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Beauty in $\gamma\gamma$ at LEP and determination of the b quark mass

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The measurement of the cross section for open-beauty production in photon-photon collisions at LEP by the L3 collaboration is presented as well as the determination of the b quark mass at the M_Z scale with the DELPHI detector at LEP.

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1. Beauty production in photon-photon collisions

The production of b quarks through hard processes constitutes a unique environment for the study of perturbative QCD, as the mass of the b quark, m_b, largely exceeds the typical non-perturbative scale of hadronic interactions. Photon-photon collisions at e^+e^- colliders give also an access to the hard production of b quarks. At LEP energies (around 200 GeV) b quarks are expected to be produced with comparable rates by the direct and single-resolved processes, illustrated in Figure 1.

The first measurement of the cross section for the $e^+e^- \to e^+e^-b\bar{b}X$ process was published by the L3 collaboration using 410 pb^{-1} of data [1]. The results were found to be in excess of the QCD prediction by a factor of three. At this conference the results are presented for the extended measurement corresponding to the whole high-energy data sample collected at LEP with the L3 detector (627 pb^{-1} of data) [2]. The production of b quarks is tagged by the detection of electrons or muons from their semi-leptonic decays. The cross section is determined from the distribution of the transverse momentum of the lepton with respect to the nearest jet.

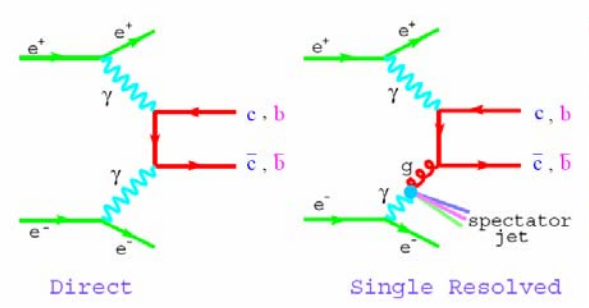

Figure 1. Dominant diagrams contributing to open-beauty production in photon-photon collisions at LEP.

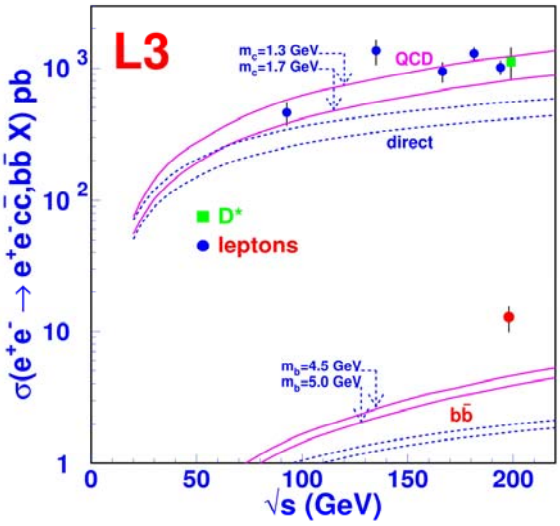

Figure 2. The open-charm, upper, and open-beauty, lower, production cross sections in photon-photon collisions measured with the L3 detector.

The measured total cross section for open-beauty production is compared in Figure 2 to next-to-leading order (NLO) QCD calculations. Figure 2 also compares the cross sections for open-charm production measured in [1] and [3] with the corresponding predictions.

In conclusion, all high-energy data collected by L3 at LEP is investigated and the $e^+e^- \to e^+e^-b\bar{b}X$ cross sections are measured within the detector fiducial volume and found to be in excess with respect to Monte Carlo predictions. The cross sections are extrapolated to the full phase space and found to be in excess with respect to the NLO QCD calculations. This confirms the previous L3 findings based on a subset of the full data-sample.

2. Determination of the b quark mass at the M_Z scale

A new determination of the b quark mass at the M_Z scale has been performed with the DELPHI detector at LEP [4, 5]. The measurement is based on the study of the normalized three-jet rate of b quark events with respect to light quark events (light = u,d,s). The Cambridge and the Durham jet algorithms have been used in the study. The results are found to agree with theoretical predictions treating mass corrections at next-to-leading order. Measurements of the b quark mass have been performed for both the b pole mass M_b and the b running mass $m_b(M_Z)$. Data are found to be better described when using the running mass. The result for $m_b(M_Z)$ reads:

$m_b(M_Z) = 2.85 \pm 0.18\ (\text{stat}) \pm 0.13\ (\text{exp}) \pm 0.19\ (\text{had}) \pm 0.12\ (\text{theo})\ \text{GeV}/c^2$.

This result plotted in Figure 3 is compatible with the other measurements and is the most precise. When compared to other b mass determinations by experiments at lower energy scales, this value agrees with the prediction of the QCD for the energy evolution of the running mass. The mass measurement is equivalent to a test of the flavour independence of the strong coupling constant with an accuracy of 7 ‰.

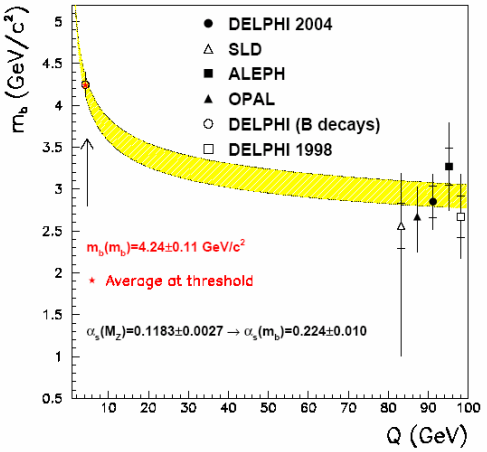

Figure 3. The evolution of $m_b(Q)$ as a function of the energy scale Q. The $m_b(M_Z)$ measured by LEP and SLC are displayed together with their total and statistical errors. All these measurements are performed at the M_Z energy scale but for display reasons they are plotted at different scales.

References

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[4] P. Bambade, M.J. Costa, J. Fuster and P. Tortosa, *Determination of the b quark mass at the* M_Z *with the DELPHI detector at LEP*, contributing paper for *LP 2005 (Uppsala) and HEP-EPS 2005 (Lisbon)*, DELPHI 2005-003 CONF 723.

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