Search for direct production of the $f_1(1285)$ resonance in $e^+e^-$ collisions

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Abstract

A search for direct production of the $f_1(1285)$ resonance in $e^+e^-$ annihilation is performed with the SND detector at the VEPP-2000 $e^+e^-$ collider. The analysis is based on data with an integrated luminosity of 15.1 pb$^{-1}$ accumulated in the center-of-mass energy range 1.2–1.4 GeV. Two $e^+e^+ \rightarrow f_1(1285)$ candidate events are found at the peak of the resonance and zero events beyond the resonance. The significance of the $e^+e^- \rightarrow f_1(1285)$ signal is $2.5\sigma$. The cross section at the maximum of the resonance is found to be $\sigma(e^+e^- \rightarrow f_1) = 45^{+33}_{-24}$ pb. The corresponding branching fraction $B(f_1(1285) \rightarrow e^+e^-) = (5.1^{+3.7}_{-2.7}) \times 10^{-9}$. We consider this result as a first indication of the process $e^+e^- \rightarrow f_1(1285)$. The measured branching fraction is consistent with the theoretical prediction.

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1. Introduction

The dominant mechanism of hadron production in $e^+e^-$ collisions is single-photon annihilation. Annihilation through two photons is suppressed by a factor of $\alpha^2$, where $\alpha$ is the fine structure constant. The only observed process of the two-photon annihilation into hadrons in $e^+e^-$ collisions is the production of two vector mesons, $\rho^0\rho^0$ and $\rho^0\phi$, in the BABAR experiment [1]. Experiments on the search for production of a single $C$-even resonance began more than 30 years ago at the VEPP-2M $e^+e^-$ collider with the ND detector [2]. In these experiments, the first upper limits were set on the probabilities of the inverse reactions, namely the decays $\eta'$, $f_0(975)$, $f_2(1270)$, $f_0(1300)$, $a_0(980)$, and $a_2(1320)$ to $e^+e^-$ pairs. In recent experiments at the colliders VEPP-2M [2, 3], VEPP-2000 [4, 5] and BEPCII [6], this inverse-reaction technique was used to set the best upper limits on the electron widths of the resonances listed above, as well as $\eta$ and $X(3872)$.

![Diagram of the process $e^+e^- \rightarrow f_1$.](image)

Figure 1: The diagram for the process $e^+e^- \rightarrow f_1$.

In this paper, we present the first search for the process $e^+e^- \rightarrow f_1(1285)$ shown in the diagram in Fig. 1. There are also no data on the $f_1(1285) \rightarrow e^+e^-$ decay. Axial-vector resonances, like the $f_1(1285)$, do not decay into two photons, but may nevertheless be produced in $e^+e^-$ annihilation, through virtual photons. Theoretically, the $f_1(1285) \rightarrow e^+e^-$ decay, as well as the $e^+e^- \rightarrow f_1(1285)$ process, are discussed in Ref. [7, 8] within the framework of the vector-meson-dominance model assuming that the virtual photons in Fig. 1 are coupled with the $f_1$ meson via intermediate $\rho^0$ mesons. The two coupling constants describing the $\gamma\gamma^* \rightarrow f_1(1285)$ amplitude and the relative phase between them are determined from the experimental data on the
$f_1(1285) \to \rho \gamma$ decay \cite{9, 10} and the $\gamma \gamma \to f_1(1285)$ reaction \cite{11}. The $e^+e^- \to f_1(1285)$ cross section is predicted to be $(31 \pm 16)$ pb. The corresponding $f_1(1285) \to e^+e^-$ branching fraction calculated using the formula

$$\sigma(e^+e^- \to f_1) = \frac{12\pi/m_{f_1}^2}{\frac{B(f_1 \to e^+e^-)}{B(f_1 \to e^+e^-)}}$$

is $(3.5 \pm 1.8) \times 10^{-9}$. The $f_1$-meson mass and width are $1281.9 \pm 0.5$ MeV and $22.7 \pm 1.1$ MeV \cite{10}, respectively. Its main decay modes are $\pi^+\pi^-\pi^0\pi^0$, $\pi^+\pi^-\pi^+\pi^-$, $\eta\pi^+\pi^-$, and $\eta\pi^0\pi^0$ \cite{10}. The first three of these final states are also produced in the single-photon annihilation and have cross sections at $\sqrt{s} = m_{f_1}$ by two to three orders of magnitude higher than the prediction for $\sigma(e^+e^- \to f_1)$. Therefore, the most viable mode for searching for the process $e^+e^- \to f_1(1285)$ is $f_1 \to \eta\pi^0\pi^0$ with the branching fraction $(17.3 \pm 0.7)$%.

The search for the direct production of the $f_1(1285)$ meson in $e^+e^-$ collisions is performed at the SND experiment at the VEPP-2000 collider \cite{13}.

2. Detector and experiment

We analyze data with an integral luminosity of 15.1 pb$^{-1}$, recorded in 2010, 2011, 2012, and 2017 in the center-of-mass energy region $\sqrt{s} = 1.2$–1.4 GeV at 12 energy points listed in Table 2. The data set at the maximum of the $f_1$ resonance $\sqrt{s} = 1.282$ GeV with an integral luminosity of 3.4 pb$^{-1}$ was collected in 2017 specifically for this analysis. For 2010-2012 energy scans the collider energy was controlled with an accuracy of 2–4 MeV. In 2017 the beam energy was monitored with an accuracy of about 80 keV by the backscattering-laser-light system \cite{14}. The center-of-mass energy spread at $\sqrt{s} = 1.282$ GeV is 630 keV.

A detailed description of the SND detector can be found in Refs. \cite{15}. This is a nonmagnetic detector, the main part of which is a three-layer spherical electromagnetic calorimeter based on NaI (Tl) crystals. The calorimeter covers about 95% of the solid angle and has an energy resolution for photons of $\sigma_E/E = 4.2%/\sqrt{E}$(GeV), and an angular resolution of 1.5°. The directions of charged particles are measured in a tracking system consisting of a nine-layer drift chamber and a proportional chamber with cathode-strip readout. The solid angle covered by the tracking system is 94% of $4\pi$. The calorimeter is surrounded by a muon system.

The search for the process $e^+e^- \to f_1(1285)$ is performed in the channel $f_1(1285) \to \eta\pi^0\pi^0$ with the subsequent decays $\eta \to \gamma \gamma$ and $\pi^0 \to \gamma \gamma$. Since the final state for the process under study does not contain charged particles, the process without charged particles $e^+e^- \to \gamma \gamma$ is used for normalization.
As a result of this normalization, systematic uncertainties associated with the event selection in the hardware trigger and beam-generated spurious charged tracks cancel in the $e^+e^- \to f_1$ cross section. The systematic uncertainty of the luminosity measurement is studied in detail in Ref. [16] and is equal to 2.2%. The distribution of the integrated luminosity over 12 energy points is given in Table 2. About 30% of the analyzed data sample is collected near the $f_1(1285)$ maximum at $\sqrt{s} = 1.280$ and 1.282 GeV.

According to the Particle Data Group (PDG) table [10], the dominant intermediate state in the $f_1(1285) \to \eta \pi \pi$ decay is $a_0 \pi$. Its fraction is $(73 \pm 8)\%$. The process $e^+e^- \to f_1(1285) \to a_0^0\pi^0 \to \eta\pi^0\pi^0$ is simulated using a Monte-Carlo (MC) event generator based on the formulas from Ref. [7]. It takes into account the identity of the final pions and the finite $a_0$ width. The $a_0$ line shape is described by a Breit-Wigner function. To simulate the remaining 27% of the $f_1(1285) \to \eta\pi\pi$ decay, a MC generator with the $f_0(500)\eta$ intermediate state is used.

Event generators for signal and background processes include radiative corrections [17], in particular, the emission of an additional photon from the initial state [18]. The Born cross sections needed for simulation of background processes are taken from existing data. For main background processes $e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$, $e^+e^- \to \omega\pi^0\pi^0 \to 3\pi^0\gamma$, $e^+e^- \to \eta\gamma \to 3\pi^0\gamma$ the recent most accurate cross section measurements [16, 19, 20, 21, 22] are used. Other processes with multiphoton final states, e.g. $e^+e^- \to \omega\eta$, $e^+e^- \to \phi\eta$, and $e^+e^- \to \omega\eta\pi^0$, have small cross sections in the energy range of interest and give negligible contributions to the background. The processes with $K_L$ mesons, $e^+e^- \to K_SK_L$, $e^+e^- \to K_SK_L\pi^0$, etc, are strongly suppressed by our selection criteria (see Sec. 3) and are also negligible.

The signal process is studied in the six-photon final state $f_1(1285) \to \eta\pi^0\pi^0 \to 6\gamma$. In the dominant background process $e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$ with five photons in the final state, an additional photon appears either because of initial state radiation, or because of splitting of electromagnetic showers, or because of superimposing beam-generated background. To simulate the latter effect, special background events are used, which were recorded during experiment with a random trigger. These events are superimposed on the simulated events.
3. Event selection

To search for the process $e^+e^- \rightarrow f_1(1285) \rightarrow \eta\pi^0\pi^0$, events with exactly six reconstructed photons and no tracks in the tracking system are selected. Photons are clusters in the calorimeter with the energy deposition greater than 20 MeV. The total energy deposition in the calorimeter $E_{\text{tot}}$ and the total event momentum $P_{\text{tot}}$ calculated using the energy depositions in the calorimeter crystals must satisfy the conditions

$$0.7 < E_{\text{tot}}/\sqrt{s} < 1.2, \quad P_{\text{tot}}/\sqrt{s} < 0.3, \quad (E_{\text{tot}} - P_{\text{tot}})/\sqrt{s} > 0.7,$$

which provide approximate energy and momentum balance in an event. To suppress cosmic-ray background, no signal in the muon system is required.

Then we select events containing two $\pi^0$ candidate and one $\eta$ candidate, which are defined as two-photon pairs with invariant masses in the windows $|M_{2\gamma} - m_{\pi^0}| < 35$ MeV and $|M_{2\gamma} - m_{\eta}| < 50$ MeV, respectively. For the selected events, a kinematic fit to the hypothesis $e^+e^- \rightarrow \eta\pi^0\pi^0$ is performed with a requirement of total energy and momentum conservation and three invariant-mass constraints. The condition on the $\chi^2$ of the kinematic fit, $\chi^2_{\eta\pi\pi} < 35$, is applied. The distribution of this parameter for the simulated signal events and background events from the process $e^+e^- \rightarrow \omega\pi^0\pi^0$ are shown in Fig. 2 (left). It should be noted that the background is suppressed by the condition that six photons form two $\pi^0$ and one $\eta$ candidates. Background events satisfying this condition have $\chi^2_{\eta\pi\pi}$ distribution not strongly different from the distribution for signal events. The distribution of 90 selected data events over the 12 energy points is shown in Fig. 2 (right).

Background events passing the selection criteria come from the processes $e^+e^- \rightarrow \omega\pi^0$, $e^+e^- \rightarrow \omega\pi^0\pi^0$, and $e^+e^- \rightarrow \eta\gamma$. The number of background events estimated from simulation is 86 ± 1, about 90% of which are from the process $e^+e^- \rightarrow \omega\pi^0$. The expected number of signal events for $\sigma(e^+e^- \rightarrow f_1)$ = 50 pb is 4.7. The calculated distributions of background and signal events over the 12 energy points are shown in Fig. 2 (right). It is seen that the data and simulated background distributions are in good agreement. At this stage of the selection, the background is too large to observe the signal of the $f_1(1285)$ decay.

Since the main background comes from the process $e^+e^- \rightarrow \omega\pi^0 \rightarrow \pi^0\pi^0\gamma$, the kinematic fit in the hypothesis $e^+e^- \rightarrow \pi^0\pi^0\gamma$ is also performed. During the fit, all possible five-photon combinations are tested. Events containing a combination with $\chi^2_{\pi\pi\gamma} < 60$ are rejected. The $\chi^2_{\pi\pi\gamma}$ distributions...
Figure 2: Left panel: The $\chi^2_{\eta\pi\pi}$ distribution for simulated signal $e^+e^- \rightarrow \eta\pi^0\pi^0$ events (solid histogram) and background $e^+e^- \rightarrow \omega\pi^0(\gamma)$ events (dashed histogram). The arrow indicates the selection criterion used. Right panel: The distribution of 90 data events selected by the condition $\chi^2_{\eta\eta\pi} < 35$ over the 12 energy points (points with error bars). The open histogram is the expected distribution for background events. The shaded histogram represents the expected signal distribution for $\sigma(e^+e^- \rightarrow f_1) = 50$ pb.

Figure 3: Left panel: The distribution of the parameter $\chi^2_{\pi\pi\gamma}$ for simulated events of the processes $e^+e^- \rightarrow \omega\pi^0(\gamma)$ (solid histogram) and $e^+e^- \rightarrow f_1 \rightarrow \eta\pi^0\pi^0$ (dashed histogram). The arrow indicates the selection criterion used. Right panel: The distribution of the normalized energy of the most energetic photon in an event for simulated events of the processes $e^+e^- \rightarrow \eta\pi^0\pi^0$ (open histogram) and $e^+e^- \rightarrow \eta\gamma(\gamma)$ (shaded histogram). The arrow indicates the selection criterion used.
for simulated signal and background $e^+e^- \rightarrow \omega \pi^0$ events are shown in Fig. 3 (left).

To calculate other two parameters helpful for background suppression, we use the energies and angles of photons after the kinematic fit to the $e^+e^- \rightarrow 6\gamma$ hypothesis. Figure 3 (right) shows the distribution of the normalized energy of the most energetic photon in an event $2E_{\gamma,max}/\sqrt{s}$ for simulated signal and background $e^+e^- \rightarrow \eta\gamma(\gamma)$ events. To suppress the $e^+e^- \rightarrow \eta\gamma(\gamma)$ background, the condition $2E_{\gamma,max}/\sqrt{s} < 0.78$ is applied.

Most of the $e^+e^- \rightarrow \omega \pi^0(\gamma)$ events remaining after applying the condition $\chi^2_{\pi\pi\gamma} > 60$ contain an additional photon emitted from the initial state at a large angle. To suppress this background, the requirement of the absence of a $\omega$-meson candidate in an event is used. The $\omega$ candidate is defined as a combination of three photons, one of which is the most energetic photon in the event, and the other two must have an invariant mass in the range $|M_{2\gamma} - m_{\pi^0}| < 35$ MeV. If there are several $\omega$ candidates in an event, one with the lowest $|M_{3\gamma} - m_{\omega}|$ value is chosen. The distribution of the invariant mass of the $\omega$ candidate $(M_{\pi\gamma})$ for simulated signal and background $e^+e^- \rightarrow \omega \pi^0(\gamma)$ events is shown in Fig. 4. Events, for which $M_{\pi\gamma} > 720$ MeV, are rejected. This condition also suppresses the background from the process $e^+e^- \rightarrow \omega \pi^0\pi^0$ by a factor of about 10.
Table 1: The effect of the selection criteria applied successively on data events ($N_{\text{data}}$), estimated background ($N_{\text{bkg}}$), and signal calculated for $\sigma(e^+e^- \to f_1) = 50$ pb ($N_{\text{sig}}$).

| Selection conditions                                      | $N_{\text{data}}$ | $N_{\text{bkg}}$ | $N_{\text{sig}}$ |
|-----------------------------------------------------------|--------------------|------------------|------------------|
| $\chi^2_{\eta \pi \pi} < 35$                            | 90                 | 86               | 4.5              |
| $+ \chi^2_{\pi^0 \pi^0 \gamma} > 60$                    | 13                 | 15.5             | 3.6              |
| $+ 2E_{\gamma, \text{max}}/\sqrt{s} < 0.78$              | 10                 | 9.4              | 3.2              |
| $+ M_{\pi \gamma} < 720$ MeV                             | 2                  | 1.1              | 1.8              |

Table 2: The center-of-mass energy ($\sqrt{s}$), integrated luminosity ($L$), number of selected data events ($N$), number of background events ($N_{\text{bkg}}$) calculated using simulation with the statistical error.

| $\sqrt{s}$ (GeV) | $L$ (nb$^{-1}$) | $N$ | $N_{\text{bkg}}$ | $\sqrt{s}$ (GeV) | $L$ (nb$^{-1}$) | $N$ | $N_{\text{bkg}}$ |
|------------------|----------------|-----|-----------------|------------------|----------------|-----|-----------------|
| 1.200            | 1185           | 0   | 0.054 ± 0.010   | 1.300            | 2220           | 0   | 0.108 ± 0.021   |
| 1.225            | 577            | 0   | 0.028 ± 0.005   | 1.325            | 559            | 0   | 0.037 ± 0.007   |
| 1.250            | 467            | 0   | 0.025 ± 0.005   | 1.350            | 1945           | 0   | 0.124 ± 0.022   |
| 1.275            | 516            | 0   | 0.022 ± 0.005   | 1.360            | 826            | 0   | 0.080 ± 0.012   |
| 1.280            | 740            | 0   | 0.045 ± 0.008   | 1.375            | 612            | 0   | 0.057 ± 0.008   |
| 1.282            | 3451           | 2   | 0.252 ± 0.044   | 1.400            | 2024           | 0   | 0.275 ± 0.032   |

The effect of the selection criteria applied successively on data events, estimated background and signal calculated for $\sigma(e^+e^- \to f_1) = 50$ pb is demonstrated in Table 1.

Finally, two events are selected in data. Their distribution over the 12 energy points in comparison with the simulated background distribution is given in Table 2.

4. Cross section for $e^+e^- \to f_1(1285)$ and $f_1(1285) \to e^+e^-$ branching fraction

It can be seen from Table 2 that the two selected data events are located at the energy point corresponding to the maximum of the $f_1(1282)$ resonance, where the calculated background is 0.25 events. The simulation reproduces background contribution reasonably well. After applying the condition $\chi^2_{\eta \pi \pi} < 35$, the number of selected data events coincides with the number of background events estimated from simulation within about 10% statistical uncertainty. The next three conditions in Table 1 suppress background by a
factor of about 80. For the main background process $e^+e^- \rightarrow \omega\pi^0(\gamma)$, these conditions remove well reconstructed events with five true photons and a spurious photon from the beam background, and six-photon events with an extra photon emitted from the initial state. Small remaining background contains improperly reconstructed events, for example, with a splitting photon from the $\omega$ decay, which fraction may be simulated incorrectly. To estimate quality of simulation of the background-suppression conditions, we study a sample of background events with $\chi^2_{\eta\pi\pi} > 35$, which are well reconstructed in the $e^+e^- \rightarrow 6\gamma$ hypothesis ($\chi^2_{6\gamma} < 30$). The number of such events selected in data (465) is in reasonable agreement with the number expected from simulation (422 $\pm$ 2). The selection criteria listed in the three last rows in Table 1 reduce the number of data events by a factor of 18 $\pm$ 3.2 and the number of simulated background events by a factor of 20 $\pm$ 0.3. From the simulation-to-data ratio 1.08 $\pm$ 0.21, we estimate that the MC simulation reproduces the effect of the background suppression conditions with a systematic uncertainty of about 20%. Taking into account 10% uncertainty due to the $\chi^2_{\eta\pi\pi} < 35$ condition discussed above, we conclude that the systematic uncertainty of the background prediction for the selection criteria listed in Table 1 is better than 30%.

The distribution of data events listed in Table 2 is fitted with a sum of signal and background distributions:

$$N_i^{\text{th}} = \varepsilon\sigma_{\text{vis}}(\sqrt{s_i})L_i + N_{\text{bkg},i}R_{\text{bkg}}$$

where $\varepsilon$ is the detection efficiency for the process $e^+e^- \rightarrow f_1(1285)$, $L_i$ is the integrated luminosity in the point with energy $\sqrt{s_i}$, $\sigma_{\text{vis}}$ is the $e^+e^- \rightarrow f_1(1285)$ visible cross section, $N_{\text{bkg},i}$ is the background distribution given in Table 2. The background scale factor $R$ is set to unity and varied during the fit within its 30% systematic uncertainty.

The visible cross section is calculated as follows:

$$\sigma_{\text{vis}}(\sqrt{s}) = \int_0^{x_{\text{max}}} W(s, x)\sigma_B(\sqrt{s(1-x)})dx,$$  

where $W(s, x)$ is the so-called radiator function, which describes the probability density for emission of photons with the total energy $x\sqrt{s}/2$ from the initial state [17]. The Born cross section, $\sigma_B$, is parametrized as follows:

$$\sigma_B(\sqrt{s}) = \sigma(e^+e^- \rightarrow f_1)\frac{m_{f_1}^2\Gamma_{f_1}^2}{(s - m_{f_1}^2)^2} + \frac{m_{f_1}^3P(s)^3}{s^{3/2}P(m_{f_1}^2)^3}.$$
where the cross section at the resonance maximum \( \sigma(e^+e^- \rightarrow f_1) = (12\pi/m_{f_1}^2) \times B(f_1 \rightarrow e^+e^-) \). In Eq. (4) we assume that \( f_1 \rightarrow \eta\pi^0\pi^0 \) decay proceeds through the intermediate state \( a_0(980)\pi^0 \). Therefore, \( P(s) \) is the \( a_0(980) \) momentum. The radiative corrections reduce the visible cross section at the resonance maximum by 20\% compared with the Born cross section.

The detection efficiency for \( e^+e^- \rightarrow \eta\pi^0\pi^0 \) events with the \( a_0(980)\pi^0 \) intermediate state depends on the energy and decreases from 5.3\% at 1.2 GeV to 4.9\% at 1.282 GeV, and then to 1.9\% at 1.4 GeV. The steep decrease of the efficiency above the resonance maximum is due to the decrease of the \( e^+e^- \rightarrow f_1 \) Born cross section. At 1.4 GeV about 80\% of signal events contain an energetic photon emitted from the initial state (see Eq. (3)).

For the \( f_0(500)\eta \) mechanism, the efficiency is 25\% lower. Assuming that \( f_1(1285) \) decay to the \( \eta\pi^0\pi^0 \) final state proceeds through these two mechanisms, and the fraction of \( a_0^0(980)\pi^0 \) is \( (73 \pm 8)\% \), we obtain that the detection efficiency at \( \sqrt{s} = 1.282 \) GeV is equal to \( (4.6 \pm 0.3)\% \). The quoted model error is estimated as a difference between the efficiencies calculated in the models \( a_0^0(980)\pi^0 \) and \( a_0^0(980)\pi^0 + f_0(500)\eta \). A detailed study of the systematic uncertainty associated with the selection of multiphoton events based on the kinematic fit was performed in Ref. [16] using \( e^+e^- \rightarrow \pi^0\pi^0\gamma \) events. Basing on this study, we estimate that the systematic uncertainty on the detection efficiency due to inaccuracy in simulation of the detector response does not exceed 5\%. Taking into account the branching fraction \( B(f_1(1285) \rightarrow \eta\pi^0\pi^0) = (17.3 \pm 0.7)\% \), the detection efficiency in Eq. (2) at \( \sqrt{s} = 1.282 \) GeV is \( \varepsilon = (0.79 \pm 0.08)\% \), where the error includes all the uncertainties discussed above.

As a result of the fit to the distribution of data events listed in Table 2, the following value of the cross section at the resonance maximum is obtained

\[
\sigma(e^+e^- \rightarrow f_1) = 45^{+33}_{-24} \text{ pb}, \tag{5}
\]

which is in agreement with the theoretical prediction \( (31 \pm 16) \) pb [8]. The significance of the \( e^+e^- \rightarrow f_1(1285) \) signal estimated by comparing the log-likelihood values for the fits with and without the resonance is found to be 2.5\( \sigma \). We consider our result as a first indication of the process \( e^+e^- \rightarrow f_1(1285) \).

The obtained value of \( \sigma(e^+e^- \rightarrow f_1) \) corresponds to the branching fraction

\[
B(f_1(1285) \rightarrow e^+e^-) = (5.1^{+3.7}_{-2.7}) \times 10^{-9}. \tag{6}
\]
Since the significance of the $f_1(1285)$ signal is not large, we also quote the 90% confidence level upper limit

$$B(f_1(1285) \to e^+e^-) < 9.4 \times 10^{-9}. \quad (7)$$

5. Summary

The search for the direct production of the $f_1(1285)$ resonance in $e^+e^-$ collisions is performed using the data sample with an integrated luminosity of 15.1 pb$^{-1}$ recorded in the SND experiment at the VEPP-2000 $e^+e^-$ collider in the energy region $\sqrt{s} = 1.2$–1.4 GeV. About 3.5 pb$^{-1}$ were collected at the maximum of the $f_1(1285)$ resonance. To search for the process $e^+e^- \to f_1(1285)$, the decay mode $f_1(1285) \to \eta\pi^0\pi^0$ has been used. After applying the selection criteria, two events have been observed at the peak of the $f_1(1285)$ resonance and zero events beyond the resonance. These two events correspond to the cross section $\sigma(e^+e^- \to f_1) = 45^{+33}_{-24}$ pb and the branching fraction $B(f_1(1285) \to e^+e^-) = (5.1^{+3.7}_{-2.7}) \times 10^{-9}$. The significance of the $e^+e^- \to f_1(1285)$ signal is 2.5$\sigma$. We consider this result as a first indication of the process $e^+e^- \to f_1(1285)$. The measured branching fraction agrees with the theoretical prediction \[8\].

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