KEK Preprint 2000-86
BELLE-CONF-0017
August 2000
H

Measurement of K^+K^- Production in Two-photon Collisions with Belle

The Belle Collaboration

Submitted to the XXX^{th} International Conference on High Energy Physics, July-August 2000, Osaka, Japan.

High Energy Accelerator Research Organization (KEK)

KEK Reports are available from:

Information Resources Division
High Energy Accelerator Research Organization (KEK)
1-1 Oho, Tsukuba-shi
Ibaraki-ken, 305-0801
JAPAN

Phone: +81-298-64-5137
Fax: +81-298-64-4604
E-mail: adm-jouhoushiryou1@ccgemail.kek.jp
Internet: http://www.kek.jp

BELLE-CONF-0017
Parallel Session: PA-01

Measurement of K^+K^- production in two-photon collisions with Belle

The Belle Collaboration

Abstract

The production of K^+K^- pairs in two-photon collisions has been studied with the Belle detector at KEKB. The excellent particle identification capability of the Belle detector provides a clear separation of the $\gamma\gamma \to K^+K^-$ process from large backgrounds. With an integrated luminosity of 3.10 fb^{-1}, we obtain the first high statistics data sample in the invariant mass range above 1.6 GeV. We report the energy dependence of the cross section for $\gamma\gamma \to K^+K^-$ for the c.m. energy range between 1.36 and 2.30 GeV.

Typeset using REVTEX

A. Abashian[44], K. Abe[8], K. Abe[36], I. Adachi[8], Byoung Sup Ahn[14], H. Aihara[37], M. Akatsu[19], G. Alimonti[7], K. Aoki[8], K. Asai[20], M. Asai[9], Y. Asano[42], T. Aso[41], V. Aulchenko[2], T. Aushev[12], A. M. Bakich[33], E. Banas[15], S. Behari[8], P. K. Behera[43], D. Beiline[2], A. Bondar[2], A. Bozek[15], T. E. Browder[7], B. C. K. Casey[7], P. Chang[23], Y. Chao[23], B. G. Cheon[32], S.-K. Choi[6], Y. Choi[32], Y. Doi[8], J. Dragic[17], A. Drutskoy[12], S. Eidelman[2], Y. Enari[19], R. Enomoto[8,10], C. W. Everton[17], F. Fang[7], H. Fujii[8], K. Fujimoto[19], Y. Fujita[8], C. Fukunaga[39], M. Fukushima[10], A. Garmash[2,8], A. Gordon[17], K. Gotow[44], H. Guler[7], R. Guo[21], J. Haba[8], T. Haji[4], H. Hamasaki[8], K. Hanagaki[29], F. Handa[36], K. Hara[27], T. Hara[27], T. Haruyama[8], N. C. Hastings[17], K. Hayashi[8], H. Hayashii[20], M. Hazumi[27], E. M. Heenan[17], Y. Higashi[8], Y. Higasino[19], I. Higuchi[36], T. Higuchi[37], T. Hirai[38], H. Hirano[40], M. Hirose[19], T. Hojo[27], Y. Hoshi[35], K. Hoshina[40], W.-S. Hou[23], S.-C. Hsu[23], H.-C. Huang[23], Y.-C. Huang[21], S. Ichizawa[38], Y. Igarashi[8], T. Iijima[8], H. Ikeda[8], K. Ikeda[20], K. Inami[19], Y. Inoue[26], A. Ishikawa[19], R. Itoh[8], G. Iwai[25], M. Iwai[8], H. Iwasaki[8], Y. Iwasaki[8], D. J. Jackson[27], P. Jalocha[15], H. K. Jang[31], M. Jones[7], R. Kagan[12], H. Kakuno[38], J. Kaneko[38], J. H. Kang[45], J. S. Kang[14], P. Kapusta[15], K. Kasami[8], N. Katayama[8], H. Kawai[3], M. Kawai[8], N. Kawamura[1], T. Kawasaki[25], H. Kichimi[8], D. W. Kim[32], Heejong Kim[45], H. J. Kim[45], Hyunwoo Kim[14], S. K. Kim[31], K. Kinoshita[5], S. Kobayashi[30], S. Koike[8], Y. Kondo[8], H. Konishi[40], K. Korotushenko[29], P. Krokovny[2], R. Kulasiri[5], S. Kumar[28], T. Kuniya[30], E. Kurihara[3], A. Kuzmin[2], Y.-J. Kwon[45], M. H. Lee[8], S. H. Lee[31], C. Leonidopoulos[29], H.-B. Li[11], R.-S. Lu[23], Y. Makida[8], A. Manabe[8], D. Marlow[29], T. Matsubara[37], T. Matsuda[8], S. Matsui[19], S. Matsumoto[4], T. Matsumoto[19], K. Misono[19], K. Miyabayashi[20], H. Miyake[27], H. Miyata[25], L. C. Moffitt[17], G. R. Moloney[17], G. F. Moorhead[17], N. Morgan[44], S. Mori[42], T. Mori[4], A. Murakami[30], T. Nagamine[36], Y. Nagasaka[18], Y. Nagashima[27], T. Nakadaira[37], T. Nakamura[38], E. Nakano[26], M. Nakao[8], H. Nakazawa[4], J. W. Nam[32], S. Narita[36], Z. Natkaniec[15], K. Neichi[35], S. Nishida[16], O. Nitoh[40], S. Noguchi[20], T. Nozaki[8], S. Ogawa[34], R. Ohkubo[8], T. Ohshima[19], Y. Ohshima[38], T. Okabe[19], T. Okazaki[20], S. Okuno[13], S. L. Olsen[7], W. Ostrowicz[15], H. Ozaki[8], P. Pakhlov[12], H. Palka[15], C. S. Park[31], C. W. Park[14], H. Park[14], L. S. Peak[33], M. Peters[7], L. E. Piilonen[44], E. Prebys[29], J. Raaf[5], J. L. Rodriguez[7], N. Root[2], M. Rozanska[15], K. Rybicki[15], J. Ryuko[27], H. Sagawa[8], Y. Sakai[8], H. Sakamoto[16], H. Sakaue[26], M. Satapathy[43], N. Sato[8], A. Satpathy[8,5], S. Schrenk[44], S. Semenov[12], Y. Settai[4], M. E. Sevior[17], H. Shibuya[34], B. Shwartz[2], A. Sidorov[2], V. Sidorov[2], S. Stanič[42], A. Sugi[19], A. Sugiyama[19], K. Sumisawa[27], T. Sumiyoshi[8], J. Suzuki[8], J.-I. Suzuki[8], K. Suzuki[3], S. Suzuki[19], S. Y. Suzuki[8], S. K. Swain[7], H. Tajima[37], T. Takahashi[26], F. Takasaki[8], M. Takita[27], K. Tamai[8], N. Tamura[25], J. Tanaka[37], M. Tanaka[8], Y. Tanaka[18], G. N. Taylor[17], Y. Teramoto[26], M. Tomoto[19], T. Tomura[37], S. N. Tovey[17], K. Trabelsi[7], T. Tsuboyama[8], Y. Tsujita[42], T. Tsukamoto[8], T. Tsukamoto[30], S. Uehara[8], K. Ueno[23], N. Ujiie[8], Y. Unno[3], S. Uno[8], Y. Ushiroda[16], Y. Usov[2], S. E. Vahsen[29], G. Varner[7], K. E. Varvell[33], C. C. Wang[23], C. H. Wang[22], M.-Z. Wang[23], T.-J. Wang[11], Y. Watanabe[38], E. Won[31], B. D. Yabsley[8], Y. Yamada[8], M. Yamaga[36], A. Yamaguchi[36], H. Yamaguchi[8], H. Yamamoto[7], H. Yamaoka[8], Y. Yamaoka[8], Y. Yamashita[24], M. Yamauchi[8], S. Yanaka[38], M. Yokoyama[37], K. Yoshida[19], Y. Yusa[36], H. Yuta[1], C.-C. Zhang[11], H. W. Zhao[8], Y. Zheng[7], V. Zhilich[2], and D. Žontar[42]

[1]Aomori University, Aomori

[2]Budker Institute of Nuclear Physics, Novosibirsk
[3]Chiba University, Chiba
[4]Chuo University, Tokyo
[5]University of Cincinnati, Cincinnati, OH
[6]Gyeongsang National University, Chinju
[7]University of Hawaii, Honolulu HI
[8]High Energy Accelerator Research Organization (KEK), Tsukuba
[9]Hiroshima Institute of Technology, Hiroshima
[10]Institute for Cosmic Ray Research, University of Tokyo, Tokyo
[11]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing
[12]Institute for Theoretical and Experimental Physics, Moscow
[13]Kanagawa University, Yokohama
[14]Korea University, Seoul
[15]H. Niewodniczanski Institute of Nuclear Physics, Krakow
[16]Kyoto University, Kyoto
[17]University of Melbourne, Victoria
[18]Nagasaki Institute of Applied Science, Nagasaki
[19]Nagoya University, Nagoya
[20]Nara Women's University, Nara
[21]National Kaohsiung Normal University, Kaohsiung
[22]National Lien-Ho Institute of Technology, Miao Li
[23]National Taiwan University, Taipei
[24]Nihon Dental College, Niigata
[25]Niigata University, Niigata
[26]Osaka City University, Osaka
[27]Osaka University, Osaka
[28]Panjab University, Chandigarh
[29]Princeton University, Princeton NJ
[30]Saga University, Saga
[31]Seoul National University, Seoul
[32]Sungkyunkwan University, Suwon
[33]University of Sydney, Sydney NSW
[34]Toho University, Funabashi
[35]Tohoku Gakuin University, Tagajo
[36]Tohoku University, Sendai
[37]University of Tokyo, Tokyo
[38]Tokyo Institute of Technology, Tokyo
[39]Tokyo Metropolitan University, Tokyo
[40]Tokyo University of Agriculture and Technology, Tokyo
[41]Toyama National College of Maritime Technology, Toyama
[42]University of Tsukuba, Tsukuba
[43]Utkal University, Bhubaneswer
[44]Virginia Polytechnic Institute and State University, Blacksburg VA
[45]Yonsei University, Seoul

I. INTRODUCTION

A high luminosity electron-positron collider is well suited for studies of meson resonances produced by two-photon collisions. The heaviest resonance whose contribution has so far been established in kaon-pair production in two-photon processes is the $f_2'(1525)$ meson, which is classified as an almost pure $s\bar{s}$ meson. Above the $f_2'(1525)$ mass, no clear resonance structure was found in the K^+K^- channel [1,2]. The L3 experiment at LEP has reported a resonance-like peak in the vicinity of 1.75 GeV in the $K_S^0K_S^0$ final state [3].

The 1.5 - 2.0 GeV region is very important for hadron spectroscopy since glueballs are expected to be found in this mass range. Some glueball candidates around 2 GeV have been observed in $J/\psi \to \gamma K\bar{K}$ decays [4] and other experiments, although none of them have been definitely established as glueballs.

Glueball searches are complicated because radial excitations of $q\bar{q}$ mesons are also expected in the same region. Since gluons do not couple to photons, the two-photon partial decay widths ($\Gamma_{\gamma\gamma}$) of glueball states are expected to be very small. Two-photon processes therefore play an important role in identifying glueballs.

Here we report preliminary results from measurements of $\gamma\gamma \to K^+K^-$ in the region of the two-photon c.m. energy (W) between 1.36 and 2.30 GeV. Our measurements of the $\gamma\gamma \to K_S^0K_S^0$ process in a similar W region are presented in a separate paper [5].

II. EXPERIMENT

In the present analysis, we use the data taken by the Belle detector [6] at the KEKB asymmetric e^+e^- collider [7] in the period from October, 1999 to May, 2000. The integrated luminosity is 3.10 fb^{-1}. Since the beam energy dependence of two-photon processes is very small, we combine the on-resonance and off-resonance data samples; the off-resonance data were taken 50 or 60 MeV below the $\Upsilon(4S)$ ($\sqrt{s} = 10.58$ GeV). The analysis is made in the "no-tag" mode, where neither the recoil electron nor positron is detected. We restrict the virtuality of the incident photons to be small by imposing a strict p_t balance requirement on the K^+K^- system.

Almost all of the signal events in the present analysis were collected by triggers based on two tracks in the central drift chamber (CDC) [8]. The charged tracks are reconstructed by the CDC and the silicon vertex detector (SVD).

The identification of charged kaons with high efficiency and low misidentification probability is very important for this analysis, since there are huge backgrounds from $\gamma\gamma \to e^+e^-$, $\mu^+\mu^-$ and $\pi^+\pi^-$. We mainly use the time of flight information provided by the time-of-flight (TOF) scintillation counters [9] for selecting kaon pairs. Information from the energy deposit in the CsI electromagnetic calorimeters (ECL), signals from the silica-aerogel Cherenkov counters (ACC) [10] as well as dE/dx information from the CDC are also used. The resolution of the time of flight measurement is 100 ps. The performance of the particle identification is found to be sufficient even in the W region above 2 GeV, where background contamination was a serious problem in previous experiments.

III. EVENT SELECTION

Events with only one pair of charged particles produced in two-photon processes ($\gamma\gamma \to X^+X^-$) are selected with the following criteria: The scalar sum of track momenta ($\sum |p|$) in an event is required to be smaller than 6 GeV/c, and the sum of the calorimeter energies in an event less than 6 GeV. The event is required to have only one positively charged track and only one negatively charged track, where each satisfies the conditions: $p_t > 0.4$ GeV/c, $|dr| < 1$ cm, $|dz| < 2$ cm, $-0.34 < \cos\theta < 0.82$, where p_t is a transverse momentum of a track with respect to the positron beam axis, and dr and dz are r and z coordinates, respectively, of the closest approach of the track to the nominal collision point in the transverse plane that is perpendicular to the positron beam axis. All of the above values are measured in the laboratory frame.

We impose additional selection criteria to reject backgrounds from radiative Bhabhas; the invariant mass of the tracks is required to be smaller than 4.5 GeV, and the missing-mass squared, calculated from the total c.m. energy, greater than 2 GeV^2.

Cosmic ray events are rejected by requiring the cosine of the opening angle of the tracks to be greater than -0.997. The events not coming from the beam axis are rejected by requiring the dz difference of the two tracks be less than 1 cm. Furthermore, events including an extra track with a higher p_t than 0.1 GeV/c are rejected. Finally, a cut imposing a good p_t balance in the e^+e^- c.m. frame, $|\sum \mathbf{p}_t^*| < 0.1$ GeV/c, is applied to select exclusive-two-track events from quasi-real two-photon collisions. After these selection criteria are applied, 9.70×10^5 events remain.

We make particle identification cuts for the tracks in the selected events in order to select K^+K^- events. Since the sample included a large fraction of $\gamma\gamma \to e^+e^-$ events, we reject them by requiring $E/p < 0.8$ for the two tracks, where E/p is the ratio of the energy deposit on ECL to the momentum. Charged kaons are selected using TOF and ACC information with the criteria that the likelihood ratios for K/π and K/p separation are larger than 0.8.

Figure 1 shows the distributions of the mass squared ($m^2_{\rm TOF}$) of each track calculated from the flight time measured by TOF and the momentum measured by CDC. The distribution with filled circles in Fig. 1(a) shows the tracks where a kaon is tagged on the opposite side. This distribution shows that e, μ and $\pi^\pm$ contamination in the kaon region is very small when both K^+ and K^- identification is required.

However, an ambiguity in the determination of the collision timing (t_0) in our measurement causes another type of background, mainly in the low K^+K^- invariant mass region, $M(K^+K^-) < 1.5$ GeV. Some $ee/\mu\mu/\pi^+\pi^-$ final-state events are assigned a wrong collision time earlier by one RF-beam-bucket spacing time ($t_s = 1.965$ ns), and contaminate the K^+K^- samples. We reject events that match the $ee/\mu\mu/\pi^+\pi^-$ final-state hypothesis when t_0 is intentionally shifted by $+t_s$. The dE/dx information from CDC is also used to reject the remaining backgrounds from this source, which is only in the low invariant mass region. After the application of all the selection criteria, 1833 events remain.

IV. INVARIANT MASS DISTRIBUTIONS

The number of events passing the selection criteria *before particle identification* is compared with expectations from the Monte Carlo (MC) calculation. Since this sample is dominated by $ee \to eeee$, $ee\mu\mu$ and $ee\pi^+\pi^-$, where the cross sections are known, this provides a good monitor of the trigger efficiency.

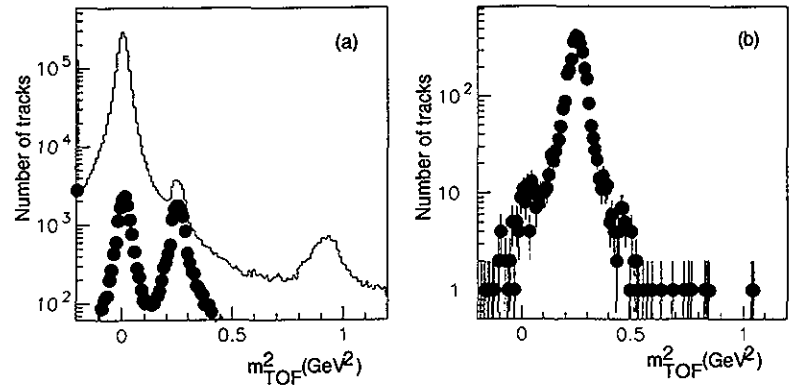

FIG. 1. The mass squared distributions obtained from the TOF information for before and after kaon identification. In (a), the histogram is for the tracks before particle identification, and the filled circles are after kaon identification is required for the opposite side track. (b) shows the distribution for kaons in the final K^+K^- samples. The left most bin in (a) includes the numbers of tracks with no good TOF information.

For this comparison, we use the values of observed cross section ($\sigma_{\rm obs}$), which is defined as the number of observed events divided by the integrated luminosity. We obtain $\sigma_{\rm obs} = 311 \pm 9$ pb from the measurement. The error is primarily due to uncertainty of the integrated luminosity. The contribution of beam backgrounds, estimated to be 0.7% from the dz distribution of tracks, is subtracted.

We have estimated the expected contributions from various processes. The expectations from two-photonic lepton-pair production, $eeee$ and $ee\mu\mu$, are estimated by using the MC event generation program by Berends *et al.*, AAFH [11]. The $ee\pi^+\pi^-$ process is estimated using the TREPS MC program [12], which combines results from previous $ee \to ee\pi^+\pi^-$ experiments [13]. The response of the Belle detector is simulated using the GEANT3 program [14]. We conclude that the expected contribution from the above three processes is $\sigma_{\rm cal} = 385 \pm 11$ pb. An additional 8 ± 3 pb contribution is expected from other processes, such as $ee\tau\tau$ and non-exclusive events as $ee\pi^+\pi^-X$, giving a total expectation of $\sigma_{\rm cal} = 393 \pm 11$ pb.

The $\sim 21\%$ difference between $\sigma_{\rm cal}$ and $\sigma_{\rm obs}$ is primarily due to trigger inefficiencies. After a trigger simulation is applied to the MC events, $\sigma_{\rm cal}$ is reduced by 15%. No appreciable p_t dependence is expected in the selection region from the simulation; the nominal p_t threshold of the CDC trigger was set at 0.2 GeV/c. The result from the trigger simulation is estimated to have an uncertainty of 5 - 10%.

In Fig. 2, we show the invariant mass distribution for the two-track samples to examine the reliability of the efficiency estimation. Here the pion mass is assigned to each track. The experimental data are compared with MC expectations from the sum of the major

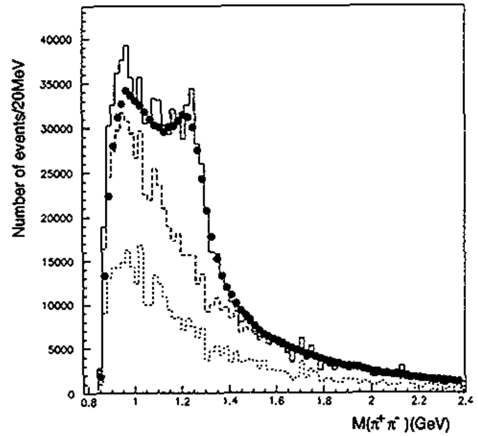

FIG. 2. The invariant mass distribution for $\gamma\gamma \to X^+X^-$ events before particle identification. A charged pion mass is assigned to all tracks. The solid histogram is the Monte Carlo expectation from the sum of three major two-photon processes for *eeee*, $ee\mu\mu$ and $ee\pi^+\pi^-$ final states. The cumulative *eeee* and $ee\mu\mu$ partial contributions are indicated by the short and long-dash histograms, respectively.

three processes, *eeee*, $ee\mu\mu$ and $ee\pi^+\pi^-$, shown by a solid histogram in the figure, where the trigger inefficiencies, estimated by the simulation, are taken into account. The MC expectations are normalized by the integrated luminosity. In the $M(\pi^+\pi^-) > 1.0$ GeV region, the experimental data show good agreement with the MC expectations. Some deficit of events is seen in the $M(\pi^+\pi^-) < 1.0$ GeV region, which indicates a loss of low-p_t tracks due to trigger inefficiencies that are not well modeled by the simulation. This inefficiency only effects the K^+K^- sample in the $W < 1.36$ GeV region, which is not considered in the analysis reported here.

Figure 3 shows the K^+K^- invariant mass distribution for the selected samples after particle identification is applied. The peak at 1.48 - 1.56 GeV is from $f_2'(1525) \to K^+K^-$. In addition, there is a broad bump in the 1.7 - 2.1 GeV region.

We demonstrate the $K/\pi(\mu)$ separation capabilities for different $M(K^+K^-)$ values in Fig. 4, where the difference between the observed TOF and the expected TOF for the kaon assumption is plotted for each track in events where the opposite side is tagged as a kaon. The events having a t_0 ambiguity have already been removed. The kaon signals near $\Delta TOF = 0$ are clearly separated from pions/muons even in the region above 2 GeV, and the structures evident in the K^+K^- yield shown in Fig. 3 are clearly visible. An enhancement of pions around 1.56 GeV (in the K^+K^- mass assignment) is due to $f_2(1270) \to \pi^+\pi^-$ and is well separated from the kaon region.

The W resolution has been determined using a MC simulation of the signal process. The systematic shift of $M(K^+K^-)$ from its generated value is found to be less than 3 MeV; the relative invariant mass resolution is around 0.2%.

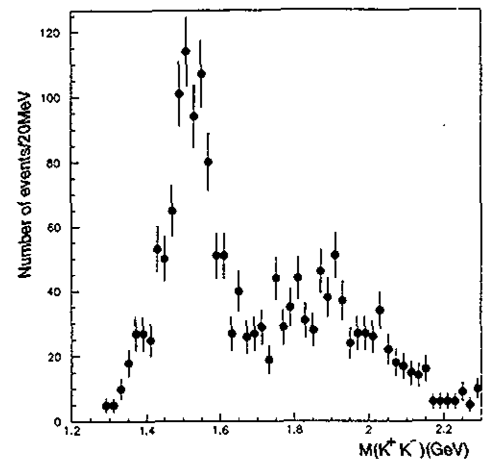

FIG. 3. The invariant mass distributions for $\gamma\gamma \to K^+K^-$ events.

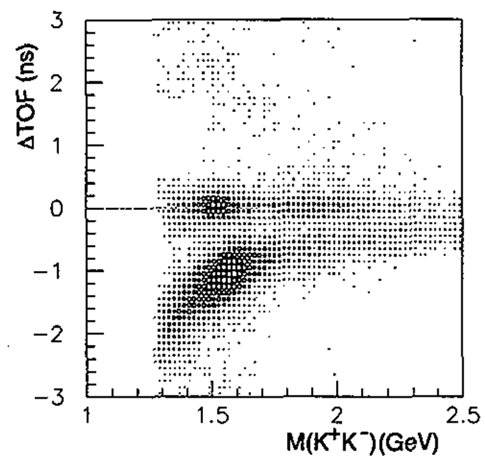

FIG. 4. A scatter plot of $M(K^+K^-)$ vs the difference of the observed TOF from the TOF expected for the kaon hypothesis for events where the opposite side is tagged as a kaon.

V. CROSS SECTION FOR $\gamma\gamma \to K^+K^-$

The evaluation of the absolute cross section for $\gamma\gamma \to K^+K^-$ is made from the present measurement. We restrict the angular range of the final state kaons in the $\gamma\gamma$ c.m. frame to lie within $|\cos\theta^*| < 0.6$. The cross section is obtained using the formula:

$$\sigma(W) = \frac{N(W - 0.5\Delta W < M(K^+K^-) < W + 0.5\Delta W)}{\Delta W L_{\gamma\gamma}(W)\eta(W)\int \mathcal{L}dt},$$

where N is the number of signal events within the invariant mass range and the angular range $|\cos\theta^*| < 0.6$, $L_{\gamma\gamma}$ is the luminosity function and η is the detection efficiency.

The efficiencies at different W points are estimated using MC events generated by TREPS [12] for the $ee \to eeK^+K^-$ signal process, with a $\sin^4\theta^*$ angular distribution, corresponding to a total spin/helicity state of $(J, \lambda) = (2, 2)$. The efficiencies for different angular distributions are different; the efficiency decreases by $\sim$10% for $J = 0$ and increases by $\sim$18% for $(J, \lambda) = (2, 0)$. We take the estimated trigger inefficiency into account, and apply a correction for the probability that the TOF system has useful particle identification information.

The preliminary cross section values, so obtained, are plotted in Fig. 5. The uncertainty in the acceptance and efficiency estimates amounts to a systematic error on the cross sections of 20%. The background contamination from particle misidentification is estimated to be $\sim$8% or smaller at each W point from the ΔTOF distribution. We also confirm that the backgrounds from non-exclusive processes are smaller than 8% by examining the $|\sum \mathbf{p}_t^*|$ distribution, which agrees with the MC expectation from the signal process. We neglect this background contamination since its fractional contribution is smaller than the systematic error.

The present results are compared with the previous experimental results [1,2,15]. Here, the ARGUS results were derived by fitting the angular distributions and extrapolating to the full angular range ($|\cos\theta^*| \leq 1$), which should give larger cross section values than our and other experiments by ten to a few times ten percent.

Overall, the cross section from this analysis agrees with previous measurements to within a factor of two. However, the behavior in the W region just above the $f_2'(1525)$ mass, 1.54 - 1.6 GeV, is somewhat different.

The dashed curve in Fig. 5 is the expected contribution from the $f_2'(1525)$, where the value of $\Gamma_{\gamma\gamma}(f_2'(1525))BR(f_2'(1525)) \to K\bar{K}) = 0.093$ keV [3] is used. The curve does not include interference effects with $f_2(1270)$ and $a_2^0(1320)$ resonances, which may be appreciable in the K^+K^- channel.

We see a broad bump structure in the 1.7 - 2.1 GeV region that peaks around 1.9 GeV. This structure has not been seen previously. If we assume the structure is from a single resonance, we find $M = 1.88 \pm 0.02$ GeV/c^2 and $\Gamma = 0.47 \pm 0.08$ GeV from a fit of a Breit-Wigner curve to the $1.7 < W < 2.1$ GeV region; $\Gamma_{\gamma\gamma}BR(K^+K^-)$ is determined to be $104 \pm 13 \pm 21$ eV ($0.84 \pm 0.11 \pm 0.17$ keV) for the tensor (scalar) meson case, where the first and second errors are statistical and systematic, respectively. We assume $\lambda = 2$ dominance for the tensor meson case.

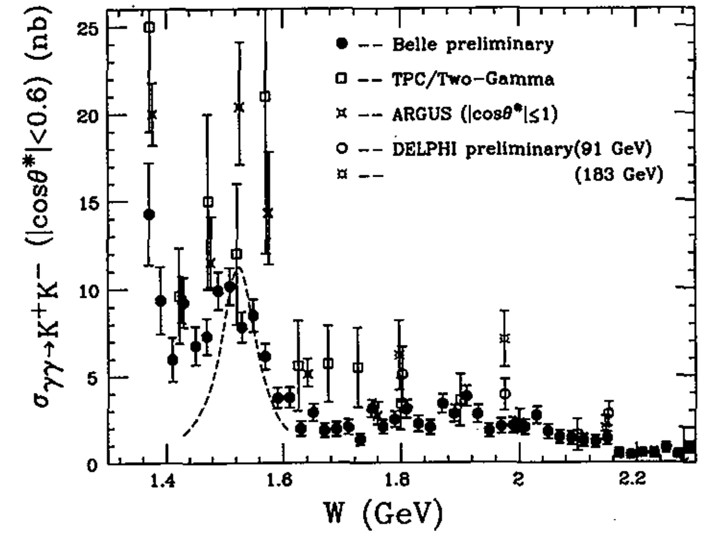

FIG. 5. The cross section for $\gamma\gamma \to K^+K^-$ in the c.m. angular region $|\cos\theta^*| < 0.6$ obtained in this experiment compared with results from previous experiments[1,2,15]. The dashed curve is the expected contribution from the $f_2'(1525)$ using the ref.[3] value for $\Gamma_{\gamma\gamma}(f_2'(1525))BR(f_2'(1525)) \to K\bar{K})$ measured in the $K_S^0K_S^0$ channel; no interference with other components is taken into account.

We find no significant enhancement near 2.23 GeV, and obtain the upper limit, $\Gamma_{\gamma\gamma}(f_J(2220))BR(f_J(2220) \to K\bar{K}) < 3.2$ eV at 95% confidence level, assuming $(J,\lambda) = (2,2)$. For the mass and total width of the $f_J(2220)$ resonance, we used the measured values, 2.231 GeV/c^2 and 23 MeV, respectively, reported from measurements using J/ψ radiative decays and other processes [16]. In the derivation of this upper limit, the number of observed events in the signal region 2.20 - 2.26 GeV (21 events) and the expected number of events from the non-resonant component estimated from a linear fit of the data in the 2.08 - 2.18 GeV and 2.28 - 2.38 GeV regions (29.1 events) are used to extract a 95% CL upper limit on the signal contribution of 7.5 events. Interference effects are not taken into account.

VI. CONCLUSION

The production of K^+K^- in two-photon collisions is studied using a high statistics data sample. The c.m. energy dependence of cross section for the process $\gamma\gamma \to K^+K^-$ is obtained in the range 1.36 - 2.30 GeV. A clear peak is seen in the $f_2'(1525)$ mass region as seen by other experiments. However, the behavior just above the $f_2'(1525)$ mass shows some differences with previous experiments. We find a broad structure in the 1.7 - 2.1 GeV region. This feature is revealed for the first time in this experiment.

We gratefully acknowledge the efforts of the KEKB group in providing us with excellent luminosity and running conditions and the help with our computing and network systems provided by members of the KEK computing research center. We thank the staffs of KEK and collaborating institutions for their contributions to this work, and acknowledge support from the Ministry of Education, Science, Sports and Culture of Japan and the Japan Society for the Promotion of Science; the Australian Research Council and the Australian Department of Industry, Science and Resources; the Department of Science and Technology of India; the BK21 program of the Ministry of Education of Korea and the Basic Science program of the Korea Science and Engineering Foundation; the Polish State Committee for Scientific Research under contract No.2P03B 17017; the Ministry of Science and Technology of Russian Federation; the National Science Council and the Ministry of Education of Taiwan; the Japan-Taiwan Cooperative Program of the Interchange Association; and the U.S. Department of Energy.

REFERENCES

[1] ARGUS Collaboration, H.Albrecht et al., Z. Phys. C48 (1990) 183.
[2] TPC/Two-Gamma Collaboration, H.Aihara et al., Phys. Rev. Lett. 57 (1986) 404.
[3] L3 Collaboration, M.Acciarri et al., Phys. Lett. B363 (1995) 118;
L3 Collaboration, S.Saremi, Nucl. Phys. B (Proc. Suppl.) 82 (2000) 344.
[4] BES Collaboration, J.Z.Bai et al., Phys. Rev. Lett. 76 (1996) 3502;
BES Collaboration, J.Z.Bai et al., Phys. Rev. Lett. 77 (1996) 3959.
[5] Belle Collaboration, A.Abashian et al., *"Measurement of $K_S^0K_S^0$ production in two-photon collisions with Belle", Contributed paper for the 30th International Conference on High Energy Physics, Osaka, Japan, Jul.27 - Aug.2, 2000*, BELLE-CONF-0018.
[6] *"Belle Technical Design Report"*, KEK Report 95-1 (1995).
[7] *"KEKB B-factory Design Report"*, KEK Report 95-7 (1995).
[8] H.Hirano et al., KEK Preprint 2000-2. to be published in Nucl. Instr. Meth. A.
[9] H.Kichimi et al., *"The Belle TOF system", Proceedings of the 7th International Conference on Instrumentation for Colliding Beam Physics, Hamamatsu, Japan, Nov.15-19,1999.*
[10] T.Iijima et al., *"Aerogel Cherenkov counter for the Belle detector", Proceedings of the 7th International Conference on Instrumentation for Colliding Beam Physics, Hamamatsu, Japan, Nov. 15-19, 1999.*
[11] F.A.Berends, P.H.Daverveldt and R.Kleiss, Nucl. Phys. B253 (1985) 441;
F.A.Berends, P.H.Daverveldt and R.Kleiss, Comp. Phys. Comm. 40 (1986) 285.
[12] S.Uehara, KEK Report 96-11 (1996).
[13] Mark-II Collaboration, J.H.Boyer et al., Phys. Rev. D42 (1990) 1350;
CELLO Collaboration, H.J.Behrend et al., Z. Phys. C56 (1992) 381;
VENUS Collaboration, F.Yabuki et al., Jour. Phys. Soc. Jpn. 64 (1995) 435.
[14] R.Brun et al., CERN DD/EE/84-1 (1987).
[15] DELPHI Collaboration, K.Grzelak, Nucl. Phys. B (Proc. Suppl.) 82 (2000) 316.
[16] Particle Data Group, D.E.Groom et al., Euro. Phys. Jour. C15 (2000) 1.