GMOS-S/N Hamamatsu CCDs Upgrades: One Down, One to Go!

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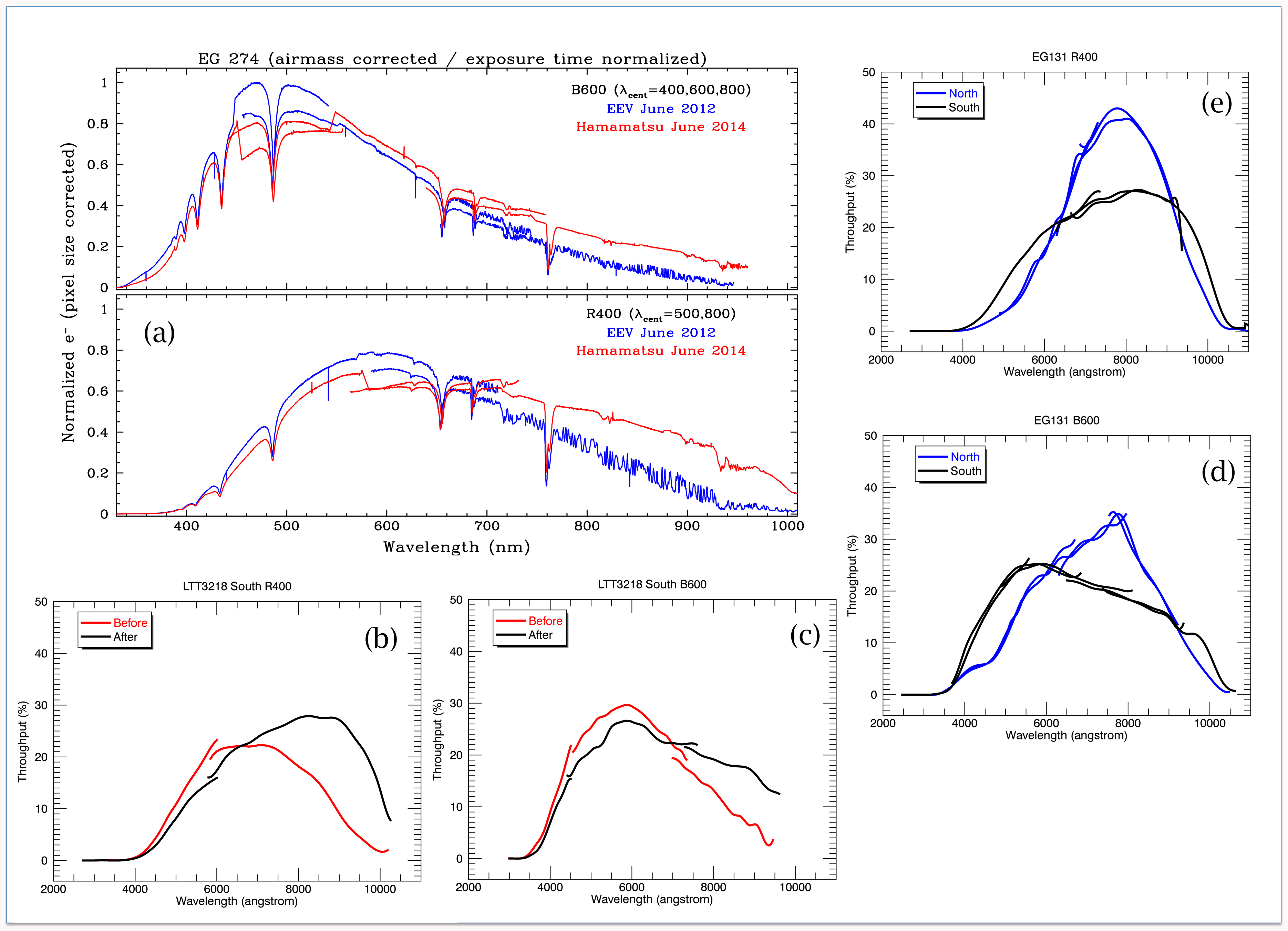

Figure 1: Sensitivity comparisons using the same star: (a) detected electrons, GMOS-S before -vs- after (b) R400 system throughput GMOS-S before –vs- after (c) B600 system throughput GMOS-S before –vs- after (d) B600 system throughput GMOS-S post upgrade –vs- GMOS-N (e) R400 system throughput GMOS-S post upgrade –vs- GMOS-N.

Hamamatsu CCDs were installed inside GMOS-S in June 2014, replacing the EEV detectors that were delivered[*] with the instrument. The driving motivation behind this exchange was to improve sensitivity, particularly at long wavelengths. In addition to this obviously very good improvement, these fully depleted CCDs afforded other advantages, but also came with one primary disadvantage, a decrease in blue sensitivity, and a few complications.

*CCD1 in the original GMOS-S EEV array had a damaged serial register and was replaced shortly after delivery in 2003

the **Good:**
- Sensitivity to “red” wavelengths longer than ~ 680 nm significantly improved for all CCDs.
- Fringing practically non-existent compared to copious fringing in the EEV detectors beyond ~ 680 nm.

the **Bad:**
- Lower sensitivity to “blue” wavelengths shorter than ~ 550 nm in some CCDs
- Thicker CCDs are inherently more impacted by cosmic ray events, limiting the advisable exposure time length

the **Complicated:**
- Hamamatsu CCD array comprised of three individual “flavors” each with a different quantum efficiency (QE) as a function of wavelength, particularly in the blue.

the **Mysterious:**
- Spectral throughput comparisons using the same star show GMOS-N is more sensitive than GMOS-S (up to ~ 15%) between 625 and 900nm, even after the GMOS-S upgrade.

Software modifications to enable data reduction routines to more easily deal with abrupt changes in QE at detector boundaries are already available, and have recently been incorporated into the Gemini IRAF package. To lessen the impact of cosmic rays we recommend exposures times not exceed 20 min.

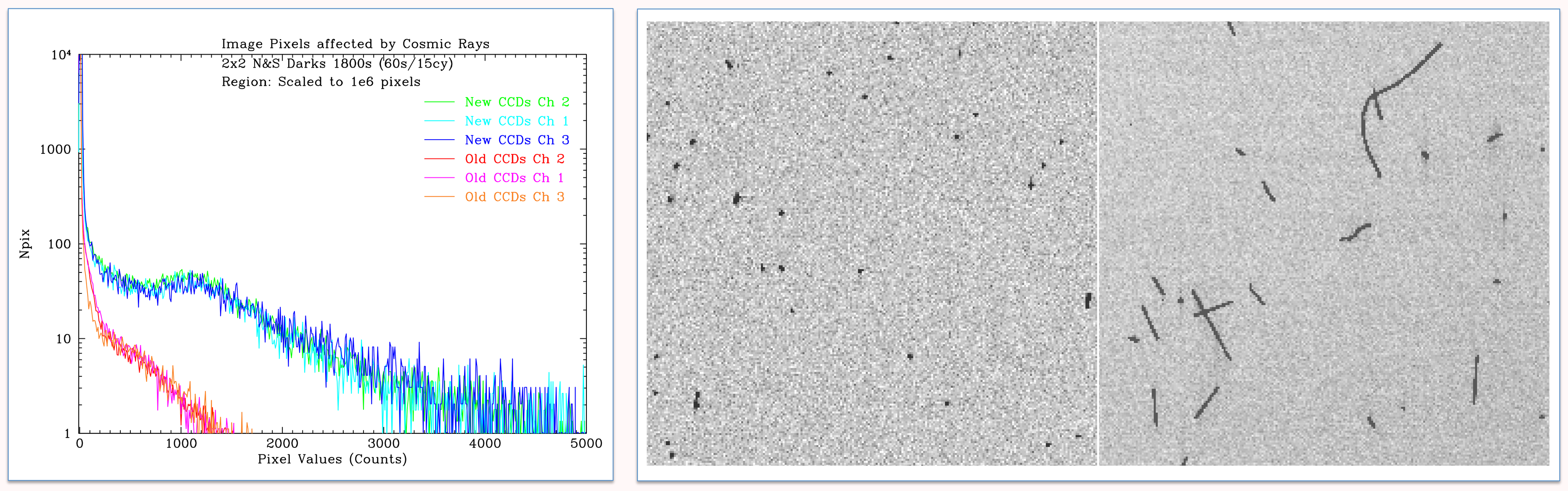

Figure 2: (left) Number of pixels affected by cosmic ray events as a function of counts generated by the event, based on 30 minute Nod&Shuffle darks. (right) Zoom showing cosmic ray details.

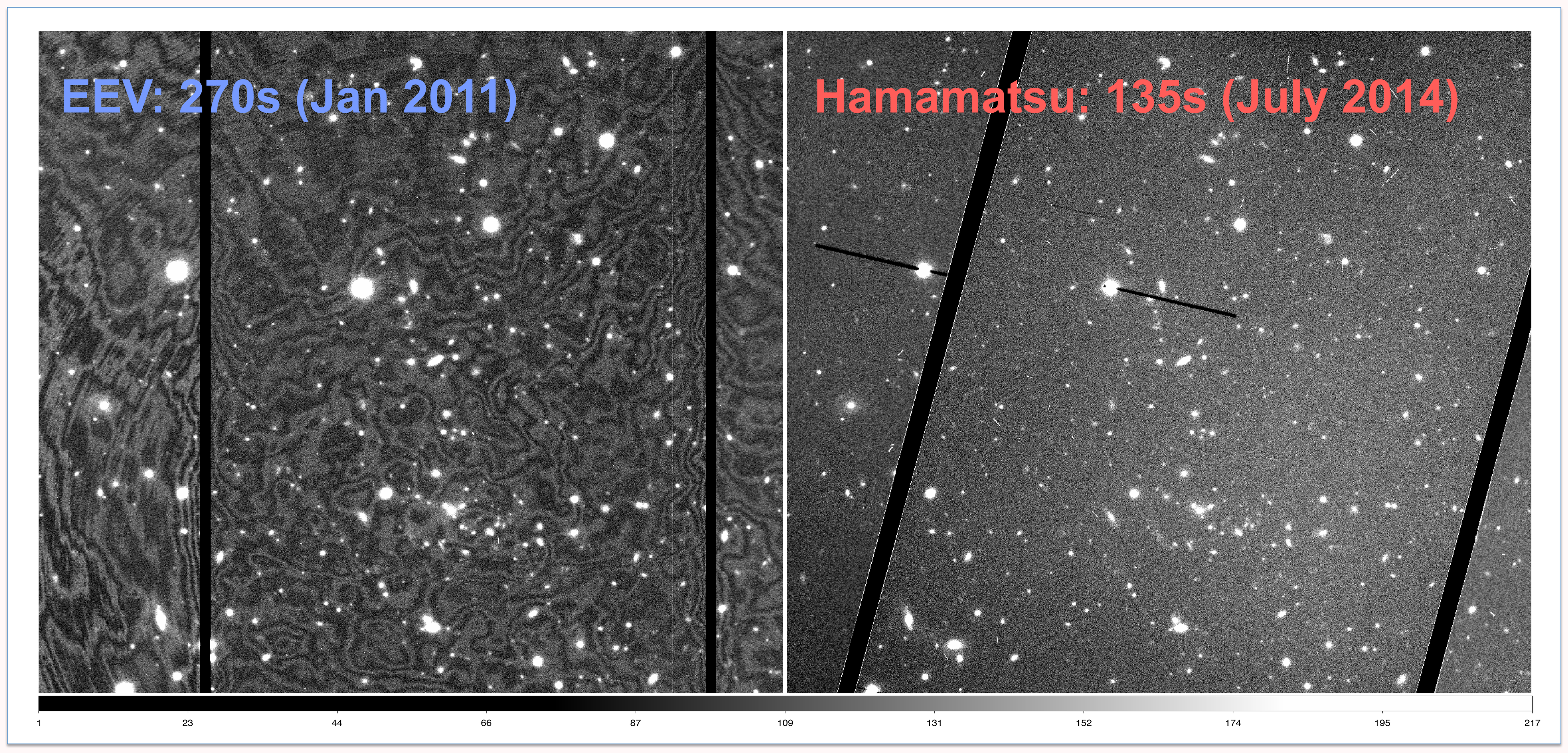

Figure 3: Raw i-band imaging of a comparison field, taken at slightly different position angles. The new CCDs exhibit virtually no fringing in i-band. Also evident are two instances of temporarily overwhelmed amplifiers caused by bright stars. One can also see the separation between detectors is slightly larger and the Hamamatsu CCDs image has more cosmic rays.

Images taken with the new CCDs at long wavelengths benefit greatly from the improved fringing characteristics. With 4 amplifiers per CCD, the CCDs read out faster than the old EEV detectors. The read noise is comparable, the pixels are slightly larger (15μm –vs- 13.5μm) and the gaps between the CCDs are ~80% larger. The imaging field of view is unchanged as that is determined by hardware within the instrument. The new array has the same number of pixels per row, increasing spectral coverage by 11%.

Early during commissioning it was recognized that pixels which are saturated negatively impact all of the other pixels in the same row, rendering the entire row ineffective (see Figure 3). Hot pixels or particularly bright cosmic rays will have the same effect. The effect is temporary, and subsequent exposures without the saturating source will not be impacted. This does not occur in unbinned mode, and is a consequence of the readout electronics and is not related to the detectors themselves. Fortunately this issue was independently recognized by the detector controller manufacturer and new electronics boards were designed that address it. Replacement hardware has already been procured and is currently undergoing characterization and testing, and will be installed in GMOS-S soon.

Nod & Shuffle mode with the Hamamatsu CCDs in GMOS-S unfortunately has been compromised:

- a “charge smearing” effect exists for CCDr (the oldest CCD and the only remaining SC detector).
- The effect worsens with number of nod cycles and shuffle distance.
- work is on-going to find a solution for this problem, which presumably arises from a low level charge transfer inefficiency that is not immediately obvious in classic (non-shuffled) data.

The GMOS-N instrument will not be outfitted with Hamamatsu CCDs until the charge smearing and banding issues have been resolved in GMOS-S. Estimates for when this may happen are uncertain, and are currently no sooner than January 2016, at the earliest.

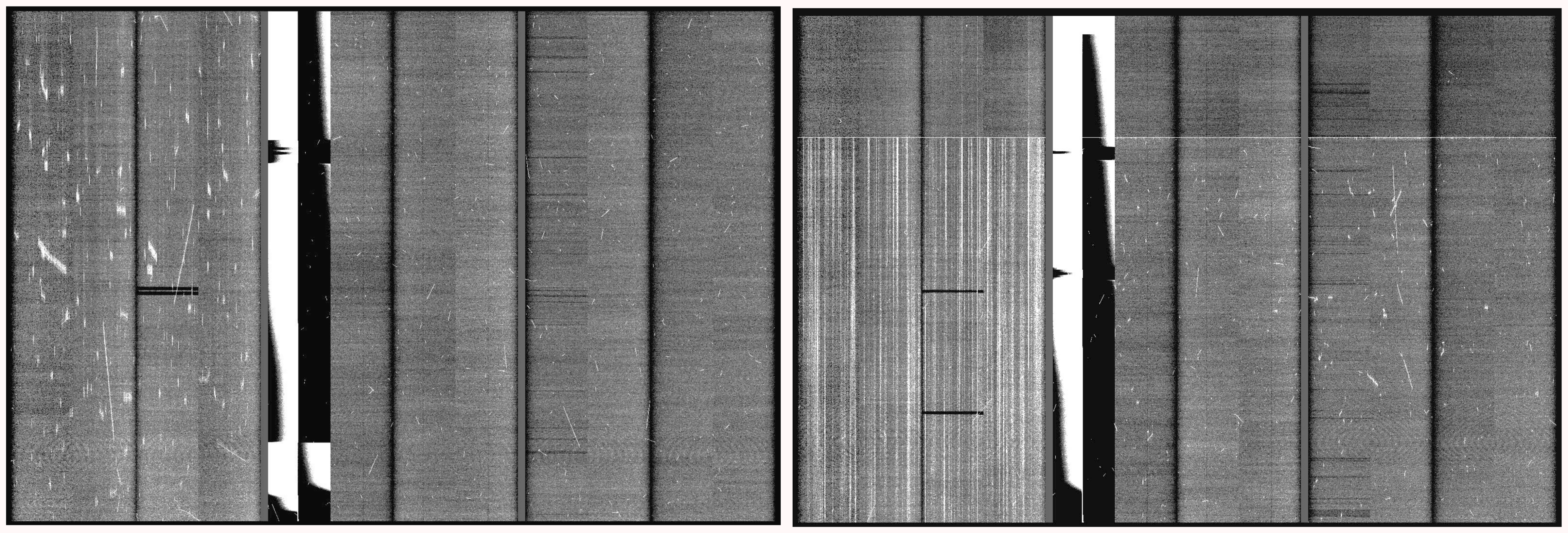

Figure 4: Identical Nod&Shuffle darks (5 minutes total exposure time, 15 nod cycles) except for the shuffle distance: (left) 1000 pixel shuffle and (right) 38 pixel shuffle. The leftmost CCD is noticeably affected by the charge smearing problem. The banding effect in amplifier 5 due to a glowing pixel is also readily apparent.

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To find out more about the GMOSs, Gemini’s twin optical imagers, multi-object, longslit and integral field spectrographs, or the Hamamatsu CCD project in particular please visit our webpages

http://www.gemini.edu/sciops/instruments/gmos/

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