Note: Changes to the CLBA design are being considered that may make this out of date, RCW.

CLBA Memo No. 16

JOINT NORTH AMERICAN ARRAYS

A Configuration Study for the CLBA Planning Committee

VLB ARRAY MEMO No. 331

The object of the configuration study reported here is to explore the 'joint operation' of various long-baseline arrays of Canadian and U.S. antennas. Two extremes of collaboration are considered. One of these is simply use of the presently planned CLBA and VLBA in joint observations with no attempt at optimizing their interaction. The other is optimization of the combined configuration of 19 antennas, without regard to the performance of the individual American and Canadian arrays.

The difference between these extremes seems to be roughly quantifiable, at least in terms of antennas: the nineteen antenna array composed of the CLBA and VLBA (called here array JT1) is approximately equivalent in coverage of the U-V plane to an array of sixteen antennas that is optimized, subject to constraints detailed below. This is the main conclusion of the study. A subsidiary conclusion is that the Canadian and U.S. constituents of an optimized array tend to be, by themselves, poor arrays, even if some attention is paid to their individual performance.

The advantage of the optimized joint configuration is that three antennas could be freed to fill in more completely around the VLA. The scientific value of doing this seems clear (and may be discussed separately by Alan Bridle). Whether it is more realistic to expect to do this by optimizing the two arrays, or in some other way, is a question that wont be addressed here.

1. Site Constraints

In the present study, five of the south-western sites of the presently planned VLBA are assumed to be fixed. Reasons for this are that the sites are either excellent high and/or dry locations at existing institutions, or are close to the VLA, providing trans-VLA/VLBA baselines. In the latter case, if other sites were chosen, they would have to be equally close to the VLA and would therefore result in no significant difference to the distribution of longer baselines.

The Hawaiian site is also taken as a fixed U.S. station. Because this is a high altitude site suitable for mm wavelengths and because it provides the longest baselines of the VLBA, informal advice from U.S. astronomers is that (understandably) it would be surrendered to non-U.S. operation only with great reluctance, if at all. Unfortunately, Hawaii is also a good site to combine with antennas in Canada. What is lacking in a two-dimensional Canadian array (such as needed to optimize a joint North-American array) are baselines in the NE-SW direction. We have NW sites that are comparatively mild, and the southernmost dip of the border is of course in Ontario. There are consequently many potential pairs of sites with a NW-SE orientation, but few running NE-SW. An Hawaiian site provides baselines with Canada that are exclusively NE-SW, and therefore tends to complement Canadian geographical features.

2. Baseline 'Projections'

Many configurations were examined in the present study. It was found convenient in comparing different arrays to consider a two-dimensional projection of their baselines, as sketched in Fig. 1. Baselines are resolved into two components: one, the projection onto the polar axis, the other, the projection onto the equatorial plane. Because, with earth rotation, only the length of the projection in the equatorial plan is important, the simplifying suppression of one dimension is possible.

Poor coverage of the U-V plane by baseline tracks seems to be reliably indicated by holes in a plot of projected baselines. Also, the positions of holes show the length and orientation of the baselines that are needed to remedy the deficiency. Not taken into account are the effects of antenna elevation limits at different site latitudes.

3. Snapshot Coverage

A potentially important argument in favor of joint operation of the U.S. and Canadian arrays is the 'snapshot' mode of observation that would be made possible. The total of 19 antennas would provide an instantaneous sample of 171 points in the U-V plane. Although no simulation has been attempted to prove that good images could be obtained, the number of samples approaches that obtained at the VLA, where the technique has been proven. With two snapshots taken at different times, images from the joint array would likely be superior to those currently coming from the VLA: the number of samples would be roughly equal but the VLBI samples would be better distributed on the U-V plane. It may be worth emphasizing that with either VLBA or CLBA alone, there are only about one quarter as many baselines as in a joint array - almost certainly too few for snapshot observations. Some plots of the instantaneous distribution of baselines are included in this report.

It is interesting to note that observing time for a snapshot observation could easily be equal to or shorter than the coherence time of the array. The sensitivity for this mode of observation would therefore be comparable to that of the VLA, especially with 32-m diameter antennas at the CLBA sites.

4. Specific Arrays: The CLBA and VLBA

One extreme in joint operation, changing nothing in the present CLBA and VLBA plans, would give two arrays of telescopes at sites listed in Table I. Projected baselines for the individual arrays are

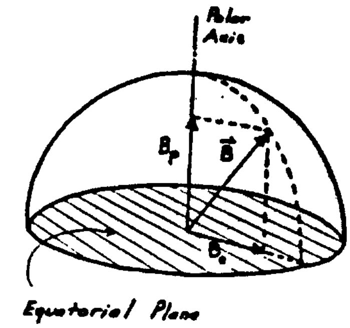

Fig. 1 Baseline projections onto polar axis & equatorial plane

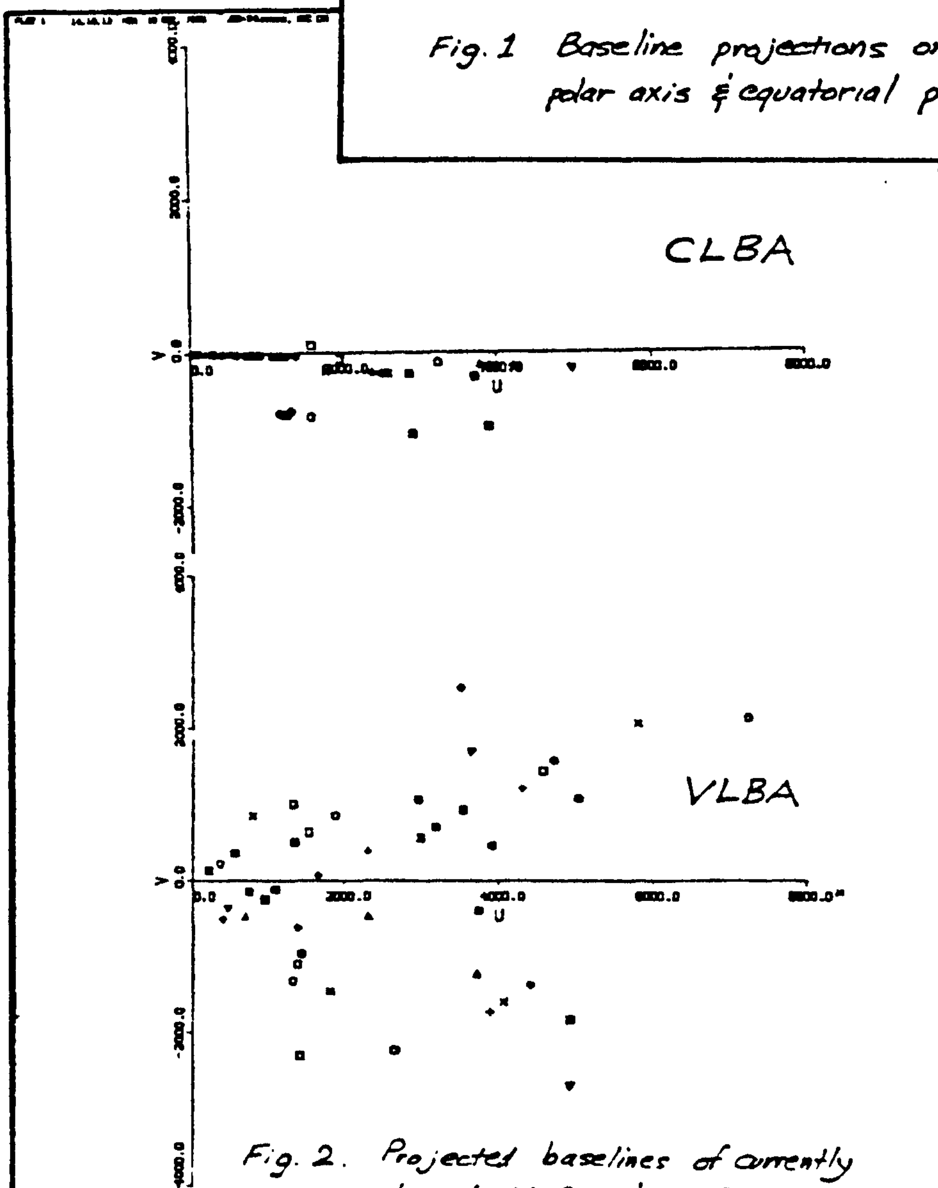

Fig. 2. Projected baselines of currently planned VLBA & CLBA.

TABLE I

Site Locations for Array JT1

CLBA (array J3M)

	Long	Lat
Holyrood, Nfld	53.11	47.36
Ste-Agathe, Qué.	74.13	46.03
Winkler, Man.	97.95	49.16
Limerick, Sask.	106.26	49.50
Admiral, Sask.	108.04	49.57
Eastend, Sask.	109.03	49.62
Lethbridge, Alta.	112.99	49.77
Campbell River, B.C.	125.74	50.25
Yellowknife, N.W.T.	114.50	62.47

VLBA

Arecibo	66.75	18.34
Haystack	71.49	42.43
Iowa	91.57	41.58
Ft. Davis	103.95	30.47
Las L2	106.27	35.81
Pietown	108.14	34.33
Kitt Peak	111.60	31.96
OVRO	118.28	37.05
Wenatchi	120.30	47.40
Hawaii	155.50	19.80

TABLE II

Site Locations for Array JT11

Canadian operated stations:

	Long	Lat
Arecibo, P. Rico	66.75	18.34
St. John, Nfld	52.70	47.70
Gatineau, Qué.	≈ 76.00	45.2
Trenton, Ont.	≈ 78.00	43.7
Windsor, Ont.	≈ 83.00	42.00
Fort William, Ont.	≈ 90.00	48.00
Saskatoon, Sask.	107.00	52.50
DRAO, B.C.	119.62	49.32
Yellowknife, N.W.T.	114.50	62.40

U.S. operated stations:

(Iowa)	91.57	41.58
Ft. Davis	103.95	30.47
Las L2	106.27	35.81
Pietown	108.14	34.33
Kitt Peak	111.60	31.96
OVRO	118.28	37.05
Hawaii	155.50	19.80

... plus three stations close to the VLA.

shown in Fig. 2. On the scale shown here, the strength of the CLBA, good sampling over a wide range of baseline lengths, is not obvious.

Projected baselines for the combined array (JT1) are shown in Fig. 3. There is clearly an impressive improvement in this distribution over that from either array alone. Inefficiency is obvious in JT1 however, where the predominantly E-W alignment of the CLBA leads to strong concentrations of samples along E-W lines.

A snapshot distribution of baselines for JT1 is shown in Fig. 4 for a source at 45° declination and transiting the meridian at 90° longitude. Full U-V tracks for JT1 are shown in Fig. 5, again for dec=45°. In the event that arrays were built in both Canada and the United States, these plots clearly illustrate that joint operation would be very worthwhile, even with no effort whatever at optimizing their joint configuration.

5. Optimized Joint Arrays

The U-V tracks of JT1 evidently give entirely adequate coverage of the U-V plane, at least over the range ≈ 70 to 5000 km. Similar coverage can be obtained more economically, and in this sense the joint array 'optimized', if the predominantly E-W orientation of the Canadian antennas is modified. There are many configurations that give much the same baseline distribution; the site locations are not strongly constrained.

An example of a more economical joint array is JT11 which has Canadian antennas at the relatively accessible locations listed in Table II. The Arecibo site is here assumed to be part of the Canadian-operated array. Other south-eastern locations that were investigated, and which give similar results, were Bermuda and Trinidad. The latter site gives some improvement in U-V sampling but would likely be more difficult to maintain than Arecibo. A more substantial improvement is provided by a site at Quito, Ecuador, a possibility suggested in an early VLBA memo.

The projected baselines of JT11, plotted in Fig. 6, are well distributed and generally similar to those of JT1. They are produced however, by 16 antennas instead of 19. Full U-V tracks for JT11 are shown in Fig. 7 and those for the individual Canadian (C12A) and U.S. (VLB7) components of JT11 are shown in Figs. 8 and 9. The arrays are complementary and the coverage of either alone is poor. This situation is improved somewhat if the sites at Hawaii and Arecibo are traded.

T.H. Legg
February 06, 1984

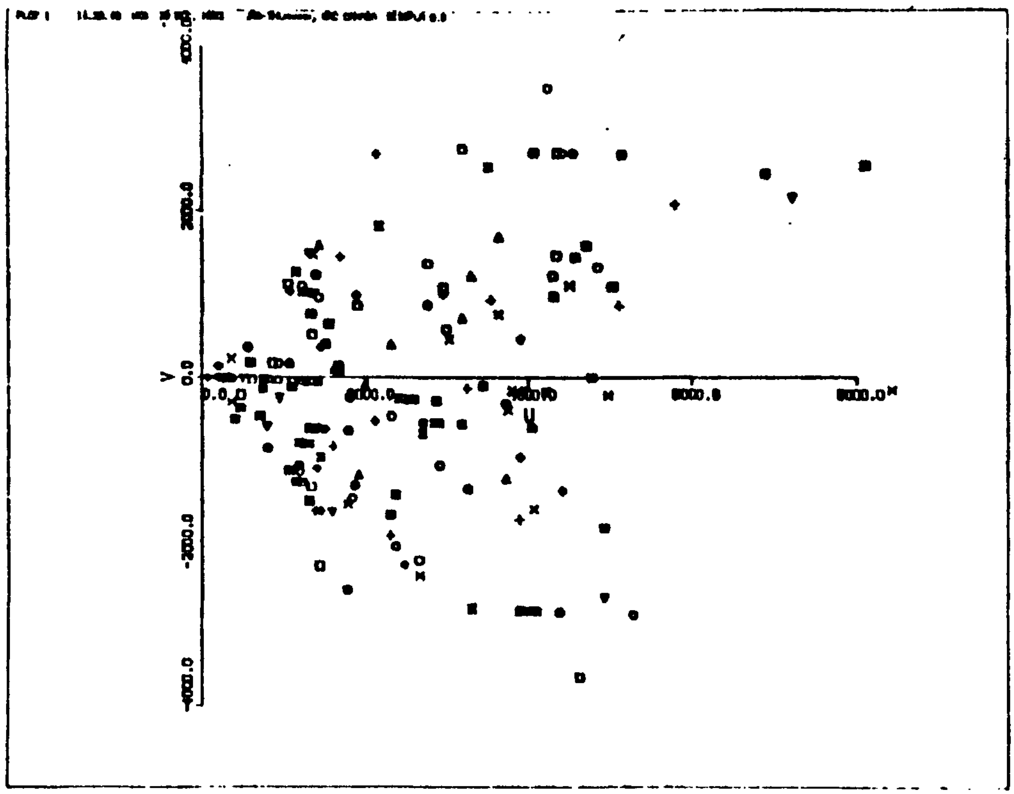

Fig. 3 Projected baselines of joint array JT1 (VLBA + CLBA)

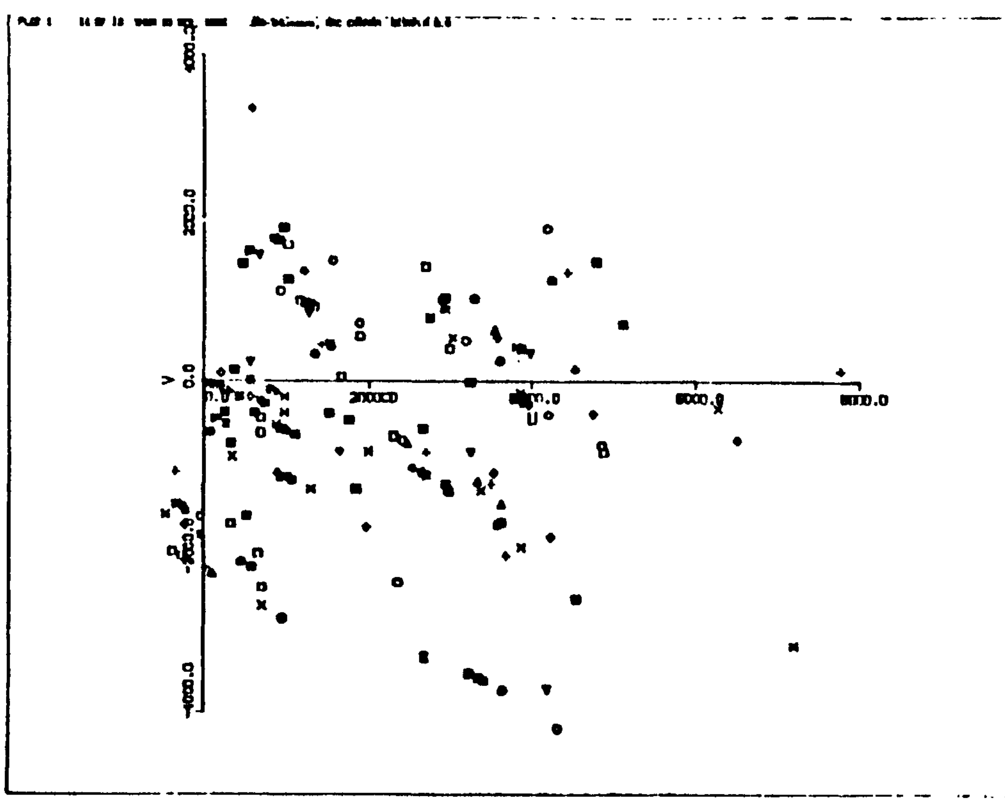

Fig. 4 'Snapshot' baseline distribution for JT1. Dec = 45°

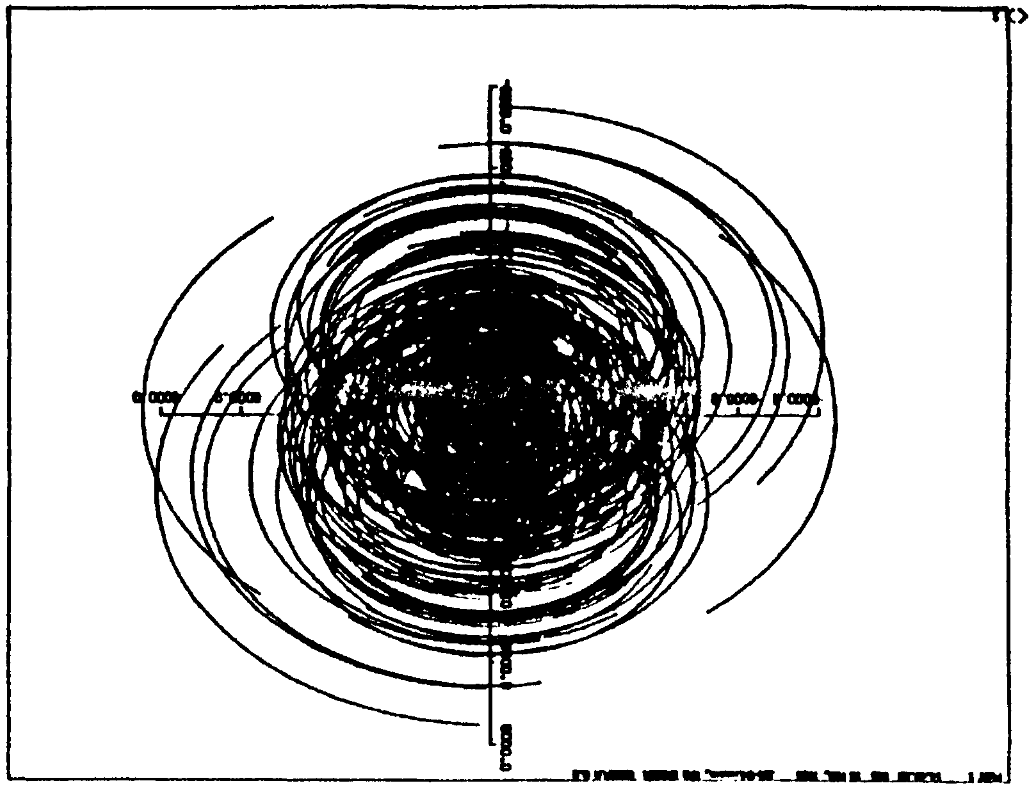

Fig. 5 U-V tracks for JT1, Dec = 45°

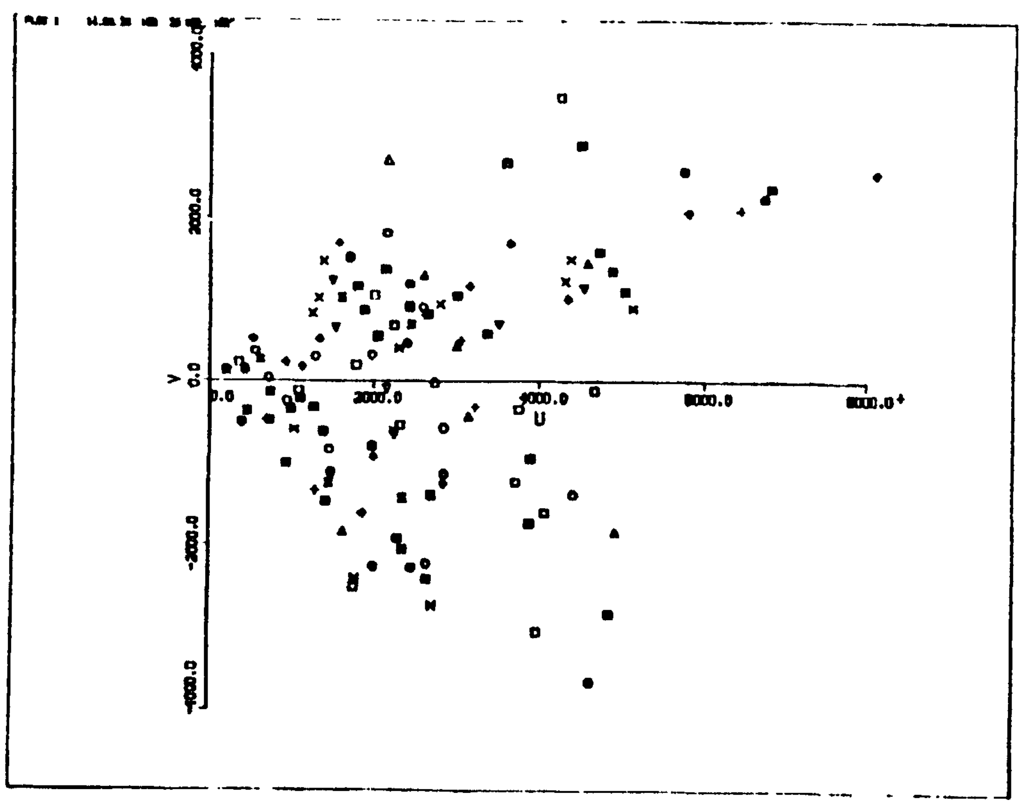

Fig. 6 Projected baselines, JT11

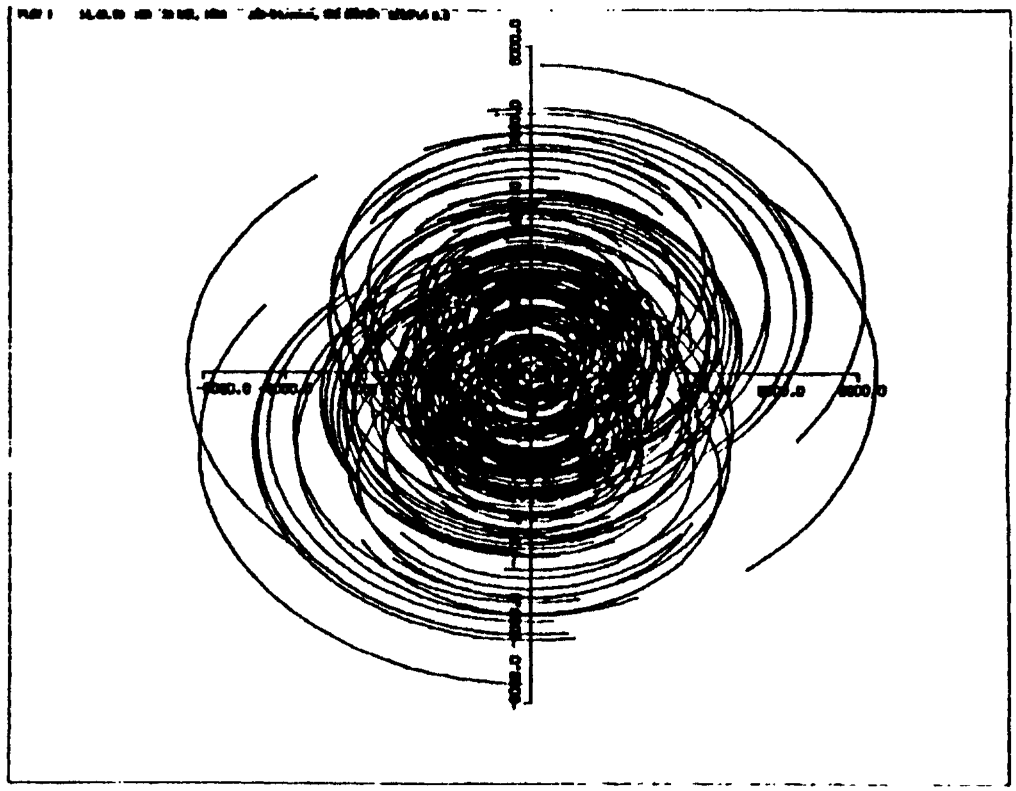

Fig. 7 U-V tracks for JT11, Dec = 45°

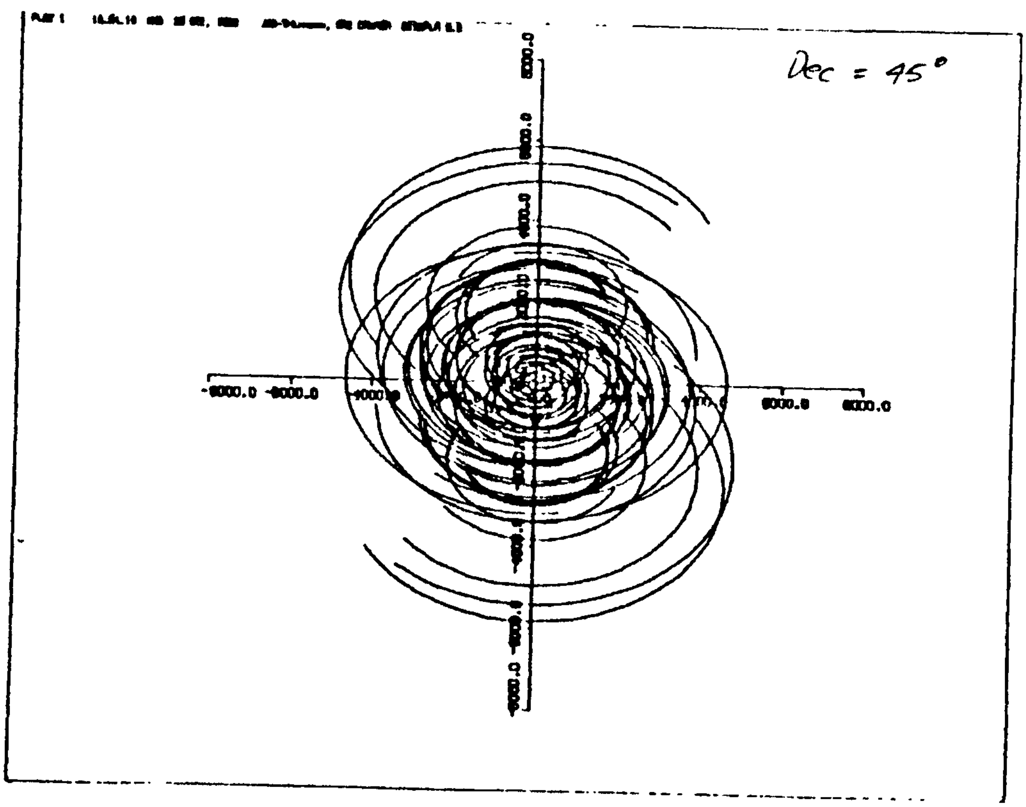

Fig. 8 U-V tracks for the Canadian part of JT11 (C12A).

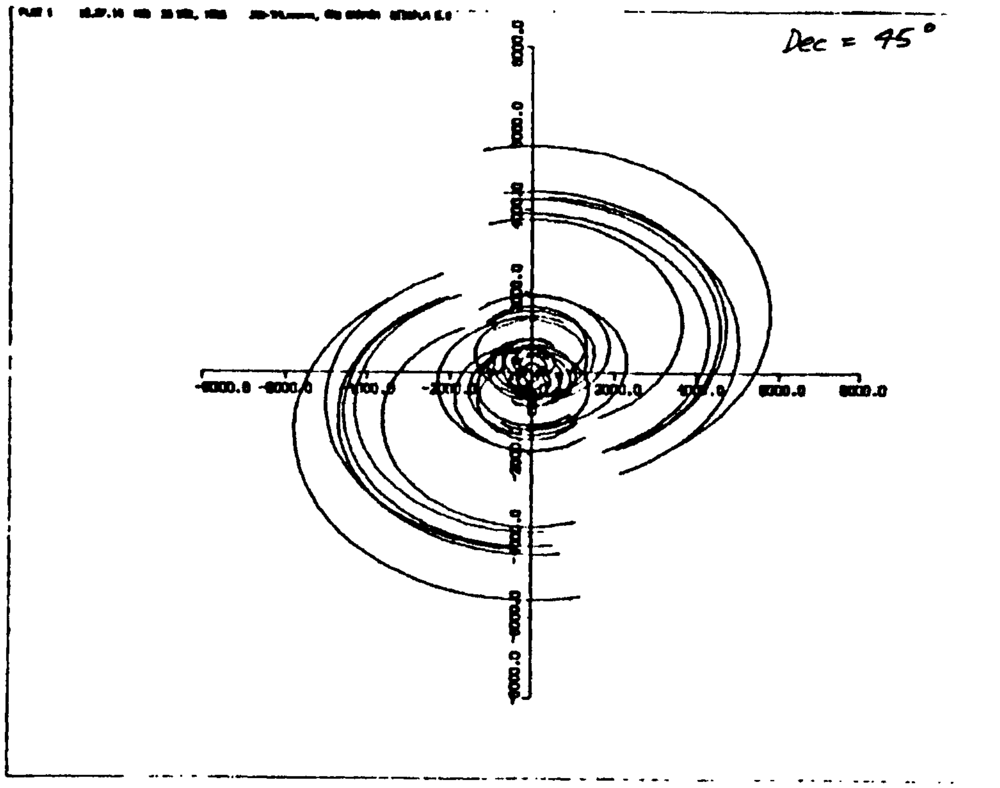

Fig. 9 U-V tracks for the U.S. part of JT11 (VLB7).