SLAC-136
UC-28
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TWO-MILE ACCELERATOR PROJECT

1 April to 30 June 1971

Quarterly Status Report

STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY
Stanford, California 94305

PREPARED FOR THE U. S. ATOMIC ENERGY COMMISSION
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ABSTRACT

A status report on the Stanford Linear Accelerator Project covering the period April 1, 1971 to June 30, 1971 is presented. Topics included are accelerator and research area operations, accelerator and research area equipment development, and physics research equipment development.

Previous reports in this series of Quarterly Status Reports:

SLAC-1,	1 April - 30 June 1962.
SLAC-8,	1 July - 30 September 1962.
SLAC-10,	1 October - 30 December 1962.
SLAC-16,	1 January - 31 March 1963.
SLAC-18,	1 April - 30 June 1963.
SLAC-23,	1 July - 30 September 1963.
SLAC-27,	1 October - 31 December 1963.
SLAC-30,	1 January - 31 March 1964.
SLAC-32,	1 April - 30 June 1964.
SLAC-34,	1 July - 30 September 1964.
SLAC-42,	1 October - 31 December 1964.
SLAC-45,	1 January - 31 March 1965.
SLAC-48,	1 April - 30 June 1965.
SLAC-53,	1 July - 30 September 1965.
SLAC-59,	1 October - 31 December 1965.
SLAC-65,	1 January - 31 March 1966.
SLAC-69,	1 April - 30 June 1969.
SLAC-71,	1 July - 30 September 1966.
SLAC-73,	1 October - 31 December 1966.
SLAC-80,	1 January - 30 June 1967.
SLAC-85,	1 July - 30 September 1967.
SLAC-87,	1 October - 31 December 1967.
SLAC-89,	1 January - 31 March 1968.
SLAC-90,	1 April - 30 June 1968.
SLAC-93,	1 July - 30 September 1968.
SLAC-98,	1 October - 31 December 1968.
SLAC-105,	1 January - 31 March 1969.
SLAC-110,	1 April - 30 June 1969.
SLAC-112,	1 July - 30 September 1969.
SLAC-116,	1 October - 31 December 1969.
SLAC-120,	1 January - 31 March 1970.
SLAC-126,	1 April - 30 June 1970.
SLAC-128,	1 July - 30 September 1970.
SLAC-130,	1 October - 31 December 1970.
SLAC-132,	1 January - 31 March 1971.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

This is the thirty-sixth Quarterly Status Report of work under AEC Contract AT(04-3)-400 and the thirtieth Quarterly Status Report of work under AEC Contract AT(04-3)-515, both held by Stanford University. The period covered by this report is from April 1, 1971 to June 30, 1971. Contract AT(04-3)-400 provides for the construction of the Stanford Linear Accelerator Center (SLAC), a laboratory that has as its chief instrument a two-mile-long electron accelerator. Construction of the Center began in July 1962. The principal beam parameters of the accelerator in its initial operating phase are a maximum beam energy of 20 GeV, and an average beam current of 30 microamperes (at 10% beam loading). The electron beam was first activated in May 1966. In August, 1970, a beam energy of 22.1 GeV was achieved. Beam currents up to 82 milliamperes peak (47 microamperes average) have been obtained.

The terms of Contract AT(04-3)-400 provide for a fully operable accelerator and for sufficient equipment to measure and control the principal parameters of the electron beam; in addition, provision is made for an initial complement of general-use research equipment with which it is possible to perform certain exploratory studies, such as measurement of the intensity and energy distribution of various secondary-particle beams.

Contract AT(04-3)-515, which went into effect January 1, 1964, provided support for the various activities at SLAC that were necessary in order to prepare for the research program which is being carried out with the two-mile accelerator, and also provides for the continuing operation of the Center after completion of construction. Among the principal activities covered in the scope of Contract AT(04-3)-515 are theoretical physics studies, experiments performed by the SLAC staff at other accelerators, research-equipment development programs (such as particle separators, specialized magnets, bubble chambers, etc.), and research into advanced accelerator technology.

1. ACCELERATOR OPERATIONS

A. Operating Hours

Manned Hours	April	May	June	Quarter
Physics Beam Hours[1]				
Machine Physics	24	13	--	37
Particle Physics	314	602	--	916
Total Physics Beam Hours	338	615	--	953
Nonphysics Hours				
Scheduled Downtime (Maintenance, Startup)	24	12	--	36
Unscheduled Downtime (Equipment Failure, Tuneup, etc.)	53	36	--	89
Total Nonphysics Hours	77	48	--	125
TOTAL MANNED HOURS	415	663	--	1,078

B. Experimental Hours[2]

1. Particle Physics

(3) Beam Line	Sched. Hrs. Electronic Experiments (a)	Electronic Experimental Hrs.		% $\left(\frac{b}{a}\right)$	Actual Bubble Chamber Hours	Test and Checkout Hours		Total Experimental Hours	
		Actual Hours (b)	(4) Charged Hours			Act. Hrs.	Chg. Hrs.	Actual Hours	Charged Hours
A	923	705	851	76.4	---	40	40	745	891
B_N	---	---	---	---	---	534	534	534	534
B_C	---	---	---	---	733	---	---	733	733
B_S	556	455	377	81.8	---	339	332	794	709
C	---	---	---	---	541	66	66	607	607
Total	1,479	1,160	1,228	78.5	1,274	979	972	3,413	3,474
2. Machine Physics								34	34
TOTAL EXPERIMENTAL HOURS								3,447	3,508

(1) Number of hours accelerator is run with one or more beams excluding accelerator beam tuneup and other nonphysics beam time.

(2) Number of hours an experiment is run including actual beam hours and beam downtime "normal to the experiment."

(3) Refer to Fig. 1 for beam line location.

(4) Charged hours are represented by the formula $T_c = T_0\left(\frac{R+20}{200}\right)$ where T_c = charged hours, T_0 = total hours beam was available to the experimenter for both checkout and data taking, and R = the average pulse repetition rate. Maximum for $\left(\frac{R+20}{200}\right)$ is 1.5 even if the calculated amount exceeds this value.

C. Overall Experimental Program Status

1. Electronic Experiments

Approved research hours at beginning of quarter	3,492
Hours charged during the quarter	1,228
New hours approved during the quarter	2,951
Approved hours remaining at end of quarter	5,215

2. Bubble Chamber Experiments

	40" BC	82" BC
Approved pictures at beginning of quarter	1,750 K	6,003 K
Pictures taken during the quarter	295 K	1,546 K
New pictures approved during the quarter[1]	(750 K)	500 K
Approved pictures remaining at end of quarter	705 K	4,957 K

D. Beam Intensity

	April	May	June	Quarter
Peak	68 mA	52 mA	---	68 mA
Average	7.8 μA	4.6 μA	---	6.2 μA

E. Klystron Experience

Total Klystron Hours	95,692	158,256	---	253,948
Number of Klystron Failures	3	6	---	9

F. Data Analysis

Spark Chamber Events Measured	19,220	13,190	15,168	47,578
Bubble Chamber Events Measured	24,918	19,471	16,188	60,577

G. Computer Operations

Manned Hours

Computation Hours				
SLAC Facility Group	86	92	91	269
Users Groups	495	483	483	1,461
Total Computation Hours	581	575	574	1,730
Noncomputation Hours				
Scheduled Maintenance	111	105	105	321
Scheduled Modifications	2	-	-	2
Unscheduled Downtime and Reruns	19	32	21	72
Idle Time	6	1	1	8
Utility Failure	-	-	6	6
Total Noncomputation Hours	138	138	133	409
TOTAL MANNED HOURS	719	713	707	2,139

(1) Two adjustments were made in pictures approved for the 40" bubble chamber.
(a) BC-18 allocation of 250 K pictures was switched from the 40" to the 82" bubble chamber.
(b) BC-25 allocation was reduced from 1,000 K to 500 K pictures.

H. Special Operating Features

1. Beam Knockout

The beam knockout was run for 665 hours.

2. Power Supplies

The 3.4 MW power supply was run for 973 hours with the analyzer magnet in beam line 14 and for 25 hours of testing with magnet 21D3 in beam line 21, a total of 998 hours.

The 5.0 MW power supply was run for 529 hours with the 82" bubble chamber.

The 5.8 MW power supply was run for 8 hours of testing with the 54" spark chamber and 23 hours of testing with magnet 21D3 in beam line 21, a total of 31 hours.

The motor generator facility was run for 883 hours with the 40" bubble chamber.

2. EXPERIMENTAL ACTIVITY

Figure 1 is a research area plan drawing showing the location of the various experiments. Table 1 is a list of presently approved high energy physics experiments. The right-hand column of Table 1 gives the status and activity of each experiment during the period.* Figure 2 is a tentative long-range schedule.

The prime users of the accelerator during the period were:

E-55 — Study of Dalitz Plot for the Decay $K_L^o \longrightarrow \pi^+ \pi^- \pi^o$

E-64 — Study of Decay $K_L^o \longrightarrow \pi^\pm \mu^\pm \nu$

E-66 — Inelastic Photoproduction of Charged Pi & K Mesons in Forward Direction

BC-11 — Study of Resonance Production with 9.3 GeV Polarized Photons

BC-18 — 4.25 GeV γ-d Experiment

BC-19 — 7.5 GeV γ-d Experiment with Polarized Photons in 82" HBC

BC-25 — Study of Pomeranchon, Meson and Baryon Exchanges by Triggering the SLAC 40" HBC on Fast Forward Particles

BC-30 — Λp Interactions in the Momentum Interval 1-5 GeV/c

BC-33 — Study of $\pi\pi$ Scattering, Extrapolation Procedures & Production in π^- p Collisions

BC-35 — γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam

BC-38 — A Study of π^+d Interactions at 15 GeV/c

BC-39 — Study of π^+ Interactions in Hydrogen at 15 GeV/c

BC-43 — A Study of π^-d Interactions at 15 GeV/c

BC-45 — ω-ρ Interference and A_2 Splitting Study with π^+p at 3.8 GeV/c

T-12 — Wire Chamber Spectrometer Checkout

T-19/E-65 — Beam Checkout for Study of Electroproduced Photons

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* E-Approved counter experiments
CE-Checkout of equipment associated with counter experiments
BC-Approved bubble chamber experiments
P-Accelerator physics
R-Research area runs
N-Parasite runs
T-General research equipment tests
D-Special short particle physics runs
Y-Beam switchyard tests
S-Survey (usually Health Physics) runs

T-28/E-68 — Beam Checkout for Inclusive Pion-Proton Scattering Experiment

T-36 — Spark Chamber Test

T-44 — Antiproton Yield Test

D-18 — Pion Yield Test

Y-5 — Spear Transport Test

A. Status of Running Experiments

E-55 — Study of Dalitz Plot for the Decay $K_L^o \rightarrow \pi^+\pi^-\pi^o$ - D. Dorfan (SLAC, Univ. of Colorado, U. C. Santa Cruz)

This experiment ran for about 200 hours at 160 pps during the May cycle. Of this time 150 hours were used for data acquisition and 50 hours for calibration and checks on systematics. About 200,000 useful $K\pi_3$ decays were detected and a portion of the data has been reconstructed. The reconstructed data is in excellent agreement with the Monte Carlo calculations and the separation between $K\pi_3$ and other decay modes of the K_L^o is more than adequate. The event rate was limited by system dead time. This dead time will be lessened when the PDP-9 memory is increased. In addition, it would be preferable to lower the primary electron beam energy to about 15 GeV in order to provide a higher percentage of low momentum K's, which give a better fraction of usable decays/triggers. During the last run it was not possible to lower the primary energy owing to the requirements of BC-25. (D. Dorfan)

E-64 — Study of the Decay $K_L^o \rightarrow \pi^\pm\mu^\pm\nu$ - M. Schwartz (SLAC, UC Santa Cruz)

During the first two weeks of the April-May cycle the experiment E-64 commenced taking data. Approximately 2.8 million triggers were taken out of which about 1.4 million have been analyzed. The hardware in the spectrometer system worked very well during this period and no serious equipment troubles were encountered. The data rate was considerably lower than eventually hoped for, but several steps are currently being implemented which should increase the rate substantially. The analysis so far has detected no serious biases in the data. In addition, three days were spent running with the regenerator to calibrate the resolution of the spectrometer. Several thousand $K_S^o \rightarrow \pi^+\pi^-$ decays were accumulated. They are undergoing detailed analysis at present to check chamber alignment, magnetic field strength, and other possible sources of systematic errors. (S. Wojcicki)

E-65/T-19 — Study of Electroproduced Hadrons - W. Toner (SLAC)

Beam installation defects continued to be a serious problem during this cycle. Several attempts to correct them during short periods of access to end station B proved fruitless. A beam spot diameter at half intensity less than 0.5 mm was nevertheless obtained, although the tail extending beyond a 6 mm diameter was a factor of 30 too intense to be usable in the experiment. In the last two weeks of the cycle, checkout work was done on various items in the electronics and spark chamber systems. Eight of the eleven shower counters for the trigger system were studied, compensated for attenuation effects in the doped lucite, and calibrated. Short runs were carried out at nominal operating power, to test switchyard protection systems and at the nominal running energy of 21 GeV to test background conditions. (W. Toner)

E-66 — Inelastic Photoproduction of Charged pi and K Mesons in the Forward Direction - S. Ecklund (SLAC)

This experiment was set up, checked out, and data taking was completed during the April-May cycle. After a difficult start up (due to new and relocated apparatus in the Counting House and the need for rapid changes in accelerator energy) all apparatus functioned quite well. In order to facilitate the bremsstrahlung subtraction, the accelerator energy was switched between two pre-set levels, typically once an hour. A link between the MCC computer which controls the A-bend magnets and the SDS 9300 computer in the end station A Counting House and the alternate use of two beam triggers allowed an energy switch to be done in one or two minutes. Data were taken primarily at energy pairs of (16, 20), and (17, 19) GeV, but some measurements were made at (8, 10) and (12, 14). Inelastic cross sections were measured for $\pi^{\pm}$, $k^{\pm}$ $p^{\pm}$ at angles from 1.5^{o} to 21^{o} lab and at momentum transfers up to 2 GeV.

As a part of the experiment a quark search was performed with the momentum of the 20-GeV spectrometer set 1 GeV above the maximum photon energy (19 GeV). High center-of-mass energy was achieved by using a copper target and looking for coherent production from the nucleus [Danos and Gibson, PRL 26, 473 (1971)]. The experiment ran for three days at the end of the May cycle. Approximately one-half of the time was used setting up end station A and the 20-GeV detection system to reject room background. The other half of the time was used for data taking. We have data for 5.6×10^{16} equivalent

quanta incident on a 1/4 inch thick copper target. Although no prominent quark signal was seen on-line, a more detailed off-line analysis will be necessary to verify the absence of a quark signal and determine the limit we will be able to put on the cross section. (S. Ecklund/R.H. Siemann)

E-68 - Inclusive Pion - Proton Scattering - J. Rothberg (Univ. of Washington)

During the first part of the April-May cycle the initial segment of the pion beam line (Beam 20) was checked out. Pion yields at 12 GeV were measured at the second focus and were found to agree with expectations. Some parasite time was used to determine the background rates in our experiment from end station B and from the early stages of the beam transport. It was found that there was an important component of charged particle background (presumably muons) which come from the beam transport system downstream of the first bending magnet (20D1) and which is quite independent of the setting of the momentum slits.

The construction of the remainder of the beam transport (Beam 21) was completed by the middle of May and we went into a testing phase to optimize the beam quality at our hydrogen target position (F-4). The beam shape and transmission at F-4 seemed satisfactory and in general agreement with Monte-Carlo calculations. During this time we used several shifts to study the operation of two of our 1-1/2 meter spark chambers. During the last week of the cycle the large spark chambers as well as some small ones were used to study beam shape and background under realistic running conditions. A component of background was discovered which decreased rather slowly with distance from the pion beam. A series of investigations suggested that this component was related to inadequately thick momentum slits and to a slightly mis-steered pion beam which illuminated a section of vacuum pipe. These conditions are now being corrected and additional shielding is being installed. (J. Rothberg)

BC-11 — Study of Resonance Production with 9.3 GeV Polarized Photons - G. Wolf (SLAC, U.C. Berkeley, LBL)

In the April cycle 295,000 pictures of 9.3 GeV γ-p were taken in the 82" hydrogen bubble chamber using the Compton scattered laser beam with light from the ruby laser doubled in frequency. These were the first pictures taken with the new 35 mm single strip camera for the 82" hydrogen bubble

chamber. Measurements of fiducials during the run showed the distance between fiducials was consistent from frame to frame to ~ 10 microns on the film. Of the 6 lenses available, by chance, two of the three used were defective, resulting in views 1 and 2 appearing to be defocussed. Further analysis will determine what effect this will have on the measurement results. Since this run the lenses have been changed.

With this run we completed taking the 800,000 pictures of the initial proposal and obtained 150,000 of the 700,000 picture extension. As a result, we plan to continue BC-11 during the July accelerator cycle and obtain the last pictures for BC-11.

The scanning and measuring of the first 650,000 pictures at 9.3 GeV is now complete. Preliminary analysis of the new data is now being carried out. (K. Moffeit)

BC-18 — A 4.25 GeV γ-Deuterium Experiment in the SLAC 40" Bubble Chamber and with Polarized Photons in the 82" Bubble Chamber. - Y. Eisenberg (Weizmann Institute)

This experiment was originally proposed for the 40" bubble chamber using the annihilation beam; with the advent of the laser beam facility, it was rescheduled for the 82" bubble chamber. The experiment is a study of vector meson production, testing the vector dominance model and measuring direct photon vector meson coupling and partial decay widths. Also, the experimenters will attempt to determine the reaction mechanism of several reactions as well as the total γ-d cross section at 4.25 GeV. During May 1971 a total of 219,856 pictures were taken, concluding the presently allotted exposure. The new single strip 35 mm sprocketless film format was used. (R. Gearhart)

BC-19 — γ-d Experiment with an Annihilation Beam of 7.5 GeV in SLAC 40" Bubble Chamber and with Polarized Photons in the 82" Bubble Chamber - A. Levy (Tel-Aviv Univ.)

This experiment was originally proposed for the 40" bubble chamber but, with the approval of the experimenter, was rescheduled for the 82" chamber. The purpose is to study vector meson production, ρ production, associated production of $\rho\Delta$ and $\omega\Delta$, higher spin mesonic resonances and baryonic resonances. The total cross section is measured as a matter of course. The ruby laser with internal second harmonic generation was used. A total of

159,328 pictures were obtained out of an approved exposure of 200K. The 35 mm single strip camera was used. (R. Gearhart)

BC-25 — Study of Pomeranchon, Meson and Baryon Exchanges by Triggering the SLAC 40" Bubble Chamber on Fast Forward Particles - C. Peck (Caltech, LBL)

During the first day of the April/May cycle the remaining obstacles to data taking were cleared up: The iron shielding put up around the counter and spark chamber array reduced the background to an acceptable level. The problem with the beam momentum resolution was solved (and the yield improved somewhat) through work on the beam tuning. The bubble chamber began to be operational about one week after the cycle began and its reliability, quite low at first, improved as the cycle progressed. The experiment was run sometimes at three, more often at four pulses per second (five PPS were achieved for a couple of days near the end). In the triggered mode about one picture is obtained for 25 bubble chamber expansions; during the cycle 250K pictures were obtained in the triggered mode. An additional 50K pictures were obtained untriggered or triggered on elastics using a π^- beam flux of about 9 per pulse. (W. Ford)

BC-30 — Λp Interactions in the Momentum Interval 1-5 GeV/c - John Kadyk (LBL)

The experiment is a study of Λp elastic scattering and the reactions $\Lambda p \longrightarrow \Lambda p\pi^+\pi^-$ and $\Lambda p \longrightarrow \Sigma^{\pm}\pi^{\pm}p$ in the momentum of about 1-5 GeV/c. The experiment should give total and differential cross sections for these reactions, as well as polarization information. The Λ particles are produced by directing a K^- beam into a platinum target placed inside the 82" bubble chamber.

The experiment received 413,560 pictures in this cycle in addition to 182,570 received in July and September, 1970. All exposures have been made with the 46 mm single strip camera. (R. Gearhart)

BC-35 — γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam - R. Poe/R. Birge (U.C. Riverside, U.C. Berkeley)

This experiment is a study of photon-meson couplings in coherent meson production reactions, partial decay widths, photoproduction of A mesons and various quasi-two-body reactions. The total cross sections γn and γd will also be measured. A total of 231,173 pictures were obtained out of an approved 500K exposures. The single strip 35 mm camera was used. It was intended that the 5.5 GeV exposure be taken using the ruby laser in a

second harmonic mode. However, a reasonable yield became a problem and it was decided to forego the second harmonic. (The second harmonic would produce a somewhat narrower spectrum.) (R. Gearhart)

BC-38 — A study of $\pi^+ d$ Interactions at 15 GeV/c - V. Hagopian (Florida State Univ., Univ. of Pennsylvania)

This experiment is a study of reaction mechanisms and production and decay properties of meson states decaying into strange and non-strange particles with both high statistics and high resolution. A total of 51,229 pictures out of an approved 250K were received. The 35 mm 3-track film format was used. (R. Gearhart)

BC-39 — Study of π^+ Interactions in Hydrogen at 15 BeV/c - C. Baltay (Columbia Univ., State Univ. of New York)

This experiment is a search for and a study of properties of mesonic and baryonic resonances and the study of high energy hadron collisions. A total of 65,430 pictures were taken out of 500 K approved. The three-strip 35 mm camera was used. (R. Gearhart)

BC-43 — A Study of $\pi^- d$ Interactions at 15 GeV/c - H. Lubatti (Univ. of Washington, U.C. Berkeley)

The experiment is a study of coherent production of 3 and 5 pion states and of diffraction dissociation of the neutron. A total of 47,579 pictures were taken out of an approved 250K. The 3-strip 35 mm camera system was used. (R. Gearhart)

BC-45 — ω-ρ Interference and A_2 Splitting Study with $\pi^+ p$ at 3.8 GeV/c - G. Goldhaber (U.C. Berkeley, LBL)

This is a high statistics experiment (1.5M pictures requested, 750K approved) to study ω-ρ interference, A_2 structure and ω production. A total of 47,837 pictures were taken and will be used primarily to study potential analysis problems. (R. Gearhart)

T-36 — Spark Chamber Test - D. Fryberger/H. Lynch (SLAC)

About one shift of 10 pps beam time was used to measure the efficiency of the small magnetostrictive wire spark chamber as a function of particle angle of incidence. The mean particle intensity used was about 1/3 particle per pulse. The angles of incidence varied from 0^o (normal) to 80^o. It was found that the general efficiency remained high — greater than 99% up to the

largest angle. However, a slight increase (about 2 kV on the dc supply) in pulse voltage was required to maintain efficiency at the larger angles. (D. Fryberger)

T-41 — Test for BC-47 (Resonance Formation with Polarized Photons from the Laser Beam - A. Rosenfeld) - K. Moffeit/J. Murray (SLAC)

Experiment BC-47 is a low energy polarized photon experiment in the 82" bubble chamber. A short test was run at $E_\gamma = 1.1$ GeV (the energy range for the experiment is to be 0.6 - 1.2 GeV). 4415 pictures were taken for the purpose of studying potential problems. (R. Gearhart)

T-42 - Shower Counter Tests - UCSB - F. Murphy (U.C. Santa Barbara)

In preparation for experiment E-76A, shower counters were tested in Beam Line 6 with 7.5 GeV/c π^+ and e^+. Measurements of the amount of light from an electromagnetic shower produced in a lead-glass block were sampled by a fibre light guide cemented to the glass. The general characteristics of several lead-glass counters and phototubes borrowed for E-76A were also studied. No difficulties were encountered and the tests were completed in about 12 hours. (F. Murphy)

Y-5 — SPEAR Transport Test - J. Harris (SLAC)

The initial section of the beam to the storage ring (SPEAR) was probed with the beam to check performance of those elements installed. All instruments performed satisfactorily and it was shown that the lab calibration of the strip line position monitor was reproduced in use with the beam.(J. Harris)

B. New Experiments

At the meeting of the Program Advisory Committee on May 7/8, 1971, the following new experiments were approved: E-74A (Measurement of the Polarization Asymmetry of Pion and Kaon Photoproduction); E-76 (Measurement of Deep Inelastic Compton Scattering); E-78 (Measurement of Inclusive Photoproduction in the $X \leq 0$ Region); and extensions to E-64, E-71, BC-18, and BC-25 were also approved.

Summaries of Newly Approved Experiments

E-74A — Measurement of the Polarization Asymmetry of Pion and Kaon Photoproduction - R. Siemann (SLAC)

This experiment will measure the dependence of several charged pion and kaon photoproduction reactions on the incident photon polarization. At high energies the polarization asymmetry and the spin-parity of the t-channel exchanges are related; therefore, asymmetry measurements give information on the quantum numbers of the t-channel exchanges. The following are the major points of interest in the reactions to be studied:

(1) There are no data on the asymmetry of $\gamma n \rightarrow \pi^- p$ at incident energies above 3.4 GeV. Higher energy π^- asymmetry data is needed to complete the comparison of photoproduction and $\pi^- p \rightarrow \rho^o n$ (which are related by vector dominance). To check the Glauber corrections asymmetry data for $\gamma p \rightarrow \pi^+ n$ will be taken from both hydrogen and deuterium.

(2) The cross sections for $\gamma n \rightarrow \pi^- \Delta^+$ and $\gamma p \rightarrow \pi^+ \Delta^o$ show there is considerable interference between I = 1 exchanges of different G-parity. From the asymmetries for $\gamma D \rightarrow \pi^+ \Delta n_s$ (n_s = spectator nucleon) and $\gamma D \rightarrow \pi^- \Delta n_s$ one can learn the spin-parities of the dominant I = 1 exchanges and determine the contributions of the two-spin parities to the observed interference.

(3) The exchanges contributing to the forward structure of π-delta photoproduction will be studied by measuring the asymmetry for $\gamma p \rightarrow \pi^- \Delta^{++}$ at small t.

(4) Nothing is known about the photon polarization dependence of K photoproduction. This dependence will be studied by measuring the asymmetry for $\gamma p \rightarrow K^+ \Lambda$ at 5 values of t from -0.08 to -0.8 $(GeV/c)^2$.

The polarized beam to be used in this experiment is produced by passing an initially unpolarized bremsstrahlung beam through a large crystal. The crystal is aligned such that photons of one polarization produce more pairs than photons of the other polarization. The resultant beam is of reduced intensity with 24% polarization at the tip of the spectrum. This polarization will be measured using the pair spectrometer in end station A.

The photoproduced pions are detected with the SLAC 20-GeV spectrometer. The spectrometer will be run in a scan mode to reduce the effect of bin-to-bin variations in the efficiency. Cross-section fitting techniques developed for working at the bremsstrahlung tip will give the asymmetry.

E-76 — Measurement of Deep Inelastic Compton Scattering - D. O. Caldwell (U.C. Santa Barbara)

A rather short attempt has been made at SLAC to look for high-energy, fairly wide-angle photons which might come from the scattering of high-energy γ-rays from point-like constituents in the nucleon (E-53). An effect was seen above the best estimates one can make of the expected background from photons from π^0 decays. While these data do not prove the existence of sub-nucleonic structure, or partons, a much-improved experiment should do so. With a much larger counter array (which has been used in an experiment at Berkeley) the "parton" signal should be much better determined, but also the π^0 background can be measured. This will permit direct comparison with inelastic electron scattering data, which should in principle determine the mean charge of the scatterer.

E-78 — Measurement of Inclusive Photoproduction in the $X \leq 0$ Region- G. Miller/ R.W. Williams (U. Washington)

This experiment will measure the distribution of an outgoing pion (or proton with magnet acceptance +) in the reaction $\gamma p \longrightarrow \pi^{\pm}$ + anything. In terms of $X = (p_{\parallel} / p_{\text{incident}})_{\text{c.m.}}$ and $Q = p_{\perp}$ the region $X = 0$ to -0.5, $Q = 0.3$ to 0.6 GeV/c will be covered. (Proton X should be ≤ -0.3). The instrumentation and particle identification are very similar to a recently concluded ρ electroproduction experiment at SLAC (E-71). E-71 data also will furnish an induction of the counting rates. The electron beam at several energies will strike a 5% radiator creating a bremsstrahlung beam in End Station A. The principal technical problem will be the elaborate bremsstrahlung subtraction required.

Measurements of the pionization region ($X \approx 0$) and the fragmentation of the proton ($X < 0$) at gamma energies 20 GeV and lower will be made; these will be compared with pp and πp data. Questions of the approach to a limiting distribution, possible factorization of the distribution, and the Q dependence of the distribution will be studied.

FIG. 1--Experiment locations.

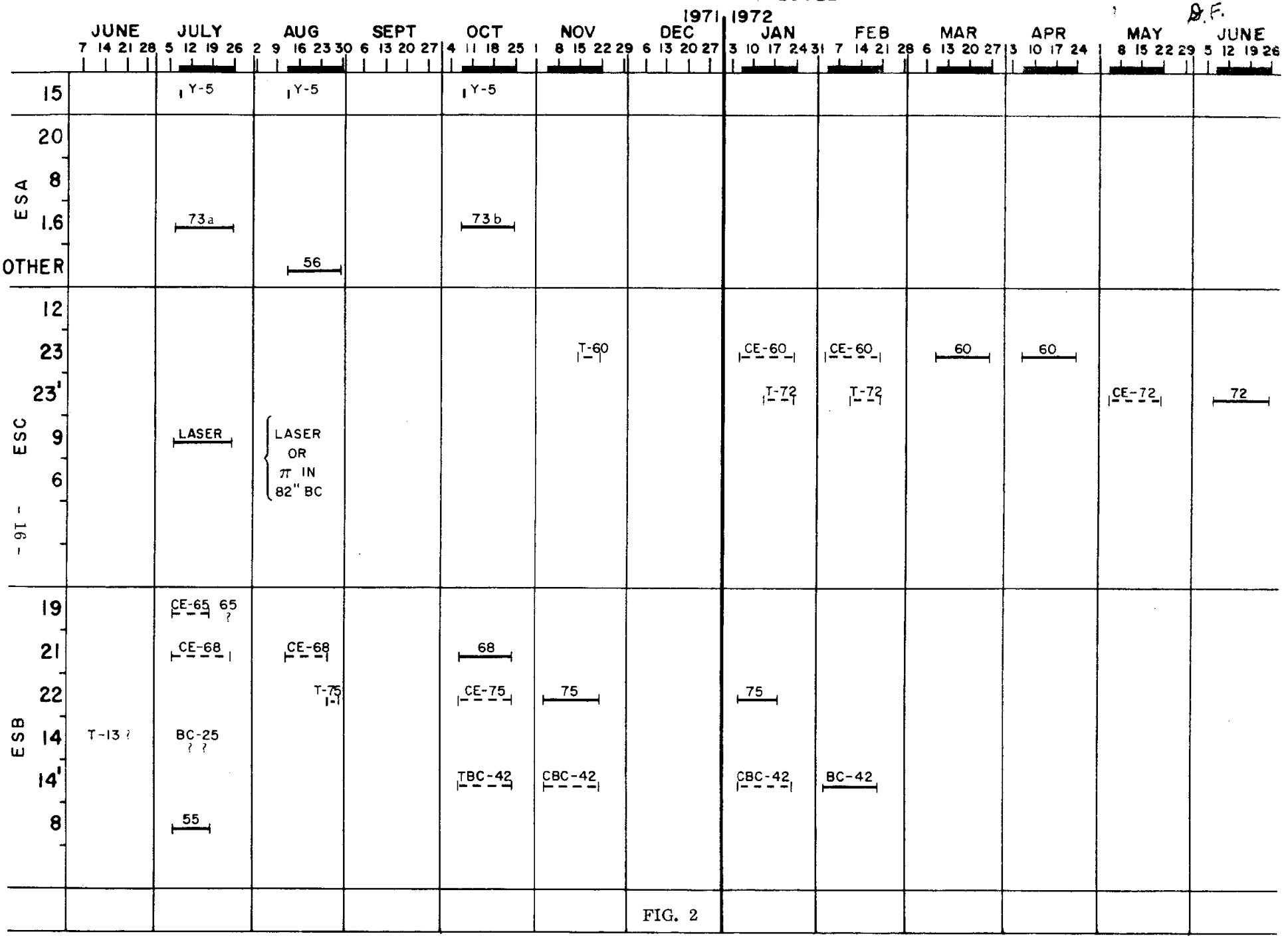
1971
1972
JUNE 7 14 21 28
JULY 5 12 19 26
AUG 2 9 16 23 30
SEPT 6 13 20 27
OCT 4 11 18 25
NOV 1 8 15 22 29
DEC 6 13 20 27
JAN 3 10 17 24 31
FEB 7 14 21 28
MAR 6 13 20 27
APR 3 10 17 24
MAY 8 15 22 29
JUNE 5 12 19 26
15
Y-5
Y-5
Y-5
ESA
20
8
1.6
73a
73b
OTHER
56
12
23
23'
9
6
ESC
T-60
CE-60
CE-60
60
60
T-72
T-72
CE-72
72
LASER
LASER OR π IN 82" BC
19
21
22
14
14'
8
ESB
CE-65 65 ?
CE-68
CE-68
68
T-75
CE-75
75
75
T-13 ?
BC-25 ? ?
TBC-42
CBC-42
CBC-42
BC-42
55

FIG. 2

TABLE 1

TABLE OF PROGRAMMED EXPERIMENTS

Number	Title	Authors	Date Approved	Status
E-43	Velocity of Light Experiment	U. C. San Diego G. Masek	12/14/68	Complete
E-55	Study of Dalitz Plot for the Decay $K_L^o \rightarrow \pi^+\pi^-\pi^o$	SLAC H. Saal U. C. SANTA CRUZ D. Dorfan U. COLORADO U. Nauenberg	5/23/70	Setup/ Checkout Running
E-56a	A Search for Short-Lived Sources of Neutrino-Like Particles	SLAC D. Fryberger, A. Rothenberg, M. Schwartz, T. Zipf U. OF PENNSYLVANIA E. Beier, A. Mann, E. Rybaczewski U. C. SANTA CRUZ D. Dorfan	10/14/70 Ext. 2/5/71	Setup
E-60	Hyperon Production in K^-p Interactions	SLAC K. Bunnell, R. Mozley, A. Odian, J. Park, B. Swanson, F. Villa, L. Wang U. C. RIVERSIDE S. Fung, A. Kernan, R. Poe, T. Schalk, B. Shen LBL M. Alston-Garnjost, R. Bangerter, A. Barbaro-Galtieri, F. Lynch, F. Solmitz	12/12/69	Planning/ Construction
E-63	Measurement of K_L^o and Neutron Total Cross Sections on Nuclear Targets	STANFORD U. J. Crawford, R. Ford, E. B. Hughes, L. Middleman, L. H. O'Neill, J. Otis	3/21/70*	Complete
E-64	Study of the Decay $K_L^o \rightarrow \pi^{\pm}\mu^{\mp}\nu$	SLAC D. Fryberger, D. Hitlin, J. Liu, M. Schwartz, S. Wojcicki U. C. SANTA CRUZ D. Dorfan	3/21/70	Checkout/ Ready to Run

Table of Programmed Experiments (cont'd) - 2

Number	Title	Authors	Date Approved	Status
E-65	Study of Electroproduced Hadrons	SLAC G. Dieterle, W. Lakin, F. Martin, E. Petraske, M. Perl, J. Tenenbaum, W. Toner	3/21/70	Setup/ Checkout
E-66	Inelastic Photoproduction of Charged Pi and K Mesons in the Forward Direction	SLAC A. Boyarski, S. Ecklund, B. Richter, R. Siemann	3/21/70	Complete
E-68	Inclusive Pion-Proton Scattering	U. OF WASHINGTON J. E. Rothberg, R. W. Williams K. K. Young, A. Schenck L. Sompayrac, M. Delay	5/23/70	Setup/ Checkout
E-70	Measurement of the Asymmetry in Compton Scattering on the Proton	SLAC R. Anderson, D. Gustavson, J. Johnson, I. Overman, D. Ritson, B. Wiik CORNELL R. Talman NORTHEASTERN U. R. Weinstein HARVARD D. Worcester	8/15/70	Inactive
E-71	Electroproduction of Vetor Mesons	SLAC E. Bloom, R. Cottrell, H. DeStaebler, C. L. Jordan M. Mestayer, G. Miller, H. Piel, R. E. Taylor U. C. SANTA CRUZ C. Prescott	6/5/70 Ext. 5/8/71	Inactive
E-72	Deep Inelastic μ - p Scattering	U. C. SANTA CRUZ D. Dorfan C. Heusch, B. Liberman, C. Prescott A. Seiden SLAC K. Bunnell, R. Mozley, A. Odian J. Park, D. Slone, W. Swanson, F. Villa, L. C. Wang LBL S. Flatte	11/14/70	Planning/ Construction

Table of Programmed Experiments (cont'd) - 3

Number	Title	Authors	Date Approved	Status
E-73	Phi-Photoproduction	SLAC R. L. Anderson, D. Gustavson J. Johnson, I. Overman, D. Ritson, B. Wiik U. OF WISCONSIN R. Prepost D. Tompkins HARVARD D. Worcester	11/14/70	Planning/ Setup
E-74 a	Polarization Asymmetry in Photoproduction	SLAC A. Boyarski, S. Ecklund B. Richter, D. Sherden, R. Siemann, C. Sinclair TUFTS U. D. Quinn	5/8/71	Inactive
E-75	Q Region Study in $K^+p \longrightarrow K^+\pi^+\pi^-p$	SLAC R. Carnegie, R. Cashmore, E. Kluge, D. W. G. S. Leith, H. L. Lynch, S. Williams, F. Winkelman, R. Giese, B. Ratcliff, H. H. Williams	11/14/70	Construction/ Setup
E-76	Deep Inelastic Compton Scattering	U. C. SANTA BARBARA D. O. Caldwell V. B. Elings, D. L. Fancher, W. P. Hesse, B. N. Kendall, R. J. Morrison and F. V. Murphy	5/8/71	Inactive
E-78	Particle Spectra at High Energy	U. OF WASHINGTON G. Miller, H. Romer, J. E. Rothberg, R. Wilkinson, R. W. Williams, K. K. Young	5/8/71	Inactive
BC-6	Study of the One Pion Exchange Contribution to γ-Nucleon Scattering (in 82-Inch Deuterium Bubble Chamber)	U. OF TENNESSEE W. M. Bugg	Ext. 2/5/71	Inactive
BC-8	Exposure of the 82-Inch Hydrogen Chamber to a Beam of π^+ Mesons at 7.0, 11.0 and 14.0 GeV/c	PURDUE D. H. Miller	Ext. 3/21/70	Inactive

Table of Programmed Experiments (cont'd) - 4

Number	Title	Authors	Date Approved	Status
BC-11	A Bubble Chamber Experiment with the Polarized Laser Induced Photon Beam (Extended 10/3/69)	SLAC J. Ballam, G. Chadwick Z. Guiragossian, P. Klein, A. Levy, M. Menke, K. Moffeit, J. Murray, C. Sinclair, I. Skillicorn, G. Wolf U. C. BERKELEY H. Bingham, B. Equer LBL M. Rabin, W. Podolsky, A. Rosenfeld	5/11/68 Ext. 2/5/71	Running
BC-18	A 4.25 GeV γ-Deuterium Experiment in the SLAC 40" Bubble Chamber and with Polarized Photons in the 82" Bubble Chamber	WEIZMANN INSTITUTE Y. Eisenberg, B. Haber, U. Karshon, L. Lyons, E. E. Ronat, A. Shapira, G. Yekutieli	9/28/68 Ext. 5/8/71	Running/ Complete
BC-19	γ-d Experiment with an Annihilation Beam of 7.5 GeV in SLAC 40" Bubble Chamber and with Polarized Photons in the 82" Bubble Chamber	TEL-AVIV U. G. Alexander, I. Bar-Nir, A. Brandstetter, S. Degan, J. Grunhaus, A. Levy, Y. Oren	Ext. 3/21/70	Running
BC-25	Study of Pomeranchon, Meson and Baryon Exchanges by Triggering the SLAC 40" Bubble Chamber on Fast Forward Particles	CAL TECH A. Dzierba, W. Ford, R. Gomez, P. Oddone, C. Peck, J. Power, C. Rosenfeld A. Tollestrup LBL R. Ely, D. Grether	6/18/69 Ext. 5/8/71	Running
BC-26	Resonance Study in R, S, T, and U Regions	DUKE U. L. Fortney	6/11/69	Inactive
BC-28	A 5 GeV/c $\pi^+ p$ Experiment in the SLAC 82-Inch HBC	WEIZMANN INSTITUTE, Y. Eisenberg, B. Haber, U. Karshon, E. Ronat, A. Shapira, G. Yekutieli	8/6/69	Inactive

Table of Programmed Experiments (cont'd) -5

Number	Title	Authors	Date Approved	Status
BC-30	Λp Interactions in the Momentum Interval 1-5 GeV/c	LBL G. Trilling, J. Kadyk, G. Goldhaber, J. Hauptman	12/12/69	Running/ Complete
BC-33	4.5 GeV/c π^-p Interactions	U. OF PENNSYLVANIA W. Selove	3/21/70	Ready to Run
BC-34a	K^-d Interactions Around 12 GeV/c	JOHNS-HOPKINS U. C. Chien, B. Cox, D. Denegri, L. Ettlinger, G. Goodman, R. Mercer, A. Pevsner, R. Sekulin, R. Zdanis	8/15/70	Inactive
BC-35	γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam	U.C. RIVERSIDE S. Fung, A. Kernan, R. Poe, T. Schalk, B. Shen U.C. BERKELEY R. Birge, R. Ely, G. Gidal, D. Grether, G. Kalmus, W. Michael	3/21/70 Ext. 2/5/71	Running
BC-38	A Study of π^+d Interactions at 15 GeV/c	FLORIDA STATE U. J. Albright, A. Colleraine, S. Hagopian, V. Hagopian, J. Lannutti, G. Yost U. OF PENNSYLVANIA J. Bensinger	8/15/70	Running
BC-39	Study of π^+ Interactions in Hydrogen at 15 BeV/c	COLUMBIA C. Baltay, L. Gerschwin, W. Cooper, S. Csorna, M. Habibi, M. Kalelkar STATE U. OF NEW YORK N. Yeh, A. Gaigalas	8/15/70	Running
BC-40	8.0 and 14 GeV/c, π^+ and π^- Exposures in the SLAC 82-Inch HBC	MIT Z. Carmel, F. Dao, B. Feld R. Hulsizer, V. Kistiakowsky, I. Pless V. Simac, F. Triantis, T. Watts, J. Wolfson, R. Yamamoto, D. Ballantyne, M. Hodous, A. Hakkasyan, A. Napier, R. Singer, P. Trepagnier	8/15/70	Inactive

Table of Programmed Experiments (cont'd) - 6

Number	Title	Authors	Date Approved	Status
BC-42	Bubble Chamber Study of Deep Inelastic Muon Scattering	SLAC E. Bloom, R. Cottrell, H. DeStaebler, C. Jordan, M. Mestayer, H. Piel, R. Taylor, J. Ballam, G. Chadwick, P. Seyboth, I. Skillicorn, H. Spitzer U.C. SANTA CRUZ C. Prescott	8/15/70	Planning
BC-43	A Study of π^-d Interactions at 15 GeV/c	U. OF WASH. P. Bastien, L. Kirkpatrick, H. Lubatti U.C. BERKELEY H. Bingham, W. Fretter	8/15/70	Running
BC-44	Measurement of the Total Hadronic γp Cross Section at Photon Energies Between 0.5 and 1.2 GeV	DESY G. Knies, P. Soding, G. Wolf	8/15/70	Withdrawn by Authors
BC-45	ω-ρ Interference and A_2 Splitting Study with π^+p at 3.8 GeV/c	U.C. BERKELEY/LBL G. Goldhaber, J.A. Kadyk, G.H. Trilling, G.S. Abrams, K.W.J. Barnham, A. Firestone	2/5/71	Ready to Run
BC-47	Resonance Formation with Polarized Photons from the Laser Beam	LBL R.G. Moorhouse, W. Podolsky, M. Rabin, A. Rosenfeld, G. Smadja, R.D. Tripp SLAC G. Chadwick, R. Gearhart, M. Menke, K. Moffeit, J. Murray, P. Seyboth, C. Sinclair, I.O. Skillicorn, H. Spitzer	2/5/71	Inactive
D-16	Tests of Large NaI(T1) Detectors	HEPL E. B. Hughes	5/29/70	Inactive
D-18	Pion Yield Test	U.C. SANTA BARBARA D. Caldwell		Running/ Complete

Table of Programmed Experiments (cont'd) - 7

Number	Title	Authors	Date Approved	Status
D-19	Measurement of Photofission Cross Sections of U-238 and Th-232	SLAC G. Svennson	12/8/70	Running
NT-3	Fast Cycling Bubble Chamber Development	SLAC H. Barney, R. Blumberg, A. Rogers, S. St. Lorant	12/15/68	Planning/ Setup
S-5	B Target Room Radiation Test	SLAC E. Sepp, R. Kase, D. Nelson	5/25/71	Ready to Run
T-12	Wire Chamber Spectrometer Checkout	SLAC S. Wojcicki	6/11/69	Complete
T-13	40-Inch Bubble Chamber Neon Fill Test	SLAC R. Watt	4/24/70	Inactive
T-15	Lead Plate Proportional Quantameter	U. OF HAWAII D. Yount	12/16/70	Inactive
T-19	Beam 19 Checkout for E-65	SLAC W. Toner/J. J. Murray		Running
T-20	Test of the Design Concepts for a High Energy Gamma Ray or Electron Detector	CAL TECH A. V. Tollestrup, R. Walker	1/13/71	Inactive
T-21	Test of UVT-Lucite Counter	LBL R. Budnitz		Complete
T-22	Calibration of a Large Cosmic Ray Detector	U. OF NEW HAMPSHIRE W. R. Weber, J. Rockstroh		Complete
T-28	Beam Line 21 Checkout	U. OF WASHINGTON J. Rothberg	4/6/71	Running
T-35	High Density Test Exposure of Nuclear Emulsions	U. OF WASHINGTON J. Lord	3/2/71	Complete
T-36	Spark Chamber Test	SLAC D. Fryberger, H. Lynch	3/22/71	Running/ Complete
T-40	Spark Chamber Test	SLAC E. Bloom	5/14/71	Running

Table of Programmed Experiments (cont'd) - 8

Number	Title	Authors	Date Approved	Status
T-41	Test for BC-47	SLAC K. Moffeit/J. Murray	5/20/71	Running/ Complete
T-42	Shower Counter Test	U. C. SANTA BARBARA F. Murphy	5/24/71	Running/ Complete
T-44	Antiproton Yield Test	SLAC J. Murray	5/26/71	Inactive
T-45	Lead Glass Counter Checkout	NAL J. K. Walker	6/2171	Inactive
T-46	Laser Beam Test	SLAC J. Murray	6/22/71	Construction/ Setup
T-47	Spark Chamber Test	SLAC D. Leith	6/22/71	Setup
T-48	Neutrino Interaction Test	SLAC S. Wojcicki	6/29/71	Setup
Y-5	SPEAR Transport Test	SLAC J. Harris, D. Walz	10/27/70	Running

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Running = Experiment is in data collection phase and was a prime user of accelerator time.
Checkout = Experiment is in checkout phase and used accelerator time for checkout purposes.
Setup = Experiment was being setup in the research yard.
Inactive = Experiment was inactive in the research yard.
Construction = Experiment and/or beam is under construction.
Ready to Run = Experiment ready for future scheduled run.
Parasiting = Used parasite beam time.
Completed = Experiment completed.
Special Test = Special test run performed.
Planning = In design and planning stage.

*Approved for checkout only.

3. EXPERIMENTAL FACILITIES

A. Operations and Improvements

The long operating cycle which started on April 13 was completed on May 22. This was the longest continuous operating cycle in SLAC history. Machine and experimental operations during the period were especially successful and productive. The highlights of the period include: (a) The successful computer-set energy switching of the accelerator and the beam switchyard by command of the E-66 experimenters' computer in the end station A counting house, (b) the exposure of over 1.25 million bubble chamber pictures which required over 9 million expansions of the bubble chamber, (c) the setup and checkout of beam line 22 for E-68, (d) data collection of over 3 million triggers of events in the K_0 spark chamber spectrometer of end station B, and finally, (e) numerous other experiments successfully performed during the period.

The rebuilding of the C-beam in the beam switchyard began in May. The equipment in this region is shared by beam lines 6, 9 and 23. When this work is completed it will be possible to run the laser beam to the 82-inch bubble chamber as scheduled in July. Considerable further work in the research yard will be required for the preparation of beam line 23 for E-60.

In end station A Experiment E-66, which began to take data toward the end of April, debugged the DATA LINK system and used it with great success. This new capability allows the Counting House computer to initiate energy changes in the primary electron beam from the accelerator. Commands initiated by the experimenters' computer in the end station A Counting House are sent through a data link to the Main Control Center computer and then through a second data link to the Central Control computer. These computers implement changes in the accelerator and the beam switchyard which produce the required energy primary electron beam.

A second silver calorimeter was assembled, instrumented, and tested and appears to be working successfully. The Power Supply Group was able to acquire a new, and smaller, supply to do the calibration of the two silver calorimeters, and the whole process is now a good deal simpler than in the past.

A large carriage for use in end station A for E-73 was constructed. Installation was completed during the June shutdown.

The 40" hydrogen bubble chamber started picture taking for BC-25 during the April cycle. This is a triggered bubble chamber experiment. At the end of April 27,759 pictures had been taken out of approximately 600,000 bubble chamber expansions at pulse rates of 3 and 4 pulses per second.

In May the chamber ran at 4 pulses per second until the 24th, at which time the rate was increased to 5 pulses per second with 22,000 pictures taken at this rate. The rate was increased to 6 pulses per second on May 27, and 1500 pictures were taken at this rate up to the end of the accelerator cycle on May 28. BC-25 uses an external spark chamber spectrometer and computer system to analyze events which trigger the bubble chamber lights and camera to obtain pictures of the selected events. As a result, many bubble chamber expansions are required for a relatively small number of pictures. During May BC-25 obtained 267,723 pictures while the bubble chamber was expanded 7.5 million times.

The new inflatable gasket and chamber modifications made in March have reduced the amount of chamber boiling during pulses; however, this was the first time rapid cycling has been attempted using the new refrigerator. (Previous running at 4 and 5 pps was done using the liquid hydrogen trailers.) Tests of rapid cycling operation were only partially successful and were discontinued after only a short trial period in order to proceed with a production exposure for BC-25.

The 82" hydrogen bubble chamber resumed picture taking on April 17, 1971 after being down for a 3-month rebuilding period. At the end of April the chamber had pulsed a total of 1,621,153 times and had experienced no mechanical breakdowns. The modifications made have reduced mechanical vibrations by a large factor. The new single strip 35 mm camera was used for the first time for BC-11 and experienced no mechanical difficulties. 413,560 pictures were taken for BC-30, and 316,577 pictures for BC-11.

The chamber started deuterium operations on May 2. Total pictures for the month of May were 837,829. BC-18 obtained 219,856 pictures and BC-19, 159,328 pictures. The chamber was then down from May 7 through May 14 to repair a fractured drive rod component. The unit that failed had accumulated a total of 30 million cycles. Picture taking resumed on May 16 and the following exposures were performed: BC-19 obtained 11,012 pictures; BC-35, 231,173; T-41, 4,415; BC-43, 47,549; and BC-38, 51,229. The chamber liquid

was changed from deuterium to hydrogen, the process taking longer than normal due to time needed to remove a large amount of dirt that appeared during the hydrogen fill. The chamber operated to the end of the cycle. BC-45 obtained 47,837 pictures; and BC-39, 65,430. There was a total of 1.7 million expansions of the 82" chamber during May.

The new 35 mm single strip camera has now taken a total of 1,055,638 pictures. New film magazines and film transport system have been designed for the 35 mm-3 strip cameras and a prototype is under construction for testing in July. The chamber was opened at the end of May for routine maintenance, including the removal of the BC-30 platinum target and installation of new optical coathangers.

B. Electronics Instrumentation Group Activities (July 1970 - June 1971)

1. High Energy Electronics Pool (HEEP)

During the past year HEEP has operated with a minimum of new equipment acquisitions. A computer inventory of all equipment on hand is updated weekly to reflect the movement of modular instrumentation from one experiment to the next. Because of effective forecasting of needs and good cooperation from users, most Pool equipment items are being utilized from 90 to 100% of the time. Some acquisitions have been made or are being made during this year. These include discriminators and scalers, two items which are in chronic short supply. A new readout and display system is being designed for the scalers (blind scalers in a CAMAC[1] package). Other items which have been procured are NIM bins and power supplies, CAMAC crates and power supplies, and a few phototube high voltage supplies. About 40 7-bit modular ADC's were built following an in-house design.

2. Instrumentation Development

Several important developments of new electronics devices or systems were made during the year. A list of the more significant items is as follows.

a. Proportional chamber electronics. Two versions of proportional chamber readout electronics have been constructed. The first version, which is now an operating system in the 20 GeV spectrometer in end station A, consists of fast IC amplifiers on each wire of the chamber, a fast delay cable to the Counting House for each signal, followed by a 4-level fast gate and latch

(1) CAMAC is a new data interface packaging standard.

on each wire. The gated latches are packaged in CAMAC. A scanner decodes the chamber digital information, stores it in a buffer memory, and later makes a transfer to an SDS 9300 main memory. The system has operated successfully in an experiment. The second version of this electronics packages a complete amplifier, electronic delay, and gated latch for each wire directly at the chamber. The scanned information leaves the chamber on a slow-speed digital dataway, rather than on high-speed coaxial cable. This system has not yet been used in a large scale experiment, but is planned for E-68. The current effort in proportional chamber electronics is aimed at producing an integrated-circuit or hybrid version of the amplifier-plus-logic. SLAC is cooperating fully with this inter-laboratory effort, and is currently responsible for negotiating for prototypes with vendors, and coordinating testing among different laboratories.

b. IC fast logic. A set of new modules is being designed for E-60. It is hoped that these units will become standard Pool equipment for use in future experiments. The units are: (1) A 16-channel discriminator-coincidence-latch with fast outputs and group-summed logic outputs, packaged in a 3-CAMAC width module; (2) A level-analyzer for performing event logic using the above summed outputs, packaged in a 2-CAMAC width module; and (3) A fast phototube amplifier, < 2 nsec rise and fall times, X90 variable gain, 8 channels packaged in a 1-width NIM module. The logic units use MECL II, and operate to rates of 50 MHz. Production cost savings over standard available modular instrumentation are conservatively estimated to be a factor of two.

c. New magnetostrictive readout electronics. A new magnetostrictive wire chamber readout system using the latest available LSI memory chips is in final construction. Cost reduction over standard available hardware of a factor of about 5 appears probable.

3. Experimental Group Support

The main areas of continuing support of research activities are in Data Analysis, and Experimental Groups A, B, and G. The principal activity in Group A has been the development of proportional chamber systems; in Group B, magnetostrictive readout and computer interface electronics; and in Group G, the implementation of a large new spectrometer involving capacitive readout wire chambers and a high-precision time-of-flight system.

4. SPEAR Support

A large effort is presently being applied to the SPEAR computer control system, position monitors and feedback controls, and transport line position monitors and displays. Additional effort in development of detector systems is anticipated shortly.

4. ACCELERATOR IMPROVEMENTS

Fabrication and installation of pulsed focusing quadrupoles continued. During the June shutdown eight magnets were installed in four locations. All coils have been wound and support hardware is on hand. Cores are being stacked and vacuum chambers fabricated to support the installation schedule which now calls for completion by the end of November. Installation can be performed only during shutdown periods. Bids were requested in June for both steering and focusing power supplies, but the one bid received was not acceptable. Additional bids will be requested. It is still planned to have the system operational by the end of the calendar year.

Work on the pulsed phase closure was suspended while awaiting delivery of new high power latching circulators which were due in May but had not been delivered by June 30. They are expected in July and installation of the system is scheduled for August or September.

Expansion of the data system to improve and speed up reporting to and from CCR and the computer of various signals along the machine continued.

Work on the DAB rack and cabling expansion continued. During April cables were installed between Building 209 and the Main Control Center and were tied into the main distribution frame during May. Some rack rearrangement in the Main Control Center was accomplished and will be continued as time and conditions allow.

Improvement to the pulse generation system continued. Oscilloscope triggering was upgraded and work was started on a short pulse amplifier required to trigger the injector for SPEAR pulses.

Fabrication of the new positron source was started. Final prints will be delivered to the shop by late July and fabrication will be completed by mid-September. Installation is scheduled for the latter part of September.

Consolidation of the two control rooms continued. Two 10×13 channel models of a crossed-wire matrix type touch panel were fabricated during the quarter and in June were mounted on 14" TV screens installed in a console in the Main Control Center. They were tested satisfactorily and will be given further tests during the July experimental run. Fabrication of a 10×13 channel ultrasonic touch panel was begun and it will be installed on a 17" TV screen during the September shutdown.

Fabrication of a digital input multiplexer was completed in May and installation was completed in June. This acts as an interface between accelerator signals and the XDS 925 computer.

5. KLYSTRON STUDIES

A. Development

1. High Power Klystrons

The development work undertaken during the past few quarters to eliminate the pulse breakup on SLAC tubes has been completed with a decision to modify the 4th and 5th cavities by increasing the nose radius. Some additional tests will be needed to determine the effect of drift tube diameter in the output cavity to obtain the best compromise between efficiency and lack of breakup. The final information on this change is not available yet because of a gassing problem which developed during the quarter and did not enable us to complete significant tests on some of the rf modifications in the tube.

The gas problem originates in the gun package and is being thoroughly investigated to determine the exact source of the gas. A residual gas analyzer is used in the investigation and the cathode package is being disassembled to determine the component responsible for the gasses observed in the residual gas analyzer. Because of this analysis no tubes have been put through bake during the last six weeks of the quarter.

In the meantime the Klystron Department has been busy on tentative designs for future improvements as follows:

a. Higher power — A working decision was made during the quarter to develop a 60 MW peak power klystron at SLAC. This tube will be designed as a microperveance 1 klystron to operate at approximately 50% efficiency in permanent magnet in either one of 2 modes; at 60 MW peak, 180 pps, or 40 MW peak, at 360 pps. Microperveance 1 was chosen after consideration of probable tube efficiency, high voltage breakdown problems and magnetic field requirements. Preliminary study in the electrolytic tank and with the computer indicates that the present seal geometry can be modified to maintain sufficiently low gradients at the anticipated operating voltage. Extensive magnetic measurements have begun on our permanent magnets to study the possibility of field reversal and field stretching for application with the new 60 MW tubes. Initial computer studies of the gun design has indicated the probability of being able to hold at the voltages needed for 60 MW peak.

b. SAD (SLAC Advanced Design) klystron — We obtained approximately 40% efficiency at 20 kV but the tube stability was not as good as had been

anticipated and computed. Excessive heating observed in the ridge waveguide output probably contributed to the pulse droop observed at long pulse length. Future development of this tube will coincide with the proposed tube for the superconducting booster for the recirculating linear accelerator.

c. Recirculating linear accelerator — Two tubes are being considered for the recirculating linear accelerator: a CW klystron with peak power output of approximately 40 kW to fit the possible standing wave superconducting accelerator which will restore the synchrotron radiation losses in the recirculation loops, or a 220 kW peak, 11% duty klystron designed to achieve the same results with standard accelerator sections. This last tube will probably be procured directly from industry but a careful study of the needed specifications has begun.

d. SLACKLY (klystron computer program) — A major effort was made at the end of the quarter to analyze and complete the klystron program based on Wessel-Berg's theoretical paper. Up to now we have experienced convergence problems which appear to be caused by the gap functions used in the program.

2. Klystron Procurement

A procurement contract was signed with RCA Tube Division, Lancaster, Pa., for the procurement of 144 - 28 MW tubes to be delivered during the next 3 years. The majority of the RCA tubes owed as replacement under the old contract are coming in as 270 kV, 28 MW tubes.

3. Windows

Operating experience has been very good from a window standpoint with only one window failure. This failure occurred on a RCA tube manufactured in late 1966. At that time RCA was experiencing difficulties in maintaining the usual window quality.

Of the 13 SLAC tubes tested after bake only one indicated what might be an excessive temperature gradient from the center to the edge. No damage was caused by this temperature gradient but neither has any reason been found why this one window had a higher gradient than normal.

B. Operation and Maintenance

Accelerator operations were limited to one long cycle this quarter. The 254,000 klystron operating hours accumulated corresponds to the longest continuous operating period thus far. It is not known if the low number of

failures and high MTBF for the quarter is due in part at least to the uninterrupted operation.

On the other hand there were 4 subbooster failures, 3 SLAC and 1 Eimac. The latter had almost 33,000 hours of operation.

1. High Power Klystron Operation

Usage and failures of klystrons from all vendors are summarized in Table 2, and is plotted in Fig. 3. As expected the cumulative MTBF is still substantially constant. What is not expected is that the mean age at failure of all tubes is still well below both the mean age of living tubes and the MTBF.

Figures 4 and 5 give the tube age distribution of all living and failed klystrons respectively in 500 hour increments.

The data shown in these last figures have been analyzed to obtain the failure and survival probability and the results are shown in Fig. 6.

2. High Power Klystron Maintenance

During the quarter sectors 25 and 26 were operated for the first time at 265 kV. In addition a special test was run in station 26-7 to investigate the possibility of recombining the power output of 2 tubes thus increasing the available power for merger to 60 MW at 180 pps. Although the failure rate is still higher for 265 kV sectors it is not dramatically so; 33% of the failures occurred at 265 kV with 20% of the machine operating at that level. However, on the small sample of 9 failures total, the expected statistical variations are much higher than the difference quoted above.

There were 28 replacements during the quarter. The number of replacements due to suspected tank failures was substantially better than previously and was only 5 out of the total replacements.

During the previous quarters a large number of Litton failures were caused by temperature limited emission between 5,000 and 7,000 hours of operation. This quarter the temperature limited failures have substantially disappeared.

A klystron was installed in the second rf separator station but lack of progress on the peripheral equipment made it impossible to process the tube in the station this quarter.

TABLE 2

KLYSTRON MTBF

Dates	PER QUARTER				CUMULATIVE			
	Operating Hours	Failures Number	Failures Mean Age	MTBF	Operating Hours	Failures Number	Failures Mean Age	MTBF
To 6/30/66					129,400	19	260	7,200
To 9/30/66	111,000	8	610	14,000	240,400	27	360	9,000
To 12/31/66	154,000	11	1,100	14,000	394,400	38	575	10,300
To 3/31/67	207,000	13	1,490	15,900	601,400	51	810	11,800
To 6/30/67	287,000	9	2,490	32,000	888,400	60	1,060	14,800
To 9/30/67	330,500	25	2,860	13,300	1,218,900	85	1,590	14,500
To 12/31/67	263,000	21	3,520	12,500	1,481,900	106	1,980	14,100
To 3/31/68	309,500	17	4,800	18,200	1,791,400	123	2,360	14,700
To 6/30/68	306,000	15	3,820	20,400	2,097,400	138	2,520	15,200
To 9/30/68	314,200	24	5,500	13,100	2,411,600	162	2,960	14,900
To 12/31/68	349,800	23	8,350	15,200	2,761,400	185	3,630	15,000
To 3/31/69	328,600	20	6,610	16,400	3,090,000	205	3,930	15,100
To 6/30/69	335,000	16	7,280	19,700	3,425,000	221	4,190	15,400
To 9/30/69	179,800	8	11,670	22,500	3,608,100	229	4,450	15,750
To 12/31/69	303,600	10	10,230	30,400	3,911,700	239	4,690	16,300
To 3/31/70	358,700	32	9,950	11,200	4,270,400	271	5,270	15,800
To 6/30/70	257,200	18	11,350	14,300	4,527,600	289	5,650	15,700
To 9/30/70	259,600	13	9,600	20,000	4,787,100	302	5,810	15,800
To 12/31/70	365,800	31	10,800	11,800	5,152,900	333	6,280	15,500
To 3/31/71	220,200	11	9,600	20,000	5,373,100	344	6,400	15,600
To 6/30/71	254,000	9	6,200	28,200	5,627,500	353	6,400	15,900

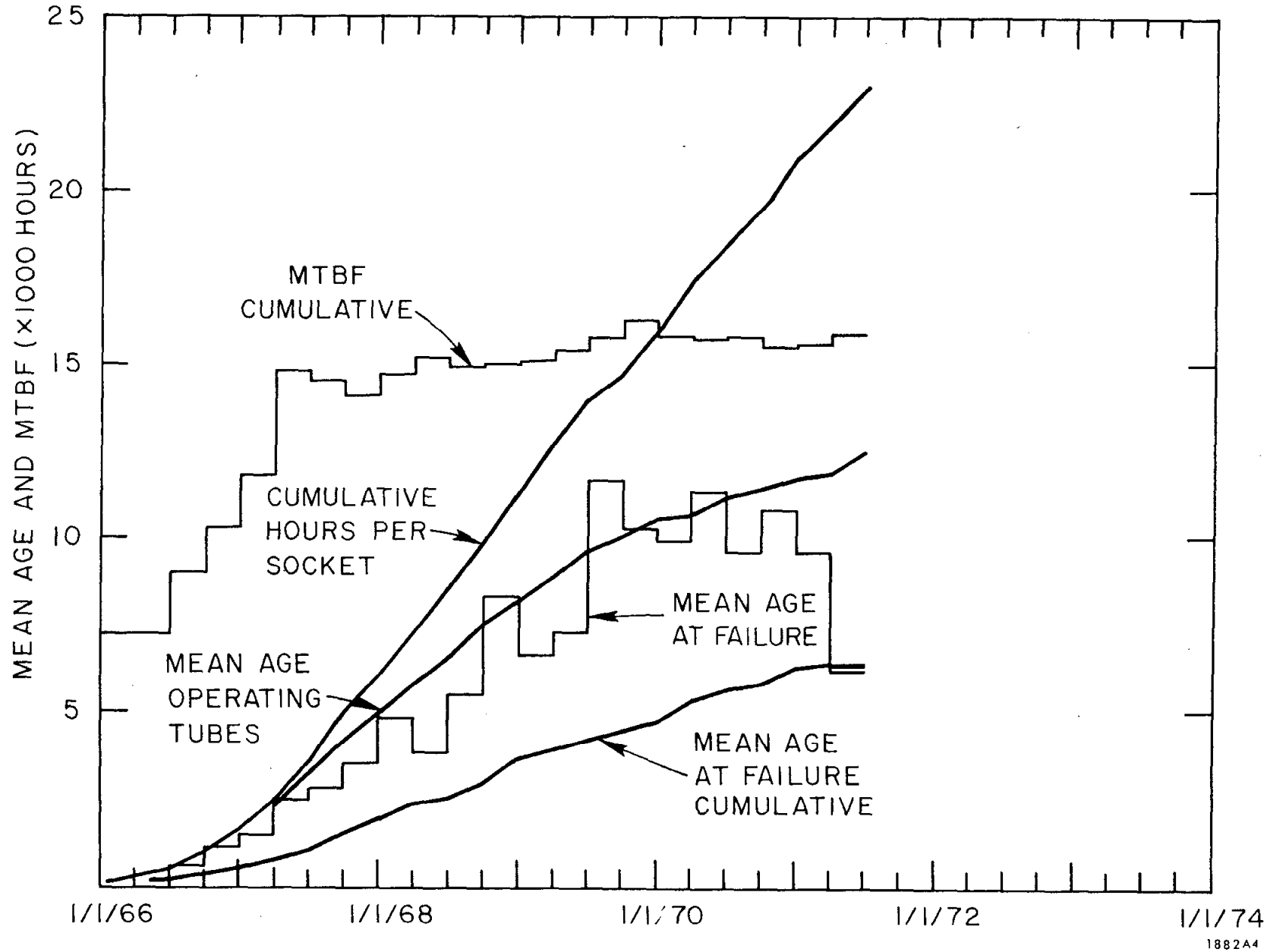

FIG. 3--High power klystrons: cumulative MTBF, mean age, mean age at failure, cumulative age at failure, and cumulative hours per socket, June 30, 1971.

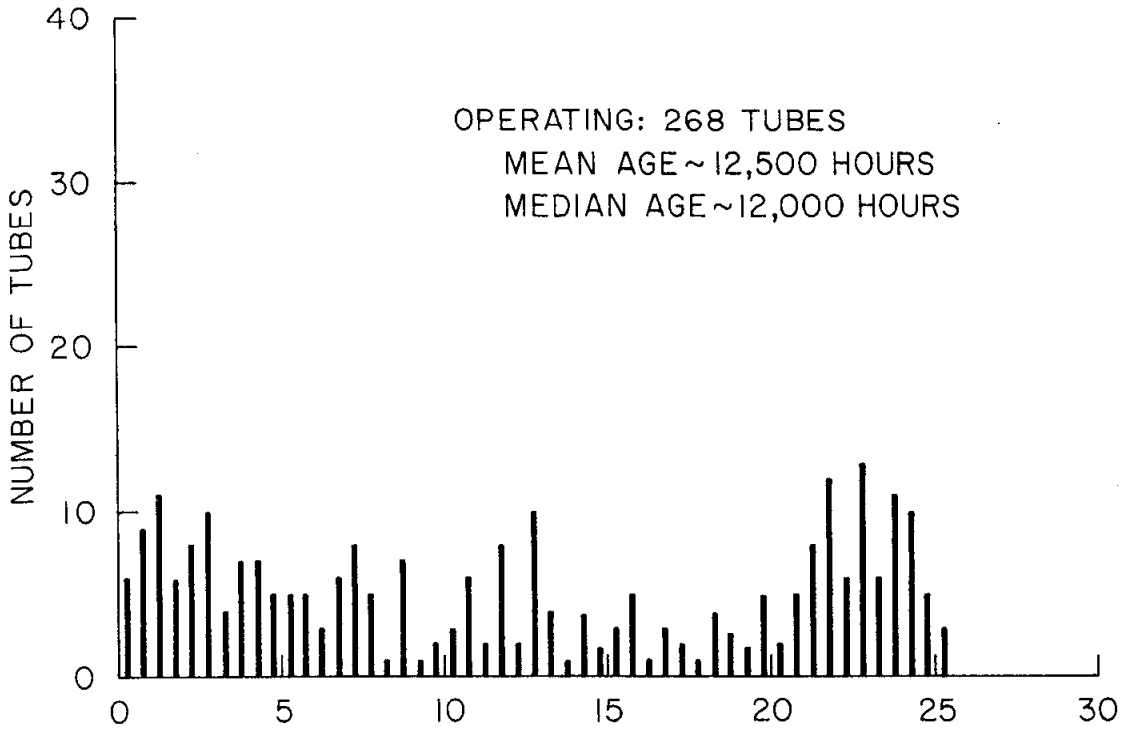

FIG. 4--High power klystrons: age distribution of operating tubes, June 30, 1971.

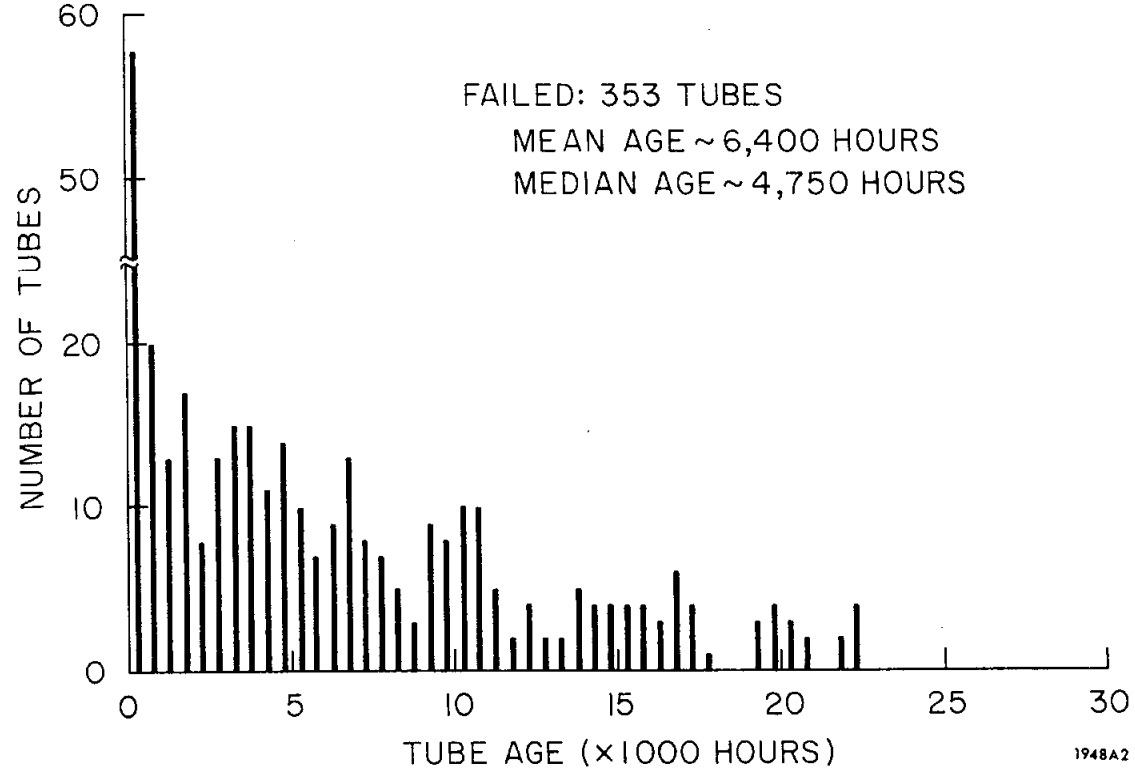

FIG. 5--High power klystrons: age distribution of failed tubes, June 30, 1971.

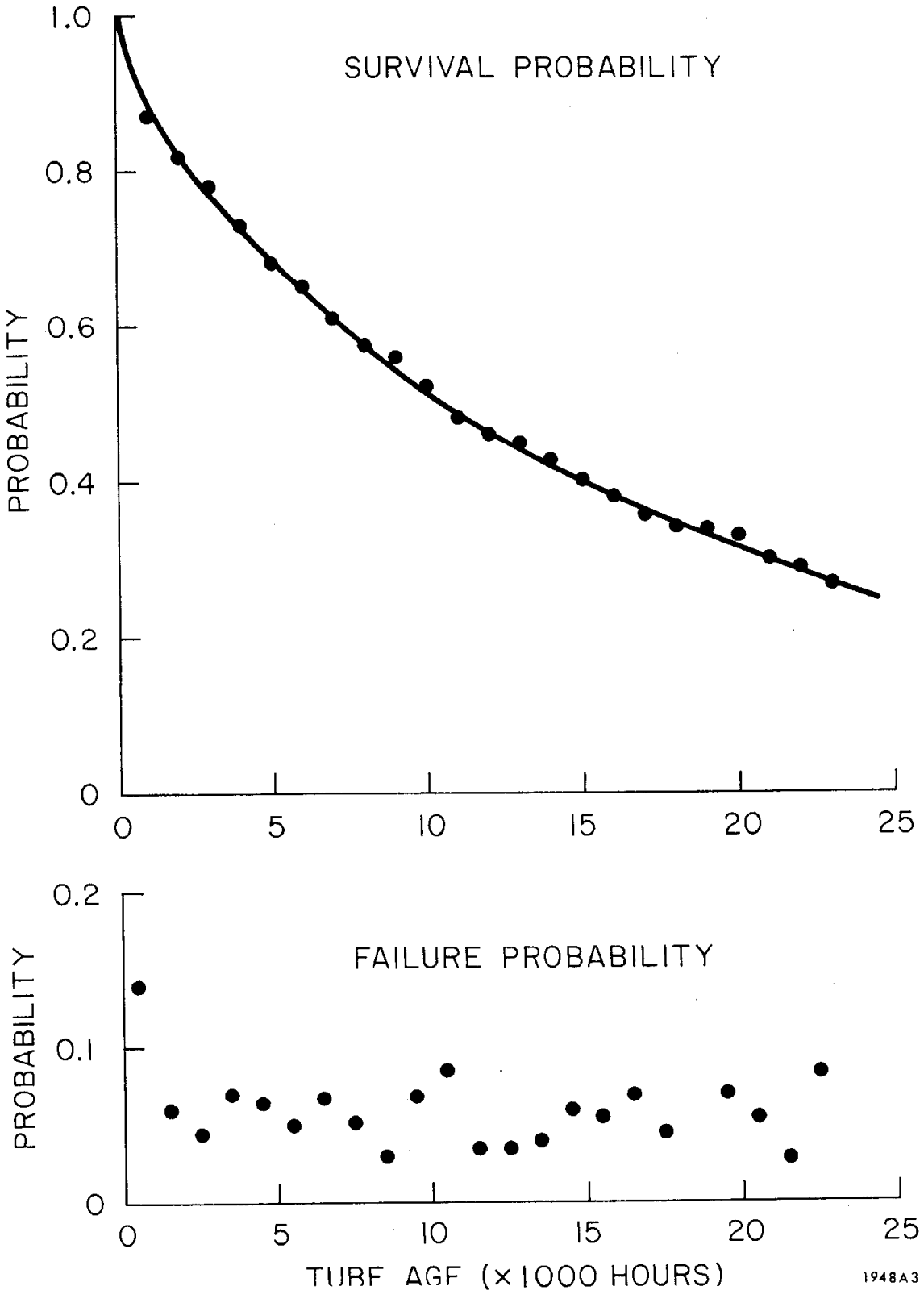

FIG. 6--High power klystrons: survival and failure probabilities, June 30, 1971.

3. Subbooster Klystrons

In spite of the 4 failures during the quarter (1 Eimac and 3 SLAC) the life statistics on SLAC built tubes continues excellent. The results are shown in Fig. 7 indicating a 60% probability of survival after 13,000 hours of operation.

4. Main Booster Klystrons

No replacements, no failures and only three trouble reports. Power output noise continues to be a concern but trimming of the tube parameters (focus current, drive power) keeps it within specifications.

The investigation of diurnal power output drift (and general tube performance) as a function of temperature, begun during the previous quarter, has continued. No elegant solution has yet been found but overall implications are that operation at approximately 70°F or less minimizes the long term (approximately .05 db in a single 36 hour period) and short term power output drift and noise. Indications are that the increase in drift rate with temperature is nonlinear and that with temperatures $< 85^{\circ}$F the long and short term drifts exceed 0.1 db within a 24 hour period.

Plant Engineering has ducted the exhaust cooling air from the two stations outside the gallery in an attempt to increase cooling.

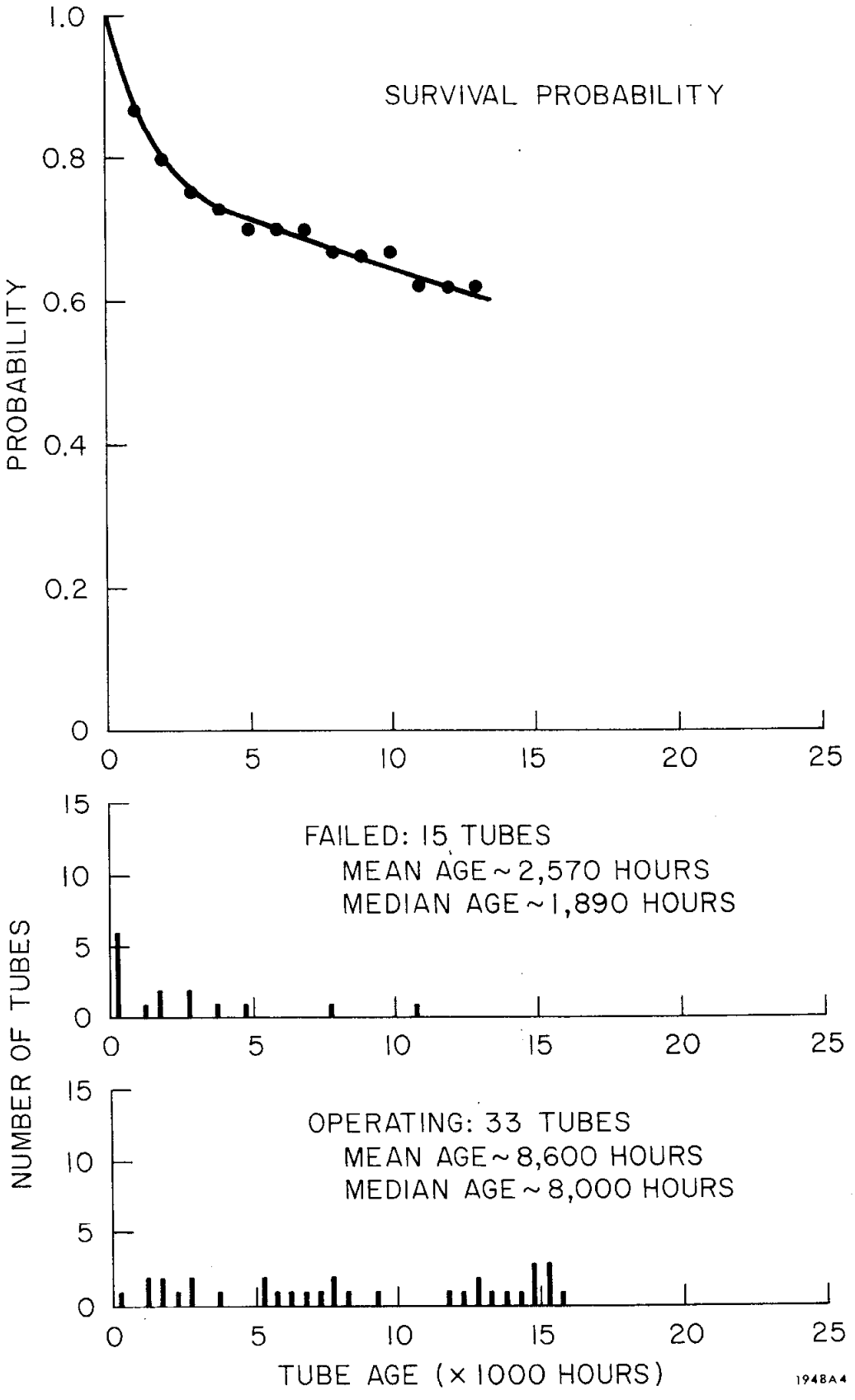

FIG. 7--Subbooster klystrons: age distribution of operating and failed tubes, and survival probability, June 30, 1971.

6. ACCELERATOR INSTRUMENTATION AND CONTROL

(January 1, 1971 to June 30, 1971)

A. Computer Software

During this period the following functions have been added to the Central Control Room (CCR) Computer System, a Digital Equipment Corporation PDP-9.

Pattern generation software — The July 1971 cycle is being run on computer-generated trigger patterns simulating the CCR switches. The plan is to eventually replace the CCR switches by software touch panels for control room consolidation.

Touch panel software — All programs to accept and execute commands from Main Control Center (MCC) over the data link are complete. Touch panels have been controlling "beam maintenance" parameters from MCC on an experimental basis during the July 1971 cycle.

Program development — An interactive program editor and assembler were written into the disk system (DS), allowing on-line program development to continue without shutting down the CCR computer system.

Quadrupole program improvements — The CCR quadrupole setting program was expanded, allowing 12 tables to be stored on the disk and edited from the typewriter.

Test programs — Software to checkout analog signals from the spectrum foils was written. These signals will be used in the fast (1 beam pulse time response) klystron replacement computer function.

Considerable effort is being made to implement a disk-oriented operating system for the MCC XDS-925 computer. It will be similar to the DS on the CCR PDP-9, including the important program development facilities. The system should be ready by September, 1971, at which time the touch panel software can be incorporated. This will allow the operators to select configurations from a great variety of touch panels on the XDS-925 drum.

B. XDS-925 Computer

1. XDS-925 tune box — A new interface was designed, built and installed replacing an earlier obsolete unit. The new interface allows up to 24 magnet power supplies in MCC to be selected and adjusted from the control console via the computer. It connects to DID1.

2. Digital input device 1 auto check — 96 bits of DID1 have been modified to allow software directed self-check of the complete DID1 system computer hardware.

3. A 6-bit parallel full duplex link was designed, built and installed between the XDS-925 in MCC and the XDS-9300 in Counting House A. The link is fully operational.

4. A fast sequential digital scanner has been installed to input digital data into the XDS-925. This is presently being used for touch panel communication.

5. A crossed-wire touch panel was developed using a 10 × 13 gold plated, stainless steel wire matrix which is to be used in conjunction with the 925 for accelerator control. Prototypes appear to operate satisfactorily and no additional electronics is required to interface these panels to the computer.

6. A priority-interrupt interface was installed to indicate and inhibit interrupts. Work is progressing on a high resolution DVM scanner to read shunts and other analog signals into the computer.

C. CCR Computer-Pattern System Interface

A pattern interface has been built and connected to the PDP-9 computer. The data channel system is used to output 8-18 bit words to storage registers in the interface. Output of these pattern words starts about 250 μsec after beam time and the 144 bits representing 144 patterns are loaded into their respective registers in about 50 μsec. The storage registers hold their information from that time until 120 μsec after the next beam time at which time all registers are reset in preparation for reloading. Level shifters (to convert the DEC logic levels to XDS levels) are also contained in this interface. The pattern system control logic has been designed with three modes: Computer, manual, and hold. The computer-manual selection is made by the CCR operator. The hold state occurs if all beams are inhibited by MCC or the experimenters or if critical voltages disappear in the interface. In the manual state, all level shifters are clamped to "no pattern" and the CCR pattern switches feed their information to the pattern system directly. In the computer mode, the computer has been programmed to read the switch positions and transmit this information to the pattern system. This is the interim or maintenance mode which is now being used to check the software and the hardware. This mode will be retained for maintenance use in the future; however, the patterns will be generated by the computer in accordance with touch panel inputs from MCC.

D. CCR Computer Analog Selectors

Three computer analog selectors have been built to enable the computer to read accelerator and CCR analogs. Signals are selected (based on the remote control command) and are digitized by the slow analog-to-digital converter (ADC) system. The digitized signals are then read by the input scanner-multiplexer and deposited in memory under DS program control. The analog voltages are either 0 to +5 or 0 to +1 volts. Provisions are being made to extend the system so that -1 to +1 voltage levels can be digitized in the future. A number of analogs (along with their respective controls) were required to implement the first version of the touch panel which is being tested now.

E. Computer Subdevice Selection

The control word of the PDP-9 has been designated so that various elements can be specified by the structure of the word. Six bits of the word specify the area in which the command will be effective, 6 bits specify the specific command (remote control channel number), 2 bits specify four possible states of the command, i.e., up, down, off, or preset (the preset option allows the complete command path to be established and then an up or down or a burst command to be sent quickly), 1 bit requests the computer interface to read a slow analog, and 3 bits have been reserved for subdevice selection. Subdevice selection can be visualized as an extension of the total number of available commands. Subdevice commands are now used to select "levels" of a control (where levels can correspond to beam lines) and to subselect identical devices in the same sector.

F. CCR Computer Signal Summary

A count of the number of CCR accelerator signals connected to the PDP-9 was made on June 30, 1971 as part of the SLAC Control Room consolidation. The log Q-direct memory access signals originate along the accelerator (together with three signals from MCC) and are sent via the existing log Q transmission system to CCR. This system can read many analog signals per beam pulse and is used to send pulsed signals, i.e., pulsed quadrupole analogs, to CCR. In the table below, DSO1 is an input multiplexer. Word 1 is the bits read every beam pulse. Words 2 and 3 scan all binary status in the gallery. Words 4 and 5 scan binary status in CCR and the slow analog signals normally presented on meters. Patterns refer to the computer generated patterns described elsewhere in this report. Remote control signals refer to the sector, CCR, and

DAB remote control signals originating in CCR. Rates are signals sent to each sector to pulse the klystrons after beam time.

The summary table follows and includes the number of signals remaining to be connected to the computer as well as the computer input/output ports available for each of these interfaces.

Signal	Connected	To Be Connected	Ports Available
Log Q-DMA	84	170	348
DSO1 Word 1	18	-	18
Word 2,3	2644	-	3968
Word 4	488	100	768
Word 5 (incl.)	199	20	1152
Slow Analogs	574	25	600
Patterns	100	-	144
Remote Control	940	150	2112
Rates	-	30	-
Total Signals	5047	495	9110

G. Sector Memory (CCR Computer)

A discrete component version of the sector memory has recently been removed from sector 16. It has been in operation for over a year and performed without failure during that period. A new (and simpler) memory proposal has been made which requires more software in the PDP-9 but less hardware in the sectors. This should result in a sizable cost reduction. The original sector memory had timing circuitry which inhibited immediate control of the relay tree (to eliminate false commands) and additional circuitry to immediately send a command to a device if the preceding command had been to that same device within a specified time. This would in effect produce a continuous command in the sector with occasional service from the CCR computer. Cost savings are also possible by selection of the fabrication method and this aspect is being investigated together with further simplification in hardware logic.

H. Beam Containment Study

As a result of studies on the effects of the SLAC high power electron beam, which included the Y8 experiments, a good deal of work has been done, and more is planned, to improve the security of protection systems. Until recently at

SLAC, there were two conceptually separate protection systems. One, the machine protection system, was required to be highly reliable, but with sufficient flexibility so that experiments could be done without unnecessary delay or expense. No unavoidable possibility of error or failure was to be tolerated in the personnel protection system. It has now become more clearly recognized that, in fact, certain elements in the machine protection system have been used to augment the personnel protection function, but that these elements had not been brought under the rigid control that is desirable for human safety. Present efforts are directed toward the creation of a third system called the beam containment protection system, which will provide security and flexibility characteristics which are intermediate between those of the two original systems.

The purpose of the new system is to assure that beam line slits, collimators, dumps, etc., are all intact, and in the event of any overheating, to shut off the beam before sufficient damage can be done to allow the beam to penetrate through barriers and produce high radiation levels in inhabitable areas. To this end, a variety of heat sensors, soft plugs, pressure switches, melt-through contactors, and radiation sensors have been installed and tested. Some new sensors and some old ones, which had belonged to the machine protection system, have been connected to the new system. It is planned that the new system will eventually be accommodated by cables which are physically separated from those belonging to other systems and that its logical elements will be mounted in separate, locked racks. Security will be increased by redundancy, self-checking circuits, and fail safe arrangements as seem suitable in different cases. The new system already has triply redundant means to shut off the beam: it breaks tone loops, stops the permissive pulses, and turns off all pattern pulses.

A beam line subdividing circuit was installed. This makes it possible to produce two beams having identical properties except for rate and destination. The feature is desirable in certain cases, e.g., when the spectrum of the experimenter's beam cannot be measured directly, and adjustments must be made using a monitor beam which is observable.

The ion chamber system at beam analyzing station 2 (BASII) in sector 20 was completed, and satisfactory performance was verified. It was connected to the tone interrupt system. The ion chambers respond to radiation which results when the beam energy doesn't agree with the BASII magnet setting, thus shutting off the beam.

Some small air filled ion chambers were tested at protection collimator PC42 in the B target room. The idea is to develop sensors that will respond to radiation produced in the device to be protected but are insensitive to radiation from other sources. Such detectors could largely eliminate a need, which now often arises, to disable parts of protection systems. This would in turn have beneficial effects on the security of the systems. The small ion chambers were mounted in a peripheral slot that had been cut into the body of PC42 to form a vacuum-loss failure indicator. Sensitivity was satisfactory and the surrounding material proved to be a very effective shield against radiation from the E64 beam (18.5 kW) which struck the 8T1 target a few feet away from PC42.

I. Personnel Protection

Several new logic systems have been built and installed within the personnel protection system (PPS).

The D9 experiment required the inclusion of door monitors and status, gates and keybank status and control of doors and keybanks. Stopper controls and status also had to be implemented to satisfy safety requirements. This complete system was later removed after four months of operation.

Logic was also installed for Experiment E-65 in Building 109 which used beam line 19. The logic for end station B was modified to include a new B slit assembly. PPS logic in CCR was modified so that BASII mode operation requires the insertion of sector 21 fast valve.

Two new types of beam disaster monitors have been developed; one is burn-through type which has been added to slit 15SL1. The other type utilizes two pressure switches and has been used at PC64 and safety collimator 9SC1.

J. Klystron Gallery

1. Beam Guidance System

Two additional quadrupole doublets have been installed in sector 30 and integrated into the CCR quad controls. The additional doublets will be used for SPEAR beams.

A new pulsed quadrupole power supply (PQPS) prototype was installed in sector 28. Its operating voltage has been reduced to prevent the arcing problems caused by the former supply. The test has been successful and this power supply design is scheduled to be used in all locations with pulsed quads.

To improve beam knockout (BKO) operation, a two level power supply is now permanently installed at the BKO.

2. Trigger System

The pattern distribution amplifier system is now completely installed. It supplies patterns to the pulsed beam guidance equipment.

Separate two level patterns are now provided for the DS10-H pulsed steering power supply (PSPS) and the horizontal deflector power supply.

Beam splitting on a research area line is provided for a scheduled experiment in July. This was done to simplify operation of the monitor beam.

3. Positron Source

The positron modulator and klystron 11.M.3C is now removed including I/C instrumentation. The unit serves now as rf separator in the research yard.

The scale of the Lin Q monitor at 11-3-5 in sector 11 was modified to provide an extended range.

4. Computer Operation

The installation of numbers of pulsed quads, pulsed steering power supplies, pulsed beam loading unit and a pulsed phase closure system has made necessary a substantial increase in the number of remote control and monitoring channels. To meet this requirement, the existing control channels have been subdivided by means of "looped" or "daisy chained" subdevice selectors installed along the klystron gallery. The selectors are operated in common by master controls in CCR. The first installation switched all such controls and monitoring circuits in one common system, and was to be awkward for multibeam operation by the CCR operators. It has accordingly been split in two to separate the phase closure function from the others. It was necessary also to make modifications to the system to accommodate computer control.

DC steering, pulsed steering, and pulsed quad controllers have additional connections to the remote control system, permitting both manual and computer control. Along with these changes, the PQPS controls were integrated with the dc quad controls in the switched sector panel.

A test is in preparation in sectors 4, 5 and 6 to read drift section dc steering signals into the log Q XY system for display in CCR on the log Q scope. If the test is successful, all drift section dc steering signals will be handled this way.

5. Modulator Test

Modulator station 26-7 was modified to test the operation of two klystrons from one modulator. The 11C instrumentation has to be changed for this test. For some time the station accelerated a beam at 180 pps.

K. SPEAR

The design of the SPEAR spectrum monitor electronics was started. The basic design criteria were settled and several prototype circuits were evaluated. The high quality triaxial cables connecting the secondary emission monitor (SEM) foils to the electronics in MCC were ordered and installed.

Instrumentation for control and monitoring of the SPEAR beam up to the slit 15SL1 has been installed and is being checked. This includes control and readout of magnets 15D1, 15Q1, 15Q2, and 15A2, profile monitor 15PR2 and all required vacuum valves and pump stations. A new trigger generator for the SPEAR pulsed magnet 15PM1 has been installed in sector 30.

L. Safety Interlocks

As noted under Section 6.H, many new protection systems have been added to give early warning of impending damage to beam line components. These include average current interlocks in the B and C beams and comparators which measure the current at one point in a beam line and compare this value with a downstream SEM. If the SEM signal drops below a preset level, the beam is shut off. SEM integrators have also been added. These turn off the beam if the integrated charge at a dump exceeds a predetermined level. Finally, redundant paths for turning off the beam have been established. These include turning all accelerator patterns to standby and shutting off the injector trigger generator via the machine protection tone loop.

M. C Beam

The new C beams installed during this period have required significant additions to the I&C control and monitoring equipment in MCC. Ten new power supplies can now be controlled from MCC, four new SEM's have been installed, a new position monitor P60 added, and new interlocks for the 6/23 K^- line, 6/23 μ^+ and beam line 9 have been added.

7. PLANT ENGINEERING

Project work continued throughout the quarter in support of the colliding beam storage ring in SLAC's north target yard. Installation of the above-ground electrical utilities is approximately 90% done. Offsite casting of concrete shielding blocks for the ring housing is under way and a number of the blocks are on hand. The power supply and control buildings are in place, mechanical services in the latter being 95% done. Partial installation of the water service is just now starting. Bids for the bridge trestle are scheduled for opening on July 1, 1971. Design is well along on the balance of the facilities and bid invitations will be issued in the next quarter. Included are these major items: Erection of the two interaction pit buildings, erection of the ring housing blocks, and installation of the balance of the water services. This overall effort is the major item in the current plant engineering field program.

Eleven individual projects, programmatically approved by the Atomic Energy Commission for fiscal year 1971 funding, relate to the Fire, Safety, and Adequacy of Operation program (FSO). The eleven are as listed below, the first seven having been completed. The remaining four are in various stages of design or construction and will be finished by the end of the next quarter.

1. Standby Computer Power - Building 214
2. Research Yard Safety
3. Remote Radiation Monitoring Power Service
4. Acid Area Protection - Crafts Building
5. Air Compressor Cooling Water Modifications
6. Fan Noise Attenuation - Crafts Building
7. Upgrading of Computer Repair Area (DAB)
8. Research Yard Emergency Power
9. LH_2 Safety Facilities near Building 111
10. SLAC Drainage Control
11. Hydrogen Target Test Cell

Additional FSO items will be covered by fiscal 1972 funding, plans to that end already having been scoped.

Field work is in progress on several other capital projects, the principal ones being as follows:

1. Film processing facility — An air conditioning system has just been added to this building and is being checked out.

2. End station B utility extension — Installation of the mechanical and electrical components in support of new beam line experiments is essentially complete. (See Item #3, below.)

3. Housing for new beam line experiments — Main buildings #403 and 413, together with associated buildings #203, #231, and #311 are now in position in the research yard. The necessary housing and utility modifications are largely done.

4. Cooling tower cell — This project increases the capacity of the BSY cooling water tower by adding a cell to the three already in service. The new basin has been constructed; erection of the tower will start in July, 1971.

5. Electrical services — A 2 MVA unit substation has been added to the research yard utility system. A transformer was procured and installed in the BSY substation, replacing a unit damaged in service at that location.

6. Sandblast and hydrogen furnace housing — A new building has been erected south of and adjacent to the Test Laboratory to house facilities in support of SLAC's klystron program. Interior partitioning and services are now being installed.

Preliminary work on various other items, as stated below, is under way.

1. Design has been started on three plant projects, these being the last remaining jobs on the FY71 General Plant Project program. Scheduled for construction in the next quarter, these are: (a) an electric communication trench connecting temporary computer Building 214 and the Central Laboratory; (b) upgrading of the ventilation system in the power supply room of the Main Control Center (DAB); (c) erection of a power supply shelter in the research yard as required for beam line #23 work.

2. Engineering studies — A new cost estimate for a recirculating accelerator beam (SUPER SLOOP) was made for SLAC management, based on a revised scope of the conventional facilities. Load studies and a revised electric power service forecase were prepared for use by the Atomic Energy Commission. An intensive study of "improved risk criteria" for fire

protection of SLAC facilities was made; the basic information will be used in connection with various FSO projects next year.

The department's on-going program of plant utilities operation and minor modifications to buildings and site structures was continued. Five new offices were constructed on the 3rd floor of the Central Laboratory in a portion of the area formerly occupied by the main SLAC library. Piping for a helium supply system was installed as a service facility connecting the research yard, end station A, and the gas storage area near the north yard. Both electrical and mechanical improvements were effected in several of the variable voltage substations along the klystron gallery. Extensive utility and housing modifications were made in many of the research yard facilities in support of the changing requirements of the experimental physics program. Assistance was given to other departments in connection with their utility requirements for machine operation, and also for the SPEAR beam transport piping, electrical, and shielding block requirements.

8. RESEARCH DIVISION DEVELOPMENT

A. SPEAR Activities

1. Main Magnet System

The four half-length bend magnets for the SPEAR lattice have been magnetically tested and found to be satisfactory. In all twenty-five standard bending magnets, eight quadrupoles, and four half-length bends have now been processed by magnetic quality control. Three distinct families of bending magnets can now be correlated with steel composition.

The prototype for the special sextupole (SDI) has been fabricated and is scheduled for magnetic measurements to evaluate the possibility of using cast cores for these magnets as was done for the standard sextupoles. The standard sextupoles have now all had their magnetic center found and fiducial marks have been placed for alignment purposes.

2. Vacuum System

The production of module girder vacuum chamber assemblies is progressing basically on schedule. The first prototype synchrotron light port was machined, chemically cleaned, and welded. The initial tests are satisfactory. The beam bump electrode for producing a vertical crossing angle at the interaction region has been designed, and the procurement of components has started.

Pumpdown and bakeout of the 11S12 drift tube, the lone "standard" straight section, has been completed. The assembly withstood a 200°C bakeout and appears adequate as far as pressure and cleanliness are concerned.

3. RF System

The rf cavity was chemically cleaned, assembled, and welded, including transitions and flanges, and initial results appear satisfactory from a vacuum standpoint. Bakeout tests are expected to be initiated in July. The cavity has been measured for resonant frequency, Q, and shunt resistance, all of which were within specification. All higher modes up to 500 MHz have been located. There are no higher modes with field on the gap axis at a harmonic of the fundamental.

In the power supply building, hangers have been installed for the support of the coaxial combining networks and connecting lines, and all coaxial line parts have been received. AC power to the 8 rf amplifiers has now been installed up to the individual disconnect switches of each amplifier.

4. Injection System

The first copper vacuum chamber for the septum magnet has been brazed and appears to be of high quality. A magnetic field survey will be made with the magnet and copper chamber in their correct relative position. The majority of the other septum parts are completed. Fabrication of the remaining septum straight-section components is proceeding.

The first shipment of kicker magnet ferrites arrived from Phillips and, despite precautions taken in procurement, the ferrite is contaminated by heavy hydrocarbons, which have been shown up in the vacuum qualification tests. An attempt at refiring at a temperature of 900 to 1000^{o}C is currently in progress. If successful, this should eliminate heavy hydrocarbon contamination and render the ferrites usable for SPEAR.

5. Transport System

The linac shutdown in the latter half of June allowed the installation of in-housing elements of the beam line to proceed. At the end of the month all items of equipment up to the slit 15SL1 are completely installed and will be ready for beam tests in July. Other elements through the second bend section of the beam are partially installed. Work has begun on cable tray and terminal installations to serve the bifurcated beam sections. Bids have been received for the shielding blocks which will be used over the beam runs external to the housing.

6. Detector System

The scintillator for the prototype shower counter being designed in collaboration with LBL was unacceptable. This factor (and others) means that the counter will have to be tested at SLAC. We have decided to replace the scintillators with wire spark chambers to detect muons transmitted through the iron. The design and construction of these counters is proceeding under the direction of H. Lynch.

7. I/C System

Bids have been received for construction of the submultiplexers for the digital input system for the Sigma 5 control computer. Delivery of the prototype units is scheduled for July.

Evaluation of the proposals for the 2214-type disk drive is complete and negotiations have started with the vendors. Modified proposals will be submitted which will include the option of purchasing a completely inferfaced system ready to connect to the Sigma 5.

The parts for the intercom system (except for a special transformer) have been received. A prototype of the transformer has been tested and a modification proposed to the vendor.

The heater-tape control chassis for vacuum chamber bakeout were completed and one is now in use by the vacuum group. This unit required modifications in the interlock circuits; the second unit will be modified as soon as possible to be available as a spare. The thermocouple scanner was completed and delivered to the vacuum group but immediately developed a problem in the logic. Since the measurement portion is operative, the vacuum group is using the scanner full time and the necessary modifications await availability of the unit. A second scanner will be built as soon as the parts arrive.

A prototype of the entire optical system of the beam profile monitor including lenses, scanning mirrors, slits, detectors, and the automatic servo for focusing is presently under construction.

B. Data Analysis Activity

1. Hardware

Hummingbirds. Part of a new film-advance circuit, capable of positioning to 1% of a frame, was installed. The remainder is scheduled to be installed in July. More accurate registration is especially important for automatic event finding.

Spiral Reader. Construction was started on a full-fledged automatic fiducial measuring hardware. This system will measure four fiducials simultaneously; the prototype measured one. Completion is scheduled for approximately September 1.

2. Software

Hummingbirds. A preliminary test was made of an automatic event recognition program for streamer chamber film on HB3. The early results were very encouraging, so a fair amount of effort will be devoted in July to make it part of our production system.

Spiral Reader. Work has started on the modifications to GENIE (the PDP-9 control program) needed for the autofiducial feature. The first step has been to "wring out" core to provide the necessary space for the changes; the manual measuring sequence has also been redesigned.

NRI System. At the request of physicists from the University of Pennsylvania (working on BC-33), some changes to the "quick fiducial measuring" program (to test the new 82" camera) are being made. This work is partially complete, and should be ready for the July 18 run.

Due to serious problems with the Vermont drum on the EMR 6020, steps have been taken to lease a Burroughs disk from EMR as a replacement. The unit should be delivered by the end of September.

Other. Work was started on a set of diagnostic programs for the SPVB measuring machine. These will have to be run on the 360/91, since the SPVB is a "stand-alone" machine, but we should be able to get a more timely indication of problems than we have at present.

3. Operations

During April 260,000 frames were scanned in 2000 hours. A total of 31,200 events were measured in 2950 hours; of this total 14,800 events were measured on the six NRI tables in 2400 hours, 10,000 on the Spiral Reader in 310 hours, and 6400 on other conventional measuring machines. Work on Hummingbird 2 in decoding the pi-rho data boxes was completed. Operators were trained on measuring the streamer chamber experiment (E-48) on Hummingbird 3; production measuring began towards the end of the month. Initial rates were 15-20 events/hour, with 90-95% of the measurements passing SYBIL.

During May 331,000 frames were scanned in 2000 hours; of the total of 36,400 events measured in 2500 hours, 14,000 events were measured on the Spiral Reader in 360 hours, 9400 events were measured on the NRI system, over 5000 events were measured on Hummingbird 3, and the remainder were done on the other conventional measuring machines.

During June 270,000 frames were scanned in 1680 hours. Measuring production was excellent with nearly 44,000 events measured in 3200 hours. Hummingbird 3 production increased, with about 6000 events measured on this machine during June. There were over 15,000 events measured on the Spiral Reader and over 15,000 events also measured on the NRI system.

C. Physical Electronics

1. Deposition Rate Monitor

Modification of a standard Sloan quartz crystal rate monitor head was continued, to produce a monitor that can operate stably while heated to 400 - 500°C. A crystal head was fabricated to hold Sloan's circular 5-MHz crystal, which is purported to be less susceptible to mode jumping than the square crystals. This design incorporates a 3-prong molybdenum wafer spring which contacts the crystal at the back and which retains its contact pressure when the assembly is heated to 500°C. Gold- or silver-plated crystals as-received are subject to surface migration and cease oscillation at about 390°C.

Several used crystals were chemically cleaned, heated by radiation from a quartz-iodine lamp, and electron-beam deposited with 3000 Å molybdenum. These circular crystals oscillate close to the original frequency of 5 MHz. Investigation continues to determine the behavior and stability of these crystals at high temperatures.

2. Resistivity Measurements

Contactless resistivity measurements have been made on a solid Nb cylinder which received an initial vacuum heat treatment at 1600°C for 16 hours. The data at 4.2°K has been reduced, yielding a value of 7.02×10^{-9} Ωm ± 1.53 percent. This corresponds to an electron mean free path of from 185 to 572 Å, depending on choice of Fermi velocity and electron number density. The data at 300°K is being analyzed. Based on 14 data curves, the resistivity ranges from 1.57 to 2.16×10^{-7} Ωm at 300°K. Based on these measurements, one may conclude that the Ginzburg-Landau order parameter, κ, is 59 percent higher for this Nb than for highly pure Nb.

Measurements have also been made on Cu and Pb samples, and the data is being reduced. The Cu has since been annealed at 900°C for 3 hours, and the Pb at 130°C for 69 hours. The Nb will soon be annealed at 2000°C. New data will be taken on these annealed samples.

3. Gas Purification

A Beckman GC-2 gas chromatograph, obtained from Government surplus sources, was reconditioned for use as a gas composition analyzer. Tests are in progress to establish optimum operating conditions for determining impurities in noble gas mixtures.

A gas discharge cell was built to be used as a continuous gas purity monitor. The ignition potential of the gas flowing through the cell changes with very small differences in the composition of the gas, thus making it possible to detect trace impurities in noble gases. The system was operated successfully and calibration procedures have been started.

4. Auger Spectrometer

Work has started on the construction of an ultra-high vacuum Auger electron spectrometer. When completed, this system will make it possible to identify surface species (1-5 monolayers) on experimental surfaces.

Journal Articles

SLAC-PUB-815
INELASTIC ELECTRON-PROTON SCATTERING AT LARGE MOMENTUM TRANSFERS. G. Miller, E. D. Bloom, G. Buschhorn, D. H. Coward, H. DeStaebler, J. Drees, C. L. Jordan, L. W. Mo, R. E. Taylor (SLAC); J. I. Friedman, G. C. Hartmann, H. W. Kendall, R. Verdier (MIT LNS). 17 p. Submitted to Phys. Rev. Lett.

SLAC-PUB-855
THE FREQUENCY DEPENDENCE OF SUPERCONDUCTING CAVITY Q AND MAGNETIC BREAKDOWN FIELD. Mario Rabinowitz. 8p. Submitted to Appl. Phys. Lett.

SLAC-PUB-856
A DEVICE TO PRODUCE HIGH CENTER-OF-MASS ENERGY e + e COLLISIONS — ACCELERATOR BEAM COLLIDING WITH A STORED BEAM. Paul L. Csonka (Oregon U.); John R. Rees (SLAC). 23p. Submitted to Nucl. Instrum. Methods.

SLAC-PUB-872
FORWARD COMPTON SCATTERING FROM HYDROGEN AND DEUTERIUM AT 8 and 16 GeV. A. M. Boyarski, D. H. Coward, S. Ecklund, B. Richter, D. Sherden, R. Siemann, C. Sinclair. 12p. Submitted to Phys. Rev. Lett.

SLAC-PUB-884
A STUDY OF THE REACTION $\pi^- p \rightarrow \rho^0 n$ AT 15 GeV/c. F. Bulos, R. K. Carnegie, G. E. Fischer, E. E. Kluge, D. W. G. S. Leith, H. L. Lynch, B. Ratcliff, B. Richter, H. H. Williams, S. H. Williams (SLAC); M. Beniston (IBM, Palo Alto). 20p. Shorter version submitted to Phys. Rev. Lett.

SLAC-PUB-885
A COMPARISON OF $\pi^- p \rightarrow \rho^0 n$ WITH SINGLE PION PHOTOPRODUCTION AT 15 GeV/c. F. Bulos, R. K. Carnegie, G. E. Fischer, E. E. Kluge, D.W. G. S. Leith, H. L. Lynch, B. Ratcliff, B. Richter, H. H. Williams, S. H. Williams. 11p. Submitted to Phys. Rev. Lett.

SLAC-PUB-888
THE REACTION $K_L^0 p \rightarrow K_S^0 p$ FROM 1.3 TO 8.0 GeV/c. A. D. Brody, W. B. Johnson, B. Kehoe, D.W. G. S. Leith, J. S. Loos, G. J. Luste, K. Moriyasu, B. C. Shen, W. M. Smart, F. C. Winkelmann, R. J. Yamartino. 13p. Shorter version submitted to Phys. Rev. Lett.

SLAC-PUB-889
INTERPRETATION OF THE REACTION $K_L^0 p \rightarrow K_S^0 p$. W. B. Johnson, D.W. G. S. Leith, J. S. Loos, G. J. Luste, K. Moriyasu, W. M. Smart, F. C. Winkelmann, R. J. Yamartino. 11p. Submitted to Phys. Rev. Lett.

SLAC-PUB-891
SEASONAL DEFORMATION OF A TWO-MILE STRAIGHT LINE. Joseph J. Spranza, Amos M. Nur. 20p. Submitted to Journal of the Soil Mechanics and Foundations Div., American Society of Civil Engineers.

SLAC-PUB-892
NONLEADING REGGE BEHAVIOR IN νW_2 AND THE POSSIBILITY OF FIXED POLES WITH POLYNOMIAL RESIDUES. F. E. Close, J. F. Gunion. 49p. Submitted to Phys. Rev.

SLAC-PUB-893
ELASTIC $K^{\pm} p$ SCATTERING AND A DUAL ABSORPTIVE MODEL. Michel Davier, Haim Harari. 13p. Submitted to Phys. Lett.

SLAC-PUB-895
THEORETICAL INTERPRETATION OF A RECENT EXPERIMENTAL INVESTIGATION OF THE PHOTON REST MASS. Norman M. Kroll. 10p. Submitted to Phys. Rev. Lett.

SLAC-PUB-897
A DUAL ABSORPTIVE MODEL FOR DIPS IN INELASTIC HADRON PROCESSES. Haim Harari. 10p. Submitted to Phys. Rev. Lett.

SLAC-PUB-900
VAN HOVE ANALYSIS OF THE REACTIONS $\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$ AND $\pi^+ p \rightarrow \pi^+ \pi^+ \pi^- p$ AT 16 GeV/c. J. Ballam, G. G. Chadwick, Z. G. T. Guiragossian, W. B. Johnson, D. W. G. S. Leith, K. Moriyasu. 82p. Submitted to Phys. Rev.

SLAC-PUB-906
ZENITH-ANGLE DISTRIBUTION OF ATMOSPHERIC MUONS ABOUT 1 TeV. S. M. Flatte, R. J. DeCoster, J. L. Stevenson (UCRL, Berkeley); W. T. Toner, T. F. Zipf(SLAC). 18p. (UCRL 20634) Submitted to Phys. Lett. B.

SLAC-PUB-907
BEHAVIOR OF THE ELECTROMAGNETIC INELASTIC STRUCTURE FUNCTIONS OF THE PROTON. J. I. Friedman, H. W. Kendall (MIT LNS); E. D. Bloom, D. H. Coward, H. DeStaebler, J. Drees, C. L. Jordan, G. Miller, R. E. Taylor (SLAC). 17p. Submitted to Phys. Rev. Lett.

SLAC-PUB-908
COMPARISON OF ABSORPTIVE ONE PION EXCHANGE MODEL WITH MEASUREMENTS OF $\pi^- p \rightarrow \pi^+ \pi^- n$. P. Baillon, F. Bulos, R. K. Carnegie, G. E. Fischer, E. E. Kluge, D.W.G.S. Leith, H. L. Lynch, B. Ratcliff, B. Richter, H. H. Williams, S. H. Williams. 10p. Submitted for publication.

SLAC-PUB-909
MEASUREMENT OF THE TWO PHOTON DECAY OF THE K_L^0 MESON. J. Enstrom, G. Akavia, R. Coombes, D. Dorfan, D. Fryberger, R. Piccioni, D. Porat, D. Raymond, K. Riley, A. Rothenberg, H. Saal, M. Schwartz, S. Wojcicki (SLAC and Stanford U. Physics Dept.). 27p. Submitted to Phys. Rev.

SLAC-PUB-910
CONCENTRIC SPHERICAL CAVITIES AND LIMITS ON THE PHOTON REST MASS. Norman M. Kroll 10p. Submitted to Phys. Rev. Lett.

SLAC-PUB-913
PHOTOPRODUCTION OF MASSIVE MUON PAIRS AT HIGH ENERGIES. Robert L. Jaffe. 47p. Submitted to Phys. Rev.

SLAC-PUB-917
NONLEADING ENERGY BEHAVIOR AND THE BREAKING OF SCALING IN νW_2. Francis E. Close, J. F. Gunion. 10p. Submitted to Phys. Rev. Lett.

SLAC-PUB-918
MASSIVE QUANTUM ELECTRODYNAMICS IN THE INFINITE-MOMENTUM FRAME. Davison E. Soper. 18p. Submitted to Phys. Rev.

Conference Papers (arranged by date of Conference)

SLAC-PUB-904
AN INTRODUCTION TO THE DIRECT EMULATION OF CONTROL STRUCTURES BY A PARALLEL MICRO-COMPUTER. Victor R. Lesser. 26p. Presented as informal paper at 3rd Annual Workshop on Micro-Programming, Buffalo, N. Y., Oct 12-13, 1970.

SLAC-PUB-876
AN INNOVATION IN CONTROL PANELS FOR LARGE COMPUTER CONTROL SYSTEMS. D. Fryberger, R. Johnson. 4p. Presented at Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-877
DESIGNS, PARAMETERS AND PROBLEMS IN THE ASSOCIATED COOLED EQUIPMENT OF A HIGH PURITY LOW CONDUCTIVITY WATER SYSTEM RATED AT 7.500 GPM AND 25.5 MEGAWATTS. W. O. Brunk, C. A. Harris, D. B. Robbins. 3p. Submitted to Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-878
OPERATING EXPERIENCE WITH HIGH POWER BEAM ABSORBERS IN THE SLAC BEAM SWITCHYARD. W. A. Reupke, D. R. Walz. 9p. Presented at Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-880
RF SYSTEM FOR SLAC STORAGE RING. M. A. Allen, R. A. McConnell. 2p. Submitted to Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-881
SYNCHROTRON FREQUENCY SPLITTING IN THE SLAC STORAGE RING. M. A. Allen, M. J. Lee, P. L. Morton. 2p. Submitted to Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-883
HYDROGEN TARGETS AT SLAC. John W. Mark, William B. Pierce. 3p. Presented at Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-894
OPENING REMARKS FOR THE PANEL DISCUSSION ON SUPERCONDUCTING LINAC DEVELOPMENT. P. B. Wilson. 2p. Presented at Particle Accelerator Conf., Chicago, Ill., Mar 1-3, 1971.

SLAC-PUB-896
DUALITY AND INELASTIC ELECTRON-NUCLEON SCATTERING. Frederick J. Gilman. 38p. Invited talk presented at Int. Conf. on Duality and Symmetry in Hadron Physics, Tel-Aviv, Israel, Apr. 5-7, 1971.

SLAC-PUB-905
PARTONS. James D. Bjorken. 25 p. Invited talk presented at Int. Conf. on Duality and Symmetry in Hadron Physics, Tel-Aviv, Israel, Apr 5-7, 1971.

SLAC-PUB-914
PHENOMENOLOGICAL DUALITY. Haim Harari (SLAC and Weizmann Inst.). 41p. Invited talk presented at Int. Conf. on Duality and Symmetry in Hadron Physics, Apr 5-7, 1971, Tel-Aviv, Israel.

SLAC-PUB-915
FABRICATION OF A SUPERCONDUCTING LINEAR ACCELERATOR BY ELECTRON BEAM WELDING. A. E. Johnston, R. R. Cochran, W. B. Herrmannsfeldt, G. P. Fritzke. 19p. Presented at 11th Symposium on Electron, Ion, and Laser Beam Technology, Univ. of Colorado, Boulder, May 12-14, 1971.

SLAC-PUB-902
GRAIN BOUNDARY MIGRATION AND MORPHOLOGY OF VACUUM ANNEALED SURFACES OF HIGH-PURITY NIOBIUM (COLUMBIUM). G. P. Fritzke. 21p. To be presented at Proc. of 4th Annual Technical Meeting of Internat'l. Metallographic Society, Denver, Colo., Sep 21-23, 1971.

Technical Reports

ANNUAL REPORT OF THE STANFORD LINEAR ACCELERATOR CENTER: 1970. 119p.

SLAC-119
TAXL- A SIMPLE HIERARCHIAL DATA STRUCTURE MANIPULATION SYSTEM. Sheldon I. Becker. 117p.

SLAC-130
TWO-MILE ACCELERATOR PROJECT, OCTOBER 1 TO DECEMBER 31, 1970: QUARTERLY STATUS REPORT. 63p.

Other Publications by SLAC Authors

THE RAPID CYCLING BUBBLE CHAMBER PROGRAM AT SLAC. A. Rogers. Proc. of Intl. Conf. on Bubble Chamber Technology, ANL, June 10-12, 1970, pp. 346-375.

FOUR-INCH HYDROGEN TARGET FOR THE 40-INCH SLAC BUBBLE CHAMBER. H. O. Petersen, K. Skarpass, R. D. Watt. Proc. of Intl. Conf. on Bubble Chamber Technology, ANL, June 10-12, 1970, pp. 567-580.

DESCRIPTION OF A SCINTILLATION COUNTER DATA ACQUISITION SYSTEM FOR USE WITH THE SLAC 40-INCH HYDROGEN BUBBLE CHAMBER. W. M. Smart. Proc. of Intl. Conf. on Bubble Chamber Technology, ANL, June 10-12, 1970, pp. 617-628.

SCALE INVARIANCE AND THE LIGHT CONE. Harald Fritzsch (Max Planck Inst., Munich, and SLAC); Murray Gell-Mann (CIT). 53p. (CALT-68-297) Presented at Coral Gables Conf. on Fundamental Interactions at High Energy, Jan 20-22, 1971.

TWO-PHOTON MECHANISM OF PARTICLE PRODUCTION BY HIGH ENERGY COLLIDING BEAMS. Stanley J. Brodsky (SLAC); Toichiro Kinoshita, Hidezumi Terazawa (LNS Cornell). Apr. 1971. 94p. (CLNS-152)

DEEP INELASTIC SCATTERING OF ELECTRONS ON A PHOTON TARGET. Stanley J. Brosky (SLAC); Toichiro Kinoshita, Hidezumi Terazawa (LNS Cornell). May 1971. 9p. (CLNS-153)

CROSS SECTIONS FOR REACTION $\gamma p \longrightarrow p\pi^+\pi^-$ BETWEEN 0.3 AND 5.8 GeV. Data of the Aachen-Berlin-Bonn-Hamburg-Heidelberg-Munchen Collaboration. H. Spitzer (SLAC). May 1971. 3p. (DESY F1-71/4)

A MULTI-PARTICLE EIKONAL MODEL WITH HIGH ENERGY S-CHANNEL HELICITY CONSERVATION. J. F. Gunion (SLAC); R. G. Roberts (Rutherford). Nuclear Physics B28 p. 205-209 (1971).

Other Publications, Based Upon Results of SLAC Research

STUDY OF THE A_2^- FROM THE REACTION $\pi^- p \longrightarrow K_S^0 K^- p$ AT 4.5 GeV/c. David J. Crennell, Howard A. Gordon, Kwan-Wu Lai, J. Michael Scarr (BNL). Mar. 1971. 12p. (BNL-15688R)

PHOTOPRODUCTION OF ρ^0 AND ω IN γd INTERACTIONS AT 4.3 GeV. Y. Eisenberg, B. Haber, E. Kogan, E. E. Ronat, A. Shapira, G. Yekutieli (Weizmann Inst.). Apr 1971. 330. (WIS 71/9 Ph)

A MEASUREMENT OF THE FORM FACTOR $f_+(q^2)$ FROM K_{e3}^0 DECAYS. C. -Y. Chien, B. Cox, L. Ettlinger, L. Resvanis, R. A. Zdanis (JHU); E. Dally, P. Innocenti, E. Seppi (SLAC); C. D. Buchanan, D. J. Drickey, F. D. Rudnick, P. F. Shepard, D. H. Stork, H. K. Ticho (UCLA). Apr 1971. 14p. (JHU-7104)

PRODUCTION OF K^+K^- AND $p\bar{p}$ PAIRS IN FOUR-BODY REACTIONS AT 13.1 GeV/c. J. A. Gaidos, T. A. Mulera, C. R. Ezell, J. W. Lamsa, R. B. Willmann (Purdue U.). June 1971. 18p.