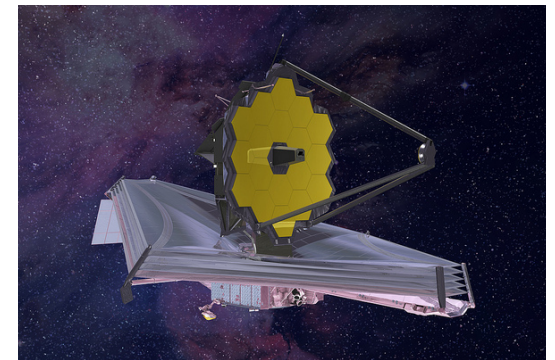
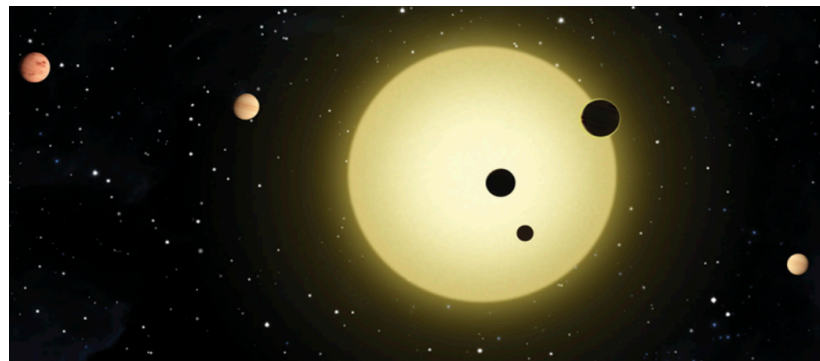




Comparing and Contrasting Detectors: JWST NIR vs HST WFC3

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Why this talk?



- HST WFC3 IR extensively used for transit observations today
- WFC3 uses a Teledyne HIR detector array
- JWST's 3 near-IR instruments (NIRCam, NIRSpec, FGS/NIRISS) use Teledyne H2RGs
- JWST will build on WFC3 experience vs. detectors
- To maximize the benefits, important to know...
 - what is likely to be the same
 - what is likely to be different, and
 - areas where more study now can pay off in better science later



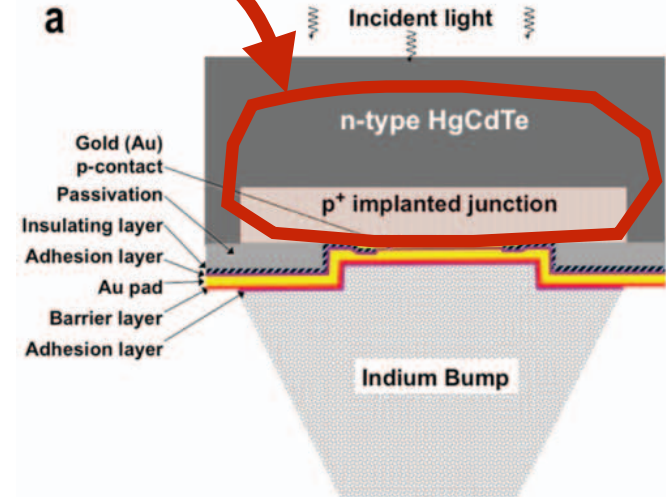
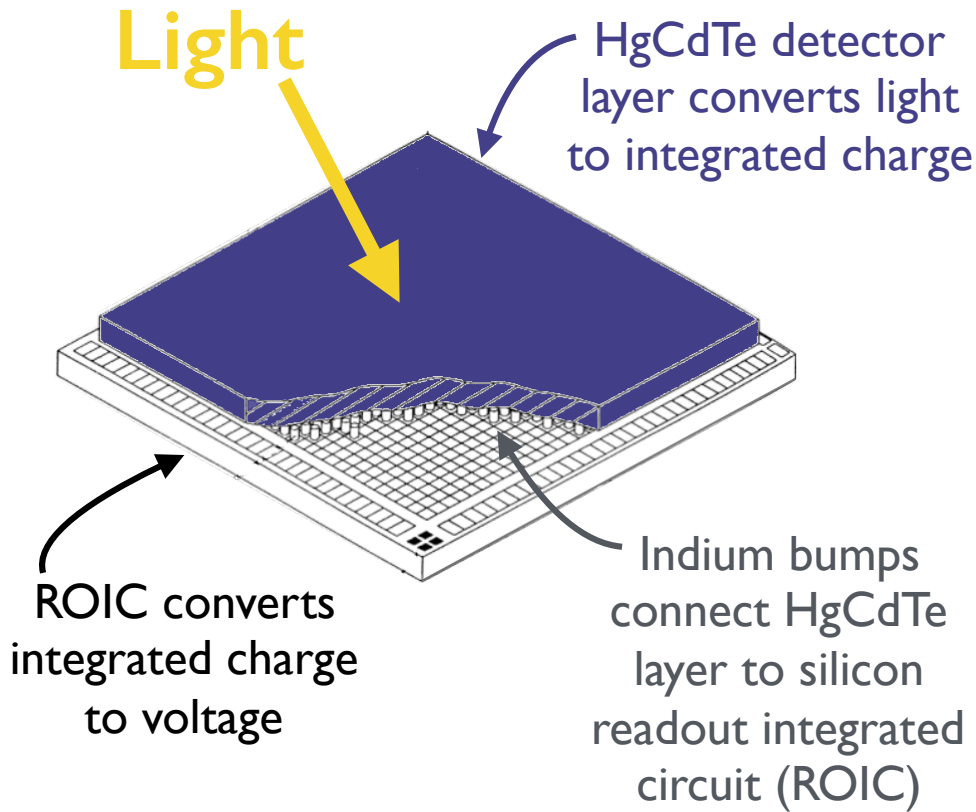
What Is the Same?



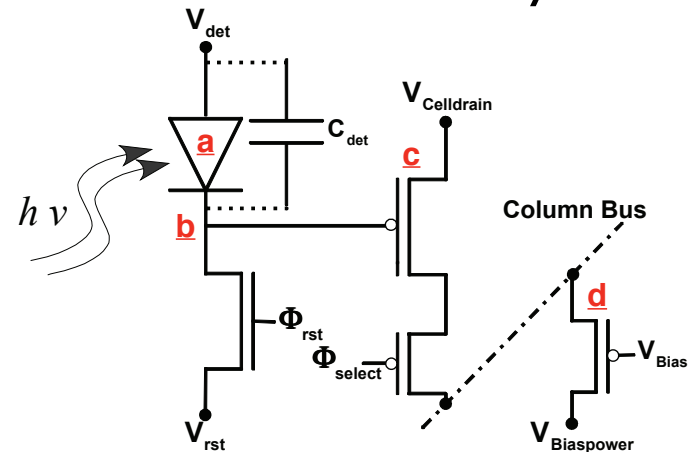
Same Basic Detector Architecture



Each pixel is a little photodiode
photodiode



At the individual pixel level, the ROIC is substantially the same





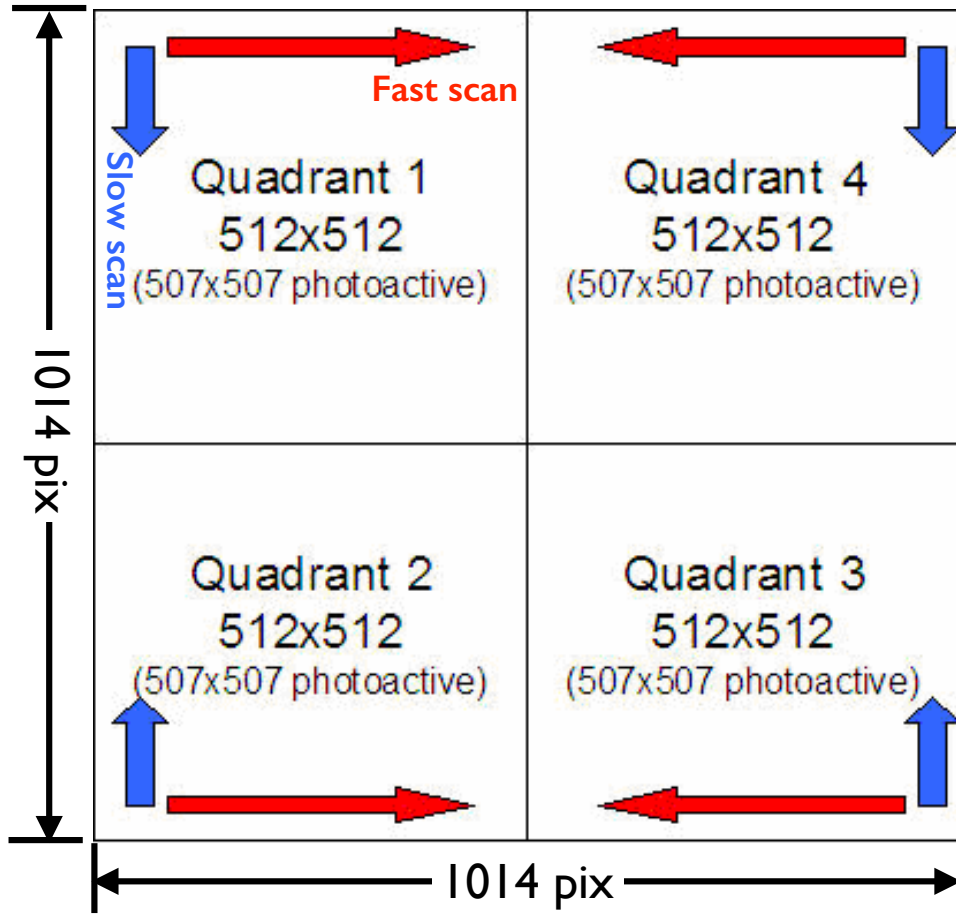
What Is Different?



How pixels are arranged

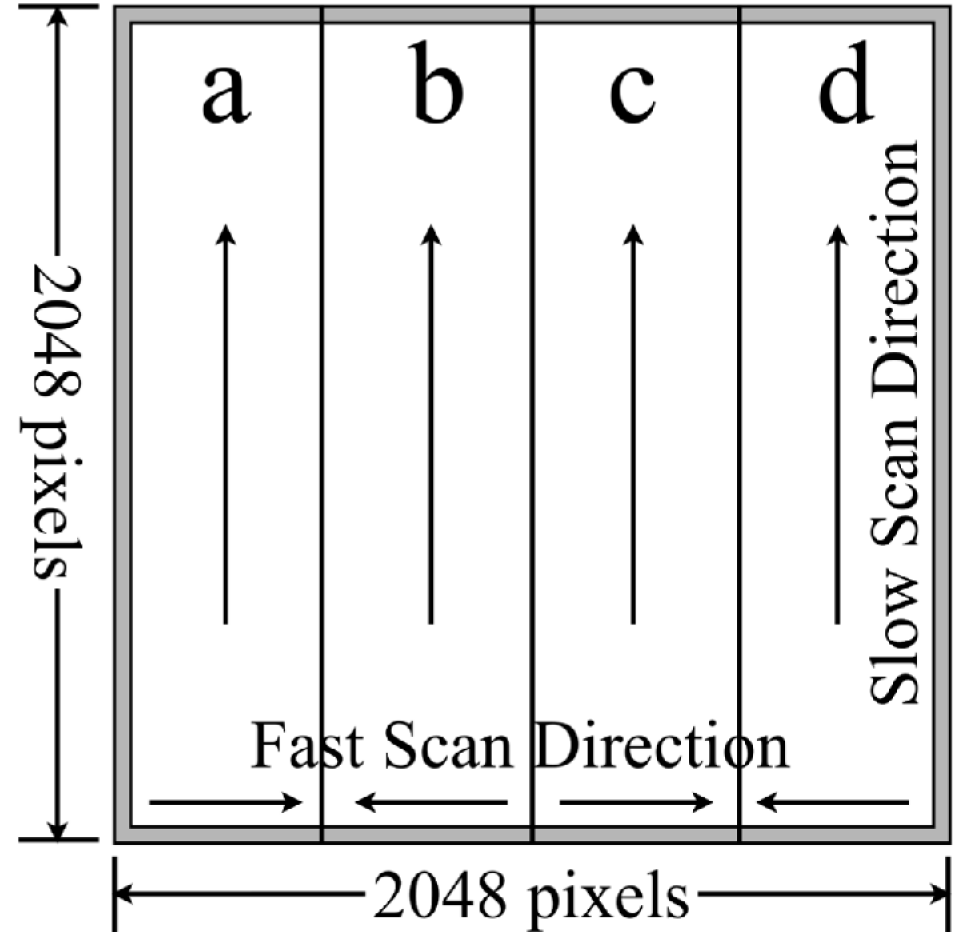


WFC3 has "quadrants"



- 5 pixel wide border of non-photosensitive reference pixels on all sides

JWST has "stripes"



white = regular pixel

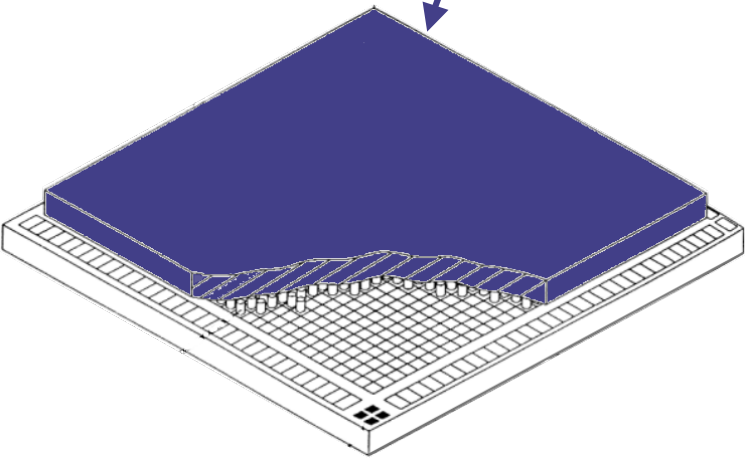
gray = reference pixel

- 4 pixel wide border of non-photosensitive reference pixels on all sides

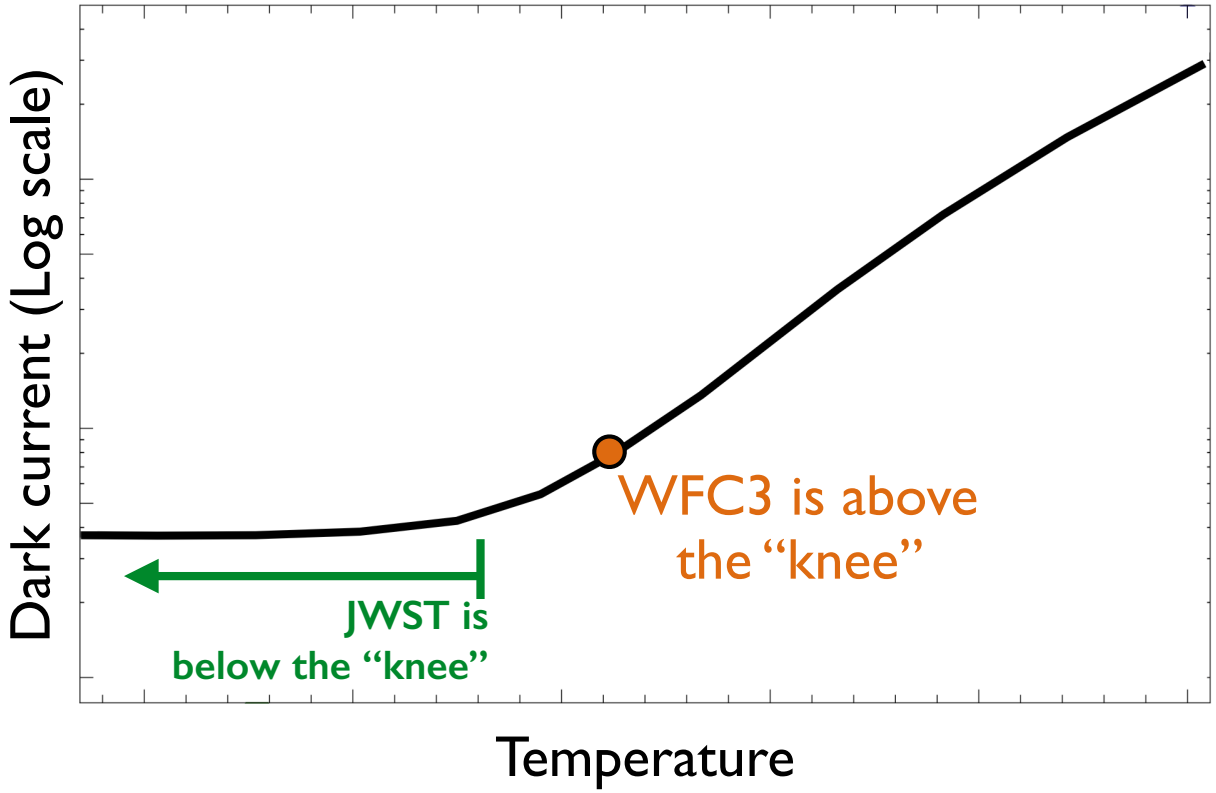


Operating temperature relative to “knee” in dark current

Pertains to HgCdTe detector layer



- Semiconductor defects that are thermally activated in WFC3 “frozen out” in JWST
- JWST’s lower operating temperature should be beneficial
 - Lower dark current
 - Less persistence
 - Better reciprocity



JWST operates 2.5 μm and 5 μm cutoff HgCdTe at $T < \sim 45 \text{ K}$. WFC3 operates 1.7 μm cutoff HgCdTe at $T \sim 145 \text{ K}$. WFC3 is significantly warmer with respect to the HgCdTe bandgap energy.

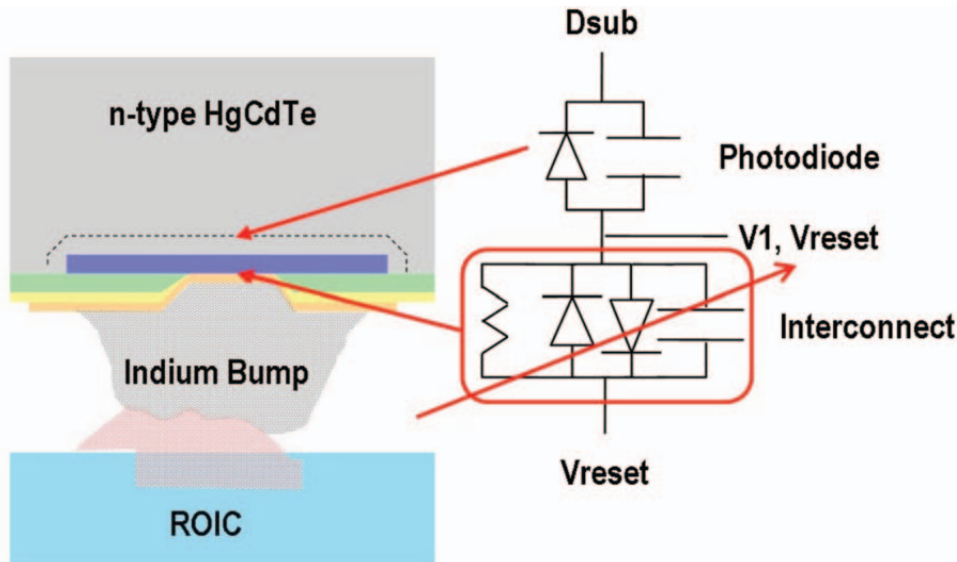
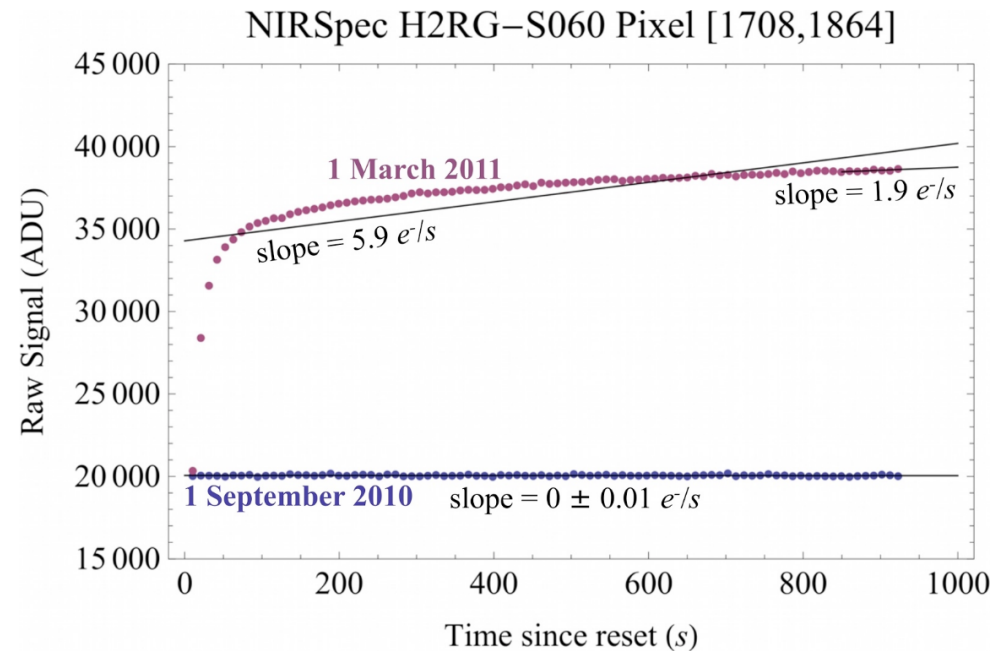


Old vs. new HgCdTe “barrier layer” design



- WFC3 detector has the same design flaw that caused “first” JWST detectors to degrade in ~2010
 - WFC3 detector likely degraded somewhat between manufacture and launch
 - Now stable. T ~ 145 K operating temperature halts degradation mechanism
- Practical effect is that many WFC3 pixels have a little parasitic capacitor in series that is not there in JWST

May see fewer “RC-type” pixels in JWST



- JWST should have less of these than WFC3
- Practical effect is that for the same source brightness, one infers higher slope immediately after reset compared to later on
- If this artifact is important, it would be beneficial to compare RC-pixel statistics for JWST and WFC3.



Readout electronics



- WFC3 uses a discrete electronics box. JWST uses Teledyne SIDECAR ASIC.
 - SIDECARs have many advantages
 - Physically small, low mass, low power dissipation, located close to detectors, very flexible programming, easy system engineering, etc...
 - But, not necessarily higher performing in all areas. The controller can play a large role in determining how stable the system is
 - More study might be desirable to understand...
- **How WFC3 bias stability compares to JWST**
 - **How WFC3 photometric stability compares to JWST**



Summary



- In many ways, WFC3's IR channel is a good indicator for what to expect with JWST
- There are some differences, most of which should be beneficial in JWST
 - JWST's lower operating temperature will freeze out charge traps that would affect WFC3. Benefits should include lower dark current, lower persistence, and better reciprocity
 - JWST's more recent HgCdTe process has lower defect density. The benefits are as described above
 - JWST uses better indium barriers. The benefits should include fewer "RC-type" pixels.
- One area where more study might be beneficial is stability. The detector electronics play a significant role in determining how stable a detector system is (v.s. bias drifts and photometry). JWST's SIDECARs are completely different from WFC3's Ball electronics
 - Studies comparing the bias and photometric stability of WFC3 and JWST might be useful to informing data acquisition and calibration strategies for JWST.