US LHC Accelerator Project
Progress Report, 2nd Quarter FY 2001
8 May 2001
J. Strait, Project Manager

I. Summary

Good technical progress continues across the Project. Cooldown of the prototype quadrupole began on 30 March. The cold mass assembly of the first 3 D1 dipoles is nearing completion. Design of the feedboxes is progressing vigorously, and large procurements for the IR absorbers are proceeding according to schedule.

The project has an unfavorable cost variance of -$5.6M (-10%), $1.5M worse than 3 months ago. This is dominated by a -$1.3M variance in dipole magnet production materials. The schedule variance is -$5.1M (-8%), $0.5M worse than last quarter. This is dominated by the dipoles and feedboxes, with partially mitigating positive variances in the quadrupole and absorber tasks. Based on an earned value of $57.1M, the project is 59% complete. The EAC remains at $103.5M. However a new bottoms-up estimate to completion has been developed and is currently under review; it will be presented in the next quarterly report.

The prototype quadrupole was completed and cooldown for initial testing was begun on 30 March. Cable production is proceeding well and industrially produced cable is now being wound into coils that will be for either the first production quadrupole or the second prototype, depending on the performance of the first prototype. The Engineering Design Review for the LQX cryoassembly was conducted on 12 March, and the design was approved. A series of monthly teleconferences between Fermilab and KEK has been initiated to discuss the integration of the KEK quadrupoles into the LQX cryoassemblies.

Dipole magnet production continues. Collaring, shell welding and end plate welding are complete on the first three of five D1s. Assembly of the first D2 is on hold after shell welding and before end plate welding until the required quench heater wire arrives. The order for the D1 cryostats has been placed, and one for the D2, D3 and D4 cryostats is expected to be place in April. Design work continues on the D3 and D4 dipoles, and a successful Interim Design Review for these magnets was conducted on 13 March.

Design for the cryogenic feedboxes is proceeding well. Three dimensional models are nearly complete, and detailed drawings are now being made from them. The Engineering Design Review was conducted on 14 March and the designs were endorsed. Pirelli has been given the go ahead to produce the first pair of HTS leads, which will be tested at CERN in July.

Procurements for the large steel and copper pieces for the IR absorbers are proceeding on schedule and first deliveries are expected in April. Production assembly planning is proceeding, and final design modifications are being finished on the TAN and TAS vacuum chambers and the TAS alignment and mounting system.

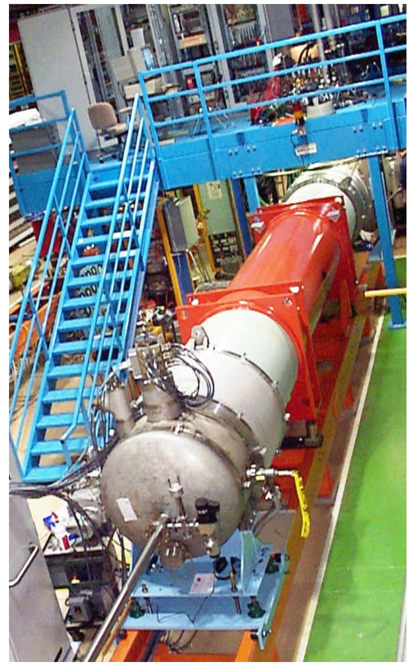
A new agreement has been reached with CERN on the number and rate of superconducting cable tests, and on the method of accounting tests against the agreed number. Production cable samples are being delivered and tested, although at a slower rate than originally planned.

Accelerator physics effort has centered on the electron cloud simulations, impedance calculations for the TAN beam chamber, beam-beam effects, optics for 2nd generation final focus systems, and energy deposition in the insertions.

II. Technical Status

1.1.1 IR quadrupoles

The prototype quadrupole cold mass and cryostat (Q2P1) was completed and installed on the test stand (see figure at right). The cryostat assembly process went very well with no major difficulties. Assembly of the magnet test stand and associated test systems were completed. After the magnet was connected to the test stand, several weeks were spent finding and fixing leaks before cool down could begin on March 30. During this time commissioning of the test stand and power systems took place.



Drawings for the production MQXB cold mass are essentially complete, and internal engineering specifications and travelers are 80% complete. Detailed design of the three different production cryostats is proceeding. Production cryostat tooling is now being set up; only some was available for the Q2P1 assembly, and some ad hoc tooling was used for it. The Q2P1 travelers were finished during the assembly process, and will serve as templates for production travelers. A production QA plan has been prepared and is under review.

Cable production at New England Electric Wire (NEEW) is proceeding well, and cable from NEEW is now being used for winding coils. Outstanding issues remain with the quantity of cable required, and the total inventory after completion of cabling on both the inner and outer cable. It appears that we will have to buy one more billet of inner wire, and this will probably be cabled by LBNL. Other vendor deliveries are proceeding well

Design continues on the Q1-Q2 and Q2-Q3 interconnection areas. A mockup is being built, which includes the bus, expansion joint, splices and correction coils, to prove the viability of the design. There is presently no bus on the first prototype. It will be added when the Q2a-Q2b assembly is completed later this year.

The Engineering Design Review for the LQX cryo-assembly, concentrating on the cryostat design and on the joining of the various magnets – KEK and Fermilab quadrupoles and CERN-provided correction coils – into complete cold mass assemblies, was held at CERN on March 12. Overall the review went very well, and having the prototype finished was certainly an advantage. The design was approved, and a significant number of detailed recommendations were made. Outstanding technical issues in the cryostat include: uncertainties in the position of beam position monitors in production magnets, which although not an impediment now, will preclude completing production magnet and interconnect drawings until these uncertainties are resolved; determination of the requirements on the beam tube liners and absorbers; and the radiation hardness of the slide material used in the cold mass support which may be marginal for the lifetime expected for these magnets. A report on the EDR is expected to be issued in May.

1.1.2 Interaction Region Dipoles / 1.2.1. RF Region Dipoles

Magnet production continues. Cable has been wrapped for 71 production coils and parts are completed for 85 coils. All the D1 magnet coils have been wound and cured. All beam tubes have been received from CERN and wrapped. All flex joints are completed. The first three D1 magnets were successfully collared (see figure at right), although some difficulty was experienced with each due to the very small clearance (~0.15 mm) between the beam tube and the coil. Yoke Collaring, shell welding and end plate welding are complete on magnets 1 through 3. Cradle welding is complete on magnets 1 and 2. The shell of the first D2 magnet was welded in December, but progress on this magnet was halted until the wire for quench heater leads arrived in March.

The vendor of the cryostat vacuum vessels for the D1 magnets ordered a steel that is commonly used in the US, but does not meet the low-temperature impact toughness requirement given in the purchase specification. Substantial time was spent with the vendor researching materials and clarifying specifications. Agreement was reached with CERN to relax, for the D1 only, the testing temperature from -50C to -30C, and the vendor was able to meet this relaxed specification. As a result, delivery of the cryostats will be delayed by at least two months.

The engineering of liquid presence indicators for the D1 phase separators was completed. D1 electro/mechanical design is complete and the assembly drawings are released. D2 magnet assembly design continues, ahead of the production need dates. Detail drawings are complete and assembly drawing are underway. Work has started on the instrumentation lead routing through the cryostat. The D2 electro/mechanical assembly drawing is released. The D2 cold mass assembly drawing is released. D2 mini-QQS design continues; detail drawings are complete and the assembly drawing is underway. D1 and D2 Interface Specifications were approved and released in the CERN EDMS.

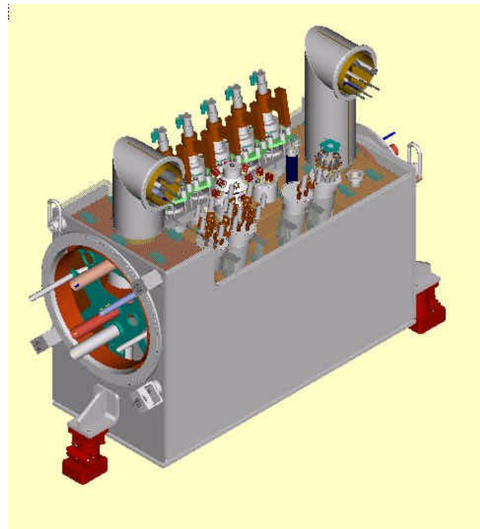
D3 and D4 cryostat drawings are released. D4A Electro/Mechanical Assembly design continues and detail drawings are 60% complete. An Interim Design Review of the D3 and D4 Magnets and held at CERN in March, and the design was found to be on track. The final report is expected to be issued in May. The Engineering Design Review will be held later in the year.

The design work for the Horizontal Test Facility (HTF) is complete and assembly has begun. The Cryostat Insertion Fixture design is complete.

<u>1.1.3 Cryogenic lead and feed boxes</u>

Design of the DFBX feedboxes is proceeding vigorously, with 3-D models being made of all 8 variants. Detailed drawings are now being produced from the models. Work is concentrating on the DFBXC, which will be used at the left side of IR2 and which includes all features that exist in any of the boxes. The 3-D models of the internal cryogenic piping for all 8 DFBX is complete, and a set of drawings for DFBXC has been produced from the model. Detailed design of the DFBX vacuum box and liquid helium vessel chamber is nearly complete. The thermal shield model for DFBXC is complete and a set of drawings has been produced from the model. The cryogenic piping models include the QRL interconnect fittings; the LQX and LBX interconnect fittings are still being developed. Pirelli provided a CAD file of the current lead that fit nicely in the 3-D model.

The feedbox Engineering Design Review (EDR) that was held at CERN On Mar. 14, 2001 concentrated on DFBXC (see figure at right). The design was approved, and the final report is expected to be issued in May. Complete drafts of all of the interface specifications are under review by the Project Management office, and all have been circulating at CERN prior to submitting them officially.



Pirelli delivered the 7500 A HTS current lead drawings in late January. Following review of the drawings and discussion with Pirelli, authorization to proceed with the first pair of leads was given on 13 February. Pirelli will ship the first pair directly to CERN for testing at the end of June. LBNL has designed modifications to the CERN HTS lead testing facility for the 7500 A leads. Detailed design work for the modification is underway and fabrication will begin soon.

R&D on the design of the lambda plate continues. Two versions have been constructed and both head unacceptable leaks. A third model, which incorporates the lessons learned from the first two, as well as CERN experience gained at the EDR, is being prepared.

<u>1.1.4 IR absorbers</u>

Procurements for the large steel components of the TAN and for the TAN and TAS coppers absorbers are proceeding on schedule with deliveries for first articles expected in April. Planning for the assembly of these devices at LBNL continues. Some design details are still being completed.

The TAN vacuum chamber was redesigned using OFS Copper ASTM C10700 (a copper alloy containing 0.1% silver) for the beam tube material. The use of this alloy is required by the CERN desire to coat the tubes with low activation temperature non-evaporable getter (NEG), which increases the beam tube temperature requirement from 150C to 200C. In reality the existing data for this NEG material indicates an activation temperature of 250C may be desirable as the number of activation cycles and amount of adsorbed gases increases with accelerator operation. The chosen material shows less annealing and loss of strength than OFHC at these higher bakeout temperatures, while still having high conductivity. Initial cost estimates for using this material were received.

CERN is progressing on the design of a telemanipulator for remote handling of the TAS flange facing the IP. This requires some changes in the design of the TAS beam tube. A favorable outcome is that the TAS beam tubes for IP1 and IP5 will now be identical. The vacuum chamber design is currently up to date, but the results of the first test of the telemanipulator may require more design changes.

The redesign of the TAS alignment mounting system was completed. Details were presented at a videoconference with CERN. Updates to the TAS interface drawings and layouts were completed and uploaded to the CDD. These updated drawings reflect the cumulative changes in the TAS design since December 2000.

The impedance of the ionization chamber for the IR luminosity instrumentation was analyzed, and the cause of the pulse broadening has been determined to be excessive inductance and capacitance in the circuit board that connects the chamber plates. A new prototype is being designed to reduce the connection inductance and capacitance. A concept has been developed to simulate the charge flow seen with real particle showers. Using this concept it should be possible to verify that <25 ns pulse width can be achieved.

1.1.5 IR System Design

A series of monthly teleconferences between Fermilab and KEK has been started to discuss integration of the KEK quadrupoles into the cryoassemblies for which Fermilab is responsible. Two such meetings took place this quarter and have proved valuable. The annual CERN-Fermilab-KEK collaboration meeting on the inner triplet system is planned for early April.

The design of the routing of the buses in the Q2 end domes is being done using 3-D models and a full scale mock-up of the Q2-Q3 interconnect region. The prototype magnet provided a good opportunity to test these ideas, as the routing for the leads is very similar to that of the Q2b production magnets. A 60 mm long prototype of the bus high current bus assembly to be used in the KEK Q3 magnet was constructed and will be taken to KEK in April for a “test fit” on their prototype. For the corrector bus work, the CERN ultrasonic welder should work within our layout. The high current bus, however, does not seem to be well suited to the CERN inductive soldering machine. Fermilab is designing a soldering fixture to make this connection and has offered to provide it to CERN. CERN has proposed that Fermilab send them a length of bus to practice making this solder connection.

Work is continuing on the design of the TAS2 and TAS3 absorber systems. Most of the current design work deals with mechanical aspects of the systems: mounting and installation of the absorber support systems, installation of the absorbers, and assembly methods and procedures. The design of the TAS2 has been complicated by the CERN proposal to move a beam position monitor into the interconnect region occupied by TAS2.

1.3.1 Superconductor Testing

A new agreement has been reached with CERN on the number and rate of testing, and on the method of accounting tests against the agreed number. The unit of measure is “Equivalent 4.2K Tests” (EFT), which is defined to be one standard production 4.2 K test. Additional testing requested by CERN on a given sample beyond the minimum required for production quality control is accounted as additional EFTs. It has also been agreed to essentially cancel the 1.9 K testing of cable at BNL and transfer the EFT budget (at 2 EFTs per 1.9K test) to cover the testing of cable for the low current quadrupoles MQM and MQY. This agreement has been codified in a memo which will be exchanged between CERN and the US Project, and which is in the final stages of revision before being signed.

During the quarter 69 cable tests performed on LHC production cable and 20 on HGQ inner cable samples. Some LHC cable samples were tested in perpendicular field with both normal and reverse polarities (this to determine the I_c difference between the thick and thin-edge of the keystoned cable), and the additional polarities were accounted as additional EFTs. The rate of testing was affected by some problems in the cryo-facility. A summary of all tests performed to date is given in Table I.

Table I. Summary of superconducting cable tests.

CABLE TEST EFT's					Updated:	04/03/01		
EFT= "Equivalent 4.2K Test"	No. days @4.2K	Non-productive days	Fraction of cryo for LHC	# of LHC EFT's	# of HGQ EFT's	# of RF-dipole EFT's	# of Reference Cable Test	TOTAL
Total to Date	128	7		331	52	40		602
Oct-00	11	0	0.367	30	4	4	0	38
Nov-00	8	2	0.364	20	0	0	6	26
Dec-00	8	1	0.438	20	0	0	0	20
Jan-01	11	0	0.393	30	8	0	0	38
Feb-01	6	0	0.333	12	12	0	0	24
Mar-01	7	0	0	27	0	0	0	27
Apr-01	0	0	0	0	0	0	0	0
May-01	0	0	0	0	0	0	0	0
Jun-01	0	0	0	0	0	0	0	0
Jul-01	0	0	0	0	0	0	0	0
Aug-01	0	0	0	0	0	0	0	0
Sep-01	0	0	0	0	0	0	0	0
Total, FY'01	51	3	0.379	139	24	4	6	173
Total FY'99	31	3		65	10	8		83
Total FY'00	46	1		127	18	28		173

1.3.2 Superconducting Cable Production Support

LBNL was requested to provide consultation and support for CERN on their order for two additional cable measuring machines, plus two additional spare measuring heads. LBNL will update the drawings and contact vendor for a quotation on these items.

1.4 Accelerator Physics

A new version of the electron cloud effect simulation code is now finished, which allows the simulation of electron cloud effects during the bunch passage, not just in between bunches as in the previous version, and which can simulate an arbitrary beam fill pattern, not just a uniform fill. Very preliminary results suggest a lower estimate for the LHC power deposition in the arc dipoles than with the previous code.

Work by LBNL continued on calculating the impedance of the TAN vacuum chamber using the ABCI and MAFIA codes. The problem has now been run in both the time and frequency domains. In order to settle the controversy over the possibility of trapped modes, the Frascati calculations in rectangular geometry will be duplicated to show that LBNL's calculations are capable of seeing them.

Work continued on the one degree of freedom simulations of strong-strong beam-beam interactions. Recent results suggest that relative intensity ratios between the beams at which the coherent ?-mode is Landau damped depends on the distribution. For a Gaussian distribution, this mode is stable when one beam has less than 60% of the intensity of the other beam.

The inner triplet Q2 quadrupole is proposed to be moved about 30 cm farther away from the IP to accommodate a move of the BPM from the Q2/Q3 interconnect to the Q1/Q2 interconnect. It was found that changes in triplet gradients by only 1-2% are sufficient to match the optics and there is negligible effect on the optical functions. This shift was also shown to result in an increase of the energy deposition at the upstream end of Q2a (closest to the IP) by about 15%. Energy deposited in other triplet quadrupoles did not change significantly. The reasons for the increase at Q2a are being investigated.

The new optics (Version 6.2) was included in the MARS model for energy deposition studies in IR1, IR5 and IR6. Full-scale high-statistics calculations of energy deposition and radiation fields have been performed in the ?215 m regions from the IP1 and IP5. Detailed studies are underway of the peak doses seen at the cold mass slides, Further understanding of the impact of detailed liner designs on the inner triple energy deposition are underway as well.

A study was begun of using Nb_3Sn for 2nd generation IR quadrupoles. Two cases were studied: quadrupoles with larger gradients of 275 T/m but the same 70 mm aperture as at present, and quads with the same 200 T/m gradient but larger apertures of 90 mm. For the 1st case, the IR quadrupoles are shorter and the optics was redesigned to minimize the beta functions. The lengths and locations of all other quads starting from Q4 were unchanged. In the 2nd case, no optics redesign is necessary. It was found that in the 1st case (larger gradients) the gain in physical aperture is small (about 1-2 sigma). In the 2nd case (larger apertures) the increase in physical aperture is significant, and there is sufficient aperture if ?* were squeezed to 25 cm to double the luminosity – a scenario that is likely not possible with the 1st generation of IR quads.

III. Financial Status

Cost and Schedule Performance

The current performance data at WBS level 2 are summarized in Table II, and the changes since the last quarter for the program as a whole are contained in Table III. The CPR (Format 1, by WBS, and Format 2, by laboratory) for the 2nd quarter of FY 2001 (the current period columns of the report represent three months of data) and three trend charts (cumulative performance, cost/schedule variance, and bull's-eye) are included as attachments. The cost performance continued to decline this quarter. BNL declined by -$1,129K, FNAL declined by -$358K, and LBNL declined by -$23K for a net decline of -$1,510K. The cumulative cost variance is -$5.6M or -10%.

At Brookhaven, the -$1,129K cost variance for the reporting period is dominated by a -$1.3M variance in production material procurements. A significant portion of this ($600K) is caused by the revised commitment for the D2/3/4 vacuum vessel procurement. In December the commitment was reduced to reflect that the original requisition was changed to cover only the D1; however, the earned value for the D2/3/4 was not reset to zero. Consequently, the new requisition for the D2/3/4 vacuum vessel procurement, estimated at $600K, entered the system as ACWP with no earned value, because the earned value had already been taken. There will be a partial offset of the $600K because the actual purchase order, issued in April, will reflect the lowest bid of $460K. BNL is still researching the causes of the remaining overrun. BNL's schedule variance worsened by -$518K. The major contributors were -$220K in magnet EDIA, -$150K in magnet production and test, -$120K in magnet parts orders, and -$55K in superconducting cable testing.

At Fermilab, the quarter's negative cost variance of -$358K is dominated by a -$210K variance in magnet test EDIA, due to the greater than anticipated difficulty in setting up the test of Q2P1, and -$170K in cold mass and cryostat parts for prototype and production. Fermilab's schedule variance got better by $112K this quarter due almost entirely to progress in acquiring and setting up cryostat tooling. The first prototype continues to be about three months behind schedule.

Table II. Current cost performance data.

	Cumulative Costs to Date					Costs at Completion		
WBS	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
1.1 IR Region	34,964	31,931	35,614	-3,033	-3,682	50,328	54,935	-4,607
1.2 RF Region	10,383	8,663	9,149	-1,720	-486	15,714	17,063	-1,349
1.3 SC Wire/Cable	6,544	6,241	6,830	-303	-605	11,868	13,143	-1,275
1.4 Accel Physics	2,533	2,533	2,482	0	+51	5,133	4,619	+514
1.5 Project Mgt	7,710	7,710	8,623	0	-912	13,612	13,753	-140
Contingency						13,345	6,486	-6,859
Total	62,134	57,078	62,697	-5,056	-5,619	110,000	110,000	0*

*Note: Total VAC is equal to sum of WBS VACs minus the Contingency VAC.

Table III. Cost performance changes since the previous report.

	Last Quarter	This Quarter
Total Project Cost (TPC)	110,000K	110,000K
Budget At Completion (BAC)	96,655K	96,655K
Cum Budget to Date (BCWS)	57,648K	62,134K
Earned Value (BCWP)	53,123K	57,078K
Actual cost & commitments (ACWP)	57,232K	62,697K
Budgeted Cost of Work Remaining (BCWR)	43,532K	39,577K
Schedule Variance (SV)	-4,526K (-8%)	-5,056K (-8%)
Cost Variance (CV)	-4,109K (-8%)	-5,619K (-10%)
Estimate At Completion (EAC)	103,514K	103,514K
Contingency (TPC – EAC)	6.486K	6.486K
Contingency as a % of BCWR	14.9%	16.4%

At Berkeley, the quarter's -$23K cost variance was caused by a -$100K cost variance in the design effort for the cryogenic feed boxes that was partially offset by favorable cost variances in absorbers and superconducting cable production support. The negative variance in design effort was expected and is included in the EAC. The schedule variance worsened by -$125K due to the cryogenic feed box not being able to place orders because the design had not been approved and the production readiness review, now scheduled for late Summer, has not occurred.

Estimate At Completion (EAC)

The EAC given here has not changed from last quarter. New bottoms-up EACs have been developed for all major elements of the Project and are currently under review by the Project Office. The revised EACs will be presented at the DOE semi-annual review on May 14, 2001.

Baseline Change Requests

No BCR was approved during the reporting period. BNL is preparing two BCRs to re-baseline their program budget based on the new EACs. One covers the magnet program and the other the superconductor testing. The latter also encompass the revised cable test definitions and schedule recently negotiated with CERN. The revised EACs and schedules at the other two laboratories will also result in BCRs. We expect all of the BCRs to be presented to the Steering Committee in the next quarter.

Funding

Funding for this fiscal year continues to be tight. The project office has distributed all funds held at DOE to the laboratories. We expect to transfer funds not needed at LBNL to BNL and FNAL, but we will wait for more months of actual expenditures to determine how much will be transferred to which laboratories. Overall, it still appears that we will have sufficient funds, but just barely. A plot comparing the funding and planned obligation profiles with actual costs is attached.

IV. Milestone Status

The status of level 2 milestones is displayed in schedule format in an attachment. Table IV lists all level 2 milestones from the beginning of the Project through FY2001, and Table V shows the level 3 milestones affected during the quarter. Changes are highlighted in bold print. Actual dates are shown for completed milestones and forecast dates are given for milestones that have slipped out of the quarter or, due to pending changes in the program schedule, are expected to be achieved at times substantially different from the baseline dates.

Table IV. Level 2 U.S. LHC Accelerator Baseline Milestones through FY2001

WBS Identifiers	Milestone Description	Baseline Date	Forecast(F) or Actual(A)
Int Region	Begin 1st inner triplet quadrupole model magnet	1 Jul 97	1 Jul 97 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 1	1 Dec 99	28 Sep 99 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 2	1 Mar 00	17 Mar 00 (A)
Int Region	Place purchase order for HTS power leads	1 Feb 00	30 Aug 00 (A)
Int Region	Begin absorber fabrication	1 Nov 00	30 Oct 00 (A)
Int Region	Complete inner triplet quadrupole prototype magnet program	1 Oct 01	1 Oct 01 (F)
Int Region	Begin interaction region beam separation dipole production assembly	1 Oct 00	25 Jul 00 (A)
Int Region	Begin inner triplet feedbox fabrication	1 Mar 01	**1 Sep 01 (F)**
RF Region	Begin assembly of 1st dipole model magnet	1 Sep 99	10 Jun 99 (A)
RF Region	Complete dipole model magnet program	1 Aug 00	8 Nov 00 (A)
SC Cable	All cable production support equipment delivered to CERN	1 Sep 99	28 May 99 (A)
SC Cable	Complete SC testing facility upgrades	1 Jun 99	30 Sep 99 (A)

Table V. Changes to Level 3 U.S. LHC Accelerator Baseline Milestones during current quarter.

WBS Identifiers	Milestone Description	Baseline Date	Forecast(F) or Actual(A)
Int Region	MQXB to LQX Cryostat Interface Specification approved	15 Oct 00	**15 May 01 (F)**
Int Region	MQXA to LQX Cryostat Interface Specification approved	1 Jan 01	**1 Jul 01 (F)**
Int Region	MQXB Functional Specification approved	15 Oct 00	**23 Apr 01 (F)**
Int Region	LQX Functional Specification approved	1 Dec 00	**15 Sep 01 (F)**
Int Region	TAS2/3 Functional Specification approved	1 Dec 00	**1 Jan 02 (F)**
Int Region	Inner Triplet Corrector Interface Specifications approved	15 Oct 00	**1 Jul 01 (F)**
Int Region	LQX (Q3) to DFBX Interface Specification approved	15 Oct 00	**1 Jun 01 (F)**
Int Region	LQX to Cold Bore Tube Interface Specification approved	1 Jan 01	**1 Sep 01 (F)**
Int Region	MQX Cryostat Engineering Design Review	1 Nov 00	**10 May 01 (F)**
Int Region	D1 Interface Specification approved	1 Aug 00	**14 Feb 01 (A)**
Int Region	D2 Interface Specification approved	15 Sep 00	**31 Jan 01 (A)**
Int Region	Delivery by CERN to BNL of all CERN-provided D1 parts	1 Dec 00	**31 Jan 01 (A)**
Int Region	Delivery by CERN to BNL of all CERN-provided parts for first D2	1 Aug 00	**31 Jan 01 (A)**
Int Region	D2 Series Production start (balance)	17 Jan 01	**17 Jan 01 (A)**
Int Region	DFBX Interface Specifications approved	1 Jul 99	**15 Jul 01 (F)**
Int Region	DFBX Engineering Design Review	1 Jul 00	**10 May 01 (F)**
Int Region	DFBX Production Readiness Review	1 Nov 00	**1 Sep 01 (F)**
Int Region	TAN and TAS Production Readiness Review complete	1 Jul 00	**15 Jul 01 (F)**

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME US LHC Accelerator Project	**a. NAME** US LHC by Qtr	**a. NAME** US LHC Accelerator Project	**a. FROM** *(YYMMDD)* 010301
b. LOCATION *(Address and ZIP Code)* Fermilab, MS 343 P.O.Box 500 Batavia, IL 60510	**b. NUMBER** 1 **c. TYPE** FFP **d. SHARE RATIO** 100/0 100/0	**b. PHASE** *(X one)* x RDT&E x PRODUCTION	**b. TO** *(YYMMDD)* 010331

5. CONTRACT DATA

a. QUANTITY	b. NEGOTIATED COST	c. EST. COST AUTH UNPRICED WORK	d. TARGET PROFIT/ FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. ESTIMATED CONTRACT CEILING
0/0/0	$96,655.1	$0.0	$0.0 / 0.0%	$96,655.1	$103,513.6	$110,000.0	$110,000.0

6. ESTIMATED COST AT COMPLETION

	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)
a. BEST CASE	$103,513.6		
b. WORST CASE	$103,513.6		
c. MOST LIKELY	$103,513.6	$96,655.1	-$6,858.5

7. AUTHORIZED CONTRACTOR REPRESENTATIVE

a. NAME *(Last, First, Middle Initial)*	b. TITLE
Jim Strait	Project Manager
c. SIGNATURE	**d. DATE SIGNED** *(YYMMDD)* 010421

8. PERFORMANCE DATA

ITEM (1)		CURRENT PERIOD: BUDGETED COST: WORK SCHEDULED (2)	CURRENT PERIOD: BUDGETED COST: WORK PERFORMED (3)	CURRENT PERIOD: ACTUAL COST WORK PERFORMED (4)	CURRENT PERIOD: VARIANCE: SCHEDULE (5)	CURRENT PERIOD: VARIANCE: COST (6)	CUMULATIVE TO DATE: BUDGETED COST: WORK SCHEDULED (7)	CUMULATIVE TO DATE: BUDGETED COST: WORK PERFORMED (8)	CUMULATIVE TO DATE: ACTUAL COST WORK PERFORMED (9)	CUMULATIVE TO DATE: VARIANCE: SCHEDULE (10)	CUMULATIVE TO DATE: VARIANCE: COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12)	REPROGRAMMING ADJUSTMENTS: BUDGET (13)	AT COMPLETION: BUDGETED (14)	AT COMPLETION: ESTIMATED (15)	AT COMPLETION: VARIANCE (16)
a. WORK BREAKDOWN STRUCTURE ELEMENT																
1.1 - Interaction Reg	2	2,951.4	2,640.4	4,080.9	-311.1	-1,440.6	34,964.4	31,931.3	35,613.6	-3,033.1	-3,682.3			50,328.2	54,935.0	-4,606.8
1.1.1 - Quadrupoles	3	1,613.0	1,759.2	2,061.6	146.1	-302.4	21,732.6	21,564.3	24,588.8	-168.3	-3,024.5			30,699.8	34,991.9	-4,292.1
1.1.2 - Dipoles	3	632.5	333.6	1,434.0	-298.9	-1,100.3	5,216.3	4,391.8	5,719.6	-824.6	-1,327.8			7,501.7	8,234.5	-732.8
1.1.3 - Cryo Feedboxes	3	324.7	90.7	196.1	-234.0	-105.4	4,611.6	2,857.2	2,272.4	-1,754.4	584.7			6,728.3	6,254.5	473.8
1.1.4 - Absorbers	3	323.4	399.1	349.7	75.7	49.4	2,658.7	2,372.9	2,384.5	-285.8	-11.6			4,006.7	4,522.5	-515.8
1.1.5 - System Design	3	57.8	57.8	39.6	0.0	18.2	745.2	745.2	648.3	0.0	96.9			1,391.7	931.6	460.1
1.2 - RF Region	2	534.9	372.0	431.8	-162.9	-59.8	10,383.2	8,663.2	9,149.3	-1,720.0	-486.1			15,714.1	17,063.4	-1,349.3
1.2.1 - Dipoles	3	534.9	372.0	431.8	-162.9	-59.8	10,383.2	8,663.2	9,149.3	-1,720.0	-486.1			15,714.1	17,063.4	-1,349.3
1.3 - SC Wire & Cable	2	326.9	270.7	254.7	-56.3	15.9	6,543.5	6,240.8	6,830.1	-302.7	-589.3			11,867.8	13,143.4	-1,275.6
1.3.1 - SC Testing	3	304.4	248.3	250.7	-56.1	-2.5	5,488.2	5,187.1	5,777.0	-301.1	-589.9			10,733.8	12,073.1	-1,339.3
1.3.2 - Cable Prod S'pt	3	22.5	22.4	4.0	-0.1	18.4	1,055.4	1,053.7	1,053.1	-1.7	0.6			1,134.0	1,070.3	63.7
1.4 - Accel Physics	2	192.6	192.6	176.2	0.0	16.4	2,532.6	2,532.6	2,481.8	0.0	50.7			5,132.7	4,619.1	513.6
1.5 - Project Mgt	2	479.8	479.8	521.8	0.0	-42.0	7,710.1	7,710.1	8,622.6	0.0	-912.4			13,612.3	13,752.7	-140.4
OV - OVERHEAD	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

8. PERFORMANCE DATA

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE						
	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	COST VARIANCE	BUDGET	BUDGETED	ESTIMATED	VARIANCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
a. WORK BREAKDOWN STRUCTURE ELEMENT															
b. COST OF MONEY 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
c. GENERAL & ADMINISTRATIVE 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
d. UNDISTRIBUTED BUDGET 2													0.0	0.0	0.0
e. SUBTOTAL *(Performance Measurement Baseline)*	4,485.6	3,955.4	5,465.5	-530.2	-1,510.0	62,133.9	57,078.1	62,697.4	-5,055.8	-5,619.3	0.0	0.0	96,655.1	103,513.6	-6,858.5
f. MANAGEMENT RESERVE 2												0.0	0.0		
g. TOTAL	4,485.6	3,955.4	5,465.5	-530.2	-1,510.0	62,133.9	57,078.1	62,697.4	-5,055.8	-5,619.3	0.0	0.0	96,655.1		
9. RECONCILIATION TO CONTRACT BUDGET BASE															
a. VARIANCE ADJUSTMENT									0.0	0.0					
b. TOTAL CONTRACT VARIANCE									-5,055.8	-5,619.3			96,655.1	103,513.6	-6,858.5

Unclassified

CLASSIFICATION *(When filled in)*

COST PERFORMANCE REPORT
FORMAT 2 - ORGANIZATIONAL CATEGORIES

DOLLARS IN Thousands

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME US LHC Accelerator Project	**a. NAME** US LHC by Qtr	**a. NAME** US LHC Accelerator Project	**a. FROM** *(YYMMDD)* 010301
b. LOCATION *(Address and ZIP Code)* Fermilab, MS 343 P.O.Box 500 Batavia, IL 60510	**b. NUMBER** 1; **c. TYPE** FFP; **d. SHARE RATIO** 100/0 100/0	**b. PHASE** *(X one)* x RDT&E x PRODUCTION	**b. TO** *(YYMMDD)* 010331

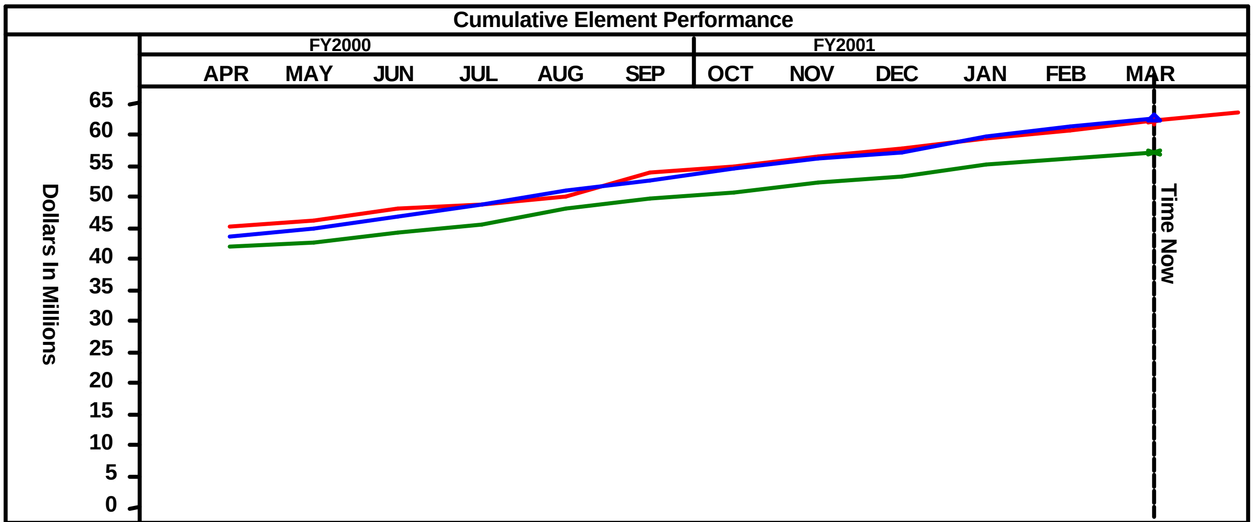
5. PERFORMANCE DATA

ITEM (1)		CURRENT PERIOD: BUDGETED COST WORK SCHEDULED (2)	BUDGETED COST WORK PERFORMED (3)	ACTUAL COST WORK PERFORMED (4)	VARIANCE SCHEDULE (5)	VARIANCE COST (6)	CUMULATIVE TO DATE: BUDGETED COST WORK SCHEDULED (7)	BUDGETED COST WORK PERFORMED (8)	ACTUAL COST WORK PERFORMED (9)	VARIANCE SCHEDULE (10)	VARIANCE COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12)	BUDGET (13)	AT COMPLETION: BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)
a. ORGANIZATIONAL CATEGORY																
BNL -	2	1,753.5	1,235.6	2,364.2	-517.9	-1,128.6	25,760.4	22,914.8	25,997.3	-2,845.7	-3,082.5			41,803.6	45,546.3	-3,742.7
FNAL -	2	1,927.9	2,040.2	2,398.3	112.3	-358.1	24,264.9	24,136.1	27,228.8	-128.8	-3,092.7			37,350.5	40,515.8	-3,165.3
LBNL -	2	804.3	679.6	702.9	-124.6	-23.3	12,108.6	10,027.3	9,471.4	-2,081.3	555.9			17,500.9	17,451.2	49.7
OV - OVERHEAD	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
b. COST OF MONEY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
c. GENERAL & ADMINISTRATIVE	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
d. UNDISTRIBUTED BUDGET	2													0.0	0.0	0.0
e. SUBTOTAL *(Performance Measurement Baseline)*		4,485.6	3,955.4	5,465.5	-530.2	-1,510.0	62,133.9	57,078.1	62,697.4	-5,055.8	-5,619.3	0.0	0.0	96,655.1	103,513.3	-6,858.2
f. MANAGEMENT RESERVE	2												0.0	0.0		
g. TOTAL		4,485.6	3,955.4	5,465.5	-530.2	-1,510.0	62,133.9	57,078.1	62,697.4	-5,055.8	-5,619.3	0.0	0.0	96,655.1		

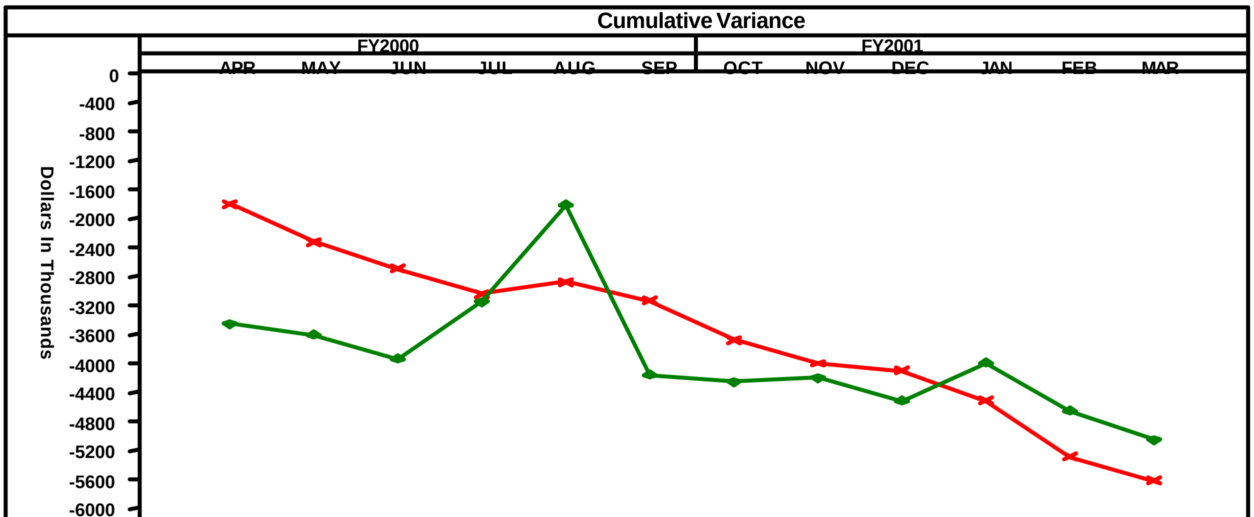
Unclassified

CLASSIFICATION *(When filled in)*

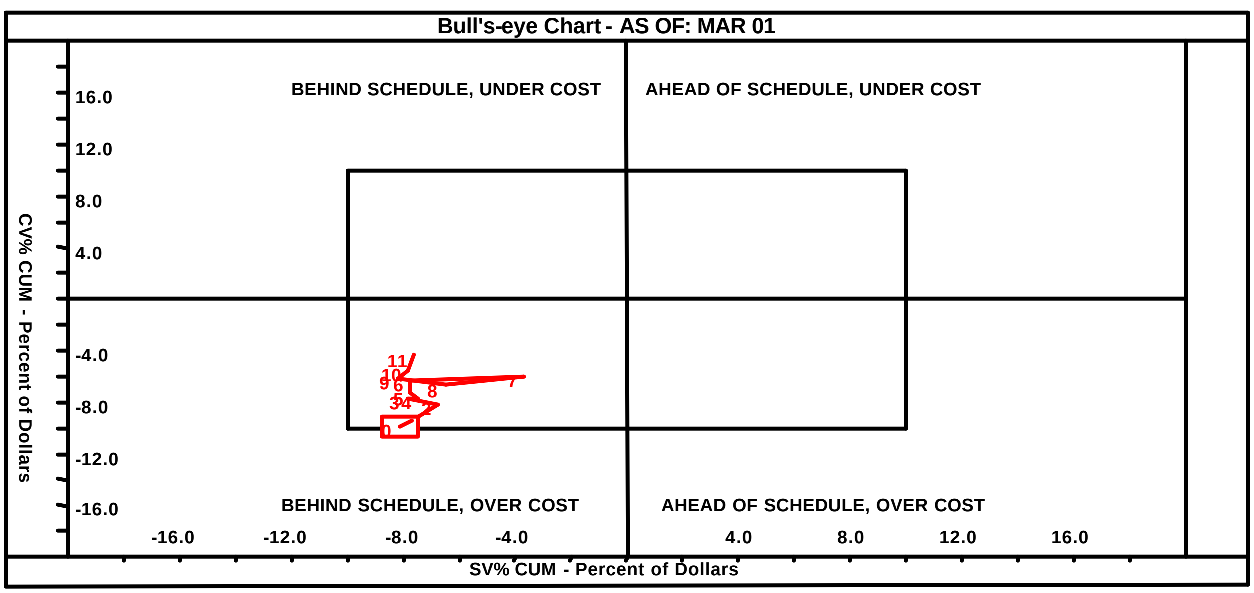
COST/SCHEDULE PERFORMANCE CHARTS

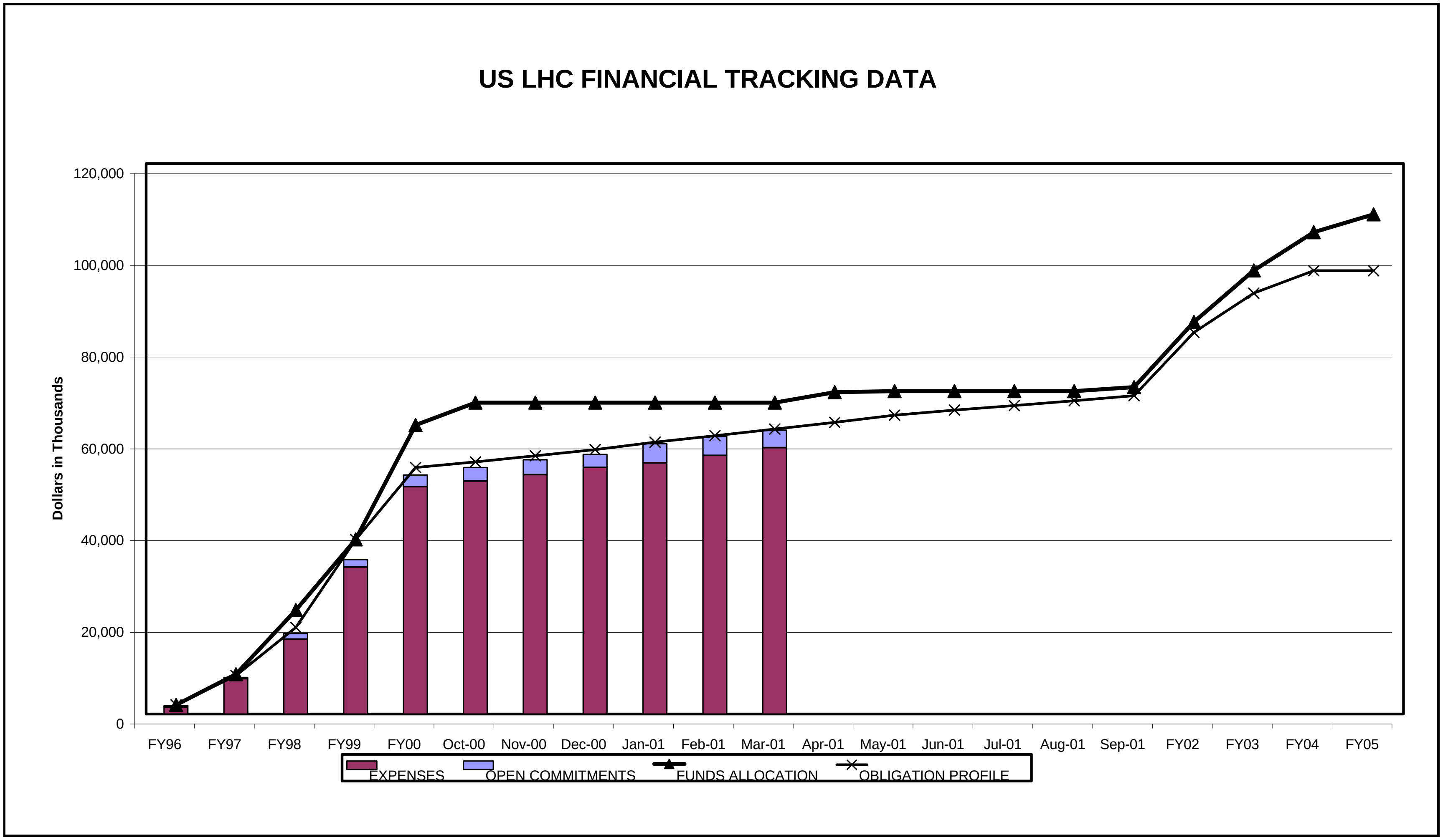


	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
BCWS	45.3	46.2	48.0	48.7	50.0	53.7	54.9	56.3	57.6	59.2	60.7	62.1
BCWP	41.8	42.6	44.1	45.6	48.2	49.6	50.7	52.1	53.1	55.3	56.0	57.1
ACWP	43.6	45.0	46.8	48.6	51.0	52.7	54.4	56.1	57.2	59.8	61.3	62.7



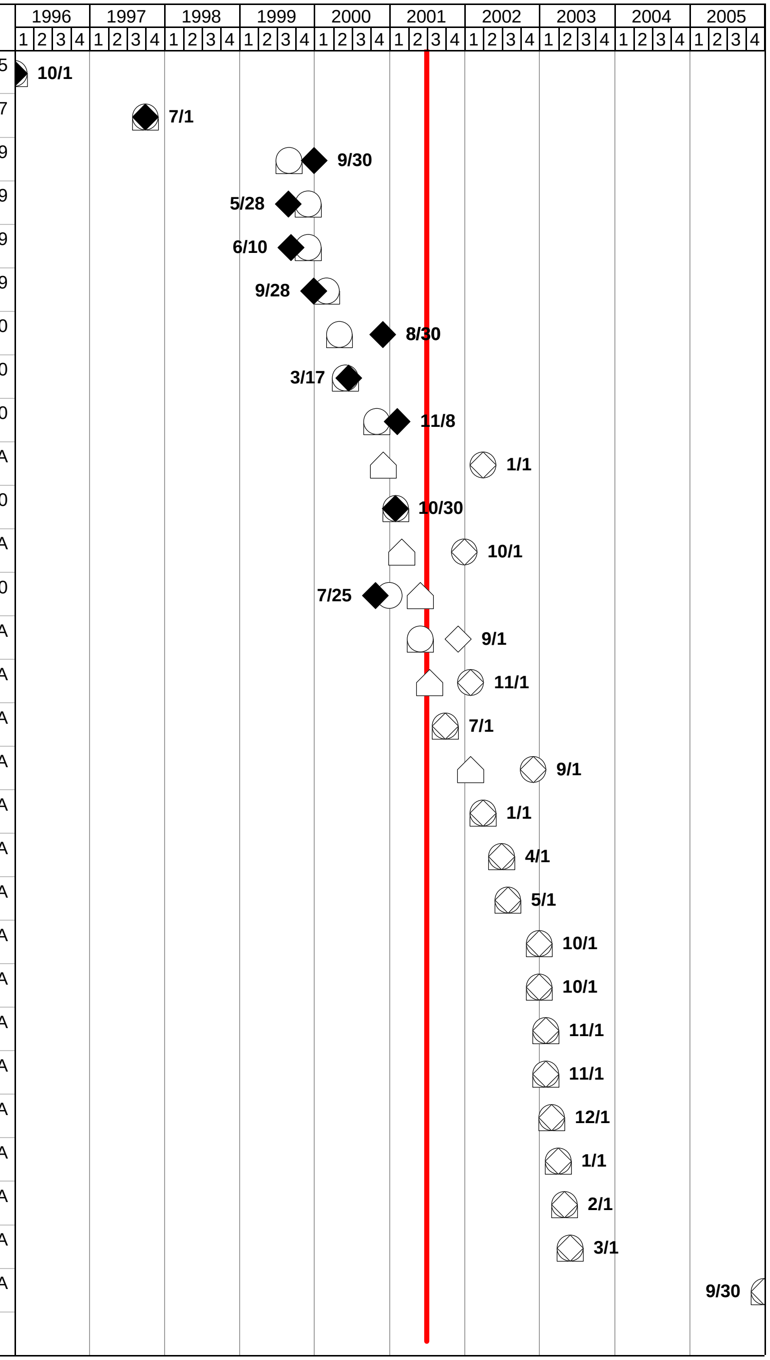
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
COST	-1810.3	-2335.1	-2699.4	-3049.9	-2875.8	-3139.7	-3686.7	-4002.5	-4109.3	-4518.3	-5289.8	-5619.3
SCHED	-3458.5	-3612.8	-3935.4	-3156.0	-1820.3	-4159.0	-4255.2	-4200.1	-4525.6	-3996.1	-4663.0	-5055.8





	FY96	FY97	FY98	FY99	FY00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	FY02	FY03	FY04	FY05
INCREMENTAL																					
FUNDS ALLOCATION	2,000	6,670	14,000	15,400	24,917	4,900	0	0	-11	0	0	2,273	270	0	0	0	863	14,200	11,200	8,330	3,900
OBLIGATION PROFILE	1,962	6,427	10,466	19,155	15,714	1,222	1,384	1,318	1,601	1,425	1,459	1,470	1,561	1,077	999	1,070	1,065	13,819	8,590	4,869	
EXPENSES	1,515	6,186	8,594	15,755	17,498	1,248	1,356	1,606	994	1,610	1,703										
OPEN COMMITMENTS	296	-43	964	366	965	372	377	-436	1,336	-74	-267										
CUMULATIVE																					
FUNDS ALLOCATION	2,000	8,670	22,670	38,070	62,987	67,887	67,887	67,887	67,876	67,876	67,876	70,149	70,419	70,419	70,419	70,419	71,282	85,482	96,682	105,012	108,912
OBLIGATION PROFILE	1,962	8,390	18,856	38,011	53,725	54,947	56,331	57,648	59,250	60,675	62,134	63,604	65,165	66,243	67,241	68,311	69,376	83,196	91,786	96,655	96,655
EXPENSES	1,515	7,701	16,296	32,051	49,549	50,797	52,153	53,758	54,752	56,362	58,065										
OPEN COMMITMENTS	296	253	1,217	1,582	2,547	2,919	3,296	2,860	4,196	4,122	3,856										

ID	Milestone	Original	Revised	Forecast	Actual
	Project Start (10/1/95)	10/1/95	10/1/95	10/1/95	10/1/95
IR	Begin 1st Inner Triplet Quadrupole Model Magnet	7/1/97	7/1/97	7/1/97	7/1/97
SC	Complete Superconductor Test Facility Upgrades	6/1/99	6/1/99	9/30/99	9/30/99
SC	All Cable Production Support Equipment Delivered to CERN	9/1/99	9/1/99	5/28/99	5/28/99
RF	Begin Assembly of 1st Dipole Model Magnet	9/1/99	9/1/99	6/10/99	6/10/99
IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 1	12/1/99	12/1/99	9/28/99	9/28/99
IR	Place Purchase Order for HTS Power Leads	2/1/00	2/1/00	8/30/00	8/30/00
IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 2	3/1/00	3/1/00	3/17/00	3/17/00
RF	Complete Dipole Model Magnet Program	8/1/00	8/1/00	11/8/00	11/8/00
RF	Begin RF Region Dipole Production Assembly	9/1/00	1/1/02	1/1/02	NA
IR	Begin Absorber Fabrication	11/1/00	11/1/00	10/30/00	10/30/00
IR	Complete Inner Triplet Quadrupole Prototype Magnet Program	12/1/00	10/1/01	10/1/01	NA
IR	Begin Interaction Region Beam Separation Dipole Prod. Assembly	3/1/01	10/1/00	7/25/00	7/25/00
IR	Begin Inner Triplet Feedbox Fabrication	3/1/01	3/1/01	9/1/01	NA
IR	Begin Inner Triplet Quadrupole Production Assembly	4/15/01	11/1/01	11/1/01	NA
RF	Decision on RF Region Quadrupoles	7/1/01	7/1/01	7/1/01	NA
IR	Complete 1st Inner Triplet Quadrupole Magnet	11/1/01	9/1/02	9/1/02	NA
RF	Delivery of D3, D4 for IR4 right	1/1/02	1/1/02	1/1/02	NA
IR	Delivery of D2 for IR8 Left	4/1/02	4/1/02	4/1/02	NA
IR	Complete Inner Triplet Feedbox Fabrication	5/1/02	5/1/02	5/1/02	NA
IR	Delivery of All Inner Triplet System Components for IR8 Left (MQX, DFBX, D1)	10/1/02	10/1/02	10/1/02	NA
RF	Complete RF Region Dipole Production Assembly	10/1/02	10/1/02	10/1/02	NA
IR	Delivery of D2 for IR5 Left	11/1/02	11/1/02	11/1/02	NA
RF	Delivery of D3, D4 for IR4 left	11/1/02	11/1/02	11/1/02	NA
IR	Complete Absorber Fabrication	12/1/02	12/1/02	12/1/02	NA
IR	Delivery of All Inner Triplet System Components for IR8 Right (MQX, DFBX, D1)	1/1/03	1/1/03	1/1/03	NA
IR	Delivery of D2 for IR8 Right	2/1/03	2/1/03	2/1/03	NA
IR	Complete Interaction Region Dipole Production Assembly	3/1/03	3/1/03	3/1/03	NA
	Project Completion (9/30/05)	9/30/05	9/30/05	9/30/05	NA



Date: 5/7/01 Original Baseline Revised Baseline Forecast Actual