabe+14)

Nearby Clusters: Coma - Subhalos!

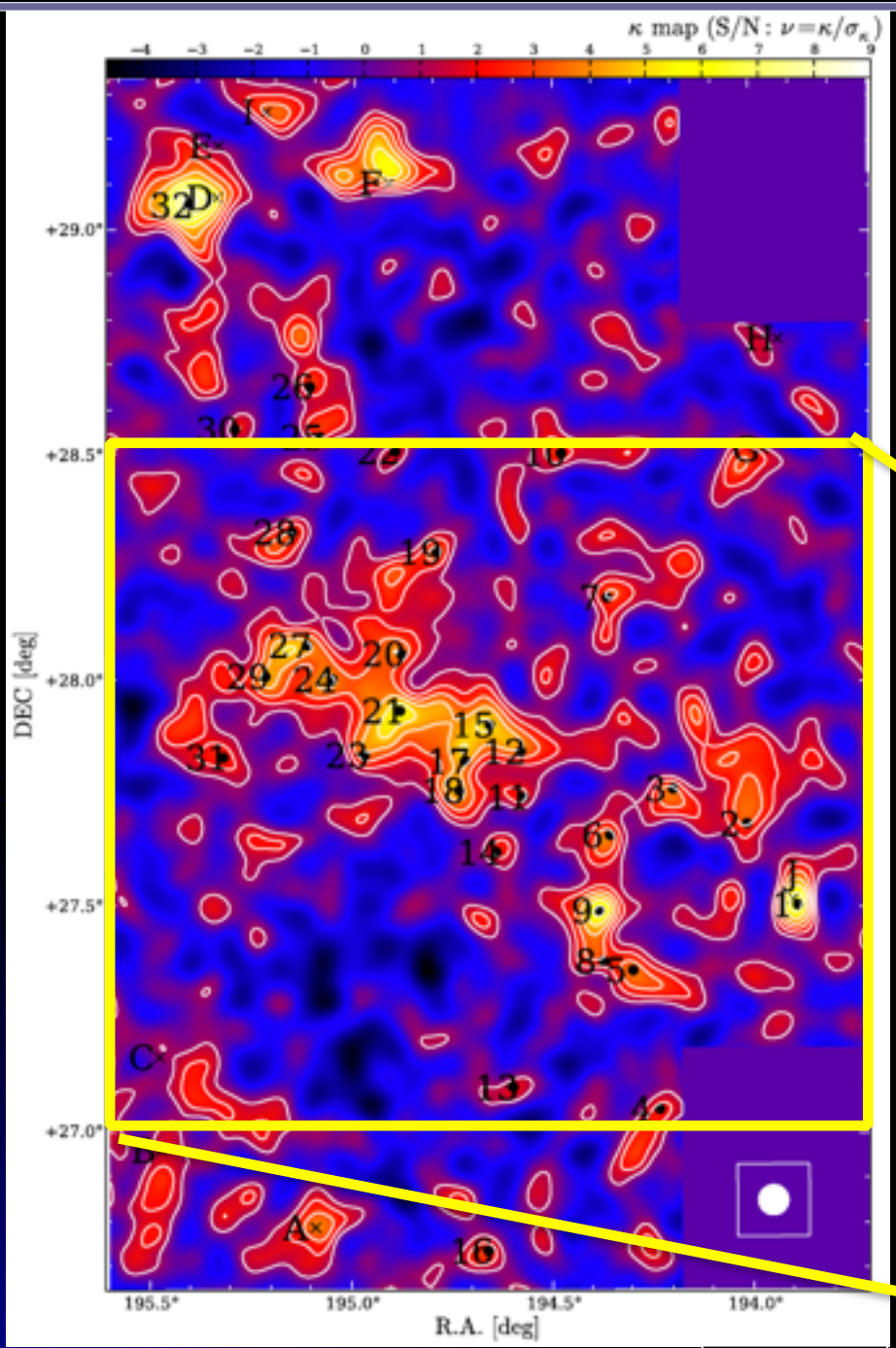




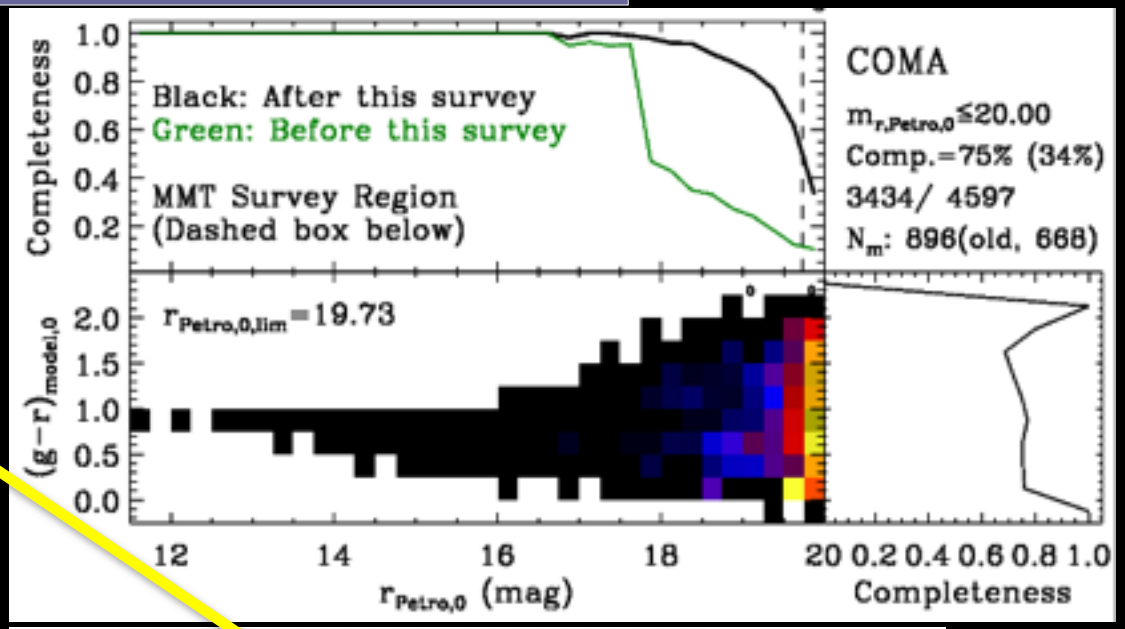


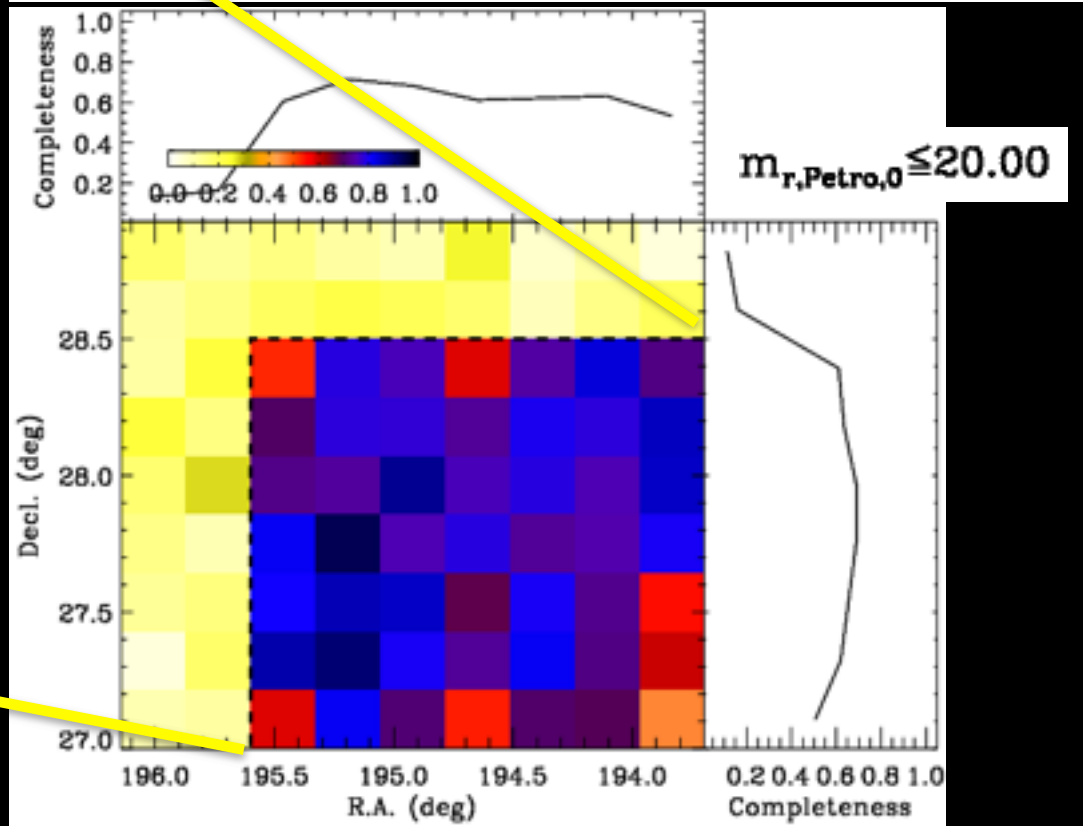
COMA (Subaru WL by Okabe+14 & KIAS MMT Redshift survey by Hwang+)

Coma Redshift Survey



Okabe+14





COMA Master Catalog: Multiwavelength Data

- Optical Spectroscopic Data
  - KIAS MMT/Hectospec Survey
  - SDSS, Mobasher+01

- Optical Imaging Data
  - SDSS
  - The HST/ACS Coma Cluster Survey (Carter+08): Galaxy Size, Dwarfs?
  - Subaru/SC (Okabe+14; Koda+15; YooJ,KoJ+;JeongH+):
    Weak Lensing, UDGs, ICL, Spin/LSS

- UV Imaging data from GALEX (Hammer+10)

- Infrared Imaging Data: Star Formation Activity
  - Mid-infrared: Spitzer/WISE (Edwards & Fadda 2011; Wright+10)
  - Far-infrared: IRAS/AKARI from all-sky survey

- X-ray data
  - ROSAT/XMM-Newton (Briel et al. 1992; 2001)

- Anyone is welcome to work on any project using these data.

COMA Cluster: Preliminary Results

Q1: Are subhalos of clusters identified in weak lensing real?

➢ **Subhalo mass function: Cosmological Test**

Q2: What are their physical properties?

Conclusions & Discussion

- Dense Redshift Surveys for the studies of
  Galaxy Groups/Clusters and
  Large-scale Structures in the Universe

- Magnitude limited Samples without any color selection

- Many Science Cases in Cosmology and Structure Formation

- More Interesting Topics by combining with
  - Deep optical images (e.g. Subaru HSC)
  - Multiwavelength data (e.g. GALEX, WISE, AKARI/IRAS)

- We thank the people at K-GMT science group for providing us
  this very important opportunity!

- Future: High Multiplexing Capability is important for our study.