Frascati Physics Series Vol. XXXVI (2004), pp.
DAΦNE 2004: Physics at meson factories – Frascati, June 7-11 , 2004
Selected Contribution in Plenary Session

PROGRESS ON Φ RADIATIVE DECAYS WITH THE KLOE EXPERIMENT.

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ABSTRACT

We describe the status of the analyses in progress on light meson spectroscopy in the KLOE experiment. We present the analyses of ϕ decays into $f_0(980)\gamma$,

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the Dalitz plot analysis of the $\eta \to \pi^+\pi^-\pi^0$ decay, the branching ratio measurement of $\eta \to \pi^0\gamma\gamma$, the upper limits on $Br(\eta \to 3\gamma)$ and $Br(\eta \to \pi^+\pi^-)$, the measurement of the ratio $Br(\phi \to \eta'\gamma)/Br(\phi \to \eta\gamma)$.

1 Introduction

The KLOE detector [1], operates at the Frascati e^+e^- collider DAΦNE [2], which runs at a CM energy W equal to the ϕ-meson mass, W∼1019.5 MeV. The analyses presented here are based on data collected in the years 2001 and 2002 for an integrated luminosity of $\sim$ 450 pb^{-1} corresponding to 20 millions of η mesons [Br($\phi \to \eta\gamma$) $\sim$ 1.3% [3]]. This means that KLOE can study η physics in a clean environment with high statistic.

2 Search for $\phi \to$f$_0\gamma$ in $\pi^+\pi^-\gamma$ events.

The ϕ radiative decays to scalar mesons, $\phi \to$Sγ, give significant insight in the assessment of the nature of lower mass scalar mesons [4]. An overall fit of these data is in progress, with the aim of extracting the f$_0$ parameters taking into account all the possible interferences of the f$_0$ term with the other amplitudes.

The search for $\phi \to$f$_0(\to \pi^+\pi^-)\gamma$ is characterized by the presence of irreducible backgrounds due to the initial state radiation (ISR), to $e^+e^- \to \pi^+\pi^-\gamma$ (FSR) and $\phi \to \rho^\pm(\to \pi^\pm\gamma)\pi^\pm$. The f$_0$ events are searched for in the large photon angle region $45^o < \theta <135^o$ to reduce ISR background. The f$_0$ signal appears as a bump in the $\pi^+\pi^-$ invariant mass M$_{\pi\pi}$ spectrum around 980 MeV. Fig.1 (left) shows the spectrum obtained at $\sqrt{s} = M_\phi$.
An overall fit to the spectrum has been done applying the following formula:

$$\frac{dN}{dM_{\pi\pi}} = \left[(\frac{d\sigma}{dM_{\pi\pi}})_{ISR} + (\frac{d\sigma}{dM_{\pi\pi}})_{FSR+f_0} + (\frac{d\sigma}{dM_{\pi\pi}})_{\rho\pi}\right] \times L \times \epsilon(M_{\pi\pi})$$

with L the integrated luminosity and $\epsilon(M_{\pi\pi})$ the selection efficiency as a function of $M_{\pi\pi}$. The f$_0$ amplitude is taken from the kaon-loop approach [4]. A forward-backward asymmetry $A = \frac{N^+(\theta>90^o)-N^+(\theta<90^o)}{N^+(\theta>90^o)+N^+(\theta<90^o)}$ is expected, due to the interference between FSR and ISR [5]. Fig.1 (right) shows the asymmetry as a function of M$_{\pi\pi}$ compared to the prediction based on the ISR-FSR interference alone. A significant deviation from the prediction is observed in the high mass region clearly due to the f_0 contribution.

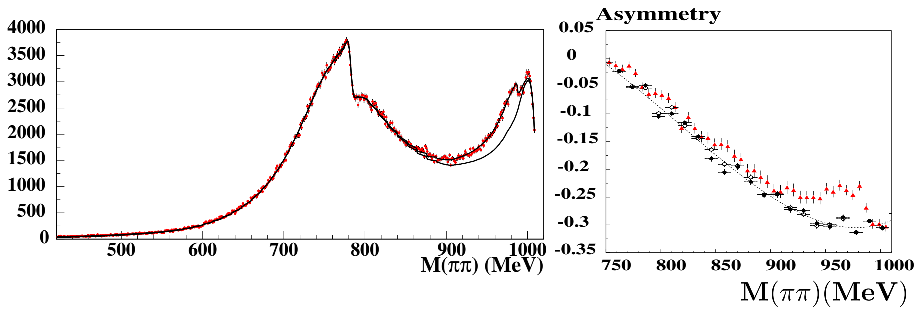

Figure 1: *(left) $M_{\pi\pi}$ spectrum of $\pi^+\pi^-\gamma$. The upper (lower) curves are the result of the fit and the estimated background due to ISR, FSR and $\rho\pi$. (right) Forward-Backward asymmetry A as a function of $M_{\pi\pi}$. The curve and the black points are the Montecarlo expectations based on the interference between FSR and ISR only. The experimental data are reported as triangles.*

3 Dynamics of $\eta \to \pi^+ \pi^- \pi^0$

The dynamics of the $\eta \to \pi^+ \pi^- \pi^0$ decay has been studied with a Dalitz plot analysis. The conventional variables X and Y are defined as: $X = \sqrt{3}\frac{T_+ - T_-}{Q_\eta}$,$Y = \frac{3T_0}{Q_\eta} - 1$, where $Q_\eta = m_\eta - 2m_{\pi^+} - m_{\pi^0}$ and T_+, T_- and T_0 are the kinetic energies of the particles. The measured distribution has been fitted as: $|A(X,Y)|^2 \simeq (1 + aY + bY^2 + cX + dX^2 + eXY + ...)$. C-parity conservation prevents odd powers in X being present in the expansion: thus parameters c and e should be zero as confirmed by our fit. The results of the fit are shown in table 3 Efficiency is ~ 36 % over the whole Dalitz plot. The

Table 1: *Fitted parameters $P(\chi^2)$ = 52 od $\eta \to 3\pi$ Dalitz plot.*

a	b	c
$-1.075 \pm .008$	$.118 \pm .009$	$-.0005 \pm .004$
d	e	f
$.049 \pm .008$	$-.004 \pm .01$	$.13 \pm .02$

evaluation of systematic effects is under completion.

4 Rare and forbidden η decays ($\eta \to \pi^0\gamma\gamma$,$\eta \to \pi^+\pi^-$,$\eta \to \gamma\gamma\gamma$)

The $\eta \to \pi^0\gamma\gamma$ decay is interesting to test the Chiral Perturbation Theory prediction for the branching ratio and $m_{\gamma\gamma}$ spectrum. [6]. The most accurate measurement for the branching ratio [7] is, infact, far from any theoretical prediction for this decay based on ChPT. Recently a new measurement has been performed [8] giving a much lower value than the previous one, with a larger error. All previous experiments were done at hadron machines, using mainly $\pi^- p \to \eta n$, and are largely dominated by $\pi^0\pi^0$ background and geometrical acceptance. KLOE can perform a measurement of competitive precision in a cleaner environment. Furthermore, it has different background topologies and experimental systematics. The signal is searched looking for a $\pi^0\gamma\gamma\gamma$ topology, where the further γ comes from $\phi \to \eta\gamma$. Five prompt clusters are required and an overall kinematic fit requiring π^0 mass is performed. The clusters energy must be > 30 MeV and azimutal angle $> 21°$ to reject fake clusters coming from machine background. The dominant background channel is $\eta \to 3\pi^0$ that has been reduced with several topological cut. With this selection we obtain an efficiency of 5.7 %. To give an idea of the sensitivity, in fig.2 we compare our data together with MC prediction based on the $Br(\eta \to \pi^0\gamma\gamma)$ measured by [7] and [8]. It is evident that our data are incompatible with [7] and are marginally in agreement with [8]. The background simulation and the efficiency for the signal is still under study.

$\eta \to 3\gamma$ decay is C violating. It is a sensitive test of C violation in the strong and electromagnetic interactions. For the details of this analysis see [9]. The KLOE result for the branching ratio is: $Br(\eta \to \gamma\gamma\gamma) \leq 1.6 \times 10^{-5}$ @90 % C.L. This limit is the experimental best limit for this decay. The expected branching ratio from the Standard Model is $\leq 10^{-12}$ [10], so any discovery of a larger decay rate would be a clear signal of Standard Model deviation.

$\eta \to \pi^+\pi^-$ decay is P and CP violating. This decay is allowed as a weak direct CP violating decay with a very low branching ratio: BR($\eta \to \pi^+\pi^-$)$\sim 10^{-27}$ [11]. Therefore the detection of this decay at an accessible level would be a signal of P and CP violation not explainable in the Standard Model

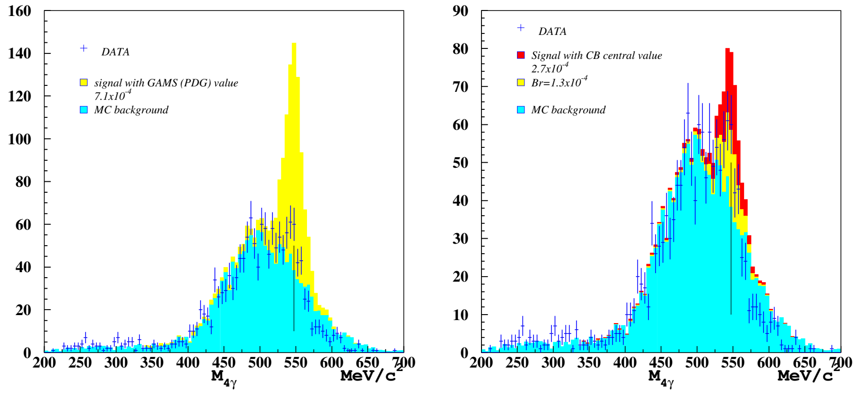

Figure 2: *$M(4\gamma)$, the spectra expected from the GAMS* [7] *and Crystall Ball* [8] *measurement are shown. In the right plot we show also the expected spectrum for a Br $\sim 1/2$ of C.B. result.*

framework. The latest published [12] direct search of this decay has given the following 90% C.L. upper limit: $BR(\eta \to \pi^+\pi^-) < 3.3 \times 10^{-4}$. In KLOE the signal is searched in the M(η) region of the $\pi^+\pi^-$ invariant mass spectrum of $\pi^+\pi^-\gamma$ events selected according to the $f_0(980) \to \pi^+\pi^-$ analysis described before (see fig. 1). The signal efficiency is: ϵ_s=16.6%. The expected signal has a Gaussian shape with a mass resolution of 1.33 MeV. No signal is observed. The background is determined by fitting the theoretical model for $\pi^+\pi^-\gamma$ sample to the full spectrum. In order to determine an upper limit, we have added to this background a Gaussian function representing the signal multiplied by a constant N_s. We obtain: $N_s = -8 \pm 24$. The 90% confidence level upper limit on the number of events is obtained using the tables in [13]: $N_s < 32$. The branching ratio is $BR(\eta \to \pi^+\pi^-) = \frac{N_s}{\epsilon_s N_\eta}$ with N_η the number of η in the sample (1.43×10^7). The 90% C.L. upper limit is: $BR(\eta \to \pi^+\pi^-) < 1.3 \times 10^{-5}$. It improves by a factor ~ 30 the present best limit.

5 η- η' mixing

Here we present the $R = \frac{\Gamma(\phi \to \eta'\gamma\ )}{\Gamma(\phi \to \eta\gamma\ )}$ measurement. The η' is identified via the decays: $\phi \to \eta'\gamma$; $\eta' \to \pi^+\pi^-\eta$; $\eta \to \pi^0\pi^0\pi^0$ and the decays $\phi \to \eta'\gamma$;

$\eta' \rightarrow \pi^0 \pi^0 \eta$; $\eta \rightarrow \pi^+ \pi^- \pi^0$. The final state is thus charachterized by two charged pions and seven photons, and has no physics background with the same topology in KLOE. After background subtraction we observe $3405 \pm 61 \pm 31$ $\phi \rightarrow \eta' \gamma$ events. We normalize to the number of observed $\eta \rightarrow \pi^0 \pi^0 \pi^0$ decays in the same runs to obtain a preliminary measurement of the ratio of BR's:$R = (4.9 \pm 0.1_{stat} \pm 0.2_{syst}) \times 10^{-3}$. This result compare favourably with our previous estimate [14] (which already dominates the world average [3]) but with considerably improved accuracy.

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