

#153

APOLLO 11, 14 AND 15

69-059C-04C

71-008C-09A

71-063C-08A

LUNAR LASER PHOTO DETECTION

FILTERED AND UNFILTERED

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC
INFORMATION SYSTEM:

<http://nssdc.gsfc.nasa.gov/nmc/>

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

- a. Associated Documents To find associated documents you will need to know the document ID number and then click here.
<http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/>

- b. Core Catalog Materials

APOLLO 11, 14 AND 15
LUNAR LASER PHOTO DETECTION
FILTERED AND UNFILTERED

69-059C-04C

71-008C-09A

71-063C-08A

THESE DATA SETS HAVE BEEN RESTORED. ORIGINALLY THERE WERE 19 7-TRACK, 500 BPI TAPES WRITTEN IN BINARY CONTAINING VARIABLE DATA FILES. THERE ARE TWO DIFFERENT KINDS OF DATA, RUN DATA WHICH ARE DESIGNATED BY A 'Z' IN THE BEGINNING OF EVERY 80 CHARACTER LOGICAL RECORD AND SHOT DATA WHICH ARE DESIGNATED BY A 'P' IN THE BEGINNING OF EVERY 80 CHARACTER LOGICAL RECORD. THE ORIGINAL TAPES WERE BLOCKED AT 64 LOGICAL RECORDS PER PHYSICAL RECORD. EACH PHYSICAL RECORD HAS AN ADDITIONAL FOUR (4) CHARACTERS AFTER BEING DUPED ON THE 7094 COMPUTER.

THERE IS ONE RESTORED TAPE. THE DR TAPE IS A 3480 CARTRIDGE AND THE DS TAPES IS 9-TRACK, 6250 BPI. THE ORIGINAL TAPES WERE CREATED ON A CDC 6600 COMPUTER.

DR#	DS#	D#	FILES	TIME SPAN	
DR02906	DS02906	D10058	1 F	08/20/69 - 12/17/70	AP11 ✓
			2-5 U	07/21/69 - 06/30/71	
		D11361	6 F	01/09/71 - 06/16/71	AP11,14
			7 U	07/04/71 - 12/30/71	
		D13609	8 F	07/07/71 - 12/27/71	AP11,14,15
			9 U	01/01/72 - 06/30/72	
		D14249	10 F	01/05/72 - 06/30/72	AP11,14,15
			11 U	07/01/72 - 12/29/72	

DR#	DS#	D#	FILES	TIME SPAN	
DR02906	DS02906	D16161	12 F	07/01/72 - 12/29/72	AP11,14,15
	CON'T.		13 U	01/12/73 - 06/26/73	
		D17752	14 F	01/12/73 - 06/26/73	
			15 U	07/05/73 - 12/30/73	
		D20494	16 F	07/07/73 - 12/30/73	
			17 U	01/01/74 - 06/30/74	
		D23015	18 F	01/04/74 - 06/30/74	
			19 U	07/01/74 - 12/23/74	
		D24011	20 P	09/04/69 - 03/24/76	
			21 F	07/01/74 - 03/24/76	
			22 U	01/04/75 - 03/24/76	
		D29193	23 P	03/10/76 - 09/28/76	
			24 F	03/10/76 - 09/28/76	
			25 U	03/08/76 - 09/30/76	
		D30416	26 P	10/03/76 - 03/31/77	
			27 F	10/03/76 - 03/31/77	
			28 U	10/03/76 - 03/31/77	
		D30960	29 P	04/01/77 - 09/30/77	
			30 F	04/01/77 - 09/30/77	
			31 U	04/01/77 - 09/30/77	
		D32370	32 P	10/01/77 - 06/27/78	
			33 F	10/01/77 - 06/27/78	
			34 U	10/01/77 - 06/27/78	
		D33870	35 P	07/10/78 - 12/20/78	
			36 F	07/10/78 - 12/20/78	
			37 U	07/10/78 - 12/20/78	
		D35139	38 P	01/05/79 - 06/28/79	
			39 F	01/05/79 - 06/28/79	
			40 U	01/05/79 - 06/30/79	
		D39137	41 P	07/06/79 - 12/31/79	
			42 F	07/06/79 - 12/31/79	
			43 U	07/03/79 - 12/31/79	
		D42431	44 P	01/01/79 - 06/30/79	
			45 F	01/01/79 - 06/30/79	
			46 U	01/01/79 - 06/30/79	
		D44016	47 P	07/03/80 - 12/31/80	
			48 F	07/03/80 - 12/31/80	
			49 U	07/03/80 - 12/31/80	
		D46762	50 P	01/21/80 - 06/22/81	
			51 F	01/21/81 - 06/22/81	
			52 U	01/26/81 - 06/24/81	

P = POINTS

F = FILTERED

U = UNFILTERED

REQ. AGENTWPP
CMM
WKD
CAWRAND NO.RC0533, 1634, 3257
RC4059, 5360, 6384
RC8144, RD1067
RC9050ACQ. AGENTWSC
RWV
RWV
RWV

APOLLO 11, 14 AND 15

LUNAR LASER PHOTO DETECTION

FILTERED AND UNFILTERED

69-059C-04C

71-008C-09A

71-063C-08A

This data set consists of 9 (1) 800 BPI, Binary, 7-track tape containing variable data files. The data were written originally on a CDC 6600 computer. There are two different kinds of data, run data which are designated by a 'Z' in the beginning of every 80 character logical record and shot data which are designated by 'P' in the beginning of every 80 character logical record. This tape is blocked at 64 logical records per physical record. Each physical record has an additional four (4) characters after being duped on the 7094 computer.

<u>D#</u>	<u>C#</u>	<u>FILES</u>	<u>TIME SPAN</u>
D-10058	C-07920	1 F 2-5 U	8/20/69 - 12/17/70 APOLLO 11 7/21/69 - 6/30/71
D-11361	C-08675	1 F 2 U	1/09/71 - 6/16/71 APOLLO 11,14 7/04/71 - 12/30/71
D-12609	C-09666	1 F 2 U	7/07/71 - 12/27/71 APOLLO 11,14,15 1/01/72 - 6/30/72
D-14249	C-11458	1 F 2 U	1/05/72 - 6/30/72 APOLLO 11,14,15 7/01/72 - 12/29/72
D-16161	C-13264	1 F 2 U	7/01/72 - 12/29/72 APOLLO 11,14,15 1/12/73 - 6/26/73

<u>D#</u>	<u>C#</u>	<u>FILES</u>		<u>TIME SPAN</u>
D-17752	C-14472	1	F	1/12/73 - 6/26/73
		2	U	7/05/73 - 12/30/73
D-20494	C-16422	1	F	7/07/73 - 12/30/73
		2	U	1/01/74 - 6/30/74
D-23015	C-17577	1	F	1/04/74 - 6/30/74
		2	U	7/01/74 - 12/23/74
D-24011	C-18099	1	P	9/04/69 - 3/24/76
		2	F	7/01/74 - 3/24/76
		3	U	1/04/75 - 3/24/76
D-29193	C-18992	1	P	03/10/76 - 09/28/76
		2	F	03/10/76 - 09/28/76
		3	U	03/08/76 - 09/30/76
D-30416	C-19394	1	P	10/03/76 - 03/31/77
		2	F	10/03/76 - 03/31/77
		3	U	10/03/76 - 03/31/77
D-30960	C-19777	1	P	04/01/77 - 09/30/77
		2	F	04/01/77 - 09/30/77
		3	U	04/01/77 - 09/30/77
D-32370	C-20261	1	P	10/01/77 - 06/27/78
		2	F	10/01/77 - 06/27/78
		3	U	10/01/77 - 06/27/78
D-33870	C-20635	1	P	7/10/78 - 12/20/78
		2	F	7/10/78 - 12/20/78
		3	U	7/10/78 - 12/20/78
D-35139	C-20766	1	P	1/05/79 - 6/28/79
		2	F	1/05/79 - 6/28/79
		3	U	1/05/79 - 6/30/79
D-39137	C-21000	1	P	7/06/79 - 12/31/79
		2	F	7/06/79 - 12/31/79
		3	U	7/03/79 - 12/31/79
D-42431	C-21260	1	P	1/01/79 - 6/30/79
		2	F	1/01/79 - 6/30/79
		3	U	1/01/79 - 6/30/79
D-44016	C-21392	1	P	7/03/80 - 12/31/80
		2	F	7/03/80 - 12/31/80
		3	U	7/03/80 - 12/31/80
D-46762	C-21921	1	P	1/21/80 - 6/22/81
		2	F	1/21/81 - 6/22/81
		3	U	1/26/81 - 6/24/81

F = Filtered

U = Unfiltered

P = Points

APOLLO 11, 14, & 15
LUNAR LASER PHOTO DETECTION
FILTERED & UNFILTERED

69-059C-04C
71-008C-09A
71-063C-08A

This data set has been restored. There were originally 19 7-track, 800 BPI tapes written in Binary. There is one restored tapes. The DR tape is a 3480 cartridge and the DS tape is 9-track, 6250 BPI. The original tapes were created on a 6600 computer. The DR and DS numbers along with the time spans are given as follows:

DR # -----	DS # -----	FILES -----	TIME SPAN -----
DR02906	DS02906	1 F	08/20/69 - 12/17/70
		2-5 U	07/21/69 - 06/30/71
		6 F	01/09/71 - 06/16/71
		7 U	07/04/71 - 12/30/71
		8 F	07/07/71 - 12/27/71
		9 U	01/01/72 - 06/30/72
		10 F	01/05/72 - 06/30/72
		11 U	07/01/72 - 12/29/72
		12 F	07/01/72 - 12/29/72
		13 U	01/12/73 - 06/26/73
		14 F	01/12/73 - 06/26/73
		15 U	07/05/73 - 12/30/73
		16 F	07/07/73 - 12/30/73
		17 U	01/01/74 - 06/30/74
		18 F	01/04/74 - 06/30/74
		19 U	07/01/74 - 12/23/74
		20 P	09/04/69 - 03/24/76
		21 F	07/01/74 - 03/24/76
		22 U	01/04/75 - 03/24/76
		23 P	03/10/76 - 09/28/76
		24 F	03/10/76 - 09/28/76
		25 U	03/08/76 - 09/30/76
		26 P	10/03/76 - 03/31/77
		27 F	10/03/76 - 03/31/77
		28 U	10/03/76 - 03/31/77
		29 P	04/01/77 - 09/30/77
		30 F	04/01/77 - 09/30/77
		31 U	04/01/77 - 09/30/77
		32 P	10/01/77 - 06/27/78
		33 F	10/01/77 - 06/27/78
		34 U	10/01/77 - 06/27/78
		35 P	07/10/78 - 12/20/78
		36 F	07/10/78 - 12/20/78
		37 U	07/10/78 - 12/20/78

38	P	01/05/79 - 06/28/79
39	F	01/05/79 - 06/28/79
40	U	01/05/79 - 06/30/79
41	P	07/06/79 - 12/31/79
42	F	07/06/79 - 12/31/79
43	U	07/03/79 - 12/31/79
44	P	01/01/79 - 06/30/79
45	F	01/01/79 - 06/30/79
46	U	01/01/79 - 06/30/79
47	P	07/03/80 - 12/31/80
48	F	07/03/80 - 12/31/80
49	U	07/03/80 - 12/31/80
50	P	01/21/80 - 06/22/81
51	F	01/21/81 - 06/22/81
52	U	01/26/81 - 06/24/81

F = Filtered

U = Unfiltered

P = Points

69-059C-04C
 71-008C-09A
 71-063C-08A

Run Card

Read a run card with, for example, the FORTRAN statements

```
READ (x,1) (A(J),J=1,22)
```

```
1 FORMAT(A1,3I,D10.3,1X,I7,I3,3I2,3X,I3,I5,5I3,A5,2I3,2I4,2I2)
```

ignoring for the moment that we have mixed our variable modes.

Then the variables A will contain the following information:

A(1) =Z
 A(2) =711 (3-digit observatory code)
 A(3) Julian date of beginning of run
 A(4) Clock epoch error, sec x 10⁶
 A(5) Ambient temperature, °C
 A(6) Ambient relative humidity, % saturation
 A(7) Wind speed, km/hr
 A(8) Atmospheric seeing, arc sec x 10
 A(9) laser energy, joules x 10
 A(10) laser frequency, Hz x 10¹⁰
 A(11) pulse length, sec x 10¹⁰
 A(12) observational resolution, sec x 10¹⁰
 A(13) photomultiplier dark count, kHz
 A(14) Moon count rate, kHz (Gross)
 A(15) Star count rate, kHz (Net)
 A(16) Calibration star identification
 A(17) Filter spectral width, Å x 10
 A(18) Filter spatial width, arc sec x 10
 A(19) Number of shots fired this run
 A(20) Year
 A(21) Month-
 A(22) Day-

The sense of the clock error is that it is to be subtracted from the clock time to give the true UTC time. This correction has not been applied to the observation epochs on the shot cards.

Shot Card

Similarly, again ignoring variable mode questions for the sake of illustration, read a shot card with

```
READ (X,2) (B(J),J=1,17)
```

```
2 FORMAT(A1,I3,D17.10,I5,1X,I1,A1,I1,D12.10,I5,I6,I5,3X,I5,I1,  

  I5,I4,2I2)
```

Then the variables B will contain the following information:

B(1) =P
 B(2) =011 (body identifier)
 B(3) Julian date of observation
 B(4) =71110 (observatory code)
 B(5) =0 (reflector code for Tranquility)
 B(6) =L (observation type)
 B(7) =1 (epoch time base is UTC)
 B(8) Observed time delay, seconds
 B(9) Observational uncertainty, seconds $\times 10^{10}$
 B(10) Electronic calibration delay, seconds $\times 10^{10}$
 B(11) Geometric delay, seconds $\times 10^{10}$
 B(12) Clock frequency offset from UTC, parts in 10^{11}
 B(13) =1 (time delay time base is UTC)
 B(14) Ambient pressure, mbar $\times 10$
 B(15) Year
 B(16) Month
 B(17) Day

The electronic and geometric delays refer to the equipment response times and the reduction to the geometric fixed point, respectively, and are to be subtracted from the observed time delay.

A word of warning is in order to the unwary users. During the report interval, many of the specified data items discussed above are not available. In the card images, a blank field is a "no information" indicator. Actual null values will be represented by zero punches. This is particularly important for clock epoch error. No clock data are presently available, although Currie (1970) estimates that the "actual epoch should be known to the order of 10 μ sec or better."

IV. Acknowledgements

The data described herein were generated at the McDonald Observatory through the collective efforts of the LURE Team and numerous supporting personnel at their several institutions.

69-059A-04C
71-008C-09A
71-063C-08A

5. COSPAR WORKING GROUPS

PROPOSED STANDARDS FOR DISTRIBUTION AND DOCUMENTATION OF LUNAR LASER RANGING DATA

A Report prepared for COSPAR Working Group 1

by J. Derral Mulholland, University of Texas at Austin, McDonald Observatory
1971 September

1. Prefatory Note

Laser ranging to the moon promises to provide the means for investigating a number of lunar and terrestrial phenomena to a much higher precision than has been heretofore possible. The interesting lunar problems can be pursued with data from any one or more observatories, although restriction to a single facility does introduce the hazard of local bias in the solutions due to unrecognized systematic errors in the observations. In contrast, very little can be accomplished in earth physics studies using range data from a single observatory. It is imperative to the effective use of these data that there exist a viable means for their distribution or exchange in a sufficiently complete and readily usable form.

This problem was first addressed during COSPAR XIII, when the Chairman of Working Group 1 directed that the present report be prepared. At the same time, a Working Party on Lunar Laser Ranging was formed within the Working Group. Subsequently, the Working Party was endorsed by both IAU and IUGG, and the membership was enlarged to include their representatives.

In an unrelated sequence of events beginning in 1964, IAU Commission 4 established a Working Group on Ephemerides for Space Research. This body served as the inspiration for an informal working group, founded in 1967, which provided working-level communication and coordination in ephemeris research within the USA. This latter group met on numerous occasions during 1967-1969. In addition to providing for standard test cases for areas of desirable duplication of effort, and direct exchange of data and software to reduce unnecessary duplication, this informal group produced two results of some interest to the present discussion. First, the transmission of data was facilitated by adoption by the participants of standard 80-column punched card formats¹. Second, the three US members of the IAU Working Group were asked to carry back to that body certain recommendations concerning international exchange of astrometric and ephemeral data. This was at least a contributing factor in the establishment last year of the IAU Information Bureau on Astronomical Ephemerides, to provide information on the existence and availability of such data. COSPAR Working Group 1 will be represented in the membership of the Bureau.

¹ O'Handley, D. A. "Card Format for Optical and Radar Planetary Data" Jet Propulsion Laboratory Tech. Rpt. 32-1296. Pasadena, 1968.

This report is based on the premise that these two lines of development towards international cooperation and exchange represent two convergent aspects of the same problem, and must be treated as complementary.

The author is pleased to acknowledge the helpful suggestions of many of his colleagues in the preparation of this report. This effort was funded by the National Aeronautics and Space Administration, under Grant No. NGR 44-012-219.

2. Philosophy of the Proposed Standards

We desire to establish some minimum criteria for the permanent recording, cataloguing, and transmission of the laser ranging data. This requires a somewhat different, more comprehensive approach to data recording and preservation than has frequently been the case in the past. The signal generation and detection devices, combined with the level of precision attainable in the observations, dictate that more parameters be preserved. It is also important to avoid crucial ambiguities. For example, the observations are time delays. Does the time delay clock run at the same rate as the clock that measures the epoch of observation? Both rates are necessary for application of the data. By presenting standards for data documentation, we do not propose to specify exactly what information is to be recorded, nor in what way to do the recording, but rather to state *minimum* guidelines for what data seem to be required to insure that the laser measures can be made to satisfy their enormous potential.

In addition to the general documentation criteria, we propose some very specific standards for the transmission of data between institutions or their deposition in public data centers. The need for machine-readable formats seems self-evident. Efficient use of machine-readable data from various sources requires the establishment of uniform standards insofar as this is possible. Since a similar exercise has been undertaken for optical and radar observations, it seems unreasonable to pursue the present goal *ab initio*. We propose, therefore, to maximize the compatibility of our data transmission formats with those of O'Handley². It is to be hoped that these formats will provide the basis for a more comprehensive codification by the Information Bureau on Astronomical Ephemerides.

We have already implied that there should exist multiple classifications of data standards, since complete archival documentation is not customarily necessary to or desired by the user of astrometric data. It seems to be convenient to discriminate three categories, to be described in detail in subsequent sections of this report. The categories can be considered as approximating the functions of journal publication, public deposition, and archive data, respectively. These represent three levels of detail, corresponding to different purposes to which the data may be applied.

In their present form, these proposals are intended as first-order approximations, evolved from experience within the laser program and from the discussions held within Working Group 1 during the 14th Plenary Meeting. As further experience is gained, some modifications will surely follow.

² op. cit.

3. Reduced Data Set

The "reduced data set" will consist of sufficient information to satisfy the requirements of non-critical application, such data as one might publish in a scientific journal. The items recommended for inclusion are:

- Epoch of observation, and its meaning;
- Observed time delay, modified by corrections for geometric and electronic calibration delays and for the atmospheric refraction delay;
- System time delay resolution;
- Telescope and reflector identification;
- Time base identification for both epoch and time delay.

These data, which are certainly adequate for many purposes, are easily accommodated on a standard 80-column punched card. A proposed card format is specified in Appendix C.

4. Astrometric Data Set

This category is of most critical interest from the standpoint of serious application of the data, and it represents those data which we propose should constitute the standard grouping for deposition in a public data center or publication comparable to observatory annals. Here we must distinguish between data provided for each observation and other data recorded at most once for each run, but which are needed for high-confidence use of the data:

Each observation

- Epoch of observation, and its meaning;
- Observed time delay, unaffected by any corrections;
- Observational uncertainty, with a description of its basis;
- Gravimetric data (*)
- Telescope and reflector identification;
- Time base identification for both epoch and time delay.

Each run

- Clock calibration data;
- Electronic and geometric calibration delays to be subtracted from the observation;
- Atmospheric data (temperature, pressure, humidity, seeing, wind speed);
- Laser parameters (energy, pulse length, frequency);
- Detector parameters (count rates, inherent resolution, range gate structure);
- Number of shots per run.

Once

- Station description;
- Nominal telescope coordinates;
- Precise separations between transmitter and receiver, if appropriate;
- Relation of primary mirror position to fixed reference point.

* The measurement of relative gravimetric data is considered desirable for those locations for which a simple analytic model is not adequate to account for solid earth tides.

A separation can be based on considerations of application. Customarily, use of the data to nanosecond accuracy requires only certain of these data. A conventional card format is proposed for these data in Appendix C. The other items permit either finer-scale reduction of the observations or re-evaluation of confidence levels and uncertainty estimates. A second machine-readable format is proposed for these data. The principal virtue claimed for these formats is that we propose immediately to begin using them in transmissions of lunar ranging data from the McDonald Observatory.

5. System Data Set

Each of the data-taking organizations will wish to maintain its own archive files, basically observatory logs, which will contain all of the information contained in the "astrometric data set" for that observatory, but also such additional items as might be useful in evaluating system performance. This might include such parameters as laser beam divergence, spatial and spectral filter width, filter/laser wavelength matching, etc. This seems to be a purely local matter of little impact on the astrometric use of the time delays, and thus this category does not lie within the scope of the present report. One will note that the McDonald formats (Appendix C) will include some of these items.

6. Distribution Mechanisms

Central to the entire purpose of this report is the precept that full utilization of these astrometric data of unprecedented precision can only occur if the data are made conveniently available outside the originating organization, indeed outside the country of origin. It may be admitted that each observing group may wish to restrict access to their own data for some specified time. It is further understood that, particularly in the early stages of an observational program, the observational identification problem (noise filtering) may not permit adherence to intended distribution schedules. Nonetheless, it seems unambiguous and unarguable that some mechanism for general and open distribution of the data need be endorsed in principle and, insofar as possible, adhered to in practice.

COSPAR has provided for open repositories of space science data in the network of World Data Centers, whose charter includes the handling of "precise positional observations... of great scientific value." There can be no question that the laser observations satisfy this description. We propose that Working Group 1 urge the WDC's to accept the responsibility of serving as a focal point for the dissemination of these data. We further propose that all lunar laser ranging facilities in countries whose National Scientific Institutions adhere to COSPAR be urged to agree to submit their observations, in the form of astrometric data sets, either to the WDC's directly or to national data centers that exercise free exchange with the WDC's (e.g. the US National Space Science Data Center). Each group should also be free to make other distribution arrangements as well, including access to reduced data sets or system data sets as they see fit.

In addition to making explicit distribution arrangements, the observing organizations should be urged to register these arrangements with the IAU Information Bureau on Astronomical Ephemerides, for the convenience of those scientists unfamiliar with the COSPAR organization. It is presumed that the COSPAR representatives in the Information Bureau organization will provide coordination between the function of the Bureau and the wishes of COSPAR Working Group 1. Dr. Veis has also suggested that the COSPAR/IUGG Central Bureau for Satellite Geodesy be kept informed of available data.

Appendix A

Notes on Selected Data Items

Epoch of observation

Systems may be designed with either the transmission time or the reception time as the epoch reference. In every case, the appropriate option must be explicitly available. In addition, if reception time is used, this must be *observed* reception time, rather than predicted.

Observational uncertainty

This parameter is somewhat subjective and, for a given observation, may be revised *ex post facto*. Its minimum value is the shot-by-shot resolution, but may be much higher if electronic or other operating problems exist in the observing system.

Electronic delay

This represents the time delay in the detection circuitry, which does not relate to a distance.

Geometric delay

The observations will need to be reduced to a point in the light path fixed relative to the telescope pier. The geometric calibration delay represents the total light path from that point to the front face of the laser, plus the total light path from the fixed point to the detector. For bistatic operation, a fixed point reference is required separately for receiver and transmitter.

Nominal telescope coordinates

These should refer to the fixed point(s) described above. The nominal coordinates should be (as nearly as practical) the best available estimate of the coordinates relative to the Earth's center of mass, along with a description of the method of determination. Spherical coordinates are to be preferred to rectangular. Astronomical coordinates (including radial distance) may be given if more appropriate data are not available.

Primary mirror

Some telescope designs require the primary mirror to describe some space path relative to a fixed point such as the intersection of the rotation axes. High-accuracy discussion of observations from such telescopes will require that such motion be taken into account.

Appendix B

Proposed Standard Codes and Units

Epoch of observation

The standard unit is the Julian Date, with decimal fraction.

Observed time delay

The standard unit is the second.

Observational uncertainty

The standard unit is the nanosecond.

Electronic and geometric delays

The standard unit is the nanosecond.

Telescope identification

This will consist of three distinct codes: one for the observatory, one to indicate whether the system uses a single telescope or separate transmitter and receiver, and a third to identify distinct telescope locations in case different arrangements have been used at a single site. The total code requires five digits.

For the basic observatory code, we propose adherence to the established three-digit code used by the IAU Minor Planet Center. The center is willing to assign codes to presently unlisted observatories in a fashion consistent with past practice.

The number of telescopes used could serve as a one-digit code by itself, but we find it convenient from external considerations to propose that a one-digit code distinguish two characteristics. The fourth digit of the observatory code specifies either a single telescope (monostatic) operation or separate transmitter and receiver (bistatic) operation, and it also specifies if the epoch refers to transmission or reception time, according to the following table:

	Monostatic	Bistatic
Transmit	1	2
Receive	3	4

Finally, each observatory will be responsible for assigning a one-digit code (0-9), the fifth digit of the observatory code, specifying distinct sites on the premises. One may note that a changeover from monostatic to bistatic operations need not affect this digit, as that change may be accommodated unambiguously by the preceding digit code.

Reflector identification

A one-digit code should suffice for this parameter, with the digits assigned in the order of emplacement, as follows

- 0 - Apollo 11 (Tranquility Base)
- 1 - Luna 17 (Imbrium)
- 2 - Apollo 14 (Fra Mauro)
- 3 - Apollo 15 (Hadley)

Other numbers will be assigned as new reflectors are activated.

Time base identification

We assume that observation epoch will always be referred to a time base available in real time, regardless of the nature of the observation. The system UTO is included for the sake of generality, even though one does not expect it to be used for laser observations. The time delay will always be based on an oscillator frequency, but we must allow for the possibility of a non-standard frequency. The proposed codes are

- 0 - UTO
- 1 - UTC
- 2 - A.1 (USNO)
- 3 - A^T (BIH)
- 4 - USSR atomic time
- 9 - non-standard frequency

Clock calibration

The standard units are microseconds (epoch) and hertz (frequency)

Atmospheric data

The standard units are: for temperature, Celsius degrees
for pressure, millibars
for humidity, % saturation
for seeing, arc seconds
for wind speed, km/hour

For the present purpose, no distinction need be made between 99 % and 100 % humidity.

Laser parameters

The standard units are joules (energy) and nanoseconds (pulse length) full width between the half-power points.

Telescope coordinates

The standard units are: for radial distance, km
for longitude, degrees east
for latitude, degrees north
for rectangular coordinates, km

Appendix C

Proposed Standard Punched Card Formats

Standard formats are presented below for the transmission of reduced and astrometric laser data via 80-column punched cards. Some of the details of the formatting were chosen for compatibility with present usage of other data familiar to the author. This is particularly true of the placement and field size of certain data, such as body identifier, epoch, and observatory code.

Reduced data card

- Col. 1: = P (11-7 punch)
2-4: = 011 (Body identifier)
5-21: Epoch of observation (Julian date with 10 decimal digit fraction, decimal implied following col. 11)
22-26: Observatory code
27: Blank (not used)
28: Reflector code
29: = L (11-3 punch, observation type)
30: Epoch time base
31-42: Two-way time delay (seconds, decimal implied following col. 32, 10 decimal digit fraction)
43-47: Observational precision estimate (nanoseconds, decimal implied following col. 46)
48-53: Refraction delay removed from observation
54-56: Blank (not used)
57-58: = -1 (identifies reduced data)
59-62: Blank (not used)
62-66: Frequency offset of time delay clock from nominal rate. If Col. 67 = 9, offset is from A^T (parts in $10''$)
67: Time delay time base
68-72: Blank (not used)
73-80: Year, month, day

Astrometric data card

- Col. 1-47: Identical with reduced format
48-53: Electronic delay (nanoseconds, decimal implied following col. 52)
54-58: Geometric delay (nanoseconds, decimal implied following col. 57)
59-67: Identical with reduced format
68-72: Atmospheric pressure (mbars, decimal implied after col. 71)
73-80: Identical with reduced format

Operational environment data card

- Col. 1: = Z (0-9 punch)
2-4: Observatory code (first 3 digits)
5-14: Julian date beginning run (truncated to 3 decimal digits, decimal implied following col. 11)
15: Blank (not used)
16-22: Clock epoch offset (μsec) to be added to clock reading
23-25: Temperature ($^{\circ}\text{C}$)
26-27: Humidity (% saturation)
28-29: Wind speed (km/hr)
30-31: Seeing (0.1 arc sec)
32-34: Blank (not used)
35-37: laser energy (0.1 joule)

Col. 38-42: laser frequency (10^{10} Hz)
43-45: pulse length (0.1 nanosec)
46-48: resolution (0.1 nanosec)
49-51: photomultiplier dark count (kHz)
52-54: Moon count rate (kHz)
55-57: Star count rate (kHz)
58-62: Calibration star identification
63-65: Filter spectral width (0.1 Å)
66-68: Filter spatial width (0.1 arc sec)
69-72: Number of shots this run
73-80: Year, month, day

69-059C-04C

71-008C-09A

71-063C-08A

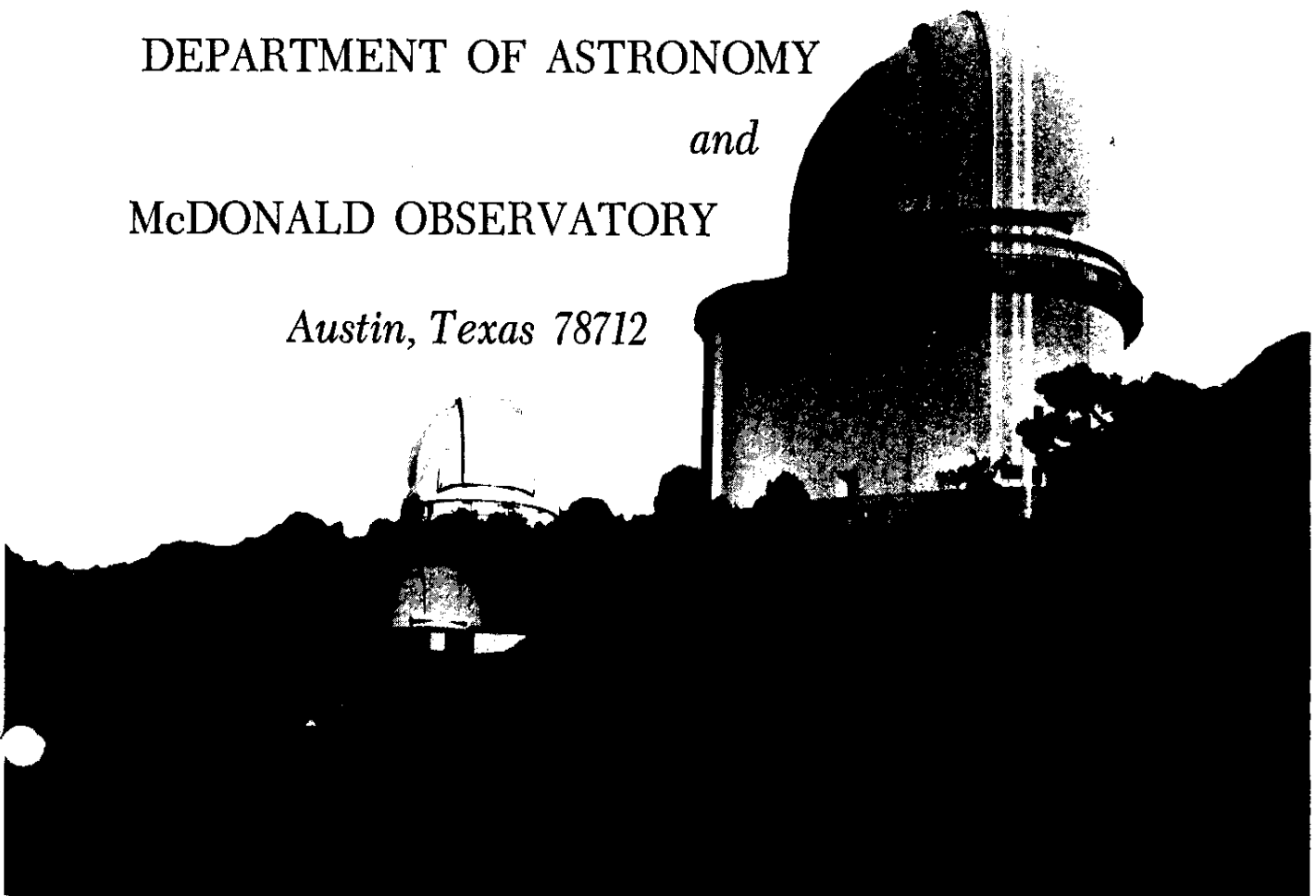
THE UNIVERSITY OF TEXAS AT AUSTIN

69-059c-04c
71-008C-09A
71-063C-08A

THE UNIVERSITY OF TEXAS AT AUSTIN

DEPARTMENT OF ASTRONOMY
and
McDONALD OBSERVATORY

Austin, Texas 78712



LUNAR LASER RANGING DATA DEPOSITED IN THE
NATIONAL SPACE SCIENCE DATA CENTER
NORMAL POINTS,
FILTERED OBSERVATIONS,
AND
UNFILTERED PHOTON DETECTIONS FOR
1 JANUARY 1981 THROUGH 30 JUNE 1981

Peter J. Shelus
University of Texas at Austin
Research Memorandum in Astronomy
1981 October

I. Introduction

Not only is the laser ranging experiment capable of rendering significant improvements to a large number of fundamental physical constants and solar system parameters, it is also possible to apply the data to study the Earth itself. However, in order that lunar laser ranging data be used to its fullest capacity it is necessary that it be made available to the scientific community in a standard, useable form with sufficient environmental and systemic description included to assure proper reduction of that data. It is unreasonable to assume that all observing stations will be identical in their hardware and software configurations; further, it is impossible to assess and reduce in real-time all relevant environmental and systemic parameters during routine observing. Thus it has been assumed that such observatory-unique "raw" data be transmitted to a central agency in order to filter signal photons from the noise, form normal points from logical sub-sets of signal returns, and, perhaps most importantly, consolidate range, environmental, and systemic information into a standard form to be made available to the general scientific community.

In August of 1980 the McDonald Observatory Lunar Laser Ranging Station completed eleven years of operations using the 2.7m reflector. During that entire period of time LLR observations were obtained in a routine manner. The University of Texas at Austin has been responsible for the routine filtering, compression, and distribution of that data since mid-1971. Archival deposits of those data have been made periodically into the National Space Science Data Center (and the World Data Center) which is maintained at the NASA Goddard Space Flight Center in Greenbelt, Maryland (USA). These McDonald observations now comprise the bulk of all available LLR information. As we continue with our second decade of activity in this experiment, we have continued and will continue to maintain a steady and timely flow of data into the general scientific community. The present report comprises the documentation to be used in conjunction with the 1981 October deposit into the NSSDC which

contains normal points, filtered observations and unfiltered photon stops for the months January through June, 1981. Note that data deposits in this series continue to be made semi-annually in the spring and fall and consist of 6-month blocks of data which end three months before the deposit date, i.e., January-June or July-December.

A microfiche copy of the January-June, 1981 McDonald Observatory LLR data set has been included at the back of this report. Also, the interested reader is referred to Appendices C and D. Appendix C is entitled "Lunar Laser Calibration Data"; Appendix D is entitled "McDonald Lunar Laser Operations Log". Both of these appendices include information in a format similar to that which had been included in the tri-annual reports issued by E. C. Silverberg under NASA Grant NGR 44-012-165. With the demise of that grant and because of the different report requirements of the present McDonald Observatory Laser Operations Contract, this type of information is presently being included in our semi-annual NSSDC LLR data deposits.

A detailed overview of the equipment used to acquire the data described in this document has been provided by E. Silverberg (1974) and the precise role played by telescope mirror geometry and its effect upon the proper reduction of the data is discussed by Shelus et al (1975). New, definitive geometric calibration information for the entire McDonald 2.7m LLR data set can be found in Appendix A of this document. The interested user is also directed to papers by Mulholland (1980a, 1980b) and by Ferrari et al (1980) for current information and a near-exhaustive bibliography regarding most phases of the LLR experiment. Finally, a summary of the statistics concerning the first ten years of McDonald Observatory LLR operations has been compiled by Shelus (1980) and can be obtained from the author upon request.

II. Observational Statistics

The 119 McDonald Observatory LLR normal points contained in this data deposit represent some 957 individual photon returns from the moon. The distribution of the data with respect to month and to reflector is presented

	REFLECTOR 0		REFLECTOR 2		REFLECTOR 3		REFLECTOR 4		TOTALS	
	Normal # of points	# of photons	Normal # of points	# of photons	Normal # of points	# of photons	Normal # of points	# of photons	Normal # of points	# of photons
Jan	1	9	1	7	5	38	0	0	7	54
Feb	4	34	5	42	17	179	0	0	26	255
Mar	2	17	2	14	15	133	0	0	19	164
Apr	3	20	6	47	15	132	3	26	27	225
May	4	19	4	19	19	109	2	10	29	157
Jun	0	0	0	0	11	102	0	0	11	102
TTL	14	99	18	129	82	693	5	36	119	957

Table I. Summary of filtered observations by month and by reflector.

in Table 1. The statistics on the number of photons per normal point can be found in Figure 1. Figure 2 presents the current normal point distribution with respect to the classical fundamental arguments of the lunar motion. Figure 3 gives similar information with respect to the lunar declination and the local hour angle. Finally, Figure 4 presents statistics on uncertainty estimates for this data set. It should be noted that the various statistical information for the present data is essentially identical to earlier deposits in this series.

III. Data Description

The data are contained on three files of a binary magnetic tape written in card-image format, using a CDC Dual Cyber 170/750. It is written with odd parity at 800 bpi. Three types of cards are present, distinguished by an alphabet character in column 1. The letter "Z" designates a "RUN" card, giving environmental and operational parameters for a series of shots. Except for clock epoch offset, these will not customarily be required for application of the range data, but serve to provide information on the observing conditions and the state of the equipment. The letter "P" in column 1 represents a "SHOT" card, containing the result of a single laser firing. The letter "N" in column 1 represents a "NORMAL POINT" card containing the information compressed from an entire "RUN". A word of warning is in order to the unwary user. Some of the specified data may not be available. In the card images, a blank field is a "no information" indicator. Actual null values will be represented by zero punches. The complete "Z", "P", and "N" card formats are as follows:

```

INTEGER ZIN(23)
READ(5,1)ZIN
1 FORMAT(A1,I3,I10,I8,I3,3I2,A1,2X,I3,I5,5I3,A5,2I3,2I4,2I2)
where ZIN(1) = Card identifier (=Z)
      (2) = Observatory code* (=711)
      (3) = Julian date x 1000
      (4) = Clock epoch offset (microseconds)
      (5) = Atmospheric temperature (Celsius)
      (6) = Humidity (% saturation)
      (7) = Wind speed (km/hr)
      (8) = Seeing (0.1 arc sec)
      (9) = Electronic calibration accuracy code
           (see Appendix A)
      (10) = Energy (0.1 joule)
      (11) = Laser Frequency (10 gigahertz)
      (12) = Pulse length (100 picoseconds)
      (13) = Shot-by-shot resolution (100 picoseconds)
      (14) = Dark count (kHz)
      (15) = Moon count (kHz)
      (16) = Star count (kHz)
      (17) = Star identification
      (18) = Spectral filter width (0.1 angstrom)
      (19) = Spatial filter width (0.1 arc sec)
      (20) = Number of shots in run
      (21) = Calendar year
      (22) = Month
      (23) = Day

INTEGER PIN(17)
READ(5,2)PIN
2 FORMAT(A1,I3,I17,I5,I2,A1,I1,I12,I5,I6,I5,3X,I5,I1,I5,I4,2I2)
where: PIN(1) = Card identifier (=P)
      (2) = Body identifier (Moon = 011)
      (3) = Observation epoch
      (4) = Observatory code* (=71110)
      (5) = Reflector code*
      (6) = Observation type (=L)
      (7) = Epoch time base*
      (8) = Observed time delay (100 psec)
      (9) = Uncertainty estimate (100 psec)
      (10) = Electronic delay (100 psec)
      (11) = Geometric delay (100 psec)
      (12) = Frequency offset (parts in 10**11),
           subtract effect from range
      (13) = Delay time base*
      (14) = Atmospheric pressure (0.1 mb)
      (15) = Calendar year
      (16) = Month
      (17) = Day

```

(*) For additional explanation see also Mulholland (1972).

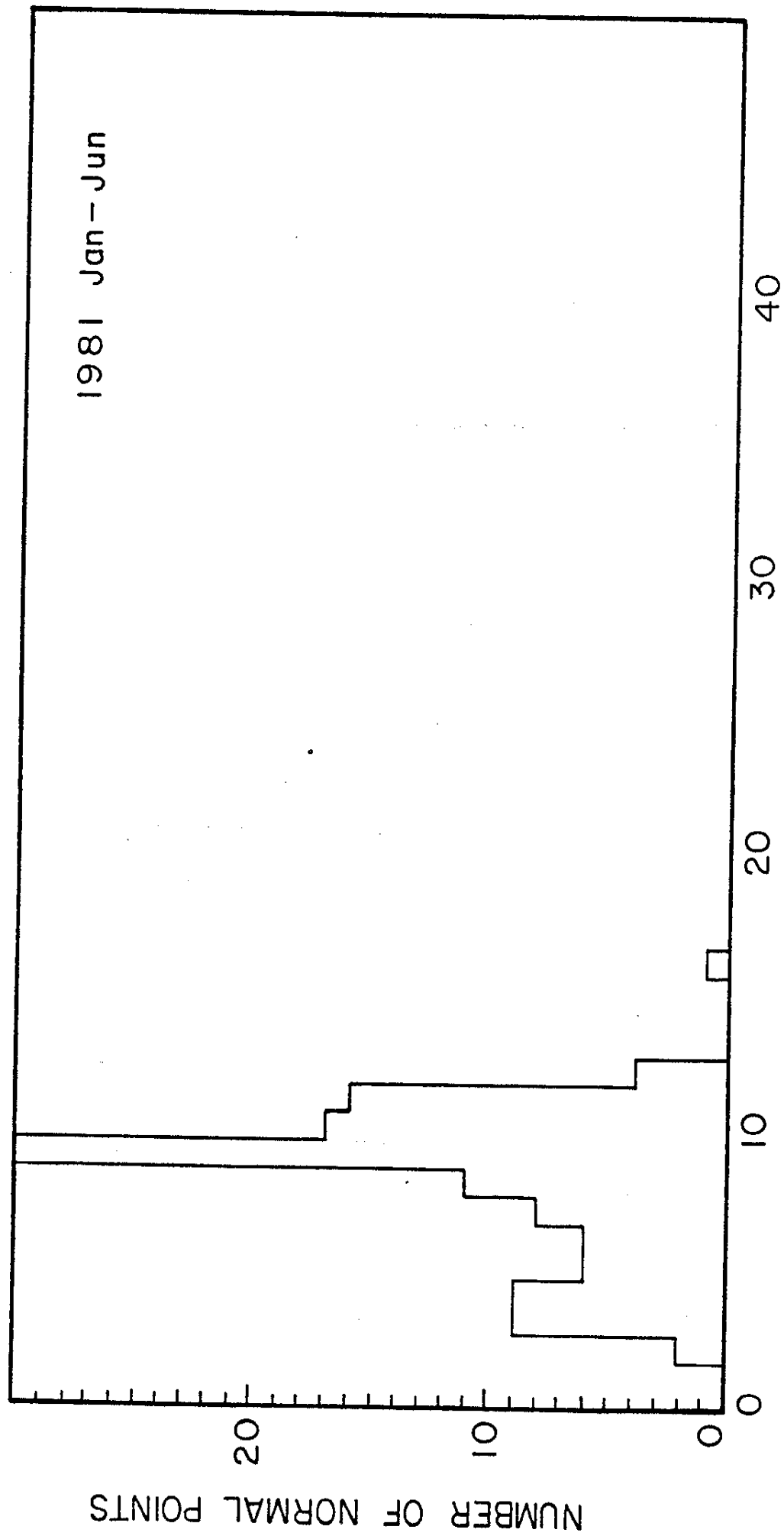


Figure 1: Distribution of signal photons per normal point for 1981.0 - 1981.5

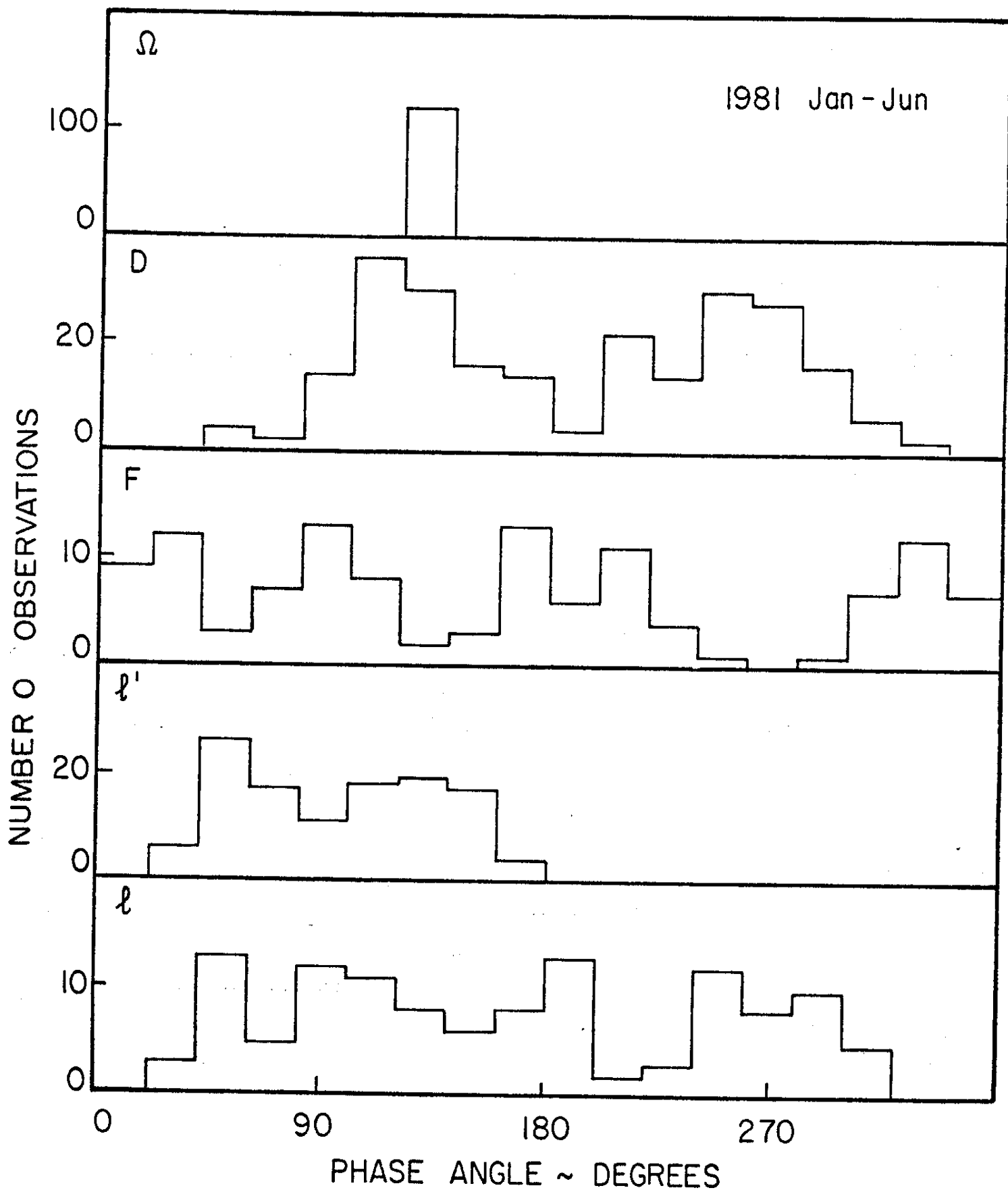


Figure 2: Histograms of the 1981.0 - 1981.5 observation distributions with respect to the phase of each of the fundamental arguments of the lunar motion. The sampling interval is 20° .

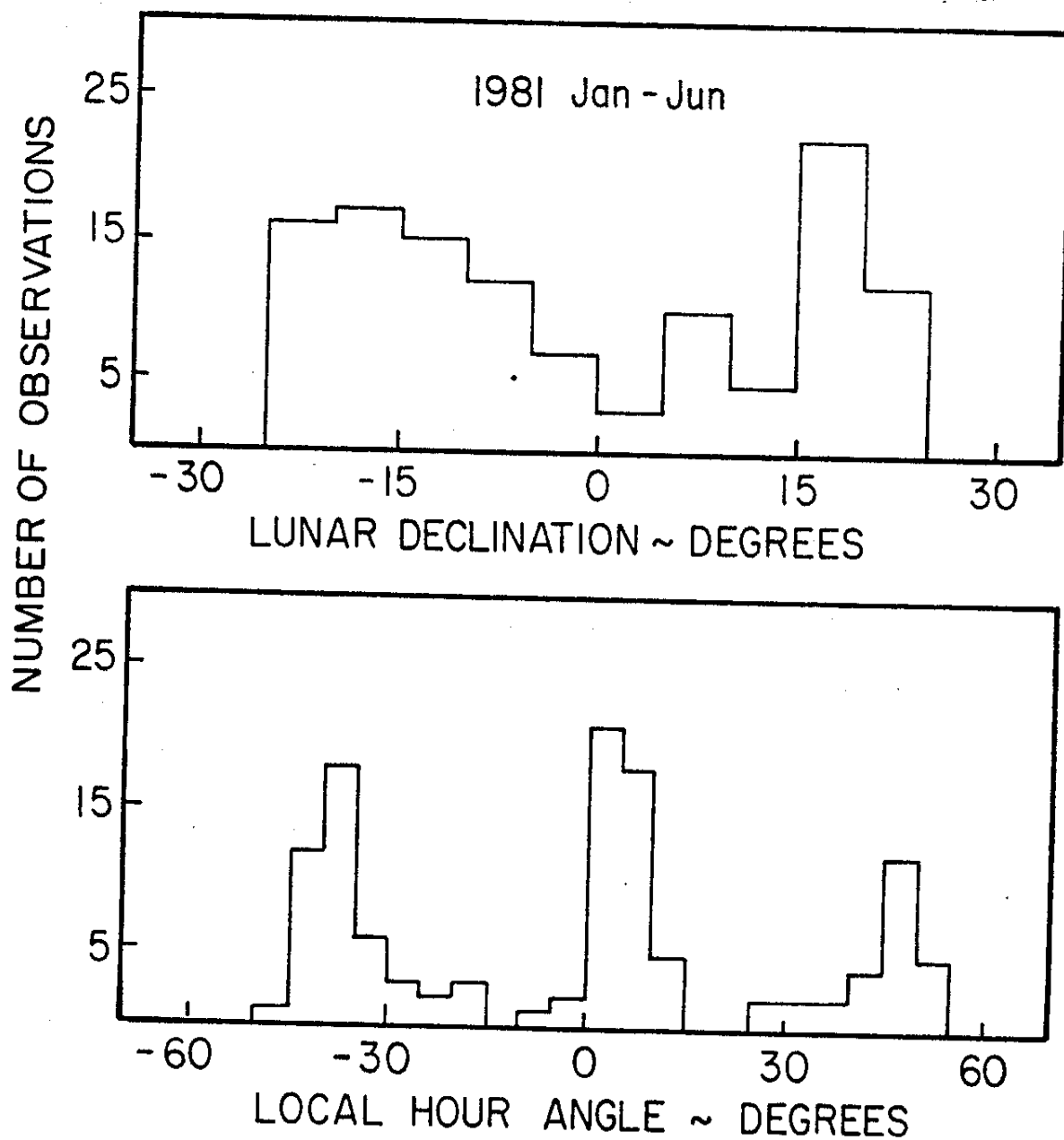


Figure 3: Histograms of the 1981.0 - 1981.5 observation distributions with respect to the lunar declination and local hour angle. The sampling interval is 5°.

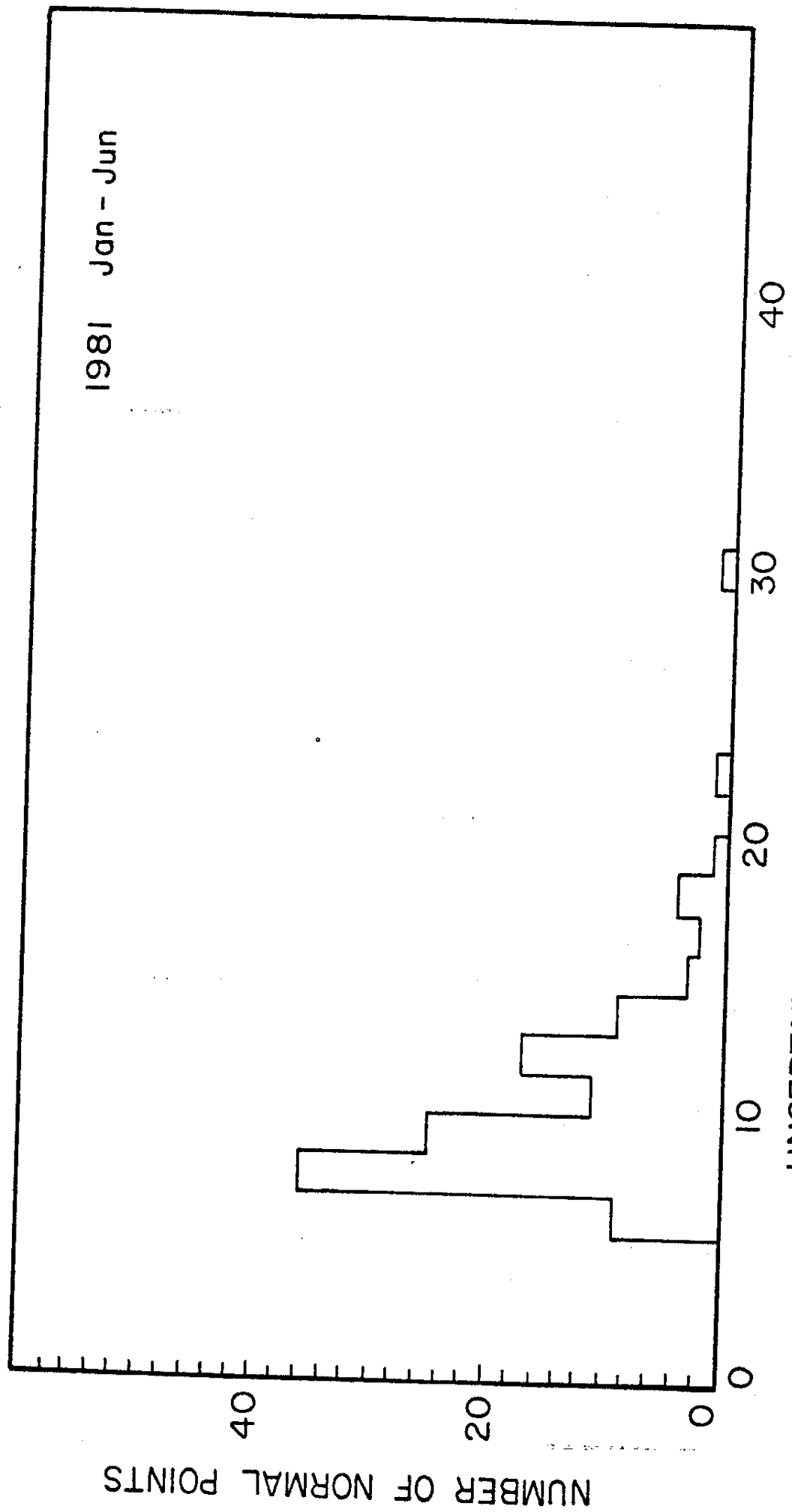


Figure 4: Histograms of the uncertainty estimates for the 1981.0 - 1981.5 McDonald Observatory LLR observation set.

```

      INTEGER NIN(18)
      READ(5,3)NIN
      3 FORMAT(A1,I3,I17,I5,I2,A1,I1,I12,I5,I6,I5,I3,I5,I1,I5,I4,2I2)
      where: NIN(1) = Card identifier (=N)
              (i) = PIN(I) for I=2,3,.. .,11 (see P-card above)
              (12) = Number of photon stops in normal point
              (J) = PIN(J-1) for J=13,14,.. .,18 (see P-card above)

```

For illustrative purposes and in order to define terminology to be used later we shall herein cite our treatment of McDonald Observatory lunar laser ranging data. Due to the fact that the McDonald Observatory obtains its lunar laser ranging observations with the 2.7 m telescope atop Mt. Locke, an instrument which is in regular and continuous use as a normal astronomical telescope, it is necessary that laser runs be scheduled in amongst other projects on-going through any lunar day. Note that by lunar day we refer to that period of time when the Moon is above the horizon at a given observatory, a definition quite analogous to the definition of a solar day. Such a scheduling has resulted in the formation of three laser observing sessions during the course of a lunar day. These three sessions at McDonald are each typically 45^m in length and are held nominally when the Moon is 3^h east of, on, and 3^h west of, the meridian. Of course day to day weather, equipment, and scheduling problems result in varying the length of such sessions and the location of the Moon with respect to the meridian during those sessions.

In the present format, during an observing session, consecutive laser firings are first made at the most favorably placed lunar surface retro-reflector until a sufficient number of returns are obtained to produce a normal point of the desired accuracy. For example, with its present configuration, the McDonald system can produce data to form a normal point with an accuracy of 7-10 cm with about 15 signal returns. Under good conditions these returns can be accumulated with 300-500 laser firings. Such consecutive laser firings at the same reflector, to form a single normal point, are referred to as a run. The observing crew will then set up on the next most favorably placed reflector and repeat the normal point formation

process. Ideally an observing session will produce a normal point for each available lunar retroreflector and then obtain a second normal point of the most favorably placed reflector to complete the cycle. The nominal 45^m observing session is completed by the taking and recording of all relevant environmental and systemic parameters.

The laser observing process does not result in directly useable range data, because the detection system cannot discriminate the source of an arriving photon. It is only the high potential accuracy of the laser system which permits the isolation of the observation from the noise. This requires elaborate computer processing incorporating a statistical filter (see Abbot et al. 1973). To emphasize the need for normal point development, note that through the present epoch, we have formed about 3,000 normal points from McDonald observations alone. Since, on the average, 10-15 photons go into each normal point we are dealing with in excess of 30,000 individual photons. Doing rigorous analysis with this sort of data at the individual photon level would increase computing and analysis costs by a factor of 10 with no significant increase in information content.

The first data file of this deposit contains the signal photon detections which have been compressed into normal points by the procedure referred to above developed at the University of Texas at Austin (Abbot et al, 1973). Each normal point represents the information content of an entire run. Such a normal point observation is comprised of a single pair of "Z" and "N" punched cards.

The second data file contains the photon detections which have been obtained by a data filtering procedure also developed at the University of Texas at Austin (Abbot et al, 1973). This process is based on the assumption of the linearity of (O-C) residuals over a relatively short interval of time and relies on Poisson statistics for establishing a level of confidence in a collection identified by the filter. Application of the process results in the identification of the observations during the subject interval. The

potential user should be aware that the laser cannot be relied upon to produce a simple pulse shape. There sometimes is a complex and/or biased structure within the pulse. Therefore, residuals derived from the signal photons are not necessarily expected to show a Gaussian distribution. The uncertainties assigned are based on the sum of the 1-sigma pulse-width and the measured uncertainty in calibrating the electronic system. Beginning with the April-May, 1972 lunation, a letter code appears in column 32 (formerly unused) of the "Z" card image which provides an estimate for the accuracy of the electronic calibration correction (see Appendix B). The data comprising an observation run consists of a single "z" card and several "p" cards (1 per identified observation).

The third data file contains the unfiltered photon stops. It is most important that the potential user observe the designation "unfiltered". By this, we mean that the real data are heavily interspersed with noise photons from any of the various sources of stray light. Any attempt to use these data in a simple Gaussian application would probably result in a solution closely adhering to the prediction ephemeris which was used to control the detector range gating. Some filtering process needs to be applied to these data before effective use can be made of them. The unfiltered data may be of direct utility or interest to those potential users who may wish to replace our filter criteria with their own. Similar to the shot-by-shot information the data comprising an observation run consists of a single "z" card and several "p" cards (1 per photomultiplier stop).

IV. Acknowledgements

This report and the data tape described herein were prepared at the University of Texas at Austin under NASA Contract NAS5-25948. The observations are obtained at McDonald Observatory under the same contract using predictions computed at the Jet Propulsion Laboratory.

V. References

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Appendix A

At the present time the geometric calibration constant for the McDonald Observatory Lunar Laser Ranging Data set is usually applied in two stages by most LLR data analysts. The first phase is the 117.2 ns or the 100.4 ns which is contained on the actual data card image. The second phase is the 120.6 ns which was presented by Shelus et al (1975) to account for the 2.7 meter telescope folded light path. Definitive calibration measurements have recently been made (Silverberg memo follows). As the Silverberg memo states "... All laser range measurements should be referred to that range which would be observed if you used an infinitesimally small instrument placed at the first non-moving point along the receive path ... All McDonald data should be uniformly corrected by the difference between the constants you are using and these newer values ...".

For the sake of consistency we are continuing to provide the geometrical calibration constant for the McDonald 2.7 meter system as 100.4 ns and are making the user responsible for applying the proper correction from the Silverberg memo. A suggestion to the user is to simply apply a "telescope" correction of 121.8 ns instead of the 120.6 ns value which is quoted in the referenced Astronomical Journal paper, i.e., Shelus et al (1975). That a proper geometrical calibration constant be applied to the McDonald LLR data set is especially important when multi-station and multi-technique experiments are being attempted.

At this time we also draw attention to paragraph 3 of the Silverberg memo which presents the measured offsets from the 2.7 meter telescope axis intersection to the NGS survey marker on the dome floor.



THE UNIVERSITY OF TEXAS
McDONALD OBSERVATORY AT MOUNT LOCKE

Robert Lee Moore Hall
Austin, Texas 78712

Date: 26 Feb 1980

MEMORANDUM

To: All Lunar Range Users, c/o Peter Shelus

From: E.C. Silverberg

Subject: McDonald Calibration Data

With the help of an NGS Field Team we have finally determined definitive calibrations for the McDonald lunar range data. Since 1973 we have been using a geometrically constant system; but one which was uncertain by as much as 2-3 nanoseconds in the overall range bias. This uncertainty has been greatly reduced by our recent work. Additional data has also been added to relate the 2.7 meter axes to the NGS survey mark on the telescope pier.

All laser range measurements should be referred to that range which would be observed if you used an infinitesimally small instrument placed at the first non-moving point along the receive path. The latter is usually the intersection of the telescope axes. Thus, a dynamical solution for station site coordinates will determine the geocentric position of a point on the #4 mirror in the 2.7 meter reflector. The relevant dimensions are given on the next page. A raw McDonald range measurement can be corrected to these conditions by subtracting a value equal to $K - K' + 70.573$ meters or $K - K' + 235.4$ nanoseconds. (The estimated error is about ± 1 cm.) K and K' are observed shot by shot by the feedback calibration system. In the past we have divided this calibration correction into an electrical component, $ELCOR = K - K' + 13.19$ nanoseconds and a geometric component (including the finite telescope size) of $GEOC = 222.2$ nanoseconds (66.621 meters) but the division is somewhat arbitrary. All McDonald data should be uniformly corrected by the difference between the constants you are using and these newer values. (We have always been certain of the relative biases of the various older systems, so any implied change in the last setup pertains to the entire eleven years.)

In addition to determining the system calibration constants we have accurately determined the offset of the 2.7 meter axes from the NGS survey mark on the dome floor. The survey marker is 5.304 meters down, .739 meters north and 0.143 meters east from the 2.7 meter calibration point.

Barring any further discoveries, this should be the last calibration work on the 2.7 meter system. I trust these calculations will lay this area to rest prior to abandoning the instrument sometime next year.


Eric C. Silverberg

Relevant Dimensions Used for the Calculations

Primary to Secondary Mirror	= 7.513 meters
Secondary to #3 Mirror	= 6.309 meters
#3 Mirror to #4 Mirror	= 3.039 meters
#4 Mirror to #6 Mirror	= 12.250 meters
#6 Mirror to PMT along the receive path	= 240.875"
#6 Mirror to the start diode behind #6	= 5 "
#6 Mirror to the feedback beam splitter along the receive path	= 195.75"
Feedback beam splitter to PMT along the feedback path	= 45.125"

Therefore: ELCOR, the difference measured if light hits the start diode and PMT simultaneously,

$$= K - K' \text{ (feedback calibration values)} \\ + 13.19 \text{ nanoseconds}$$

and

GEOC, the correction to the intersection of telescope axes plus the correction for finite telescope size

$$= 30.491 \text{ meters} + 36.130 \text{ meters (respectively)} \\ \text{or } 222.2 \text{ nanoseconds}$$

Appendix B

Code for the accuracy of the McDonald Observatory electronic calibration
correct ion:

- A - better than $(+/-)200$ picoseconds
- B - $(+/-)200$ to $(+/-)400$ picoseconds
- C - $(+/-)400$ to $(+/-)600$ picoseconds
- D - $(+/-)600$ to $(+/-)1000$ picoseconds
- E - $(+/-)1.0$ to $(+/-)1.5$ nanoseconds
- F - $(+/-)1.5$ to $(+/-)2.0$ nanoseconds
- G - $(+/-)2.0$ to $(+/-)4.0$ nanoseconds
- H - worse than $(+/-)4.0$ nanoseconds

These calibration codes were established by E. C. Silverberg.

Appendix C

The Lunar Laser Calibration Data

from

1 January 1981 to 30 June 1981

EXPLANATION OF THE CALIBRATION DATA

The following pages contain the calibration constants for the six lunations covered by the present report. Pertinent information concerning the photodetectors and related timing discriminators is presented above the columnar data. The columnar categories are explained below.

- A (pulser): This column contains the uncorrected calibration constant for the entire lunar ranging system as measured by an electronic start and a light emitting diode-PMT stop of the TDC-100 timer. Due to differing cable lengths of the start and stop paths in the system, this number is not the magnitude of the actual system calibration value. It is, however, a measure of the relative shift in the calibration value on a day-to-day basis. The units are nanoseconds.
- B (laser pulse): This column shows the single shot uncertainty as keyed to the following code: (all values are in nanoseconds)
A = ± 0.4 , B = ± 0.5 , C = ± 0.6 , D = ± 0.7 , E = ± 0.8 , F = ± 1.0 ,
G = ± 1.2 , H = ± 1.4 , I = ± 1.7 , J = ± 2.0 , K = ± 2.4 , L = ± 2.9 ,
M = ± 3.5 , N = ± 4.2 . The absence of a letter will indicate the single shot uncertainty of J.
- C (feedback): This column gives the arithmetic mean in nanoseconds of the "feedback calibration returns" through the entire ranging system as recorded by the system teletype during actual ranging. A "feedback calibration return" is produced by a start-diode start and a PMT stop of the TDC-100 timer. The uncertainty gives the standard deviation of data points within 5 nsec of the mean.

D (ELCOR): This column shows the value of ELCOR which has been determined by subtracting the nominal value of K' (15.3 nsec) and adding 13.9 nanoseconds (geometrical delay) to the average in column C. The units are tenths-of-nanoseconds. The minus sign was added to coincide with how this additive constant appears on the preliminary data cards. Letters following the numerical value indicate the uncertainty in the determination of ELCOR based on the feedback uncertainty according to the code (all values are in picoseconds):

$$\begin{aligned} 0 &\leq A \leq \pm 200 \\ \pm 200 &\leq B \leq \pm 400 \\ \pm 400 &\leq C \leq \pm 600 \\ \pm 600 &\leq D \leq \pm 1000 \\ \pm 1000 &\leq E \leq \pm 1500. \end{aligned}$$

NOTE: It should be remembered that ELCOR values, as given by these publications, are preliminary estimates determined at the ranging site using simple algorithms. As of March 1976, the final calibration constants, incorporating formal derivations of the calculation uncertainties, have been determined by the data reduction group in Austin, headed by P. Shelus.

SYSTEM CALIBRATION DATA
January 1981

PMT type: 30034
 PMT voltage: 1630V
 PMT gain: (Ortec 454) course: 5, fine: 2.
 Differentiate time constant: 5 nanoseconds.
 Integrate time constant: out nanoseconds.
 PMT discriminator: (Ortec 453) lower level disc.: 2.5,
 fraction: 0.5.
 Start Diode discriminator: (Ortec 453) 1.1.disc.: 9.0,
 fraction: 0.4.

UTC	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
012	50.2	--	-----	-----
013	50.5	--	-----	-----
014	53.2	--	-----	-----
015	53.5	I	75.7+0.16	-742B
016	----	--	-----	-----
017	52.0	--	-----	-----
018	----	--	-----	-----
019	----	--	-----	-----
020	54.2	--	-----	-----
021	53.4	H	76.1+0.14	-746A
022	52.8	--	-----	-----
023	54.0	I	75.6+0.10	-741A
024	53.4	--	-----	-----
025	53.3	--	-----	-----
026	53.2	--	-----	-----
027	55.1	--	-----	-----
028	54.0	H	75.4+0.10	-739A
029	52.8	--	-----	-----
030	51.5	--	-----	-----
031	53.3	--	-----	-----

SYSTEM CALIBRATION DATA

FEBRUARY 1981PMT type: 31034 .PMT voltage: 1630 .PMT gain: (Ortec 454) course: 5, fine: 2.Differentiate time constant: 5 nanoseconds.Integrate time constant: out nanoseconds.PMT discriminator: (Ortec 453) lower level disc.: 2.5, fraction: 0.5.Start Diode discriminator: (Ortec 453) 1.1.disc.: 9.0, fraction: 0.4.

UTC DAY	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
042	-	-	-	-
043	53.5	-	-	-
044	52.8	J	75.2+0.23	-737B
045	53.7	H	75.7+0.10	-742A
046	53.8	I	75.4+0.12	-739A
047	53.9	-	-	-
MT=1600V 048	53.3	I	75.1+0.21	-736B
MT=1610V 049	55.3	I	75.8+0.18	-743A
050	-	-	-	-
051	-	-	-	-
052	-	-	-	-
MT=1630V 053	54.7	-	-	-
054	54.6	-	-	-
055	54.3	I	74.8+0.15	-733A
056	54.1	I	75.5+0.11	-740A
057	53.6	-	-	-
058	53.2	-	-	-
059	51.7	-	-	-
060	-	-	-	-
061	-	-	-	-

SYSTEM CALIBRATION DATA
March 1981

PMT type: 31034

PMT voltage: 1630

PMT gain: (Ortec 454) course: 5, fine: 2.
 Differentiate time constant: 5 nanoseconds.
 Integrate time constant: out nanoseconds.
 PMT discriminator: (Ortec 453) lower level disc.: 2.5,
 fraction: 0.5.
 Start Diode discriminator: (Ortec 453) 1.1.disc.: 9.0,
 fraction: 0.4.

UTC	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
070	55.0	--	-----	-----
071	54.4	--	-----	-----
072	54.4	--	-----	-----
073	55.0	I	96.1+0.23	-746B
074	----	I	76.8+0.20	-753B
075	52.6	--	-----	-----
076	53.6	H	76.2+0.18	-747A
077	54.2	H	76.1+0.25	-746B
078	54.4	H	76.1+0.17	-746A
079	54.5	H	76.2+0.21	-746B
080	53.2	--	-----	-----
081	53.2	--	-----	-----
082	54.1	H	75.4+0.13	-739A
083	NO LASER RUN DUE TO SUPER NOVA OBSERVATION			
087	53.1	--	-----	-----
088	----	--	-----	-----
089	53.5	--	-----	-----
090	----	I	75.2+0.18	-737A
091	54.8	I	75.2+0.20	-737B

SYSTEM CALIBRATION DATA
April 1981

PMT type: 31034

PMT voltage: 1630

PMT gain: (Ortec 454) course: 5, fine: 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out nanoseconds.
PMT discriminator: (Ortec 453) lower level disc.: 2.5,
fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1.: 9.0,
fraction: 0.4.

UTC	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
098				
099	----	I	75.6+.18	-741A
100	53.4	--	-----	-----
101	53.0	I	75.6+.13	-741A
102	54.1	I	75.8+.23	-743B
103	54.0	I	75.9+.24	-744B
104	53.0	--	-----	-----
105	53.8	--	-----	-----
106	54.4	--	-----	-----
107	53.6	--	-----	-----
108	53.5	--	-----	-----
109	----	--	-----	-----
110	----	--	-----	-----
111	----	I	75.4+.27	-739B
112	54.4	--	-----	-----
113	53.1	--	-----	-----
114	53.3	--	-----	-----
115	53.5	I	75.6+.11	-741A
116	53.6	I	75.5+.12	-740A
117	53.6	I	75.5+.17	-740A
118	53.6	H	76.3+.22	-748B
119	52.8	I	76.1+.16	-746A
120	----	--	-----	-----

SYSTEM CALIBRATION DATA
May 1981

PMT: type: 31034

PMT voltage: 1630

PMT gain: (Ortec 454) course: 5, fine: 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out nanoseconds.
PMT discriminator: (Ortec 453) lower level disc.: 2.5,
fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1.disc.: 9.0,
fraction 0.4.

UTC	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
128	54.7	--	-----	-----
129	53.4	--	-----	-----
130	53.3	--	-----	-----
131	54.3	--	-----	-----
132	52.7	I	75.9+0.11	-744A
133	52.8	I	75.3+0.12	-738A
134	53.2	I	75.1+0.14	-736A
135	53.6	I	75.8+0.14	-743A
136	----	J	74.0+0.37	-725B
137	----	--	-----	-----
138	53.0	I	76.0+0.19	-745A
139	55.1	I	76.2+0.26	-747B
140	54.8	I	75.3+0.18	-738A
141	54.2	--	-----	-----
142	53.4	I	74.7+0.11	-732A
143	54.4	I	74.8+0.11	-733A
144	----	--	-----	-----
145	53.5	I	75.1+0.12	-736A
146	----	I	74.7+0.12	-732A
147	52.4	I	74.3+0.13	-728A
148	----	I	75.3+0.20	-738A

SYSTEM CALIBRATION DATA

June 1981

PMT type: 31034

PMT voltage: 1630

PMT gain: (Ortec 454) course: 5, fine: 2.
 Differentiate time constant: 5 nanoseconds.
 Integrate time constant: out nanoseconds.
 PMT discriminator: (Ortec 453) lower level disc.: 2.5,
 fraction: 0.5.
 Start Diode discriminator: (Ortec 453) l.l.disc.: 9.0,
 fraction 0.4.

UTC	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
159	----	--	-----	-----
160	52.2	--	-----	-----
161	----	--	-----	-----
162	53.8	H	74.8+0.16	-733A
163	53.9	I	74.9+0.16	-734A
164	53.9	I	75.0+0.14	-735A
165	54.4	--	-----	-----
166	51.2	J	74.6+0.36	-731B
167	53.8	--	-----	-----
168	----	--	-----	-----
169	----	--	-----	-----
170	----	--	-----	-----
171	----	--	-----	-----
172	53.4	J	-----	-----
173	53.0	I	74.9+0.17	-734A
174	53.2	--	-----	-----
175	52.7	J	-----	-734B
176	53.6	--	-----	-----
177	----	--	-----	-----
178	----	--	-----	-----

Appendix D

The McDonald Lunar Laser Operations Log

from

1 January 1981 to 30 June 1981

EXPLANATION OF THE OPERATIONS LOG

The information presented in the McDonald Lunar Laser Operations Log is as follows:

- DATE (column 1): The local calendar date at the start of the day's ranging operation.
- LUNAR DAY (column 2): The approximate number of days which have elapsed since the previous new moon. This estimate comes from the American Ephemeris and Nautical Almanac: Ephemeris for Physical Observations of the Moon.
- UTC DAY (column 3): The Universal Coordinated Time day of the calendar year as read from the McDonald station clock at the beginning of a range attempt.
- TIME (column 4): The UTC hour and minute as read from the station clock at the beginning of a range attempt.
- REFL. NO (column 5): The lunar reflector site: 0 = Apollo 11, 1 = Luna 17, 2 = Apollo 14, 3 = Apollo 15, 4 = Luna 21.
- RETURNS/SHOT (column 6): The number of lunar returns divided by the number of laser shots fired. Returns are as identified by the laser crew.
- SIGNAL LEVEL (column 7): The number of lunar photoelectrons per laser shot for the range attempt. Double photoelectrons are counted as single photoelectron events.
- DOUBLES (column 8): The number of returns which were greater than single photoelectron events. Lunar return doubles are presented without parenthesis; noise doubles are presented within parenthesis.
- WEATHER (column 9): The general weather conditions at the time of the range attempt.

SEEING (column 10): The guider's estimate of the general seeing conditions in arcseconds, based on stellar or lunar observations.

COMMENTS (column 11): Comments which seem pertinent to the laser crew at the time of ranging.

STATION LOG - JANUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Jan. 7	1	007	1545	-	-	-			Started MCD 148 Changed Laron Content from 72476 to 7254 30014 to 30028
Jan. 9	3	009	2315						
Jan. 10	4	010	-				Cloudy		No runs. No cage change Clouds, fog
Jan. 11	5	011	-				Cloudy		No runs. No cage change Clouds, fog
Jan. 12	6	012	2130 0030 0330	- - -	- - -	- - -	Cloudy Cloudy Cloudy		Cancelled Clouds, Fog Cancelled Clouds, Fog Cancelled Clouds, Fog
Jan. 13	7	013	2230 0130 0433	- - -	- - -	- - -	Cloudy Cloudy Cloudy		Cancelled Clouds, Fog, Rain Cancelled Clouds, Fog, Rain Cancelled Clouds, Fog, Rain
Jan. 14	8	014	2200						TPHC2 & TPHC2 repaired - Start & Stop Tunnels Aged #1 Installed
Jan. 14	8	014	2330	-	-	-	Clear	6-8	Cancelled Poor Seeing Good Image Motion
			0230	-	-	-	Clear	7-10	Cancelled Poor Seeing Good Image Motion
			0530	-	-	-	Clear	6-7	Cancelled Poor Seeing

STATION LOG - JANUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Jan. 15	9	015	0000	-	-	-	Cloudy	-	Cancelled Clouds
			0300	3	0/266	-	Cloudy	3-5	Heavy Cirrus
			0600	-	-	-	Cloudy	-	Cancelled Clouds
Jan. 16	10	017	0100	-	-	-	Cloudy	-	Cancelled Clouds Snow
			0400	-	-	-	Cloudy	-	Cancelled Clouds Snow
			0700	-	-	-	Cloudy	-	Cancelled Clouds Snow
Jan. 17	11	018	0200	-	-	-	Cloudy	-	Cancelled Snow
			0500	-	-	-	Cloudy	-	Cancelled Snow
			0800	-	-	-	Cloudy	-	Cancelled Snow
Jan. 18	12	019	0300	-	-	-	Cloudy	-	Cancelled Clouds Snow
			0600	-	-	-	Cloudy	-	Cancelled Clouds Snow
			0900	-	-	-	Cloudy	-	Cancelled Clouds Snow
Jan. 20	14	020	0401	-	-	-			Reset Loran C
			0400	-	-	-	Hazy	-	Cancelled High Humidity
			0700	-	-	-	Clear	-	Cancelled High Humidity
			1000	-	-	-	Clear	-	Cancelled High Humidity
Jan. 21	15	021	0500	3	7/278	-	Ptly. Cldy.	4	
			0800	0	3/328	-	Ptly. Cldy.	5-6	Poor Contrast
			1100	-	-	-	Clear	8	Cancelled Seeing
Jan. 22	16	022	0600	-	-	-	Clear	-	Cancelled Air Conditioning Problem 3 Glycol Unit
			0900	-	-	-	Clear	-	Cancelled Air Conditioning Problem 3 Glycol Unit
			1200	-	-	-	Clear	-	Cancelled Air Conditioning Problem 3 Glycol Unit

STATION LOG - JANUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Jan. 23	17	023	0630	-	-	-	Clear	5-7	Cancelled seeing, image, motion
			0930	3	10/089	4	Clear	4	Slight image motion
			1230	2	10/306	1	Clear	5	Slight image motion
				0	13/236	1	Clear	4	
				2	43/280	0	Clear	4-5	
Jan. 24	18	024	0730	-	-	-	Cloudy	5-8	Cancelled by clouds, bad image motion
			1030	-	-	-	Cirrus	7-10	Cancelled good seeing, terrible image motion
			1330	-	-	-	Cirrus	7-10	Cancelled good seeing, terrible image motion
Jan. 25	19	025	0800	-	-	-	Clouds	-	Cancelled clouds
			1100	-	-	-	Clouds	-	Cancelled clouds
			1400	-	-	-	Clouds	-	Cancelled clouds
Jan. 26	20	026	0830	-	-	-	Cloudy	-	Cancelled clouds
			1130	-	-	-	Cloudy	-	Cancelled clouds
			1430	-	-	-	Cloudy	-	Cancelled clouds
Jan. 27	21	027	0930	-	-	-	Clear	9-12	Cancelled terrible seeing
			1230	-	-	-	Clear	9-12	Cancelled terrible seeing
			1530	-	-	-	Clear	9-12	Cancelled terrible seeing
Jan. 28	22	028	1000	3	12/203	4	Light Cirrus	4-7	Chiller problems
			1300	3	5/357	1	Lt-Hvy Cirrus	4-8	Stopped by seeing (Carlini, unrecognizable)
			1600	3	8/350	2	Light Cirrus	3-6	Poor contrast (seeing variable)
Jan. 29	23	029	1100	-	-	-	Clear	7-10	Cancelled Bad Seeing Image Motion
			1400	-	-	-	Cloudy	-	Cancelled
			1700	-	-	-	Cirrus	7-10	Cancelled Seeing Contrast

STATION LOG - JANUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Jan. 30	24	030	1130	-	-	-	Cloudy	-	Cancelled Clouds
			1430	-	-	-	Cloudy	-	Cancelled Clouds
			1730	-	-	-	Cloudy	-	Cancelled Clouds
Jan. 31	25	031	1230	-	-	-	Ptly. Cldy.	10-15	No Cage change seeing bad cold at 82"
		031	1530	-	-	-	Ptly. Cldy.	10-15	Cancelled No Cage change seeing contrast
			1700	-	-	-	Ptly. Cldy.	10-15	Cancelled No Cage change seeing contrast

STATION LOG - FEBRUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Feb. 1	26	032	1330	-	-	-	Clear	15-20	No cage change bad seeing contrast
			1600	-	-	-	Clear	15-20	No cage change bad seeing contrast
			1800	-	-	-	Clear	15-20	No cage change bad seeing contrast
		032	1500	-	-	-	-	-	No cage change bad seeing contrast Copied MCD 148

STATION LOG - FEBRUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Feb. 2	27	033	1430	-	-	-			Started MCD 149
Feb. 2	27	042	2200	-	-	-	Cirrus	6-8	Cancelled Poor Seeing Contrast Bad Image Motion
Feb. 2	27		0100	3	0/29	-	Cirrus	5-7	Stopped TDG Problems - Flip Mirror Changing El Wrong Time
Feb. 2			0400	-	-	-	Cloudy		Cancelled Clouds. TDG Problem (2 Second Card Bad)
Feb. 12	7	043	0830						TDG, Card ?, Q7 Replaced to get 2 Sec. Delay to Work
Feb. 12	7	043	2300	3	12/162	2	Light Cirrus	3-4	Poor Contrast
			0200	-	-	-	Clouds	-	Cancelled Clouds
			0500	-	-	-	Clouds	-	Cancelled Clouds
Feb. 13	8	045	0000	3	14/138	3	Clear	3-6	Very Variable Seeing, (Should be 376 on log)
				2	8/143	3	Clear	3-6	Very Variable Seeing
			0300	3	17/147	3			
				0	11/129	1	Clear	3-4	
			0600	3	12/135	2	Clear	3-4	
				3	9/44	4	Clear	3	
				0	8/142	2	Clear	3	
				2	11/186	4	Clear	3	
Feb. 14	9	046	0100						
			0400	3	10/45	3	Clear	1-2	
			0700	3	12/60	3	Clear	1-2	
Feb. 15	10	047	0200	-	-	-	Cloudy	-	Cancelled

STATION LOG - FEBRUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Feb. 15	10	047	0500 0800	- -	- -	- -	Cloudy Cloudy	- -	Cancelled Cancelled
Feb. 16	11	048	0230	3 3 0 2 3	11/92 12/129 10/190 9/96 9/338	1 1 2 - 1	Clear Clear Clear Clear Clear	1-2 1-2 1-2 1-2 3	V=1630 PMT V=1600 PMT Poor Contrast Full Moon
Feb. 17	12	049	0330	3 3 2 3	8/374 8/234 8/192 0/235	- 1 - -	Clear Clear Clear Clear	2-3 2-3 2-3 3	Poor Contrast Full Moon (PMT= V=1610) Poor Contrast Full Moon (PMT = V=1610) Poor Contrast Full Moon (PMT = V=1610) Poor Contrast Full Moon (PMT =V=1610)
Feb. 22	17	053	0630 0930 1230	- - -	- - -	- - -	Clear Clear Clear	10-12 9-11 8-10	Cancelled Bad Seeing PMT=1630V Cancelled Bad Seeing Cancelled Bad Seeing
Feb. 23	18	054	0730 1030 1320	3 3 -	0/? - -	- - -	Clear Clear Clear	4-6 5-7 5-7	Cancelled TDG Problems Seconds Board Bad Cancelled TDG Problems Seconds Board Bad Cancelled TDG Problems Seconds Board Bad
Feb. 23	18	054	2200						Replaced Q7 & Q9 On Seconds Board In TDG
Feb. 24	19	055	0800 1000 1400	3 - 3 0	11/119 - 10/83 0/241	1 - 2 -	Cirrus Clouds Partly Cldy. Partly Cldy.	1-2 3-4 3-4	Light to Heavy Cirrus Cancelled Poor Contrast

D-10

STATION LOG - FEBRUARY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Feb. 25	20	056	0900	3	11/116	1	Ptly. Cloudy	2	Clouds
			1200	3	10/57	4	Clear	2	
			1200	2	9/274	-	-	2	
			1200	0	9/143	-	-	2	
			1500	3	11/203	1	Clear	4-5	Poor Contrast
Feb. 26	21	057	0930	-	-	-	Cloudy	3-5	Cancelled Clouds
			1230	-	-	-	Cloudy	-	Cancelled Clouds
			1530	-	-	-	Cloudy	-	Cancelled Clouds
Feb. 27	22	057	1000	-	-	-	Cloudy	-	Clouds Cancelled
			1300	-	-	-	Cloudy	-	Clouds Cancelled
			1600	-	-	-	Cloudy	-	Clouds Cancelled
Feb. 28	23	059	1100	-	-	-	Clouds	-	Cancelled Clouds Rain
			1400	-	-	-	Clouds	-	Cancelled Clouds Rain
			1700	-	-	-	Clouds	-	Cancelled Clouds Rain
Mar. 1	24	060	1200	-	-	-	Ptly. Cloudy	6-8	Cancelled Seeing Clouds
			1500	-	-	-	Cloudy		Cancelled
			1800	-	-	-	Clear	6-8	Cancelled Seeing Contrast
Mar. 2	25	061	1300	-	-	-	Cloudy		Cancelled Clouds
			1500	-	-	-	Cloudy		Cancelled Clouds
Mar. 2			1524						Copied MCD 149

STATION LOG - MARCH 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Mar 2	25	061	1632	-	-	-		-	Started MCD 150
Mar 11	5	070 071	2100 0000 0010 0300	- - - -	- - - -	- - - -	Cloudy Cloudy - Cloudy	- - - -	Cancelled Clouds Fog Rain Cancelled Clouds Fog Rain Recopied MCD 149 Cancelled Clouds, Fog
Mar 12	6	071 072	2130 0030 0330	- - -	- - -	- - -	Cloudy Cloudy Cloudy	- - -	Cancelled Clouds Fog Cancelled Clouds Fog Cancelled Clouds Fog
Mar 13	7	072 073	2300 0200 0500	- 3 0 3	- 10/63 0/160 12/175	- 2 - 1	Cloudy Clear Clear Hazy	3-4 4 4	Cancelled Clouds
Mar 14	8	074	0000 0300 0600	3 3 -	7/355 12/142 -	- 3 -	Cirrus Clear Cloudy	4-8 4-6 -	Varying Seeing (Bad Image Motion) Cancelled Clouds Wind Gusts to 50 MPH West
Mar 15	9	075	0100 0400 0700	- - -	- - -	- - -	Cloudy Cloudy Cloudy	- - -	Cancelled Clouds Cancelled Clouds Cancelled Clouds
Mar 16	10	076	0130 0430 0730	3 3 0 -	10/78 10/111 8/237 -	1 3 2 -	Clear Clear Clear Cloudy	4-6 4-6 4-6 -	Hazy Variable Seeing Hazy Variable Seeing Cancelled Clouds
Mar 17	11	077	0230 0530 0830	0 - 3	0 - 13/184	0 - 2	Cirrus Clear Clear	- 7-9 4-6	Cancelled Wind 61MPH Unable to Open Dome Cancelled Rad Seeing Wind 48MPH Image Motion
Mar 18	12	078	0300 0600 0900	3 3 3	11/87 11/266 10/273	2 3 4	Clear Lt. Cirrus Clear	4-5 4-6 4	Variable Seeing

STATION L_A - MARCH 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Mar 19	13	079	0400 0700 1000	3 - -	8/366 - -	2 - -	Ptly.Cldy. Cloudy Cloudy	4-6 - -	Lt.to Heavy Cirrus (Poor Contrast) Cancelled Clouds Cancelled Clouds
Mar 20	14	080	0430 0730 1030	- - -	- - -	- - -	Cloudy Cloudy Cloudy	- - -	Cancelled Clouds Cancelled Clouds Cancelled Clouds
Mar 21	15	081	0530 0830 1130	- - -	- - -	- - -	Dsty.&Wndy. Dsty.&Wndy. Dsty.&Wndy.	6 8 8	Cancelled Seeing Cancelled Seeing Cancelled Seeing
Mar 22	16	082	0600	3 0 2 3 3	11/041 11/174 7/331 10/111 11/59	2 - 1 3 3	Clear Clear Clear Ptly.Cldy. Ptly.Cldy.	2 2 2 3 3	PMT = 1630 Light Cirrus
Mar 23-27			-	-	-	-	-		No Laser Runs/Telescope In Cass Observing Super NOVA.
Mar 28	22	087	1000 1300 1600	- - -	- - -	-	Cloudy Clear Clear	8 10+ ?	Cancelled Seeing Cancelled Seeing Cancelled, High Winds
Mar 29	23	088	1017 1200 1500	- - -	- - -	-	Windy Windy Windy	8-10	Cancelled Run for Occultation Cancelled High Winds Cancelled High Winds
Mar 30	24	089	1130 1400 1630	- - -	- - -	-	Clear Clear Clear	4-9 4-9 4-9	Cancelled Bad Seeing Cancelled Bad Seeing Cancelled Bad Seeing
Mar 31	25	090	1330 1600	2 3 -	10/220 8/249	2 0 -	Ptly.Cldy. Ptly.Cldy. Clear	3 3 4-5	Cooler Problems Cooler Problems Cancelled Bad Contrast
Apr 1	26	091	1330 1630 1649	2 - -	10/152 - -	1 - -	Clear - -	3	Cancelled for Dome Repairs Copied MCD 150

STATION LOG - APRIL 1981

D-14

STATION LOG - APRIL 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Apr 16	11	106	0230	-	-	-	Cloudy		Cancelled Clouds
			0530	-	-	-	Cloudy		Cancelled Clouds
			0830	-	-	-	Cloudy		Cancelled Clouds
Apr 17	12	108	0300	-	-	-	Cloudy	-	Cancelled, Clouds
			0600	-	-	-	Cloudy	-	Cancelled, Clouds
			0900	-	-	-	Cloudy	-	Cancelled, Clouds
Apr 20	15	111	0530	3	12/134	4	Cirrus	2-3	
			0830	-	-	-	Cloudy	-	Cancelled Clouds
			1130	-	-	-	Cloudy	-	Cancelled Clouds
Apr 22	17	112	0600	-	-	-	Cloudy	-	Cancelled Clouds
			0900	3	9/152	3	Clear	3-5	
			1200	0	9/191	1	Clear	3-5	
				-	-	-	Cloudy	-	Cancelled Clouds
Apr 23	18	113	0700	-	-	-	Cloudy	-	Cancelled Clds Rain
			1000	-	-	-	Cloudy	-	Cancelled Clds Rain
			1300	-	-	-	Cloudy	-	Cancelled Clds Rain
Apr 24	19	114	0730	-	-	-	Cloudy	-	Cancelled, Clouds
			1100	-	-	-	Hazy	9+	Cancelled, Seeing
			1330	-	-	-	Cloudy	-	Cancelled, Clouds
Apr 25	20	115	0830	3	10/175	4	Clear	3-5	
			1130	3	10/75	2	Clear	3	
				2	9/260	2			
				4	10/180	1			
			1400	3	9/92	4	Clear	3	
Apr 26	21	116	0930	3	11/039	2	Clear	3	
			1230	3	11/058	4	Clear	3	
				2	10/251	1	Clear	3	
				4	7/284	1	Clear	3	
			1500	-	-	-	Clear	4-6	Cancelled, Seeing, Contrast
Apr 27	22	117	1030	2	10/146	1	Clear	4	
				3	4/213	0	Cirrus	4	
			1300	2	6/316	0	Cirrus	3-4	Clouds - Cirrus (no logs, just shots)
			1630	-	-	-	Cirrus	4-6	Cancelled, Seeing & Contrast

STATION LOG - APRIL 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
Apr 28	23	118	1100	-	-	-	Hvy. Cirrus	4-6	Cancelled Clouds
			1230	3	9/91	3	Clear	3	
			1630	2	7/143	0	Cloudy		Cancelled Clouds
Apr 29	24	119	1200	3	4/453	1	Ptly. Cldy.	2-3	In and Out of Clouds
			1430	-	-	-	Cldy	-	Cancelled Clouds
			1830	-	-	-	Clear	4-6	Cancelled Poor Contrast Seeing
Apr 30	25	120	1230	-	-	-	Cloudy	-	Cancelled Clouds
			1530	-	-	-	Cloudy	-	Cancelled Clouds
			1830	-	-	-	Cloudy	-	Cancelled Clouds
Apr 30		120	1330						Copied MCD 151

STATION LOG - MAY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
May 7	3	127	1930	-	-	-	Cloudy	-	Cancelled Clouds Rain No Cage Change
			2230	-	-	-	Cloudy		Cancelled Clouds Rain No Cage Change
		126	0130	-	-	-	Cloudy		Cancelled Clouds Rain No Cage Change
May 8	4	128	2000	-	-	-	Clear	7-9	Cancelled Very Poor Contrast Seeing Checked at 82" No CageChn
			2300	-	-	-	Clear	7-9	Cancelled Bad Seeing No Cage Chn
		128	0200	-	-	-	Clear	7-9	Cancelled Bad Seeing No Cage Chn
May 9	5	129	2100	-	-	-	Clear	7-10	Cancelled Poor Contrast, Bad Seeing Yes Cage Change
			2330	-	-	-	Clear	7-10	Cancelled Bad Seeing No Cage Chn
		130	0230	-	-	-	Clear	7-10	Cancelled Bad Seeing No Cage Chn
May 10	6	130	2200	-	-	-	Clear	7-8	Cancelled Bad Seeing No Cage Chn
		131	0000	-	-	-	Clear	6-7	Cancelled Bad Seeing No Cage Chn
			0300	-	-	-	Clear	6-7	Cancelled Bad Seeing No Cage Chn
May 11	7	131	2300	-	-	-	Cloudy	-	Cancelled Clouds
			0200	3	010/116	1	Cirrus	2	Cirrus
				0	08/210	2	Cirrus	2	Cirrus
			0500	3	10/83	2	Pt.Cldy.	1-2	Partly Cloudy
				4	10/162	2	Pt.Cldy.	1-2	Partly Cloudy
				2	0/177	-	Pt.Cldy.	3-4	Partly Cloudy
May 12	8	133	0000	3	9/42	1	Cirrus	2-4	Partly Cloudy
				2	9/144	-	Cirrus	2-4	Partly Cloudy
				0	8/194	-	Cirrus	2-4	Partly Cloudy
				4	8/142	1	Cirrus	2-4	Partly Cloudy
			0300	3	10/187	3	Pt.Cldy.	3	Partly Cloudy
			0600	3	9/95	5	Clear	4-5	Clear
		134	0015	3	12/82	4	Clear	4	
				2	9/96	1	Clear	4	
				0	9/190	1	Clear	4	
				3	10/47	2	Clear	2-3	
				3	11/50	1	Clear	2	

STATION LOG - MAY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
May 14	10	135	0130 0430	- 3 2 0	- 10/138 9/47 7/237	- 1 0 2	- Hazy Hazy Pt. Cldy	- 2-3 2-3 2-3	Cancelled Clouds
			0730	-	-	-	Cloudy	-	Cancelled Clouds
May 15	11	136	0700 0500 0800	3 - -	10/176 - -	2 - -	Cloudy Cloudy Cloudy	3-4 - 4-6	Cancelled Clouds Cancelled Clouds
May 16	12	137	0300 0600 0900	- - -	- - -	- - -	Clear Clear Clear	- - -	Cancelled Crew Sick Cancelled Crew Sick Cancelled Crew Sick
May 17	13	138	0330	3	3/216	-	Clear	2-4	Variable Seeing Full Moon V = 1660 PMT
			0630	2	4/206	-	Clear	2-4	Variable Seeing Full Moon V = 1660 PMT
			0930	-	-	-	Very Hazy	5-7	Cancelled Seeing Image Motion Poor Contrast
				-	-	-	Very Hazy	7-10	Cancelled Seeing Image Motion Poor Contrast
May 18	14	139	0400	3	3/249	0	Clear	2-3	1 Day Past Full Moon V=156
			0700	2	0/106	0	Clear	2-3	
			1000	3	7/325	0	Clear	2-3	
				-	-	-	Clear	10-15	Cancelled Bad Seeing
May 19	15	140	0800 2800 1100	3 - -	5/329 - -	1 - -	Clear Cloudy Cloudy	4-6 - -	PMT =1630 Cancelled Clouds Cancelled Clouds
May 21	17	141	0530 0830 1130	- - -	- - -	- - -	Cloudy Clear Cloudy	- 8-10 -	Cancelled Clouds Cancelled Seeing Cancelled Clouds
May 22	18	142	0630	3	10/93	2	Pt. Cldy.	4	
			0930	2	0/188	-	Pt. Cldy.	4	
				3	12/79	3	Pt. Cldy.	3	
			1230	0	7/322	3	Pt. Cldy.	3	
				-	-	-	Cloudy	-	Cancelled Clouds

STATION 1 - MAY 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
May 23	19	143	0730	3	10/85	1	Clear	4-6	Variable Seeing
				0	9/259	1	Clear	4-6	Variable Seeing
			1030	3	10/211	2	Clear	5	Variable Seeing
			1300	2	0/79	-	Clear	5	Too Much Variation in Seeing
				3	10/199	-	Clear	4-5	
May 24	20	144	0800	-	-	-	Cloudy	-	Cancelled Clouds
			1100	-	-	-	Cloudy	-	Cancelled Clouds
			1400	-	-	-	Cloudy	-	Cancelled Clouds
May 25	21	145	0900	3	8/232	1	Clear	4-8	Variable Seeing
			1200	3	9/137	4	Clear	3-4	
			1400	2	9/233	3	Clear	3-4	
				3	5/279	-	Clear	5	Stopped by Seeing Contrast
May 26	22	146	1000	2	3/369	1	Clear	4-5	
			1300	3	3/248	-	Clear	4-5	
			1600	3	10/144	-	Cirrus	4-5	Variable Seeing
				2	6/255	1	Cirrus	4-5	Variable Seeing
				-	-	-	Cloudy	-	Cancelled Clouds
May 27	23	147	1100	2	5/258	1	Ptly. Cldy	3-8	
				3	6/190	1	Ptly. Cldy	3-8	
			1330	3	10/279	1	Clear	3-4	
			1530	3	9/173	1	Clear	3-4	Poor Contrast
May 28	24	148	1130	-	-	-	Cloudy	-	Cancelled Clouds
			1430	3	6/350	-	Clear	3	
			1730	-	-	-	Cloudy	-	Cancelled Clouds

STATION LOG - JUNE 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
May 29	25	149	1400	-	-	-	-	-	Started McD 153
June 5	3	156	2000						Changed 200 Cap in-2V P.S.
June 7	5	158	2100	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
		158	2200	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
		158	2300	-	-	-		-	Cancelled Clouds No Cage Chng
June 8	6	159	2130	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
		160	0130	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
			0400	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
June 9	7	160	2230	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
		161	0230	-	-	-	Cloudy	-	Cancelled Clouds No Cage Chng
June 10	8	161	2030	-	-	-	-	-	Started McD L153 (Lower Deck)
		161	2330	-	-	-	Cldy.Rain	-	Cancelled, Rain, Clouds
June 11	9	162	0230	3	11/66	1	Cirrus	-	
			0530	3	10/131	2	Hazy	4-6	Seeing Variable Image Motion
				0	0/136	0	Hazy	4-6	Seeing Variable, Image Motion
June 12	10	163	0100	3	10/080	2	Cloudy	3-4	
			0300	0	0	0	Cloudy	-	Cancelled Clouds
			0500	3	10/108	2	Ptly.Cldy.	4-5	
				2	0/178	0	Ptly.Cldy.	5	Stopped by Seeing
Jan 13	11	164	0130	3	10/166	2	Ptly.Cldy.	4	Poor Contrast
			0330	3	11/180	4	Ptly.Cldy.	3-5	Varying Seeing
				2	?/71	-	Cloudy	3-5	Stopped By Clouds
			0630	3	6/253	3	Ptly.Cldy.	4-6	Seeing Worse at End of Run
June 14	12	165	0130	-	-	-	Cloudy	-	Cancelled, Clouds
			0430	-	-	-	Cloudy	-	Cancelled, Clouds
			0730	-	-	-	Cloudy	-	Cancelled, Clouds
June 15	13	166	0200	3	9/203	1	Clear	3	
		166	0500	-	-	-	Cirrus	5-7	Cancelled seeing
			0800	-	-	-	Cloudy	-	Cancelled, cloud

STATION LOG -- JUNE 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
June 16	14	167	0300	-	-	-	Cloudy	-	Cancelled Clouds
			0600	-	-	-	Cloudy	-	Cancelled Clouds
			0900	-	-	-	Cloudy	-	Cancelled Clouds
June 17-19	-	-	-	-	-	-	-	-	No ranging Full Moon
June 19	17	170	1930	-	-	-	-	-	Copied McD L153- McD 153
June 20	18	171	-	-	-	-	-	-	No ranging Full Moon
June 21	19	172	0700	3	2/252	-	Clear	5-8	Bad Image Motion Hazy (Flip Cage) Windy
			1000	-	-	-	Clear	6-8	Cancelled Poor Seeing, Bad Image Motion, Hazy, Windy
			1300	-	-	-	Clear	6-8	Cancelled Poor Seeing, Bad Image Motion, Contrast Windy
June 22	20	173	0800	3	9/92	1	Ptly. Cldy	4-6	Seeing Variable, Image Motio (Windy)
			1110	3	10/140	2	Cirrus	4-7	Bad Image Motion Seeing
			1340	3	9/238	2	Ptly. Cldy	4-5	Variable (Flip Cage) Windy Poor Contrast
June 23	21	174	0900	-	-	-	Hvy. Cirrus	8-10	Cancelled Clouds Poor Seeing
			1200	-	-	-	Fog	-	Cancelled fog
			1500	-	-	-	Cloudy	-	Cancelled Clouds
Jan 24	22	175	0930	3	0/208	0	Clear	5-6	
			1230	-	-	-	Clear	6-8	
			1500	-	-	-	Clear	8-10	
June 25	23	176	1030	-	-	-	Cloudy	3-5	Cancelled Poor Seeing
			1300	-	-	-	Cloudy	-	Cancelled Seeing Poor Contra
			1600	-	-	-	Cloudy	-	Stopped by Clouds
				-	-	-			Cancelled Clouds
June 26	24	177	1100	-	-	-	Cloudy	-	Cancelled Clouds
			1400	-	-	-	Cloudy	-	Cancelled Clouds
			1700	-	-	-	Cloudy	-	Cancelled Clouds

STATION LOG - JUNE 1981

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	DOUBLES	WEATHER	IMAGE QUALITY	COMMENTS
June 27	25	178	1200- 1600	-	-	-	Cloudy	-	Cancelled Clouds No Cage Change
June 27	25	178	1811	-	-	-	-	-	Copied McD L153 - and - McD 133

Dr02906

INPUT TAPE CN1123 ON HT
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(56)	37337413641	33333542442	424242423434	443555331474	555537442655	47344444353
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(624)	34333333355	23334363537	37337413641	553334364143	434343423434	343555331434
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(721)	213334343537	34337403641	353373744141	414141423434	343355331434	553537444037
(768)	55553737375	34344235555	55555555555	34555555555	344441445543	3533000000000
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(2736)	344	344	344	344	344	344

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(3264)	343356374034	343356374034	343356374034	555536433435	555536433435	555537373755
(3312)	344441445543	343356374034	343356374034	555536433435	555536433435	555537373755
(3360)	344441445543	343356374034	343356374034	555536433435	555536433435	555537373755
(3408)	344441445543	343356374034	343356374034	555536433435	555536433435	555537373755
(3456)	373444443533	343356374034	343356374034	555536433435	555536433435	555537373755
(3504)	105 00111011	343356374034	343356374034	555536433435	555536433435	555537373755
(3552)	343333333355	343356374034	343356374034	555536433435	555536433435	555537373755
(3600)	343334343537	343356374034	343356374034	555536433435	555536433435	555537373755
(3648)	555537373755	343356374034	343356374034	555536433435	555536433435	555537373755
(3696)	373337414244	343356374034	343356374034	555536433435	555536433435	555537373755
(3744)	343442355555	343356374034	343356374034	555536433435	555536433435	555537373755
(3792)	334143423744	343356374034	343356374034	555536433435	555536433435	555537373755
(3840)	555555555555	343356374034	343356374034	555536433435	555536433435	555537373755
(3888)	555555555555	343356374034	343356374034	555536433435	555536433435	555537373755
(3936)	413355444133	343356374034	343356374034	555536433435	555536433435	555537373755
(3984)	343435531434	343356374034	343356374034	555536433435	555536433435	555537373755
(4032)	344441445544	343356374034	343356374034	555536433435	555536433435	555537373755
(4080)	553541373641	343356374034	343356374034	555536433435	555536433435	555537373755
(4128)	553700000000	343356374034	343356374034	555536433435	555536433435	555537373755
(4176)	5540334 1553	343356374034	343356374034	555536433435	555536433435	555537373755
(4224)	343333333355	343356374034	343356374034	555536433435	555536433435	555537373755
(4272)	203334343537	343356374034	343356374034	555536433435	555536433435	555537373755
(4320)	555537373755	343356374034	343356374034	555536433435	555536433435	555537373755
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(						

[illegible]

(3688)	414134423441	434443343743	344234343433	533314345535	413733353540	404336425555	533642555555
(3936)	423455555555	555555553455	424335343444	423355363441	405411415555	401100002033	374343537373
(3984)	363453743343	434234343433	533314345535	413733363434	403541415555	533642555555	374234537373
(4032)	555555553455	424335343444	423355363441	413733353444	400100002033	344234537373	414134423342
(4080)	344234343433	533314345535	423355363441	413643335555	533642555555	374234537373	423355555555
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(4176)	533314345535	413733363433	424035423535	533642555555	374234537343	423555555555	555555553455
(4224)	423355363444	413733363433	413733363433	413733363433	413733363433	374036423336	423453434435
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(4368)	444344000000	553642555555	374234537373	423555555555	555555553455	423355363441	413733363441
(4416)	2033	343335373737	4742134423342	413741345444	555555553455	553314345535	423355363441
(4464)	533642555555	374234537373	423555555555	3342537334237	533314345535	413733363441	413733363441
(4512)	334343537373	414134423342	433537334237	555555553455	533314345535	413733363441	434244345535
(4560)	374343453434	423555555555	555555553455	424353434444	423355363441	00100002033	533642555555
(4608)	414134423343	344437373737	374234343433	533314345535	413733363441	323234344555	533642555555
(4656)	423555555555	555555553455	424335363441	413740363442	000000002033	553642555555	343435373737
(4704)	403435414435	414233424343	553314345535	000000002033	334334425555	553642555555	374234537373
(4752)	555555553455	423355363441	423355363441	423355363441	400000002033	374234537373	423355555555
(4800)	424234343433	533314345535	413749373635	363741343455	533642555555	374234537373	423355555555
(4848)	423355363441	423355363441	400000000000	533642555555	374234537373	414134423342	423355555555
(4896)	533314345535	413740374141	400000000000	533642555555	414134423342	423355555555	423355555555
(4944)	423355363441	400000000000	400000000000	533642555555	414134423342	423355555555	414134423342
(4992)	413741434441	413741333555	533642555555	374234537373	423355555555	363735404435	555555553455
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(5088)	333334425555	533642555555	374234537373	423355555555	424044354044	354237434373	533314345535
(5136)	414134423343	424335343444	423355363441	413733353540	404336425555	401100002033	374343537373
(5184)	363453743343	434234343433	533314345535	413733363434	403541415555	533642555555	374234537373
(5232)	555555553455	424335343444	423355363441	413643335555	533642555555	344234537373	414134423342
(5280)	344234343433	533314345535	423355363441	413643335555	533642555555	374234537373	423355555555
(5328)	423453434344	423355363441	413733363433	401100002033	344234537373	414134423	

FILE	INPUT RECS.	DATA RECORDS INPUT	MAX. SIZE	READ ERROR PERM ZERO	SUMMARY SHORT UNCE.	INPUT RETRIES TOTAL#
1	17	17	3843	0	0	0

FILE	52	RECORD	1	LENGTH	512 BYTES
()	304	234343537	3	73741353441	364255555546
(48)	33343353443	35333315524	3	33333315524	412555555533
(96)	37374135341	364335413544	3	333436423453	443355361454
(144)	343333375555	4533555554637	3	345542444144	444443345534
(192)	36433733532	443333423534	3	433553614133	553537344133
(240)	355355554637	345542444444	3	344443345534	344443345534
(288)	374 42423434	343335361474	3	553537344133	404442335357
(336)	34534244444	344443345534	3	344130000000	55555344055
(384)	343355561434	553537344133	3	413443353634	203333434537
(432)	344443345534	344111015247	3	000001000000	343333375555
(480)	353337344133	413541363444	3	555553441355	373741353441
(528)	344135373441	000000000000	3	203334345537	373741353441
(576)	413637413742	555553441355	3	555542373455	373343353743
(624)	344135373441	213334345337	3	373741353341	373343353743
(672)	555555544055	555542373455	3	343333375555	55555554637
(720)	203334345337	373741353341	3	373343353341	373343353743
(768)	555542373455	343333375555	3	555555554637	345542444044
(816)	373741353341	373436344437	3	441414242534	343335361474
(864)	343333375555	55555554637	3	345542444044	344443345534
(912)	373440413544	343554423434	3	343335551434	553537344133
(960)	35535554637	345542444444	3	344443345534	344100000000
(1008)	363741423434	343335361474	3	553537344133	424233354435
(1056)	345542444044	244443345534	3	344130000000	55555344055
(1104)	343355361434	553537344133	3	443644373436	21333434537
(1152)	344443345534	344110000000	3	55555344055	373741353441
(1200)	553537344133	44443643434	3	555542373455	343333375555
(1248)	344100000000	000000000000	3	203334345537	373741353441
(1296)	333353362444	555553441355	3	373741353341	343333375555
(1344)	373443345534	373741353341	3	373741353341	343333375555
(1392)	555553441355	555542373455	3	343333375555	345542444044
(1440)	203334345337	373741353341	3	373641374043	374037423434
(1488)	555553373455	343333375555	3	345542444044	344443345534
(1536)	37374135341	373641373455	3	343335361474	553537344133
(1584)	343333375555	345542444044	3	344100000000	344100000000

624

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