December 1988 SSC Monthly Report SSC-203

PROJECT SUMMARY	1	CENTRAL DESIGN GROUP (CDG)
	2	BROOKHAVEN NATIONAL LABORATORY (BNL)
	3	FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)
	3	LAWRENCE BERKELEY LABORATORY (LBL)
CDG REPORT	5	MAGNET PROGRAM
	10	ACCELERATOR PHYSICS
	13	ACCELERATOR SYSTEMS
	14	CONVENTIONAL FACILITIES
BNL REPORT	16	MODEL MAGNETS
	16	TOOLING AND FACILITIES
	17	TESTS AND MEASUREMENTS
	18	INDUSTRIALIZATION
FNAL REPORT	19	DIPOLE CRYOSTAT
	20	MAGNETIC MEASUREMENTS
	20	LONG MAGNET FABRICATION
LBL REPORT	23	SUPERCONDUCTOR AND CABLE
	23	MAGNET MODELS
PROJECT COST DATA	25	INDEX

PROJECT SUMMARY

CENTRAL DESIGN GROUP (CDG)

Magnet Program

Planning for the Magnet Industrialization Program (MIP) advanced rapidly in December. DOE approved the industrial participants in the first phase of the MIP, Technology Orientation. Twenty firms, representing joint ventures in four cases, were selected as the 16 participants in the Phase I program of lectures, tours, and fabrication demonstrations that will take place at BNL, CDG, FNAL, and LBL during January and February of 1989. All invited participants have accepted.

The preparation of a first draft Request for Proposal (RFP) for the second phase of the MIP (collider dipole tooling and production of magnet prototypes) was completed at the CDG. A precursor document outlining business strategies for the full SSC collider dipole procurement of approximately 8,000 magnets was submitted to DOE and discussed with key DOE officials.

Careful and detailed finite-element analyses of stress in collars and yokes were completed. The low-carbon steel yoke is subject only to brittle fracture at cryogenic temperatures; critical-crack-length studies confirmed that yoke stresses will not result in failure under SSC magnet loads. The collar studies indicate (as suspected) that the maximum stresses occur in the keyways. The critical-crack-length study of this area indicates that some material will yield, but fatigue fracture will not occur under SSC operating parameters. Both new results confirm the design.

A three-month-long effort to establish a database system for recording superconductor properties and relating them to the final magnet application took a significant step forward with publication of the first report defining this system. Entry of the existing technical information from a variety of data sources will begin soon. Extension of the database to include the cable/magnet relationship will be the next step.

A fundamental expectation of the SSC construction plan is that production dipole magnets for the collider will be field-mapped at room temperature, but will not require routine field measurements in the superconducting state. This plan depends on a reliable correlation between warm and cold field properties. A study of the warm/cold field quality correlation for a population of 14 short SSC model dipoles was published as SSC-N-578. If the tight correlation observed in this sample holds for the production dipoles, then a sample of approximately 100 magnets will be needed to establish the warm/cold correlation for long magnets. This is a helpful result for the magnet quality issue.

Accelerator Physics

Studies were made on the maximum integrated luminosity for the SSC as a function of filling time, cycle time, beam emittance, and beam-beam tune shifts.

The Correction Elements Working Group continued its studies and began to summarize its findings, in order to prepare a report for the Parameters Working Group.

Experimental techniques used to measure superconducting wire short-sample limits were examined, and new analyses to understand the results were begun.

Conventional Facilities

Development of design concepts for collision halls and associated staging areas continued with RTK and M. G. D. Gilchriese. A. Autin developed a functional model of the surface complexes and developed a workable layout. Reports were prepared on collision hall conceptual designs, collider tunnel cross sections, geotechnical site characterization, and plans for a site-specific conceptual design. Those materials, along with schedule and budget information, were prepared for use by the M&O contractor.

Digitization of site data from state submissions and SSC Site Task Force compilations continued, including digitization of terrain and geology for three-dimensional modeling. Procedures for coalescing site and technical features were developed and successfully executed.

Protocols and procedures were developed for transforming construction estimate data from contractor formats to project formats. That will facilitate summary examination and analysis. Progress was made on analogous techniques for project schedules.

BROOKHAVEN NATIONAL LABORATORY (BNL)

Assembly of DD0017 was essentially completed, as were preassembly operations for DD0018.

DSS13 was successfully tested this month. Both initial training and retraining after a thermal cycle were minimal; the plateau quench current at 4.35 K was 6925 A (~ 7 T), and the multipoles were also satisfactory. This 1.8-m dipole features a line-to-line fit of yoke and collar, C358D coil cross section, improved ramp splice, and monolithic yoke construction.

A full-length (10-m) sextupole trim coil is awaiting installation in DD0019.

FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)

Magnet DD0013 was disassembled. The cold mass for DD0016 arrived from BNL on December 20. Cryostat parts from DD0013 are being used to assemble magnet DD0016, which should be complete approximately January 20, 1989.

Preparations are under way at MTF for testing DD0016 and subsequent magnets in the series. Modifications to the feed and return cans will allow the magnetic field measuring devices to be installed. Improvements were also made to the strain-gauge monitoring system and its associated software to improve operation and reliability.

Magnet development work involved continued effort on new end designs and the start of a program to study using the magnet yoke to support the collared coil. Magnet DSS12 (1.8 m) was received from BNL and tested prior to modification with new yoke systems. It unexpectedly exhibited training, even though tests at BNL showed that the magnet remembered its training after a thermal cycle. The program will continue in order to enable important features of the structural integrity of the magnet with different yoke systems to be evaluated with the in-coil strain gauges.

LAWRENCE BERKELEY LABORATORY (LBL)

The first production runs of SSC cable using the Dour cabling machine were completed. Three long lengths of 12,800, 13,600, and 12,600 feet of outer-layer cable were manufactured from strand made by Supercon, Inc. Dimensional and critical current measurements indicate that these cables meet the SSC specifications. This cable should be sufficient to meet the outer cable needs of the SSC 17-m dipole programs at BNL (5 dipoles) and FNAL (2 dipoles), as well as the needs of the 1.8-m and 1-m dipole programs at LBL, BNL, and FNAL.

Production cabling work for inner cable is scheduled to begin in January at NEEW, and Supercon will manufacture cable for the five 17-m dipoles scheduled for construction at BNL. The inner cable for the two 17-m dipoles scheduled for construction at FNAL will be manufactured by IGC, from wire currently in process and due for completion in May.

The use of unannealed rather than annealed wire in the SSC cable is being investigated. Results of further tests will be reported in January.

D15A-4FR1, a 1-m dipole, was cryogenically tested December 14–21. The original D15A-4F had its first training quench at 6238 A and reached its 4.3 K plateau of 7090 A on the fifth quench; several of the training quenches were in the outer layer. D15A-4FR1, the first rebuild,

incorporated two changes: azimuthal preload in the outer layer was increased, and the aluminum collars were tightly clamped in the iron through the use of shims between the collars and the iron. This magnet performed exceptionally well: the first quench occurred at 6745 A and the plateau of 7153 A was reached on the third quench; there were no quenches in the outer layer at 4.3 K and only one at 1.8 K. After thermal cycling to room temperature, no retraining was required.

D15A-5R4, the fifth reassembly of 1-m D15A-5, is being reassembled around a stainless steel bore liner designed to keep the inside surface of the coil under permanent outward radial pressure.

The first flared-end model, D15C-1, will be tested in January. The collars will be shimmed to come in contact with the yoke along their entire periphery as in model D15A-4FR1.

CDG REPORT

MAGNET PROGRAM

MSI Meeting

The MSI meeting was held December 14–15 at FNAL. A report on CDG administrative issues and R&D activities was made, including the Workshop on Superconductivity at LBL on November 13–14, where the welcome news was revealed of a 10 percent improvement in J_c by omitting the final anneal. The status of the Phase I industrialization activities was also summarized.

Next came a review of FNAL's short model program and cryostat developments there. The report was followed by an update on LBL activities, including cable procurement and the performance of recent 1-m dipole models. BNL's report covered the status of DD0016, 17, 18; DSS13 and 14; and, finally, rebuilt magnet DDA010.

Detailed reports covered recommended cable test facility specifications, the status of the cable database, further details of FNAL's short magnet program, and reviews of the MIITs concept, as well as the concept of superconductor margin, several reports on finite-element modeling, and discussions of measured collar deformations and progress on constant-perimeter ends. The phased magnet procurement strategy was summarized, and warm bore and mole developments and test results with FNAL model F3 were reported on.

The rest of the presentations covered the status of the various long magnets either tested or slated for early tests: DD0011 (autopsy), DDA010 (reassembled), DD0015 (low-temperature results), DD0016 (next in the test dock), and DD0017.

The next MSI meeting, first scheduled for January, was subsequently rescheduled for February 27–28 at FNAL.

Magnet Industrialization Program

A major milestone was reached on December 16 when DOE approved the list of candidates recommended by the evaluation board and selected by the Selection Official for participation in Phase I (Technology Orientation) of the MIP. The evaluation board had considered 27 applications by companies wishing to participate in the transfer of magnet technology from the national laboratories to private industry. Sixteen of the applicants were found to meet the requirements of potentially being capable of developing production magnet designs and then mass-producing large numbers of highly reliable magnets. The 16 selected Phase I applicants included four teaming ventures, so there are actually 20 companies represented in the program. The selected participants demonstrate a truly international interest in the SSC: of the 20 companies selected, eight American, seven Japanese, and five European firms will participate.

Immediately following approval of the results of the Phase I selection process, invitations to visit the CDG (January 9–10), LBL (January 11–12), BNL (January 23–27), and FNAL (February 20–23) were sent to each successful applicant. Preparation of lecture material for the Phase I CDG presentations was one of the principal CDG activities during the latter part of the month. Information packages, including a complete set of drawings of R&D magnet DD0014, were distributed. Letters of regret were sent to those applicants who did not meet the requirements of the program. In the solicitation for participation in the Phase I program, it was emphasized that these activities related only to the very demanding collider dipole magnet program; later there will be many opportunities to participate in other aspects of the construction of the SSC for companies not qualified for the collider-dipole production program, including the possibility of constructing some of the 3000 other magnets required for the machine.

Phase I, Technology Orientation, will be completed by early March 1989, at which time the SSC Magnet Division intends to solicit proposals from industry for Phase II, Tooling Development and Magnet Preproduction. Goals in Phase II will be (1) provision for dipole magnet tooling design and demonstration, (2) adaptation of the R&D dipole magnet design and R & D laboratory procedures to mass production, (3) proof of magnet reproducibility, and (4) demonstration of production rate capability. While these explicit program goals are being achieved, an experienced and qualified industrial base for mass production of collider dipoles will have been developed in the Phase II process. Up to five vendors will be selected to participate in Phase II, which is expected to be accomplished on multiyear contracts, both cost-type and fixed-price. The Request for Proposal (RFP) to begin the solicitation of industrial proposals for Phase II is anticipated to be issued in March 1989.

A draft document outlining possible acquisition strategies for Phase II was presented to DOE in November 1988. A preliminary review of that document was held at the DOE Chicago Operations office at the beginning of December. It is hoped that concurrence or recommendations concerning the strategy will be available to the CDG in January, since key issues not currently resolved will affect the final version of the Phase II RFP. For example, the degree and type of foreign contributors (if any) could greatly influence the level of domestic interest in Phase III. In spite of these potential concerns, the RFP has been undergoing intensive development at the CDG, based on the procurement strategy elaborated in greatest detail in the acquisition strategy document. Several consultants have contributed to drafting the RFP (with contract language, technical specifications, applicable documents, quality assurance provisions, etc.). The first draft of the RFP was completed on schedule. A second revision is due by the middle of January; if DOE approves a recommended acquisition strategy by then, the RFP itself will quickly be ready for DOE review.

Mathematical Analysis of Magnets

Fracture mechanics studies of the dipole collars and yoke continued.

Results on steel collars and the iron yoke have been documented in Magnet Division Note MD-TA-112. Analyses were based on the C358 cross section. Failures due to sudden fracture and to fatigue were considered. Using stress data from previous finite-element calculations, critical crack lengths (the crack length that will result in sudden, unstable crack growth) for the Nitronic-40 collar were computed. The areas of highest stress are near the keyways. It was determined that the critical crack length is larger than the width of the section where cracks are likely to propagate. Therefore, the only possible cause of failure due to crack propagation is fatigue. Using an empirical relationship for crack growth rate, it was determined that the collar will survive well over one million cycles before failure.

It is essentially impossible to cause fatigue in low-carbon steel at 4 K; therefore, only sudden fracture was considered for the yoke. Critical crack lengths were calculated for various load combinations. For all but the most severe case (no skin prestress, 4000 pounds/quadrant load), critical crack lengths are large enough to ensure the structural integrity of the yoke.

In a further study, using finite-element techniques, stress concentrations in the yoke and collars were calculated precisely. Accurate ANSYS sub-models were developed that included specified radii and fine meshes. Both NC9 and C358 collars showed local yielding in the area surrounding the keyway and in the corner adjacent to the outer radius of the outer-coil pole turn. While the highest stresses are confined to a region roughly equal to the radius of the corner where the peak stress occurs, yielding may occur over a wide area, as seen in previous finite-element calculations. Peak stresses in the yoke did not reveal any local yielding. Results are documented in MD-TA-113.

A report has been received from LLNL documenting the first phase of material property measurements on representative coil sections. Tests were performed on four samples at temperatures of 300 K, 77 K, and 4.2 K in each of two distinct geometrical configurations. First, a set of experiments was performed in which a section of the block was loaded in shear with respect to its neighbors. It was determined that the coefficient of sliding friction between turns is about 0.5, but that prior to actual slip the turns can move elastically with respect to one another with a very low modulus. Second, the coil sections were loaded in direct compression in the "azimuthal" direction while deflections in three orthogonal directions were monitored. There was large sample-to-sample variation in the outcome, as a result of the composite nature of the twisted-strand cable composition. On the average, at a compressive stress of 10 ksi, the compressive modulus is 1.4×10^6 at 300 K, increasing to 1.7×10^6 at 4.2 K. The poisson ratio results at low temperature exhibit too much sample-to-sample variation to be useful. At room temperature, one mil of deflection in the azimuthal direction results in 0.7 mil in the radial direction but only 0.1 mil in the longitudinal direction.

Detailed examination of archival data from magnet tests continues. Report MD-TA-109, "Time Histories for Mechanical Quantities on DD0015," was distributed.

Magnet-Cable Database

The structure of a general data base to inventory and trace SSC cable and strand material has been fully specified and is being implemented on a SUN computer network using the SYBASE relational database management system. The organization and detailed contents of this database are described in SSC-N-582. In addition to listing all important cable-production parameters, this report also provides formats and naming conventions to be used for identifying strand, cable, coils, and magnets. The database is being extended to encompass the production and inventory of coils and magnets. The eventual goal is to provide a complete description and history of the superconductor in each SSC collider dipole. Magnet performance and characteristics can then be easily categorized and monitored for accelerator physics purposes during machine installation.

BNL and LBL short magnets were added to the SYBASE magnet cable data summary. A SYBASE program to flag new data in the magnet cable data summary has been written. SSC/CDG workstations, made available with the SYBASE data management software, are now installed at both BNL and FNAL. Work is under way to use SYBASE for SSC cable-related activities at those labs, which will speed and better control the transfer of information.

A new VAX account, LBLSSCDB, has been set up to exchange cable data with LBL.

Magnet Testing

No long SSC dipole magnets were tested during December. This testing hiatus presented the opportunity to send one of our group members, A. Devred, to the HERA superconducting magnet test facility at DESY. He was able to spend a week at Hamburg, exchanging information about test programs and participating in the testing of HERA dipole magnet.

Data Analysis and Software Development

Test data from DSS13 (a 1.8-m BNL magnet) were transferred to the LBL VAX and analyzed. Modifications to existing analysis routines were made to accommodate the new BNL format. Data from the first SSC short magnet test at FNAL were also transferred to the LBL VAX cluster, and modifications to software were performed to allow calibration of strain-gauge data. Strain-gauge data were analyzed both at the CDG and at FNAL, and results were discussed at the December Magnet Systems Integration meeting at FNAL.

CDG programming support for the FNAL cryogenic monitoring program upgrade continued during December. Minor improvements in the CDG software that reads the cryogenic data were also made.

The Sun 4/280 server, the centerpiece of the Magnet Division data management and analysis workstation network, arrived at the beginning of December. Two 4/110 workstations were configured with SCSI disk drives to make them stand-alone units and shipped to FNAL

and BNL for use in the SSC/CDG database project. The server and one workstation are connected to the LBL Ethernet and are accessible to the outside world. Other Ethernet connections await an expansion of the system and the allocation of appropriate network identification numbers.

Magnet Instrumentation

Carbon-glass thermometers to measure the static temperature distribution inside an SSC magnet were ordered from Lake Shore Cryotronics. A holder for a thermometer to make dynamic measurements of SSC magnet helium temperature was designed and built. This thermometer would be in the collar pole piece. An investigation was made to find a thermometer with good sensitivity and fast response time (on the order of a millisecond or less): it was found that, with some care, most of the phenolic insulation of an 1/8 W Allen-Bradley carbon resistor could be ground away to expose about three-fourths of its bare carbon surface. Calculations indicate the response time of this sensor should be less than 1 millisecond. Mounting and testing of this proposed sensor is planned for January.

Magnet Measurements

The statistical question was examined of how many magnets must be field-mapped at cryogenic temperature, in addition to the standard maps at room temperature, to assure compliance of higher multipoles within limits specified by the SSC Magnet System Requirements. Preliminary conclusions can be found in report SSC-N-578. If the correlation between cold and warm multipoles is as strong as observed for the short R&D dipoles, then a sample of approximately 100 magnets will suffice for establishing the correlation between the two kinds of measurements. Monitoring of magnet production, at least as far as compliance of multipoles within their specifications is concerned, can then be based primarily on warm measurements. Elimination of cold measurements of field shape on a routine basis will represent a significant cost and schedule advantage for mass production and installation.

Dynamic Studies of a Collider Dipole Magnet

Studies of the dynamic behavior of a collider dipole magnet are being performed under contract with two California companies, EQE and Vibration Engineering Consultants. EQE has developed a mathematical model of the magnet suitable for structural support and vibration mode studies, and Vibration Engineering has performed a modal analysis of an actual 16-meter dipole (DD0014).

This work continued in December with the release of a contract with EQE to modify the mathematical model to make it conform with experimental test results obtained from the modal analysis.

The identification of a seismically quiet site in Texas has alleviated earlier concerns about the stability of the current magnet design when excited by ambient seismic motion. Loadings due to transportation accelerations are still under study, however. Transportation models developed for the vibration model have been based on extrapolation of existing data; they require refinement before they can be accepted with a high degree of confidence. To further these studies a contract was signed with Vibration Engineering to measure the dynamic performance of a magnet on a trailer when subjected to realistic transportation conditions. In preparation, a special model magnet has been assembled at FNAL, and a suitable trailer has been ordered from Fruehauf. It is anticipated that measurements will be carried out by Vibration Engineering early in 1989.

Cable-Measuring Machine

Testing of the hydraulic pressurization system continued. Life-cycle testing of the cable-clamping rams was completed: no oil leakage was detected at the seals. A design was developed to reduce hydraulic pressure variations, and the components required for the modifications were ordered. The electrical and software system designs used in these new machines are an upgrade of the original machine designs and reflect the experience gained from operating the existing units. Design of these two systems is approximately 80 percent complete.

Cable-Insulating Machine

An RFP for the insulating line was issued in November to nine vendors. Their proposals are due at the CDG by January 20. Two of the vendors have declined to propose; inquiries by the other potential vendors, however, indicate that we can expect a good response from industry.

ACCELERATOR PHYSICS

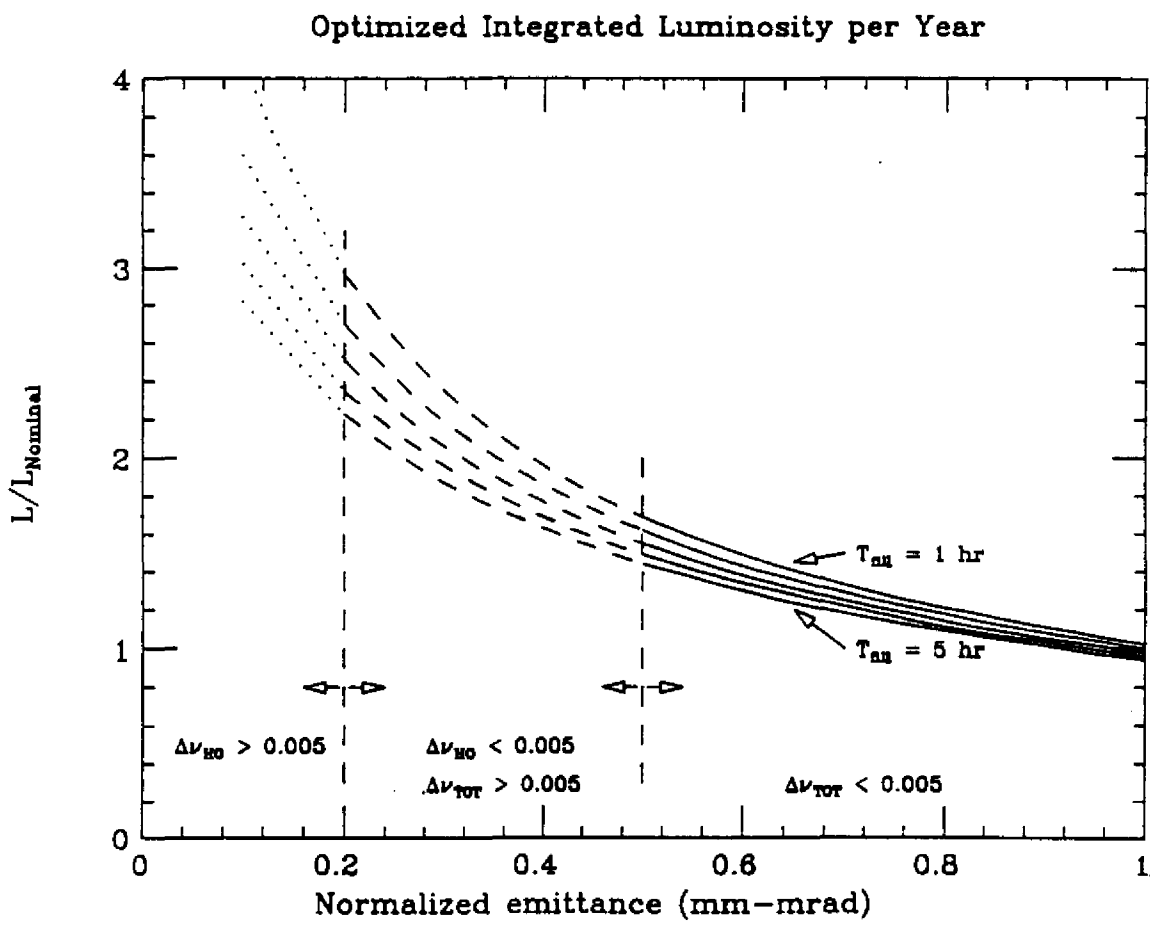
Luminosity Optimization Study

A study was carried out to determine the optimal yearly integrated luminosity for the SSC low-beta interaction regions as a function of initial normalized emittance for a variety of machine filling times. For each case, the optimum SSC cycle time was calculated. A program was written to calculate machine luminosity as a function of time for any initial values of various conditions: number of particles per bunch, number of bunches, energy, beta-star values, and emittance. This program calculates the time dependence of beam loss due to inelastic interactions, nuclear interactions, and Touschek scattering, and at the same time calculates the time dependence of the beam emittance due to elastic and multiple scattering, intrabeam scattering, and synchrotron radiation. As a function of time, the program then calculates the quantities of interest: luminosity, head-on and long-range beam-beam tune shifts, and the amount of synchrotron radiation into the beam pipe. For a given initial emittance and a particular

assumed filling time, the optimal machine cycle time is then determined, and the total integrated luminosity for a year's perfect running is projected.

This program was used to look at the range of normalized emittances ranging from the standard 1.0 π to 0.1 π mm-mrad. A range of filling times from 1 to 5 hours was assumed. The results of this study are given in SSC-N-583. A plot showing some of the results is shown below. For reference, the nominal case has

$$\varepsilon_N = 1.0\pi \text{ mm} - \text{mrad},$$
$$T_{fill} = 2.0 \text{ hr.},$$
$$\mathcal{L}_0 \text{ (low} - \beta) = 10^{33} \text{ cm}^{-2}\text{s}^{-1},$$
$$T_{cycle} = 41.5 \text{ hr, and}$$
$$\int_{year} \mathcal{L}dt = 5.15 \times 10^{40} \text{ cm}^{-2}.$$



Correction Elements Working Group

The Correction Elements Working Group is summarizing its work as of the end of 1988. Many of the results are too detailed to describe here, but one sentence for each of the more important conclusions or indications follows: Two lumped-corrector schemes have been found that compensate comparably with the bore-tube correctors of the Conceptual Design Report; this permits the final choice to be based on such factors as manufacturing feasibility, desirability of separating functions, preserving flexibility, and cost. Systematic errors, by themselves and in conjunction with random errors, have been found to be rather easily correctable—that is, to make the "linear aperture" exceed the "needed aperture." CDR projections about correction of closed orbits, tunes, chromaticities, and so forth have been largely confirmed, except that remote correctors in the CDR design, and remote correctors in general, appear to be unacceptably sensitive to closed-orbit uncertainties. Undesirable conspiracy, such as this, between two or more defects requires that many effects be included simultaneously in the lattice simulations. This simulation has been found to be sensitive to closed-orbit errors; that issue will be the focus of study in the near future. For this particular problem, estimates have been made for the improvement that could be realized by increasing the dipole bore size or increasing the injection energy.

Superconducting-Wire Stability

The stability of superconducting wire had previously been analyzed using a one-dimensional heat-flow equation, which assumes that the temperature profile across the wire cross section is uniform. In reality, frictional heat is generated due to wire movements in the cable. This heat originates at the surface of the wire, which consists of a copper jacket enclosing a matrix of copper and niobium-titanium filaments. The heat will travel transversely across the jacket into the niobium-titanium filaments, but it can also be conducted away longitudinally along the jacket. If the longitudinal conduction is faster than the transverse conduction, the heat will hardly affect the niobium-titanium filaments. An oversimplified two-dimensional analysis shows that the penetration is only about 1 percent of the thickness of the copper jacket. If only that part becomes normal, the remaining niobium-titanium may still be able to carry the transport current, and no quench will result. However, if the jacket is too thin, due to low copper-to-superconductor ratio, the temperature of the penetration may reach a temperature so high that eventually, as the temperature levels off, a large part of the niobium-titanium filament will not be in the superconducting phase. This argument leads to the conclusion that a high copper-to-superconductor ratio close to the critical limit is preferable, which agrees better with experiments. Analysis of this effect is continuing.

Degree of Confidence in Predictions of "Cold" Multipoles Based on "Warm" Field Measurements on SSC Dipole Magnets

An examination of this problem was undertaken by B. Berkes of the CDG Magnet Division in collaboration with the Accelerator Physics Division.

As only a small number of dipole magnets for the SSC will have both cold and warm measurements, with the rest measured only warm, the number to be measured cold in order to comply with the requirements for the overall field quality of cold magnets must be determined. Based on the assumption that there is only a weak correlation between a particular cold and warm multipole measurement, the number of magnets n, to be measured in both states, was determined for various degrees of confidence. The figures for n depended very strongly upon the field requirements for the particular multipole and were generally of the order of several hundred. This study, as well as a study of measurement precision, is reported in SSC-N-543.

ACCELERATOR SYSTEMS

Cryogenics

Major work again involved writing drafts of a Request for Proposals (RFP) for a Magnet Testing Laboratory (MTL) to be built on or near the SSC site in Waxahachie. All parts of the RFP have been started and are beyond the first draft. It is still intended to have a Request for Information issued in February, with the RFP to follow a month or two later.

A document about the MTL was prepared to be passed on to the new M&O contractor.

Correction Elements

The Correction Elements Working Group continues to meet weekly. As expected there is considerable sensitivity of the tune shift and smear at high amplitude (> 5 mm) to systematic errors in the presence of orbit and alignment errors. It appears that the so-called remote schemes may not be effective. The final report will be published in mid-to-late January.

Correction Magnet Prototype Program

The design of the winding machine for prototype correction coils progressed. Engineering drawings for specific parts for the winding machine were made. The design for the cryostat cover and prototype coil holder was reviewed. It was decided to have the design incorporate the possibility of lowering the temperature below 4.2 K (to ~ 2 K), but not to realize this capability in the first stages of the prototype program. A correction coil design that used conductor insulated with Kapton was investigated at BNL by D. Bintinger. Although these coils achieved short sample after one or two quenches, BNL's efforts to have outside contractors fabricate these

coils had largely failed. Plans to have coils wound by the BNL outside contractors for this program were then dropped. A plan to have BNL itself fabricate coils for the SSC was also dropped after discussions with P. Limon. An order for 30,000 feet of superconducting wire with various insulations was given to R. Remsbottom. The wire will be obtained from R. Scanlan and then sent out to be insulated.

Software and Controls

Sun Microsystems workstations continue to arrive. Members of this division are helping the Magnet Division set them up. The relevant machines have been sent off to BNL and Fermilab. Fermilab is looking over databases other than SYBASE, which was the CDG choice after some study. The possibility of a different database manager is not appealing and would cause us extra work, but could be accommodated.

CONVENTIONAL FACILITIES

Collision Hall Studies

Following the completion of the report on collision halls, several possible collider ring schemes were developed that spanned different experimental complex layouts. These configuration examples are used to explore potential construction techniques appropriate to the site's geology. Profile and cross-section drawings are then produced to highlight the technical issues for various configurations. For example, preliminary determinations can be made concerning the use of cut/cover or chamber construction techniques. A tentative determination of the nature of the underground enclosures permits associated surface facilities to be planned. It is hoped that it will be possible to prepare example detector assembly schedules to help understand the project's critical path.

Geotechnical Characterization Plan

RTK and its sub-contractor, TETC, have narrowed the previously prepared BQL geotechnical investigation plan to cover the requirements for a specific site. They have evaluated the quality of the data shown in the proposal and have recommended a program to acquire supplemental information on geology and geohydrology. Using layout and profile drawings prepared for the overall siting studies, they have prepared illustrations of the location and depth for supplemental test borings around the site.

Conceptual Design Preparations

In conjunction with the previously described technical studies, RTK and CDG have continued the development of procedures and tools to handle the preparation of a conceptual design for a specific site. A major goal is the ability to prepare an overall schedule for construction of conventional facilities. RTK is reconstructing a previous schedule (for Case A from the CDR) to demonstrate the feasibility of analyzing large-scale schedules in a PC-based computer environment. Later, schedules will be prepared incorporating construction sequences and times for the site. In addition, database files and example work breakdown structures (WBSs) are being organized so that site-specific cost estimates can be prepared.

USNC/TT Subcommittee Meeting

On December 1-2, the subcommittee of the National Committee on Tunnel Technology studying the range of suitable contracting practices for the underground portions of the SSC project met in Dallas. T. Toohig acted as a consultant. It is hoped that a final draft report will be available for review in February.

M & O Briefing

From December 12–14, D. Theriot of Fermilab and representatives of the Sverdrup Corporation, which is involved in conventional construction for URA's M&O contract proposal, were briefed on plans developed by the Conventional Facilities Division. Briefings were conducted at CDG and at RTK. A thorough review was provided of the design status; particular emphasis was placed on substantial developments since publication of the CDR. In addition, the tools developed to position the site footprint, given the geology and topology of the site, were demonstrated. The digitized site data and detailed plans for geotechnical site characterization were explained. Requirements for a supplemental EIS were discussed with D. Getz, who has been deeply involved with the draft EIS. Drawings and documentation were provided as requested.

BNL REPORT

MODEL MAGNETS

Magnet Assembly

DD0017 was successfully collared, using revised collar loading procedures, and the yoke was assembled. The monolithic yoke construction replaces the former gaps between yoke blocks with stainless steel spacers (slotted for helium flow). The length of the yoke is determined by rods that are removed when assembly is complete.

Coil stress profile measurements were performed in the ramp splice and coil end regions of DD0018. Strain gauge transducer calibrations were also completed for this magnet. Collars for DD0018 are being reworked to ensure adequate density of collars in each pack and to eliminate the possibility of coil shims becoming displaced during assembly.

Trim Coils

A 10-m trim coil was mounted on a bore tube. Scheduling changes prevented this assembly from being deployed in DD0018; it is now earmarked for DD0019.

A 1.6-m sextupole coil was produced and tested, and two more 1.6-m sextupole coil patterns were produced by Multiwire.

Beam Tubes

Recent weeks have been devoted to preparing beam tubes for DD0016, 17, and 18.

Silvex has completed the preparation of six 17-m beam tubes, each copper-plated internally over its full length. Adhesion is excellent.

Trent Tubing has started production of the next lot of bore tubes.

TOOLING AND FACILITIES

Coils

The first curing press was adjusted to eliminate the need for quick heating system disconnects for both long and short dipoles. The experimental 1.8-m outer DSS EDM-treated formblock was assembled and installed in the first curing press. All stacking and welding tasks for the new 17-m inner and outer formblocks were completed; two new strongbacks for 17-m coils were also completed.

Collars

Design work continued on the tapered-key insertion attachment of the collaring press. Layout drawings were completed and approved for the tapered-key attachment of the preproduction collaring press.

Shell

Work continued on various aspects of the longitudinal shell welding fixture, including encoders, torch, wire and welder tip, overhead cables, and spare parts.

Test Equipment

Layouts and assembly drawings were completed for modifications to the coil compression gauge fixture. The strain-gauge calibration system has been upgraded and moved to its permanent location, where it is in full operation.

Detailing and design work for Mole C was completed. The coil drive is being assembled. All parts of the frame and housing are finished and await assembly.

Design work continues on components for Mole D, and machining of various parts has started.

Trim-Coil Test Facility

Design is complete and awaits final approval.

Warm Bore-Tube Development

Tubing was ordered, and design work on a helium-cooled warm bore-tube system has started.

TESTS AND MEASUREMENTS

1.8-m dipole DSS13 was successfully tested this month. The most significant new construction features were the line-to-line fit of the yoke and collar, the revised coil cross section (C358D), an improved ramp splice, yoke midplane alignment keys, and monolithic yoke construction. The inner-coil cable has a copper-to-superconductor ratio of 1.5:1, six-micron filaments, and a calculated quench current of 6885 A at 4.35 K.

The quench performance of the magnet was good. Training and retraining after a thermal cycle were minimal: the plateau quench current at 4.35 K was 6925 A (about 7 T). The highest quench exceeded 8100 A (3.35 K).

At the end of the second round of 3.35 K (i.e., 8 T) testing, a problem developed in the connection between the magnet lead and the power supply that caused erratic quench behavior.

The problem, because of its location, was associated with the magnet hookup in the vertical test equipment rather than with the magnet itself. (Preliminary inspection of the magnet after testing revealed a possible source of friction-induced heating.)

The multipoles of the magnet were also good. The shims used to assemble the magnet were within 3 mils of the design. All measured terms were within SSC tolerances (insofar as can be determined from one magnet).

INDUSTRIALIZATION

Preparation continued of written procedures and documentation for the forthcoming Phase I Technology Orientation sessions.

FNAL REPORT

DIPOLE CRYOSTAT

Thermal performance measurements of the Design B insulation system from 300 to 80 K continue to be deferred. It is planned to begin measurements in January.

Study continued of the buckling of the 20 K shield of DD0014. Studies to improve the circumferential welds joining the longitudinal sections of the shield were completed. Improved thermal insulation between the backside of the shield and the MLI blankets will allow proper heating of the aluminum to improve the quality of the weld without damage to the blanket. Blanket protection details were worked out and evaluated in the lab; they will be incorporated in the construction of subsequent model magnets.

The short shield test was set up, but difficulty has been encountered in developing adequate heat transfer between the heating element and the 20 K coolant tube.

Close attention is being paid to the shields during removal of magnet DD0015 from the test stand and its subsequent disassembly. Disassembly of the interconnections showed that the shield bridges have not buckled due to test stand operations, a result of modified shield bridge installation methods. The body shields will also be examined.

Work on the long shield bowing test was deferred until near-term problems and their solutions are understood.

Resolution of differences between predicted and measured structural dynamic responses of SSC magnets progressed. The response predictor (EQE) and the modal analyzer (Vibration Engineering) agreed on the validity of the response measurements. The analytical model is being modified with recent Fermilab support-post spring-constant data and revised end conditions. These modifications will reduce the fundamental frequencies in the direction of the measured values.

Work was completed on the dedicated cryostat model (DSHIP) for the warm measurement of magnet structural response to shipping, handling, and seismic loads. The state of strain in DSHIP suspension system components will be monitored during handling and outdoor storage prior to actual over-the-road measurements. The process to procure a trailer for the over-the-road measurements began.

Work on the vertical-probe transporters continues. The control system for the Inchworm is being developed. Procurement of components for a self-storing transporter continues.

Magnet industrialization preparations continue. Details of Phase I of the Magnet Industrialization Program continue to be put in final form. Work was completed on a video describing the magnet cryostat assembly.

Work on an SSC interconnection mockup continues. The initial proposal for the mockup was reviewed by the CDG, and a subsequent proposal addressing mockup configuration, schedule, and cost in greater detail is being prepared by Fermilab.

Work continues on the Design C cryostat.

MAGNETIC MEASUREMENTS

The Stand 5 end cans were aligned, and the annular beam tube feed-throughs (ABFT's) were installed. The tight tolerance on alignment required for successful operation of the mole required careful installation. Connection of the ABFT instrumentation wires to connectors was nearly completed. New reinforcements are being installed to support the feed can and turnaround can against pressure-induced lateral bellows instability. (Such an instability was observed during the high-pressure quench of DD0011.) The new reinforcements should increase the safe pressure rating of the test system. It is planned to determine the safe operating pressure before cooldown of DD0016 begins in early February.

Bellows instability is also being studied on stand 4. Magnet DD0015 remains in place on stand 4 and is being used to test new software. The improved strain-gauge monitoring system was successfully tested in conjunction with the associated new software. The obsolete TI5 sequencer, a key component of the interlock system for the test facility, has been replaced by a new TI30 system; checkout of the new system was completed.

LONG MAGNET FABRICATION

Progress on Cold Mass Pilot Production Factory Setup

Laminated Tooling. Assembly of the upper laminated collaring mold is complete. Laminations for the lower portion are being stamped. Assembly of the laminations will begin in mid-January.

The inner and outer winding mandrels are 75 percent complete.

Problems with the inner- and outer-coil mold laminations have delayed fabrication of the coil mold assemblies. The problem resides in lamination-to-lamination dimensional variations caused by the vendor's shaving die. The vendor has reworked his tooling, and sample laminations are being inspected.

Presses. Assembly of the curing and collaring press is under way. Not all vendor-supplied parts are on hand; however, delivery schedules seem reasonable.

Work is in progress on the yoke and skinning press. Mounting of the base plates onto the concrete slab was begun.

Winding Table. Electrical and control hook-up has begun for the winding machine. Trial operation and debugging should begin soon.

Cryostats

DD0013 – Tear-down was completed in mid-December. Parts from DD0013 are to be used on DD0016. The cold mass is being stored.

DD0016 – The cold mass was received from BNL on December 20. Completion is expected approximately January 20, 1989.

DD0014 – The cold mass was returned to BNL on December 14. Two vacuum bellows and four 20-foot sections of cold mass skin were also shipped then.

DSHIP – Assembly was completed on December 10. The model will be stored while waiting for the flat-bed trailer.

Magnet Development

DSS12, intended for experiments on the use of the yoke to support the collared coil, was received from Brookhaven and tested "as is" at Lab 2. Data were recorded from the collar-pack strain gauges and the return-end bullet strain gauges. However, only seven of the 57 voltage taps were wired: the five quarter-coil taps and the two taps defining the ramp splices. This magnet had previously been tested at Brookhaven at temperatures as low as 3.4 K and had undergone at least three cooldowns. Despite its earlier training, the first two quenches, at 5690 A and 6530 A, were well below the critical current. A stable quench plateau, at a current of 6890 A with a spread of about 10 A, was then established at an operating temperature of 4.2 K. This quench current is within 20 A of the value extrapolated from the quench current measured at Brookhaven at 4.35 K. The first training quench was in the lower inner coil; the second training quench and all plateau quenches were in the upper inner coil. None in a ramp splice. Because most of the voltage taps were not used, the precise origin of the quenches cannot be determined. Several strain-gauge runs were taken up to a maximum current of 6820 A. The data agree reasonably well with similar data taken at BNL.

By pumping on the liquid in the dewar, the magnet temperature was lowered below 3 K. Strain-gauge data were taken up to a current of A on the way to the first of three low-temperature quenches. The quench currents—7310, 7119 and 7510—are well below the critical current at 3 K; however, because of significant temperature gradients across the magnet during these tests and significant quench-to-quench temperature variations, it is difficult to draw quantitative conclusions from these results.

Magnetic measurements were then performed on DSS12 at 4.2 K. Multipole harmonics (dipole through octupole) were studied using a 0.95-cm radius Morgan coil and the Lab 2

magnetometer. A warm finger was built by evacuating and superinsulating the space between the existing beam pipe and a 1.2-cm inner bore tube. The transfer function and higher-order harmonics were in good agreement with those measured at Brookhaven.

DSS12 has been warmed to room temperature and moved to Industrial Building 3. The first re-yoking, with a horizontally split "line-fit" yoke similar to DSS13 and DD0016, will proceed when yoke laminations are received from BNL in late January.

F Series Model Program

Magnet F3 is being disassembled. The skin was removed. Strain-gauge readings on both the coil and skin are being taken during disassembly. The BNL strain-gauge pack will be cold-calibrated after the magnet is disassembled.

Measurements of F4 inner coils reveal the coils to be oversize. Investigation showed the cable to have a 60 percent Kapton overlap instead of the required 50 percent. New coils will be wound.

The ends of the F4 inner coils were potted and sectioned to determine cable placement.

One F4 outer coil was wound and cured. The ends will be potted and sectioned. The body will be cut into cookies. Winding of magnet F5 will begin in late January.

Design of end parts for magnet F7 (C358 cross section) is complete. Detailing is now taking place. Parts will be ready for machining in January.

LBL REPORT

SUPERCONDUCTOR AND CABLE

The first production runs of SSC cable using the Dour cabling machine were completed. Three long lengths of 12,800, 13,600, and 12,600 feet of outer-layer cable were manufactured from strand made by Supercon, Inc. Dimensional and critical current measurements indicate that these cables meet the SSC specifications. This cable should be sufficient to meet the outer-layer cable needs of the SSC 17-m dipole programs at BNL (5 dipoles) and FNAL (2 dipoles), as well as the needs of the 1.8-m and 1-m dipole programs at BNL, FNAL, and LBL. Production cabling work for inner cable is scheduled to begin in January at NEEW; Supercon will manufacture cable for the five 17-m dipoles scheduled for construction at BNL. The inner cable for the two 17-m dipoles scheduled for construction at FNAL will be manufactured by IGC, from wire scheduled to be ready in May.

The use of unannealed rather than annealed wire in SSC cable is being investigated. Initial results on cable fabrication, coil winding, and magnet performance of cable made from unannealed wire look promising. Further tests will be made and reported in January.

MAGNET MODELS

Dipole Models

D15A-4FR1. This dipole was cryogenically tested December 14–21. This is the most successful 1-m dipole to be tested in four years. The original D15A-4F reached its 4.3 K plateau of 7090 A on the fifth quench, and the first training quench occurred at 6238 A. Several of the training quenches were in the outer layer.

Two major changes were made to the D15A-4F magnet when it was rebuilt as D15A-4FR1. Pole shims were changed to increase the azimuthal preload in the outer layer, and aluminum collars were tightly clamped in the iron through the use of shims between the collars and the iron. A gap exists between the iron halves after the iron is clamped and bolted.

There were no quenches in the outer layer at 4.3 K and only one at 1.8 K. The first quench at 4.3 K was at 6745 A; the plateau of 7153 A was reached on the third quench. After thermal cycling to room temperature, no retraining was required.

D15A-5R4. This is the fourth reassembly of D15A-5. The coils will be reassembled around a stainless steel bore liner that has a soft plastic layer between the tube and the inner coil surface. During collaring the inner coil will be compressed against this bore liner and will hold the inside

surface of the coil under permanent outward radial pressure. Movement of the inner strands should be minimized, but cooling of the inner coils is less effective.

D15C-1. This is the first flared-end model with a complete CAD-based mechanical and magnetic design. The collars will be shimmed to come in contact with the yoke along their entire periphery, as in model D15A-4FR1. Winding and assembly proceeded smoothly. The ends are fully clamped. Yoke insertion and clamping will take place immediately after the Magnet Industrialization Program orientation meetings in January.

Tooling

Assembly of the Fermilab-type laminated tooling for 1-m models is nearly complete.

Analysis

Per Fermilab's request, a magnetic analysis was made of their dipole ends. The geometry is based on the C358D cross section with their own ends, designed with CAD. After four geometrical iterations a solution has been reached with low integrated multipoles.

PROJECT COST DATA

INDEX

SSC PROGRAM	Table	Figure
Central Design Group	C-1	1
Brookhaven National Laboratory	C-2	2
Fermi National Accelerator Laboratory	C-3	3
Lawrence Berkeley Laboratory	C-4	4
SSC Program Summary	C-5	5
Monthly and Cumulative Summary	C-6	

TABLE C-1

CENTRAL DESIGN GROUP

DECEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	112.8	172.9	70.0	355.6	845.2	6246.0
1.2	PROGRAM PLANNING & MANAGEMENT	24.0	13.1	13.5	50.6	127.8	1190.0
1.3	ACCELERATOR R & D	244.5	198.7	134.3	577.5	1434.8	17004.0
1.4	CONVENTIONAL SYSTEMS DEVELOPMENT	28.6	17.4	4.1	50.1	124.5	1740.0
	PROGRAM COSTS	409.9	402.1	221.9	1033.8	2532.3	26180.0
1.41	RTK COSTS	0.0	72.0	0.0	72.0	174.6	750.0
	CDG/RTK COSTS	409.9	474.1	221.9	1105.8	2706.9	26930.0
	COMMITMENTS					1746.4	
	DELTA COMMITMENTS					-162.3	

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY

DECEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	MAGNET DESIGN	55.7	46.4	32.2	134.3	404.9	3348.0
2.2	17-M COLD MASS FABRICATION	157.7	155.1	98.7	411.5	1042.5	4134.0
2.3	TOOLING & FIXTURES	9.3	161.6	53.9	224.8	567.8	640.0
2.4	BEAM TUBE DEVELOPMENT	18.6	0.0	5.9	24.5	79.2	633.0
2.5	1.8-M DIPOLE FABRICIATION	9.3	0.0	2.9	12.2	242.2	538.0
2.6	TRIM COIL DEVELOPMENT	18.6	3.4	6.9	28.9	86.5	752.0
2.7	MAGNET MEASUREMENT	92.8	115.9	65.9	274.6	634.7	3341.0
2.8	INDUSTRIALIZATION	9.3	7.8	5.4	22.5	50.6	316.0
	MAGNET TOTALS	371.3	490.2	271.8	1133.3	3108.2	13702.0
2.9	ACCELERATED LIFE TESTS	23.2	7.6	9.7	40.5	116.3	898.0
	BNL R & D TOTALS	394.5	497.8	281.5	1173.8	3224.5	14600.0
	COMMITMENTS					2063.0	
	DELTA COMMITMENTS					54.0	
	EQUIPMENT COSTS	0.0	36.1	0.0	36.1	117.0	2947.0
	EQUIPMENT OPEN COMMITMENTS					140.0	

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY

DECEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	0.0	14.6	5.0	19.6	33.9	160.0
3.2	LONG MAGNET FABRICATION	1.7	147.5	51.0	200.2	418.5	1361.0
3.3	MAGNETIC MEASUREMENTS	18.3	34.1	17.9	70.3	252.3	1560.0
3.4	COLD MASS FABRICATION	13.3	90.5	35.4	139.2	459.4	2766.0
3.5	INDUSTRIALIZATION	5.9	3.1	3.1	12.1	50.9	300.0
3.6	CELL TESTS	0.0	0.0	0.0	0.0	0.0	0.0
	PROGRAM COSTS	39.2	289.8	112.4	441.4	1215.0	6147.0
	COMMITMENTS					550.0	
	DELTA COMMITMENTS					-40.2	
	EQUIPMENT COSTS	0.7	27.6	0.0	28.3	107.5	1640.0
	EQUIPMENT OPEN COMMITMENTS					534.6	

TABLE C-4

LAWRENCE BERKELEY LABORATORY

DECEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
4.1	GENERAL	6.7	1.9	4.1	12.7	31.0	350.0
4.2	SUPERCONDUCTOR & CABLE	16.7	12.6	13.9	43.2	109.7	1340.0
4.3	CABLE SHORT SAMPLE TEST FACILITY	8.9	0.0	4.2	13.1	54.3	50.0
4.4	DIPOLE MAGNET DEVELOPMENT	63.9	9.9	35.1	108.9	393.7	760.0
4.5	QUADRUPOLE MAGNETS	0.0	0.0	0.0	0.0	0.0	260.0
4.6	COIL PROPERTIES	0.0	0.0	0.0	0.0	0.0	200.0
4.7	TECHNOLOGY TRANSFER TO INDUSTRY	6.9	0.4	3.5	10.8	10.8	50.0
	MAGNET R & D TOTALS	103.1	25.0	60.8	188.9	599.9	3010.0
4.8	ACCELERATOR THEORY SUPPORT	12.8	0.7	6.4	19.9	65.7	410.0
	R & D COST TOTAL	115.9	25.7	67.3	208.8	665.7	3420.0
	COMMITMENTS					96.0	
	DELTA COMMITMENTS					-2.0	

TABLE C-5

PROGRAM SUMMARY - SUPERCOLLIDER

DECEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	409.9	402.1	221.9	1033.8	2532.3	26180.0
1.41	RTK PROGRAM	0.0	72.0	0.0	72.0	174.6	750.0
2.	BNL SSC PROGRAM	394.5	497.8	281.5	1173.8	3224.5	14600.0
3.	FNAL SSC PROGRAM	39.2	289.8	112.4	441.4	1215.0	6147.0
4.	LBL SSC PROGRAM	115.9	25.7	67.3	208.9	665.7	3420.0
	TOTAL SSC PROGRAM COSTS	959.5	1287.4	683.0	2929.9	7812.1	51097.0
	COMMITMENTS					4455.4	
	DELTA COMMITMENTS					-150.5	
	EQUIPMENT COSTS					224.5	4587.0
	EQUIPMENT OPEN COMMITMENTS					674.6	

TABLE C-6

MONTHLY AND CUMULATIVE SUMMARY
OF PLANNED AND ACTUAL COSTS AND COMMITMENTS

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	1158.0	1158.0	236.1	236.1	1027.3	2035.9	1799.8	791.2
NOV	1238.8	2396.8	1365.0	1601.1	1473.9	3509.8	1908.7	108.9
DEC	1319.6	3716.3	1105.8	2706.9	943.5	4453.3	1746.4	-162.3
JAN	1400.4	5116.7						
FEB	1588.9	6705.6						
MAR	1831.2	8536.8						
APR	2154.4	10691.2						
MAY	2477.6	13168.8						
JUN	2827.7	15996.4						
JUL	3177.7	19174.2						
AUG	3608.6	22782.8						
SEP	4147.2	26930.0						

2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	1216.7	1216.7	1033.8	1033.8	3502.9	3502.9	2469.1	2469.1
NOV	1216.7	2433.3	1017.1	2050.9	557.0	4059.9	2009.0	-460.1
DEC	1216.7	3650.0	1173.8	3224.7	1227.8	5287.7	2063.0	54.0
JAN	1216.7	4866.7						
FEB	1216.7	6083.3						
MAR	1216.7	7300.0						
APR	1216.7	8516.7						
MAY	1216.7	9733.3						
JUN	1216.7	10950.0						
JUL	1216.7	12166.7						
AUG	1216.7	13383.3						
SEP	1216.7	14600.0						

3.0 FERMI NAT'L ACCEL LAB - SUPERCOLLIDER

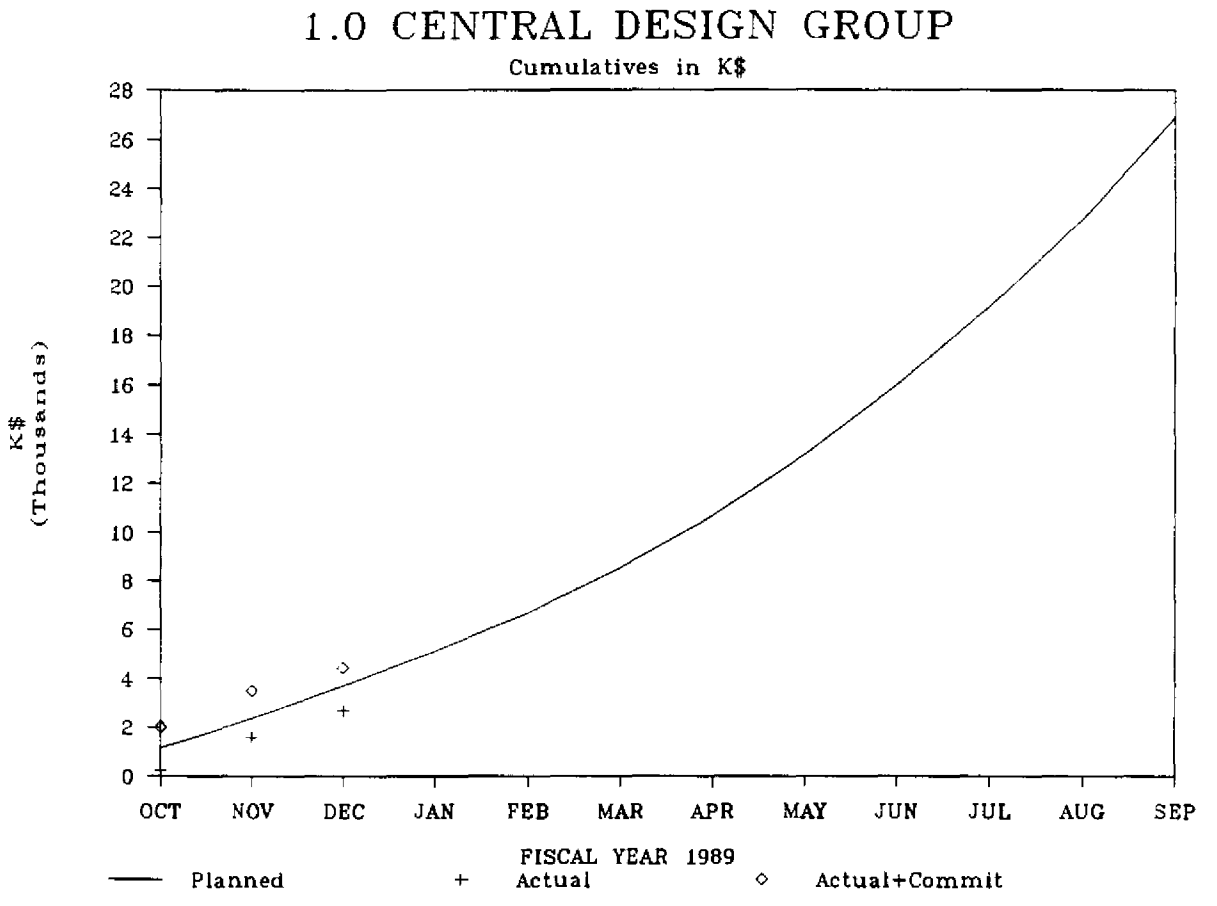
MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	512.3	512.3	266.4	266.4	1043.4	1043.4	777.0	777.0
NOV	512.3	1024.5	507.2	773.6	320.4	1363.8	590.2	-186.8
DEC	512.3	1536.8	441.4	1215.0	401.2	1765.0	550.0	-40.2
JAN	512.3	2049.0						
FEB	512.3	2561.3						
MAR	512.3	3073.5						
APR	512.3	3585.8						
MAY	512.3	4098.0						
JUN	512.3	4610.3						
JUL	512.3	5122.5						
AUG	512.3	5634.8						
SEP	512.3	6147.0						

4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	285.0	285.0	244.6	244.6	-5.4	339.6	95.0	-250.0
NOV	285.0	570.0	212.2	456.8	215.2	554.8	98.0	3.0
DEC	285.0	855.0	208.8	665.6	206.8	761.6	96.0	-2.0
JAN	285.0	1140.0						
FEB	285.0	1425.0						
MAR	285.0	1710.0						
APR	285.0	1995.0						
MAY	285.0	2280.0						
JUN	285.0	2565.0						
JUL	285.0	2850.0						
AUG	285.0	3135.0						
SEP	285.0	3420.0						

0.0 PROGRAM SUMMARY - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	3171.9	3171.9	1780.9	1780.9	5568.2	6921.8	5140.9	3787.3
NOV	3252.7	6424.6	3101.5	4882.4	2566.5	9488.3	4605.9	-535.0
DEC	3333.5	9758.1	2929.8	7812.2	2779.3	12267.6	4455.4	-150.5
JAN	3414.3	13172.4						
FEB	3602.8	16775.2						
MAR	3845.2	20620.3						
APR	4168.3	24788.6						
MAY	4491.5	29280.1						
JUN	4841.6	34121.7						
JUL	5191.7	39313.3						
AUG	5622.5	44935.9						
SEP	6161.1	51097.0						


1.0 CENTRAL DESIGN GROUP
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 1989
Planned
Actual
Actual+Commit

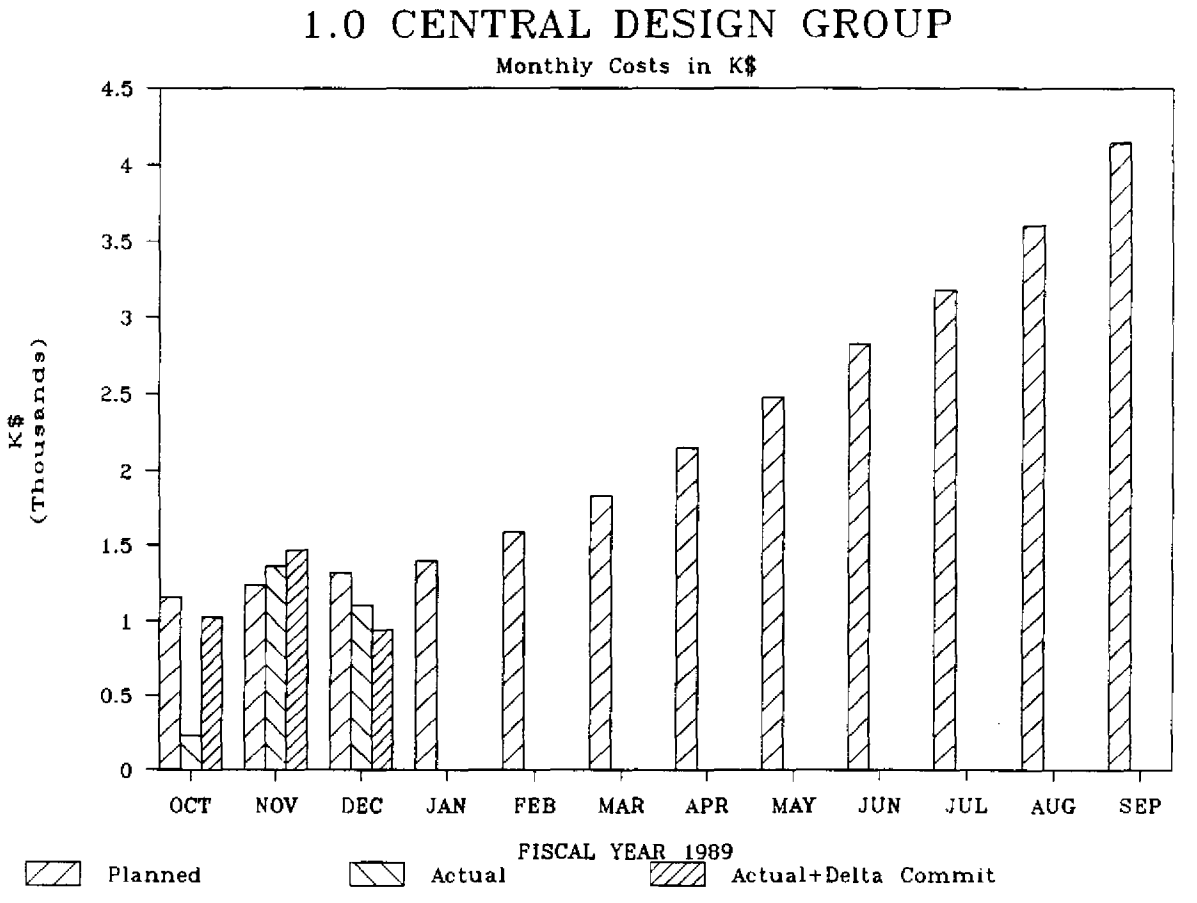
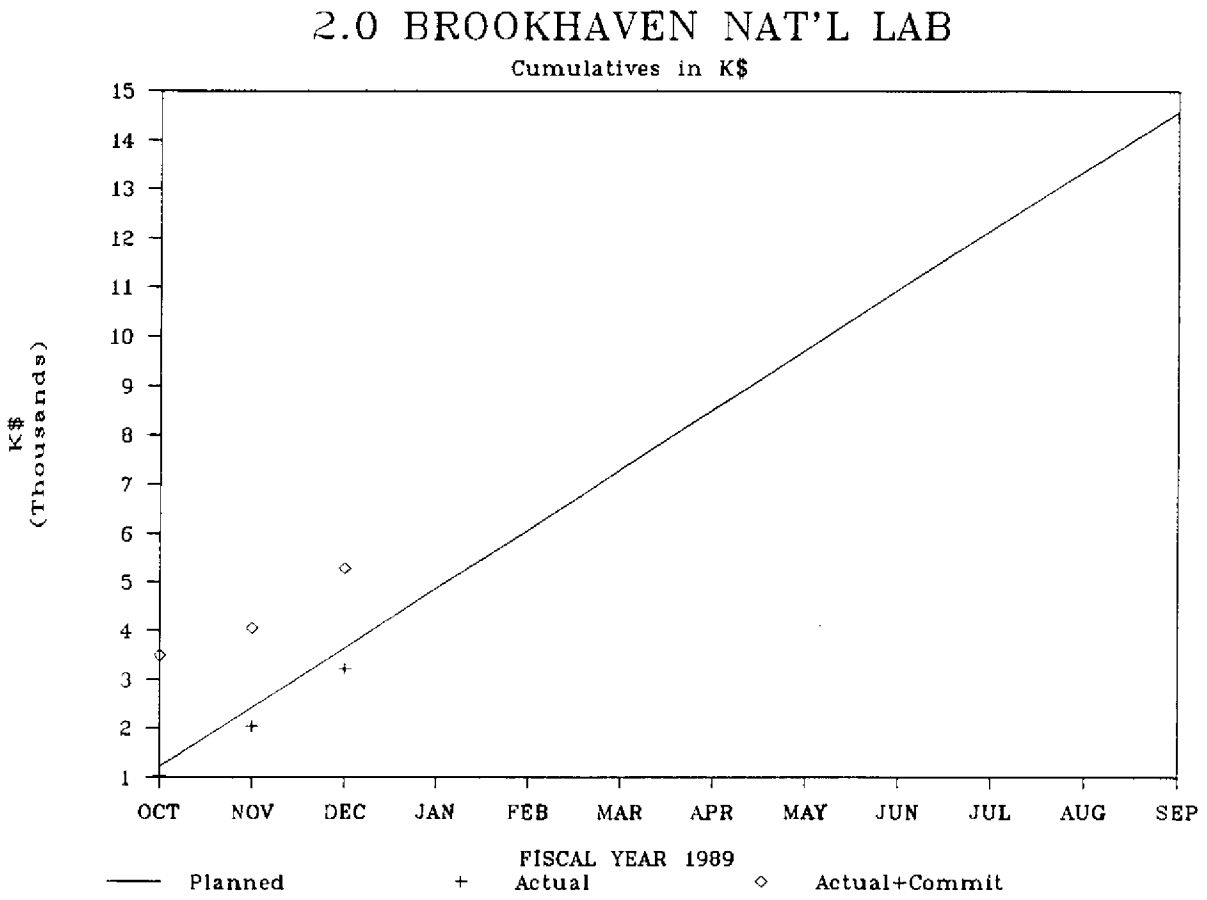

1.0 CENTRAL DESIGN GROUP
Monthly Costs in K$
K$ (Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 1


2.0 BROOKHAVEN NAT'L LAB
Cumulatives in K$
K$ (Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

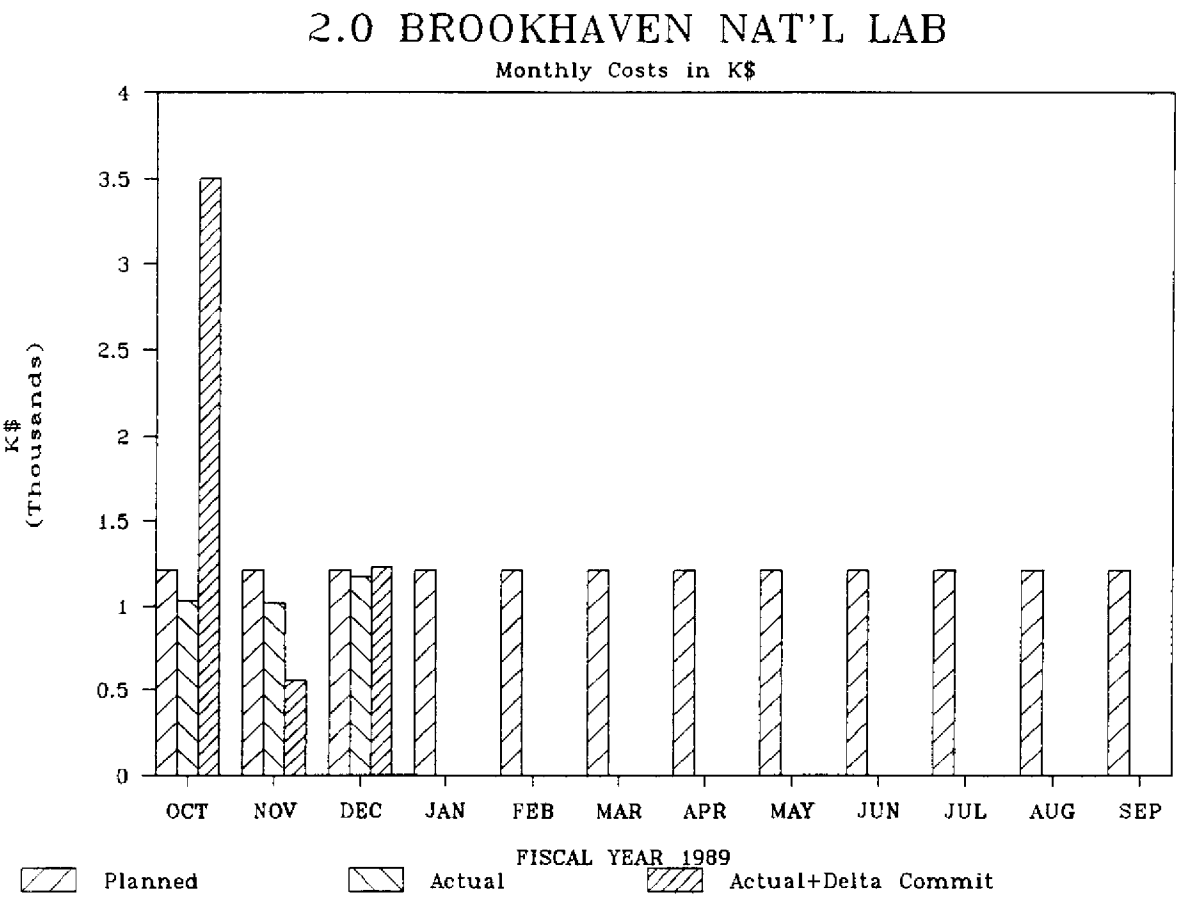
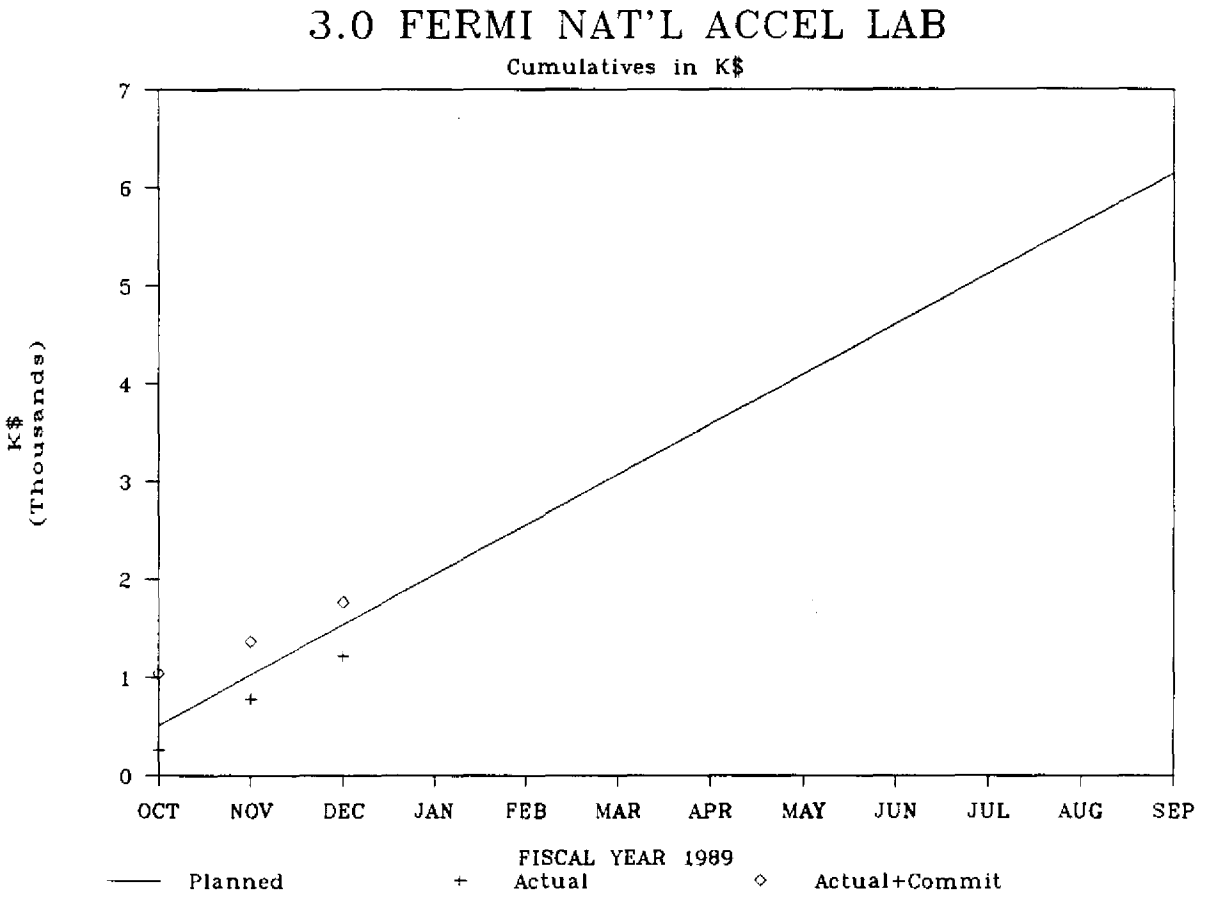

2.0 BROOKHAVEN NAT'L LAB
Monthly Costs in K$
K$ (Thousands)
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 2


3.0 FERMI NAT'L ACCEL LAB
Cumulatives in K$
K$ (Thousands)
0
1
2
3
4
5
6
7
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

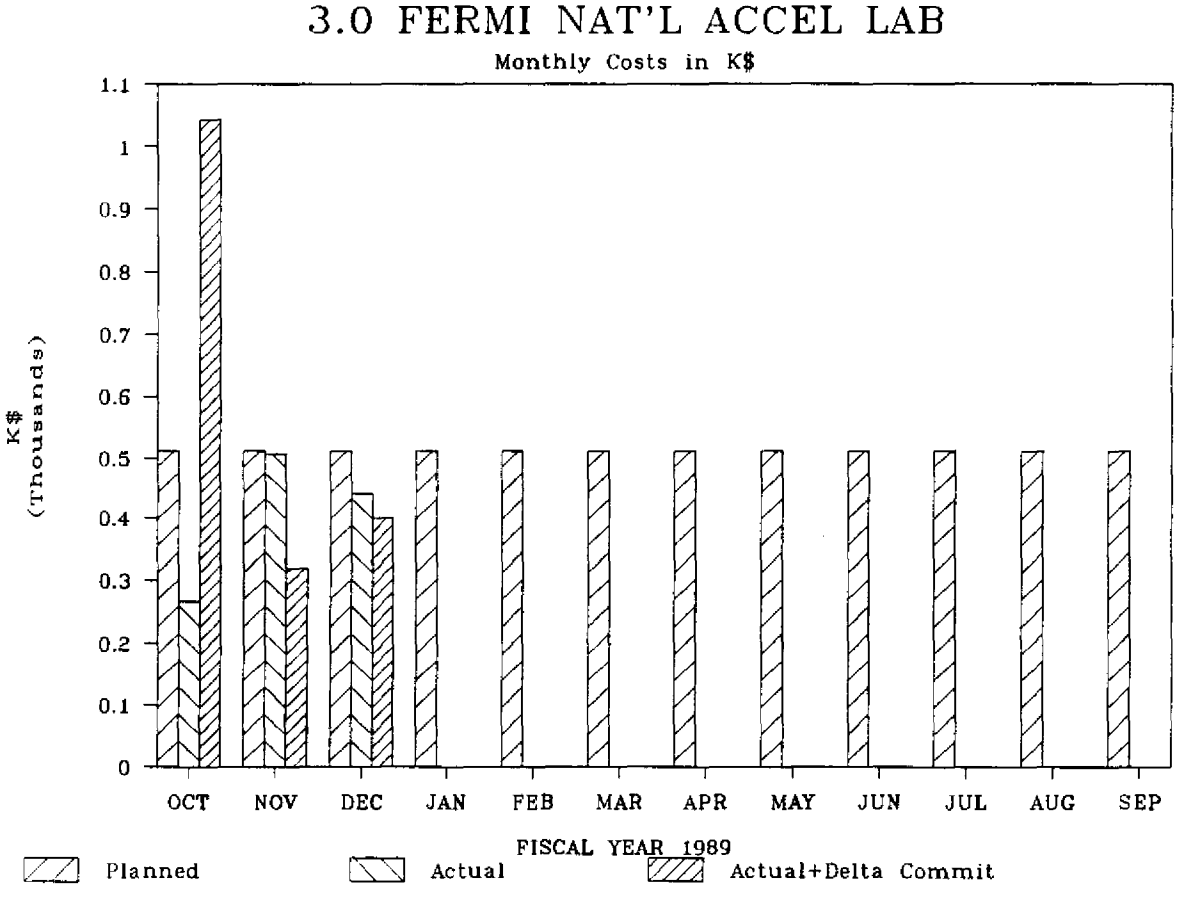
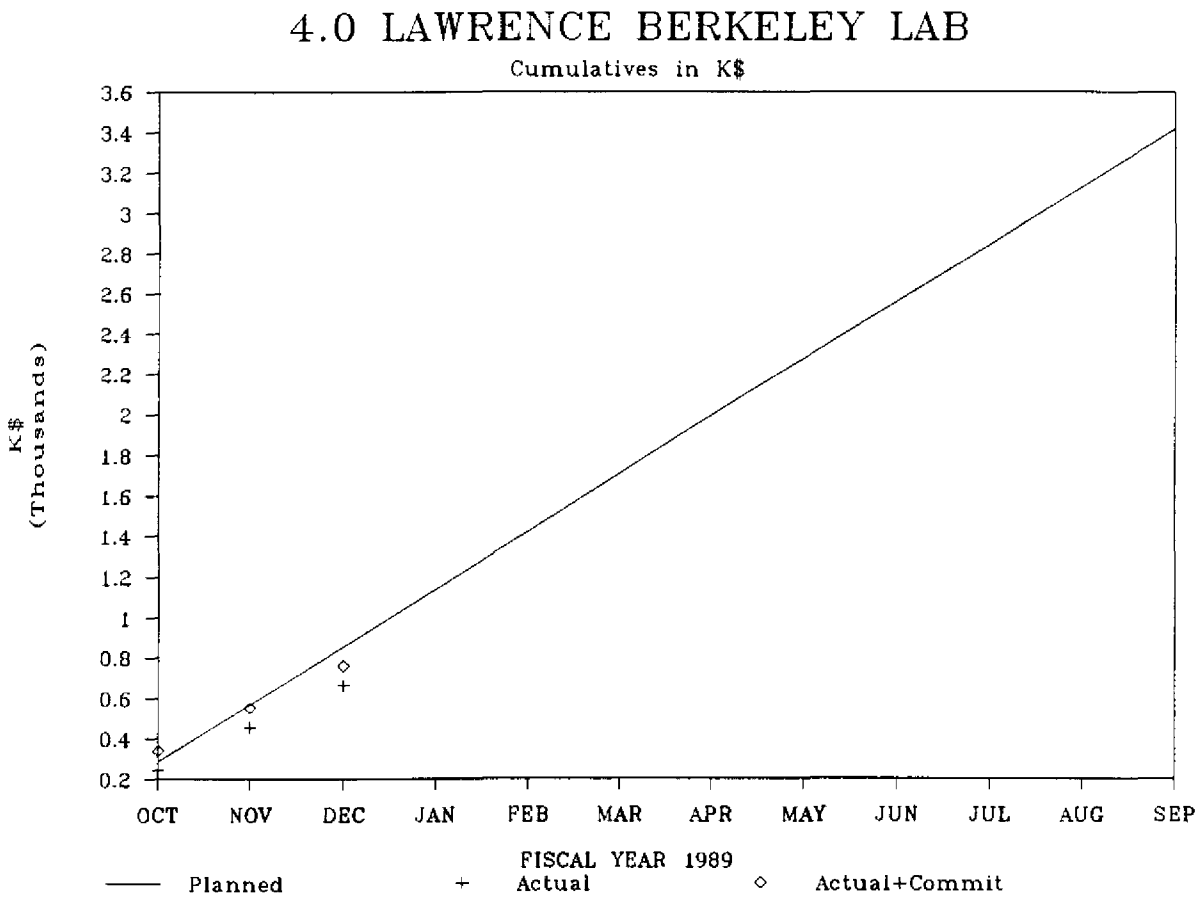

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$ (Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 3


4.0 LAWRENCE BERKELEY LAB
Cumulatives in K$
K$ (Thousands)
3.6
3.4
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 1989
Planned
Actual
Actual+Commit

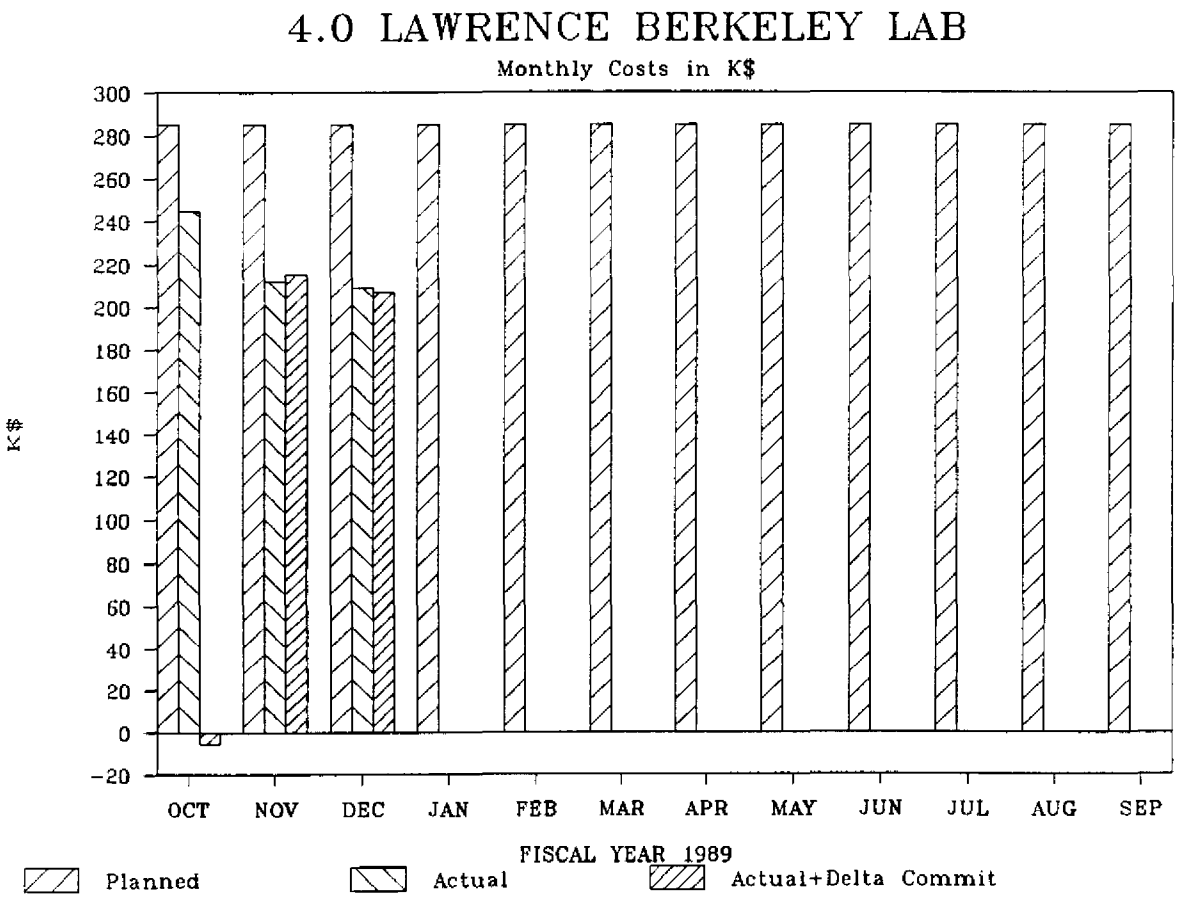
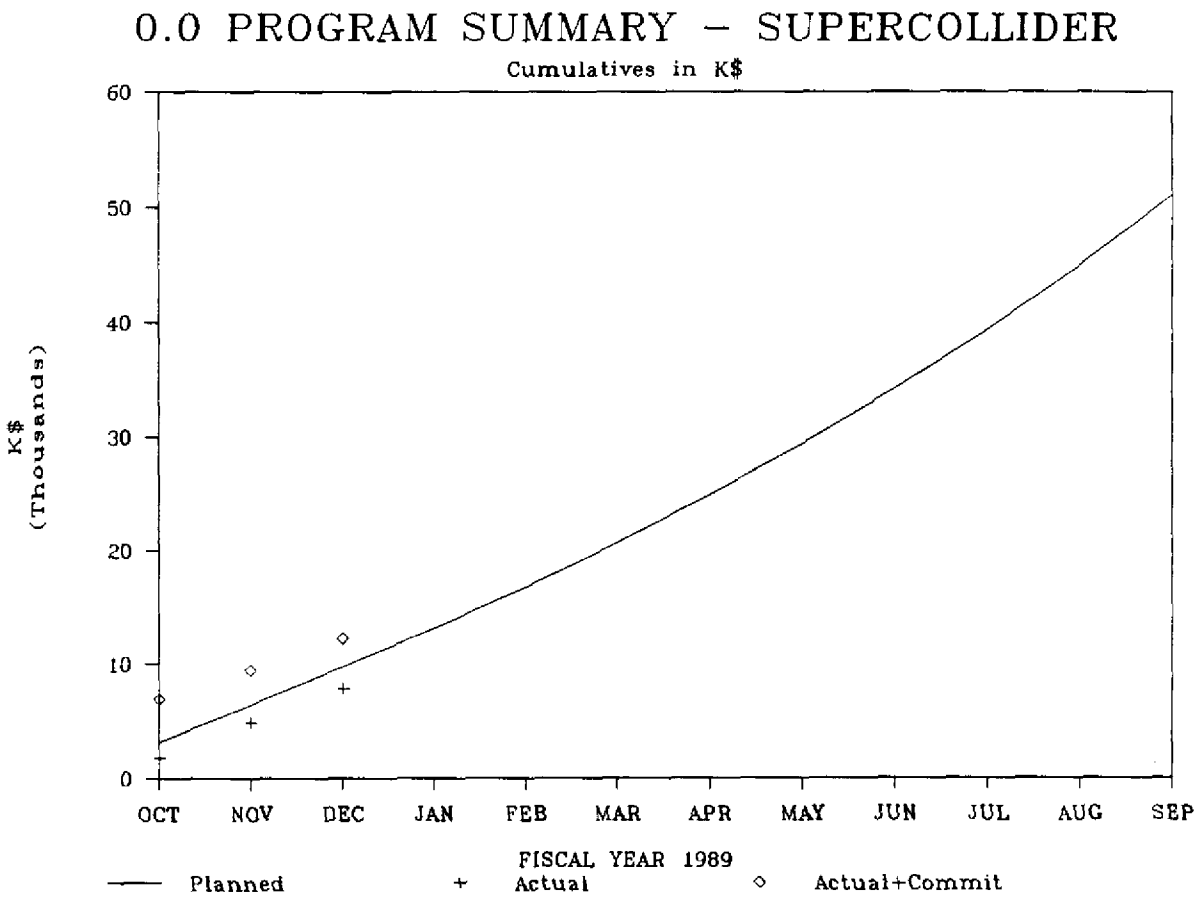

4.0 LAWRENCE BERKELEY LAB
Monthly Costs in K$
K$
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 4


0.0 PROGRAM SUMMARY - SUPERCOLLIDER
Cumulatives in K$
K$ (Thousands)
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

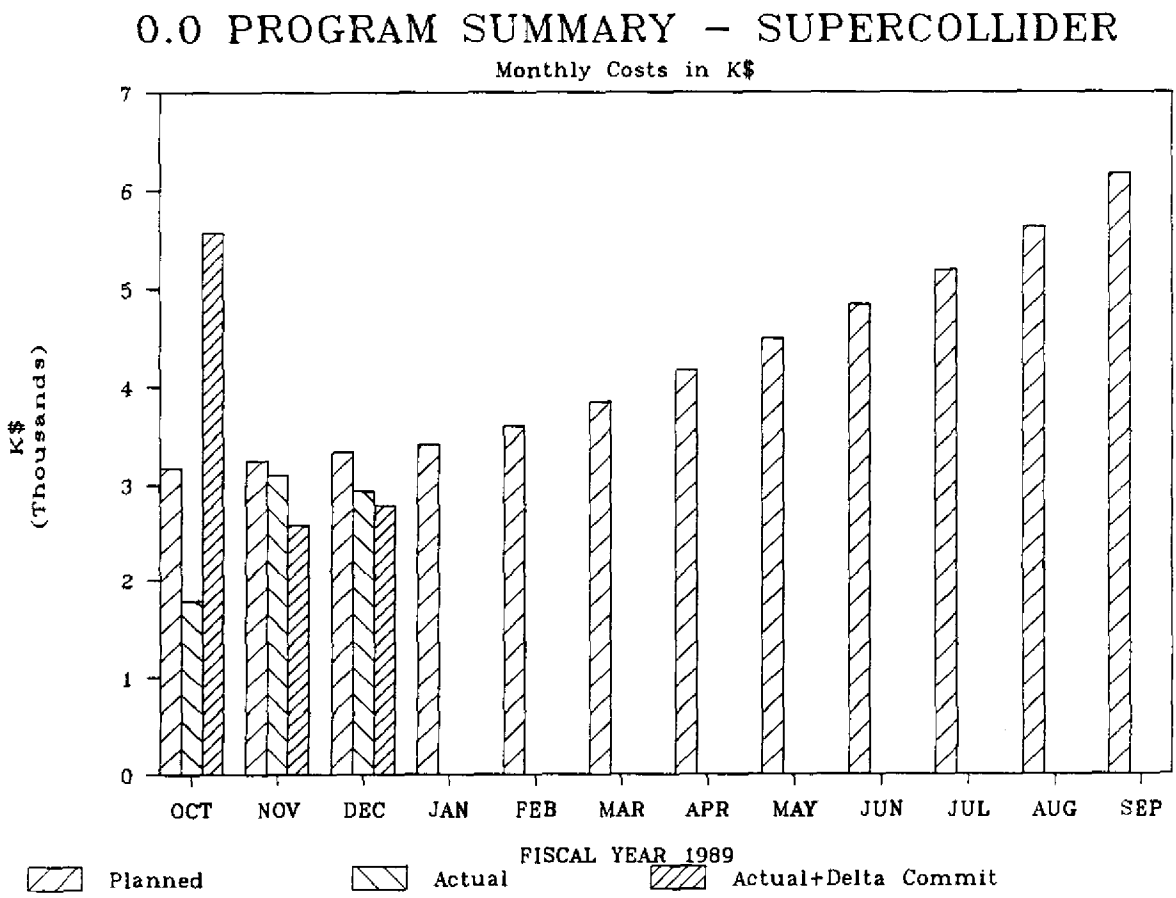

0.0 PROGRAM SUMMARY - SUPERCOLLIDER
Monthly Costs in K$
K$ (Thousands)
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 5