SSC-42

Superconducting Super Collider Laboratory

SSC-42

SSC Monthly Report

May 1985

SSC MONTHLY REPORT

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A. Project Summary

- Eleven papers, including four invited talks, were submitted at the 1985 Particle Accelerator Conference in Vancouver, British Columbia, May 13-16. The invited talks were given by Maury Tigner, "Where Is the SSC?"; Alex Chao, "Accelerator Physics Issues for the SSC"; Peter Limon, "Accelerator Systems Aspects of the SSC"; and Jim Sanford, "Civil Systems Aspects of the SSC."

  Other authors and papers included D. Douglas and E. Forest, "A Method to Render Second Order Beam Optics Programs Symplectic"; E. D. Courant, D. R. Douglas, A. A. Garren, and D. E. Johnson, "SSC Test Lattices"; D. Douglas, "Ion Stability in Bunched Electron Beams"; B. T. Leemann, D. R. Douglas, and E. Forest, "Tracking the SSC Test Lattices"; J. Bisognano, "Collective Effects and the Design of the SSC"; M. Furman and A. Chao, "Effect of Long Range Beam-Beam Interactions on the Stability of Coherent Dipole Motion"; and S. Peggs, "The Dependence of Single Particle Stability on Net Chromaticity in CESR, Near $Q_h = 9 + 1/3$."

- Another step in setting up the magnet selection process was taken this month with the appointment of a Magnet Selection Advisory Panel. Members of this panel are:
  - Frank Sciulli, Columbia University, Chairman
  - John Rees, SLAC
  - Bjorn Wiik, DESY
  - Neal Lane, University of Colorado
  - Alvin Tollestrup, Fermilab
  - Eberhard Keil, CERN
  - Michael McAshan, Stanford University.

- Minor changes were made to the Siting Parameters Document during the month. The items concerned clarifications of technical statements, editorial comments, and format adjustments. The manuscript awaits approval and agreement on its distribution. A mailing list of at least 200 individuals has been assembled.

- The first Wednesday Conventional Systems Forum was held on May 30. This is a series of discussions started by Tim Toohig to provide an opportunity for an exchange of technical information, know-how, and opinions among project personnel at the CDG.

- The first SSC Users Meeting was held May 20-21 on the UC, Berkeley, campus. There were 135 attendees from 57 different institutions.

- The 2°K Operations Task Force held its second meeting on May 17.

- The SSC theory group conducted a lattice workshop May 29–June 1.

- BNL. The tooling for collaring and assembly of the 4.5 m long model dipoles of 4 cm aperture became operational. Initial collaring of a first set of coils, wound and cured last month, was performed using a bore tube with (conventionally wound) trim coils as mandrel. An additional 10 inner coils, some using LBL cable, and 7 outer coils were wound and cured. Some of these coils must use recycled pole piece extensions ("bones") due to their present scarcity. The cryostat cost estimates were reviewed with representatives of Fermilab and Westinghouse.

- Fermilab. Cryostat development activity during the month included measurements on the two cryostat models and refinements to the design of the style D cryostat. The results of the heat leak model and the magnetic effects model that have so far been analyzed indicate the soundness of the Reference Design B no iron magnet concept. The experience gained from the models has been applied to the optimization of the Design D cryostat. The design of the style D cryostat is being prepared in consultation with members of the high field collaboration for submission on July 1 for the SSC magnet style selection.

  Three more one meter dry wound models were completed. Although difficulties are still being encountered in the collaring of the dry wound coils, progress is encouraging. The success of the models tested so far is increasing confidence in this technique.

- LBL. Model magnet D12C-4 will be completed in mid-June on schedule and magnet D12C-5 in early July. Testing was completed on magnet D12C-2, which reached 6.6 T at 4.4K and 7.9 T at 1.8K. This is our first test of a magnet with stainless-steel collars. Training behavior was good in spite of the observed inadequate pre-stress.

  Procurement of superconductor strands for the Design D collaboration was completed with IGC's delivery of 1640 lbs. Delivery was on schedule and critical current density exceeded the specification value.

  Fabrication of fine filament material is proceeding on schedule. In addition to the cable made by New England Electric Wire (NEEW), about 8,000 ft of cable was made at LBL.

- TAC. The magnetic measurement probe is still being rebuilt and should be finished next month. The earlier results from the magnetic measurements have been reanalyzed, and the new errors are smaller than the errors reported last month. These errors appear sufficiently good for the SSC, and they are not expected to improve with time. The measurement of the susceptibility for 6 in. lamination packs has been initiated. The idea of the program is to measure current vs. magnetic field, therefore, susceptibility, for each of the 6 in. packs of laminations. These packs can then be shuffled to arrive at magnets with uniform susceptibility.

In preparing data for the Operations and Commissioning Task Force, the superferric machine has been redesigned. In particular, the number of refrigerators has been reduced to 12, the number of power supplies around the ring to 4, and one additional cryogenic line has been added so that the machine can operate with a 20° radiation shield. These changes will improve the operation and reduce the cost of operating the SSC.

B. Project Report

I. Central Design Group

Magnet Program. Another step in setting up the magnet selection process was taken this month with the appointment of a Magnet Selection Advisory Panel. The charge to this panel is as follows:

A number of Basic Magnet Types have been considered for possible SSC service. They include mechanically linked dual aperture magnets which may or may not be thermally or magnetically linked (2-in-1) and mechanically, magnetically, and thermally independent single aperture magnets (1-in-1). Both high field (6 T or more) and low field (about 3 T) versions of these types have been studied and developed to a greater or lesser extent. After considerable study of the many possible combinations, five have emerged as most likely to provide economical and reliable options for the SSC. These five are: i) a low field, mechanically and thermally linked, magnetically independent 2-in-1 type; ii) a high field, mechanically, thermally, and magnetically linked 2-in-1 type; iii) a high field 1-in-1 type with cold iron; iv) a low field 1-in-1 type; v) a high field, warm iron 1-in-1 type.

During the last quarter of Fiscal Year 1985, one of these Basic Magnet Types will be selected for final prototype development by the Director of the Central Design Group. In aid of this selection, the Advisory Panel will submit a report to the Director containing the Panel's recommendation in the form of an ordered list of these five Basic Magnet Styles. The rationale for this recommendation should be given in detail. If no clear choice emerges this should be clearly stated and justified.

In making its recommendation, the Advisory Panel will be guided by the Criteria set forth below, using technical materials supplied by the CDG and such other technical inputs as it may solicit at its discretion.

The report of the Advisory Panel is due by September 1, 1985.

Criteria

In its deliberations the Panel will consider the SSC to be a hadron collider designed ultimately to achieve 20 TeV per beam at a luminosity of $10^{33}cm^{-2}sec^{-1}$.

In rendering its judgment the Advisory Panel should consider the general implications of low field and high field and 1-in-1 and 2-in-1 features, as well as details of proposed mechanical, thermal, and magnetic designs. Both system features and characteristics of the magnets considered as individual components need to be taken into account. While the dipoles are the major cost component of the magnet system, the quadrupoles and various correctors inherent to the various Basic Magnet Types must receive due consideration.

The Criteria to be used in making an overall recommendation are:

1. Relative capital cost of an SSC facility employing a particular Basic Magnet Design;

2. Workability of the Basic Designs presented;

3. Complexity of the overall magnet system inherent to the particular Basic Design;

4. Operational complexity of an SSC employing the particular Basic Design;

5. Relative flexibility of an SSC design employing the particular Basic Design;

6. Likely impact of the Basic Magnet Design on the SSC construction schedule;

7. R&D time and effort needed to develop the Basic Design;

8. Accelerator physics considerations;

9. Other considerations deemed appropriate by the Advisory Panel.

Members of this Advisory Panel are Frank Sciulli, Columbia University, Chairman; John Rees, SLAC; Bjorn Wiik, DESY; Neal Lane, University of Colorado; Alvin Tollestrup, Fermilab; Eberhard Keil, CERN; Michael McAshan, Stanford University. It is hoped that an additional person expert in undergravel construction will be added soon.

As reported last month, additional cost estimates for certain of the magnets were contracted with industry. Visits to the contractors by CDG show that the firms (General Dynamics Corporation and Westinghouse Corporation) are well along with understanding the drawings and specifications for the magnets and have made a good beginning on devising manufacturing plans upon which to base a cost estimate.

Conventional Systems. There were several occasions where talks were given during the month on the conventional facilities and site parameters for the SSC. Since many questions concerned siting criteria developed for the new accelerator, the following table displays the summary criteria statements that have been recommended to DOE.

Summary Criteria Statements

Setting	Space for ring circumference of 60-100 miles Looking for a site for a planar machine flat (level) or with a tilt <1° Need up to 11,000 acres.
Environment	SSC will comply with NEPA Need base line data
Geology and Tunneling	Long, uniform material Extensive characterization Avoidance of active faults Good soil stability Avoid unconsolidated solids with ground water Awareness of seismic activity
Community	Staff needs: housing, education, cultural Reasonable commuting times Major airport, all-weather roads Adequate industrial/construction resources
Utilities	≤2000 gal/min of water ≤250 MW, separate feeds, outages <2/yr
Man-Made Disturbances	Excessive noise--avoidance Vibration--3 Hz is bad
Climate	Desirable average temperature 35°-80°F Desirable average relalative humidity 25%-70%
Cost and Schedule	Land costs, utility rates What's being offered

Attempts were made during the month to transfer the conventional systems scheduling exercises to a computer-based system. An IBM PC was outfitted with the appropriate software to support the schedule development. The major topics that form the basis for the planning are: milestones, planning and coordinating, siting studies, conceptual design, preliminary design, detailed design, and early occupancy. In addition to the schedules, resource tables and budgets were developed for inclusion in the Interim Report, to be released next month.

Fermilab sponsored a tunneling workshop which brought together contractors, designers, tunnel boring machine builders, and accelerator engineers and scientists. Discussions were held on topics aimed at reducing tunnel costs. R&D work on tunneling machinery and muck removal systems received attention, as well as contract terms and risk sharing.

DOE Chicago is preparing for contract discussions with an A/E firm, RTK. CDG personnel provided an analysis of their cost proposal.

The first Wednesday Forum was held on May 30. This is a series of discussions started by Tim Toohig to provide an opportunity for an exchange of technical information, know-how, and opinions among project personnel at the CDG. The initial Forum discussions focussed on possible tunnel cross sections including examples of two-in-one and one-in-one magnets and associated hardware. A later meeting concerned the possible location of the magnets on the inside or outside (away from the ring center) wall of the collider tunnel.

Accelerator Theory and Computation. In addition to continuing the aperture work, the accelerator physics studies included a workshop on the complete and realistic lattice for the SSC (LBL May 29-June 4). The workshop was initiated in preparation for the studies expected after the magnet selection in September. A lattice that includes all known accelerator physics and systems features is expected to be the first step needed in order to proceed. The main goals of the workshop include:

- Review of past lattice designs
- Listing and evaluation of previous solutions (and invention of new ones) on specific problems, e.g., over-under, side-by-side, 2-in-1, 1-in-1, etc.
- Create an example lattice

Eighteen participants attended the workshop, and various issues were studied at length; a first example lattice has been created. A workshop report is being prepared, and various alternatives to specific problems will continue to be studied. The example lattice will then evolve, taking into account the study results.

Accelerator Systems. The 2K Magnet Operation Task Force held its second meeting on May 17 at LBL. Membership is as follows:

W. Fowler, Fermilab
W. Hassenzahl, LBL
P. Limon, SSC CDG
M. McAshan, Stanford University, Chairman
R. Shutt, BNL
C. Taylor, LBL
M. Tigner, SSC CDG
P. Vander Arend, Cryogenic Consultants, Inc.

Various schemes were discussed for removing the synchrotron heat load at temperatures higher than 2K (or even 4.5K), and for producing and circulating the 2K coolant. The cost saving, it was decided, would be realized only in the case where one could operate a magnet at high field (8T), thus reducing the size of the ring. This would require some changes in the magnet design, and, of course, in the cryogenics. How much cost saving there might be, if any, is yet to be determined.

Photodesorption Experiment. The experiment of molecular desorption by synchrotron photons on a room temperature beam tube was started on May 20 at the VUV ring at the NSLS at BNL. It appears that the results agree qualitatively and roughly quantitatively with previous results of Gröbner et al., Vacuum 33, 397 (1983). This provides confidence that the measurement technique and calibration of the mass spectrometer is correct. Analysis is proceeding, and it is expected that the cryogenic beam tube experiment will be started at NSLS in early to mid July.

Work continued on:

- Realistic lattice designs. Of particular concern are the interaction regions, the injection and abort regions, and the arrangement of correction elements.
- Clustered interaction regions. The Accelerator Systems group has performed some calculations on the beam losses at interaction regions and the resulting muon flux at neighboring interaction regions. The preliminary results indicate that there will be no significant muon background in the interaction regions, but it might be necessary to place assembly buildings on the inside of the ring.
- R&D program. Effort continued toward refining the details of the R&D program through FY 1988.

SSC Users Meeting. The first SSC Users Meeting was held May 20-21 in LeConte Hall on the UC, Berkeley, campus. There were 135 attendees from 57 different institutions. G. Stever of URA and B. McDaniel from Cornell University and Chairman of the SSC Board of Overseers welcomed the participants.

M. Tigner, Director of the SSC Central Design Group, gave the opening talk, "Overview of the SSC." Following his presentation, Deputy Director of OSTP, J. McTague, spoke on "The View from Washington." A. Kernan from UC, Riverside, reported on "Recent Results from CERN," and P. Reardon, BNL, briefed the audience on the "Status of the Magnet Program."

Other speakers and their topics included:

P. Limon, CDG	"Accelerator Systems"
I. Hinchliffe, LBL	"Physics at the SSC"
J. Sanford, CDG	"Site and Conventional Facilities"
M. Krebs, LBL	"SSC & the ERAB Long Range Energy R&D Study"
A. Chao, CDG	"Accelerator Physics Questions"
E. Kolb, FNAL	"Cosmology and the SSC"
M. Gilchriese, Cornell	"Detector R&D Plans."

SSC Detector R&D Task Force. An SSC Detector R&D Task Force has been established under the chairmanship of M. Gilchriese of Cornell University. The Task Force will advise on the detector R&D needed to assure timely construction of detectors capable of exploiting the luminosity and energy of the SSC at turn-on. The Task Force is also requested to advise as to what role, if any, the SSC Central Design Group should play in facilitating this detector R&D.

II. Laboratory Programs

A. BNL.

1. Model Magnets

a. 4.0 cm Aperture x 4.5 m Long Magnets. Insulated coils for the first model magnet of 4 cm aperture were mounted, using stainless-steel collars, on a bore tube containing a set of trim coils. The measured pre-stress on the outer coils, ~7 K psi, is adequate; however, the inner coil will be reshimmed to increase the pre-stress to ~8 K psi.

Winding of additional inner and outer coils for the 4 cm aperture program continued. Coil size is being monitored in order to assess the field quality performance in the subsequent magnets in this series. A total of 10 inner coils and 7 outer coils had been successfully wound and cured by the end of the month, the last few using reusable Tedlar-wrapped pole piece extensions. One outer coil was wound with rerolled LBL cable, subsequently found to be badly degraded electrically.

Preliminary coil modulus studies were made on samples (one each) of inner and outer coils, with more extensive measurements underway on coils incorporating NEEW cable as well as coils wound from cable produced at LBL.

"Travelers" for accompanying the coil assembly stops have been prepared.

The lower yoke half has been assembled on the stacking fixture, awaiting final assembly of the collared coils.

Design changes introduced as a result of experience gained thus far in the assembly include:

- Longer creased Kapton insulation to ensure additional overlap of layers and enhanced electrical creep path.
- The center collar to end collar interface was changed from a 1/8-in. stainless-steel spacer to a 3/16-in. G10 spacer to provide adequate pole piece extension collar insulation and creep path (this required removal of one collar lamination).

- Additional top and bottom strain gauges were added to provide further data on the assembly of the 4.0 cm aperture x 4.5 m long magnets.

- The void between the strip heaters is being filled with Kapton and Fiberglas, after shearing of Kapton insulation by the strip heater edge gave rise to a heater-to-collar electrical short in the assembly of 4.0 cm aperture x 4.5 m long magnets.

b. 4.0 cm Aperture x 16.6 m Long Magnets

- Wedges, pole piece extensions, and helium containment shells were ordered.

- Yoke laminations have been ordered for two full-length magnets, with the following revisions:

  (i) Holes sized for slip-fit over standard 3/8-in. diameter shaft for pinning assembly in lieu of epoxy bonding.

  (ii) A cutout has been added at the midplane for a welding backup strip.

  (iii) A T-slot was added in the cutout for the electrical hub to facilitate yoke handling and lifting.

- A mechanical description of the main bus lead assembly, including flexible joints, diode assembly, quench protection heaters, and trim leads, as well as a description of the yoke assembly and interconnections, has been prepared for review by the Central Design Group.

2. Tooling and Facilities

a. Coil Fabrication Tooling.

- Progress continued on the long coil winder and associated tooling. A considerable portion (60%) of this tooling is in the shops. Some assembly work connected with the long winder has started in Bldg. 924.

- Design of a full-length coil transporter for Bldg. 924 was started.

- Instrumentation in the curing fixture is now operational. Data on curing stress and coil relaxation is being collected. The study of the coil elastic modulus, as measured in the curing fixture, is under way as noted earlier.

b. Coil and Yoke Assembly Tooling.

- A finite element analysis of the incremental press was completed. As a result of this analysis, a few small changes in the system were made.

- Initial design of the long collaring press commenced, with the aim of facilitating the handling of long coils.

- As evidenced by the activities surrounding the initial collaring of the 4.0 cm aperture x 4.5 m long magnets, the collaring press became operational.

- Likewise, the yoke stacking and handling fixtures were assembled and used to assemble the yoke for the 4.0 cm aperture x 4.5 m long magnets. This tooling was modified to prevent a twist from occurring during assembly.

- A method was devised to maintain alignment of the long magnet, using existing tooling.

c. Bore Tube and Trim Coil Tooling.

- The first conventionally wound trim coil and bore tube was included in the assembly of the 4.0 cm aperture magnet.

- Bumpers for the second trim coil are being modified to accommodate the unexpected deformation of the collars. The second trim coil bore tube assembly is ~75% complete, and the third 25% complete.

- Work was started on the first 4.5 m long trim coil at Multiwire, using the substrate transporter supplied by BNL. Meanwhile, design work is continuing on multilayer composite trim coils.

- In the bore tube area, problems encountered at Trent Tube Inc. with high-permeability welded seams appear to have been resolved; techniques for proper annealing have been found, and processing is proceeding.

- Erection of bore tube tooling is continuing in the RHIC tunnel.

- R&D plating contracts were awarded to two vendors, and investigations are continuing with other vendors in the following areas: seamless 316-L stainless-steel tubing, sputtering tantalum as a barrier between copper and steel; possible foreign production of seamless 2169 tubing.

- Finally, design was started on an automatic bumper application system.

d. Magnet Test Facilities.

- Work continued on the horizontal test facility in the following areas: adaption of the existing CBA lead pot, incorporation of an inflative vacuum seal to enhance turn-around time for magnet testing.

- Assembly of the vertical measuring coil for 4 cm aperture magnets was completed, with calibration expected to take place shortly. This coil will be used for both low temperature and room temperature measurements.

- Preliminary design of a Morgan coil is progressing. The Multiwire technique is being investigated as an alternative to conventionally wound Morgan coils.

- Calibration of the DESY measuring coil was successfully completed.

- Design work is continuing on the B version of the mole. Piezoelectric components have been tested in magnetic fields without any change in performance; this allows the use of a harmonic drive system. Long-term testing of components is continuing. The A version of the mole has been modified for upgraded operation; the drive components have been completed at the vendor and are in route from Europe.

3. Superconductor

a. Cable Procurement. Replies to the Requests for Quotation for proposals to produce fine-filament, high J_c cable for Reference Design D model magnets, received from manufacturers in Europe, Japan, and the U. S. have been reviewed. Placement of purchase orders is awaiting resolution of minor details but is expected shortly.

b. Coil Manufacturing. The activity during the month of May centered on the winding and curing of 4.5 m long coils for model magnets of Reference Design D type. Lengths of cable for this purpose were fabricated at NEEW in February under supervision by LBL and BNL staff. Two cable reels (one inner and one outer) were used in April and early May in the construction of coils for two such magnets. Subsequent cable manufacturing has been done at LBL. Lengths of cable for approximately two more magnets were manufactured during April. Examples of cable from these lengths were found to have acceptable electrical prperties. However, the mean thickness of the cable was approximately 0.4 mil above the maximum tolerance in both cases. Based on experience from molding previous coils, it was decided to attempt to use the inner cable but to utilize higher molding pressure. The outer cable, too large to be used for this technique, was returned to LBL for rerolling.

Rerolling at LBL did in fact produce cable that was acceptable mechanically, but electrical tests have shown the cable to be severely degraded in a way not previously seen. Extensive measurements are now under way to understand the causes for this degradation. LBL has since produced additional cable for two more magnets and is prepared to replace the damaged cable when additional electrical tests have been completed.

4. Tests and Measurements

Additional testing of the fourth 4.5 m long 2-in-1 dipole was done in order to increase the sensitivity of the measurement of the quadrupole term at SSC injection fields.

Work progressed on a new measuring coil for the magnets of 4 cm aperture. Preparations were made to operate the sextupole trim coil and the main coil of the 4.0 cm aperture magnet together and to measure the magnetic field at room temperature.

5. Power Supplies, Quench Protection, Electrical Systems

A re-evaluation of the possibility of passive quench protection for the Reference Design D magnet system was made in light of recent quench propagation measurements using heaters. These measurements were performed by Ganetis and Prodell and reported at the 1985 Particle Accelerator Conference.

They show that the peak in the curve of the integral of I^2dt vs. quench current occurs at lower current than previously expected. As a result the peak value of the integral of I^2dt is smaller and the resulting local temperature rise lower. These changes are sufficient to reverse an earlier estimate, and it is now estimated that the Reference Design D magnet can be protected with a double diode-type quench protection scheme.

Development has been initiated on a new "cold" diode rated for 7000 A with a sample lot of larger diode wafers ordered from Westinghouse. These wafers will have the same slice thickness and other processing as those that were developed successfully for the CBA project. Upon arrival, they will undergo low temperature measurements, including high current pulsing, and then be evaluated for the SSC application.

The two power supplies utilized in the model magnet test program were replaced with newer versions supplied by the AGS Department. Time was spent verifying their proper operation in the testing system.

6. Cryogenic Systems

The liquid helium production for the Short Sample Testing has improved since the charcoal dust removal reported last month. This refrigerator still exhibits a high pressure drop in the 80K to 20K heat exchanger. A shutdown will be scheduled at a later date to continue investigation into the causes for this high drop.

First draft of a technical note on the conceptual design of a cryogenic system for SSC-D magnet system has been prepared. This design, when completed, will be used as a basis of a cost estimate for the cryogenic system. The refrigerator design used is similar to SSC-A except that a circuit for a 20K heat shield has been added.

B. FNAL.

1. Cryostat Development

a. Magnetic Effects Model. Data analysis of the Phase I test program is proceeding. This phase evaluated operation of the magnet model with the coil and vacuum vessel axes concentric. The significant conclusions are as follows:

(i) LVDT's are effective for the measurement of motions of single phase assemblies, shields, etc.

(ii) LVDT's require shielding from stray magnetic fields.

(iii) The post suspension with hinged end connections functioned well during cooldown and warmup.

(iv) The single phase assembly was displaced less than 1 mm by the decentering forces at 5300 A.

(v) The single phase vessel was positioned relative to the vacuum vessel within the specified manufacturing tolerances (±2mm).

(vi) The 10K shield survived with the magnet currents up to 5300 A. The deflection of the shield was elastic and the heating was not excessive. The 10K shield went from 8K to 39K experimentally while the final predicted temperature was 21K.

The analysis of the data will continue and the conclusions will be refined.

Phase II of the test is complete. This phase evaluated operation of the model magnet with the coil axis decentered laterally ≈ 3 mm from the vacuum vessel axis. The magnet was operated at several currents and de-energized by both dumping and quenching. No adverse effects were noted during the test run. Data analysis has begun.

Phase III of the test program will not be conducted at this time. This phase would evaluate operation during asymmetric quenching of the coil assembly.

b. Heat Leak Model. The 12 m heat leak model for the 4.5, 10, and 80K systems has been measured. The predicted heat leaks and the preliminary results from the measuements are as in Attachment A.

Very good agreement of the predicted and measured model heat leaks to 80K and 10K was achieved, i.e., 2.46 vs. 2.79 W/m for 80K and 0.190 W/m vs. 0.190 W/m for 10K. The initial agreement of the 4.5K values was poor; i.e., 0.011 W/m vs. 0.051 W/m. Subsequent analysis of the temperature profile as measured for an instrumented support in the Magnetic Effects Model suggests a 10K temperature rise from the connection point on the 10K shield to the 10K intercept of the support. This measured temperature rise, when applied to the Heat Leak Model, results in the 10K intercept of the support operating at ≈20K rather than 10K. The agreement of the measured and predicted 4.5K values, when adjustsed for a 20K intercept, is better. i.e., 0.037 W/m vs. 0.051 W/m.

The results from the Heat Leak Model indicate it is possible to design and build an SSC type cryostat and achieve performance that, in general, agrees well with predictions. The 4.5K results indicate that close attention to detail must be followed in the design and construction of all cryostat elements, such as connections to heat intercepts. Future evaluation of the heat leak for supports using the heat leak suspension dewar will be done with the heat intercept connections as built.

The predicted heat leaks for the model were higher than the Design B heat leak budget due to the different and simplified geometry employed for the model. The Design B heat leak budget should be achievable with the Design B geometry and improved heat intercepting.

c. Suspension R&D. Measurements of MLI insulation in the Heat Leak Suspension Dewar are under way. The initial MLI system to be evaluated is aluminized Mylar with a Fiberglas mat spacer. The MLI system consists of 10 bright and 10 insulation layers and is the same as that used in the Magnetic Effects and the Heat Leak Models.

The initial data have been taken for the creep of shrink fit joints between FRP tubes and metal end connections. The data were taken at a temperature of ≈70°F and indicated no significant creep. The test apparatus has been elevated to a temperature 105°F and data taking has been initiated.

A mock up test fixture is being developed to evaluate the assembly and adjustment characteristic of a tension member support system. The model will be used to evaluate adjustment procedures for the position of the single phase assembly.

Test members are being fabricated for the structural and thermal evaluation of (i) a folded post and (ii) a post-arch suspension.

d. Cryostat Design. Work continues on the conceptual design for a cold iron cosine theta magnet cryostat. Two principle suspension system designs are being pursued, i.e., the folded post and tension member concepts. At this time, the folded post is preferred due to its known ability to make single phase assembly adjustments in position.

The National Bureau of Standards (Boulder) has begun work on material evaluations of the Design D cryostat. The initial input will be received by the end of the month, with study completion by the end of September, 1985.

Work was completed on the cryostat cost estimate for the Design D cost magnet. The costs were provided to BNL for compilation of the overall cost estimate.

2. Magnet Models

a. 5 cm 824 Dipole Dry Winding. SG-1005 was collared on April 29, 1985. Inner to outer coil shorts developed during the collaring operation. Disassembly revealed the inter-coil insulation had failed. Attempts to repair the insulation were ineffective. Further repair would have been too extensive to be practical. The magnet was scrapped. Inter-coil insulation faults continue to plague these magnets. The problems are technique oriented, and improvements are continually being made. SG-1006 was completed and sent for warm magnetic measurement on May 7, 1985.

Large measured sextupole moments in the SG series prompted review of the coil optimization. The problem turned out to be quite basic. A misinterpretation of the coil optimization data resulted in the SG series being built with one too few turns in each quadrant of the inner coil, the missing turn being replaced by an increase in the wedge thickness. The correct coil geometry is utilized in the SJ series--the first of which was completed on May 20, 1985.

b. 5 cm 824 Dipole, Wet Winding. The first wet wound coils contained the same error as the dry SG series (one too few turns for inner coil). It was decided not to proceed with further assembly. Instead coil winding and molding of the SK series has begun. The SK (wet) series are the same in all respects as the SJ (dry) series except for the 0.1 mil of "B" stage epoxy applied to the coil insulation.

c. 4 cm Design D (Dry Winding). Collars from BNL are still being awaited. Coil winding will not begin until collars are on hand. BNL has advised delivery by June 10, 1985.

d. Cable Measurements. Work is progressing on completion of the cable measuring equipment.

e. Traveling Collar Press. The unit is functional for pressing short magnets. Motor drive is being procured to move and index the press.

f. Magnet Model Measurements. SSC prototype dipoles SG1003 and SG1004 were cold tested. Both magnets had similar performance with the first quench of 6250 A which corresponds to a measured central field of 5.15 T. After low temperature stressing of the coil structure, the magnets attained more than 7100 A at 4.2K (5.75 T). Also their sextupole moments were the same, -43 units at 5 T and the hysteresis was also similar. The large sextupole moment is due to the use of an oversized copper wedge in the first few prototypes that were built.

Off center force tests for the 6 meter Magnetic Effects Model were performed. The measurements were made to measure the effective spring constants associated with posts used to support the single phase asembly and to check the as built alignment of the single phase assembly in the 16 in. diameter external iron vacuum vessel. Original measurements indicated the centering of the single phase assembly was done to about 1.5 mm and that under excitation to anticpated Design B levels the single phase assembly moves about 1 mm.

A 5 cm aperture quadrupole was cold tested and obtained a gradient of 1.56 T/cm at 4.25K. The cable used in winding this magnet was made from five separately insulated pieces of conductor each with a slightly different cross section to give a keystoned shape. The training was less than 5% and the 12 pole normal and skew moments were -3.8 and 0.3×10^{-4} at 1 cm respectively.

Work continues on a 30 in. long short sample testing facility that utilizes magnet RD1001 with iron. This device will enable measurement of critical current in cable conductor as a function of angle and magnetization in a field up to 5.5 T.

C. LBL.

1. Magnet Models.

a. D12C4. During May, fabrication and assembly work continued on D12C4 and, as reported last month, the schedule calls for completion of this magnet by mid-June. Assembly work also continued on a flush type (non-flared coil end) dipole magnet. Some shorts developed during the installation of rings and collets on this flush magnet, and it was decided to postpone electrical testing for the present. Initial design and fabrication work on D12C5 was started in May, and the schedule calls for completion of this magnet in early July. The following tasks were completed:

- Fabrication of strain gauge blocks for measuring coil pre-load.
- Forming Kapton coil layer insulation.
- Fabrication of coil end support saddles.
- Fabrication of coil end assembly cones.
- Fabrication of inner and outer layer coil end tear drops.
- Mechanical measuring of cable while under a loading of 10,000 psi.
- Winding of two inner and two outer layer coils.
- Curing of the inner and outer layer coils.
- Mechanical measuring of completed coils under a loading of 10,000 psi.

b. D12C5. Initial design and fabrication work on D12C5 was started in May, and the schedule calls for completion of this magnet in early July. The fol- lowing tasks were completed:

- Cables for both the inner and outer layers have been manufactured and mechanically measured.
- Coil end tear drops have been fabricated for the inner and outer lay- ers.
- Moulding of the coil end wedges is complete.
- Forming of Kapton for coil layer insulation has been completed.

The winding of coils for this magnet is expected to be complete by mid-June. Construction of D12C5 is identical to that of D12C4. Both magnets use copper coil wedges, punched Nitronic 40 collars, and the "C5" coil cross section. Particular attention has been given to the design of these two magnets to maintain coil preload in coil tear drop area.

2. <u>Superconductor</u>. Intermagnetics General Corp. (IGC) completed delivery of 840 lbs. (320,000 ft) of inner and 800 lbs. (453,000 ft) of outer layer superconductor for use in the 4.5 m model dipole magnets to be constructed at BNL. This superconductor was delivered on schedule, and the critical current densities exceeded the 5 T specification value (2400 A/mm^2) by 5% for the inner and 13% for the outer layer material. This wire will be cabled at LBL and NEEW during May and June, 1985. This delivery completes the procurement of large filament NbTi superconductor for the Design D collaboration for FY 1985. During the remainder of FY 1985 and the first half of FY 1986, several lots of fine filament NbTi will be delivered. This material will be used for evaluation (J_c and magnetization) and for construction of dipole magnets.

<u>Cable</u>. A total of 8,000 ft of cable was made at LBL for use in dipole magnets at BNL, FNAL, and LBL. This cable was made without crossovers or sharp edges. One length was found to be out of specification on the mid-thickness and this length was re-rolled in order to reduce the mid-thickness by approx. 0.75 mil. The re-rolled cable appeared satisfactory from the dimensional standpoint. However, critical current measurements at BNL indicated that the re-rolling had changed the direction of I_c anisotropy with respect to the field and also degraded the value of I_c (field parallel to cable wide face) by approximately 20%. The cause for this behavior is under investigation. Meanwhile, a new length of cable is being manufactured in order to complete the final 4.5 m model at BNL. The I_c measurements for the other lengths of cable show typical behavior with respect to anisotropy and degradation. Thus, our conclusion at present is that cable can be made reliably for the Design D specifications; however, more work needs to be done in

order to better understand the mechanism responsible for I_c anisotropy and degradation in cables.

3. Analysis--

a. POISSON Computer Program. A paper was presented at the Particle Accelerator Conference in Vancouver, BC, covering the addition of elliptical region boundaries and the simulation of an infinite outer iron-free and current-free region.

b. Magnetization Effects. Magnetization effects were calculated for magnet D12C2. Several modifications were made to the program to improve the accuracy of the sextupole and decapole calculations.

c. Effect of Random Manufacturing Errors on Field Quality. A paper was presented at the Particle Accelerator Conference covering the estimation of magnetic field aberrations for the various circular-aperture SSC reference designs by extrapolation from SSC and Tevatron experience.

d. HP-1000 Computer System. A translator was written to facilitate moving FORTRAN codes to the MFE CRAY from the HP-1000, eliminating HP-1000-dependent features. The writing of a similar translator for moving programs to the LBL VAXes is being considered.

The data-acquisition system in Bldg. 58 was upgraded in the following ways:

- Temperature sensor data were moved from the initialization program to files. This should facilitate modification and addition of data, at the cost of a longer startup time.
- Programs FLUKE and SORTFLUKE have been reactivated.
- A program called SWAPBACK was written to help users swap the data packs on the disk without corrupting other systems.

4. Instrumentation and Measurements

Final testing for SSC model dipole D12C2 was completed in May, 1985. Initial testing in He I was interrupted by piston ring leakage in the helium refrigerator. Extensive repair was required and testing was resumed toward the end of May.

The maximum field in He I, at 4.4K, of 6.6 T was reached in four quenches after the magnet was held at about 100K for over a month. In He II, at 1.8K, six quenches were needed to achieve the maximum central field of 7.9 T. It was observed from the imbedded strain gauges, that the pressure at the pole of the inner layers reached zero at 4 T, but that the magnet, nevertheless, trained rapidly above this level.

D. TAC.

1. Short Magnets

Another one meter 2-in-1 cold mass magnet has been assembled. Radiation shields are now being put on to be certain that the design for the shields is efficient. The assembly of another 7 meter magnet is also being started.

2. Long Magnets

During May, concentration was on preparing materials and supplies for General Dynamics. The iron cores (lamination stacks) for the first 28 meter magnet have already been sent to General Dynamics. The beam tube, plastic ears, cable, etc., have also been shipped. The delivery of cable was late by about one month; however, General Dynamics estimates that this may not delay the delivery of the first magnet, scheduled for the end of September.

3. Theory and Design

The old design for the superferric collider had 24 refrigerators and 6 power supplies distributed around the ring. During the Operations and Commissioning Task Force, it was estimated that 24 refrigerators required twice as many people to operate as 12 refrigerators, even though they were half the capacity. Accordingly, the layout of the machine was redesigned so that there are now only 12 refrigerators and 4 power supplies distributed around the ring. It has become clear that a higher temperature shield (20° instead of 10°) would require less electrical power in cooling the magnets, so this design change was also implemented. This necessitated adding one single one inch line to the magnet design. The only other modification to the cross section due to the above changes is to increase the two nitrogen lines to 2 in. diameter. The helium lines remain unchanged because their dimension was set for other reasons. The total electrical power for cooling the superferric ring is then reduced from 23.9 MW to 16.3 MW.

In studying the number of people required to operate the SSC, it is proposed that the SSC will need modern operational techniques different from the present laboratories. In this regard, it is estimated that the total number of people required to operate the SSC could be reduced.

C. Project Cost Data

(Index)

TABLE C-1

CENTRAL DESIGN GROUP - SUPERCOLLIDER

MAY 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	83	76	41	200	1425	1935
1.2	PROGRAM PLANNING & MANAGEMENT	3	17	10	30	197	380
1.3	ACCELERATOR R & D	45	21	57	123	677	1680
1.4	CONVENTIONAL SYSTEMS DEVELOP.	4	161	2	167	289	1130
	PROGRAM COSTS	135	275	110	520	2588	5125
	COMMITTMENTS					357	

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY - SUPERCOLLIDER

MAY 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	GENERAL	20	31	16	67	489	800
2.2	MAGNET MODELS	90	79	55	224	1514	2305
2.3	TOOLING	27	18	15	60	601	800
2.4	MAGNET MEASUREMENT & DEVEL.	20	7	9	36	315	400
2.5	POWER SUPPLIES & QUENCH PROT.	15	2	5	22	254	280
2.6	CRYOGENIC TESTING	27	5	13	45	363	500
	PROGRAM COSTS	199	142	113	454	3536	5085
	COMMITMENTS					242	
	EQUIPMENT						475

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER

MAY 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	4.3	6	3.5	13.8	123	340
3.2	MAGNET MODELS	48.9	46.3	33.1	128.3	2324.7	3320
3.3	FACILITY DEVELOPMENT	9.9	5.1	5.3	20.3	234.6	340
	PROGRAM COSTS	63.1	57.4	41.9	162.4	2682.3	4000
	COMMITMENTS					34.2	
	EQUIPMENT					25	25

TABLE C-4

LAWRENCE BERKELEY LABORATORY - SUPERCOLLIDER

MAY 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
4.1	GENERAL	3	1	2	6	87	115
4.2	MAGNET MODELS	13	3	8	24	245	395
4.3	ANALYSIS	3	0	2	5	94	125
4.4	INSTRUMENTATION/MEASUREMENTS	4	0	2	6	79	155
	PROGRAM COSTS	23	4	14	41	505	790
	COMMITMENTS					2	

TABLE C-5

TEXAS ACCELERATOR CENTER - SUPERCOLLIDER

MAY 1985 COST AND COMMITTMENT REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
5.1	GENERAL	0	72.9	16.6	89.5	527.5	825
5.2	SHORT MAGNET MODELS	20.7	-72.9	8.3	-43.9	726.6	1150
5.3	LONG MAGNET MODELS*	20.7	-62	0	-41.3	82.1	1660
5.4	TOOLING	0	0	0	0	0	630
5.5	THEORETICAL ANALYSIS	20.7	0	0	20.7	95.5	130
5.6	FACILITY DEVELOPMENT	0	4.4	0	4.4	238.3	605
	PROGRAM COSTS	62.1	-57.6	24.9	29.4	1670	5000

*Does not include 1062 K$ obligation to General Dynamics Corp. for fabrication of long magnets

TABLE C-6

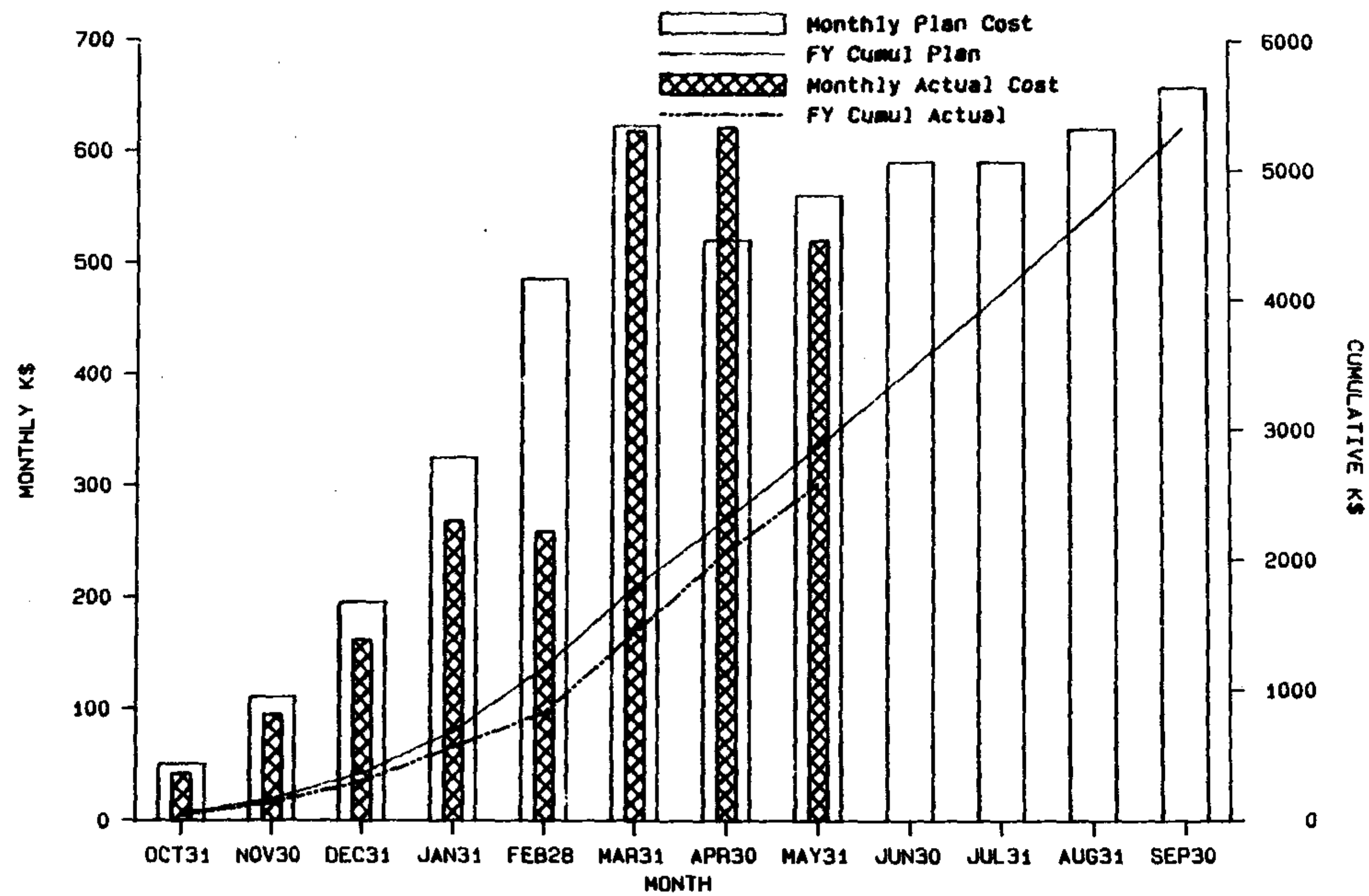
PROGRAM SUMMARY - SUPERCOLLIDER

MAY 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	135	275	110	520	2588	5125
2.	BNL SSC PROGRAM	199	142	113	454	3536	5085
3.	FNAL SSC PROGRAM	63.1	57.4	41.9	162.4	2682.3	4000
4.	LBL SSC PROGRAM	23	4	14	41	505	790
5.	TAC SSC PROGRAM	62.1	-57.6	24.9	29.4	1670	5000
	TOTAL SSC PROGRAM COSTS	482.2	420.8	303.8	1206.8	10981.3	20000

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	50	110	195	325	485	623	520	560	590	590	620	657
FY Cumul Plan	50	160	355	680	1165	1788	2308	2868	3458	4048	4668	5325
Monthly Actual	42	95	162	269	259	619	622	520				
FY Cumul Actual	42	137	299	568	827	1446	2068	2588				

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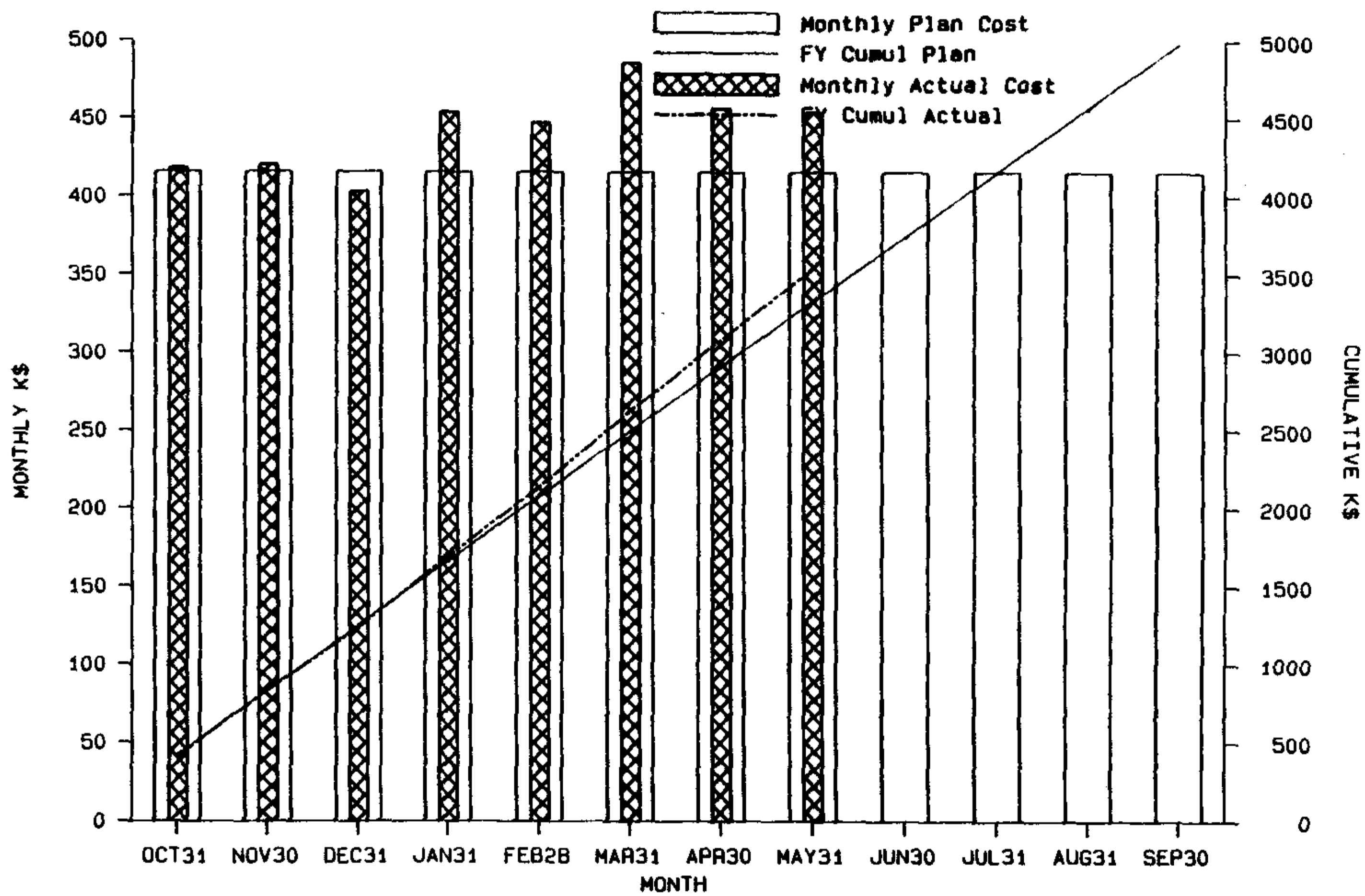
(JSZ)
1:35 pm
25-JUN-85

2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	415	415	415	415	415	415	415	415	415	415	415	415
FY Cumul Plan	415	830	1245	1660	2075	2490	2905	3320	3735	4150	4565	4980
Monthly Actual	418	420	403	454	447	486	457	454				
FY Cumul Actual	418	838	1241	1695	2142	2628	3085	3539				

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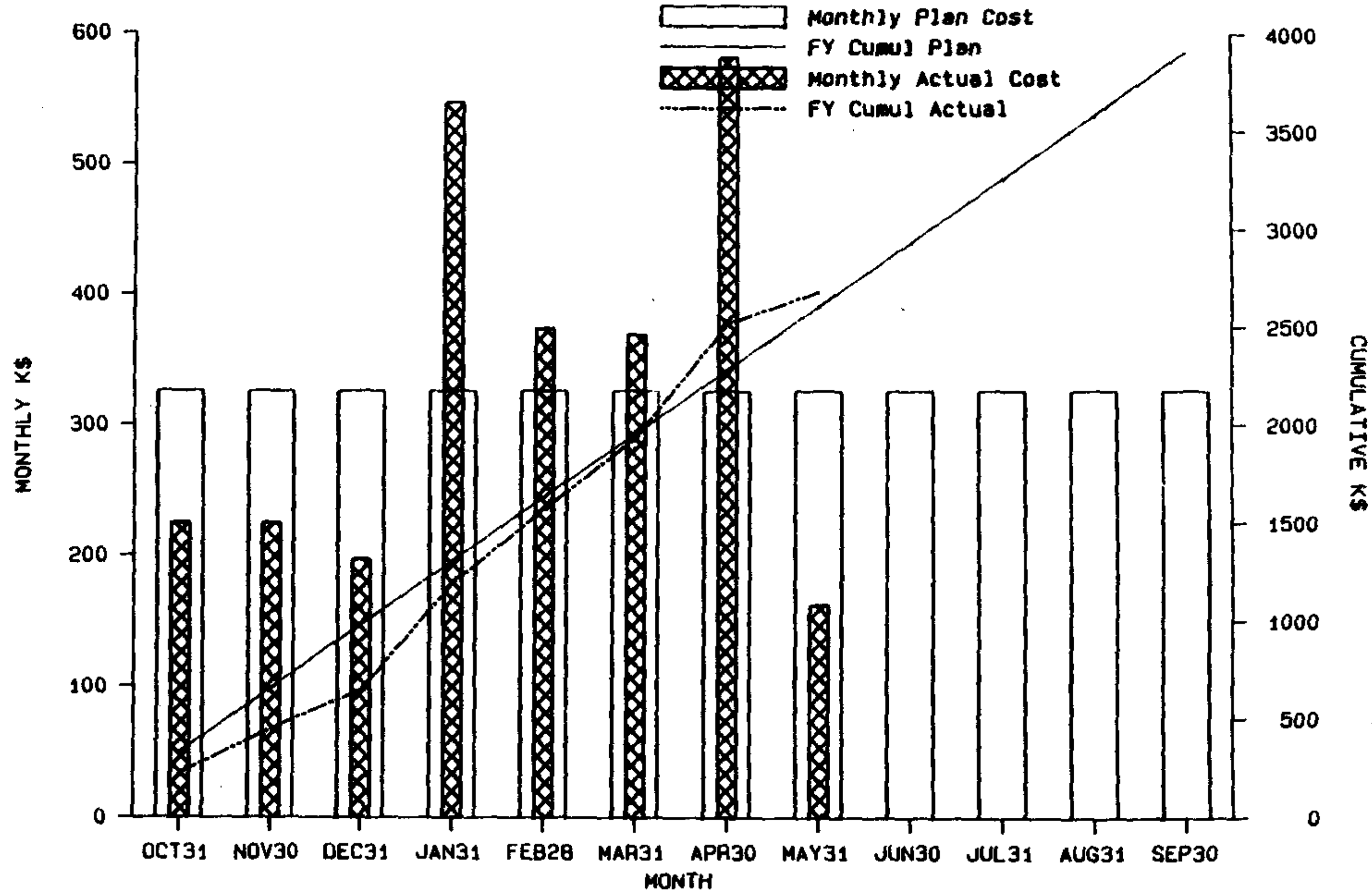
1:36 pm
25-JUN-85

3.0 FERMI NAT'L ACCEL LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	325	325	325	325	325	325	325	325	325	325	325	325
FY Cumul Plan	325	651	976	1302	1627	1953	2278	2603	2929	3254	3580	3905
Monthly Actual	225	225	197	547	374	370	582	162				
FY Cumul Actual	225	450	647	1194	1568	1938	2520	2682				

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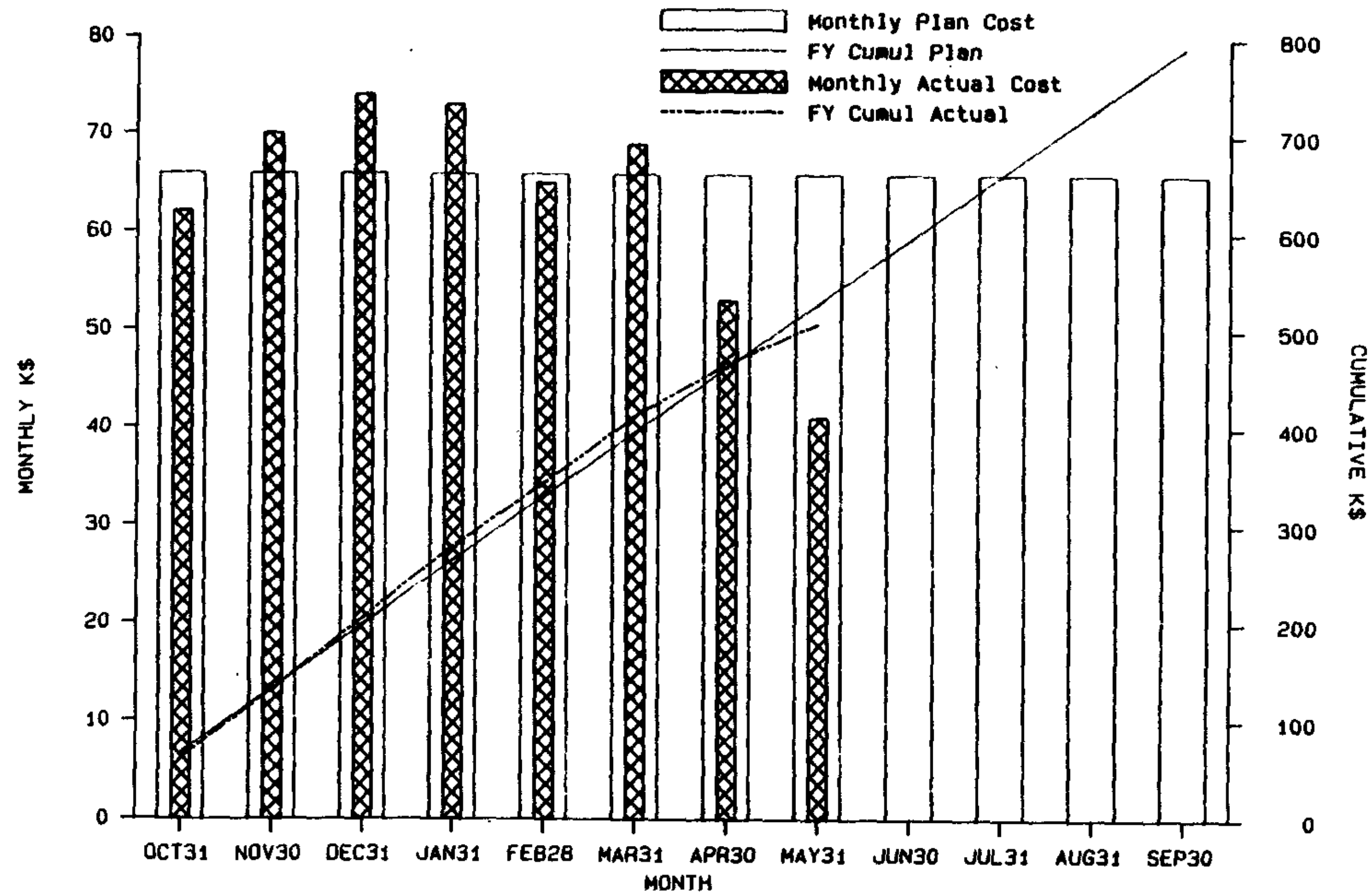
1: 37 pm
25-JUN-85

4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	66	66	66	66	66	66	66	66	66	66	66	66
FY Cumul Plan	66	132	198	263	329	395	461	527	592	658	724	790
Monthly Actual	62	70	74	73	65	69	53	41				
FY Cumul Actual	62	132	206	279	344	413	466	507				

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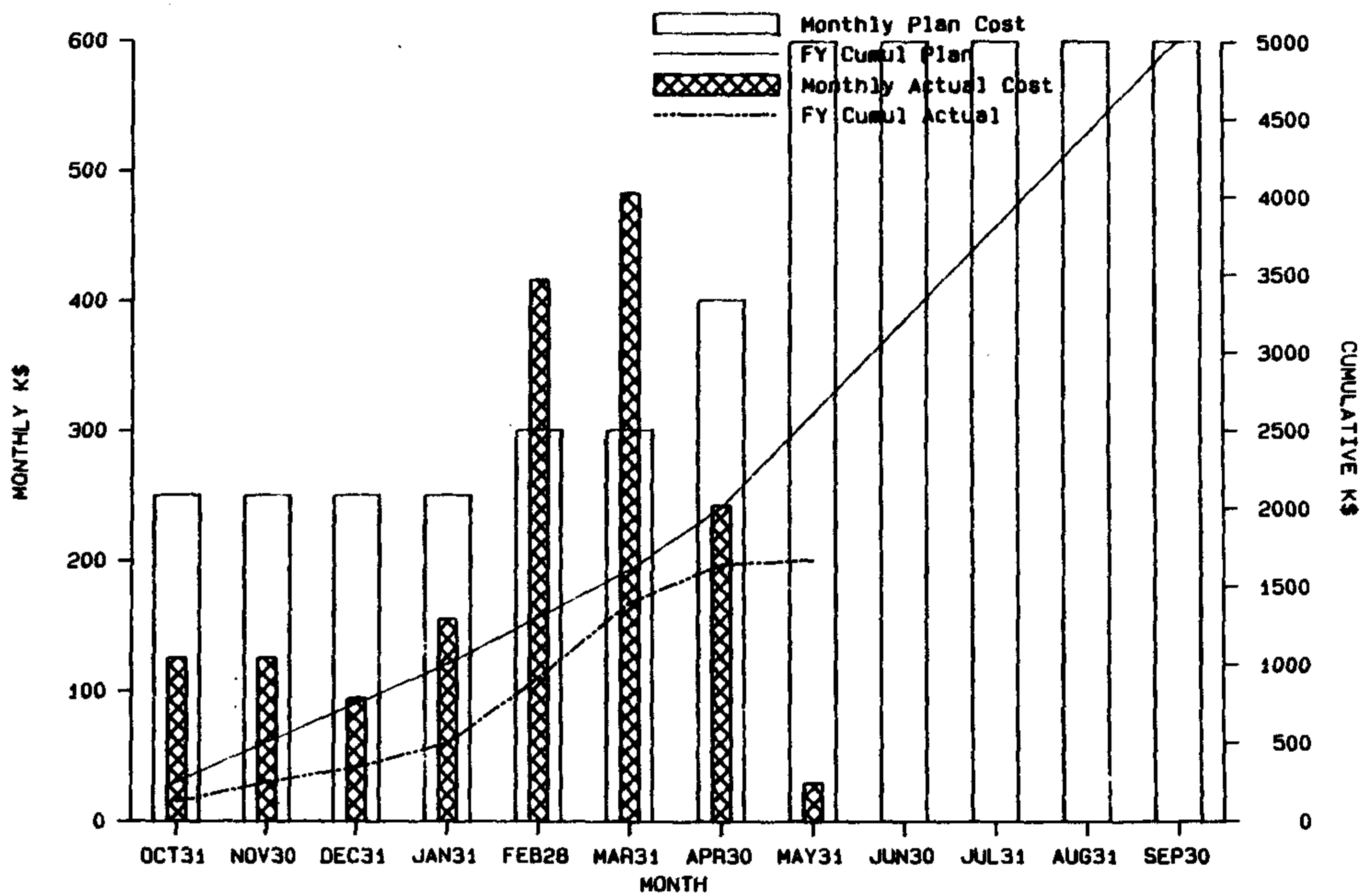
(JSZ)
1:37 pm
25-JUN-85

5.0 TEXAS ACCELERATOR CENTER - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	250	250	250	250	300	300	400	600	600	600	600	600
FY Cumul Plan	250	500	750	1000	1300	1600	2000	2600	3200	3800	4400	5000
Monthly Actual	125	125	94	155	416	483	242	29				
FY Cumul Actual	125	250	345	500	916	1399	1641	1670				

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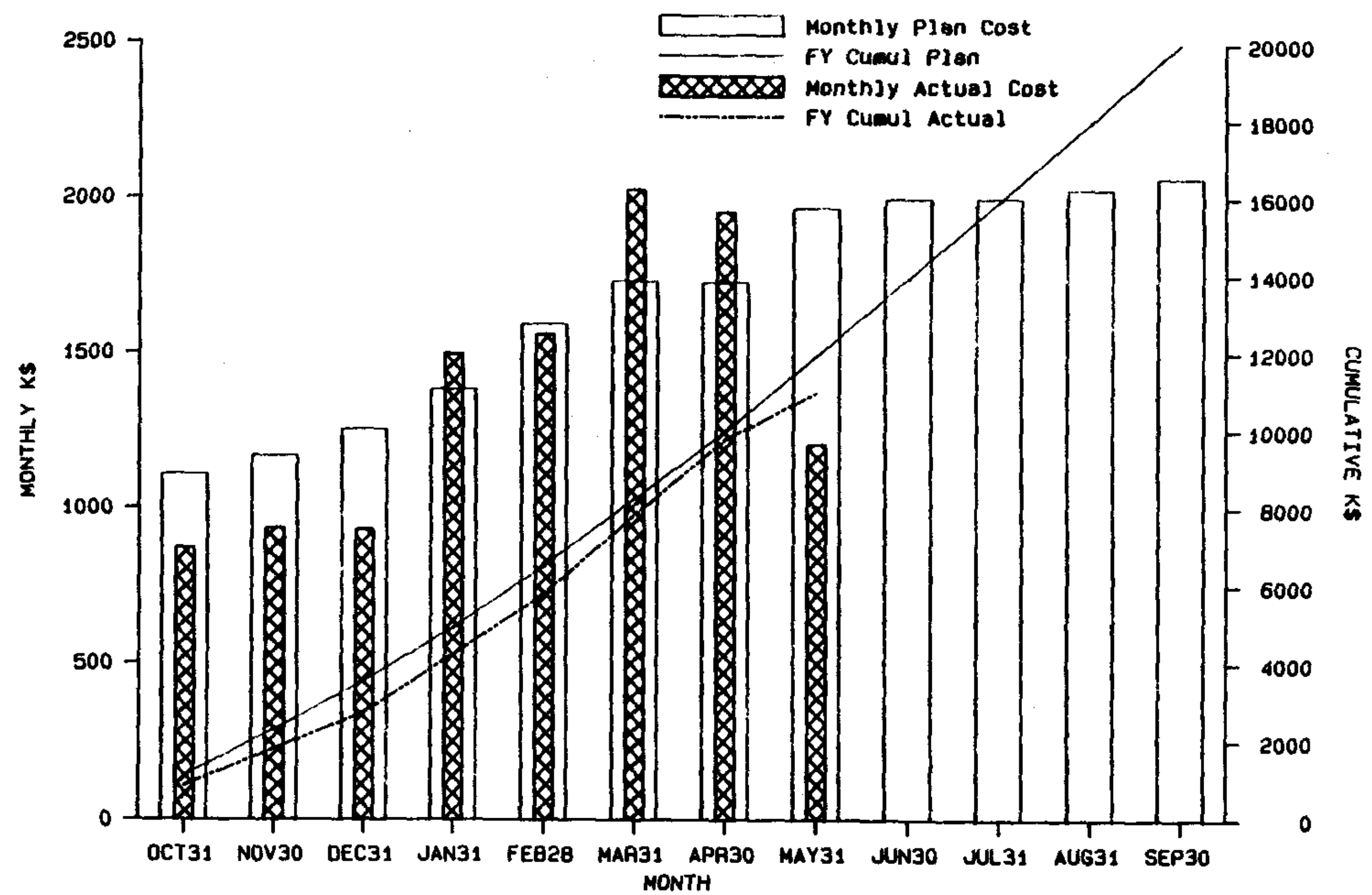
(JSZ)
1:38 pm
25-JUN-85

0.0 PROGRAM SUMMARY - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	1106	1166	1251	1381	1591	1729	1726	1966	1996	1996	2026	2063
FY Cumul Plan	1106	2273	3524	4905	6496	8226	9952	11918	13914	15910	17937	20000
Monthly Actual	872	935	930	1498	1561	2026	1956	1207				
FY Cumul Actual	872	1807	2738	4236	5797	7823	9780	10986				

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(JSZ)
1:34 pm
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