PROCEEDINGS OF SCIENCE

First Results from LHCb

Sheldon Stone*
Department of Physics, Syracuse University
Syracuse, N. Y., U. S. A., 13244
E-mail: stone@physics.syr.edu

I report the first results on measurements from the LHCb experiment using 7 TeV proton-proton collisions at the LHC collider. I will concentrate on measurements of the $b\bar{b}$ cross-section, though other results have been shown. Using semileptonic b decays into a D^0 and a μ^- we find that the average cross-section to produce b-flavoured or $\bar{b}$-flavoured hadrons is (75.3±5.4±13.0) μb in the pseudorapidity interval $2 < \eta < 6$ and integrated over all transverse momenta. Using decays into $J\psi$ meson we find in the same phase space (84.5±6.3±15.6) μb. Averaging the two results and extrapolating over the entire kinematic region gives $\sigma(pp \to b\bar{b}X) = (298 \pm 15 \pm 43)$ μb. (For more material presented at the conference that page constraints have forced me to omit, see http://indico.cern.ch/contributionDisplay.py?contribId=1055&confId=73513 .)

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*Speaker.

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1. Introduction

I report on the first results from the LHCb experiment [1] using 7 TeV center-of-mass energy proton-proton collisions at the LHC collider. As the raison d'être for LHCb is to measure CP violating and rare decays of hadrons containing b and $\overline{b}$ quarks, it was necessary to measure the cross-section for $b\overline{b}$ production in order to accurately estimate our future sensitivities. These measurements also allow us to compare with QCD predictions. Furthermore, $b\overline{b}$ cross-section measurements are useful for predicting backgrounds to higher mass processes.

I report here on two methods of measuring $\sigma\left(pp \to b\overline{b}X\right)$ at $\sqrt{s} = 7$ TeV in the forward region defined by $2 < \eta < 6$, where $\eta = -\ln\left[\tan(\theta/2)\right]$, and θ is the angle of the weakly decaying b or $\overline{b}$ hadron with respect to the proton direction. Our sensitivity extends down to zero transverse momentum ($p_{\rm T}$).

In the first method decays of D^0 mesons into the final state $K^-\pi^+$ are sought. Candidates are found by requiring that we have two tracks of opposite charge where one identified by the RICH system as a kaon and the other a pion. These tracks must form a common vertex and be detached significantly from the primary interaction vertex. A muon is also required, of the same charge as the kaon, that also does not come from the primary but forms a common vertex with the extrapolated direction of the $K\pi$ pair. We use two samples, one of 2.9 nb^{-1} whose trigger requires the presence of only some minimal detector activity (called microbiased) and another sample of 12.2 nb^{-1} that was triggered on the presence of muon with $p_{\rm T} > 1.3$ GeV. For lack of space we show only of the data from the larger sample in Fig. 1. The large right-sign signal is due to b production. The small wrong-sign signal is indicative of low backgrounds. The corrected yields given as a function of η are shown in Fig. 2.

The cross section is measured as $\sigma(pp \to H_b X) = (75.3 \pm 5.4 \pm 13.0)$ μb in the interval $2 < \eta < 6$. The first error is statistical, the second systematic. The largest systematic errors, both $\pm 10\%$ arise from uncertainty in the absolute luminosity, and the tracking efficiency for the three tracks. The breakdown of the various b-flavoured hadrons has been measured by LEP. These "fragmentation fractions" are used to determine the central value of the cross-section [4]. Use of these fractions provides internal consistency to our results as $\mathscr{B}(b \to D^0 X \mu^- \overline{\nu})$ was also measured at LEP. The measured value changes if the b-hadron fractions differ. Fractions have also been measured at the Tevatron, albeit with large uncertainties [4]. The largest change with respect to LEP is that the b-baryon percentage rises from (9.1$\pm$1.5)% to (21.4$\pm$6.8)%. If the Tevatron fractions are used, our result changes to (89.6$\pm$6.4$\pm$15.5) μb [5].

The cross-section was also measured using $b \to XJ/\psi \to \mu^+\mu^-$ decays [6]. In Fig. 3 the peudo-lifetime, t_z distribution of candidate J/ψ mesons from 14.2 pb^{-1} of data is shown. Here $t_z \equiv d_z M_{J/\psi}/p_z$, where d_z is the measured distance from the primary vertex downstream in the beam direction $M_{J/\psi}$ is the mass, and p_z the measured component of momentum along the beam.

The long tail at large t_z results from b decays into J/ψ. The cross-section in $2 < \eta < 6$ is, $(84.5 \pm 6.3 \pm 15.6)$ μb using LEP fragmentation fractions and 86.2 μb using Tevatron fragmentation. Averaging the two results, using LEP fragmentation fractions, and extrapolating over all η we find

$$\sigma(pp \to b\overline{b}X) = (298 \pm 15 \pm 43)\ \mu\text{b}. \tag{1.1}$$

Both the absolute value and the shape are in agreement with the theoretical predictions.

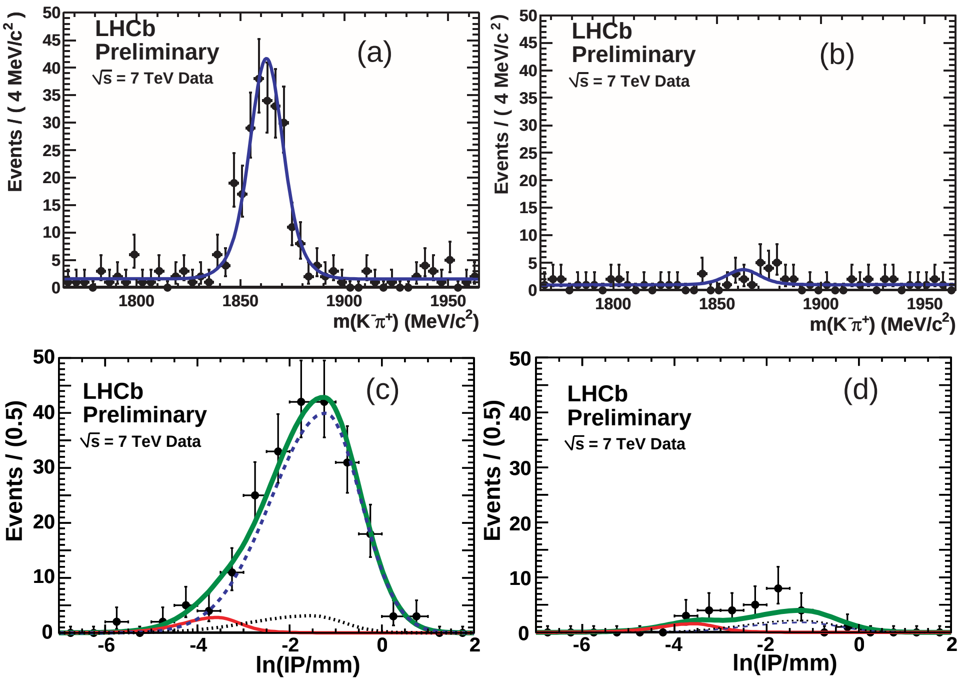

Figure 1: The $K^-\pi^+$ mass distribution from (a) right-sign and (b) wrong-sign $K^-\pi^+$-muon combinations. Also the natural logarithm of the D^0 candidate IP in the 12.2 nb^{-1} triggered sample for (c) right-sign and (d) wrong-sign D^0-muon candidate combinations. The dotted curves show the D^0 sideband backgrounds, the thin solid curves D^0 mesons produced directly, the dashed curve the D^0 from b signal, and the thick solid curves the totals.

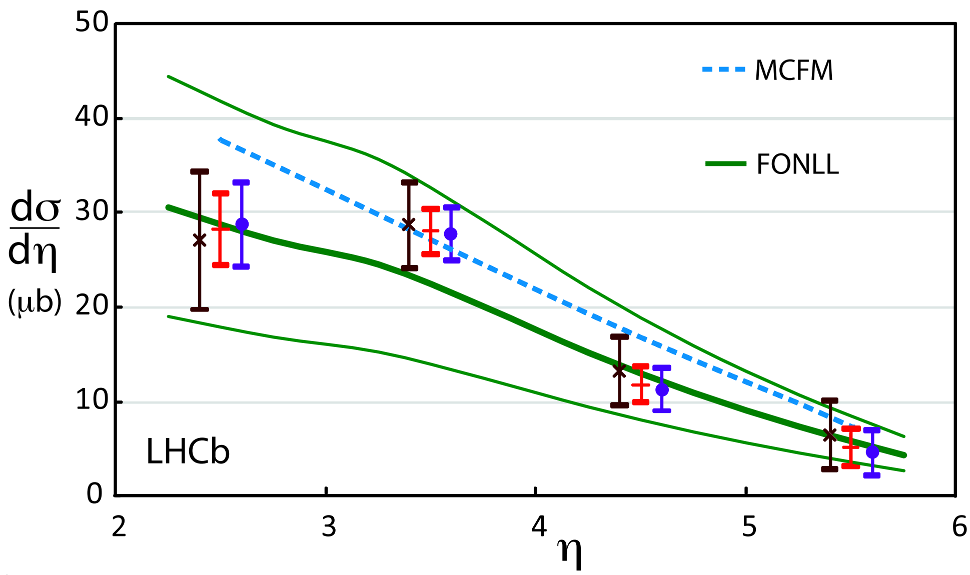

Figure 2: $\sigma(pp \to H_b X)$ as a function of η for the microbias ($\times$) and triggered ($\bullet$) samples, shown displaced from the bin center and the average (+). The data are shown as points with error bars, the MCFM prediction [2] as a dashed line, and the FONLL prediction as a thick solid line [3]. The thin upper and lower lines indicate the theoretical uncertainties on the FONLL prediction. The systematic uncertainties in the data are not included.

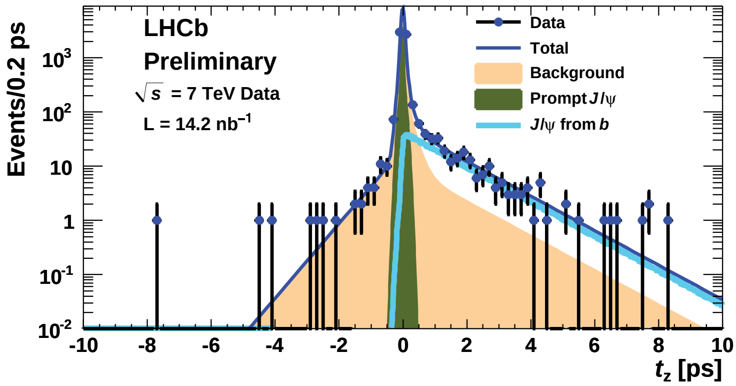

Figure 3: t_z distribution for J/ψ events detected in the $\mu^+\mu^-$ decay mode.

LHCb has also measured yields of direct charm meson production, direct charmonium production, K_s, protons, and $W^{\pm}$ and Z^0 bosons. These first results indicate a bright future for the experiment.

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References

[1] A. Augusto Alves Jr. *et al.*, (LHCb Collaboration) “The LHCb Detector at the LHC", JINST 3 (2008) S08005.

[2] The MCFM version 5.8 computer program was used to evaluate the $b\bar{b}$ production cross-section. See J. M. Campbell and K. Ellis “MCFM - Monte Carlo for FeMtobarn processes", at http://mcfm.fnal.gov/.

[3] Private communication from M. Cacciari, P. Nason, S. Frixione, M. Mangano, and G. Ridolfi. See also M. Cacciari, S. Frixione, M. L. Mangano, P. Nason and G. Ridolfi, JHEP 0407 (2004) 33; M. Cacciari, M. Greco and P. Nason, JHEP **9805** (1998) 007.

[4] Both the LEP and Tevatron averages are compiled by the Heavy Flavor Averaging Group, and given at http://www.slac.stanford.edu/xorg/hfag /osc/PDG_2010/, see also T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. D77 (2008) 072993.

[5] These results have been published. See R. Aaij et al, Phys. Lett. B **694** (2010) 209 arXiv:1009.2731 [hep-ex].

[6] For more information on J/ψ production see the talk of G. Passaleva at this conference.