BEAUTY PRODUCTION IN TWO-PHOTON REACTIONS AT LEP*

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The cross section for open beauty production in photon–photon collisions is measured using the L3 detector at LEP using a data sample of 627 pb^{-1} collected at a e^+e^- center-of-mass energy $\sqrt{s}$ = 189–209 GeV. The $e^+e^- \to e^+e^-b\bar{b}X$ cross section is measured within our fiducial volume and then extrapolated to the full phase space. These results are found to be in significant excess with respect to Monte Carlo predictions and next-to-leading order QCD calculations before and after extrapolation.

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1. Introduction

The study of b quark production constitutes a reliable test of perturbative QCD, as the b quark mass, m_b, largely exceeds the typical non-perturbative scale of hadronic interactions. Much debate has taken place on the apparent disagreement between the measured cross section for b-quark production in $p\bar{p}$ collisions at the Tevatron [1] and the next-to-leading order (NLO) QCD calculations [2]. Some recent results of open beauty production in $e^{\pm}p$ collisions at HERA are in better agreement [3], while others still show an excess [4, 5]. A summary of the situation can be found in Ref. [5].

The hard production of b quark can also be accessed in two-photon collisions at LEP thanks to the high e^+e^- centre-of-mass energy, $\sqrt{s}$. In this environment, b quarks are expected to be produced with comparable rates by the direct $\gamma\gamma \to b\bar{b}$ and single-resolved processes [6]. The main contribution to the resolved-photon cross section is the photon–gluon fusion process

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$\gamma g \to b\bar{b}$, which depends on the gluon density in the photon. The cross section for open-beauty production in photon–photon collisions is measured using the L3 detector at LEP using a data sample of 627 pb^{-1} collected at $\sqrt{s} = 189$–209 GeV [7].

2. Cross section measurement

Hadronic events from photon–photon interactions are selected through their specific multiplicity and topology. The production of b quarks is then tagged by the detection of electrons or muons from their semi-leptonic decays. The cross section $\sigma(e^+e^- \to e^+e^- b\bar{b}X)$ is determined from the distribution of the transverse momentum of the lepton with respect to the nearest jet. The result are compared to the predictions obtained with the CASCADE Monte Carlo program [8], which relies on the CCFM equation [9]:

$$\begin{aligned} \sigma^{\text{obs.}}_{\text{electron}} &= 0.41 \pm 0.11 \text{ pb}\,, \qquad \sigma^{\text{CAS.}}_{\text{electron}} = 0.11 \pm 0.02 \text{ pb}\,, \\ \sigma^{\text{obs.}}_{\text{muon}} &= 0.56 \pm 0.14 \text{ pb}\,, \qquad \sigma^{\text{CAS.}}_{\text{muon}} = 0.14 \pm 0.02 \text{ pb}\,. \end{aligned}$$

The uncertainty on the CASCADE predictions corresponds to a variation of m_b in the range 4.75 ± 0.25 GeV. A disagreement of about three standard deviations is observed for both flavours of the final-state leptons.

3. Comparison with NLO QCD predictions

The total cross section for open-beauty production in photon–photon collisions is then determined by an extrapolation of the observed cross section to the full phase space and by correcting for the semi-leptonic branching ratio of b quarks. The extrapolation factors are determined with the PYTHIA Monte Carlo [10], but similar results are obtained if the CASCADE Monte Carlo is used. As the results for electrons and muons are in perfect agreement, they are combined in a single measurement. The total cross section for open-beauty production is compared in figure 1 to NLO QCD calculations [6]. Our measurement is a factor of three, and three standard deviations, higher than expected. Compatible preliminary results are obtained by other LEP collaborations [11]. It is interesting to remark that the prediction of CASCADE agrees with those from NLO QCD, and the excess is seen in our data before and after the extrapolation to the full phase-space. For completeness, the cross section for open-charm production [12] is also indicated in figure 1 with the corresponding predictions.

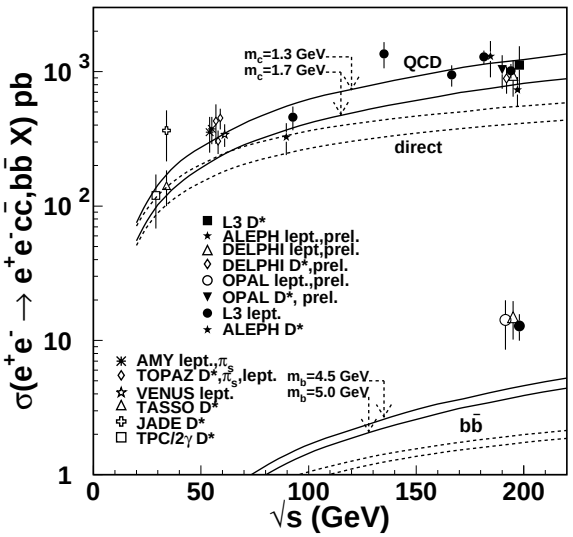

Fig. 1. The open-charm, upper, and open-beauty, lower, production cross sections in photon–photon collisions. The dashed lines correspond to the direct-process contribution only. The effects of a different choice of the values of the quark masses, m_c and m_b, are illustrated.

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