MC 572
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BOX 3 FOLDER 5

[HEPAP] [1973] - meeting agenda, minutes, correspondence, reports

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UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

MINUTES

HIGH ENERGY PHYSICS ADVISORY PANEL

Germantown, Maryland

January 3-4, 1973

The agenda for this meeting is attached (p. A1-2).

Participants:

HEPAP

V.F. Weisskopf, Chairman
B.C. Barish
D.B. Cline
J.W. Cronin
T.H. Fields
L.J. Laslett
F.E. Low
R.R. Rau
B. Richter
J.L. Rosen
J.R. Sanford
G.F. Tape
W.A. Wenzel
W.D. Wales, Exec. Secy.

NSF

M. Bardon, Head, Physics Section
A. Abashian, Program Dir. for Elementary Particle Physics

AEC

J.M. Teem, Director, Div. of Phys. Res.
D.R. Miller, Deputy Director, Div. of Phys. Res.
H.L. Kinney, Special Asst. to the Dir., Div. of Phys. Res.
W.A. Wallenmeyer, Asst. Dir. for HEP, Div. of Phys. Res.
B. Hildebrand, HEP, Div. of Phys. Res.

Consultant

G.A. Smith, Chairman, NAL Users Org.

The meeting was held in Room E-401 at AEC Headquarters. After J.M. Teem was introduced to the Panel, the minutes of the previous meeting (September 27-28, 1972) were considered.

PRIVILEGED INFORMATION

Corrections to Minutes

P. 6, 1. 7 - It is the design of 60 Kilogauss magnets which is planned.

P. 13, 1 4-9 - (third and fourth full sentences)
The concensus of the Panel disagreed strongly with the sentiments reported. Accordingly, these two sentences were deleted from the minutes.

It was suggested that it would be helpful if the minutes could reach the Panel at an earlier time. (The Executive Secretary was stung to the quick by this unkind suggestion, and is planning to retire at the earliest possible date.)

Agency Presentations

The AEC budgets for FY 1973 and FY 1974 were discussed by W.A. Wallenmeyer. Information on AEC HEP budgets since FY 1967, a FY 1974 "budget exercise" (p. A3), and tentative HEP program assumptions (p. A4-5) was presented and discussed with the Panel. A $2M reduction in FY 1973 funding which occurred during November was due to the President's effort to keep total spending for the year below $250 billion.

The FY 1974 budget would give each segment of the program except NAL less than in FY 1973. LBL and ANL would receive relatively large cuts.

The closeout costs at CEA are not known precisely. The budgeted amount in FY 1974 is believed to be the minimum necessary if the facility is shut down in April of 1973.

The cuts at LBL were aimed most heavily at the Bevatron and at ERA R&D. The funding reductions at the ZGS were indicated in a way to preserve the very productive ZGS research program. Operating categories were indicated to increase at the expense of R&D efforts. Although this would permit maintenance of near the present level of operation, the resultant severe reductions in R&D categories threaten the long-term viability of this accelerator.

The increase at NAL was held to the minimum considered consistent with its expanding program to try to maintain, as much as possible, the programs at SLAC and BNL. An increase in facilities operation at SLAC should help permit exploitation of the SPEAR capabilities, while increases in both operating categories at BNL should help permit exploitation of the improvement project. In each case, such increases require additional reductions from other parts of the program at the respective laboratory.

Construction funds are available for completing NAL and for a computer building at SLAC. Accelerator improvement projects for all laboratories is now a single budget line-item.

There was some discussion of the budgeting process, and particular concern was expressed at the continued scarcity of capital funds for equipment, AIP, and new construction. It was suggested that the operating cuts at the laboratories were more damaging than they appeared, since overhead costs at most laboratories had already been reduced as far as practicable. The obvious advantages of longer funding cycles were pointed out - however, there appears to be little prospect for changing the present system.

W.A. Wallenmeyer continued the AEC presentation with a manpower table (p. A6) and a graph (p. A7). The figures for FY 1974 shown on the table and graph assume a linear relation between funding and staff levels and 5½% inflation between FY 1973 and FY 1974. Since manpower levels peaked at a later date than funding levels, the ratio of materials and services to total expenditures must have decreased over the past decade.

M. Bardon presented the details of the NSF physics budget. The overall NSF research budget is in the \$250M - \$260M range. For physics, which includes atomic and molecular, nuclear, and theoretical physics as well as elementary particle physics, the yearly funding, in current year dollars, is shown:

FY 72	FY 73	FY 74
\$33.4M	\$35.0M	\$36.5M

Physical science is not faring worse than most other segments of the NSF program.

A. Abashian presented details of the elementary particle physics fraction of the NSF physics budget for FY 1973:

Cornell (12 GeV synchrotron + Cornell group)	\$ 3.1
HEP (35-40 grants to user groups of various sizes)	9.2
Accel. Dev. (HEPL)	0.8
Cosmic Ray	1.0
E.P. Theory	2.5
TOTAL	~\$ 16.6M

There was some discussion on the relative effectiveness of research funding with large and small contracts. B. Hildebrand provided (p. A8) a list of contracts included in the "Washington Administered" category.

W.A. Wallenmeyer directed the Panel's attention to the "budget exercise" figures (p. A3). He noted that HEPAP's general advice on appropriate reaction to such levels would be very helpful to the Division when quick budget exercises are necessary. He then outlined the basic rationale used for the apportionment of the "high case" and of the "low case" funds.

The Panel did not reach specific conclusions on the appropriate distribution of funds in these cases.

Role of HEPAP

J.M. Teem introduced the topic by stating that he felt that it was the most important part of this meeting. He pointed out that a measure of the vitality of the Panel is its willingness to question its role. He had sensed, from his laboratory visits and from AEC contacts, that the Panel in the past has been effective in some cases, but ineffective in others. The impending Federal Advisory Committee Act makes introspection especially timely. He stated that the Panel is needed by the AEC, by high energy physics, and by the country - especially when more austerity for the program may be in prospect.

An important role of HEPAP is as an informed advocate of high energy physics, both to the Division of Physical Research and to the outside world. Teem pointed out that he is not, per se, an advocate of high energy physics, and that HEPAP should persuade him of the promise of the field and its needs.

HEPAP also provides discipline to the program management. The feedback to program decisions is extremely important in the formulations of guidelines for the future. The Panel gives important advice on priorities, evaluates plans for new facilities, and judges the obsolescence of older ones.

HEPAP provides a forum for looking at broad concerns of the community. It is the principal area in which national and international strategies can be debated.

The discussion which followed Teem's remarks stressed the boundary conditions within which the Panel operates and the difficulties with which it contends. The privileged nature of much of the material discussed hinders broad interaction with the community. The Panel has been frustrated at its inability to present an effective case for high energy physics. On the other hand, it was pointed out that funding for high energy physics has not been reduced more than most other research fields.

W.D. Wales pointed out the pertinent passages in the Federal Advisory Committee Act. The Director for the Office of Management and Budget has been given overall responsibility for reviewing the justification of existing committees. He will prepare administrative guidelines which will be used by the agencies for committee management. Advance notice of meetings must be given in the Federal Register, and meetings must be open unless specific exemption is given by the head of the agency. Wales' opinion was the HEPAP probably would be able to get sufficient exemption to permit it to continue to function effectively.

Status Report (on Federal Advisory Committee Act)

The continuation of HEPAP was approved by the Commission on February 1, 1973. A new charter, which is a prerequisite to meeting or taking any action, has been filed with the Commission and with the Joint Committee on Atomic Energy. Meetings or portions of meetings may only be closed following a determination by the Commission's Advisory Committee Management Officer that the meeting is concerned with, in the case of HEPAP, intra-agency memoranda which would not be available by law. Such determination requires thirty (30) days notice.

The discussion which followed generally indicated that many parts of the meetings could be open, although some reservation was expressed at the prospects of press coverage. There appeared to be a reasonable concensus that meetings should be more open, both for visibility and for more effective interaction with the community. However, the need for some closed executive sessions to permit probing discussions was recognized.

The discussion then returned to HEPAP's role, the advantages of high energy physics, and problems with making specific budget recommendations. No obvious concensus appeared from this discussion. J.M. Teem asked the Panel for a "shopping list" of roles it might play. It was suggested that the Panel's advice would be more effective if it were made more emphatically; however, it was not clear what mechanism was appropriate for disseminating any concensus the committee might reach.

NAL Status

J.R. Sanford presented a table summarizing the progress at NAL over the past year:

	January 72	July 72	Dec. 72	Design
Energy	20 GeV	200 GeV	300 (400 max)	200
Intensity	10^{9} p/p	7×10^{10}	4×10^{11} (1.5×10^{12} max)	5×10^{13}
Experiments in progress (taking data)	0	4	10	20/yr + B.C.

The progress on energy and intensity has been very creditable - the increase in energy has been relatively easy, while increases in intensity have been more difficult.

The Accelerator Section is working on intensity, beam splitting, and extraction efficiency. The installation of new blocking capacitors in the booster RF system now permits injection of 12-13 pulses into the main ring. There is no significant variation in these pulses, but control problems cause bunch losses.

The slow extraction efficiency is 85 $\pm$ 5%, which may be improved by the adjustable Lambertson magnets which were installed in the extraction channel over the year-end shutdown. The immediate goal is to reach 90% extraction efficiency to permit extended running with 10^{12} p/p at 300 GeV. The radioactivity buildup is already a problem in handling the magnets.

The current flat-top is 0.4 - 0.5 sec out of a 4 sec cycle time. Stretching this to 1.0 sec should be no problem. The present micro-structure in the spill should be greatly reduced by using all of the booster pulses and by reducing the 720 Herz ripple in the power supplies.

The elements for splitting the proton beam between the neutrino and proton areas were installed in the switchyard in January. The long-range objective is to run all areas routinely at 300 GeV. The long distances in the beam lines are causing some problems.

The use of 300 GeV protons in the Meson Area presently requires pulsing the magnets in the proton transport line. The primary beam is directed downward prior to hitting the target assembly to provide additional earth shielding for the forward cone of muons. This results in slightly larger production angles for the secondary beams. The Meson Area is clearly behind schedule, primarily because of delays in the construction of the main building and because of target problems. The short-term objective is to run experiments with three of the five secondary beams (two quark searches, one total cross-section measurement) upstream of the large building. Installation of experiments in the building and downstream from it will begin in May.

The Neutrino Area is the most advanced of the three external experimental areas. The muon, neutrino, and hadron beams have been commissioned, their shortcomings realized, and improvements begun. The number of neutrinos per proton on target is within design limits, while the number of muons per proton is down by a factor of between three and ten, probably because of compromises in the beam design. The present proton flux is obviously very low for the neutrino and muon experiments.

The magnet for the 15' chamber performed as advertised (30 Kilogauss) on the first attempt. The piston has failed two tests, and may cause some delay. The current plans include using a metal piston for cooldown and expansion tests, and then designing and fabricating a new non-metallic piston for research operation.

The Proton Area is the least advanced. Protons have been brought to the area, but targeting has not yet been entirely successful - the long beam lines without focusing elements cause some problems.

Sanford reported that on the average 70 hr/wk have been scheduled since July for HEP and switchyard work, of which about 50 hr/wk have actually been available. About 35 hr/wk have been usefully used for particle physics research. The Lab is now using a two-week cycle, with five days for accelerator work followed by nine days for HEP, to try to reduce end effects.

The research program is not slowing down accelerator development - in part because accelerator studies have limited priority even during time scheduled for HEP. The operation of the machine, if undisturbed, is very stable. Operation at 300 GeV is not very different than at 200 GeV, except that the emittance at 300 GeV is better. The internal target area has been very useful for precision experiments, and operates in a very parasitic mode. The needs of the Laboratory include:

1. More staff (esp. physicists) in each area
2. More intensity (and better extraction)
3. Beam splitting

NAL User's Organization

Gerald A. Smith (Michigan State University), who is Chairman of the NAL User's Organization, reviewed their relations with NAL. The User's group, which has a total membership of about 700, is represented by an Executive Committee of thirteen elected by the larger body. The Executive Committee meets periodically with the Laboratory Directorate and with URA to try to help solve some of problems users face and perceive at the Laboratory. They have tried to focus on long-range problems in the following areas:

1. Energy doubler
2. Manpower
3. Scheduling
4. Personnel policies
5. Housing

The discussions of a possible energy doubler have caused the users great apprehension that this project would interfere with the completion and commissioning of the original facilities planned at the Laboratory. The Committee felt that their emphasis of this apprehension to the Directorate had led to the present low-key approach to the project. The Committee feels that the energy doubler should not be built until it is clear that the original design specifications for the Laboratory have been met. They are concerned that money necessary for meeting these specifications may be withheld in deference to the doubler.

NAL has a long range planning committee on which the users are represented. In response to Wilson's request, this committee developed a list of possible new projects which will be the subject of the 1973 summer study.

After a brief discussion of the energy doubler, W.A. Wallenmeyer read the Laboratory's official request for permission to proceed on the prototype project. He noted that the JCAE had urged that the Laboratory proceed with work to define the scope and costs of the energy doubler. The request from NAL is for the use of $3M of construction funds in the next calendar year to permit realistic cost estimates to be made.

G.A. Smith reviewed the history of scheduling experimental time at NAL, which has evolved from a chaotic day-by-day operation last summer to the present system which involves regular weekly scheduling meetings and published schedules which are firm and detailed for one week in advance and tentative for four weeks in advance. It was clear that major improvements had been made in this area.

The users are acutely aware of morale problems, especially among the younger scientists on the staff. Since the overall manpower is too low to carry out the ambitious program planned, everyone is working extremely hard. Young physicists are trying to handle accelerator duties and research simultaneously. Since it is not clear to them on what basis their performance is judged, they are very concerned about their future. Smith suggested that the Laboratory has not been adequately sensitive to this problem, but is now taking steps to clarify the review procedures and perform them more consistently.

National Facilities Survey

R.R. Rau presented a survey of facilities available at the U.S. accelerator. It was the concensus that HEPAP should examine the situation to see if some cost-saving efficiencies could be realized without jeopardizing the goals of the program.

Future Facilities

The discussion of studying future facilities concentrated on appropriate timing. Suggestions that HEPAP should make immediate plans to organize community-wide discussions on the impending major projects were countered by the claim that such discussions would not be productive without concrete proposals. The specific plan which emerged from the discussion is to examine those projects for which proposals to the AEC now exist at the next meeting. In addition, an examination of Cornell's plans, which might compete with RLA, was suggested. Delegation of responsibility for arranging presentations was made as follows:

LBL Booster - T. Fields

ANL Booster - W. Wenzel

RLA - L.J. Laslett

Cornell - L.J. Laslett

Physics Overview

W.A. Wallenmeyer introduced the question of taking an overall view of physics research. Competition among the laboratories, although unquestionably healthy in its net effect, may result in more redundancy than desirable for an effective national program. In addition, R&D important to the overall program might be done inadequately or not at all. HEPAP discussed the advantages and disadvantages of setting up a formal mechanism for overall review. M. Bardon gave his strong support for some mechanism to perform this function. (The feasibility of annual meetings of HEP Laboratory Directors and the funding agencies is now being investigated.)

Budget Discussions

The shortage of funds in the FY 1974 budget for operation at BNL and SLAC was agreed to be a very serious problem. The following points emerged:

1) BNL and SLAC should receive more funds for accelerator and experimental facilities operations. A careful examination of NAL's budget should be made to see if funds can be diverted. In addition, the R&D programs at BNL and SLAC should be examined to see if the transfer of funds to operation is feasible.

2) The ZGS and the Bevatron face very tight budgets which will certainly reduce their R&D capabilities. Both still offer very important research capabilities to the national program.

A discussion of strategy in an era of declining budgets centered on the issue of closing down some facilities vs. maintaining the present set of accelerators. The severe impact of sudden changes was emphasized. The Chairman suggested the committee think about the problem of facing eroding budgets and try to address it at the next meeting.

NAL Doubler

The Panel has many misgivings about the doubler project. A memo which indicates many of these misgivings is attached (p. A9-10). The Panel decided that they would not attempt to endorse any formal set of recommendations to the Division of Physical Research but would depend on the Director's interpretation of the discussions he had heard.

(Subsequent to this HEPAP meeting, J.M. Teem held extensive discussions, with N. Ramsey and R.R. Wilson, about the scope of the doubler prototype project and its place in the overall priorities of the Laboratory. R.P. McGee and W.D. Wales also met with Wilson and other members of the Laboratory to ascertain the scale of the projected prototype work and its possible impact on the Laboratory. The Division of Physical Research has recommended that NAL be permitted to spend approximately $1.5M in construction funds for the prototype work. It is clearly understood by all parties that the completion of a productive and effective facility for HEP research will remain the primary goal at NAL, and that the achievement of this goal will command first priority on all resources available.)

Next Meeting

The next meeting is now scheduled at LBL on April 2-3, 1973.

AGENDA

HIGH ENERGY PHYSICS ADVISORY PANEL

January 3-4, 1973

AEC, Germantown - Room E-401

Wednesday, January 3, 1973

9:00	AM	- Introduction of Dr. John M. Teem, Director of Division of Physical Research
9:10		- Minutes of September 27-28, 1972, Meeting
9:15		- Agency Presentations; J.M. Teem, W.A. Wallenmeyer (AEC); M. Bardon, A. Abashian (NSF)
11:00		- Discussion of Agency Presentations
12:30	PM	- LUNCH
1:30		- Discussion of Role of HEPAP; J.M. Teem and Panel This discussion will review the role of HEPAP in advising the Division of Physical Research. The implications of the Federal Advisory Committee Act should also be considered.
5:00		- End of First Day Session
6:30		- The Abashian's have invited us to their home for a buffet dinner. A map is attached.

Thursday, January 4, 1973

9:00	AM	- Review of NAL Status; J.R. Sanford
9:30		- Relations between NAL and Experimenters; G.A. Smith; NAL Users on HEPAP
10:00		- Discussion of NAL

Thursday, January 4, 1973 - cont.

11:30		- Discussion of Formation of Subpanels
		Future Facilities; V.F. Weisskopf Physics Overview; W.A. Wallenmeyer
12:30	PM	- LUNCH
1:30		- General Discussion (HEP priorities, long-range plans, etc.)
4:00		- End of Meeting

Enclosure:
Map to Abashian's home

PRIVILEGED INFORMATION

FY 74 BUDGET EXERCISE

Operating (Costs)	Actual FY 72	Latest FP FY 73	Low Case FY 74	Med. Case FY 74	High Case FY 74
TOTAL	116392	124400	103400	127200	140400
CEA	2156	2000	200	600	900
BNL	22648	24600	22000	24300	26200
ANL	15770	15600	7800	14500	15700
LBL	15580	15200	7000	13500	14000
SLAC	24081	24950	22000	24400	25900
NAL	12749	19200	26000	27200	33200
Universities	23408	22850	18400	22700	24500

Equipment (Oblig)	Actual FY 72	Latest FP FY 73	Low Case FY 74
TOTAL	14496	44498	23650
ANL	840	600	300
BNL	1880	2500	1550
CEA	200	50	0
LBL	511	450	250
NAL	7420	16258	10550
SLAC	2960	2650	1550
Universities	685	1150	750
Chicago Area Comp.	-	10401	-
SLAC Large Comp.	-	10439	-
BNL Large Comp.	-	-	8700

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1/2/73

HEP PROGRAM ASSUMPTIONS
(in FY 1974 $)

	FP FY 73	FY 74$ FY 73	Blue Book* FY 74	FY 74	Blue Book FY 75	FY 75	Blue Book FY 76	FY 76	Blue Book FY 77	FY 77	FY 78	FY 79
Operating (Costs)	124.4	131.2	153.0	127.2	164.6	166.0	174.0	173.0	179.4	175.0	175.0	175.0
NAL	19.2	20.2	29.7	27.2	35.9	42.0	42.2	46.0	45.4	48.0	50.0	50.0
NAL Users	4.9	5.2	7.3	6.0	11.6	12.0	13.7	14.0	14.8	15.0	16.0	16.0
Base Program	100.3	105.8	113.9	94.0	113.9	109.0	113.9	109.0	113.9	107.0	103.0	100.0
New Projects	-	-	2.1	-	3.2	3.0	4.2	4.0	5.3	5.0	6.0	9.0
Equipment (Oblig)	44.5	46.7	36.8	28.9	30.5	30.0	26.2	39.0	28.3	26.0	36.0	25.0
NAL	16.5	17.3	24.2	15.0	18.9	20.0	14.7	16.0	14.7	13.0	10.0	10.0
Base Program	7.4	7.8	12.6	5.2	11.6	10.0	10.5	10.0	10.5	10.0	9.0	9.0
New Progects	-	-	-	-	-	-	1.0	1.0	3.1	3.0	5.0	6.0
Central Comp.	20.6	21.6	-	8.7	-	-	-	12.0	-	-	12.0	-
AIP (Oblig)	2.5	2.7	4.3	1.7	4.3	7.0	5.4	7.0	6.5	8.0	9.0	8.0
NAL	-	-	-	-	1.1	2.0	2.2	3.0	3.3	4.0	5.0	5.0
Base Program	2.5	2.7	4.3	1.7	3.2	5.0	3.2	4.0	3.2	4.0	4.0	3.0
Construction (Oblig)	42.9	46.3	19.5	10.7	17.3	19.4	14.0	29.0	10.8	47.0	40.0	15.0
NAL Base Projects	42.9	46.3		10.2								
SLAC Comp. Bldg. ($2.9M)				0.5		2.4		-				
RLA ($18M)				-		7.0		9.0		2.0	-	-
Coll. Beam Fac. ($100M)				-		5.0		15.0		40.0	35.0	5.0
Project X ($50M)				-		-		-		-	-	5.0
General				-		5.0		5.0		5.0	5.0	5.0
TOTAL	214.3	226.9	213.6	168.5	216.7	222.4	219.6	248.0	225.0	256.0	260.0	223.0

*All Blue Book figures have been adjusted to FY 1974 dollars.

PRIVILEGED INFORMATION

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PRIVILEGED INFORMATION

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OPERATING PROJECTIONS

EXERCISE SHEET
(FY 74 dollars)

Operating (Costs)	B B FY 73	B B FP FY 73	B B FY 74	FY 74	B B FY 75	Project FY 75	B B FY 76	Project FY 76	B B FY 77	Project FY 77	Project FY 78	Project FY 79
TOTALS	133.3	131.3	153.0	127.2	164.6	166.0	174.0	173.0	179.4	175.0	175.0	175.0
CEA	2.3	2.1	2.3	.6	2.3		2.3		2.3			
BNL	26.1	26.0	28.5	24.3	28.5		28.5		28.5			
ANL	16.2	16.5	16.4	14.5	16.4		16.4		16.4			
LBL	16.0	16.0	16.1	13.5	16.1		16.1		16.1			
SLAC	26.6	26.3	28.5	24.4	28.5		28.5		28.5			
200 BeV	20.3	20.3	29.7	27.2	35.9		42.2		45.4			
Universities	25.8	24.1	29.4	22.7	33.7		35.8		36.9			
New Projects	0	0	2.1	0	3.2		4.2		5.3			

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PRIVILEGED INFORMATION

AEC HIGH ENERGY PHYSICS PROGRAM MANPOWER
PERSONNEL COUNT* AT END OF FISCAL YEAR

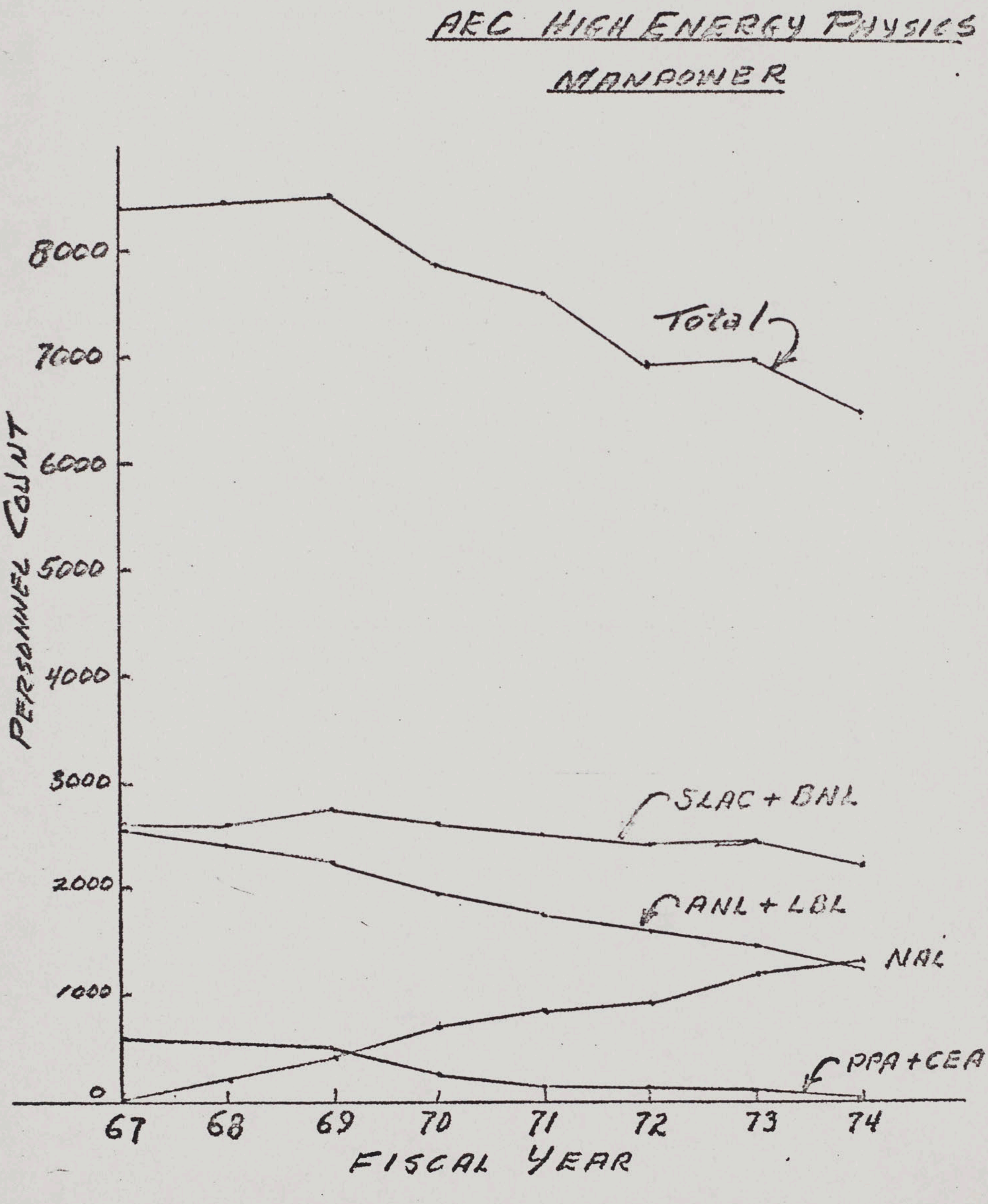
		FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	FY 73**	FY 74
PPA	Total[1]	336	320	295	95	0	0	0	(0)
	Physicists	7	7	7	4	0	0	0	
	Other Prof	50	50	50	20	0	0	0	
CEA	Total[1]	233	230	216	146	126	121	90	(0)
	Physicists	18	18	18	18	11	10	10	
	Other Prof	45	45	46	38	37	33	30	
ANL	Total[1]	1,070	1,000	950	790	732	683	625	(545)
	Physicists	49	55	64	62	65	62	60	
	Other Prof	170	165	159	133	110	115	105	
	Grad Students	31	20	3	4	0	0	0	
LBL	Total[1]	1,481	1,350	1,291	1,145	1,025	896	835	(695)
	Physicists	108	105	103	102	100	93	90	
	Other Prof	204	190	184	170	158	132	125	
	Grad Students	111	110	104	92	87	60	55	
BNL	Total[1]	1,250	1,305	1,365	1,276	1,204	1,110	1,155	(1,075)
	Physicists	100	105	110	103	95	101	100	
	Other Prof	170	180	187	169	132	121	120	
SLAC	Total[1]	1,350	1,300	1,397	1,330	1,319	1,310	1,285	(1,185)
	Physicists	85	90	99	104	110	122	110	
	Other Prof	215	220	222	223	169	162	160	
	Grad Students	20	30	38	28	35	31	30	
Laboratory Subtotal (except NAL)	Total[1]	5,720	5,505	5,514	4,782	4,406	4,120	3,990	(3,500)
	Physicists	367	380	401	393	381	388	370	
	Other Prof	854	850	848	753	606	563	540	
	Grad Students	162	160	145	124	122	91	85	
University Programs[2]	Total[1]	2,682	2,759	2,606	2,378	2,342	1,904	1,795	(1,690)
	Physicists	645	659	641	639	673	590	618	
	Other Prof	190	190	175	145	146	128	133	
	Grad Students	647	660	626	594	539	400	357	
Program Subtotal (except NAL)	Total[1]	8,402	8,264	8,120	7,160	6,748	6,024	5,785	(5,190)
	Physicists	1,012	1,039	1,042	1,032	1,054	978	988	
	Other Prof	1,044	1,040	1,023	898	752	691	673	
	Grad Students	809	820	771	718	661	491	442	
NAL	Total[1]	-	200	410	695	850	920	1180	(1,070)
	Physicists	-	15	36	56	74	76	80	
	Other Prof	-	30	63	93	239	262	300	
TOTAL PROGRAM	Total[1]	8,402	8,464	8,530	7,855	7,598	6,944	6,965	(6,260)
	Physicists	1,012	1,054	1,078	1,088	1,128	1,054	1,068	
	Other Prof	1,044	1,070	1,086	991	991	953	973	
	Grad Students	809	820	771	718	661	491	442	

*Personnel Count and Man Years Effort are not significantly different except within the University Program.

**Estimated on the basis of the FY 73 November Financial Plan

[1] The Total for each laboratory includes, in addition to Physicists, Other Professional, and Graduate Students, all other personnel supported by the program eg. technicians, accelerator operators, scanners, machinists, craftsmen, etc. In accounting parlance there are, in addition to "direct" and "indirect" people, also many "contract" heads included in the count in cases where their numbers are directly affected by the level of HEP program support.

[2] ~ 15% of the support for the research effort carried out by the people listed under University Programs is provided by University contribution. No "indirect" or "contract" type heads are included in the University head count (see footnote 1).


AEC HIGH ENERGY PHYSICS
MANPOWER
Total
SLAC + BNL
ANL + LBL
NAL
PPA + CEA
PERSONNEL COUNT
8000
7000
6000
5000
4000
3000
2000
1000
0
67
68
69
70
71
72
73
74
FISCAL YEAR

PRIVILEGED INFORMATION

A8

HEP Washington Administered Program-FY 1973

Cost-Type Contracts	FY 1973
Brown-Feldman	135
Brown-Shapiro	200
UC, Irvine-Reines	350
UC, Los Angeles-Ticho	414
UC, Santa Barbara-Caldwell	(190)
Colorado-Nauenberg	130
Columbia-Serber	280
Hawaii-Peterson	360
Hawaii-Tuan	62
Maryland-Snow	655
Minn.-Gasiorowicz/Courant	280
Northwestern-Rosen	275
Ohio St.-Romanowski/Tanaka	305
Purdue-Loeffler	451
Purdue-Sugawara	126
Purdue-Fowler	31
Rockefeller-Cool	360*
Rockefeller-Pais	170*
Stanford-Ritson	(320)
Tufts-Cormack	290

SRSA Contracts	FY 1973
Brandeis-Kirsch/Schnitzer	165
UC, Davis-Lander	(75)
UC, Irvine-Schultz	160
UC, Riverside-Kernan	210
UC, Santa Cruz-Heusch	150
Duke-Walker	185
Florida St.-Lannutti	170
Harvard-Wu	(30)
Indiana-Heinz/Neal	188
Indiana-Chu/Hendry	32
Johns Hopkins-Domokos	(45)
Massachusetts-Schaffer	149
Oregon-Moravcsik	97
Princeton-Dashen	(135)
Syracuse-Wali	125
Tennessee-Bugg	(60)
Texas-Sudarshan/Ne'eman	165
Washington-Lord	(50)
Wayne St.-Gupta	25

Numbers in parentheses are tentative

*Funding is for research in FY 1972 and FY 1973

PRIVILEGED INFORMATION

I would make following points.

1. The most important part of NAL program requires high intensity and reliable operation in the 200-400 GeV energy region.

2. Highest priority in use of unexpended construction funds should be in achieving goals of 1) and in supplying a sufficiency of support facilities to allow efficient operation of a multiplicity of experiments.

3. The operating level of 27M and 15M of equipment proposed by AEC for NAL in FY 74 may be more than the maximum reasonable level consistent with the operations which NAL can support while the goals of 1) & 2) are being accomplished.

4. It is unwise to devote a significant amount of funds to the study of the energy doubler project at this time because of the diversion of manpower from that required to accomplish 1), 2) & 3) above.

5. The AEC is already supporting several studies of AC superconductivity and we are not convinced of the wisdom of starting another such program at this time.

6. Superconducting technology is sufficiently advanced to now allow a reasonable cost estimate of a superconducting ring for operation up to 400 GeV (20 KG). Such an estimate would enable the AEC to evaluate the estimated savings in operating costs from reducing power requirements.

7. Operation of NAL at 1000 GeV will require extensive hardening of experimental areas and replacement of most of existing beam transport. These costs must be included in estimate of cost of an energy doubler project.

8. I am not convinced at this time that 1000 GeV at NAL is the highest priority major project in HEP nor convinced that accomplishing the goals of (1) and (2) will leave the surplus in construction funds which the NAL management has indicated may be expected.

9. The recent communication to the user community from NAL (December 1972) does not make clear the time schedule which the NAL management feels will accomplish the goals of (1) and (2).

10. The specific comments of both URA and the NAL Director (including time schedule) are urgently required on the points of # 1 - 9 above in order to evaluate the direction and level of support of the NAL program.

Memorandum to: G. Stever May 1, 1973

From: S. Drell and V. F. Weisskopf

Re: <u>The Support of High Energy Physics in the U.S.A.</u>

The field is in deep trouble.

<u>Facts</u>:

1. The operating budgets have decreased since 1967 in real value by about 12% inspite of the fact that two new large national facilities started operation (SLAC and NAL), that one large facility increased its capacity by an order of magnitude (AGS), and that the other national facilities (Bevatron, ZGS) are still very productive.

2. No new construction was approved since the approval of NAL in 1968. Because of this fact the total yearly expenses for High Energy Physics from FY 1974 on, will be reduced by about 25% from the average value during the previous 6 to 7 years.

3. The funds for H.E.P. expended in Western Europe is steadily increasing. Their expenditure overtook ours last year and rises continuously. During the next years they will spend considerably more money in this field than the U.S.A.

<u>Consequences</u>:

The previously unchallenged leadership, vitality and ingenuity of U. S. High Energy Physics are diminishing and will erode during the coming decade, inspite of the activities at the newly completed NAL. The reasons for this development are:

1. The shrinking scientific manpower in H.E.P. reduces significantly the influx of young researchers who provide most of the vitality.

2. None of the proposed innovative construction programs have been approved, such as the upgrading of SLAC by means of a recycling device (~20M$, 3 years construction time) or colliding beam devices in the 100 GeV region (~100 M$, 5-7 years construction time). Only SLAC was able to squeeze in the construction of a new device (electron-positron storage ring SPEAR) by using operational equipment funds at the expense of reduced running time and other needed improvements. Because of the long time

interval between approval and exploitation, the present indefinite postponements of new construction will prevent the extension of the frontier of H.E.P. in the U.S.A. at the end of this decade. Already today the U.S. is behind in this extension because of the great success of the proton storage ring (ISR) in Geneva.

3. A decreasing total amount of operational money must cover the operation of NAL and the other facilities. This state of affairs hampers the exploitation of the new accelerator at NAL and severely restricts research at the other accelerators. Many excellent research projects are indefinitely postponed or must be carried out with insufficient means. Funds are lacking to introduce the best and most efficient instrumentation. The scope of U.S. High Energy Physics is shrinking and great opportunities for discoveries are left untapped. This can't go on much longer without changing the character of much of the work from pioneering at the most interesting frontline to routine work behind the front. If this happens, the intellectual and financial investment would be wasted to a large extent.

4. Apart from the decreasing amounts of support, the erratic and short-range budget planning interferes severely with efficient management of the facilities. The same amounts of money would be better used if the budgets were known in advance for a longer time interval.

<u>Effects of the Decline of H.E.P. in the U.S.:</u>

H.E.P. represents a vital spearhead of physical science; it is the continuation of a frontier that started with Rutherford's discovery of atomic structure, continued towards the insights into nuclear structure, and is now penetrating into the structure of elementary particles. It always attracted the best and most innovative minds because of its great challenges, in respect to theory, experimentation and instrumentation. One faces problems, technical and theoretical, that go far beyond what has been achieved before. This is why so many innovations have come from H.E.P. that were of use in other fields of science and technology, ranging from high vacuum techniques, sophisticated methods of data analysis, short time measurements, the construction of superconductive magnets, to the concepts of quasi-particles now used in solid state physics. If vitality and forcefulness is drained from this field, the effects will be felt all over. U. S. science would loose one of its main driving powers.

Recommendations:

In planning future budgets for H.E.P.,construction and operation funds should be considered together. The future survival of the field requires that, in the average, about 20% of the expenditures be devoted to construction of new facilities.

The total yearly expenditures in H.E.P. must be higher than the figure reached in FY 1974 when the NAL construction has practically ceased. That figure would represent a reduction of 25% below the average of the last 6 to 7 years. An increase of this figure, allowing some new construction to begin in the near future, is a precondition for a program that may keep the U.S. in the forefront at least in some areas of the field. It is a necessary step for the maintenance of the innovative seminal effect of H.E.P. on the scientific life of the nation.

June 23, 1973

Professor Jerome L. Rosen
Department of Physics
Northwestern University
Evanston, Illinois 60201

Dear Jerry:

This is just to remind you of the sub-committee on the study of physics merits of RLA. You are Chairman! I consider this as a very important committee and I hope that the report will be useful. If you remember, we plan to have Burt Richter and Leon Lederman as the others on the committee. I have talked with Panofsky about this as I couldn't reach Burt. Panofsky will "order" Burt to participate. Leon Lederman is a little reluctant to join. He will join if we don't find anyone else, and he is spending the whole month of July at NAL where you can easily reach him after your return from Europe. Leon asked me to get Rubbia or Sam Ting as his replacement. I am pessimistic that I can get those two people, since they are mostly at CERN. I have asked Burt to supply the SLAC version of RLA's physics importance as soon as possible to you and to me and to the other member. You then will have to use the time after you return for critical discussions and prepare a report that should be in the hands of John Teem around the 20th of July. Please don't wait longer! He must have digested it and must have made a decision by July 30th.

I hope this letter reaches you wherever you are in Europe. Let me know immediately where you are in Europe and how I can reach you by phone. Mail telegrams should be sent to CERN but telephone calls should go to France: (50) 41 51 20, preferably during the evening hours.

With best regards,

Victor F. Weisskopf

VFW:dle

June 25, 1973

Dr. John Teem
Director, Division of Research
Atomic Energy Commission
Washington, D.C. 20545

Dear John:

The days were too filled during last week in order to talk about all problems.

Here is a list of people I would suggest as new HEPAP members:

George Thrilling [Berkeley] -- (As a possible replacement of Bill Wenzel).

Carlo Rubbia [Harvard].

Aihud Pevsner [Johns Hopkins] -- (He was on for a year in the past and I believe could be called back for the rest of his term).

Valentine Telegdi [Chicago] -- (Would be very useful to enliven the discussions).

Boyce McDaniel [Cornell].

M. (Bud) Good [Stonybrook]

Robert Williams [Seattle]

Dave Nygren [Columbia]

You find here enclosed a letter that I received too late to take along to Chicago from Barry Barish. It is of some importance because we didn't hear much criticism of NAL at HEPAP. I am sending copies to all members of HEPAP.

My personal impression based on the opinions of HEPAP members and my own is that we should support NAL financially slightly more than the budget proposals indicate. It is my personal opinion however -- perhaps not the opinion of the members -- that SLAC and to some extent AGS, but in particular SLAC, should be given the favorable treatment, they had in the Agency's Proposal for '75.

I regret very much that Burt Richter wasn't present at the meeting. RLA has received too much negative critique. I believe the RLA would be a unique instrument and that it is very worthwhile to support it as the next construction project. I hope and expect that the appointed study group will bring this out clear enough so that you can act on July 30th.

The last HEPAP meeting again has shown to me that your interest and intense participation greatly increase the importance of HEPAP for High Energy Physics.

Please feel free to call me up at any time. You can reach me either at CERN or at my home in France. (50) 41 51 20. The best time to reach me at my home would be your late afternoon between 4:00 and 5:00 p.m. (Washington time).

With best regards,

V. F. Weisskopf

VFW:dle

cc: W. Wallenmeyer

CALIFORNIA INSTITUTE OF TECHNOLOGY

CHARLES C. LAURITSEN LABORATORY OF HIGH ENERGY PHYSICS
PASADENA, CALIFORNIA 91109

June 14, 1973

Professor V. Weiskopf
Physics Department
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki,

Since I will be unable to attend the HEPAP meeting, I thought it might be useful for me to write down my assessment of the current situation at NAL. Let me just list several main topics of concern and a few comments on each.

1. The Accelerator

Paul Reardon's assuming the responsibility for the responsibility for the accelerator section, I believe, represents an improvement. The "troika" scheme was unworkable, since the ultimate responsibility and planning was too diffused. A new intensity record ~4 10^{12}p/pulse was recorded last week.

Despite these improvements, I still feel that real expertise and direction in the accelerator section is lacking. The biggest problem for conducting any viable experimental program remains reliability. The actual number of protons per week delivered to the experimental areas averaged over the past 3 months is far below what these real intensities indicate.

2. The Experimental Program

There has been a large mobilization of experiments over the past months. Both the meson labs and the proton labs are starting experiments.

The week-by-week schedule which J. Sanford has developed is very useful. The lack of a 3-6 month schedule with priorities and goals is inexcusable. It makes experimental planning almost impossible.

3. The Users

The lack of on-site housing has become a critical problem. Motels and off-site apartments just are not a reasonable match to the irregular and uncertain schedule of experimenters using the machine. Quiet, "shuteye" type bachelor quarters, ala BNL, are the most crucial need.

4. The Management

The chair of command with respect to decision making is still far too blurry. Most of the decisions are made by the director. This is an unhealthy situation, no matter how wise he might be. Lack of action by the director generally means status quo or no decision in many areas. He can only focus, at a given time, on a few things which then become super high priority with respect to everything else.

5. The Atmosphere

The most disturbing single area at NAL, in my opinion, is the general morale and atmosphere. This laboratory is the center of high energy physics in the USA. We should all expect it to be a stimulating and exciting place to spend time. The accelerator, flow of visitors, etc., are the ingredients needed to have an exciting, pleasant laboratory. Instead, one finds that NAL is pervaded by unhappiness, complaints and backbiting. This is just a symptom of an environment for both staff and users which not only should, but must be changed if NAL is to become the type of laboratory we all want.

These are the main negative aspects of NAL as I see it at the present time. I am sure the positive aspects will be apparent when you are at NAL during the HEPAP meeting.

Sorry I must miss the meeting. I would much rather make constructive suggestions than point out difficulties.

Regards,

Barry C. Barish /wf

Barry C. Barish
Professor of Physics

cc: Dr. Walter Wales
AEC

Old HEPAP

DRAFT

MINUTES

HIGH ENERGY PHYSICS ADVISORY PANEL

Orange Room, Central Laboratory Bldg.
Stanford Linear Accelerator Center
Stanford, California

December 17-18, 1973

The revised preliminary agenda for the public portions of the High Energy Physics Advisory Panel (HEPAP) meeting is attached (A1-2).

Participants:

HEPAP

V.F. Weisskopf, Chairman
B.C. Barish
M.Q. Barton
D.B. Cline
J.W. Cronin
S.D. Drell
T.H. Fields
L.J. Laslett
F.E. Low
R.R. Rau
B. Richter
J. Sandweiss
J.R. Sanford
G.F. Tape
G.W. Wheeler
W.D. Wales } Exec. Secy.

NSF

A. Abashian, Program Dir. for Elementary Particle Physics

AEC

H.L. Kinney, Asst. Dir. Administration, Div. of Phys. Res.

W.A. Wallenmeyer, Asst. Dir. HEP, Div. of Phys. Res.

Role of ZGS in HEP Program

R. Sachs, the Director of Argonne National Laboratory, spoke to the Panel about the balance and vitality of the High Energy Physics Program. He referred to the Elementary Particle Physics Panel of the Bromley Committee and pointed out that the Panel had learned things that might be useful. The pinch in basic research funding and high energy physics in particular has been worse than any anticipated by the Panel, and may have led to imbalance in the overall program. Sachs pointed out that physicists must never draw lines between domains of physics separating "good physics" from "bad physics" on a topical basis. That is just an invitation for someone else to draw the line differently. The separation must always be based on quality. Sachs stated that the evaluation based on topic rather than quality seems to have led to a "Sergeant York" phenomenon (pick 'em off one-by-one from behind) and that the budget reflects this game plan.

Since the budget is now at a bare bones level, the entire spectrum of high energy physics experiments should be treated in an integrated fashion with the idea of obtaining a maximum of high quality physics for the money. Sachs remarked that high energy physics research is going to be done primarily by university users since universities have much of the strength in people and physics ideas. Accordingly, the opportunities to do physics at universities should be maximized.

On the other hand, the accelerator and facilities strength and capabilities are at the accelerator laboratories. Accelerator and facilities development, as well as instrumentation and diognostic development from other laboratories is important even for NAL. NAL cannot do all of the physics research or all of the necessary research and development on accelerators and devices but depends in part on the other laboratories. Sachs suggested an analogy to the top of a tree which cannot flourish if the trunk is cut in half.

He suggested that in the present budget climate there is a problem of providing the necessary experimental redundancy within the U.S. He pointed out that high energy laboratories must be considered a single entity and that the overall national productivity must be optimized within the limitations of the total budget. We must fall back on international competition to provide some of the necessary redundancy under existing funding limitations. However, he disclaimed suggesting the use of a national scheduling committee, but did suggest that the overall national effort should be coordinated between accelerators by asking laboratory directors to work together much more closely. He pointed out that this can be controlled to some extent by means of budget distribution and budget distribution should be based on a careful gauging of productivity and quality. Although HEPAP, in principle, performs the latter job, Sachs feels that more careful attention to each laboratory is required in order to make these critical judgments.

Sachs also suggested that on the basis of HEPAP quality judgments, cost effectiveness and power effectiveness could be examined more closely by the AEC.

Sachs suggested that it is important to remind people that a national laboratory is a resource for meeting national problems. At ANL the ZGS is a necessary and integral part of the overall laboratory program and makes major contributions to solving energy problems. He cited as an example the applications of the light collection concepts developed by R. Winston to a collector of solar energy. Sachs stated that it was HEPAP's responsibility to see that this sort of capability does not wither.

Cambridge Electron Accelerator (CEA)

The NAL Long Range Advisory Committee and the NAL in-house Task Group set up by R. R. Wilson both have recommended that the laboratory not proceed with the electron target. Accordingly, NAL no longer is interested in receiving the entire CEA. The disposition of the CEA equipment and machine components among the various laboratories is being determined by the AEC.

AEC Energy Activities

W. A. Wallenmeyer discussed the relationship between high energy physics and the proposed Energy Research and Development Administration (ERDA), which may be in existence within six months. The basic research mission including high energy physics is to remain in the charter of this new agency. No role in the immediate energy crisis has yet been assigned to high energy physics.

H. Kinney made some remarks on the energy report ("The Nation's Energy Future") which was distributed to members of the Panel. He stated that some opponents felt the five-year time scale envisaged in the report was too long and questioned whether a three-year program of the same size might not be more appropriate. The amount of new funding included in the $10 billion program is roughly one-half the total.

The administration's initiative to set up ERDA and a Nuclear Energy Commission (NEC) divorced from a superdepartment does not appear compatible with Senator Jackson's bill for a ten-year $20 billion non-nuclear program focused on NSF and the Departments of Interior and Commerce. The future of Congressional relations with an energy agency is uncertain and whether a Joint Congressional Committee would have cognizance over the major segment of the nation's energy program is not clear. The charter of ERDA provides for an administrator, a deputy, and five assistant administrators, all confirmed by the Senate.

H. Kinney pointed out that the OMB will get two opportunities to examine the FY 1975 budget. They will first examine the base budget, then later the budget for energy add-ons. Kinney pointed out that an overriding question on energy add-ons was whether manpower was available. The only way the energy program could be cut to three years would be to move large numbers of technically trained people from other programs. This would affect the nation's high energy physics program to a major degree.

W. A. Wallenmeyer pointed out that J. M. Teem had planned to address the Panel on energy problems but that ill health and bad weather had prevented his attendance at the meeting. However, Wallenmeyer used Teem's notes on what he planned to present to the Panel on the energy program. The highlights of the report were presented first, followed by an analysis of the meaning of the report to the scientific community.

The evolution of energy policy will be affected by environmental concerns, basic research capability, and the availability of trained manpower. The addition of $1 billion to the $10 billion energy program has been recommended over the five-year period for these needs. The recommended distribution would be $650 million for environmental concerns, $300 million for basic research, and $50 million for manpower development. The energy program is divided among short-term (before 1985), mid-term (1985 - 2000), and long-term (beyond 2000) components. The short-term components envisage a considerable contribution from private industry while the long-term components are exclusively federally supported. The basic research envisioned is primarily research on properties of materials and on chemical and biological processes. High energy physics does not appear except implicitly as a source of trained manpower.

During the next five years money and fuel for high energy physics are expected to be limited. Major requests for power reductions are expected during the winter. For high energy physics there are two basic questions which must be asked relative to the energy shortage. First, the problem of minimizing the effects of the energy shortage on the research program must be faced. Second, possible roles for high energy physicists in energy R&D must be investigated. In particular, the problems of doing such work at single-purpose laboratories such as SLAC and NAL or at universities must be considered. Wallenmeyer pointed out that a specific HEPAP recommendation to Teem would be useful.

The Panel discussed an appropriate response as a community to the energy shortage and the national need. Facilities should be made energy-economical. Continuing commitments to superconducting magnets were generally recommended. The possibility of emphasizing development in some laboratories and operation in others was also suggested. It was also pointed out that high energy physics could serve as a model for setting up central sites at which effort by university physicists could be focused to help solve energy-related problems. The Panel discussed the production of physicists both for research in high energy physics and for assimilation in other parts of the scientific society.

W. Wallenmeyer showed a graph (A3) of the number of physicists (graduate students, physicists, and other professional) as a function of time. The number of graduate students in the program had decreased by a factor of two from 1967 to 1974. The Panel discussed the problem of the future age distribution which this trend implies. It was suggested that a possible side benefit of the energy crisis would be to have some of the older people in the field go into energy-related fields. However, it was not clear how such transitions are to be effected.

It was the consensus of the Panel that the questions involved required more detailed consideration as well as more information than the Panel had available. Accordingly, a subpanel was authorized to look carefully at the energy crisis and recommend an appropriate response for high energy physics. In particular, the subpanel was asked to: (1) examine the energy consumption of high energy physics to find the most appropriate means of conserving energy; (2) to note existing efforts and see how high energy physics capabilities should be used to assist in meeting the immediate crisis; and (3) to note the long-range importance of research in high energy physics in attacking the basic energy problems. J. Sandweiss was appointed Chairman of this subpanel. It is hoped that this committee will be able to make a report at the next meeting of HEPAP.

NAL Status

J. Sanford reported on the progress made at NAL during the last few months. He showed a plot of the integrated beam intensity (A4). This plot indicated that about 4×10^{17} protons per pulse had been delivered during September and October. There has been a steady improvement in the beam intensity. The peak intensity thus far is 6×10^{12} protons per pulse. The average is now about $4\text{-}5 \times 10^{12}$ protons per pulse. Sanford also presented a research facility performance table (A5) which showed the experimental stations and the number of experiments in progress at different points of time. It is expected that about 20 experiments will be in progress by July 1975. A plot of accelerator reliability (A6) showed that the high energy physics component of the scheduled time has been consistently expanding. The accelerator failure rate has been constant at about 200 hours per month during the past year. It is not clear why this rate has not decreased. A graph of a failure survey (A8) showed the distribution of failure among the linac, booster, main ring, controls, and external beam. The peak corresponds to RF failures. The magnet replacement rate is now about two or three per month. (It should be noted that the time assigned for various component failures in this latter plot is not exclusive, i.e., the accelerator is often down for two failures simultaneously. Thus, the actual failure time during any particular month is generally less than the sum of the system downtimes.)

Sanford pointed out that the radiation exposure to personnel working on the extraction gear is now below its peak rate. Although the intensity of the beam is now higher than previously, the higher extraction efficiency and the better reliability of the components in the extraction system have allowed the Laboratory to reduce radiation exposure in the extraction area.

Sanford presented a diagram (A9) showing the location of the experiments which are currently in progress. The Laboratory has finished a cycle of operation at 200 and 300 GeV and is now beginning a cycle at 400 GeV. The Laboratory plans to run the 400 GeV cycle with a 12 second repetition rate which will consume the same amount of power as a 6-7 second repetition rate at 300 GeV. The peak energy demand at the Laboratory is now 60 megawatts. Highlights of the accelerator operation since the last HEPAP meeting include delivering the first proton beam to the Proton West area and obtaining the first photographs in the 15' bubble chamber.

In the Meson Area all of the experiments listed in the diagram (except Experiment 82) have taken data. The area is now off for several weeks during the 400 GeV operation. In the Neutrino Area neutrinos have recently been used by Experiment 1A for a search for evidence of neutral currents and by Experiment 21 for a measurement of total cross sections. In the Proton Area data have been taken by Experiment 70 searching for heavy leptons and by Experiment 100 measuring charged particle yields.

The plans for the immediate future include the addition of a "front porch" on the magnet cycle to permit simultaneous running at two different energies and the implementation of the horn system. The 15' bubble chamber is now down due to difficulties with a seal on the system. A second set of Soviet scientists has arrived to begin work on Experiment 186 which will measure p-d scattering with the gas-jet target. These scientists have come with their wives and with some of their children.

The fear that the NAL pulsating power demands would be detrimental to the peaker generators in the Consolidated-Edison system have turned out to be ill-founded. It appears that the operation of NAL has no more effect on the generators than do the operations of many other of Consolidated-Edison's customers. However, since these generators are part of the small fraction of the total Consolidated-Edison capacity which is oil-fired, they may be more affected by the energy shortage than the rest of the system. Power-factor capacitors which would reduce the effects of the pulsating load should be delivered in March and be ready for use in April.

The laboratory is now focussing more strongly on the energy doubler, which they now also call the "energy saver." It is expected that results from tests on 20' prototype superconducting magnets working in the Protomain will be available in two to three months. NAL has permission to use $1.5 million on prototypes for the doubler project during the year beginning in January 1973, but cannot spend more than this without permission from the AEC. The Panel discussed the relative merits of the doubler and of the proposed "mini-project" as tests of superconducting accelerator technology.

The Panel decided to set up a subcommittee to study superconductivity and accelerators. T. Fields and M. Barton agreed to chair this subcommittee. A presentation and report on the energy doubler should be made at the next HEPAP meeting.

SLAC Presentation

The agenda for the SLAC presentation is attached (A10). During this part of the meeting the audience for the public HEPAP meeting reached its maximum of about 20, mostly from SLAC itself. S. Drell presented diagrams showing the SLAC organization (A11), a membership list of the SLAC Advisory Committees (A12), a statistical survey of SLAC users (A13), and a survey of experiments since the beginning of operation at the accelerator (A14). The number of experiments being done has obviously increased as has the relative use of the accelerator by outside users.

S. Drell presented an analysis of the budget of the past few years (A15-16). Most of the recent equipment funds have been devoted to LASS, SPEAR, and the hybridization of the 40" bubble chamber.

Drell showed another chart (A17) which showed the utilization of the accelerator. Full operation by definition is 830 shifts at 360 cycles per second during the year. During FY 1974 most of the running has been at 180 cycles. The marginal cost of operation at 180 cycles is $2,000 per shift as compared with $3,200 per shift at 360 cycles. During the remainder of FY 1974 it is planned to use $150,000 to convert 122 shifts from 180 cycle to 360 cycle operation. This change will permit the acquisition of more data from approved experiments.

Other graphs presented included a history of percentage utilization (A18), the accelerator operations history (A19), the manpower and layoff status (A20-21), and the multiplicity (A22). The multiplicity has dropped from 4.7 in FY 1973 to 3.6 at the present time. This has been primarily due to the fact that fewer experiments can be run simultaneously during operations at 180 cycles. The total laboratory manpower has been gradually decreasing since 1970.

Drell used a map of the q^2-W^2 plane (A23) to show the areas which have been investigated at SLAC thus far. The southern (space-like) region has been well explored to the limits accessible with the present accelerator energy. Significant advances in this region from SLAC are only likely when higher energy, either through higher klystron power or a storage scheme (SLED), becomes available. The northern (time-like) part of the map was investigated in a very preliminary way by CEA. SPEAR I is beginning to fill in this region in more detail.

B. Richter discussed the program at SPEAR. The beam is available for 69.5% of the up-time, fill-time occupies 14.7% of the time, failure accounts for 12.7% of the time, and linac failure accounts for 3.1% of the total. The experimental program is now well underway. One experiment, SP-4 (annihilation reaction and 'Compton' reaction-Stanford), has been completed; SP-2 (multiparticle final states-LBL/SLAC) has about half its data; and another, SP-8 (inclusive reactions-Princeton-Pavia-Maryland), is running.

The SPEAR facility will be shut down on the first of July for the installation of new power supplies and RF capabilities. It is expected to be ready for experiments at the new energy (4.5 GeV x 4.5 GeV), by January of 1975. The luminosity will be 5 x 10^{31} cm^2 per second at 3.8 GeV. DORIS, which is the main competition for SPEAR II, will have an energy of 4.2 GeV, about the same luminosity as SPEAR II at this energy, and about ten times higher luminosity at SPEAR's present energy. It is expected to be ready for physics use in the fall of 1974.

Richter, in discussing the present results from SPEAR experiments, pointed out that very high energy densities are available, and that some of the simplest experiments make the sharpest tests of theory. The ratio of the total cross section to the μ pair production cross section is expected theoretically to be constant. The experiment indicates that this ratio is growing with energy and is approximately six at 5 GeV total energy. Although there is concern that there may be some two-photon contamination, the present evidence is that the data are not so contaminated. The trend of the charged multiplicity is consistent with older data provided that it is assumed that the neutral multiplicity is equivalent to the total charged multiplicity. Data pertaining to the inclusive cross section, in which the $d\sigma/pdp_{\perp}$ is plotted as a function of p look remarkably like the results of Cronin's experiment (E100 at NAL) in which the $d\sigma/Edp$ is plotted as a function of $p_{\perp}$. The similarity of the two plots stimulates speculation that electrons and positrons may have strong interactions. There is no data as yet on QED.

J. Ballam reviewed the present experimental program at SLAC. The accelerator is heavily committed. The big spectrometers are scheduled for the next year and a half while the other areas are scheduled for the next year. The experiments which Ballam reviewed included E89 which is investigating inelastic ep and en scattering with 1.6 and 20 GeV spectrometers. This experiment will fill in the whole area of the attainable space-like domain of the q^2-W^2 plot. E88, an experiment done by the UC- Santa Barbara group is looking at inclusive π^o production. Experiment E104 is using a μ beam and the reaction $\mu^- d \rightarrow \mu^- X p_s$ in a liquid deuterium target inside a streamer chamber. Experiment E97 is investigating inclusive production of kaons and pions ($ep \rightarrow e(^K_\pi)X$) in hydrogen and dueterium. The primary electron beam in this experiment is guided through the magnet in a superconducting tube which shields the beam and the low energy secondary electrons from the magnetic field. E92 is a study of neutral K interactions in a rapid cycling hydrogen target with magnets and wire chambers downstream. Experiment BC58 utilizes the 40" bubble chamber and a calorimeter to investigate reactions such as $\pi^- p \rightarrow nB^o, \Delta^- B^+, N^{o*} B^o$.

Proposed experiments envision use of the polarized electron beam on a polarized target and the use of polarized monoenergetic photons. In addition the hybrid 40" system is expected to be developed and utilized extensively. Stage 1 of the hybridization includes the moving of steel from the back of the present magnet and installation of three planes of multiwire proportional chambers and a huge Cerenkhov counter. Stage 2 would add a large downstream spectrometer. The 82" bubble chamber has now been moth-balled. During the five and one-half years in which the system was used at SLAC the chamber was pulsed 58.7 million times and 24.3 million photographs were taken. Two million photographs were taken in the last thirty-six days of the chamber operation.

R. Neal pointed out that the results of the operation at 180 cycles had been very good. During FY 1974 43% of the year will be operated at 360 cycles with the rest at 180 cycles. Neal presented some graphs of the accelerator operations history (A24) and the accelerator operations summary (A25-27).

Most of the electric power for the laboratory comes from the Bureau of Reclamation. The laboratory has a firm committment of 25MW from the Bureau of Reclamation, 12.6MW available on a withdrawal basis, and purchases the remainder of the power necessary from Pacific Gas and Electric. Since the laboratory normally operates with between 25 and 40 MW, most of the power used is available through the Bureau of Reclamation at favorable rates. Unfortunately, these will be increased in April 1974.

Neal reviewed the improvement program at the accelerator. Several years ago a program was begun to replace 20MW klystrons which failed with a newer 30MW tube. The machine has been about 40% converted. During the last few months a 40MW tube has been developed which uses the same modulators and consumes the same power. This tube has an efficiency of about 65% compared to 35-40% for the original 20MW tubes. The control system (A28) has been improved with the former two control rooms having been combined into one so that all operations can be controlled from a single area. Neal also showed a diagram of the special beams for

SPEAR (A29). More RF power is needed for the ring and a shorter but more intense beam pulse. New klystrons are being developed for SPEAR II.

Neal discussed the operations history of the klystrons at length (A30-33). The tubes had logged a total of 8.4 million hours by 9/30/73. During this time there have been 521 failures. The mean-time between failures has been 15,000 hours as compared with the 2,000 hours which was projected when the accelerator was first proposed. The cost of replacing tubes is now comparable to the cost of power.

Neal showed several diagrams (A34-36) of the proposed computer building, its schedule, and cost breakdown. The three-floor building, which will cost $2.9 million, will be devoted to computer user facilities and to housing the SLAC central computer. He also showed a diagram illustrating the operation of PEGGY, the polarized electron gun (A37).

Neal finally showed several drawings (A38-42) which outlined a proposal scheme to double the SLAC accelerator energy. This project which is called SLED (SLAC Energy Doubler), stores RF power to double the effective power of the RF tubes. The shorter pulse lengths which result would reduce the duty cycle by a factor of ten. However, this reduction in duty cycle would probably not adversely affect many experiments. The beam power would be reduced by less than a factor of two. The accelerator could be operated in the normal mode, if desired, by detuning the cavities. The cost of the project is estimated to be between 4 and 7 million dollars.

S. Drell and J. Rees reviewed the collaboration between SLAC and LBL on a colliding-ring accelerator. The two laboratories have continued working together and will submit a joint proposal for FY 1976 by April 1, 1974. This proposal will be for a 15 GeV single e^+e^- ring. Although this ring will be compatible with a possible future full PEP project (also including a superconducting proton ring), the scientific and technical justifications for the present PEP proposal will be solely based on the e^+e^- physics which can be done with the single ring. Both laboratories will be involved in the project which will be located at SLAC. The Directorate and senior staff of the project will be chosen in a balanced manner. The cost of the ring over the four years projected for its completion will be between $50 and $60 million. The compatibility with a possible future PEP development represents about 10% to the total cost. Conceptual studies are now underway. Talks with the Stanford and University of California administrations about tentative plans have begun. It is hoped that the contract would be part of the present SLAC contract and that the arrangements between the two laboratories would be made by means of an exchange of letters (with official sanction) between the two laboratory directors.

The proposed accelerator would have a luminosity of 10^{32} cm^{-2} sec^{2}. The electron beam energy would be variable between 5 and 15 GeV. The design would be compatible with the later installation of a 200 GeV superconducting ring for protons. The six-sided electron ring would circle the present end stations at SLAC and would have a radius of curvatures of about 220 meters. The lengths of the long straight sections would be about 130 meters. Most of the enclosure for the ring would be tunneled. Five interaction areas would be developed including one large interaction hall, two medium-sized interaction halls, and two small interaction halls. Modified SPEAR II klystrons at somewhat higher power would be used. The energy loss per turn would be about 25 MeV which would require a minimum RF voltage of 45MV per turn. At full energy the radiated power would be 4.7MW out of the total power of 7.2MW. The present level of R&D effort on the project is about $400,000 per year at each of the two Laboratories. If authorized in the FY 1976 budget, the project could be running in 1979.

The formal SLAC presentation was concluded by a visit to SPEAR and LASS. The massive LBL/SLAC particle detector occupies one of the SPEAR interaction areas while O'Neill's experiment (SP-8) occupies the other. LASS is now beginning to take final shape. It is dominated by the huge 25 kilogauss superconducting solenoid. In addition, LASS includes a 30 kilogauss-meter conventional dipole and many assorted magnetostrictive wire spark chambers and multiwire proportional chambers.

The discussion of the SLAC presentation centered on the community interaction with PEP and the general user problems at SLAC. SLAC and LBL are organizing a formal summer study on future facilities for the PEP ring which will include a major involvement of the national user community.

The user problem at SLAC is intrinsic to the accelerator and is in part due to the fact that the in-house physicists at SLAC are extremely competent. It was pointed out, in this respect, that capable university groups who do use SLAC find it easier to work there than at other laboratories.

The Panel discussed the relative merits of SPEAR and LASS. There was general agreement that SPEAR is a first-class success. There was some expression that the physics which would be done by LASS could also be done at proton accelerators.

Future Construction Projects

The Panel discussed the relative merits of PEPSI and ISABELLE. The acceptance of the PEPSI project might push ISABELLE into the future. Thus, PEPSI becomes a very major decision. It was also pointed out that NAL may propose 1000 GeV x 1000 GeV rings for FY 1976. The Long Range Planning Committee at the Laboratory, after studying the results of the Summer Study, has decided to support construction of new experimental areas but is not enthusiastic about the proposed large spectrometer or the several small storage rings which were considered. However, the Long Range Planning Committee at NAL reportedly does support the idea of building very large rings.

US/USSR Relations

S. Drell briefly reviewed the report which his subpanel had prepared for the previous HEPAP meeting. That report had suggested that a subcommittee of the negotiating committee be set up which would include an experimentalist, an accelerator type, a theorist, and a member of the parent committee from each country. This subcommittee would monitor the progress of the existing committee, propose modifications to existing agreements, and expedite exchanges of people. The present HEPAP meeting was to look at specific proposals in the three categories: 1) expand participation in joint experiments and exchange visits; 2) undertake joint R&D programs in accelerator technology and in the construction of major experimental instruments or facilities at existing accelerators; and 3) initiate major new construction projects. The Panel is clearly very pessimistic about the possibility of making any progress whatever on category 3 type projects. They believe that progress is more likely in categories 1 and 2. The report was amended by including these reservations and by including references to possible collaborations with Western Europe. The amended Subpanel report, which was adopted as a HEPAP report, is attached.

Current Frontiers in Physics

F. Low presented an analysis of the current status of high energy physics (see A43 47 attached). Three myths have recently been destroyed. The Fermi interaction with charged currents does not appear to be valid. If evidence for neutral currents persists a very attractive type of theory (a la Weinberg) is possible. The second myth which has recently been destroyed is the exponential fall-off of $p_\perp$ distribution. The third myth which has disappeared has been the constant total cross sections. Since no deep understanding of the previous apparent constancy had been satisfactory the new non-constancy has not been surprising. However, now one must again attempt to find an appropriate model to explain diffractive scattering and the almost constant cross section.

<u>Productivity Indicators</u>

The Panel discussed the documentation of claims that high energy physics is approaching an unhealthy state. V.F. Weisskopf noted that the laboratory inputs from the letters to the AEC do not contain enough concrete examples. The panel is concerned that very few youn physicists are being attracted to the field. Many Americans are now going to Europe to do their experiments and, more significantly, most of the new instrumentation and techniques are now being developed in Europe.

W.A. Wallenmeyer presented a number of indicators which his office had assembled. These included a graph as a function of time of government support for high energy physics in the United States and Europe (A~~44~~48), a table of high energy manpower as a function of time (A~~45~~49), and data on publications (A~~46-54~~50-58). The rate of experimental publication by US groups is going down while the corresponding rate for European groups is increasing. Wallenmeyer pointed out that he hoped that HEPAP would be able to suggest better indicators. It was the consensus of the meeting that the details of indicators should be looked at more closely. A Subpanel consisting of D. Cline (Chairman), J. Sanford, and J. Cronin agreed to prepare something for the next meeting.

Washington APS Meeting

F. Low, the Program Chairman for the Division of Particles and Fields, reported that he has been asked to set up a session at the Washington meeting which would help the community keep abreast of the status of major items being considered at national laboratories. The Panel was quite favorable to this idea. Low plans to secure speakers from each of the laboratories to participate in this session.

Monday Evening Activities

After a social hour and dinner with SLAC and LBL staff, a joint tribute was made to Professor Weisskopf for his distinguished and valuable contributions to physics in general and for his service as HEPAP Chairman in particular. Weisskopf then presented a public lecture on the development of high energy physics during the past three decades.

Executive Sessions

The Executive Sessions were devoted to a study of the current budgets and the funding prospects over the next five years. The scheduled Panel discussion of long range planning was cancelled due to lack of time.

Next Meeting

The next meeting of HEPAP was scheduled for February 25-26, 1974, in Germantown, Maryland.

REVISED PRELIMINARY AGENDA

HIGH ENERGY PHYSICS ADVISORY PANEL

Orange Room, Central Laboratory Bldg
Stanford Linear Accelerator Center
Stanford, California

December 17-18, 1973

Monday, December 17, 1973

9:00 AM	Role of ZGS in High Energy Physics Program - R.G. Sachs	OPEN
9:45	Report on AEC Energy Activities - J.M. Teem	OPEN
10:45	Discussion of Measures for Conservation of Energy in High Energy Physics	OPEN
12:00 NOON	NAL Status Report - J.R. Sanford	OPEN
12:30 PM	Lunch	
1:30	Presentation of SLAC Program	OPEN
5:00	Discussion of SLAC Presentation	OPEN
6:00	Adjourn	
8:30	Public Lecture on Status of High Energy Physics - V.F. Weisskopf	SLAC AUDITORIUM OPEN

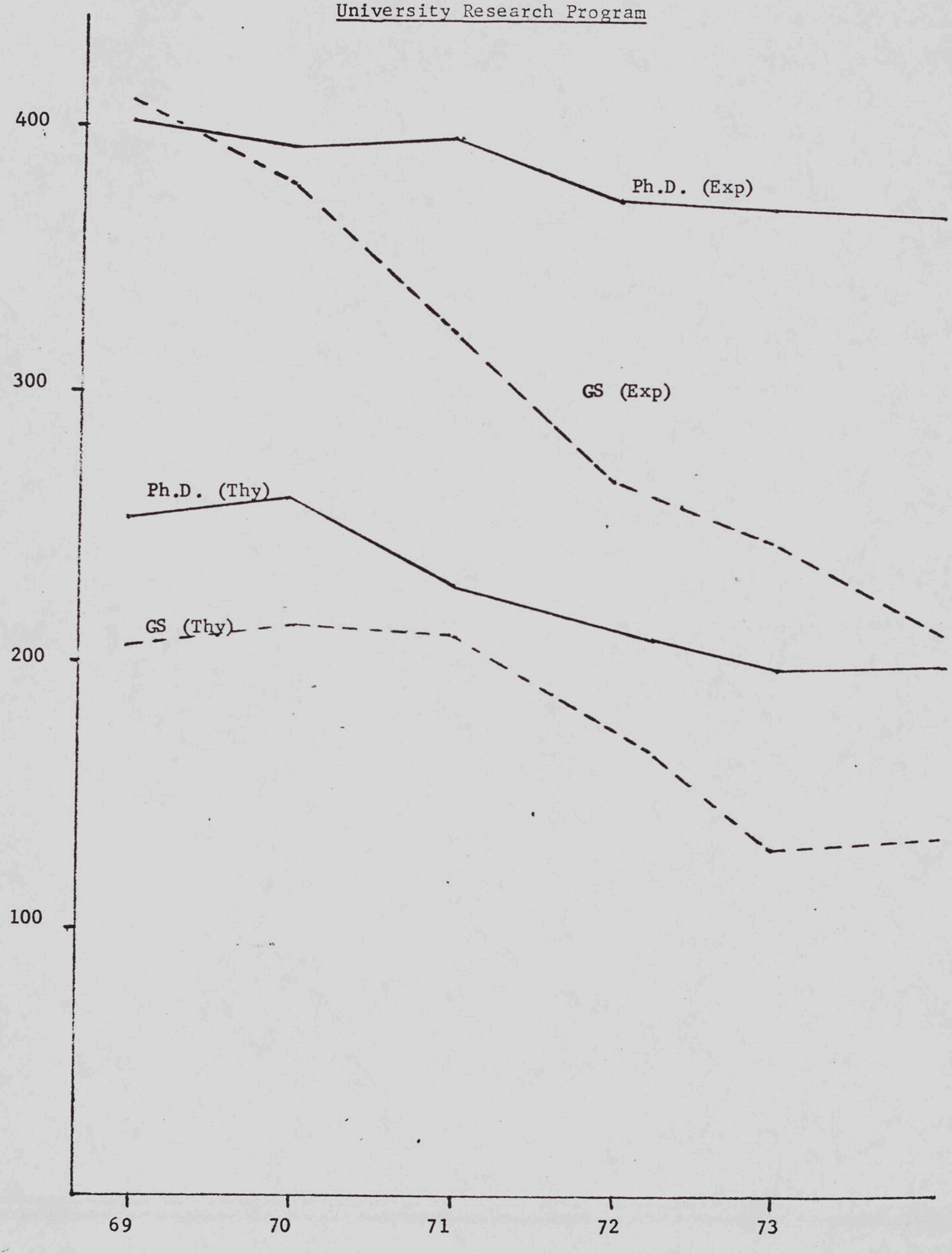
Tuesday, December 18, 1973

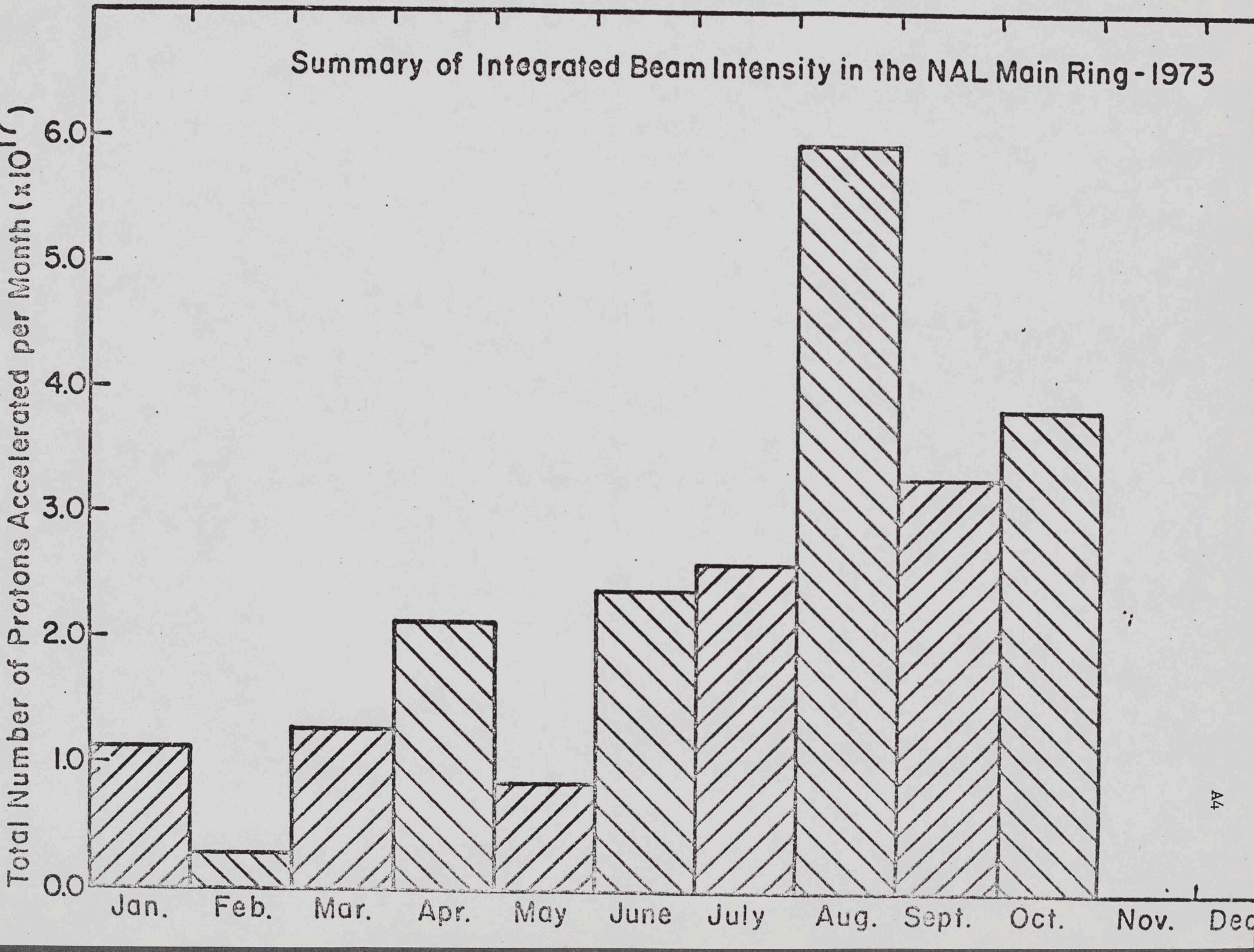
9:00 AM	EXECUTIVE SESSION	CLOSED
12:00 NOON	Lunch	
1:00 PM	US/USSR Cooperation in High Energy Physics	OPEN
2:00	Panel Discussion of Long Range Planning Required for New Construction Projects	OPEN

Tuesday, December 18, 1973

3:00	Discussion of Health of High Energy Physics - Present Physics Outlook, F. Low - Output Indicators - Report to Science and Technology Policy Office	OPEN
5:00	EXECUTIVE SESSION	CLOSED
6:00	Adjourn	

Head Count for AEC University Research Program





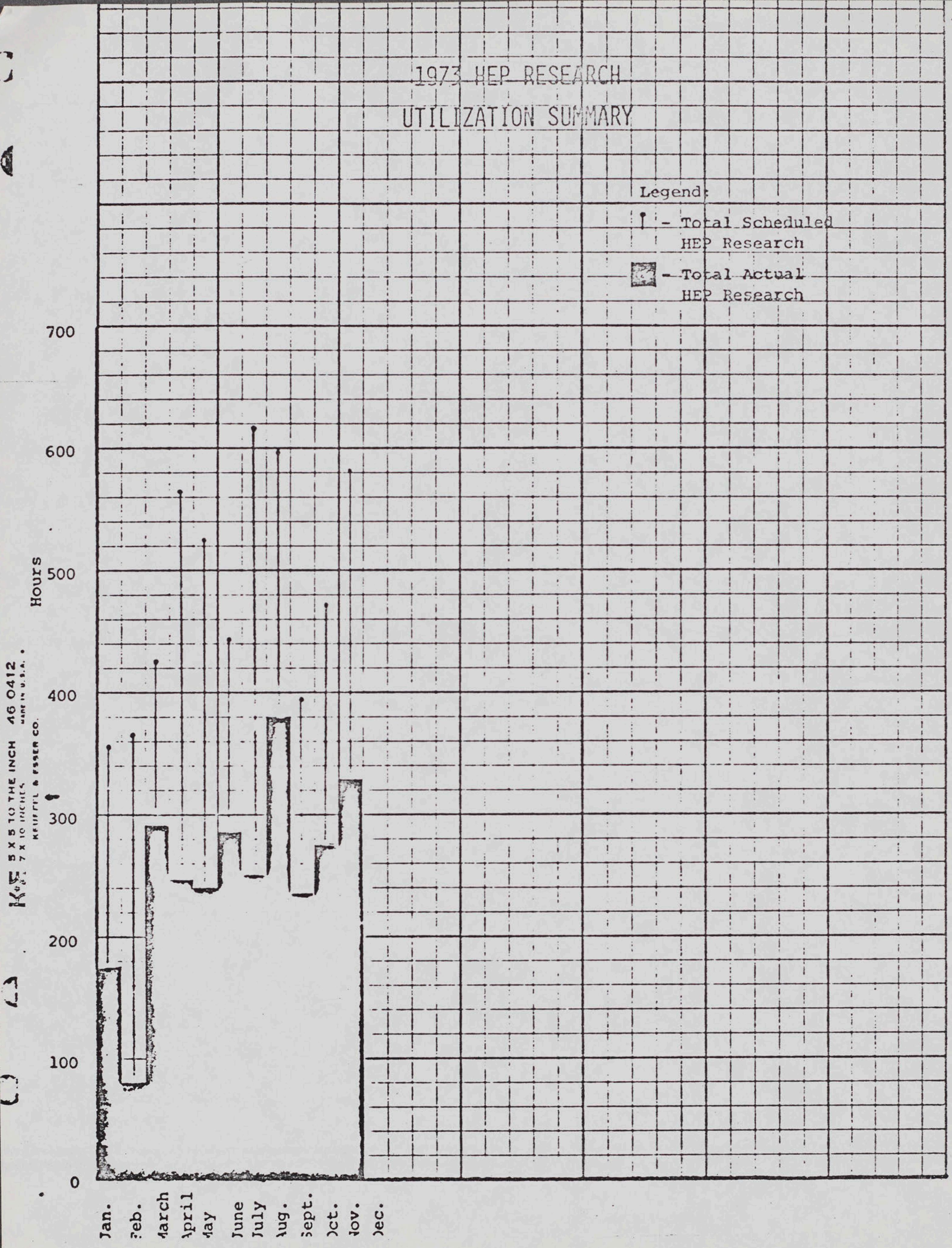
Summary of Integrated Beam Intensity in the NAL Main Ring - 1973
Total Number of Protons Accelerated per Month ($\times 10^{17}$)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec
A4

J.R.S.
12-4-73

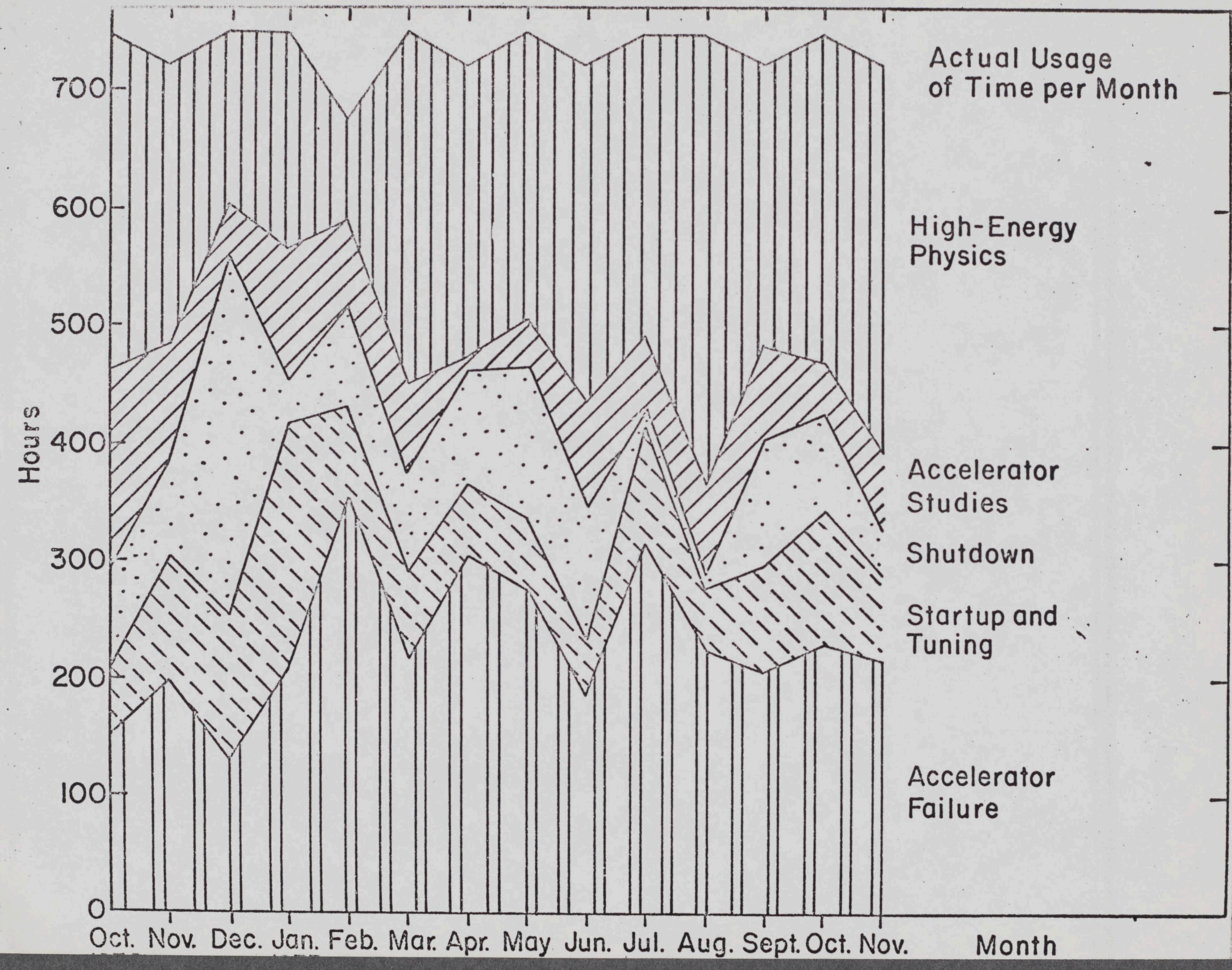
NAL RESEARCH FACILITY
PERFORMANCE TABLE

	Jan. '72	July '72	Jan. '73	July '73	Jan. '74	July '74	Jan. '75	July '75
Energy (GeV)	20	200	300/400	300/200	300	300		
Intensity-peak (10^{12} protons/pulse)	.001	.07	1	3	5			
Primary Target Locations Operating	0	2	3	5	7			
Detector Stations Available for Use	0	6	8	13	15			
Experiments in Progress at a time (average)	0	4	~6	~9	~10	12(est)	16(est)	20(est)
Number of Completed Experiments	0	0	10	16	36			
External Detector Stations Operating at a time (exclusive of b.c.)	0	2	3	5	6	8(est)	9(est.	10(est)

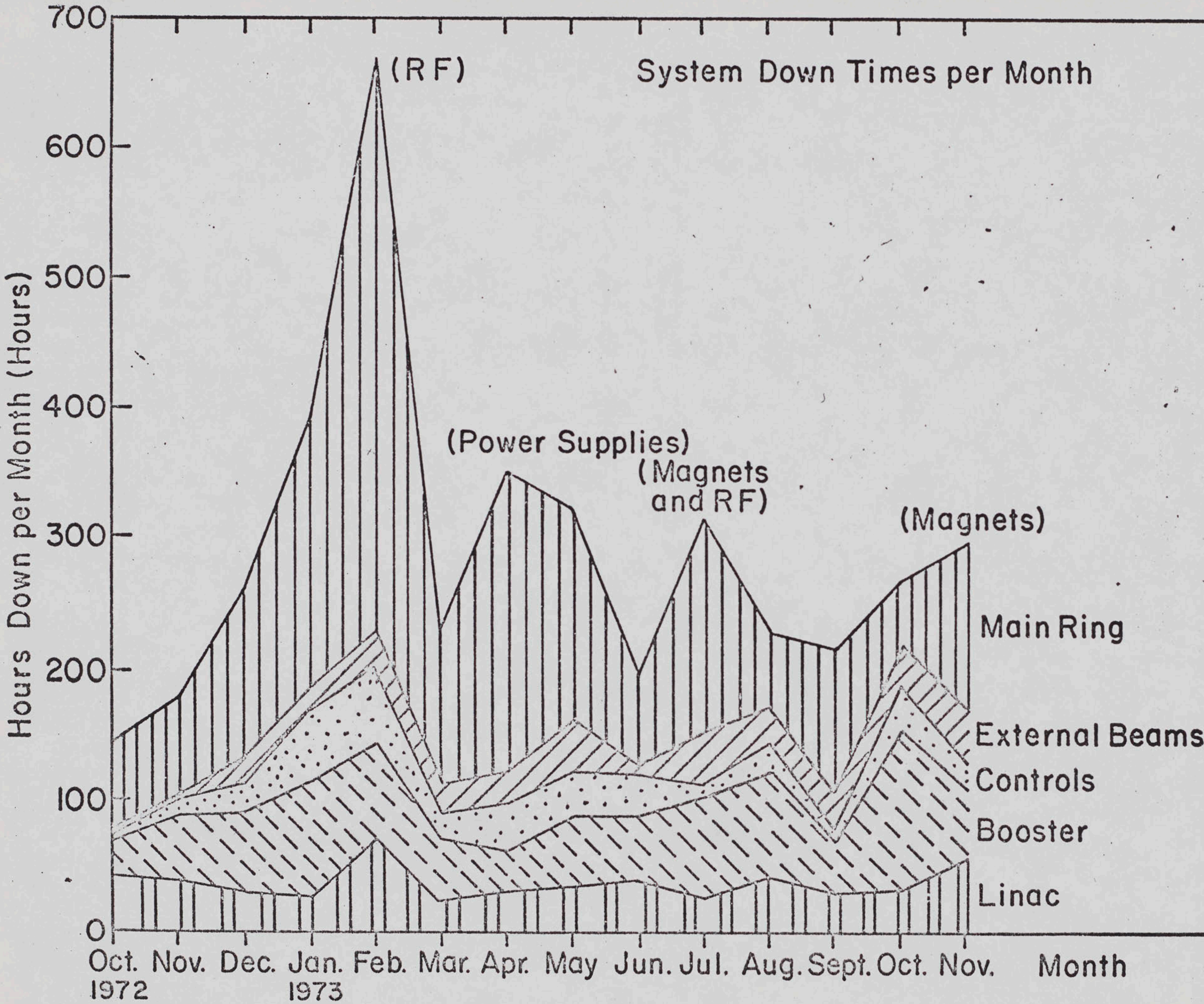
A6



1973 HEP RESEARCH
UTILIZATION SUMMARY
Legend:
- Total Scheduled HEP Research
- Total Actual HEP Research
Hours
700
600
500
400
300
200
100
0
Jan.
Feb.
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.



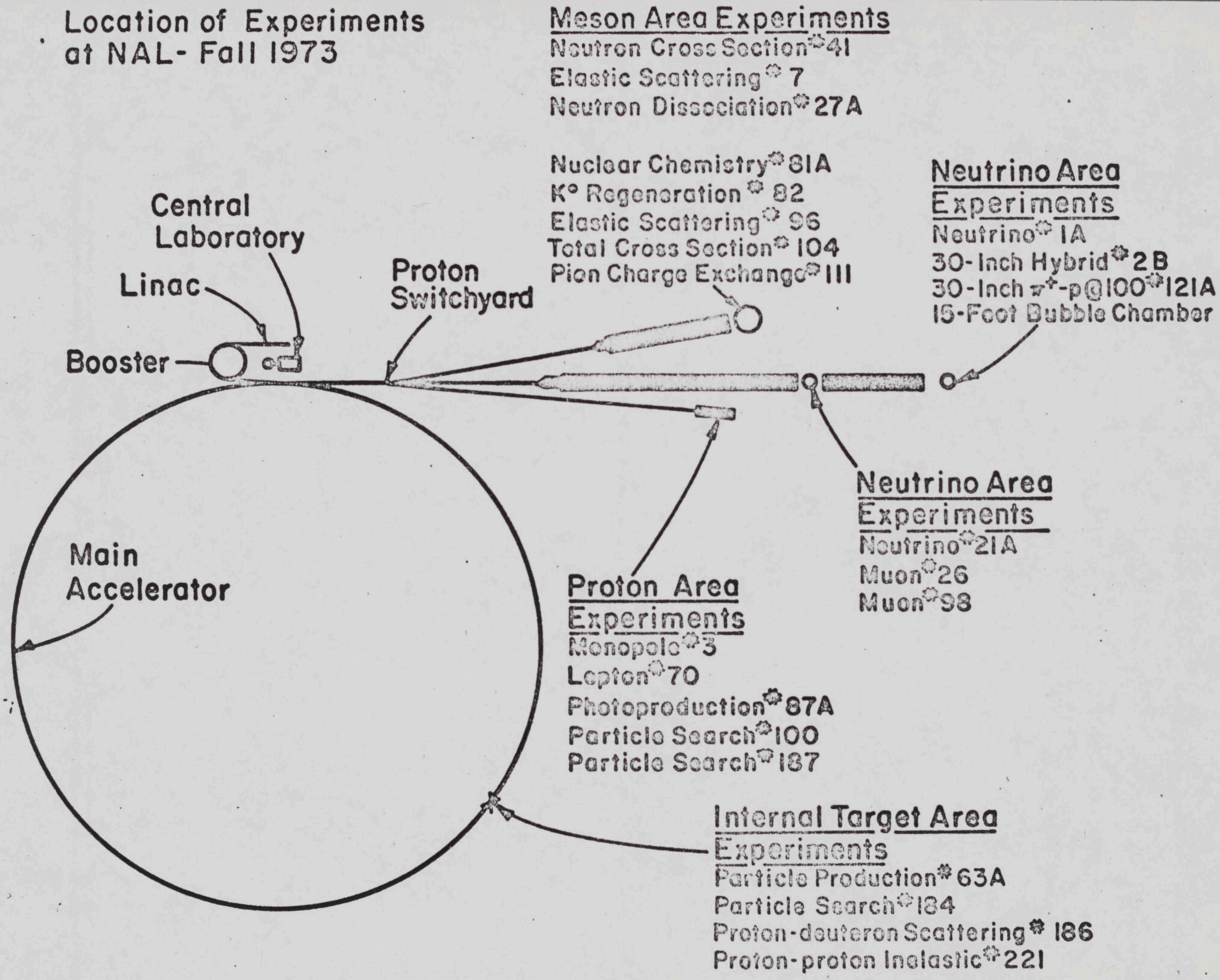
Actual Usage of Time per Month
High-Energy Physics
Accelerator Studies
Shutdown
Startup and Tuning
Accelerator Failure
Hours
700
600
500
400
300
200
100
0
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sept.
Oct.
Nov.
Month



System Down Times per Month
Hours Down per Month (Hours)
700
600
500
400
300
200
100
0
(RF)
(Power Supplies)
(Magnets
and RF)
(Magnets)
Main Ring
External Beams
Controls
Booster
Linac
Oct.
1972
Nov.
Dec.
Jan.
1973
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sept.
Oct.
Nov.
Month

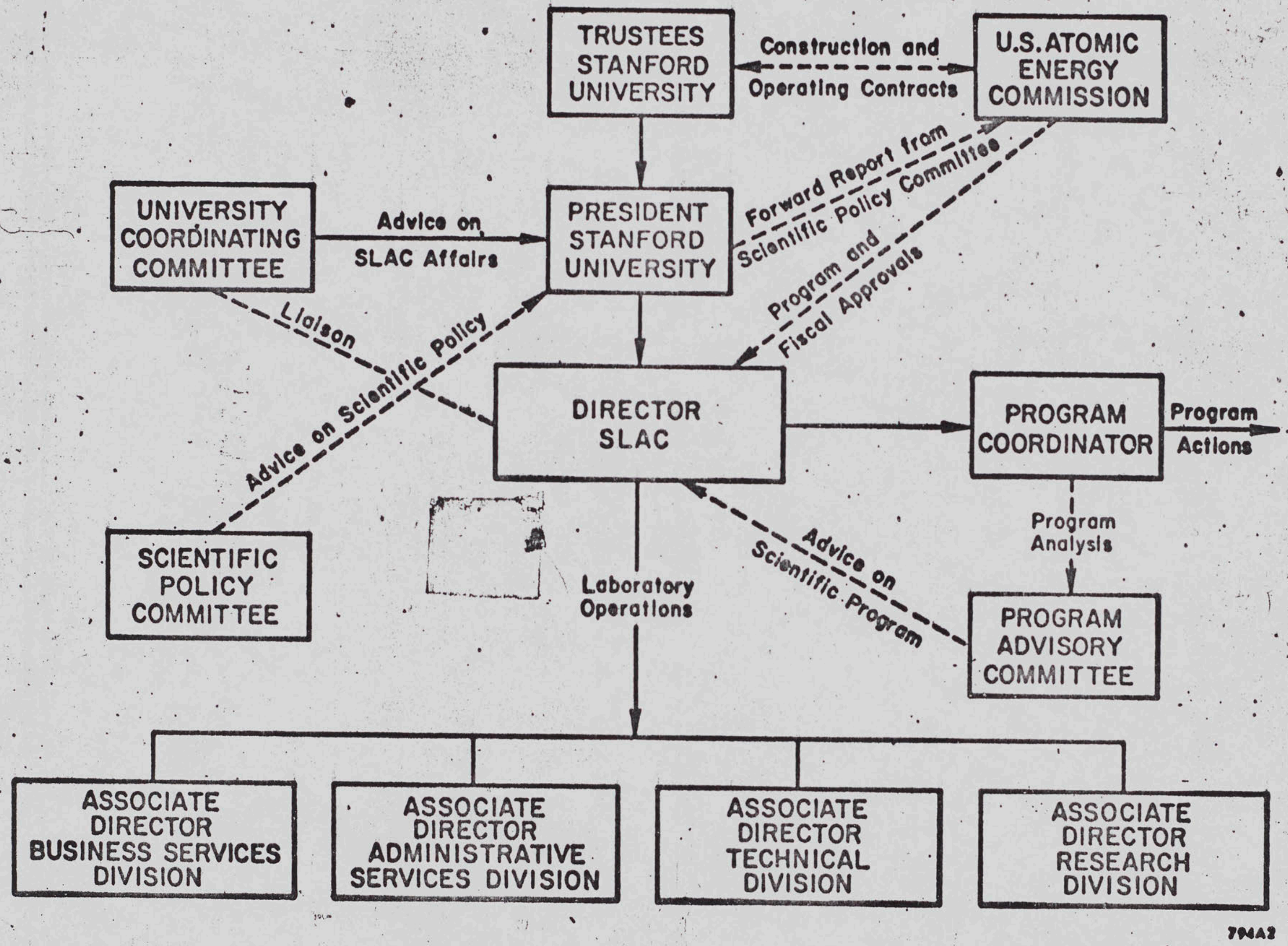
A6

Location of Experiments at NAL- Fall 1973



SLAC PRESENTATION

1:30 - 2:00	The general outlook at SLAC	S. Drell
2:00 - 2:30	Preliminary results from Exp. SPEAR-2 SPEAR upgrading	B. Richter
2:30 - 3:00	SLAC experimental program Hybrid bubble chamber project	J. Ballam
3:00 - 3:30	SLAC accelerator performance and plans (incl. brief SLED description)	R. Neal
3:30 - 4:15	PEPSI	S. Drell, J. Rees
4:15 - 5:00	Vist to LASS and SPEAR	


TRUSTEES STANFORD UNIVERSITY
Construction and Operating Contracts
U.S. ATOMIC ENERGY COMMISSION
UNIVERSITY COORDINATING COMMITTEE
Advice on SLAC Affairs
PRESIDENT STANFORD UNIVERSITY
Forward Report from Scientific Policy Committee
Program and Fiscal Approvals
Liaison
Advice on Scientific Policy
DIRECTOR SLAC
PROGRAM COORDINATOR
Program Actions
Program Analysis
SCIENTIFIC POLICY COMMITTEE
Laboratory Operations
Advice on Scientific Program
PROGRAM ADVISORY COMMITTEE
ASSOCIATE DIRECTOR BUSINESS SERVICES DIVISION
ASSOCIATE DIRECTOR ADMINISTRATIVE SERVICES DIVISION
ASSOCIATE DIRECTOR TECHNICAL DIVISION
ASSOCIATE DIRECTOR RESEARCH DIVISION
794A2

A11

SLAC Scientific Policy Committee Membership

Member	Institution
W. Fry	Wisconsin
R. Birge	LBL
J. Cronin	Chicago
R. Dashen	IAS, Princeton
M. Derrick	ANL
M. Hine	CERN
G. Masek	UC, San Diego
J. Rosen	Northwestern
C. Yang	SUNY, Stony Brook
F. Low	M.I.T.
N. Samios	BNL
E. Henley	University Washington
M. Sands	UC, Santa Cruz
F. Pirone	Princeton

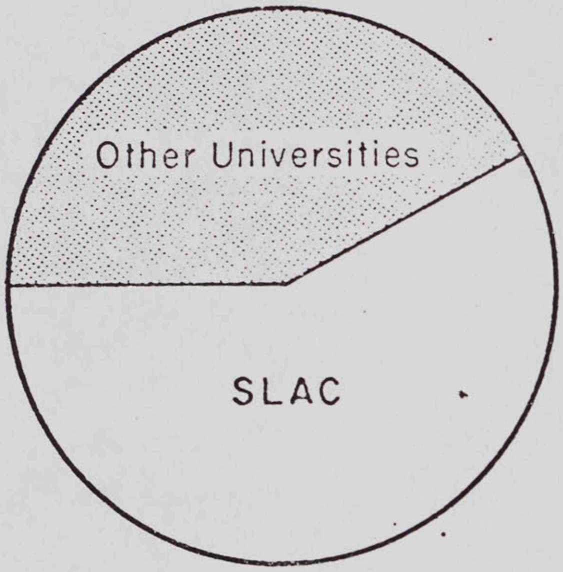
SLAC Program Advisory Committee Membership

S. Adler	Princeton Institute of Advanced Study
S. Finkelstein	Columbia
G. Goldhaber	LBL
T. Kycia	BNL
V. Telegdi	Chicago
S. Ting	M.I.T.
J. Ballam	SLAC
J. Brodsky	SLAC
H. Davier	SLAC
D. Ritson	SLAC

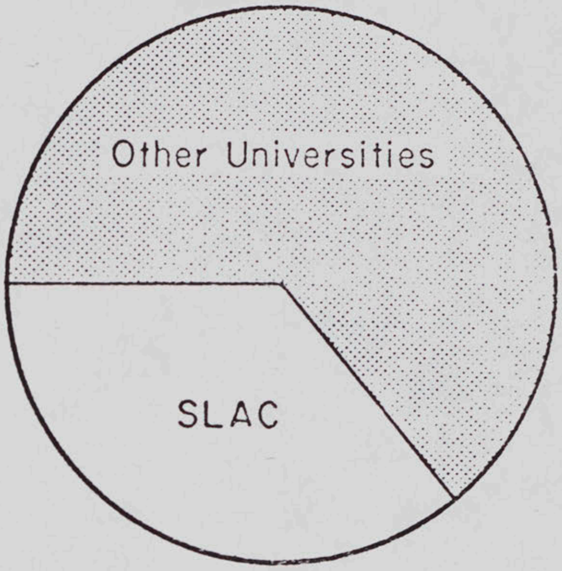
SLAC EXPERIMENTAL PROGRAM

ELECTRONIC EXPERIMENTS

Hours Run

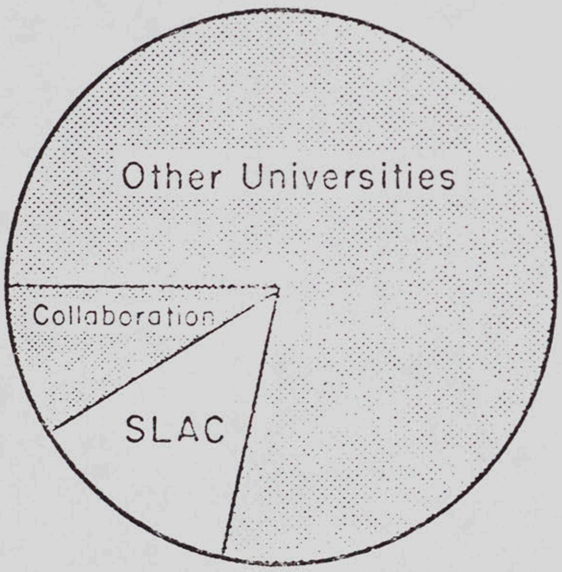


Hours Remaining

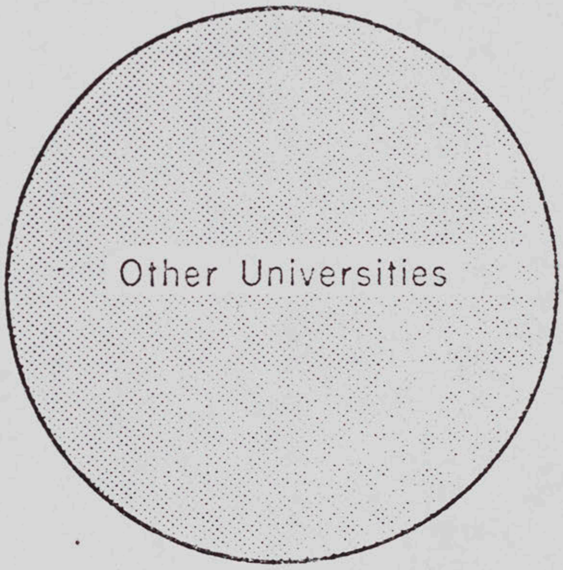


BUBBLE CHAMBER EXPERIMENTS

Photos Taken



Photos Remaining



2357A4

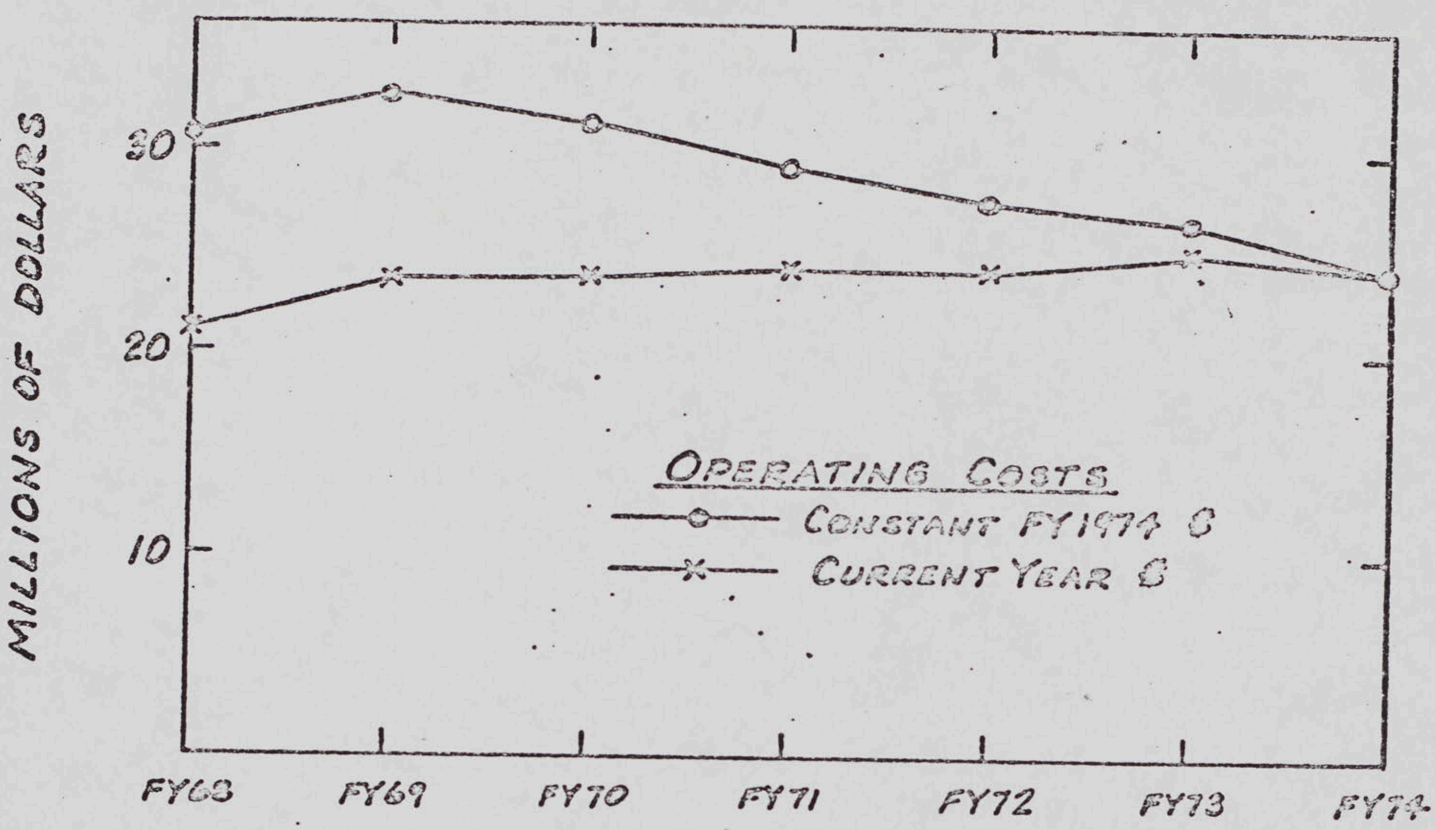
SELECTED INFORMATION ON THE SLAC PROGRAM

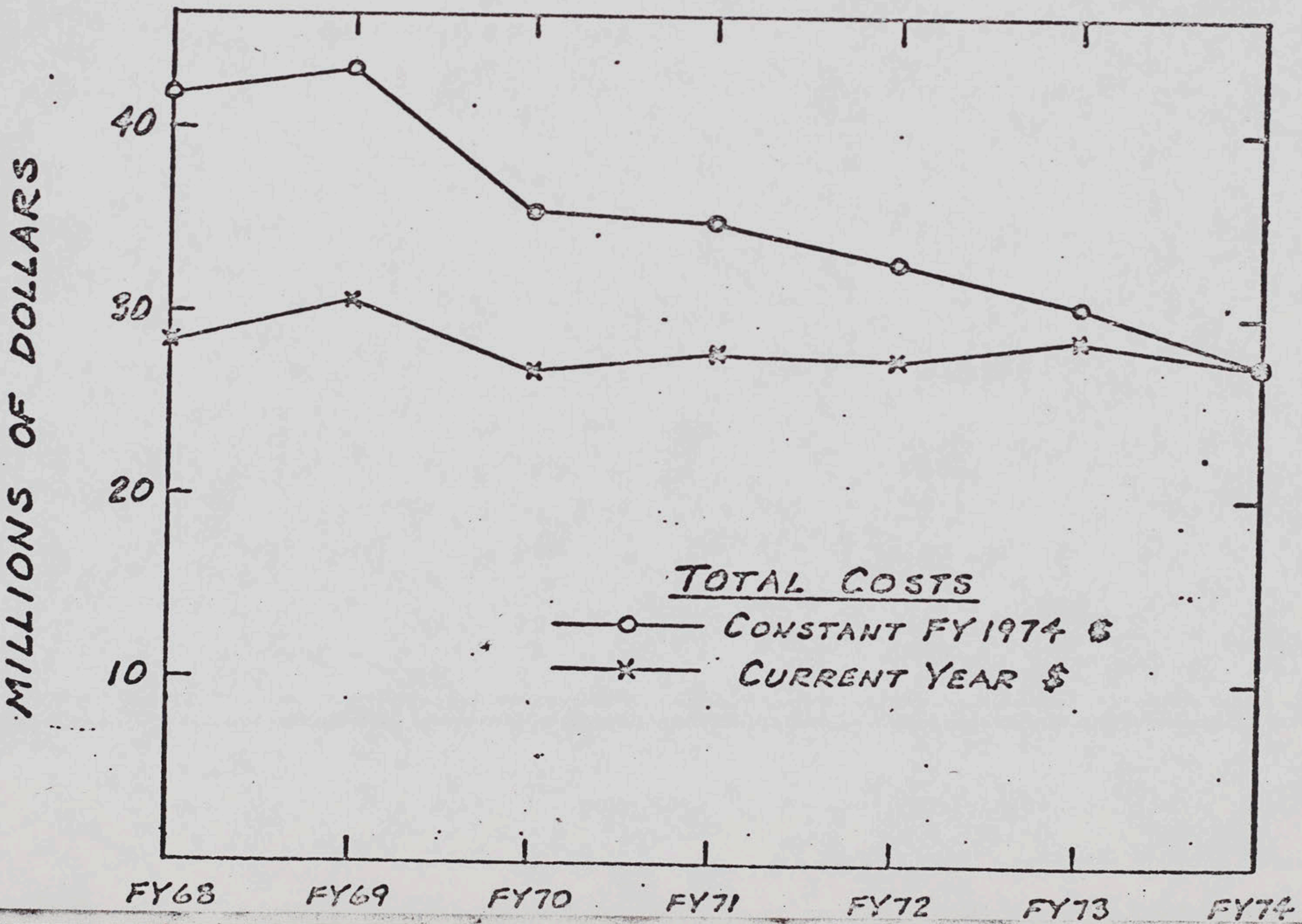
1.	Start of experimental research at SLAC		November 1966
2.	Number of experiments completed or approved		160
	Electronics experiments	94	
	Bubble chamber experiments	66	
3.	Number of physicists participating		360
	From Stanford	105	
	From other institutions	255	
4.	Number of physics graduate students participating		200
	From Stanford	75	
	From other institutions	125	
5.	Number of institutions participating	48	
6.	Number of Stanford Ph.D.'s awarded for thesis work at SLAC	56	
	Experimental Physics	18	
	Theoretical Physics	21	
	Computer Science	13	
	Other	4	

7. Number of RA's at SLAC

	Now	Since 1966
Experimental	30	63
Theoretical	10	39
	40	102

SLAC FUNDING IN CURRENT-YEAR DOLLARS AND IN CONSTANT FY1974 DOLLARS





11/5/73

Available Resources

Dollars in Thousands

	Actual			Estimated
	FY1971	FY1972	FY1973	FY1974
Operating Funds	$24,200	$24,100	$25,050	$24,300
Current Year Equipment Funds	2,438	2,960	2,594	1,750
Prior Year Carryover	2,609	1,577	2,050	1,577
Year-End Carryover	(1,577)	(2,050)	(1,577)	(522)
Subtotal	3,470	2,487	3,067	2,805
Current Year Accelerator Improvement Funds	950	0	1,025	550
Prior Year Carryover	573	560	15	651
Year-End Carryover	(560)	(15)	(651)	(276)
Subtotal	963	545	389	925
Current Year General Plant Project Funds	500	500	600	520
Prior Year Carryover	169	264	241	349
Year-End Carryover	(264)	(241)	(349)	(309)
Subtotal	405	523	492	560
Available Resources	29,038	27,655	28,998	28,590
Adjustment for Escalation Based on SLAC's Experience	6,330	4,094	1,856	NA
Adjusted Resources	$35,368	$31,749	$30,854	$28,590 1/

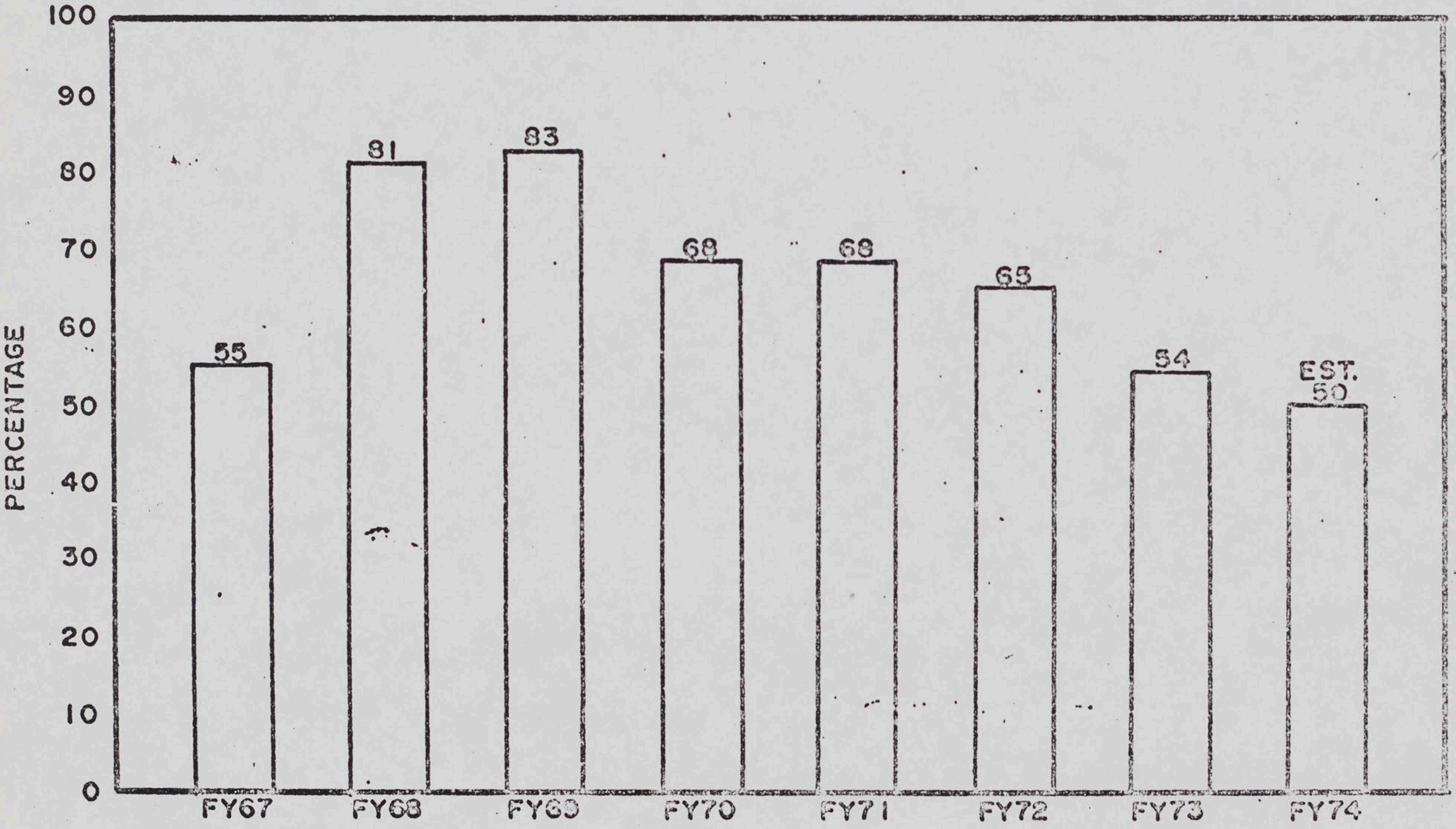
1/ Excludes $2.9M for Permanent Computer Building

PLANNED UTILIZATION OF ACCELERATOR

	Number of Operating Shifts	Number of Shifts at		Total Pulses Generated	Utilization
		360 pps	180 pps		
"Full Operation"	830	830	0	8.6×10^9	100%
FY71	562	562	0	5.8×10^9	68%
FY72	542	542	0	5.6×10^9	65%
FY73	489	417	72	4.7×10^9	54%
FY74 (Est.)	657	164	493	4.3×10^9	50%
FY75 (Est.)	657	657	0	6.8×10^9	79%

2312A14

ACCELERATOR PULSE GENERATOR



ACCELERATOR OPERATIONS HISTORY

Number of Scheduled Shifts

	Machine Physics	Particle Physics	Total	Beam Multiplicity
FY 1967	145	311	456	1.3
FY 1968	105	572	677	1.9
FY 1969	76	604	680	3.0
FY 1970	48	513	561	3.0
FY 1971	35	527	562	3.1
FY 1972	62	480	542	4.2
FY 1973	36	453	489	4.7
FY 1974				3.6 (1st Quarter)

2312A13

10/9/73
Revised 11/5/73

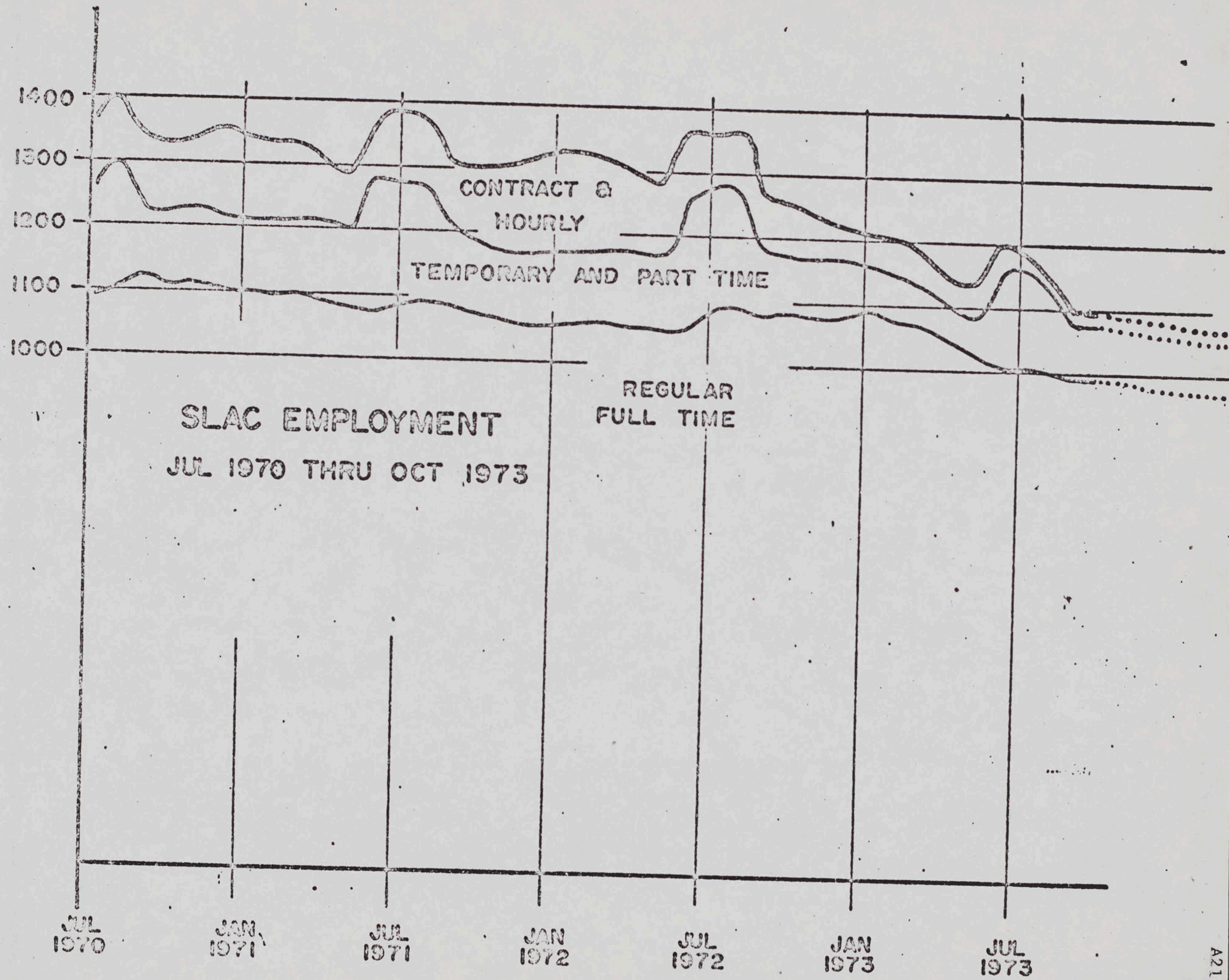
HEADCOUNT STATUS

Division	Reduction Target of Jan. 1973	Reduction Balance as of 7/31	Additional Quota Imposed 8/2/73	Revised Balance as of 7/31/73	Progress Since 7/31/73	Balance
Technical	95 1/	4	9	13 2/	3	10
Research	35	3	7	10	2	8
Business Services	6	(3)	4	1	0	1
Administrative Services	4	2	2	4	0	4
Total	140	6	22	28	5	23

1/ Includes 20 contract employees

2/ This target was increased to 18 from other than electronics assembly shop as a result of the approval to increase that shop headcount by 5 within a fixed division headcount. It has now been decided to increase that shop headcount by 3 thereby revising the target to 16 for other than electronics shops. Actual attrition of 6 has occurred.

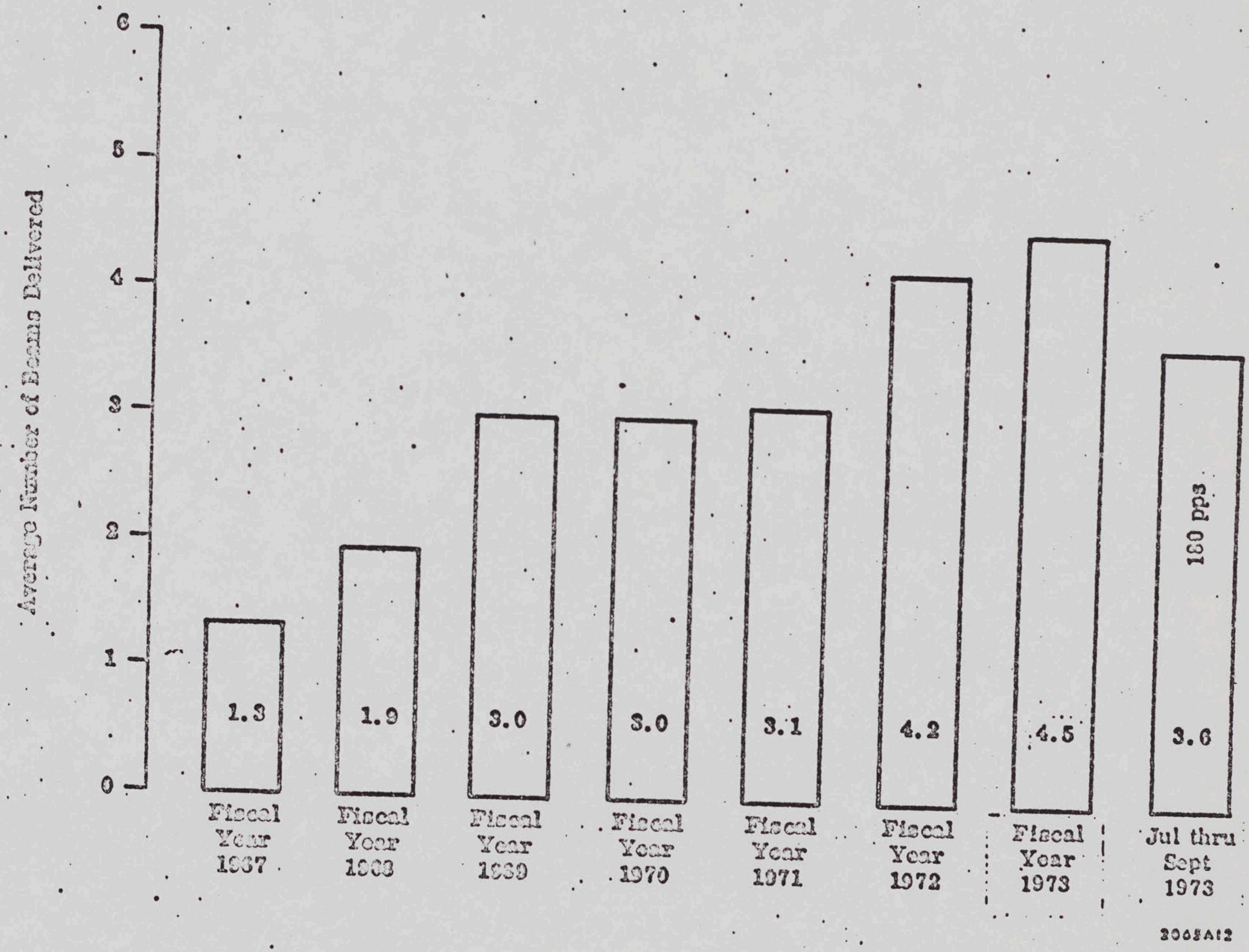
A20



1400
1300
1200
1100
1000
CONTRACT & HOURLY
TEMPORARY AND PART TIME
REGULAR FULL TIME
SLAC EMPLOYMENT
JUL 1970 THRU OCT 1973
JUL 1970
JAN 1971
JUL 1971
JAN 1972
JUL 1972
JAN 1973
JUL 1973

A21

ACCELERATOR OPERATION SUMMARY



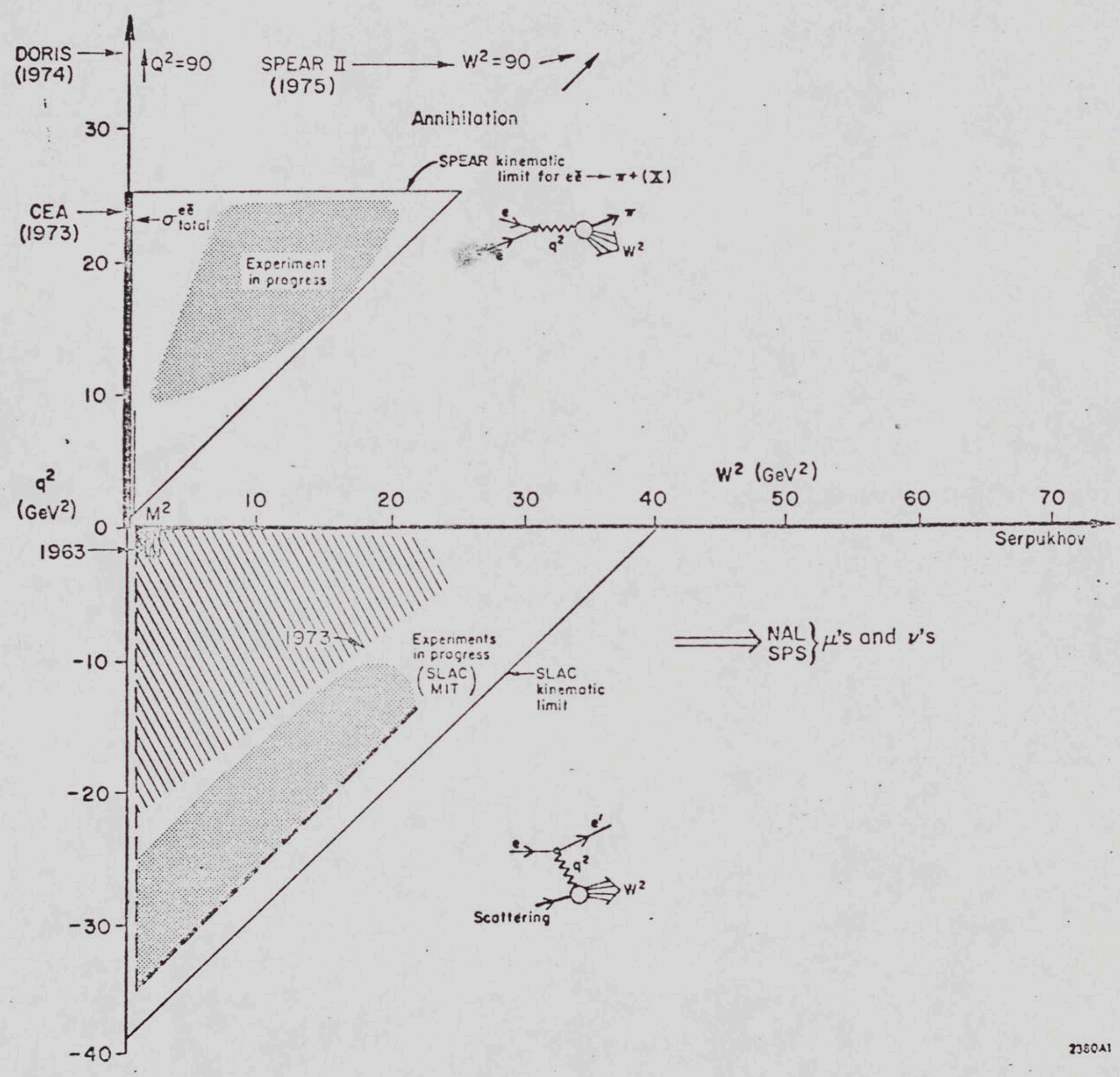

DORIS (1974)
Q² = 90
SPEAR II (1975)
W² = 90
Annihilation
SPEAR kinematic limit for e ē → π + (X)
CEA (1973)
σ total
Experiment in progress
q²
(GeV²)
W² (GeV²)
M²
Serpukhov
1963
1973
Experiments in progress (SLAC MIT)
SLAC kinematic limit
NAL SPS } μ's and ν's
Scattering
2380A1

Fig. 1

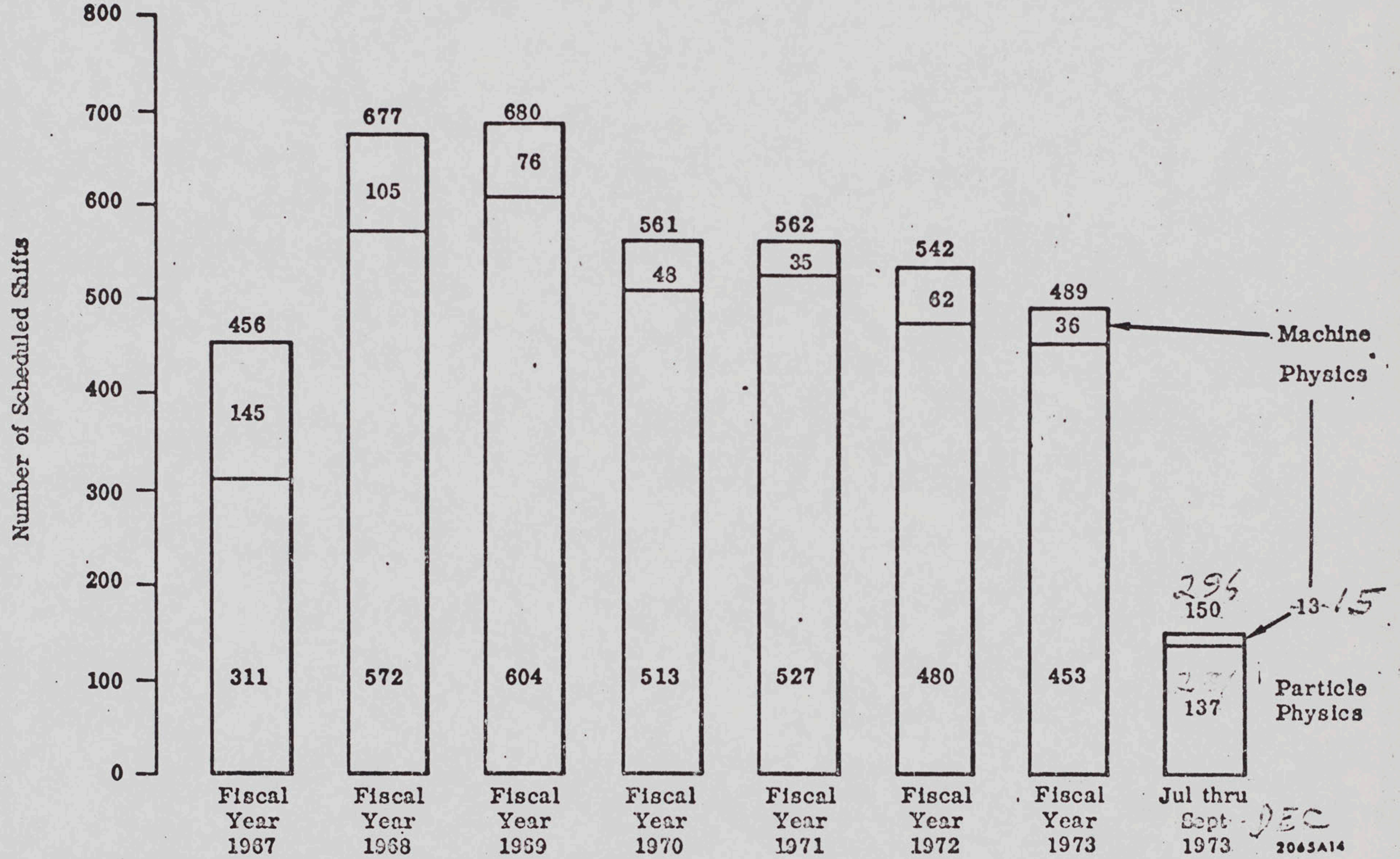
ACCELERATOR OPERATIONS HISTORY

Number of Scheduled Shifts

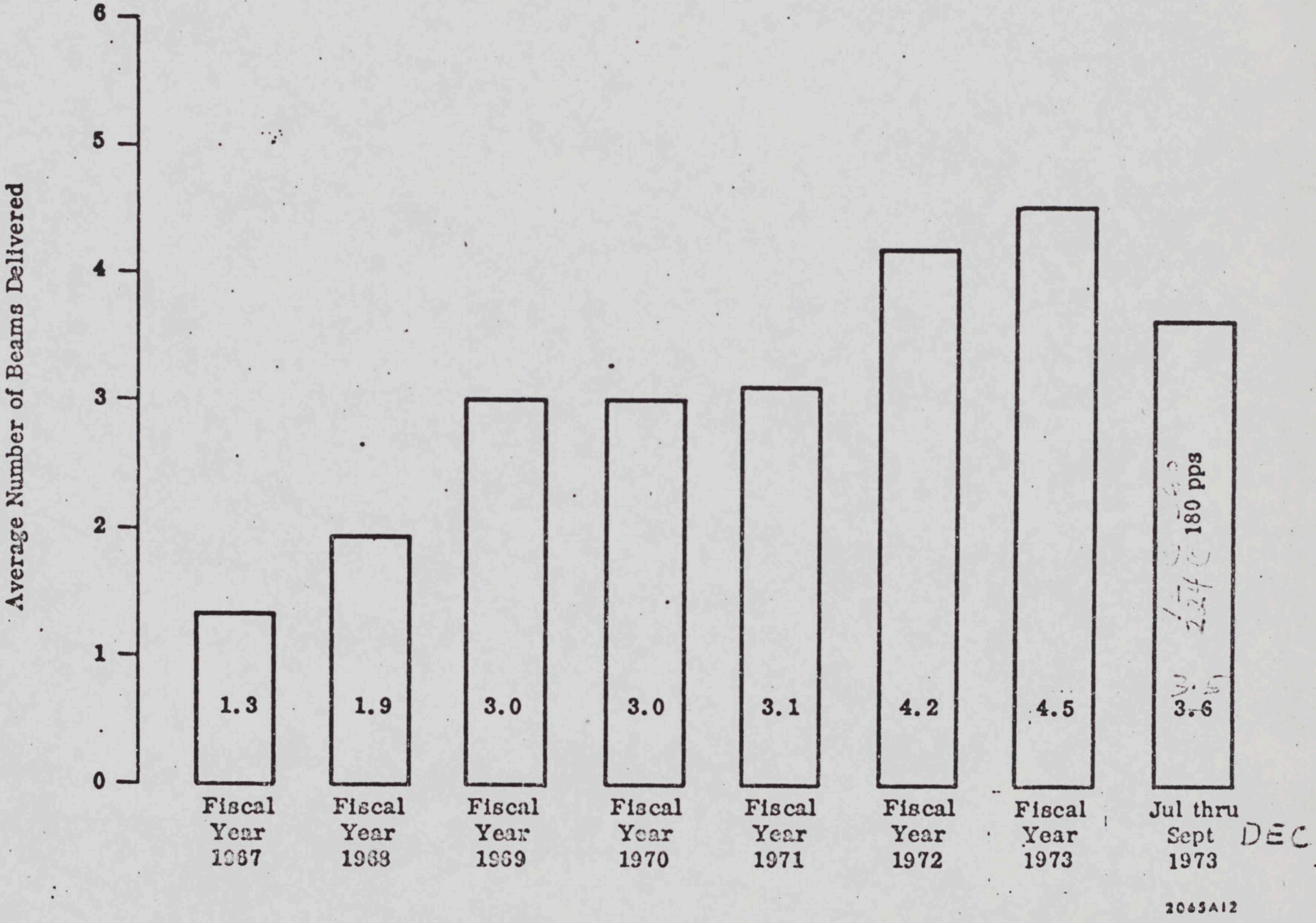
	Machine Physics	Particle Physics	Total	Beam Multiplicity
FY 1967	145	311	456	1.3
FY 1968	105	572	677	1.9
FY 1969	76	604	680	3.0
FY 1970	48	513	561	3.0
FY 1971	35	527	562	3.1
FY 1972	62	480	542	4.2
FY 1973	36	453	489	4.5
FY 1974 (6 mo.)	15	281	296	3.5

2312A15

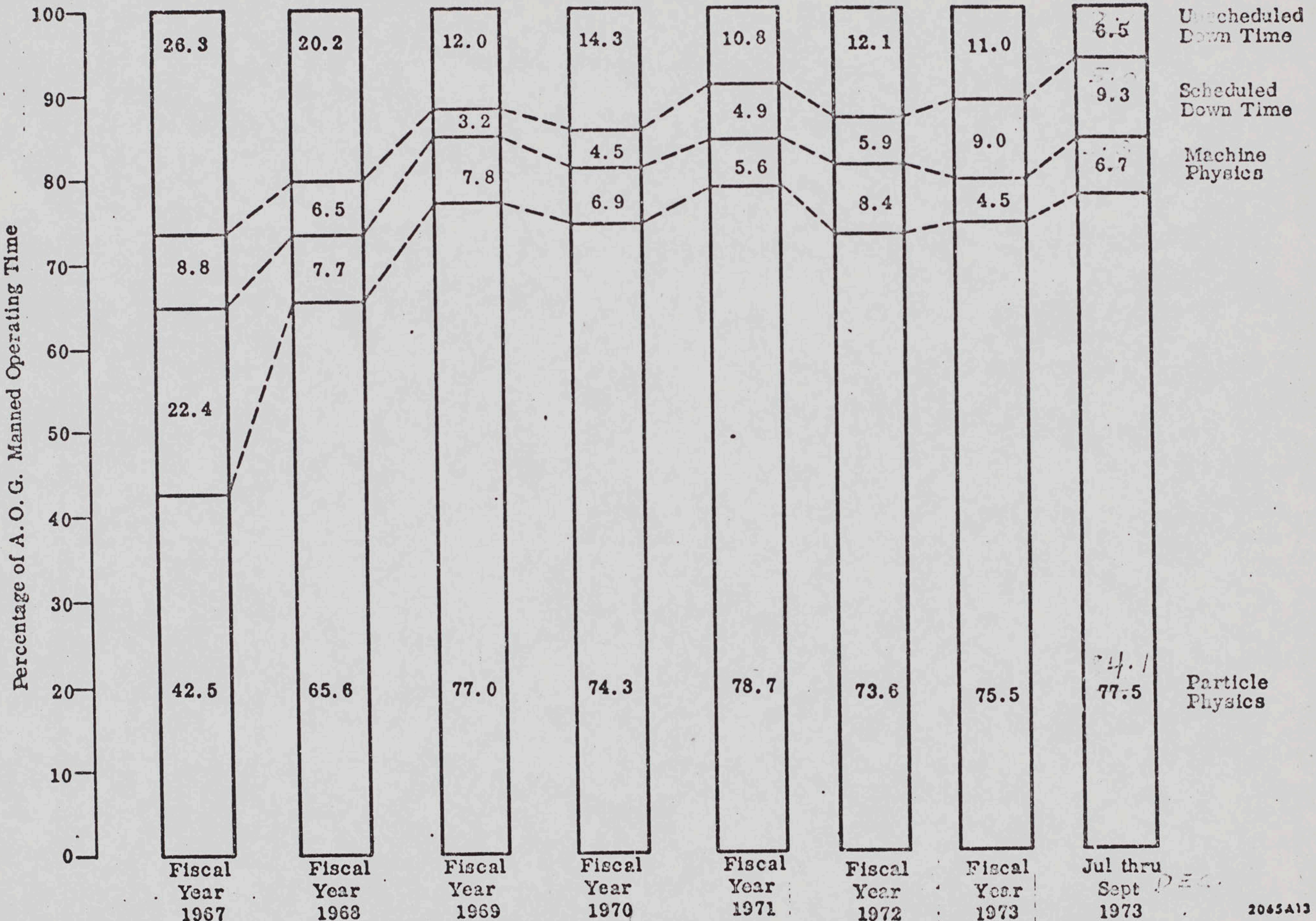
ACCELERATOR OPERATION SUMMARY



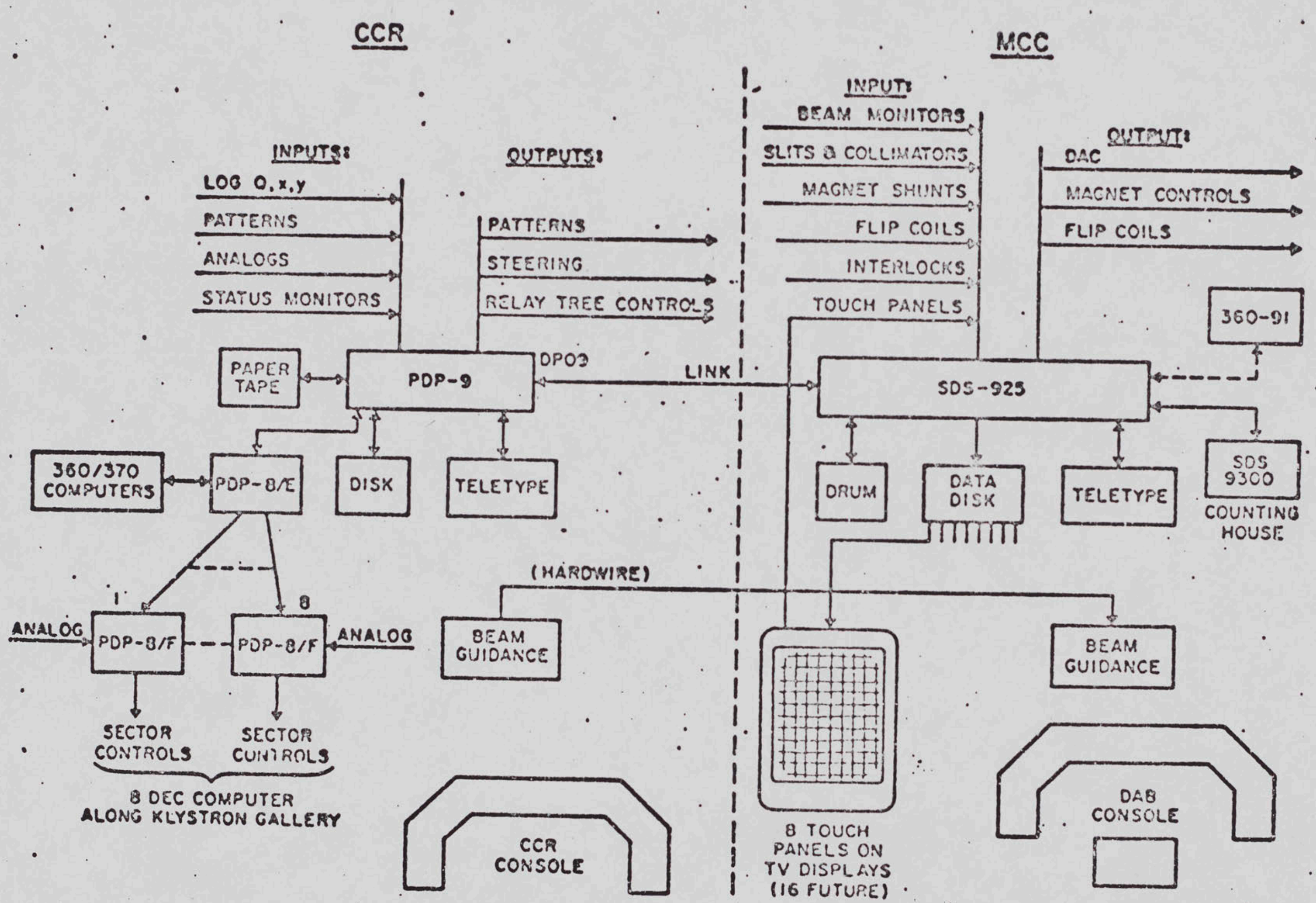
ACCELERATOR OPERATION SUMMARY



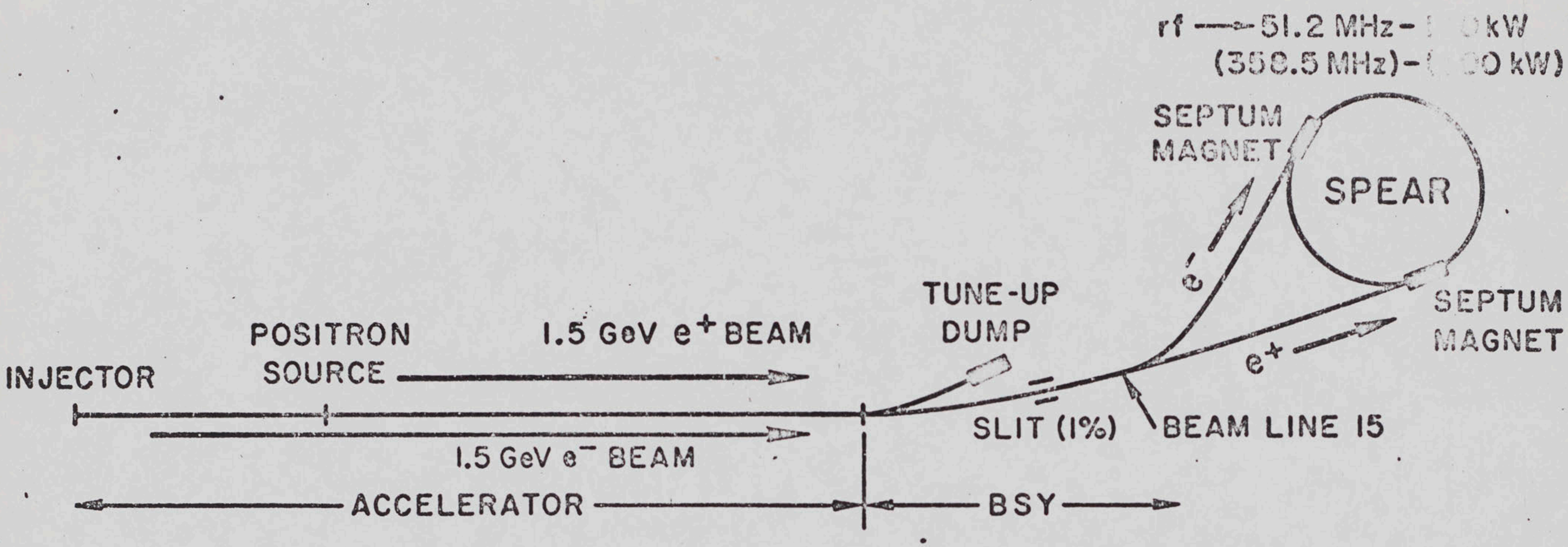
ACCELERATOR OPERATION SUMMARY

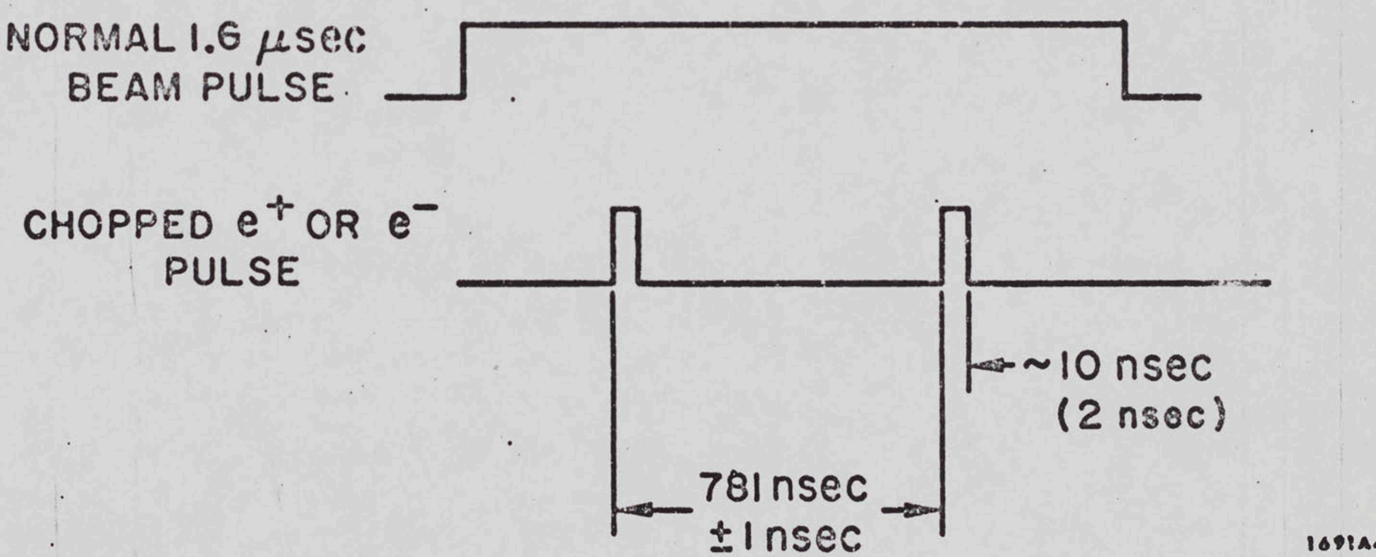


2065A13



Schematic diagram of control room consolidation through computer link.





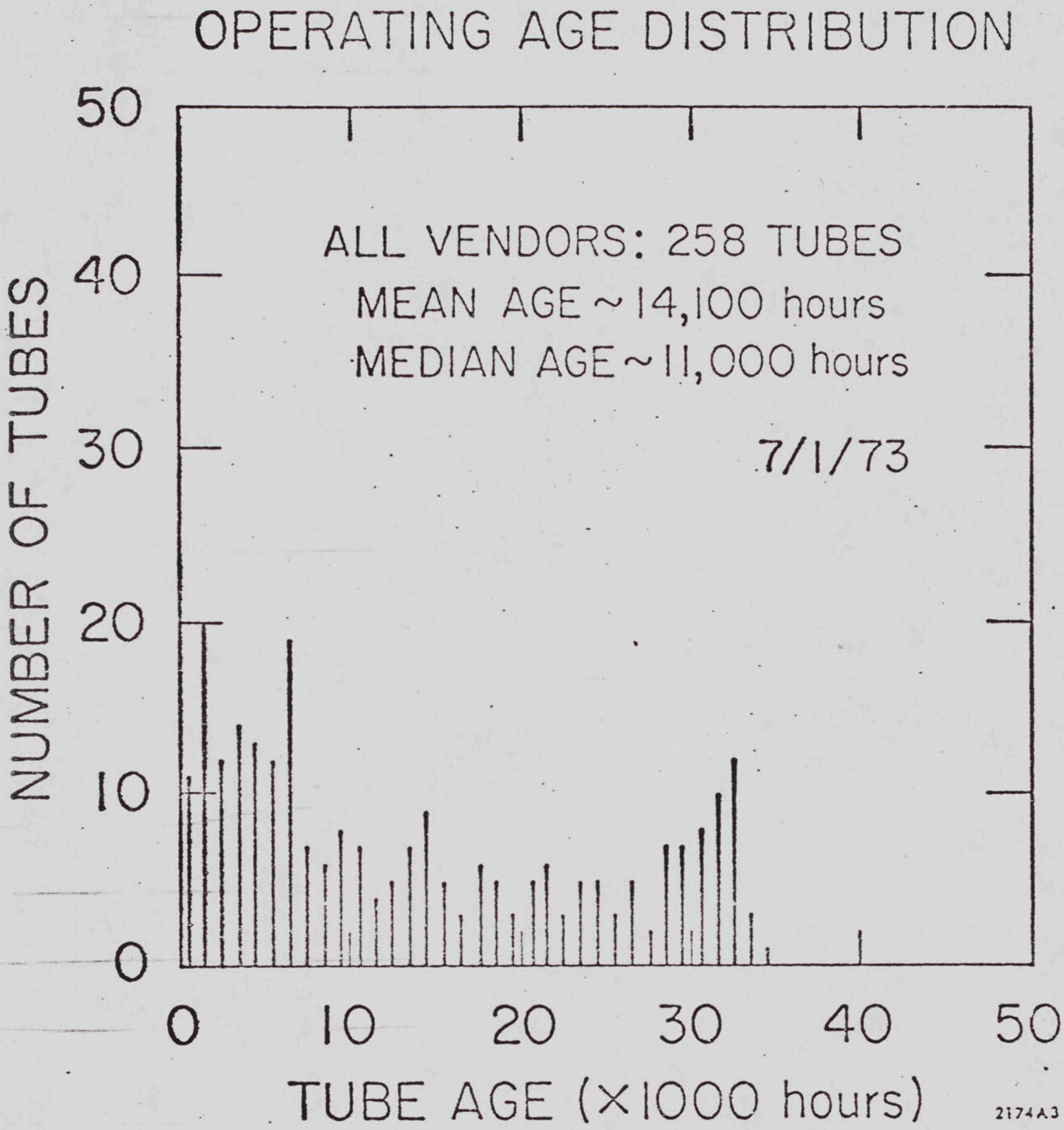
	SPEAR I	SPEAR II
e^- current	10 mA	40 mA
e^+ current	4 mA	20 mA
Burst Length	10 nsec	2 nsec
Pulse Rate	20 pps	20 pps

Special Accelerated Beams for Injection into SPEAR I (SPEAR II)

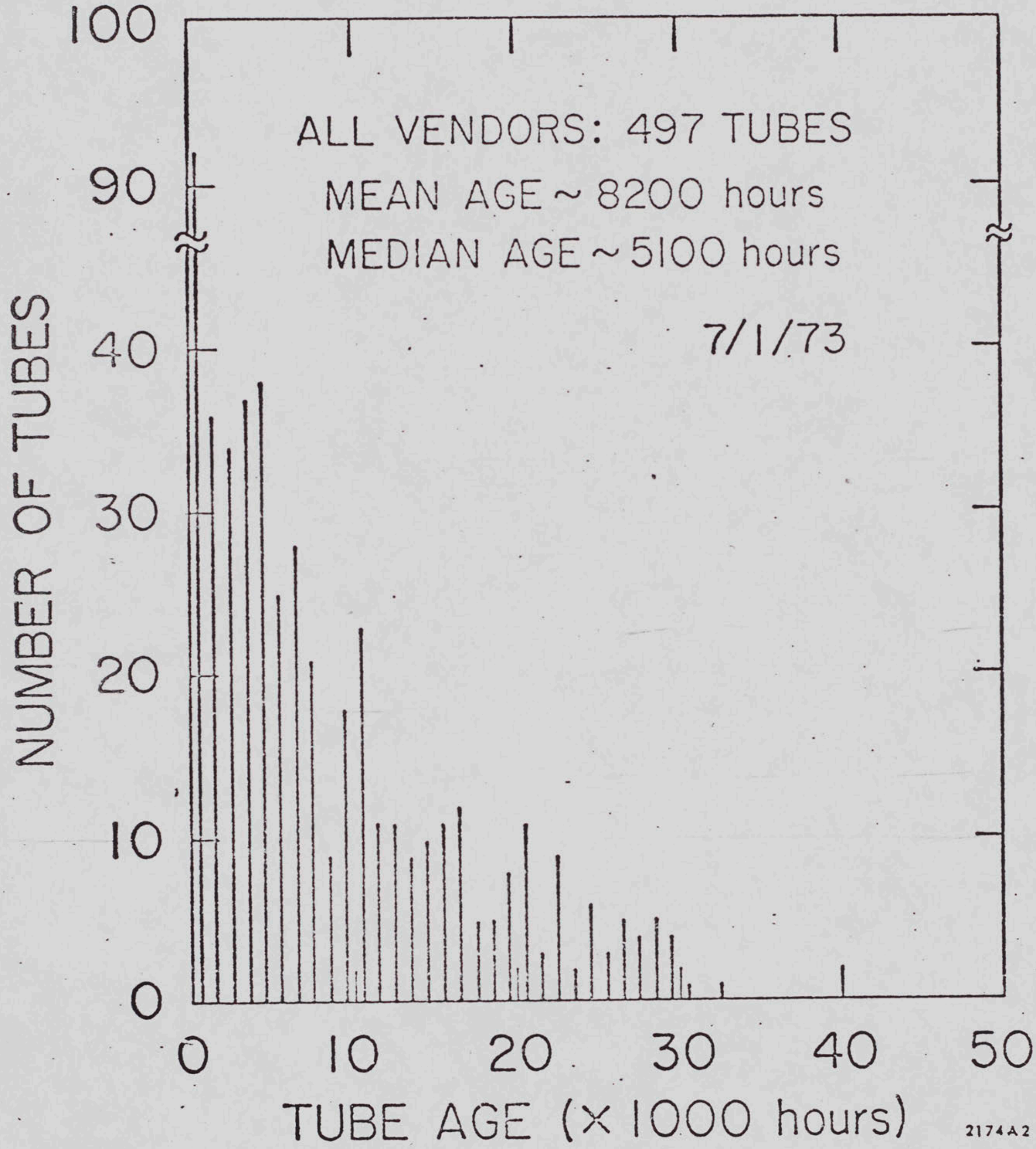
TABLE I

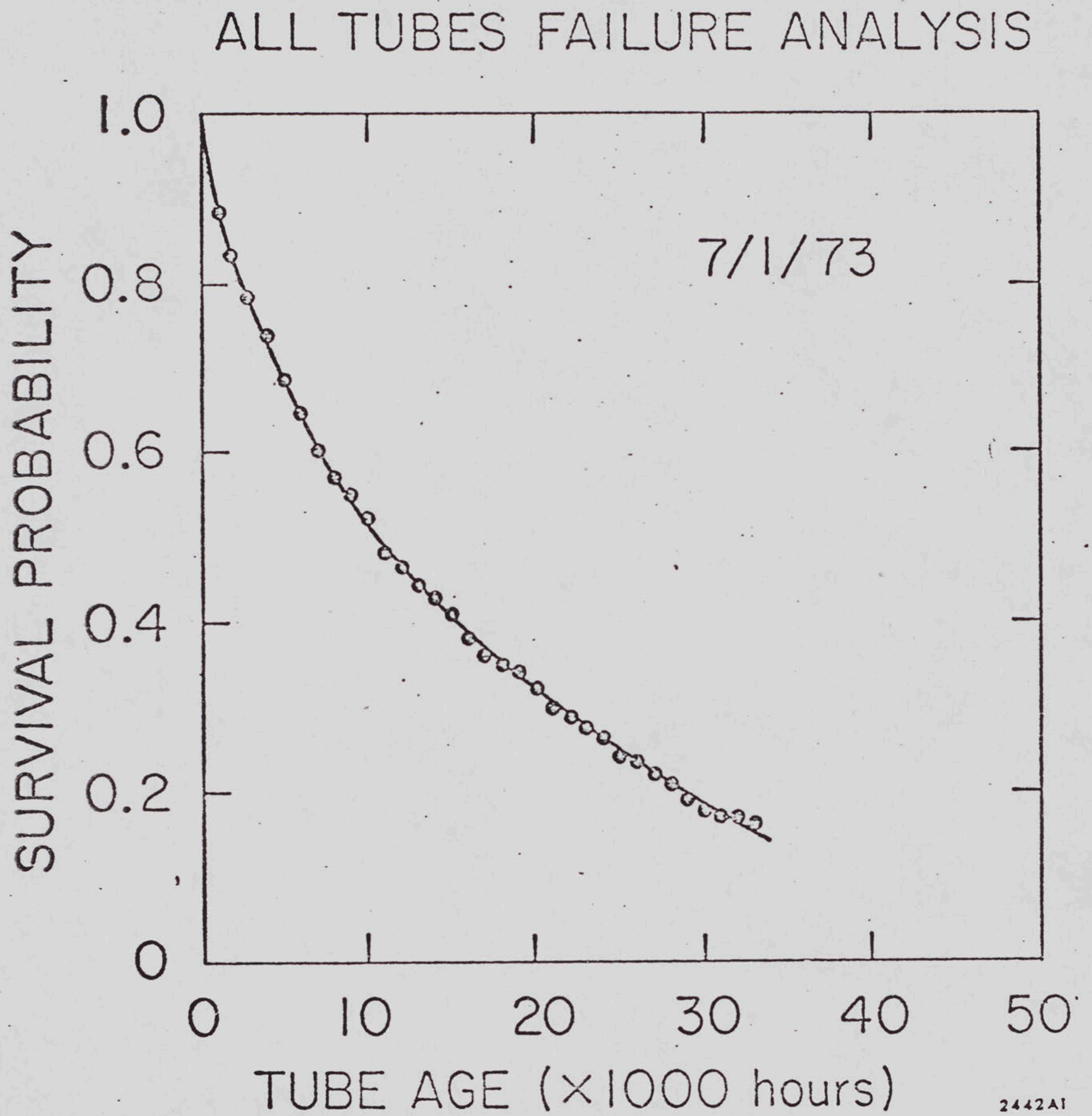
KLYSTRON MTBF

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 6/30/67					888,400	60	1,060	14,800
To 6/30/68					2,097,400	138	2,520	15,200
To 6/30/69					3,425,000	221	4,190	15,400
To 6/30/70					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	254,400	9	6,200	28,200	5,627,500	353	6,400	15,900
To 9/30/71	202,100	15	11,700	13,500	5,829,600	368	6,650	15,800
To 12/31/71	217,000	30	9,300	7,250	6,046,600	398	6,850	15,200
To 3/31/72	350,900	33	9,850	10,600	6,397,500	431	7,050	14,850
To 6/30/72	314,100	22	11,800	14,300	6,711,600	453	7,350	14,800
To 9/30/72	311,300	16	11,250	19,400	7,022,900	469	7,600	15,000
To 12/31/72	148,500	9	16,500	16.500	7,171,400	478	7,800	15,050
To 3/31/73	181,300	13	19,350	13,900	7,352,700	491	8,100	14,950
To 6/30/73	366,600	15	11,650	24,500	7,719,300	506	8,200	15,250
To 9/30/73	301,500	15	15,550	20,100	8,020,800	521	8,400	15,400


OPERATING AGE DISTRIBUTION
ALL VENDORS: 258 TUBES
MEAN AGE ~ 14,100 hours
MEDIAN AGE ~ 11,000 hours
7/1/73
NUMBER OF TUBES
50
40
30
20
10
0
0
10
20
30
40
50
TUBE AGE (×1000 hours)
2174A3

FAILURE AGE DISTRIBUTION




ALL TUBES FAILURE ANALYSIS
1.0
0.8
0.6
0.4
0.2
0
SURVIVAL PROBABILITY
7/1/73
0
10
20
30
40
50
TUBE AGE (×1000 hours)
2442A1

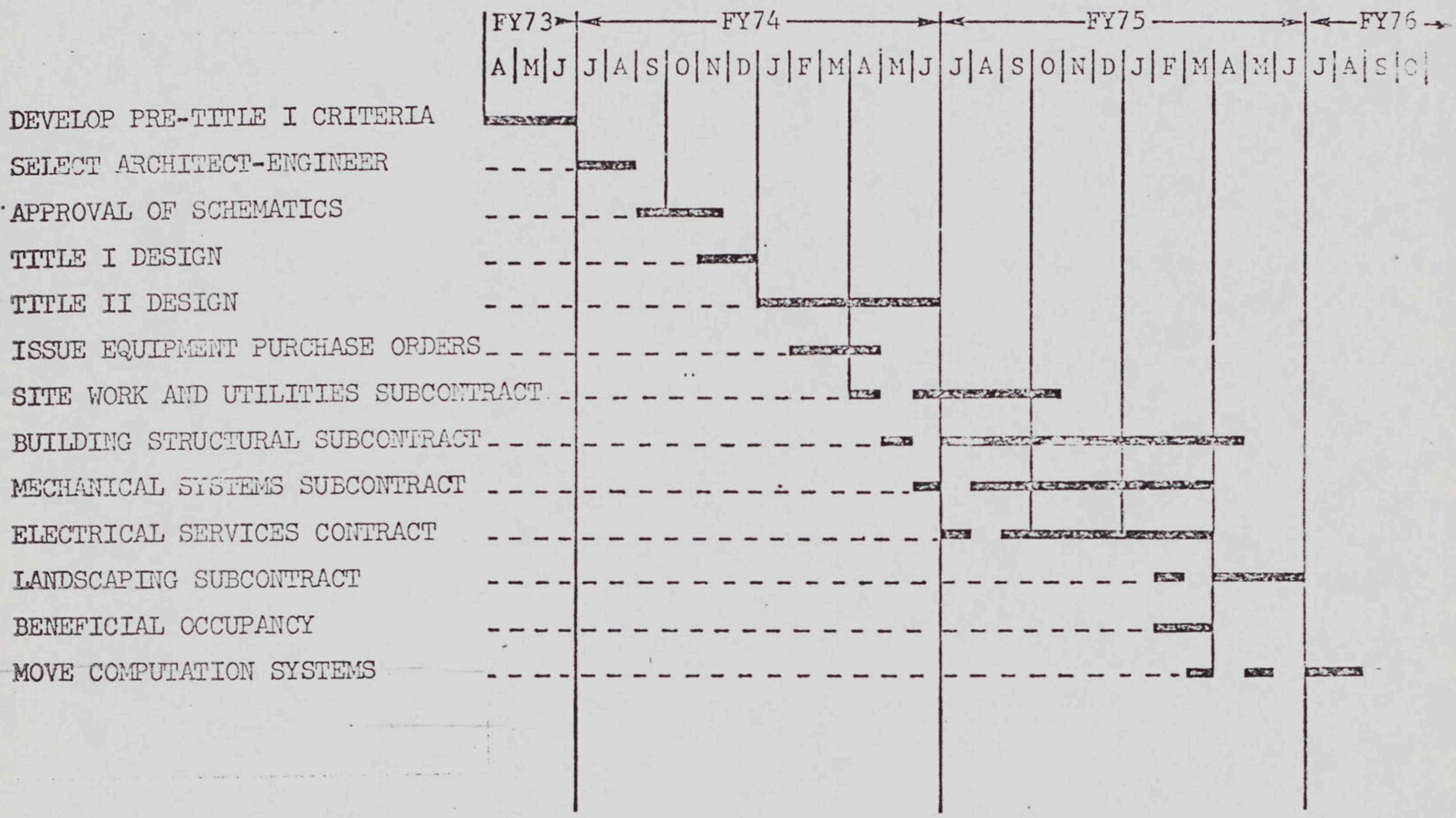
SLAC COMPUTATION CENTER BUILDING

SIZE AND USAGE

I. AREA AND FUNCTION	GROSS SQ. FT.
FIRST FLOOR:	12,800
USER LOBBY - COMPUTATION DISPATCH	
UNIT RECORD EQUIPMENT AND TAPE DRIVES	
DATA PREPARATION, KEY PUNCH AND TERMINALS	
GRAPHICS SCOPES	
TAPE STORAGE (READY AND ARCHIVAL)	
SECOND FLOOR:	13,500
COMPUTATION MACHINERY INCLUDING:	
IBM 360/91 SYSTEMS (2)	
IBM 370/168 SYSTEM	
HUMMINGBIRD MARK II AND MARK III	
GRAPHICS INTERPRETATION FACILITY	
THIRD FLOOR:	13,900
OFFICES (APPROX. 100 SCC STAFF)	
EQUIPMENT SHELTER:	8,300
ROOF MOUNTED CORRUGATED SHEET METAL	
COMMUNICATIONS TUNNEL:	1,600
DIRECT LINK TO THE CENTRAL LAB.	50,100

II. SPACE ALLOCATION	USEFUL SQ. FT.
COMPUTATION MACHINERY AND MAINTENANCE	11,213
DISPATCH, SCHEDULING, DATA PREPARATION, CONSOLES	4,290
LABORATORIES AND LABORATORY OFFICES	1,191
DATA WORK AND CONSULTATION	1,231
TRAINING AND CONFERENCE ROOMS	651
FILM, TAPE, DISK AND CARD STORAGE	5,440
OFFICES AND SECRETARIAL SPACE	8,490
	32,506

SLAC COMPUTATION CENTER DESIGN AND CONSTRUCTION SCHEDULE

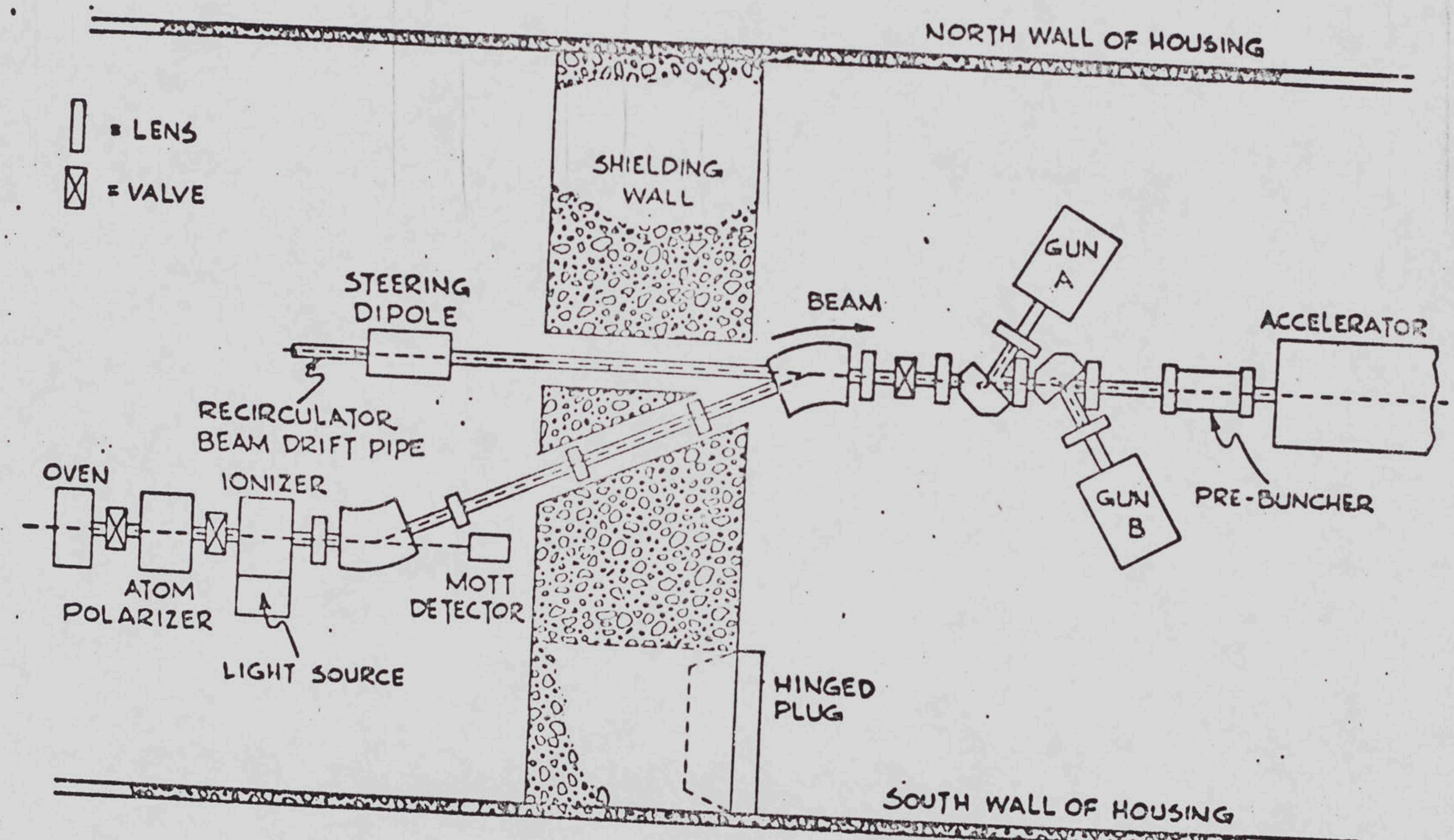


SLAC COMPUTATION CENTER BUILDING

COST ESTIMATE

ENGINEERING		$278,000
ARCHITECT AND ENGINEER (ALBERT HOOVER AND ASSOCIATES)	$112,000	
SLAC ENGINEERING AND CONSTRUCTION MANAGEMENT	166,000	
CONSTRUCTION		2,180,000
SITE WORK	$ 62,000	
LANDSCAPING	25,000	
BUILDING STRUCTURE	1,155,000	
MECHANICAL SYSTEMS	521,000	
ELECTRICAL SERVICES	289,000	
COMMUNICATIONS TUNNEL	45,000	
UTILITIES	68,000	
OFFICE EQUIPMENT	15,000	
INDIRECT COSTS		47,000
CONTINGENCY		395,000
TOTAL COST		$2,900,000

PEGGY - THE POLARIZED ELECTRON GUN



PLAN VIEW

A37

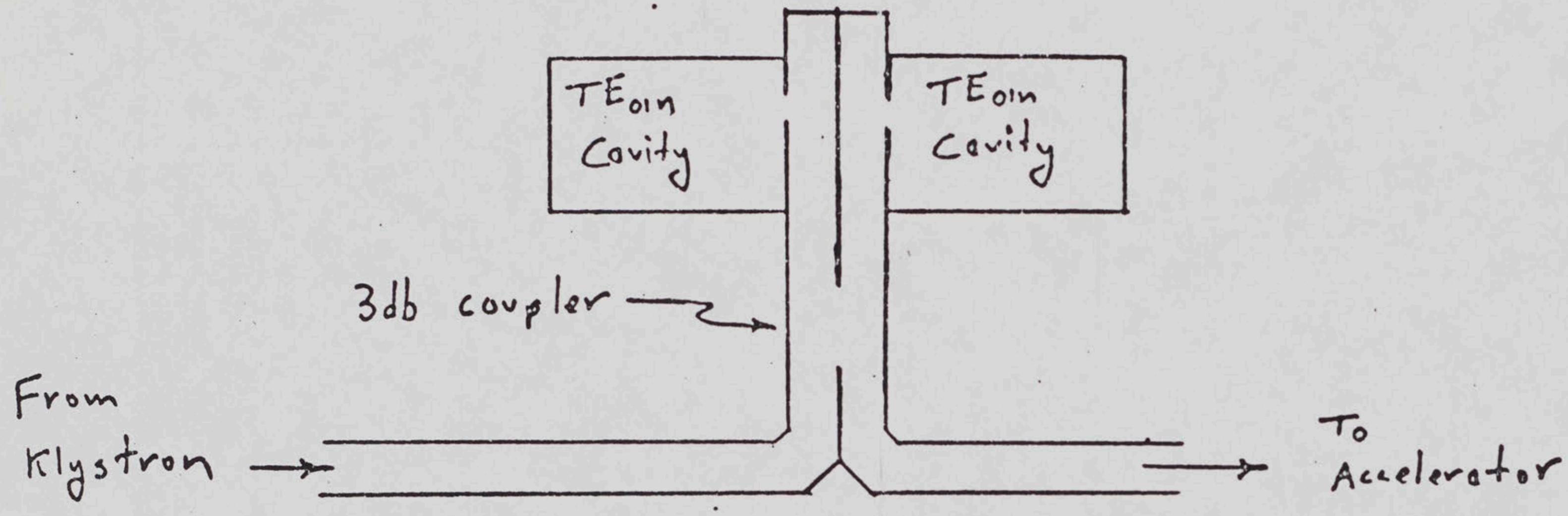


Fig. 1 -- Schematic diagram of a typical power enhancement network.

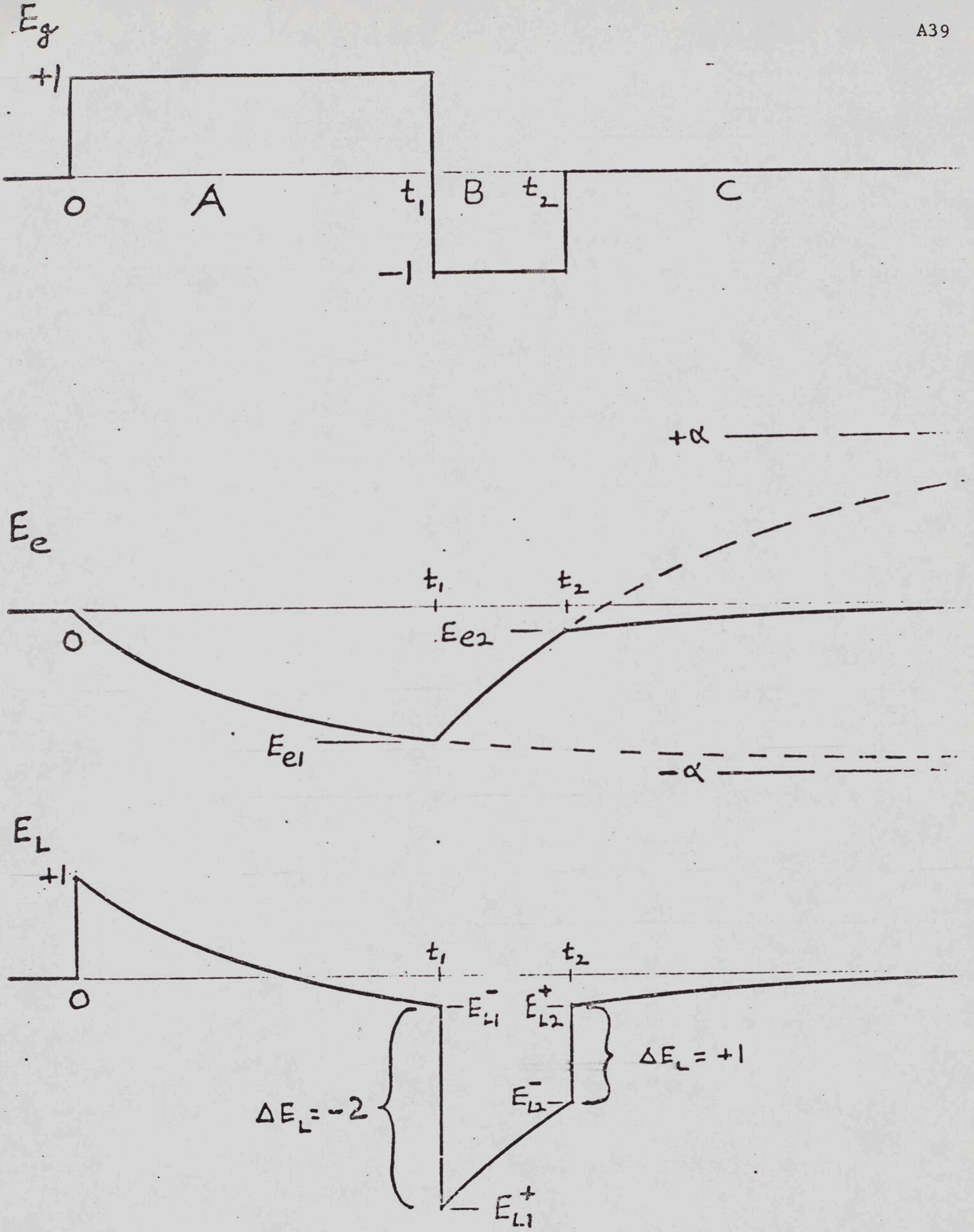
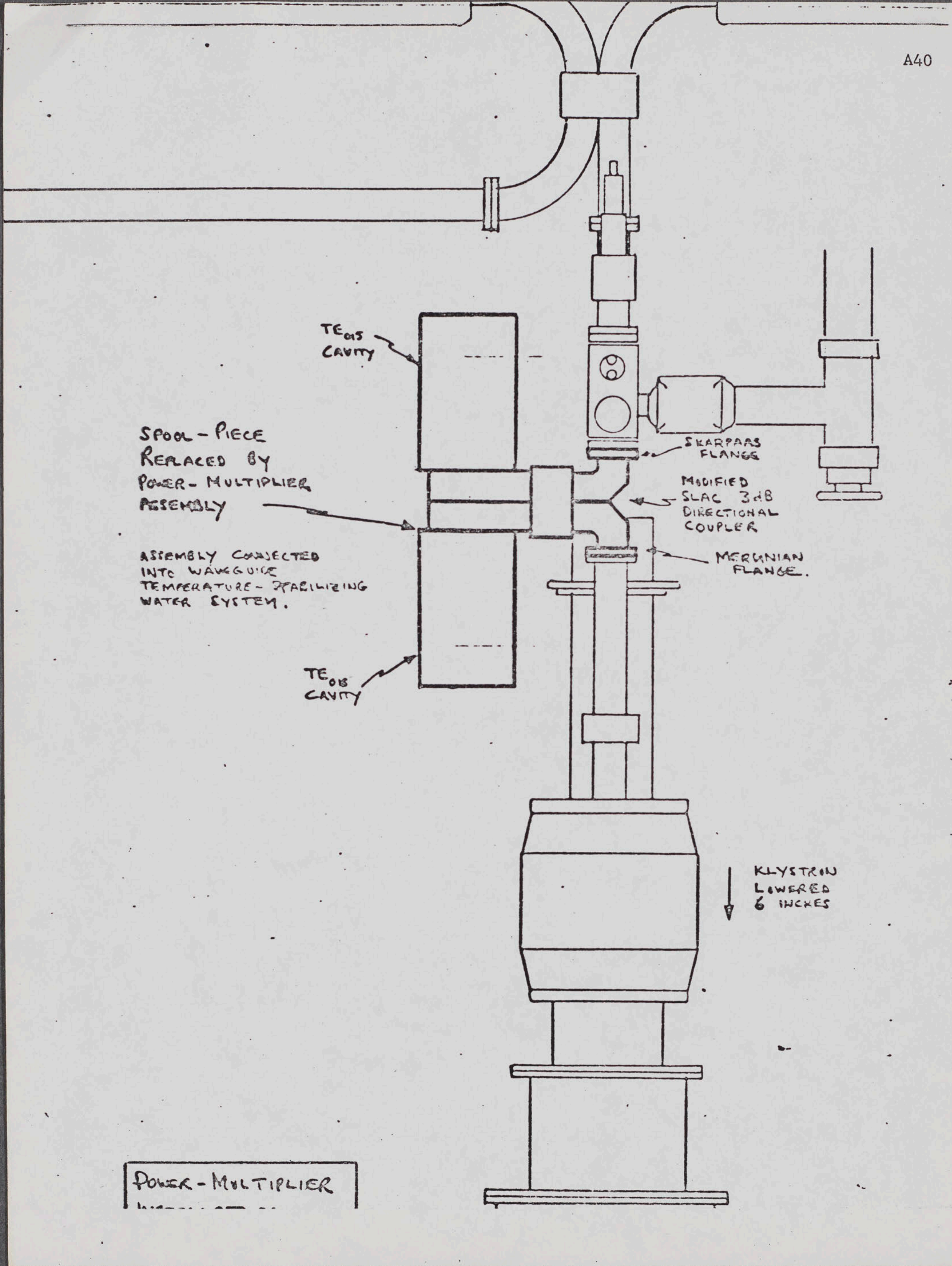


Fig 2 -- Waveforms for the incident generator field E_g, the field E_e emitted from the PEN cavities, and the output field E_L into the load.


TE015 CAVITY
SPOOL-PIECE REPLACED BY POWER-MULTIPLIER ASSEMBLY
ASSEMBLY CONNECTED INTO WAVEGUIDE TEMPERATURE-STABILIZING WATER SYSTEM.
TE015 CAVITY
SKARPAAS FLANGE
MODIFIED SLAC 3dB DIRECTIONAL COUPLER
MERGNIAN FLANGE.
KLYSTRON LOWERED 6 INCHES
POWER-MULTIPLIER

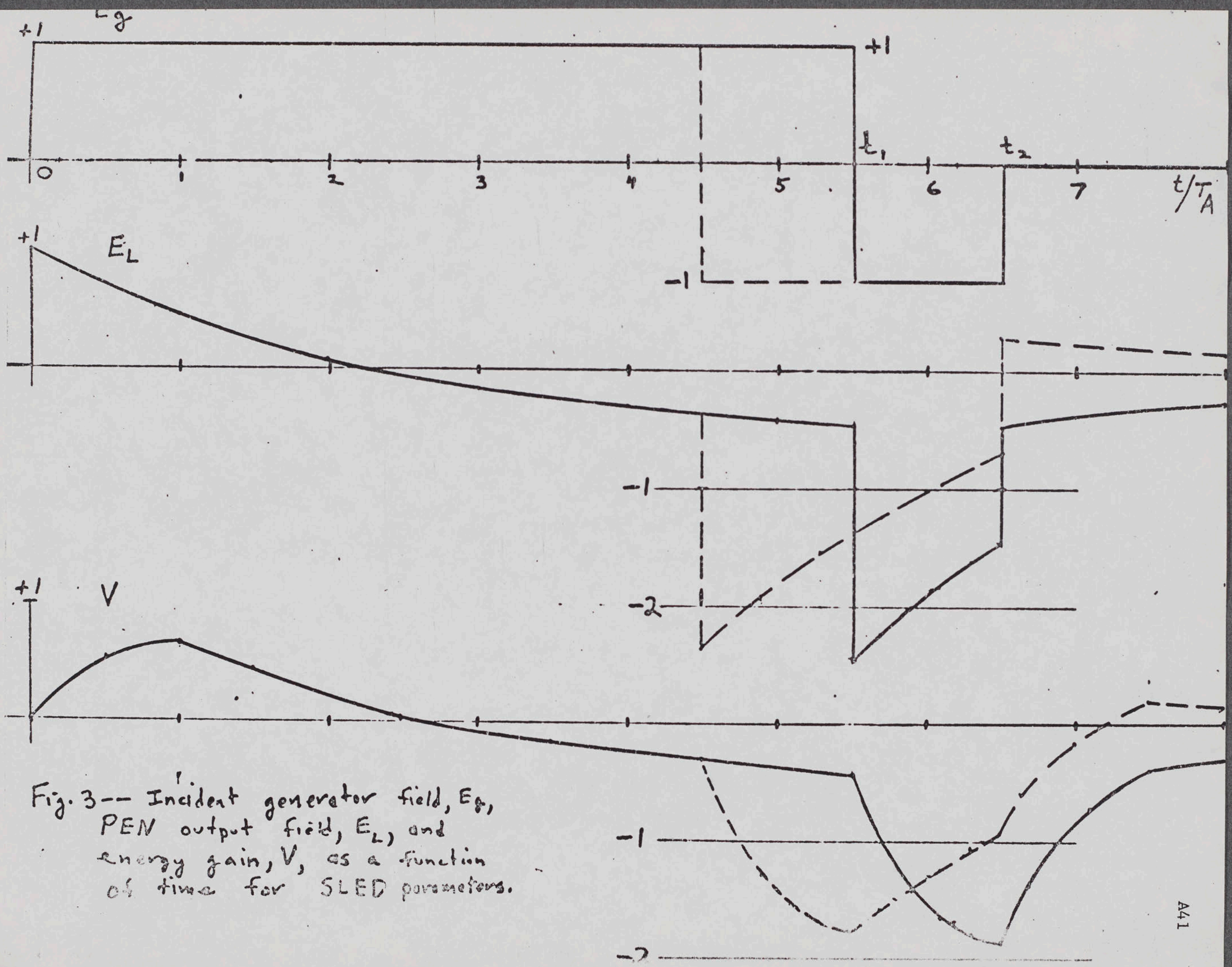


Fig. 3-- Incident generator field, E_g, PEN output field, E_L, and energy gain, V, as a function of time for SLED parameters.

A41

Comparison of SLED and Present SLAC Parameters

(Computed assuming 30 MW klystrons)

		Present SLAC	SLED
Unloaded Energy	(GeV)	26	48
Loaded Energy	(GeV)	23.5	43
Repetition Rate	(pps)	360	180
Rf Pulse Width	(μsec)	2.7	5.4
Beam Pulse Width	(μsec)	1.6	0.33
Average Current	(μA)	40	13
Peak Current	(mA)	70	220
Duty Cycle		6×10^{-5}	6×10^{-6}
Energy Spread	(%)	1.0	0.5*
Average Beam Power	(kW)	940	560

*Assumes 280 mA pulse for the first 0.16 μsec, then 170 mA for the next 0.16 μsec. For constant 220 mA peak current, estimated energy spread is 1.8%.

TABLE II.

F. Low, Remarks to HEPAP, December, 1973

The last year has seen the destruction of three myths which have dominated the thinking of high energy physicists for the past few decades. This is a healthy development for physics, made possible by more accurate measurements and higher energy accelerators. It opens up exciting possibilities of new experimental and theoretical investigation. It is surely not, however, a healthy sign for U.S. high energy physics that these breakthroughs have all been made in Europe.

1. The first of these myths was the absence of neutral currents, i.e., the absence of events such as

$$\nu + p \to \nu + p \quad (1)$$

or

$$k^0 \to \mu^+ + \mu^- . \quad (2)$$

Indeed, the second reaction is still absent, in the sense that if present at all it can be accounted for (in order of magnitude) as a radiative correction to the known non-leptonic decay

$$k^0 \to 2\gamma \quad (3)$$

with the two virtual γ's producing the final μ pair. This branching ratio is less than one part in 10^8, so that it is correct that strangeness-changing neutral currents are highly suppressed. It was natural to assume, and generally was assumed, that strangeness-conserving neutral currents were also absent, although this certainly was not a theoretical consequence, nor was its experimental support as strong. In particular, the reaction (1) was known to be suppressed relative to the normal charged reaction, but the upper limit fluctuated from 4% to 50% depending on the analysis.

The recent experiments in the large bubble chamber at CERN seem to have demonstrated the existence of neutral strangeness-preserving reactions of the type

$$\nu + \text{nucleus} \rightarrow \nu + X \qquad (4)$$

at a level of about 30% of the normal reaction

$$\nu + \text{nucleus} \rightarrow \mu + X. \qquad (5)$$

It is most interesting that the simplest unified gauge theory of the weak and electromagnetic interactions (in fact the model originally proposed by Weinberg) predicts that the reaction (4) should take place at a finite level with one adjustable parameter which can be made compatible with the CERN experiments. One cannot really claim a theoretical prediction, since there are unified gauge theories which do not require neutral currents.

The future of neutrino physics now looks extraordinarily exciting. One major question that has been raised is the energy dependence of the neutral current phenomena. The theoretical expectation would be that the neutral and charged currents should have similar energy behavior. However, the first NAL experiments seem to indicate otherwise. A second question has to do with the mysterious absence of strangeness-changing neutral currents. The most natural (but not the only) explanation for this requires a new quantum number, for example charm, and excited states carrying non-vanishing value of this quantum number, at about 4 GeV.

2. The second myth has to do with the high transverse momentum ($p_\perp$) behavior of cross sections. The content of the myth was an exponential fall off of some kind. Originally seen as $e^{-\alpha p_\perp^2}$, it then developed into $e^{-\beta p_\perp}$, with $\beta \sim 6 \text{ GeV}^{-1}$. It now seems that as one approaches high $p_\perp$ the experimental curves begin to differ significantly from exponentials, and indeed are better fitted to power laws.

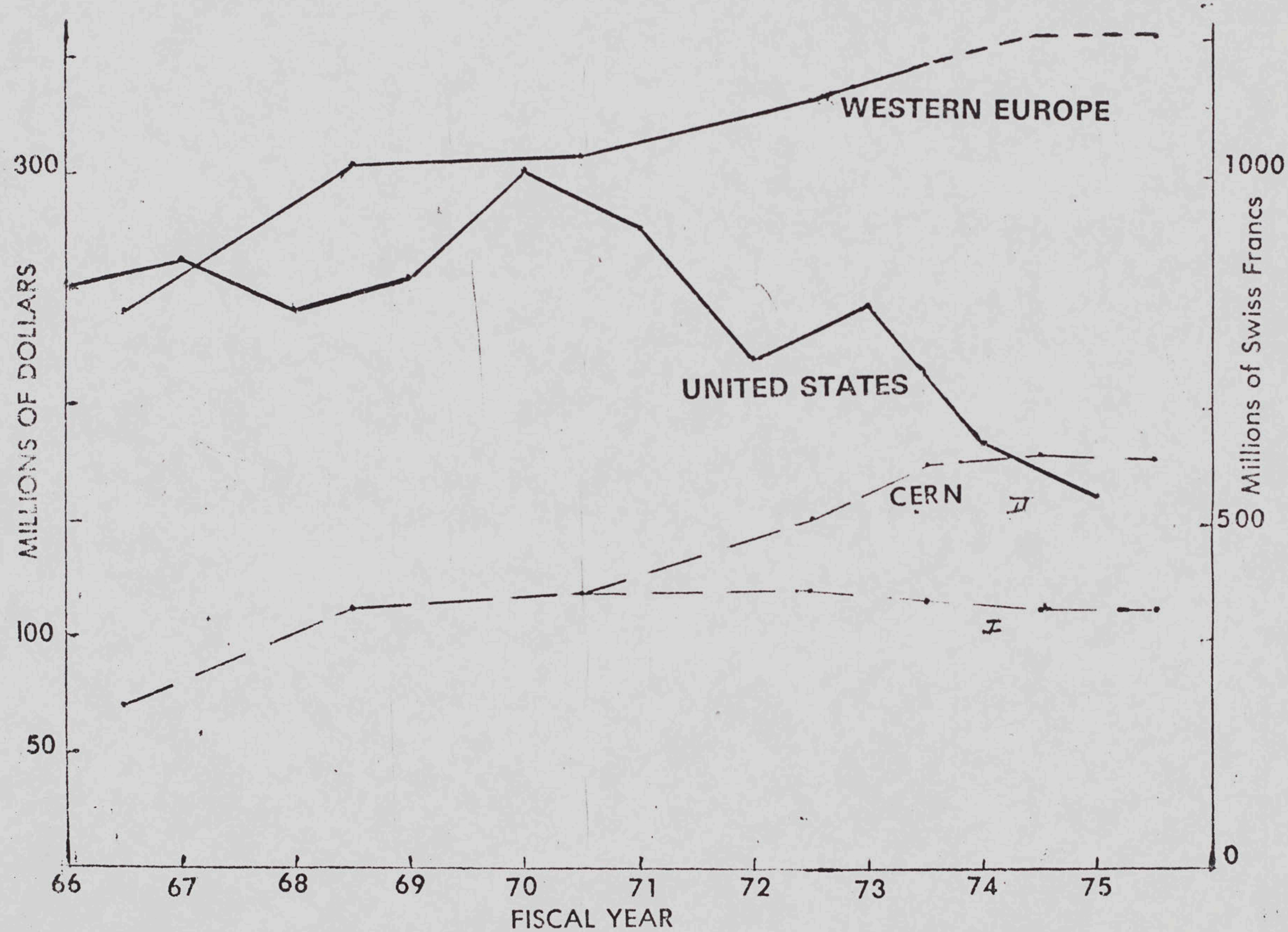
From the theoretical point of view, it was always very hard to account for asymptotic exponential behavior; local field theories invariably lead to power laws, no matter how hard one tried for exponentials. Non local models, such as the dual, or string model, do give exponential behavior in low order; however, it is clear that all higher order corrections are crucial for the high $p_\perp$ behavior, so that even here we would not expect the exponential to persist.

One is tempted to conjecture that the behavior seen here is in some way connected to the elementary point interactions which are presumed responsible for MIT-SLAC scaling.

3. The myth of the asymptotically constant total cross section is the last one which I wish to discuss. I do not know of any framework within which one was able to understand an exactly constant cross section. The simplest phenomenology that could describe it postulates the existence of a Regge pole, the pomeron, with $\alpha_P(0) = 1$. On the other hand, there are very severe theoretical problems connected with $\alpha_P(0) = 1$, sufficiently severe so that many theorists had come to doubt the validity of the constancy even before the recent experiments. Now that we are freed from the myth, we can attack the tremendously interesting question of the nature of diffraction scattering.

The problem arises in the following way. Two particles collide and produce a spray of secondaries, with a total cross section which in first approximation, let us say, is given by $\sigma_T \sim \beta S^{\alpha(0)-1}$, with S the energy and β and $\alpha(0)$ parameters, where $\alpha(0)$ is close to 1. The shadow of this cross section (in elastic scattering, diffraction disassociation, etc.) gives rise to a corrected total cross section $\sigma'_T \sim \beta' S^{2(\alpha(0)-1)}$, (to within <u>logarithms</u>), which in turn gives rise to further corrections (the shadow of the shadow) $\sigma''_T \sim \beta'' S^{3(\alpha(0)-1)}$, etc. Clearly, were $\alpha(0)$ substantially less than 1, these terms would get progressively smaller, and eventually the first term would be revealed. With $\alpha(0)$ substantially greater than 1, the series might be represented well by the first term for small S, but as S gets larger, more and more terms would be needed. Eventually the Froissart bound must limit the growth to $(\log S)^2$. In either of these two cases, we would probably by now have a good understanding of the mechanism giving rise to $\alpha(0)$. The difficulty of diffraction scattering is that $\alpha(0)$ is very close to 1, a remarkable and as yet unexplained fact. (The exact value $\alpha(0) = 1$ has the special property that there must be terms in the cross section that asymptotically grow with energy like logarithms, so that even in this case we do not have a constant cross section.) It appears now that an analysis of the successive approximations described above should be possible, but this will require detailed studies of many processes at higher energies.

4. I should mention here, however briefly, the quark-parton model and the recent CEA-SPEAR experiments on $e^+ + e^- \to$ hadrons, which have somewhat rescued our national honor! I do not consider the failure of $\sigma_{hadron}/\sigma_{\mu\ pair}$ to level off at 2/3, 2, 4 or whatever to be a violation of a myth (much less of a theory), since the extension from MIT-SLAC early scaling to CEA-SPEAR early scaling is not even an extrapolation, but an application of an approximate model in an entirely new experimental area. The fact that the model fails here is most interesting, as will be the detailed analysis of the way it fails, at present and hopefully future energies, or whether scaling indeed finally sets in at a higher energy.



TOTAL GOVERNMENT SUPPORT FOR HIGH ENERGY PHYSICS

(in FY 1974 dollars)

1/9/74

A48

AEC HIGH ENERGY PHYSICS PROGRAM MANPOWER
PERSONNEL COUNT* AT END OF FISCAL YEAR

		FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	FY 73	FY 74**
PPA	Total[1]	336	320	295	95	0	0	0	0
	Physicists	7	7	7	4	0	0	0	0
	Other Prof	50	50	50	20	0	0	0	0
CEA	Total[1]	233	230	216	146	126	121	32	20
	Physicists	18	18	18	18	11	10	4	2
	Other Prof	45	45	46	38	37	33	11	5
ANL	Total[1]	1,070	1,000	950	790	732	683	592	600
	Physicists	49	55	64	62	65	62	58	41
	Other Prof	170	165	159	133	110	115	100	120
	Grad Students	31	20	3	4	0	0	0	0
LBL	Total[1]	1,481	1,350	1,291	1,145	1,025	896	658	611
	Physicists	108	105	103	102	100	93	94	80
	Other Prof	204	190	184	170	158	132	93	88
	Grad Students	111	110	104	92	87	60	39	25
BNL	Total[1]	1,250	1,305	1,365	1,276	1,204	1,110	1,086	1,057
	Physicists	100	105	110	103	95	101	87	93
	Other Prof	170	180	187	169	132	121	125	120
SLAC	Total[1]	1,350	1,300	1,397	1,330	1,319	1,310	1,161	1,162
	Physicists	85	90	99	104	110	122	124	124
	Other Prof	215	220	222	223	169	162	155	157
	Grad Students	20	30	38	28	35	31	18	18
Laboratory Subtotal (except NAL)	Total[1]	5,720	5,505	5,514	4,782	4,406	4,120	3,529	3,450
	Physicists	367	380	401	393	381	388	367	340
	Other Prof	854	850	848	753	606	563	484	490
	Grad Students	162	160	145	124	122	91	57	43
University[2] Programs	Total[1]	2,682	2,759	2,606	2,378	2,342	1,904	1,795	1,700
	Physicists	645	659	641	639	637	590	582	580
	Other Prof	190	190	175	145	146	128	122	115
	Grad Students	647	660	626	594	539	400	377	350
Program Subtotal (except NAL)	Total[1]	8,402	8,264	8,120	7,160	6,748	6,024	5,324	5,150
	Physicists	1,012	1,039	1,042	1,032	1,018	978	949	920
	Other Prof	1,044	1,040	1,023	898	752	691	606	605
	Grad Students	809	820	771	718	661	491	434	393
NAL	Total[1]	-	200	410	695	1,053	1,250	1,400	1,450
	Physicists	-	15	36	56	74	76	80	100
	Other Prof	-	30	63	93	239	262	300	300
TOTAL PROGRAM	Total[1]	8,402	8,464	8,530	7,855	7,801	7,274	6,724	6,600
	Physicists	1,012	1,054	1,078	1,088	1,092	1,054	1,029	1,020
	Other Prof	1,044	1,070	1,086	991	991	953	906	905
	Grad Students	809	820	771	718	661	491	434	393

*Personnel Count and Man Years Effort are not significantly different except within the University Program.

**Estimated on the basis of the FY 1974 Financial Plan

[1] The Total for each laboratory includes, in addition to Physicists, Other Professional, and Graduate Students, all other personnel supported by the program, e.g. technicians, accelerator operators, scanners, machinists, craftsmen, etc. In accounting parlance there are, in addition to "direct" and "indirect" people, also many "contract" heads included in the count in cases where their numbers are directly affected by the level of HEP program support.

[2] ~ 15% of the support for the research effort carried out by the people listed under University Programs is provided by University contribution. No "indirect" or "contract" type heads are included in the University head count (see footnote 1).

12/15/73

COMMENTS ON PUBLICATIONS SURVEY

1. Rough publication counts were obtained from listings supplied by the Oak Ridge Technical Information Center which maintains a computer based summary of all articles included in Nuclear Science Abstracts.

2. The split between "US" and "NON-US" publications is done by looking at the authors' institution. If a collaborative effort is involved the institution of the first named author is used.

3. The count for "US" articles was done by looking at the actual abstract with its journal reference.

4. The count for "NON-US" publications was done by looking at lists of abstract numbers for these articles and consequently involves the assumption (accurate to within 10 per cent) that the articles appear in Nuclear Science Abstracts in the same order as they are published in a given journal.

5. The division between theory and experiment corresponds to the AIP's indexing system for classifying articles in high energy physics. Our "theory" category includes all the theory subdivision used in that scheme.

PUBLICATIONS - "US" HIGH ENERGY PHYSICS PROGRAM

(Experimental)

Journal	1968	1969	1970	1971	1972
Physics Letters B	25	24	29	25	18
Physical Review Letters	124	121	101	92	72
Nuclear Physics B	10	14	37	33	35
Physical Review	73	75	-	-	-
Physical Review D	-	-	91	75	57
	232	234	258	225	182

(Theoretical)

Journal	1968	1969	1970	1971	1972
Physics Letters B	35	45	44	69	110
Physical Review Letters	121	127	97	116	80
Nuclear Physics B	26	32	62	69	66
Physical Review	531	603	-	-	-
Physical Review D	-	-	557	626	581
	713	807	760	880	837

Letter Journals	1968	1969	1970	1971	1972
Experimental	149	145	130	117	90
Theoretical	156	172	141	185	190

12/15/73

PUBLICATIONS - "NON-US" HIGH ENERGY PHYSICS PROGRAM

(Experimental)

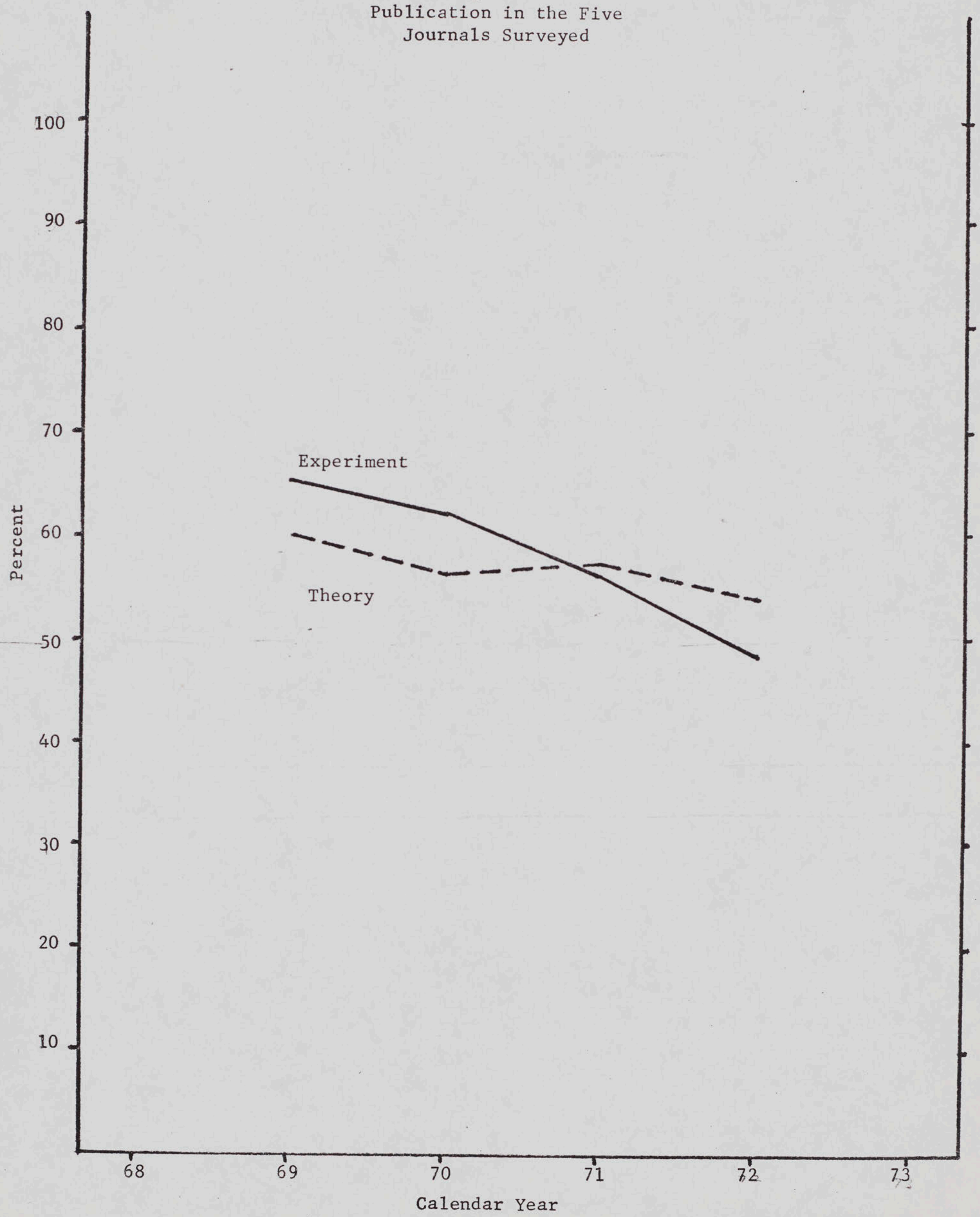
Journal	1968	1969	1970	1971	1972
Physics Letters B	-	55	65	76	76
Physical Review Letters	-	11	15	10	4
Nuclear Physics B	-	47	74	83	110
Physical Review	-	15	-	-	-
Physical Review D	-	-	7	11	12
	-	128	161	180	202

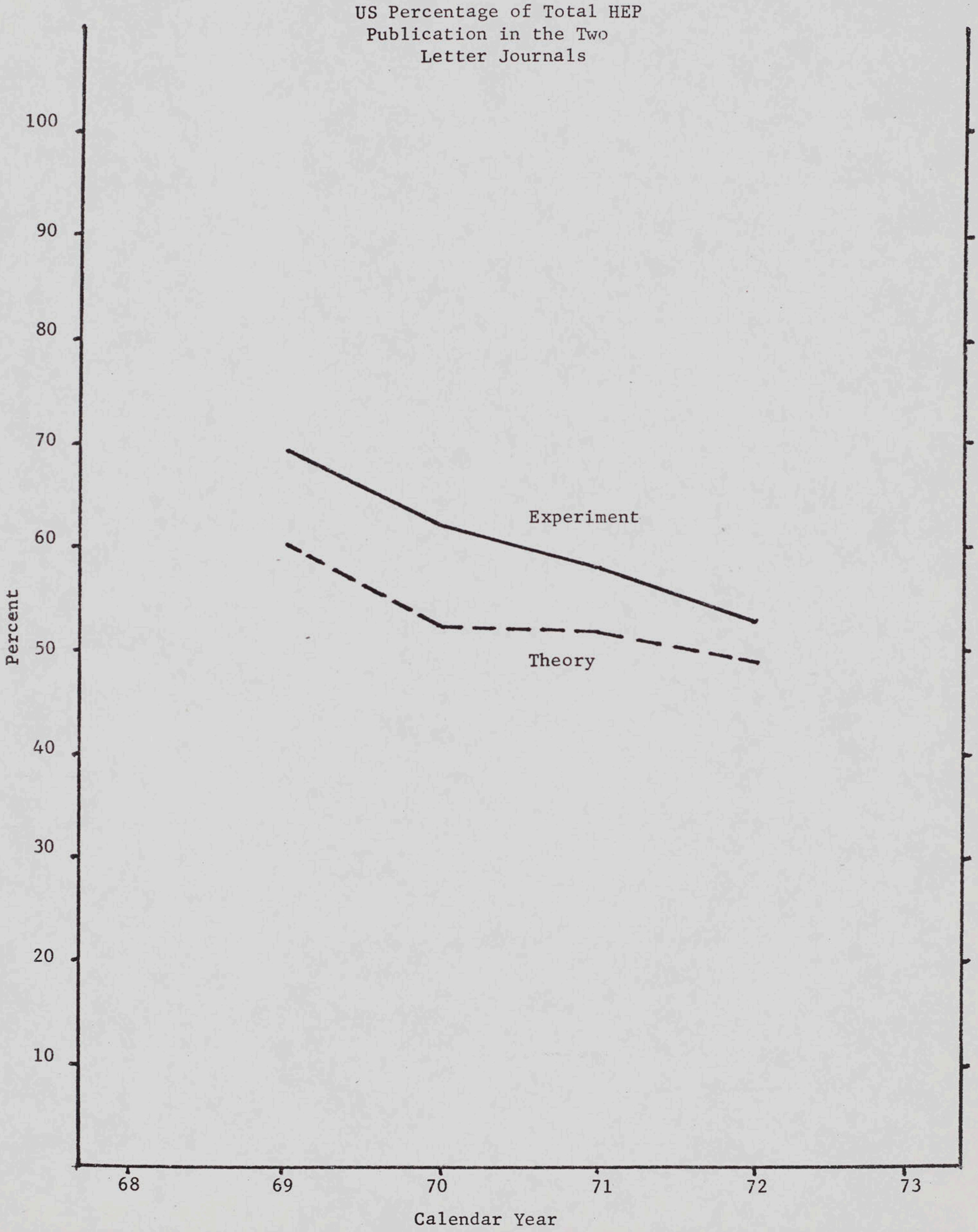
(Theoretical)

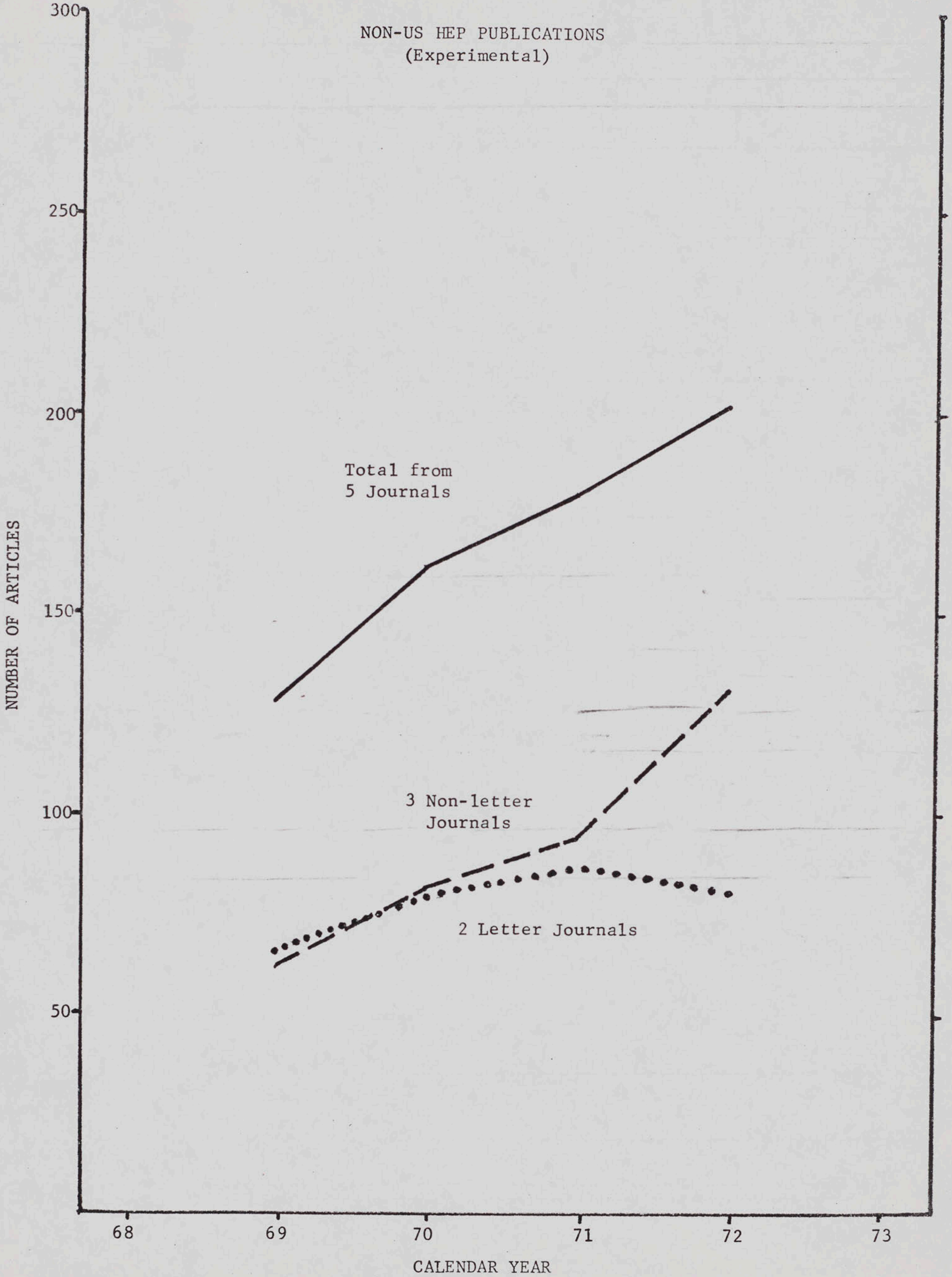
Journal	1968	1969	1970	1971	1972
Physics Letters B	-	84	110	150	184
Physical Review Letters	-	33	20	21	15
Nuclear Physics B	-	241	281	303	351
Physical Review	-	172	-	-	-
Physical Review D	-	-	175	191	173
	-	530	586	665	723

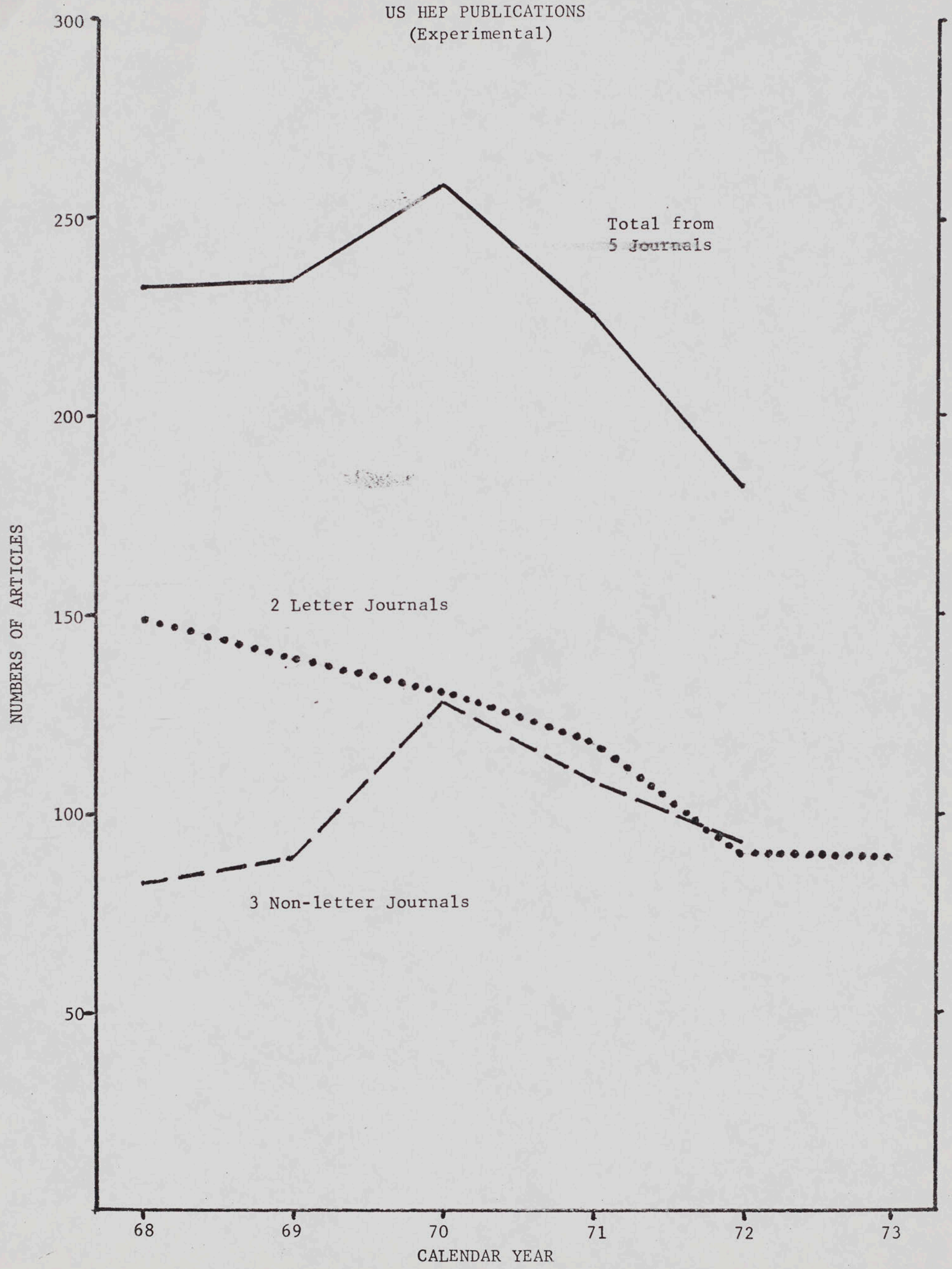
Letter Journals	1968	1969	1970	1971	1972
Experimental	-	66	80	86	80
Theoretical	-	117	130	171	199

US Percentage of Total HEP
Publication in the Five
Journals Surveyed

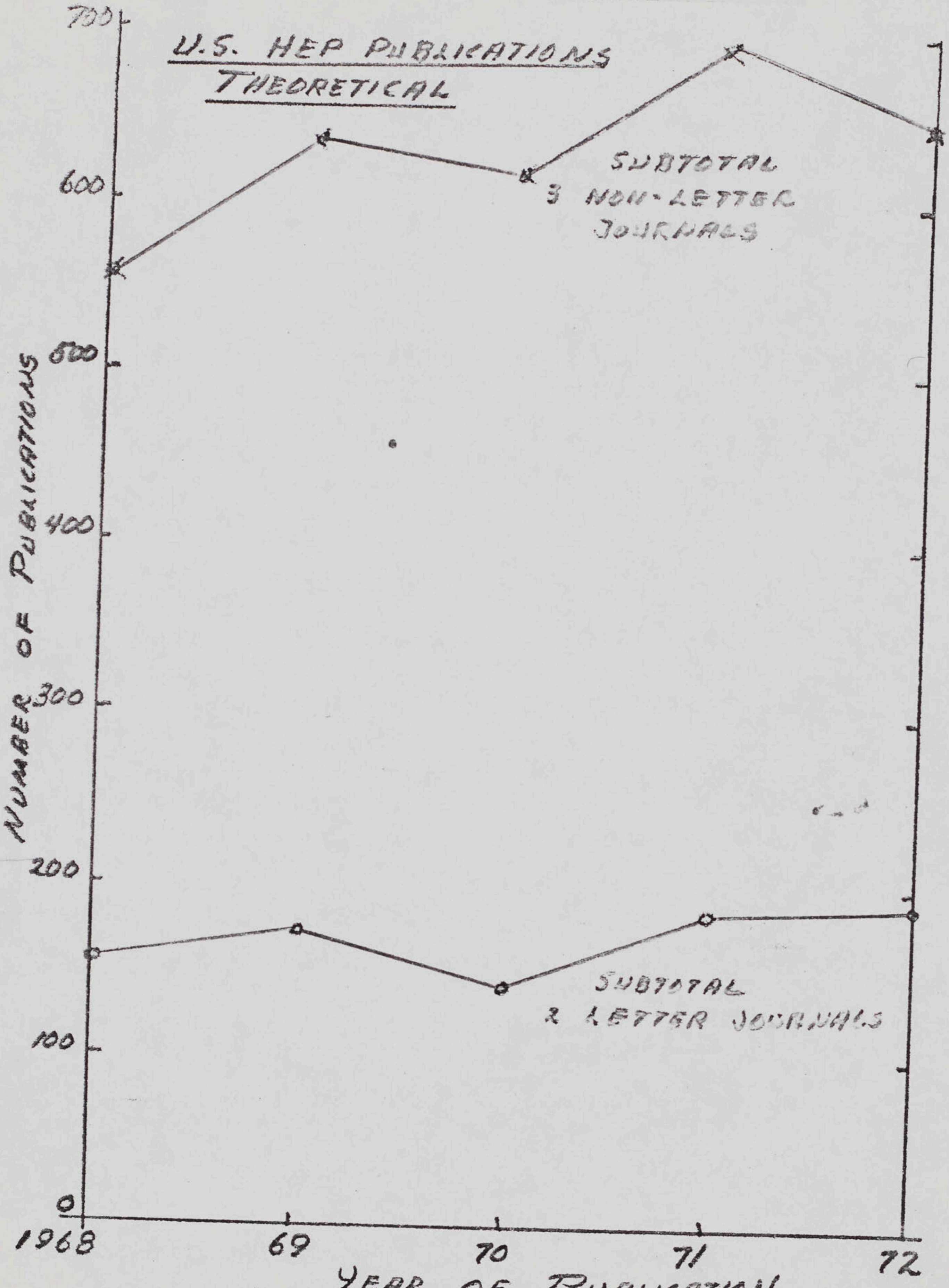



US Percentage of Total HEP
Publication in the Two
Letter Journals
100
90
80
70
60
50
40
30
20
10
Percent
Experiment
Theory
68
69
70
71
72
73
Calendar Year

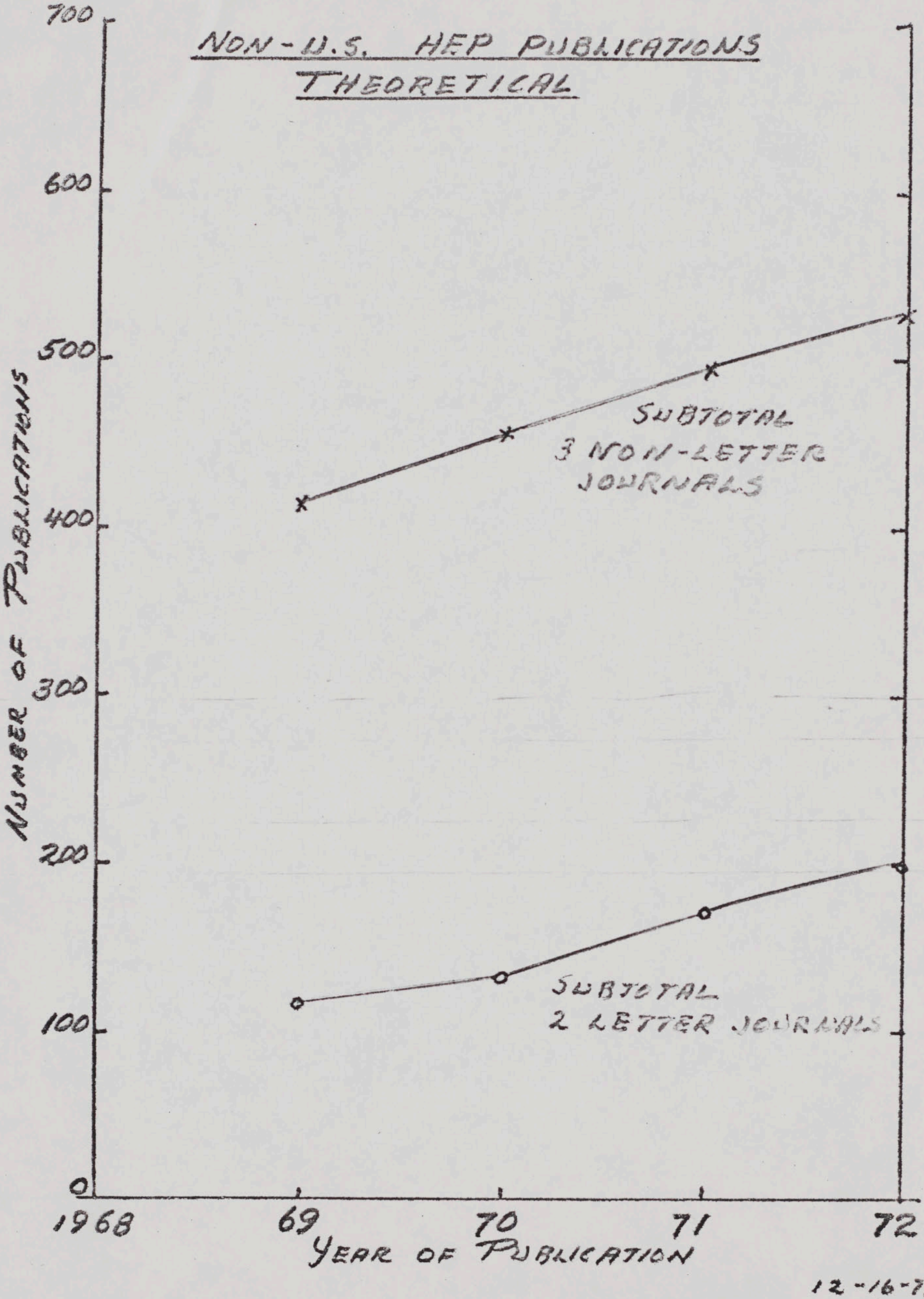

NON-US HEP PUBLICATIONS
(Experimental)
300
250
200
150
100
50
NUMBER OF ARTICLES
Total from
5 Journals
3 Non-letter
Journals
2 Letter Journals
68
69
70
71
72
73
CALENDAR YEAR


US HEP PUBLICATIONS
(Experimental)
300
250
200
150
100
50
NUMBERS OF ARTICLES
Total from
5 Journals
2 Letter Journals
3 Non-letter Journals
68
69
70
71
72
73
CALENDAR YEAR

A57
~~A52~~



12-16-73


NON-U.S. HEP PUBLICATIONS
THEORETICAL
700
600
500
400
300
200
100
0
NUMBER OF PUBLICATIONS
SUBTOTAL
3 NON-LETTER
JOURNALS
SUBTOTAL
2 LETTER JOURNALS
1968
69
70
71
72
YEAR OF PUBLICATION

12-16-73