POST-COSTAR FOS "SMALL" APERTURE RELATIVE THROUGHPUTS DERIVED FROM SMOV DATA

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Abstract

White light (mirror) post-COSTAR throughputs for observations of point source targets using the FOS "small" apertures are measured relative to those for the target centered in the `1.0` aperture. The data acquired during SMOV proposal 5619 and cycle 4 FOS calibration proposal 5649 are used to determine the aperture losses for observations of point sources that are not centered in the aperture. Plots of observed aperture relative throughput versus radius are presented.

I. Test Description

The precise centers of the "small" FOS apertures (`0.25-PAIR`, `0.1-PAIR`, `0.3`, `0.25X2.0`, `2.0-BAR`, and `0.7X2.0-BAR`) are determined for each detector by SMOV proposal 5619 and cycle 4 FOS calibration proposal 5649. These proposals executed on 1994 March 21 (day 94.080; 5619 blue side), 1994 March 28 (day 94.087; 5619 red side), and 1994 May 23 (day 94.143; 5649). The operation of these proposals is described in detail by Evans et al. (1995), which should be consulted for additional information. Suffice it to say here that a star in the continuous viewing zone is scanned across each aperture in the FOS X and/or Y directions with a scan step size equal to 1/10th of the nominal aperture dimension. At each step position, a short exposure using the mirror as the spectral element is obtained; and the total white-light counts observed are recorded, together with the mean $V2$, $V3$ position of the target during the exposure. The X and Y aperture centers are determined from the observed scan profiles.

For every step position in the X and Y scans of each aperture, the radial distance between the measured aperture center and the step position is determined using the equation

$$r = \sqrt{(V2_{\rm step} - V2_{\rm center})^2 + (V3_{\rm step} - V3_{\rm center})^2},$$

where r is radius of the scan step position, $V2_{\rm step}$, $V3_{\rm step}$ is the mean measured $V2$, $V3$ position of the target at the step position, and $V2_{\rm center}$, $V3_{\rm center}$ is the $V2$, $V3$ position of the aperture center determined by Evans et al. (1995). The aperture center positions used here are determined from the dwell scan data directly, without intervening aperture or filter-grating wheel motions. Therefore, the uncertainty of the radius determination for each step position is simply the error arising from self-consistency of the X and Y aperture scan centroids and centers, and is $\lesssim 0''.005$ for each axis (Evans et al. 1995).

Comparison of the number of counts detected from the target at each step position with some fiducial value is a measure of the relative throughput of the aperture at the radius of the scan step position. Since precise measurements of the observed flux for a target that is perfectly centered in each aperture are not available, the observed total number of counts when the target is well centered in the appropriate (blue or red) `1.0` aperture is used as a reference. At the 1% statistical error level that defines the limiting accuracy of these tests, the flux from a point source target that is centered in the `1.0` aperture with an accuracy of $\sim 0''.1$–$0''.15$ does not vary with target position. Therefore, this choice of fiducial has the added advantage that the throughput for a perfectly centered point source target in the smaller apertures may be estimated relative to that for a perfectly centered point source target in the `1.0` aperture by extrapolation to zero radius.

II. Results

Observed aperture throughputs for point sources relative to a target centered in the appropriate `1.0` aperture are summarized in Figure 1. For each aperture, the data derived from the X and Y aperture scans are indicated by different symbols. For the `0.25X2.0` slit aperture, only the Y scan across the slit exists, while for the `2.0-BAR` and `0.7X2.0-BAR` bar apertures, only X scans across the occulting bars are obtained.

For the non-circular apertures, the X and/or Y scans are approximately perpendicular to the aperture edges, rather than along aperture diagonals. Therefore, the measured relative throughput of the aperture at any "radius" should be an approximate lower bound to the throughput for a radial displacement at an arbitrary position angle.

Even for the circular apertures, there is a dependence of the measured aperture relative throughput on position angle. There are several contributors to this azimuthal dependence, including the anamorphic magnification of the COSTAR optics, azimuthal asymmetry of the detailed structure of the point spread function, lack of perfect symmetry of the apertures, and uncertainties in the measured rotation angle of the FOS apertures. In the absence of strong observational evidence to the contrary, the effects of these azimuthal dependencies are assumed not to alter significantly the radial dependence of the aperture relative throughputs.

The extrapolated white-light (mirror) throughputs for centered point source targets (i.e., at zero radius) relative to the appropriate `1.0` aperture are in good agreement with the values determined by Bohlin and Colina (1995). For the blue side, the extrapolated white-light relative throughputs coincide with those authors measured H27 throughput ratios (their Table 3) to better than 3% for the common apertures, while for the red side the extrapolated white-light relative throughputs are $\sim 4\%$ lower than the measured H40 throughput ratios reported by Bohlin and

Colina.

Inspection of the 0.1-PAIR aperture data for zero radius (Fig. 1) reveals higher throughput for the lower paired apertures compared to the upper paired apertures, for both detectors. Although the dimensions of the 0.1-PAIR upper and lower paired apertures are not uniform, the differences between the measured sizes (e.g., Evans et al. 1995) cannot account for the observed throughput variations. The variation of the core width of the COSTAR point spread function over the FOS field is likely to be a major effect in determining the throughput for the smallest apertures. Inspection of the COSTAR/FOS field maps (Hartig 1995) reveals that the encircled energy within $0''.1$ radius at the *nominal* location of the FOS upper paired apertures is $\sim$ 0.8–0.9 times that expected at the location of the FOS lower paired apertures. Although the observed discrepancy between the 0.1-PAIR upper and lower paired apertures is more extreme than predicted, the field maps reveal that the encircled energy varies strongly with position. Therefore, a small displacement of the FOS aperture locations from their nominal positions could readily degrade the upper/lower throughput ratios to the values observed. The exact position of FOS apertures relative to their nominal positions in the COSTAR field depends on the mechanical latching of the instruments, and is not readily determined. Even though the throughputs of the 0.1-PAIR lower paired apertures are larger than those of their upper counterparts, we nevertheless recommend using the 0.1-PAIR upper paired apertures when data from both detectors is required because of the large difference between the sizes of lower paired apertures for the blue and red detectors.

References

Bohlin, R. C. and Colina, L. 1995, FOS Instrument Science Report CAL/FOS-136

Evans, I. N., Koratkar, A. P., Keyes, C. D., and Taylor, C. J. 1995, FOS Instrument Science Report CAL/FOS-138

Hartig, G. F. 1995, private communication

Figure Captions

Fig. 1 — Aperture relative throughputs as a function of radius. Each panel is identified by detector and aperture. "X/Y Offset" is the radial displacement between the target position and the measured aperture center in arcseconds. "Fractional X/Y Offset" is the radial displacement between the target position and the measured aperture center expressed as a fraction of the aperture radius determined by Evans et al. (1995). "Relative Throughput" is the fractional white light throughput relative to a target centered in the appropriate (blue or red) 1.0 aperture. The data from the X and Y aperture scans are plotted as 'X'es and crosses, respectively.

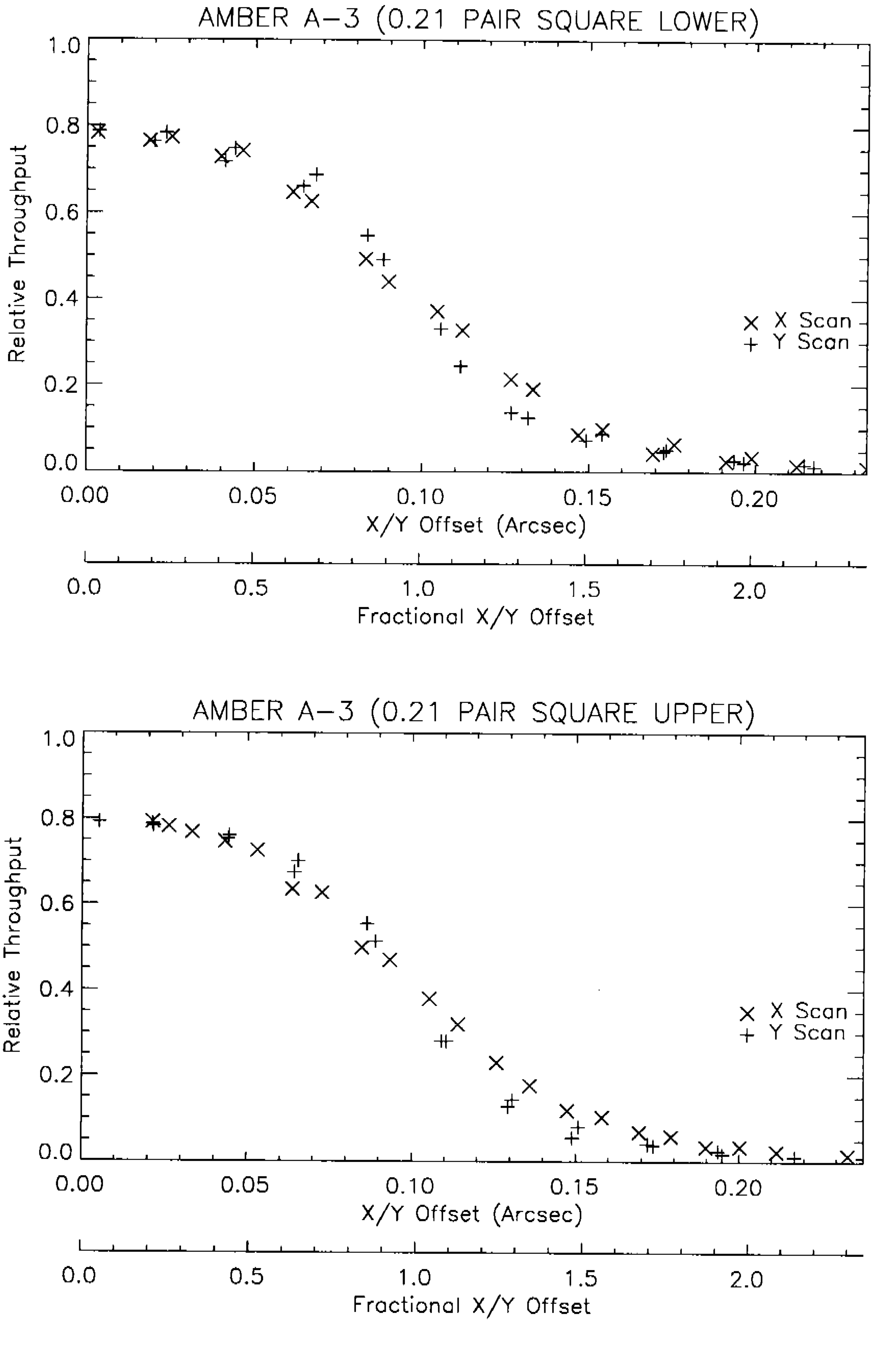
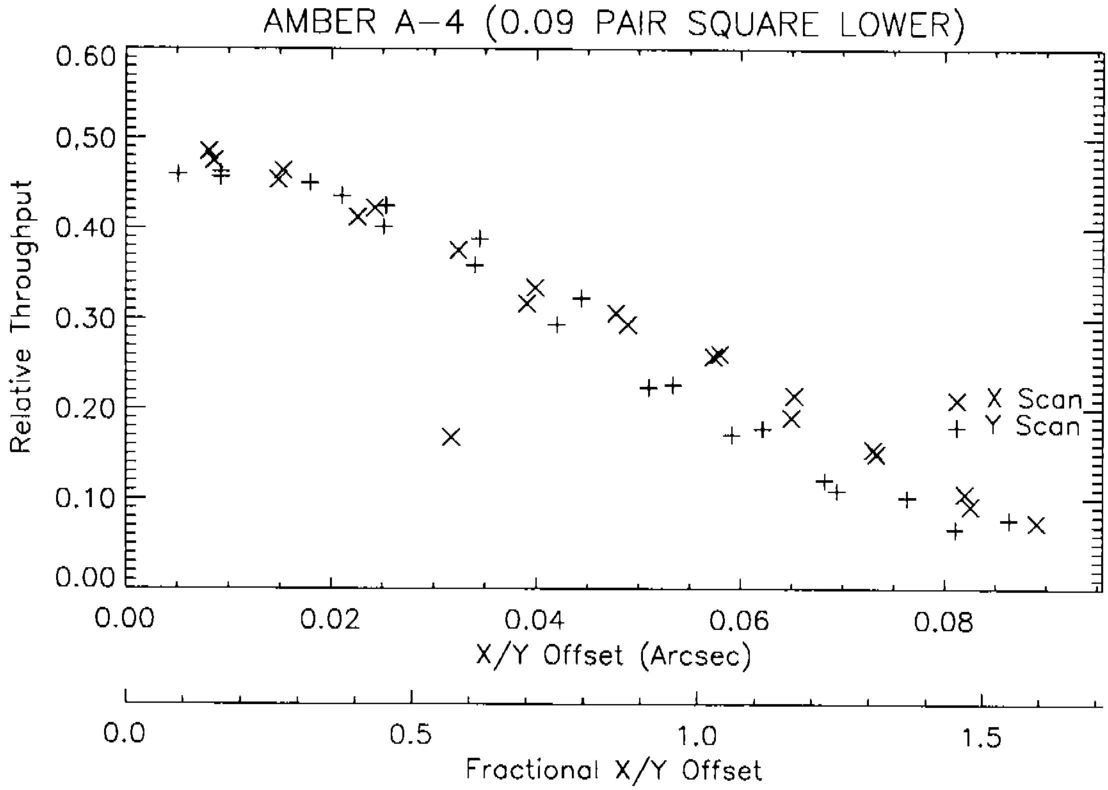
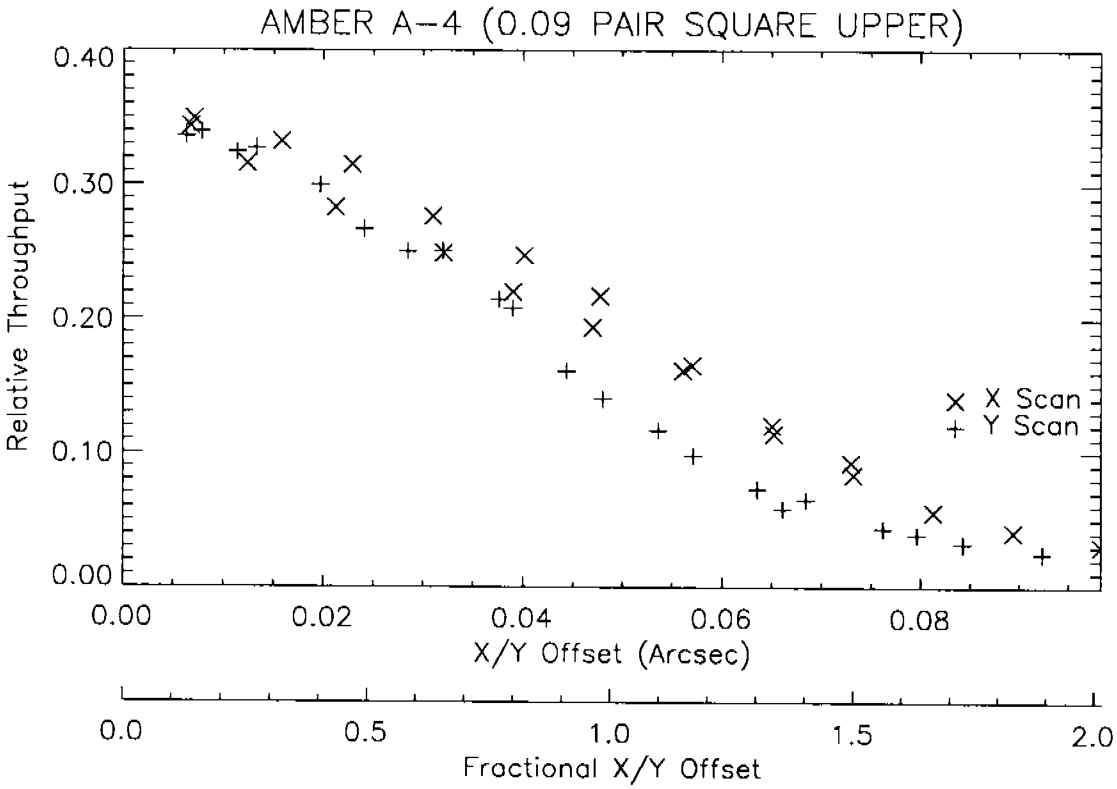

AMBER A-3 (0.21 PAIR SQUARE LOWER)
Relative Throughput
X/Y Offset (Arcsec)
Fractional X/Y Offset
X Scan
Y Scan
AMBER A-3 (0.21 PAIR SQUARE UPPER)
Relative Throughput
X/Y Offset (Arcsec)
Fractional X/Y Offset
X Scan
Y Scan

Figure 1





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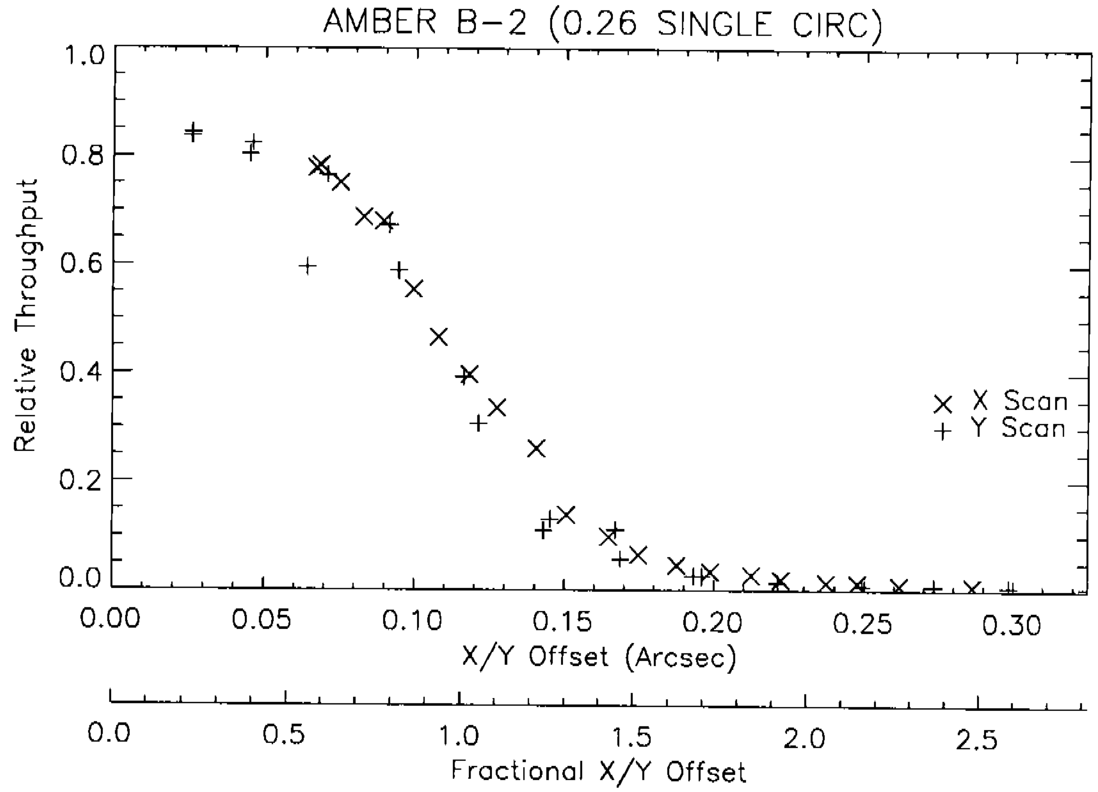

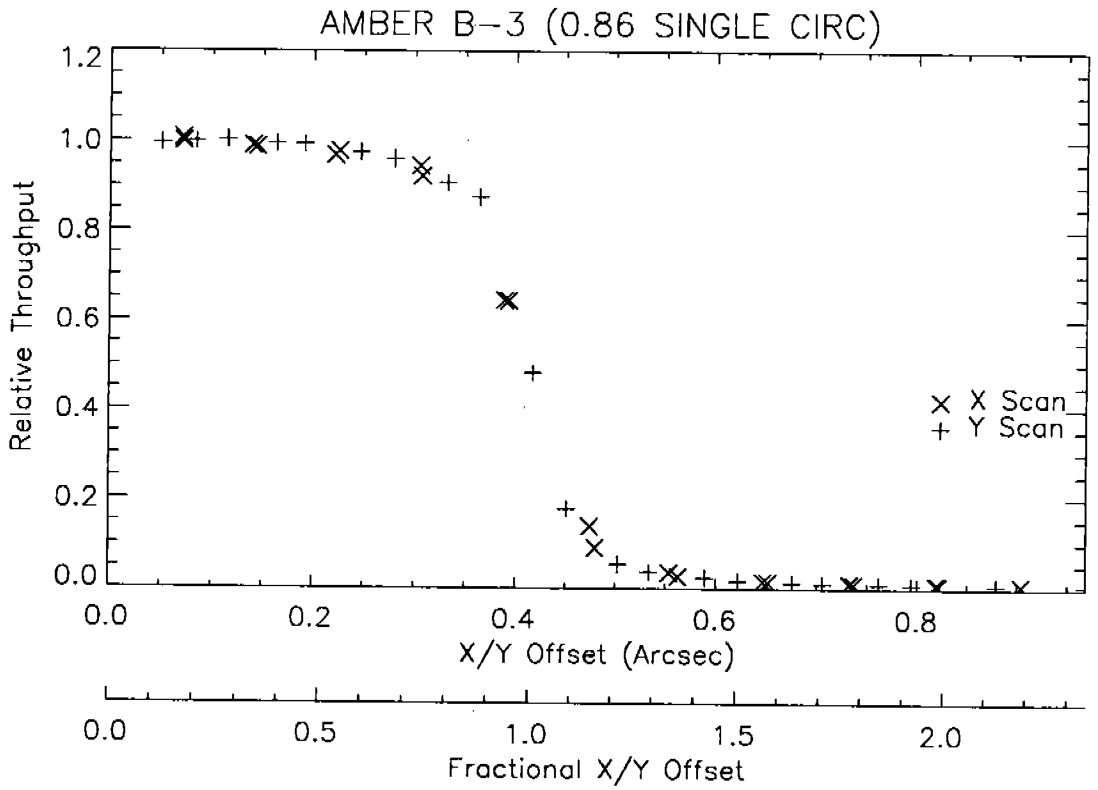

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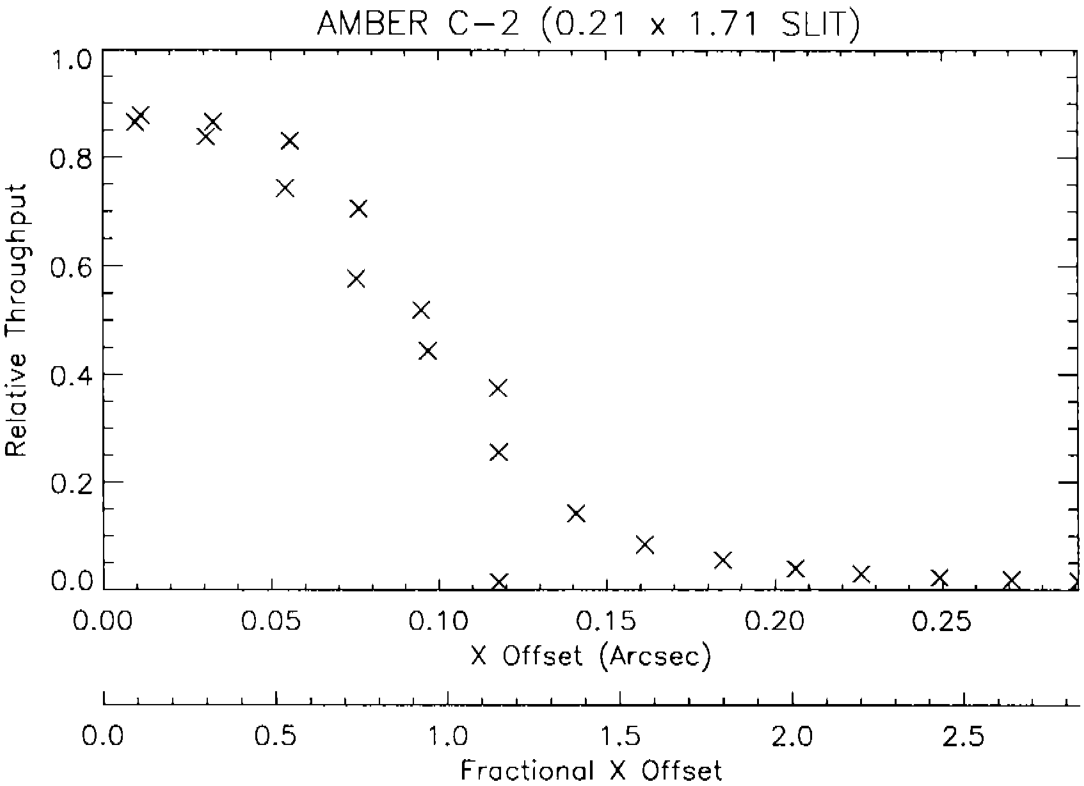

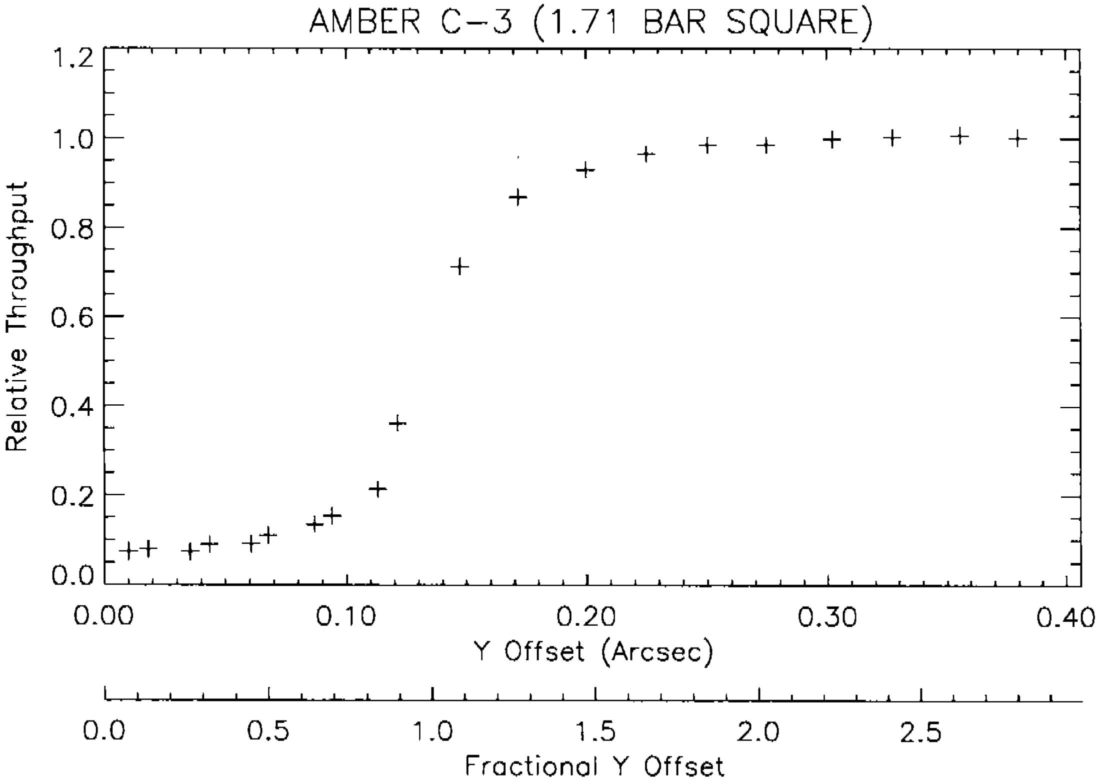

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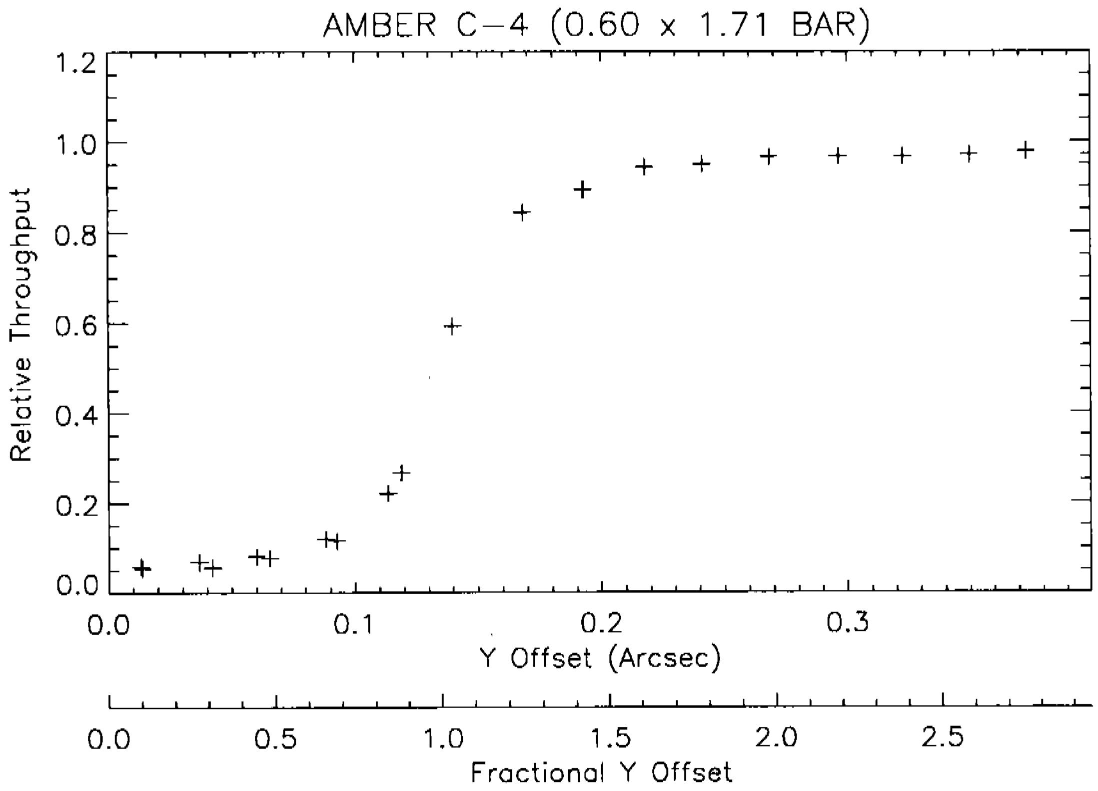

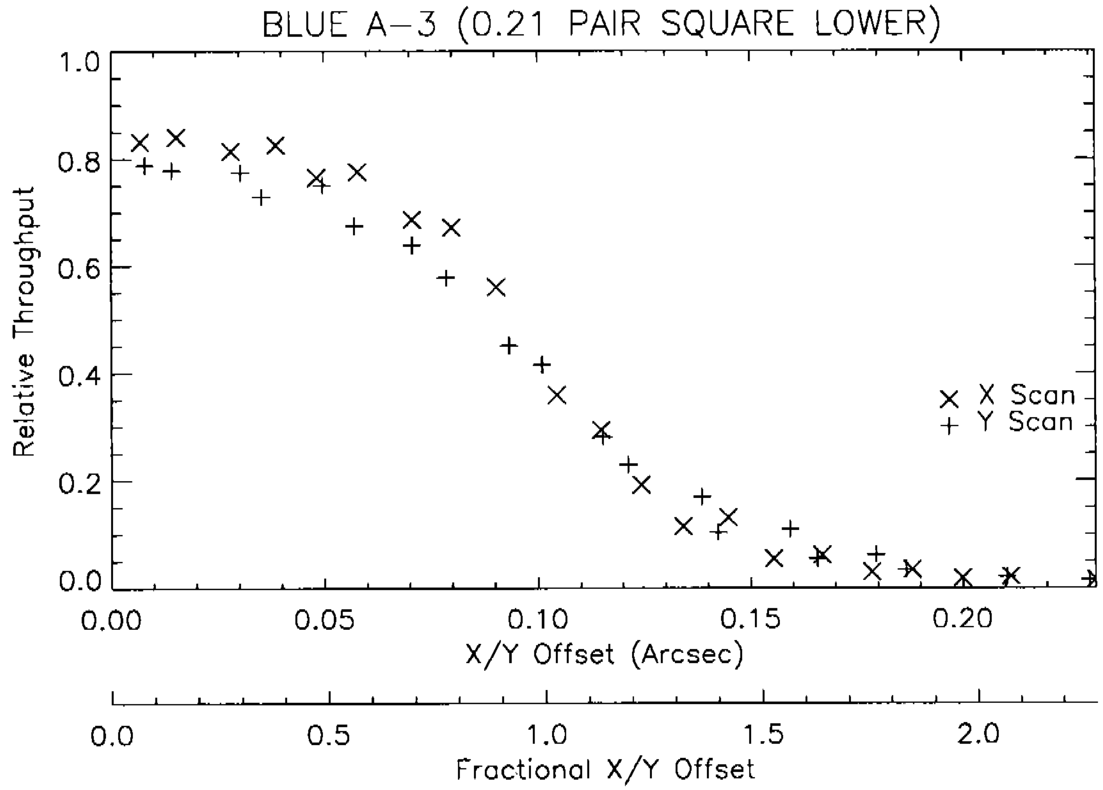

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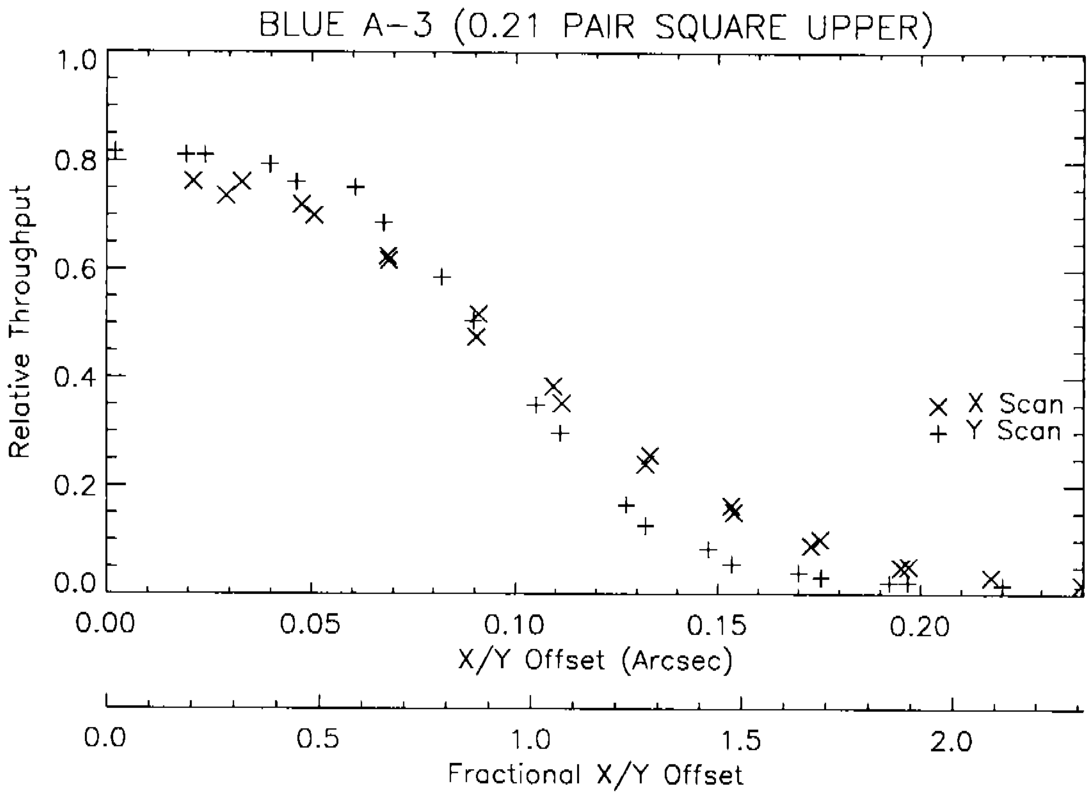

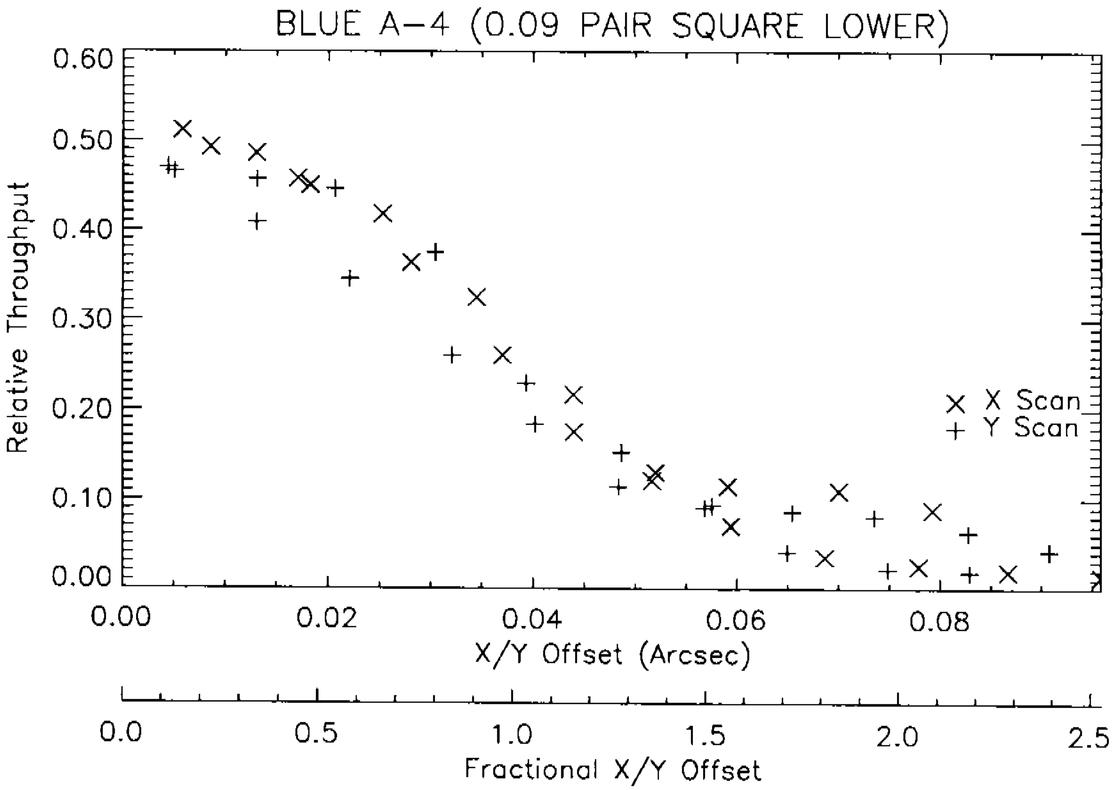

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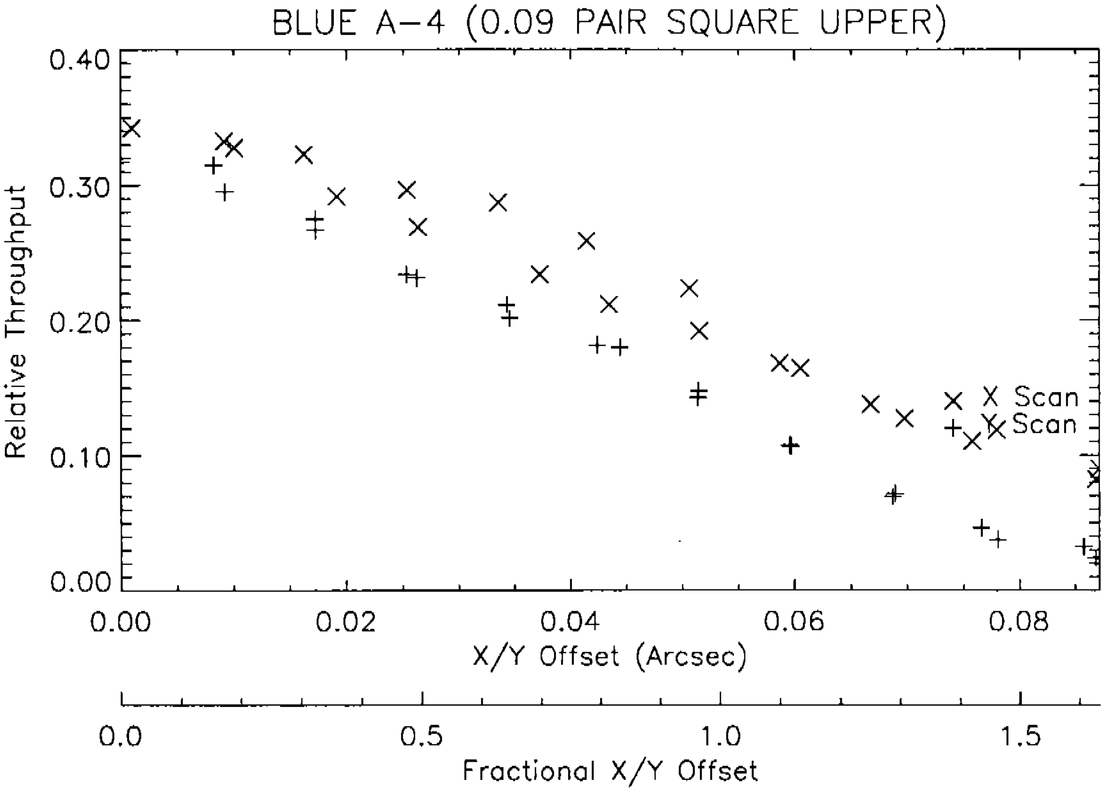

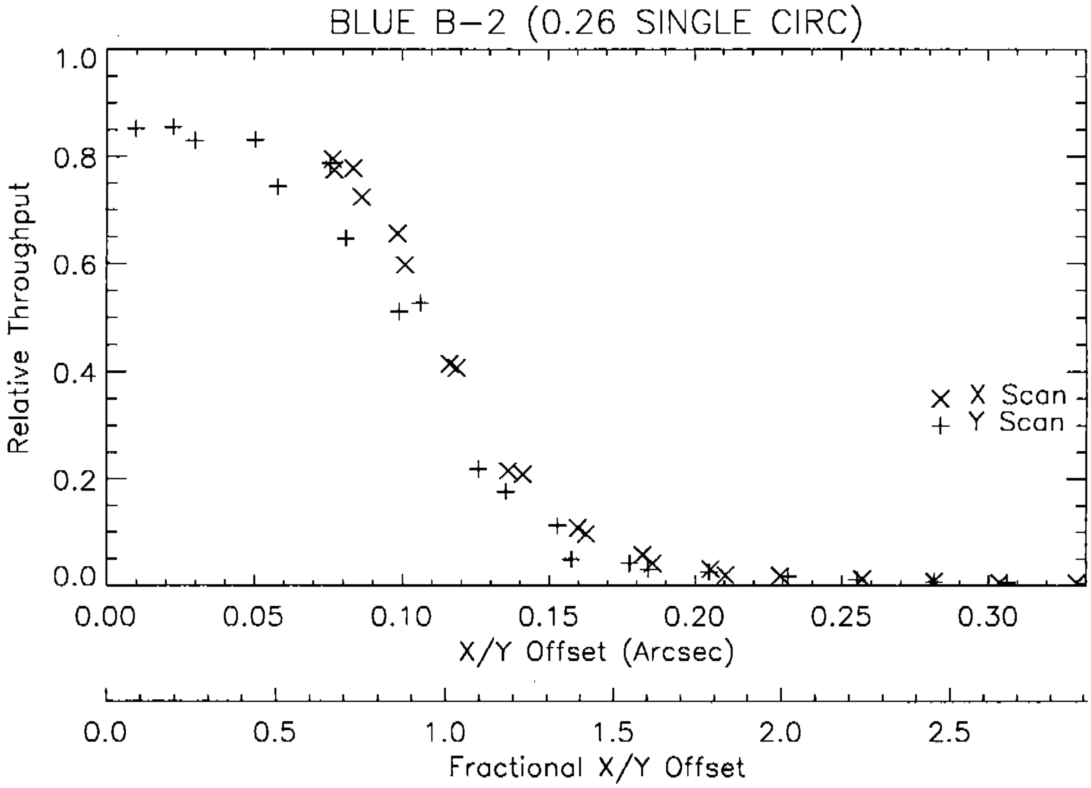

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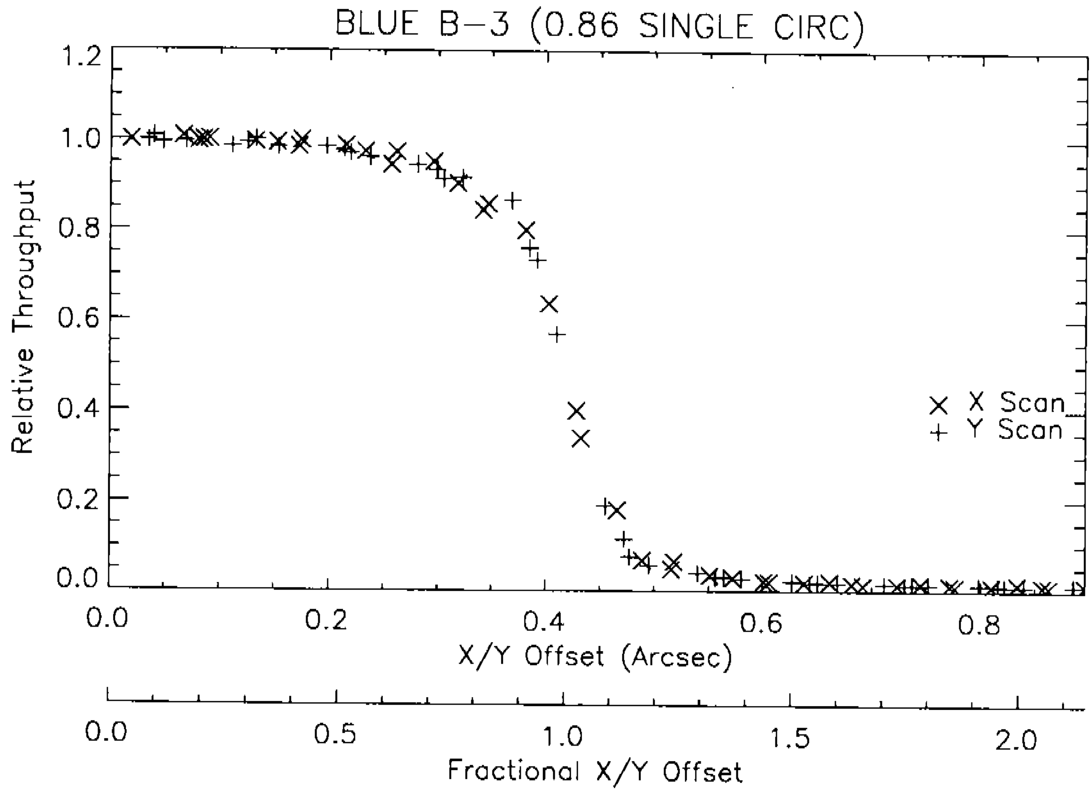

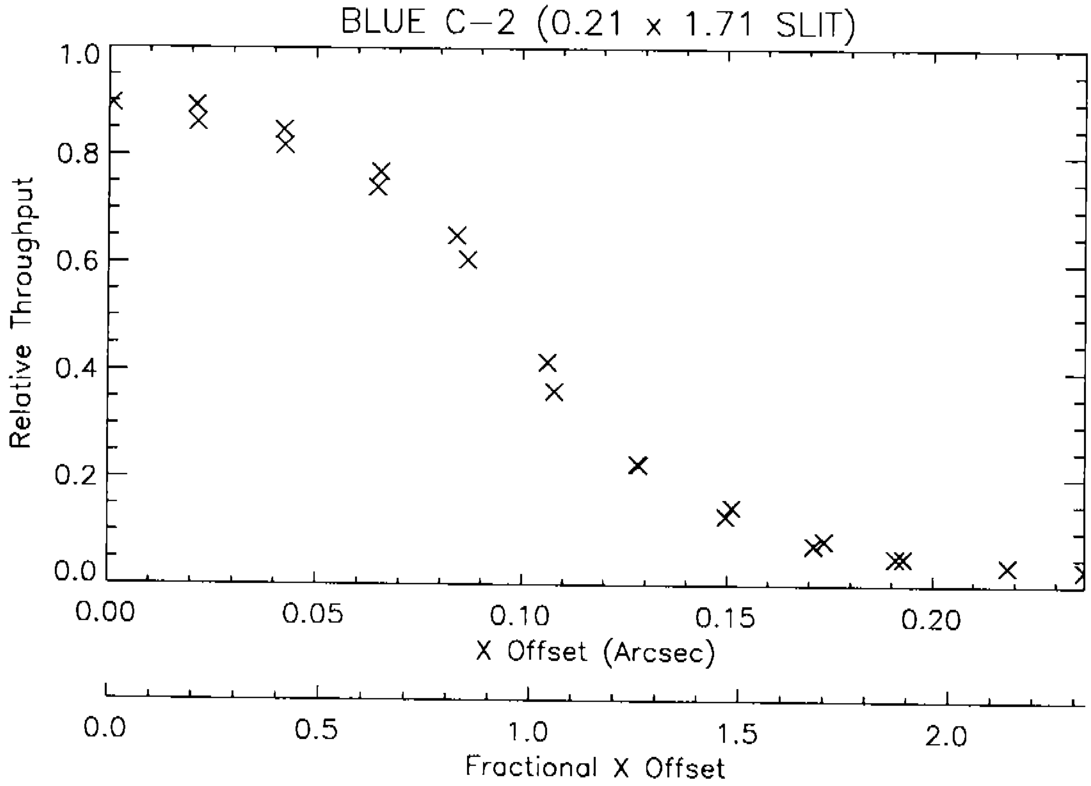

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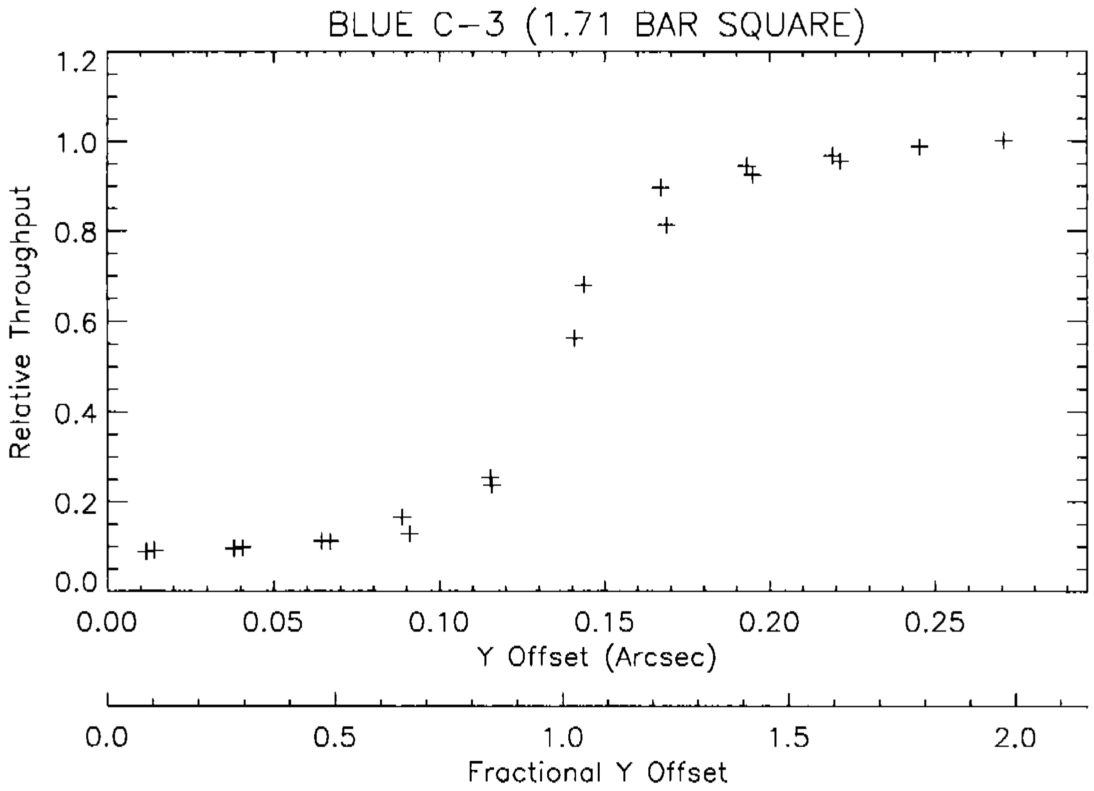

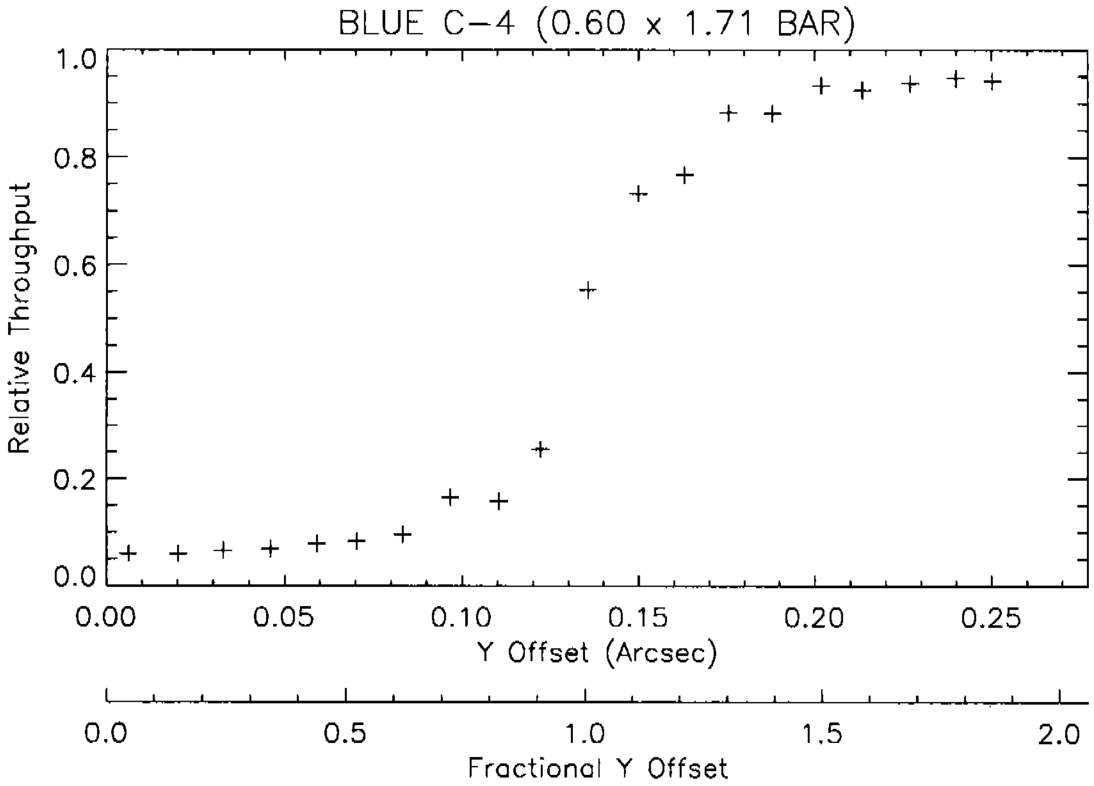

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