

Understanding JWST detectors Q&A

1. What is the difference between the JWST NIR and MIR detectors? JWST uses two different types of detectors: mercury-cadmium-telluride (HgCdTe) H2RG detectors for the 0.6-5 μm near-infrared and arsenic doped silicon (Si:As) detectors for the 5-28 μm mid-infrared. They also have significantly different readout electronics.
2. What is the fundamental difference between a CCD and a JWST detector readout? Unlike CCDs, the JWST detectors use the up-the-ramp/MULTIACCUM method, that samples (and records) the pixel signal multiple times as charge accumulates during an integration.
3. What is a frame? A frame is a single sample of all pixels in the detector array (or subarray).
4. What is a group? A group is the on-board average of multiple non-destructive frames. Each group is transferred to the solid-state recorder for downlinking to the ground.
5. What's the meaning of "group gap" or "dropframes" in the JWST NIR detectors? These are frames between groups that are sampled but not included in the group average.
6. What is a reset? A reset is the action of closing the detector readout circuit reset switch to reestablish the detector reset voltage. This removes the accumulated charge within a pixel and prepares it for the next integration.
7. What is an integration? An integration is a set of groups starting with the first group after a reset and ending with either the last group before a reset (NIR) or the last read-reset group (MIRI).
8. What is an exposure? An exposure is a set of identical integrations that are separated by only a constant number of resets (nominally 1).
9. Suppose you have data from a CCD and from a JWST detector. They both reach the saturation level in one-half of the total integration time. Can you describe what the main difference is? Can you recover information in the saturated pixels? CCDs accumulate signal/charge over the whole integration resulting in a single value/read per pixel. Flux information from the pixel cannot be recovered if it becomes saturated at any time during the integration. JWST detectors use the up-the-ramp/MULTIACCUM technique, that allows to recover discrete information on how the pixel charge/signal increases over time. When a pixel saturates the information pre-saturation can be recovered and used to estimate the flux in the pixel. This is not possible when the source is so bright that pixels become saturated in the first group.
10. What will be the impact of a cosmic ray in a JWST integration? Can information be recovered? When a pixel receives a cosmic ray impact, the result is a "jump", a discontinuity in the ramp. Effectively the integration is divided into two semi-ramps. Both semi-ramps can be used to recover signal information.
11. What is the practical difference between a MIRI SLOW mode exposure and a NIR exposure with NFRAMES=8. MIRI SLOW mode data is more robust against cosmic rays because all samples happen within 80 microseconds. Which has a higher data rate: a single MIRI Si:As detector running in SLOW mode or a single NIRCAM H2RG detector

using the MEDIUM8 readout pattern? MIRI, because it has 5 amplifiers, whereas NIRCам has only 4.

12. Given a certain readout pattern, why is the group time different for full and subarray mode? Because in subarray mode a smaller section of the detector is readout, and that takes less time. The smaller the subarray the shorter the group time.
13. If a user defines a single NIRCам exposure (i.e. no dithers) with all modules in FULL array and BRIGHT1 readout pattern, that uses 10 groups and 1 integration, the exposure time is 203.99 second. 10 groups and 2 integrations result in 418.73 seconds. Why the total time of 2 integrations is not twice as long as one? Can you guess why that would not be the case for MIRI?

Readout mode: BRIGHT1, 1 integration of 10 groups takes 203.99 seconds, two integrations take 418.73 seconds. The clock time of two integrations is more than twice one integration, because there is a reset in between. This would not be the case for MIRI because a read-reset (rather than a reset) is executed between integrations, adding no extra time.