MC 572

BOX 1 S.8 FOLDER 3

HEPAP - Correspondence, Budget Reports, Meeting Agenda, minutes

1967-1968; 1971

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF PHYSICS
CAMBRIDGE, MASSACHUSETTS 02139

April 12, 1971

To All Members of HEPAP

Dear Friends:

Enclosed you will find the preamble and the relevant Chapter 9 of the report of the High Energy Subcommittee of the Bromley Committee. Please read it and be ready to discuss and criticize it at our next meeting in Washington where Bob Sachs will be present and will be glad to receive critical comments, constructive and destructive. I am looking forward to seeing you in Washington.

Sincerely yours,

Viki

Victor F. Weisskopf

VFW:gpm
Enclosures

Copy to W. A. Wallenmeyer
P. Donovan
M. Bardon

WAYNE STATE UNIVERSITY
COLLEGE OF LIBERAL ARTS
DETROIT, MICHIGAN 48202

DEPARTMENT OF PHYSICS

April 7, 1971

Dr. Glenn T. Seaborg
Chairman
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Dr. Seaborg:

During the past several months I have taken the liberty of sending you copies of my letters to Dr. Hildebrand, Dr. Wallenmeyer, and Professor Weisskopf. I now find it necessary to write to you directly, because I am convinced that the unfairness experienced by me must be brought to your personal attention. There is an Indian adage that it is sufficient to test one grain of rice to see whether the cooking is done, and I am citing at present just one example of lack of integrity to give you some idea of the atmosphere surrounding the AEC and the high-energy-physics community. I have chosen for this purpose Dr. Alexander Abashian who was recently appointed to the AEC's staff, and it certainly should not take too much of your time to investigate my complaint against him.

I am enclosing a Xerox copy of a paper by Abashian, Booth, and Crowe, Phys. Rev. Letters 5, 258 (1960), which gives a preliminary account of their work on a pion resonance. They have referred to the work of several theoretical physicists, including three papers of mine, which inspired them to undertake their experimental investigation. After completing their work at the Lawrence Radiation Laboratory at Berkeley, Abashian, Booth, and Crowe published their detailed findings in four papers in Phys. Rev. 132, 2296, 2305, 2309, 2314 (1963). Strangely enough, in these four papers there is no reference whatsoever to my papers, although their experimental findings are close to the predictions of my papers and differ from those of the other theoreticians referred to in their preliminary work.

After you have verified to your satisfaction the obviously unfair attitude of Dr. Abashian toward my research work, I intend to submit to you in equally clear terms how the AEC research funds are being distributed on the basis of a scientist's personal relationships rather than the scientific merit of his research proposal. I intend to establish before you and the Congressional Joint Committee on Atomic Energy, if necessary, that the AEC is funding research proposals in my field that are mediocre and at best of the most transient interest despite the cry of "tight budget situations and severe budget cuts." I have personally concluded that peer reviews of research proposals have been turned into a farce, and that it has become increasingly impossible for a physicist to give all his attentions and abilities to scholarly pursuits and still obtain Federal research support.

Sincerely,

Suraj N. Gupta

Suraj N. Gupta
Distinguished Professor
of Physics

Copy: Senator Robert P. Griffin
Professor Victor S. Weisskopf
Dr. William A. Wallenmeyer

POSSIBLE ANOMALY IN MESON PRODUCTION IN $p+d$ COLLISIONS*

Alexander Abashian, Norman E. Booth, and Kenneth M. Crowe
Lawrence Radiation Laboratory, University of California, Berkeley, California
(Received August 11, 1960; revised manuscript received August 22, 1960)

Several authors have proposed the existence of new particles and π - π resonances.[1-5] Along these lines we are studying the reactions

$$p+d \rightarrow \begin{cases} He^3+\pi^0 & (1a) \\ He^3+\omega^0 & (1b) \\ He^3+\pi^++\pi^- & (1c) \\ He^3+\pi^0+\pi^0 & (1d) \end{cases}$$

$$p+d \rightarrow \begin{cases} H^3+\pi^+ & (2a) \\ H^3+\omega^+ & (2b) \\ H^3+\pi^++\pi^0, & (2c) \end{cases}$$

where ω may be a particle of mass intermediate between that of a π meson and a K meson. Our first experiment consists of measuring at a fixed laboratory-system angle of 11.7 deg the He^3 momentum spectrum from 1.0 Bev/c to 1.6 Bev/c for incident proton energies ranging from 624 Mev to 743 Mev.

Figure 1 is a schematic drawing of the experimental arrangement. Protons extracted from the 184-inch cyclotron impinged upon a Y-shaped gaseous deuterium target operated at a pressure of 320 psi and at liquid-nitrogen temperature. He^3 nuclei produced at an angle of 11.7±0.2 deg passed through the collimators C_2 through C_4 into the magnet spectrometer and were detected by scintillation counters S_1 through S_7. Q_1, an 8-inch triplet quadrupole magnet, focused the particles initially at f_1, and Q_2 (a lens similar to Q_1) focused them finally at S_3. The slit at f_1 was 0.5 in. wide at full proton energy of 743 Mev and 2.0 in at reduced proton energies, thereby yielding momentum intervals of ±0.6% and ±2.5%, respectively.

Identification of He^3 was made by requirements of momentum, time of flight, range, and dE/dx in S_3. For He^3 momenta greater than 1200 Mev/c, $S_1S_2S_3S_4S_5\bar{S}_6\bar{S}_7$ coincidences were required, while below 1100 Mev/c, $S_1S_3S_4\bar{S}_6\bar{S}_7$ were required. The momentum interval between 1100 and 1200 Mev/c was measured with both arrangements to check that they agreed. Backgrounds were measured by using H_2 gas of the same stopping power as the D_2 in the target. The backgrounds thus measured agreed with target-empty measurements when corrections were made for energy losses. At the full proton energy the backgrounds were always less than 1% of the maximum counting rates. However, at reduced energies they amounted to as much as 20% of the peak rate because the greater dimensions of the incident proton beam due to scattering in the energy degrader increased the production of He^3 in the walls of the target.

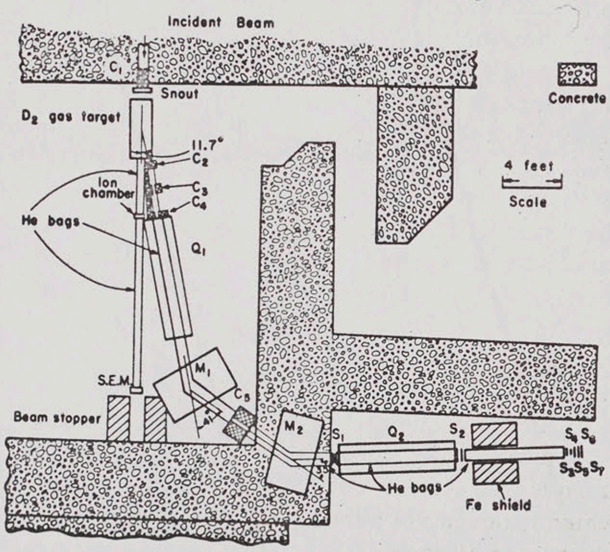

FIG. 1. Experimental arrangement.

Figure 2 shows the He^3 momentum spectra corrected for energy loss and for the change in momentum interval, Δp, with momentum p. The assigned errors are statistical and constitute the major part of the error. Each spectrum has a high-momentum peak due to single π^0 production and a lower momentum continuum associated with double meson production. The solid curves drawn for the π^0 peaks are the calculated momentum-resolution functions of the system, normalized to the area under the experimental points.

For comparing the continua with theory, we have chosen a simple phase-space calculation as a first approximation. The expression used for the phase-space volume element ϕ_S is

$$\phi_S = \frac{d^2\rho}{dp_3\,d\Omega} = \frac{p_3^{\,2}}{\omega_3}\left(\frac{t-4}{t}\right)^{1/2}, \qquad (3)$$

where ρ is the relativistically invariant three-body phase-space volume, ω_3 and p_3 are the total

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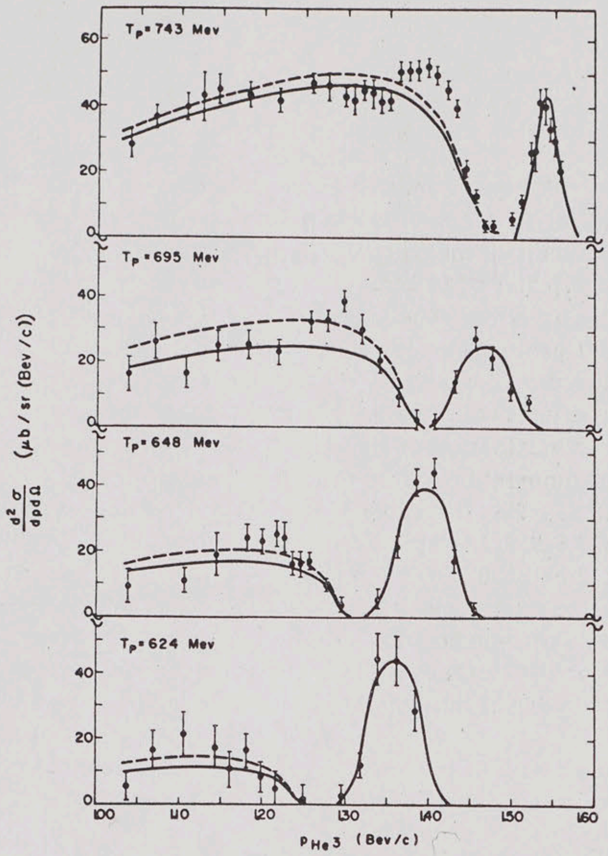

FIG. 2. He^3 momentum spectra for various incident proton energies. (See text for description of curves.) Ordinate scale is correct to within a factor of two.

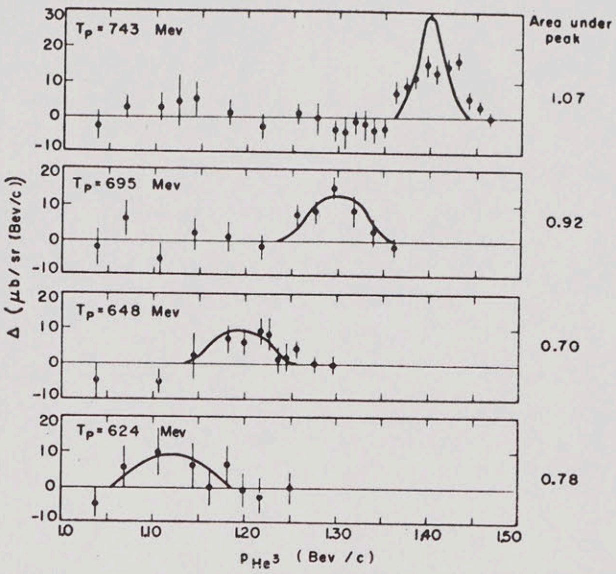

FIG. 3. Difference between He^3 data and solid curves of Fig. 2 for various incident proton energies. (See text for description of curves.)

energy and momentum of the He^3, respectively, and t is the square of the total energy of the two pions in their own c.m. system in units of the pion mass. The dashed curves drawn in the continua are these calculations fitted by the method of least squares to all of the experimental points.

It is clear that these calculations alone cannot reproduce the peaks that occur in the continua. We have investigated some of the conventional mechanisms for extending these calculations: for example, the effects of Bose statistics for the two pions, pion-nucleon interaction, and final-state wave function for the He^3 nucleus. Our crude calculations of these effects do not give quantitative agreement with the data. We have therefore attempted to fit only that part of the data outside the peaks with ϕ_S; the results are shown as the solid curves in Fig. 2. In Fig. 3, Δ, the differences between the data and the solid curves of Fig. 2, have been plotted as a function of He^3 momentum. The curves are the calculated resolution functions for a particle or a resonance of zero width and located according to kinematics for a mass or total energy of 310 Mev. The areas under the curves have been normalized to the areas under the points.

Some caution must be exercised before firm conclusions are drawn about the rather broad observed peak at full energy, as contrasted to the more narrow distribution expected. First, since the peak resides so close to the sharply changing edge of the continuum, the subtraction is sensitive to errors in momentum settings and the exact shape of ϕ_S. Second, the data have been combined over many runs, so that errors in settings from run to run tend to smear out any narrow peaks. We think that it is unlikely that these two possibilities are the entire explanation for the width observed. We therefore fitted the widths of the peaks with a simple Breit-Wigner one-level formula with experimental resolution folded in. The results of these calculations gave, for the natural linewidth, $\Gamma_{BW} = 10 \pm 6$ Mev. No definite conclusion on the linewidth can be drawn at this time.

Information on the isotopic spin assignments for the particle or resonance may be obtained from a study of Reactions (2a), (2b), and (2c), which proceed via pure $I = 1$ production. Figure 4 shows our attempts to measure these reactions at the highest proton energy. Because our spec-

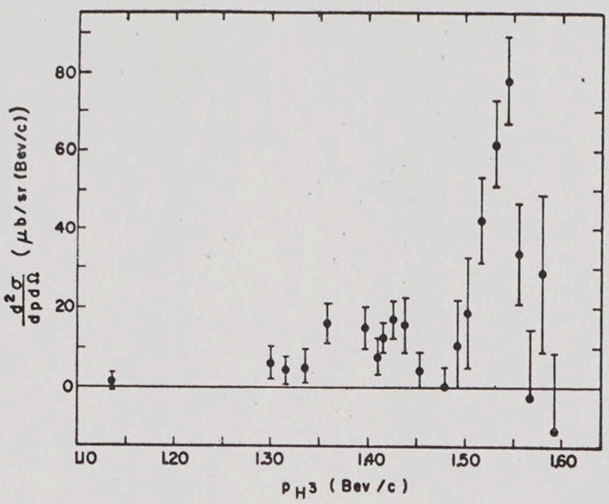

FIG. 4. H^3 momentum spectrum for incident proton energy of 743 Mev. Ordinate scale is arbitrary.

trometer was designed for the He^3 measurements, we had to degrade the H^3 with Be to a momentum of 800 Mev/*c*. The small number of points and the large errors assigned are results of the large backgrounds and low counting rates. Experimentally, we find that the ratio of the cross sections of (2a)/[(2b) + (2c)] is about 2.3:1. We expect from charge independence the same ratio for the $I=1$ part of (1a)/[(1b) + (1c)] or (1a)/ peaks if the He^3 peaks are $I=1$ and the remainder of the continuum is $I=0$. From our fits, we find the ratio (1a)/peaks to be 1.9:1. Thus, within the large errors involved, an $I=1$ assignment for the peak is possible.

Upon the suggestion of Chew we attempted to fit the full-energy He^3 data with a combination of an *S*-wave ($I=0$) ϕ_S and a *P*-wave ($I=1$) resonant ϕ_P given by

$$\phi_P = c_1\phi_S[(t-4)/t]|F_\pi|^2, \qquad (4)$$

$$|F_\pi|^2 = [(t-t_\gamma)^2 + (t-4)^3\Gamma^2/t]^{-1},$$

where $(t_\gamma)^{1/2}$ is the position of the resonance in units of the meson mass and Γ is a parameter appearing in the expression for the pion form factor F_π of Frazer and Fulco.[3] We obtained reasonable agreement for $c_1 \approx 3$, $t_\gamma = 5.0 \pm 0.2$, and $\Gamma = 1.0$ to 2.0. These values of t_γ and Γ do not agree with those of Frazer and Fulco, who predict t_γ between 12 and 16 and $\Gamma = 0.4$ in fitting the nucleon form factors and magnetic moments.

In concluding, we can summarize the following:

1. The data are inconsistent with the relativistically invariant phase space assumed. The discrepancy appears in the form of a narrow peak which kinematically behaves like a system with a mass or total energy of 310 ± 10 Mev. The natural linewidth of this system is not more than about 16 Mev.

2. Plausible explanations of the line are the existence of a new neutral particle or a resonant π-π system. The possible isotopic spin assignments are $I=1$ or $I=0$. The H^3 data crudely support the $I=1$ assignment.

3. Alternate explanations may be possible although we have not found any in quantitative agreement with the data. Further experimental work, particularly on the H^3 reactions, is clearly essential. Our present conclusions therefore must be regarded as tentative.

A more complete discussion of the experiment and any new results will be forthcoming shortly in a more extensive article.

We would like to thank Professor Geoffrey Chew, Professor Kenneth Watson, and Professor Emilio Segrè for several enlightening discussions of the experiment and the results. We also wish to thank Mr. Morris Pripstein for his assistance during the early phases of the experiment, and Mr. James Vale and the cyclotron crew for their cooperation.

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*Work carried out under the auspices of the U. S. Atomic Energy Commission.

[1]Y. Nambu, Phys. Rev. 106, 1366 (1957).
[2]S. N. Gupta, Phys. Rev. 111, 1436 (1958); Phys. Rev. 111, 1698 (1958); Phys. Rev. Letters 2, 124 (1959).
[3]W. R. Frazer and J. R. Fulco, Phys. Rev. Letters 2, 365 (1959); Phys. Rev. 117, 1609 (1960).
[4]G. F. Chew, Phys. Rev. Letters 4, 142 (1960).
[5]J. J. Sakurai, Nuovo cimento 16, 388 (1960).

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF PHYSICS
CAMBRIDGE, MASSACHUSETTS 02139

April 1, 1971

Dr. William A. Wallenmeyer
Assistant Director for High
Energy Physics Program
Division of Research
United States Atomic Energy Commission
Washington, D. C. 20545

Wallenmeyer

Dear Bill:

Thanks for your letter of March 22 in which you answer my emergency appeal in respect to our Theoretical Group. No, it is not help to define our priorities which I wanted from you. I wanted to use the dire situation in our theory group as an example of the tragic consequences of the recent 9% cut in the LNS funds. I consider this cut unwarranted in view of the fact that the total budget was trimmed by 4.3% and that most of the university groups were cut by this amount only.

This is why I am delighted to learn that Bernie and Al are coming for review of the program, and that there will be an external technical review later on. The outcome of these reviews can only be one of these two alternatives: Either you will be convinced that our program is at least as good per dollar as most of your other programs and therefore the discriminatory cut was not justified; or I will be convinced that LNS is not doing as well as most other groups. I believe that the first result is much more likely.

With best wishes.

Yours sincerely,

Victor F. Weisskopf
Head, Department of Physics

VFW/mlu

March 26, 1971

Dr. Bernard Hildebrand
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Bernie:

May I ask you to extend my reservations in the Park Central Hotel for the next HEPAP meeting until Tuesday morning. It is perhaps an exaggeration if I say I am looking forward to our next meeting and the confrontation at the APS, but I am sure it will be exciting.

With best regards,

Victor F. Weisskopf

VFW:gpm

March 26, 1971

Dr. William McElroy
National Academy of Sciences
2101 Constitution Avenue, N. W.
Washington, D. C.   20418

Dear Dr. McElroy:

I have heard from Manny Piore that you would be interested in some statements about the present state of high energy physics which I made as the Chairman of the High Energy Physics Advisory Panel and of a short analysis of the situation by William Panofsky.

I am sending you these two documents and I would be glad to supply any information if you so desire.

Very sincerely yours,

Victor F. Weisskopf

VFW:gpm
Enclosures

E. R. Piore
Old Orchard Road, Armonk, New York 10504

March 22, 1971

Professor Victor F. Weisskopf
Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki:

I spoke to Bill McElroy and suggested that he hear your report with Pief's addendum on high energy physics, and told him that Ed David and Weinberger of OMB have heard it.

I told him that the report has hard figures on what is happening and he ought to be aware of the facts.

Best regards.

Sincerely,

Manny

Piore

March 11, 1971

Dr. E. R. Piore
Old Orchard Road
Armonk, New York 10504

Piore

Dear Mannie:

Thanks for your letter regarding my documents to Paul McDaniel. You will have received the corrected version in which I took account of some of the criticisms from other sides.

I understand that you are not impressed by the manpower argument because any group of men in physics can make the same observations. I would reply that every group should make this observation, and this is why I put it in.

I agree with you about Pief's document and that it should get wider circulation. It already went further than McDaniel's file, and I know that the Commissioners of AEC have it, and Pief and I went personally to Ed David to show it to him and talk about it. It also went to Weinberger, the Deputy Director of the OMB. Bob Sachs also received it and is going to use the information in his subcommittee report to Allan Bromley. You offered to help in transmitting it to McElroy, and I should like to encourage you to do so. He has not, to my knowledge, received this document as yet. You could add a copy of my letter to Paul if you feel this would be helpful.

I am very sorry that we did not see you at so many of our meetings. Ihhope you will come next time on April 24th.

With best regards,

Victor F. Weisskopf

VFW:gpm

E. R. Piore
Old Orchard Road, Armonk, New York 10504

March 1, 1971

Professor Victor F. Weisskopf
Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki:

I am sorry that I failed to reply to your letter by February 25. I have no comment on your letter, but the manpower argument leaves me cold. Every group in physics can to various degrees make the same observation.

Pief's document is the best I have seen and it must get wider circulation than Paul McDaniel's file. A presentation by Pief with charts should be made to the General Manager and the Commissioners of AEC, Bill McElroy, Ed David, and the Director of the Office of Management and Budget. Furthermore, Allan Bromley should try to inject some or all of the information in his present labors. I would be prepared to intervene with McElroy and David if this would be helpful.

Best regards.

Sincerely,

Mannie

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

HEPAP

MAR 5 1971

Professor Victor F. Weisskopf
Head, Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02138

Dear Professor Weisskopf:

Thank you for your letter of March 2, 1971, expressing the grave concerns of the High Energy Physics Advisory Panel with respect to the effects of reduced support for this Nation's program in high energy physics research.

We will circulate your letter for the information of the Commission so that others may also benefit from your advice.

Sincerely,

Paul W. McDaniel

Paul W. McDaniel, Director
Division of Research

March 2, 1971

TO: HIGH ENERGY PHYSICS ADVISORY PANEL MEMBERS

R. L. Cool	G. A. Snow
B. Cork	G. F. Tape
E. R. Piore	K. M. Terwilliger
B. Richter	S. B. Treiman
J. L. Rosen	V. F. Weisskopf, Chairman
J. R. Sanford	W. A. Wenzel
A. M. Sessler	W. J. Willis

FROM: Bernard Hildebrand, Exec. Secy.

R E M I N D E R

The next HEPAP meeting has been scheduled for Saturday and Sunday, April 24-25, 1971, in Washington, D. C., just prior to the Washington American Physical Society Meetings.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF PHYSICS
CAMBRIDGE, MASSACHUSETTS 02139

March 2, 1971

Dr. Paul McDaniel, Director
Division of Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

McDaniel

Dear Paul:

I am obliged to transmit to you the distress and despondency of the members of HEPAP when faced with the continuing reductions in the high energy physics budgets, produced by direct decrease of funds as well as the indirect reductions caused by inflation. We considered it to be the duty of our Panel to advise you as to how high energy physics should be developed productively by turning towards the most interesting and challenging research projects and facilities. The Panel feels helpless and frustrated when it has to do nothing but advise you how to distribute insufficient funds so as to minimize the damage to the field. At the same time we have warned of the effects these reductions were having in decreasing productivity, in missing opportunities, and in postponing innovations.

The recent additional cut of $4.3 million in the operational funds has dramatized this situation which has existed since 1968, and has become more critical every year. We appreciate greatly the efforts of the Commission, of the OST and of the National Science Foundation to increase the support of high energy physics from other sources, in order to partially fill the losses caused by this recent cut. We must point out, however, that the situation was dangerously critical, even before this cut.

In 1970 the decision was made to close the 3-GeV proton accelerator at Princeton and to restrict work at the Cambridge Electron Accelerator to colliding-beam research. Although the work at these labs was of considerable importance, it was felt that the financial picture of high energy physics was sufficiently bleak to require relatively more support to the higher energy and high priority machines. Since that decision was made, total operating funds available to high energy physics have decreased by more than $6 million--an amount greater than that saved by the cutback of PPA and CEA. In addition, since 1970, the necessary minimal support for the developing experimental program at the National Accelerator further curtails the funds available for exploiting the other high energy machines.

This bleak situation is in glaring contrast to the state of the field. We find ourselves today in a period of unusual activity and promise. New exciting results, new ideas and new methods appear on many fronts of high energy physics. As examples I quote the evidences pointing to smaller subunits of the proton found at SLAC, the unexpected phenomena discovered at Frascati, the new ideas of Veneziano, the development of wire spark chambers, proportional chambers, and superconducting devices. High energy physics has discovered and systematized a whole new layer of natural phenomena within the last ten years: The field of hadron-spectroscopy opened shortly after 1960, the SU_3-symmetries were found, the structure of the proton was explored, the vector dominance model was born; the violation of time-reversal invariance was discovered; the exploration of weak interactions began; etc. All this indicates that the last decade showed a high rate of discovery.

The promise of this decade is at least as great. The largest accelerator in the world will be working soon, the other accelerators are ready to deliver higher intensities and better beams, electron-positron clashing beam devices are being built. These facilities could keep up the pace of discovery and innovation if the support of high energy physics would allow their proper use. If the present budget trends continue, however, the laboratories will be forced to neglect innovation and daring advances in a desperate attempt to keep the present facilities alive. The restricted funding was tolerable for a certain time, since the United States physics program has accumulated a large reservoir of strength during the past decades. But this time has now run out. We will soon be surpassed by the Western Europeans in quality and quantity of research. They are already spending more money on high energy physics than we are, and their facilities are better supported than ours.

A most alarming damage resulting from the insufficient funding is the effect on the manpower situation. The high energy physics program has always been a producer and a pool of some of the finest scientific talents. Due to the intellectual challenge of the field, the high energy physicists--the physicists working on the front line of the search into the structure of matter--have an excellent tradition in training people who are ready and able to help solving important problems of great complexity as the experience in World War II and after has shown. This pool begins to dry up because the influx of young people is severely reduced by the lack of funds and, consequently, of jobs. We do not ask for a return to the abnormal growth rates of the post-war period, but we sincerely believe that a return to reasonable funding levels and patterns which allow systematic planning and innovating is a necessary condition, not only for the productivity of high energy physics, but for the continuing development of U. S. Science as a whole.

Yours sincerely,

Viki

Victor F. Weisskopf

VFW:gpm
Enclosure

P. S. I include as background information a slightly shortened version of a paper by W. Panofsky.

W. K. H. Panofsky and SLAC Staff
February 1971

HIGH ENERGY PHYSICS AND THE FY'72 PRESIDENT'S REPORT

A Brief Outline of the Challenges and Problems

1. THE SCIENCE

High Energy Physics (the physics of elementary particles at energies above 1 BeV) has become the frontier of elementary particle research as it has evolved over the years. Exploration of the field is in full swing; new results which modify profoundly man's view of the most basic nature of the physical evidence continue to evolve. The procession of discoveries in elementary particle physics which have in a very real sense introduced new dimensions into physical thought are briefly listed in Attachment I. The richness of the field in terms of basic discoveries continues to increase; yet a real synthesis of these results in a unifying picture is still eluding us.

As the frontier of elementary particle physics moves to higher energies, the relation of the earlier results to other sciences bares itself; the elementary particle physics of yesterday is the basis of nuclear structure physics of today. The relation of high energy physics to processes in cosmic systems is now beginning to be evident.

2. LONG RANGE PLANNING VS CURRENT FUNDING

There is an enormous disparity between the actual funding of high energy physics and the planning assumptions which were made when those high energy laboratories now operating were created. In 1965, on the request of the Joint Committee for Atomic Energy, the Congress received a Guideline for Policy for High Energy Physics. Actual funding for FY'72 adjusted to a fixed dollar is below that guideline by more than a factor of two. Total operating costs for high energy physics in fixed dollars have actually been decreasing substantially since 1966. This decrease has been occurring even while two large new laboratories (SLAC and NAL) have reached or are reaching the operating state and while a large new construction project (BNL) which will greatly increase the research potential of the laboratory is being completed.

Meaningful planning with some degree of commitment is essential for effective pursuit of high energy physics: The time interval between inception of new experiments and final analysis of the data is generally three years. Instrumental innovation, so essential in maintaining the vitality of the field, necessarily precedes actual participation in the experimental program by several years.

3. UNDER-UTILIZATION OF FACILITIES

As a result of this funding deficiency all existing high energy facilities in the United States are seriously under-utilized. High energy accelerator laboratories have large fixed costs. The result is that any additional funding would buy a much more than proportional amount in productivity. If, as is indicated, FY'72 funding in dollars will be lower, then this fact, combined with inflation, means that operations will decrease further. All laboratories are severely under-utilized. A recent report in preparation by the General Accounting Office documents these facts quantitatively for each high energy accelerator; Figure 4 in Attachment II shows the graphical result.

4. ACCELERATOR SHUT-DOWN

The problem of under-funding of existing facilities became critical during the budget process for the Fiscal Year 1971. As a result it was reluctantly concluded that the logical economic response should be to decrease the total number of laboratories; in consequence it was decided to close the Princeton-Pennsylvania Accelerator, although it was a new and highly productive installation at that time. This step was taken in the full expectation that the funds freed by this shutdown plus additional funds which might be available in the future would increase the effectiveness of the remaining laboratories. The budgetary decreases for FY'71 and FY'72, combined with inflation, not only swallow the cost reduction derived from the PPA shutdown, but go considerably beyond that. As a result the total cost-effectiveness of the remaining laboratories is decreased even further. The regular research program at CEA has been terminated in order to make it possible to carry on the development of the highly promising colliding beam "by-pass" facility. All other laboratories, all of which have been continuously modernized through various improvement programs, are carrying a large backlog of highly competitive experiments which they are unable to schedule.

5. COMPARISON WITH SUPPORT OF EUROPEAN FACILITIES

U.S. funding contrasts sharply with the support of European high energy physics. Western Europe operates a smaller number of accelerators than does the United States but, in contrast, total funding for their operation is not only larger but is rising at a substantially higher rate. Consequently, the degree of exploitation of corresponding European installations is much greater. Attachment II documents this situation in some detail. The European "300 GeV" accelerator, of cost comparable to that of NAL, is expected to be authorized shortly.

The storage ring (colliding beam) technique, first developed and exploited successfully in the U.S., had been taken over almost entirely by U.S. and USSR laboratories until quite recently; the result is a highly unbalanced situation described in Attachment II.

6. SOVIET HIGH ENERGY PHYSICS

The Soviet high energy proton accelerator at Serpukhov is currently the world's highest energy machine, soon to be surpassed by NAL. The initial results from Serpukhov have been important contributions. Existing technological developments involving storage rings are being carried out at Novosibirsk. With these exceptions, generally speaking, most important high energy physics results continue to originate in the West. No simple budgetary comparison appears feasible.

There is excellent communication between Western and Soviet high energy physicists which is borne out by the fact that many Western European and some U.S. physicists are participating in the work at Serpukhov.

7. IMPACT OF AN EXPECTED EARLY TURN-ON OF THE NAL ACCELERATOR

The situation affecting the programs of the operating high energy laboratories for FY'72 is complicated further by the great success achieved by the National Accelerator Laboratory (NAL) at Chicago in advancing its expected completion date by almost one year beyond that originally envisaged, and in expecting to do so at less than estimated cost. Due to this earlier than expected turn-on date, planning of the scientific community to utilize this machine is advanced also; in consequence the need for operating funds for the groups preparing for experimental use of the facilitity has increased. Moreover, the operating cost of NAL itself is increasing substantially in FY'72. It is clear that the early utilization of NAL offers a challenging opportunity.

It seems to me that the scientific community should not be penalized for its successes such as with the National Accelerator machine. I should like to add that the high energy physics community has an enviable record in constructing accelerators at the highest energies on schedule and within projected budgets. Relative to other technological undertakings supported by the Federal Government this fact is truly exceptional, if you consider that design and construction of new accelerators involve at least as much extrapolation into new technology as is involved in space and military systems.

8. DISCOURAGEMENT OF INNOVATION

High energy physics is justly proud of many new technological developments it has achieved in the past such as in the areas of superconductivity, computer science, and high power microwave technology. Yet just such innovations are being actively discouraged by the present funding pattern. Each laboratory finds that if it diverts a small fraction of its resources for innovation it loses many times that amount in terms of current operating efficiency.

As documented in Attachment II, capital equipment funds for high energy physics have been reduced disproportionately in the budgeting process. It is these funds which not only increase future research opportunities but which are also needed for support of the ongoing research. Experiments in high energy physics involve such massive installations that many of the costs inherent in the normal experimental program are formally budgeted as capital equipment or accelerator improvements funds.

9. RELATION TO OTHER RESEARCH FUNDING

It appears incongruous to decrease high energy physics funding in the face of all these specific circumstances while other basic research funding, in particular that in the NSF, is now taking an upturn. Recent extremely exciting results in high energy physics need further follow-up to achieve better understanding. As discussed in Attachment I, indications are that these results have uncovered another layer of totally new phenomena whose impact is not as yet understood, but which is expected to have far-reaching importance.

10. IMPACT ON SCIENTIFIC PERSONNEL

I can add to these problems specific to high energy physics a remark on the more common problem of employment: High energy physics has already lost a substantial part of its manpower and the human impact of the reduction in effort implied by the FY'72 pattern is particularly severe, since more of the high energy physics laboratories are located in areas which are already impacted by the decrease in technological spending by the government. The extent of the personnel losses is discussed in Attachment II; an alarming feature is that a substantial fraction of the U.S.-trained Ph.D. physicists have left the United States.

****

High energy physics has given to the United States increased knowledge, trained people stimulated by intellectual challenge, world leadership in exploration, and tools of science kept in frontier condition. Thus, I recommend that, on the basis of the serious situation outlined, supplementary funds for FY'72 be requested to relieve some of the inequities and inefficiencies generated.

ATTACHMENTS

ATTACHMENT I. HIGHLIGHTS OF HIGH ENERGY PHYSICS RESEARCH

High energy physics aims to explore the nature of the physical universe to the smallest possible dimensions. Man's knowledge about our world is bounded on both the infinitesimal and the cosmic ends of the scale. Research in both areas continues to provide new insights and understanding of man's physical environment. Regularly, as both knowledge and techniques advance, discoveries greatly change man's view of his world.

The following table lists the most startling and profound observations and discoveries of high energy physicists over the past 25 years.

DATE	DISCOVERY	EXPLORATION
1947	Lamb shift: "g-2" of the electron	Limits of quantum electro-dynamics*
1947	Properties of the Pion*	Pion-nucleon interactions
1952	Bubble Chamber* for investigation of strange particles*	Interactions of strange particles
1954	Composite nature of the nucleon*	Electron scattering and nucleon spectroscopy
1955	Anti-proton*	Matter/Anti-matter symmetry
1956	Violation of parity conservation*	Weak interactions
1961	Hadron symmetries (SU^3)* and discovery of omega-minus (1964)	Whole hadron spectroscopy
1962	A second neutrino	Search for new leptons
1964	Violation of CP conservation	Search for T violation
1968	Point structure within hadrons	Deep inelastic scattering and e^-e^+ storage rings

*Work leading to Nobel Prizes.

A brief outline of the significance of each of these discoveries follows:

The development of the theory of quantum electrodynamics in 1946 opened a whole new all-inclusive way of understanding electromagnetic interactions. It predicted with uncanny accuracy the "Lamb shift" in atomic structure and provided an extremely precise quantification of the magnetic moment ("g-2") of the electron.

The pion (pi-meson) had been predicted in the late 1930's to be the "glue" holding the neutrons and protons together in the atomic nucleus.

The discovery of the pion in 1947 led to hopes that the new and strange "strong force" (or "nuclear force") would soon be understood; the properties of the new particles were rapidly explored.

Strange particles had indeed been observed in nature but just in the form of unaccounted-for particles discovered in cosmic rays.

In the constant shower of cosmic rays, physicists had earlier discovered the existence of unknown and bewildering "strange" elementary particles. It was not until 1953 and the advent of the new generation of accelerators, with energies high enough to produce the new particles under controlled laboratory conditions, that the full extent of the "strangeness" of these particles was realized. The strange particles were found to be produced copiously using high energy beams of the new accelerators, yet their decays were of a weak nature. Since both production and decay seemed to involve similar particles it was puzzling why they took place with such drastically different strengths. What was eventually discovered was the existence of a new conserved quantity in nature. This new quantum number, "strangeness," went far to explain the peculiar interactions of the strange particles in the 1950's. However, the full and rather deep implications of the strangeness quantum number were yet to come 10 years later with the discovery of SU(3) symmetry.

The new accelerators also probed smaller distances than had been explored before. In probing the proton by various scattering experiments, physicists found that the suspected point-like nature of the proton was not there; instead, the proton was an extended structure with a definite size. This result was first obtained by electron scattering experiments. In addition excited levels of the proton, or proton resonances, were found, further implying a compound structure.

When the Bevatron at the University of California became operational in 1954, an opportunity to test the concept of anti-matter symmetry was presented. The positron (anti-electron) had been discovered in cosmic rays in the late 1930's, opening the possibility of the existence of a complete anti-matter world, symmetric to the known particle spectrum. With the higher energy available at the Bevatron, one could hope to produce the first strongly interacting Fermian anti-particles seen in nature, anti-protons. Indeed, anti-protons were so produced, and as time has progressed most other elementary anti-particles have been found.

In 1964 at the AGS, the anti-deuteron was produced, strongly indicating the possibility of complete anti-particle symmetry through the elements.

In the mid-1950's the bubble chamber was invented, a device which proved to be invaluable in examining in detail the production and decays of what then amounted to 30 elementary particles. One such bubble chamber built in 1956 is still operating in the SLAC beam today. The bubble chamber was instrumental in precipitating, through measurements of unprecedented precision, perhaps the most profound discovery of the decade of the 50's, parity violation.

In 1956 it was shown that parity, i.e., right-left symmetry, was violated in the weak interactions. This discovery was truly momentous since physics from its inception had always assumed that nature could not distinguish right-handed and left-handed systems. The incorporation of this astounding fact into the framework of the weak interactions led to the inclusion of the neutrino and muon in the fundamental equations of particle physics in a beautifully symmetric fashion. These equations were then suggestive of more general forms ultimately leading to the inclusion of the weak interactions as essential reflections of the basic structure of matter in symmetry schemes of recent times.

In 1962 an elaborate experiment proved that contrary to the previous picture there was not just one neutrino in the world but indeed there were two - adding to the list of leptons (electrons, muons, etc.) in the list of elementary particles. This has led to extensive experimental searching for yet further leptons - the question of the role of a multiplicity of leptons in nature remains one of the great open problems in physics.

In 1964, approximately eight years after the discovery of parity violation, another fundamental symmetry principle was found to be violated: Time reversal invariance (or "CP conservation"). The forces driving processes in the forward and backward direction in time were determined not to be necessarily equal: An extremely weak violation was found, the full implication of which has yet to be resolved. Physicists have gained a great deal of insight through the investigation of such basic symmetry principles, and will continue to test established laws to the limits of obtainable precision.

As high energy physics entered the 1960's, the particle explosion really began. New bubble chamber and counter techniques, and the invention of spark chambers, permitted much more extensive and precise experiments to be performed. It seemed that each new experiment discovered at least one new particle.

By 1965 over a hundred particles were claimed to exist; a new nuclear physics had evolved. After considerable theoretical effort in the late 1950's and early 1960's, it was found in 1961 that a strong pattern was evident in the particle spectrum than extant. This pattern took mathematical expression through group theoretical approaches. In particular, the group (or symmetry) SU(3) had profound predictive power in describing not only the particle spectrum, but particle interactions as well. One great success of SU(3) was the prediction of the "omega-minus" meson, the first strangeness-3 object. This prediction was spectacularly verified in 1964.

Another dramatic implication of SU(3) was the idea of "quarks" - new ultra-basic elementary particles. With the quark concept many particle properties were explained in a rather simple way. Indeed, the accuracy of many calculations of particle properties is difficult to understand in light of the simplicity of the models used. Basically, the idea is that all known particles with strong interaction are composite objects, the constituents being quarks.

New experiments at SLAC involving the scattering of electrons from protons at energies higher than ever before appear to have uncovered another inner layer of matter. The additional available energy (and intensity) have yielded new results implying the existence of elementary point-like constituents in the proton; these may or may not be the quarks predicted from the SU(3) particle spectra. Experiments done with storage ring facilities in Europe have obtained similar results. More experiments are necessary to really prove or disprove these ideas of a new layer of matter. These are presently under way or will be in the near future at SLAC.

The beams of the National Accelerator Laboratory will provide an excellent testing ground for these ideas. Indeed with the much higher energy of NAL, one might actually be able to produce a "quark" in the laboratory. The new storage rings in Europe and the U.S. will add a totally new experimental approach to the field. Then an entire new world in high energy physics may open.

This brief historical outline amply documents that the rate of truly profound discoveries in elementary particle physics has by no means decreased - the field is still wide open. However the total impact of these fundamental revelations on our thinking and understanding of the natural world cannot be evaluated until a more comprehensive synthesis of theoretical ideas emerges.

ATTACHMENT II

THE EFFECTS OF BUDGET TRENDS ON HIGH ENERGY PHYSICS IN THE UNITED STATES

A. Comparison of Present Trend with Prior Planning

On January 26, 1965, the Congress received a Report on National Policy for the High Energy Physics Program.[1] In that report a program was detailed that would maintain the leadership of the United States in elementary particle physics. Figure 1 strikingly shows the implications of past budgets and further reductions as departures from that program. It is evident that national funding for high energy physics has fallen to less than half of that projected by the 1965 policy planning.

The annual budgets proposed in 1965 are shown on the figure, escalated by the Consumer Price Index over the intervening years. Shown on the same figure are the dollars obligated by high energy physics for the intervening years and the obligation levels contained in the President's Budget for FY1972. The totals shown correspond to the entire program for federally supported high energy physics in the United States.

The U. S. Atomic Energy Commission supports the greater part of this program; the National Science Foundation is the next largest supporter, and a small fraction of support came from the National Aeronautics and Space Administration and the Department of Defense. For example, in the FY1970 budget, about $13.7 million was contributed from the National Science Foundation and about $3 million was shared by the Office of Scientific Research of the Air Force, the Office of Naval Research, and the National Aeronautics and Space Administration. The contribution to high energy physics of the latter three organizations for FY1971 and FY1972 is not included but is very small and is not oriented towards high energy accelerators.

Some additional support (not indicated) comes from costs shared by the universities, largely in the form of salary contributions, some computer time, some equipment, some reduction in overhead, and the provision of some facilities for their "user groups."

The Atomic Energy Commission is considered to be the "Executive Agent" responsible for coordinating the nation's High Energy Physics Program.

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[1] Congress: Joint Committee on Atomic Energy, High Energy Physics Program: Report on National Policy and Background Information, February, 1965, 89th Congress, 1st Session, Committee Print.

B. Comparison of European and U. S. Support of High Energy Physics

Until recently the United States has held a fairly clear position of world leadership in elementary particle physics. The European community has been working very actively in high energy physics at an increasing pace. The member countries have established an international laboratory of 3650 people at Geneva, Switzerland, called CERN (European Organization for Nuclear Research). In addition, there are several national laboratories and scores of active user groups at the universities in the various countries.

Figure 2 compares the money spent in Europe in the last few years compared to that obligated by the United States. For a valid comparison, the National Accelerator Laboratory with its 200 GeV accelerator under construction has been listed separately; it is expected to cost about $250,000,000. This laboratory corresponds to a 300 GeV accelerator which the European community is expected to approve within the next few months. It will cost $267,000,000 (at 1970 prices).

Table I attempts to compare the financial support available to the major accelerator centers in the United States and Europe. It can clearly be seen that for corresponding laboratories the United States facilities are at a financial disadvantage by about a factor of two. The total monies available to the United States, even with two additional major centers of activity, is less than that for Europe.

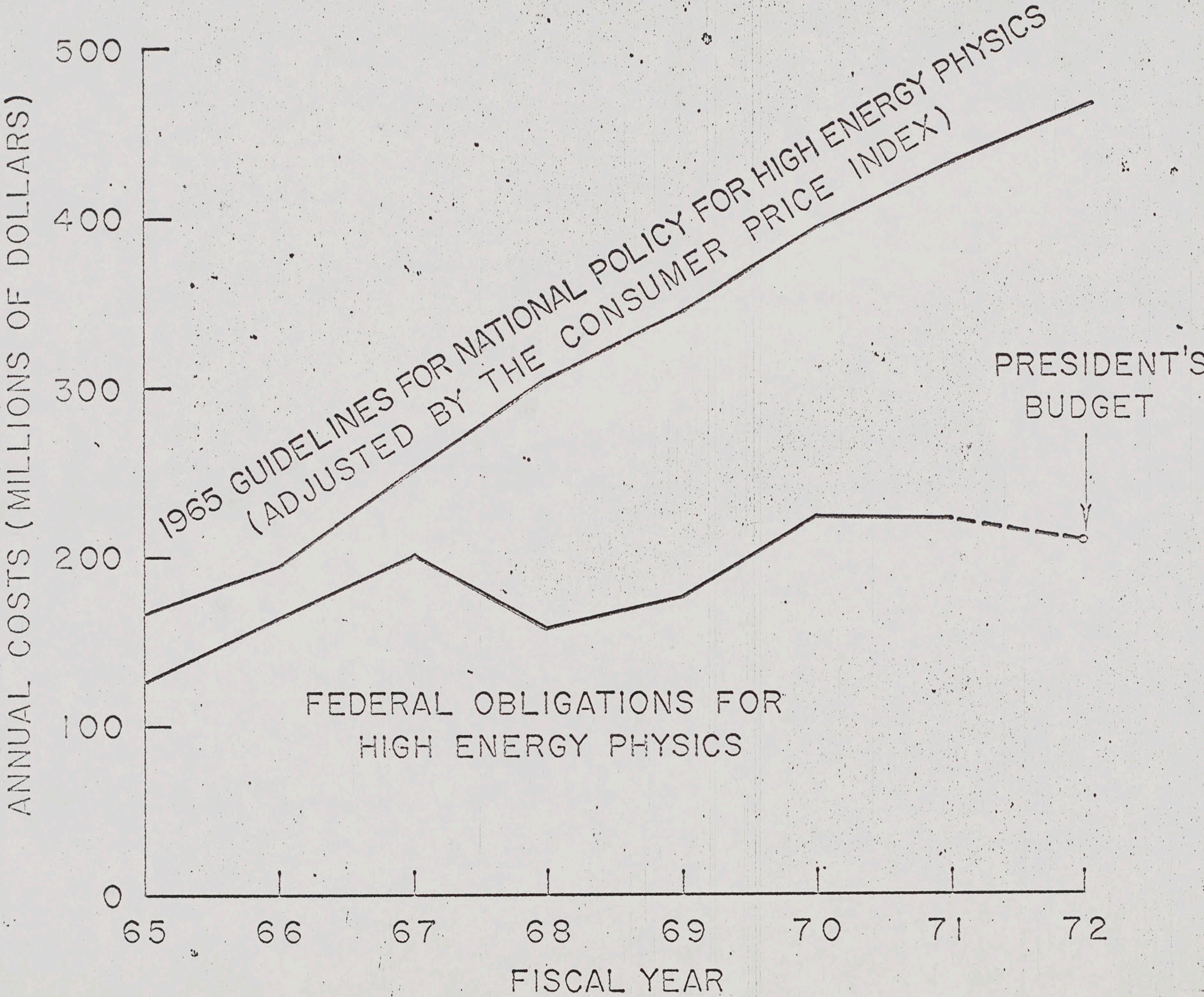
Table II illustrates the future relative positions of the United States vis-a-vis Europe and Russia in Colliding Beam-Storage Ring Projects. This area of research may represent the next frontier in the study of high energy particles. The United States, during past years has continuously been postponing or refusing proposals in this field; during the last years two efforts (CEA and SLAC) have gone forward at the expense of ongoing projects.

In colliding beam facilities, two beams of high energy accelerator particles collide head on, rather than having one beam striking a stationary target (as is customary). In such facilities the following special features accrue:

1. The energy available in the center of mass of the collision is very much larger; as an example, the CERN intersecting storage ring (ISR) which is now undergoing initial tests, will produce a reaction energy which corresponds to an ordinary accelerator of 1800 GeV.

2. If electrons and positrons are used as the colliding particles, not only is high center of mass energy obtained but in addition the reactions are of a particularly simple nature because no strongly interacting particles are present in the initial state; therefore, the reactions are produced by the closest equivalent to a source of "pure energy."

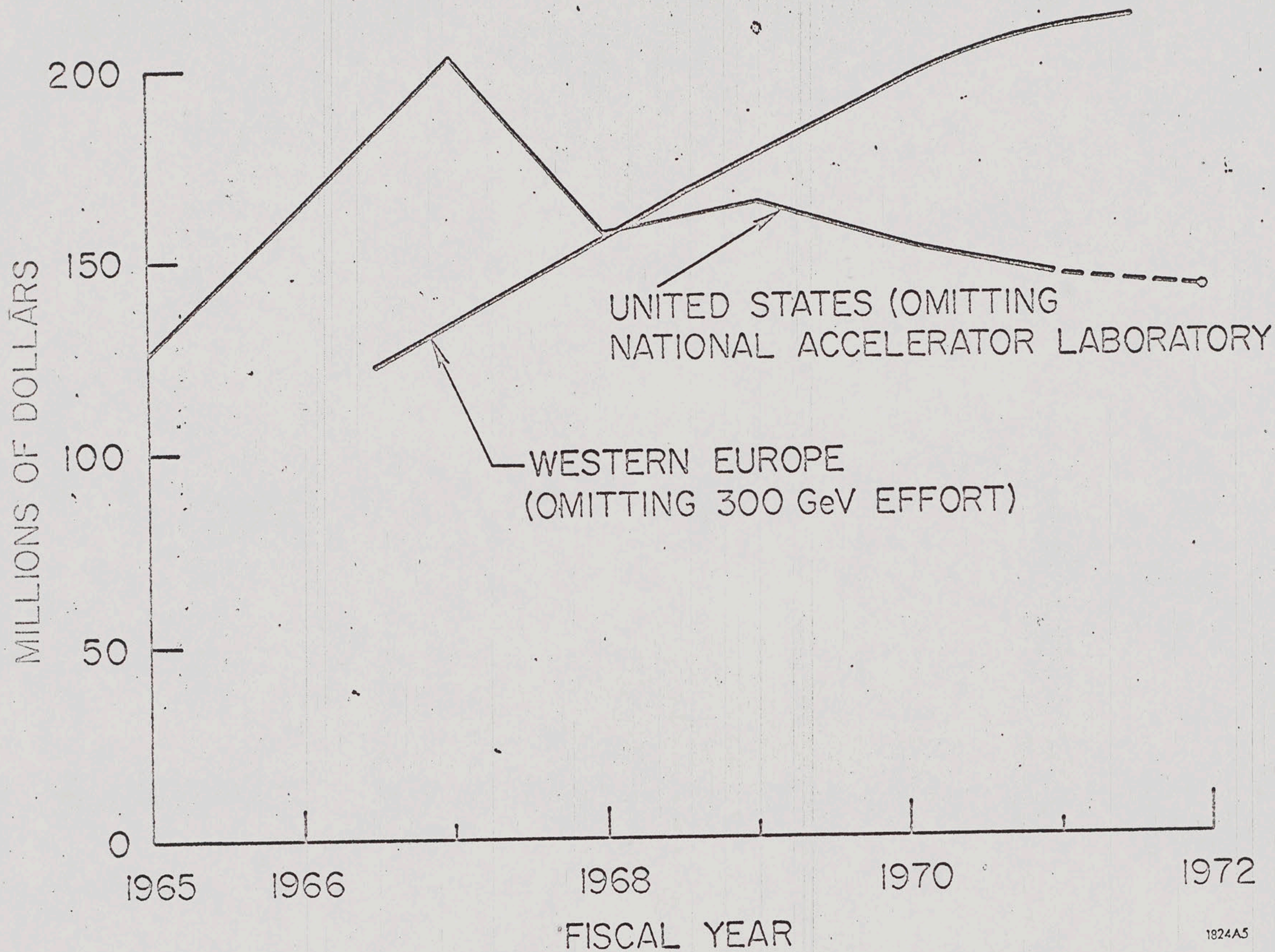
NOTE: The European numbers were hastily gathered from published sources. The accounting systems in the various countries differ widely. There has always been an active scientific interchange between the United States and Western Europe. An attempt is under way by the U.S.A.E.C. Division of Research and the CERN Planning Office to understand and relate the financial aspects of the high energy physics in the two parts of the world. The attempt has been made to compare the total laboratory programs including current construction.



ANNUAL COSTS (MILLIONS OF DOLLARS)
500
400
300
200
100
0
1965 GUIDELINES FOR NATIONAL POLICY FOR HIGH ENERGY PHYSICS
(ADJUSTED BY THE CONSUMER PRICE INDEX)
PRESIDENT'S
BUDGET
FEDERAL OBLIGATIONS FOR
HIGH ENERGY PHYSICS
65
66
67
68
69
70
71
72
FISCAL YEAR

FIG. 1

1824A6



UNITED STATES OBLIGATIONS vs EUROPEAN
EXPENDITURES IN HIGH ENERGY PHYSICS

FIG. 2

TABLE I

SUPPORT OF CORRESPONDING ACCELERATOR LABORATORIES (OPERATING ABOVE 3 GeV)
Millions of Dollars a/

United States		Europe	
AGS - Brookhaven (33 GeV)	$ 33.9 b/	PS, CERN - Geneva (28 GeV)	$ 78.4 c/
CEA - Harvard/MIT (6 GeV)	2.9	DESY - Germany (6 GeV)	22.0 d/
Bevatron - Berkeley (6 GeV)	26.7 e/	Nimrod - United Kingdom (7 GeV)	17.2
Cornell f/ (10 GeV)	2.7	NINA - United Kingdom (4 GeV)	8.3
Total Corresponding Accelerator Support	66.2		125.9
ZGS - Argonne (13 GeV)	19.0	-----	
SLAC - Stanford (22 GeV)	28.2 g/	-----	
Total Major Accelerator Support	$113.4		$125.9

FOOTNOTES:

a/ This is the total support for the laboratories as can be ascertained. It includes Operating, Capital Equipment, Accelerator Improvement Projects, and General Plant Projects and computers for the U.S. Facilities. The European figures have been hastily gathered from published sources. The U.S. figures represent support for FY1971. The European figures represent support for calendar 1970 except for PS, CERN which are for calendar 1971. European monetary units have been converted at official rates.

b/ Includes $7,000,000 construction cost in FY'71 of the AGS conversion program.

c/ Includes several "line items" -- storage rings, the Serpukhov/Saclay collaboration, Big European Bubble Chamber, etc.

d/ Includes $5,900,000 for storage ring construction.

e/ Includes one time cost of $8,700,000 for a large computer and $1,500,000 for ERA development. A recent study of relative manpower shows that the Bevatron has about half the support of Nimrod.

f/ Funded by National Science Foundation.

g/ Includes storage ring SPEAR.

TABLE II

COLLIDING BEAM - STORAGE RING PROJECTS

Location	Beam Energy	Relative Luminosity	Status and Comments	Total Cost (Millions $)
U.S.A.				
CEA, Cambridge	3.5 GeV	30.0	Scheduled operation: 1971	(Modification)
SLAC, Stanford	2.5 GeV	300.0	Scheduled operation: 1972	$ 5
Western Europe				
Frascatti, Italy	1.5 GeV	1.0	Operating	9
Orsay, France	0.55 GeV	0.05	Operating	2
Orsay, France	1.5 GeV	500.0	Proposed	10
DESY, Germany	3.5 GeV	3000.0	Scheduled completion: 1974	20
CERN, Geneva	28.0 GeV	10.0	Scheduled operation: 1971	85
			Total Europe	$126
U.S.S.R.				
Novosibirsk	0.75 GeV	0.1	Operating	
Novosibirsk	0.75 GeV	10.0	Scheduled completion: 1972	
Novosibirsk	3.5 GeV	10.0	Scheduled operation: 1971	
Novosibirsk	6-10 GeV	?	Proposed	
Novosibirsk	24.0 GeV	?	Under construction	
Kharkov	2-3 GeV	30	Under construction	

C. Nationwide Loss of Personnel from High Energy Physics

The reduction in high energy physics support together with increased costs is having a severe effect on the manpower of the national laboratories. A preliminary survey by the Division of Research of the U.S.A.E.C. indicates a reduction in personnel from FY1971 to FY1972 of some 863 people out of under 7000. These people will have to be separated from the laboratories and associated University user groups. This is an especial hardship for these people; the laboratories are generally located in areas of high technical activity and the current unemployment in these areas will make reasonable industrial employment for these specialized individuals difficult.

A case in point is a recent involuntary separation list from the engineering department of one of the major laboratories. It lists seventeen people; they have an average age of 48 years and an average of eleven years experience in that particular laboratory.

Professor Grodzins of Massachusetts Institute of Technology is Chairman of the Economic Concerns Committee for the American Physical Society. He is conducting a man-to-man survey to find out what is happening to the entire physics Ph.D. population of the country. His survey learned that in 1970, there were 1500 new Ph.D.'s looking for positions. He estimated that there were about 1700 experienced physicists looking for positions. Of this 3200 total, about 2000 found positions in the United States in physics jobs. The 1200 remaining did not. Of this 1200, two-thirds were experienced physicists and one-third were new Ph.D.'s. Half of these 1200 found work outside the United States, one-fourth left physics all together, and one-fourth remain unemployed.

Another survey has shown that, contrary to the case for all other Ph.D's, Federal research and development funding is the principal support of the endeavors of physics Ph.D.'s.

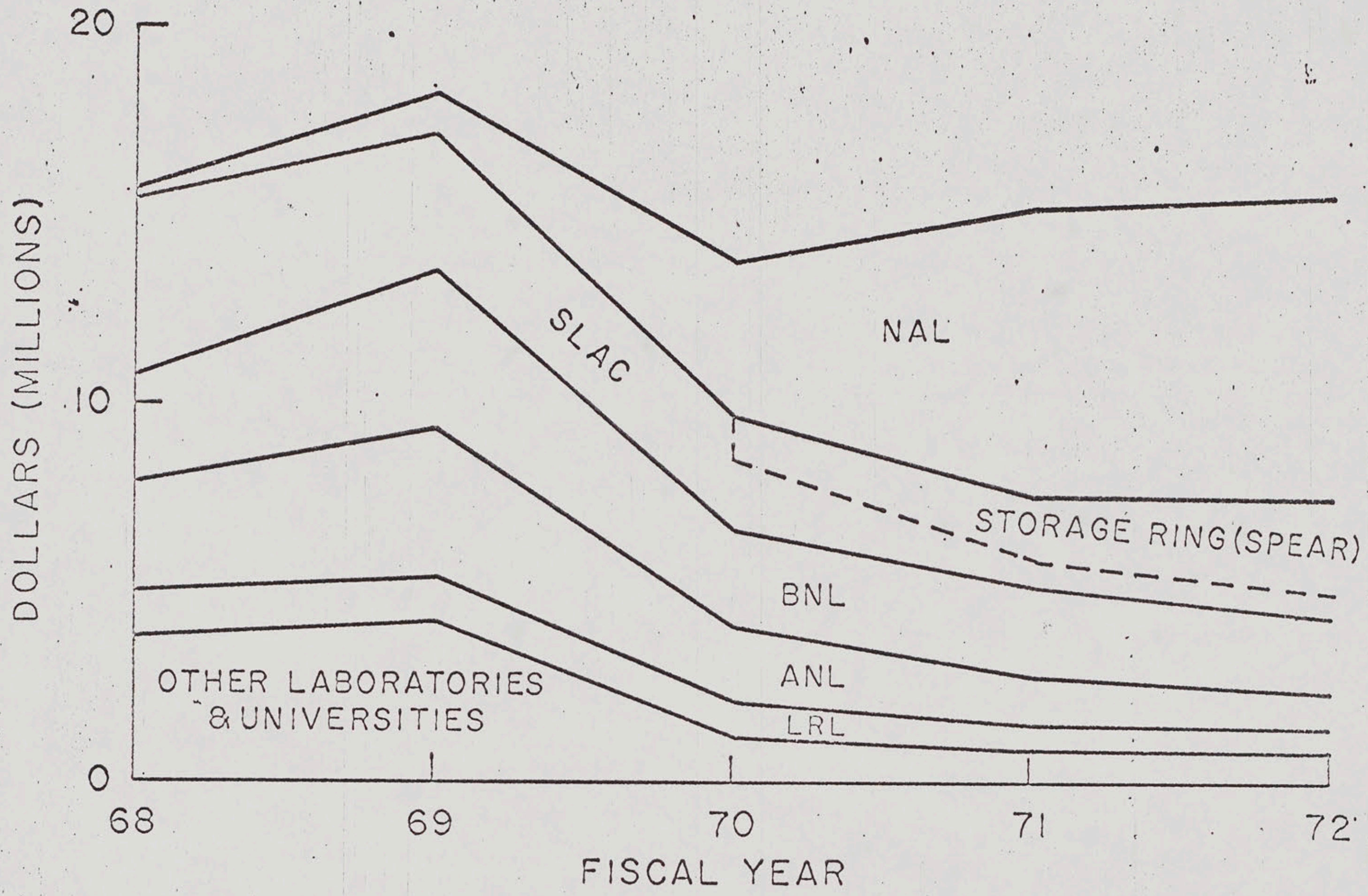
D. Trends in AEC Equipment Obligations for High Energy Physics

Figure 3 graphically illustrates the problems of high energy physics with respect to equipment. It shows the history of equipment obligations to the large AEC high energy physics laboratories (excluding purchases of very large computers).

The money available for equipment for laboratories has decreased in spite of two new major projects being approved: The National Accelerator Laboratory, which must be equipped, and the SLAC Storage Ring, which is being built primarily as equipment.

Carrying on an experiment involves very complex apparatus, such as magnets and separators; the evident stringency has at times restricted the number of experiments that could be run simultaneously, cutting down on the incremental utilization of the accelerator. The equipment stringency has also curtailed the efforts to improve the efficiency of existing equipment, further reducing laboratory utilization. The development of new experimental devices has been curtailed; this inhibits future growth and utilization and efficiency. The types of experiments which could be carried out have been restricted. Performance of some types of frontier physics is being prohibited.

The equipment and accelerator improvement funds play a very different role in high energy physics than they do in connection with, for example, lower energy ongoing programs. The apparatus of high energy physics is so large that the process of shifting from one experiment to the other as part of the regular ongoing program requires re-installation and re-furbishing of major pieces of equipment. By the current fiscal practices, a substantial part of this ongoing expense - part of the regular experimental program - has to be charged to capital equipment and to construction funds in the accelerator improvement categories. Accordingly only a fraction of those funds budgeted for equipment and accelerator improvements represent actual expansion of new opportunities. Therefore, the selective cutting of equipment and accelerator improvement funds has had a disproportionately large effect on technical innovation and the support of generally new experimental opportunities.



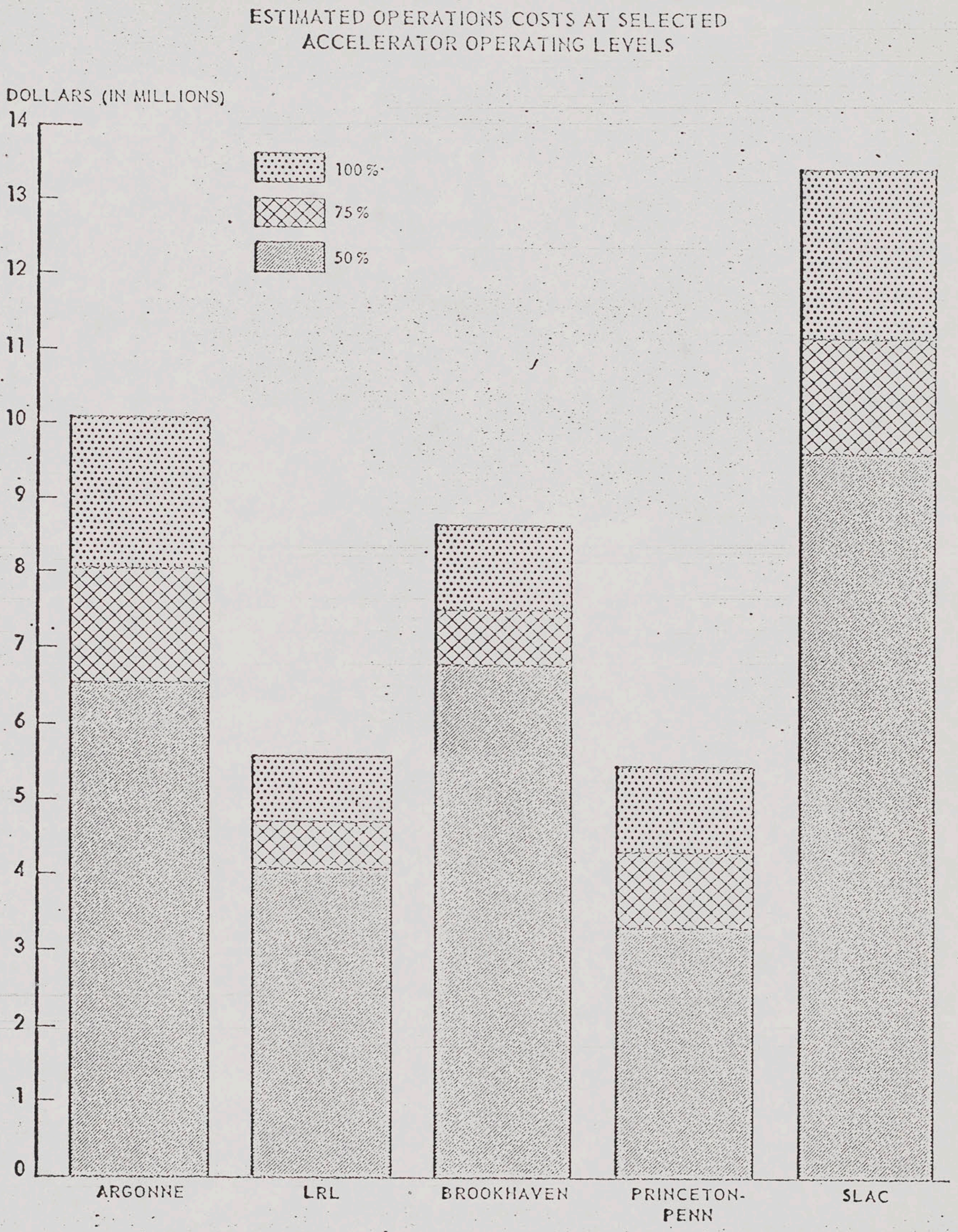
AEC EQUIPMENT OBLIGATIONS

FIG. 3

1824A7

E. Under-Utilization of Existing Accelerators

Figure 4 shows the operating costs of existing accelerators for funding levels permitting 50%, 75% and 100% utilization, respectively. The economy of full operation is evident. The data are taken from the Report dated February 8, 1971, from the Comptroller General to the JCAE of the Congress on "Use and Operating Costs of the AEC's High Energy Accelerators."



ESTIMATED OPERATIONS COSTS AT SELECTED ACCELERATOR OPERATING LEVELS
DOLLARS (IN MILLIONS)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
100%
75%
50%
ARGONNE
LRL
BROOKHAVEN
PRINCETON-PENN
SLAC

Fig. 4

HEPAC

WAYNE STATE UNIVERSITY
COLLEGE OF LIBERAL ARTS
DETROIT, MICHIGAN 48202

DEPARTMENT OF PHYSICS

February 26, 1971

Dr. Bernard Hildebrand
Chief, University Research Branch
High Energy Physics Program
Research Division, Atomic Energy Commission
Washington, D. C. 20545

Dear Dr. Hildebrand:

I received your undated letter on February 23, 1971, and I would like to thank you for sending me the referees' reports concerning my proposal in accordance with our telephone conversation of January 12, 1971. I deeply appreciate your courtesy, but I cannot help making the following remarks:

1. In your letter you have made it more or less clear that the AEC is not going to support my proposal. I do not understand why you have not invited me to comment fully on the referees' report and then consider my reply with an open mind.

2. You have already received a copy of my letter of November 23, 1970, to Professor Weisskopf, in which I have explained in reasonably simple language the significance of my current research contributions. Neither you nor Professor Weisskopf have bothered to discuss the contents of my letter in an objective manner.

3. I have also pointed out in my letter to Professor Weisskopf, by giving specific examples, that the AEC is supporting the routine research activities of numerous theoretical physicists. It is, therefore, unfair to use the excuse of shortage of funds in dealing with my modest request for research support.

I could send you a detailed reply to the referees' report if you are really interested in a fair evaluation of my proposal. Moreover, since a majority of your reviewers seem to think that I am entitled to research support on a lower scale than what has been suggested in the proposal, I am willing to come to any reasonable agreement, and I certainly do not insist that I receive summer salary for full three months. If you still decide to reject my proposal altogether, I am even prepared to submit another proposal to the AEC to assure you of my friendly intentions. However, if the AEC continues to treat me with obvious unfairness, I shall ultimately have to take up this matter with the Congressional leaders and President Nixon.

In spite of your kind advice during our conversation, I am not at this time prepared to submit another proposal to the NSF, because I am having extensive correspondence with the NSF, the Senate Committee on Labor and Public Welfare, and the President's Office of Science and Technology. It could easily take a year or two before all aspects of my charges against the NSF have been fully investigated.

I am still hopeful that we shall continue to be friends, and I shall certainly attempt to meet you when I visit Washington next time.

Sincerely,

Suraj N. Gupta

Suraj N. Gupta
Distinguished Professor
of Physics

Copy: Dr. Glenn T. Seaborg
Professor Victor S. Weisskopf

HECAP

Yale University New Haven, Connecticut 06520

DIRECTOR OF GRADUATE STUDIES
Physics Department
217 Prospect Street

February 25, 1971

Professor Victor F. Weisskopf
Department of Physics
Massachusetts Institute of Technology
Cambridge, Mass. 02139

Dear Viki:

I like the letter to McDaniel, but pointing out that Europe is better off because it has fewer facilities invites an obvious rejoinder. Sending along Pief's document is a good idea, though there is a certain pro-SLAC bias throughout the later sections.

Sincerely yours,

Bill

William J. Willis
Director of Graduate Studies

WJW/ks

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF PHYSICS
CAMBRIDGE. MASSACHUSETTS 02139

February 18, 1971

To All Members of HEPAP

Dear Friends:

Here is the first draft of the letter which I am supposed to write to Paul McDaniel. Please make suggestions, changes, deletions or additions. If I do not receive any answer by February 25, I shall assume that you agree with the formulation.

You will also receive a document written by Panofsky in regard to the present situation. This document contains some of the back-up material, and I should like to send it with my letter, with the exception of his Attachment III, which only concerns SLAC. Please let me know your opinion on this. I have not yet asked Pief for permission, but I suppose I shall get it.

Sincerely yours,

Viki

Victor F. Weisskopf

VFW:gpm

D R A F T

Dr. Paul McDaniel
Director
Division of Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Paul:

I am obliged to transmit to you the distress and despondency of the members of HEPAP when faced with the continuing reductions in the High Energy Physics budgets by inflation and by cuts in dollar value. The Panel feels helpless and frustrated when it is requested to advise how the losses should be distributed, and when there is only one way to save the field; an increase of appropriations.

The recent cut of $4.3 million in the operational funds has dramatized this situation which has existed since 1968 and has become more critical every year. We appreciate greatly efforts of the Commission and of the National Science Foundation to increase the support of High Energy Physics by the National Science Foundation in order to partially fill the losses caused by this recent cut. We must point out, however, that the situation was disastrously critical, even before this cut.

As far as the actual research is concerned, we find ourselves today in a period of unusual activity and promise. Far from becoming a routine operation, new, exciting results, new ideas and new methods appear on many fronts of High Energy Physics. As examples I quote the evidences pointing to smaller subunits of the proton found at SLAC and at Frascati, the new ideas of Veneziano, and the development of wire spark chambers and superconducting devices. Let us not forget that High Energy Physics has discovered and systematized a whole new layer of natural phenomena within the last ten years: Hadron-spectroscopy started after 1960, and the SU_3-symmetries were found in that period. However, the scarcity of funds does not allow a vigorous follow-up of new discoveries and the exploitation of new methods and devices. The continuing cuts are forcing the laboratories to neglect innovations and daring advances in order to keep the present facilities alive. Such conditions can be tolerated for a certain amount of time, since U. S. Physics has accumulated a large resevoir of strength during the past decades, but it has run out this time. We will soon be surpassed by the Western Europeans in quality and quantity of research. They are already spending more money on High Energy Physics than we do, and they use this money for fewer facilities, most of which are vastly better supported (roughly by a fact or two) than the corresponding facility in the United States.

The worst damage resulting from the insufficient funding is the effect on the manpower situation. The High Energy Physics manpower was always a producer and a pool of the best scientific brains. The High Energy physicists--the physicists working on the front line of the search into the structure of matter--have an excellent tradition in their readiness and ability to help solving important problems of great complexity during World War II and after. This pool begins to dry up because the influx of young people is severely reduced by the lack of funds and, consequently, of jobs. We do not ask for a return to the abnormal growth rates of the post-war period, but we sincerely believe that a return to a reasonable and steady growth rate which allows systematic planning and innovating is a necessary condition, not only for the survival of High Energy Physics, but for the survival of Science as a whole in the United States.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY · HARVARD UNIVERSITY

HE-PAP

CAMBRIDGE ELECTRON ACCELERATOR

HARVARD UNIVERSITY
42 OXFORD STREET
CAMBRIDGE, MASS. 02138

February 10, 1971

Dr. William A. Wallenmeyer
Assistant Director
High Energy Physics Program
Division of Research
Washington, D.C. 20545

Dear Bill:

This is to appraise you of the impact on CEA of the budget figures for FY 72 which I understand to be $2,150,000 for operations, $100,000 for equipment and $75,000 for A.I.P. The programmed operations budget of $2,150,000 represents an 8.9 percent reduction from our FY 71 figure of $2,350,000 and an 18.7 percent reduction from the figure of $2,593,000 which we submitted to you for FY 72 for "continued operation at the pace set by the FY 71 budget". After the drastic reorganization of CEA forced by the FY 71 budget, we have no longer any one project whose elimination could even partially compensate for the reduction in funds from FY 71 to FY 72. We will simply have to reduce our overall pace below the minimum previously planned. The slow-down will affect all parts of our program, with the most long-term project, the magnetic detector, being affected most seriously.

On July 1, 1970, our staff consisted of 125 persons. Our FY 71 budget was based on 118 employees. The FY 72 budget requires a further reduction to 109 persons. If at all possible, I wish to avoid another lay-off, even a minor one, and we hope to be able to carry out this reduction through attrition. Although hating to even think of it, we realized that the overall money picture for the AEC in High Energy Physic was not likely to become much brighter in FY 72. We had therefore already stopped making new commitments to replace several people who have or are leaving CEA during this fiscal year; this will reduce our staff to 113 people on June 30, 1971. I very much hope that the required additional reduction will occur naturally.

Since the magnetic detector program is a joint enterprise of CEA and M.I.T., with some support by Southeastern Massachusetts University and Northeastern University, I have not yet been able to assess the full impact of the projected FY 72 budgets at the relevant institutions on this program. The minimum equipment budget of $216,000 which we requested for FY 72 included $101,000 for the magnetic detector; the remaining $115,000 was for miscellaneous equipment necessary to support the accelerator and BOLD, the on-line detector. Thus as a first approximation the programmed FY 72 equipment figures do not include any funds for the magnetic detector in FY 72. Unless additional funds can be made available for this project, I do not believe that it can be completed in FY 72, even in its phase 1 mode. You have recognized the importance of this program in the past and I very much hope that it will be possible to provide the funds necessary for its completion on schedule.

The proposed funding of $75,000 for A.I.P. will allow us a small start in the colliding beam improvement program but as you know from the 5-year cost projection which we sent you in November 1970, much more is needed to raise the beam energy to 5 GeV. However, improvement of such components as the vacuum system will immediately benefit the work in the 1.0 to 3.5 GeV region.

You can be assured that we will continue to do our very best with the means that we are given; as I am writing this sentence I am reminded of former President Sproul of the University of California who each year, when looking at the graduating class, exclaimed: "This is undoubtedly <u>the</u> finest class that ever graduated". He meant it, I mean it - but it does sound stale and how I wish that the boundary conditions were more reasonable for all of us!

With warm personal regards,

Karl

Karl Strauch
Director

KS/mr

HEPAD

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, L.I., N.Y. 11973
TEL. AREA CODE 516 YAPHANK 4-6262

DIRECTOR'S OFFICE

February 8, 1971

Dr. William A. Wallenmeyer
Division of Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Bill:

You requested George Vineyard to ask me to prepare an impact statement for the effect of the Presidential FY 1972 budget on the Brookhaven high energy physics program.

We have worked hard over the past week or ten days coming to grips with the implications of the Presidential budget. I cannot give you a definitive statement since the ramifications are so large, not only on the high energy program but on how the budgets of the other programs at Brookhaven will react back on the high energy program through the General and Administrative budget and through the various budgets for Technical Services. You will recall that a few weeks ago George Vineyard, Fred Mills, Mark Barton and I visited you, Spoff English and others to alert you and the AEC to the effects on Brookhaven and the high energy physics program if the Laboratory and that program should receive no increases in the President's budget for 1972. You will recall that we estimated a decrease of approximately 80-100 people in our manpower in the operational high energy budget. We presented to you various detailed pieces of information with respect to the inflationary trends in heating, electricity and other smaller items such as increases in Social Security. At that time we did not bring to your attention the impact on the program, should we lose this large pool of manpower. Our current estimate is that we will have to reduce manpower approximately 60 people. (Total reductions since FY 1967 would then amount to 25% of the personnel in the high energy program. The largest loss would be in 1972. In 1966 the fraction of budget for salaries was 70%; in 1971 it is 78%. Concurrently, since 1967 the money available for Material, Supplies and Travel has been reduced by one-third.)

This estimate is based on the assumption that the per cent of the G&A budget remains fixed at the same value for FY 1972 as for 1971. It may not be possible for the Laboratory to hold that percentage in view of the high inflation during the past year. We are struggling to do so. Last year in passing from FY 1970 to FY 1971 the personnel in the G&A area was severely reduced in order to meet the financial crisis at that time. This year the amount needed to keep a fixed percentage is approximately $1.2 million. Should we reduce the manpower sufficiently to absorb these costs, services within the Laboratory will be reduced to a level below the minimum. It is not a viable procedure to continue for many years.

I would like to give you our preliminary estimates of the impact on the program. In our recent exercise called the Six-Year Forecast, we estimated that we would need approximately 100 people added to the operational personnel to be transferred from the Conversion Project in order to make use of a large fraction of the increased capabilities of the new AGS. Clearly, the current Presidential budget for 1972 demands a decrease not an increase in the manpower on the operational budget. We assume that our requested $1,150,000 addition for the Conversion Project will be granted. This number contains $680,000 to finish the project, $245,000 for demobilization costs, and $225,000 for contingency and escalation. In addition we assume that we will receive $195,000 at this midyear in order to cover the remainder of the demobilization pay for personnel on the construction project. If these requests are not granted, the consequences on the operational program will be devastating.

Our preliminary consideration of the President's FY 1972 budget leads us to predict the following:

1. We will be forced into a 15-shift equivalent operation of the AGS. We would probably operate three weeks running and one week off. We would expect to net about 70% of the current experimental time. This action would reduce the personnel needed on shift, the overtime currently needed for maintenance, and the power required. All shift people would become available for AGS maintenance, experimental floor, and facility work during the one week off. We, of course, would hope that our efficiency would remain high when running.

2. During the coming year we expect to have 12 beam positions available for experiments with up to 8 running simultaneously. We would expect to finish approximately 12 experiments. However, because of the reduction in manpower, we would expect to be able to remove only six finished experiments and set up only six new experiments. The great potential for doing physics with the new AGS results mostly from the Conversion Project, but it also is the result of new ideas on beam splitting and sharing. Changes in experiments are of two general varieties, both of them important: (a) The beam stays fixed but the detector changes. This is a relatively small change. (b) We build new beams or facilities complete with detector. An example of this situation is our new B target station which will share beam with our target station C by means of a beam splitter system as well as share beam with our G10 internal target. In 1972 in order to bring target station B into use, other experiments will have to remain in place

as we will not have the manpower to accomplish both tasks. Our users group (HEDG) has repeatedly urged us to increase the number of "spigots" available. That we have done and are doing, but we will now be unable to move the "buckets." They may, therefore, overflow!

3. The Presidential budget for 1972 will lead to delays in realizing full benefit from the Conversion. (a) Reduction in manpower will delay us in reaching the full scale 200 MeV linac operation and this will limit intensity. Under any conceivable circumstances we intend to reach the stated intensity of 10^{13} particles per pulse at some time, even if it is delayed. We feel it is part of our commitment to the high energy community. (b) The final overall completion of the Siemens power supply will be delayed. The Siemens set is at present in use at the AGS, at an increased repetition rate. However, it is not operating in a manner to exploit fully its inherent flat-top flexibility. (c) Subsystems in the main ring, including the rf stations, will be delayed. (d) It is likely that the North Area (H10) will be delayed. This has the unfortunate implication of delaying very high priority neutrino experiments using the 7-foot chamber.

4. We will reduce our operations to one bubble chamber, that is, either the 80-inch or one small chamber will operate at a time.

5. Particle research by in-house groups will be further reduced.

Incidentally, knowledge of the Presidential Operation and Capital budgets for FY 1972 led us to the decision, which you know about, not to expand the 7-foot bubble chamber but to modify it for an operating facility at essentially its present size. This is a decision which we will not change even should additional monies become available since it is necessary for our people to get on with commitments to the modification program. In this decision we also took into account the fact that under the budget proposed we would have no chance of procuring deuterium and neon for a larger chamber.

The Capital, ARAM, and Conversion budgets are very intimately related. Assuming again that we receive the requested additional money for the Conversion, in FY 1972 we will be short about $1,000,000 distributed roughly evenly between Capital and ARAM. This money would be for additional beam equipment, electric power distribution, water, and shielding. Smaller amounts from ARAM are needed for important specific projects associated with assuring the highest intensity and the best duty cycle from the AGS.

It is clear to us that in the current budgetary situation it is unlikely that Brookhaven's high energy program could be funded adequately to make complete use of the full capabilities of the new AGS. I would estimate, and this is a very crude estimate, that we would need approximately $2.7 million additional operating funds. This is composed of about $1.2 million in escalation and increased power usage, and about $1.5 million for the extra 100 people needed to do the job properly. In addition we would need approximately $1.5 million extra in Capital and ARAM. (However, given the Presidential total high energy budget for the nation, I believe that the nation's needs could be best met, taking into account that the new AGS is the most exciting tool currently available in the United States, if $1.5 million could be moved into Brookhaven's budget.) The operational budget is the most crucial item and the one which determines the level of operation. The additional $1,000,000 of ARAM and Capital funds are necessary for the extension of the program. I would hope that in your considerations of these consequences you will remember the fact that the AGS is the single most productive element currently operating in high energy physics. During the period February to October 1970 there were 32 universities doing physics here; there were 40 groups from these universities. The time delivered during the past calendar year to experiments using counter and spark chamber equipment was the highest ever, by almost a factor of 2. The program is running with the maximum effort of each individual. In short, we are flat out. We shall continue to make every effort, no matter what the budgetary situation is, to do the best for the nation's high energy physics program that we can. It is not solely Brookhaven's problem -- it is a problem for the entire high energy physics community.

Please let me know if I can be of further assistance and also please remember that the problems which I have outlined above are so large that our estimates of consequences can only be called preliminary at this time. Let me remind you again that the foregoing impact has been described under the assumption that the additional funds requested for the Conversion, including the necessary operational money for demobilization pay, will be provided. Failing that, all bets are off!

Sincerely,

R. Ronald Rau

hld

cc: P. W. McDaniel
M. Goldhaber
F. E. Mills
G. H. Vineyard
J. Weneser

bcc: R. L. Cool
H. C. Grahn
V. R. O'Leary
V. F. Weisskopf
W. Willis

COLUMBIA UNIVERSITY
New York, New York 10027

February 8, 1971

Dr. William A. Wallenmeyer
Division of Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Bill:

This letter is an appeal from the "floor" of the AGS. We all know how difficult things are and have at least some idea of your problems in steering the program. However, we thought it could be useful to bring a short-range problem to your attention.

We are all in various stages of data taking on the AGS floor. Some of our setups are extremely elaborate, some simpler. Much of this is the culmination of two or more years of hard work. We believe that this assemblage represents the best high energy physics program in the world.

Financial crisis dictates that the AGS shut down March 24th. We are appealing to the AGS to find some way of prolonging this for one month. The extra cost is of the order of $150K. The physics return of the extra month is incalculable. It means hard data for the following experiments:

- The hyperon beam (Yale, NAL; Sandweiss, et al.)
- The muon beam (NAL, Columbia, Rochester, Harvard)
- The Collins experiment ($p + p \rightarrow$ everything)
- The Steinberger K^o program
- The Mann K_{e4} program
- J. Rosen's study of coherence in particle production
- V. Fitch's regeneration study
- J. Orear's πp scattering at high energy
- B. Maglic's $\bar{p}p \rightarrow$ heavy boson
- G. O'Neill's $pp \rightarrow$ isobar production and decay

All of this plus two bubble chamber programs plus trial of the slow K beam area can be substantially aided by the extra $150K. On the other hand, premature shutdown will leave all of these unfinished -- some without enough time to use the shutdown for improvements, others with not enough data for decisive conclusions. Considering the investment, rational weighing of efficiency strongly dictates the extension we request. The strength of this program, we believe, is unprecedented for parallel and simultaneous operation at any accelerator anywhere, ever!

Any help you can give BNL to extend this running period would be clearly of great service to the physics program of the AEC and to the 80 or so scientists involved in the program. Somehow, the system should be able to produce a way of making such a reasonable step possible!

Yours sincerely,

L. M. Lederman

J. Christenson

J. Sandweiss, W. Willis

A. Melissinos

R. Wilson

J. Orear

J. Rosen

G. Collins

A. Mann

G. O'Neill

B. Maglic

cc: V. F. Weisskopf

NATIONAL ACCELERATOR LABORATORY
P.O. BOX 500
BATAVIA, ILLINOIS 60510
TELEPHONE 312 231-6600
DIRECTORS OFFICE

January 29, 1971

Professor Victor F. Weisskopf
Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki:

Thanks very much for your letter of January 15 sending the article submitted to "Science" magazine by Phil Anderson.

I think it would be far better for someone not directly involved in NAL to write whatever response might appear with or following the publication of the Anderson article. I understand, as a matter of fact, that the article may not appear at all. Perhaps that would be the best way to resolve the problem. However I think it would be very bad to give Mr. Anderson and any others of the opponents of high energy physics an opportunity to accuse us of quashing criticism.

Ned Goldwasser was recently at Princeton and had occasion to discuss the article with Murph Goldberger and Sam Treiman. They had already heard about it in devious ways. They are quite interested in writing a response or in contributing to its formulation. I think they could do a very good job. It may be that as chairman of HEPAP, a response written by you, eloquent though I am sure it would be, might be less effective than one written by free spirits, not administratively involved. You should be the judge of that. In the meantime, Ned has informed Bob Sachs of Goldberger's and Treiman's interest.

If you should still want something from me, the best I could do would be to send a copy of my testimony before the JCAE that you used in your article.

Best regards,

Bob

R. R. Wilson

THE CITY COLLEGE
OF
THE CITY UNIVERSITY OF NEW YORK
CONVENT AVE. at 138 ST.
NEW YORK, NEW YORK 10031

OFFICE OF THE PRESIDENT

January 18, 1971

Professor Victor F. Weisskopf
Massachusetts Institute of Technology
Department of Physics
Cambridge, Massachusetts 02139

Dear Victor:

Thank you for sending me a copy of Gregory's letter concerning international collaboration in high energy physics. I am too busy to get involved myself in this situation, but I do hope that you will attempt to bring up again the question of setting up an international study group to design the next generation of high energy accelerators. The Russians seem quite ready for this type of discussion and I trust that Gregory's eloquence about international cooperation can be matched by his deeds.

I look forward to seeing you at T. D. Lee's on February 2. *

Sincerely yours,

Bob

R. E. Marshak
President

REM:ca

* and at our home on Feb. 3!

PRIVILEGED INFORMATION

DRAFT
WDWales
11/22/72

MINUTES

HIGH ENERGY PHYSICS ADVISORY PANEL

Brookhaven National Laboratory

September 27-28, 1972

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

Participants:

HEPAP

V.F. Weisskopf, Chairman
B.C. Barish
D.B. Cline
J.W. Cronin
T.H. Fields
F.E. Low
R.R. Rau
J.L. Rosen (9/28)
J.R. Sanford
W.A. Wenzel

NSF

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

AEC

S.G. English, Asst. Gen. Man. for Res. (9/27)
D.R. Miller, Acting Dir., Div. of Phys. Res. (9/27)
H.L. Kinney, Special Asst. to the Dir., Div. of Phys. Res.
W.A. Wallenmeyer, Asst. Dir. for HEP, Div. of Phys. Res.
R.L. Fricken, HEP, Div. of Phys. Res.
W.D. Wales, Exec. Secy. for HEPAP

The HEPAP meeting was opened with a morning session in the Berkner Hall auditorium. The detailed agenda for this part of the meeting is attached (pg. A3). After introductory remarks by D.R. Miller and V.F. Weisskopf, the chair for the meeting was assumed by R.R. Rau, who presided during the Brookhaven presentation.

PRIVILEGED INFORMATION

I. Brookhaven Program Presentation

M. Goldhaber, the Director of BNL, began the presentation by outlining the Laboratory's problems and progress. He pointed out that the nearly-completed $50M Conversion Program has resulted in a larger machine which must now be run with a smaller work force than prior to the Conversion. This fact is very disappointing to the Laboratory and will make the exploitation of the improvements to the AGS much more difficult. He stated that BNL's plan for an Intersecting Storage Accelerator (ISA) (ISA = ISABELLE) has received impetus from CERN's favorable experience with the ISR. He emphasized the need for the higher energies which ISA would provide. A cost estimate for the ISA is expected next year.

D. Berley then outlined the present experimental situation at the AGS. A list of experiments and the present floor layout is attached (pg. A4-9). Currently there are three target stations; it is possible to have thirteen electronics experiments set up simultaneously, with as many as nine simultaneously collecting data.

D. Nygren discussed the results from the recent Columbia-CERN-NYU experiment to measure the rate for the decay $K_L \rightarrow \mu^+ + \mu^-$. The preliminary results indicated a branching ratio to other decays of 10 x 10^{-9}, which is in contradiction to the upper limit of 2×10^{-9} found in the recent experiment at LBL. Many details of this experiment were not yet well understood.

T. Kycia summarized the recent physics results which have been achieved in the Laboratory spark chamber and counter programs. These included a recent Princeton measurement of η_{oo}, a Columbia-CERN muon-proton scattering experiment, a study of K_{e4} decays by a University of Pennsylvania group, a Cornell-BNL $\pi^- p$ elastic scattering experiment, a measurement of K^+p and K^-p total cross sections, a measurement of the magnetic moment of the anti-proton, and a study of the decay $K^{\pm} \rightarrow \pi^{\pm} + \pi^{o} + \gamma$.

K. Lai outlined the planned bubble chamber program, emphasizing that the work on strong interactions had shifted from a study of resonances to an investigation of interaction dynamics.

E. Courant discussed the status of the Brookhaven ISA project. The basic parameters include two intertwined superconducting rings with a circumference of about two kilometers. A 30 GeV proton beam injected into the rings from the AGS would be slowly accelerated (120 sec.) to 200 GeV. The planned luminosity, with 15 amperes circulating in each ring, would be somewhat under

$10^{34} cm^{-2} sec^{-1}$. The current plans call for two 400m and four 220m straight sections. The construction of a 7-10 GeV electron machine is being considered to permit e-p collisions. No serious problems appear to have been uncovered during the recent summer study. Firm cost estimates are apparently still many months away.

N. Samios outlined some of the physics prospects with ISA. He emphasized the search for new particles such as the W meson, the study of structure functions, the quest for asymptopia, and the possibilities of completely unexpected new phenomena.

R.R. Rau reviewed the operation of the AGS during the past year. He pointed out that the overall efficiency of the operation had not been very good -- at least partly due to large manpower layoffs in the spring of 1971, a strike, and the fact that the shutdown completed last October had not been long enough to finish all of the necessary instrumentation. During the winter manpower was diverted from other projects to try to improve the machine performance. The results of this effort were beginning to show up in the machine record during the three weeks immediately preceding the August 19 failure of the rotor. The winter shutdown has been moved up, Conversion work has been proceeding, and the machine should be back in operation late in October. He expected to be able to run 5500-5900 hours in FY 1973.

Rau summarized the accomplishments of the past year at BNL:

1. Successful operation of the 200 MeV linac.

2. Improvement in the average intensity of the AGS from 1.9×10^{12} p/p to more than 4×10^{12} p/p.

3. Flattops of 1 second on internal targets, 0.75 second on external targets.

4. Development of new beams - a new hyperon beam, a low energy separated charged kaon beam (5×10^4/pulse at 750 MeV/c), and an improved separated beam to the 80" chamber.

5. Multipulsing of the 30" and 80" chambers.

6. Successful use of the PDP-10 for AGS monitoring and control.

7. Centralization of cryogenic facilities

8. Development of a superconducting beam splitter (now under test).

9. Development of a model of a superconducting 8° bending magnet (now under test).

New items which should come into operation during the next year include a split in the B/C beam lines, the Multi-Particle Spectrometer facility, and the 7' chamber. Particularly interesting future experiments include an attempted measurement of the sigma minus magnetic moment, further study of two muon decay mode of neutral kaons, hyperon beam experiments, and exposures with neutrino and anti-neutrino beams in the 7' bubble chamber.

The fiscal pinch in FY 1973 will mean that experimental facilities operation and research will have to be somewhat curtailed to place more emphasis on running the accelerator. The superconductivity program will be emphasized and model magnets for the ISA will be built. Rau was optimistic about the linac and the effectiveness of the maintenance program, and expects a very productive year.

The Panel was taken to the old Cosmotron building, in which a central cryogenics facility has been set up. G.T. Danby discussed progress on building superconducting beam line magnets and showed the facilities available there. They were working with 40Kg magnets, but expected to try 60Kg soon. He claimed that the fabrication of superconducting magnets is now at least as cheap as conventional ones, and that pulsing at low rates (a few seconds) causes no serious problems.

The tour then moved to the 7' bubble chamber, where R.I. Louttit showed the group the facilities there. Finally, W.B. Sampson showed the group the work being done on the construction of models for the ISA magnets.

II. Agency Presentation

D.R. Miller and W.A. Wallenmeyer presented information on the AEC FY 1973 budget, FY 1974 budget (Agency plan as of June 1972), and on manpower trends (pg. A10-20). Modifications to the FY 1973 budget which had been made since the last HEPAP meeting were pointed out. The Panel discussed the rumored limitation on FY 1973 expenditures. The members of the Panel were distressed at the lack of current information on the planned budget for FY 1974.

The Panel recognized that special circumstances would occasionally prevent the AEC from providing them with current information. However, the Panel indicated that their efforts to provide useful advice to the Division would be severely hampered unless current financial information was generally available to them.

M. Bardon presented the following information for the NSF budgets:

	FY 1972	FY 1973 (requested)	FY 1973 (so far)	FY 1974 (requested)
All physics	$33.249M	35.0	34.2	37 (?)
Elem. Particle physics-experiment	13.742	14.5	?	
Elem. Particle physics-theory	2.3	2.5	?	
Particle physics in Science Development Grants	1.0	0.5		

M. Bardon indicated that the NSF probably will not do as well in FY 1974 as in FY 1973 when inflation is taken into account. He pointed out that the NSF has funded a computer and a new experimental area for the Cornell 10 GeV electron synchrotron, as HEPAP had recommended.

III. CEA Status

K. Strauch reviewed the present situation at CEA. The first run with BOLD has been completed, and much of the data has been analyzed and presented. The run covered a total luminosity of $10^{34}cm^{-2}$. Their results with 2 GeV electrons colliding with 2 GeV positrons has given results consistent with theory for the reactions $e^+e^- \rightarrow e^+e^-$ and $e^+e^- \rightarrow \gamma\gamma$. The multi-hadron production which they have observed is much higher than expected.

New focussing magnets and rebuilt separation plates were being installed to permit operation at energies as high as 3 GeV in each beam. Strauch indicated that experiments would begin by January 1 and run for three or four months. He expected results would be available by April or May.

Strauch indicated that he believed that the CEA luminosities could be increased by a factor of five to ten. Since even this increased luminosity would be well below that available at SPEAR, he is planning to terminate particle physics research at CEA after the planned experiment is completed. A proposal for support to run the machine as a dedicated synchrotron radiation facility for experiments in solid state physics, chemistry, biology, and medicine was to be submitted to the NSF within the next ten days. Strauch would not serve as Director of this facility, but would return to active particle physics research as a member of the Harvard faculty. Strauch expected that the synchrotron radiation facility, if approved, would use about 20 of his present staff, and that shutdown work at CEA would involve another ten manyears in FY 1974. He thus faces the task of terminating a large fraction of his current staff of about 100 by summer. Since two key people were already preparing to leave, he felt that he must inform his entire staff as soon as possible. Strauch noted that it was important that the staff should not think that only the senior staff was aware of the Laboratory's situation.

The members of the Panel expressed a great deal of sympathy for the problems with personnel. It was pointed out that rumors of personnel cutbacks at other Laboratories have been extremely damaging to productivity. The Panel felt that the most demoralizing aspect of personnel cuts was a staff's uncertainty. They suggested that it would be best to provide full information to the staff as soon as possible.

The Panel later deliberated about the CEA situation, and took a very favorable view of the work at higher energy, particularly if done quickly. They recommended that support for HEP at CEA should continue to the completion of the contemplated experiments, and that the accelerator should then be shutdown as a high energy physics facility.

IV. Report on XVI International Conference

J.W. Cronin and F.E. Low reported on the experimental and theoretical highlights, respectively, of the Conference. (A summary of their reports is included on pg. A21-25).

It was the concensus of the Panel that the International Conferences have been extremely valuable in highlighting new results and permitting productive interactions among active physicists. The XVI Conference was judged to be an "unusually rich Conference."

V. European High Energy Physics

V.F. Weisskopf discussed the current state of high energy physics in Europe and Russia. He reported that the program in Europe is very active.

A 10% cut in the CERN I "base" program has been made to permit the construction of the CERN II Laboratory. CERN's four-year financial plans, with two years fixed and two years tentative, permit the Laboratory a good deal of flexibility. On the whole, the available money is being used well. The PS, in part because of the many setups which are available, is currently undersubscribed. There are no definite plans for any project beyond the SPS. The 3.7 meter bubble chamber will be cooled down in a few months, the Omega project is going ahead, and the SPS is on schedule. The tunnel construction is under contract and conventional magnets for part of the ring are on order. A decision on whether the rest of the ring will be superconducting magnets or additional conventional magnets must be made within a year.

At DESY, DORIS is on schedule and should operate in 1974. A 1.0 GeV proton synchrotron is being planned. Protons from this machine would be fed into one ring of DORIS, where their energy would be raised to a maximum of 4.2 GeV for use in ep collisions. There has been no reduction in the rate at which funds are being made available in Germany.

The British are talking of phasing out NINA or NIMROD, probably the former, over the next five years. The Panel felt that the time scale was excessively long.

The 76 GeV machine at Serpukhov works reasonably well. Future options under consideration in the USSR include an ERA of $\sim$ 2 TeV, a 2-3 TeV conventional synchrotron, perhaps with superconducting magnets, and an ISA-type machine at Serpukhov.

The comment that the time is ripe for global strategy on large machines led to a general discussion of problems involved in exchange between Russia and the United States. J. Sanford pointed out that the Russian-U.S. p-p experiment at NAL is going along fairly well. The problems which might arise from giving both a Russian-U.S. group and a U.S. group each an inadequate anti-neutrino exposure (50K pictures each-NAL Proposals No. 180 and 172) were discussed. W.A. Wallenmeyer indicated the AEC would like to encourage under the AEC/SCAE Memorandum any good experimental collaboration on Soviet machines, whether by an AEC-supported group or a NSF-supported group. He intends to see that the new Memorandum presently being discussed with the Soviets is formally transmitted to the NSF and their participation in the HEP cooperative efforts formally encouraged.

VI. General Information

W.A. Wallenmeyer discussed some of the details of that part of University support which is administered directly from Washington (last item on pg. A12). The dates for future IUPAP Conferences were provided (pg. A26). The request which LBL made to keep the second CDC 6600 to help with I-O and interactive work at their computer center has been rejected. LBL will explore other solutions to their problems, and the 6600 will be sent to NAL as planned.

The AEC was forming a group to look at bubble chamber operations (pg. A27-28). The addition of someone to the group who is not exclusively bubble chamber oriented was suggested (pg. A28 reflects this suggestion).

VII. JCAE Report and General Discussion

The discussion of the draft of the report being prepared for the JCAE led to a discussion of general funding problems in high energy physics. A letter from B. Richter (pg. A29-30), which is pertinent, was discussed. The discussion included the general priorities of the Laboratories, the consequences of a "no shutdown" stand, and how any cuts should in fact be shared. There was strong sentiment on the Panel for sharing future cuts among the four base program Laboratories rather than trying to preserve a high funding level at SLAC and BNL. It was suggested that these two Laboratories had not yet faced decisions as hard as those faced by ANL and LBL. All four accelerator Laboratories were considered of high importance to the program at this time.

HEPAP discussed a letter from W.A. Wenzel (pg. A31-32) which commented on the FY 1971 high energy physics funding levels given in the NAS report, Physics in Perspective. It was noted that the LBL figures for that year included the acquisition of the CDC 7600. The concensus was that HEPAP should take no action at this time.

VIII. NAL Status

J. Sanford reported on the status of NAL. Since the last meeting of the Panel, the 30" bubble chamber had run experiments at 100, 200, and 300 GeV, and experiments had been set up and run in the internal target area (C-0). The main ring magnets had been pulsed to 400 GeV, at which point the pulse load on the power lines ($\sim$ 1%)

exceeded that agreed to in the contract between NAL and the utility. Beam had been taken to the neutrino target hall, to the 30" chamber, to the meson target area, and to the first of the proton laboratories. Nine emulsion experiments were run during the week prior to the meeting of the Panel. Resonant extraction, with efficiency greater than 50% and spill time of 200 ms, had been achieved. Efforts were being placed on multiple injection from the booster to the main ring.

At the time of the meeting, the losses in the main ring were larger than that prior to the long shutdown in August. Although 10^{11} protons were injected on each booster cycle, four-fifths of these were lost (as opposed to half prior to August) in the first 20 turns. Full intensity from the machine will only come after eliminating these losses, using all possible booster pulses (factor of twelve), using four turn injection into the booster (factor of four), and cutting down other losses (factor of ten). Present concentration has been on reducing the losses in the main ring.

The construction of the Neutrino Laboratory was 90% complete, the Meson Laboratory was 67% complete, and the Proton Laboratory was 50% complete. The main worries were intensity, as mentioned above, and the shortage of manpower in the experimental laboratories, where 200 more workers were needed.

IX. General Discussion

The effectiveness of the various committees which advise NAL was discussed in some detail. It was suggested that concern for their own experiments impairs the effectiveness of many of the users on the advisory committees. The URA Trustees, who have more authority, do not believe in interfering with the management of the Laboratory.

Some impressions of the BNL presentation were exchanged. The superconducting effort looked very good. The attitude of management toward machine operation appeared very promising. The Panel discussed the general function of the Laboratory presentations for HEPAP meetings. Although these meetings cannot serve as a general review, they are useful as sources of information to HEPAP and for stimulating the staff at the Laboratory visited. The concensus favored more interaction with Laboratory staff, at luncheons and in the evenings, when HEPAP visits a Laboratory.

X. Next Meeting

The next meeting will be held in Berkeley, California on January 18-19, 1973. The new Director for the Division of Physical Research, Dr. John M. Teem, expects to be able to attend this meeting. R.R. Rau is collecting beam statistics from the Laboratories which will be made available prior to this meeting. The question of forming a subpanel to consider future facilities was deferred to this January meeting.

September 19, 1972

A-1

HIGH ENERGY PHYSICS ADVISORY PANEL

September 27-28, 1972

Brookhaven National Laboratory

Wednesday, September 27, 1972

The morning meeting will be in the Berkner Hall Auditorium and will be open to the staff and guests of BNL.

9:00	AM	- Welcome to new HEPAP members, D. Miller, V.F. Weisskopf
9:15		- Program and Plans at Brookhaven, BNL Staff
12:30	PM	- Box Lunch
1:00		- Tour of Superconducting Magnet Project and Seven Foot Bubble Chamber Facility

During the afternoon the Panel will meet in Executive Session:

2:00	- Budget Status and HEP Manpower, D. Miller, W.A. Wallenmeyer (AEC); M. Bardon, A. Abashian (NSF)
3:00	- CEA Program and Plans, K. Strauch
4:00	- Comments on Highlights of XVI International Conference and possible inferences for U.S. Program, J. Cronin, F. Low
5:00	- Report and Discussion of European HEP, V.F. Weisskopf
5:30	- End of first day session
6:00	- Cocktails and Dinner

Continued: A-2

Thursday, September 28, 1972

9:00	AM	- Discussion of report for Joint Committee on Atomic Energy (a rough draft of this report is enclosed)
10:00		- Discussion of the formation of a Subpanel to consider Future Facilities
10:30		- NAL Status and Plans, J. Sanford
12:00	Noon	- Box Lunch
12:30	PM	- General Discussion of Problems in HEP Program
4:00		- End of HEPAP Meeting

REMINDER: Transportation and housing arrangements should be made with Mrs. H. D'Ambrosio at BNL (516-345-3830).

HEPAP - BNL Program Presentation - Wednesday, 9/27/72

9:15 - 9:25	Introductory remarks	Goldhaber
9:25 - 9:45	Ongoing Experimental Program	Berley
9:45 - 10:15	$K_L^o \rightarrow \mu^\pm$ Experiment	Nygren
10:15 - 10:35	BNL Spark Chamber & Counter Program	Kycia
10:35 - 10:50	BNL Bubble Chamber Program	Lai
10:50 - 11:10	ISA - The Machine	Courant
11:10 - 11:35	ISA - The Physics	Samios
11:35 - 12:10	BNL High Energy Physics Overview	Rau
12:10 - 12:30	Discussion	

Box Lunch

1:00 - 2:00	Tour	

6:00	Cocktails and dinner	

396 -	E. W. Anderson, P. Schubelin, K. Moy, A.M. Thorndike, F. Turkot - BNL J.R. Ficenec, W.P. Trower, G.B..Collins - VPI	An investigation of multiparticle production in p-p collisions
415 -	J. Fox - BNL; D. Jenkins, R. Powers - VPI; J. Kane, M. Eckhause, R. Welsh - Wm & Mary; R. Sutton, P. Barnes - CMU; B. Budick - NYU	To observe x-rays and gamma rays emitted when K's and $\bar{p}$'s stop in matter; measure K^-, Σ^-, and $\bar{p}$ interactions with nucleons; Σ^-, and $\bar{p}$ magnetic moment; excited states of hypernuclei
430 -	H. Kraybill, V. Hungerbuhler, R. Majka, J. Marx, P. Nemethy, J. Sandweiss, W. Tanenbaum, W. Willis - Yale; M. Atac, S. Ecklund, J. Maclachlan, J. Lach, A. Roberts, R. Stefanski, D. Therriot, P. Gollon - NAL; C. Wang - BNL	Study of production and decay of high energy Σ^-, Ξ^-, Ω^-, and X^-; Σ^- and Ξ^- leptonic decays, weak form factors
477 -	L.M. Lederman - Columbia; A. Melissinos, Rochester; M. Tannenbaum - Rockefeller; A. L. Read, J. Sculli, T. Yamanouchi, NAL; T. Kirk - Harvard	To study interaction of $\sim$6 GeV/c muons with protons, concentrating on collisions involving momentum transfers greater than 1 $(GeV/c)^2$ and extending, with reasonable statistics, to $\sim$ 4 $(GeV/c)^2$
478 -	W. Carithers, D. Nygren, J. Steinberger, T. Pun - Columbia; J. Christenson - NYU	High precision experiment to measure some parameters characterizing CP violation in K° decay
500 -	C. Ankenbrandt, L. Leipuner, H. Kasha, H. Williams, L. Smith - BNL; R. Adair, B. Higgs, R. Turner, P. Wanderer - Yale	Measure of charge asymmetries in K°_L decays
527 -	L. Guerriero - Bari; R.E. Lanou - Brown; L. Rosenson - MIT	Study of $\bar{p}p$ annihilation into neutral, non-strange mesons (e.g., $\pi^\circ\pi^\circ$, $\eta^\circ\eta^\circ$, $\eta^\circ\pi^\circ$, etc.); cross sections and angular distributions are measured at several energies as a way of studying boson resonances in the direct channel and baryon exchange in the cross channel
530 -	A.S. Carroll, T.F. Kycia, K.K. Li, D.N. Michael, P.M. Mockett, R. Rubinstein - BNL	To measure to a very high precision total cross-sections of $K^\pm$ mesons, $\pi^\pm$ mesons and antiprotons on protons and deuterons below 1.2 GeV/c; to, in part, to resolve the question of whether the I=0 structure in $K^\pm$-N total cross-sections is double peaked; to settle some questions about possible structure in $\bar{p}$-p total cross-sections associated with already observed structures in backward scattering

533 -	D.C. Cheng, D. Grossman, G.K. O'Neill, D. Coyne - Princeton; G. Goggi, D. Scannicchio - Pavia	To study single isobar production and decay in p-p interactions at an incident energy of 25 GeV; measure decay branching ratios, momentum transfer dependence and decay angular distributions of more than 10^6 resonance events in the isobar mass region from 1200 to 2350 MeV/c^2 and in the momentum transfer range from -.1 to -.4 $(GeV/c)^2$
570 -	G.R. Kalbfleisch, V. VanderBurg - BNL; K. Cohen, B.C. Maglic, F. Sannes - Rutgers; C. Ankenbrandt, B. Brabson - Indiana	Measurement of cross sections near threshold versus energy for $A_2^{\pm}$ $R^{\pm}$ and $K^{*+}(1420)$ and possibly (narrow) $\delta^-(962)$; search for structure in A^2 and R regions (splittings); s-wave production very near threshold
577 -	I.H. Chiang, A. Entenberg, H. Jostlein, J. Kostoulas, A. Melissinos - Rochester	Search for heavy leptons by missing mass technique
580 -	K. Foley, M. Kramer, W. Love, S.J. Lindenbaum, S. Ozaki, E. Platner, A. Saulys, E. Willen, BNL M. Margulies - CCNY	Investigation of strange and non-strange bosons decaying into $K\bar{K}$ and $K\pi$
584 -	L. Lederman, P. Limon, M. May, P. Rapp - Columbia; M. Tannenbaum - Rockefeller; A. Melissinos, H. Jostlein, A. Entenberg, J. Kostoulas - Rochester; T. Kirk, H. Gittleson, M. Murtagh - Harvard; J. Sculli, T. Yamanouchi, D.H. White - NAL	Deep inelastic muon-nuclear scattering
585 -	L. Lederman, P. Limon, M. May, P. Rapp - Columbia M. Tannenbaum - Rockefeller; A. Melissinos, H. Jostlein, A. Entenberg, J. Kostoulas - Rochester; T. Kirk, H. Gittleson, M. Murtagh - Harvard; J. Sculli, T. Yamanouchi, D.H. White - NAL	Muon inelastic scattering in deuterium
599 -	J. Rosen, B. Gobbi - Northwestern; R. Edelstein - CMU	Proton dissociation $p + A \to A + \pi^+ + \pi^-$ to compare with $p\pi^\circ$ channel diffractive dissociation; yield as a function of nuclear size to give N^{*-} nucleon σ_T; decay distributions for $\Delta^{++}\pi^-$, $\Delta^\circ\pi^\pm$ and $p\rho^\circ$ clustering; are 1470 and 1690 bumps Deck effects in $\Delta\pi$ and $p\rho^\circ$ channels, respectively?

APPROVED EXPERIMENTS - NOT YET RUNNING

Beam 5A

590	BNL - Kycia	Search for $K^{\circ}_{S} \to 2\gamma$ down to its unitarity limit as well as a measurement of the K°_{S}-K°_{L} interference of this decay and a remeasurement of the $K^{\circ}_{L} \to 2\gamma$ 3 GeV/c

Beam 6A

558	Columbia/CERN/NYU - Nygren	Measurement of charge asymmetry in the decays $K_L \to \pi^{\pm} e^{\mp} \nu$ and $K_L \to \pi^{\mp} \mu^{\pm} \nu$

Beam B1

550	Purdue/BNL - Gutay	To investigate the production and decay of boson resonances of the three body final state $\pi^{-}NX^{\circ}$
551	Max-Planck/Wisconsin/ VPI/IBM/BNL/Pennsylvania- Erwin	To compare multiparticle production by high energy $\pi^{\pm}$, $K^{\pm}$, $\bar{p}$ and proton beams; the interrelation of inclusive and exclusive reactions will be studied
555	Pennsylvania - Weisberg	Particle production spectra and multiplicities in $\pi^{\pm}$, $K^{\pm}$, and $p^{\pm}$ collisions with protons. Coverage of essentially the complete kinematic range of produced $\pi^{\pm}$, $K^{\pm}$, and $p^{\pm}$ particles; multiplicities will be determined by integration of the measured distributions. Test of limiting fragmentation behavior and of various features (target independence, 1/x behavior) of parton model speculations
588	Michigan - Meyer	Test of exchange degeneracy by $K^{-}p \to \pi^{-}\Sigma^{+}$ and $\pi^{+}p \to K^{+}\Sigma^{+}$ from 4-18 GeV/c

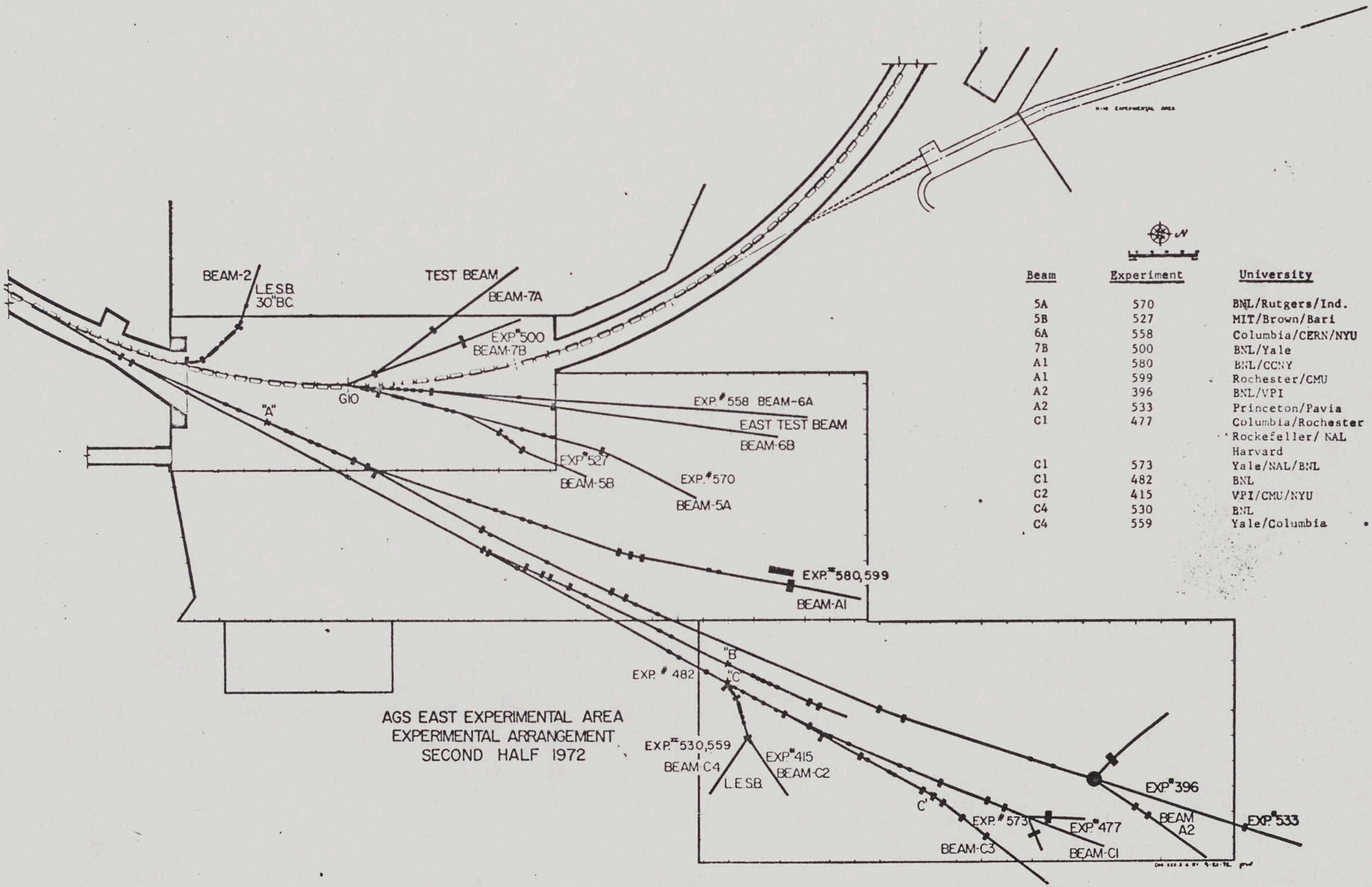
Beam B4

546	Carleton U/Nat'l. Research Council, Canada/ BNL - Walters	To examine the $K^{*}(1420)$ mass region for fine structure and splitting

Beam B5		
572	Princeton - Kreisler	To measure the branching ratio for $K_S \to \mu^+ + \mu^-$ that is below the current theoretical estimates of $\sim 10^{-7}$
Beam B2 - MPS		
594	BNL/CCNY - Lindenbaum/ Ozaki	Survey experiment with MPS; systematic study of the production and decay of boson resonances and production of Vee particles - negative and positive beam at maximum usable momentum and several GeV/c below
596	Carnegie-Mellon - Edelstein	$\bar{p}p$ annihilation into boson pairs; backward π^-p elastic and inelastic scattering; angular distributions and s-dependence of these and exotic exchange reactions - 4-6 GeV/c K; 4-10 GeV/c $\bar{p}$
601	Brandeis/Syracuse	Study of channels characterized by the topology $\bar{p}p \to V° + V° +$ neutrals to obtain polarization and correlation information to test dynamical models, to measure spin-parities and differential cross sections, and to search for boson resonances
Beam C2		
548	Princeton - Smith	Precision study of the decay $\Sigma^- \to n\, e^- \nu$ to determine the sign and magnitude of the form-factor ratio g_A/g_V; search for the decay $\Sigma^+ \to n\, e^+ \nu$ to test the $\Delta S = \Delta Q$ rule; study of the decay Dalitz plot to investigate the models of hyperon leptonic weak interactions.
Beam C3		
573	Yale/NAL/BNL/ - Marx	Measurement of Σ^--p and Ξ^-p differential cross sections $d\sigma/dt$ for $-.25 < t < -.04$ (GeV/c)^2
583	Pittsburgh - Engels	Study of Y^{*-} resonances produced in hyperon-nucleon collisions
Beam C4		
524	Yale/BNL - Hughes	Precise measurement of the asymmetry (or polarization P) in elastic scattering of K^+ and K^- mesons from polarized protons with kaon momenta between 0.7 and 1.2 GeV/c ; Simultaneous measurement of $d\sigma/d\Omega$ and of the rotation parameter R ; Auxiliary Coulomb interference measurement at 0.5 GeV/c ; K^+p interaction, including search for S = +1 baryon states (Z^*); K^-p interaction, including study of resonance states

Beam New A

598	MIT/DESY - Ting	To measure the $\pi^+\pi^-$, K^+K^-, e^+e^-, $\bar{p}p$ mass spectra in the mass region 1.5 - 5 GeV/c^2 with mass resolution $\Delta m = \pm 10$ MeV in order to search for new resonances, to study their quantum numbers, and to check the μe universality in the time-like region



AGS EAST EXPERIMENTAL AREA
EXPERIMENTAL ARRANGEMENT
SECOND HALF 1972

Beam	Experiment	University
5A	570	BNL/Rutgers/Ind.
5B	527	MIT/Brown/Bari
6A	558	Columbia/CERN/NYU
7B	500	BNL/Yale
A1	580	BNL/CCNY
A1	599	Rochester/CMU
A2	396	BNL/VPI
A2	533	Princeton/Pavia
C1	477	Columbia/Rochester Rockefeller/NAL Harvard
C1	573	Yale/NAL/BNL
C1	482	BNL
C2	415	VPI/CMU/NYU
C4	530	BNL
C4	559	Yale/Columbia

HEP OPERATING BUDGET

	Actual FY 68	Actual FY 69	Actual FY 70	Actual FY 71	Actual FY 72	IFP FY 73	Agency Plan FY 74
TOTAL	113289	118630	120483	118466	116400	126400	146000
1. PPA	5150	4974	4129	1989	0	0	0
2. CEA	3505	3555	3476	2353	2156	2200	2250
A/O				1796	1840	1880	
A/R&D				50	50	50	
EF/O				507	266	270	
3. BNL	20969	21153	21473	22243	22648	25000	26800
PR				5268	4901	5175	
A/O				3955	4888	5525	
A/R&D				2495	2465	2875	
EF/O				8350	8254	8675	
EF/R&D				2175	2140	2750	
4. ANL	17196	17386	17250	16749	15770	15700	16000
PR				3280	2787	2800	
A/O				4481	4585	4600	
A/R&D				1740	1524	1650	
EF/O				4548	4835	4700	
EF/R&D				2700	2039	1950	

	Actual FY 68	Actual FY 69	Actual FY 70	Actual FY 71	Actual FY 72	IFP FY 73	Agency Plan FY 74
5. LRL	17182	17648	17738	16632	15580	15500	15700
PR				7462	6752	6500	
A/P				1975	2017	2100	
A/R&D				2515	2334	2400	
EF/O				3745	3327	3500	
EF/R&D				935	1150	1000	
6. SLAC	21167	23465	23819	24183	24081	25450	27000
PR				6738	6106	6050	
A/O				6865	6677	6950	
A/R&D				940	892	975	
EF/O				7265	7893	9325	
EF/R&D				2375	2513	2150	
7. 200 BeV	2394	4030	6597	9149	12749	19200	32500
PR				1014	1900	2600	
A/O				750	1950	6100	
A/R&D				5085	1800	2600	
EF/O				0	2800	4600	
EF/R&D				2300	4299	3300	

	Actual FY 68	Actual FY 69	Actual FY 70	Actual FY 71	Actual FY 72	IFP FY 73	Agency Plan FY 74
8. Universities	25726	26419	26001	25168	23408	23350	25750
Ames	410	420	425	431	420	430	
CalTech	1490	1491	1473	1355	1352	1350	
UCSD	1208	1055	962	922	729	600	
Carnegie	910	881	965	856	793	840	
Columbia	2100	1936	1951	2001	1640	840	
Harvard	1335	1352	1315	1233	1226	122	
Illinois	1420	1400	1315	1290	1210	1230	
MIT	3210	3147	3089	2921	2660	1240	
Michigan	780	790	775	785	750	2800	
ORNL	377	373	391	360	294	760	
Penn	1600	1495	1390	1290	1230	300	
Princeton	1175	1470	1490	1450	1150	1240	
Rochester	900	925	895	870	830	1100	
Wisconsin	1600	1560	1502	1405	1320	840	
Yale	1030	1105	1038	1065	1112	1360	
Wash. Admin.	6181	7019	7125	6934	6692	1115	
						8023	

PRIVILEGED INFORMATION 9/26/72

A-13

HEP EQUIPMENT BUDGET
(Obligations)

	Actual FY 68	Actual FY 69	Actual FY 70	Actual FY 71	Actual FY 72	IFP FY 73	Agency Plan FY 74
TOTAL	15663	21787	13710	23873	14496	44498	40200
ANL	2890	3984	2000	1230	840	600	800
BNL	2799	4120	2560	2400	1880	2500	3300
CEA	615	850	250	386	200	50	500
LRL	1165	1218	940	554	511	450	700
200 BeV	269	980	4000	7551	7420	16508	21500
PPA	350	500	60	0	-	0	0
SLAC	2800	3565	3021	2438	2960	2650	3200
Universities	2860	2835	879	614	685	900	1200
SLAC IBM 360-91	1915	3735	-	-	-	-	-
LRL - CDC 7600	-	-	-	8700	-	-	-
Chicago Area Comp.	-	-	-	-	-	10401	-
SLAC Large Comp.	-	-	-	-	-	10439	9000

PRIVILEGED INFORMATION

HEP CONSTRUCTION BUDGET
(Obligations)

	Actual FY 68	Actual FY 69	Actual FY 70	Actual FY 71	Actual FY 72	IFP FY 73	Agency Plan FY 74
TOTAL	8103	20304	72870	63600	48760	45350	17100
Accel. Improvements	3270	5730	2870	3600	760	2500	4000
ANL	1000	1775	650	900	225	400	700
BNL	400	1295	700	925	280	475	1300
CEA	100	95	75	0	75	75	200
LRL	1050	1440	680	825	180	525	800
PPA	170	180	125	0	0	0	0
SLAC	550	945	640	950	0	1025	1000
200 BeV Accelerator (TEC - $250 million)	4833	14574	70000	60000	45800	42850	10300
Computer Bldg. SLAC	-	-	-	-	-	-	2800

A-15

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**
PPA	Total[1]	336	320	295	95	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	111
	Physicists	18	18	18	18	11	10	10
	Other Prof	45	45	46	38	37	33	32
ANL	Total[1]	1,232	1,150	1,089	897[3]	732	683	629
	Physicists	49	55	64	62	65	62	62
	Other Prof	170	165	159	133	110	115	106
	Grad Students	31	20	3	4	0	0	0
LBL	Total[1]	1,481	1,350	1,291	1,145	1,025	896	848
	Physicists	108	105	103	102	100	93	92
	Other Prof	204	190	184	170	158	132	125
	Grad Students	111	110	104	92	87	60	57
BNL	Total[1]	1,250	1,305	1,365	1,276	1,204	1,110	1,170
	Physicists	100	105	110	103	95	101	99
	Other Prof	170	180	187	169	132	121	125
SLAC	Total[1]	1,350	1,300	1,397	1,330	1,319	1,310	1,306
	Physicists	85	90	99	104	110	122	113
	Other Prof	215	220	222	223	169	162	163
	Grad Students	20	30	38	28	35	31	31
Laboratory Subtotal (except NAL)	Total[1]	5,881	5,655	5,653	4,889	4,406	4,120	4,064
	Physicists	367	380	401	393	381	388	376
	Other Prof	854	850	848	753	606	563	551
	Grad Students	162	160	145	124	122	91	88
University[2] Programs	Total[1]	2,682	2,759	2,606	2,378	2,130	1,650	1,680
	Physicists	645	659	641	639	604	480	490
	Other Prof	190	190	175	145	138	135	135
	Grad Students	647	660	626	594	484	325	330
Program Subtotal (except NAL)	Total[1]	8,563	8,414	8,259	7,267	6,536	5,770	5,744
	Physicists	1,012	1,039	1,042	1,032	985	868	866
	Other Prof	1,044	1,040	1,023	898	744	698	686
	Grad Students	809	820	771	718	606	416	418
NAL	Total[1]	-	200	410	695	816	916	1,150
	Physicists	-	15	36	56	74	76	80
	Other Prof	-	30	63	93	239	262	300
TOTAL PROGRAM	Total[1]	8,563	8,614	8,669	7,962	7,352	6,686	6,894
	Physicists	1,012	1,054	1,078	1,088	1,059	944	946
	Other Prof	1,044	1,070	1,086	991	983	960	986
	Grad Students	809	820	771	718	606	416	418

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

**Estimated on the basis of the FY 73 Interim 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.

[2] ~ 15% of the support for the research effort carried out by the people listed under University Programs is provided by University contribution.

[3] ANL indirect manpower computed by a different method after FY 70. Actual drop in manpower between FY 70 and FY 71 was not as great as appears from these data.

US HEP Manpower Losses[1]

Year of Ph.D	Present US HEP Manpower	Outflux since beginning of census (1966) To Foreign[2]	Outflux since beginning of census (1966) To Non HEP[3]	Outflux in 1971 To Foreign[2]	Outflux in 1971 To Non HEP[3]
71	124	25	75	24	64
70	165	41	119	9	27
69	105	29	81	10	26
68	110	36	87	8	12
67	118	56	110	11	16
66	108	41	90	3	11
65	91	34	52	4	2
64	85	28	42	4	10
63	96	19	34	2	4
62	84	21	33	3	5
61	43	12	26	0	3
60	59	16	16	3	3

Notes

1. Based on preliminary results from the 1972 HEP Census. Reflects information as of 1/1/72.
2. Examination of the data shows that these are overwhelmingly HEP locations.
3. Includes industrial, other academic specialities, small colleges, unknown, etc.

US HEP Manpower Losses Breakdown

Ph. D. 1967 to Non HEP in 1971 **Total: 16**

Center for Naval Analysis
NSF
Computer Science Corp.
G. D. Searle, Inc.
Math, Pittsburgh
Applied Science, BNL
Medium Energy Physics
Hamline University, St. Paul

US HEP Manpower Losses Breakdown

Ph. D. 1971 to Non HEP since 1966 (examples)	**Total:**	**75**
Industry		19
	Raytheon IBM, Cranford, N. J. Esso, Houston Bell Labs, Illinois Rochester Applied Science Corp. Bendix Systems Div. Employee Systems Developemtn Inc.	
Left field		21
	Editor, Sky and Telescope Johns Hopkins Med. Sch. Astrophysics Biomedical Statistics Psychobiology, Univ. of Pittsburgh Institute for Environmental Studies, University of Wisconsin	
Small colleges		16
	University of Evansville Millersville State College Mt. Holyoke College University of Georgia	
Location unknown		17
Unemployed		2

US HEP Manpower Losses Breakdown

Ph. D. 1967 to Non HEP since 1966 **Total: 110**
(examples)

Industry		17
	Computer Sciences Corp.	
	Bell Labs, N. J.	
	Lockheed	
	IBM, Oswego	
	Physics International	
	Cornell Aeronautical Lab.	
	Philco - Ford	
	G. D. Searle, Inc.	
Government		9
	Army Research Off-Durham	
	NRL	
	NASA	
	NSF	
Left field		14
	Medicine, Dublin	
	Math, Pittsburgh	
	Anatomy, UCLA	
	Applied Science, BNL	
	Meterology	
Small College & Universities		38
	Bentley College	
	Point Park College	
	Swarthmore	
	Western Illinois Univ.	
	Idaho	
	Dartmouth	
	Lewis Tech.	
	North Carolina A&T	
Unknown		32

US HEP Manpower Losses Breakdown

Ph. D. 1971 to Foreign Location (examples) **Total: 25**

University of British Columbia	
Oxford	
Saclay	x2
India	x3
Venezuela	
Germany	x2
Holland	
Frascati	
CERN	x2
Iran	x2
NRC-Canada	
Trieste	
University of Manitoba	
Karlsruhe	
Rutherford	

XVI CONFERENCE HIGHLIGHTS
(from notes taken by WDW on reports to HEPAP)

J.W. Cronin

I. Old Puzzles

A. "Keuffel effect." The Utah group, after re-evaluating biases and Cerenkov inefficiencies, feels that their data is not inconsistent with the assumption that all muons observed originate from pion and kaon decays.

B. $K_{\ell 3}$ decays. A SLAC experiment has very carefully examined the Dalitz Plot for $K_{\ell 3}$ decays. The results are consistent with theory.

C. Boson Resonances. Additional evidence was presented against the splitting of the A_2. The sharp S, T, and U mesons do not seem to appear in recent experiments.

D. $K_L \rightarrow \mu^+\mu^-$. The BNL measurement of this decay will, if verified, help eliminate the pressure on theory which the apparent absence of the decay in an earlier LBL experiment created.

II. New Puzzles

A. CERN-Heidelberg reported a value for η_{+-} which is 40% higher than the well-established world average.

B. Massive stable particles which penetrate iron were reported from an ISR experiment. Note: Both A and B represent very preliminary results.

III. New Results

A. Neutrino Interactions. The elastic ($\nu + n \rightarrow \mu^- + p$) and inelastic ($\nu + p \rightarrow \mu^- + N^*$) cross sections for neutrinos have been measured in the Argonne 12' bubble chamber. The freon-filled "Gargamelle" has been used to measure inverse hyperon beta decay ($\nu + p \rightarrow \Lambda + e$). The total cross sections for neutrino and anti-neutrino processes have been measured at $0.7 \times E \times 10^{-38}$ and $0.27 \times E \times 10^{-23}$ respectively to 10 GeV. The searches for neutral currents have been pushed to about ten percent of the allowed currents. This limit is beginning to push hard on the simplest form of Weinberg's theory.

B. Colliding Beams.

(1) e^+e^-: Multi-hadron cross sections are unexpectedly higher than $\mu^+\mu^-$ cross sections at high energies.

An examination of the events with four pions shows a peak (ρ') at 2E = 1.6 GeV.

(2) p-p (ISR): The p-p elastic cross section at 2E = 44 GeV shows optical-type behavior for $t > 1\ GeV^2$. The total cross section seems flat at 38.5 mb. From about 50 GeV (Lab) to 1500 GeV (Lab equivalent) extensive measurements of scaling have been made. The yields of protons and anti-protons are within a factor of two at 90^o, indicating a tendency for particle and anti-particle production to be equal in the central region. The general features of the p-p interactions seem mapped out in this energy range. Details will probably come from experiments at conventional accelerators. The measurements for π^o events indicate that the yield is flatter than $e^{-6p_\perp}$ at high energies. This provides background for W searches which make them more difficult.

C. <u>p-p multiplicity measurements at NAL.</u>

The average charged multiplicity, which is 8.8 at 300 GeV, seems to vary as log s or faster. The neutral pion yield is about one-half the charged pion yield. The ratio

$$\frac{\langle n_{ch}\rangle}{\left|\langle n_{ch}\rangle^2 - \langle n_{ch}^2\rangle\right|^{\frac{1}{2}}}$$ seems to approach 2 as the energy increases, for reasons which aren't obvious.

F.E. Low

Low began by pointing out that the statement "the theory predicts" is nonsense, since there are currently almost as many theories as there are classes of phenomena. However, he suggested that the present situation may be the most promising in the past twenty years, since it appears theories may be coming together. A single theory may in fact be in the offing. Low divided theoretical approaches into "out from in" and "in from out."

I. Out from In

The most exciting prospect is the unification of weak and electromagnetic interactions. Weinberg has introduced broken symmetries to produce a renormalizable field theory of weak and electromagnetic interactions. This very exciting development allows calculation of masses. If the simplest form of the theory fails, work must be done to find the lowest order correct theory.

Problems with hadronic currents via PCAC have been mitigated by modifying the theory ($\pi^o \rightarrow 2\gamma$ and $\eta \rightarrow 3\pi$) and by doing better experiments (the Callen-Trieman limit is now approached by the most accurate $K_{\ell 3}$ data).

Quark fields and quark Lagrangians do not exist. The Veneziano model, although wrong, may be a good first order model, since it gives an exponential in transverse momentum dependence and a spectrum of states. Progress may come from making refinements to this model.

II. In from Out (Mueller, multi-particle, scaling)

Feynman scaling holds in the fragmentation region. Mueller systematics have the advantage of definiteness and (contrasted with Feynman) straightforward methods of calculation. Low was very enthusiastic about these developments.

STANFORD UNIVERSITY

STANFORD LINEAR ACCELERATOR CENTER

Mail Address
SLAC, P. O. Box 4349
Stanford, California 94305

September 9, 1972

Dr. William A. Wallenmeyer
Assistant Director for High Energy Physics
Division of Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Bill:

At the meeting of the High Energy Commission at the International Union of Pure and Applied Physics held on Friday, September 8 the following dates of international conferences bearing on high energy physics were introduced:

1. XVII International Conference on High Energy Physics - London Imperial College, July 1-10, 1974

2. Conference on High Energy Electron and Photon Interactions - Bonn, Germany, August 27-31, 1973.

3. Conference on the Use of High Energy Particles for Nuclear Structure Physics (approximate title) - Upsala, Sweden, June 18-22, 1973.

4. International Conference on Instrumentation for High Energy Physics - Frascati, Italy, May 8-12, 1973.

5. European Conference on High Energy Physics (not sponsored by IUPAP) - Aix en Provence, September 1973.

6. International Conference on Accelerators - SLAC, Stanford, May 2-7, 1974.

7. There was discussion but no resolution of the time and place of the XVIII International Conference on High Energy Physics set for sometime in 1976. By the regular time cycle this would be held in the Soviet Union but the Japanese representative asked that this be modified in favor of Japan.

Charge to Working Group

The advent of very large bubble chambers makes it timely to re-evaluate the management of bubble chamber facilities, giving special attention to costs, operation, safety, and special gas problems. We would appreciate it if you would serve on an informal working group which would attempt to review the management aspects of bubble chamber operation. We hope the group might collect information on present practices and then work out specific recommendations where appropriate.

Some of the specific items we expect this group to consider include:

(1) Operations with superconducting/high field magnets.

(2) Annual operating costs.

(3) Multiple pulsing and/or rapid cycling.

(4) Whether the current or planned procedures provide assurance of a mechanically safe operation.

(5) Procedures for periodic evaluation of operation.

(6) Operator training.

(7) Sharing/pooling supplies of rare/expensive gases.

(8) Other.

BUBBLE CHAMBER WORKING GROUP

Co-Chairmen:

Dr. Clarence R. Richardson
Division of Physical Research
U. S. Atomic Energy Commission
Washington, D. C. 20545
301-973-3367

Mr. Robert P. McGee
Division of Physical Research
U. S. Atomic Energy Commission
Washington, D. C. 20545
301-973-3367

Members:

Dr. Halsey L. Allen
National Accelerator Laboratory
Post Office Box 500
Batavia, Illinois 60510
312-231-6580

Mr. Jay O. Hunze
U. S. Atomic Energy Commission
Safety Division
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439
312-739-2088

Dr. F. Russell Huson
National Accelerator Laboratory
Post Office Box 500
Batavia, Illinois 60510
312-231-6600

Dr. E. Gale Pewitt
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439
312-739-4881

Dr. Albert G. Prodell
Brookhaven National Laboratory
Upton, New York 11973
516-345-4658

Dr. Robert Watt
Stanford Linear Accelerator Center
Stanford University
Post Office Box 4349
Stanford, California 94305
415-854-2757

Mr. Arnold Weintraub
Division of Operational Safety
U. S. Atomic Energy Commission
Washington, D. C. 20545
301-973-3161

Professor Don D. Reeder
Department of Physics
University of Wisconsin
Madison, Wisconsin 53706
608-262-8798

Advisor:

Dr. H. Paul Hernandez
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720
415-843-5275

STANFORD UNIVERSITY

STANFORD LINEAR ACCELERATOR CENTER

Mail Address
SLAC, P. O. Box 4349
Stanford, California 94305

Privileged

22 September 1972

Dr. V. F. Weisskopf
Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki:

Since I find that I am still unable to attend the HEPAP Meeting next week I am following your suggestion and sending you my opinions on the three major questions I believe will be up for discussion - CEA, NAL, and the budget.

CEA

At present the maximum CEA luminosity is approximately 2×10^{28} and is limited by a combination of injection problems and "long range beam-beam interactions" (the effect of two beams on each other when they pass in a relatively high-beta region). SPEAR is now operating at a peak luminosity of 2×10^{30} and should improve that by an order of magnitude in the next 6 to 12 months. CEA's problems cannot be cured in any simple way. An increase in injection energy would require a large addition of money. The long-range interaction is not understood well enough to say how it can be cured (the SPEAR approach of a single short e^+e^- bunch is not possible for CEA). CEA has the potential of going to a maximum energy of about 5 GeV at the present sorts of luminosities, but this in itself requires additional funds for rf and bypass modifications and improvements. At the same time SPEAR is already scheduled for an increase in energy to 4.5 GeV (scheduled for completion around July of 1974).

There would be good reason, I think, to keep two competitive colliding beam projects going, for there is a great deal of physics to do. However, CEA is not a competitive project now, and will be even less competitive when DESY turns on in 1974. Considering the wretched state of the high energy physics budget, I believe there is no responsible course open other than the termination of CEA operations at the end of this fiscal year. To its great credit, the CEA staff itself has recognized this and Karl Strauch has begun to seek positions for his key people and has had a considerable amount of success already (Patterson is going to SLAC, Voss to DESY). Also the experimental groups which have been involved in the physics program have recognized the handwriting on the wall and are moving on to other things.

Continuation of the CEA program beyond the end of the fiscal year can only absorb resources which are desperately needed in higher priorty parts of the high energy physics program.

At the last HEPAP meeting I brought up the subject of CEA's possible use as a national synchrotron light facility. The biomedical and solid-state people seem very excited by this field of physics and the NSF is now faced with, I think, three proposals for national facilities - a group from the West planning to build a facility at SPEAR, a group from Wisconsin which wants to replace their existing synchrotron light facility, and a group from Harvard, MIT (I'm not sure that this last has reached the official proposal stage yet). I personally have not made a sufficient study of this field to be able to say whether any one of these facilities has overwhelming advantages vis-a-vis any of the others. I think that must remain the NSF's problem, but I also think that if the NSF determines that CEA would indeed make the best national facility for synchrotron light work, that the AEC should consider supporting the CEA operations at some level of around $500 K per year to allow a smooth transition from high energy physics work supported by the AEC to synchrotron light work completely supported by the NSF.

<u>NAL</u>

As far as I can see the NAL situation has not changed in any fundamental way. While I have not spent any great deal of time with people at NAL, I did talk to Boyce McDaniel during my short visit to the high energy physics meeting in Chicago. McDaniel's feelings were that they were making slow progress but there was still a long way to go. I think that I would not disagree with that judgement, and I sincerely hope that progress does not come to a complete stop with McDaniel's return to Cornell. I am afraid that I am pretty certain of winning my bet with Sessler that it will be at least next July before NAL operates with 10^{12} per pulse and a slow extracted beam with the machine running 50% of the time for experiments.

I continue to be disturbed by the emphasis of the effort at the NAL which seems to be more on energy then current. I think that the recent efforts to run at 300 GeV and now to run even higher then 300 GeV are very nearly a total waste of time and resources when the major problem is that Bob has no one to talk to whom he respects, and that this problem is of his own making rather than forced by circumstance. I talked to Leon Madansky, who is on the scientific subcommittee of URA, and he says that this scientific subcommittee is merely a rubber stamp. McMillan is Chairman and does not seem very forceful. I think perhaps a laboratory director is not the right person to ask hard questions of another laboratory director. As you know much better then I, Norman Ramsey is a Pollyanna, who is unwilling to even admit that there could be a problem at NAL. I come from a laboratory with a strong director and I think that the strong director system is a good thing for high energy physics. However, I also think that it is essential that there be some responsible group who will ask the laboratory director nasty questions and force him to answer. There is no one at NAL to ask the director hard questions, and that can only be bad for the laboratory and bad for the entire National High Energy Physics Program.

Dr. V. F. Weisskopf 22 September 1972

Budget

This year I only hear vague rumors about the high energy physics budget for the next fiscal year. The rumors I hear are all very grim and the fact that the AEC has clamped an absolute secrecy on the next fiscal year's plans makes me think that there may be more then a little truth to these rumors. I think that it is unlikely that the AEC will even tell HEPAP about their thoughts on the next year's budget at the meeting next week and that we will have to make recommendations completely in the dark. If this is true, then I wonder what HEPAP is for - but that is a subject for another discussion. Since there is no hard information on which to base specific recommendations, I can only give you my general opinion on the broad subject of the budget.

What Wallenmeyer likes to call the base program (Argonne, Berkeley, Brookhaven, and SLAC) is already suffering a terrible pinch and no one of these laboratories is operating at the level that it should be. The uniform erosion of this base program cannot continue without high energy physics heading inexorably for a uniform level of mediocrity. Some hard decisions have to be made to improve the purchasing power of some of these laboratories, even if it is at the expense of closing one of them. If the budget is as bad as I expect it to be, then on physics grounds the machine which should be first to be shut down is the Bevatron followed by the ZGS (I am assuming that CEA will definitely be shut down). In making this suggestion I am considering only the elementary particle physics work coming out of the laboratory and not such things as heavy ions, cancer research, etc. These other considerations may dictate a different choice.

An excessive optimism about the level of operations at NAL has contributed greatly to the present difficulties in operations for the base program. NAL is not now an operating laboratory and at best can only be a partially operating laboratory next fiscal year. However, NAL's operating budget continues to grow at a rapid rate while the rest of the laboratories have not even been able to keep up with inflation. I think it would be a major disaster if this situation continued again next fiscal year. At the very least Brookhaven and SLAC must have an increase in operating funds which makes up for the increase in the cost of living. NAL should be concentrating on completing the accelerator and achieving a reasonable level of operations. I am very disturbed by hearing that NAL now has a design group which is beginning serious work on the energy doubler. I consider this a major piece of idiocy since every nickel of NAL's construction money may well be required to make the machine perform as advertised. Until the machine performs as advertised, or one can see clearly the course required to make it perform as advertised, no funds at all should be diverted to future projects.

I hope I am wrong about the budget and that this new mantle of secrecy comes from the style of the Chairman of the AEC and not because things are so bad that the AEC wants to hide them. I'm sorry this letter is so negative and pessimistic but that is the way I see the situation right now. I hope things look better at the next HEPAP Meeting.

Best regards,

Burt

Burton Richter
Professor

BR:skd

LAWRENCE BERKELEY LABORATORY A-32

UNIVERSITY OF CALIFORNIA

BERKELEY, CALIFORNIA 94720
TELEPHONE (415) 843-2740

September 14, 1972

Professor V. F. Weisskopf
Massachusetts Instutite of Technology
Physics Department
Cambridge, Massachusetts 02138

Dear Vicki,

In the NAS report, Physics in Perspective, is the accompanying table intended to show the FY71 costs of the various high energy accelerator programs. The number given for the Bevatron, $26M, is seriously in error. Including operation and R & D for the accelerator, operation and R & D for the facilities, in house research connected with the accelerator, capital equipment and accelerator improvements funds, a more accurate figure would be about $9M. For the other accelerators the numbers should be checked. I think that they are not far off and that in fact the relative costs of the Bevatron, ZGS, SLAC, and AGS programs are in ratio about 1: 2: 3: 3, not roughly equal as is implied.

I have discussed this matter with Bob Sachs, chairman of the Elementary Particle subpanel of the Committee, and Ed Lofgren has written to Allan Bromley. I believe that the error survived unintentional oversights by members of the Committee and staff, who necessarily handled enormous amounts of data in preparation of their report. In any case it is much too late to alter the Committee's report.

My concern is that this erroneous information, now widely distributed in both scientific and non-scientific circles will perpetuate a continuing failure to appreciate the nature of the programs in the various laboratories. Two years ago HEPAP attempted some clarification by helping the AEC to establish new reporting categories for laboratory operating costs. It is the appropriate group to set the record straight now in the matter of accelerator program costs by publishing an accurate lucid, and updated (say FY-71, 72, 73) record.

Bill
W. A. Wenzel

WAW/mh
Enclosure
cc: HEPAP Members
D. Miller
W. A. Wallenmeyer
R. G. Sachs
D. A. Bromley

13223

Funding and Manpower

ELEMENTARY-PARTICLE PHYSICS (1971)

PROGRAM ELEMENTS	FEDERAL SUPPORT ($ Millions)[1]	PhD MANPOWER[2]
1. Accelerator developments	3.6 (?)	–[3]
2. National Accelerator Laboratory	–[4]	
3. Other major facilities (e.g., AGS improvement project)	1.5 (?)	–[3]
4. Stanford Linear Accelerator	27 27.6	99
5. Brookhaven AGS	27 25.6	99
6. Argonne ZGS	20 18.9	65
7. Berkeley Bevatron	26 25.6 – 8.7 = 16.9	100
8. Cornell Synchrotron	3	20
9. CEA Bypass Storage Ring	2.3 2.7	11
10. University groups	37 25.7(AEC)	1245[5]

[1] Construction costs not included.

[2] Includes approximately 300 scientists having the following specialties or combinations of them: computer employment in research, accelerator design and development, accelerator operation, device design and development, and emulsion experiments.

[3] Manpower included in elements 4 to 9.

[4] No NAL figures are given for FY 1971 since the accelerator will not be in operation until FY 1972.

[5] Includes approximately 245 PhD's doing particle research but not supported directly by federal funds. Nonfederal support estimated to be of the order of 5 percent of total federal funding.

Description of Program Elements

1. These activities are an integral part of the ongoing work at each of the major accelerator laboratories. They have a creative content quite apart from the particle research itself, although neither can progress without the other. The technological requirements lead to innovation and development in such fields as radiofrequency engineering, superconducting magnets, ultra-fast electronics, computer technology, radiation detection instruments, pattern recognition, and particle orbit theory.

2. 200-500 GeV proton accelerator to be for some years the only controlled source of protons in the world for research* in the energy range above 80 GeV and the only one in the United States above 33 GeV. Also includes in-house research activities comprising a small fraction of the particle research to be carried out at the accelerator.

3. They are major additions to the capabilities of accelerators–other than NAL–that have been planned or under construction for some years and are now complete or nearing completion. Includes: the major modification of the AGS to increase its intensity and capabilities, the SPEAR storage ring at SLAC, and the 12-ft liquid hydrogen bubble chamber at the ZGS. Each facility offers unique opportunities to perform ground-breaking research but will require incremental operating and equipment funds for the purpose.

4. 22-GeV electron accelerator, which is the only controlled source of electrons in the world for research* in the energy range above 10 GeV. Also includes in-house research activities comprising a substantial fraction (about one half) of the research carried out with this accelerator.

5. The 33-GeV proton accelerator at BNL, which is the principal source in the United States for research using protons in energy range 12-33 GeV. Includ in-house research comprising about 25 percent of the total research activity.

6. The 12.5-GeV accelerator at ANL, which is the principal source in the United States for research* using protons in the energy range 6-12 GeV. Includ in-house research effort comprising about 25 percent of the total research activi

7. The 6-GeV proton accelerator at LRL, which is the principal source in the United States for research using protons in the energy range 1-6 GeV. Inclu substantial in-house research activity.

8. A 10-GeV electron accelerator. This is a high-duty-cycle machine (in con trast to SLAC) for research* with electrons in the energy range 1-10 GeV. The in-house research activity is dominant, but there is potential for expansion to include more research by outside users.

9. A 6-GeV electron accelerator with a high duty cycle, which has recently been limited to activities associated with the development of a by-pass to serve a a storage ring to study the collisions of 3.5-GeV electrons and positrons. It is the only such facility presently available in the United States and is currently under test.

10. University research groups responsible for carrying out most of the exper mental particle-physics research at the major accelerator laboratories. Includes activities of professors, postdocs, graduate students, and associated technical services required to provide electronics, detection equipment, data handling and analysis systems, etc. to the extent that these aspects of the research can be mounted at the universities. Includes both experimental and theoretical physicist

*Each accelerator is a source of the indicated primary particles and many beams of secondary particles (pions, K-mesons, neutrinos, muons, antiprotons, hyperons, etc.).

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

December 7, 1967

Professor Victor F. Weisskopf
Chairman, High Energy Physics
Advisory Panel
Massachusetts,Institute of Technology
Cambridge, Massachusetts 02139

Dear Viki:

Enclosed is the budgetary material which will be discussed at the December 8-9, 1967, HEPAP meeting. Also enclosed is material on international collaboration which will be briefly touched upon at ANL.

Please note that some of the above is Privileged Information.

We all here wish you well.

Sincerely yours,

Bernard Hildebrand, Chief
University Research Branch
High Energy Physics Program
Division of Research

Enclosures:
As stated above

U. S. ATOMIC ENERGY COMMISSION
FY 1968 Budget Estimates
Appropriation - Operating Expenses

PHYSICAL RESEARCH PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1968	$272,000,000
Estimate FY 1967	255,290,000
Increase	$ 16,710,000

The theoretical and experimental investigations conducted under the Physical Research Program are concerned with discovering and understanding natural laws relevant to the Commission's responsibilities for the development, use and control of nuclear energy. The ultimate objective is the reduction of many different phenomena to fundamental principles through which known facts are understood and from which new principles may be predicated. Within this framework, investigations are undertaken in the fields of physics, chemistry, metallurgy and materials, and controlled thermonuclear research. There follows a brief statement of principal objectives within each scientific discipline:

Physics

1. To attain a comprehensive understanding of those phenomena which contribute to the establishment of a consistent theory, explaining, in general, the behavior of nuclei, nuclear components and nuclear forces.

2. To advance the study of nuclear forces and to build-up both a theoretical and empirical knowledge of nuclear structure and nuclear processes.

3. To develop basic nuclear data, particularly in the field of neutron cross sections.

4. To improve existing and to develop new devices such as accelerators and computers that will be of use in the overall AEC program.

5. To devise new methods of treating mathematical problems that arise in connection with AEC programs.

PHYSICAL RESEARCH PROGRAM - continued

Chemistry

1. To advance basic knowledge in those fields of chemical science related to atomic energy.

2. Where the state of knowledge permits, and the need exists, to orient this knowledge toward, and develop it for, the practical operations of the Atomic Energy Program.

3. To provide for use in the Atomic Energy Program the necessary quantities of rare, highly enriched special isotopes.

Metallurgy and Materials

1. To evolve a true, coherent concept of the basic structures and mechanisms which govern the properties and behavior of materials related to the Atomic Energy Program.

2. To apply the basic knowledge evolved to the development of materials technology in order to alleviate materials-related problems of the Atomic Energy Program.

Controlled Thermonuclear

1. To heat and confine a plasma at a particle energy sufficient to yield significant amounts of thermonuclear energy during the time of confinement.

2. To study such plasma, and, if it be found feasible, to design and build a pilot thermonuclear plant yielding net power.

3. To produce economically competitive fusion power.

PHYSICAL RESEARCH PROGRAM - continued

The increase of $16,710,000 in FY 1968 over the level of $255,290,000 estimated for FY 1967 is summarized as follows:

1.	An increase in High Energy Physics of	$ 8,427,000
2.	An increase in Medium Energy Physics of	100,000
3.	An increase in Low Energy Physics of	1,064,000
4.	An increase in Mathematics and Computer Research of	93,000
5.	An increase in Chemistry Programs of	2,136,000
6.	An increase in Metallurgy and Materials Programs of	1,316,000
7.	An increase in Controlled Thermonuclear Programs of	3,574,000
	Total Increase	$16,710,000

PHYSICAL RESEARCH PROGRAM - continued

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
RES-4	1. High Energy Physics	$ 97,432,967	$108,073,000	$116,500,000
RES-13	2. Medium Energy Physics	9,164,425	11,000,000	11,100,000
RES-15	3. Low Energy Physics	26,384,546	28,336,000	29,400,000
RES-18	4. Mathematics and Computer Research	5,277,782	6,107,000	6,200,000
RES-20	5. Chemistry Research	49,578,745	52,864,000	55,000,000
RES-24	6. Metallurgy and Materials Research	24,847,598	26,284,000	27,600,000
RES-30	7. Controlled Thermonuclear Research	21,768,984	22,626,000	26,200,000
	Total Physical Research Program	$234,455,047	$255,290,000	$272,000,000

JUSTIFICATION OF CATEGORIES

1. High Energy Physics $116,500,000

High Energy Physics is primarily concerned with the basic constituents and forces of nature. These are studied via the interactions of elementary particles at very high energies. Investigations are chiefly carried out in experiments employing intense and well-controlled primary, secondary and tertiary beams of elementary particles -- the basic elements of matter -- produced by high energy accelerators. As particle energies increase, the interaction distance between particles tend to decrease. In this manner the capability for probing deeper into the nature of matter and into the forces which determine the behavior of matter is enhanced. These forces play a role in the microscopic world of high energy physics, in the macroscopic world in which mankind lives, and in the astrophysical world of the stars and galaxies. Experimental studies in the recent past have resulted in a broader understanding of the significant phenomena that occur with elementary particles. Continuing advances in accelerator technology, in the development of improved detectors, and in advanced data analysis systems play a vital and significant role in the progress of this field of research. Theoretical studies augment the experimental work and are required to both interpret the experimental results and to suggest directions for future experimental efforts. The close liaison and interplay between theoretical and experimental effort has contributed greatly to the success of the U. S. High Energy Physics Program. This liaison has benefited greatly from the active participation of the many university user groups in high energy physics research.

PHYSICAL RESEARCH PROGRAM - continued

In FY 1968 the Stanford Linear Accelerator Center (SLAC) will enter its first full year of operation. It is anticipated that the FY 1967 year-end operating schedule of 10 shifts per week will be maintained in FY 1968. In addition, several large new experimental devices, including the 40" and 82" bubble chambers will begin limited operation. The Alternating Gradient Synchrotron (AGS) will be entering its seventh operating year with maximum intensities of 1 x 10^{12} protons per second for certain experiments. The Zero Gradient Synchrotron (ZGS) will be entering its fourth year of full research operation with an intensity above 10^{12} protons per pulse. The Cambridge Electron Accelerator (CEA) will be entering its sixth year of operation. A new higher energy injector will provide the CEA with an intensity increase to about 10^{12} electrons per second plus improved reliability and stability of operations. The Princeton-Pennsylvania Accelerator (PPA) will begin its fifth year of operation with intensities above 10^{12} protons per second. In addition, the new external beam facility which approximately doubles the research capability of the PPA will be available for the full year. The productive research program of the Bevatron will be centered about the expanded capabilities of the external beam facility.

Bubble chambers and spark chambers will continue to be the principal devices used for detection of particle interactions in the conduct of experimental programs. Filmless spark chamber systems are being developed rapidly and the use of on-line computers with spark chamber and counter systems for "in situ" data processing will be expanded. The development of improved data analysis apparatus such as the automatic Hough-Powell Device (HPD), the Precision Encoding Pattern Recognition (PEPR) systems, and the semi-automatic Spiral Reader will be continued to allow individual groups to efficiently analyze the high statistics experiments which are necessary to permit significant progress in this complex field of research.

The university user group concept has proven to be highly successful in performing high energy physics research. The growth in accelerator capability, resulting from the availability of new and significantly improved accelerator facilities, increases their potential for investigating many unanswered questions facing the high energy physicist.

The aforementioned increases in machine intensity, parallel improvements in data reduction and handling techniques, the need for initiation and development of new user groups, the greater sophistication of the new particle detection apparatus, the strong theoretical interest in and promise of the new symmetry rules for elementary particles and resonance particles, the availability of six major accelerators, and the pursuit of technological advances such as superconducting magnets are all factors which contribute to the need for increased funding of research programs in FY 1968.

PHYSICAL RESEARCH PROGRAM - continued

To insure continuing progress in this field, it is necessary to plan now for the accelerators of the future since they take as much as 6-10 years to construct. The program of research directed toward future accelerator capability includes comprehensive studies related to the 200 Bev proton accelerator. There is also a more general advanced accelerator research and development effort which will undoubtedly lead to new accelerators in the future and to significant improvements in existing accelerators. One of the principal long range goals is the conceptual design of an accelerator with an energy near 1,000 Bev. There follows a breakdown of the estimates for each major accelerator:

	FY 1966	FY 1967	FY 1968
A. Princeton-Pennsylvania Accelerator ..	$ 7,494,134	$ 7,900,000	$ 8,250,000
B. Cambridge Electron Accelerator	7,933,338	8,180,000	8,450,000
C. Alternating Gradient Synchrotron	16,394,743	18,650,000	20,000,000
D. Cosmotron	3,372,437	1,450,000	100,000
E. Zero Gradient Synchrotron	15,807,490	16,800,000	17,450,000
F. Bevatron	14,611,054	15,150,000	15,200,000
G. Stanford Linear Accelerator Center ..	9,091,361	15,300,000	21,300,000
H. General Research and Development	22,728,410	24,643,000	25,750,000
Total High Energy Physics	$97,432,967	$108,073,000	$116,500,000

A. Princeton-Pennsylvania Accelerator

	FY 1966	FY 1967	FY 1968
a. Research	$ 2,722,851	$ 2,900,000	$ 3,000,000
b. Design and Development of Devices	280,445	350,000	350,000
c. Operations	4,490,838	4,650,000	4,900,000
Total	$ 7,494,134	$ 7,900,000	$ 8,250,000

The PPA is now operating on an 18 shift per week basis with an average intensity greater than 10^{12} particles per second. The accelerated proton beam has been successfully extracted from the ring and the external beam facility will be available for experiments in the latter half of FY 1967. This facility will permit the PPA to conduct twice as many simultaneous experiments as it can now accommodate. It will also make possible many highly sophisticated experiments which cannot be conducted with present beams and facilities.

The requested increase of $350,000 and a reduction of activity in the presently operating secondary beam area will permit experimental utilization of the external beam facility.

B. Cambridge Electron Accelerator

	FY 1966	FY 1967	FY 1968
a. Research	$ 4,584,427	$ 4,710,000	$ 4,815,000
b. Design and Development of Devices	289,102	270,000	360,000
c. Operations	3,059,809	3,200,000	3,275,000
Total	$ 7,933,338	$ 8,180,000	$ 8,450,000

The experimental groups at Harvard and Massachusetts Institute of Technology (MIT) continue to exploit the present capabilities of the CEA. In addition, the CEA staff is developing the "beam by-pass" which would permit the CEA to be used as its own storage ring. If successful, this will provide a small window into phenomena at very high energies. With this apparatus the available energy for reaction of colliding contrarotating electrons and positrons will be as much as 6 Bev, which is equivalent to the energy available when a positron from a 36,000 Bev accelerator strikes a stationary electron. Many new and interesting problems can be studied in this fashion.

The increase of $105,000 in research funds will be used by the Harvard and MIT research groups to help maintain their current level of activity. The $90,000 increase in design and development of devices will be used to further pursue the beam by-pass effort. The $75,000 increase in operations will provide for continuation of accelerator operations and experimental support activities at about the same level as FY 1967.

C. Alternating Gradient Synchrotron

	FY 1966	FY 1967	FY 1968
a. Research	$ 9,767,436	$11,150,000	$12,100,000
b. Design and Development of Devices	3,297,319	3,750,000	3,900,000
c. Operations	3,329,988	3,750,000	4,000,000
Total	$16,394,743	$18,650,000	$20,000,000

The AGS is expected to operate in FY 1968 with an average beam intensity of about 10^{12} particles per second. The AGS has been the source of most of the major advances in particle physics for the last several years and can be expected to be the source of a large part of the major U. S. advances in the immediate future. It will be the highest energy machine in the U. S. for many years and the highest energy machine in the world until the 70 Bev Serpukhov accelerator comes into operation.

Both of the fast extracted beams, the new slow extracted beam, and multiple internal targets will be available for operation. Three major bubble chambers will be available for full time service in addition to numerous spark chambers and counter hodoscope detection systems, some of which include on-line data processing capability. The demand for research time on the AGS and its major experimental facilities continues to increase. The growing requirements for high statistics experiments and the shutdown of the Cosmotron (December 23, 1966) places AGS accelerator time at an even higher premium.

The increase of $1,350,000 provides for full-year operation of the AGS at the level attained in the latter half of FY 1967 (which reflected the transfer of experienced personnel from the Cosmotron) and will permit prosecution of the more complex and sophisticated experiments required for the higher momentum particle interactions which are of greatest interest and highest priority. Increased funding is also required to exploit the research potential of the slow extracted beam which is planned for operation in early FY 1968 and to intensify those activities directed toward increasing the experimental flexibility and beam sharing capability of the accelerator.

D. Cosmotron

	FY 1966	FY 1967	FY 1968
a. Research	$ 1,777,397	$ 850,000	$ 0
b. Design and Development of Devices	390,767	0	0
c. Operations	1,204,273	600,000	100,000
Total.................	$ 3,372,437	$ 1,450,000	$ 100,000

Operation of the Cosmotron was terminated December 23, 1966. The machine will be mothballed for about a year prior to disassembly. The requested funds will maintain various systems of the accelerator in an operable condition during this interim period.

E. Zero Gradient Synchrotron

	FY 1966	FY 1967	FY 1968
a. Research	$ 7,425,768	$ 8,800,000	$ 9,200,000
b. Design and Development of Devices	4,570,012	3,800,000	3,850,000
c. Operations	3,811,710	4,200,000	4,400,000
Total	$15,807,490	$16,800,000	$17,450,000

The ZGS, which is the second highest energy proton machine in the U. S. has reached a significantly increased level of productivity, having attained a beam intensity greater than 10^{12} protons per pulse and developed a more efficient beam extraction system.

The increase of $650,000 will permit continuation of research activities at about the FY 1967 level. The increased beam intensities provide the capability of performing those important experiments requiring higher statistics. Additionally, emphasis will be placed on exploiting the special capabilities of the ZGS, such as beam sharing, in which an experiment can be conducted at a sequence of energies while others are simultaneously conducted at full beam energy.

F. Bevatron

	FY 1966	FY 1967	FY 1968
a. Research	$11,175,523	$11,400,000	$11,400,000
b. Design and Development of Devices	250,265	300,000	300,000
c. Operations	3,185,266	3,450,000	3,500,000
Total	$14,611,054	$15,150,000	$15,200,000

The reduced level of experimental activity implicit in the funding requested for the Bevatron will be partially offset by the transfer of the rebuilt 82" bubble chamber to the Stanford Linear Accelerator Center. Although the Bevatron will remain on a schedule of 21 shifts/week, less extensive utilization of the beam facilities for bubble chamber, spark chamber and counter experiments is anticipated.

The experimental program continues to be directed primarily toward research on strong interactions. Such studies yield information on the relative strength of competing interactions and decays, determination of the quantum numbers associated with resonances and the longer lived states, and the correlation of experimental data with theory. Complementing the research effort is the laboratory's excellent program directed towards development of detector devices, fast electronics, and instrumentation.

Bevatron operations have yielded a record high beam amplitude for steady operation of 3×10^{12} protons per pulse. Efforts will continue to increase machine efficiency, increase the flexibility of multiple experimental operations, and to bring into operation the new double external proton beam.

G. Stanford Linear Accelerator Center

	FY 1966	FY 1967	FY 1968
a. Research	$ 1,622,696	$ 5,000,000	$ 8,500,000
b. Design and Development of Devices	6,107,751	4,525,000	3,900,000
c. Operations	1,360,914	5,775,000	8,900,000
Total	$ 9,091,361	$15,300,000	$21,300,000

PHYSICAL RESEARCH PROGRAM - continued

A major redirection of effort has been accomplished at the Stanford Linear Accelerator Center during the period of transition from construction to experimental operations. Program plans anticipate 10 shift/week operation of the accelerator during the last half of FY 1967 and research utilization of three spectrometers (2, 8 and 20 Bev) and two spark chamber arrays. The FY 1967 last quarter level of operation, plus the cost of the associated research and support activities, requires an estimated base operating level of $20,100,000 for FY 1968. The effective increase of $1,200,000 above this level will permit limited operation of major experimental facilities which will be ready for operation early in FY 1968. These include the 40-inch and 82-inch liquid hydrogen bubble chambers and the large volume magnet spark chamber facility. The accelerator is expected to remain on a 10 shift/week schedule through FY 1968.

H. General Research and Development

	FY 1966	FY 1967	FY 1968
a. Research and Development	$18,991,800	$20,103,000	$20,910,000
b. Design and Development of Devices	238,702	240,000	240,000
c. Operations	0	300,000	150,000
d. Advanced Accelerator Design Studies	3,497,908	4,000,000	4,450,000
Total	$22,728,410	$24,643,000	$25,750,000

This activity can best be discussed under the following headings:

(1) University User Groups .... FY 1966: $14,544,874 FY 1967: $15,938,000 FY 1968: $16,815,000

The university user program supports the design, development, fabrication and testing of certain types of apparatus for use in experiments to be performed at the major accelerator centers as well as the sizeable costs associated with the analysis and interpretation of the data obtained subsequent to the completion of the experiments.

Strong university user groups insure the productivity and national character of the high energy physics program. User groups have proven remarkably successful, and at present they conduct a large part of the high energy physics research in this country. The close collaboration between theorists and experimentalists engendered by the activities of the university users is an essential ingredient for a successful research program. In addition, the interaction of students and professors provides an excellent forum for the infusion of new ideas into the program. The universities also contribute to the long range stability of the program by training physicists in an active research atmosphere.

PHYSICAL RESEARCH PROGRAM - continued

In recent years, new accelerators and significant improvements to existing accelerators have been provided which allow more difficult and demanding research problems to be attacked. In order to carry out studies made possible by the improved accelerator capabilities, new user groups should be established, and many existing groups should be strengthened.

The requested increase of $877,000 will provide for continuing the existing level of activity of user group effort.

(2) Associated Midwest Universities (AMU) .... FY 1966: $ 34,885 FY 1967: $ 35,000 FY 1968: $ 35,000

The activities of AMU are planned to continue at the FY 1967 level.

(3) Ames Laboratory .... FY 1966: $ 375,236 FY 1967: $ 400,000 FY 1968: $ 400,000

Activities at the Ames Laboratory are concentrated on bubble chamber and spark chamber physics. Also supported is an excellent theoretical program in elementary particle physics. No increase is provided for this program in FY 1968.

(4) Lawrence Radiation Laboratory (LRL) .... FY 1966: $2,423,902 FY 1967: $2,300,000 FY 1968: $2,300,000

Included in this activity are all theoretical studies at LRL as well as activities related to developing new and improved data analysis systems (Hough-Powell Device and Spiral Reader). Also included is a small effort in cosmic ray physics and those activities related to developing improved instrumentation and experimental apparatus. No increase is provided for FY 1968.

(5) Oak Ridge National Laboratory (ORNL) .... FY 1966: $ 374,024 FY 1967: $ 400,000 FY 1968: $ 400,000

Included herein is a group performing calculations and studies pertaining to shielding requirements for high energy accelerators. Also included is a user group engaged in the analysis of bubble chamber film. No increase is provided for FY 1968.

(6) California Institute of Technology (CIT) .... FY 1966: $1,477,581 FY 1967: $1,570,000 FY 1968: $1,350,000

The effort supported under this contract includes operation and use of a 1.5 Bev synchrotron, user group activities utilizing other accelerators and theoretical studies of elementary particles. The reduction of $220,000 envisages a phasing out of the 1.5 Bev electron synchrotron and associated research effort. Greater emphasis would be placed on user type activities utilizing primarily the higher energy SLAC facility. The user groups at Cal Tech have been collaborating with SLAC and MIT in preparing experiments involving use of the SLAC spectrometers and the linac.

(7) Advanced Accelerator Design Studies .... FY 1966: $3,497,908 FY 1967: $4,000,000 FY 1968: $4,450,000

Included under this activity are studies of advanced accelerator concepts directed primarily toward extension of accelerator parameters such as energy and intensity.

A summary by contractor follows:

	FY 1966	FY 1967	FY 1968
Yale University	$ 171	$ 0	$ 0
Argonne National Laboratory ...	590,526	600,000	600,000
Brookhaven National Laboratory.	1,097,417	1,200,000	1,200,000
200 Bev Accelerator	1,809,794	2,200,000	2,650,000
Total	$3,497,908	$4,000,000	$4,450,000

Activities at Argonne National Laboratory (ANL), and Brookhaven National Laboratory (BNL) include research and development on new and improved methods of injection, acceleration extraction and beam handling. The aim of this work is to produce higher intensity beams and more efficient accelerator performance. A major goal of these studies is to develop the conceptual basis for the design, at a later date, of a proton accelerator in the 1,000 Bev range. In addition to these activities, studies associated with the conversion of the AGS are also being conducted at BNL. This effort is directed primarily toward component development during this period.

PHYSICAL RESEARCH PROGRAM - continued

Activities pertaining to the 200 Bev accelerator are aimed primarily at developing data and specifications for sub-systems of the machine. In FY 1968, research and development on the full power radiofrequency system for the linear accelerator will be in progress. A complete system, including an rf level servo system is being developed. Research and development on the following sub-systems will also continue: the main ring and injector synchrotron, the main ring and injector magnet power supply systems, phase and level control servo system, control systems, and the fast pulsed magnet.

Development of test equipment for the production checking of components, such as gradient magnets, rf cavities and electronic gear, will be initiated along with a program of ion source development, which will provide testing of Cockcroft-Walton designs.

Other smaller programs will involve vacuum system components evaluation and the development of mechanical components such as survey and measuring apparatus and models of the minor magnetic elements of both synchrotrons such as Collins quadrupoles, steering magnets, etc.

2. Medium Energy Physics $11,100,000

A comparison of costs for this category follows:

	FY 1966:	FY 1967:	FY 1968:
Research	$ 4,305,724	$ 4,420,000	$ 4,435,000
Design and Development of Devices	841,478	1,330,000	1,320,000
Operations	1,887,508	2,350,000	2,445,000
Meson Factory Design Studies	2,129,715	2,900,000	2,900,000
Total Medium Energy Physics	$ 9,164,425	$11,000,000	$11,100,000

Research investigations in the medium energy region (50 Mev to 1,000 Mev primary proton or electron beam energy) are concerned with improving knowledge about the structure of the nucleus. Both primary and secondary beams developed by intermediate energy accelerators (sector-focussed cyclotrons, electron linacs, synchrocyclotrons and the 800 Mev proton linac planned at the Los Alamos Scientific Laboratory (LASL)) are used as probes to obtain information on the basic question of how neutrons and protons are bound together to form an atomic nucleus. This type of data is required to test theories which include descriptions of the forces holding the nucleons within the nucleus together.

U. S. ATOMIC ENERGY COMMISSION
FY 1968 Budget Estimates
Appropriation - Plant and Capital Equipment

PHYSICAL RESEARCH PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
A - Obligations for Construction Projects	$37,653,363	$118,168,000	$22,500,000
B - Obligations for Capital Equipment Not Related to Construction	44,814,306	40,080,000	39,800,000
Total Obligations for Plant and Capital Equipment	$82,467,669	$158,248,000	$62,300,000

Section A - FY 1968 Obligations for Construction Projects:

Project No.	Title	Total Estimated Cost	Estimated Obligations FY 1968
68-4-a	Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York	$ 1,095,000	$ 1,095,000
68-4-b	Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois	1,900,000	1,900,000
68-4-c	Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California	1,740,000	1,740,000
68-4-d	Accelerator improvements, Cambridge and Princeton accelerators	400,000	400,000
68-4-e	Accelerator improvements, Stanford Linear Accelerator Center, California	865,000	865,000
68-4-f	Omnitron accelerator, Lawrence Radiation Laboratory, Berkeley, California, (AE only)	4,000,000	4,000,000
68-4-g	200 Bev accelerator, Weston, Illinois (AE only)	10,000,000	10,000,000
68-6	General plant projects	2,500,000	2,500,000
	Total Physical Research Construction Projects	$22,500,000	$22,500,000

PHYSICAL RESEARCH PROGRAM - continued

Section A - Obligations for Construction Projects - continued

EXPLANATION OF PROJECTS ABOVE

1. Project 68-4-a Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York $1,095,000

Funds requested for this project are required for the large research machine facilities which need annual modifications, improvements and additions. Accelerator and reactor additions and modifications depend to some degree on the extension of existing techniques that cannot be established in all details in advance. Some modifications are planned to adapt the existing accelerator and reactor facilities to newly planned research programs. Others result from unexpected failures to facility components and from obscure effects which cannot be predicted and which may appear only after extended operating periods. Consequently, it is clear that changes in the list of modifications must be anticipated. The cost estimates for these projects are by necessity of a preliminary nature.

It is anticipated that the funds requested for this project in FY 1968 will provide improvements to the major research machines at Brookhaven as follows:

Details of Cost Estimate

a. High Flux Beam Reactor (HFBR)		$ 510,000
(1) Cold Neutron Moderator	$ 350,000	
(2) Improvements and Modifications to the Reactor and Associated Experimental Facilities	160,000	
b. Alternating Gradient Synchrotron (AGS)		495,000
(1) Additional High Density Experimental Area Shielding	100,000	
(2) Improvements to Extracted Beams	220,000	
(3) Improvements and Additions to Services and Facilities	175,000	

PHYSICAL RESEARCH PROGRAM - continued

Section A - Obligations for Construction Projects - continued

c. 60" Cyclotron		$ 90,000
(1) Extension of Beam Transport and Gamma Cave Modifications	$ 90,000	
Total Project Cost		$1,095,000

2. Project 68-4-b Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois $1,900,000

Incorporated in this project are ZGS modifications and improvements planned to increase the efficiency, safety, and utility of this machine and its associated experimental facilities. The items shown here reflect current planning and are subject to later revision since research and technological demands cannot always be predicted in advance. The $1,900,000 requested for FY 1968 is tentatively planned to be used as follows:

Details of Cost Estimate

40" Heavy Liquid Bubble Chamber Facility	$ 710,000
RF System Additions	250,000
Ring Magnet Power Supplies	210,000
Control Room Improvements	225,000
Helium Recovery and Purification Facility	150,000
Targetry Improvements	145,000
Vacuum System Improvements	130,000
Hydrogen Safety Improvements	80,000
Total Project Cost	$1,900,000

Overall planning for accelerator improvements is based on a logical progression of modification and refinement of the research machines consistent with program requirements.

Section A - Obligations for Construction Projects - continued

3. Project 68-4-c Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California $1,740,000

This project consists of modifications and improvements to the Laboratory accelerators to upgrade and modernize them to meet programmatic needs. It reflects a continuing effort to maintain the pace of physical and technological advancement by maintaining the scientific effectiveness of the accelerators. The needs shown here reflect current planning and are subject to later revision since research and technological demands cannot always be predicted in advance. It is presently planned that the funds requested will be used to improve the research machines as follows:

Details of Cost Estimate

a. Bevatron		$1,000,000
(1) External Proton Beam Enclosure and Installation of Electric Power and Water Distribution Systems	$ 600,000	
(2) Proton Beam Extraction System Improvements	200,000	
(3) Additional Concrete Pads and Trenches for Utilities Distribution	200,000	
b. 88" Cyclotron		280,000
(1) Improve the Duty Factor by Modifications to the RF Systems	190,000	
(2) Pulsed Injection System	90,000	
c. 184" Cyclotron		190,000
(1) 1250 KW DC Power Supply	100,000	
(2) Special Shielding	70,000	
(3) Additional Clean Air Supply System	20,000	
d. Heavy Ion Linear Accelerator		270,000
(1) Computer Instrumentation and Control System	270,000	
Total Project Cost		$1,740,000

PHYSICAL RESEARCH PROGRAM - continued

Section A - Obligations for Construction Projects - continued

4. Project 68-4-d Accelerator improvements, Cambridge and Princeton accelerators ....$ 400,000

This project is required to modify and improve the Cambridge Electron Accelerator at Cambridge, Massachusetts, and the Princeton-Pennsylvania Accelerator at Princeton, New Jersey, as part of the continuing effort to sustain the performance capabilities of these research machines in accordance with the technological and research demands of the programs they support. Since these demands cannot always be predicted in advance, the items proposed for FY 1968 must remain tentative.

Tentatively planned CEA improvements are related to an improved RF system. The principal items planned at the PPA include modifications to the external beam switchyard and internal targeting.

Details of Cost Estimate

Princeton-Pennsylvania Accelerator		$ 250,000
Improved Internal Targeting	$ 250,000	
Cambridge Electron Accelerator		150,000
Improved RF System	150,000	
Total Project Cost		$ 400,000

5. Project 68-4-e Accelerator improvements, Stanford Linear Accelerator Center, California ....$ 865,000

This project will provide for necessary modifications to the accelerator-switchyard-target area complex at the Stanford Linear Accelerator Center (SLAC). While many of the components of this complex have undergone operational testing, it is anticipated that certain elements will require improvements in order to optimize the total systems performance.

PHYSICAL RESEARCH PROGRAM - continued

Section A - Obligations for Construction Projects - continued

Details of Cost Estimate

a.	High Power Slits for B-Beam	$ 125,000
b.	Separation of Low Conductivity Water System in End Station Area	335,000
c.	Accelerator and End Station Utility Distribution	155,000
d.	Central Beam System	250,000
	Total Project Cost	$ 865,000

6. Project 68-4-f Omnitron accelerator, Lawrence Radiation Laboratory, Berkeley, California, (AE only) $4,000,000

This project covers partial design services necessary to develop drawings, specifications, and a more definitive cost estimate for a new, versatile, alternating gradient synchrotron which will accelerate all atoms of the periodic system to energies as high as 500 Mev per nucleon.

The Omnitron Accelerator will be jointly used to conduct basic investigations in Nuclear Chemistry and in Biology and Medicine. In addition to being highly versatile in terms of ion acceleration capability, it will have the features of continuously variable energy and high energy definition.

The Omnitron is being designed to make possible many new and important research efforts in various fields of Nuclear Chemistry by providing for the first time copious quantities of energetic ions of all the elements. It will have the basic capacity of producing hundreds of new nuclides covering a wide range of nuclear types and thus is likely to enlarge the fields of nuclear level spectroscopy.

In experimental neurophysiology this machine would make it possible to destroy in depth, without damage to intervening tissue, areas in the brain of an experimental animal with an exactitude which has been hitherto impossible, as well as to treat brain tumors and other conditions which are ameliorated by the destruction of localized areas of the brain or by severing clearly defined pathways in the central nervous system. It will also permit extension of "heavy ion radiobiology" for the very much needed better understanding of the biological effects of the radiations associated with the newly developed multi-billion volt accelerators, including the effects of particles accelerated to relativistic velocities; and the biological effects of ionizing particles associated with interplanetary space explorations and colonization.

Section A - Obligations for Construction Projects - continued

The principal physical components of the Omnitron project are: The Omnitron main ring and storage ring structure; high-bay experimental space for Biology-Medicine and for Chemistry; low-bay experimental space; operations space; utilities and equipment areas; and external service areas.

Details of Cost Estimate

The preliminary cost estimate for the total project is $25 million. The $4 million requested will permit an orderly progression of design effort, and will provide cost information upon which to base a future request for construction authorization.

7. Project 68-4-g 200 Bev accelerator, Weston, Illinois, (AE only) $10,000,000

This project covers partial design services necessary to develop drawings, specifications, and a more definitive cost estimate for the 200 Bev Accelerator Laboratory.

The principal research tool of the Laboratory will be a 200 Bev strong focusing proton synchrotron, approximately one mile in diameter. This facility will have an intensity greater than 10^{12} protons per second; however, the design of the machine will incorporate features which will permit the intensity to be raised and additional target stations to be added at a later date. The design will be based upon adherence to conservative and conventional criteria and design principles in order to emphasize reliability.

The need for construction of this facility at this time has been established in the Policy for National Action in the Field of High Energy Physics which was transmitted by the President to Congress in January 1965. The policy document states that proton energy is the single most important parameter to be extended. The next logical step in meeting this need is the immediate design and construction of an alternating gradient synchrotron in the 200 Bev energy range.

This accelerator facility will provide experimental data in a new energy range with beam energy almost an order of magnitude higher than provided by presently operating accelerators. The data sought are crucial for progress in the understanding of elementary-particle physics in which the present state of knowledge allows the posing of many definite questions that are of significant consequence to a deeper understanding. These questions can be answered only by experiments at higher energy. The accelerator techniques to reach these energies and the experimental techniques to perform meaningful tests are within the scope of present technology.

Section A - FY 1968 Obligations for Construction Projects - continued

Details of Cost Estimate

The estimated cost of partial design services provided for under this project is $10,000,000. The approximate total cost of the project is $240,000,000, excluding research equipment, **and a large bubble chamber which will be funded separately as programmatic needs are clarified.**

8. Project 68-6 General plant projects ....$ 2,500,000

This project provides for minor new construction and other capital alterations, additions, and retirements to land, buildings, and utilities systems. The estimate also includes the cost of installed equipment which is an integral part of the general plant sub-projects.

Although it is difficult to detail this type project in advance, various sub-projects are under consideration. In general, the estimated costs of the sub-projects are preliminary in nature and primarily indicative of the size of the project. It should be noted also that the continuing study of requirements will result in some of the projects being changed in scope; it will also result in other projects being added with the necessary postponement of some now planned, all depending on conditions or situations not apparent at this point in time.

The funds requested for FY 1968 are estimated as follows:

Ames Laboratory (all programs)	$ 270,000
Brookhaven National Laboratory (all programs)	1,500,000
Notre Dame Radiation Laboratory	10,000
Princeton Plasma Physics Laboratory	75,000
Princeton-Pennsylvania Accelerator	150,000
Cambridge Electron Accelerator	150,000
Stanford Linear Accelerator Center	245,000
Contract Research Program	100,000
Total FY 1968 Obligations	$ 2,500,000

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction:

Activity	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
A. High Energy Physics	$21,249,999	$21,760,000	$21,750,000
B. Medium Energy Physics	1,387,322	1,400,000	1,650,000
C. Low Energy Physics	6,380,092	5,500,000	5,000,000
D. Mathematics and Computer Research	427,152	450,000	450,000
E. Chemistry Research	5,276,768	5,290,000	5,270,000
F. Metallurgy and Materials Research	2,540,639	2,600,000	2,600,000
G. Controlled Thermonuclear Research	1,767,592	1,780,000	1,780,000
H. Other Capital Equipment	5,784,742	1,300,000	1,300,000
Total Physical Research Capital Equipment not Related to Construction	$44,814,306	$40,080,000	$39,800,000

JUSTIFICATION

Equipment requirements for the Physical Research Program are estimated at $39,800,000 for FY 1968 representing a decrease of $280,000 from FY 1967. The estimate is based on requirements as indicated by the needs of the research program planned for FY 1968. Included in the estimates for FY 1968 is approximately $500,000 for acquisition of a small accelerator for a University group or an accelerator injector to be added to an existing University Accelerator facility. The major portion of the equipment provided under this heading will support the high energy, medium energy and low energy physics, mathematics and computer, chemistry, metallurgy and

Section B - Obligations for Capital Equipment not Related to Construction: - continued

materials and controlled thermonuclear programs. Because of rapidly changing technology it is difficult to forecast needs with absolute precision and accuracy. The items of equipment listed in this document are representative of the types of equipment required based on the current status of the experimental process. It is expected that the apparatus finally procured shall reflect the current state of the experimental art and that flexibility to deviate from the items listed is both desirable and warranted.

A. High Energy Physics $21,750,000

Experimental programs in high energy physics are characterized by the use of large particle accelerators and the related need for major equipment items.

The availability, in FY 1968, of the improved Bevatron, the Zero Gradient Synchrotron (ZGS), the Alternating Gradient Synchrotron (AGS), the Princeton-Pennsylvania Accelerator (PPA), the Cambridge Electron Accelerator (CEA), and the Stanford Linear Accelerator (SLAC) reflect the need for an accompanying increase in requirements for experimental equipment. The need for additional equipment is related primarily to needs for increased data collection capability and increased capability for data analysis and evaluation. This in turn stems from the improved operating characteristics of the accelerators, including the increased availability of external beam ports. These needs also reflect the large scientific advances made in recent years requiring a finer more sophisticated art of experimentation to achieve scientific results of the first order. Currently, many experimental studies are concerned with the investigation of particle events which are very rare and short-lived but which have proved to be of fundamental importance. Consequently, present-day experiments are more difficult to conceive, design, execute and analyze than those conducted in the past. The resultant demand is for groupings and arrays of spark chambers, bubble chambers and their accompanying large magnets and power supplies as well as automatic and semi-automatic data analysis systems and their associated computers. The funds required for the Washington administered program are primarily to provide semi-automatic and automatic data analysis devices and on-line data handling devices for the University user groups.

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

There follows an explanation of each contractor's needs:

1. Ames Laboratory ....$ 100,000

This request provides for the acquisition of various items of equipment required for the spark chamber research effort of the Ames group and for the bubble chamber data analysis effort.

2. Argonne National Laboratory (ANL) ....$ 3,850,000

The equipment requested by Argonne National Laboratory is required to maintain a productive research program at the ZGS, to maintain the accelerator and associated major equipment items in operable condition and to provide the data analysis facilities necessary to process the experimental data acquired. The FY 1968 request anticipates acquisition of the following major types of apparatus:

Beam Transport Magnets and Power Supplies	$ 900,000
RF Particle Separators	500,000
Electronic Equipment for Experiments	350,000
Cryogenic Target Systems	200,000
Proton Beam Switching Magnets and Power Supplies	270,000
Equipment for 30" and 40" Chambers	200,000
Shielding - Concrete and Steel	250,000
Semi-automatic Scanning and Measuring Devices	125,000
On-line Computer System	100,000
Automatic Data Reduction Apparatus	150,000
Superconducting Magnet	150,000
Advanced Accelerator Development Equipment	150,000
Logging System - Second Proton Area	80,000
RF and Vacuum Test Equipment	75,000
New Detector System	150,000
Superconducting Magnet Development Equipment	200,000

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

3. Brookhaven National Laboratory (BNL) ....$ 3,700,000

A significant part of the request for FY 1968 involves equipment to be used in providing additional experimental beams. The further development of the external beam facilities will provide the AGS with capability of supporting additional parallel experiments required to satisfy the needs of the research program. The increased output of experimental data also requires the provision of additional data analysis facilities. Some of the major procurements anticipated in FY 1968 include:

Beam Transport Magnets and Power Supplies	$ 450,000
Particle Separators	250,000
Cryogenic Targets	150,000
Superconducting Magnets	300,000
Large Volume Magnet	200,000
Electronics	450,000
Advanced Accelerator Development Equipment	150,000
Bubble Chamber Improvement Equipment	300,000
Control Room Equipment	350,000
Bubble Chamber Data Terminal	150,000
Data Measuring and Analysis Facilities	400,000
Counter Hodoscope Facilities	400,000
Memory Addition for PDP-6	150,000

4. Cambridge Electron Accelerator (CEA) ....$ 1,780,000

Equipment funds provided under this heading are allocated to three contracts with two universities. A breakdown of the estimate is shown in the following table:

Harvard University (CEA Operations)	$ 850,000
Harvard University (Research)	630,000
Massachusetts Institute of Technology (Research)	300,000
Total	$1,780,000

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

The funds requested for Harvard (CEA Operations) are related primarily to the need for a new spectrometer system and the positron source and by-pass systems. Specific items include:

Spectrometer System	$ 400,000
By-Pass Elements	225,000
Positron Source Equipment	25,000
Cryogenics	50,000
Electronics	75,000
Magnets and Power Supplies	75,000

Included in the funds requested for Harvard (Research) is an estimated $450,000 for a Sigma-7-type computer system including peripheral equipment to expand and improve the spark chamber data analysis complex and to permit efficient handling of the large volume of data resulting from on-line operation at the CEA. This computer will also handle part of the large general purpose computing load of the laboratory. Other smaller equipment needs to support experiments on the AGS as well as the CEA are also included.

The MIT request will provide for modifications to the highly successful SPASS automatic analysis system, additions to the PDP-6 on-line to the PEPR system, and standard items of laboratory equipment such as pulse height analyzers, an encoding machine, power supplies, and oscilloscopes.

5. Princeton-Pennsylvania Accelerator (PPA) ....$ 1,550,000

Equipment funds provided under this heading are allocated to the University of Pennsylvania and Princeton University, the latter being the operating contractor for the PPA. The funds requested are needed for items such as the following:

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

Princeton University	$ 800,000
Fast Logic Electronics	100,000
On-Line Data Handling and Interface Equipment	125,000
Sweeping Magnets	200,000
Beam Separator	125,000
Experimental Support Equipment (Vacuum Equipment, Special Targets, Shielding, etc)	100,000
Research Support Equipment for Princeton Research Group	150,000

University of Pennsylvania ....$ 750,000

This will provide $460,000 for an IBM 360-44 computer for use with the Hough-Powell Device, and $290,000 for general research equipment such as a large volume spark chamber magnet ($80,000), modifications to the HPD ($50,000), wire spark chamber system ($75,000), on-line data acquisition system ($50,000) and other items such as fast logic modules, scales, cameras, power supplies, optics and scopes which are required for the experimental program.

6. Lawrence Radiation Laboratory (LRL) ....$ 4,500,000

To meet the laboratory's increasing demand for high speed computational capacity acquisition of a second 6600 computing system (or equivalent) is proposed in FY 1968. This demand is based on the increased output of the experimental program and the concomitant requirement for analysis of the data generated by this program. In the high energy physics program this demand is based on the increased output of the two spiral readers, increased usage of the flying spot digitizer and the rapidly expanding requirement for on-line data analysis of counter-spark chamber type experiments. Other laboratory programs, particularily those in biology, chemistry and inorganic materials will also benefit from installation of this facility. Additional experimental equipment is also required in support of the planned expansion of the Bevatron external beam facility. Examples of proposed procurements include:

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

CDC-6600 Computing System or Equivalent	$ 3,000,000
Magnets and Power Supplies	550,000
Data Measuring Equipment	420,000
Interfaces and Data Storage Devices	280,000
Small Computers for On-line Applications	250,000

7. Stanford Linear Accelerator Center (SLAC) ....$ 4,800,000

By FY 1968, the Stanford Accelerator is expected to be operating 10 shifts per week. Procurement of additional equipment for use in target areas, and requirements for increased data analysis capability, are anticipated from the general increase in research activity at this facility. Specialized research equipment such as a Cerenkov counter, spark chamber magnets and counting and detection equipment will also be required for those groups engaged in the SLAC experimental program. Some examples of planned acquisitions include:

Spectrometer Improvements	$ 415,000
Additions to Large Computer System	1,000,000
Bubble Chamber - Improvement Equipment	250,000
Large Volume Magnets and Power Supply	450,000
Conventional Data Analysis Systems	350,000
Automatic Data Analysis Equipment	200,000
Cerenkov Counter	250,000
Electronics	450,000
Magnets and Power Supplies	300,000
Cameras and Optics	100,000
Superconducting Magnet Development	100,000
Equipment Associated with Accelerator Operations	200,000
Shielding	450,000
Beam Dumps	100,000
Targets and Monitors	185,000

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

8. Oak Ridge National Laboratory (ORNL) ....$ 70,000

The equipment funds requested for the ORNL user group are to permit more effective analysis of bubble chamber events and for the shielding calculation group so that they can gather certain experimental data required to confirm results of their calculation. Some specific items are:

Data Link from Measuring Machines to Main Computer ....$	25,000
Scanning Equipment	20,000
Electronic Equipment	25,000

9. 200 Bev Accelerator ....$ 300,000

In order to carry out testing and modeling programs required for the R&D studies relating to the 200 Bev Accelerator, certain items of equipment are required.

Continuation of the development programs initiated in FY 1967 on the main ring, injector control system, vacuum system and survey and alignment system, will require additional procurements approximating $100,000. The equipment requirements to support the build-up of R&D programs on other critical systems are estimated to require an additional $200,000 and includes oscilloscopes, standard power supplies, small current and voltage regulating equipment and test equipment.

10. Contract Research Program ....$ 1,100,000

Equipment funds requested here support the research programs conducted by university user groups which conduct more than one half of the research at the major accelerators. Thus the productivity of the high energy physics program depends in large measure on the results obtained by the user groups. The principal needs are primarily semi-automatic and automatic scanning and measuring devices and on-line experimental and data analysis systems including computers. The provision of increased capability

PHYSICAL RESEARCH PROGRAM - continued

Section B - Obligations for Capital Equipment not Related to Construction: - continued

A. High Energy Physics - continued

in the automatic data handling area is necessary to make possible the orderly advance of experimentation and analysis into higher energy and higher statistics experimentation. The estimated cost of the apparatus comprising one of these systems is dependent upon the complexity of the system and the extent of cost participation by the University. There are under consideration, active proposals from Carnegie Institute of Technology, Duke University, University of Maryland, University of Rochester and the University of Wisconsin. The total costs of these needs are in excess of $3,500,000. The highest priority requirements will be accommodated within the $1.1 million requested for FY 1968.

B. Medium Energy Physics ....$ 1,650,000

Experimental equipment is required in this program for medium energy accelerators (50-1,000 Mev) and for the research program conducted on these machines. In addition, equipment funds are required for items needed in connection with accelerator design efforts at Ames, LASL, and ORNL. Procurement of additional equipment is necessary because of the general advancement in the technology underlying the science which has provided increasingly complex, but also increasingly expensive experimental and detection apparatus.

The following is a listing of examples of some major items required in this program:

1. Ames Laboratory ....$ 50,000

This request contains a data acquisition system ($10,000), an interface system ($30,000), solid state detectors and several other minor items ($10,000) to be used with the electron synchrotron.

2. Columbia University ....$ 10,000

Detectors and electronic equipment for the mu-mesic x-ray program requires additional items of equipment to sustain a vigorous program.

PHYSICAL RESEARCH PROGRAM

BACK-UP DATA FOR CONGRESSIONAL SUBMISSION

FY 1968 OPERATING EXPENSES

Prepared by:
Division of Research
Budget Branch
December 1966

UNCLASSIFIED

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
High Energy Physics	$ 97,433	$108,073	$116,500
Medium Energy Physics	9,165	11,000	11,100
Low Energy Physics	26,385	28,336	29,400
Mathematics and Computer Research	5,277	6,107	6,200
Chemistry Research	49,579	52,864	55,000
Metallurgy and Materials Research	24,848	26,284	27,600
Controlled Thermonuclear Research	21,768	22,626	26,200
Total Physical Research Program	$234,455	$255,290	$272,000

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
High Energy Physics	$ 97,433	$108,073	$116,500
Ames	375	400	400
ANL	16,398	17,400	18,050
AMU	35	35	35
BNL	20,864	21,300	21,300
CIT	1,478	1,570	1,350
CEA	7,933	8,180	8,450
Harvard 2076	3,349	3,470	3,635
Harvard 2752	1,334	1,350	1,375
MIT 2098	3,250	3,360	3,440
Carnegie 882	879	910	925
Columbia 1932	2,118	2,140	2,140
DUSAF	101	0	0
Illinois 1195	1,400	1,450	1,490
LRL	18,744 1/	19,450 2/	17,500
Michigan 1112	713	735	775
NYU (Computer Rental)	0	223	349
ORNL	374	400	400
PPA	7,494	7,900	8,250
Pennsylvania U. 2171	1,648	1,700	1,750
Princeton 2137	5,846	6,200	6,500
Rochester 875	775	850	925
SLAC	9,092	15,300	21,300
Wisconsin 881	1,616	1,600	1,640
Yale 2726	955	1,020	1,050
200 Bev Accelerator	0	0	2,650
Contract Research	6,089	7,210 3/	7,521

1/ Includes $1,709 - 200 Bev Accelerator
2/ Includes 2,000 - 200 Bev Accelerator
3/ Includes 200 - 200 Bev Accelerator

UNCLASSIFIED

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
High Energy Physics	$ 97,433	$108,073	$116,500
1. PPA	7,494	7,900	8,250
Research	2,723	2,900	3,000
Design and Development of Devices	280	350	350
Operations	4,491	4,650	4,900
2. CEA	7,933	8,180	8,450
Research	4,584	4,710	4,815
Design and Development of Devices	289	270	360
Operations	3,060	3,200	3,275
3. AGS	16,395	18,650	20,000
Research	9,768	11,150	12,100
Design and Development of Devices	3,297	3,750	3,900
Operations	3,330	3,750	4,000
4. Cosmotron	3,372	1,450	100
Research	1,777	850	0
Design and Development of Devices	391	0	0
Operations	1,204	600	100
5. ZGS	15,807	16,800	17,450
Research	7,426	8,800	9,200
Design and Development of Devices	4,570	3,800	3,850
Operations	3,811	4,200	4,400

UNCLASSIFIED

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
High Energy Physics - continued			
6. Bevatron	$ 14,611	$ 15,150	$ 15,200
Research	11,175	11,400	11,400
Design and Development of Devices	250	300	300
Operations	3,186	3,450	3,500
7. SLAC	9,092	15,300	21,300
Research	1,623	5,000	8,500
Design and Development of Devices	6,108	4,525	3,900
Operations	1,361	5,775	8,900
8. General R&D	22,729	24,643	25,750
Research and Development	18,992	20,103	20,910
Design and Development of Devices	239	240	240
Operations	0	300	150
AADS	3,498	4,000	4,450
Research and Development	18,992	20,103	20,910
AMU	35	35	35
Ames	375	400	400
Cal. Tech.	1,478	1,270	1,200
Carnegie 882	879	910	925
Columbia 1932	2,118	2,140	2,140
Illinois 1195	1,400	1,450	1,490
LRL	2,424	2,300	2,300
Michigan 1112	713	735	775
NYU (Computer Rental)	0	223	349
ORNL	135	160	160
Rochester 875	775	850	925
Wisconsin 881	1,616	1,600	1,640
Yale 2726	955	1,020	1,050
Contract Research	6,089	7,010	7,521

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
High Energy Physics - continued			
Design and Development of Devices	$ 239	$ 240	$ 240
ORNL	239	240	240
Operations	0	300	150
Cal. Tech.	0	300	150
AADS	3,498	4,000	4,450
200 Bev Accelerator	1,810	2,200	2,650
LRL	1,709	2,000	0
Undesignated	0	0	2,650
DUSAF	101	0	0
Contract Research	0	200	0
600-1,000 Bev Accelerator	865	975	900
ANL	591	600	600
BNL	274	375	300
Other AAD	823	825	900
BNL (AGS Conversion)	823	825	900

BACK-UP DATA FOR FY 1968 ESTIMATES
CONTRACTOR SUMMARY
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
Ames	$ 6,320	$ 6,755	$ 7,030
AMU	35	35	35
ANL	34,750	36,580	37,664
AI	705	707	712
BMI	98	85	35
BNL	32,707	33,575	34,000
Cal Tech (68)	1,478	1,570	1,350
CEA	7,933	8,180	8,450
Harvard 2076	3,349	3,470	3,635
Harvard 2752	1,334	1,350	1,375
MIT 2098	3,250	3,360	3,440
Carbide K-25 (ORO)	23	50	50
Carnegie 882	1,604	1,610	1,600
Columbia 1932	2,118	2,140	2,140
Columbia Gen. 72	1,155	1,200	1,210
DUSAF (SAN)	101	0	0
Illinois 1195	1,400	1,450	1,490
Illinois 1198	1,366	1,500	1,575
KAPL	451	535	575
LRL	38,114	39,725	39,630
LASL	4,239	5,300	5,700
Michigan 1112	1,572	1,660	1,675
MIT 2098 (Other)	1,120	1,260	1,350
Mound	430	480	480
NYU 1480	1,399	1,915	2,195
Research	1,399	1,140	1,204
Computer Rental	0	775	991
Notre Dame	974	1,000	1,020

BACK-UP DATA FOR FY 1968 ESTIMATES
CONTRACTOR SUMMARY
(In Thousands)

Category and Laboratory	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
ORNL	$ 30,021	$ 31,393	$ 32,434
PNL	1,980	2,100	2,270
PPA	7,494	7,900	8,250
Penn U. 2171	1,648	1,700	1,750
Princeton 2137	5,846	6,200	6,500
Phillips Petroleum	85	140	150
Princeton 2137 (Chem)	139	170	190
PPPL	6,141	6,320	7,270
PRNC	213	252	252
Rochester	1,566	1,470	1,415
SLAC	9,092	15,300	21,300
Wisconsin	1,616	1,600	1,640
Yale	2,340	2,640	2,740
200 Bev Accelerator	0	0	2,650
Contract Research	33,676	38,693	41,473
Total Physical Research Program	$234,455	$255,290	$272,000

BACK-UP DATA FOR FY 1968 ESTIMATES
OPERATING EXPENSES
(In Thousands)

Contract-Research Program - High Energy Physics			Actual FY 1966	Estimate FY 1967	Estimate FY 1968
Cost-Reimbursement Contracts					
Brown University	(Feldman-Shapiro)	Experimental and Theoretical Physics..	$ 296	$ 320	$ 325
Calif., Univ. of	(Piccioni-Kroll-Masek)	Experimental and Theoretical Particle Physics	726	1,050	1,095
Case Inst. of Tech.	(Raines)	Research in Neutrino Physics, Cosmic Rays and Elementary Particles	687	650	625
Chicago, Univ. of	(Dalitz)	Theoretical Research in Elementary Particle Physics	269	335	340
Colorado, Univ. of	(Marshall)	High Energy Physics User Group	220	325	340
Hawaii, Univ. of	(Peterson)	Experimental Elementary Particle Physics	291	340	350
Maryland, Univ. of	(Snow)	Properties of Mesons and Hyperons	955	660	680
Nat. Aca. of Sci.	(Piore)	Site Evaluation Committee	100	20	0
Ohio State Univ.	(Romanowski)	Experimental and Theoretical High Energy Physics Research	151	290	280
Purdue University	(Tautfest-Steffen)	Fundamental Particle Physics	588	670	680
Tufts University	(Knipp)	High Energy Physics User Group and Theoretical Research	209	365	375
Total - Cost-Reimbursement			4,492	5,025	5,090
Other			1,597	2,185	2,431
Total - High Energy Physics			$ 6,089	$ 7,210	$ 7,521

BACK-UP DATA FOR FY 1968 ESTIMATES
CAPITAL EQUIPMENT
(In Thousands)

	Fiscal Year					
	1966	1967	1968	1966	1967	1968
	Obligations			Costs		
High Energy Physics	$21,250	$21,760	$21,750	$16,541	$17,000	$17,000
Medium Energy Physics	1,386	1,400	1,650	2,174	1,750	1,950
Low Energy Physics	6,380	5,500	5,000	5,878	4,950	5,050
Mathematics and Computer Research	427	450	450	360	400	400
Chemistry Research	5,277	5,290	5,270	5,151	5,100	5,150
Metallurgy and Materials Research	2,541	2,600	2,600	2,559	2,400	2,500
Controlled Thermonuclear Research	1,768	1,780	1,780	1,332	1,500	1,700
Other Capital Equipment	5,785	1,300	1,300	3,199	3,400	2,550
Total Physical Research Program	$44,814	$40,080	$39,800	$37,194	$36,500	$36,300

BACK-UP DATA FOR FY 1968 ESTIMATES
CAPITAL EQUIPMENT
(In Thousands)

	Obligations 1966	Obligations 1967	Obligations 1968	Costs 1966	Costs 1967	Costs 1968
High Energy Physics	$21,250	$21,760	$21,750	$16,541	$17,000	$17,000
Ames	200	100	100	34	140	120
ANL	8,474 5/	3,700	3,850	3,735	5,300	5,200
BNL	3,502	3,850	3,700	3,663	3,300	3,300
CEA	1,078	1,150	1,780	1,697	950	1,000
Harvard (2076)	730	650	850	1,150	550	600
MIT (2098)	173	300	300	247	250	200
Harvard (2752)	175	200	630 4/	300	150	200
LRL	1,597	1,200	4,500 6/	2,569	900	1,000
Michigan University	75	0	0	21	0	0
ORNL	90	60	70	36	40	40
PPA	1,000	1,000	1,550	837	800	800
Princeton (2137)	700	700	800	684	650	600
Pennsylvania (2171)	300	300	750 3/	153	150	200
SLAC	4,923	9,800 1/	4,800 2/	3,912	4,922	4,800
Yale (2726)	295	0	0	7	188	90
200 Bev	0	0	300	0	0	150
Contract Research	16	900	1,100	30	460	500

1/Includes $4.5 million for a computer.
2/Includes $1.0 million for additional computing capacity.
3/Includes $0.460 million for an IBM 360/44 or equivalent system.
4/Includes $0.450 million for a Sigma 7 computer and periphery.
5/Includes $4.5 million for a computer.
6/Includes $3.0 million for a CDC 6600 and periphery.

U. S. ATOMIC ENERGY COMMISSION
FY 1968 Budget Estimates
Appropriation - Plant and Capital Equipment

PHYSICAL RESEARCH PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1966	Estimate FY 1967	Estimate FY 1968
A - Obligations for Construction Projects	$37,653,363	$118,168,000	$22,500,000
B - Obligations for Capital Equipment Not Related to Construction.	44,814,306	40,080,000	39,800,000
Total Obligations for Plant and Capital Equipment	$82,467,669	$158,248,000	$62,300,000

Section A - FY 1968 Obligations for Construction Projects:

Project No.	Title	Total Estimated Cost	Estimated Obligations FY 1968
68-4-a	Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York	$ 1,095,000	$ 1,095,000
68-4-b	Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois	1,900,000	1,900,000
68-4-c	Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California	1,740,000	1,740,000
68-4-d	Accelerator improvements, Cambridge and Princeton accelerators	400,000	400,000
68-4-e	Accelerator improvements, Stanford Linear Accelerator Center, California	865,000	865,000
68-4-f	Omnitron accelerator, Lawrence Radiation Laboratory, Berkeley, California, (AE only)	4,000,000	4,000,000
68-4-g	200 Bev accelerator, Du Page and Kane Counties near Chicago, Illinois (AE only)............................	10,000,000	10,000,000
68-6	General plant projects	2,500,000	2,500,000
	Total Physical Research Construction Projects	$22,500,000	$22,500,000

MAR 2 9 1967

HEP FUNDING COSTS

	FY 64	FY 65	FY 66	FY 67	FY 68
AEC - Op.	79,514	87,147	97,433	108,073	116,500
AEC - Eq.	16,949	15,503	16,541	17,000	17,000
AEC - Const.	30,587	47,190	45,546	19,151	22,874
AEC-Total	127,050	148,840	159,520	144,224	156,374
NSF	3,940	8,250	9,000	12,900	11,000
ONR	3,480	3,910	4,700	~~6,900~~ 5.8	~~6,900~~ 5.2 ≅ 2 M$?
Other	920	700	4,000	2,500	2,400
TOTAL	135,390	161,700	177,220	~~166,524~~	~~176,674~~
	8,340	12,860	17,700	22,300	20300

Data status report / Curve

upper curve

change values

3.) Buildings

Change of procedures

1.) Meersmink

General 69?

2.) Commenting on 69 Projection (are they met)

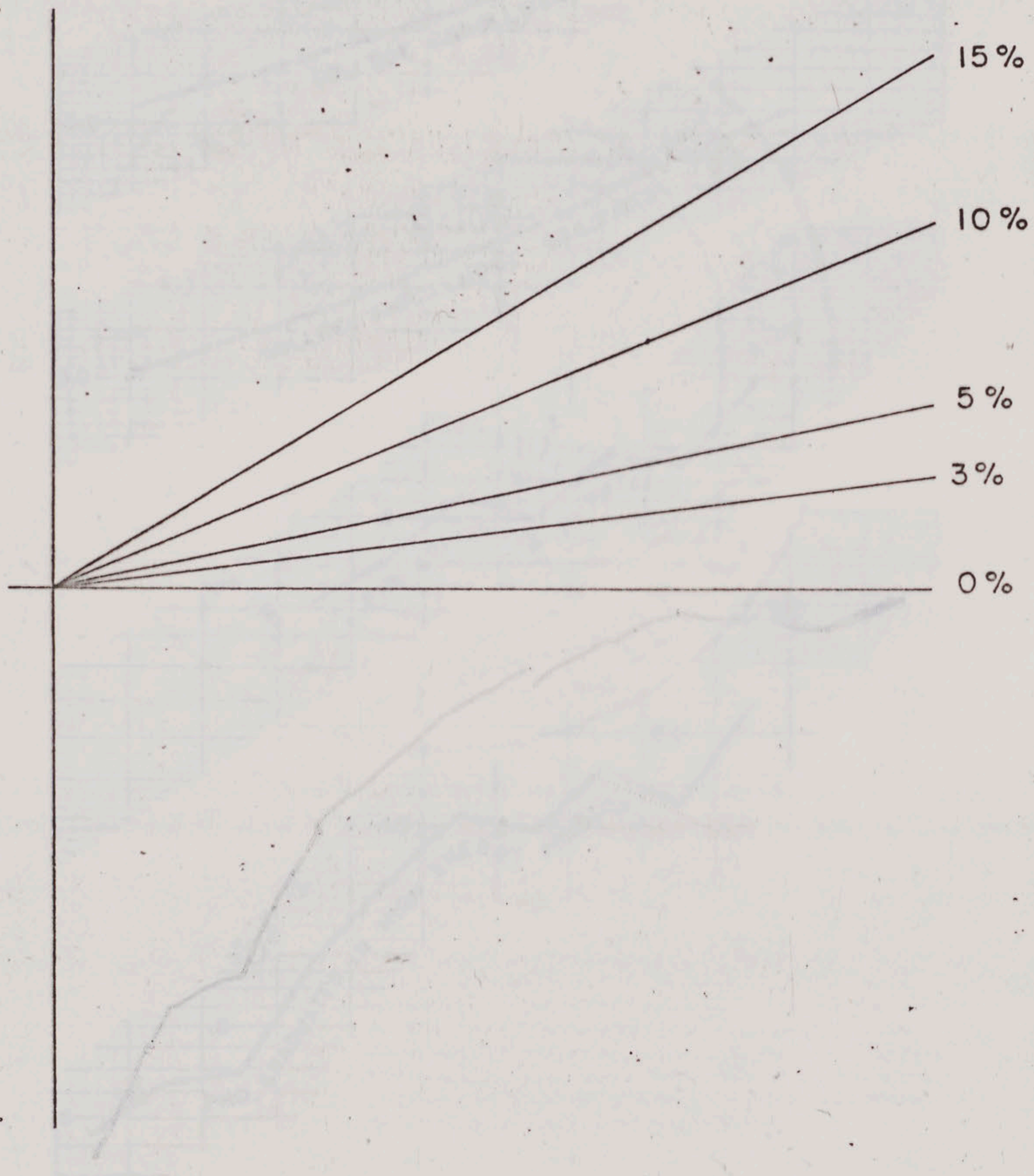
bubble chamber in curve and chart

spell out European escalation

Booklet has practical results.

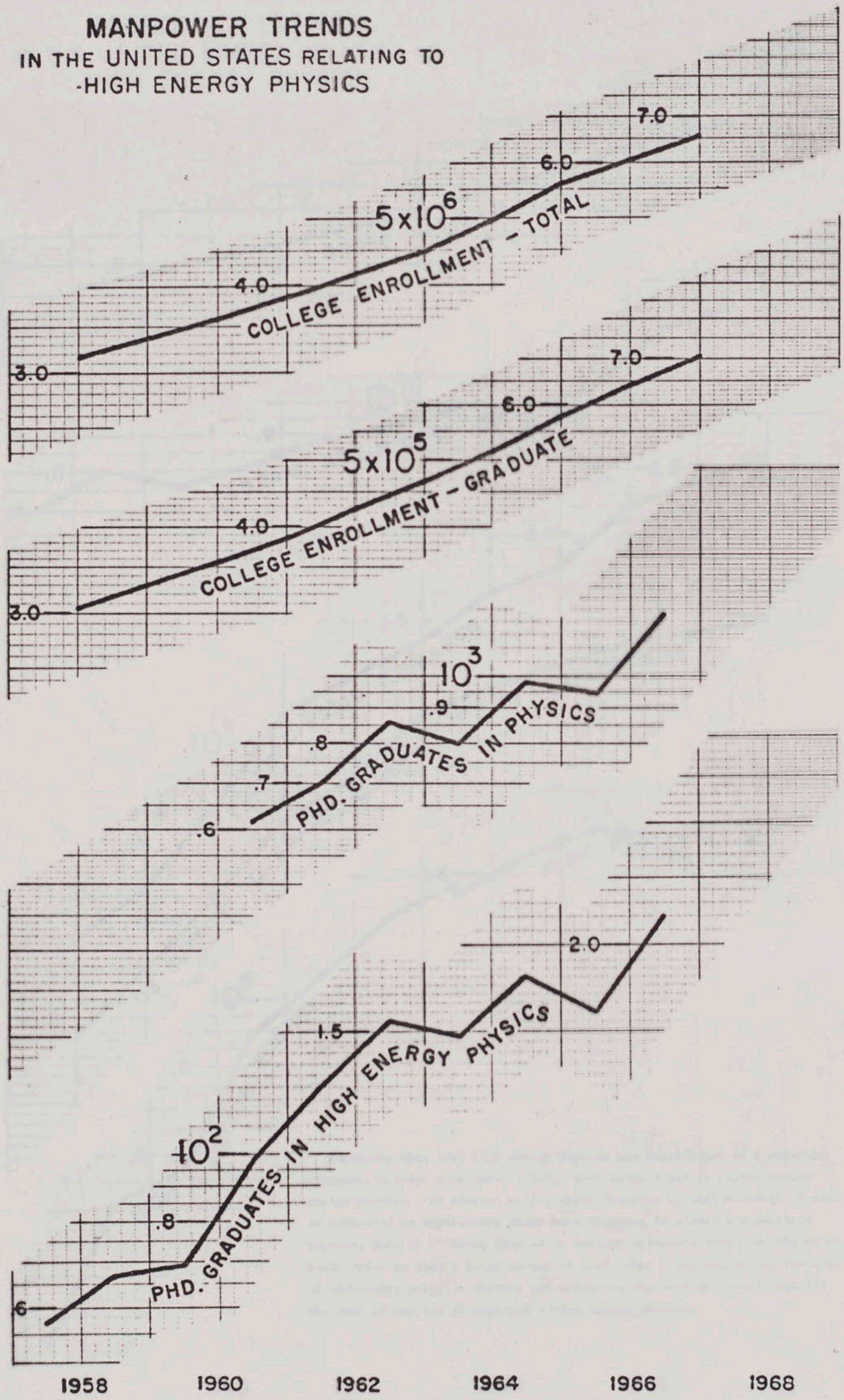
(Letter Pessimism about Meeting)

(La Jolla) Georg Music

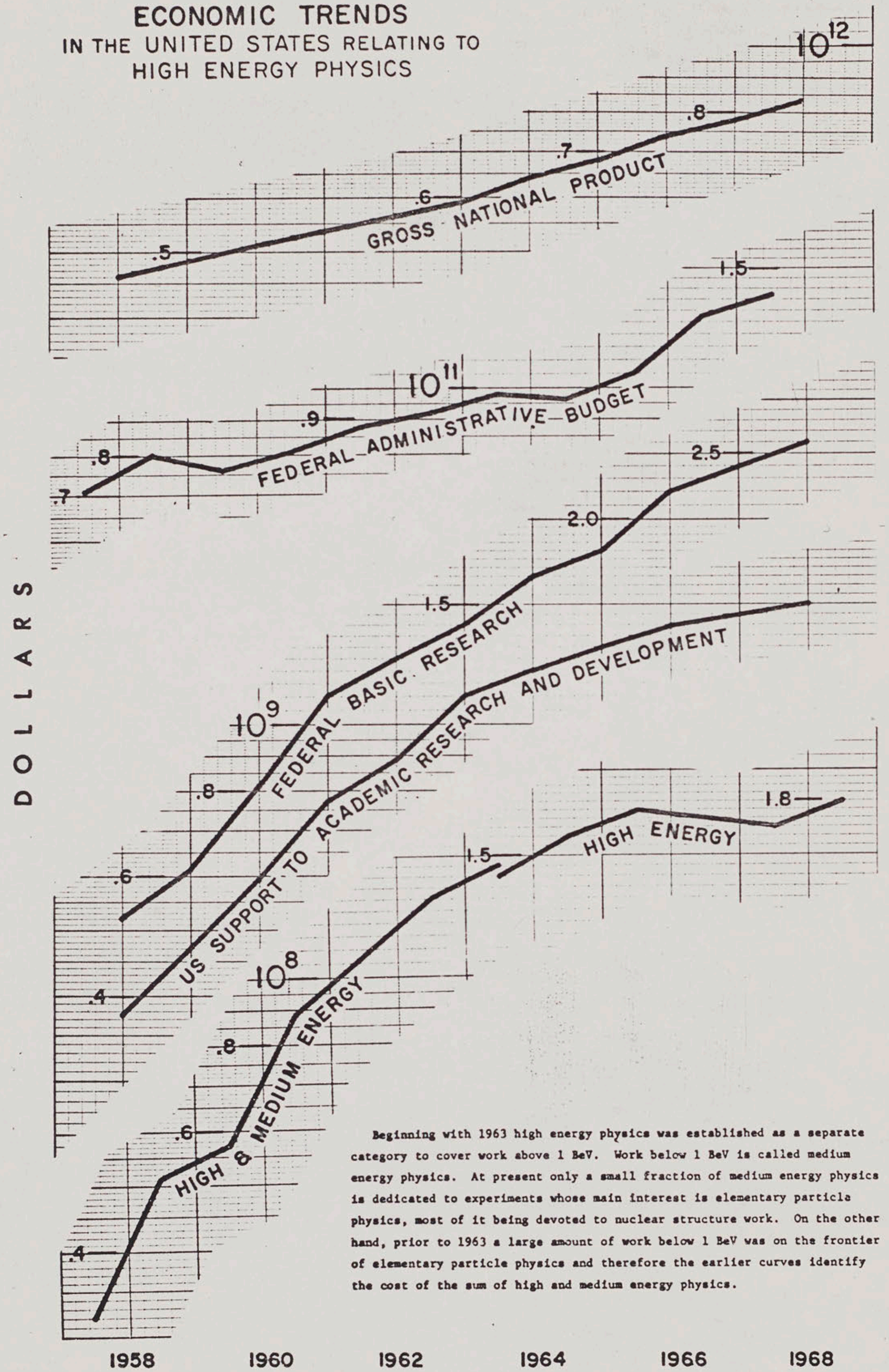


SLOPE—PERCENTAGE INCREASE PER YEAR

MANPOWER TRENDS
IN THE UNITED STATES RELATING TO
HIGH ENERGY PHYSICS



ECONOMIC TRENDS
IN THE UNITED STATES RELATING TO HIGH ENERGY PHYSICS



Beginning with 1963 high energy physics was established as a separate category to cover work above 1 BeV. Work below 1 BeV is called medium energy physics. At present only a small fraction of medium energy physics is dedicated to experiments whose main interest is elementary particle physics, most of it being devoted to nuclear structure work. On the other hand, prior to 1963 a large amount of work below 1 BeV was on the frontier of elementary particle physics and therefore the earlier curves identify the cost of the sum of high and medium energy physics.

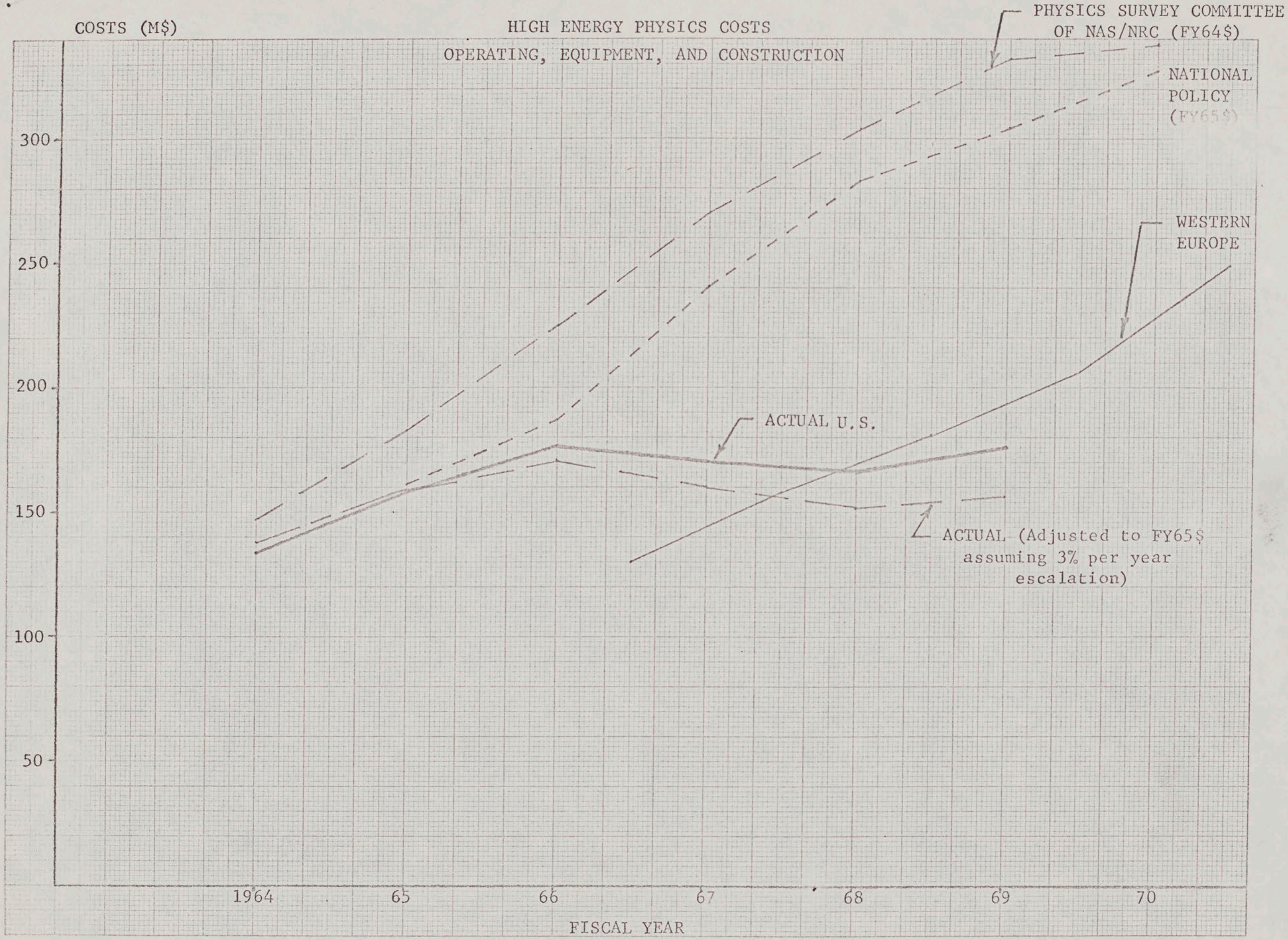
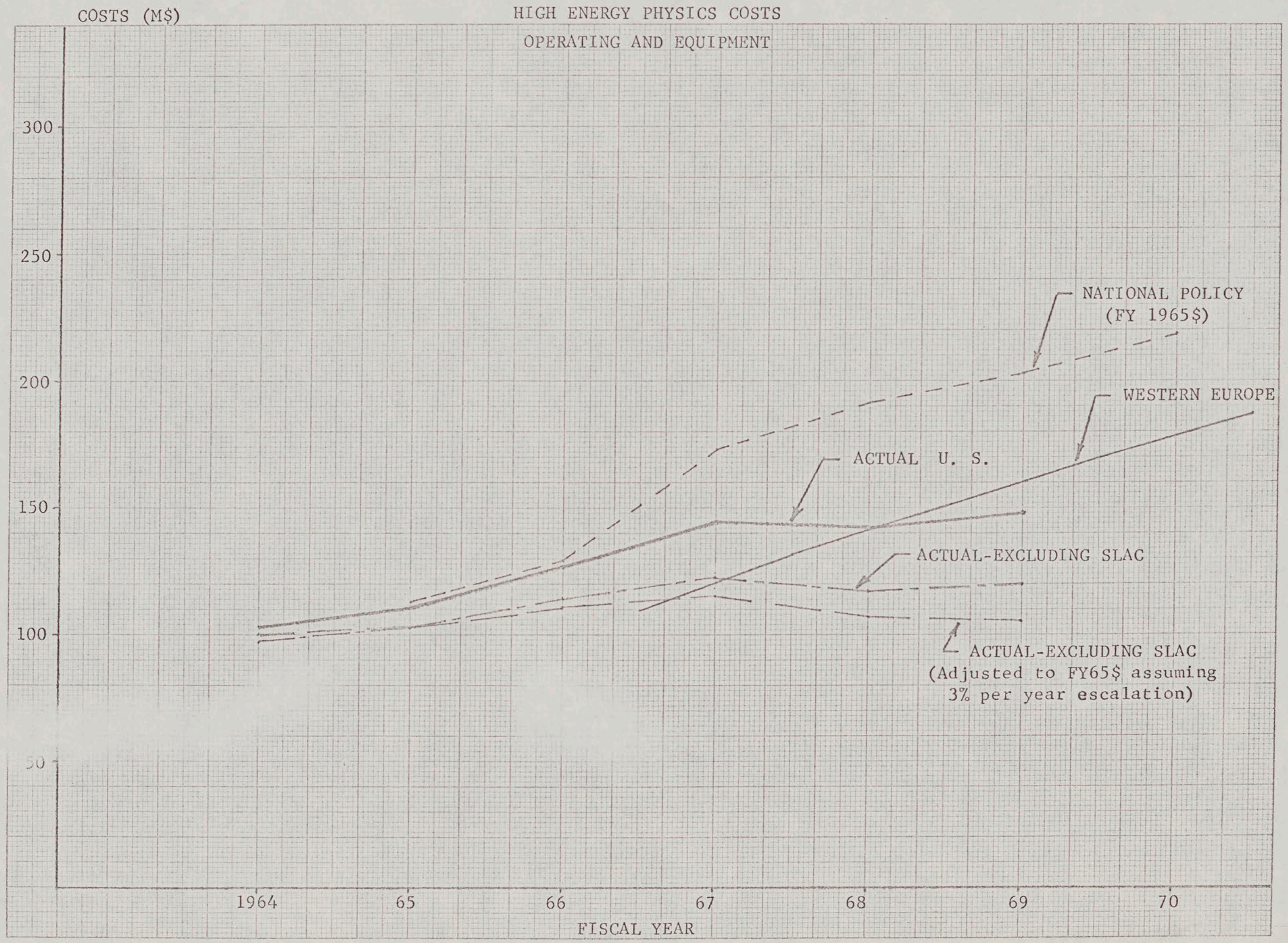
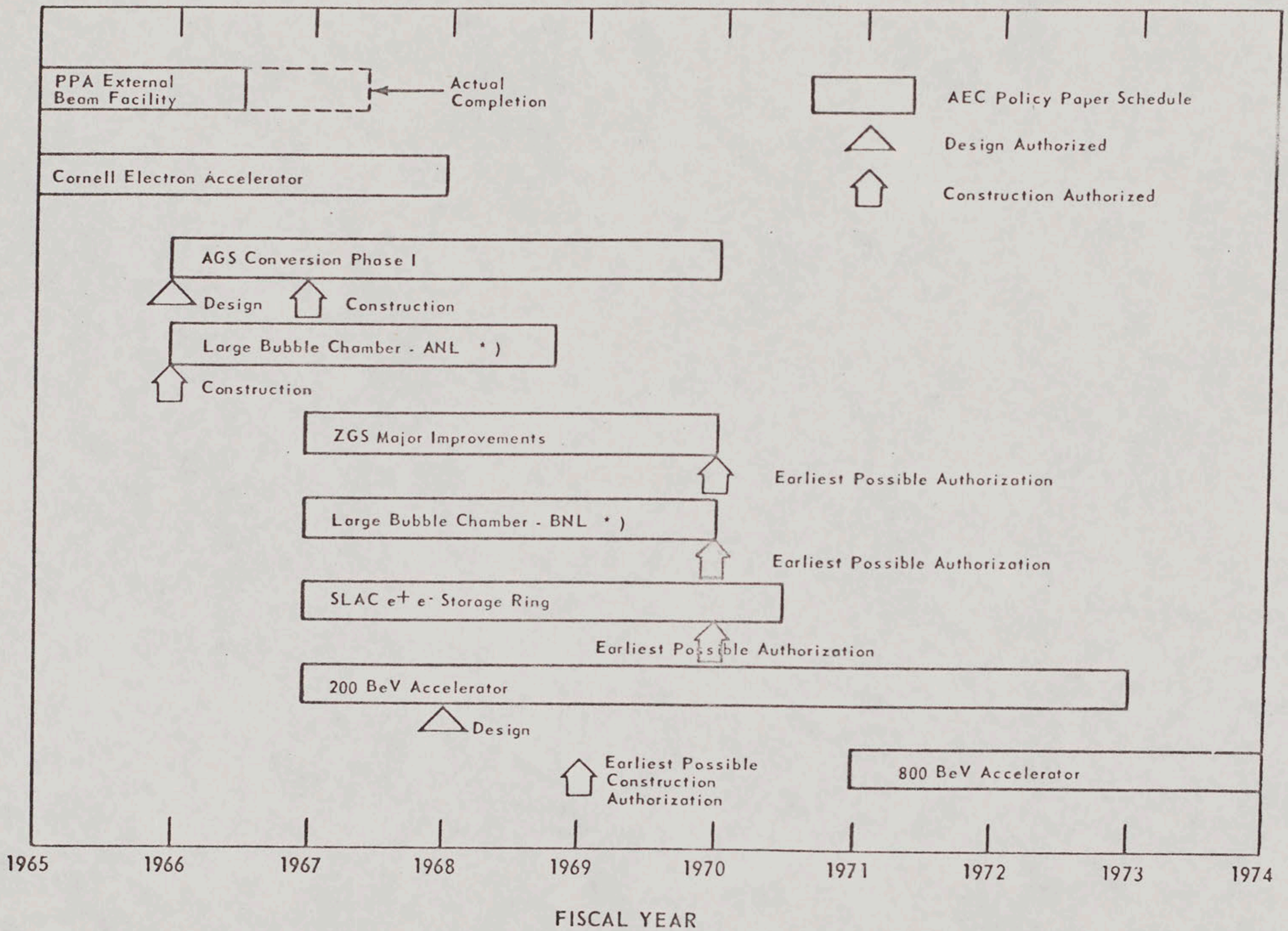

COSTS (M$)
HIGH ENERGY PHYSICS COSTS
OPERATING, EQUIPMENT, AND CONSTRUCTION
PHYSICS SURVEY COMMITTEE OF NAS/NRC (FY64$)
NATIONAL POLICY (FY65$)
WESTERN EUROPE
ACTUAL U.S.
ACTUAL (Adjusted to FY65$ assuming 3% per year escalation)
300
250
200
150
100
50
1964
65
66
67
68
69
70
FISCAL YEAR

Fig. 1b


COSTS (M$)
HIGH ENERGY PHYSICS COSTS
OPERATING AND EQUIPMENT
300
250
200
150
100
50
NATIONAL POLICY
(FY 1965$)
WESTERN EUROPE
ACTUAL U. S.
ACTUAL-EXCLUDING SLAC
ACTUAL-EXCLUDING SLAC
(Adjusted to FY65$ assuming
3% per year escalation)
1964
65
66
67
68
69
70
FISCAL YEAR

MAJOR CONSTRUCTION ASSUMPTIONS
1965 AEC POLICY PAPER VS. AUTHORIZATIONS RECEIVED OR PLANNED



*) THE AEC POLICY PAPER INDICATED THAT 2 TO 3 LARGE BUBBLE CHAMBERS SHOULD BE STARTED WITHIN 1 TO 3 YEARS OF FY 1965 (Page 42, Item No. 8). THE LARGE CHAMBER REQUESTED BY BNL WAS TO FOLLOW THE FY 1966 AUTHORIZATION OF ANL'S CHAMBER.

FIG. 2