Studies of the $\eta \to \gamma\, e^+e^-$ decay in pd reactions measured with WASA-at-COSY

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At the turn of October and November 2008, the WASA-at-COSY collaboration performed an experiment to collect data on the η meson decays in pd $\to {}^3$He$\,\eta$ reactions. The COSY accelerator provided a proton beam of momentum 1.7 GeV/c which has been used to produce η mesons by collisions with the deuteron target. Decay products of short-lived mesons were registered in the central part of the WASA detector and ^{3}He ions in the forward part. We report on the results of an investigation of the $\eta \to e^+e^-\gamma$ conversion decay. It is a very interesting decay since the electron and positron in the final state come from the conversion of a virtual γ quantum and, therefore, they constitute a rich source of knowledge about the electromagnetic structure of decaying meson. It is a very important feature of this decay process since the η meson is a short-lived neutral particle and it is not possible to investigate its structure via the classical method of particle scattering.

The performed analysis [1] allowed for the extraction of the η transition form factor as a function of the e^+e^- mass and, therefore, for the calculation of the slope parameter, related to the charge radius of the η meson.

525 ± 26 events of the $\eta \to e^+e^-\gamma$ decay channel were reconstructed. The applied restrictions allowed to suppress the background from the other η decays to a negligible level and the multipion background was subtracted from the signal, based on missing mass distributions evaluated for each $M_{e^+e^-}$ separately. The analysis chain led to the determination of the value of the slope parameter,

$$\begin{aligned} b_P &= \frac{dF_\eta}{dq^2}|_{q^2\simeq 0} = \Lambda^{-2} \\ &= (2.27 \pm 0.73_{\text{stat.}} \pm 0.46_{\text{sys.}})\,\text{GeV}^{-2}, \end{aligned} \qquad (1)$$

where the estimated systematical uncertainty should be treated as an upper limit only [1, 2]. This preliminary result is consistent with the one obtained by CB/TAPS collaboration, $(1.92 \pm 0.35_{\text{stat.}} \pm 0.13_{\text{sys.}})$ GeV^{-2} [3]. Distributions of the transition form factor as a function of the $M_{e^+e^-}$ mass extracted in both experiments are shown in the upper panel of **Fig.** 1. Within the statistical uncertainty, the obtained spectrum confirms the calculations of the Vector Meson Dominance (VMD) model (b_P= 1.78 GeV^{-2})[4]. The preliminary result obtained in this work is also in agreement with the one obtained using the $\eta \to \mu^+\mu^-(\gamma)$ decays, studied in the heavy ion experiment NA60, $(1.95 \pm 0.17_{\text{stat.}} \pm 0.05_{\text{sys.}})$ GeV^{-2}, in which photons were not registered [5].

The three results mentioned above, enabled to estimate the charge radius of the η meson

$$\begin{aligned} < r_\eta^2 >^{1/2} &= \sqrt{6 \cdot b_P} \\ &= 0.68 \pm 0.02 \text{ fm}. \end{aligned} \qquad (2)$$

This value is in disagreement with the VMD one ($< r_\eta^2 >^{1/2}$= 0.64 fm), calculated using the slope parameter given in [4], at the level of two standard deviations. It is also interesting to notice that the obtained radius of the η meson is smaller than the radius of charged pion of $< r_\pi^2 >^{1/2}$= (0.74 ± 0.03) fm [6].

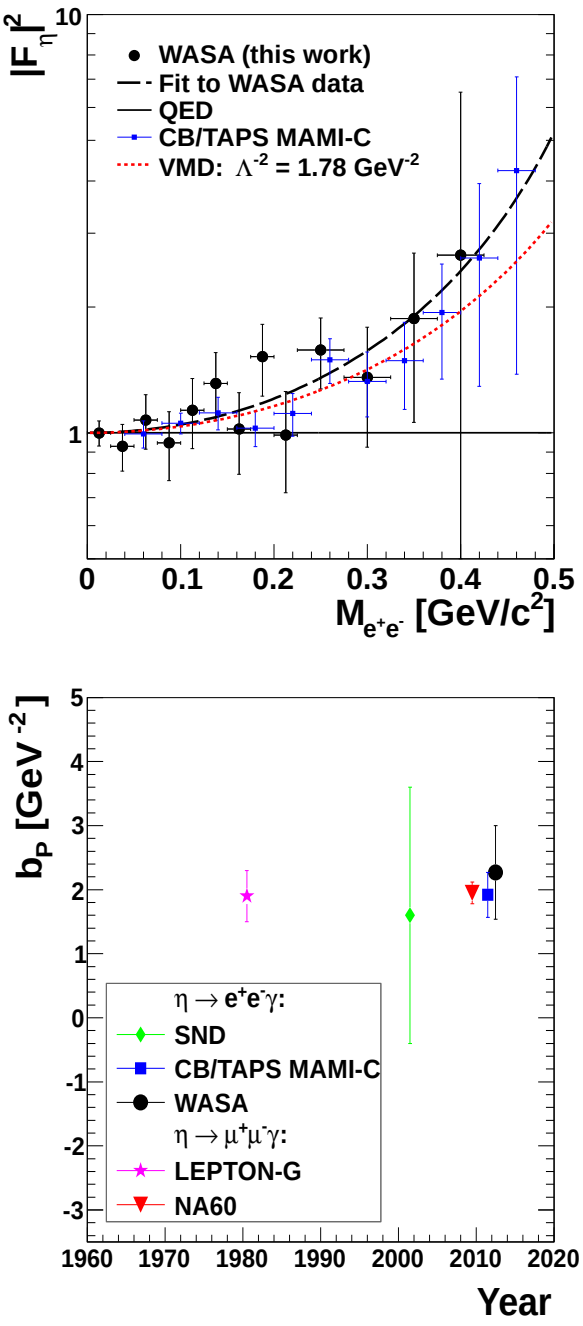

Fig. 1: **Upper panel:** Experimental spectrum of the squared transition form factor, $|F_\eta|^2$, as a function of the $M_{e^+e^-}$ obtained in this work (black points) and by the CB/TAPS experiment (blue points). The black, solid line shows the QED prediction for a point-like particle while the red, dashed line is the prediction of the VMD model. **Bottom panel:** The slope, b_P, of the η transition form factor. The preliminary result of this work is shown in comparison with previous results.

Based on the data collected in 2008 it was shown that WASA-at-COSY is a suitable tool to study the η transition form factor via the $\eta \to e^+e^-\gamma$ decay with a negligible background from other η decay channels. The estimated systematical uncertainty is negligible with respect to the statistical one. Therefore, it is tempting, in this context, to analyze the next data sample with higher statistics.

References:

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