

Effects of Pattern Noise on WISE Astrometry

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Summary

An analysis of the effects of pattern noise on WISE astrometry reveals that degradation is measurable at a *very* low level for most sources and is somewhat greater for sources dominated by W3. It is close enough to ordinary statistical fluctuations so that occasionally astrometric parameters are slightly better *with* the noise. It does not appear that a significant threat to astrometric requirements is posed by pattern noise at the level simulated, nor does it appear that any special processing or mission-critical decisions are needed.

Discussion

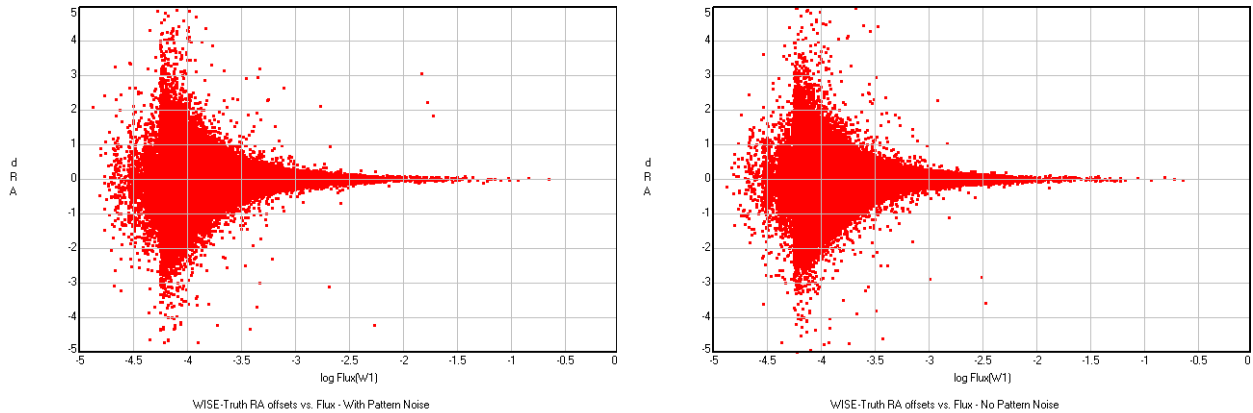
The WISE sources extracted from the four co-adds designated for pattern-noise analysis were used with the “truth” source list to estimate the effects of W3/W4 pattern noise on source position accuracy. There were two sets of WISE sources, those with pattern noise simulated, and those without. These will be labeled **P** and **N** sources for “Pattern noise” and “No pattern noise”, respectively, and the “truth” sources will be labeled **T**. All references to “flux” are with respect to “truth” flux.

Source matching was performed for the three pairings **PT**, **NT**, and **PN**, as follows. In each case, the two source lists were merged with the *gsa* utility program; the radial matching distance was 5 arcseconds, and all matches were retained, including multiple matches, which were numerous in all three cases. Each merged file was then run through a filtering program that computed the position 2-D chi-square parameter for each pair of matched sources. Any pair with chi-square greater than 16 was discarded (this threshold has a cumulative probability of 0.9996645, i.e., one true pair out of every 2981 is sacrificed in the attempt to attenuate the false match rate). When any two matches contained a common source, the one with the higher chi-square was discarded. This process reduced the **PT** list from 198,927 matches to 123,303, the **NT** list from 198,588 to 123,187, and the **PN** list from 148,266 to 136,413. Using a large radial matching distance and subsequent filtering of multiple matches and large position chi-squares should result in a better combination of complete and reliable matches.

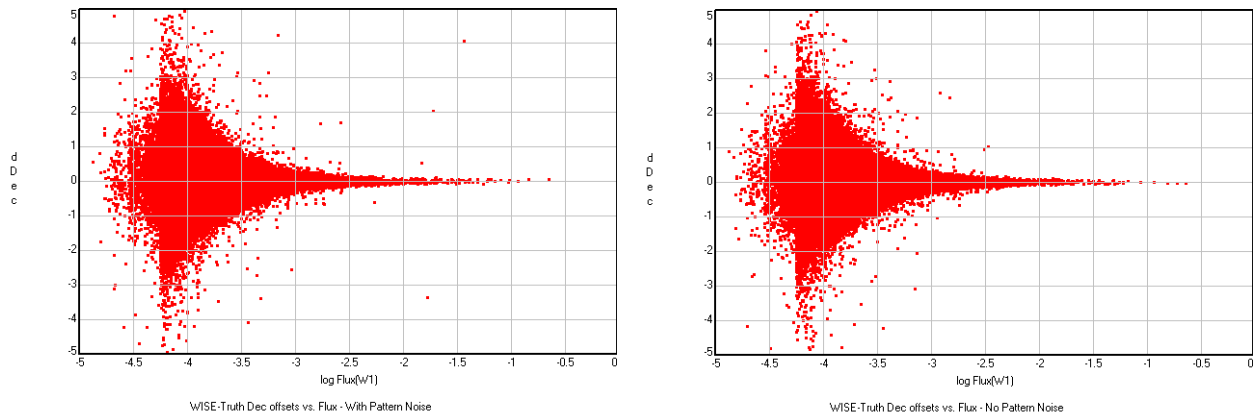
The **PT** and **NT** lists were used to produce two new lists each as follows. In each list, sources with W3 flux greater than *both* W1 and W2 flux were written to a separate list; these will be called the **PT3** and **NT3** lists. In each list, sources with maximum flux in W4 were written to a separate list; these will be called the **PT4** and **NT4** lists. No truth fluxes exist for the **PN** list, so no such breakdown was possible. The **PT3** and **NT3** lists contain 45,734 and 45,732 matches, respectively. The **PT4** and **NT4** lists contain 83,208 and 82,905 matches, respectively. Thus the latter lists contain more matches than the W3 lists, and about 67% of the total lists.

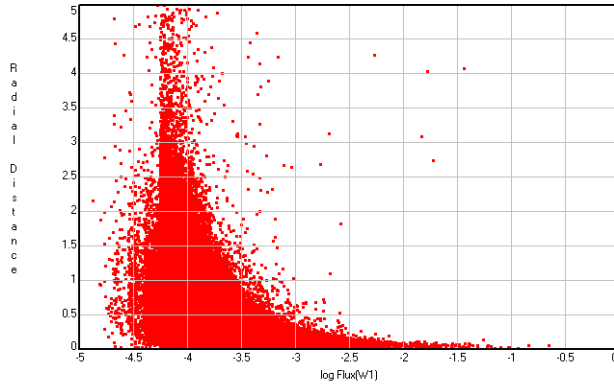
Each list contains parameters of astrometric interest: $\Delta\alpha$ (WISE - Truth Right Ascension in true arcsec), $\Delta\delta$ (WISE - Truth Declination in arcsec), r (radial distance in arcsec), and χ^2 (2-D position chi-square). These were all examined as functions of flux except in **PN**, where they were histogrammed over all matched source pairs. χ^2 behaved as expected and will not be discussed further (details are available on request).

PT vs. NT

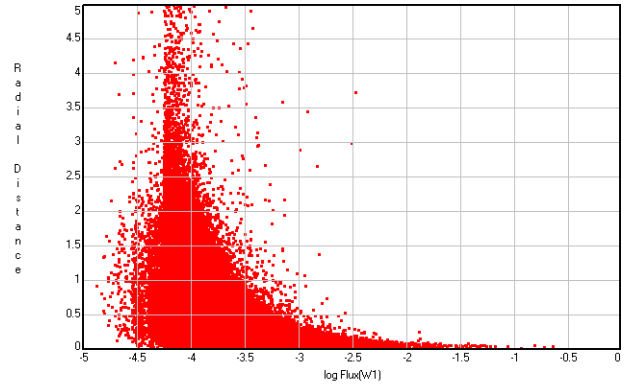


The plot on the left shows $\Delta\alpha$ in arcsec as a function of W1 flux with pattern noise; the plot on the right is similar except for the absence of pattern noise. All plots show WISE-Truth offsets in arcsec. The degradation due to pattern noise is very slight and probably not obvious to the eye; these offsets and the others may be more easily assessed in the summaries below, where averages and standard deviations in flux bins are displayed; the flux bins correspond to the grid lines in the plot. The boundary at about -4.25 on the abscissa appears to correspond to the minimum flux detected in W3 and W4; the region to the left is empty in plots using W3 and W4 for the abscissa. The sudden onset of greater dispersion to the right of this boundary in both cases shows the effect on astrometry when the longer wavelengths contribute to position information. Except for the **PN** analysis, the rest of the plots and tables will be presented without comment, as they are quite self-explanatory.





WISE-Truth Radial offsets vs. Flux - With Pattern Noise



WISE-Truth Radial offsets vs. Flux - No Pattern Noise

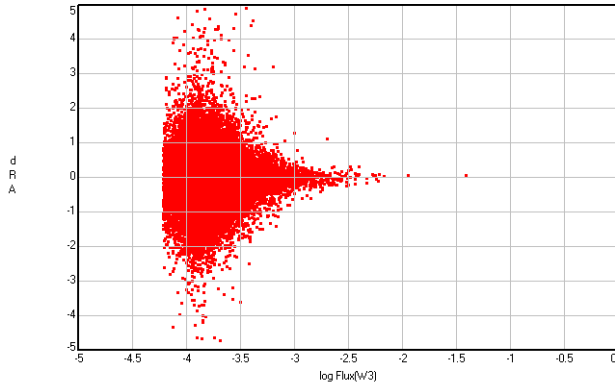
$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	297	-0.084	0.936	0.165	0.954	1.098	0.784	2.33	1.76
-4.25	62872	-0.066	0.691	0.065	0.741	0.826	0.594	2.10	1.52
-3.75	47599	-0.031	0.426	0.052	0.526	0.538	0.415	3.21	2.67
-3.25	9934	-0.007	0.227	-0.010	0.265	0.264	0.229	4.05	3.52
-2.75	2066	-0.002	0.144	-0.006	0.131	0.149	0.126	5.98	5.46
-2.25	414	-0.009	0.217	-0.006	0.073	0.094	0.209	7.10	6.58
-1.75	93	0.076	0.429	-0.013	0.414	0.160	0.580	8.04	7.52
-1.25	26	-0.009	0.037	0.160	0.782	0.202	0.773	8.14	7.62
-0.75	3	0.008	0.017	0.033	0.020	0.039	0.017	9.90	9.38
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	123304	-0.046	0.566	0.053	0.629	0.656	0.540	2.77	2.22

PT Parameters (With Pattern Noise)

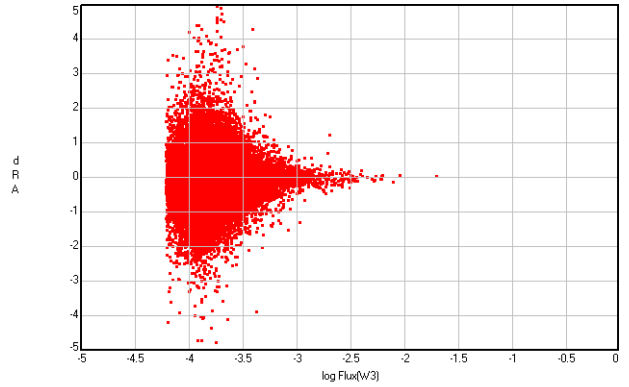
$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	290	-0.053	0.860	0.128	0.924	1.046	0.719	2.14	1.56
-4.25	62655	-0.061	0.691	0.068	0.742	0.827	0.594	2.10	1.52
-3.75	47533	-0.026	0.433	0.050	0.526	0.540	0.419	3.23	2.68
-3.25	10015	-0.006	0.223	-0.010	0.263	0.263	0.223	4.00	3.46
-2.75	2125	-0.005	0.153	-0.003	0.148	0.150	0.151	6.02	5.50
-2.25	452	-0.011	0.181	-0.002	0.084	0.095	0.176	7.51	6.99
-1.75	91	-0.006	0.048	0.004	0.045	0.057	0.032	7.45	6.93
-1.25	22	-0.002	0.036	-0.005	0.032	0.046	0.014	9.44	8.92
-0.75	4	-0.001	0.028	-0.024	0.008	0.036	0.014	6.62	6.10
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	123187	-0.042	0.567	0.053	0.629	0.656	0.540	2.79	2.23

NT Parameters (No Pattern Noise)

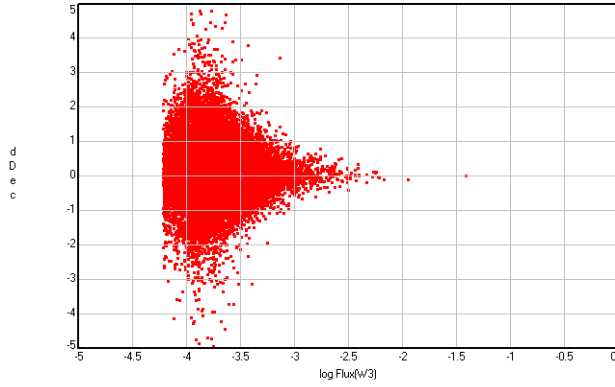
PT3 vs. NT3



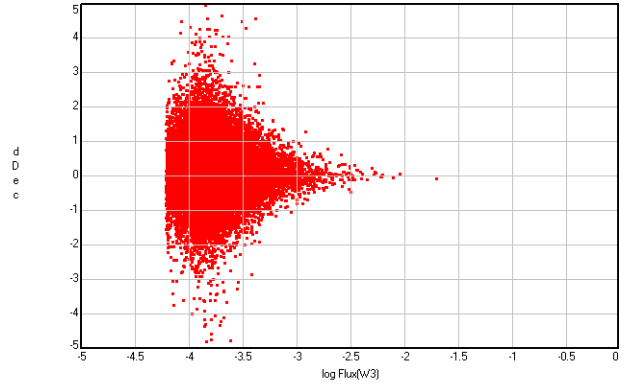
WISE-Truth RA offsets vs. W3 Flux - With Pattern Noise



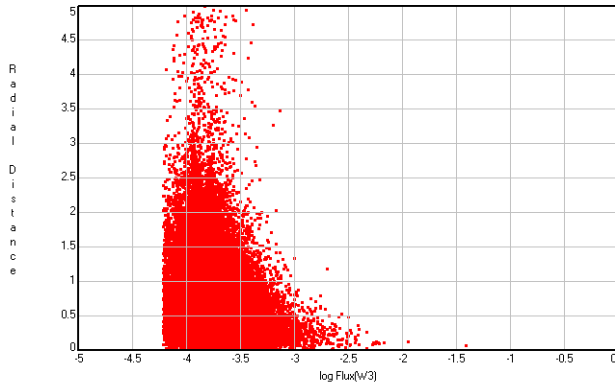
WISE-Truth RA offsets vs. W3 Flux - No Pattern Noise



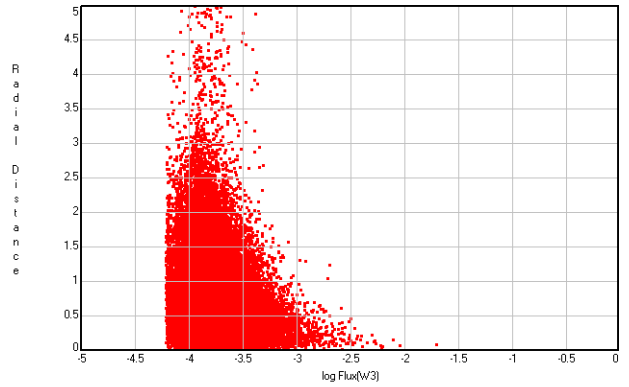
WISE-Truth Dec offsets vs. W3 Flux - With Pattern Noise



WISE-Truth Dec offsets vs. W3 Flux - No Pattern Noise



WISE-Truth Radial offsets vs. W3 Flux - With Pattern Noise



WISE-Truth Radial offsets vs. W3 Flux - No Pattern Noise

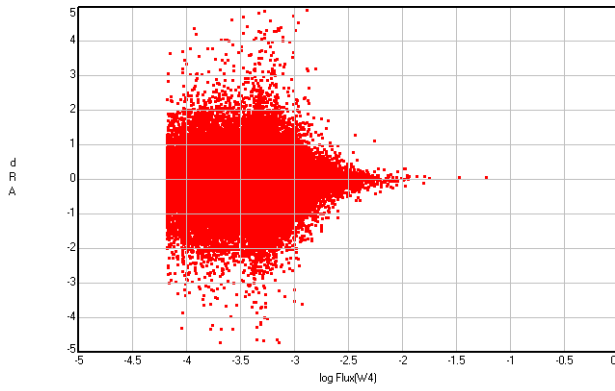
$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-4.25	4811	-0.074	0.729	0.076	0.753	0.862	0.605	2.00	1.41
-3.75	35988	-0.060	0.659	0.087	0.718	0.789	0.581	2.69	2.14
-3.25	4634	-0.022	0.426	0.068	0.517	0.534	0.410	4.26	3.73
-2.75	278	-0.020	0.193	0.055	0.271	0.287	0.179	5.42	4.90
-2.25	21	0.040	0.125	0.021	0.122	0.158	0.087	6.99	6.47
-1.75	1	0.044	0.000	-0.120	0.000	0.128	0.000	10.89	10.38
-1.25	1	0.068	0.000	0.013	0.000	0.069	0.000	11.98	11.47
-0.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	45734	-0.057	0.645	0.083	0.702	0.768	0.575	2.80	2.24

PT3 Parameters (With Pattern Noise, $W3 > W1, W2$)

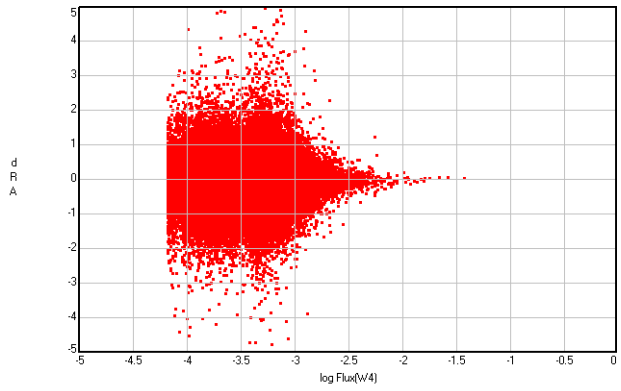
$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-4.25	4859	-0.065	0.740	0.071	0.753	0.868	0.609	2.01	1.42
-3.75	35931	-0.051	0.655	0.090	0.718	0.788	0.578	2.70	2.14
-3.25	4654	-0.021	0.402	0.066	0.526	0.529	0.404	4.24	3.71
-2.75	266	-0.029	0.212	0.024	0.282	0.290	0.205	4.94	4.42
-2.25	21	-0.017	0.079	0.035	0.112	0.126	0.068	4.94	4.41
-1.75	1	0.015	0.000	-0.080	0.000	0.081	0.000	10.31	9.80
-1.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-0.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	45732	-0.049	0.642	0.085	0.703	0.767	0.572	2.80	2.24

NT3 Parameters (No Pattern Noise, $W3 > W1, W2$)

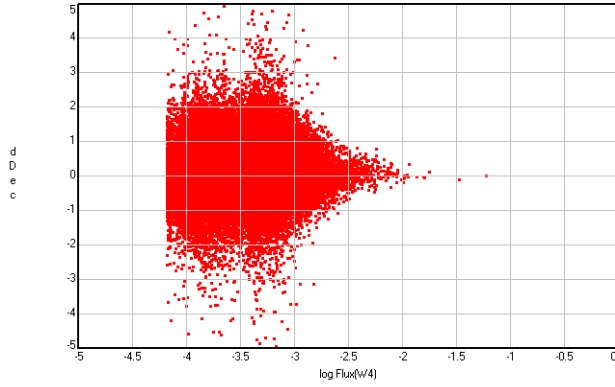
PT4 vs. NT4



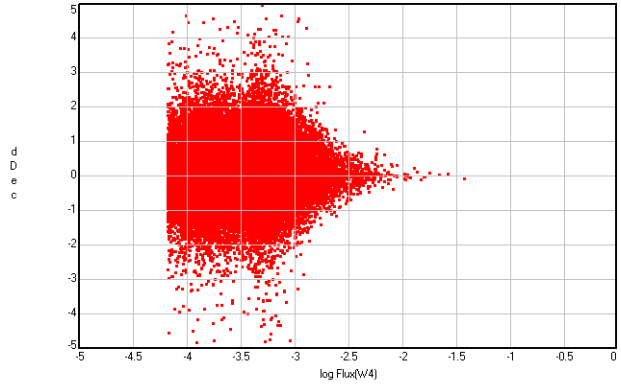
WISE-Truth RA offsets vs. W4 Flux - With Pattern Noise



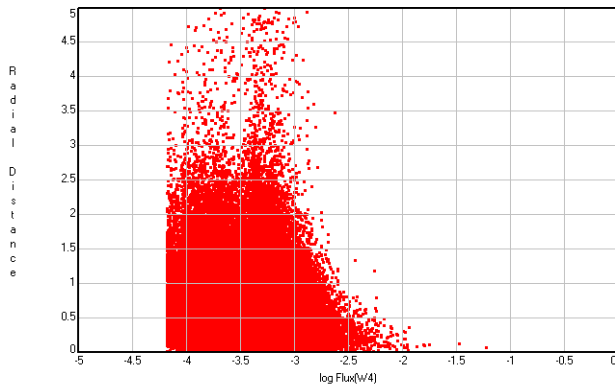
WISE-Truth RA offsets vs. W4 Flux - No Pattern Noise



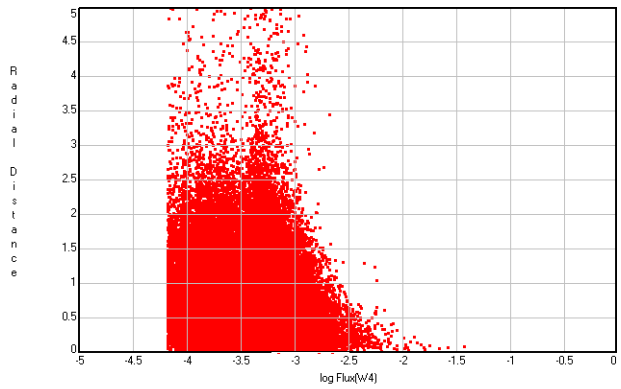
WISE-Truth Dec offsets vs. W4 Flux - With Pattern Noise



WISE-Truth Dec offsets vs. W4 Flux - No Pattern Noise



WISE-Truth Radial offsets vs. W4 Flux - With Pattern Noise



WISE-Truth Radial offsets vs. W4 Flux - No Pattern Noise

$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-4.25	4547	-0.057	0.703	0.021	0.738	0.840	0.580	1.83	1.23
-3.75	31744	-0.057	0.625	0.056	0.692	0.752	0.557	2.34	1.78
-3.25	40614	-0.057	0.637	0.081	0.696	0.757	0.572	2.77	2.22
-2.75	6018	-0.032	0.445	0.073	0.538	0.552	0.435	4.24	3.70
-2.25	269	-0.010	0.205	0.080	0.255	0.277	0.191	5.75	5.23
-1.75	14	0.051	0.128	0.002	0.117	0.153	0.097	5.15	4.62
-1.25	2	0.056	0.012	-0.053	0.066	0.099	0.029	11.43	10.92
-0.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	83208	-0.055	0.623	0.068	0.686	0.743	0.561	2.67	2.12

PT4 Parameters (With Pattern Noise, $W4 > W1, W2, W3$)

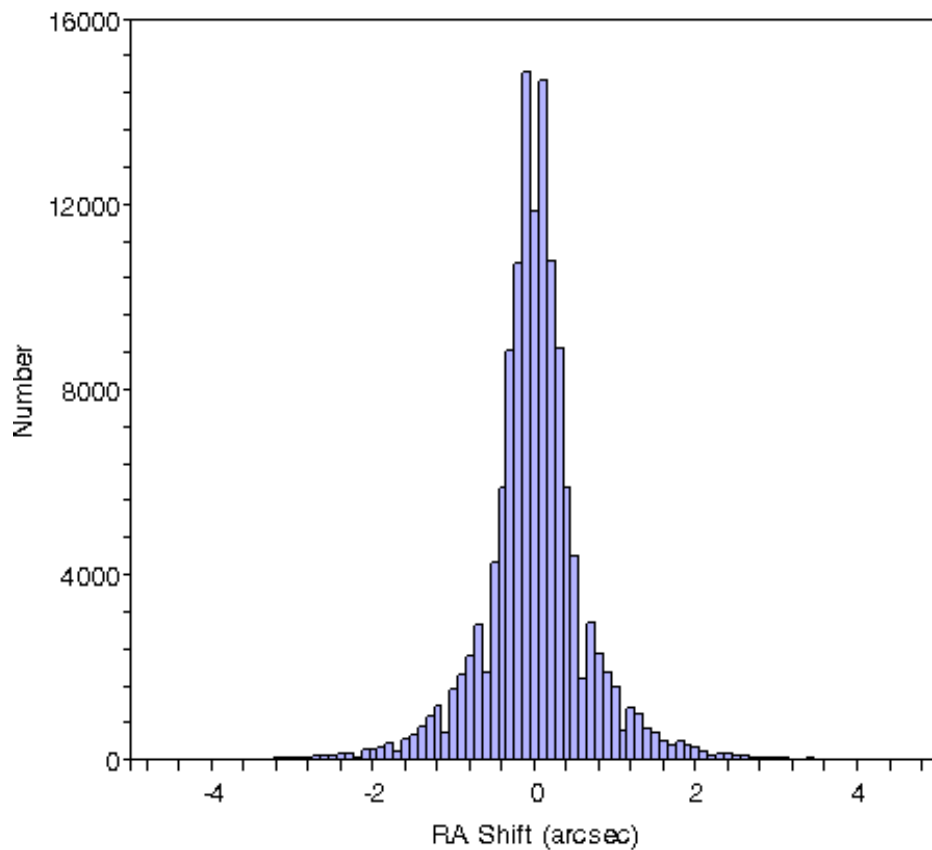
$\log F_{\text{center}}$	N	$\Delta\alpha$	σ_α	$\Delta\delta$	σ_δ	r	σ_r	χ^2	σ_{χ^2}
-4.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-4.25	4523	-0.073	0.712	0.051	0.798	0.872	0.626	1.95	1.36
-3.75	31527	-0.052	0.629	0.053	0.687	0.752	0.554	2.35	1.78
-3.25	40526	-0.048	0.636	0.083	0.698	0.759	0.570	2.79	2.24
-2.75	6058	-0.031	0.426	0.069	0.543	0.546	0.428	4.19	3.66
-2.25	255	-0.016	0.201	0.031	0.270	0.283	0.186	5.46	4.94
-1.75	15	0.003	0.077	0.008	0.087	0.102	0.057	4.89	4.36
-1.25	1	0.015	0.000	-0.080	0.000	0.081	0.000	10.31	9.80
-0.75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
-0.25	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
All	82905	-0.049	0.624	0.069	0.689	0.745	0.561	2.69	2.13

NT4 Parameters (No Pattern Noise, $W4 > W1, W2, W3$)

PN

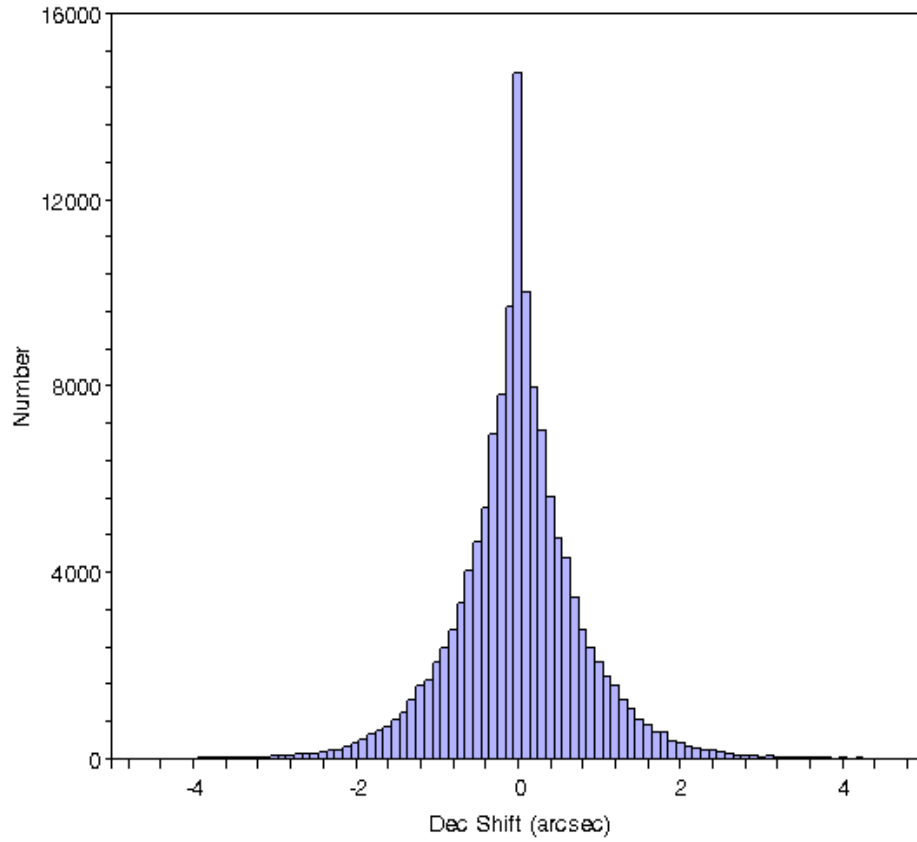
The WISE **P** and **N** source lists were matched against each other in the same way as described above in order to probe the effects of pattern noise on WISE source position repeatability. Histograms of the position parameter discrepancies are shown below. The pattern-noise parameters were subtracted from the no-pattern-noise parameters. The RA and Dec distributions are leptokurtic, i.e., more centrally peaked than a Gaussian and with broader tails.

WISE Source Position Discrepancies With vs. Without Pattern Noise



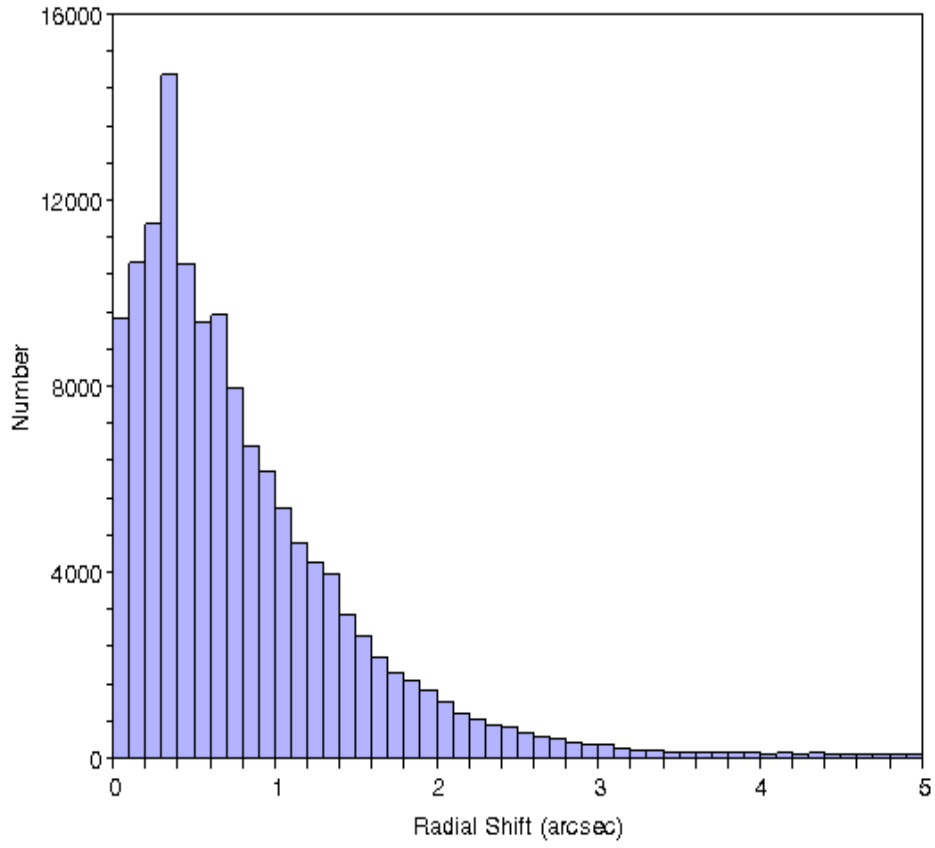
mean = 0.003406280926
sigma = 0.7026259953
skewness = -0.01282102243
kurtosis = 9.445377816
1% - 99% range: -2.086 to +2.083

WISE Source Position Discrepancies With vs. Without Pattern Noise



mean = 0.001336595486
sigma = 0.8167688817
skewness = 0.03029130397
kurtosis = 6.427387640
1% - 99% range: -2.25 to +2.296

WISE Source Position Discrepancies With vs. Without Pattern Noise



mean = 0.8088110957
sigma = 0.7117798811
mode = 0.055
1% - 99% range: 0.006 to 3.345