Finding (and using) Clusters in the SDSS

People looking for clusters:

Jim Annis (Fermilab) - - - maxBCG
Rita Kim (JHU) - - - AMF and VTT
Tomo Goto (CMU) - - - Cut and Enhance
Ryuichi Kurosawa (Pitt) - - - AMF with photo z's
Andreas Berlind (Chicago) - - - Groups w/z's
Chris Miller (CMU) - - - C4 (four color)
Brian Lee (Fermi) - - - Groups

Motivation:

- Tracing Large Scale Structure
- Cluster Abundance
- Galaxy Formation and Evolution
- Scaling Laws
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- Multiwavelength Targets
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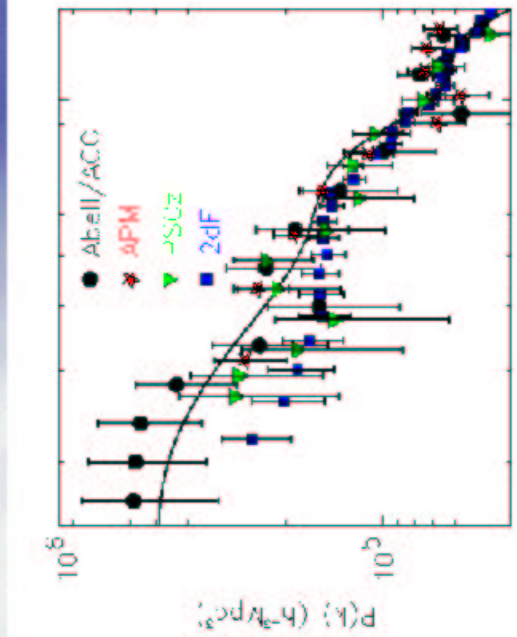
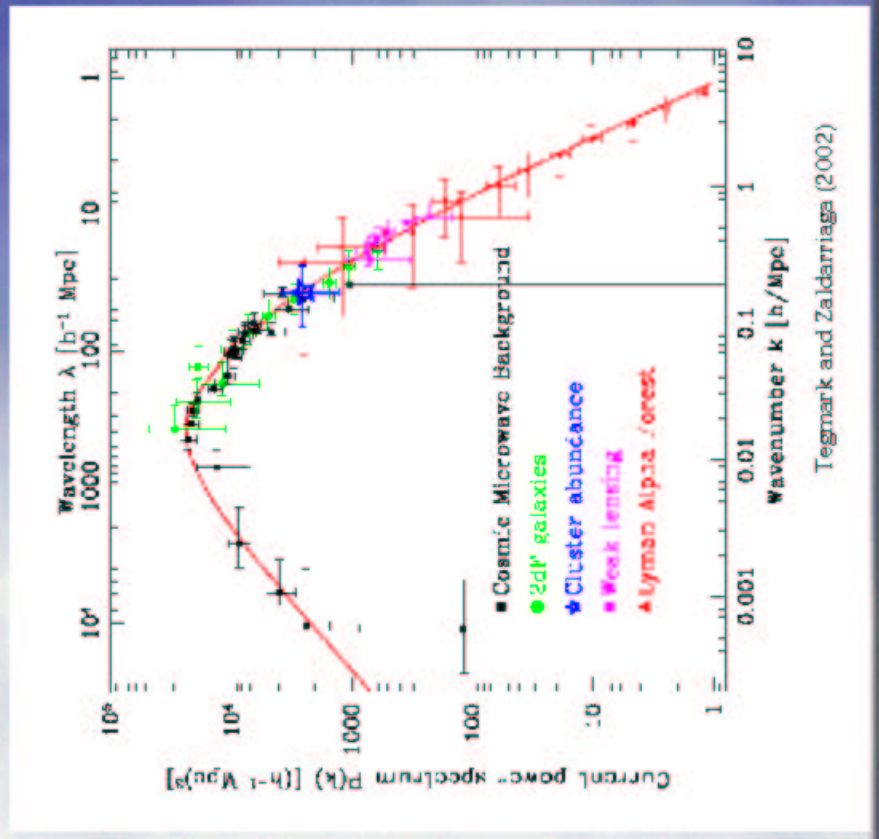


Miller, Nichol, and Chen (2002)



Tegmark and Zaldarriaga (2002)

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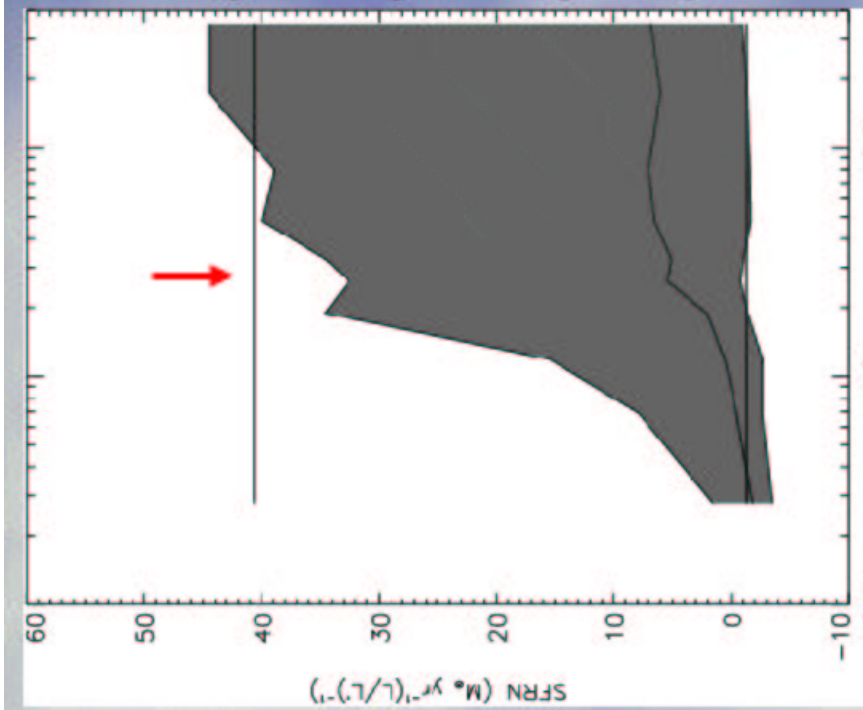

Gomez, Nichol, Miller et al. (2002)

- 17 clusters/groups (~300 to ~1000 km/s)
- Statistically different from field at <3 R_{vir}
- Arrow marks density ~ 1 Mpc^{-2})
- See Lewis et al. 2002 as well (same result)

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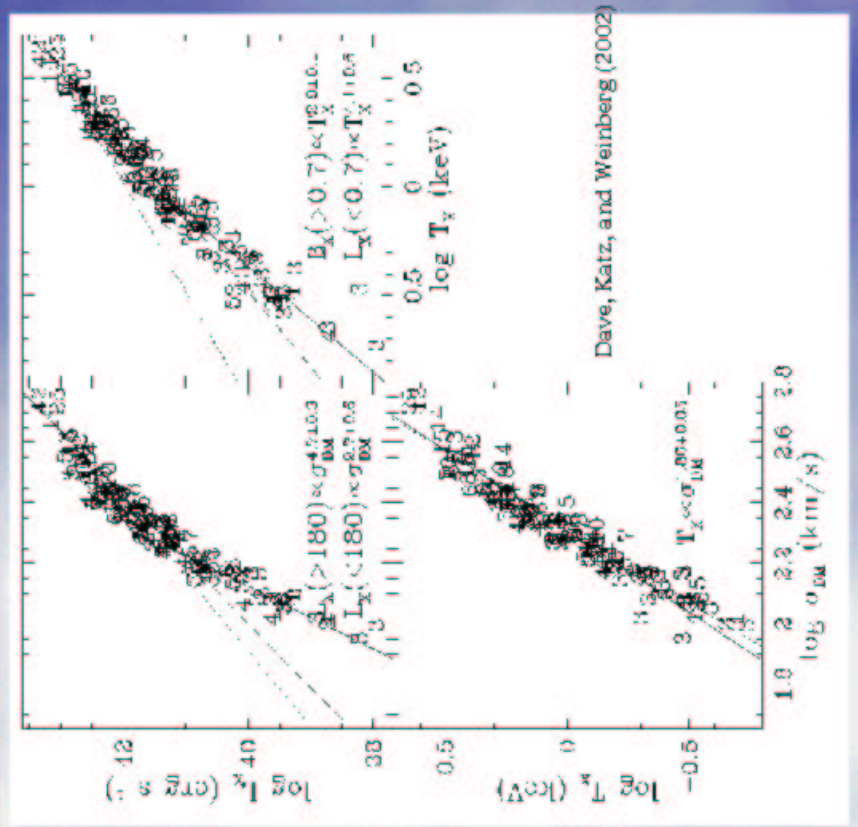

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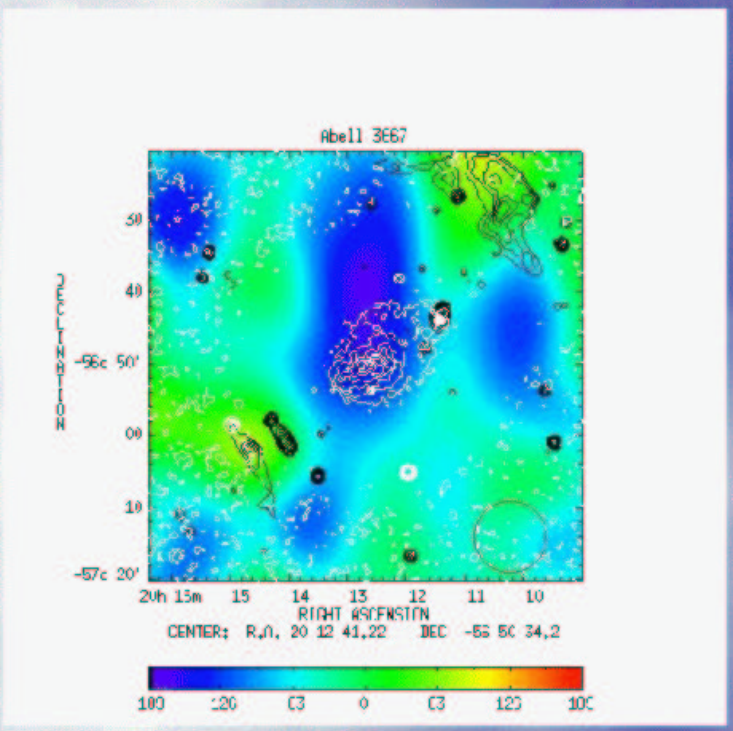

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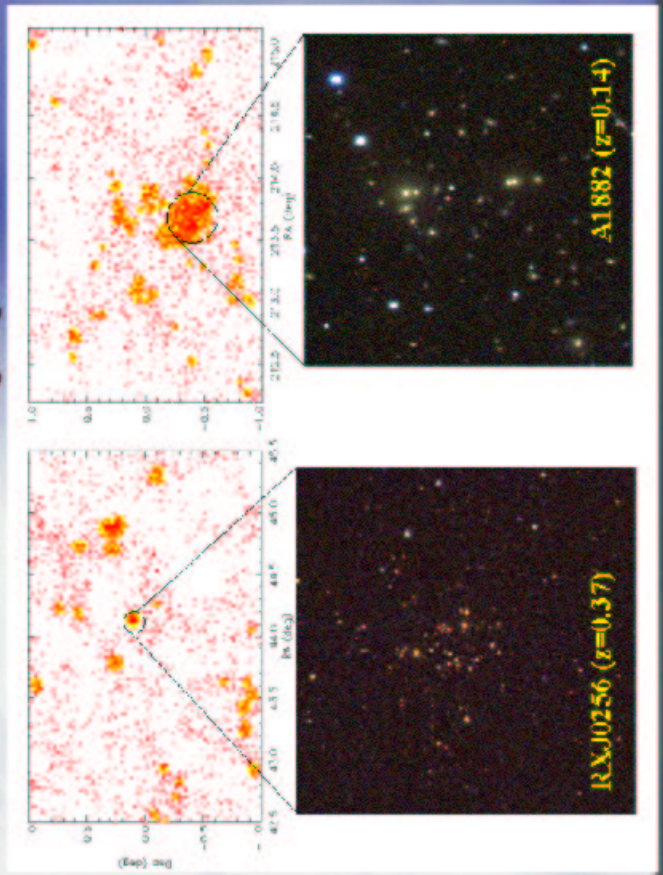
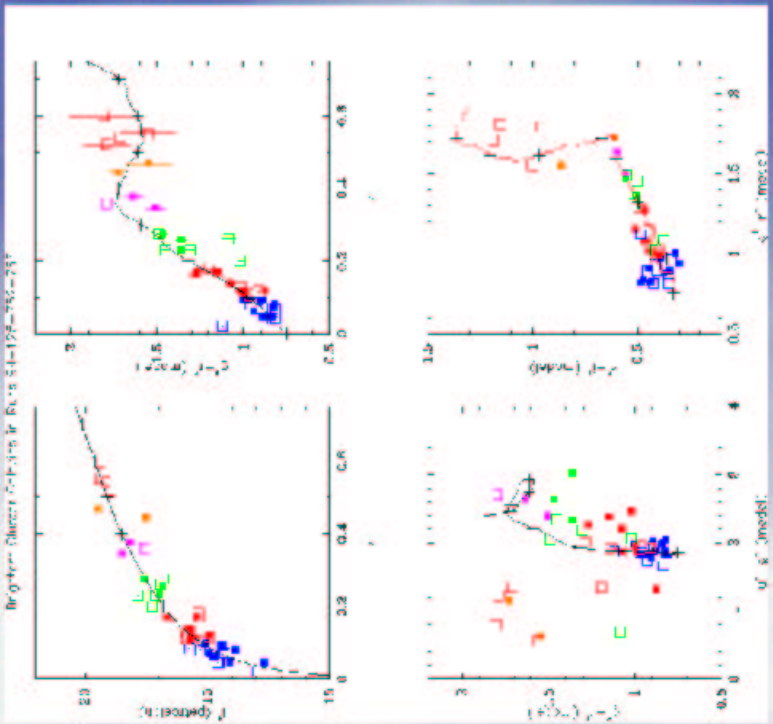
Finding Clusters in the SDSS

The Sloan Digitial Sky Survey provides 5- band CCD imaging.



The maxBCG Technique



Compute the likelihood that a galaxy resembles a BCG

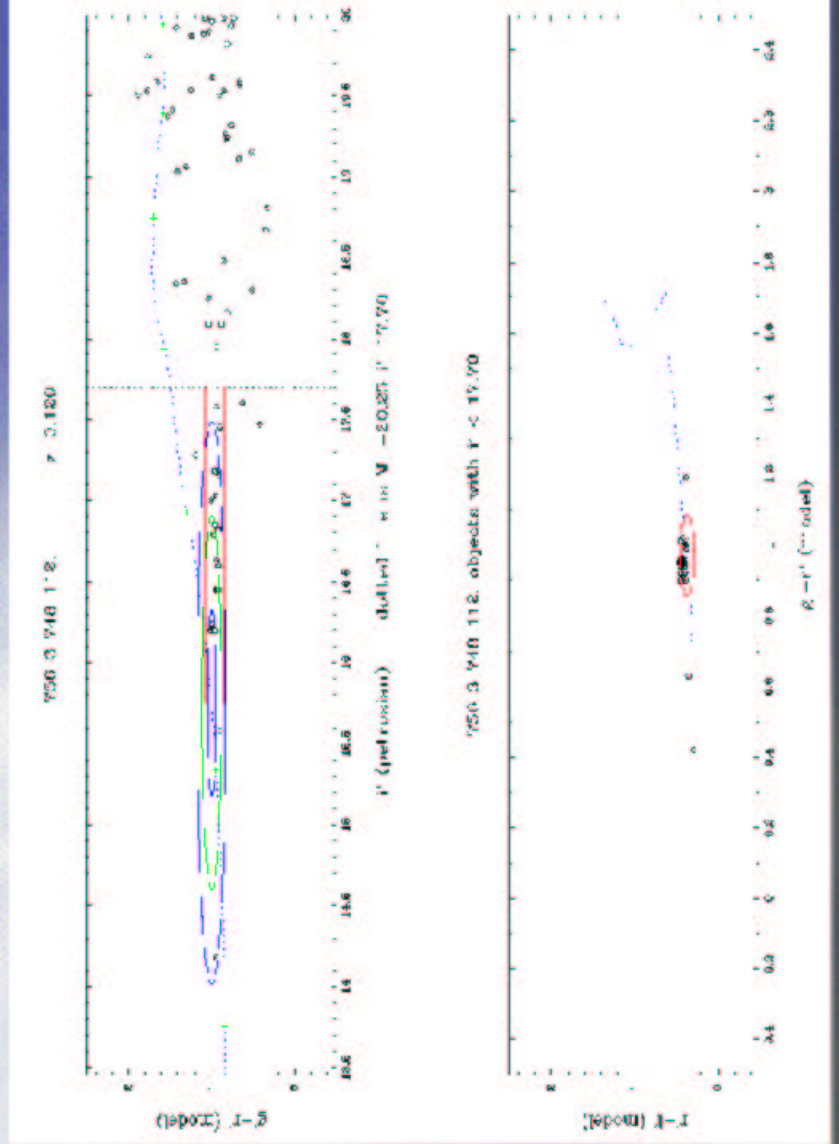
$$P_{mag} \propto \exp\frac{\left[-(m-m_{bcg}(z))\right]}{\sigma_{bcg}}$$

$$P_{g-r} \propto \exp\frac{\left[-(m_{g-r}-m_{g-r,bcg}(z))\right]}{\sigma_{bcg}}$$

$$P_{r-i} \propto \exp\frac{\left[-(m_{r-i}-m_{r-i,bcg}(z))\right]}{\sigma_{bcg}}$$

$$L=\sigma_{mag}+\sigma_{g-r}+\sigma_{r-i}+\ln(n_{gals})$$

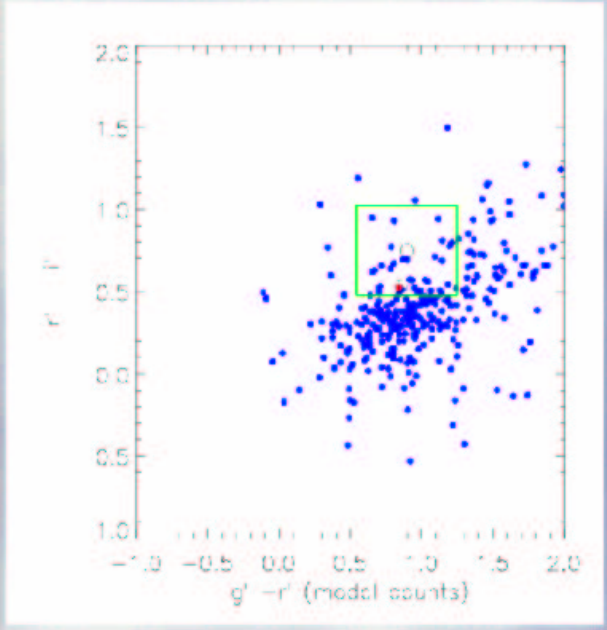
Maximize Likelihood with z



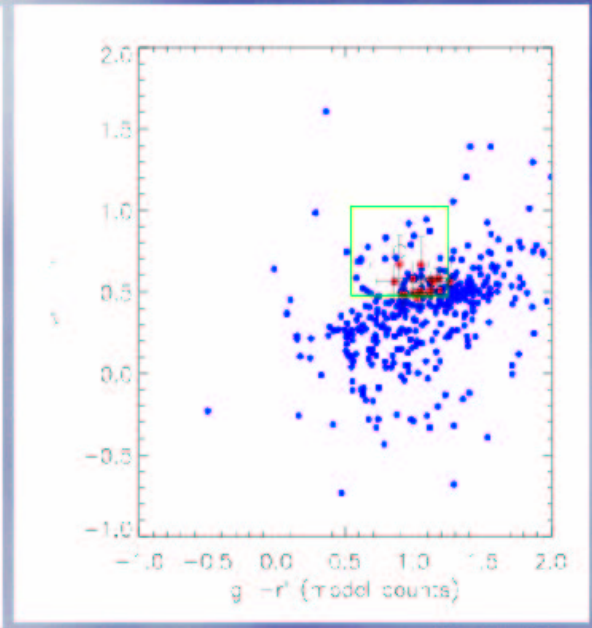
Nonparametric Clustering in Seven Dimensions

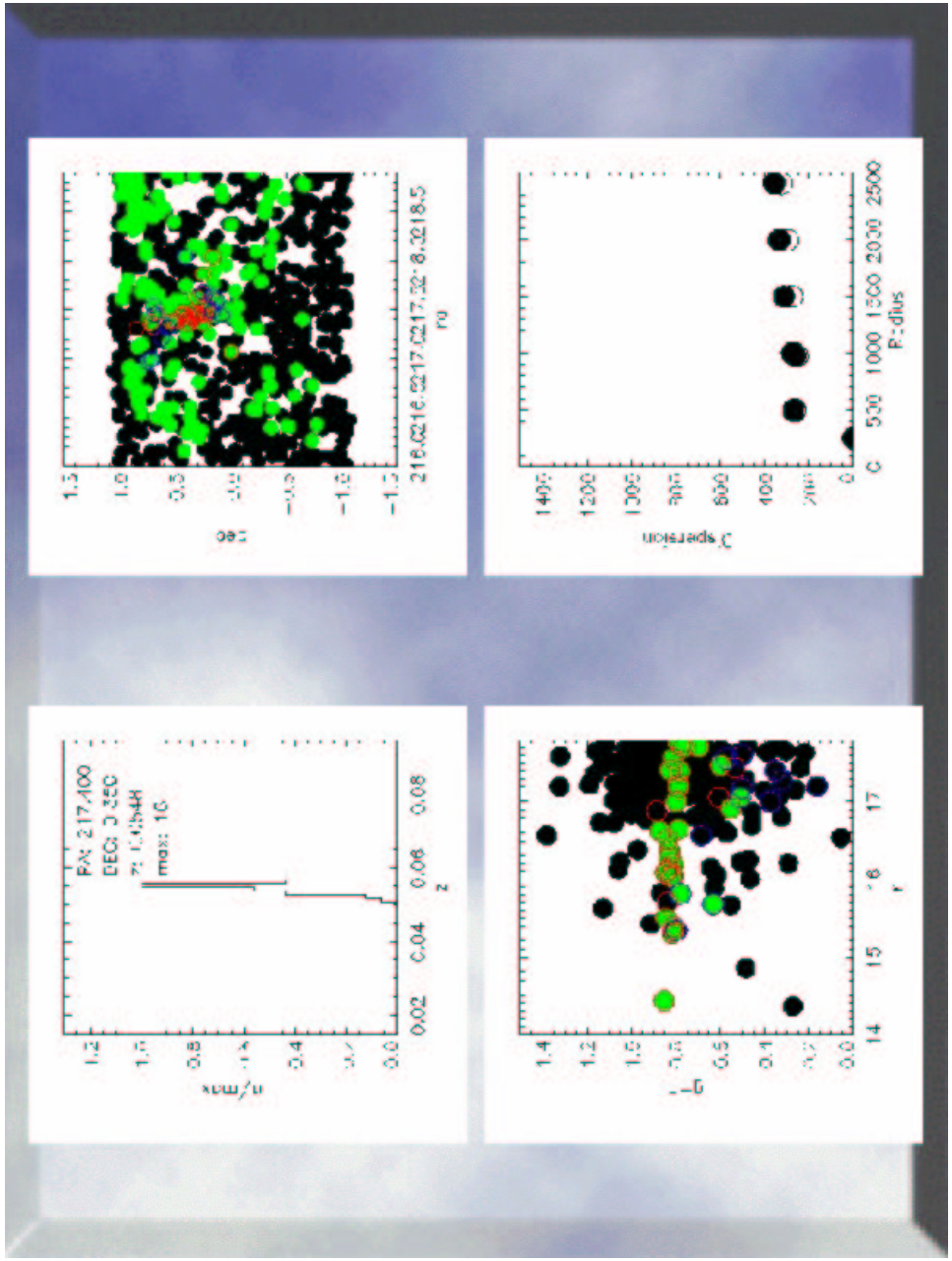
- Place a 7- dimensional "box" around a test galaxy.
  - RA, Dec, z (very coarse), u- g, g- r, r- i, i- z
  - Count the number of galaxies in the box.
- Move that same box to 100 *random* locations
  - Count (using the same box size)
- From the distribution of counts based on 100 random locations, determine the probability that the test galaxy is in a dense environment.

"Field-like" galaxy

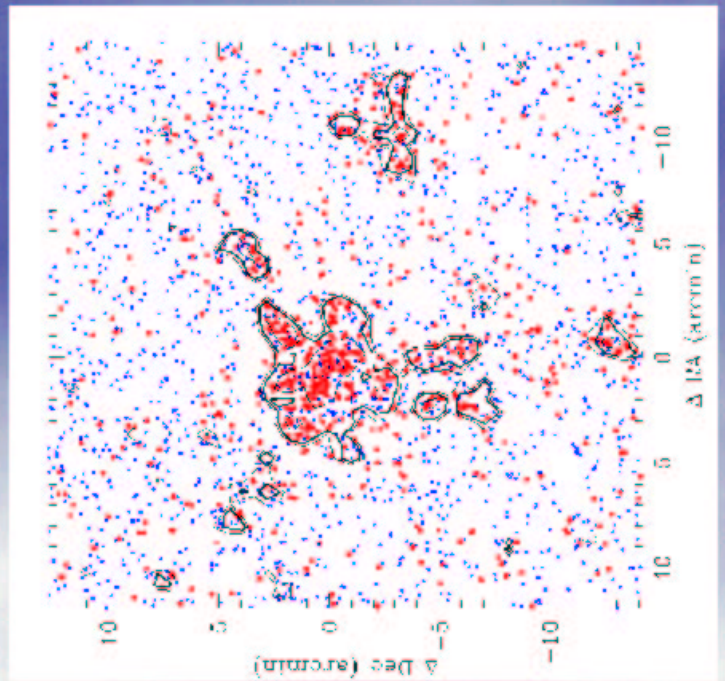


"Cluster-like" galaxy





Clusters and their Satellites
(z =0.41 using the 8.3m Subaru)



Abell 851

z = 0.41

Kodama et al. 2001

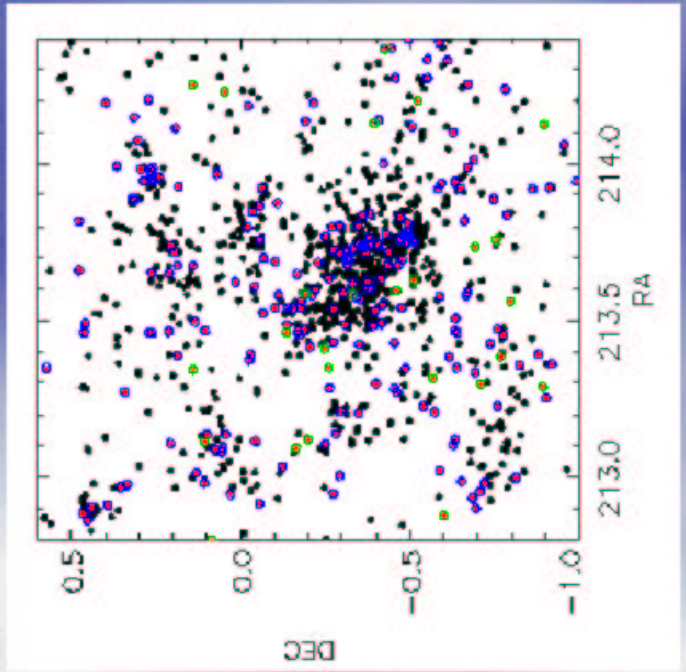
1 night observing
the 8.3m Subaru
Suprime-Cam

Clusters and their Satellites (z = 0.14 via the SDSS)

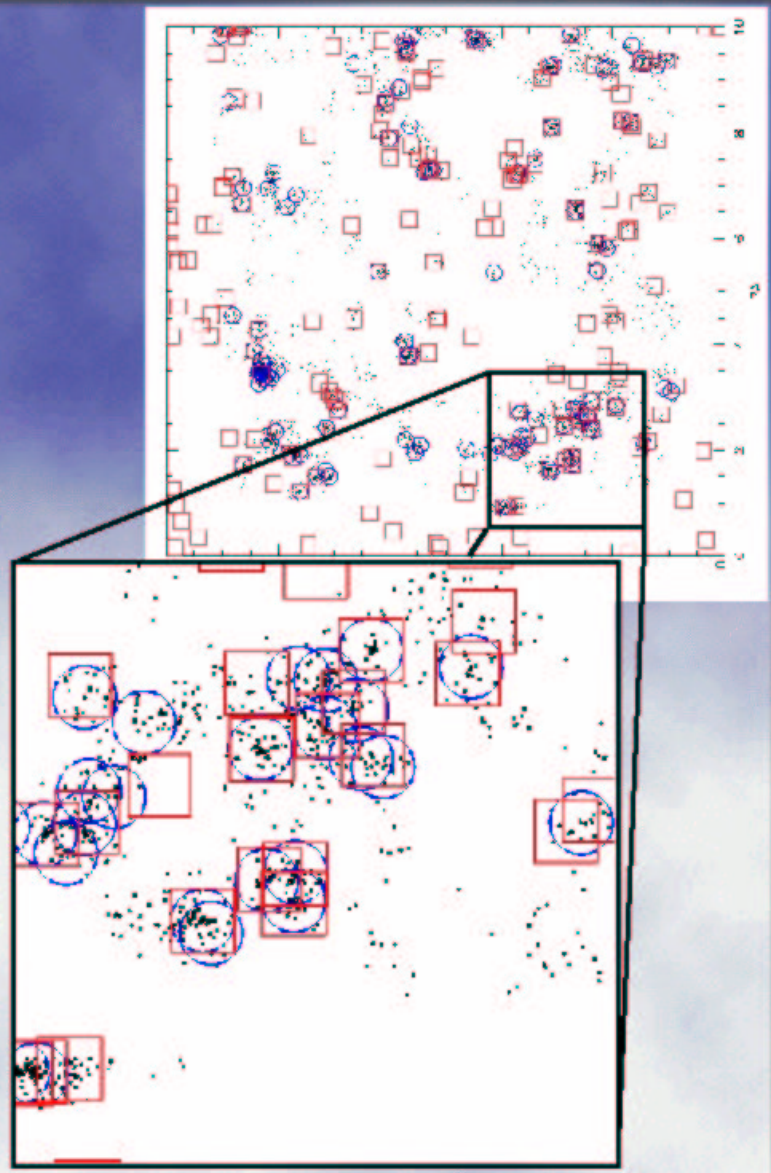
Abell 1882

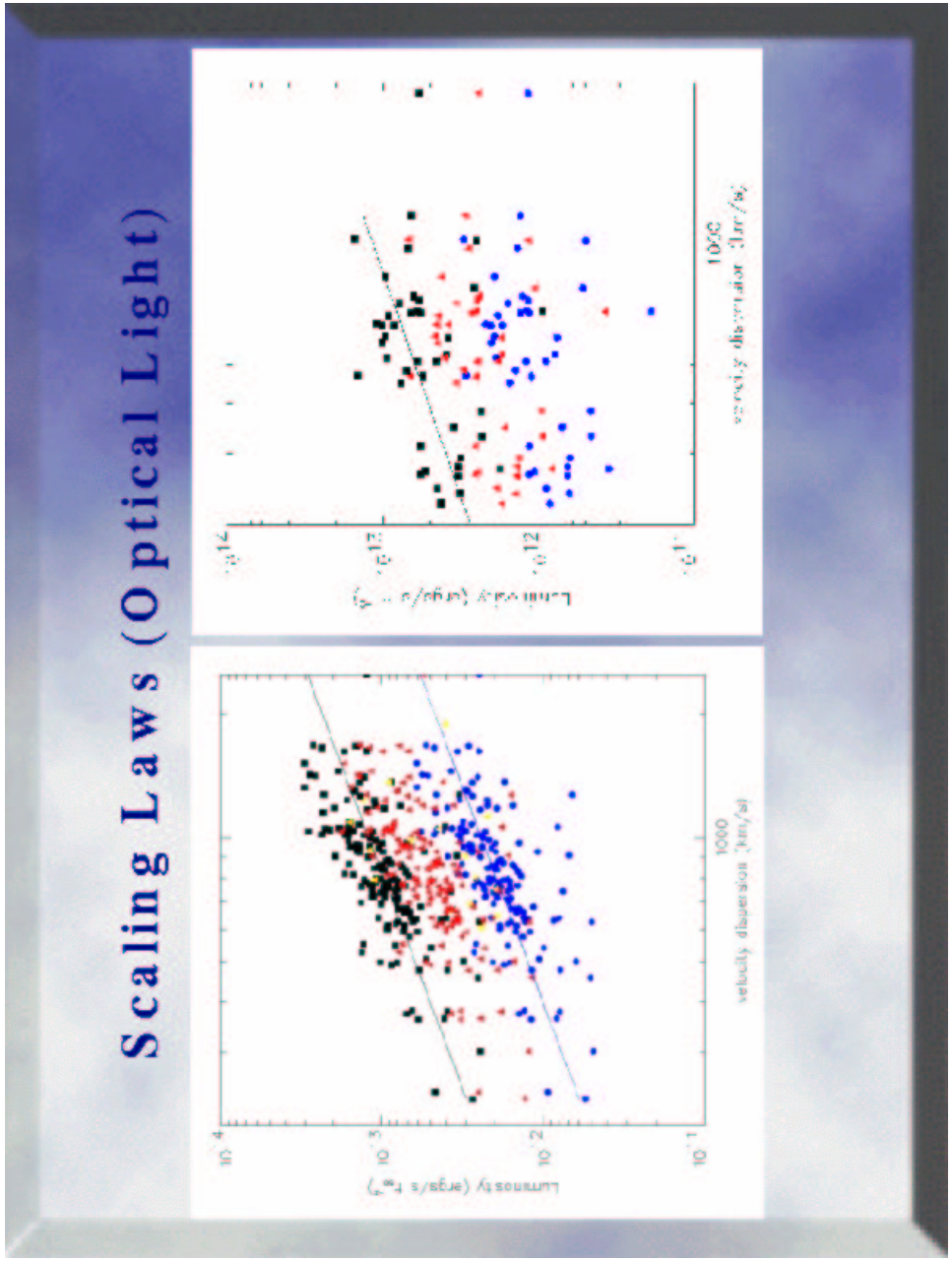
z = 0.14

Using the SDSS EDR data.



Testing via the Virgo Simulations




Scaling Laws (Optical Light)
Luminosity (ergs/s h₈₀⁻²)
velocity dispersion (km/s)
1000
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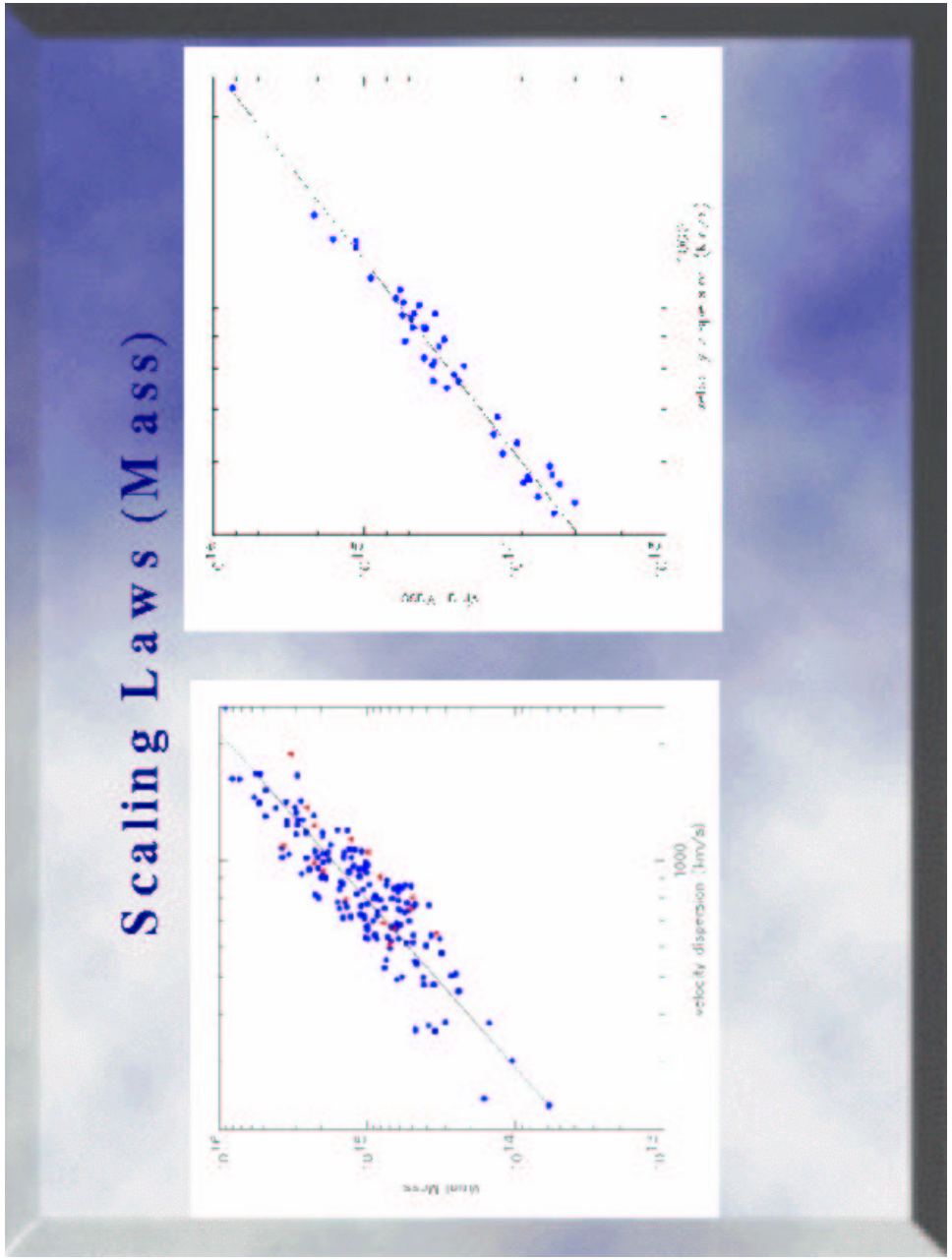
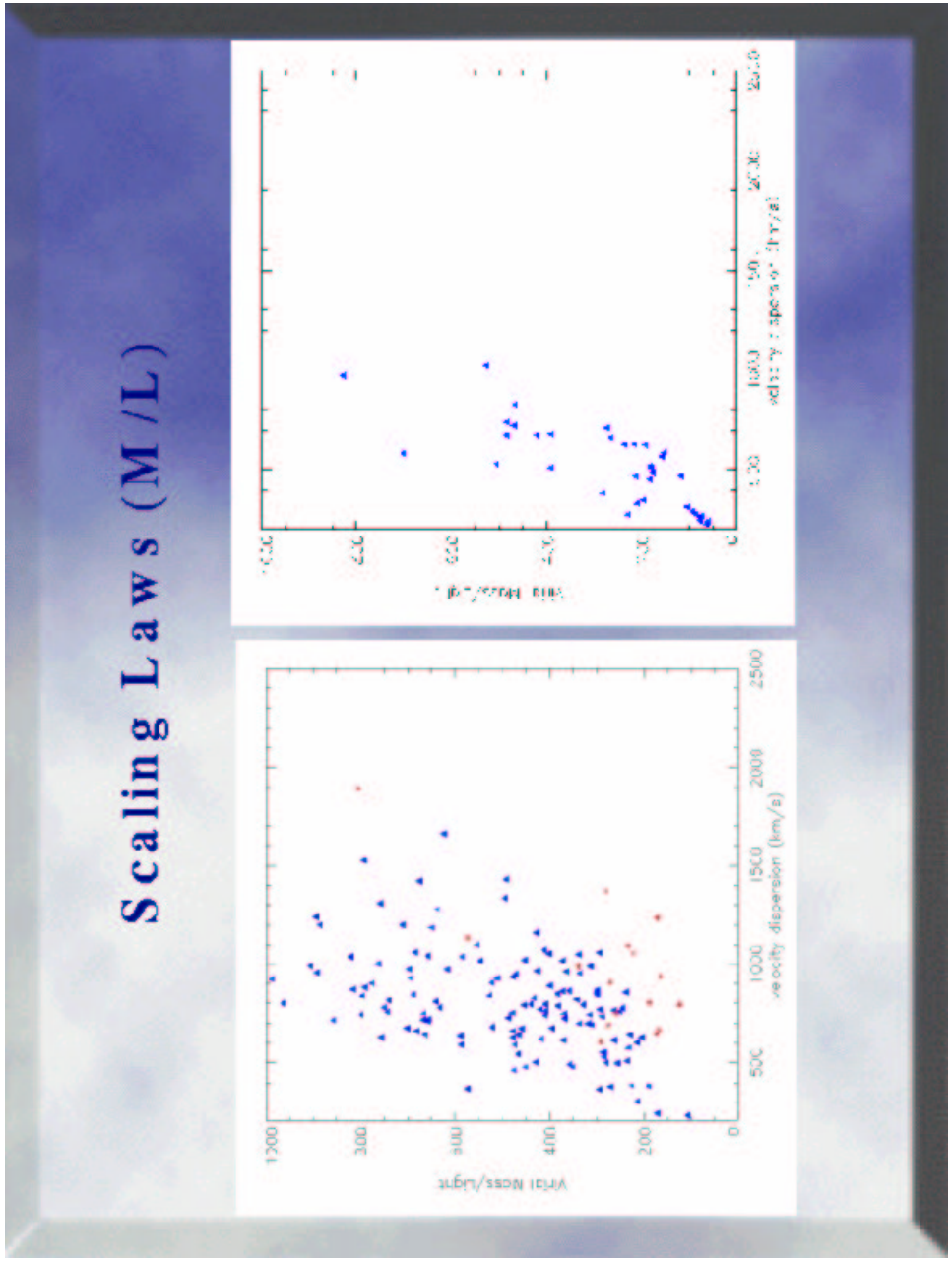
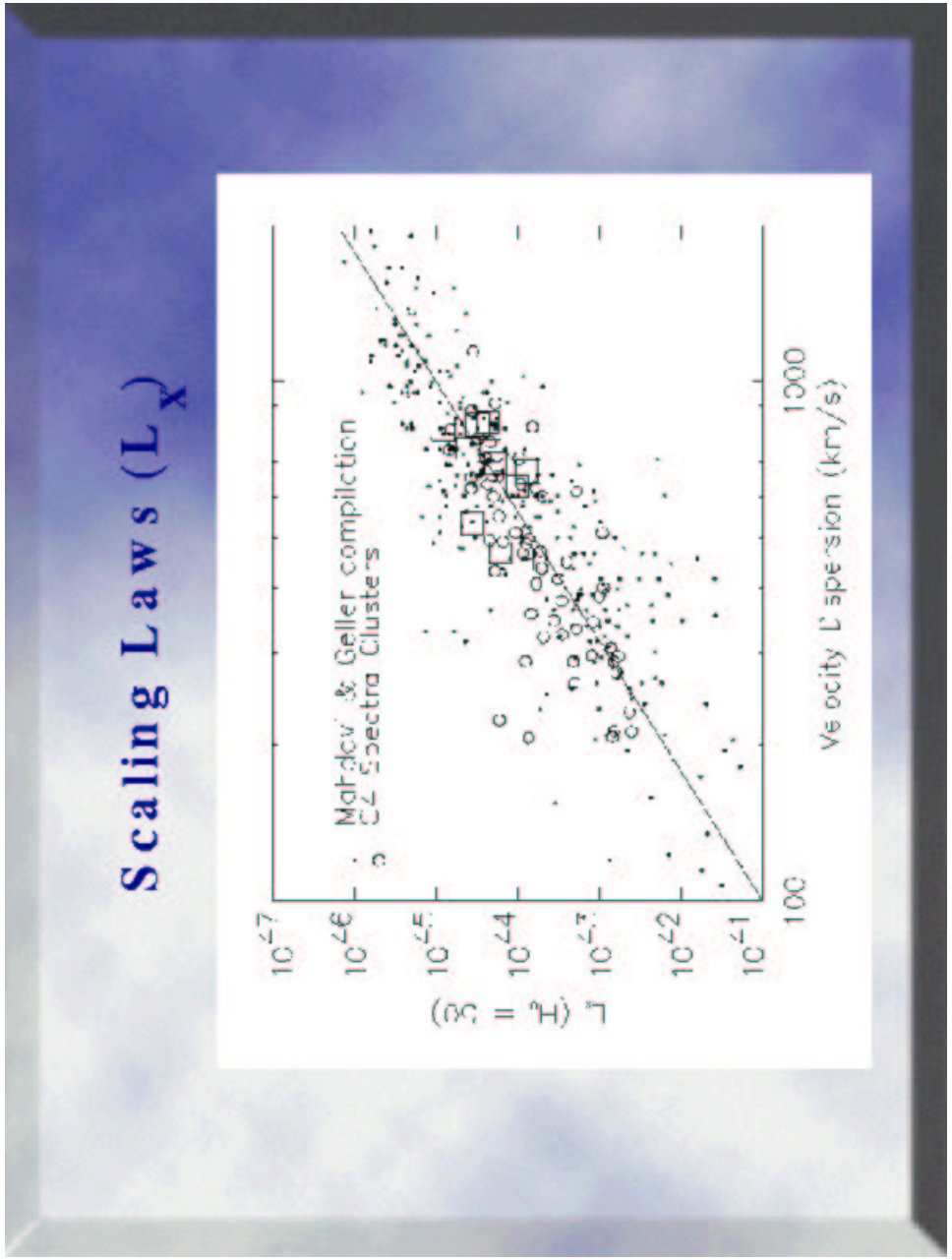
velocity dispersion (km/s)
1000


Scaling Laws (Mass)
total Mass
velocity dispersion (km/s)
1000
total Mass
velocity dispersion (km/s)
1000


Scaling Laws (M/L)
Virial Mass/Light
Velocity dispersion (km/s)


Scaling Laws (L_X)
Mahdavi & Geller compilation
CfA Spectra Clusters
Velocity Dispersion (km/s)

Conclusions

- Finding Clusters is Important
- The Photometry of the SDSS allows us to seach for clusters in new ways
- Expect to see numerous SDSS cluster catalogs (choose carefully).
- Significant advances will come with "photometric " N- body simulations