VLA HYBRID CONFIGURATIONS

A Critical Look

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The VLA hybrid configurations (DnC, Cnb, BnA) were implemented to provide good u,v coverage and a round beam for sources in the far south or the far north, where the u,v coverage of the array is foreshortened by the low elevation. They do have several disadvantages:

1. The time allocated for moves between main configurations is three weeks (plus the two week hybrid), whereas going directly from one main configuration to another could be done in two weeks. This extra three weeks per configuration cycle is thus a loss of efficiency of about 4.5%.
2. The time requests in the hybrid configuration are heavily weighted to the galactic center LSTs, and the remainder of the day is not used as efficiently as might be.
3. High frequency observations in the hybrid are more subject to vicissitudes of the weather, as the timescale for change in the weather are not much shorter than the two week duration of the hybrid.
4. Hybrids are a mild scheduling inconvenience for the men and machines necessary to perform the move.

There is an alternative, weighting the u,v plane to produce a round beam. This does produce a loss of sensitivity, as one is essentially excluding data too far from the v axis. However, the loss of sensitivity is not as great as one might think. To illustrate, consider the case of a snapshot observation on the meridian of a source at -30 degrees declination. This is slightly too far south for even the hybrid configuration to produce a round beam. For natural weighting in the BnA hybrid configuration, the dirty beam is elongated, 5.4" (east-west) by 8.4" (at 1 GHz – this can be simply scaled to other configurations and frequencies). If we take the A configuration and apply a gaussian taper in the east-west direction, we get the results in the table below. The first column is the taper, half power point in km. The second column is the beam size, and the third is the sensitivity loss in terms of the increase of the RMS noise relative to natural weighting.

Taper	Beam Size	RMS noise
No Taper	2.16” x 5.36”	1.00
18 km	2.77” x 5.41”	1.04
15 km	2.92” x 5.44”	1.06
12 km	3.44” x 5.55”	1.11
10 km	3.94” x 5.67”	1.15
8 km	4.77” x 5.82”	1.23
7 km	5.38” x 5.92”	1.27

Comparing with the hybrid configuration beam of 5.37” by 8.44”, we see that producing a beam as round as that of the hybrid configuration requires only a 10 km taper, with a 15% sensitivity loss.

The sensitivity loss of the tapered A configuration could be made up by assigning an additional 30% of time to the observation. The seventeen days in each of three hybrids per configuration could be made up by adding 67 days to the main configurations, approximately the same as the 63 days of hybrid+move time of the current cycle.

In the past, it has been argued that the hybrid is better than the tapered main configuration on the grounds of u,v coverage and sidelobe levels; that one would like the u,v points moved to the area where you need them, rather than just weighting them away. I rather think this point loses much of its force in the era of wide bandwidths and multifrequency synthesis.

There remains one additional point – a psychological one. Observers will not casually throw away their extra thirty percent of data. This is a good thing. They will make maps using all their data, and extract whatever is in the data. But I suggest that for presentation and publication purposes, one often wishes to force the data to make a round beam. The software to accomplish this needs a little thought. Doing something simple, like restoring with a round clean beam, may have repercussions on the photometry of the resulting image. In at least one case, though, I would argue that simply discarding the extra resolution north-south is the right thing to do. This is the case of surveys – maintaining uniformity in the product images is more important than the discarded information.

The bottom line is that doing without the hybrid configurations would not have much impact on the VLA scientific productivity.