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PROJECT SUMMARY

CENTRAL DESIGN GROUP (CDG)

Magnet Program

Progress was made in three general areas of magnet R&D: long magnet testing (DD0015); analysis of experimental data and of finite-element collider dipole mechanical models ; and preparations for the Magnet Industrialization Program (MIP).

Magnet DD0015 was a special R&D model designed to verify the calculated performance of a collared coil able to slide freely relative to the iron yoke in the axial direction, except where secured to the yoke at the middle of the magnet. This magnet, as constructed, exhibited the predicted performance; hence it was a successful engineering test. One coil in this magnet (lower inner) was reused from an earlier magnet, DD000Z, and it showed a lower quench current than the new coils, somewhat limiting the magnet's performance. It is doubtful that this type of sliding coil design will be pursued further.

The powerful instrumentation developed and installed on long magnets following DD000Z has enabled design concepts associated with coil support system as well as realization of these concepts in construction to be verified by experimental measurements on tested magnets. In November, rapid progress made in the complementary finite-element mathematical models resulted in significant advances in the understanding and verification of magnet mechanical performance. Ancillary analysis of coil heating during quench and the associated topic of quench propagation velocity also contributed to the clarification of our knowledge of magnet quench behavior. All these analysis gains are being fed back to the R&D laboratories (BNL, FNAL, LBL) for use in engineering design and construction improvements in future magnets.

Advances were made in the MIP, including drafting a document outlining possible magnet procurement strategies and work on a draft request for proposal (RFP) on industrially-supplied collider dipole tooling and magnet proofs (Phase II of the MIP). Engineering work continued on a set of CAD drawings that will provide the technical basis and product specifications of the RFP (now anticipated to be released about March 1989). Other industrialization activity included release of an RFP to industry for design and fabrication of a cable-wrapping machine for insulating SSC superconducting magnet cable.

Work also continued on the construction of a comprehensive cable database suitable for detailed tracking of all the NbTi wire and cable; the database will be expanded later to allow the tracking

Accelerator Physics

Summaries of magnetic multipole measurements for a large number of dipoles were made and compared with the SSC specifications.

A number of software improvements related to the Sun workstations were completed. Other improvements are under way.

Work continued on the beam crossing angle effects and on the conversion of SYNCH to the CRAY.

A final analysis of the tune modulation data from experiment E778, looking at the long-term resonant data at Fermilab, was begun.

Work has continued on the differential algebra program XMAP and its application to the correction-element analysis being undertaken by the Correction Element Working Group (CEWG).

Two reports summarizing the magnet aperture studies and major lattice-design decisions were prepared.

A more detailed study of the effects of ground motion on the SSC operation was begun.

Accelerator Systems

Drafts have been written of an RFP for the SSC Magnet Testing Laboratory to be built on or near the SSC site. It is planned to issue a Request for Information in January.

The study of corrections of systematic errors in the dipoles is essentially complete; the study of the effects of random errors is well along. The first prototype corrector will be the dipole corrector. Design of a winding machine for the correction magnet prototypes is under way.

Conventional Facilities

The Conventional Facilities Division continued to work with RTK and M. Gilchriese on the development of design concepts for collision halls and associated staging areas. A. Autin developed a functional model of the surface buildings and a diagrammatic layout evolved. Draft reports were prepared on collision hall conceptual designs, collider tunnel cross sections, geotechnical site characterization, site-specific conceptual design, and the supplemental EIS.

BROOKHAVEN NATIONAL LABORATORY (BNL)

DD0016 was successfully collared. The final yoke assembly was started.

All inner and outer coils for DD0017 and DD0018 have been wound and cured. Coil assembly and collaring are under way.

Coil assembly operations were completed on rebuilt dipole DDA010.

An end effect associated with the modified long curing press is well understood and can be compensated for.

Warm measurements were under way on DSS13, while DSS14 was in the shell welding stage.

FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)

The testing of magnet DD0015 was completed. The unique features of this magnet were (1) the provision for low-friction sliding between the collared coil and the yoke and (2) the absence of the usual rigid coil end restraint. (The Tevatron magnet ends are unrestrained.) Unfortunately, the performance of this magnet was limited by a weakly supported ramp splice. Otherwise the magnet performed remarkably well. Neglecting quenches originating in the ramp splice, there was only one training quench before the magnet reached a plateau at 6400 amps limited by the critical current in the outer coil. The test of DD0015 clearly demonstrated that rigid axial end restraints on the coil are unnecessary.

F3, a short LBL-style model assembled at Fermilab with coils wound at LBL, was tested at the R&D test facility. Although originally intended only to test Fermilab dipole tooling, the magnet evolved into a vehicle for comparing the coil strain gauge systems developed at BNL and LBL. Even though the two strain gauge packs were placed side by side, the measured response was dramatically different. The BNL gauge showed that the magnet performed essentially the same as the BNL magnets: nearly linear unloading with the square of the current and with a slope predicted by calculation. The LBL gauge, on the other hand, showed the same puzzling nonlinear variation with I^2 and "ratcheting." The quench performance was surprisingly good. Since measurement of quench performance was not a primary objective of the test, the magnet was quenched only twice. The quenches occurred at 6580 A and 6820 A, higher initial quenches than nearly all magnets previously tested.

LAWRENCE BERKELEY LABORATORY (LBL)

A cable R&D debriefing meeting was held at LBL on November 2–3 attended by representatives of the three U.S. superconductor wire manufacturers, the SSC-CDG, DOE HEP, University of Wisconsin, LBL, FNAL, and BNL. The purpose of this meeting was to review the results of the SSC cable program and to receive input for the FY89 program from the wire manufacturers and others. The possible advantage of using unannealed wire and cable in magnets was raised.

The second series of cabling trials was performed by LBL on the Dour Cabling Machine at New England Electric Wire the week of November 14–18. Inner-layer cable was made for the first time, and cable was made to SSC specifications at over 31 feet per minute. A workshop attended by industry representatives was then held in order to demonstrate the set-up and operation of the cabling machine.

During November, the work on upgrading the cable measuring machines was completed. Software improvements include the use of screens that make the operation more user-friendly and the introduction of subroutines to reduce the data and make graphs. Hardware improvements include new hydraulic cylinders to replace those that leaked and new relay logic to make operation more failsafe. These upgrades were completed on the machine at LBL and NEEW during November and will be completed on the machine at FNAL early in December.

D15A-4FR1 is a reassembly of the original model D15A-4F for the primary purpose of studying field decay; in addition, the coil assembly was recollared, and the collars were made to contact the iron yoke along its entire outerside surface by introducing radial shims between the collar and yoke. It will be tested in December.

D15A-5R3 is the fourth test of the D15A-1 coils recollared with an augmented iron yoke clamping system that prevents the horizontal deflection of the yoke under Lorentz loading. Testing was done during November 1–17. The 5R3 version trained much like 5R2; it took five quenches to reach the plateau value of 7200 A at 4.3 K as compared with four quenches for 5R2.

Magnet D15B-1, the first magnet with internally supported straight ends, had excellent training: high plateau current at 4.3 K; two quenches to 6950 A. A second cooldown of the magnet was performed in which the RRR of the inner coil was measured as 62; cable tests at BNL gave a value of 34 for unannealed cable and 130 for the annealed cable, indicating that partial annealing might have occurred during curing of the coils. New experiments will take place in December to resolve this remaining question.

D15C-1, the first flared-end model, was collared with inner and outer coil stresses of 8500 psi and 9300 psi, respectively. Trial clamping of the ends was completed; dimensions are as

expected. The yoke and shell assembly from model D15A-4FR1 is required to complete this assembly. The model should be ready for testing in early January. Warm field multipoles (no iron) for the ends were measured and agreed with predicted values.

CDG REPORT

MAGNET PROGRAM

MSI Meeting

The MSI meeting was held November 9–10 at BNL. The meeting began with a brief report on CDG activity, by T. Kirk. M. Tigner noted in particular tentative plans for accelerating the schedule for near-term long magnets (DDA010, DD0016–18); the accelerated deployment of these magnets would be accomplished by foregoing warm testing and simplifying certain instrumentation.

Next came activity reports from the three laboratories, starting with BNL's report given by E. Willen. Measurements on coils for DD0016 indicate that the improved coil tooling and single cure procedure does generally meet the required coil size tolerances. P. Mantsch reported that several organizational changes had been made at FNAL, and that testing of DD0015 was under way. C. Taylor reported for LBL that the Dour cabling machine is installed and commissioned at NEEW; the balance of the report was given to an overview of recent 1-m model tests, including the many retests of D15A-5R.

Several speakers reviewed the status of ongoing cable database activities, followed by a tutorial summary of cable training measurements in BNL's measurements group and the principal factors affecting training: Cu:SC ratio, prestress, and direction of force. BNL also reported on the new strip heater design, modified to avoid a concentration of current and corresponding hot spots.

The next pair of reports examined plans for both static and dynamic temperature measurements—the former to sharpen short-sample criteria and the latter to aid in quench development analysis. It appears that carbon glass sensors are well suited for the task. Following a detailed report on the Dour cabling machine (and various backup options), the status of cable procurements was reviewed. For some of the material, the option remains open, for now, for revising the specifications on Cu:SC ratio, twist, or annealing. It appears that the cable needed for the balance of BNL's long magnets for the current fiscal year (DD0019, 20, 26, 27, and 28) can be met on the needed magnet production schedules.

BNL's new yoke support concept, under study as an R&D option, relies on prestressing coils by the iron yoke, similar to the RHIC magnets; the scheme might also raise the operating margin. Magnetic and mechanical aspects of the scheme were presented. Next came a review of the FNAL short magnet program, the main objectives of which are aiding in the development of new tooling features, investigating improved coil support features, and providing practice in producing short magnets before embarking on long magnets. Components of the program include short magnet models with both NC9 and C358 cross sections but featuring FNAL-

designed coil ends. Further tests and mechanical support studies will be made on SSC short model magnet DSS12

The disassembly of successful long magnet DD0012 produced no evidence of coil damage or disturbed conditions (heating, scuffing, cracks, or displacements). Analysis of quench events in DD0011 indicates that the quenches originated in several distinct regions. Considerable discussion was devoted to the quench analysis results, including the final event at 1.8 K that resulted in a ground fault and magnet failure. The initial performance of DD0015 was judged "better than might be expected, with brief training in the ramp splice followed by repeated quenching in a coil of particularly low prestress."

It was decided that the voltage-tap instrumentation of DD0016 will be somewhat simplified, in order to expedite the schedule for the long magnet test program.

The history and status of the version of the flux-return yoke modified to provide a line-to-line yoke/collar fit and incorporating stainless-steel laminations between module blocks was discussed. The status of the trim coil program was also reviewed, showing that training performance has gradually improved but is not yet eliminated.

The meeting closed by noting that Phase I of the Industrialization Program is on track and on schedule, with written documentation from BNL, FNAL, and LBL making good progress toward timely completion.

The next MSI meeting will be held December 14–15 at FNAL.

Magnet Industrialization Program

The applications received from industrial companies for participation in Phase 1 of the Magnet Industrialization Program (MIP) were evaluated by the MIP Evaluation Board appointed for this task. Recommendations were forwarded to the Selection Official, T. Kirk, who reviewed the board's recommendations with the CDG Director, M. Tigner. The recommendations were accepted with no changes. The announcement of the successful applicants will be made following approval by the DOE.

Assuming that this approval is obtained in a timely fashion, the first technology orientation session will be held at the CDG on January 9–10, 1989. The current schedule for the laboratory programs is: LBL, January 11–12; BNL, January 23–27; and FNAL, February 20–23.

Following completion of the technology orientation program, it is anticipated that (subject to concurrence by the new management and operations contractor for the SSC Laboratory) contracts to develop industrial capability for production of long dipole magnets will be issued; that magnet production capability will be developed in Phase II of the three-phase Magnet Industrialization Program. Last month, a careful study of various possible business strategies related to procurement plans for Phase II was completed. The plans were detailed in a draft report, entitled *SSC Magnet Industrialization Program: Possible Acquisition Strategies for Collider Ring Dipole Magnets*, which was released in draft form for DOE review at the end of

November. Approval of the acquisition strategy will clear the way for issuing the Phase II Request for Proposals (RFP) in March and keep the tight industrial pre-production magnet development schedule on track.

The RFP to accomplish Phase II has been undergoing development in parallel with the Acquisition Strategy. A draft of the RFP is scheduled for release to DOE for agency review in early January; the pace of activities necessary to achieve this goal on schedule has been good. Expert contracts advice and software was obtained from CDG and national laboratory personnel as well as from selected consultants. Excellent technical collaboration by FNAL and BNL provided procedures and part drawings that will be used for technical guidance by proposers responding to the RFP. Development of the technical portion of the RFP (format, acceptance standards, and other applicable reference documents) was undertaken by means of a personal services contract with Martin Marietta. Their effort is in addition to the continued development of the magnet performance criteria by CDG personnel. Quality assurance provisions for the RFP have been studied, and a draft QA program was developed in accordance with MIL-Q-9858 Quality Program Requirements. Liaison with several potential magnet vendors confirms that the MIL-Q approach is superior to NQA-1 for this procurement. Final approval to utilize the preferred QA program should be forthcoming with approval of the acquisition strategy by DOE.

Magnet Components and Materials

During November, discussions were held with several industrial vendors concerning different magnet parts and components. In particular a method of producing a beam tube with a copper liner by drawing down a heavy-wall stainless-steel tube with a copper tube inside it was discussed.

Also of note was a meeting with an insulation manufacturer (DuPont), which included a discussion of some improved coil insulation materials, including alumina-loaded Kapton polymer, for possible use in the dipole R&D program.

Cryostat-Tunnel Integration

The third cryostat-tunnel integration meeting was held at the CDG on November 29. This was attended by representatives from FNAL, Martin Marietta Aerospace, RTK, and the CDG. The group discussed methods of supporting the magnets, different tunnel cross sections, and the necessity for personnel access behind the magnets during magnet installation in the tunnel.

A report that has been prepared by RTK to address the means of handling, installing, and supporting the magnets was reviewed at the meeting and is expected to be available in final form soon. M. McAshan of the Accelerator Systems Division presented for discussion a scenario for connecting and leak-checking a series of magnets following their placement in the tunnel. This procedure will be incorporated into the draft Installation Traveler. R. Bossert of FNAL reviewed

the cryostat interconnections; R. Niemann of FNAL described a proposal for the fabrication of a full-scale mock-up of the interconnection region of two magnets.

Mathematical Analysis

Work has continued on the ANSYS finite-element model of the C358D dipole magnet cross section. The model has been used to study assembly loading of the dipole, cooldown to 4.2 K, and energization of the dipole (including both magnetic and structural behavior). The horizontal and vertical components of stress, the radial stiffness of the dipole, was also calculated. The calculations show the expected trends when compared with previous calculations using the NC-9 model. Results that depend upon collar stiffness show clearly the effects of changing the collars from aluminum to steel, whereas results that depend only upon conductor properties are almost identical in the two models. Agreement with the limited amount of relevant experimental data presently available is fair to good.

Specifically, the calculations yield radial collar deflections due to assembly loading (coil prestress) that are consistent with those measured for BNL dipoles with square keys. The model has not shown the larger collar deflections seen on tapered-key collars. However, it is suspected that these may be the result of plastic deformation that has not been included in the present model. Further investigation is planned in this area as well as in deformation measurements on used collars. The calculated results for cooldown to 4.2 K show coil prestress loss on the order of that measured for BNL square-key collars; however, there is substantial scatter in the measured values. The radial stiffness of the dipole (horizontal and vertical) has been calculated to provide results that can be verified by straightforward experimental measurements.

The C358 finite-element model, in contrast with the NC-9 model previously developed, has been used to calculate the magnetic field and the resultant Lorentz forces. The forces agree to within 10 percent with those calculated at BNL and at the CDG using different methods. In addition, the coil pole stress change during excitation, as calculated by the model, is consistent with measured values.

A mechanical analysis of the SSC yoke was performed using the finite-element method. The FEA model was based on the NC-9 cross section; both horizontally and vertically split yokes were investigated. A variety of load cases were examined: skin prestress was varied from 0–50 ksi and horizontal loading due to magnet excitation varied from 0–5000 pounds/quadrant. Both the horizontally split and vertically split configurations were given tapers of varying degree on the split midplane as a means of optimizing the load deflection characteristics. The analysis showed that a properly designed taper on the midplane could improve mechanical performance slightly. However, if improperly chosen, a taper could worsen performance significantly. The study revealed that the most promising configuration was a vertically split yoke with a taper designed to prevent the midplane from opening upon loading. In addition, the investigation showed that one of the most practical ways to increase the overall yoke stiffness was to increase

the outer skin prestress by controlling weld shrinkage. The study is documented in "A Finite Element Analysis of an SSC Yoke Used for Mechanical Support of the Collared Coil," which will appear as an SSC Note.

A new program has been written to automate the process of determining quench propagation velocities. The program computes the propagation time with respect to the straight section voltage taps. A comparison was made with several previous hand calculations. In all cases agreement was within 5 percent; most cases agreed to within 1 percent.

Data Analysis

Axial and azimuthal strain gauges have been mounted on the shell of all long magnets beginning with DD0010. While these gauges have yielded interesting information during magnet excitation, until now we have been unable to obtain a consistent picture of the shell behavior during cooldown. Furthermore, plots of the time history of these gauges over the magnet lifetime have shown puzzling artifacts that seemed to be correlated with refrigerator operation rather than with magnet operation. An explanation for these phenomena has now been found, and it will be possible to recover considerably more detail from previous tests on the mechanical behavior of the shell. The explanation is based on self-heating of the compensating gauges (by the electrical current flowing through them); these gauges are mounted on free-standing stainless-steel tabs and offer considerably poorer thermal contact with the magnet than the active gauges, which are cemented directly to the shell. The compensating gauges thus tend to be 4–5 K warmer then the shell. More important, because the thermal conductivity of steel varies linearly with temperature near 4.2 K, a small change in magnet temperature causes a corresponding change in active gauge temperature, but a much smaller change in compensating gauge temperature. The artifacts in the data then result from the significant temperature coefficient of the strain gauges, about 100 μstrain/K at 4.2 K.

Magnet Tests

Quench testing of magnet DD0015 took place during November. Magnet DD0015 was designed to allow free motion of the collared coil assembly within the yoke blocks (the coil was fixed to the yokes at the center of the magnet). The end plates, which are normally in contact with the coil and are typically pre-loaded with several thousand pounds of force, were backed off so that the coil did not come in contact with them.

A total of fifteen spontaneous quenches were recorded: the first nine occurred at temperatures of about 4.4 K and the following six occurred at temperatures of 3.8 K and 3.5 K. Three of the first four quenches occurred in the lower inner turn 16 feed-end voltage tap segment that includes the ramp splice region; the remaining quenches occurred in the lower outer coil, which does not have voltage tap information for individual turns. The quench currents appear to plateau (in the outer coil) after the first four quenches. A crude longitudinal position analysis

using the pressure data indicated that all but one of the outer coil quenches occurred near the return end of the magnet. When plotted against the return-end temperature, quenches 5 through 9 (all outer coil) lie on a line that has the approximate temperature dependence expected for the conductor used in this coil; however, it falls several hundred amps below the predicted values. Due to programmatic constraints, the lower outer coil of DD0015 was reused from magnet DD000Z. It was at the return end of DD000Z where the inner coil failure occurred, possibly indicating that overheating in the inner coil of DD000Z caused degradation of the superconductor in the adjacent regions of the outer coil of that magnet. This could explain the lower performance of the DD0015 lower outer coils.

There were two quenches at 3.8 K, both in the lower outer coil, and four quenches at 3.3 K, all in the lower-inner-coil-turn-16 voltage tap segment that includes the ramp splice. These quenches were all far below short-sample predictions, indicating unsatisfactory mechanical behavior of the coil support system.

Members of the Magnet Division participated in the disassembly and inspection of magnet DD0011, which took place at LBL during November.

Data Analysis and Software Development

Quench position analysis of magnet DD0011 data was performed. Magnet DD0011 had two quenches in the inner coils: the first at a temperature of 4.4 K and the second at a temperature of 1.8 K. The first one was in the upper inner coil 7 m from the feed end; the last one was in the lower inner coil close to the feed-end tap left of turn 15, where turn 15 becomes 14. The other twenty quenches occurred in the upper outer coil (fourteen quenches at 4.4 K, five at 3.3 K, and one at 1.8 K). The analysis shows that these quenches occur at three locations in the turn-20 straight section right side (which includes the ramp splice): 40 cm from the feed end, 1.8 m from the feed end, and 3.4 m from the feed end.

New routines were developed to calculate the adiabatic quench propagation, the MIITs integral, and the short-sample current for SSC cable (turn and cross-section specific). A detailed study of MIITs (a measure of energy deposition in the conductor during a quench that is related to the final temperature the conductor reached) versus temperature for specific inner and outer conductors was performed using these new routines. The results have been incorporated into more precise limits on allowed MIITs for magnet tests in the future.

Work continues on software for analysis of data from the CRYOMONITOR system at the FNAL Magnet Test Facility. The Magnet Division continued to provide programmer support for the software upgrade. Additional routines were developed to provide the capability of recalibrating the strain gauge data from this system.

The first Sun 4/110 workstation, a part of the Magnet Division computer network that will be used for management of magnet test data, arrived during November. Lacking the server, the workstation was configured with an external disk drive. Initial effort will be devoted to gaining

experience with Unix and Sun operating system version 4.0, under which the workstations will run. An upgrade to Sybase for operating system 4.0 has been ordered.

Instrumentation for Magnets DD0016

The CDG proposal for new temperature and helium-flow sensors was presented at the November MSI meeting. The initial thrust will be to concentrate on improved static temperature measurements in the vicinity of the coil. The time scale for obtaining and testing the thermometers precludes installation in magnets DD0016 and DD0017.

Database Work

The first magnet cable data summary created entirely with Sybase was issued. Investigations into the use of Sybase with the cable database continued.

Cable-Measuring Machine

Inspection of the measuring machine fabricated parts was completed. Only one type of part did not meet the drawing requirements. Such parts were rejected for being out of tolerance; the vendor is remaking them. Testing of the hydraulic pumping unit and the cable clamping rams started in late November. Initial tests results indicate that there is excessive variation in the ram hydraulic pressure. Modifications to the hydraulic system are being developed to reduce the pressure variations to an acceptable value. The hydraulic rams are being subjected to life-cycle tests to demonstrate their reliability.

Cable-Insulating Machine

Final drafts of the insulating line specification and RFP for an industrially designed and fabricated cable-wrapping machine, completed during October, were reviewed internally. A list of nine candidate industrial firms having the technical design and fabrication capabilities to produce the cable-wrapping machine was made. The RFP was issued to these firms in November; their proposals are scheduled to be received and evaluated at the CDG in late January.

Staff Expansion

Candidates for engineering positions within the CDG Magnet Division were interviewed, and at least one candidate will be offered a position. The naming of Waxahachie, Texas, as the preferred site for the SSC is expected to simplify the task of recruiting.

Magnet Quality Surveys

A summary of available data on magnetic multipoles due to geometric effects from measurements on 7 long and 18 short SSC model magnets shows that the SSC specifications for systematic geometric multipoles are generally satisfied except for the allowed multipole coefficients b_2, b_4, and b_6 and the non-allowed quadrupole coefficients a_1 and b_1. The specifications on the random rms variations also are generally satisfied, except for the quadrupole widths $\sigma(a_1)$ and $\sigma(b_1)$.

A summary of measurements on the multipole strengths due to persistent superconducting currents at injection ($B_0 = 0.33$ tesla) in 13 short SSC model magnets with 5-micron filaments showed the following averages and rms variations (after scaling each datum to the case of 6-micron filaments and critical-current density of 2,750 A/mm^2):

$$b_2 = -7.6 \pm 1.8 \times 10^{-4}\, B_0 \text{ at 1 cm}$$
$$b_4 = +0.8 \pm 0.3$$
$$b_6 = -0.2 \pm 0.1$$

Software Improvements

Software support has fallen primarily into three areas: rewriting a set of graphical interfaces based on TEAPOT, automating Correction Element Working Group (CEWG) simulations, and developing software for interconnecting modeling programs with different basic views of the accelerator.

Graphical interfaces are being rewritten with the InterViews toolkit, a C++ language-based library that provides an object-oriented approach to writing graphical interfaces for the X10 and X11 window systems. InterViews is a promising candidate for the final base on which future graphical interfaces will be built. So far, an interface for chromaticity plotting and correction has been implemented in C++ using the C language version of TEAPOT. The major goals of this work are to obviate the need for the obsolete version of TEAPOT on which the graphical interfaces are now built, to provide graphics under X-Windows for the operational simulations, to gain experience with InterViews, and to begin the design of a set of graphics objects to aid in writing future interfaces.

The CEWG simulations that have been automated comprise six steps: creating a lattice input file for the given random seed, setting the random correctors using a binning scheme, adding in systematic and random errors, correcting and closing the resultant orbit, subsequent tune and chromaticity tuning, and finally tracking the machine to determine smears. A series of scripts was written so that these functions (which for the most part entail TEAPOT runs using particular input files) can all be done automatically. This enables a series of different seeds and

correction scheme studies to be left running overnight on each of the available computers (each seed/scheme combination takes several hours on a Sun-4). So that this procedure can be fully automated, the orbit correction program was modified to have a non-interactive mode in which it iteratively corrects the machine until a good closed orbit is achieved.

The last area of work involves the beginnings of an effort to allow various modeling programs to be interconnected even though they have different views of the accelerator. To this end, a program (TPOT2FLAT) was written to convert TEAPOT-style machine files, which use only thin elements, to the "flat, thick" format used by the XMAP program. Another program, DBSF, already exists for generating either TEAPOT/MAD input or XMAP flat-format input from the database. The next step is to add to these programs the capability of generating SDS (standard data set) output so truly portable, efficient representations of the machine can be created.

Crossing Angle and SYNCH Conversion

The October 1988 monthly report mentioned the effort under way to produce a version of SYNCH to run on a CRAY-2 computer. Such a version is needed because, although SYNCH has the capabilities for dealing with the crossing angle problem, the computations are sufficiently complex that a computer faster than a VAX is needed to get results within a reasonable turnaround time. By October the groundwork for a CRAY version had already been laid, namely a rewriting of the program in ANSI standard FORTRAN. By using this version, and updating it to include the features recently introduced for application to the crossing angle problem, a CRAY version has been created and successfully debugged. This tool is now available for further studies. In order to obtain still faster performance, time analyses of the program are being carried out so that it can be run more efficiently.

E778 Analysis

Final analysis of the tune modulation data has begun, starting with the "resonant" BPM data. The goal is to quantitatively understand both amplitude and frequency modulation signals, and to identify the different kinds of behavior theoretically expected in the space of tune modulation amplitude versus tune modulation frequency. For example, there should only be an amplitude modulation signal when the modulation frequency is sufficiently slow such that the behavior may be considered adiabatic. Possible nonlinear synchrobetatron sidebands have been observed, but await confirmation from analysis of the "peak detector" BPM data. These data have a better signal-to-noise ratio than the resonant BPM data, but they are also more nonlinear.

XMAP

The XMAP differential algebra tool has been joined by a new program, XORT, which is in a final pre-production debugging phase. The output from XMAP is a set of high order polynomial series

maps that describe motion through a beam line. When this output is used as input to XORT, there are four such polynomials, expanded in five variables—four transverse phase space variables and an energy offset, which is constant. The output of XORT includes Hamiltonians representing the beam line under study, in different coordinate bases, and their corresponding generating functions. Differentiation of one of these Hamiltonians gives the two transverse tunes as polynomial expansions in horizontal and vertical amplitudes, and in energy offset. This analysis is being applied to the problems of the Correction Element Working Group.

Summary Reports

Two reports are being prepared to summarize the present status of two accelerator physics studies. One concerns the magnet aperture and the other addresses the lattice and the site footprint. In the aperture report, the studies since 1984 are reviewed and the continuing efforts are discussed. At present, the dipole inner coil inner diameter has been chosen to be 4 cm. The report discusses what in the next studies could still impact this choice and what the alternatives are if that happens. The lattice report summarizes the ISP lattice, the generation of the footprint, the ways to fit the lattice to the site, and the tools available to handle the site and lattice information. Also included is a summary of the pros and cons of the various lattice decisions made before and after the CDR.

Ground Motion Study

Motion of the quadrupole magnets due to seismic waves or to manmade ground disturbances affects the closed orbits in the two collider rings differently and so tends to separate the two beams at the four interaction points. These effects have been studied in the past, but a more detailed study is now being attempted. The magnitudes of these separations are being studied for a variety of conditions. So far, only a few relatively simple cases of plane waves have been examined, and they.have been found to be rather complicated in that the magnitudes of the separations vary rapidly with the wavelength and with the angle of incidence of the ground wave. The magnitudes are such that dynamic correction of these effects will probably be necessary in order to maintain optimum luminosity. For example, a 1-micron wave amplitude can produce an rms separation of up to 5 microns at the low-beta interaction points and up to 13 microns at the medium-beta interaction points, where the rms beam widths are 4.8 and 22 microns, respectively.

Cryogenics

The cryogenics work emphasized writing drafts of a Request for Proposals for a Magnet Testing Laboratory (MTL) to be built on or near the SSC site. R. Sah has been assigned the task of pulling the RFP together. M. McAshan is the leader of the cryogenic effort. Most parts of the RFP have been started and are beyond the first draft. Some important aspects are not yet understood, particularly since we do not yet understand the siting or the schedule. It is still intended to have a Request for Information issued in January or February, with the RFP to follow a month or two later.

Air Products and Chemicals, Inc., has started work on the static simulation part of SSCDYSIM, the dynamic simulator. This software is used to get a converged set of starting data for the dynamic simulation. A first report was sent to the CDG and has been reviewed. Comments have been returned to APCI.

Correction Elements

The Correction Element Working Group continues to meet regularly every week. The study of the corrections of the systematic errors in the dipoles is essentially complete. The study of the effects of the random errors is well along; it appears that the random errors do not supply a sensitive criterion for selecting the best correction scheme. Work has just begun on the study of systematic errors in the presence of orbit and alignment errors.

The Correction Magnet Prototype Program proceeded on several fronts. Preliminary ideas for a winding machine were tried out in hand-winding setups. From these trials a design of a winding machine to produce a slightly ordered wind was begun. The goal of the slightly ordered wind is to reduce the number of strand crossings and to increase the strand packing density. Ovens for epoxy curing were found to exist at LBL; however, their availability is unclear. A cryostat for prototype magnet testing was ordered, and a design for a combined cover and test magnet support was begun. A second cryogenics designer was brought into the program for the cryostat cover design. R. Remsbottom will handle procurement and insulation of the superconducting strand. Space for the program has been designated in Building 25. It was decided that the first corrector prototype to be attempted will be the dipole corrector. The initial method for construction will be random (slightly ordered) wound epoxy-potted magnet.

CONVENTIONAL FACILITIES

Collision Hall Studies

Development with RTK of design concepts for collision halls and associated staging areas continued during November. Two independent example schedules were developed for the construction of a large model hall by excavating a cavern; these agreed quite well with one another. With assistance from interested experimenters, concepts were developed for accommodations for model beauty spectrometer experiments.

Lattice Footprint Adaptation to the SSC Site

Selection on November 10 of the Waxahachie, Texas, site as the preferred site for the SSC focused the lattice adaptation studies. The U.S. Geological Survey quadrants for the site were digitized with specific site features (e.g., railroads, roads) on separate levels, to allow these features to be separately overlaid on the footprint for clarity; mitigations proposed in the EIS can also be studied more readily.

Geotechnical Characterization

A draft report on a generic plan for geotechnical characterization of the SSC site was prepared, principally by M. Werner of Earth Technology, the geotechnical resource of the RTK joint venture. (Earth Technology was principally responsible for the geotechnical aspects of site characterization for the DOE EIS, so they have considerable familiarity with the geotechnical requirements of the project.) Specialization of these generic considerations to the Texas site was begun.

Tunnel Cross Section Report

The draft report on the tunnel cross section studies was presented by J. Brown of RTK to the interdivisional group examining the cryostat-tunnel interface requirements. The report was favorably received. Comments from the group will be incorporated into the report. Modification of the tunnel cross section to allow additional space above the magnets simplifies provision of shielded niches and alcoves in the tunnel. This in turn allays safety concerns associated with the projected equipment and personnel transport system for the tunnel. A final version of the report will be transmitted by RTK in mid-December. Follow-on studies have been initiated to examine the effectiveness of the use of local troglodytic resources to ease installation at the Texas site.

Development of Strategic Scheduling Tools

To facilitate exploration of possible options in the planning and scheduling of conventional construction, the overall schedule for the conventional facilities from the Conceptual Design Report was transferred to TimeLine, a PC-based project management software system. TimeLine is more suitable for strategic manipulation of project options than the more comprehensive Open Plan system, the project management system used by the CDG Project Planning and Management Division to handle all the elements of the project. At the behest of the CDG, Symantec, Inc., the authors of TimeLine, and Wellcom Software, the authors of Open Plan, have developed mutual export and import capabilities in their systems to allow TimeLine to be used for strategic planning with a hand-off of the broad strategies to Open Plan for detailed implementation and tracking. The TimeLine version of the CDR schedule will be used to develop an optimized method for exploiting the planning strategies made possible by this two-level approach.

BNL REPORT

MODEL MAGNETS

Magnet Assembly

DD0016 was successfully collared, and final yoke assembly was under way at the end of the month. Final coil prestress for this magnet is quite high. Meanwhile, all inner and outer coils for DD0017 and DD0018 were wound and cured; coil assembly and collaring were under way. Longitudinal coil size data for both of the latter magnets are generally within the prescribed 2-mil band, but with some "end effect" still evident in the measurements. The cause of this effect is associated with the use of the end vertical hydraulic cylinders during heating to 90°C without shims in place between tophat and formblock. Expectations are that DD0019 coils will show significantly less size deviations in the ends, since for this magnet these cylinders will be left disengaged until the shims are installed. (DD0016, 17, and 18 will utilize modified coil shims in the ends to compensate for this effect.) Coil stress profile measurements in the ramp splice region and coil ends were also completed on long magnets DD0016, DD0017, and DDA010.

Collar assembly was completed on rebuilt dipole DDA010. Several difficulties were encountered, including higher than expected coil stresses and some assembly problems associated with the restamped keyways of the original DD0010 collars.

Strain gauge transducer calibrations were completed for DD0016 and DD0017.

Warm measurements were under way on DSS13 at the close of the month. DSS14 was in the shell welding stage.

TOOLING AND FACILITIES

Coils

Welding of stacking fixtures and modules for the new inner and outer formblocks continues in Building 924; about 65 percent of the work is finished. Detailing of parts for the short coil curing press continues; about 80 percent of the work was completed and released to the shops. Assembly drawings for the press are also being produced in the design room.

Horizontal Test Facility

Work continued on the fabrication of feed and return end cans for Bays A and B, as well as on the plant layout generally in the Magcool area. Work also continued on the 7 kA power supply system, particularly on the power leads.

Cable Procurement

The cable required for DSS 16, 17, and 18 was inspected and insulated.

Tooling

All tests on the wrapping line modified to permit faster wrapping were completed; the higher speed (8 feet/minute) is now routinely utilized.

LBL has ordered a new, larger cable spool for use with the high speed Dour cabler. To accommodate this larger spool, BNL must modify its wrapping line pay-off spooler; these modifications have been initiated.

Miscellaneous

BNL representatives participated in a workshop to familiarize future users with the new Dour cabling machine located at New England Electric Wire.

FNAL REPORT

DIPOLE CRYOSTAT

The Heat Leak Test Facility was reconfigured for the measurement of the Design B insulation system from 300 to 80 K. Measurements will begin in December.

The study of long magnet model DD0014 20-K shield buckling continued. The studies include evaluations of the quality of the shield-shell weld joint at the point of buckling and a warmup buckling test using a short shield section. The short shield test setup is nearly complete; measurements will be made in December.

Work continued to resolve differences between the predicted and measured vibration responses of SSC cryostats. The stiffness parameters for the support posts and the cold mass were remeasured and given to the analytical modeler and to the modal analyzer.

Work began on the dedicated cryostat model (DSHIP) for the warm measurement of magnet structural response to shipping, handling, and seismic loads. The support posts, tie bars, and so forth were instrumented with strain gauges for measurements during dynamic excitations. Accelerometers will be placed on the cold mass and on the vacuum vessel structure.

Initial testing of the prototype of the Inchworm was completed. The Inchworm has traversed, down and back, the equivalent of 50 cryostat lengths without significant performance degradation. Further testing will be conducted in a full-length beam tube, to be provided by BNL. Procurement of components for a self-storing transporter continued.

Cryostat component commercialization continues for FY89 long magnet cryostats. The components are being procured in quantities adequate to produce the anticipated twelve FY89 model magnet assemblies. All components are to Design B drawings and specifications.

Details of Phase I of the Magnet Industrialization Program are being finalized. Work began on a video describing the cryostat assembly.

The Magnet Installation Working Group met at the CDG. Discussions included the proposed details of an interconnection mockup to be built and used for evaluations of tunnel geometry, logistics, interconnections, and so forth. The Fermilab proposal for the mockup is being evaluated by the CDG.

Work began on the Design C cryostat. It is an objective of the study to develop an improved design suitable for Phase II of the Magnet Industrialization Industrialization Program. The current plan is to complete a design suitable for Phase II by late spring 1989.

MAGNETIC MEASUREMENTS

The new cold compressor system, purchased for use in cooling stand 4 to temperatures as low as 3.3 K, was installed and tested. Initial attempts to operate the system were unsuccessful, due to

the extremely close tolerances on the piston-cylinder fit and, possibly, to contamination. The room-temperature vacuum pumping system installed for use with stand 5 was connected to stand 4 and successfully used to lower the temperature of magnet DD0015 to 3.8 K. The magnet was quenched twice at this temperature. One quench, at 6600 A, was at or near the return end of the lower outer coil, the same location as all outer coil quenches at 4.4 K. The other quench was at an anomalously low current (5840 A) toward the middle of the lower outer coil. The cause of this low current quench is not understood. The new cold compressor was then used to lower the temperature to 3.4 K. At this temperature a strain gauge run was taken to 6800 A without quenching, and the magnet was quenched four times. Quench currents varied between 6560 A and 6880 A, but with no obvious upward trend. All four quenches were in the lower ramp splice. The strain gauge run data show no behavior not seen in the earlier runs at 4.4 K. At the conclusion of these tests, DD0015 was warmed to room temperature. It remains on the test stand as a testbed for software development.

The test facility is being prepared for operations beginning in February with DD0016. The realignment of stand 5 (after the last quench of DD0011) was nearly completed. To insure safe operation with DD0016, internal support members are being checked for slight bending, which could contribute to elastic instability. The installation of the annular beam tube feed-throughs will then proceed. This installation is complicated by the tight tolerances required on straightness, 0.5 mm per meter, for proper operation of the mole.

LONG MAGNET FABRICATION

Progress on Cold Mass Pilot Production Factory Setup

Assembly of both curing and collaring presses began. Press cross beams were set in place and 3-inch tie rods are being installed.

The upper collaring mold assembly is 90 percent complete; the outer winding mandrel was stacked. Work will continue when the end plates are completed.

The mechanical assembly of the coil winding table was completed.

DSHIP Transportation Model

The tow tray and position tray were assembled. The D0004 dummy cold mass was installed on posts and cradles. The cold mass was anchored to the center cradle. Work will continue when an instrumented HYBAS is available.

F Series Model Program

F3 was tested successfully at Lab 2. F3 contains collar pack strain gauges of both LBL design ("Hotel" gauges) and BNL design (beam type), allowing the two techniques for measuring coil

stress to be compared. Numerous strain gauge runs were taken to progressively higher currents; the highest current data were taken at 6250 A. The LBL gauges indicated a progressively higher apparent stress at zero current after each excitation cycle ("ratcheting") and significant non-linearity when apparent stress is plotted against the square of the current; both of these phenomena have been typical of data taken with similar gauges at LBL. The BNL gauges, however, showed comparatively little variation in apparent stress from cycle to cycle, were much more linear with current squared, and indicated a much slower decrease in coil stress with increasing current. A complete analysis of the strain gauge data will be carried out by CDG personnel.

Following the strain gauge runs, the magnet was quenched twice, at 6580 A and 6820 A. Both quenches were in the upper outer coil. Because the principal purpose of the magnet test was to compare the two strain gauge load cell types, no attempt was made to establish a quench plateau.

Magnet F2 is being disassembled. An autopsy report on the ground short will be completed this month.

Inner coils for F4 are complete. F4 outer coil winding is beginning. Collaring of F4 is scheduled for late December. Magnet F4 will then be potted and cut into cookies. The coil ends will be sectioned to determine cable placement.

Winding of magnet F5 will begin in January 1989.

Design of end parts for magnet F7 (C358D cross section) continues. Parts will be ready for machining by January 1989.

LBL REPORT

SUPERCONDUCTOR AND CABLE

A cable R&D debriefing meeting was held at LBL November 2–3. Participants included representatives of the three U.S. superconductor wire manufacturers, the SSC-CDG, DOE HEP, University of Wisconsin, LBL, FNAL, and BNL. The purpose was to review the results of the SSC cable program and to receive suggestions for the FY89 program. One new direction proposed by R. Stiening is using unannealed wire in the cable and magnets. LBL has made cable from unannealed wire in the past; the questions concerning coil winding and magnet performance are now being evaluated.

On the other side of the country, the second series of cabling trials was performed by LBL on the Dour Cabling Machine at NEEW the week of November 14–18. Inner-layer cable was made for the first time, and cable was made to SSC specifications at over 31 feet per minute. At the end of the week a workshop was held in order to demonstrate the set-up and operation of the cabling machine; the cabling demonstration was run by LBL and NEEW for the benefit of representatives from the other users of this cabling line, including Supercon, IGC, OST, and BNL.

Upgrading the cable measuring machines was completed. Software improvements include the use of screens that make the operation more user-friendly and the introduction of subroutines to reduce the data and make graphs. Hardware improvements include new hydraulic cylinders to replace the originals, which leaked, and new relay logic to make operation more failsafe. These upgrades were completed on the machine at LBL and NEEW during November and will be completed on the machine at FNAL early in December.

MAGNET MODELS

D15A-4FR1

The primary purpose of this model, a reassembly of the original model D15A-4F, is to study field decay as influenced by the Furukawa cable made with a double-stack process. In addition, the coil assembly was recollared (without coil disassembly) to achieve 7900 psi coil stress in each layer, and the collars were made to contact the iron yoke along its entire outerside surface by introducing radial shims between the collar and yoke. When the yoke clamps were applied and torqued the coil stress increased to about 10,200 psi. The gap in the iron will decrease during cooldown and excitation but will remain open between 0.005 inches and 0.010 inches. Testing will be done in December.

D15A-5R3

This fourth test of the third reassembly of D15A-5 is to evaluate the augmented iron clamping system. To date, the LBL 1-m models use demountable clamps to hold the iron yoke closed instead of welding the shell. The previous clamping system had clamps over only one-third of the axial extent of the iron; the new system provides complete coverage, preventing excessive horizontal deflection of the yoke under Lorentz loading.

Testing was done during November 1–17. The training behavior of the 5R3 version is almost identical to that of the previous 5R2; five quenches to the plateau value of 7200 A at 4.3 K as compared with four quenches. A new, faster method of magnetic measurements during the current ramp was implemented.

Dipole D15B-1

Magnet D15B-1 (which has a new end design—straight with internal support) is one of our most successful dipoles. It showed good training and reached a high plateau current at 4.3 K: two quenches to 6950 A. To see whether the inner-layer cable was not annealed before being wound into the coil, an additional cooldown of the magnet was performed November 19–30. The BNL cable tests show an RRR = 34 for the unannealed cable and an RRR = 130 for the annealed cable. The LBL magnet cooldown test gives a value of 62, which is low for fully annealed cable but high for unannealed cable; this partial annealing might have occurred during curing of the coils. New experiments will take place in December to resolve this question.

D15C-1

The coil assembly for this first flared-end model was collared with inner and outer coil stresses of 8500 and 9300. Dimensions measured after trial clamping of the ends are as expected. All parts are fabricated and assembly is proceeding. The yoke and shell assembly from model D15A-4FR1 will complete this assembly. The model should be ready for test in early January.

Measured warm field multipoles (no iron) for the ends agree with predicted values.

ANALYSIS

A program called STRAUZF was written that extracts coordinates from a CAD file and computes Lorentz forces. It has been used to calculate the Lorentz forces on each individual strand of the NC9 dipole and Q22 arcquad. The forces computed on the dipole are in close agreement with those calculated with POISSON.

PROJECT COST DATA

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TABLE C-1

CENTRAL DESIGN GROUP

NOVEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	135.0	171.1	80.6	386.6	489.6	6246.0
1.2	PROGRAM PLANNING & MANAGEMENT	0.5	17.3	4.1	21.9	77.2	1190.0
1.3	ACCELERATOR R & D	338.4	297.5	189.2	825.1	857.3	17004.0
1.4	CONVENTIONAL SYSTEMS DEVELOPMENT	53.4	24.9	10.9	89.2	74.4	1740.0
	PROGRAM COSTS	527.2	510.9	284.7	1322.8	1498.5	26180.0
1.41	RTK COSTS	0.0	42.2	0.0	42.2	102.6	750.0
	CDG/RTK COSTS	527.2	553.1	284.7	1365.0	1601.1	26930.0
	COMMITMENTS					1908.7	
	DELTA COMMITMENTS					108.9	

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY

NOVEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	MAGNET DESIGN	56.8	48.1	39.0	143.9	270.6	3348.0
2.2	17-M COLD MASS FABRICATION	137.4	100.6	88.3	326.3	630.9	4134.0
2.3	TOOLING & FIXTURES	9.5	118.9	47.7	176.1	343.0	640.0
2.4	BEAM TUBE DEVELOPMENT	9.5	56.5	10.0	76.0	230.0	633.0
2.5	1.8-M DIPOLE FABRICIATION	18.9	0.0	7.0	25.9	54.8	538.0
2.6	TRIM COIL DEVELOPMENT	18.9	1.1	7.4	27.4	57.6	752.0
2.7	MAGNET MEASUREMENT	94.7	48.3	48.7	191.7	360.1	3341.0
2.8	INDUSTRIALIZATION	9.5	0.5	3.7	13.7	28.1	316.0
	MAGNET TOTALS	355.2	374.0	251.8	981.0	1974.9	13702.0
2.9	ACCELERATED LIFE TESTS	23.7	2.6	9.8	36.1	75.8	898.0
	BNL R & D TOTALS	378.9	376.6	261.6	1017.1	2050.7	14600.0
	COMMITMENTS					2009.0	
	DELTA COMMITMENTS					-460.1	
	EQUIPMENT COSTS	0.0	80.9	0.0	80.9	80.9	2947.0
	EQUIPMENT OPEN COMMITMENTS					140.0	

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY

NOVEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	0.0	10.5	3.3	13.8	14.3	160.0
3.2	LONG MAGNET FABRICATION	17.7	85.3	32.4	135.4	218.3	1361.0
3.3	MAGNETIC MEASUREMENTS	51.6	15.8	21.2	88.6	182.0	1560.0
3.4	COLD MASS FABRICATION	48.7	147.9	62.0	258.6	320.2	2766.0
3.5	INDUSTRIALIZATION	8.0	0.2	2.6	10.8	38.8	300.0
3.6	CELL TESTS	0.0	0.0	0.0	0.0	0.0	0.0
	PROGRAM COSTS	126.0	259.7	121.5	507.2	773.6	6147.0
	COMMITMENTS					590.2	
	DELTA COMMITMENTS					-186.8	
	EQUIPMENT COSTS	3.3	53.5	0.0	56.8	79.2	1640.0
	EQUIPMENT OPEN COMMITMENTS					246.7	

TABLE C-4

LAWRENCE BERKELEY LABORATORY

NOVEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
4.1	GENERAL	4.4	-0.1	2.1	6.4	18.2	350.0
4.2	SUPERCONDUCTOR & CABLE	24.7	3.5	13.5	41.7	66.5	1340.0
4.3	CABLE SHORT SAMPLE TEST FACILITY	15.0	0.4	7.3	22.7	41.2	50.0
4.4	DIPOLE MAGNET DEVELOPMENT	77.0	8.5	40.6	126.1	284.7	760.0
4.5	QUADRUPOLE MAGNETS	0.0	0.0	0.0	0.0	0.0	260.0
4.6	COIL PROPERTIES	0.3	0.0	0.1	0.4	0.4	200.0
4.7	TECHNOLOGY TRANSFER TO INDUSTRY	0.0	0.0	0.0	0.0	0.0	50.0
	MAGNET R & D TOTALS	121.4	12.3	63.6	197.3	411.0	3010.0
4.8	ACCELERATOR THEORY SUPPORT	9.6	0.5	4.8	14.9	45.8	410.0
	R & D COST TOTAL	131.0	12.8	68.4	212.2	456.8	3420.0
	COMMITMENTS					98.0	
	DELTA COMMITMENTS					3.0	

TABLE C-5

PROGRAM SUMMARY - SUPERCOLLIDER

NOVEMBER

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	527.2	510.9	284.7	1322.8	1498.5	26180.0
1.41	RTK PROGRAM	0.0	42.2	0.0	42.2	102.6	750.0
2.	BNL SSC PROGRAM	378.9	376.6	261.6	1017.1	2050.7	14600.0
3.	FNAL SSC PROGRAM	126.0	259.7	121.5	507.2	773.6	6147.0
4.	LBL SSC PROGRAM	131.0	12.8	68.4	212.2	456.8	3420.0
	TOTAL SSC PROGRAM COSTS	1163.1	1202.2	736.2	3101.5	4882.2	51097.0
	COMMITMENTS					4605.9	
	DELTA COMMITMENTS					-535.0	
	EQUIPMENT COSTS					160.1	4587.0
	EQUIPMENT OPEN COMMITMENTS					386.7	

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						
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						
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

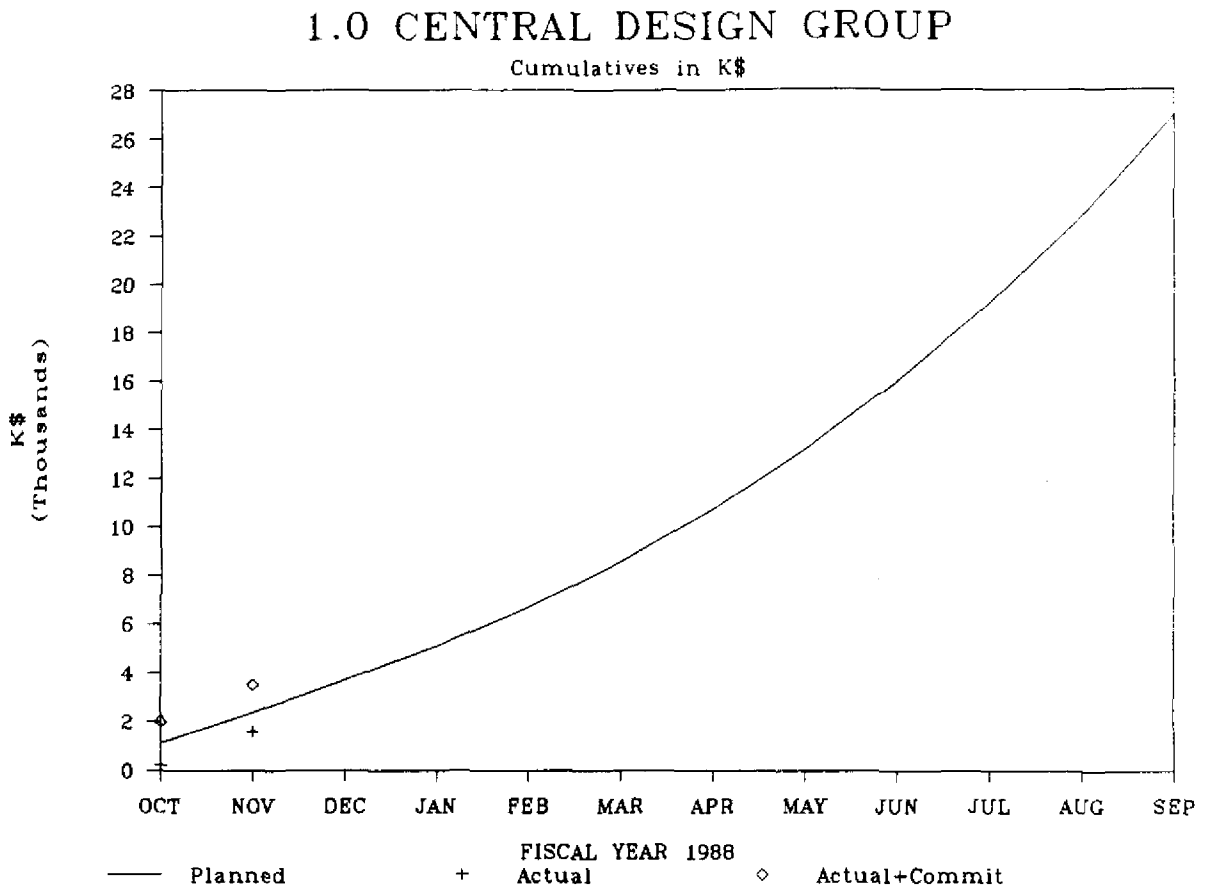
MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	512.3	512.3	266.4	266.4	1043.4	1043.4	777.0	777.0
NOV	512.3	1024.5	507.2	773.6	320.4	1363.8	590.2	-186.8
DEC	512.3	1536.8						
JAN	512.3	2049.0						
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						
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						
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 1988
Planned
Actual
Actual+Commit

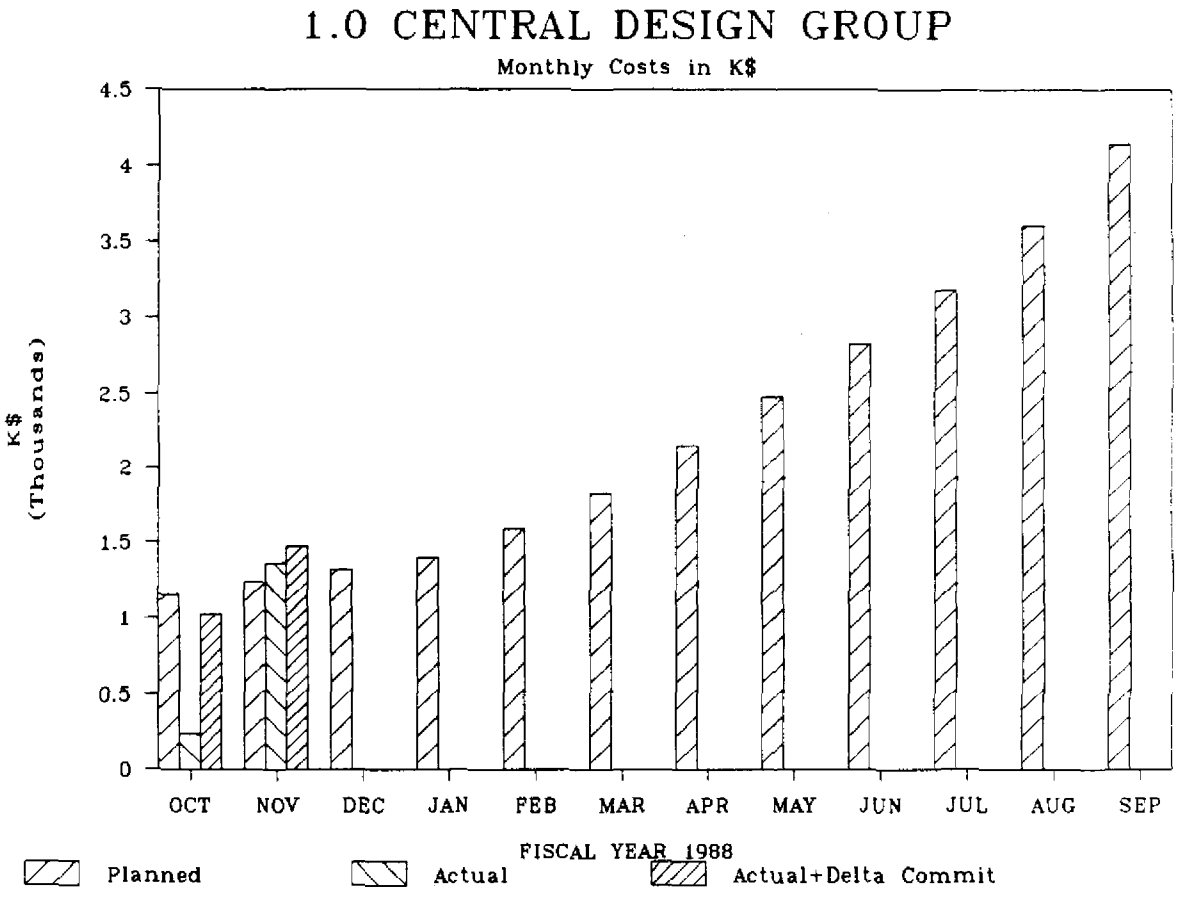
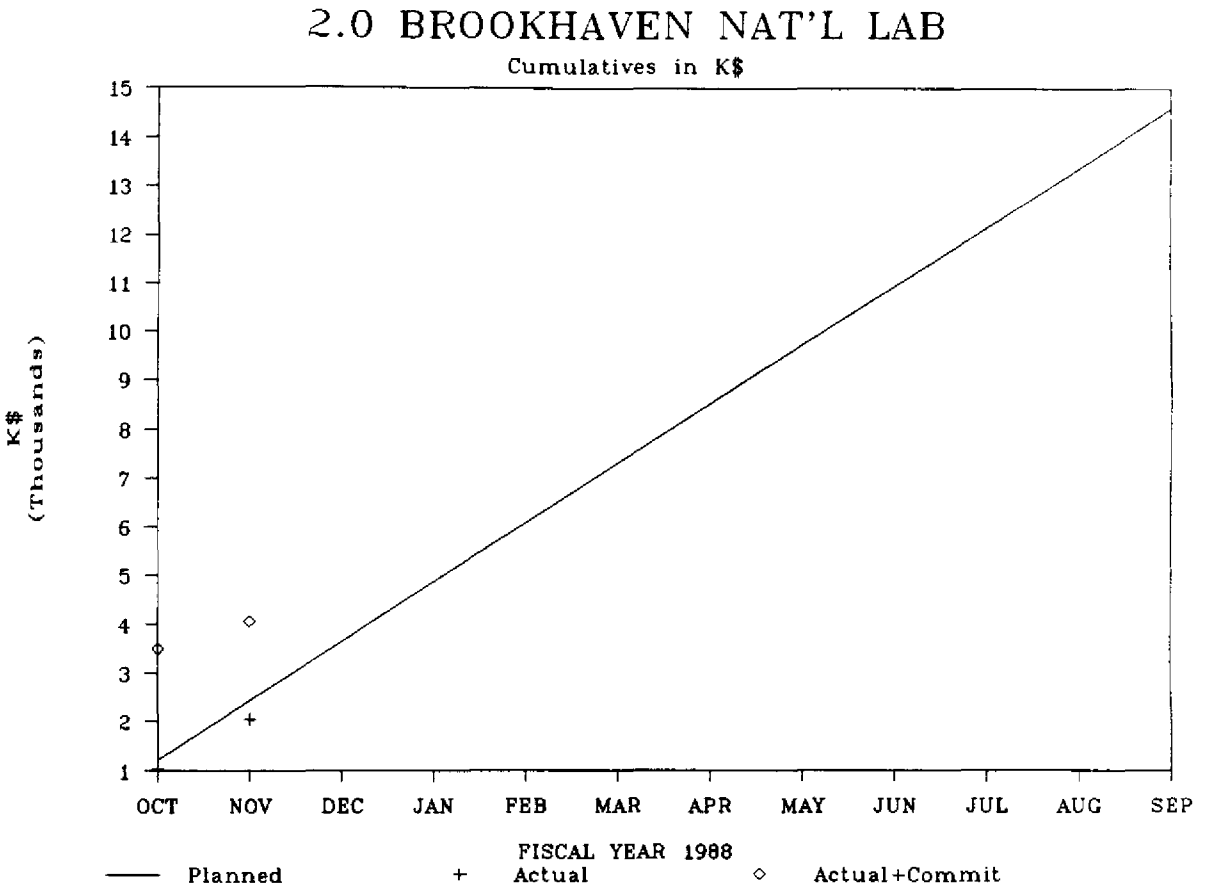

1.0 CENTRAL DESIGN GROUP
Monthly Costs in K$
K$ (Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

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 1988
Planned
Actual
Actual+Commit

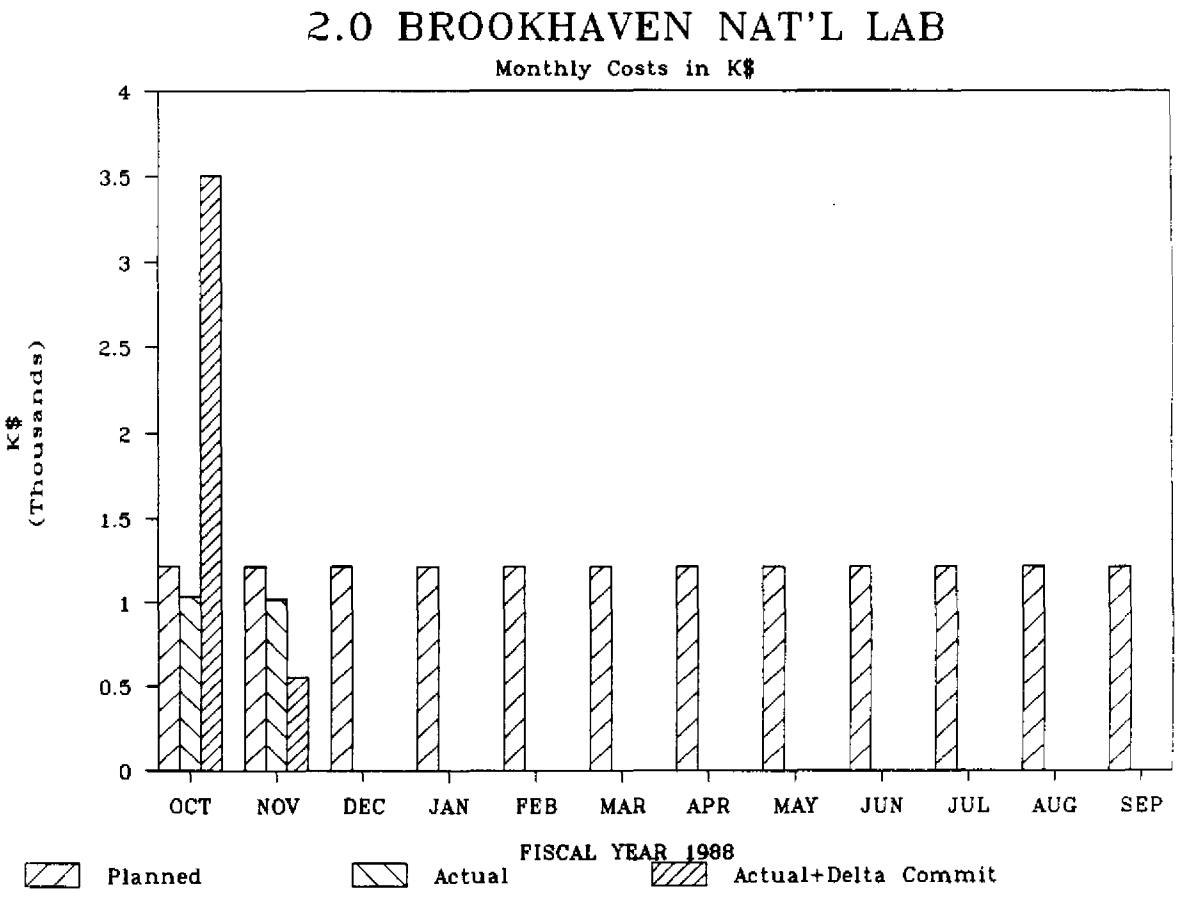
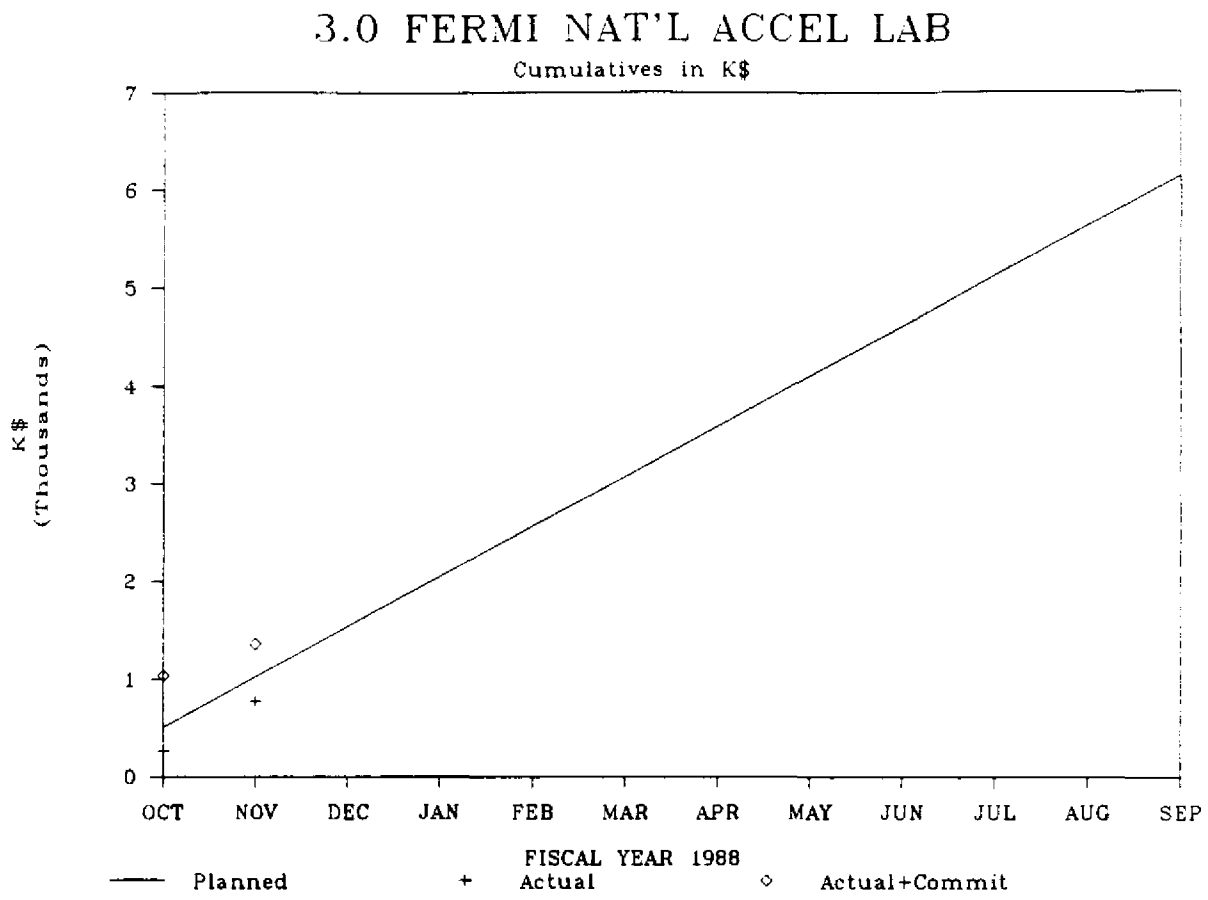

2.0 BROOKHAVEN NAT'L LAB
Monthly Costs in K$
K$ (Thousands)
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

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 1988
Planned
Actual
Actual+Commit

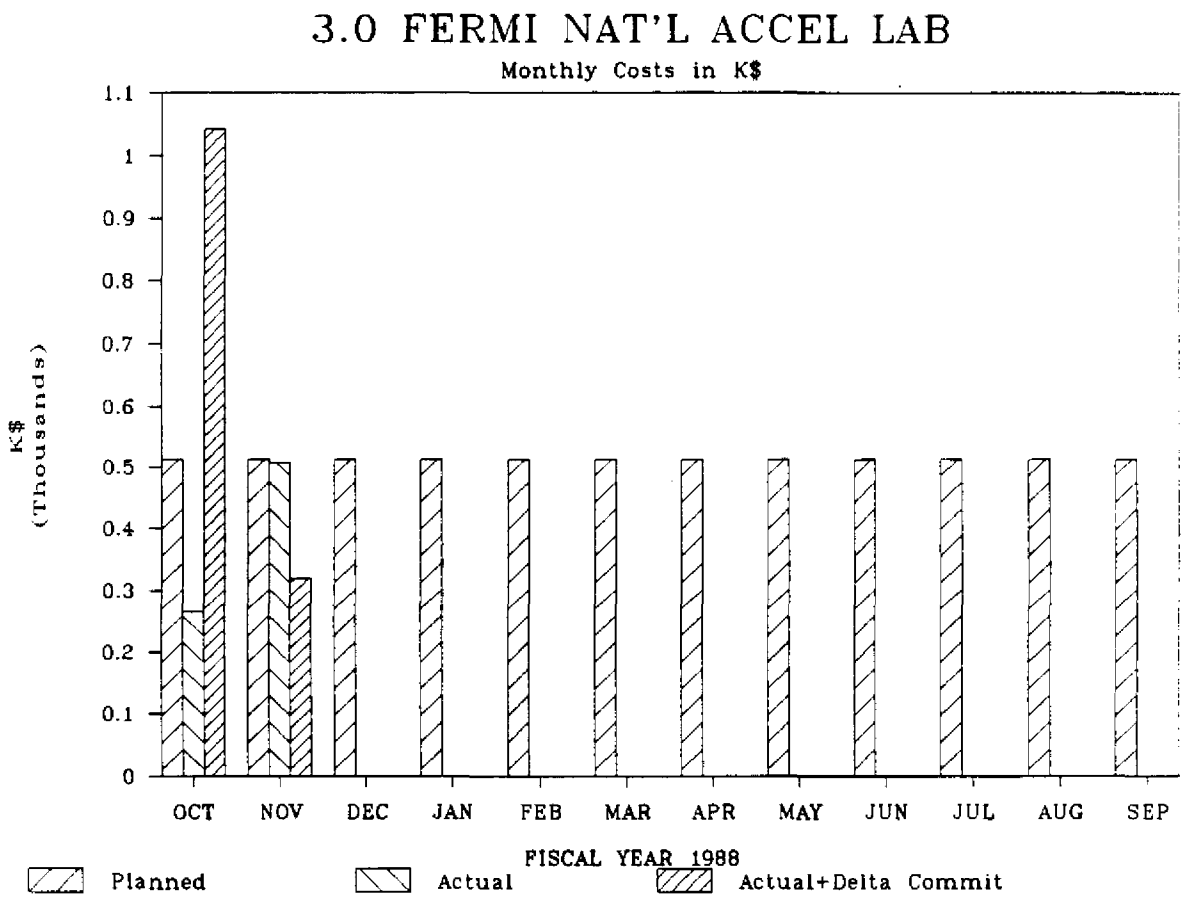
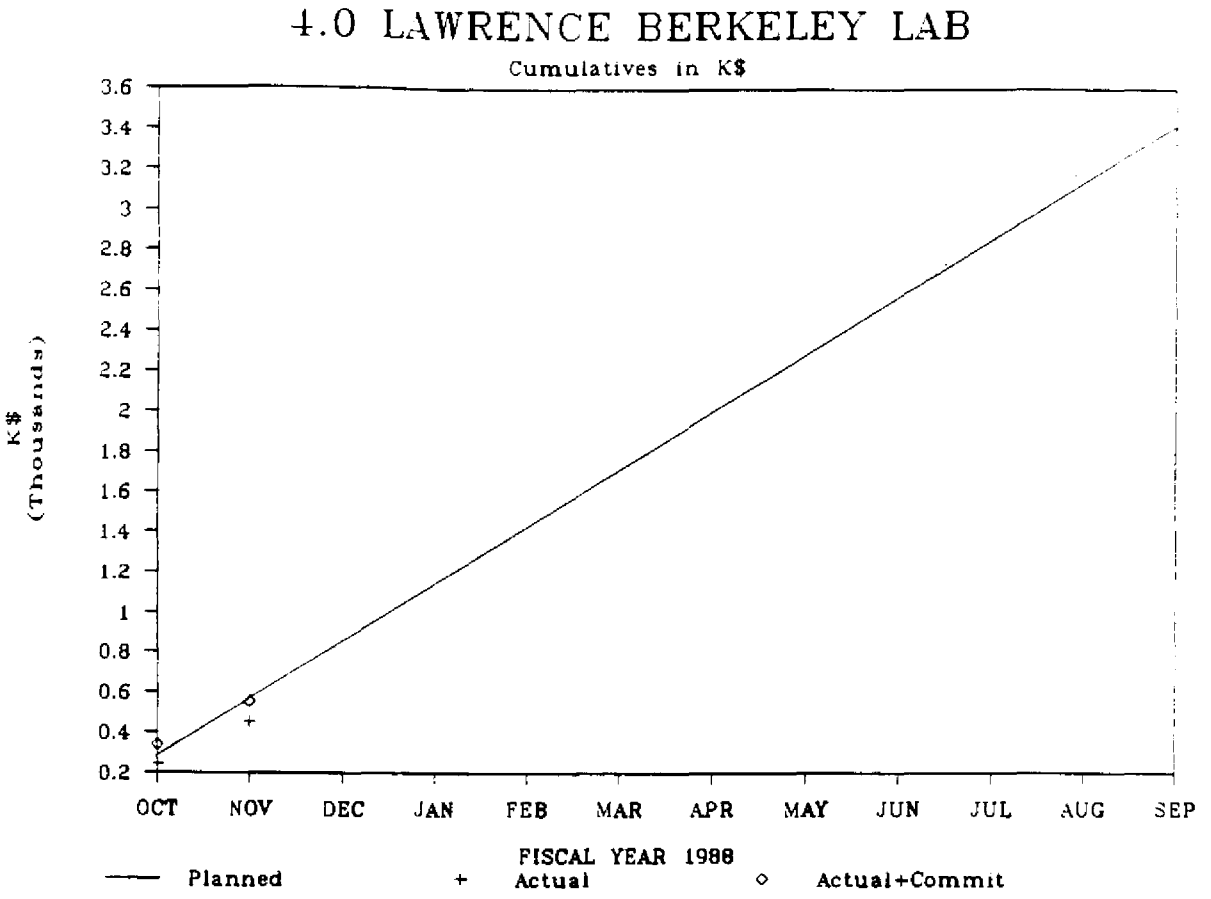

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$ (Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

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 1988
Planned
Actual
Actual+Commit

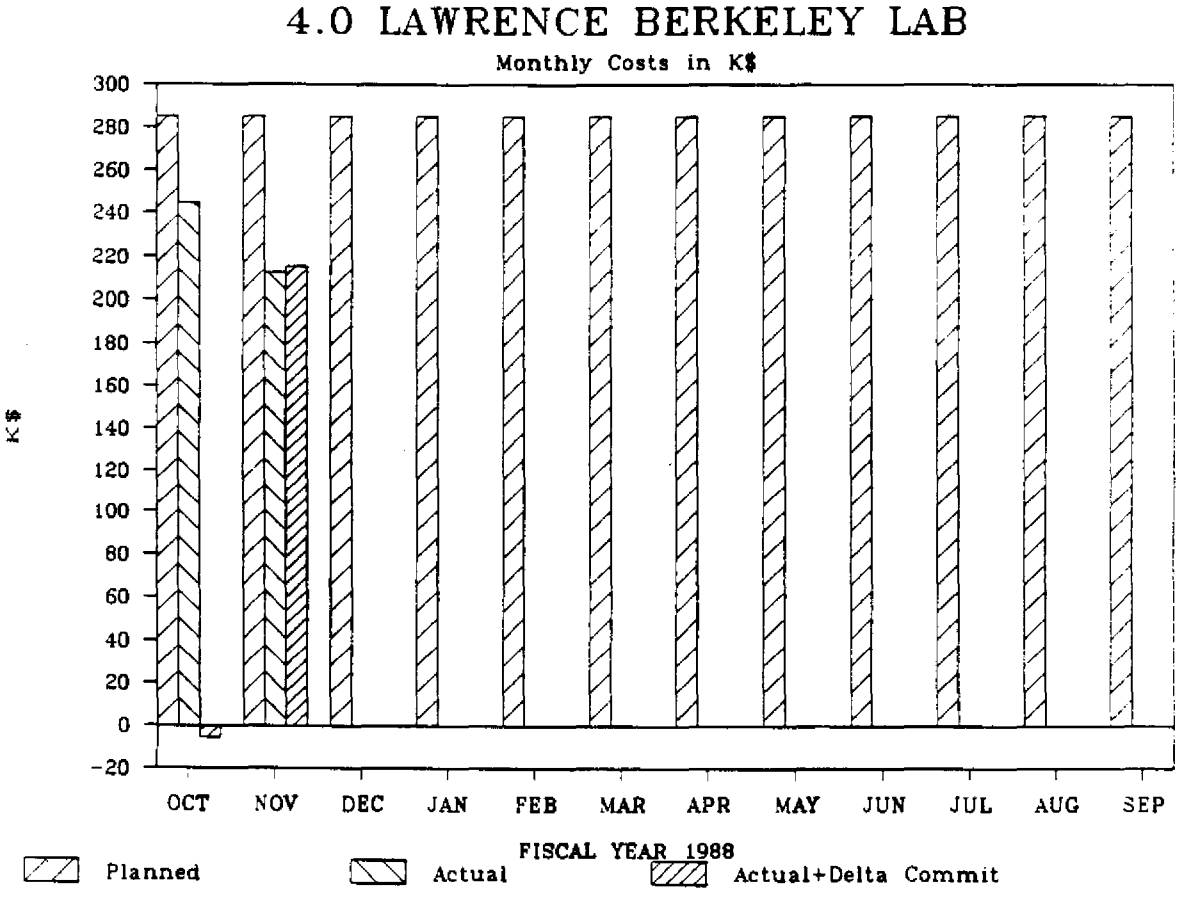
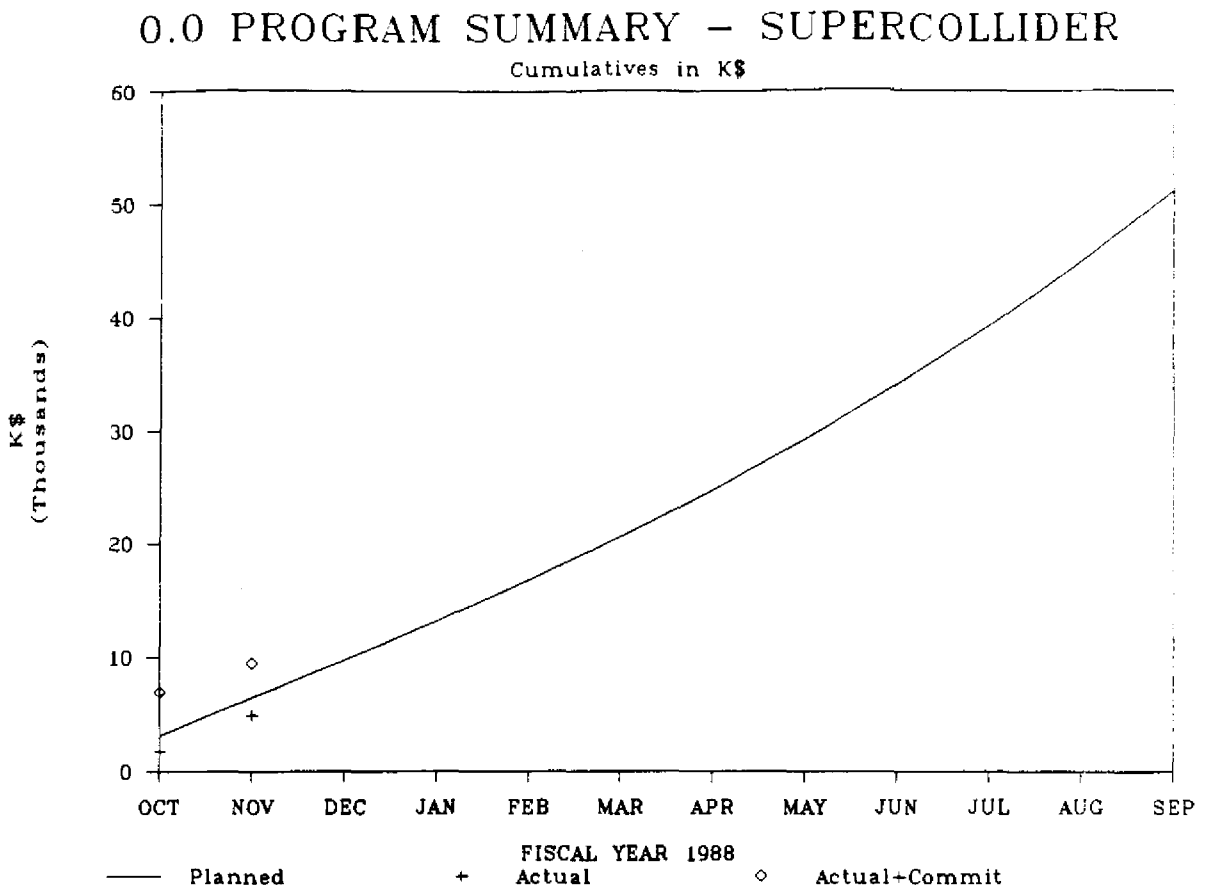

4.0 LAWRENCE BERKELEY LAB
Monthly Costs in K$
K$
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

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 1988
Planned
Actual
Actual+Commit

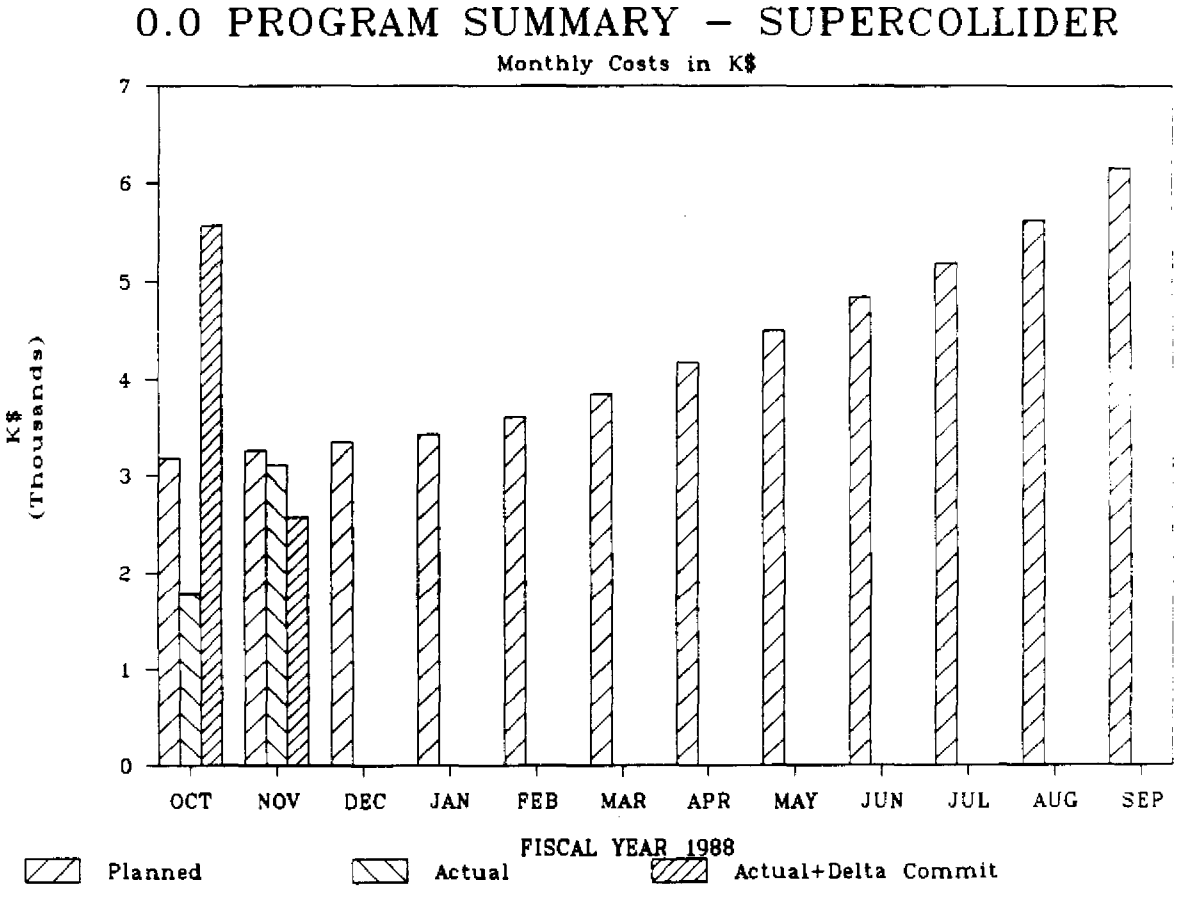

0.0 PROGRAM SUMMARY - SUPERCOLLIDER
Monthly Costs in K$
K$ (Thousands)
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 5