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Wide-Field Infrared Surveys: WISE and NEOWISE-R

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Astronomers' Wish List: Giant Scopes, Satellites, and Lots of Moola

by Yudhijit Bhattacharjee on August 13, 2010 11:15 AM | Permanent Link | 0 Comments

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Every 10 years, the U.S. astronomy community goes through the collective exercise of ranking its dream projects, hoping that a few of them will see the light of day with the blessing of the U.S. Congress and funding agencies. The latest such "decadal survey," has been released this morning and two megascopes have emerged as the top choices for the next decade. On land, the winner is the $463 million Large Synoptic Survey Telescope (LSST), a wide-field optical telescope that will help investigate dark energy, supernovae, and other areas. In space, the community's top choice is the $1.6 billion Wide-Field Infrared Survey Explorer—until now known as the Joint Dark Energy Mission—which will enable researchers to study dark energy, find Earth-like planets, and survey multiple galaxies, including our own. Both are in the planning and design phase, having already received funds on the order of a few million dollars from public and private sources.

The new decadal survey, released today by the National Research Council, is the sixth in a series of such reports that have been written since the 1960s. Although these reports have always been influential—policymakers like scientists to rank their needs—only two of the seven major projects that appeared on the wish list in the 2001 survey have been funded, leading astronomers to wonder if the exercise is as useful as they'd like it to be.

Previous surveys have also been faulted for providing unrealistic cost estimates, as low as a fifth of what certain missions have ended up costing. As a result, there has been considerable pressure on the committee that authored today's report to prioritize projects more effectively and estimate costs better.

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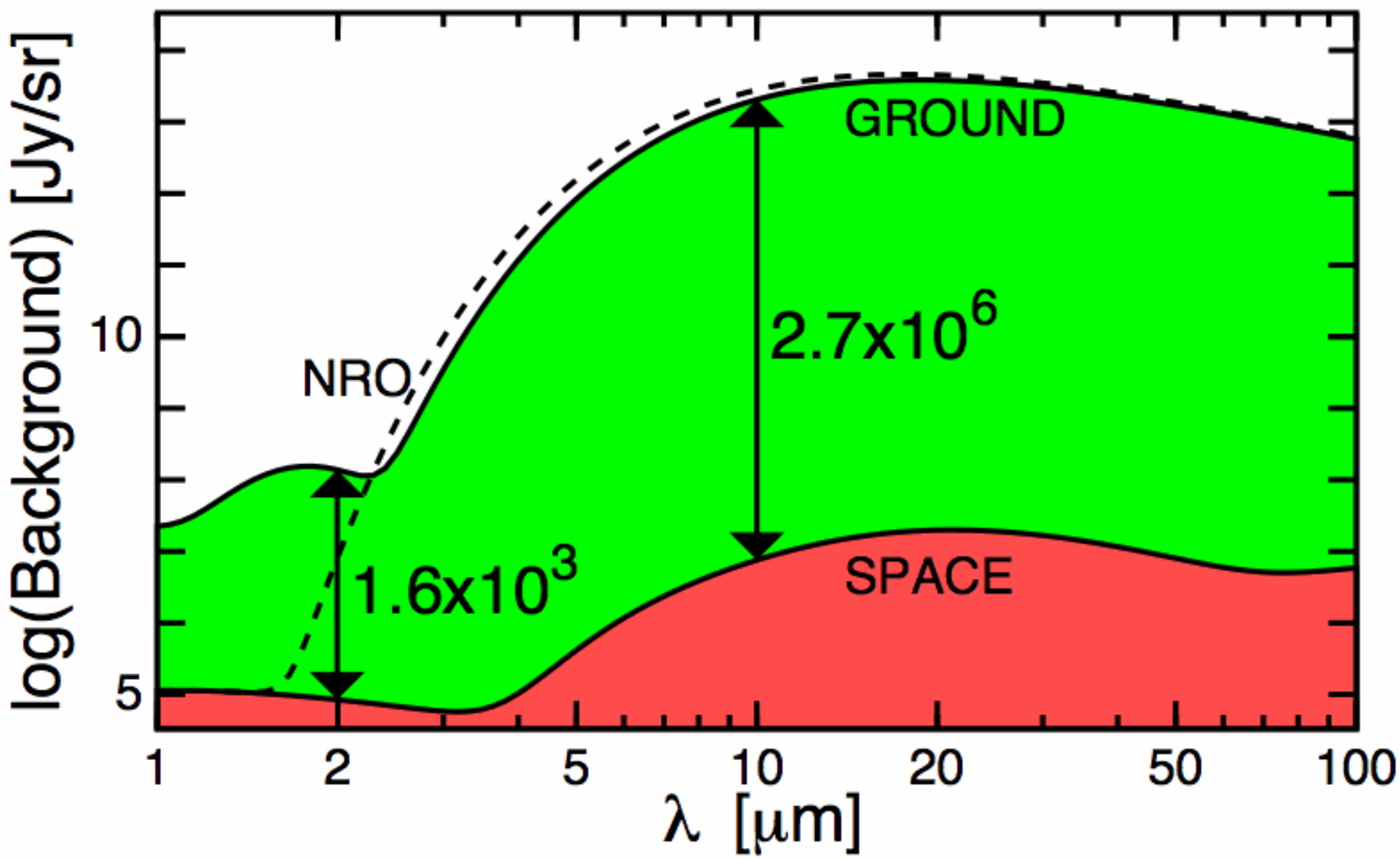
NWNH according to Science

- "In space, the community's top choice is the $1.6 billion Wide-Field Infrared Survey Explorer"
  - Unfortunately they meant WFIRST
  - $1.6 billion would have been nice

Why Space?

"Ground-based infrared astronomy is like observing stars in broad daylight with a telescope made out of fluorescent lights'' — George Rieke.



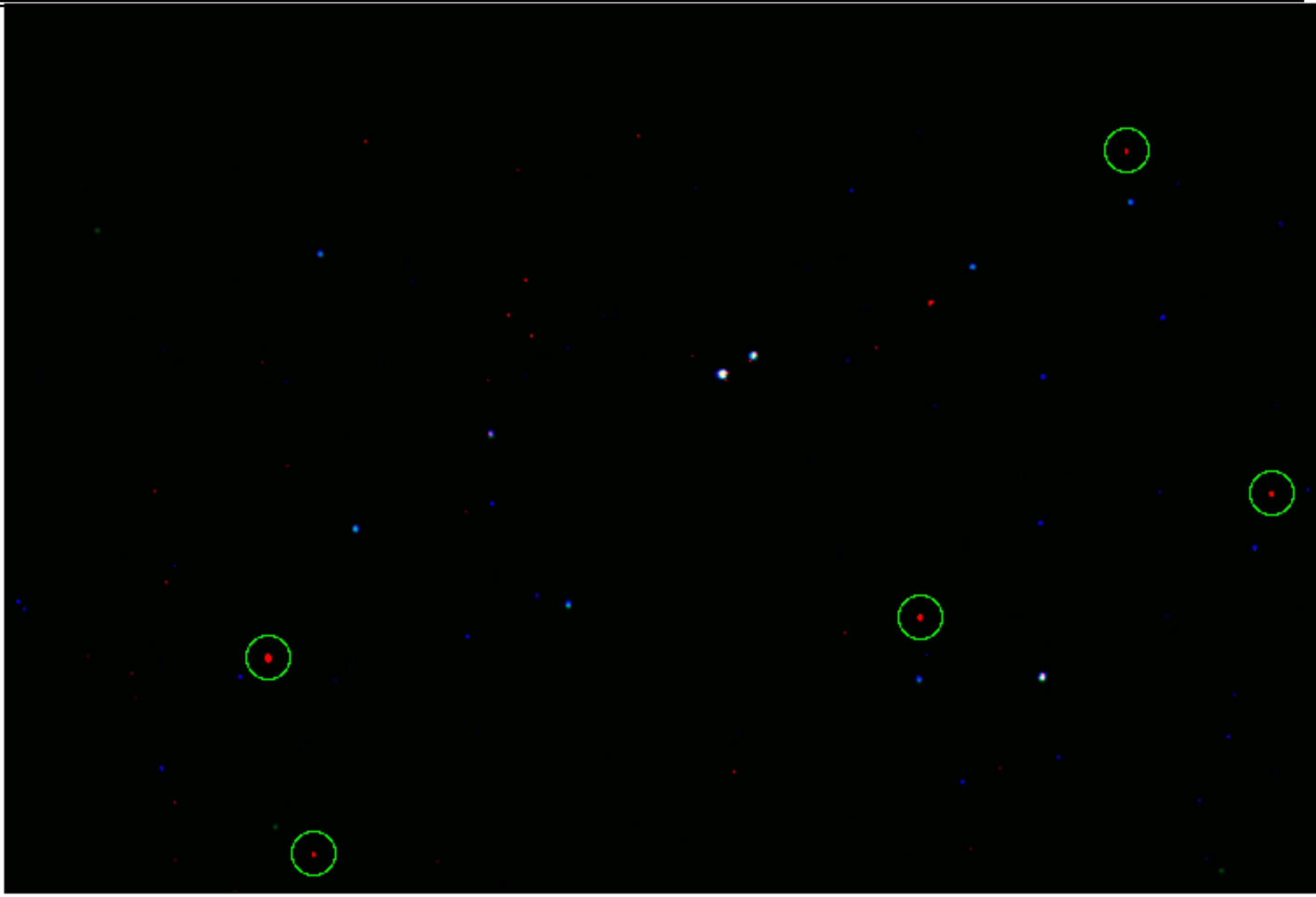
40 cm WISE telescope in space equals six thousand 8-meter telescopes on the ground!

Asteroids Move

- Four frames of data taken on 2010 Jan. 8 during in-orbit checkout.

- Blue = 3.6um; green = 4.6um; red = 12um

- Circled asteroids are (L to R in the first frame, diameters in km):
  17818 MBA D~12.4
  153204 MBA D~2.8
  22006 MBA D~11.5
  87355 MBA D~4.3
  80590 MBA D~4.1

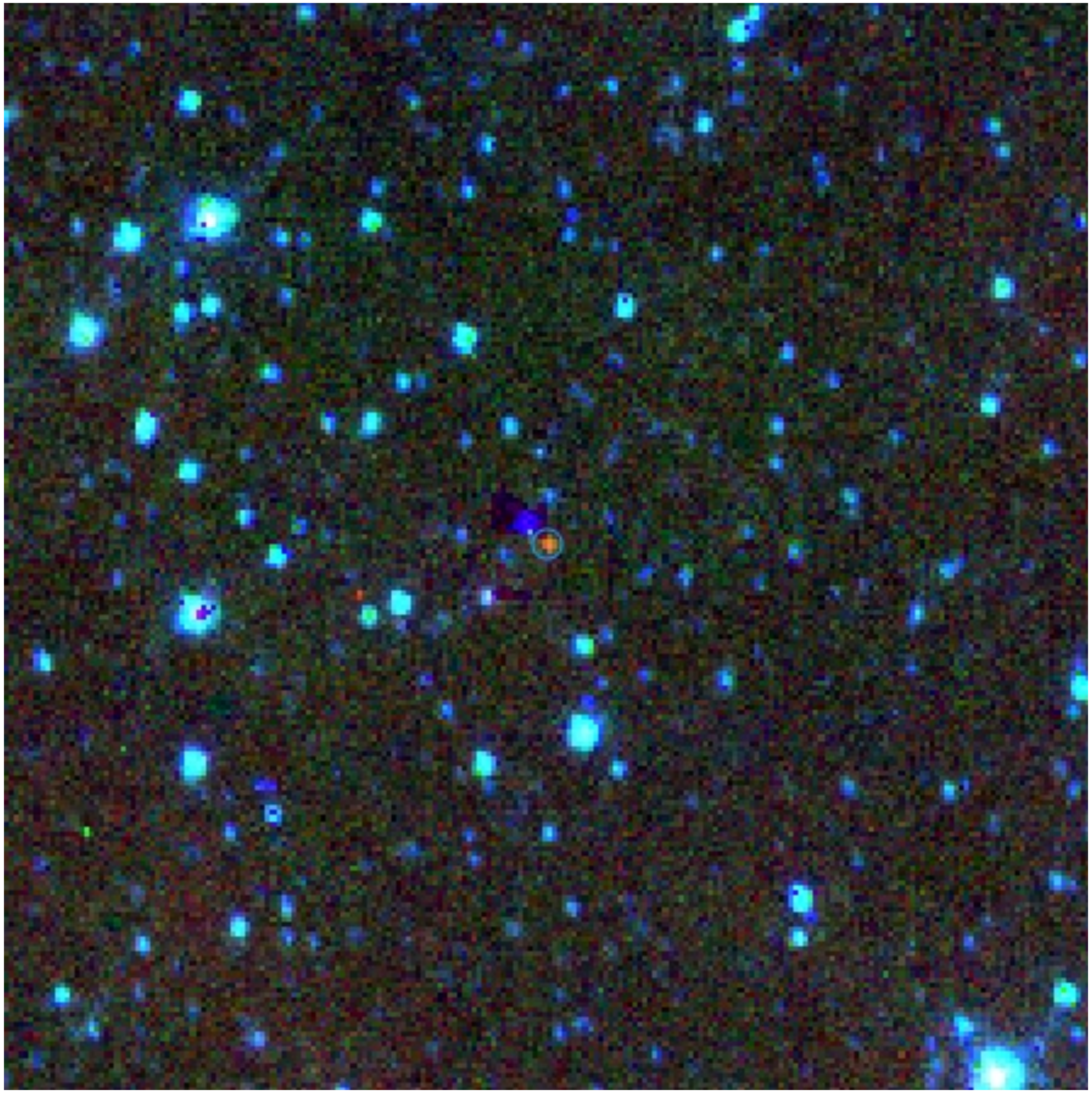


Field of view = 34 x 25 arcmin (whole WISE FOV is 47 x 47 arcmin)

Most Hazardous WISE Discovery

- 2010 MU_{112} - recovered in Feb 2013 by David Tholen
- Minimum Orbit Intersection Distance = 0.0011 AU
- Closest approach in next hundred years, 12 Dec 2082 at 0.007 AU
- Diameter 600 m, Albedo = 2.2%, estimated mass 200 megatons
- $a = 1.756$ AU, $e = 0.54$, $i = 48^o$
- $v_\infty = 29.5$ km/sec
- Impact energy in TNT equivalent $= \text{Mass}*(v_\infty{}^2+11^2)/2.9^2$

24 billion tonnes TNT



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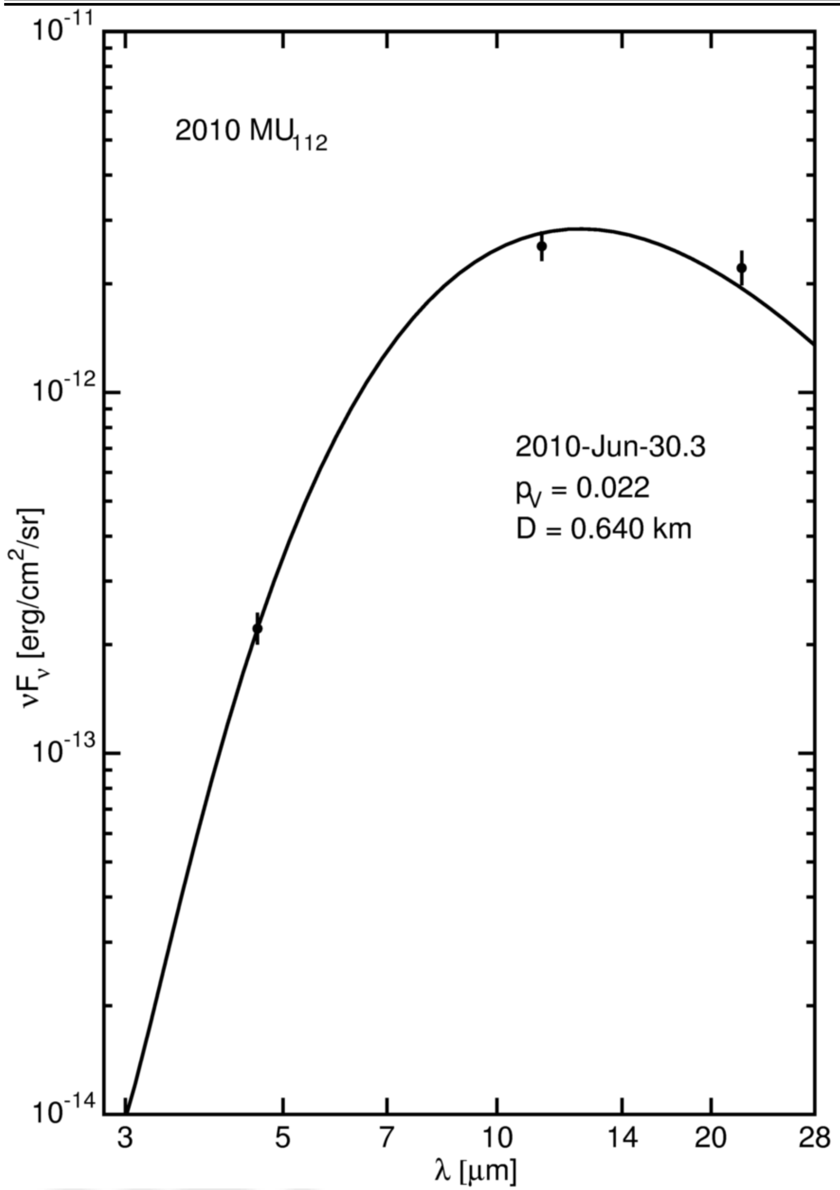
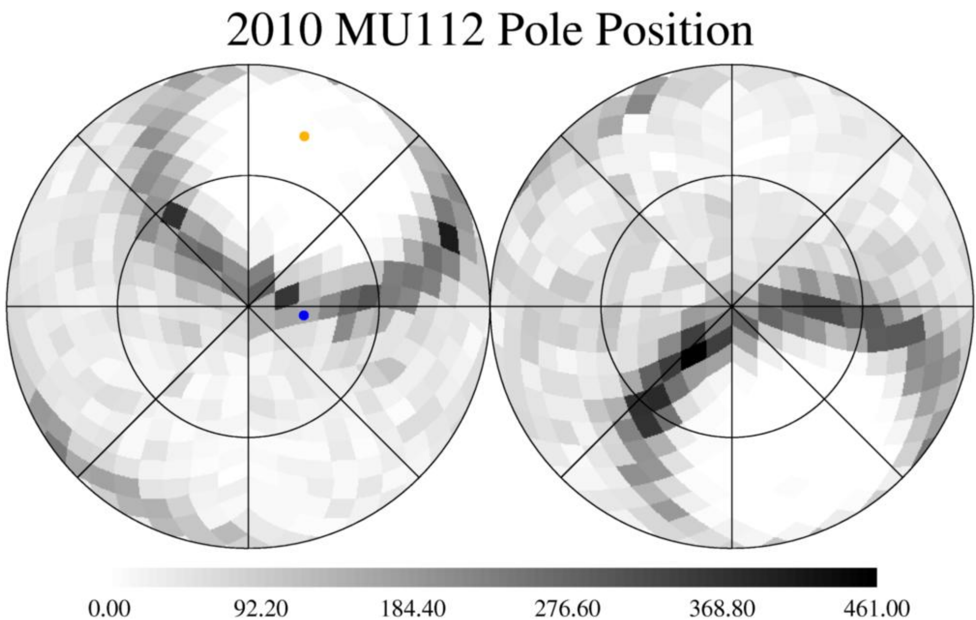
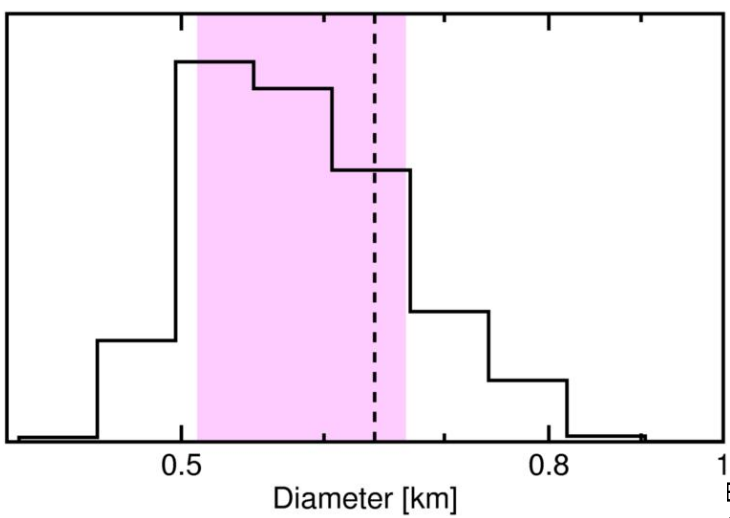
Wide-field Infrared Survey Explorer (WISE)

2010 MU_{112}







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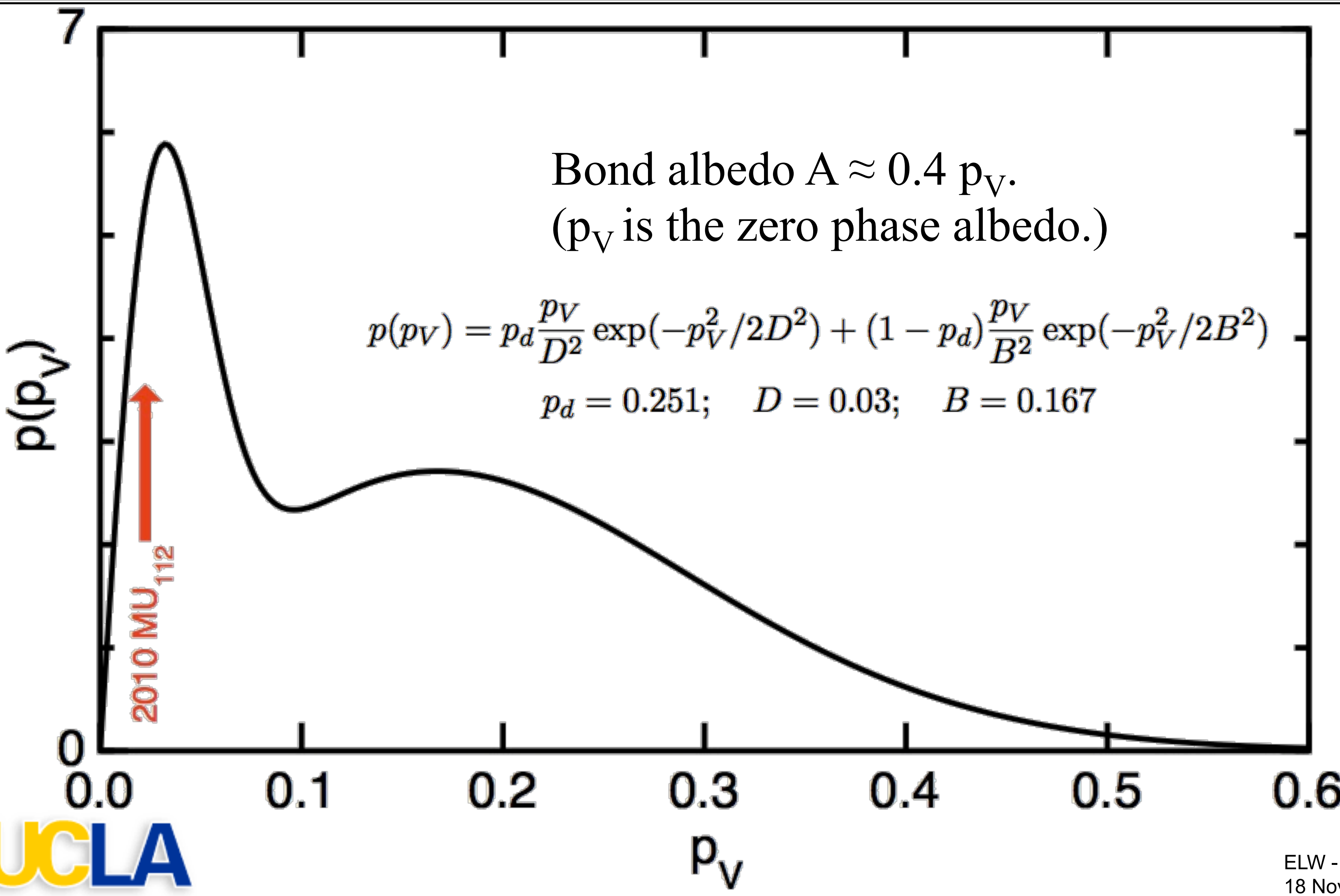
Wide-field Infrared Survey Explorer (WISE)

NEO albedo distribution model



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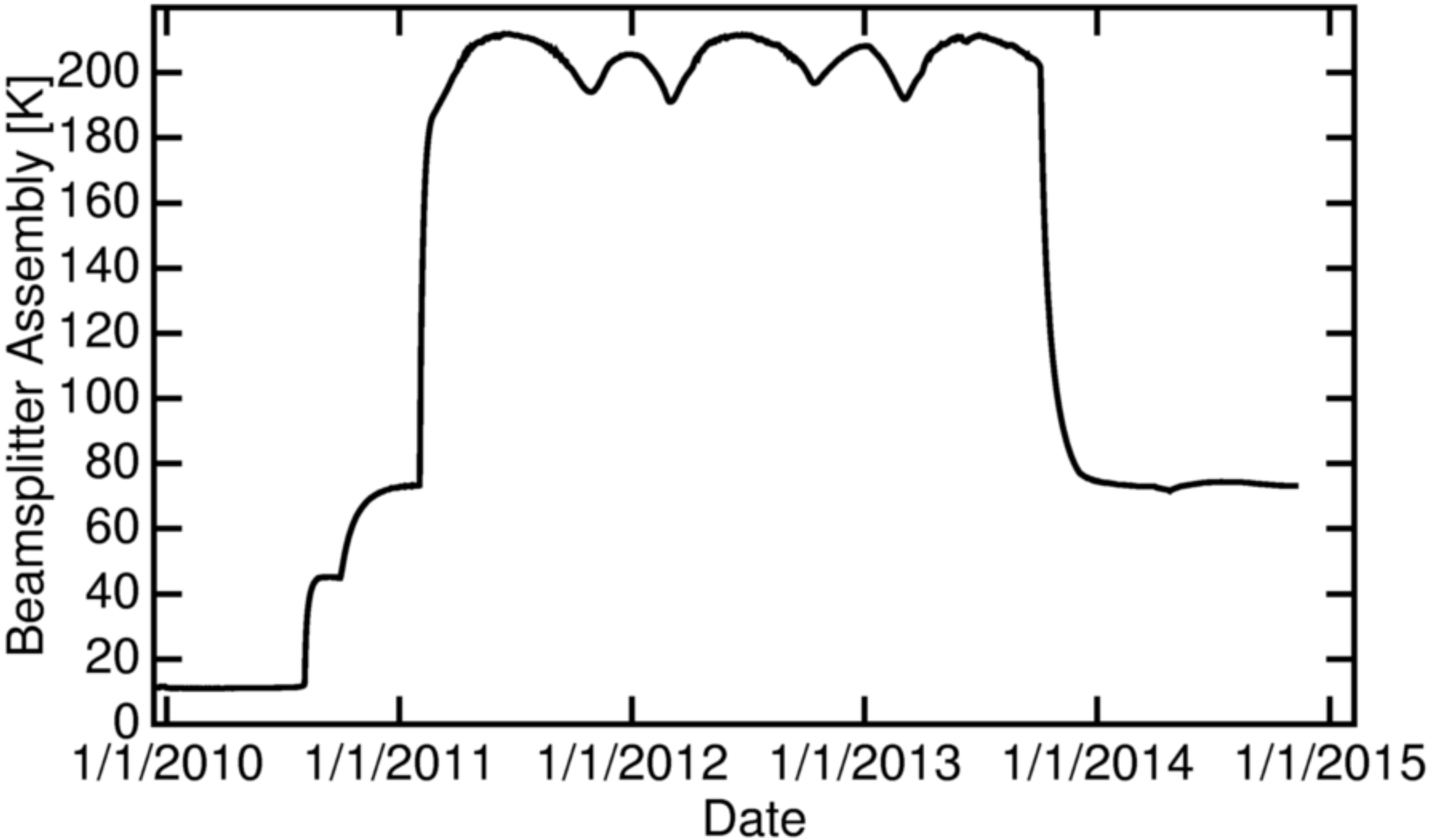
WISE Re-Animated



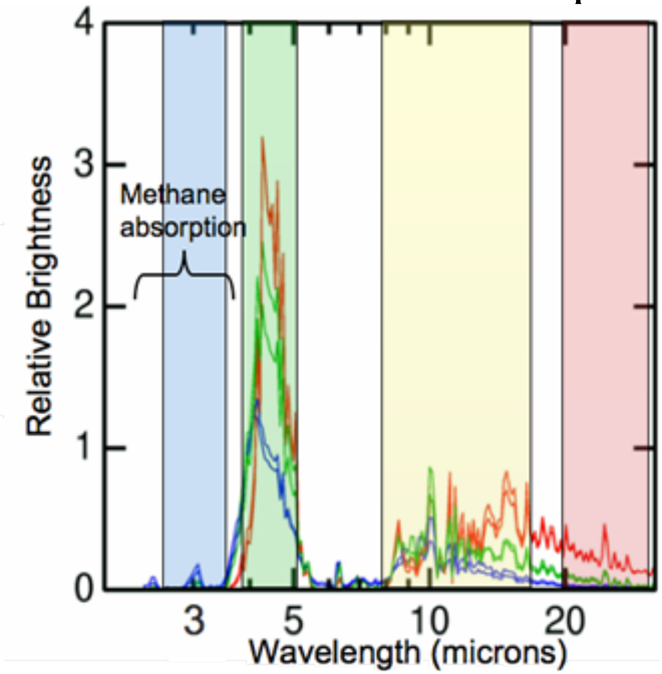
- Planetary Division of NASA is funding new observations by WISE to search for NEOs. This is NEOWISE-R.

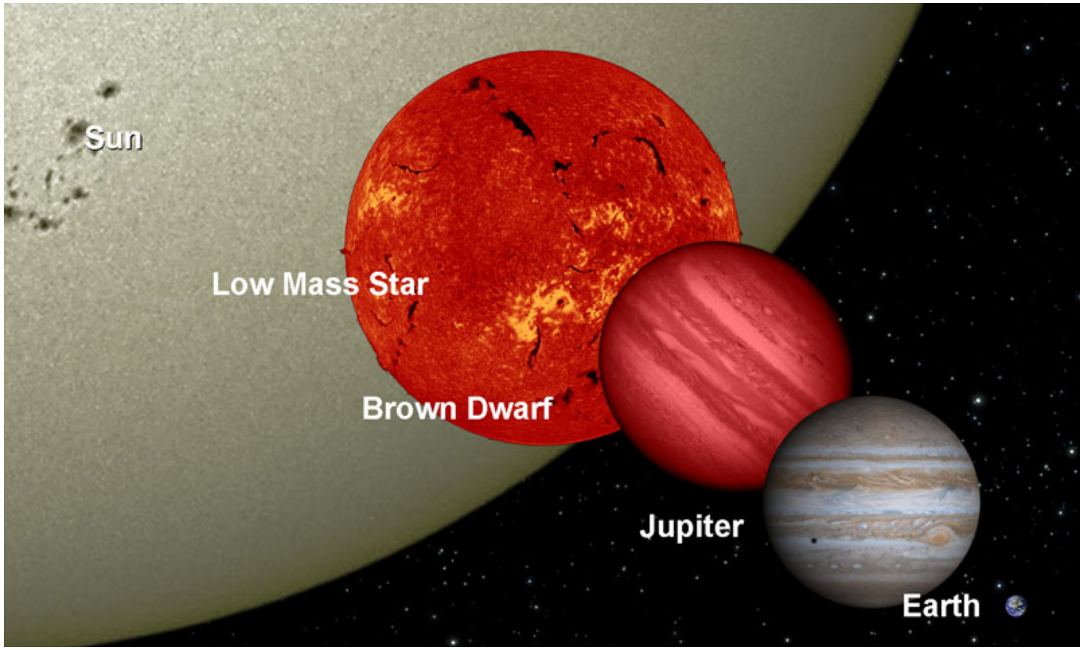
Protecting the Planet Again

- Chelyabinsk: about 20 m dia, 450 kT TNT
- 2010 MU_{112}: 600 m dia, 24,000,000 kT TNT

WISE and Brown Dwarfs

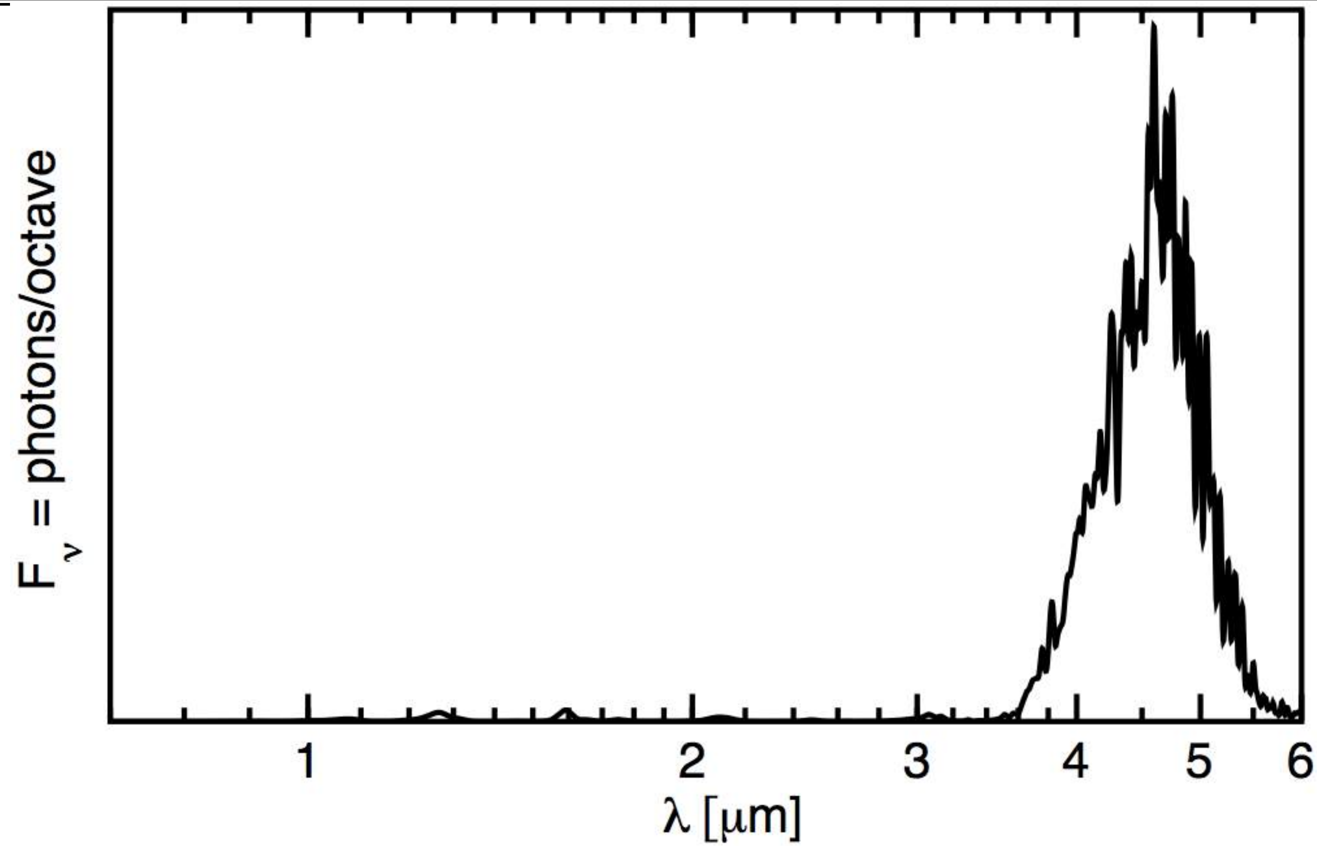
- Brown Dwarfs are stars with too little mass to fuse Hydrogen into Helium.
- WISE two short wavelength filters are tuned to methane dominated brown dwarf spectra.





- WISE could identify brown dwarfs as cool as 200 Kelvin (-100 Fahrenheit) out to 4 light years, the distance to the nearest known star.

Morley dusty model, T=400 K



- Model has J-W2=7.35, so reddest WISE objects to date have 30x less flux at 1.27 µm than shown in this figure
- JWST at 4.5 µm is >5000x more sensitive than HST or WFIRST-AFTA for cold brown dwarfs.

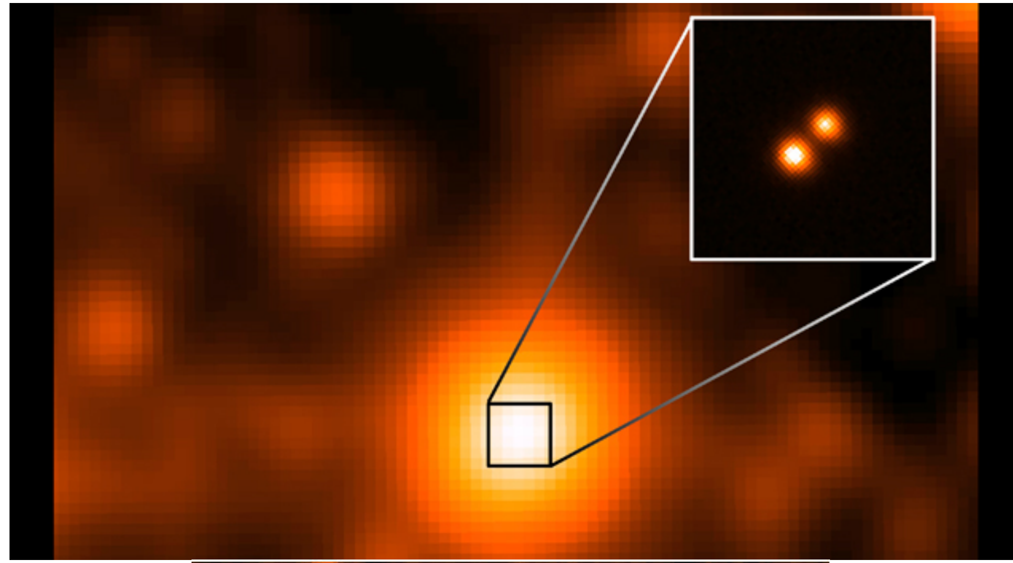
WISE 0855-0714

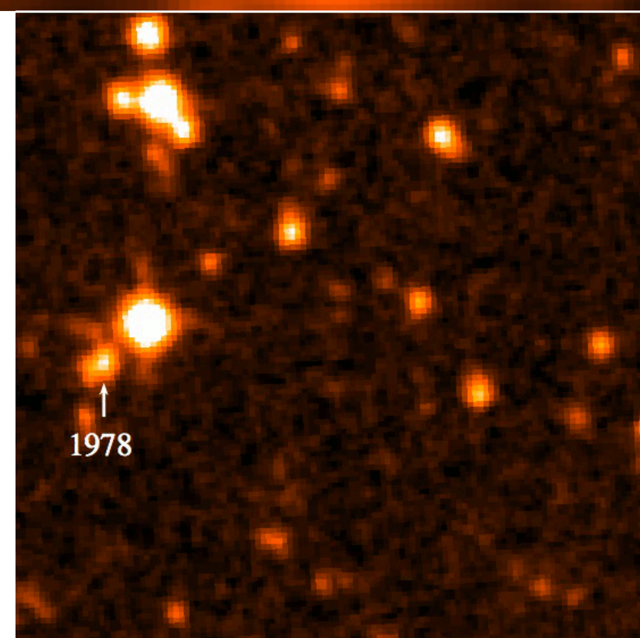
- Flagged by Kirkpatrick *et al.* (2014, arxiv:1402.0661) as high proper motion without 2MASS counterpart
- Independently flagged by Luhman (2014, arxiv: 1404.6501) whose Spitzer followup showed W0855 is the reddest and dimmest brown dwarf. Or free floating planet
- 4th closest star system to Sun

- D = 2.31 ± 0.08 pc (Luhman & Esplin, 2014)
- Proper motion 8.1 "/yr
- $M_{W2} = 17.20 \pm 0.09$
- $W1\text{-}W2 = 5.0^{+2.2}_{-0.7}$ (Wright *et al.* 2014)
- $J\text{-}W2 = 11^{+0.53}_{-0.33}$ (Faherty *et al.* 2014)
- $T_{eff} = 250$ K, could be 1 Gyr old and 3 M_J, or 10 Gyr old and 10 M_J

WISE 1049-5319 @ 2 pc!

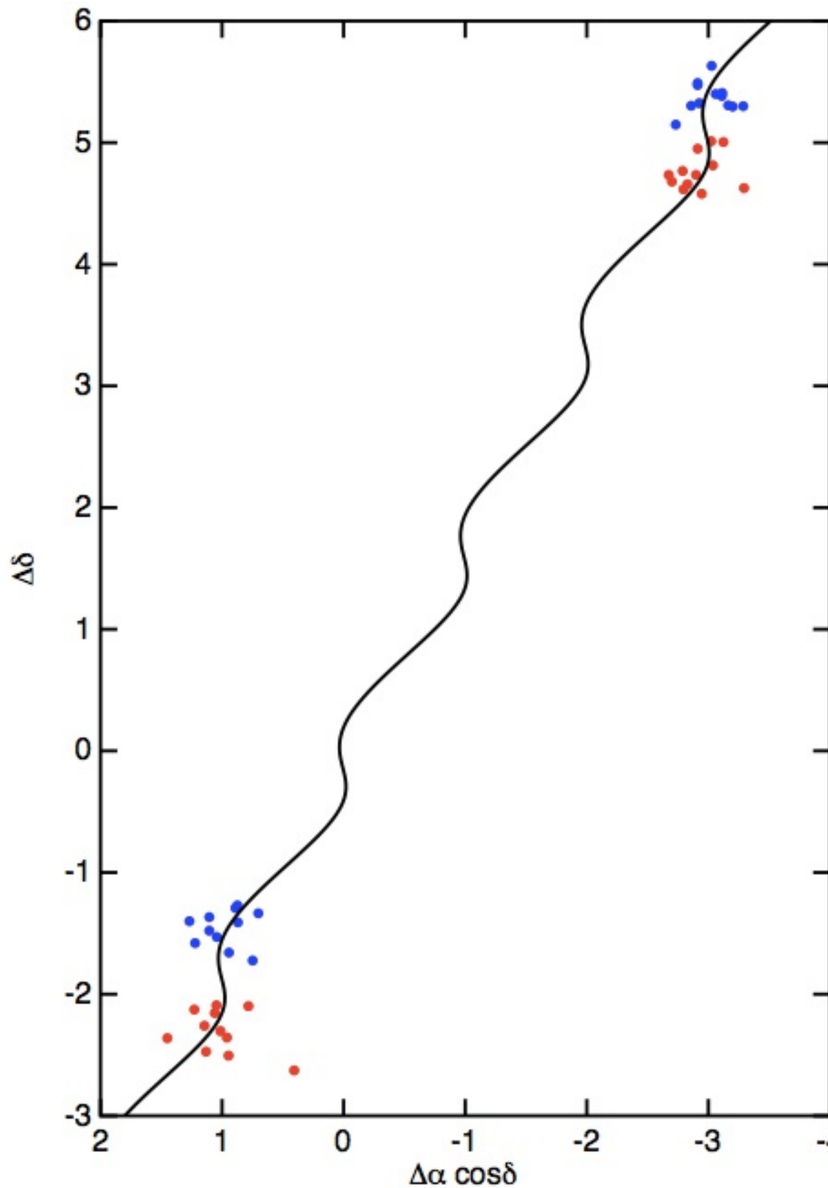
- Luhman (2013), arxiv:1303.2401
- Discovered by proper motion using single frame detections
- Parallax 0.5”
- 3rd closest star system to Sun
- 1.5” binary
- A component is L8, B component is T1





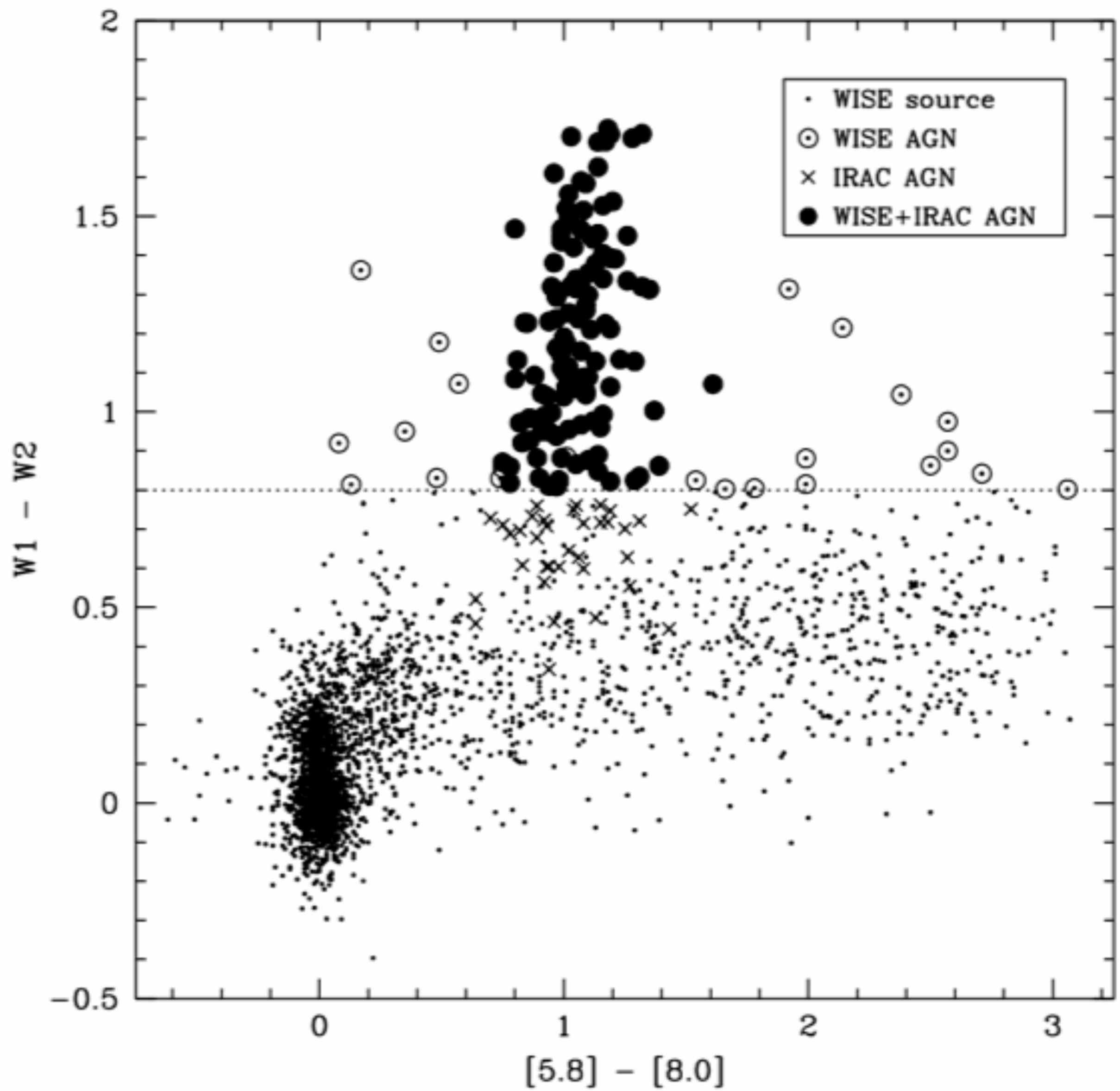
WISE only Parallax

- Gl 570D in 2010 & 2014
- Gl 570A from Hipparcos
  - $\mu_\alpha = 1037$ mas/yr
  - $\mu_\delta = -1726$ mas/yr
  - $\varpi = 171$ mas
- Gl 570D from WISE
  - $\mu_\alpha = 996 \pm 13$ mas/yr
  - $\mu_\delta = -1736 \pm 14$ mas/yr
  - $\varpi = 225 \pm 23$ mas
- Relative orbital motion of ≈30 mas/yr expected



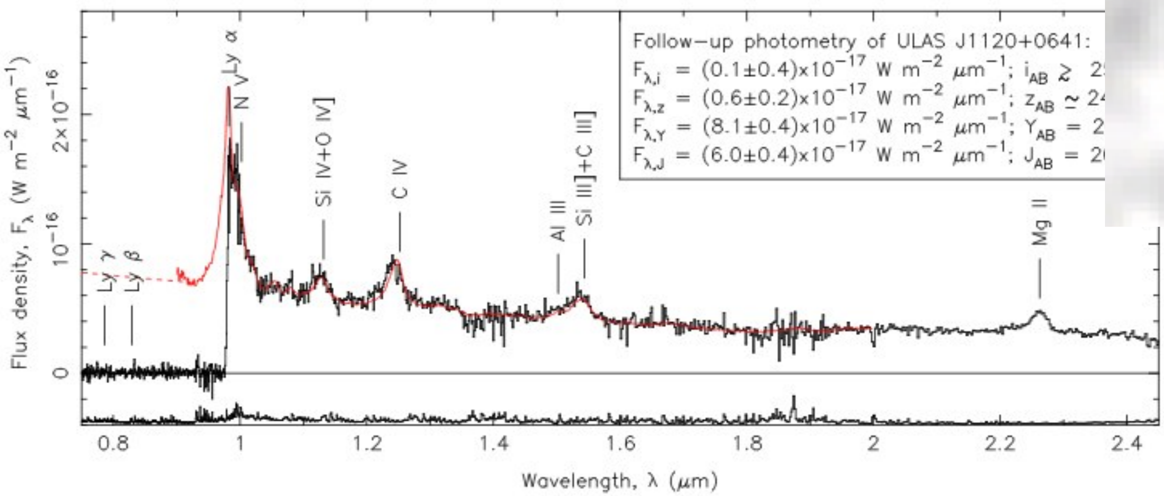
AGN Selection

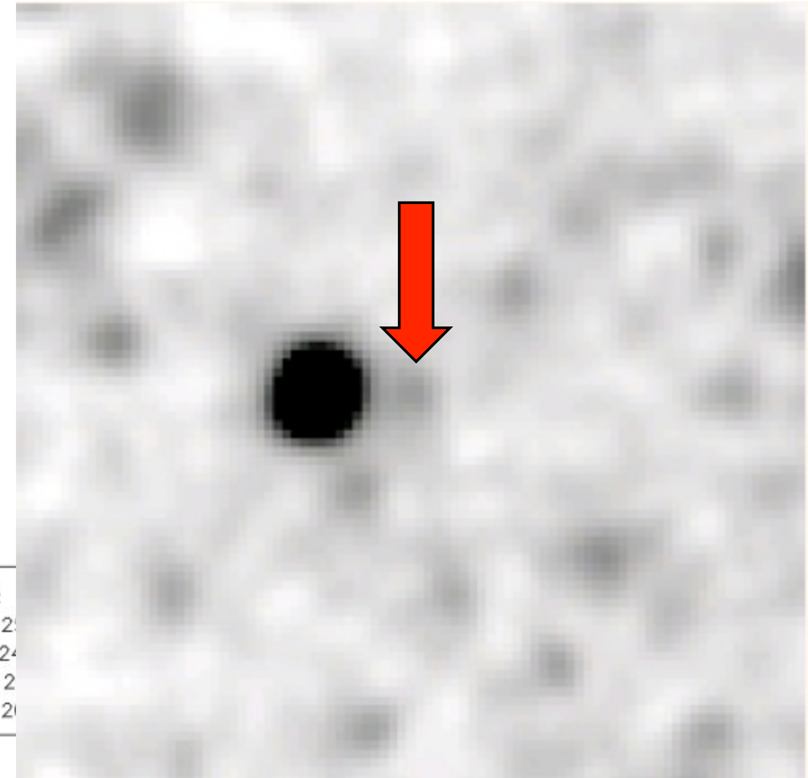
- Stern et al 2012, ApJ, 753, 30
- Density 70/sq.deg
- 60% have published z' s in COSMOS field



ULAS 1120+0641

- W1-W2 ≈ 1.17±0.31
- ≈43±8 μJy at 3.4 μm
- $z = 7.085$
- Mortlock etal, 2011, Nature, 474, 616, arXiv:1106.6088





- Need zYJH to find high redshift dropouts
- Width more important than depth

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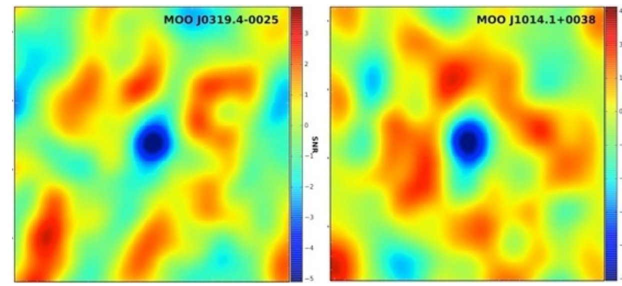
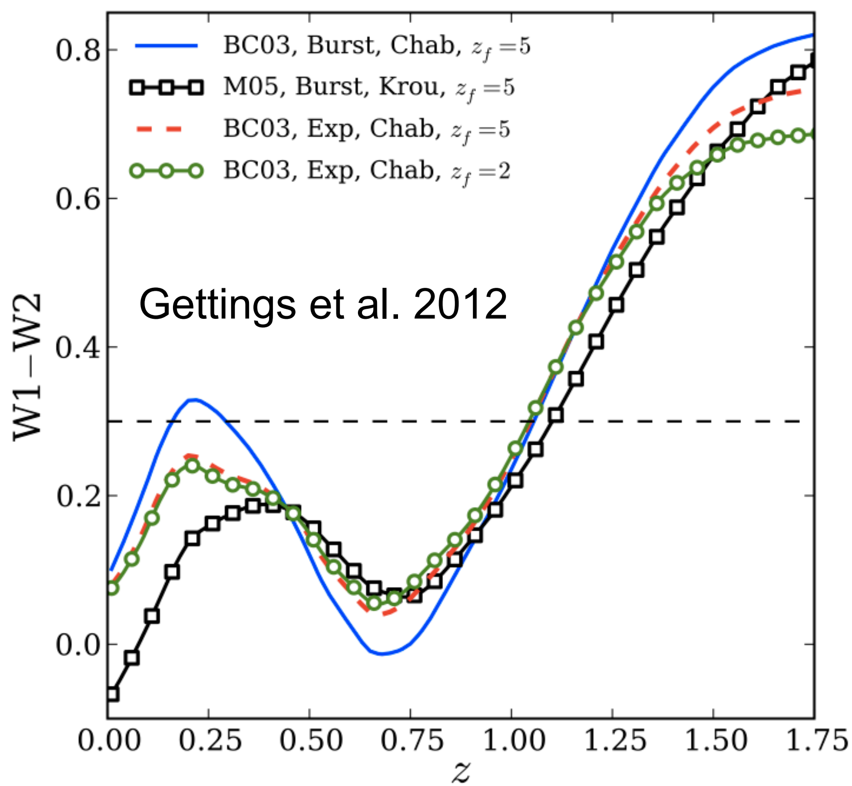
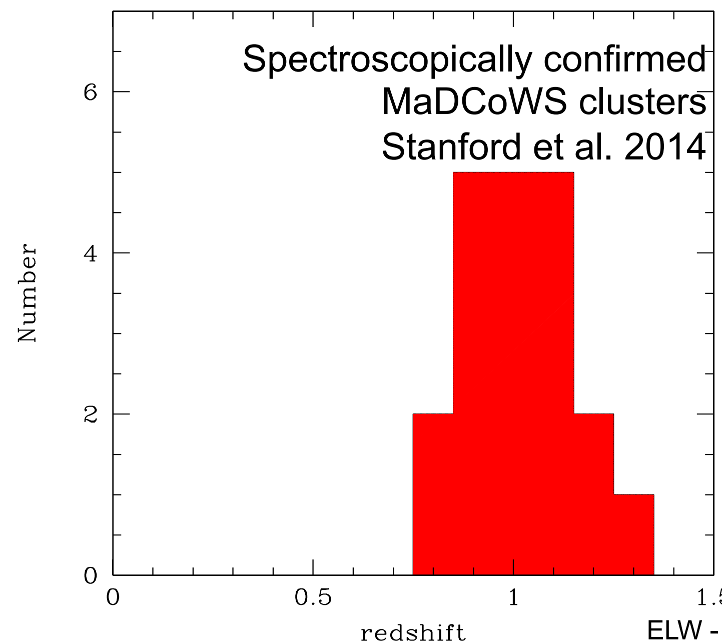
Massive Distant Clusters of WISE Survey (MaDCoWS)

- 20 MaDCoWS clusters at z ~ 1 (Stanford et al. 2014)
- CARMA S-Z signatures for 7 (Brodwin et al. 2014)
  - Time for 20 more allocated
- Current MaDCoWS sample W1 selected
- With MaxWISE, can select on W2 and probe massive structure growth in first half of Universe



M~5×10^{14} M$_{\odot}$ from CARMA S-Z
Brodwin et al. 2014





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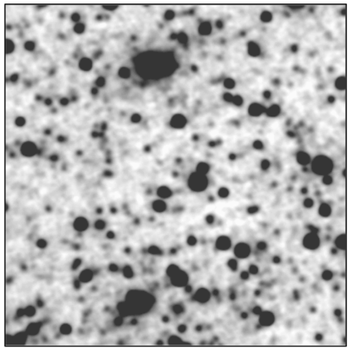
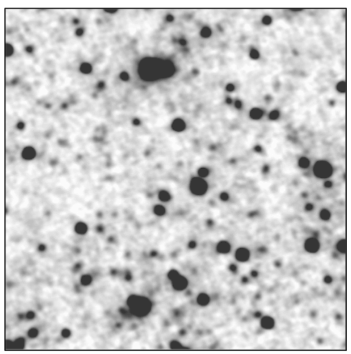
Distant Galaxies and MaxWISE

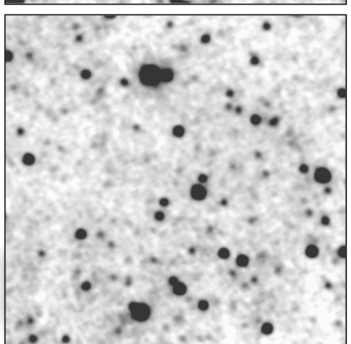
Increasing Exposures on North Ecliptic Pole



MaxWISE Depth

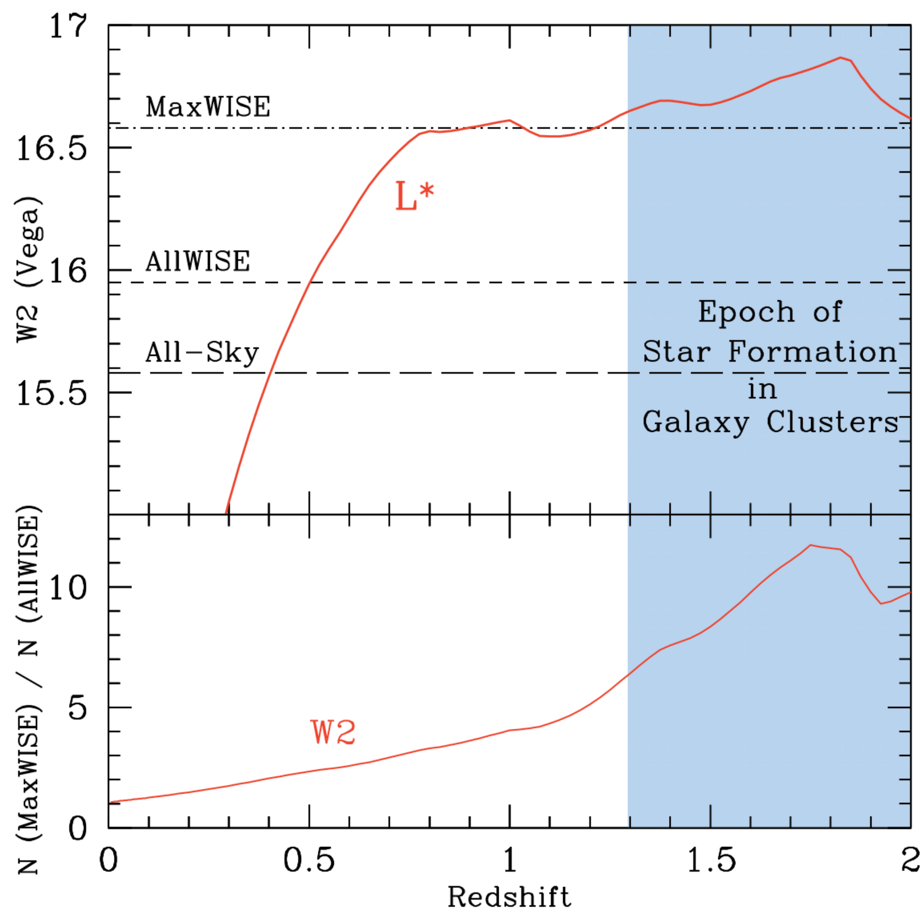


AllWISE Depth



WISE Depth

With four times as many exposures as AllWISE, MaxWISE sensitivity reaches a plateau for typical (L*) cluster galaxies that extends vastly further into the distant Universe



Astrophysics with NEOWISE-R

- Planetary only funds analysis up to single frame images and detection lists.
- A grand co-add of all the old WISE and new WISE data will be very valuable for astrophysics:
  - Proper motions get an order of magnitude better, parallax gets separated
  - Better 3.4 & 4.6 μm sensitivity yields many more $z > 1$ clusters of galaxies and millions of new QSOs & AGN
  - IR variability over hourly, semi-annual and longer time scales for stars and AGN, RR Lyr, Cepheids, LPVs
- Transient alerts using image subtraction
- Proposal submitted to NASA Astrophysics, 1st to the Explorer MoO call that was defunded, 2nd an unsolicited proposal @ their request, then to the senior review since Astrophysics was broke as usual. Unfunded again…