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Status of the LHCb Experiment

Report to October 2003 RRB
By the LHCb Collaboration

I) Introduction

In September, two Technical Design Reports (TDR's) were submitted to the LHCC for the trigger and the reoptimized detector, respectively. The TDR's for all the subsystems have now been completed, except one for Computing scheduled for early 2005. In the reoptimization TDR, the cost of the experiment is re-evaluated. Reoptimization of the detector decreased substantially the cost of the Outer Tracker due to the reduction of the number of stations by roughly half, while the cost of the Silicon Tracker increased since one of the stations became fully silicon. The RICH cost increased due to the reoptimization of the RICH 1 design and the use of the Multi-anode Photo Multiplier Tubes (MaPMT's) with analogue readout as baseline option. The current cost of the detector is 72.74 MCHF, i.e, 2.31 MCHF less than that evaluated in the Construction Memorandum of Understanding (MoU). The new cost is in fact 0.56 MCHF less than the total funding request at the time of the MoU. However, some flexibility to shift the funding among various subsystems is now needed to profit from this reduction of the total cost of the experiment.

II) Detector Subsystems

II-1) Beam Pipe

Design work for the beam pipe has been completed and the Engineering Design Review (EDR) was conducted in September. In addition to the finite element calculations, various prototypes have been manufactured: e.g. the exit windows of the VELO tank, 25 mrad section of the beryllium beam pipe and Al bellows.

Changes: none

Concerns: none

Plans: Perform the verification of the prototypes in the coming months. Refine the details of the interface between the detectors and the beam pipe (particularly the last section). Begin the radiation activation studies in the coming months.

II-2) Magnet

The assembly for the lower part of the yoke was completed and the 27 iron plates were tied together with tie-rods. The vertical part of the yoke is now being built from 46 iron plates.

Changes: none

Concerns: none

Plans: Finish the magnet assembly in the first quarter of 2004 and move the magnet to the final position. Start the commissioning and the magnetic field measurement in spring 2004.

II-3) Vertex Locator

Several errors in the Beetle1.2 readout chip were identified during the test from the spring to summer 2003 and were corrected for the version 1.3. Initial tests of the Beetle 1.3 show encouraging results. A review in August looked at the overall geometry of the sensor designs. Wafer design of the ϕ sensor was completed in September and of the *r*

sensor will be in October. Ordering of sensors was delayed due to the delivery problem of previous prototype sensors from the manufacturer, which will be settled by November. Production of the mechanics and vacuum system has started. It has been agreed that the CERN vacuum group will do the routine service while NIKHEF will be responsible for the expert intervention. Preparation of the space at CERN for the final VELO assembly started.

Changes: none

Concerns: none

Plans: Perform tests of Beetle1.3 with the final hybrid and bonded to the final sensor. Order sensors by the end of this year. Prepare EDR of the station module for February 2004. Complete the vacuum system by May 2004.

II-4) Silicon Tracker

Various prototype tests have been performed to validate the design of the Trigger Tracker (TT) presented in the reoptimization TDR. The 30 cm long ladders with Si sensors of different thicknesses read out by the Beetle 1.2 were tested with the test beam and laser. A full prototype readout link was operated successfully in the laboratory. Neutron irradiation of critical components of the digital optical readout link was carried out showing no significant deterioration of performance for fluences corresponding to up to 350 years of operation at the LHC. The mechanical design of the detector ladders and the station frames is progressing. The mechanical design of detector boxes and station frames for the Inner Tracker (IT) is being re-evaluated for a further reduction of the material budget.

Changes: Responsibilities for the mechanical design of IT and TT have been redefined: the mechanical design of IT (ladders and station mechanics) by Lausanne and TT by Zurich.

Concerns: none

Plans: Define the final specifications for silicon sensors for IT and TT and launch a pre-production run. Finalize the design of interconnect cables and continue the mechanical design of the TT. Complete the mechanical design of the IT. Prepare production sites for TT and IT.

II-5) Outer Tracker

EDR for the Outer Tracker (OT) module design has passed in June. The main components for the mass production (straws, panels, etc.) are being distributed to the production sites (Heidelberg, NIKHEF and Warsaw). The first batch of the main module assembly tools (straw-template and panel handling device) is already operational, while a more automated version of the existing straw preparation tool is being completed. Production of the full-size modules in all production sites start soon. For the aging study, a charge equivalent to 10 LCHb years at the hottest detector spot has been collected. The front-end electronics design has been completed and a first batch of the front-end boards has been ordered for a full system test by the end of this year. The TDC chip design has been reviewed successfully and a production run is expected soon.

Changes: none

Concerns: Some delay in finalizing some of the module mass production tools. Uncertainty in the delivery of the full batch (28 wafers) of ordered ASDBLR02 chips with DMILL technology.

Plans: Prepare for the OT module PRR and complete the production of 10% of the modules by February 2004. Prepare for the OT electronics review in February 2004.

II-6) RICH

The new RICH 1 design with reduced material budget and satisfactory shielding of the magnetic field for the baseline photon detectors was presented in the TDR for the LHCb detector reoptimization. The construction of the large light-weight RICH 2 windows is in progress. The exit window is finished and assembly of the entrance window will be completed in November. The purchase order for manufacturing the main structure was sent out in September. The orders and the delivery of all the optical components are following the schedule. Delays in the HPD development resulted in a switch to the MaPMT as the baseline RICH detector. A cluster of nine MaPMTs was tested in a charged particle beam. A choice of technology will be made in October.

Changes: MaPMT with Beetle readout is the new baseline

Concerns: Tight schedule for completion of RICH 1 mechanics.

Plans: Make photon detector decision in October 2003. Prepare Production Readiness Review (PRR) for the photon detector mounting of RICH 2 for January 2004.

II-7) Calorimeter

The production of the required 3300 ECAL modules has been completed at ITEP Moscow and 90% of the modules have been delivered to CERN. The production of some 50 spare modules is still ongoing. For the HCAL detector, 16 modules out of a total of 52 have been produced at IHEP Protvino. So far, 14 of them have been delivered to CERN of which 10 are fully equipped with the optics components. The series production of the Preshower and SPD detector has started in spring 2003. The required 12000 Scintillator tiles are being manufactured in Ukraine of which the first 3780 tiles have been delivered. Mass production of fibre gluing to the scintillators has also started at INR and 780 tiles with glued wavelength shifting fibres have passed the quality control procedures. Three Preshower module boxes from the pre-series production (inner, middle and outer type) have been qualified in test beam in September 2003. The first pre-series batch of photomultipliers for the ECAL and HCAL has been received in April 2003. The 300 tubes (out of a total of 7800) have passed the acceptance test on three test-benches operated by IHEP, ITEP and Orsay respectively.

Changes: none

Concerns: none

Plans: Prepare PRR for Preshower planned for November 2003, from experience of 10% pre-production. Produce half of the required HCAL modules at IHEP by March 2004.

II-8) Muon

The MWPC EDR passed in April. Pre-production of 400 panels is ongoing and other material for a pre-series MWPC production has been ordered. CERN and LNF sites have begun production and PNPI will follow. The PRR for these sites will take place by December. Preparation of the tooling and clean areas for Ferrara and Florence is progressing. Results of global aging tests on several chamber prototypes for the inner region of M1 (M1R1) are being evaluated. The Electronics Architecture Review took place and the design was approved. The final CARIOCA and SYNC chips were submitted in June and received in September for testing. The final DIALOG chip will be submitted for the October Multi Project Wafer run. The Off-Detector Electronics board is fully tested except for the optical link (to be done before the end of the year) and for the final SYNC chip (present tests have been with the FPGA SYNC emulator). Several other electronics boards are ready for production. A review was held at CERN in June for the muon filter chariots and the chamber and electronics support structure.

The production documents for the chariots are being finalized and the order goes out in October 2003.

Changes: No major change

Concerns: Effective chamber production rates of centres. Delays of the chip engineering and production runs. Lack of manpower for support structure design and integration.

Plans: Call for tenders for full material procurement (MWPC). Make all the five production centres operational. Make final decision on M1R1 and Addendum to the TDR in March 2003. Validate the CARIOCA as the muon front-end chip. Make final versions of all chips ready for engineering run and all electronics boards for production. Prepare review (EDR) of the support structure design.

II-9) Trigger

The Trigger TDR summarizes the activity of the Trigger project. A single DAQ system for implementing both Level-1 and the High Level Trigger (HLT) has been adopted. All sub-systems which provide data to the Level-1 now use the same readout board. The resulting modified DAQ is described as part of the TDR. In the document, all Level-0 sub-systems are described, and their expected performance is given using detailed simulation work. The full Level-1 algorithm and the tracking part of the HLT algorithm were benchmarked, and match the projected size of the online computing farm, assuming a factor six improvement in performance between a 1 GHz Pentium III, and the nodes which will be available in 2006. The robustness of the trigger has been studied by varying the assumptions in the event generation and detector performance, showing that even under the most pessimistic assumptions the efficiencies will not deteriorate by more than ~25%.

Changes: no major change

Concerns: no major concern

Plans: Finalise the prototype work for the Level-0 components. Improve algorithms for the Level-1. Develop a detailed strategy for the HLT.

II-10) Computing

Online: Full system tests with existing TFC prototypes show that performance required by the Front-End electronics can be met. Changes related to the revised DAQ system architecture have all been incorporated. In the DAQ system, the data protocol has been changed eliminating the Network Processor for multiplexing and data merging functionality. The DAQ system now consists completely of commercial components. The new system design is described in the Trigger System TDR. For the Experimental Control System, the hardware interfaces to the electronics have been finalized. A redesign of the controls framework within the JCOP project was started in July, making it easier for the users to set up and configure the system. The SPECS master PCI card has been finished at Orsay and is ready for test by the users. The glue-card for the Credit-Card PC has been designed in its final form and the prototype performs according to the specifications.

Offline Software: Progress has been made with the new OO simulation application (GAUSS) and digitisation application (BOOLE) and these will be used in the scheduled data challenge in spring 2004. The software manpower for the core computing was reviewed and a report presented to the LHCC in September.

Offline Computing: Monte Carlo data production continued in low level over the summer for the trigger and reoptimization TDR's.

Changes: no major change

Concerns: Lack of manpower for the core software, which was also pointed out by the software manpower review. Lack of manpower in online computing is still partially present.

Plans: Test final TFC prototypes and start module production in spring 2004. Develop a DAQ test-bed, including data sources, switches and subfarms and model the behaviour of the system for simulation studies. Study cooling and mechanical issues as well as development of software, such as event-building code and study of performance. Acquire Credit-Card PCs and produce glue-cards to be able to distribute the ECS interfaces to the subdetectors in quantities and finish low-level software. Start developing of the configuration database describing the entire online system. Prepare for the spring data challenge to test

1) a robustness of the LHCb software and production system
2) the LHCb computing model, including distributed analysis, and
3) the LCG software and environment.

III) Experimental Area

Construction of the metallic structures dedicated to the gas control racks and the cooling system located behind the pillars of the main radiation shield have been achieved in June 2003, as scheduled. The modifications and adaptations of the services have been delayed by eight weeks in order to ease the installation of the LHC cryogenic equipment at the end of the UX85 cavern. These delays have no impact on the installation of the LHCb detector. The co-ordination between the LHC Machine and LHCb Experiment for the work planning at the UX85 underground area is efficient and no major conflicts or clashes between the installation activities is foreseen.

IV) Organization

No change.

V) Milestone Plot

Figure: Cumulative plot of the LHCb Milestones.