ATLAS *B*-physics performance update

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Abstract. An update of the *B*-physics performance of the ATLAS experiment is presented. After a short review of *B* production and decays at LHC, the main features of the ATLAS detector are described, and the present construction status is shown. Physics topics which are presented are: precision measurements, rare decays, and *B* production. It is shown that despite of recent changes in the trigger strategy and initial detector layout, ATLAS retains an excellent potential for measurements of $\sin(2\beta)$ and rare dimuon decays. A large spectrum of *B*-physics studies is also feasible - here we present examples of precision measurements with B_s mesons, B_c mesons, and *B* production.

1. INTRODUCTION

1.1. *B* production and decays at the LHC

The Large Hadron Collider, LHC, is a proton-proton collider designed to operate at a center-of-mass energy of 14 TeV and at high luminosity, starting in the second half of 2007. The high collision energy and luminosity of LHC gives the possibility of exploring a new high-energy frontier at the TeV scale. The design luminosity of the LHC is $L = 1 \times 10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. The initial luminosity, however, will be $L = 2 \times 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$, and it is this initial running period which is most feasible for *B* physics studies in view of trigger rates, pile-up, event reconstruction, *etc.* Some parts of the *B*-physics programme can be continued even at the design luminosity, such as rare *B* decays to dimuons.

The LHC allows for high-precision measurements of *B* hadrons, in particular of the B_s, B_c, and *B*-baryons. LHC is thus complementary to the present asymmetric e^+e^- *B* factories. The statistics at LHC will be much larger than at the Tevatron, which gives the possibility for testing the origin of *CP* violation by overconstraining the Unitarity Triangle and searching for rare decays mediated by loop diagrams in the Standard Model. This gives the possibility to observe deviations from the Standard Model and to disentangle any new physics components from the Standard Model ones.

For the proton-proton operation of LHC, there will be two general-purpose experiments, ATLAS and CMS, and an experiment designed for *B* physics, LHCb, operating at a reduced luminosity $L = 2 \times 10^{32}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. The general-purpose experiments are, however, in many ways complementary to LHCb for *B*-physics studies. ATLAS/CMS cover the central rapidity region while LHCb is a forward spectrometer. ATLAS/CMS triggers are based on lepton signatures while the LHCb trigger is a mixture of lepton and hadron triggers. Hadron triggers make it possible for LHCb to collect a large sample of purely hadronic decays, but the advantage of the lepton triggers is a clean sample and the possibility to continue data-taking even at the highest LHC luminosity.

The total cross-section at the LHC is about 100 mb, and the total $b\overline{b}$ cross-section is about 500 μb. The $b\overline{b}$ cross-section is about $100\,\mu$b within the ATLAS (CMS) acceptance (requiring that at least one of the *b*-quarks has $|\eta(b)|<2.5$ and $p_T(b) > 10\,\mathrm{GeV}$)[1]. The sample sizes for a year of operation are comparable in ATLAS (CMS) and LHCb, the difference being that the data samples of the general-purpose detectors are dominated by dimuon events, while about half of the LHCb event sample is collected with the hadronic trigger.

1.2. The ATLAS detector

1.2.1. Overview

The ATLAS experiment has been designed to maximise the discovery potential for new physics and to have the capability of high-accuracy measurements. ATLAS accommodates, nevertheless, features which make it possible to incorporate an ambitious *B*-physics programme in particular in the first years of running during the lower

[1] η is pseudorapidity, and p_T is transverse momentum with respect to the beam direction.

luminosity operation. For a full review of the ATLAS detector and physics performance, see Refs. [1, 2].

ATLAS has a tracking system covering the pseudorapidity range $|\eta| < 2.5$. The tracking system comprises pixel and silicon strip detector layers, and a transition radiation tracker (TRT). The pixel layer closest to the beampipe provides high-accuracy measurements of the primary and secondary vertices. Electrons can be identified for transverse momenta down to 0.5 GeV by using the e/π separation provided by the TRT. For more details on the tracking system, see Ref. [3]. The LAr electromagnetic calorimeters can be used for electron and photon identification and measurements starting from about $E_T = 2\,\mathrm{GeV}$. High-precision muon momentum measurements are achieved by combining information from the muon spectrometer and the inner tracking system. The muon system is embedded in an air-core toroid magnet, while the inner detector is surrounded by a smaller central solenoid, providing a 2 T magnetic field.

ATLAS has a flexible and efficient multi-level trigger system. The system consists of three levels, reducing the trigger rates from 40 MHz to $\mathcal{O}(200)$ Hz. The multi-level scheme allows for selecting events with multiple trigger objects with low p_T or E_T-thresholds. This is particularly crucial for the *B*-physics programme, where a significant reduction of the event rate has to be achieved on-line, due to the large total cross-section and high luminosity.

1.2.2. Construction status

All subdetector parts of ATLAS are under construction. Installation activities in LHC Point 1 have started: parts of the underground cavern (UX15) were delivered to ATLAS in April 03, and the cavern hand-over to ATLAS took place in May 03. The barrel calorimeter system is the first one to be installed in the cavern. The installation will start in March 04, and the foreseen mechanical completion date is November 04. The installation schedule thereafter is: barrel toroid 06/04 - 03/05, end-cap calorimeters and barrel muon detectors 03/05 - 04/06, end-cap large muon detectors 09/05 - 03/06, inner detector 10/05 - 06/06, end-cap toroids 01/06 - 07/06, and end-cap small muon detectors 04-05/06. The final work in the cavern will take place June-August 06, and the global commissioning of ATLAS is foreseen to take 60 days from August to October 06. 30 days are reserved for cosmic tests between November and December 06 [2]. The construction status in the cavern in December 03 is shown in Fig. 1.

[2] The schedule is obtained from M. Kotamäki, ATLAS Schedule and Milestones Manager, private communication.

FIGURE 1. Construction status in the ATLAS cavern in December 9, 2003.

1.2.3. Initial detector and recent design changes

Some parts of ATLAS subdetectors are foreseen to be installed at a later stage: the middle pixel barrel layer, the second layer of end-cap pixel disks, and the TRT C-wheels (the most outward wheels at $|z| = 2818$-3363 mm). Compared to the full detector, the effect on the proper-time resolution of *B*-decays is small, since the closest layer will have the largest significance for the proper-time resolution. Furthermore, the fact that there are fewer measurement points is compensated by the reduced amount of material. The mass resolutions are not affected by the staging. It should be pointed out, however, that there are other factors which have deteriorated the proper-time resolution compared to what was presented in the ATLAS Physics Technical Design Report in 1999 [1, 2]. The closest pixel layer is now located at an average radius of 5.5 cm instead of 4.3 cm, the material in the beam pipe has increased, and the pixel length in z will be $400\,\mu$m instead of $300\,\mu$m. We are in the process of evaluating the effects of the worse proper-time resolution and re-optimizing the cuts for the Δm_s measurement.

The *B*-physics trigger strategy has recently been revised due to changes in the planning for the LHC initial luminosity, staging of some subdetector parts, and tight funding constraints. The trigger scenario which we assumed in previous studies was based on a single muon trigger at level-1, with $p_T > 6\,\mathrm{GeV}$ and $|\eta| < 2.4$, followed by muon confirmation at the level-2 and a track search over the whole inner detector.

The new trigger scenario is based on multi-object triggers. The level-1 *B*-physics trigger has to consist of at least two muons (dimuon trigger), a muon and a low-E_T jet (muon-jet trigger), or a muon and a low-E_T electromagnetic cluster (muon-electron trigger). The trigger is foreseen to be flexible so that the baseline is the dimuon trigger at the nominal initial luminosity, and further triggers are added and/or thresholds are lowered later in the beam-coast or for lower luminosity fills. The new level-2 B-physics trigger strategy is based on a track search within a Region of Interest given by the level-1 calorimeter trigger object (electron or jet), instead of the full scan of the inner detector. Results are promising so far, and a strong reduction in processing requirements compared to the previous scenario can be achieved at the expense of some loss in efficiency. For more details see Ref. [4].

2. PRECISION MEASUREMENTS

2.1. Angles of the Unitarity Triangle

When neutral B and $\bar{B}$ mesons decay into the same final *CP* eigenstate, *CP* violation can in general have contributions both from direct *CP* violation and from interference between direct and mixed decays. In this case, the time-dependent *CP* asymmetry can be expressed as follows:

$$\begin{aligned} a_{CP}(t) &= \frac{\Gamma(B_q^0(t) \to f) - \Gamma(\bar{B}_q^0(t) \to f)}{\Gamma(B_q^0(t) \to f) + \Gamma(\bar{B}_q^0(t) \to f)} \\ &= A_{CP}^{dir}(B_q^0 \to f)\cos(\Delta m_q t) \\ &+ A_{CP}^{int}(B_q^0 \to f)\sin(\Delta m_q t), \end{aligned} \quad (1)$$

where A_{CP}^{dir} is the direct *CP*-violation amplitude and A_{CP}^{int} is the mixing-induced *CP*-violation amplitude. Subscript q indicates a d- or an s-quark, and Δm_q is the mass difference of the B_q^0 eigenstates. Here it is assumed that there is no width difference of the B_q^0 eigenstates, which is valid for B_d mesons. For B_s however, the width difference can be sizeable, 15% or so, and the formula has to be modified accordingly.

If the decay of a neutral B meson is dominated by a single CKM amplitude, the mixing-induced *CP*-violation amplitude is $A_{CP}^{int} = \Lambda \sin(\phi_M - \phi_D)$. The mixing phase ϕ_M is $+2\beta$ in case of B_d mesons and $-2\delta\gamma$ for B_s mesons, and Λ is the *CP* eigenvalue of the final state. The *CP*-violating weak decay phase ϕ_D is zero for dominant $\bar{b} \to \bar{c}c\bar{s}(\bar{d})$ amplitudes, and -2γ for dominant $\bar{b} \to \bar{u}u\bar{d}(\bar{s})$ amplitudes.

The angle β can be measured cleanly using the decays $B_d \to J/\psi K_S^0$. This decay is dominated by the decay amplitude $\bar{b} \to \bar{c}c\bar{s}$, since the penguins are expected to be small and moreover, they have the same weak phase as the tree-level decays. Therefore, the direct *CP*-violation contribution is very small and can be neglected, *i.e.* $A_{CP}^{dir} \simeq 0$, and the mixing-induced *CP*-violation amplitude is $A_{CP}^{int} = -\sin(2\beta)$.

ATLAS will be able to make a very precise measurement of the *CP*-violation parameter $\sin(2\beta)$. The event samples are:

- $B_d \to J/\psi K_S^0 + \bar{B} \to X,\ J/\psi \to \mu^+\mu^-,\ p_T(\mu_1) > 5\,\text{GeV},\ p_T(\mu_2) > 6\,\text{GeV}$,
- $B_d \to J/\psi K_S^0 + \bar{B} \to \mu X,\ J/\psi \to e^+e^-,\ p_T(e) > 1\,\text{GeV}, p_T(\mu) > 6\,\text{GeV}$.

In our study of this channel, the K_S^0 was required to decay into charged pions. The tagging methods used were same-side jet-charge tagging and lepton (electron and muon) tagging for the dimuon sample, and muon tagging for the dielectron sample (a muon is always included in the triggered data sample).

The sensitivity of the $\sin(2\beta)$ measurement was estimated with a maximum likelihood fit. The detector performance parameters were first determined from a full detector simulation and reconstruction of the signal events and the background. The time resolution function was approximated with a Gaussian with a width $\sigma = 69\,\text{fs}$, and the wrong-tag fractions were assumed to be $w = 0.24$ for the lepton tags, and $w = 0.41$ for the jet-charge tags. The decay-time distributionof the background was determined from the simulation and parametrised as $C\exp(-\Gamma_0 t)$, where C is the level of the background and Γ_0 is the average decay rate. The direct *CP* violation term A_{CP}^{dir} was assumed to be zero. The parameter $\sin(2\beta)$ was thus the only free parameter in the fit. More details of the likelihood fit can be found in Ref. [5].

The expected event yields and the sensitivities to $\sin(2\beta)$ are summarized in Table 1. Results are given both for the new trigger scheme, assuming only a dimuon trigger with p_T thresholds of 5 GeV and 6 GeV for the muons, and the old full trigger scheme, with lower dimuon trigger thresholds (3 GeV and 6 GeV) combined with the dielectron sample which has been triggered at level-1 with a single muon. The new trigger scheme is able to collect dielectrons with a single muon, but the efficiency will be lower than in case of the old trigger scheme. The trigger efficiency for the dielectron sample is still under study. The sensitivity to $\sin(2\beta)$ with the new trigger scheme, assuming conservatively that only the dimuon sample is available, is 0.016, while the sensitivity with the old full trigger is 0.010. The systematic uncertainty was estimated to be 0.005.

The angle α can be measured with the decay $B_d \to \pi^+\pi^-$. This decay has, however, contributions from both penguin and tree decay graphs. Including the penguin contributions the *CP*-violation amplitudes are: $A_{CP}^{dir} = 2\frac{A_P}{A_T}\sin(\delta)\sin(\alpha)$ and

TABLE 1. ATLAS statistical sensitivity to $\sin(2\beta)$ with $30\,\mathrm{fb}^{-1}$. Here $\mu 6 = (p_T(\mu) > 6\,\mathrm{GeV}), \mu 5 = (p_T(\mu) > 5\,\mathrm{GeV}), \mu 3 = (p_T(\mu) > 3\,\mathrm{GeV}), e1 = (p_T(e) > 1\,\mathrm{GeV})$.

	$J/\psi\,(\mu 6\mu 5)$	$J/\psi\,(\mu 6\mu 3)$	$J/\psi\,(e1e1)$
Number of reconstructed events	250 000	490 000	15 000
Signal/background ratio	32	28	16
$\delta\sin(2\beta)$, lepton tag	0.030	0.023	0.018
$\delta\sin(2\beta)$, jet-charge tag	0.019	0.015	-
$\delta\sin(2\beta)$, combined tags	0.016	0.013	0.018
$\delta\sin(2\beta)$(stat.), combined results	0.016	0.010	

$A_{CP}^{int} = -\sin(2\alpha) - 2\frac{A_P}{A_T}\cos(\delta)\cos(2\alpha)\sin(\alpha)$, where A_P/A_T is the ratio of the penguin and tree amplitudes, and δ is the strong phase difference between the amplitudes. If the ratio A_P/A_T can be predicted accurately with the help of additional branching ratio measurements, α and δ can be extracted from the measured asymmetry.

Other two-body final states $B_{d,s}(\Lambda_b) \to h^+h^-$ make it difficult to obtain a clean signal without charged-hadron identification. ATLAS can use a maximum likelihood fit to extract the *CP* asymmetry parameters A_{CP}^{dir} and A_{CP}^{int} for all the decay modes (both signal and backgrounds) together with the ratio A_P/A_T and the strong phase δ. The precision on A_{CP}^{int} does not depend on the actual values of α, A_P/A_T and δ, but the resulting sensitivities on α and γ do. Due to changes in the trigger, particle identification and decay-time resolution, the old results in Ref. [2] are largely obsolete by now. A new analysis is in progress. It can be expected that ATLAS alone will not have a good sensitivity in this channel, but can contribute to the overall LHC combined measurement.

2.2. B_s decays

ATLAS can perform precise measurements of the parameters of the $B_s - \bar{B}_s$ system: the width Γ_s, the width difference $\Delta\Gamma_s$ and the mass difference Δm_s of the mass eigenstates. The experimental determination of these parameters will be valuable input for determining parameters of the CKM matrix: the ratio $\Delta m_s/\Delta m_d$ is related to $|V_{ts}/V_{td}|^2$. ATLAS can also probe the B_s mixing phase $\phi_{\mathrm{M}} = -2\delta\gamma = -2\lambda^2\eta$. In the Standard Model, this phase is expected to be negligibly small (0.024-0.054 radians, see Ref. [6]), so a measurable effect would be a sign of physics beyond the Standard Model.

The parameter Δm_s will be measured from flavour-specific final states $B_s \to D_s\pi$ and $B_s \to D_s a_1$. Already with an integrated luminosity of $10\,\mathrm{fb}^{-1}$ the sensitivity of the Δm_s measurement will reach $36\,\mathrm{ps}^{-1}$, covering fully the Standard Model allowed range ($14.3\,\mathrm{ps}^{-1}$ to $26\,\mathrm{ps}^{-1}$) [7]. The measurement reach is shown in Fig. 2.

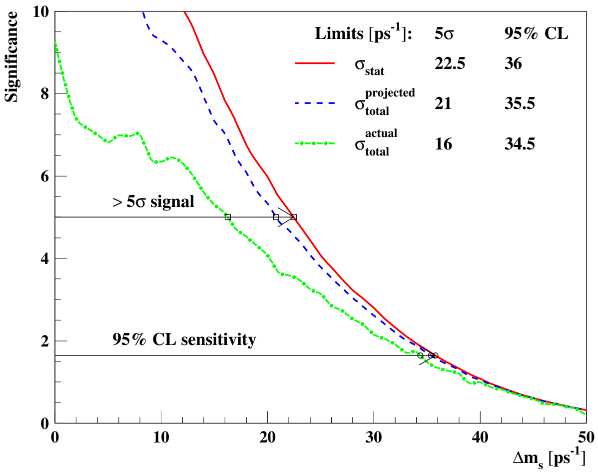

FIGURE 2. The significance of the oscillation signal versus Δm_s for $10\,\mathrm{fb}^{-1}$. The solid line shows the significance including only statistical errors, the dotted line the significance including also systematic errors (present-day knowledge), and the dashed line including projected systematic errors (systematic errors as we expect them to be at the time of the LHC start-up, see [7]).

The parameters $\Delta\Gamma_s$, Γ_s and ϕ_{M} can be determined by angular analyses of the final state $B_s \to J/\psi\,\phi$. The parameter $\Delta\Gamma_s$ can be determined with a relative error of 12% (stat) with $30\,\mathrm{fb}^{-1}$. The sensitivity to ϕ_{M} depends on the actual value of the mixing parameter Δm_s. For Δm_s in the range (14-27)$\,\mathrm{ps}^{-1}$, the sensitivity achieved with the analysis of the decay mode $B_s \to J/\psi\,\phi$ is between 0.08 and 0.15 radians.

The decay mode $B_s \to J/\psi\,\eta$ is analogous to the mode $B_s \to J/\psi\,\phi$, and it can thus be used as a cross-check for measurements of Γ_s and ϕ_{M}. Since the final state $J/\psi\,\eta$ is a *CP* eigenstate, an angular analysis is not needed. The reconstruction is, however, hampered by the small expected branching fraction and the low efficiency of η reconstruction. In ATLAS, about 10 000 signal events can be reconstructed with an integrated luminosity of $30\,\mathrm{fb}^{-1}$, with a signal-to-background ratio of about 1:1 [8]. ATLAS can thus measure the branching fraction of this decay mode, and contribute to the lifetime measurement of the B_s (Γ_s). The sensitivity to the weak mixing phase $\phi_{\rm M}$ is in the range 0.27-0.31 radians for $\Delta m_s = (14-21)\,{\rm ps}^{-1}$.

2.3. B_c properties

The expected large production rates at the LHC will allow for precision measurements of the properties of the B_c mesons, such as mass, lifetime, production mechanism, decay properties, *etc.* The B_c meson is particularly interesting from a QCD point of view, being a particle composed of two heavy quarks with explicit (non-hidden) flavour.

Studies of the experimental aspects of B_c mesons require a dedicated event generator, since producing events through normal b-quark fragmentation (*e.g.* through the standard PYTHIA generator [9]) is far too ineffective. Two dedicated Monte Carlo generators have recently been interfaced with PYTHIA, a fragmentation approximation model, and a full matrix-element calculation for the subprocess $gg \to B_c(B_c^*) + b + \bar{c}$ based on an extended helicity approach (grouping of the 36 contributing Feynman diagrams into gauge-invariant sub-groups) [10]. The cross-sections for B_c and B_c^* obtained with the full matrix-element calculation are shown in Fig. 3a.

Assuming a branching fraction of $B(b \to B_c) = 10^{-3}$, and the old ATLAS trigger scenario, the number of events in the $B_c \to J/\psi(\mu\mu)\pi$ decay mode would be 5 600 for an integrated luminosity of $20\,{\rm fb}^{-1}$. This mode can be used for mass and lifetime measurements, since the final state can be fully reconstructed. The decay mode $B_c \to J/\psi(\mu\mu)\mu\nu$ is interesting, for example for determining the term $|V_{cb}|$ of the CKM matrix. The ATLAS trigger is less effective for hadronic decay modes due to the muon trigger requirement: for example, in the decay mode $B_c \to B_s\pi$ the number of events would be about 100 per $20\,{\rm fb}^{-1}$.

$B_c \to J/\psi(\mu\mu)\pi$ events were generated with the BCVEGPY simulation program interfaced with PYTHIA, and passed through the full ATLAS detector simulation and event reconstruction (initial layout). The mass resolution was found to be 74 MeV, as shown in Fig. 3b. More detailed studies of B_c mesons are in progress.

3. RARE DECAYS

The flavour-changing neutral currents $b \to s$ and $b \to d$ occur only at loop level in the Standard Model, and the branching ratios are of the order of 10^{-5} or less. These decays, so called rare decays, constitute thus an excellent probe of new physics effects, originating from new particles in the loop, tree-level decays, or modified couplings, which typically enhance the branching fractions of these channels.

The dimuon decays $B_{s,d} \to \mu^+\mu^-$ are self-triggering modes with a clear signature. The dimuon trigger allows for triggering these events even in high-luminosity data taking. The branching fractions in the Standard Model are tiny, $\mathscr{B}(B_s \to \mu^+\mu^-) = 3.5\cdot 10^{-9}$ and $\mathscr{B}(B_d \to \mu^+\mu^-) = 1.5\cdot 10^{-10}$ [11], so these channels are ideal for searches for effects beyond the Standard Model.

After one year of data taking at high luminosity (integrated luminosity of $100\,{\rm fb}^{-1}$), ATLAS is expected to observe a $B_s \to \mu^+\mu^-$ signal with a 4.3σ significance. The event rates are summarized in Table 2. There is an indication of possible improvement of background conditions with another vertex-fit procedure, but this work is in progress.

The decay mode $B_d \to K^{*0}\mu^+\mu^-$ ($B_d \to \rho^0\mu^+\mu^-$) is sensitive to the CKM matrix element $|V_{ts}|$ ($|V_{td}|$). Combining these decay modes one can obtain an independent measurement of the involved matrix elements, with a reduced dependence on the form factors. ATLAS is expected to measure the ratio of the branching fractions $\mathscr{B}(B_d \to K^{*0}\mu^+\mu^-)/\mathscr{B}(B_d \to \rho^0\mu^+\mu^-)$ with a statistical precision of 14% with an integrated luminosity of $30\,{\rm fb}^{-1}$. The event rates are shown in Table 2.

The shape of the forward-backward asymmetry of the two muons in the decay $B_d \to K^{*0}\mu^+\mu^-$ is sensitive to new physics effects. The forward and backward hemispheres are defined according to the angle between the lepton ℓ^+ and the B-meson direction in the rest frame of the lepton pair. The Standard Model predicts an asymmetry which is positive at low $\hat{s}$ ($\hat{s} = q^2/M_B^2$), zero at $\hat{s} \simeq 0.14$, and negative at high $\hat{s}$ apart from the resonance region. In the Minimal Supersymmetric Standard Model (MSSM), the shape of the forward-backward asymmetry is sensitive to the Wilson coefficient $C_{7\gamma}$. For $C_{7\gamma} > 0$ the shape of the asymmetry is similar to that in the Standard Model, but for $C_{7\gamma} < 0$ the asymmetry is negative at low $\hat{s}$ and can thus be easily distinguished from the shape predicted by the Standard Model.

In the lowest mass region $\hat{s}$ = $\hat{s}_{min}$ - 0.14 ($\hat{s}_{min} = 4m_\ell^2/M_B^2$, where m_ℓ is the lepton mass), the average forward-backward asymmetry A_{FB} is expected to be +10% in the Standard Model. The statistical sensitivity for the forward-backward asymmetry, δA_{FB}, is expected to be ±5% in ATLAS with the $B_d \to K^{*0}\mu^+\mu^-$ sample collected with $30\,{\rm fb}^{-1}$. In the MSSM, the average A_{FB} is expected to be (-17±0.5)% with $C_{7\gamma}$<0, so the expected measurement accuracy can clearly distinguish the two cases. The distributions are shown in Fig. 4.

ATLAS can also study the decay mode $B_d \to K^{*0}\gamma$, which has an expected branching ratio $\mathscr{B} = (4.2 \pm 0.4)\cdot 10^{-5}$. The expected statistics is 10 500 events per

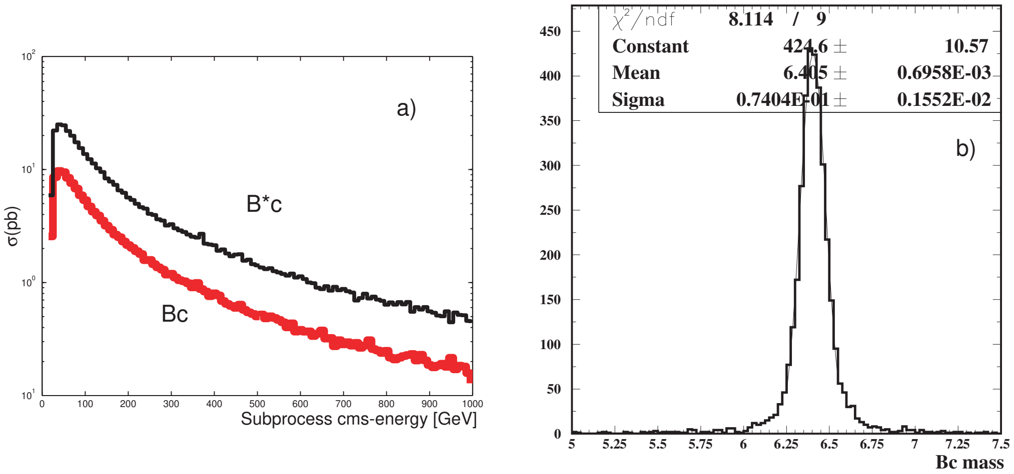

FIGURE 3. a) The total production cross-sections of B_c and B_c^* versus subprocess centre-of-mass energy, from Ref. [10]. b) The reconstructed $B_c \to J/\psi\,\pi$ mass distribution.

TABLE 2. Event rates of rare decays for ATLAS.

Channel	Expected $\mathscr{B}$ (SM)	Integrated luminosity (fb^{-1})	N(signal)	N(background)
$B_s \to \mu^+\mu^-$	$3.5 \cdot 10^{-9}$	100	92	660
$B_d \to \mu^+\mu^-$	$1.5 \cdot 10^{-10}$	100	14	660
$B_d \to K^{*0}\mu^+\mu^-$	$1.5 \cdot 10^{-6}$	30	2 000	290
$B_d \to \rho^0\mu^+\mu^-$	$1 \cdot 10^{-7}$	30	220	950
$B_s \to \phi^0\mu^+\mu^-$	$1 \cdot 10^{-6}$	30	410	140

$30\,\mathrm{fb}^{-1}$, with a signal significance of 5.7σ. The resolution for the B mass measurement is 57 MeV.

4. B PRODUCTION

The LHC will allow for probing strong interactions in a new region both in energy and in fractional momentum (Bjorken x). The high $b\bar{b}$ cross-section will enable measurements of the single-b cross-section, $b\bar{b}$ correlations and multiple heavy quark production well beyond the Tevatron reach. The event samples available are exlusive B-decays (low-p_T region), semi-inclusive $B \to J/\psi X$ decays, and b-tagged jets at very high p_T.

There has been a long-standing discrepancy between the beauty cross-sections measured by CDF and DØ and NLO QCD calculations [12, 13, 14]. The calculated beauty cross-section in the central region was roughly a factor of two below the measured values. The Tevatron results have been statistics limited, in particular when it comes to $b\bar{b}$ correlations. At LHC, the statistics will be sufficient for using exclusive channels instead of b-jets for correlation studies. In particular the kinematic region in which the b-quarks are close to each other in azimuthal angle is sensitive to higher-order QCD contributions.

ATLAS can measure $b\bar{b}$ production correlations using exclusive B-decays and semileptonic decays to muons. In the simulation study, the azimuthal angle $\Delta\phi$ was measured from the angular difference between the J/ψ and muon in the following decay modes:

- $\bar{b} \to B_d \to J/\psi(\mu\mu)K_S^0 + b \to \bar{B} \to \mu X$,
- $\bar{b} \to B_s \to J/\psi(\mu\mu)\phi + b \to \bar{B} \to \mu X$,

The numbers of events were 48 000 and 32 000, respectively, per $30\,\mathrm{fb}^{-1}$. No degradation of efficiency was observed at low angular differences. The contribution from $K \to \mu\nu$ background was, however, found to be significant at low angular differences in case of the B_s decays due to the hadronization correlation of B_s and kaons.

An example of a specific measurement with B baryons is the measurement of Λ_b polarization. The angular distribution of the $\Lambda_b \to J/\psi(\mu\mu)\Lambda(p\pi)$ depends on five measurable decay angles, helicity amplitudes and the polarization P_b. A combined fit with 75 000 events (statistics with $30\,\mathrm{fb}^{-1}$) gives a statistical sensitivity of 0.016 to the polarization measurement. More details of the analysis can be found in Ref. [2].

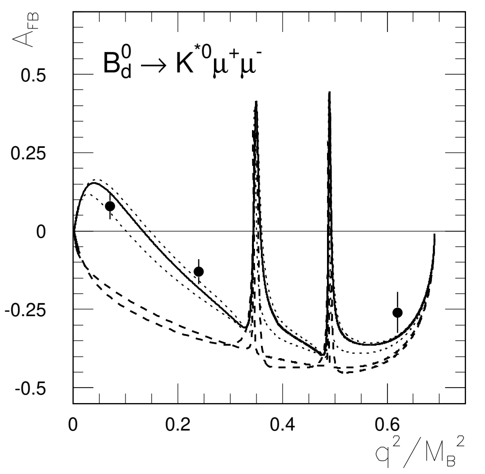

FIGURE 4. The forward-backward asymmetry A_{FB} in decays $B_d \to K^{*0}\mu^+\mu^-$. The points show the simulated experimental values, averaged over three different regions of $\hat{s}$, with statistics corresponding to $30\,\mathrm{fb}^{-1}$. The solid line shows the expected Standard Model distribution, the dotted lines the MSSM distributions with $C_{7\gamma} > 0$, and the dashed lines the MSSM distributions with $C_{7\gamma} < 0$.

5. SUMMARY

ATLAS is preparing a multithematic physics programme for a thorough study of *B*-hadron production and decays. The large samples of all types of *B* hadrons allow for high-precision measurements, searches for evidence of physics beyond the Standard Model, and measurements of beauty production. In particular, ATLAS will be able to make a very precise measurement of the angle β. ATLAS will also perform precise measurements of the properties of B_s and B_c mesons and *B* baryons.

Rare decays of the type $B \to \mu\mu(X)$ have a favourable experimental signature, allowing ATLAS and CMS to trigger these events also at the highest LHC luminosity. These experiments will thus be the first ones which can probe the decays $B_{s,d} \to \mu\mu$.

All the ATLAS subdetectors are now under construction, and the aim is to commission the detector in 2006 and be ready for regular data taking in 2007. The new ATLAS *B*-physics trigger strategy aims at maximizing the physics potential within the tight constraints.

ACKNOWLEDGMENTS

This overview is based on studies performed within the ATLAS Collaboration, and the author wishes to thank colleagues for providing her with the material. The studies have made use of the physics analysis framework and tools which are the result of collaboration-wide efforts.

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