The $\eta \to \gamma\, e^+e^-$ Decay from pd Reactions with WASA-at-COSY

M.Hodana[a b] *and P.Moskal[a b]

We report on the analysis of the $pd \to {}^3He\eta \to {}^3He\gamma e^- e^+$ reaction, measured with the WASA-at-COSY detector at a proton beam momentum of 1.69 GeV. The aim of this measurement is the investigation of the electromagnetic structure of the η meson by determining the transition form factor. Predictions based on the assumption that the η is a point-like particle (QED) as well as results of calculations in the framework of the Vector Meson Dominance (VMD) model [1] are compared in Fig 1. The points show the invariant mass distribution of e^+e^- pairs obtained from simulations using the WASA Monte Carlo software.

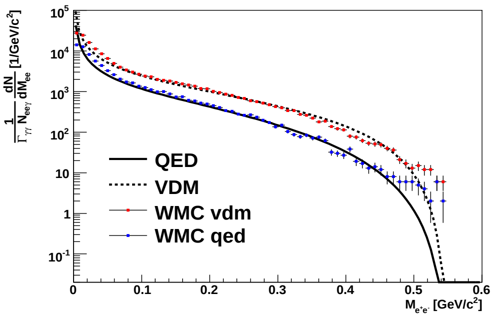

Fig. 1: Invariant mass distribution $M_{e^+e^-}$ for the $\eta \to e^+e^-\gamma$ decay. The solid line shows the QED predictions for a point-like particle while the dashed line represents the VMD form factor. Points indicate simulations of 2.5×10^5 $\eta \to e^+e^-\gamma$ events in the case of QED and 5×10^5 $\eta \to e^+e^-\gamma$ events for VMD model.

In order to select the reaction of interests the following criteria for the particle identification have been applied. ${}^3He$ has been identified based on the energy deposition in the forward detector (FD) - see Fig. 2, left. Additionaly, based on the simulation a restriction on the ${}^3He$ polar angle to be less then 10° has been made (Fig. 3).

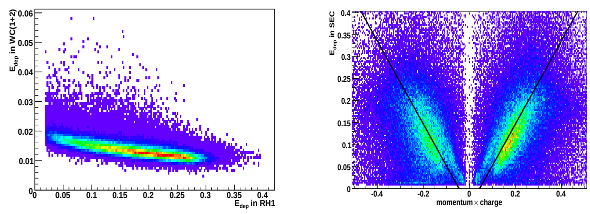

Fig. 2: Left: Energy loss in both layers of the first, thin forward detector array (FWC) versus energy loss in the first layer of the forward range hodoscopes (FRH) - the band of ${}^3He$ particles is visible. Right: e/π identification with the CD - energy loss in the calorimeter (SEC) versus magnetic rigidity. Both spectra are obtained from data.

The e^+e^- pairs are selected by demanding events with two, opposite charged tracks in the central detector and distinquishing between electrons and pions by their energy deposit. For the identification of the γ particle, the following is required: γ energy higher than 120 MeV and, in the η rest

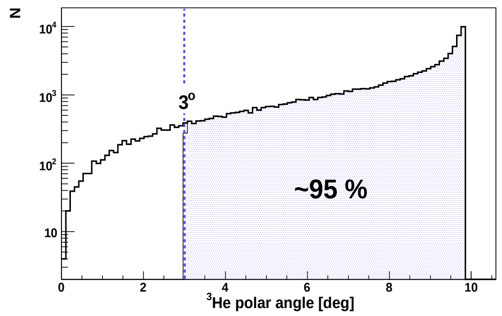

Fig. 3: PLUTO simulation of the ${}^3He$ emission angle. The dotted line shows the geometrical boundary of the forward detector (due to the central hole for the beam pipe). Nearly 95% of ${}^3He$ are within the forward acceptance.

frame, the opening angle between the photon and the lepton pair (which forms the virtual photon) closest to 180° .
The acceptance of the WASA detector for these cuts is plotted in Fig. 4. For the simulation the PLUTO[2] events generator has been used.

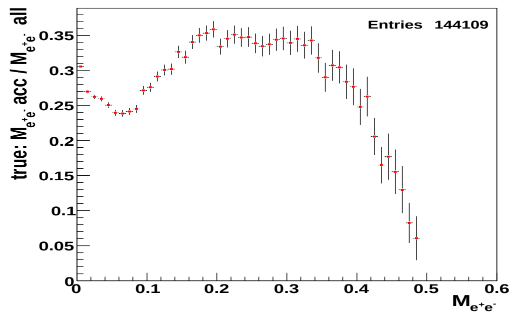

Fig. 4: The acceptance for the $pd \to {}^3He\eta \to {}^3Hee^+e^-\gamma$ reaction obtained from the simulation of 5×10^5 η-Dalitz events.

The most important background contributions stem from reactions with pions due to pion-electron misidentification. Of great importance is the $\eta \to \gamma\gamma$ decay due to its high branching ratio and the high possibility of external conversion. For the background studies, the following reactions have been considered:

$$\eta \to \gamma\gamma \to (e^+e^-)\gamma$$
$$\eta \to \pi^+\pi^-\gamma$$
$$\eta \to \pi^+\pi^-\pi^0 \to \pi^+\pi^-(\gamma\gamma)$$
$$\eta \to \pi^0\pi^0\pi^0 \to 6\gamma$$
$$pd \to {}^3He\pi^+\pi^-$$
$$pd \to {}^3He\pi^+\pi^-\pi^0$$

with the conditions:

70°	<	$\gamma^*\gamma$ opening angle (lab.)	<	-
2.6 GeV	<	$MM_{e^+e^-\gamma}$	<	2.9 GeV
80°	<	$\lvert\Phi_{\gamma*} - \Phi_\gamma)\rvert$	<	300°

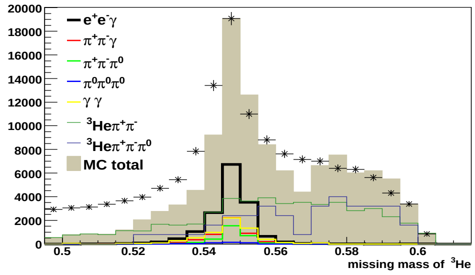

Fig. 5: Missing mass of ^3He. The Monte Carlo spectra are normalized with the respective cross sections. Data are normalized to the total Monte Carlo in order to compare shapes of spectra.

The Monte Carlo spectra have been normalized according to the appropiate cross sections, for 10^7 $pd \rightarrow {}^3He\eta$. The data have been scaled to the total simulation using the maximum bin content.
The further, refined analysis will be done in order to suppress the pion contribution.

References:

[1] L. G. Landsberg, Physics Reports, **128** (6), p.301-376, Nov 1985.
[2] I. Frhlich et al., PoS ACAT2007, 076 (2007) [arXiv:0708.2382 [nucl-ex]]

[a] Institut für Kernphysik and Jülich Center for Hadron Physics, D-52425 Jülich, Germany
[b] Institute of Physics, Jagiellonian University, PL-30059 Cracow, Poland
* Supported by COSY-FFE