VLA SCIENTIFIC MEMORANDUM #148

"UT1 AND POLAR MOTION STUDIES FROM THE 1982 A CONFIGURATION BASELINES"

BY

R. SRAMEK

July, 1983

I. Introduction

The VLA was in the A configuration from January to June 1982. During that period, after the initial array set up, we had 8 baseline observing runs to monitor the array antenna positions (Table I). Each observing run typically lasted about 4 hours and included 50 phase measurements at 6 cm observing wavelength of about a dozen calibrators. Ant 17 at station W8 was always used as the reference antenna.

During the A configuration observing, it was noted that the antenna positions as given by BASFIT changed by as much as 100 psec on time scales of weeks, with the largest changes associated with antennas at the ends of the array arms. Antenna positions derived from the 8 baseline observing runs were used to study these variations.

TABLE I

Earth Rotation Angles from
A Configuration Baseline Observations

DAY	DATE	x	y	UT1-UTC
1	82 FEB 09	-".008	".091	".289
2	FEB 13	.022	-.077	-.124
3	FEB 19	-.052	.028	-.007
4	MAR 13	.090	.061	.083
5	APR 07	-.119	.079	-.051
6	APR 25	.091	.008	-.149
7	MAY 18	.017	-.170	.041
8	JUN 05	-.045	-.023	-.072

(NOTE: all angles are relative to the values adopted at the VLA on the date of observation)

II. Solving for Rotations

Let $\underline{B}_i$ be the reference position vector for the ith antenna, and let $\delta\underline{B}'_{ij}$ be the measured vector displacement of antenna i on day j, relative to $\underline{B}_i$.

A set of zero mean displacement vectors $\delta\underline{B}_{ij}$ were used in the analysis,

$$\delta\underline{B}_{ij} = \delta\underline{B}'_{ij} - \langle\delta\underline{B}_{ij}\rangle_j$$

The dispersions of the displacement vector components $\langle\delta\underline{B}^2_{ij}\rangle^{\frac{1}{2}}_j$ as a function of antenna distance from the array center are shown in Fig. 1. The observed increase in the dispersion for long baselines could arise from either worse phase stability on the longer baselines, or from apparent rotations of the array due to UT1 and polar motion errors, software errors, or large scale atmospheric refraction. The Earth orientation angles were calculated to determine whether the antenna displacements were random or if they arose from coherent rotations of the array.

A rotation of the array is modeled by

$$\delta\hat{\underline{B}} = E\,\underline{B} \quad ,$$

where E is the infinitesimal rotation matrix

$$E = \begin{matrix} 0 & -t & -x \\ t & 0 & y \\ x & -y & 0 \end{matrix}$$

where t is UT1 - UTC, and x and y are polar motions along the VLA meridian at longitude, λ_{VLA}, and along $\lambda_{VLA} + 90°$. A positive angle x corresponds to the pole of rotation moving along longitude λ_{VLA}, relative to the pole of figure (fixed on the surface of the earth).

The Earth orientation angles were solved for each day by a least square fit to the displacement vectors, minimizing

$$L_j = \Sigma_i\ (\delta\hat{\underline{B}}_{ij} - \delta\underline{B}_{ij}) \cdot (\delta\hat{\underline{B}}_{ij} - \delta\underline{B}_{ij}).$$

A necessary condition for a solution is that there be at least two non-parallel $\underline{B}_{ij}$. The sixteen longest baselines were used for each solution.

The measured rotation angles are given in Table I. These values are relative to the values of x,y, and UT1 used at the VLA on the day of observation. The x and y values have been rotated to the longitude 0° and 90° coordinate system.

The vector dispersions of Fig 1 are replotted in Fig 2 with the measured Earth rotations removed. The dispersions on the longest baselines were reduced from about 30 or 40 psec to about 10 psec, and the dispersions are fairly constant with baseline length. Most of our baseline problems are the result of array rotations, and a major cause of the rotations are errors in the UT1 we use.

The average differences between x, y, and UT1 used at the VLA and the BIH final value for the eight baseline runs are given in table II. The values used at the VLA are taken from the BIH Rapid Service. For UT1 we extrapolate the rapid service values forward about 2 weeks, and for x and y we simply adopt the 2 week old values. If we had used the USNO smooth prediction of the BIH values we would have improved the dispersion of our timing error by nearly a factor of three, from 8.9 msec to 3.4 msec.

The VLA is currently using the USNO smooth prediction with the added improvement that we use a dial up line to the USNO computer to get these parameters, thus reducing the minimum extrapolation period from 10 days to about 4 days.

Table II - Average Earth Rotation Parameter Errors

	VLA Adopted minus BIH final	USNO prediction minus BIH final
x	-"050 (.016)	-"025 (.016)
y	"017 (.014)	"015 (.019)
UT1	^{s}0025 (.0089)	^{s}0034 (.0034)
	"037 (.134)	"051 (.051)

III. The Earth Orientation Angles

The Earth orientation angles derived at the VLA and the USNO final values are shown in Figs. 3 and 4. All angles are relative to the BIH final values as reprinted in USNO Series 7. The VLA results have been adjusted to zero mean with respect to the BIH since an arbitrary mean displacement was removed from each antenna.

Our UT1 measurements in Figure 3 agree quite well with the BIH values, with an rms difference of 0.036" (2.4 ms). The USNO final values diverge from the BIH from January to June 1982, a trend which we do not see.

Fig 4 shows the VLA measurements of x and y, rotated to the longitude 0°, 90° coordinate system. Both x and y have a dispersion of about 0".075, twice that of our UT1 measurements. This is due mostly to the large values of x on day 5 and y on day 7. These anomolous rotations of over 0.1 arc-second may be due to large scale atmospheric refraction, which could limit the accuracy of VLA polar motion measurements.

The USNO x and y final values agree very well with the BIH values, and have a dispersion of less than 0".01. The VLA results would surely be improved by averaging repeated measurements, but it's not clear if we could improve on this level of accuracy.

RS/bmg
7/7/83

FIG. 1

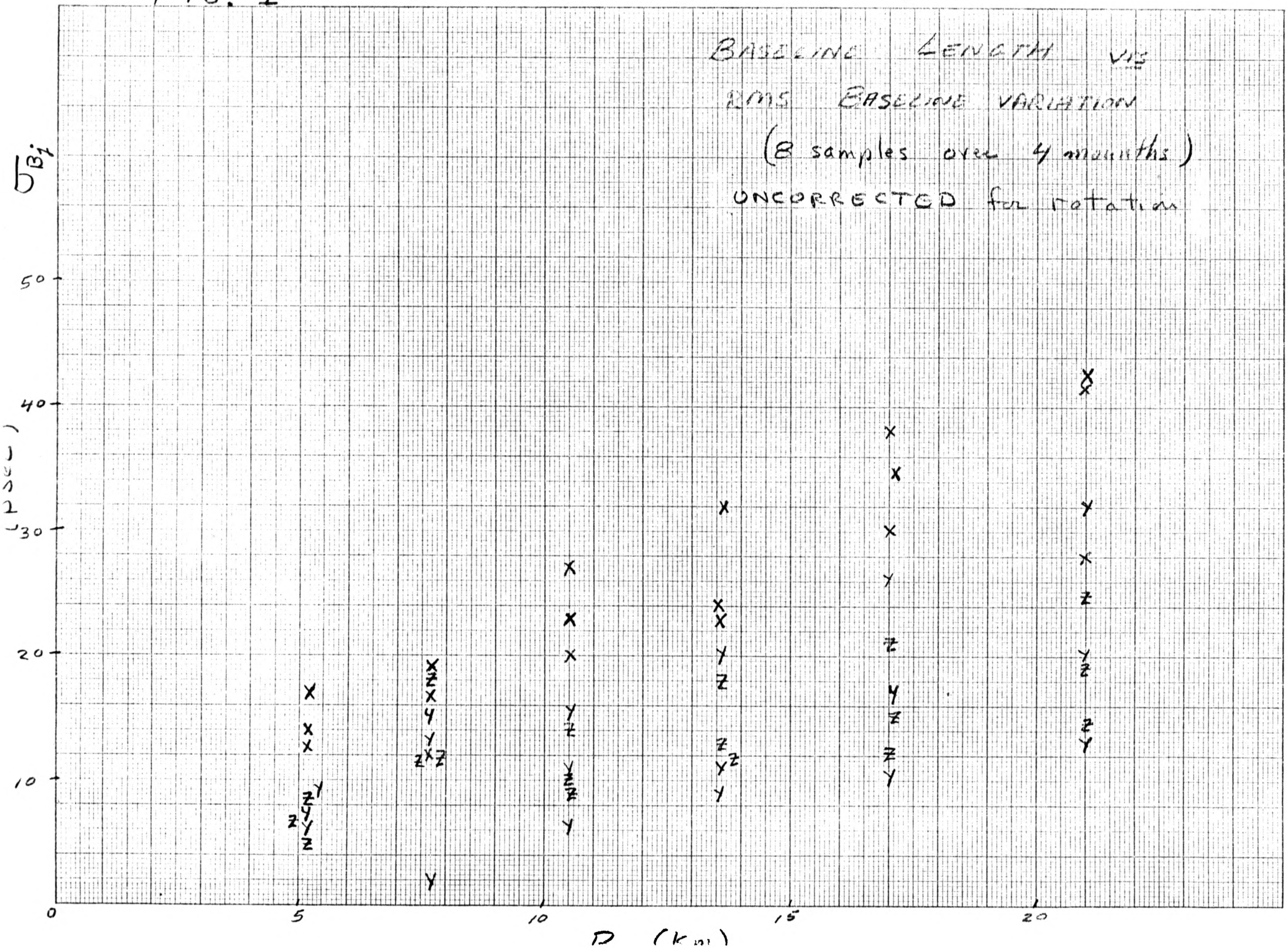
BASELINE LENGTH VS
RMS BASELINE VARIATION
(8 samples over 4 months)
UNCORRECTED for rotation
σ_{B_i}
(nsec)
50
40
30
20
10
0
5
10
15
20
D (km)

FIG. 2

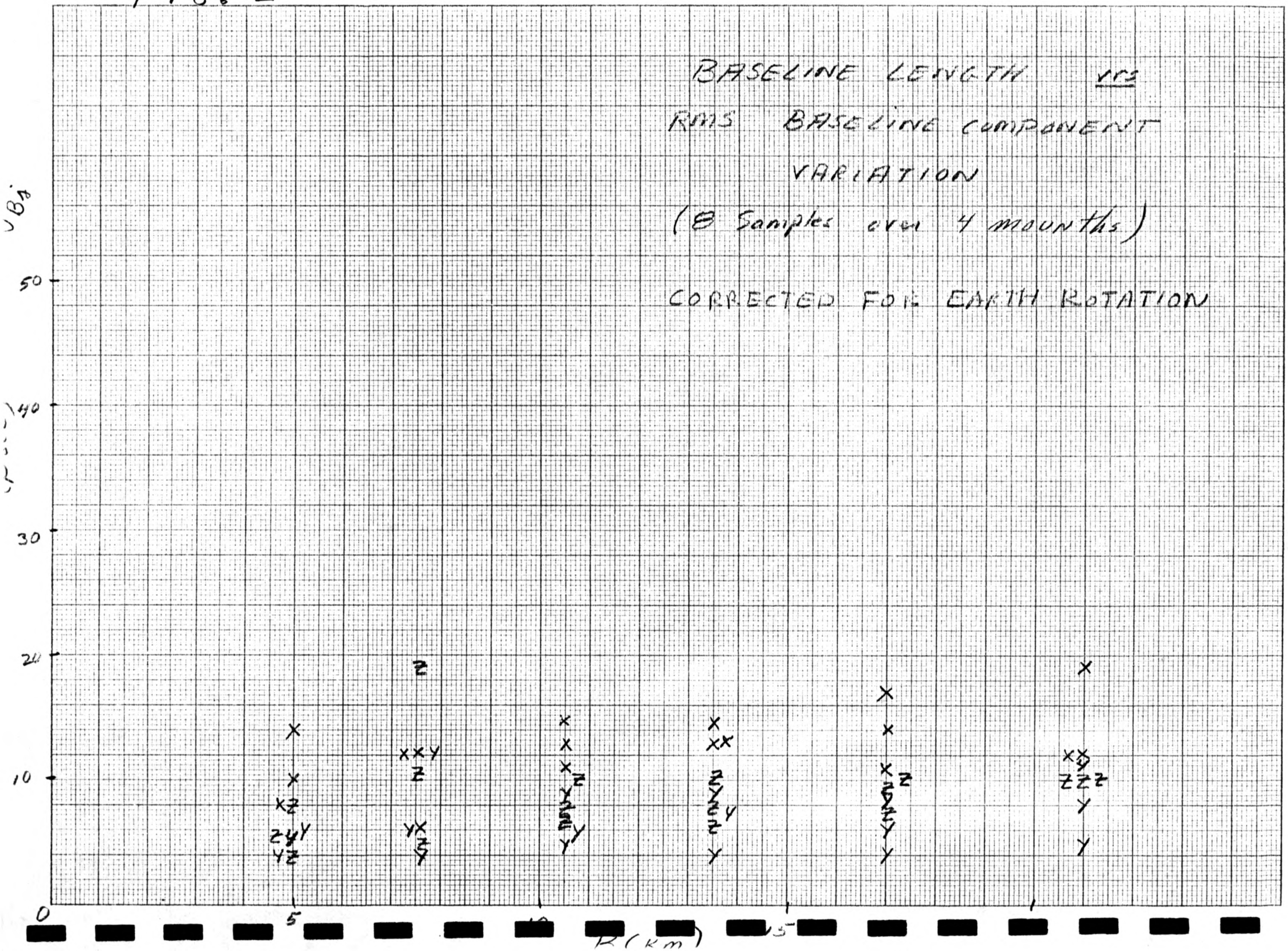
BASELINE LENGTH vrs
RMS BASELINE COMPONENT
VARIATION
(8 Samples over 4 mounths)
CORRECTED FOR EARTH ROTATION
50
40
30
20
10
0
5
R(km)

FIG. 3

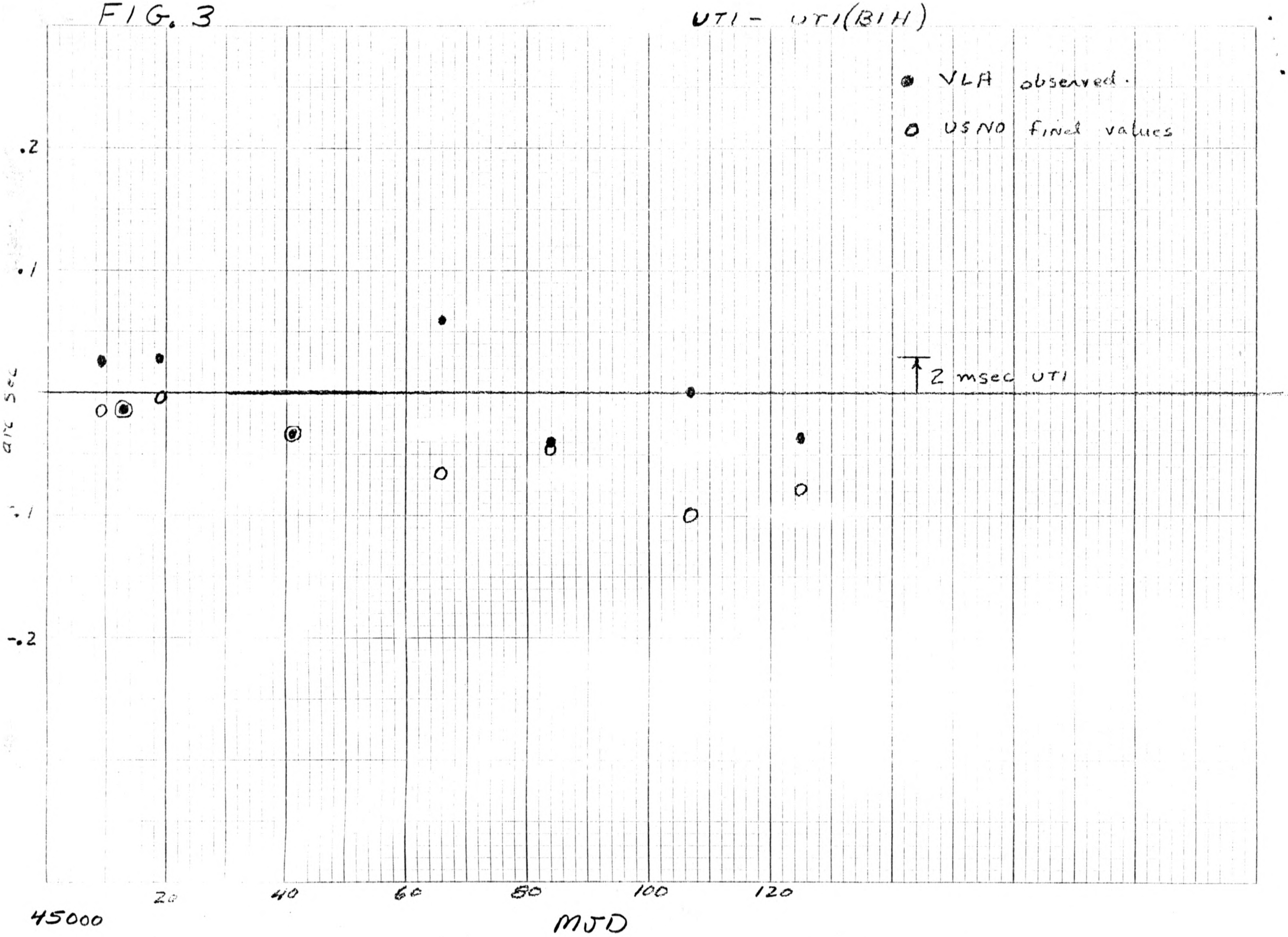
UT1 - UT1(BIH)
VLA observed.
USNO final values
2 msec UT1
.2
.1
-.2
arc sec
20
40
60
80
100
120
45000
MJD

FIG. 4

Polar Motion - BIH (final)