KLOE FIRST RESULTS ON HADRONIC PHYSICS

THE KLOE COLLABORATION[a]
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The KLOE experiment has collected 2.4 pb^{-1} of integrated luminosity during the 1999 data-taking. This data sample has been used to study the radiative decays of the $\phi(1020)$ meson: $\phi \to \pi^0\pi^0\gamma$, $\pi^+\pi^-\gamma$, $\eta\pi^0\gamma$ and $\phi \to \eta\gamma$, $\eta'\gamma$. The preliminary results are reported in this paper. The analysis of the Dalitz plot of the decay $\phi \to \pi^+\pi^-\pi^0$ is also presented.

1 Introduction

The KLOE experiment [a,1] has started taking data at the DAΦNE ϕ-factory[2] in April 1999. An integrated luminosity of 2.4 pb^{-1} has been collected during the 1999 run, that correspond to about 8 millions of ϕ produced. Such a statistics has been used to perform some studies of the ϕ radiative decays, providing also a good check of the detector performances. The decays $\phi \to \pi^0\pi^0\gamma$, $\pi^+\pi^-\gamma$, $\eta\pi^0\gamma$ have been exploited to study the scalar mesons $f_0(980)$ and $a_0(980)$. With $\phi \to \eta\gamma$, $\eta'\gamma$ a measurement of the $\eta-\eta'$ mixing angle has been performed. The Dalitz plot of the decay $\phi \to \pi^+\pi^-\pi^0$ has been analysed, looking for a possible contribution of the direct decay, and to obtain a new measurement of the ρ line-shape parameters.

A more detailed description of the analyses presented in this paper can be found in ref.[3].

2 Radiative decays

2.1 *The scalar sector: $\phi \to f_0\gamma$, $a_0\gamma$*

The nature of the scalar mesons $f_0(980)$ and $a_0(980)$ is not well established, alternative hypotheses with respect to the standard $\mathrm{q\bar{q}}$ structure have been proposed: a $\mathrm{q\bar{q}q\bar{q}}$ state or a $K\bar{K}$ bound state. According to the theory the branching ratios of $\phi \to f_0\gamma$ and $\phi \to a_0\gamma$ are sensitive to the structure of the particles, then their measurement can help in understanding the nature of $f_0(980)$ and $a_0(980)$.

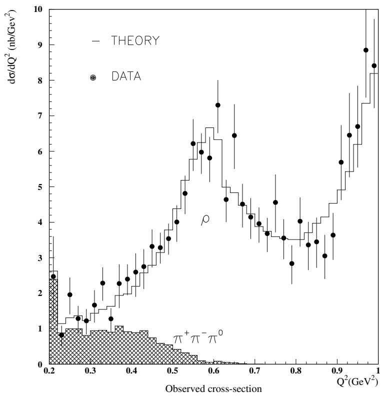

Figure 1. $\phi \to \pi^+\pi^-\gamma$ cross-section as a funcion of $Q^2 = M^2_{\pi\pi}$, compared to the theoretical one for pure QED contribution.

Three processes are expected to contribute to the $\phi \to \pi^+\pi^-\gamma$ decay: *(i)* the $f_0\gamma$ intermediate state, with $f_0 \to \pi^+\pi^-$, *(ii)* the Initial State Radiation in which the photon is emitted by an incoming electron or positron, and *(iii)* the Final State Radiation in which the photon is emitted by a pion (interference with $\phi \to f_0\gamma$ is expected).

$\pi^+\pi^-\gamma$ events have been selected from a partial sample of 1.8 pb^{-1} with an overall efficiency of 50%, evaluated by Montecarlo (MC). The invariant mass spectrum of the

[a] The full author list can be found in ref.[3]

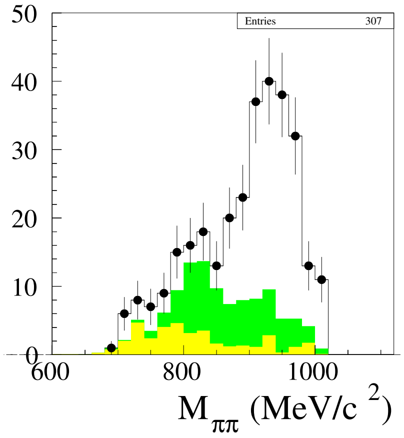

Figure 2. Invariant mass of the $\pi^0\pi^0$ system for $\phi \to f_0\gamma$ selected events. Points: data; histograms: backgrounds (mainly from $e^+e^- \to \omega\pi^0$).

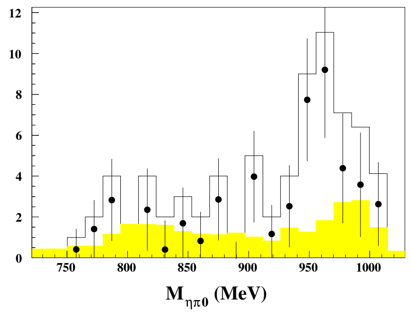

Figure 3. Invariant mass of the $\eta\pi^0$ system, histogram: data; shadowed histogram: expected background (MC); points: data-background difference.

two pions (fig.1) has been fitted to the theoretical prediction, excluding the f_0 region, $M^2_{\pi\pi}$ >0.84 GeV^2. By extrapolating to the signal region, no evidence of the f_0 has been found, then the upper limit Br($\phi \to f_0\gamma \to \pi^+\pi^-\gamma$)< 1.6$\cdot10^{-4}$ at 90% C.L. can be set.

The 5 photon events have been selected to study both $\phi \to f_0\gamma$ (with $f_0 \to \pi^0\pi^0$) and $\phi \to a_0\gamma$ (with $a_0 \to \eta\pi^0$ and $\eta \to \gamma\gamma$) decays. The main background for the first decay is the non resonant process $e^+e^- \to \omega\pi^0$ with $\omega \to \pi^0\gamma$. The two processes can be separated by using a kinematic fit. In fig.2 is reported the invariant mass spectra of the two pions for $\phi \to f_0\gamma$ selected events. 307$\pm$18 $f_0\gamma$ events have been selected from the 1.8 pb^{-1} sample, with 40% efficiency and with an estimated background of 112$\pm$11 (from MC), corresponding to Br($\phi \to f_0\gamma \to \pi^0\pi^0\gamma$)=(0.81$\pm$0.09$_{stat}\pm$0.06$_{syst}$)$\cdot10^{-4}$.

With different topological cuts 529$\pm$23 $\omega\pi^0$ events have been selected (ε=35%) with a background of 93$\pm$10 events. The cross section at the ϕ peak can be extracted: $\sigma(e^+e^- \to \omega\pi^0)$=0.67$\pm$0.04$_{stat}\pm$0.05$_{syst}$ nb.

Concerning the $\phi \to \eta\pi^0\gamma$ decay, the whole 2.4 pb^{-1} sample has been analysed, and 74$\pm$9 events have been selected with an efficiency of 23%. The expected contamination is 21$\pm$6 events. In the $\eta\pi$ invariant mass spectrum, reported in fig.3, is clearly visible the peak of the $a_0(980)$. Using the value Br($\eta \to \gamma\gamma$)=39.2% from PDG, one obtains Br($\phi \to \eta\pi^0\gamma$)=(0.77$\pm$0.15$_{stat}\pm$0.10$_{syst}$)$\cdot10^{-4}$.

2.2 *The pseudoscalar sector: $\phi \to \eta\gamma,\ \eta'\gamma$*

The reason for studying the radiative ϕ decays into η and η' is twofold since the measurement of Br($\phi \to \eta'\gamma$) can help in defining the gluonic content of η' while from the ratio R=Br($\phi \to \eta'\gamma$)/Br($\phi \to \eta\gamma$) the value of the $\eta - \eta'$ mixing angle ϑ_p can be extracted[4].

Charged ($\phi \to \eta\gamma \to \pi^+\pi^-\pi^0\gamma$ and $\phi \to \eta'\gamma \to \eta\pi^+\pi^-\gamma$ with $\eta \to \gamma\gamma$) and neutral ($\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$ and $\phi \to \eta'\gamma \to \eta\pi^0\pi^0\gamma$ with $\eta \to \gamma\gamma$) final states have been exploited.

In the charged final state, 21$\pm$4.6 $\eta'\gamma$ events have been selected (see fig.4), with an overall efficiency of 19%, togheter with about 6700 $\eta\gamma$ events (ε=32%). From these numbers a value of R=(7.1$\pm$1.6$_{stat}\pm$0.3$_{syst}$)$\cdot10^{-3}$ has been obtained. From the known Br($\phi \to \eta\gamma$), one can obtain also Br($\phi \to \eta'\gamma$)=(8.9$\pm$2.0$_{stat}\pm$0.6$_{syst}$)$\cdot10^{-5}$.

Concerning the 7 photon final state, the decay chain $\phi \to \eta'\gamma \to \eta\pi^0\pi^0\gamma$ has been detected for the first time: $6^{+3.3}_{-2.2}$ events have been selected with an esti-

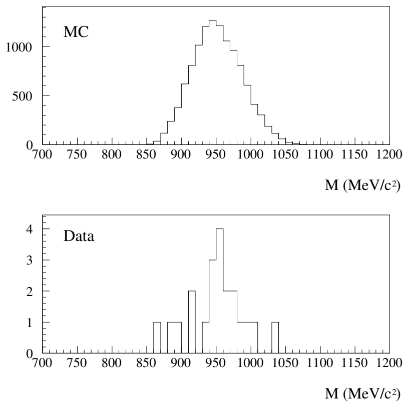

Figure 4. Invariant mass of the two charged tracks and the two most energetic photons for the 21 events selected as $\phi \to \eta'\gamma$, compared to MC.

mated efficiency of 13%. From these events and from the about 11000 $\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$ selected ones (ε=41%), a value R=$(6.9^{+3.3}_{-2.2}\,_{stat}\pm0.9_{syst})\cdot10^{-3}$ can be derived. Combining the two R measurements one obtains for the mixing angle ϑ_p=$(-18.9^{+3.6}_{-2.8}\,_{stat}\pm0.6_{syst})^o$.

3 $\phi \to \pi^+\pi^-\pi^0$

About 15% of the ϕ decay into $\pi^+\pi^-\pi^0$, three different processes are expected to contribute to this final state: *(i)* $\phi \to \rho\pi$ in all the three possible charge states, *(ii)* the direct decay $\phi \to \pi^+\pi^-\pi^0$ and *(iii)* $e^+e^- \to \omega\pi^0$ with $\omega \to \pi^+\pi^-$. The Dalitz plot (fig.5) has been filled with 330000 events selected in a 2.1 pb^{-1} partial sample and then fitted to the function (X and Y are the two Dalitz plot variables, and $\vec{p}^{\,+}$, $\vec{p}^{\,-}$ are the momenta of π^+ and π^-):

$$f(X,Y) = |\vec{p}^{\,+}\times\vec{p}^{\,-}|^2\cdot|\mathbf{A}_{\rho\pi}+\mathbf{A}_{\mathbf{direct}}+\mathbf{A}_{\omega\pi}|^2 \quad (1)$$

The free parameters of the fit are: the ρ^0 mass, the mass difference ΔM between the charged and neutral ρ, the ρ width, a modulus and a phase for the direct term $\mathbf{A}_{\mathbf{direct}}$, and a modulus and a phase for $\mathbf{A}_{\omega\pi}$ term, while the ω mass and width have been fixed to the PDG values. The results of the fit are shown in tab.1 where the parameters are compared to the PDG values: the ρ line-shape parameters are in agreement with the PDG ones, the mass difference is compatible with zero, and there is an indication of a sizeable direct term (10% of the $\rho\pi$ term) with a relative phase close to 90^o.

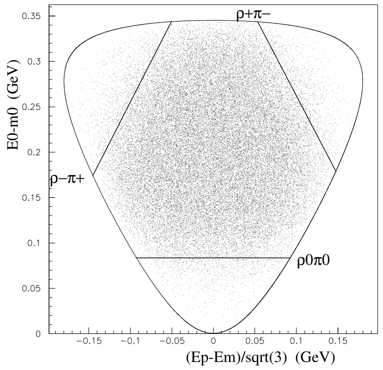

Figure 5. Dalitz plot of $\phi \to \pi^+\pi^-\pi^0$.

Table 1. Results of the fit to the Dalitz plot.

Parameter	Fit result	PDG value
M_{ρ^0} (MeV)	776±1.0	776.0±0.9
ΔM (MeV)	-0.5±0.7	0.1±0.9
Γ_ρ (MeV)	145.6±2.2	150.9±2.0
$A_{direct}/A_{\rho\pi}$	0.10±0.01	-0.15±0.11
phase$_{direct}$/phase$_{\rho\pi}$	$(114\pm12)^o$	

References

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2. S.Guiducci et al., Proceedings of PAC99, New York, March 1999.
3. The KLOE Collaboration, Contributed paper No.220 to this Conference, hep-ex/0006036 (2000).
4. A.Bramon et al., *Eur.Phys.J.* C **7**, 271 (1999).