Study of using Median or Mean for Common Mode Noise removal

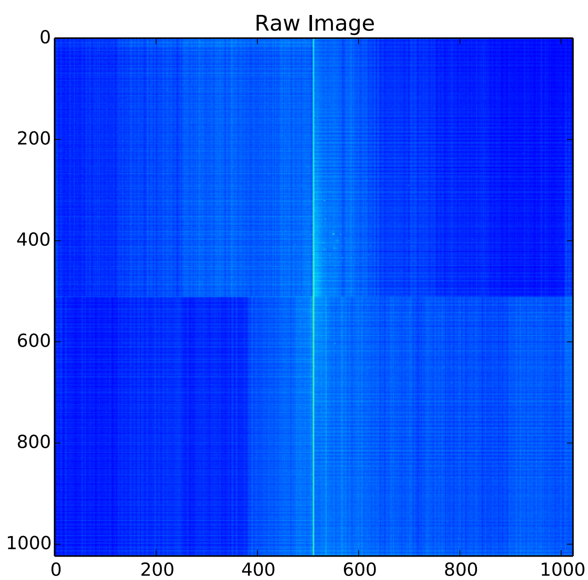
Recent SXR/AMO experiment amob5114 took runs with the pnCCD running at low gain (1/64) and high gain (1). For each low and high gain, the image and pixel histogram are shown for raw image, after dark image pedestal subtraction, and common mode noise removal using mean and median.

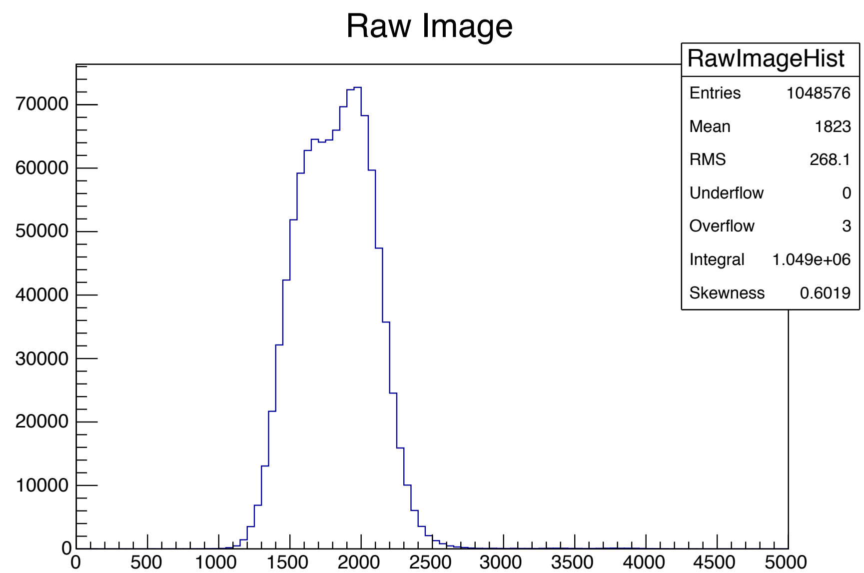
PNCCD High Gain (x1)

Dark Image: Run 121, event 1
Signal Image; Run 127, event 1

Raw Image

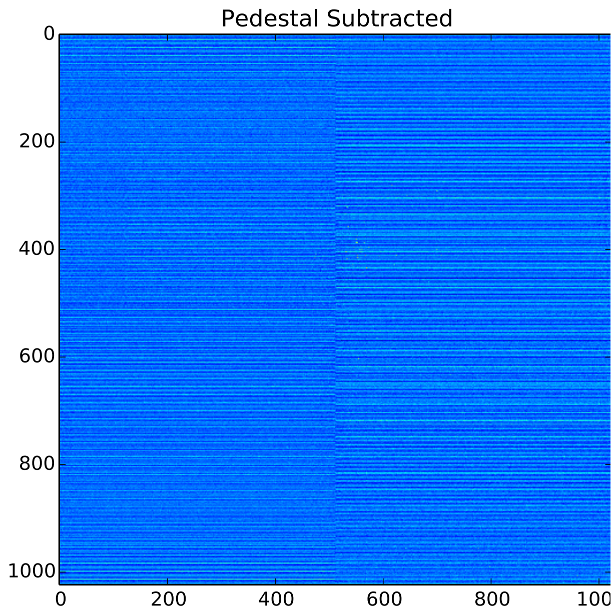
The image and histogram below are the raw data without any corrections applied.

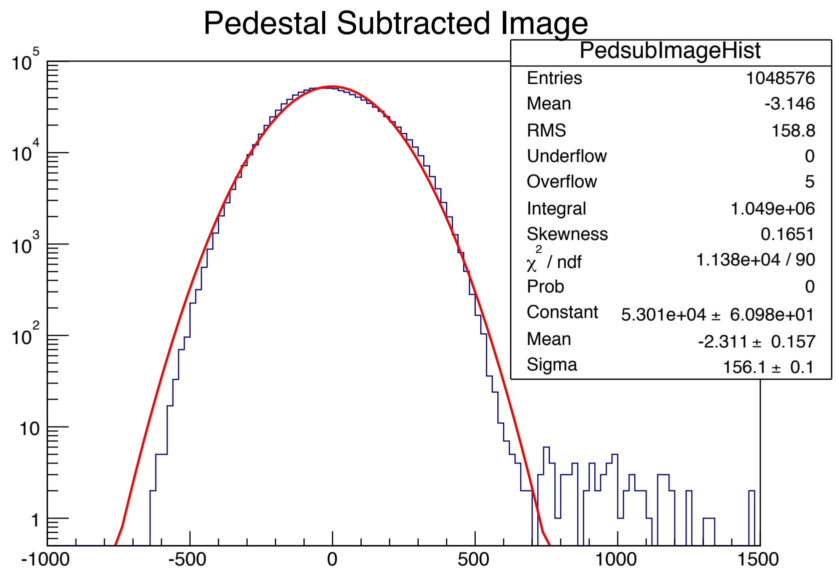




Dark Image (Pedestal) Subtraction

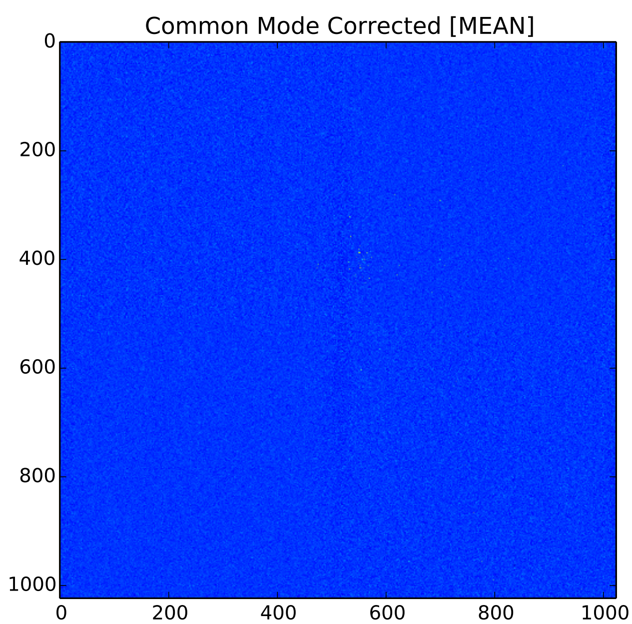
The image and histogram below are after the dark image (pedestal) subtraction. After the pedestal subtraction, common-mode noise dominates. The red line is a Gaussian fit to peak around zero.

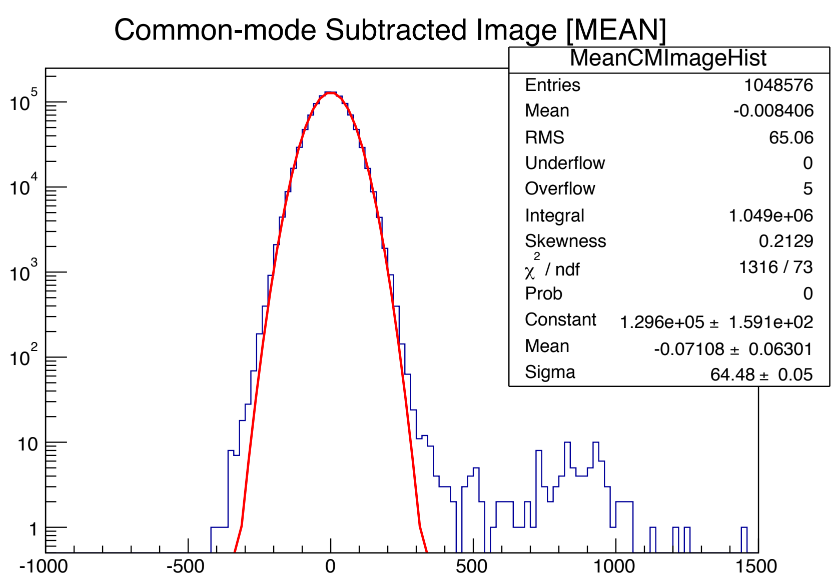




Common mode (MEAN) Subtraction

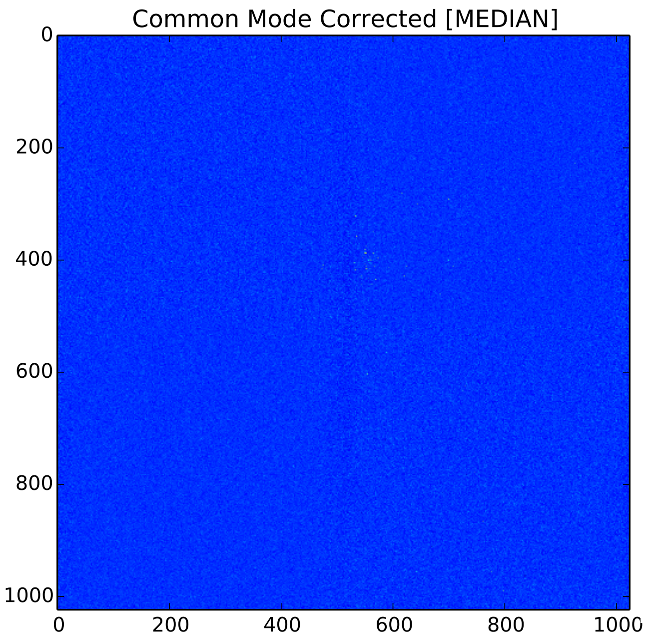
The common mode is removed from the pedestal subtracted image. In the plots below, the mean is used to determine the common mode. The correction removes the common mode artifact. This is also demonstrated in the reduction of the RMS by 2. The red line is a Gaussian fit to the peak around zero.





Common mode (MEDIAN) Subtraction

The common mode is removed from the pedestal subtracted image. In the plots below, the median is used to determine the common mode. The correction removes the common mode artifact. This is also demonstrated in the reduction of the RMS by 2, compared with the pedestal subtracted. However, the reduction is similar to using the mean. The red line is a Gaussian fit to the peak around zero.



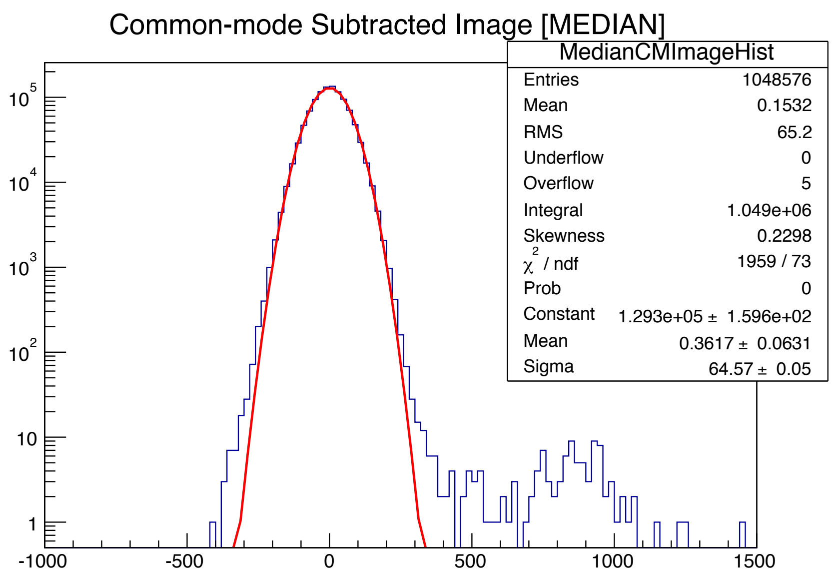
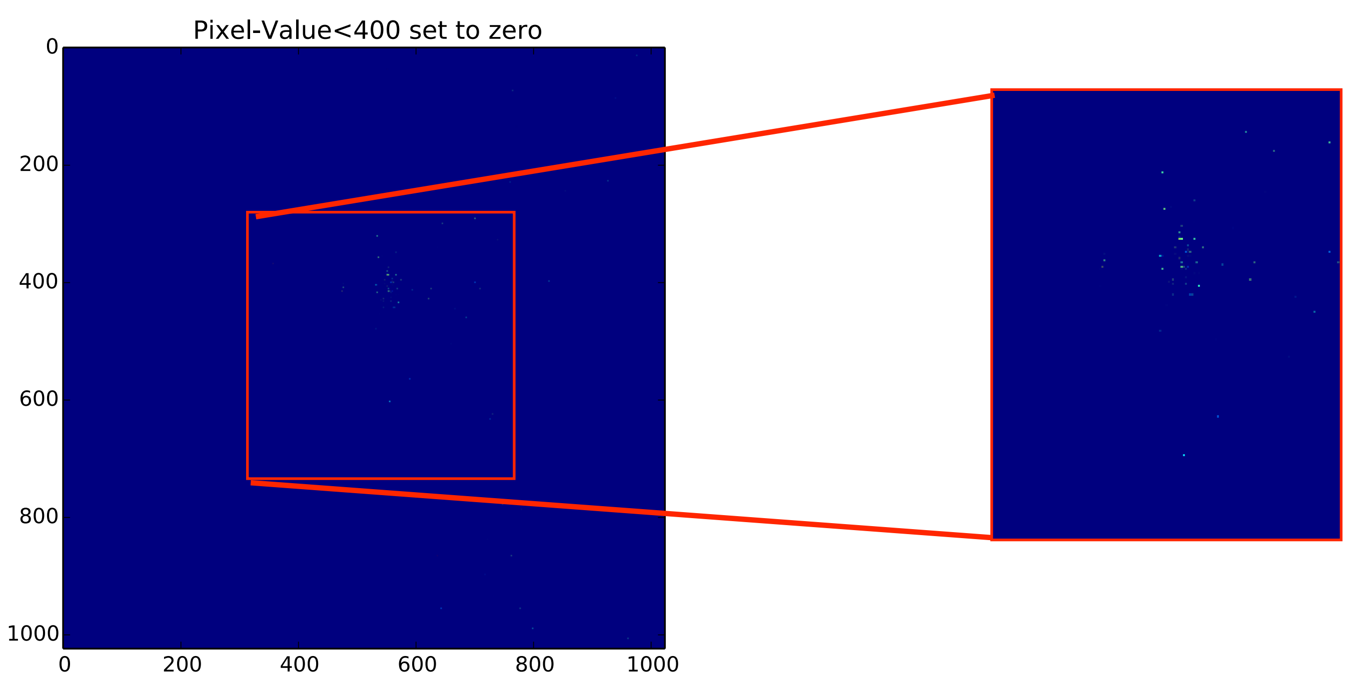


Image Thresholding

After the pedestal subtraction and common mode removal, the contrast is still poor. However, the pixel histograms show there's a large amount of noise at low values. A threshold of 400.0, where all pixel values < 400 are set to zero, is applied. The image below are after the thresholding. The individual hit pixels are easier to see.

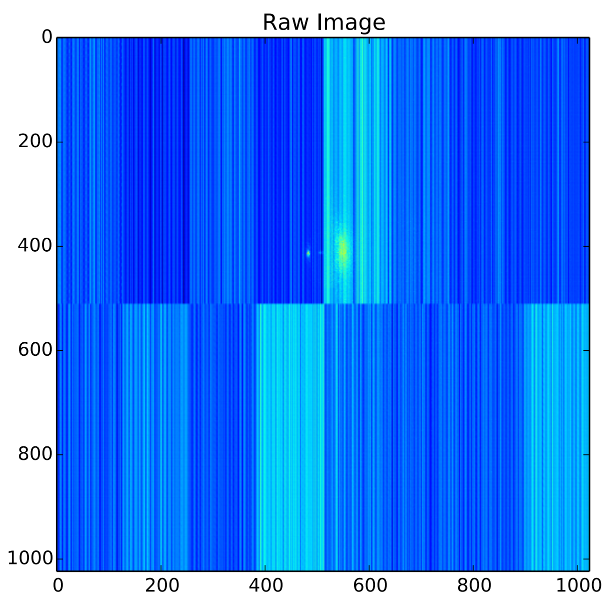


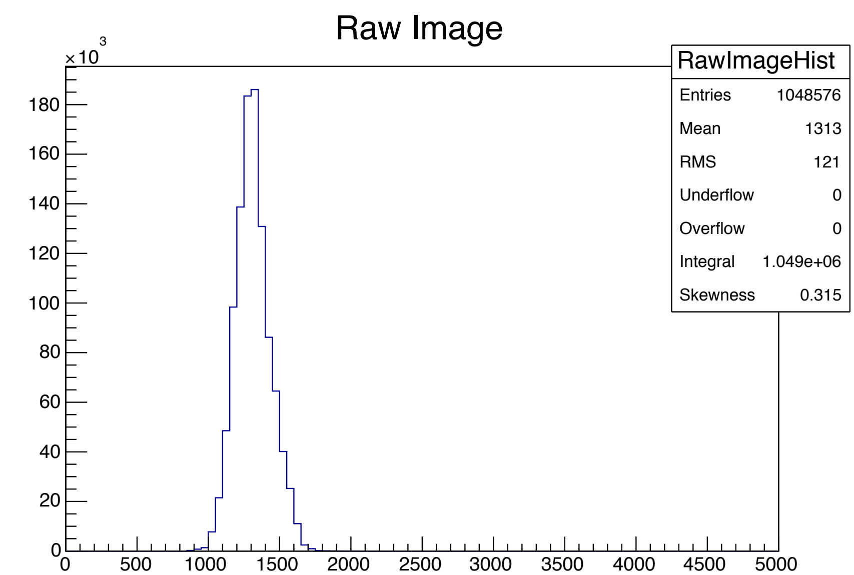
PNCCD Low Gain (x1/64)

Dark Image: Run 325, event 1
Signal Image; Run 329, event 1

Raw Image

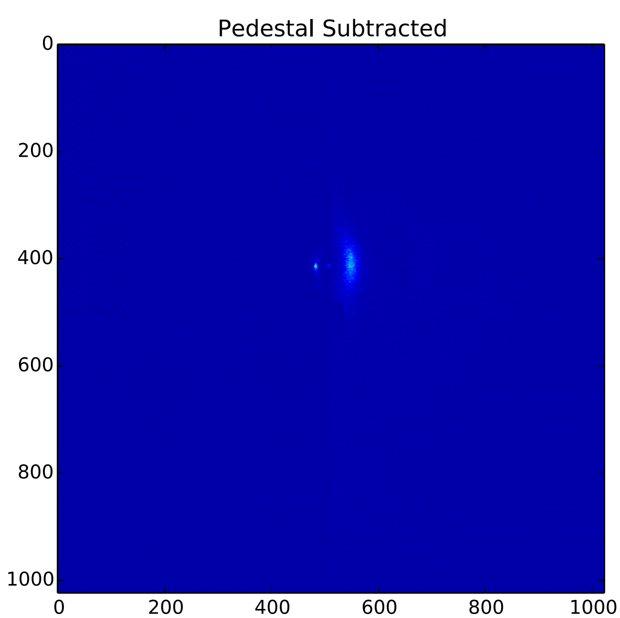
The image and histogram below are the raw data without any corrections applied. The common mode artifacts are strong. But the signal is visible.

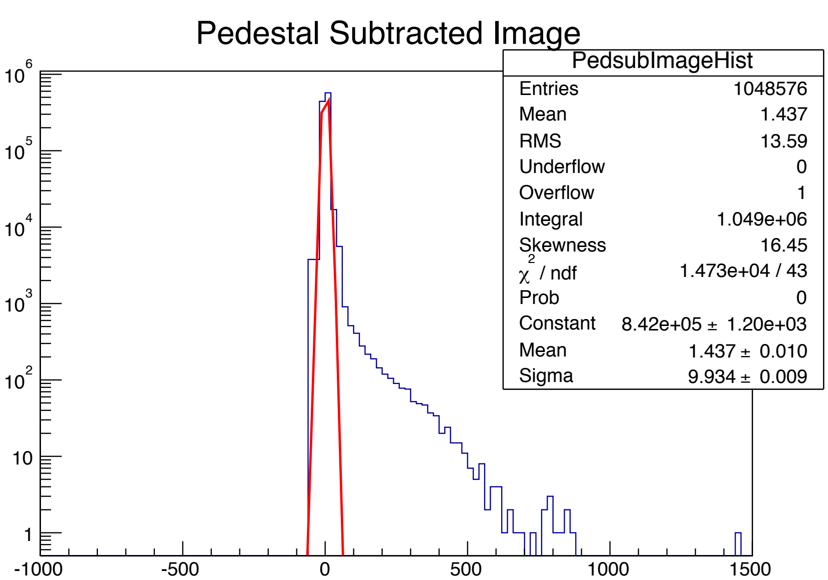




Dark Image (Pedestal) Subtraction

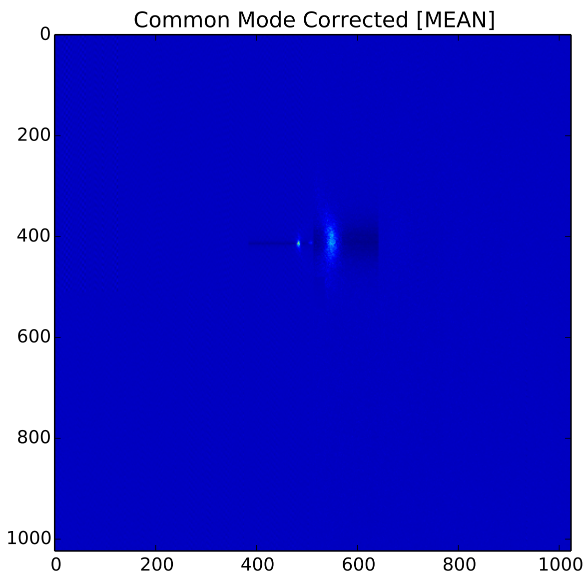
The image and histogram below are after the dark image (pedestal) subtraction. After the pedestal subtraction, the signal is clearly visible. The red line is Gaussian fit about the peak at zero.

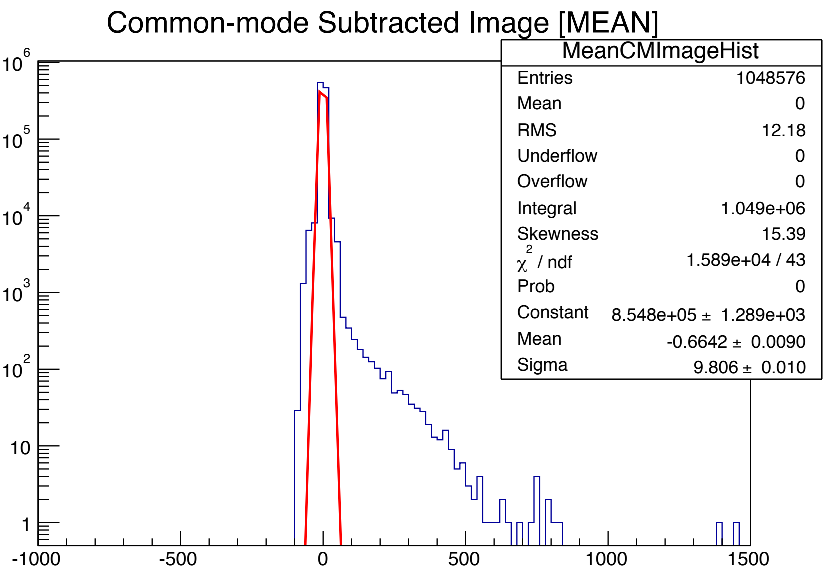




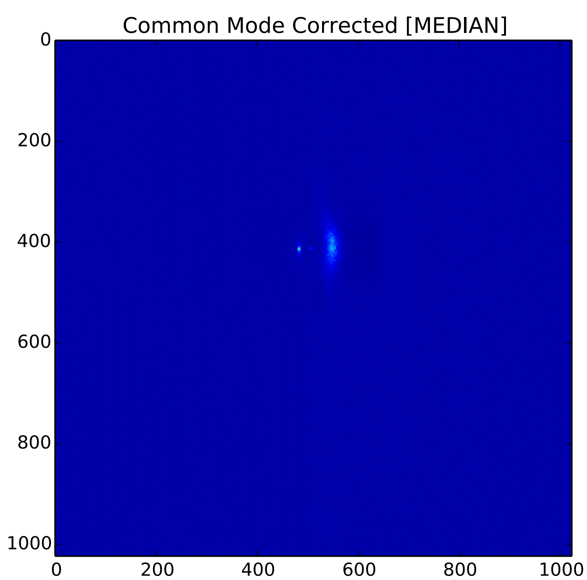
Common mode (MEAN) Subtraction
After the pedestal subtraction, the image is visible and a common mode correction is not really needed. But, to be conscientious, we examine its effect. The common mode is removed from the pedestal subtracted image. In the plots below, the mean is used to determine the common mode. The red line is a Gaussian fit to the peak around zero.

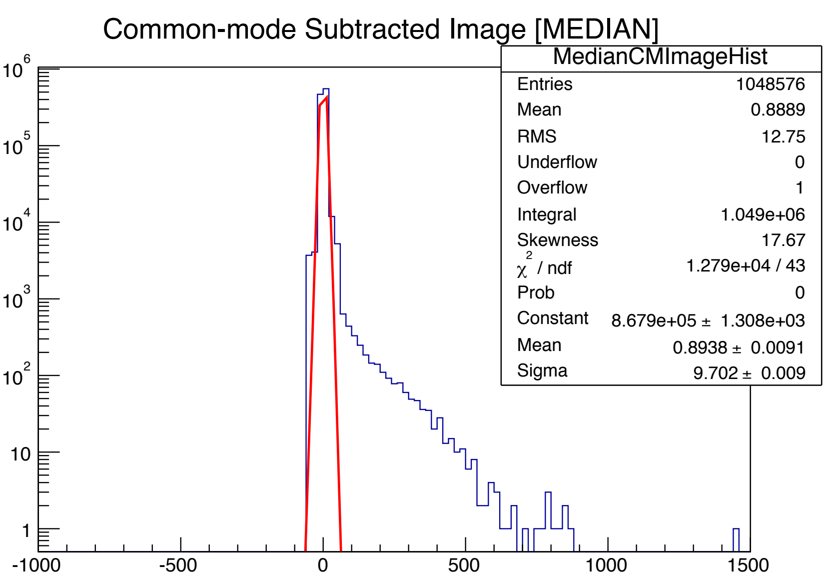
Using the mean to calculate the common mode creates an artifact around the signal. It is likely the signal pixels are biasing the mean.





Common mode (MEDIAN) Subtraction
The common mode is removed from the pedestal subtracted image. In the plots below, the median is used to determine the common mode. The red line is a Gaussian fit to the peak around zero. There is no artifact around the signal as the median is a more robust estimator of the common mode.





Conclusion

For high-gain, common-mode correction is essential and either mean or median common mode correction works equally well. However, in low gain, a common mode correction is not essential. But if it is used, the median common mode correction should be used as it is a more robust estimator of the common mode correction.