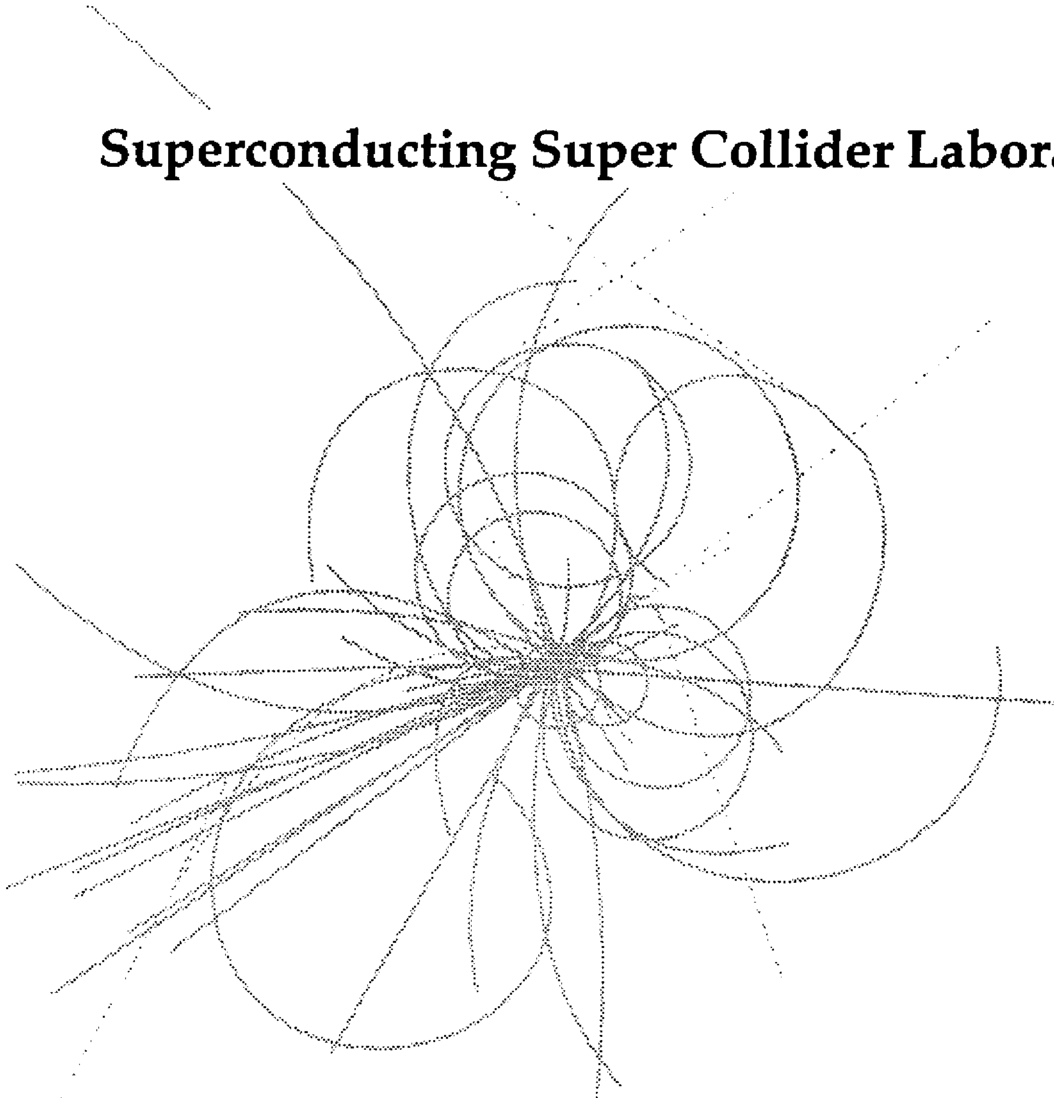
SSC-222

# Superconducting Super Collider Laboratory

SSC-222



# SSC Monthly Report

May 1989

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# PROJECT SUMMARY

SSC LABORATORY (SSCL)

***Erratum***

The quench performance of magnet DD0018 was incorrectly reported in the Project Summary section of the April 1989 report. The data were reported correctly in the SSCL Report under the heading *DD0018*.

*Magnet Systems Division*

Leadership of the Magnet Systems Division passed from T. Kirk to T. Bush, and the division staff began preparing for relocation to Dallas.

The Request for Proposals for Phase II of the Magnet Industrialization Program became the subject of ongoing high-level review by the DOE and the SSCL. Policy on foreign participation has not yet been established by the DOE.

Analysis of magnet behavior using the finite element method (ANSYS) continued with detailed studies of the effect of nonlinear materials' properties on long magnets during cooldown. Studies of alternate dipole cross sections also continued.

No new long magnets were tested. Efforts concentrated on upgrading facilities and testing methods and on preparing for magnetic measurements of DD0017 and DD0018. Analysis of data from earlier tests of DD0017 confirmed that in the event of a quench the outer layer is the limiting conductor, even though the temperature of the conductor is actually lower than previously predicted. More accurate calculation of quench-start locations on DD0017 confirmed that short-sample quenches all occurred at the same location, near the ramp splice. Plots of quench propagation velocity versus fraction of short sample show that all available data—except from DD0012—fit a single curve.

A program for automatically creating forms from the database was tested, with promising results, and a problem that had existed in building identification strings was solved.

Plans were developed for construction near the site of a magnet support center for both fabricating and testing magnets. It will be completed on the shortest possible time scale.

Analysis began of alignment data for existing long magnets.

*Accelerator Physics*

Three SSCL representatives presented talks at the Third Advanced ICFA Beam Dynamics Workshop in Novosibirsk, U.S.S.R., and attended workshops in theory, simulations, and experiments. Using MACSYMA, analytical experiments were developed for the smear and tune shifts due to systematic and random multipoles. The bore-tube correction scheme and the effects of feed-down due to closed-orbit distortions and dispersion were determined.

ZTRACK, a code for fast long-term multiparticle tracking in a storage ring, was completed along with ZMAP, a code that produces a one-turn map.

*Accelerator Systems*

The cryostat for the correction magnet prototype program was successfully tested. Preparation began for winding coils with superconducting wire. Tests were started on the interaction of epoxies with insulated superconducting wires.

The oven for curing epoxy-potted coils is nearly complete. The dump resistor to be used during magnet testing was constructed. The safety hood for exhausting epoxy fumes was completed and tested.

*Conventional Construction*

Major efforts for construction coordination focused on development of the collider footprint, injector placement studies, development of experimental hall concepts, setting forth experimental program scenarios (including schedules and costs), and development of calibration beam lines and experimental area layouts. All of this work is aimed at a definitive footprint, with a target date of August 1.

Field work began on the first phase of the geotechnical program including supporting survey work to clarify uncertainties in the geological profile and to determine vibration characteristics in the vicinity of shallow ring crossings. This work is being carried out by the project A-E contractor, RTK, under the supervision of R. Crawley. Technical oversight is provided by a geotechnical working group drawn from SSCL, RTK, and the Texas National Research Laboratory Commission.

A first draft, based on the ISP lattice, was produced of a "Site-Specific Study of SSC Support Facilities for Four Generic Detector Designs," under the direction of M. Marx. This will include generic schedules to assess program priorities. A cost estimate will be generated as a basis for funding decisions.

A cooperative effort is under way between SSCL, under J. Bensinger, and FNAL, under R. Stefanski, to develop designs and layouts of calibration beams from the high-energy booster.

*Project Planning and Management*

The SSC Project Management team, with D. Briggs as Project Manager and T. Kozman as Deputy Project Manager, concentrated on site-specific updates of the 1986 Conceptual Design Report.

DOE personnel met with SSCL Project Management staff May 17–19, to plan the activities and formulate the goals of both offices during the next few months. Discussions centered around the staffing of both offices and the development of information baselines and documentation to begin project construction, including the following: Management Information System, Systems Engineering and Integration Contract, Site Specific Conceptual Design Report, and Project Management Plan.

Work continued on development of the Work Breakdown Structure. To date, five level-one elements have been defined: Technical Systems, Conventional Systems, Project Management, Operations, and Experimental Systems.

The draft of the SSCL Project Planning, Monitoring and Reporting System (PMRS) implementation plan was completed and distributed, as was a PMRS general design criteria and functional requirements document. Evaluation and procurement of software for the PMRS (C/SCSC) was initiated.

An implementation plan for the SSCL project management systems was outlined and preparation began.

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## BROOKHAVEN NATIONAL LABORATORY (BNL)

Short magnet DSS17 was tested, with good results. The first quench at 4.35 K occurred at 6600 A, and the next quench was at the plateau current of 6920 A. The magnet eventually reached quench currents above 8000 A at 3.35 K. The field shape was good and in line with results of previous tests.

DD0019 is now ready for yoke assembly.

Coils were wound and cured for DD0020, DD0027, and DD0028. Coil assembly was completed for DD0026.

DSS15 was assembled and collared with quarter-inch-thick yoke laminations. In this configuration, the yoke acts as a collar and the midplane is tapered.

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FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)

An effort began to isolate the cause of the ground current observed during the two quenches of DD0018. Measurements revealed a cold-to-warm difference in inductance of 45 percent.

Measurements made on the completed magnet DDA010 during transport to BNL revealed changes due to transportation in the shape of both the cold mass and the vacuum vessel. These changes are being investigated. DSHIP, the magnet assembled for transport tests, will be used for further study.

Preparations continued for cold magnetic measurements of magnet DD0017, scheduled for June.

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LAWRENCE BERKELEY LABORATORY (LBL)

A series of R&D cable lengths was made and sent to BNL for critical-current measurements. These included 23- and 28-strand cable with SSC inner-type strand and 36-strand cable with SSC outer-type strand. The 28-strand cable showed no degradation. Nor did it show any training, even though the copper-to-superconductor ratio is 1.2:1, whereas in a previous test cable made with identical wire showed significant training with 9–15 quenches. The 36-strand cable showed a critical-current degradation of 4 percent, which is typical for standard SSC cable made from the same wire.

At NEEW, practice cable was made from surplus CBA wire. A new cable-measuring machine was installed.

A new clamping scheme for the cable test facility uses metal swaging for clamping samples; results of preliminary tests are promising.

Assembly of Dipole D15C-2 was completed. This model has special collar packs for clamping the coil ends, rather than the split bolted clamp used on D15C-1. It also has new strain gauge load cells. Coils were wound for Dipole D15C-3.

Dipole D16A-1, a 1-m model designed for the cable test facility, uses the new 28- and 36-strand cables. Assembly of the curing cavities is under way.

Quadrupole model QA1 was recollared (QA1-R1) to a higher coil prestress, and the collars were clamped in the iron yoke. The training was almost identical to that of previous tests, despite the significant change in mechanical constraint of the coils. It is suspected that excessive epoxy penetrated the cable. Coils are being fabricated for QA2 using standard dipole-type cable insulation, and for QA3 using the newer all-Kapton insulation, which has carefully controlled epoxy content.

Two inner QA coils were made using different cable insulation to determine whether epoxy would be found on the strands following curing. The coil with the new all-Kapton insulation showed no epoxy invasion. The coil with standard dipole insulation had extensive invasion of epoxy into the strands. Similar epoxy invasion was seen in several coil samples from magnet DD0011. This suggests that the existing dipole insulation scheme using the fiberglass tape should be carefully reexamined.

Design of winding and curing tooling for QB began; yoke and shell layouts and collar drawings were completed.

# SSCL REPORT

## MAGNET PROGRAM

### *Division Changes*

T. Bush became Head of the Magnet Systems Division of the SSC Laboratory on May 1, replacing T. Kirk, who left to become Director of the High-Energy Physics Division at Argonne National Laboratory. Dr. Bush moved to the SSC Laboratory headquarters in Dallas, and transfer of Magnet Systems Division personnel to the new location began. Many of the division's activities took place in the new offices. Organization of the division was modified to enhance engineering, test, production, and quality-assurance functions. Recruiting of senior managers and experienced physics and engineering personnel is under way.

### *Magnet Industrialization Program*

Phase I of the Industrialization Program is essentially complete. On May 5, representatives from DOE Chicago and Germantown met for an in-depth critique of the Request for Proposals (RFP) for production of dipole magnets. Results were incorporated into the RFP. The revised RFP was submitted to the DOE on May 23. The program now stands at the threshold of Phase II. Further progress on the RFP awaits DOE decision on foreign participation policy.

### *Magnet Analysis*

Finite-element calculations including known nonlinear properties of the dipole components were conducted. In one study, the nonlinear elastic modulus measurements obtained at Lawrence Livermore National Laboratory (LLNL) were used to determine the effects on coil prestress losses during excitation. In particular, it was thought that nonlinearity might contribute to the experimentally observed difference between magnets with constrained collars and those with unconstrained collars. At low excitation, the calculated results were identical to linear analyses. Results for a "line-to-line-fit" magnet agreed with test results (initial loss was approximately 85 ksi/kA$^2$). However, for an unconstrained collared coil the calculated stress loss (90 ksi/kA$^2$) was considerably less than the experimental value (115 ksi/kA$^2$ for DD0015). The calculated slope at high excitation was 15–20 percent less than the initial slope. This effect is not seen in linear analyses; it is seen to an even greater extent in most magnet tests.

A second nonlinear analysis was an investigation of plasticity of the collars during assembly, based on the DD0016 assembly loads and on various possible stress-strain curves for the collar material. Significant plasticity was observed for annealed Nitronic 40, the actual amount depending on the detailed characterization of the stress-strain curve. When the yield strength is raised to 90 ksi, no plasticity occurs. In analyses where plasticity did occur, it was apparent that the horizontal keying press was the main contributor, although subsequent investigation revealed that the forces used in the study may have been overly severe.

Magnet Division staff produced five internal notes describing the mechanical behavior of DD0012, DD0014, DD0015, DD0016, and DD0017 as the magnets were energized. The azimuthal shell strains on DD0012 and DD0014 decreased as the magnets were energized, indicating that the small gaps between the half-yokes on these magnets remained open when the magnets were cold. The shell gauges on DD0016 and DD0017 were not functioning properly during magnet testing, and it is therefore difficult to determine whether the yokes on these magnets were open or closed when the magnets reached liquid-helium temperatures. However, the slopes of the average inner-coil stress versus the square of the current for DD0016 and DD0017 are slightly higher than for DD0012 and are close to the theoretical prediction for a magnet with a closed yoke at 4.2 K. Therefore, it is believed that the yokes on DD0016 and DD0017 were closed when the magnets were at 4.2 K. The mechanical data from DD0015 indicate that the friction between yokes and collars was small compared with the axial Lorentz force as the magnet was energized, and that the primary goal of this magnet was attained. Another internal note was written describing the behavior of the mechanical quantities on long magnet DD0017 throughout the course of the magnet's testing and thermal cycling.

In addition to studies carried out on the current 4-cm baseline dipole design, ANSYS was used to calculate the field of a dipole magnet formed by overlapping two cylinders. A functional dependence between the central field of the dipole and the radius of the imposed Neumann or Dirichlet boundary condition was determined. The numerical answer was compared with the closed-form solution for this problem and found to agree within 0.1 percent.

Computer modeling of the mechanical and magnetic behavior of the KEK wedgeless 5-cm dipole continued, as did documentation of the NC-9 and C358 finite-element studies.

*Magnet Testing*

Plans were developed for field measurements of magnets DD0017 and DD0018, still mounted on test stands at FNAL. Additional effort went into understanding and improving diagnostic techniques for detecting insulation weakness in long magnets. New methods of impulse testing, which can create significant turn-to-turn voltages, were investigated.

Improvements were made in documentation of the wiring of the test-stand end racks housing important monitoring electronics. Forms were created to make the documentation complete and understandable; two of the end racks were completed using the improved documentation.

*Data Analysis and Software Development*

Analyses of data from DD0017 were completed for the correlation of temperature versus MIITs for the outer layer. It appears that the outer-layer conductor is safer than predicted by the analytical calculations: for a given number of MIITs, the actual temperature reached is 100 K lower than predicted. However, it was verified that the outer conductor was the limiting conductor from the safety point of view: an 8.25-MIITs quench gives a maximum temperature of 180 K when it originates in the inner coil, but 278 K when it originates in the outer coil. The conclusion of the study is that a MIITs value of 10 is a safe limit to observe in order to keep the outer coil conductor under 800 K during a quench.

Modifications to analysis routines—scaling of voltage-tap signals—allowed more accurate calculations of the quench-start origins in the DD0017 ramp splice. It appears that the short-sample quenches all occurred at the same location, very near the edge of the G-10 box that holds the splice.

A summary plot was made of propagation velocity versus fraction of short sample for all available long magnet data at 4.35 K for quenches originating in the inner coil (velocity measured on the turn where the quench occurs). It was observed that the data from all magnets but DD0012 lie on the same curve, indicating that despite the unexpectedly high values of these velocities (between 100 and 250 m/s) the quench development mechanism is reproducible from magnet to magnet. The behavior of DD0012 is still under investigation.

The program VT-ANALX (voltage tap analysis routine) and associated files were transferred to the Sun computer and modified to run with the data in the SDS format. Replacements for VAX Run-Time library functions were created, as were several math routines.

*Database Work*

Two important developments occurred in the Forms Project. An automatic forms creation program was tested, with very encouraging results, and the problem of building the identification strings was solved.

The automatic forms generator creates a form descriptor file from a given database table specification. The menu of operations and the standard fields—recordLock, username, modifyDate—constitute a basic descriptor to which new lines are added. The first version simply added prompts and fields for table elements. The current version will add help text, will process date and identification fields, and will create forms with two columns of entry fields. A document describing the details is being written and will be produced in June.

In the application, there are approximately 11 identification (ID) strings (concatenations of names, dates, and numbers) that are formed from 49 sub-fields. In general, the ID string must be rewritten each time a sub-field is changed. The problem is to know which string to rewrite and how to rewrite it using the information contained in the form; the solution is to first examine the form to find out which ID strings are present, and then to build a list of fields in such a way that once the current subfield is known, that field and the other subfields can be determined. A binary tree provides this list. The implementation consists of a function that, when called from any field, constructs the correct ID string.

It is expected that the 69 forms that serve the 69 tables defined in SSC-N-582 (description of the cable database organization) will be more widely available for public use by the end of June. Documentation is being created that describes the use of the database with forms and the algorithms employed in the code

The cable test data at 5 T from BNL was moved into SSC-CABLE, the official SSC cable database.

*Magnet Support Center*

Significant effort was directed to planning for the construction near the SSC site of a magnet support center, which has been assigned a high priority within the division. This center will include magnet fabrication tooling for use in the construction of magnets up to 17 m long and a cold test stand that will eventually be capable of cooling ten magnets at a time for testing. A series of meetings was held, attended by personnel from the Accelerator Systems, Conventional Construction, and Technical Support divisions, to develop criteria for the buildings and to develop the requirements and scheduling for the entire center; these meetings will continue.

*Magnet Alignment*

Dipole magnet alignment studies were carried out at FNAL by an SSC consultant. Until now, the alignment of magnets has not been emphasized, so it was not surprising to discover that the alignment achieved to date is not within specification. A report of these findings has been drafted, along with proposals for an improved closed-loop alignment method and other changes that should bring future magnets within specification.

*Other Activities*

Offices were completed for the Magnet Division in the SSC Laboratory temporary headquarters in Dallas. Some phones and personal computers were made available.

Schedules are being developed for the orderly transfer of the Hewlett-Packard CAD system and the Sun computer system to the new offices. Because of the ongoing cable database activities that involve support personnel at the SSC offices at LBL, the move of the Sun system will be accomplished in stages to maintain capability at LBL as it is being developed in Dallas. A 4/110 workstation will be configured as a temporary server for use in Dallas until the 4/280 is moved at the end of the summer.

*ICFA Beam Dynamics Workshop*

A. Chao, S. Peggs, and M. Furman attended the Third Advanced ICFA Beam Dynamics workshop held in the U.S.S.R., May 29–June 3. The workshop took place at the Institute for Nuclear Physics in Academgorodok near Novosibirsk. There were 20 participants from Europe and the U.S.; 33 from the INP. The subject of the workshop was the beam-beam effect in proton-proton, proton-antiproton, and electron-positron colliders, especially its limiting effects on luminosity and lifetime. The mornings were devoted to plenary sessions with invited and contributed talks, while the afternoons were devoted to working groups in theory, simulations, and experiments. The SSCL participants presented talks and participated in each of the working groups.

*Analytical Calculation of Smear and Tune Shift*

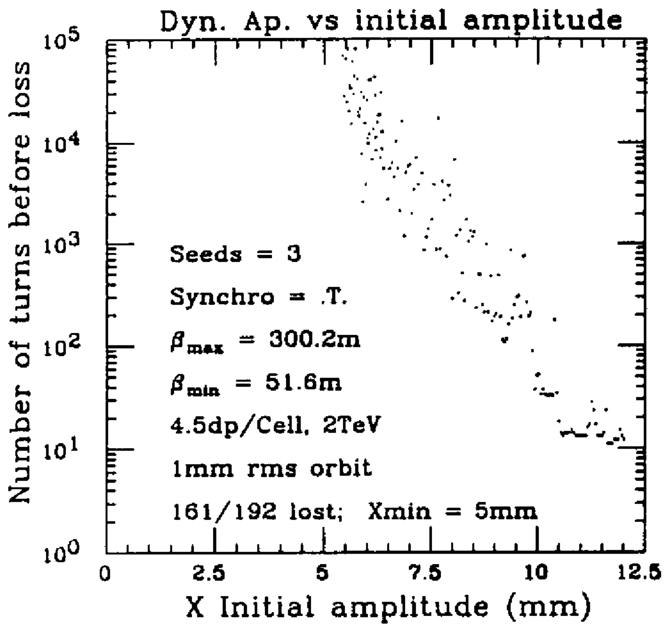
By using the analytical formalism developed by E. Forest (SSC–95) and the computer algebra system MACSYMA, analytical expressions were developed for the smear and tune shifts due to systematic and random multipoles up to decapoles. The bore-tube correction scheme for the systematic multipoles was determined, as were the effects of feed-down due to closed orbit distortions and dispersion. MACSYMA was used to obtain FORTRAN subroutines for the evaluation of these expressions.

A program exists for using the linear lattice functions and specifications of the multipole errors to determine smear and tune shifts according to different multipoles, closed orbit distortions, and dispersion. The execution time is around one minute on the VAX. The results (except for the orbit effects) were compared with tracking and show good agreement. A program was also developed to make contour plots of the smear due to the random multipoles as a function of tune. These plots may be useful in choosing the working point.

*ZTRACK*

ZTRACK was completed. This code was developed mainly for fast long-term multiparticle tracking in a storage ring. A thin-element machine file (in TEAPOT format) and a command file should be provided by the user. The codes are vectorized for multiparticle tracking in parallel, and will keep reducing the particle number to exclude lost particles. The user can also choose to substitute a new particle for each of the lost particles in order to maintain a multiple of 64 particles, thereby taking the best advantage of the CRAY computer vectorization. This code is best suited for long-term dynamic aperture study.

The figure below shows the special feature of the program ZTRACK. Particles with large amplitude are lost in early turns; the majority of particles with amplitudes lower than 5.5 mm survive for 100,000 turns.




Accompanying ZTRACK is the code ZMAP, which produces a one-turn map using truncated power series algebra (TPA or "differential algebra"). A private library, the TPALIB, should be loaded with ZMAP. The routines in TPALIB are optimally vectorized and use dynamic memory. A binary version of TPALIB is available in the MFE.

## ACCELERATOR SYSTEMS

### *Correction Magnet Prototype Program*

The cryostat for the correction magnet prototype program was successfully tested with a dummy magnet prototype acting as a heat load. Test coils of copper wire were wet-wound and cured in preparation for winding coils with superconducting wire. Tests were started on the interaction of epoxies with the Kapton and the polyester-amide/polyester-imide insulated superconducting wires. Fabrication of the oven for curing the epoxy-potted prototype coils is 90 percent complete. The dump resistor to be used during magnet testing was constructed. The safety hood for exhausting epoxy fumes was completed and satisfactorily tested.

*Footprint Specification Document (FSD)*

Preparation of a preliminary draft continued. When the updated experimental halls document is complete, it will provide essential data on site-specific construction aspects. Substantial portions of the FSD can be expected to undergo revision as knowledge of the site geology improves and conceptual design features are further developed.

*Geotechnical Field Program*

The startup geotechnical and survey programs began on May 22. The survey program, led by D. Scapuzzi, consists of two parts. In the first part, locations of emplaced rebar monuments were surveyed by Global Positioning System (GPS) techniques. The second part consists of point-to-point field surveys using electronic distance-measuring (EDM) techniques to set survey operation markers and locate previous boreholes.

Approval of a subcontract with Halliburton Geotechnical Services, Inc., for the surveying effort to support the geotechnical field program was received from the contracting officer on May 12. The contract was signed and work began on that date.

The geotechnical program, led by M. Werner, includes drilling, laboratory testing of rock samples, vibration monitoring, and field survey and mapping operations. Support was received from Texas National Research Laboratory Commission (TNRLC) on land access and environmental clearances prior to the start of the field work, and preparation of access agreements continued.

Specific work instructions for geotechnical field studies and laboratory tests were completed.

Vibration monitoring holes were drilled and geophysically logged at four different locations. Vibration monitoring of road and rail traffic and quarry blasts began, as did drilling and laboratory testing. Field mapping is largely complete, and the cored slant drilling of fault zones is slated to begin in mid-June.

The Underground Technology Advisory Panel (UTAP) met April 30 through May 2. The panel heard from TNRLC representatives, discussed the technical issues, and issued a report of recommendations, many of which were incorporated into the current geotechnical and survey programs.

*Experimental Area Schedules*

Preliminary schedules for development of models for detectors, halls, and surface areas were completed and presented for review during a meeting on the status of experimental area planning.

A conception of the experimental program, called Case 5, was used for this exercise. Based on suggestions from meeting participants, the schedules were further revised and are being used to sketch a Case 6 scenario for the experimental area development.

*Calibration Beams*

A preliminary description of calibration beams and a calibration hall was completed, and a report is in preparation. This work is being done with R. Stefanski and coworkers at FNAL. Efforts are under way to integrate this design with the detector halls, surface areas, and the current footprint.

*A-E Contributions*

Work continued on development of detector and interaction hall concepts using Intergraph. Fifty-three new and revised drawings were delivered to SSCL on May 19 for review.

Cost estimates for Case 5, Experimental Halls K-1, K-2, K-5, and K-6, were prepared using Texas labor rates and material costs.

"Design of the Digital Footprint," a report summarizing work done on definition of the land boundary for the project in the Texas Coordinate System, was drafted and distributed for comments on May 9. A revised draft was prepared and distributed on May 24.

Approval of the geotechnical characterization program for the SSC site was received from DOE on May 12 with an initial increment of funding. Work scopes (subcontract amendments) for Mason-Johnston Associates and Southwestern Laboratories for footprint field studies and laboratory tests were implemented, and the two subcontracts were awarded immediately upon approval from DOE.

Tunnel unit cost estimates were prepared and submitted on May 19, using Texas wages, materials, and equipment costs for tunneling in Austin Chalk and Taylor Marl.

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## PROJECT PLANNING AND MANAGEMENT

The SSC Project Management team, with D. Briggs as Project Manager and T. Kozman as Deputy Project Manager, concentrated on site-specific updates of the 1986 Conceptual Design Report. Development of site-specific technical, cost, and schedule baselines is under way, with a goal of completing the baseline documentation prior to the DOE review scheduled for January 1990.

DOE personnel met with the SSCL Project Management staff May 17–19. Discussions centered around the staffing of both offices and the development of information baselines and documentation to begin project construction, including the following:

- Management Information System (scope to be defined in June 1989, first monthly report to use the SSCL accounting system in August 1989, and initial MIS output using dummy CSCS data in October 1989).

- Systems Engineering and Integration Contract (draft RFP and dates to be given to DOE in May 1989, RFP to be issued in June 1989, and letter contract to be awarded and initial complement of people in place at SSCL in August, 1989).

- Site-Specific Conceptual Design Report (footprint to be established and presented at the DOE semiannual review scheduled for August 1989, with completion of the baseline estimate and master schedule by December 1989, and joint DOE/SSCL review in January 1990).

- Project Management Plan (first draft outline given to DOE in May 1989, initial draft of the plan due in August 1989, and the final draft due in November 1989).

Work continued on development of the Work Breakdown Structure. To date, the following level-one elements have been defined:

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|---|---|
| WBS 1. | Technical Systems |
| WBS 2. | Conventional Systems |
| WBS 3. | Project Management |
| WBS 4. | Operations (R&D, Laboratory operations) |
| WBS 5. | Experimental Systems (Detectors). |

Laboratory operations applicable to the PACE construction will be under WBS 3 and those of an institutional nature under WBS 4.

The draft of the SSCL Project Planning, Monitoring, and Reporting System (PMRS) implementation plan was completed and distributed for review, both within the SSCL and to selected DOE experts. A PMRS general design criteria and functional requirements document was prepared and issued for review. The process of evaluating, selecting, and procuring software for the PMRS (C/SCSC) was initiated. The current PMRS implementation schedule includes installation of software to be complete by the end of July 1989. Staffing and development of the SSCL PMRS office continued.

An implementation plan for the SSCL project management systems was outlined and preparation began. The plan covers implementation of all project management, administration, and technical support systems for the SSCL construction project, including systems engineering, systems integration, quality assurance, environmental safety and health, and configuration management. Regulatory compliance and public relations are also addressed.

# BNL REPORT

## MODEL MAGNETS

### *Long Magnets*

Yoke blocks and collar packs were fabricated for DD0019. The magnet was collared, and by the end of the month preparations were well advanced for yoke assembly.

Coil assembly was completed for DD0020. However, it was decided to use the coils in DD0026. Consequently, new inner coils were wound and cured for DD0020, as well as for DD0027 and DD0028.

Wiring continued on DDA010, and at the same time wiring and fabrication of components for the HTF continued in preparation for hookup to the DDA010 cold mass/cryostat assembly.

### *Short Magnets*

DSS17 was tested, as detailed below under Tests and Measurements, with good results.

DSS15 was assembled and collared with quarter-inch-thick yoke laminations. In this configuration, the yoke acts as a collar and the midplane is tapered. Limitations in the collaring press capacity resulted in a prestress somewhat lower than expected (6.3 kpsi for the inner coil and 4.1 kpsi for the outer coil). It is believed, however, that welding the shell will close the midplane and bring up the coil prestress.

DSK13, the reassembled version of DSS13, was fully assembled from collaring to endplate work, and dressing of voltage tap leads was done along with other preparations for testing the magnet in June.

### *Trim Coils*

The trim coil for DD0020 was delivered but rejected, due to poor bonding of pole spacers. PCK will attempt the necessary repairs.

A 1.8-m trim coil with 3.2:1 copper-to-superconductor ratio was delivered, and one was bonded to a tube assembly. Further work was postponed because of testing priorities in other areas.

Most of the parts for the trim coil test facility are now finished, and assembly and welding of the various components began.

A preliminary cross-section layout of a corrector assembly was prepared and forwarded to SSCL Berkeley for evaluation.

*Beam Tubes*

The beam tube for DD0019 was received. The tube for DD0026 was completed and awaits delivery.

Mill work for the new batch of SSC beam tubes is 85 percent complete. The first 30 tubes should be delivered to BNL by the end of June, pending onsite inspection.

A recurring plating adhesion problem has been under study by the plating vendor, and now appears to be under control. A safety problem with the present anode system at Silvex has arisen. The layout of the strongback for Silvex has been approved, and detailed design work has been initiated.

*Warm Bore Tubes*

The first warm bore tube was assembled, welded, and leak-checked.

*Insulation R&D*

Various tests were performed on a selection of DuPont sample films, allowing tentative conclusions with respect to optimum content of alumina filler and film layer overlap. Work is under way to determine exact bonding and film-thickness parameters.

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TOOLING AND EQUIPMENT

*Coils*

A total of six inner coils and ten outer coils have now been wound and cured, using the new formblocks, for magnets DD0019, DD0020, DD0026, DD0027, and DD0028.

Assembly of the short curing press began. All drawings of this press were completed in the design room, as were all drawings for the 1.8-m and 17-m inner-mandrel modifications.

*Collars*

Drawings for the tapered-key insertion device were finished and checked and should be released to the shops shortly.

*Cold Mass Insertion*

Cold mass insertion equipment was completed in the shops.

*Horizontal Magnet Test Facility*

Construction continued in the feed- and end-can areas as well as in the interconnect areas of bays A and B.

*Test Equipment*

Work began on the assembly of mole DII. The mole shipped to FNAL was set up, enabling both warm and cold measurements to be made.

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## SUPERCONDUCTOR

*Cable Procurement*

Cable SC12-00007 arrived at BNL on May 5, but was found to be defective. BNL personnel performed an extensive study of cable and wire samples, using photomicrographs and acid etching. Representatives from Supercon, the supplier, visited BNL to inspect this cable. It was found that only approximately 500 feet of cable had to be rejected. Enough for two magnets was acceptable. Nevertheless, this problem pushed back the completion of cable insulation to May 23.

The balance of outer cable requiring insulation was completed. All SSC cable on hand has now been insulated and is ready for coil winding.

*Tooling*

Construction of the electrical-insulating-film test fixture was completed.

*Miscellaneous*

The insertion of six short experimental coils into the DSS program required a revision of the DSS flow chart, completed at the end of May. These coils will be vehicles for testing low-epoxy fiberglass and properties of woven fiberglass.

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## TESTS AND MEASUREMENTS

Dipole DSS17 was tested. In determining the quench performance of this magnet, a new method was used for ramping to the first quench following a change in helium temperature. This method, dubbed the "increasing sawtooth," involved ramping the magnet first to a current where no quench was expected (e.g., 5500 A), back down to a current that is 70 percent of the expected plateau current, up to a current 100 A higher than the previous maximum, down to the same minimum current, and so forth, until the magnet quenched. The idea was to see whether any strains locked in during assembly could be released gradually.

For DSS17, the first quench at 4.35 K at 6600 A, above the SSC operating current. The next quench was at the plateau current of 6920A. The magnet eventually reached quench currents above 8000 A at 3.35 K, but the performance at this temperature was erratic, with alternate quenches occurring at currents near 6900 A. The location of these quenches has been determined and will serve as a guide when the magnet is inspected.

In determining the quench performance after a thermal cycle, the increasing sawtooth current waveform was used, and the magnet was tested at a helium temperature 1 K below the usual temperature to see whether the added current-carrying capacity of the conductor would affect retraining. At 3.35 K, the magnet was quenched once; that quench was on plateau.

The field shape was good, and in line with the previous three C358D 1.8-m magnets in this series. Some added measurements were made. For example, the room-temperature field measurements did not change as a result of the first cooldown or quenching of the magnet.

# FNAL REPORT

## DIPOLE CRYOSTAT

Measurement of the 300-to-80 K performance of the design B insulation system continued. Measurement of the blanket with the sewn seams removed was completed. Its performance, using insulating vacuum to control heat leak, is superior to the earlier blanket that incorporated a double aluminized mylar reflector with spunbonded nylon spacer material.

The blanket incorporating a staggered sewn seam, as planned for design C, is being installed in the Heat Leak Test Facility. Measurements are scheduled to begin in June. This will complete the 300-to-80-K insulation measurement program.

Work continued on the design C cryostat. Plans remain in effect for completion of the preliminary design in June 1989.

Work continued on SSC cryostat alignment. The available model magnet alignment data are being evaluated, and a summary report is being prepared.

Evaluation continued of the lateral elastic instability of the single-phase bellows when pressurized. Preliminary results indicate that instability will occur at pressures less than the single-phase design pressure of 20 atm. Stability can be improved by increasing length, decreasing diameter, and/or increasing lateral stiffness of the bellows. A measurements program is under way.

The data recorded before and after shipment of DDA010 from FNAL to BNL have been analyzed. The vertical locations of the cold mass and the vacuum vessel were measured relative to the two external vacuum vessel supports. The measurements show a change in shape of both the cold mass and the vacuum vessel resulting from transportation.

Additional data on deflection of the cold mass and vacuum vessel due to shipping will be obtained during the DSHIP transportation response measurements program. A study will be undertaken to determine possible methods of controlling such deflections, and the results of this study will be incorporated, where practical, into the production of near-term long magnet models.

Planning continued for off-site over-the-road testing of DSHIP. Two initial tests, planned for June, will evaluate the performance of DSHIP on the leased trailer with the air bag platforms and on the SSCL extendable trailer with hard mounts. DSHIP will be equipped with the hydraulic axial restraint and end caps employed in the shipment of DDA010 to BNL. Instrumentation will be added to measure the accelerations of cold mass ends.

## MAGNETIC MEASUREMENTS

In order to be able to apply substantial turn-to-turn voltages to DD0018 and possibly to identify the source of the breakdown observed during the two spontaneous quenches of that magnet, a technique was developed for "ringing" SSC dipoles by creating a resonant circuit containing the dipole and a capacitor. This technique, in which the initial energy is supplied as current in the inductance of the magnet rather than as charge in the capacitor, allows the resonant frequency and the voltage to be varied easily and does not result in anomalous voltage distributions that might locally overstress the magnet. Although high-voltage testing will not be performed until magnetic measurements on DD0018 are complete, a measurement of the cold and warm inductances produced values of 39 and 57 millihenries, respectively. This interesting result, at about 80 Hz, is not fully understood and is being investigated. Similar measurements will be performed on DD0017 in the near future.

The instrumentation of Test Stand 4 that produced anomalous results during some of the quenches of DD0017 was tested, but no problems that might have caused these results were seen. Further quench-testing of DD0017 is not expected to be adversely affected by the instrumentation.

The warm bore for magnetic measurements was lengthened to accommodate the test stand length resulting from addition of the annular beam-tube feed-throughs, and the bore was installed. The mole measurement system was tested and debugged on Tevatron magnets, the mole was inserted in DD0017, and magnetic measurements at 10 A at both polarities were then completed. Cold magnetic measurements are planned for June.

Transverse bellows stability was investigated, using the DD0018 installation on Test Stand 5, by measuring cold-mass bellows displacement versus force and pressure. Stability of the cold-mass bellows up to the design pressure of the ring, 300 psi, occurs if the bellows spring constant is high, as it was for the most recent bellows procurement.

## LONG MAGNET FABRICATION

Posts and cradles were assembled for the next magnets and then sent for inspection.

All of the new iron pipe from the curing press to the heat exchanger has been installed. The expansion tank on the heat exchanger has been relocated.

The inner and outer curing molds are complete except for manifolding.

Optical surveys of the beam tube and vacuum vessel were done on DSHIP.

*Curing Press*

The new upper beam for the curing press was received and installed. Final alignment is now under way. The lower beam is due to arrive approximately June 9.

*Collaring Press*

The collaring press is complete except for the guide rail for the mold insertion. The insertion table is roughly in place. The collaring mold subassemblies cannot be assembled on the table until parts are received for modification to the table for the chain drive and the table is aligned; this should take place about July 10.

*Yoke/Skinning Press*

More of the upper modules with laminations were attached to the yoke/skinning press; the remainder should be completed by June 9 and the final alignment will begin approximately June 12.

*Winding Table*

All of the legs of the winding table were grouted, and the mandrel supports are optically aligned.

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## MAGNET DEVELOPMENT

Further analysis of DSS012 cold test data shows that after warmup, both inner and outer coil prestress values return to approximately the same values they had before reyoking. In addition, the pattern of azimuthal skin stress change as a function of current and distance from the midplane can be understood, at least qualitatively, as indicating that the yoke halves are bending under the Lorentz force and that therefore a midplane gap is most likely present at helium temperature.

Disassembly of DSS012 began in preparation for reassembly with vertically split yoke laminations. The vertically split laminations were received and assembled into packs. Instrumentation was designed and is currently being built to measure deflections of the collars with respect to the yoke and of one yoke half with respect to the other.

*F Series Model Program*

Cross sections F4#2 and F4#3 were repackaged with different ground-wrap schemes. They were recollared, potted, and sectioned to determine the ground-wrap configurations for future SSC magnets. These different ground-wrap schemes were made to solve two problems: outer-coil collaring shims being driven into the inner coil and nonconformity to the Shutt scheme for helium flow.

Results indicate that it is desirable to eliminate all collaring shims and collaring shoes from magnets. Magnets F5 and F6 will be built without collaring shims and shoes. They will be cycled repeatedly and autopsied to observe any deterioration in ground wrap due to the absence of the shims and shoes.

All F5 coils are wound. Packaging is under way in preparation for collaring.

Manufacturing of F7 end parts continues. Return end parts are expected by late June.

Programs were completed for creating surfaces needed to make F10 end parts (grouped with developable surface).

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ACCELERATOR

"Energy Deposition in Large Targets by 1-20 TeV Proton Beams," by S. Qian and A. VanGinneken was completed (Fermilab FN 514) and is at the Fermilab Publications Office awaiting distribution. This note summarizes work done with a program created especially to study energy deposition in beam dumps and scrapers, etc.; in the multi-TeV regime the program can be adapted to analyze more complex geometries than are included in the report.

# LBL REPORT

## SUPERCONDUCTOR AND CABLE

### *Cable Parameters*

A series of R&D cables was made in order to evaluate various design trade-offs. These included 28-strand cable with SSC inner-type strand, 36-strand cable with SSC outer-type strand, and 23-strand cable with SSC inner-type strand where keystone angle and percentage compactions were varied.

Samples were sent to BNL for critical-current measurements. The 28-strand cable showed no degradation due to cabling. It also showed surprising behavior in the BNL short-sample training test: the sample showed no training, even though the copper-to-superconductor ratio was 1.2:1. In a previous test at BNL, standard SSC inner cable made with identical wire showed significant training, with 9–15 training quenches. The reasons for this behavior are being investigated. The 36-strand cable showed a critical-current degradation of 4 percent, typical for standard SSC cable made from the same wire. Samples are still being measured to explore the effect of keystone angle and compaction.

Activities involving the Dour cabling machine line at NEEW included fabrication of practice cable from surplus CBA wire and the installation of a new cable-measuring machine that can operate at higher cabling line speeds.

### *Cable Test Facility*

A new clamping scheme was designed, based on the use of metal swaging for clamping samples. Preliminary tests are promising, and it is planned to pursue this potentially simple compact and efficient scheme.

## MAGNET MODELS

### *Dipole D15C-2*

Assembly of this model was completed, with care taken to preload the ends uniformly. Each coil end was loaded to 2500 pounds at assembly for a total axial preload of 10,000 pounds. This model has special collar packs for clamping the coil ends instead of the split bolted clamp used on D15C-1. It also has two new designs of strain gauge load cells installed for evaluation.

*Dipole D15C-3.*

Coils were wound for dipole D15C-3.

*Dipole D16A-1*

This is a 1-m model designed for use in the cable test facility. It has a 5-cm aperture and uses the new 28- and 36-strand cables. New tooling was designed and produced for fabrication of the coils. Assembly of the curing cavities is under way. Detailed design of the yoke system is in process.

*5-cm Bore Design*

Conceptual design of a 5-cm-bore 6.6-T dipole (D17A) as an alternative to the present SSC dipole is in progress. With an inner layer of 28-strand cable and an outer layer of 36-strand cable the magnet has the same transfer function as the current 4-cm SSC dipole but has about 20 percent more superconductor in the cross section. This results in a greater operating margin.

The 4-wedge design has excellent field quality. The outer-layer pole angle is identical to that of magnet D16A; thus, a model could be built using the existing tooling.

Parametric studies are being done on collar thickness and yoke design.

*Quadrupole QA1-R1*

SSC model quadrupole QA1 was tested twice in 1987 and exhibited considerable training. The magnet was recently recollared to a higher coil prestress, and the collars were clamped in the iron yoke; the rebuilt magnet is QA1-R1.

The training was almost identical to that of the previous two tests, despite the significant change in mechanical constraint of the coils. However, it is possible that the amount of epoxy used in the fabrication of these first coils, which in early 1987 had a special all-Kapton insulation on the cable, might have resulted in excess epoxy penetrating the cable. This could cause excess training. New coils are being wound using the standard dipole magnet insulation scheme and will be tested in a new model, QA2. QA2 will be identical to QA1 except for the cable insulation.

It was also found that the difference between the measured quadrupole gradient at room temperature and at helium temperature was attributable to bowing of the measurement coil due to differential contraction of the components.

*Quadrupole QA2*

Coils are being fabricated using standard Kapton/glass dipole-type cable, to determine whether changing insulation type will mitigate the training experienced in the QA1 model.

*Quadrupole QA3*

This model will use the newer all-Kapton insulation with a carefully controlled epoxy content.

*Cable Insulation Tests*

Two inner QA coils were made using different cable insulation to determine whether epoxy would be found on the strands following curing. On autopsy, microscopic examination revealed that the coil with the new all-Kapton insulation, with about 0.2 mil of B-stage epoxy coating the outside of the outer Kapton wrap, showed no epoxy invasion. The coil with standard dipole insulation, Kapton overwrapped with fiber glass tape impregnated with epoxy, had extensive invasion of epoxy into the strands. Subsequently, similar epoxy invasion was seen in several coil samples from magnet DD0011.

This suggests that the existing dipole insulation scheme using the fiber glass tape should be carefully reevaluated. Examination of additional coils is planned.

*Quadrupole QB*

Winding and curing tooling is being designed. Yoke and shell layouts were completed. Collar drawings were completed and are ready for RFQ's. Effort has been concentrated on the design of a 1-m model. Conceptual layouts for the full-length SSC magnet design were begun.

# PROJECT COST DATA

INDEX

TABLE C-1
CENTRAL DESIGN GROUP
May-89

| | PROGRAM ELEMENT | LABOR | MAT'L & SERVICES | G & A | MONTH TOTAL | YEAR TO DATE | ANNUAL BUDGET |
|---|---|---|---|---|---|---|---|
| 1.1 | ADMINISTRATION | 324.5 | 931.6 | 52.6 | 1308.7 | 4264.6 | 6246.0 |
| 1.2 | PROGRAM PLANNING & MANAGEMENT | 68.9 | 122.8 | 5.9 | 197.6 | 643.6 | 1190.0 |
| 1.3 | ACCELERATOR R & D | 363.3 | 402.6 | 33.5 | 799.4 | 5245.1 | 17004.0 |
| 1.4 | CONVENTIONAL SYSTEMS DEVELOPMENT | 204.5 | 117.2 | 2.9 | 324.6 | 1411.8 | 1740.0 |
| | PROGRAM COSTS | 961.2 | 1574.2 | 94.9 | 2630.3 | 11565.1 | 26180.0 |
| 1.41 | RTK COSTS | 0.0 | 89.8 | 0.0 | 89.8 | 560.0 | 750.0 |
| | CDG/RTK COSTS | 961.2 | 1663.9 | 94.9 | 2720.1 | 12125.1 | 26930.0 |
| | COMMITMENTS | | | | | 2526.4 | |
| | DELTA COMMITMENTS | | | | | 343.7 | |
| | EQUIPMENT COSTS | | | | | 0.0 | |
| | EQUIPMENT COMMITMENTS | | | | | 312.3 | |

TABLE C-2
BROOKHAVEN NATIONAL LABORATORY
May-89

| | PROGRAM ELEMENT | LABOR | MAT'L & SERVICES | G & A | MONTH TOTAL | YEAR TO DATE | ANNUAL BUDGET |
|---|---|---|---|---|---|---|---|
| 2.1 | MAGNET DESIGN | 57.0 | 180.0 | 101.2 | 338.2 | 1615.9 | 3348.0 |
| 2.2 | 17-M COLD MASS FABRICATION | 99.7 | 68.6 | 71.9 | 240.2 | 3215.9 | 4134.0 |
| 2.3 | TOOLING & FIXTURES | 0.0 | 0.0 | 0.0 | 0.0 | 914.5 | 640.0 |
| 2.4 | BEAM TUBE DEVELOPMENT | 9.5 | 10.0 | 8.3 | 27.7 | 439.0 | 538.0 |
| 2.5 | 1.8-M DIPOLE FABRICIATION | 19.0 | 2.5 | 9.2 | 30.7 | 227.6 | 633.0 |
| 2.6 | TRIM COIL DEVELOPMENT | 19.0 | 2.2 | 9.1 | 30.3 | 350.5 | 752.0 |
| 2.7 | MAGNET MEASUREMENT | 95.0 | 39.4 | 57.4 | 191.9 | 1599.9 | 3341.0 |
| 2.8 | INDUSTRIALIZATION | 9.5 | 1.1 | 4.5 | 15.0 | 172.8 | 316.0 |
| | MAGNET TOTALS | 308.5 | 303.8 | 261.6 | 874.3 | 8535.9 | 13702.0 |
| 2.9 | ACCELERATED LIFE TESTS | 66.5 | 21.9 | 37.8 | 126.2 | 566.8 | 898.0 |
| | BNL R & D TOTALS | 375.0 | 325.7 | 299.4 | 1000.5 | 9102.7 | 14600.0 |
| | COMMITMENTS | | | | | 1891.0 | |
| | DELTA COMMITMENTS | | | | | -257.0 | |
| | EQUIPMENT COSTS | 100.1 | 239.0 | 0.0 | 339.1 | 899.1 | 2947.0 |
| | EQUIPMENT OPEN COMMITMENTS | | | | | 545.0 | |

TABLE C-3
FERMI NATIONAL ACCELERATOR LABORATORY
May-89

| | PROGRAM ELEMENT | LABOR | MAT'L & SERVICES | G & A | MONTH TOTAL | YEAR TO DATE | ANNUAL BUDGET |
|---|---|---|---|---|---|---|---|
| 3.1 | GENERAL | 0.0 | 8.0 | 6.4 | 14.4 | 198.5 | 222.0 |
| 3.2 | LONG MAGNET FABRICATION | 33.5 | 41.3 | 25.3 | 100.1 | 1135.7 | 1891.0 |
| 3.3 | MAGNETIC MEASUREMENTS | 115.1 | 34.7 | 67.0 | 216.8 | 1043.5 | 2168.0 |
| 3.4 | COLD MASS FABRICATION | 170.4 | 103.6 | 98.2 | 372.2 | 1898.8 | 3845.0 |
| 3.5 | INDUSTRIALIZATION | 7.7 | 0.0 | 0.8 | 8.5 | 143.6 | 417.0 |
| 3.6 | CELL TESTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.7 | ACCELERATOR STUDIES | 7.6 | -0.1 | 4.2 | 11.7 | 74.1 | 71.0 |
| 3.8 | HALF-CELL TESTS SUP. (REE) | 3.2 | 1.0 | -0.4 | 3.8 | 31.1 | 466.0 |
| 3.9 | CRYOGENIC R & D (RAC) | 41.5 | 6.6 | 31.6 | 79.7 | 480.2 | 1009.0 |
| 3.10 | GENERAL MAGNET R & D (RAE) | 18.2 | 6.8 | 11.8 | 36.8 | 212.0 | 1384.0 |
| 3.11 | MTF MODIFICATION (RAI) | 20.0 | 162.8 | 3.6 | 186.4 | 262.0 | 278.0 |
| 3.12 | DIPOLE TOOLING R & D (RAJ) | 50.4 | 41.3 | 35.2 | 126.9 | 791.8 | 417.0 |
| | PROGRAM COSTS | 467.6 | 406.0 | 283.7 | 1157.3 | 6271.3 | 12168.0 |
| | COMMITMENTS | | | | | 809.9 | |
| | DELTA COMMITMENTS | | | | | -158.2 | |
| | EQUIPMENT COSTS | -2.9 | 11.1 | 0.0 | 8.2 | 518.3 | 1640.0 |
| | EQUIPMENT OPEN COMMITMENTS | | | | | 472.3 | |

TABLE C-4
LAWRENCE BERKELEY LABORATORY
May-89

| | PROGRAM ELEMENT | LABOR | MAT'L & SERVICES | G & A | MONTH TOTAL | YEAR TO DATE | ANNUAL BUDGET |
|---|---|---|---|---|---|---|---|
| 4.1 | GENERAL | 10.0 | 32.1 | 20.0 | 62.1 | 200.8 | 350.0 |
| 4.2 | SUPERCONDUCTOR & CABLE | 10.2 | 131.7 | 12.3 | 154.2 | 515.3 | 1340.0 |
| 4.3 | CABLE SHORT SAMPLE TEST FACILITY | 42.0 | 4.1 | 21.9 | 68.0 | 203.5 | 50.0 |
| 4.4 | DIPOLE MAGNET DEVELOPMENT | 47.2 | 17.5 | 30.7 | 95.4 | 977.5 | 760.0 |
| 4.5 | QUADRUPOLE MAGNETS | 46.7 | 1.0 | 22.7 | 70.4 | 188.0 | 260.0 |
| 4.6 | COIL PROPERTIES | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 200.0 |
| 4.7 | TECHNOLOGY TRANSFER TO INDUSTRY | 0.0 | -0.8 | -0.4 | -1.2 | 51.2 | 50.0 |
| | MAGNET R & D TOTALS | 156.0 | 185.6 | 107.2 | 448.9 | 2142.1 | 3010.0 |
| 4.8 | ACCELERATOR THEORY SUPPORT | 20.3 | 1.1 | 10.2 | 31.6 | 254.7 | 410.0 |
| | R & D COST TOTAL | 176.3 | 186.7 | 117.4 | 480.5 | 2396.8 | 3420.0 |
| | COMMITMENTS | | | | | 625.0 | |
| | DELTA COMMITMENTS | | | | | 98.0 | |

TABLE C-5
PROGRAM SUMMARY - SUPERCOLLIDER
May-89

| PROGRAM ELEMENT | LABOR | MAT'L & SERVICES | G & A | MONTH TOTAL | YEAR TO DATE | ANNUAL BUDGET |
|---|---|---|---|---|---|---|
| CDG PROGRAM | 961.2 | 1574.2 | 94.9 | 2630.3 | 11565.1 | 26180.0 |
| 41 RTK PROGRAM | 0.0 | 89.8 | 0.0 | 89.8 | 560.0 | 750.0 |
| BNL SSC PROGRAM | 375.0 | 325.7 | 299.4 | 1000.1 | 9102.7 | 14600.0 |
| FNAL SSC PROGRAM | 467.6 | 406.0 | 283.7 | 1157.3 | 6271.3 | 12168.0 |
| LBL SSC PROGRAM | 176.3 | 186.7 | 117.4 | 480.4 | 2396.8 | 3420.0 |
| TOTAL SSC PROGRAM COSTS | 1980.1 | 2582.3 | 795.4 | 5357.9 | 29895.9 | 57118.0 |
| COMMITMENTS | | | | | 5852.3 | |
| DELTA COMMITMENTS | | | | | 26.5 | |
| EQUIPMENT COSTS | | | | | 1417.4 | 4587.0 |
| EQUIPMENT OPEN COMMITMENTS | | | | | 1329.6 | |

TABLE C-6

MONTHLY AND CUMULATIVE SUMMARY
OF PLANNED AND ACTUAL COSTS AND COMMITMENTS

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

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| 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 | 1180.3 | 3886.9 | 1145.9 | 5598.9 | 1712.0 | -34.4 |
| FEB | 1588.9 | 6705.6 | 1263.2 | 5150.1 | 1626.7 | 7225.6 | 2075.5 | 363.5 |
| MAR | 1831.2 | 8536.8 | 1848.2 | 6998.3 | 1931.7 | 9157.3 | 2159.0 | 83.5 |
| APR | 2154.4 | 10691.2 | 2406.8 | 9405.1 | 2430.5 | 11587.8 | 2182.7 | 23.7 |
| MAY | 2477.6 | 13168.8 | 2720.1 | 12125.2 | 3063.8 | 14651.6 | 2526.4 | 343.7 |
| 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

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| 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 | 1355.4 | 4580.1 | 1316.4 | 6604.1 | 2024.0 | -39.0 |
| FEB | 1216.7 | 6083.3 | 1147.9 | 5728.0 | 913.9 | 7518.0 | 1790.0 | -234.0 |
| MAR | 1216.7 | 7300.0 | 1401.6 | 7129.6 | 1902.6 | 9420.6 | 2291.0 | 501.0 |
| APR | 1216.7 | 8516.7 | 973.6 | 8103.2 | 830.6 | 10251.2 | 2148.0 | -143.0 |
| MAY | 1216.7 | 9733.3 | 1000.5 | 9103.7 | 743.5 | 10994.7 | 1891.0 | -257.0 |
| 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

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| 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 | 1014.0 | 1014.0 | 366.1 | 366.1 | 1178.9 | 1178.9 | 812.8 | 812.8 |
| NOV | 1014.0 | 2028.0 | 670.2 | 1036.3 | 488.4 | 1667.3 | 631.0 | -181.8 |
| DEC | 1014.0 | 3042.0 | 613.1 | 1649.4 | 593.5 | 2260.8 | 611.4 | -19.6 |
| JAN | 1014.0 | 4056.0 | 787.2 | 2436.8 | 807.2 | 3068.2 | 631.4 | 20.0 |
| FEB | 1014.0 | 5070.0 | 829.0 | 3178.7 | 931.7 | 3912.8 | 734.1 | 102.7 |
| MAR | 1014.0 | 6084.0 | 921.9 | 4100.8 | 1095.7 | 5008.7 | 907.9 | 173.8 |
| APR | 1014.0 | 7098.0 | 1013.4 | 5114.4 | 1073.6 | 6082.5 | 968.1 | 60.2 |
| MAY | 1014.0 | 8112.0 | 1157.3 | 6271.9 | 999.1 | 7081.8 | 809.9 | -158.2 |
| JUN | 1014.0 | 9126.0 | | | | | | |
| JUL | 1014.0 | 10140.0 | | | | | | |
| AUG | 1014.0 | 11154.0 | | | | | | |
| SEP | 1014.0 | 12168.0 | | | | | | |

4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

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| 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 | 343.9 | 1009.5 | 508.9 | 1270.5 | 261.0 | 165.0 |
| FEB | 285.0 | 1425.0 | 273.2 | 1282.7 | 377.2 | 1647.7 | 365.0 | 104.0 |
| MAR | 285.0 | 1710.0 | 373.5 | 1656.2 | 525.5 | 2173.2 | 517.0 | 152.0 |
| APR | 285.0 | 1995.0 | 258.8 | 1915.0 | 268.8 | 2442.0 | 527.0 | 10.0 |
| MAY | 285.0 | 2280.0 | 480.5 | 2395.5 | 578.5 | 3020.5 | 625.0 | 98.0 |
| 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

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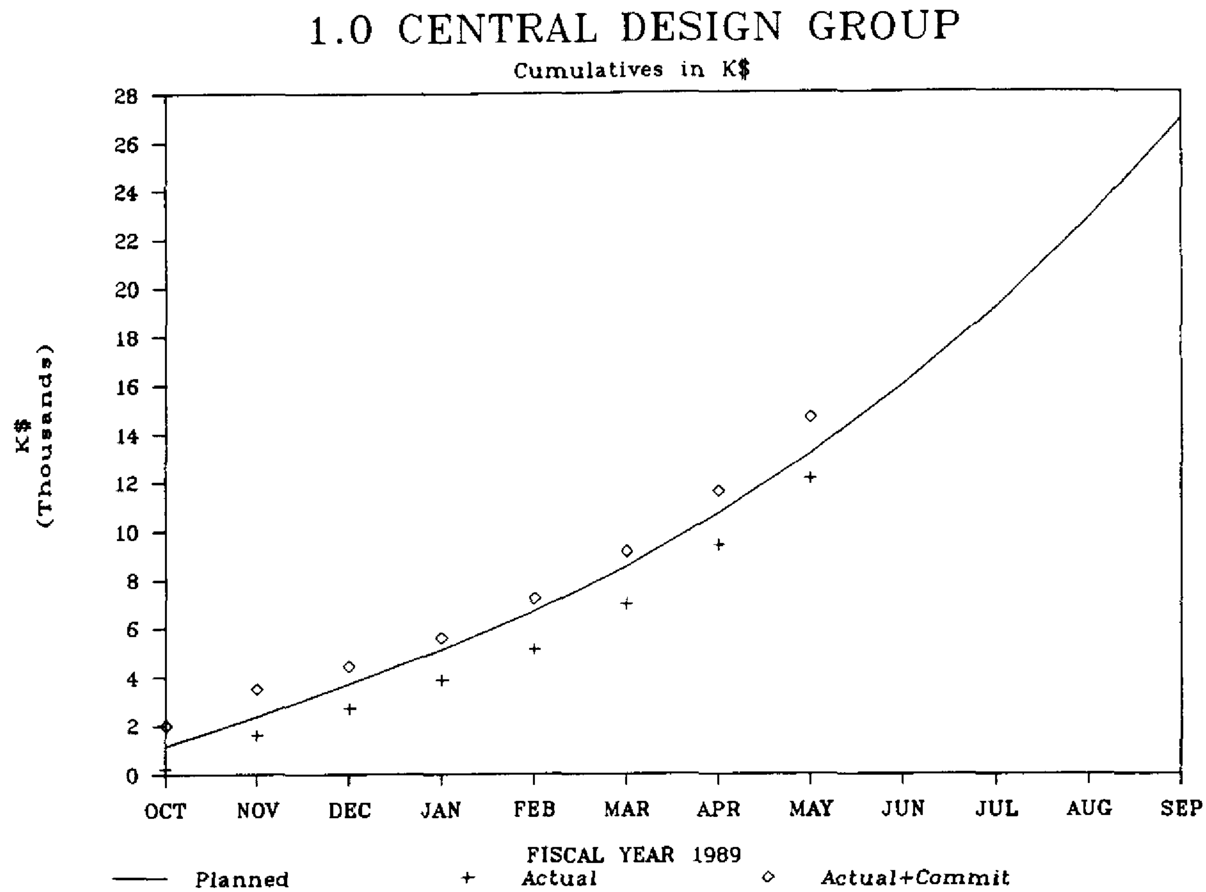
| MONTH | MONTHLY PLANNED COSTS | FY PLANNED CUMULAT | MONTHLY ACTUAL COSTS | FY ACTUALS CUMULAT | MO ACT+ DELTA COMMITS | CUM ACT + COMMITS | CURRENT COMMITS | DELTA COMMITS |
|---|---|---|---|---|---|---|---|---|
| OCT | 3673.7 | 3673.7 | 1880.6 | 1880.6 | 5703.7 | 7057.3 | 5176.7 | 3823.1 |
| NOV | 3754.4 | 7428.1 | 3264.5 | 5145.1 | 2734.5 | 9791.8 | 4646.7 | -530.0 |
| DEC | 3835.2 | 11263.3 | 3101.5 | 8246.6 | 2971.6 | 12763.4 | 4516.8 | -129.9 |
| JAN | 3916.0 | 15179.4 | 3666.8 | 11913.3 | 3778.4 | 16541.7 | 4628.4 | 111.6 |
| FEB | 4104.5 | 19283.9 | 3513.3 | 15339.5 | 3849.5 | 20304.1 | 4964.6 | 336.2 |
| MAR | 4346.9 | 23630.8 | 4545.2 | 19884.9 | 5455.5 | 25759.8 | 5874.9 | 910.3 |
| APR | 4670.1 | 28300.9 | 4652.6 | 24537.7 | 4603.5 | 30363.5 | 5825.8 | -49.1 |
| MAY | 4993.2 | 33294.1 | 5358.4 | 29896.3 | 5384.9 | 35748.6 | 5852.3 | 26.5 |
| JUN | 5343.3 | 38637.4 | | | | | | |
| JUL | 5693.4 | 44330.8 | | | | | | |
| AUG | 6124.3 | 50455.1 | | | | | | |
| SEP | 6662.9 | 57118.0 | | | | | | |


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

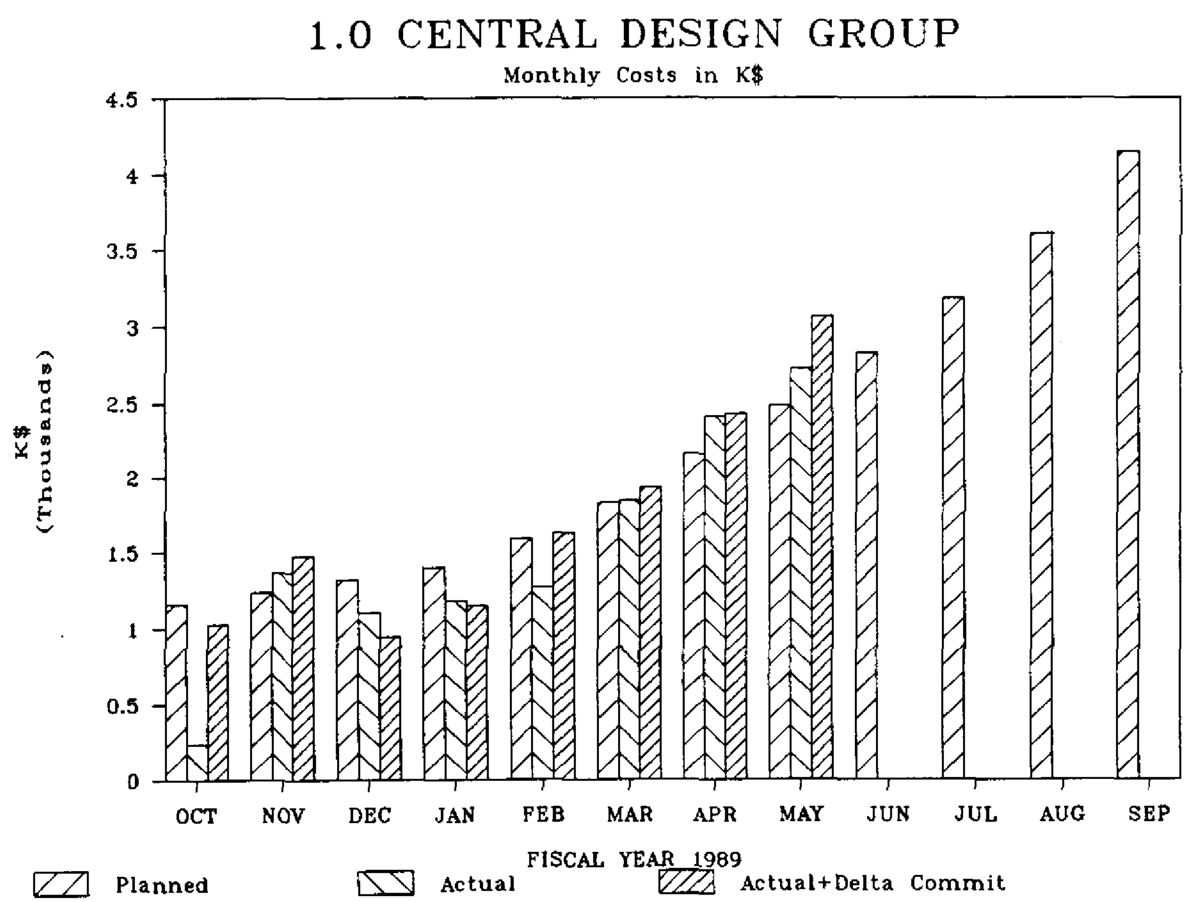
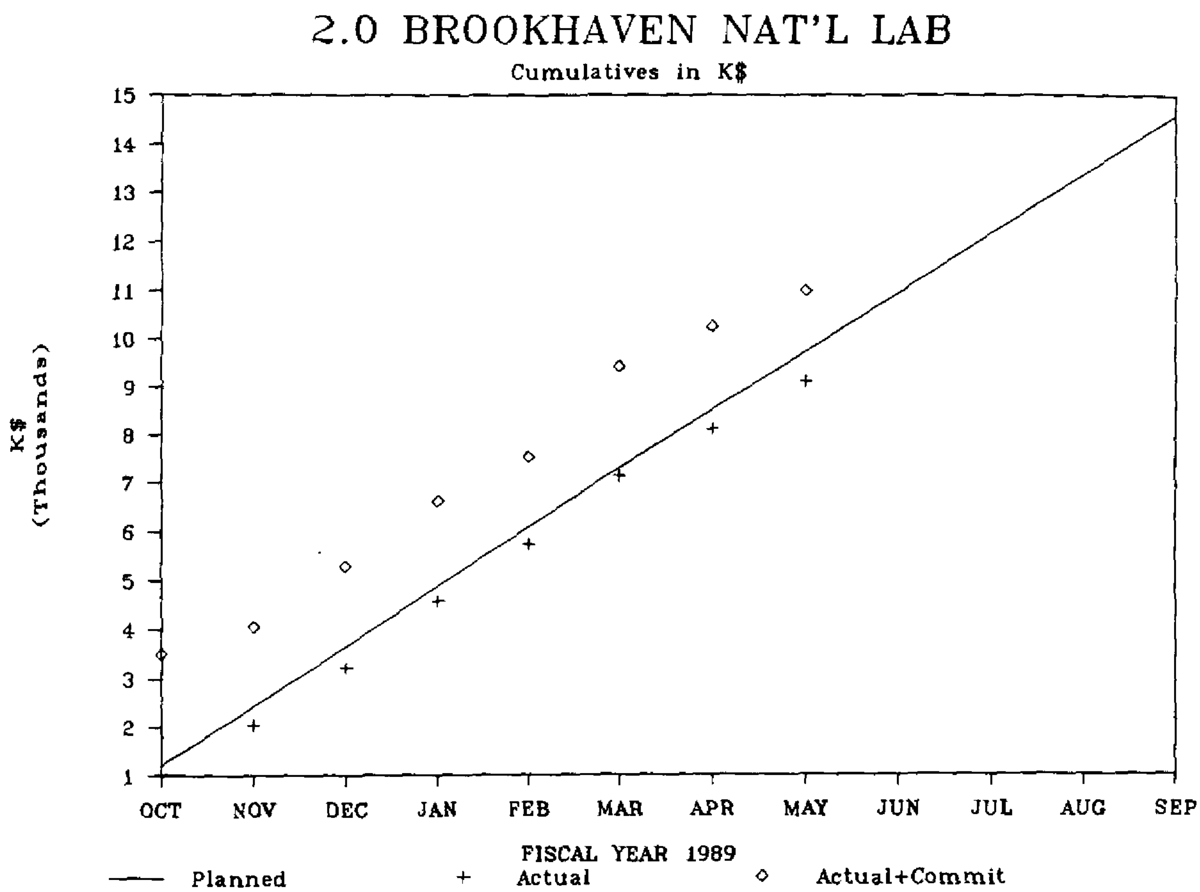
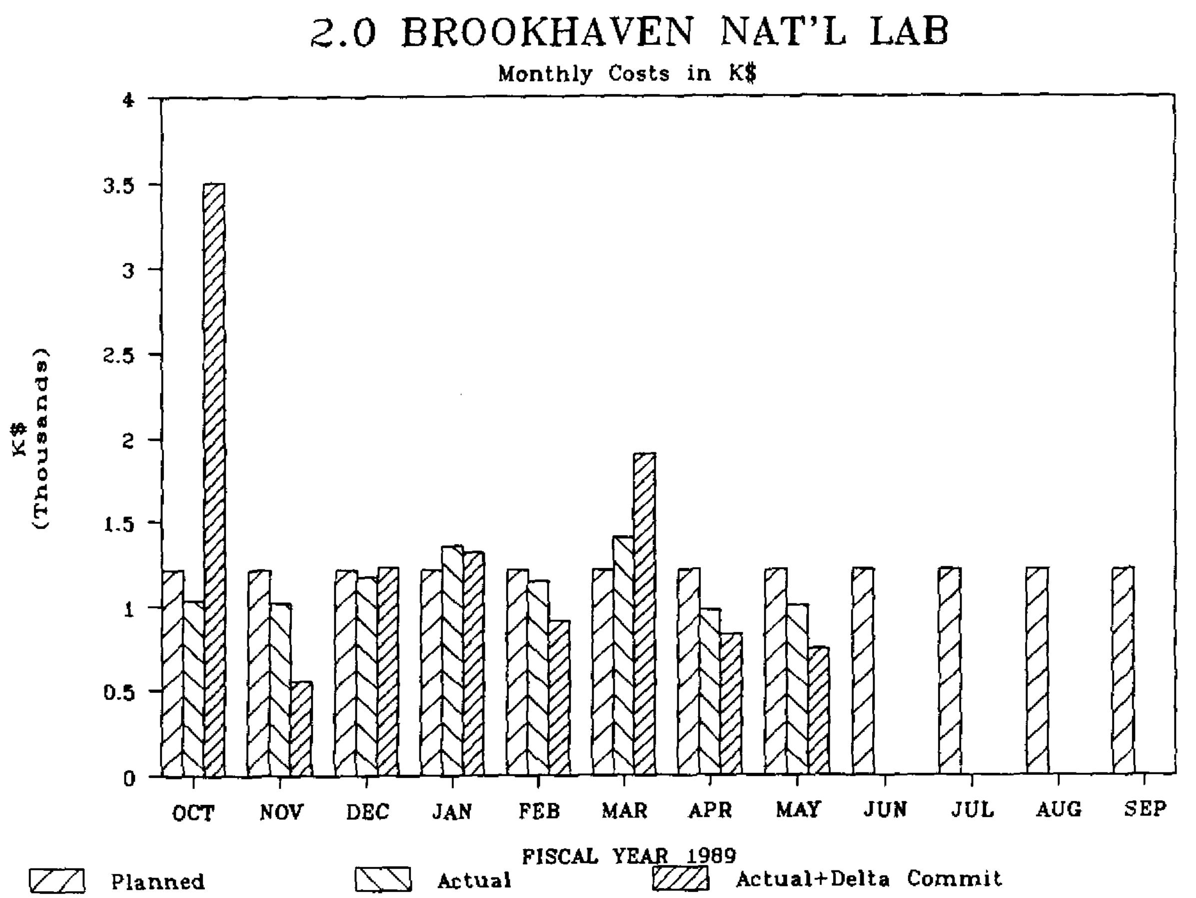

1.0 CENTRAL DESIGN GROUP
Monthly Costs in K$
K$
(Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

**Figure 1**

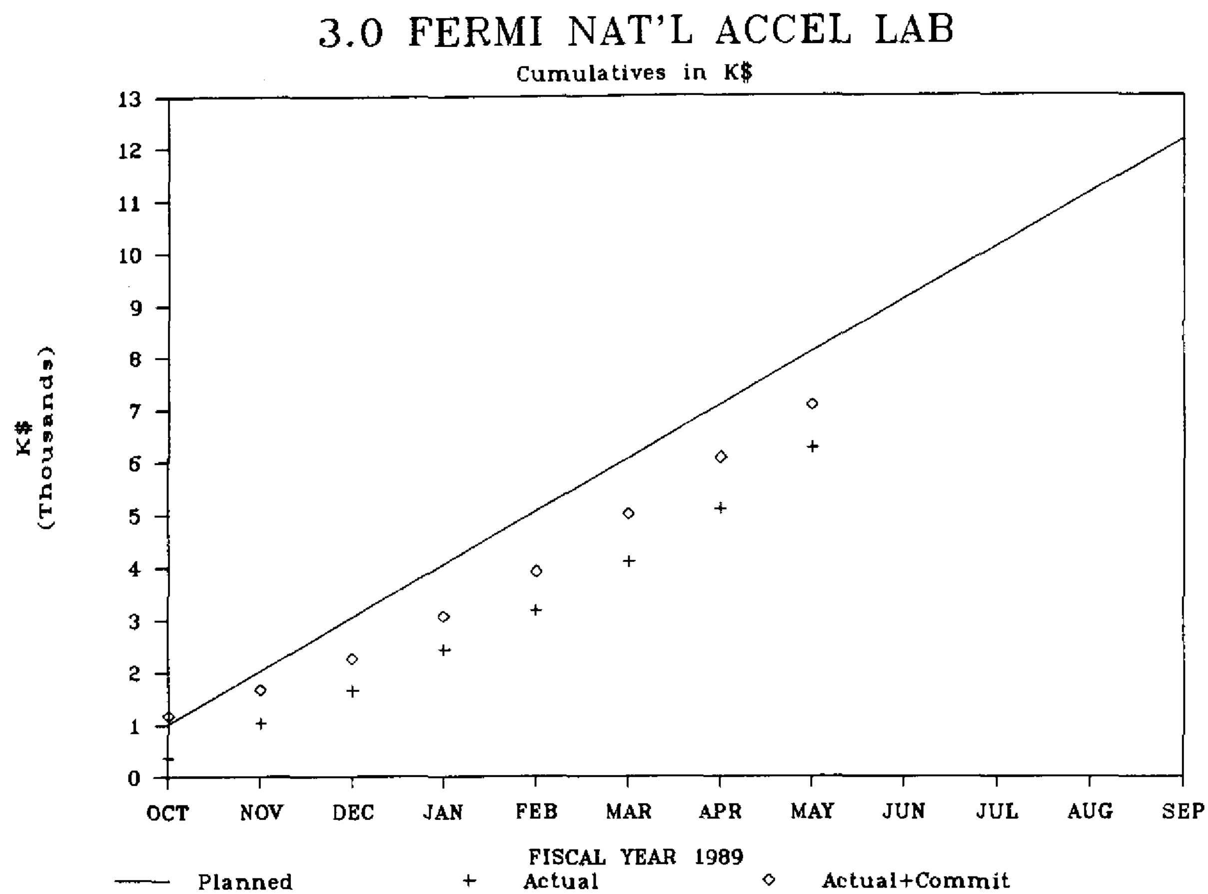


2.0 BROOKHAVEN NAT'L LAB
Cumulatives in K$
K$ (Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

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
8
9
10
11
12
13
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

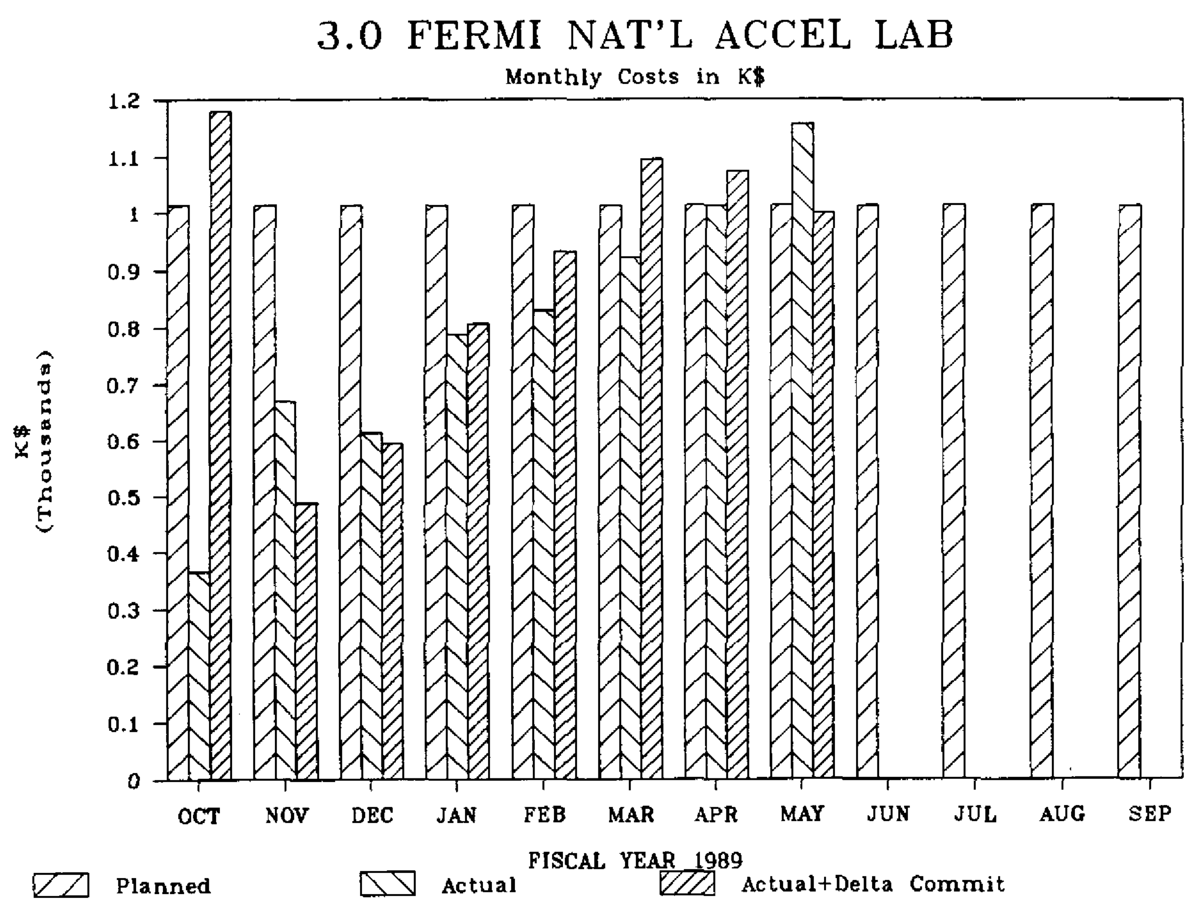
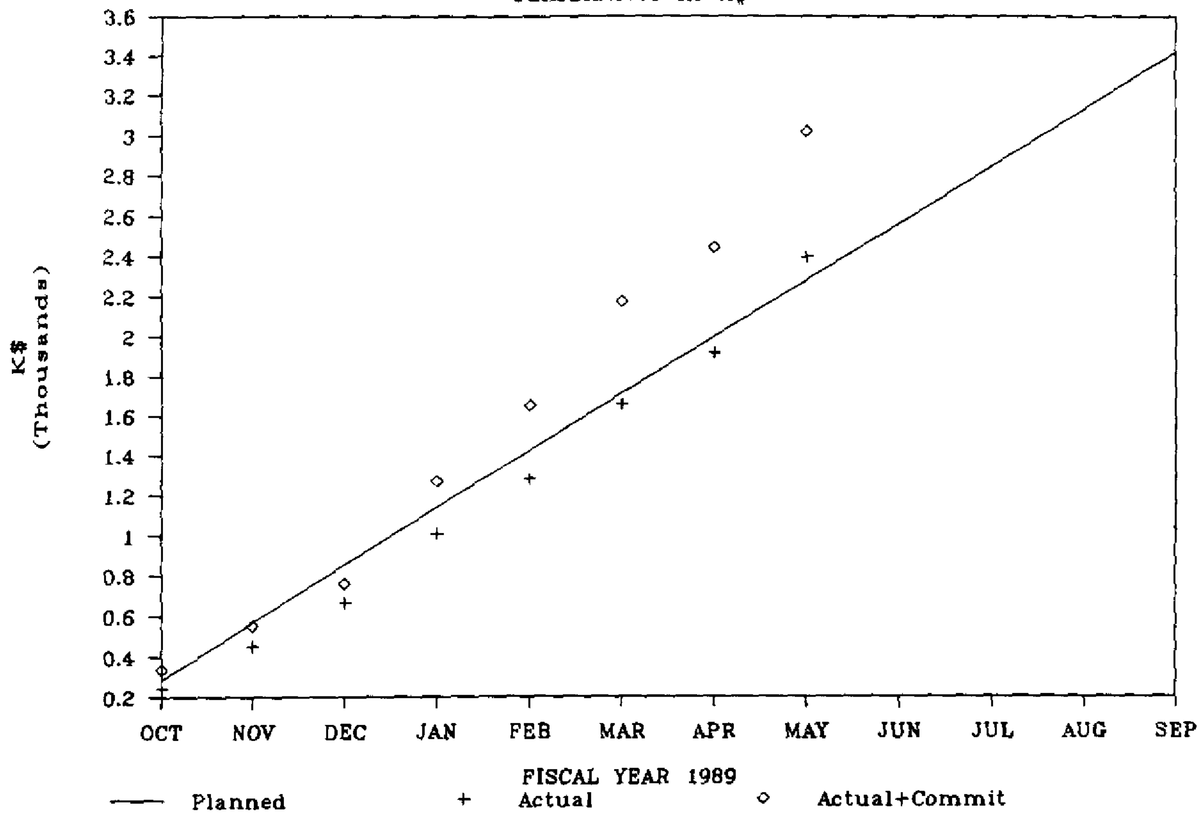

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$
(Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 3

# 4.0 LAWRENCE BERKELEY LAB

Cumulatives in K$




# 4.0 LAWRENCE BERKELEY LAB

Monthly Costs in K$

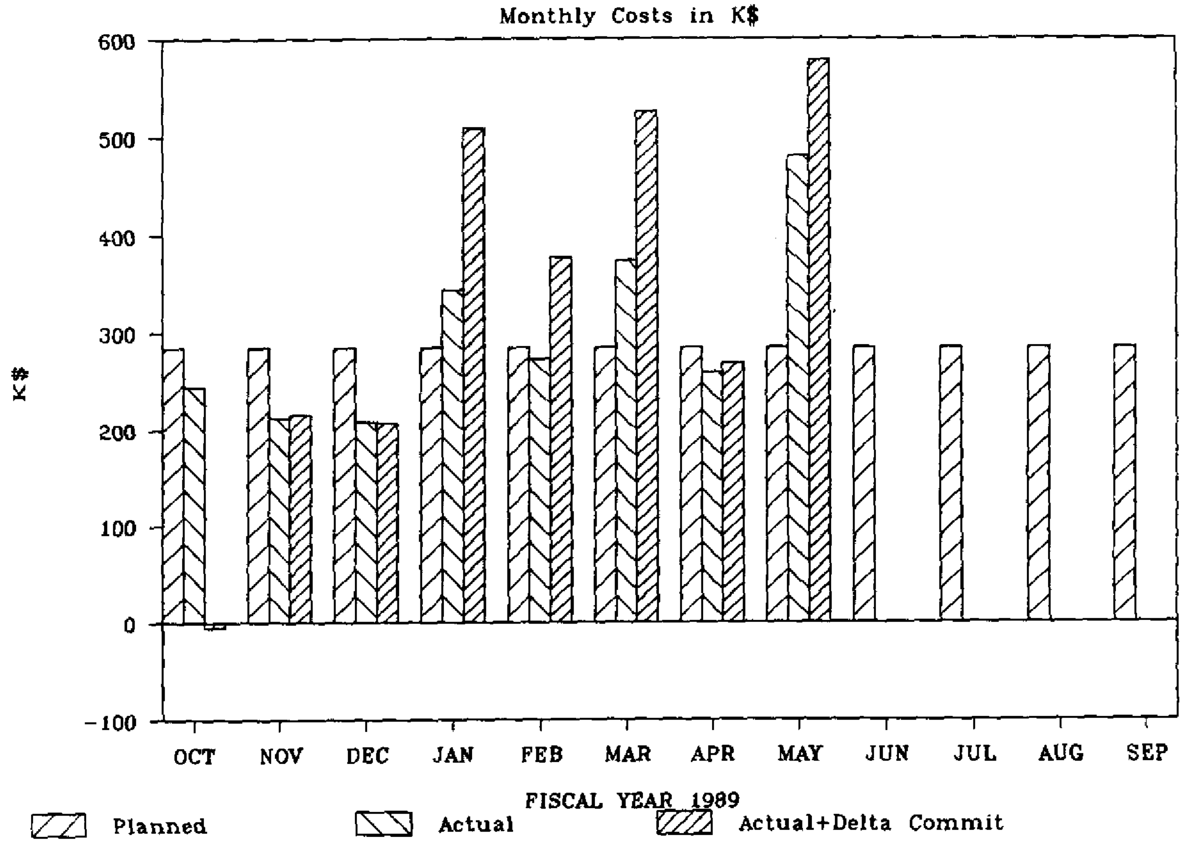
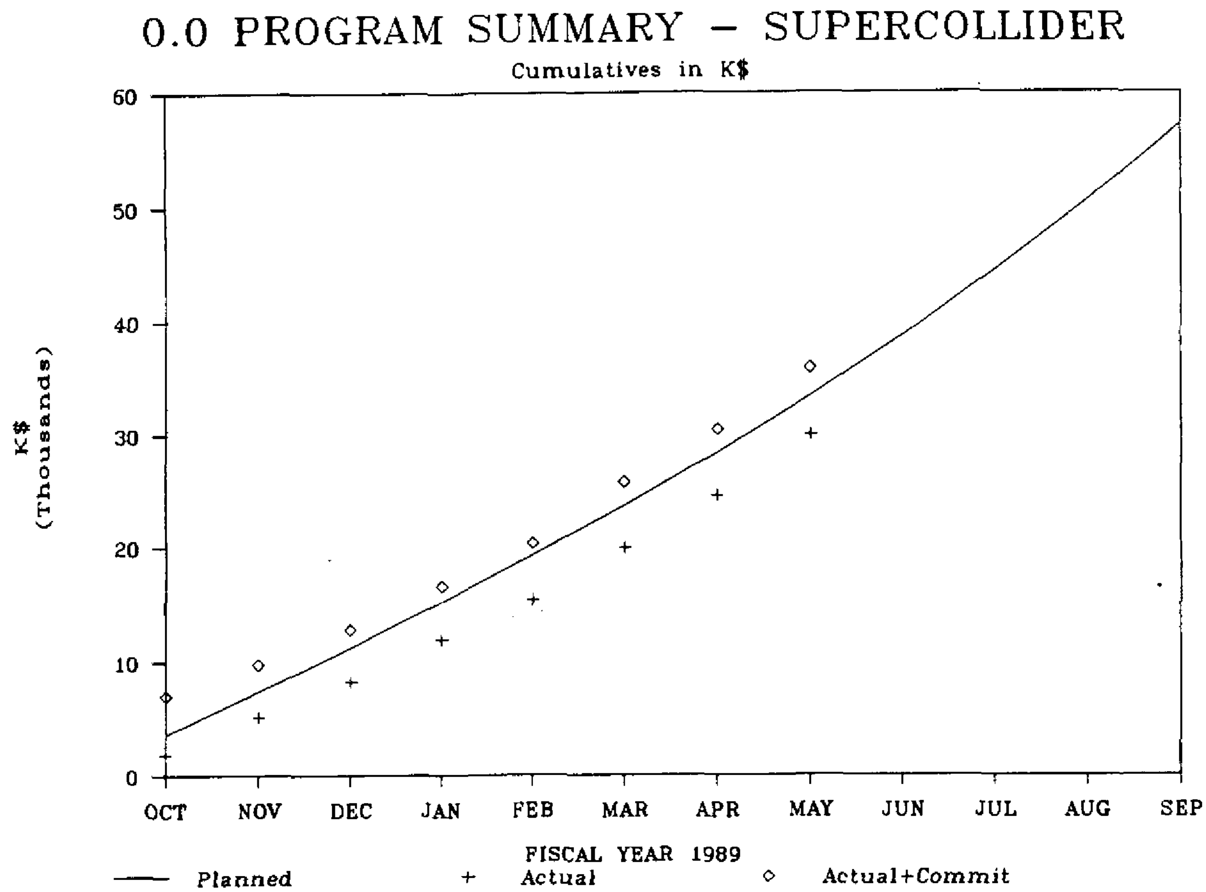



Figure 4


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

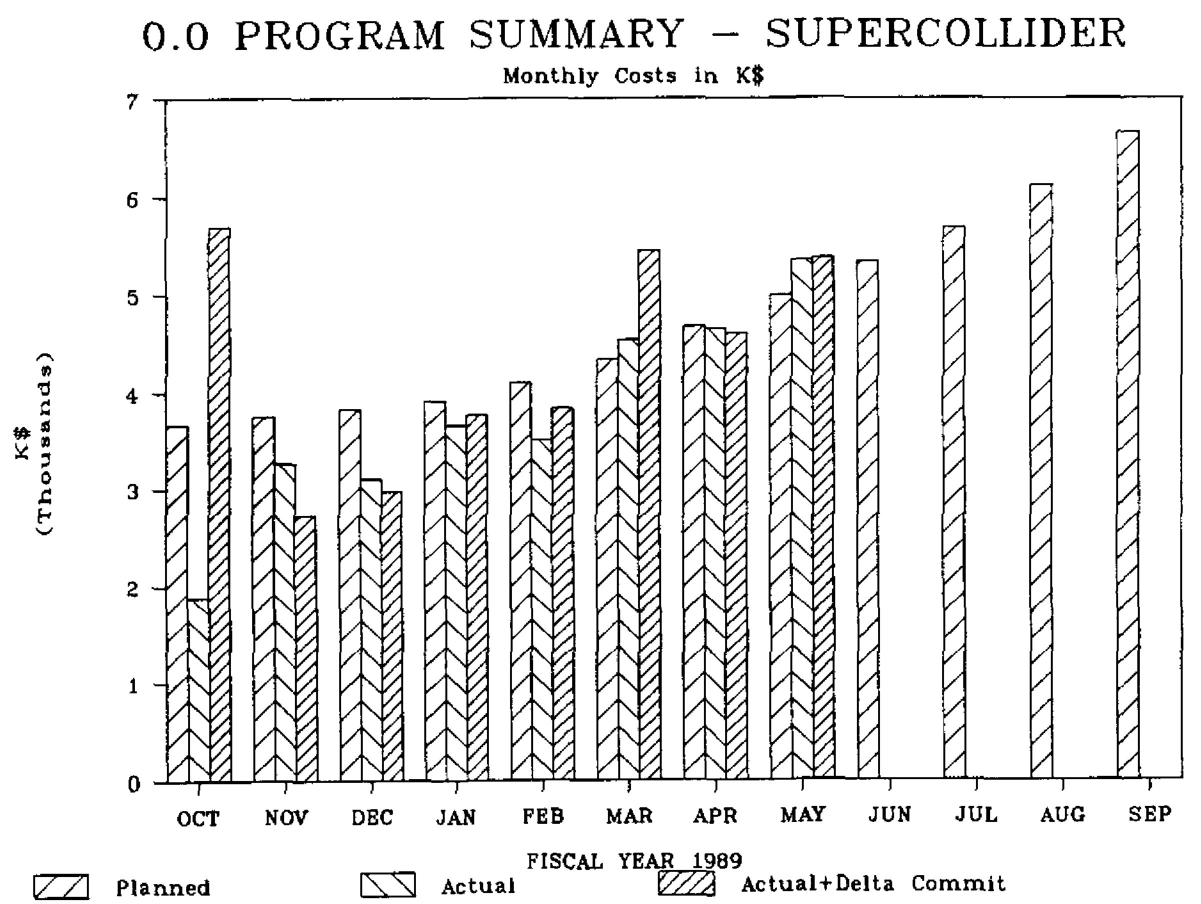

0.0 PROGRAM SUMMARY – SUPERCOLLIDER
Monthly Costs in K$
K$ (Thousands)
0
1
2
3
4
5
6
7
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 5