

DOE
Review Committee Report

on the

Baseline Review

of the

**RUN IIb CDF and
D-ZERO DETECTOR
PROJECTS**

September 2002

EXECUTIVE SUMMARY

The Division of High Energy Physics requested that a baseline readiness review for the Run IIb CDF and D-Zero projects be conducted September 24-26, 2002 at Fermi National Accelerator Laboratory. The upgrades are two separate projects with very similar physics motivation and technical scope, therefore the projects were reviewed simultaneously. The purpose of the review was to assess the readiness of the projects to establish technical, cost, schedule, and management baselines, which are needed for Critical Decision 2, Approve Performance Baseline (CD-2) and Critical Decision 3, Approve Start of Construction (CD-3). The Committee was asked to address the following specific items:

1. Is the proposed schedule reasonable and appropriate in light of the technical tasks required, addressing timing, funding, and resources?
2. Is the cost estimate credible, and in sufficient detail to evaluate the contingency?
3. Have the major technical, schedule and cost risks been adequately identified and assessed, and is the contingency adequate for the risk?
4. Is the management structure adequate and appropriate?
5. What is the status of the documentation required to support CD-2 and CD-3?

Run IIb of the Tevatron will occur after the current Run IIa, which should last about four years. Portions of the CDF and D-Zero detectors will need to be replaced or improved for Run IIb. By the end of Run IIa the silicon vertex detectors will begin to have degraded performance due to the radiation dose they will have received. Therefore, the silicon vertex detectors of both detectors will be replaced so that the experiments can continue to perform optimally. The complete silicon vertex system from sensors to readout electronics will use the newest radiation hard technologies to ensure their survival until the end of Run IIb.

Additional changes are required by the peak luminosities planned for Run IIb. At the highest luminosities the detectors will be seeing approximately ten events at each beam crossing. This results in much higher occupancies in the detector, and more complicated trigger requirements. A series of selective upgrades to the readout electronics, trigger, and data acquisition systems are required to handle these high interaction rates. Specific to CDF, the Run IIa Central Preshower Detector is the last gas-based portion of the calorimetry system at CDF, used primarily to improve electron identification.

A simple electronics upgrade is not sufficient to handle the higher interaction rates expected for Run IIb, so it will be replaced with a scintillating tile system like the rest of the CDF calorimeters. Specific to D-Zero, the silicon track trigger must be modified to accommodate the geometry of the new silicon vertex detector.

The Committee commented on the advanced maturity of the technical design and concluded that the upgrades are technically ready to be baselined.

The Committee reviewed the cost estimate detail and concluded that the base cost estimates for Silicon were slightly low. However, the Committee was of the opinion that the contingencies assessed against the base costs are too high for the observed risks. The Committee recommended that Fermilab consider re-evaluation of the base costs and the contingency costs based on the comments provided by the Committee in this report.

The Committee reviewed the proposed schedule and found that there are three tiers of milestones established for this project:

- The Project Manager's Milestones—no explicit slack.
- The Director's/DOE Project Manager's Level 2 Milestones—modest contingency.
- The DOE Level 1 Milestones—additional added contingency.

The intent of the project is to manage their schedules to the Project Managers' Milestones, which the Committee concluded were very aggressive. However, the schedule contingency contained in the Level 1 and 2 milestones appears to be more than adequate to complete the project by the Level 0 Critical Decision 4, Approve Start of Operations. The Committee recommended that Fermilab re-evaluate the schedule float based on the comments provided by the Committee.

The Committee found that experienced project management teams are in place, and that the collaborations seem to be committed to support the upgrade with manpower and in-kind contributions. The required project documentation to support CD-2 and CD-3 appears to be essentially complete.

The overall judgment of the Committee is that the Run IIb CDF and D-Zero Detector projects are technically advanced and have good management teams in place. Once the cost and schedule adjustments have been made, the Committee recommends that the projects should be baselined.

CONTENTS

Executive Summary	i
1. CDF Detector Upgrade Project.....	1
1.1 Technical Systems Overview	1
1.1.1 Silicon Tracker (WBS 1.1)	2
1.1.2 Calorimeter Upgrades	6
1.1.3 DAQ/ Trigger Upgrade	7
1.2 Cost and Schedule	10
1.3 Management	12
2. D-Zero Detector Upgrade Project.....	15
2.1 Technical Systems Overview	15
2.1.1 Silicon Tracker (WBS 1.1)	16
2.1.2 Trigger Upgrades	20
2.1.3 DAQ/Online Upgrade	25
2.2 Cost and Schedule	27
2.3 Management	30

Appendices

- A. Charge Memorandum
- B. Review Participants
- C. Review Agenda
- D. Cost Tables
- E. Schedule Tables
- F. Organization Charts

1. CDF DETECTOR UPGRADE PROJECT

1.1 Technical Systems Overview

The Run IIb CDF Detector project consists of the replacement of the current silicon vertex detector, the addition of timing information to the electromagnetic calorimeter readout, a replacement for the preshower detector, replacement of the TDC's for the Central Outer Tracker (COT), upgrades of Level 1 track trigger, the silicon vertex trigger, the Level 2 trigger decision system, and the Level 3 trigger processor farm.

The new silicon vertex detector replaces all detector elements inside of the intermediate silicon layers. It is designed to be more radiation hard and simpler to construct than the current detector. It is highly modular with all layers but the innermost using a single sensor type. There are axial sensors that measure the ϕ coordinate and some sensors are slightly rotated to give small angle stereo that will supply some z information. Only single-sided silicon sensors are used.

The readout of the silicon utilizes a newly developed improvement of the SVX chips currently used by both CDF and D-Zero. This version, SVX4, will be implemented in submicron silicon technology, which is radiation hard when appropriate design rules are followed. It is functionally equivalent to the current readout chip used by CDF, the SVX3. The readout chain beyond the SVX4 is retained from Run IIa.

The Run IIa Central Preshower Detector is the last gas-based calorimeter left in CDF. It will not be able to operate at the rate expected for Run IIb. Its primary purpose is to improve electron identification. The replacement is scintillator tile based with multianode photomultiplier readout like those used by MINOS.

The Electromagnetic Calorimeter readout will be modified to add timing information. This allows the rejection of cosmic ray and beam halo backgrounds in SUSY and Large Extra Dimension Searches. The timing measurement system is modeled on the one already used by the hadronic calorimeter.

The higher luminosity of Run IIb will result in higher occupancies that the trigger must handle. In addition, the data acquisition bandwidth will remain the same, so it will be necessary to make the trigger more selective. The planned upgrades of the trigger and data acquisition are:

- the time-to-digital converters on the COT
- the fast track processor used to find tracks in the COT at Level 1
- the silicon vertex tracker in the Level 2 trigger
- the event builder switch and Level 3 processor farm, and the Level 2 decision crate

1.1.1 Silicon Tracker (WBS 1.1)

1.1.1.1 Schedule

CDF presented a detailed, resource-loaded schedule for the Run IIb Silicon Vertex detector replacement project.

The Level 3 “Manager’s Schedule” has a duration of 680 working days, with completion scheduled for May 20, 2005. Contingency has been added to the Level 3 milestones to produce an 830-working-day, Level 2 “Director’s Schedule” with a completion date of December 23, 2005. A Level 1 schedule with a 1,092-day duration ends on November 24, 2006. All schedules assume an immediate start of construction. The schedule assumes a five-day week with one shift per day.

Most of the required components have been successfully prototyped, including the SVX4 chip, hybrid, and sensors. Two prototype outer layer modules have been built and successfully tested.

The procurement department at the Fermi National Accelerator Laboratory (Fermilab) is already involved and early planning of major procurements has started. Quotes-in-hand included commitments for delivery on many parts.

The Level 3 milestones were intentionally constructed without contingency in order to define the core of the project. This is an explicitly success-oriented schedule with limited provision for handling delays. The Level 2 Director’s Schedule milestones include some contingency that extends the project duration by 22 percent compared to the Level 3 plan. As a management and planning tool, the Level 3 schedule is probably useful, but the Committee believes it is not a realistic predictor of the project evolution. The Level 2 schedule is probably achievable, but not with a high level of certainty.

The schedule depends on the timely arrival of many different components and a smooth assembly process. During module and stave production, the pace is set by hybrid deliveries, assuming sensors can be stockpiled early. Any problems in procurement, parts quality, and/or availability of

manpower or machines would require either a delay in the completion date or a work-around. Examples of work-arounds include, for example: increased manpower, additional shifts, expanded facilities or fixturing, or possibly financial incentives or the qualification of additional suppliers.

The collaborations are ready to proceed with the major procurement of silicon sensors. Delays beyond mid-February 2003 will translate directly into delays of the end date.

Recommendations

1. Proceed with expeditious sensor procurement and continue to negotiate for increased sensor delivery rate.
2. Proceed with expeditious procurement of the second prototype SVX4 chip.
3. Increase the schedule contingency from 150 to approximately 200 working days. This implies an end date in mid-June 2006.

1.1.1.2 Manpower and Resources

Manpower at SiDet has been reviewed in detail. The integrated project requirement for Fermilab technical support is estimated at 63 K hrs, compared with the Run IIa actual usage of 98 K hrs. The difference is attributed to the intermediate silicon layers construction in Run IIa.

The significant discrepancy between CDF and D-Zero manpower estimates that appeared in the Director's Review (August 2002) has been fully understood and resolved. When compared on the same basis, both experiments now show equivalent manpower requirements.

When broken down by different types of manpower, mechanical technicians (for module and stave production) are a large component of the total need. There is current, approximately 50 percent, shortfall in this category but studies of Laboratory personnel indicate that the shortfall can be made up by redirecting labor with the Laboratory. The Committee was shown a list of forty-two qualified technicians. Additional technicians could be hired from the outside if needed.

Overall demands on the Sidet facility by CDF, D-Zero, CMS, and BTeV have been taken into consideration, and both human and technical resources appear to be allocated without overlap. Allocation analysis in the peak period (2004) indicates that maximal demand can be accommodated.

Key questions about total manpower demands have been studied carefully and the resolution of CDF and D-Zero discrepancies lends confidence in the projections.

The Committee notes, however, that the difference between 63 K hrs projected for Run IIb and 98 K hrs recorded for Run IIa is very large. With a more streamlined design, more accumulated experience, and absent the intermediate silicon layers construction, it is natural to expect that Run IIb construction demands will be lower. However, this estimate seems optimistic. The Committee notes that 98 K hrs is 56 percent larger than 63 K hrs, so the room for error in either manpower peak-demand estimates, or in the estimate of the overall project duration, is large compared with contingency provisions. For example, a 56 percent increase in project duration is almost three times the contingency allowed in the Level 2 schedule.

Recommendation

1. Begin transfer and training of mechanical technicians as soon as is practical.

1.1.1.3 Cost

The integral of the at-year spending profile (overhead included) is \$14.4 million, of which \$9.46 million is DOE project cost. The rest is from outside sources (Italy and Japan) or from R&D. The M&S and labor split is approximately 60/40.

All 2002 expenditures are classed as R&D.

Major cost drivers are sensors, hybrids, SVX4 chips, cables, and stave assembly. Sensors are approximately \$500 each, hybrids \$700 each, and SVX4 chips \$100 each.

Net contingency is estimated at 53 percent by propagating contingency estimates on individual elements. Most contingencies are placed at 50 percent with some adjusted up or down for special considerations.

The Committee is confident in the estimate of the base cost, which appears to be quite reasonable. Bases of estimates are quotations in most cases.

Cost contingencies appear large. Many cost drivers, including sensors, hybrids, and SVX4 chips are well-advanced and do not seem to warrant approximately 50 percent contingencies.

The large cost contingencies and small schedule contingencies do not seem to be in harmony. In addition, the Committee believes that actual risks are larger for schedule than for cost, which is opposite to the contingency strategy shown in the project plan. The Committee noted that not all schedule delays can be compensated by spending more money.

Labor costs reflect the Level 3 schedule, and any stretch in the schedule will draw additional labor cost from the cost contingency.

Recommendations

1. Revise contingency estimates.
2. Increase base labor costs to reflect a realistic schedule.

1.1.1.4 Risk

Technical risk exists in the chip performance, analog cable production, and noise performance. Spares are planned to be 10-20 percent in most major components. A sole-source vendor is planned for sensors, and at most two sources for hybrids.

The collaboration has taken risk-assessment seriously and developed an algorithm for evaluating risk. In addition, Run IIa experts conducted a review of the risk.

Technical risk analysis is in good shape. Key items are at a well-advanced stage of development, and the first working modules appear to work very well. The sensors are sole-sourced but the vendor is known to be extremely reliable and the design requirements are straightforward. The Committee did not, however, probe mechanical design and fabrication issues, and therefore cannot comment on the technical risk there.

Cost risk does not seem large, and as noted in the previous section, has probably been overestimated.

Schedule risk appears to be quite high. Provisions to accommodate delays are primarily plans to parallelize construction, but delays due to technical setbacks, vendor mistakes, and other interruptions in the flow are not necessarily addressed by increased parallelization in the production assembly lines.

1.1.1.5 Recommendation

1. The project should be baselined with a revised schedule (as described above).

1.1.2 Calorimeter Upgrade

The calorimeter upgrade is an important component of the proposed upgrades to ensure the proper operation of the CDF detector for Run IIb running conditions. The project leaders have properly characterized the scope, schedule, and cost. The Committee recommends this system be baselined.

1.1.2.1 Preshower/Crack Calorimeter Upgrade

CDF has identified a system that requires upgrading the calorimeter. This system is the preshower calorimeter along with their crack shower detectors. The upgrade will replace the aging gas-based preshower with scintillating tile technology. The scope and cost of the project are modest.

The technical aspects of this upgrade are sound in that well-known technology is in use, consisting of scintillating tiles with a fiber light guide to channel the photons to 16-channel phototubes.

CDF has progressed well into the project by demonstrating the basic functionality of a single tile and has started basic performance measurements. Currently, there is excellent photoelectron yield that is well above the minimum standard.

The designs are in place to build full-scale module prototypes that pose no known technical challenge. Detailed work needs to be done to finalize the placement of the fibers and phototubes within the calorimeter system.

The tasks of the full project are well specified along with the assignments of said tasks.

Recommendation

1. The project shows all signs of being well prepared, well managed, and the costs well estimated. There is no need for any change to the current project.

1.1.2.2 Electromagnetic Timing

CDF is fixing a deficiency in their calorimeter by adding timing information to the electromagnetic calorimeter portion of their calorimeter system. The novel use of an inductive pickup looks to be working fine. The scope and cost of the project is modest.

This upgrade is independent of Run IIb luminosity conditions, but it does serve to fix some serious problems in the physics reach of the detector for certain physics channels. For example, this will reduce serious backgrounds in photon susy searches.

The Committee notes that some items will be obtained by recycling items from the Run IIa detector (i.e., some TDCs and VME crates). The cost listed for these items was not reduced to zero, but was instead offset as an in-kind contribution.

Recommendation

1. The funds of all items that will effectively have zero real cost to the project should be removed and listed separately so that its clear to anyone auditing the project that the items are really of zero cost, or the recycled items should be listed as having zero cost.

1.1.3 DAQ/Trigger Upgrade

The DAQ/Trigger upgrade is an important component of the proposed upgrades to ensure the proper operation of the CDF detector for Run IIb running conditions. The project leaders have properly characterized the scope, schedule, and cost. The Committee recommends that this system be baselined.

1.1.3.1 TDC Replacement

CDF has properly identified this system within the DAQ as needing upgrading in order for the detector to properly operate at Run IIb luminosity conditions.

This requires a full overhaul to the COT TDC system. TDC data processing time needs to be addressed. The current processing time will cause a bottleneck in the trigger. Data readout and transport to the VRB systems needs to be addressed. Its current maximum bandwidth will not suffice for Run IIb luminosity conditions.

CDF is pursuing the use of novel off-the-shelf technology by using the latest Altera Stratix FPGA chips.

A large number of boards will be replaced, therefore more attention needs to be given to project management.

Recommendations

1. Measure the timing characteristics of the Altera Stratix FPGA TDC circuit, as soon as possible and publish the results in an internal CDF technical document.
2. Secure the purchase of Altera Stratix FPGA chips early in the project to ensure that there are no procurement problems that would lead to delays of the fabrication stage.

1.1.3.2 Level 2 Trigger

CDF is concerned about the maintenance and reliability of their Level 2 system. The current Level 2 system is based on a DEC Alpha system along with many custom-built boards.

The Committee recognizes the need for the upgrade in order for it to be maintainable. The use of the pulsar board currently being developed will solve the problem. The project is very well underway with full board prototypes already in hand.

Recommendation

1. Measure the latency of the processor component of this project and publish the results in an internal CDF technical memorandum. This should be done as soon as possible in order to alleviate doubts about whether a PC running a real time version of Linux can do the job.

1.1.3.3 eXtremely Fast Tracker Upgrade

CDF has determined that the Level 1 trigger rejection will suffer due to Run IIb luminosity conditions with respect to the Level 1 track finding algorithms. The solution requires a substantial upgrade to the eXtremely Fast Tracker (XFT) trigger.

The project is large in scope, but technically well under control. The basic upgrade requires expanding the size of lookup tables used in the XFT Level 1 trigger. The team that built the Run IIa version of the XFT hardware is in charge of the Run IIb upgrade. This is a good sign that the project should do well.

1.1.3.4 Event Builder

Due to the larger data volume that is expected with Run IIb luminosity conditions, CDF needs to upgrade their event builder switch. This requires changing from an October 3- to October 12-based ATM switch that will increase their bandwidth substantially.

The project is straightforward and should require no major change to the fundamental design of the event builder system. CDF was asked to look into alternative technologies like miranet or gigabit as a possible replacement to their ATM setup. CDF is following up on this recommendation.

Recommendation

1. Review in detail the change of technology schedule and ensure ample development time to integrate the system into the existing DAQ. This should be done if a decision is made to switch to an different technology.

1.1.3.5 Level 3 Processors

CDF needs more processing in order to maintain the needed rejection at the Level 3 stage of the trigger system. This is a straightforward upgrade requiring the purchase of newer more powerful PCs.

1.1.3.6 SVT Upgrade

Due to the upgrade of the silicon vertex trigger (SVT), CDF needs to upgrade the SVT Level 2 trigger. The project basically requires building a modest number of existing boards. There appeared to be no real R&D effort.

1.2 Cost and Schedule

1.2.1 Findings

Microsoft Project 2000 and COBRA have been chosen as the primary project tools for cost and schedule development. A resource-loaded schedule has been developed. All materials and services, labor, contingency estimates, and risk factors have been loaded into the schedule. Costs have been developed using a mix of engineering estimates, vendor quotes, and experience from Run IIa. Project costs reflect technical manpower only. Physicists are not costed but are loaded and used for project planning. The COBRA project-tracking tool is in place and will be used to determine earned value measurements.

A summary of the CDF costs for Run IIb, including R&D, general and administrative, contingency, and escalation, is shown in Table 1-1. All costs to date are attributed to R&D. Additional cost details can be found in Appendix D.

Table 1-1. Summary of CDF Costs for Run Iib

	To-Date Cost	To-Go Cost	Contingency %	Contingency \$	Total Project Cost
Silicon	711	13672	53	7189	21573
Calorimeter	55	1078	34	363	1496
DAQ/Trigger	0	5103	55	2802	7904
Admin.	67	1149	53	608	1825
Total Project Cost	833	21002	52	10962	32798

There are three tiers of milestones established for this project:

- The Project Manager's Milestones are extracted directly from the schedule details with no explicit slack.
- The Director's/DOE Project Manager's Milestones, which have a modest amount of schedule contingency introduced.
- The DOE Level 1 Milestones, which have additional added contingency.

The schedule is being managed to the Project Manager's Milestones. This schedule is based on starting work on the non-R&D portion of the project on October 2, 2002. Initial procurement activities would commence in November 2002.

The completion goals for the project are defined in the draft Project Execution Plan and Project Management Plan. Key completion milestones at the three tiers are shown in Table 1-2 and funding sources are shown in Table 1-3. Additional schedule details can be found in Appendix E.

Table 1-2. Three-Tier Milestones

	Project Manager's Milestone	Director/DOE Proj. Manager's Milestone	DOE Level 1 Milestone
Silicon Outer Detector Complete	March 11, 2005	September 28, 2005	March 2006
Silicon Ready for Installation	May 20, 2005	December 23, 2005	November 2006

Table 1-3. Funding Sources

K\$	2001	2002	2003	2004	2005	2006	Total
Equipment	0	3,500	3,469	9,401	8,508	2,602	27,480
R&D	0	1,670	480	0	0	0	2,150
Foreign/University	0	319	1,793	1,037	19	0	3,168
Total	0	5,488	5,742	10,439	8,527	2,602	32,798

1.2.2 Comments

The Committee reviewed the cost estimate detail and concluded that the base cost estimates for Silicon were slightly low. However, the Committee is of the opinion that the contingencies assessed against the base costs are too high for the observed risks. An assessment of the costs is included in Appendix D.

Due to uncertainties in the Tevatron schedule, the beginning of installation of the detector upgrades cannot be determined at this time. Installation and commissioning are not considered part of the project. The end of the project is defined as "Silicon Tracker Ready for Installation." This separates the project from the Tevatron Operations and provides for a means to achieve completion of the project independent of physical installation and commissioning.

There is schedule contingency contained in the Level 1 and 2 milestones that appears to be more than adequate to complete the project by the Level 0 Critical Decision 4, Approve Start of Operations.

1.2.3 Recommendations

1. Consider re-evaluation of the base costs and the contingency costs based on the comments provided in this report.
2. Re-evaluate the schedule float based on the comments provided in this report.

1.3 Management

1.3.1 Findings

For the proton-antiproton collider Run IIB, Fermilab plans on increasing the luminosity before the start-up of the LHC (envisaged for 2007). This will be an excellent opportunity for the U.S. community to hunt for the Higgs particle using a local facility. Recent progress has been made on achieving high luminosity in the collider (peak luminosity $L=3E31$, 60 percent of the design goal at this time).

To cope with the increase in luminosity, and to replace the radiation-damaged inner detectors, the CDF and D-Zero collider detectors will have to be upgraded too. The upgrade of the CDF detector for Run IIB consists of replacing the silicon vertex detector, modernizing the pre-shower calorimeter, as well as improvements to the data acquisition system and the trigger.

The design of the detector upgrades is based on the operating experience gained with the present Run IIA. In many critical cases, prototypes of detector components have been built and tested successfully.

The total cost of the project has been estimated at \$32,798 K, including \$2,800 K DOE R&D funding and \$3,168 K contributions from foreign and other non-DOE funding sources. The DOE funding will be part of Fermilab's operating budget. The cost-to-go is \$21,002 K, leaving a contingency of \$10,962 K or 52 percent. The status of the project documentation is given in Table 1-4.

Table 1-4. Status of Project Documentation

Document	Status
Technical Design Report	Available for review
Mission Need Verification	PAC Report
PEP	Draft prepared
ES&H	Included in PEP
AEP	Submitted to DOE HQ
PMP's	Drafts prepared
PMCS Review	Planned for 10/2002
External Independent Review	ASAP

1.3.2 Comments

The detector design is technically mature, the technical risks have been identified, and mitigating measures are in place. Costs have been estimated and the baseline costs appear reasonable. An experienced project management team is in place. Administrative help has been identified and is in place. The collaboration seems to be committed to support the upgrade with manpower and in-kind contributions. Negotiations on the Memoranda-of-Understanding with collaborating institutions have been started, although the final documents still have to be signed.

In view of the technical maturity of the project, the contingency assignments seem to be too conservative and should be re-examined.

Three schedules with different risk levels have been prepared: a very aggressive one for internal purposes, a more realistic one for Fermilab, and a relaxed schedule for official reporting. This is potentially confusing, and only one official schedule should be used. The Fermilab Director's Schedule seems to be best suited, although the Committee expressed concern about the silicon part of the schedule being tight. Also, all schedules have been derived under the assumption that project approval is imminent. It is important for DOE to provide guidance to the experimenters on the anticipated start date.

The project reporting structure is presently being put in place. A particular problem is the reporting on the progress of foreign or non-DOE funded parts of the project. It seems to be sufficient to report on the technical progress, but not on earned value. Keeping contingency on non-DOE funded parts of the project will give project management some additional flexibility.

The overall judgment of the Committee is that the Run IIB CDF Detector project is mature and has a good management team in place; the Committee sees no reason to delay the start of construction.

1.3.3 Recommendations

1. Get written commitments (Memoranda-of-Understanding) for manpower and other contributions from collaborating institutions.
2. Develop a credible schedule, taking into account comments made by the Committee.
3. Re-evaluate base costs.
4. Re-examine contingency assignments.
5. Obtain guidance from DOE for project start date.
6. DOE should move forward expeditiously with the approval of Critical Decision 1 (Approve Preliminary Baseline Range), CD-2 (Approve Performance Baseline), and CD-3a (Long-Lead Procurements) of the Run IIB CDF Detector project (after schedule and contingency issues are clarified).

2. D-ZERO DETECTOR UPGRADE PROJECT

2.1 Technical Systems Overview

The Run IIb D-Zero Detector project consists of the replacement of the current silicon vertex detector, upgrade of the data acquisition system, and upgrades to a number of the trigger subsystems: the Level 1 calorimeter trigger, the Level 1 calorimeter to track matching, the Level 1 tracking, the Level 2 trigger processors (beta boards), and the Level 2 silicon track trigger.

The new silicon vertex detector completely replaces the Run IIa vertex detector. It is very similar to the CDF silicon vertex detector. It is designed to be more radiation hard and simpler to construct than the current detector. It is modular with a small number of sensor types. All sensors from layer 2 to 5 use a single sensor type mounted on staves to provide axial and small angle stereo measurements. In layer 0 and 1, sensors are only axial and are mounted on an integrated carbon fiber support. Only single-sided silicon sensors are used. The silicon vertex detector is split in two along the z -axis, facilitating installation without complete removal of the endcap calorimeter.

The readout of the silicon utilizes a newly developed improvement of the SVX chips currently used by both CDF and D-Zero. This version, SVX4, will be implemented in submicron silicon technology that is radiation hard when appropriate design rules are followed. It has a mode of operation that is compatible with the current D-Zero readout system. This allows the re-use of the rest of the current readout system.

The bandwidth through the trigger and data acquisition system will not be changed, so it is necessary to be more selective. The rejection in the Level 1 trigger is increased, and processing power in Level 2 is increased to allow more complex algorithms to be run. The silicon track trigger must be modified to accommodate the new geometry of the silicon vertex detector.

The calorimeter trigger upgrade will add digital filtering of the inputs and a new clustering algorithm for jets, electromagnetic clusters, and taus based on the algorithm developed by ATLAS. This sharpens the trigger efficiency thresholds in p_t .

The Level 1 track trigger will use narrower tracker roads by using single fiber hits rather than pairing adjacent fibers. This requires the replacement of the FPGA in the track trigger by a larger one capable of processing more combinations.

The Level 1 track to clustering matching will have finer granularity in ϕ , which exploits improvements in the Level 1 calorimeter trigger. The rejection of fake electromagnetic clusters is improved by a factor of 2 and the rejection of fake taus is improved by a factor of 10.

The data acquisition system and online upgrade is focused on providing more processing power in the Level 3 filter farms. An additional 96 nodes of faster processors will give a factor of seven increase in processing power. The current control system is an industry standard EPICS system. Half of the control system processors will be replaced with modern EPICS processors.

2.1.1 Silicon Tracker (WBS 1.1)

The existing D-Zero Run IIa silicon vertex detector is not expected to survive much beyond 4 fb^{-1} , while the luminosity goal for Run IIb is 15 fb^{-1} . The D-Zero collaboration has considered two options: partial replacement of the inner layers, and a full replacement of the entire detector. The former was rejected because it is very risky and will incur a very long shutdown. The new silicon vertex detector that D-Zero proposes to build is much simpler and stronger than the Run IIa detector. It is built from 2,304 single-sided silicon sensors of three different sizes. There are 888 BeO hybrids and 7,440 SVX4 readout integrated circuits for a total of 952K readout channels, compared to 793K in the Run IIa detector. The modular design and the smaller number of different parts were chosen to speed up the construction schedule. The proposed detector meets or exceeds the performance of the Run IIa detector, and will allow D-Zero to extend the search for new physics up to the highest luminosities the Tevatron is expected to deliver.

2.1.1.1 Schedule and Resources

D-Zero presented a very detailed, resource-loaded schedule for the Run IIb Silicon Vertex detector replacement project.

Many of the required components have been designed and successfully prototyped, including the SVX4 chip, hybrid, and sensors. Prototype modules for both Layer 0 and Layer 1 module were built and successfully tested.

The procurement department at Fermilab is already involved and early planning of major procurements has started. Quotes already received include commitments for delivery on many parts.

A committed and enthusiastic management team is in place. There is a small amount of overlap with CMS, which has a beneficial aspect through the exchange of ideas with the CMS silicon group.

There is a significant shortfall in the required number of mechanical technicians in SiDet, but there is a plan to make up this shortfall by redirecting labor with the Laboratory.

SiDet facility usage has been carefully considered. The conclusion presented shows that there are enough CMM machines, wirebonders, etc. to accommodate CDF, D-Zero, and CMS.

The “Manager’s Schedule” has a completion date of July 22, 2005 and little or no float. The “Director’s Schedule” has a completion date of December 26, 2005 and includes float assigned by the Project Manager totaling approximately 15 percent more calendar time.

Many activities are close to the critical path (within 30 days). The schedule is dominated by module construction and assembly that, in turn, depend on timely delivery of chips, hybrids, sensors, and cables.

Some time has been allocated to ramp-up construction and assembly tasks, but the assumed turn-on rate is rather steep.

The D-Zero collaboration has done a thorough job of understanding and quantifying the silicon detector construction project schedule.

Technically, the project is in very good shape with few major risks and no major problems. The level of prototyping is well-advanced for a project at this stage.

This is a complex project requiring many technically challenging components to merge in a timely way, and it is very likely that some delays will occur due to unforeseen circumstances.

The Manager’s Schedule was intentionally constructed without contingency to push the project through as quickly as possible. The Director’s Schedule is more credible, but still ambitious.

Recommendations

1. Baseline the schedule to have a high degree of confidence, but without excessive contingency. For example, adding 110 working days to the Level 2 milestones (a 30 percent increase over the Manager's Schedule) would bring the completion date to approximately May 2006. The Committee believes that there is a high probability the project will be completed by this date.
2. If the start of construction funding is delayed beyond the assumed start (November 2002) adjustment should be made to the completion date as necessary.
3. Proceed expeditiously with the R&D program, including the procurement of the second prototype SVX4 chip.
4. Proceed expeditiously with sensor procurement and explore options to increase the rate of sensor delivery.

2.1.1.2 Cost

The total cost of \$22,935 K includes a contingency of \$8,178 K or 68 percent.

The basis of estimate was very well documented, with vendor quotes for all of the cost drivers and prototypes delivered and tested.

A detailed examination of the sensor and hybrid cost estimates checked out, with solid quotes from reliable vendors, reasonable allowance for spares, and consistent calculation of overhead.

Manpower is costed according to the aggressive Manager's Schedule with additional contingency added to cover possible delays and the resulting increase in labor costs.

Contingency has been estimated using extremely conservative assumptions, resulting in a high overall contingency despite the relatively advanced technical state.

The high cost contingency is in marked contrast to the schedule, where very little contingency has been assigned.

Adding additional contingency to the baseline schedule will result in higher estimated labor costs, but overall contingency could be significantly reduced.

Recommendations

1. Increase the labor costs to be consistent with the revised schedule baseline. In a sample exercise based on a May 2006 baseline schedule, this resulted in a net increase of \$1.47 million to the base cost, from \$12.038 to \$13.508 million.
2. Reduce contingency to reflect the technical readiness of the project. A sample exercise resulted in a total contingency of just over \$4 million, or 30 percent of the adjusted base cost. Total project cost, in this example, was reduced by \$2.6 million (approximately 11 percent).
3. Once the collaboration has undertaken a re-evaluation of the cost to build according to a more realistic schedule, and reduced the contingency to reflect the technical progress, the cost should be ready to be baselined.

2.1.1.3 Risk

The overall technical risk of the project is moderate to low. D-Zero has identified many ways to reduce complexity and limit technical risk, for example, by laying out the hybrid with large vias so it could be screen printed, and finding a solution for the analog flex cable based on two overlapping cables each with twice the required pitch.

The remaining areas where R&D is still required to reduce technical risk include the SVX4 chip, the cooling system, and the grounding and shielding design, which should be fully prototyped.

The Committee did not have time to identify risk in the areas of mechanical support, module and stave design, or final assembly.

The main risk is in the area of schedule as discussed above.

Overall the project is in good shape and ready for baselining once cost and schedule are adjusted. A lengthy delay in construction start will risk losing key manpower and may disrupt the plans to begin pre-production work.

Recommendations

1. Adjust the project cost and schedule baseline to be both credible and self-consistent. The project managers should be confident in the baseline as they will be held to it.
2. Proceed rapidly with project execution once DOE approval is obtained.

2.1.2 Trigger Upgrades

2.1.2.1 Overall Findings

Most of the Run IIa D-Zero trigger system has been successfully commissioned and is operational and commissioning of the silicon vertex trigger is underway.

The trigger system is not pipelined, and each “Level 1 accept” causes read-out dead-time at a rate of one percent per kHz. The architecture of the trigger system will not change for Run IIb. The expected rate limits will be:

Level 1 accept	5kHz (limited by silicon detector readout)
Level 2 accept	1 kHz (limited by calorimeter readout)
Level 3 accept	50-100 Hz

Sufficient Run IIa data has been accumulated to test trigger simulations. Good agreement is found for occupancies, jet rates, etc.

Using these simulation tools the collaboration showed that without an upgrade at the Run IIb baseline luminosity (2×10^{32}) Level 1 rates would be as high as 30 kHz. The proposed upgrades reduce this to 3.9 kHz, which is well within the rate budget.

Different scenarios were studied to evaluate schedule sensitivity. Worst case would be an extra prototype cycle for the DFEA boards that is part of the track trigger. Still the trigger upgrade will be completed by August 2005.

Simulations and extrapolations performed by the D-Zero group indicate that the proposed trigger upgrade for Run IIb will function well at a luminosity of 2×10^{32} and 396 ns. The Committee accepts this conclusion.

Problems might arise at higher luminosities. At 4×10^{32} , dead-time could be nine percent or higher (compared to less than five percent at the baseline Run IIb luminosity). However, trigger simulations do not yet take full advantage of the additional features offered by the new Level 1 system and it is quite possible that new trigger algorithms can keep the Level 1 rate to 5 kHz or less.

The high occupancies expected at high luminosities will reduce the effectiveness of the Level 2 silicon track trigger. Early studies have indicated that adding the sixth layer of the vertex detector to the trigger will not solve this problem. More work on the Level 2 algorithms is required.

Software and trigger development are explicitly excluded from the trigger upgrade project. Nevertheless, the Committee feels that this could require significant manpower, and a detailed plan including resource-loaded schedule should be developed.

Recommendation

1. Develop a plan for software and trigger algorithm design.

2.1.2.2 Level 1 Calorimeter Trigger

The Level 1 calorimeter trigger is well described in the project documentation. The two major improvements are digital filtering of the input signals and the implementation of a sliding window algorithm to improve cluster reconstruction. The calorimeter-track matching trigger will use this feature.

EM and Jet trigger rates will be reduced by a factor of two to three. Inter-Cryostat detector information is made available to the Level 1 trigger. The project is well advanced, prototype boards have been developed and scheduled for completion in early 2005. The project will require 11.5 FTE years—mostly at universities. The cost is \$2,271 K (actual year) including 45 percent contingency.

The schedule and base cost are reasonable. The technical solution is sound. Integration tests should start soon.

The sliding window algorithm requires complex data routing that also happens to be at the interface between two systems designed by two different laboratories. This should be tested as soon as possible.

Scheduling the integration task as early as possible leaving enough buffer time to address potential problems mitigates schedule risks. The Schedule Sensitivity Study found that the potential delay is less than a month.

Recommendation

1. This project is ready to be baselined.

2.1.2.3 Level 1 Calorimeter Track Matching

This new trigger exploits the improved granularity provided by the new Level 1 calorimeter trigger. It is based on the existing design for the Run IIa muon trigger, currently the only Level 1 system that combines information from several detector components.

The use of an existing design minimizes both the cost and risk of the proposed upgrade. There are no schedule risks and completion is expected by late 2004. This project will require 2.8 FTE years—mostly at universities. The cost is \$396 K (actual year) including 42 percent contingency.

The Committee did not perform a detailed technical, cost, and schedule analysis of this subproject. The Committee agrees with the findings of the Director's review committee in that this upgrade is a prudent and cost-effective measure. This system can become very useful at higher luminosities when fake trigger rates might be a problem.

Recommendation

1. This project is ready to be baselined.

2.1.2.4 Level 1 Tracking Trigger

The Run IIb Level-1 track trigger is an upgraded version of the L1CTT trigger designed for Run IIa. It is of critical importance for the success of the D-Zero trigger system and hence the entire Run IIb physics program. Improved performance is achieved by using single fiber hits as opposed to pairs or doublets used in the current Run IIa system.

Significant effort has already been expended on many design details of the upgraded L1CTT. New trigger algorithms have successfully been compiled and simulated using FPGA design tools.

The baseline algorithms have been defined, and a suitable FPGA has been selected. The schedule for completion is the second quarter 2005. A schedule risk has been identified in the “Digital Front-End Daughter” board subproject. This will require 6.7 FTE years—mostly at universities, with about one-fourth provided by Fermilab. The cost is \$1,483 K (actual year) including 52 percent contingency. Base cost and schedule are reasonable.

Central to this upgrade is the replacement of digital front-end daughter boards that perform the trigger decision in four momentum bins. Two prototype cycles for these boards have been included in the schedule. Should a third prototype become necessary, the sub-project would be delayed by approximately three months. Including this potential shift the sub-project would still be completed in third quarter 2005.

The group has demonstrated that the Level 1 tracking trigger logic can be implemented in Xilinx XC2V6000 gate arrays. About 40 percent of the resources of the FPGA chip are used. It was argued that there are some remaining uncertainties, in particular at high p_T . This might require a switch to the larger XC2V8000 chip. This chip has the same footprint but it is significantly more expensive (\$3,224 vs. \$1,248). A large (70 percent) contingency is added to cover this uncertainty. The Committee sees the need for the contingency at this state of the project. However, it is the Committee’s understanding that only one of the four FPGA on the modules has to be changed to the larger version of the XILINX chip. The Committee therefore suggests that the group consider reducing the contingency to 40 percent, which would cover the uncertainty of replacing one of the 4 FPGA chips on each trigger module with the larger XCV8000 chip.

Recommendations

1. Complete simulation, prototype, and FPGA evaluation and decide whether the smaller chip (Xilinx XC2V6000) will be sufficient.
2. Consider reducing contingency for the FPGA chip, increase labor contingency from 25 to 50 percent.
3. This project is ready to be baselined.

2.1.2.5 Level 2 Beta Processor

The Beta system was developed for Run IIa to replace current boards based on using an Alpha CPU, which is rapidly approaching obsolescence.

The system consists of a commercial Compact PCI CPU module and a custom designed bracket, which provides the required interfaces to the D-Zero system.

It is proposed to populate some of the boards with faster CPUs (towards the end of the project to obtain the highest performance per dollar).

Level 2 algorithms have to be ported to the new hardware. This will be simplified somewhat because both are Linux based. There are no schedule risks. Schedule for completion is second quarter 2005 (project start is 2004). This project will require 2.2 FTE years—all at universities. The cost is \$190 K (actual year) including 81 percent contingency.

The project is well advanced. The scope and cost of the project are modest. Ideas for new Level 2 trigger algorithms have been presented but the development of software is not part of this project. Schedule and base cost are reasonable.

Recommendation

1. This project is ready to be baselined.

2.1.2.6 Level 2 Silicon Track Trigger

The Run IIa Level 2 Silicon Track Trigger is still being commissioned.

The same hardware will be used for Run IIb. Additional processor boards are required. There is one new hardware module, and some firmware changes are needed.

Simulations indicate adequate performance at baseline luminosity.

The subproject suffers from high occupancies at a luminosity of 4×10^{32} . Proponents believe this can be addressed with more advanced algorithms. No hardware modifications would be required. There are no schedule risks with a scheduled completion in the second quarter of 2005. This system will require 6.4 FTE years, mostly at universities. The cost for this system is \$379 K (actual year) including 44 percent contingency. Base cost and schedule are reasonable. High luminosity performance needs to be addressed.

Recommendations

1. Study performance at high luminosities and develop trigger algorithms.
2. This project is ready to be baselined.

2.1.3 DAQ/Online Upgrades

The D-Zero collaboration proposes to upgrade their online and DAQ system, mainly to increase Level 3 processing power and to upgrade some components of the control system. Software architecture is unchanged from Run IIa. The system is built entirely out of commodity items. There are no schedule risks. This system will require approximately seven FTE years, mostly provided by Fermilab.

2.1.3.1 Level-3 Processor Farm

The Run II Level-3 system of D-Zero consists of a scalable farm of Linux PCs, allowing the experiment to make use of commodity hardware for compute nodes, networking infrastructure and data storage.

The designs for the Level-3 systems allow a straightforward upgrade to increase the throughput and processing power.

There are still significant uncertainties in the estimated computing needs for Run IIb. At current luminosities, the Level 3 processing time required on a 1 GHz Pentium III processor is about 300 ms per event. Assuming a linear scaling of the current processing needs to the Run IIb situation with multiple interactions per bunch crossing, D-Zero estimates 1.5 CPU seconds per event, again on a 1 GHz Pentium III.

This uncertainty is covered by a large contingency (70 percent) that would allow D-Zero to purchase additional farm nodes should the events turn out to be more complex.

It has been assumed that CPU performance will continue to increase by a factor of about 1.7 each year.

D-Zero proposes to upgrade 32 nodes in FY 2004 and 64 nodes in FY 2005, at a total cost of \$210K plus 70 percent contingency.

Base cost and schedule are reasonable.

The Committee agrees that periodic upgrades of the Level 3 computer resources are necessary. Moving the purchase to the last possible date allows the group to take advantage of the improving performance of commodity PCs.

Instead of contingency, maybe the uncertainty in the size of the Level 3 farm can be handled differently (e.g., as part of standard Run IIb operation costs, similar to the planned farm upgrades for Run IIa).

Recommendation

1. This project is ready to be baselined.

2.1.3.2. Network and Host Systems

The collaboration proposed to increase the online disk storage to 4 TB (covering up to 48 hours of data taking). A Fibre Channel SAN with RAID disk arrays for Database and

Fileservers will be implemented. Database servers will migrate from DEC Alpha to Linux/Intel technology. The cost is \$695 K (actual year) including 41 percent contingency. Base cost and schedule are reasonable.

The Committee supports the proposed upgrades to the online system. The system is built out of commodity items that will be easy to obtain. This approach also reduces the maintenance overhead.

The contingency is very high for a project with a small cost, technical, or scheduling risk.

Recommendation

1. This project is ready to be baselined.

2.1.3.3 Control Systems

The subsystem uses an EPICS-based control system using a mix of Motorola 68K and Power PC CPU modules. Some of the older boards will become obsolete in a few years and need to be replaced. Some subsystems would benefit from higher (CPU) performance. The cost is \$308 K (actual year) including 35 percent contingency.

The control system uses commodity items and is based on a software package that is widely used in the high energy physics community. Upgrades will be straightforward (no technical, cost, or schedule risk). Base cost and schedule are reasonable.

Recommendation

1. This project is ready to be baselined.

2.2 Cost and Schedule

2.2.1 Findings

Microsoft Project 2000 and COBRA have been chosen as the primary project tools for cost and schedule development. A resource-loaded schedule with approximately 1,800 elements

has been developed. All materials and services, labor, contingency estimates, and risk factors have been loaded into the schedule. Costs have been developed using a mix of engineering estimates, vendor quotes, and experience from Run IIa. Project costs reflect technical manpower only. Physicists are not costed but are loaded and used for project planning. The COBRA project-tracking tool is in place and will be used to determine earned value measurements. A summary of the D-Zero costs for Run IIb, including R&D, general and administrative, contingency and escalation, is shown in Table 2-1. All costs-to-date are attributed to R&D. Additional cost details are shown in Appendix D.

Table 2-1. Summary of D-Zero Costs for Run Iib

	To-Date Cost	To-Go Cost	Contingency %	Contingency \$	Total Project Cost
Silicon	2,719	12,038	68	8,178	22,935
Trigger	452	2,737	56	1,540	4,728
On-Line	0	1,014	48	489	1,503
Admin.	0	1,197	51	607	1,803
Total Project Cost	3,171	16,985	64	10,814	30,970

There are three tiers of milestones established for this project:

- The Project Manager’s Milestones are extracted directly from the schedule details with no explicit slack.
- The Director’s/DOE Project Manager’s Milestones, which have a modest amount of schedule contingency introduced.
- The DOE Level 1 Milestones, which have additional added contingency.

The schedule is being managed to the Project Manager’s Milestones. This schedule is based on starting work on the non-R&D portion of the project on October 2, 2002. Initial procurement activities would commence in November 2002.

The completion goals for the project are defined in the draft Project Execution Plan and Project Management Plan. Key completion milestones at the three tiers are shown in Table 2-2. The funding sources by fiscal year are shown in Table 2-3. Additional schedule details can be found in Appendix E.

Table 2-2. Tier Three Milestones

	Project Manager's Milestone	Director's/DOE Proj. Manager's Milestone	DOE Level 1 Milestone
Silicon Stave Production Complete	March 25, 2005	July 24, 2005	April 2006
Silicon Ready to Move to Assembly Building	July 22, 2005	December 26, 2005	November 2006

Table 2-3. Funding Sources

K\$	2001	2002	2003	2004	2005	2006	Total
Equipment	0	3,500	4,131	8,588	5,832	2,354	24,406
R&D	0	1,499	1,000	0	0	0	2,499
Foreign/University	17	1,778	1,345	880	44	0	4,065
Forward Funding	0	0	2,000	0	0	-2,000	0
Total	17	6,777	8,477	9,468	5,876	354	30,970

2.2.2 Comments

The Committee reviewed the cost estimate detail and concluded that the base cost estimates for Silicon were slightly low. However, the Committee is of the opinion that the contingencies assessed against the base costs are too high for the observed risks. An assessment of the costs is included in Appendix D.

Due to uncertainties in the Tevatron schedule, the beginning of installation of the detector upgrades cannot be determined at this time. Installation and commissioning are not considered part of the project. The end of the project is defined as "Silicon Tracker Ready for Installation." This separates the project from the Tevatron Operations and provides a means to achieve completion of the project independent of physical installation and commissioning.

There is schedule contingency, contained in the Level 1 and 2 milestones, that appears to be more than adequate to complete the project by the Level 0 Critical Decision 4 completion date.

2.2.3 Recommendations

1. Consider re-evaluation of the base costs and the contingency costs based on the comments provided by the Committee in this report.
2. Re-evaluate the schedule float based on the comments provided by this Committee.

2.3 Management

2.3.1 Findings

For the proton-antiproton collider Run IIb, Fermilab plans on increasing the luminosity before the start-up of the LHC (envisaged for 2007). This will be an excellent opportunity for the U.S. community to hunt for the Higgs particle using a local facility. Recently, progress has been made on achieving high luminosity in the collider (peak luminosity $L=3E31$, 60 percent of the design goal at this point in time).

To cope with the increase in luminosity, and to replace the radiation-damaged inner detectors, the CDF and D-Zero collider detectors will have to be upgraded too. The upgrade of the D-Zero detector for Run IIb consists of replacing the silicon vertex detector and improvements to the data acquisition system and the trigger.

The design of the detector upgrades is based on the operating experience gained with the present Run IIa. In many critical cases, prototypes of detector components have been built and tested successfully.

The total cost of the project has been estimated at \$30.970 K, including \$2,499 K DOE R&D funding and \$4,065 K contributions from foreign and other non-DOE funding sources. DOE funding will be part of Fermilab's operating budget. The cost-to-go is \$16,985 K, leaving contingency at \$10,814 K or 64 percent. The status of the project documentation is shown in Table 2-4.

2.3.2 Comments

The detector design is technically mature, the technical risks have been identified, and mitigating measures are in place. Costs have been estimated, and baseline costs appear reasonable.

Table 2-4. Status of Project Documentation

Document	Status
Technical Design Report	Available for review
Mission Need Verification	PAC Report
PEP	Draft prepared
ES&H	Included in PEP
AEP	Submitted to DOE HQ
PMP's	Drafts prepared
PMCS Review	Planned for 10/2002
External Independent Review	ASAP

An experienced project management team is in place. Administrative help has been identified and is in place. The collaboration seems to be committed to support the upgrade with manpower and in-kind contributions. Negotiations on the Memoranda-of-Understanding with collaborating institutions have been started, although the final documents still have to be signed.

In view of the technical maturity of the project, the contingency assignments seem to be too conservative and should be re-examined.

Three schedules with different risk levels have been prepared: a very aggressive one for internal purposes, a more realistic one for Fermilab, and a relaxed schedule for official reporting. This is potentially confusing, and only one official schedule should be used. The Fermilab Director's Schedule seems to be best suited, although the Committee expressed concern regarding the tight silicon schedule. Also, all schedules have been derived under the assumption that project approval is imminent. It is important for DOE to provide guidance to the experimenters on the anticipated start date.

The project reporting structure is presently being put in place. A particular problem is the reporting on the progress of foreign or non-DOE funded parts of the project. It seems to be sufficient to report on the technical progress, but not on earned value. Keeping contingency on non-DOE funded parts of the project will give the project management some additional flexibility.

The overall judgment of the Committee is that the D-Zero detector upgrade for Run IIb project is mature and has a good management team in place; the Committee sees no reason to delay the start of the construction.

2.3.3 Recommendations

1. Get written commitments (Memoranda-of-Understanding) for manpower and other contributions from collaborating institutions.
2. Develop credible schedule taking into account the comments made by the Committee.
3. Re-evaluate base costs.
4. Re-examine contingency assignments.
5. Obtain guidance from DOE for project start date.
6. DOE should move forward expeditiously with the approval of Critical Decision 1 (Approve Preliminary Baseline Range), CD-2 (Approve Performance Baseline), and CD-3a (Long-Lead Procurements) of the Run IIb D-Zero Detector project (after schedule and contingency issues are clarified).