Status of the LHCb experiment

CERN-RRB-2013-036

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1 Introduction

The LHCb experiment has been successfully collecting data during the whole of 2012, recording proton-proton collisions for an integrated luminosity in excess of 2.0 fb^{-1}. Data taking has been stable at a constant instantaneous luminosity of 4×10^{32} $\text{cm}^{-2}\text{s}^{-1}$, a L0 trigger rate of 1 MHz and an HLT rate up to 5 kHz. On the detector side, individual subsystems have shown excellent stability and very high operational efficiency, without ageing effects that could affect the quality of the data. At the end of 2012 run, LHCb made tests in higher luminosity conditions (up to 6×10^{32} $\text{cm}^{-2}\text{s}^{-1}$, with the full detector and up to 10^{33} $\text{cm}^{-2}\text{s}^{-1}$ for some subsystems) to obtain useful information for the operation in 2015 and for the preparation of the upgrade. Moreover, in the data taking of early 2013, the experiment has participated to the proton-Pb run, integrating a luminosity of 2 nb^{-1}. LHCb recorded events with proton and ions in both directions and with the two magnetic field polarities. The detector occupancies were similar to those of proton-proton collisions and in line with expectations. These data will allow detailed studies of Drell-Yan processes to be performed in an (x, Q^2) region unique to LHCb and not accessible to other LHC experiments.

Since the last RRB, several new results have been presented at the end of 2012 and at the 2013 winter conferences. Among them, the most important have been the first evidence for the $B_s^0 \to \mu^+\mu^-$ decay, the measurement of the D^0–$\overline{D}^0$ oscillation parameters (both shown at the HCP conference), and more recently, the determination of the $X(3872)$ quantum numbers, the update of the B_s^0 oscillation parameters Δm_s and ϕ_s, and the update of CP violation in charm $D \to hh$ events with two independent methods, from prompt D^* and from B semileptonic decays (presented at La Thuile and Moriond workshops, respectively). Several other results have been produced in flavour and non-flavour physics, allowing LHCb to submit, very recently, its 100^{th} publication.

The reprocessing of 2011 and 2012 data is now ready and will allow the collaboration to present updated results at the 2013 summer conferences with a fully calibrated sample of 3 fb^{-1}. The status of the LHCb upgrade is described in a separate document [1].

2 Detector sub-systems

After very successful data taking over the last three years, LHCb entered the two-year LHC shutdown period. The LHCb experiment has been in operation since 2009 and this without any major intervention over the last four years. Therefore, extensive consolidation and maintenance work has been scheduled for the shutdown period of more than 20 months. This work comprises all general and detector related services, equipment and safety systems. A detailed planning has been established including all tasks that will be performed by the individual sub-detectors. A new visitor platform will be installed in the second quarter of 2013. The third section of the beryllium beam pipe has to be exchanged and on this occasion, LHCb will replace the support structures of the second beam pipe section for a lighter one. The magnet requires a thorough consolidation which has been scheduled for the second half of 2013 and will require a time slot of three months. A concern is the lack of general cooling due to maintenance during several periods, which will be partially recovered with a temporary cooling station. Major upgrade work on the electrical network has been started and is progressing well.

2.1 Beam pipe

Following an engineering design review in June 2012 new and lighter support collars in beryllium for sections UX85/2 and UX85/3 have been finalized. The collars have been manufactured, delivered to CERN and are ready for installation next year. A small penalty has been applied to the payment due to a minor imperfection that nevertheless does not prevent their use. The results of irradiation tests showed that one of the carbon-based proposed solutions for the support cables did not meet the recommended safety factors; an alternative solution is under investigation. Aluminum bellows between the beryllium section and stainless steel bellows between UX85/3 and UX85/4 have been fabricated and are ready for installation. Preparation activities for the removal of all but section UX85/1 will take place in the next two months are well advanced. The re-installation of all sections including the new UX85/3 and new supports is scheduled toward the end of LS1.

2.2 Vertex Locator (VELO)

All components of the system have performed well throughout the 2012 run with an overall channel efficiency of 99.3%. The majority of the activities on the current VELO over the next 18 months are focused on LS1-related tasks. This will include extraordinary maintenance of several of the sub-systems. Some components will be replaced to ensure reliable operation after LS1. For example most crate and power supply fans, the LV bulk power supplies and the LV connectors will be refurbished. The control software will be migrated to new OS and to WinCC, combined with software consolidation work. There will be substantial developments on the monitoring and data quality software. The monitoring framework will be re-built and further automations of the monitoring will be implemented. These software tasks will not require any capital investment but require a significant investment in manpower, hence subsistence costs as the work takes place at CERN. There has been an agreement between the LHC vacuum group and LHCb that the VELO does not have to be removed for bake-out after the beam pipe replacement. A change in this decision would require a large effort from the VELO to temporarily remove the VELO for bake-out. Some additional spares will be produced and tested during LS1. The two detector halves for the replacement are fully assembled but some costs still remain to be covered for the metrology and the storage and display of the replacement detector halves.

2.3 Silicon Tracker (ST)

The two detectors that constitute the Silicon Tracker, the Trigger Tracker (TT) and the Inner Tracker (IT), performed extremely well at luminosities well above the design value throughout the last run. The operation of the detector was very stable and the Silicon Tracker was controlled by the central LHCb shift crew with occasional support from the on-call piquet. The number of working channels is 99.61% and 98.71% in TT and IT respectively. This number is lower for IT as accessing the read-out electronics for repairs requires the detector to be opened; this would require a major intervention. These channels will be recovered during LS1. Radiation damage in the silicon sensors has been monitored carefully and the results are so far fully consistent with the design predictions. There have been problems throughout the run with the reliability of cooling for the Silicon Tracker. The temperature of the TT detector box together with one box in IT has been rising since the last technical stop in September 2012. This was due to a decrease in the flow of the C_6F_{14} coolant and was solved by an intervention on the regulator valves at the beginning of LS1. A second problem has been seen which resulted in a loss of cooling power in the plant. The problem could be cured in the short-term by making a "re-circulation" of the cooling plant during an inter-fill period. However, towards the end of the run this intervention was required every day. This is clearly unacceptable and not maintainable in the long term. A major intervention is planned to upgrade the cooling system during LS1. It will involve the installation of a new cooling system composed of an inverted chiller, a heat exchanger and a brine pump located at the upper level of the counting rooms, and a circuit which will follow the route of the mixed water pipes from the chiller to the IT and TT cooling plants. This intervention is scheduled in May 2013. In addition, filters will be installed in the cooling circuits to remove the debris responsible for the decrease in the flow of C_6F_{14} coolant.

2.4 Outer Tracker (OT)

The detector and readout electronics operated reliably at the instantaneous luminosity of 4×10^{32} cm^{-2}s^{-1} in 2012, and even up to 6×10^{32} cm^{-2}s^{-1} for a brief period at the end of 2012. A detailed offline analysis showed that in the second half of 2012 typically 80 channels out of a total of 53,760 showed either too many hits (noisy), or too few hits (disconnected), resulting in 99.85% perfectly functioning channels. A large analysis effort is continuously being made to allow for a timely determination of the onset of ageing effects, based on the usage of tracking to map the stability of the detector. Every 400 pb^{-1} dedicated runs are performed to study the hit efficiency at elevated amplifier threshold values. The last of such dedicated runs was taken in the very last proton-proton run of the LHC, a few days before the start of the shutdown (LS1). So far no reduced gain from ageing has been observed, but possible ageing remains a concern and will be watched closely. During LS1 work is planned on the detector modules (disconnect channels with short-cuts), on the front-end electronics (improve the grounding to further reduce noise), on the gas system (improve gas tightness and monitoring setup) and on the software (upgrade of PVSS). Also further ageing tests are scheduled using ^{90}Sr sources in situ during the LS1. To test the sensitivity of the readout electronics to possible synchronization problems at higher beam energies, the OT readout was successfully checked at a slightly higher clock frequency, in February 2013.

2.5 RICH systems

The RICH system has performed extremely well, in spite of the challenging running conditions, with an overall channel efficiency of more than 99%. Preliminary data from 2012 confirmed the excellent RICH single photon Cherenkov angle resolutions. All interventions, carried out over the last years and aimed at improving, stabilizing and consolidating the RICH performance and reliability, have shown their effectiveness and durability. This allowed the RICH operation team to study in detail the behaviour of the front-end electronics (the LHCb pixel chip inside the HPDs, and the RICH L0 system) at high trigger rates of up to 1 MHz and to further improve their settings, achieving up to 15% improvement in hit densities. An improved MDCS (Magnetic Distortion Control System) scan for the RICH-1 to correct for magnetic distortions has also minimized small differences in polarity dependent RICH-1 single-photon Cherenkov-angle resolutions. Operation of the system is made easier by a wealth of automated reactions for DCS, DAQ and safety systems. The HPD replacement campaign is progressing according to expectations from ion feedback measurements, although there was an unsatisfactory yield for a few repaired batches, which has slightly reduced the amount of available spares. However, first results from improved HPD fabrication procedures show promising signs to further reduce, or even suppress, the onset of ion feedback.

2.6 Calorimeters (SPD, PS, ECAL and HCAL)

The calorimeters have run smoothly; all channels are functional but 72 SPD channels located in a single VFE board (64 channels) and on one ASIC of a second board (8 channels). These two boards will be replaced during LS1. Detector ageing is scrutinized regularly. It affects detector response and trigger rates but the severity of the impact on data depends on the detector type and of its use. A new method based on raw occupancy has been developed to follow the ageing and can be used for the four calorimeter detectors.

It has been tested with data and is very promising. More checks will be performed during LS1 and it will be used to automate the change of PMT HV to keep the detector response constant over long fills. Otherwise, the usual maintenance of the calorimeters involves exchange of faulty electronics boards and of bad PMTs (high dark current or rate effect). The change of the optical plastic fibres of the ECAL LED monitoring system is under study. As they are also affected by radiation damage, they cannot be used to estimate the ageing of ECAL at present. Quartz fibers, more robust to radiation damage, are considered. A prototype has been made and is under evaluation. If quartz fibers are qualified, the change of optical fibers will be performed beginning of 2014.

2.7 Muon system

The muon system has successfully completed the LHC Run I. There are no major hardware problems to be reported for this last data-taking period. Both, detectors and electronics have performed very well. The fraction of working channels exceeds 99%. System performance tests have been done at high luminosity and the muon detector operated well without any major issues up to a luminosity of $10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$. These tests are providing very important input to better understand the expected muon system performance during the upgrade. The activities programmed for LS1 have started: the PNPI MWPC HV system will be upgraded by doubling the channel number to improve the system redundancy; detectors with non-operating gaps will be replaced; work on ECS will take place, both at the hardware and software level, to improve its performance and reliability; more shielding will be added behind the last muon station (M5) to reduce particle back-scattering on the upper part of this station.

2.8 Online system

In the report period the deferred triggering was perfected and its operation completely automated. As an operational by-product the general operation of the online system was very much relaxed, as a loss of parts of the farm only resulted in a corresponding increase in the deferral rate. Early in 2013 the proton-ion run data was successfully acquired. The start of LS1 was characterized by a complete refurbishment of the electrical distribution in the computer room and the redundant UPS system. The new data storage system was installed and is being commissioned. Preparations for the replacement of the control PCs and the various upgrades of operation are starting. Work is also going on for implementing the controls part for the future split of HLT1 and HLT2.

3 Operations

LHCb has been steadily taking data with high efficiency in 2012 and recorded about $2.1\,\mathrm{fb}^{-1}$ of pp collisions at a centre-of-mass energy of 8 TeV. Figure 1 shows the delivered luminosity during this period. LHCb has taken data at a constant instantaneous luminosity of $4 \times 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ (3.7 in 2011). This results in an average number of visible pp

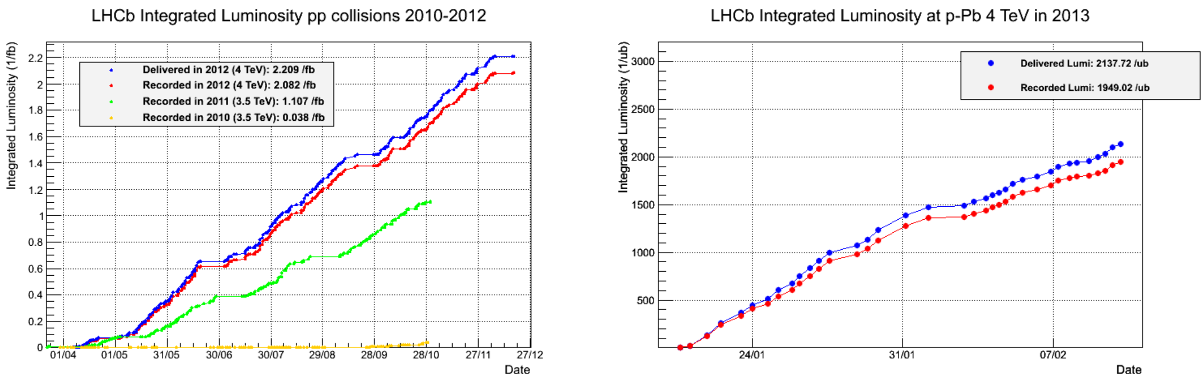

Figure 1: LHC delivered luminosity at the LHCb interaction point and LHCb recorded luminosity for 2012 (left), and 2013 (right).

interactions per bunch crossing (μ) of around 1.7 (1.5 in 2011), during the duration of the fills.

In December 2012 LHCb participated in the tests with 25 ns bunch spacing. We took data with number of visible pp interactions per bunch crossing of around 1.0 to emulate the multiplicity we would get at $4 \times 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ with 25 ns bunch spacing from 2015. The total number of bunches being low, the instantaneous luminosity was much lower than nominal. We also used part of one fill to run at higher $\mu = 1.7$, corresponding to $6 \times 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, to test the detector in conditions close to those expected in 2015, when the higher energy would increase the multiplicity. All components behaved well during these runs, apart from L0 which saturated as expected during the high luminosity run. The High Level Trigger (HLT) coped with the higher multiplicity thanks to the deferred processing of part of the data. The subdetector performance in these conditions is being studied by all subdetector groups.

For the overall performance, first studies show that the yields of high statistics control channels ($D \to K\pi$, $J/\psi \to \mu\mu$, $B \to J/\psi K$) per unit luminosity are consistent with expectation: there is a small loss (a few percent) due to a slightly lower efficiency in high multiplicity events at these high luminosities, and the level of background is marginally higher. Conversely, in the 25 ns run the yields per unit luminosity are slightly higher than in typical 2012 data due to the less busy events. These test runs thus make us confident the detector is in a good shape to cope with the anticipated running conditions from 2015 onwards.

We also took some data at $10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ mainly to test the muon system in upgrade conditions. All other subdetectors except RICH and OT participated as well. No obvious problems were found and the data is still being analysed.

3.1 Trigger

The Level-0 (L0) trigger has been run with stable thresholds during the year 2012. Only minor modifications have been applied in order to adapt to the ageing of the calorimeters.

The High Level Trigger (HLT) ran smoothly thanks to the deferred triggering technique that allows to store around 20% of the events at the input of the HLT for processing during the inter-fill periods when the HLT farm would otherwise be idle. The increased b and c cross-sections at higher $\sqrt{s}$ will set strong constraints on the trigger, and the output rate is likely to be increased again. Improvements of the trigger and the deferral procedure allowing a more extensive use of particle ID are under study.

3.2 Data processing (offline computing)

Detailed reports on computing resources have been published about 2012 usage [2] and 2013 prospects [3].

In summer 2012 we stopped processing all of the recorded data, focusing only on the amount needed for data quality monitoring and calibrations (about 30%). Once the calibration and alignment constants are available—typically a few weeks after data taking—the reprocessing of the full 100% starts. This allowed the reprocessing of the 2012 data to be finished at the end of the year. The 2011 data was subsequently reprocessed with updated alignment and calibration during winter 2013. This allows the collaboration to have the full $1+2$ fb^{-1} sample processed with the latest reconstruction software available.

The 2013 data (2.76 TeV, pA and Ap) is now next in line for this reprocessing. Another round of reprocessing is planned for late 2014. In the mean time several incremental strippings (selections for new channels) will be run.

Work is being done to improve the real-time data quality monitoring, essentially by running the offline reconstruction on an even smaller fraction of events in real time. Some of the data will also be used to monitor the global alignment parameters and the RICH refractive index.

The higher trigger rates will set strong constraints on computing operations. The processing of the data with "final" calibrations will need to span over the year as was done in the second half of 2012. Improvements on data quality procedures and calibrations are needed to accommodate this change in the computing model.

4 Physics results

Between October 2012 and April 2013, LHCb's physics programme has focused mainly on publishing results from its data sample of $1.0\,\text{fb}^{-1}$ of $7\,\text{TeV}$ pp collisions recorded in 2011, though some notable first results using the 2012 data have also been published. At the time of writing, LHCb has submitted a total of 105 papers for publication, of which 86 are already published. This corresponds to an increase of 33 in the number of submitted papers since the last RRB report. The strength of the LHCb physics output is also clear from its representation at the major international conferences: a wide range of new results have been presented at the 2013 winter conferences and many more will be revealed at upcoming meetings. In the remainder of this section, some of the highlights of the most recent results are briefly described.

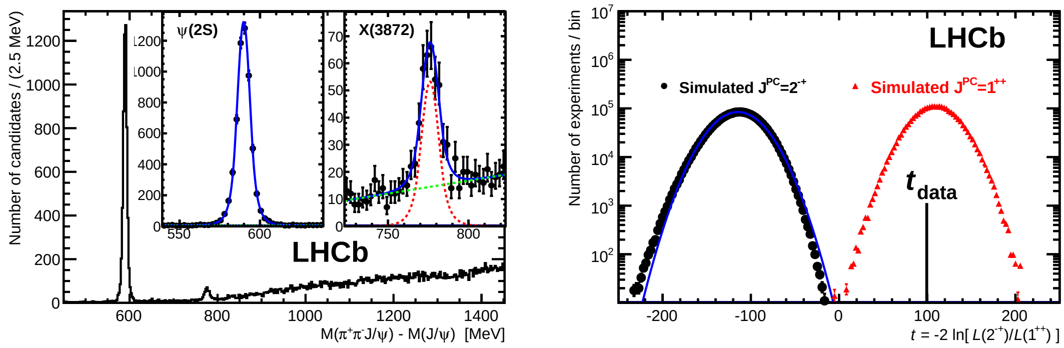

Figure 2: (Left) signal for $B^+ \to X(3872)K^+$, $X(3872) \to J/\psi\,\pi^+\pi^-$, $J/\psi \to \mu^+\mu^-$ decays; (right) distribution of the test statistic for simulated experiments with $J^{PC} = 2^{-+}$ (black circles) and with $J^{PC} = 1^{++}$ (red triangles). A Gaussian fit to the 2^{-+} distribution is overlaid (blue solid line). The value of the test statistic for the data is shown by the solid vertical line. From Ref. [8].

The big discovery of the last year in particle physics has been the observation, by ATLAS and CMS, of a particle consistent with being the Standard Model Higgs boson. LHCb has limited capability to contribute to this sector, but nonetheless can exploit its unique forward geometry and detection ability to perform measurements that are complementary to those from other experiments. A good example is the recent adaptation of an analysis measuring the $Z \to \tau^+\tau^-$ cross-section [4] to provide model-independent limits on Higgs-like bosons decaying to tau lepton pairs [5]. Studies of LHCb's potential to study the key decay channel $H \to b\bar{b}$ are in progress, and first preliminary results on the forward-central asymmetry in $b\bar{b}$ production have been presented [6]. This measurement may provide insight into the anomalous forward-backward asymmetry in $t\bar{t}$ production observed by the Tevatron experiments. The result,

$$A^{b\bar{b}}_{\rm FC}(M_{b\bar{b}} > 100\,{\rm GeV}) = (4.3 \pm 1.7\,({\rm stat}) \pm 2.4\,({\rm syst}))\,\%$$

is consistent with zero and with the Standard Model. These analyses illustrate the increasingly broad scope of LHCb's physics programme, which is also entering the study of relativistic heavy ion collisions, with first results from the data collected during pA and Ap data taking expected to complement those from the pilot run [7] within the next months.

LHCb has excellent potential in the field of heavy flavour spectroscopy, and has recently demonstrated this by answering one of the key questions concerning the mysterious $X(3872)$ particle [8]. This state was discovered by Belle a decade ago, but its nature is still not understood: its mass, width and pattern of decay rates do not fit into the expected spectrum of conventional hadrons. An analysis by CDF had limited the possibilities for its quantum numbers to be $J^{PC} = 1^{++}$ or 2^{-+}, with most exotic explanations where the $X(3872)$ is a DD^* molecule or a tetraquark favouring the former possibility. Now, with a five-dimensional angular analysis of the decay chain

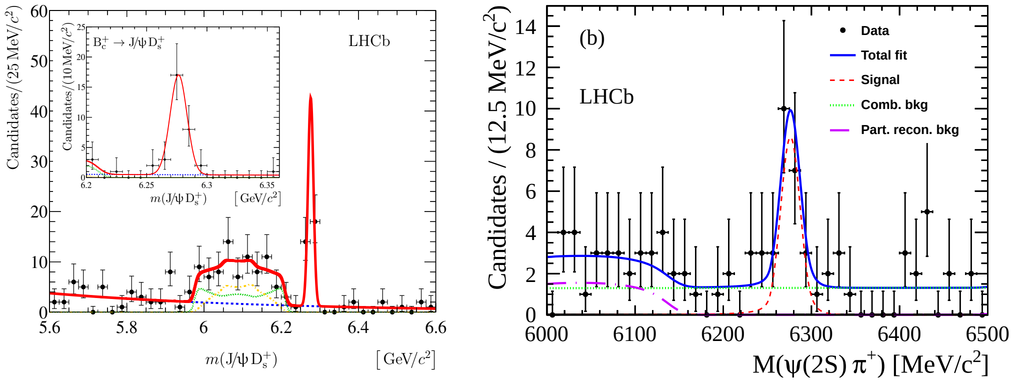

Figure 3: Signals of B_c^+ decays to (left) $J/\psi\, D_s^+$ [11] and (right) $\psi(2S)\pi^+$ [12].

$B^+ \to X(3872)K^+$, $X(3872) \to J/\psi\,\pi^+\pi^-$, $J/\psi \to \mu^+\mu^-$, LHCb has established that the quantum numbers are $J^{PC} = 1^{++}$ with significance corresponding to more than 8 standard deviations (σ), as shown in Fig. 2.

While providing crucial new information about, and favouring exotic explanations for, the $X(3872)$ state, the mystery is still not fully understood, and further investigations will be needed. One crucial question is to establish whether the mass is above, below or at the DD^* threshold. Previous measurements of the mass of the $X(3872)$ [9] have already reached sufficient precision that improved knowledge of the masses of the charmed mesons are necessary. With a detailed survey of momentum scale systematics, LHCb has been able to improve the measurements of these fundamental parameters [10]. The improvement in the knowledge of the D_s^+ meson mass is particularly significant. This comes at an opportune moment, since together with the observation of the decay $B_c^+ \to J/\psi\, D_s^+$ [11] (one of a number of recently discovered new B_c^+ decay modes [12,13], see Fig. 3) it enables a measurement of the B_c^+ meson mass with dramatically reduced systematic uncertainty compared to previous results.

There has also been notable progress in the understanding of mixing and *CP* violation in the charm sector. Evidence for charm oscillations had been reported by several previous experiments, but with no single measurement exceeding the $5\,\sigma$ threshold it was important to obtain definitive confirmation. This has now been provided by LHCb in a study of the decay time evolution of the wrong-sign to right-sign ratio of $D \to K^\mp\pi^\pm$ decays [14], which is inconsistent with the no-mixing hypothesis at the level of $9\,\sigma$ as shown in Fig. 4 (left). On the other hand, evidence for *CP* violation that had been previously reported by LHCb [15] and other experiments has not been confirmed (see Fig. 4 (right)). The previous result was in tension with the Standard Model prediction, and although not considered a clear signal of new phenomena had provoked much interest in the theoretical community [16]. New analyses based on the $1.0\,\mathrm{fb}^{-1}$ dataset collected in 2011 provide measurements that are consistent at the $2\,\sigma$ level, and indicate that the *CP* violation effect is smaller. The first [17] uses the same tagging technique as all previous measurements, in which the initial flavour of the D meson (D^0 or $\overline{D}^0$) is inferred from the charge of the

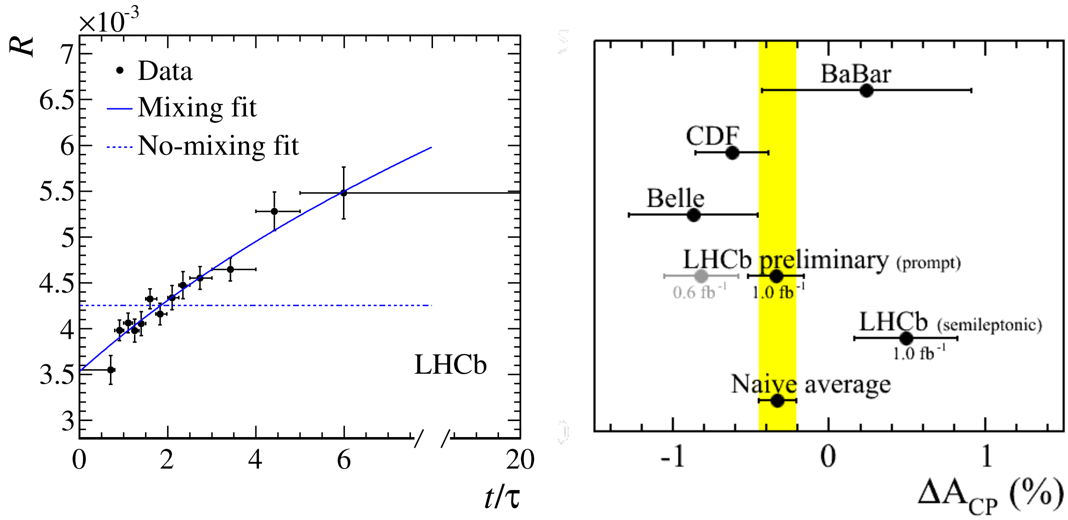

Figure 4: (Left) decay-time evolution of the ratio, R, of $D \to K^{\mp}\pi^{\pm}$ wrong-sign to right-sign yields (points) with the projection of the fits with mixing allowed (solid line) and no-mixing (dashed line) fits overlaid [14]. (Right) summary of the latest results on ΔA_{CP} [17, 18].

pion in the decay $D^{*+} \to D^0\pi^+$. The second [18] uses D mesons produced in semileptonic b-hadron decays, where the charge of the associated muon provides the tag. In addition, improved searches for CP violation in D^+ decays [19] remain consistent with zero. Further updates with the full LHCb data sample are keenly anticipated, though it should be noted that controlling all sources of systematic uncertainty to the level demanded by the statistics is a challenge that requires careful analysis.

New results on mixing and CP violation in the B^0_s sector have also been presented. The B^0_s oscillation effect can now be clearly observed in the data, as shown in Fig. 5 (left) [20], with the oscillation frequency being given by

$$\Delta m_s = 17.768 \pm 0.023\,(\mathrm{stat}) \pm 0.006\,(\mathrm{syst})\,\mathrm{ps}^{-1}\,.$$

This provides a benchmark measurement that can be used for searches for new phenomena in B^0_s oscillations, for example through CP violating observables. An updated measurement of the phase in $B^0_s \to J/\psi\,\phi$ and $B^0_s \to J/\psi\,\pi^+\pi^-$ decays [21] gives

$$\phi_s = 0.01 \pm 0.07\,(\mathrm{stat}) \pm 0.01\,(\mathrm{syst})\,\mathrm{rad}\,,$$

as shown in Fig. 5 (right), which is the most precise to date and illustrates sufficient control over systematic uncertainties that significant improvement can be anticipated with larger datasets. In addition, the first measurement of the equivalent parameter using the $b \to s$ flavour-changing neutral current decay $B^0_s \to \phi\phi$, which will be a key mode for the LHCb upgrade, has been performed [22].

Among rare processes, significantly improved limits in searches for charm decays to final states containing dimuons have been presented [23, 24]. A significant step forward

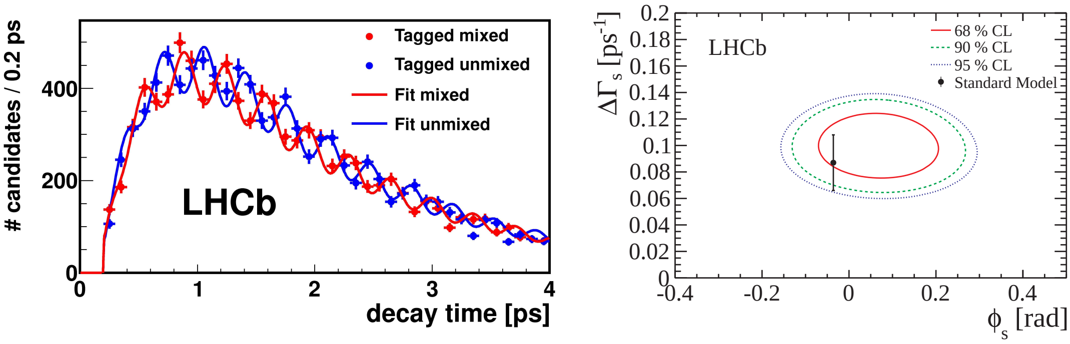

Figure 5: (Left) oscillations in the dataset of $B_s^0 \to D_s^- \pi^+$ decays used to measure Δm_s [20]. (Right) two-dimensional statistical profile likelihood in the $(\Delta\Gamma_s, \phi_s)$ plane for the $B_s^0 \to J/\psi\, K^+ K^-$ dataset [21]. The Standard Model expectation is shown as the black point.

in flavour physics has also been achieved with the first evidence for the $B_s^0 \to \mu^+\mu^-$ decay [25], shown in Fig. 6. This is one of the key channels to search for new phenomena at the LHC, due to the extreme suppression of the branching fraction in the Standard Model. Previous results from LHCb had ruled out large enhancements, but the latest analysis, which includes half of the data taken in 2012, is the first to be able to measure the branching fraction, finding a value

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \left(3.2\,^{+1.5}_{-1.2}\right) \times 10^{-9}\,,$$

where the uncertainty is dominated by the statistics. The result is consistent with the Standard Model at the current precision, and opens the door for more detailed studies of the decay in future.

5 Financial issues

The status of the accounts is healthy and there is no cash flow problem foreseen. For the 2012 M&O Cat. A budget the expenditures have generally respected our forecast. Year 2012 was our third full operations year, therefore "Detector related expenditures" and "General Services", as in the previous two years, have shown a little underspending. However, together with a few contingencies which caused an overspending, the total budget has shown good balance. In view of the long shutdown in 2013–14 and of the foreseeable important interventions on subdetectors and on general safety and infrastructure, LHCb has assessed in detail the expected M&O expenditures. Taking in account the Cat. A funds buffered in the previous years, we are confident to be able to satisfy our requirements during LS1 with essentially no budget increase.

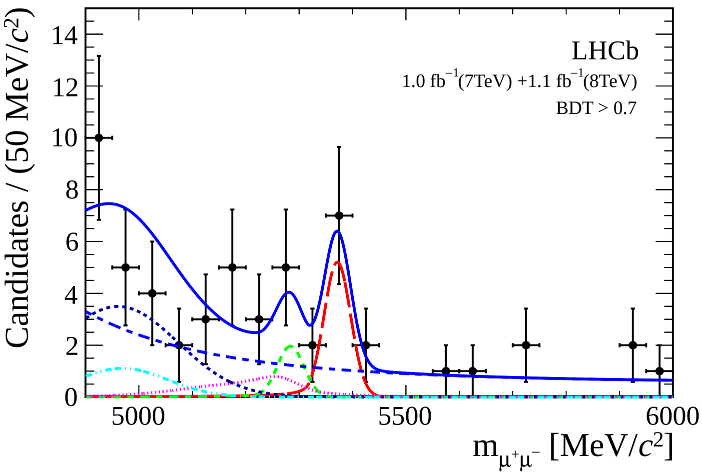

Figure 6: Invariant mass distribution of selected $B^0_{(s)} \to \mu^+\mu^-$ candidates in the combined 2011+2012 dataset. The result of the fit is overlaid (blue solid line), and the B^0_s (red long dashed) and B^0 (green medium dashed) signals shown together with the different background categories [25].

6 Collaboration matters

At the LHCb Collaboration Board meetings of November 2012 and February 2013, two new groups have been accepted as full members. The MIT group, led by Prof. Michael Williams (former member of LHCb at Imperial College) has interests in the area of studies of B decays and CP violation, of HLT trigger and tracking studies for the upgrade. The group has submitted a funding grant request to NSF in October 2012. The Cincinnati University group, led by Prof. Michael Sokoloff, has changed its status from associate member to full member. The Cincinnati group is active in the area of charm physics, of HLT trigger and of the Trigger Tracker upgrade.

In the same Collaboration Boards, two other groups have been accepted as associated members. The Celal Bayar University (Manisa, Turkey), led by Prof. Erhan Pesen, associated to CERN group, has shown interest in working on luminosity determination and in activities for the upgrade of the Trigger Tracker. The Groningen University, led by Prof. Gerco Onderwater, associated to NIKHEF group, has shown interest in working on HLT project and on use of GPU for the online farm. LHCb is currently composed of 63 institutes from 17 countries including 5 associated institutes. The Ukrainian institutes (KIPT-Kharkiv and KINR-Kiev) have signed the Memorandum of Understanding for Maintenance and Operation of the LHCb Detector (CERN-RRB-2002-032, Adds. 9 and 11).

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