**Search for a narrow resonance about the $\xi(2230)$
in the formation channel $\bar{p}p \rightarrow K^+ K^-$**

G. Bardin ¹⁾, G. Burgun ²⁾, R. Calabrese ³⁾, G. Capon ⁴⁾, R. Carlin ⁵⁾, P. Dalpiaz ³⁾,
P.F. Dalpiaz ³⁾, J. Derre ²⁾, U. Dosselli ⁵⁾, J. Duclos ¹⁾, J.L. Faure ²⁾, F. Gasparini ⁵⁾,
M. Huet ¹⁾, C. Kochowski ²⁾, S. Limentani ⁵⁾, G. Marel ²⁾, E. Mazzucato ⁶⁾, F. Petrucci ³⁾,
M. Posocco ⁵⁾, M. Savrie ³⁾, R. Stroili ⁵⁾, L. Tecchio ⁷⁾, C. Voci ⁵⁾ and N. Zekri ¹⁾

Abstract

The reaction $\bar{p}p \rightarrow K^+ K^-$ has been studied for incident antiproton momenta between 1.3 and 1.5 GeV/c. A continuous scan has been made for invariant masses of the $p\bar{p}$ system between 2220 and 2240 MeV/c² with a resolution of 0.6 MeV in the $\xi(2230)$ region. No structure has been observed. Upper limits are given.

(Submitted to Physics Letters B)

-
- ¹⁾ Depart. de Phys. Nucleaire, CEN de Saclay, France.
²⁾ Depart. de Phys. des Particules Elementaires, CEN de Saclay, France.
³⁾ Dipartimento di Fisica, Universita and INFN, Ferrara.
⁴⁾ CERN, Geneva, now at Laboratori Nazionale di Frascati, Italy.
⁵⁾ Dipartimento di Fisica, Universita and INFN, Padova.
⁶⁾ CERN, Geneva, Switzerland
⁷⁾ Istituto di Fisica Superiore and INFN, Torino.

A narrow resonance, the $\xi(2230)$, has been observed by Mark III at SLAC in the K^+K^- and $K_S^0\bar{K}_S^0$ mass spectrum of the J/Ψ radiative decay [1]. The reported mass in the K^+K^- channel is 2230 ± 15 MeV/ c^2 , and the width is smaller than 45 MeV. However no signal has been detected in a similar experiment at Orsay - DM2 [2]. If existing, the ξ - meson is compatible with a narrow structure observed recently at 2220 MeV/ c^2 in the $\eta\eta'$ system from the reaction $\pi^-p \rightarrow \eta\eta'n$ at 38 and 100 GeV incident pion energy [3] the width is smaller than the instrumental resolution: 100 MeV. Such narrow objects in this mass region raise a great interest. Several possible interpretations have been suggested including a glueball, a Higgs scalar boson and a $J^{PC} = 2^{++} s\bar{s}$ meson [1].

We present here a search for a narrow signal from the reaction:

$$\bar{p}p \rightarrow \xi \rightarrow K^+K^- \quad (1)$$

The peak cross-section for such a process is:

$$\sigma_{\text{peak}} = [4\pi\hbar^2 c^2 (2J+1)/(s-4m_p^2)] \cdot \text{BR}(\xi \rightarrow \bar{p}p) \cdot \text{BR}(\xi \rightarrow K^+K^-) \quad (2)$$

The signal observed in the SLAC experiment corresponds to a product of branching ratios $\text{BR}(J/\Psi \rightarrow \gamma\xi) \cdot \text{BR}(\xi \rightarrow K^+K^-)$ of $4 \cdot 10^{-5}$. As no signal has been observed in the inclusive photon spectrum [4] a large branching ratio of about 10% is expected for the ξ decay into K^+K^- . For a coupling of the ξ to the $p\bar{p}$ system corresponding to a branching ratio $\xi \rightarrow p\bar{p}$ of 1%, the peak cross-section of reaction (1), according to the formula (2) would be $3\mu\text{b}$ ($J=0$) or $16\mu\text{b}$ ($J=2$). Such an effect is measurable above to the non-resonant cross-section ($50\mu\text{b}$), provided the mass resolution of the apparatus is smaller than the width of the resonance.

A study of the reaction $\bar{p}p \rightarrow K^+K^-$ has been made for incident $\bar{p}$ momenta between 1.3 and 1.5 GeV/ c including a continuous scanning with a high resolution between 1.415 and 1.470 GeV/ c . The reaction $\bar{p}p \rightarrow \pi^+\pi^-$ has been used as a monitor assuming that the relative amount of resonant effect in the $\pi^+\pi^-$ channel is smaller than in the K^+K^- one [1].

The measurement has been done using the apparatus of the PS170 experiment of LEAR at CERN mainly designed to detect the reaction $\bar{p}p \rightarrow e^+e^-$. Figure 1 is a top view of the apparatus [5]. A 30 cm long liquid hydrogen target is located at the center of a (1.3 Tesla) circular magnetic field ($\phi = 1\text{m}$, $h = 0.4\text{m}$). The target is surrounded by several detectors including a central detector of ca-

thode readout multiwire proportional chambers (CD), a 28-cell Cherenkov counter (C), 100 drift tubes (DTR), 2 hodoscopes of scintillators (H1,H2) and 9 planes of limited streamer tubes and Pb absorbers of an electromagnetic calorimeter (SHO). The trigger selects 2 charged particles in the hodoscopes H1,H2 with an opening angle compatible with a 2-body event. At least 2 hits are required in the regions of the central detector corresponding to the fired hodoscopes. Such a trigger contains about 1% of good 2-body events.

The performance of the apparatus is described elsewhere [5]. The overall acceptance for the present measurement (efficiency $\times$ solid angle) is about 5%. The angular acceptance is effective in the CM between 40° and 140° . In this angular range the differential cross-section of the non-resonant reaction $\bar{p}p \rightarrow K^+K^-$ is almost constant around $3.5 \mu\text{b/str}$. The off-line analysis selects without any ambiguity the 2-body events (e^+e^- , $\pi^+\pi^-$, K^+K^-) from the other annihilation processes. A clear separation is obtained between the K^+K^- and $\pi^+\pi^-$ events from the momentum measurement. The momentum loss of an antiproton in the 30 cm long target is 11.7 MeV/c, corresponding to a 4 MeV range of the $\bar{p}p$ invariant mass. After cuts the effective length of the target is 27 cm and the mass range 3.6 MeV. The step between two momentum settings has been chosen correspondingly. In that interval, the reconstruction of the annihilation vertex gives the invariant mass with a resolution of 0.6 MeV limited by the beam momentum spread ($\Delta p/p = 10^{-3}$).

With an average intensity of $5 \cdot 10^4 \bar{p}/\text{sec.}$, $2 \cdot 10^{10}$ antiprotons were received in the target providing about 65,000 $\pi^+\pi^-$ and 16,000 K^+K^- events. A continuous scanning in the range $2.18 \div 2.28 \text{ GeV}/c^2$ has been made in the $\xi(2230)$ region and discrete points have been measured further away in order to study the non-resonant background. Both pion and kaon channels were analysed using a 2-body fit. On the mass distribution shown on figure 2 a fit has been made using 2 gaussian peaks above a polynomial background distribution. The result is expressed as the yield ratio of K^+K^- to $\pi^+\pi^-$ events. No correction has been made for the decay in flight of the kaons. Furthermore, the K/π ratio has no well defined meaning since it depends on the angular acceptance of the apparatus. However this factors for non-resonant reactions are expected to vary slowly in the relevant energy domain.

The result is shown on figure 3 as a function of the $\bar{p}p$ invariant mass. The target has been taken as a whole or split into 6 parts providing 2 plots of bin widths respectively: 3.6 and 0.6 MeV. There is

no evidence for any structure from the results. Upper limits at 3 standard deviations have been calculated, assuming various width for a possible ξ -meson and the 2 possible quantum numbers $J^{PC}=0^{++}, 2^{++}$. The non-resonant cross-sections of the pion and kaon channels have been taken from previous measurements [6] and folded with the angular acceptance of the apparatus. The $J^{PC}=2^{++}$ state implies $S=1$ and $L=1$ or 3 with the corresponding angular distributions: $1+3\cos^2\theta$ and $1-2\cos^2\theta+5\cos^4\theta$. Due to the limited angular acceptance the sensitivity is reduced by 23% compared to the isotropic case $J=0$. The results are given in table 1 in terms of peak cross-section for the ξ -meson and the product of branching ratio:

$$BR2 = BR(\xi \rightarrow \bar{p}p) \cdot BR(\xi \rightarrow K^+K^-).$$

Table 1: Upper 3σ limits on a possible resonance about the $\xi(2230)$.

$\Gamma(\text{MeV})$	$J^{PC}=0^{++}$		$J^{PC}=2^{++}$	
	$\sigma(\text{peak})$ (μb)	BR2 (10^{-4})	$\sigma(\text{peak})$ (μb)	BR2 (10^{-4})
1	10	30	13	7.7
3	6	18	7.7	4.6
30	1.8	5.4	2.1	1.3

In conclusion, upper limits have been obtained on the production reaction: $\bar{p}p \rightarrow \xi \rightarrow K^+K^-$. The investigation has been pushed down to a resonance width of 1 MeV. Although the sensitivity is limited by the high non-resonant cross-section, the upper limits obtained imply a very small coupling to the $\bar{p}p$ system for a $J^{PC}=2^{++}$ ξ -meson.

Figure captions

Figure 1 : Top view of the apparatus

Figure 2 : Mass distribution of the two particles from the 2-body fit.

Figure 3 : Ratio of K^+K^- to $\pi^+\pi^-$ yield for various mass bins, A:3.6, and B:0.6 MeV.

References

- [1] R.M.Baltrusaitis et al. Phys. Rev. Lett. 56 (1986) 107.
- [2] J.E. Augustin et al. LAL/85-17.
- [3] D. Alde et al. Phys. Lett. B177 (1986) 120.
- [4] E.D. Bloom, Aspen winter Physics Conference, 1985 and SLAC-PUB 3573 (1985).
- [5] G. Bardin et al., Physics at LEAR with Low Energy Antiprotons, Plenum Press 1984 (ed. U. Gastaldi, R. Klapisch) Erice 1982 p. 347. G. Bardin et al. submitted to Nucl. Inst. Meth.
- [6] E. Eisenhandler et al., Nucl. Phys. B96 (1975) 109.

FIGURE 1

Figure 2

Figure 3