CERN-RRB-2003-043
28 March 2003

Status of the LHCb Experiment

Report to April 2003 RRB
By the LHCb Collaboration

I) Introduction

A written report on the status of reoptimizing the LHCb detector (LHCb-light) has been submitted to the LHCC in January 2003. Although preliminary, it shows that the LHCb-light detector can achieve the physics goal described in the Technical Proposal. Software development necessary for the Trigger and LHCb-light Technical Design Reports (TDR's) was completed and a large number of events necessary for the full physics study are being generated. Both TDR's will be submitted in September. In the mean time, construction of the detector components unaffected by the reoptimization is advancing.

II) Detector Subsystems

II-1) Beam Pipe

A beryllium prototype for the first 25-mrad section is being manufactured. Material qualification of the aluminium blocks for the exit window of the VELO vacuum tank has been performed successfully. A prototype window is currently being produced at CERN together with test equipment. A prototype of the aluminium bellows in the transition from the 25-mrad to 10-mrad sections has been produced.

Changes: none

Concerns: none

Plans: Qualification tests of all the prototypes will be performed in the coming months. Mechanical studies for the overall beam pipe, including supports, are being done. The EDR of the beam pipe is foreseen for summer 2003.

II-2) Magnet

At the end of 2002, SigmaPhi in France completed the production of the two coils consisting of five triplets each. The coils arrived in January 2003 and are now stored in the experimental area. The steel plates for the yoke (total 1500 tons) are being delivered by Jebens in Germany and 20% have arrived at CERN so far. Assembly of the support structure has started.

Changes: none

Concerns: none

Plans: Assembly of the magnet will be completed by September 2003.

II-3) Vertex Locator

Tests showed that both front-end chips, Beetle and SCTA-VELO, fulfilled the VELO requirements. The Beetle chip had been selected for reasons of better radiation hardness, higher yield and the guaranteed availability of the production process. The Engineering Design Review of the vacuum tank by the experts from the LHC machine groups and TIS was successfully completed and an approval procedure for engineering drawings has been established. The precise layout of the silicon sensors was defined at the silicon design review in February 2003. It was decided by many sub-detector groups to use a common Level-1 readout board based on the design developed for the VELO

detector. This causes a delay of a few months to complete the board design in order to accommodate necessary changes.

Changes: The design of the VELO Level-1 readout board is being modified to become a common Level-1 readout board, to be used by most of the sub-detectors.

Concerns: none

Plans: One more Multi Project Wafer run for the Beetle chip is planned for June 2003 to cure minor problems. Fabrication of the VELO vacuum vessel and mechanics will start soon. A Production Readiness Review for pre-production of the final sensors is planned for June 2003. The layout of the common Level-1 readout board will be completed by July.

II-4) Silicon Tracker

Silicon micro-strip detectors are used for the tracking station just after RICH1 (TT) and in the region close to the beam pipe for the three tracking stations after the magnet (T1 to T3), called the Inner Tracker. The Inner Tracker TDR had been submitted to LHCC in November 2002 and the Research Board approved the choice of technology in February 2003. The main activity of the group now focuses on the necessary research and development work for the TT station, where the number of readout channels and material budget must be minimized. In order to test whether a sufficient signal to noise ratio can be obtained, approximately 30 cm long silicon sensor ladders with various thicknesses were constructed. Also, a 55 cm long prototype interconnect cable was produced and is ready for testing. In parallel, a mechanical design of the station is being studied.

Changes: no major change

Concerns: none

Plans: Ladders will be tested using a laser test stand and test beam. The TT design will be described in the LHCb-light TDR in September.

II-5) Outer Tracker

The Outer Tracker Project is currently preparing for the start of the detector construction. Clean-rooms for the chamber production are already operational at NIKHEF, Heidelberg and Warsaw. Prototypes of the OT Module components (straws, panels, wires, wire locators, wire-support PCBs, etc.) have been tested and contracts for the mass production of all these components are being finalized. Prototype studies were made for the Front-End electronics including the detailed cooling aspects. Orders for the mass production of several items, such as the TTCrx, the radiation-hard power regulators and the ASDBLR02 pre-amp/discriminators are being made.

Changes: none

Concerns: none

Plans: The Engineering Design Review for the detector is planned in May 2003 followed by pre-production.

II-6) RICH

A Production Readiness Review of the RICH-2 superstructure and the mirrors was passed in February 2003 and the spherical mirrors have been ordered. For the redesign of the RICH-1 detector, solutions have been found for many critical design features, particularly those involving interfaces with the VELO and the beryllium beam pipe installation. An HPD with 10 MHz readout chip was produced using an improved bump-bonding procedure and performs as expected in all respects. However, microscopic examination of the bump bonds following a simulated bake-out thermal cycle revealed

significant deterioration of the solder bump structure, giving rise to serious concerns for the long-term reliability. Following the recommendations of a review panel report in January, a programme of developments with qualification criteria for the bump bonds and HPD ageing has been defined. More resources have been directed to study the read-out chain for the multianode photomultiplier based on the Beetle chip.

Changes: Increased effort for the multianode photomultiplier activity.

Concerns: Delay in HPD R&D.

Plans: Orders for the RICH-2 flat mirrors and superstructure will be made in July 2003. The new RICH-1 detector design and its particle identification performance will be reported in the LHCb-light TDR in September 2003. The choice of photon detector will be made by September 2003.

II-7) Calorimeter

A total of 2400 ECAL modules, corresponding to 72% of the final number, were delivered from ITEP Moscow to CERN. The first 8 modules out of a total of 52 HCAL modules were delivered to CERN by IHEP Protvino. The optics assembly of these modules started in January 2003 at CERN and the first module has been completed. All components necessary for producing the first 10% of the Preshower/SPD modules were delivered to the assembly site at INR. The choice of photomultiplier tubes for ECAL and HCAL had been taken and an order was placed in January 2003. For the Preshower/SPD detector, a low gain multianode photomultiplier with 8 stages is chosen, solving the ageing problem that was observed with the high gain 12-stage tube. The production and acceptance test of the ECAL/HCAL front-end electronic chips was completed, with a yield of 90%.

Changes: no major change

Concerns: none

Plans: Series production of the Preshower/SPD modules will start soon. Delivery of the first batch of ECAL/HCAL phototubes is expected in May.

II-8) Muon

Following the decision to replace RPC's by MWPC's, an Addendum to the Muon TDR describing this change, in particular the impact to the organizational aspects of the project, was submitted to the LHCC and approved by the Research Board in February 2003. The production centres are being equipped with the construction tools, and contracts for the mass production of the chamber components are being prepared. All components of the FE-electronics chain have been prototyped and a review of the architecture took place in March 2003. Some problems are still present in the CARIOCA chip. The design has been reviewed and a modified version submitted at the end of February. Work on the seismic stability of the muon filter design is in progress.

Changes: No major change

Concerns: Short time left for the CARIOCA chip development

Plans: The EDR for the muon chambers is scheduled for April 2003 and their mass production will start at three centres in July 2003. A review for the muon filter is scheduled for May.

II-9) Trigger

For Level-0, the muon trigger processing board prototype is being tested. The Hybrid has been designed for the Pile-up Veto detector and prototypes were produced. A strategy to distribute the Leven-0 bandwidth among various triggers for optimal physics per-

formance is being studied. For Level-1, the maximum output rate is fixed to 40kHz. Similarly, the buffer length in the Level-1 electronics is defined to be 58254. A Level-1 implementation based on common hardware with the DAQ/HLT (Higher Level Trigger) is being studied. For the HLT, studies to reconstruct tracks from the VELO and T1 to T3 stations after the magnet show encouraging results in terms of the efficiency and execution time.

Changes: no major change

Concerns: no major concern

Plans: TDR in September 2003

II-10) Computing

Online: The necessary revision due to the intention to integrate the Level-1 trigger in the DAQ system is being studied. There are no major architectural changes, however the scale of the system will increase. A new prototype of the Credit-Card PC glue-card has been designed. Projects have been launched to adapt the Gaudi framework to the online environment and also to interface Gaudi to the ECS system, as well as to design and implement a configuration database.

Offline Software: The LHCb software, used for event generation, detector simulation, event reconstruction and physics analysis, is now in a stable production phase. The LCG (LHC Computing Grid Project) software components will be incorporated as they become available. The LHCb software team is also making major contributions to LCG developments (SEAL, POOL). An interface between Gaudi and the Grid (GANGA) is a common project between LHCb and ATLAS. A simulation program based on Geant4 (Gauss) has been implemented making use of a Gaudi-Geant4 gateway (GiGa). All sub-detectors have been included in Gauss, which has now reached its validation phase.

Offline Computing: The new LHCb production system, written largely in (machine independent) Python language with little use of UNIX shell scripts, was successfully deployed at 15 sites and over a 4-week period during the Christmas vacation 4.4M events were produced. Over 80% of these events were produced outside of CERN with the data being copied back to CASTOR. The status of the current data challenge, which will finish by the end of April, is that 16 sites are active and 16.4M events have been produced in a month, a faster rate than planned as seen from Figure 2, with nearly 90% of events produced externally to CERN. In addition the current production system was able to incorporate the European Data Grid testbed. Strategies are being developed to deal with the analysis of this data for the LHCb reoptimization and trigger TDR's.

Changes: no major change

Concerns: Lack of manpower for DAQ implementation

Plans: For the Online project, activities for the following six months will be mainly to perform the market survey and tendering for the design and production of the Network Processor based readout module. For Offline activities, application software from the LCG project will be continuously incorporated. Low-level background Monte Carlo production will continue over the next 6 months. In parallel the new OO simulation will be introduced into the production system in time for the next scheduled data challenge in Spring 2004.

III) Experimental Area

The metallic structures in the PZ area (stairs, barriers) have been installed and the reinstallation of the general service in the UX85 cavern is progressing as scheduled. The support structure for the LHCb dipole is being installed. The major constraint for the

detector installation comes from the transportation and installation activities of the LHC machine. The transportation is done through PX84 shaft and across the UX85 (LHCb) experimental area into the tunnel, and a cryogenic facility will be installed in UX85.

IV) Organization

John Harvey had been appointed as Group Leader of EP Software Group and could no longer act as LHCb Computing Coordinator. As from 1st of March 2003, the Computing Project was split into three projects: Online, Offline Software and Offline Computing with the following project leaders.
Beat Jost (CERN): Online Project Leader
Philippe Charpentier (CERN): Offline Software Project Leader
Nick Brook (Bristol): Offline Computing Project Leader

V) Milestone Plot

Figure 1: Cumulative plot of the LHCb Milestones.

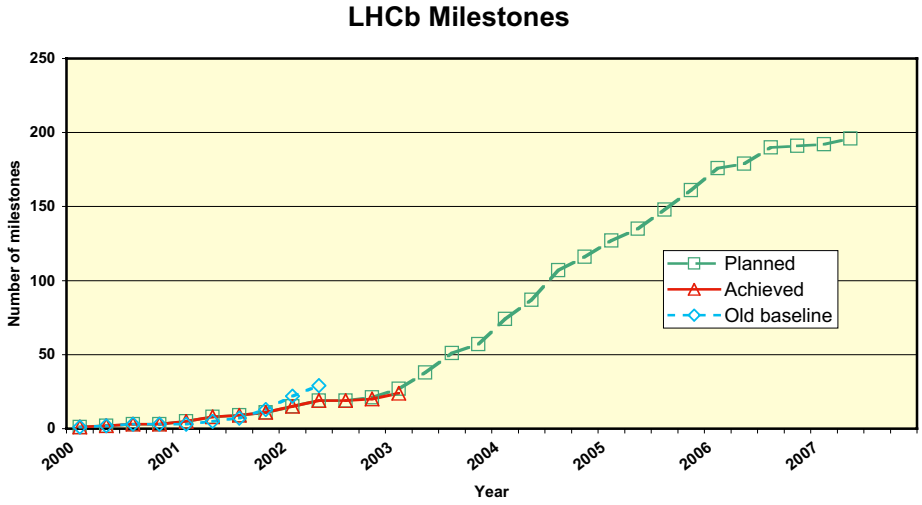

Figure 2: Data production for the Trigger and LHCb-light TDR.