NEOCam

The Near-Earth Object Camera

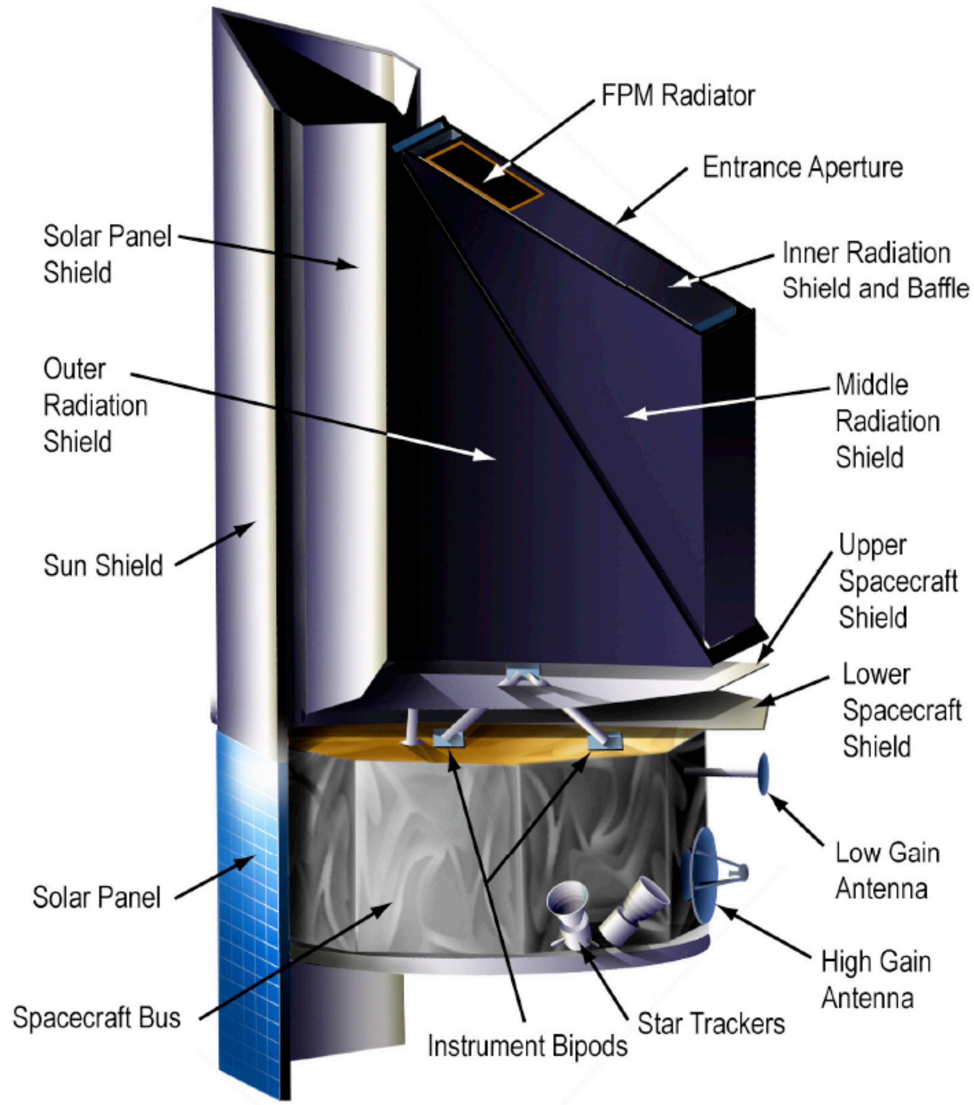
Dr. Amy Mainzer

JPL

SBAG 2009 Nov. 18

NEOCam: The Near-Earth Object Camera

- NEOCam is a Discovery-class 50 cm cryogenic IR space telescope that could launch in 2016 for a five year mission
- Current plan is to orbit at Earth-Sun L1 Lagrange point
- Current NEOCam design features two IR bands: 3 – 5 µm, 6 – 10 µm
- Large FOV: 11.56 square degrees
- A space-based IR survey is not a new concept – Tedesco & Cellino proposed it a few years back; IRAS; Spitzer
- *Passively cooled ONLY to 30K* using technique proven on Spitzer Space Telescope
- Uses latest generation long-wavelength cutoff HgCdTe detectors, Hawaii 2-RG multiplexer, SIDECAR ASIC cryogenic A/D converter by Teledyne



The NEOCam Team

Amy Mainzer	JPL – Spitzer, WISE
Bidushi Bhattacharya	IPAC – Spitzer
William Bottke	SwRI
Steve Chesley	JPL – Sentry, NEAR
Paul Chodas	JPL
Dale Cruikshank	NASA Ames – Spitzer
Roc Cutri	IPAC – Spitzer, WISE
Peter Eisenhardt	JPL – Spitzer, WISE
Joshua Emery	SETI – Spitzer
Joe Masiero	JPL - MOPS
Robert McMillan	LPL – Spacewatch
Robert Jedicke	Pan-STARRS, MOPS
William Reach	IPAC – Spitzer
Judy Pipher	U. Rochester – Spitzer
William Forrest	U. Rochester – Spitzer
Mark Sykes	PSI – Spitzer, IRAS
Russ Walker	MIRA – IRAS, WISE
Edward Wright	UCLA – WISE, Spitzer, COBE, WMAP
Don Yeomans	JPL – NEAR, CONTOUR, DI, Hayabusa
Erick Young	U. Arizona – IRAS, HST, Spitzer, JWST

NEOCam Science Goals

- *Assess the present-day risk of NEO impacts*

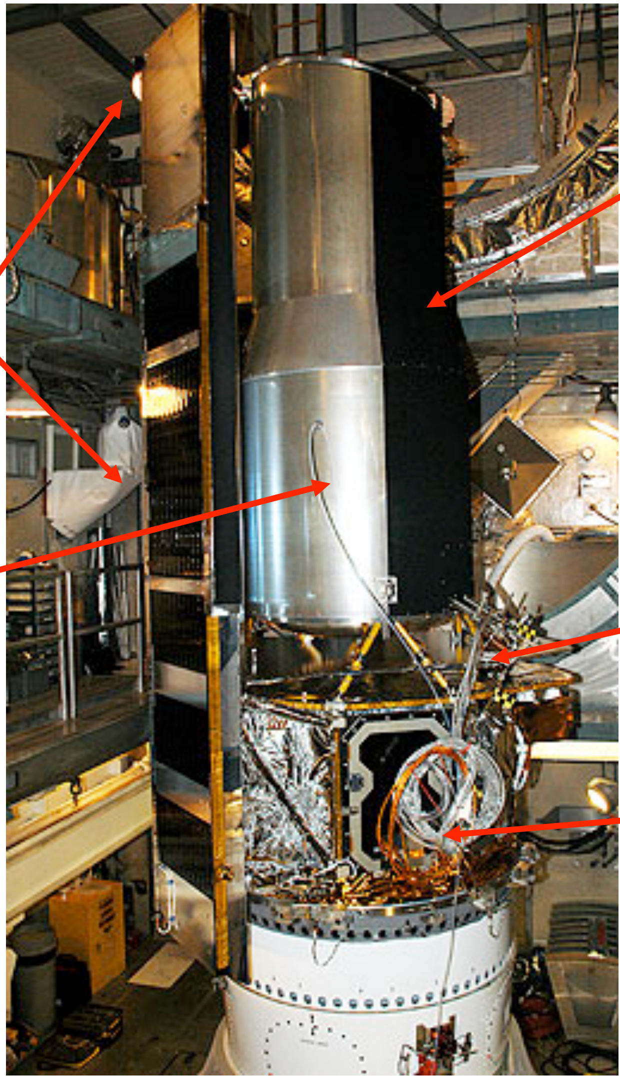
- *Understand the origin and ultimate fate of the asteroids*

Mission Summary

Parameter	**Value**
Aperture Size	50 cm
FOV	11.56 square degrees
Wavelength	3 – 5 μm, 6 – 10 μm
Detectors	HgCdTe + SIDECAR ASIC
Array Format	2048^2
Sky Coverage	Step and Stare – 4500 sq deg/day
Sensitivity	143 μJy @ 8 μm in 182 sec 5-σ
Slew/Settle Time	30 sec to move 1.7° and settle
Image Quality	Strehl = 80% @ 9 μm
Daily Data Storage	82 Gbits/day
Orbit	L1 halo
Launch Vehicle	Atlas V?
Mission Lifetime	5 years + possible 5 year extension
Data Products	Multi-epoch image atlas, point source catalog, database of moving objects, orbits, diameters, albedos

Passive Cooling Example: *Spitzer Space Telescope*

- The ability to reject heat dissipated by the focal plane instruments radiatively
- Spitzer has the equivalent of 1 thumbprint's worth of molecular contamination over its entire surface area
- Now that cryogen has run out, focal plane has equilibrated to 29 K with ~3 mW continuous dissipation



NEOCam Science Goals (1)

- Detect and characterize at least 2/3 of all potentially hazardous NEOs larger than140m in diameter within 5 years (90% in 10 years): ~100x more NEOs than currently known.
- Provide a modern albedo-insensitive asteroid survey
- Measure diameters for all objects significantly more accurately than visible observations.
- Retire the statistical risk of sub-global NEO impacts by 60% in 5 years (90% in 10 years)
- Obtain albedos

NEOCam Science Goals (2)

- Discover and characterize 75% of asteroids lying interior to Earth’s orbit (IEO).
- Characterize population of small objects (30 m < D < 140 m) which could still pose impact hazard
- Establish the role of the Yarkovsky and YORP effects in asteroid transport.
- Discover most Main Belt asteroids larger than 1 km.
- Find new targets for in-situ missions.

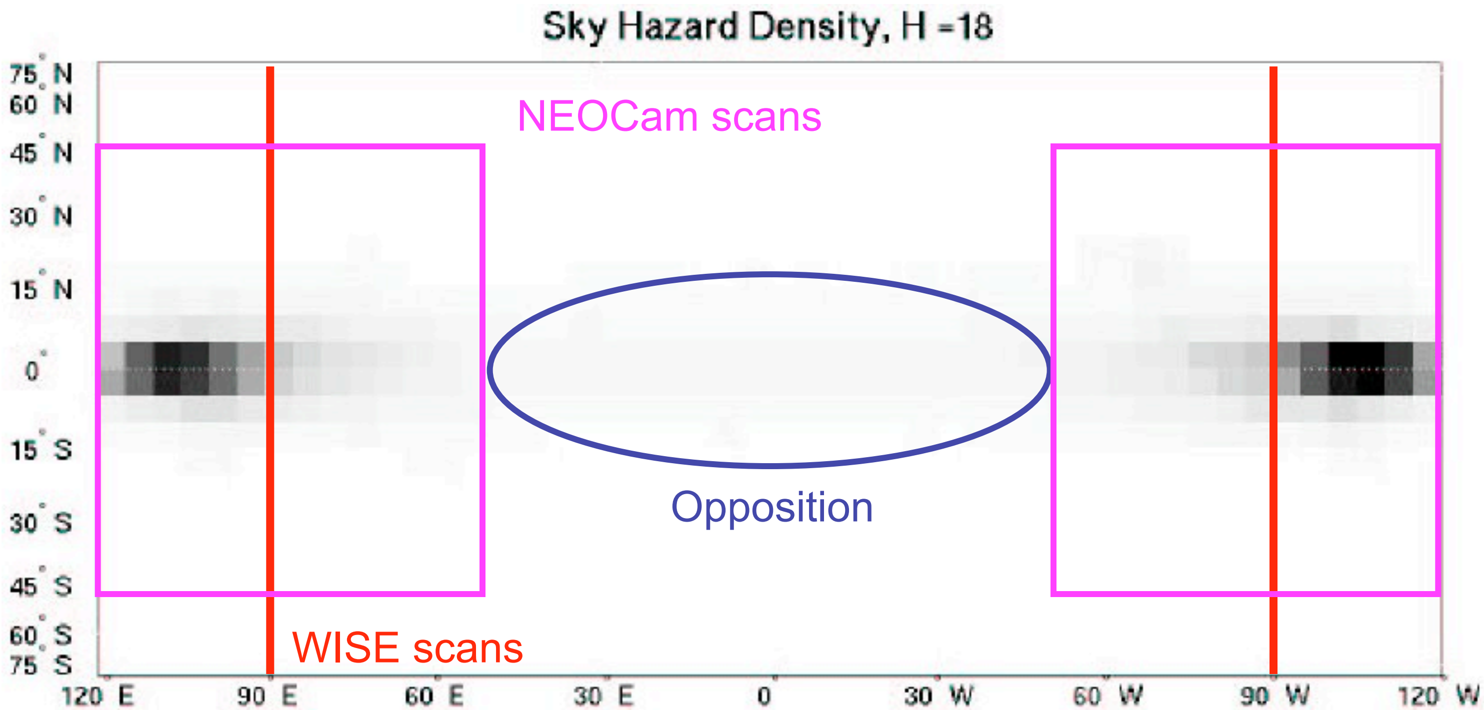
Key Science Questions Addressed by NEOCam

- Establish the size frequency distribution (SFD) of NEOs and MBAs by direct measurements which are insensitive to albedo.
- Provide a statistically significant sample of orbits and accurate diameters suitable for testing and refining NEO population models (e.g. Bottke et al. 2002).
- The importance of the Yarkovsky effect in transporting asteroids throughout the Solar System measured by observing morning/evening temperature variations
- Only a handful of objects interior to Earth's orbit (IEOs) are known to date; the SFD is a sensitive function of NEO transport models. NEOCam will discover 1000's of IEOs >140m (using Bottke et al. 2002 model).
- Albedo-specific studies possible with the ~60% of objects >140m discovered both by Pan-STARRS/LSST and NEOCam
  - Abundance of dark/bright objects
  - Fraction of comets?

NEOCam Orbit & Search Regions

- NEOCam spends all of its time surveying the low elongation regions where hazardous NEOs spend most of their time (Chesley & Spahr 2003)
- Current survey region: 40 - 125º elongation, ±45º latitude
- Observation method: step and stare, 182 sec integration time, 30 sec slew/settle time; 4500 sq deg/day
- 2 visits per “night”; entire search region every ~5 days for maximum efficiency at linking tracks and tracklets
- On-sky time = >23 hrs/day

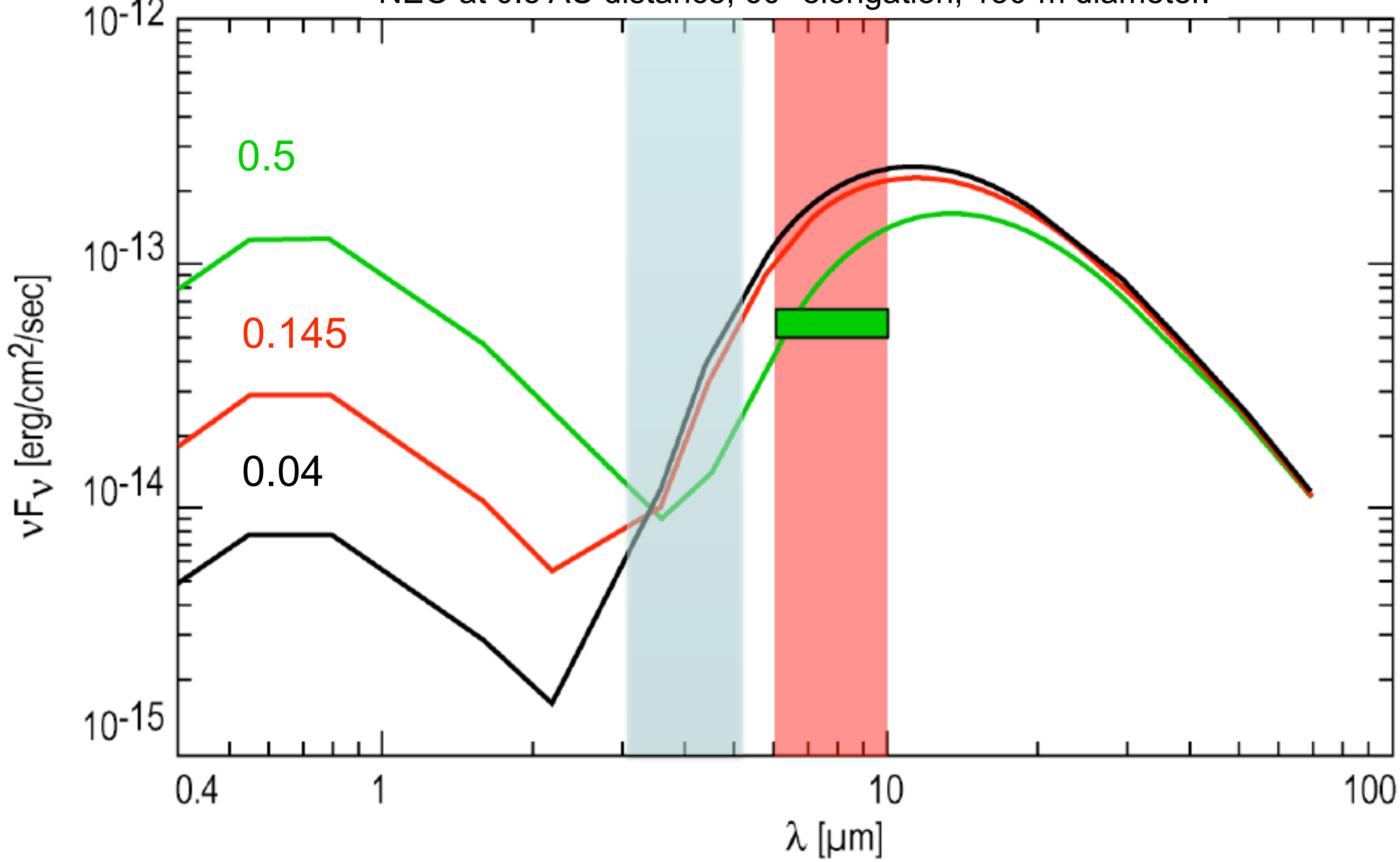
Why Space?



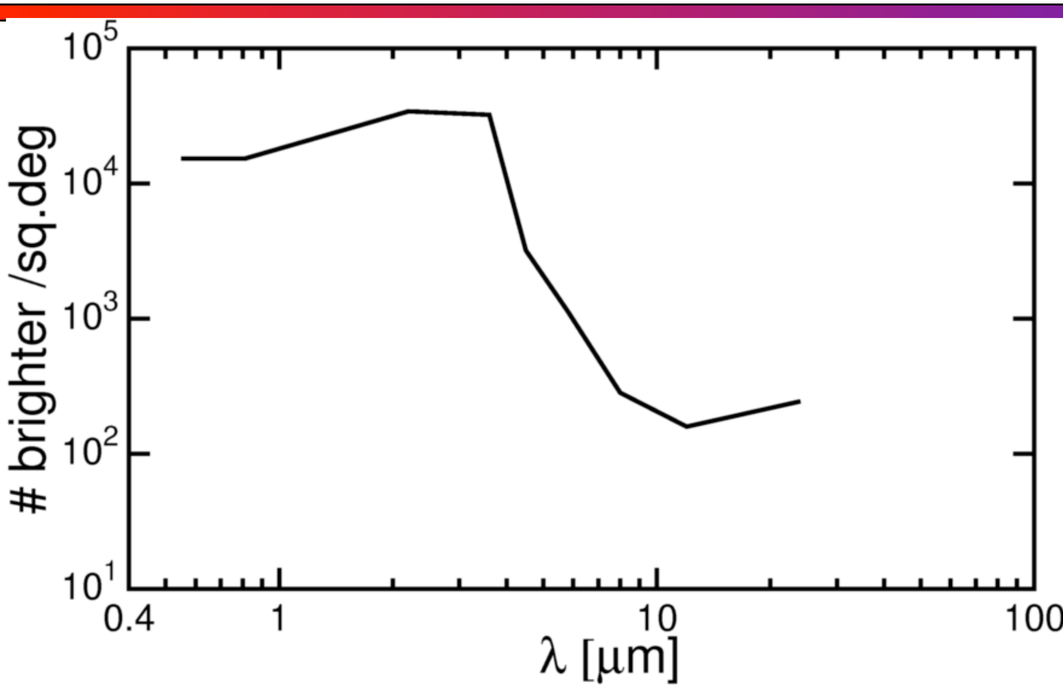
- Chesley and Spahr (2003) found that potentially hazardous asteroids are better found by observing close to the Sun. In space, you can observe almost 24/7 down to 40° from the Sun, while current surveys work close to opposition from the Sun. Ground-based surveys have more limited access to low elongation regions around sunrise/sunset.

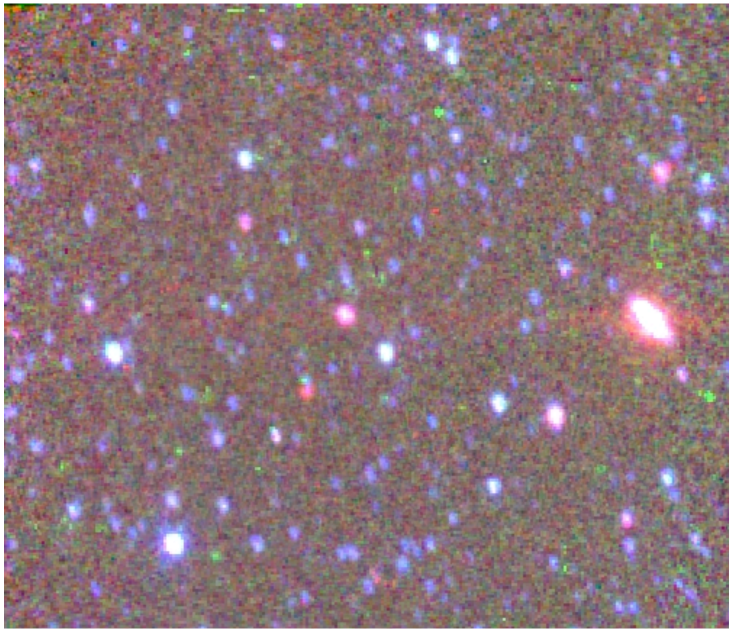
Why Thermal IR?

NEO at 0.5 AU distance, 60º elongation, 150-m diameter.



Why Mid-IR?

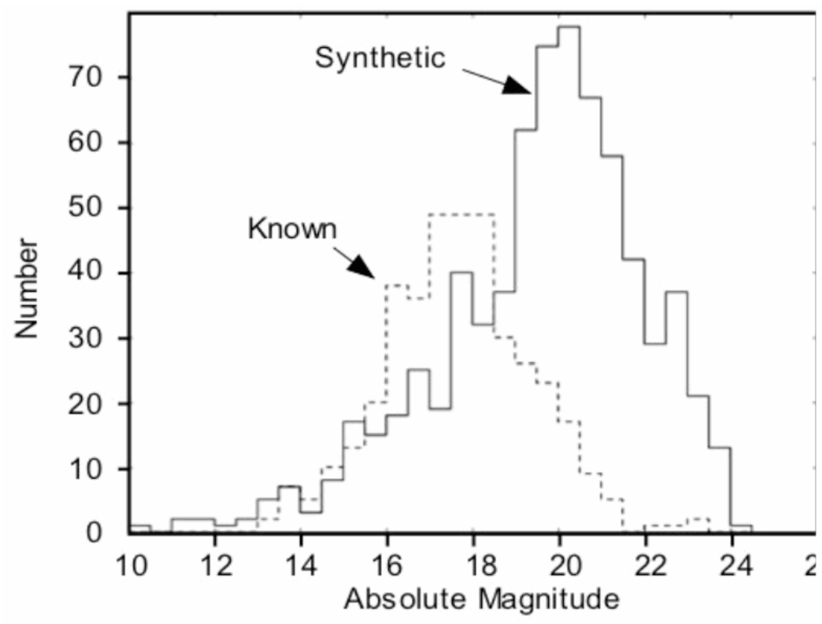




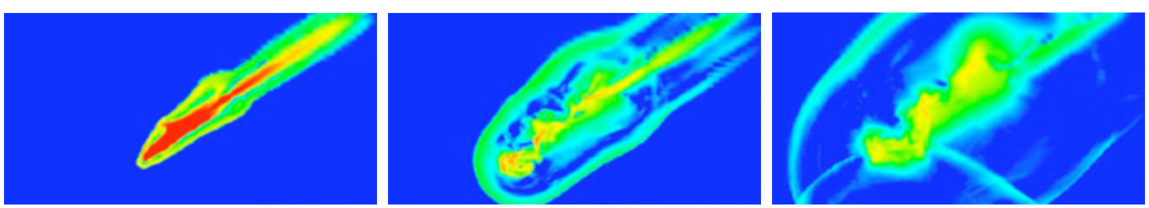
Blue = 3.6 μm; red = 8 μm

- Source density brighter than a 150 m diameter asteroid seen at 60^o elongation and DE = 0.5 AU
- There are ~100x fewer sources (stars, galaxies) at 10-20 μm than in the optical that an asteroid could be confused with.
- Reduced confusion w/ fixed sources means can get away with smaller telescopes (0.5 m vs. 8 m) and fewer pixels (16e6 vs. 3.2e9)

WISE: Prototype for NEOCam



- WISE will tell us about the size-frequency distribution down to ~300 m; will find smaller objects, but not enough to get good size dist'n
- WISE will find ~300 new NEOs out of population estimated to be 20,000 – 200,000
- Would like to know SFD of smaller objects both from hazard standpoint and purely scientific
  - Do smaller objects lack regolith? Rapid rotators should be solid.
  - Boslough's work indicates that airbursts are hazardous - Tunguska may have been more like 30 m instead of 100 m diameter



NEOCam and Visible Observations

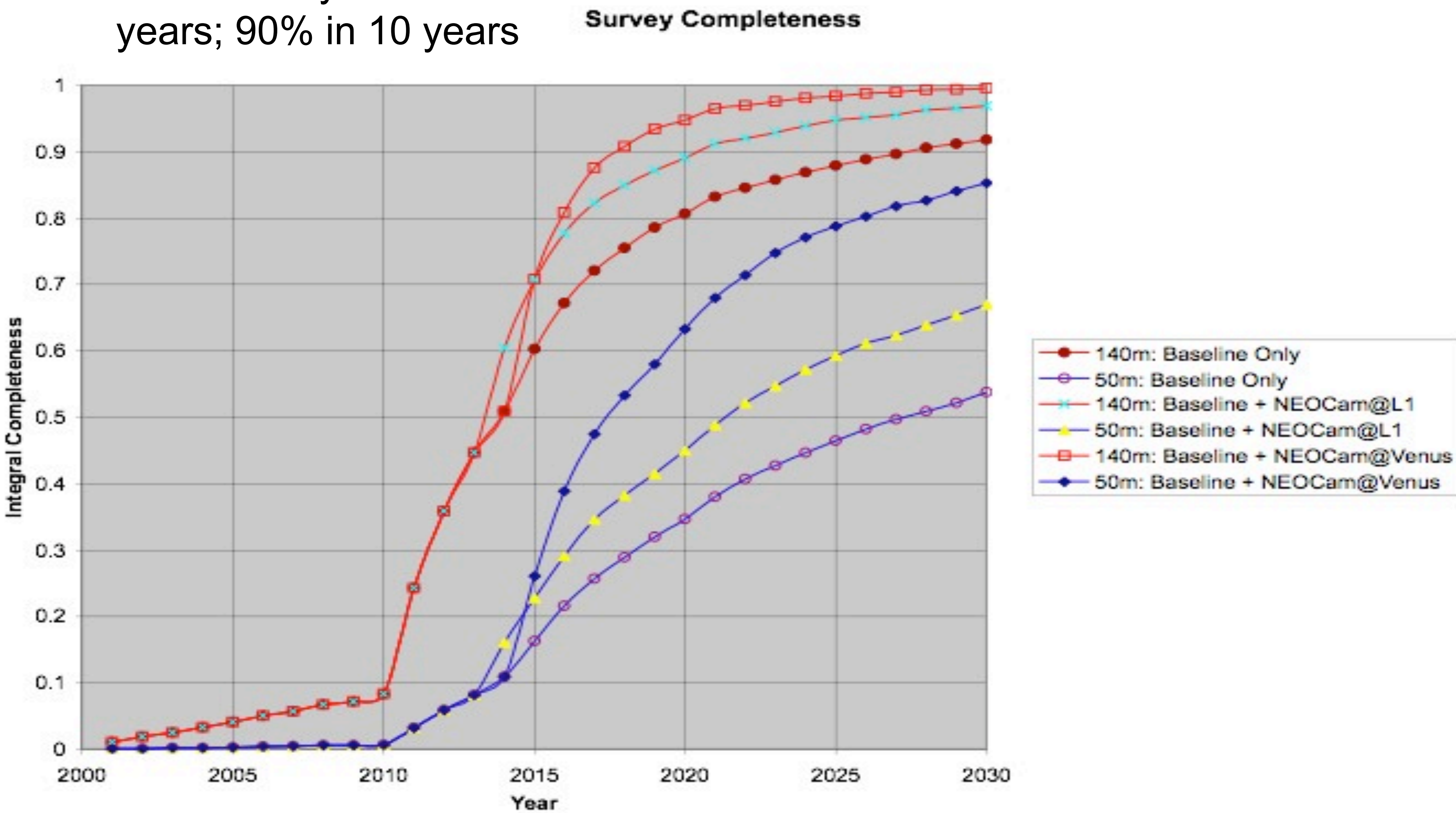
- NEOCam is planning to use the Pan-STARRS Moving Object Processing Software (MOPS) for moving object detection and linking
- Dr. R. Jedicke is a member of the NEOCam Science Team
- Capitalizes on Pan-STARRS and WISE MOPS (WMOPS) implementations
- Using MOPS allows us to automatically link visible & thermal IR measurements where visible data are available
- Albedo will be automatically computed as part of the NEOCam data processing pipeline for objects with visible data
- Data processing will be done by IPAC

NEOCam's Data Products

- A moving object catalog of astrometric data, orbits, diameters, and albedos
- A celestial source catalog of fixed and transient IR sources
- A multi-epoch image archive of ~30,000 square degrees at 3 – 5 μm and 6–10 μm bandpasses.
- The moving object catalog and basic calibrated data will be released to the public via NASA's Planetary Data System (PDS) and Infrared Science Archive (IRSA) without any proprietary period, within 2 weeks of receipt from flight system

NEOCam Capabilities

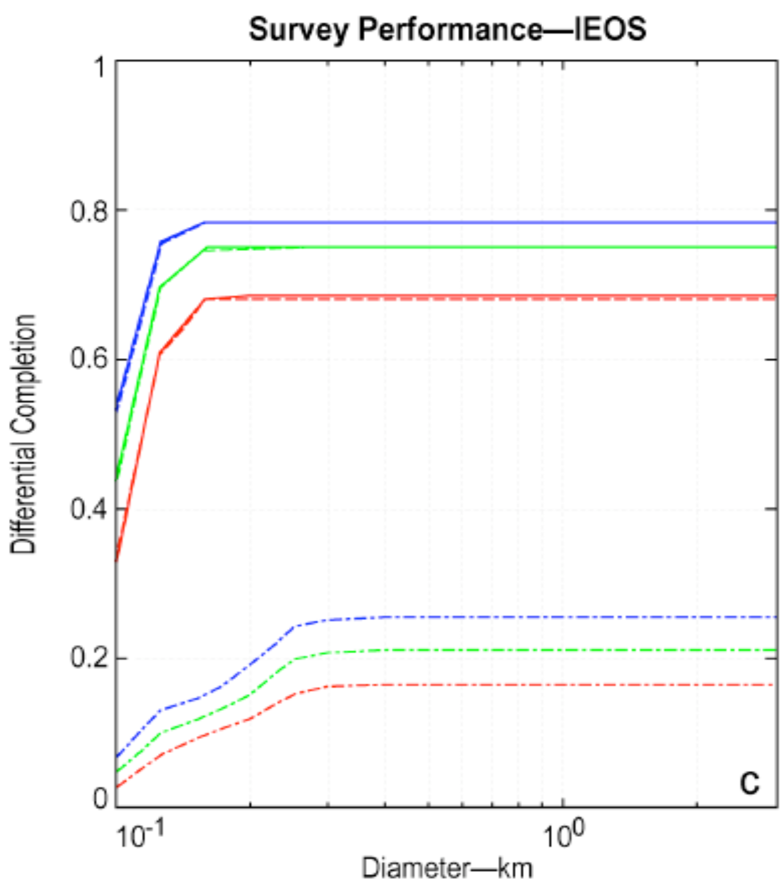
- NEOCam by itself at L1 will see about 75% of all PHOs >140 m in 5 years; 90% in 10 years

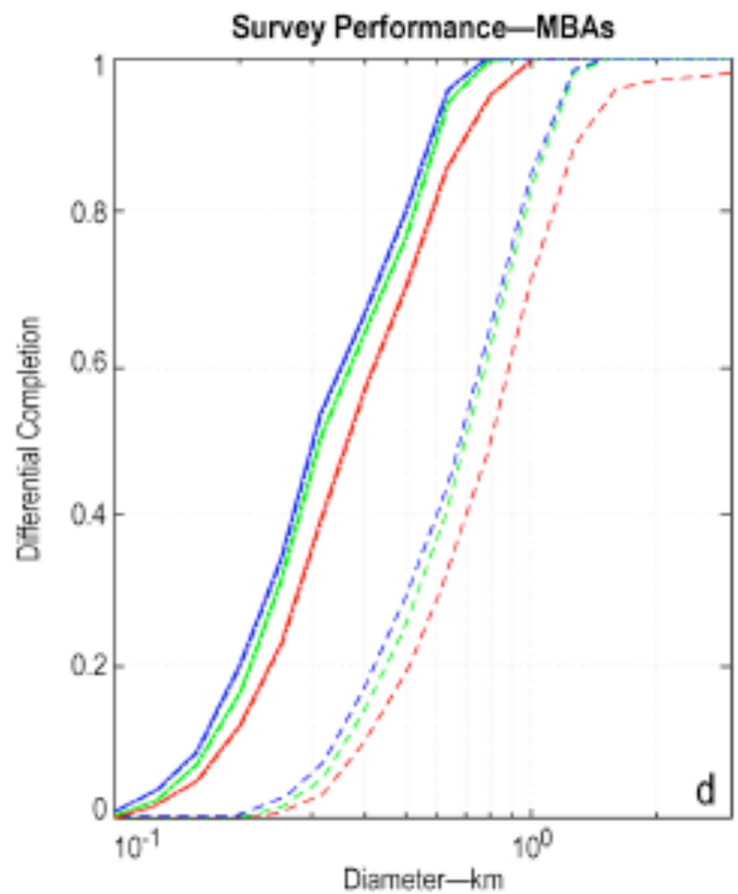


IEOs and MBAs

- NEOCam will detect virtually all the NEOs Interior to Earth's Orbit (IEOs) that pass within its field of view: >1000

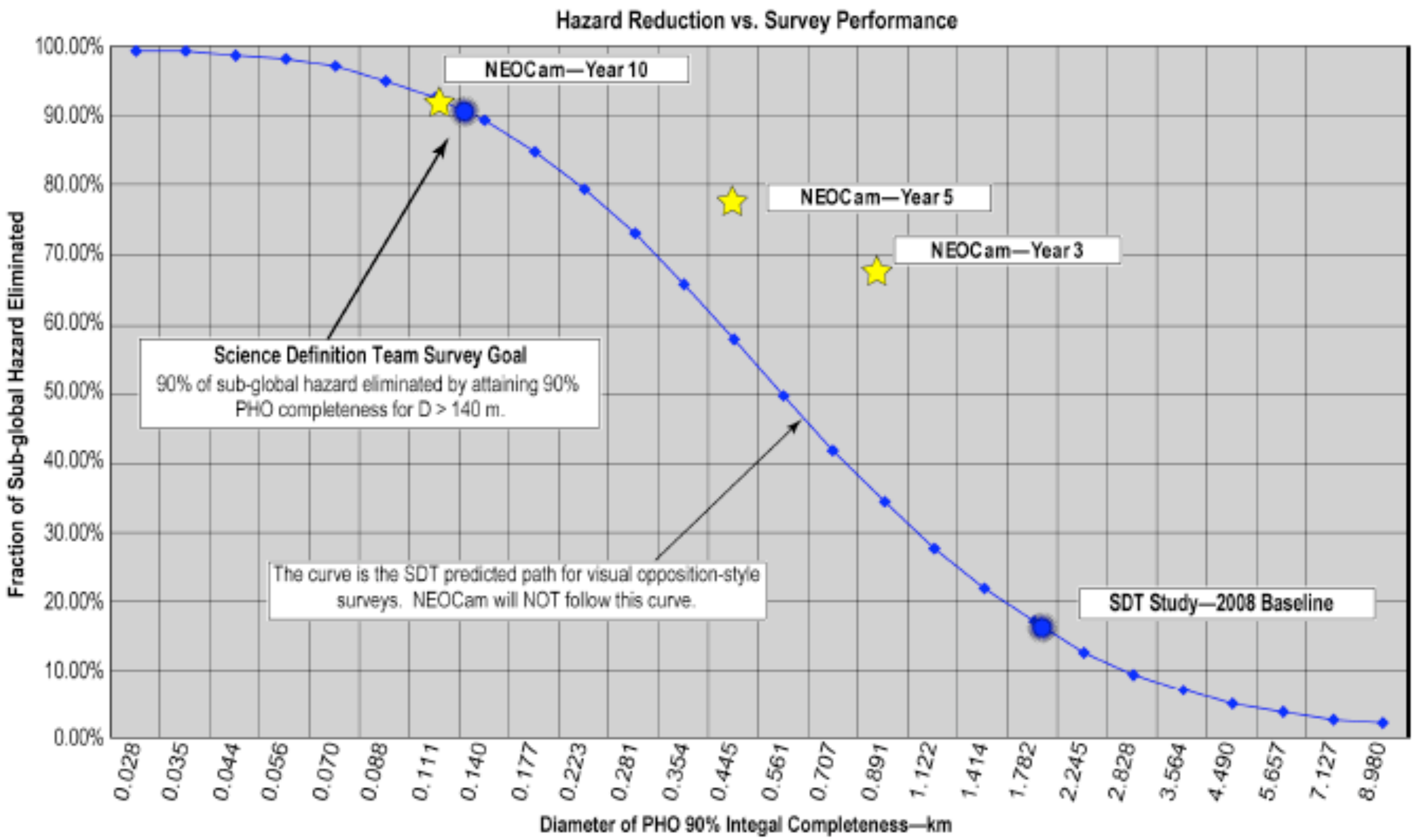
- NEOCam will find ~1 million Main Belt Asteroids





NEOCam Risk Retirement

- NEOCam will progress more rapidly than ground-based surveys toward the SDT goal of finding 90% of all Potentially Hazardous Objects (PHOs) in 15 years



Conclusions

- Space-based mid-infrared cameras have matured to the point of offering excellent detection and characterization of asteroids, particularly in conjunction with visible surveys

Detectability Assumptions

- 50-50% mix of low albedo (7%) vs. high albedo (23%) assumed
- Bottke et al. (2002) population model used
- Sensitivity estimated based on Spitzer model
- Astrometric precision ~0.3” with 3” pixels – based on 2MASS centroiding capability
- IR background: Leinert et al. 1999 confirmed by Spitzer
- Assumed 2 “nights” in 7 days, 3 in 40 days.
- Corresponds to V_{lim} = 24.1 for p_v = 0.14 and V_{lim} = 25.4 for p_v = 0.05