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CALIBRATION OF P-BAND DATA

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For VLA users used to calibration at L or C bands, calibration of VLA data taken at P band (330 MHz) will likely be a shocking experience. The reason for this is the effect of background sources in the primary beam. Background sources contribute more than 5 Jy in every field of view, and use of narrow bandwidths means that most or all of these sources will contribute to every baseline. Thus, unless a calibrator has a flux density exceeding, say, 50 Jy, unfamiliarly high closure errors will always accompany every gain solution. Fortunately, extensive testing has shown that the stability of the gain solutions is remarkably stable under high closure errors, so that in some cases, sources as weak as 5 Jy make acceptable phase calibrators. This memo summarizes my experience with P-band calibration, and lists all sources which will make acceptable calibrators at this band.

Experience with observing at P-band has shown that phase stability is always very good when the array is in the 'C' and 'D' cofigurations. Since the effects of confusion are worst in these configurations, I recommend that calibration sources be chosen first on the basis of their strength, and not on their proximity to the target field. In most cases, I recommend that the chosen calibrator have a flux density exceeding 25 Jy. This level will reduce amplitude fluctuations due to confusion to an acceptable level. Further calibration of the target region can always proceed via self-calibration.

However, in 'A' and 'B' configurations, the potential of unstable phases is always present, and it is advisable to pick a close calibrator. Since the amplitude solutions on a 5 Jy source are very uncertain, I recommend that the amplitude solution be done on the strongest acceptable calibrator (preferably exceeding 25 Jy). One or two observations of this amplitude calibrator should suffice, as the amplitude stability of the P-band receivers is very good. The phase calibration should be made using the nearest acceptable calibrator. Use of a 5 Jy source for phase calibration will likely result in 10 to 20 degree errors, but this is more than sufficient to allow the wonders of self-calibration to proceed, using the target field itself.

The provided list is derived from extensive observations of all potential objects. The original source list was defined as all catalogued radio sources whose 330 MHz flux density was known or expected to exceed 5 Jy. I used the Robertson all-sky survey, the 4C survey, the Texas survey and our own existing calibrator list as input. All objects were observed at P-band, in either the 'A' or 'C' configurations. The observations in 'C' configuration were in 'LP' band, so the equivalent of 'B' configuration resolution information was also obtained. From these data, determination of the usable UV ranges and flux densities was made. I have deleted from the list all objects with flux density less than 10 Jy which would have been usable only in 'C' and 'D' configurations.

In the list, the IAU source name is in the first column, and the associated 3C or 4C name is in the second. The OBSERV program doesn't recognize all of the 3C/4C names, so I recommend usage of the IAU designations. Column 3 gives the approximate P-band flux density, column 4 the allowed UV range (in thousands of nanoseconds, the 'official' VLA unit of distance). Configurations for which the calibrator can be used are listed in column 5. If the object is not in the current master calibrator list, the coordinates are given in columns 6 and 7. Many of these sources have poorly determined positions, with errors of up to an arcsecond in some cases. We hope to correct this situation shortly.

A LIST OF CALIBRATORS FOR P-BAND OBSERVING

IAU	3C, 4C	S_{90} Jy	UVRANGE μsec	Configs	RA	Dec
0000 − 177		7	0 − 20	B,C,D	00 00 48.42	−17 43 54.0
0003 − 003	2	12	0 − 8	C,D	00 03 48.87	−00 21 06.0
0012 + 610	60.01	9	2 − 20	B,C		
0016 − 129		9	0 − 20	B,C,D	00 16 18.80	−12 59 12.5
0017 + 154	9	10	0 − 4	C,D	00 17 50.00	15 24 48.0
0023 − 263		20	0 − ∞	ALL		
0032 − 203		9	0 − 20	B,C,D	00 32 38.64	−20 20 31.0
0038 + 328	19	10	4 − 12	B,C		
0039 − 445		13	2 − 8	C,D		
0041 + 660	21.1	7	2 − 20	B,C	00 41 39.25	66 02 16.0
0042 − 357		7	2 − 15	B,C		
0051 − 038	26	9	0 − 50	ALL	00 51 35.67	−03 50 11.0
0111 + 481	48.06	6	2 − ∞	A,B,D	01 11 26.320	48 08 01.45
0114 − 211		13	0 − ∞	ALL		
0117 − 155	38	15	0 − 6	C,D		
0127 + 233	43	9	4 − 50	A,B		
0132 + 079	46	7	2 − 12	B,C,D	01 32 37.47	07 55 48.0
0134 + 329	48	45	0 − ∞	ALL		
0138 + 136	49	8	4 − 80	A,B,C		
0139 − 273		6	2 − 12	B,C,D	01 39 08.00	−27 21 15.0
0159 − 117	57	5	10 − ∞	A,B		
0202 + 149	15.05	6	2 − ∞	B,C,D		
0218 − 021	63	15	0 − 5	C,D		
0220 + 397	65	12	0 − 5	C,D	02 20 36.57	39 47 19.0
0221 + 276	67	10	4 − 25	B,C		
0223 + 774	77.03	10	10 − 100	A,B	02 23 39.589	77 29 52.20
0240 − 002	71	15	0 − 2	D	02 40 07.07	−00 13 31.0
0310 − 150		8	4 − 12	B,C	03 10 25.86	−15 01 04.5
0311 + 430	43.09	6	10 − ∞	A,B	03 11 23.270	43 02 58.0
0316 + 162	16.09	7	6 − ∞	A,B,C		
0316 + 413	84	8	40 − ∞	A		
0320 + 053	05.14	7	3 − ∞	ALL	03 20 41.563	05 23 34.45
0334 + 506	91	10	0 − 5	C,D	03 34 03.95	50 36 07.0
0345 + 337	93.1	8	2 − ∞	ALL		
0349 + 727	72.06	7	4 − 12	B,C	03 49 17.78	72 45 48.0
0406 − 180		6	4 − ∞	A,B,C	04 06 52.11	−18 05 01.0
0406 + 387	38.13	5	6 − ∞	A,B		
0411 − 346		5	5 − 25	B,C	04 11 08.17	−34 37 45.0
0413 − 210		7	5 − 25	B,C		
0429 + 415	119	18	0 − ∞	ALL		
0433 + 295	123	130	0 − 2	D	04 33 55.00	29 34 14.0
0445 − 221		5	4 − ∞	B,C,D	04 45 29.29	−22 08 52.5
0453 − 206		12	2 − 5	C,D		
0459 + 252	133	18	0 − 6	C,D	04 59 54.37	25 12 11.0

0518 + 165	138	20	0 – ∞	ALL		
0519 – 208		8	0 – 60	ALL		
0521 – 365		42	0 – 10	C?,D	05 21 13.00	–36 30 17.0
0531 + 194		15	5 – ∞	B,C,D		
0538 + 498	147	54	0 – ∞	ALL		
0538 + 474		7	4 – 12	B,C	05 38 02.90	47 27 40.0
0600 + 219	22.12	7	6 – 25	B,C	06 00 50.83	21 59 48.0
0601 + 203	152	9	4 – 40	A,B,C		
0605 + 480	153	12	2 – 12	B,C		
0614 – 349		5	4 – ∞	A,B,C		
0622 + 147	14.18	6	20 – ∞	A,B		
0624 – 058	161	33	30 – ∞	A		
0651 + 542	171	13	0 – 5	C,D	06 51 11.01	54 12 49.0
0659 + 445	44.15	8	4 – ∞	A,B,C	06 59 16.47	44 35 36.0
0704 – 231		7	5 – 40	A,B,C		
0711 + 146	175.1	6	2 – 12	B,C		
0732 + 332	33.21	7	2 – ∞	A,B,C	07 32 41.80	33 13 50.0
0733 + 705	184	9	0 – ∞	B,C,D		
0740 + 380	186	7	4 – 50	A,B,C	07 40 56.76	38 00 31.0
0741 – 063	–06.18	10	4 – ∞	A,B,C		
0758 + 143	190	9	4 – 20	B,C		
0802 + 103	191	8	0 – 25	B,C,D		
0809 + 483	196	45	0 – 8	C,D		
0810 + 461	46.17	5	10 – 100	A,B	08 10 58.58	46 05 48.0
0812 – 029	196.1	11	0 – 15	B,C,D	08 12 57.07	–02 59 13.0
0825 – 202		11	0 – 5	C,D		
0831 + 557	55.16	9	0 – ∞	ALL		
0834 – 196		14	0 – ∞	ALL	08 34 56.11	–19 41 25.0
0838 + 133	207	8	0 – 12	B,C,D		
0906 + 432	216	15	0 – 15	B,C,D	09 06 17.23	43 05 59.0
0931 + 834	220.3	13	0 – 8	C,D		
1003 + 351	236	7	4 – 100	A,B,C	10 03 05.39	35 08 48.0
1019 + 222	241	8	0 – ∞	ALL	10 19 09.36	22 14 39.5
1030 – 340		7	0 – 60	ALL	10 30 56.20	–34 03 17.5
1039 + 029	03.18	7	5 – 20	B,C	10 39 04.00	02 58 13.0
1111 + 408	254	13	0 – 8	C,D		
1116 – 027	255	10	4 – ∞	B,C,D	11 16 52.17	–02 46 25.5
1120 + 057	257	6	0 – 60	ALL	11 20 34.20	05 46 49.0
1136 – 135		14	0 – 6	C,D	11 36 38.64	–13 34 09.0
1140 – 114		7	2 – 50	A,B,C	11 40 02.29	–11 25 09.5
1140 + 223	263.1	14	0 – 10	C,D	11 40 49.20	22 23 35.0
1143 + 500	266	6	5 – 25	B,C		
1151 – 348		11	0 – ∞	ALL		
1153 + 317	31.38	7	2 – 50	A,B,C	11 53 44.08	31 44 46.5
1157 + 732	268.1	17	0 – 4	C,D	11 57 44.34	73 17 27.0
1203 + 645	268.3	10	5 – 50	A,B,C		
1239 – 044	275	11	0 – 12	B,C,D		
1249 – 197		8	6 – ∞	A,B,C		
1250 + 568	277.1	6	6 – 50	A,B,C		
1254 + 476	280	15	0 – 2	D		

1306 − 095		8	19 − ∞	A,B	13 06 02.10	−09 34 33.5
1306 + 660	65.14	5	4 − ∞	A,B		
1308 − 220		25	0 − ∞	ALL		
1318 + 113	11.45	7	2 − 20	B,C	13 18 49.56	11 20 30.0
1323 + 321	32.44	7	20 − ∞	A,B		
1328 + 254	287	15	0 − ∞	ALL		
1328 + 307	286	28	0 − ∞	ALL		
1335 − 061		12	0 − 4	C,D		
1336 + 391	288	12	0 − 5	C,D	13 36 38.37	39 06 24.0
1345 + 125	12.50	8	3 − ∞	A,B,C		
1346 − 391		7	2− > 40	A,B,C		
1350 + 316	293	9	10 − 60	A,B	13 50 03.21	31 41 33.0
1409 + 524	295	58	0 − 15	B,C,D		
1416 + 067	298	30	0 − 60	ALL		
1419 + 419	299	9	2 − 12	B,C		
1422 − 297		9	4 − 15	B,C		
1436 − 167		6	2 − 25	B,C	14 36 42.00	−16 46 12.0
1448 + 634	305	11	0 − 15	B,C,D		
1458 + 718	309.1	19	0 − 45	ALL		
1508 − 055	−05.64	8	0 − 15	B,C,D	15 08 15.00	−05 31 49.0
1547 + 215	324	10	0 − 12	B,C,D		
1553 + 202	326.1	7	4 − 20	B,C	15 53 57.19	20 13 00.0
1602 − 174		7	6 − 20	B,C	16 02 10.00	−17 26 07.0
1602 + 014	327.1	18	4 − 10	C	16 02 12.90	01 25 59.0
1622 − 310		7	0 − 20	B,C,D	16 22 44.88	−31 01 22.5
1643 − 223		7	0 − 12	B,C,D		
1657 − 298		6	0 − 15	B,C,D	16 57 59.04	−29 50 20.0
1709 + 460	352	8	2 − 15	B,C		
1709 − 281		17	0 − 4	C,D	17 09 48.30	−28 06 02.0
1711 − 251		9	4 − ∞	A,B,C	17 11 43.26	−25 11 12.5
1802 + 110	368	8	4 − 15	B,C		
1819 − 096		13	0 − ∞	ALL	18 19 43.59	−09 40 28.5
1827 − 360		28	0 − ∞	ALL		
1830 − 210		12	0 − 50	ALL	18 30 40.61	−21 06 00.0
1828 + 487	380	43	0 − 6	C,D		
1857 + 129	394	12	0 − 5	C,D	18 57 04.48	12 55 00.0
1859 − 235		14	0 − 8	C,D	18 59 47.40	−23 34 17.0
1921 − 293		8	5 − ∞	A,B,C		
1922 + 333	33.48	8	10 − ∞	A,B	19 22 24.92	33 23 33.0
1938 − 155		17	0 − 8	C,D		
1953 − 077	404	7	4 − 15	B,C	19 53 29.40	−07 44 55.5
2007 + 520	52.47	6	4 − 15	B,C	20 07 35.48	52 04 40.0
2037 + 511	418	12	4 − 40	A,B,C		
2044 − 027	422	7	4 − 60	A,B,C		
2104 + 763	427	17	0 − 2	C	21 04 47.26	76 20 59.0
2111 − 259		7	2 − 12	B,C		
2128 − 208		7	6 − ∞	A,B,C		
2135 − 209		10	6 − ∞	A,B,C		
2146 − 209		10	6 − ∞	A,B,C		
2146 − 133		6	4− > 40	A,B,C		
2149 − 287		6	4 − 50	A,B,C		
2154 + 482	48.56	5	4 − 25	B,C		

2201 + 624	440	9	4 – 15	B,C,D		
2203 – 188		10	4 – ∞	A,B,C		
2216 – 281		8	4 – ∞	A,B,C	22 16 53.404	–28 11 25.70
2229 + 539	53.50	7	4 – ∞	A,B,C	22 29 20.19	53 54 09.0
2223 – 052	446	15	0– > 50	ALL		
2230 + 114	11.69	8	2 – 60	A,B,C		
2248 + 712	454.1	9	4 – 50	A,B,C		
2249 + 185	454	8	4 – ∞	A,B,C	22 49 07.709	18 32 43.85
2251 + 158	454.3	15	4 – 20	B,C		
2252 + 129	455	8	4 – 15	B,C,D	22 52 34.49	12 57 33.0
2309 + 090	456	9	3 – 15	B,C,D	23 09 56.63	09 03 10.0
2314 + 038	459	18	0 – 8	C,D	23 14 02.33	03 48 55.0
2318 – 166		10	6 – 50	A,B,C	23 18 24.79	–16 39 32.0
2322 – 123		9	4 – 12	B,C	23 22 43.76	–12 23 56.5
2338 + 132	13.22	7	4 – ∞	A,B,C	23 38 00.930	13 16 23.0
2339 – 353		7	4 – 100	A,B,C	23 39 08.08	–35 23 01.0
2348 + 643	468.1	27	0 – 60	ALL		