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Evidence for a Narrow Resonance at 10.01 GeV in Electron-Positron Annihilations

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Abstract

We observe evidence for a second narrow resonance in the reation $e^+e^- \to$ hadrons at $\sqrt{s}$ around 10 GeV using the DASP detector at the DORIS storage ring. The mass of the resonance is (10.01 ±.02) GeV; its width is in agreement with the storage ring resolution of ≃ 9 MeV. From the integrated cross section, an electronic width of Γ_{ee} = (0.35 ±0.14) keV is derived.

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The observation of the Y meson[1,2] as a narrow resonance in electron-positron annihilations in the DORIS storage ring indicates that the Y is a bound $J^{PC} = 1^{--}$ state of a new quark and its antiquark. If this interpretation is correct, there should be narrow excited states of the Y, in analogy with the J/ψ family. The FNAL experiment[3], which originally discovered the Y in proton-nucleus interactions, found evidence for further peaks in the mass spectrum at 10.0 (Y') and 10.4 (Y") GeV. As the Y, Y' and Y" are generally interpreted as 1 S, 2 S and 3 S states, the determination of their exact mass is of great importance; once the level spacing between the different Y states and their decay widths are known, the shape of the quark-quark interaction potential can be determined with high accuracy[4,5].

We have therefore used the upgraded electron positron storage ring DORIS to measure the energy dependence of the cross section $e^+e^- \rightarrow$ hadrons in the Y' range. We report here on data taken in August 78 at centre of mass energies from 9.98 to 10.10 GeV. As for the Y scan, DORIS was operated in a single bunch, single ring mode[6]. Additional RF cavities allowed a maximum centre of mass energy of 10.2 GeV. Typical currents were 15 mA per beam, corresponding to luminosities of about $10^{30}/cm^2s$. The rms spread of the centre of mass energy was 9 MeV, the uncertainty of the absolute centre of mass energy[7] was $\pm$20 MeV.

Electron-positron interactions were measured with the Double-Arm Spectrometer DASP, consisting of a non magnetic inner detector which covers about 50 % of 4 π and a magnetic spectrometer that covers 5 %.

Multihadron events were selcted using particle tracks in the five layer scintillator hodoscopes of the inner detector, followed by a computer reconstruction of tracks in the proportional tube chambers and by a visual scan; the overall efficiency of the detector and the selection criteria[1] being 42 %.

Details of the detector, of the data analysis, and of the luminosity monitoring are given elsewhere[1,8].

Data were taken at 15 different centre of mass energies between 9.98 and 10.104 GeV; the total luminosity accumulated was about 120 nb^{-1}.

The resulting cross sections are given in Fig. 1.

We observe evidence for a narrow resonance at (10.012 ±.020) GeV; the error reflects mainly the uncertainty of the energy calibration of DORIS. The measured rms width of 9 MeV is consistent with the mass resolution of the machine.

As part of the error in the energy calibration cancels for mass differences[7], the the mass splitting between the Y and the new resonance which we identify as the Y' can be estimated with higher accuracy:

$$m_{Y'} - m_{Y} = (555 \pm 11)\ \text{MeV}$$

This value is slightly smaller than that obtained from the three-peak fit to the FNAL data by Innes et al.[9], (610 ±42) MeV .

The partial decay width Γ_{ee} is evaluated from the integrated cross section $\int \sigma_h\, dE$ for hadron production assuming R = (4.5 ±.5) and imposing a constant acceptance of 42 ±4 % and applying radiative corrections.[10]

$$\Gamma_{ee} \simeq \Gamma_{ee}\, \Gamma_h/\Gamma = (0.35 \pm 0.14)\ \text{keV}$$

The error contains systematic uncertainties.

In summary, we observe evidence for the formation of a narrow resonance at 10.01 GeV in e^+e^- annihilations which we identify as the Y'. The measured value

of Γ_{ee} favours the description of the Y and the Y' as bound states of a new heavy quark-antiquark pair with quark charge 1/3 [11].

Acknowledgements

We express our thanks to Dr. Degèle and the DORIS group for their excellent work in upgrading and operating the storage ring, and to Profs. H. Schopper and G. Weber for their support and encouragement. We wish to thank the members of the original DASP collaboration for building the detector, allowing us to use the considerable amount of software for data aquisition and reduction, and for many fruitful discussions. The non-DESY members of our collaboration thank the DESY directorate for their hospitality.

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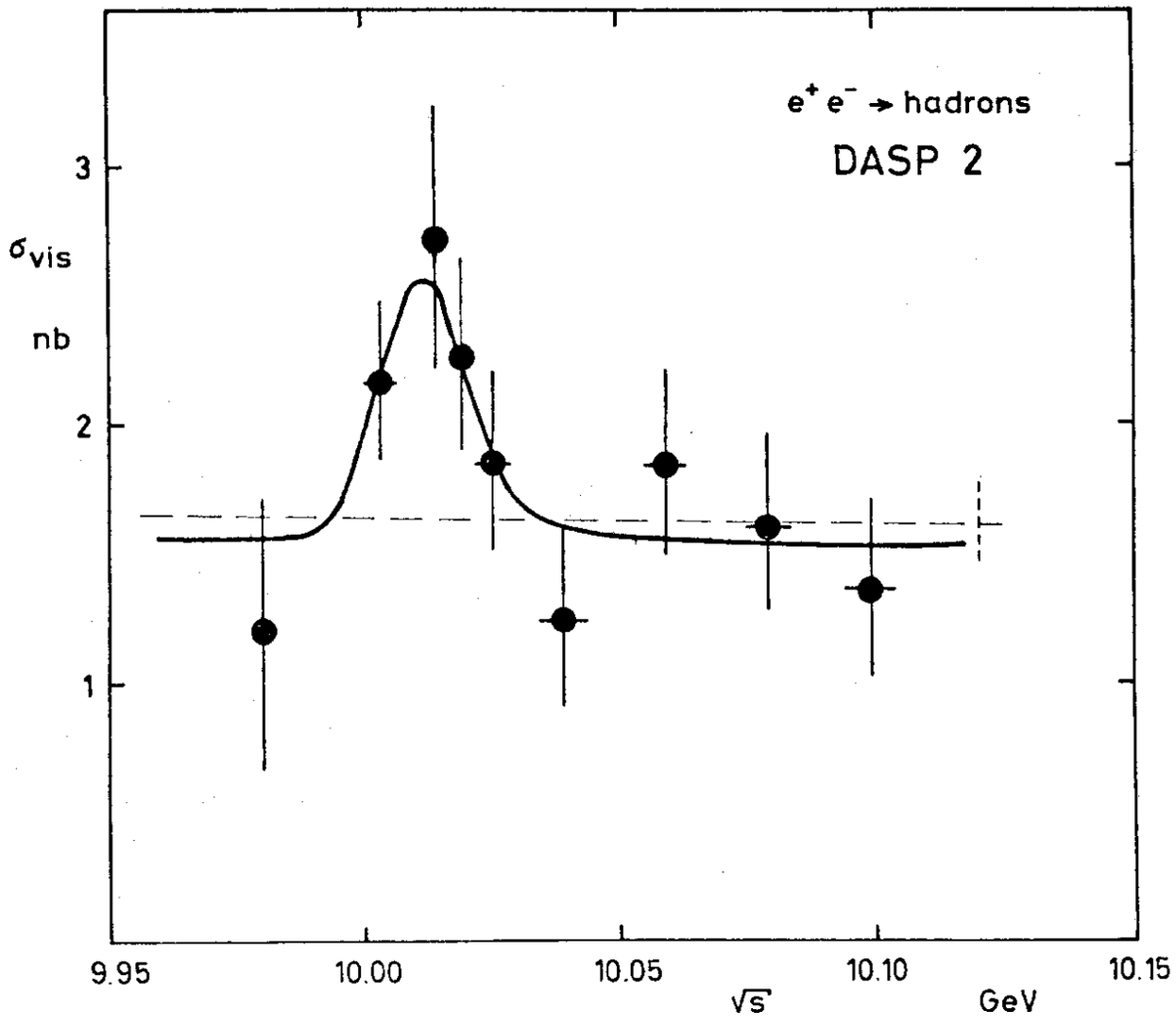
Figure Caption

Fig. 1 Visible cross section of the reaction $e^+e^- \rightarrow$ hadrons. Measured values within ±6 MeV have been averaged. The dashed curve is the non-resonant cross section extrapolated from the measurements made between 9.35 and 9.50 GeV. The solid curve is the best fit for one narrow resonance including gaussian resolution and radiative corrections.


$e^+ e^- \rightarrow$ hadrons
DASP 2
σ_{vis}
nb
3
2
1
9.95
10.00
10.05
10.10
10.15
$\sqrt{s}$
GeV