Charge Spilling and the Brighter-Fatter Effect in JWST NIR Detectors

Slides extracted from:

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- Upon saturation, the JWST H2RG detectors spill additional photocharge into neighboring pixels in a manner similar to “blooming” in CCDs. This shows up as a distinct increase in the apparent slope of any unsaturated neighbors as they continue to accumulate charge up-the-ramp.

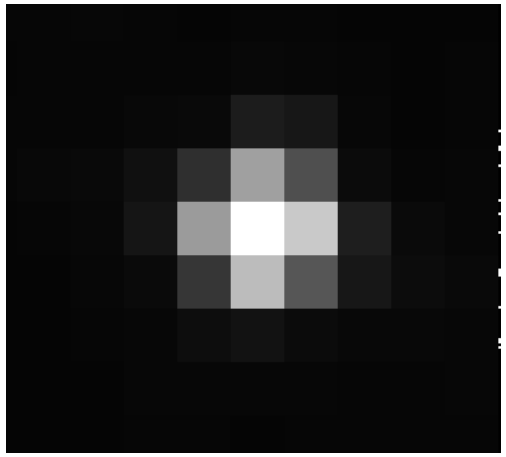
- This behavior was not seen in the NICMOS or WFC3 H1R detectors, but is apparent in **ALL** of the JWST H2RG arrays, including the NIRSpec detectors in the ODL and data from CV3 and OTIS testing of the flight arrays in the other NIR instruments. High contrast between adjacent pixels is necessary to see the effect on slopes.

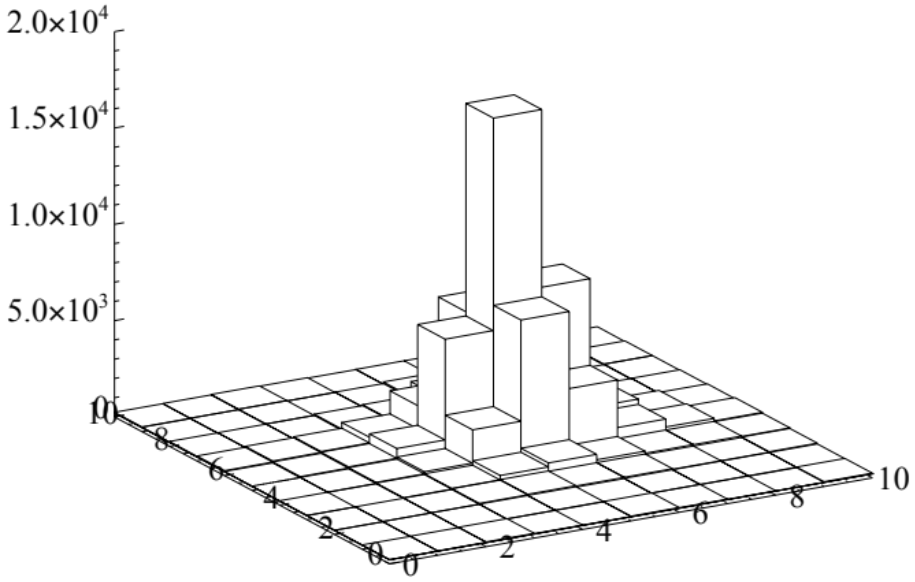
- Spilling is strongest into immediate neighbors, but some charge reaches many pixels beyond. Flagging the immediate neighbors of saturated pixels to stop slope fitting may provide a simple 1st order pipeline solution.

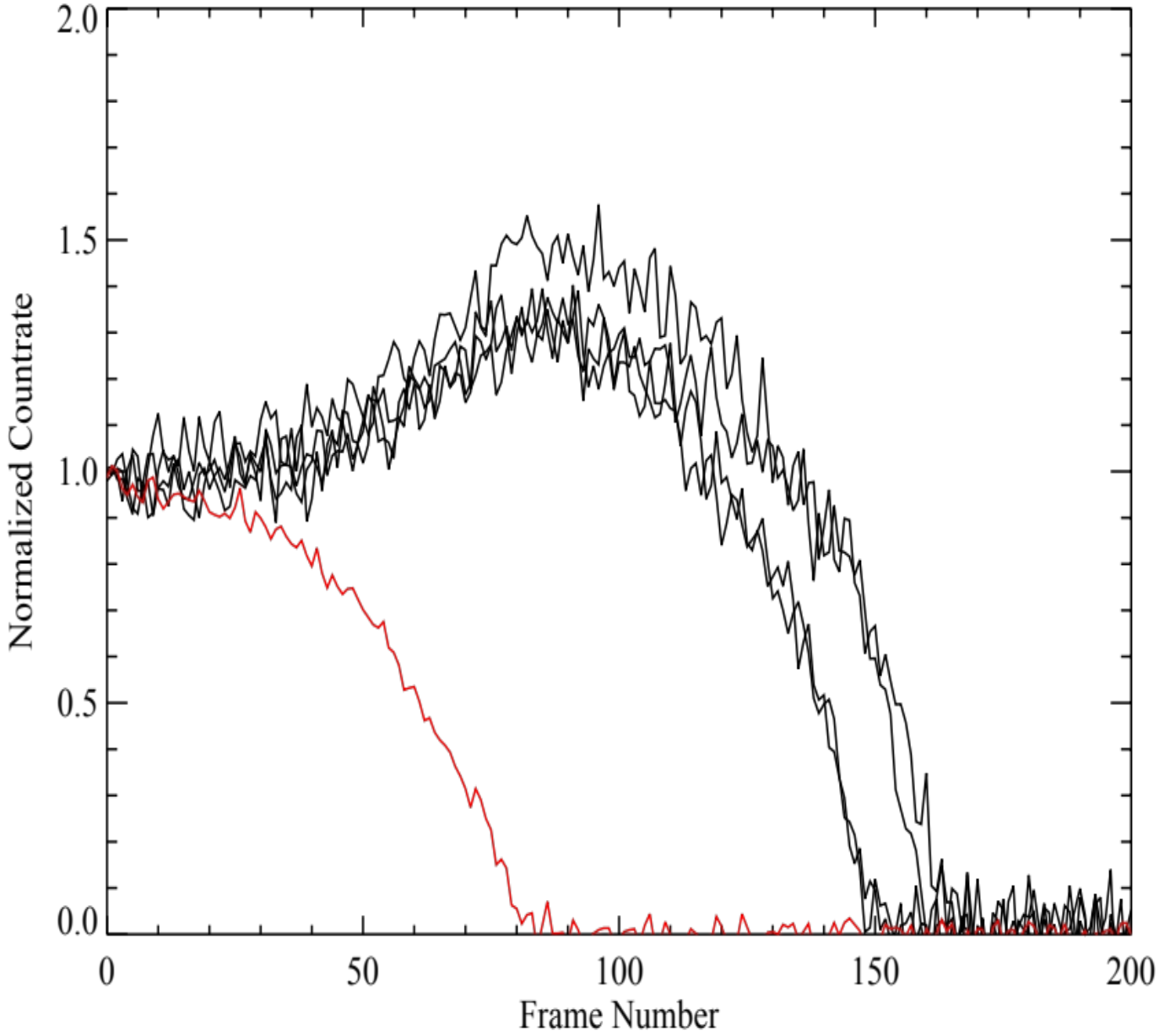
- Charge conservation: Is all the spilled charge captured in the neighbors?

- Charge spilling at saturation is likely the ultimate end-point of the same physical mechanism behind the “Brighter-Fatter” effect in these NIR arrays.

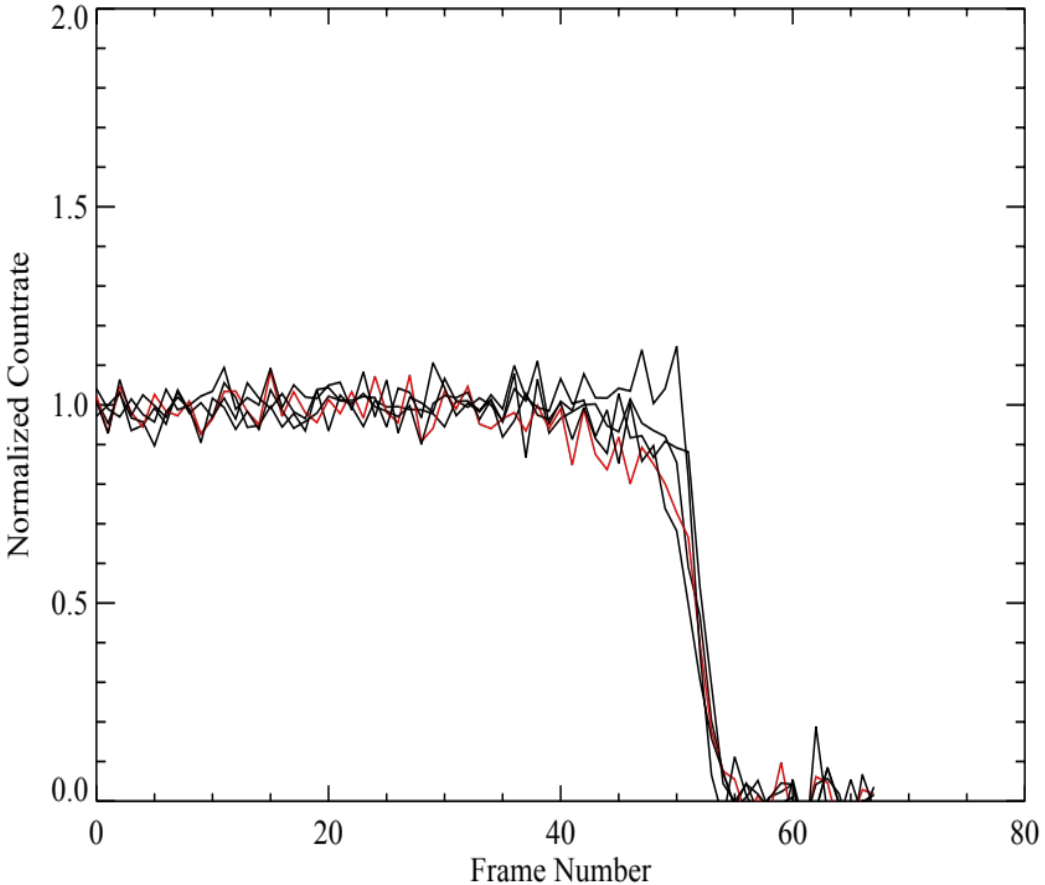
In-focus image of a 1um pinhole, already corrected for nonlinearity. Plots of countrate vs frame number as the integration proceeds show re-distribution of charge from the core pixel (red) to the four adjacent neighbors (black).

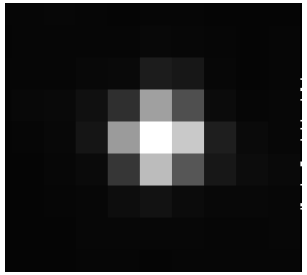


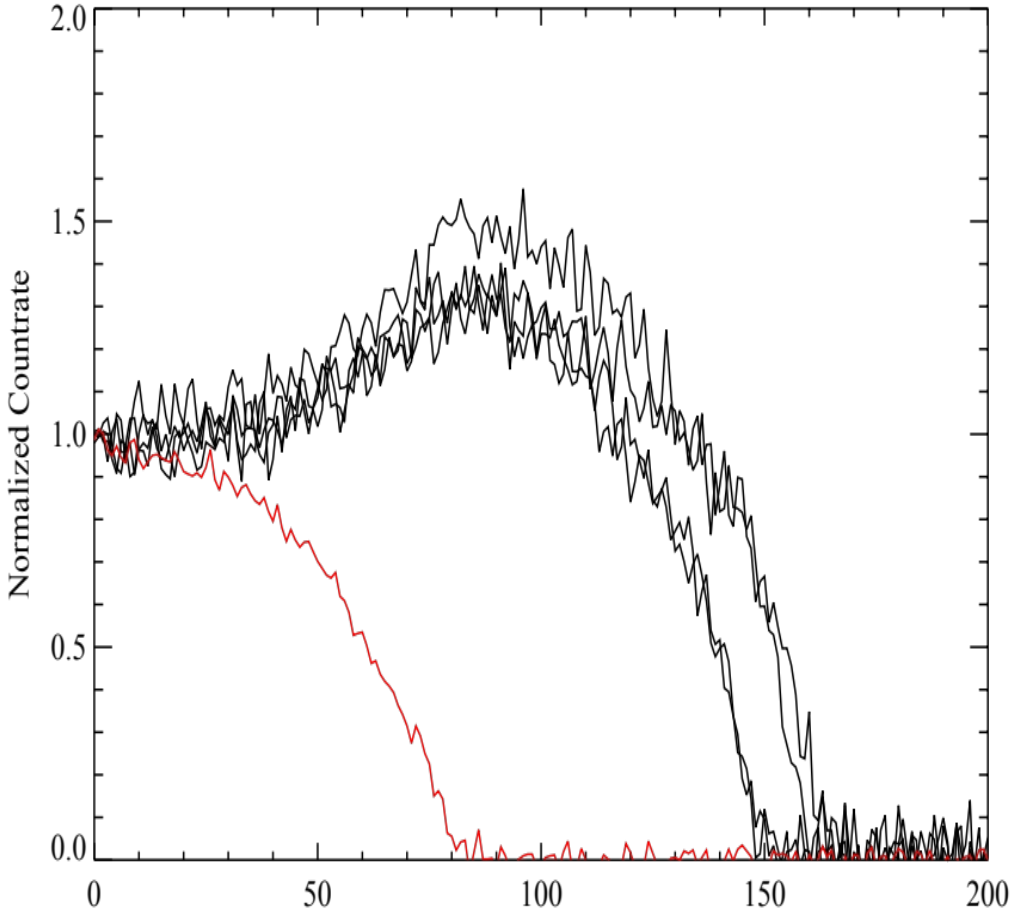




For comparison, countrate plots of the same 5 pixels when taken with a uniform flatfield illumination (left) vs. when illuminated by the high-contrast pinhole image (right). Both have been corrected for classic nonlinearity:







Summary

- The JWST H2RG detectors exhibit the “brighter-fatter” effect, redistributing signal from the higher-total-count pixels to adjacent lower-total-count pixels as signal accumulates. Up the ramp signal can become curved, resulting in slope fitting errors.

- Upon saturation, the JWST H2RG detectors spill (all) additional photocharge into neighboring pixels in a manner similar to “blooming” in CCDs. Spilled charge can dramatically affect the accumulating ramp signal in neighboring pixels if not accounted for.

- Most of the spilled charge is collected in the nearest unsaturated neighbors, but some charge does end up many pixels away.

- While the WFC3 H1R detector shows a “brighter-fatter” effect it doesn’t seem to spill upon saturation the way the JWST H2RG devices do.

- A 1st order correction for the pipeline might be to flag the immediate neighbors of saturated pixels to stop slope fitting at that point. More complex solutions that address the “brighter-fatter” charge redistribution up and through saturation may be possible.