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JPL Radar Range and Doppler Observations of Venus, 1961–1966

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Abstract

The JPL radar doppler observations of Venus taken during the inferior conjunctions of 1961, 1962, 1964, and 1966 and the radar range observations taken in 1964 and 1966 have been reduced from about 35,000 actual observations to 1179 compressed data points. This compressed data is presented along with a brief discussion of the observations.

I. INTRODUCTION

D. A. O'Handley
Jet Propulsion Laboratory

Venus radar data was taken over the period 1961–1966. The material in this Report represents the current set of Jet Propulsion Laboratory (JPL) data used in evaluating the orbital elements of Venus. The doppler data taken over the period 1961–1966 are maintained in our files; capability, for its use in determining corrections to the orbital elements, exists in the series of programs which simultaneously integrate the motions of the nine major planets. Because of the greater accuracy obtained using the method of planetary-ranging and its greater weight in the process of orbit determination, only the range data is currently used.

The Appendix contains the values of the range data for 1964 and 1965/66. The first 135 points and the data for 1966 are reduced by the method described in Chapter 3 of this Report.

An error was found in the digital logic originally used to process part of the 1964 JPL range data.[1] The range data during period from day 190 to the end of the 1964 range period, day 213, were affected. D. O. Muhleman reprocessed this part of the data by desk calculator. Those points having an asterisk to the right of the Julian Date were so processed. The corrections are reported to be on the order of ± 50 μsec. There were 31 fewer points and 81 points in error, from the original processing.

A more complete description of the basic techniques used during this series of observations can be found in Ref. 1.

These data contained in this Report are available on punched cards. There are two notes with regard to the data contained on the cards:

1. These data are in the standard format adopted by the Informal Working Group for Ephemeris Development, Ref. 2
2. The standard deviation σ_b given on the cards is ± 20 μsec. This standard deviation is discussed in Section II

Requests for this JPL data should be directed to the Systems Analysis Research Section, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91103, attn: Douglas A. O'Handley.

[1]Lawson, C. L., and Holdridge, D. B., Compression of JPL Venus Radar Data, JPL Section 314 Technical Memorandum 155, Jet Propulsion Laboratory, Pasadena, Calif., February 3, 1967.

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II. DESCRIPTION OF THE JPL RADAR RANGE AND DOPPLER OBSERVATIONS OF VENUS

D. O. Muhleman
California Institute of Technology

A. Introduction

The Jet Propulsion Laboratory of the California Institute of Technology has periodically carried out radar observations of Venus from March 1961 to the present. In particular, an observational period of several months centered around each succeeding Venus inferior conjunction has been covered. The data are summarized in Table 1. Observations were made at the various facilities of the NASA/DSN Goldstone Deep Space Radio Tracking Station located at Goldstone, California. Different antenna systems were employed whose coordinates are listed in Table 2. Their pertinent system characteristics are discussed briefly below.

This Report presents the observed values of the doppler velocity frequency shifts and the propagation time (range) measurements. There are approximately 35,000 separate observations in all which have been compressed to a series of *normal points* for the purposes of this publication. The associated statistics on each normal point have been computed formally using conventional statistical techniques and are entirely based on the intrinsic data noise. The true uncertainties in the observations are caused by many factors some of which are:

1. Propagation effects in the interplanetary medium and the Venusian atmosphere; these are believed to be extremely small owing to our use of a very high frequency
2. Errors in the radar calibrations, oscillator settings, and the like; however, all possible care has been taken to minimize the possibility of errors
3. The essentially unknown effects of the surface of Venus on the planetary echo due to surface roughness and variations in such roughness as a function of the Venusian longitude of the subradar point
4. The unknown effects of the various radar-system transfer functions which have not been removed by the calibration procedures
5. The intrinsic data noise caused by sampling signals whose signal-to-noise ratios are finite and, in some cases, actually small.

Table 1. Summary of JPL Venus radar data

Data	Actual data tape identification	Minimum and maximum run lengths, sec	First observation date	Conjunction date	Last observation date	Number of data points	Number of runs	Number of compressed data points
1961 DOP[a]	N6184	360 34670	1961 March 23 243 7381.5	1961 April 11 243 7400.5	1961 May 10 243 7429.5	12865	34	285
1962 DOP	N6181	280 6670	1962 October 11 243 7948.5	1962 November 12 243 7980.5	1962 December 15 243 8013.5	7679	54	261
1964 DOP	N6722	160 19870	1964 May 3 243 8518.5	1964 June 19 243 8565.5	1964 July 26 243 8602.5	10179	51	320
1966 DOP	N6192	3350 5080	1966 January 16 243 9141.5	1966 January 26 243 9151.5	1966 February 24 243 9180.5	1139	6	43
1964 RNG[b]	N6183	1647 5622	1964 May 25 243 8540.5	1964 June 19 243 8565.5	1964 July 31 243 8607.5	1081	44	250
1966 RNG	N6189	1260 2820	1965 December 15 243 9109.5	1966 January 26 243 9151.5	1966 February 22 243 9178.5	98	6	20
					Totals	33041	195	1179

[a]Doppler
[b]Range

Table 2. Station parameters for Venus data

Parameter	Data
Transmitter frequency	2388×10^6 Hz exactly
1961 Data	
Transmitter radius	6372.0362 km
Transmitter geocentric latitude	35°.119983
Transmitter East longitude	243°.195194
Receiver radius	6372.0355 km
Receiver geocentric latitude	35°.206019
Receiver East longitude	243°.151750
Data after 1961	
Transmitter and receiver radius	6372.2599 km
Transmitter and receiver geocentric latitude	35°.066620
Transmitter and receiver East longitude	243°.205070

The statistics reported here are primarily a measure of factor 5, above. The observations may be used to study the basically interesting problems of factors 1 and 3. Unfortunately, very little can be said concerning 2 and 4, in that all possible care has previously been taken to minimize their importance. Indeed, we know from our extensive experience in using the actual observations in computations of the Astronomical Unit (AU) and corrections to the orbital parameters of the Earth and Venus[2] that the standard deviations reported here are optimistic, in some cases by over an order of magnitude. We have carefully avoided making "engineering estimates" of the effects of factors 1 through 5, since we believe that the true statistics are best obtained a posteriori in celestial mechanical calculations with the data.

[2]See Ref. 3–5.

B. Observational Methods

The particular characteristics of each data type will be discussed in chronological order. In all cases the basic transmission frequency was exactly 2.388×10^9 Hz (cycles per second) to within the stability of the fundamental oscillators.

1. 1961 doppler observations. The observations were made using a transmitting antenna and a receiving antenna separated by about 8 km. The details of the complete system are given in Ref. 6 and 7. Since the transmitting and receiving systems were isolated electronically it was possible to continuously illuminate Venus and to simultaneously receive the radar echo. A pure monochromatic signal at 2338 MHz was transmitted. The returned signal was spread in frequency by amounts varying from about 40–80 Hz, depending on the Earth-Venus geometry, apparently symmetrically about the doppler-shifted center frequency. The frequency spreading was caused by the differential doppler shifts arising from the rotation of the planet relative to the Earth station. Consequently, the echo signal was no longer monochromatic and it was necessary for the radar receiver to automatically find the center frequency of the echo spectrum.

The center frequency, of course, is the doppler shifted frequency corresponding to the relative motion of the center of mass of Venus.

The shape of the echo spectrum is determined by the Venusian-surface radar backscatter law, Ref. 8. It can be shown that the spectrum width at the half-power point is never greater than about 8 Hz at our frequency. Consequently, the doppler signal was successfully tracked using a phase-locked tracking loop with a 10-Hz bandwidth. The doppler measuring system is shown very schematically in Fig. 1. The tracking loop was designed to detect a monochromatic signal in the presence of white noise and it is necessary to assume that the loop yields an unbiased measurement of the center frequency of the Venus echo spectrum. The raw data was sampled at rates of either 1 sample/2 sec or 1 sample/10 sec and exhibited an rms deviation from the mean of from ± 1 to ± 4 Hz depending on the signal-to-noise ratio.

A fundamental limitation on the accuracy of these data was the frequency stability of the master oscillator during a round-trip propagation time. The oscillator used was an Atomichron which in the laboratory demonstrated a stability of about 0.2 Hz (at 2388 MHz) for these time intervals. No statistical model for this instability exists and it is *not* clear whether or not this error is random from run to run (day to day). One must be wary of assuming that this error will be reduced according $N^{-1/2}$ for a a large number of samples, N. No other free-running oscillator existed in the system.

2. 1962 doppler observations. A single transmit/receive antenna system was used; see Table 2. Consequently, it was necessary to alternately transmit the radar signal for the (variable) Earth-Venus round trip propagation time followed by a receive interval of the same length. The doppler measurement system was the same as that used in 1961. This mode of operation apparently yielded somewhat reduced measurement accuracy.

3. 1964 doppler observations. The same procedure as that of 1962 was employed with approximately a factor-of-10 improvement in signal-to-noise ratio. A full factor-of-10 improvement in accuracy was not realized since the data noise is practically limited by the intrinsic Venusian spectral broadening. The master-oscillator instability was reduced to about 0.05 Hz.

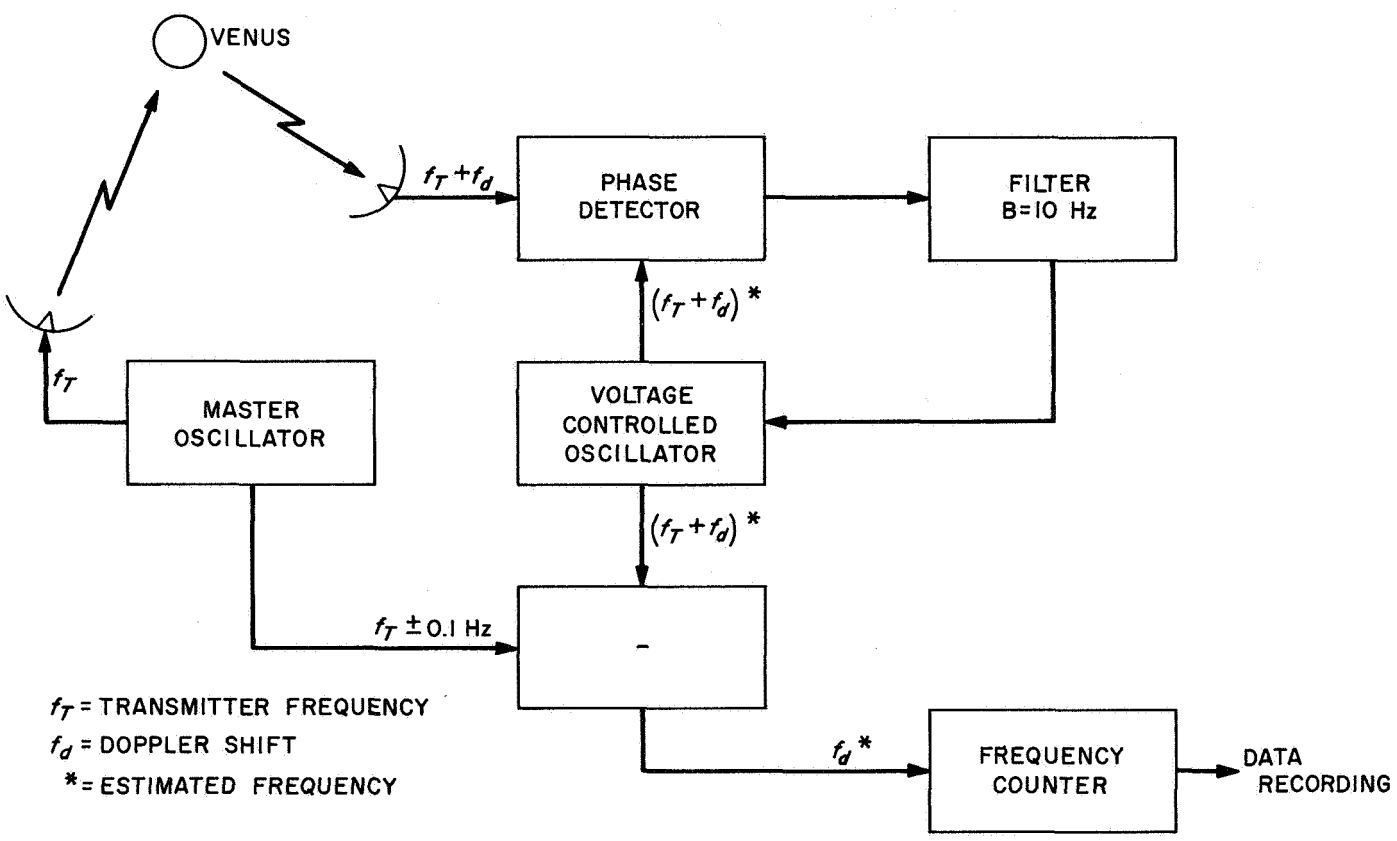


Fig. 1. Schematic block diagram of 10-Hz doppler tracking loop

4. 1966 doppler observations. The same radar facilities as in 1962 were utilized but the doppler was not measured with an automatic-tracking closed-loop system. An ephemeris-controlled local oscillator was used to remove the ephemeris-predicted doppler shift and the difference in the true doppler from the predicted instantaneous value was measured in the manner of Fig. 1. The ephemeris predicted values were then added digitally to these differences to obtain the estimates of the true doppler shifts. Some degree of "system coherence" was lost in this way but no statistical model exists for this error source. The master oscillator instability was about 0.05 Hz at 2388 MHz.

5. 1964 and 1965-66 range observations. The propagation time from the receiver to Venus and back to the transmitter was measured unambiguously using the continuous wave system coherently phase modulated with discrete 90-deg phase shifts according to a pseudorandom code sequence. The propagation time was measured by cross-correlating the echo signal with the delayed code sequence. The details of this system and the calibration data analysis have been reported by Tausworthe, Ref. 9. The fundamental period of "range gate" width was 125 μsec and the range could be resolved to approximately 10% of this value. The system was ephemeris-assisted and basically measured the difference between the true range and the ephemeris-predicted value.

The range measurements consisted of two separate procedures. For each day's observations, called a run, the system was calibrated by offsetting the range gate in "front" of the planet and sequentially stepping the range gate onto the planet to trace out the planet response. It was then possible to compute the range correction in microseconds to the front edge of the planet from a knowledge of the system transfer function and a rough estimate of the planet backscatter function. The procedure yielded an overall rms accuracy of about ± 20 μsec which is the basic range accuracy contained in the observations. After the calibration curve was obtained the system was switched to an automatic tracking mode which essentially tracked on the planetary surface where the echo power was equal in two (differenced) range gates. The tracking mode operated for approximately 1 hr yielding about thirty samples of the range (delay) to this tracking point. The correction to the front edge of the planet was applied using the single value from the calibration mode for the entire run. The standard deviations for the range normal points, listed in Table A-1–A-6 in the Appendix, reflect only this system noise. These standard deviations are good estimates of the relative accuracy between range runs (and should be used accordingly) but are nearly meaningless in terms of the true accuracy. The experience of the authors with the actual data in celestial mechanical calculations indicate that a basic accuracy estimate of ± 20 μsec is reasonable.

Detailed studies of Venus-echo spectra indicate that small asymmetries appear in the spectral shape which move across the spectra at the projected rotational rate of the planet. These asymmetries are apparently caused by surface anomalies. The spectral prominences represent just a few percent of the echo power but do, in principle, affect the doppler and range measurements. Since the rotational period of Venus appears to be related to the orbital periods of both the Earth and Venus, errors of this type would be correlated with the errors in orbital-parameter corrections computed with the data. This error source, however, is infinitesimal compared to the analogous error in optical observations due to the planetary phases.

III. COMPRESSION OF JPL VENUS RADAR DATA

C. L. Lawson and D. B. Holdridge
Jet Propulsion Laboratory

A. Summary of the Data Types

The radar data are of two types: *range* and *doppler*. A range datum is the time interval between transmission of a radar signal to Venus and the reception of the reflected signal returning from Venus. The round trip distance to Venus is approximately 0.5 AU at closest approach and about 0.8 AU 1 mo before or after closest approach. Therefore, the range data lie between 250 and 400 sec.

A doppler datum is a change of frequency in the sense of received frequency minus transmitted frequency. With a transmitted frequency of 2388 MHz the doppler varies from about 2×10^5 Hz 1 mo before closest approach to about -2×10^5 Hz, 1 mo after closest approach.

Due to the daily rotation of the Earth, the range changes by about 0.035 sec and the doppler by about 6×10^3 Hz in the course of a day.

For both range and doppler, the epoch associated with a datum is the epoch of reception of the reflected signal. This epoch was recorded to the nearest second of time according to a clock which was synchronized with radio station WWV. WWV time is an approximation to Universal Time.

B. Data Grouping in Time

As is shown in Table 1, doppler data was taken in 1961, 1962, 1964, and 1966 and range data was taken in 1964 and 1966. During one potential view period (Venus rise to Venus set) the experiment was conducted over an observation period which will be called a run. A typical run would last about 1–2 hr, although, as is shown in Table 1, runs were as short as 160 sec and as long as 9.6 hr.

The 1961 experiments used separate 85-ft antennas for transmission and reception (see Table 2) resulting in observations which were equally spaced in time throughout any run.

The post-1961 experiments used a single 85-ft antenna alternately as a transmitter and a receiver. The transmission was continuing for about 5 min followed by about 5 min of reception. The data gathered during one of these reception periods will be called a burst in this Report. The data compression method described in this Report

was designed to reduce the data collected during each burst to a single representative data point.

Since the runs of the 1961 data do not have any natural subdivisions into bursts, this data was arbitrarily partitioned into bursts of approximately 500-sec duration and each of these bursts was then reduced to a single representative data point.

C. The Construction of Table 3

The JPL planetary radar predictions program, RADAR1, was used to compute tables of range and doppler predictions on a few selected dates near inferior conjunction and one month before inferior conjunction. Polynomial fits to these tables and to subsets of these tables were computed using polynomials of various degrees. From this empirical study, Table 3 was constructed showing the minimum degree polynomial sufficient to fit the range and doppler predictions over various time intervals with maximum fitting errors of 0.1 μsec in range and 0.001 Hz in doppler.

Table 3. Number of coefficients to be used for fit to Venus data

Number of coefficients[a]	Doppler data (good to 0.001 Hz) time interval
4	$T < 2088$ sec
5	$2088 \leq T < 5472$ sec
6	$5472 \leq T < 11772$ sec
7	$11772 \leq T < 17946$ sec
8	$17964 \leq T < 28800$ sec
9	$28800 \leq T < 36360$ sec
10	$36360 \leq T$
Number of coefficients[a]	**Range data (good to 0.1 μsec) time interval**
4	$T < 4140$ sec
5	$4140 \leq T < 10908$ sec
6	$10908 \leq T < 16560$ sec
7	$16560 \leq T < 31968$ sec
8	$31968 \leq T < 38880$ sec
9	$38880 \leq T$

[a]A k-coefficient polynomial is of degree $d' = k - 1$.

D. The Data Compression Procedure

Let t_i, y_i, $i = 1, \ldots, n$, represent the data constituting one run. The total time span of the run is $s = t_n - t_1$. Table 3 is entered with the argument s to determine the nominal degree d', of the polynomial appropriate to represent the physical phenomenon over the time span s.

The polynomial p of degree $d \leq d'$ which best fit the data in the sense of uniformly-weighted least squares was computed. The fitting algorithm used stepwise Jordan elimination and statistical tests similar to the procedure described in Ref. 10. This algorithm avoided solving for coefficients which were of very low statistical significance and thus produced in some cases polynomials whose degree d was less than d'. This algorithm was general in the sense that nothing was assumed regarding the time spacing of the data. Numerical ill-conditioning was avoided by scaling the time span to the interval $[-1,1]$ and using Chebyshev polynomials rather than monomials as the basic functions.

Let $r_i = y_i - p(t_i)$, $i = 1, \ldots, n$, denote the residuals from the polynomial fit. The standard deviation of the data from the polynomial was estimated by

$$\sigma_p = \left(\frac{1}{n-d-1} \sum_{i=1}^{n} r_i^2 \right)^{1/2}$$

If any residuals exceeded $3\sigma_p$ in magnitude those data points were permanently deleted and the polynomial fit was recomputed.

Let r_i, $i = 1, \ldots, m$, denote the residuals in the first burst of the run. If $m \leq 3$, no normal place value was computed for the burst. Otherwise, a mean residual for the burst and a standard deviation of the residuals from that mean were computed:

$$r_b = \frac{1}{m} \sum_{i=1}^{m} r_i$$

$$\sigma_b = \left[\frac{1}{m-1} \frac{1}{m} \sum_{i=1}^{m} \left(r_i - r_b \right)^2 \right]^{1/2}$$

A normal place epoch, T, for the burst was selected by rounding the midpoint, $\frac{1}{2}(t_m + t_1)$, to the nearest second. The normal place value was computed as $y = p(T) + r_b$. The standard deviation associated with y was σ_b.

The procedure described in the above paragraph was repeated for each burst within the run, producing a triple of quantities; T, y, σ_b for each burst.

These final normal place quantities were recorded on punched cards, as described in the appendix.

Appendix
Compressed JPL Radar Data

I. Compressed Data Cards

The entire set of cards containing the compressed data is presented in Tables A-1 through A-6. The cards are separated into six data sets corresponding to the six rows of Table 1. The last card of each data set in these Appendix tables contains checksums for each of the first six fields.

Field 1 contains the run identification number. This number is also called a file identification number in some documentation. Fields 2 and 3 together give the Universal Time (UT) epoch for each compressed datum. Note that the Reference Julian Date is kept constant throughout any single run with the result that the numbers in Field 3 exceed 86400 sec (= 24 hr) in some cases.

Fields 4, 5, and 6 contain the quantities respectively called y, σ_b, and m in the preceding discussion, in Section III of this Report. Field 7 distinguishes between DOPPLER, RANGE, and CHECKSUM cards. Field 8 contains a card sequence number.

II. Data Cards for Distribution

The format of the data card distributed upon request is described fully in Ref. 2. A partial copy of relevant sections will be sent with the distributed decks.

This format has been agreed upon by the Informal Working Group for Ephemeris Development, which consists of members from NASA, U.S. Naval Observatory, Naval Weapons Laboratory, and Jet Propulsion Laboratory.

III. Explanation of Residual Plots

A residual plot was prepared for each of the runs. A selection of three plots each for the six data sets is included in Fig. A-1–A-18. On the figures, asterisks represent residuals, called r in the Report, and circles represent compressed residuals, called r_b. The quantity labeled S.D. DATA is the quantity called σ_p in the Report.

In comparing different plots, in the 18 figures, care should be taken to observe that the scaling generally differs from plot to plot.

Table A-1. 1961 doppler data

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
820	2437381.5	472	127205.05	0.117	200	DOP	1
820	2437381.5	973	127019.33	0.106	244	DOP	2
820	2437381.5	1261	126915.12	0.316	36	DOP	3
820	2437381.5	1571	126805.09	0.118	238	DOP	4
820	2437381.5	2067	126632.82	0.119	241	DOP	5
820	2437381.5	2563	126466.71	0.119	246	DOP	6
820	2437381.5	3063	126304.42	0.120	238	DOP	7
820	2437381.5	3569	126146.59	0.113	247	DOP	8
820	2437381.5	4069	125997.50	0.181	219	DOP	9
820	2437381.5	4324	125929.81	0.506	5	DOP	10
821	2437381.5	69586	129965.75	0.285	36	DOP	11
821	2437381.5	70031	129777.68	0.263	39	DOP	12
821	2437381.5	70696	129491.38	0.245	47	DOP	13
821	2437381.5	71196	129271.82	0.251	47	DOP	14
821	2437381.5	71696	129049.66	0.241	48	DOP	15
821	2437381.5	72156	128842.70	0.285	40	DOP	16
821	2437381.5	74226	127885.82	0.364	46	DOP	17
821	2437381.5	74721	127652.42	0.333	37	DOP	18
821	2437381.5	75151	127449.71	0.333	35	DOP	19
830	2437382.5	64506	126679.50	0.249	48	DOP	20
830	2437382.5	65006	126513.52	0.293	41	DOP	21
830	2437382.5	65506	126341.18	0.288	42	DOP	22
830	2437382.5	66001	126165.83	0.284	46	DOP	23
830	2437382.5	66506	125981.12	0.285	49	DOP	24
830	2437382.5	66996	125797.09	0.282	47	DOP	25
830	2437382.5	67536	125589.14	0.273	45	DOP	26
830	2437382.5	68056	125382.44	0.302	40	DOP	27
840	2437383.5	7666	114917.11	0.271	48	DOP	28
840	2437383.5	8161	114829.81	0.376	34	DOP	29
840	2437383.5	8666	114747.49	0.304	45	DOP	30
840	2437383.5	9166	114673.17	0.312	49	DOP	31
840	2437383.5	9666	114606.66	0.401	46	DOP	32
840	2437383.5	10176	114546.51	0.281	47	DOP	33
840	2437383.5	10616	114501.25	0.443	35	DOP	34
880	2437387.5	68766	95132.10	0.204	35	DOP	35
880	2437387.5	69266	94904.08	0.235	49	DOP	36
880	2437387.5	69776	94669.38	0.269	48	DOP	37
880	2437387.5	70286	94430.26	0.220	50	DOP	38
880	2437387.5	70786	94194.10	0.280	50	DOP	39
880	2437387.5	71166	94012.21	0.272	26	DOP	40
880	2437387.5	71546	93829.63	0.204	50	DOP	41
880	2437387.5	72046	93587.09	0.312	50	DOP	42
880	2437387.5	72546	93342.96	0.293	45	DOP	43
880	2437387.5	73056	93093.26	0.318	45	DOP	44
880	2437387.5	73556	92847.33	0.345	48	DOP	45
880	2437387.5	73881	92685.78	0.692	13	DOP	46
890	2437388.5	63766	90457.44	0.320	44	DOP	47
890	2437388.5	64266	90269.92	0.265	50	DOP	48
890	2437388.5	64766	90077.00	0.250	48	DOP	49
890	2437388.5	65266	89878.07	0.234	44	DOP	50
890	2437388.5	65751	89682.02	0.542	25	DOP	51
890	2437388.5	67011	89148.77	0.595	8	DOP	52
890	2437388.5	68226	88610.51	0.365	47	DOP	53
890	2437388.5	68741	88375.94	0.381	45	DOP	54
890	2437388.5	69051	88233.56	0.766	9	DOP	55
900	2437389.5	6276	78452.33	0.300	48	DOP	56
900	2437389.5	6816	78354.75	0.250	49	DOP	57
900	2437389.5	7316	78271.55	0.276	46	DOP	58

Table A-1 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
900	2437389.5	7811	78197.05	0.223	49	DOP	59
900	2437389.5	8316	78128.89	0.177	49	DOP	60
900	2437389.5	8791	78071.49	0.247	45	DOP	61
901	2437389.5	64146	83341.78	0.232	49	DOP	62
901	2437389.5	64646	83145.21	0.204	50	DOP	63
901	2437389.5	65146	82942.52	0.254	44	DOP	64
901	2437389.5	65646	82735.29	0.185	50	DOP	65
901	2437389.5	66146	82524.34	0.203	48	DOP	66
910	2437390.5	616	72946.31	0.236	49	DOP	67
910	2437390.5	1116	72780.72	0.264	49	DOP	68
910	2437390.5	1616	72620.51	0.368	41	DOP	69
910	2437390.5	1981	72508.19	0.610	12	DOP	70
910	2437390.5	2466	72363.62	0.416	25	DOP	71
910	2437390.5	3101	72185.54	0.356	47	DOP	72
910	2437390.5	3606	72050.13	0.367	27	DOP	73
910	2437390.5	4106	71925.03	0.207	50	DOP	74
910	2437390.5	4606	71805.58	0.147	50	DOP	75
910	2437390.5	4886	71742.21	0.236	6	DOP	76
930	2437392.5	78326	54135.58	0.267	47	DOP	77
930	2437392.5	78826	53893.94	0.212	47	DOP	78
930	2437392.5	79326	53656.31	0.208	50	DOP	79
930	2437392.5	79826	53421.44	0.237	45	DOP	80
930	2437392.5	80326	53189.85	0.212	50	DOP	81
930	2437392.5	80701	53018.79	0.225	25	DOP	82
930	2437392.5	81446	52685.08	0.260	49	DOP	83
930	2437392.5	81946	52467.45	0.270	46	DOP	84
930	2437392.5	82311	52310.45	0.384	22	DOP	85
940	2437393.5	62756	53801.36	0.207	49	DOP	86
940	2437393.5	63256	53599.04	0.211	43	DOP	87
940	2437393.5	63756	53391.27	0.198	48	DOP	88
940	2437393.5	64256	53179.13	0.218	48	DOP	89
940	2437393.5	64756	52961.67	0.179	45	DOP	90
940	2437393.5	65256	52740.52	0.209	46	DOP	91
940	2437393.5	65756	52514.64	0.211	45	DOP	92
940	2437393.5	66256	52284.91	0.185	42	DOP	93
940	2437393.5	66696	52080.97	0.299	35	DOP	94
950	2437394.5	57566	47630.31	0.221	46	DOP	95
950	2437394.5	58066	47485.28	0.210	47	DOP	96
950	2437394.5	58936	47217.72	0.213	49	DOP	97
950	2437394.5	59436	47054.41	0.183	50	DOP	98
950	2437394.5	59936	46885.03	0.175	47	DOP	99
950	2437394.5	60416	46716.27	0.227	32	DOP	100
950	2437394.5	60871	46551.49	0.261	34	DOP	101
950	2437394.5	61296	46393.16	0.228	48	DOP	102
950	2437394.5	61791	46203.64	0.166	49	DOP	103
950	2437394.5	62211	46038.37	0.338	25	DOP	104
950	2437394.5	62956	45735.68	0.206	43	DOP	105
950	2437394.5	63456	45526.63	0.260	43	DOP	106
950	2437394.5	63956	45312.51	0.225	46	DOP	107
950	2437394.5	64456	45093.55	0.220	49	DOP	108
950	2437394.5	64751	44961.42	0.574	9	DOP	109
960	2437395.5	4286	33760.44	0.227	50	DOP	110
960	2437395.5	4786	33663.18	0.245	46	DOP	111
960	2437395.5	5286	33575.11	0.215	49	DOP	112
960	2437395.5	5786	33492.96	0.251	45	DOP	113
960	2437395.5	6281	33420.62	0.251	44	DOP	114
960	2437395.5	6786	33353.95	0.252	46	DOP	115
961	2437395.5	66156	36162.53	0.177	48	DOP	116

Table A-1 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
961	2437395.5	66656	35923.34	0.219	48	DOP	117
961	2437395.5	67141	35687.31	0.183	45	DOP	118
961	2437395.5	67546	35488.80	0.347	16	DOP	119
961	2437395.5	69046	34737.79	0.182	50	DOP	120
961	2437395.5	69546	34484.02	0.180	48	DOP	121
961	2437395.5	69976	34264.02	0.242	36	DOP	122
961	2437395.5	70406	34042.93	0.175	49	DOP	123
961	2437395.5	70906	33785.37	0.205	49	DOP	124
961	2437395.5	71406	33526.38	0.178	49	DOP	125
961	2437395.5	71806	33319.65	0.299	30	DOP	126
961	2437395.5	91906	25447.27	0.219	47	DOP	127
961	2437395.5	92406	25374.83	0.197	49	DOP	128
961	2437395.5	92786	25324.11	0.193	25	DOP	129
980	2437397.5	5926	17196.72	0.180	48	DOP	130
980	2437397.5	6396	17138.69	0.189	41	DOP	131
1000	2437399.5	63511	3916.60	0.232	43	DOP	132
1000	2437399.5	64026	3675.01	0.225	43	DOP	133
1000	2437399.5	64396	3499.83	0.286	23	DOP	134
1000	2437399.5	65216	3103.22	0.159	46	DOP	135
1000	2437399.5	70616	340.09	0.251	41	DOP	136
1001	2437399.5	71726	-241.33	0.655	4	DOP	137
1001	2437399.5	72356	-571.34	0.201	46	DOP	138
1001	2437399.5	72866	-836.89	0.167	49	DOP	139
1001	2437399.5	73271	-1047.31	0.290	30	DOP	140
1001	2437399.5	74136	-1492.27	0.213	46	DOP	141
1001	2437399.5	74636	-1747.43	0.158	46	DOP	142
1001	2437399.5	74961	-1912.39	0.326	15	DOP	143
1001	2437399.5	75641	-2253.32	0.249	43	DOP	144
1010	2437400.5	57866	-2185.47	0.195	48	DOP	145
1010	2437400.5	58366	-2366.14	0.194	47	DOP	146
1010	2437400.5	58866	-2552.85	0.188	43	DOP	147
1010	2437400.5	59366	-2745.13	0.167	49	DOP	148
1010	2437400.5	59856	-2939.29	0.268	39	DOP	149
1010	2437400.5	60366	-3147.06	0.202	34	DOP	150
1010	2437400.5	60766	-3313.57	0.330	20	DOP	151
1010	2437400.5	60946	-3389.86	0.728	6	DOP	152
1010	2437400.5	61411	-3589.78	0.188	43	DOP	153
1010	2437400.5	61926	-3815.96	0.166	43	DOP	154
1010	2437400.5	62426	-4039.86	0.195	47	DOP	155
1010	2437400.5	62926	-4268.14	0.193	47	DOP	156
1010	2437400.5	63426	-4500.33	0.192	47	DOP	157
1010	2437400.5	63881	-4715.38	0.222	38	DOP	158
1020	2437401.5	2476	-15567.25	0.238	46	DOP	159
1020	2437401.5	2986	-15661.69	0.237	46	DOP	160
1020	2437401.5	3486	-15746.77	0.230	49	DOP	161
1020	2437401.5	3821	-15799.33	0.468	16	DOP	162
1021	2437401.5	55196	-9703.81	0.212	47	DOP	163
1021	2437401.5	55696	-9854.64	0.238	41	DOP	164
1021	2437401.5	56196	-10011.92	0.222	47	DOP	165
1021	2437401.5	56471	-10100.26	0.911	4	DOP	166
1021	2437401.5	56926	-10253.66	0.277	22	DOP	167
1021	2437401.5	57916	-10602.62	0.224	48	DOP	168
1021	2437401.5	58416	-10788.53	0.173	48	DOP	169
1021	2437401.5	58926	-10984.05	0.226	44	DOP	170
1021	2437401.5	59426	-11181.47	0.165	48	DOP	171
1021	2437401.5	59926	-11384.41	0.179	47	DOP	172
1021	2437401.5	60321	-11548.74	0.248	28	DOP	173
1021	2437401.5	60726	-11720.60	0.244	47	DOP	174

Table A-1 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1021	2437401.5	61226	-11936.81	0.349	48	DOP	175
1021	2437401.5	61726	-12157.26	0.229	49	DOP	176
1021	2437401.5	62041	-12299.39	0.518	13	DOP	177
1021	2437401.5	77766	-20193.67	0.184	48	DOP	178
1021	2437401.5	78266	-20421.54	0.258	47	DOP	179
1021	2437401.5	78766	-20645.81	0.250	42	DOP	180
1021	2437401.5	79276	-20869.12	0.245	33	DOP	181
1021	2437401.5	79776	-21083.19	0.227	48	DOP	182
1021	2437401.5	80276	-21292.31	0.239	48	DOP	183
1021	2437401.5	80551	-21406.93	0.736	5	DOP	184
1021	2437401.5	80826	-21515.88	0.209	49	DOP	185
1021	2437401.5	81326	-21713.64	0.238	45	DOP	186
1021	2437401.5	81826	-21905.78	0.218	50	DOP	187
1021	2437401.5	82326	-22091.99	0.232	45	DOP	188
1021	2437401.5	82826	-22271.76	0.234	44	DOP	189
1021	2437401.5	83326	-22445.50	0.197	47	DOP	190
1021	2437401.5	83826	-22612.65	0.259	48	DOP	191
1021	2437401.5	84326	-22773.04	0.196	49	DOP	192
1021	2437401.5	84826	-22927.20	0.215	50	DOP	193
1021	2437401.5	85096	-23007.20	0.278	4	DOP	194
1021	2437401.5	85366	-23085.38	0.251	49	DOP	195
1021	2437401.5	85866	-23224.97	0.241	46	DOP	196
1021	2437401.5	86366	-23357.32	0.269	47	DOP	197
1021	2437401.5	86866	-23482.36	0.227	48	DOP	198
1021	2437401.5	87366	-23599.53	0.233	48	DOP	199
1021	2437401.5	87856	-23707.61	0.202	48	DOP	200
1021	2437401.5	88376	-23814.62	0.282	47	DOP	201
1021	2437401.5	88876	-23909.14	0.250	47	DOP	202
1021	2437401.5	89376	-23996.45	0.217	48	DOP	203
1030	2437402.5	60676	-20083.00	0.188	47	DOP	204
1030	2437402.5	61176	-20302.27	0.231	47	DOP	205
1030	2437402.5	61671	-20523.68	0.185	44	DOP	206
1030	2437402.5	62176	-20754.47	0.224	42	DOP	207
1030	2437402.5	62691	-20993.72	0.280	24	DOP	208
1030	2437402.5	63196	-21231.99	0.233	39	DOP	209
1030	2437402.5	63696	-21472.35	0.188	49	DOP	210
1030	2437402.5	64206	-21721.00	0.191	48	DOP	211
1030	2437402.5	64561	-21895.34	0.334	21	DOP	212
1030	2437402.5	65166	-22195.99	0.261	46	DOP	213
1030	2437402.5	65666	-22448.62	0.218	45	DOP	214
1030	2437402.5	66111	-22674.20	0.321	32	DOP	215
1030	2437402.5	66556	-22902.06	0.283	46	DOP	216
1030	2437402.5	67056	-23159.71	0.339	47	DOP	217
1030	2437402.5	67466	-23372.29	0.401	29	DOP	218
1030	2437402.5	68311	-23813.55	0.306	42	DOP	219
1030	2437402.5	68866	-24103.80	0.221	50	DOP	220
1030	2437402.5	69366	-24366.05	0.221	47	DOP	221
1030	2437402.5	69861	-24626.56	0.246	47	DOP	222
1030	2437402.5	70366	-24891.66	0.270	50	DOP	223
1030	2437402.5	70876	-25158.91	0.237	47	DOP	224
1030	2437402.5	71376	-25420.65	0.305	47	DOP	225
1030	2437402.5	71806	-25644.63	0.350	29	DOP	226
1040	2437403.5	59786	-28020.35	0.240	48	DOP	227
1040	2437403.5	60276	-28229.66	0.190	47	DOP	228
1040	2437403.5	60786	-28452.83	0.209	40	DOP	229
1040	2437403.5	61286	-28675.93	0.212	43	DOP	230
1040	2437403.5	61796	-28908.72	0.273	40	DOP	231

Table A-1 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1040	2437403.5	62296	-29140.41	0.266	44	DOP	232
1040	2437403.5	62791	-29373.72	0.252	36	DOP	233
1040	2437403.5	63296	-29615.47	0.289	38	DOP	234
1040	2437403.5	63811	-29866.26	0.347	33	DOP	235
1040	2437403.5	64341	-30127.36	0.263	35	DOP	236
1040	2437403.5	64856	-30383.98	0.311	33	DOP	237
1040	2437403.5	65256	-30585.18	0.377	12	DOP	238
1090	2437408.5	59406	-67728.81	0.263	47	DOP	239
1090	2437408.5	59901	-67949.21	0.316	47	DOP	240
1090	2437408.5	60406	-68179.09	0.307	46	DOP	241
1090	2437408.5	60906	-68410.93	0.244	49	DOP	242
1090	2437408.5	61406	-68646.45	0.288	49	DOP	243
1090	2437408.5	61876	-68871.38	0.323	41	DOP	244
1110	2437410.5	63106	-84292.26	0.342	47	DOP	245
1110	2437410.5	63571	-84525.59	0.468	35	DOP	246
1111	2437410.5	86126	-93743.22	0.338	32	DOP	247
1111	2437410.5	86626	-93819.92	0.350	47	DOP	248
1111	2437410.5	87126	-93888.47	0.380	49	DOP	249
1111	2437410.5	87626	-93948.58	0.284	49	DOP	250
1111	2437410.5	88126	-94001.35	0.422	48	DOP	251
1111	2437410.5	88431	-94029.97	0.604	11	DOP	252
1150	2437414.5	47390	-105611.21	0.536	22	DOP	253
1150	2437414.5	47916	-105701.80	0.668	17	DOP	254
1150	2437414.5	48396	-105793.21	0.753	20	DOP	255
1150	2437414.5	48941	-105903.96	0.566	9	DOP	256
1170	2437416.5	50661	-118372.86	0.531	19	DOP	257
1170	2437416.5	51171	-118515.24	0.441	28	DOP	258
1170	2437416.5	51696	-118668.98	0.405	33	DOP	259
1170	2437416.5	52196	-118823.96	0.446	31	DOP	260
1170	2437416.5	52696	-118984.15	0.409	33	DOP	261
1170	2437416.5	53211	-119155.48	0.569	27	DOP	262
1170	2437416.5	53736	-119336.75	0.516	37	DOP	263
1170	2437416.5	54096	-119465.87	0.733	14	DOP	264
1171	2437416.5	80731	-131005.00	0.263	40	DOP	265
1171	2437416.5	81246	-131132.99	0.343	37	DOP	266
1171	2437416.5	81746	-131251.37	0.303	37	DOP	267
1171	2437416.5	82246	-131361.26	0.350	43	DOP	268
1171	2437416.5	82706	-131456.68	0.356	38	DOP	269
1181	2437417.5	51026	-124147.51	0.354	48	DOP	270
1181	2437417.5	51526	-124293.64	0.383	47	DOP	271
1181	2437417.5	51991	-124437.35	0.456	36	DOP	272
1210	2437420.5	45956	-138595.36	0.585	44	DOP	273
1210	2437420.5	46366	-138659.86	0.626	16	DOP	274
1220	2437421.5	48761	-143854.11	1.186	20	DOP	275
1230	2437422.5	47666	-148094.52	0.661	33	DOP	276
1230	2437422.5	48166	-148201.74	0.487	37	DOP	277
1230	2437422.5	48511	-148280.92	0.919	17	DOP	278
1230	2437422.5	50701	-148861.64	0.943	9	DOP	279
1230	2437422.5	51241	-149024.73	0.876	9	DOP	280
1230	2437422.5	51781	-149198.36	0.591	9	DOP	281
1240	2437423.5	62426	-157970.17	0.721	43	DOP	282
1240	2437423.5	62881	-158184.24	0.798	39	DOP	283
1300	2437429.5	57746	-177096.20	0.806	41	DOP	284
1300	2437429.5	58031	-177213.95	2.120	7	DOP	285
282081	694658556.5	16408246	2862322.72	88.790	12865	CHK	286

Table A-2. 1962 doppler data

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
2840	2437948.5	79731	179195.78	1.200	30	DOP	1
2840	2437948.5	81046	178642.54	0.719	40	DOP	2
2840	2437948.5	81941	178268.48	1.193	17	DOP	3
2840	2437948.5	82626	177980.11	0.943	38	DOP	4
2840	2437948.5	83501	177620.42	1.145	19	DOP	5
2840	2437948.5	84191	177343.51	0.660	39	DOP	6
2840	2437948.5	84976	177032.21	0.543	39	DOP	7
2840	2437948.5	85776	176724.01	0.770	39	DOP	8
2850	2437949.5	79861	176557.92	0.357	39	DOP	9
2850	2437949.5	80641	176226.91	0.581	39	DOP	10
2850	2437949.5	81421	175895.91	0.874	35	DOP	11
2850	2437949.5	82201	175568.50	0.767	34	DOP	12
2850	2437949.5	82966	175250.72	0.791	39	DOP	13
2850	2437949.5	83746	174933.15	0.840	38	DOP	14
2850	2437949.5	84516	174624.53	0.468	38	DOP	15
2880	2437952.5	67981	172649.81	0.451	30	DOP	16
2880	2437952.5	68691	172413.80	0.338	35	DOP	17
2880	2437952.5	69441	172153.53	0.273	36	DOP	18
2880	2437952.5	70161	171895.72	0.336	32	DOP	19
2890	2437953.5	71896	168051.44	0.578	36	DOP	20
2890	2437953.5	72631	167756.21	0.523	37	DOP	21
2890	2437953.5	73356	167461.11	0.515	36	DOP	22
2890	2437953.5	74031	167181.83	0.881	21	DOP	23
2890	2437953.5	74846	166840.12	0.687	26	DOP	24
2890	2437953.5	75536	166544.66	0.483	32	DOP	25
2890	2437953.5	76261	166232.83	0.522	37	DOP	26
2890	2437953.5	76986	165919.32	0.447	35	DOP	27
2890	2437953.5	77731	165597.85	0.647	34	DOP	28
2900	2437954.5	63111	167518.56	0.501	23	DOP	29
2900	2437954.5	63776	167362.56	0.383	33	DOP	30
2900	2437954.5	64456	167192.07	0.340	28	DOP	31
2900	2437954.5	65401	166936.58	0.298	38	DOP	32
2921	2437956.5	64141	160125.61	0.518	35	DOP	33
2921	2437956.5	64831	159937.45	0.356	35	DOP	34
2921	2437956.5	65526	159737.23	0.456	32	DOP	35
2921	2437956.5	66221	159525.41	0.430	35	DOP	36
2921	2437956.5	66971	159288.05	0.672	43	DOP	37
2921	2437956.5	68271	158843.11	0.625	35	DOP	38
2960	2437960.5	3846	137833.75	1.231	26	DOP	39
2960	2437960.5	4531	137652.02	0.437	33	DOP	40
2960	2437960.5	5086	137513.24	1.216	30	DOP	41
2980	2437962.5	2286	129064.11	0.535	30	DOP	42
2980	2437962.5	2926	128875.99	0.557	32	DOP	43
2980	2437962.5	3561	128697.32	0.470	31	DOP	44
2980	2437962.5	4196	128530.04	0.661	31	DOP	45
2980	2437962.5	4726	128398.66	1.152	9	DOP	46
2981	2437962.5	61663	134745.38	0.319	54	DOP	47
2981	2437962.5	62312	134575.41	0.237	63	DOP	48
2981	2437962.5	62943	134402.10	0.317	62	DOP	49
2981	2437962.5	63637	134201.09	0.410	36	DOP	50
2990	2437963.5	3891	123675.07	0.455	31	DOP	51
3000	2437964.5	1091	119341.99	0.959	29	DOP	52
3000	2437964.5	1701	119146.17	0.890	30	DOP	53
3000	2437964.5	2321	118954.17	0.756	25	DOP	54
3000	2437964.5	2936	118776.11	0.426	30	DOP	55
3000	2437964.5	3551	118608.13	0.749	31	DOP	56
3000	2437964.5	4111	118459.94	1.508	16	DOP	57
3030	2437967.5	1531	102303.21	0.281	29	DOP	58

Table A-2 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
3030	2437967.5	2121	102128.15	0.349	28	DOP	59
3030	2437967.5	2716	101960.03	0.322	29	DOP	60
3030	2437967.5	3291	101807.33	0.329	24	DOP	61
3031	2437967.5	72651	102609.62	0.452	27	DOP	62
3031	2437967.5	73241	102334.01	0.452	27	DOP	63
3031	2437967.5	74361	101807.44	0.339	29	DOP	64
3031	2437967.5	74951	101529.78	0.378	29	DOP	65
3031	2437967.5	75536	101255.57	0.454	29	DOP	66
3031	2437967.5	76121	100980.30	0.369	29	DOP	67
3040	2437968.5	2591	95895.09	0.345	29	DOP	68
3041	2437968.5	73021	96088.49	0.379	29	DOP	69
3041	2437968.5	73606	95811.96	0.399	28	DOP	70
3041	2437968.5	74181	95539.16	0.310	29	DOP	71
3041	2437968.5	74766	95261.56	0.274	28	DOP	72
3050	2437969.5	58836	95084.74	1.294	7	DOP	73
3050	2437969.5	59516	94905.43	0.345	27	DOP	74
3050	2437969.5	60086	94746.60	0.341	27	DOP	75
3050	2437969.5	60661	94578.40	0.386	29	DOP	76
3050	2437969.5	61231	94403.87	0.293	29	DOP	77
3050	2437969.5	61811	94218.45	0.260	29	DOP	78
3060	2437970.5	85706	77160.57	0.290	28	DOP	79
3060	2437970.5	86266	76975.06	0.462	26	DOP	80
3060	2437970.5	86836	76793.78	0.276	28	DOP	81
3060	2437970.5	87401	76622.51	0.269	29	DOP	82
3060	2437970.5	87966	76457.71	0.315	28	DOP	83
3060	2437970.5	88476	76315.97	0.491	16	DOP	84
3090	2437973.5	85586	55420.03	0.229	28	DOP	85
3090	2437973.5	86136	55245.02	0.314	28	DOP	86
3090	2437973.5	86686	55077.10	0.195	28	DOP	87
3090	2437973.5	87241	54915.40	0.286	27	DOP	88
3100	2437974.5	85786	47696.22	0.274	28	DOP	89
3100	2437974.5	86341	47525.41	0.216	27	DOP	90
3100	2437974.5	86886	47365.50	0.321	25	DOP	91
3100	2437974.5	87336	47239.32	0.647	8	DOP	92
3110	2437975.5	83221	40732.33	0.190	27	DOP	93
3110	2437975.5	83761	40536.65	0.236	27	DOP	94
3110	2437975.5	84301	40347.02	0.381	27	DOP	95
3110	2437975.5	84851	40162.64	0.637	14	DOP	96
3110	2437975.5	85391	39986.77	0.237	27	DOP	97
3110	2437975.5	85936	39817.44	0.250	28	DOP	98
3110	2437975.5	86481	39654.99	0.171	27	DOP	99
3110	2437975.5	86976	39514.12	0.560	17	DOP	100
3120	2437976.5	86271	31735.58	0.267	27	DOP	101
3120	2437976.5	86766	31596.06	0.364	16	DOP	102
3130	2437977.5	60641	34915.87	0.243	28	DOP	103
3130	2437977.5	61316	34650.49	0.484	6	DOP	104
3130	2437977.5	62811	34034.89	0.247	27	DOP	105
3130	2437977.5	63356	33799.82	0.225	27	DOP	106
3130	2437977.5	63901	33559.77	0.243	26	DOP	107
3170	2437981.5	63251	588.12	0.299	20	DOP	108
3170	2437981.5	63756	357.81	0.356	25	DOP	109
3171	2437981.5	68781	-2118.82	0.806	8	DOP	110
3171	2437981.5	69226	-2348.49	0.216	26	DOP	111
3171	2437981.5	69766	-2623.44	0.264	26	DOP	112
3171	2437981.5	70301	-2894.60	0.219	27	DOP	113
3172	2437981.5	65091	-283.25	2.472	21	DOP	114
3172	2437981.5	65626	-538.48	1.622	25	DOP	115
3172	2437981.5	66161	-803.60	1.788	27	DOP	116

Table A-2 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
3172	2437981.5	66696	-1064.81	2.170	22	DOP	117
3172	2437981.5	67231	-1331.79	1.975	21	DOP	118
3172	2437981.5	67771	-1606.07	2.284	21	DOP	119
3172	2437981.5	68646	-2051.83	2.392	18	DOP	120
3180	2437982.5	60316	-6466.04	0.243	26	DOP	121
3180	2437982.5	60856	-6696.32	0.173	26	DOP	122
3180	2437982.5	61396	-6931.29	0.217	24	DOP	123
3180	2437982.5	61921	-7164.66	0.200	27	DOP	124
3181	2437982.5	82621	-16741.95	0.332	25	DOP	125
3181	2437982.5	83146	-16912.72	0.256	26	DOP	126
3181	2437982.5	84206	-17234.72	0.300	24	DOP	127
3181	2437982.5	84731	-17384.07	0.197	21	DOP	128
3190	2437983.5	78131	-23331.97	0.290	27	DOP	129
3190	2437983.5	78666	-23555.25	0.262	25	DOP	130
3190	2437983.5	79201	-23772.39	0.272	27	DOP	131
3190	2437983.5	79741	-23985.96	0.297	27	DOP	132
3190	2437983.5	80281	-24192.61	0.286	25	DOP	133
3190	2437983.5	80751	-24366.66	0.526	15	DOP	134
3200	2437984.5	67461	-26423.55	1.066	13	DOP	135
3200	2437984.5	67961	-26677.72	1.389	5	DOP	136
3200	2437984.5	69446	-27435.73	0.267	26	DOP	137
3200	2437984.5	69916	-27674.21	0.291	14	DOP	138
3200	2437984.5	70521	-27980.61	0.304	25	DOP	139
3200	2437984.5	71061	-28253.36	0.286	27	DOP	140
3200	2437984.5	71601	-28524.45	0.351	27	DOP	141
3200	2437984.5	72136	-28791.85	0.327	26	DOP	142
3210	2437985.5	82846	-41342.93	0.392	22	DOP	143
3210	2437985.5	83361	-41490.91	0.220	27	DOP	144
3210	2437985.5	83911	-41642.26	0.410	24	DOP	145
3250	2437989.5	80731	-71491.74	0.348	27	DOP	146
3250	2437989.5	81256	-71650.95	0.410	22	DOP	147
3250	2437989.5	82021	-71868.15	0.498	26	DOP	148
3250	2437989.5	82576	-72018.88	0.406	27	DOP	149
3270	2437991.5	49286	-72731.81	0.418	18	DOP	150
3270	2437991.5	49796	-72844.70	0.371	28	DOP	151
3270	2437991.5	50366	-72980.63	0.377	28	DOP	152
3270	2437991.5	50926	-73122.91	0.462	28	DOP	153
3270	2437991.5	51501	-73277.46	0.243	27	DOP	154
3270	2437991.5	52086	-73444.65	0.401	30	DOP	155
3271	2437991.5	64351	-78575.22	0.320	29	DOP	156
3271	2437991.5	64916	-78856.91	0.264	28	DOP	157
3271	2437991.5	65491	-79144.27	0.384	29	DOP	158
3280	2437992.5	63271	-84921.54	0.405	21	DOP	159
3280	2437992.5	63806	-85185.97	0.245	28	DOP	160
3280	2437992.5	64376	-85468.18	0.262	28	DOP	161
3280	2437992.5	64946	-85751.61	0.259	28	DOP	162
3280	2437992.5	65526	-86040.94	0.317	28	DOP	163
3280	2437992.5	66091	-86323.53	0.345	28	DOP	164
3280	2437992.5	66661	-86608.80	0.370	28	DOP	165
3300	2437994.5	79961	-105166.58	0.353	29	DOP	166
3300	2437994.5	80541	-105323.48	0.371	29	DOP	167
3300	2437994.5	81126	-105468.45	1.289	27	DOP	168
3300	2437994.5	81706	-105610.51	0.527	26	DOP	169
3310	2437995.5	80586	-111404.53	0.297	20	DOP	170
3310	2437995.5	81146	-111540.91	0.307	28	DOP	171
3320	2437996.5	71006	-113803.03	0.609	28	DOP	172
3320	2437996.5	71596	-114066.98	0.759	29	DOP	173
3320	2437996.5	72206	-114332.72	0.269	31	DOP	174

Table A-2 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
3321	2437996.5	76131	-115890.81	0.675	25	DOP	175
3321	2437996.5	76706	-116092.62	0.575	30	DOP	176
3340	2437998.5	78916	-127761.81	0.530	28	DOP	177
3340	2437998.5	79521	-127919.46	0.630	31	DOP	178
3340	2437998.5	80581	-128170.20	0.808	21	DOP	179
3370	2438001.5	55086	-132546.09	0.291	21	DOP	180
3370	2438001.5	55756	-132816.11	0.257	32	DOP	181
3370	2438001.5	56436	-133099.06	0.320	32	DOP	182
3370	2438001.5	57091	-133378.97	0.295	33	DOP	183
3370	2438001.5	57741	-133661.83	0.265	33	DOP	184
3370	2438001.5	58386	-133948.24	0.253	31	DOP	185
3370	2438001.5	59036	-134242.48	0.226	30	DOP	186
3370	2438001.5	59686	-134540.75	0.344	31	DOP	187
3370	2438001.5	60331	-134839.47	0.323	31	DOP	188
3380	2438002.5	79486	-147100.66	0.528	32	DOP	189
3380	2438002.5	80081	-147228.29	1.122	19	DOP	190
3390	2438003.5	60496	-143833.79	0.817	28	DOP	191
3390	2438003.5	61171	-144146.37	0.579	27	DOP	192
3390	2438003.5	61886	-144485.18	0.596	34	DOP	193
3390	2438003.5	62181	-144631.00	1.066	8	DOP	194
3390	2438003.5	62936	-144983.73	0.450	28	DOP	195
3400	2438004.5	77721	-155013.36	0.688	33	DOP	196
3400	2438004.5	78396	-155176.99	0.754	31	DOP	197
3400	2438004.5	79076	-155329.07	0.553	34	DOP	198
3400	2438004.5	79696	-155456.68	0.829	22	DOP	199
3410	2438005.5	76606	-158589.59	0.482	29	DOP	200
3410	2438005.5	77271	-158766.91	0.574	34	DOP	201
3410	2438005.5	77961	-158938.03	0.495	34	DOP	202
3410	2438005.5	78651	-159095.12	0.635	34	DOP	203
3410	2438005.5	79286	-159229.95	0.878	23	DOP	204
3440	2438008.5	54326	-159916.74	1.033	36	DOP	205
3440	2438008.5	55061	-160211.12	1.195	32	DOP	206
3440	2438008.5	55711	-160475.26	1.216	25	DOP	207
3440	2438008.5	56486	-160807.83	0.615	36	DOP	208
3440	2438008.5	57206	-161111.30	1.147	32	DOP	209
3450	2438009.5	60981	-166012.55	0.769	33	DOP	210
3450	2438009.5	61836	-166411.00	1.656	9	DOP	211
3450	2438009.5	62446	-166690.10	0.704	36	DOP	212
3450	2438009.5	63161	-167023.38	1.262	33	DOP	213
3460	2438010.5	44431	-163315.80	1.965	7	DOP	214
3460	2438010.5	45026	-163407.78	0.719	34	DOP	215
3460	2438010.5	45776	-163542.25	0.815	32	DOP	216
3460	2438010.5	46521	-163691.00	0.645	37	DOP	217
3460	2438010.5	47261	-163858.32	0.558	37	DOP	218
3461	2438010.5	59006	-168126.68	0.682	30	DOP	219
3461	2438010.5	59711	-168445.52	0.739	30	DOP	220
3470	2438011.5	51161	-167811.99	0.379	33	DOP	221
3470	2438011.5	51896	-168061.30	0.558	38	DOP	222
3470	2438011.5	52646	-168328.39	0.602	34	DOP	223
3470	2438011.5	53406	-168608.85	0.878	37	DOP	224
3470	2438011.5	54156	-168898.19	1.043	34	DOP	225
3470	2438011.5	54916	-169202.33	0.676	37	DOP	226
3470	2438011.5	55666	-169508.49	0.857	34	DOP	227
3470	2438011.5	56426	-169828.74	0.779	37	DOP	228
3470	2438011.5	57186	-170152.85	0.939	36	DOP	229
3471	2438011.5	72511	-176726.81	0.471	35	DOP	230
3471	2438011.5	73256	-176973.07	0.587	38	DOP	231
3471	2438011.5	74006	-177207.05	0.580	38	DOP	232

Table A-2 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
3471	2438011.5	74766	-177432.62	0.522	38	DOP	233
3471	2438011.5	75526	-177642.14	0.693	36	DOP	234
3471	2438011.5	76286	-177837.27	0.535	38	DOP	235
3471	2438011.5	77046	-178013.99	0.846	37	DOP	236
3471	2438011.5	77806	-178179.23	0.694	37	DOP	237
3471	2438011.5	78531	-178317.97	0.972	30	DOP	238
3480	2438012.5	51036	-170446.99	0.465	40	DOP	239
3480	2438012.5	51831	-170717.62	0.538	39	DOP	240
3480	2438012.5	52651	-171009.16	0.773	39	DOP	241
3480	2438012.5	53446	-171305.54	0.935	38	DOP	242
3480	2438012.5	54236	-171610.07	0.931	36	DOP	243
3480	2438012.5	55011	-171920.43	0.733	37	DOP	244
3480	2438012.5	55771	-172233.12	0.857	39	DOP	245
3480	2438012.5	56546	-172559.70	0.749	38	DOP	246
3480	2438012.5	57316	-172891.79	0.734	39	DOP	247
3481	2438012.5	75276	-180200.38	0.687	37	DOP	248
3481	2438012.5	76046	-180398.11	0.580	37	DOP	249
3481	2438012.5	76816	-180580.45	0.592	38	DOP	250
3481	2438012.5	77591	-180746.15	0.592	39	DOP	251
3481	2438012.5	78381	-180900.43	0.802	39	DOP	252
3490	2438013.5	50976	-172949.21	0.620	37	DOP	253
3490	2438013.5	51756	-173214.75	0.704	40	DOP	254
3490	2438013.5	52551	-173496.98	0.901	35	DOP	255
3490	2438013.5	53336	-173789.02	0.628	36	DOP	256
3490	2438013.5	54121	-174089.04	0.924	34	DOP	257
3490	2438013.5	54881	-174393.07	0.866	37	DOP	258
3490	2438013.5	55671	-174718.08	0.675	40	DOP	259
3491	2438013.5	77711	-183235.74	0.777	36	DOP	260
3491	2438013.5	78401	-183361.06	1.366	21	DOP	261
835115	636313939.5	16886307	-4782593.42	154.568	7679	CHK	262

Table A-3. 1964 doppler data

Run number	Epoch of compressed data: Reference Julian date, Universal time	Epoch of compressed data: Seconds past reference Julian date	Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
5240	2438518.5	80876	210959.71	0.378	40	DOP	1
5240	2438518.5	81996	210511.51	0.318	50	DOP	2
5240	2438518.5	83041	210092.81	0.275	49	DOP	3
5240	2438518.5	84106	209668.87	0.252	50	DOP	4
5240	2438518.5	85166	209250.92	0.292	49	DOP	5
5240	2438518.5	86186	208855.40	0.461	34	DOP	6
5250	2438519.5	46	208755.79	0.579	10	DOP	7
5250	2438519.5	886	208439.45	0.265	50	DOP	8
5250	2438519.5	12216	205289.30	0.358	50	DOP	9
5250	2438519.5	13266	205144.27	0.317	50	DOP	10
5250	2438519.5	14326	205028.45	0.333	48	DOP	11
5250	2438519.5	15386	204943.07	0.244	48	DOP	12
5250	2438519.5	16326	204894.46	0.807	23	DOP	13
5250	2438519.5	17496	204869.04	0.357	50	DOP	14
5250	2438519.5	18546	204878.20	0.287	50	DOP	15
5250	2438519.5	19606	204920.73	0.342	48	DOP	16
5270	2438521.5	13786	203081.10	0.332	42	DOP	17
5270	2438521.5	14776	202987.28	0.259	48	DOP	18
5270	2438521.5	15816	202917.89	0.286	46	DOP	19
5270	2438521.5	16821	202880.97	0.349	49	DOP	20
5270	2438521.5	17856	202871.88	0.295	47	DOP	21
5270	2438521.5	18866	202892.19	0.305	49	DOP	22
5280	2438522.5	76861	208222.93	0.368	21	DOP	23
5280	2438522.5	77721	207895.80	0.387	46	DOP	24
5280	2438522.5	78721	207504.82	0.331	47	DOP	25
5280	2438522.5	79726	207105.94	0.344	44	DOP	26
5280	2438522.5	80721	206707.39	0.305	48	DOP	27
5280	2438522.5	81721	206303.77	0.346	47	DOP	28
5280	2438522.5	84201	205304.33	0.177	47	DOP	29
5290	2438523.5	65811	210147.79	0.376	46	DOP	30
5290	2438523.5	66651	209996.57	0.331	19	DOP	31
5331	2438527.5	4926	197021.63	0.281	43	DOP	32
5331	2438527.5	5881	196729.96	0.271	47	DOP	33
5331	2438527.5	6841	196454.79	0.250	48	DOP	34
5331	2438527.5	7791	196201.92	0.248	47	DOP	35
5331	2438527.5	8761	195965.59	0.193	44	DOP	36
5331	2438527.5	9721	195752.70	0.242	47	DOP	37
5331	2438527.5	10681	195562.76	0.239	47	DOP	38
5331	2438527.5	11641	195397.00	0.272	46	DOP	39
5332	2438527.5	83936	198073.55	0.232	41	DOP	40
5332	2438527.5	84841	197709.85	0.256	43	DOP	41
5332	2438527.5	85771	197342.07	0.224	41	DOP	42
5340	2438528.5	276	196991.83	0.282	43	DOP	43
5340	2438528.5	1561	196509.07	0.243	44	DOP	44
5340	2438528.5	2481	196176.96	0.223	45	DOP	45
5340	2438528.5	3451	195840.02	0.234	38	DOP	46
5340	2438528.5	4421	195517.65	0.250	45	DOP	47
5340	2438528.5	5446	195195.54	0.269	46	DOP	48
5340	2438528.5	6376	194921.53	0.276	45	DOP	49
5350	2438529.5	15241	191574.59	0.625	6	DOP	50
5350	2438529.5	16166	191533.12	0.239	34	DOP	51
5350	2438529.5	17081	191515.27	0.316	40	DOP	52
5350	2438529.5	18001	191521.69	0.277	39	DOP	53
5350	2438529.5	18861	191549.42	0.265	35	DOP	54
5360	2438530.5	17126	189628.91	0.381	19	DOP	55
5360	2438530.5	17936	189636.26	0.259	35	DOP	56
5360	2438530.5	18771	189663.26	0.237	36	DOP	57
5372	2438531.5	70196	195496.74	0.291	40	DOP	58

Table A-3 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
5372	2438531.5	71066	195226.65	0.258	39	DOP	59
5372	2438531.5	71936	194943.10	0.235	41	DOP	60
5372	2438531.5	72816	194642.51	0.300	40	DOP	61
5372	2438531.5	73741	194312.32	0.371	29	DOP	62
5372	2438531.5	74901	193882.16	0.261	43	DOP	63
5372	2438531.5	75801	193535.32	0.216	36	DOP	64
5372	2438531.5	76576	193231.86	0.304	26	DOP	65
5390	2438533.5	10076	183834.80	0.259	41	DOP	66
5390	2438533.5	10936	183677.36	0.302	41	DOP	67
5390	2438533.5	11786	183542.13	0.327	42	DOP	68
5390	2438533.5	12641	183426.22	0.320	41	DOP	69
5390	2438533.5	13496	183330.17	0.266	42	DOP	70
5390	2438533.5	14346	183254.94	0.230	41	DOP	71
5390	2438533.5	15206	183199.74	0.264	42	DOP	72
5390	2438533.5	16061	183165.56	0.296	40	DOP	73
5390	2438533.5	16906	183152.48	0.304	42	DOP	74
5390	2438533.5	17756	183159.43	0.289	42	DOP	75
5390	2438533.5	18476	183180.54	0.435	14	DOP	76
5400	2438534.5	1621	183796.60	1.130	7	DOP	77
5400	2438534.5	2461	183492.31	0.701	7	DOP	78
5400	2438534.5	3301	183199.87	0.615	6	DOP	79
5400	2438534.5	4141	182918.00	0.314	7	DOP	80
5400	2438534.5	4981	182650.90	0.648	6	DOP	81
5400	2438534.5	6661	182159.30	0.644	6	DOP	82
5400	2438534.5	7501	181937.54	0.677	7	DOP	83
5400	2438534.5	8311	181738.86	0.737	6	DOP	84
5410	2438535.5	16151	178074.99	0.690	7	DOP	85
5410	2438535.5	16831	178066.27	0.346	35	DOP	86
5410	2438535.5	17656	178074.62	0.268	37	DOP	87
5420	2438536.5	16986	175270.19	0.330	34	DOP	88
5420	2438536.5	17781	175283.46	0.296	37	DOP	89
5440	2438538.5	83871	170394.31	0.370	24	DOP	90
5440	2438538.5	84716	170043.72	0.215	36	DOP	91
5440	2438538.5	86151	169465.50	0.265	37	DOP	92
5450	2438539.5	526	169162.93	0.288	36	DOP	93
5450	2438539.5	1301	168869.12	0.265	37	DOP	94
5450	2438539.5	2076	168585.46	0.222	36	DOP	95
5450	2438539.5	2856	168309.46	0.252	36	DOP	96
5450	2438539.5	3626	168047.49	0.248	32	DOP	97
5460	2438540.5	64191	170443.00	0.271	35	DOP	98
5460	2438540.5	64941	170273.48	0.198	37	DOP	99
5460	2438540.5	65691	170089.80	0.307	35	DOP	100
5460	2438540.5	66441	169892.66	0.247	35	DOP	101
5460	2438540.5	67296	169652.13	0.350	22	DOP	102
5460	2438540.5	67976	169451.16	0.865	6	DOP	103
5460	2438540.5	69096	169091.27	0.261	32	DOP	104
5460	2438540.5	69826	168845.45	0.257	36	DOP	105
5460	2438540.5	70781	168508.79	0.268	37	DOP	106
5470	2438541.5	67441	165670.20	0.254	35	DOP	107
5470	2438541.5	68186	165438.97	0.281	36	DOP	108
5470	2438541.5	68926	165197.66	0.256	36	DOP	109
5470	2438541.5	69671	164943.48	0.305	34	DOP	110
5470	2438541.5	70416	164678.81	0.268	34	DOP	111
5470	2438541.5	71031	164454.00	0.488	11	DOP	112
5470	2438541.5	71816	164157.02	0.371	20	DOP	113
5470	2438541.5	72626	163840.91	0.309	34	DOP	114
5480	2438542.5	67601	161458.61	0.390	21	DOP	115
5480	2438542.5	68256	161249.58	0.245	35	DOP	116

Table A-3 (contd)

Run number	Epoch of compressed data: Reference Julian date, Universal time	Epoch of compressed data: Seconds past reference Julian date	Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
5480	2438542.5	68991	161003.47	0.275	35	DOP	117
5480	2438542.5	69726	160746.45	0.302	34	DOP	118
5480	2438542.5	70456	160481.87	0.280	36	DOP	119
5480	2438542.5	71346	160145.75	0.647	4	DOP	120
5542	2438548.5	61996	133203.62	0.251	31	DOP	121
5542	2438548.5	62686	133037.22	0.333	28	DOP	122
5542	2438548.5	63546	132811.13	0.276	32	DOP	123
5542	2438548.5	64216	132623.26	0.288	31	DOP	124
5542	2438548.5	64886	132423.42	0.313	31	DOP	125
5542	2438548.5	65556	132213.34	0.251	31	DOP	126
5542	2438548.5	66226	131993.52	0.226	32	DOP	127
5542	2438548.5	66896	131763.96	0.335	30	DOP	128
5542	2438548.5	67566	131524.89	0.219	32	DOP	129
5542	2438548.5	68236	131277.32	0.277	31	DOP	130
5570	2438551.5	85271	105255.41	0.319	17	DOP	131
5580	2438552.5	211	104734.82	0.208	29	DOP	132
5580	2438552.5	856	104497.05	0.206	30	DOP	133
5580	2438552.5	1496	104269.05	0.194	30	DOP	134
5580	2438552.5	2141	104048.16	0.244	29	DOP	135
5580	2438552.5	2781	103837.81	0.245	29	DOP	136
5580	2438552.5	5536	103046.46	0.223	30	DOP	137
5580	2438552.5	6216	102880.49	0.307	22	DOP	138
5580	2438552.5	6816	102745.42	0.178	30	DOP	139
5590	2438553.5	1726	97534.20	0.211	24	DOP	140
5590	2438553.5	2351	97325.43	0.249	28	DOP	141
5590	2438553.5	2976	97126.57	0.208	29	DOP	142
5590	2438553.5	3611	96932.92	0.323	28	DOP	143
5590	2438553.5	4246	96749.77	0.241	30	DOP	144
5590	2438553.5	4881	96576.80	0.198	29	DOP	145
5590	2438553.5	5516	96414.36	0.199	30	DOP	146
5590	2438553.5	6146	96263.89	0.215	29	DOP	147
5590	2438553.5	6781	96123.41	0.270	29	DOP	148
5600	2438554.5	60806	95035.07	0.205	30	DOP	149
5600	2438554.5	61476	94848.50	0.234	29	DOP	150
5600	2438554.5	62101	94664.18	0.228	29	DOP	151
5600	2438554.5	62716	94472.55	0.198	30	DOP	152
5600	2438554.5	63336	94271.05	0.218	30	DOP	153
5600	2438554.5	63956	94061.25	0.214	30	DOP	154
5600	2438554.5	64586	93837.51	0.225	30	DOP	155
5600	2438554.5	65206	93610.34	0.188	30	DOP	156
5600	2438554.5	65826	93375.40	0.216	30	DOP	157
5600	2438554.5	66446	93131.70	0.206	30	DOP	158
5610	2438555.5	85046	77284.83	0.201	27	DOP	159
5610	2438555.5	85661	77047.13	0.204	29	DOP	160
5610	2438555.5	86261	76822.19	0.266	26	DOP	161
5621	2438556.5	486	76596.18	0.201	30	DOP	162
5621	2438556.5	1101	76382.26	0.182	29	DOP	163
5621	2438556.5	1716	76177.41	0.225	24	DOP	164
5621	2438556.5	2331	75981.35	0.220	28	DOP	165
5621	2438556.5	2946	75794.30	0.207	27	DOP	166
5621	2438556.5	3561	75617.22	0.231	29	DOP	167
5621	2438556.5	4171	75450.70	0.215	28	DOP	168
5621	2438556.5	4786	75292.59	0.215	28	DOP	169
5621	2438556.5	5391	75147.62	0.219	28	DOP	170
5622	2438556.5	63156	79567.60	0.215	26	DOP	171
5622	2438556.5	63756	79353.71	0.194	28	DOP	172
5622	2438556.5	64371	79125.83	0.230	29	DOP	173
5622	2438556.5	64971	78896.28	0.227	27	DOP	174

Table A-3 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
5622	2438556.5	65746	78588.81	0.212	28	DOP	175
5622	2438556.5	66361	78336.57	0.216	28	DOP	176
5622	2438556.5	66971	78080.74	0.255	29	DOP	177
5622	2438556.5	67581	77818.39	0.184	29	DOP	178
5622	2438556.5	68186	77552.26	0.218	28	DOP	179
5622	2438556.5	68796	77279.15	0.254	28	DOP	180
5622	2438556.5	69411	76998.65	0.258	27	DOP	181
5622	2438556.5	70016	76718.03	0.172	28	DOP	182
5650	2438559.5	65471	54901.17	0.326	21	DOP	183
5650	2438559.5	66021	54663.60	0.177	29	DOP	184
5650	2438559.5	66621	54398.73	0.216	28	DOP	185
5650	2438559.5	67216	54130.84	0.191	27	DOP	186
5650	2438559.5	67816	53855.88	0.174	26	DOP	187
5650	2438559.5	68411	53578.29	0.172	28	DOP	188
5650	2438559.5	68971	53313.42	0.261	19	DOP	189
5650	2438559.5	70196	52723.31	0.199	28	DOP	190
5650	2438559.5	71406	52128.47	0.212	24	DOP	191
5650	2438559.5	71986	51840.92	0.249	27	DOP	192
5750	2438569.5	75486	-36498.92	0.378	19	DOP	193
5750	2438569.5	76046	-36765.15	0.228	28	DOP	194
5750	2438569.5	76636	-37041.22	0.285	28	DOP	195
5750	2438569.5	77226	-37311.69	0.212	28	DOP	196
5750	2438569.5	77831	-37584.04	0.229	27	DOP	197
5750	2438569.5	78421	-37843.30	0.204	28	DOP	198
5750	2438569.5	79001	-38093.28	0.213	25	DOP	199
5750	2438569.5	79456	-38284.75	0.795	4	DOP	200
5760	2438570.5	71261	-42899.77	0.332	9	DOP	201
5760	2438570.5	71756	-43151.24	0.225	27	DOP	202
5760	2438570.5	72521	-43536.26	0.244	29	DOP	203
5760	2438570.5	73116	-43833.31	0.214	28	DOP	204
5760	2438570.5	73716	-44130.72	0.188	27	DOP	205
5760	2438570.5	74306	-44419.14	0.213	28	DOP	206
5760	2438570.5	74896	-44703.77	0.260	27	DOP	207
5760	2438570.5	75486	-44985.11	0.190	28	DOP	208
5760	2438570.5	76081	-45263.87	0.230	28	DOP	209
5760	2438570.5	76676	-45538.16	0.274	27	DOP	210
5760	2438570.5	77266	-45804.37	0.216	28	DOP	211
5770	2438571.5	63198	-47226.33	0.453	21	DOP	212
5790	2438573.5	69071	-66334.04	0.239	23	DOP	213
5790	2438573.5	69641	-66621.66	0.196	29	DOP	214
5790	2438573.5	70251	-66929.08	0.240	29	DOP	215
5790	2438573.5	70851	-67229.91	0.213	29	DOP	216
5790	2438573.5	71456	-67531.55	0.259	28	DOP	217
5790	2438573.5	72056	-67828.06	0.225	28	DOP	218
5790	2438573.5	72646	-68116.91	0.195	20	DOP	219
5810	2438575.5	59301	-76989.93	0.209	28	DOP	220
5810	2438575.5	59911	-77253.24	0.187	27	DOP	221
5810	2438575.5	60541	-77531.05	0.254	30	DOP	222
5810	2438575.5	61171	-77815.16	0.152	28	DOP	223
5810	2438575.5	61791	-78100.34	0.185	29	DOP	224
5810	2438575.5	62401	-78384.98	0.128	29	DOP	225
5831	2438577.5	1711	-95554.10	0.214	29	DOP	226
5831	2438577.5	2346	-95614.85	0.199	26	DOP	227
5831	2438577.5	2956	-95661.49	0.198	28	DOP	228
5831	2438577.5	3506	-95693.38	0.266	14	DOP	229
5832	2438577.5	58916	-91200.87	0.255	22	DOP	230
5832	2438577.5	59501	-91452.49	0.241	28	DOP	231
5832	2438577.5	60126	-91727.67	0.236	30	DOP	232

Table A-3 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
5832	2438577.5	60756	-92010.58	0.244	30	DOP	233
5832	2438577.5	61376	-92294.75	0.164	30	DOP	234
5832	2438577.5	62001	-92585.17	0.206	29	DOP	235
5840	2438578.5	78841	-107041.00	0.273	18	DOP	236
5840	2438578.5	79416	-107233.69	0.155	30	DOP	237
5840	2438578.5	80061	-107439.53	0.231	28	DOP	238
5840	2438578.5	80691	-107630.16	0.203	29	DOP	239
5840	2438578.5	81336	-107814.87	0.234	28	DOP	240
5840	2438578.5	81961	-107983.37	0.185	28	DOP	241
5840	2438578.5	82596	-108143.30	0.215	29	DOP	242
5840	2438578.5	83231	-108291.96	0.257	29	DOP	243
5840	2438578.5	83876	-108430.84	0.302	27	DOP	244
5850	2438579.5	66966	-108341.93	0.236	30	DOP	245
5850	2438579.5	67611	-108658.17	0.204	31	DOP	246
5850	2438579.5	68256	-108974.00	0.204	31	DOP	247
5850	2438579.5	68906	-109289.82	0.175	30	DOP	248
5850	2438579.5	69551	-109601.09	0.218	30	DOP	249
5880	2438582.5	64621	-125188.71	0.317	21	DOP	250
5880	2438582.5	65236	-125485.64	0.229	31	DOP	251
5880	2438582.5	65906	-125808.73	0.265	29	DOP	252
5880	2438582.5	66576	-126132.00	0.158	32	DOP	253
5880	2438582.5	67241	-126451.39	0.238	31	DOP	254
5921	2438586.5	62396	-144521.05	0.217	32	DOP	255
5921	2438586.5	63096	-144848.72	0.273	34	DOP	256
5921	2438586.5	63796	-145178.33	0.190	33	DOP	257
5921	2438586.5	64506	-145513.49	0.244	34	DOP	258
5921	2438586.5	65206	-145844.19	0.242	34	DOP	259
5922	2438586.5	83461	-152153.76	0.219	32	DOP	260
5922	2438586.5	84156	-152236.99	0.259	28	DOP	261
5922	2438586.5	84781	-152299.74	0.308	17	DOP	262
5922	2438586.5	85381	-152348.26	0.255	26	DOP	263
5922	2438586.5	86041	-152388.56	0.442	17	DOP	264
5922	2438586.5	86746	-152417.34	0.261	25	DOP	265
5931	2438587.5	63026	-149322.22	0.222	34	DOP	266
5931	2438587.5	63741	-149657.65	0.234	35	DOP	267
5931	2438587.5	64461	-149995.94	0.210	35	DOP	268
5931	2438587.5	65166	-150326.21	0.173	34	DOP	269
5931	2438587.5	65896	-150668.07	0.213	34	DOP	270
5931	2438587.5	66616	-151002.94	0.239	33	DOP	271
5932	2438587.5	84301	-156619.36	0.342	19	DOP	272
5932	2438587.5	85336	-156701.91	0.212	33	DOP	273
5932	2438587.5	86056	-156739.41	0.224	34	DOP	274
5961	2438590.5	59381	-159893.23	0.305	30	DOP	275
5961	2438590.5	60116	-160221.27	0.252	32	DOP	276
5961	2438590.5	60866	-160560.14	0.243	33	DOP	277
5961	2438590.5	61616	-160902.03	0.223	34	DOP	278
5961	2438590.5	62366	-161247.42	0.224	34	DOP	279
5961	2438590.5	63116	-161593.61	0.267	34	DOP	280
5961	2438590.5	63866	-161940.29	0.240	34	DOP	281
5961	2438590.5	64616	-162286.89	0.231	34	DOP	282
5961	2438590.5	65366	-162632.22	0.237	34	DOP	283
5962	2438590.5	82811	-168315.26	0.256	33	DOP	284
5962	2438590.5	83576	-168393.88	0.187	36	DOP	285
5962	2438590.5	84336	-168453.61	0.237	33	DOP	286
5962	2438590.5	85096	-168495.86	0.165	32	DOP	287
5962	2438590.5	85821	-168520.00	0.237	30	DOP	288
5970	2438591.5	83016	-171893.59	0.244	34	DOP	289
5970	2438591.5	83781	-171961.06	0.245	34	DOP	290

Table A-3 (contd)

Run number	Epoch of compressed data		Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
5970	2438591.5	84551	-172010.44	0.248	34	DOP	291
5970	2438591.5	85396	-172043.85	0.195	34	DOP	292
5980	2438592.5	83186	-175275.97	0.194	34	DOP	293
5980	2438592.5	83961	-175334.29	0.216	25	DOP	294
5980	2438592.5	84741	-175373.30	0.194	35	DOP	295
5980	2438592.5	85461	-175393.54	0.296	22	DOP	296
5990	2438593.5	64276	-172564.98	0.188	38	DOP	297
5990	2438593.5	65066	-172922.78	0.220	38	DOP	298
5990	2438593.5	65851	-173275.81	0.171	37	DOP	299
5990	2438593.5	66636	-173624.95	0.167	37	DOP	300
5990	2438593.5	67426	-173971.29	0.198	38	DOP	301
6010	2438595.5	48656	-172534.74	0.198	34	DOP	302
6010	2438595.5	49471	-172748.15	0.169	39	DOP	303
6010	2438595.5	50281	-172976.60	0.215	30	DOP	304
6010	2438595.5	51086	-173218.74	0.153	40	DOP	305
6010	2438595.5	51901	-173479.31	0.204	29	DOP	306
6010	2438595.5	52711	-173752.30	0.186	39	DOP	307
6010	2438595.5	53521	-174039.41	0.206	39	DOP	308
6010	2438595.5	54331	-174338.55	0.185	38	DOP	309
6010	2438595.5	55136	-174646.51	0.204	35	DOP	310
6030	2438597.5	82421	-189463.95	0.270	22	DOP	311
6030	2438597.5	83276	-189517.26	0.233	35	DOP	312
6030	2438597.5	84116	-189548.20	0.216	38	DOP	313
6060	2438600.5	62446	-190160.39	0.191	41	DOP	314
6060	2438600.5	63321	-190547.07	0.203	43	DOP	315
6060	2438600.5	64201	-190933.59	0.223	43	DOP	316
6060	2438600.5	65081	-191316.21	0.197	43	DOP	317
6060	2438600.5	65956	-191691.77	0.229	40	DOP	318
6080	2438602.5	82741	-199991.54	0.249	43	DOP	319
6080	2438602.5	83641	-200014.47	0.246	42	DOP	320
1801577	780338383.0	16627482	13108624.38	86.844	10179	CHK	321

Table A-4. 1966 doppler data

Run number	Epoch of compressed data: Reference Julian date, Universal time	Epoch of compressed data: Seconds past reference Julian date	Compressed doppler data in Hz	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
160	2439141.5	83096	63201.63	0.097	24	DOP	1
160	2439141.5	83631	62964.64	0.103	15	DOP	2
160	2439141.5	84141	62743.46	0.124	16	DOP	3
160	2439141.5	84631	62535.48	0.069	15	DOP	4
160	2439141.5	85136	62326.27	0.089	24	DOP	5
160	2439141.5	85666	62112.45	0.079	24	DOP	6
160	2439141.5	86226	61892.96	0.126	22	DOP	7
170	2439142.5	58891	66636.74	0.140	23	DOP	8
170	2439142.5	59411	66502.41	0.148	21	DOP	9
170	2439142.5	59956	66352.92	0.120	25	DOP	10
170	2439142.5	60536	66184.65	0.151	26	DOP	11
170	2439142.5	61051	66027.48	0.128	21	DOP	12
170	2439142.5	61636	65840.51	0.107	26	DOP	13
170	2439142.5	62191	65654.71	0.126	26	DOP	14
170	2439142.5	62756	65457.45	0.139	26	DOP	15
171	2439142.5	74776	59914.04	0.125	23	DOP	16
171	2439142.5	75316	59634.61	0.096	26	DOP	17
171	2439142.5	75906	59329.54	0.115	26	DOP	18
171	2439142.5	76466	59040.67	0.135	25	DOP	19
171	2439142.5	77036	58747.75	0.080	26	DOP	20
171	2439142.5	77591	58464.21	0.113	25	DOP	21
171	2439142.5	78161	58174.73	0.113	27	DOP	22
180	2439143.5	58921	59181.77	0.185	21	DOP	23
180	2439143.5	59436	59041.40	0.161	26	DOP	24
180	2439143.5	59981	58885.00	0.173	25	DOP	25
180	2439143.5	60536	58717.05	0.171	26	DOP	26
180	2439143.5	61086	58542.20	0.167	28	DOP	27
180	2439143.5	61646	58356.33	0.127	26	DOP	28
180	2439143.5	62221	58156.75	0.129	25	DOP	29
180	2439143.5	62761	57962.01	0.134	25	DOP	30
180	2439143.5	63351	57741.21	0.102	27	DOP	31
530	2439178.5	71316	-171274.40	0.100	34	DOP	32
530	2439178.5	72201	-171621.04	0.123	32	DOP	33
530	2439178.5	73021	-171929.17	0.162	17	DOP	34
530	2439178.5	73691	-172171.48	0.076	35	DOP	35
530	2439178.5	74431	-172428.03	0.104	35	DOP	36
530	2439178.5	75181	-172675.81	0.109	35	DOP	37
550	2439180.5	63894	-173992.95	0.115	32	DOP	38
550	2439180.5	64642	-174336.32	0.123	36	DOP	39
550	2439180.5	65410	-174686.98	0.122	36	DOP	40
550	2439180.5	66176	-175031.93	0.059	36	DOP	41
550	2439180.5	66946	-175377.14	0.057	35	DOP	42
550	2439180.5	67706	-175713.19	0.056	35	DOP	43
11777	104883573.5	2998761	-174915.41	5.078	1139	CHK	44

Table A-5. 1964 range data

Run number	Epoch of compressed data		Compressed range data in μsec[a]	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1460	2438540.5	60258	374498999.	3.2	4	RNG	001
1460	2438540.5	60943	374449940.	3.6	5	RNG	002
1460	2438540.5	62171	374362035.	7.1	6	RNG	003
1460	2438540.5	62886	374310909.	10.5	5	RNG	004
1470	2438541.5	60378	368563368.	2.4	6	RNG	005
1470	2438541.5	61117	368511656.	2.8	6	RNG	006
1470	2438541.5	61856	368459948.	2.1	6	RNG	007
1470	2438541.5	62565	368410403.	4.1	5	RNG	008
1480	2438542.5	59115	362866619.	2.3	5	RNG	009
1480	2438542.5	59788	362820621.	1.7	5	RNG	010
1480	2438542.5	60461	362774655.	2.7	5	RNG	011
1480	2438542.5	61134	362728705.	3.4	5	RNG	012
1480	2438542.5	63123	362593094.	2.4	4	RNG	013
1501	2438544.5	08423	354943256.	0.8	5	RNG	014
1501	2438544.5	09088	354902423.	4.1	5	RNG	015
1501	2438544.5	10114	354839517.	3.0	4	RNG	016
1501	2438544.5	10779	354798774.	4.5	4	RNG	017
1501	2438544.5	11692	354742882.	3.9	4	RNG	018
1502	2438544.5	58389	351807157.	2.9	5	RNG	019
1502	2438544.5	59051	351764352.	2.5	5	RNG	020
1502	2438544.5	59713	351721578.	5.3	5	RNG	021
1502	2438544.5	60375	351678815.	1.8	5	RNG	022
1502	2438544.5	61037	351636085.	4.6	5	RNG	023
1502	2438544.5	61698	351593437.	1.3	5	RNG	024
1502	2438544.5	62331	351552649.	4.3	4	RNG	025
1531	2438547.5	06251	339377987.	5.1	5	RNG	026
1531	2438547.5	06901	339341981.	3.9	5	RNG	027
1531	2438547.5	07551	339306002.	3.6	5	RNG	028
1531	2438547.5	08201	339270071.	4.4	5	RNG	029
1531	2438547.5	08851	339234165.	5.4	5	RNG	030
1531	2438547.5	09501	339198298.	3.7	5	RNG	031
1531	2438547.5	10121	339164133.	2.9	4	RNG	032
1532	2438547.5	58220	336438638.	2.3	5	RNG	033
1532	2438547.5	58867	336400879.	2.9	5	RNG	034
1532	2438547.5	59514	336363151.	5.5	5	RNG	035
1532	2438547.5	60161	336325438.	3.3	5	RNG	036
1532	2438547.5	60808	336287765.	4.5	5	RNG	037
1532	2438547.5	61425	336251871.	5.0	4	RNG	038
1540	2438548.5	57480	331731034.	3.0	5	RNG	039
1540	2438548.5	58122	331695029.	2.3	5	RNG	040
1540	2438548.5	58764	331659039.	2.5	5	RNG	041
1540	2438548.5	60048	331587149.	2.7	5	RNG	042
1540	2438548.5	60690	331551249.	3.1	5	RNG	043
1540	2438548.5	61302	331517053.	4.5	4	RNG	044
1560	2438550.5	56948	322875737.	9.2	5	RNG	045
1560	2438550.5	57581	322843343.	5.2	5	RNG	046
1560	2438550.5	58214	322810961.	10.9	5	RNG	047
1560	2438550.5	58847	322778590.	7.8	5	RNG	048
1560	2438550.5	59480	322746267.	5.2	5	RNG	049
1560	2438550.5	60083	322715487.	1.8	4	RNG	050
1570	2438551.5	56255	318794065.	5.0	4	RNG	051
1570	2438551.5	56854	318764937.	4.6	5	RNG	052
1570	2438551.5	57483	318734375.	4.9	5	RNG	053
1570	2438551.5	58112	318703838.	4.3	5	RNG	054
1570	2438551.5	58741	318673331.	9.1	5	RNG	055
1570	2438551.5	59370	318642860.	3.3	5	RNG	056

[a]Units of time delay are given in seconds of UT.

Table A-5 (contd)

Run number	Epoch of compressed data		Compressed range data in μsec[a]	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1570	2438551.5	59969	318613856.	6.6	4	RNG	057
1610	2438555.5	54158	304787964.	4.6	4	RNG	058
1610	2438555.5	54743	304766157.	7.2	5	RNG	059
1610	2438555.5	55358	304743251.	6.0	5	RNG	060
1610	2438555.5	55973	304720361.	6.5	5	RNG	061
1610	2438555.5	56588	304697489.	3.5	5	RNG	062
1610	2438555.5	57173	304675767.	6.7	4	RNG	063
1620	2438556.5	55092	301866583.	3.8	4	RNG	064
1620	2438556.5	55644	301847737.	3.6	4	RNG	065
1620	2438556.5	56196	301828894.	1.8	4	RNG	066
1620	2438556.5	56748	301810097.	3.0	4	RNG	067
1620	2438556.5	57300	301791317.	4.3	4	RNG	068
1620	2438556.5	57852	301772567.	1.7	4	RNG	069
1640	2438558.5	61233	296746005.	3.6	4	RNG	070
1640	2438558.5	61780	296731218.	5.8	4	RNG	071
1640	2438558.5	62327	296716484.	0.7	4	RNG	072
1640	2438558.5	62874	296701791.	1.2	4	RNG	073
1650	2438559.5	52903	294916618.	5.1	4	RNG	074
1650	2438559.5	53993	294889980.	3.5	4	RNG	075
1650	2438559.5	54538	294876685.	2.6	4	RNG	076
1650	2438559.5	55083	294863401.	3.2	4	RNG	077
1650	2438559.5	55628	294850158.	4.3	4	RNG	078
1650	2438559.5	56173	294836919.	6.6	4	RNG	079
1660	2438560.5	54997	293106074.	7.6	4	RNG	080
1660	2438560.5	55541	293094706.	5.2	4	RNG	081
1660	2438560.5	56085	293083347.	2.4	4	RNG	082
1680	2438562.5	53767	290502737.	4.9	4	RNG	083
1680	2438562.5	54308	290495178.	0.8	4	RNG	084
1680	2438562.5	54849	290487634.	1.7	4	RNG	085
1680	2438562.5	55390	290480132.	3.9	4	RNG	086
1740	2438568.5	60876	290089853.	4.9	4	RNG	087
1740	2438568.5	61417	290094564.	5.6	4	RNG	088
1740	2438568.5	61958	290099356.	2.4	4	RNG	089
1750	2438569.5	54979	291054700.	2.7	4	RNG	090
1750	2438569.5	55521	291060899.	2.9	4	RNG	091
1760	2438570.5	51153	292316642.	4.9	4	RNG	092
1760	2438570.5	51696	292324557.	5.8	4	RNG	093
1760	2438570.5	52239	292332480.	5.4	4	RNG	094
1760	2438570.5	52782	292340436.	5.8	4	RNG	095
1760	2438570.5	53325	292348423.	3.2	4	RNG	096
1760	2438570.5	53868	292356468.	6.0	4	RNG	097
1760	2438570.5	54411	292364514.	3.9	4	RNG	098
1770	2438571.5	51136	293921688.	6.0	4	RNG	099
1770	2438571.5	51680	293931487.	4.1	4	RNG	100
1770	2438571.5	52224	293941328.	3.1	4	RNG	101
1780	2438572.5	52146	295843767.	4.7	4	RNG	102
1780	2438572.5	52692	295855505.	3.5	4	RNG	103
1780	2438572.5	53238	295867297.	3.0	4	RNG	104
1790	2438573.5	52539	298046103.	6.4	4	RNG	105
1790	2438573.5	53088	298059761.	5.4	4	RNG	106
1790	2438573.5	53637	298073462.	4.0	4	RNG	107
1800	2438574.5	49451	300435311.	3.2	4	RNG	108
1800	2438574.5	50002	300450646.	3.0	4	RNG	109
1800	2438574.5	50553	300466006.	3.5	4	RNG	110
1800	2438574.5	51104	300481394.	7.3	4	RNG	111
1800	2438574.5	51655	300496794.	2.2	4	RNG	112
1800	2438574.5	52206	300512234.	4.2	4	RNG	113
1830	2438577.5	51130	309504995.	1.9	5	RNG	114

Table A-5 (contd)

Run number	Epoch of compressed data		Compressed range data in μsec[a]	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1830	2438577.5	51750	309528009.	2.8	5	RNG	115
1830	2438577.5	52370	309551053.	3.5	5	RNG	116
1830	2438577.5	52990	309574148.	2.6	5	RNG	117
1830	2438577.5	53580	309596173.	3.3	4	RNG	118
1850	2438579.5	46620	316582077.	3.8	5	RNG	119
1850	2438579.5	47217	316607320.	1.0	4	RNG	120
1850	2438579.5	49764	316715287.	3.4	4	RNG	121
1850	2438579.5	50361	316740677.	2.5	5	RNG	122
1850	2438579.5	50988	316767383.	3.8	5	RNG	123
1850	2438579.5	51585	316792835.	2.5	4	RNG	124
1880	2438582.5	46562	329138332.	2.7	5	RNG	125
1880	2438582.5	47202	329170171.	4.3	5	RNG	126
1880	2438582.5	47842	329202045.	2.3	5	RNG	127
1880	2438582.5	48482	329233953.	1.8	5	RNG	128
1880	2438582.5	49122	329265887.	1.4	5	RNG	129
1880	2438582.5	49762	329297860.	2.1	5	RNG	130
1880	2438582.5	50372	329328370.	4.9	4	RNG	131
1890	2438583.5	46903	333755686.	1.7	5	RNG	132
1890	2438583.5	47547	333789209.	0.7	5	RNG	133
1890	2438583.5	48161	333821198.	4.6	4	RNG	134
1890	2438583.5	49449	333888407.	1.9	4	RNG	135
1900	2438584.5*	51512	338797773.	13.0	5	RNG	136
1900	2438584.5*	52161	338833253.	10.0	5	RNG	137
1900	2438584.5*	52810	338868806.	10.0	5	RNG	138
1900	2438584.5*	53459	338904401.	10.0	5	RNG	139
1900	2438584.5*	54108	338940056.	10.0	5	RNG	140
1910	2438585.5*	45684	343451971.	16.0	5	RNG	141
1910	2438585.5*	46338	343488729.	18.0	5	RNG	142
1910	2438585.5*	46992	343525507.	4.0	5	RNG	143
1910	2438585.5*	47646	343562335.	15.0	5	RNG	144
1910	2438585.5*	48300	343599192.	11.0	5	RNG	145
1910	2438585.5*	48954	343636077.	12.0	5	RNG	146
1910	2438585.5*	49578	343671308.	13.0	5	RNG	147
1920	2438586.5*	44379	348520545.	8.0	5	RNG	148
1920	2438586.5*	45038	348558836.	9.0	5	RNG	149
1920	2438586.5*	45697	348597147.	10.0	5	RNG	150
1920	2438586.5*	46356	348635489.	14.0	5	RNG	151
1920	2438586.5*	47015	348673857.	10.0	5	RNG	152
1920	2438586.5*	47674	348712256.	6.0	5	RNG	153
1920	2438586.5*	48333	348750690.	10.0	5	RNG	154
1920	2438586.5*	48992	348789154.	10.0	5	RNG	155
1930	2438587.5*	43555	353778290.	10.0	3	RNG	156
1930	2438587.5*	44099	353810887.	10.0	5	RNG	157
1930	2438587.5*	44823	353854312.	10.0	5	RNG	158
1930	2438587.5*	45487	353894152.	10.0	5	RNG	159
1930	2438587.5*	46091	353930418.	10.0	5	RNG	160
1930	2438587.5*	46755	353970301.	10.0	5	RNG	161
1930	2438587.5*	47419	354010216.	10.0	5	RNG	162
1930	2438587.5*	48084	354050240.	10.0	5	RNG	163
1930	2438587.5*	48749	354090294.	10.0	5	RNG	164
1940	2438588.5*	43874	359260940.	10.0	5	RNG	165
1940	2438588.5*	44544	359302309.	11.0	5	RNG	166
1940	2438588.5*	45214	359343693.	8.0	5	RNG	167
1940	2438588.5*	45884	359385087.	11.0	5	RNG	168
1940	2438588.5*	46554	359426534.	12.0	5	RNG	169
1940	2438588.5*	47284	359471716.	9.0	5	RNG	170
1940	2438588.5*	47894	359509507.	8.0	5	RNG	171
1940	2438588.5*	48564	359551052.	12.0	5	RNG	172

Table A-5 (contd)

Run number	Epoch of compressed data		Compressed range data in μsec[a]	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
	Reference Julian date, Universal time	Seconds past reference Julian date					
1950	2438589.5*	45481	364975991.	10.0	6	RNG	173
1950	2438589.5*	46156	365018857.	10.0	6	RNG	174
1950	2438589.5*	46832	365061822.	10.0	6	RNG	175
1950	2438589.5*	47628	365112460.	10.0	6	RNG	176
1950	2438589.5*	48424	365163153.	10.0	6	RNG	177
1950	2438589.5*	49100	365206246.	10.0	6	RNG	178
1960	2438590.5*	43063	370576542.	10.0	3	RNG	179
1960	2438590.5*	43744	370620792.	6.0	6	RNG	180
1960	2438590.5*	44485	370668998.	11.0	6	RNG	181
1960	2438590.5*	45226	370717207.	9.0	6	RNG	182
1960	2438590.5*	45967	370765434.	13.0	6	RNG	183
1970	2438591.5*	47425	376756013.	9.0	6	RNG	184
1970	2438591.5*	48172	376805917.	6.0	6	RNG	185
1970	2438591.5*	48919	376855865.	6.0	6	RNG	186
1970	2438591.5*	49666	376905890.	6.0	6	RNG	187
1970	2438591.5*	50353	376951934.	8.0	6	RNG	188
1980	2438592.5*	43443	382508094.	10.0	5	RNG	189
1980	2438592.5*	45488	382647203.	12.0	4	RNG	190
1980	2438592.5*	46181	382694395.	5.0	6	RNG	191
1980	2438592.5*	46934	382745718.	10.0	6	RNG	192
1980	2438592.5*	47627	382792981.	15.0	6	RNG	193
1990	2438593.5*	43996	388684979.	6.0	6	RNG	194
1990	2438593.5*	44815	388741805.	12.0	6	RNG	195
1990	2438593.5*	45514	388790332.	11.0	6	RNG	196
1990	2438593.5*	46273	388843071.	11.0	6	RNG	197
1990	2438593.5*	47032	388895848.	10.0	6	RNG	198
1990	2438593.5*	47731	388944498.	16.0	6	RNG	199
2020	2438596.5*	44359	407792664.	10.0	6	RNG	200
2020	2438596.5*	45137	407849523.	10.0	6	RNG	201
2020	2438596.5*	45915	407906425.	10.0	6	RNG	202
2020	2438596.5*	46693	407963369.	10.0	6	RNG	203
2020	2438596.5*	47471	408020372.	10.0	6	RNG	204
2030	2438597.5*	42659	414228413.	11.0	6	RNG	205
2030	2438597.5*	43444	414286585.	8.0	6	RNG	206
2030	2438597.5*	44229	414344773.	9.0	6	RNG	207
2030	2438597.5*	45014	414402990.	11.0	6	RNG	208
2030	2438597.5*	45799	414461258.	9.0	6	RNG	209
2030	2438597.5*	46524	414515106.	9.0	6	RNG	210
2040	2438598.5*	45631	421102777.	9.0	6	RNG	211
2040	2438598.5*	46363	421157888.	16.0	6	RNG	212
2040	2438598.5*	47275	421226625.	10.0	6	RNG	213
2040	2438598.5*	48007	421281844.	9.0	6	RNG	214
2040	2438598.5*	48739	421337124.	9.0	6	RNG	215
2050	2438599.5*	50022	428177924.	6.0	5	RNG	216
2050	2438599.5*	50821	428239229.	7.0	7	RNG	217
2050	2438599.5*	51680	428305227.	10.0	7	RNG	218
2050	2438599.5*	52539	428371322.	6.0	7	RNG	219
2050	2438599.5*	53398	428437532.	6.0	7	RNG	220
2060	2438600.5*	42488	434420056.	6.0	7	RNG	221
2060	2438600.5*	43353	434486656.	9.0	7	RNG	222
2060	2438600.5*	44218	434553285.	5.0	7	RNG	223
2060	2438600.5*	45083	434619959.	6.0	7	RNG	224
2060	2438600.5*	45948	434686684.	9.0	7	RNG	225
2060	2438600.5*	46813	434753462.	8.0	7	RNG	226
2070	2438601.5*	43041	441355878.	5.0	7	RNG	227
2070	2438601.5*	43913	441423776.	10.0	7	RNG	228
2070	2438601.5*	44845	441496384.	4.0	7	RNG	229
2070	2438601.5*	45657	441559704.	12.0	7	RNG	230

Table A-6. 1966 range data

Run number	Epoch of compressed data: Reference Julian date, Universal time	Epoch of compressed data: Seconds past reference Julian date	Compressed range data in μsec[a]	Standard deviation, σ_b	Number of actual observations	Data type	Card sequence number
2070	2438601.5*	46529	441627754.	11.0	7	RNG	231
2080	2438602.5*	42639	448288313.	6.0	7	RNG	232
2080	2438602.5*	43518	448357445.	6.0	7	RNG	233
2080	2438602.5*	44397	448426617.	6.0	7	RNG	234
2080	2438602.5*	45276	448495816.	10.0	7	RNG	235
2080	2438602.5*	46155	448565087.	6.0	7	RNG	236
2090	2438603.5*	42225	455285431.	7.0	7	RNG	237
2090	2438603.5*	43111	455355755.	7.0	7	RNG	238
2090	2438603.5*	43997	455426123.	6.0	7	RNG	239
2090	2438603.5*	44883	455496520.	5.0	7	RNG	240
2090	2438603.5*	45769	455566986.	7.0	7	RNG	241
2100	2438604.5*	41321	462304574.	5.0	4	RNG	242
2100	2438604.5*	42094	462366446.	7.0	7	RNG	243
2100	2438604.5*	42987	462437937.	8.0	7	RNG	244
2100	2438604.5*	43880	462509463.	8.0	7	RNG	245
2100	2438604.5*	44773	462581034.	10.0	7	RNG	246
2100	2438604.5*	45666	462652678.	10.0	7	RNG	247
2130	2438607.5*	51552	484748339.	5.0	4	RNG	248
2130	2438607.5*	52407	484819115.	6.0	8	RNG	249
2130	2438607.5*	53352	484897462.	5.0	8	RNG	250
452598	609643881.0	12319833	88722019700.	1590.2	1282	CHK	251

END OF 1964 RANGE DATA

1965–1966 RANGE DATA

3490	2439109.5	73470	446473851.	0.5	6	RNG	1
3490	2439109.5	74640	446379026.	0.6	7	RNG	2
3490	2439109.5	75480	446311078.	0.8	7	RNG	3
3650	2439125.5	07800	349757219.	1.3	5	RNG	4
3650	2439125.5	08520	349711845.	1.4	5	RNG	5
3650	2439125.5	09180	349670298.	1.6	5	RNG	6
3650	2439125.5	09840	349628786.	0.8	5	RNG	7
3770	2439137.5	00990	293603719.	2.2	4	RNG	8
3770	2439137.5	01530	293582195.	1.6	4	RNG	9
3900	2439150.5	69930	268217738.	1.4	4	RNG	10
3900	2439150.5	70410	268218091.	1.9	4	RNG	11
3900	2439150.5	70950	268218537.	4.3	4	RNG	12
4020	2439162.5	72330	289825547.	2.2	4	RNG	13
4020	2439162.5	72870	289847191.	1.8	4	RNG	14
4020	2439162.5	73410	289868898.	2.0	4	RNG	15
4020	2439162.5	73950	289890660.	1.5	4	RNG	16
4020	2439162.5	74490	289912467.	1.1	4	RNG	17
4180	2439178.5	54870	367084986.	1.0	6	RNG	18
4180	2439178.5	55590	367134496.	1.2	6	RNG	19
4180	2439178.5	56370	367188224.	0.7	6	RNG	20
76950	48782905.0	1006620	6680524852.	29.9	98	CHK	21

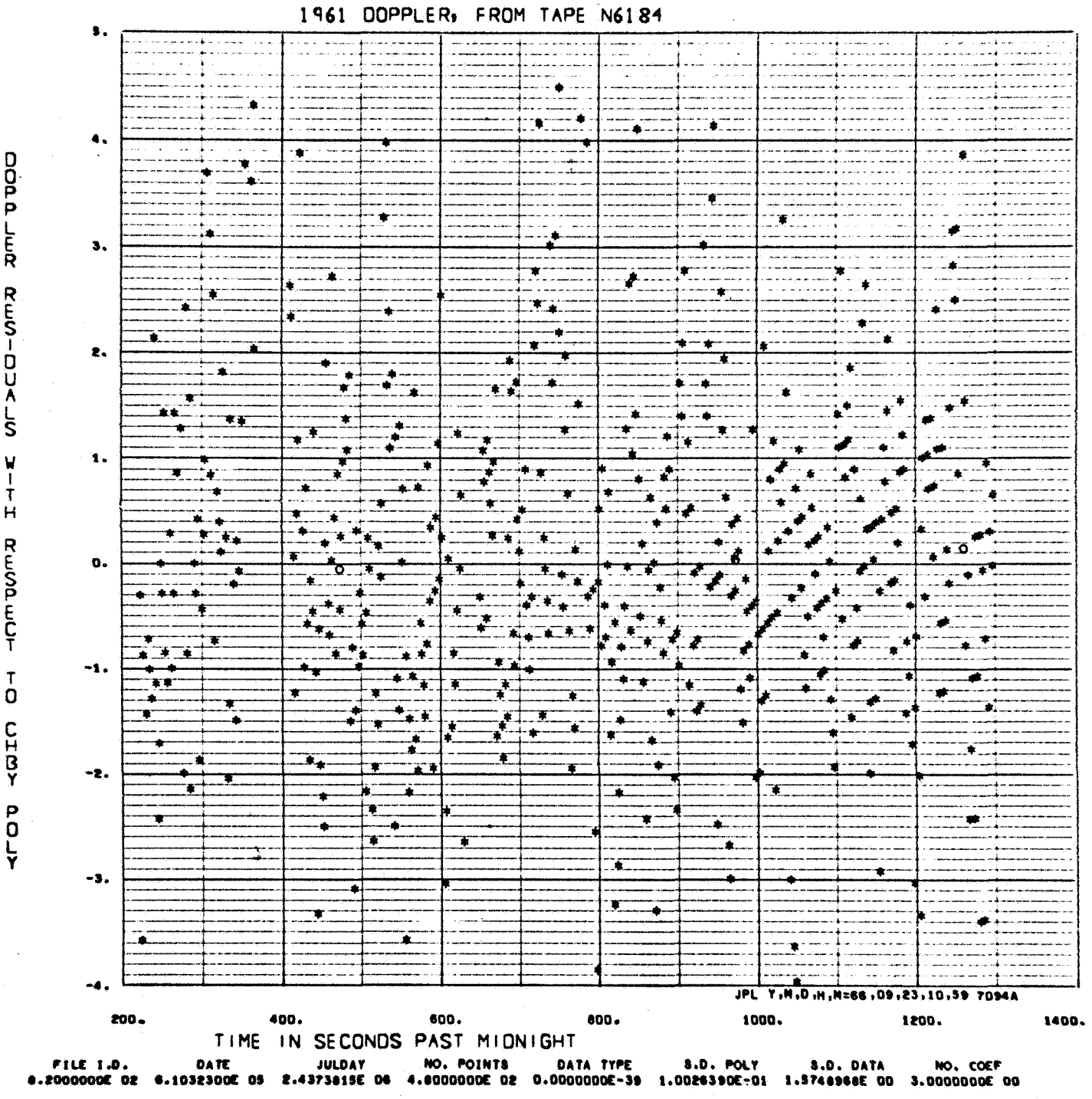


Fig. A-1. 1961 doppler data, run 820 of Table A-1

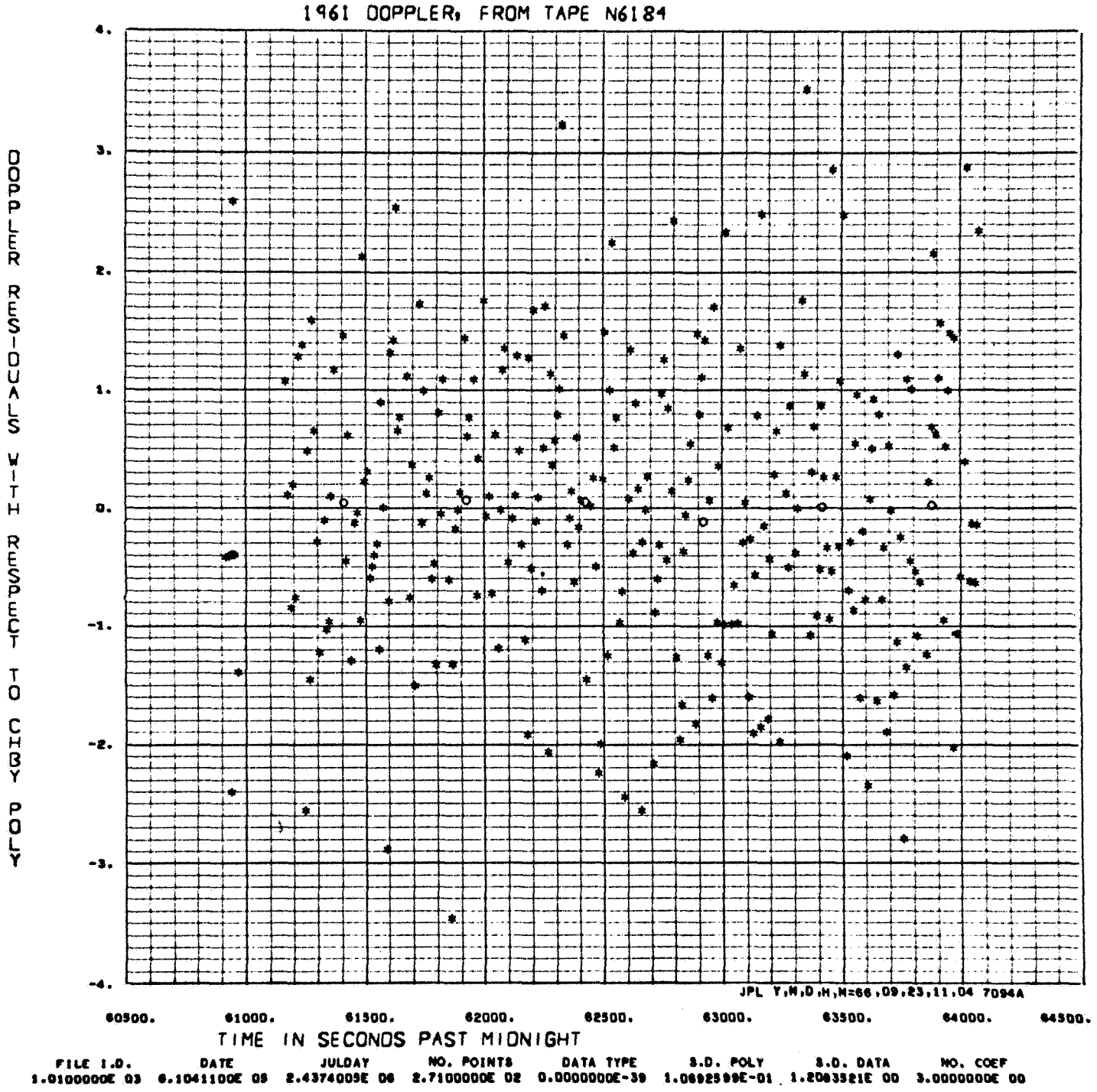


Fig. A-2. 1961 doppler data, run 1010 of Table A-1

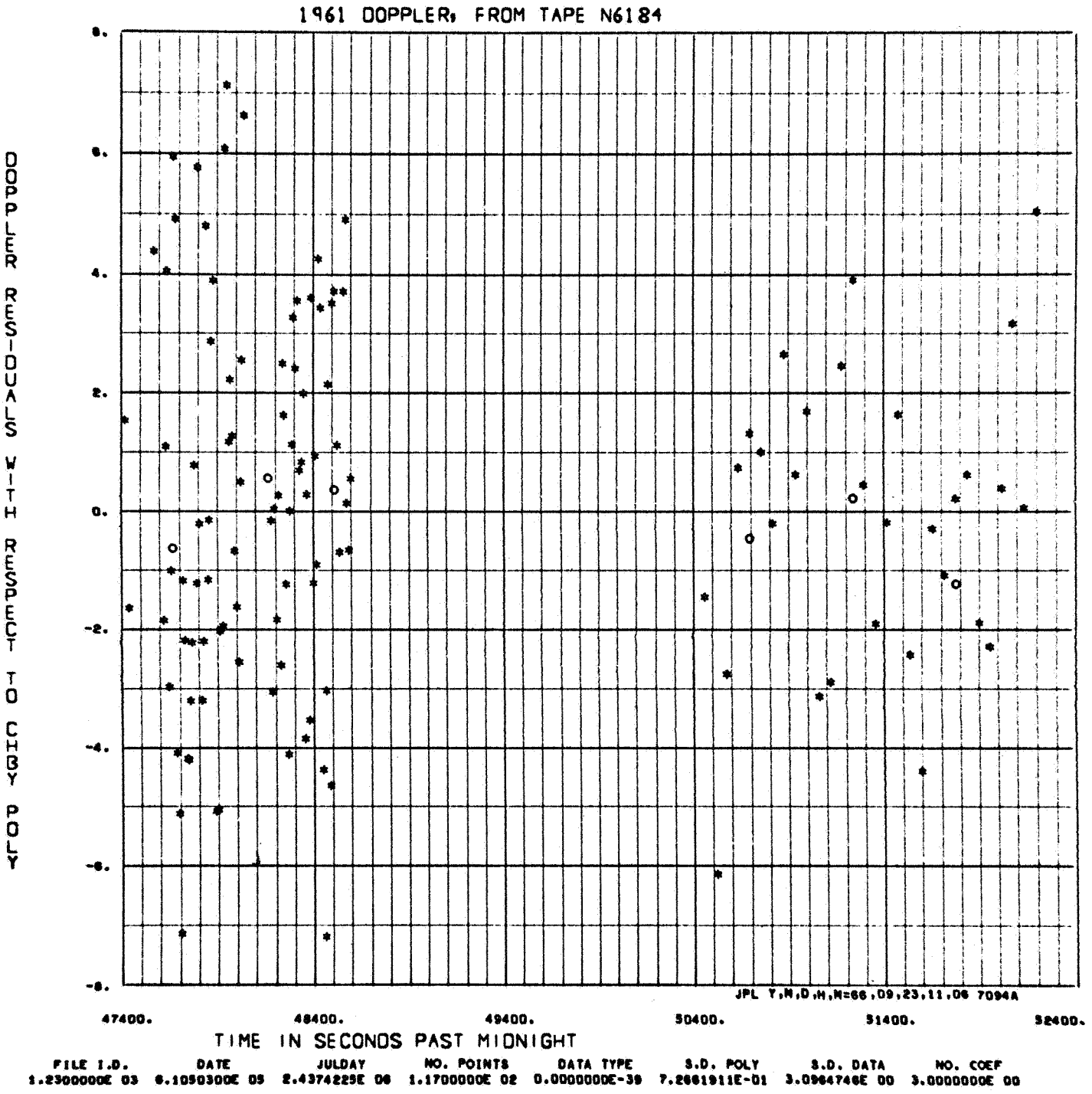


Fig. A-3. 1961 doppler data, run 1230 of Table A-1

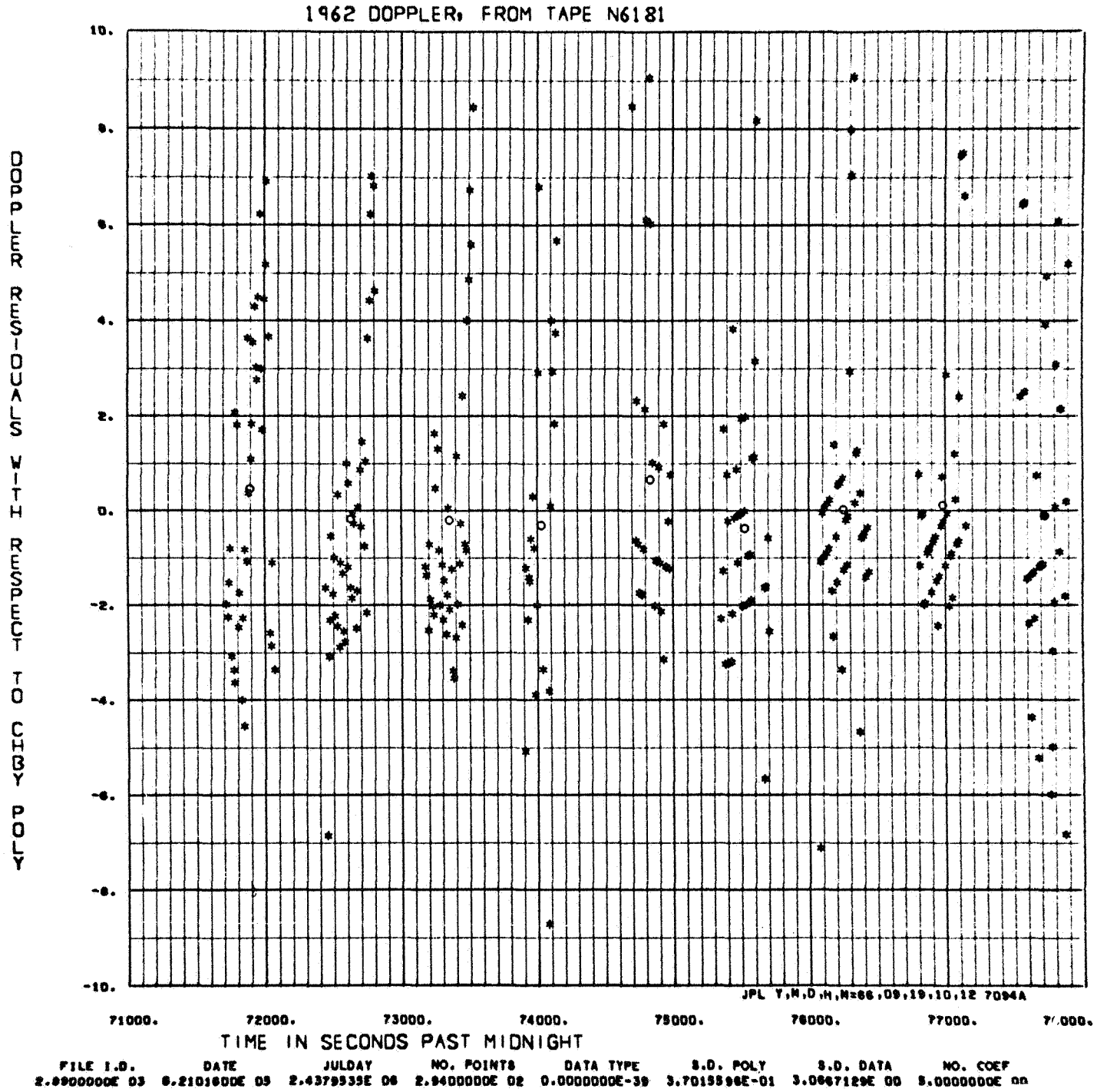
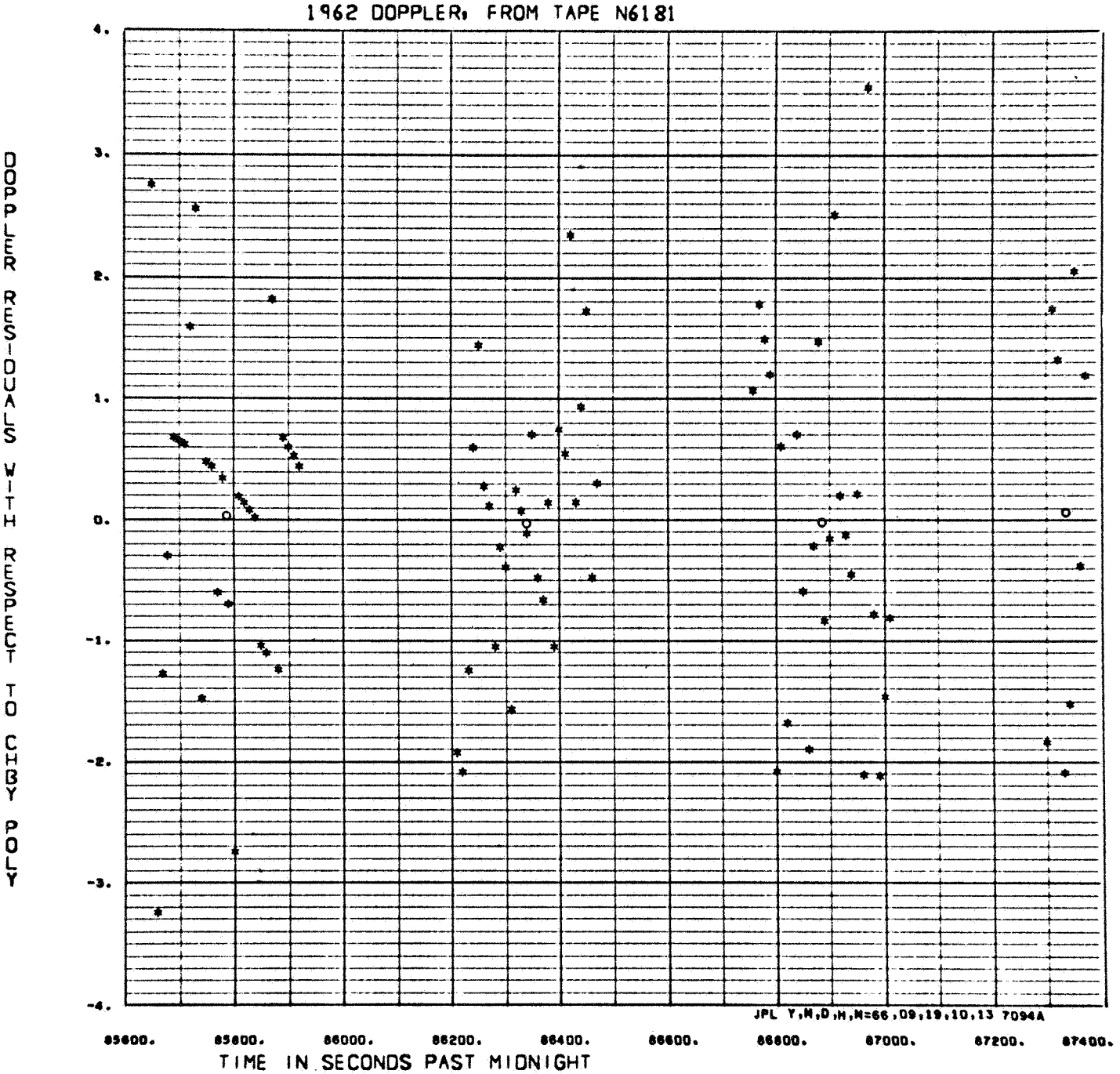


Fig. A-4. 1962 doppler data, run 2890 of Table A-2



FILE I.D.	DATE	JULDAY	NO. POINTS	DATA TYPE	S.D. POLY	S.D. DATA	NO. COEF
3.1000000E 03	6.2110600E 05	2.4379745E 06	8.6000000E 01	0.0000000E-39	2.1475186E-01	1.3472498E 00	3.0000000E 00

Fig. A-5. 1962 doppler data, run 3100 of Table A-2

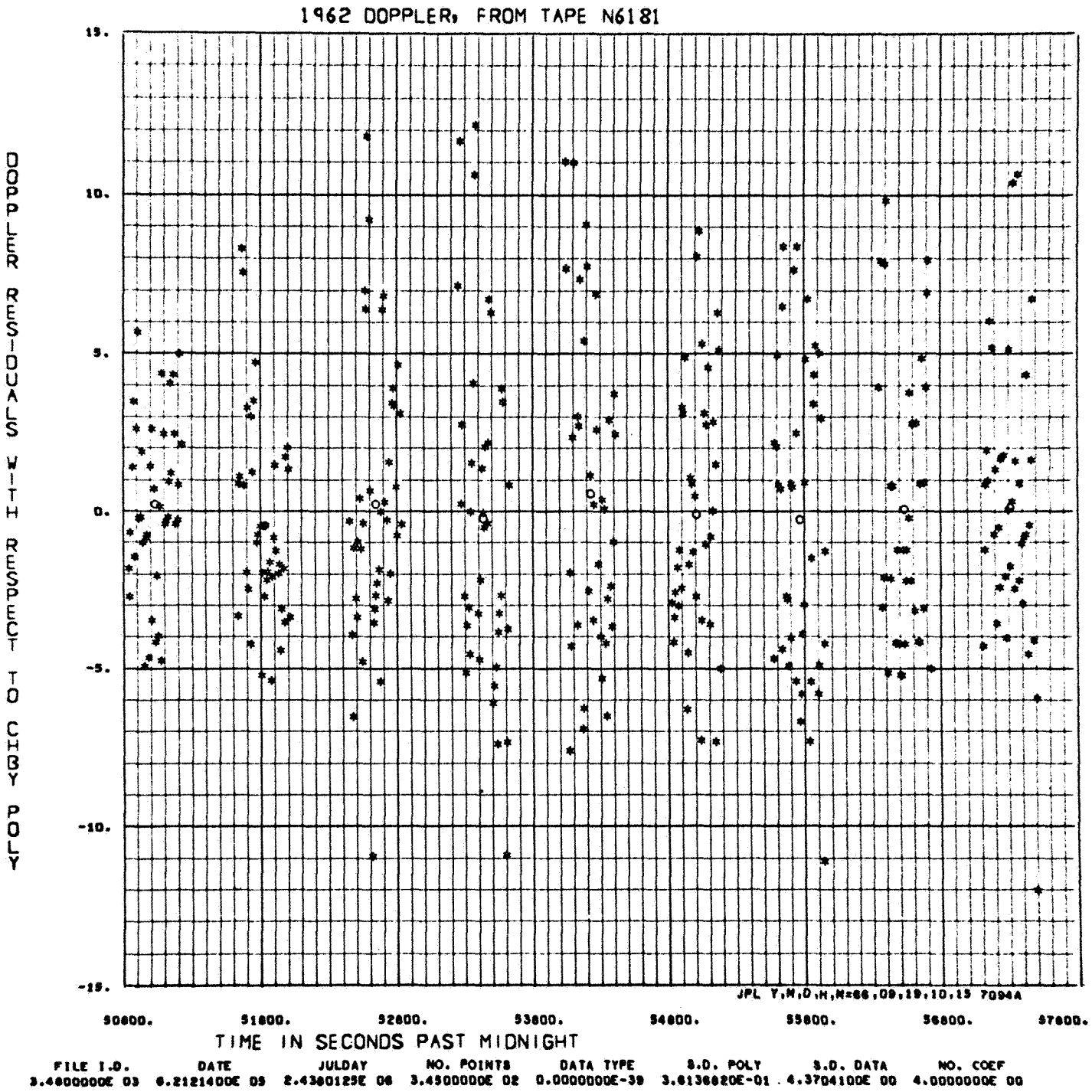


Fig. A-6. 1962 doppler data, run 3480 of Table A-2

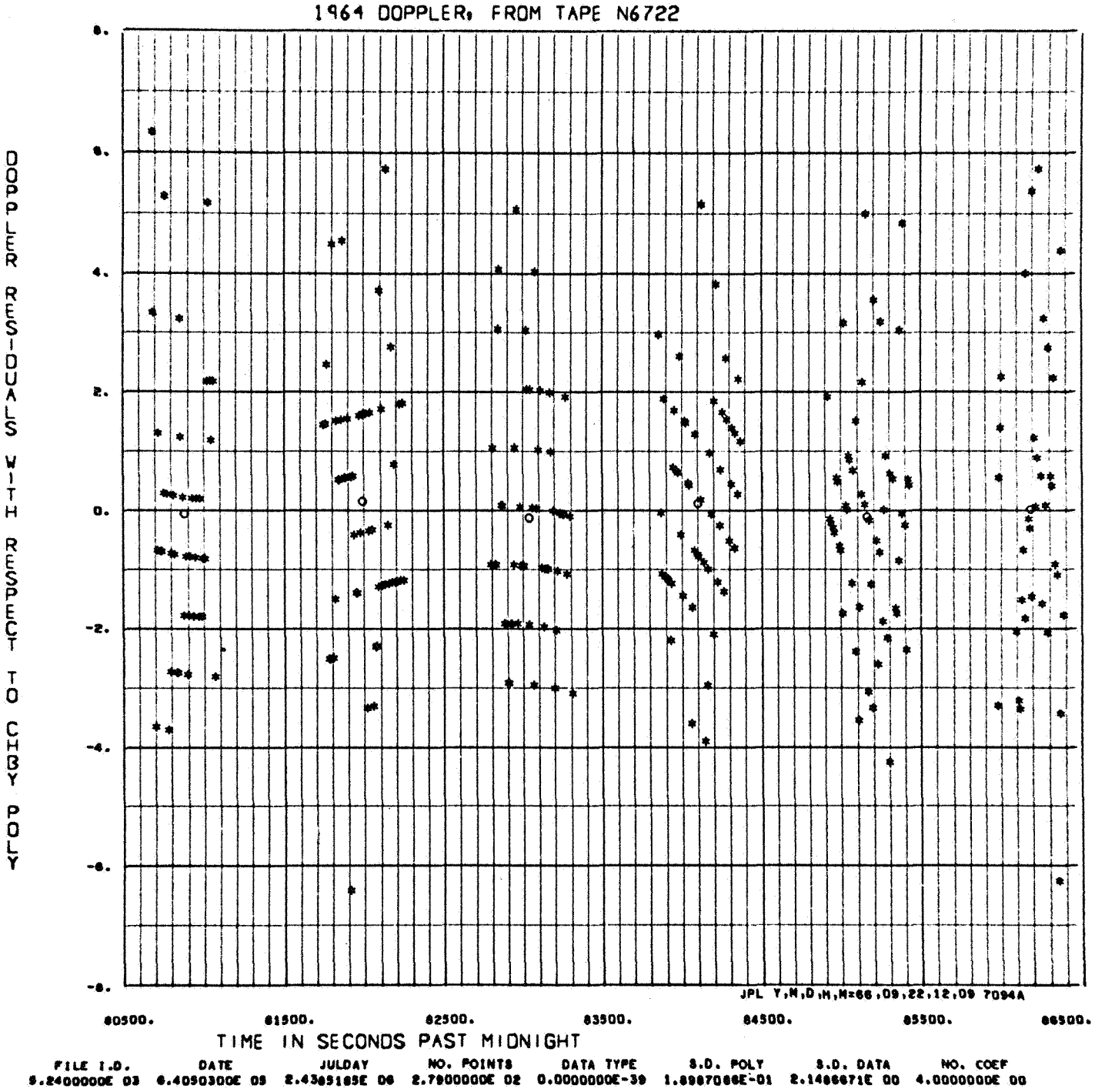


Fig. A-7. 1964 doppler data, run 5240 of Table A-3

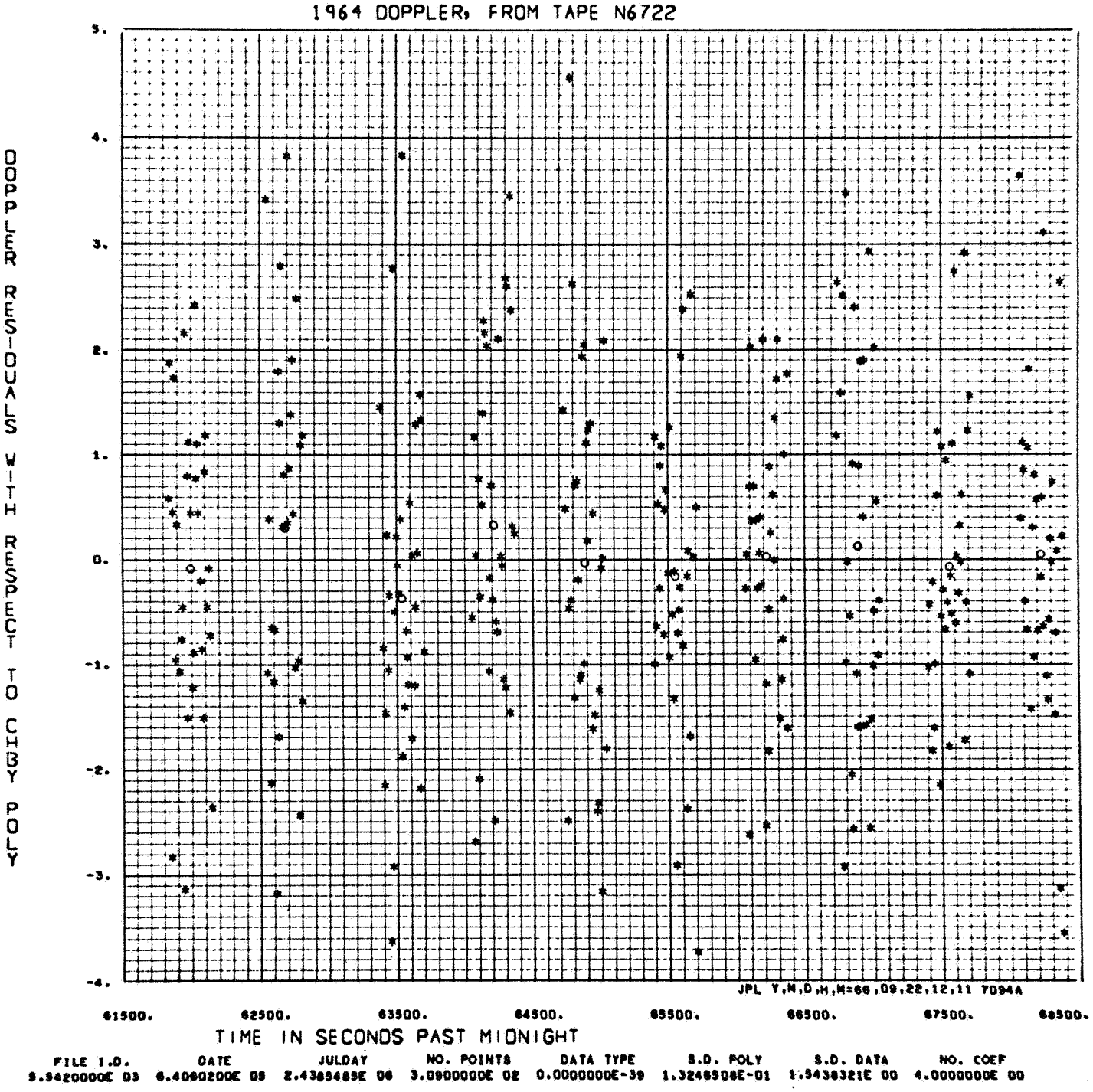


Fig. A-8. 1964 doppler data, run 5542 of Table A-3

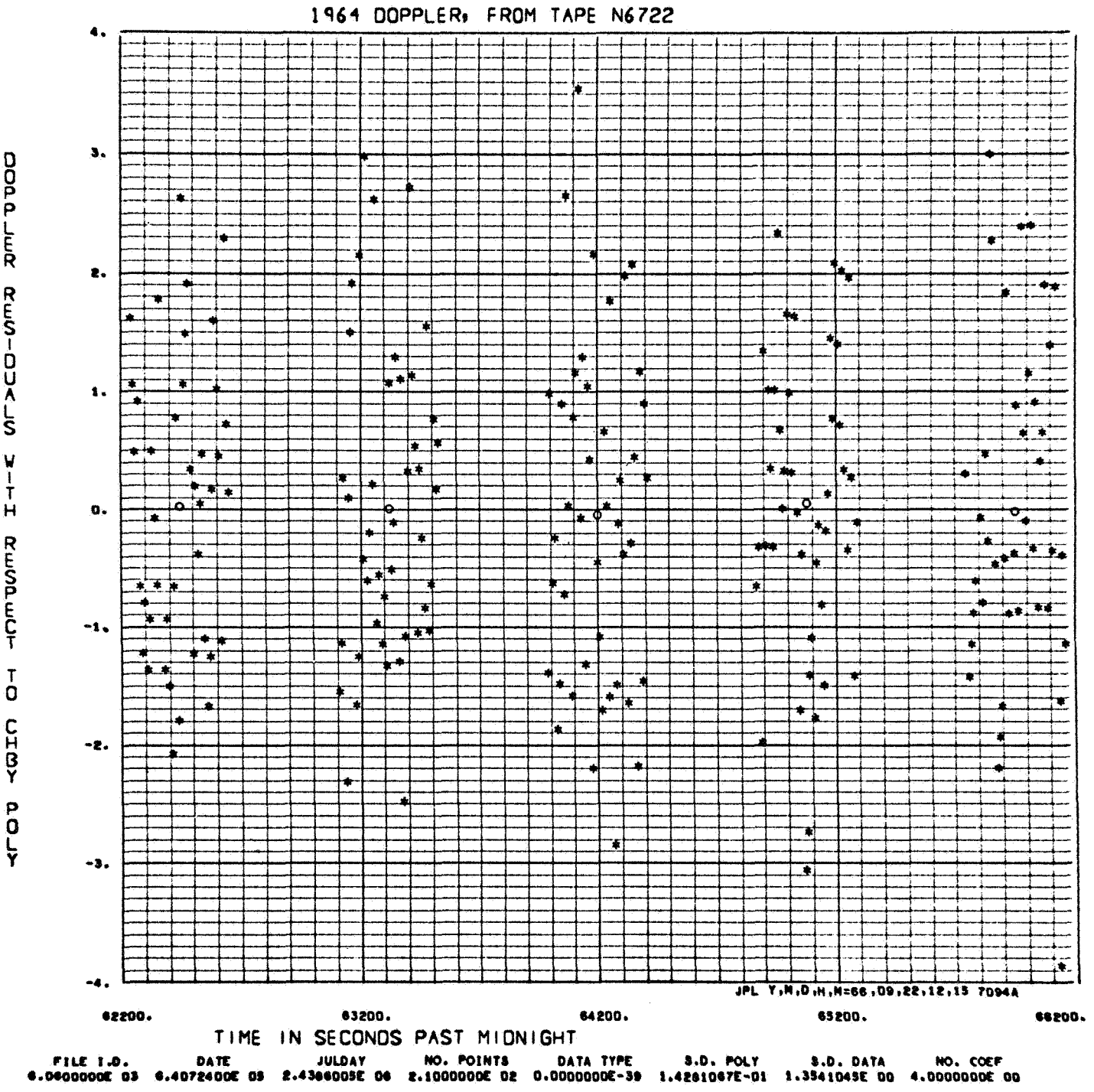


Fig. A-9. 1964 doppler data, run 6060 of Table A-3

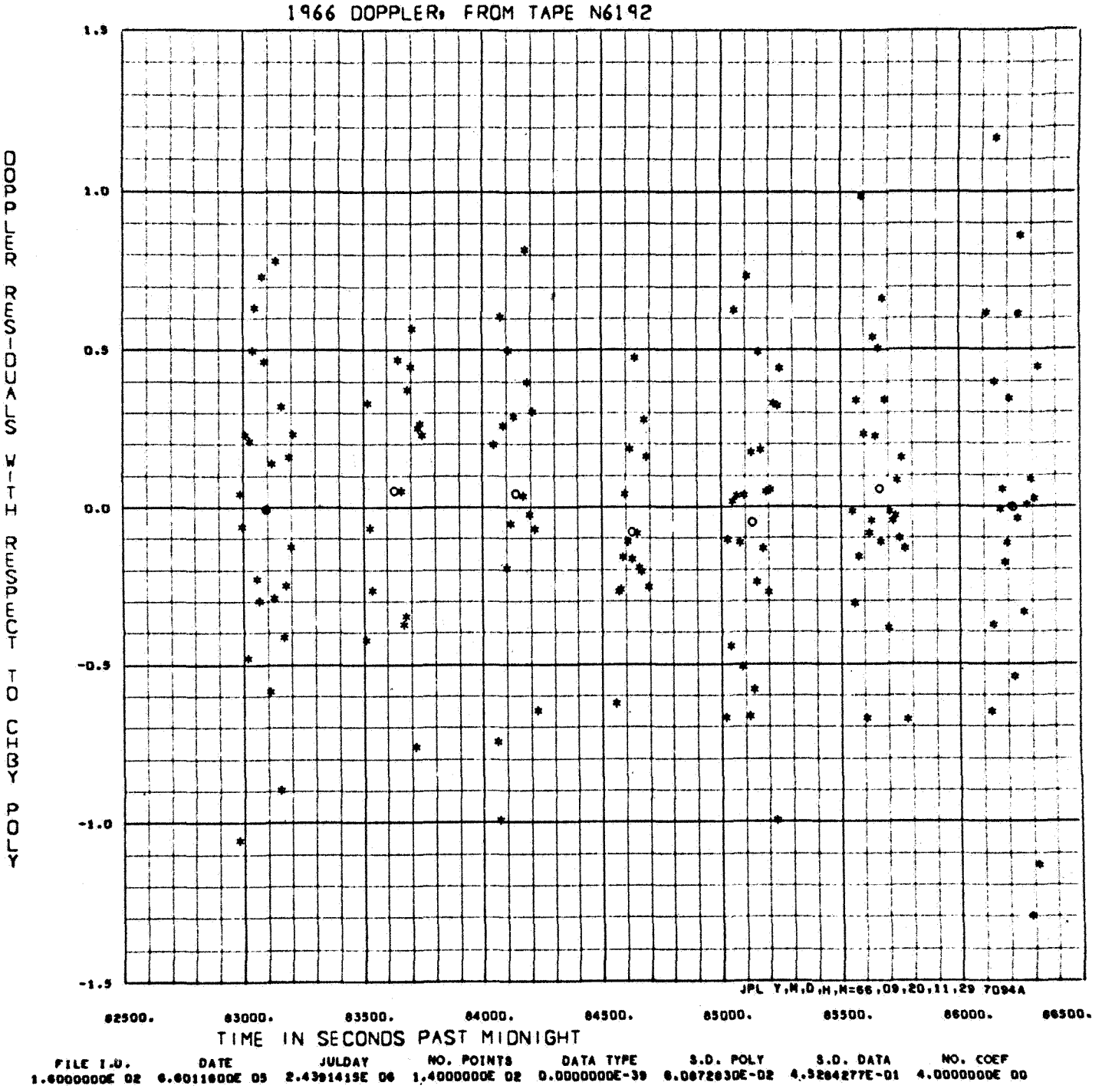


Fig. A-10. 1966 doppler data, run 160 of Table A-4

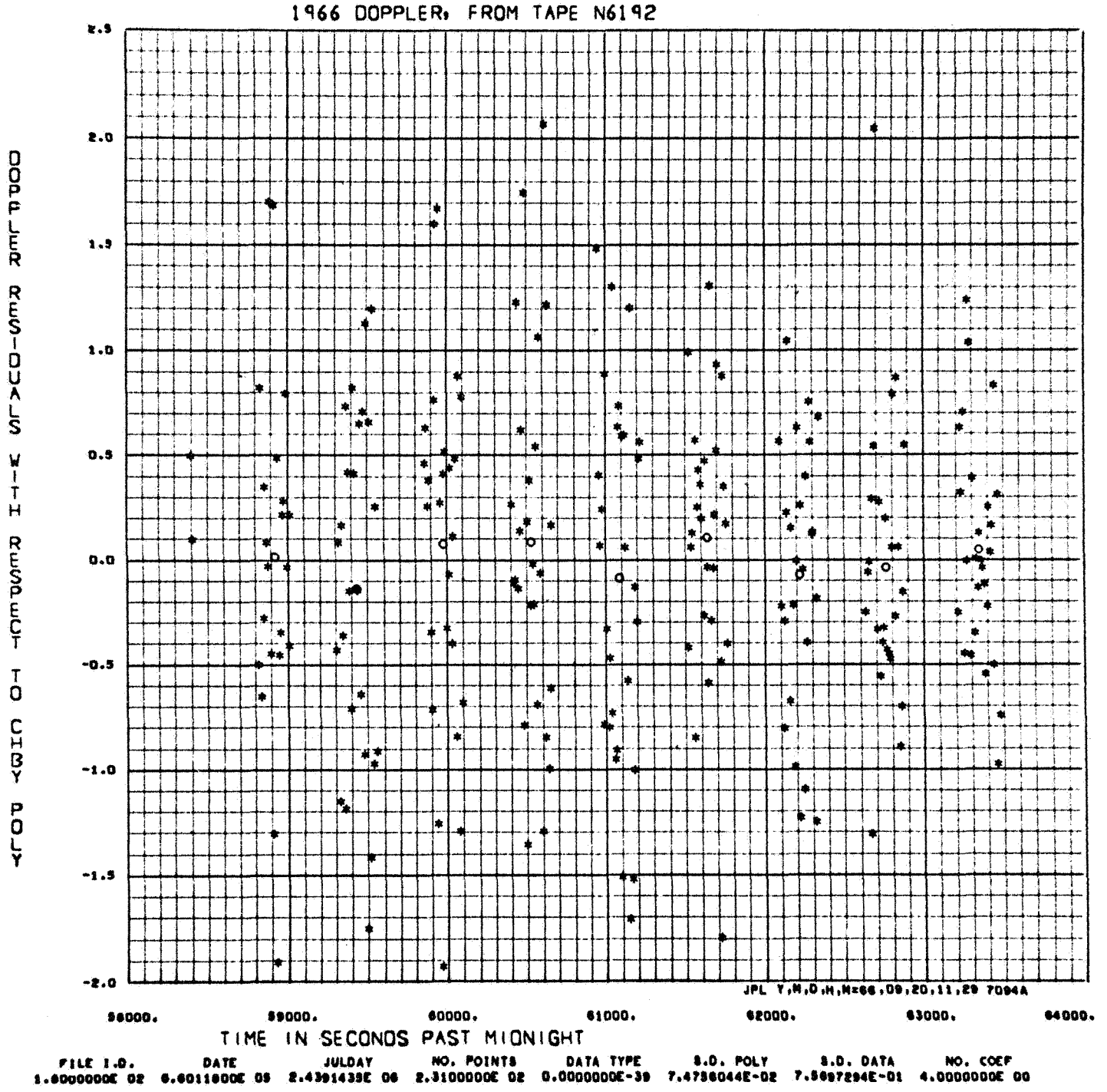


Fig. A-11. 1966 doppler data, run 180 of Table A-4

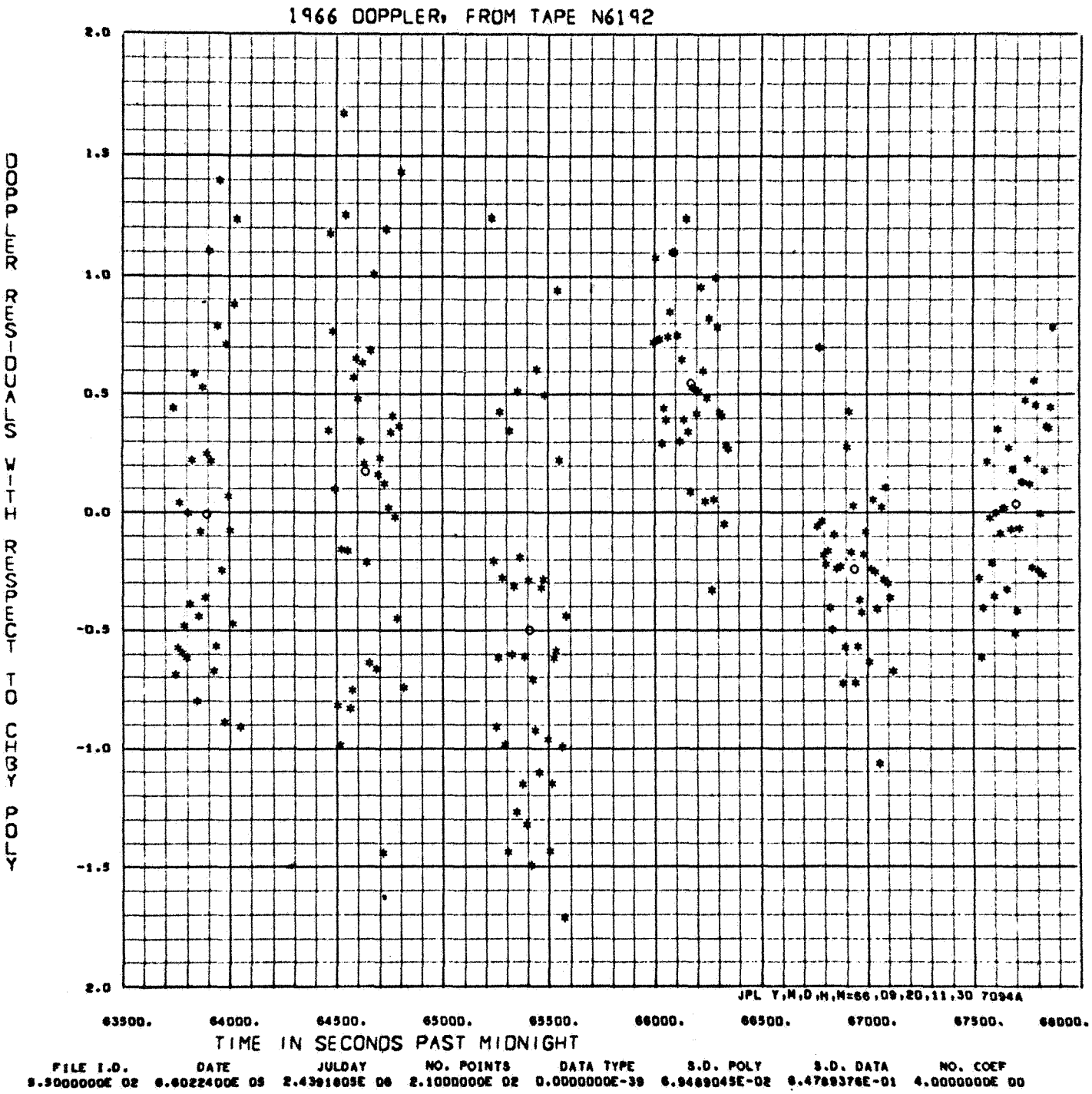


Fig. A-12. 1966 doppler data, run 550 of Table A-4

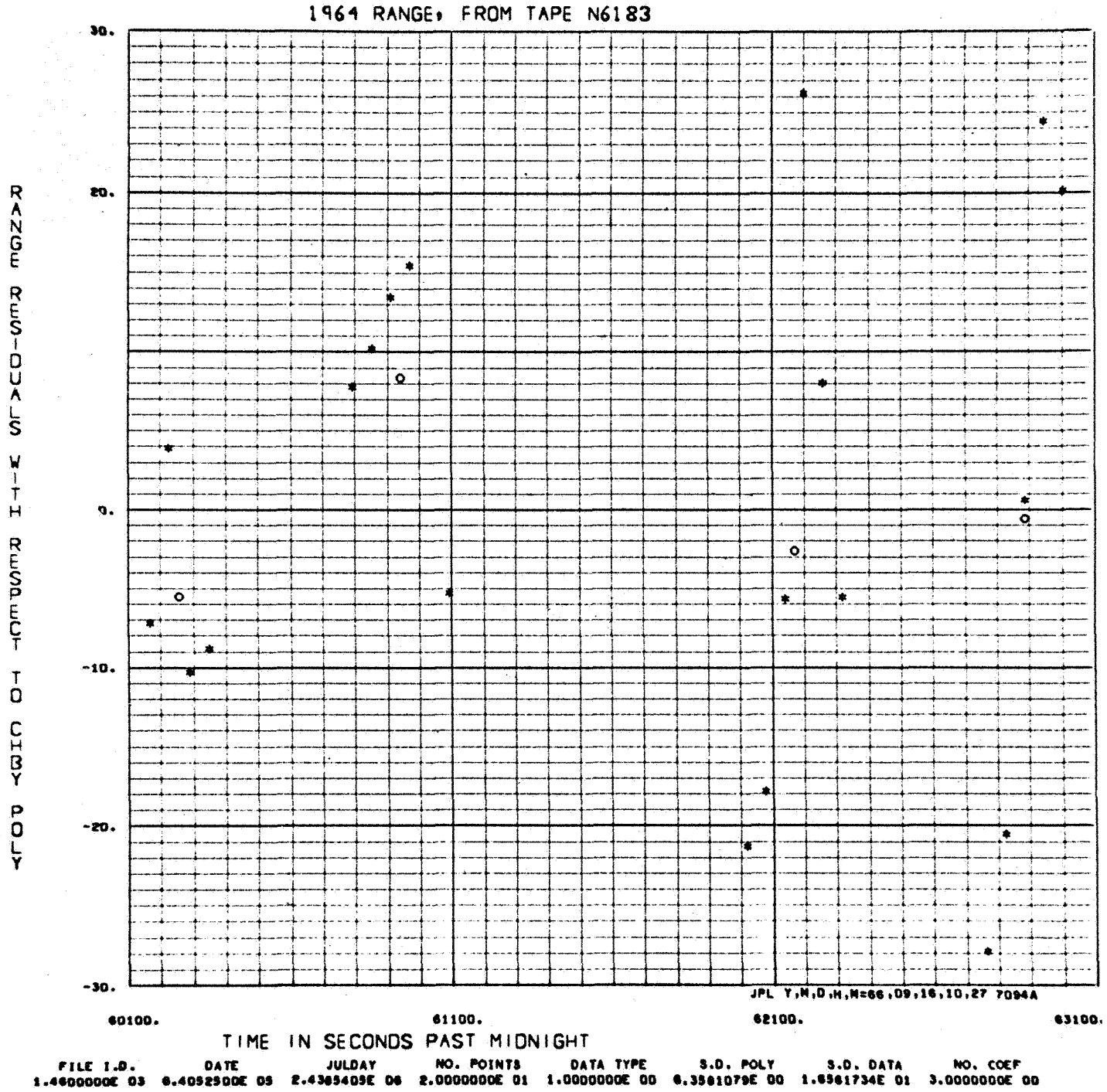


Fig. A-13. 1964 range data, run 1460 of Table A-5

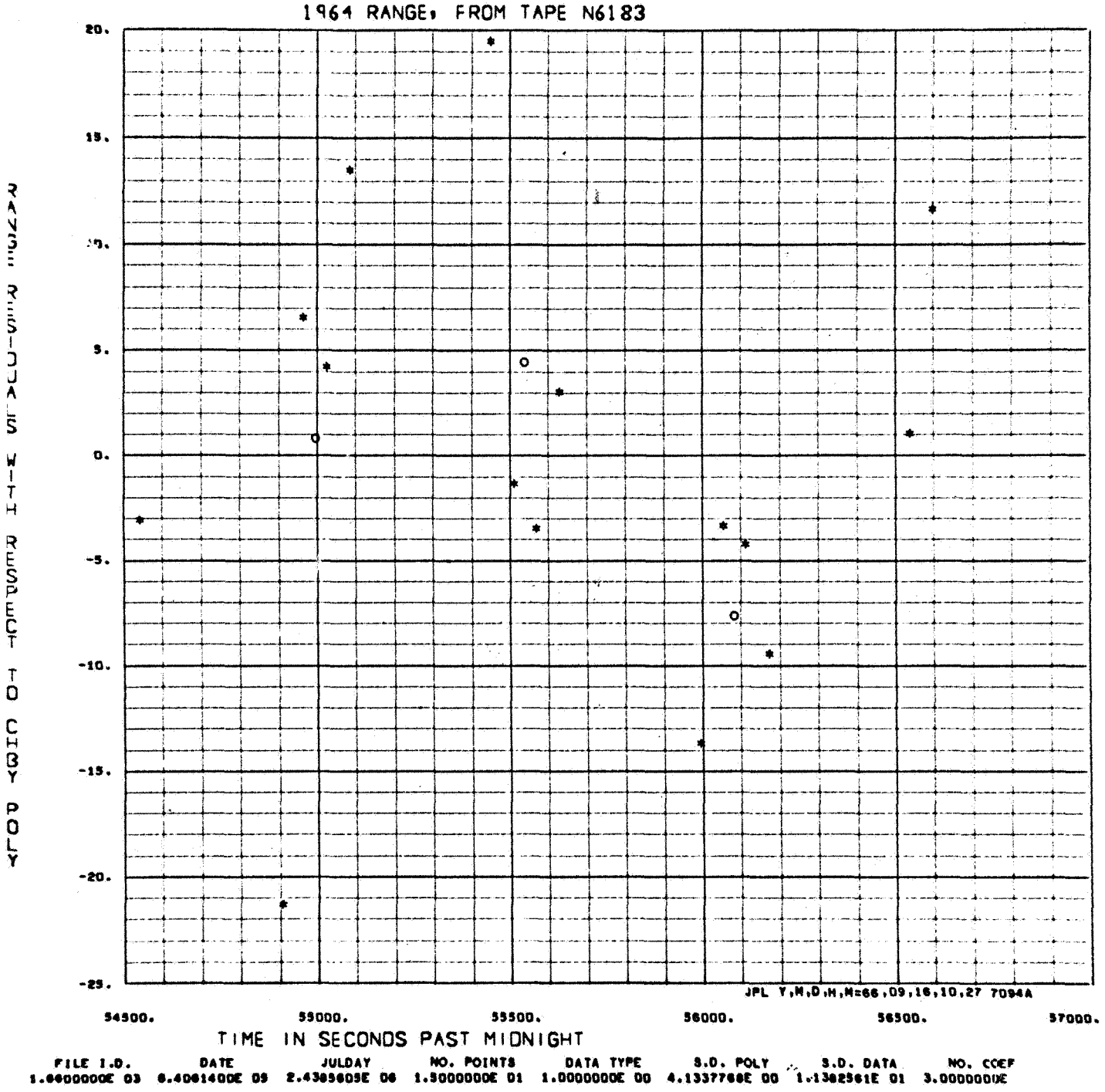


Fig. A-14. 1964 range data, run 1660 of Table A-5

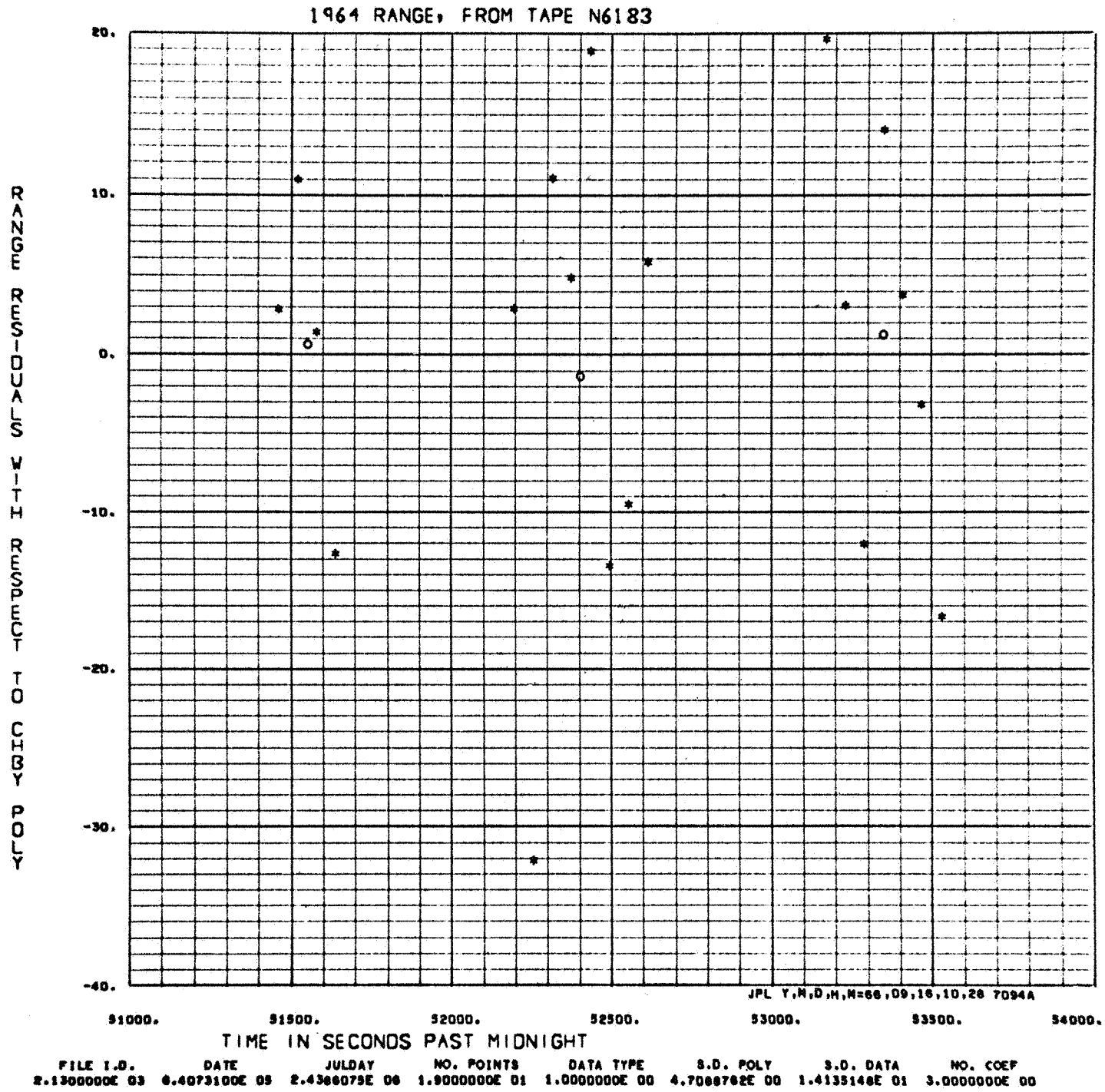


Fig. A-15. 1964 range data, run 2130 of Table A-5

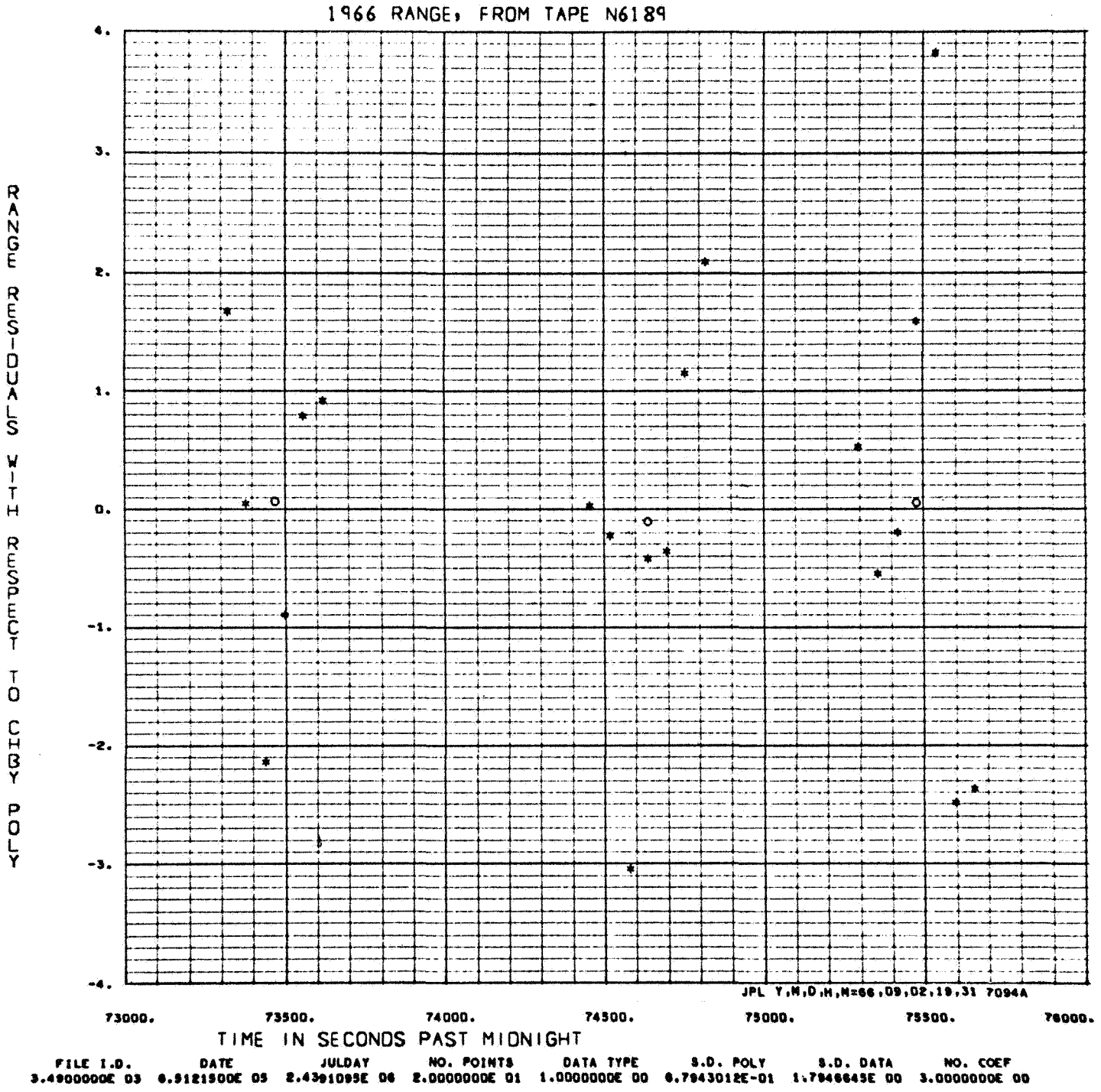


Fig. A-16. 1966 range data, run 3490 of Table A-6

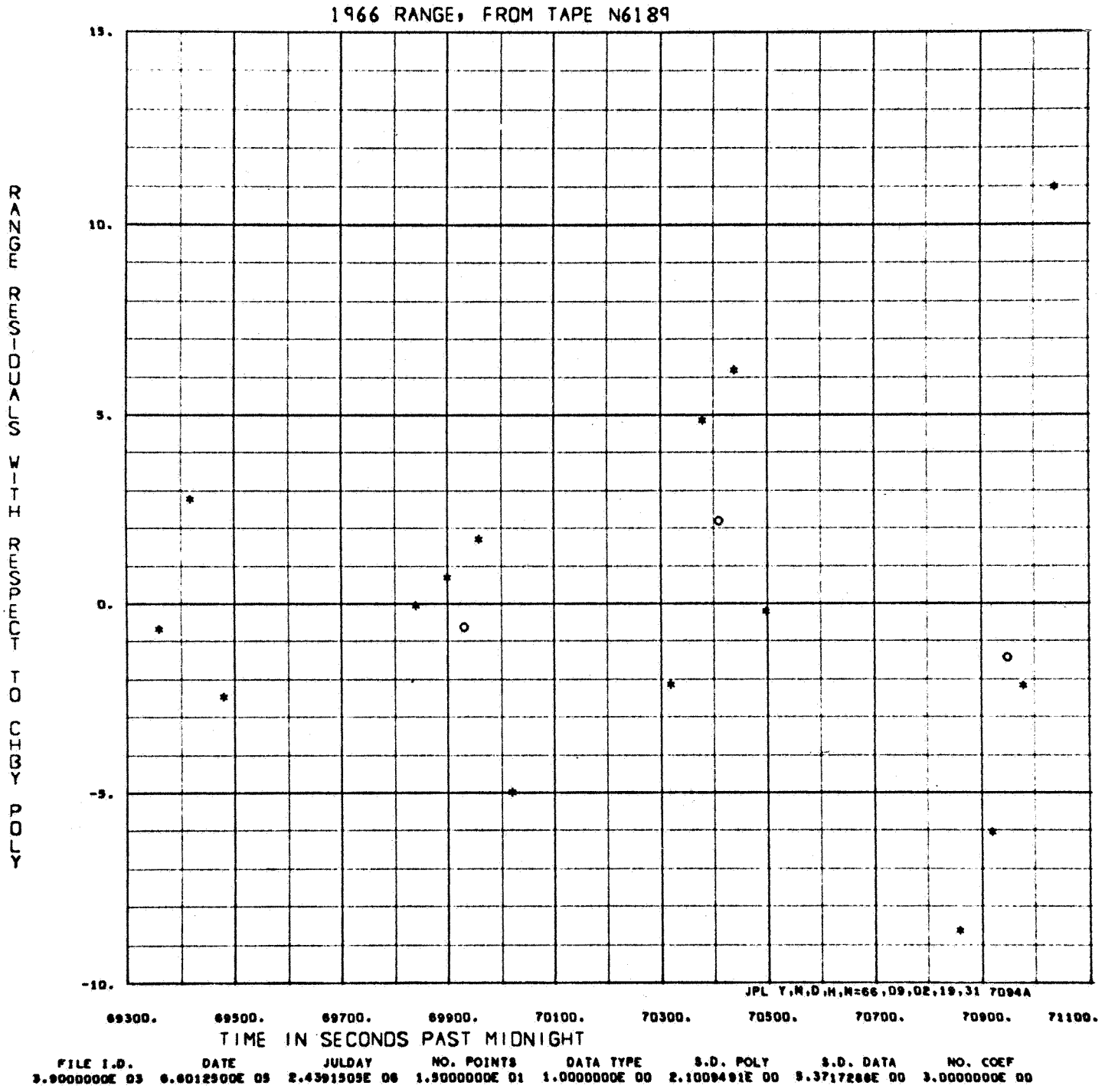


Fig. A-17. 1966 range data, run 3900 of Table A-6

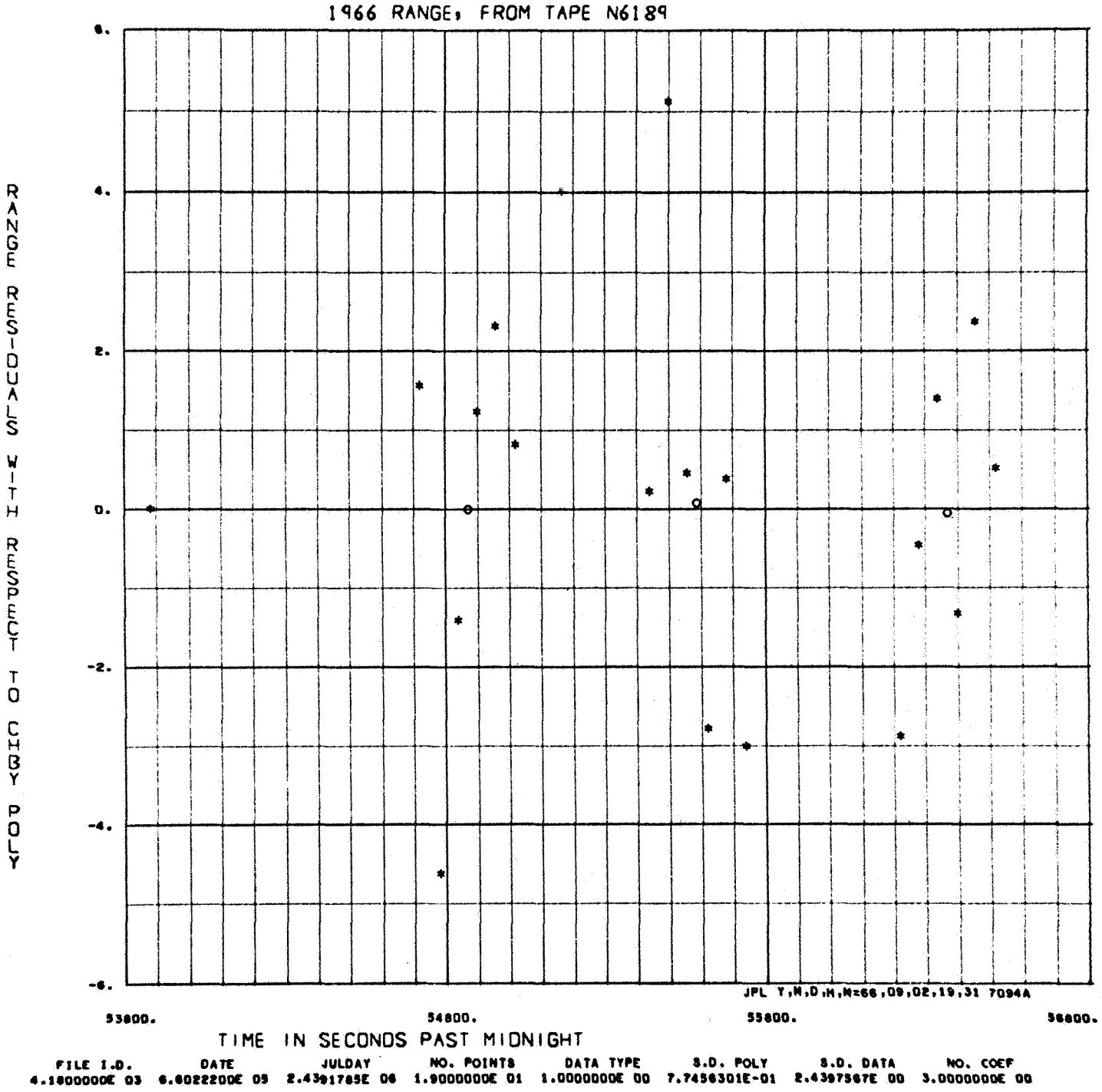


Fig. A-18. 1966 range data, run 4180 of Table A-6

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