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PROJECT SUMMARY

CENTRAL DESIGN GROUP (CDG)

The attention of the Magnet Division has been focused on the design of the long magnet ends. Long magnets are affected differently than short magnets by axial forces due to preload, residual assembly stresses, thermal contraction, and magnet forces. Theoretical and experimental studies of the ends will enable the factors affecting their performance to be better understood. Other work included analysis of the end plate and spacer rings; interpretation of a final report on the response of the dipole magnets to seismic and transportation loads; material property studies of the magnet yoke steel (in collaboration with BNL and LBL); calculation of stresses during energization of two short magnets; further magnet system reliability/availability studies (in collaboration with R. E. Barlow of the University of California Engineering System Research Center); study of the effects of manufacturing tolerances on dipole magnet field quality; examination of forces on a bore tube made of aluminum alloy plated with pure aluminum; planning further analysis of dipole sensitivity to variation in both vacuum and shield temperatures and to high coil temperture following a quench.

The Accelerator Physics Division efforts during October included tolerance studies of magnet end-field multipoles and comparisons of tolerance requirements to existing data, fifth-order nonlinear dynamics analyses and algebraic programming, more SSC lattice beam bypass design work, further development and evaluation of database management systems, and further investigation of beam-beam effects.

The CDG organized a workshop on distributed multipole correction coils at BNL on October 13-14.

A task force to estimate the residual radioactivation of SSC accelerator and potential detector components met at the CDG October 1–2. The members were J. D. Cossairt (FNAL); G. Drouet (CDG); K. Edwards (CDG); M. Gilchriese, Chair (CDG); D. Groom (CDG); C. T. Murphy (FNAL); K. O'Brien (consultant to the CDG); S. Pichler (CERN); G. Stevenson (CERN); and T. Toohig (CDG). The estimates produced by the task force will provide information for the environmental impact study of the SSC, which is being prepared by the DOE and consultants. A draft task force report was produced and distributed to members for review. A final report will appear in November as SSC-SR-1029.

The Conventional Systems Division met with DOE representatives October 21 at the CDG to discuss SSC operational safety. The Division also participated in the task force on radioactivation. Good progress was made on the draft Safety Review Document.

Closing the accounting books for fiscal year 1987, preparing them for their annual outside audit by Ernst and Whinney, and preparing for the quarterly DOE review dominated activity in the Project Planning and Management Division during October.

The DOE quarterly review was held at the CDG October 22-23.

The CDG hosted the International Advisory Committee on Generic Detector R&D October 25-27. H. H. Williams (University of Pennsylvania) chaired the meeting.

BROOKHAVEN NATIONAL LABORATORY (BNL)

Activities for October centered on the collaring and assessment of long magnet DD0010; initial assembly of DD0011 and DD0012; assembly and testing of short magnet DSS6; assembly of DSS9.

Performance of DSS6 was excellent, with virtually no training necessary to reach its short sample at 4.5 K. Field measurements were also encouraging.

FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)

SSC magnet D000Z was completed on October 2 and delivered to the Magnet Test Facility. About two weeks later it was ready for tests. The performance of D000Z resembled that of D000X, in that eleven quenches were required to reach the short sample plateau. On the thirteenth quench, a ground fault trip occurred. On the fourteenth quench, magnet insulation on one of the turns failed and the conductor was damaged. No further testing was possible. The magnet cold mass will be removed and shipped to BNL for an evaluation of the possible causes of failure.

The cryogenic feed and turn around cans for the second SSC test stand at the Magnet Test Facility have been delivered and are being installed. Commissioning is complicated by the need to accommodate over a hundred additional analog data channels for coil voltage taps. The objective is to commission the stand using a previously tested SSC dipole. Commissioning is expected to be complete in January.

Cryostat subassemblies are being prepared in anticipation of the arrival of magnet coil/cold masses for DD0010 and the subsequent cold masses BNL will ship.

Parts for the dipole tooling are beginning to arrive and assembly is under way.

The change to the design B cryostat configuration will begin with the next cold mass after DD0010. The changeover will be complete two magnets later. The third B cryostat will be extensively instrumented to document the performance of the new features.

LAWRENCE BERKELEY LABORATORY (LBL)

Orders were placed for the remaining cable needed for the FY88 dipole magnets.

Testing of 1-meter dipole model D15A3 was completed with 1.8 K operation at 9400 A. No loss of training occurred after two successive warm-up cycles to 290 K and 340 K. (This magnet had one outer layer training quench when initially energized to 6212 A.)

A major effort continues to be assembly of magnets DSS9, DD0011, and DD0013 at BNL, as well as building and calibrating instrumentation for them.

Models D15A4F (Furukawa Cable) and D15A5 (DD0011 cable) are ready to collar.

A new data acquisition system for magnet testing and a system for general magnet analysis on a Sun-4 computer are being acquired.

TEXAS ACCELERATOR CENTER (TAC)

TAC received ten DS6000 diodes that were ordered in September. The radioactive cryostat was cleared for transport by Texas A&M and is at TAC. After careful evaluation, the cryostat will be prepared for testing the DS6000 diodes down to liquid helium temperature. This testing and cool down should be completed by the middle of November.

CDG REPORT

MAGNET PROGRAM

MSI Meeting

The monthly CDG Magnet System Integration Meeting was held at Fermilab on October 6, 1987.

The agenda for the meeting was as follows:

SSC program plans and budget update	CDG
End design requirements	CDG
End design comments and discussion	General
Status of 17-meter magnets Z,10,11,12,13	FNAL/BNL
Cryostats for 17-meter magnets 10,11,12,13	FNAL
Instrumentation on 17-meter magnets Z,10	BNL
Test results 1.8-meter magnet DSS4	BNL
Test results 1-meter magnet D15A3	LBL
Test plans for 1.8-meter magnet DSS9	LBL
Error budget studies	CDG/BNL
Tooling schedule report	FNAL
Superconducting cable status	LBL
FNAL plans for using mole/small mole	FNAL
Review of test stand	FNAL

CDG Director M. Tigner announced that he had reluctantly accepted V. Karpenko's request to be relieved of his duties as head of the Magnet Division for reasons of health. J. Peoples, from Fermilab, will take over these duties; E. Goldwasser will act as his deputy.

Magnet R&D program plans call for building and testing five long magnets by the end of March, 1988, although the budget is still uncertain.

V. Karpenko (CDG) started a discussion of the design of the coil ends of the long magnets by elaborating on the design requirements. He emphasized that the design must be limited to elastic behavior, discussed the need for sufficient prestress in the ends, and described a method for improving the mechanical support of the ends. R. Schermer (CDG) then suggested some possible improvements to the end design and described effects related to thermal contraction.

A. Morgan (BNL) described how details of the current BNL end design are based on criteria of low peak field, good harmonic content, and ease of construction. He also discussed

constant perimeter end design, in which superconducting cable is subjected to the minimum applied stress.

J. Carson (FNAL) also emphasized the desirability of constant perimeter ends and discussed the advantages of an internal support cone. C. Taylor (LBL) described a proposal for bulging the ends of the coils and using an internal support cone. This would simplify the manufacturing process and improve reliability.

The status of the next five long magnets was reported. D000Z is on the test stand at FNAL, being prepared for tests (test results are presented in the FNAL section of this report); the cold mass for D0010 will be shipped from BNL to FNAL on November 18; the cold mass for DD0011, the first long aluminum-collared magnet, is being assembled; DD0012, which is almost identical to DD0010, and DD0013, which is almost identical to DD0011, are being fabricated and are due to be shipped on December 16 and January 18, respectively. The assembly at FNAL of cryostats for these magnets will keep pace with the cold mass delivery schedule.

Improved instrumentation is being installed on the long magnets. Extensiometers and strain gauges will detect axial motion and revised load cells will measure coil prestress. Long magnet DD0010 also has 134 voltage taps for quench location.

Short magnet DSS4, which was retested with unrestrained ends, had exhibited erratic quench characteristics when cooled below 4.5 K. It is now believed that this behavior can be attributed to temperature stabilization problems.

The excellent test performance of magnet D15A3 was reported by LBL, and a plan for testing DSS9, the aluminum-collared precursor to DD0011, was presented.

As part of a study of permissible tolerance for coil components, BNL proposed to manufacture a series of coils using varying parameters. The CDG will evaluate this proposal.

Following some further brief status reports, M. Kuchnir (FNAL) presented a new method of measuring the thermal conductance of superconducting strands.

General Progress

As a result of the recent test program, attention has been focused on the design of the ends of the long magnets. There are axial forces in these magnets due to preload, residual assembly stresses, thermal contraction, and magnet forces. Effects resulting from these forces in the long magnets differ both quantitatively and qualitatively from effects in short magnets. Within the CDG the magnet ends are under analytical study. In addition, a test plan is evolving that, with the cooperation of participating laboratories, will lead to a better understanding of the factors affecting the performance of magnet ends.

Good progress was reported on theoretical studies, including a review of the Lorentz forces that have been calculated for other accelerator magnets and BNL calculations for the C358A cross section. During past testing of the magnet assembly, the spacer rings and the end plate were

instrumented with strain gauges to determine their behavior under axial loads that simulate the quench condition.

To evaluate the response of the end plate and spacer rings, the EQE company initially constructed finite element models of the end plate and clip, spacer rings, and the epoxy filler. They assessed which aspects of the model would most affect response. Model boundary conditions at the interfaces between the clip and the vacuum vessel and between the spacer ring and the collar, material properties of the epoxy filler, and contact interaction between model components were identified as parameters important to end plate response. A series of finite element analyses was conducted in which these modeling parameters were varied. Analysis results provided a range of spacer ring strains and end plate displacements and strains. The range of values reflects uncertainty in defining actual material properties and component interactions. A summary of the results shows that given an axial load of 15,000 pounds, the end plate deflects a maximum of about 55 mils. This deflection results in approximately 2500 microstrain units on the top surface of the plate.

A new IBM PC-AT personal computer has been received by the Magnet Division to assist in the exchange and storage of magnet-related information. Open Plan is being used to develop project plans that will be integrated into the SSC planning and management system. The PC is connected to local and to national networks.

Database planning is proceeding on two fronts: participation in the LBL Database Resource Group meetings and collaboration with the SSC database definition task force. The Magnet Division is exploring the use of the INGRES database system on the Sun computer used by the Accelerator Physics Division, and the Database Resource Group is comparing databases already in use at LBL by solving the same test problem in each of the database languages.

SSC materials data records are now available on a computerized database, and work on materials properties is continuing.

Material property studies of the magnet yoke steel are under way in collaboration with BNL and LBL. The goal is to determine technical procurement specifications that are cost effective and that satisfy magnet system performance and reliability requirements. Steel vendors are providing special test data on their candidate steel materials.

Progress is reported on the National Bureau of Standards tests on the beam-tube weld (Program A) and on the aluminum alloys that may be used in the aluminum-collared magnets (Program B). The tests are scheduled to be completed next year, the former in February and the latter in May.

The CDG recommendation to use ASTM A537 grade A steel for the vacuum vessel material has been accepted by FNAL. FNAL has started a cost and availability study to compare this material with earlier baseline materials (C1020 carbon steel and SA5166 steel).

In response to a CDG request, the LLNL Materials and Evaluation section has submitted a proposal to provide three-dimensional materials properties of the coil at normal and at cryogenic

temperatures. Precise values of these properties are required for the three-dimensional analysis calculations.

Two-dimensional analysis codes were used to calculate stresses during energization for two short magnets: steel-collared DSS6 and aluminum-collared D15A3. The calculations emphasized the importance of friction and compared well with values measured during tests at BNL and LBL. (Ref. SSC-N-399, 23 October 1987, "Comparison of NIKE2D with Strain Gauge Pre-Stress Measurements at BNL and LBL.") An earlier publication (SSC-126, 7 April 1987, "Non-Linear Finite Element Analysis of the SSC Superconducting Magnet") contained calculations of cool-down, operational, and quench-induced stresses for both aluminum and stainless steel collars. These calculations have been refined using a bi-linear coil model based on materials properties data of the coil recently obtained at BNL by Goodzeit and at LBL by Zbasnik. Both aluminum and stainless steel collars were investigated. Again, the importance of friction in all aspects of operation was emphasized. The results have been presented orally and will be published shortly.

The codes MAZE, TACO, NIKE 2D, and ORION are now being adopted by the Accelerator Systems Division with the help of the Magnet Division. They will be used to solve transient thermal stress problems.

The EQE company submitted a final report on the dynamic analysis of dipole magnets that shows the response of the cold mass, cryostat, and supports to seismic and transportation loads. This analysis indicated that stiffening the central posts and vessel support legs will be required to meet the stated dynamic environment. The proposed increase in lateral stiffness will shift the natural frequency of the system away from the amplification region of the seismic response spectra. The scope of work was extended to evaluate SSC magnet response to ambient vibration environments. Effects that concern beam motion due to magnet motions are described, and an estimated tolerance on magnet motion is given in the SSC Conceptual Design Report. Such vibrations can be manmade (rail or vehicle traffic) or natural (ground subsidence or other geological phenomena). Given the vibration excitation, dynamic analysis will be conducted to determine magnet responses and to compare them with design tolerances. Also, a scope of work was prepared and a proposal received from Vibration Engineering Consultants, Inc., to perform model analysis tests on the dipole magnet to verify previously described dynamic analysis calculations performed by EQE. The process involves exciting magnets with an instrumented shaker and measuring response to input. This test will provide actual characteristics of the structure, including mode shapes, frequencies, and damping ratios. The analytical model can then be verified by comparing the eigenvalues and eigenvectors with measured model frequencies and mode shapes.

The final report on the integrated thermal model of the dipole magnets was received. Based on a review of the report, the General Dynamics Company, which prepared the report, was requested to submit a proposal for additional design modification and optimization studies. The proposal was reviewed and accepted by the Magnet Division. The sensitivity analysis will be

extended to include wider variation in both vacuum and shield temperature parameters. The effect of high coil temperature following a quench will be analyzed.

As previously reported, the predicted coil temperature rise of 0.174 K, due to synchrotron radiation, will require more detailed examination. The model and all thermal material properties will be re-evaluated. Estimates will be made of the benefit derived from the mixing of helium in the beam tube annulus and yoke cooling channels, caused by natural convection in the gaps between collar and yoke lamination sub-assemblies.

R. E. Barlow, of the University of California Engineering System Research Center, and Magnet Division staff continued reliability/availability studies. A preliminary listing of failure modes and effects analysis for critical components was prepared. Thirty-seven critical areas were identified. Failure modes and effects were defined. The Magnet Division reviewed this list and resubmitted it to Professor Barlow for further analysis. The next step is to assign best available failure rates to each item. This study, as indicated before, focuses attention on the necessity for a high degree of engineering excellence in all facets of magnet analysis, design, materials fabrication, and assembly, in order to achieve acceptable system availability levels.

Work continued on a study of the effects of manufacturing errors (tolerances) on field quality for the ring dipole magnets. Analyses have been published of the effects of random turn-to-turn variations in the conductor thickness, and of a linear taper in the thickness of the conductor from one end of a winding to the other. In the previous analysis of the effects of turn-to-turn conductor thickness variation, it is implicitly assumed that the thickness changes suddenly at the end of each half turn. A more realistic assumption is that the thickness changes at random positions along the conductor, as a reflection of conductor properties, turkshead temperature-distribution changes, and turkshead readjustments. If the distance over which the thickness changes is very short in relation to the length of the magnet, then the effect on field quality is very small. On the other hand, if that distance is very long in relation to the length of conductor in one winding, the effect on field quality is again very small. For intermediate distances, however, where the distance for thickness variations is comparable with the magnet length, the effect on field quality can be large. An examination is under way of the effects of random conductor thickness changes at random positions along the conductor.

An investigation of forces on an aluminum-alloy bore tube plated with a pure aluminum was started. It soon became apparent that there is insufficient reliable information concerning magnetoresistive effects on aluminum and its alloys. Further pursuit of the subject awaits measurements.

Effects of Multipoles in Magnet End Fields

Tolerance of the SSC to end-field magnetic perturbations. The tolerance of the SSC design to the multipole components of the dipole magnet end fields was studied. A preliminary estimate of the tolerance to the end-field sextupole component, based upon the stop-band width of a sixth-order betatron resonance, is that the integral of the sextupole strength at 1 centimeter, over the end region, satisfy

$$\frac{1}{B_0} \int_{end} B_2(z)dz \leq 5 \times 10^{-4} \text{ m} \quad ,$$

or 5 "sextupole unit" meters. A more extensive analysis is under way. The tolerance to other multipole components has not yet been examined.

Comparison of tolerances with existing experimental information. The end fields of several hundred Tevatron dipoles were measured after construction, and their multipole distribution is known. The Tevatron dipoles have an inner coil winding diameter of 7.6 cm. Scaling these data to the SSC winding diameter of 4 cm, the resulting average integrals of the end-field multipoles at 1 cm would be

Sextupole $(b_2l)_{end}$	=	–20 unit-meters
Octupole $(b_3l)_{end}$	=	–0.1
Decapole $(b_4l)_{end}$	=	–1.6
12-pole $(b_5l)_{end}$	=	–0.005
14-pole $(b_6l)_{end}$	=	0.13
18-pole $(b_8l)_{end}$	=	–0.32

The end fields of LBL model D14B dipoles were tailored to produce minimal end-field multipoles. Beginning with a design that approximated a theoretically neutral end field, two iterations were required to systematically reduce the sextupole end-field integral from 4 to 0.2 unit-meters and to reduce the decapole end-field integral from 0.18 to –0.06 unit-meters. This method of reducing the end-field components through iteration is seen as very effective and will be pursued in the future.

The magnetic field of the first long SSC dipole, D0001, which had dog-bone ends, was measured over its length in 2-foot steps. Because of the uncertainty in the exact position of the mole when it measured the magnet ends, the end-field multipole integrals are quite uncertain.

The approximate value for the sextupole end-integral is, to within a factor of two, 40 unit-meters. That is not unexpected, as the dog-bone end was not designed to be magnetically neutral.

Analysis of Nonlinear Dynamics

The SSC design code TEAPOT was upgraded in order to allow extraction of fifth-order transfer maps from a lattice design. These maps are obtained in a direct and straightforward manner, using differential algebraic methods. In this approach, all arithmetic operations required to track individual particles through a lattice are performed with elements of the differential algebra. This process is facilitated by the use of the differential algebra precompiler DAFOR.

The fifth-order TEAPOT was compared with the fifth-order code COSY. COSY uses a library of formulas describing the terms through fifth order, generated by the formula manipulator HAMILTON. Both codes were used to generate fifth-order maps for the Los Alamos proton storage ring. These maps were found to agree to five digits for every term through fifth order. This result serves as an excellent check for both COSY and TEAPOT, as the two methods of extracting the maps are completely independent.

Additional software was developed to translate the differential algebraic maps into a Lie algebraic representation of the fifth-order analysis routines. With these tools the TEAPOT map was verified to be symplectic to computer precision. The first- through fourth-order chromaticities, as well as the first- and second-order tune shifts with amplitude, were calculated using the fifth-order maps of TEAPOT and THINTRAC for an SSC cell with a systematic b_2 of three units. These numbers agreed to within one part in 10^4.

Further Beam Bypass Design

Another design for a possible beam bypass for the SSC has been developed. This design is a variant of the triple interaction region bypass developed this summer. In this version, each bypass leg, containing three interaction regions, has no net horizontal bending. Radiation spray from one leg into the detector regions of the other leg is thus eliminated. The interaction regions in the two legs are separated by 50 and 100 meters (outer and center). The bypassed region is between two short utility regions, suitable for injection into the two rings. The entire length from utility to utility will fit into the land area specified in the Invitation for Site Proposals. Because the utility regions have been shortened, the beam aborts must be in the opposite straight section.

ICFA Panel Meeting

The third meeting of the ICFA Beam Dynamics Panel was held on October 1–3 at LBL, just prior to the ICFA Seminar at BNL. Members from Novosibirsk, CERN, KEK, DESY, Cornell, BNL, CEBAF, and SSC/CDG were present. The panel discussed the organization of the next Beam Dynamics Workshop, to be held in Lugano, Switzerland, in April 1988, on the subject of

aperture limitations. Each panel member gave a presentation of the beam dynamics activities (ongoing as well as planned) of his region. Special speakers from SLAC, FNAL, and LBL gave reports on their activities. These reports are to be assembled into a newsletter and published as a DESY special report. The possibility of organizing an elementary-level school, perhaps on the subject of storage ring physics, was also discussed. This would be specifically for the benefit of the third-world countries, whose participation in ICFA activities has been relatively small. The meeting approved a status report by the panel to ICFA.

Database Development

An evaluation of commercial relational database management systems continued, along with the design of an SSC-wide integrated database architecture. A lattice-description database was installed on the Sun workstation system under INGRES. This database is accessed by C programs to generate a prototypical skeleton description of the SSC and a lattice input file in a standard format. Such a skeleton description will form a common node through which data distributed throughout the SSC site may be accessed. The same lattice data set and high-level programs will soon be installed under SYBASE for comparison purposes.

Beam-Beam Effects

The code TALD4, written and tested in the past months, is now being used to investigate both the stability of tails of the SSC particle bunches under the influence of short and long range beam-beam interactions, and the non-linear fields in the interaction region triplet quads. Preliminary results indicate four conclusions of interest:

- Motion in the tails is sensitive to machine tune, and resonant-like behavior occurs at identifiable coupling resonance lines.
- Particles at radii greater than seven times the core radius diffuse quickly to larger radii and are lost. (It has been assumed in calculating the long range beam-beam force that the bunches are separated by seven core radii.)
- When the tune is modulated at the proposed synchrotron tune by a depth of 0.001, then particles at radii greater than four to five times the core radius are lost.
- Inclusion of the interaction region quadrupoles with strength of the multipoles as proposed in the most recent design specifications affects this situation only slightly.

Further work will investigate how particle loss is influenced by the frequency and depth of tune modulation, by the change of initial tune values, and by the separation of the bunches as

they approach the intersection point. Particulars of the loss mechanism will be studied in further detail.

ACCELERATOR SYSTEMS

SSC Workshop on Distributed Multipole Correction Coils

The SSC Workshop on Distributed Multipole Correction Coils was held at Brookhaven National Laboratory, October 13–14. The workshop was organized by the SSC Central Design Group. Its purpose was to discuss the present status of specifications and designs for distributed actively-powered multipole correction coils (i.e., bore tube windings) for the SSC. Twenty-five persons participated, including seven from industry and one from DESY. A written report of the workshop results will be prepared.

The Workshop was organized into four consecutive sessions to discuss the following topics: requirements for distributed correction coils, distributed correction coil designs, materials issues, and future plans for R&D. The following conclusions were drawn:

(1) Distributed multipole correction coils represent a feasible, flexible method of correcting magnetic field errors in the SSC.

(2) Considerable progress has been made at BNL on developing a technique to manufacture distributed correction coils. (Industry has played a very important role in this effort.)

(3) Preliminary results from an experiment to study radiation damage to organic materials can provide some guidance in selecting the best materials to use in correction coils.

(4) A plan has been developed to build and test many short correction coil models before long models are constructed. This plan permits many design options to be studied in a short time.

CONVENTIONAL SYSTEMS

Task Force on Radioactivation

Members of the Division participated in the task force on radioactivation at the SSC on October 1–2. The meeting was chaired by M. G. D. Gilchriese and held at the CDG. The charge was to identify those elements of the SSC complex that may become significantly radioactive during the potential life of the SSC, and to estimate the levels of activation where appropriate. A major motivation was to provide information for the environmental impact process connected with selecting a site.

Valuable contributions were made by CERN participants, who had carefully planned and documented the dismantling of the Intersecting Storage Ring and the West Area. Fermilab participants provided important information on their radiation experience for various repair and construction activities, as well as detailed information on the design considerations and calculations for the Tevatron abort dump at C-zero.

Operational Safety

A meeting on operational safety for the SSC was held October 21 at the CDG with representatives of DOE's Environment and Health, Energy Research, and Chicago Operations. The morning was devoted to detailed discussions of the relative roles of each DOE unit in support of operational safety at the SSC. One immediate need that was discerned was communication about the developing safety-related design plans of the CDG. A committee was formed that included a representative of each DOE entity and the CDG. The committee was charged with ensuring that developing plans are mutually communicated and with assisting preparation of responses to information requests. The Committee has already proven helpful in making available to the CDG the expertise required to answer questions about various design requirements.

The afternoon was dedicated to a CDG presentation on the foundation of safety provisions in the present SSC design. G. Drouet, on loan from CERN, made an excellent presentation on operational safety at CERN. He paid special attention to the LEP tunnel, which has exit spacings not greatly different from those in the SSC design. He had acquired an advance copy of the comprehensive safety report for the LEP project submitted to the French government. The thorough report and Drouet's talk helped to illuminate many of the parallel safety concerns for the SSC. P. VanderArend presented a preliminary report of a detailed study of cryogenic safety in the SSC tunnel. The report is being prepared under contract to the CDG.

Safety Review Document

Concentrated efforts to prepare a comprehensive draft of the Safety Review Document were greatly advanced by the presence at the CDG of L. Jones (University of Michigan) and K. Edwards (Carleton University). Both are spending sabbatical leave periods at the CDG.

Quarterly Review

In concert with the rest of the CDG, the Conventional Systems Division reviewed their program for the last three months and presented a program projection at the DOE quarterly review on October 22–23. The review focused on studies relating various lattices to the template specified in the Invitation for Site Proposals. The program projection explored the steps leading up to the

beginning of construction in relationship to milestones specified by DOE. Meeting the milestones requires an accelerated schedule of activities.

The Conventional Systems Division was represented in a group working to define database needs and to explore database options for the CDG. Weekly meetings, one with staff from the LBL database design group, were held during the month.

PROJECT PLANNING AND MANAGEMENT

Year-end closing of the FY87 accounting books, preparations for outside auditors, and preparations for the quarterly DOE review were the predominant activities in October.

A workshop on Distributed Multipole Correction Coils for SSC Dipoles was held at Brookhaven National Laboratory October 13–14. R. Sah was a co-organizer of the workshop and contributed to its success. (The workshop is described in the Accelerator Systems section of this report.)

Good progress was made on another inter-laboratory project, setting up Open Plan, the R&D project management program. The goal is to have a fully functional program in place by December of this year. Initial organization is now largely complete. Tying the component lab parts together in a single program environment will be the next step. That will be followed by setting up program activity updating, so that program tracking is maintained.

Closer to home, the Division involved itself heavily in computer activities within the CDG. Budget detail listings for several CDG divisions were incorporated in a commercial Apple Computer spreadsheet program, Microsoft's Excel. The frustrating—but necessary—multiple budgeting exercises that must be carried out as the FY88 funding picture changes from week to week justified the efforts in the data-entry phase of the Excel effort. The return on this work has been rapid, accurate processing of final budget figures as budget elements are varied.

Considerable effort was also expended to allow CDG Sun Workstation users access to the CDG Apple Computernet and laser printers. This goal has been accomplished, providing a useful new capability, especially helpful to the accelerator physicists.

The DOE quarterly review of the SSC absorbed a considerable amount of PP&M effort. Information on the FY88 R&D Program budget, schedule, and activities was assembled and prepared for presentation. Following the review, several items required further support activity. Among those was a request to update the formal SSC construction plan software to match currently anticipated project milestones and funding profiles. This task was duly accomplished, and selected summary portions were supplied to DOE.

The SSC Accounting Group has changed. Its two staff members left for new positions elsewhere in LBL at the end of October. Their replacements are now hard at work learning the CDG accounting ropes. The system they inherit was given high marks by the firm of Ernst and Whinney, which audited the CDG books for URA during October. In their summary oral report, the chief auditor praised the recordkeeping and organization of CDG finances. An official letter

will be sent with a formal audit report to the president of URA. The new accounting staff will strive to maintain this exemplary record.

BNL REPORT

MODEL MAGNETS

As noted in the summary statement, long magnet program activity accelerated. Dipole DD0010 was collared in six locations while strain gauges were monitored to evaluate coil stress. A report on coil stress as a function of coil size is being prepared. The new beam-type strain gauge transducers were used in these collaring experiments. The magnet was collared successfully with no shorts, despite the presence of 134 voltage taps. Only one tap was lost during the collaring operation.

One inner/outer coil pair was insulated and is ready for DD0012. A decision was made to install voltage taps on this long magnet similar to the system of taps deployed in DD0010. The second coil pair is presently being inspected. Inspection of sample collars indicated that the alignment of the key and keyway were out of tolerance, due to die wear. Following discussions with the vendor, Danco, the die plate was ground to recover the tolerances. Sample laminations are expected at the beginning of November. In parallel, the central shops are preparing to rework the collars in the event that the tolerances are not, in fact, recovered.

With regard to coil activities, the pole spacer surfaces have been redesigned to optimize the fit into the magnets. This is a critical parameter, in that oversize parts lead to high stress concentration and eventually cause coil-to-coil shorts. In an attempt to strengthen the ends of the coils, we have coated G10 end spacers with B-stage epoxy. These laminated end spacers have been successfully die-cut and will be incorporated into coils next month. We are also trying out a "prepreg" material, to obviate the second step of filling coil ends outside the curing press.

A number of runs have been made on the longitudinal thermal contraction of a collared coil between ambient and liquid nitrogen temperatures. Measured contraction integrals of the outer coils between these temperatures ranged from 2.78 to 2.93 in./in.-deg.

Collared coil segments from DSS4, designated for photography, have been epoxy potted for sectioning. The lead end was sliced longitudinally and photographed. In examining the section some interesting conditions were noted, although not everything is understood. For example, there is some asymmetry in the turns, and the epoxy potting appears to fill the voids completely.

With regard to trim coil activities, tests are under way to determine the vendor to provide superconductor for FY88. Test results on 0.6 m coils yielded results similar to those for long coils. A workshop was held at BNL where a group of experts reviewed the program. Major conclusions centered on radiation hardening of substrates, introduction of multifilament wire with a larger diameter, and emphasis on tests with 0.6 m and 1.8 m coils before incorporating these features into long coils.

The beam tube program involved the continued processing at Trent Tube of the Nitronic 40 tubes and discussions with the finalists of the plating proposals.

Yoke shell activities involved updating the design to incorporate bullet-type strain gauge transducers in the return end plates; coil end force set screws in the lead end; extensiometers on the lead end; circumferential strain gauge monitoring of the lead-end bonnet, to evaluate longitudinal shell contraction; and a peelable lead-end strain pack, to produce coil loading.

A Technical Note on the use of shell welding as a coil compression method, and on the use of the yoke as a collar to provide coil prestress, has been finished and issued. Progress was also made on the automatic shell welding system for long magnets. Staff members attended a Cryogenic Structural Materials Workshop and obtained the latest data on Nitronic 40.

Preparation of industrialization procedures continued at a relatively high level of effort. These include electrical procedures, such as impulse and turn-to-turn short testing, and warm measurements. Video tapes have been completed on coil compression testing and coil measurements.

TOOLING AND FACILITIES

Coils

Winder components have been prepared for shipment to Fermilab with magnet DD0010 in November.

Design activities centered on 17 m winding mandrels and formblocks, on 1.8 m EDM'd formblocks, and on efforts to eliminate scuffing of coil end cable.

Collars

Completed modifications to the collaring press will permit use of tapered keys. Some problems with initial insertion of tapered keys still exist.

Activities on the preproduction collaring press focused on the control panel requirements and on completion of the cradle assembly.

Design of the welding fixture test stand commenced.

Accelerated Life Test Preparations

Progress was made on the feed can assembly stand for the Accelerated Life Test, as well as on fabrication of other parts. There will be a delay of several months in the completion of the Accelerated Life Test due to the funding profile that has been provided.

Test Facilities Generally

Design work continues on Mole C.

SUPERCONDUCTOR

Cable Procurement

All the cable required for DD0012 and DD0013 has been insulated. The outer cable from Furukawa is presently being insulated. In addition, the cable required for DSS10, DSS11, and DSS12 was received from LBL and has been insulated.

Tooling

Work began on the completion of sketches for a set of guide rollers to assure proper placement of the wires within the cable.

A set of Fowler Digital Indicators was received for our second "10" Stack Fixture. These will complete the upgrading of our fixture and greatly simplify its operation. As soon as this fixture is modified with these indicators, the fixture will be available for vendor use.

Miscellaneous

No firm conclusions have been made as of this date in regard to cure tests of the sample of pre-impregnated fiberglass cloth received from Westinghouse. Another source is being investigated that may be able to provide the fiberglass to size in long lengths, which would eliminate the need for slitting and splicing. This vendor has supplied Brookhaven with a pre-impregnated production size sample. This sample will be tested in early November.

Because of the problems encountered at New England and Electric Wire Corporation in the production of RHIC cable, an extensive study was made during September and October to determine the cause of such high cable degradation. An experimental run is planned for the first week in November to test our conclusions.

TESTS AND MEASUREMENTS

This month, short dipole DSS6 was tested. (DSS6 utilizes the same conductor as DSS4, DSS5, and D000Z. The ratio of copper to superconductor is 1.6:1. Its ends are filled with an aluminum/epoxy mixture, it has G11 end shoes, and there is no iron over the coil ends.) The magnet exhibited virtually no training at 4.5 K, to reach a quench plateau of ~ 6.6 T (6466 ± 14 A) — within 2 percent of the calculated level, based on the conductor short-sample properties. Subsequently, it reached 7.1 T at 4.0 K and 7.5 T at 3.5 K. No retraining was

observed after thermal cycling. With regard to multipoles, the systematic b_2 value needs adjustment amounting to a few mils; the σ's were essentially all within tolerance.

FNAL REPORT

CRYOSTAT DEVELOPMENT

Performance evaluations of the Help Your Buddy Anchor System (HYBAS), using the D0004 cold mass and the design B support post, have been completed. The system load sharing agreed very well with predictions. The system survived the 25,000 pound axial load sequence testing. The natural frequencies in the lateral and axial directions were respectively measured to be 6.45 and 11.09 Hz. The D0004 suspension evaluation apparatus will be disassembled; several of its components will be used for long magnet model construction.

The redesign of the shield has been completed and components are being procured.

Work continues on analysis and measurement of the shield bowing. The shield bowing analytical model is essentially complete. Temperature distributions predicted by the General Dynamics Space System integrated thermal math model will be put into this model. Components are being procured for the full-length shield section bowing measurements.

Practice insulation blankets have been wound. Blankets for the first cold mass to be placed in a B cryostat and for subsequent long magnet models will be fabricated in November.

Study of an axial shipping restraint is focusing on restraints connecting to the HYBAS.

Work continues on the cryostats for the next three long magnet cold masses to be shipped from BNL. Because components made to the final design are unavailable, the HYBAS and the shields for the first two will be compromise configurations. The first will be instrumented to monitor HYBAS performance. The third will have extensive cryostat instrumentation for monitoring both structural and thermal performance of the support post, the anchor system, and the shields.

The magnet assembly alignment procedure has been completed and will be transmitted to the CDG.

MAGNETIC MEASUREMENTS

Cool down began twelve working days after magnet D000Z arrived. This was followed by a 54-hour cool down and by a 2-day test of the quench protection system. Quench testing began 16 days after delivery of the magnet. The magnet was quenched fourteen times, with quenches 11–13 at 97–98 percent of the calculated short sample limit. Unlike previous long magnets, the training quenches (defined here to be quenches 1–10) were not all at the lead (feed) end; four were at the lead end, three were near but probably not at the non-lead (return) end, and three were clearly in the body. Training quenches occurred in both the upper and lower inner coils.

Five lead events tripped the lead quench protection circuit. In all cases, the voltage appeared in the negative lead in the region including the expansion joint and the through and

connected buses. The first event was at 3464 A, and subsequent events were at monotonically increased current up to 6109 A. The voltage signals are incompatible with those expected for resistance growth of a normal zone, given the large rate of rise and the return of the voltage to zero within about 10 milliseconds of the beginning of the event. The current hypothesis is that this behavior represents conductor motion rather than quenching, but a quantitative model has not been worked out to explain the results.

Beginning with quench 10, evidence is present in the data for "sparking" at the level of a few milliamperes in the ground current detector. This was not noticed until a large ground fault on quench 13 drew a peak current estimated to be about 10 A (the ADC overflows at 5 A). Following this fault, the magnet resistance to ground was several hundred ohms. Inductance ratio measurements placed the location of the ground in the lower inner coil, 2 percent by inductance away from voltage tap D, which is at the splice between the lower inner and upper inner coils. This is approximately equal to the calculated inductance fraction in the pole turn, suggesting that the fault was near the lead end. Examination of the voltage and pressure data from a power lead trip that occurred just before quench 13 shows the lower inner coil quenching near the return end within 20 milliseconds of the trip, before the strip heaters had quenched the outer coils. If this unusual occurrence was caused by the ground fault, that would place the fault near the non-lead end. Attempts to measure the resistance of the ground fault as a function of voltage up to 45 V yielded values varying between 100 ohms and 100 kilo-ohms.

The magnet was then grounded through the voltage tap nearest the fault, giving a total of 226 ohms in the explicit ground. The magnet was subsequently ramped to quench at 3134 A and the beam pipe ruptured. (The insulating vacuum is independent of the beam pipe vacuum and was unaffected.) Evidence of significant sparking exists in the coil voltage signals before substantial ground current developed, which suggests the presence of turn-to-turn as well as coil-to-ground shorts. The octupole trim coil is now shorted to ground, which suggests that the beam pipe rupture is in the quarter of the magnet closest to the non-lead end, the region occupied by this coil. The magnet is currently being warmed up to allow visual inspection.

Work on the feed can and turnaround box for test stand 5 continued. During this period the magnet cryostat design evolved into the design B geometry. The feed can and turnaround box were modified to accommodate the new cryostat. Consequently, the delivery date was postponed by about one week, to early November. Test stand hardware in the Magnet Test Facility was prepared for installation of these components. Due to delays at the manufacturer, the vacuum pump is not expected until late November, and the vacuum heat exchanger parts are not expected before December. Tests of stand 5 with D000X are planned at 4.3 K in December. Low temperature operation is not expected until January.

LONG MAGNET FABRICATION

D000Z

The magnet was completed on October 2 and delivered to the Magnet Test Facility.

DD0010

Subassemblies salvaged from HLM II have been refurbished for use in the assembly of DD0010. All preliminary subassemblies of supports and piping have been completed. The cold mass from BNL is expected by November 18.

DD0012

Modification of the vacuum vessel assembly tooling is under way to enable fabrication of the two-footed vacuum vessel.

Alignment

Experiments are in progress to understand obtainable measurement accuracy of a target within the beam tube.

Cold Mass Tooling

All coil-winding and curing tooling for the 1-meter magnet program has been released for fabrication. Samples of all laminations were rejected, due to poor edge quality. The edge problem is correctable, and new samples are expected in the second week of November. Procurement of forming retainers is requiring more time than anticipated, because of required precision. A vendor has been selected, and samples have been received that demonstrate the ability to produce parts to specified precision. The schedule for winding the first coil will thus be postponed by one month. The remaining components have been placed with vendors with deliveries on schedule. Mold heat tube expansion tooling has been obtained and demonstrated successfully.

Coil Collaring

All parts for 1-meter collaring tooling are on hand except for the laminations, which are expected by late November. The tooling is expected to be assembled and ready for use by early December.

Yokes and Skinning

Development continues on a full length fiducial system. The third dummy cold mass will be assembled in late November. An R.F.Q. has been issued for full length auto-welding equipment.

Full Length Press

Design and procurement is proceeding on schedule. An R.F.Q. has been issued for the curing press heat/cool system.

Winding Machine

Work at BNL is continuing on schedule. Two FNAL technicians visited BNL in October to become familiar with assembly details. Space is being cleared at ICB to accommodate this machine.

Accelerator

Work continues on upgrading CASIM to handle energy deposition at SSC energies. The hadron production model (above 1 TeV) has been changed to be in better agreement with CERN Collider results and with reasonable SSC expectations. "History" files for 20-TeV-proton-induced cascades will soon be written. These files can then be analyzed in different geometries. Writing the analysis program will be the next step, which will be followed by actual "production" runs. This work will be summarized in a document on generic energy deposition in thick targets at SSC energies.

String Test

The beam tube has been leak checked. Electrical connections have been completed and insulated. Installation of the cryostat vacuum system has begun.

Photodesorption

Drawing details were finalized, parts put in the shop and received for construction. Modifications were made to the shield, due to a material pulling problem during welding. Warming filaments were constructed and installed. The first assembly, including a test cryostat, was completed at the end of the month. Test cool downs are planned for the week of November 2, before shipment to Wisconsin–SRC.

Work continues on documentation for the cryogenic safety committee.

LBL REPORT

SUPERCONDUCTOR AND CABLE

Orders were placed for the cable required to complete the dipole magnets scheduled for FY88, as well as for back-up cable for three additional long dipoles. This cable has been ordered from Supercon, Inc., and is expected in April, 1988. Supercon will deliver finished cable, which will be fabricated at New England Electric Wire. The cable will be made on the new SSC production cabling machine, if the cabling machine trials are completed as planned in March, 1988.

DIPOLES

Dipole Models

SSC dipole model D15A3 was tested October 1–14 with 1.8 K operation at 9400 A. There was no loss of 4.3 K quench current following two thermal cycles to room temperature (290 K and 340 K).

Model D15A4F and D15A5 coils were assembled and are ready for collaring. Gauge collar packs for A4F are ready and collaring will begin immediately. Work on gauge packs for A5 is in progress. Gauge packs for DD0013 are completed.

Analysis of coil pressure gauge blocks was completed. Predicted and measured gauge outputs agree reasonably well, although some variation in gauge outputs did occur. Results were presented at the November MSI meeting at FNAL and will be discussed in a forthcoming SSC-MAG note.

Several methods of analyzing dipoles with conical ends are under investigation. One way is to generate the geometry on a three-dimensional CAD system (like ME30) and then to calculate the field based on the geometry wire frame. Another approach is to mathematically generate the wire frame.

A major effort continues to be assembly of magnets DSS9, DD0011, and DD0013 at BNL, in addition to building and calibrating instrumentation for them.

Analysis

Orders were placed for a Sun computer system to support the magnet test data acquisition in Building 58.

Orders are ready to be placed for a new computer system for general magnet analysis.

Several programs from the POISSON group have been converted and tried on a Sun demonstration unit. We have started generating the interface program between AutoCAD and PK.

PROJECT COST DATA

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TABLE C-1

CENTRAL DESIGN GROUP - SUPERCOLLIDER

OCTOBER 1987 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	-23.6	79.3	-19.7	36.0	36.0	3818.3
1.2	PROGRAM PLANNING & MANAGEMENT	20.4	12.6	-13.5	19.5	19.5	686.8
1.3	ACCELERATOR R & D	-73.5	26.6	9.2	-37.8	-37.8	5644.7
1.4	CONVENTIONAL SYSTEMS DEVELOP.	2.7	-10.0	1.6	-5.7	-5.7	726.3
	PROGRAM COSTS	-74.0	108.5	-22.5	12.0	12.0	10876.0
1.41	RTK COSTS	0.0	21.5	0.0	21.0	21.0	175.0
	CDG/RTK COSTS	-74.0	130.0	-22.5	33.0	33.0	11051.0
	COMMITMENTS					463.0	
	CHANGE IN COMMITMENTS (Delta)					463.0	
	EQUIPMENT					0.0	229.0

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY - SUPERCOLLIDER

OCTOBER 1987 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	LONG MAGNET FABRICATION	118.3	40.2	69.1	227.6	228.0	2980.0
2.2	TOOLING & FIXTURES	33.8	98.6	57.7	190.1	190.0	2594.0
2.3	SHORT MODEL MAGNETS	21.1	0.0	9.2	30.3	30.0	616.0
2.4	INDUSTRIALIZATION	8.4	0.8	4.0	13.2	13.0	250.0
2.5	ACC. LIFE TEST (CRYO)	0.0	25.6	11.2	36.8	37.0	1560.0
	PROGRAM COSTS	181.6	165.2	151.2	498.0	498.0	8000.0
	COMMITMENTS					1597.0	
	CHANGE IN COMMITMENTS (Delta)					1597.0	
	EQUIPMENT					0.0	500.0

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER

OCTOBER 1987 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	2.2	2.4	1.5	6.1	6.1	195.0
3.2	LONG MAGNET FABRICATION	45.4	22.4	21.9	89.7	89.7	834.0
3.3	MAGNETIC MEASUREMENTS	58.6	44.5	33.3	136.4	136.4	1206.0
3.4	COLD MASS FABRICATION	14.4	48.0	20.1	82.5	82.5	3083.0
3.5	INDUSTRIALIZATION	0.0	0.0	0.0	0.0	0.0	190.0
3.6	CELL TESTS	0.0	0.0	0.0	0.0	0.0	222.0
	PROGRAM COSTS	120.6	117.3	76.8	314.7	314.7	5730.0
	COMMITMENTS					477.8	
	CHANGE IN COMMITMENTS (Delta)					477.8	
	EQUIPMENT	0.8	3.2	0.0	4.0	4.0	271.0

TABLE C-4

LAWRENCE BERKELEY LABORATORY - SUPERCOLLIDER

OCTOBER 1987 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET*
4.1	GENERAL	4.0	0.0	1.9	5.9	5.9	190.0
4.2	SUPERCONDUCTOR	6.6	0.0	4.0	10.6	10.6	1170.0
4.3	QUADRUPOLE DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	300.0
4.4	COMP. DEVELOP. & TESTS	79.5	35.5	70.4	185.4	185.4	975.0
4.5	INDUSTRIALIZATION	0.0	0.0	0.0	0.0	0.0	50.0
	MAGNET R & D TOTALS	90.1	35.5	76.3	201.9	201.9	2685.0
4.6	ACCELERATOR PHYSICS R & D	18.3	1.0	9.3	28.6	28.6	410.0
	LBL/THEORY COSTS	108.4	36.5	85.6	230.5	230.5	3095.0
	COMMITMENTS					432.0	
	CHANGE IN COMMITMENTS (Delta)					432.0	

TABLE C-5

PROGRAM SUMMARY - SUPERCOLLIDER

OCTOBER 1987 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	-74.0	108.5	-22.5	12.0	12.0	10876.0
1.41	RTK PROGRAM	0.0	21.5	0.0	21.0	21.0	175.0
2.	BNL SSC PROGRAM	181.6	165.2	151.2	498.0	498.0	8000.0
3.	FNAL SSC PROGRAM	120.6	117.3	76.8	314.7	314.7	5730.0
4.	LBL SSC PROGRAM	108.4	36.5	85.6	230.5	230.5	3095.0
	TOTAL SSC PROGRAM COSTS	336.6	449.0	291.1	1076.2	1076.2	27876.0
	COMMITMENTS					2969.8	
	CHANGE IN COMMITMENTS (Delta)					2969.8	
	EQUIPMENT					4.0	1000.0

TABLE C-6

MONTHLY AND CUMULATIVE SUMMARY OF PLANNED AND ACTUAL COSTS AND COMMITTMENTS

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	920.9	920.9	33.0	33.0	496.0	496.0	463.0	463.0
NOV	920.9	1841.8						
DEC	920.9	2762.8						
JAN	920.9	3683.7						
FEB	920.9	4604.6						
MAR	920.9	5525.5						
APR	920.9	6446.4						
MAY	920.9	7367.3						
JUN	920.9	8288.3						
JUL	920.9	9209.2						
AUG	920.9	10130.1						
SEP	920.9	11051.0						

2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	666.7	666.7	498.0	498.0	2095.0	2095.0	1597.0	1597.0
NOV	666.7	1333.3						
DEC	666.7	2000.0						
JAN	666.7	2666.7						
FEB	666.7	3333.3						
MAR	666.7	4000.0						
APR	666.7	4666.7						
MAY	666.7	5333.3						
JUN	666.7	6000.0						
JUL	666.7	6666.7						
AUG	666.7	7333.3						
SEP	666.7	8000.0						

3.0 FERMI NAT'L ACCEL LAB - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	477.5	477.5	314.7	314.7	792.5	792.5	477.8	477.8
NOV	477.5	955.0						
DEC	477.5	1432.5						
JAN	477.5	1910.0						
FEB	477.5	2387.5						
MAR	477.5	2865.0						
APR	477.5	3342.5						
MAY	477.5	3820.0						
JUN	477.5	4297.5						
JUL	477.5	4775.0						
AUG	477.5	5252.5						
SEP	477.5	5730.0						

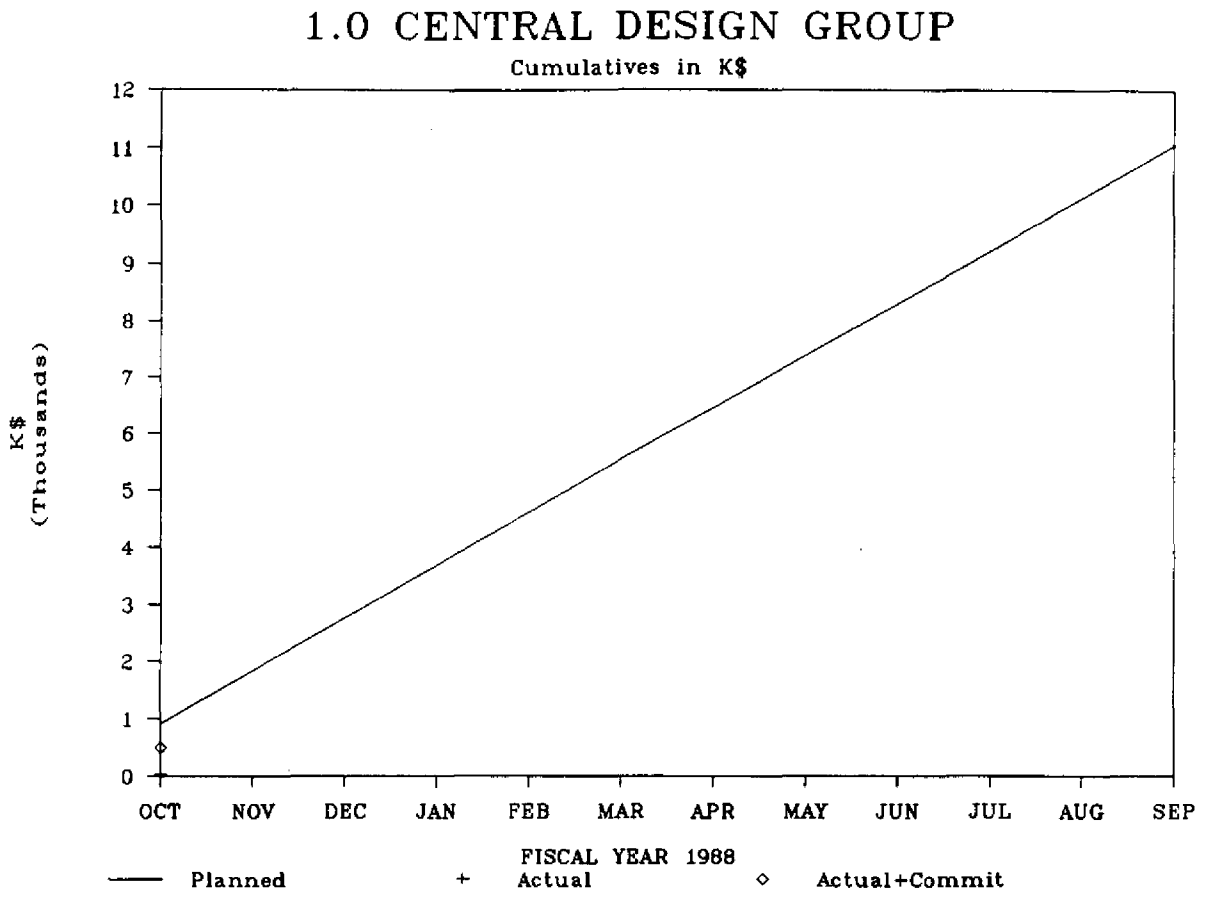
4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	257.9	257.9	230.5	230.5	662.5	662.5	432.0	432.0
NOV	257.9	515.8						
DEC	257.9	773.8						
JAN	257.9	1031.7						
FEB	257.9	1289.6						
MAR	257.9	1547.5						
APR	257.9	1805.4						
MAY	257.9	2063.3						
JUN	257.9	2321.3						
JUL	257.9	2579.2						
AUG	257.9	2837.1						
SEP	257.9	3095.0						

0.0 PROGRAM SUMMARY - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	2323.0	2323.0	1076.2	1076.2	4046.0	4046.0	2969.8	2969.8
NOV	2323.0	4646.0						
DEC	2323.0	6969.0						
JAN	2323.0	9292.0						
FEB	2323.0	11615.0						
MAR	2323.0	13938.0						
APR	2323.0	16261.0						
MAY	2323.0	18584.0						
JUN	2323.0	20907.0						
JUL	2323.0	23230.0						
AUG	2323.0	25553.0						
SEP	2323.0	27876.0						

Figure 1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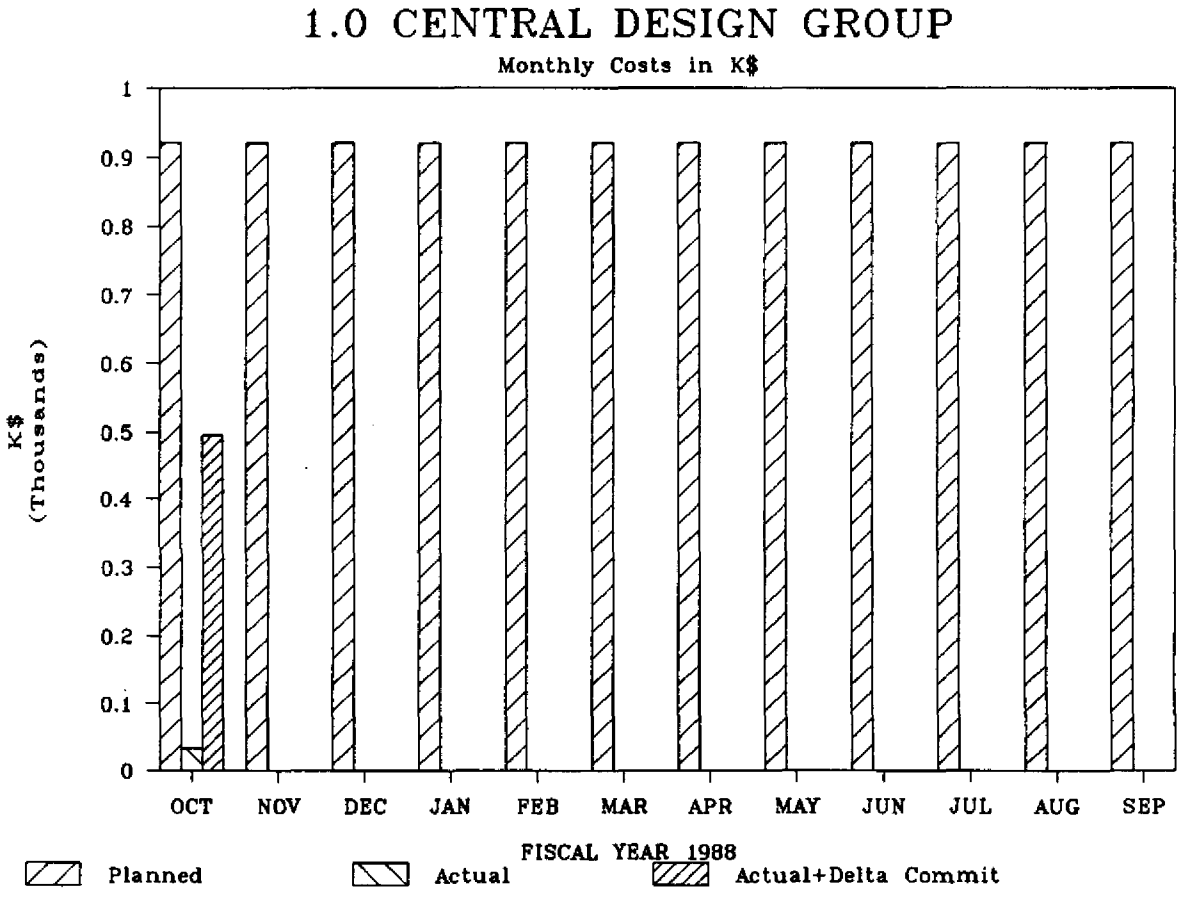
1
2
3
4
5
6
7
8
9
10
11
12
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit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Monthly Costs in K$
K$ (Thousands)
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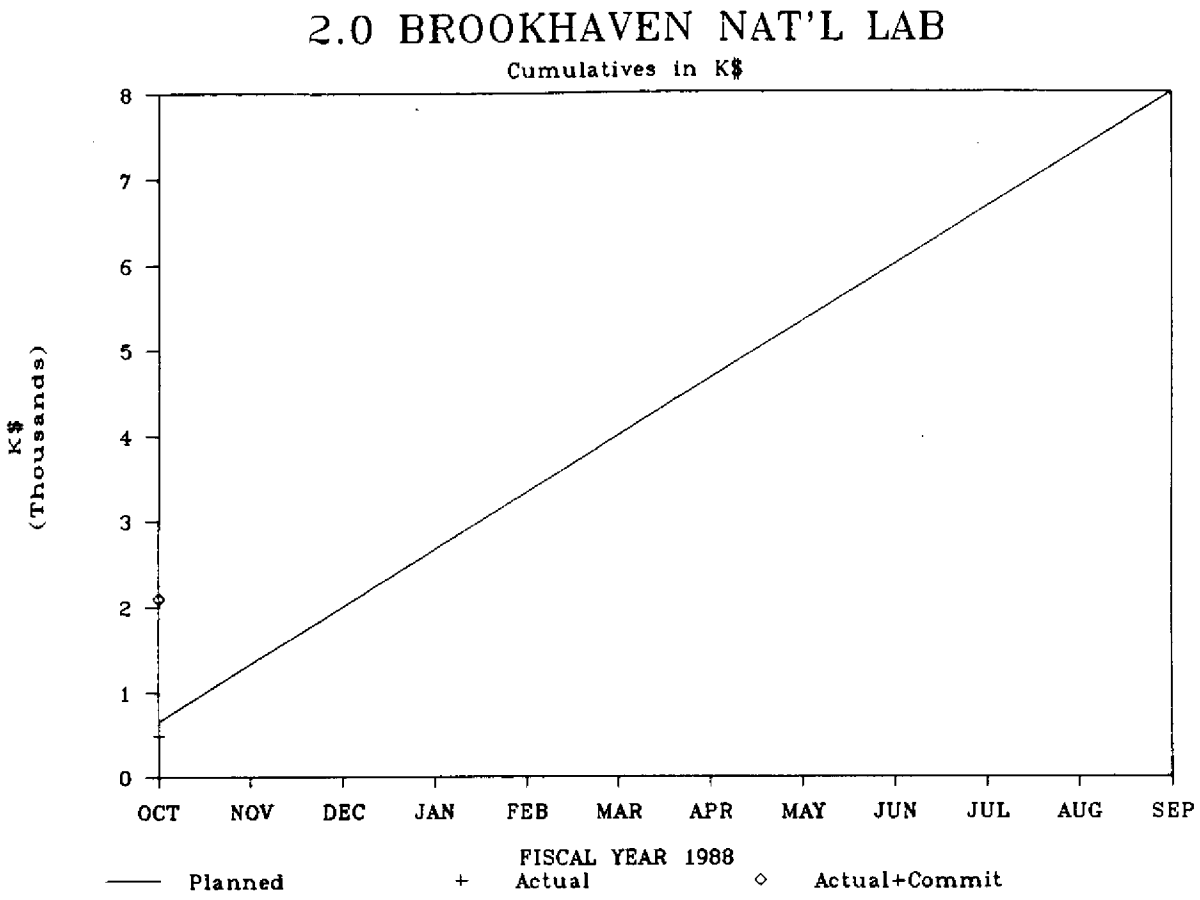
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 2


2.0 BROOKHAVEN NAT'L LAB
Cumulatives in K$
K$ (Thousands)
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1
2
3
4
5
6
7
8
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

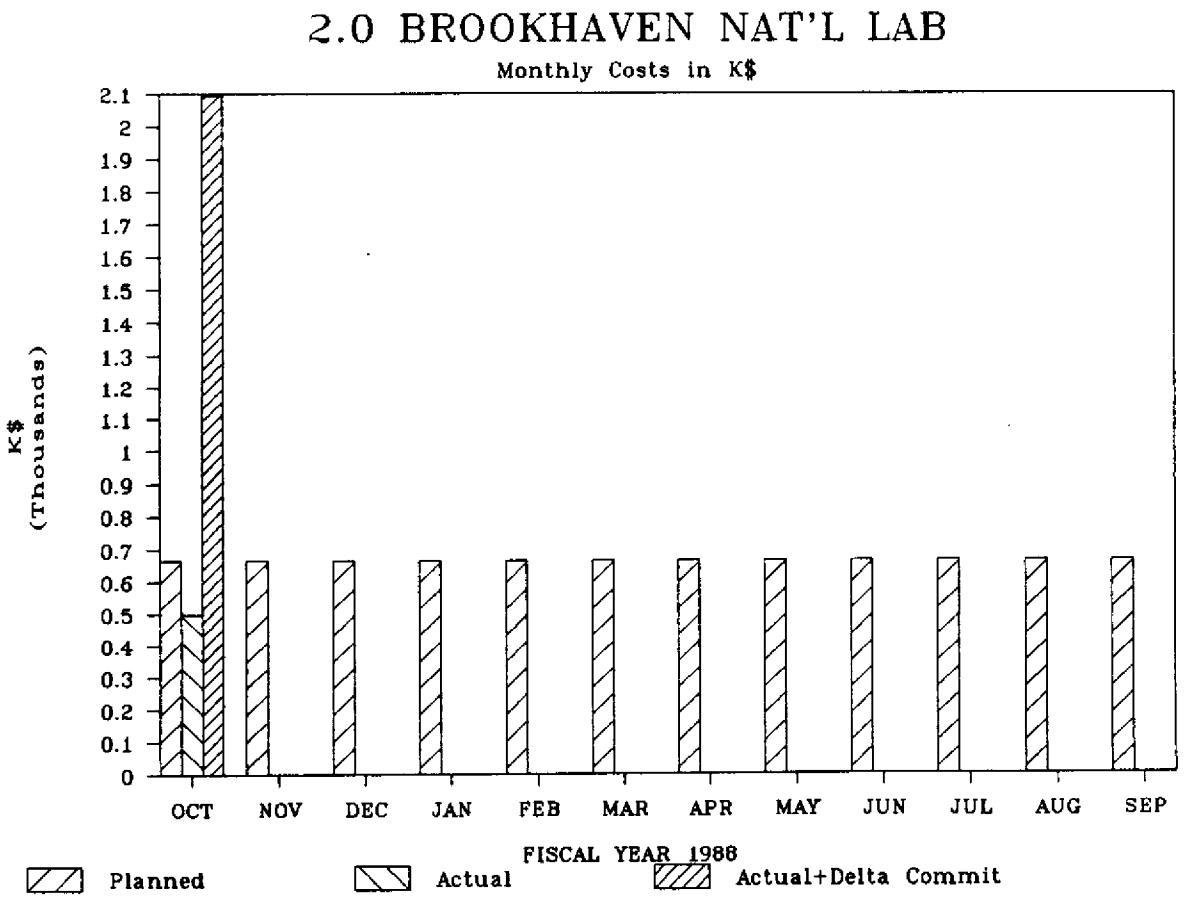
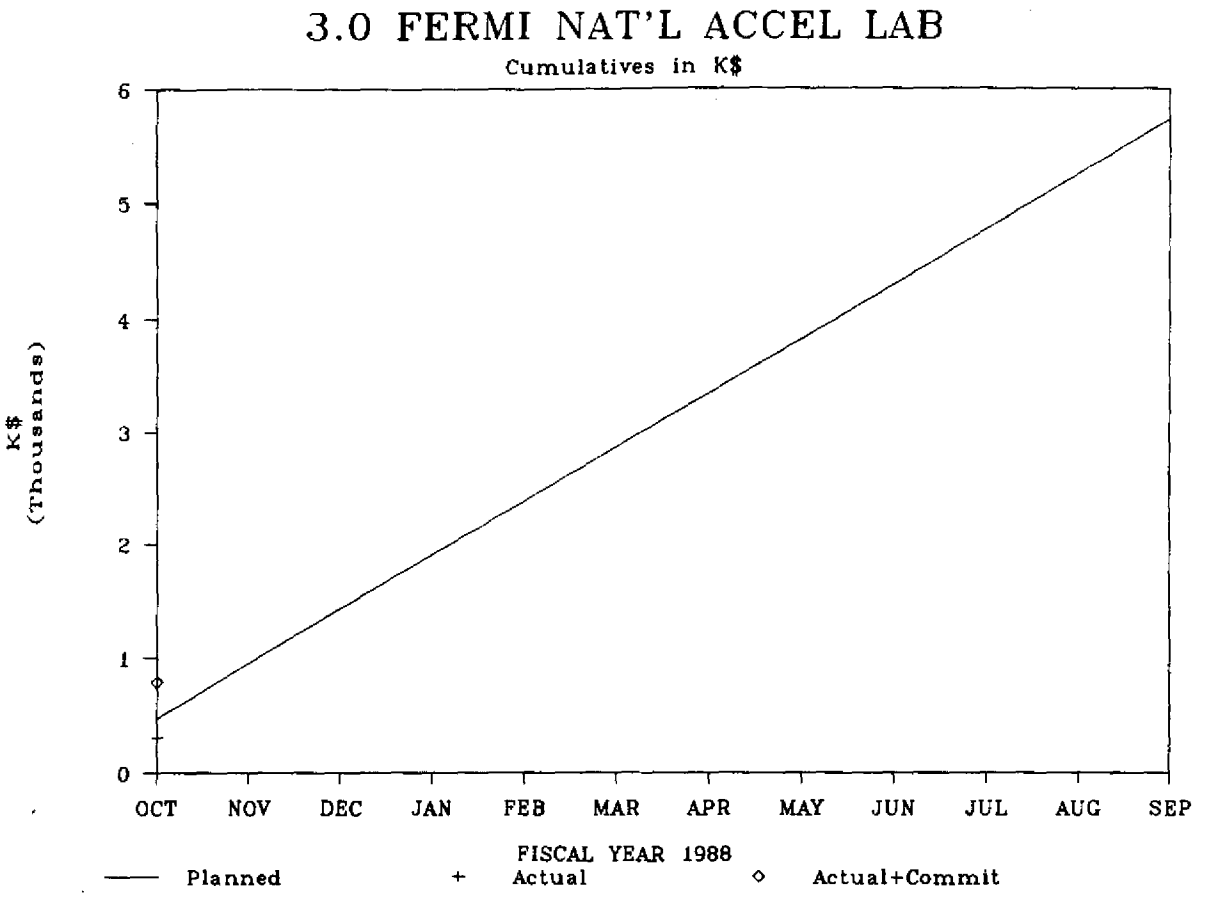

2.0 BROOKHAVEN NAT'L LAB
Monthly Costs in K$
K$ (Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 3


3.0 FERMI NAT'L ACCEL LAB
Cumulatives in K$
K$ (Thousands)
0
1
2
3
4
5
6
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

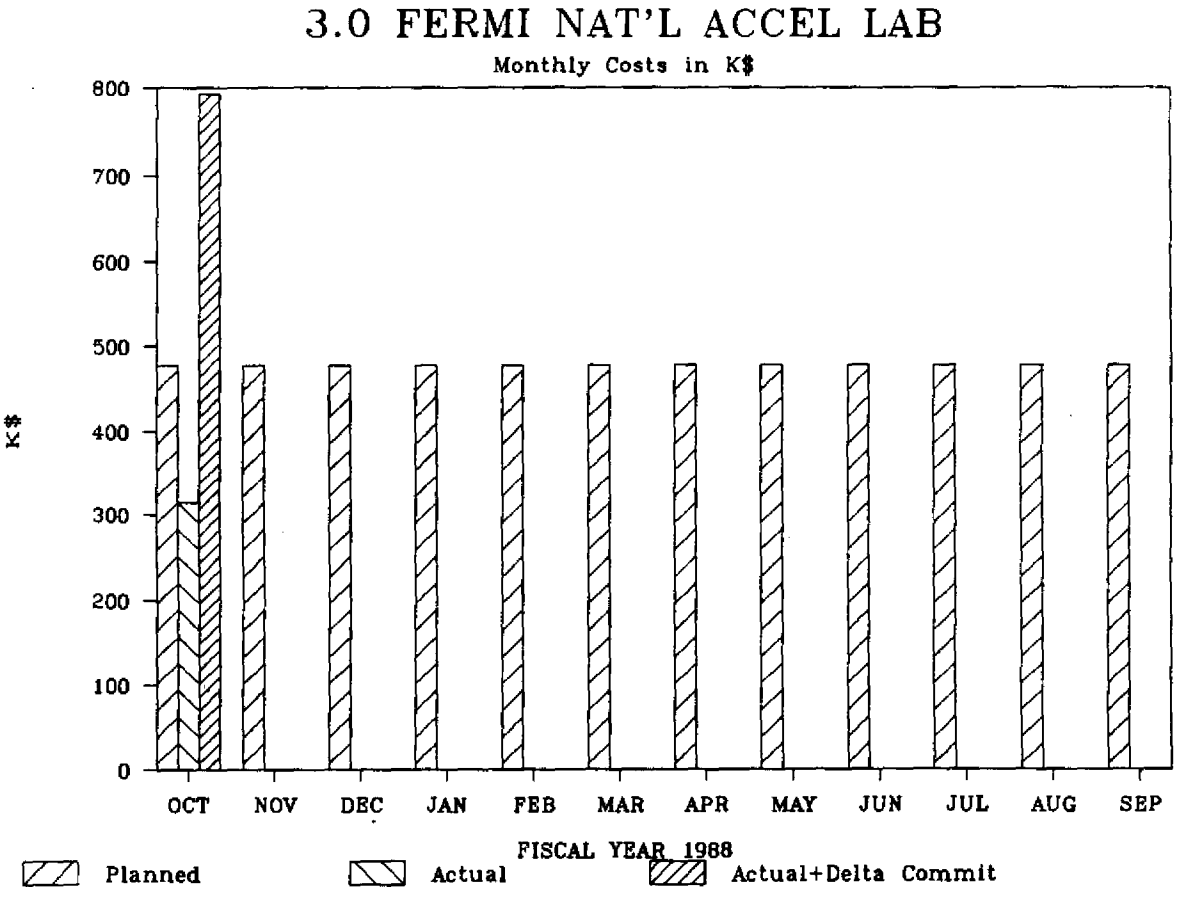
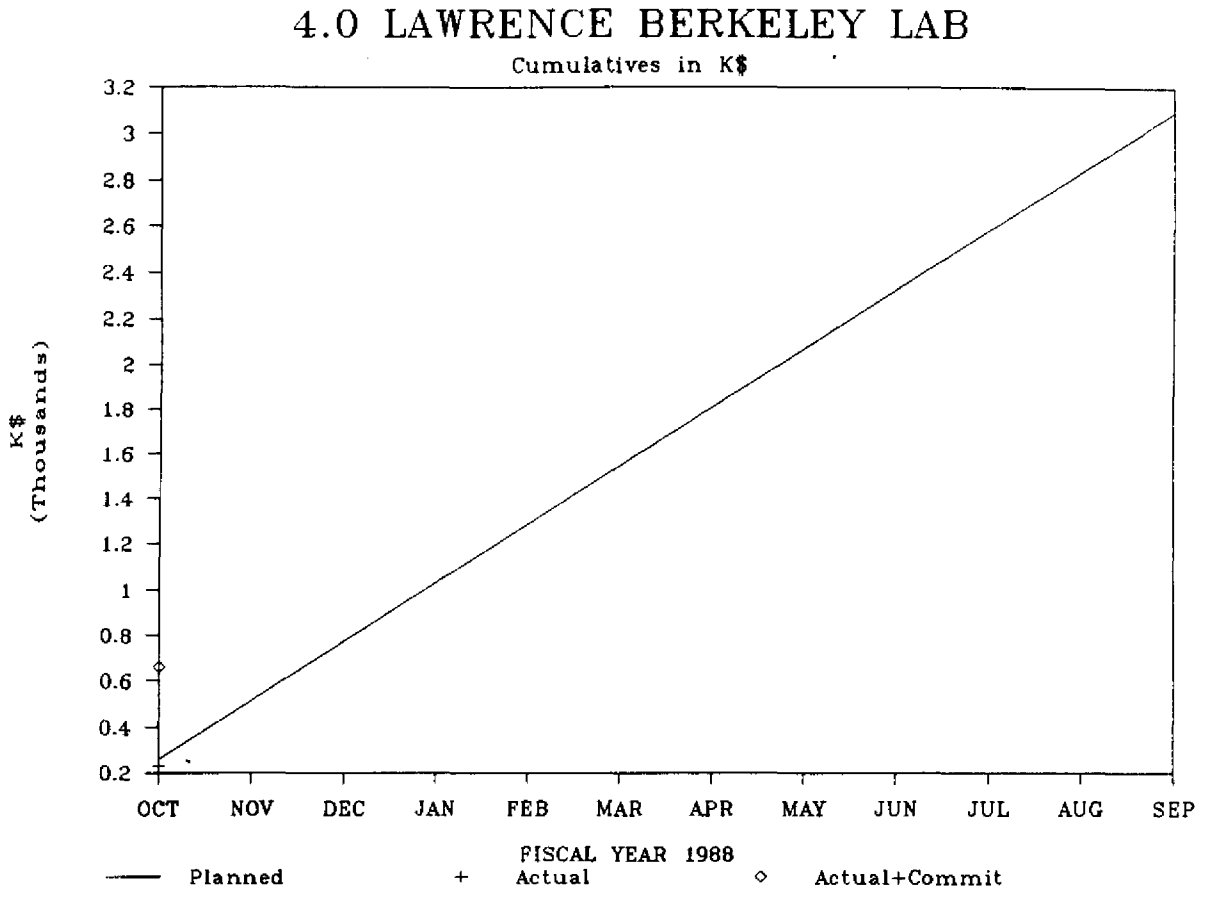

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$
0
100
200
300
400
500
600
700
800
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 4


4.0 LAWRENCE BERKELEY LAB
Cumulatives in K$
K$ (Thousands)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

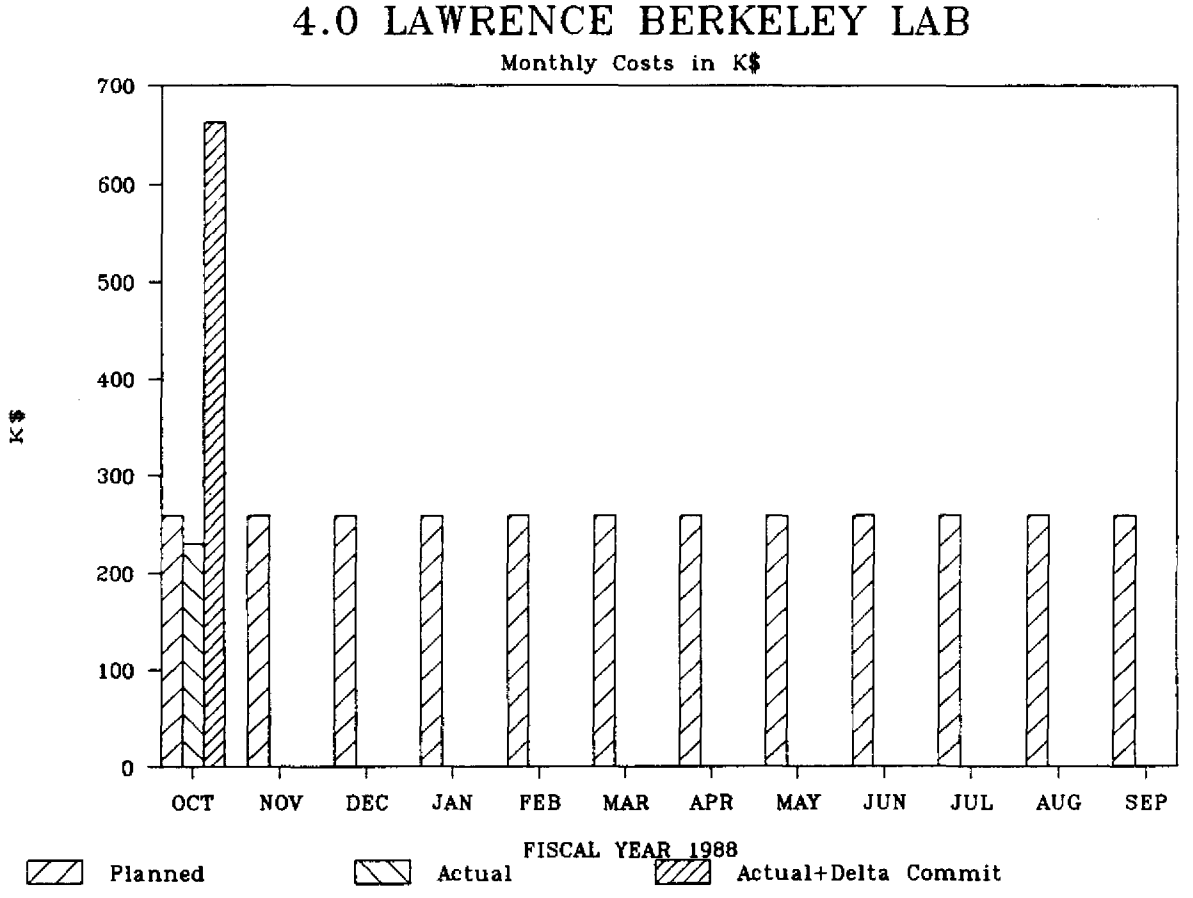
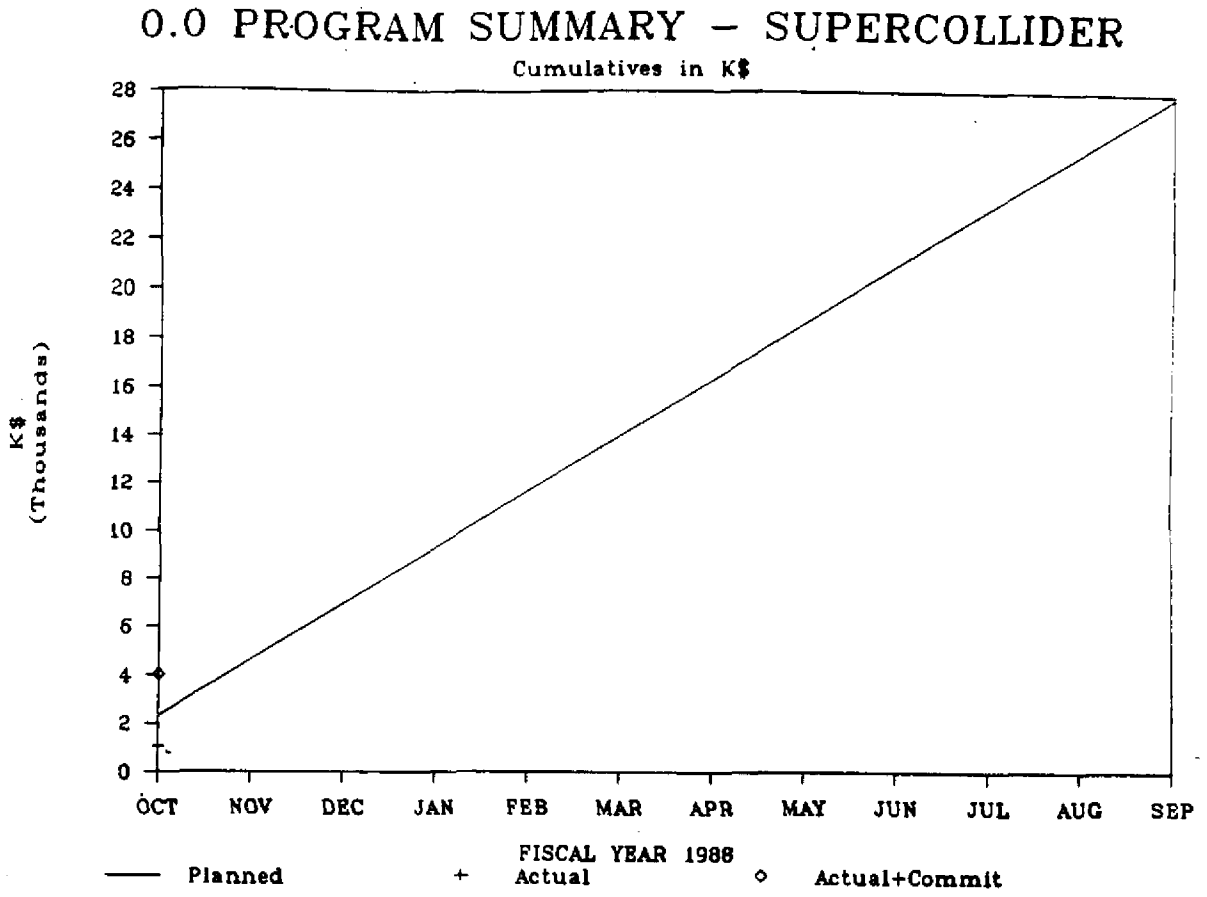
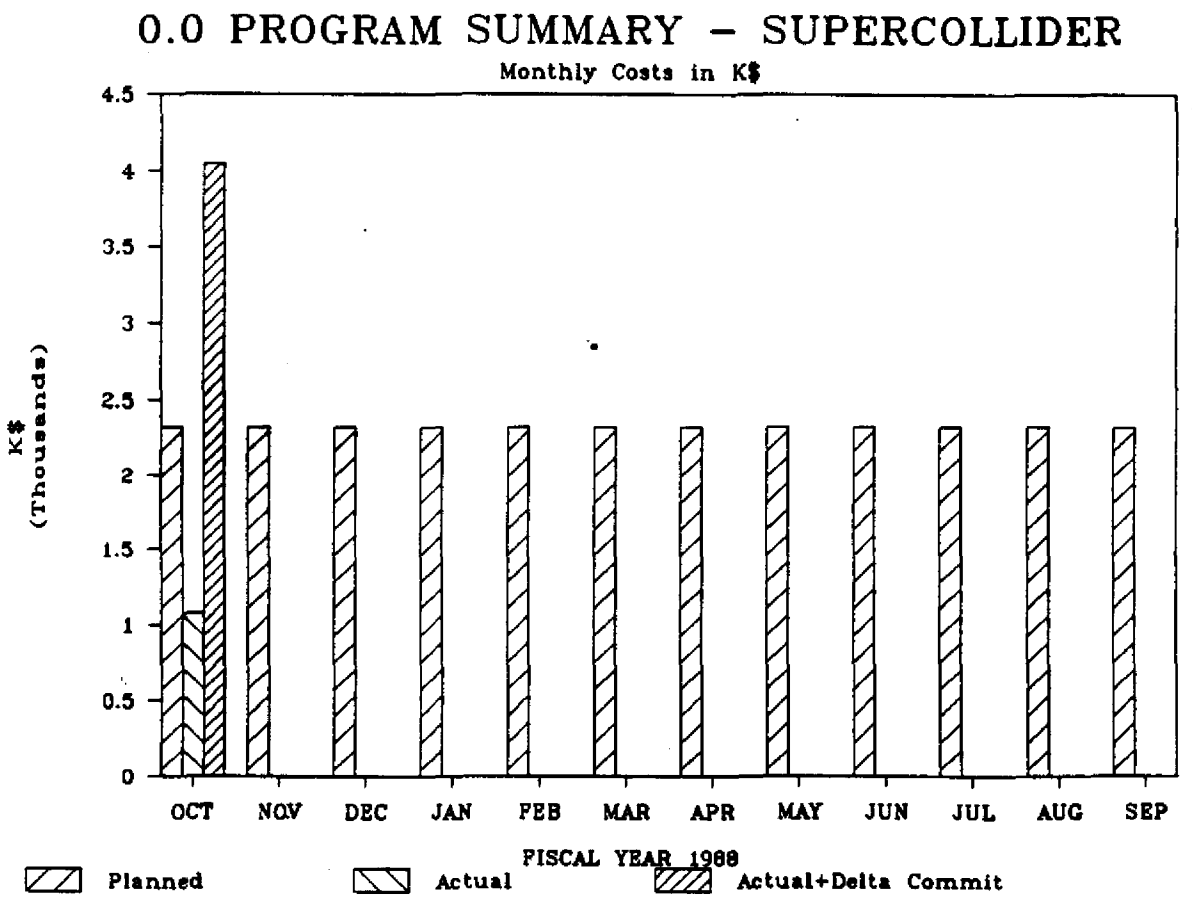

4.0 LAWRENCE BERKELEY LAB
Monthly Costs in K$
K$
700
600
500
400
300
200
100
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 5


0.0 PROGRAM SUMMARY – SUPERCOLLIDER
Cumulatives in K$
K$ (Thousands)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit


0.0 PROGRAM SUMMARY – SUPERCOLLIDER
Monthly Costs in K$
K$ (Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit