SMOV REPORT II. FOS COARSE ALIGNMENT 4907

CAL/FOS-117

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SUMMARY

Plate scale, orientation, and aperture positions can be derived from the FOS Coarse Alignment proposal 4907, run January 1, 1994. Since the initial updates must be done rapidly to allow the early run of the COSTAR/FOS alignment program, and since the plate scale does not affect the COSTAR/FOS alignment program, only aperture positions will be updated in the Science Instrument Aperture Files (SIAF) of the Project Data Base (PDB). Accurate updates will be made for all parameters following 4908, the FOS fine alignment program.

DISCUSSION

Test Description

The FOS coarse alignment test consisted of a two stage peak-up followed by a number of confirmatory acquisitions interleaved with offsets for both the red side and the blue side. The first peak-up was carried out in the large (3.6"X1.2") aperture and covered a pattern of 3X9, or 10.8"X 10.8" on the sky. The red side located the target in position 11 (the second row in X and the fourth column in Y in an X,Y matrix). Position 11 would have been within the target acquisition aperture (assuming zero error in pointing), although not centered in the aperture. The blue side located the target in position 8 (second row in X and third column in Y). For the blue side, the target would have been outside the 3.6" aperture, and the target acquisition would have failed. Although these initial positions are close to predicted positions, the aperture positions must be updated before on-board target acquisitions can be expected to succeed.

The peak-up in the large aperture was followed by peak-ups into the 1.0" circular aperture, using a 2X6 pattern covering 3.6"X1.2" with steps of 0.6". The final peak up position was used to calculate aperture position for both red and blue side. The peak-up was followed by a confirmatory image on both red and blue sides. The distance between the target and the aperture center was used to correct the aperture position, as described below. Following the confirmatory image, the red side uplinked a slew of size (-0.2,-0.3) in arcseconds in the FOS (X,Y) direction and a second image was taken. The resulting red side image did show an offset of the correct size and direction, verifying that uplinks from OSS perform as expected. There was no real time uplink with a small slew performed on the blue side. Both red and blue sides were offset by 0.5" first in X and then in Y using `POS TARG` command, with images after each change in position. The optimum positions of the target, referred to in Table 1 as positions 1 through 4 on the red side, correspond to the FOS (X,Y) positions of (0.0,0.0), (-0.2,-0.3), (0.3,-0.3), and (-0.2, 0.2), respectively, in units of arcseconds relative to final peak-up pointing. Those are the positions the target would have taken if the target had been prefectly centered after the peak-up target acquisition. Positions 1 through 3 on the blue side refer to FOS (X,Y) positions of (0.0,0.0), (0.5,0.0), and (0.0,0.5), respectively, in units of arcseconds relative to final peak-up pointing.

The first post-COSTAR images with FOS show a greatly improved point spread function, as illustrated for the red side in Figures 1 and 2.

Aperture Positions

The aperture positions are derived first from the peak-up position based on the crude peak-up map. If the peak-up had resulted in a perfect centering, the star would be exactly centered in the 3.6" aperture in the confirmatory image taken after the peak-up. Corrections to the aperture postion derived from the original peak-up position are calculated from the confirmatory image by calculating the target position relative to aperture center.

The most confusing aspect of the derivation is the units. The aperture positions in the Project Data Base are given as (V2,V3) in units of in arcseconds. Meanwhile, the `aperlocy` package in STSDAS used to derive centroids of the stellar positions uses units of diodes in X and y-base units in Y. The matrix used to convert from FOS (X,Y) coordinates to (V2,V3) arcseconds uses units of pixels, where the target acquisition aperture is assumed to be 48 X 48 pixels in size, with the center of the aperture at (X, Y) = (25, 25). One pixel is a 1/4 diodes in X and 16 y-base units in Y.

The `aperlocy` package used in STSDAS locates a point source observed in a standard confirmatory image (`FOS/RD ACQ`) by cross-correlating a two-dimensional boxcar function of the appropriate size with the image. The target positions are listed in Table 1 in units of diode number for X, where diodes are numbered from 0 to 511, and in units of y-base for Y, where the target acquisition aperture is 768 y-base units tall.

TABLE 1
Target Positions in Confirmatory Images

Position	Side	X position Diodes	Y position Y-base	(X,Y) arcsec[1]
1	Red	268.1747	-301.587	(0.0,0.0)
2	Red	267.4288	-331.175	(-0.2,-0.3)
3	Red	269.1190	-355.053	(0.3,-0.3)
4	Red	267.4301	-264.440	(-0.2,0.2)
1	Blue	242.3281	-1034.811	(0.0,0.0)
2	Blue	243.9405	-1030.876	(0.5,0.0)
3	Blue	242.4931	-929.202	(0.0,0.5)

[1]Position of target relative to the final peak-up pointing, in units of arcseconds.

The red side aperture center is given in PDB pixel units as (25,25) and in units of diodes in X and y-base in Y as (266,-228). In units of X diodes and y-base, the target was found in position (268.1747,-301.587), the offset from the aperture center being (δX, δY) = (2.1747,-73.587). The X and Y offsets from aperture center of the target in PDB pixel units is then given by

$$\delta X_R = 4 \times \delta X$$

$$\delta X_R = 8.6988$$

$$\delta Y_R = 48/768 \times \delta Y$$

$$\delta Y_R = -4.599$$

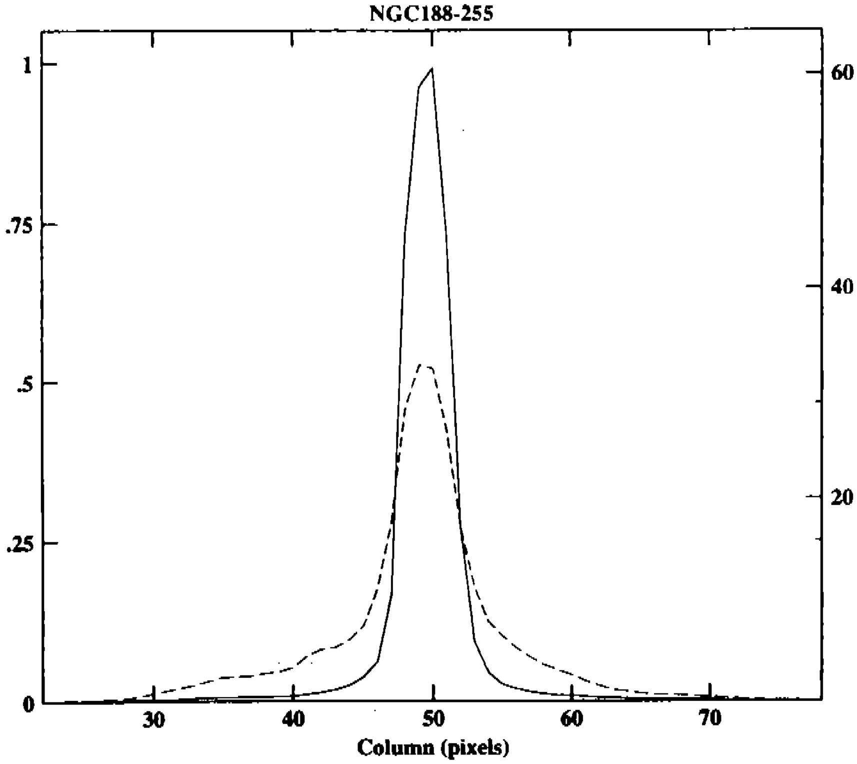

Figure 1. Cross cut of counts for an FOS image of NGC188-255 pre COSTAR (dotted line) and post COSTAR (solid line) normalized to area under the curve from proposal 4907. Note that the counts in the broad wings of the original PSF are now concentrated in the core. One pixel corresponds to 0.08".

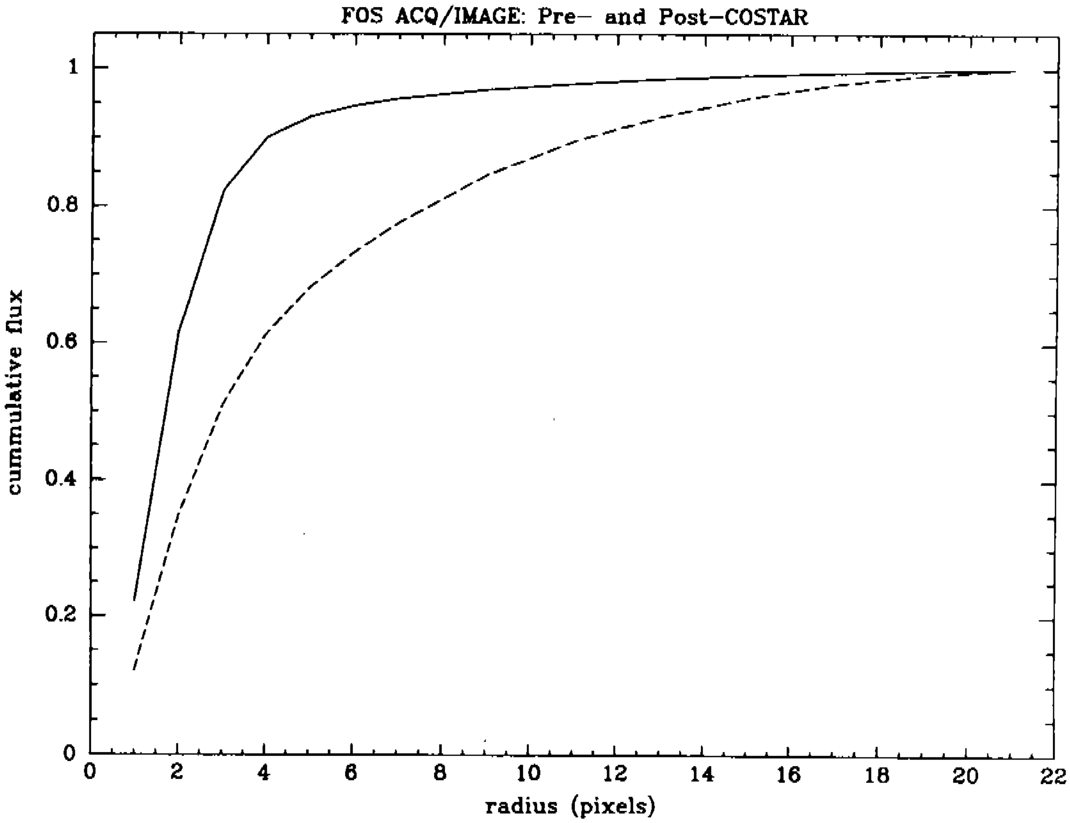

Figure 2. The cumulative flux in the red side pre COSTAR image of NGC188-255 (dotted line) and the post COSTAR image (solid line). One pixel corresponds to 0.08".

On the blue side, the aperture center is given in PDB pixel units as (25,25) and in units of diodes in X and y-base in Y as (240,-1024). In units of X diodes and y-base, the target was found in position (242.3281,-1034.811), the offset from the aperture center being (δX, δY) = (2.3281,-10.811). The X and Y positions of the target, in PDB pixel units is then given by

$$\delta X_B = 4 \times \delta X$$

$$\delta X_B = 9.3124$$

$$\delta Y_B = 48/768 \times \delta Y$$

$$\delta Y_B = -0.676$$

TABLE 2

Position of 3.6" Aperture Center and of Target

Side	X-Center pixels	Y-Center pixels	X-Center Diodes	Y-Center Y-base	X position Diodes	Y position Y-base
Red	25	25	266.0	-228.0	268.1747	-301.587
Blue	25	25	240.0	-1024.0	242.3281	-1034.811

The (V2,V3) coordinate (in sky coordinates in arcseconds) derived from the last peak-up position on the red side is (384.18,-303.44). Using the rotation matrix with the derived values for plate scale (P_X and P_Y given below) and the assumed angle between (X,Y) and (V2,V3) of 98.1898^o,

$$\delta V2 = P_X \times \delta X_R \times cos\theta + P_Y \times \delta Y_R \times sin\theta$$

$$\delta V2 = 0.076 \times 8.6988 \times (-0.1424) + 0.077 \times (-4.599) \times 0.9898$$

$$\delta V2 = -0.444$$

$$\delta V3 = -P_X \times \delta X_R \times sin\theta + P_Y \times \delta Y_R \times cos\theta$$

$$\delta V3 = -0.076 \times 8.6988 \times 0.9898 + 0.077 \times (-4.599) \times (-0.1424)$$

$$\delta V3 = -0.957$$

These δV2 and δV3 values are in detector coordinates, so they must be converted to sky coordinates by multiplying by -1.0, leading to aperture positions on the red side of

$$V2_R = 384.18 + 0.444$$

$$V2_R = 384.62$$

$$V3_R = -303.44 + 0.957$$

$$V3_R = -303.40$$

The old values in the PDB for aperture position for the red side were $V2_R = 385.22$ and $V3_R = -304.64$. The new aperture locations require changes of $\delta V2_R = -0.40$ and $\delta V3_R = 1.24$.

The (V2,V3) coordinate (in sky coordinates) derived from the last peak/up position on the blue side is (329.02,-357.31). Using the blue side θ_B = -8.1898, and the same assumptions for plate scale as on the red side we derive

$$\delta V2 = P_X \times \delta X_B \times cos\theta + P_Y \times \delta Y_B \times sin\theta$$

$$\delta V2 = 0.077 \times 9.3123 \times (0.9898) + 0.077 \times (-0.676) \times (-0.1424)$$

$$\delta V2 = -0.1071$$

$$\delta V3 = -P_X \times \delta X_B \times sin\theta + P_Y \times \delta Y_B \times cos\theta$$

$$\delta V3 = -0.077 \times 9.3125 \times 0.1424 + 0.077 \times (-0.676) \times 0.9898$$

$$\delta V3 = -0.005$$

These δV2 and δV3 values are again in detector coordinates, and must be converted to sky coordinates by multiplying by -1.0, leading to aperture positions on the blue side of

$$V2_B = 329.02 + 0.1071$$
$$V2_B = 329.13$$
$$V3_B = -357.31 + 0.005$$
$$V3_B = -357.30$$

The old values in the PDB for aperture position for the blue side were $V2_B = 330.13$ and $V3_B = -359.45$. The new aperture locations require changes of $\delta V2_B = -1.00$ and $\delta V3_B = 2.15$.

Plate Scale and Orientation

The FGS values can be used to determine both the size of the slews on the sky, and the orientation. Both agree within measurement uncertainties in this coarse alignment test with predicted values. For example, the slews are measured to be 0.514" on the red side and 0.496" on the blue side; the orientation is measured to be within measurement error of predicted; the plate scale on the blue side is measured to be P_X = 0.080"/pixel and P_Y = 0.075"/pixel. In the derivations below, we use the predicted values of these parameters.

A preliminary value of plate scale can be derived by assuming that the POS TARG's were in fact 0.5" on the sky and measuring the number of diodes and/or y-base units that the target was observed to move. Likewise, orientation can be derived by comparing requested slews with observed slews.

Using the values in Table 1, the red side plate scale (P_X) in the X direction, in units of arcseconds per pixel, where the FOS large aperture is 48X48 pixels, is given by

$$P_X = 0.5/(4 \times (267.429 - 269.119))$$

$$P_X = 0.0740 \text{ arcsec/pixel.}$$

The red side plate scale for Y is

$$P_Y = 0.5/(301.5867 - 355.05316)/(48/768))$$

$$P_Y = 0.150 \text{ arcsec/pixel.}$$

The derived red side plate scale in the Y direction is not correct. The direct plots from the OSS show an approximately correct plate scale in the red side Y direction. The positional error in the running of the `aperlocy` program has not yet been tracked down.

The blue side plate scale (P_X) in X, is given by

$$P_X = 0.5/(4 \times (242.328 - 243.941))$$

$$P_X = 0.0775 \text{ arcsec/pixel.}$$

The blue side plate scale for Y is

$$P_Y = 0.5/(1034.811 - 929.202)/(48/768))$$

$$P_Y = 0.0758 \text{ arcsec/pixel.}$$