CERN-RRB-2005-090
30 September 2005

Status of the LHCb Experiment

Report to October 2005 RRB
by the LHCb Collaboration

1. Introduction

More than half of the LHCb experiment has been constructed by now. Production of VELO, Outer Tracker, RICH, Calorimeters, and Muon system is advancing well, and pre-production has started for the Inner Tracker and TT station. The overall schedule remains tight, but installation of the detector is expected to finish in time to be ready for collisions in Summer 2007. Brazil remains the only country that has not yet signed the Memorandum of Understanding (MoU) for the Construction of the LHCb Detector. Although the cost of the experiment remains the same as that in the MoU, there is a shortfall of funding. In this document, we propose a funding strategy for timely completion of the detector construction.

2. A New Collaborator

After the cancellation of BTeV in the US, the Syracuse University had expressed their wish to join the LHCb experiment, and was admitted in June. They were one of the leading groups in BTeV and LHCb will benefit a lot from their long experience in B physics in CLEO. Due to the decision by the US Congress, they are not allowed to contribute directly to the construction cost of the current detector. However, they can contribute to the computing, maintenance and operation, and possible future detector upgrade. NSF has authorized them to transfer their R&D fund allocated for the BTeV experiment. Using part of this R&D money combined with other sources from the university, they agree to contribute to the reconstruction CPU farm, which helps in finding a solution for the current funding shortfall, as explained later. They are requesting further funding for increasing the CPU power of the experiment.

3. Detector Subsystems

3.1 Beam Pipe

Construction of the third beryllium section of the beam pipe, UX85/3, is ongoing at Komposit (Russia). Vacuum tests of the beryllium section UX85/2 are in progress at Protvino (Russia). Delivery of UX85/2 to CERN is foreseen at the end of October 2005. The stainless steel section of the beam pipe, UX85/4, has been ordered and is being manufactured at TTM (Spain). The aluminium bellows and flange section (including spares) have been fabricated at CERN. Vacuum tests and bake-out of this section are in progress. The order for the stainless steel bellows and flange section has been placed to SKODOCK (Germany). Fabrication of VELO exit window at CERN is close to completion. Further iteration on the design of supports and fixed points is in progress to optimize material and mechanical properties. Design of the aluminium spare beam pipe has been finalized and tendering is in progress.

Changes: Delivery of the beryllium sections has been shifted: UX85/2 from May to October 2005, UX85/3 from October to December 2005.

Concerns: Short time available for tests and assembly on the surface after the delivery of the beam pipe sections, before the installation in the cavern.

Plans: Finalize design of supports and fixed points and start fabrication. Perform acceptance tests of UX85/2 and /3 after delivery to CERN. Carry out tests of the VELO window and perform its assembly with the 25 mrad section of the beryllium beam pipe. Perform vacuum leak tests and bake-out of all delivered components. Carry out design and fabrication of assembly tools.

3.2 Magnet

In May and June, the field map was measured inside the volume of the magnet and in the region upstream with the RICH1 iron shielding box in position. The results are in good agreement with simulation. Hysteresis has been recorded with positive and negative polarity in August 2005 and field measurements inside the RICH1 iron box with Mu-metal shielding have been performed. Electric insulation of the coils has been reinforced in order to avoid a grounding problem caused by the movement of the coils during the operation.

Changes: None.
Concerns: Insulation failures towards ground due to the movement of the coils: further improvements of insulation under work.

Plans: Measurement of magnetic field map with all magnetic iron structures in their final position, in November 2005.

3.3 Vertex Locator (VELO)

Beetle front-end chips have been produced and tested. A pre-series production of all analogue link electronics boards has been made and a pre-series batch of Kapton interconnects has been ordered. The ECS boards have successfully undergone a first prototype production. Silicon sensor production is ongoing, but at a worryingly slow pace. A detector module EDR was held in April and will be followed soon by a production readiness review (PRR) in October. The vacuum system and positioning system are complete and work is now focusing on PLC programming and testing of the vacuum procedures. The right-side detector support (including large rectangular bellows) was produced and the left-side one is in production. The CO_2 transfer lines have been designed and ordered, and the CO_2 evaporator has been produced. A prototype cooling plant was built and successfully tested. Production of the RF boxes is continuing and NEG-deposition was successfully tested on a prototype RF box. Production of mechanics and infrastructure required for the integration and installation has started.

Changes: Detector module PRR shifted to end of October. Detector commissioning with test beam in North Hall has been confirmed, but is now planned for June 2006 (instead of April 2006).

Concerns: Silicon sensor delivery rate. Slow start-up of the detector module assembly, which may delay seriously the delivery of 42 tested modules. Fabrication of the final RF boxes prior to vacuum system installation.

Plans: Conduct PRRs of all electronics board and cables in October and/or November, followed by final production. Start production of detector modules and deliver up to 42 modules. Assemble both left and right detector halves at CERN. Carry out a full-system test with each detector half in the lab. Install CO_2 transfer lines, vacuum and positioning system in the pit.

3.4 Silicon Tracker

The production of silicon sensors for Inner Tracker (IT) and Trigger Tracker (TT) is now running smoothly, delivery of the last batch of sensors is expected in December. The quality of the received sensors is excellent. The production and testing of Beetle front-end readout chips is almost complete, a factor of three more good chips are now available than will be needed for the full detector. Pre-series of IT and TT front-end hybrids have been produced and the full series productions are about to be started. Minor modifications of the detector module designs were implemented to improve the robustness of the modules under operation at high bias voltages. This has caused some delay in the start-up of the module production. The pre-series production of detector modules has now been completed and the series production has started (TT) or is about to start (IT). Module test stands are in place and almost fully operational. They use all major components of the final LHCb readout electronics. Pre-series of digitizer boards has been produced and tested successfully and series production of these boards will be launched soon. A prototype of the Service Box control card is currently being tested, although progress is currently slowed down by problems with the LHCb-wide SPECS system. The design of IT support frames has been modified to improve cable routing and reduce the amount of dead material in front of the OT. Design work on the integration of the TT station is ongoing, although progress has been slow due to work overload of the integration team at CERN.

Changes: None.

Concerns: No contingency left for the detector module production. Lack of manpower for detector-specific software. Delays in the design for TT frames and integration hardware. Funding profile for Germany (MPI) and Spain.

Plans: Continue the production of detector modules. Finalize the integration of detectors, and produce and install the support frames in IP8. Produce the full readout electronics. Start working on detector-specific software.

3.5 Outer Tracker

Module production proceeds steadily and has now reached 90% of the total. All materials necessary are already in hand and production is expected to be completed in time. All produced modules are fully tested with radioactive source and are now being prepared for shipment to CERN. The ¼-station prototype test was successfully completed and evaluated in an EDR. The station frame design was then finalized, price enquiries made, and a production contract signed. The production of the aluminium C-frames supporting the modules is proceeding according to schedule and should be completed in time. The analysis of the beam tests (DESY Hall 22 with a 6 GeV e^- beam) has been completed. The most important detector characteristics (drift-time spectra, RT-relation, intrinsic efficiency and resolution, noise and cross-talk level) were found to be within the requirements for physics performance. The front-end electronics has been successfully reviewed in a PRR and mass production started.

Changes: Design of the support infrastructure required further reinforcement to increase the stiffness and reduce the bending. Number of gas lines will be reduced due to space limitations.

Concerns: Delay in the realization of the infrastructure (support structure, cooling etc.).

Plans: Complete the tender of the main elements of the OT infrastructure (support structure, gas system components, etc.) and re-evaluate status of schedule and resources.

3.6 RICH

For the RICH1 detector the two magnetic shielding boxes were installed in May, and measurements made with full magnet current gave an acceptable maximum field of 25 gauss inside the boxes, consistent with expectations. The gas enclosure has now been manufactured and is almost ready for leak testing. The first beryllium mirror out of the eight required has been tested and, although delivered 6 months late due to R&D technical difficulties, has acceptable optical properties. The mirror PRR was successfully concluded and the order for the remaining seven mirrors has now been placed through ISTC, with the last delivery expected at CERN in 12 months time. The PRR for the aerogel has been concluded, and its procurement is expected to be finished by the end of the year. For RICH2, the assembly of the mechanical structure was completed on schedule and the spherical and planar glass mirrors have all been fabricated and installed. Mirror alignment has been completed prior to transportation to the LHCb pit. The production of the mechanics for the HPD mounting assembly has started. For the HPD photon detectors, the production is now fully underway and the first 15 tubes have been delivered. Unforeseen technical difficulties in a manufacturing sub-process resulted in a delay of two months, and delivery of the final batch of tubes is now scheduled for January 2007. The HPDs already produced have been tested and are within specifications; the two test centres have been prepared for production. We now have 500 sensor assemblies in hand and the yield is better than 80%. We expect the steady-state production rate of 30 HPDs per month to be achieved by October. For the electronics, final prototypes of the Level-0 and Level-1 readout electronics, together with the link modules between the HPDs and the Level-0 cards, are being verified in a full system test. The low voltage and high voltage distribution cards are also being tested in their final layout. The PRR of the Level-0 and LV cards has been concluded.

Changes: None.

Concerns: The tight schedules for the completion of RICH1 mechanics and the beryllium mirrors. The timescale for the production of the final HPDs, to be ready for installation in the RICH detectors.

Plans: Complete the PRRs for the remainder of the RICH1 mechanical components (the mirror mounts and HPD assembly). Assemble the RICH1 gas enclosure at CERN by the end of the year. Install the RICH2 structure in the cavern in October. Complete the system test of a full column of 16 HPDs with the pre-production readout chain by October. Start full electronics production in November.

3.7 Calorimeter

The assembly of the ECAL detector from 3300 shashlik modules in IP8 was completed in June 2005 and all modules have been aligned. Cabling has been completed of both the monitoring system with clear fibre bundles at the front face and the readout side on the back. The assembly of the HCAL detector from its pre-cabled 52 modules has been completed in July 2005 and all modules have been aligned. The radioactive source calibration system has been installed and leak tested. Both electronics platforms of ECAL and HCAL that will host the front-end electronics have been installed. The production of the Preshower/SPD detector is ongoing and the outer- and inner-type modules at INR have been finished. The middle-type modules are expected to be completed in October. Two out of the 16 super-modules have been equipped with the clear fibre bundles that transport the light from the Preshower modules to the multi-anode photomultiplier tubes (MAPMT) at the detector periphery. After delivery of new fibres with better quality, the fibre bundle production at CERN and Clermont is progressing well. All 220 MAPMTs have been delivered and are undergoing qualification tests in

Barcelona and Clermont. The Market Survey and Invitation to Tender for the Preshower lead converter have finished and the order has been placed at the beginning of September 2005. The qualification tests of final prototypes for the very-front-end (VFE) cards for Preshower and SPD are progressing well. Due to limitations in the LHCb infrastructure the cooling system for the VFE cards has undergone a redesign from air to water cooling. Final prototypes of the ECAL and HCAL front-end boards have been received and are under test. The electronic cards for the LED monitoring systems and the Cockroft-Walton HV system for the Preshower/SPD are under production.

Changes: None.
Concerns: The production and testing schedules for the Preshower super-module production and the ECAL/HCAL and Preshower/SPD FE cards.

Plans: Start ECAL and HCAL commissioning with LED monitoring systems by the end of 2005. Complete the production of Preshower super-modules by the end of 2005. Start SPD/PS VFE card production by the end of 2005. Begin ECAL/HCAL and SPD/PS FE card production in the first quarter of 2006.

3.8 Muon

About 85% of M2-M5 panels have been produced with good quality, and material delivery to PNPI is progressing smoothly. There exist still occasional problems with low quality panels and wire spool. The order for M1 honeycomb panels has been placed and the pre-production is starting. All the MWPC production sites are operating and the global production rates are as planned. More than 620 MWPCs have been produced. The TDR Addendum on the inner part of M1 has been accepted by the LHCC. Two triple-GEM pre-production detectors (out of 12) have been built and are now under test. All the custom chips (CARIOCA, DIALOG and SYNC) have been produced and are now being packaged and tested. The PRR for the Electronics Boards was successful and the production of most of the boards is in progress or finished. All the filters MF1-MF4 have been installed. The support structures for stations M2-M5 have been produced and are ready for installation.

Changes: None.

Concerns: Further delays in the cryo-line commissioning. Delay in the detector cable and gas pipe installation due to late delivery of cables and design modification in the on-detector gas distribution. Stable MWPC production rates. Manpower for M1 support structure design and integration.

Plans: Install electronics on chambers, followed by a final chamber test. Install support structures and services (racks, cables, gas pipes etc.) for muon stations M2-M5, starting on the cryogenics side, followed by chamber installation. Produce M1 detectors (MWPCs and triple-GEMs). Complete production of electronics boards.

3.9 Trigger

Tests have been successfully completed for the following Level-0 electronics: trigger interfaces of the calorimeter front-end boards, prototypes of optical mezzanine boards, a prototype of the hybrid for the pile-up system, and a prototype of the Level-0 decision unit. The final design has been made for the Level-0 calorimeter validation card and selection board, the Level-0 muon processing board and for the pile-up vertex finder board. The final design is in progress for the remaining boards: controller board and back-plane for the Level-0 muon trigger; hybrid, optical and output boards for the pile-up system. The Level-1 and High Level Trigger (HLT) codes have been used in the Real Time Trigger Challenge (RTTC), and after some initial debugging ran without problems. The corresponding timing measured in the RTTC corresponds well with the expectation, showing that no extra overhead losses appeared in a real environment. In the Level-1 algorithm a new way to recuperate low p_T muons lost in Level-0 shows that the selection efficiency for the lifetime unbiased dimuons can be improved. In the HLT a new flow of the so-called Generic selection has been worked out, mainly to improve the selection of candidate B-decay tracks to improve the long tracking. In the Specific selection, much progress has been made in showing that inclusive selections, such as an inclusive ϕ selection, can have a high efficiency, and in combination with using the RICH information can have an acceptable rate. Given the new 1 MHz readout scheme, the Level-1 and HLT triggers will now be combined in one process. The experience obtained with the RTTC on the monitoring will be used to design and implement a monitoring strategy for the trigger.

Changes: None.

Concerns: Tight time schedule and a lack of manpower for the Level-0 decision unit and for the pileup system.

Plans: Test the final version of all Level-0 trigger boards. Organize PRR for all subsystems. Launch the production. Adapt L1/HLT to the 1 MHz scheme. Implement L1/HLT performance monitoring.

3.10 Online

The TFC system is now in full production. To date 10 Readout Supervisors have been produced and 8 will follow soon. Some delay was accumulated due to production problems at the PCB manufacturer, which are now fixed. The controls software for the system is finished and the modules are in use by several detector groups. The implementation of the Experiment Controls System (ECS) is going well. The low-level access software for the different controls mechanisms (SPECS, Credit-Card PCs) is finalized, integrated in PVSS and also in use by several detector groups. A new implementation of the Finite State Machine toolkit was produced and deployed, addressing some performance problems discovered by the RTTC. The configuration database project is making good progress and a first prototype is ready for use. In the data acquisition subsystem the major activity was the RTTC, which took place in July. Its purpose was to exercise the complete DAQ event filter farm with one full subfarm at maximum speed. It was the first time that all components of trigger software, data acquisition software and controls software were brought together. Many lessons were learnt, and problems identified are being addressed. In the pit the network cabling was finished and the water and power distribution in the barracks is currently being installed.

Changes: The design of the DAQ system has now been modified to readout the full detector in 1 MHz, i.e. at the Level-0 accept rate, eliminating an explicit Level-1 trigger.

Concerns: Tight manpower for the ECS system. Lack of manpower in some subsystem online teams.

Plans: Install the controls infrastructure and a rudimentary data acquisition system for the subsystem commissioning. Make a second RTTC for the end of 2005, testing the 1 MHz scheme, and bring all components together to determine the improvements made.

3.11 Computing

The computing TDR was submitted in June. The TDR included new event size estimates and resource profiles that had been requested during the review of the computing model in January. A review of the sub-detector and core software, particularly the new event model, has been made. The results of the review and implementation planning were presented in the September software week. All the modifications will be implemented by the end of the year. Some core developments in GAUDI await the finalisation of the merge of ROOT and SEAL in the LCG application area. After many teething problems, the stripping part of the Data Challenge ran relatively smoothly over the summer, particularly at the external Tier-1 centres CNAF (Italy) & PIC (Spain). The stripping will continue with data simulated over the summer to further stress the system. A geometry framework has been implemented in GAUDI, to allow positioning of the sub-detectors with given alignment constants, as well as the conditions database for the alignment constants. The configuration of the condition database service for LHCb, with an ORACLE backend, has been requested from CERN-IT. The VELO group is studying in detail their alignment procedure and is starting to use the new framework. Work has progressed towards the Service Challenge. Tools have been developed for data management, in particular a transfer agent that interacts with the FTS (file transfer system) from the LCG. In addition, tools are under development to allow automated production to be triggered as data files become available. GANGA has been used to submit analysis, based on the use of logical file names, to three sites on the LCG. The submission was made via a DIRAC backend. The matching of the available data and CPU is made at the LCG resource broker that accesses the LCG File Catalogue implementation, LFC.

Changes: Event model will be adapted to the new 1 MHz scheme.

Concerns: The time-scale for the LCG to provide a new set of framework services in the Applications Area (SEAL+ROOT merge), in particular for linear algebra (replacing CLHEP).

Plans: Finalise software for production commencing January 2006. Perform analysis at Tier-1 centres. Develop the final alignment strategy.

4. Experimental Area

The installation of the electrical power station (2×1.25 MVA) located in the PZ area (radiation free area) is advancing; the equipment is in place, cabling is in progress and commissioning will start in October. Delays have occurred compared to the initial schedule due, in particular, to unexpected delays in the installation of the platform for the secondary electrical distribution facility and the delivery of the cabinets for the primary electrical distribution facility. The engineering design and realization of various metallic structures is advancing around the LHCb detectors, such as the structure behind the muon system and beside the dipole magnet. The design work has finished and price enquiries have been launched. Installation is scheduled from October until December. For the integration of all the detector services, computer 3-D mock-ups (using EUCLID) have been made and updated. Their manufacturing and installation are ongoing, in particular the gas and cooling pipes.

Changes: The installation of the upper part of the main radiation shield in the UX85 cavern, initially scheduled for November-December 2005, is now shifted to Spring 2006, due to other activities with higher priority in this area.

Concerns: Delays in the installation of the QRL cryogenic lines, which lead to delays for LHCb activities, such as the modifications to the metallic structure for the muon system in the RB86 area and the installation of the muon towers.

Plans: Install all the metallic structures around the detectors by the end of December and continue the installation of the detector services such as the cable trays, cooling pipes and gas piping up to the sub-detectors.

5. Installation

The last Muon Filter MF4 has been installed on its support structure. All modules of the Electromagnetic and Hadron calorimeters are in place and detector cabling has started. The RICH1 shielding has been installed in front of the magnet and the M1/PS/SPD support structure has been assembled.

Changes: Transport and installation of RICH2 in the experimental area has been shifted to October 2005.

Concerns: Delay of LHC cryo-line installation and tests, delaying the Muon system installation.

Plans: Installation of RICH2 and assembly of first part of Muon support structure in October 2005. Mounting of metallic structures around the magnet and installation of additional cranes is scheduled from December until February 2006. Installation of Vertex Locator is planned for February 2006.

6. Organization

In order to prepare for the commissioning of the experiment, a Commissioning Task Force has been established with the following tasks:

- Defining the mode of operation for data taking, and identifying, producing, implementing and testing all the tools necessary for this operation;
- Commissioning the sub-systems;
- Preparing the detector for steady data taking, through global commissioning, including the pilot run.

It consists of a Commissioning Coordinator and representatives from the subsystems. Olivier Callot from Orsay has been appointed as the Commissioning Coordinator. The mandate of the task force will continue until the pilot run.

7. Cost and Funding Status

7.1 Funding Evolution

As indicated in the MoU in November 2000, 73.300 MCHF was requested to the participating funding agencies for the construction of the LHCb detector. All the participants except Brazil, where 1.700 MCHF had been requested, have now signed the MoU. China, Germany (BMBF) and Russia signed the MoU with their contributions reduced by 150 kCHF, 1043 kCHF and 500 kCHF (of which 350 kCHF was compensated by CERN), respectively. The MoU signed contributions are summarised below.

MoU signed LHCb Funding (August 2005) in MCHF

Brazil	China	France	Germany (BMBF)	Germany (MPI-HD)
0.000	0.100	7.500	3.757	2.200
Italy	Netherlands	Poland	Romania	Russia
10.000	6.300	0.500	0.300	2.500
Spain	Switzerland	UK	Ukraine	CERN
2.000	7.900	10.300	0.200	12.700+4.000(μ-filter)
Total	70.257 MCHF			

7.2 Cost Evolution

In the MoU, the cost of the LHCb detector was estimated to be 75.045 MCHF, i.e. 1.745 MCHF more than the requested funding. Since then, major reoptimization of the LHCb detector has been performed and summarised in the Reoptimization TDR published in September 2003. The number of the tracking stations has been reduced in order to reduce the material budget of the detector, and magnetic field was introduced in the region of RICH1 in order to improve the trigger efficiency. As a result, the designs of the following subsystems were affected: RICH, Inner Tracker (called now Silicon Tracker), Magnet and Outer Tracker. More than half of the detector construction has been now completed and we have a much better estimate for the detector cost. The cost evolution to this date is given below:

Cost evolution of the subsystems in MCHF

	MoU	Reoptimization TDR	Now
VELO	4.760	4.822	4.822
ST	5.150	5.870	5.870
OT	10.085	6.230	7.550
RICH	7.700	9.570	9.817
Calo	15.360	15.060	14.930
Muon detector	7.450	6.930	8.560
Muon filter	4.000	4.000	4.000
L0 trigger	2.720	2.430	2.260
Magnet	6.000	6.000	5.774
Infrastructure	4.000	4.000	4.373
Data Handling	7.820	8.000	7.385
Total	75.045	72.910	75.341

Data Handling includes DAQ, Experiment Control, Computing Infrastructure and CPU-farm.

7.3 Strategy to Cope with Funding Shortfall

Although the cost of the detector remains practically unchanged from the MoU, there exists a funding shortfall of 5.084 MCHF, compared to the approved funding. To resolve this, the LHCb collaboration would like to apply the following strategy: As stated in previous RRB meetings, we first try to solve a funding problem within the subsystem as far as possible, unless the funding shortfall is due to an unforeseen reduction of the expected contribution, or due to a cost increase in order to cope with enhanced requirements or due to unexpected external constraints. The groups responsible for the subsystems ask for extra funds from their funding agencies. If this is not sufficient, we move money from the CPU-farm in such a way that all the detector hardware should be funded, so that timely completion of the detector construction can be guaranteed. We finally ask all the funding agencies for extra contribution to the CPU-farm.

7.4 First Step

With the strategy outlined above, we still have the Muon Detector, RICH, Outer Tracker and DAQ/CPU-farm under-funded.

Muon System: For the Muon detector, after the unexpected funding reduction due to Brazil has been filled by the Common Fund, 1.730 MCHF (including initial shortfall) should be financed by the groups responsible, reflecting the original contributions. The proposed solution is indicated as "Current request" below.

Muon Detector funding in MCHF

	Brazil	CERN	Italy	Russia	Common Fund
MoU anticipated	1.220	0.200	4.850	0.560	0
MoU signed	0	0.310	4.850	0.430	0
Current request	0	0.495	6.395	0.430	1.240

RICH: For the RICH system, the cost increase due the introduction of the magnetic field into the RICH1 region is taken care of by the Common Fund. The remaining shortfall, 1.430 MCHF, is proposed to be covered by the groups responsible as below.

RICH funding in MCHF

	CERN	Italy	UK	Common Fund
MoU anticipated	1.000	1.000	5.700	0
MoU signed	1.000	1.000	5.700	0
Current request	1.614	1.172	6.344	0.687

Outer Tracker: For the MoU, in addition to the groups who were responsible for the construction of the Outer Tracker system, contributions from CERN and the Common Fund of 3.4 MCHF and 0.9 MCHF, respectively, were used to finance the construction. Due to the reduced number of stations needed after the reoptimization, the CERN contribution was no longer required for the Outer Tracker. The cost has since increased by 1.320 MCHF, of which 0.762 MCHF can be considered as the responsibility of the participating groups. We propose to finance this by requesting a funding increase for the Netherlands and German groups of 381 kCHF and 381 kCHF, respectively. The remaining 558 kCHF is considered as a result of the extended requirement and cost increase of the raw material beyond the control of the group, and is covered by returning the Common Fund contribution to its original level and reintroducing a small fraction of the original CERN contribution as summarised below.

OT funding in MCHF

	China	BMBF	CERN	Netherlands	Poland	CF
MoU anticipated	0.180	1.920	3.400	3.000	0.360	0.900
MoU signed	0.072	2.167	3.400	3.000	0.360	0.900
Reoptimization	0.072	2.167	0	3.000	0.360	0.631
Current request	0.072	2.548	0.289	3.381	0.360	0.900

The total contribution of CERN, Germany (BMBF), Italy, the Netherlands and UK to the experiment would become 13.499 MCHF, 4.138 MCHF, 11.545 MCHF, 6.681 MCHF and 10.344 MCHF, respectively. If the requests are granted by the relevant funding agencies, the total funding of the experiment would increase to 73.407 MCHF with a remaining funding shortfall of 1.934 MCHF for the CPU-farm. This should be compared to the current cost of the CPU-farm, 3.420 MCHF. The CPU-farm is also used for offline processing and this can be considered to be a part of computing to which the U.S. can contribute. Therefore, the newly joined group from the Syracuse University is ready to contribute initially 400 kCHF towards this cost, reducing the final shortfall to 1.534 MCHF, i.e. roughly the half of the required CPU's. The resulting complete Cost-Funding matrix is given in Table 1.

7.5 Second Step

As the second step to cope with the remaining shortfall of 1.534 MCHF, we would like to ask all the funding agencies to contribute to this shortfall. These contributions could come in 2007 or beginning of 2008, since the full capacity of the CPU farm will not be required before then.

Summary Table for October 2005 RRB in kCHF

Funding agencies	Total funding	Common Fund funding	Project funding	VELO	ST	OT	RICH	CALO	Muon detector	L0	DAQ CPU farm	ECS, TFC Comp. infrastru.	Magnet	Infra-structure
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China	100	28	72	0	0	72	0	0	0	0	0	0	0	0
France	7500	2100	5400	0	0	0	0	3820	0	1580	0	0	0	0
Germany-BMBF	4138	864	3274	370	356	2548	0	0	0	0	0	0	0	0
Germany-MPG	2200	834	1366	0	1366	0	0	0	0	0	0	0	0	0
Italy	11545	2850	8695	0	0	0	1172	0	6395	430	698	0	0	0
Netherlands	6681	1800	4881	1250	0	3381	0	0	0	250	0	0	0	0
Poland	500	140	360	0	0	360	0	0	0	0	0	0	0	0
Romania	300	90	210	0	0	0	0	210	0	0	0	0	0	0
Russia	2500	700	1800	0	0	0	0	1370	430	0	0	0	0	0
Spain	2000	570	1430	0	800	0	0	430	0	0	0	200	0	0
Switzerland	7900	2250	5650	2142	2508	0	0	0	0	0	500	500	0	0
UK	10344	2940	7404	1060	0	0	6344	0	0	0	0	0	0	0
Ukraine	200	60	140	0	70	0	0	70	0	0	0	0	0	0
CERN	13499	3520	9979	0	770	289	1614	3740	495	0	1486	1585	0	0
Funding sum	69407	18746	50661											
CF contribution				0	0	900	687	5290	1240	0	482	0	5774	4373
CF usage sum			18746											
Project Funding			69407	4822	5870	7550	9817	14930	8560	2260	3166	2285	5774	4373
Muon-filter in kind contribution from CERN			4000											
Project Funding with CERN in kind			73407											
Project Cost			71341	4822	5870	7550	9817	14930	8560	2260	5100	2285	5774	4373
Muon-filter			4000											
Project Cost with Muon filter			75341											
Balance			–1934	0	0	0	0	0	0	0	–1934	0	0	0

US contribution to CPU-farm	400

Total					
Cost	75341	Funding	73807	Balance	–1534

Table 1 Revised LHCb cost-funding matrix proposed to the RRB.