Three experiments, among the LHC project, are getting ready to explore the b quark flavour sector. While ATLAS and CMS are general purpose experiments, where the study of B mesons is going to proceed in parallel with the Higgs boson and supersymmetry searches, the LHCb experiment is devoted to B physics studies. The key parameters entering the physics analyses and the performances achieved in all the three experiments are presented. Given the large B physics program foreseen in the LHC experiments, the studies reported in this paper have been selected as those with higher likelihood to provide solid and interesting new results on Standard Model validation and New Physics processes search with early data.

1. INTRODUCTION

In the context of the large effort performed within the LHC experiments in order to finalize the construction of the Standard Model (SM) and to shed some light on the building blocks of its future extension, the B physics program plays a very important role.

In a complementary way to the direct searches of Higgs boson(s) and new particles, the New Physics (NP) processes can be studied by making precision measurements in the flavour sector, where we do expect significant effects if the NP scale is not completely decoupled from the TeV energy range.

In this framework, the B meson system is a natural place where to look. The \( B_d \) mesons properties have already been studied in detail by the B-factories experiments (CLEO, BaBar, Belle) yielding and impressive agreement with the SM expectations. The properties of the \( B_s \) mesons, not available at \( e^+e^- \) colliders\(^1\), are much less constrained and there’s still room to account for significant contributions from NP effects. Moreover, the study of the B system with high statistics samples of different b hadrons can be used to further constrain the SM CP violation mechanism described by the Cabibbo-Kobayashi-Maskawa (CKM) matrix.

Three LHC experiments, LHCb \(^2\), ATLAS \(^3\) and CMS \(^4\), have defined a research program that includes the search of rare decays and NP signatures through precision measurements of the meson decays.

While LHCb \(^2\) is devoted and optimized for the measurement of the B meson properties, the other two are general purpose experiments where the study of B mesons proceeds in parallel with the Higgs boson and supersymmetry searches.

The doability of such B physics programs at the hadron machines is demonstrated by the recent results of Tevatron experiments (CDF, D0)\(^5\) with their nice measurements of \( \Delta m_s \) \(^6\) and \( \Delta \Gamma_s \) and \( \phi_s \) \(^7\).

The LHC environment, the expected resolutions of the various detectors and their triggering strategies are reviewed in section\(^2\) while section \(^3\) contains the detail description of the physics program and of the expected performances that can be achieved with the data samples collected during the first year of operation of LHC.

\[^{1}\text{The Belle experiment, since last year, started a physics program at the } \Upsilon(5S). \text{ The small statistics of } B_s \text{ mesons collected, will mainly be used to measure some absolute branching ratios.}\]
Figure 1: Production angle of B vs. angle of B in the laboratory (in units of rad.), calculated using PYTHIA. The peaks in the forward directions shows the correlation between their respective production directions.

Table I: Center of mass energy, cross sections, luminosity and number of interactions per crossing expected in the LHCb, ATLAS and CMS experiments.

| Parameter                | LHCb   | ATLAS, CMS |
|--------------------------|--------|------------|
| Energy (TeV)             | 14     | 14         |
| σ(pp) (mb)               | 100    | 100        |
| σ(bb) μb                 | 500    | 500        |
| Visible σ(bb) μb         | 230    | 100        |
| L (cm$^{-2}$ s$^{-1}$)   | 2·10$^{32}$ | 1·10$^{34}$ |
| #int/crossing            | 1      | 23         |

2. LHC DETECTORS FOR B PHYSICS

The parameters summarizing the LHC environment for B physics studies (center of mass energy, cross sections, luminosity) are reported in Table I for the LHCb, ATLAS and CMS experiments.

The very large cross section for $b\bar{b}$ production, yielding $O(10^4)$ $b\bar{b}$ pairs per second ($L = 10^{32}$ cm$^{-2}$ s$^{-1}$) with all the b-hadrons species being produced, extend down to $10^{-9}$ the Branching Ratio (BR) measurement capability for the rare B decays.

For this aim a huge effort is needed in order to reduce the large background coming from the pp interactions, whose production cross section is two orders of magnitude higher than the b quarks production one.

Attention should also be paid to the choice of running luminosity (L): while larger L provides larger data samples, the number of interactions per crossing increase rapidly with L, creating problems to the B hadron reconstruction and identification (see Table I).

The main difference in the visible cross section between the LHCb detector, a single arm forward spectrometer accepting events with $1.8<|\eta|<5$, and the ATLAS/CMS detectors, that are accepting events with $|\eta|<2.5$, comes from the lower $p_T$ threshold that can be achieved in the former. The production of $b\bar{b}$ pairs in LHC, according to PYTHIA simulations, occurs with the $b\bar{b}$ pairs highly collimated (as shown in Figure 1): this also favor the LHCb forward design with respect to the $4\pi$ design of the others two experiments.

The main experimental ingredients entering the B mesons decays study, like the tracking, particle identification and tagging performances and proper time measurements, are presented in detail in the next paragraphs, as well as the currently implemented trigger strategies.
Table II: Typical B mesons mass and proper time resolutions in the LHCb experiment. The last raw contains the value obtained for the \( B_s \) meson mass resolution after having applied a mass constraint on the \( J/\psi \).

| Parameter                      | Value       |
|--------------------------------|-------------|
| Proper time                    | 40 fs       |
| Mass (\( B_s \to \mu\mu \))   | 18 MeV/c\(^2\) |
| Mass (\( B_s \to D_s\pi \))   | 14 MeV/c\(^2\) |
| Mass (\( B_s \to J/\psi\phi \)) | 14 MeV/c\(^2\) |
| Mass (\( B_s \to J/\psi\phi \)) | 8 MeV/c\(^2\) |

2.1. Tracking

The track reconstruction performance is of primary importance in the various steps of the B meson decays analysis: the capability of triggering interesting events, the event selection and background suppression.

In the ATLAS and CMS detectors a large part of the B physics program is performed using channels involving muons, either as the particles triggering the acquisition (high \( p_T \) tracks) or in the final states (\( J/\psi \) decays). The high overall muon reconstruction efficiency (>98%, CMS) achieved is due to the good muon transverse momentum resolution (1–2\%) and impact parameter resolution (10 \( \mu m \)) in the trackers.

The LHCb detector is able to use kaons and pions in the trigger, in addition to the electrons and muons that are available also in ATLAS and CMS. The expected performances are: a relative momentum resolution in the range 0.3–0.5\% depending on the track momentum and a very high reconstruction efficiency (>95\%) for particles travelling in the whole detector with a small (<4\%) contamination of ghost tracks (having applied a \( p_T > 0.5 \text{ GeV/c} \) cut).

The track impact parameter resolution is \( \sim 30 \text{ \( \mu m \)} \) and the typical B meson mass resolution, obtained in some benchmark channels studying the reconstruction of fully simulated events, are given in Table II. Those values are remarkable when considering the very high charged particles multiplicity environment of the experiment: \( \sim 70 \) charged particles are expected for each \( b\bar{b} \) event at nominal luminosity (see Table I).

2.2. Particle Identification

While the ATLAS and CMS detectors are concentrating all the efforts on the analysis of B meson decays involving muons, the LHCb experiment is able to identify also kaons and pions by means of two Cerenkov detectors: the RICH1 and RICH2. The combined information coming from those two detectors is used to achieve a very good \( \pi,K \) separation in a wide kinematic range (2–100 GeV/c). The LHCb efficiency and misidentification distributions are shown in the left plot of Figure 2. These quantities will be calibrated with data using pions and kaons from the \( D^{*-+} \to D^0(K^-\pi^+)+\pi^+ \) decay (expected rate: 16 Hz), where a very pure sample of kaons and pions can be selected using only kinematic cuts.

The LHCb capability of identifying pions and kaons enhance the B physics program richness allowing the analysis of non leptonic channels, like the \( B \to hh \) or \( B \to \phi\phi \) ones. These channels can be used to improve the knowledge of the U spin symmetry breaking, to constrain the CKM angle \( \gamma \) (see par. 3.4) or to measure the CKM angle \( \phi_s \) (see par. 3.1).

The separation of the several contributions (\( \pi\pi, K\pi, KK \) channels) in the \( B \to hh \) analysis can be achieved in LHCb only thanks to the excellent particle identification (PID) performance: see for example the B\( \to hh \) mass spectra in the right up (down) plots of Figure 2 obtained before (after) the use of PID information for the selection of the \( B_s \to K\pi \) decay.

The muon identification in LHCb is provided by the muon system, achieving a very high reconstruction efficiency (\( \epsilon > 95\% \)) with a low misidentification (\( \leq 1\% \) for \( p>10 \text{ GeV/c} \)). These performances will be calibrated and measured on data using dedicated samples. The muon PID can use the generic \( \mu \) (50 Hz), prompt \( J/\Psi \) (2 Hz) and \( J/\Psi \) from B.
Figure 2: The efficiency (above 30%) and misidentification (below 30%) distributions for two different delta log likelihood cuts, $\Delta \ln L_{K\pi} > 0$ as shown with the dashed line and $\Delta \ln L_{K\pi} > 4$ shown with the open dots, in the kinematic range 0 to 100 GeV/c. Right: B to hh mass spectra before (left) and after (right) the use of particle ID information for the selection of the $B_s \to K \pi$ decay.

(0.03 Hz) events while the misidentification can be measured using $\Lambda$ decays that provide a clean sample of protons and pions using only kinematic constraints and the hadrons reconstructed in the $B \to hh$ decay chain (0.02 Hz).

2.3. Tagging

The tagging performances are determined using different strategies and algorithms exploiting the detector capabilities in the different experiments. These performances are expressed in terms of the effective tagging efficiency ($\epsilon_{eff}$) defined as $\epsilon_{eff} = \epsilon_{tag}(1 - \omega)^2$, where $\epsilon_{tag}$ is the tagging efficiency (probability that the tagging procedure gives an answer) and $\omega$ is the wrong tag fraction (probability for the answer to be incorrect when a tag is present).

The ATLAS experiment quotes an $\epsilon_{eff} = 4.6\%$ using the lepton and jet charge tagging algorithms on the opposite side candidates, while the CMS experiment is still developing the tagging strategy to assess the tagging performance. The LHCb experiment is also using the kaon tagging from the opposite side B and the pions ($B_d$) or kaons ($B_s$) taggers from the same side as the signal candidate, achieving an overall $\epsilon_{eff} = 6.6\%$. The tagging performances will be evaluated with data by using control channels like $B^+ \to D^0 \pi^+$. The LHCb experiment can use the $B_s \to D_s^+ \pi^- \pi^0$ decays to get a clean measurement of $\Delta m_s$ and of the $B_s$ oscillations, extracting the proper time resolution.
2.5. B Physics Triggers

In order to reduce the high rate of events coming from the pp collisions selecting only those that are likely to contain a B meson, dedicated trigger algorithms are needed. The three LHC experiments are using a similar approach: a first level trigger, hardware based, is used for the fast selection of high \( p_T \) events, while a second level trigger, software based, is used to reduce the event rate to an acceptable amount while keeping a maximum efficiency for signal events.

The ATLAS and CMS first level (L1) trigger has an output rate of <100 kHz and uses the information from the muon chambers and the calorimeters to select high \( p_T \) muons. The LHCb first level (L0) trigger has a 1 MHz output rate and uses the input from the muon system, the calorimeters and the pileup system in order to select hard, \( h, \mu, e, \gamma \) and \( \pi^0 \) over a minimum \( p_T \) threshold. The L0 trigger efficiency (\( \epsilon_{L0} \)) is >80\% for channels with \( J/\Psi \), while ~40\% for other hadronic channels.

The software trigger for the LHC experiments is executed after the full event readout. ATLAS and CMS experiments have an overall output rate of 200 Hz: only ~10\% of these events can be used for B physics studies. In addition, for the study of leptonic decays, \( O(1) \) kHz bandwidth of di-\( \mu \) events is available.

The LHCb High Level Trigger (HLT) has an output rate of 2 kHz. Starting from the L0 confirmation the trigger bandwidth is divided between inclusive and exclusive selections as follows: 200 Hz is the bandwidth allocated for the core B physics program (exclusive reconstruction), 600 Hz are devoted to the reconstruction of high mass dimuons events (allowing for an unbiased proper time selection of \( J/\Psi \) decays), 900 Hz are available for an inclusive B meson selection using semileptonic decays (\( B \to \mu \)) mainly devoted to data mining studies and the remaining 300 Hz will be used for the \( D^* \) reconstruction to be used for the particle ID calibration and charm studies.

3. B PHYSICS PROGRAM

The B physics program of the ATLAS, CMS and LHCb experiments covers several different areas: from the cross section to the leptonic decays studies, from the rare decays to the CP violation studies, from the NP searches to the Dalitz analysis and data mining.

All the studies reported here have been performed on events coming from the standard simulation, digitization and reconstruction experiments software. The statistics used to quote the results, unless specified otherwise, do refer to one fourth of a nominal year running: 2.5 fb\(^{-1}\) for ATLAS and CMS and 0.5 fb\(^{-1}\) for LHCb. These data samples will be likely available in 2009.

Only few topics have been chosen and will be reported here: the study of \( b \to s \) transitions in the \( B_s \to J/\Psi \phi \) channel, \( b \to s l l \) decays, the measurement of the \( B_s \to \mu \mu \) branching ratio, the measurement of the CKM angle \( \gamma \) and of the B production cross sections.

3.1. \( B_s \to J/\Psi \phi \)

The study of the \( B_s \to J/\Psi \phi \) decays can be used to measure the CKM angle \( \phi_s \), predicted to be very small by the SM:

\[
\phi_s[SM] = \arg(V_{ts}^2) = 2\lambda^2 \eta = 0.0368 \pm 0.0018
\]

and hence sensible to NP processes that could give measurable contributions.

From the experimental point of view this decay is particularly suited for the detection and reconstruction in all the LHC experiments, since it involves 2 muons from the \( J/\Psi \) decay, allowing an efficient trigger, and has an high predicted BR: \(~3\times10^{-5}\).

The value of \( \phi_s(-2\beta_s) \) can be extracted from the measurement of the time dependent CP asymmetries \( A_{CP}(t) \):

\[
A_{CP}(t) = \frac{-\eta_f \sin \beta_s \sin(\Delta m_s t)}{\cosh(\Delta \Gamma_s t/2) - \eta_f \cos \beta_s \sinh(\Delta \Gamma_s t/2)}
\]
Figure 3: Definition of angles $\theta, \theta_{tr}$ and $\phi_{tr}$, used in the three angle analysis of the $B_s \rightarrow J/\Psi \phi$ decay.

Table III: B mass resolutions, B/S ratios and number of selected events for the analysis of $B_s \rightarrow J/\Psi \phi$ events in the LHC experiments.

| Parameter                  | ATLAS | CMS  | LHCb |
|----------------------------|-------|------|------|
| $N_{rec}$                  | 23k   | 27k  | 33k  |
| $N_{eff-tag}$              | 1k    | -    | 2.2k |
| $\sigma_m$ [MeV/c$^2$]    | 16.5  | 14   | 14   |
| B/S                       | 0.18  | 0.25 | 0.12 |
| $\sigma(\phi_s)$         | 0.159 | -    | 0.042|
| $\sigma(\Delta \Gamma_s)/\Delta \Gamma_s$ | 0.41  | 0.13 | 0.12 |

where $\eta_f = 1(-1)$ for odd(even) CP states. Since the decay final state is not a pure CP eigenstate, an angular analysis is needed that involves the three angles $\theta, \theta_{tr}, \phi_{tr}$ defined as shown in Figure 3. Together with the angles, the measurement of the $B_s$ candidates mass, proper time and tagging informations are needed as input to the analysis.

The sensitivity to the $\phi_s$ angle heavily depends on the tagging performance (entering through the $\epsilon_{eff}$ term) and the proper time resolution: the different detectors performances have been already reported in paragraphs 2.3 and 2.4.

The specific cuts, used in the selections of the signal events, are described in 8. The number of reconstructed events is shown in the first row of Table III, while the number of the flavour tagged events is given in the second row.

The candidates have mass resolutions of $\sim 15$ MeV/c$^2$ with background over signal ratios (B/S) in the range 0.25–0.12 (see the third and fourth rows in Table III). It should be noted that the LHCb result is obtained without using the $J/\Psi$ mass constraint allowing a better background control.

The resolutions on $\phi_s$ and $\Delta \Gamma_s$, that can be achieved with data collected during 2009 are shown in the last two columns of Table III.

With the quoted values, LHCb is able to exclude/measure NP contributions to $\phi_s$ beyond the SM (see for example 3 for a discussion of the impact of LHCb measurement of $\phi_s$ in constraining NP contributions to $b \rightarrow s$ transitions). Further improvements could also come by adding other decay channels, like $J/\Psi q$, $q \phi$ or $D_s^+ D_s^-$, to the $\phi_s$ analysis. By 2013, ATLAS and CMS are expected to achieve the SM level sensitivity, while LHCb will test the SM prediction at the 5$\sigma$ level.
3.2. $B_s \to \mu\mu$

The $B_s \to \mu\mu$ decay is predicted in the SM to be very rare, since it involves flavour changing neutral currents and experiences a large helicity suppression ($\sim m_\mu/m_b$), with a BR at the level of $10^{-9}$.

Various attempts have already been made to measure the BR: the current experimental situation, concerning both $B_d$ and $B_s$ decays, is summarized in Figure 4 where the current best limits are coming from CDF \cite{10} (BR < $4.7 \times 10^{-8}$ @90\% CL) and D0 \cite{11} (BR < $7.5 \times 10^{-8}$ @90\% CL) measurements.

The study of this decay is of particular interest when probing NP models, like the MSSM, that allows for large modifications of the BR: the contribution of a $\tan^6\beta/M_A^4$ term, for example, can significantly enhance the measured value if the $\tan\beta$ value is large, as suggested by other experimental results like $b \to s\gamma$, $(g-2)_\mu$ and $B \to \tau\nu$.

The measurement of the $B_s \to \mu\mu$ BR can thus play a major role in constraining/measuring the NP contributions and even help selecting/ruling out a given theoretical model \cite{12}.

The analysis strategies pursued are different in LHCb \cite{13} and in ATLAS and CMS \cite{14}. In the LHCb approach the topological informations are used to build a geometrical likelihood for each event (GL). Then the three dimensional space built with the GL, mass and particle ID informations is divided for all the events in N bins. For each bin the expected number of events for the signal and for the signal plus background hypothesis are computed and used to place a limit (or evaluate the measurement sensitivity) on the BR.

The ATLAS and CMS experiments are instead using a cut and counting approach. The geometrical and particle ID informations are used to select the events by applying cuts. The mass distribution is then used to count the events: CMS opens a $\pm 2.3 \sigma$ window, while ATLAS performs a bayesian number of events estimate.
Figure 5: Left: BR($B_s^0 \rightarrow \mu^+\mu^-$) excluded at 90% CL as a function of the integrated luminosity (L) if no signal is present. Right: Luminosity needed for the observation of a given BR at 3σ (grey circles) and 5σ (black stars) level.

The normalization channel used in the BR measurement is the $B^+ \rightarrow J/\Psi K^+$: one million of such events is expected for each fb$^{-1}$ of data in all the LHC experiments. The LHCb experiment also foresees the use of $B \rightarrow hh$ decays as a control channel, while the background will be extracted from the side bands.

The expected number of events after a nominal year of running (2 fb$^{-1}$ LHCb, 10 fb$^{-1}$ ATLAS and CMS) is quoted in the second and third rows of Table IV. The sensitivities of LHCb as a function of the integrated luminosity are given in Figure 5 while the ATLAS result is shown in Figure 6.

The LHCb experiment has the potential of measuring a BR of $9(15) \times 10^{-9}$ at 3(5)σ level with 0.1 fb$^{-1}$ of data and $5(9) \times 10^{-9}$ with 0.5 fb$^{-1}$. The SM BR can be assessed with a 3(5)σ evidence(observation) with 2(6) fb$^{-1}$.

The ATLAS and CMS experiments, when properly rescaling the integrated luminosity, are contributing with comparable performances.

3.3. $b \rightarrow s ll$ decays

The study of exclusive $b \rightarrow s ll$ decays is another way to look for NP effects in $b \rightarrow s$ transitions at a hadron collider: the leptons in the decay provide an efficient trigger while the exclusive reconstruction reduce the background.

Figure 6: ATLAS perspective for measuring the $B_s^0 \rightarrow \mu^+\mu^-$ branching ratio as a function of the time (integrated luminosity).
Table V: Expected event yields and inclusive $b\bar{b}$ over signal events ratio for several B to D decays studied in LHCb.

| Decay mode                                      | Event yield | $B_{bb}/S$ |
|------------------------------------------------|-------------|------------|
| $B^{-,+} \to D(K\pi)K^{-,+}$ favoured          | 28k         | 0.6        |
| $B^{-,+} \to D(K\pi\pi)K^{-,+}$ favoured       | 28k         | 0.6        |
| $B^{-,+} \to D(K\pi)K^{-,+}$ supp.              | 100         | >2         |
| $B^{-,+} \to D(K\pi\pi)K^{-,+}$ supp.           | 200         | >2         |
| $B^{-,+} \to D(hh)K^{-,+}$                       | 4k          | 2          |
| $B_{s}^{-,+} \to D_{s}K^{-,+}$                   | 6.2k        | 0.2        |

contribution.

These semileptonic decays proceed through suppressed loops in SM and thus are sensitive to NP contributions, that can be of SM size, affecting the BR and the angular distributions.

Accurate SM predictions can be obtained for some specific observables, like the Forward-Backward asymmetry ($A_{FB}$), the invariant $\mu\mu$ mass ($q^2$) value where $A_{FB}$ reach its zero value ($s_0$), the transversal asymmetries and the ratio of BR for $ee$ and $\mu\mu$ decay modes, where it is possible to obtain

As an example, for the $B \to K^{*}\ell\ell$ decay channel, the SM predictions [15] are: $\text{BR}(B_d \to K^{*}\mu\mu) = (1.22^{+0.38}_{-0.32}) \times 10^{-6}$ and zero crossing of $A_{FB}$

$$s_0 = s_0(C_7,C_9) = 4.39^{+0.35}_{-0.35} \text{GeV}^2$$

In the LHCb experiment a selection yielding a $B_{bb}/S$ of 0.2±0.1 has been developed: 1.8 k events are expected in 0.5 fb$^{-1}$, to be compared with the 450 events expected from the B factories with a 2 ab$^{-1}$ integrated luminosity. With 2 fb$^{-1}$ the sensitivity on $s_0$ is 0.46 GeV$^2$, while with 10 fb$^{-1}$ the present theoretical precision (0.27 GeV$^2$) is reached.

The ATLAS experiment expect $\sim$3 k events with 30 fb$^{-1}$, achieving a $\sim$4% statistical error on the $A_{FB}$ distribution in $q^2$ bins. The CMS studies have just started.

3.4. CKM $\gamma$ angle

The measurement of the CKM angle $\gamma$ trough the analysis of hadronic decays, like $B \to DX$ or $B \to hh$, is only feasible and addressed so far in the LHCb experiment, the reason being the need of kaon and pion identification that is not available in ATLAS and CMS.

The selection of several decay modes has been studied in detail: the modes under study, together with their expected number of events (in 2 fb$^{-1}$ integrated luminosity) and inclusive $b\bar{b}$ background over signal ($B_{bb}/S$) ratios are given in Table V.

Several strategies can be pursued in order to measure $\gamma$. The analysis of $B \to DK$ channels, through the ADS or GLW and GGSZ approaches uses the large statistics that can be collected at the cost of a dependence on the D strong phases affecting the sensitivity. The study of the less abundant $B_s \to D_s K$ decay mode yields instead a clean extraction of $\gamma$ from the interference of $b \to u$ and $b \to c$ transitions in the $B_s$ mixing. Other Dalitz and 4 body decay analyses can be pursued as well, yielding the expected resolutions quoted in Table VI.

3.5. Cross section for $b\bar{b}$ production

The current prediction of $\sigma(b\bar{b}) \sim 500 \mu b$ comes from the extrapolations of Tevatron results: a precise measurement of such cross section is of major importance in order to test the MC simulations, the NLO QCD calculations used for the extrapolations and the Parton Density Functions (PDF) knowledge. For the rare decays, NP and new particle searches the knowledge of $\sigma(b\bar{b})$ is also important to achieve a good estimate of the background level.
Table VI: Expected precision on the CKM angle $\gamma$ for several B to D decays studied in LHCb. The B and D decay modes and the analysis method are shown for each decay in the first three columns.

| B Decay mode | D decay mode | Method | $\sigma(\gamma)$ |
|---------------|--------------|--------|-----------------|
| $B_s \rightarrow D_s K$ | KK$\pi$ | tagged, A(t) | 10° |
| $B^+ \rightarrow D^+ K$ | $K\pi + K\pi + K\pi/\pi\pi$ | counting, ADS,GLW | 5–13° |
| $B^+ \rightarrow D^* K$ | $K\pi$ | counting, ADS,GLW | Under study |
| $B^+ \rightarrow D K$ | $K_s\pi\pi$ | Dalitz, GGSZ | 7–12° |
| $B^+ \rightarrow D K$ | $K\pi\pi$ | 4 body Dalitz, GGSZ | 18° |
| $B^+ \rightarrow D K$ | $K\pi\pi$ | 4 body Dalitz, GGSZ | Under study |
| $B^0 \rightarrow D K^{*0}$ | $K\pi + K\pi + \pi\pi$ | counting, ADS+GLW | 9° |

Inclusive and exclusive strategies can be used to measure the cross section. All the LHC experiments plan to use $J/\Psi$ events to measure the production rate: the muons in the decay ensure an high efficiency in triggering and reconstructing those channels. In ATLAS and CMS experiments an additional requirement on the transverse energy ($E_T$) is used in order to enhance the b quark component in the data sample.

The statistical error that can be achieved is $\sim 1\%$, already with small data samples ($L \sim O(10) pb^{-1}$). More detailed analyses, aiming at a full $p_T$ scan, achieving a resolution of $\sim 10\%$ in all bins, have been performed in CMS assuming $L \sim 10 fb^{-1}$.

4. CONCLUSIONS

The LHC program is proceeding without major delays: first beam is expected in September and the first collisions soon afterwards. There are currently three experiments getting ready for the B physics challenge: with the expected performance they will be able to test SM and beyond SM (NP) effects.

The first analysis approach reported here is related to the $b \rightarrow s$ observables, that can cleanly reveal some NP effects. A first goal of the LHC experiments is the measurement of the $B_s \rightarrow \mu\mu$ BR down to its current SM prediction and of the $\phi_s$ angle with a 0.04 absolute precision. These goals can be achieved with data collected during 2009.

The analysis of $b \rightarrow sll$ decays is also presented: with few years of data taking the measurements precision will reach the level of present theoretical uncertainty.

The LHCb detector will also address the study of $B \rightarrow DK$ and $B \rightarrow hh$ decay modes that can be used to reduce the CKM $\gamma$ angle uncertainty down to 10°, with data collected during 2009.

The measurement of $b \bar{b}$ production cross section within few %, with early data, and the full $p_T$ scan (@ 10% level), with few years of data taking, can also be achieved.

The LHC experiments, whose B physics program highlights have been reported here, are ready to provide new measurements that will enrich the LHC program by exploring a new whole experimental region in the b quark phenomenology.

Acknowledgments

The author wish to thank A. Policicchio (ATLAS) and U. Langenegger (CMS) for their help in preparing these proceedings.
References

[1] L. Evans and P. Bryant, “LHC Machine”, 2008, JINST, 3 S08001, available at [http://www.iop.org/EJ/journal/1748-0221](http://www.iop.org/EJ/journal/1748-0221)

[2] The LHCb Collaboration, “The LHCb Detector at LHC”, 2008, JINST, 3 S08005, available at [http://www.iop.org/EJ/journal/1748-0221](http://www.iop.org/EJ/journal/1748-0221)

[3] The ATLAS Collaboration, “The ATLAS Experiment at the CERN Large Hadron Collider”, 2008 JINST 3 S08003, available at [http://www.iop.org/EJ/journal/1748-0221](http://www.iop.org/EJ/journal/1748-0221)

[4] The CMS Collaboration, “The CMS experiment at the CERN LHC”, 2008 JINST 3 S08004, available at [http://www.iop.org/EJ/journal/1748-0221](http://www.iop.org/EJ/journal/1748-0221)

[5] CDF Collaboration, D. Acosta et al, Phys. Rev. D 71, 032001 (2005), D0 Collaboration, V.M. Abazov et al, Nucl. Instrum. Methods A 565, 463 (2006).

[6] A. Abulencia et al., Phys. Rev. Lett. 97, 242003 (2006)

[7] The CDF Collaboration, “First Flavor Tagged Determination of Bounds on Mixing Induced CP Violation in $B_s \to J/\psi \phi$ Decays”, [http://arxiv.org/abs/0712.2397v1](http://arxiv.org/abs/0712.2397v1)

[8] P. Clarke, C. McLean, A. Osorio-Oliveros, “Sensitivity studies to $\beta_s$ and $\Delta \Gamma_s$ using the full $B_s \to J\Psi \phi$ angular analysis at the LHCb”, CERN-LHCb-2007-101

[9] Z. Ligeti et al., “Implications of the measurement of the $B_s^0 - \bar{B}_s^0$ mass difference”, Phys. Rev. Lett. 97, 101801 (2006)

[10] The CDF Collaboration, “Search for $B_s \to \mu^+\mu^-$ and $B_d \to \mu^+\mu^-$ Decays with 2fb$^{-1}$ of ppbar Collisions”, [http://arxiv.org/abs/0712.1708v1](http://arxiv.org/abs/0712.1708v1)

[11] F. Scuri [CDF Collaboration and D0 Collaborations], “Measurements of B rare decays at the Tevatron,” [arXiv:0705.3004](http://arxiv.org/abs/0705.3004) [hep-ex].

[12] G. Isidori e P. Paradisi, Phys Lett. B 639, 499 (2006)

[13] D. Martinez Santos, “$B_s^0 \to \mu^+\mu^-$ in LHCb”, CERN-LHCB-2008-018

[14] A. Policicchio and G. Crosetti, “Study of DiMuon Rare Beauty Decays with ATLAS and CMS”, Eur. Phys. J. C 55, 173-176 (2008) DOI: 10.1140/epjc/s10052-008-0594-6

[15] M. Beneke et al., “Exclusive radiative and electroweak $b \to d$ and $b \to s$ penguin decays at NLO”, arXiv:0412400 [hep-ph]

[16] D. Atwood, I. Dunietz, A. Soni, Phys. Rev. Lett. 78, 3257 (1997) and and Phys. Rev. D 63, 036005 (2001); M. Gronau and D. Wyler, Phys. Lett. B 265, 172 (1991); M. Gronau and D. London, Phys. Lett. B 253, 483 (1991); A. Giri, Yu. Grossman, A. Soffer and J. Zupan, Phys. Rev. D 68, 054018 (2003).