THE MASSIVE AND DISTANT CLUSTERS OF WISE SURVEY

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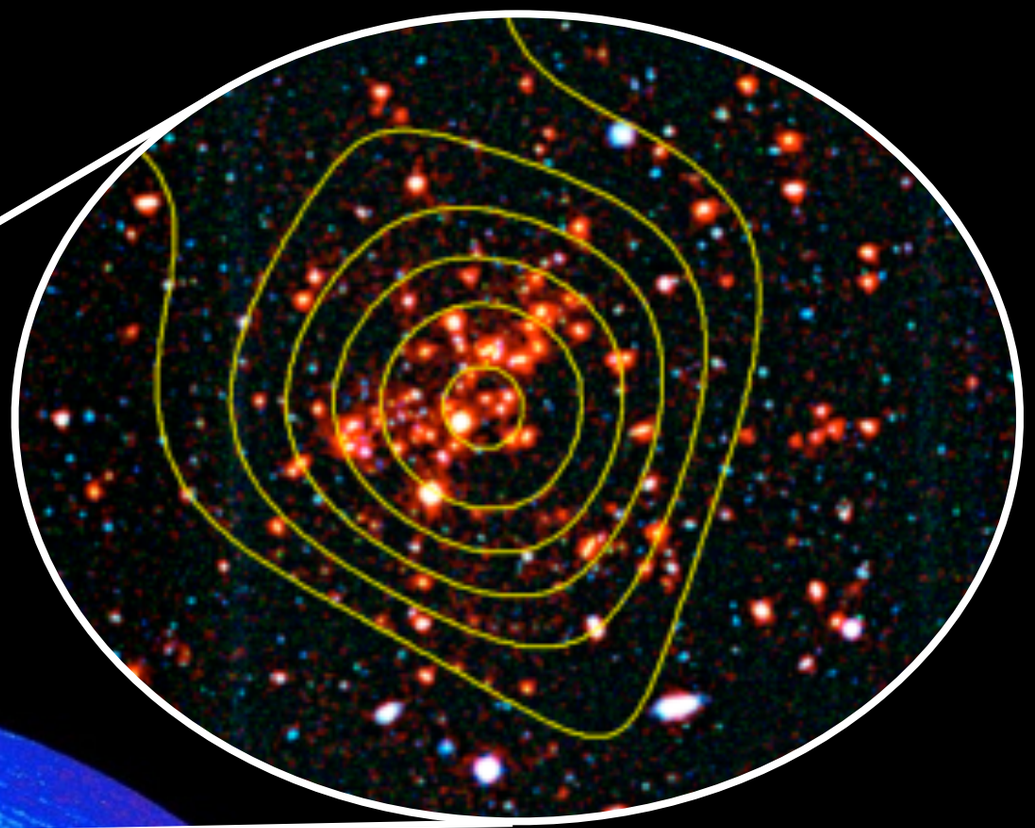
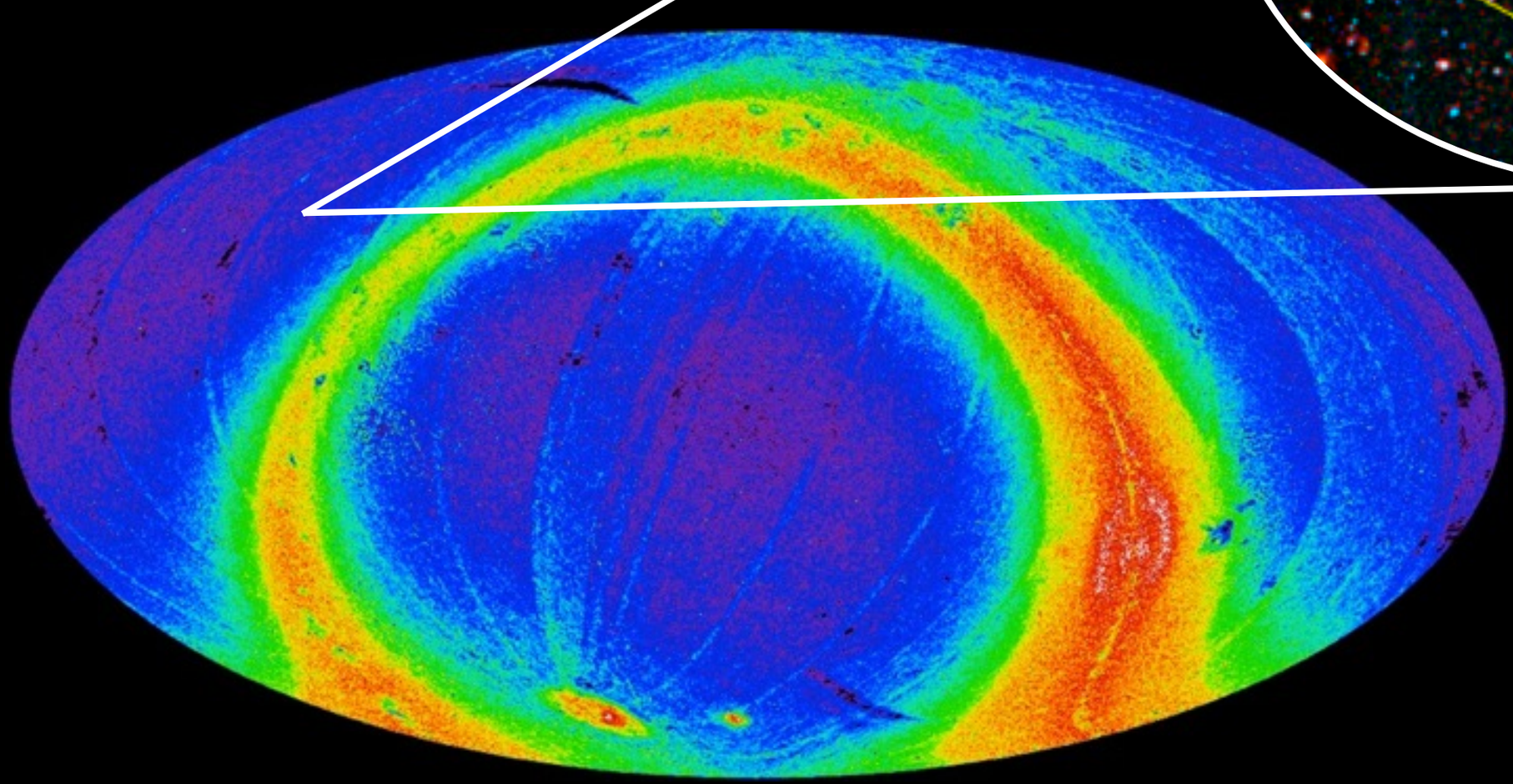




Pasadena, 11 February, 2015

WHY HIGH REDSHIFT GALAXY CLUSTERS?

MaDCoWs

Cosmology

- Evolution of Galaxy Cluster Mass Function
- Evolution of Hot Gas Baryon Fraction (f_{gas} test)
- High-redshift Supernovae Searches
- Arc Statistics
- Extreme Mass Clusters (Primordial non-Gaussianity)

Gravitional Telescopes

- Magnified windows onto early universe
- Less impact from ICL than low-z clusters

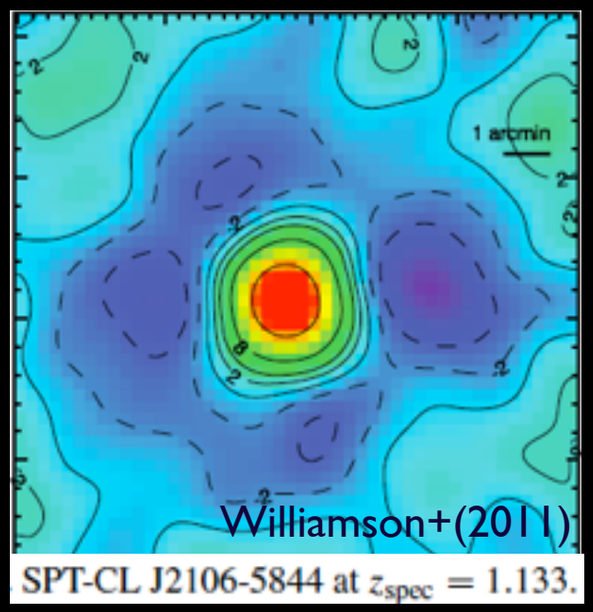
Cluster Evolution

- Epoch of Cluster Formation
  - Rapid Mass Growth
  - Intracluster Medium (ICM) Enrichment
- Galaxy Evolution
  - Window on Formation of Cluster Galaxies
    - Approaching Era of Cluster Galaxy Assembly
    - Approaching Era of Peak Star Formation
  - Formation of Intracluster Light (ICL)

HIGH-REDSHIFT CLUSTER SEARCHES

State of the Art

Sunyaev - Zel'dovich Effect



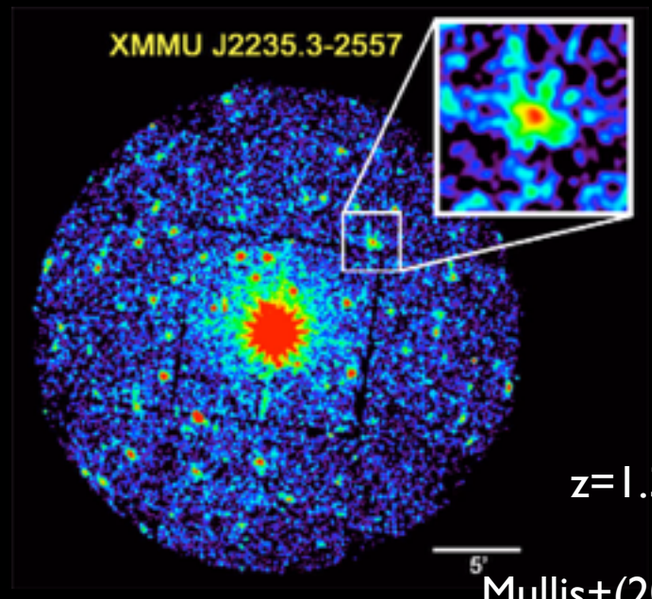
Existing surveys:
SPT, ACT
2500 sq. degrees

Results: Handful of massive ($M>5x10^{14}$ $M_\odot$) clusters published at $1<z<1.5$

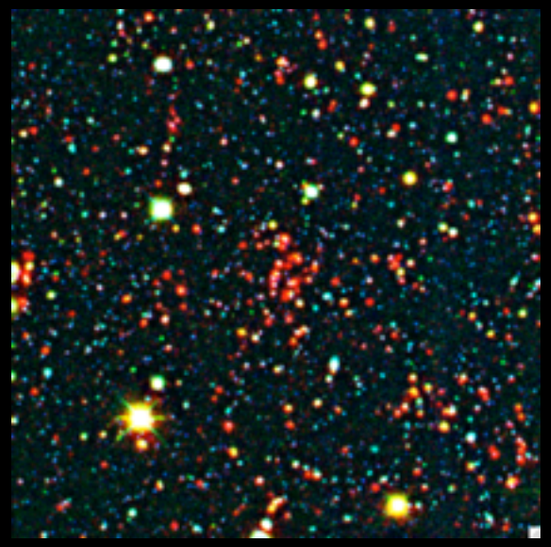
X-ray

Existing : XMM
100's of sq degrees

Results: ~20 clusters with $M\sim10^{14}$-10^{15} $M_\odot$ published $1<z<1.6$



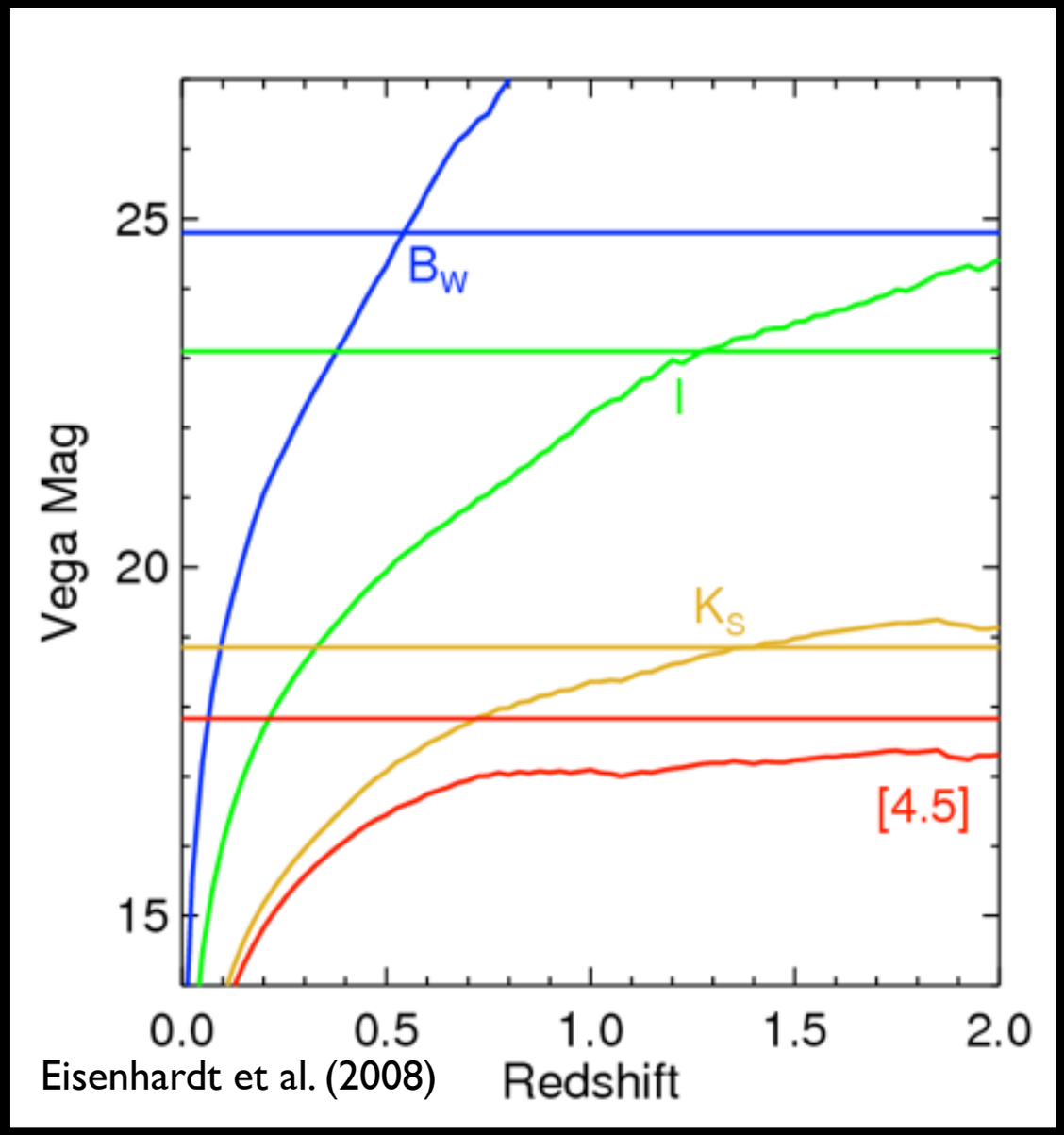
Galaxies



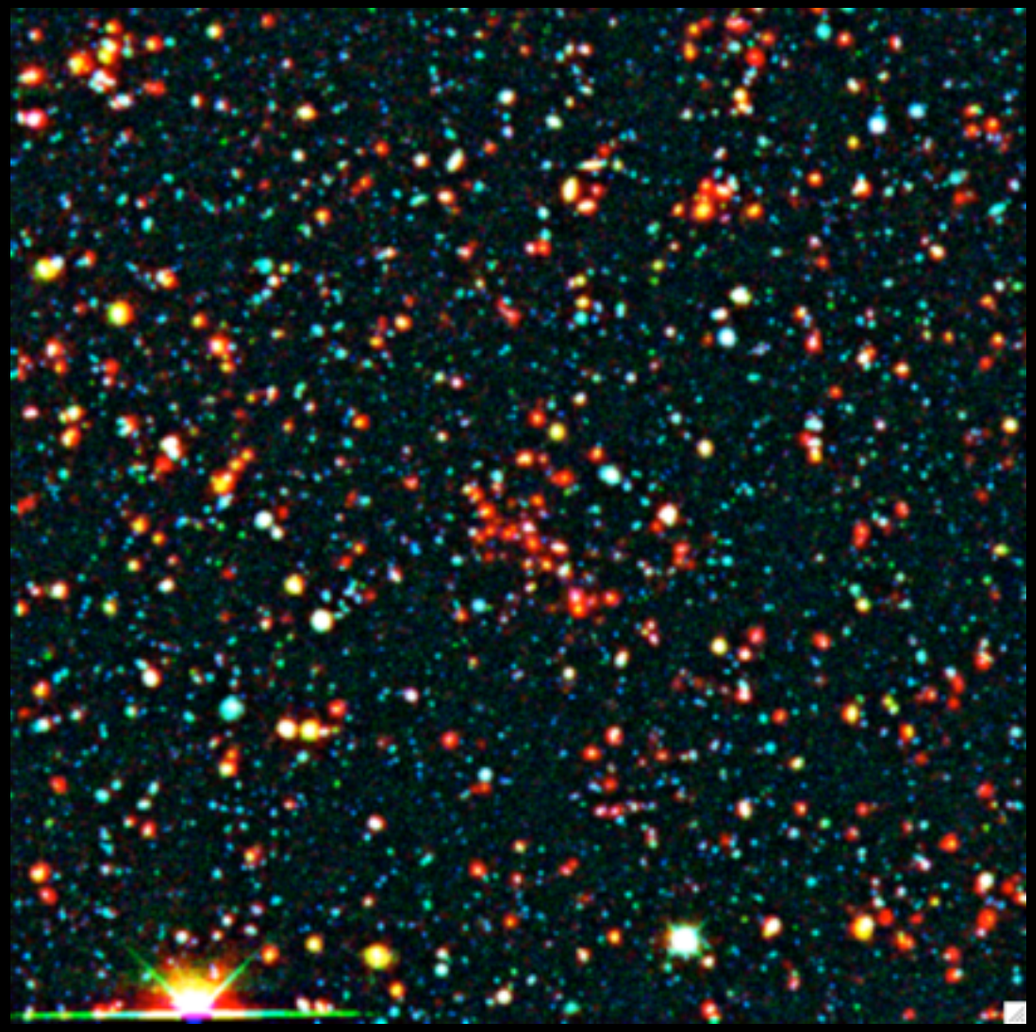
Existing: Spitzer, Near-infrared
10's of sq degrees (100's for optical)

Status: Dozens of clusters and groups with $M\sim5x10^{13}$ - $5x10^{14}$ $M_\odot$ published at $1<z<2$

WHY INFRARED SEARCHES WORK



Mid-infrared selection of galaxies yields a nearly constant stellar mass limit at z>0.7.



<z> = 1.487

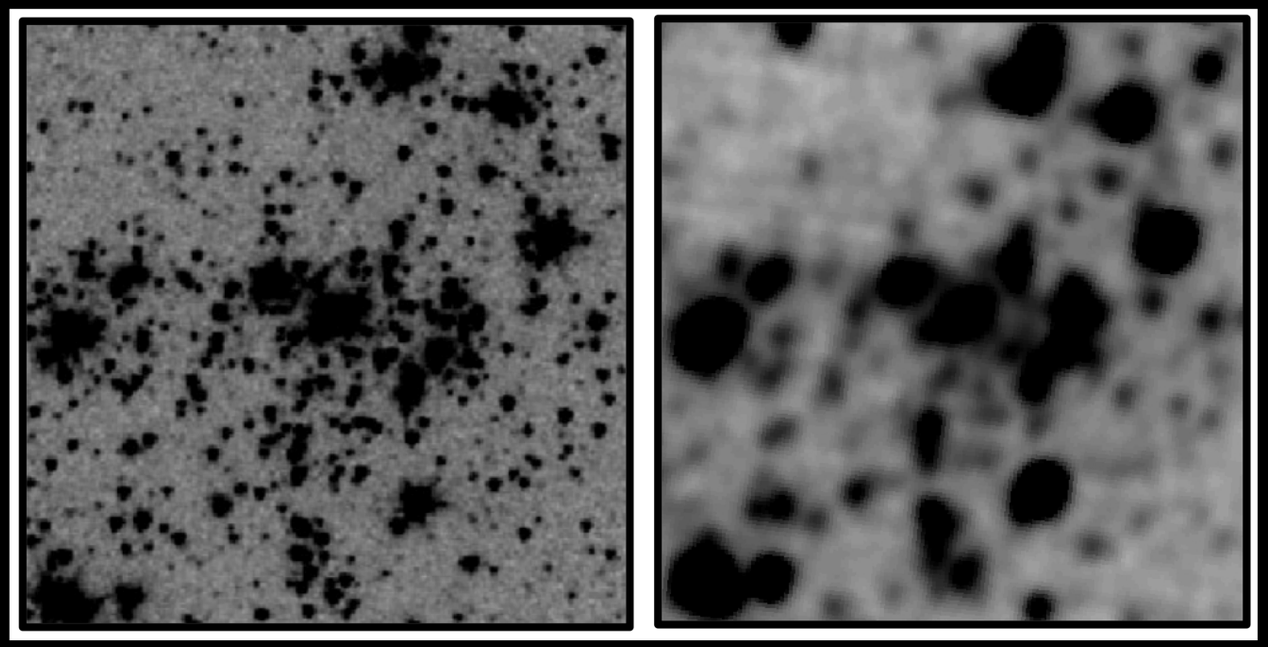
$B_wI[4.5]$

IRAC Shallow Cluster Survey Example

The Massive and Distant Clusters of WISE Survey

MaDCoWs

Objective: a full-sky catalog of massive clusters at z~1

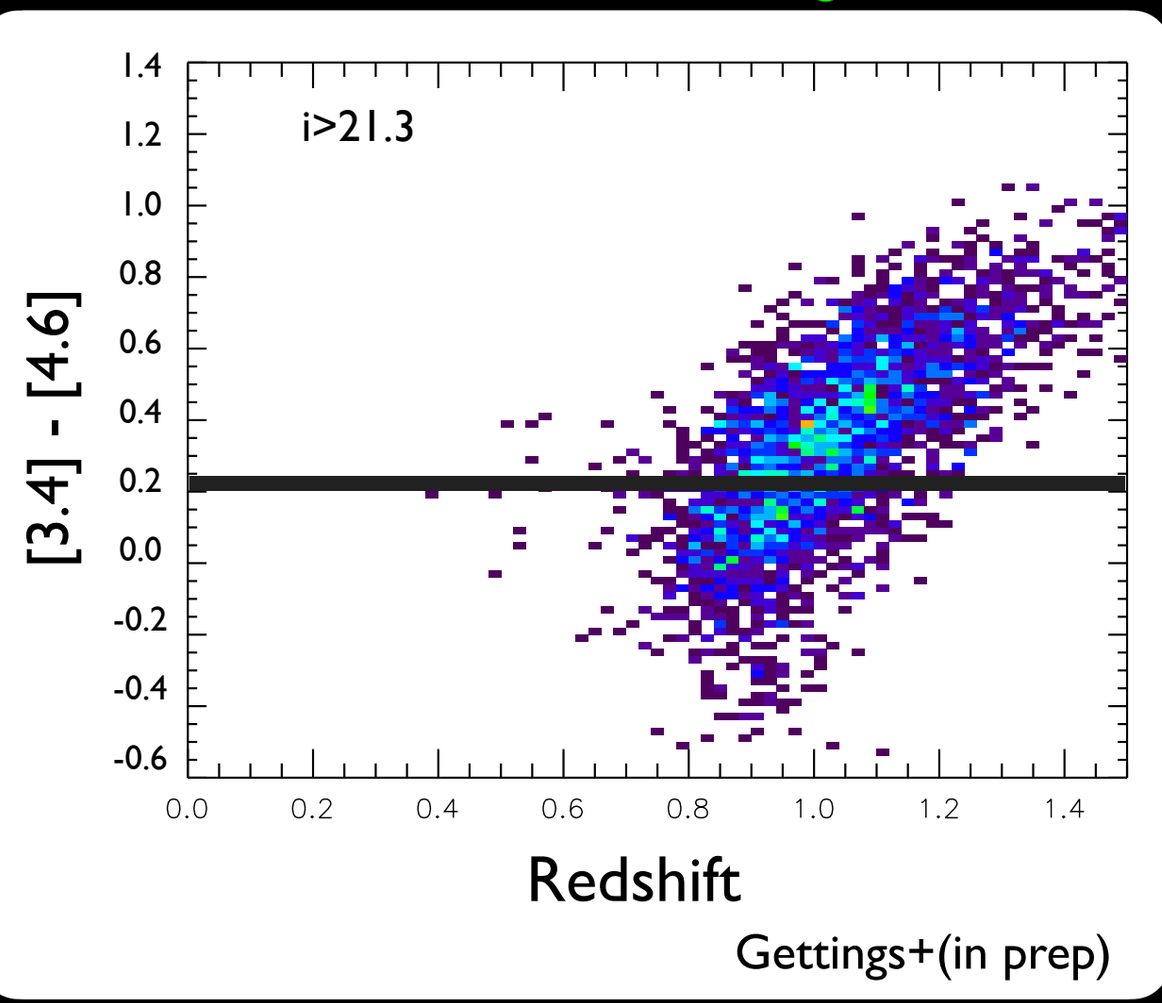


Spitzer/IRAC WISE

SPT-CL J0546-5345 (z=1.06)

There is clearly signal to detect...

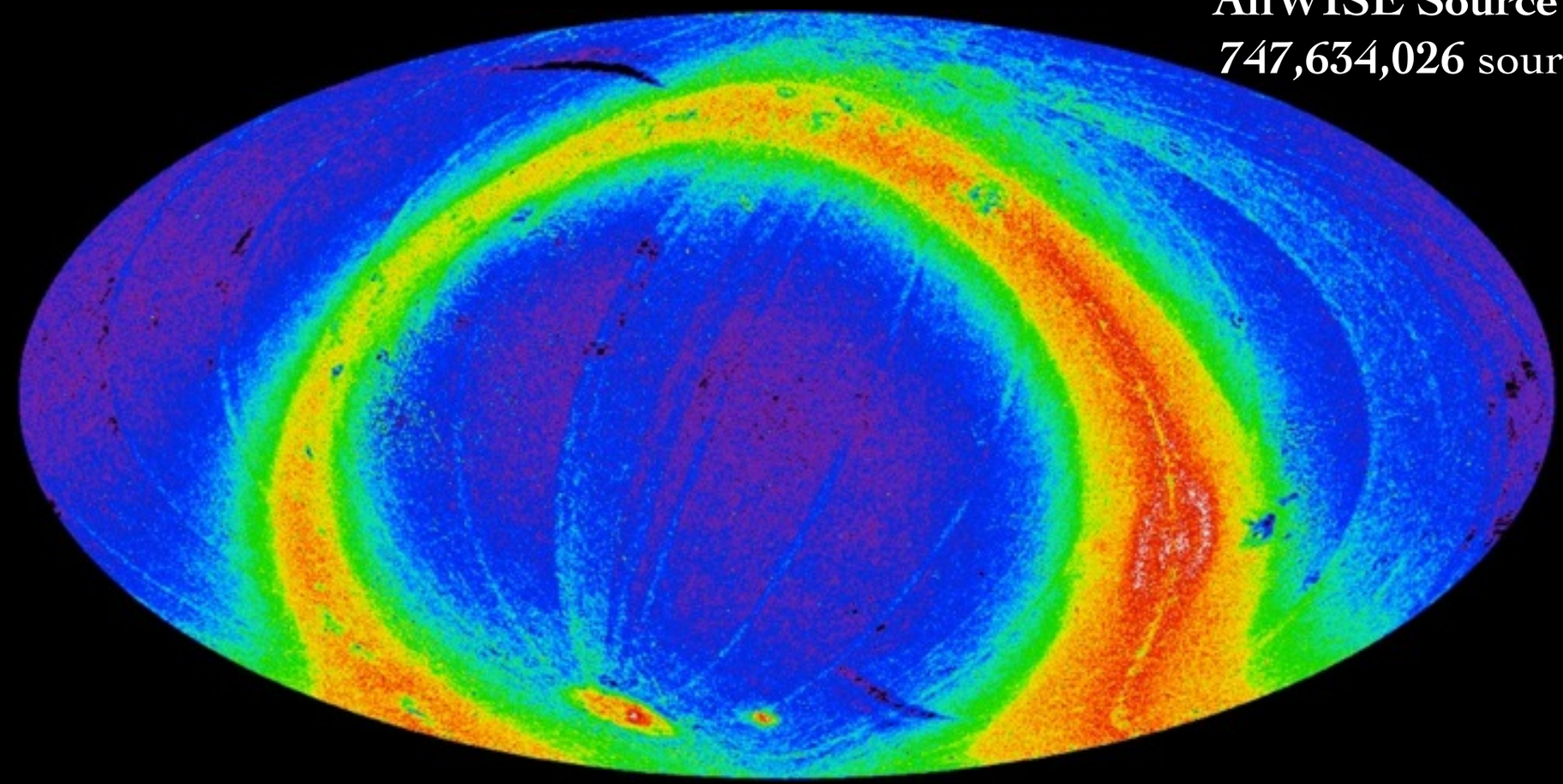
WISE colors of SDWFS galaxies



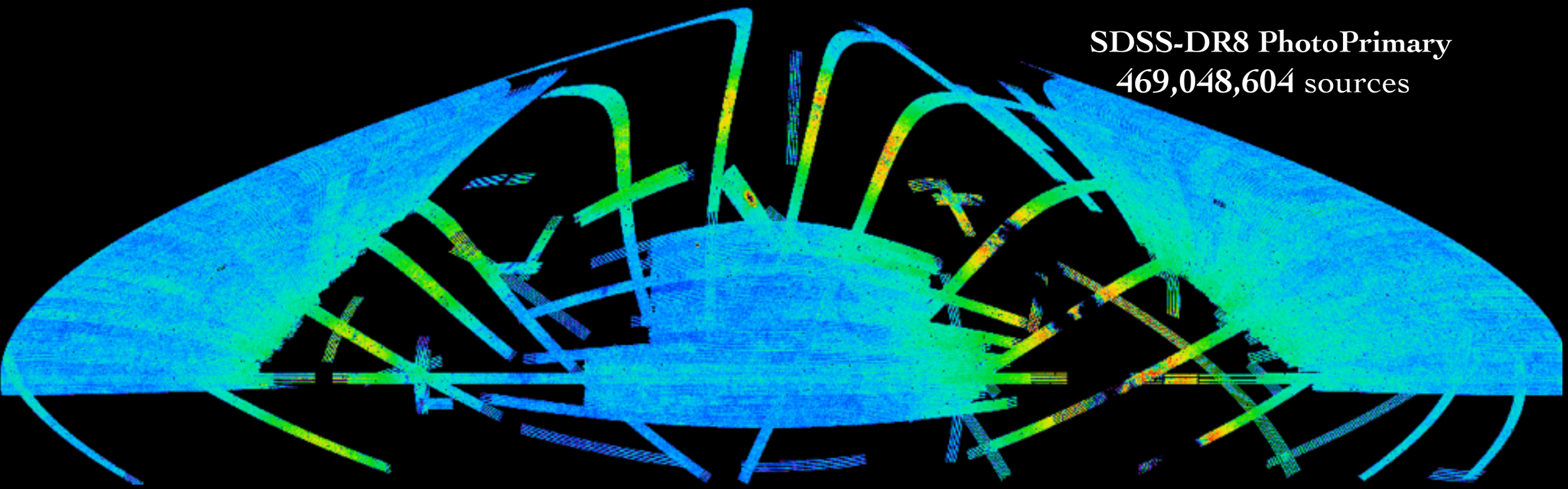
Gettings+(in prep)

MaDCoWS Search Method

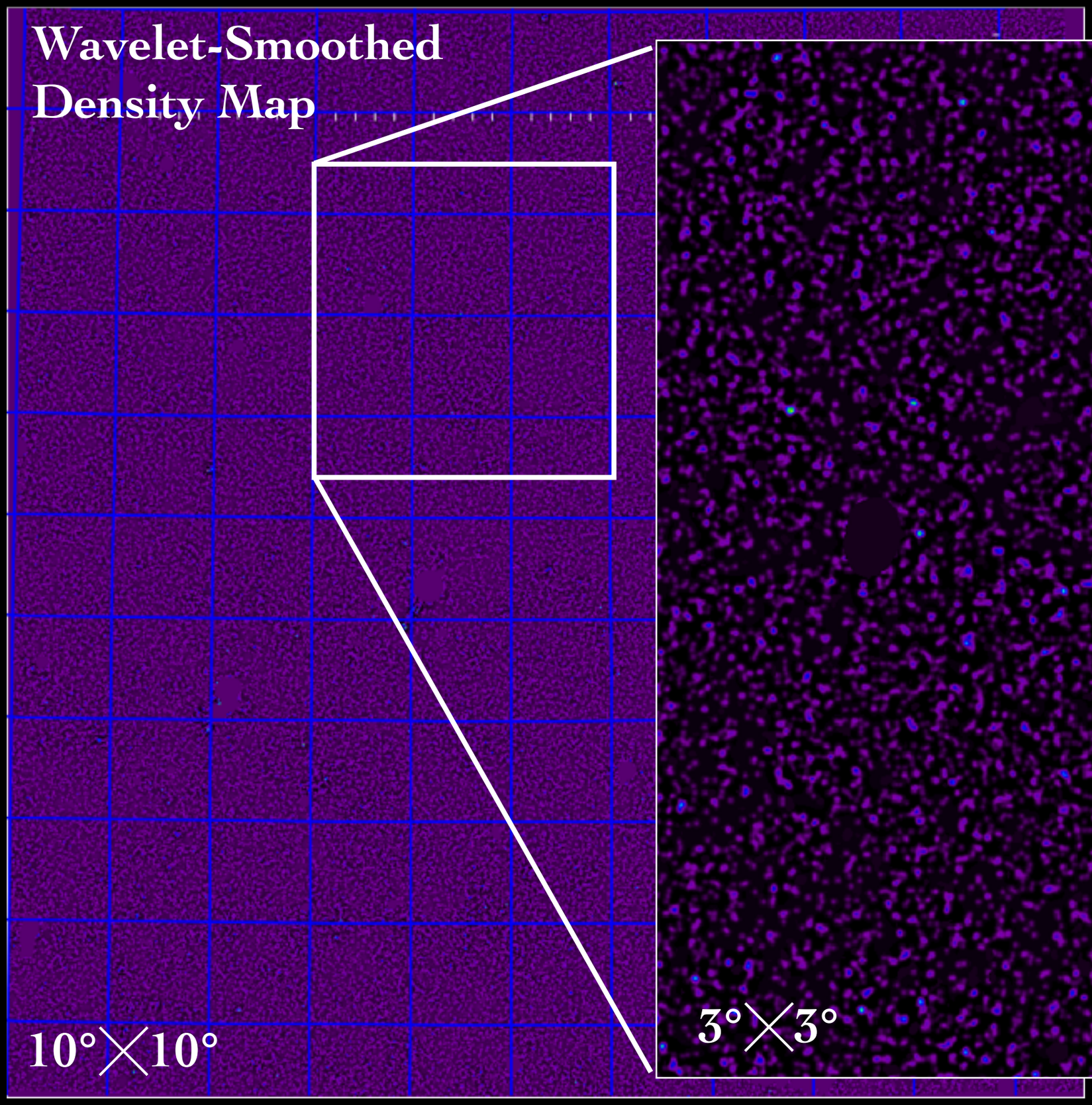
AllWISE Source Catalog
747,634,026 sources



SDSS-DR8 PhotoPrimary
469,048,604 sources



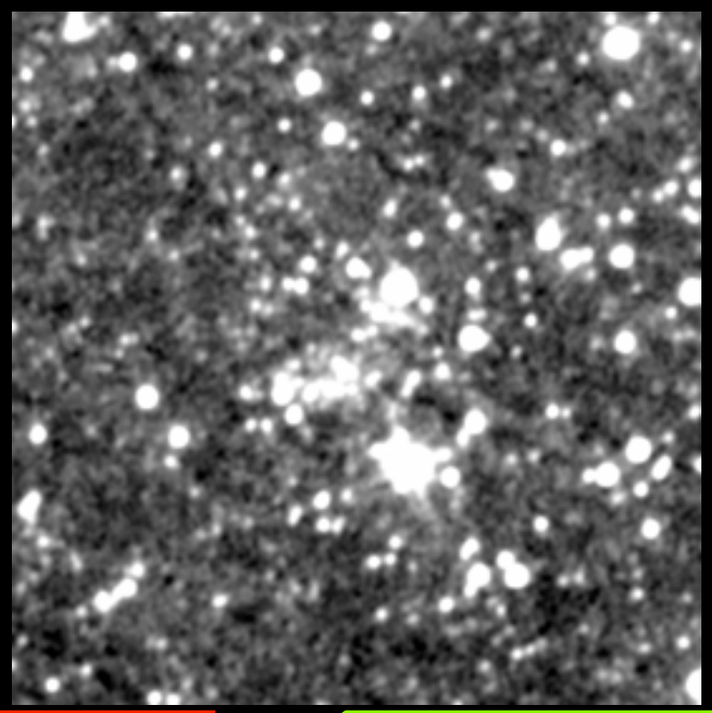
MaDCoWS Search Method

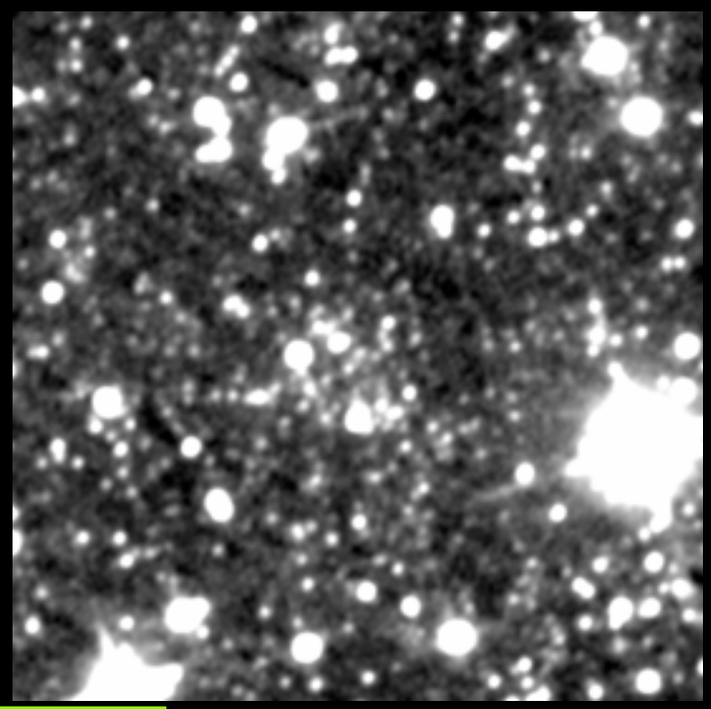


A WISE VIEW OF GALAXY CLUSTERS

MaDCoWs

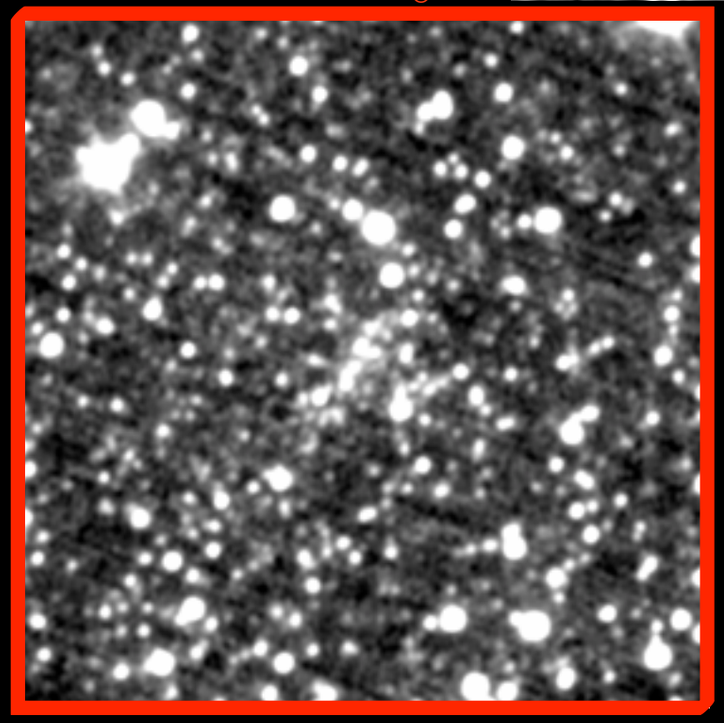
MaDCoWS Candidates
& SPT-CL J2106-5844

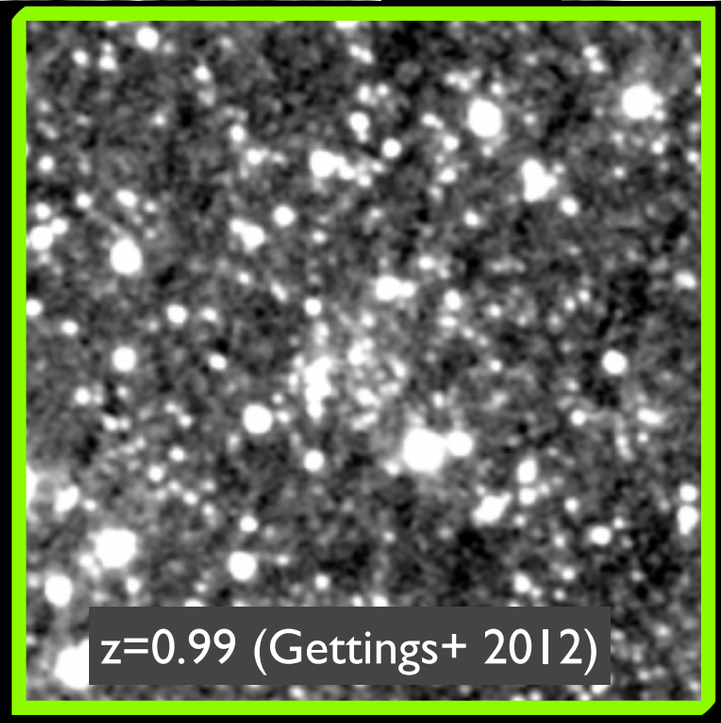




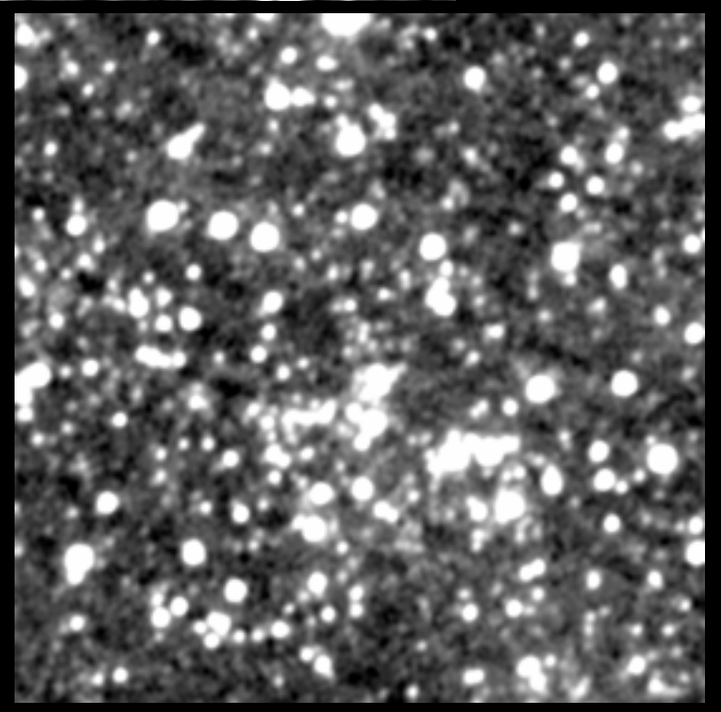
10′x10′

SPT (M=1.7x10^{15} M$_{\odot}$)





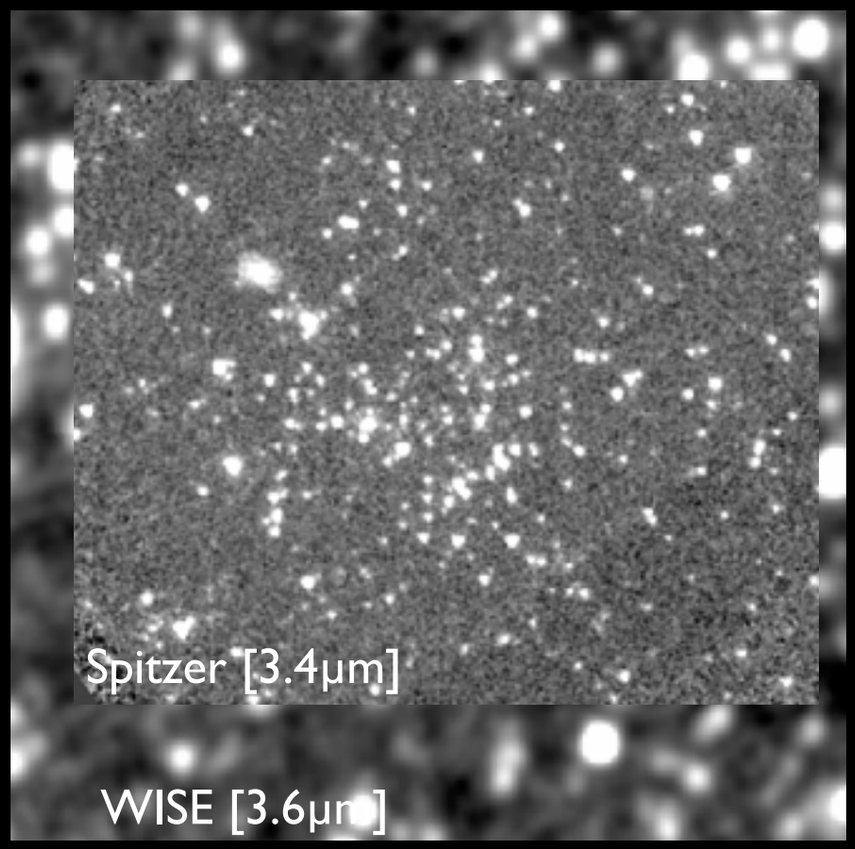
z=0.99 (Gettings+ 2012)

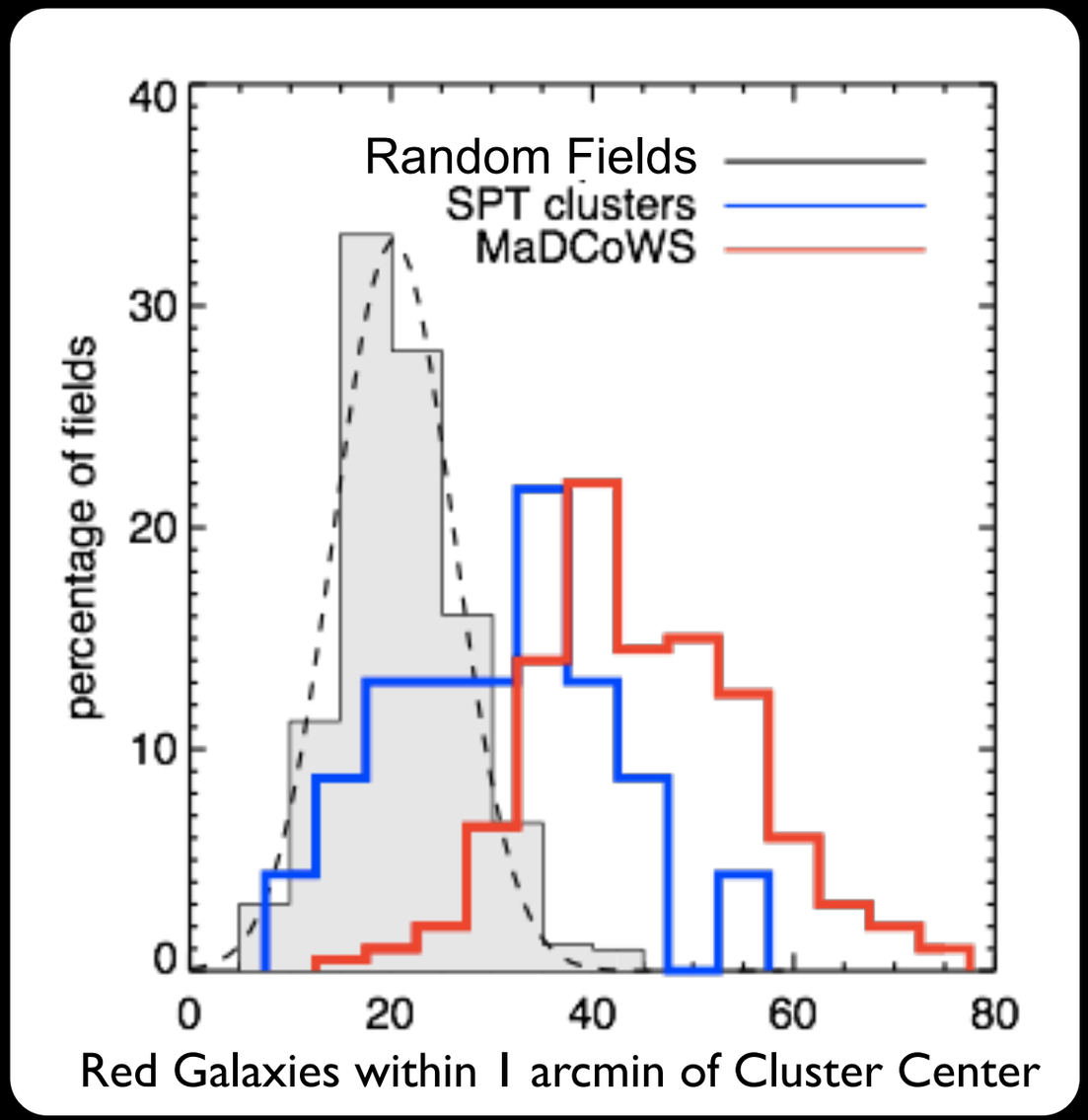


MADCOWS: ARE THEY CLUSTERS?

Confirmation and Characterization

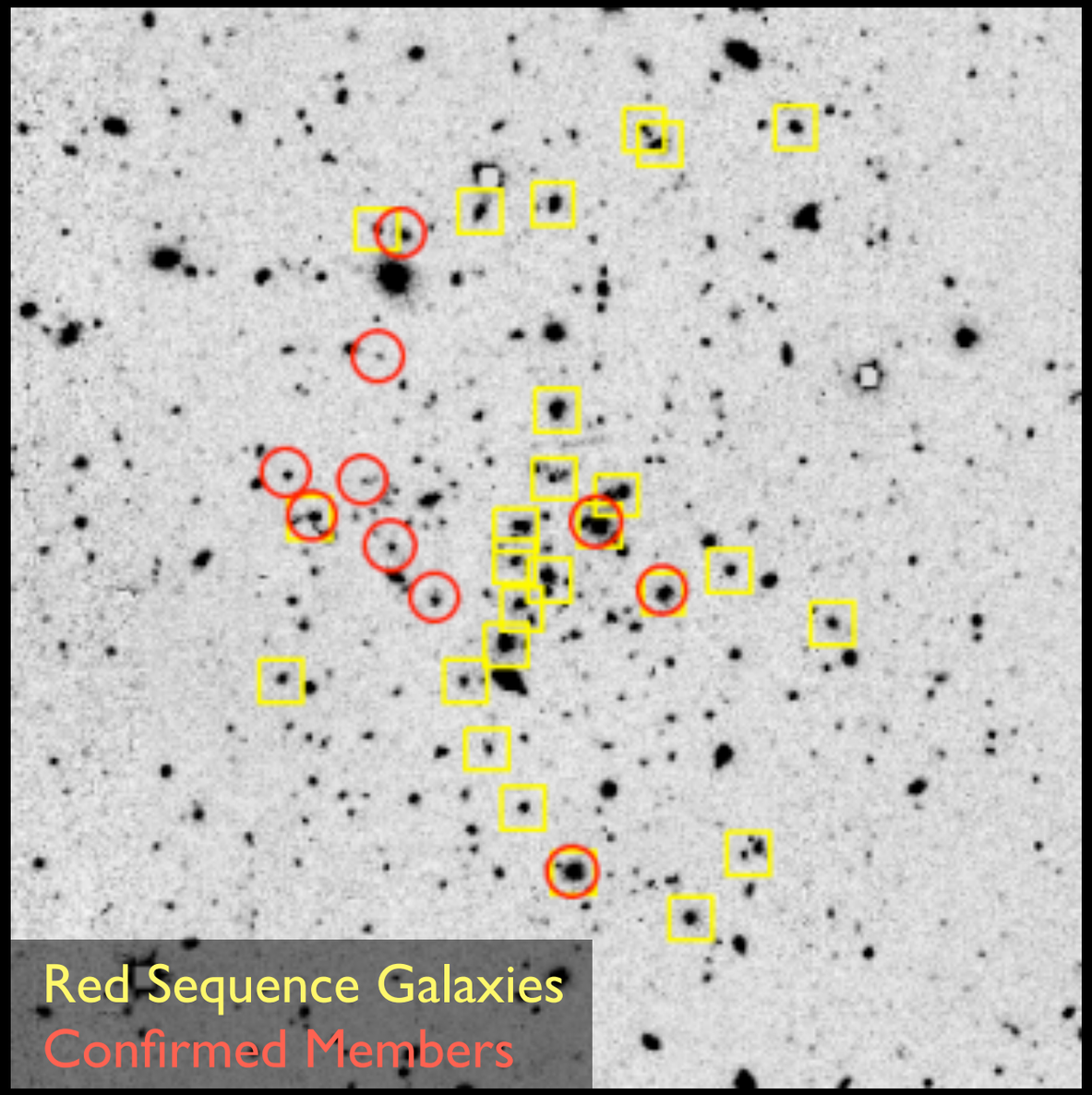
1. Spitzer Space Telescope:
   - Imaging of 200 highest S/N detections
   - Improved depth and spatial resolution





(Dominika Wylezalek)

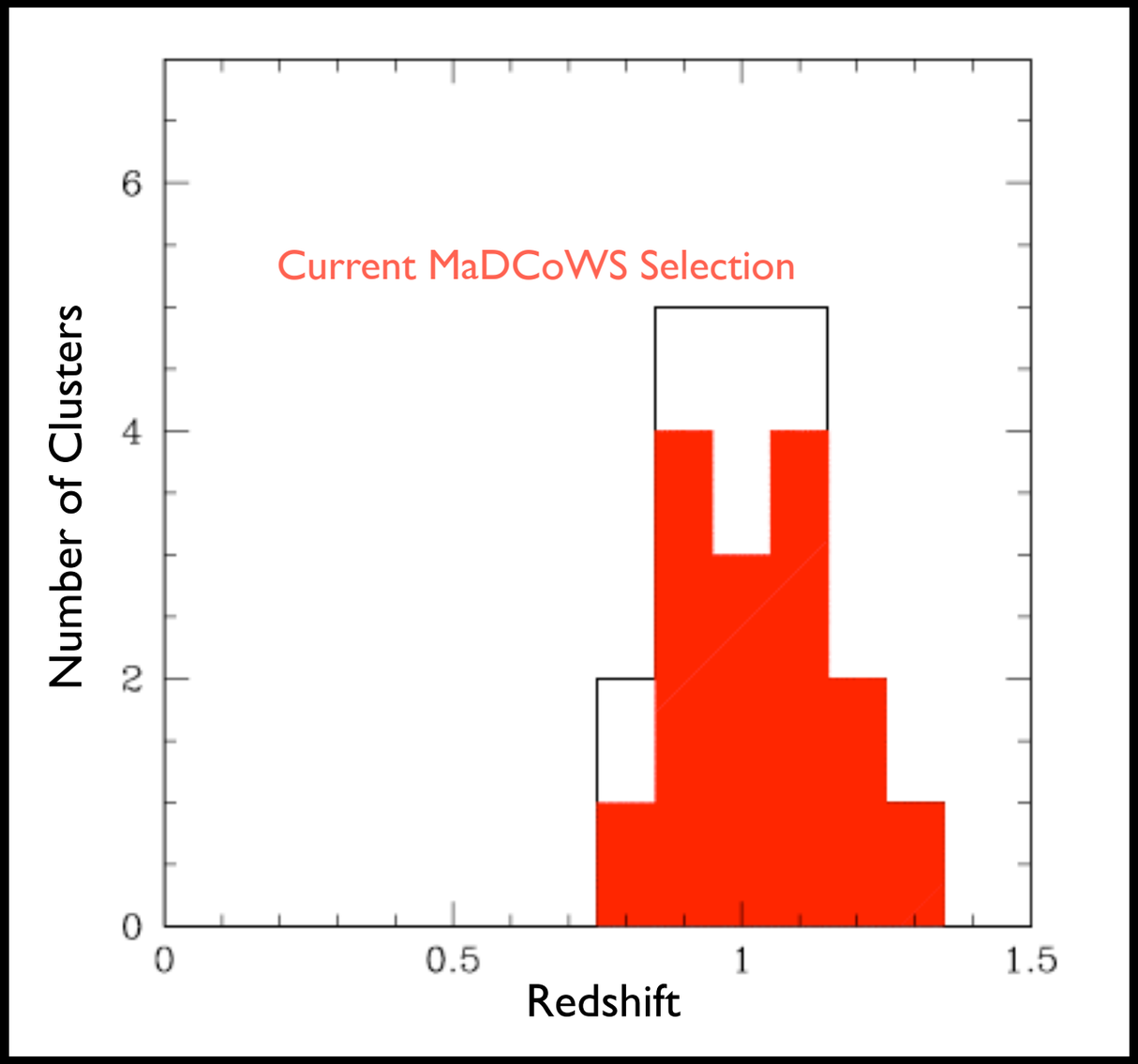
MADCOWS: ARE THEY DISTANT?



II. Gemini + Keck spectroscopy

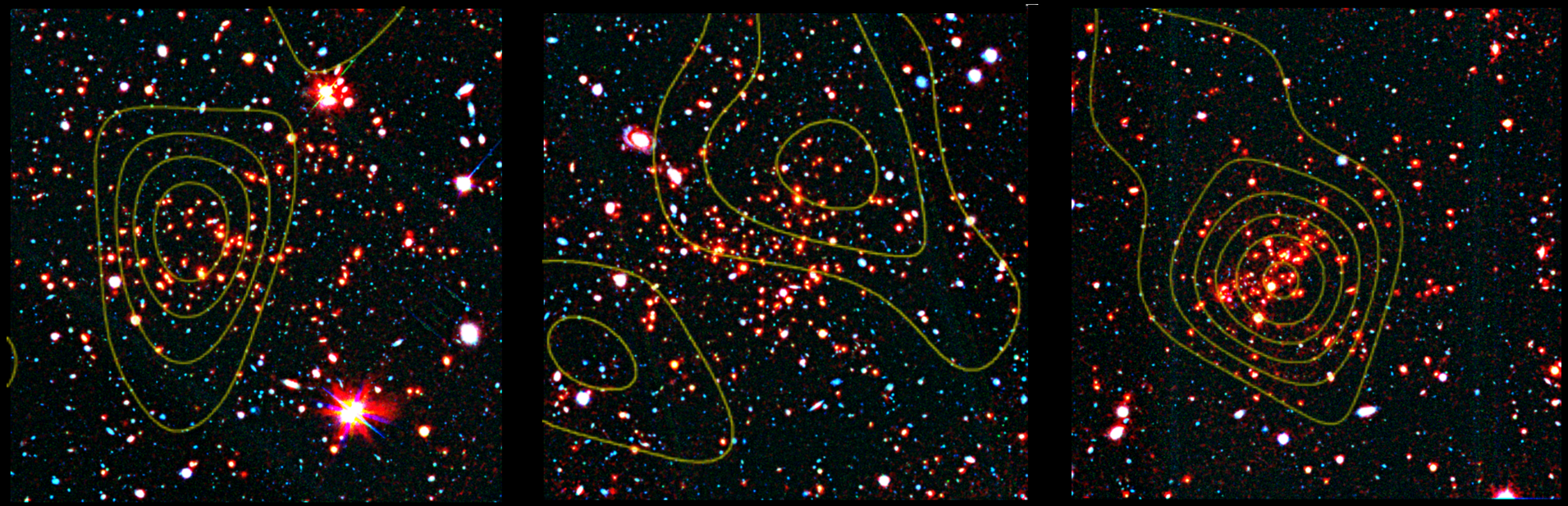
20 confirmed clusters
0.75<z<1.3

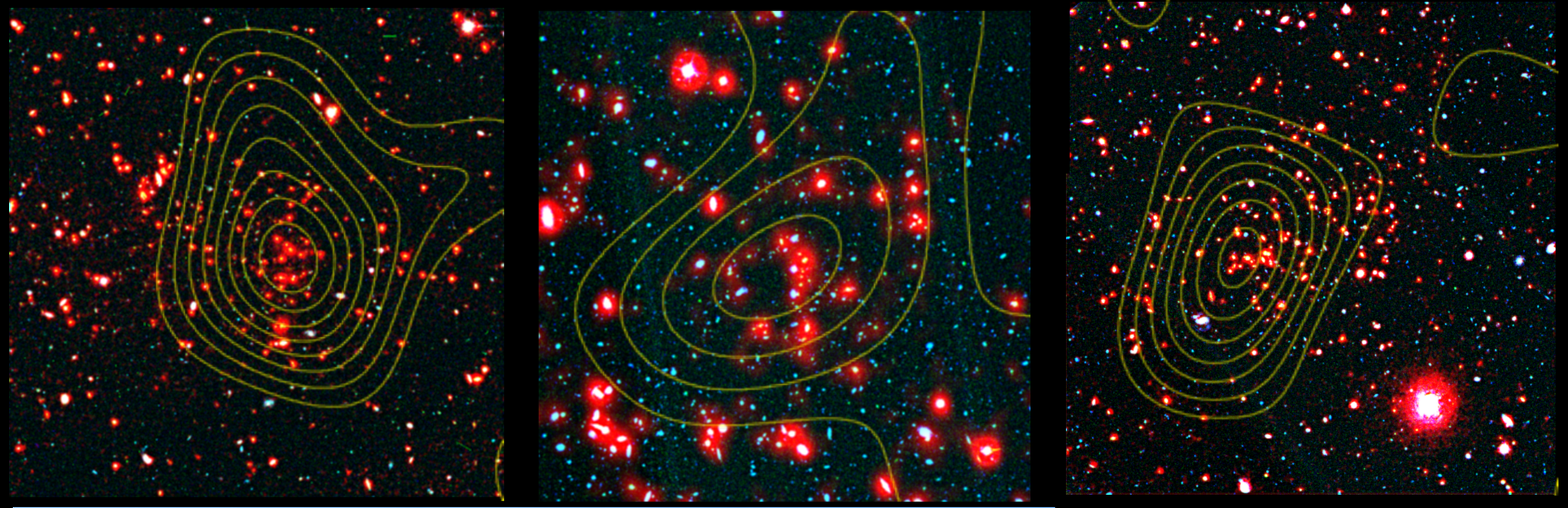
Stanford+(2014)



MADCOWS: ARE THEY MASSIVE?

III. CARMA SZ Observations





4' x 4'

Spitzer/WISE

CARMA = contours

First 6 clusters with S/N>3

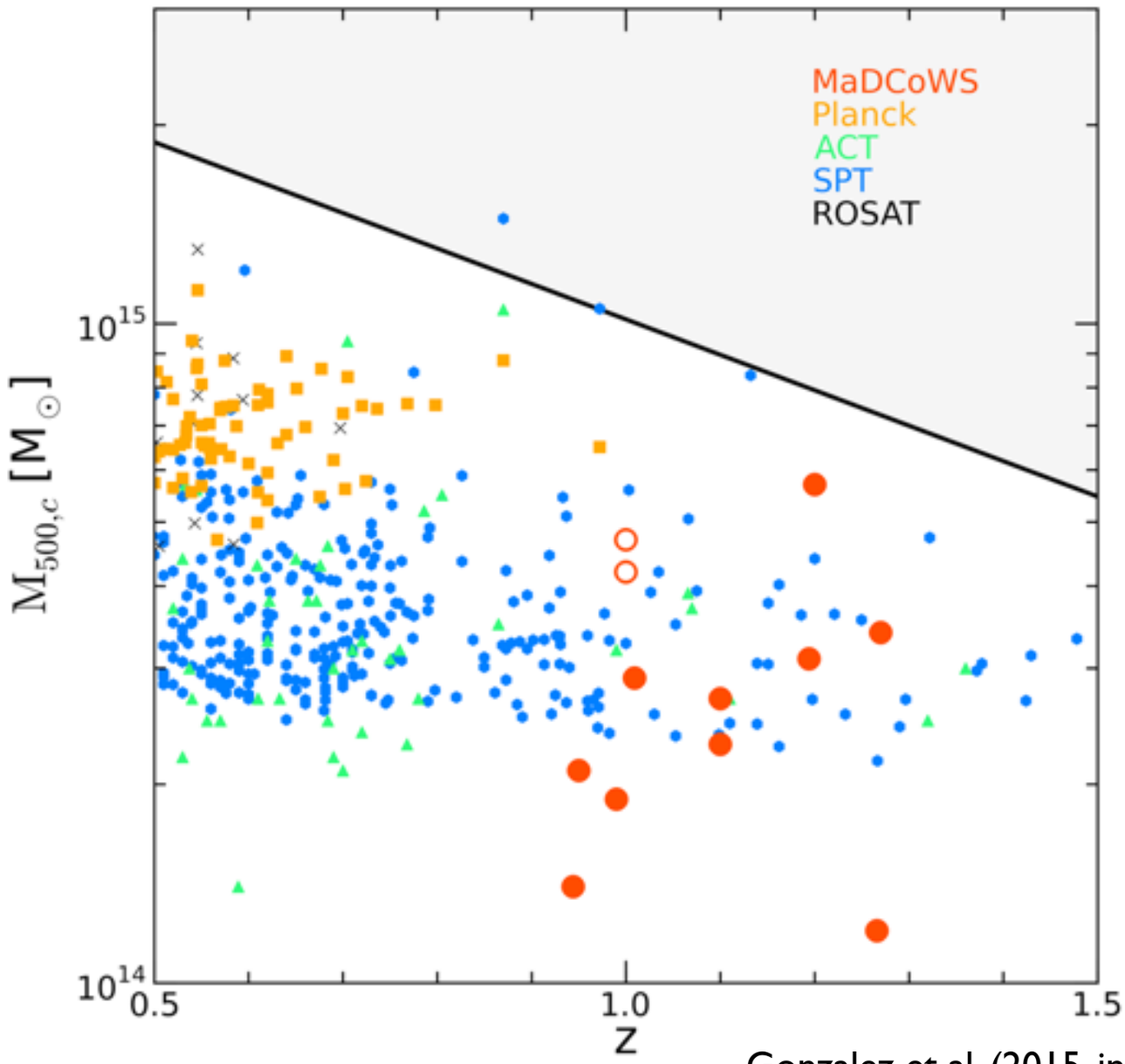
Brodwin+ (2015)

$M_{500} = 1\text{-}6 \times 10^{14}\ M_{sun}$

MADCOWS IN CONTEXT

MaDCoWs

A Comparison with SZ & X-ray Surveys



Gonzalez et al. (2015, in prep)

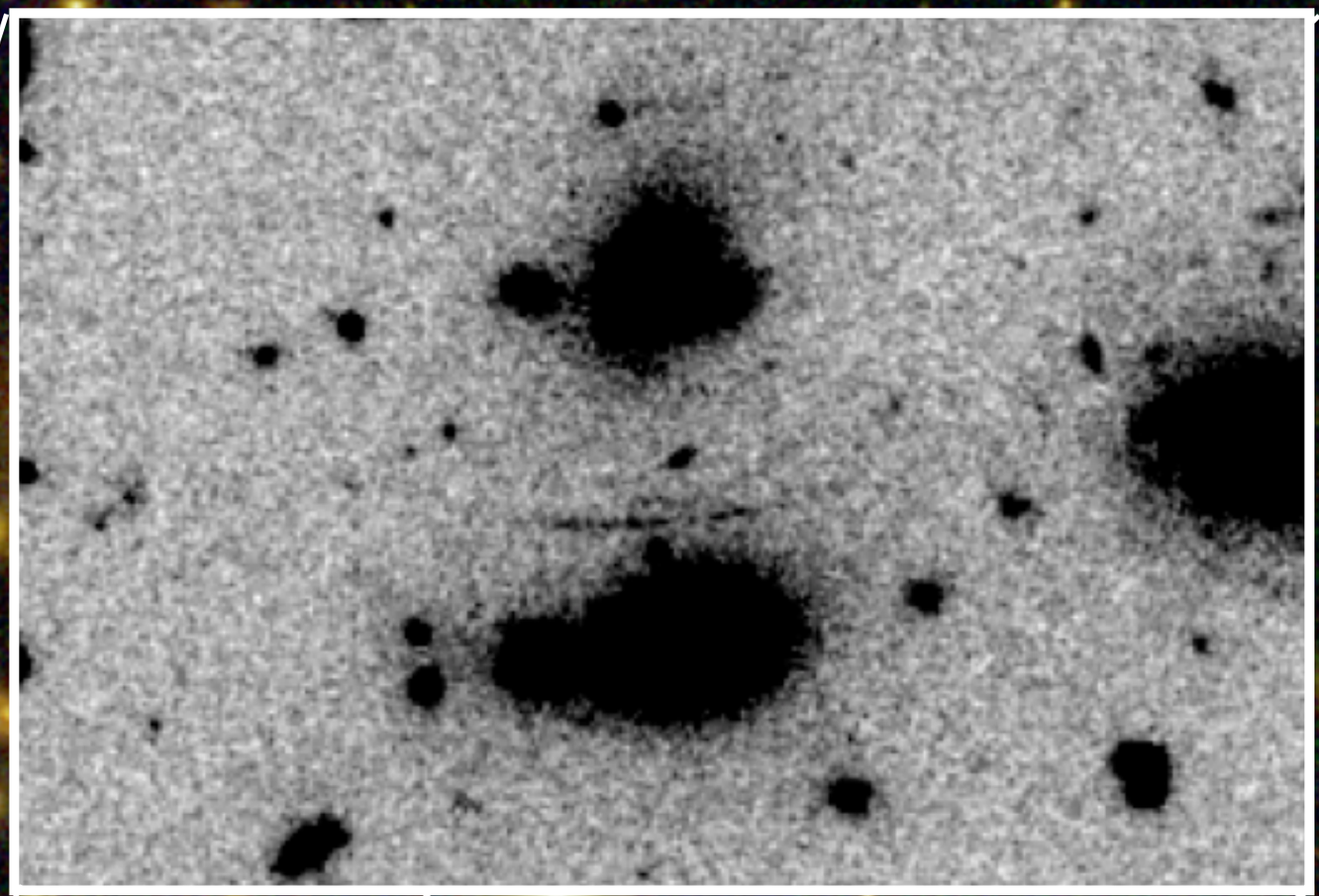
Similar masses to SPT-SZ & ACT clusters

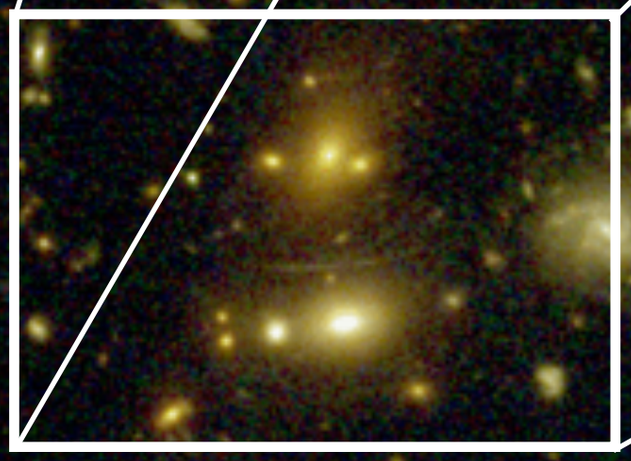
First 12 MaDCoWS detected with CARMA

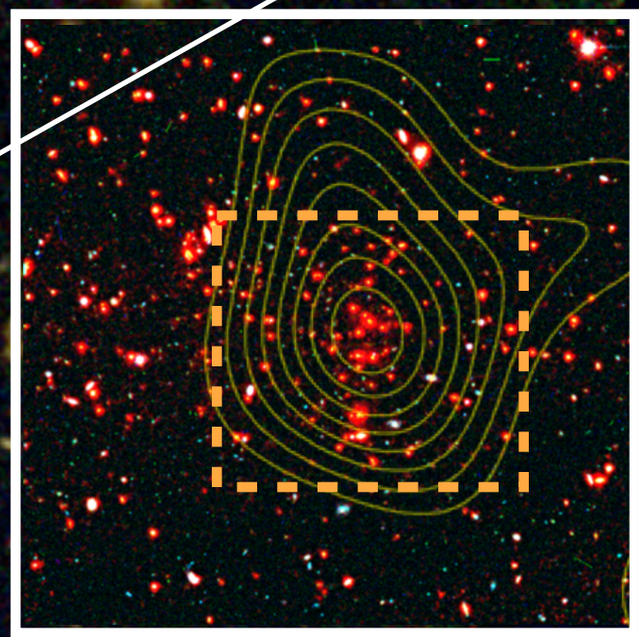
M_{500} =1-6x10^{14} M_{sun}

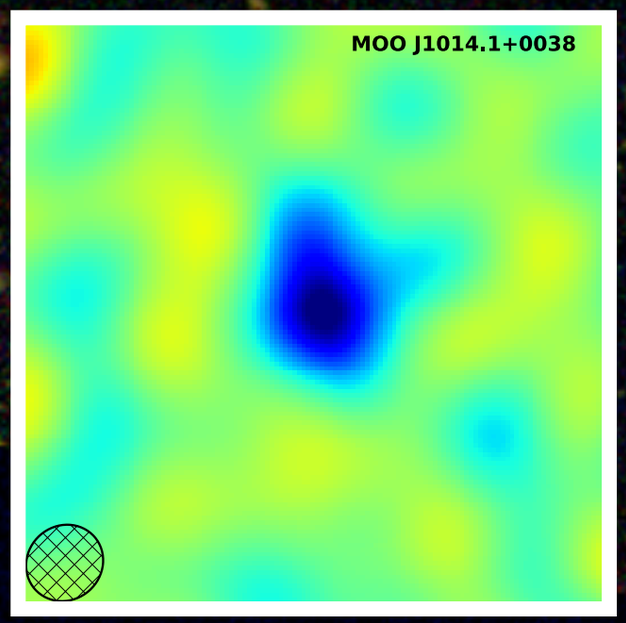
MOO J1014.1+0038

MaDCoWS is working.
What next?



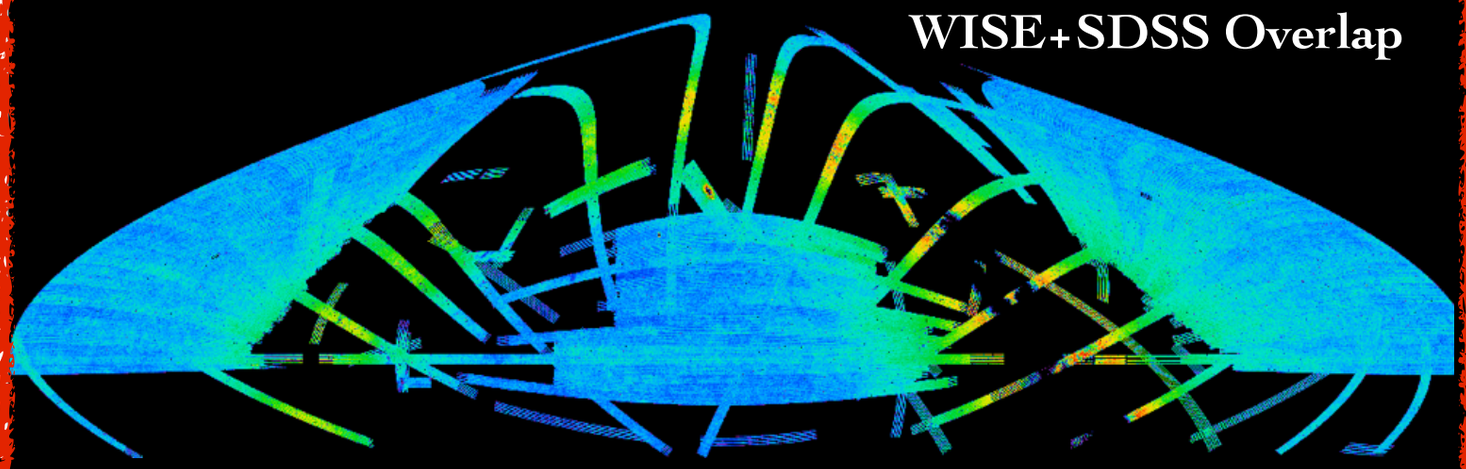






F814W,F105W,F140W
Perlmutter, PID 13677

EXTENSIONS TO MADCOWS

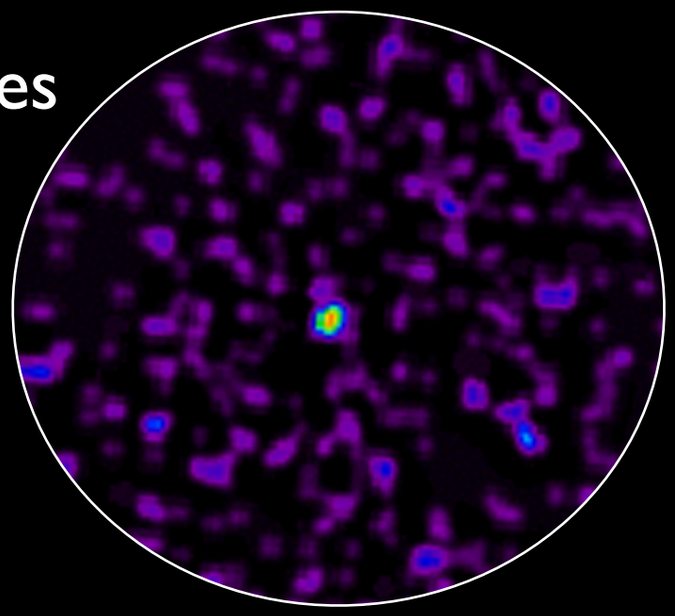


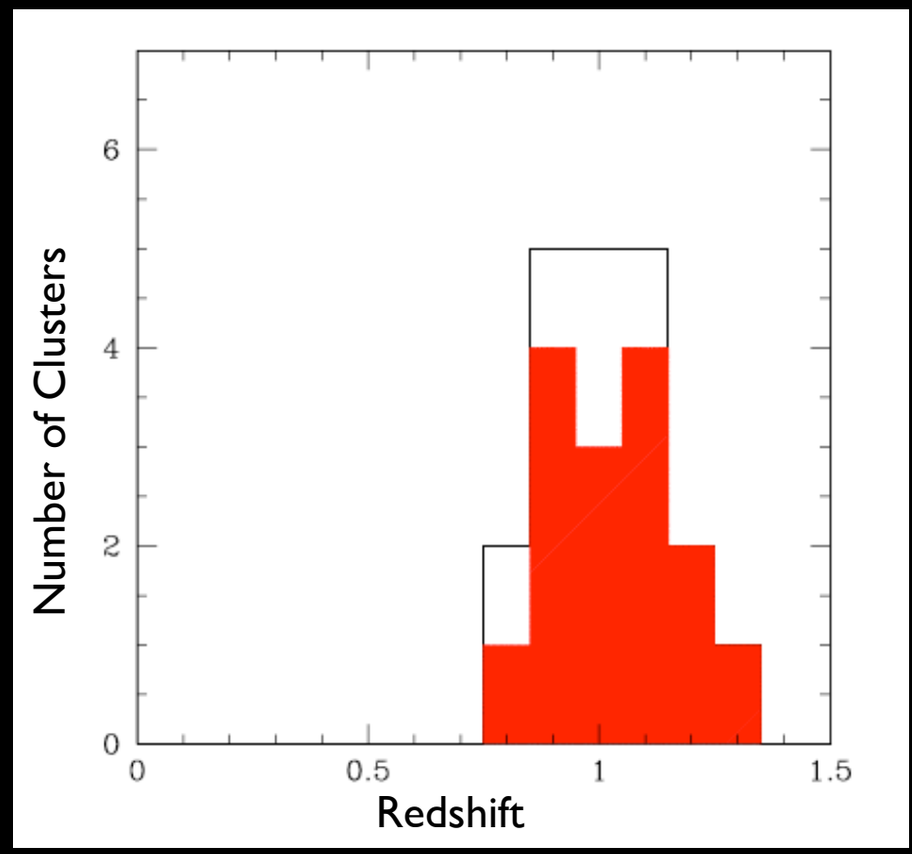
I. Cover full extragalactic sky

Optical data beyond SDSS

II. Better Mass Estimates

Improved Mass Proxy





Deeper WISE data

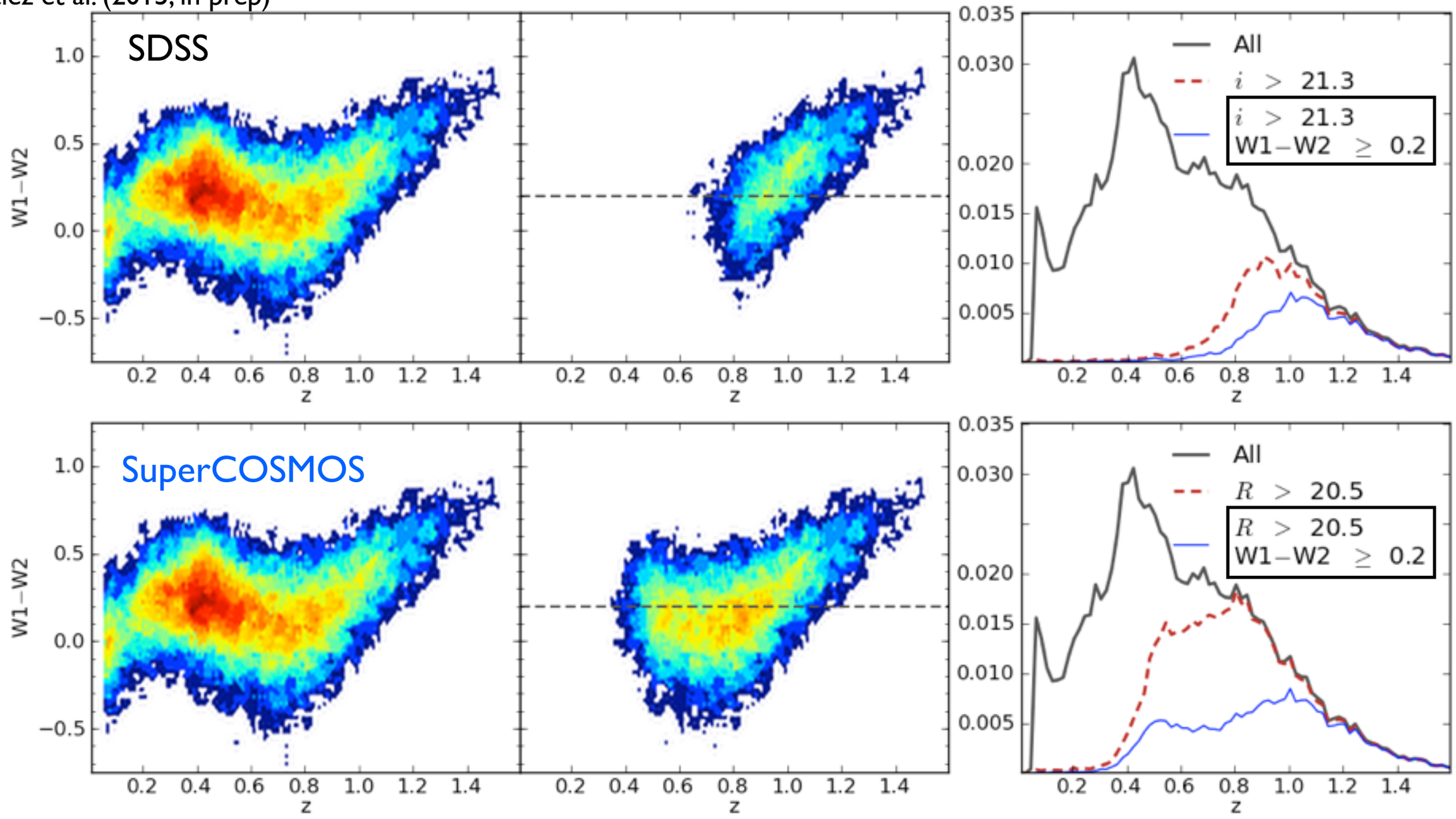
III. Push to higher redshift

BEYOND THE SDSS FOOTPRINT

MaDCoWs

Initial: SuperCOSMOS [All-sky but shallow]

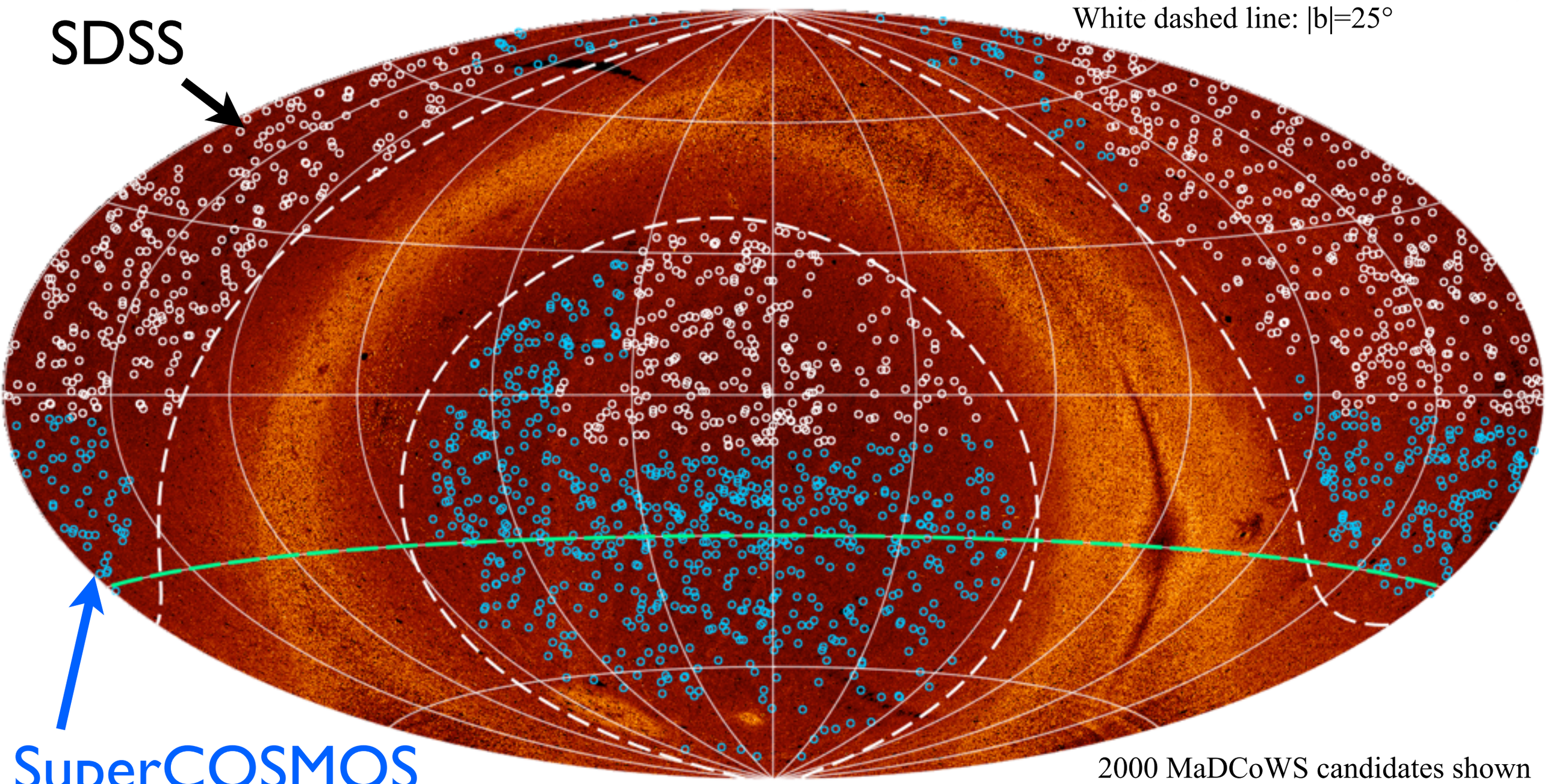
Gonzalez et al. (2015, in prep)



FIRST ALL-SKY ALLWISE + OPTICAL SEARCH

MaDCoWs

Background: AllWISE source density
White dashed line: |b|=25°



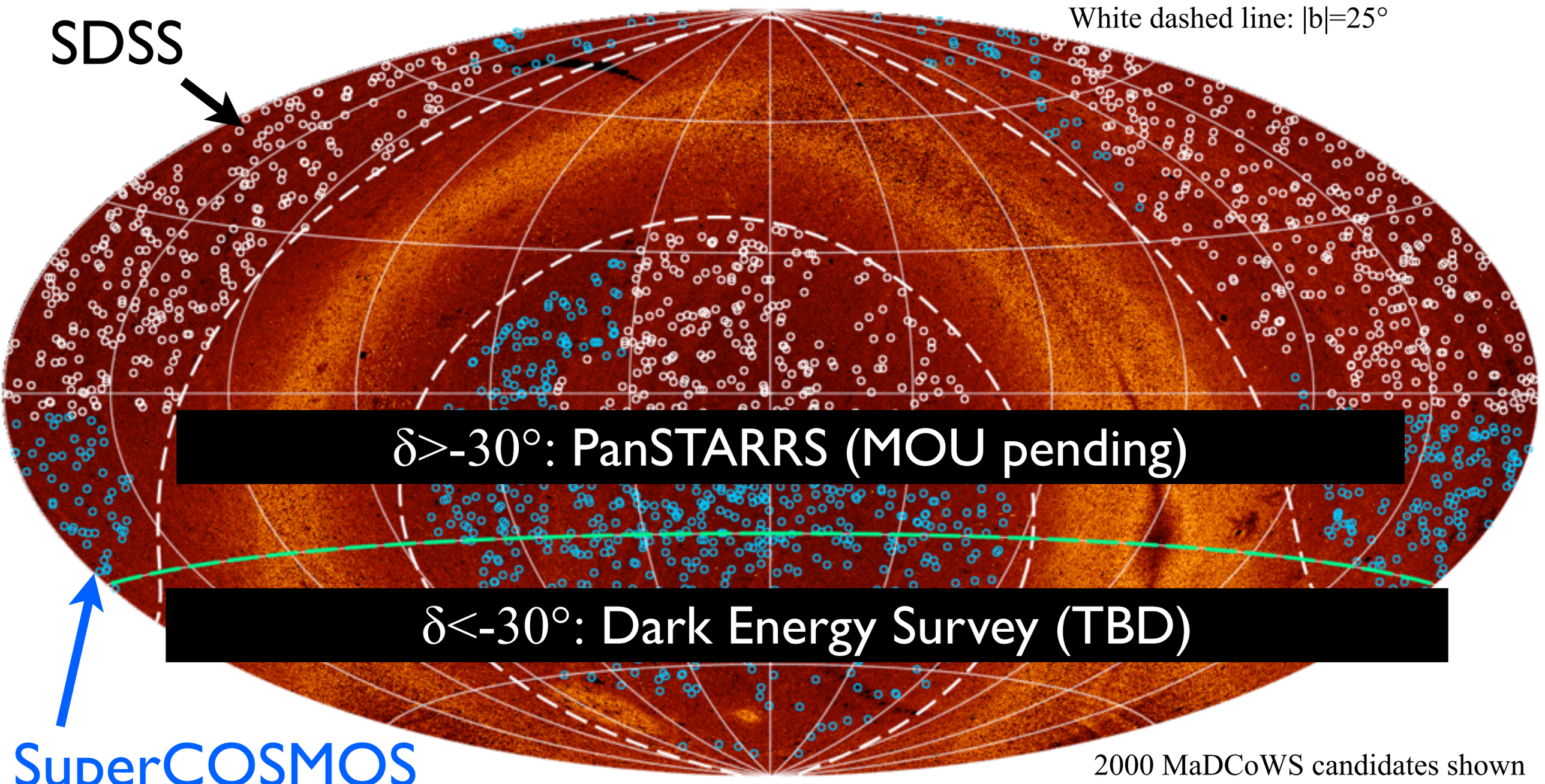
2000 MaDCoWS candidates shown

NEW OPTICAL SURVEYS

MaDCoWs

Better: Next Generation Surveys

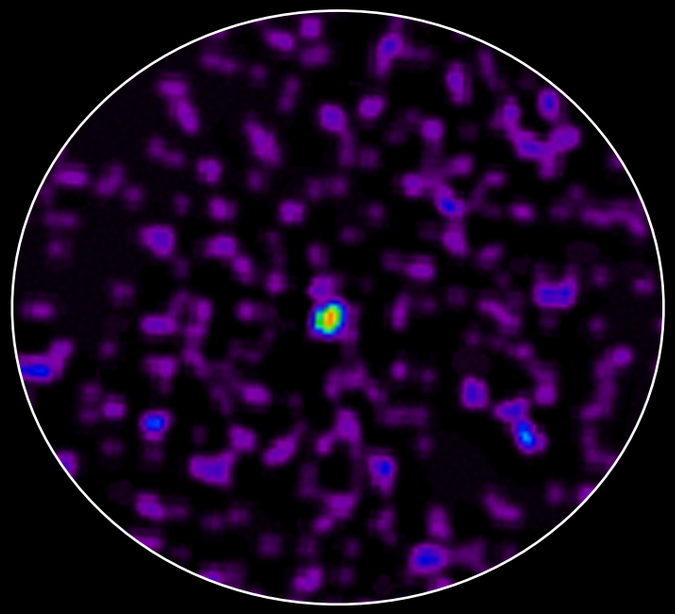
Background: AllWISE source density
White dashed line: |b|=25°



2000 MaDCoWS candidates shown

TOWARDS BETTER MASS ESTIMATES

MaDCoWs



Current: Strength of Detection

Poor mass proxy

Better: Spitzer Radial Density Profile

Parameters:

central density (n_0)

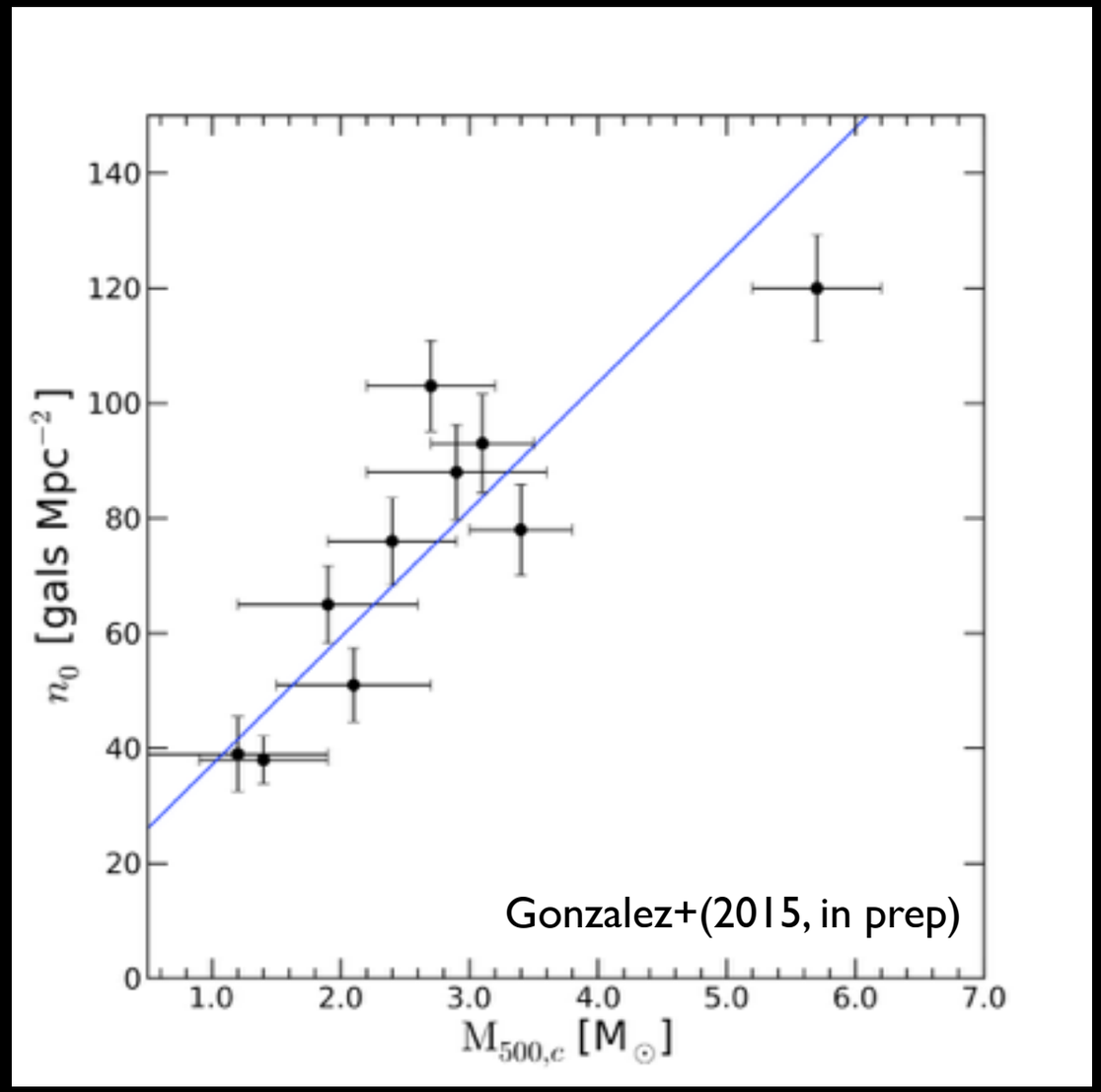
cluster concentration

background density

n_0: ~30% scatter vs CARMA Masses

Cycle 11 Spitzer snapshot proposal approved.

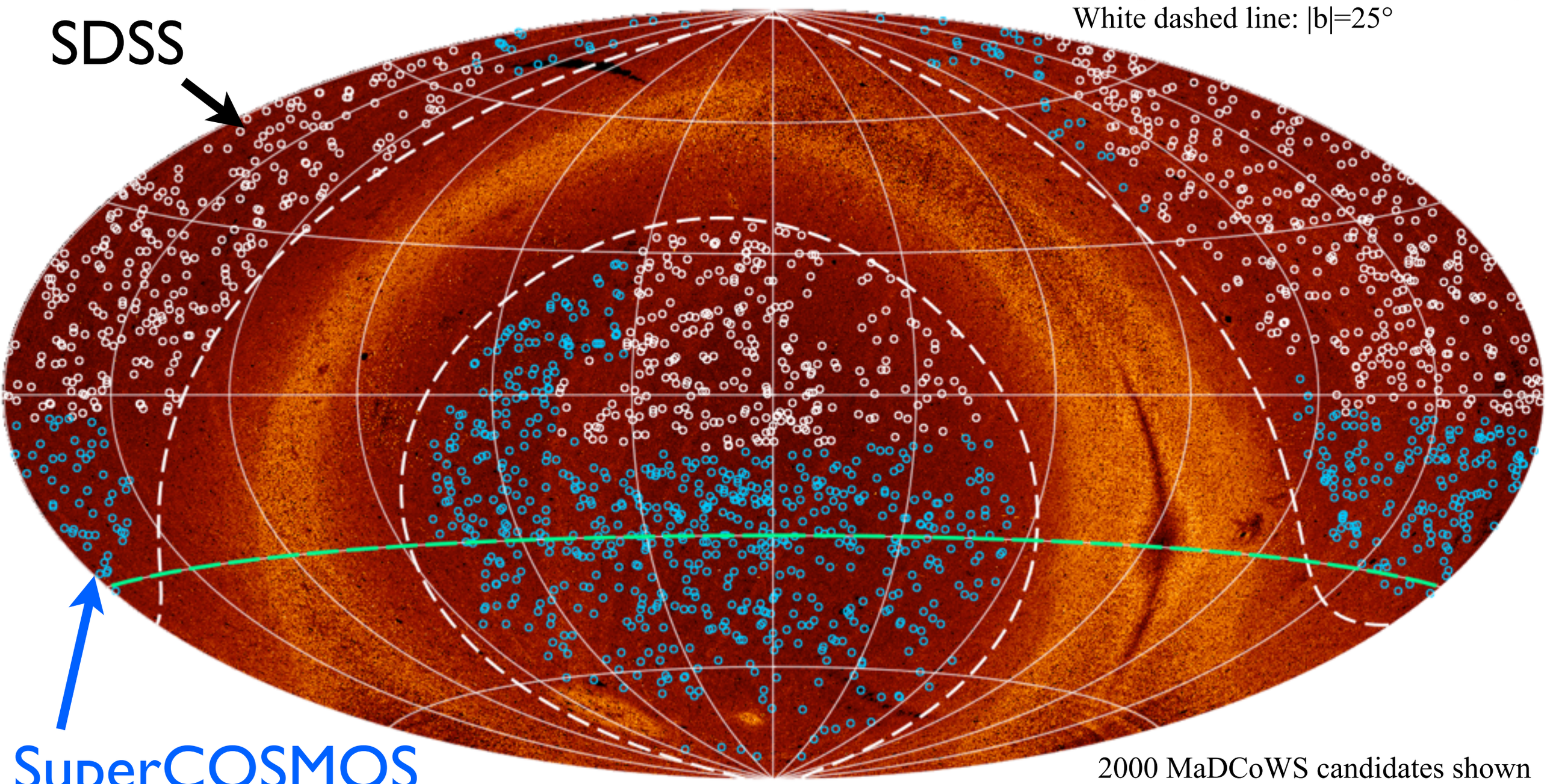
Will result in a total of ~2000 MaDCoWS with Spitzer imaging.



FIRST ALL-SKY ALLWISE + OPTICAL SEARCH

MaDCoWs

Background: AllWISE source density
White dashed line: |b|=25°

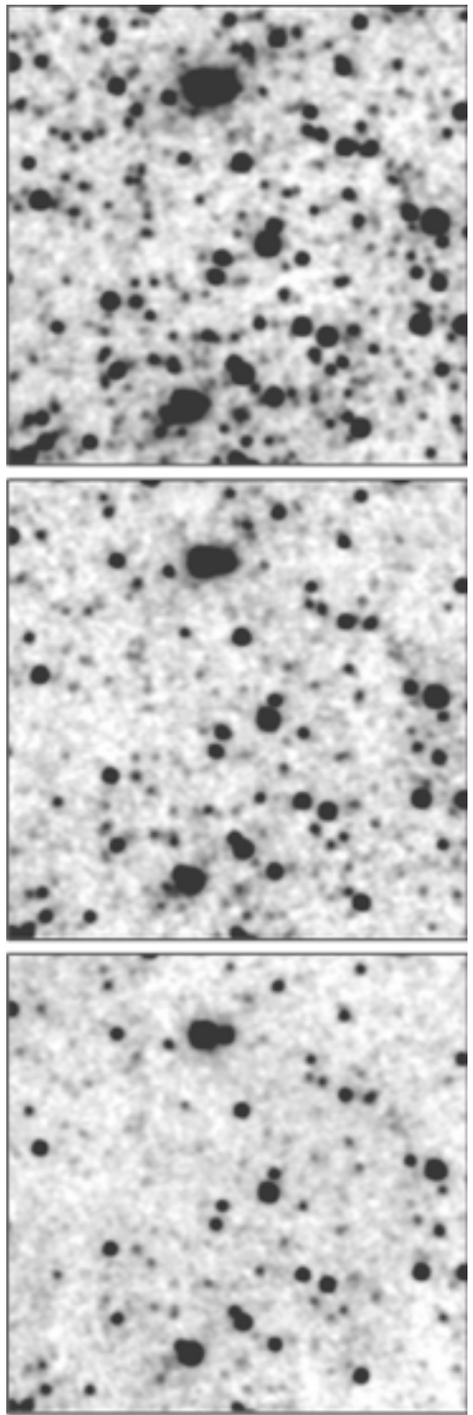


2000 MaDCoWS candidates shown

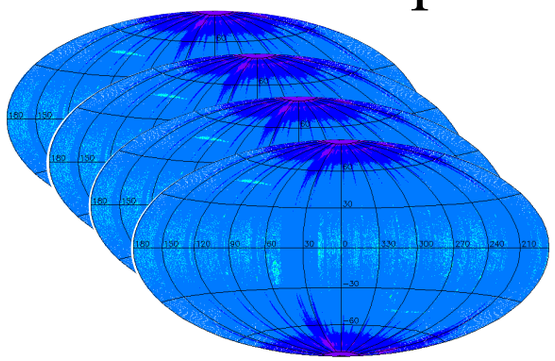
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

MaxWISE: The Next Generation WISE Survey

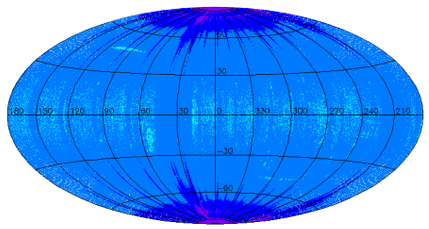
Expect clusters to be detectable to z~2



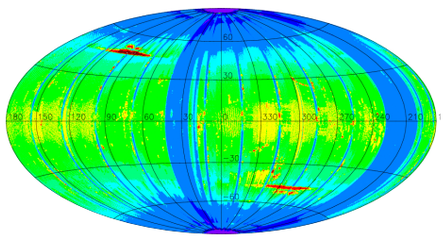
MaxWISE Depth



AllWISE Depth

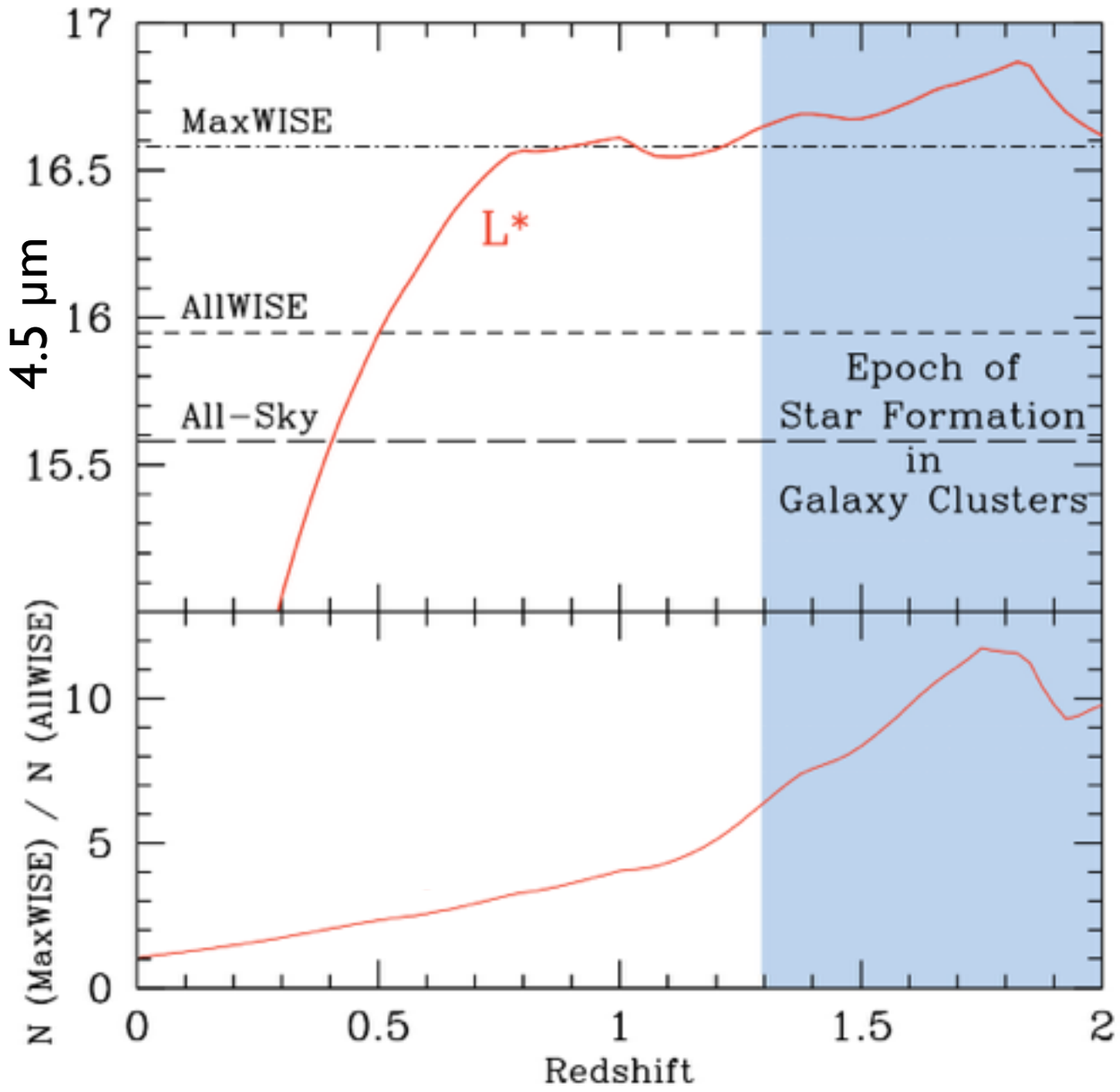


All Sky Depth



See Peter Eisenhardt's poster

MaxWISE sensitivity reaches a plateau for typical (L*) cluster galaxies that extends vastly further into the distant Universe.

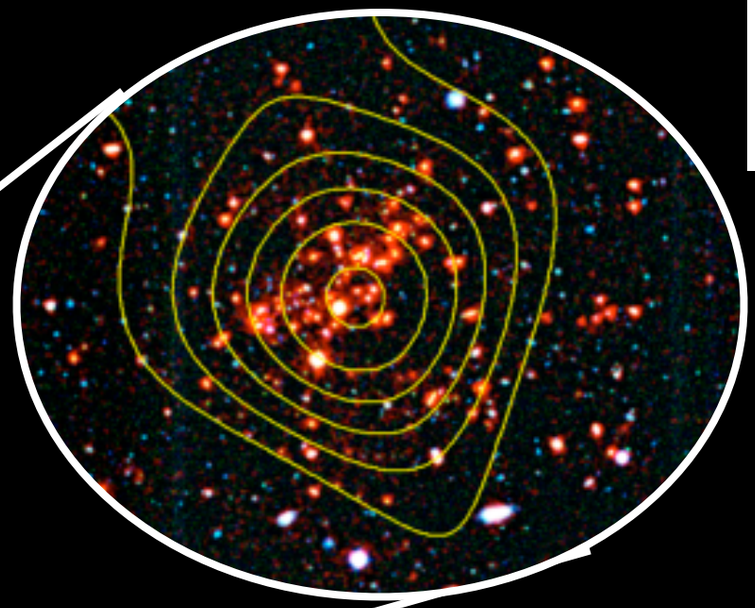


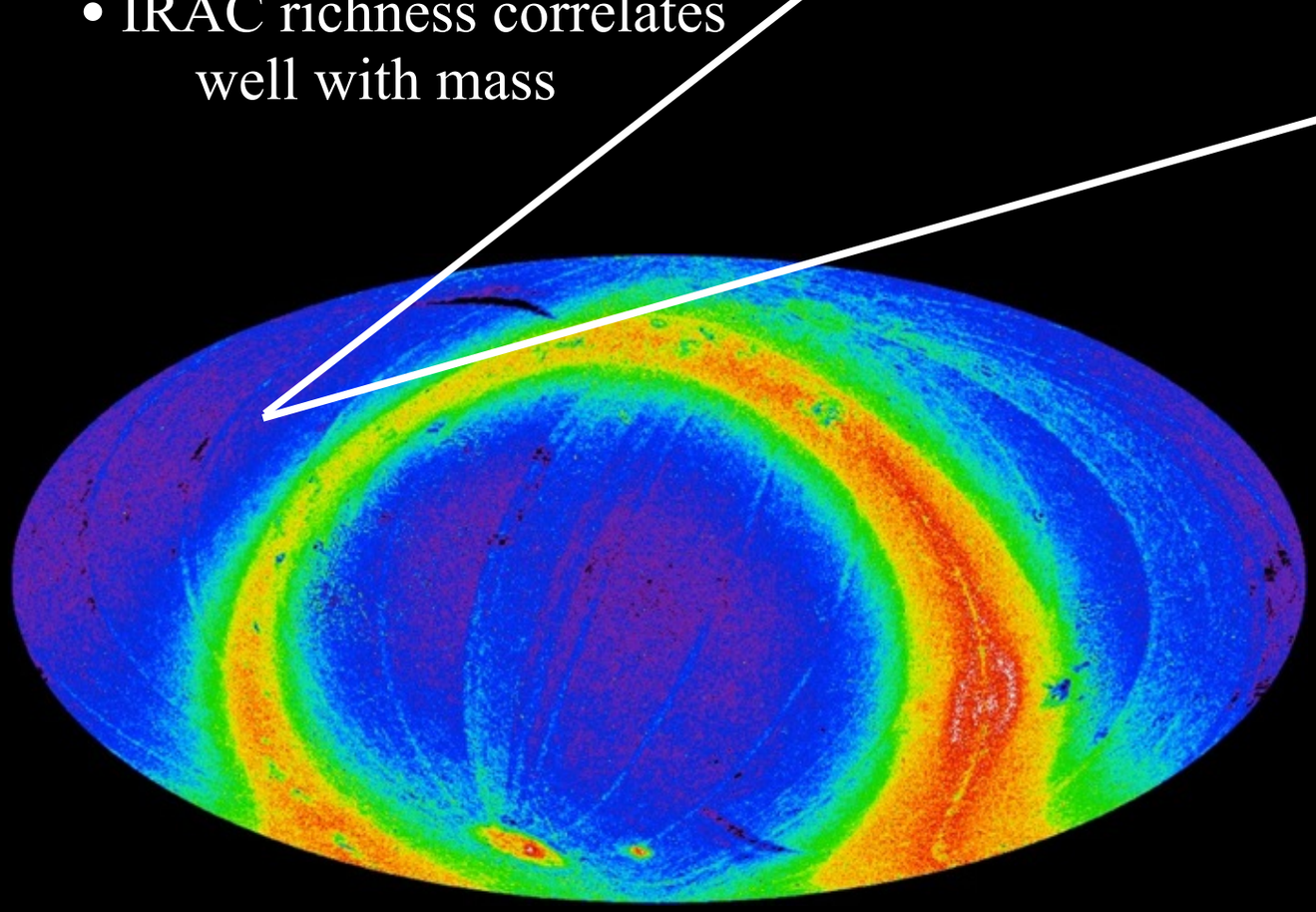
The Massive and Distant Clusters of WISE Survey

MaDCoWs

Present

- Massive clusters to z~1.3 over 10,000 deg^2
  - •v0: All Sky Survey (SDSS)
  - •v1: AllWISE (SDSS+SuperCOSMOS)
- First phase of follow-up:
  - 200 with Spitzer imaging -- rich!
  - 20 spec-z clusters at 0.9<z<1.3
  - 12 SZ confirmed clusters
  - IRAC richness correlates well with mass





In Progress

- v2: AllWISE (v1+PanSTARRS)
- Mass-richness calibration
- Large *Spitzer* snapshot program
  - Mass estimates for ~2000 clusters
- Clustering analysis
- XMM program

Future

- MaxWISE

  ➞ Would enable detection of massive clusters to z~2 over the full extragalactic sky, sampling the epoch of cluster galaxy formation.

Pasadena, 11 February 2015