CIRS Field-of-View Overview

Observations:

The CIRS field-of-view (FOV) has been characterized during flight with four observational sequences. Table 1 gives a brief summary of these observations

Date	scet	Target	Target diameter	Quantities retrieved
April 28-29, 2001	988483519–933555947	Jupiter	1.24 mrad	FP 3/4 location, FWHM
July 11, 2001	994811232–994894312	IR-bright stars	--------	FP 3/4 location, FWHM
Oct. 30-31, 2001	1004405438–1004508147	Jupiter	0.484 mrad	FP1 location, FWHM. FP3/4 location
May 10-11, 2002	1021015893–1021129151	Jupiter	0.290 mrad	FP1 location, FWHM, spatial response

Table 1. Summary of in-flight observations to characterize the CIRS FOV.

For each of the three sets of Jupiter observations, two sets of data were taken in a raster scan mode with one set of scans parallel to the spacecraft X-axis and one set parallel to the Z-axis. The scans had a spatial resolution of 0.095 mrad between observations in a scan and also a spatial resolution of 0.095 mrad between scans. For each FP1, FP3, and FP4 spectrum we use the uncalibrated integrated power under the interferogram as a measure of the observed signal from Jupiter.

FP1 Location:

The location of the FP1 center was determined by fitting the data to a 2-D Gaussian with the form:

$$S = C + A * \exp(-(r/r0)^{**}2)$$
$$r = \mathrm{sqrt}[\ (X - x0)^{**}2 + (Z - z0)^{**}2\ ]$$

where S is the computed signal, C is a constant representing the deep space signal for FP1, A is the amplitude of the signal at the FP1 center, r0 is the width in mrad of the 2-D Gaussian, and r is the distance in mrad between the observation and the FP1 center. The parameter C was computed using data taken with Jupiter out of the FP1 field of view. The parameters A, r0, x0, and z0 were fit minimizing the c^2 difference between computed and observed signal. The best-fit values for the May 2002 observations were x0=+5.71 mrad, z0=–0.01 mrad, r0=1.505 mrad. The best-fit values for the October 2001 observations were x0=+5.68, z0=+0.03, r0=1.536 mrad. Based on the differences between the results of the two tests, the estimated uncertainty in x0, z0, and r0 is ±0.03 mrad. The May 2002 observations and resulting best-fit 2-D Gaussian are shown in the upper two panels of Figure 1.

FP1 FWHM and Spatial Response:

The bottom panel of Figure 1 shows the observed FP1 signal as a function of radial distance from the FP1 center. Each black "x" shows the observed signal in an individual spectrum. The green line is the best-fit 2-D Gaussian. The red line is an averaged representation of the data, or the observed radial profile of FP1 signal. Although a 2-D Gaussian fits the data reasonably well, there are distinct differences in shape. The blue line shows the difference between the observed and gaussian radial profiles. The observed radial profile is more flat in the center 0.5 mrad, drops off more quickly than gaussian between r=0.5 and 1.2 mrad, has a "shoulder" at about 2.0 mrad, and then quickly falls to zero signal at about 2.6 mrad without the extended tail of the gaussian profile. The full-width half-maximum (FWHM) of the observed radial profile is about 2.4 mrad. The FWHM of the best-fit 2-D Gaussian is 2.51 mrad.

Figure 2 (top panel) shows the residual spatial response of FP1 as a function of ΔX and ΔZ (the distance from the center location of FP1) after the best-fit 2-D Gaussian profile has been subtracted. The difference in the radial profile between the data and the Gaussian fit is evident by the "bulls-eye" pattern of high residual at ΔX=ΔZ=0 surrounded by low residual surrounded by high residual. The bottom panel shows the residual spatial response of FP1 after subtracting the radial average profile (red line in bottom panel of Figure 2). The amplitude of the features is from roughly –5 (purple) to 0 (green) to +5 (red) units. That can be compared with the total amplitude of the FP1 signal (45 units) and the RMS noise level (7.1 units). The residual appears to have a ring-like structure that is offset in the –Z direction from the center of FP1. The "ring" is somewhat oval in shape with the long axis along X (axis length about 4.2 mrad) and the short axis along Z (axis length about 3.6 mrad). The center of the ring is near ΔX=0, ΔZ=–0.7 mrad (uncertainty of about 0.1 mrad).

FP3&4 Pixel Locations:

The angular size of Jupiter was larger than FP3&4 pixels in October 2001, so the observed integrated radiance was modeled by assuming that it was proportional to the fraction of the CIRS pixel filled by Jupiter. The effective radius of the CIRS FP3&4 pixel was found to be r0=0.160 mrad both from ground testing and the results of the April 2001 observations. The center position

of the CIRS pixel (x0, z0) was fit for using the October 2001 data. Results are given in the Summary section below. The FP3&4 locations derived from the October 2001 are within 0.05 mrad in X and 0.10 mrad in Z to the locations derived from April 2001 observations. This consistency is within 1/3 of a FP3&4 pixel size.

FP4, detector 10 appears to be somewhat out of position relative to the other 19 detectors (see Figure 3). It is displaced by about +0.05 mrad in X and –0.02 mrad in Z from where it might be expected based on the location of the other 19 detectors. Both the FP3 and FP4 detector arrays appear to have a very slight tilt such that in both cases higher detector numbers correspond to lower x0 values (neglecting FP4, #10). The tilt amounts to less than 1/4 degree for both FP3 and FP4.

Taking the average x0 value for FP3 (1.23 mrad) and FP4 (2.17 mrad) gives the separation between FP3 and FP4 to be 0.94 mrad. This value is somewhat larger than the 0.89 mrad separation derived from the Oxford pre-flight tests. The average x0 and z0 values for the 20 FP3 and FP4 detectors give the location of the CIRS boresight as X=+1.70, Z=–0.04 mrad.

Summary:

The best results for FP1 come from the May 2002 observations. The best results for FP3 and FP4 come from the October 2001 observations. By combining results from the all four FOV tests we can estimate uncertainties in the estimated values. Below is summary of current best estimates for CIRS FOV parameters:

The location of FP1:	**X=+5.70 ±0.03 mrad**
	Z=+0.00 ±0.03 mrad
FWHM of FP1 (observed radial profile):	**2.42 ±0.03 mrad**

The FWHM of FP1 using the best-fit Gaussian is 2.51 mrad. A ring-like residual with amplitude of 5–10% of the peak FP1 response is present after the radial-average FP1 response is removed. The ring is centered near ΔX=0, ΔZ=–0.7 mrad. It has a long-axis diameter of 4.2 mrad along X and a short-axis diameter of 3.6 mrad along Z.

The location of PF3 and FP4 pixels:

FP / Det	x0	z0
3 / 1	1.237	1.254
3 / 2	1.226	0.972
3 / 3	1.224	0.676
3 / 4	1.224	0.386
3 / 5	1.228	0.097
3 / 6	1.230	–0.192
3 / 7	1.229	–0.487
3 / 8	1.221	–0.787
3 / 9	1.226	–1.080
3 / 10	1.216	–1.381
4 / 1	2.184	–1.349
4 / 2	2.169	–1.056
4 / 3	2.167	–0.758
4 / 4	2.181	–0.459
4 / 5	2.167	–0.164
4 / 6	2.158	0.125
4 / 7	2.175	0.408
4 / 8	2.162	0.718
4 / 9	2.168	1.002
4 / 10	2.207	1.268

Table 2. Best-fit location (x0, z0) of FP3&4 centers (mrad). Estimated uncertainty is 0.01 mrad for FP3 and 0.05 mrad for FP4.

The X-location of FP3: **X=+1.23 ±0.01 mrad**
The X-location of FP4: **X=+2.17 ±0.05 mrad**
X distance between FP3 and FP4 arrays: **ΔX=0.94 ±0.05 mrad**

Mean spacing in Z between FP3&4 pixels: **ΔZ=0.295 ±0.005 mrad**

The location of CIRS boresight: **X=+1.70 ±0.02 mrad**
Z=–0.04 ±0.07 mrad

In words, the spacecraft –Y axis must be moved 1.70 mrad along +X and 0.04 mrad along –Z to get to the CIRS telescope boresight. These quantities are summarized in Figure 3.

Michael Smith
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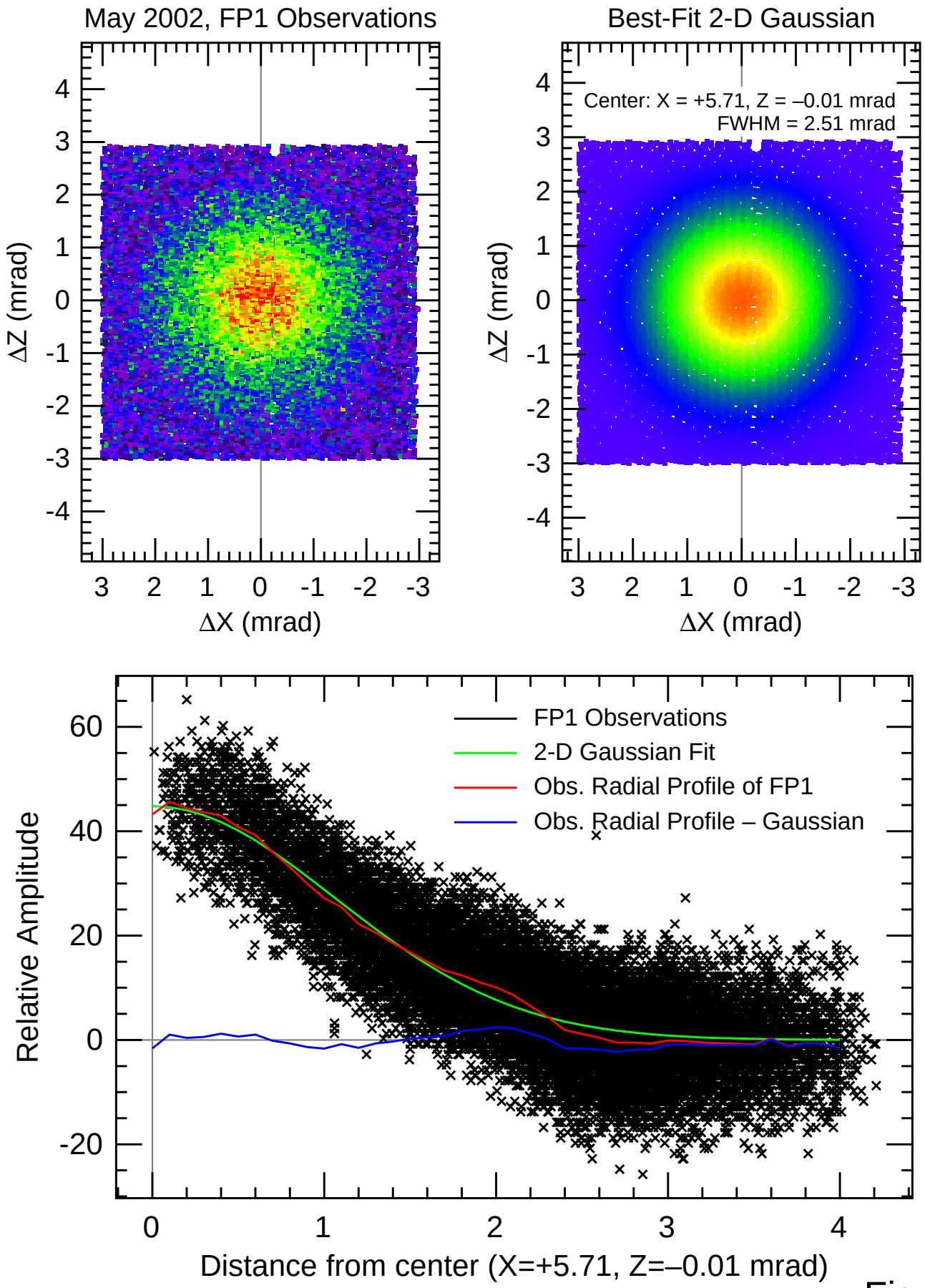
May 2002, FP1 Observations
Best-Fit 2-D Gaussian
Center: X = +5.71, Z = –0.01 mrad
FWHM = 2.51 mrad
ΔZ (mrad)
ΔX (mrad)
FP1 Observations
2-D Gaussian Fit
Obs. Radial Profile of FP1
Obs. Radial Profile – Gaussian
Relative Amplitude
Distance from center (X=+5.71, Z=–0.01 mrad)

Fig. 1

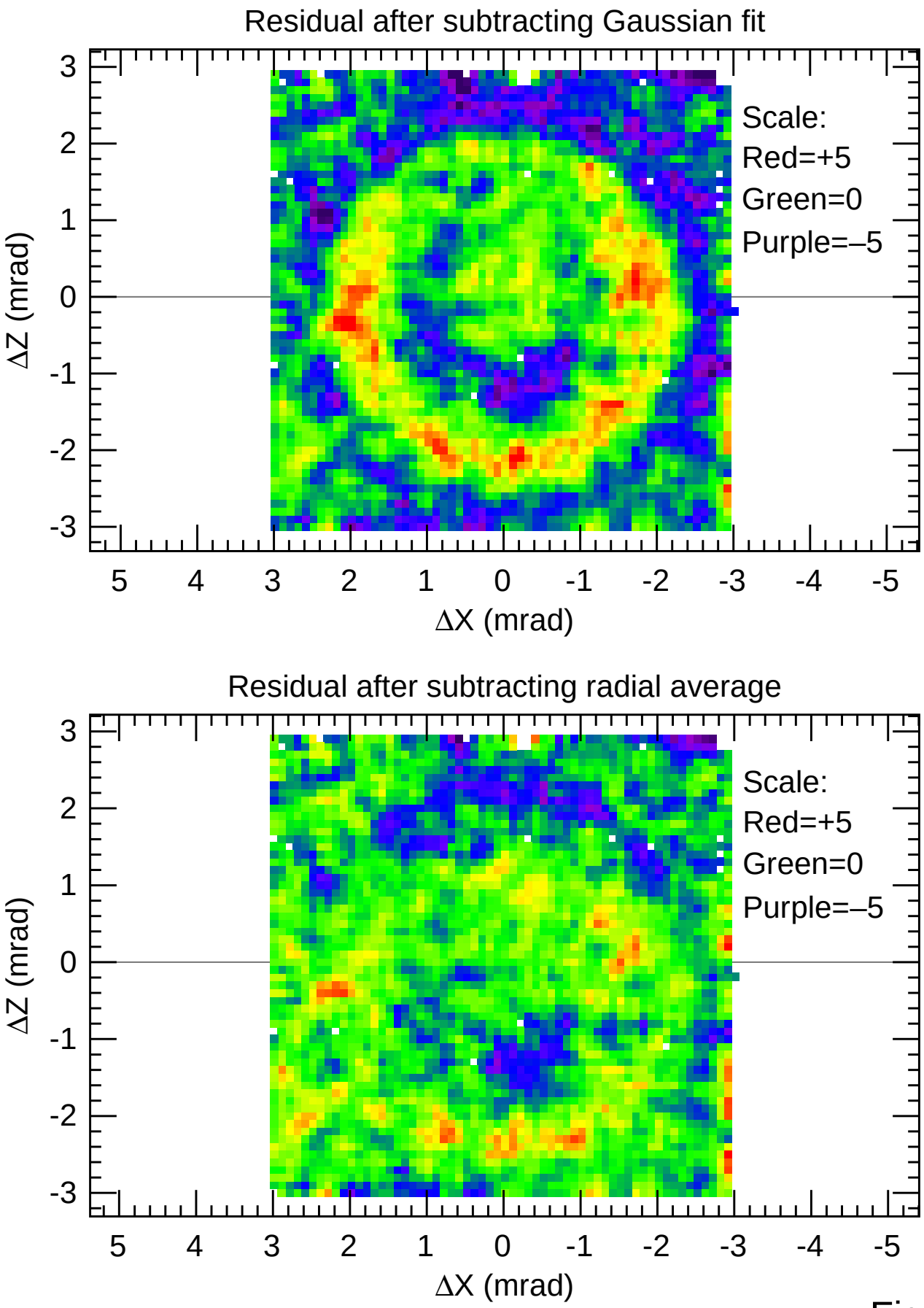
Residual after subtracting Gaussian fit
Scale:
Red=+5
Green=0
Purple=–5
ΔZ (mrad)
ΔX (mrad)
3
2
1
0
-1
-2
-3
5
4
3
2
1
0
-1
-2
-3
-4
-5
Residual after subtracting radial average
Scale:
Red=+5
Green=0
Purple=–5
ΔZ (mrad)
ΔX (mrad)

Fig. 2

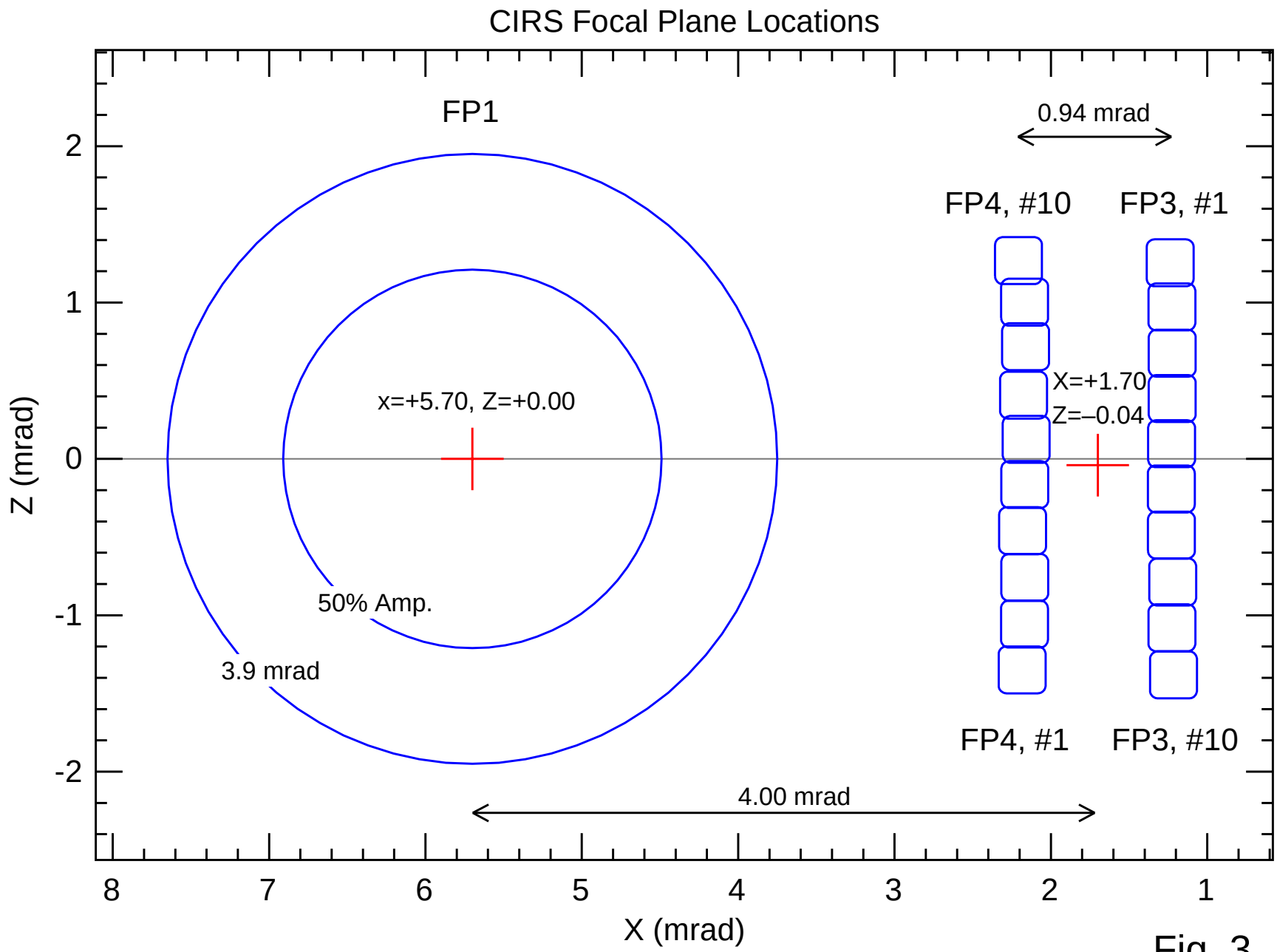
CIRS Focal Plane Locations
FP1
0.94 mrad
FP4, #10
FP3, #1
x=+5.70, Z=+0.00
X=+1.70
Z=–0.04
50% Amp.
3.9 mrad
FP4, #1
FP3, #10
4.00 mrad
Z (mrad)
X (mrad)
2
1
0
-1
-2
8
7
6
5
4
3
2
1

Fig. 3