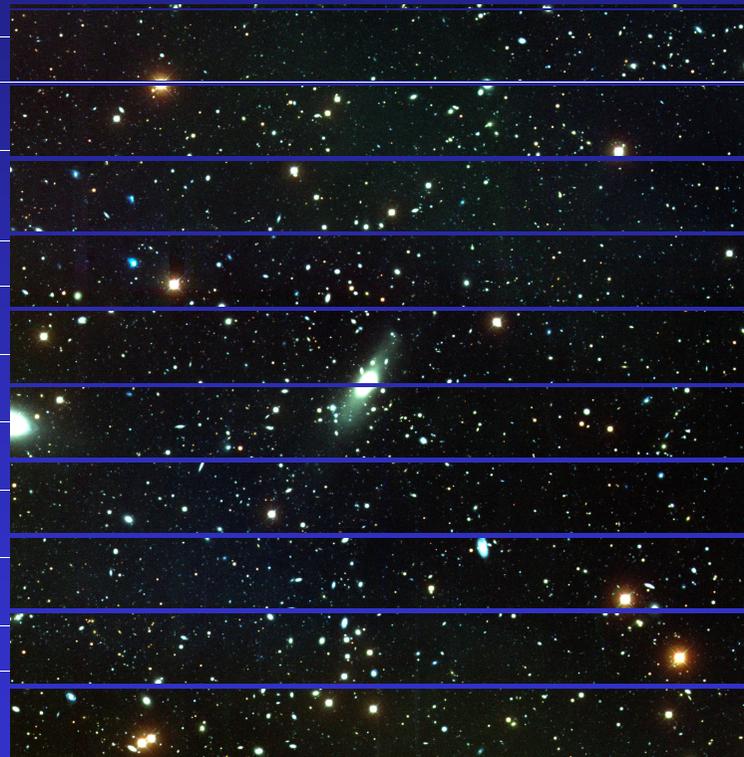
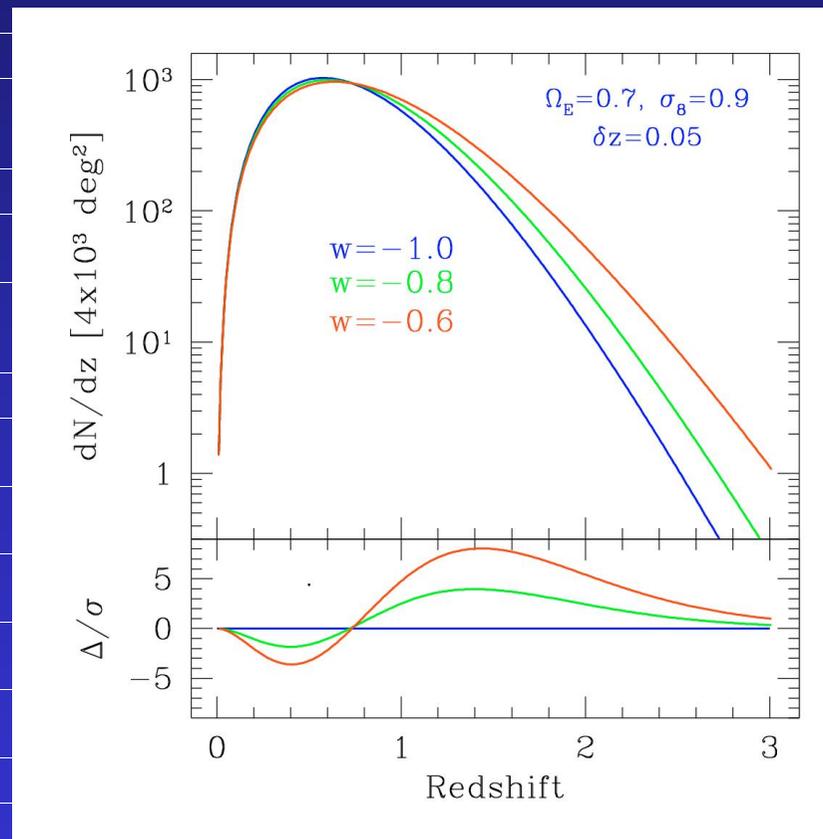


Finding Optical Galaxy Clusters Red Sequence VTP

Wayne A. Barkhouse
(University of Illinois Urbana-Champaign)



$$\frac{d^2 N}{dz d\Omega} = \frac{c}{H(z)} d_A^2(z) (1+z)^2 \int_0^\infty dM \frac{dn}{dM}(M, z) f(M, z)$$



Mohr 2004

Optical Cluster Detection Methods

Eyeball

cut and enhance technique

surface brightness fluctuations

matched filter method

voronoi tessellation

smoothing kernels

counts-in-cells

c4 algorithm

red sequence technique

percolation techniques

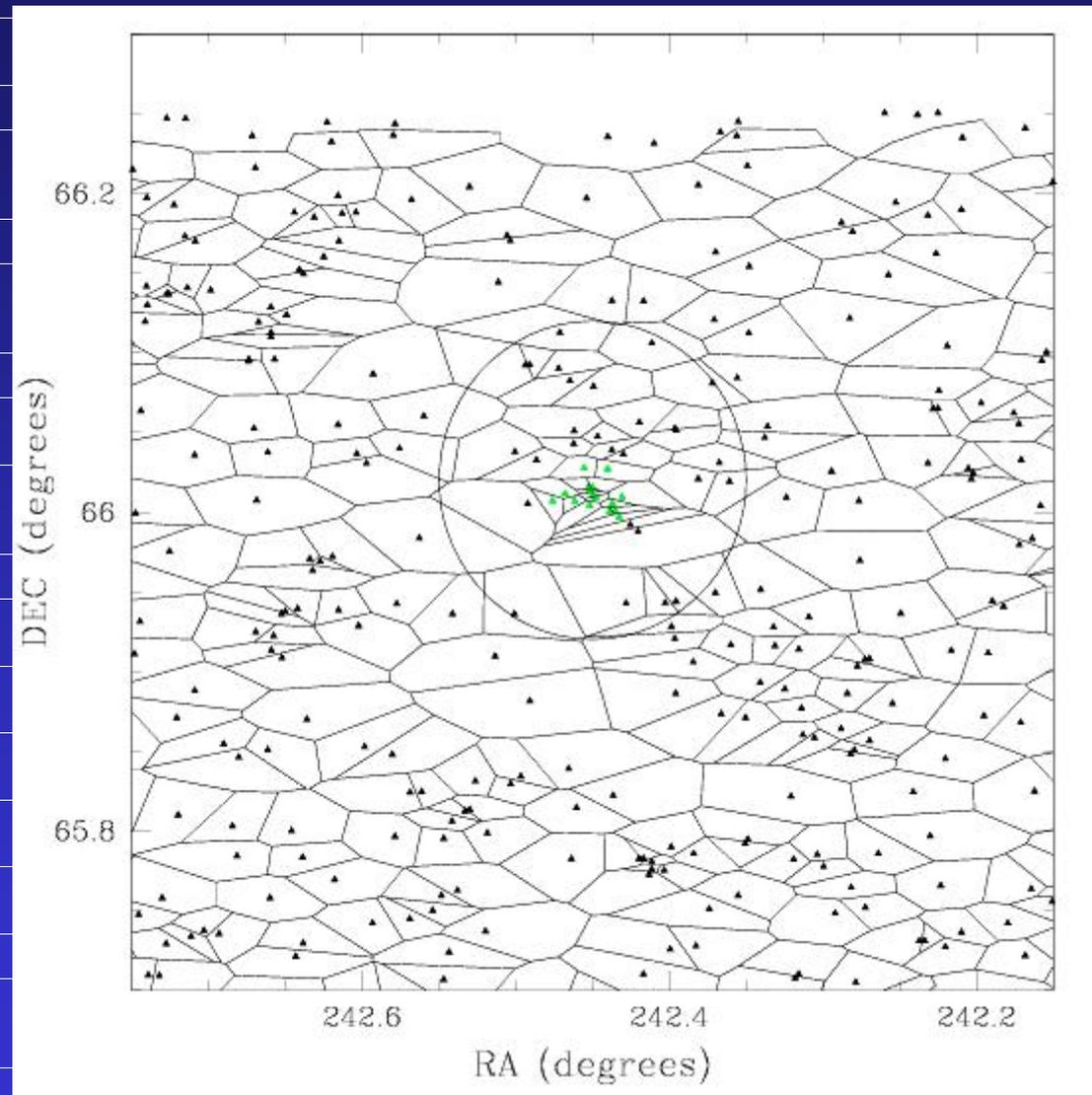
maxBCG

various hybrid methods...

Cluster Detection Methods

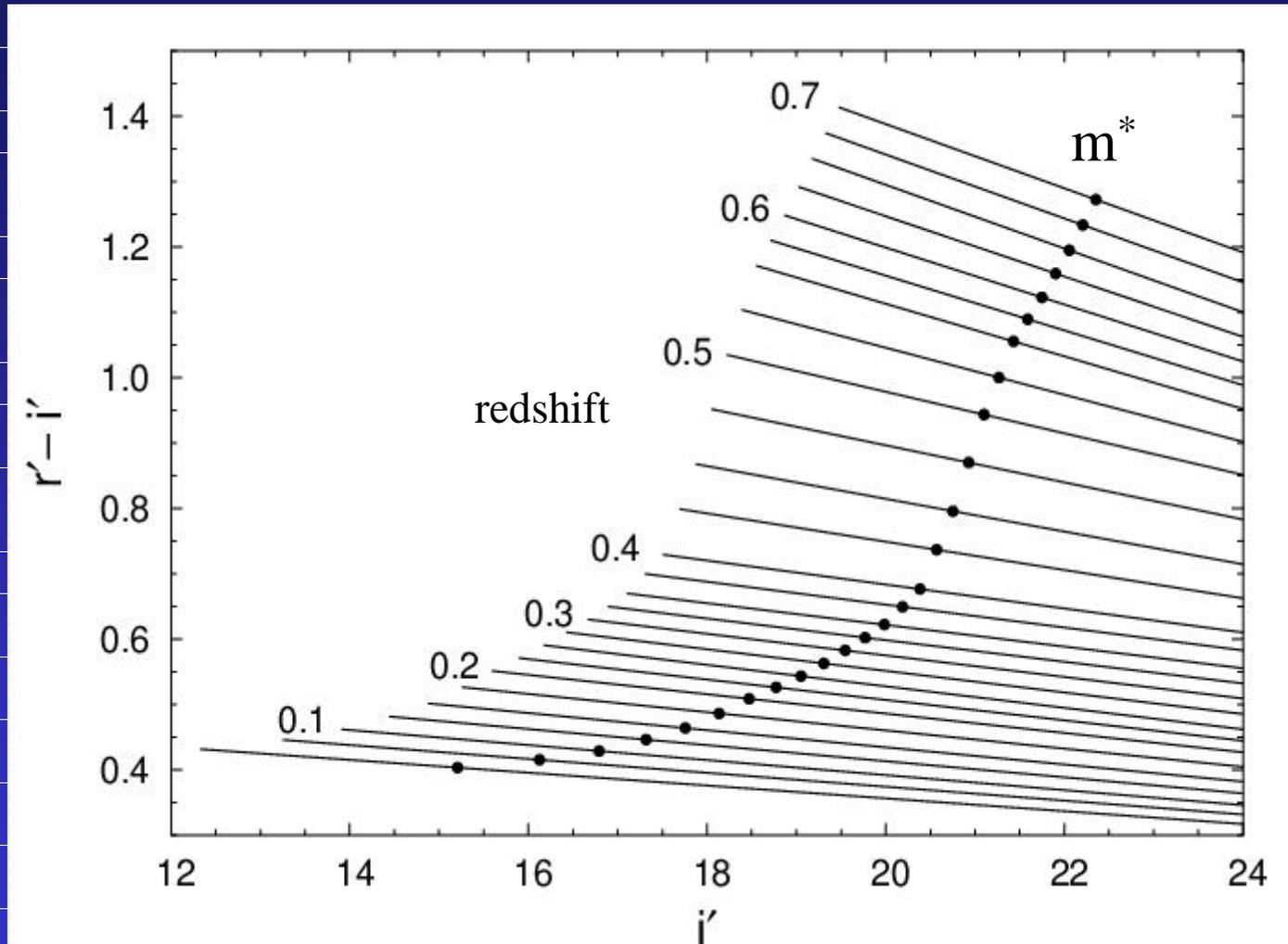
- Voronoi Tessellation and Percolation (VTP) technique (Ebeling & Wiedenmann 1993; Ramella *et al.* 2001)
- Independent of cluster shape (irregular + symmetric clusters)
- Galaxy plane divided into cells containing a unique galaxy
- clusters selected as overdensities in cell numbers grouped using percolation technique
- detection significance derived from comparison to random field

Voronoi Tessellation



$z = 0.527$

Model Galaxy Cluster Red Sequences



Sample cluster redshifts out to $z \sim 0.7$

T. Kodama models.

Chandra Multiwavelength Project

- 13 deg² survey of serendipitous X-ray sources from 130 AO 1&2 *Chandra* archival data
- Optical follow-up using MOSAIC camera at NOAO/4m telescopes
- 56 mosaic fields in g' , r' and i' -band
(mag. depth $\Rightarrow r' \sim 25$ for 5s detection)
- 6.1 deg² overlap between *Chandra* fields and optical data

Main Goals

Make an unbiased comparison of X-ray and optical cluster detection methods.

Interesting Questions:

- 1) Are there massive, X-ray luminous clusters that are optically poor?
- 2) Do all massive clusters emit X-rays?
- 3) What types of optical clusters retain hot gas and why?

Barkhouse et al. 2006

Monte Carlo Simulations

- Monte Carlo simulations used to fine-tune detection parameters

a) randomize galaxy positions:

$$C = N_S/N_D = 12.8\%$$

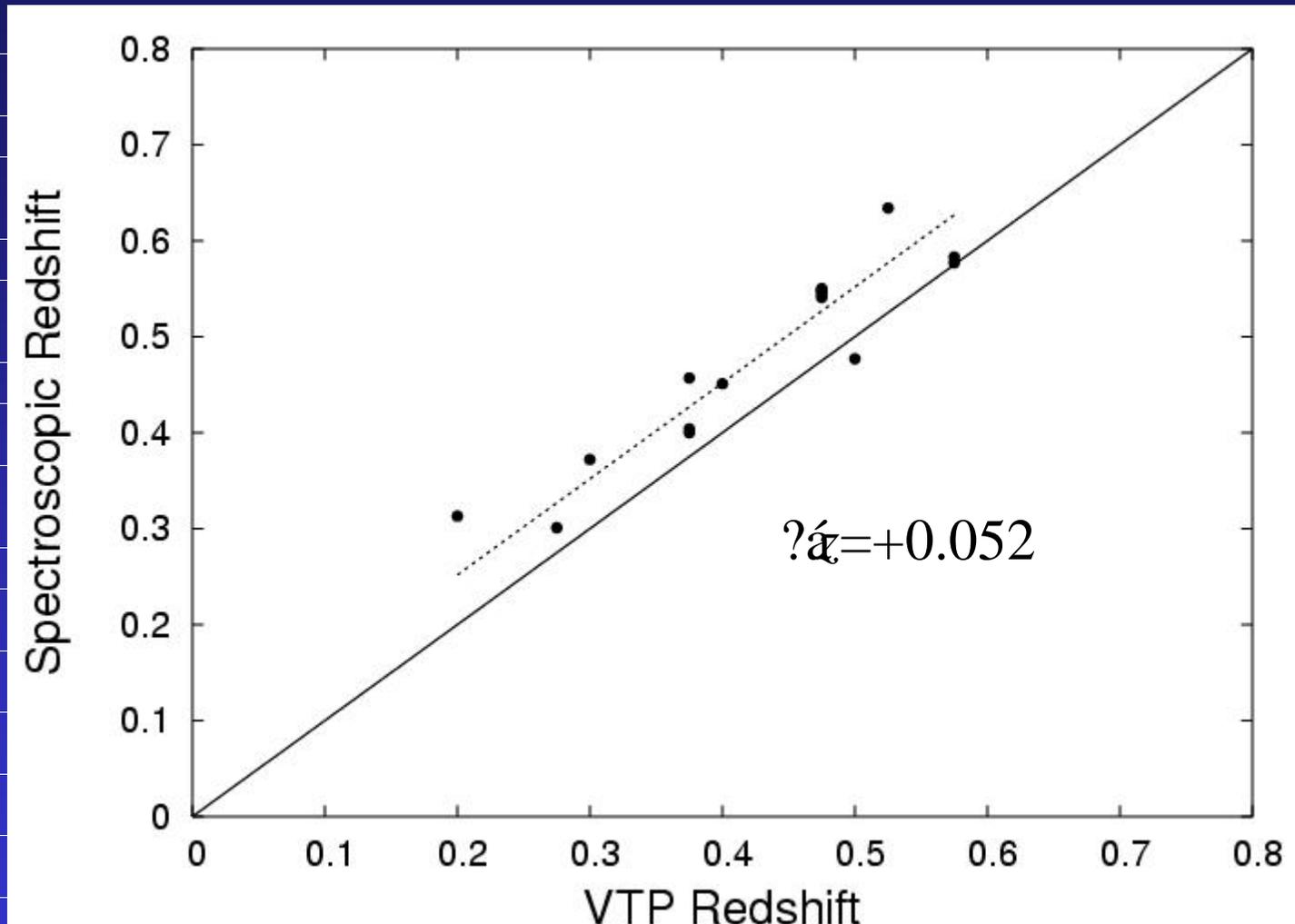
b) shuffle galaxy magnitudes:

$$C = 20.8\%$$

c) shuffle galaxy colors:

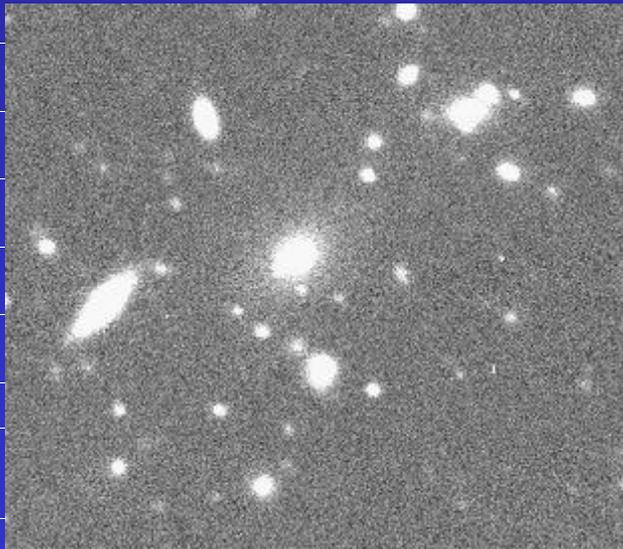
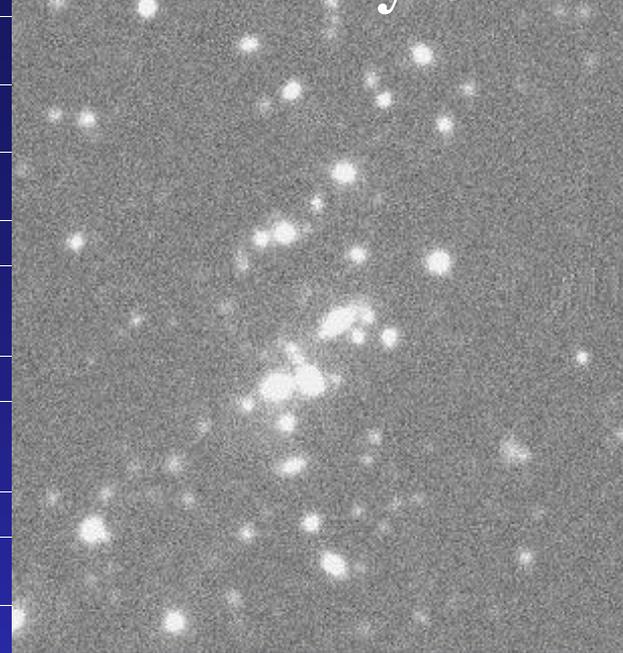
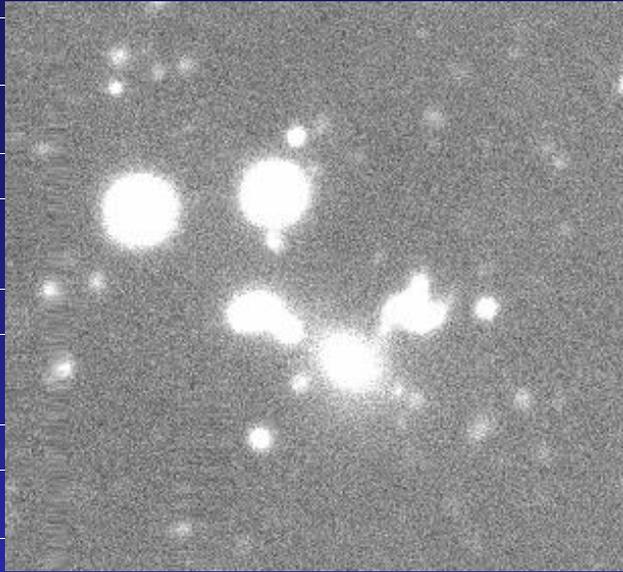
$$C = 7.5\%$$

Calibrating the Red-Sequence VTP Estimates

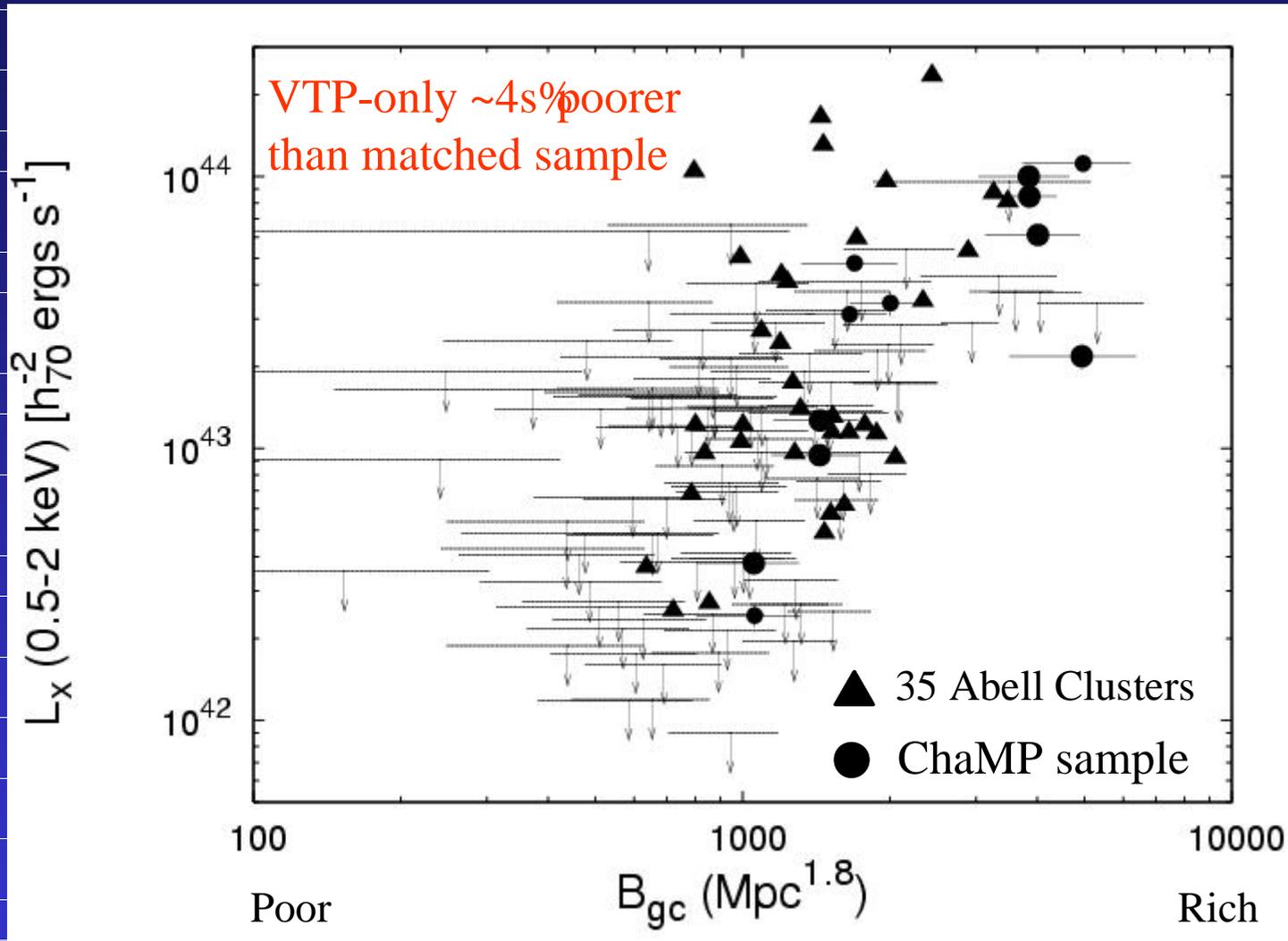


15 known clusters with $0.3 \leq z \leq 0.7$

Optical Counterparts to Extended X-ray Sources



Distribution of L_x with Optical Cluster Richness



$B_{gc} \Rightarrow$ galaxy/cluster center correlation amplitude

BCS
Observing

Blanco Cosmology Survey

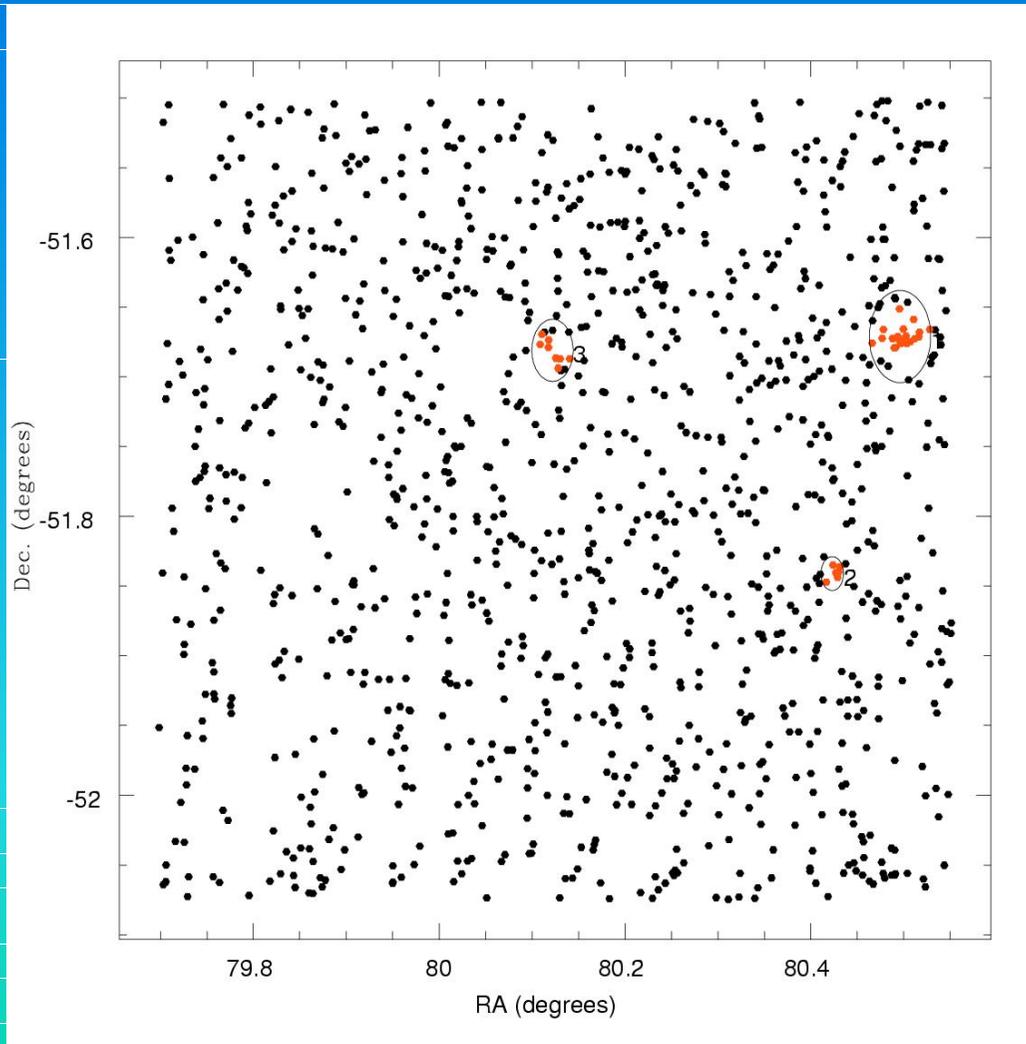


- MOSAIC II imager => g , r , i and z filters
- image depths: $g=24.0$, $r=23.9$, $i=23.6$, and $z=22.3$
(10s; in 2.2" aperture; ~2 magnitudes deeper than SDSS)
- Survey Area: two 50 deg² patches
(15 nights during Fall 2005, 2006, and 2007)
- area to be observed by mm-wave experiments
- Optical data provides photometric redshifts for
SZE-detected clusters

PI: J. Mohr

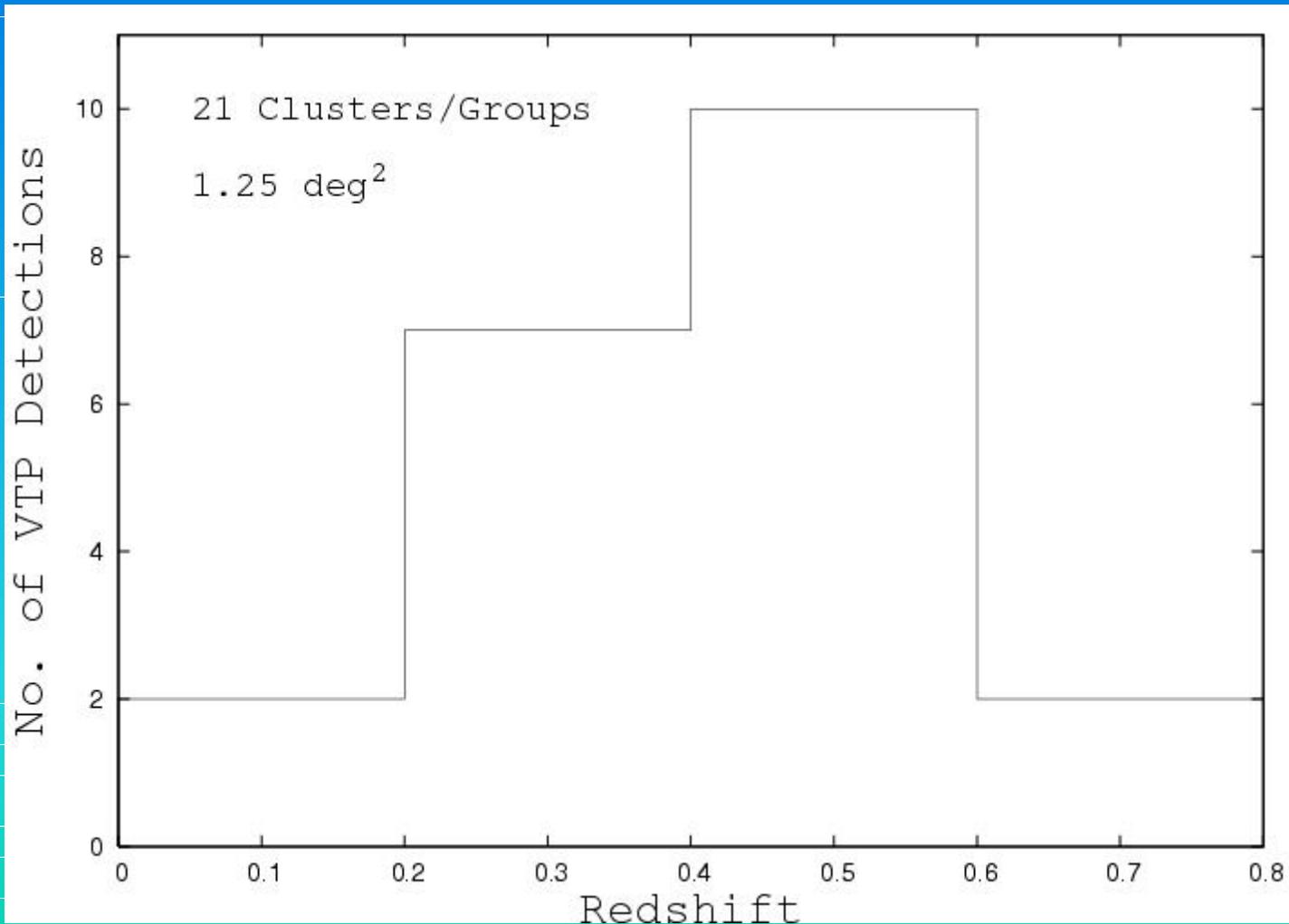
BCS
Observing

Blanco Cosmology Survey



BCS
Observing

Blanco Cosmology Survey

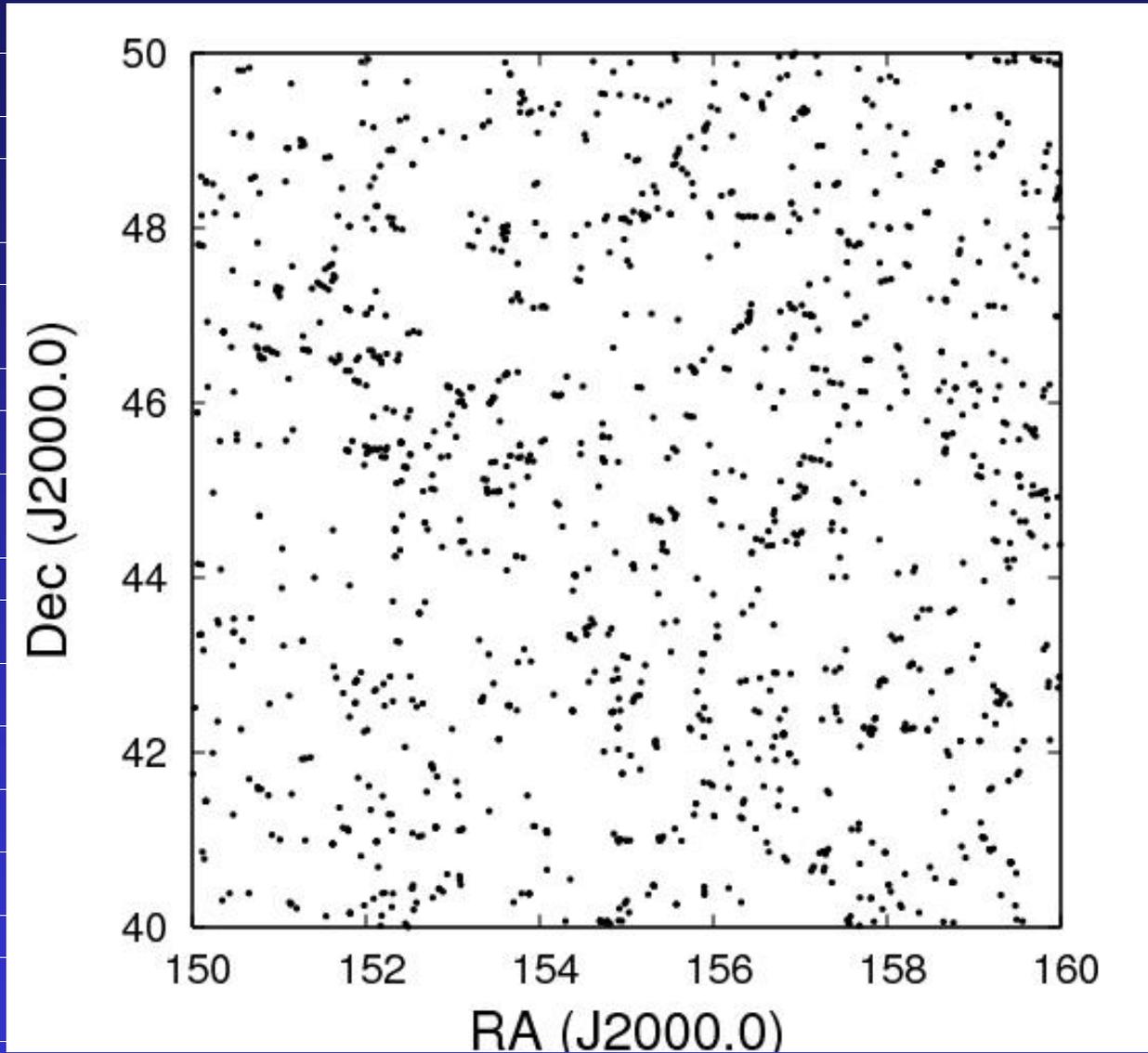


BCS
Observing



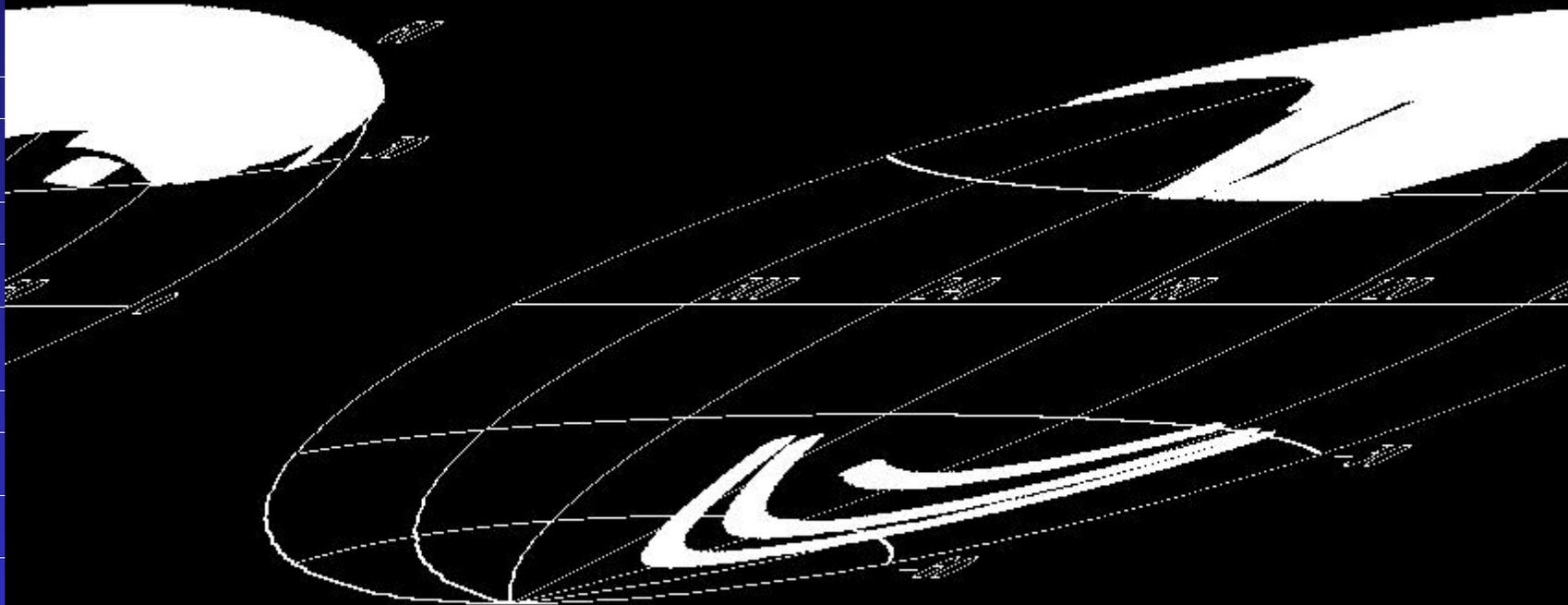
Sign of things
to come.

VTP Clusters/Groups from SDSS DR5



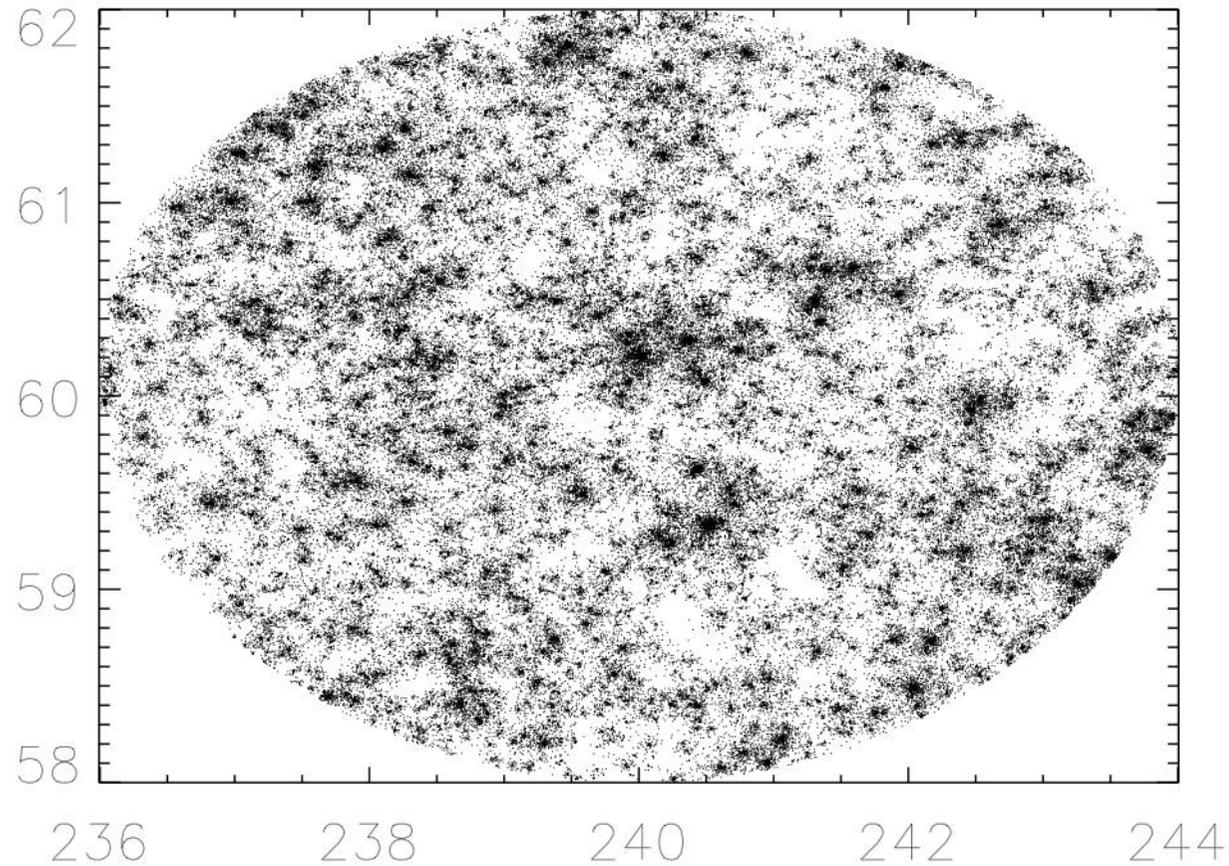
Barkhouse, Hacker, Song & Mohr (2007)

~150,000 SDSS DR5 cluster candidates



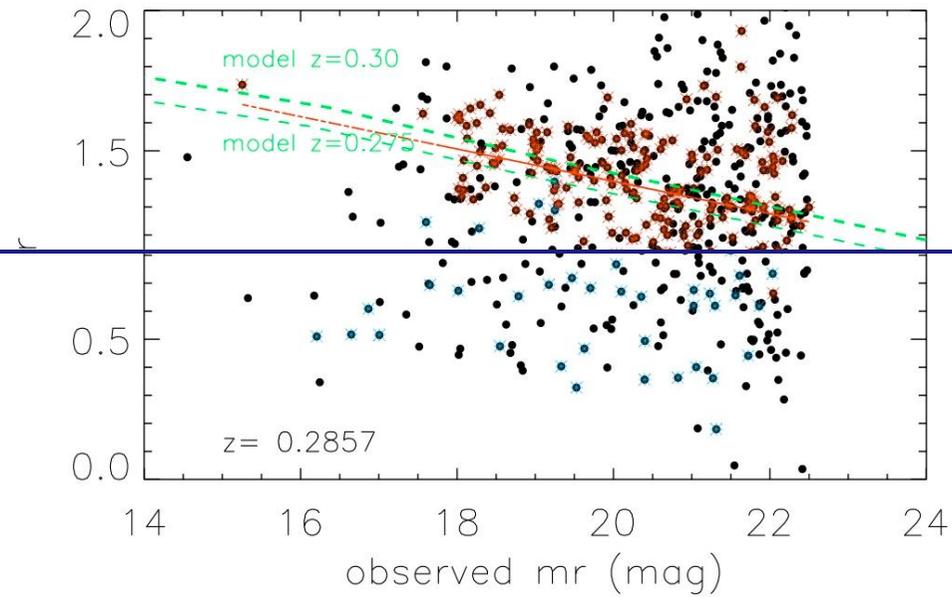
$|b| > 30^\circ$

N-body Simulations



$400h^{-1}$ Mpc cube (provided by Michael Warren)
Flux limited survey \Rightarrow K=20 mag

Song & Mohr



- vary blue fraction, etc.

Estimate VTP Mass-selection function

Seattle AAS Meeting.

Application to Dark Energy Survey

Stay Tuned!