Systematic Error Correction

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1 SUMMARY

According to previous results, there are two kinds of systematic errors that downgrade the quality of photometry and need to be corrected.

1. images that are taken with different dithering positions have significant difference in photometry. The most possible cause is bad flat fielding.

2. Short timescale variation on the light curves. Red noise needs to be caught and corrected. Following effects can contribute to red noise: ramp effect, jitter of the telescope, telescope temperature fluctuation, intra-pixel response fluctuation, cosmic rays.

2 RED NOISES

2.1 RAMP EFFECT AND POINTING PROBLEM

According to Deming et al. 2013, Wilkins 2014, ramp effect becomes significant when exposure level is larger than 30000 e^- per pixel. For both F125W and F160W images, the largest count rate per pixel at the planetary companions place is 2000 - 2200 e^-s^-. For F125W images, the exposure time is 30s for each image while for F160W is 15s. Therefore, the pixel that is the peak of the PSF of the companion object in the F125W image may be affected by ramp effect.

In Figure 2.1, I plotted the count for one pixel that has the largest flux at the PSF region of ABPIC-B for every image. In short time-scale (i.e. in one exposure set, does not demonstrate in the plot), peak fluxes do not have a clear and common ramp effect pattern. For first 3 orbits, the counts have large scatterings for different dithering positions. because the peaks of the PSF could locate at the center or edge of the pixel. For the last 3 orbits for which dithering is not applied, the peak pixel count demonstrates clear trend. In the 4th and 6th orbits, the peak pixel count decreases with time while for 5th orbits, it slightly increases with time.

First of all, I cannot be certain whether ramp effect plays a significant role in this trend. The exposure levels of peak pixel for F125W images are more than 70000 e^-, for 5th orbit they are near 90000 e^-, which are almost reach the fully saturation level of 100000 e^-. However, short timescale variations are random and no 'hook shaped' (Wilkins et al. 2014) light curves appeared.

This trends for peak pixel count are correlated with the positions of PSF centroids. I plot the PSF centroids that are measured by Gaussian fitting for 4th, 5th and 6th orbits in Figure 2.2. The PSF centroids shifted in a specific direction within one orbit. In 4th and 6th orbits, the centroids shift to +y direction and in 5th orbit they shift to (+x, +y) direction. In 4th and 6th orbits, the centroids shift to the edge of the pixel while in 5th orbit, they slightly shift to the pixel center.

To sum,

1. Peak pixels have high exposure levels, especially for F125W, ramp effect needs to be considered.

2. Telescope has a pointing shift within each orbit, and caused the peak pixel count varies in a specific trend. Since peak pixel contains ~ 25% of the total flux, if there were a considerable intra-pixel response variation, this pointing shift could be an error source.

2.2 Cosmic Rays in Up-the-Ramp Fitting

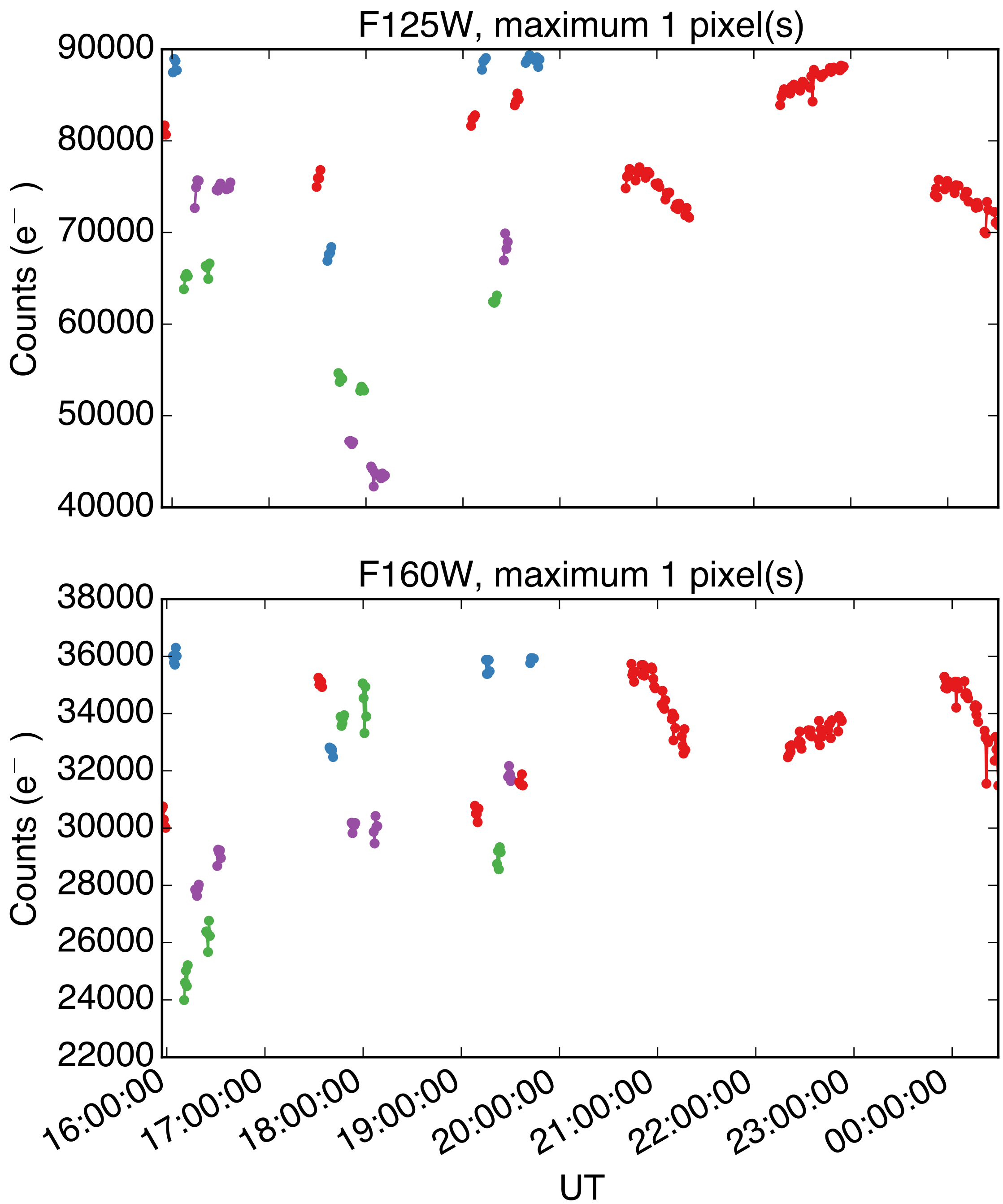

Figure 2.1: Count for peak pixel on the image of ABPIC-B. Different color indicate different dithering position. Count rates are measured from the original `ima` files (no primary subtraction applied)

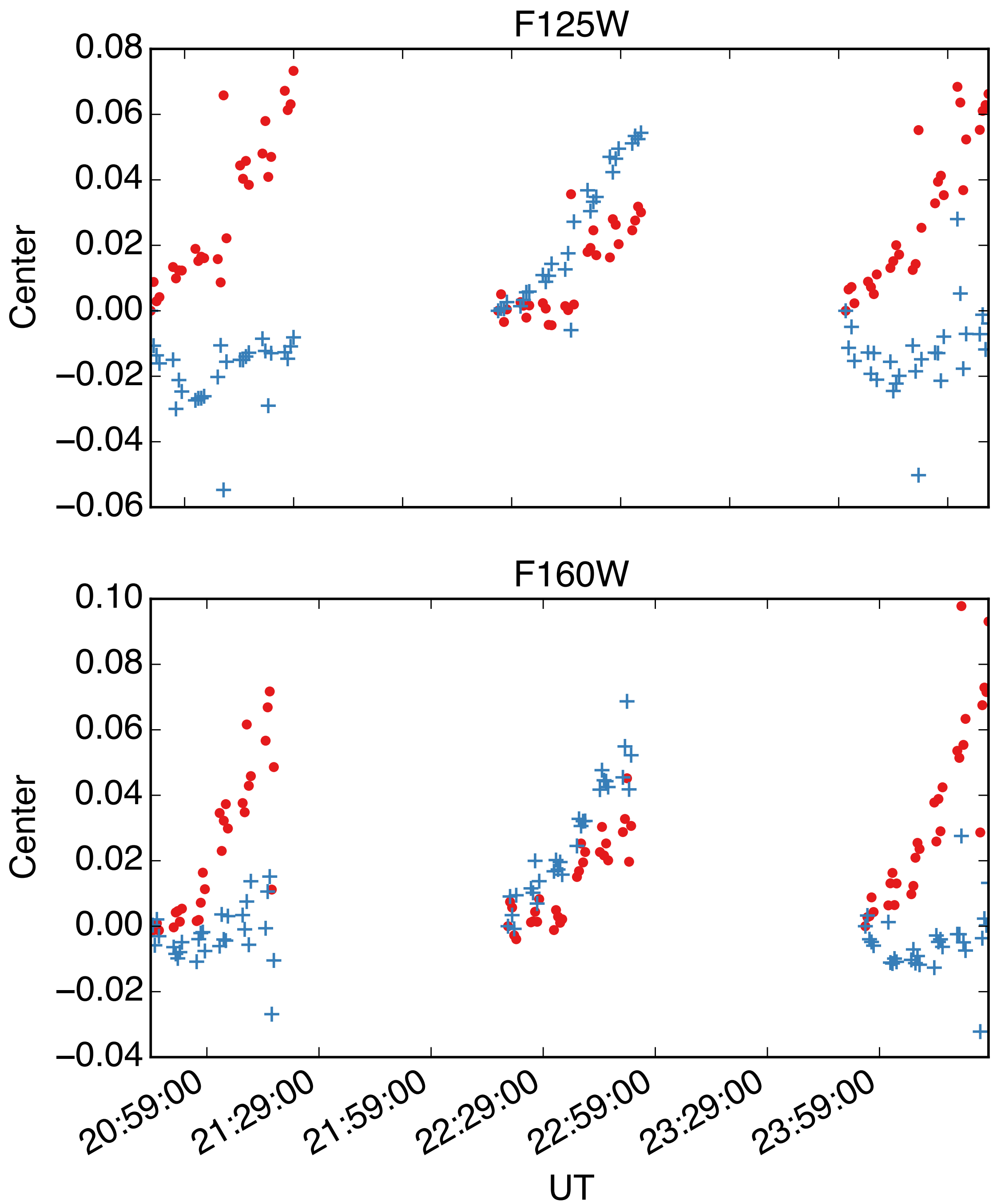

Figure 2.2: PSF centroid shift for ABPIC-B in 4th, 5th, and 6th orbits. Y-axes are the centroid coordinates (x, y) minus the those for the first image in each orbit (x_0, y_0). Red dots are for x-direction and blue + are for y-direction.