Redshift Surveys of Galaxy Clusters with Weak-lensing Maps

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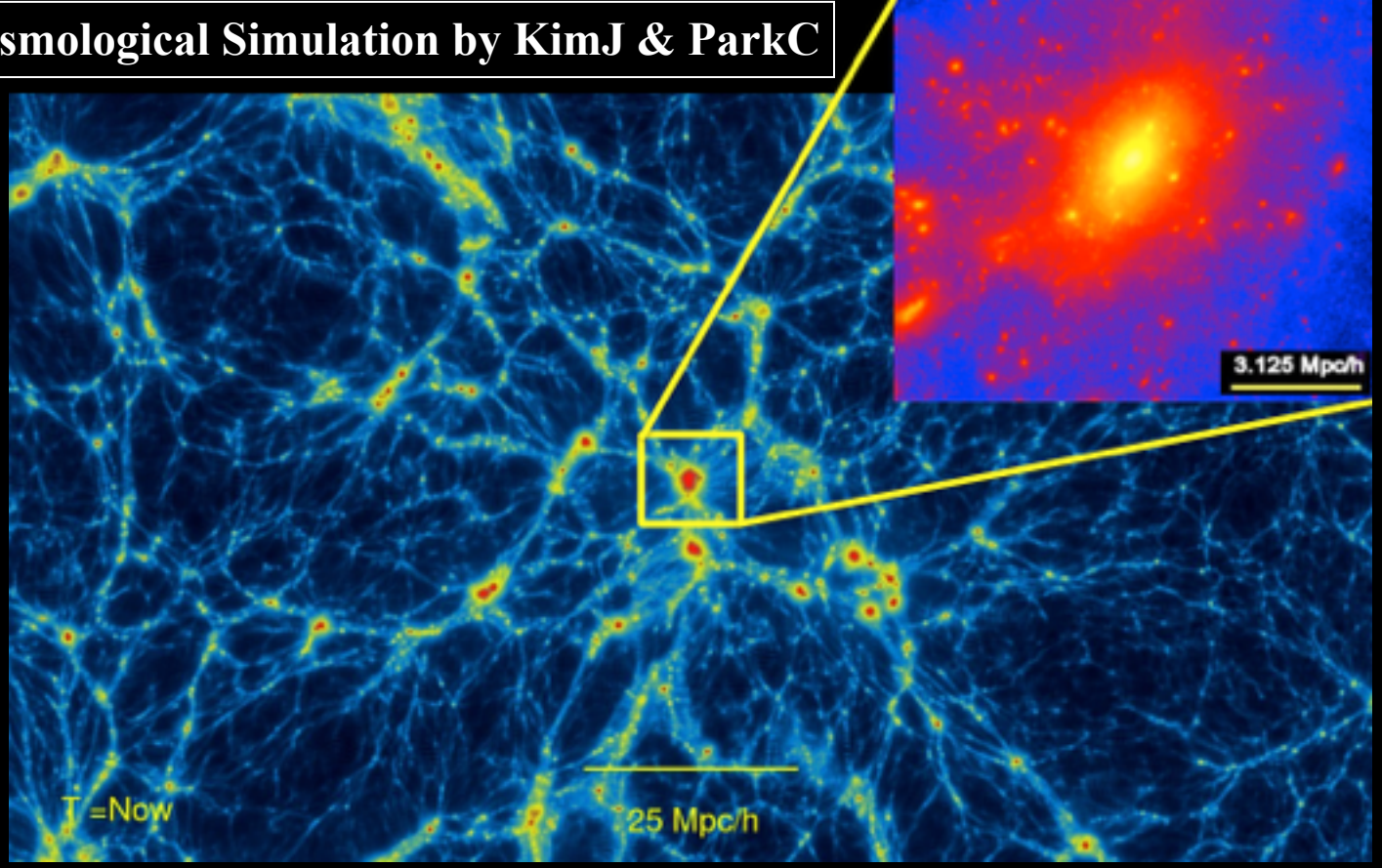
Korea Astronomy & Space Science Institute

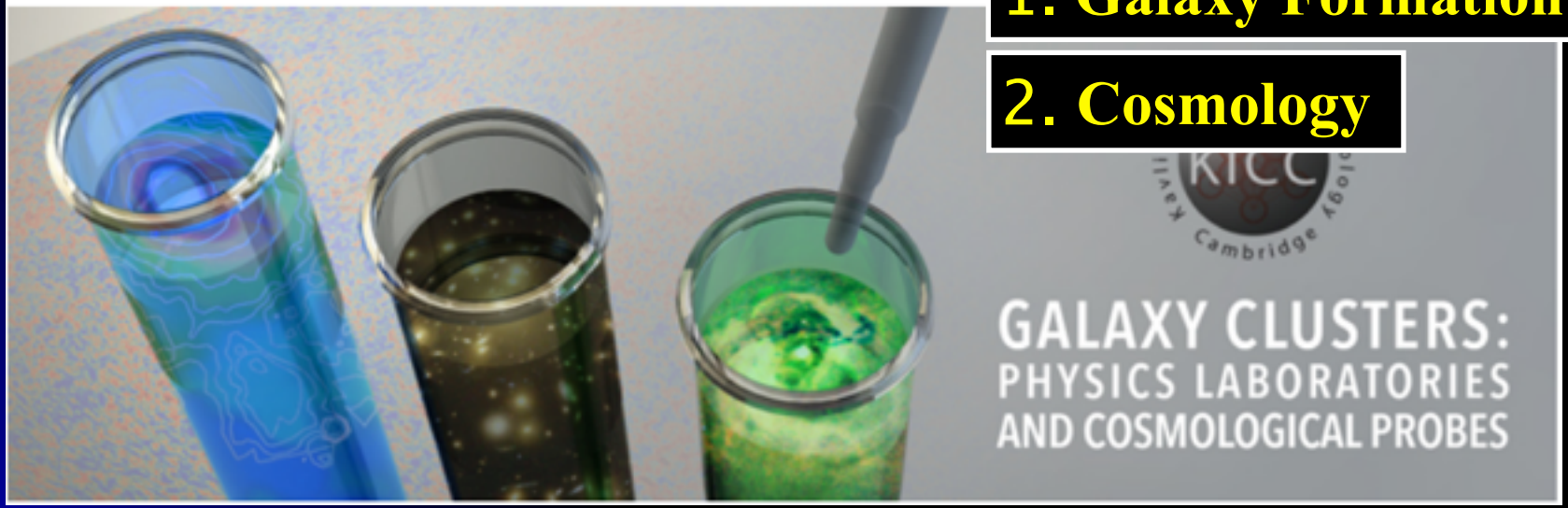
A2744 (Merten+11)

Cosmological Simulation by KimJ & ParkC



Galaxy clusters: physics laboratories and cosmological probes

5 December 2016 - 9 December 2016



1. Galaxy Formation & Evolution

2. Cosmology

➢ Our goal is to have a combined view of
the three components in galaxy clusters

➢ Galaxy Redshift Surveys in and around Galaxy Clusters

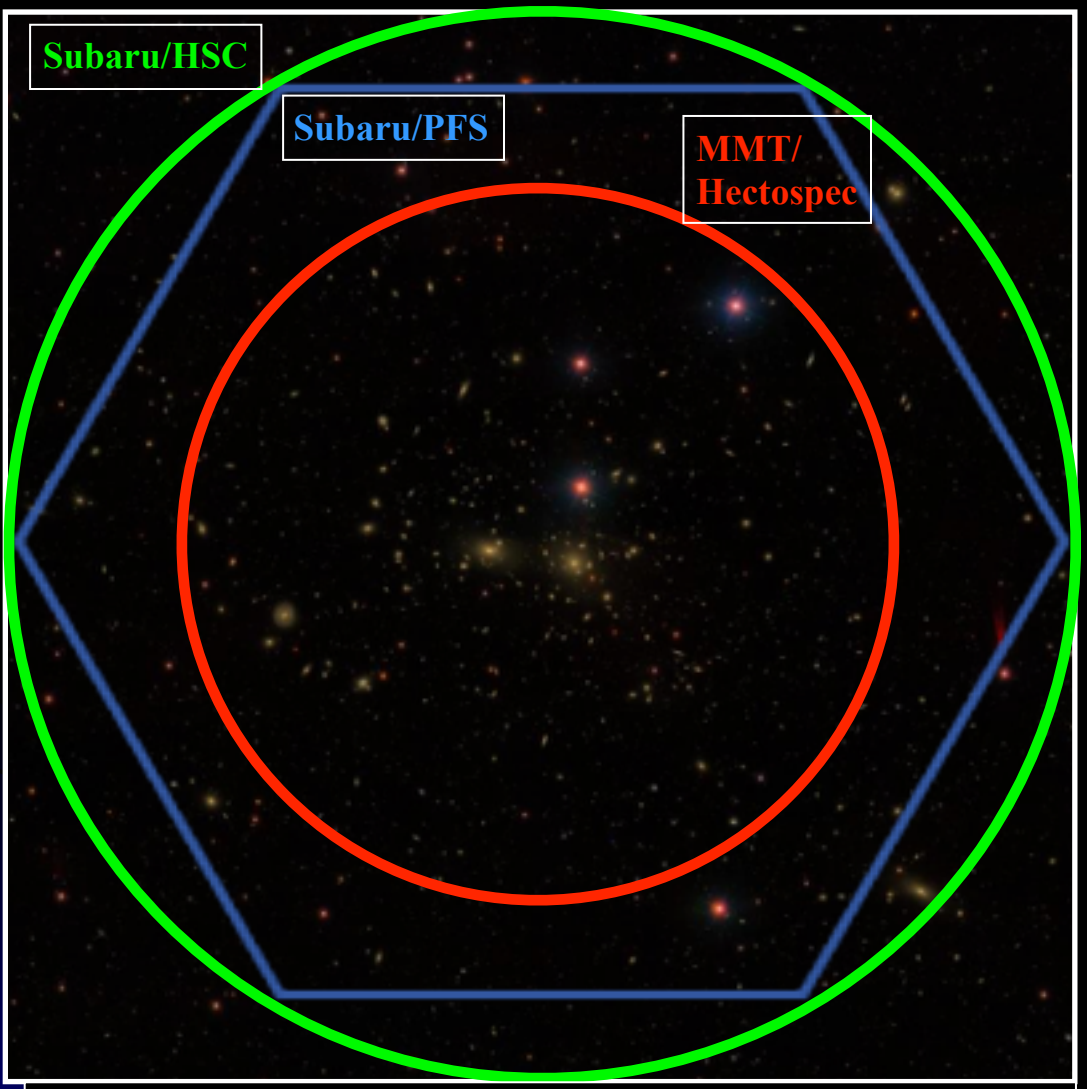
➢ Combination with the data from

1. deep optical images:
   - ➢ dark matter distribution from weak lensing
   - ➢ galaxy property studies (e.g. size)

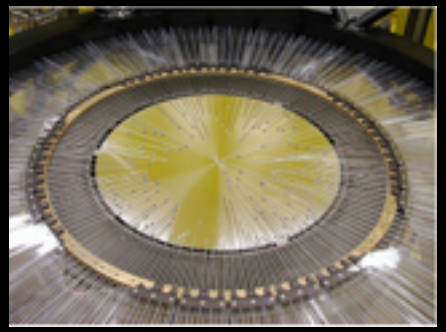
2. X-ray images: hot gas properties

➢ Ultimately, to study structure formation in the universe
(galaxy clusters + large-scale structures)

1. What we have been doing in this context
2. What we would like to do with Subaru/HSC+PFS



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

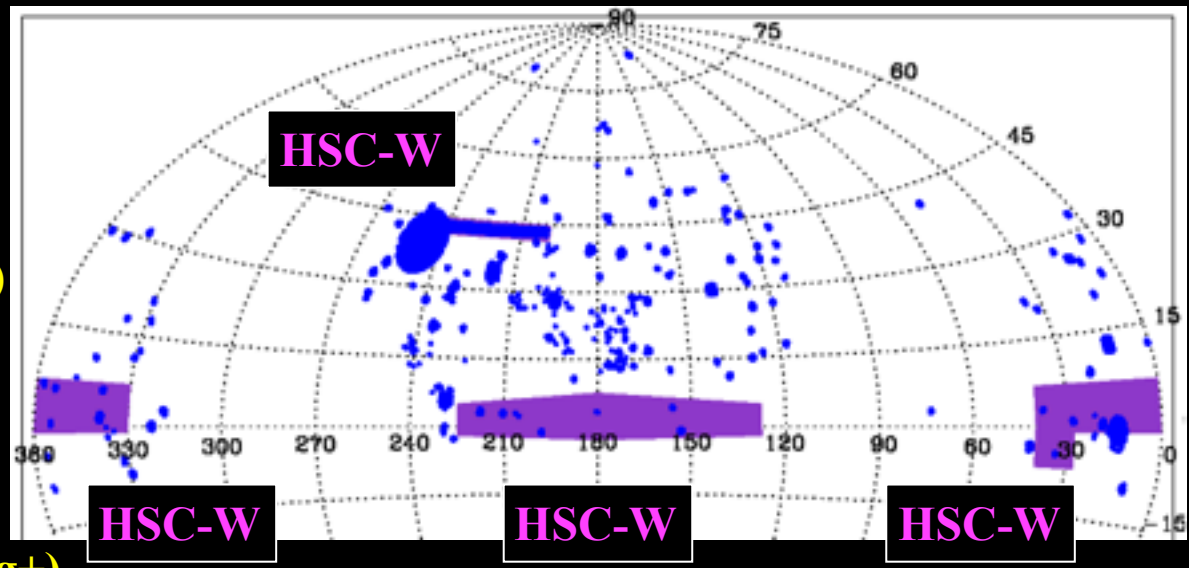
➢ 300 fibers (2" diameter) with 1 deg diameter FOV:
R ~ 6 Mpc at z~0.2;
ideal for studying the infall region of clusters

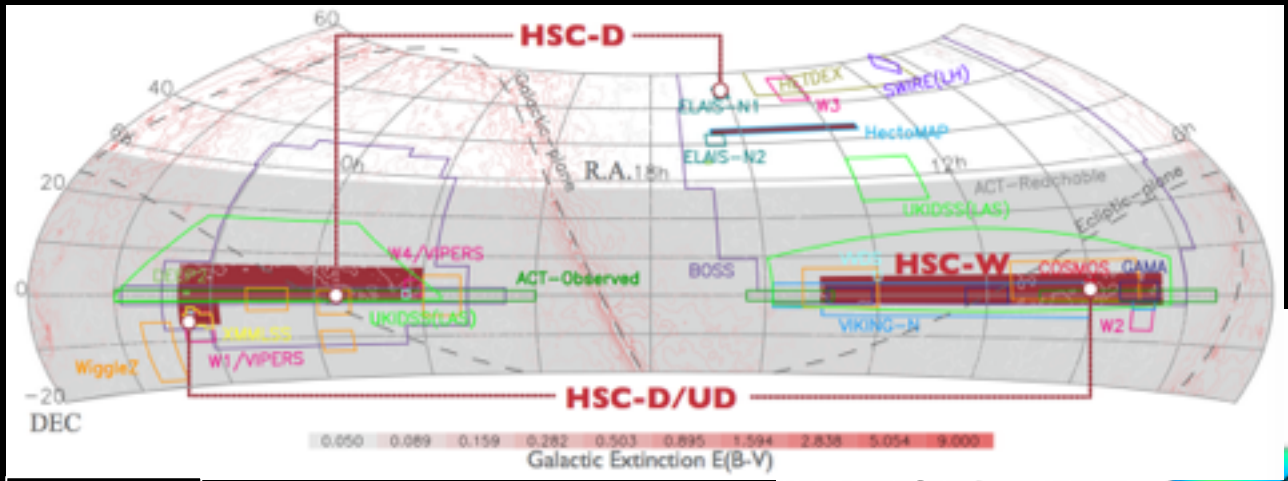
➢ Wavelength:
365 - 920nm with R~1000 (cz_{error}~30 km s^{-1})

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

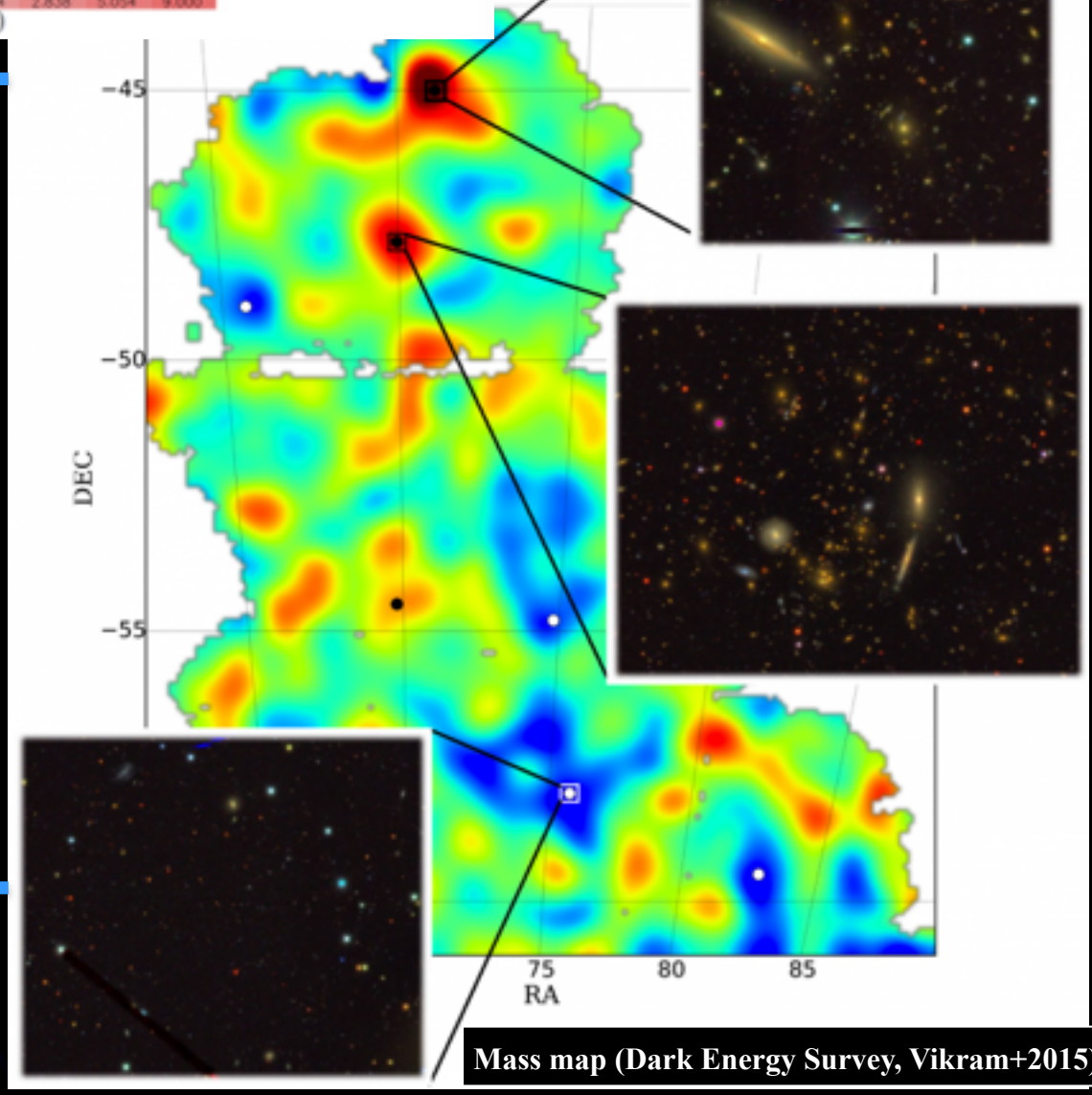
Redshift Surveys of Galaxy Clusters (CfA+KIAS+KASI)

- **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)
  - HectoMAP clusters
- **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+)





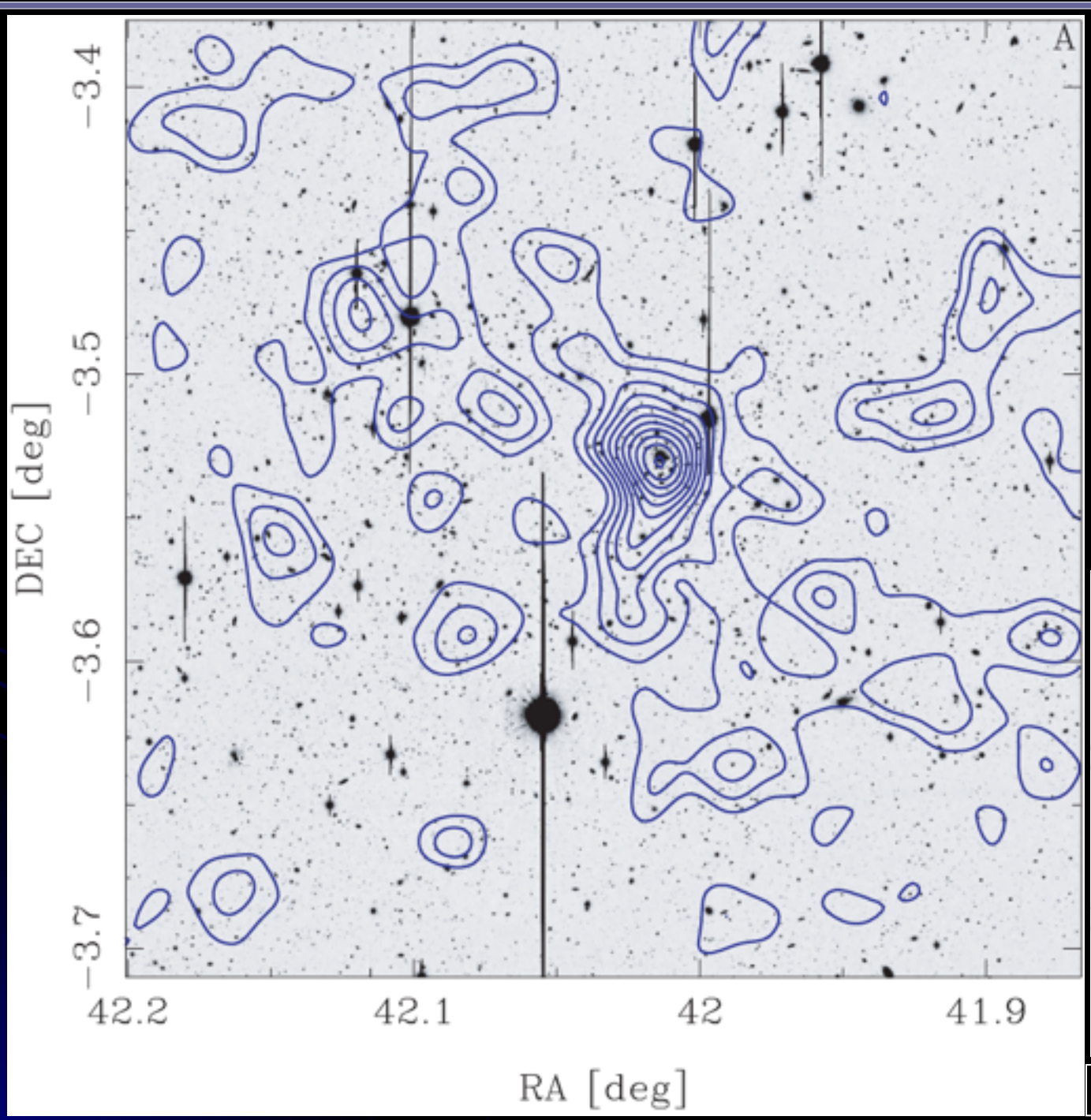
HSC SSP

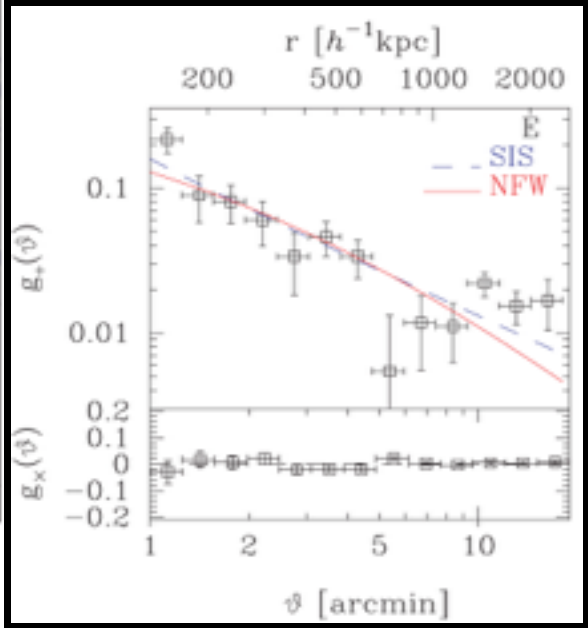


~1.5 Gly (~450 Mpc)
at distance of galaxies at z~0.3

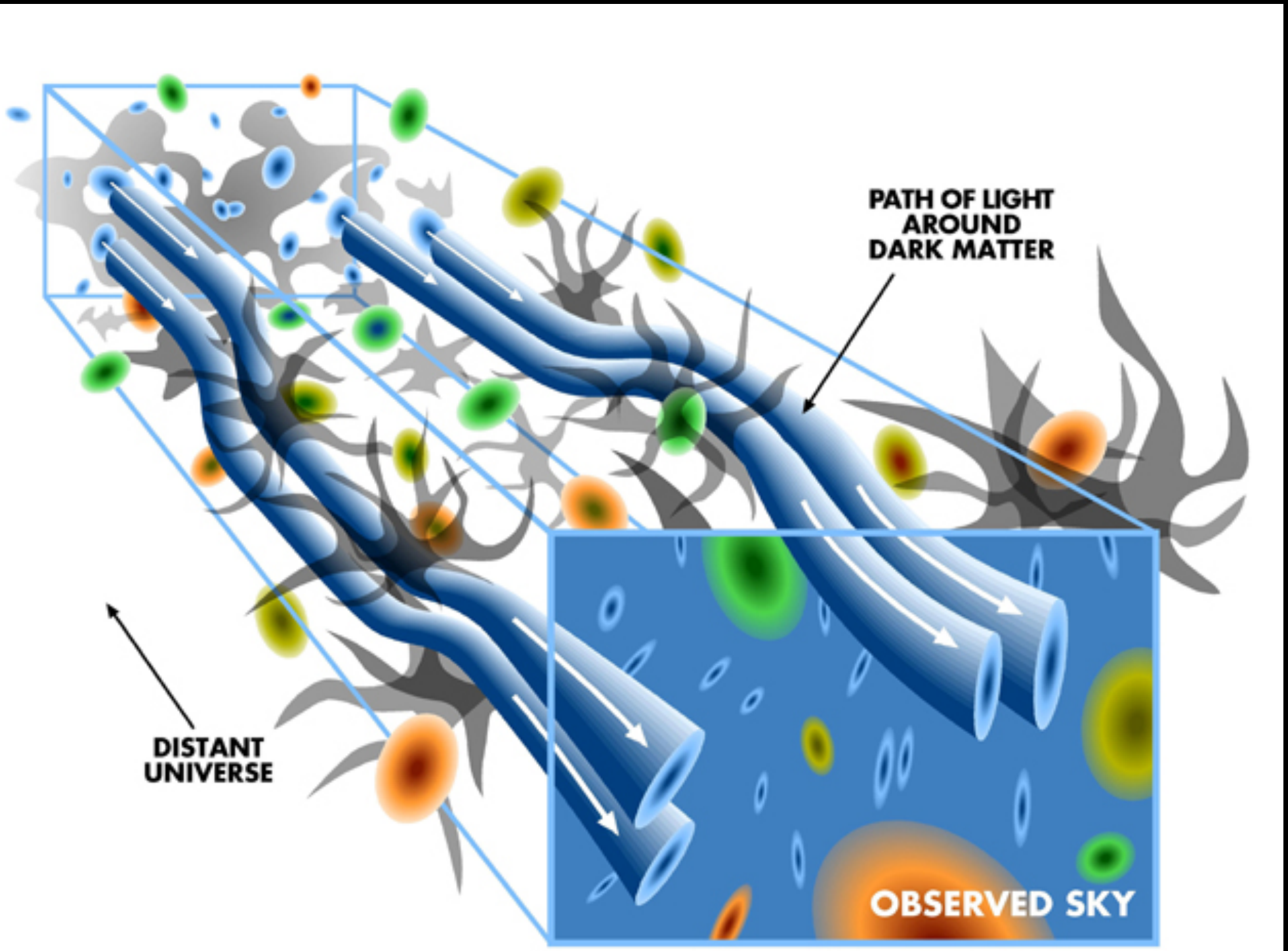
Mass map (Dark Energy Survey, Vikram+2015)

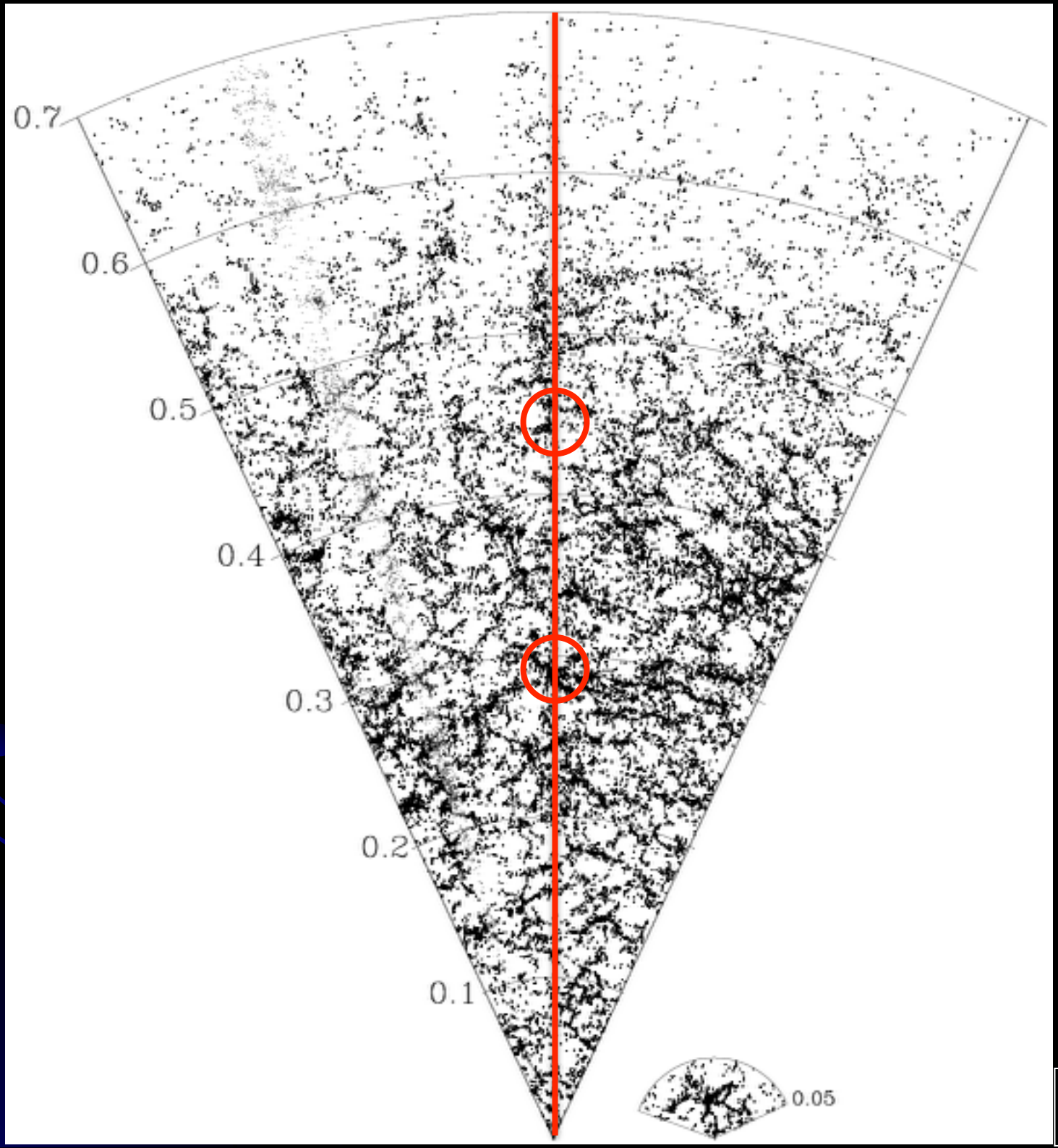
Weak Lensing for Galaxy Clusters





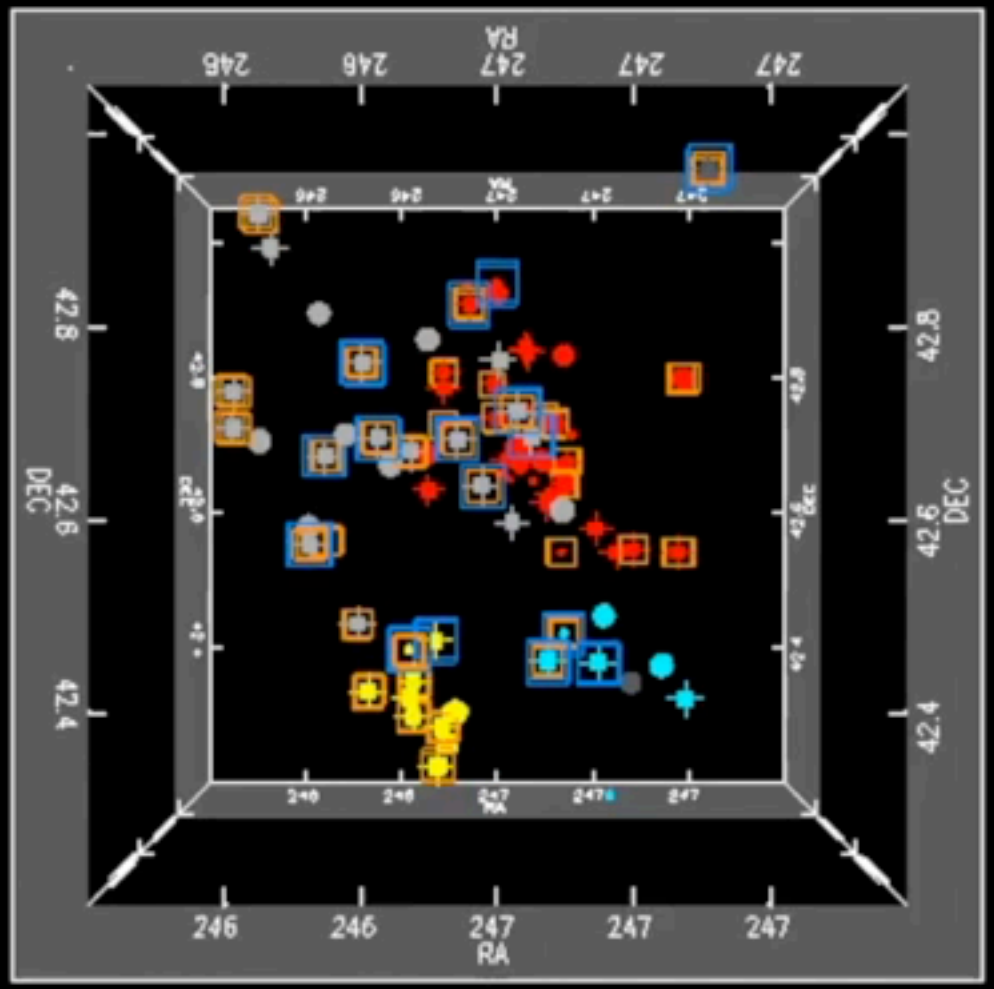
A383 (Okabe+10; Subaru/SC)

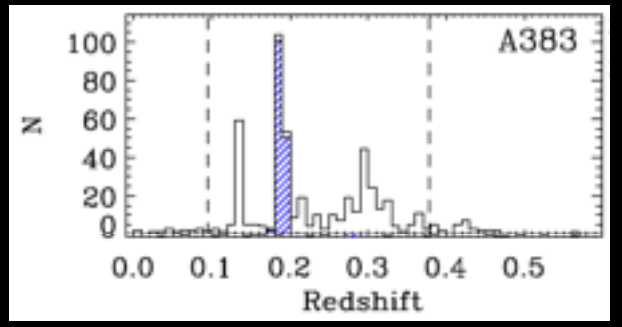

PATH OF LIGHT
AROUND
DARK MATTER
DISTANT
UNIVERSE
OBSERVED SKY

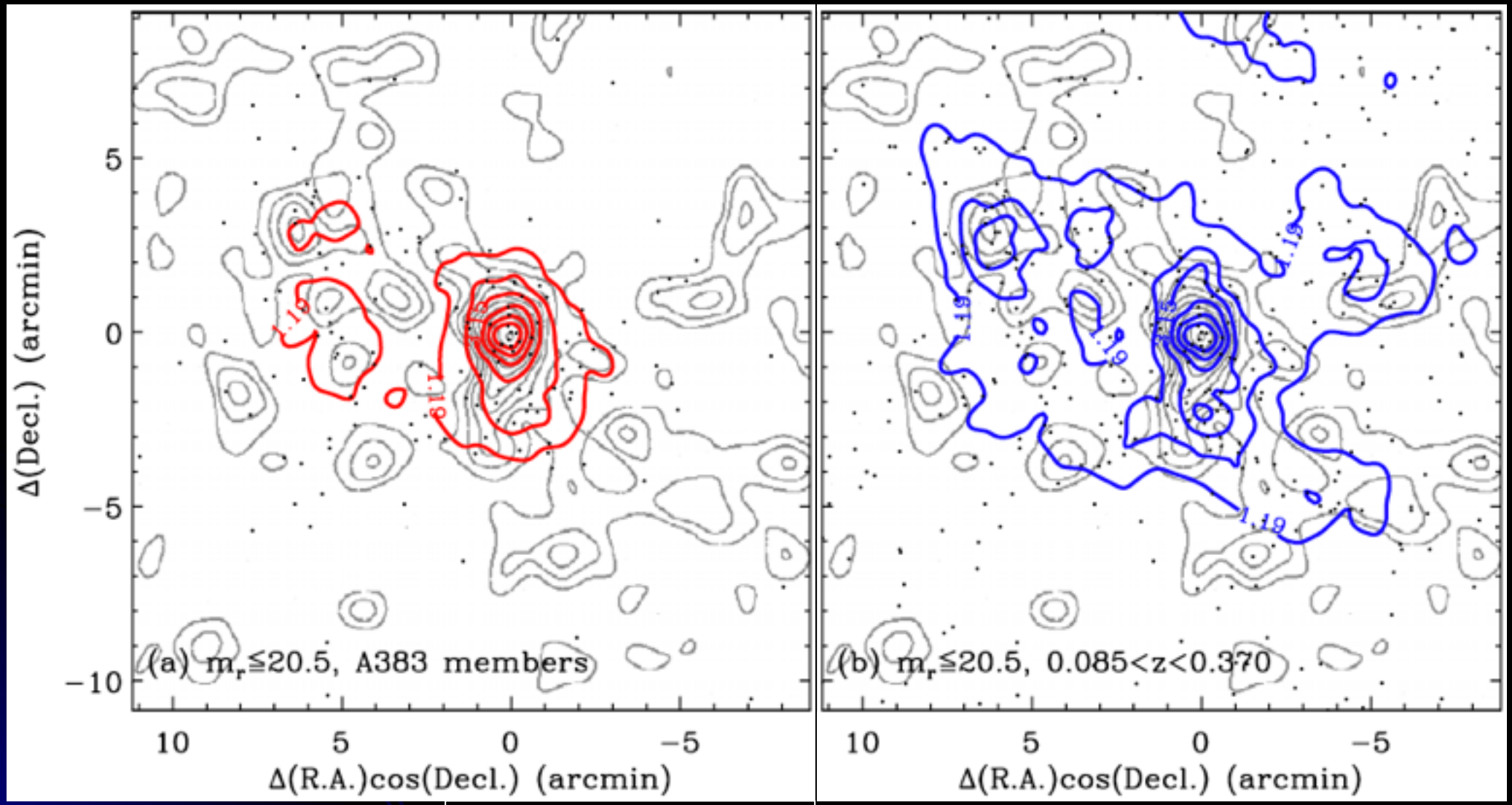


HectoMAP
(Geller, Hwang+14)

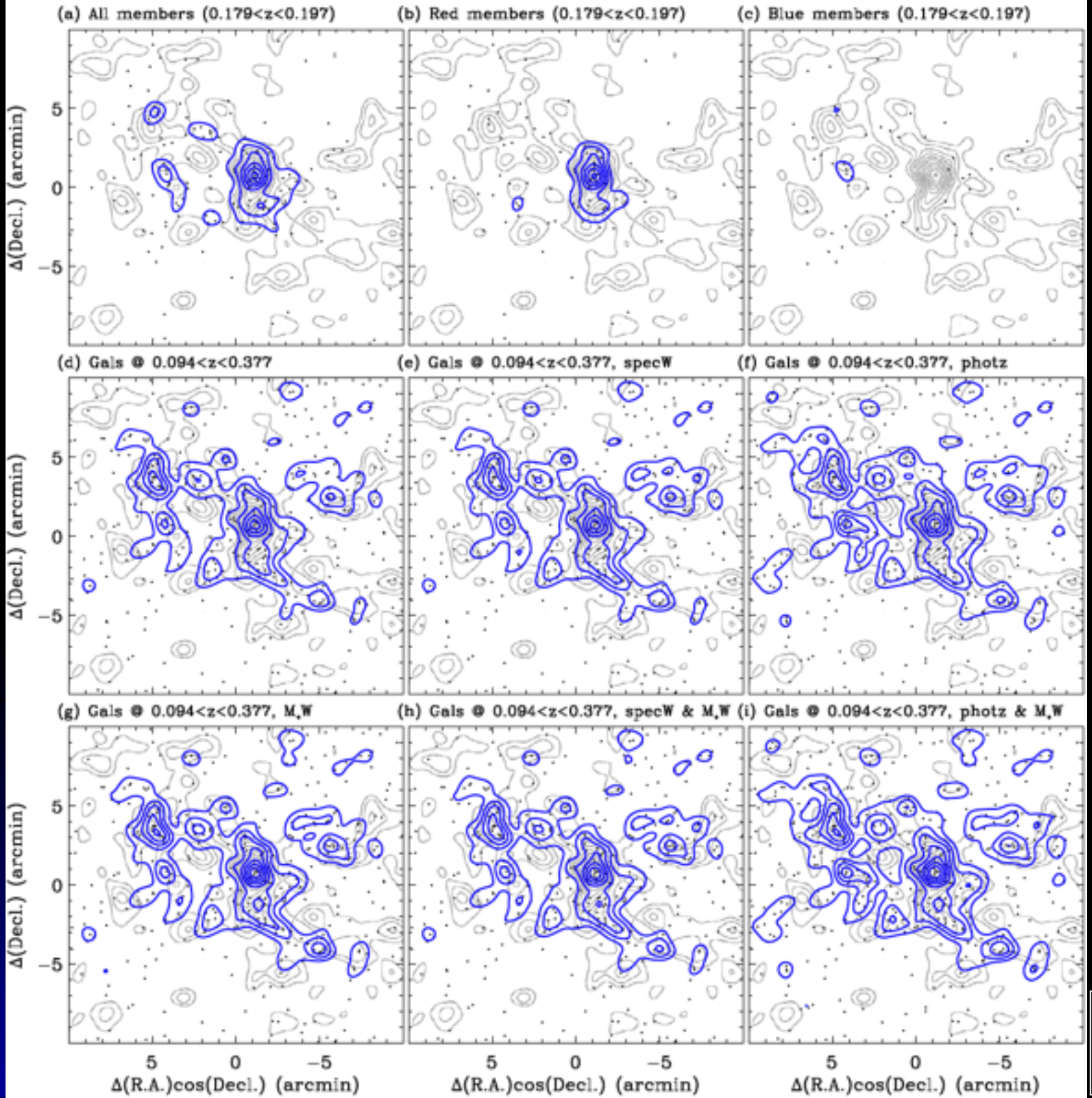
A2192 (Jaffe+2013)





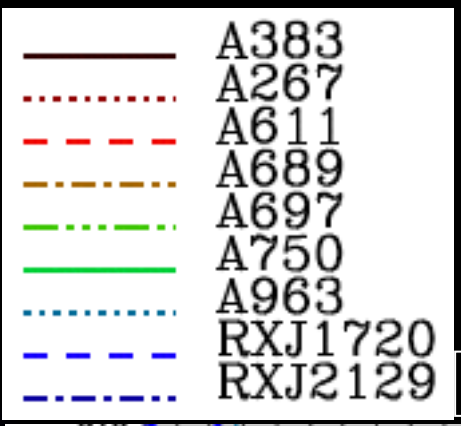


Geller,Hwang+14
(Subaru WL by Okabe+10 &
MMT Redshift survey)

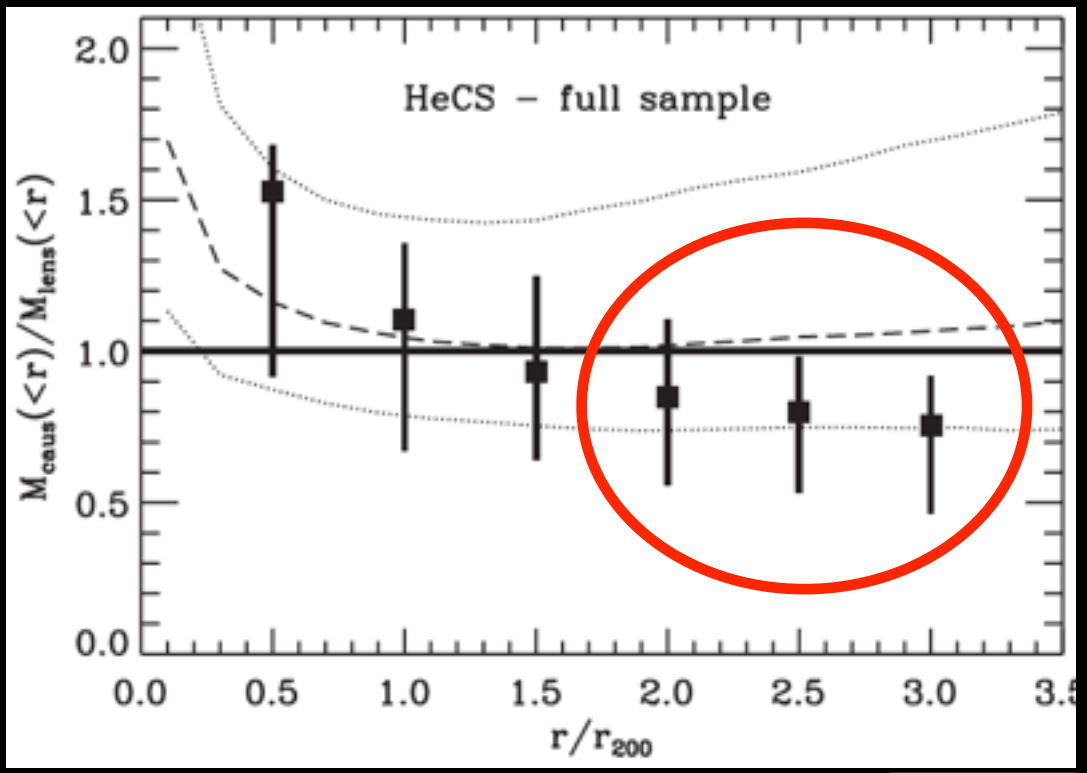


Hwang+14
(Subaru WL by Okabe+10 & MMT Redshift survey)

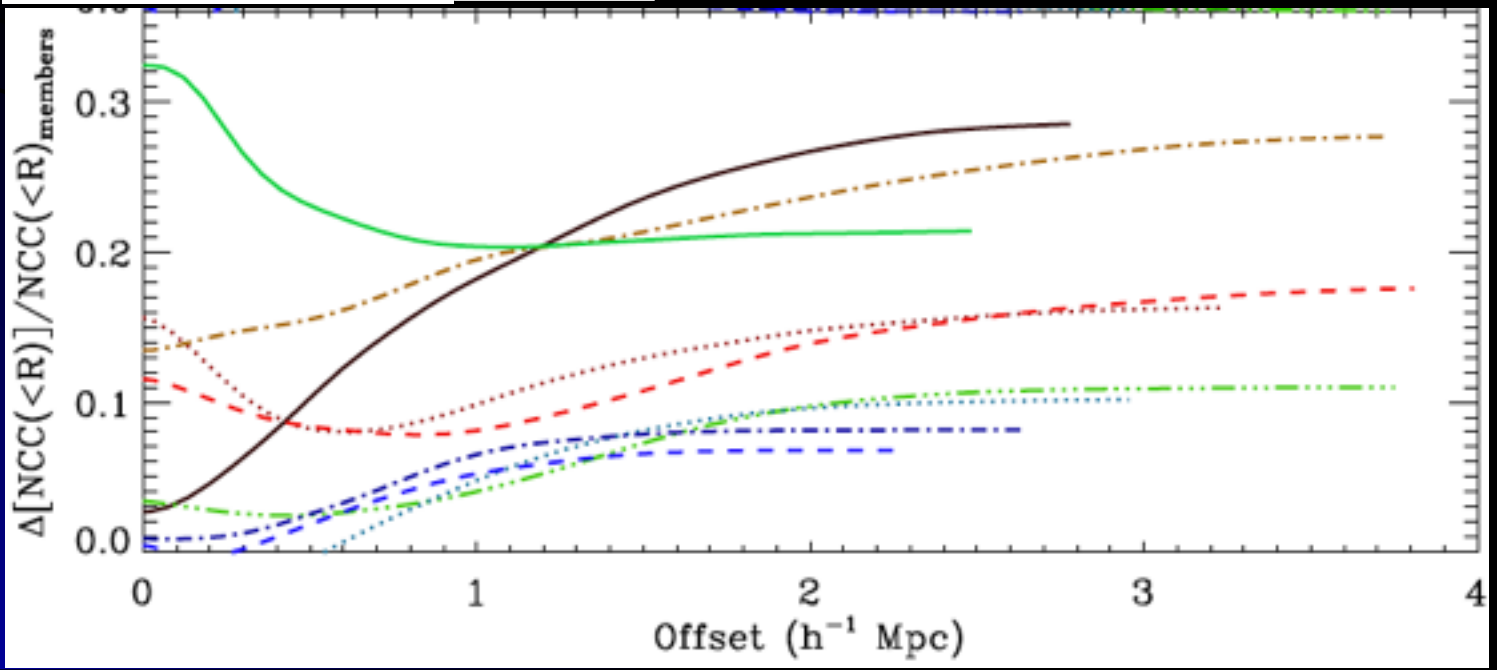
Cross-correlation of the galaxy number density maps with the WL maps



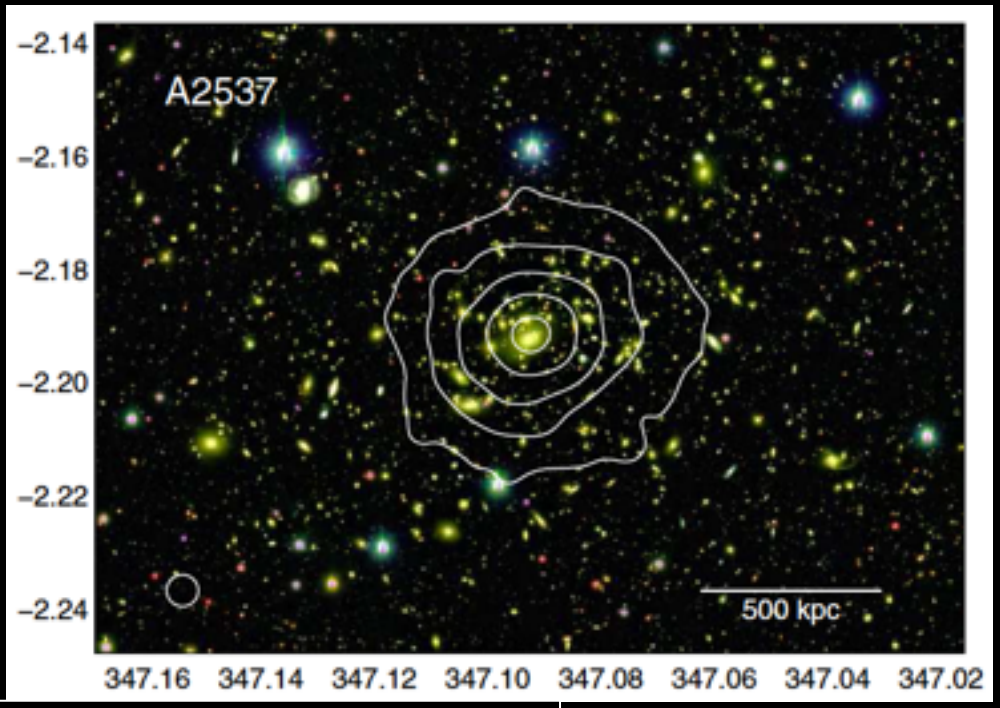
Hwang+14

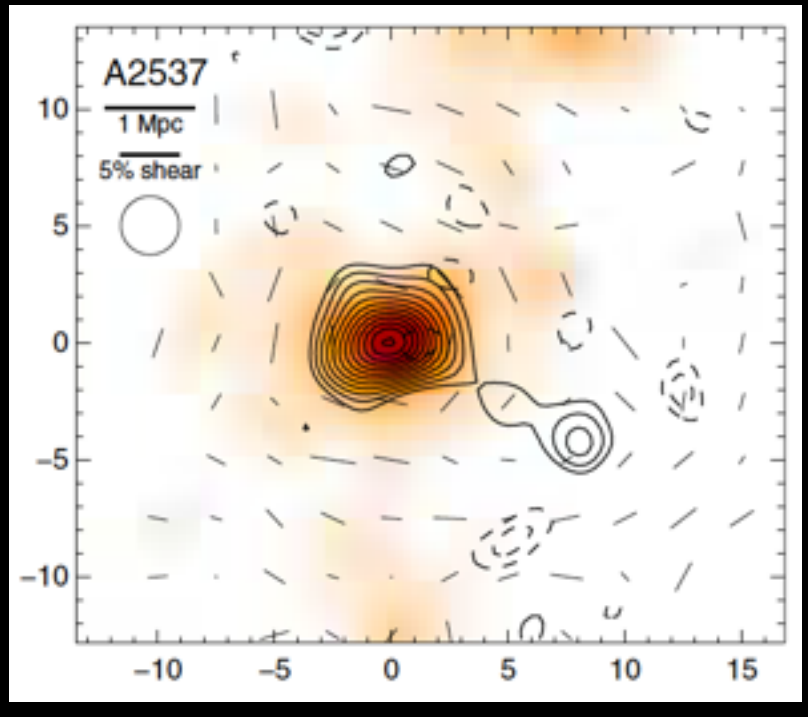


Geller+13

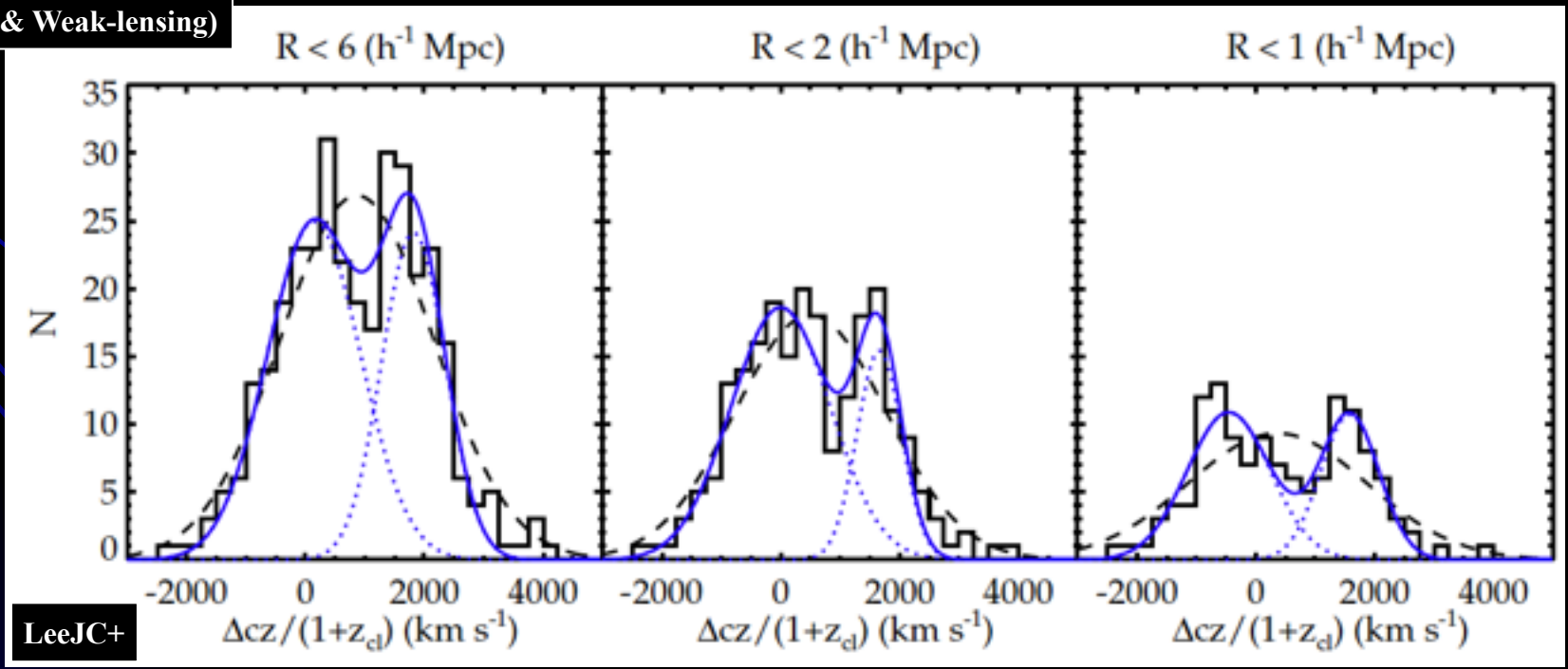


Merging Clusters: Critical role of spectroscopy



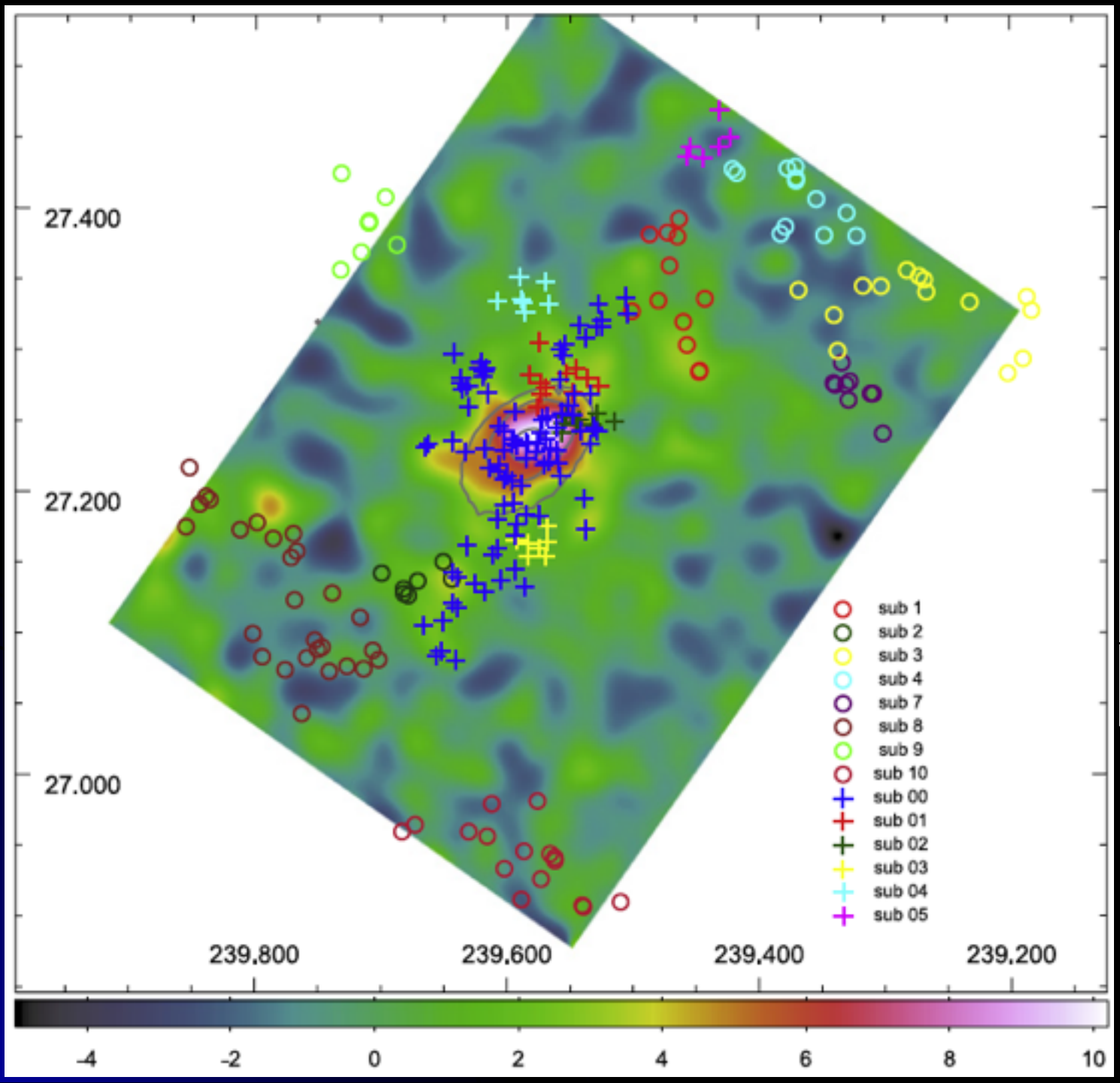


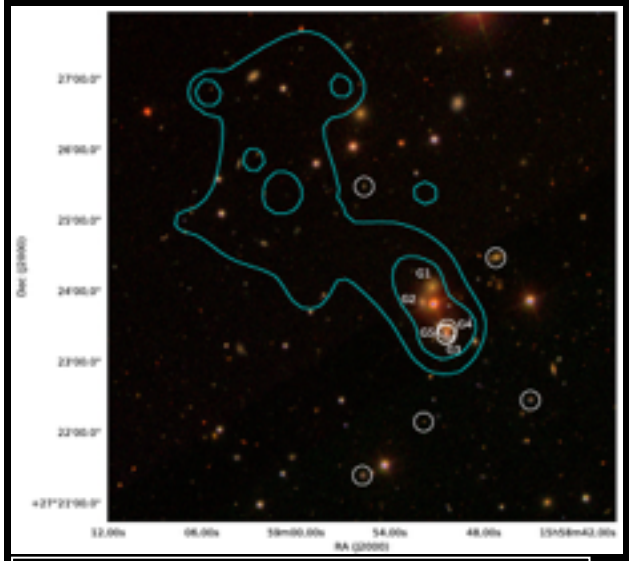
A2537 (Newman+2013, X-ray & Weak-lensing)



LeeJC+

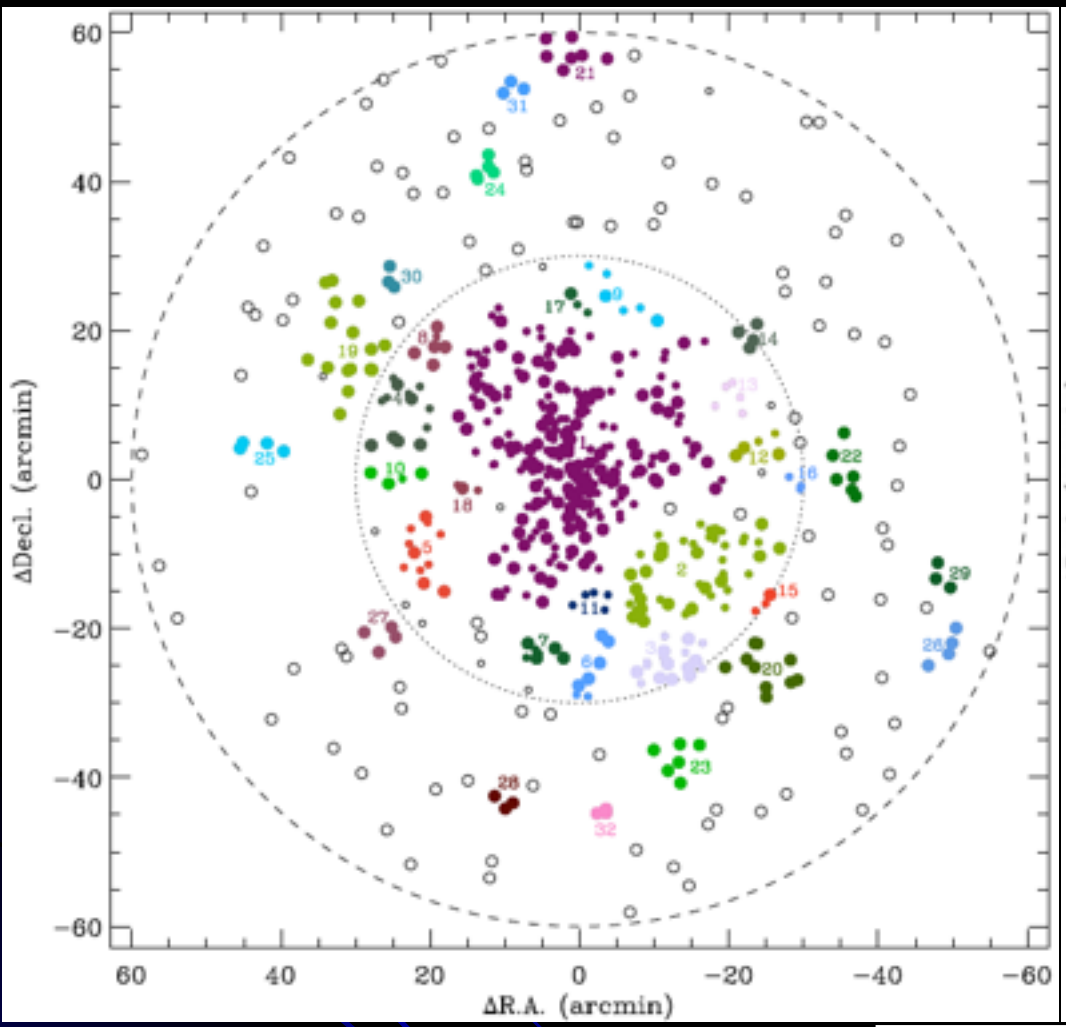
Merging Clusters: Critical role of spectroscopy

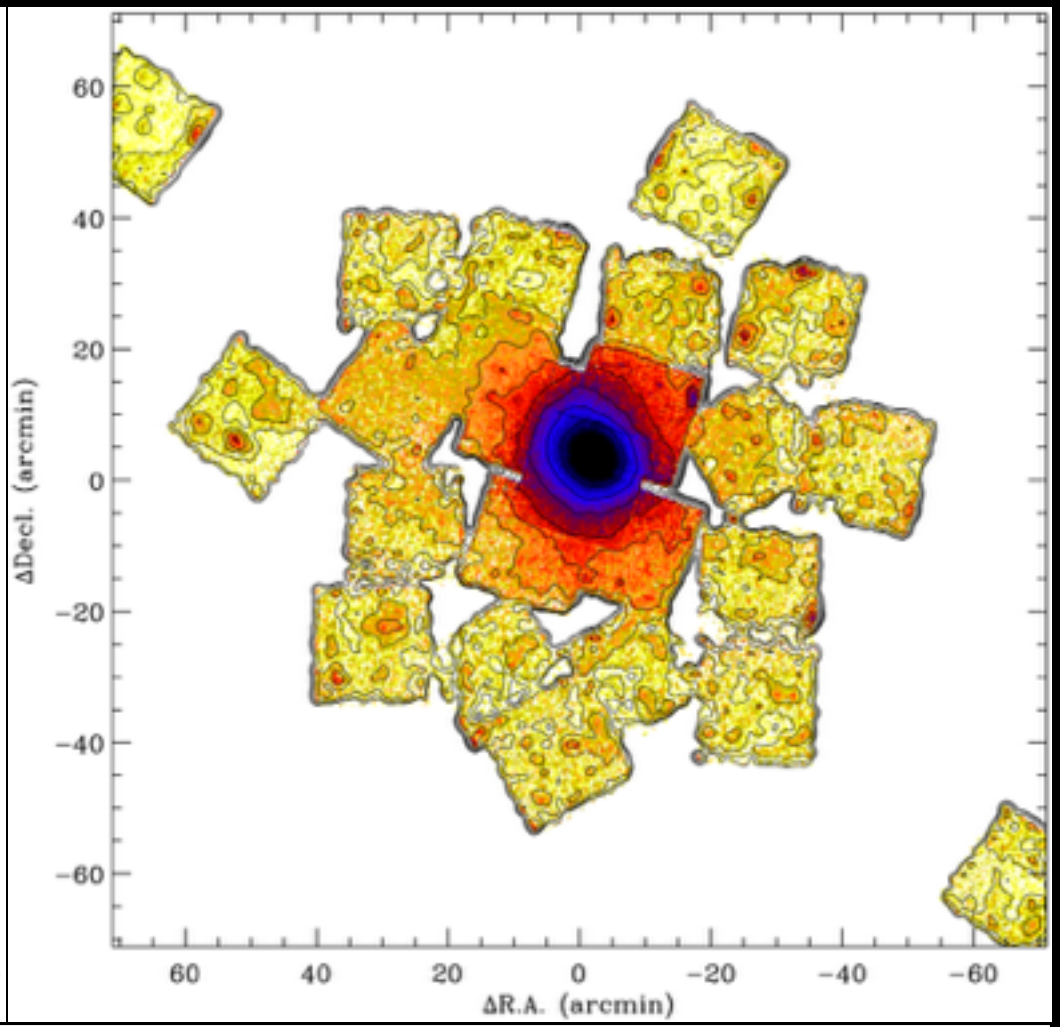




A2142 (Liu+18; Subaru WL + MMT Redshifts + Chandra X-ray)

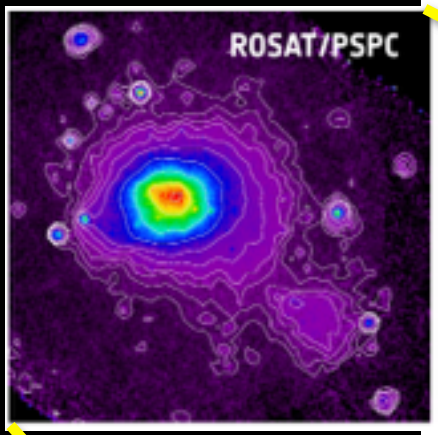
Nearby Clusters: X-ray, Redshift Survey & (Weak Lensing?)

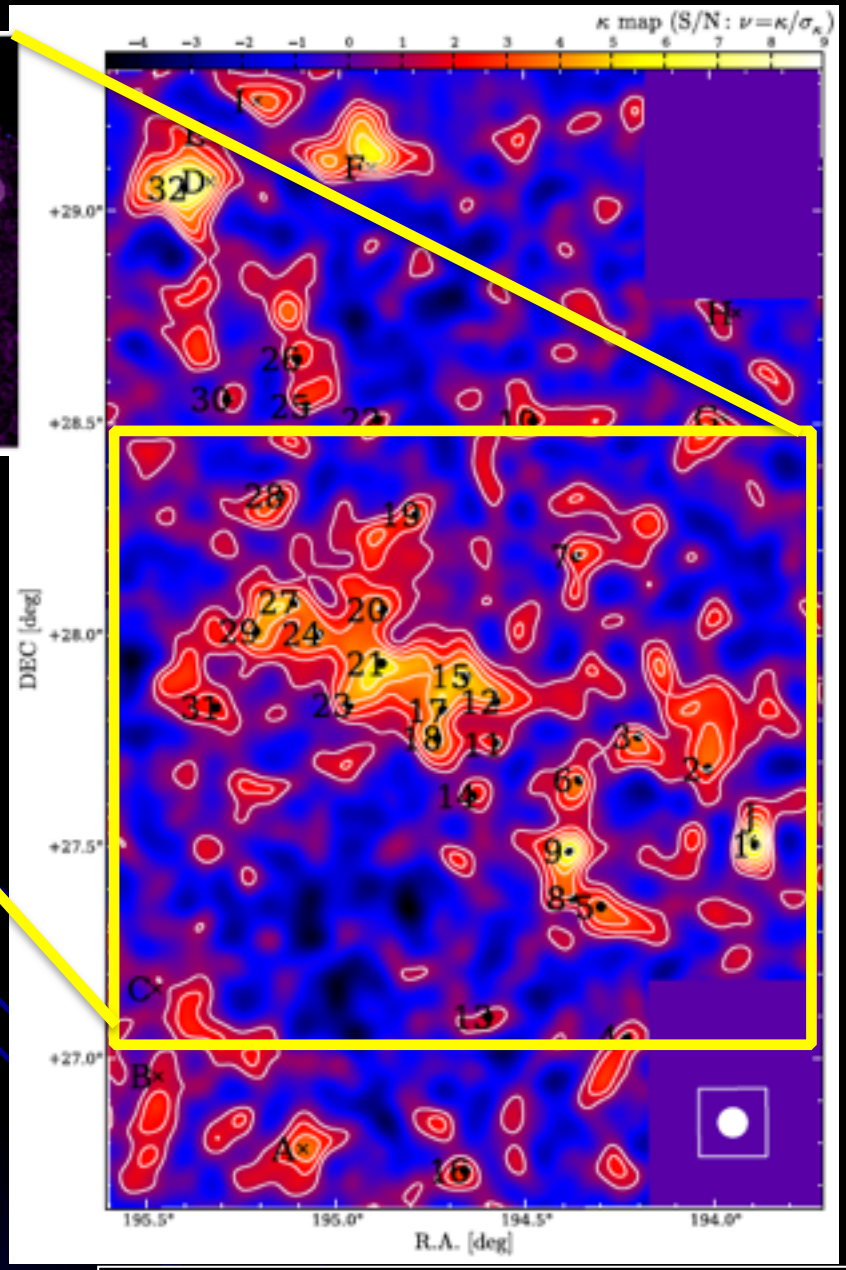


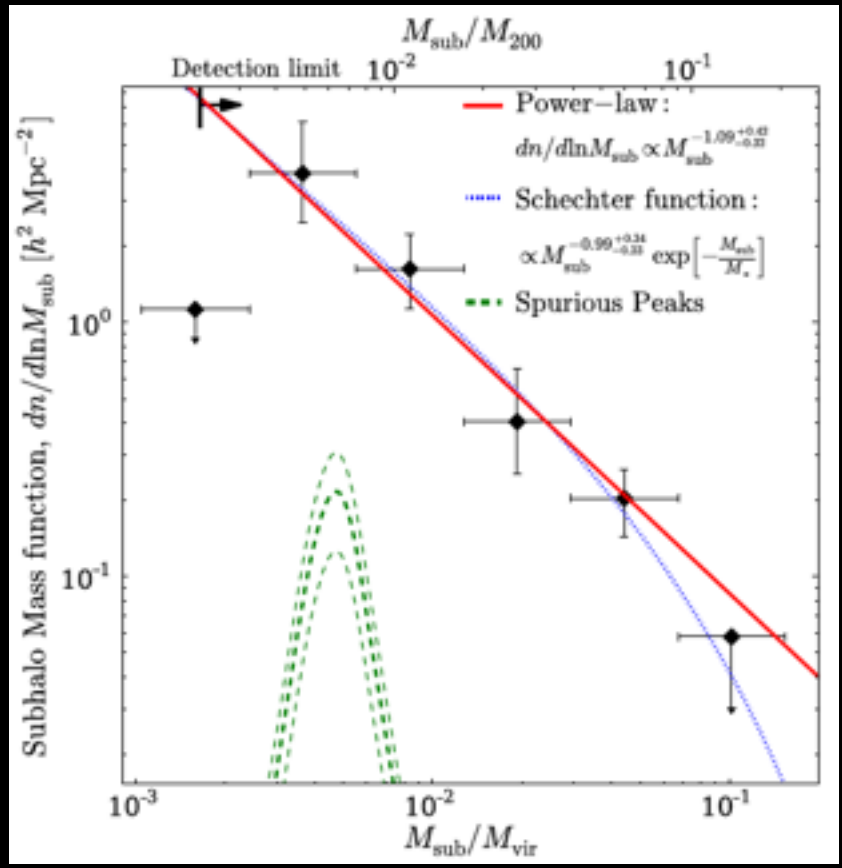


A2199 (Suzaku X-ray by Tamura+17 & MMT Redshift survey by Song+17)

Nearby Clusters: Coma - Subhalos!

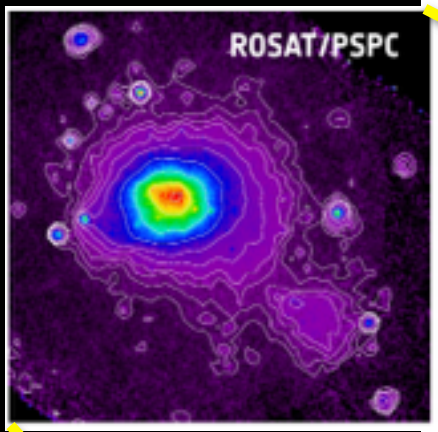


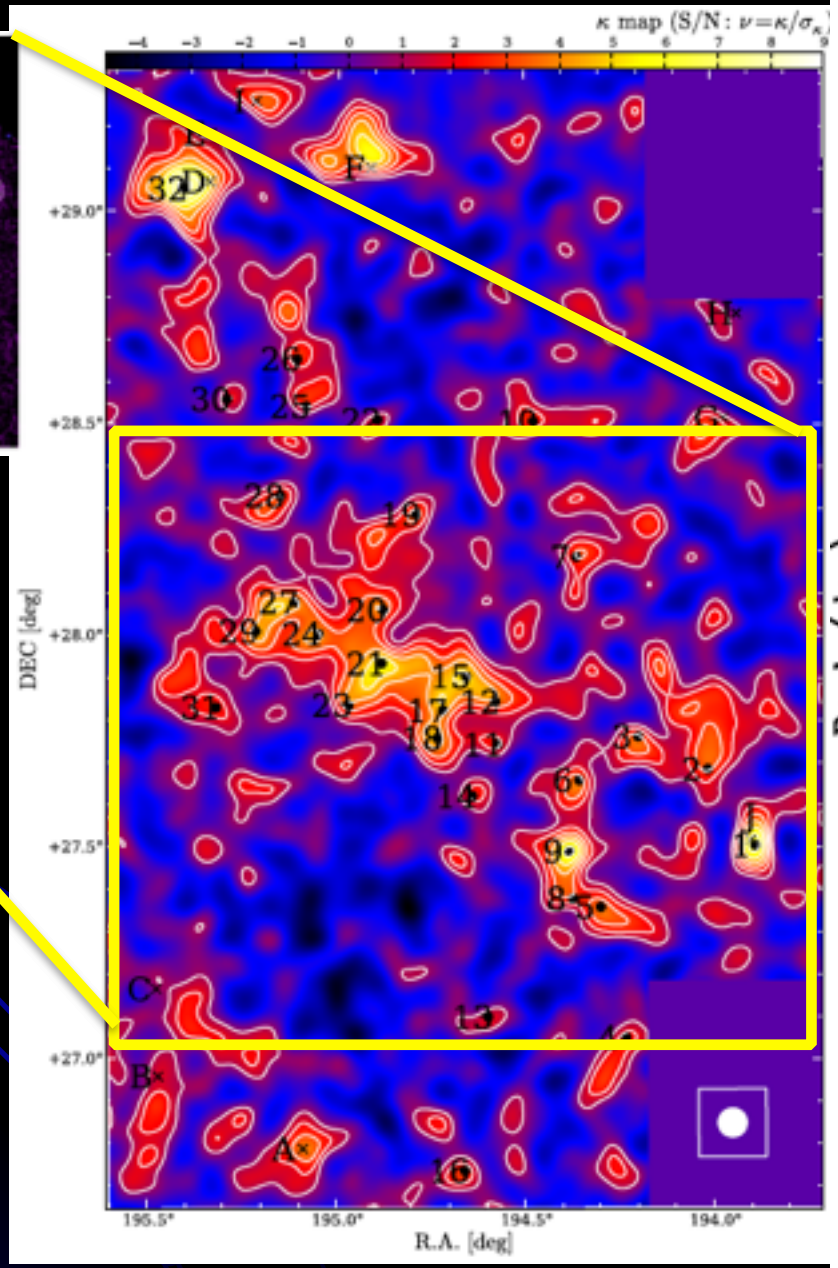


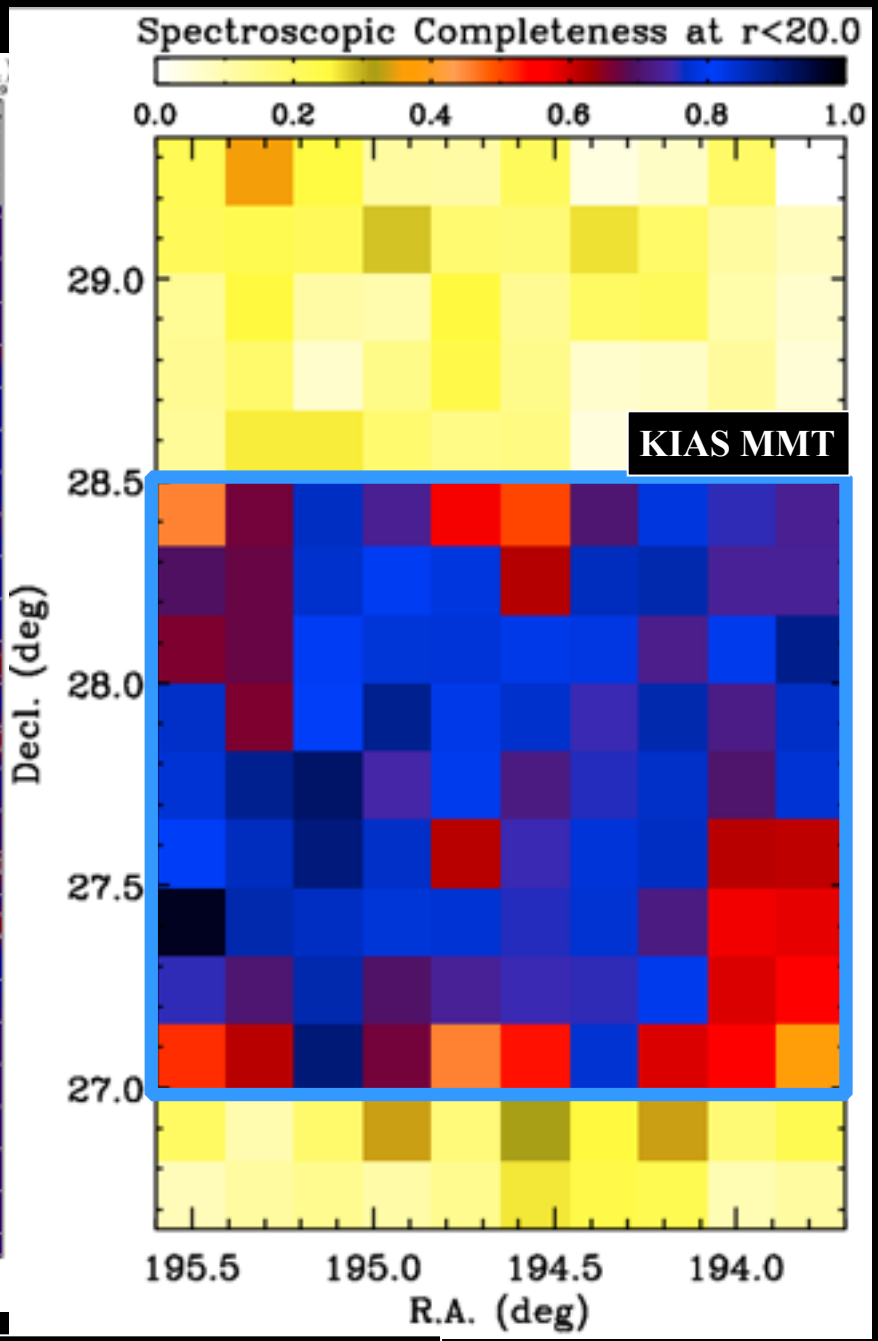


COMA (Subaru WL by Okabe+14 & KIAS MMT Redshift survey by Hwang+)

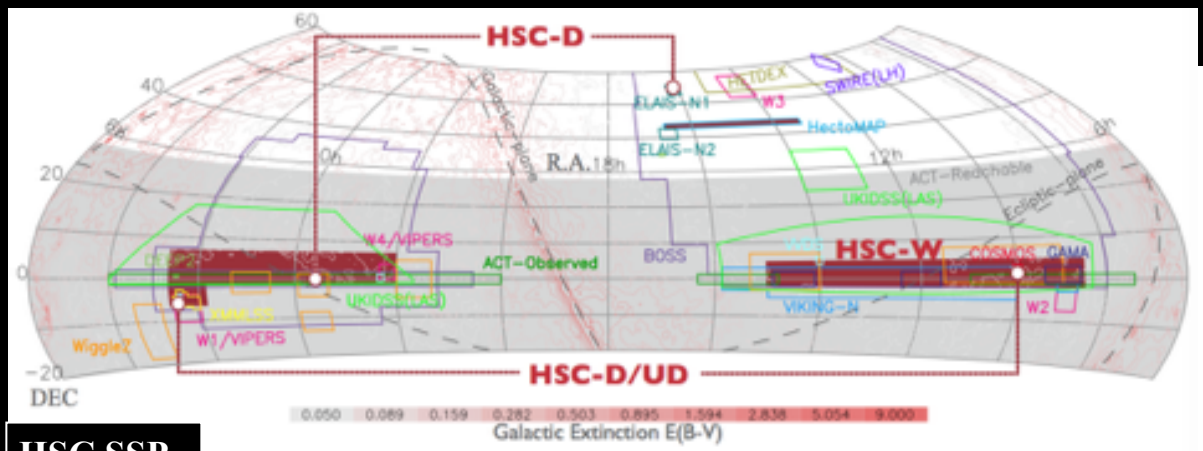
Nearby Clusters: Coma - Subhalos!



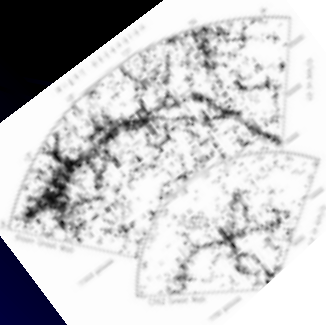




COMA (Subaru WL by Okabe+14 & KIAS MMT Redshift survey by Hwang+)



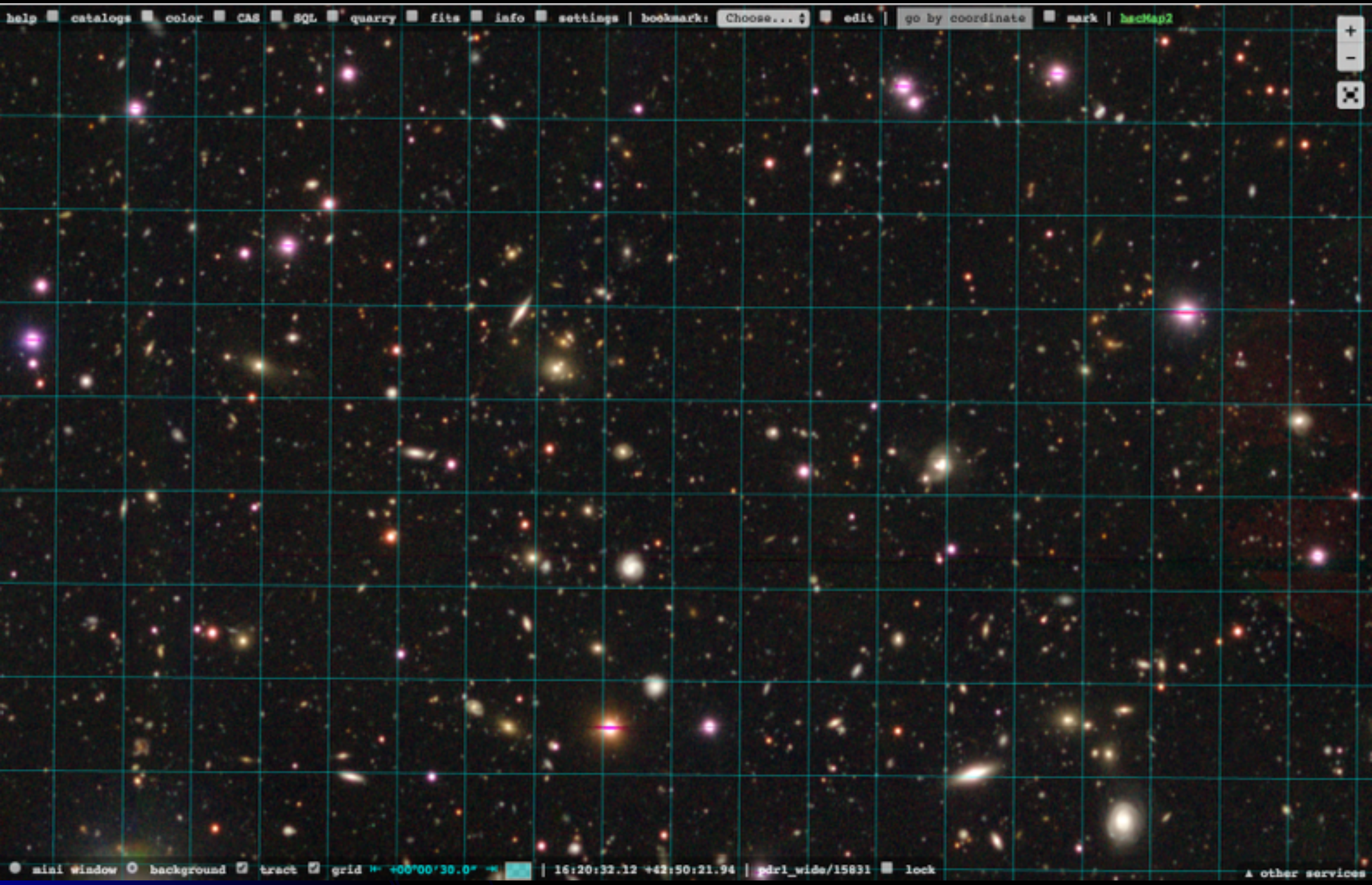
HSC SSP



HectoMAP (Geller, Sohn, Hwang+

- One of densest and complete survey of red galaxies at r<21.3 (Geller+11, Geller & Hwang 15)
  - HectoMAP: ~1250 gals/deg^2, BOSS: ~150 gals/deg^2
  - Examine the Large-scale Structure at Intermediate Redshifts (Hwang+16)

Weak Lensing Analysis of Subaru/HSC images in the HectoMAP region



HectoMAP Galaxy Cluster Survey

SohnJ+2018a;b

Cluster Identification	HectoMAP
Photometry	Subaru/HSC
Spectroscopy	HectoMAP
Weak Lensing	Subaru/HSC
X-ray	ROSAT (eROSITA)
Sunyaev-Zel'dovich	Planck

Slide from Jubee Sohn

- HSC of Subaru
  - Deep imaging surveys of nearby galaxy clusters
    - Weak-lensing analysis for subhalos
    - Other galaxy property studies (e.g. UDGs, sizes)

- PFS of Subaru (meanwhile, Hectospec of MMT)
  - Wide-field, dense spectroscopic surveys of nearby galaxy clusters
    - 3D distribution of galaxies in and around clusters

- Combination of the two is the key for our studies of galaxy clusters

Conclusions and Future Prospects

- What I would like to have is
"the combination of spectroscopic (PFS) and imaging (HSC) surveys of nearby galaxy clusters"

- Study of (Nearby: Wide & Deep) Galaxy Clusters!

  - Accurate Mass Measurements of Galaxy Clusters
    - Combination of Kinematics and Weak Lensing
    - Subhalos: mass function!

  - Faint Features of Cluster Galaxies + Intracluster light (ICL)

  - Faint-end slope of Galaxy Luminosity Function

  - Environmental Dependence of Galaxy Properties

Thank you!