LRISr CCD orientation and xSECn header keywords
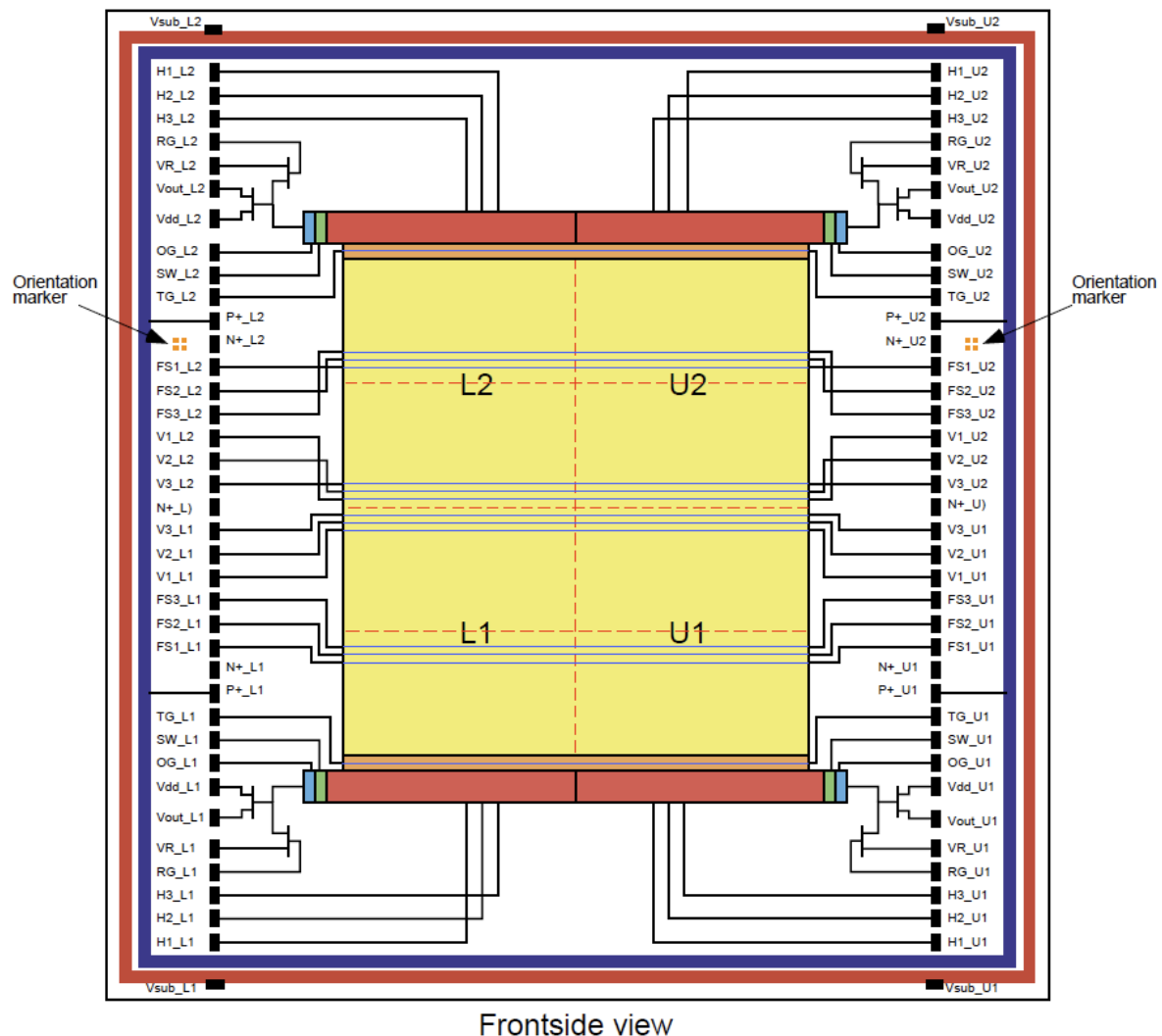
Detector orientation

Figure 1. LBNL CCD quadrant layout according to LBNL documentation. The four quadrants correspond to the four amplifiers designated L1, L2, U1 and U2. The CCD is read out from the corners. The rest of the pin layout is beyond the scope of this document.

The LBNL 4k x 4k CCD installed in April 2020 has four amplifiers for image readout (see Figure 1). They are designated as L1, L2, U1 and U2. **Most installations of DS9 will display this with a vertical flip: L1 & U1 on top, L2 & U2 on the bottom** because of how the CCD is mounted on the instrument (see the 2021 image). When the CCD is read out in the 4-amplifier mode, the image has four quadrants corresponding to the four amplifiers and these quadrants are separated by the overscan regions in the center (See Figure 2 and 3).
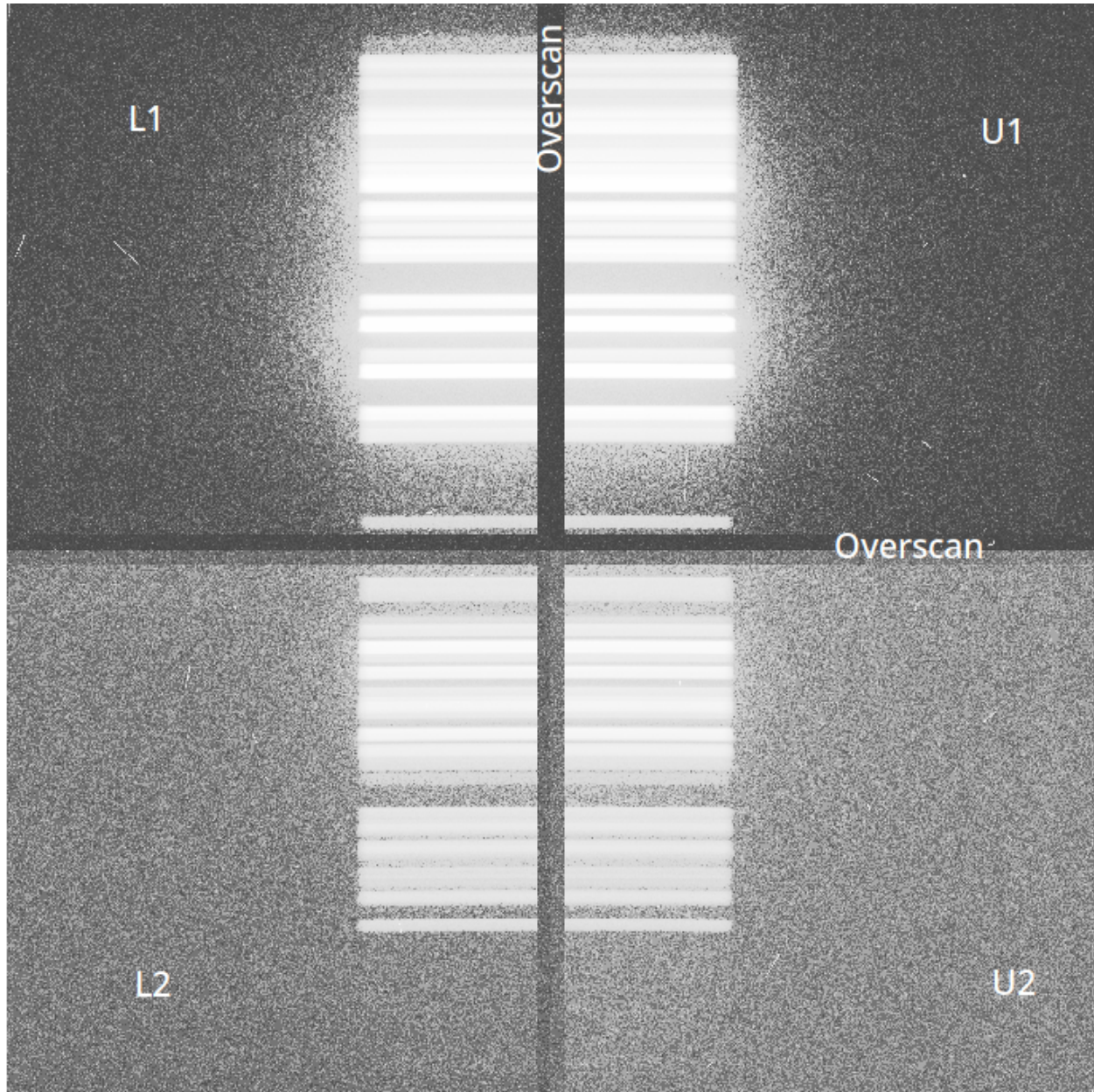

Figure 2. An arc image taken with the 4-amp mode. Note the four quadrants and the cross-shaped overscan regions separating them.

Each amplifier produces horizontal and vertical overscan regions. All the overscans taken together in the current state produce a cross pattern in the image and this is due to the nature of the readout. Charge is read row-by-row and pixel-by-pixel along each row. At the end of a row,

extra pixels are read out and these make up the vertical overscan regions (see Figure 3). After all physical rows are read, extra rows are read out by the amplifier to make the horizontal overscans.
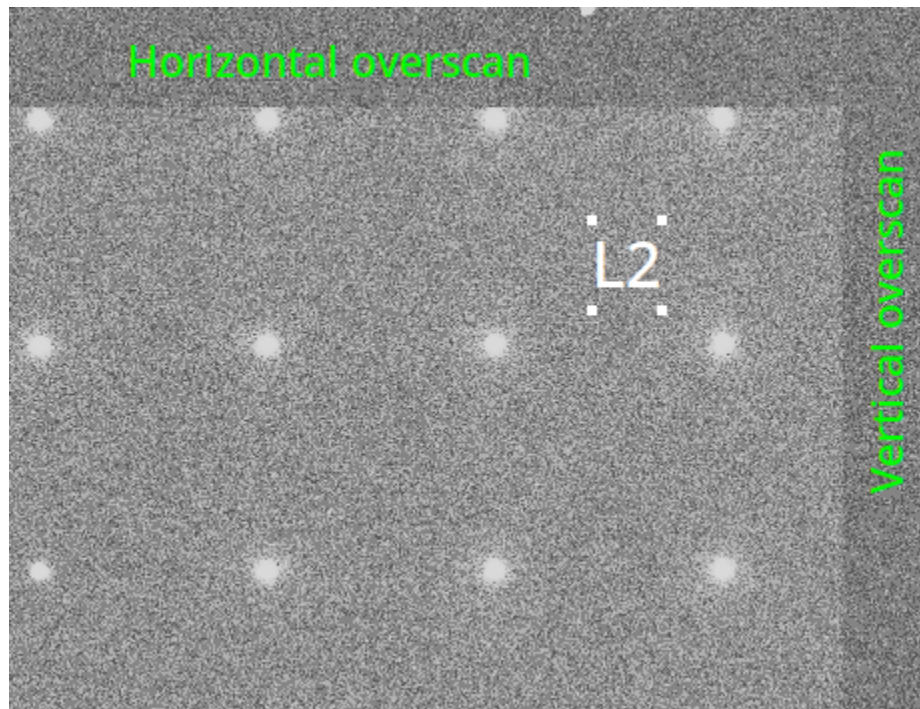

Figure 3. Zoomed in version of Figure 2 showing the overscan regions of L2.

LRISr operates mainly in 3 amplifier modes to read out the full detector:
1. 4-amp mode. (via L1, L2, U1, U2)
2. 2-amp mode (horizontally split, read upwards; i.e. via L2 and U2; see Figure 4)
3. 1-amp mode (via L2)

Currently, windowed readout is not available for the detector.

Figure 4. An arc taken with 2-amp readout (L2, U2). Note the overscans in the middle and the top.

Region header keywords

Each FITS file contains the data in a single HDU (HDU 0) as opposed to the previous version where each amplifier's readout was assigned an HDU. The FITS header contains information regarding the various regions of the raw CCD image in the keywords named xSECn where x belongs to [A, B, C, D] and n belongs to [0, 1, 2, 3]. Each n corresponds to a different amplifier and the mapping is

- 0: L1
- 1: L2
- 2: U1
- 3: U2

The keywords are defined here and here. For the purposes of separating the data from the overscan for reduction, DSECn (DATASEC) and BSECn (BIASSEC) should be sufficient. These are IRAF region definitions for the data and the bias respectively. Unfortunately, these keywords are incorrect for red data collected between April 15 2021 and XX (TBD as of Oct 19 2021). The specific values depend on the BINNING and AMPMODE keywords. The correct values for your specific combination of BINNING and AMPMODE can be found in the headers of the files here. The reference files are named "**pixelsAMPMODE_binx_biny.fits**". The AMPMODE key value in your LRIS fits files may not look like this and in that case, here's the necessary translation:

AMPMODE value in LRISr FITS header	Part of the name of reference FITS file in shared folder
HSPLIT, VSPLIT	L2U2L1U1
HSPLIT, VUP	L2U2
HSPLIT, VDOWN	L1U1
HLEFT, VSPLIT	L2L1
HLEFT, VUP	L2
HLEFT, VDOWN	L1
HRIGHT, VSPLIT	U2U1
HRIGHT, VUP	U2
HRIGHT, VDOWN	U1

The images also have prescan regions which are 7 columns unbinned and 3 binned (on the left for L1, L2 and right for U1, U2). Currently, there is no header keyword that explicitly states this in the raw files but the DSECn region starts right after the prescan and therefore can be used to determine the number of binneed prescan pixels. In the future, there will likely be PPSFPIXn keywords containing this information. The reference files have the PPSFPIXn keywords.