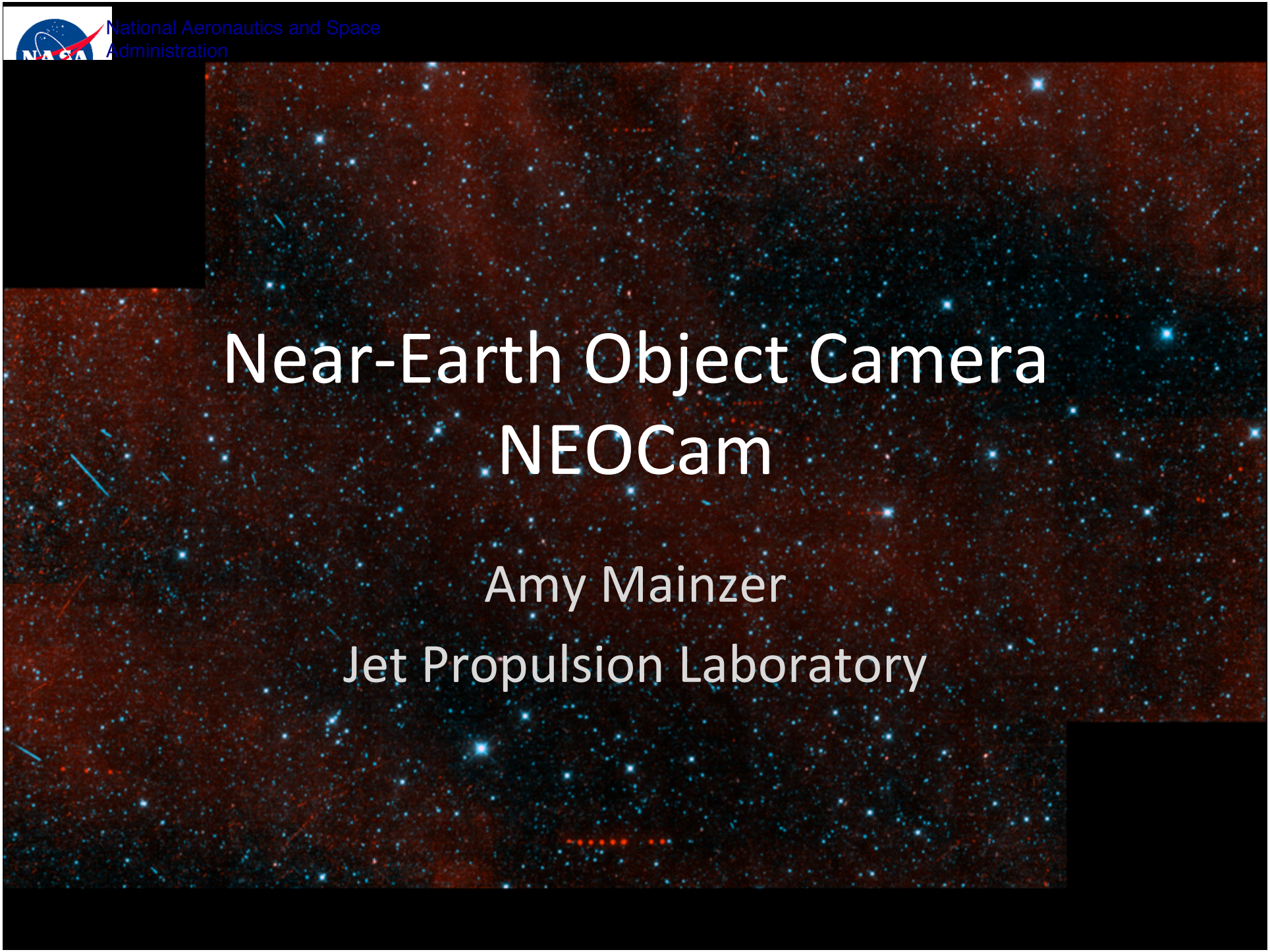

Near-Earth Object Camera NEOCam

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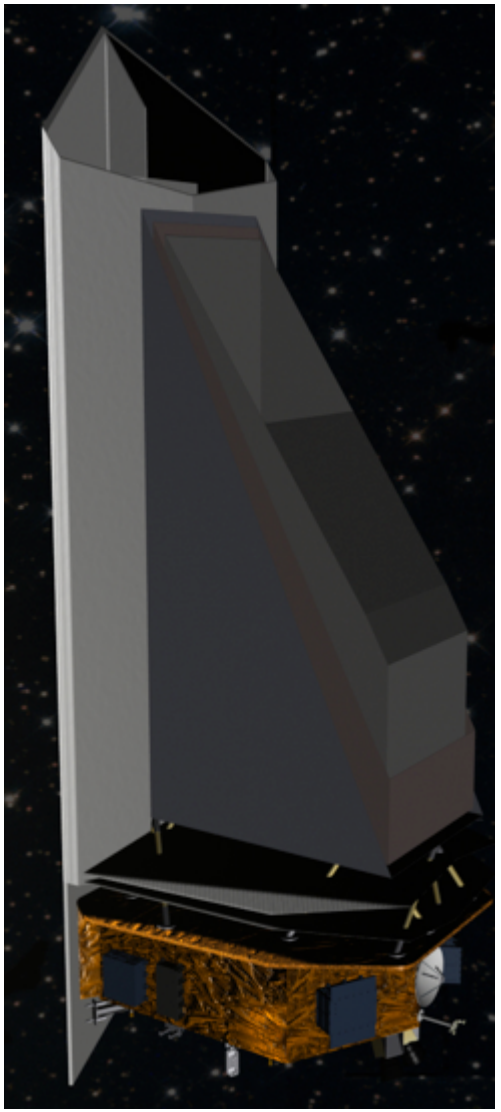
Near-Earth Object Camera (NEOCam)

- NEOCam's primary science objectives are threefold:
  - To assess the present-day risk of near-Earth object (NEO) impact.
  - To study the origin and ultimate fate of our solar system's asteroids.
  - To find the most suitable NEO targets for future exploration by robots and humans.
- Discovery proposal submitted in 2005, 2010
  - Awarded technology development in 2010
- Wide-field imager operating at 2 wavelengths: 4-5 & 6-10 μm
- Mission to discover & characterize 2/3 of near-Earth objects (NEOs) >140m, many smaller NEOs, Main Belt asteroids, comets



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Heritage

- WISE/NEOWISE, Spitzer, Kepler
  - WISE/Spitzer instrument heritage
  - Spitzer passive cooling
  - WISE/NEOWISE data processing
  - Kepler/WISE spacecraft bus

- Partners: JPL, Ball Aerospace, Space Dynamics Lab, Teledyne Imaging Sensors, IPAC
  - Competed selection of partners managed by small team at JPL
  - Science team includes experts in small bodies, IR telescopes, detectors

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NEOWISE

- WISE imaged entire sky in 4 IR wavelengths over 1 year mission
  - Partners: JPL, SDL, Ball, IPAC, Teledyne, DRS
- NEOWISE augmentation allowed detection & discovery of new minor planets
  - Physical parameters determined: diameters, albedos, etc.
  - Albedo-insensitive survey detects bright and dark asteroids equally well

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2011 GAO Report

Table 3: Cost Growth from Confirmation for Selected Major NASA Projects That Established Baselines Prior to Fiscal Year 2009 (dollars in millions)

Project	Development cost			
	Baseline	Current	Difference	Change (%)
Aquarius	$193.0	$227.3	$34.3	17.8
Dawn	$198.0	$266.4	$68.4	34.5
GLAST	$384.0	$418.8	$34.8	9.1
Glory	$159.0	$337.6	$178.6	112.3
Herschel	$95.0	$126.7	$31.7	33.4
Kepler	$313.0	$388.7	$75.7	24.2
LRO	$421.0	$451.3	$30.3	7.2
MSL	$969.0	$1,802.0	$833.0	86.0
NPP	$513.0	$780.1	$267.1	52.1
OCO	$187.0	$230.2	$43.2	23.1
SDO	$597.0	$667.0	$70.0	11.7
SOFIA	$306.0	$1,128.4	$822.4	268.8
WISE	$192.0	$191.8	-$0.2	-0.1
Average			**$191.5**	**54.99**
Total development cost	**$4,527.0**	**$7,016.3**	**$2,489.3**	

Source: GAO analysis of NASA data.

Note: "Baseline" refers to the cost baseline established when the project was confirmed.

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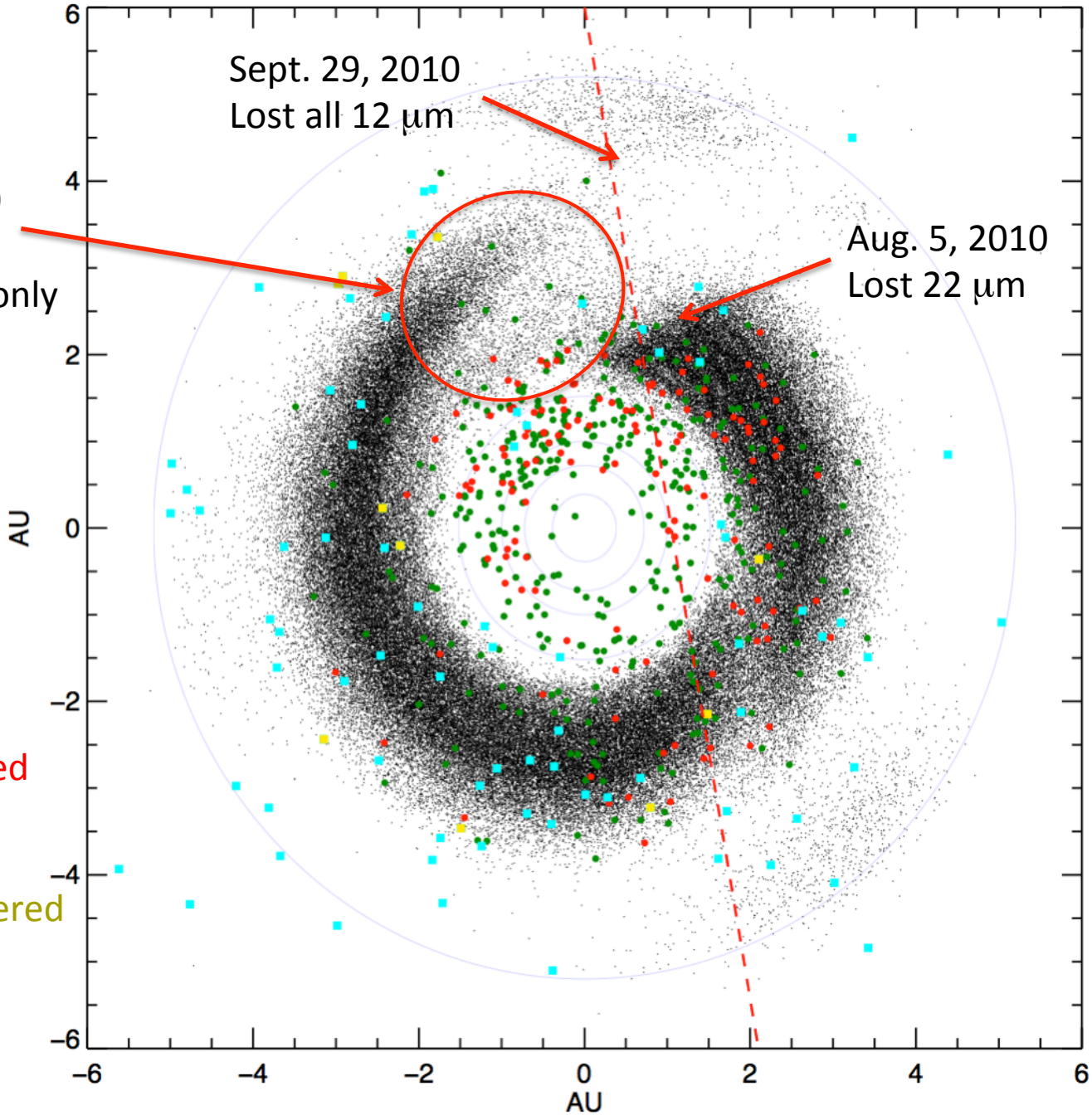
1 YEAR NEOWISE SURVEY



NEOs – NEOWISE-discovered
NEOs – others' detected
Comets – others' detected
Comets – NEOWISE-discovered
All other detected objects

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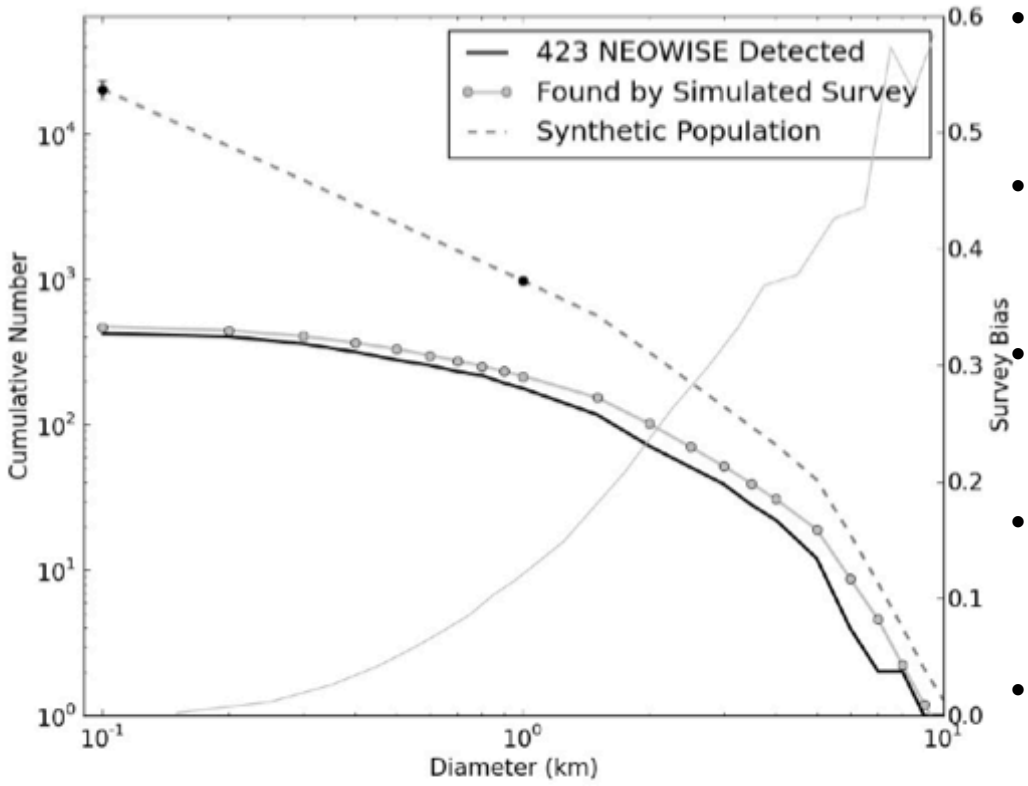
Revised NEA Size Frequency Distribution



- Spaceguard goal met: >90% of NEAs >1 km now discovered
- New result shows much shallower SFD: slope is -1.32+/-0.14
- Produces fewer NEOs down to ~100m
- 20,500+/-3000 @ 100m vs. prior estimates of 36,000 – 100,000
- Previous work (Harris 2008) shows another break at ~100 m, showing increase in slope below this size, below 100m, we cannot say (only 4 objects <100m detected)
  - Mainzer et al. 2011 ApJ 743, 156

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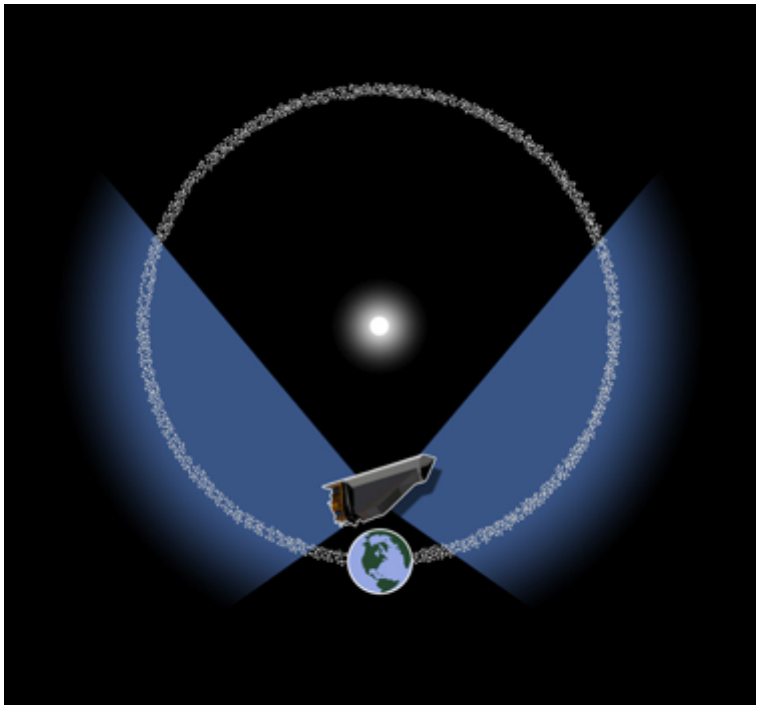
NEOCam's Orbit – Why L1

- Earth-Sun L1 Lagrange point allows large fraction of Earth's orbit to be visible at any time
- Cold environment allows passive cooling c.f. Spitzer Warm Mission
- Constant close distance (~1e6 km) allows full-frame data to be downlinked, leveraging WISE/ NEOWISE science data processing heritage
- L1 orbit has heritage from SOHO, Genesis



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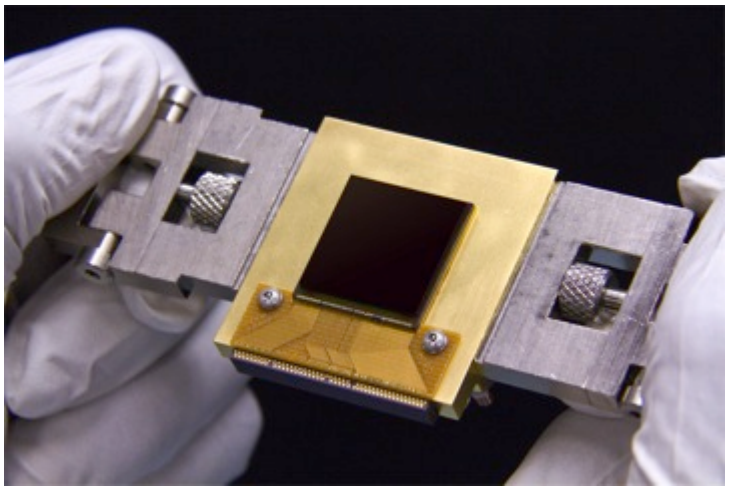
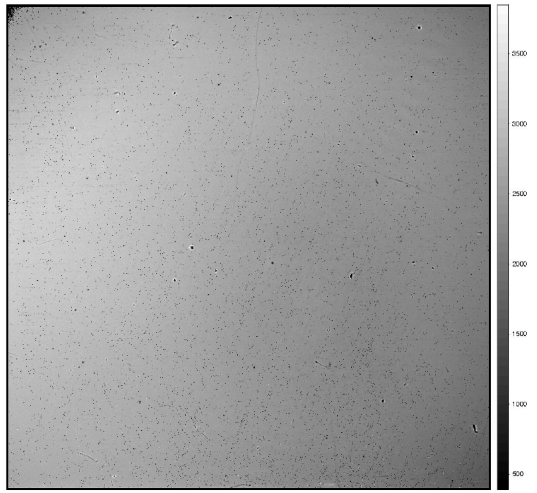
NEOCam Detectors

- Teledyne Imaging Sensors HAWAII 1RG and 2RG HgCdTe detectors selected for NEOCam

- Space astronomy heritage: WISE, Hubble WF3, OCO-2, JWST

- We are fabbing & testing new lots of detectors, funded by NASA Discovery & APRA
  - 5 μm cutoff arrays are TIS standard product
  - 10 μm cutoff material is created by altering Hg:Cd ratio, bonded to HAWAII 1RG WISE/OCO mux





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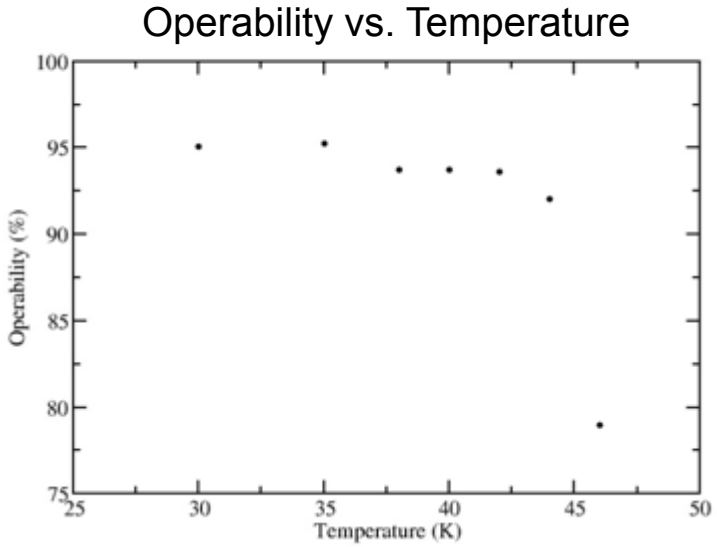
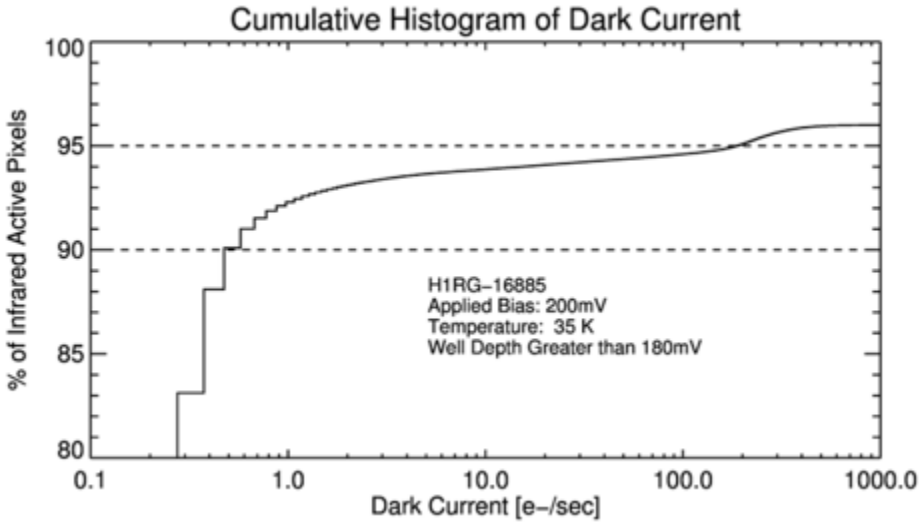
Detectors: Recent Success

- 4 goals for NEOCam detector development:
  - Increase cutoff wavelength to ~10 μm: **DONE**
  - Increase % pixels meeting dark current spec to >=90%: **DONE**
  - Increase operability (well depth): **DONE**
  - Increase format from 512x512 to 1024x1024 pixels: **DONE**
- McMurtry et al. 2013 **accepted** to Journal of Optical Engineering





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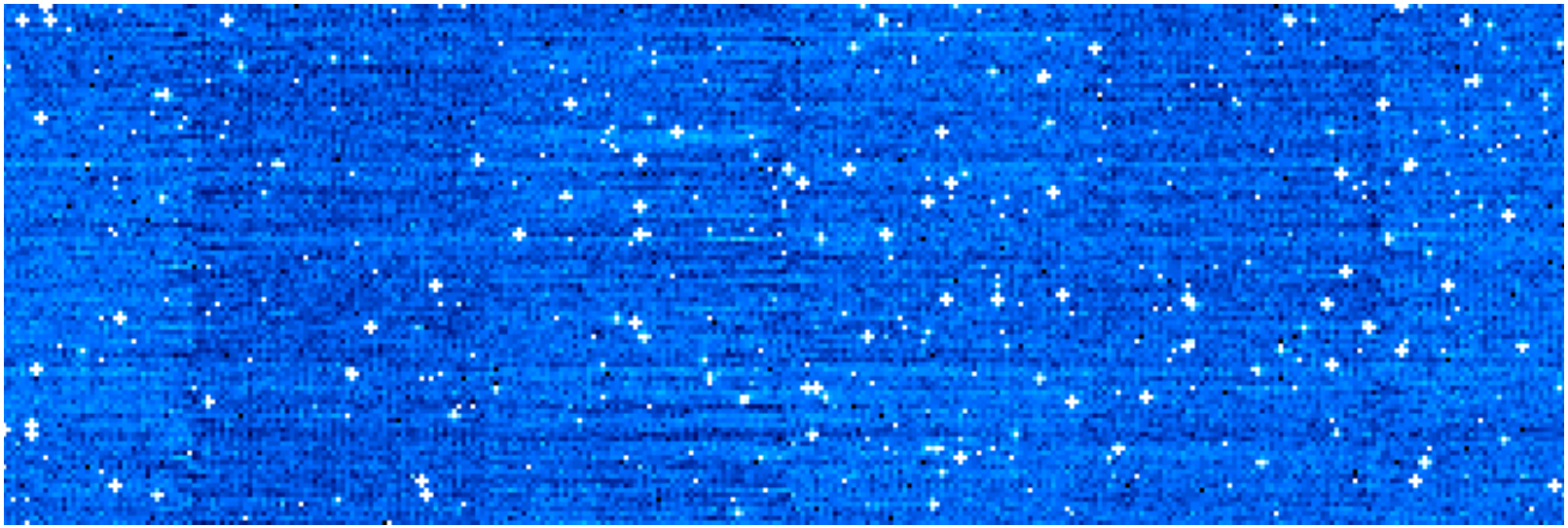
NEOCam
Science Data Processing

- Location @ L1 allows full-frame data to be downlinked
  - Leverages existing science data processing pipeline & archive heritage from WISE/NEOWISE
- When discovering new objects, most are found at low SNR
- Success at detecting sources & linking into tracklets depends on accurate artifact ID, astrometric & photometric calibration
- Developing & testing NEOCam cadence via synthetic survey



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Survey Simulation

- Detailed survey simulation (Mainzer et al. 2013 in prep) using synthetic populations based on NEOWISE results comparing L1 vs. Venus-trailing orbits
  - Mainzer et al. 2011, 2012; Grav et al. 2011; Bottke et al. 2002
- Survey sim includes generation of realistic source lists, including stars & galaxies based on WISE & Spitzer data
- Adapted asteroid-hunting pipeline from WISE/NEOWISE/ PanSTARRS to work with new cadence
- Survey sim accounts for trailing losses by predicting on-sky velocity and using model of SNR losses when objects are trailed – assumes trailing losses work the same for both surveys

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Survey Sim Results for NEOs >140 m

- Using Fast Rotating Model of Harris 1998 to model thermal fluxes

Table 3. All-sky survey simulation results for L1 and Venus-trailing missions using the FRM (Harris 1998). Column and row headings are the same as Table 2. The detection threshold is SNR=5, and trailing losses are included.

	L1						Venus					
Year	1	2	3	4	5	6	1	2	3	4	5	6
Atens												
Seen	349	513	605	671	716	755	176	343	428	495	556	590
Seen & Known	145	191	214	237	250	260	82	156	186	215	231	238
Optical	293	293	293	293	293	293	293	293	293	293	293	293
Known	497	615	684	727	759	788	387	480	535	573	618	645
% Complete	53.5	66.2	73.6	78.3	81.7	84.8	41.7	51.7	57.6	61.7	66.5	69.4
Apollos												
Seen	1079	1826	2478	2936	3339	3668	868	1450	1949	2317	2644	2945
Seen & Known	598	984	1281	1472	1632	1749	552	885	1138	1303	1424	1558
Optical	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380
Known	2861	3222	3588	3844	4087	4299	2696	2945	3191	3394	3600	3767
% Complete	41.3	46.5	51.8	55.5	59.0	62.1	38.9	42.5	46.1	49.0	52.0	54.4
Amors												
Seen	474	803	1091	1299	1477	1640	695	1231	1721	2012	2213	2407
Seen & Known	346	563	745	866	965	1062	471	795	1070	1220	1304	1391
Optical	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116
Known	2244	2356	2462	2549	2628	2694	2340	2552	2767	2908	3025	3132
% Complete	46.6	49.0	51.2	53.0	54.6	56.0	48.6	53.0	57.5	60.4	62.9	65.1
Total	5602	6193	6734	7120	7474	7781	5423	5977	6493	6875	7243	7544
% Complete	44.2	48.9	53.2	56.2	59.0	**61.4**	42.8	47.2	51.3	54.3	57.2	**59.6**

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Conclusions

- Survey simulations: L1 is right choice for NEOCam from cost/risk/performance perspective
- Detectors exceed spec
- Will repropose to next Discovery AO


Thank You