

Status of the LHCb Experiment

Report to October 2004 RRB

By the LHCb Collaboration

I) Introduction

The MoU for the Construction of the LHCb Detector was signed by the BMBF Germany. Remaining countries to sign the MoU are Brazil and Poland. Purchase of many detector components is advancing and the cost of the experiment is becoming better known. The cost increase identified in the RICH and Muon systems can no longer be absorbed by redistributing the saving that resulted from the reoptimization effort. Institutes responsible for those subsystems are asking for additional funding to their funding authorities: CERN, INFN-Italy and PPARC-GB for RICH, and CERN and INFN-Italy for Muon. No other cost increase has been detected so far.

II) Detector Subsystems

II-1) Beam Pipe

Contracts for the beryllium sections of the Beam Pipe were placed in June to Komposit in Russia and the construction has started. A prototype of the aluminium flange connecting the two long beryllium sections is undergoing qualification tests. Bimetallic flanges to connect the beryllium vacuum chamber with the stainless steel bellow section are being fabricated. Aluminium with appropriate specifications has been purchased for all the bellows and flanges including contingency for replacements. Design of fixed points and supports is proceeding. Global mechanical analysis of the beam pipe with the foreseen design and locations of supports has been performed. Specifications for the clearance and supports of the sub-detectors in the proximity of the beam pipe have been defined.

Changes: none.

Concerns: none.

Plans: Finalize the design of supports and fixed points. Approve final design, perform tendering procedures and place contract for the stainless steel section of the beam pipe. Manufacturing at CERN of the VELO exit window and its assembly with the 25 mrad beryllium cone.

II-2) Magnet

The magnet has been assembled and moved to its final position. It has been aligned to follow the beam line. All the electric connections for the control and powering have been made.

Changes: Due to a cumulative delay in the final phases of assembly, procurement, and cabling, the revised schedule foresees the magnet commissioning and the start of field mapping in October.

Concerns: none.

Plans: Commission the magnet and start the field map measurements.

II-3) Vertex Locator (VELO)

For the VELO mechanics, the stand, center frame and positioning system have been produced, assembled and are now being tested. The RF box and rectangular bellows are being prototyped. Delivery of the VELO vacuum vessel is expected in November. Test

measurements show that permeation through the viton seals can be kept under control and there is no danger of deteriorating the NEG coating. For the electronics, tests of the analogue chain including the 60 m cable were successfully carried out with a fully populated hybrid. The design of the analogue receiver card was finalized and a number of prototype boards ordered. A Production Readiness Review (PRR) for the Beetle front-end chip was held in April 2004. An engineering run had been made and wafers came back in August. First Kapton hybrids were produced and laminated onto the carbon-fiber/TPG substrates. After minor modifications, a new hybrid version will be submitted by the end of this year. The order for the silicon sensors was placed and first pre-series sensors (200 and 300 μm) have arrived in October.

Changes: none.

Concerns: Delivery time for sensors and hybrid assemblies.

Plans: Verify the chips from the engineering run and launch the production run. After testing with TELL1, start the production of the analogue chain. After testing pre-series sensors, order hybrids and start the sensor module production. Together with the vacuum vessel, assemble the full vacuum system.

II-4) Silicon Tracker

The mechanical design of the detector box for the TT station has been finalised and its support structure and interface to the rest of the LHCb experiment are being designed. Details of the mechanical design of the silicon ladders had to be modified, due to unexpected manufacturing problems at vendors. The tendering process for the silicon sensors has been completed and details of the contract are currently being worked out. A full mechanical prototype of a detector box for an IT station is being built. The design of the silicon ladders has been completed. Silicon sensors have been ordered and the pre-production of the ladders will start as soon as silicon sensors arrive. An irradiated IT prototype ladder and a TT prototype ladder with a full-length Kapton interconnect cable have been tested successfully in a beam test at CERN. Beetle chips from the engineering run have been delivered to MPI Heidelberg and are currently being tested in the laboratory. The preparation of the production and test sites at Universität Zürich (TT) and at EPFL/CERN (IT) is being finalised, and production and quality assurance teams are being trained.

Changes: none.

Concerns: Minimise the impact of the aforementioned design changes on the pre-production of TT ladders.

Plans: Build and test final prototype of TT ladder. Start pre-production of IT ladders as soon as sensors arrive. Start construction of TT station mechanics.

II-5) Outer Tracker

Material (panels, straws, wires, wire locators, PCBs, etc.) necessary for 50% of the production is in stock. PRR's were successfully conducted for all the three production sites, NIKHEF, Heidelberg and Warsaw, and more than 10% of the modules were produced at all the sites. All those modules have been successfully tested. Production tools have been improved continuously and production is running smoothly. Front-end electronics boxes were tested stand-alone and together with a chamber exposed to a radioactive source and cosmic rays. The test shows that the electronics is working reliably. The first prototype frame for a 1/4 station is ready at NIKHEF and being loaded with modules. Survey measurements will follow.

Changes: none.

Concerns: Six-month delay in the module production. Possible shortage in manpower for the module assembly and installation.

Plans: Increase module production rate. Complete the study of 1/4 station. Perform beam tests and aging studies.

II-6) RICH

The EDR for RICH 1 was held in August 2004 and was followed by the PRR for the magnetic shielding boxes. The process for ordering their production has started. An order has been placed for the first full-scale beryllium mirror prototype. The assembly of the RICH 2 structure is progressing according to schedule. A total of 34 out of 56 spherical mirror substrates have been accepted and coated. The order for the planar mirror substrates has been issued. A letter of intent for the production of the HPDs has been released to DEP in September. Pixel readout chip wafers have been produced with a yield better than 55 % after probing, and 27 out of a total of 42 pixel sensor wafers have been delivered as scheduled. The mechanics for the photon detector matrices and the on- and off-detector electronics is progressing satisfactorily. Final prototypes of the L0 electronics together with the link module between the HPD and the L0 card are being tested. The low voltage and high voltage distribution cards are being tested in their final layout. The L1 read-out module is well advanced.

Changes: None.

Concerns: Tight schedule for completion of RICH 1 mechanics. Holding production of bump-bonded assemblies for the HPDs due to the delamination of the aluminium on the sensor back side.

Plans: Make RICH 1 PRR for the gas enclosure in November, followed by the PRR for the beryllium mirrors in December. Order the planar mirrors in October 2004. Install RICH 2 overall magnetic shielding in the superstructure in November, followed by the installation and alignment of the spherical mirrors. Receive pre-series HPD units and make a system test of the whole readout chain in October/November 2004.

II-7) Calorimeter

All of the 3300 ECAL modules delivered at CERN are being calibrated using cosmic rays. For the Hadron Calorimeter, 46 modules (out of a total of 52) have been delivered to CERN and 44 of these have been assembled with optics and have undergone successfully the quality control check with a radioactive source. Out of the 7800 ordered photomultipliers for the ECAL and HCAL detectors a total of 5300 have been delivered, and 90% of these have been tested on the three dedicated test benches. For the HCAL 100% and for the ECAL 50% of the required Cockroft-Walton high voltage bases have been produced and tested. For the Preshower and SPD out of the required 444 detector modules, 225 have been assembled and have successfully undergone quality control tests. A full size pre-series Preshower Super-Module has been assembled and tested for its mechanical stability. The production of fibre bundles that transport the light from the Preshower modules to the Multi Anode Photomultiplier Tubes (MAPMT) at the detector periphery has started at INR and Clermont. First quality checks have revealed problems with the fibre quality, which could lead to some delays in the super-module assembly. The MAPMT for the Preshower and SPD detectors have been ordered. Production of the ECAL and HCAL support chariots is on schedule. Designs are being finalized for the Preshower support, the Calorimeter electronics platforms, and the overall Calorimeter gantry structure. The amplifier integrator ASIC for the Preshower (PS) and Scintillator Pad Detector (SPD) and the delay-chip ASIC have been fabricated in summer of 2004 and are being encapsulated. Prototype work for the Very Front-End cards for PS and SPD is in progress. The procurement of radiation tolerant

FPGA's has been initiated. Prototypes of all the front-end cards are being tested. The PRR for the cards has been delayed, by six months, to December 2004.

Changes: none.

Concerns: The tight schedules for the Preshower Super-Modules production and the ECAL/HCAL and PS+SPD FE cards production and testing.

Plans: Receive ECAL/HCAL support chariots in October 2004. Finish HCAL modules production by end 2004. PRR for the ECAL/HCAL FE-cards in December and for the VFE-cards of PS and SPD in January 2005. Start assembly of ECAL in early 2005.

II-8) Muon

Production of panels is ongoing with good quality. At CERN, LNF and PNPI 1, chambers are produced with 80% of the planned production rates and about 8.5% of total chambers have been produced. PRR's for Ferrara (8 June) and Firenze (8 September) were successfully completed. Tooling for PNPI 2 has been shipped in September. First prototypes of Triple-GEMs for the inner most region of the first muon station are being produced in Cagliari and LNF. Production plans among the centres have been rearranged to cope with delays. PRR for all the ASIC chips was done in June. After modification of the SYNC chip design suggestions by the review panel, they were submitted for an engineering run in September. The complete readout chain has been tested and production of all the PCB's is in progress. The muon filter construction is in progress. Engineering Design Review for the support infrastructure has been completed. Tender for the support structure is in preparation.

Changes: None.

Concerns: Lower chamber production rates than planned and delay in production start-up. Possible lack of manpower for the chamber production and for M1 support structure design and integration.

Plans: Reach the nominal chamber production rates at Ferrara and Firenze. Start chamber production at PNPI 2. Start tendering procedure for the support structure. Test and package the chips from the engineering run and complete several tens of front-end boards. Build the first Triple-GEM chambers. Complete the muon filter.

II-9) Trigger

For the Level-0 calorimeter trigger, the part of the calorimeter and preshower front-end cards needed is being debugged on the final prototype. The prototype of the mezzanine board driving optical links is under fabrication. The final prototype for the validation card and the selection board is on the way. A complete prototype of the L0 muon trigger has been assembled and tested. The Level-0 decision unit is now based on optical links and the TELL1 board. Test of the first prototypes started. The architecture of the Pile-up veto has been simplified. The new implementation of the L1 software ran smoothly during the DC04 data production. The L1 algorithm has been modified resulting in a better performance. In the High Level Trigger several software components have been developed in parallel, and are under test at the moment. In the first part of the HLT the L1 algorithm is refined leading to a factor four reduction of the rate, twice lower than what was obtained in the TDR. Exclusive selection algorithms for benchmark channels are being developed based on commonly defined particles and vertexes. For studying systematics and introducing robustness of the trigger during the start-up of the experiment, a scenario to add inclusive HLT trigger algorithms is being investigated, which could also allow to extend the physics scope. However, this may lead to an increase of the trigger rate.

Changes: none.

Concerns: none.

Plans: Start the design of the final L0 muon trigger boards. Complete a fully functional HLT algorithm by the end of 2004 for 10 benchmark channels.

II-10) Computing

Online: The barracks in the pit are being prepared for receiving the electronics. Testing of various network switches is making very good progress. Studies of the event-building protocol to identify suitable Subfarm Controllers (SFC) are ongoing. The implementation studies for the CPU farm (cooling and powering), a common effort by the four LHC experiments, are finalized and suitable equipment has been identified. The components of the Timing and Fast Control (TFC) sub-system are being produced and test procedures and equipment are prepared. In the Experiment Control System the first batch (100) of GlueCards for the Credit-Card PCs are being produced and will be ready for distribution towards the end of 2004. The rest will become available in 2005. Prototypes of the SPECS slave cards are distributed to interested groups. The Configuration Database project is making good progress. The Database schema is finalized and software to navigate through the system is available in prototype form. A graphical user interface and visualization tool has been developed for controlling and monitoring of the experiment. Pre-series TELL1 common detector readout boards are being produced. The pre-series boards should be ready by the end of 2004 and will be distributed to interested groups.

Offline: Phase 1 of the LHCb Data Challenge (DC04) finished at the end of August resulted in 190M events being generated and reconstructed corresponding to 425 CPU years. The LCG share in the total volume of produced data grew from 11% in May to 73% in August. The new software suite for the detector simulation and event reconstruction has been successfully tested by the DC04. Detailed preparations are under way for the data challenge in 2005. The LHCb production system (Dirac) has been re-engineered completely, in order to make it compliant with the LCG ARDA recommendations. LHCb have selected the AliEn file catalogue as the main catalogue for the coming data challenge and its integration with the production system is being commissioned. Effort to develop framework and strategy for the detector calibration and alignment has started. A cost-sharing model for the offline computing has been agreed within the collaboration. This will provide input to the ongoing computing MoU discussion.

Changes: none.

Concerns: Lack of manpower for the core software and the ECS system.

Plans: Installation of the Ethernet cables in the pit. Start the acquisition procedure for the network switches. Finalise the detailed specifications of the SFC's and start the purchasing procedure. Producing the LHCb computing model.

III) Experimental Area

The temporary bridge across the UX85 cavern dedicated for the LHC machine transportation activities was removed in two steps as specified. The first part was dismantled in May 2004 in order to achieve the additional cutting of the concrete structure for RICH1 in that region. The dipole magnet was moved to its final position (mid-August). Due to the change in the transportation of the LHC cryogenic lines for the sector 8-1, the second part of the bridge was removed at the end of June. This allowed us to make the grooves in the UX85 ground required for the calorimeters in August. The cutting of the concrete blocks for the installation of the last muon-filter was achieved in October. In parallel, the connection of the services to the dipole magnet was done in order to be ready for the first powering tests by the end of October. Other infrastructure issues in

the cavern were achieved as scheduled. The central part of the main radiation wall was installed in May along with the ventilation ducts passing across through chicanes.

Changes: none.

Concerns: Delay in installation due to the interference with the machine activities. Possible interference due to the installation of the QRL segment from the QUI interconnection box in the UX85 cavern to the LHC tunnel.

Plans: Install rails for the calorimeters by November 2004. Extend the cooling pipes and gas pipes up to the protected area (Q4/04). Construct and install the upper part of the main radiation shield (Q2/05).

IV) Milestone Plot

Figure: Cumulative plot of the LHCb Milestones, as presented to the LHCC.

