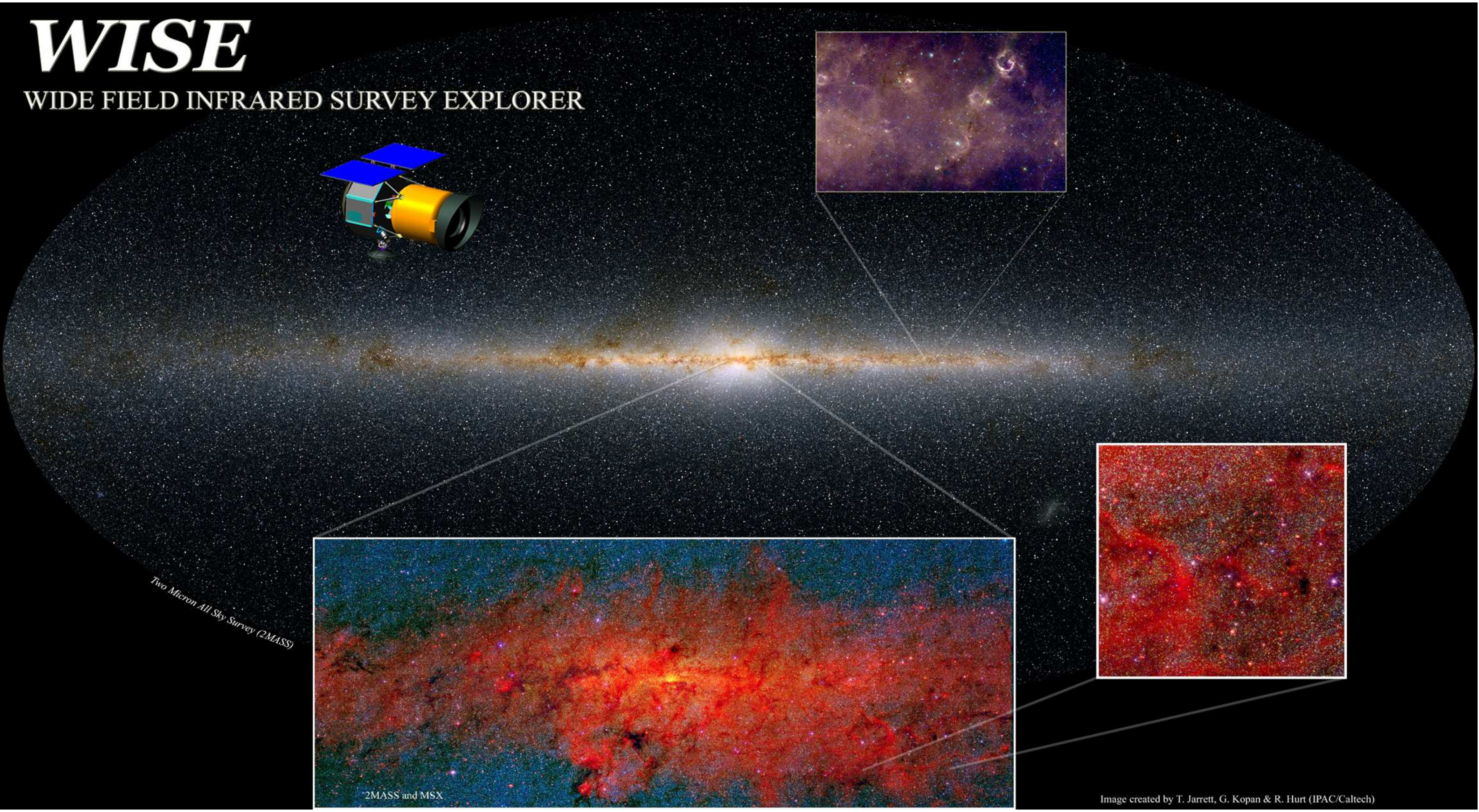
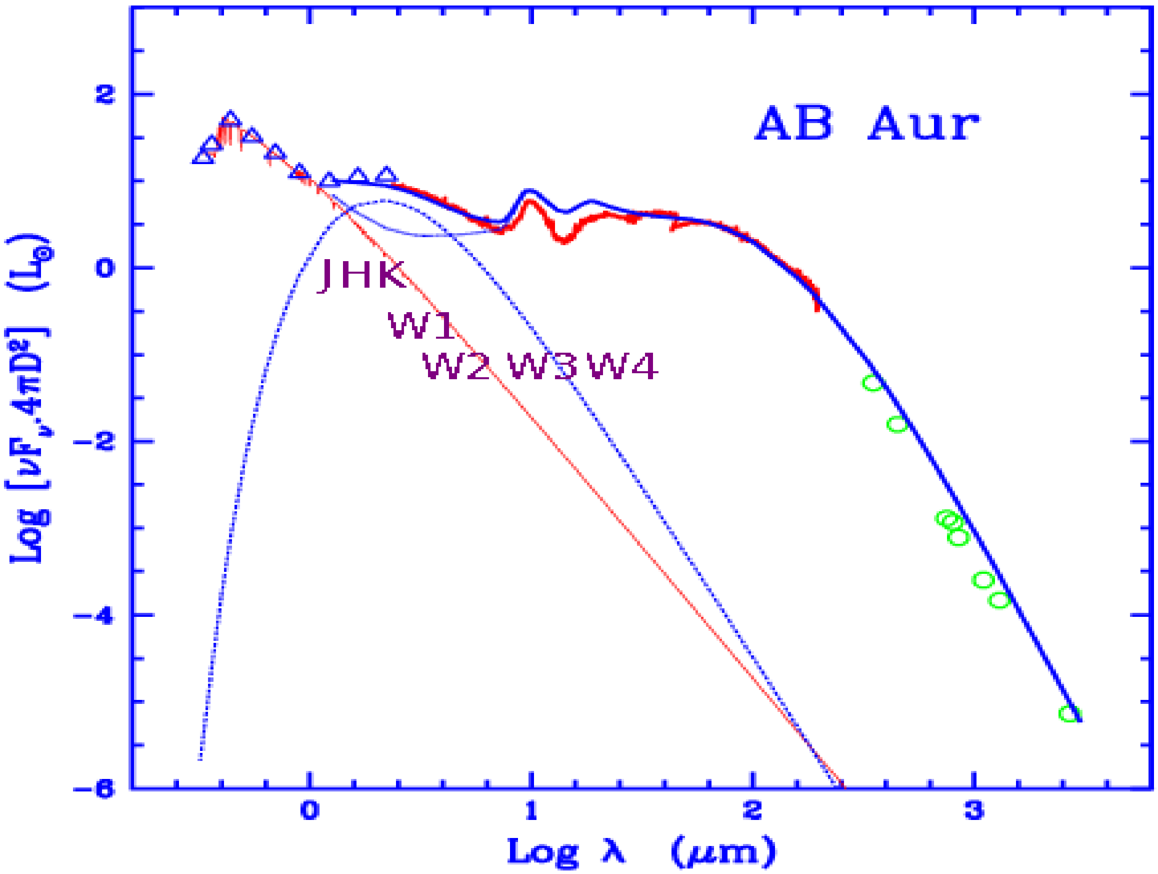

WISE
WIDE FIELD INFRARED SURVEY EXPLORER
Two Micron All Sky Survey (2MASS)
2MASS and MSX
Image created by T. Jarrett, G. Kopan & R. Hurt (IPAC/Caltech)

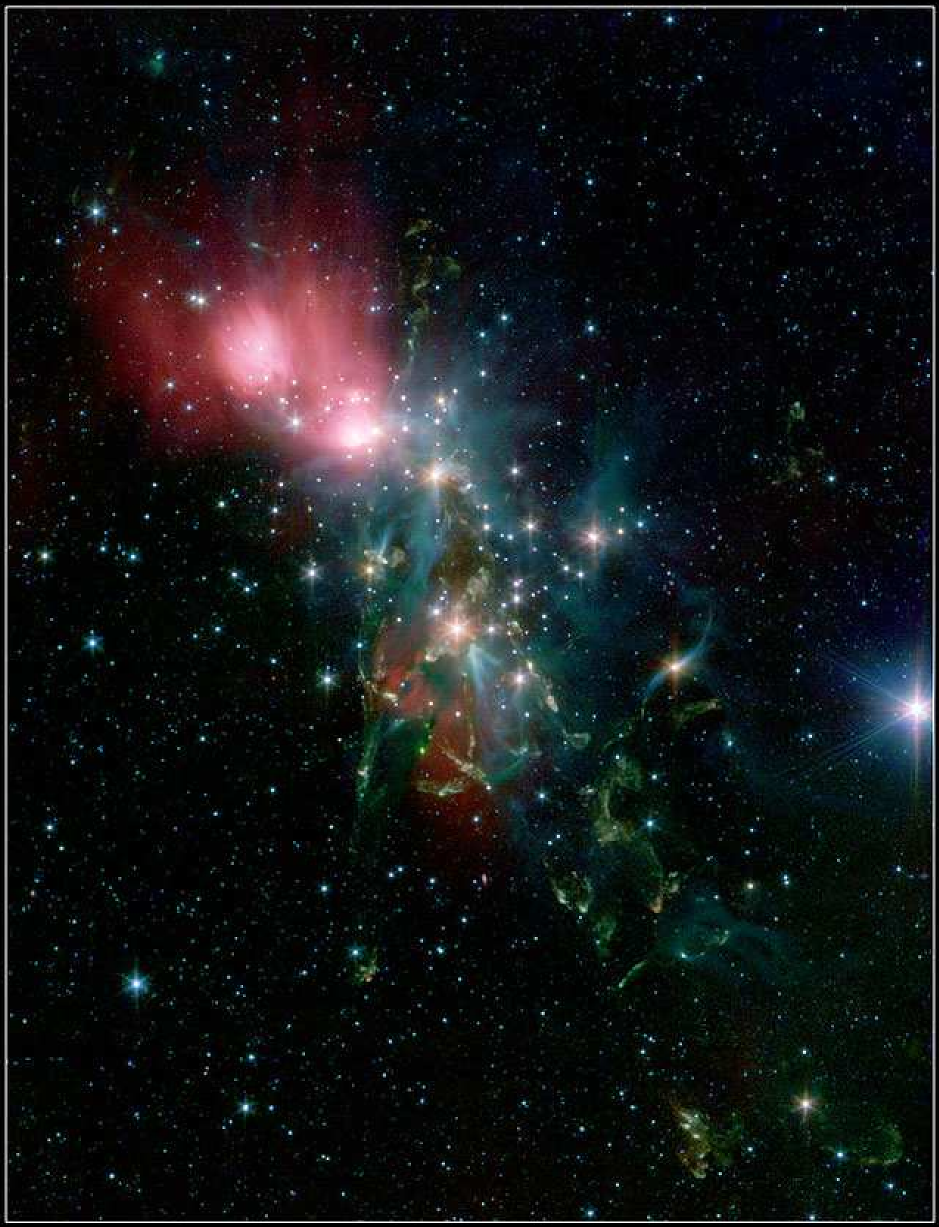
Mid-infrared Context

- On the first morning of this meeting three speakers/questioners emphasized the importance of "mid-infrared context" in the interpretation of sub-mm/mm observations.



Mid-infrared Context

- *Spitzer*, of course, has provided such context observations, but for a small portion of the sky.

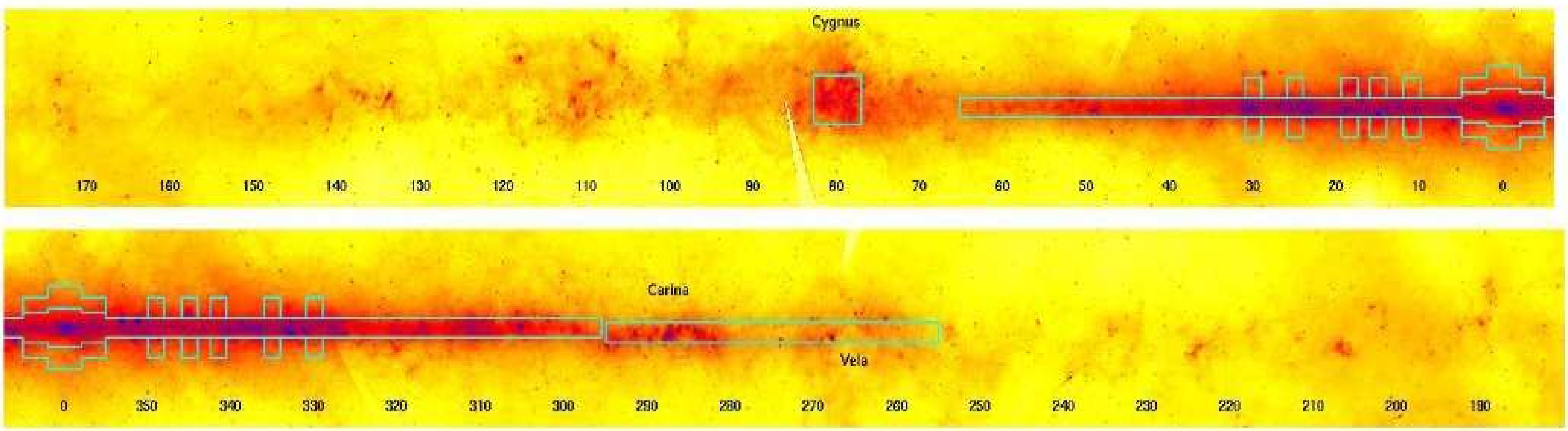


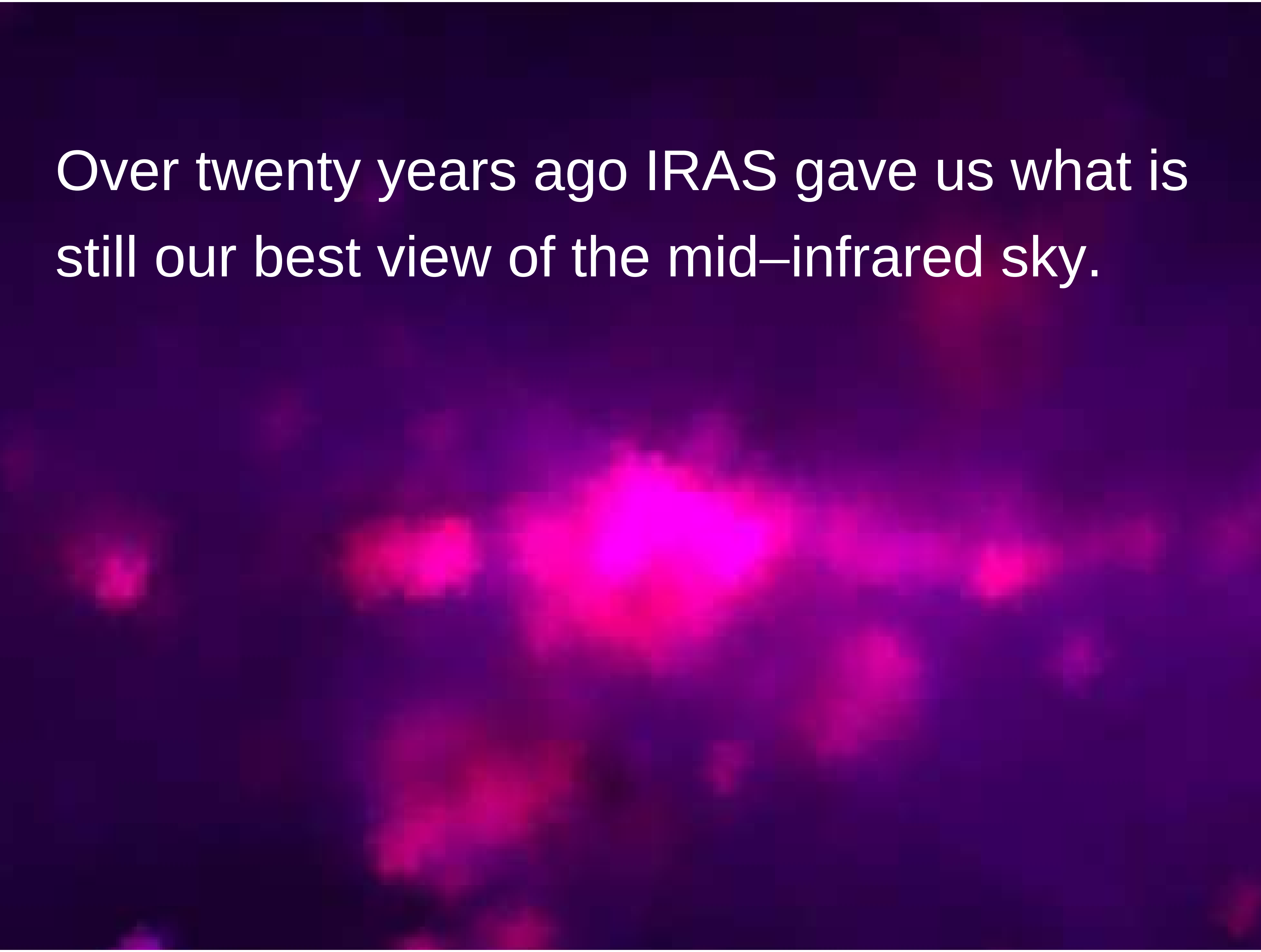
Star-Forming Region NGC 1333 Spitzer Space Telescope • IRAC

NASA / JPL-Caltech / R. Gutermuth (Harvard-Smithsonian Center for Astrophysics) ssc2005-24a

Mid-infrared Context

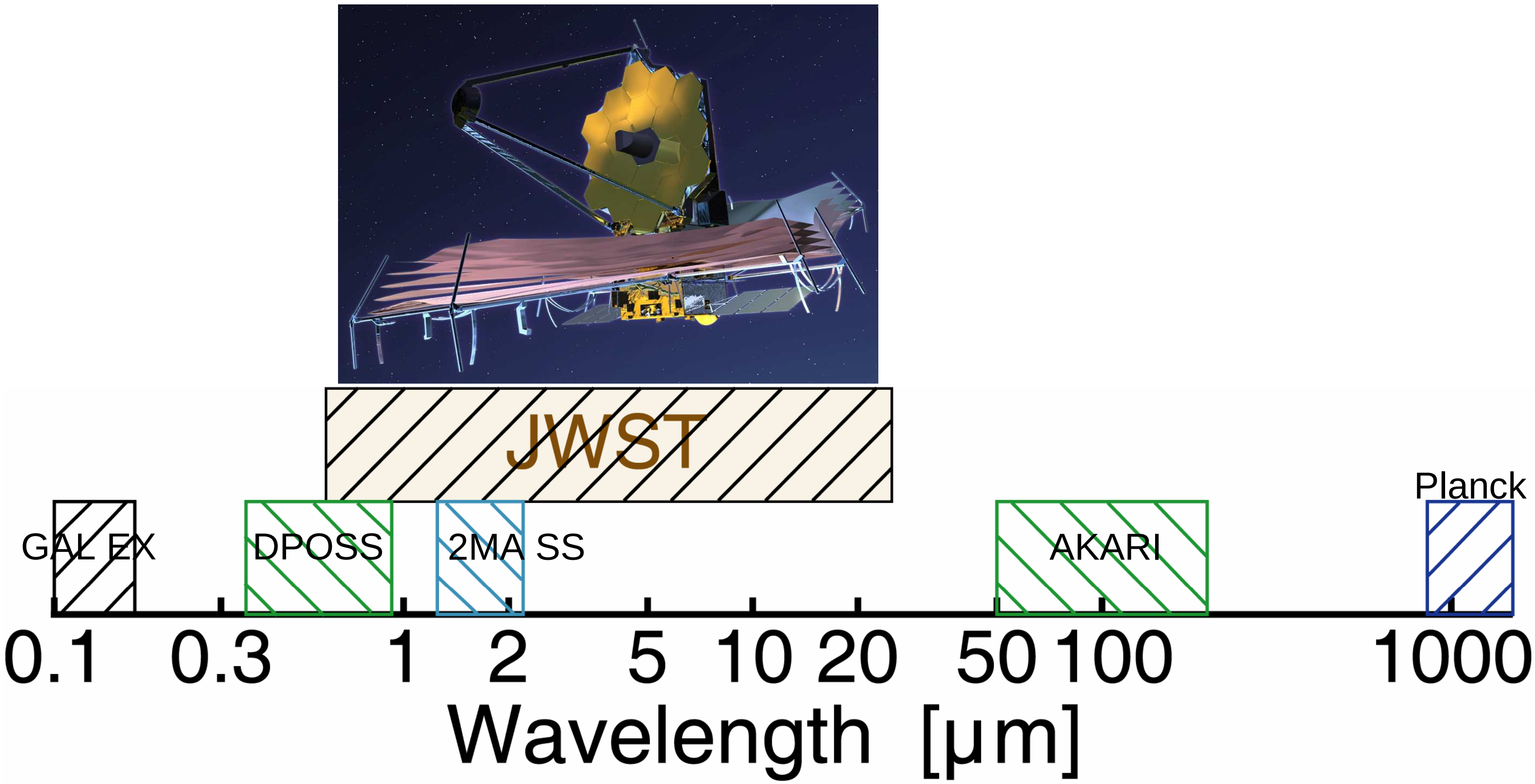
- *Spitzer*, of course, has provided context observations, but for a small portion of the sky.



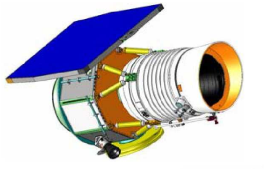

Over twenty years ago IRAS gave us what is still our best view of the mid–infrared sky.

WISE will map the entire sky with resolution comparable to the few square degrees shown here, achieving 500 times better sensitivity than IRAS at 12 and 23um and 10,000 times better than COBE at 3.3 and 4.7um.

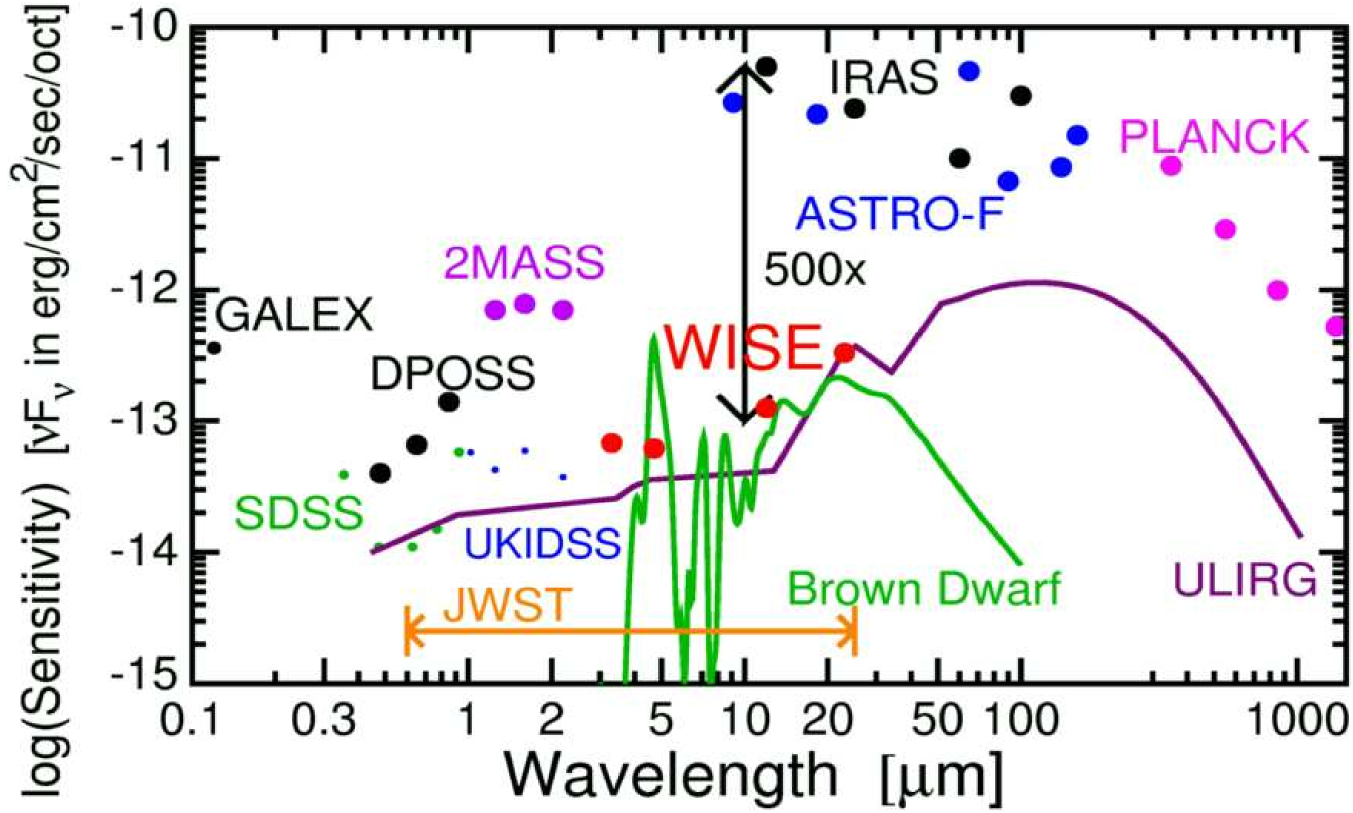
A critical gap in wavelength coverage

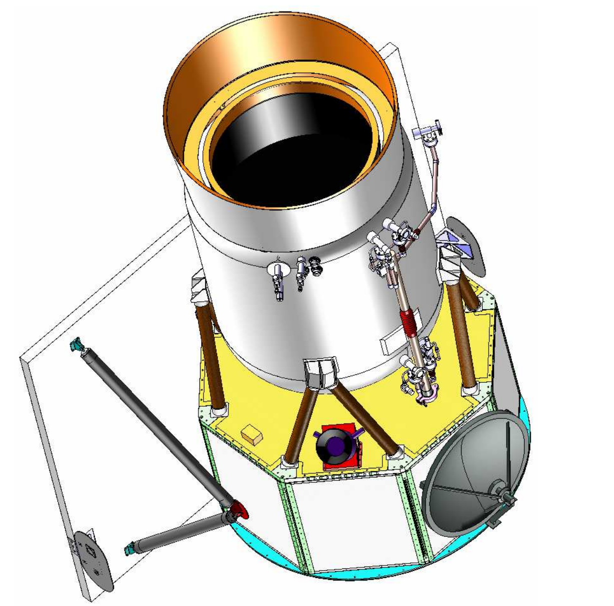


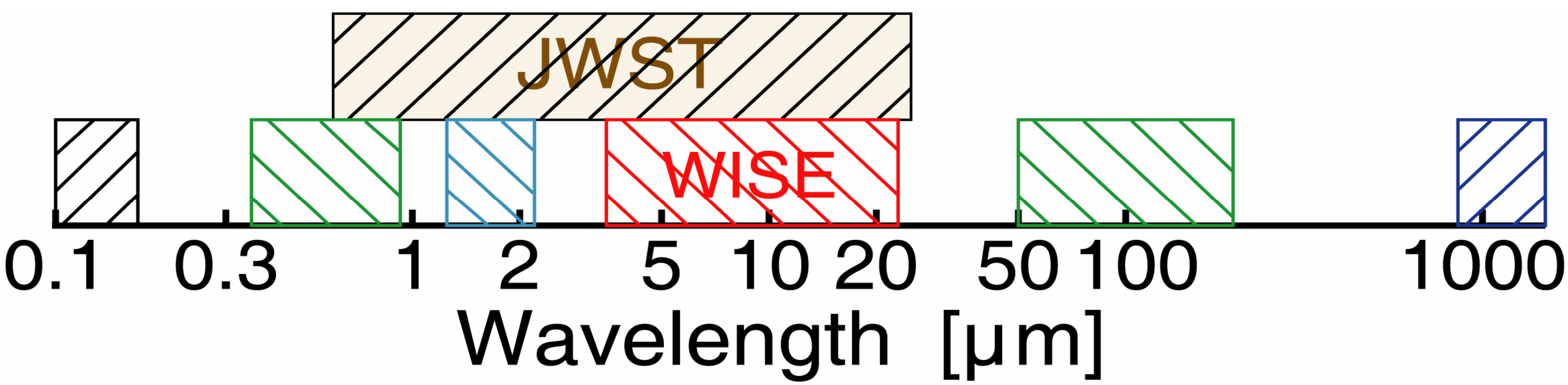
- ALMA and JWST science will be supported by existing and planned large scale, sensitive surveys except in a “gap” between 2.2 and 50 µm

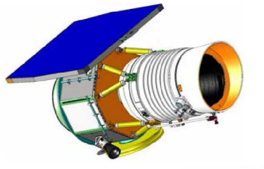


WISE Will Fill “the Gap”



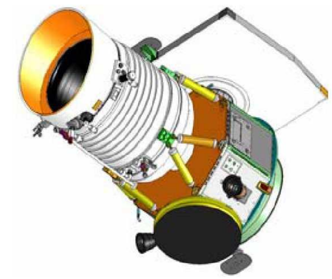




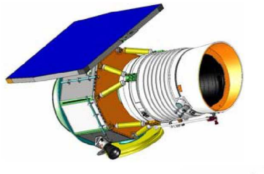


What Is WISE?

- Wide-field Infrared Survey Explorer (NASA MIDEX)
  - An all-sky survey at 3.3, 4.7, 12 & 23 um
    - ~150 uJy 5-sigma sensitivity in the shortest bands
    - ~ 1 mJy sensitivity at 12 and 23 um
  - Enabled by the latest “megapixel” mid-infrared arrays
  - Scheduled for launch in November 2009



- WISE will deliver to the scientific community
  - Over 1 million calibrated images covering the sky in the four bands with 6” resolution (12” at 23um)
  - Catalogs of about 3 x 10^8 objects seen in these 4 IR bands



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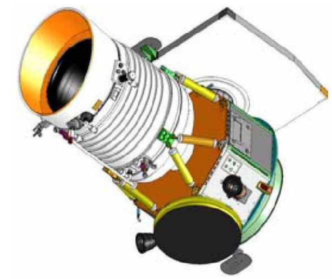

- WISE will deliver to the scientific community
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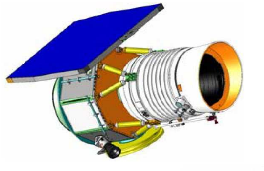

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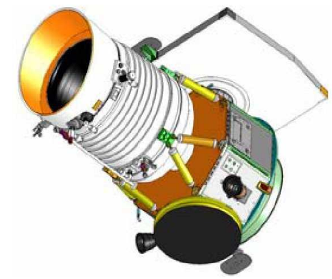
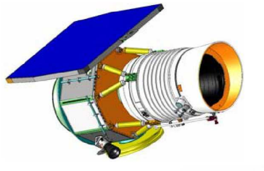


- WISE will deliver to the scientific community
  - A bucketload of previously unknown primary targets for ALMA
  - Mid-infrared context anywhere in the sky

Why *another* Survey?

- Large scale surveys point the way for myopic large telescopes.
  - e.g. POSS in support of Palomar

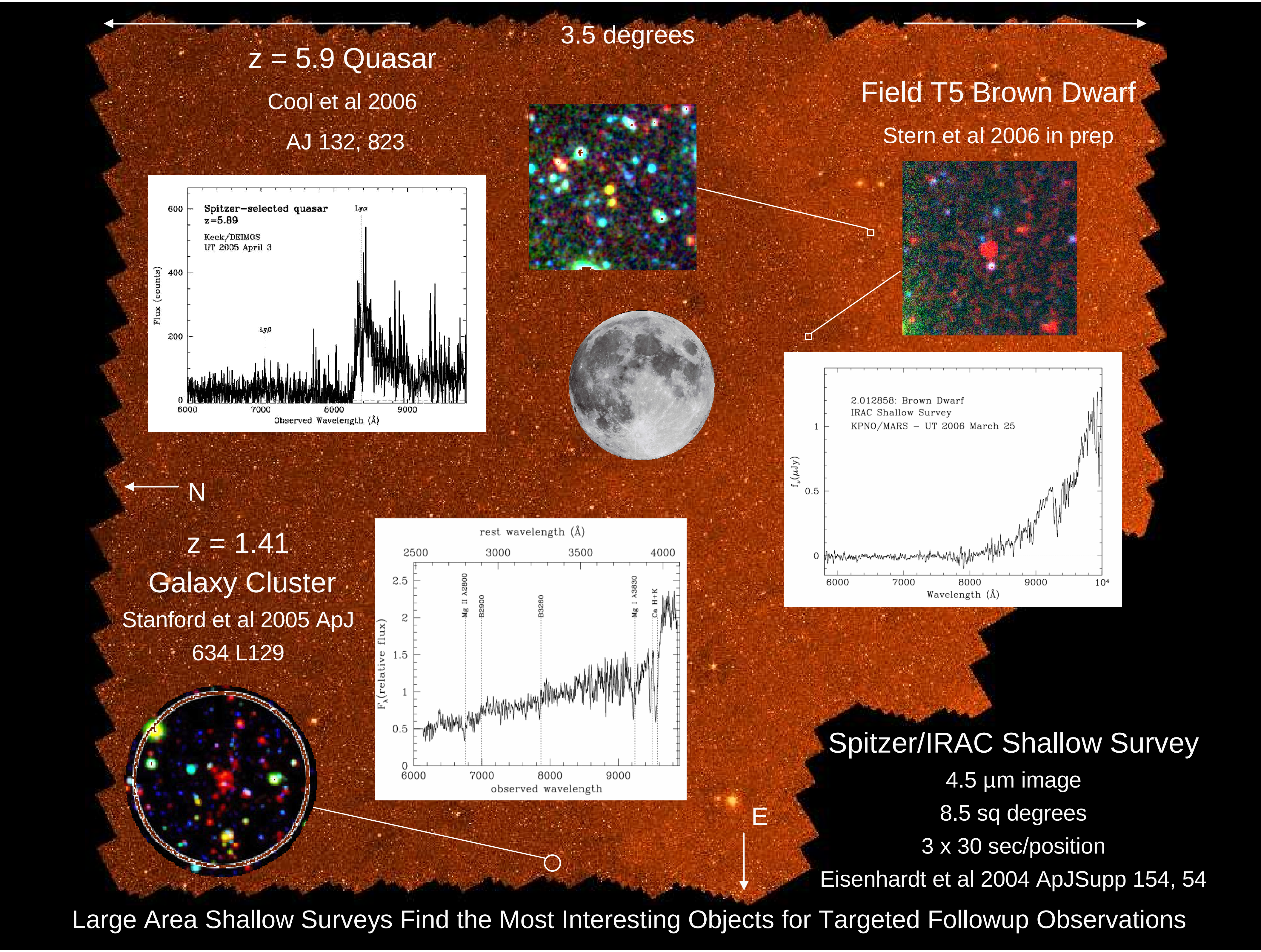


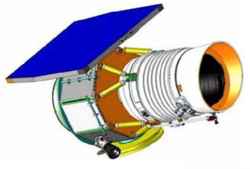
Why All Sky?

- For superlative and/or unique objects, such as the nearest stars or the most luminous galaxies, only an all-sky survey will do.

- For uniformly distributed objects, a fast shallow survey finds more sources per unit time than a deep narrow survey.

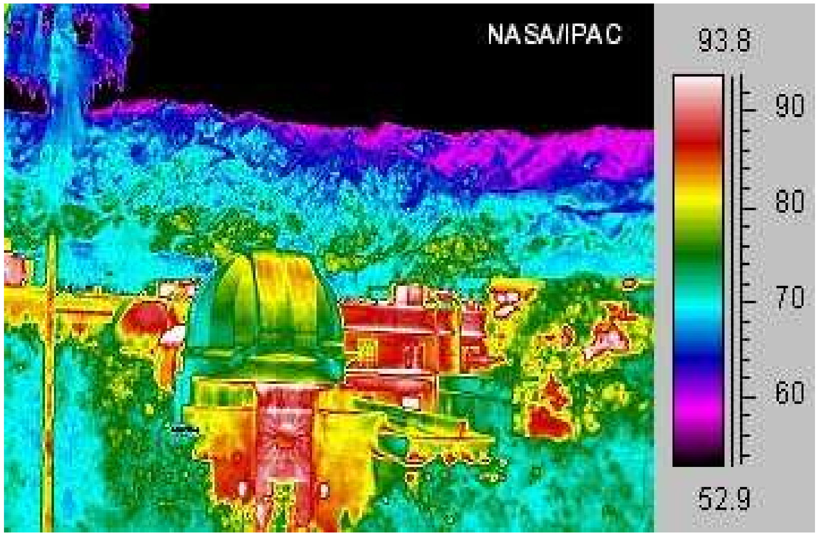
- An all-sky survey finds the brightest objects in a class, which are the easiest to follow up in detail with JWST, ALMA, etc.

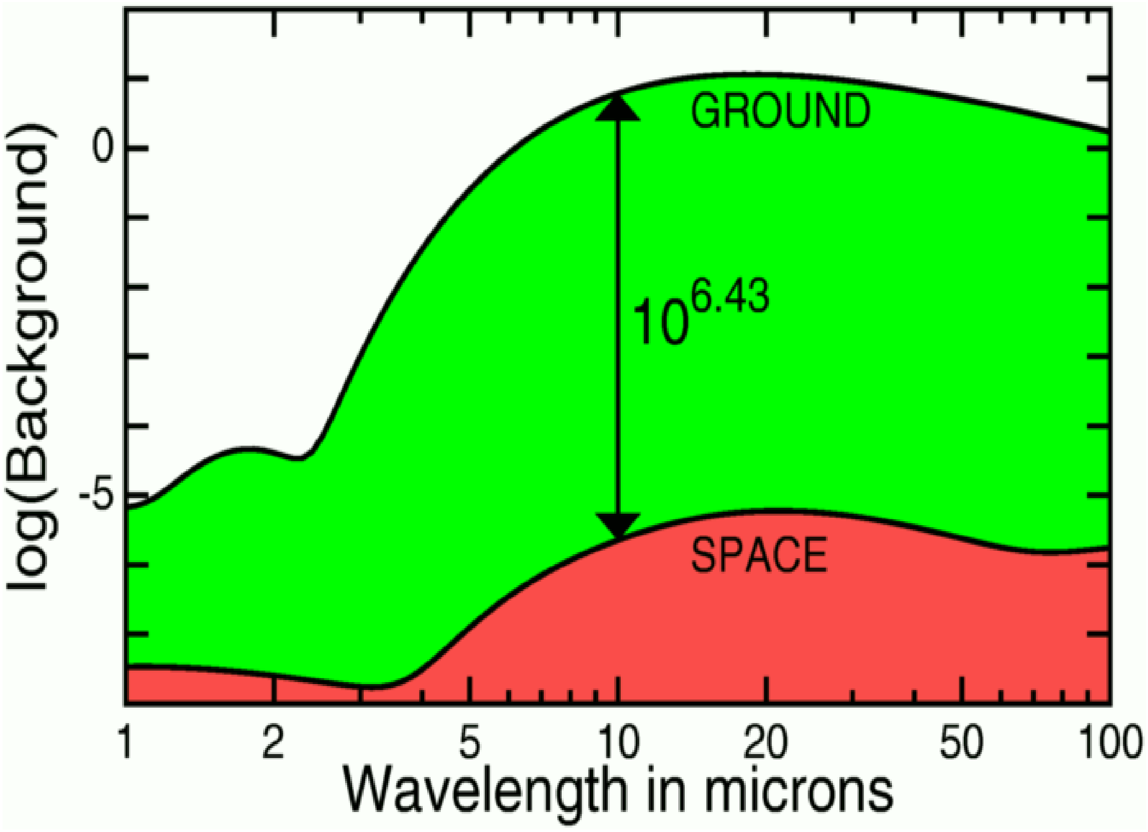

3.5 degrees
z = 5.9 Quasar
Cool et al 2006
AJ 132, 823
Spitzer−selected quasar
z=5.89
Keck/DEIMOS
UT 2005 April 3
Lyα
Lyβ
Flux (counts)
Observed Wavelength (Å)
Field T5 Brown Dwarf
Stern et al 2006 in prep
2.012858: Brown Dwarf
IRAC Shallow Survey
KPNO/MARS − UT 2006 March 25
f_ν (μJy)
Wavelength (Å)
N
z = 1.41
Galaxy Cluster
Stanford et al 2005 ApJ
634 L129
rest wavelength (Å)
F_λ(relative flux)
Mg II λ2800
B2900
B3260
Mg I λ3830
Ca H+K
observed wavelength
E
Spitzer/IRAC Shallow Survey
4.5 μm image
8.5 sq degrees
3 x 30 sec/position
Eisenhardt et al 2004 ApJSupp 154, 54
Large Area Shallow Surveys Find the Most Interesting Objects for Targeted Followup Observations



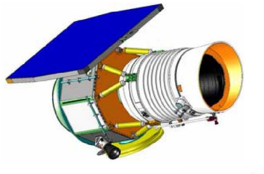
Why a Small Telescope in Space?

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





The 40 cm WISE telescope operating at 17K in space equals hundreds of 8-meter telescopes on the ground!

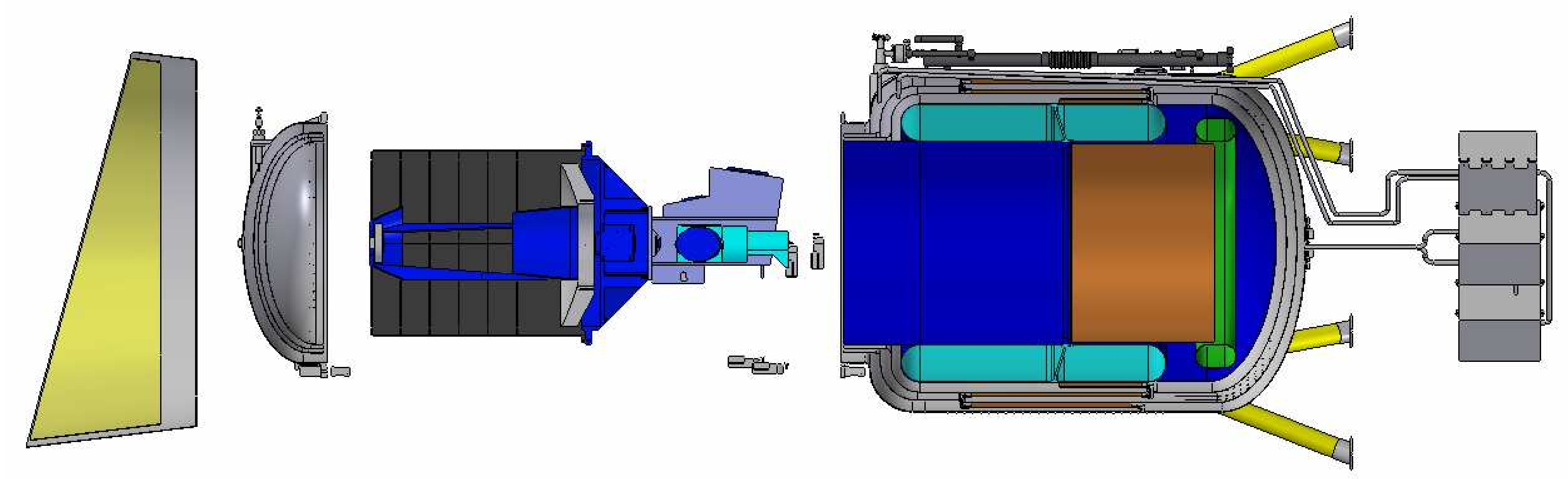


Implementing WISE

2-Stage Aperture Shade
- Radiatively cooled
- Protects aperture from stray sun/ earth radiation
-

Telescope Assembly
- 40-cm afocal front end
- Scan mirror
- Refractive MWIR imager
- Reflective LWIR imager

Cryostat
- 2-stage solid hydrogen
- Secondary tank cools optics & MCT FPAs
- Primary tank cools Si:As FPAs
- 2 vapor-cooled shields
- Composite support-tube structure



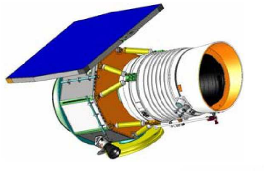
Aperture Cover
- Deployed on-orbit
- Seals vacuum space on ground

Focal Planes
- 2 MWIR MCT arrays
- 2 LWIR Si:As arrays
- Cryogenic cables

Electronics
- Focal-plane electronics
- Command/Control/ Telemetry
- Housekeeping/scan-mirror control
- Data Compression

WISE Science Team

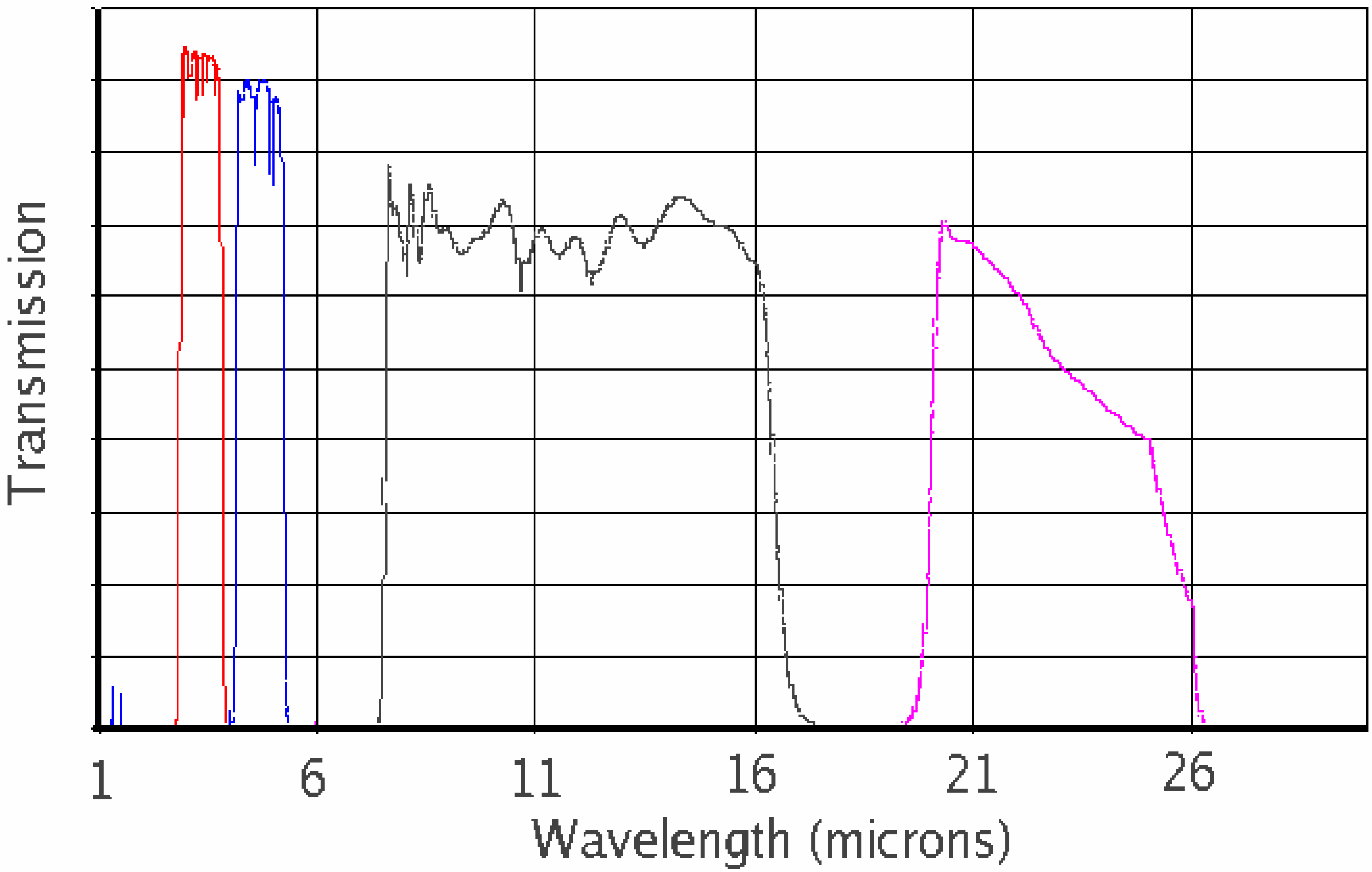
- **Edward L. Wright** UCLA (PI)
- Andrew Blain Caltech
- Martin Cohen MIRA
- Nahide Craig UC Berkeley
- Roc Cutri IPAC/Caltech
- Peter Eisenhardt JPL (Proj. Sci)
- T. Nick Gautier JPL
- Isabel Hawkins UC Berkeley
- Thomas Jarrett IPAC/Caltech
- J. Davy Kirkpatrick IPAC/Caltech
- David Leisawitz GSFC
- Carol Lonsdale IPAC/Caltech
- Amanda Mainzer JPL
- John Mather GSFC
- Ian McLean UCLA
- Robert McMillan Univ. of Arizona
- Deborah Padgett IPAC/Caltech
- Michael Ressler JPL
- Michael Skrutskie Univ. of Virginia
- S. Adam Stanford UC Davis
- Russell Walker MIRA



Science Drivers = Bandpass Selection

- The defining feature of any survey is the wavelength coverage
- WISE primary science objectives
  - Find the most luminous galaxies in the Universe
    - 10 – 30 ❍m required
  - Find the closest “stars” to the Sun
    - 3 – 5 ❍m ideal
- Additional key science
  - Detect thermal emission from nearly a million asteroids
  - Enable a complete census of Galactic star formation and structure
  - Broadly survey for debris disk candidates
  - Survey every nearby normal galaxy (and clusters to z~1)
  - Serendipity TBD

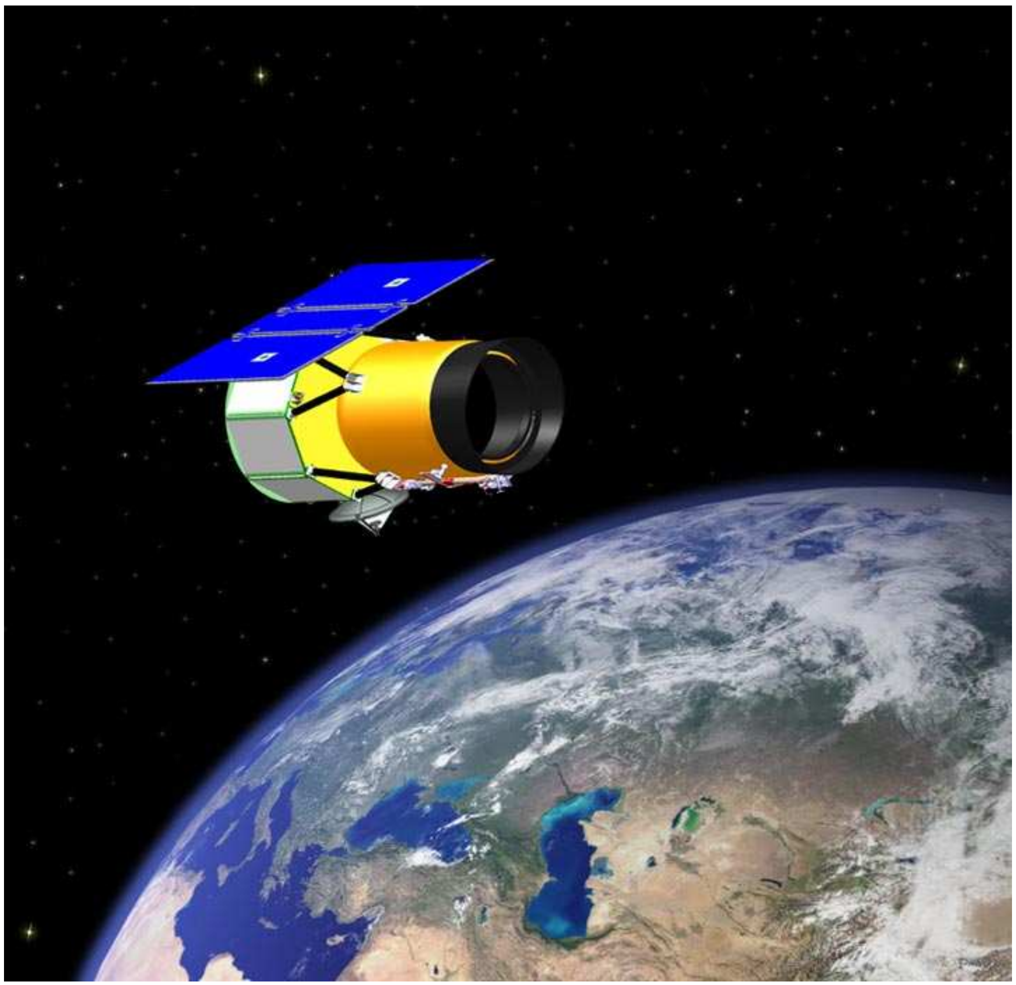
WISE Bandpasses

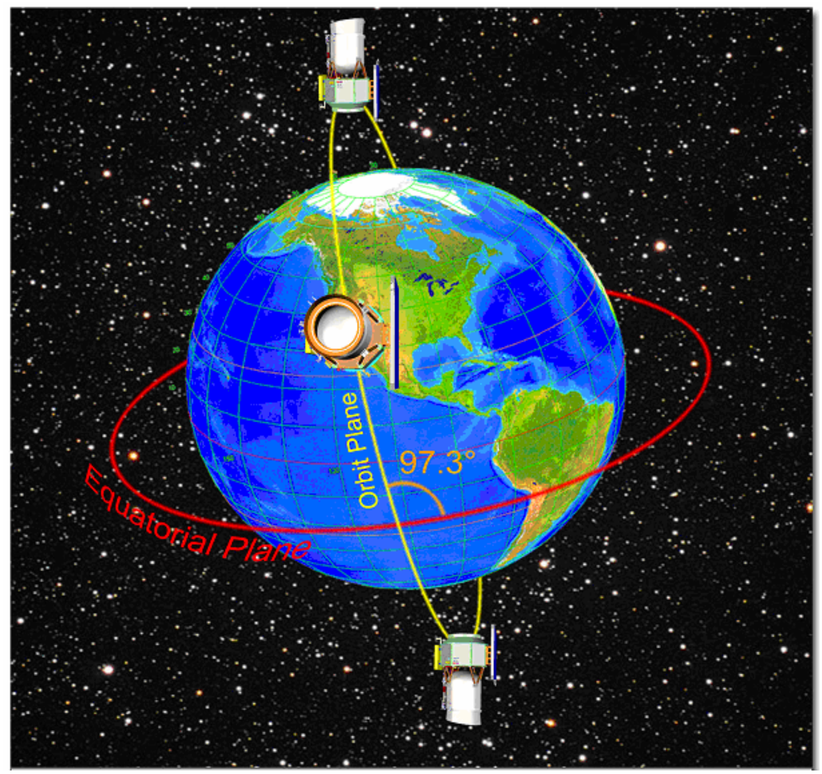


A Precessing Sun-synchronous Orbit

– "IRAS/COBE" orbit

- Blitzer, Weisfield, and Wheelon, *J. Appl. Phys,* (1957)
- 525km, inclination 98 degrees





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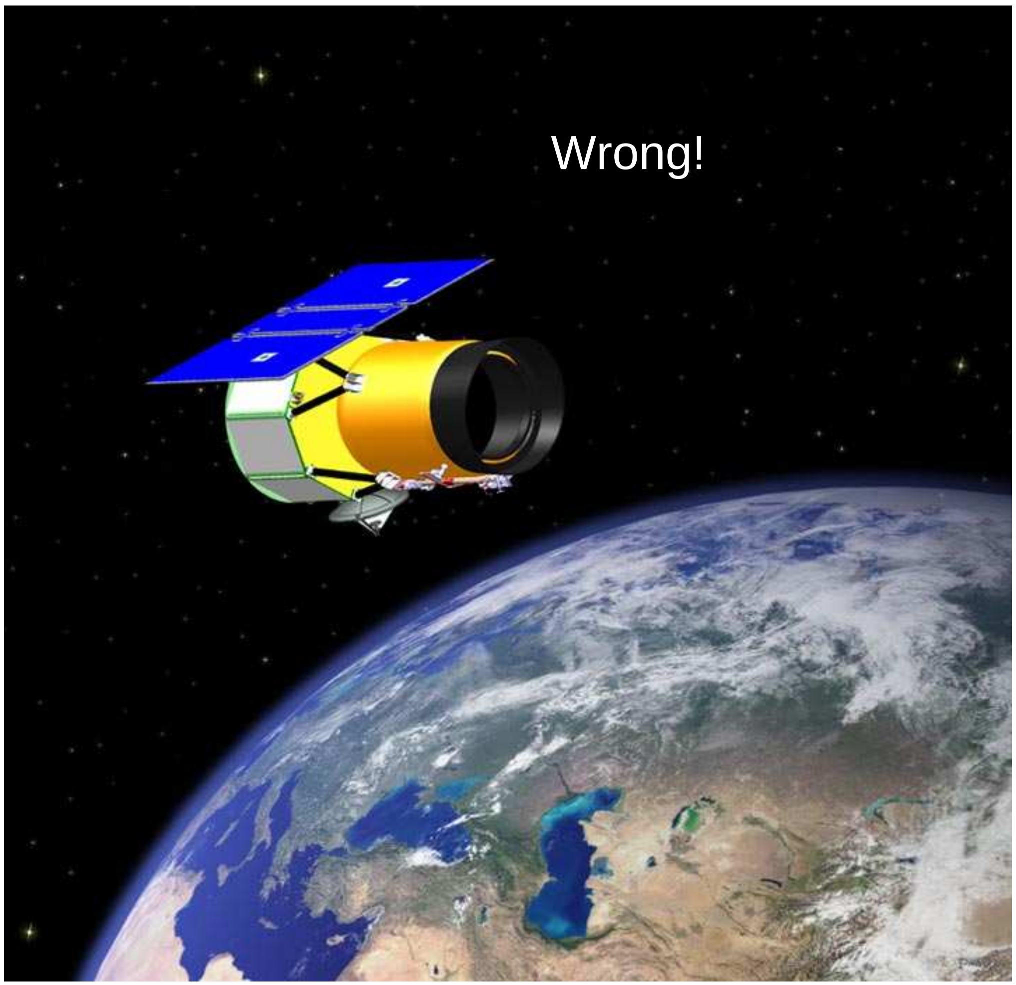
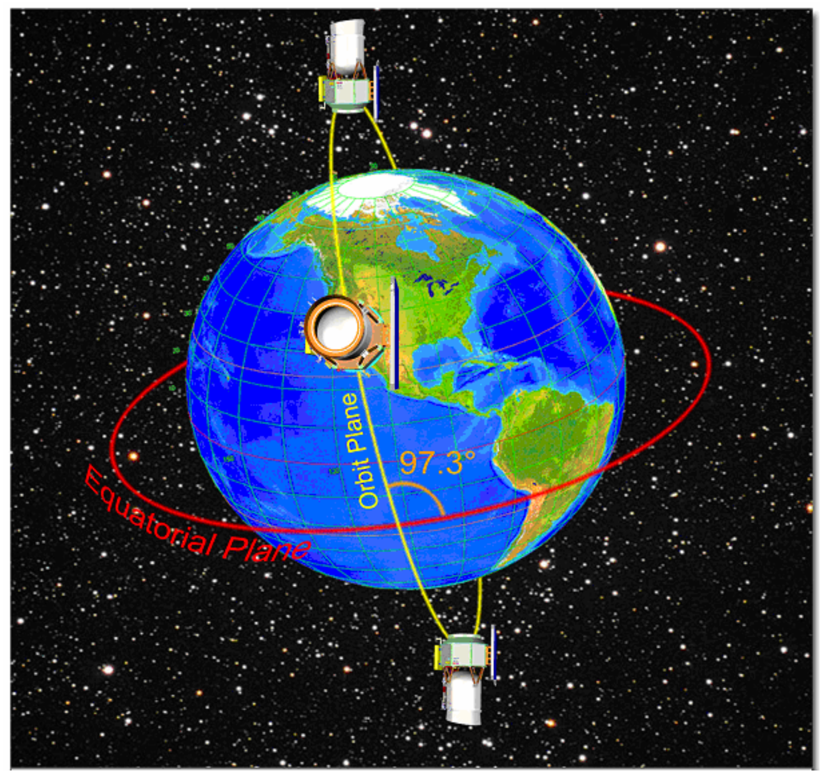
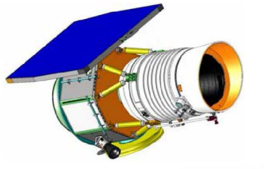


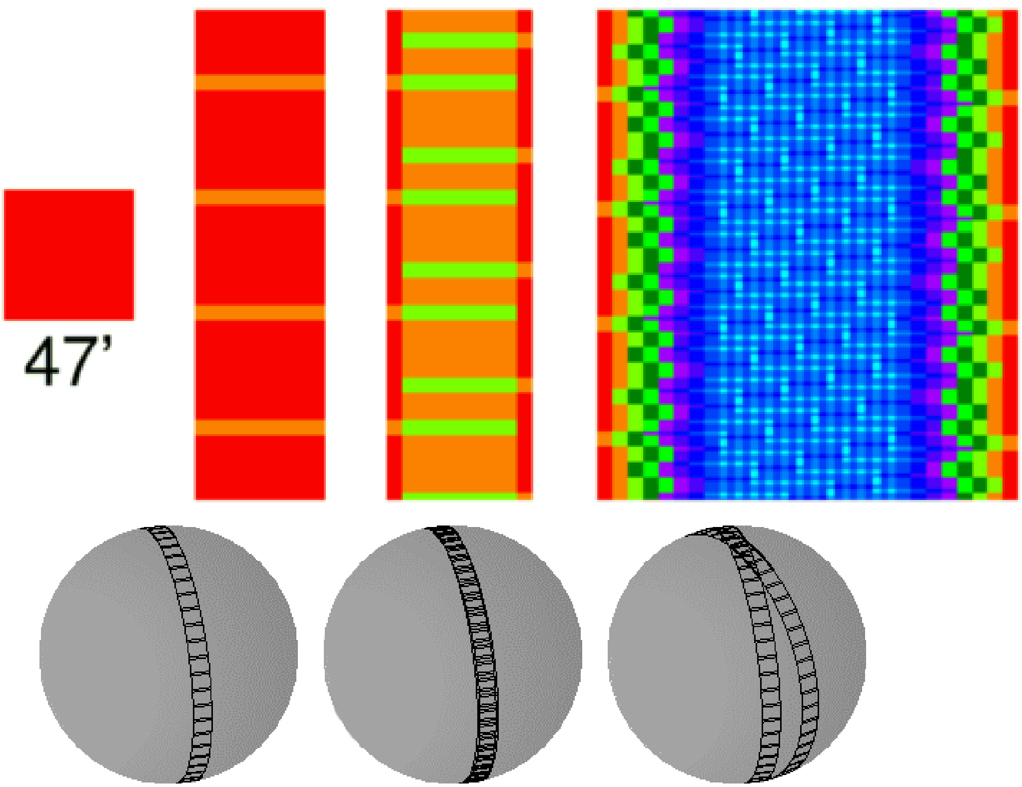




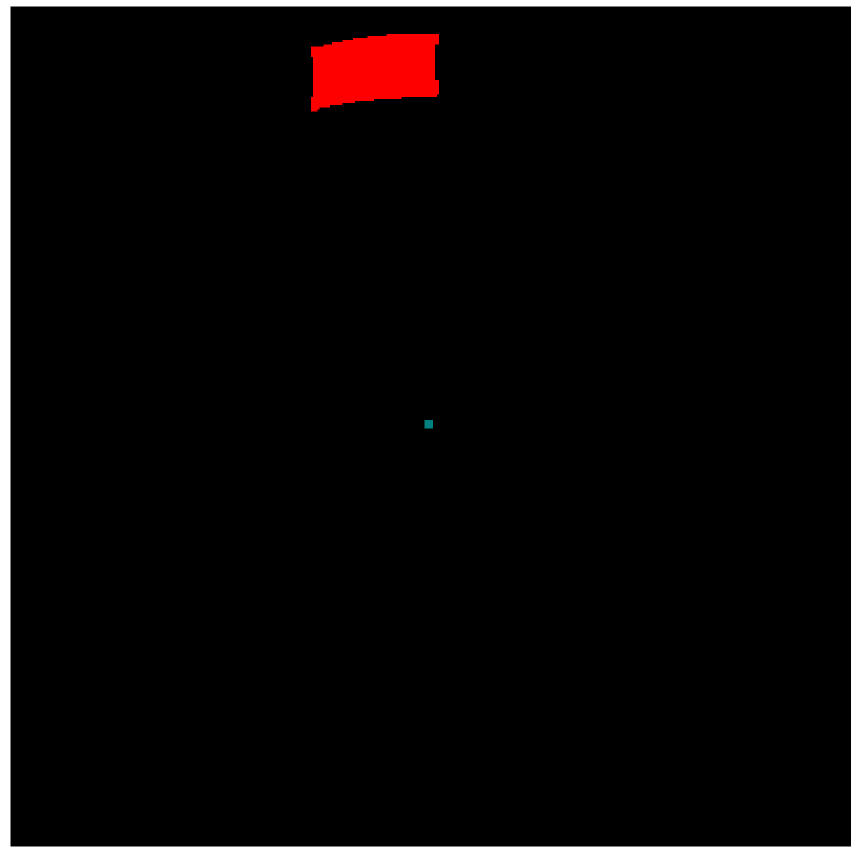
WISE Survey Strategy Provides ≥8 Exposures Per Position

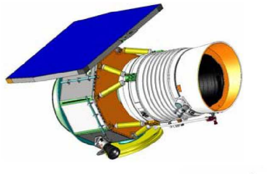
- Scan mirror enables efficient surveying
  - 8.8-s exposure/11-s duty cycle
- 10% frame to frame overlap
- 92% orbit to orbit overlap
- Sky covered in 6 months observing

- Single observing mode
- 8 or more over 99+% of sky, median 14 exposures/position after losses to Moon and SAA



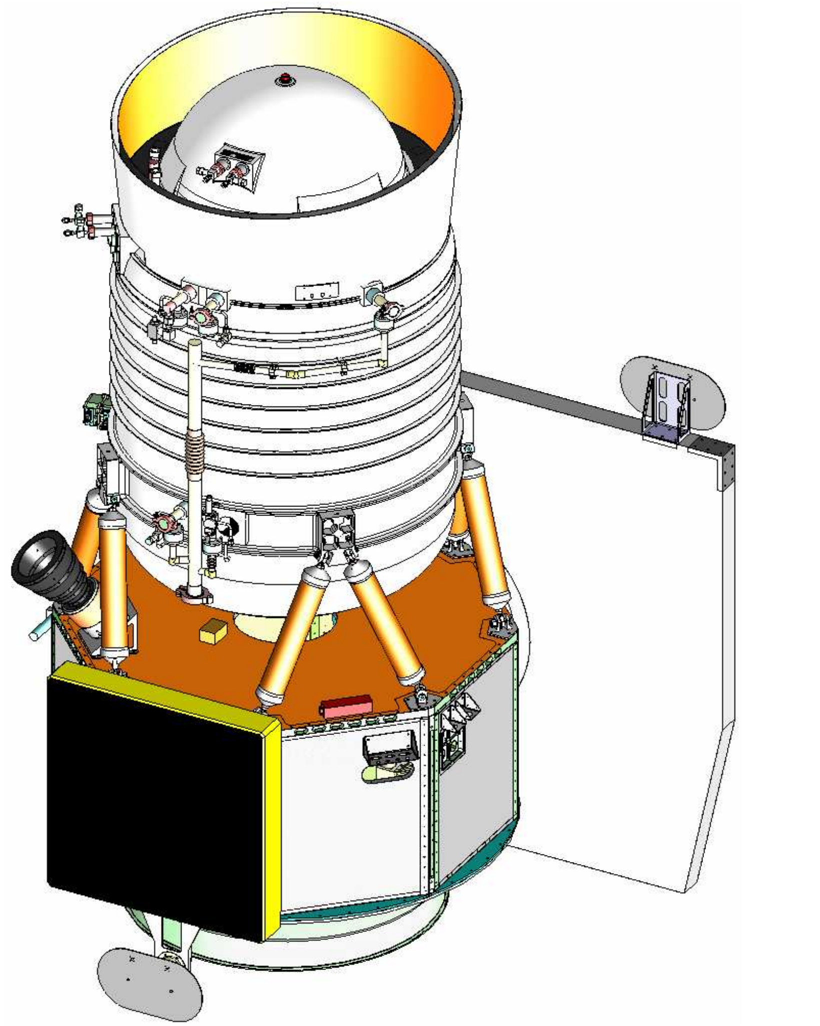
1 Orbit | 2 Consecutive Orbits | 2 Orbits 20 Days Apart



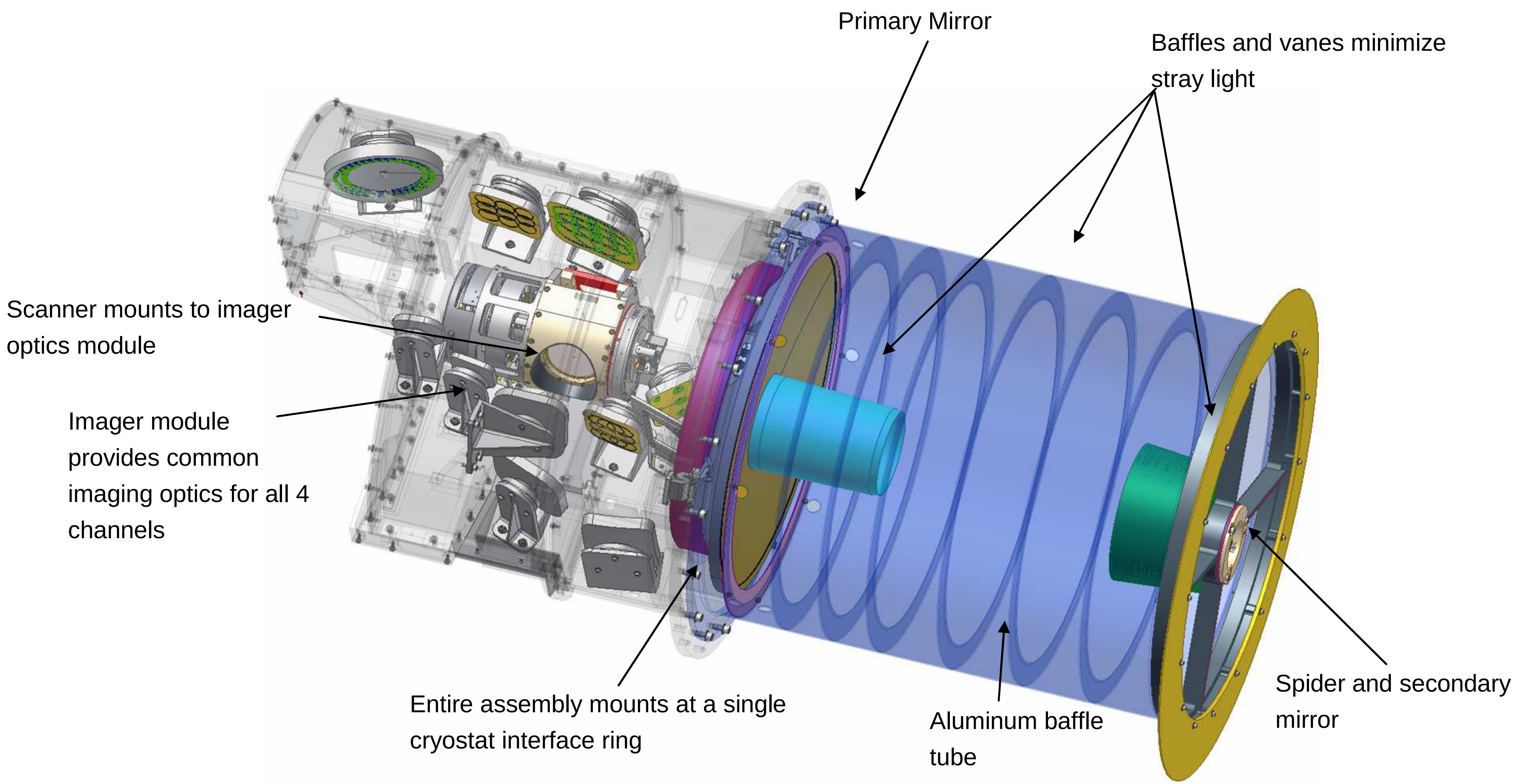


Flight System

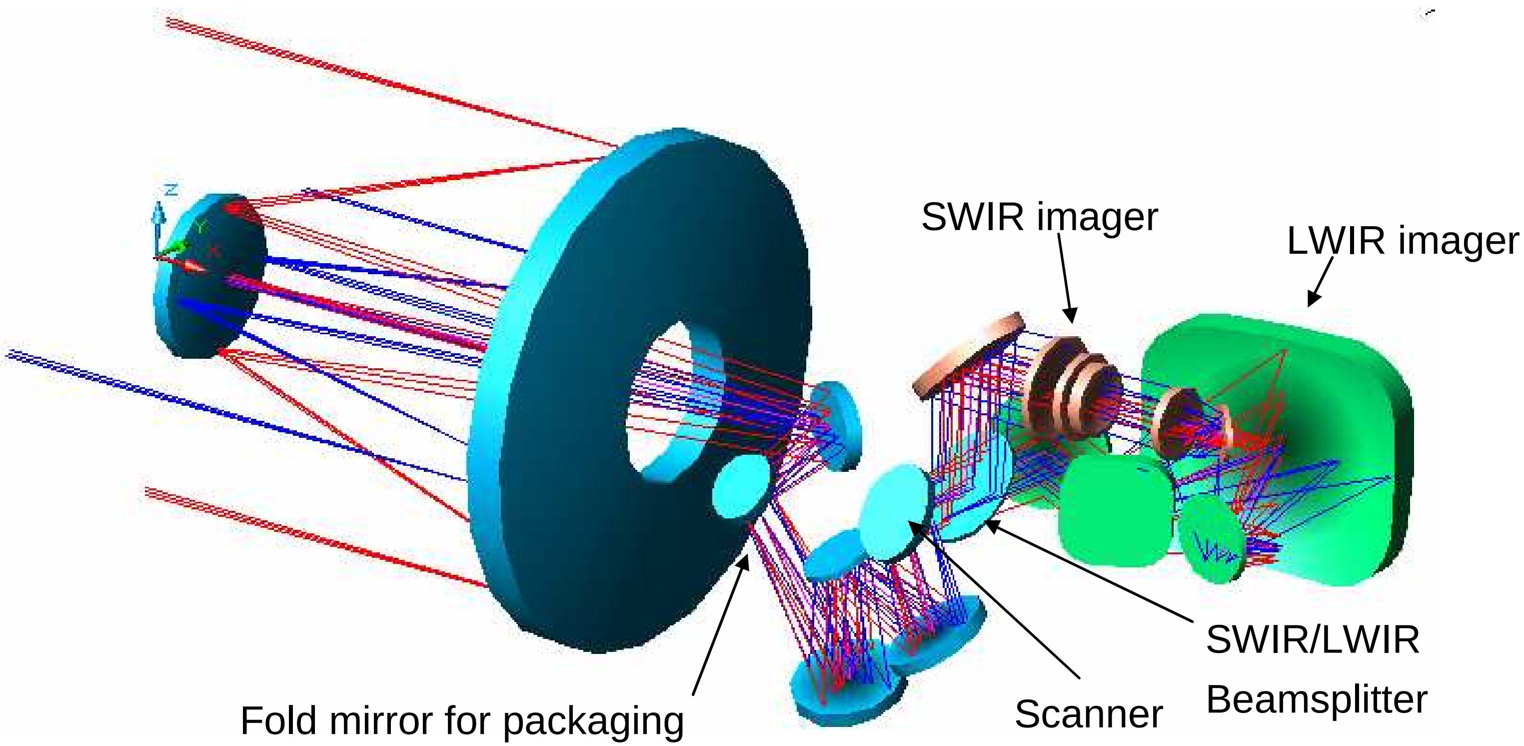
- 4 imaging channels covering 3 - 25 microns wavelength
- HgCdTe and Si:As arrays with 1024^2 2.75 arcsec pixels
- 40 cm diamond turned aluminum telescope primary operating at <17K
- Two stage solid hydrogen cryostat
- Delta launch from Vandenberg in Nov, 2009
- Sun-synchronous 6am/6pm 500km orbit
- Scan mirror provides efficient mapping
- Operational life: 7 months (130% margin)



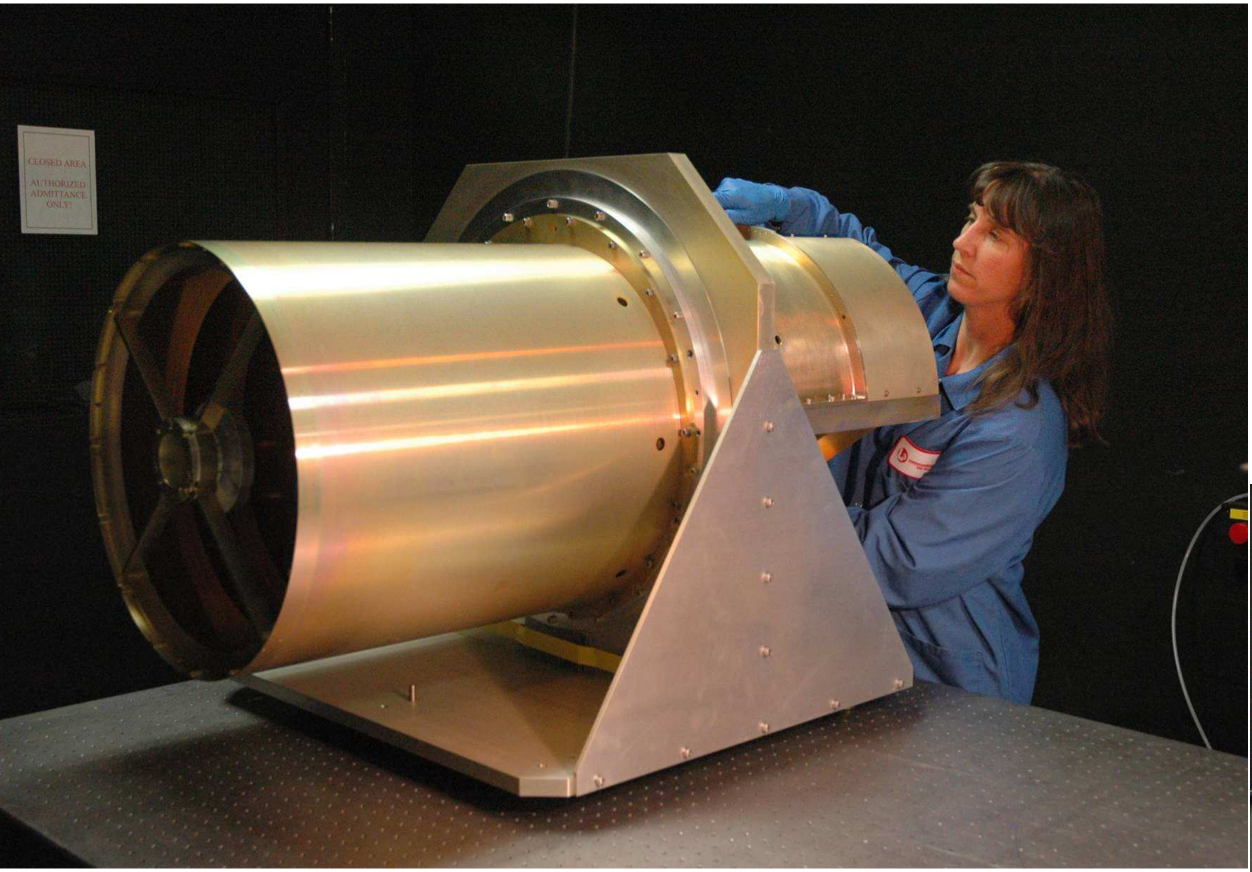
The WISE End-to-End Optical System with Embedded Scanner

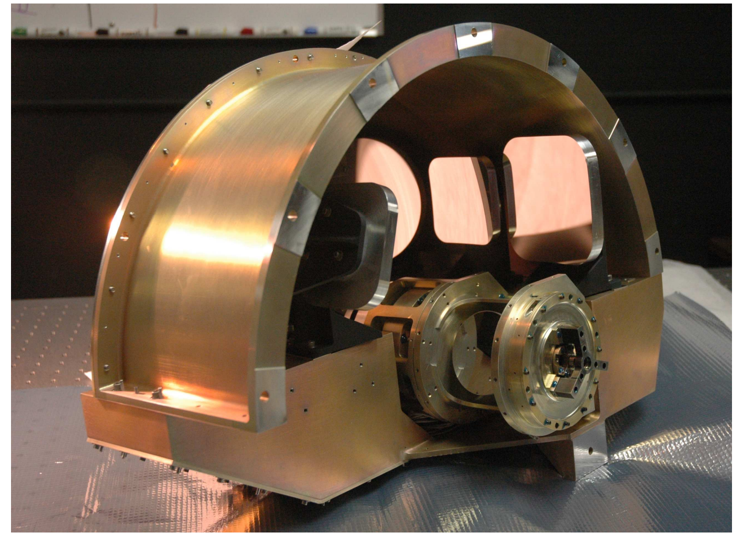


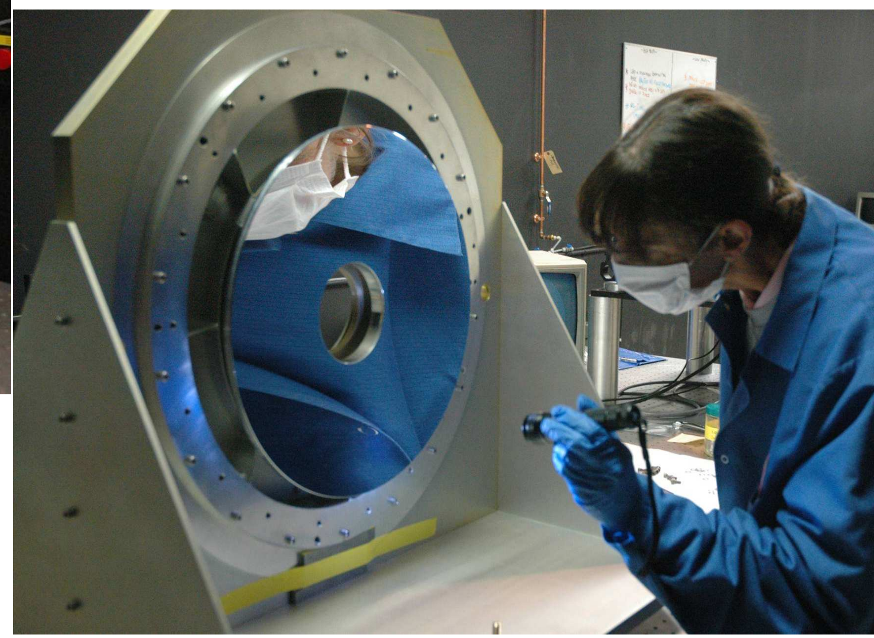
The Complete Optical Module

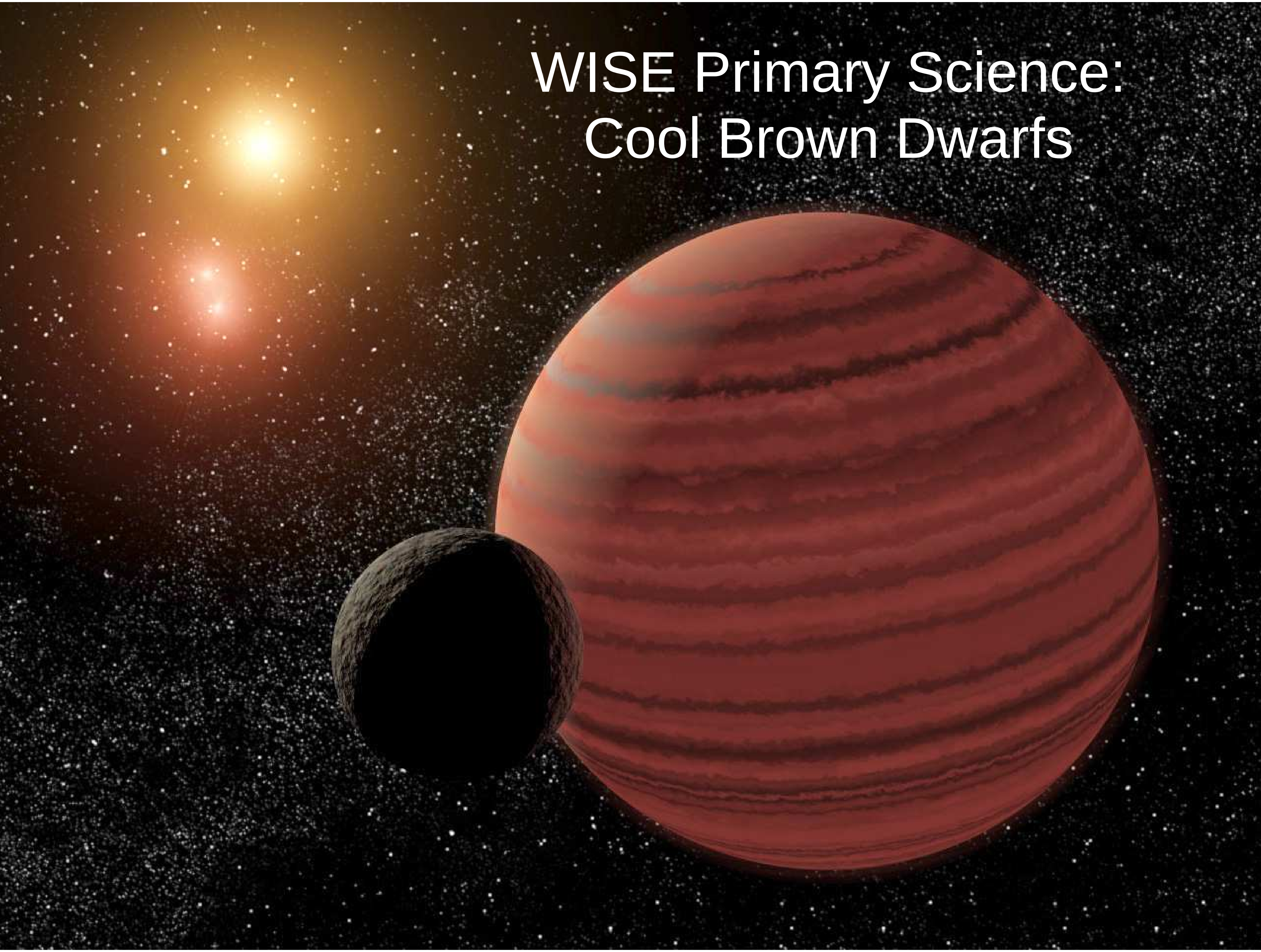


Flight Hardware



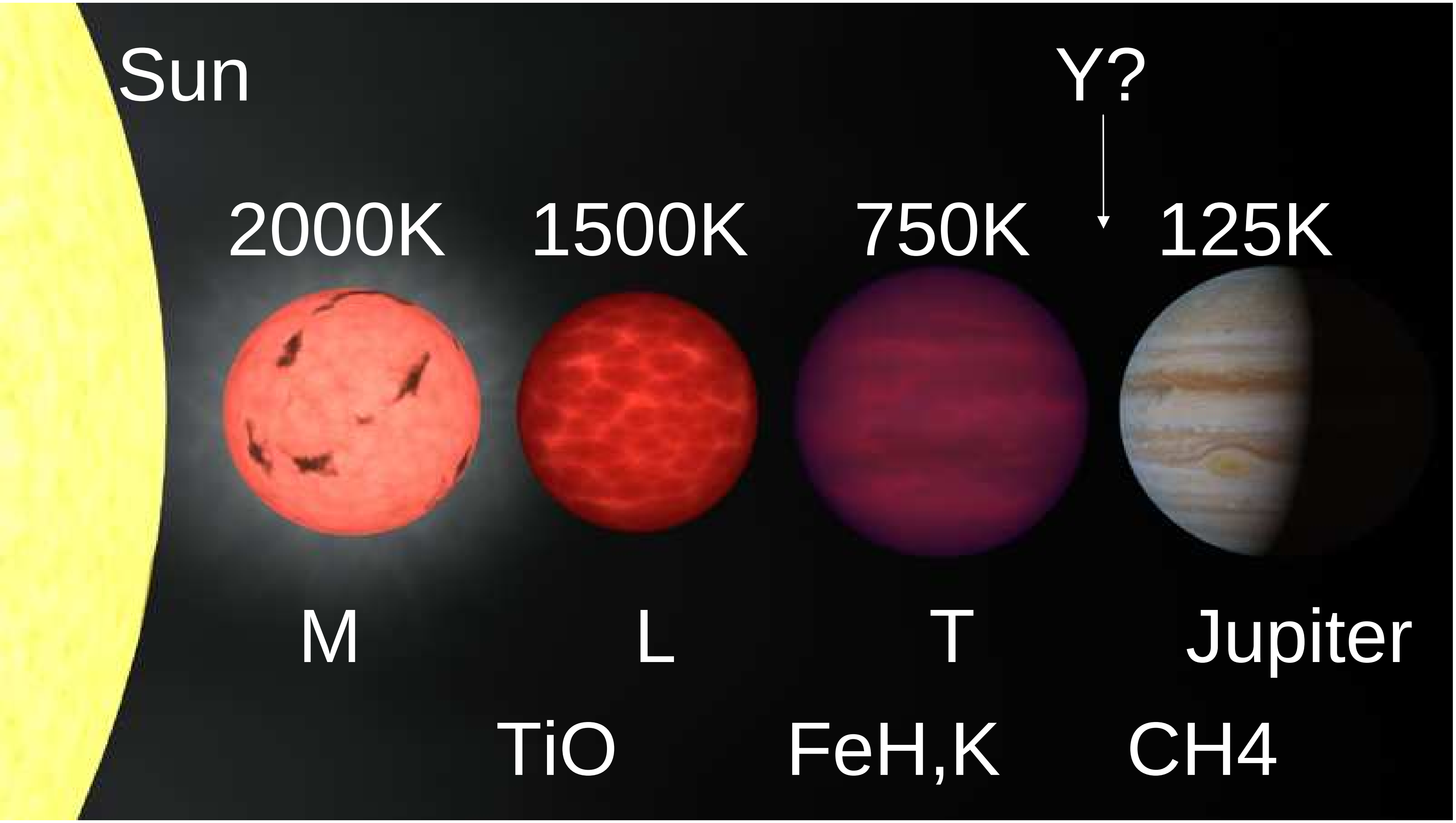





WISE Primary Science:
Cool Brown Dwarfs

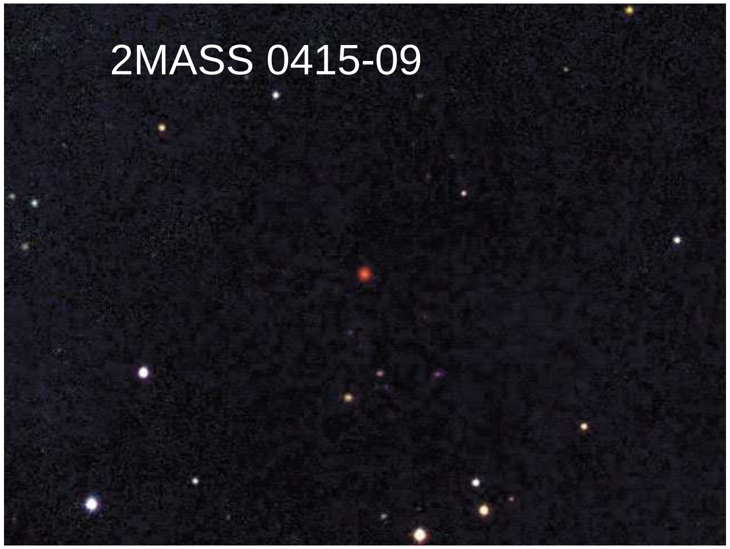
The Low-mass Menagerie

(thanks to Robert Hurt)

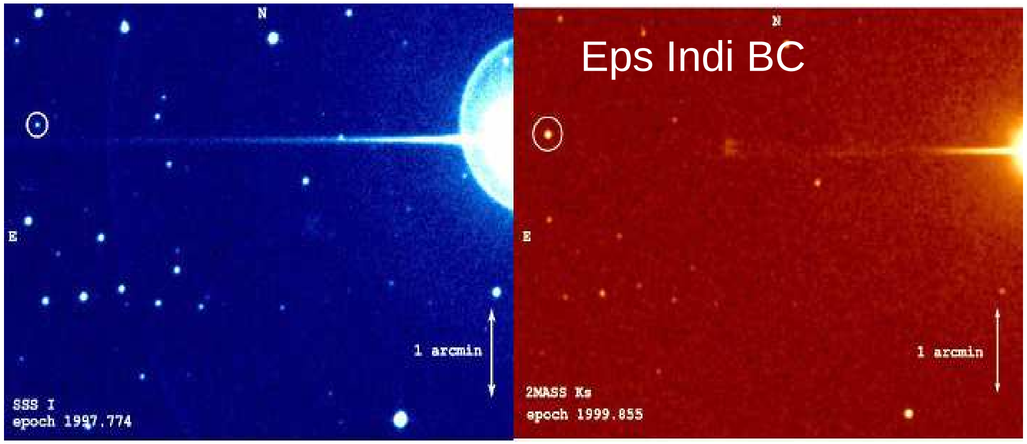


Current Knowledge of BDs

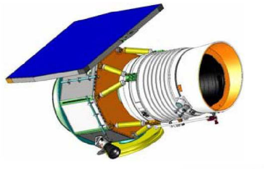
- Large-area sky surveys (e.g. 2MASS and SDSS) have revealed more than 500 L and T dwarfs. However, the sensitivity of these surveys limits study to the warmest examples.



- The coolest BD currently known is 2MASS 0415-09, a T8 dwarf with T~750 K and d=5.7 pc (Vrba et al. 2004).

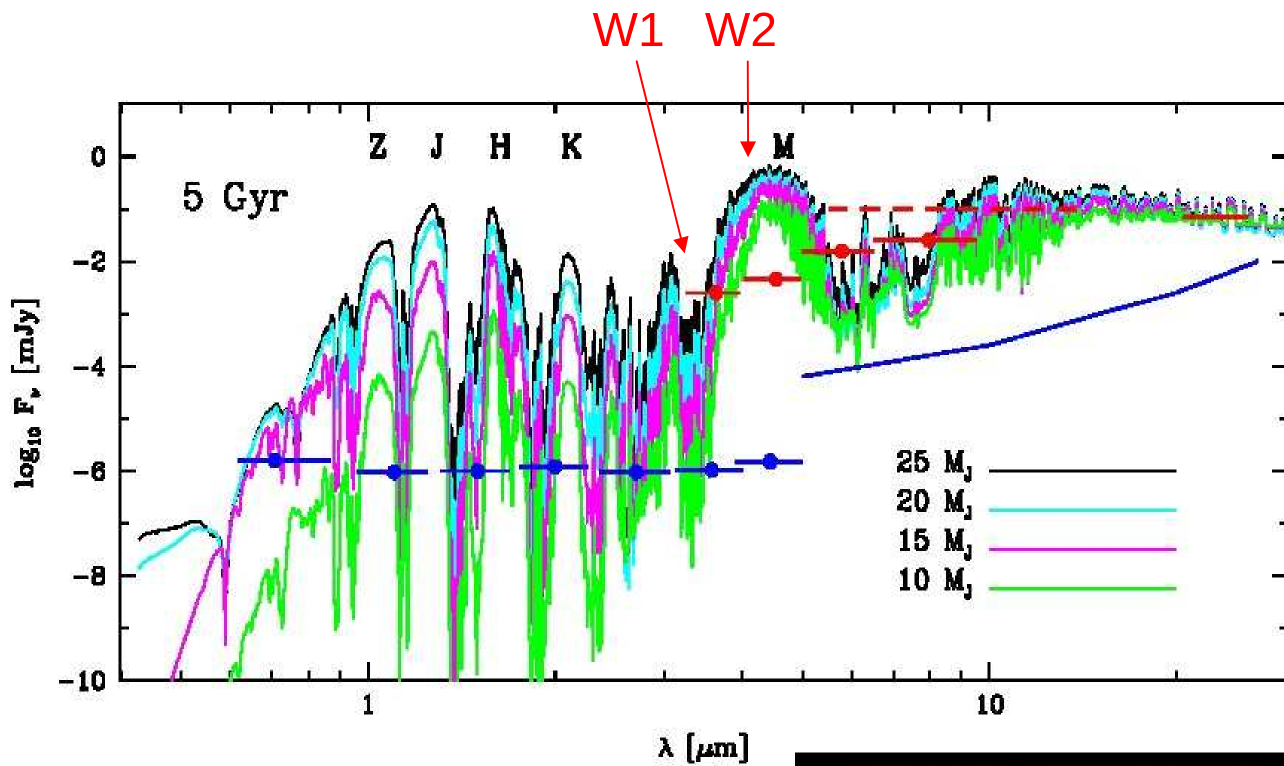


- The closest BD currently known is epsilon Indi BC, a T1+T6 double at d=3.6 pc (Scholz et al. 2003).



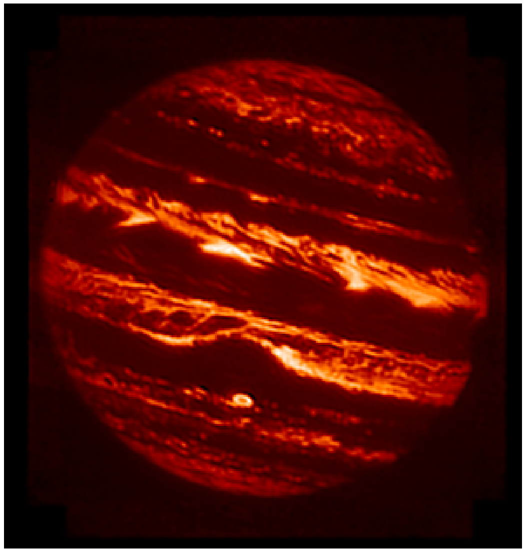
WISE Leverage on Brown Dwarfs

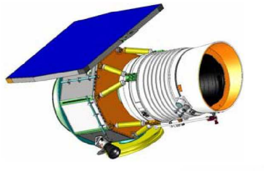
- 3.3 vs 4.8um color is uniquely diagnostic of methane (T/Y) brown dwarfs.
- WISE will probe far below T~750 K, enabling us to investigate the lowest mass end of “star” formation.
- WISE will find the closest BDs. Given our current best estimate of the substellar mass function, most of the present-day BD population has Teff >~150K, and the nearest BD will likely be closer than Proxima Centauri.



temp	distance
450 K	10 pc
300 K	4.5 pc
150 K	2.2 pc

WISE 160 µJy (5σ) detection limits at 4.7 um



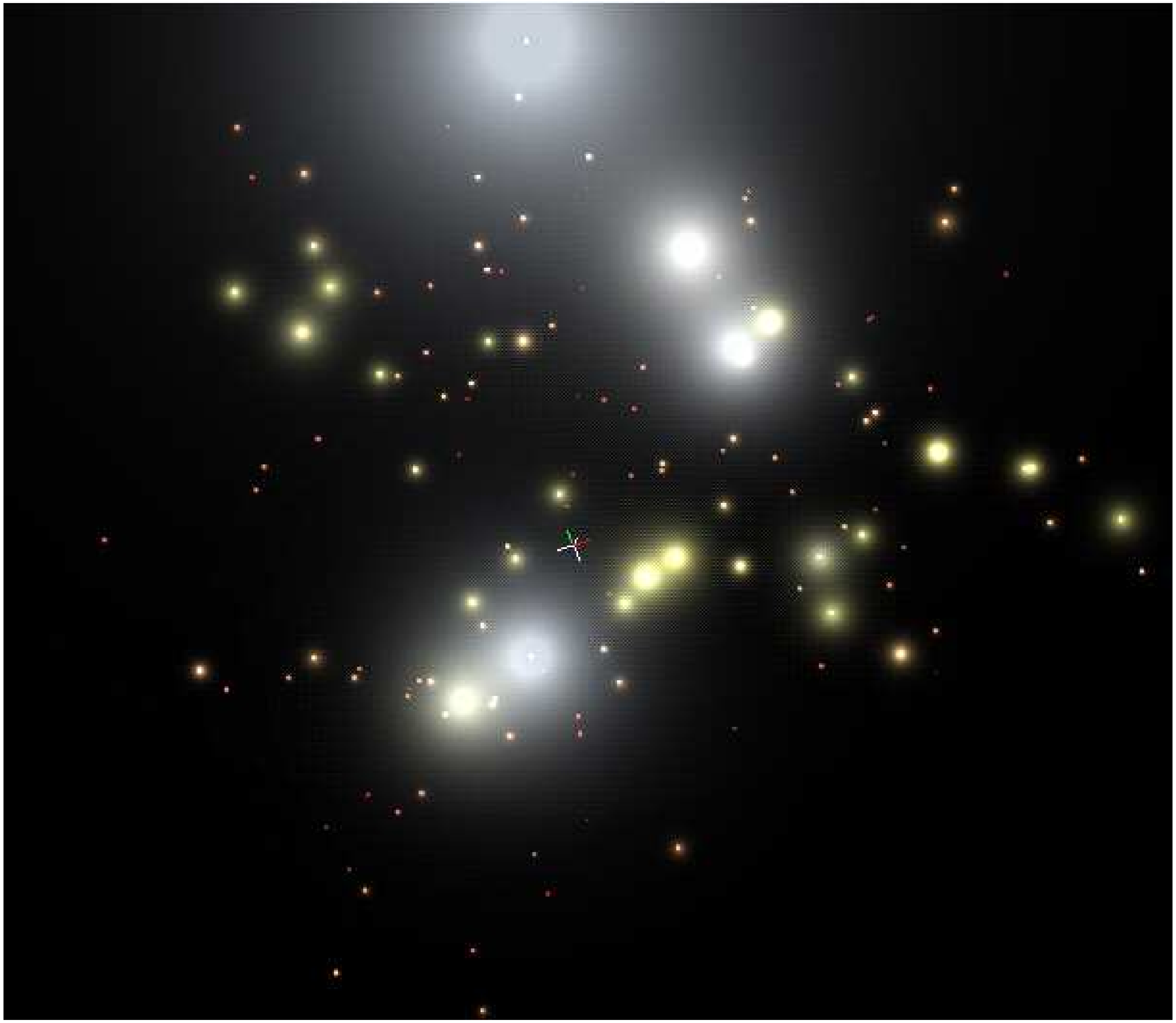


How many BDs?

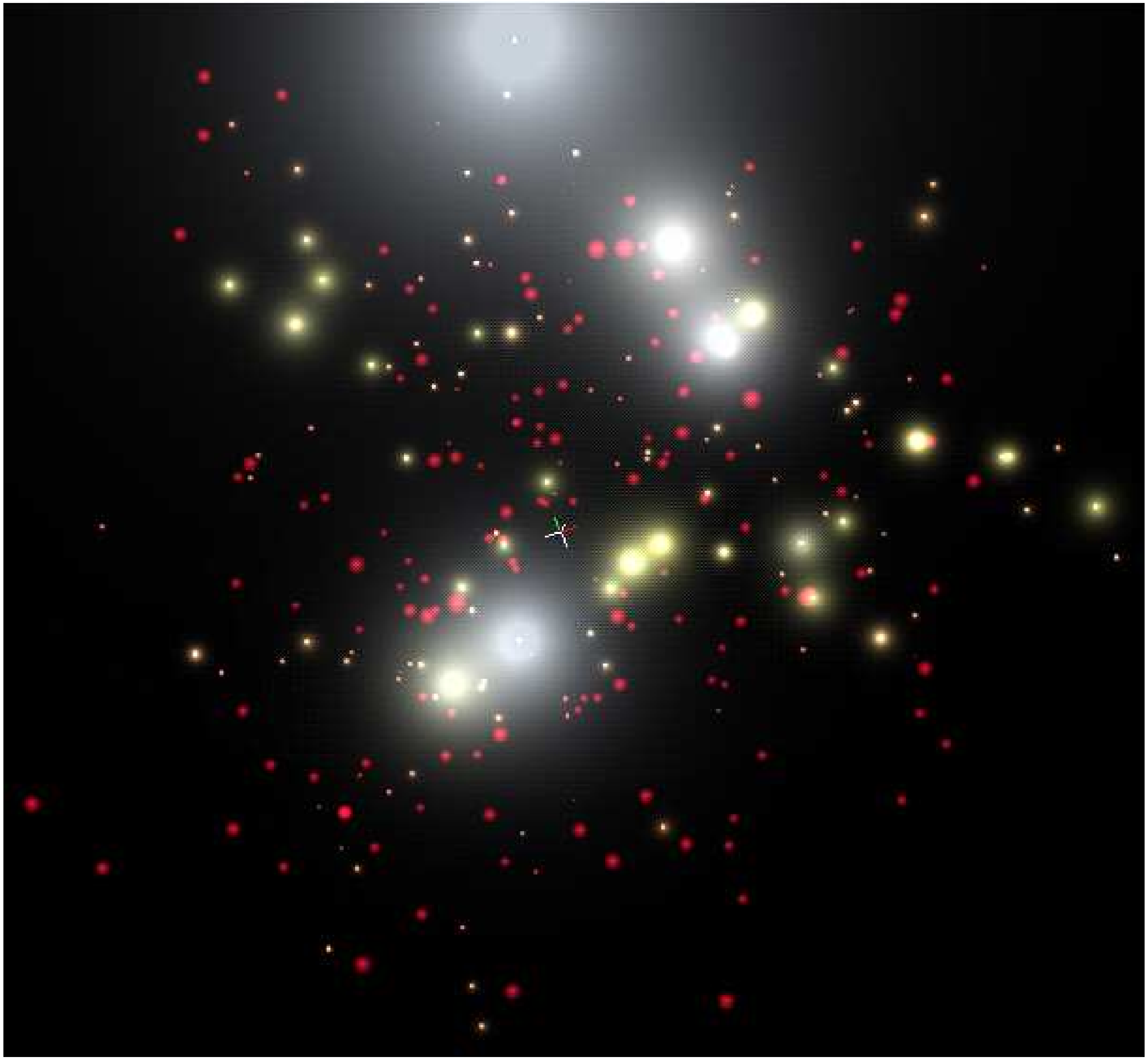
Mass Function	T_{eff} < 300	T_{eff} < 500	T_{eff} < 750	d < 1.3 pc
Chabrier etal log-normal	7	221	1340	0.88
Reid etal $M^{-0.4}$	3	76	503	0.33
Reid etal $M^{-0.7}$	5	121	671	0.53
Reid etal $M^{-1.0}$	11	197	921	0.93
Reid etal $M^{-1.3}$	22	330	1310	1.74

Assuming uniform star formation rate over the past 10 billion years & that WISE just meets its 4.8 μm sensitivity requirement.

Known Stars within 8 parsecs

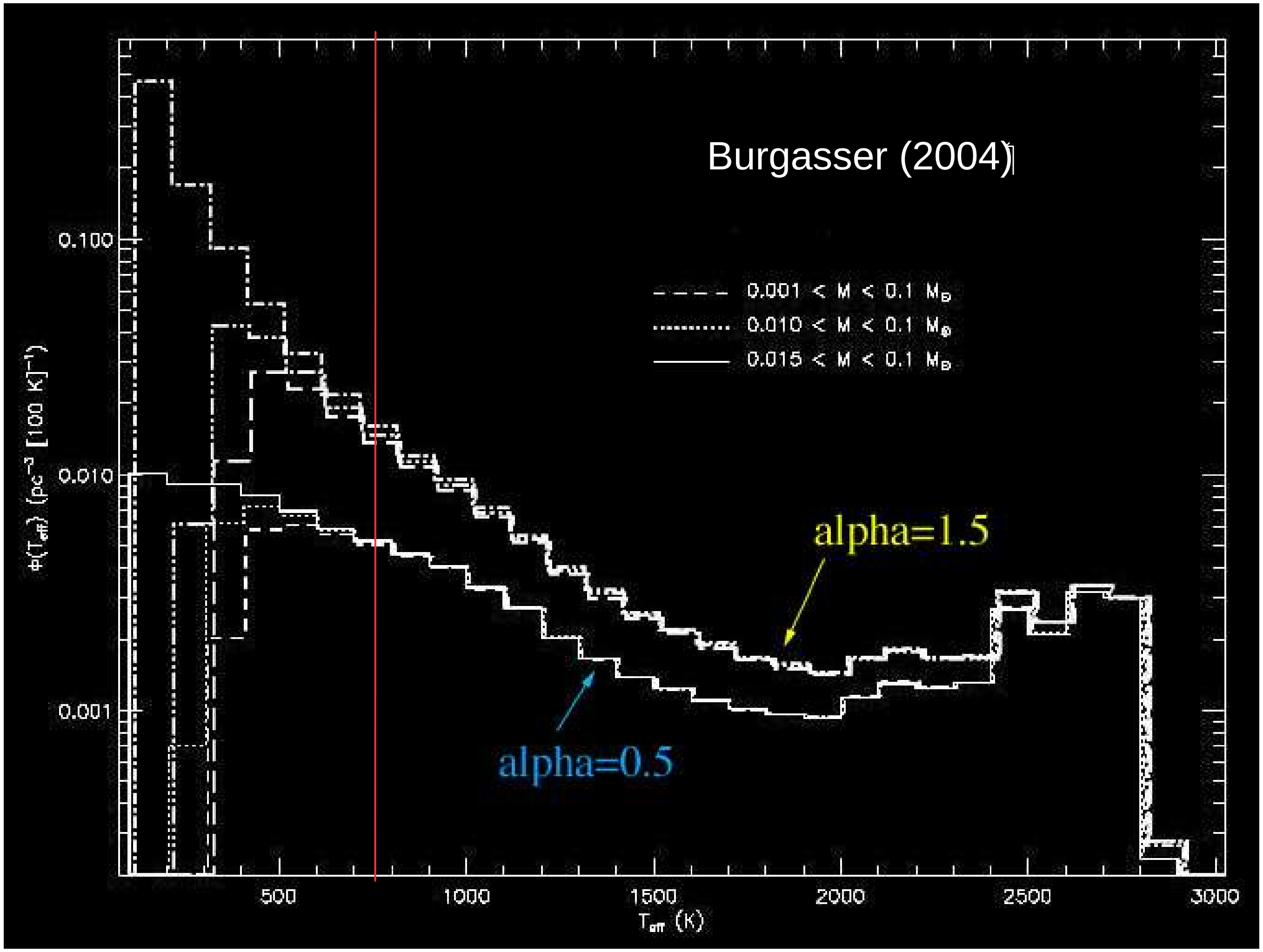


WISE stars within 8 parsecs

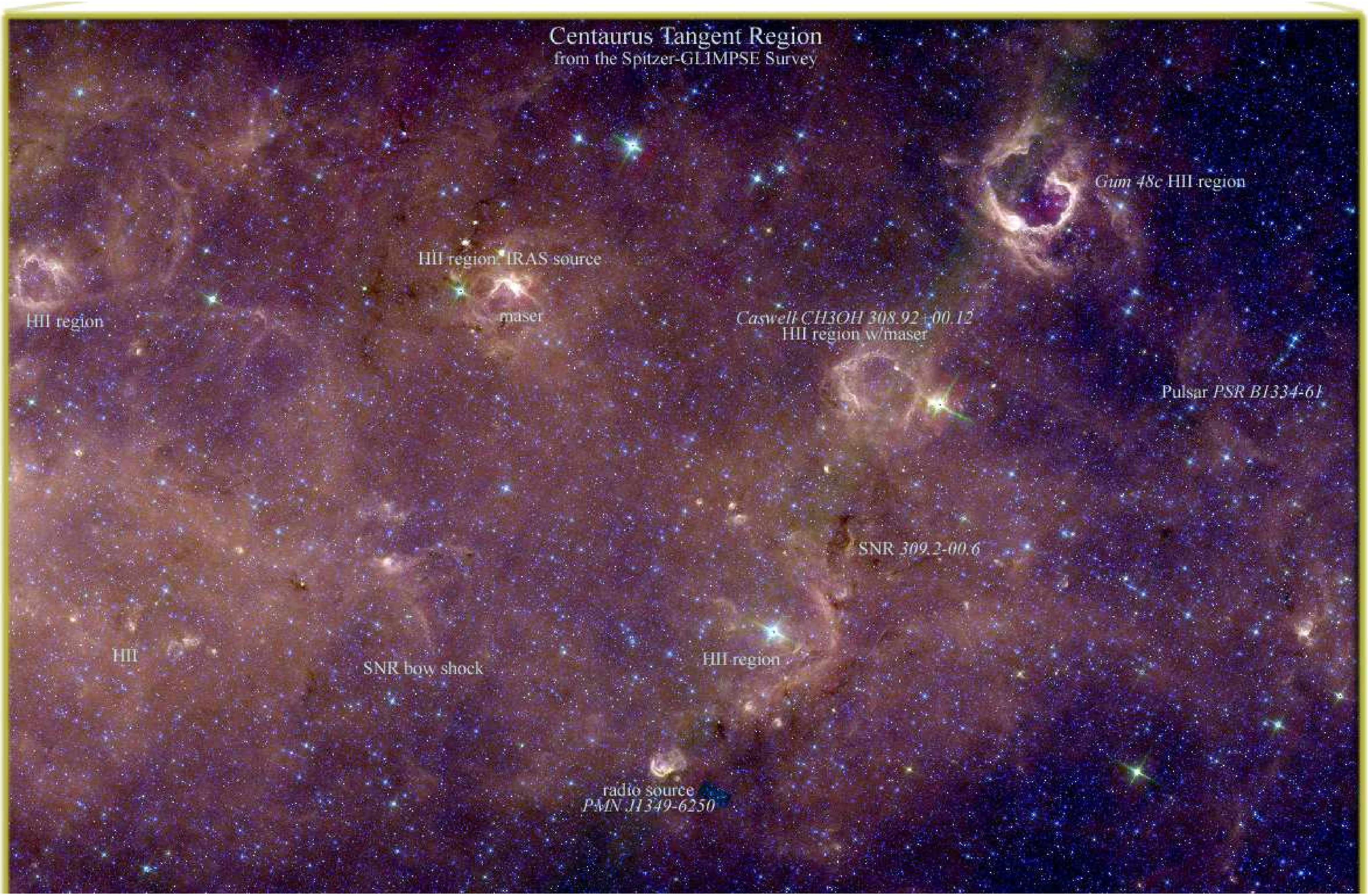


Establishing the Low-mass Cutoff for Star Formation

- Current surveys for Brown Dwarfs only detect the "warmest" targets and do not differentiate models with different low-mass cutoffs for star formation.
- WISE will detect hundreds of candidates with T<750K sampling the region that is sensitive to low-mass cutoff



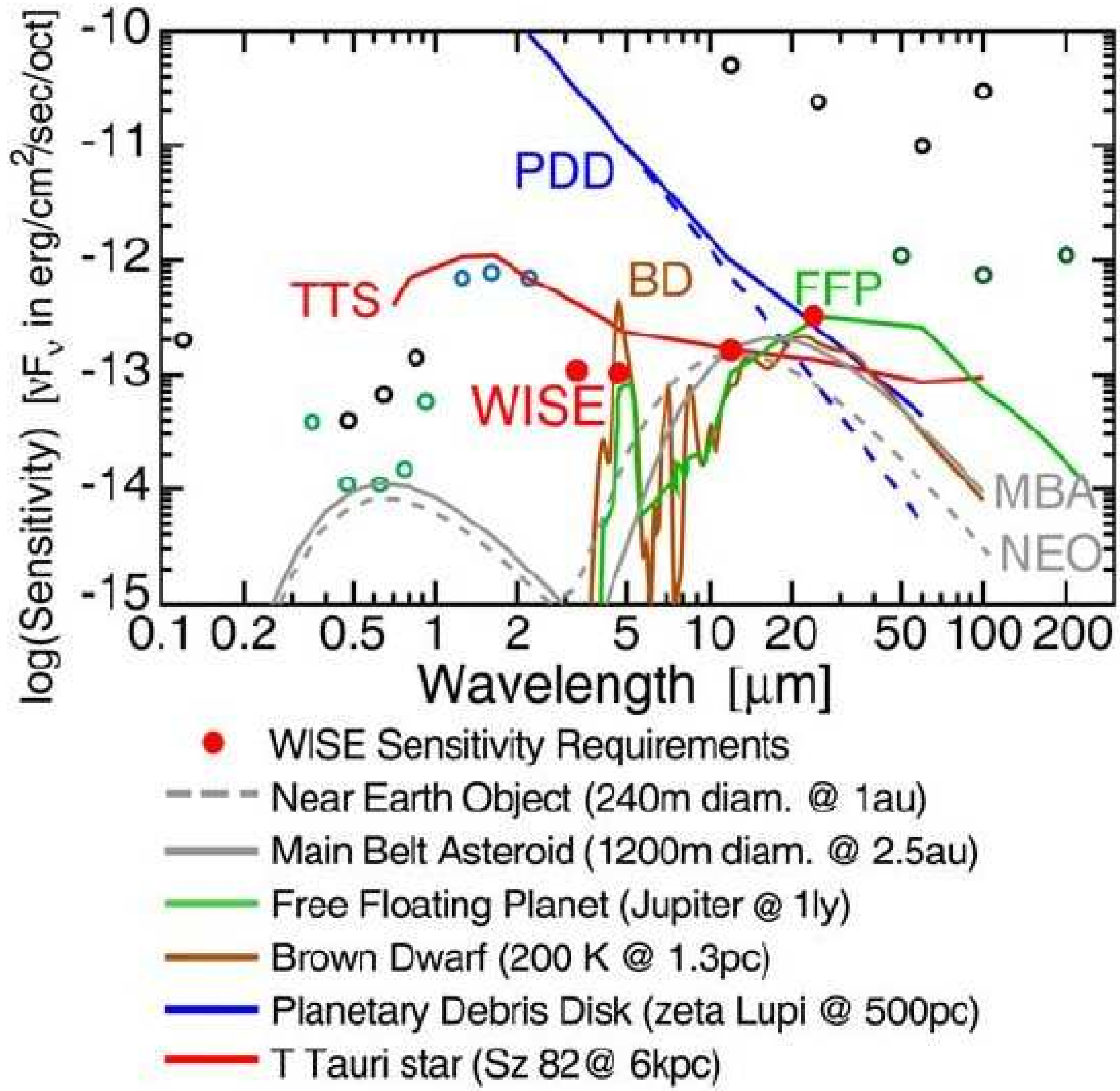
Star Formation



Debris Disks

- WISE will survey the entire sky for 23um excess sources with greater spatial resolution and greater sensitivity than IRAS.

WISE Sensitivity



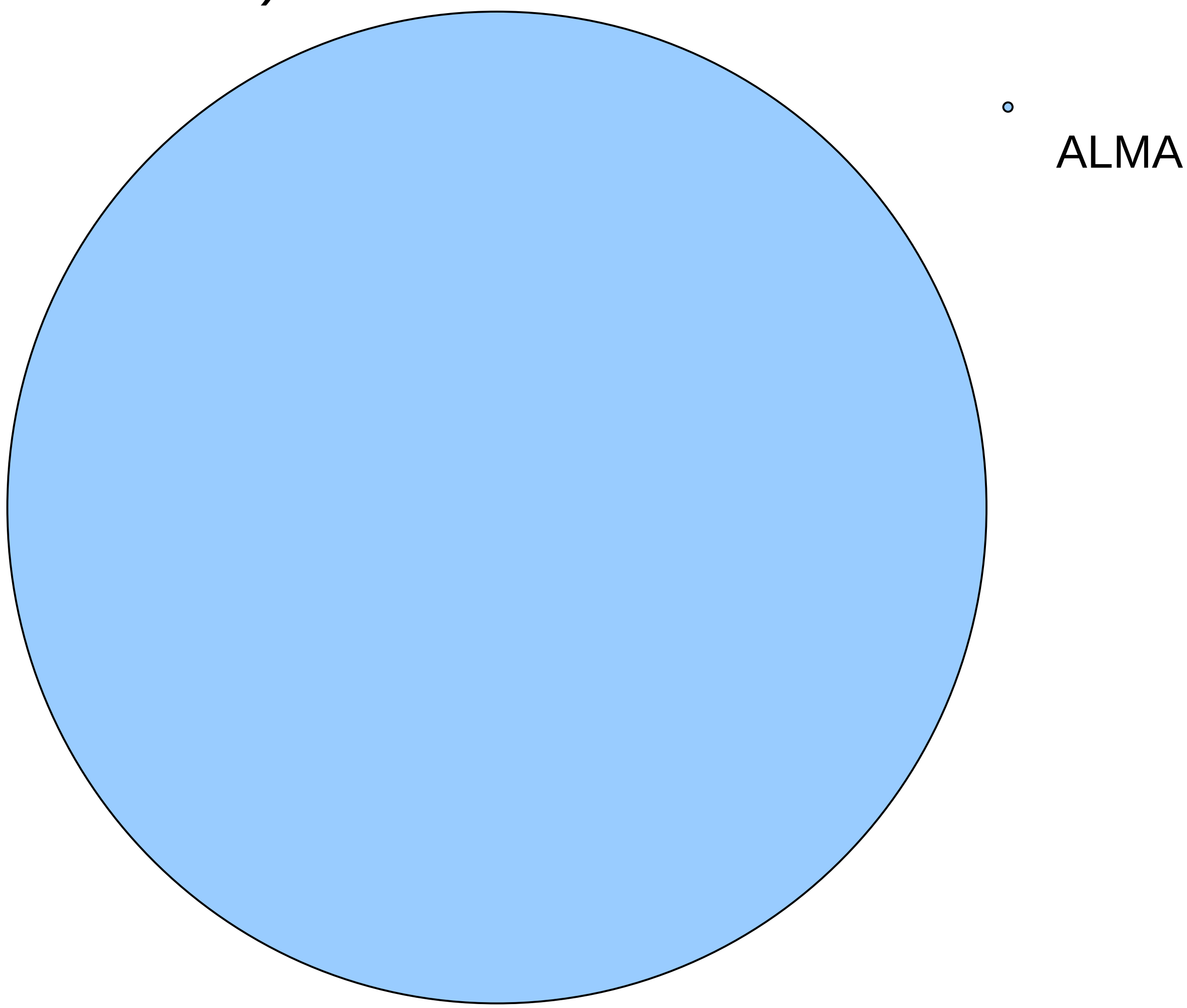
ZAMS Photospheric Sensitivity

100 pc Flux Density (mJy)				Distance at WISE limit (pc)		
K7	G2	A0		K7	G2	A0
29	146	961	3.3um	1500	3400	8900
15	75	497	4.7	1000	2100	5500
2.6	13	86	12	200	450	1100
0.7	3.3	22	23	50	100	275

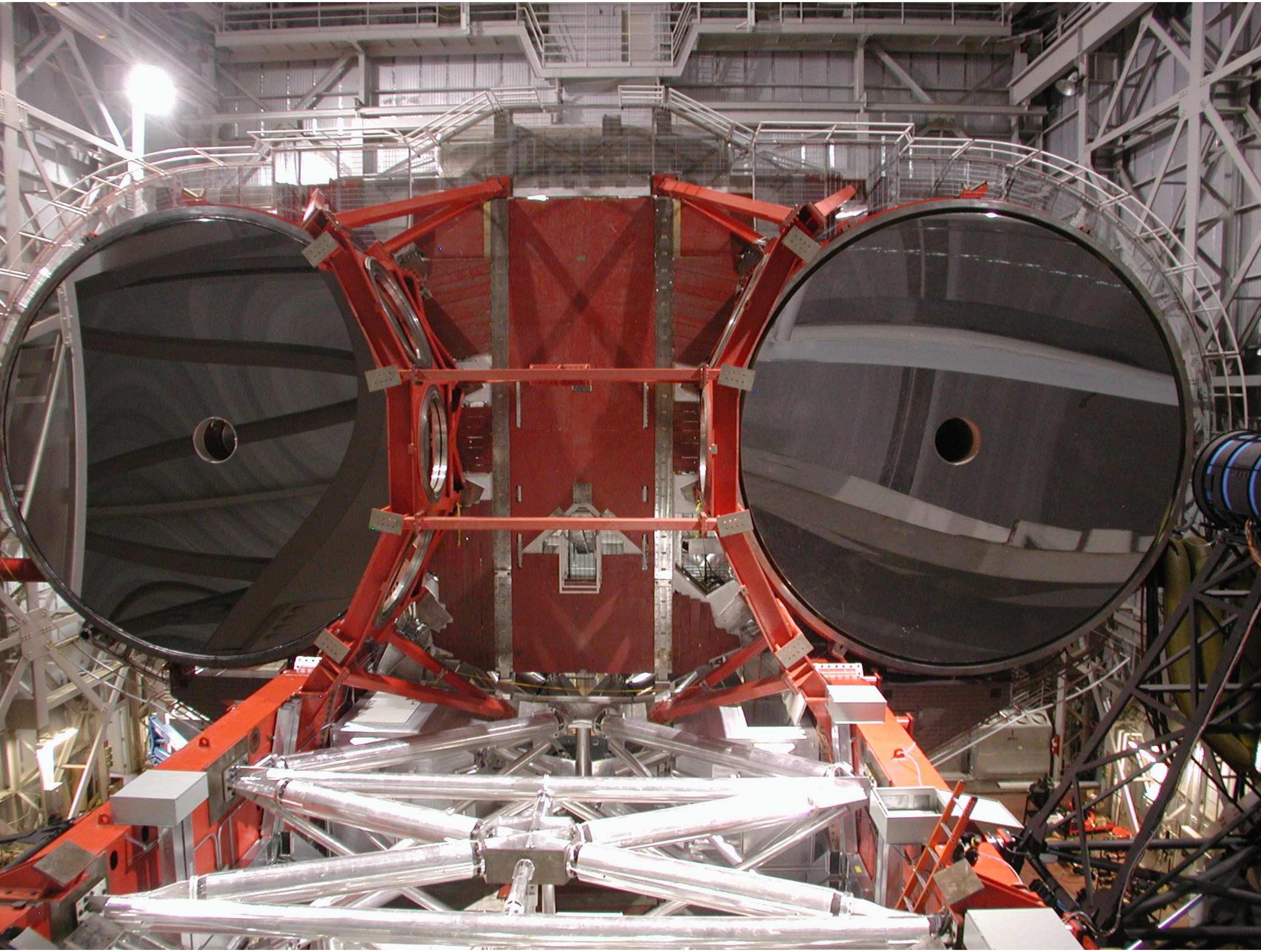
- For debris disks, YSOs, and particularly transition disk YSOs photospheric detectability is the key to identification.
- Key distances are 140 pc (Taurus, Chameleon, Lupus) and 450 pc (Orion)

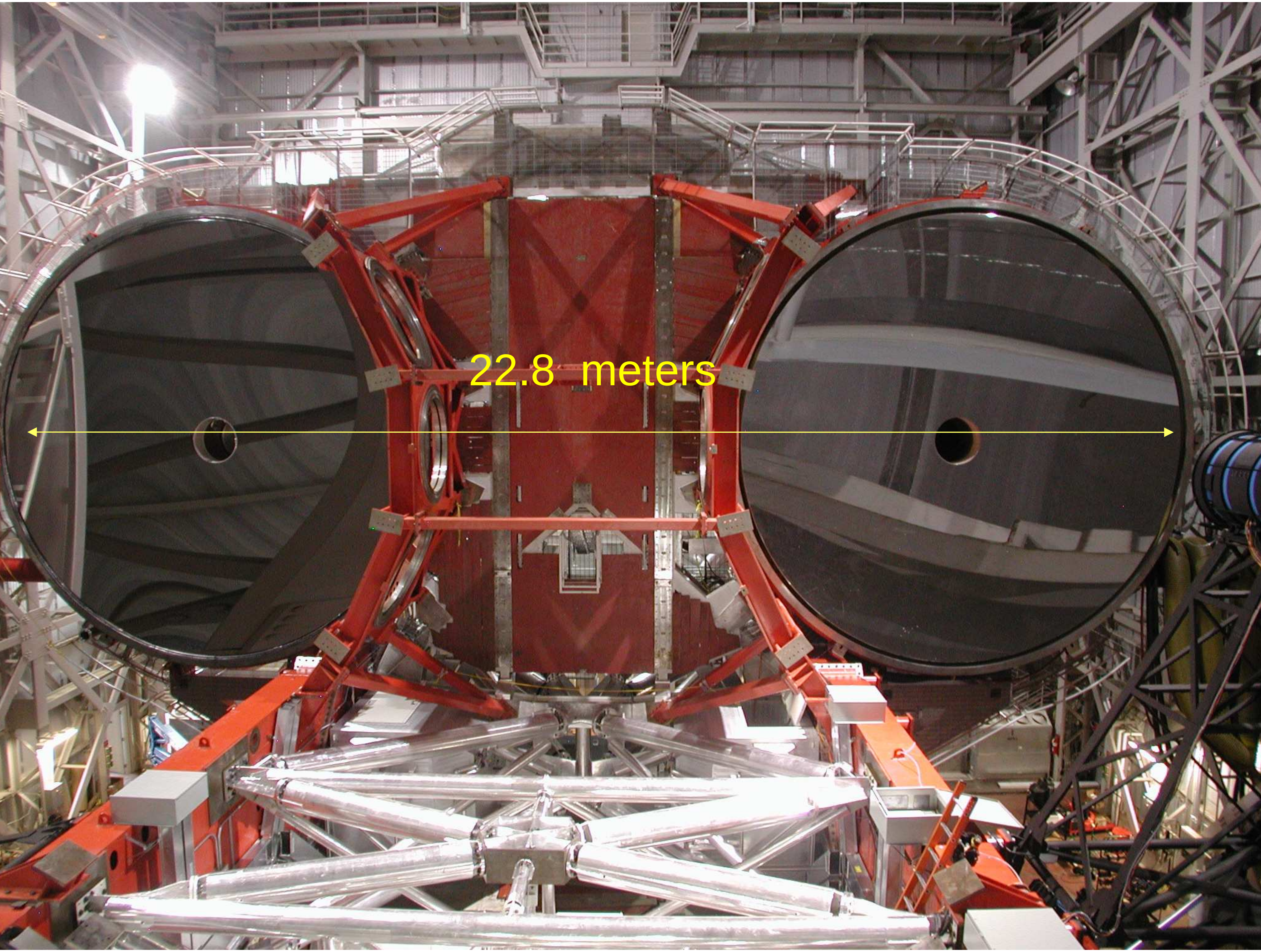
WISE vs. ALMA resolution

- WISE (6 arcseconds)

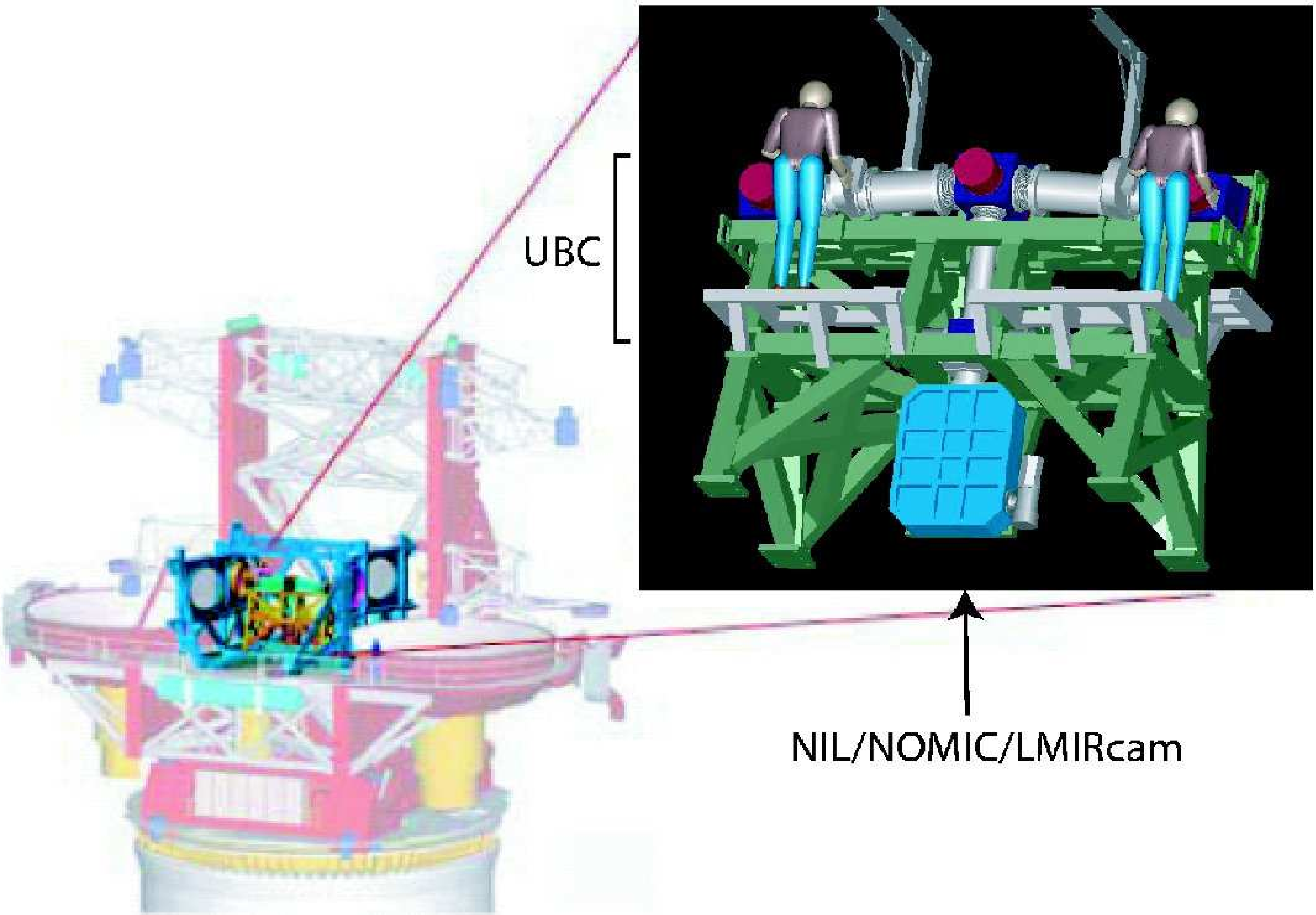


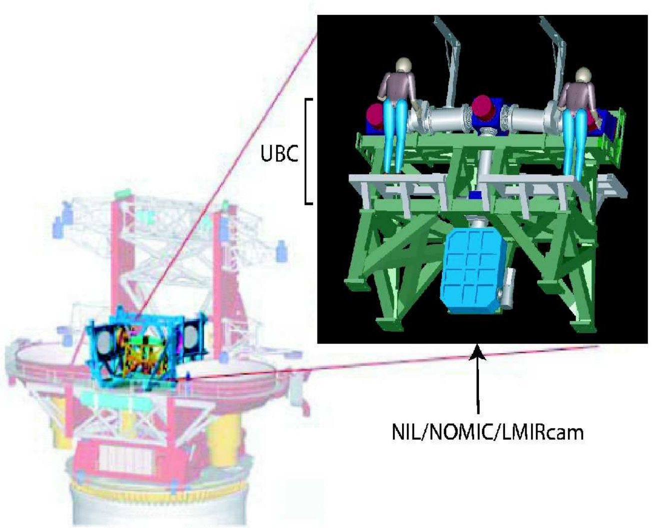
The Large Binocular Telescope



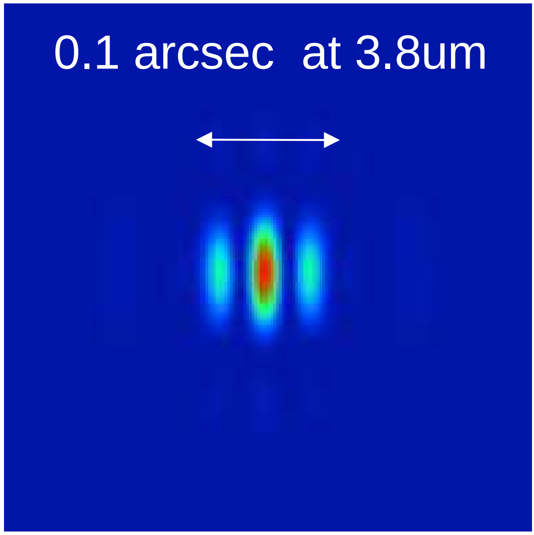

22.8 meters

LMIRcam

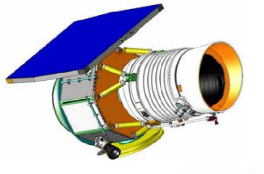




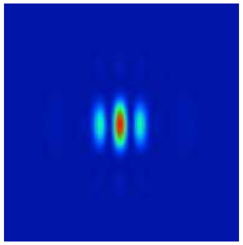
LMIRcam



- LMIRcam is a 3-5 micron direct imager working at the combined focus of the two mirrors of the LBT being constructed at UVa
  - 10" field-of view on a 1024x1024 array.
  - shares instrument volume with Arizona's 10um nulling camera.
- Having two mirrors on a phased pointed mount permits
  - direct "Fizeau" imaging rather than individual baseline U-V visibilities.
  - elimination of "warm" reflections maximizing mid-infrared sensitivity.
- Bottom line(at 3.6um)
  - 30 milliarcseconds to the first null
  - microJansky sensitivity owing to the small angular PSF footprint

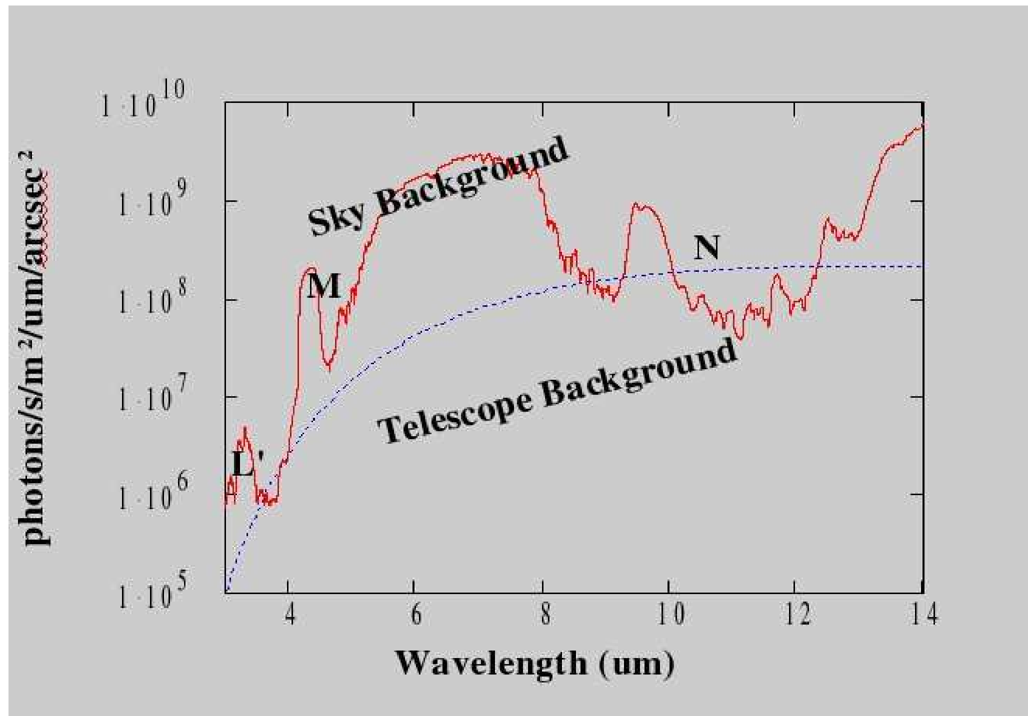


LMIRcam Sensitivity and Science



Not only wonderful spatial resolution, but the background reduction resulting from such a small angular image footprint yields unprecedented ground-based mid-IR sensitivity.

Band	1hour (uJy/mag) Sensitivity uJy	mag
K (2.2um)	0.06	25
L'(3.8um)	1.7	20.5
M (4.8um)	18	17.3



- Science objectives
  - "Hot" Jupiters
  - YSO disk structure
  - Brown dwarfs and binarity in young clusters
  - AGN structure

Launch: November 2009

- One month in-orbit-checkout
- Primary survey requires 6 months.
  - Early data products delivered 6 months after completion of primary survey (High SNR / 50% of sky).
  - Final data products due 17 months after completion of primary survey.
  - Data served by the Infrared Science Archive (IRSA)
  - Extended mission with second full sky coverage possible due to 15 month cryogenic lifetime, but not currently funded.

WISE will...

- Find the 2/3 of the stars in the solar neighborhood that have not yet been seen, including the closest “stars” to the Sun and hundreds cooler than 750K.
- Survey star formation in the Milky Way and in massive Ultra-Luminous Infrared Galaxies.
- Discover new and potentially hazardous asteroids and provide accurate diameters for >200,000 objects.
- Image all nearby galaxies and delineate large scale structure out to z=1 over the entire sky.
- Probe through deep extinction in the Milky Way to illuminate galactic structure.

- Enable investigations yet to be imagined providing a **lasting legacy** for decades to come, just like IRAS and 2MASS before it via

  - an extracted source catalog containing hundreds of millions of objects

  - an atlas of images in four bands covering the entire sky.

  all feeding the next generation of capable observatories like JWST and ALMA.