

Issues for Future Progress: Clusters

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Issues for progress

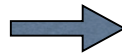
- Number of clusters
- High redshift
- Precision in Redshift estimate
- Accurate Selection
- Precision in Mass estimate

Number and redshift: current cluster samples

| $z < 0.5$ | $0.5 < z < 1$ | $1 < z < 1.45$ | $1.45 < z < 2$ | $z > 2$ |
|--------------------------------|---------------------------|--------------------------------------|----------------|-------------------------|
| ~10,000's | ~100's | ~15-20 | | ~10 |
| Rosat, SDSS, CFHT LS Wide, etc | Rosat, EDICS, COSMOS, etc | Rosat, XMM XCS, SpARCS, Booties, etc | | Protocluster detections |

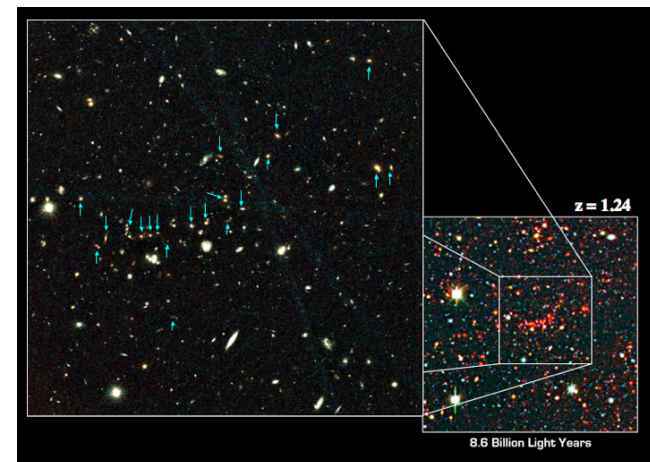


Red sequence



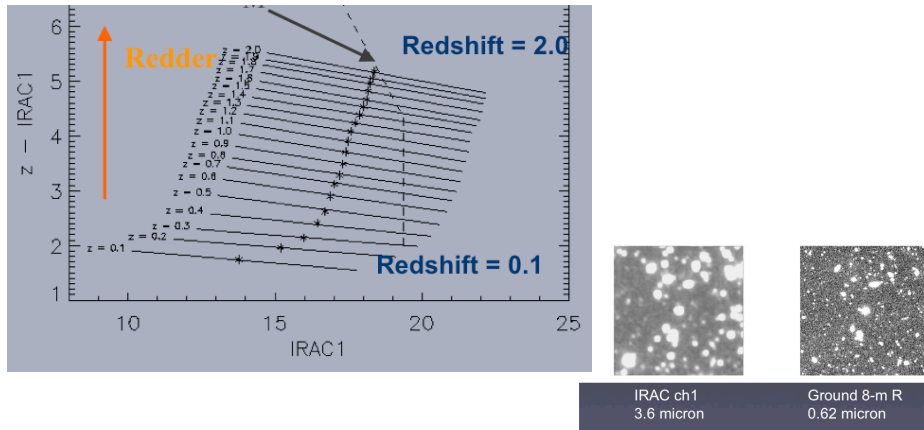
Star forming

Far-Infrared + Optical/NIR



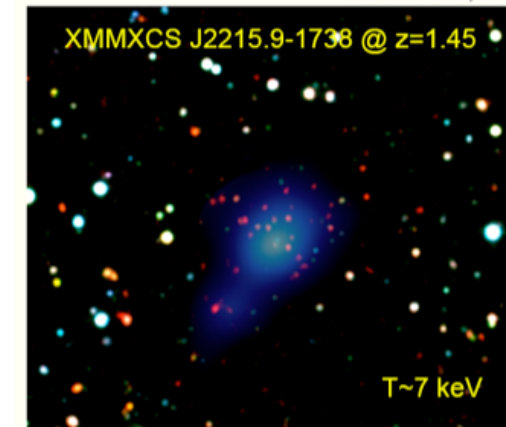
Eisenhardt et al. 2008, Brodwin et al. 2008

SpARCS



(Wilson et al. 2009; Muzzin et al 2009)

X-ray selected



Stanford et al. 2005, see also Mullis et al. 2005

Redshift range

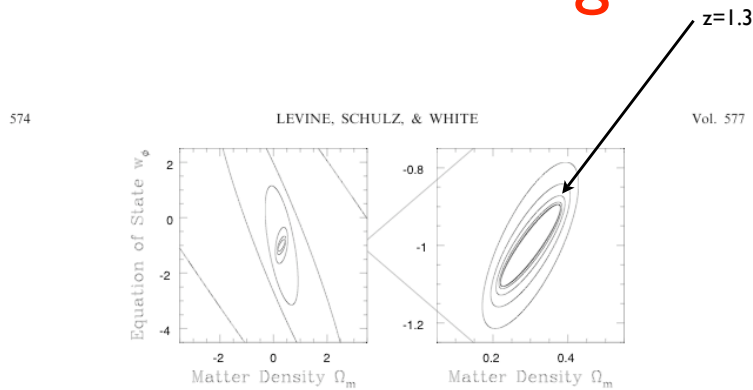
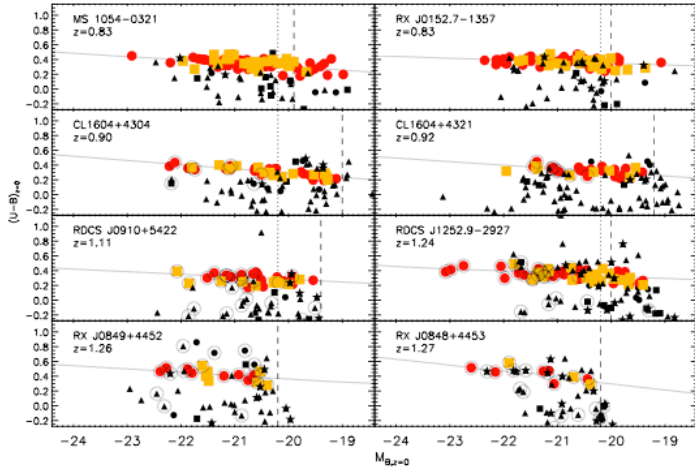


FIG. 3.— Shows 1σ regions of maximum likelihood in the $\Omega_m - w_0$ plane for a series of cluster surveys differing only in survey depth. In the left-hand panel, constraints are plotted for $z_{\text{red}} = 0.1, 0.2, 0.3, 0.5, 0.7, \text{ and } 0.9$, decreasing in size. The right-hand panel shows $z_{\text{red}} = 0.9, 1.1, 1.3, 1.5, 1.7, \text{ and } 1.9$. All surveys have an area of 1000 deg^2 and a temperature threshold of 5 keV .

Precision in redshift: Cluster redshift

- Galaxy clusters at $0.5 < z < 1.3$ have a well defined red sequence, e.g. a dominant early-type population
- Photometric redshifts, averaged on cluster candidates have reasonable statistical uncertainties
- Projection effects (Mock catalogs, e.g. SDSS)



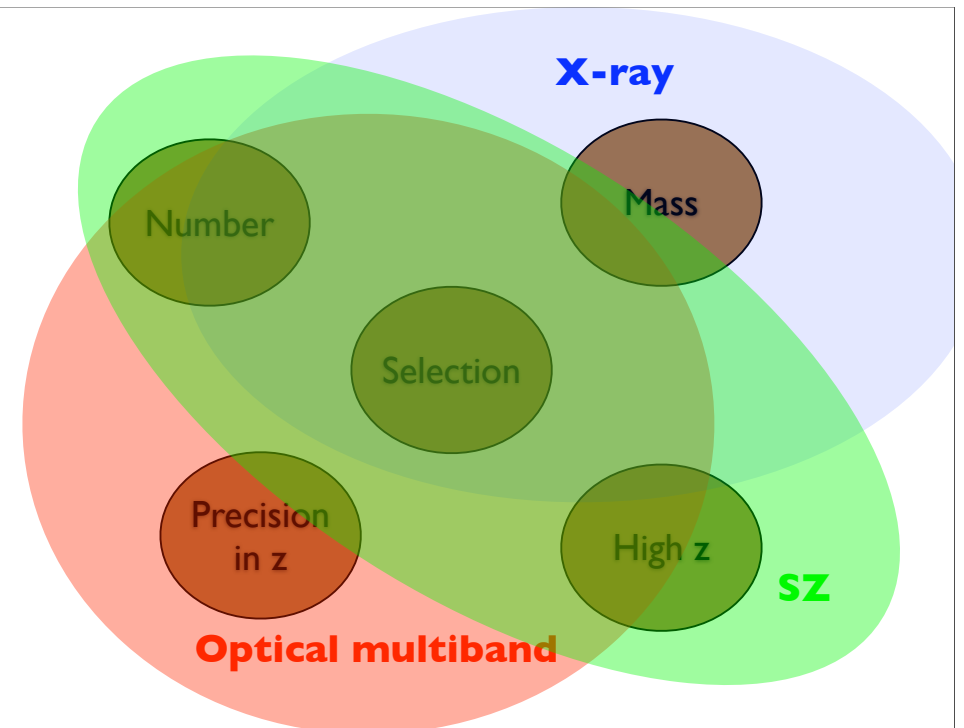
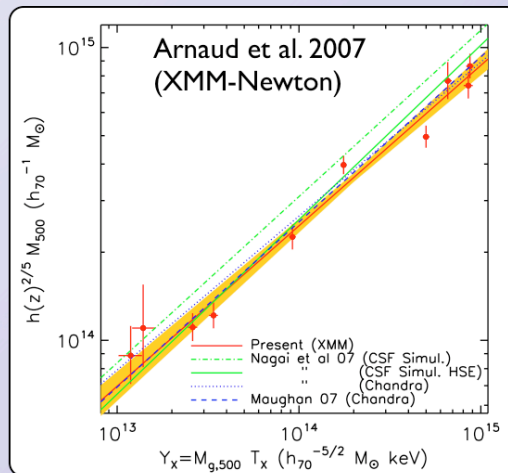
Mei et al. 2009

Precision in Mass estimate

- X-ray : Flux/Temperature (Arnaud et al. 2007)
- Weak and strong lensing **Precision in photometric redshift** of few hundreds of magnitude

$$Y_X \propto M_{gas} T_X$$

$$\sigma_M \leq 10\%$$



Optical Surveys: wide up to $z \sim 1$

- PAN-STARRS (current; 30,000 sq.deg. up to $z \sim 1-1.5$; g,r,i,z,y)
- DES (current; 5000 sq. deg. up to $z \sim 1$; g,i,r,z)
- LSST (>2015; 20,000 sq.deg up to $z \sim 1-1.5$; u,g,r,i,z,y)

X-ray Surveys

- XMM Cluster Survey (current, 500 deg.sq.)
- e-Rosita (all-sky; >2012)
- Wide Field X-ray Telescope (half sky; >2020)

Targeted Observations for Flux and Temperature precision measurements

- XMM, Chandra (current)
- IXO (>2020)

SZ Wide Surveys

- SPT (Oct 2008, first cluster detected from SZ observations; 4000 sq. deg. up to $z \sim 1-2$)
- ACT (400 sq. deg., up to $z \sim 1-2$)
- Planck (All sky, up to $z \sim 1$)

Targeted Observations for precision measurements

- AMI, AMEBA, SZA, APEX

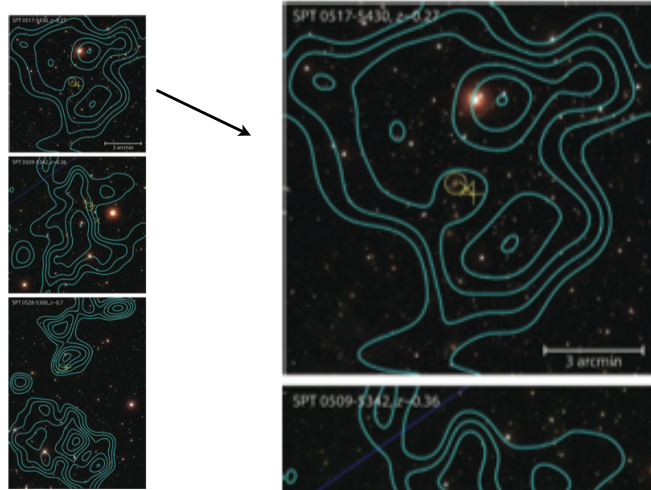
Combined Optical/X-ray, SZ Studies

- SPT (Blanco Cosmology Survey, DES)
- ACT (Blanco Cosmology Survey, GALEX)
- Planck (All sky up to $z \sim 1$, SDSS, and dedicated follow-up)

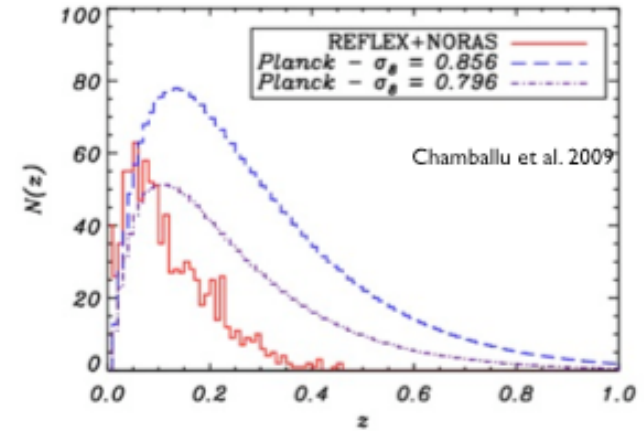
First lensing measurements of SZ-detected clusters

Rachel N. McInnes,^{1*} Felipe Menanteau,² Alan F. Heavens,¹ John P. Hughes,² Raul Jimenez,³ Richard Massey,¹ Patrick Simon¹ and Andy Taylor¹

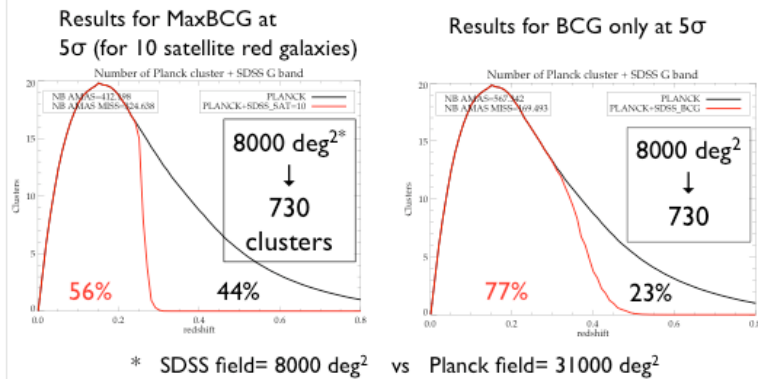
¹ Scottish Universities Physics Alliance (SUP)
² Rutgers University, Department of Physics
³ ICREA and ICE/CSIC-IEEC, UAB campus



Planck X-ray follow-up



Planck Optical follow-up



Fromenteau et al. 2009