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Light meson production in $\gamma\gamma$ interactions with KLOE

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Summary. — Preliminary studies on $\gamma\gamma$ processes with the KLOE experiment without tagging of electrons/positrons are presented.

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The coupling of the photon to scalar and pseudoscalar mesons brings information on their quark structure and can be measured directly in e^+e^- colliders via the reaction $e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-X$. Of particular interest is the measurement of the $\gamma\gamma$ partial width of the $\sigma(600)$ meson, the lowest level of the nonet of scalar mesons [1]. If the e^+e^- beams have energy E, the cross section for production of the X state is

$$\sigma(e^+e^- \to e^+e^-X) = \int \frac{\mathrm{d}L}{\mathrm{d}z}\,\sigma_{\gamma\gamma\to X}(z)\,\mathrm{d}z, \tag{1}$$

where $z = w/2E$ and w is the $\gamma\gamma$ invariant mass. In case of no e^+e^- tagging, the differential $\gamma\gamma$ luminosity can be expressed in the Equivalent Photon Approximation [2,3], and for a narrow resonance of spin 0 and mass M_X the resulting cross section is

$$\sigma_{e^+e^-\to e^+e^-X} = \frac{16\alpha^2\Gamma_{X\gamma\gamma}}{M_X^3}\left(\ln\frac{E}{m_e}\right)^2\left((z^2+2)^2\ln\frac{1}{z} - (1-z^2)(3+z^2)\right). \tag{2}$$

DAΦNE is an e^+e^- collider operating at $\sqrt{s} \simeq 1$–$1.02\,\mathrm{GeV}$. The KLOE detector consists of a large-volume drift chamber surrounded by a lead and scintillating-fibers calorimeter. Charged-particle momenta are reconstructed with resolution $\sigma_p/p \simeq 0.4\%$ for large-angle tracks. Energy clusters are reconstructed with energy and time resolution of $\sigma_E/E = 5.7\%/\sqrt{E(\mathrm{GeV})}$ and $\sigma_t = 57\,\mathrm{ps}/\sqrt{E(\mathrm{GeV})} \oplus 100\,\mathrm{ps}$. The sample used for the present analyses consists of data taken by KLOE at $\sqrt{s} = 1\,\mathrm{GeV}$, which allows reduction of the background from ϕ decays, with an integrated luminosity of $240\,\mathrm{pb}^{-1}$. Data are processed with a dedicated $\gamma\gamma$ filter allowing for a significant amount of missing energy. A search for the $e^+e^- \to e^+e^-\eta$ process is performed, with $\eta \to \pi^+\pi^-\pi^0$. The selection of these events asks for two photons, constrained to originate from a π^0 decay, and two tracks with

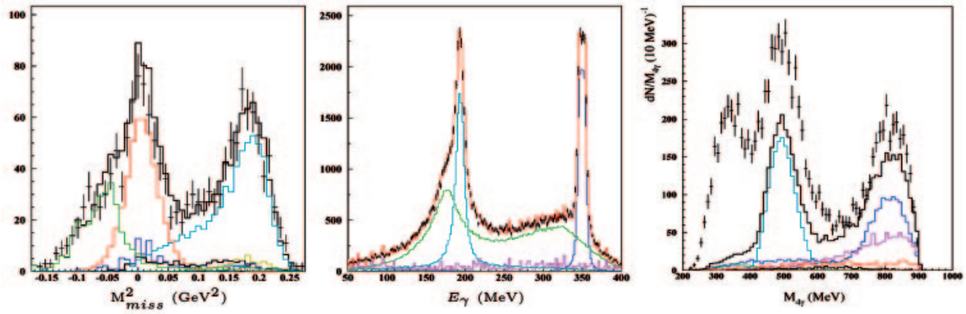

Fig. 1. – Left: fit of the M^2_{miss} distribution for the $e^+e^- \to e^+e^-\eta$ analysis. Main contributions are: $e^+e^-\gamma$ at negative M^2_{miss} values due to the pion mass assigned to e^+e^- tracks, $\eta\gamma$ at $M^2_{miss} \sim 0$, signal events at high M^2_{miss} values. Middle: fit of the monochromatic photon energy spectrum for $e^+e^- \to \eta\gamma$ events. The $\eta\gamma$ peak at about 350 MeV and the $\omega\gamma$ peak at about 180 MeV are visible; the broad distribution is due to $\omega\pi^0$ events. Right: $M_{4\gamma}$ spectrum for events selected in the $e^+e^- \to e^+e^-\pi^0\pi^0$ data analysis, compared with the sum of the expected backgrounds from Monte Carlo. The $K_S \to \pi^0\pi^0$ peak and structures related to other processes with two π^0 are visible: $\omega(\to \pi^0\gamma)\pi^0$ and $f_0(980)(\to 2\pi^0)\gamma$. The cut on $M_{4\gamma} < 900$ MeV is due to the requirement on the total energy in the calorimeter to reject $e^+e^- \to \gamma\gamma$ events.

opposite curvature coming from the collision point. The charged pion mass is assigned to the two tracks and a least squares function based on Lagrange multipliers imposes that $\pi^+\pi^-\pi^0$ come from an η decay. Therefore most background events are suppressed, except for the irreducible process $e^+e^- \to \eta\gamma \to \pi^+\pi^-\pi^0\gamma$, with the monochromatic photon lost in the beam pipe. Figure 1 (left) shows the distribution of M^2_{miss} for data fitted with the superposition of MC shapes for signal and background. An independent fit is performed with the distribution of p_L. Both fits show the same yields for the background processes and more than 600 signal events. Figure 1 (middle) shows the distribution of the energy of the monochromatic photon for a control sample of $e^+e^- \to \eta\gamma \to \pi^+\pi^-\pi^0\gamma$ events, selected asking for three photons in the final state and after performing a kinematic fit requiring energy and momentum conservation. Finally, a search for $e^+e^- \to e^+e^-\pi^0\pi^0$ events is performed, motivated by the interest in the $\gamma\gamma \to \sigma$ dynamics [4]. The main requirements of the data analysis are: four photons originated from $2\pi^0$ decays, no tracks in the drift chamber, photon energy fraction > 0.8, $p_{T4\gamma} < 80$ MeV, energy sum of the 2 least energetic photons > 60 MeV. The spectrum in the 4γ invariant mass compared with the expected backgrounds is shown in fig. 1 (right). From the plot, an excess is evident at low $M_{4\gamma}$ values, consistent in shape with expectations from $e^+e^- \to e^+e^-\pi^0\pi^0$ events. These results are encouraging in view of the forthcoming data-taking campaign of the KLOE-2 project [5], when both low- and high-energy $e^\pm$ tagging devices will be available.

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