Low Read Noise CCDs for MAESTRO and Blue Channel

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In order to quantify how bad the high read-noise of the Loral CCDs is, I computed the number of photons expected from the sky versus wavelength, to see when we are read-noise versus sky-noise dominated, for the anticipated resolution and sampling of MAESTRO, and the high resolution gratings of the MMT Blue spectrograph. The sky was computed from Craig Foltz's memo of June 15, 1988 which gives measurements of the dark sky brightness over Mt. Hopkins.

I assume flexure and cosmic rays will limit single exposures to 1800 seconds for most applications. In the spatial direction, I assume the spectrum is spread over 2.5 pixels, and for MAESTRO I calculate two cases for the dispersion direction: (1) a 1 arcsec slit and R=50,000 (the most common observing mode) assuming on-chip binning to 2 pixels per R, and (2) 2 pixel resolution of R=95,000 and a 0.5 arcsec slit, the maximum spectral resolution. For both cases, I assume a total system throughput (telescope + spectrograph) of 20% which is wildly optimistic, and favors the higher readnoise CCDs. The result is in the attached plot.

Mike reports that the Lorals he has processed lately have read-noise of 8-9 electrons RMS, and the current Blue Channel CCD has 7.2 electrons. These would be terrible over most of the MAESTRO wavelength range. For the R=50,000 mode, 3 electrons would be acceptable on the blue side, and it looks like we need the low read-noise on the red side also.

To illustrate the gain in sensitivity, suppose you observe an object which delivers 5 times the photons per second as the sky, in the R=50,000 mode. At 4500 $\AA$, to get to the same signal-to-noise takes 2.0 times longer if the readnoise is 7-electrons and 2.3 times longer if the readnoise is 9-electrons, compared to 3 electrons. At 6500 $\AA$, to get the same signal-to-noise takes 1.3 times longer with 9-electrons compared to 3 electrons, so there are significant gains to be had on the red side as well.

I made the same comparison for Blue Channel and the 832 l/mm 2nd order and echellette gratings, where I've assumed a 1 arcsec slit and an overall system throughput of 15%. Clearly getting down to 3 electrons would mean a big gain in sensitivity.