US LHC Accelerator Project
Progress Report, 1st Quarter FY 2004
29 April 2004
J. Strait, Project Manager

## I. Summary

Good technical progress continues across the Project. A total of five beam separation dipoles and four IR absorbers have been shipped to CERN. The balance of beam separation dipoles, IR absorbers, and DFBX feedboxes are in production and progressing well. Quadrupole production has resumed with the successful testing of the third Q3 quadrupole.

The Project has an unfavorable cost variance of -$1.3M (-1%) and schedule variance of -$2.6M (-3%). The large improvement from the previous quarter is largely, although not entirely the result of a baseline change which brought the budget for the work at BNL into line with past experience and with the current plan. The net cumulative schedule variance is essentially all in quadrupole production., while the cost variance is spread over several tasks. Based on an earned value of $98.5M, the project is 91% complete. The EAC is $108.3M and has been updated with the most recent BCRs in process.

The second Q2 quadrupole (LQXB02), which was unable to reach the required current level, was removed from its cryostat. The under performing cold mass, MQXB04, was disassembled. The other cold mass, MQXB03, was returned to inventory for use in another Q2 assembly. The third Q2 (LQXB03), consisting of cold masses MQXB05 and MQXB06, was tested and met the performance requirements. The fourth Q2, LQXB04 is nearly complete and will be tested next. The rate of deliveries of MCBX corrector magnets from CERN has increased. We have currently have enough to support quadrupole production, but will continue to monitor the situation closely.

The last D1 dipole magnet, D1L101, was retested to verify that a low insulation resistance between a heater and the coil was not detrimental to the performance. The magnet performed as required and will be shipped to CERN next quarter. All nine D2 magnets have been completed and tested. Seven of them have had cryogenic feed pipe assemblies, QQS, installed. The first D2 was shipped to CERN. The first of three D3 magnets (two cold masses in one assembly) is being cryostated. All three D4 cold masses are complete and testing of the first will begin next quarter.

The cryogenic feedbox fabrication vendor is progressing well, being on schedule overall and ahead of schedule on small parts. The four TAS absorbers that arrived at CERN last quarter passed the CERN acceptance testing. Testing is complete on three of the four TAN absorber beam tubes. After testing is complete on the last beam tube, all four TAN absorber assemblies will be shipped to CERN.

## II. Technical Status

1.1.1 IR quadrupoles

We have now received a total of 11 corrector magnets from CERN. Seven of those arrived in the last quarter. If the pace continues, we will have adequate supplies of correctors to support our production of quadrupole magnets.

The test report for the first Q2 (LQXB01) was released. We are preparing the documentation for the Fermilab LHC magnet acceptance committee. The results will be submitted to CERN before the magnet is shipped.

The second Q2 (LQXB02), which failed to reach the specified training gradient of 230 T/m, was removed from the stand early in the quarter and disassembled. The cold mass in which the failure occurred, MQXB04, has been disassembled and sections of cable believed to be at the cause of the low current quenches have been sent to BNL for cold testing. MQXB03, the other cold mass in LQXB02, tested successfully and has been returned to inventory for use in another Q2 cryo-assembly.

LQXB03 (consisting of MQXB05 and MQXB06) was tested to 230 T/m successfully. All other electrical and alignment measurements were completed.

LQXB04, consisting of MQXB07 and MQXB12, is being cryostated. The cold mass pressure and leak tests have been completed. MQXB08, MQXB09, MQXB10, MQXB11, have been completed and are ready for cryostat. MQXB13 is yoked. Final assembly is taking place this month. MQXB14 cable insulation has started.

The second set of final assembly tooling is in place. The first Q1 (LQXA01), consisting of a cold mass from KEK in a Fermilab cryostat, is being prepared for assembly. The MCBX corrector was installed. The absorber surrounding the beam tube, consisting of laminations of Nitronic-40 material, has been assembled. The bus expansion loop and correction coil have been installed.

**Figure 1 Q2 being transported to test facility.**

1.1.2 IR Dipoles and 1.2.1 RF Region Dipoles

Additional cold testing was successfully completed on the last D1 dipole magnet, D1L101. The additional cold testing confirmed quench safety of the magnet, which had developed a electrical resistance in the insulation between one of the quench heaters and magnet coil. The results will be reviewed by the BNL magnet acceptance committee and forwarded to the CERN magnet evaluation board before the magnet is shipped to CERN. Fabrication of the D1 non-lead end interconnect hardware continues in the BNL shops. The lead end interconnect design work is continuing.

Cold testing is complete on all nine D2 magnets and QQS assemblies have been installed on seven of them. The first D2 arrived in Europe in late December where it was held in port until after the CERN holiday shutdown.

The first two D3 cold masses, which will be become the first D3 magnet assembly are installed on their common cradles and are being prepared for insertion into the cryostat. See Figure 1. End volumes are complete on two cold masses that make up the second magnet assembly. Electro/mechanical assembly is complete on the ends of the last two cold masses. A number of minor design modifications in the cryostat were completed to accommodate the constraints in the interface to the CERN-built QQS module.

Assembly is complete on all three D4 magnets. The first D4 will be installed on the test stand in January.

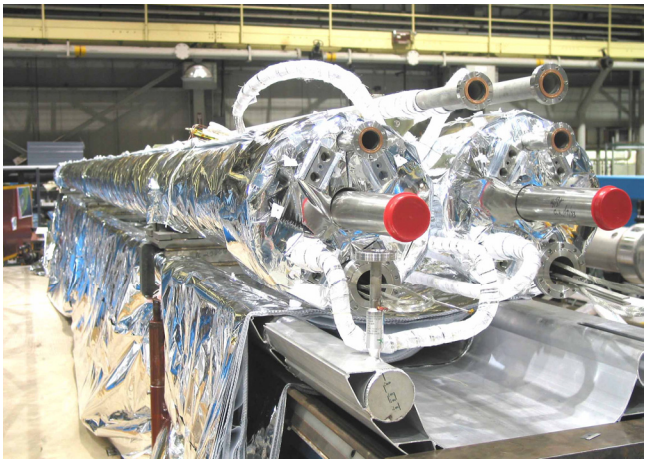


**Figure 2 Left – First D3 magnet completed on common cradles and being prepared for assembly into cryostat. Right – First D2 magnet to arrive at CERN.**

1.1.3 Cryogenic Feed Boxes

Feedbox fabrication is continuing on schedule at the vendor. The helium vessels are complete as are the thermal shields and most small parts. See Figure 3. Assembly of the first two feedboxes is underway.

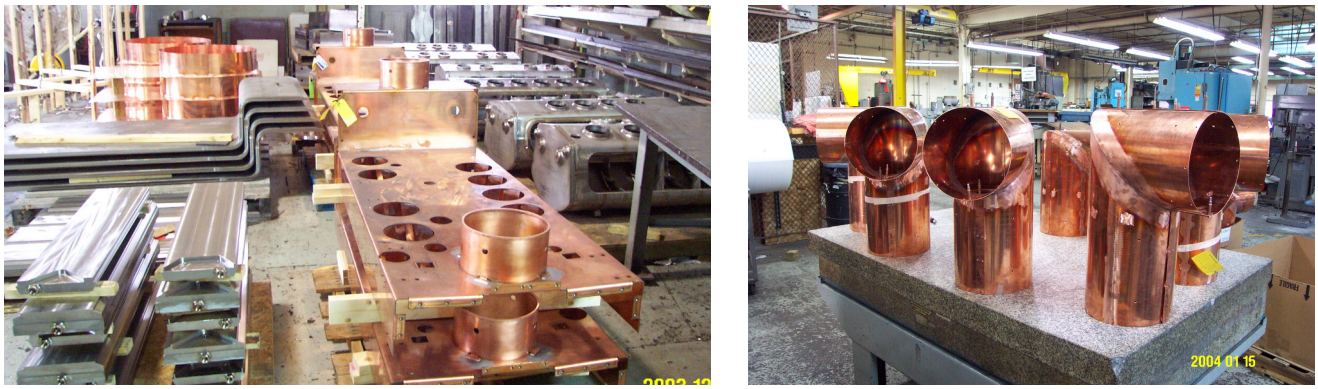



**Figure 3 DFBX parts in fabrication at the vendor. Above left, helium vessel cover plates, vacuum vessel top plates, thermal shield top plates and helium vessels. Above right, thermal shield jumpers. Additional images are at** http://tdpc02.fnal.gov/peterson/tom/DFBXimages/IndexDFBX.html

The helium vessel was installed under the top plate of the first feedbox and the power lead chimneys are being attached. See Figure 4.

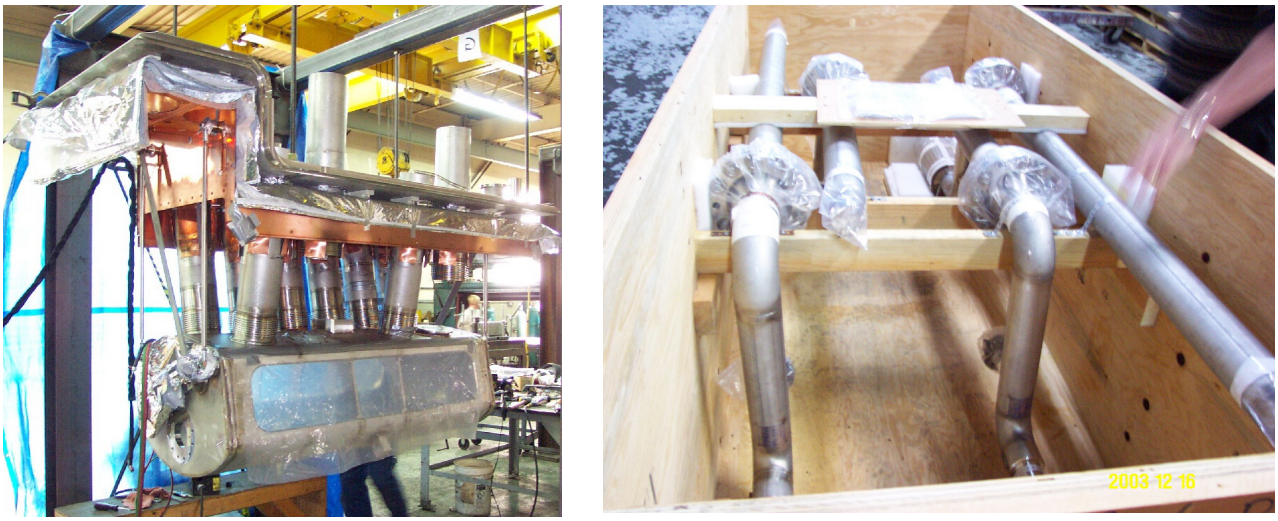



**Figure 4 Helium vessel installed under top plate. Top plate thermal shield, thermal insulation and lead chimneys have also been installed.**

Work on key feedbox subassemblies at LBNL is complete. All eight beam tube assemblies have been shipped to the feedbox fabricator. Two quadrupole and dipole bus ducts have also been shipped. See Figure 4. The remaining units were crated for shipment early next quarter.

Six sets of vapor cooled leads have been delivered from the vendor to the feedbox fabricator. The delivery of the remaining two sets is expected early next quarter, well in advance of the requirements for DFBX assembly.

Testing of the HTS leads continues at FNAL. Representatives from the vendor visited FNAL to evaluate test results and plan repairs. The most common problems were vacuum leaks around screws in electrical connector bodies. The vendor developed a procedure to seal the leaks. The repair will be implemented on all leads as a preventive measure against a possible systematic failure. Most other failures were one-of-a-kind and were repaired during the visit. Two of the leads had to be returned to the vendor for disassembly and more extensive repair.

1.1.4 IR Absorbers

The four TAS absorbers passed the acceptance vacuum leak tests at CERN. An electrical test is planned to test heaters and thermal couples. An engineering analysis is underway to address design deficiencies of the TAS horizontal support rods. Several solutions were identified and will be discussed with the CERN engineers.

The vendor was able to repair one of the two leaky TAN beam tubes. However, the beam tube with excessive porosity could not be repaired and a new beam tube was fabricated using spare components. Three of the four TAN beam tubes have completed final leak testing and bake-out, and the fourth is nearly complete. Room temperature verification of the Helicoflex seals and quick-disconnect clamps used on the 12-inch flange of each beam tube have been completed on two of the four.

1.1.5 IR System Design

The design of the Q1 bus splice and expansion loop and verification with the mock-up were completed. The assembly of the first Q1, LQXA01, is underway and will be completed next quarter.

The bus and expansion loop layout for the Q3 has proven to be more complicated due to the repositioning of the higher order correctors from the IP end to the non IP end of the Q3. However, the details for the Q3 bus splice and expansion loop are nearly complete. A mock-up of the end of the Q3 is being assembled using a KEK model magnet and mock-ups of the CERN correctors.

1.3.1 Superconductor Testing

Cable test activity occupied 32 days of testing at 4.3K, with 163 cable tests performed on LHC production cable samples. See Table I. The testing rate was impressive considering the lost testing days due to an emergency cryoplant shutdown and a power outage for extensive building roof repairs. CERN has been shipping samples at a steady rate reflecting the increased rate of production by CERN's cable vendors and we ended the quarter with a backlog of 81 samples. Several tests were extended to measure in both a- and b-directions as requested by CERN.

**Table I. Number of Superconducting Cable Tests.**

| EFT = Equivalent 4.2K Test | No. Days @4.2K | Non-prod. days | Fract of cryo for LHC | LHC EFTs | MQXB EFTs | BNL Dipole EFTs | Ref Cable Tests | All Tests |
|---|---|---|---|---|---|---|---|---|
| EFT Budget | | | | 3430 | 84 | 40 | 48 | 3602 |
| Plan to Date | | | | 2473 | 84 | 40 | 36 | 2633 |
| Total to Date | 457 | 8 | | 1668 | 74 | 44 | 36 | 1822 |
| FY1999 | 31 | 3 | | 65 | 10 | 8 | | 83 |
| FY2000 | 46 | 1 | | 127 | 18 | 28 | | 173 |
| FY2001 | 98 | 3 | 0.39 | 320 | 42 | 4 | 10 | 376 |
| FY2002 | 113 | 1 | 0.47 | 417 | 4 | 4 | 14 | 439 |
| FY2003 | 137 | 0 | 0.55 | 576 | 0 | 0 | 12 | 588 |
| Oct 03 | 9 | 0 | 0.48 | 42 | 0 | 0 | 0 | 42 |
| Nov 03 | 8 | 0 | 0.50 | 34 | 0 | 0 | 0 | 34 |
| Dec 03 | 15 | 0 | 0.70 | 87 | 0 | 0 | 0 | 87 |
| Jan 04 | | | | | | | | |
| Feb 04 | | | | | | | | |
| Mar 04 | | | | | | | | |
| Apr 04 | | | | | | | | |
| May 04 | | | | | | | | |
| Jun 04 | | | | | | | | |
| Jul 04 | | | | | | | | |
| Aug 04 | | | | | | | | |
| Sep 04 | | | | | | | | |
| FY2004 | 32 | 0 | 0.56 | 163 | 0 | 0 | 0 | 163 |

1.3.2 Superconducting Cable Production Support

There was no activity during the reporting period. A small budget remains to cover the cost of shipping cable measuring equipment back to LBNL and for consulting on cable production issues.

1.4 Accelerator Physics

All Accelerator Physics tasks were completed 30 September 2002.

## III. Financial Status

Cost and Schedule Performance

The current performance data at WBS level 2 are summarized in Table II (G&A is included on each line), and the changes since the last quarter for the program as a whole are contained in Table III. Variances by laboratory are summarized in Table IV. The CPR (Format 1, by WBS, and Format 2, by laboratory) for the reported quarter (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.

**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 | 59,160 | 57,052 | 57,734 | -2,107 | -682 | 63,159 | 64,047 | -888 |
| 1.2 RF Region | 15,802 | 15,356 | 14,245 | -446 | 1,110 | 15,854 | 15,854 | 0 |
| 1.3 SC Wire/Cable | 10,123 | 10,110 | 10,010 | -13 | 100 | 11,912 | 11,911 | 0 |
| 1.4 Accel Physics | 3,359 | 3,359 | 3,288 | 0 | 71 | 3,359 | 3,358 | 0 |
| 1.5 Project Mgt | 12,627 | 12,630 | 14,441 | 3 | -1,811 | 13,425 | 13,154 | 271 |
| Contingency | | | | | | 2,292 | 1,676 | +616 |
| Total | 101,071 | 98,507 | 99,718 | -2,564 | -1,211 | 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) | 106,237K | 107,709K |
| Cum Budget to Date (BCWS) | 99,409K | 101,071K |
| Earned Value (BCWP) | 94,331K | 98,507K |
| Actual cost & commitments (ACWP) | 97,286K | 99,718K |
| Budgeted Cost of Work Remaining (BCWR) | 11,906K | 7,990K |
| Schedule Variance (SV) | -5,078K (-5%) | -2,564K (-3%) |
| Cost Variance (CV) | -2,955K (-3%) | 1,211K (-1%) |
| Estimate At Completion (EAC) | 107,809K | 108,324K |
| Contingency (TPC – EAC) | 2,191K | 1,676K |
| Contingency as a % of BCWR | 18% | 18% |

**Table IV. Schedule and cost variances by laboratory.**

| Lab | SV – Quarter | CV – Quarter | SV – Cum | CV - Cum |
|---|---|---|---|---|
| BNL | $1,988K | $1,930K | -$46K | -$163K |
| FNAL | $151K | -$158K | -$2,486K | -$608K |
| LBNL | $332K | -$71K | -$76K | -$484K |

Brookhaven's +$1,930K cost variance and +$1,988K schedule variance for the quarter reflect the results of BCR 55, which rebaselined the whole BNL LHC Project, which recognized past cost and schedule variances, and provided a consistent plan to complete the project. The new baseline reset cost and schedule variances to zero as of 31 May 2003, and it was implemented in the December cost performance report. The cumulative schedule and cost variances are -3% and -4% respectively for the period June – December 2003.

Fermilab's -$158K cost variance for the quarter results from negative variances in quadrupole production and DFBX work, partially offset by positive variances in quadrupole EDIA and Fermilab-LHC Project Management. The +$151K schedule variance for the quarter is primarily due to recovery in cold mass and cryostat parts and in DFBX work, partially offset by lingering delays in quadrupole assembly and testing.

Berkeley's -$71K cost variance for the quarter is dominated by the absorbers and results largely from leak problems, now resolved, with the TAN beam tube and greater than anticipated cost related to the review of the TAS support with regard to seismic loads. The +$332K schedule variance results from good progress towards completing the work on both the DFBX and the absorbers.

Estimate At Completion (EAC)

The EAC of $108,324K is about $0.5M larger than that from last quarter. Most of this increase ($0.4M) is in indirect costs at BNL, and reflects both a substantial underestimate of these costs in the previous EAC, and a more modest overestimate of the indirect costs in the new baseline (BCR 55), which will be corrected in future reports.

Baseline Change Requests

There were three BCRs approved during this reporting period. BCR 55 re-baselines the entire dipole and superconductor cable testing program. The magnet construction program is over 90% complete. The BCR accounts for variances in construction costs and numerous small changes and additions to the program. The BCR also changes the superconductor testing from baseline of set number and rate of cable samples to be tested to a level-of-effort task extending through early April 2005. BCR 58 updates the level 2 milestones for delivery of equipment to CERN for the LHC insertion regions. BCR 60 changes the final milestones for each level 3 task from insertion in the LHC to acceptance by CERN. This is necessary because the LHC installation schedule for some of this equipment extends beyond the 30 September 2005 completion date for the US Project.

Funding

The overall funding available is anticipated to be adequate to support the program for the coming year, as indicated in the attached funds tracking chart.

## IV. Milestone Status

Tables V and VI list all level 1 and 2 milestones through the end of the Project in 2005, and Table VII 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. Level 1 and 2 milestones are displayed graphically in an attachment. The forecast dates have been entered in cases in which the projected completion date is later than the baseline date.

**Table V. Level 1 U.S. LHC Accelerator Project level 1 milestones.**

| Milestone No. | | | Baseline Date | Forecast Date | Actual Date |
|---|---|---|---|---|---|
| 1 - 1 | | Project Start | 1 Oct 1995 | | 1 Oct 1995 |
| 1 - 2 C | | Decision as to whether or not the U.S. Project includes RF region quadrupoles | 1 Jul 2001 | | 20 Jun 2001 |
| 1 - 3 | | Project Completion | 30 Sep 2005 | 30 Sep 2005 | |

## Table VI-a. U.S. LHC Accelerator Project interaction region level 2 milestones.

| Milestone No. | | | Baseline Date | Forecast Date | Actual Date |
|---|---|---|---|---|---|
| | WBS 1.1 Interaction Regions | | | | |
| 2 -1.1- 1 | | Begin 1st inner triplet quadrupole model magnet | 1 Jul 1997 | | 1 Jul 1997 |
| 2 -1.1- 2 | | Complete inner triplet quadrupole model magnet program phase 1 | 1 Dec 1999 | | 28 Sep 1999 |
| 2 -1.1- 3 | | Complete inner triplet quadrupole model magnet program phase 2 | 1 Mar 2000 | | 17 Mar 2000 |
| 2 -1.1- 4 | | Place purchase order for HTS power leads | 1 Feb 2000 | | 30 Aug 2000 |
| 2 -1.1- 5 | | Begin absorber fabrication | 1 Nov 2000 | | 30 Oct 2000 |
| 2 -1.1- 6 | | Complete inner triplet quadrupole prototype magnet program | 1 Oct 2001 | | 31 Aug 2001 |
| 2 -1.1- 7 | | Begin interaction region beam separation dipole production assembly | 1 Oct 2000 | | 25 Jul 2000 |
| 2 -1.1- 8 | | Begin inner triplet feedbox fabrication | 1 Mar 2001 | | 27 Mar 2003 |
| 2 -1.1- 9 | | Begin inner triplet quadrupole production assembly | 1 Nov 2001 | | 1 May 2001 |
| 2 -1.1- 10 | | Complete 1st inner triplet quadrupole magnet | 1 Sep 2002 | | 11 Mar 2003 |
| 2 -1.1- 12 | | Complete inner triplet feedbox fabrication | 31 Aug 2005 | | |
| 2 -1.1- 13 C | | Delivery of all inner triplet system components for IR8 left (MQX, DFBX, D1, D2) | **24 Sep 2004** | | |
| 2 -1.1- 15 | | Complete absorber fabrication | 1 Feb 2003 | | 27 Jan 2004 |
| 2 -1.1- 16 C | | Delivery of all inner triplet system components for IR8 right (MQX, DFBX, D1, D2) | **11 Mar 2005** | | |
| 2 -1.1- 18 | | Complete interaction region beam separation dipole production assembly | 1 Apr 2003 | 3 Mar 2004 | |
| 2 -1.1- 19 C | | Delivery of all inner triplet sys. components for IR1 left (MQX,DFBX,D2,TAS,TAN) | **11 Mar 2005** | | |
| 2 -1.1- 23 C | | Delivery of all inner triplet sys. components for IR5 left (MQX,DFBX,D2,TAS,TAN) | **22 Jul 2005** | | |
| 2 -1.1- 25 C | | Delivery of all inner triplet sys. components for IR5 right(MQX,DFBX,D2,TAS,TAN) | **30 Sep 2005** | | |
| 2 -1.1- 26 C | | Delivery of all inner triplet sytem components for IR2 right (MQX, DFBX, D1, D2) | **29 Oct 2004** | | |
| 2 -1.1- 27 C | | Delivery of all inner triplet sys. components for IR1 right(MQX,DFBX,D2,TAS,TAN) | **30 Sep 2005** | | |
| 2 -1.1- 30 | | Complete inner triplet quadrupole production | 1 Mar 2005 | | |
| 2 -1.1- 32 C | | Delivery of all inner triplet system components for IR2 left (MQX, DFBX, D1, D2) | **30 Sep 2005** | | |
| 2 -1.1- 33 | | Interaction Region task complete | 30 Sep 2005 | | |

**Table VI-b. U.S. LHC Accelerator Project RF region and SC cable level 2 milestones.**

| Milestone No. | | | Baseline Date | Forecast Date | Actual Date |
|---|---|---|---|---|---|
| | WBS 1.2 RF Region | | | | |
| 2 -1.2- 1 | | Begin assembly of 1st dipole model magnet | 1 Sep 1999 | | 10 Jun 1999 |
| 2 -1.2- 2 | | Complete dipole model magnet program | 1 Aug 2000 | | 8 Nov 2000 |
| 2 -1.2- 3 | | Begin RF region beam separation dipole production assembly | 1 Jan 2002 | | 3 Dec 2001 |
| 2 -1.2- 4 C | | Delivery of D3, D4 for IR4 right | **22 Jul 2005** | | |
| 2 -1.2- 5 | | Complete RF region beam separation dipole production assembly | 1 Sep 2003 | 7 Jul 2004 | |
| 2 -1.2- 6 C | | Delivery of D3, D4 for IR4 left | **23 Sep 2005** | | |
| 2 -1.2- 7 | | RF Region task complete | 30 Sep 2005 | | |
| | WBS 1.3 Superconducting Wire and Cable | | | | |
| 2 -1.3- 1 | | All cable production support equipment delivered to CERN | 1 Sep 1999 | | 28 May 1999 |
| 2 -1.3- 2 | | Complete SC testing facility upgrades | 1 Jun 1999 | | 30 Sep 1999 |
| 2 -1.3- 3 | | Series wire and cable testing complete | 31 Mar 2005 | 31 Aug 2005 | |
| 2 -1.3- 4 | | Superconducting Wire and Cable task complete | 30 Sep 2005 | | |

**Table VII. U.S. LHC Accelerator Project level 3 milestones active during the current quarter.**

| Milestone No. | | Baseline Date | Forecast Date | Actual Date |
|---|---|---|---|---|
| | WBS 1.1.1 Interaction Region Quadrupoles | | | |
| 3 -1.1.1- 6b C | MQXA to LQX Cryostat Interface Specification approved | 1 Jan 2001 | **1 May 2004** | |
| 3 -1.1.1- 10c C | TAS2/3 Functional Specification approved | 1 Dec 2000 | **1 May 2004** | |
| 3 -1.1.1- 15 C | LQX Tunnel Installation and Alignment Specifications approved | 1 Jun 2001 | **1 May 2004** | |
| 3 -1.1.1- 16b C | LQX Cold Bore Tube Interface Specification Approved | 1 Jan 2001 | **1 May 2004** | |
| 3 -1.1.1- 16c C | LQX to BPM Interface Specification Approved | 1 Apr 2001 | **1 May 2004** | |
| 3 -1.1.1- 16d C | LQX to LQX Interface Specification Approved | 1 Jun 2001 | **1 May 2004** | |
| 3 -1.1.1- 16e C | LQX (Q1) to Warm Beam Vacuum Interface Specification Approved | 1 Jun 2001 | **1 May 2004** | |
| 3 -1.1.1- 25 | Begin assembly of first MQXA | 1 Aug 2002 | | **1 Dec 2003** |
| 3 -1.1.1- 26 | IR8 left MQX ready to deliver | 1 Mar 2003 | **1 Jun 2004** | |
| 3 -1.1.1- 27 | IR8 right MQX ready to deliver | 1 Jul 2003 | **1 Oct 2004** | |
| 3 -1.1.1- 28 | IR1 left MQX ready to deliver | 1 Nov 2003 | **22 Dec 2004** | |
| 3 -1.1.1- 29 | IR1 right MQX ready to deliver | 1 Dec 2003 | **11 Jan 2005** | |
| | WBS 1.1.2 Interaction Region Dipoles | | | |
| 3 -1.1.2- 9 | D2 series production complete | 1 Jan 2003 | **3 Mar 2004** | |
| 3 -1.1.2- 11 | D1 production complete | 1 Apr 2002 | 1 Apr 2004 | |
| | WBS 1.1.3 Interaction Region Cryogenic Feed Boxes | | | |
| 3 -1.1.3- 4 C | DFBX interface specification approved | 1 Jul 1999 | **1 May 2004** | |
| | WBS 1.1.4 Interaction Region Absorbers | | | |
| 3 -1.1.4- 14 | Complete assembly of TAN and TAS | 1 Nov 2002 | | **27 Jan 2004** |
| | WBS 1.2.1 RF Region Dipoles | | | |
| 3 -1.2.1- 3c C | D3 interface specification approved | 15 Mar 2002 | 15 Feb 2004 | |
| 3 -1.2.1- 12 | D4 production complete | 1 Mar 2003 | **14 Apr 2004** | |
| 3 -1.2.1- 15 | D3 production complete | 1 Jun 2003 | **7 Jul 2004** | |

COST PERFORMANCE REPORT

FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN: Thousands



| 1. Contractor | 2. CONTRACT | 3. PROGRAM | 4. REPORT PERIOD |
|---|---|---|---|
| a. NAME<br>US LHC Accelerator Project | a. NAME<br>US LHC by Qtr | a. NAME<br>US LHC Accelerator Project | a. FROM (CCYYMMDD)<br>20031001 |
| b. Location<br>MS 343<br>PO Box 500<br>Batavia, IL 60510 | b. NUMBER<br><br>c. TYPE | | B. TO (CCYYMMDD)<br>20031231 |

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 |
|---|---|---|---|---|---|---|---|
| PROD: 0<br>R&D: 0 | $107,707.7 | $0.0 | $0.0 / 0.0% | $107,707.7 | $108,324.0 | $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 | $108,324.0 | | |
| b. WORST CASE | $108,324.0 | | |
| c. MOST LIKELY | $108,324.0 | 107,707.7 | -616.3 |

7. AUTHORIZED CONTRACTOR REPRESENTATIVE

| a. NAME | b. TITLE | c. SIGNATURE | d. DATE (CCYYMMDD) |
|---|---|---|---|
| James Strait | US LHC Accelerator Project Manager | | 20040426 |

8. PERFORMANCE DATA

| ITEM | | | CURRENT PERIOD | | | | | CUMULATIVE TO DATE | | | | | REPROGRAM ADJUSTMENTS | | AT COMPLETION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | BUDGETED COST | | ACTUAL COST WORK PERFORMED | VARIANCE | | BUDGETED COST | | ACTUAL COST WORK PERFORMED | VARIANCE | | | | | | |
| | | | WORK SCHEDULED | WORK PERFORMED | | SCHEDULE | COST | WORK SCHEDULED | 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) |
| **WBS ELEMENT** | | | | | | | | | | | | | | | | | |
| 1 | US LHC Accelerator | 1 | 1,662.1 | 4,175.9 | 2,431.8 | 2,513.8 | 1,744.1 | 101,070.8 | 98,507.1 | 99,718.2 | -2,563.7 | -1,211.1 | | | 107,707.7 | 108,324.0 | -616.3 |
| 1.1 | IR Regions | 2 | 2,563.5 | 3,826.0 | 1,714.0 | 1,262.4 | 2,112.0 | 59,159.8 | 57,052.4 | 57,734.0 | -2,107.4 | -681.6 | | | 63,158.6 | 64,046.7 | -888.1 |
| 1.1.1 | IR Quadrupoles | 3 | 489.7 | 638.0 | 709.7 | 148.3 | -71.7 | 33,843.9 | 31,471.5 | 32,237.3 | -2,372.4 | -765.8 | | | 35,142.9 | 35,874.4 | -731.5 |
| 1.1.2 | IR Dipoles | 3 | 1,799.1 | 2,544.5 | 193.0 | 745.4 | 2,351.6 | 10,685.8 | 11,160.4 | 10,422.7 | 474.6 | 737.7 | | | 11,633.8 | 11,633.9 | -0.1 |
| 1.1.3 | Cryo Feedboxes | 3 | 255.3 | 503.9 | 620.3 | 248.6 | -116.5 | 8,209.8 | 8,004.0 | 8,474.7 | -205.9 | -470.8 | | | 9,921.7 | 10,016.0 | -94.3 |
| 1.1.4 | Absorbers | 3 | 0.0 | 120.3 | 181.7 | 120.3 | -61.4 | 5,281.9 | 5,278.3 | 5,440.4 | -3.6 | -162.1 | | | 5,281.9 | 5,281.8 | 0.1 |
| 1.1.5 | System Design | 3 | 19.3 | 19.3 | 9.4 | 0.0 | 10.0 | 1,138.3 | 1,138.3 | 1,159.0 | 0.0 | -20.6 | | | 1,178.3 | 1,240.6 | -62.3 |
| 1.2 | RF Region | 2 | -317.5 | -215.4 | 170.8 | 102.1 | -386.2 | 15,802.1 | 15,355.7 | 14,245.4 | -446.4 | 1,110.3 | | | 15,854.0 | 15,853.9 | 0.1 |
| 1.2.1 | RF Dipoles | 3 | -317.5 | -215.4 | 170.8 | 102.1 | -386.2 | 15,802.1 | 15,355.7 | 14,245.4 | -446.4 | 1,110.3 | | | 15,854.0 | 15,853.9 | 0.1 |
| 1.3 | SC Wire & Cable | 2 | -862.3 | 283.7 | 287.2 | 1,146.0 | -3.4 | 10,123.2 | 10,110.1 | 10,010.0 | -13.1 | 100.1 | | | 11,911.5 | 11,911.4 | 0.1 |
| 1.3.1 | SC Testing | 3 | -869.1 | 283.7 | 287.2 | 1,152.8 | -3.4 | 9,090.2 | 9,077.1 | 8,938.2 | -13.1 | 138.9 | | | 10,878.5 | 10,878.5 | 0.0 |
| 1.3.2 | Cable Prod S'pt | 3 | 6.8 | 0.0 | 0.0 | -6.8 | 0.0 | 1,033.0 | 1,033.0 | 1,071.8 | 0.0 | -38.8 | | | 1,033.0 | 1,032.9 | 0.1 |
| 1.4 | Accel Physics | 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3,358.8 | 3,358.8 | 3,288.1 | 0.0 | 70.7 | | | 3,358.8 | 3,358.4 | 0.4 |
| 1.4.1 | BNL AP | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,394.5 | 1,394.5 | 1,234.7 | 0.0 | 159.9 | | | 1,394.5 | 1,394.5 | 0.0 |
| 1.4.2 | FNAL AP | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,120.1 | 1,120.1 | 1,207.6 | 0.0 | -87.4 | | | 1,120.1 | 1,119.8 | 0.3 |
| 1.4.3 | LBNL AP | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 844.2 | 844.2 | 845.9 | 0.0 | -1.7 | | | 844.2 | 844.1 | 0.1 |
| 1.5 | Project Mgt | 2 | 278.4 | 281.5 | 259.7 | 3.1 | 21.7 | 12,626.9 | 12,630.0 | 14,440.6 | 3.1 | -1,810.6 | | | 13,424.8 | 13,153.6 | 271.2 |
| 1.5.1 | US LHC PM | 3 | 81.6 | 81.6 | 87.3 | 0.0 | -5.7 | 3,437.6 | 3,437.6 | 3,327.9 | 0.0 | 109.7 | | | 3,690.6 | 3,661.6 | 29.0 |
| 1.5.2 | BNL PM | 3 | 92.5 | 95.6 | 122.1 | 3.1 | -26.5 | 5,226.8 | 5,229.9 | 7,522.6 | 3.1 | -2,292.7 | | | 5,475.7 | 5,475.8 | -0.1 |
| 1.5.3 | FNAL PM | 3 | 75.2 | 75.2 | 31.3 | 0.0 | 43.9 | 2,333.6 | 2,333.6 | 2,003.1 | 0.0 | 330.5 | | | 2,547.4 | 2,305.0 | 242.4 |
| 1.5.4 | LBNL PM | 3 | 29.1 | 29.1 | 19.1 | 0.0 | 10.0 | 1,628.9 | 1,628.9 | 1,587.0 | 0.0 | 41.9 | | | 1,711.0 | 1,711.2 | -0.2 |
| | Performance Measurement Baseline | 2 | 1,662.1 | 4,175.9 | 2,431.8 | 2,513.8 | 1,744.1 | 101,070.8 | 98,507.1 | 99,718.2 | -2,563.7 | -1,211.1 | | | 107,707.7 | 108,324.0 | -616.3 |

COST PERFORMANCE REPORT

FORMAT 1 - ORGANIZATIONAL CATEGORIES

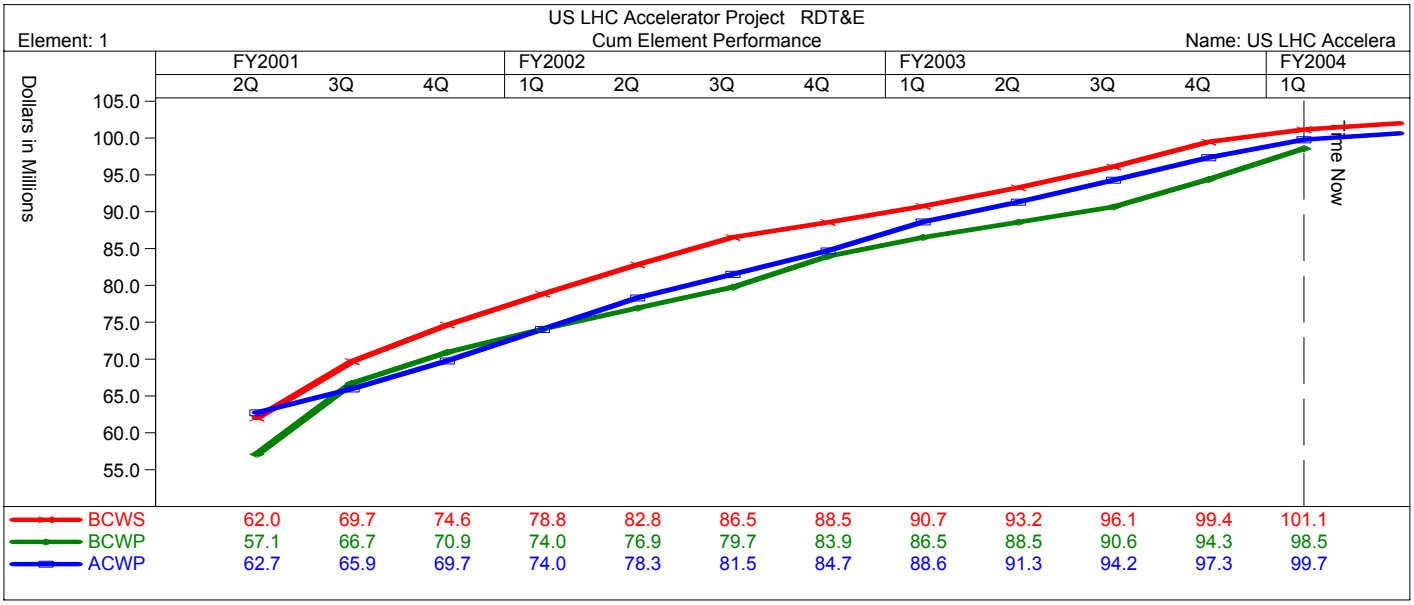
DOLLARS IN: Thousands

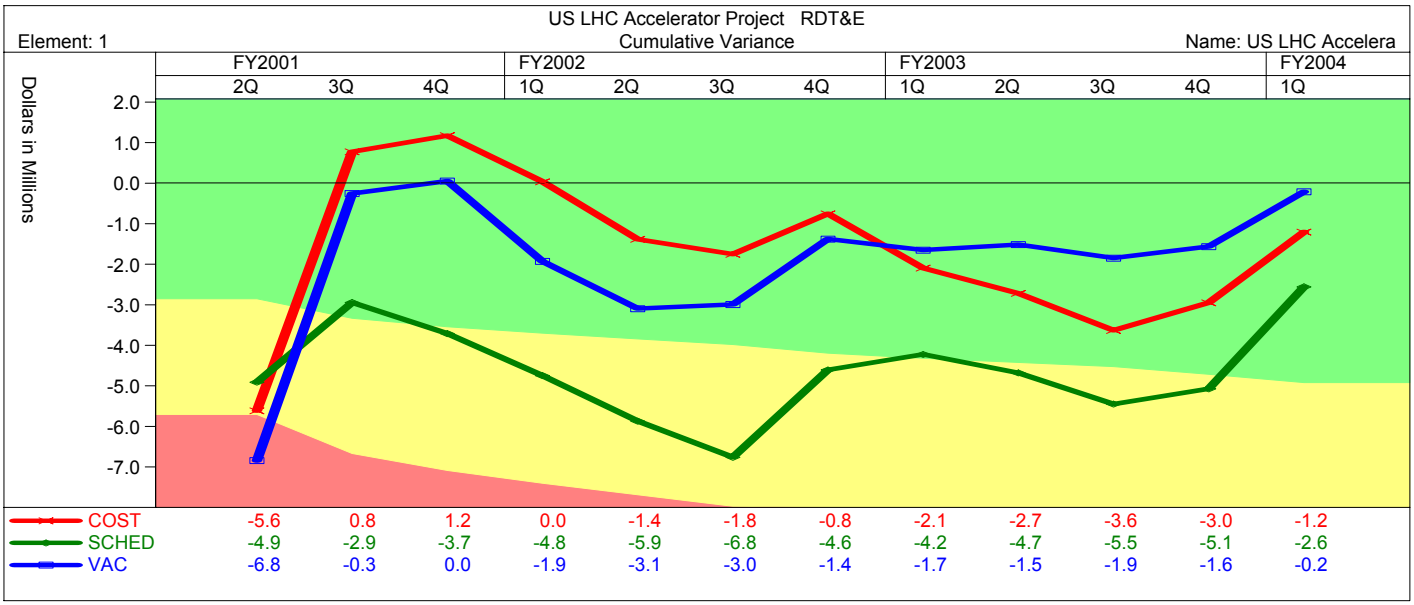


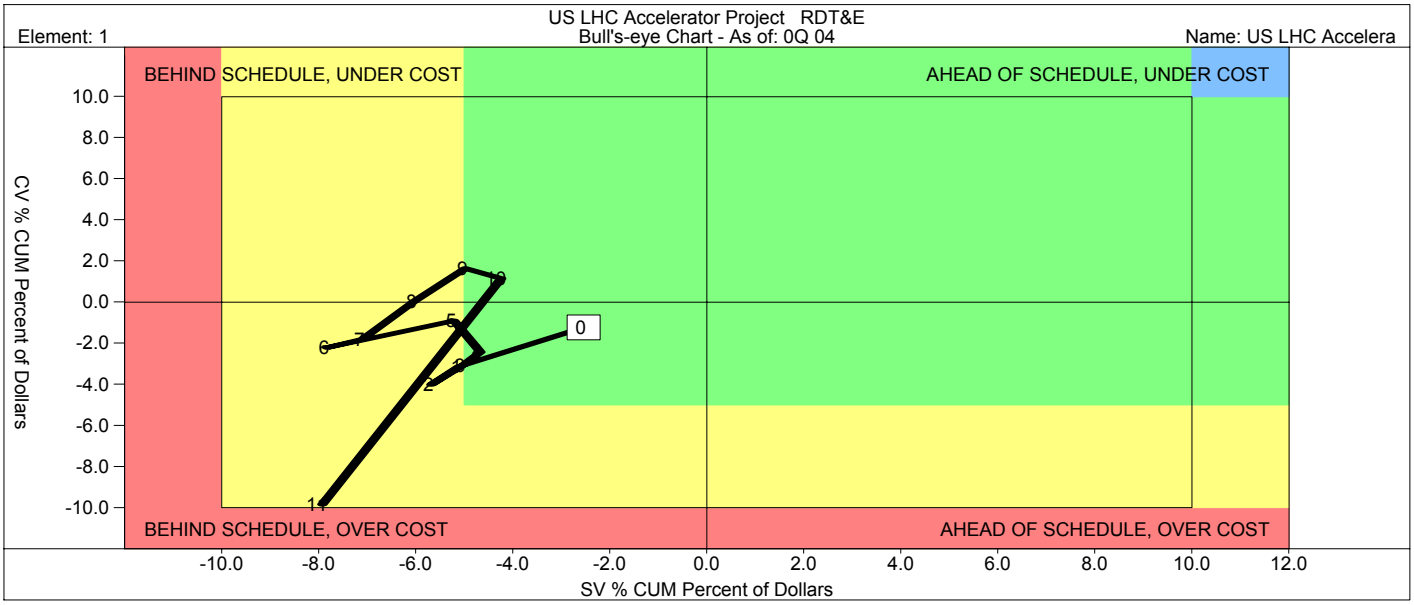
| 1. Contractor | 2. CONTRACT | 3. PROGRAM | 4. REPORT PERIOD |
|---|---|---|---|
| a. NAME<br>US LHC Accelerator Project | a. NAME<br>US LHC by Qtr | a. NAME<br>US LHC Accelerator Project | a. FROM (CCYYMMDD)<br>20031001 |
| b. Location<br>MS 343<br>PO Box 500<br>Batavia, IL 60510 | b. NUMBER<br><br>c. TYPE | | B. TO (CCYYMMDD)<br>20031231 |

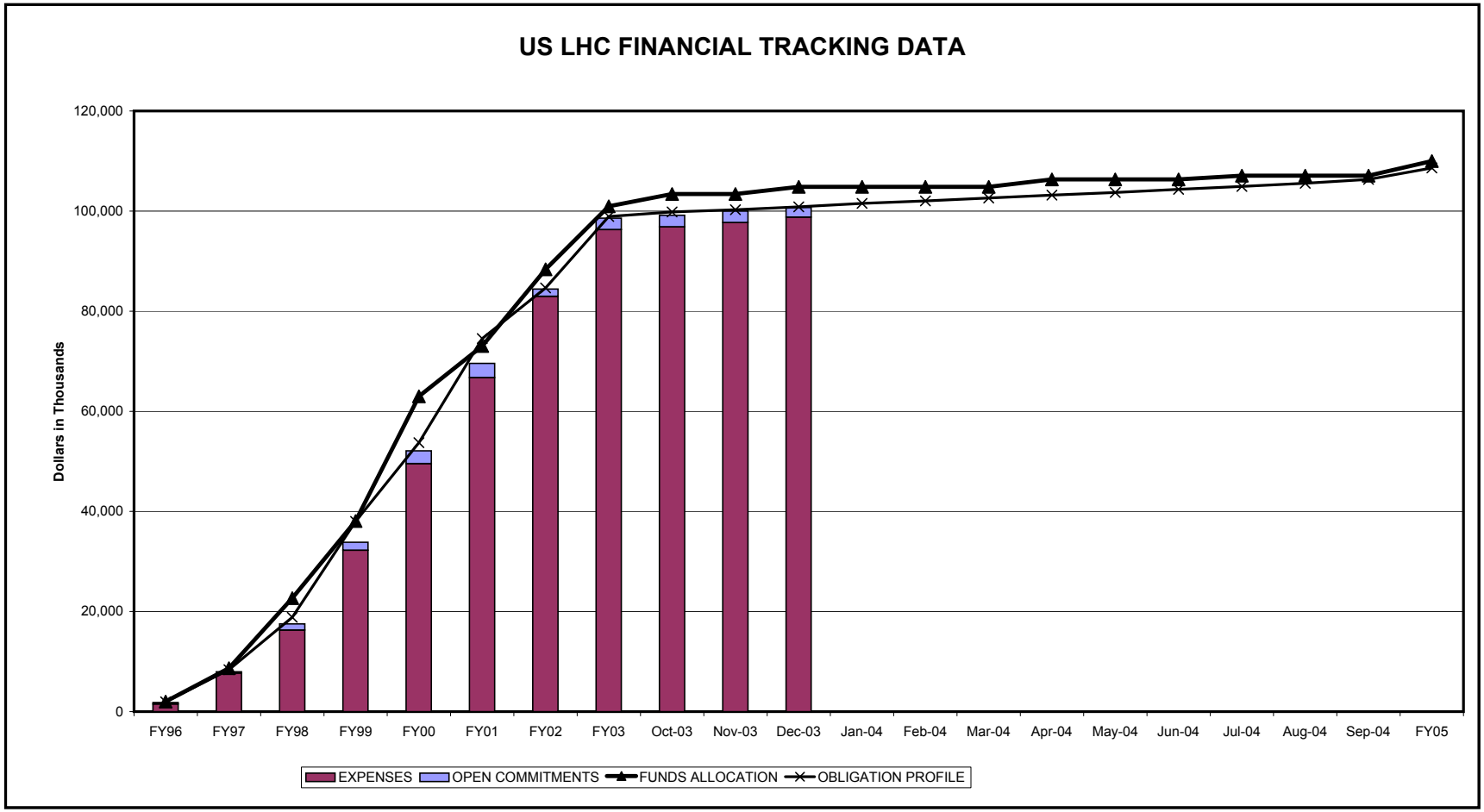
5. PERFORMANCE DATA

| ITEM | CURRENT PERIOD | | | | | CUMULATIVE TO DATE | | | | | REPROGRAM ADJUSTMENTS | | AT COMPLETION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BUDGETED COST | | ACTUAL COST WORK PERFORMED | VARIANCE | | BUDGETED COST | | ACTUAL COST WORK PERFORMED | VARIANCE | | | | | | |
| | WORK SCHEDULED | WORK PERFORMED | | SCHEDULE | COST | WORK SCHEDULED | 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) |
| **ORGANIZATIONAL CATEGORY** | | | | | | | | | | | | | | | |
| BNL 2 | 711.3 | 2,699.3 | 769.6 | 1,988.0 | 1,929.8 | 42,295.5 | 42,250.0 | 42,413.1 | -45.5 | -163.0 | | | 45,340.4 | 45,340.5 | -0.1 |
| FNAL 2 | 682.2 | 832.7 | 990.7 | 150.5 | -158.0 | 40,130.6 | 37,644.6 | 38,252.2 | -2,486.0 | -607.6 | | | 42,000.5 | 42,616.9 | -616.4 |
| LBNL 2 | 268.6 | 600.3 | 671.5 | 331.6 | -71.2 | 18,644.7 | 18,568.9 | 19,052.9 | -75.8 | -484.0 | | | 20,366.8 | 20,366.7 | 0.1 |
| Performance Measurement Baseline | 1,662.1 | 4,132.3 | 2,431.8 | 2,470.1 | 1,700.6 | 101,070.8 | 98,463.5 | 99,718.2 | -2,607.3 | -1,254.6 | | | 107,707.7 | 108,324.1 | -616.4 |


US LHC Accelerator Project RDT&E
Element: 1
Cum Element Performance
Name: US LHC Accelera
FY2001
FY2002
FY2003
FY2004
2Q 3Q 4Q 1Q 2Q 3Q 4Q 1Q 2Q 3Q 4Q 1Q
Dollars in Millions
105.0
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
Time Now
BCWS 62.0 69.7 74.6 78.8 82.8 86.5 88.5 90.7 93.2 96.1 99.4 101.1
BCWP 57.1 66.7 70.9 74.0 76.9 79.7 83.9 86.5 88.5 90.6 94.3 98.5
ACWP 62.7 65.9 69.7 74.0 78.3 81.5 84.7 88.6 91.3 94.2 97.3 99.7

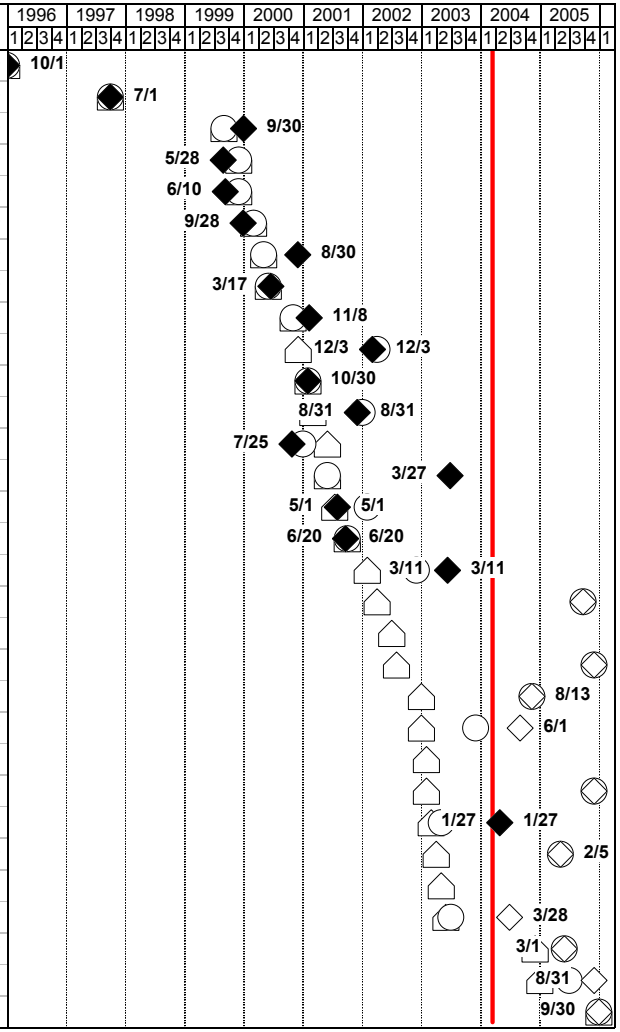

US LHC Accelerator Project RDT&E
Element: 1
Cumulative Variance
Name: US LHC Accelera
FY2001
FY2002
FY2003
FY2004
2Q 3Q 4Q 1Q 2Q 3Q 4Q 1Q 2Q 3Q 4Q 1Q
Dollars in Millions
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
COST -5.6 0.8 1.2 0.0 -1.4 -1.8 -0.8 -2.1 -2.7 -3.6 -3.0 -1.2
SCHED -4.9 -2.9 -3.7 -4.8 -5.9 -6.8 -4.6 -4.2 -4.7 -5.5 -5.1 -2.6
VAC -6.8 -0.3 0.0 -1.9 -3.1 -3.0 -1.4 -1.7 -1.5 -1.9 -1.6 -0.2


US LHC Accelerator Project RDT&E
Element: 1
Bull's-eye Chart - As of: 0Q 04
Name: US LHC Accelera
BEHIND SCHEDULE, UNDER COST
AHEAD OF SCHEDULE, UNDER COST
BEHIND SCHEDULE, OVER COST
AHEAD OF SCHEDULE, OVER COST
CV % CUM Percent of Dollars
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-10.0 -8.0 -6.0 -4.0 -2.0 0.0 2.0 4.0 6.0 8.0 10.0 12.0
SV % CUM Percent of Dollars
0




| | FY96 | FY97 | FY98 | FY99 | FY00 | FY01 | FY02 | FY03 | Oct-03 | Nov-03 | Dec-03 | Jan-04 | Feb-04 | Mar-04 | Apr-04 | May-04 | Jun-04 | Jul-04 | Aug-04 | Sep-04 | FY05 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INCREMENTAL | | | | | | | | | | | | | | | | | | | | | |
| FUNDS ALLOCATION | 2,000 | 6,670 | 14,000 | 15,400 | 24,917 | 10,062 | 15,304 | 12,596 | 2,450 | 0 | 1,450 | 0 | 0 | 0 | 1,487 | 0 | 0 | 743 | 0 | 0 | 2,921 |
| OBLIGATION PROFILE | 1,962 | 6,427 | 10,466 | 19,155 | 15,714 | 20,803 | 10,127 | 14,260 | 924 | 444 | 575 | 674 | 492 | 599 | 556 | 547 | 613 | 587 | 646 | 765 | 2,289 |
| EXPENSES | 1,515 | 6,186 | 8,594 | 15,946 | 17,307 | 17,193 | 16,232 | 13,327 | 551 | 853 | 1,085 | | | | | | | | | | |
| OPEN COMMITMENTS | 296 | -43 | 964 | 366 | 965 | 280 | -1,365 | 822 | 5 | -23 | -369 | | | | | | | | | | |
| CUMULATIVE | | | | | | | | | | | | | | | | | | | | | |
| FUNDS ALLOCATION | 2,000 | 8,670 | 22,670 | 38,070 | 62,987 | 73,049 | 88,354 | 100,950 | 103,400 | 103,400 | 104,850 | 104,850 | 104,850 | 104,850 | 106,336 | 106,336 | 106,336 | 107,079 | 107,079 | 107,079 | 110,000 |
| OBLIGATION PROFILE | 1,962 | 8,390 | 18,856 | 38,011 | 53,725 | 74,528 | 84,655 | 98,915 | 99,839 | 100,283 | 100,857 | 101,531 | 102,024 | 102,623 | 103,179 | 103,726 | 104,339 | 104,927 | 105,573 | 106,338 | 108,627 |
| EXPENSES | 1,515 | 7,701 | 16,296 | 32,242 | 49,549 | 66,742 | 82,974 | 96,300 | 96,851 | 97,704 | 98,789 | | | | | | | | | | |
| OPEN COMMITMENTS | 296 | 253 | 1,217 | 1,582 | 2,547 | 2,828 | 1,463 | 2,285 | 2,328 | 2,304 | 1,936 | | | | | | | | | | |

| Number | ID | Milestone | Original | Revised | Forecast | Actual | Variance |
|---|---|---|---|---|---|---|---|
| 1-1 | | Project Start (10/1/95) | 10/1/95 | 10/1/95 | 10/1/95 | 10/1/95 | 0 days |
| 2-1.1-1 | IR | Begin 1st Inner Triplet Quadrupole Model Magnet | 7/1/97 | 7/1/97 | 7/1/97 | 7/1/97 | 0 days |
| 2-1.3-2 | SC | Complete Superconductor Test Facility Upgrades | 6/1/99 | 6/1/99 | 9/30/99 | 9/30/99 | 87 days |
| 2-1.3-1 | SC | All Cable Production Support Equipment Delivered to CERN | 9/1/99 | 9/1/99 | 5/28/99 | 5/28/99 | -68 days |
| 2-1.2-1 | RF | Begin Assembly of 1st Dipole Model Magnet | 9/1/99 | 9/1/99 | 6/10/99 | 6/10/99 | -59 days |
| 2-1.1-2 | IR | Complete Inner Triplet Quadrupole Model Magnet Program Phase 1 | 12/1/99 | 12/1/99 | 9/28/99 | 9/28/99 | -46 days |
| 2-1.1-4 | IR | Place Purchase Order for HTS Power Leads | 2/1/00 | 2/1/00 | 8/30/00 | 8/30/00 | 151 days |
| 2-1.1-3 | IR | Complete Inner Triplet Quadrupole Model Magnet Program Phase 2 | 3/1/00 | 3/1/00 | 3/17/00 | 3/17/00 | 12 days |
| 2-1.2-2 | RF | Complete Dipole Model Magnet Program | 8/1/00 | 8/1/00 | 11/8/00 | 11/8/00 | 71 days |
| 2-1.2-3 | RF | Begin RF Region Dipole Production Assembly | 9/1/00 | 1/1/02 | 12/3/01 | 12/3/01 | -21 days |
| 2-1.1-5 | IR | Begin Absorber Fabrication | 11/1/00 | 11/1/00 | 10/30/00 | 10/30/00 | -2 days |
| 2-1.1-6 | IR | Complete Inner Triplet Quadrupole Prototype Magnet Program | 12/1/00 | 10/1/01 | 8/31/01 | 8/31/01 | -21 days |
| 2-1.1-7 | IR | Begin Interaction Region Beam Separation Dipole Prod. Assembly | 3/1/01 | 10/1/00 | 7/25/00 | 7/25/00 | -49 days |
| 2-1.1-8 | IR | Begin Inner Triplet Feedbox Fabrication | 3/1/01 | 3/1/01 | 3/27/03 | 3/27/03 | 540 days |
| 2-1.1-9 | IR | Begin Inner Triplet Quadrupole Production Assembly | 4/15/01 | 11/1/01 | 5/1/01 | 5/1/01 | -132 days |
| 1-2 | | Decision on RF Region Quadrupoles | 7/1/01 | 7/1/01 | 6/20/01 | 6/20/01 | -8 days |
| 2-1.1-10 | IR | Complete 1st Inner Triplet Quadrupole Magnet | 11/1/01 | 9/1/02 | 3/11/03 | 3/11/03 | 136 days |
| 2-1.2-4 | RF | Delivery of D3, D4 for IR4 right | 1/1/02 | 6/24/05 | 6/24/05 | NA | 0 days |
| 2-1.1-11 | IR | Delivery of D2 for IR8 Left **DELETED** | 4/1/02 | | | | |
| 2-1.1-12 | IR | Complete Inner Triplet Feedbox Fabrication | 5/1/02 | 8/31/05 | 8/31/05 | NA | 0 days |
| 2-1.1-13 | IR | Delivery of All Inner Triplet System Components for IR8 Left (MQX,DFBX,D1,D2) | 10/1/02 | 8/13/04 | 8/13/04 | NA | 0 days |
| 2-1.2-5 | RF | Complete RF Region Dipole Production Assembly | 10/1/02 | 9/1/03 | 6/1/04 | NA | 196 days |
| 2-1.1-14 | IR | Delivery of D2 for IR5 Left **DELETED** | 11/1/02 | | | | |
| 2-1.2-6 | RF | Delivery of D3, D4 for IR4 left | 11/1/02 | 8/31/05 | 8/31/05 | NA | 0 days |
| 2-1.1-15 | IR | Complete Absorber Fabrication | 12/1/02 | 2/1/03 | 1/27/04 | 1/27/04 | 256 days |
| 2-1.1-16 | IR | Delivery of All Inner Triplet System Components for IR8 Right (MQX,DFBX,D1,D2 | 1/1/03 | 2/5/05 | 2/5/05 | NA | 0 days |
| 2-1.1-17 | IR | Delivery of D2 for IR8 Right**DELETED** | 2/1/03 | | | | |
| 2-1.1-18 | IR | Complete Interaction Region Dipole Production Assembly | 3/1/03 | 4/1/03 | 3/28/04 | NA | 259 days |
| 2-1.1-30 | IR | Complete Inner Triplet Quadrupole Production | 9/1/04 | 3/1/05 | 3/1/05 | NA | 0 days |
| 2-1.3-3 | SC | Series Wire and Cable Testing Complete | 10/1/04 | 3/31/05 | 8/31/05 | NA | 109 days |
| 1-3 | | Project Completion (9/30/05) | 9/30/05 | 9/30/05 | 9/30/05 | NA | 0 days |




Date: 1/28/04

Original Baseline

Revised Baseline

Forecast

Actual