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DEPARTMENT OF ASTRONOMY

and

McDONALD OBSERVATORY

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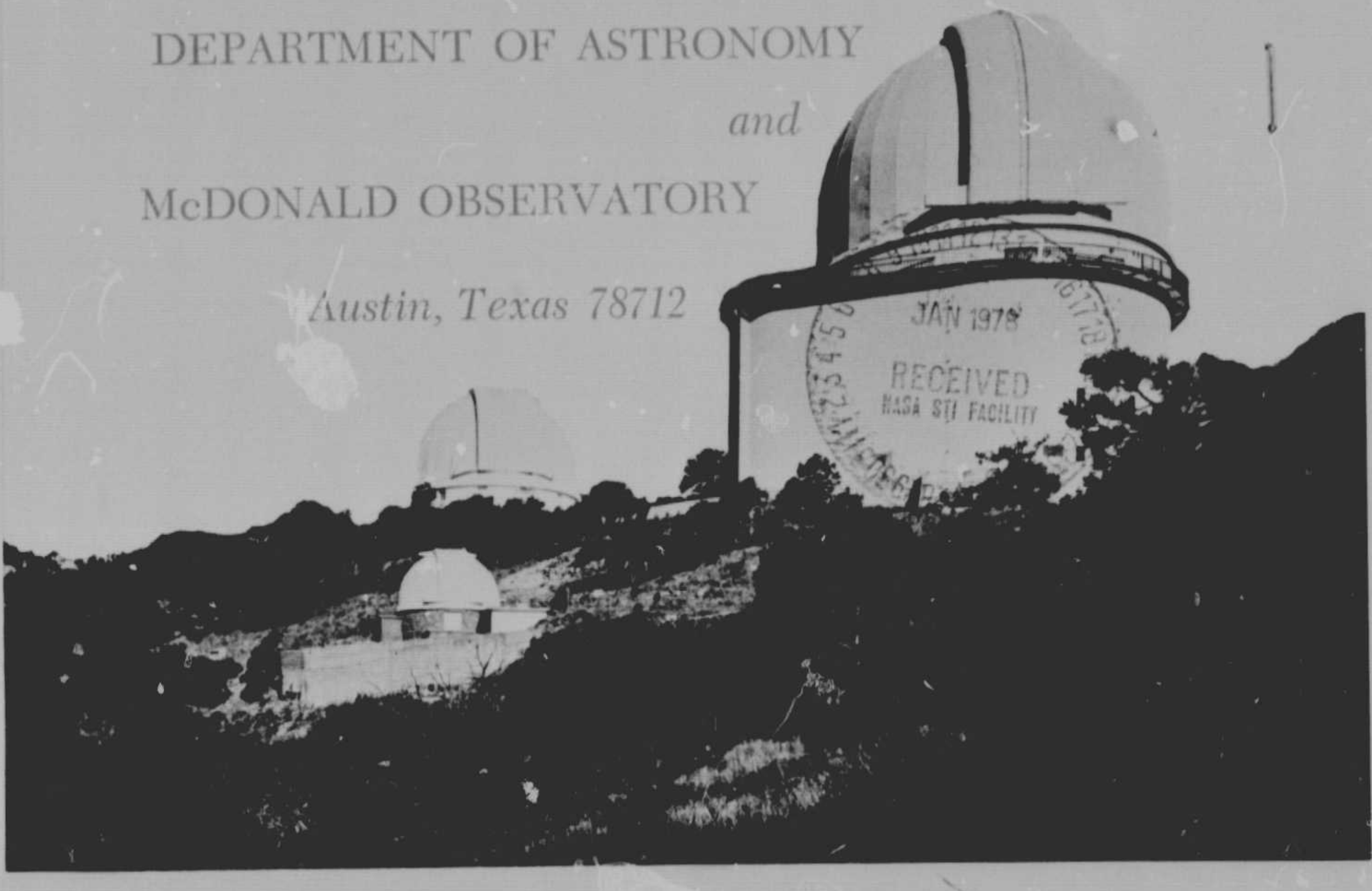

REPORT ON THE
LUNAR RANGING
AT
MCDONALD OBSERVATORY
FOR THE PERIOD
19 JUNE 1977 TO 12 OCTOBER 1977*

by

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Research Memorandum # 77-005

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ABSTRACT

Significant improvements in both the laser and detector have led to the highest quality lunar range data yet attained. Range measurements to an accuracy of 5 cm are now anticipated on a routine basis.

REPORT ON THE LUNAR RANGING AT MCDONALD OBSERVATORY
FOR THE PERIOD 19 JUNE 1977 TO 12 OCTOBER 1977

I. SUMMARY OF OPERATIONS

The four lunations documented by this report were responsible for a large number of high quality lunar range measurements, particularly large for the summer months of a calendar year. Improvements in the detector system and in the laser system raised the performance of the McDonald equipment to higher levels than at any other time in the eight year history of this experiment. The average signal throughout the quarter was twice the average of the last year, leading not only to a high success rate in the acquisition of data, but to better accuracy for the normal point measurements (see Table I). The average signal during the last two lunations was the best average ever recorded for any two month period.

The summary of the month's activities shows 97 acquisitions during this reporting period. This total is slightly lower than usual, but does not reflect any decrease in activity by the ranging team. We have, to some extent, traded the number of acquisitions for their quality. In order that we provide the most accurate measurements for the Earth Rotation Campaign, the ranging crew concentrated on acquiring a large number of photoelectrons from the Apollo 15 reflector whenever possible. This concentration on Apollo 15 came at the exclusion of the other reflectors during the first two lunations. In a response to a request from the analysis

TABLE I

Summary of the Operations for this Ranging Period

Reflector	Number of Attempts	Number of Shots	Successful Ranges	Number of Photoelectrons	Signal Level (p.e./shot)
Apollo 11	6	1131	5	41	.036
Apollo 14	7	1394	5	55	.039
Apollo 15	90	20204	82	1382	.068*
Lunakhod 21	5	718	5	54	.075
TOTALS	108	23447	97	1532	.065

Success Rate = 90%

*Signal Level = .096 for the last two lunations on Apollo 15 (637 for 6637) team, a more varied program was undertaken such that the last two lunations reflect a better distribution in the retroreflector acquisitions. It is for reasons like this that it is preferable to use the number of recognized photoelectrons as a measure of a lunar station's effectiveness rather than the number of range measurements.

The highlight of the four lunations was the successful upgrade of the McDonald laser system. The laser improvements, coupled with the successful installation of a higher efficiency photomultiplier, brought to fruition 18 months of effort in this area. As a result we now have several McDonald acquisitions since August 1977 which are thought to be at the 5 cm accuracy level. The details of the changes are presented in Section II. Our success in bringing the McDonald station to this level of accuracy with very little additional cost beyond the normal operation is, we feel, a very important demonstration which has implications beyond the data now being produced.

As far as we know at this time, there were no equipment problems which require amendments to the data during the summer months. That is not to say that we did not have the usual number of minor failures, but that these equipment failures were not of the type that produced any data which needs later correction. We will, therefore, skip the section on data amendments and concentrate on explaining the equipment changes which occurred during the last quarter. As usual, a day by day summary of the operations is included in Appendix A and the daily calibration data can be found in Appendix B.

II. MCDONALD EQUIPMENT CHANGES

Laser

Since early 1977, we have attempted to range to the moon using a laser triggered spark gap system as described in the Quarterly Report of March 1977. As we indicated in our last report (June 1977) the system has some undesirable characteristics. Principally, these failings center around the lack of a graceful failure mode. In the event of damage to any component in the laser oscillator, or the misadjustment by the operator, the system can produce double pulses or prepulses in a manner which can seriously confuse the data reduction process. C. Palm who designed the system, pointed out that the last report may have misled the readers on the true state of affairs regarding this oscillator section. It should be clearly stated for those who might wish to work in this area, that the laser triggered spark gap did itself work very well and it did produce the best pulse parameters yet attained with the K-2600 laser. However, the LTSG system was very unforgiving with regard to alignment and damage in the cavity. The operators were not able to consistently maintain single pulse performance in a night-after-night, operational regime. As a further clarification of this matter, I include the following supplementary comments concerning the laser configuration which were written by C. S. Palm on 9-6-77.

> SUPPLEMENTARY COMMENTS CONCERNING THE REPORT ON THE LUNAR RANGING at MCDONALD OBSERVATORY FOR THE PERIOD 21 FEBRUARY 1977 to 18 JUNE 1977.
>
> -C. S. Palm 9/6/77
>
> After reading the published version of the above-referenced lunar ranging report, I felt that a few additional comments concerning the laser

stability and the anomalies in pulse shape may be of value to potential users of the lunar range data.

LASER INSTABILITY, LTSG CONFIGURATION

The last problem which could be directly attributed to the LTSG (laser-triggered-spark gap) proper was corrected on January 19, 1977. Since then, virtually all observed laser instability problems have been traced to misalignment or damage of laser oscillator components, or to improper pumping of the laser oscillator rod. It is true that the LTSG system is far less tolerant to marginal performance by other laser components, because even moderate instability disrupts the critical nanosecond timing required for successful LTSG operation. However, a persistantly unstable LTSG operation can be avoided by throwing one toggle switch on the LTSG high voltage power supply. This makes the LTSG components passive and allows the laser to be operated in the more tolerant conventional-PTM configuration, but this also causes the uncertainty in the range accuracy to increase.

The time periods between 3/28/77 - 4/9/77 (day 87 - day 99) and 6/1/77 - 6/8/88 (day 153 - day 159) produced 7600 and 2600 consecutive, stable laser shots using the LTSG system. Three different laser operators successfully operated the system during these periods with no outstanding problems. Virtually every laser shot was recorded on polaroid film using a Korad fast photodiode and a Tektronix 519 oscilloscope. Usually, the pulse shapes were recorded by superposing 50 consecutive laser shots with the oscilloscope time base set at 5 nsec/cm. These photographs indicate an average pulse shape of 2.5 - 3.0 nsec FWHM and 4.5 - 5.0 nsec at the base (less than tenth-maximum points). The photographs from the day 87 - day 99 period are in good agreement with the electronic K-calibration data used in the data reduction process. The photographs from the day 153 - day 159 period do not correlate well with the K-calibration data, but this was due to a noisy cable used with the new C31034 photomultiplier tube and excessively high sample rates in producing K-calibration data; i.e., the fault was in the calibration electronics, not in the laser or LTSG components. Other time periods show varying degrees of stable operation using the LTSG system; the electronic K-calibration data and the photographs of pulse shapes both reflect the degree of laser instability with reasonable correlation.

Charles Palm, who was the operations supervisor at McDonald, and furthermore, the person developing the laser improvements, resigned for personal reasons on 30 June. The loss of considerable technical skill, as well as extra hands for tasks such as laser repair and laser alignment, made it imperative that any laser improvements occurring following his departure, be extremely reliable and trouble-free. Palm was invited back on a consulting basis in the last week in August to make a final attempt to install the laser-triggered-spark-gap configuration and to work out those problems which were preventing operational reliability with that system. After several days of installing and testing, it was apparent that no new information had been uncovered which would significantly deviate the problems we had experienced earlier. We decided, therefore, to modify the laser system back to the pulse-transmission-mode configuration and use a greatly shortened cavity so as to decrease the pulse length.

Early in 1974, following the availability of faster pockel cells and thin film polarizers, we had attempted to run the Korad laser with a shortened pulse-transmission-mode cavity, but had little success. We were bothered by pre-lase problems, non-uniformity in the beam pattern, and instabilities in the gain, causing us never to fully realize the advantages of the shortened cavity. Since that time a great many things have occurred which warranted a retrial of this method. They included: 1) the redesign of the pockel cell mount by Palm so as to eliminate stressing of the pockel cell crystal; 2) the construction of an improved electrically-triggered spark gap by J. R. Wiant for sharpening the electrical pulse from the K-2600 electronics; 3) the successful use of a brewster plate in the laser cavity so as to eliminate the pre-pulsing due to the vertically polarized radiation; 4) Palm's development of much improved alignment techniques for working with the oscillator system; and 5) improvements in the thin film polarizer technology such that their lifetime in our system cavity increased by several times. As the accumulative result of all of these improvements, the shortened pulse-transmission-mode cavity which we installed in late August was an unqualified success. The laser now outputs approximately a 2.5 joule laser pulse with a full width at half maximum of approximately 2.5 nanoseconds, and a full width at one tenth maximum of 5.3 nanoseconds. There is no detectable pre-pulsing or after-pulsing and the laser is sufficiently stable that groups of 50 shots trace a single line on a high-speed oscilloscope photograph. Single shot uncertainty, as measured by the jitter in the calibration feedback returns, and from the distribution returned from the lunar surface, has consistently averaged between 1.3 and 1.5 nanoseconds RMS. Trouble-free performance of the laser since that time and extremely encouraging feedback from the data reduction group in Austin have greatly encouraged us and led us to believe that this long overdue improvement had been thoroughly successful.

A schematic of the new laser oscillator configuration is shown in Figure 1. A picture of the rail with the key components labled is Figure 2. As you can see the configuration is extremely compact with little room left for shortening a system of this type. Note also that the spark gap is now enclosed within the shielding of the triggering cable so that its appearance is merely a fat spot in the cable. The spark gap was built by Wiant using two polished electrodes from a used flashlamp. The electrodes were slid inside a glass tube and the spacing chosen by observing the spark gap rise time on a 519 oscilloscope. The cable shielding was then

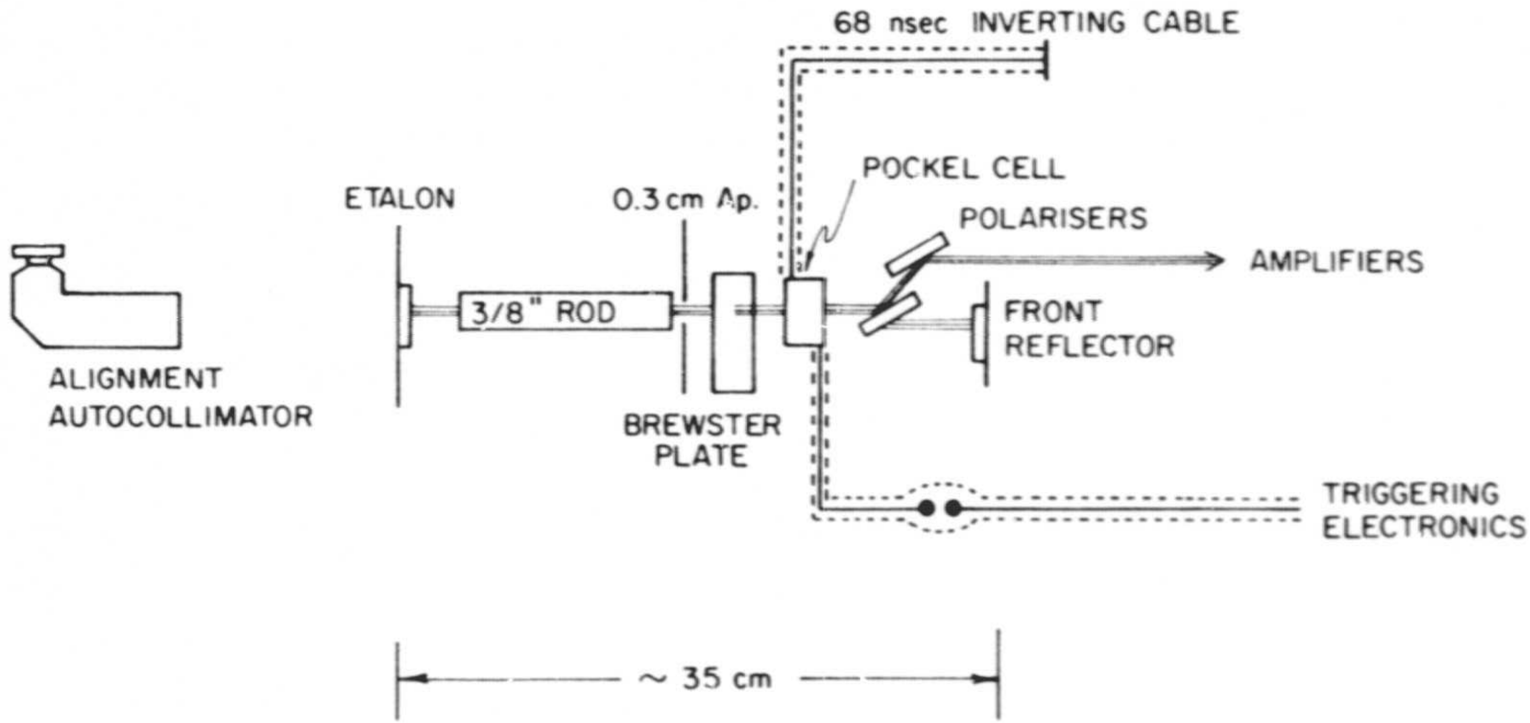

FIGURE 1 : LASER OSCILLATOR CONFIGURATION AS INSTALLED ON 25 AUG 1977. (SIDE VIEW)

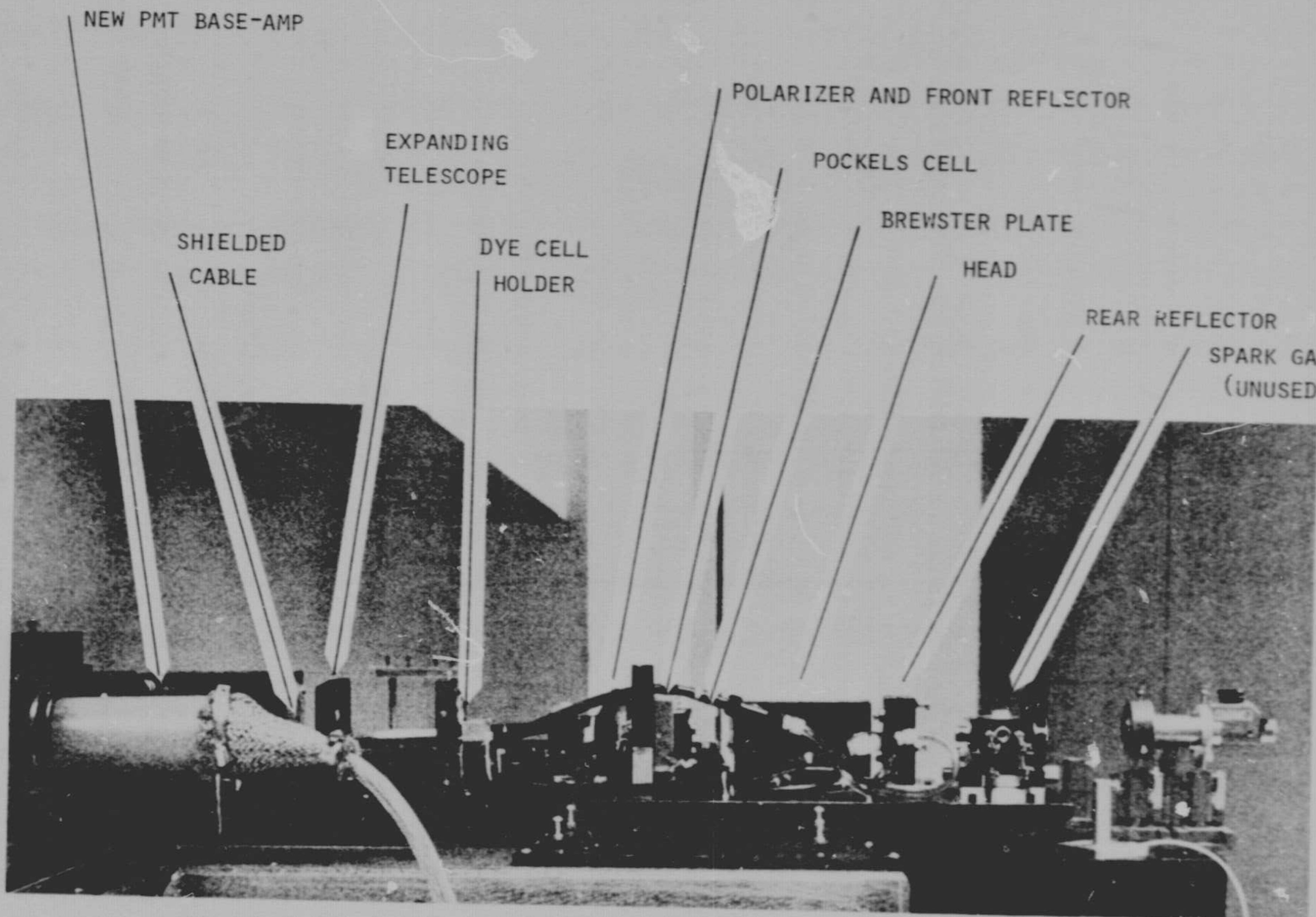

FIGURE 2: FRONT VIEW OF THE CURRENT PTM LASER OSCILLATOR

reconnected over the entire assembly. Building the spark gap in this manner has greatly lessened the electrical noise during the laser firing, an advantage which permitted us to make the photomultiplier modifications which will be outlined in the next section.

The laser shown in Figures 1 and 2 produces a triangular shaped pulse with approximately a 5.5 nsec width at the base. The lack of energy in the wings of the pulse as compared with the Gaussian shaped distribution may enable us to use a more efficient statistical averaging process in the future. At our next opportunity, we intend to install a weak dye solution ahead of the oscillator section to attempt to clean out the remaining small amount of energy which is contained in the wings of the present pulse. If this is successful, it will leave us with a bounded pulse distribution which should be extremely effective in decreasing the uncertainty in the measured normal points.

Photomultiplier Changes

During this reporting period, we installed a high efficiency RCA 31034 photomultiplier tube. These photomultipliers have been available for many years; however, the lower gain of this tube, as compared with the 31000 type which we have been using, as well as severe average current limitations, have prevented us from employing it in the McDonald laser system. In order to install the tube we purchased a Pacific Photometric 3262/2A33 amplifier-base combination. The amplifier contained in the base, having a gain of 25 and a rise time of about 2 nanoseconds, is used as a pre-amplifier in our system to increase the amplitude of the photomultiplier pulse prior to transmission over to the timing electronics rack. For the first two months of this reporting period, we used a 50 ohm transmission line, later switching to an RG63 125-ohm system because of the greater efficiency. Photomultiplier pulse is still conditioned by an Ortec 454 timing-filter amplifier prior going to the 453 discriminator, so as to create a pulse shape which is suitable for a zero-crossing mode of discrimination.

From the onset we were very encourated by the efficiency which we obtained with this new photomultiplier system. The galium-arsenide tube which we had in-house was some improvement over the previous detector and a second tube which we purchased and installed prior to the August-September lunation was a factor of 2 higher still. Furthermore, we found that with the new spark gap configuration, the shielded photomultiplier base-amplifier system and additional shielding on the RG63 cable, our electrical noise pickup was down approximately two orders of magnitude from the old value. As a result, we can now run the galium-arsenide photomultipliers at very modest operating voltages ($\sim$1600V), so that we do not exceed the current limitations, and still are able to monitor the calibration feedback during laser firing at the single photoelectron level. As near as we can determine the timing accuracy is unaffected by the use of the 2A33 pre-amplifier in this manner. The next step, however, will be to determine exactly what timing accuracy we are attaining with this photomultiplier system and optimize the detector as much as possible. Faster but lower gain amplifiers are available from the same manufacturer which will permit us to make timing corrections in this area if they should prove necessary.

Minor Calibration Change

Prior to the August-September lunation we moved the position of the start diode from behind the hole in the #6 telescope mirror to a position which viewed the total laser beam as it scattered off the face of the #6 mirror. The effect of this modification is to create slight changes in both the electronic as well as the geometric calibration constants. The old geometric calibration constant is now slightly higher than it should be while the calculated electronic calibration constant is slightly lower than it should be. The total calibration correction, however, remains constant since the two changes exactly cancel each other. Since the normal points are unaffected, we will not report these minor changes in ELCOR & GEOC at this time, but will instead save the corrected versions until such time as a definitive report can be written on this entire area. As near as we can tell, the electronic calibration constants in the system are valid at accuracy levels near the 0.25 nsec mark. The same cannot be said, however, of the geometric calibration corrections, that is, those measurements which link the range data to the intersection of the axes in the 107-inch telescope. The additional geometric correction, which accounts for the finite size of the telescope from the intersection of the axes, is also quite uncertain at this time. Measuring these quantities by crawling through the tubes with tape measures is extremely difficult. An attempt to measure the telescope distances with an electronic distance measuring device during the NGS visit was only partially successful. Therefore, with regrets, I report that there could be a bias in all of the McDonald data by as much as 2 nanoseconds due to our inability to get a definitive measure of these geometric calibration corrections. We will make it a point to nail down these corrections as soon as possible for such time as a 1 nanosecond bias becomes important to this experiment.

<u>Miscellaneous</u>

The laser doubles counter was unhooked prior to the June lunation with installation of the new photomultiplier system. It was, however, reinstalled on the 26th of September and is again available for statistical studies on the return signal strength. The number of doubles is reported on the log sheets for each run. While a "doubles" detection is not 100% reliable on a shot-by-shot basis, the data should be statistically reliable for studies of the signal fluctuations.

Since the initiation of the feedback calibration system in 1972, the single shot uncertainty for the laser system has been estimated on site by an observer who measures the width of the feedback calibration distribution. With the variable pulse shape, multiple pulse distributions, and various observers making the estimate, this has proven over the years to be a somewhat shakey manner in which to get our single shot uncertainty. Comparisons of these on-site estimates with formal calculations made by Shelus in Austin indicated that the observers were consistently overly conservative in this regard, particularly when the pulse distribution was somewhat anomolous. Beginning with the September lunation, the single shot uncertainty is determined on-site as the standard deviation of all of the feedback returns within ± 5 nanoseconds of the average. These calculations agree, as they should, with the formal calculations made by Shelus in Austin when he produces the normal point data. It is also interesting to point out that the standard deviation of the feedback returns has almost identically agreed with the standard deviation of the return distribution from the corner reflectors on the lunar surface. Detailed comparison of these two pulse shapes remains, as it always has been, a most positive indication that our electronic, photomultiplier and calibration systems are operating correctly.

During laser operations the operator can monitor the energy in each shot by the integrated output of a photodiode. He can monitor the pulse shape by observing the photodiode pulse on the 519 oscilloscope, and he can monitor the energy distribution in the beam by holding Polaroid film in front of the beam during the firing of a laser shot. In order to give the operator real time access of all three parameters, we have diverted most of the energy in the feedback calibration path (which would have been attenuated anyway) outside of the switching box to a small white screen. A negative lens outside the box blows up the image of the laser beam to approximately 6 inch diameter. The operator can, as a result, now monitor all three parameters without leaving his position next to the pockel cell control circuitry. These three parameters give the operator the total information he needs to make adjustments on the laser during firing. We hope that by adding external controls to the adjustments in the laser cavity the operator will be able to maintain the laser in good adjustment without having to open the laser box and use the autocollimating system. If successful, this will increase the efficiency of the operation and the number of shots which can be fired during any 45 minute period.

As mentioned earlier, we were very sorry to lose the services of C. Palm on 30 June. Palm was with the project for about 18 months and was a tremendous asset to the system operations. To date, a replacement has not been hired.

III. OTHER SUPPORTING ACTIVITIES

Validation Related

A large scale of activity continues around McDonald Observatory in preparation for making the site a suitable base from which long baseline geodetic measurements may be measured. This includes a large program of geophysical monitoring, being conducted by the Marine Science Institute in Galveston, Texas, the first phase of a geodetic monitoring program being conducted by the National Geodetic Survey and some so-called validation activities which were initiated in expectation that this station would provide one of the sites where the three extraterrestrial techniques could be intercompared. We continue to interact with these other programs and provide, whenever possible, logistic support to help their efforts. In the smallest case, this logistic support involves changing a chart in the laser room every few days so as to maintain the recording on the multistation seismometer network. In the other extreme, however, the Observatory spent considerable time and effort soliciting bids for, and starting the construction on, a validation site on a nearby hilltop. The validation effort was terminated following the construction of several hundred yards of road by the observatory staff. Apparently, the construction bids for the facility greatly exceeded the available resources and forced a cancellation of plans. We should go on record to point out that the validation site can be completed at the selected site for very reasonable funding provided that we tailor the design of the facility to more economically utilize the available terrain and we make better use of the talents of our local physical plant personnel. We are still hopeful that the McDonald

Observatory site will become part of the intercomparison program and that the validation site can be completed in a cost-effective manner.

Maui Related Activities

Early in August, following an exchange of letters between our observatory director and the director of the LURE Observatory at Haleakala, it was determined that we could be of significant assistance to the Maui facility by supplying some of our observatory personnel on a limited basis. As a result, one observer and two computer programmers flew to Maui in mid-September to help out in whatever way they could on the Haleakala station. The cost of this effort was shared equally between the Texas and University of Hawaii grants with the concurrence of our technical montior. While it is still a little early to tell, the programmers do report that they made significant progress in the areas of need during the cooperative effort. We were happy to be able to make this manpower available and trust that these small expenditures will be many times repaid in the months ahead.

APPENDIX A

The McDonald Lunar Laser Operations Log

from

19 June 1977 To 12 October 1977

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 days 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.

GMT DAY (column 3): The Greenwich Mean 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/SHOTS (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 JUN-JUL 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
										V=1860, G=4, diff=5, 250mv. f=0.5
Jun 20	3	171	20:20	-	-----	----	-	---	-	Started McD. 105
Jun 21	4	172	20:00	-	-----	----	-	---	-	Installed new glass spark gap mod. GSG-1. Raised pockel voltage dial reading to 9.3.
Jun 22	5	173	23:00	3	0/39	0	-	P. cldy.	3	Stopped by clouds.
		174	03:00	-	-----	----	-	Rain	-	Cancelled, rain.
Jun 23	6	174	22:00	-	-----	----	-	Cloudy	-	Cancelled, clouds.
		175	01:00	3	9/226	.040	-	Clear	3	
		175	04:10	3	0/44	0	-	P. cldy.	4	Stopped by clouds.
Jun 24	7	176	00:00	3	15/259	.057	-	Clear	3	
			01:30	3	13/320	.041	-	Clear	3-4	
			04:30	3	15/339	.044	-	Clear	4-5	
Jun 25	8	176	23:30	-	-----	----	-	Cloudy	-	Cancelled.
		177	02:00	3	15/139	.108	-	Clear	3-4	
		177	05:00	-	-----	----	-	Clear	3-4	Cancelled, Data Reduction.
Copied	McD. 105		03:00							Copied McD. 105.
Jun 26	9	177	23:30	-	-----	----	-	---	-	Cancelled, clouds.
		178	02:30	-	-----	----	-	---	-	" "
		178	05:30	-	-----	----	-	---	-	" "
Jun 27	10	179	00:30	-	-----	----	-	---	-	Cancelled, clouds.
		179	03:30	-	-----	----	-	---	-	" "
		179	06:30	-	-----	----	-	---	-	" "
Jun 28	11	180	01:30	-	-----	----	-	Cloudy	-	Cancelled.
		180	04:30	-	-----	----	-	Cirrus	5-7	Cancelled (seeing cirrus); filter problems due to AC cutting off room temp. fluctuating.
		180	07:30	3	0/108	----	-	Cirrus	4	Stopped by clouds.

STATION LOG JUN-JUL 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Jun 29	12	181	03:00	-	-----	----	-	Clouds	2	Stopped by clouds.
Jun 30	13	181	05:30	-	-----	----	-	Clouds	-	Cancelled.
			08:30	-	-----	----	-	"	-	"
		182	04:00	-	-----	----	-	Clouds	-	"
Jul 1	14	182	07:00	-	-----	----	-	Clouds	-	Cancelled.
			09:30	-	-----	----	-	"	-	"
Jul 2	15	183	05:00	-	-----	----	-	Clouds	-	Cancelled.
			08:00	-	-----	----	-	Clear	4	Blew #1 amp F.L. after 5 shots.
			11:00	-	-----	----	-	Cloudy	-	Cancelled.
Jul 3	16	184	05:30	3	4/312	.013	-	Cirrus	4-5	Half run, K cable disconnected.
			08:30	3	6/90	.067	-	Clear	4-5	Water temp. trouble, K cable disconnected.
			11:30	3	7/269	.026	-	Clear	4 7	Image motion, K cable disconnect.
Jul 3	16	184	15:30	-	-----	----	-	---	-	Copied McD. 105.
Jul 4	17	185	01:95	-	-----	----	-	---	-	K cable had to be disconnected previously because of a bad "Nor" transistor in "OR" gate (init. & delay).
	17	185	06:40	3	17/211	.080	-	Clear	4	Image motion.
			09:40	3	15/230	.065	-	P. cldy.	4	Bad image motion.
			12:00	3	-----	----	-	Cloudy	-	Cancelled, clouds.
Jul 5	18	186	07:00	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			10:00	-	-----	----	-	"	-	" "
			12:30	-	-----	----	-	"	-	" "
Jul 6	19	187	08:15	3	23/137	.147	-	Clear	2-3	
			11:00	3	26/133	.195	-	"	3	Image motion.
			13:00	3	22/86	.255	-	"	2-3	
Jul 7	20	188	09:00	3	16/140	.114	-	Lt. cirrus	2-3	
			12:00	3	20/160	.125	-		2-3	
			15:00	-	-----	----	-	Cirrus	5-6	Cancelled- seeing, contrast.

STATION LOG JUN-JUL 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Jul 8	21	189	09:25	3	17/122	.139	-	Clear	2-3	
			12:00	3	24/232	.103	-	"	3	
			14:00	3	14/251	.055	-	"	3	
Jul 9	22	190	10:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			12:30	-	-----	----	-	"	-	" "
			14:30	-	-----	----	-	"	-	" "
Jul 10	23	191	11:00	3	7/276	.025	-	Clear	4	
			13:00	3	15/211	.071	-	"	3-4	
			15:00	3	0/250	0	-	"	4	Poor contrast.
Copied McD. 105		191	16:13							Copied McD. 105
Jul 11	24	192	11:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			13:30	-	-----	----	-	"	-	" "
			15:30	-	-----	----	-	Cirrus	-	Cancelled, poor contrast.
Jul 12	25	193	15:07	-	-----	----	-	---	-	Copied McD. 105.

REFLECTOR	ATTEMPTS	SUCCESSES
0	0	0
2	0	0
3	24	20
4	0	0
TOTALS	24	20

STATION LOG JUL-AUG 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Jul 12		193	16:09	-	-----	----	-	---	-	Started McD. 106.
Jul 19	3	200	18:30	-	-----	----	-	Clds,rain	-	Cancelled, rain.
			21:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
		201	00:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
Jul 20	4	201	19:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			22:30	-	-----	----	-	"	-	" "
		202	01:30	-	-----	----	-	"	-	" "
Jul 21	5	202	20:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			23:30	-	-----	----	-	"	-	" "
		203	02:30	-	-----	----	-	"	-	" "
Jul 22	6	203	21:00	-	-----	----	-	Clds,rain	-	Cancelled, rain.
		204	00:00	-	-----	----	-	" "	-	" "
			03:00	-	-----	----	-	Clouds	-	Cancelled, clouds.
Jul 23	7	204	22:30	3	0/274	.036	-	P. cldy.	3	Poor contrast, image motion.
		205	01:00	3	15/285	.052	-	Clear	3	Image motion.
		205	04:00	3	16/292	----	-	"	3	
		205	04:43	-	-----	----	-	---	-	Copied McD. 206.
Jul 24	8	205	23:00	3	15/349	.043	-	P. cldy.	3-6	Variable seeing, Varian stopped three times.
		206	02:00	3	18/148	.122	-	Clear	2	
		206	04:30	3	12/238	.050	-	P. cldy.	3-5	Image motion.
Jul 25	9	206	23:30	-	-----	----	-	P. cldy.	5-7	Cancelled, seeing, contrast.
		207	01:00	3	22/121	.182	-	P. cldy.	4-5	Varian stopped 3 times.
		207	04:00	3	17/158	.114	-	Clear	3	Varian stopped 3 times.
Jul 26	10	208	00:30	-	-----	----	-	Cloudy	-	Cancelled.
		208	02:00	3	17/139	.122	-	Clear	3	
			05:30	3	17/261	.065	-	Clear	-	
Jul 27	11	209	01:30	3	20/217	.092	-	P. cldy.	3	
			04:00	3	11/138	.080	-	Int. clds	3	Stopped by clouds.
			07:00	-	-----	----	-	Clouds	-	Cancelled.

STATION LOG JUL-AUG 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Jul 28	12	210	02:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			05:00	3	0/333	0.0	-	P. cldy.	4	1st 171 shots with K-cable off.
			07:30	3	8/352	.023	-	" "	3	Varian stopped 7 times
Jul 29	13	210	19:00	-	-----	----	-	---	-	Changed "stop" "or" gate.
Jul 29	13	211	03:30	-	-----	----	-	Cloudy	-	Cancelled.
Jul 30	14	211	06:30	3	0/227	0	-	P. cldy.	4	Stopped by clouds.
			09:00	-	-----	----	-	" "	-	Cancelled, cirrus.
Jul 30	14	212	04:30	3	13/286	.045	-	Clear	3	1800 down.
Jul 31	15	212	07:30	3	14/323	.043	-	Clear	3	1800 down; bad image motion.
		212	10:00	3	5/325	.015	-	Clear	3	" "
Jul 31	15	213	04:00	-	-----	----	-	---	-	Copied McD. 106.
Aug 1	16	213	05:00	3	13/318	.041	-	Clear	4	1800 down.
		213	08:00	3	16/131	.122	-	"	2-3	" "
		213	11:00	3	12/355	.034	-	"	4	" "
Aug 2	17	214	05:30	3	17/161	.106	-	Clear	3	1800 down.
			08:30	3	17/233	.073	-	"	3	" "
			11:30	3	3/286	.010	-	"	5	" "
Aug 2	17	214	19:00	-	-----	----	-	---	-	TDC-100 fan gummed up. Adj. internal power supplies; adj. TDC-100 to 100 KHz.
Aug 3	18	215	06:30	-	-----	----	-	Cloudy	-	
			09:30	3	17/189	.090	-	P. cldy.	3	
			12:30	3	6/340	.018	-	" "	4	
Aug 3	17	215	16:00	-	-----	----	-	---	-	Now using original "stop" "or" gate. Northern Scientific repaired.
Aug 4	19	216	07:30	-	-----	----	-	Clear	-	Cancelled Varian comp. problem.
			10:30	3	10/379	.026	-	"	3	
			13:00	3	12/331	.036	-	P. cldy.	3	
Aug 5	20	217	08:30	3	16/138	.116	-	Clear	3	
			11:00	3	19/83	.229	-	Clear	2	
			13:30	-	-----	----	-	"	6-8	Cancelled, seeing, contrast.

STATION LOG JUL-AUG 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Aug 6	21	218	09:00	3	15/279	.054	-	Clear	4-6	
		218	12:00	3	16/215	.074	-	"	4-6	
		218	13:30	-	-----	----	-	"	6-8	Cancelled, seeing/contrast.
Aug 7	22	219	10:30	-	-----	----	-	Clear	6-8	Cancelled, seeing.
		219	12:30	-	-----	----	-	"	6-8	Cancelled, seeing, contrast.
		219	13:30	-	-----	----	-	"	6-8	" " "
Aug 7	22	219	13:50	-	-----	----	-	---	-	Copied McD. 106.
Aug 8	23	220	11:30	3	10/350	.028	-	Clear	3-4	
			14:00	3	11/379	.029	-	Clear	4-5	
			16:00	-	-----	----	-	Cloudy	-	Cancelled, clouds.
Aug 9	24	221	11:00	-	-----	----	-	Lt. cirrus	6-8	Cancelled seeing.
		221	14:00	3	4/350	.011	-	P. cldy.	4	Stopped by seeing, contrast.
		221	16:00	-	-----	----	-	" "	-	Cancelled, seeing, contrast.
Aug 10	25	222	12:00	-	-----	----	-	Cloudy	-	Cancelled.
			14:00	-	-----	----	-	"	-	"
			16:00	-	-----	----	-	"	-	"
Aug 11	26	223	13:18		End of Tape					Copied McD. 106.

REFLECTOR	ATTEMPTS	SUCCESSES
0	0	0
2	0	0
3	34	32
4	0	0
TOTALS	34	32

STATION LOG AUG-SEP 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Aug 11	26	223	14:35	-	-----	----	-	---	-	Started McD. 107.
										New PMT: V=1600, Dis.=250, G=10, Diff = 5, f=0.5, out.
Aug 26	11	239	02:00	-	-----	----	-	---	-	Cancelled, clouds.
Aug 27	12		05:00	-	-----	----	-	---	-	Cancelled, clouds.
			08:00	-	-----	----	-	---	-	" "
Aug 28	13	240	02:45	-	-----	----	-	---	-	Cancelled, clouds.
			05:30	-	-----	----	-	---	-	" "
			08:30	-	-----	----	-	---	-	" "
Aug 29	14	241	04:00	3	9/267	.034	-	Clear	3	V = 1550.
		241	07:00	3	0/302	0	-	P. cldy.	4	
			10:00	-	-----	----	-	Cloudy	-	Cancelled, clouds.
Aug 29	14	241	21:30							Damaged connector replaced on 519 o'scope sig input.
Aug 30	15	242	04:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			07:30	-	-----	----	-	P. cldy.	5-8	Cancelled, seeing & cirrus.
			10:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
Aug 31	16	243	05:30	3	27/178	.152	-	Lt cirrus	3	V=1650v.
			08:30	3	5/223	.022	-	" "	3	V=1600v.
			11:30	-	-----	----	-	" "	-	Cancelled.
Sep 1	17	244	06:30	-	-----	----	-	P. cldy.	-	Cancelled, power failure, sustained low voltage.
		244	09:30	3	21/214	.098	-	Lt cirrus	3	V=1530 before run equipment off.
		244	12:30	3	13/427	.030	-	Cirrus	4	V=1530, TDC 100 unstable.
Sep 1	17	244	16:00							Replaced faulty IC in Ortec 772 counter (74690).
Sep 2	18	245	07:30	-	-----	----	-	P. cldy.	6-8	Cancelled, seeing, clouds, (Ortec counter down).
		245	10:30	3	28/294	.095	-	Lt cirrus	4-7	Ortec counter down last 2 days, disregard CTS.
		245	13:30	3	27/238	.113	-	Clear	4	

STATION LOG AUG-SEP 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Sep 3	19	246	08:30	3	40/160	.250	-	Clear	2	
		246	11:30	3	28/184	.152	-	Clear	3	
				0	10/123	.081	-	"	3	
				4	14/95	.147	-	"	3	
				2	10/241	.041	-	"	3	
		246	14:00	3	28/94	.298	-	"	3	
Sep 4	20	247	09:00	3	26/94	.277	-	Clear	2	
		247	15:50	3	21/79	.265	-	"	3	
				2	11/37	.297	-	"	3	
				4	9/131	.068	-	"	3	
				0	7/213	.032	-	"	3	
		247	14:05	3	22/93	.236	-	Lt cirrus	3	
		247	14:32							McD. 107 copied.
Sep 5	21	248	10:00	-	-----	----	-	---	-	Cancelled, clouds, Loran print-out on operation log incorrect.
			12:00	-	-----	----	-	---	-	Cancelled, clouds.
			14:30	-	-----	----	-	---	-	Cancelled, clouds.
Sep 6	22	249	10:30	-	-----	----	-	---	-	Cancelled, foggy.
			12:30	-	-----	----	-	---	-	Cancelled.
			15:00	-	-----	----	-	---	-	Cancelled, clouds.
Sep 7	23	250	11:00	2	18/306	.059	-	P. cldy	2	
			13:00	-	-----	----	-	---	-	Cancelled, clouds.
			15:30	-	-----	----	-	---	-	" "
Sep 8	24	251	11:50	3	20/343	---	-	Clear	2	
			13:45	3	21/120	---	-	"	3	
			13:45	2	9/202	---	-	"	3	
			15:35	3	8/278	---	-	"	4	
Sep 9	25	252	11:50	2	7/364	---	-	Clear	4	
			14:00	-	-----	----	-	"	-	Cancelled, poor contrast.
		252	14:47							Copied McD. 107.

STATION LOG AUG-SEP 1977

REFLECTOR	ATTEMPTS	SUCCESSES
0	2	2
2	5	5
3	17	16
4	2	2
TOTALS	26	25

STATION LOG SEP-OCT 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Sep 17	4	260	20:00	-	-----	----	-	Cloudy	-	Cancelled, clouds, TDG problems.
			01:30	-	-----	----	-	"	-	" " "
Sep 18	5	261	22:30	-	-----	----	-	---	-	Replaced shorted capacitor in load circuit of TDG.
	5	261	21:30	-	-----	----	-	---	-	Cancelled, clouds. 2 runs JPL Int.
		262	00:50	0	10/257	.039	-	P. cldy.	4	
				4	9/190	.047	-	" "	4	
Sep 19	6	262	21:30	-	-----	----	-	Cldy, rain	-	Cancelled, 2 runs JPL int.
		263	01:00	3	15/240	.062	-	P. cldy.	3	
				4	15/145	.103	-	" "	3	
				0	9/231	.039	-	" "	3	
Sep 20	7	263	22:30	-	-----	----	-	P. cldy	6-8	Cancelled, seeing, clouds.
		264	01:30	3	22/144	.153	-	" "	3	Two runs JPL Int.
				4	7/157	.045	-	" "	3	Stopped by clouds.
Sep 21	8	265	00:00	-	-----	----	-	Cloudy	-	Cancelled.
			03:30	3	33/188	----	-	Clear	3-5	Image motion.
				0	0/258	----	-	"	3-5	" "
				2	0/76	----	-	"	3-5	" "
Sep 22	9	266	01:00	3	39/190	.206	-	Cirrus	3	Image motion, 1800 TTY down.
			04:30	3	11/298	.037	-	"	5-8	" " " " "
Sep 23	10	267	01:30	-	-----	----	-	Cloudy	-	Cancelled, clouds.
			05:00	3	31/121	.256	-	P. cldy	3-5	
				2	00/168	.000	-	" "	3-5	Stopped by clouds.
Sep 24	11	267	15:15							Copied McD. 107.
Sep 27	14	270	03:30	-	-----	----	-	Cloudy	-	Cancelled,
			06:30	3	00/136	.000	-	P. cldy	3	Light to heavy clouds.
			09:30	-	-----	----	-	Cloudy	-	Cancelled, V=1550.

STATION LOG SEP-OCT 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Sep 28	15	270	04:30	3	23/250	.092	2	Clear	2	V=1560.
		271	07:30	3	18/298	.060	-	Cl.,hazy	3	V=1560.
		271	10:30	-	-----	----	-	P. cldy.	6-8	Cancelled, seeing, clouds.
Sep 29	16	272	05:30	-	-----	----	-	Cldy,rain	-	Cancelled.
			08:30	-	-----	----	-	Cloudy	-	"
			11:30	-	-----	----	-	"	-	"
Sep 30	17	273	06:30	3	24/251	.096	7	Clear	3	V=1600.
				3	26/271	.096	10	"	3-4	
				3	10/255	.039	1	"	4-7	Stopped by seeing.
Sep 30	17	273	23:00							Adjusted TDG, replaced bad capacitor in +24V Ortec supply - low bin in 100Hz which caused jitter.
Oct 1	18	274	07:00	3	21/129	.162	6	Clear	4	
			10:00	3	12/91	.131	2	"	-	
			10:00	0	5/49	.102	0	"	4	
			12:30	3	8/187	.143	1	P. cldy	5-6	
Oct 2	19	275	08:00	-	-----	----	-	Cloudy	-	Cancelled.
			11:00	-	-----	----	-	"	-	"
			14:00	-	-----	----	-	"	-	"
Oct 2	19	275	11:22							Copied McD. 107, 269-275.
Oct 3	20	276	09:00	-	-----	----	-	Cloudy	-	Cancelled, clouds, occultation.
			12:00	-	-----	----	-	"	-	" "
			15:00	-	-----	----	-	"	-	" "
Oct 4	21	277	09:30-15:30		-----	----	-	Cloudy	-	All runs cancelled.
Oct 5	22	278	10:30-15:30		-----	----	-	Cloudy	-	All runs cancelled.
Oct 6	23	279	11:00-16:00		-----	----	-	Cloudy	-	All runs cancelled.

STATION LOG SEP-OCT 1977

DATE	LUNAR DAY	UTC DAY	TIME	REFL. NO.	RETURNS/ SHOT	SIGNAL LEVEL	DOUBLES	WEATHER	SEEING	COMMENTS
Oct 7	24	280	15:57	-	-----	----	-	---	-	Ended McD. 107.
Oct 7	24	280	16:00	-	-----	----	-	---	-	Started McD. 108.

REFLECTOR	ATTEMPTS	SUCCESSES
0	4	3
2	2	0
3	15	14
4	3	3
TOTALS	24	20

APPENDIX B

The Lunar Laser Calibration Data

from

19 June 1977 to 12 October 1977

EXPLANATION OF THE CALIBRATION DATA

The following pages contain the calibration constants for the four 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 = $\pm$0.4, B = $\pm$0.5, C = $\pm$0.6, D = $\pm$0.7, E = $\pm$0.8, F = $\pm$1.0, G = $\pm$1.2, H = $\pm$1.4, I = $\pm$1.7, J = $\pm$2.0, K = $\pm$2.4, L = $\pm$2.9, M = $\pm$3.5, N = $\pm$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):

$$0 \leq A \leq \pm 200$$

$$\pm 200 \leq B \leq \pm 400$$

$$\pm 400 \leq C \leq \pm 600$$

$$\pm 600 \leq D \leq \pm 1000$$

$$\pm 1000 \leq E \leq \pm 1500.$$

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 calibration uncertainties, have been determined by the data reduction group in Austin, headed by P. Shelus.

SYSTEM CALIBRATION DATA
JUNE 1977

PMT type: 31034 (with 125 or system)
PMT voltage: 1800
PMT gain: (Ortec 454) coarse = 2, fine = 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out
PMT discriminator: (Ortec 453) lower level disc: 2.5, fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1 disc: 6.5, fraction: 0.4.

GMT DAY	A (pulser)	B (laser pulse)*	C (feedback)	D (ELCOR)
172	55.9	-	----------	-----
173	57.3	-	----------	-----
174	57.5	-	----------	-722C
175	57.4	L	73.7 ± .27	-722B
176	----	L	73.9 ± .12	-724A
177	56.2	L	74.3 ± .27	-728B
178	58.0	-	----------	-----
179	56.7	-	----------	-----
180	55.8	L	72.6 ± .32	-711B
181	57.1	-	----------	-----
182	57.0	-	----------	-----
183	57.8	-	----------	-----
184	58.2	K	73.7 ± .26	-722B
185	----	L	73.4 ± .16	-719A
186	57.6	-	----------	-----
187	58.9	K	73.5 ± .11	-720A
188	57.1	K	73.9 ± .13	-724A
189	57.2	L	73.9 ± .10	-724A
190	----	-	----------	-----
191	59.2	L	73.8 ± .10	-723A

SYSTEM CALIBRATION DATA
JULY-AUGUST 1977

PMT type: 31034
PMT voltage: 1800
PMT gain: (Ortec 454) coarse = 2, fine = 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out.
PMT discriminator: (Ortec 453) lower level disc: 2.5, fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1 disc: 6.5, fraction: 0.[illegible].

GMT DAY	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
200	----	-	----------	-----
201	59.3	-	----------	-----
202	----	-	----------	-----
203	55.3	-	----------	-----
204	58.3	-	----------	-----
205	59.5	M	73.4 ± .11	-719A
206	----	K	73.2 ± .14	-717A
207	60.9	J	74.0 ± .18	-725A
208	59.7	K	73.7 ± .15	-722A
209	59.1	J	74.1 ± .15	-725A
210	59.4	K	73.7 ± .14	-722A
211	57.1	K	74.9 ± .21	-722B
212	57.0	M	73.9 ± .13	-724A
213	57.7	M	74.0 ± .18	-725A
214	58.6	K	74.7 ± .19	-732A
215	57.9	J	74.8 ± .20	-733B
216	57.1	K	74.4 ± .11	-729A
217	59.1	J	75.2 ± .19	-737A
218	58.3	J	74.2 ± .15	-727A
219	----	-	----------	- --
220	58.8	L	74.5 ± .13	-730A
221	59.6	J	74.4 ± .17	-729A
222	----	-	----------	-----

SYSTEM CALIBRATION DATA
AUGUST-SEPTEMBER 1977

PMT type: 31034 (N30447)
PMT voltage: 1600V (usually)
PMT gain: (Ortec 454) coarse = 5, fine = 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out.
PMT discriminator: (Ortec 453) lower level disc: 2.5, fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1 disc: 8.0, fraction: 0.4.
(now viewing front of #6 mirror)

	GMT DAY	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
PMT V = 1550					
	241	----	I	76.9 $\pm$ .13	-754A
	242	61.0	-	----------	-----
PMT V = 1650					
	243	61.2	I	76.3 $\pm$ .16	-748A
PMT V = 1530					
	244	61.3	I	77.5 $\pm$ .14	-760A
	245	61.0	I	77.0 $\pm$ .14	-759A
	246	61.0	I	77.0 $\pm$ .11	-755A
	247	61.6	J	76.9 $\pm$ .12	-754A
	248	61.1	-	----------	-----
	249	----	-	----------	-----
	250	----	J	77.0 $\pm$ .17	-755A
	251	61.5	I	77.0 $\pm$ .10	-755A
	252	60.9	I	76.9 $\pm$ .17	-754A

SYSTEM CALIBRATION DATA
SEPTEMBER-OCTOBER 1977

PMT type: 31034
PMT voltage: 1600V
PMT gain: (Ortec 454) coarse = 5, fine = 2.
Differentiate time constant: 5 nanoseconds.
Integrate time constant: out.
PMT discriminator: (Ortec 453) lower level disc: 2.5, fraction: 0.5.
Start Diode discriminator: (Ortec 453) 1.1 disc: 8.0, fraction: 0.4.

GMT DAY	A (pulser)	B (laser pulse)	C (feedback)	D (ELCOR)
260	----	-	----------	--- -
261	----	-	---------	-----
262	61.1	J	77.2 ± .19	-757A
263	63.0	I	77.0 ± .15	-755A
264	60.8	J	77.4 ± .21	-759B
265	62.5	J	76.4 ± .18	-749A
266	62.4	J	77.4 ± .17	-759A
267	60.7	J	77.3 ± .21	-758B
268	----	-	----------	-----
269	----	-	----------	-----
270	63.6	-	----------	-----
271	----	-	----------	-----
272	----	-	----------	-----
273	61.8	J	77.0 ± .17	-755A
274	----	I	76.9 ± .18	-754A
275	----	-	----------	-----