

# MaDCoWS: The Massive Distant Clusters of WISE Survey

Daniel Gettings

(University of Florida -- [gettings@astro.ufl.edu](mailto:gettings@astro.ufl.edu))

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Growing-up at high redshift: from proto-clusters to galaxy clusters

## Selected Key People:

Mark Brodwin (UMKC)

Adam Stanford (UC Davis/LLNL)

Peter Eisenhardt (**WISE Co-I**) (JPL)

Daniel Stern (JPL)

Anthony Gonzalez (**Thesis Advisor**)(UF)

Ned Wright (**WISE PI**) (UCLA)

# MaDCoWS:

The *Massive Distant Clusters of WISE Survey*



## Goal:

Create an *All-Sky* Sample of *High-Mass, High-z* Galaxy Clusters using WISE

## Main Science Driver:

Find the extreme  $z \gtrsim 1$  galaxy clusters that can place limits on *primordial non-Gaussianity*

# Inflation $\Rightarrow$ Non-Gaussianity $\Rightarrow$ Clusters

## What:

Phase of accelerated expansion in very early Universe

## Cause:

- ◆ Scalar field dominating the energy budget of the Universe
- ◆ Causes enormous negative pressure

## Results:

1.  $a_{\text{end}}/a_{\text{start}} \gtrsim e^{60}$
2. Ensures flatness
3. Ensures large-scale temperature homogeneity
4. Fills Universe with hot matter
5. Imprints initial inhomogeneity spectrum

Inflation  $\Rightarrow$  **Non-Gaussianity**  $\Rightarrow$  Clusters

## What:

Initial inhomogeneities don't follow Gaussian statistics

## Cause:

Can be caused by violation of any “vanilla” assumptions:

- (1) Single scalar “Inflaton” field
- (2) Canonical kinetic energy
- (3) Slowly-changing field -- “slow roll”
- (4) Adiabatic initial vacuum state

Inflation  $\rightsquigarrow$  **Non-Gaussianity**  $\rightsquigarrow$  Clusters

Violation of (1) is parameterized as:

$$\Phi(\mathbf{x}) = \phi_g(\mathbf{x}) + f_{\text{NL}} \phi_g^2(\mathbf{x})$$

$\mathbf{x}$  = spatial scale

$\phi_g$  = Gaussian density field

$\Phi$  = total density field

$f_{\text{NL}}$  = correction coefficient

## Effect:

Non-zero  $f_{\text{NL}}$  modifies power on large scales

Scale dependence:  $\sim 1 / k^2$

Redshift dependence:  $\sim (1 + z)$

- Deviation becomes more pronounced at larger scale modes and higher-redshift

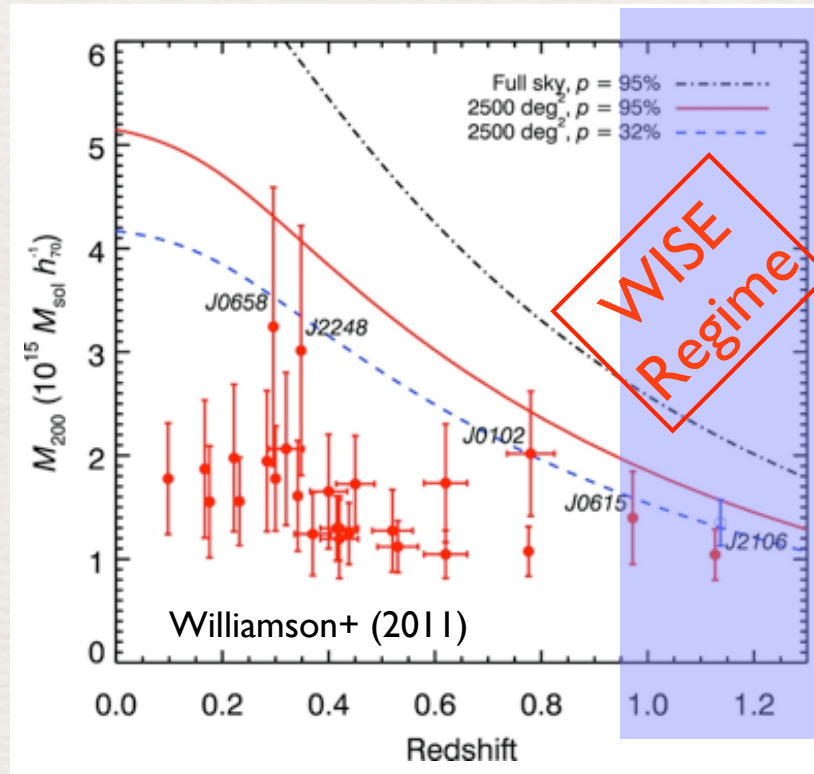
Inflation  $\rightsquigarrow$  Non-Gaussianity  $\rightsquigarrow$  Clusters

## Non-zero $f_{NL}$ and clusters:

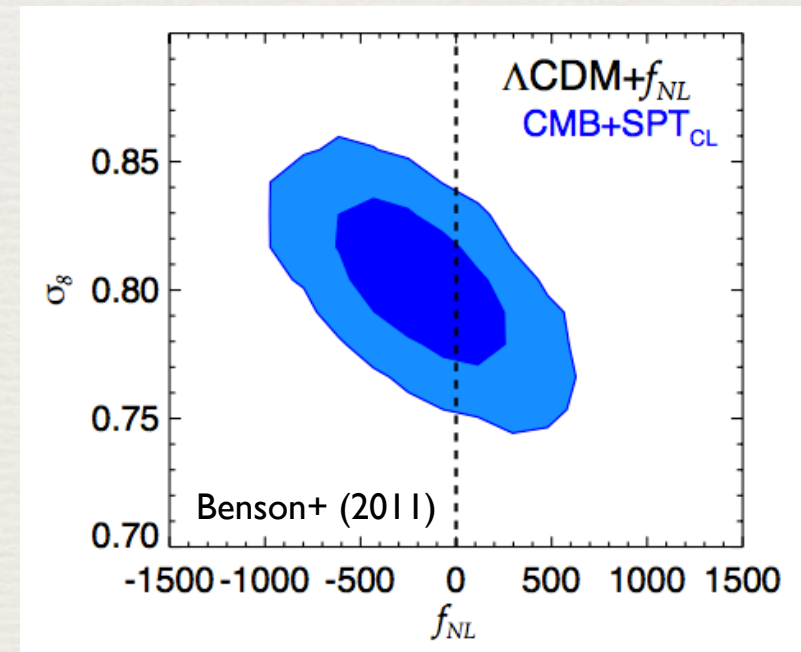
$f_{NL} < 0 \Rightarrow$  **Decreases** abundance of high-M, high-z clusters

$f_{NL} > 0 \Rightarrow$  **Increases** abundance of high-M, high-z clusters

## Cluster Survey Constraints



[Short-Term]

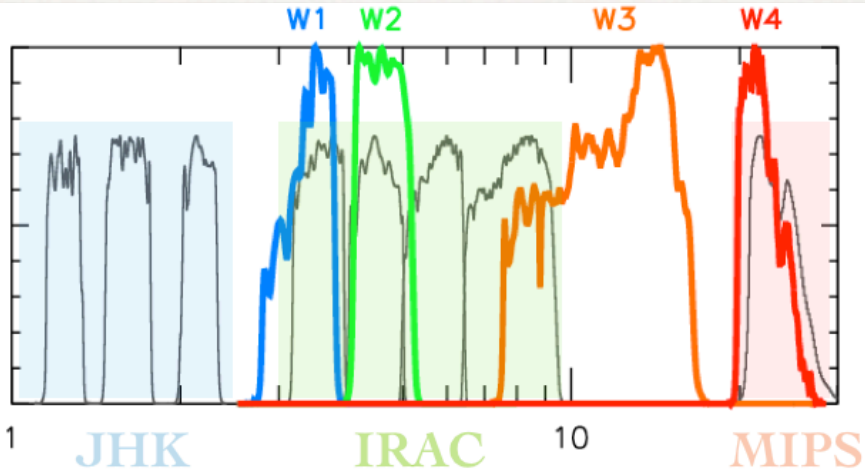


[Long-Term]

# The WISE Mission

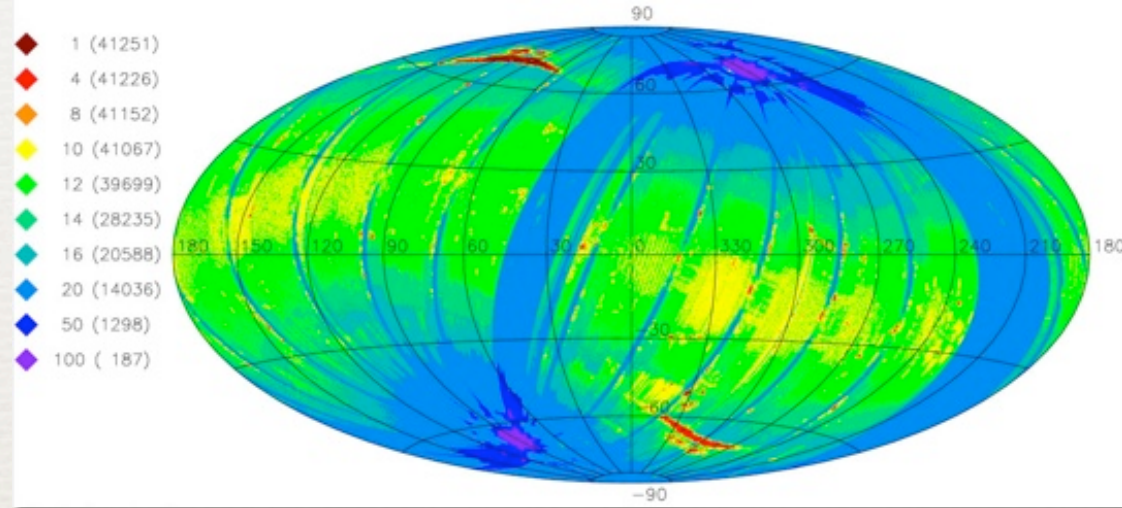
Wright+ (2010) — <http://wise.ssl.berkeley.edu/>

$\lambda$  Coverage: 3.4, 4.6, 12 and 22 $\mu$ m

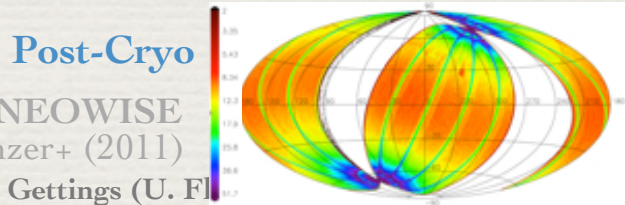
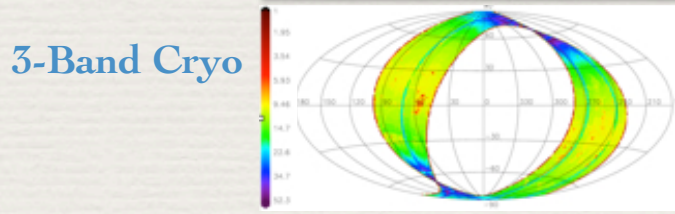
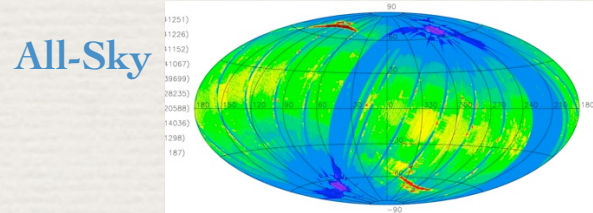


All-Sky Release: 14 March 2012

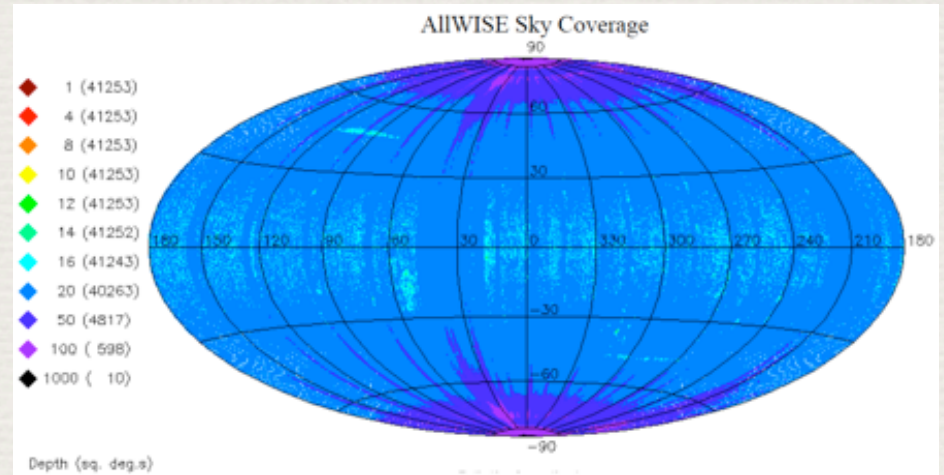
Data archive: <http://irsa.ipac.caltech.edu/Missions/wise.html>



Upcoming (Funded by NASA):



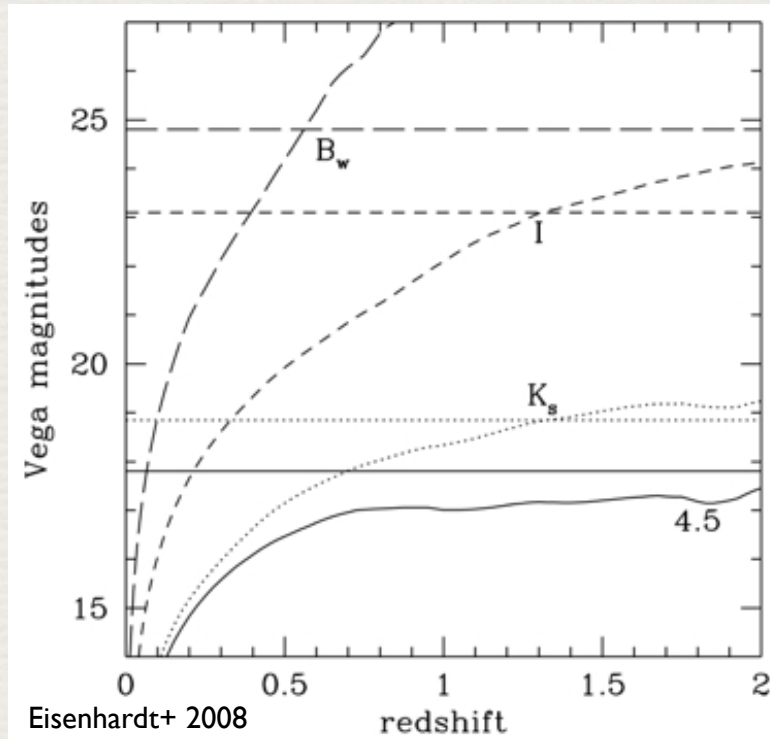
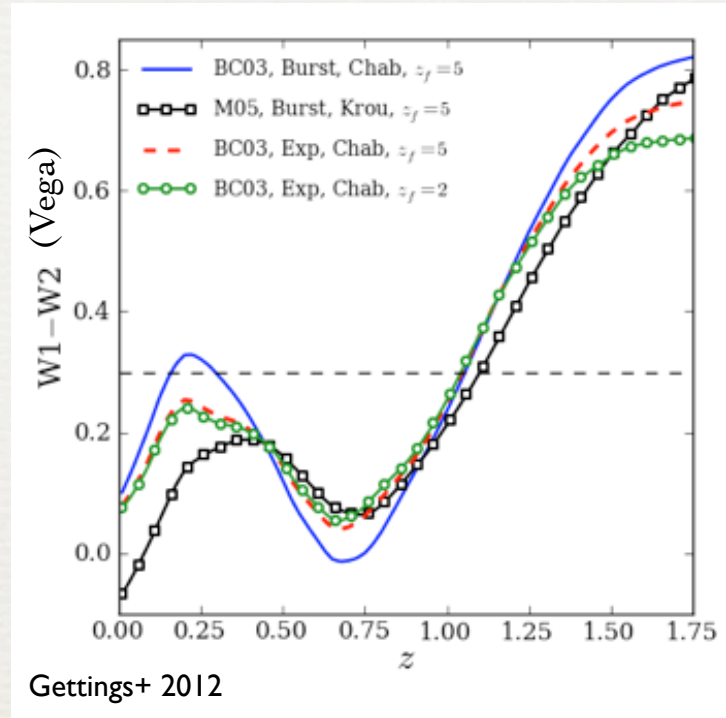
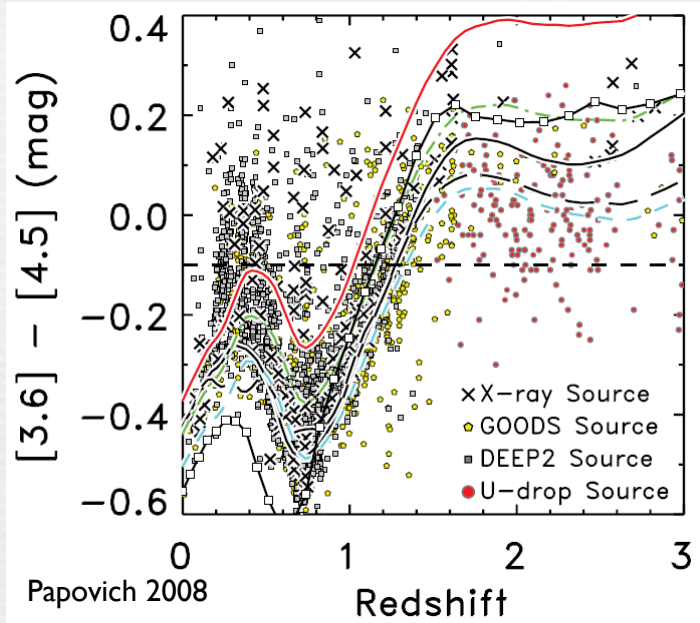
## AllWISE



Clusters 2012

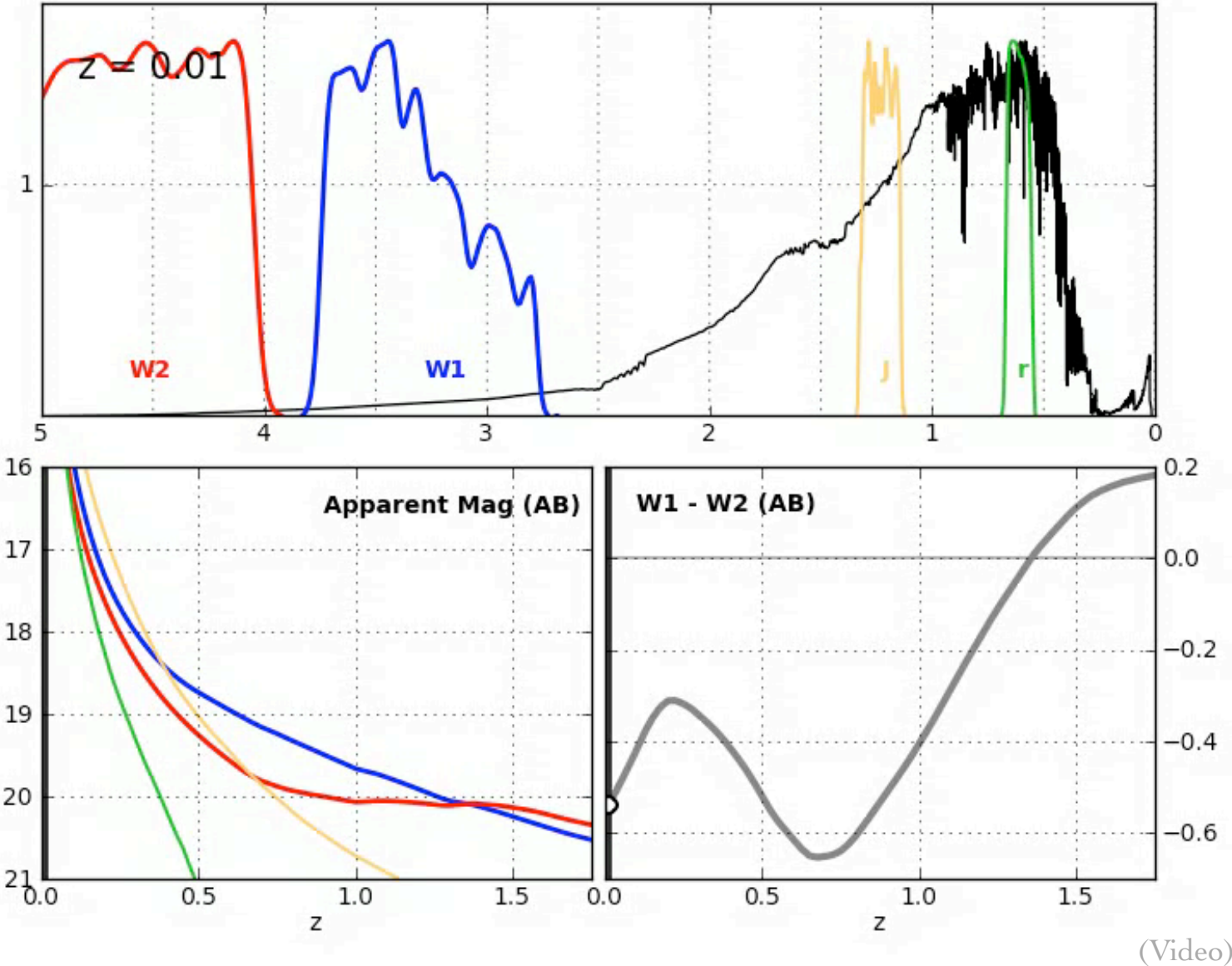
NEOWISE  
Mainzer+ (2011)  
Daniel Gettings (U. Fl)

# Cluster Galaxies in WISE



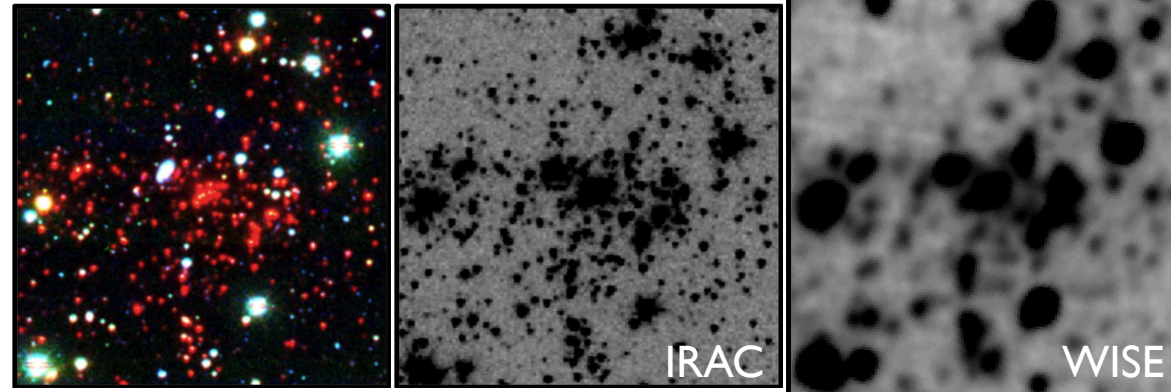
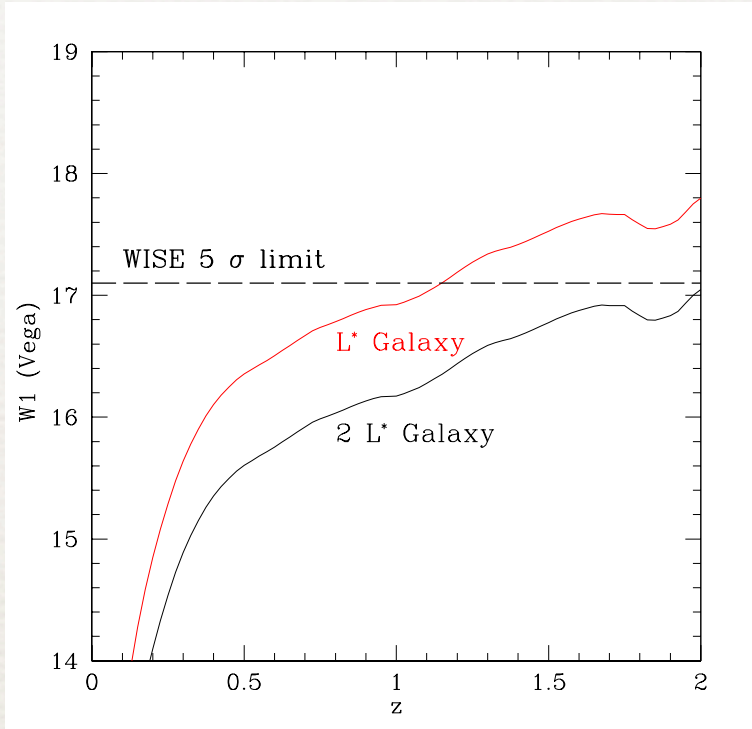


# Cluster Galaxies in WISE



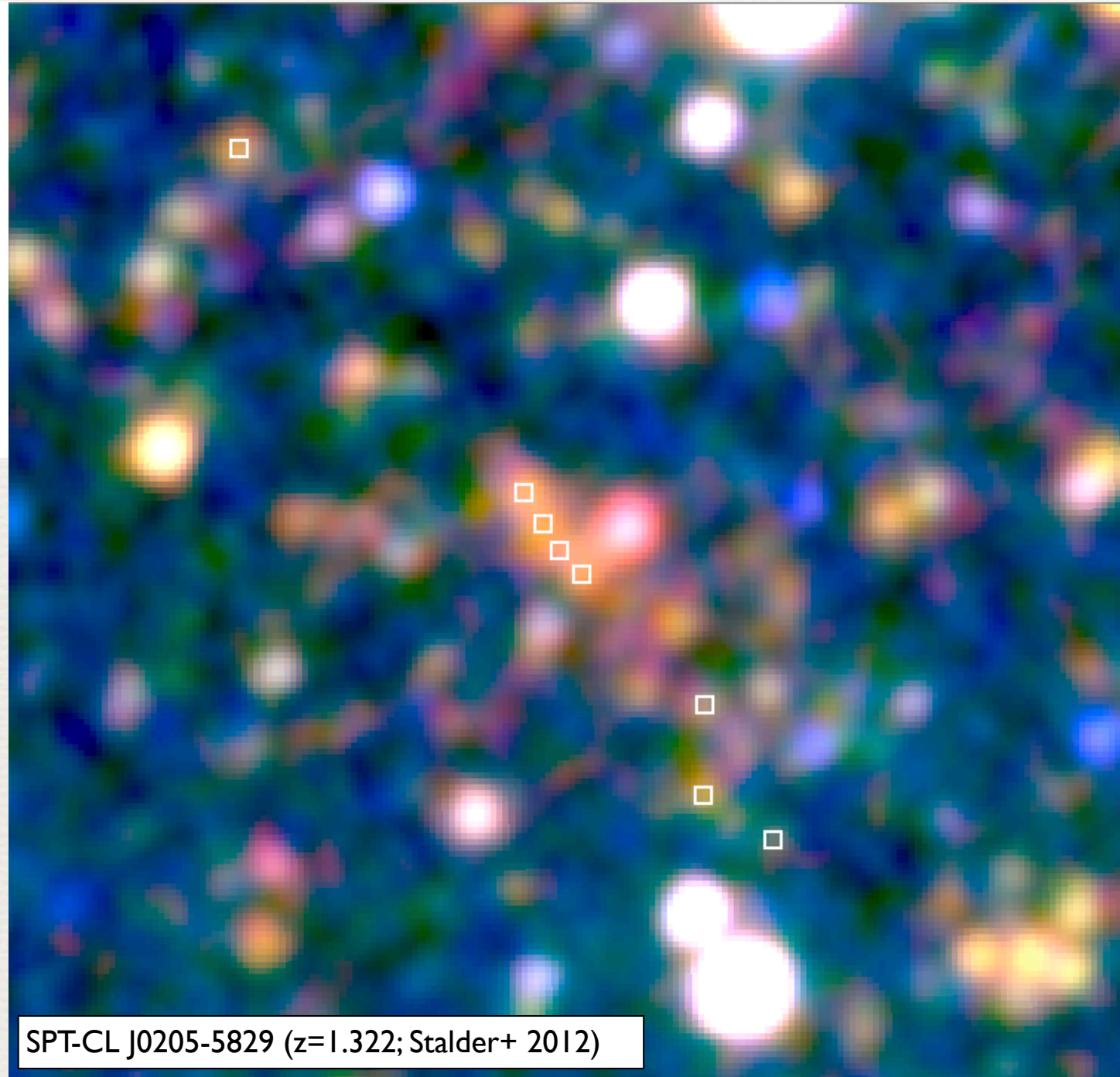
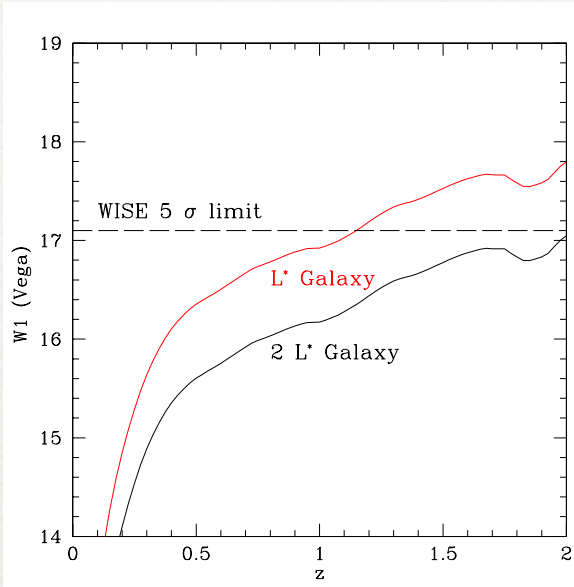
(Video)

# Are $z \sim 1$ Clusters Visible in WISE?

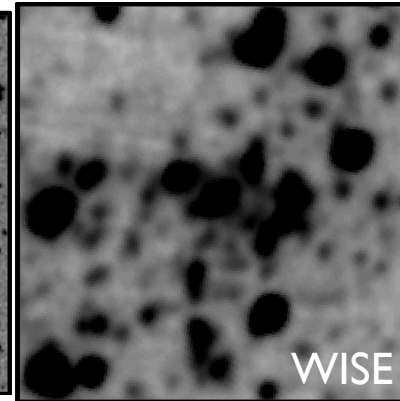
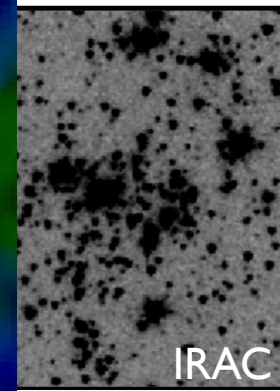
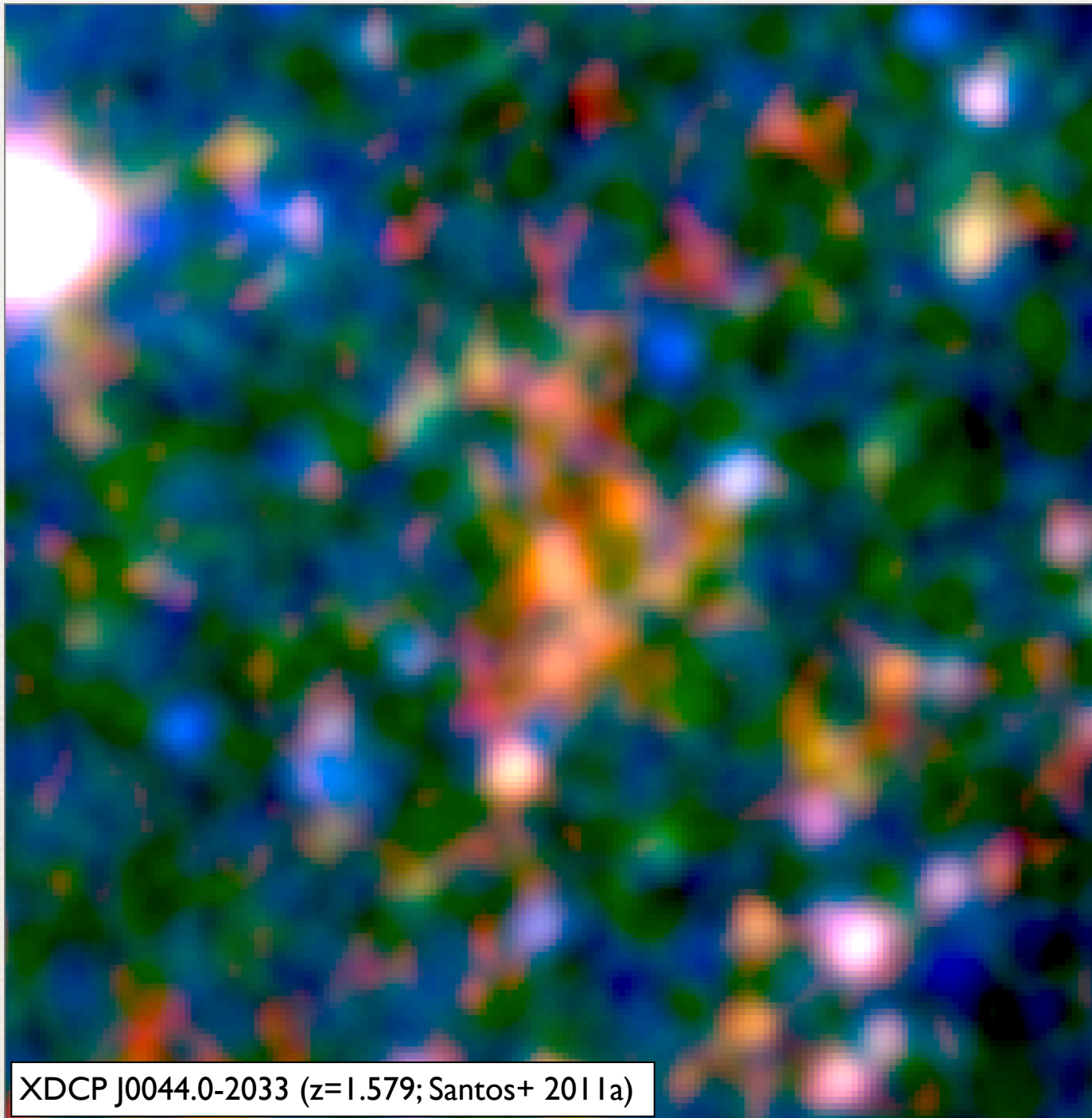


SPT-CL J0546-5345 ( $z=1.067$ ; Brodwin+ 2010)

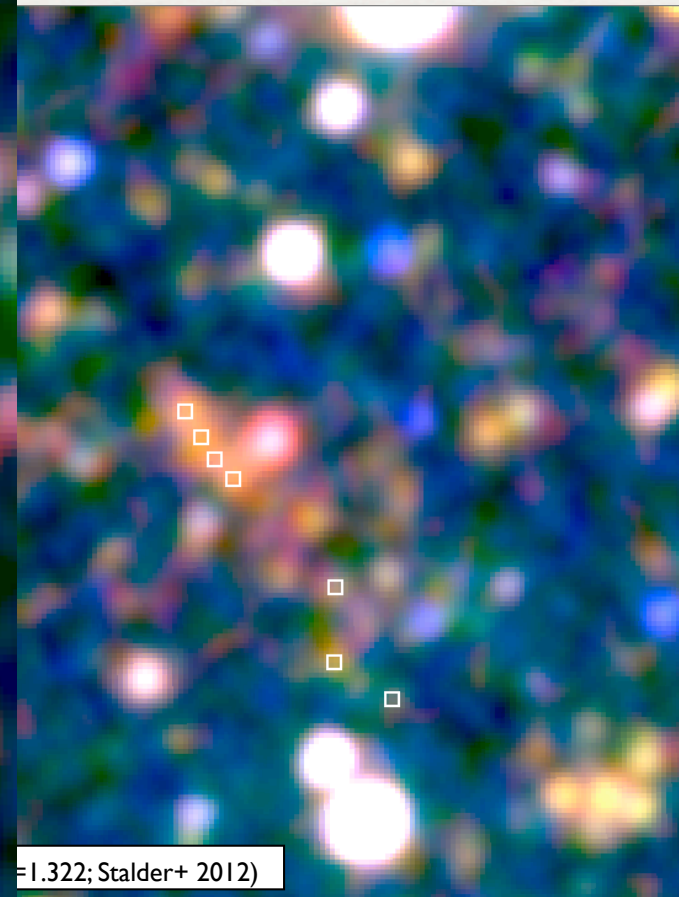
# Are $z \sim 1$ Clusters Visible in WISE?



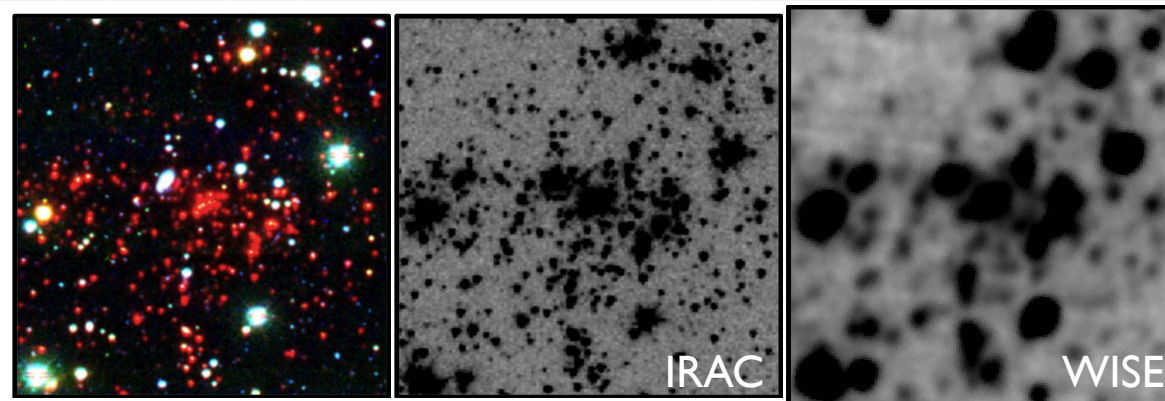
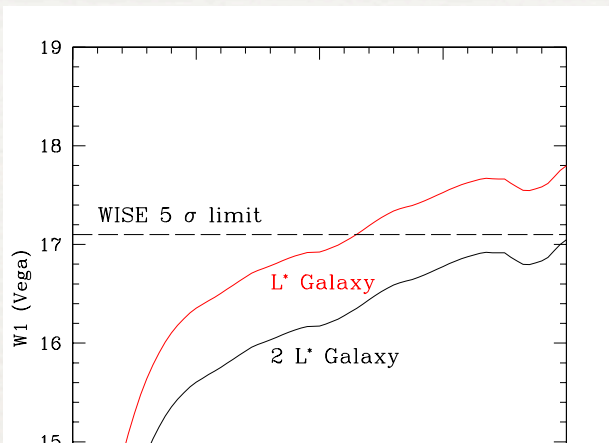
# Are $z \sim 1$ Clusters Visible in WISE?



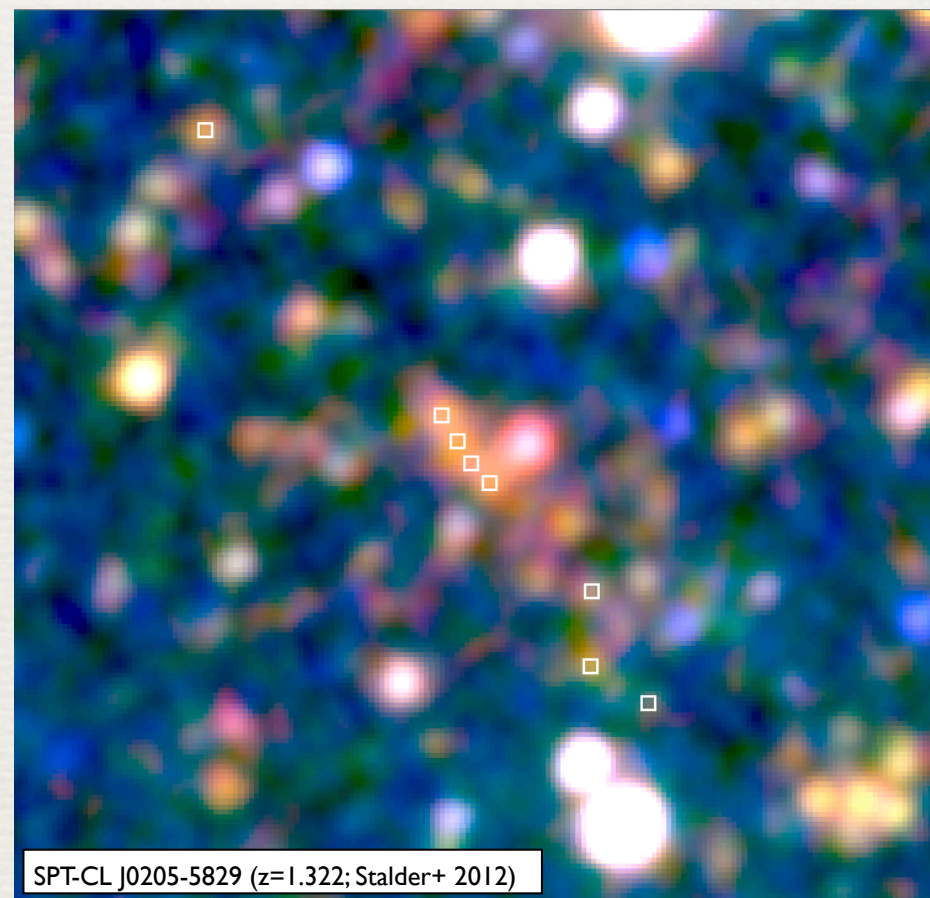
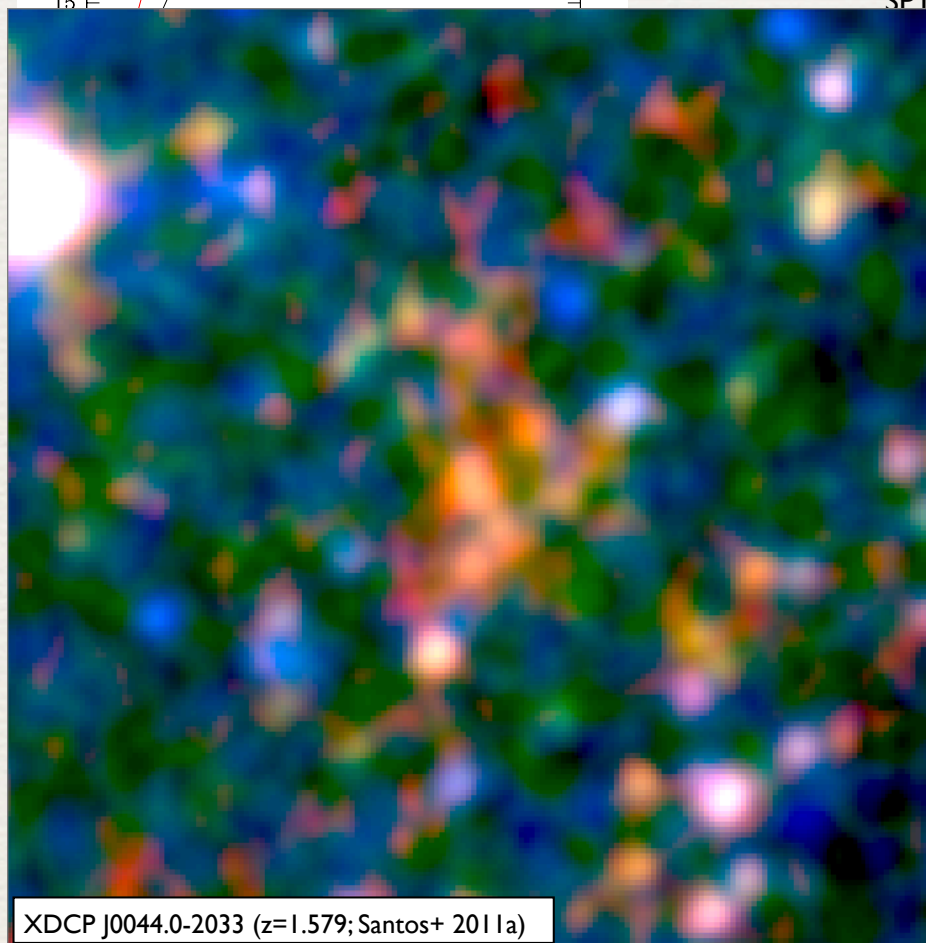
011)



# Are $z \sim 1$ Clusters Visible in WISE?



SPT-CL J0546-5345 ( $z=1.06$ ; Brodwin+ 2011)

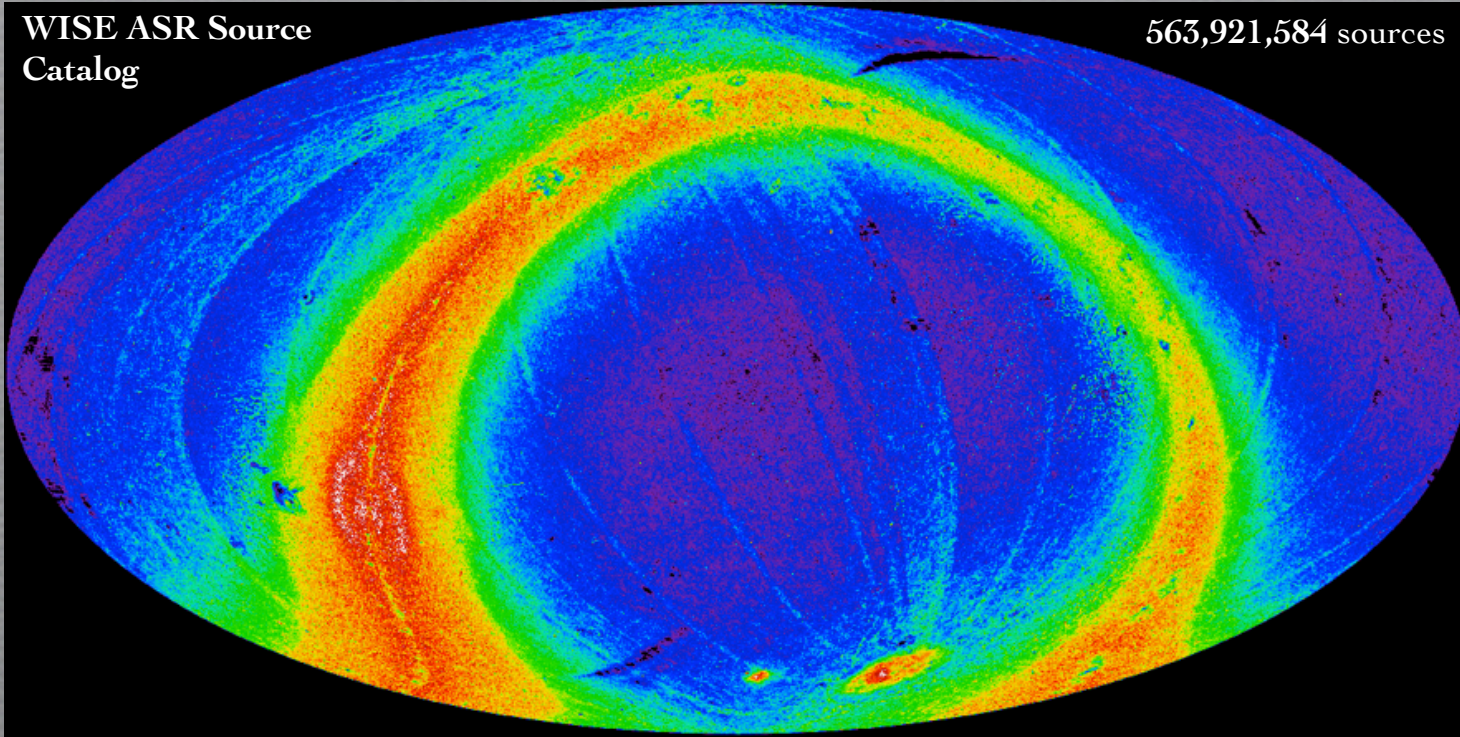


SPT-CL J0205-5829 ( $z=1.322$ ; Stalder+ 2012)

# MaDCoWS Search Method

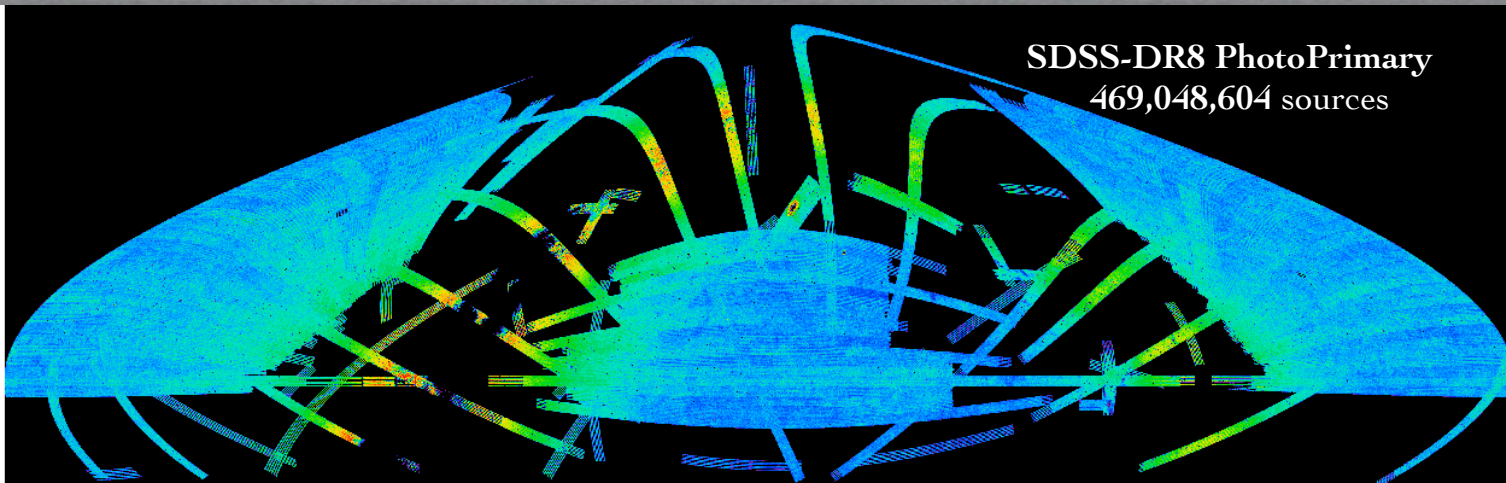
WISE ASR Source  
Catalog

563,921,584 sources

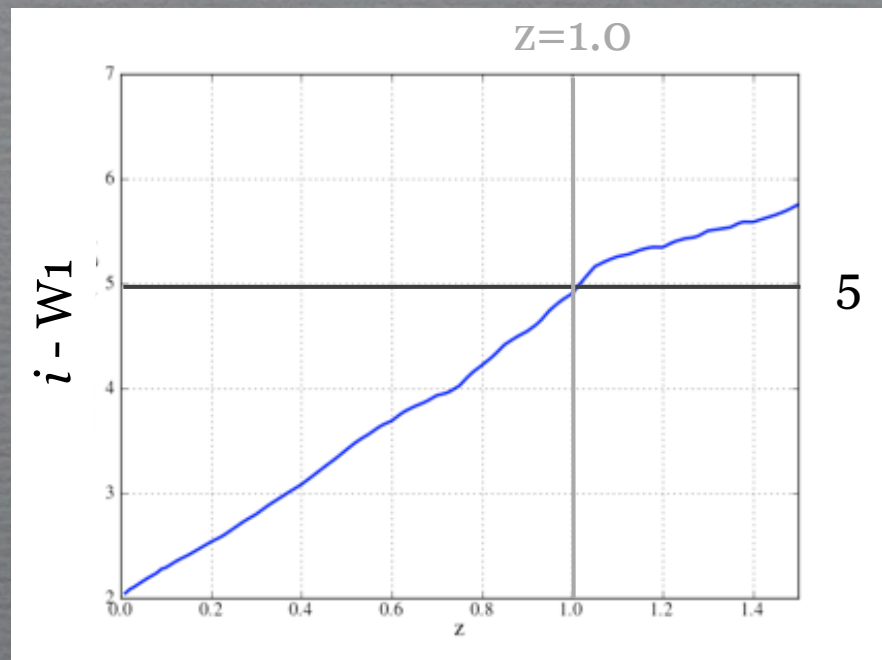
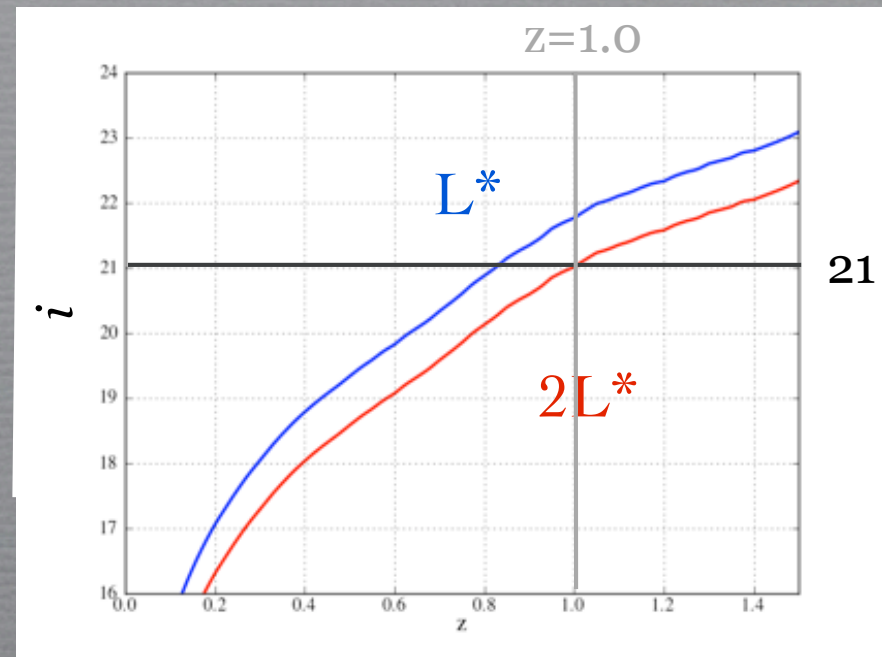
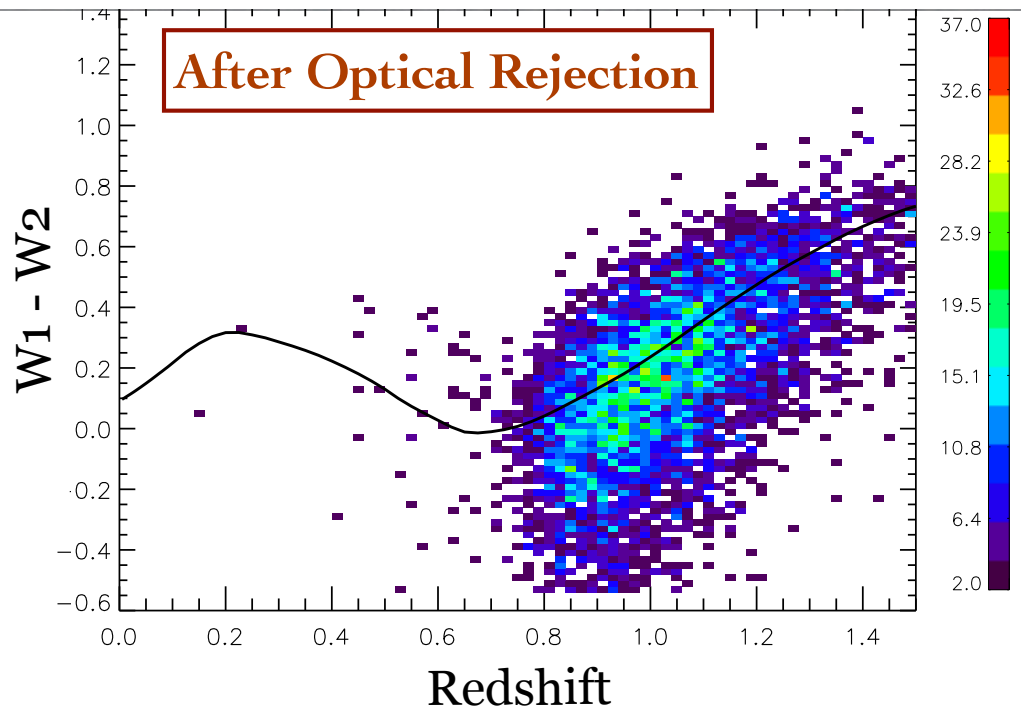
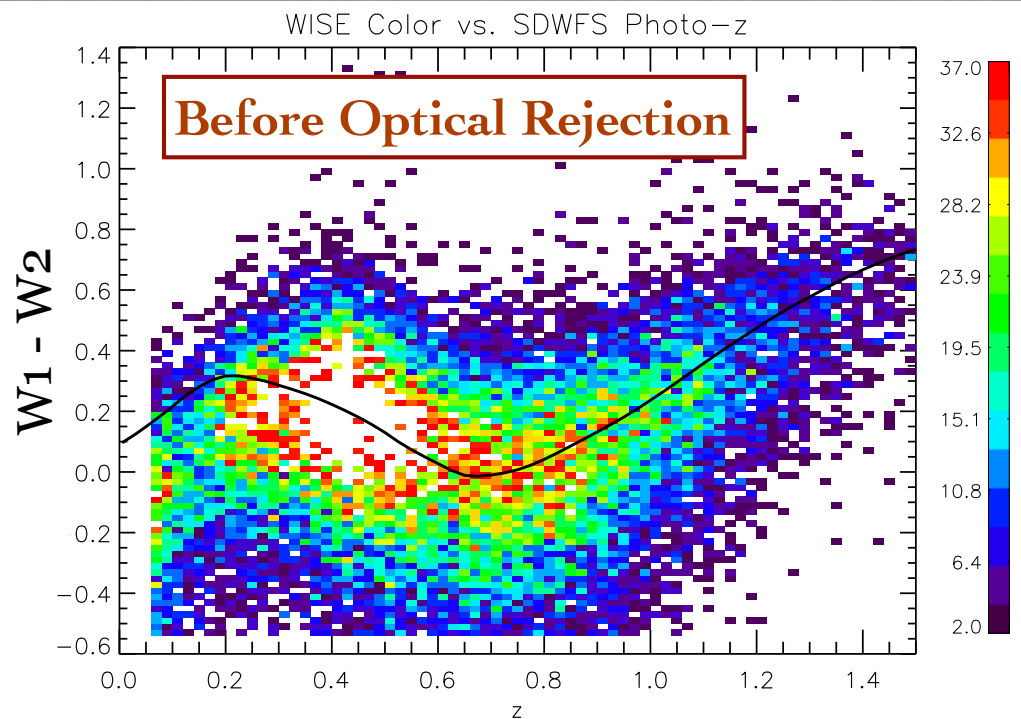


Overlap:  $\sim 10,000 \text{ deg}^2$

SDSS-DR8 PhotoPrimary  
469,048,604 sources



# MaDCoWS Search Method

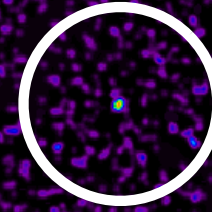


# MaDCoWS Search Method

Wavelet-Smoothed  
Density Map

$10^\circ \times 10^\circ$

$3^\circ \times 3^\circ$

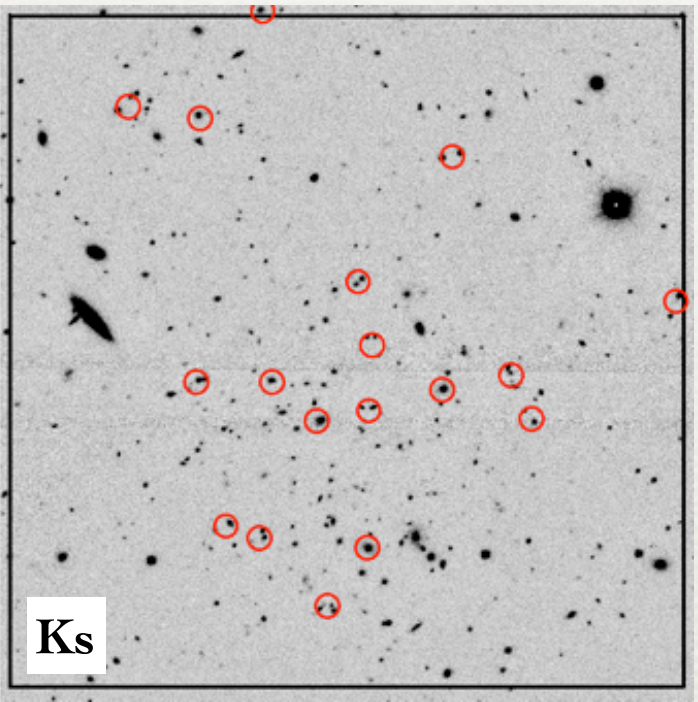
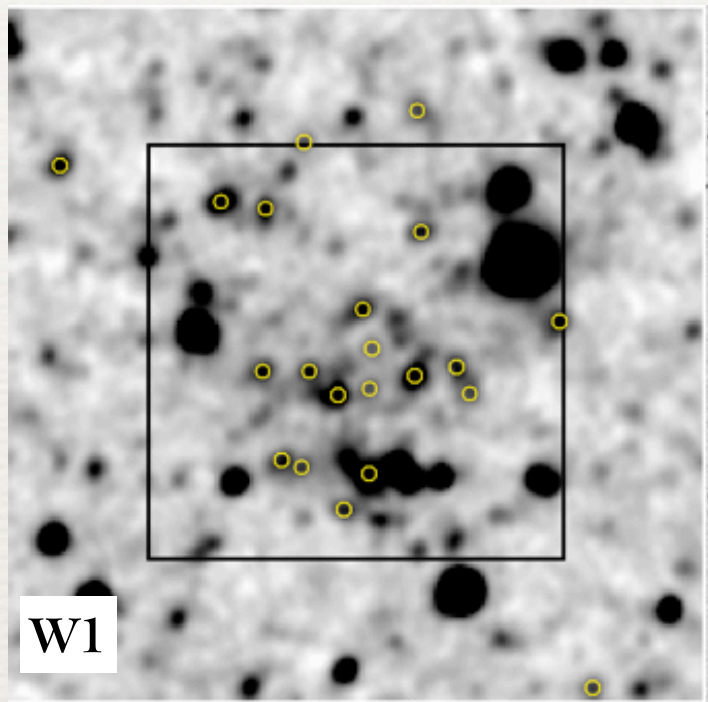




# First Discovery: MOO J2342.0+1301

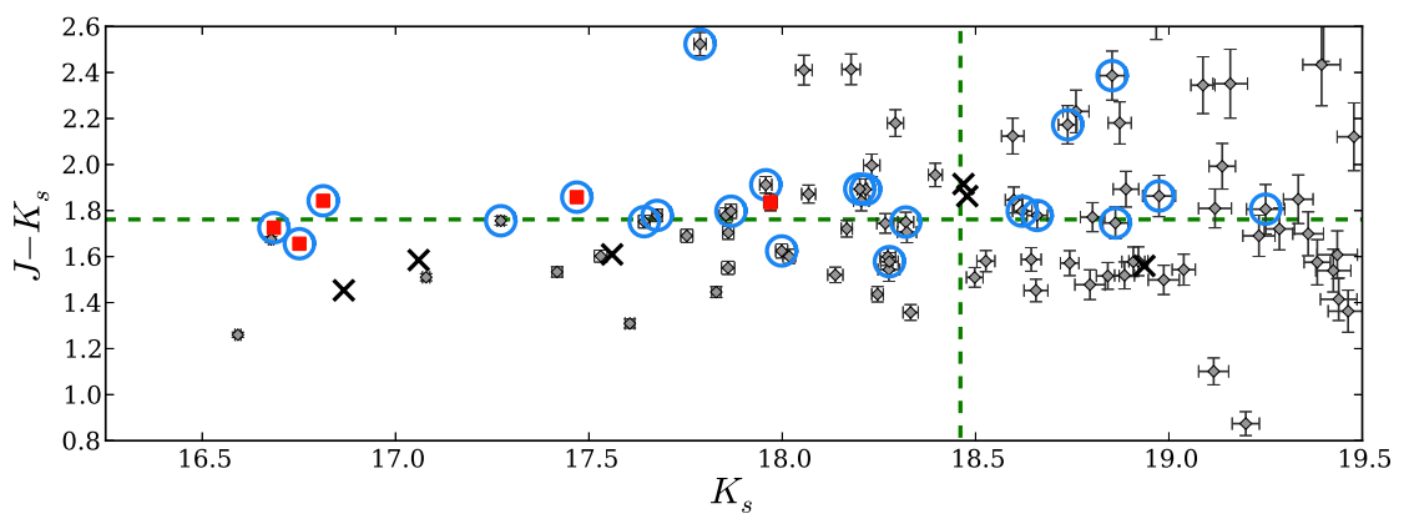
## The Massive Distant Clusters of WISE Survey: The First Distant Galaxy Cluster Discovered by WISE

Daniel P. Gettings<sup>1</sup>, Anthony H. Gonzalez<sup>1</sup>, S. Adam Stanford<sup>2,3</sup>, Peter R. M. Eisenhardt<sup>4</sup>,  
Mark Brodwin<sup>5</sup>, Conor Mancone<sup>1</sup>, Daniel Stern<sup>4</sup>, Gregory R. Zeimann<sup>3</sup>, Frank J. Masci<sup>6</sup>,  
Casey Papovich<sup>7</sup>, Ichi Tanaka<sup>8</sup>, Edward L. Wright<sup>9</sup>



W1-W2 Selected  
W1-W2 Selected  
Spec-z Confirmed

**ApJL in press**



# Ongoing Follow-Up Campaign

## Phase I -- Optical/NIR Imaging

More time in 2012B

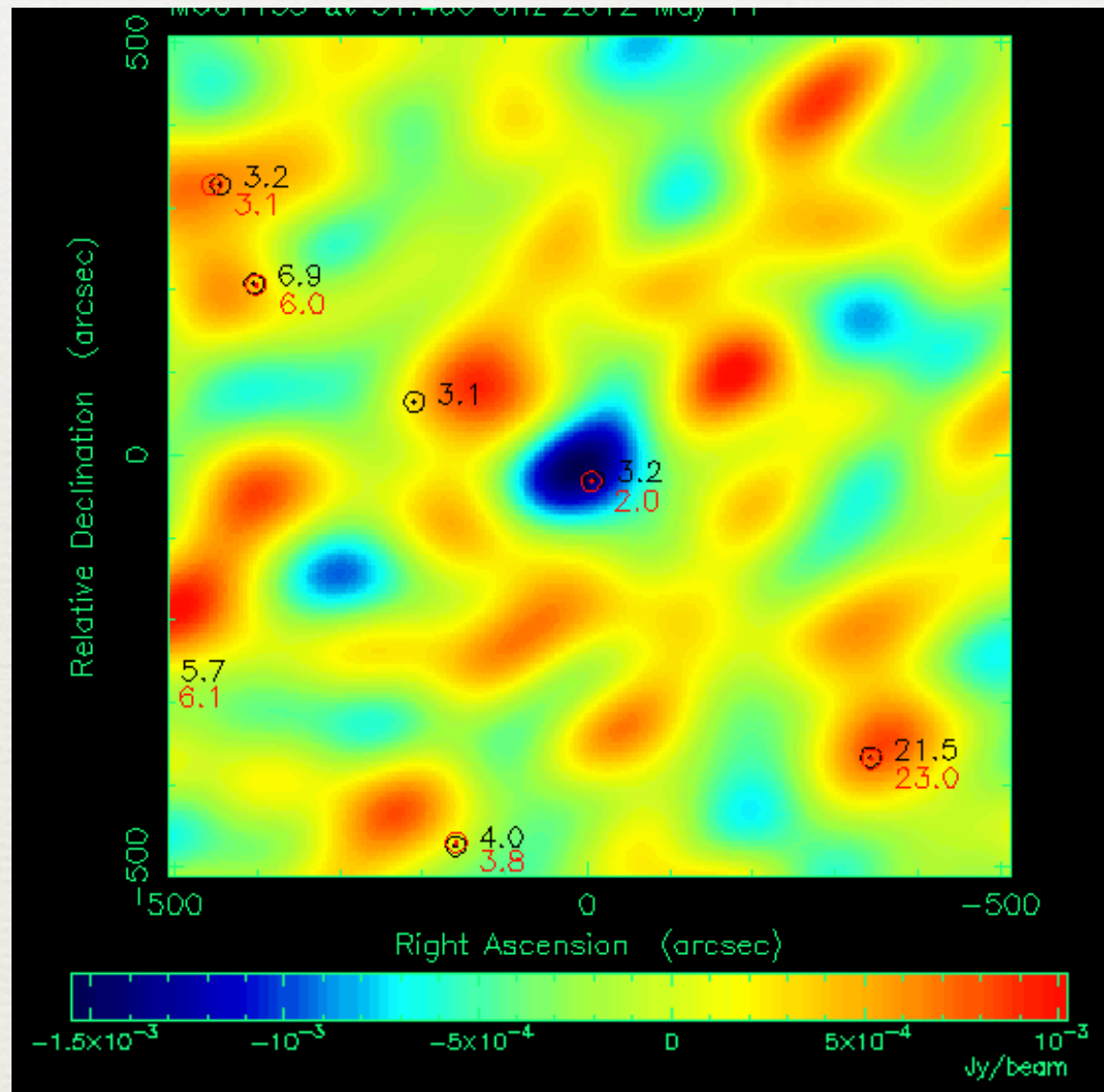
## Phase II -- Multi-Object Spectroscopy

First dedicated MaDCoWS run:

2012 October

## Phase III -- Cluster Masses

- ◆ Program on **CARMA / SZA** for SZ effect ongoing
- ◆ First SZ Detection!



# Thanks

MaDCoWS:  
The *Massive Distant Clusters of WISE Survey*

