LYRA Detectors: Positions, Flatfields, Consequences

IED, 20 Mar 2007 (updated 21 Nov 2007, with new found coordinates (formerly 0) from GI 2006, and new measurements from NI 2007)

The LYRA team collected five sets of detector flatfield measurements, performed in five BESSY campaigns:

- “crosses” from NI 2005 for channels *-1, *-2, *-3
- “crosses” from GI 2005 for channels *-3, *-4
- “surfaces” from NI 2006 for channels *-1, *-2, *-3
- “surfaces” from GI 2006 for channels *-3, *-4
- “surfaces” from NI 2007 for channels *-1, *-2, *-3

(for parameters, see Tables 1, 2, 3, 4, 5.)

“Cross” means that only two scans, rectangular to each other, were done; “surface” means that a 2D field was scanned.

The monitored coordinates are not absolute. The measurements were made relative to a different coordinate system each time. NI 2007 was even made in another scanning sense (i.e. 180 degree rotated, or looking from the other side of the plane) as compared with NI 2005 and NI 2006. Apart from that, the scan resolution was different each time, varying from 0.15, 0.2, 0.3, 0.5, to 0.6 mm. Results were sometimes given in V, sometimes normalized to maximum or to center value. The measurements in the GI campaigns are rotated by 90 degrees, as compared to the NI campaigns, i.e. horizontal and vertical axes are swapped. On the other hand, channels *-3 are measured in both NI and GI, although using different wavelengths.

Therefore, the exact position of the flatfields within the detector area, or the exact position of the solar beam through the 3 mm precision hole, cannot be determined. In other words, it is not known whether the center of the scan (cross or surface) is identical to the center of the detector, or whether it is identical to the center of the solar beam. Nevertheless, the results of the “crosses” were compared with the “surfaces”, and the position of the flatfields relative to each other (i.e. their orientation on the detector plane) was confirmed.

Assuming

- a linear offset between NI 2005 and NI 2006 such that the center of the cross coincides, in average, with the center of the surface,
- rotation and offset between NI 2005 and GI 2005 such that the centers of the cross of channel 2-3 coincide,
- a linear offset between GI 2005 and GI 2006 such that the center of the cross coincides, in average, with the center of the surface,
- a linear offset between NI 2006 and NI 2007 such that the centers of the measurements coincide, in average, with each other,

then the locations of the various observations can be marked on the detector plane, in coordinates of NI 2006, as demonstrated in Figure 1 (following Tables 1,...,4 [black] and Table 5 [red]).

Table 1: **NI 2005 (crosses)**

ch.	wave.	hor.scan	at vert.pos.	resol.	vert.scan	at hor.pos.	resol.	/ mm
1-1	121nm	1.0,....,7.0	@88.0	21*0.3	85.0,....,91.0	@4.0	21*0.3	
1-2	210nm	1.0,....,7.0	@101.0	21*0.3	98.0,...,104.0	@4.0	21*0.3	
1-3	60nm	14.0,...,20.0	@88.0	21*0.3	85.0,....,91.0	@17.0	21*0.3	
2-1	121nm	1.0,....,7.0	@149.0	21*0.3	146.0,...,152.0	@4.0	21*0.3	
2-2	210nm	1.0,....,7.0	@162.0	21*0.3	159.0,...,165.0	@4.0	21*0.3	
2-3	60nm	12.5,...,21.5	@149.0	31*0.3	146.0,...,152.0	@17.0	21*0.3	
3-1	121nm	1.0,....,7.0	@210.0	21*0.3	207.0,...,213.0	@4.0	21*0.3	
3-2	210nm	1.0,....,7.0	@223.0	21*0.3	220.0,...,226.0	@4.0	21*0.3	
3-3	60nm	13.0,...,19.0	@210.0	21*0.3	207.0,...,213.0	@16.0	21*0.3	

Measured is "abs. signal (V), offset corrected". The vertical position of the horizontal scan is not explicitly given; it is assumed to be in the middle of the vertical scan, and vice versa. (Channel 2-3 is indeed the only one to be scanned with 31 steps in horizontal direction.)

Table 2: **GI 2005 (crosses)**

ch.	wave.	hor.scan	at vert.pos.	resol.	vert.scan	at hor.pos.	resol.	/ mm
2-3	1nm	-10.00,..,-4.90	@81.30	35*0.15	79.00,..,83.50	@-7.87	31*0.15	
2-3	18nm	-10.50,..,-5.40	@81.31	35*0.15	79.00,..,83.65	@-8.09	32*0.15	
2-4	1nm	2.50,...,7.15	@81.34	32*0.15	79.00,..,83.65	@4.86	32*0.15	
2-4	10nm	2.50,...,9.55	@81.31	48*0.15	79.00,..,84.10	@4.86	35*0.15	
3-3	1nm	50.00,..,55.60	@81.34	29*0.2	79.00,..,83.80	@53.00	25*0.2	
3-3	18nm	51.00,..,55.05	@81.37	28*0.15	79.00,..,84.55	@52.94	38*0.15	
3-4	1nm	62.00,..,68.20	@81.23	32*0.2	79.00,..,84.20	@65.92	28*0.2	
3-4	10nm	63.50,..,68.45	@81.23	34*0.15	79.00,..,83.95	@65.65	34*0.15	

Measured is "Signal (V)". The vertical position of the horizontal scan is explicitly given, and vice versa.

Table 3: **NI 2006 (surfaces)**

ch.	wave.	horizontal scan	resol.	vertical scan	resol. / mm
1-1	121.6nm	0.9,....,6.3	10*0.6	86.9,....,91.1	8*0.6
1-2	210.0nm	0.9,....,5.7	9*0.6	99.1,...,103.9	9*0.6
1-3	50.0nm	13.8,...,19.2	10*0.6	86.5,....,91.9	10*0.6
2-1	121.6nm	0.2,....,4.2	9*0.5	148.4,...,152.4	9*0.5
2-2	210.0nm	0.9,....,5.7	9*0.6	160.1,...,164.9	9*0.6
2-3	50.0nm	13.6,...,19.0	10*0.6	147.6,...,153.0	10*0.6
3-1	121.6nm	0.9,....,5.7	9*0.6	208.6,...,213.4	9*0.6
3-2	210.0nm	0.9,....,5.7	9*0.6	221.0,...,225.8	9*0.6
3-3	50.0nm	13.3,...,18.7	10*0.6	208.6,...,214.0	10*0.6

Measured is the relative response, U(Diode)/I(Ring) with 3, 12, 24, 50, 100% aperture size, offset corrected, and normalized by the maximum signal. For comparison, the 100% values were used. The horizontal axis of channel 2-1 might be wrong by 0.7 mm.

Table 4: **GI 2006 (surfaces)**

ch.	wave.	horizontal scan	resol.	vertical scan	resol. / mm
1-3	18nm	-70.14,..,-66.54	13*0.3	79.43,..,83.03	13*0.3
1-4	10nm	-57.31,..,-53.71	13*0.3	79.41,..,83.01	13*0.3
2-3	18nm	-9.00,...,-5.40	13*0.3	79.45,..,83.05	13*0.3
2-4	10nm	3.65,....,7.25	13*0.3	79.43,..,83.03	13*0.3
3-3	18nm	51.80,...,55.40	13*0.3	79.50,..,83.10	13*0.3
3-4	10nm	64.55,...,68.15	13*0.3	79.28,..,82.88	13*0.3

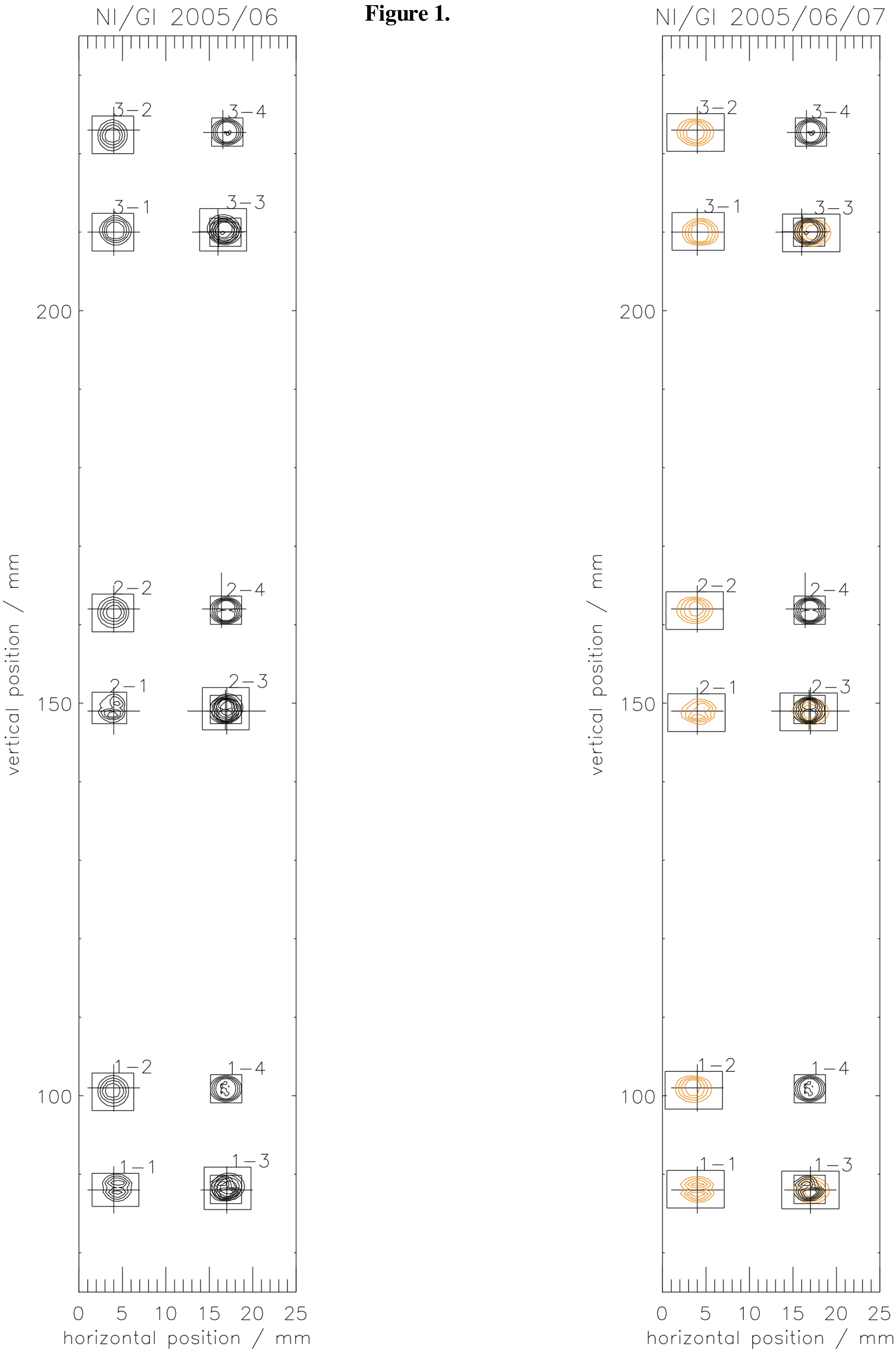
Measured is the relative responsivity, normalized to the value of the center point. The coordinates of the center points are given [this was not considered in the previous version of this report]. They are only slightly offset from GI 2005.

Table 5: **NI 2007 (surfaces)**

ch.	wave.	horizontal scan	resol.	vertical scan	resol. / mm
1-1	121.6nm	15.0,...,21.6	12*0.6	76.0,....,80.8	9*0.6
1-2	210.0nm	15.2,...,21.8	12*0.6	88.6,...,.93.4	9*0.6
1-3	50.0nm	1.8,....,8.4	12*0.6	75.9,....,80.7	9*0.6
2-1	121.6nm	14.9,...,21.5	12*0.6	136.7,...,141.5	9*0.6
2-2	210.0nm	15.1,...,21.7	12*0.6	149.7,...,154.5	9*0.6
2-3	50.0nm	2.0,....,8.6	12*0.6	136.8,...,141.6	9*0.6
2-3	50.0nm	2.0,....,8.6	12*0.6	136.8,...,141.6	17*0.3
3-1	121.6nm	15.0,...,21.0	11*0.6	198.0,...,202.8	9*0.6
3-2	210.0nm	15.0,...,21.6	12*0.6	210.6,...,215.4	9*0.6
3-3	50.0nm	1.7,....,8.3	12*0.6	197.8,...,202.6	9*0.6

Measured is the relative responsivity, normalized to the maximum signal. The horizontal scanning sense had to reversed to make the measurements comparable to the other campaigns.

Figure 1.


NI/GI 2005/06
NI/GI 2005/06/07
3−2
3−4
3−1
3−3
2−2
2−4
2−1
2−3
1−2
1−4
1−1
1−3
200
150
100
0 5 10 15 20 25
vertical position / mm
horizontal position / mm

The flatfield measurements have an influence on the responsivity and thus – indirectly – on the radiometric model. During the BESSY campaigns, responsivity could not be measured under realistic in-flight conditions. Rather, it was only measured at selected wavelengths, and it was not measured such that the beam covered most of the detector surface, as the Sun eventually will: 7.068 square millimeter, i.e. the area of the 3-mm-diameter precision aperture. During the most recent responsivity tests, the NI beam for measuring channels *-1, *-2, and *-3 was a rectangle of 2.5 mm (horizontal) x 1.0 mm (vertical). The GI beam for measuring channels *-3, and *-4 was a square of 1.5 mm x 1.5 mm.

Usually, the detectors are more sensitive in the center. Nevertheless, until now the responsivity measurements were treated as if the response was homogeneous all over the detector. Therefore, the effect of inhomogeneity had to be simulated with the help of the flatfields. In most cases, the simulation result was such that the responsivity had been overestimated, and for calibration purposes the LYRA output must now be multiplied with a factor > 1.0 to compensate for this overestimation. In detail, the simulations lead to the following factors:

channel		NI2006	GI2006	NI2007	selected
1-1	MSM	1.05		0.96	1.01
1-2	PIN	1.18		1.15	1.16
1-3	MSM	1.25	1.32	1.24	1.28
1-4	AXUV		1.19		1.19
2-1	MSM	0.93		1.12	1.03
2-2	PIN	1.19		1.16	1.18
2-3	MSM	1.22	1.24	1.19	1.22
2-4	MSM		1.18		1.18
3-1	AXUV	1.16		1.10	1.13
3-2	PIN	1.20		1.16	1.18
3-3	AXUV	1.19	1.22	1.17	1.20
3-4	AXUV		1.19		1.19

The NI rasters were usually taken with 0.6 mm step size, the GI rasters with 0.3 mm. For channel 2-3, two rasters were made at NI 2007; one of them with 0.6 mm vertical step size, the other with 0.3 mm. The simulation results both deliver a factor 1.19, so this does not point to an influence of raster resolution. Since there is no reason to trust the results from NI 2007 more than those of NI 2006, the factors were averaged. Thus, the two contradictory results for MSM channels 1-1 and 2-1, who both have a complicated topology, do not lead to a major correction. In the case of channels *-3, the NI results (taken at 50 nm wavelength) are averaged with the GI result (taken at 18 nm). As one can see, apart from channels 1-1 and 2-1, the results are rather consistent, especially within the group of PIN and AXUV detectors.

On the next three pages, Figures 2-1, 2-2, and 2-3 demonstrate the simulations for the three LYRA heads.

For the detectors of the Aluminium channels *-3, the GI campaign values were used for Figures 2 and 3, since the short-wavelength part probably dominates the output signal of these channels.

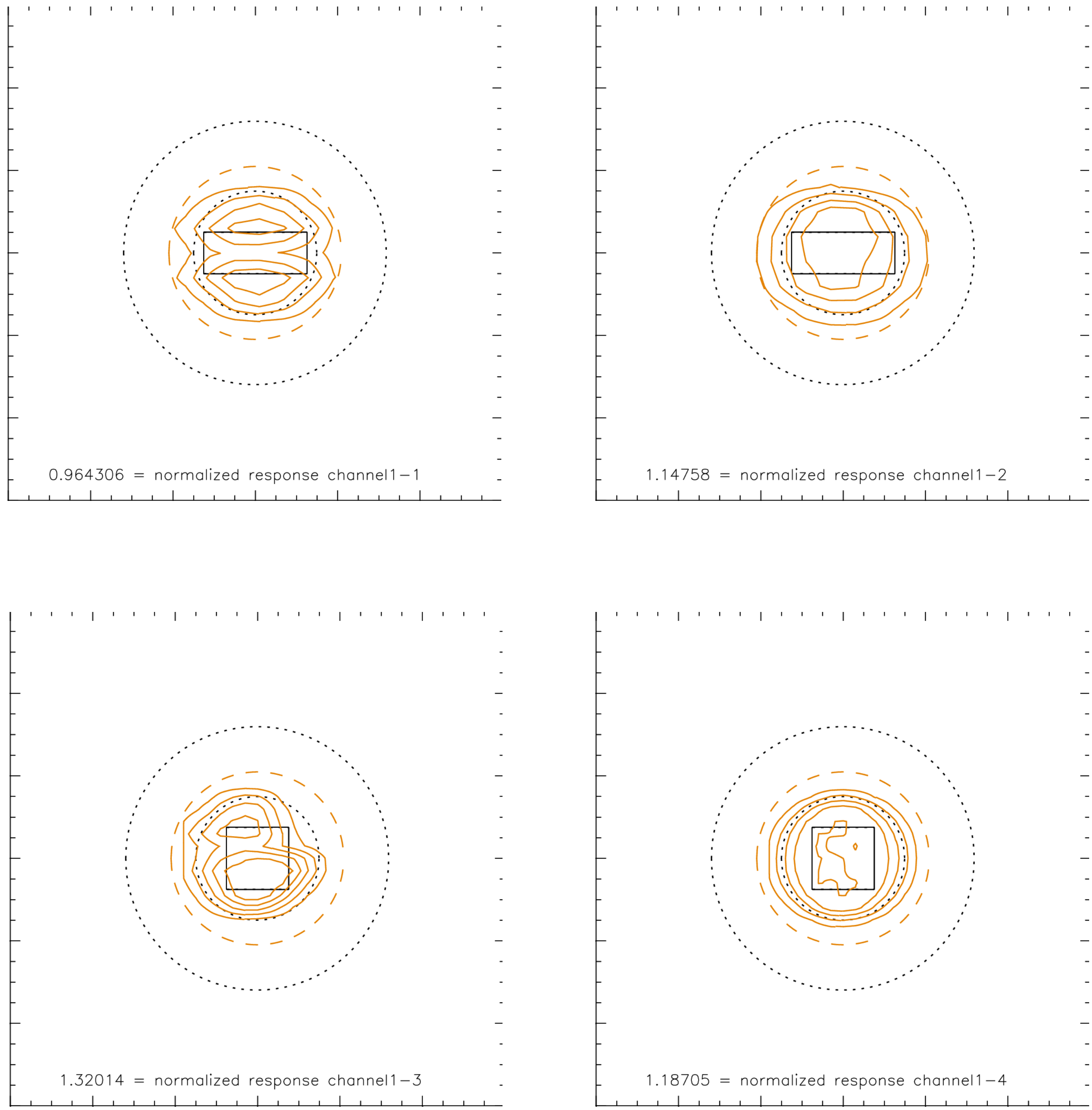

0.964306 = normalized response channel1−1
1.14758 = normalized response channel1−2
1.32014 = normalized response channel1−3
1.18705 = normalized response channel1−4

Figure 2-1.

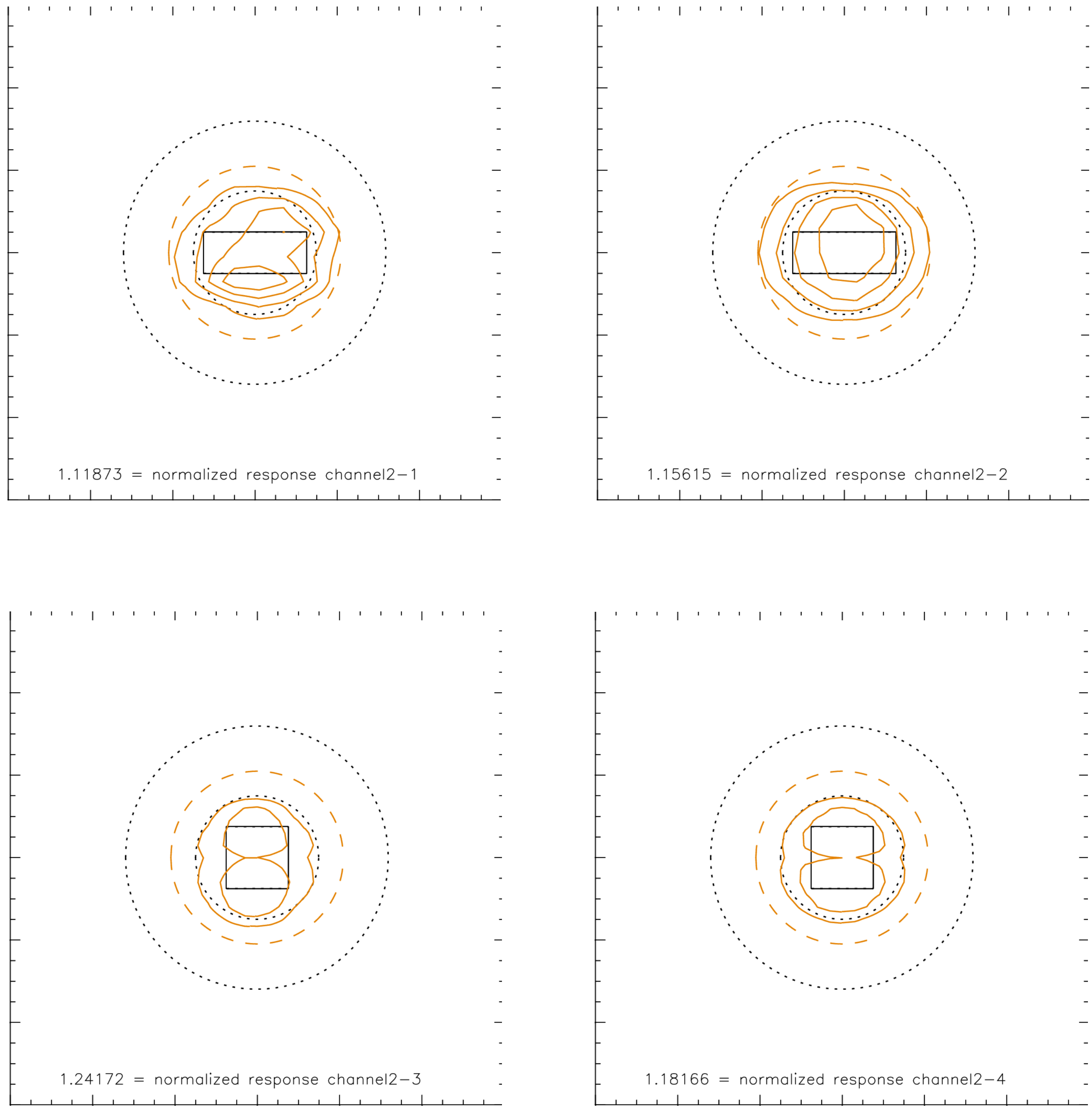

1.11873 = normalized response channel2−1
1.15615 = normalized response channel2−2
1.24172 = normalized response channel2−3
1.18166 = normalized response channel2−4

Figure 2-2.

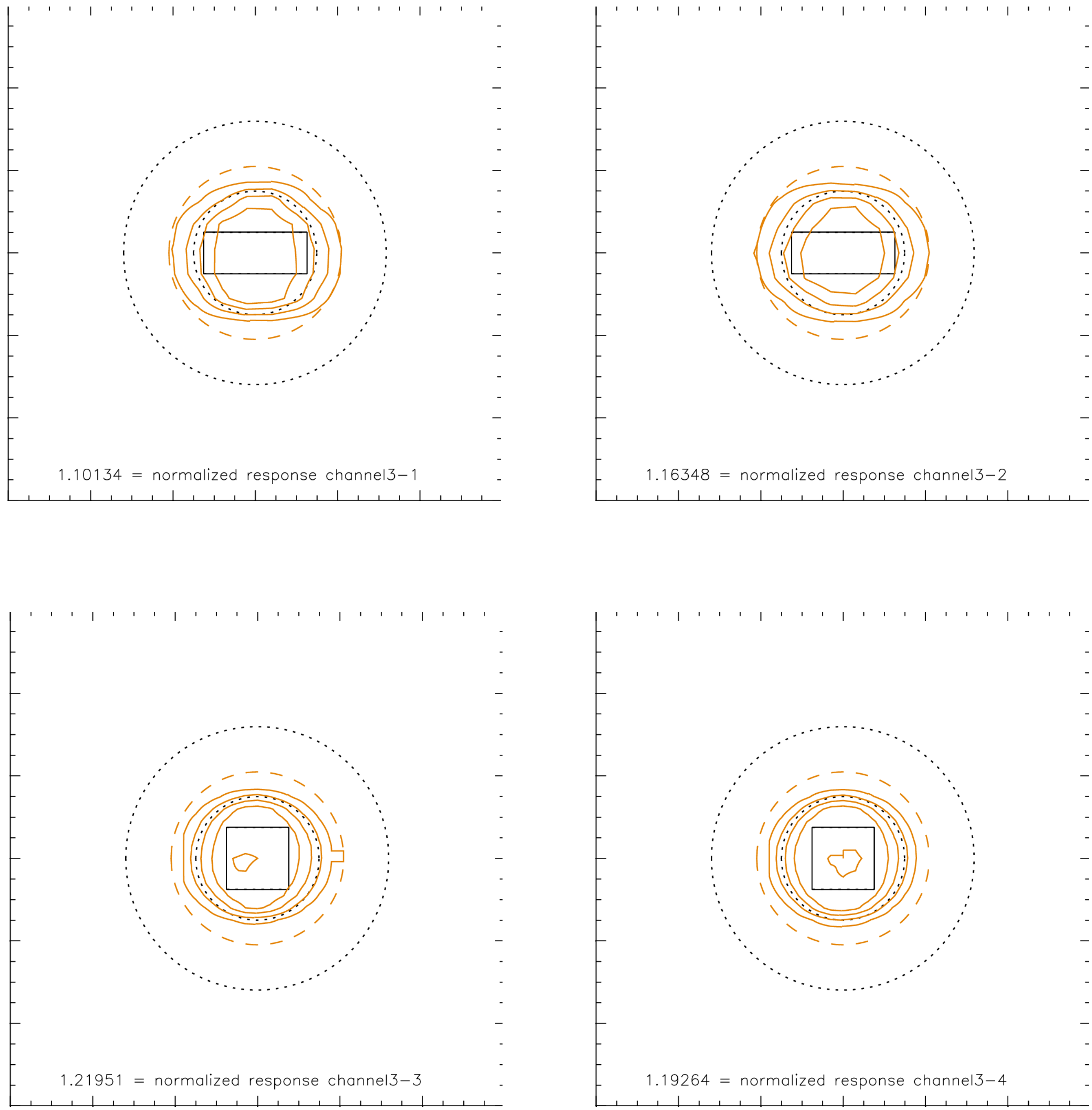

1.10134 = normalized response channel3−1
1.16348 = normalized response channel3−2
1.21951 = normalized response channel3−3
1.19264 = normalized response channel3−4

Figure 2-3.

Based on this common orientation, reactions to off-pointing can be simulated in a way described in another report (cf. *IED_20061025_LYRA_Calibration.pdf*). Additionally, off-pointing has been simulated here covering a whole range of possible values, namely from -1 degree to +1 degree, in east-west as well as in north-south direction. This grid of simulations leads to a surface of normalized responses as shown on the next three pages in Figures 3-1, 3-2, and 3-3. It is assumed that north is up (i.e. on the upper side of the detector plane as shown in the previous Figures 1 and 2), and that the solar beam hits the detector plane in the same sense as one looks onto the figures. A possible roll angle should be implemented in the simulation software (TBD). - Numbers within the images show the variations in the correction factor (maximum and minimum for +/- 1 degree off-pointing, and for +/- 5 arcmin off-pointing around the center position).

It is not claimed here that the in-flight reaction of LYRA will be exactly like the simulations. The real positions of the various detectors on the plane might be slightly different, the nominal pointing might not be exactly centered, the response to the real solar beam might differ from the BESSY test situation in many ways (small beam size, fixed wavelength). Nevertheless, the simulation technique presented here may help to interpret in-flight findings during the commissioning phase.

It is suggested to test various off-pointing positions during the commissioning phase in co-operation with SWAP, in order to get – for each LYRA channel - a grid of relative responses comparable to the simulations described here. In the most favourite case, the simulated grids can be confirmed, maybe with a linear offset. Combining the simulations and the in-flight tests, there should emerge a tabled function of relative responses - for each channel - with pointing coordinates and roll angle as input, and a correction factor around 1.0 (= nominal pointing) as output.

Simulations show that +/- 1 degree off-pointing leads to approx. 20-25% reduction from the nominal response. Off-pointing in the order of the nominal jitter of PROBA2 (5 arcmin, TBC) leads to fluctuations of approx. +/- 1% around the nominal response. Off-pointing in the order of the promised maximal offset between SWAP and LYRA (2 or 10 or 20 arcsec over 10 or 60 s, TBC) will therefore not be detectable.

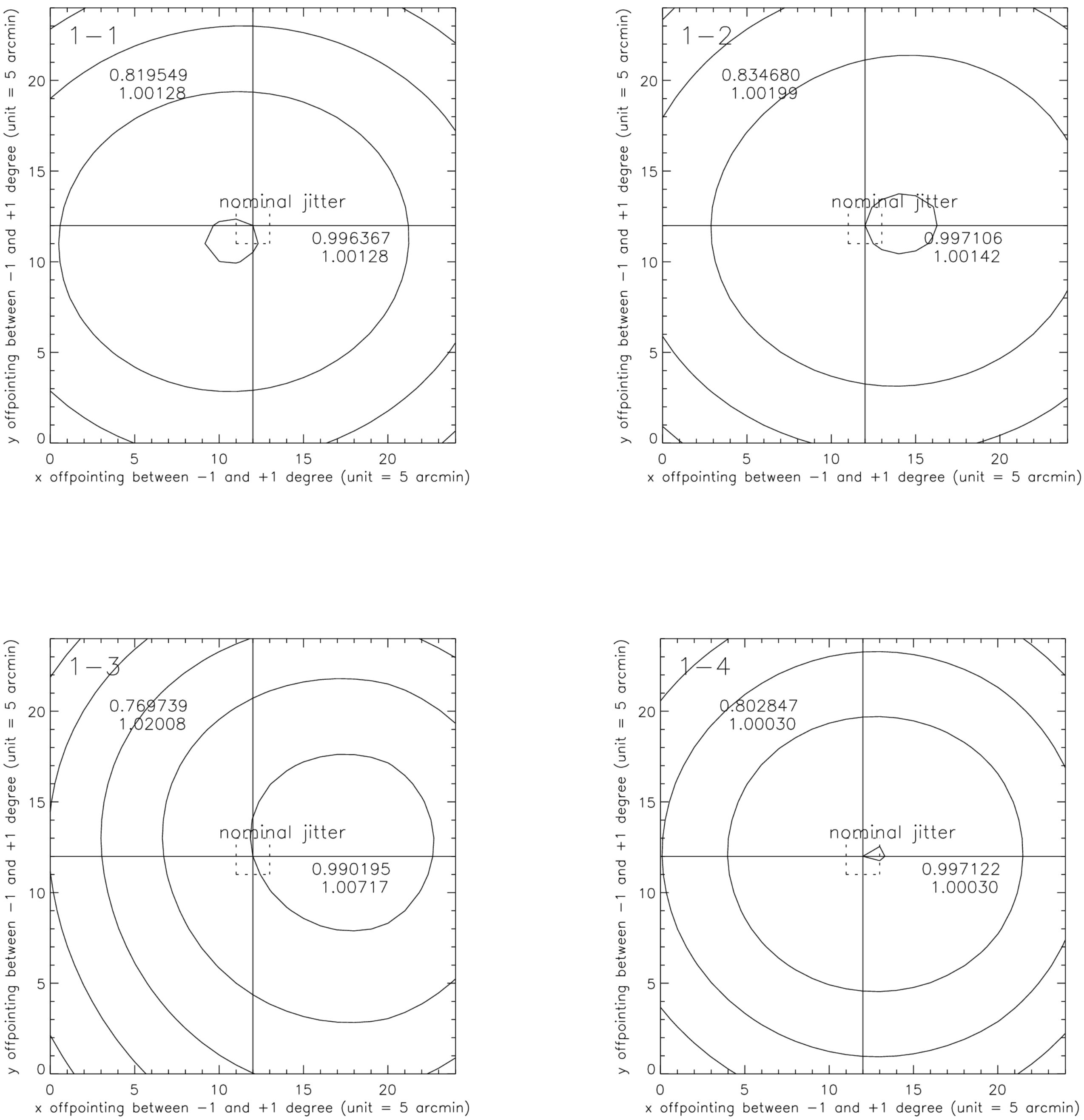

1−1
0.819549
1.00128
nominal jitter
0.996367
1.00128
1−2
0.834680
1.00199
nominal jitter
0.997106
1.00142
1−3
0.769739
1.02008
nominal jitter
0.990195
1.00717
1−4
0.802847
1.00030
nominal jitter
0.997122
1.00030
x offpointing between −1 and +1 degree (unit = 5 arcmin)
y offpointing between −1 and +1 degree (unit = 5 arcmin)

Figure 3-1.

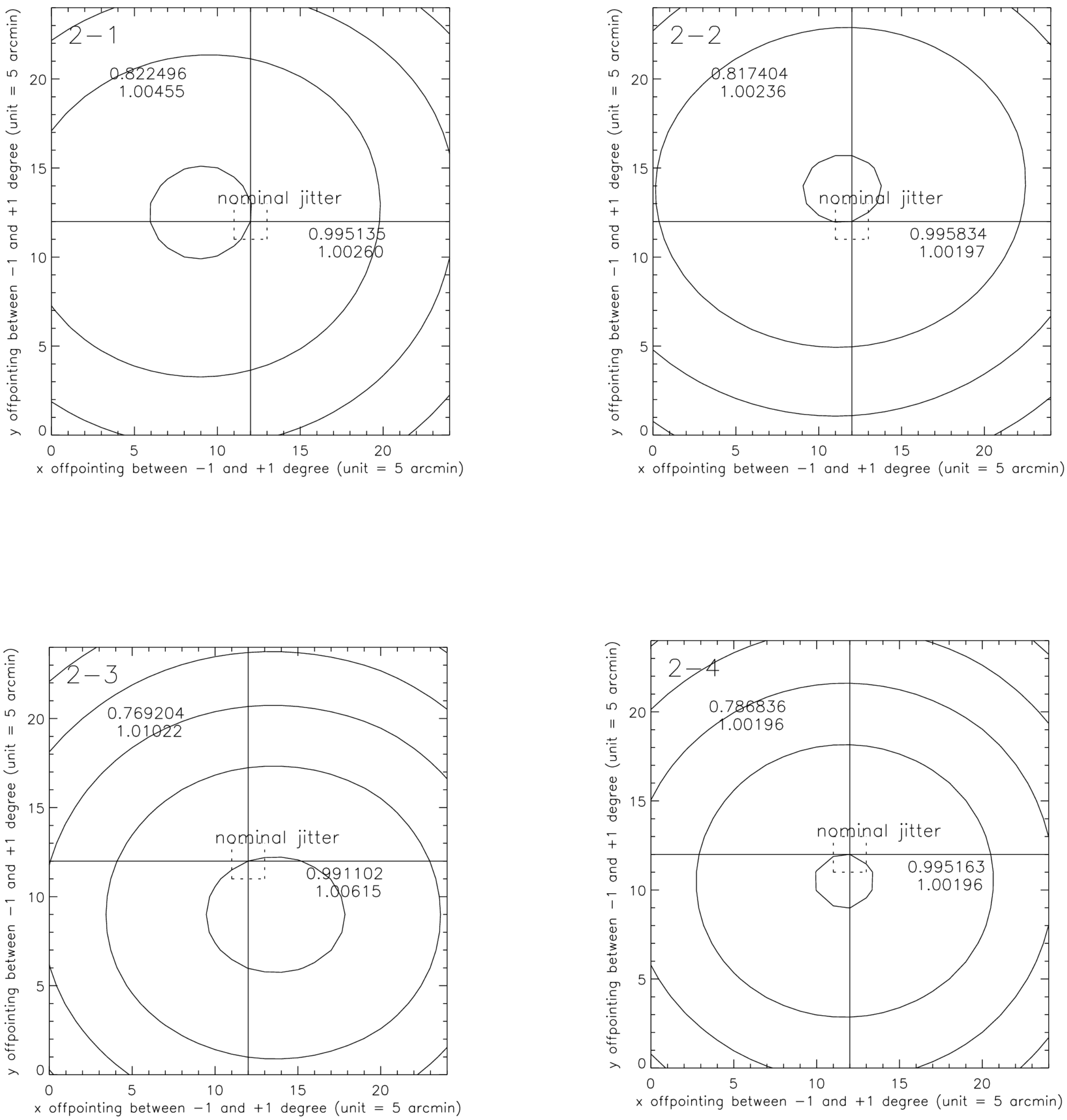

2−1
0.822496
1.00455
nominal jitter
0.995135
1.00260
2−2
0.817404
1.00236
nominal jitter
0.995834
1.00197
2−3
0.769204
1.01022
nominal jitter
0.991102
1.00615
2−4
0.786836
1.00196
nominal jitter
0.995163
1.00196
x offpointing between −1 and +1 degree (unit = 5 arcmin)
y offpointing between −1 and +1 degree (unit = 5 arcmin)

Figure 3-2.

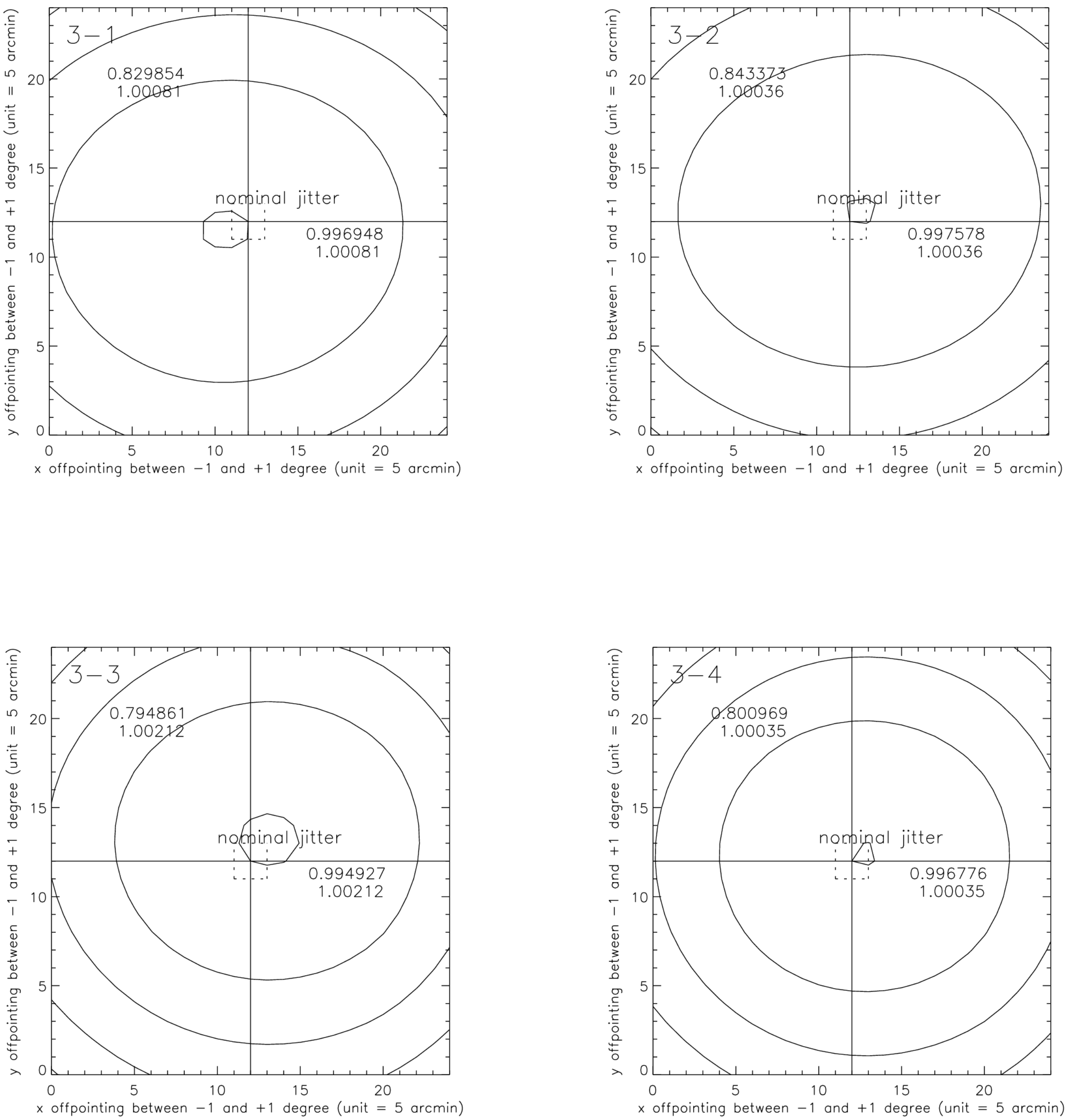

3-1
0.829854
1.00081
nominal jitter
0.996948
1.00081
3-2
0.843373
1.00036
nominal jitter
0.997578
1.00036
3-3
0.794861
1.00212
nominal jitter
0.994927
1.00212
3-4
0.800969
1.00035
nominal jitter
0.996776
1.00035
x offpointing between −1 and +1 degree (unit = 5 arcmin)
y offpointing between −1 and +1 degree (unit = 5 arcmin)

Figure 3-3.