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VLA Primary Beam and Pointing at 333 MHz

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The VLA P band feed consists of a pair of crossed dipoles that use the subreflector as a ground plane. As is well known, the subreflector is shaped in order to illuminate the Cassegrain feeds and the dipoles are $\sim 0.4\lambda$ closer to the primary reflector than what would be required for correct focusing. Extensive tests run from January 1990 to February 1991 have shown that the primary beam of the VLA antennas at P-band is somewhat different from what was previously assumed. We have found that between 330 MHz and 335 MHz it behaves as follows

- The HPBW (333 MHz) is about $145'$.
- Between 330 MHz and 335 MHz the HPBW is a steeper function of frequency than what corresponds to a correctly focused beam. Indeed, in this range (a 1.5% change in frequency) the HPBW changes by 4.5%. This induces steep spectral indices on sources away from the central area of the primary beam. For example, a source 1° from the beam center (still at about the 60% of the peak response) acquires a "spectral index" of ~ 5; and a source 1.5° away from the center acquires a "spectral index" of ~ 10. This effect must be responsible in part for our failure to reach the rms noise levels given by the receiver noise and the confusion noise. This trend does not hold across the entire P band as the HPBW at 317.5 MHz is $\sim 152'$.
- The antennas have been consistently mispointed by about $8'$, a small fraction ($\sim 6\%$) of the HPBW. This small error has significant consequences at P band as the entire field of view is littered with faint radio sources. Although the primary beam is very nearly circularly-symmetric (the non-circularity is $\leq 4\%$), as the sky rotates the mispointing causes sources to be modulated in amplitude and again disturbs the power in the sidelobes of the synthesized beam from what is theoretically expected, thereby impeding correct cleaning.

We have recently (Feb 13, 1991) successfully observed 3C196 in pointing mode with the appended subreflector rotation file. The measured (average) pointing offsets for the array at 333.125 MHz were

$$\Delta AZ = +0.2 \pm 0.7; \Delta EL = -1.6 \pm 0.7 \text{ for IF - A}$$
$$\Delta AZ = +0.7 \pm 0.7; \Delta EL = +0.5 \pm 0.7 \text{ for IF - C}$$

And for the average

$$\Delta AZ = +0.4 \pm 0.7; \Delta EL = +0.5 \pm 0.7$$

(with all values expressed in minutes of arc). The errors are standard deviations derived from the fits and are mainly due to confusion. That is the reason why the errors derived for the averages of the A and C IFs are the same as those for the individual IFs.

The individual antennas do not show significant offsets from the average albeit the errors here are much larger due to confusion. We plan to improve on our pointing tests using a few different sources on a single run in order to decrease the uncertainties on the individual antennas.

Meanwhile, we propose that the appended file (currently known to the On-line system as OFFPROT) replace the default SYSPROT file.

SUBREFLECTOR FILE (OFFPROT) FOR P BAND WITH FE FILTERS OF 12/25MHz BANDWIDTH.

00001-5.63+5.84	2524.	6400.	TTTTTTTT2121
00002-4.69+6.84	2491.	6400.	TTTTTTTT2121
00003-5.19+5.78	2385.	6400.	TTTTTTTT2121
00004-4.93+7.36	2127.	6400.	TTTTTTTT2121
00005-5.48+6.42	2334.	6400.	TTTTTTTT2121
00006-6.93+5.75	2577.	6400.	TTTTTTTT2121
00007-5.91+4.55	2483.	6400.	TTTTTTTT2121
00008-4.96+6.46	2531.	6400.	TTTTTTTT2121
00009-5.30+7.36	2594.	6400.	TTTTTTTT2121
00010-5.81+6.90	2389.	6400.	TTTTTTTT2121
00011-6.58+5.75	2386.	6400.	TTTTTTTT2121
00012-6.20+7.29	2542.	6400.	TTTTTTTT2121
00013-3.68+8.68	2511.	6400.	TTTTTTTT2121
00014-5.62+7.01	2495.	6400.	TTTTTTTT2121
00015-5.13+6.64	2530.	6400.	TTTTTTTT2121
00016-6.82+8.48	2494.	6400.	TTTTTTTT2121
00017-4.57+7.67	2553.	6400.	TTTTTTTT2121
00018-4.91+7.69	2525.	6400.	TTTTTTTT2121
00019-3.51+9.11	2513.	6400.	TTTTTTTT2121
00020-5.44+9.14	2091.	6400.	TTTTTTTT2121
00021-4.46+8.06	2495.	6400.	TTTTTTTT2121
00022-3.56+7.39	2514.	6400.	TTTTTTTT2121
00023-4.18+7.83	2517.	6400.	TTTTTTTT2121
00024-5.24+8.69	2524.	6400.	TTTTTTTT2121
00025-4.77+6.20	2422.	6400.	TTTTTTTT2121
00026-5.73+7.02	2409.	6400.	TTTTTTTT2121
00027-6.26+7.62	2082.	6400.	TTTTTTTT2121
00028-6.00+6.32	2511.	6400.	TTTTTTTT2121