

7. PC1 Stray Light Patterns

Description: One or more broad arcs of light on PC1. In some cases there is a single bright arc with sharp edges near the pyramid apex (type 1 or “PC direct stray light” pattern). In other cases there are multiple arcs with a softer appearance together with a diffraction spike at the outer edges of the PC (type 2 or “PC diffraction stray light” pattern). In both cases the arcs continue into the pyramid shadows along the X~0 and Y~0 edges of the CCD.

Cause: There are two similar but distinct patterns. Both are caused by a bright star which is on the PC pyramid facet, but outside the region imaged by the PC CCD.

The single arc with sharp edges near the pyramid apex (type 1 or “PC direct stray light” pattern) is caused by a moderately bright star (usually $m < 14$) falling near the outer corner of the PC1 pyramid facet. This stray light is caused by incomplete baffling of the PC Cassegrain relay secondary mirror, which allows light to take a non-standard path through the PC1 camera relay optics -- light passes directly from the articulating fold mirror (AFM) to the CCD, without the usual re-imaging. The pattern has been successfully reproduced by ray-tracing the WFPC2 optics. The intensity of the stray light can be estimated from the count rate of the offending star, the F/24 OTA focal ratio, the specification of the AFM (concave with radius 587 cm and located 16.0 cm from OTA focal plane), and the distance from the AFM to the CCD (110.0 cm). Stars producing this pattern have a blur diameter of 5.0 cm, or ~3500 PC pixels, at the CCD. Hence a star which would generate 1 electron sec^{-1} when imaged in the normal manner, will thus produce a “direct” pattern with an average intensity of 1.1×10^{-7} electrons sec^{-1} pixel^{-1} . This is why the stray light pattern is only seen for bright stars -- the light is severely out of focus so patterns due to faint stars are lost in the background and read noise. The pattern can reach two or three times this average intensity along its edges, where diffraction effects are important.

The type 2 or “PC diffraction stray light” pattern is caused by a moderately bright star (usually $m < 13$) located anywhere in the L-shaped region which is reflected by the pyramid, but is not imaged on the PC (i.e. the “missing” region of the PC field). Light from objects in this region cannot pass directly from the AFM to the CCD; however, some combination diffraction, scattering, and multiple reflection still allows light to reach the CCD. The *maximum* intensity in the pattern is about 1.3×10^{-7} electrons sec^{-1} pixel^{-1} for a star + filter producing 1 electron sec^{-1} (similar to *mean* intensity in the “direct” pattern).

Examples: Figure 7.1.a shows a typical example of a “PC direct stray light” pattern with a sharp arc near the pyramid apex. The GASP (Sky Survey) chart in Figure 7.1.b shows the presence of an 11.0 (+/- 0.2) magnitude star at the outer corner of the PC1 pyramid facet. For this star, the F702W filter, and the 140 sec. exposure, we would predict a pattern with 5 ± 1 electrons pixel^{-1} , which is close to the 7 ± 1 electrons pixel^{-1} in the observed pattern. Figures 7.2.a and 7.2.b show another example -- a 1500 sec. exposure in F606W with an $m=13.8$ star at the outer corner of the PC pyramid facet. Here we predict 6 ± 1 electrons pixel^{-1} in the pattern, and 6 electrons pixel^{-1} are observed. Figures 7.3.a and 7.3.b show a variation where the offending star ($m=11.4$) is along an outer edge of the PC pyramid facet, but ~20 arcseconds from the outer corner.

Figure 7.4.a shows a type 2 or “PC diffraction stray light” pattern with two arcs which are softer in appearance. The diffraction spike provides a hint of the bright star just off the PC1 field and Figure 7.4.b clearly shows the situation. Figures 7.5.a and 7.5.b show a similar example where three arcs are seen.

Figure 7.6.a and 7.6.b show an intermediate case between type 1 and type 2. The star is located along the outer edge of the PC1 pyramid facet, but far from the facet corner.

This anomaly also impacts flat fields for PC1. For both internal and external flats, light striking the outer corner of the PC pyramid facet is imaged into a broad arc on PC1 near the pyramid apex. Hence the flats are too high in this region, and the flat fielded data will be too low. The affected region is illustrated by Figure 7.7 which shows a POLQN18 + F555W VISFLAT divided by an F555W VISFLAT. The negative 18 degree rotation of the polarizer filter wheel has caused the clear (or open) filter hole on that wheel to move in front of the outer corner of the PC pyramid facet, while light striking the PC through the normal optical path still passes through the polarizer. Hence the pattern is enhanced over its normal intensity, and it becomes clearly visible in the ratio image as a broad arc near the pyramid apex in Figure 7.7. The effect on flats can be deduced from the polarizer transmission and the 8% height of the observed stray light pattern -- flats will be in error by 4% to 5% over this region of PC1. We note that the sky background will be properly flattened, since the illumination is identical to that of the flats, but objects will suffer this 4% to 5% error.

Impact: Faint targets can be lost over large regions of PC1. Also, objects will suffer 4% to 5% flat fielding errors on PC1 in the “direct” pattern region near the pyramid apex (see Figure 7.7).

Correction: Can attempt to derive and subtract local background inside the pattern.

Prevention: STScI routinely provides observers with GSSS (or GASP) finding charts of all targets prior to final proposal scheduling. Observers can use these charts and the overlay in Figure 7.8 to check for bright stars in problem regions of the WFPC2 field of view. The standard target positions (aperture locations PC1, etc.) are indicated on the overlay. The overlay also contains images of stars which are taken from the GSSS images, which can be used to estimate stellar magnitudes (+/- 0.5 mag.). These star images are given for sky survey plate exposures of 5, 20, and 70 minutes (listed on GSSS charts as “Exposure (min)”). The overlay should be rotated counter-clockwise about the selected aperture (PC1, etc.) by the angle specified in the ORIENT special requirement in the phase II proposal. The avoidance magnitudes indicated on the overlay assume a 600 sec. exposure in filter F555W, and would result in stray light intensities reaching about 1 electron pixel⁻¹.

Figure 7.1.a. Mosaicked image showing type 1 “direct” stray light pattern on PC near pyramid apex.

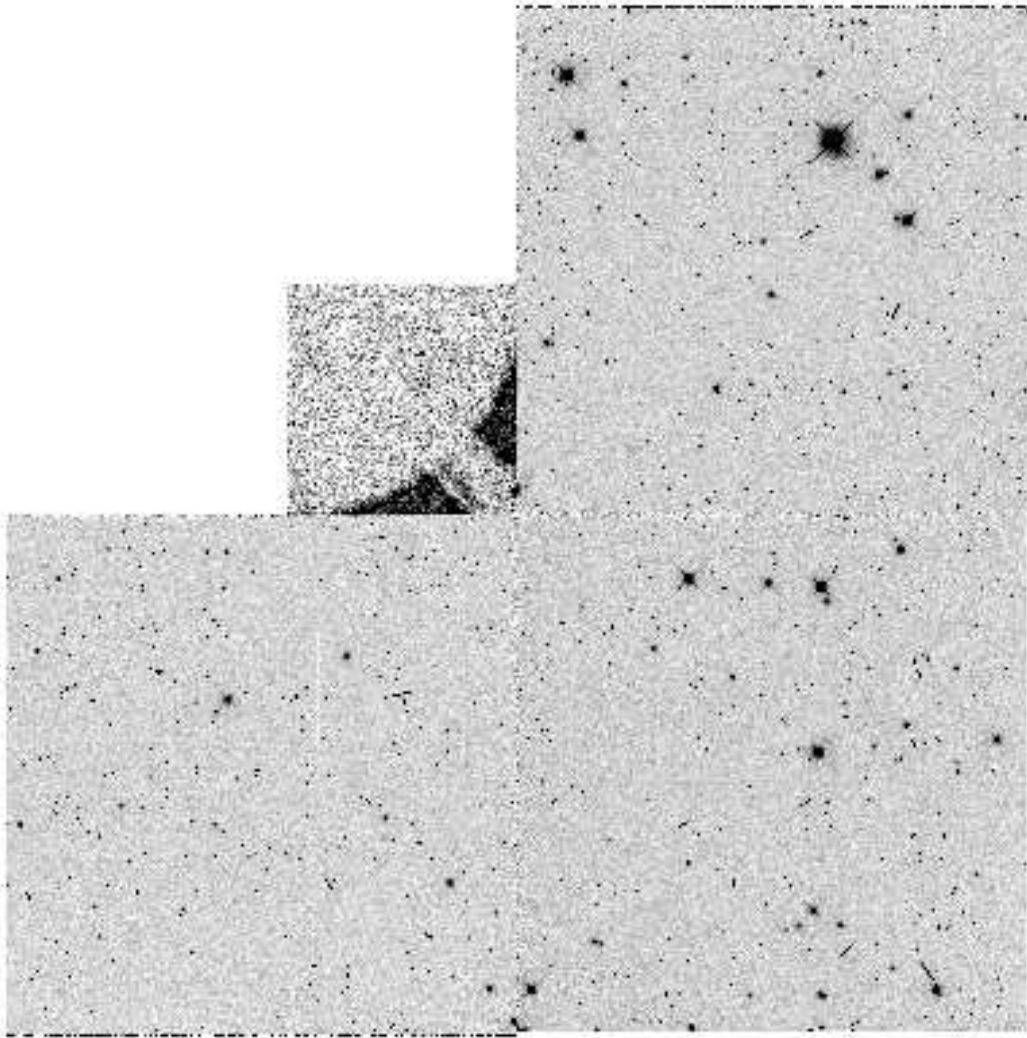


Figure 7.1.b. GASP image for type 1 pattern in Figure 7.1.a, showing bright star (11.0 magnitude) near the outer corner of the PC pyramid facet.

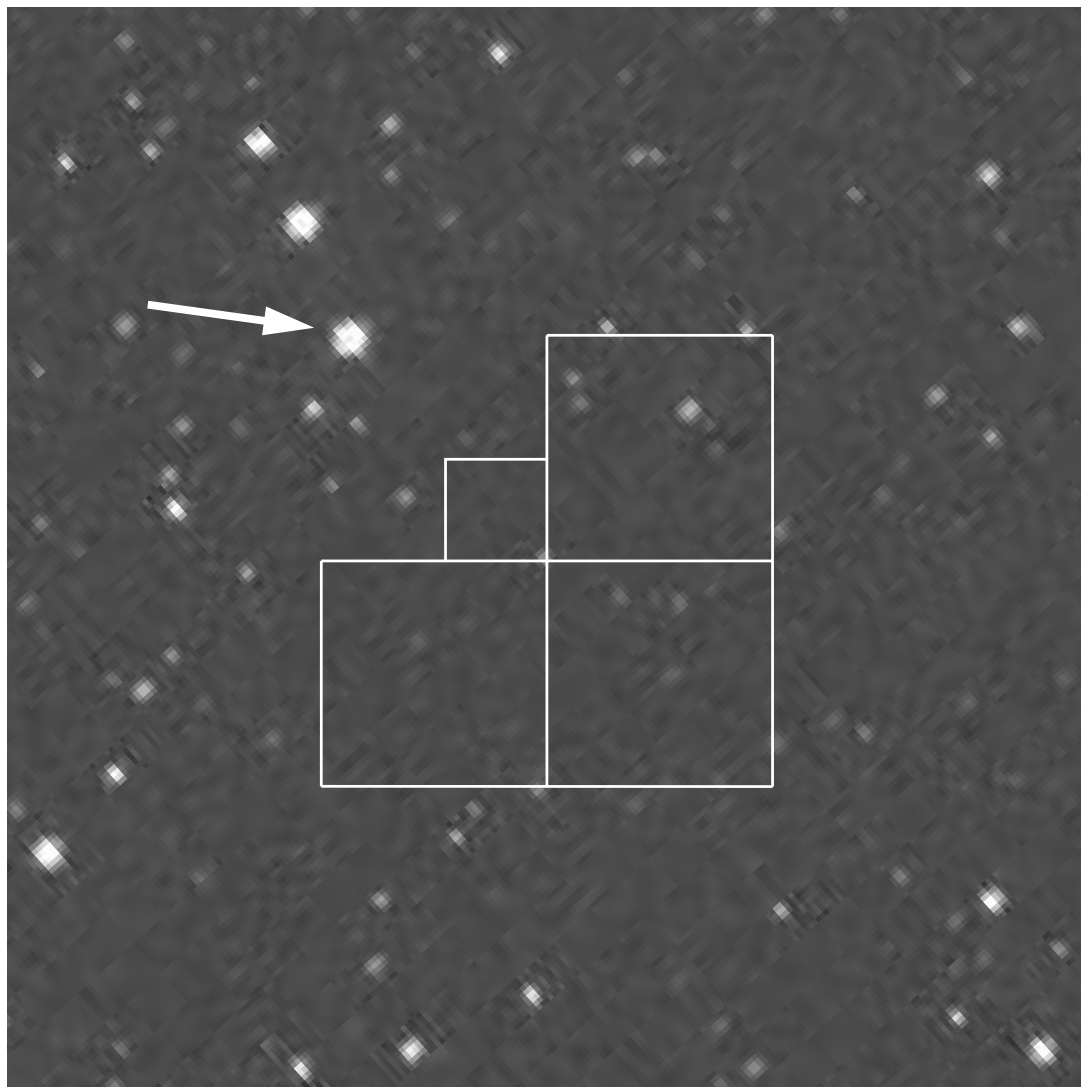


Figure 7.2.a. Mosaicked image showing type 1 “direct” pattern on PC near pyramid apex.

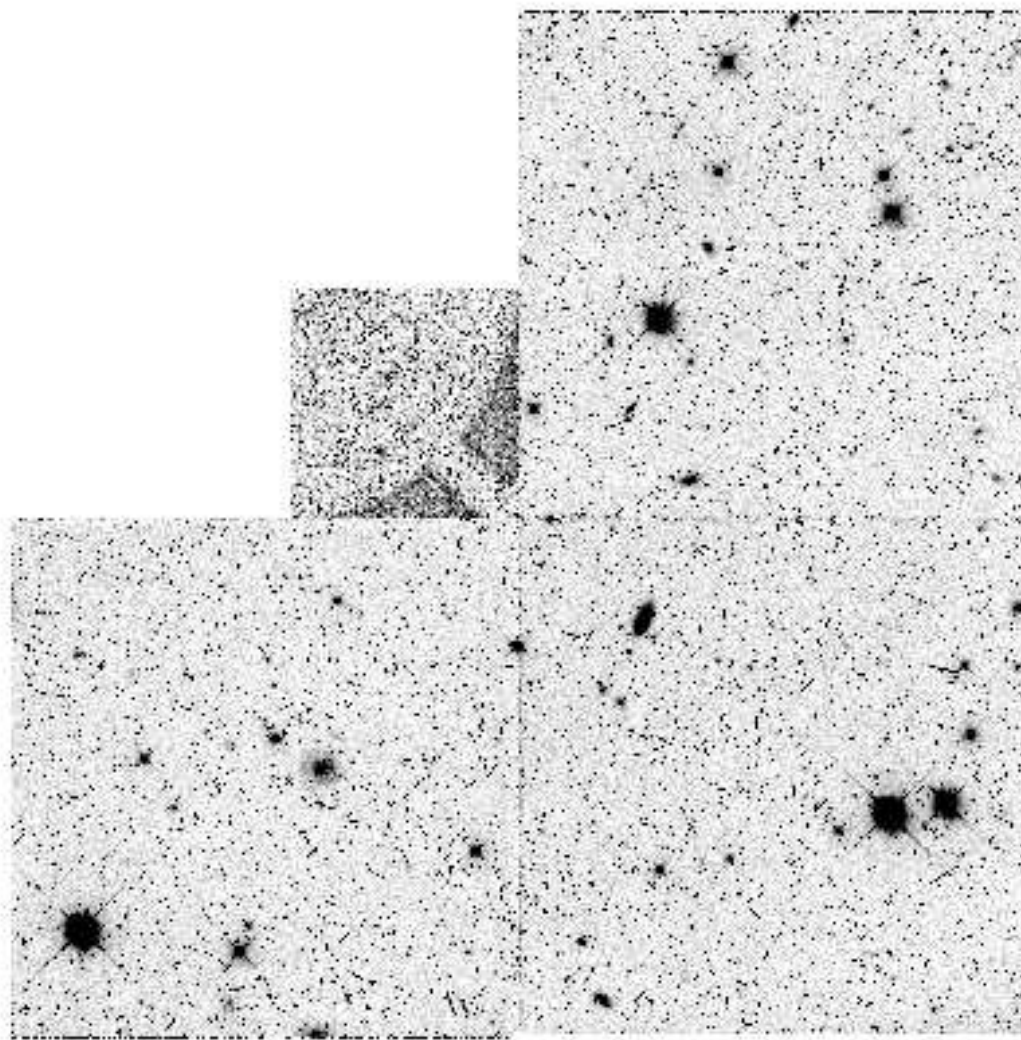


Figure 7.2.b. GASP image for type 1 pattern in Figure 7.2.a, showing a moderately bright star (13.8 magnitude) near outer corner of the PC pyramid facet.

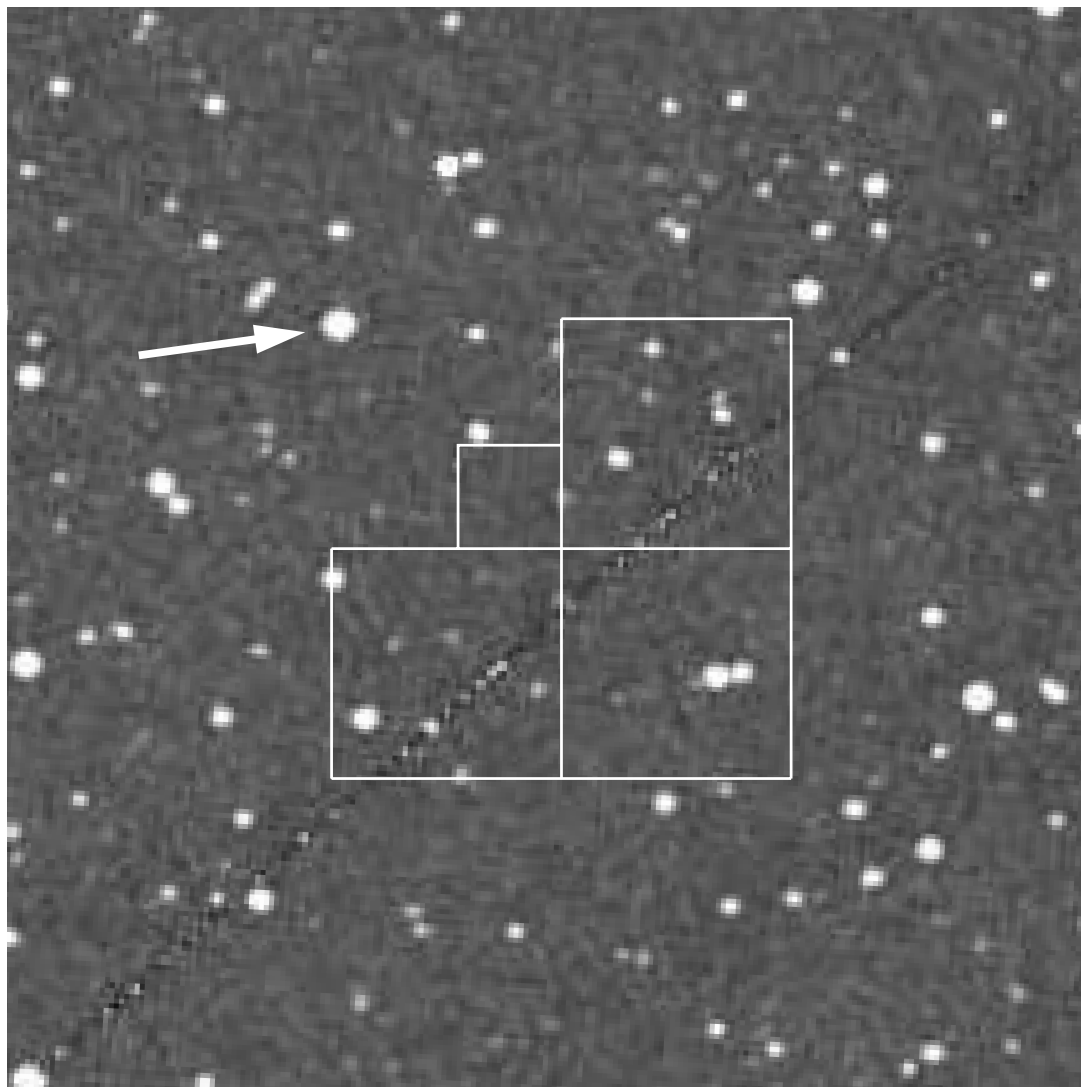


Figure 7.3.a. Variation of PC type 1 “direct” stray light pattern. Note that pattern is shifted relative to those in Figure 7.1 and 7.2. The shift occurs when the offending star is along outer edge of PC1 pyramid facet, instead of at outer corner.

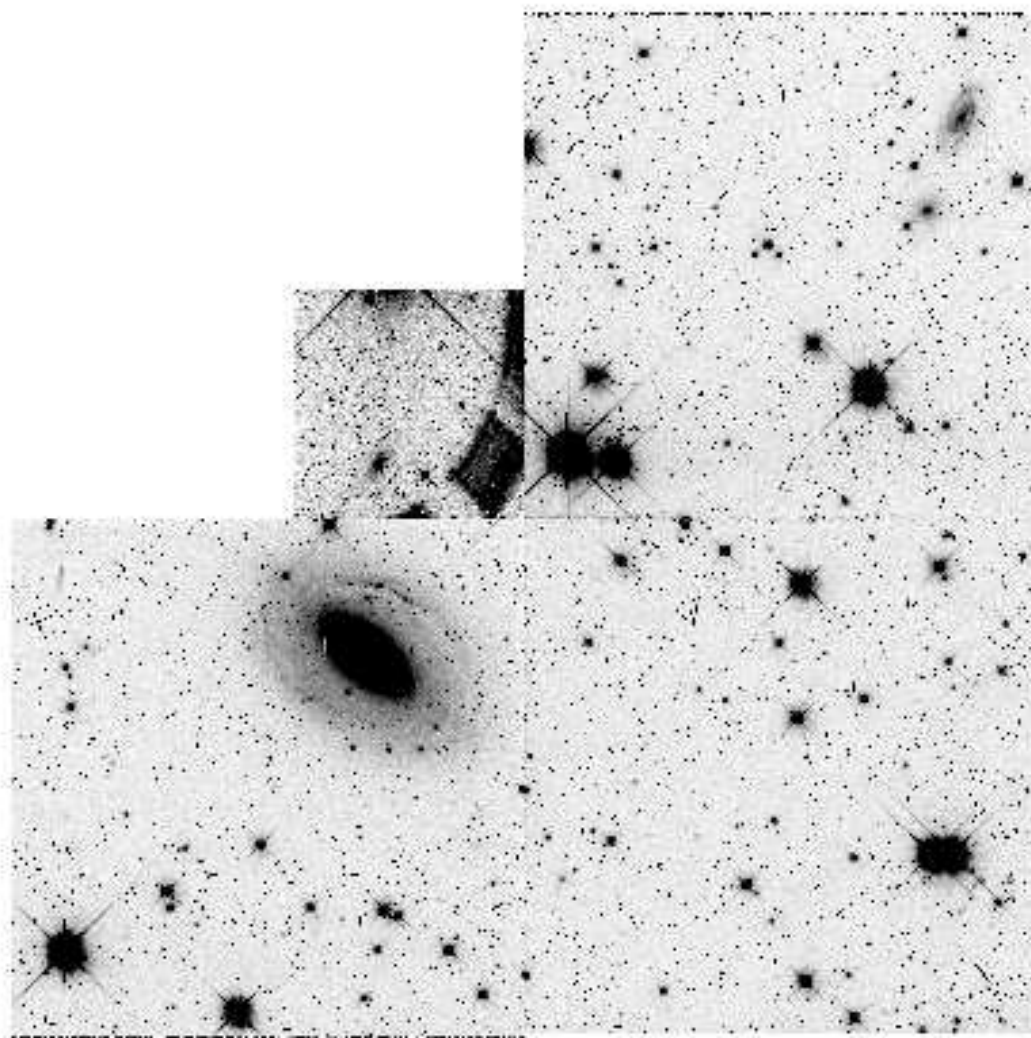


Figure 7.3.b. GASP chart for Figure 7.3.a showing bright star (m=11.4) near outer edge of PC1 pyramid facet.

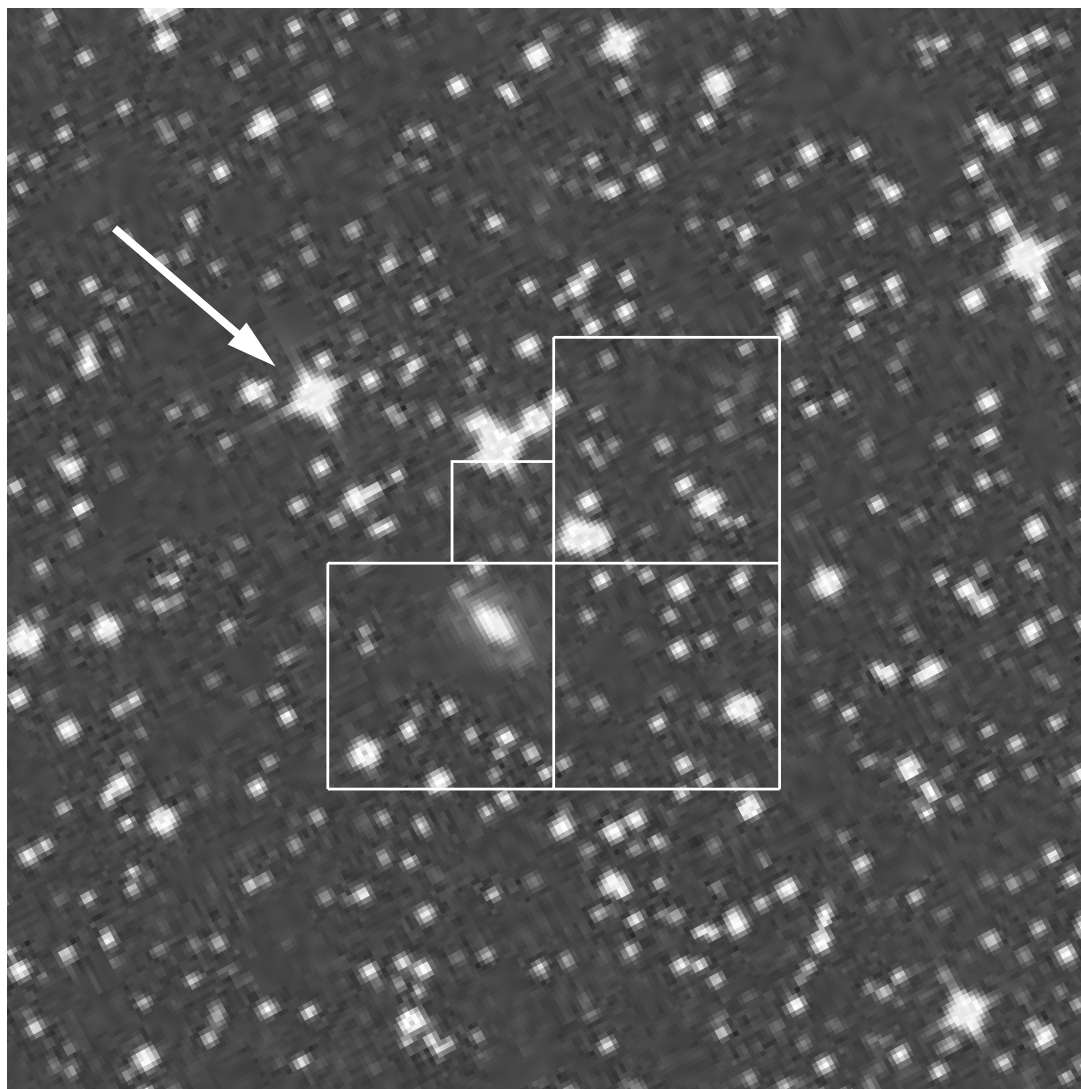


Figure 7.4.a. PC type 2 or “diffraction” pattern with two arcs and spike.

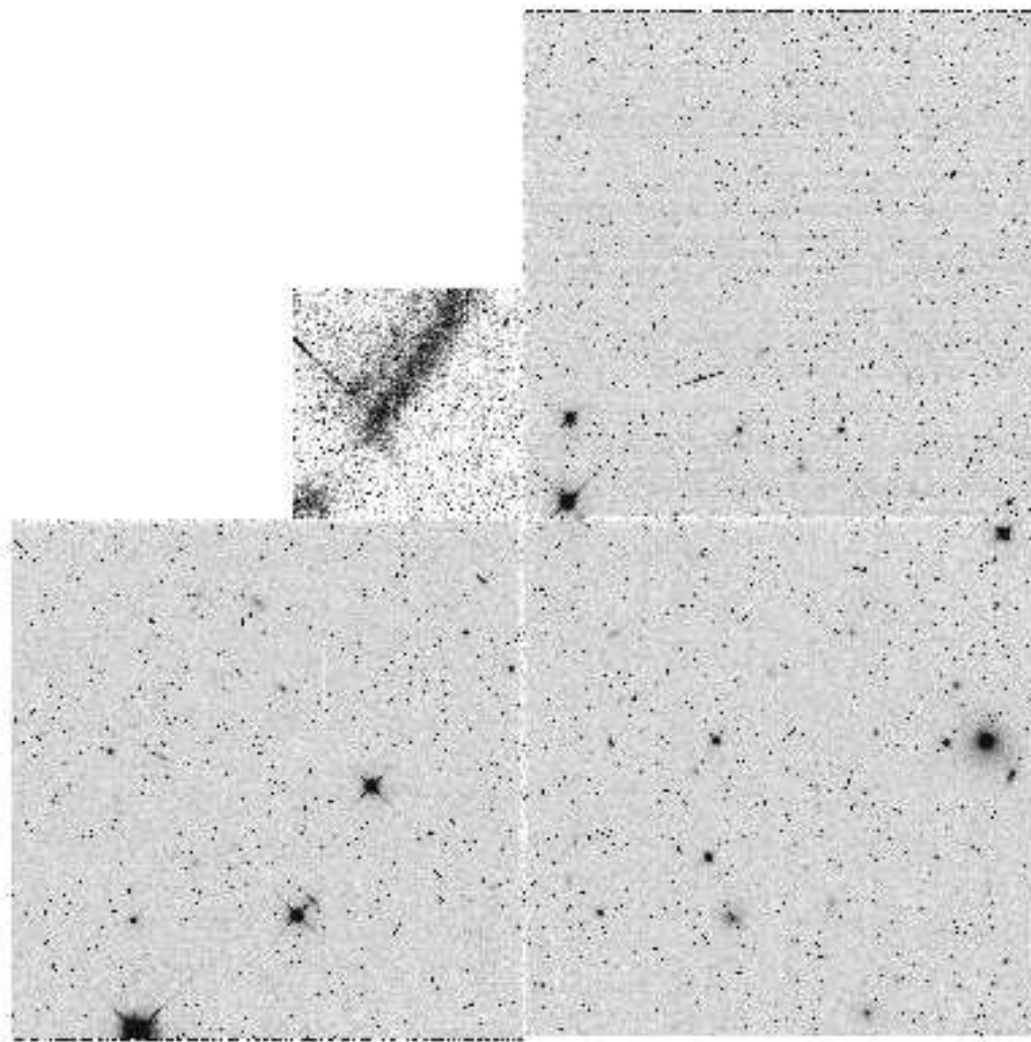


Figure 7.4.b. GASP image for PC type 2 or “diffraction” pattern in Figure 7.4.a, showing bright (10.8 magnitude) star on the PC pyramid facet just outside PC field of view.

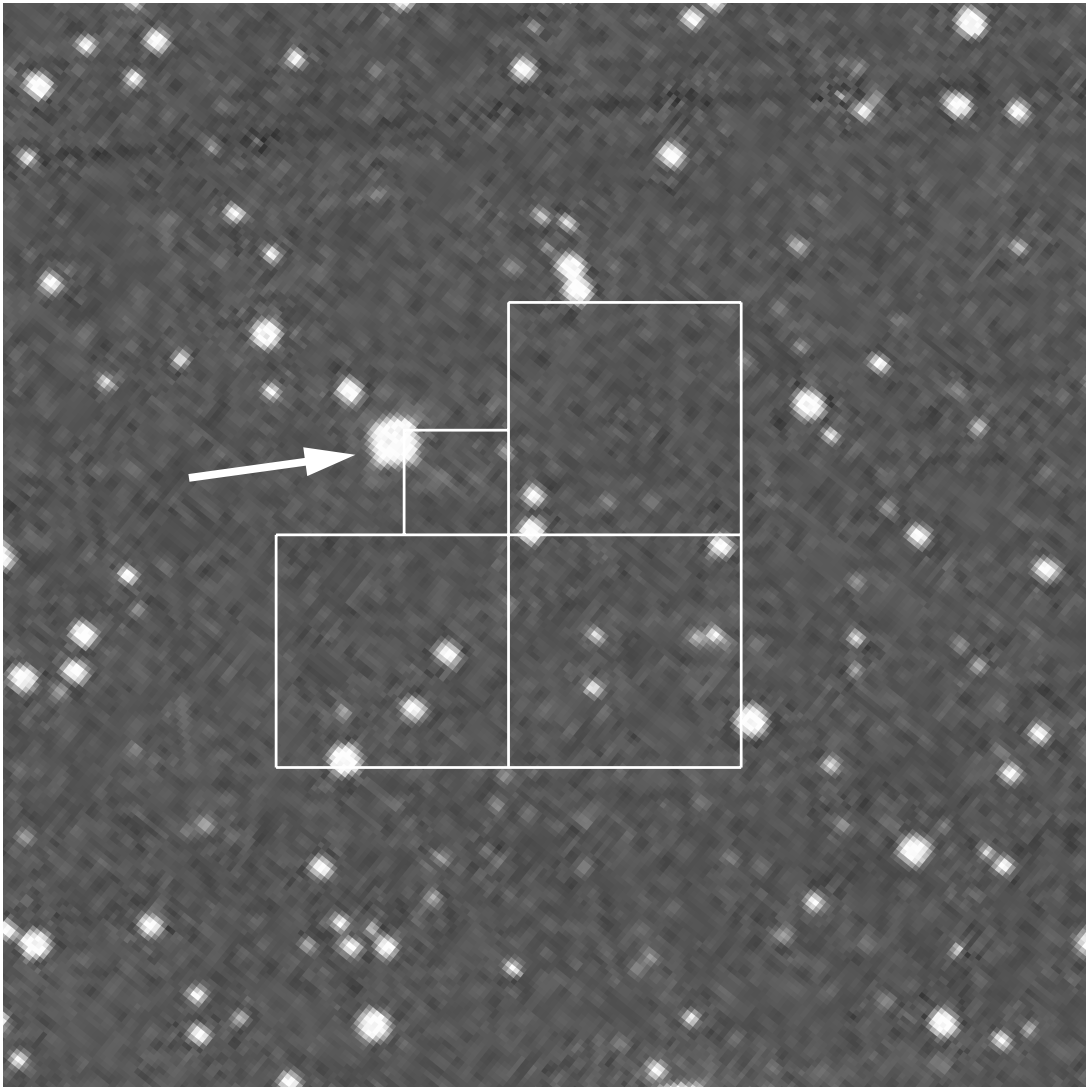


Figure 7.5.a. PC type 2 or “diffraction” pattern showing multiple arcs and spike.

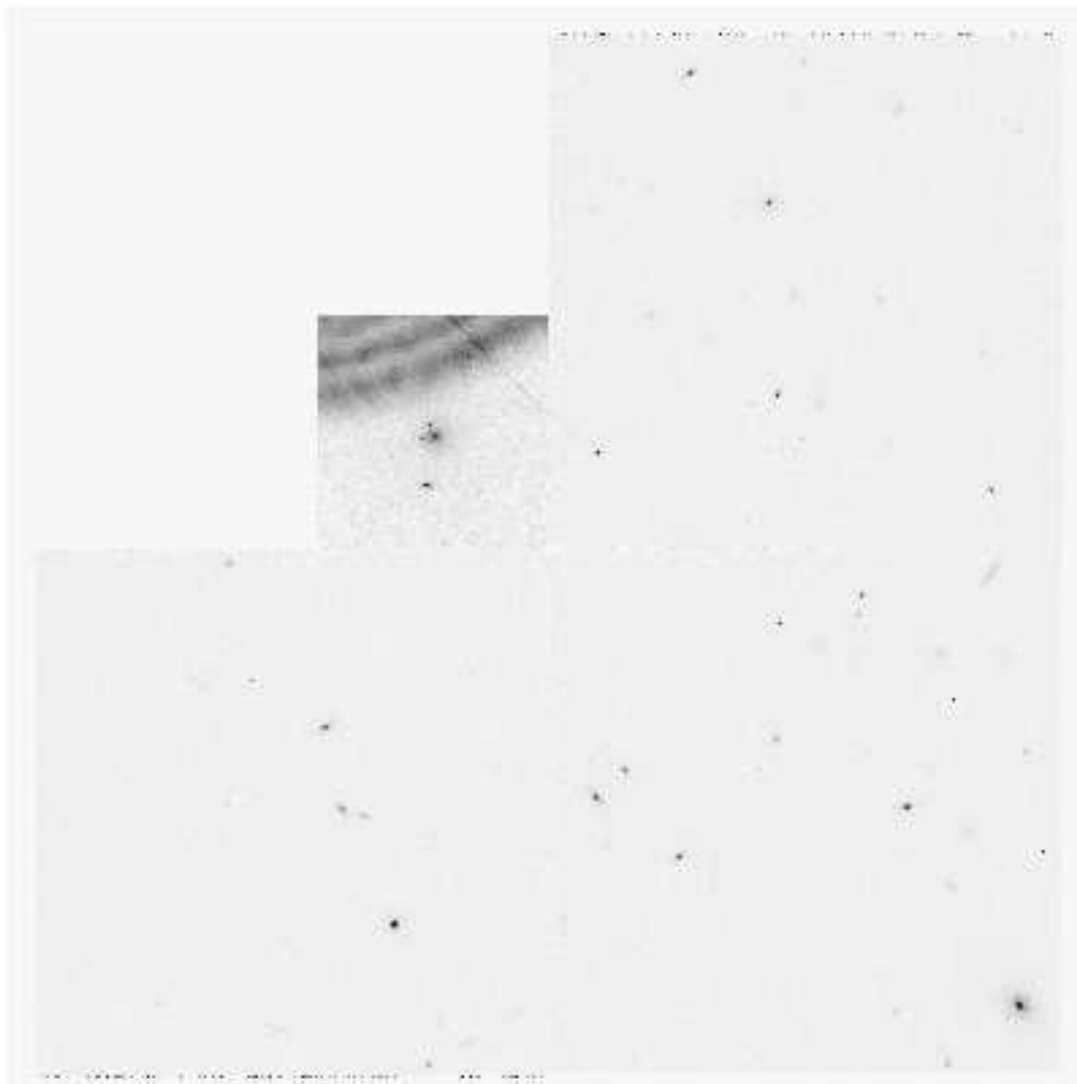


Figure 7.5.b. GASP image for Figure 7.5.a showing bright (9.4 magnitude) star on the PC pyramid facet just outside the PC field of view.

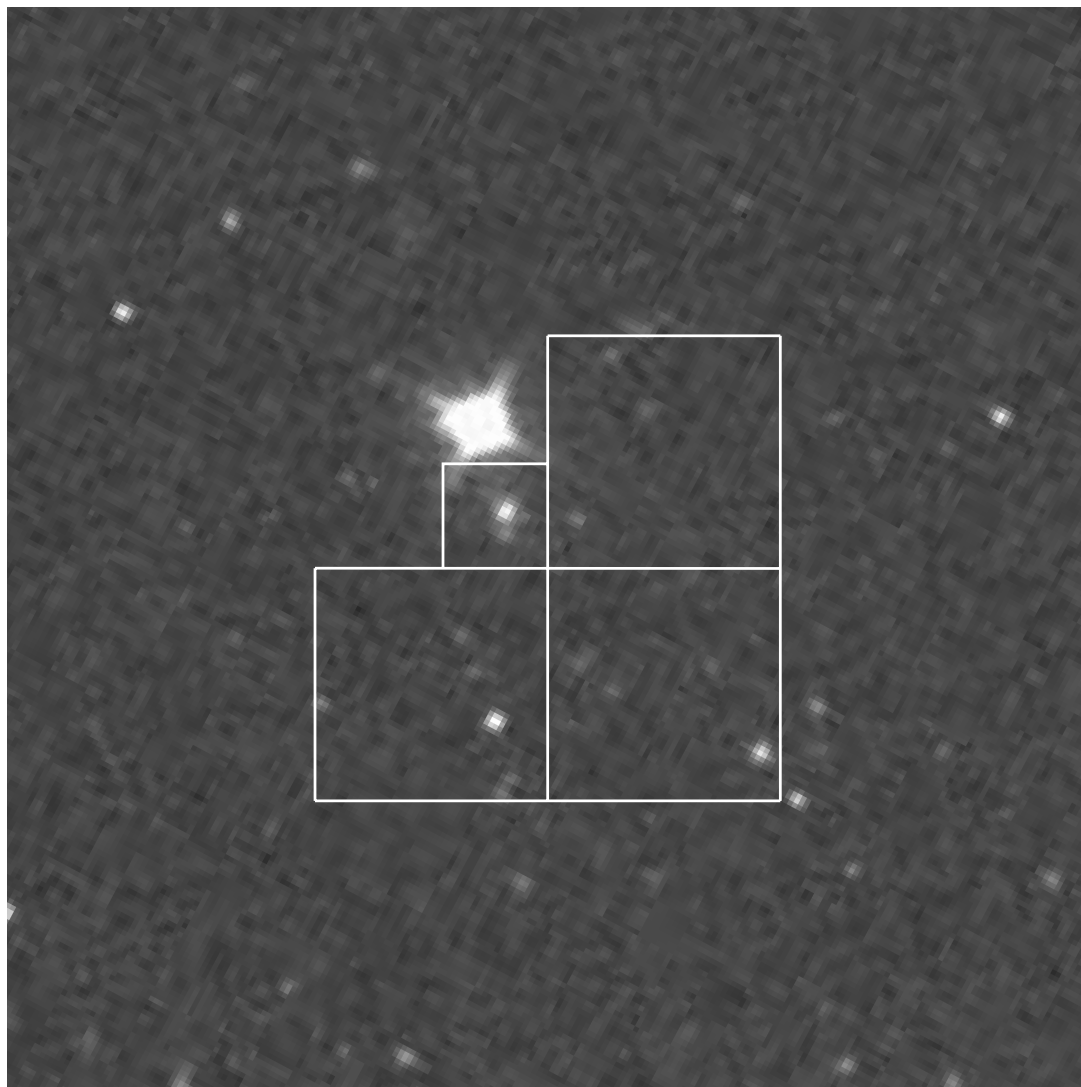


Figure 7.6.a. PC1 stray light pattern which is intermediate between type 1 and type 2.

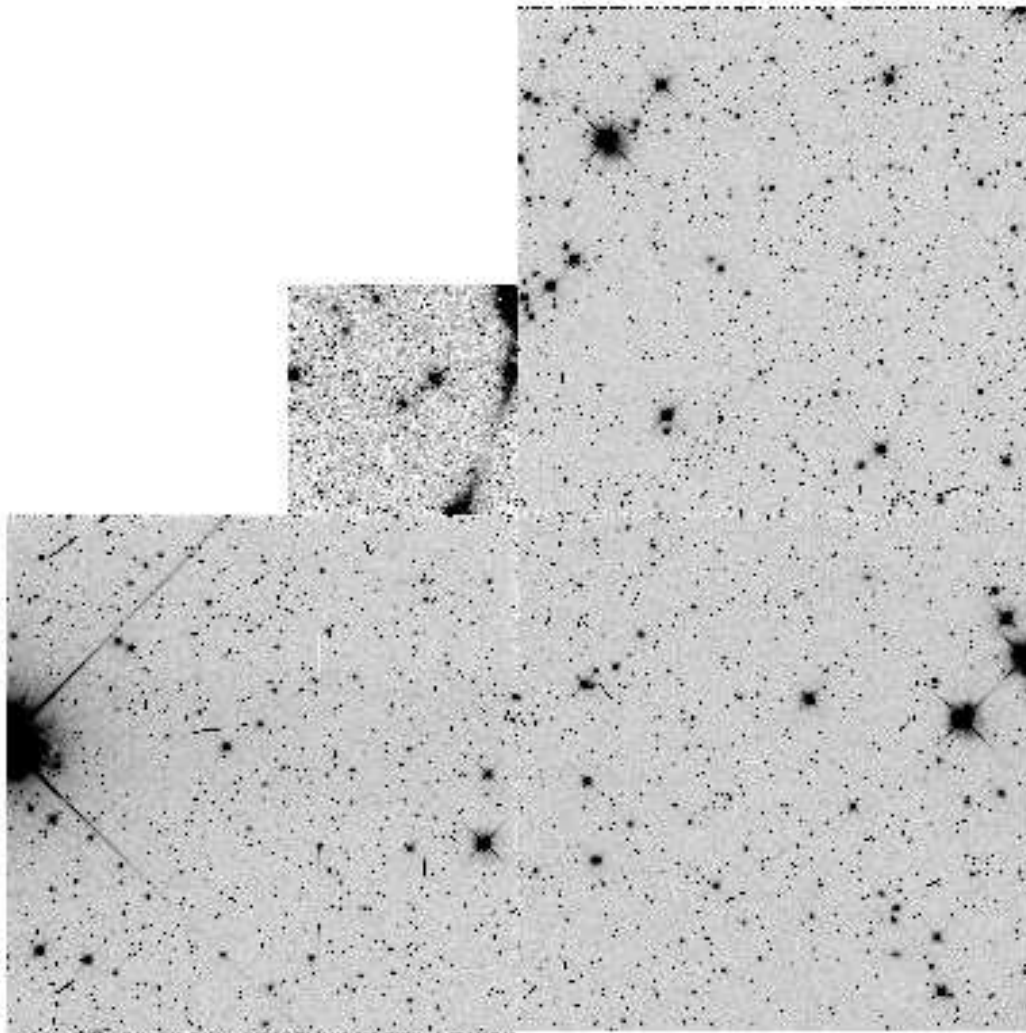


Figure 7.6.b. GASP image for Figure 7.6.a. A bright star is present along outer edge of PC pyramid facet, but far from the outer corner.

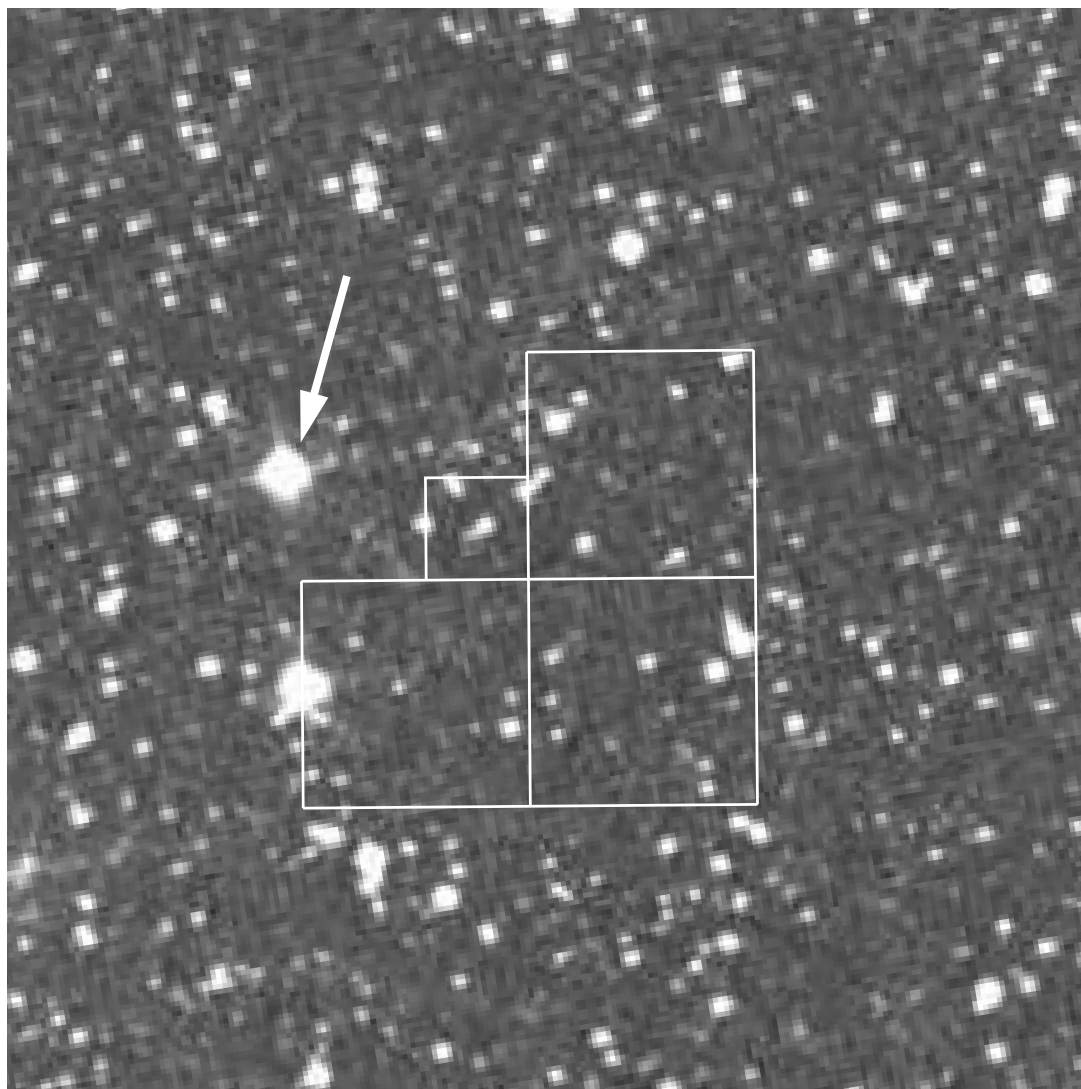


Figure 7.7 Ratio of a POLQN18 + F555W visflat divided by a F555W visflat. The “direct” stray light pattern is visible as a bright arc in the lower left (near pyramid apex). The POLQ rotation causes light forming the pattern to pass through the open position on the filter wheel, and hence the pattern is intensified and becomes apparent in this ratio image.

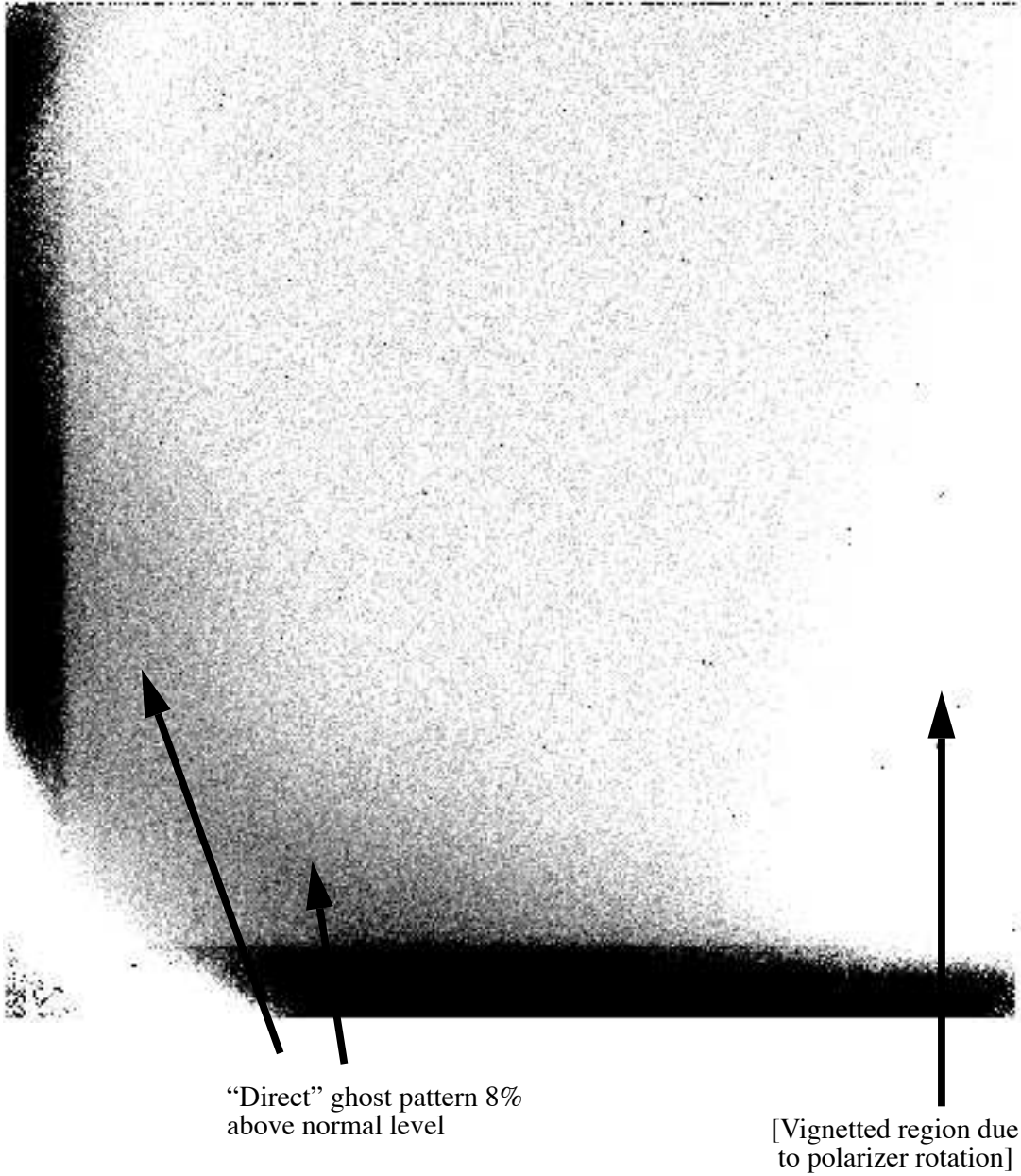
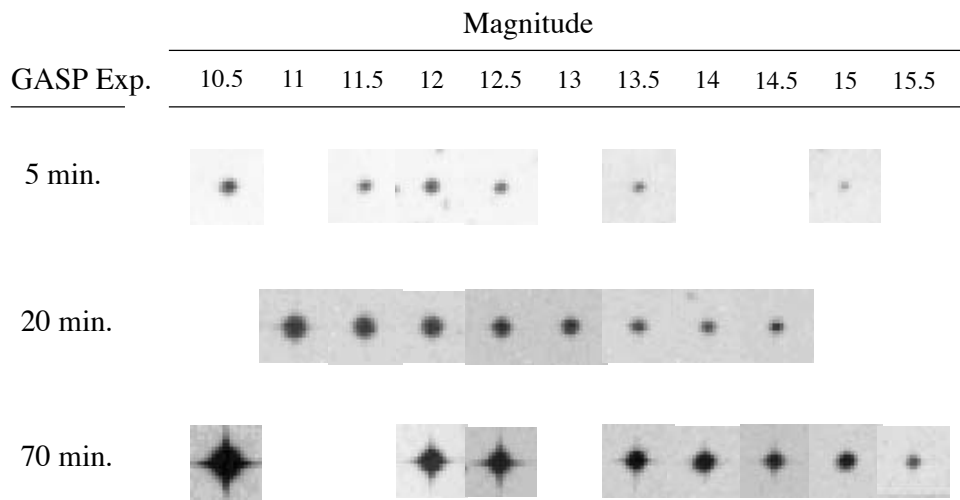
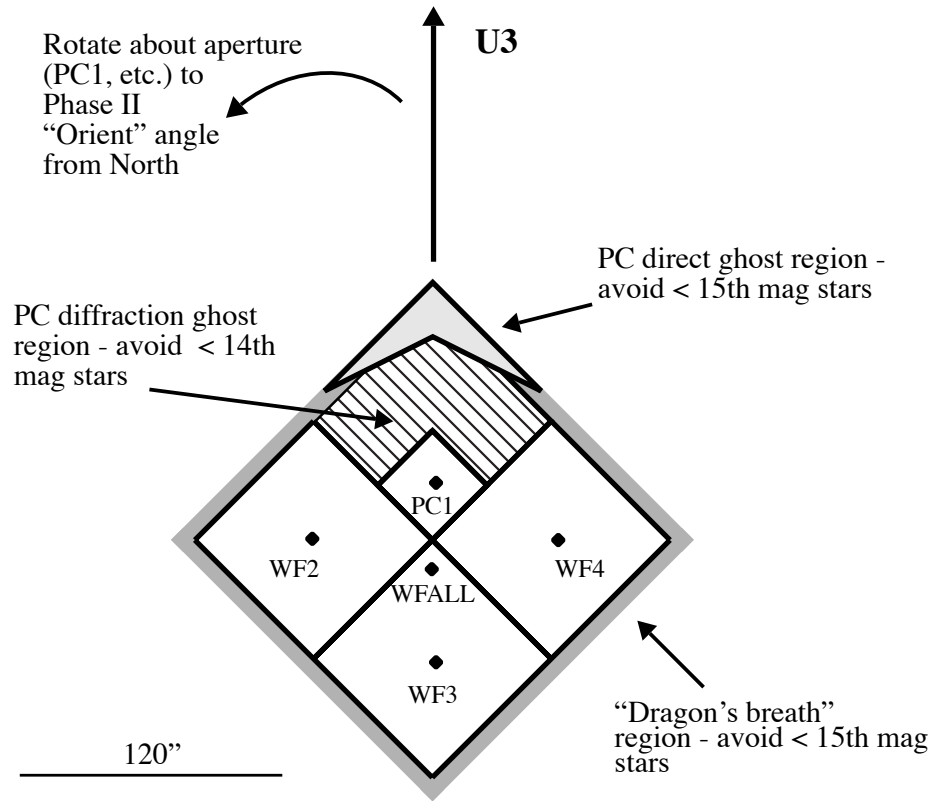


Figure 7.8. GASP chart overlay showing bright star avoidance regions near WFPC2 field of view. Stated avoidance magnitudes assume 600 sec. exposure in F555W producing 1 electron pixel⁻¹ stray light pattern. Sample GASP star images with approx. magnitudes are shown at bottom.



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