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The LHC provides new opportunities to improve our understanding of the b quark using high statistics data samples and the 14 TeV center-of-mass energy. The prospects to measure the cross section for inclusive b production in events containing jets and at least one muon are presented. Studies of detector systematic effects and theoretical uncertainties are included. QCD aspects of the beauty production are discussed. An outline of the basic vertex reconstruction algorithms used in CMS is given.

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On flavour production in CMS

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Abstract. The LHC provides new opportunities to improve our understanding of the *b* quark using high statistics data samples and the 14 TeV center-of-mass energy. The prospects to measure the cross section for inclusive *b* production in events containing jets and at least one muon are presented. Studies of detector systematic effects and theoretical uncertainties are included. QCD aspects of the beauty production are discussed. An outline of the basic vertex reconstruction algorithms used in CMS is given.

1. Inclusive b-quark production at LHC

The Large Hadron Collider will provide unique opportunities for fundamental physics research based on its unprecedented collision energy and luminosity. *B* production will be one of the most copious sources of hadrons at LHC. Three mechanisms contribute to the beauty production at hadron colliders: gluon-gluon fusion and $q\bar{q}$ annihilation (flavor creation in hard QCD scattering), flavor excitation (semi-hard process) and gluon splitting (soft process). It is important to measure the *B*-hadron p_T spectra within large range to be able to disentangle the contributions of those mechanisms. Flavor creation refers to the lowest-order, two-to-two QCD $b\bar{b}$ production diagrams. Flavor excitation corresponds to diagrams where a $b\bar{b}$ pair from the quark sea of the proton is excited into the final state due to one of the *b* quarks undergoes a hard QCD interaction with a parton from the other proton. Gluon splitting refers to the processes in which the $b\bar{b}$ pair arises from a $g \to b\bar{b}$ splitting in the initial or final state. Neither of the quarks from $b\bar{b}$ pair participate in the hard QCD scattering in this case. Inclusive *b*-quark production has been studied at other proton and electron colliders. The observed shapes of distributions and correlations are reasonably well explained by perturbative QCD. However, the observed cross-sections at the Tevatron (Run I) are larger than QCD predictions [1-3]which is confirmed by Run II data. Similar effects are observed in γp collisions at HERA [4-6] and in γγ interactions at LEP [7,8]. The agreement between experiment and theory has improved due to more precise parton density functions and proper estimates of fragmentation effects [9]. But an agreement is not complete and phenomenological input to the calculations is required.

2. Vertex reconstruction in CMS

The CMS experiment at CERN relies on a silicon pixel and micro-strip tracker for the reconstruction of tracks and vertices of charged particles. Vertex reconstruction involves two steps, vertex finding and vertex fitting. The standard algorithms for vertex reconstruction and fitting in CMS make extensive use of the Kalman filter [10]. Several vertex fitting algorithms have been implemented in CMS , differing mainly in their sensitivity to outlying tracks, which are either mismeasured tracks or tracks from another vertex. Algorithms are sufficiently flexible to be adapted for the use in the High Level Trigger (HLT) and for the reconstruction of heavy ion collisions. The robustness of vertex reconstruction has been improved using adaptive fitters.

A good estimation of secondary vertex parameters is important for b-tagging. Secondary vertices are reconstructed with the Trimmed Kalman Fitter (TKF). TKF is the conventional robust version of the Kalman vertex fitter, where tracks incompatible with the vertex are removed one by one from the vertex, starting with the least compatible track [11]. The algorithm searches for vertex candidates among the input set of tracks in an iterative way. After a first fit to the complete set of tracks the ones compatible with the vertex candidate are removed. Secondary vertex candidates are validated using a selection on the distance to the primary vertex and an upper cut on the invariant mass. In most cases *B*-hadrons produce a tertiary vertex because the decay chain proceeds via charm production. If tracks coming from a tertiary vertex are also used to fit the secondary vertex the measured flight distance is shifted to a higher value. The resolution on the reconstructed flight distance is 765μm for b- and 550μm for c-vertices (the 68 % coverage).

3. B production measurement at LHC with CMS

A study [12] has been performed in CMS on Monte Carlo events generated with PYTHIA [13] to investigate methods of identifying in CMS of *b*-jets (*b* "tagging") in an inclusive sample of events containing jets and at least one muon. We present here the capability to measure the inclusive *b*-quark production cross section as a function of the *B*-hadron transverse momentum p_T and pseudorapidity η.

The study of the CMS capability to measure the inclusive *b* production is based on full detector simulation. The measurement of the differential cross sections is studied for *B*-hadrons of $p_T > 50$ GeV/c and within the fiducial volume of $|\eta| < 2.4$. The event selection requires a *b*-tagged jet in the fiducial volume to be present in the event. *B* tagging is based on inclusive secondary vertex reconstruction in jets [14]. At Level-1 (L1) trigger, the single muon trigger is used. At the HLT trigger level we require the "muon + *b*-jet" trigger. The most energetic *B*-hadron inside the phase space defined above is selected. Good correspondence between the generated *B*-particle and the reconstructed *b*-tagged jet is observed. The corresponding relative resolutions for *B*-particles with $p_T >$ 170 GeV/c are 13 % and 6 % for p_T and pseudorapidity, respectively. The average *b* tagging efficiency is 65 % in the barrel region, while the efficiency is about 10 % less for the endcap region.

The signal fraction is determined from a fit to the data distribution using the simulated shapes for the signal and background. To do so we apply a lepton tag by selecting inclusive muons. Each reconstructed muon is associated to the most energetic b tagged jet. The muon must be closer to this b tagged jet than to any other jet in the event. Otherwise the event is discarded. In most cases the tagged muon is inside the b jet. The average efficiency of associating the muon with the b tagged jet is 75 %. We calculate the transverse momentum of the muon with respect to the b-jet axis which effectively discriminates between b events and background.The event fractions are well reproduced [12] within statistical errors by the fit.

The total event selection efficiency is about 5 %. By correcting for the semi-leptonic branching ratio of *b* quarks and *c* quarks it amounts to about 25 % on average. It turns out that the total efficiency is almost independent of transverse momentum and angle of the *B*-particle. Therefore the measurement of the differential cross section is less affected by systematic uncertainties due to bin-by-bin efficiency corrections.

Several potential sources for systematic uncertainties are considered and their impact on the observed cross section is detailed in [12]. The largest uncertainty arises from the 3 % error [15] on the jet energy scale which leads to a cross section error of 12 % at E_T > 50 GeV/c. The estimated statistical, systematic and total uncertainty as function of the *b* tagged jet transverse momentum with respect to the beam line is shown in Figure 1.

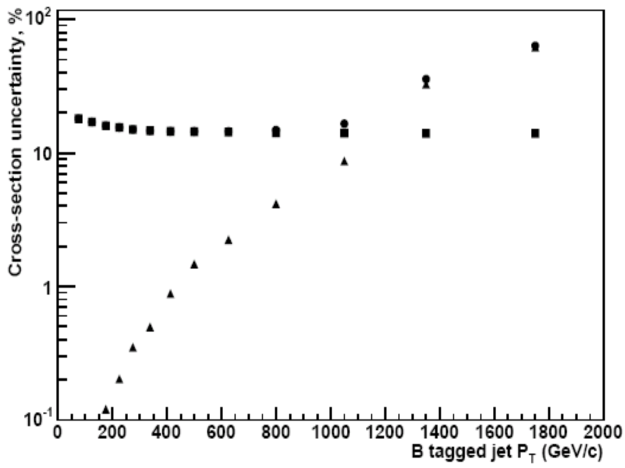

Figure 1. The statistical uncertainty for the cross section measurement (triangles), systematic (squares) uncertainty and total (dots) uncertainty as function of the b tagged jet transverse momentum with respect to the beam line. Total uncertainty comprises the statistical and systematic uncertainties added in quadrature.

The event selection for inclusive *b* production measurement at CMS will allow to study *b* production mechanisms on an event sample of 16 million *b* events for 10 fb^{-1} of integrated luminosity. The *b* purity of the selected events varies as function of the transverse momentum in a range from 70 % to 55 %. Our estimate shows that with the CMS detector we can reach 1.5 TeV/c as the highest measured transverse momentum of *B* hadrons. The results are preliminary, the improvements are likely as further jet calibration tunings, software and analysis algorithm developments are foreseen.

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