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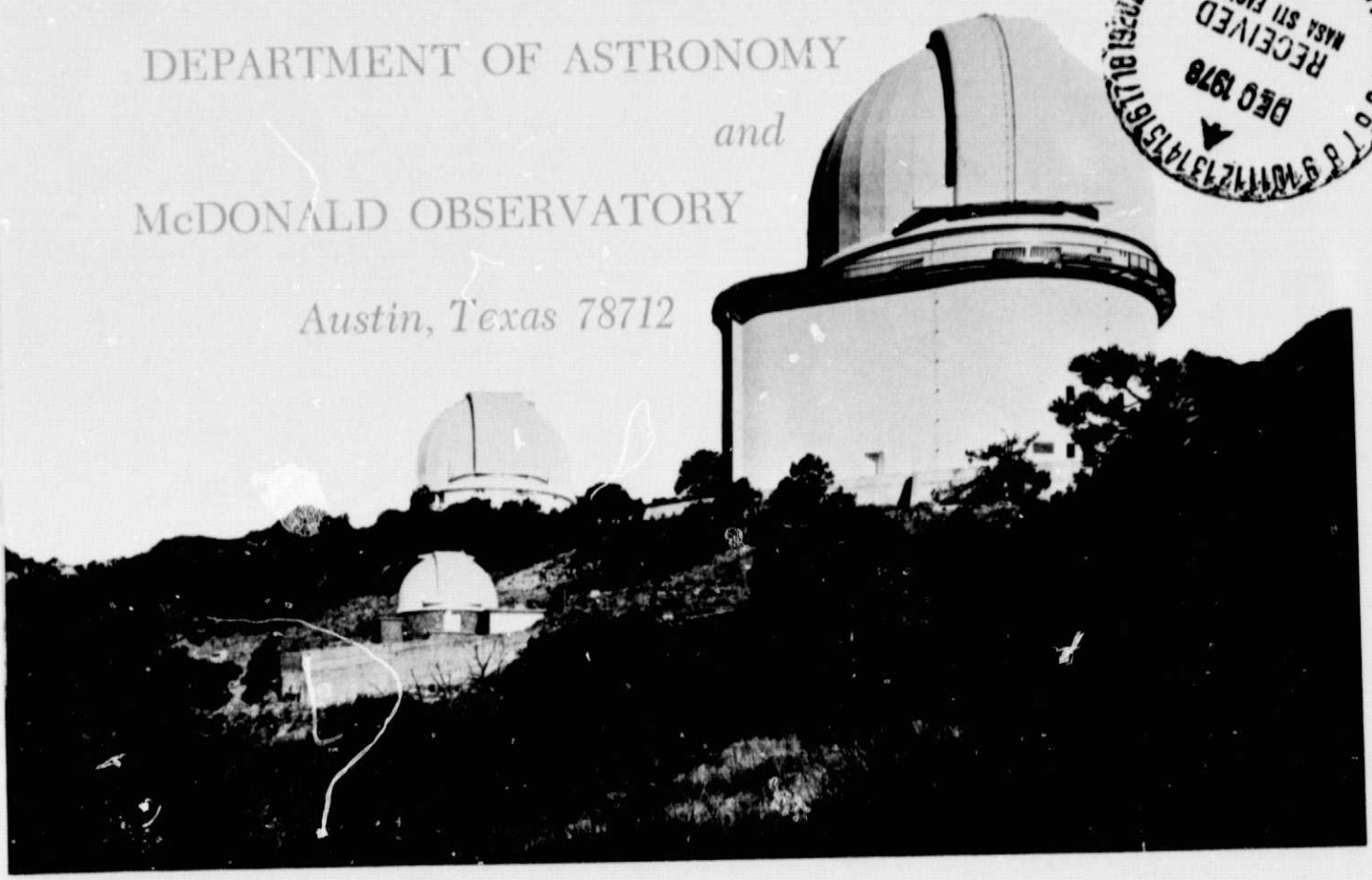

ANNUAL REPORT OF THE MCDONALD OBSERVATORY LUNAR LASER RANGING PROJECT *

FOR THE PERIOD

1 SEPTEMBER 1977 TO 31 AUGUST 1978

by

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Annual Report of the McDonald Lunar Laser Ranging Project

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INTRODUCTION

As has been the custom in the past, we present the following summary of the activities of the McDonald lunar laser ranging station at Fort Davis for the FY 77-78 fiscal year. The lunar laser experiment uses the observatory 2.7m reflecting telescope on a thrice-per-day, 21-day-per-lunation schedule. On any single laser run, as many as several hundred shots may be fired at a lunar reflector resulting in the recognition of from 5 to 20 single photoelectron returns. These data are recorded on magnetic tapes and sent to the University of Texas at Austin where the data is processed by a separate grant under the direction of Dr. Peter Shelus. After processing, the data is distributed to interested analysis centers and later to the National Space Science Data Center where it is available for routine distribution. To date, the principal impact of these data has been to more accurately determine a number of fundamental constants such as the gravitational mass of the earth, to differentiate between various theories of relativity, and to begin an interesting study of the rotation of the earth.

Detailed reports are published on the McDonald operations after every fourth lunation or approximately once every 115 days. These reports contain a day-by-day documentation of the ranging activity, detailed discussions of the equipment development efforts, and an abundance of other information as is needed to document and archive this important data type.

This annual report is a summary of the more detailed tri-annual submissions. Further copies of this annual report or copies of the more detailed tri-annual report can be obtained by contacting the author.

OPERATIONS

The success of the laser ranging project is quite weather dependent, with both good transparency, moderate seeing, and reasonable contrast (sky brightness), all required for a successful laser run. In addition, the equipment must be running properly which, considering the complexity of the hardware, is not always easy. In both of these respects, FY '78 was about average. The summary of the year's activities is shown in Table 1, which also lists comparative figures for previous years. About 660 laser runs would have been possible in ideal circumstances, with about 250 runs actually used after qualifying under the full set of environmental constraints. Equipment failures were slightly worse than usual, but only 17 runs were cancelled which could have otherwise been taken. As a result, about 66,000 laser shots were actually fired at the lunar corners. Most of the equipment problems were of the nuisance level, with two laser failures accounting for most of the lost observing time. The monthly record as compared to the last few years is shown in Figure 1. At this writing, the McDonald lunar laser project has produced approximately 2,500 range measurements over the lifetime of this station.

Although the total number of range measurements is well below some of the best years at the Observatory this should not be interpreted as any decrease in activity. The main reason for the lower number of measurements is two-year concentration on the Apollo 15 corner reflector for earth

rotation measurements. The result of adding a new photomultiplier to the system in the latter part of the previous fiscal year is apparent, with the average signal for the year approaching one photoelectron per 20 laser shots, approximately 50 percent higher than at any time previously. About 25 percent of the ranges are on the smaller reflectors as opposed to 15 percent one year ago.

Engineering:

Very few engineering changes were made to the McDonald laser system in FY 78, reflecting the maturity of the experiment. Technical efforts concentrated primarily on repairs and general preventive maintenance. Two minor exceptions were the efforts to improve guiding via a TV camera and an upgrade of the track capability of the 2.7 meter. Tests of the TV guiding were conducted using the guide apparatus purchased for the Transportable Laser Station. Although the results were not spectacular, the lessened observer fatigue and improved image contrast seemed worthwhile, leading to the ordering of the appropriate hardware.

The tracking system of the 2.7 meter was upgraded by developing software to move the telescope at satellite rates along a precalculated set of positions. Additional work on the transmit/receive switch of the laser allowed switching at ranges compatible with the NTS2 satellite. It is hoped to implement both developments shortly with a limited program of satellite ranging.

Personnel:

Williams, Gonzalez and Aubuchon share most of the observing, along with the 2.7 meter assistant observer who is scheduled each night. Wiant continues to be responsible for implementing most R & D efforts at the

TABLE I

Ranging Statistics 1 September 1977 to 31 August 1978

Reflector	Attempts	Successful Ranges	% Successful	Laser Shots	Return Photoelectrons	Signal Level Photoelectrons/ Shot
Apollo 11	28	18	64%	6151	140	.023
Luna 21	36	27	75%	7442	276	.037
Apollo 14	29	18	62%	6111	142	.023
Apollo 15	220	182	82%	46,592	2,582	.055
TOTAL FY 78	313	245	78%	66,296	3,140	.047
FY 77	304	228	75%	69,272	2,445	.035
FY 76	497	412	83%	100,113	3,762	.038
FY 75	424	291	68%	86,762	2,993	.035
FY 74	553	443	80%	121,987	4,378	.036
FY 73	460	339	74%	86,964	2,958	.034

About 650 laser runs scheduled . . FY 78

About 250 laser runs used

No ranging on Luna 17 site.

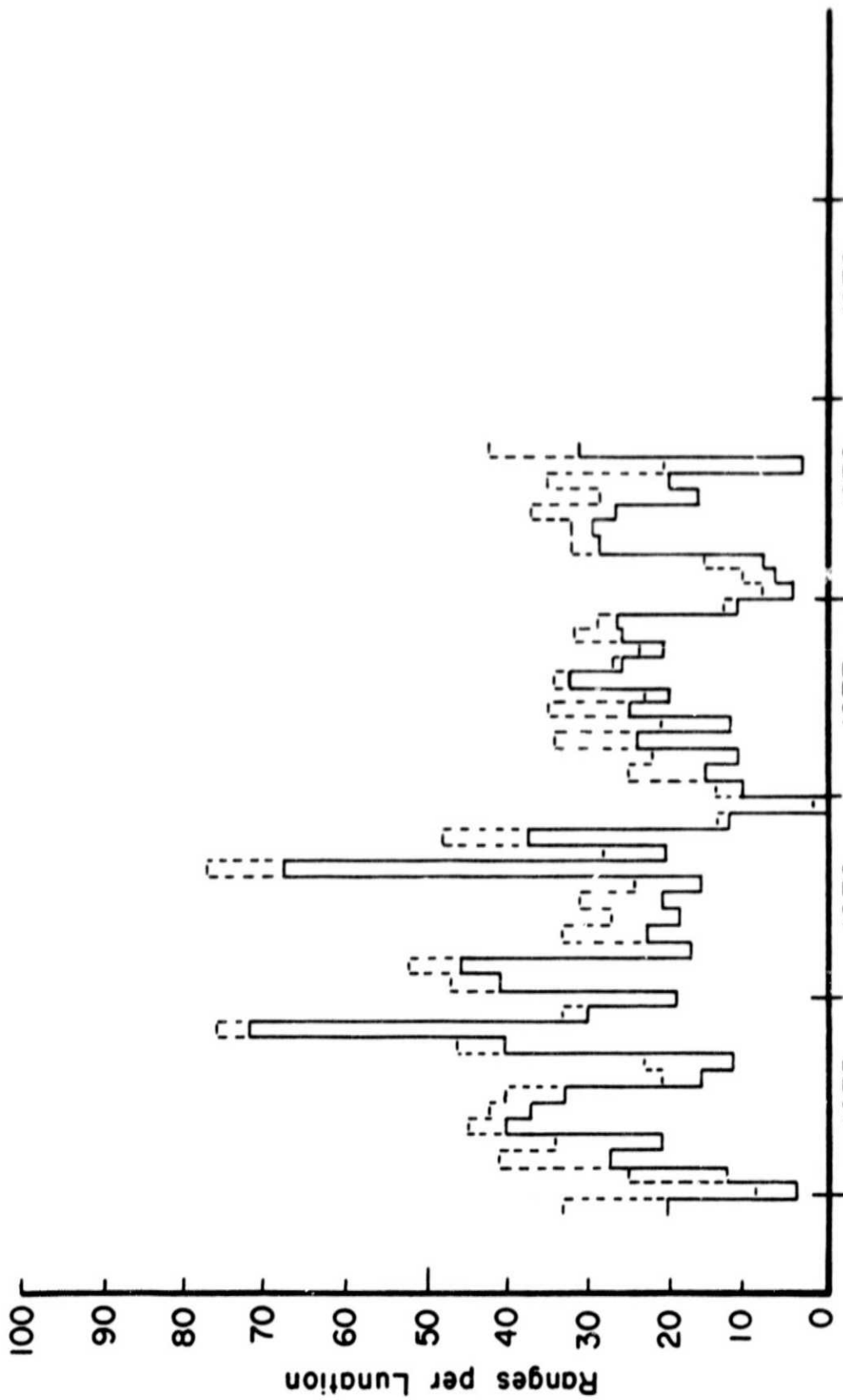

Figure 1 : Histogram of attempted (----) and successful (—) lunar ranges at McDonald Observatory since 1975.

station. Little was added to the crew in May to help with reporting and summertime observing coverage. The NTS2 programming was accomplished by O. Strohacker, temporarily assigned to the project. The project is under the direction of E. Silverberg, resident in Austin.

Travel:

Aside from routine business within the State, major travel was limited to two trips in FY '78. The principal investigator travelled to Maui for one week in the Spring of 78 to discuss difficulties at the Hawaiian laser station. He also travelled to Europe for three weeks in May to deliver papers at IAU Symposium #82, and the COSPAR Sponsored Laser Ranging Workshop and to visit the French and German laser ranging facilities.

Publications:

The following documents were prepared in this report year with full or partial support from this grant. Most concern the application of these lunar ranging techniques to the field of satellite geodesy.

- Report on the Lunar Ranging at McDonald Observatory for the Period 19 June 1977 to 12 October 1977, by E. C. Silverberg, University of Texas, McDonald Observatory, Res. Mem. #77-005, 1977.
- Report on the Lunar Ranging at McDonald Observatory for the Period 12 October 1977 to 7 February 1978, by E. C. Silverberg, Univ. of Texas, McDonald Observatory, Res. Mem. #78-002, 1978.
- Report on the Lunar Ranging at McDonald Observatory for the Period 8 February 1978 to 5 June 1978, by E. C. Silverberg and C. T. Little, Univ. of Texas, McDonald Observatory, Res. Mem. #78-004, 1978.

- A Proposal for the Design and Application of a High Mobility, Low-Cost Satellite Laser Ranging System, by P. Wilson, E. Silverberg, R. Schutz, I. Malevich, and S. Ramsden, in Proceedings of the European Workshop on Space Oceanography and Geodynamics, held at Schloss Elmau, Jan. 1978, (ESA SP-137).
- Scientific Goals of Lunar Laser Ranging, by J. D. Mulholland and O. Calame, paper presented at the COSPAR Workshop on Laser Ranging Instrumentation, Lagonissi, Greece, May 1978.
- A Proposal for a Very Compact Laser Station for Operational Geodesy, by E. C. Silverberg, B. Schutz, P. Wilson, and I.A. Malevich, Ibid.
- The Development of a Highly Transportable Lagoes Station: Status Report, by E. C. Silverberg, Ibid.
- Multistop Timing Electronics for High Altitude Satellite Ranging, by E. C. Silverberg and I. A. Malevich, Ibid.
- On the Effective Use of Lunar Ranging for the Determination of the Earth's Orientation, by E. C. Silverberg, paper presented at IAU Symposium #82, Cadiz, Spain, May 1978.
- Mobile Satellite Ranging, by E. C. Silverberg, paper presented to GEOP 9, Columbus, Ohio, Oct., 1978.

FUTURE PLANS

Long term plans for the McDonald site call for the finishing of a 76 cm telescope, started for the transportable lunar station, and using it at the McDonald site to remove operations from the 2.7 meter reflector. Since this changeover could occur in two to three years, heroic efforts to upgrade the current station are not necessary. The current system is adequate for routine ranging at decimeter level under reasonable weather conditions. Its major failings, the inability to range nearer new moon or to provide 3 cm range measurements, are not subject to quick solutions and must be left for the 76 cm system. All of this is in good accord with the major scientific interests for these data, which are oriented toward long-term earth rotation studies, gravitational theories and lunar dynamics.

In the next fiscal year the only relatively new activity is likely to be the onset of some NTS2 ranging. The guiding system will be slightly improved along with, possibly, some minor laser changes. Lunar operations will continue on a full 21-day-per-lunation schedule, with emphasis on earth rotation data. Barring some unforeseen circumstance, we are confident that the McDonald station can continue a good record of performance in gathering these important fundamental measurements.