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First Results from MARK III at SPEAR*

The MARK III Collaboration
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1. INTRODUCTION

The MARK III detector, operating at SPEAR, has collected $\sim 2.7 \times 10^6$ ψ decays and 4500 nb^{-1} of ψ'' decays. Preliminary results from the full ψ sample are presented.

The detector is a general purpose magnetic spectrometer optimized for the SPEAR energy region. Several features of the detector relevant to the reported results are: charged particle tracking over .85 of 4π [1], 175 psec TOF resolution,[2] and a finely segmented gas proportional tube/lead shower counter.[3] A 4–C kinematic fit is done, using all the particles in the final state, to improve the overall resolution. The resulting mass resolution is $\sigma_m = 5$–20 MeV for final states containing up to 4 or 5 photons. Typical efficiencies are 20%-50%for detection, reconstruction and fitting of such final states.

2. RESULTS ON HADRONIC DECAYS

The decay $\psi \to \pi^+\pi^-\pi^0$ has been measured to proceed predominantly through the two body intermediate state $\rho\pi$. The Dalitz plot (Fig. 1) indicates the ability of the MARK III to reconstruct this final state over the full kinematic range. The rate has been measured to be: $BR(\psi \to \pi^+\pi^-\pi^0) = (1.49 \pm .22) \times 10^{-2}$, where the quoted error is entirely systematic. This result is consistent with previous measurements.

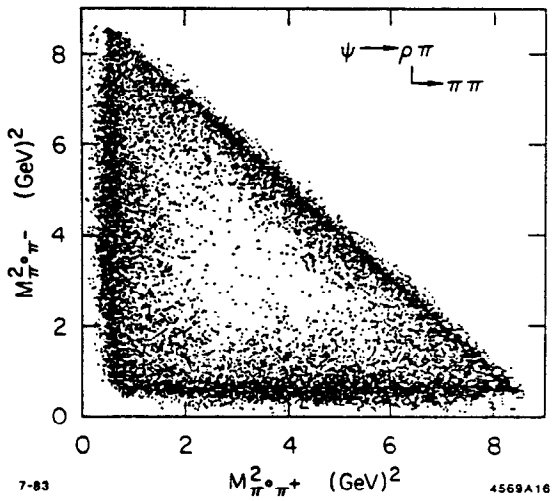

Fig. 1. $\psi \to \pi^+\pi^-\pi^0$ Dalitz plot showing $\rho\pi$ dominance.

3. DECAYS OF THE η_c

The decay $\eta_c \to p\bar{p}$ has been observed. The measured rate is: $BR(\psi \to \gamma\eta_c) \times BR(\eta_c \to p\bar{p}) = (2.2 \pm .6 \pm .5) \times 10^{-5}$ and the measured parameters are: $m = 2.980 \pm .005$ GeV , $\sigma = .020 \pm .010$ GeV. The measured width is consistent with the current understanding of the detector resolution. Using the Crystal Ball measurement for the inclusive rate: $BR(\psi \to \gamma\eta_c) = (1.27 \pm .36) \times 10^{-2}$, one gets: $BR(\eta_c \to p\bar{p}) = (.18 \pm .09) \times 10^{-2}$ which is similar to the analogous measurement: $BR(\psi \to p\bar{p}) = (.22 \pm .02) \times 10^{-2}$.

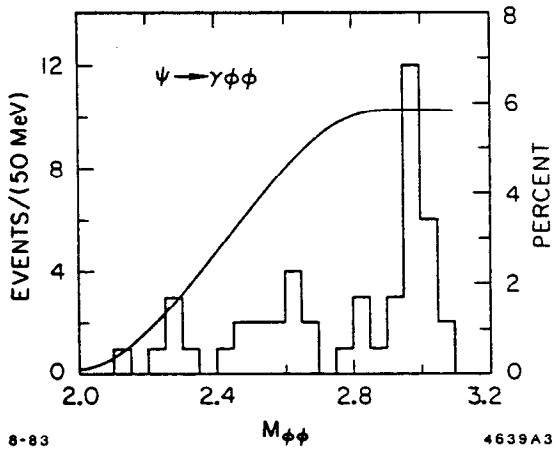

Fig. 2. $\psi \to \gamma\phi\phi$ mass plot with the detection efficiency overplotted.

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The decay $\eta_c \rightarrow \phi\phi$ has been observed for the first time (Fig. 2). The measured rate is: BR($\psi \rightarrow \gamma\eta_c$) $\times$ BR($\eta_c \rightarrow \phi\phi$) $= (1.2 \pm .3) \times 10^{-4}$ and the measured parameters are: m=2.978 $\pm$ .006 GeV , σ =.028 $\pm$ .006 GeV. Again, the measured width is consistent with the detector resolution. Using the Crystal Ball measurement for the inclusive rate, one gets: BR($\eta_c \rightarrow \phi\phi$) = $(1.0 \pm .4) \times 10^{-2}$. Further analysis of $\eta_c \rightarrow \phi\phi$ was done to extract the quantum numbers of the η_c. Following the analysis of Trueman [4], the angle χ is defined as the azimuthal angle between the $\phi \rightarrow K^+K^-$ decay planes. The expected distribution is $1+\beta \cos 2\chi$, where β is sensitive to the parity as well as the spin. A non-zero value for β implies the spin is even, in which case the sign of β gives the parity of the parent particle. A maximum likelihood fit to the data gives: $\beta = -1.0^{+0.09}_{-0.0}$, in excellent agreement with the expected value of β =-1.0 for $J^P = 0^-$ (Fig. 3).

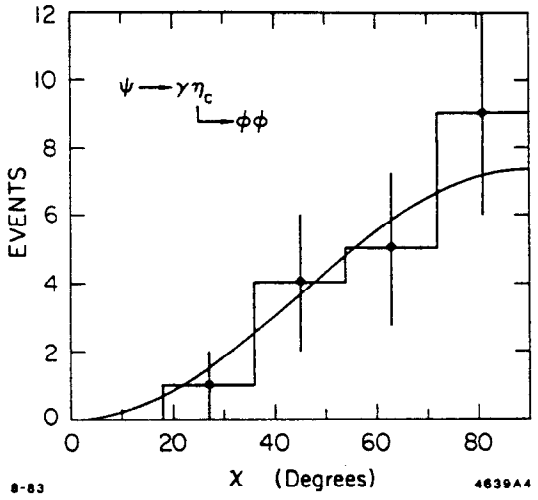

Fig. 3. $\psi \rightarrow \gamma\eta_c$, $\eta_c \rightarrow \phi\phi$ distribution in the χ angle with the $J^P = 0^-$ curve overplotted.

4. RESULTS ON RADIATIVE DECAYS

The decay $\psi \rightarrow \gamma\pi^+\pi^-$ has been measured and the dominant process is $\psi \rightarrow \gamma f(1270)$. The rate has been measured to be: BR($\psi \rightarrow \gamma f(1270)$) $\times$ BR($f(1270) \rightarrow \pi\pi$) $= (1.41 \pm .07 \pm .20) \times 10^{-3}$ and the results of a Breit-Wigner fit are: m = 1.278 $\pm$ .005 GeV , Γ = .155 $\pm$ .015 GeV. In addition, an angular correlation analysis of the polarization of the $f(1270)$ yields: x = A_1/A_0 =.77 $\pm$ .05 and y = A_2/A_0 =.01$\pm$ .06, where A_0, A_1, A_2 are the amplitudes for helicity 0,1,2 respectively. These results are in agreement with previous measurements made at SPEAR and DORIS.

The decay $\psi \rightarrow \gamma\eta'$ has been observed in two modes: $\eta' \rightarrow \gamma\rho^0$ and $\eta' \rightarrow \eta\pi^+\pi^-$. The results for the two modes are in agreement and indicate the mass resolution attainable with kinematic fitting in 2 and 3 photon final states. For $\eta' \rightarrow \gamma\rho^0$ the results are: BR($\psi \rightarrow \gamma\eta'$) = $(4.7 \pm .3 \pm .9) \times 10^{-3}$, m = .957 $\pm$ .0005 GeV , σ = .009 $\pm$ .0004 GeV. For $\eta' \rightarrow \eta\pi^+\pi^-$ the fit results are: BR($\psi \rightarrow \gamma\eta'$) = (4.6 $\pm$ .4 $\pm$ .65) $\times 10^{-3}$, m = .958 $\pm$ .0003 GeV , σ = .0057 $\pm$ .0005 GeV.

The decay $\psi \rightarrow \gamma\iota(1440)$ has been seen by the MARK III in three different $K\bar{K}\pi$ modes: $\iota \rightarrow K^+K^-\pi^0$, $\iota \rightarrow K^0_S K^\pm \pi^\mp$, and $\iota \rightarrow K^0_S K^0_S \pi^0$. The $K^0_S K^0_S \pi^0$ mode has been observed for the first time. The results from an analysis of the $K^+K^-\pi^0$ final state BR($\psi \rightarrow \gamma\iota$) $\times$ BR($\iota \rightarrow K\bar{K}\pi$) = $(5.3 \pm 0.6 \pm 1.9) \times 10^{-3}$ and a Breit-Wigner fit gives: m = 1.46 $\pm$ .01 GeV , Γ =.097$\pm$ .025 GeV.

The decay $\psi \rightarrow \gamma K\bar{K}$ has been seen in two modes K^+K^- (Fig. 4) and $K^0_S K^0_S$. There are two mass regions of interest. In the 1-2 GeV mass region, the $f'(1515)$ and the $\theta(1700)$ are clearly separated. The results from a fit using incoherent Breit-Wigners are: BR($\psi \rightarrow \gamma f'$ (1515)) $\times$ BR($f'(1515) \rightarrow K^+K^-$) = $(1.6 \pm .3 \pm .35) \times 10^{-4}$ and BR($\psi \rightarrow \gamma\theta(1700)$) $\times$ BR($\theta(1700) \rightarrow K^+K^-$) = $(4.8 \pm .7 \pm .9) \times 10^{-4}$, where the $f'(1515)$ parameters are fixed to be: m = 1.515 GeV , Γ = .075 GeV; and the $\theta(1700)$ parameters are measured to be: m = 1.719 $\pm$ .006 GeV , Γ = .117 $\pm$ .023 GeV.

The higher mass region contains a suprising new state seen at $\sim$ 2.2 GeV. The statistical significance of this state is $\sim 7\,\sigma$ in the K^+K^- channel. It has also been seen in the $K^0_S K^0_S$ channel. The combination of statistical significance and observation in two independent channels have encouraged the tentative christening of the state as the $\xi(2220)$. The results from the fit shown in Fig. 4 are: BR($\psi \rightarrow \gamma\xi(2220)$) $\times$ BR($\xi(2220) \rightarrow K^+K^-$) = $(8.0 \pm 2.0 \pm 1.6) \times 10^{-5}$ and the resonance parameters are: m = 2.220 $\pm$ .015 $\pm$ .020 GeV , Γ = .030 $\pm$ .015 $\pm$ .020 GeV. The measured width is consistent with the current understanding of the detector resolution and is perhaps the most interesting feature of this new object.

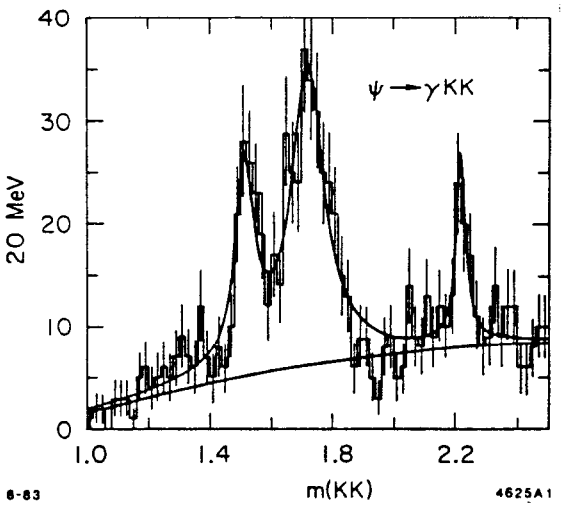

Fig. 4. $\psi \rightarrow \gamma K^+ K^-$ mass distribution with results of fit to three Breit-Wigners.

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