Superconducting Super Collider Laboratory

SSC Monthly Report

September 1985
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A. Project Summary

The Magnet Selection Advisory Panel (MSAP), and its Consultants, were unanimous in their recommendation that a high field cosine theta, cold iron, single channel magnet be used as the basis for the SSC design. The report of the Panel, dated September 9, includes a statement signed jointly by the industrial consultants. A news release on this selection was issued on September 19, 1985.

An informal meeting, organized by Jim Cronin, University of Chicago, and Jack Sandweiss, Yale University, was held at LBL on September 26 and 27. In attendance were representatives of the high-energy physics community, including laboratory directors, elected officials of the DPF, and accelerator users organizations, and distinguished senior physicists (Nobelists, former laboratory directors, etc.). The purpose of the meeting was to hear about the progress of the SSC R&D program, especially the magnet type selection described above, and to re-examine the physics motivation and need for the SSC.

The Task Force on Detector R&D for the SSC held its first meeting on September 26 and 27. The members of the Task Force are A. Astbury, TRIUMF; B. Cox, Fermilab; F. Dydak, CERN; M. Gilchriese (Chairman) and D. Hartill, Cornell; H. Gordon and F. Paige, BNL; P. Grannis, Stony Brook; J. Jaros and P. Kunz, SLAC; T. Kondo, KEK; S. Loken and D. Nygren, LBL; S. Mori, Tsukuba; A. Selden, UC Santa Cruz; M. Shochet, Chicago; A. Wagner, Heidelberg; and S. Wojcicki, CDG. The major goal of the Task Force is to prepare a report reviewing the status of detector R&D that will be relevant to the SSC and to formulate recommendations for future directions and priorities of detector R&D for the SSC.

The major Accelerator Systems R&D for FY 1986 will involve the construction and operation of the Half-Cell Test. It has been decided to conduct these tests at Fermilab and negotiations have been going on with Fermilab to arrive at a mutually acceptable scope and design for the tests.

A third run of the cryogenic photon-induced gas desorption experiment was completed on September 25-29, only slightly interrupted by Hurricane Gloria. During this run a light chopper was installed in the upstream part of the beam line. This allowed for observation of the fast...
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A workshop was held on clustered interaction regions (IR) on September 4-6 at LBL. The purpose was to make a detailed comparison between the distributed IR design with a variety of clustered IR designs. It was concluded the clustered and distributed designs gave very comparable potential of performance, the clustered case being better in some features while the distributed case being better in other, although the differences are not overwhelming. A decision by the CDG is expected in the next month on whether to adopt clustered IR's and, if so, which variation to use. The study results are summarized in the report SSC-SR-1014.

A preliminary SSC parameters list is being created. The list uses the one-in-one cosine theta magnet design according to the magnet selection decision. The first round of this list is based on the Reference Designs Study and updated by the recent studies accumulated afterwards. Evolution of this list is expected to be an important activity in the coming months.

BNL. During the month of September, three 4.5 m Reference Design D dipoles were tested, including SLN-012, the fifth of six magnets comprising this particular series of magnets. Dipole SLN-013 is in the assembly state. Remaining activities centered on coil winding and other preparations for constructing several further short model dipoles sans dogboned ends, and preparation of tooling and components for the first full-length dipole also continued on schedule.

Fermilab. Cryostat design refinements continue. Preparations were made for the fabrication of cryostats and assembly of the first six high-field magnets. Quotations for some parts and materials were received in anticipation of placing orders in October. Factory space for magnet assembly was planned and preparation of the area was started. Work on coil development included the completion of one 1-meter model and winding of four others. Three magnets were tested.

LBL. Model magnets D12C-7 and D12C-8 with Kapton-epoxy/glass insulation were completed. D12C-7 was tested with excellent results; central field was 6.6 T after four quenches; the initial quench was at 6.0 T. D12C-8 will be tested at a later date. Improved strain-gauge configurations for in-coil stress measurements were developed, calibrated, and installed in magnet D12C-8. Significant improvements were made in computer codes for design and analyzing of magnet cross sections. POISSON has been improved and installed on the MFE X-MP CRAY.
The 19 filament composite hex rods and extrusion cans for the first two hydrostatic billets were completed. Strands with 5μm filaments were produced and wound into a 30-strand cable; this cable will be tested in a future 1-m model.

TAC. Operating at nominally 50% above normal to produce results for the magnet selection process, TAC constructed and tested more than 12 magnet models (1 meter and 7 meter) and is well underway with three 28-m magnets. Industry is involved as a major collaboration in the R&D of these long magnets.
B. Project Report

I. Central Design Group

Magnet Program. A major milestone in the design of the SSC was achieved in September with the announcement that the Magnet Selection Advisory Panel (MSAP) unanimously recommended the Design D high field, cosine theta, single channel type with cold iron magnet, one of five basic types being considered, as the preferred design for the SSC. This magnet was a collaborative effort between Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (Fermilab), and Lawrence Berkeley Laboratory (LBL).

The MSAP and its Consultants met at Berkeley August 25-28 to hear presentations, deliberate, and produce a first draft of their report. The report of the MSAP, dated September 9, includes a statement signed jointly by the industrial consultants. The cosine theta type design was favored by the Panel and Consultants for its well understood behavior and its predictable cost. High field was favored by the Panel for operational and cost reasons. SSC Central Design Group Director Maury Tigner, upon consultation with senior colleagues, accepted the recommendation of the Panel.

With style selection behind it, the community can move forward towards full-scale magnet models. It is expected that all of the institutions participating in the FY 85 program R&D will continue in FY 86, working together to develop the chosen style. In addition to building and testing full-scale dipole models, a number of other R&D items should be pursued in FY 1986:

- further superconductor and cable development
- optimization of magnetic measuring and warm testing techniques
- development of arc quadrupoles
- exploration of achievable gradients for IR quads
- optimization of low field corrections through bore tube winding, fine filaments, or other methods
- design and modeling of spool pieces
- measurement of quench propagation in full-length models
- exploration of low temperature operation
- optimization of coil design to minimize systematic multipoles
- optimization of iron and collar design
- exploration of $a_1$ and $b_1$ correction by shimming in the iron
- further minimization of training
- determination of random multipole correlation length
- cold radiation testing of high current diodes
- further optimization and modeling of the cryostat, including piping sites, suspension and insulation scheme, heat leak measurements.

On the planning side, work will soon be underway to make a non-site specific conceptual design and detailed cost estimate for submission to the DOE by April, 1986, and to the HEP community in time for the 1986 Snowmass meeting of the DPF.

**Conventional Systems.** During September Jim Sanford visited the two major Western European accelerator construction projects, HERA at DESY in Hamburg, Germany, and LEP at CERN in Geneva, Switzerland. Very fruitful discussions were held with principals involved in the design and construction of the projects. It was possible to visit both construction sites and to observe the tunneling machines in operation. The experience at both locations is very instructive for the design work for the SSC.

From September 4-6 the Group Leaders from the joint venture RTK visited the Fermilab site to gain some insight into the layout and operation of the superconducting accelerator facility. Fermilab personnel were most cooperative in sharing their experiences with the RTK personnel, as well as touring and explaining the various facilities. There were good exchanges with the Tevatron Construction Group, with the AD Cryogenics Group, and with the Magnet Facility personnel.

On September 6, Don Rose of RTK arranged for tours of 6.5 ft and 12 ft tunnels being bored in rock, part of the Chicago Tunnel and Reservoir Project (TARP). The 6.5 ft tunnel is nearing completion, while the TBM had just been
inserted into the 12 ft tunnel. It was an interesting opportunity to observe different phases of tunneling work.

On September 20-21, T. Toohig attended the Underground Tunneling Research Council (UTRC) conference in Ithaca, New York. R. Matyas made a presentation on the SSC as part of a panel discussion on future directions in underground construction. September 20 was spent in touring the extensive network of tunnels being constructed in shale in Rochester as part of their combined flood-water and sewage control project. During the conference, T. Toohig met with representatives of the National Research Council Canada to discuss a cooperative project in developing the technology of continuously slip-forming tunnel linings. This development could have a potential for cost savings in the construction of the SSC tunnels. Dr. Boyce McDaniel, President of the URA Board of Overseers, toured L. Temple (DOE) and T. Toohig through the CESR tunnel at Cornell University on the September 21 as an example of a working accelerator in a tunnel.

On 25 September a presentation was made to the HEPAP Subpanel on Advanced Accelerator Technology relative to innovative possibilities in tunneling technology for construction of the SSC. This presentation drew heavily on the material acquired by RTK from the Deep Basing projects for the ICBM and MX projects.

Also on the 25th, a group of underground specialists from RTK visited a tunneling site in the Sierras near the town of Strawberry, California. Average daily advances achieved are 140 ft/day, which is considered phenomenal, especially since the tunneling is in granite. The group were able to study the project and obtain much useful information. Most encouraging is that RTK personnel were subsequently able to successfully model the project on the new tunneling code being programmed for the SSC job which is based on definitive work from Norway.
Accelerator Systems. The main effort of the Accelerator Systems Division during September was in three areas: 1) Preparations for the writing of the Conceptual Design Report (CDR); 2) Outlining a program for the R&D for FY 1986; and 3) One more data run of the Photodesorption experiment.

A temporary organization of Accelerator Systems was started for the purpose of writing the CDR and managing the R&D for FY 1986. For the purposes of the CDR, the subsystems have been divided into four main groups: 1) Mechanical Systems (cryogenics, vacuum, magnet installation, correction elements, and spool pieces); 2) Electrical systems (main power supplies and quench protection, correction element power supplies and quench protection, control systems, rf systems and feedback, beam instrumentation); 3) Beam systems (beam injection, beam abort, beam loss calculations, interaction region design, external beams, operations); 4) Headquarters (safety systems, reliability and quality assurance, management of R&D, editorial functions).

During September, two physicists were hired for Accelerator Systems. Starting October 1, there will be seven members of the division who will remain at least through the completion of the CDR. These are D. Bintinger, D. Groom, M. Harrison, H. Kagan, P. Limon, M. McAshan, and D. Stork. In addition to these, a few more physicists, and a number of engineers from various laboratories, will assist in the detailed design work necessary for the CDR.

The major R&D for FY 1986 will involve the construction and operation of the Half-Cell Test. It has been decided to conduct these tests at Fermilab, and negotiations have been going on with Fermilab to arrive at a mutually acceptable scope and design for the tests. This test and other R&D work will be made part of the agreements with the R&D centers.
A third run of the cryogenic photon-induced gas desorption was completed on September 25 to 29, only slightly interrupted by Hurricane Gloria. During this run a light chopper was installed in the upstream part of the beam line. This allowed us to observe the fast part of the desorption process, in bins of 10 μs, in order to show that gas molecules are indeed desorbed by some fast process. This is shown in Fig. 1. Note that when the beam is turned off, there is a fast decrease in the desorption, followed by a slower decrease. The slower decrease is probably due to the fact that some of the molecules bounce around a number of times.

In addition to the chopper, data were taken with the VUV at two energies, 750 MeV (the normal energy) and 600 MeV. These correspond to photon characteristic energies of 570 eV and 250 eV, respectively. The last value corresponds to the photon characteristic energy in the SSC. The data are presently being analyzed. Data from a room temperature stainless steel tube were also taken. They are presently being analyzed, but they look quite different from the data taken earlier on aluminum. Since this will be the last run for a number of months, the equipment was disassembled and stored at BNL.

Accelerator Theory and Computation. A workshop was held on clustered interaction regions (IR) on Sept. 4-6 at LBL. The purpose was to make a detailed comparison between the distributed IR design with a variety of clustered IR designs. The workshop had two preliminary meetings on April 25 and on June 6 to define the issues to be studied. The participants are members of a clustered IR study group consisting of A. Chao, M. Furman, A. Garren, D. Groom, B. Leemann, P. Limon, S. Peggs, L. Schachinger, and T. Toohig, SSC; R. Talman, SSC/Cornell; A. Wrulich, SSC/LBL; E. Courant, BNL; D. Johnson, FNAL/SSC; W. Swanson, LBL; D. Neuffer, TAC; and K. Steffen, DESY. It was concluded in the workshop that, in all issues studied, the clustered and distributed designs gave very comparable potential of performance; the clustered
Fig. 1

- Hydrogen/750 MeV
- Lecroy Amp./rga A

channel number (80 μs/chan)
case is better in some features while the distributed case is better in others, although the differences are not overwhelming.

Since the clustered and the distributed options are quite comparable in the accelerator physics issues studied, and since there are conventional facilities gains to be made by clustering the IR's, the study group has made their recommendation to the CDG that a clustered design be taken as the current non-site specific conceptual design model. The group did not make a recommendation as to which particular clustering pattern to adopt but did point out the pros and cons of these variations. A decision by the CDG is expected in the next month on whether to adopt clustered IR's and, if so, which variation to use. The study results were summarized in the report SSC-SR-1014.

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Several accelerator physicists from the CDG participated in the Fermilab Tevatron antiproton studies during September. The operational experience of the Tevatron has intimate implications on the SSC design considerations, in particular the aperture requirements and various operational issues. CDG physicists participated in the operation of the Main Ring, the Tevatron, and the accumulator ring. They reported what they learned to the CDG in a seminar.
II. Laboratory Programs

A. BNL.

1. General

Analytical Studies. Computer analysis, using the POISSON code, of the 32 mm coil i.d., 2-in-1 SSC design was completed. The computed results agree pretty well with the measurements (model SBN-004) for both equal and unequal excitation in the two apertures. In the equal excitation case, the quadrupole component stays below $0.5 \times 10^{-4}$ both in calculations and in measurements—all the way from the field at injection to the field at the maximum energy (6.5 T). The shift in the sextupole component due to saturation was computed to be $17.7 \times 10^{-4}$; the measurements gave $17.6 \times 10^{-4}$. The agreement in other harmonics is also very good. In the unequal excitation cases, the effect on harmonics was examined at low field and at high field. In the low field case, the low field side was kept at injection and high field side at respectively 2, 3, 4, 5 times higher current. The quadrupole component remained $< 1 \times 10^{-4}$ units in all these cases; the measurement gave $1.3 \times 10^{-4}$ for $1:5$ ratio of current in the two apertures. All other harmonics remained practically unchanged in both calculations and in measurements. In the high field case, the current at the low field side was kept at 90% the value of that at the high field side. The calculations were carried out for the high field aperture at 5.2, 6.0, and 6.5 T, respectively. The measurements were done for the high field aperture at 5.2 and 6.5 T. Neither the calculations nor the measurements showed any change in harmonics due to unequal excitation for the high field case.

2. Model Magnets

a. 4.0 cm Aperture x 4.5 m Long Magnets.

As noted in the Summary Statement, the assembly and initial test of dipole SLN-012 was completed this month. This is a heavily instrumented dipole, equipped with multiple quench heaters and numerous
voltage taps, for measuring longitudinal and azimuthal quench propagation velocities.

- Initial assembly of SLN-013 was begun; however, the magnet has been plagued with numerous shorts at the lead end, resulting in a number of reassemblies. The source of the shorts is attributed to build-up of epoxy on the flared coil end. Upon removal of this excess epoxy, which results in high localized pressures, the shorts may disappear. Strain gauges for SLN-013 were calibrated at 4 K to repeat the coil stress measurements initially reported on SLN-011. The earlier results were confused, and by repeating the measurements it is hoped to acquire a more consistent record concerning loss of prestress on cooldown.

- Three inner and three outer coils have been completed for the straight-ended magnets. A fourth outer coil is presently being wound. Coil assembly is underway on the first two coil pairs. This operation includes filling of voids in coil ends between turns (with Alumina-loaded epoxy), applying insulation, soldering inner-to-outer coil transition, and filling "turn-around" region with "green putty." A scheme has been devised for insulating the lead end and internal splice of assembled magnets of this type. Other components for straight-ended magnets currently being re-worked in the Shops include end plates, collars for accommodating the conductor ramp yoke blocks, inner-to-outer solder joint ramp, brass spacer filler laminations for end collars, and center post. Laminated end spacers were designed and fabricated.

- Tests have been made to improve collar performance, with studies focusing on tooling modifications to limit prestress loss.

b. 4.0 cm Aperture x 16.6 m Long Magnets.

- Half shells for the yoke containment vessel sufficient for three long SSC dipoles were shipped to BNL on September 27.

- The design section has started layouts of a quadrupole adjustment of the collared coil mounted in the yoke.

- Details of all magnet parts are complete and in the Shops.

- All samples for the yoke laminations have been received and approved. Laminations sufficient for two long magnets are beginning to arrive at BNL.

- Kapton caps have been ordered with thickness increased to 3 mils, instead of 2 mils, in order to minimize the probability of midplane shorts.

- Extensive discussions regarding the interconnection region were conducted among Magnet Division staff and with our collaborators at Fermilab and LBL. Topics addressed included:
  a. Bellows for high vacuum beam tube
  b. Flexible electrical joints
c. Bus work
d. Single phase bellows
e. External piping and bellows
f. Heat shields
g. Assembly procedures
h. Welding clearances
i. Alignments
j. Cut-off tooling to disassemble a magnet from its neighbor.

3. Tooling and Facilities

a. **Coil Fabrication Tooling.**

- Mechanical assembly of the 17 meter coil winder is essentially complete. Electrical assembly of the winder will commence in October. Initially the unit will be operated under manual control.

- All drawings pertaining to the 16.6 m coil lifting rigs are complete and have been released to the Shops.

- Work continues in the design section on the assembly drawings and the interface with the form blocks for the oil heater and cooler for curing the coils.

b. **Coil and Yoke Assembly Tooling.**

- Coil assembly has been shifted from Bldg. 924 to Bldg. 905 due to the paucity of coil storage space in the former building.

- Work stations have been defined for unloading coils from mandrel/strongback and placement into storage boxes.

- Drawings for floor posts, table top, and compression gauge table parts have been forwarded to Central Shops for fabrication.

- Design and development continued of coil/magnet transport carts for buildings 924 and 902/905. All lifting and rigging hardware has been ordered. Similar devices have been designed to handle trim coils and transport them from the tunnel to building 902/905. A study of the tractive power required to transport these coils and magnets throughout these buildings is also being done. An order for two fork lifts capable of performing the required functions will be placed shortly.

- An incremental press based on a new concept has been designed and proposed for collar assembly. This press is similar in design to our existing curing press, in that the press is stationary. The disadvantage with this design is that it requires twice the length; the advantages are that the cylinders are not exposed and pressures are considerably lower, thus making the press safer.
c. Bore Tube and Trim Coil Tooling.

- Task 6 of the Multiwire contract has been completed, and all remaining 4.5 m coils have been delivered to BNL.

- The trim coil for SLN-014 has been completed, and assembly of the next for SLN-015 is under way.

- Bore tube related activities completed include the system for translating the bore tube over the surface plates and through the wrapping machine; electrical work for bore tube wrapper controls, power supply, and bore tube curing oven; alternative method of applying Teflon adhesive to the Kevlar of the bore tube.

- Prints of the bumper application device have been delivered to the Shops. Quotations are being prepared by the vendor for the new Kapton laminated bumpers.

- Conceptual work has started on a device to detect electrical and mechanical errors in a production run of SSC trim coils.

- Extensive tests have been carried out on the SSC bore tube order from Trent Tube. No leaks have been found; the tubes have, accordingly, been accepted.

- Tubes have been cleared, leak checked, wrapped in plastic, back filled with nitrogen and stored safely for use next year.

- Bore tube strongback tooling parts are being produced in the Laboratory Shops.

d. Magnet Test Facilities.

- Preparations were made for updating layouts of the end caps to be compatible with the current end design by Fermilab.

- Work continued on laying out the inflatable seal assembly and methods to carry the thrust load due to differential pressure between atmosphere and vacuum.

- Considerable progress was made on the MOLE in the following areas:
  a. Tests show an improvement in the speed control, although further work is needed to produce a reliable system;
  b. A heavier lead composite flywheel has been installed;
  c. Flexible shafts, 70 ft. long, have been ordered as an alternative to the air motor and harmonic drive;
  d. Work has started on a dynamic balance fixture for reducing errors in RPM due to vibration losses;
  e. Work has started on a DC dynamometer to check dynamic friction in individual MOLE components;
  f. Work in the various shops is continuing on the final MOLE design, and parts are arriving from vendors; quotations are being received from outside job shops to produce the harmonic drive system;
g. Gravity sensors for the final version have been completed and are undergoing tests at vendor.

4. Superconductor

Tooling.

- The support hardware mentioned in June's Monthly Report required for the "hand held" cable measuring device has been released to Shops for fabrication.

- Two "10-stack" measuring devices are in Shops for fabrication by November 1, 1985. These inspection fixtures are to be loaned to our cable manufacturing vendors to assure uniformity of cable measurement and inspection.

- The following items of tooling have been completed by our Shops and await manpower for assembly and test:
  a. Three lump detectors;
  b. Kapton wrapper machine modifications.

4. Tests and Measurements. Three 4.5 m Reference Design D dipoles were tested during the month. Tests on SLN-011 had begun during August and were concluded during the first part of the month. Next, testing on SLN-010 resumed. (Initial tests of SLN-010 during August were interrupted by tests of SLN-011.) The pause in the testing of SLN-010 provided an opportunity to study the effects of a thermal cycle. The magnet reached its previous field level after a couple of quenches. At the end of the month, initial tests on SLN-012 were made. This magnet is particularly interesting because it is instrumented to allow triggered quenches and direct measurement of quench velocities. Generally speaking, the test results obtained during September were similar to those obtained from earlier magnets, and were quite satisfactory. No testing took place during the last two days of the month due to Hurricane Gloria.

5. Cryogenic Systems. Engineering studies are continuing for the SSC Cryogenic System. An effort is being made to review and update, where possible, the earlier SSC Tech. Note No. 28 "Conceptual Design of a Cryogenic System for SSC Magnet D." A more detailed estimate of the expected power lead
losses did not reveal any significant difference from the published estimates. Only a slight difference is noted between the current D magnet design and the original heat load budget included in the note. There are no detailed estimates available for the heat loads of the quads or the spool pieces because there are no firm designs for their cryostats. It is expected that this information will prove useful as a departure point for the SSC Cryogenic System Workshop which is scheduled at LBL in October.

The first attempt at cooldown for the acceptance test of the 24.8 kW Helium Refrigerator occurred in the last week of August. A design problem in the labyrinth seals of the turboexpanders prevented the refrigerator from reaching its design temperature. Rotoflow, the subcontractor who built the expanders, has redesigned the seal area, remachined the seals and has personnel at BNL to reinstall the turbines. A run of the expanders to test the effect of the repair is expected during October. If this is successful, it will be followed by another cooldown attempt as soon as that can be scheduled.
B. FNAL.

1. Magnet Models

a. 5 cm 824 Dipole Dry Winding.

- SJ-1007 was completed (i.e., collared) on September 19, 1985. This magnet uses the insulating scheme developed for SJ-1006. Although the magnet was collared successfully in terms of layer-to-layer shorts, work was abandoned due to severe insulation damage caused by an errantly positioned strain gauge.

- SJ-1008 commenced winding on September 20, 1985, and was completed on September 28, 1985. This magnet also used the SJ-1006 insulation scheme and assembly went quite smoothly.

- SJ-1009 was begun on September 28, 1985, with completion scheduled for October 6, 1985.

b. 5 cm 824 Dipole, Wet Winding. Coils for SK-1003, 1004, and 1005 were completed and measured. Coil size is very uniform (< 0.003 in.). Assembly of SK-1003 was begun on September 27, 1985, and was complete on October 8, 1985.

c. 4 cm Design D (Dry Winding). DA-1002 winding is completed and assembly is underway. Completion is for October 7, 1985. The cable in this magnet is proper in terms of filament numbers and Cu to SC ratio. It was made to Design D specifications which considered Kapton plus glass insulation. Since this magnet uses only Kapton and the insulation build can only be varied in 0.001 in. increments, the coil preload will be excessive (> 13 kpsi) as was the case for DA-1001.

The cable for DA-1003 is being processed at LBL to a new set of dimensions tailored to the all Kapton insulation. The inner cable has been received and will be measured with and without insulation. The outer cable delivery is tentatively scheduled for October 11, 1985.

d. Model Testing.

- There have been three SSC Design B coils measured during September. Two coils were dry wound, SJ1001 and SJ1006. One coil was a wet wound, SK1002.
The quench performance of magnet SK1002 was excellent. The first quench was over 5.0T, the second over 5.5T, and the third almost 6.0T, which is within 100 amps of short sample.

A cold iron Tevatron collared coil assembly was tested, which is to be used to make long cable sample measurements. The cold iron Tevatron collared coil assembly, RB1001-Fe, obtained a central field of 5.96T at 4.3K. Short sample cable and strand data was taken for various SSC and Tevatron conductor configurations during the month of September.

The magnet measuring system software has been improved to a point that harmonics can be taken and plotted within an hour thereby enabling one to investigate interesting and surprising phenomena on the same cooldown.

2. Conductor Development

The revised measuring head has been completed and is currently being inspected using the Cordax. Initial trials using solid steel masters configured to the nominal cable dimension indicates the angle of the masters can be repetitively measured to within 0.17 milliradians. The Cordax will be used to verify the size of all contemplated set masters. The head will be installed in the cable line the week of October 6, 1985. Modifications are contemplated to increase the cable loading range during measuring from 0-2,000 psi to 0-25,000 psi. This will not impact on the initial startup at 0-2,000 psi range measurements.

3. Cryostat Development

a. Suspension R&D. The analysis of the measurement data for the thermal intercept linkage effectiveness of the Magnetic Effects Model and the Heat Leak Models is complete. The analysis indicates that the temperature difference across the linkage as measured in the Suspension Heat Leak Dewar is greater than that measured in the Magnetic Effects Model. The data also indicate that when the cold end of the linkage is operated at 10K, a simulation of the Heat Leak Model operating point, the intercept on the support post runs at approximately 20K. The remeasured heat leak, under these conditions, to 4.5K
is 86 mW per support. The measurements confirm that the approach used to predict the heat leak for the Heat Leak Model is valid, an intercept temperature of 20K was assumed and the heat leak to 4.5K was taken to be 88 mW. Following the measurements, the test apparatus was carefully disassembled and studied in order to understand the difference in the temperature drops between the Magnetic Effects Model and this measurement. The reason for the difference is felt to be the inconsistency in the wetting of the solder joint between the copper braid thermal linkage and the aluminum end connections. Studies have begun to develop an improved thermal linkage with a reliable joint between the flexible member and its end connections. At present aluminum braiding or bundles of parallel conductor with welded end connections are being studied.

A re-entrant post for thermal evaluation has been instrumented and is being installed in the Suspension Heat Leak Dewar. The initial measurements will establish the temperature profile and the heat leak when the intercepts are connected in an "ideal" fashion. Subsequent to the measurement, the post will be remeasured with intercepts using thermal linkages identical to those to be employed in the "long" high field magnet models.

The flexural testing of the re-entrant post has begun. The purpose of the test will be to develop the deflection versus load characteristics for the post and determine the ability of the post to withstand a 1 g lateral load.

The measurement of the creep characteristics of the shrink fit joints continues. At least one month's more data are needed to permit the first extrapolation to a twenty year creep effect.

The testing of the creep of G10 tubes in compression has been delayed due to thermal problems in the test apparatus. This test apparatus is being revised to reduce the thermal mass of the test section.
Aluminum to stainless transition joints, received from a vendor, have been evaluated for their vacuum leak tightness after repeated immersions at liquid nitrogen temperature. Preparations are underway to determine their pressure integrity at liquid nitrogen temperature with a 20 atmosphere internal pressure.

b. Cryostat Design. The detailed design of a support post of an integral shipping restraint continues. The design indicates that, for a conservatively stressed restraint member, the overall diameter for the support may grow by = 1 in. The effect of the loading as transferred from the restraint to the vacuum vessel is being considered. It is planned to finalize the details of the post so that components can be procured to obtain an accelerated test and evaluation program. It is planned to employ this post in the first long high field dipole models.

Work continues on the specification of the interconnections. Considerable interfacing has occurred between Fermilab and BNL and progress is being made in this area. A two-day workshop to discuss matters pertaining to the long magnet models was conducted at Fermilab. The interconnection region was discussed thoroughly.

The detailed planning for the production of long magnets continues. Procurement of certain long lead items has begun. A detailed factory layout has been developed to produce the magnets in the Industrial Center Building and the space is being readied for occupancy by mid-fall 1985. A draft manufacturing procedure has been developed including procedures, personnel, and scheduling. The manufacturing plan is being subjected to in-house review at this time.
Consultant work packages have been developed for analysis of the SSC cryostat. At present, five individual tasks have been detailed and are as follows:

1. Cryostat structural analysis
2. Cryostat failure mode analysis
3. Thermal performance evaluations
4. Vacuum vessel material
5. Multilayer insulation improvements

The use of a component transporter is being evaluated. A transporter would be used to transport long components for the long magnet models both off site and on site. It is hoped that the development of this transporter can be coordinated with the Brookhaven effort to enable the gaining of transportation experience in the transport of the single phase assemblies from BNL to Fermilab. It is planned to instrument the loads to obtain a dynamic record of their shipment.

Liaison has begun with Intermagnetics General Corporation to learn of the procedures for the design of mobile superconducting magnet cryostats for magnetic resonance imaging systems. The design requirements of these systems is very similar to the SSC cryostat in that a cryostat that is very reliable, has high thermal efficiency, built in one location and traveled over the road and expected to be function properly at the installation point. The firm has done extensive work in the consideration of shipping and handling criteria, developing a methodology for a cryostat and the conduct of an experimental program to evaluate components and completed assemblies.

4. Accelerator Physics

a. The Photodesorption Experiment at NSLS for the SSC. On September 28 and 29 desorption data were taken on the cold beam tube. The cryostat was equipped with the two quadrupole mass spectrometers in the standard configuration, where one looks at neutrals emerging from the illuminated strip of the cold tube, and the other looks at right angles.
As a first measurement, an estimate of the amount of UV light bouncing off the cold walls and emerging from the downstream opening of the cold tube was obtained. Using the pressure rise in the warm end space as a measure, the effect of direct illumination (with the cryostat in the forward orientation) was compared to that of the reflected light. To the degree that warm surface desorption provides a good weighting of the light spectrum for estimating the desorption from cold surfaces, it was found that only about 10% of the incident radiation escapes through the downstream opening, reassuring us that the cryostat tube was long enough to encompass the whole light scattering cascade.

Data were then taken on hydrogen using a newly installed light chopper in an effort to distinguish direct neutral release from any release by beam heating. The light chopper opens the beam line at a rate of 120 openings per second, at about 50% duty factor. The mass spectrometers are operated in ion counting mode, where the SEM gain is raised to the point where individual ions trigger a discriminator. A multiscaler unit, synchronized to the phase of the light chopper, recorded the time spectra. With an electrom beam of 300 mA incident at 11 mrad (corresponding to approximately 10 times the power density expected at the SSC), a 5% modulation of the counting rate between "light on" and "light off" was obtained, indicating that real and instantaneous gas desorption was detected.

The measurements were obtained at two electron beam energies, i.e., 650 MeV and 750 MeV, where the lower energy delivers photons with a characteristic energy matching that of the SSC at 20 TeV.

b. Progress on Design D Transmission Line Study. A Technical Memo titled "Initial Estimate of Transmission Line Effects in SSC Design D Magnets" is about 80% completed. The abstract and introduction from this paper are given below:
Abstract

The response of the SSC accelerator magnet string to transient excitation from the power supply is considered. Some criteria for the selection of the optimum damping resistors for the SSC magnets are discussed. Once the damping resistors are chosen, the transient response of the load to power supply transients, including the effect of the power supply filter is analyzed. A comparative analysis is made of the differences between two possible configurations in the distribution of the magnets (with and without a return bus).

Introduction

Superconducting magnet strings have electrical properties similar to signal transmission lines. Voltages from the power supply cause a 'slow' electrical wave to propagate along the string, resulting in a spatial variation of currents in the magnets during the response time. These waves do not typically see a characteristic impedance termination, so reflections add to the original signal, causing a standing-wave pattern of current and voltage in the string. The eddy current losses in the magnets eventually damp this response, but in order to reduce the effect of this response on the accelerator operation to an acceptable level, it is usually necessary to provide some external damping resistance.

- Preliminary computer output from SPICE analyses done for this study have been sent to the Central Design Group (P. Limon).

- Cases are included for two values of damping resistance:

1. 25.5 ohms/dipole - suitable for minimizing the influence of 120 Hz ripple, as used in the Energy Saver.

2. 6.25 ohms/dipole - suitable to damp the natural 33 Hz resonance of the magnet string.

- The optimum value for an actual design is probably somewhere in the these two values. One has to trade off the damping performance desired with power dissipation and shunt current effects when the actual ramping voltage to be used is better known. An estimate of the eddy current effect inherent to the magnets has been included.

- Since we do not know what actual coil and bus configuration is to be used, we analyzed two cases:
1. A global return bus system in which all inductance is on the bus connected to the power supply terminals with a stabilized return bus outside the magnetic field running the total length of the sector.

2. A "split-bus" system in which half of the inductance is on to busses (either as in one of H. Edwards' variations of SSC magnet design, or with alternations of coils and return busses as in the Energy Saver) assuming that the effective current contributing to the magnetic field is the sum of the currents in the two busses.

This latter case shows an interesting compensation effect, i.e., the sum of the magnet currents in the two busses varies less with distance from the power supply. How practical this possible compensation is will of course depend on the viability of a split bus magnet design or whether the effect on the beam can be integrated over the span of several magnets with their coils distributed between the two busses.

c. Preliminary Results of Two-Phase Helium Tests. The preliminary results of the two-phase helium tests show that

- Saturated liquid in a venturi does not obey the normal flow squared relationship of differential pressure versus mass flow rate, but follows a higher order one due to flashing in the throat. This in turn produces premature choking of the venturi.

- Stratified flow occurs at much higher velocities than predicted by the Baker diagram (several orders of magnitude). We were not able on this run to produce high enough steady state flow to find any boundaries.

For detailed information see FNAL SSC CRYO 85-9.
C. LBL.

1. Magnet Models. Magnet D12C7 and D12C8 were completed during the month of September. These one meter long magnets are identical and utilize a Kapton plus epoxy/glass insulation system identical to that being used at BNL. Fabrication of components for these magnets has proceeded well. Winding and curing of the coils was accomplished without any problems. The dimensions of the finished coils were very similar and within a few mils of the desired size.

D12C7 was completed on September 16th and then installed in the Bldg. 58 cryostat for magnetic testing. Preliminary test results are presented in Section D of this report. D12C8 was completed on September 25th and will be cold tested as soon as the Bldg. 58 cryostat becomes available.

a. D12C7. In September, the following tasks were completed:

- Collaring of the coil assembly.
- Completion of the end assembly and the installation of instrumentation wiring and voltage taps.
- Installation of the collared coil assembly in the yoke blocks.
- Installation of the collar position indicators and completion of the coil lead splices.

During the collaring operation, we encountered minor problems in selecting the proper thickness pole shims. This resulted in a larger preload on the outer coil layer than on the inner coil layer. Our "as collared" preload on the inner coil was only 5000 psi as compared to a desired preload of about 9000 psi.

b. D12C8 Status. In September, the following tasks were completed:

- Winding and curing of the outer layer coils.
- Assembly of the inner and outer coil layers on the assembly mandrel.
- Collaring of the coil assembly.
- Installation of the end assembly instrumentation wiring, voltage taps and end insulators.
- Installation of the collared coil assembly in the yoke blocks.
- Installation of the collar position indicators and the completion of the coil lead splices.
Collaring of this coil assembly went very well and we achieved and "as collared" preload of about 9000 psi in both coil layers. D12C8 mechanical assembly was completed on September 25 and it will be cold tested in Bldg. 58 as soon as the cryostat is available.

2. Analysis

a. Improvements to the code POISSON. A paper was presented at the Ninth International Conference on Magnet Technology, Zurich, Switzerland, "Incorporation of Boundary Condition into the Program POISSON," by S. Caspi, M. Helm, and L. J. Laslett (LBL-19172; SSC-MAG Note-51).

b. POISSON work falls into several main classes:

1) Translator - The HP1000-to-CRAY Fortran translator was completed. This tool takes care of incompatibilities between the two systems' FORTRAN compilers, eliminating the need for hand labor and obviating the requirement for multiple versions of the source code. This tool will be used on other codes as needed. In principle it can be adapted to port VAX FORTRAN code also.

2) Sets of libraries were developed to allow POISSON to expand (more regions, points, better relaxation, etc.) at some future date, and to allow POISSON to take care of system features (file system, timing, backup, interactive, etc.) and to ease "porting" to strange systems.

3) The POISSON family codes POISSON, LATTICE, were ported to the MFE X-HP CRAY and demonstrated to work to our satisfaction. A practical production code would require some further work to reduce excessive charges for CPU memory usage and some user-oriented odds and ends. Particularly crying is the need for some graphical output. However, a version of TEKPLOT at LBL uses a graphics package available at MFE. (Not yet implemented.)

c) New cross section work.

1) The conductor orientation in PARTIALKEYSTONE is now variable. (Previously, the conductor block was constrained to be radial; now it can be tilted.)

2) An analysis code has been developed to complement the design code PARTIALKEYSTONE. The analysis code predicts multipoles of a cross section based on such mechanical measurements as are available. Analysis gives reasonably good agreement with experiment, particularly at higher order multipoles, but we are continuing to investigate disparities.
3) Several new cross-section designs have been proposed, iterated upon, and are being considered as possible magnet designs. A procedure has been developed for producing cross-section designs.

3. Instrumentation and Measurements

SSC model dipole D-12C-7 was tested from September 17-27, 1985. The major difference in this magnet from the previous magnets in the series is the use of BNL insulation on the conductors; glass plus Kapton rather than two layers of Kapton. The first quench in HeI occurred at 6.0 tesla, 6.4 tesla on the second quench, and the peak of 6.6 tesla on the fourth quench— an excellent training behavior. Three of the four quenches occurred in the outer layer. The magnetic field quality is slightly better than our preceding model, D-12C-6, and is about the same as the corresponding BNL dipole models.

Lower temperature operation was limited by a persistent vacuum leak to approximately 3.3K, at which temperature a central dipole field of 7.4 tesla was reached. A re-testing, after a system warmup, will be carried out next month. A repair plan to correct the system vacuum leak in the next one or two month has been arranged.

4. Superconductor

During September, essentially all components required for two experimental hydrostatic extrusion billets were completed. These include 19 filament composite hex rods, copper cans, copper nose pieces, and copper tail pieces. These components will be assembled and welded during October in preparation for extrusion in November.

Samples of the first 30-strand cable with 5 μm diameter filaments have been made and are being evaluated. If the results of critical current tests are acceptable, enough cable for two 1-m model magnets will be fabricated. Other cabling activity included fabrication of cable for the Fermilab dry-wound model dipoles. We are collaborating with Fermilab personnel in the
development of more precise cable measuring techniques which are necessary for cable used in dry-wound magnets.
D. TAC.

Short Magnets

TAC magnets have been operated up to 3.3 T. No quenches occur below this level for the final magnet design. The multipoles (as presented to MSAP) for these magnets are generally sufficient for good SSC operation. This has been verified by TAC and CDG calculations. There are minor modifications that will be implemented to improve the skew quadrupole component.

Long Magnets

The first 28-m magnet at General Dynamics is nearing completion. Delivery is expected about November 1 when testing can begin.
### SSC Program Table

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<tr>
<th>SSC Program</th>
<th>Table</th>
<th>Figure</th>
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### TABLE C-1

CENTRAL DESIGN GROUP - SUPERCOLLIDER
SEPTEMBER 1985 COST REPORT (K$)

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<th>PROGRAM ELEMENT</th>
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### TABLE C-2

BROOKHAVEN NATIONAL LABORATORY - SUPERCOLLIDER
SEPTEMBER 1985 COST REPORT (K$)

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**TABLE C-3**

FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER

SEPTEMBER 1985 COST REPORT (K$)

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**TABLE C-4**

LAWRENCE BERKELEY LABORATORY - SUPERCOLLIDER

SEPTEMBER 1985 COST REPORT (K$)

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TEXAS ACCELERATOR CENTER - SUPERCOLLIDER
SEPTEMBER 1985 COST AND COMMITMENT REPORT (K$)

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PROGRAM COSTS
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*Does not include $668 K obligation to General Dynamics Corp. for fabrication of long magnets

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

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TOTAL SSC PROGRAM COSTS
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1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

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

MONTHLY K$

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Fig. 1
2.0 BROOKHAVEN NAT' L LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

Fig. 2
3.0 FERMI NAT’L ACCEL LAB - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

**Fig. 3**
Planned vs. Actual Costs for FY 1985

MONTHLY K$

FISCAL YEAR 1985

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Fig. 4
5.0 TEXAS ACCELERATOR CENTER - SUPERCOLLIDER

Planned vs. Actual Costs for FY 1985

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Fig. 5