Superconducting Super Collider Laboratory

SSC Monthly Report

July 1985
SSC MONTHLY REPORT

JULY 1985

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A. Project Summary

- The SSC Commissioning and Operations Task Force Report SSC-SR-1005 was completed and distributed.

- The SSC Magnet Cost Estimating Task Force met with Laboratory representatives and consultants to review cost data for the various magnet styles under consideration for the SSC.

- A final Interim Report, SSC-SR-1011, was prepared from the version drafted last month for the SSC CDG Annual Review.

- The SSC Magnet Technical Review Panel met at TAC, BNL, and LBL. A final report SSC-SR-1010 was prepared.

- The final report of The Task Force on Low Temperature Magnet Operations SSC-SR-1007 was issued July 2.

- Work was initiated with the new A/E firm, RTK, who will be providing design services to the SSC for the next two years. Meetings have been held on a regular basis. As part of the initial mobilization, work is under way on defining procedures within the RTK team and between the RTK team and SSC. Task orders have been issued for studies of safety in tunnels, and geotechnical conditions at generic sites.

- Progress was made on moving beyond the median site of the RDS to provide a costing model that will have validity for the sites to be submitted in the various state proposals.

- A major activity in July was the aperture evaluation for the cost comparison between the cosine theta magnet Design D and the superferric magnet Design C. Studies have concentrated on obtaining the minimum inner diameter of the superconducting coils needed for single particle stability as well as the optimum cell length for each magnet design. It is concluded, using the best estimates of the magnet errors so far, that an inner coil diameter of 4 cm is sufficient for both the C and the D magnet designs. These results are summarized in an SSC CDG report SSC-SR-1013.
BNL. During the month of July the major activities centered on the assembly of the second 4.5 m dipole for Reference Design D, and its successful test, as well as the initial assembly operations for the third model dipole. The performance of Magnet No. 2 was a duplicate of that of Magnet No. 1. It achieved the design operating field, 6.5 T at 4.5 K, with negligible training, and exhibited excellent field quality, i.e., allowed harmonics in good agreement with the calculated values and small unallowed harmonics.

This month saw the completion of winding and curing of all coils required for the present 4.5 m long model magnet program, and preparations were initiated on replacing the flared ("Dog Bone") coil ends with straight ends. The modified coil ends will be developed initially through a sequence of 3.5 m long model magnets.

Excellent progress continues to be made in the area of bore tube preparation and trim coil development. The first Multiwire trim coil to be utilized in a model magnet was completed; it is scheduled for deployment in the fourth 4.5 m dipole. The final version of the MOLE was released to the Shops, incorporating certain modifications introduced following prototype tests under power in the second 4.5 m dipole.

Fermilab. One meter models, built to perfect the dry winding technique for both the 4- and 5-cm coils, continue to be built and analyzed.

Facilities for cable cross-section and harmonic measurements continue to be developed.

Experimental work to measure the thermal performance of cryostat insulation systems and suspension system heat intercept continues. Folded support posts, having a geometry comparable to the first long Design D magnets, are being built for structural and thermal evaluation.

The Design D cryostat design was reviewed by the CDG. Recommendations were made relative to further work on the cryostat.

Linear aperture calculations as performed for Design D were extended to the Design C.

Tevatron accelerator experiments were discussed with the CDG.

The photodesorption experiments at the NSLS continued. A cold SSC beam tube was exposed to synchrotron light and resulted in gas desorption that is within the SSC specification. The experimental apparatus is being developed to improve the understanding of the phenomenon.
LBL. Two 1-m magnet models, D12C-4 and -5, were tested and performed well. Training behavior of five collared magnets is shown in Fig. 1, including these latest two; D12C-4 quenched first at 6.47 Tesla and reached its critical value of 6.63 Tesla on the forth quench; D12C-5 had improved cable, but was assembled with lower pre-stress, and started at 5.7 Tesla. It reached its critical field of 6.8 Tesla on the eighth quench.

The first wire from the Supercon 4164 filament billet has the highest $J_C$ (5T, 4.2K) yet achieved in a production-size billet: 2950 A/mm² at 0.0318 in. diam. (8µm filaments) and 0.012 in. diam. (3µm filaments).

The first IGC double-stack samples (6 in. and 3.5 in. billets) also gave good results although somewhat lower $J_C$. From these results the practical achievement of high $J_C$ and fine filaments appears to be demonstrated.

TAC. Three one meter magnets have been assembled during July and they will be measured next month. These magnets will confirm the random errors associated with the field and the capability of tuning most of the multipole coefficients of 0. One of these magnets was a complete assembly including cryogenic shield, superinsulation, and vacuum chamber. Experience gained from this activity will be valuable in assembling the 92 foot magnet. Work is ready to proceed on adding the cryogenic shields and vacuum chamber. This magnet is on schedule and should be delivered the end of September.

Three different tunnel structures being built for a sewage system at Austin, Texas, were recently examined. Two of the tunnels had an i.d. of 7 ft and one had an i.d. of 8 ft. The projected cost per foot was about $300. This is a complete concrete sealed tunnel without utilities. It is believed that a very similar tunnel of 7 ft i.d. could be used for the superferric magnet in the SSC.
B. Project Report

I. Central Design Group

**Conventional Systems.** Work was initiated with the new A/E firm, RTK, who will be providing design services to the SSC for the next two years. Meetings have been held on a regular basis. As part of the initial mobilization, work is under way on defining procedures within the RTK team and between the RTK team and SSC. Data acquisition, electronic mail, CAD, and the interfacing of Conventional Systems data into the SSC Artemis system are being developed. A suitable WBS structure is also being developed. RTK is reviewing tunneling studies by other agencies, with particular emphasis on the deep basing studies done for the MX and ICBM programs. The tunneling cost program COSTUM, developed for the DOT is being reviewed as a possible vehicle for comparing costs at various sites in a normalized way.

Task orders have been issued for studies of safety in tunnels, and geotechnical conditions at generic sites.

Tunnel safety needs to be studied under three aspects: during construction, during installation of technical components, and during operation of the collider. Safety during construction is assumed to be the responsibility of the tunneling contractor; however, safety requirements may impact on the design of the tunnel, e.g., ventilation requirements affect the cross section. During operation the safety requirements for logistics, ventilation, fire safety, and evacuation need to be considered. It is anticipated that the most serious safety problems will be during installation. At that time there will be a fairly high density of technicians and tradespeople along with heavy traffic of material and equipment.

Progress was made on moving beyond the median site of the RDS to provide a costing model that will have validity for the sites to be submitted in
the various state proposals. Drawing on extensive basing studies a series of models based on recognized physiographic provinces of the continental U.S. are being defined. This looks like a very promising approach.

Special studies were carried out in support of the magnet selection process. Tunnel costs were reviewed in depth making use of the newly released study of the U.S. National Committee on Tunneling Technology commissioned by the National Research Council. The logistics and costs associated with inserting very long magnets into the collider tunnel were also evaluated.

Accelerator Theory and Computation. The main activity in July was the aperture evaluation for the cost comparison between the cosine theta magnet Design D and the superferric magnet Design C. Studies have concentrated on obtaining the minimum inner diameter of the superconducting coils needed for single particle stability as well as the optimum cell length for each magnet design. It is concluded, using the best estimates of the magnet errors so far, that an inner coil diameter of 4 cm is sufficient for both the C and the D magnet designs. These results are summarized in an SSC CDG report SSC-SR-1013.

Some effort has gone into improving the interaction region optics. The interaction region contains the low-beta insertion, the horizontal dispersion suppressor, the vertical beam separation and suppression section, and the phase trombone. A few possible designs were created and compared. There have not yet been strong reasons that compel one design or another.

Two studies on the coherent beam-beam effect were initiated this month: (a) the existing simulation program for dipole beam-beam motion is being extended to include clustered interaction regions as well as gaps in the beam bunch sequence. (b) Higher multiple beam-beam effects are studied using a Vlasov equation technique. Long-range collisions are included in both studies. Results are expected in the next one or two months.
Magnet Program. The Magnet Technical Review Panel has had two series of meetings. The first occurred in the fall of 1984, and in an extensive series of meetings lasting more than ten days, carried out a review of the magnet R&D program for the SSC. The accomplishments of FY84 and the plans of FY85 were studied, and an Interim Report summarizing the studies was written. A by-product of this series of meetings was the proposal for a new style magnet, type D, by a consortium of BNL, FNAL, and LBL.

In April, 1985, Maury Tigner again convened the panel with slightly different membership to review the state of cable development, to report on the state of development of the individual styles of magnet, and to enumerate the time and manpower effort to complete the preprototype R&D prior to style selection.

Members of the committee were H. Hirabayashi, KEK; F. R. Huson, TAC; R. Lundy, FNAL; P. J. Reardon, BNL; C. Taylor, LBL; A. Tollestrup, Chairman, FNAL; R. Watt, SLAC; and R. Yourd, LBL.

The charge to the Magnet Technical Review Panel was as follows:

- Review magnet and cable development programs at BNL, FNAL, and TAC.
- Write a report evaluating the technical status of dipole and quadrupole magnet design and development work for the one-in-one and two-in-one low- and high-field magnet styles. For each style enumerate the R&D remaining before each style can prudently be carried to the full-scale prototype stage. This enumeration should include an estimate of the time and manpower effort needed to complete the pre-prototype R&D. The report should include a detailed account of model tests for the various designs.
- Evaluate and report on the status of superconducting cable development and enumerate further development objectives which could reasonably be expected to be complete in time to have a beneficial impact on SSC magnet cost, reliability, and ease of operation.

The Panel met at TAC (July 1-2) and at BNL (July 11-12). A final report was prepared and issued July 25 (SSC-SR-1010), and the results of the findings are summarized below:
The R&D program for superconducting wire and cable has produced spectacular results. The current density of commercially available NbTi cable equals 2600 A/mm², and may become even higher. Magnets using this conductor and operating at 4.2K routinely achieve fields greater than 6 T.

The technology for superconducting magnet design has a solid base. Good computer codes exist for magnet stress analysis, the behavior of a magnet under quench, and for relating random and systematic errors in magnetic field to the magnet structure. The technological base is widespread, and good communication exists between the various R&D centers.

No magnet-related problems were found that would threaten achieving successful design for the SSC. The present technology is such that any of the proposed magnets can be successfully evolved to the preproduction stage. However, the remaining R&D is style specific and has a strong interaction with the overall accelerator design. If a style choice can be made now, it will narrow the scope of the remaining engineering R&D and thus conserve funds, make optimum use of the available intellectual resources, and expedite the design of the SSC.

**Magnet Design.** The SSC Central Design Group organized a review of the Design D cryostat that was held at FNAL on July 8 and 9. W. B. Fowler, FNAL, was Chairman, and the other members were J. V. Sant, LLL; K. Kennedy, LBL; and F. Barrera, SLAC. The seven major recommendations of the panel are given in Section II-B (FNAL) of this report.

**Magnet Cost Estimating Task Force.** The Magnet Cost Estimating Task Force continued with preparations for evaluating costs for the various magnet styles under consideration for the SSC. During July a series of meetings were held with the laboratory representatives preparing cost data for each style. A comprehensive review was held July 18-24. The agenda for the review process is given on the next page.
SSC–CDG COST ESTIMATING TASK FORCE
JULY 18–24, 1985

Participants:
Task Force: Tom Elioff, Ron Yourd, Ken Mirk, Carl Goodzeit
Laboratory Consultants: Norb Engler (7/18&19 only), Greg Kobliiska (7/18&19 only),
Russ Huson (7/24 only),
Industrial Estimates: General Dynamics (Bob Baldi), Westinghouse (Andy Jarabak)

Agenda:
July 18, 1985
9 – 10am Introduction: describe scope of our work, the procedures we will
use to assemble report, the materials available, and how we will
arrive at a CDG table of costs for overall comparisons.

10am – 4pm Review Design Style A: laboratory estimates, GD materials, and
Westinghouse materials; review material quotes and unit costs;

July 19, 1985
9 – 12am Review Design Style A: laboratory estimates, BNL scaling factors,
extrapolation of style D data base, etc.
1 – 4pm Review Design Style B: laboratory estimate, FNAL data
extrapolation from style D data base, etc.

July 22, 1985
9am – 4pm Complete Style D Package: review Carl’s aperture scaling factors,
length factors, Quadrupoles, Spool Pieces, Installation, Cryogenic
Systems, etc.

July 23, 1985
9am – 4pm Review Style C and C* Materials: review laboratory
estimates, review GD and Westinghouse estimates, assemble CDG
estimate, evaluate scaling factors, etc.

July 24, 1985
1 – 4pm Review Complete Style C and C* Packages
II. Laboratory Programs

A. BNL

1. General

Analytical Studies. An analytical expression for the field of a cosh dipole with constant permeability iron was used to estimate tolerable permeability variations. A relative permeability between 1550 and 4650 corresponds to a transfer function variation of +0.01% centered on 99-98% of the infinite-permeability value. This permeability range is appropriate at injection ($B_0 = 0.325$ T).

The effects of a midplane gap (due, for example, to incomplete closure during assembly) were examined using the saturable program MPD. A 10 mil gap results in a transfer function fractional decrease of 0.00185. The allowable gap variations are $+1/2$ mil for 0.01% random error. The sextupole change is negligible (0.2 unit).

The tolerance on high-field (6.5 T) permeability variation was studied using MPD with the result that a 1% packing factor variation results in $DB/B = 0.0010$. The allowable iron weight variations are $+0.1\%$ for $DB/B = +0.01\%$.

The pole shims used in the test magnets are thicker than the allowed values by 6 mil (inner) and 1 mil (outer). This is calculated to result in a transfer function fractional increase of $16 \times 10^{-4}$, a $b_2$ increase of 3.1 units, and a $b_4$ decrease of 0.4 unit (for infinite permeability).

2. Model Magnets

a. 4.0 cm Aperture x 4.5 m Long Magnets.

- As noted in the Summary Statement, assembly and testing of SLW-009, the second magnet in this series, was successfully accomplished.

- Assembly of SLW-010 was plagued by electrical shorts. After two aborted assembly attempts the magnet is presently (i.e., as of the end of July) collared and undergoing final assembly. A total of
nine coils were assembled into collars during the course of these operations, the history of which went as follows. During the initial assembly, a turn-to-turn short was encountered. Rather than delay the assembly, a new set of coils was supplied while the shorted coil pair was returned for analysis. On inspection, a speck of solder was discovered and removed at the inner-to-outer coil transition. These coils will be repaired and reused. The replacement coil pair was produced with cable supplied by LBL. This "inner" cable was slightly oversize when compared to cable originally supplied by NEEW, which necessitated higher curing pressure to maintain proper coil size. The new coil pair was joined with the remaining old set of coils, reinsulated and collared. An inner coil-to-outer coil short at the midplane developed at the lead end which was detected, repaired, and collaring was then repeated. On subsequent testing the coils failed the high pot test at 4.5 kV. Analysis revealed that the midplane cap was completely deteriorated in numerous locations on the inner, upper and lower coils. These sets of coils behaved somewhat differently than earlier coils in that they required a higher prestress in the collaring operation. This may be attributable to the higher curing pressure required for sizing the coils. Some additional electrical problems with these coils—an inner coil-to-collar short and an end turn-to-turn short—were clearly related to prestress, since they disappeared upon relieving the coil stress. In view of the various electrical problems, it was decided to proceed with new coils, reinsulate, reduce the shim size, and limit the prestress on the inner coil to below 18,000 psi while collaring. Consequently, a collared magnet free of shorts was obtained.

The trim coil for the fourth magnet in the series is complete and awaiting magnet assembly. This is the first Multiwire trim coil using 0.006 in. diameter superconducting wire. All previous trim coils were "conventionally" wound.

Evaluation began of coil collars and yoke designs to facilitate construction of a straight-ended magnet (i.e., one without flared coil ends).

Investigation was started on collar yielding, as well as on magnet end plate stresses and deflections.

The quench protection heater design was modified to minimize shorts during assembly. Also, the insulation scheme for the present flared ends was modified, utilizing a spiral wrap of Kapton, to eliminate shorts in this region.

A SSC R&D quadrupole coil was wound.

Strain gauges were calibrated in the Metallurgy Division at 300K and 4K and at various field strengths (3, 6.5, and 8 T) to ascertain their performance as a function of temperature while subjected to Lorentz forces.
Results of coil modulus measurements show LBL inner coils and cable to behave very similar to NEEP inner coils and cable. Outer coil data are still being analyzed.

Finally, all coils required for the present series of 4.5 m dipoles have been cured—representing 13 inner and 12 outer coils.

b. 4.0 cm Aperture x 16.6 m Long Magnets:

Stainless steel pins for manufacturing yoke blocks were received. Note that this is a different assembly procedure than utilized thus far, in that epoxy-bonding yoke blocks will no longer be a step in the assembly.

Shipment of 60-ft long bore tubes has been received from Trent Tube in Wisconsin.

c. Bore Tubes and Trim Coils.

Work is continuing at PCK Technology Division of Kollmorgen and Battelle on the copper plating of bore tubes. PCK has succeeded in producing an adhesive copper layer, 0.001 in. thick, which will serve as the base of the high purity copper layer. Six-inch long copper plated bore tube samples are being prepared by PCK and Battelle for subsequent resistance ratio measurements.

Prototype Multiwire trim coils have been successfully tested.

All trim coil production tooling has been transferred to the RHIC tunnel, west of the Wide Angle Hall. Work is continuing on the assembly and trouble shooting of tooling intended for use in producing full-length trim coils.

Studies are continuing on optimization of the long trim coil assembly, including the following items: assemblies of test coils with Teflon-impregnated Kevlar yarn; investigation of lower temperature, fast-curing adhesives with higher resistance to radiation than Teflon; a method for producing "bumper" assemblies which lends itself to automated assembly.

The electrical work associated with the powering of the bore tube measurement laser, curing oven, and wrapping machine is nearing completion.

Work is continuing in the Shops on parts for the high field evaluation of copper plated tubes.

3. Tooling and Facilities

a. Coil Fabrication Tooling.

Assembly drawings for the 16.6 m long winder were completed.
- Tooling drawings for the 4 cm aperture, 3.5 m long magnet with non-flared coil ends were released to the Shops.

- Assembly continues on the long winder in Bldg. 924.

- Preliminary engineering on the SSC quadrupole coil winding tooling was initiated.

b. Coil and Yoke Assembly Tooling.

- Design commenced on new work stations for the long coils in Bldg. 924.

- New long coil transport boxes to facilitate coil handling are being fabricated. A fixture has been designed to move wound coils from the winder to the curing press, to the assembly table, and to the transport trunk and trailer. A similar transporter has been designed to move collared coils in Bldg. 902/905.

- A new collaring press design capable of 40,000 pounds per linear inch is in the early design stage.

- Lifting tongs for the long SSC collar and cradle have been released to the Shops.

c. Magnet Test Facilities.

- The prototype MOLE was fitted with an encoder and tested up to 6 T in SLN-009. The high speed motor experienced some degradation in speed in a field. The electronics appeared not affected by the field. Work is underway to correct the speed reduction problem, involving substitution of stainless steel components for brass gearing. All low speed bearings will utilize beryllium copper, and high speed bearings will utilize either ceramic or sapphire components.

- The final version of the MOLE has been released to the Shops for completion in October.

- Design work is continuing on a) harmonic drive for the gravity sensor and b) installation of a flywheel which is not affected by a field, designed to maintain constant speed within ±0.001 sec.

- The horizontal test facility design was reviewed. Design of carriage and support structure commenced.

3. Superconductor

a. Cable Procurement.

- All cable requested from LBL, including that to replace the rejected lot XT015-3012HH, has been received, tested, inspected, and insulated.
The vendors chosen to produce SSC cable in accordance with the previously mentioned RFQ are Oxford Superconducting Technology, Supercon, Inc., and the Furukawa Electric Co., Ltd. Brookhaven representatives visited OST during July to review their production plans and schedule.

During July Brookhaven representatives visited LBL for the purpose of reviewing Berkeley's cabling methods.

Cable required for the new 3.5 m magnet program is either in house or on order. Cable not in house will be delivered during August.

b. Tooling.

The device for measuring mean cable thickness has been completed. It will be delivered to NEEW when BNL makes its next cable run, scheduled for August.

The following items of tooling are in preparation: three lump detectors, a hand-held cable measuring device, and modifications to a Kapton wrapping machine.

4. Tests and Measurements. In mid-July vertical dewar tests were under way on the second 4.5 m long model dipole for Reference Design D, SLN-009. The first quench at 4.5 K occurred at 6.03 T (5894 A), with a quench plateau of about 6.60 T (6520 A) reached on the third training quench. This plateau is virtually identical to that observed with the first dipole at this temperature. It is also in reasonably good agreement with the short sample prediction at 4.5 K for the (identical) cable utilized in the two magnets. At the time of writing, testing of SLN-009 in sub-cooled helium had not been completed. As in the first magnet, the measured harmonics were small, with individual values differing from the design values by no more than an rms width and the data for both magnets showing a magnet-to-magnet variation also well within the rms band.

5. Cryogenic Systems. Room temperature mechanical tests of the turbomachinery of the 24.8 kW helium refrigerator were completed in July. A total of 13 expanders and 3 compressors were tested. As a result of the tests, some changes in the turbine oil system are being made by the vendor. The refrigerator will be used in the SSC program to cool the Long Magnet String.
B. FNAL.

1. Magnet Models

a. 5 cm 824 Dipole Dry Winding. SJ1003, which originally experienced shorting during fabrication, was repaired and measured. Due to cabling difficulties the inner cable width was slightly larger than the design required and therefore contributed \(2 \times 10^{-4}/\text{cm}^2\) units of \(b_2\) (sextupole). The new 5.5 T design field was exceeded on the fourth quench of the magnet model which eventually reached 6.2 T at 4.5K. The maximum performance of the prototype was ramp sensitive to less than 4% up to 0.167 T/sec.

SJ1004 was wound and collared resulting in inner to outer layer shorts. Further work on this magnet was stopped.

SJ1005 is being wound and collared employing a different inter-coil insulation scheme consisting of a Kapton stainless-steel composite. The composite consists of two layers of 0.003 in. thick Kapton sandwiching a single 0.005 in. stainless-steel stiffener. The intent is to stiffen the insulation to prevent internal coil-to-coil meshing and subsequent shorting during collaring. Strain gauges will monitor coil loading.

b. 5 cm 824 Dipole, Wet Winding. The apparent asymmetry in the first two sets of coils was determined to be due to tooling. Incorrect clearances of male and female mold parts caused the winding key to be loose in its tapered seat thereby allowing the key to rotate from the center line. Tooling modifications to correct the situation are underway.

SK1001 was assembled with asymmetrical coils. Assembly went smoothly with no insulation problems. The coil is mounted and ready for test.

c. 4 cm Design D (Dry Winding). Inner coils have been wound, with the winding of outer coils continuing. The inter-coil insulation was changed to be the same type as SJ1005, i.e., Kapton-stainless composite. Collar hard-packs have been prepared.
2. Facility Development

The three different devices used to measure harmonics continue to be calibrated against one another. The computer control logic development to operate two of the devices simultaneously has begun.

The cable cross-section measurement system was made operational and tested. All mechanical and electrical systems functioned quite well; however, consistency of measurement was not acceptable. The geometry of the cable clamping mechanism is being revised to improve the reliability of measurements. While these modifications are made, the system is being installed in the cable insulation line.

3. Cryostat Development

a. Suspension R&D. The remeasurement of the MLI insulation in the suspension dewar is complete. Good agreement has been achieved between the predicted and the measured insulation system apparent thermal conductivities. The insulation system consists of a blanket of thirteen reflective and twelve spacer layers having an installed thickness of 1/4 in. The apparent thermal conductivity between 300 and 80K as measured is $3.5 \times 10^{-5}$ BTU/FT·°R as compared to the design value of $3.6 \times 10^{-5}$ BTU/FT·°R. Evaluation of other insulation systems will be deferred to free the suspension dewar for measurement of support post heat leak.

The measurements of the effectiveness of the thermal intercept linkage of the M10 and Heat Leak Model Support Post has begun.

A folded post similar to that to be used in the first long Design D magnets are being fabricated. The posts will be tested in tension and compression at both 300 and 80K and in bending at 300K. A folded post is presently being instrumented for the measurement of the heat leak in the suspension dewar.
The measurement of the creep characteristics of shrink fit joints continues. The joints have been at the simulated storage temperatures of 105°F for approximately two months. The creep versus time curve has reached its knee. At this point, predictions can be made of the long term creep of the material. The long term creep data will then be factored into analysis of the loss of force to slip for the shrink fit joint.

Work continues on the development of the test apparatus for measuring the creep of G10 tubes when loaded in compression. It is expected that the creep measurements will begin in August.

The load tests of the elliptical arch model are complete and the analysis of the predicted versus the measured stresses and deflections is underway. The analysis should be complete early in August.

d. Cryostat Design. Work continues on the optimization of the Design D cryostat elements. Components being considered are the suspension post, the single phase assembly mount, and shields. A new single phase assembly position adjustment method is being developed with the adjustment in the tooling. This approach would reduce cryostat costs and should result in a more functional system.

Work continues on the development of the interconnections. Interfacing is being carried out with BNL to establish the requirements of the single phase assembly and its connections. A mock assembly of the inter-connection region will be built.

The Design B selection package has been updated to final form and transmitted to the CDG.

The materials related work of the National Bureau of Standards (Boulder) is complete. The reports received from NBS will be summarized and provided to
the CDG as reference material. A scope as future possible NBS work on cryo-stat related materials problems will be developed.

A CDG review of the Design D cryostat was conducted. A report of the review panel is to be submitted to CDG in July.

4. Accelerator Physics

a. Magnet Design. The SSC Central Design Group organized a review of the Design D cryostat that was held at Fermilab on July 8 and 9, 1985. W. B. Fowler of Fermilab was Chairman and the other members were James Van Sant of LLL, Kurt Kennedy of LBL, and Frank Barrera of SLAC. The seven major recommendations of the panel are given below:

1. Consider early component test of a single complete column support with glide cradle and bottom adjustment bracket under load conditions.

2. Develop the details of five-column or post-support system including shoulder stops for fiberglass epoxy cylinders. This should include the complete assembly procedure from roll-in of the single-phase unit into vacuum tank, to rail extraction, alignment and final closure.

3. Consider test of shield to column connection which allows shield to cycle through cooldown and warmup motions at low temperature, and in vacuum to verify non-galling of the aluminum-on-aluminum joint.

4. The shields should be studied in detail. A shield fabricated from variable thicknesses might give favorable weight savings with only a minor disturbance in temperature. Deflection between supports must be considered.

5. The Panel recommends that the elliptical arch support work be phased down due to the need for column supports for ends of the arch which overly complicate the design. This, in addition to the large amount of radial space used in the vacuum tank, justifies the discontinuance of this option.

6. The Panel concurs with the Fermilab decision to select the five-column or post design cryostat for the initial long "D" magnets being fabricated by BNL. The concept that this option has the fewest penetrations through the 80K shield and the 10K shield justifies this choice.

7. Consideration should be given to reducing the number of column supports in order to minimize the penetrations through the heat shields.
This would require an addition to the magnet structure (strong back or thicker shell) in order to meet the tolerance on the sag between supports.

b. Calculations Department. At the request of the CDG, the linear aperture calculations which had been performed for the Design D magnet were extended to the Design C case. The results were consistent with anticipated scaling; sextupole moments remain the main source of smear in the two degree of freedom amplitude plot. The tracking calculations that were performed in the period May through July have been summarized in a technical memorandum by Norman Gelfand.

A one-day meeting was held on Saturday, July 13, to discuss accelerator experiments on the Tevatron with members of the CDG. Talks were given by Helen Edwards, Alex Chao, Rol Johnson, Ferdi Willeke, and Steve Peggs. Long and short term goals were discussed, and a limited set of measurements identified for possible attention before the shutdown at the end of September.

Fortunately, some of the measurements referred to in the preceding paragraph are performed in the normal course of events during Tevatron studies. The performance of the transverse dampers was the subject of a series of measurements on July 16. The beam was kicked at 400 GeV on the 800-GeV ramp and flying wire profiles recorded with and without the dampers. It was interesting to observe that, without damping, some three seconds are required for the beam to resume its gaussian-like shape.

As an aftermath of his visit to the CDG in June, K.Y. Ng has written three reports relating to impedances in the SSC. They are titled, "An Investigation of the Skin Depth Effect of a Metallic Coating on a Ceramic Beampipe Inside a Kicker", "Impedances of the Shielded Bellows in the SSC and the Effects on Beam Stability", and, co-authored with Joseph Bisognano, "An Estimate of the Contributions of the Bellows to the Impedances and Beam Instabilities of the SSC."
c. The Photodesorption Experiment at NSLS for the SSC. On July 12 and 13, 1985, the cold beam tube was exposed to synchrotron light for the first time, and there was no abnormally large desorption of gas from its walls.

Only hydrogen and helium showed any difference in response between light on and light off. Helium was only seen after the cold tube was intentionally coated with a fraction of a monolayer of helium on the second day of the experiment.

Interpreting the light on/off difference as a true light desorption signal (hydrogen case) and making conservative estimates of the transmission probability through the hole in front of the analyzers, the following are tentative limits on gas desorption from the cold wall at 2.2 mrad and 100 mW/m of beam tube:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Room temperature equivalent pressure to give the same density</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
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<td>CO</td>
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<tr>
<td>CO₂</td>
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These numbers fulfill the specification for the SSC (< 1x10⁻⁹ Torr, nitrogen, room-temperature equivalent density), but as yet not with a large safety margin. Questions remain whether the hydrogen signal modulation with light on/off is true light-stimulated desorption or a heating effect on some surfaces.

Another run on August 8, 1985, is being prepared with one of the analyzers installed in the beam tube directly. If it can survive the light intensity, the various processes contributing to the neutrals signal might be better understood in order to learn if there is a true signal.

For the next run, to begin in September or early October, a light chopper and multiscaler photon counting system should be available, which will enable clean separation of the direct signal from heating effects.
C. LBL.

1. Magnet Models. During the July reporting period, the fabrication and assembly of D12C5 was completed. The magnet was installed in the Bldg. 58 cryostat and cooled down to operating temperature. Initial testing was started by the end of the month and test results are presented in another section of this report.

Fabrication and assembly work also continued on D12C6. The design of this magnet is very similar to D12C-5; both magnets use an all-Kapton cable insulating system, Nitronic 40 collars, and split-iron type yokes.

Initial fabrication of parts for magnet D12C7 was started. This magnet will utilize a Kapton/glass epoxy insulating system identical to that used at BNL on their 4.5 m series of magnets now under test. All other design features of D12C7 will be similar to D12C-5 and D12C6.

a. D12C5. In July, the following tasks were completed:

- Fabrication of G-10 coil end saddles.
- Fabrication of collar keys.
- Calibration of collar position indicator.
- Collar pack assemblies.
- Assembly and calibration of coil load cells.
- Assembly of inner and outer coil pairs on hard assembly mandrel.
- Collaring of coil assembly.
- Installation of end assembly and voltage taps.
- Installation of coil/collar assembly in yoke blocks.
- Installation of collar position indicators and instrumentation wiring.
- Installation of magnet in test cryostat.
- Cool down and testing started.

b. D12C6. In July, the following tasks were completed:

- Fabrication of G-10 end islands for inner and outer coils.
- Insulation of coil wedges.
- Mechanical size measurements of cable at 10,000 psi.
- Modification of coil load cell gauge blocks.
- Fabrication of coil assembly cones.
- Molding of coil end wedges.
- Forming of Kapton interlayer coil insulation.
- Fabrication of G-10 coil end saddles.
- Winding and curing of inner and outer layer coils.
- Mechanical size measurements of coils at 10,000 psi.
- Assembly and calibration of coil load cells.
- Assembly of inner and outer layer coils on hard assembly mandrel.
- Collaring of coil assembly.

2. Analysis

a. **POISSON Computer Program.** POISSON has been found to calculate inaccurately the field contribution from the iron under some conditions. Corrective measures have been taken, and improvement has been demonstrated.

   A paper on improved boundary conditions for programs such as POISSON, to be presented at MT-9, has been completed.

   Calculation of the effects of magnetization on field quality has continued.

b. **Magnet Cross-Section Design Program.** R. Fernow's program, formerly called MAG2PL, is now called PARTIAL KEYSTONE. The program has been used to design and analyze several cross sections for the SSC dipoles. Results are in good agreement with the microcomputer program, based on a simplified mathematical model of the cross section, developed by R. Meuser (LBL). Meuser's program is used to obtain rough designs quickly, which are refined using PARTIAL KEYSTONE.

   A package to permit drawing cross sections has been added to PARTIAL KEYSTONE, making it easier to detect impractical solutions.

3. Instrumentation and Measurements

   SSC model dipole D12C-4 was tested from July 1 to July 9, 1985. Model D12C5 was tested from July 29 to August 1. Both of these magnets use the stainless steel collars (Nitronic-40) and mechanically are identical except for a thin mid-plane shim added to D12C5 to improve the magnetic field.

   D12C4 has the best training behavior of this series: in HeI at 4.4K, the first quench occurred at 6.47 Tesla and the maximum of 6.63 Tesla was reached.
on the fourth quench. The presence of a vacuum leak prevented us from operating in HeII, but we were able to cool to about 2.2K. Only two quenches were done at this temperature and a central field of 7.4 Tesla was reached.

D12C5 has an outer layer conductor that carries several hundred amperes more than the corresponding cable in D12C4. As an assembly experiment, the prestress was lower in magnet D12C5. In HeI, at 4.4K, the first quench was only 5.7 Tesla, but the second quench was 6.4 Tesla. The limit reached was 6.8 Tesla, but the training behavior was somewhat slow (8 quenches). The vacuum leak mentioned above got worse and the lowest temperature we were able to reach was 3.3K. The one quench at that temperature occurred at 7.1 Tesla.

A summary of the training of various SSC dipole models at LBL is provided in Fig. 1.

4. Superconductor

Superconductor Developments. Both Supercon and IGC delivered samples from the first phase of their programs to fabricate fine filament NbTi. Supercon successfully extruded a production size (12 in. diam.) billet containing 4164 filaments. They processed wire to two sizes (0.0318 in. diam. with a 8µm filament diam. and 0.012 in. diam. with a 3µm filament size), and optimized the critical current by varying the heat treatment. The results showed $J_c$ (5T, 4.2K) values of 2950 A/mm$^2$ for both wires. These values, confirmed by BNL, are probably the highest yet achieved in a production-size billet.

IGC delivered samples from a 6 in. diam. billet produced under contract for LBL and samples from a 3.5 in. diam. billet produced on internal funding. The wire from the 6 in. billet had a $J_c$ (5T, 4.2K) of about 2600 A/mm$^2$ with a filament size of 5 µm and the wire from the 3.5 in. diam. billet had a $J_c$ value of about 2800 A/mm$^2$. These results from both IGC and Supercon
FIG. 1

TRAINING LBL–SSC DIPOLE MODELS

$B_0$ (tesla)

1.8 K  1.8 K  1.8 K

I  II  III  IV  V

N (Quench)
indicate that a fine filament, high \( J_c \) conductor is technically achievable. The remaining tasks are to select the best production approach and to establish the cost of fine filament NbTi. Work is underway at LBL, IGC, and Supercon in order to answer these remaining questions.
D. TAC.

1. Short Magnets

One single channel one meter magnet (TAC007) and one dual one meter magnet (TAC006) with all cryogenic shields and vacuum chamber have recently been completed. In addition, modification occurred on one single channel one meter magnet (GD1P). The GD1P is slightly different from the TAC007 because GD1P has old cable in the magnet. In particular, the correction coil winding is different by approximately 20 mils. This slight difference will have to be simulated by computer program. The magnet TAC006 with complete assembly was made mainly for finalizing the design on cryogenic shields and vacuum chamber. Slight modifications were made for the shield assembly; however, General Dynamics feels that it can easily complete the assembly of the 28 meter magnet with these simplified modifications.

2. Long Magnets

General Dynamics has completed the helium container which included the coils and iron for the first 28 meter magnet. It was found during this assembly that it was necessary to put more force in clamping the two magnet halves together than was anticipated. Once this modification was made the magnet closed completely. The next step on the magnet assembly is to mount the 28 meter long helium container onto the four supports which are sitting on surveyed monuments. At that point the alignment of the magnet can be checked. Next will be the attachment of cryogenic piping and shields and superinsulations before insertion into the vacuum chamber.
C. Project Cost Data

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<th>Figure</th>
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PROGRAM COSTS: 345 173 109 407 7671 5125

COMMITHENTS: 272

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PROGRAM COSTS: 276 91 108 472 4116 5095

ADJUSTMENT FROM PREVIOUS MONTHS: 150

COMMITHENTS: 228

EQUIPMENT: 447
### TABLE 3-3
FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER  
JULY 1985 COST REPORT (M$)

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**COMMITMENTS**
147.7

**EQUIPMENT**
25  25

### TABLE 3-4
LAWRENCE BERNEKEL LABORATORY - SUPERCOLLIDER  
JULY 1985 COST REPORT (M$)

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**COMMITMENTS**
98
### TABLE C-5
**TEXAS ACCELERATOR CENTER - SUPERCOLLIDER**
**JULY 1985 COST AND COMMITMENT REPORT (K$)**

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**PROGRAM COSTS**
- 102.6 737.5 39.4 504.5 2441.7 5000

*Does not include 1982 R & D obligation to General Dynamics Corp. for fabrication of long magnets*

---

### TABLE C-6
**PROGRAM SUMMARY - SUPERCOLLIDER**
**JULY 1985 COST REPORT (K$)**

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<th>PROGRAM ELEMENT</th>
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**TOTAL CSE PROGRAM COSTS**
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Fig. 1
2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

Fig. 2
Planned vs. Actual Costs for FY 1985

MONTH

FISCAL YEAR 1985

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Fig. 3
4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

- Monthly Plan Cost
- FY Cumul Plan
- Monthly Actual Cost
- FY Cumul Actual

MONTHLY $:

MONTH:
OCT31 NOV30 DEC31 JAN31 FEB28 MAR31 APR30 MAY31 JUN30 JUL31 AUG31 SEP31

FISCAL YEAR 1985

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Fig. 4
0.0 PROGRAM SUMMARY - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

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Fig. 6