Some WISE Detector Anomalies & Calibration Issues

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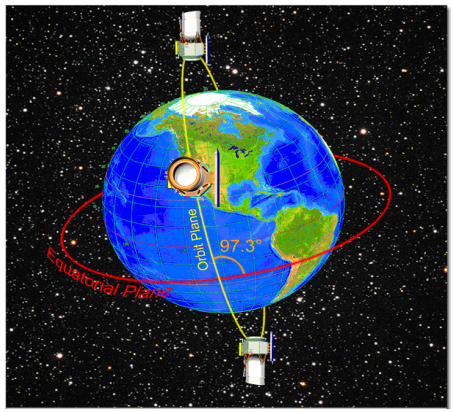
Detector Summary

The **W**ide-field **I**nfrared **S**urvey **E**xplorer:

- performed an all-sky survey in 2010 in four IR bands: ~ **3.4**, **4.6**, **12**, **22 μm**
- sun-synchronous Earth-polar orbit
- we focus here on the WISE band **W3** (12um) and **W4** (22um) detectors
- Si:As BIB, 1024 x 1024 pixel arrays from DRS, Indium bump bonded to mux.
- 8.8 sec exposures, 9 SUR samples, W4 was 2 x 2 binned on-board

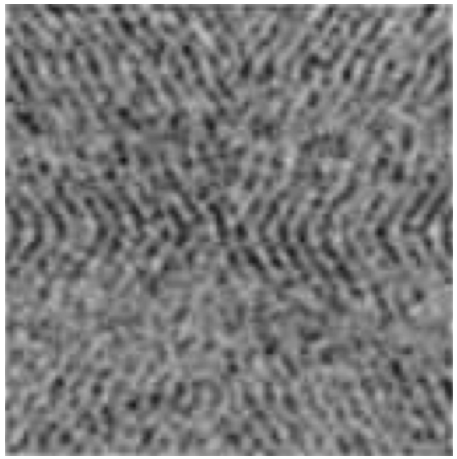


Parameter	Si:As Performance (W3 and W4)	Revised:
Wavelength Range (μm)	7.5-16.5 (W3) 20-28 (W4)	
Operating Temperature (K)	7.8±0.5	~ 6.8 K (flight)
Array Format	1024x1024	
Quantum Efficiency (mean over band, with AR coating (%)	>60	
Pixel Pitch (μm)	18	
Pixel Operability	>90%	
Dark Current (mean, @ operating temperature) (e-/sec)	<100	~ 7, 64 e-/sec (SDL ground)
Read Noise (e-, CDS rms)	103	~ 115e-, 209e- (SUR, flight) ~ 138, 158 [x10^3 e-] (SDL ground)
Well Capacity (e-)	>100,000	
Power Dissipation (mW)	3.7	
Outputs	4	

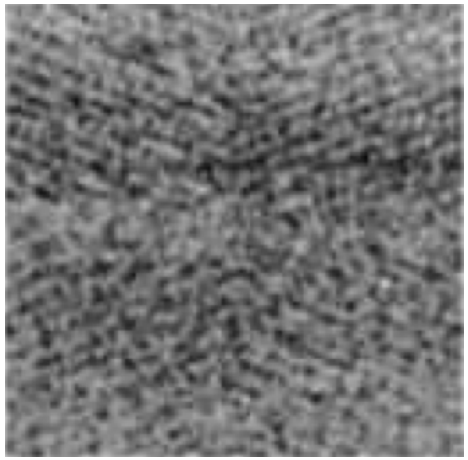
electronic gains (flight-derived):
W3 ~ 6.83 e-/DN
W4 ~ 24.5 e-/DN

Correlated (pattern) noise & IPC

- Additive, spatially correlated noise mostly seen in ground testing when connected to test electronics (EMI effect?); mild to negligible in-flight against higher background.



ground W3, e.g. 1

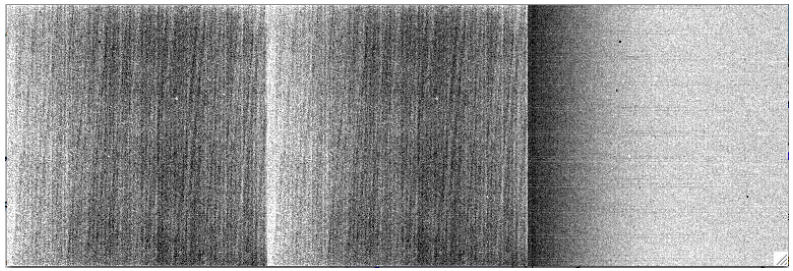


ground W3, e.g. 2

flight W3, banding ~ 0.6%

- IPC: ~ 5-6% coupling in signal in adjacent pixels (W3 and W4). Accounted for in gain, QE estimates.

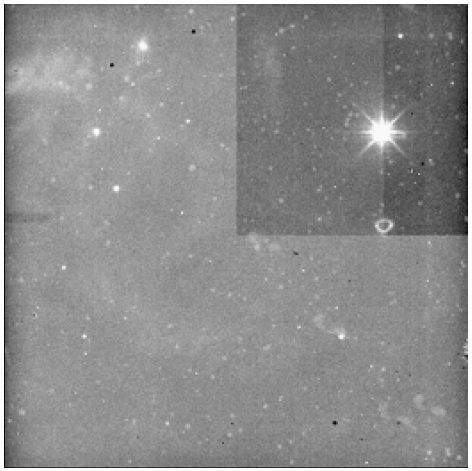
- **IRAC-ch3:** two short exptime frames, then differenced; courtesy S. Carey

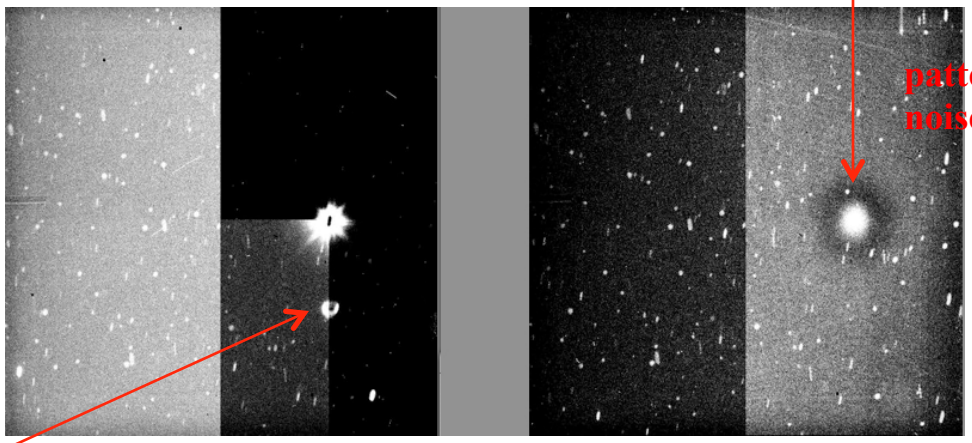


Droop Effects

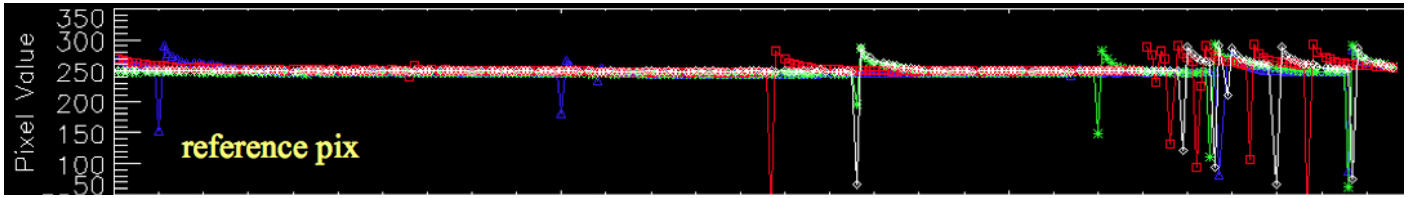
Two flavors (both additive):
(i) output quadrant amplifier dependent droop
(ii) intra-quadrant "split droop" at saturated pixels and bad pixel clusters

- quad biases corrected using reference (bare mux) pixels at top/bottom of arrays
- splits corrected using robust estimates of level differences in active pixels





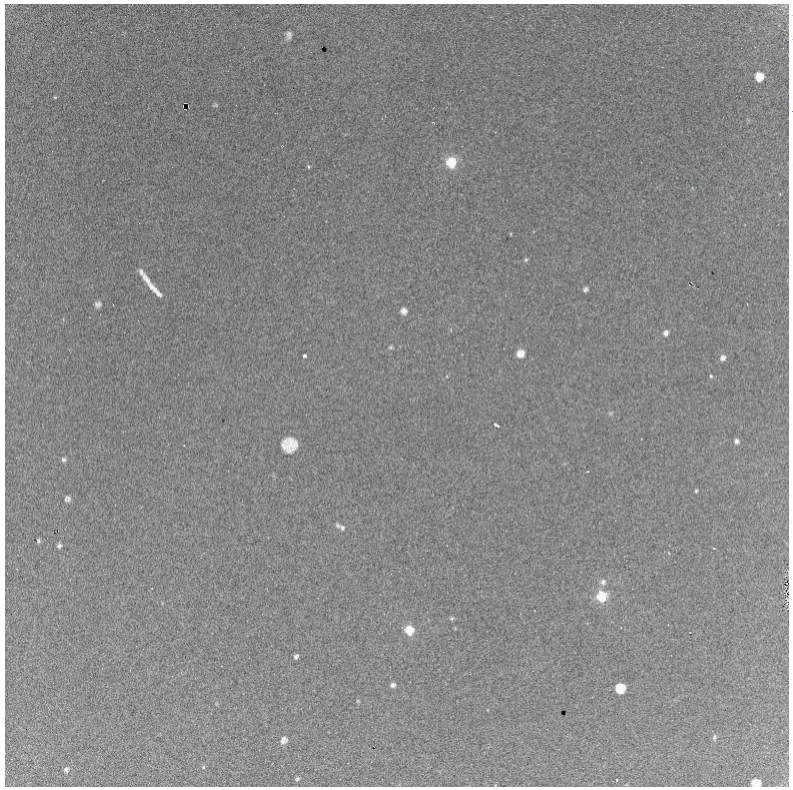
two consecutive frames (11 sec apart)
=> note the "droop-rebound" effect



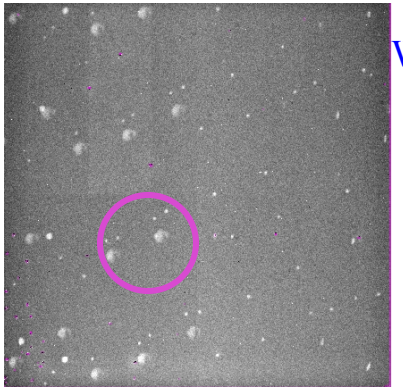
sequential frame number: 1 – 250 (~ 46 minute span)

Image persistence (latents)

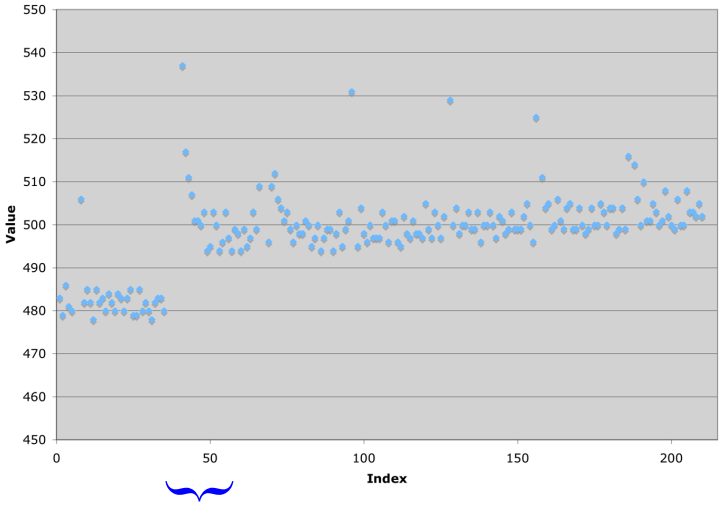
- Long term latents from bright (unsaturated, >~ 5-10 Jy) sources lasted until next anneal
  => resulted in blotches corresponding to elevations in responsivity of up to ~ 10%
- Short term latents: e-folding time ~ 3 sec



Blink animation of W3 frame processed with and without dynamic flat-field calibration.



W4 array



"short" latent phase (W4 array)

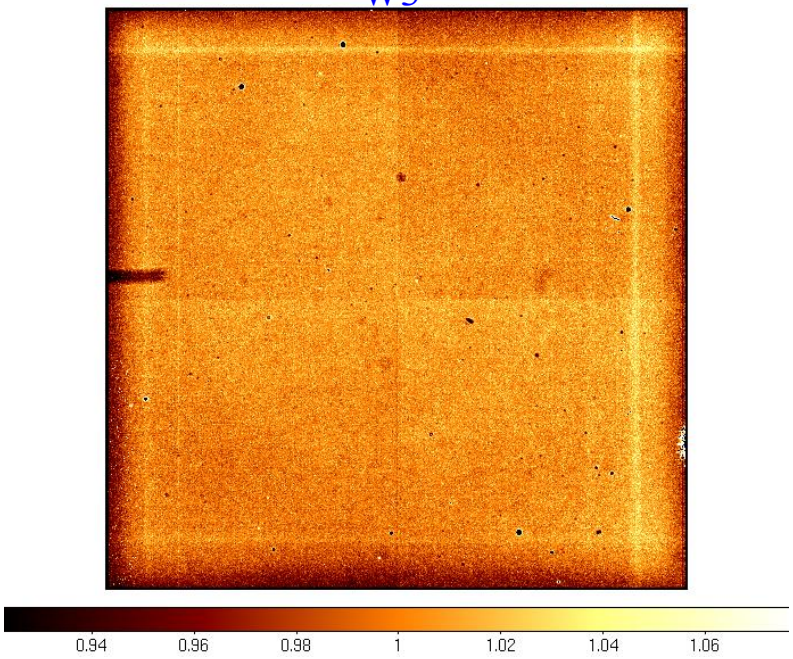
Annealing

- Annealed W3 & W4 arrays to ~15 K from nominal operating temp of ~6.8 K
- Annealed every 12 hours, mostly to wipe out accumulated long-term latents
- Backgrounds restored ~30 min following anneal

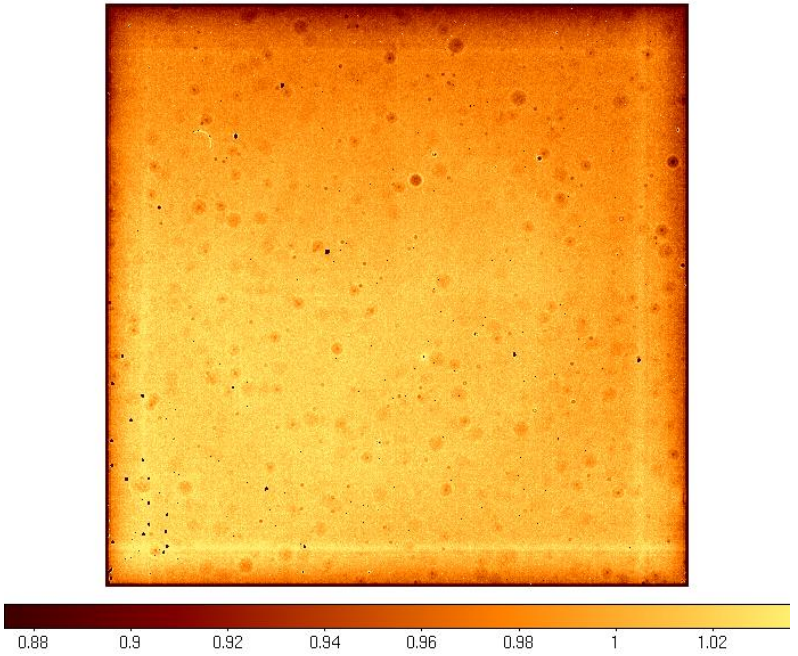
Photometric (responsivity) spatial variations

- High frequency relative pixel-to-pixel responsivity maps (variation ~ ±8%: 5-95th percentile range)
- Determined to an accuracy of ~0.04% per pixel using flight data

W3



W4

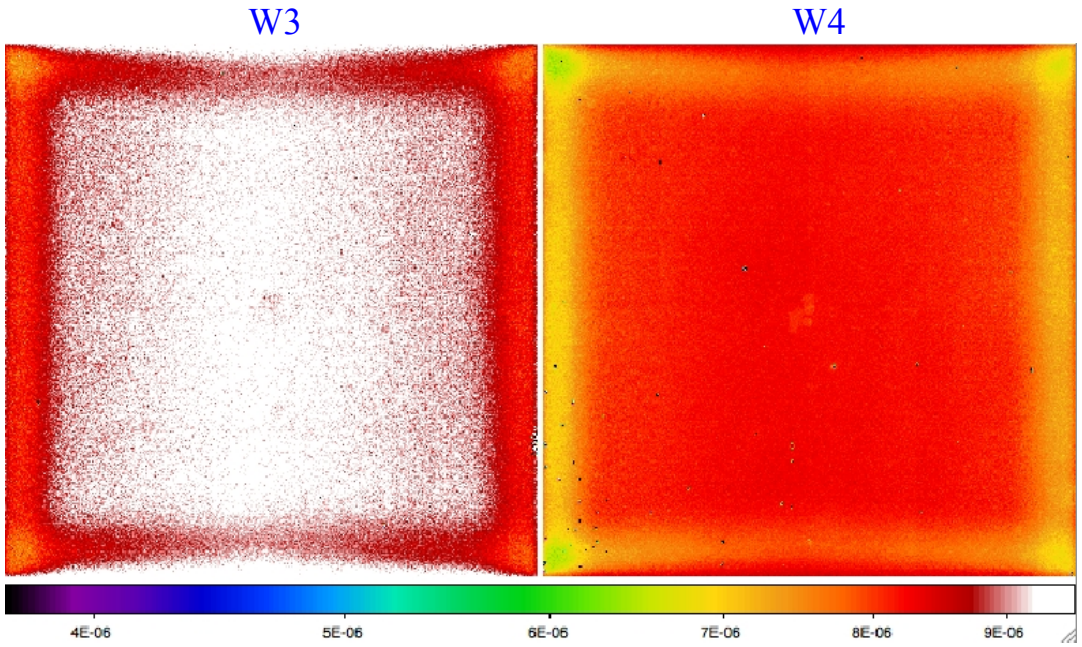


- Also made low-frequency responsivity maps to catch residuals in gain/ZP variations (from point-source photometry) after high-ν maps above were applied: variation ~ ±3%

Linearization

- Calibrated on the ground using uniform illumination, per pixel using quadratic model fits to sample-up-the ramp data (note: SUR samples not downlinked in flight)
- Able to linearize up to onset of saturation: ~ 85 – 90% full well (max A/D)
- To an accuracy of ~ 0.24% and 0.62% (random/statistical uncertainties from ground repeatablity)
- Validated in flight using point sources in special experiment in IOC, then empirically using CMDs and comparing to external photometry (Spitzer and 2MASS).

Variation in non-linearity model calibration coefficient:



W3 %NL; m_{obs}	W4 %NL; m_{obs}
3.29; 3157	10.23; 10767
4.09; 4365	10.14; 11511
5.16; 6392	10.46; 11116
7.14; 10606	10.66; 11455
10.49; 18311	10.89; 11855
*18.98; *32051	11.60; 13103
too saturated	13.58; 18417
too saturated	*24.04; *30266

In-Orbit-Checkout, advisories

- Have a (re)calibration plan in place

- Obvious checks: photometric sensitivities, instrumental throughput

- Software/tools in place to derive/validate all calibrations
  => dynamic (self-calibration) plan in mind to mitigate latents, bias and amplifier drifts, bad pixel transients
  => includes PSFs, variation over each array, distortion, etc..

- Be prepared for the 'unknown unknowns':
  => e.g. for WISE, the different flavors of latents and droop caught us by surprise
  => FOV distortion calibration was harder than expected (especially in W3, W4: scarcity of sources)
  => W4 sensitivity was x2 lower than expected (bluer filter response than measured on ground coupled with lower transmission at a dichroic)