

Near-Infrared – Submm Surveys:
Clusters and AGN with the new WISE All-
sky mid-IR Survey

Carol J Lonsdale

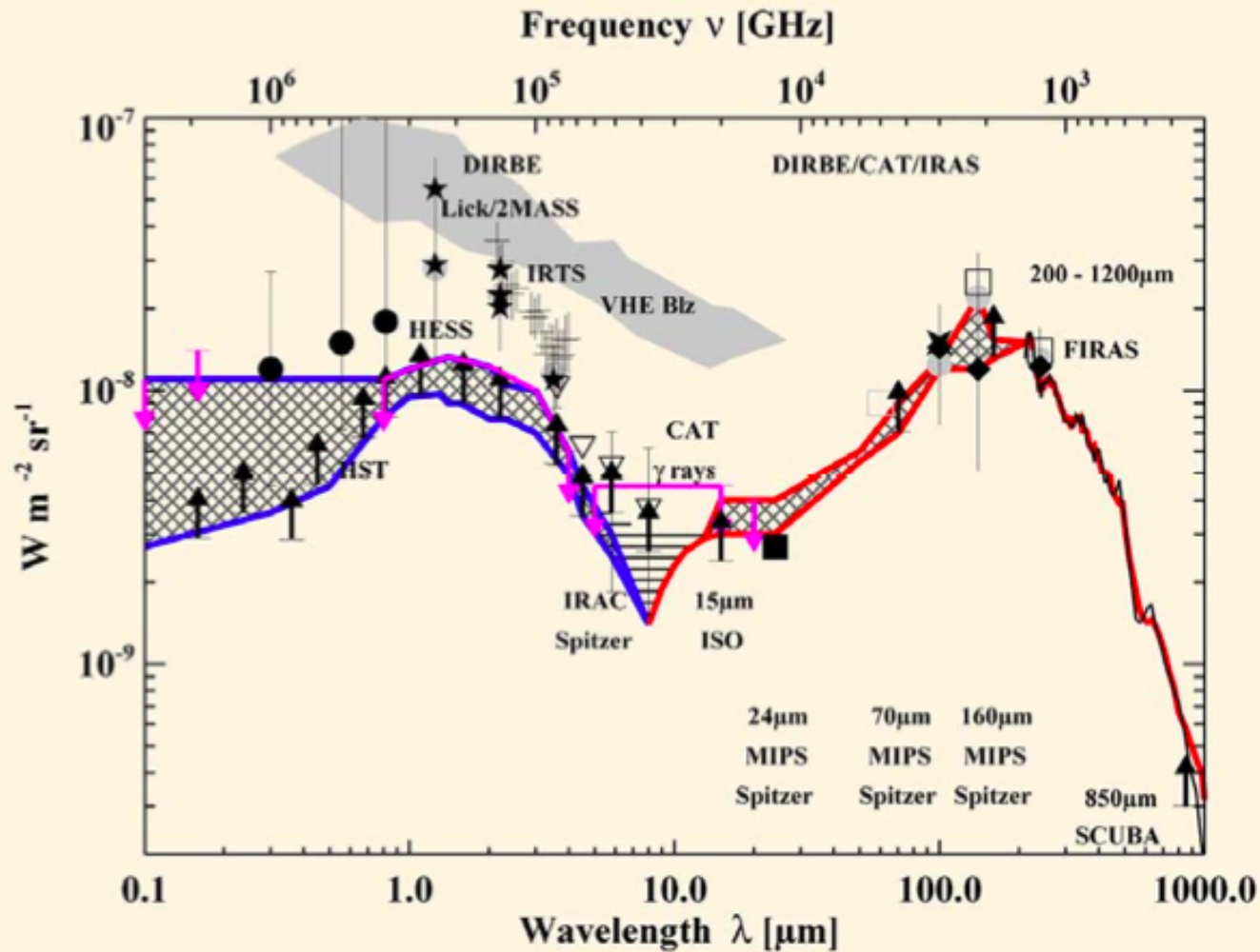
North American ALMA Science Center
NRAO

Image: the Fornax Cluster with WISE

Outline

- Quick overview of the major large area surveys
 - Near Infrared
 - Mid and Far Infrared
 - Submm/mm
- Synergies with X-ray surveys; focus on Spitzer and WISE
 - Clusters
 - AGN
- Prospects for eROSITA

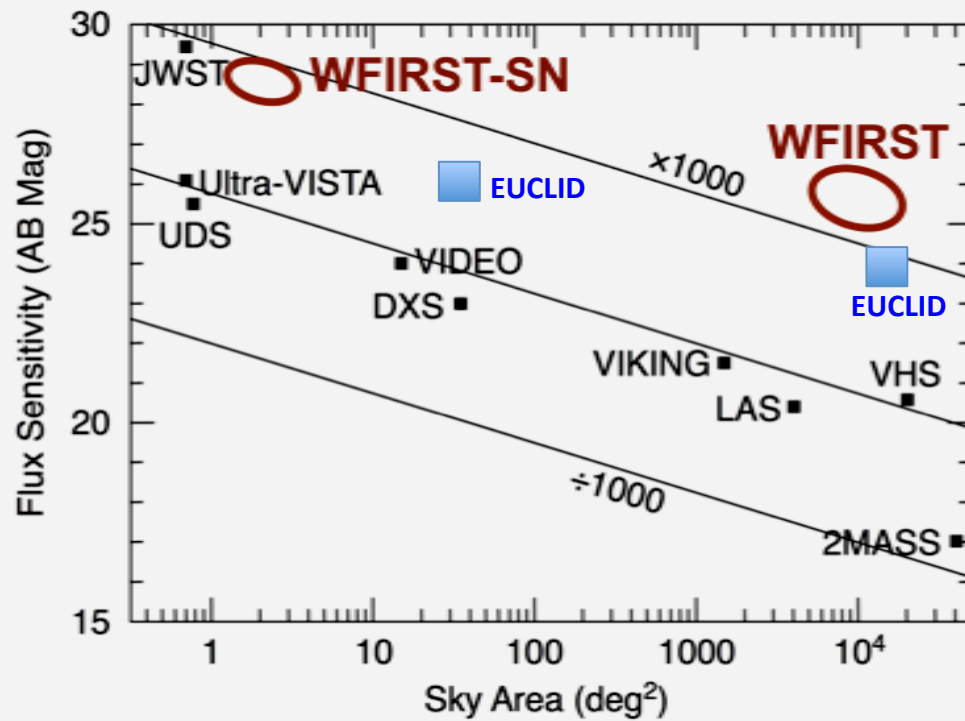
Half the Energy in the Universe is in the IR



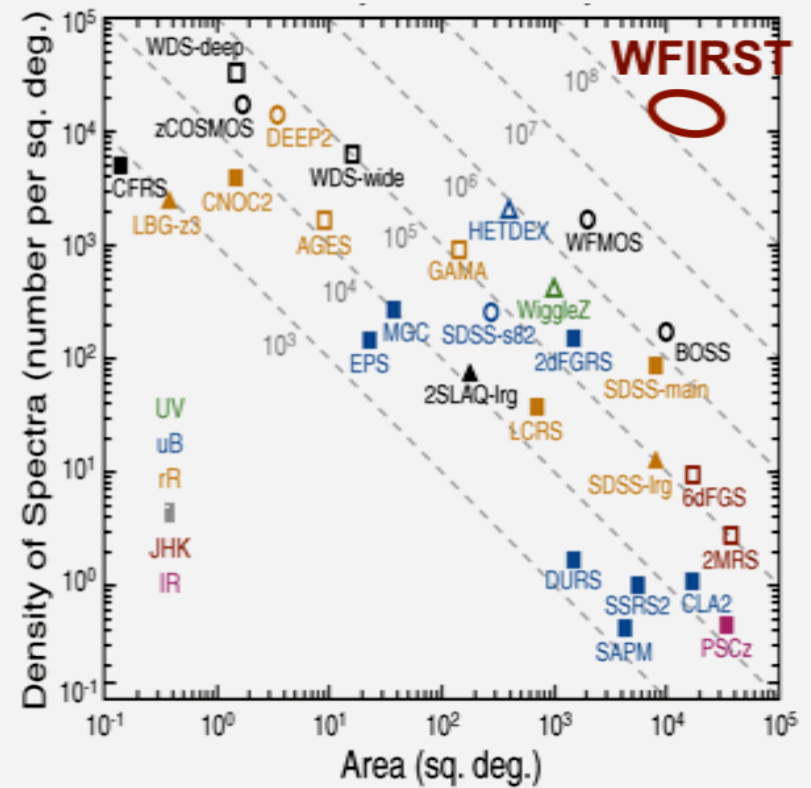
Harwit et al,
2008, Decade
Review white
paper

Near Infrared Surveys

NIR Imaging Surveys



NIR Redshift Surveys





EUCLID

- EUCLID: ESO Cosmic Vision 2015-2025 mission to determine the nature of dark energy and dark matter
 - 1.2m, visible imager & near-IR spectrometer and photometer
 - Launch to L2 on Soyuz from Kourou, 2018
 - Wide: 15,000 sq. deg.
 - Deep: 40 sq. deg.
 - Vis,Y,J,H: 0.55 - 2 microns

Euclid
Mapping the geometry
of the dark Universe

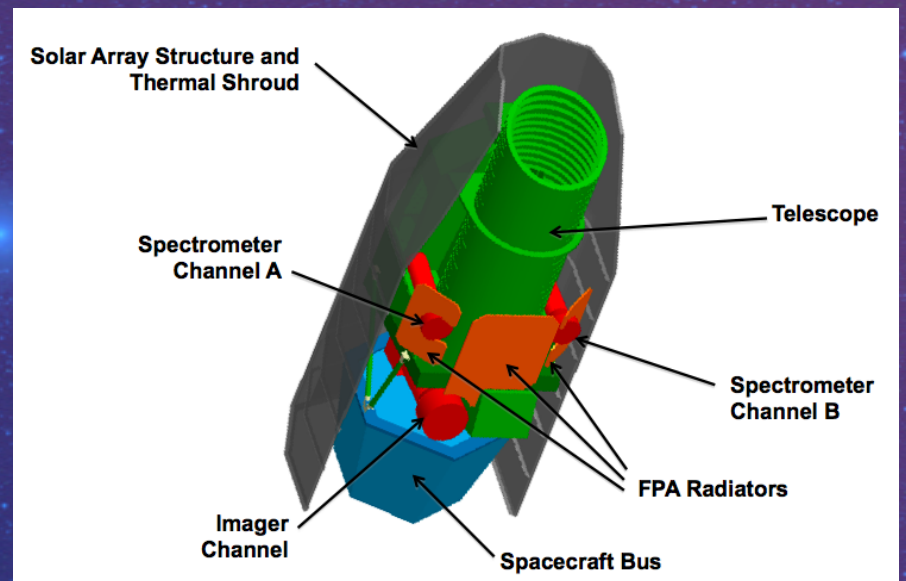
The image shows a 3D rendering of the Euclid spacecraft, a large orange and yellow structure, positioned over a grid of yellow lines. The background is a dark space with a purple and blue cosmic web visualization. The spacecraft is shown from a side profile, appearing to be in a low orbit or scanning the space.

Definition Study Report

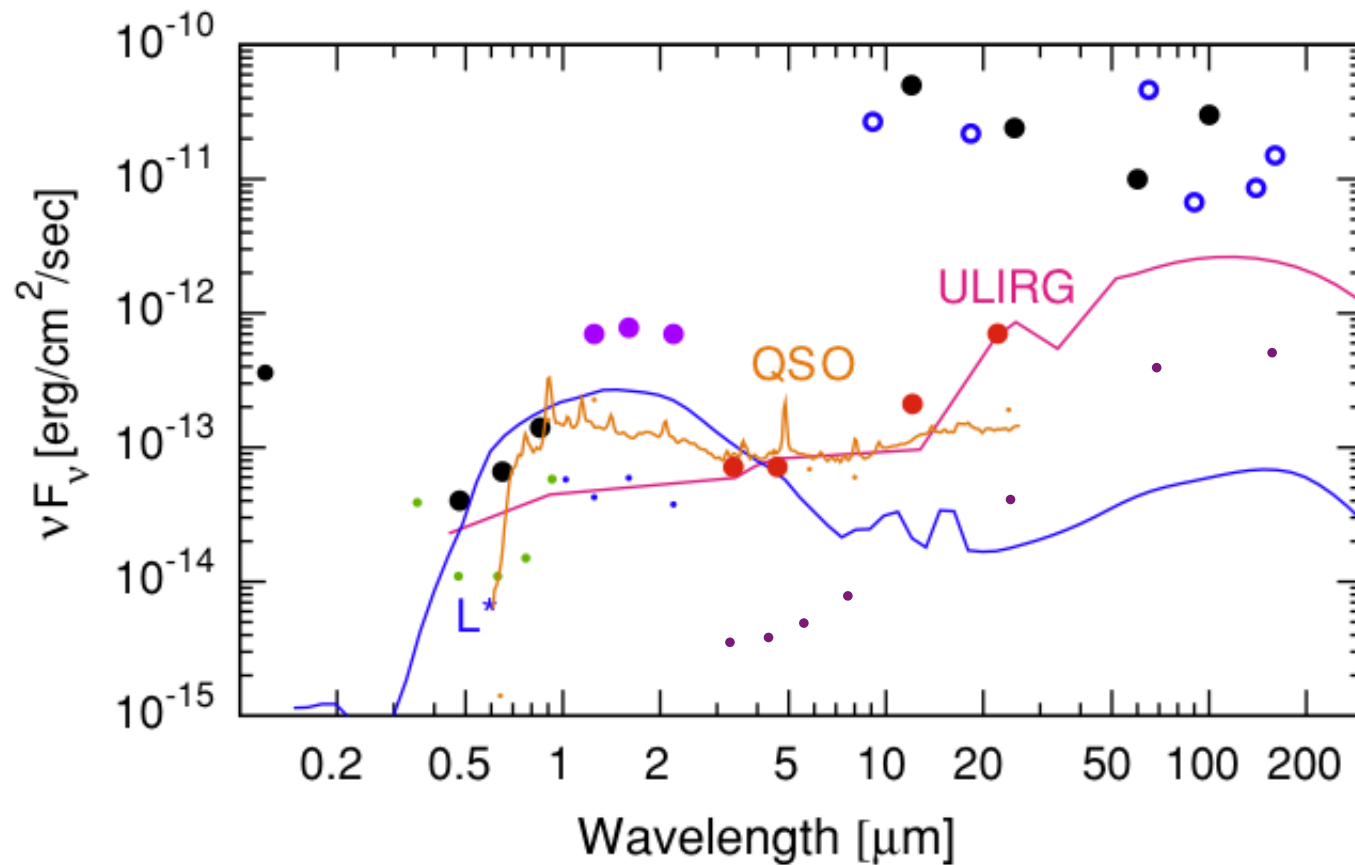
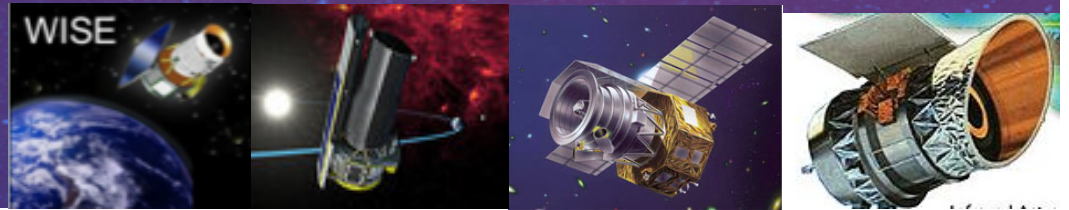
WFIRST



- WFIRST: Candidate mission promoted by US 2010 Decade Review
 - Area: 13,700 sq. deg. (1 year), 23,250 sq. deg. (5 years)
 - Imager (0.6 - 2 μ m) and 2 slitless spectrometers (1.1 - 2 μ m)
 - 1.3m telescope
 - Launch to L2 in 2020



Mid and Far Infrared Surveys



IRAS
AKARI
Spitzer, <100 sq deg
WISE
2MASS
UKIDSS LAS
SDSS
GALEX

ULIRG at $z=3$
 $z=6.42$ QSO

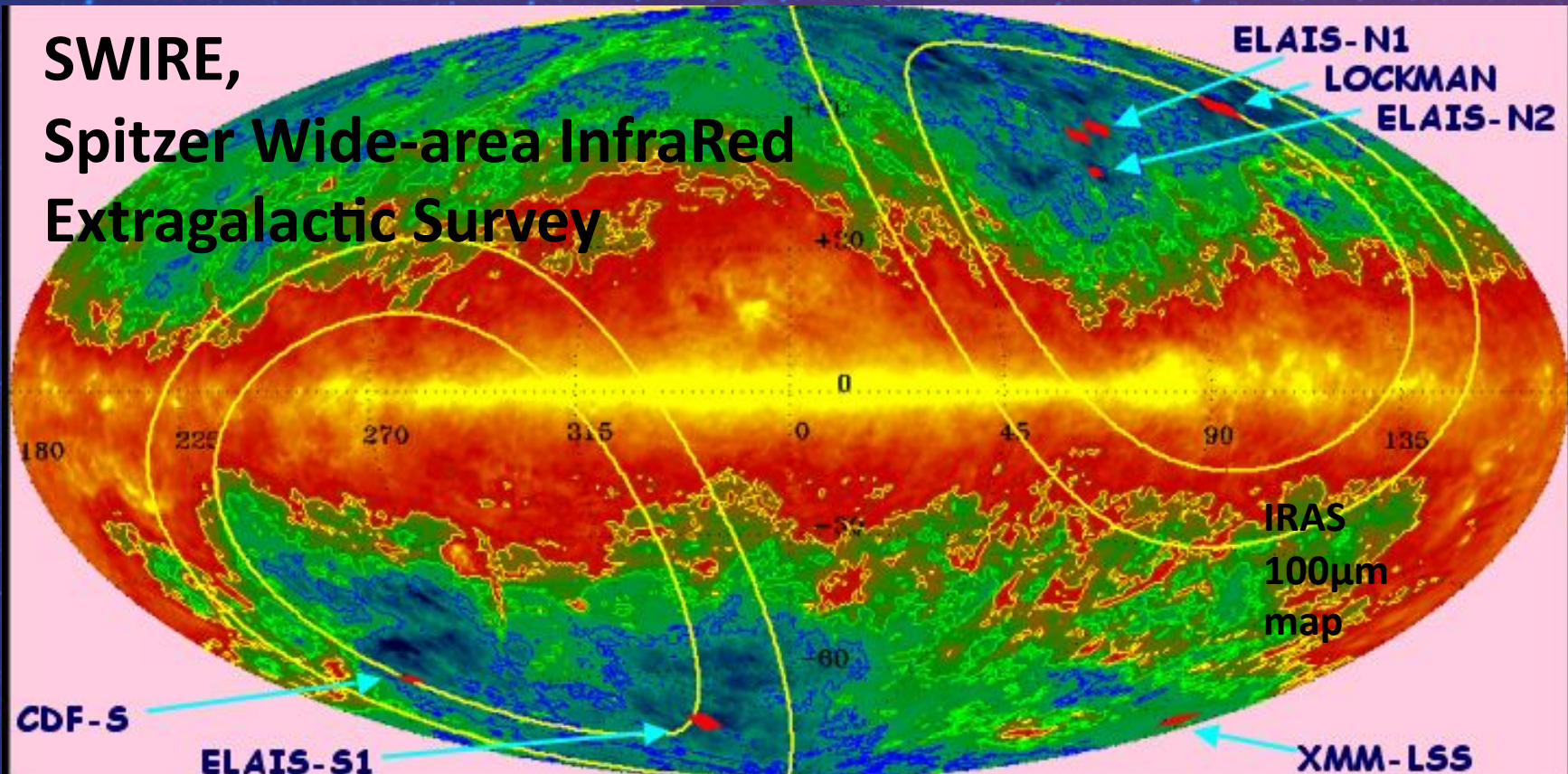
Wright et al. 2011

Spitzer's Largest Surveys

SWIRE: 49 sq deg [Lonsdale et al](#)

SERVS: 18 sq deg within SWIRE at 3.6 and 4.5 [Lacy et al](#)

NOAO Deep Wide Field Survey in Bootes: 9 sq deg [GTO teams](#)



Herschel 160 μ m Surveys

PACS Evolutionary Probe

Lutz et al

Herschel Multi-tiered
Extragalactic Survey

Oliver et al

Herschel GOODS

Elbaz et al

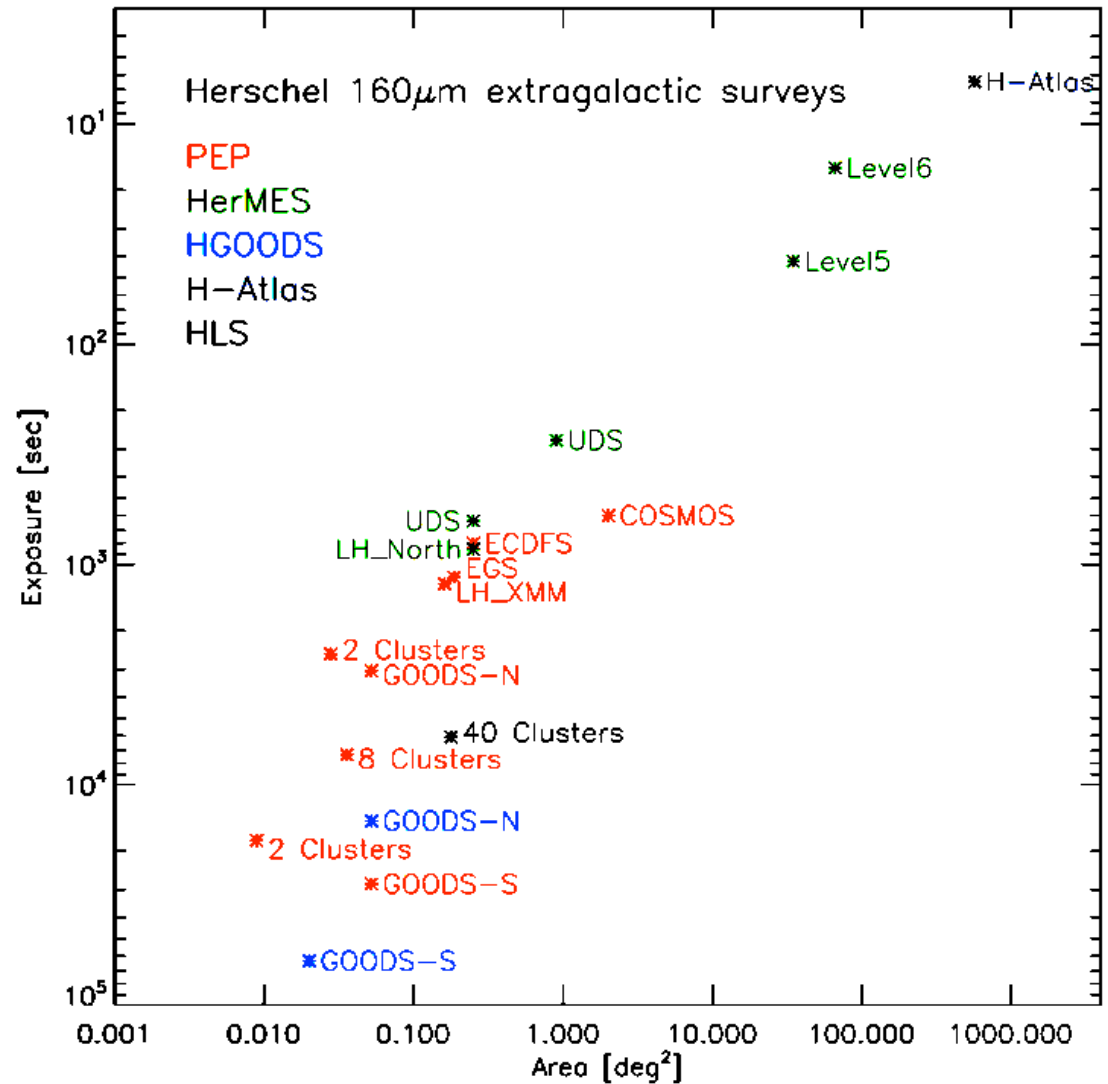
Herschel ATLAS

Eales et al

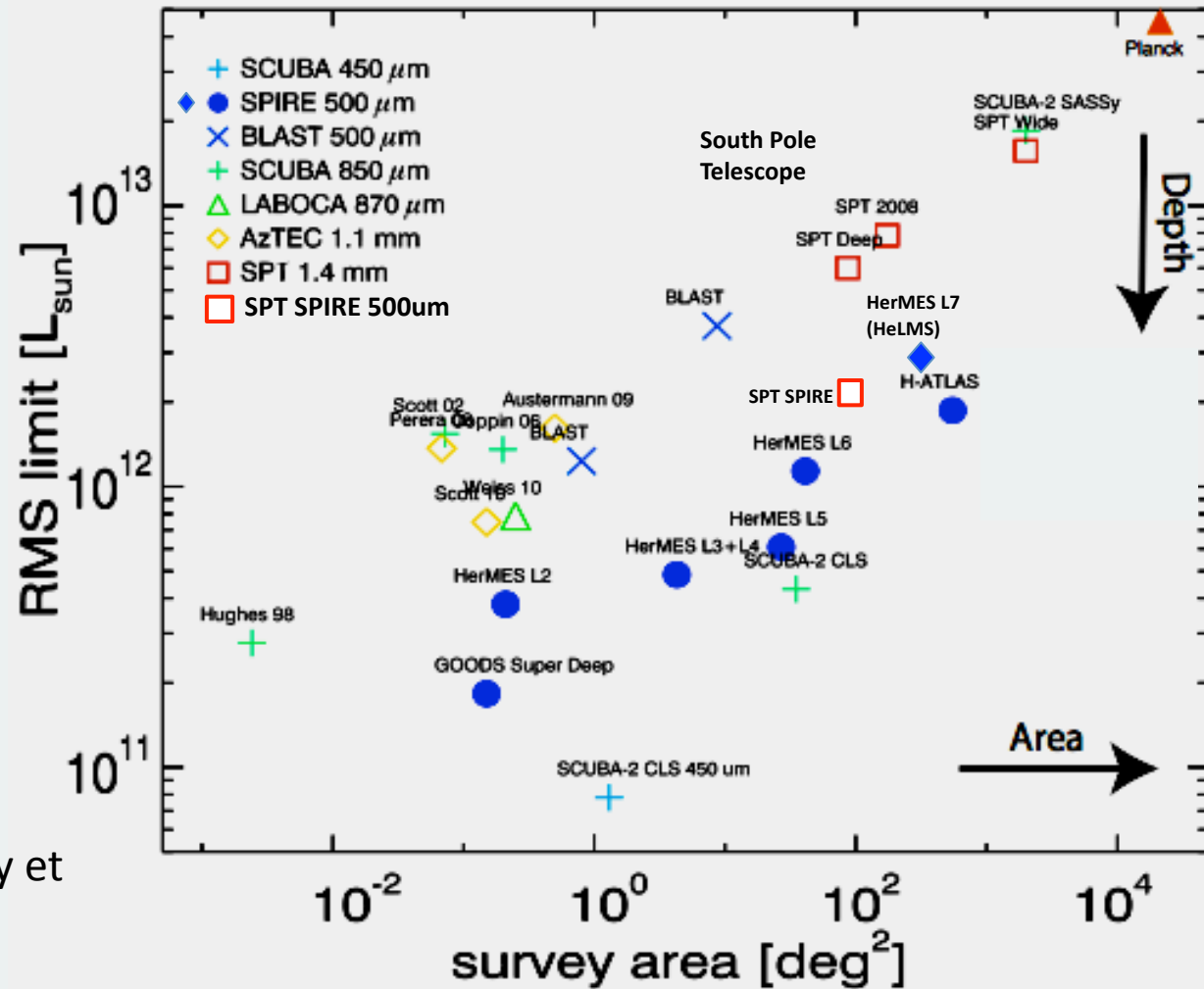
Herschel Lensing Survey

Egami et al

Lutz et al 2011



Submm/mm Surveys

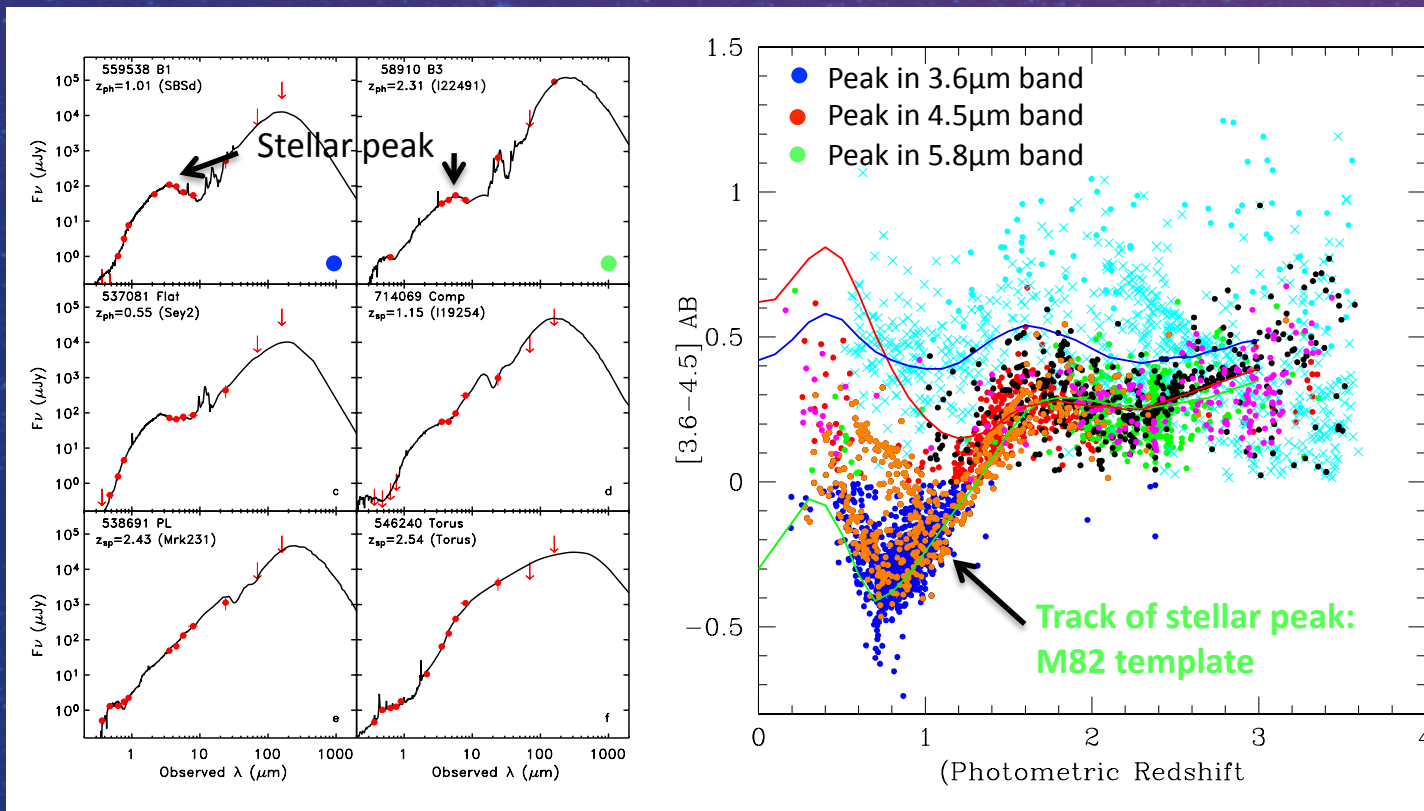


Based on Cooray et al 2010

Clusters in Spitzer & WISE

Red sequence method or photometric redshifts.

- [3.6]-[4.5] has strong dependence on z as the restframe $\sim 1.6\mu\text{m}$ stellar peak shifts through the bands.
- Illustrated by Spitzer/SWIRE SED-fitting and photometric redshifts



SWIRE: Spitzer Wide field InfraRed Extragalactic survey, Lonsdale et al (2004)

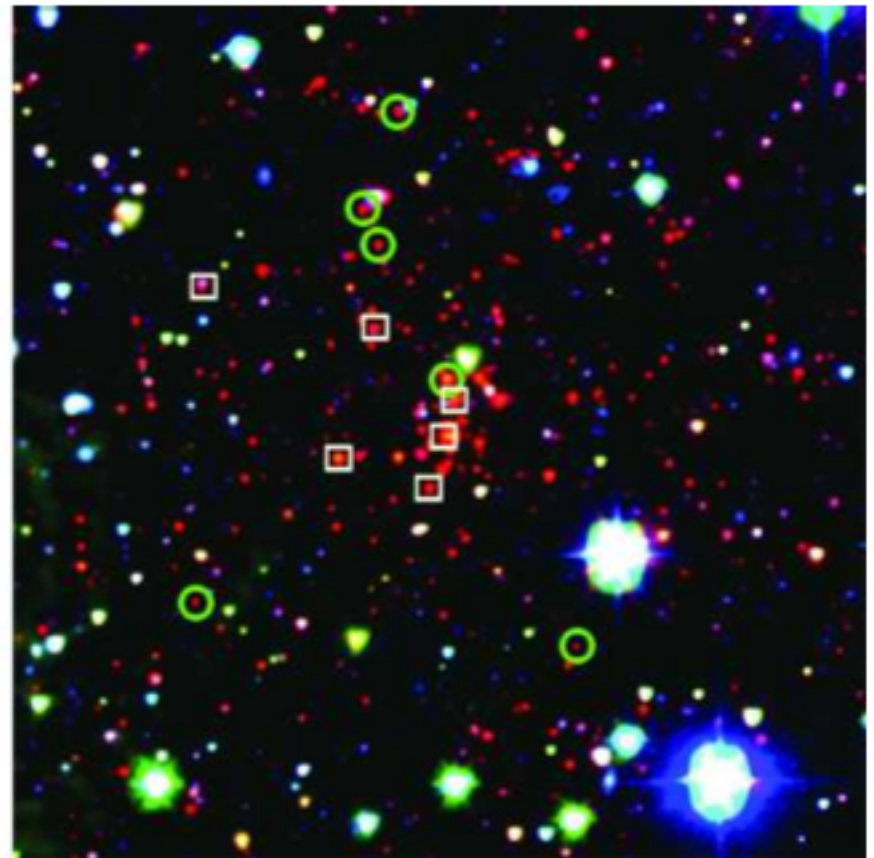
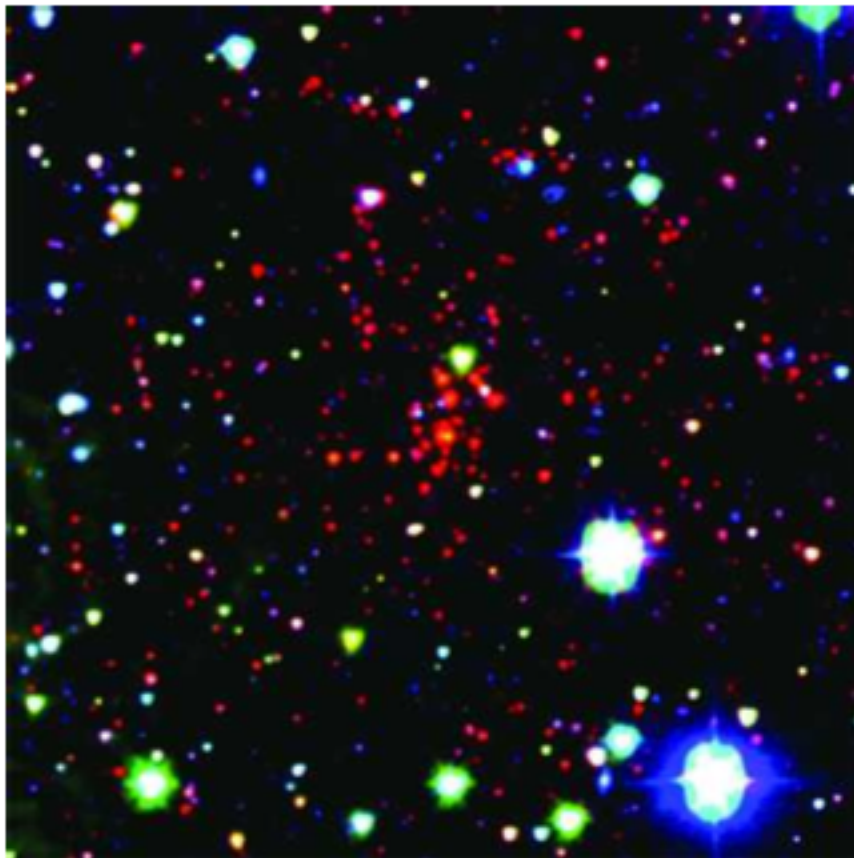
SWIRE Clusters: SpARCS collaboration

Wilson et al. Uses $[z'] - [3.6\mu\text{m}]$ color

Several hundred cluster candidates

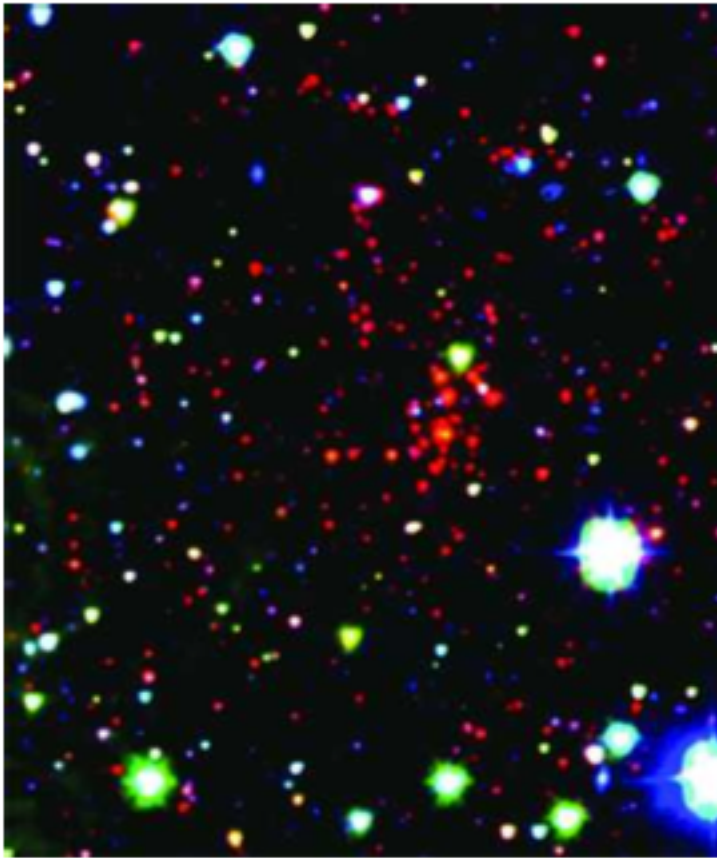
Demarco et al. 2010

$z=1.16$

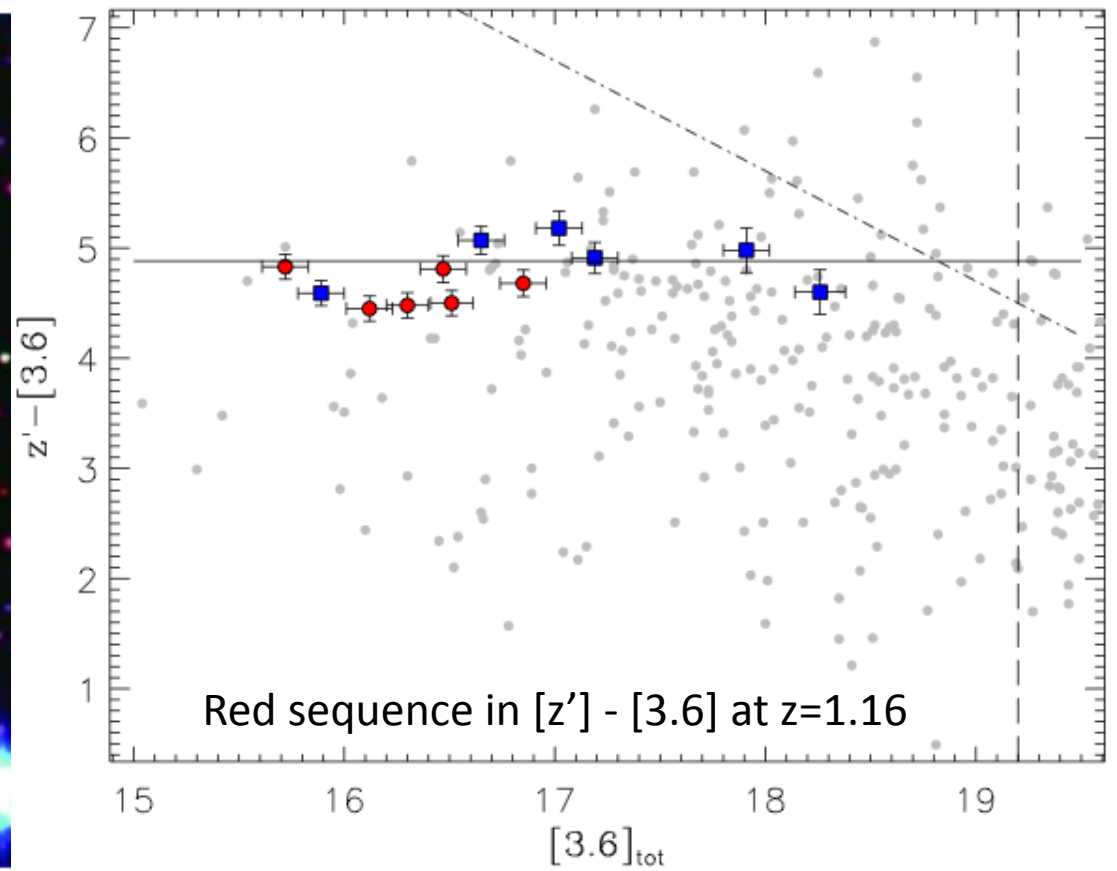


SWIRE Clusters: SpARCS

Several hundred candidates

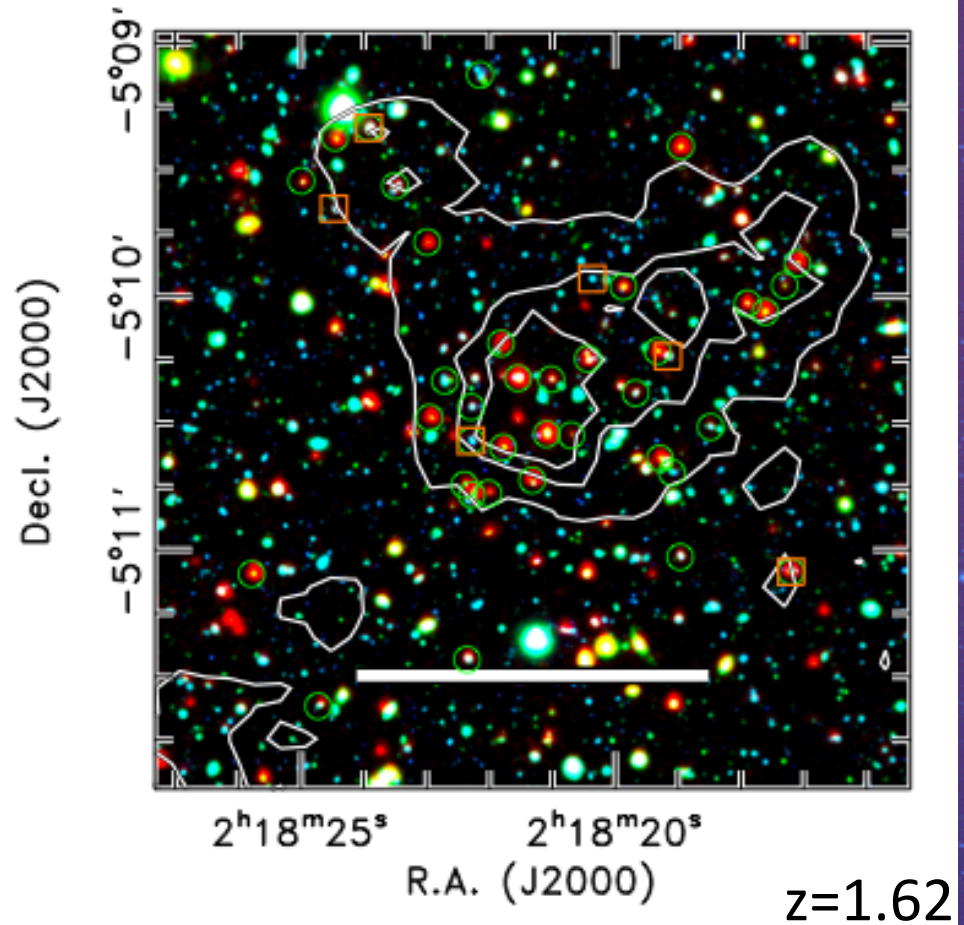
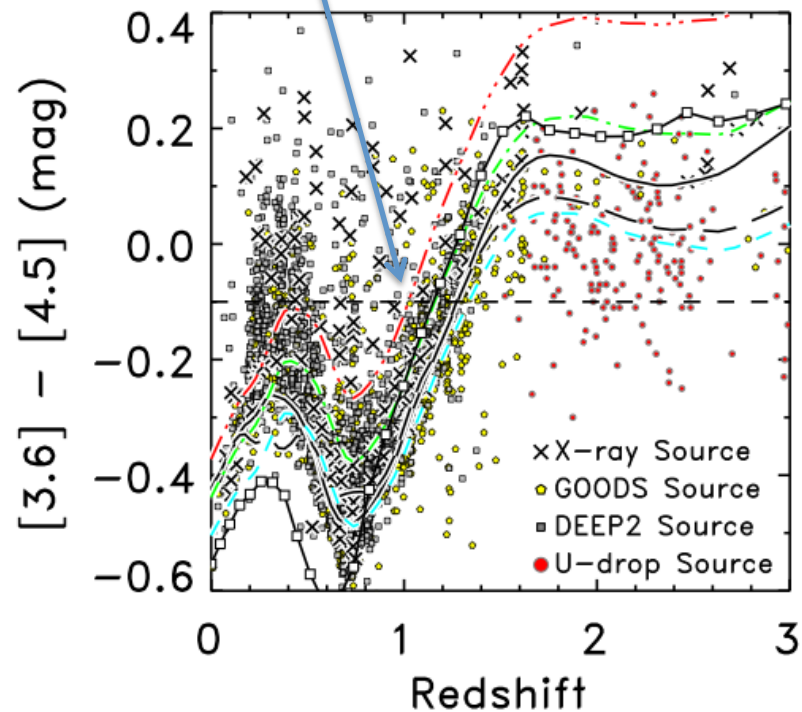


Demarco et al. 2010 $z=1.16$



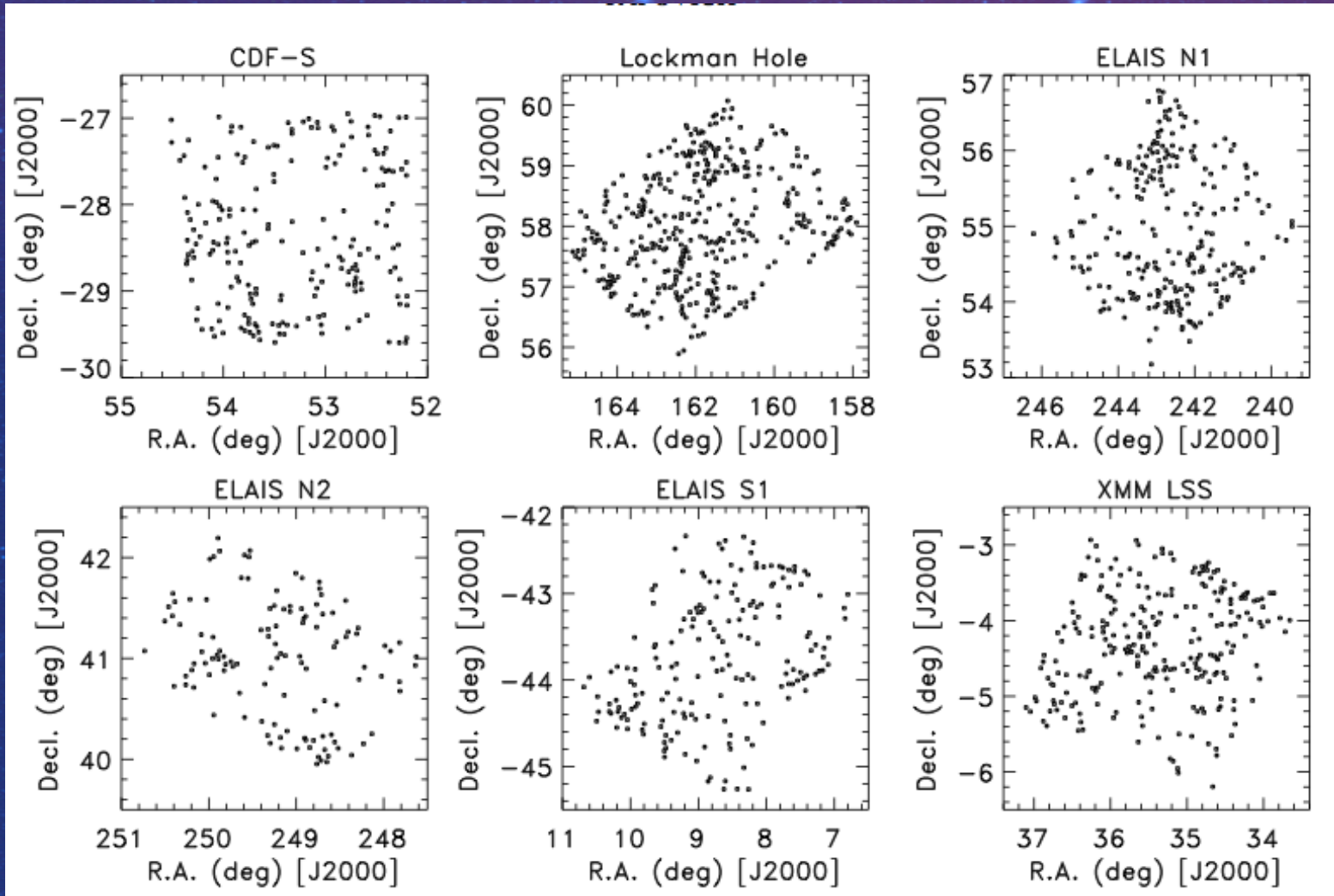
SWIRE Clusters: Papovich et al. 2010

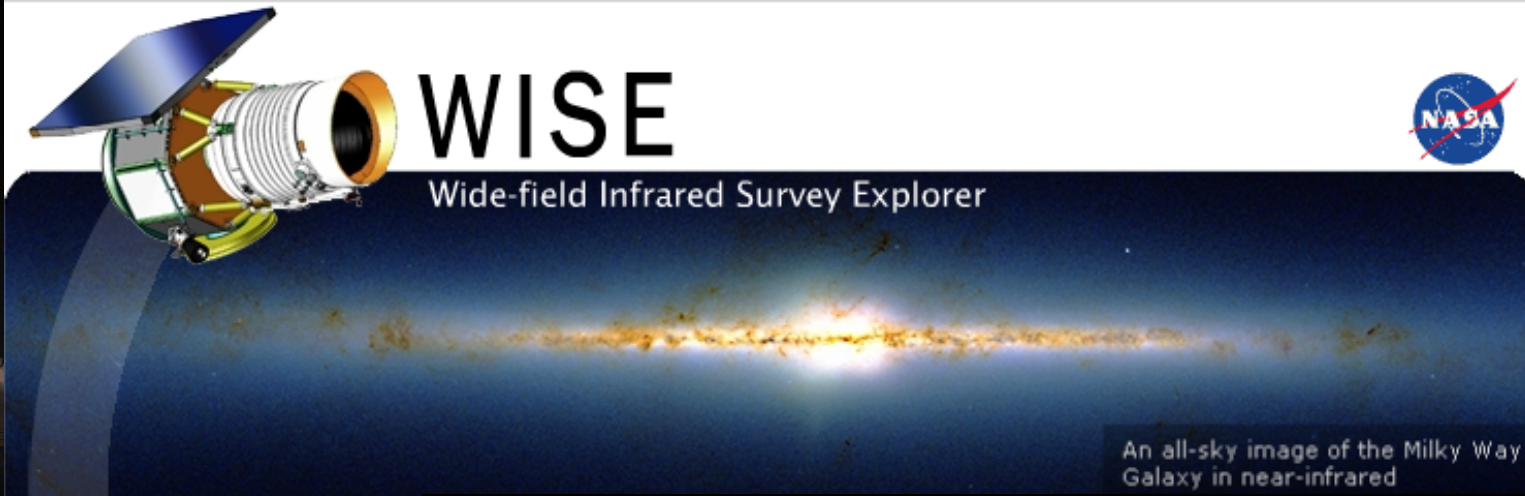
[3.6]-[4.5] color method



SWIRE Clusters: Papovich

Many candidate clusters found across the 49sq deg SWIRE fields



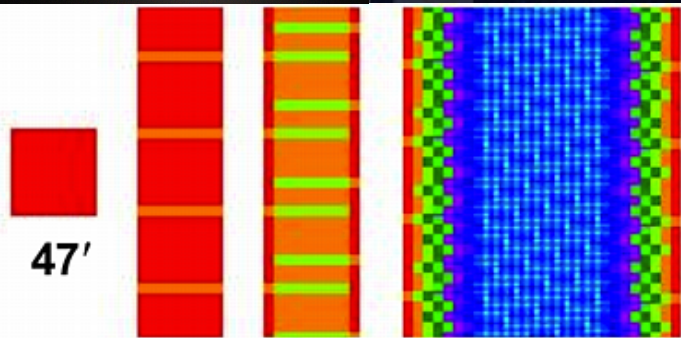


WISE

Wide-field Infrared Survey Explorer



An all-sky image of the Milky Way Galaxy in near-infrared

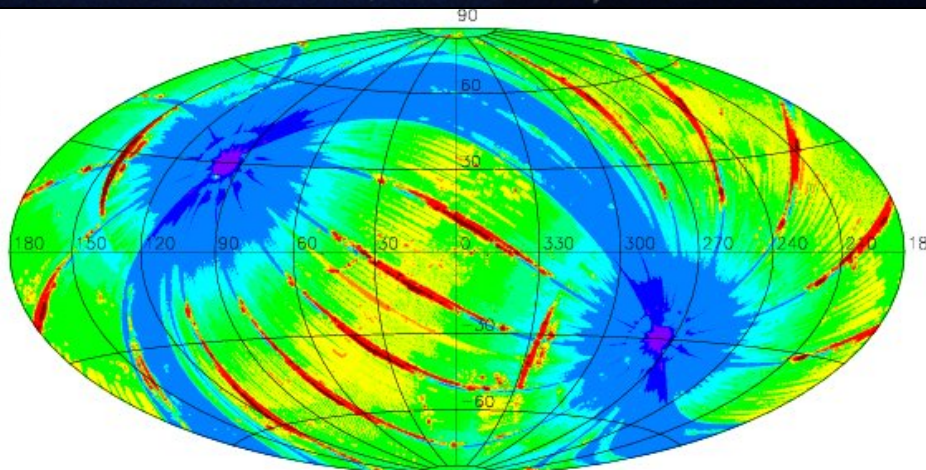


One frame One orbit Two orbits Many orbits

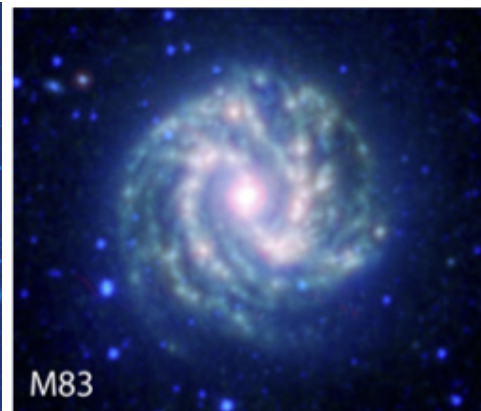
3.4, 4.6, 12, 22 μ m

- ◆ 1 (41250)
- ◆ 4 (41152)
- ◆ 8 (40576)
- ◆ 10 (40008)
- ◆ 12 (37091)
- ◆ 14 (25682)
- ◆ 16 (18649)
- ◆ 20 (12488)
- ◆ 50 (1185)
- ◆ 100 (177)

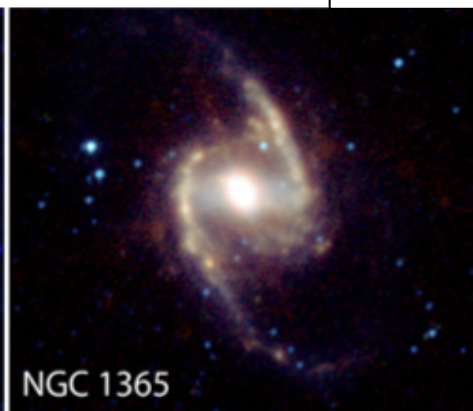
Depth (sq. deg.s)



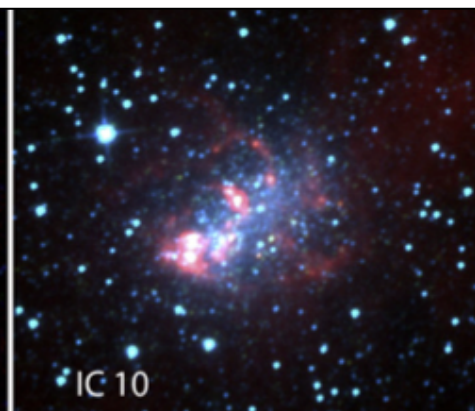
WISE sky coverage, equatorial system



M83



NGC 1365



IC 10



M101

Wright et al, 2011

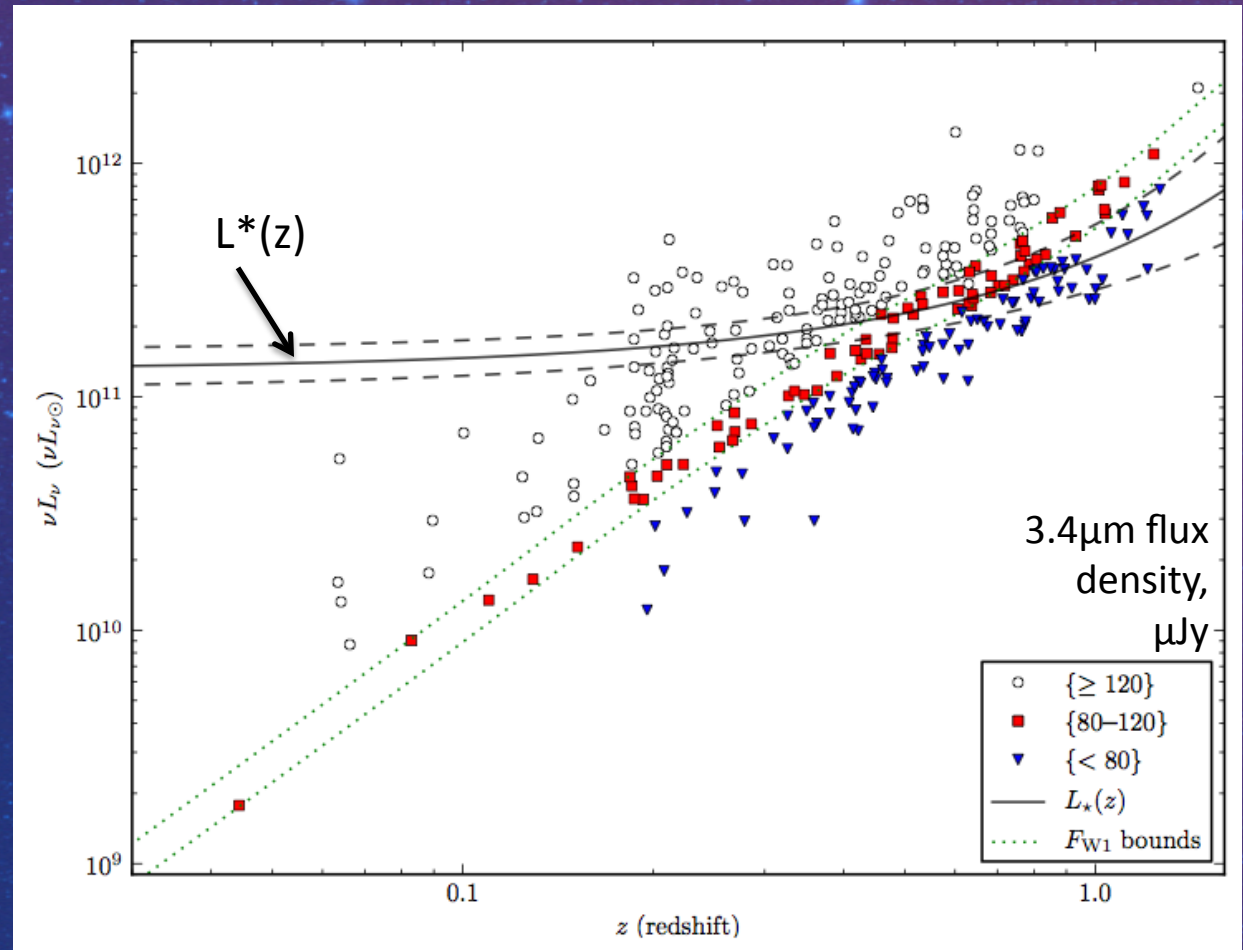
Finding Clusters with WISE

Deimos observations
of WISE galaxies

Lake et al, 2011

L^* galaxies can be
seen by WISE to $z > 1$
at $3.4\mu\text{m}$.

Several candidate
clusters are being
investigated by the
WISE team

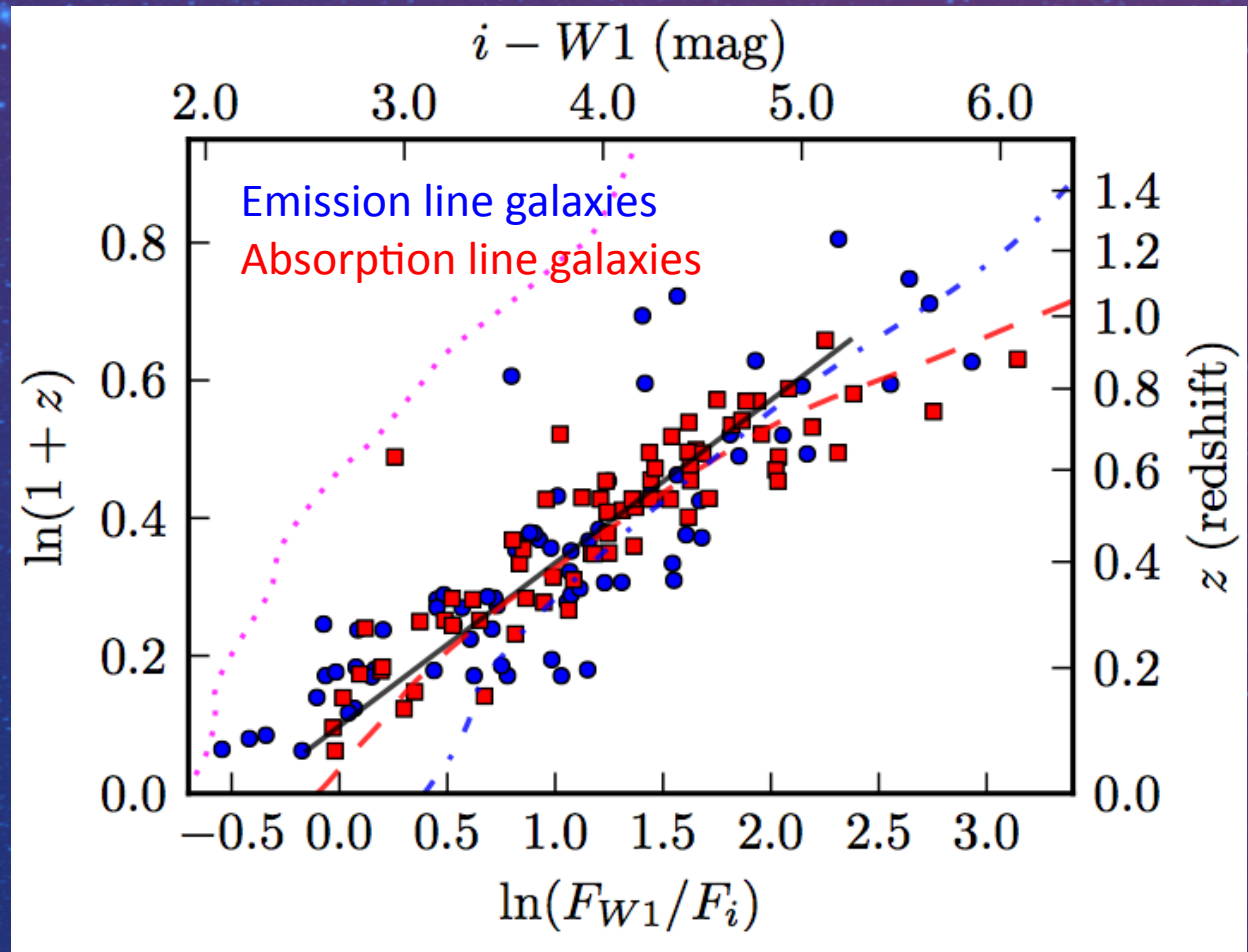


Finding Clusters with WISE

Deimos
observations of
WISE galaxies

Lake et al, 2011

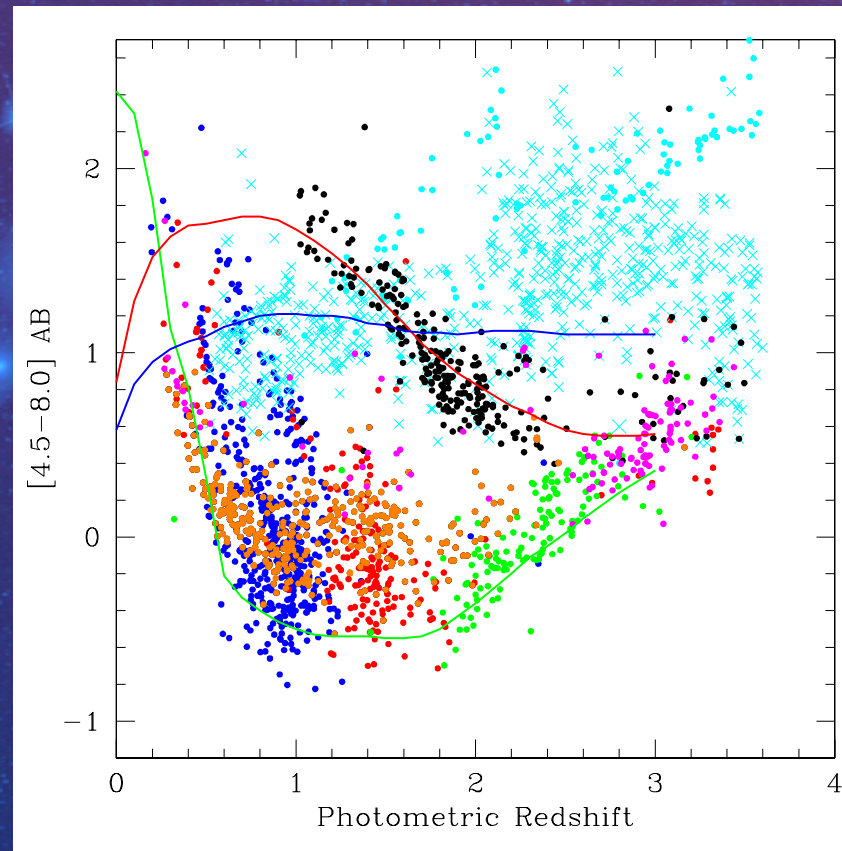
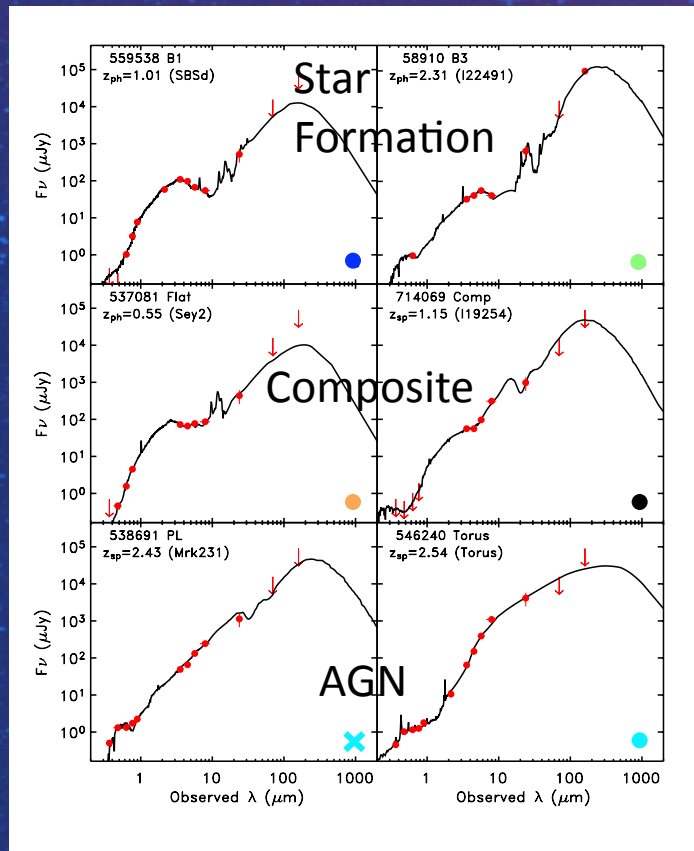
Demonstration of
color-redshift
relation due to
stellar peak shifting
through the $3.4\mu\text{m}$
WISE band



WISE AGN

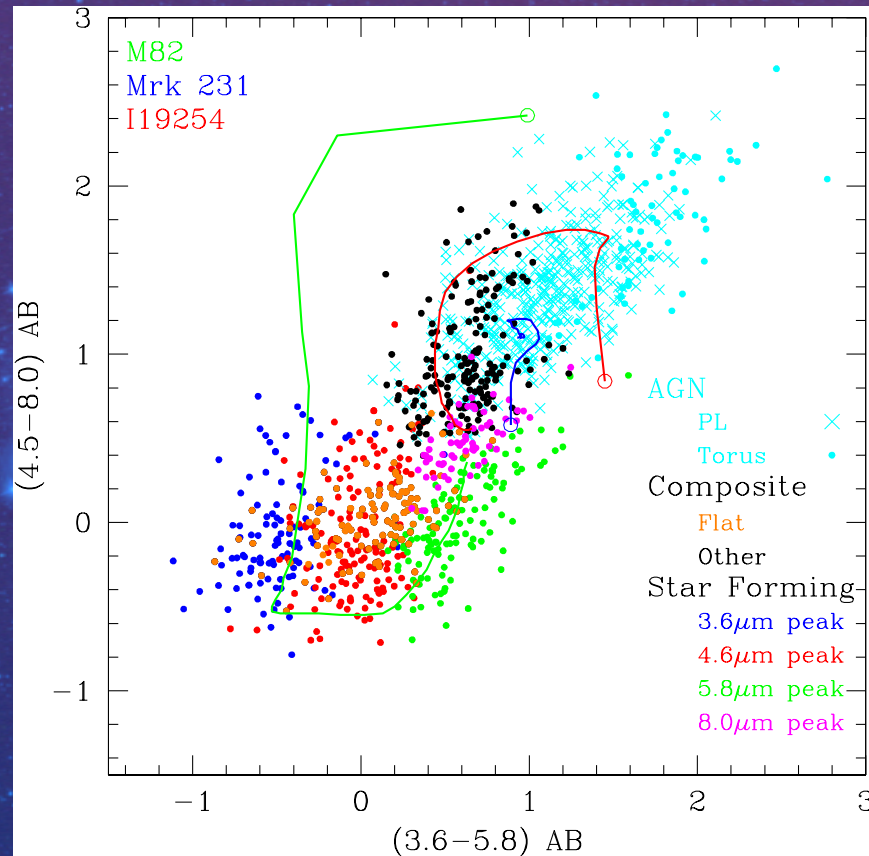
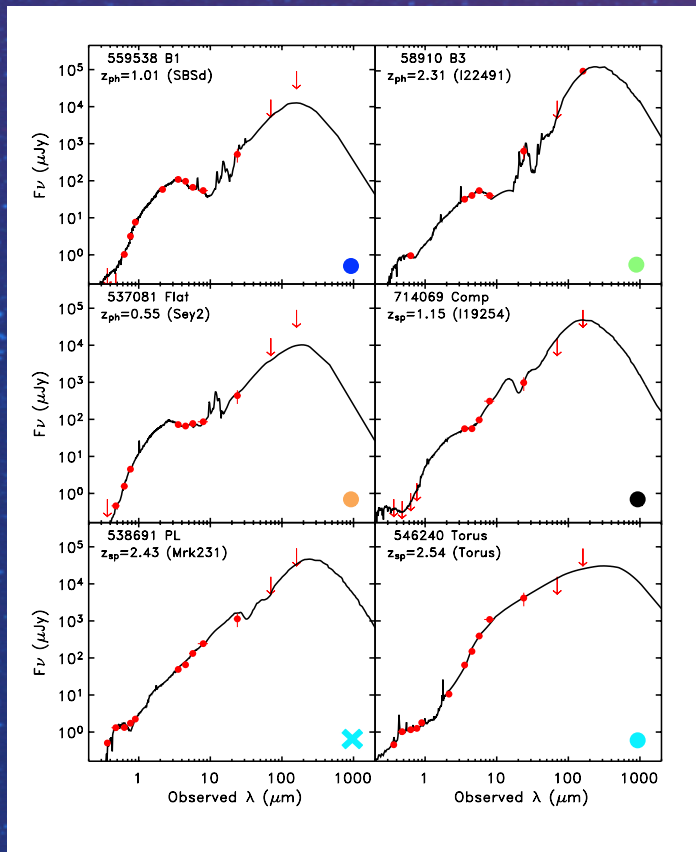
Translating Spitzer AGN color selection to the WISE bands

- Optical, UV and soft Xray biases: obscuration
- MIR is powerful for obscured AGN identification



SWIRE SED-typing (left) and location in color-photo-z (right) ; Lonsdale et al

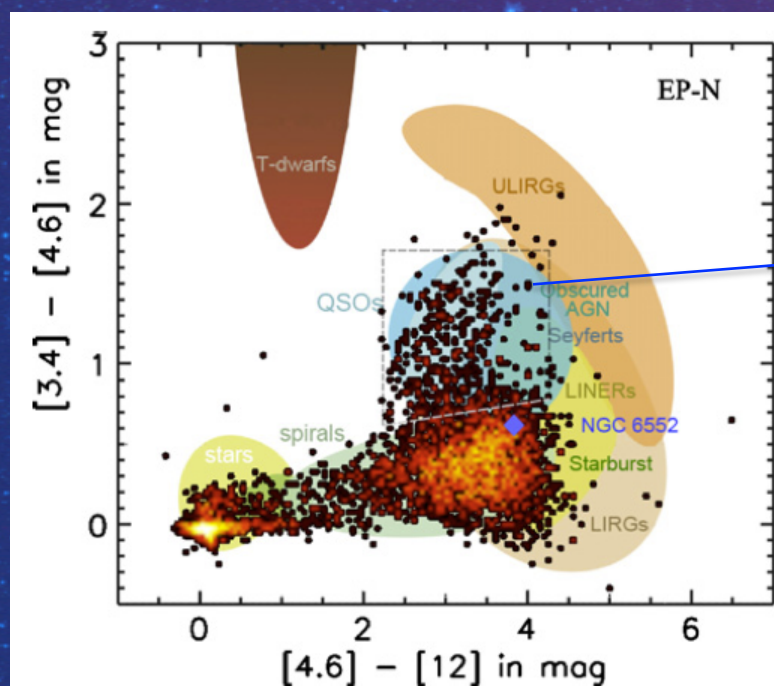
Spitzer AGN Identification



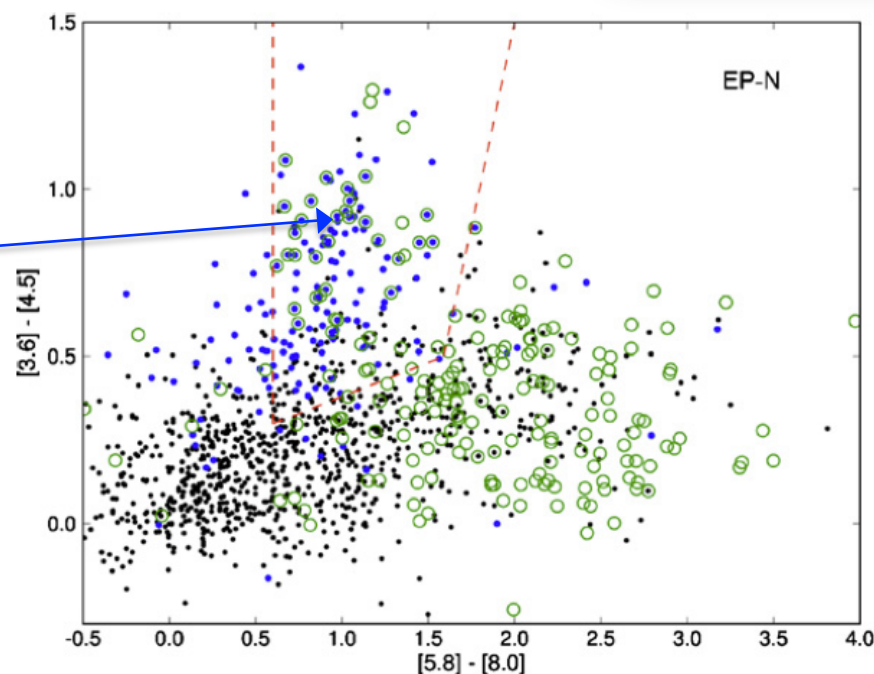
SWIRE SED-typing (left) and location in Lacy et al (2004) color-color plot (right) ($z < 1$ galaxies removed), Lonsdale et al. AGN (• ×) lie in the red “AGN wedge” region

Allsky WISE AGN Samples

- WISE color-color AGN selection validated with Spitzer data



WISE colors, Jarrett et al. 2011



Spitzer colors of WISE sources and the AGN wedge of Stern et al., 2005. ● WISE-selected AGN

A New WISE-Radio AGN Sample

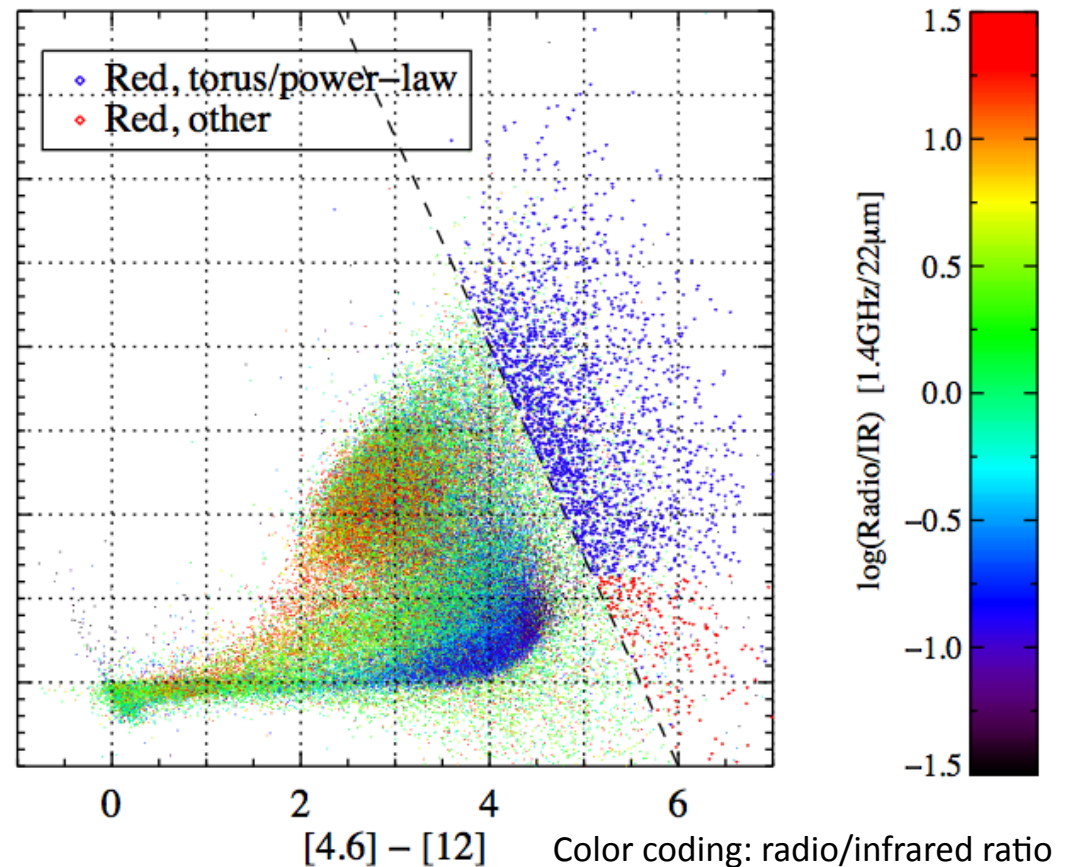
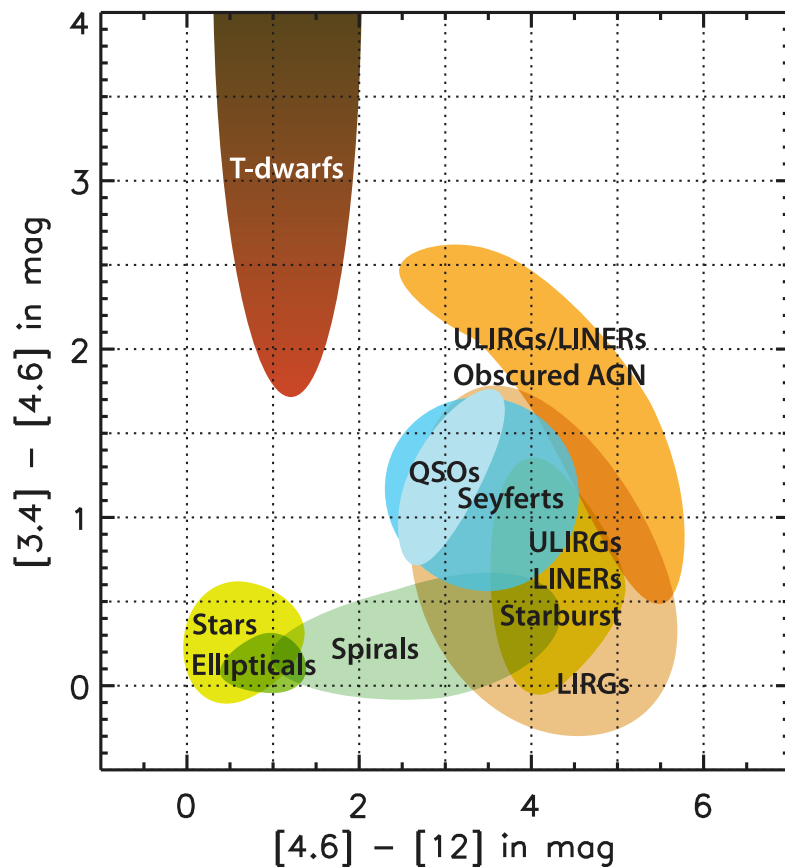
Full sky WISE database matched to NVSS

64,405 sources detected at 12 and/or 22 μ m

2343 “red” obscured AGN candidates

Kimball et al 2011

Lonsdale et al 2011

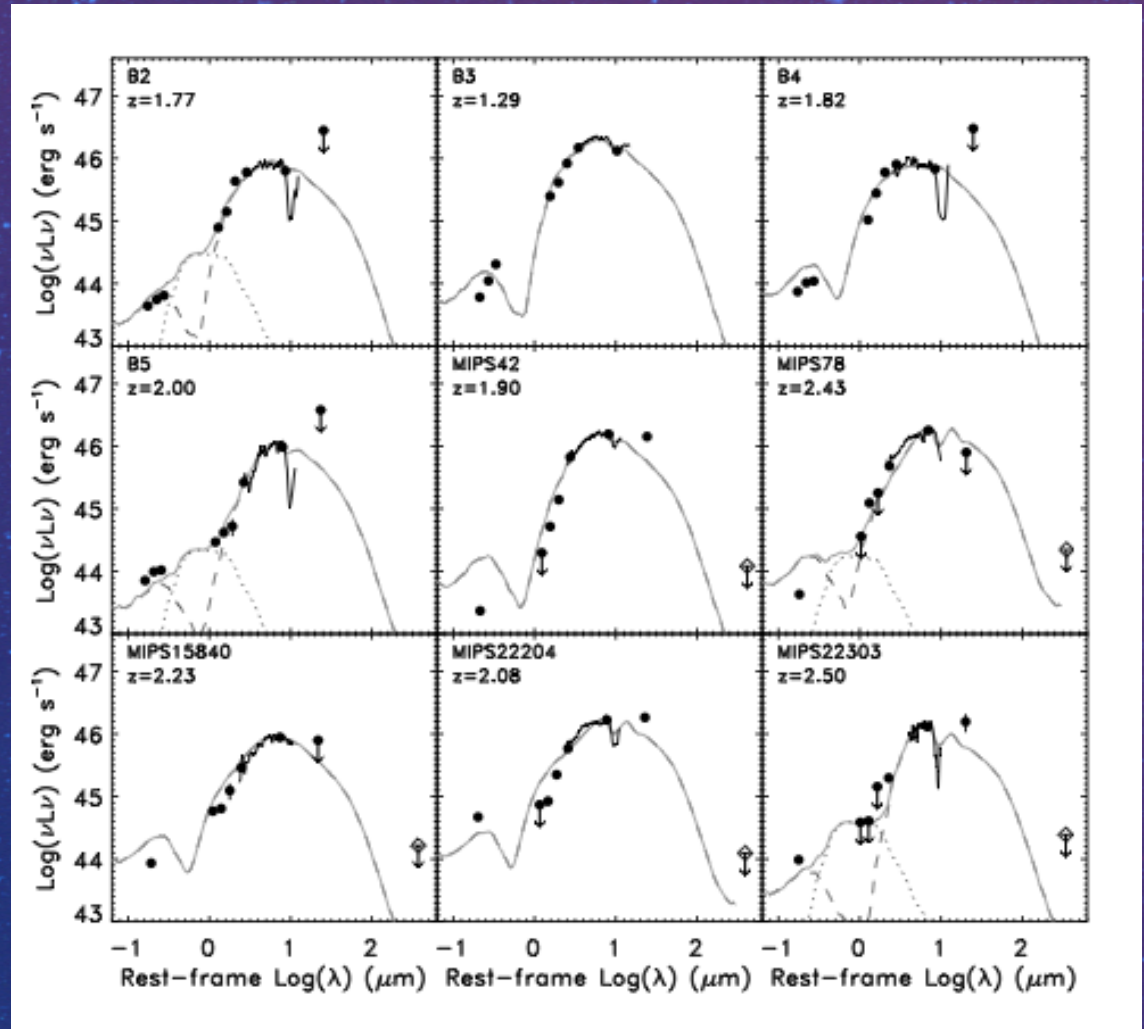


The Very Red WISE AGN Sample compared to Spitzer highly obscured QSOs

“torus”-like shape in
mid-IR SED
identifies $z > 1$
obscured QSOs well

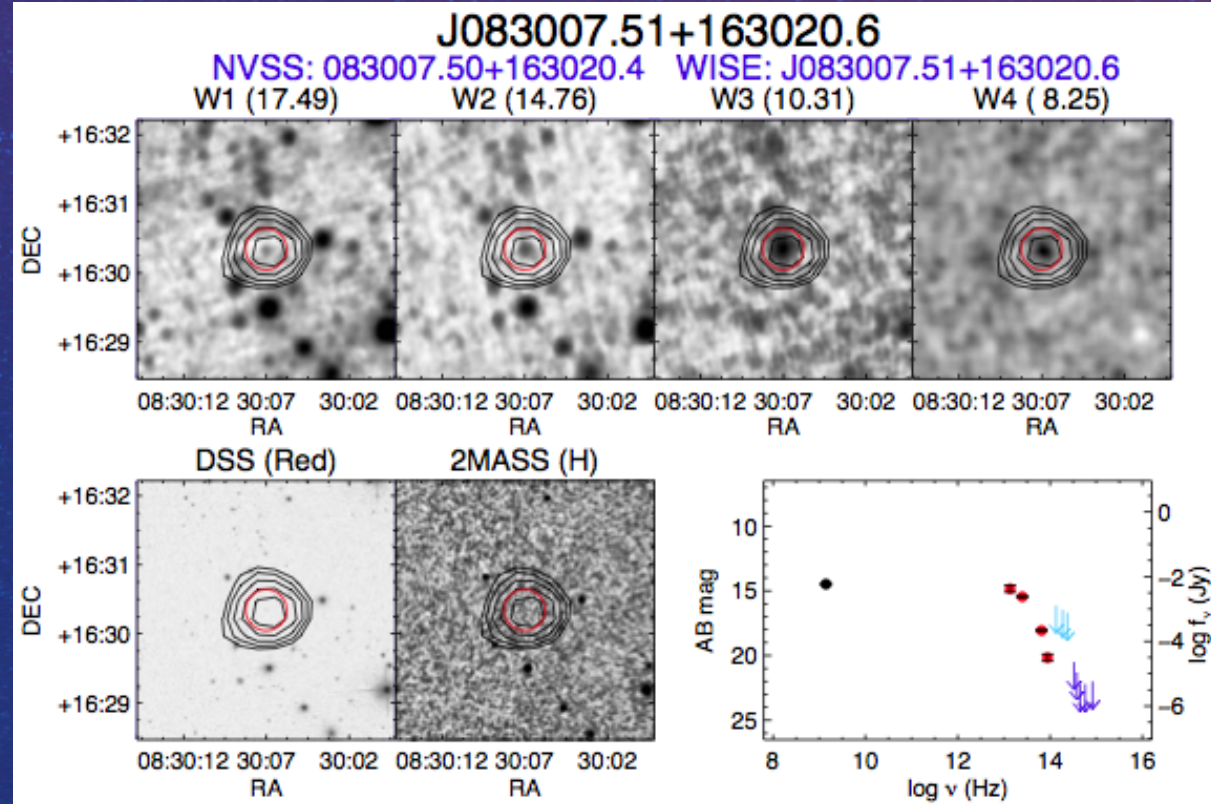
Polletta et al, 2007

Torus model (Honig et al
2006) fits to red Spitzer/
SWIRE QSOs



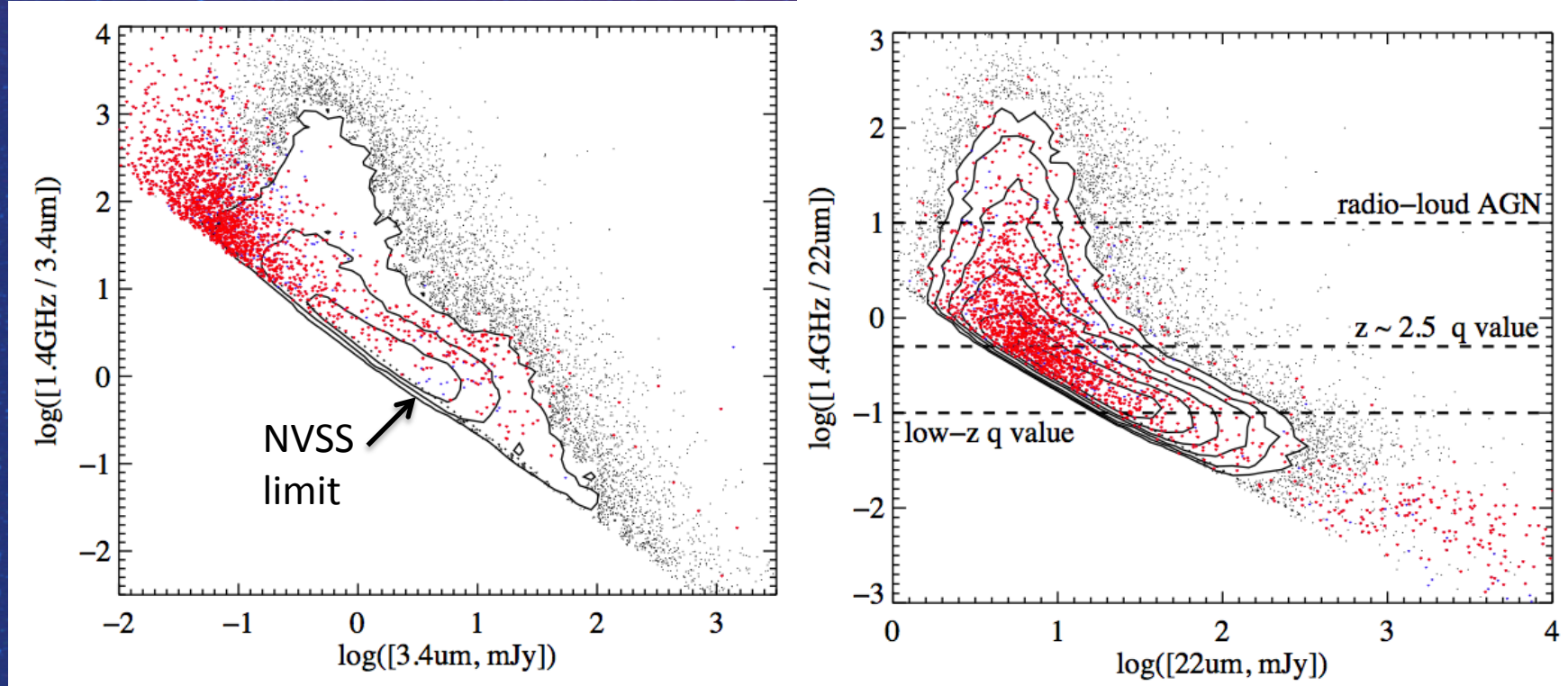
WISE Very Red Obscured QSO Candidate with “Torus”-like SED

- WISE images and NVSS contours. Upper limits in SED plot are 2MASS and SDSS



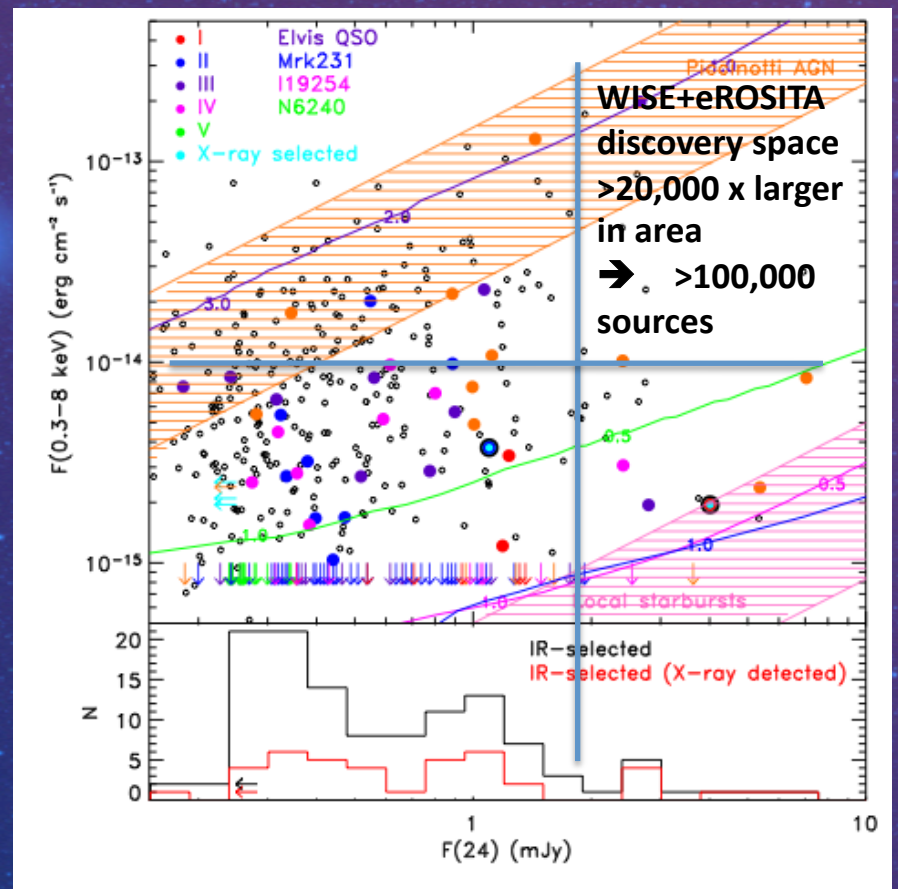
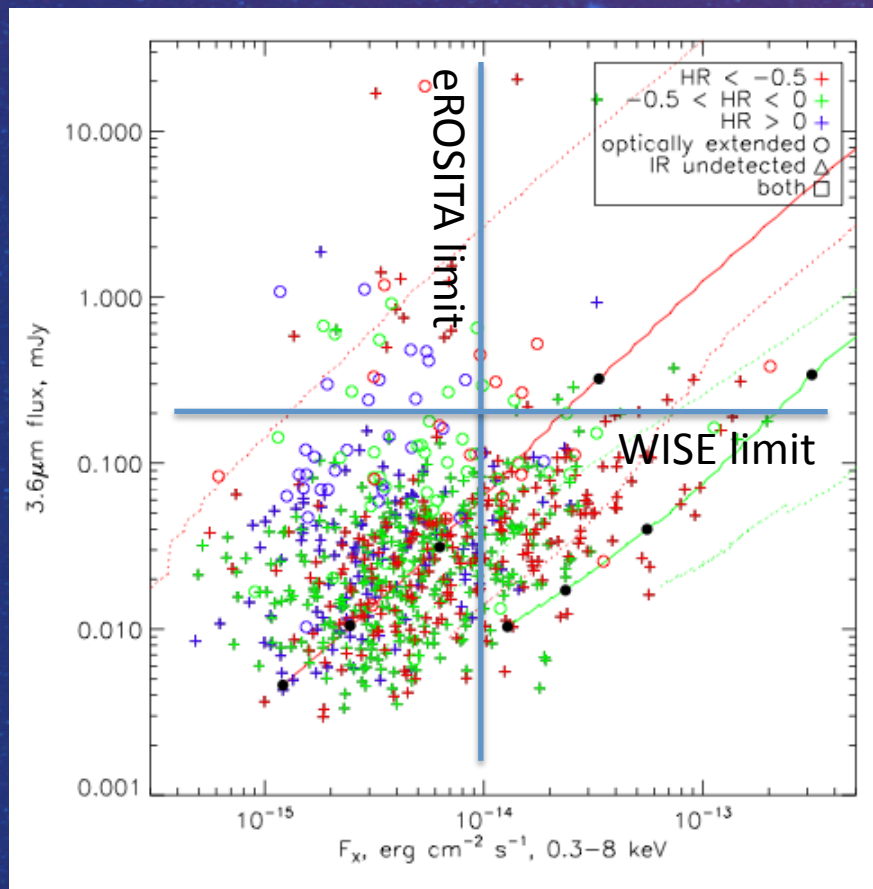
WISE Radio AGN Sample

The WISE-selected radio AGN sample (red points: power-law and torus SED shapes) is extremely red in WISE colors; ie. faint at 3.4 μ m compared to the full WISE-NVSS sample (contours)



WISE & eROSITA

Lockman SWIRE Deep-Wide Field: Wilkes et al 2009, Polletta et al 2006. X-ray compared to $3.6\mu\text{m}$ (left) and $24\mu\text{m}$ (right)



Summary

IR-submm surveys vary greatly in depth and coverage

- NIR surveys cover whole sky and will reach much deeper at $2\mu\text{m}$ over \sim half the sky with the advent of EUCLID, and possibly WFIRST
- WISE presents 1-2 orders of magnitude increase in sensitivity in the MIR, whole sky
- Spitzer surveys total <100 sq deg. They are fundamentally important for informing the larger & shallower WISE survey
- Herschel/PACS surveys cover several 100 sq deg (H-ATLAS)
- In the submm Planck is all sky. Nested deeper & high resolution surveys reach over 100 sq deg with Herschel/SPIRE and over 1000 sq deg with the South Pole Telescope

Summary, cntd.

Spitzer results can be used to inform what we can expect from matching eROSITA with WISE

- Galaxy Clusters
 - WISE can see L^* galaxies to $z > 1$ with the two short wavelength bands (3.4 & 4.6 μm)
 - The [3.4]-[4.6] color alone can do surprisingly well at indicating clusters by the red sequence method. Full phot-z solutions are of course better
 - WISE data are powerful for constraining cluster galaxy masses
- AGN
 - WISE will play a central role in discovering highly obscured AGN
 - Spitzer has shown us that there is a wide dispersion for AGN in the observed MIR-Xray MIR plane
 - Based on these small Spitzer MIR-Xray surveys we can expect $> 100,000$ WISE-eROSITA AGN