AIPS Memo 107

KRING versus FRING Tests

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ABSTRACT

This comparison was designed to discover whether KRING or FRING should be used for most, if not all, fringe fitting problems. Within reasonable uncertainty, FRING and KRING performed very similarly. There is some indication that the default signal to noise cutoff in KRING is too low for low signal to noise cases. As one would expect, for high flux density sources the solution interval should be set as low as possible. For low flux density sources the solution interval should be set considering both the ability to find a good solution and to interpolate accurately. The only consistent difference between KRING and FRING is that KRING runs faster than FRING a vast majority of the time, typically by factors of 1.5 to 4.

1. Method

In order to compare KRING and FRING one needs to create a dataset where the "answer" is known. To do this I used the following procedure:

1. Select a dataset and use SPLIT to create a single source data file. In this case a 5 GHz data set was used.
2. Run task UVMOD on this dataset to remove original data and add point source or Gaussian with given flux density and size (for Gaussian). No noise is added at this time.
3. Run MULTI to create multisource data set. Copy a CL table from original data set which has all the fringe fit solutions from the original data set applied, but does not contain any amplitude calibration. The CL table used here is shown in figure 1. Run SPLIT applying that CL table.
4. Run UVMOD again to add noise.
5. Run MULTI again to provide KRING and FRING with a multisource dataset.
6. Run KRING and FRING with similar input values.

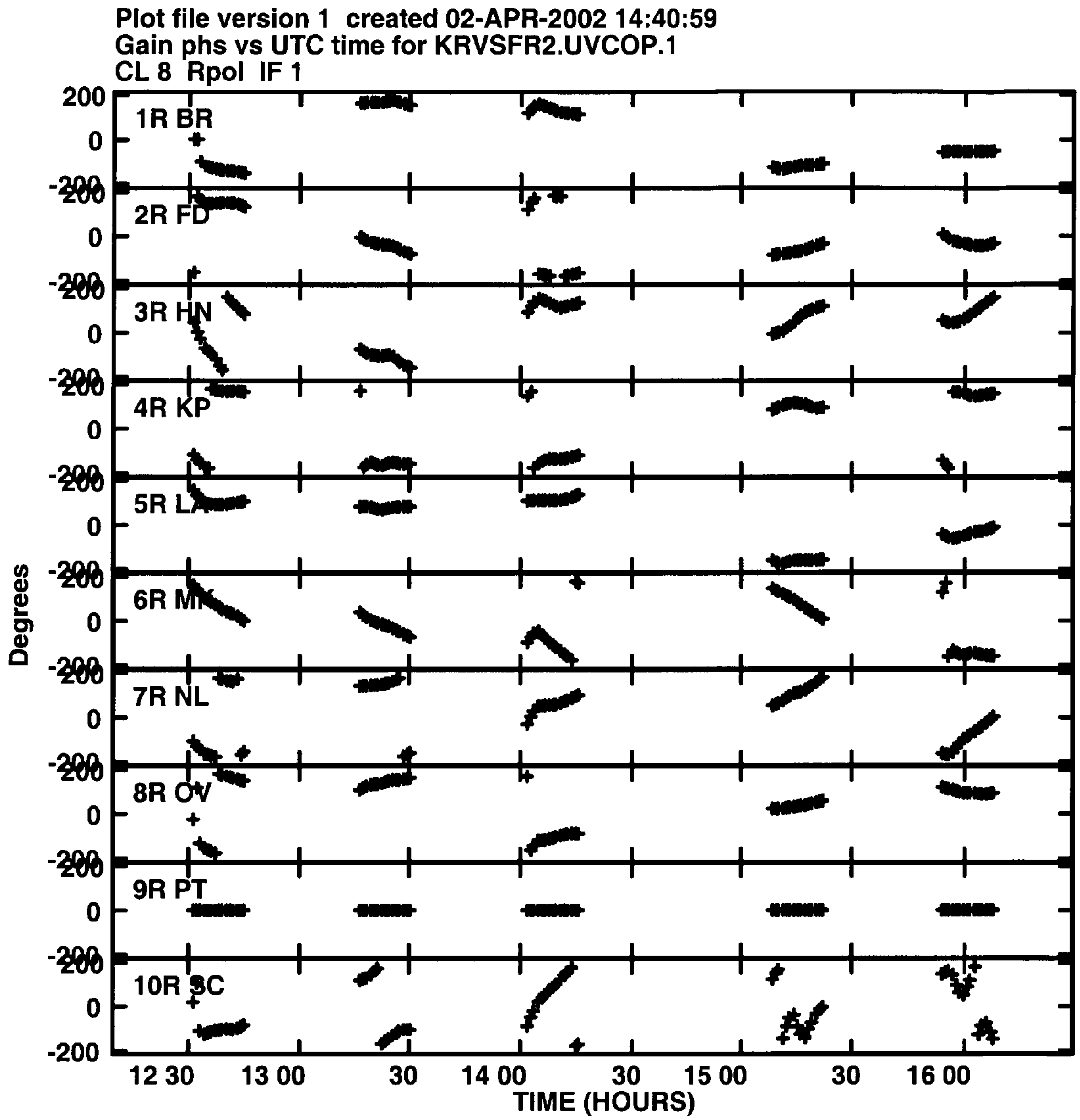

Fig. 1.— SNPLT of phases for 1 IF for the CL table applied to the simulated data to introduce known phase, rate and delay errors.

7. Copy CL table that was used in step 3 to data set on which KRING and FRING were run. Run CLCAL using this CL table as the GAINVER and the SN tables out of KRING and FRING as the SNVER. If KRING FRING and CLCAL were perfect then the resulting CL table will have rates, delays and phases which are all zero. Figure 2 shows the result of applying the SN table from running KRING on a 250 mJy point source to the CL table shown in figure 1.

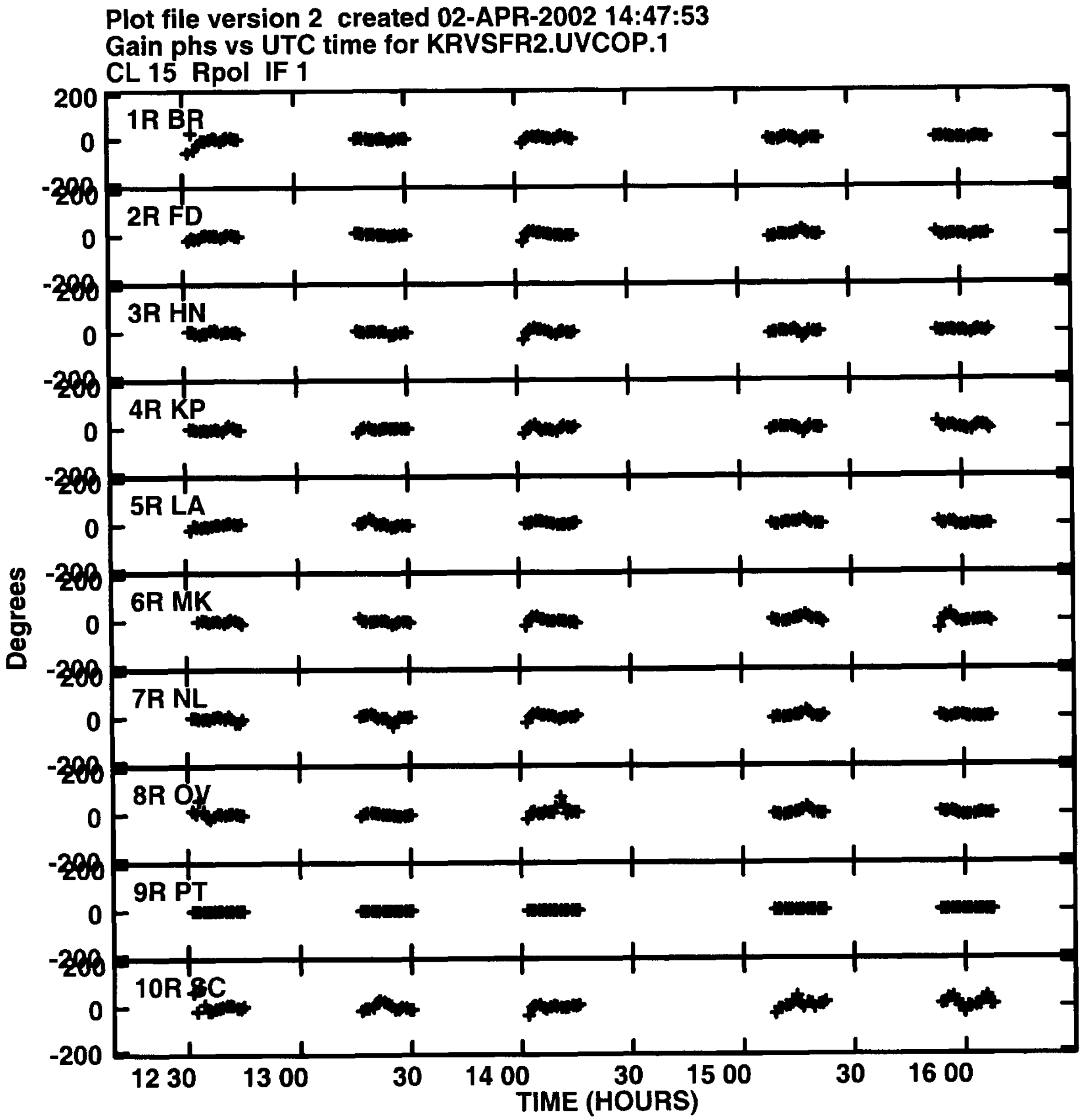

Fig. 2.— SNPLT of phases for 1 IF of a CL table produced by applying the solutions from running KRING on a 250 mJy point source to the original CL table (shown in figure 1). As expected the solutions are near but not always exactly zero (except for the reference antenna, whose phase is, by definition, zero).

8. Repeat all these steps with various flux densities, and SOLINT values.

9. Histograms of the resulting phases, rates and delays are made.

Of course, one weakness with this method of comparing KRING and FRING is that CLCAL does not always interpolate perfectly, but this should affect both KRING and FRING and therefore not hurt the comparison.

2. Point sources

Point sources with flux densities of 1 Jy, 500 mJy, 250 mJy, 175 mJy and 100 mJy were simulated. All histograms, for all flux densities, and solution intervals show a Gaussian distribution of residual phases centered at zero, see figure 3. However, a slow but steady degradation of the solutions is evident as the flux density of the point source decreases. This is seen in figure 3 as the growth of the width of the distribution of residual phases and the lowering of the peak. Table 1 shows the percent of reported good solutions from FRING and KRING; this shows a significant change in the ability of both FRING and KRING to find good solutions between 175 mJy and 100 mJy, particularly at low solution intervals. This break between 175 mJy and 100 mJy is influenced by the CL table (*e.g.*, how rapidly the phases change with time due to atmospheric coherence) used to introduce the errors that KRING and FRING must fix and the amount of noise in the data. Therefore this break could be at a different flux for different data sets. Since the signal to noise ratio (SNR) in KRING and FRING are calculated differently it is not meaningful to compare the percent reported solutions directly.

Table 1 also lists the percent of actual good corrections, *i.e.*, the percent of residual phases near 0 after CLCAL is run. For the high flux density cases nearly all the passed solutions have a very high SNR, so we must conclude that the difference between the reported good solution and the actual good solutions from FRING and KRING result from "bad" solutions with high SNR. There is also the factor that between the reported good solutions and the actual good corrections CLCAL is run, which probably corrupts some fraction of the solutions. Particularly suggestive is the fact that many more of the corrections are considered bad as the solution interval increases, so CLCAL is understandably less accurate when interpolating over larger gaps in time. However this could also be caused if the solution interval becomes larger than the atmospheric coherence time. For the 100 mJy case the SNR cutoff may be too low. KRING usually runs faster than FRING but the difference for the 100 mJy case is much larger than the other flux densities which suggests that FRING spent more time searching different baselines for possible solutions. In this case, FRING finds *significantly* more good solutions than KRING which may be the result of additional searching. Both FRING and KRING will search multiple baselines if solutions they find are below their respective SNR cutoffs. So, setting the KRING SNR cutoff higher may have resulted in more actual good solutions. This low flux density case also does not follow the pattern of longer time interval, fewer good corrections. This is probably because for the low flux density FRING and KRING needed a long solution interval to find any good solution at all.

If the actual good corrections for FRING and KRING are compared, it is evident that for 500 mJy and more KRING does a slightly better job, for 250 mJy and 175 mJy FRING does a slightly better job and for 100 mJy FRING does a much better job. Again the higher percent good corrections for

FRING in the 100 mJy case may have to do with the SNR cutoff for FRING being more reasonable than the one in KRING. There is some indication that KRING's rate solutions are better than FRING, which may explain KRING's slightly better performance for the high flux density point sources.

For all but 2 cases KRING ran faster than FRING; see last 2 columns in table 1. The difference increased as the solution interval increased. As mentioned above, the huge differences seen for the 100 mJy case are probably caused by FRING searching more baselines for good solutions than KRING.

3. Gaussian sources

A slightly resolved Gaussian was used to test if there is a significant difference between a point source and a slightly resolved source. For the most part there is not; see figure 4. Table 2 shows one difference: when the flux is spread over a slightly resolved Gaussian, it is more difficult for KRING and FRING to find good solutions. Also instead of the slight bias towards KRING for the strong point sources, FRING always seems to do a slightly better job, but not as startlingly better for the 100 mJy source. Again, the run times indicate that KRING is faster.

4. Conclusions

1. In ability to find good solutions, there does not seem to be a clear advantage to using FRING or KRING. A possible exception is for very low SNR, where FRING seems to do a better job; however see the next point.

2. For low signal to noise cases, where one probably wants FRING or KRING to search many possible baselines for good solutions, one should be careful about setting the SNR cutoff.

3. For weak sources, increasing the SOLINT must be balanced with the ability to interpolate accurately between solutions with a very large SOLINT. How to make this choice is unclear; for the 100 mJy point source the maximum solution interval seemed to be between 6 and 8 minutes. Of course, this depends on flux density of the source, and how complicated the phases are. If one wanted to be very careful, one could do simulations similar to mine to determine the best SOLINT for an expected flux density and phase behavior.

4. KRING seems to run faster then FRING so where time is an issue KRING seems to be the better choice, particularly since there is no clear "winner" in other ways.

Table 1. Point Source

flux (mJy)	sol. int. (min)	% reported good solutions[a] FRING	KRING	% actual good corrections[b] FRING	KRING	run time (sec)[c] FRING	KRING
1000	2	85.9	94.2	90.4	88.3	32	30
1000	4	80.9	92.9	81.0	82.0	68	45
1000	6	83.8	92.6	68.4	70.4	112	50
1000	8	83.8	92.6	67.9	70.0	167	76
1000	10	93.5	93.5	50.8	51.8	166	77
500	2	83.7	93.6	88.2	92.1	33	34
500	4	79.7	92.9	80.8	81.6	71	43
500	6	81.7	92.6	68.6	70.7	120	52
500	8	81.7	92.6	68.1	70.3	172	80
500	10	88.4	93.5	50.5	51.4	173	78
250	2	83.2	92.5	81.0	81.5	36	35
250	4	79.5	92.9	76.5	76.1	68	48
250	6	82.9	92.6	68.0	66.2	109	56
250	8	82.9	92.6	67.6	65.9	171	75
250	10	82.9	93.5	50.2	49.5	169	73
175	2	83.2	91.5	69.4	58.4	41	38
175	4	82.5	92.9	71.2	64.7	73	52
175	6	78.5	92.6	65.5	61.9	136	85
175	8	78.5	92.6	65.2	61.8	200	102
175	10	91.7	93.5	49.4	47.7	207	106
100	2	32.1	37.2	26.9	20.8	104	101
100	4	66.3	50.5	40.7	14.2	483	156
100	6	76.2	76.4	51.5	21.8	726	148
100	8	76.2	76.4	51.9	22.1	620	159
100	10	74.1	91.7	41.0	30.6	817	161

[a]As reported by FRING or KRING.

[b]Calculated as number of solutions with residual phase within ±10° of 0° over the total number of non-flagged solutions.

[c]CPU time.

Table 2. Single Gaussian

flux (mJy)	sol. int. (min)	% reported good solutions[a] FRING	KRING	% actual good corrections[b] FRING	KRING	run time (sec)[c] FRING	KRING
1000	2	82.7	94.5	77.1	73.5	85	96
1000	4	93.1	94.5	72.5	71.7	168	116
1000	6	91.3	93.6	55.3	56.2	280	127
1000	8	93.5	94.8	42.7	41.4	371	141
1000	10	93.5	94.8	42.6	41.3	371	142
500	2	82.4	94.5	74.7	70.5	86	93
500	4	91.6	94.5	69.5	69.0	181	111
500	6	89.8	94.2	54.2	55.3	320	121
500	8	93.5	94.8	42.2	40.3	386	134
500	10	93.5	94.8	42.1	40.1	395	133
250	2	82.3	89.6	62.9	57.2	100	98
250	4	91.3	94.0	62.2	57.1	174	116
250	6	89.9	93.8	51.7	50.9	291	128
250	8	93.5	94.8	41.2	39.0	384	132
250	10	93.5	94.8	41.0	38.8	372	133
175	2	80.3	83.7	51.7	40.5	166	112
175	4	89.3	93.6	47.7	40.4	235	133
175	6	90.6	94.0	46.3	41.1	336	131
175	8	93.3	94.4	37.1	34.9	401	137
175	10	93.3	94.4	37.0	34.8	429	140
100	2	14.2	10.1	13.4	8.7	559	254
100	4	34.6	15.0	12.4	7.5	1007	251
100	6	68.8	42.6	21.4	10.6	1440	227
100	8	82.0	68.1	23.6	12.6	1388	233
100	10	82.0	68.1	23.7	12.6	1512	234

[a]As reported by FRING or KRING.

[b]Calculated as number of solutions with residual phase within $\pm 10^\circ$ of 0° over the total number of non-flagged solutions.

[c]CPU time.

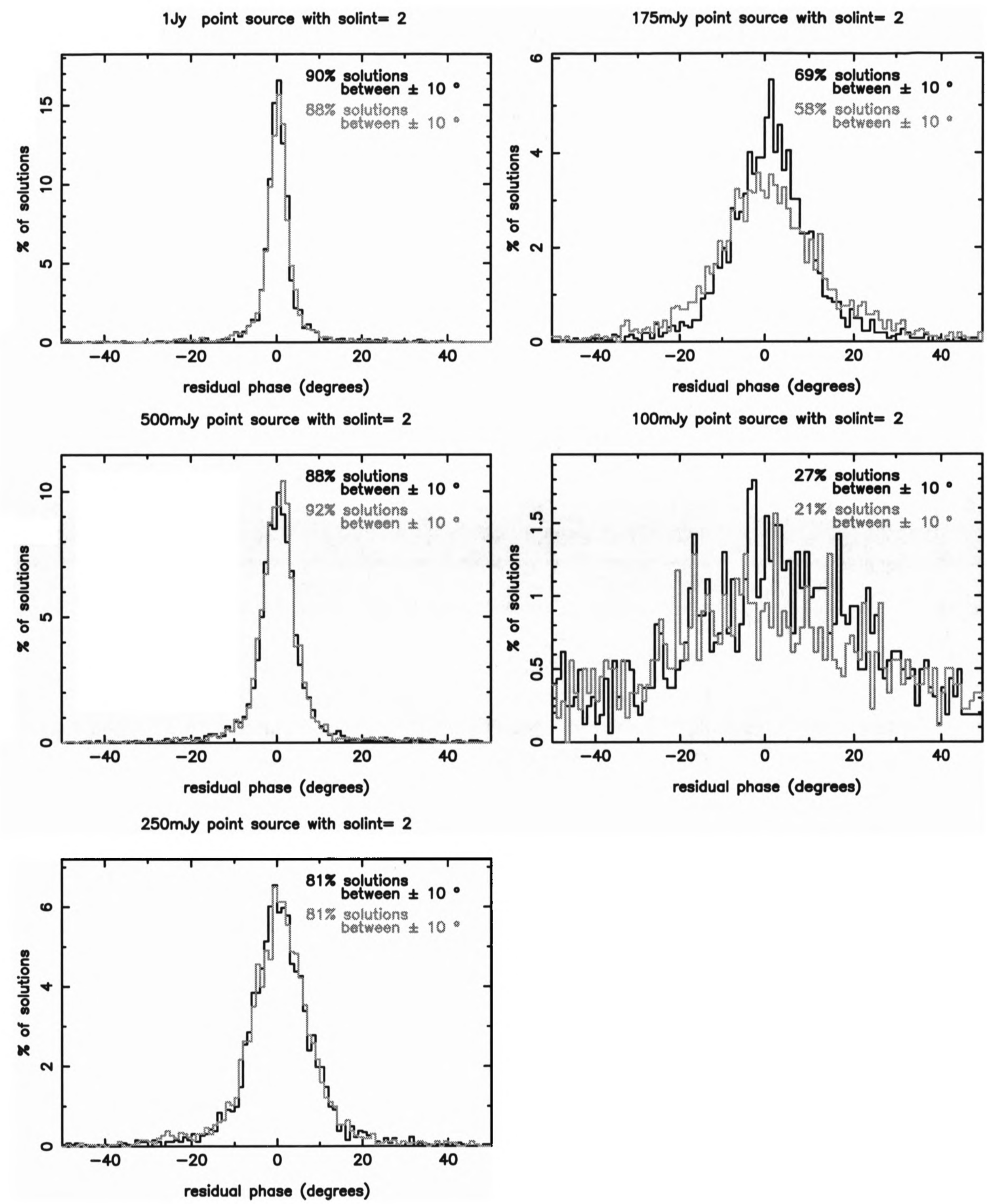

Fig. 3.— Histogram of residual phase for point sources with various flux densities. The black lines the results for **FRING** and the gray (blue) from **KRING**.

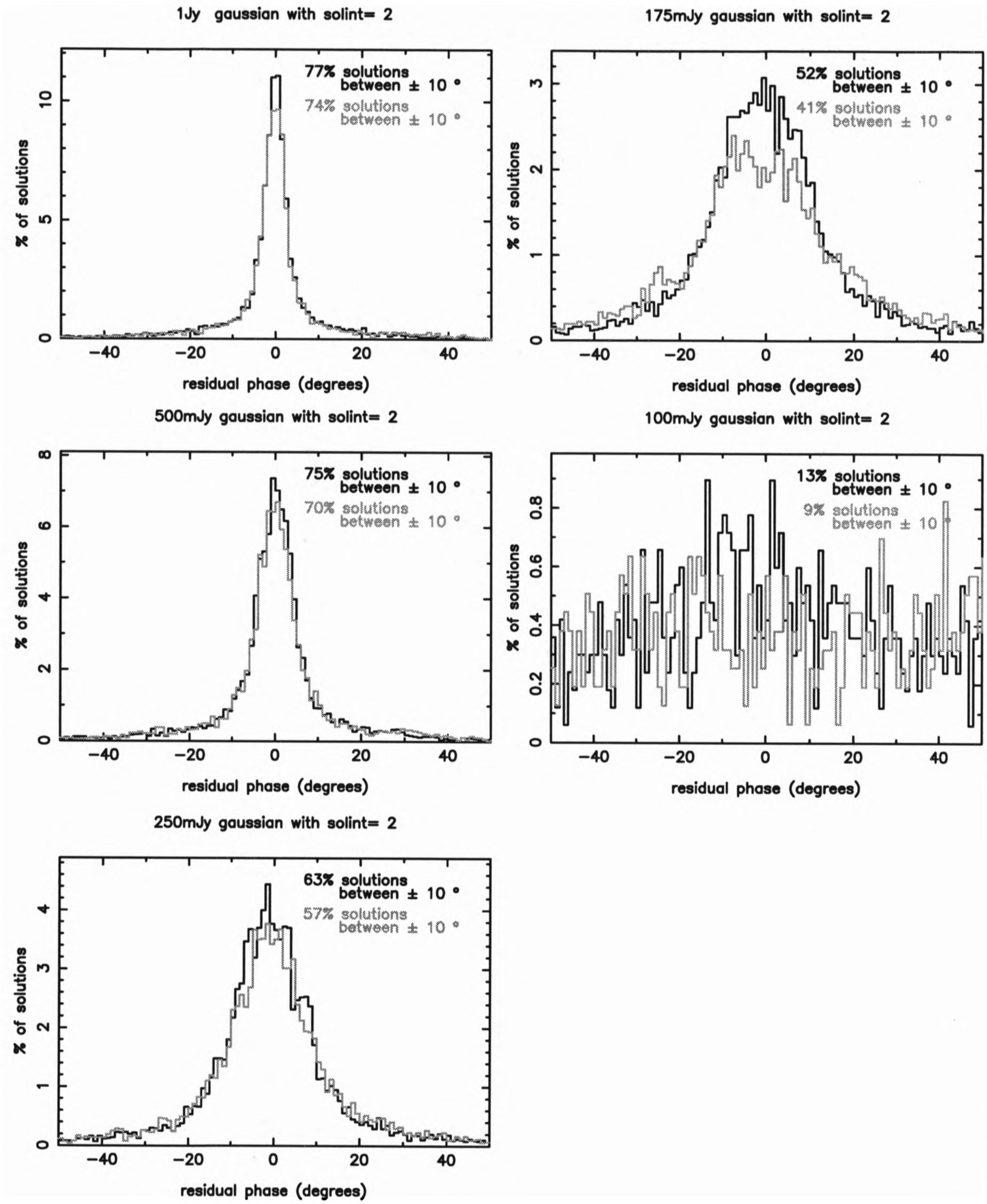

Fig. 4.— Histogram of residual phase for a slightly resolved Gaussian with various flux densities. The black lines the results for **FRING** and the gray (blue) from **KRING**.