Indication of $\xi(2230)$ Production in Hadronic Z Decays

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Abstract. An indication of $\xi(2230)$ production in hadronic Z decays is presented. For the first time, by using the data collected by the L3 detector at LEP, a signal consistent with ξ is observed in the $K_s^0K_s^0$ channel. It is seen in the less energetic jets of three-jet events.

During the last decade, interest has been attributed to the $K\bar{K}$ system in the 2.25 GeV mass region in radiative J/ψ decays. In 1986, the MARK III collaboration reported the observation of a narrow structure at 2230 MeV in the $K_s^0K_s^0$ and K^+K^- channels (1). This resonance has been named $\xi(2230)$ and its width has been evaluated to be Γ=21 MeV. More recently, in 1996, the BES collaboration has also reported in J/ψ radiative decays the observation of such a narrow structure at 2230 MeV, not only in the $K\bar{K}$ system, but also in several other channels not involving strange quarks (2). The interest for the ξ is that it may be a new kind of object not interpreted as an ordinary $q\bar{q}$ state. On the basis on the most recent observations provided by the BES collaboration, its narrow width, its flavor independence decays, its presence only in radiative J/ψ decays, and its very small radiative width measured by CLEO(3), the received assumption is that the $\xi(2230)$ may be a Glueball candidate(4). Nevertheless, presently no signals have been reported around 2.25 GeV from pp and $p\bar{p}$ experiments, excepted GAMS in the $p\pi\rightarrow\eta\eta'$ reaction(5). Hence, new data concerning this state are always welcome to improve the interpretation of ξ. In this report, the first observation in hadronic Z decays of a signal consistent with the $\xi(2230)$, in the $K_s^0K_s^0$ channel, is presented.

The 3.6 million of hadronic Z decays collected from 1991 to 1995 by the L3 detector have been used. Very strong cuts have been applied to reduce as much as possible the combinatorial background to the $K_s^0K_s^0$ channel and to keep only well reconstructed K_s^0 mesons. Used tracks have to point to the central region of the detector, have a Distance of Closest Approach to the beam axis greater than 1.5 mm and a transverse momentum greater than 400 MeV. Only K_s^0 meson candidates with an angle α smaller than 20 mrad,[2] with a reconstructed mass in a 50 MeV wide mass

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[2)] α is the angle between the transverse direction of flight and the transverse momentum

window around the nominal mass, with a transverse distance of flight D_{flight}, before to decay, greater than 3 cm and a momentum greater than 1.5 GeV, are kept. Hence, only very well reconstructed K^0_s candidates with a relatively high momentum are used to reconstruct $K^0_sK^0_s$ system. Then, the LUCLUS jet finder algorithm is used to reconstruct jet energies and directions. The parameter d_{join}, used to discriminate jets, is fixed to 5 GeV. Hence, the fraction of two-jet events is 55%. For simplicity, events with more than two jets are called three-jet events.

The obtained $K^0_sK^0_s$ invariant mass distributions obtained for two-jet and three-jet events are shown in Figure 1. A signal with 51±11 candidates at 2340±18 MeV is present only in three-jet events. A Gaussian function, with σ=74±21 MeV, fits to the signal. After having associated $K^0_sK^0_s$ system to the closest reconstructed jet in three-jet events, one observes, in Figure 2, that the signal is mainly associated to the less energetic jets. According to Monte-Carlo, more than 72% of the less energetic jets of three-jet events are originating from gluon fragmentation. The same effect is observed with other procedures of selection, for example with lower momentum and shorter D_{flight} thresholds and by selecting only jets with a small number of tracks (<8) or with no more than two K^0_s candidates associated to the same jet to reduce the combinatorial background. It has been also observed that the angle between the direction of ξ candidates and the two most energetic jets is greater than 300 mrad. In this case, it is not necessary to count the number of jets in the event to get the result in Figure 1.

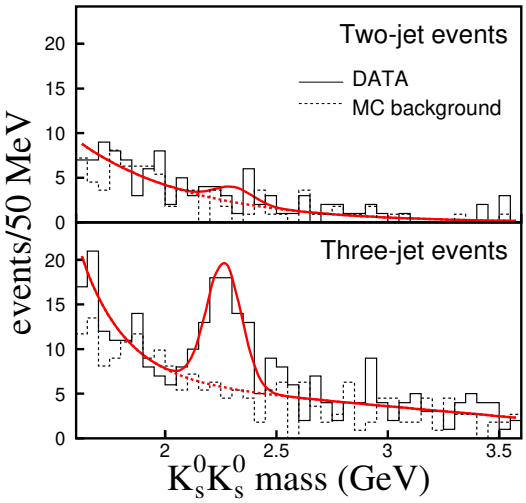

FIGURE 1. $K^0_sK^0_s$ invariant mass distributions observed in two-jet events (top) and three-jet events (bottom). Hatched lines stand for the $Z\to q\bar{q}$ Monte Carlo expectation not including ξ(2230). The smoothed line represents the fit of the background plus a Gaussian for the signal.

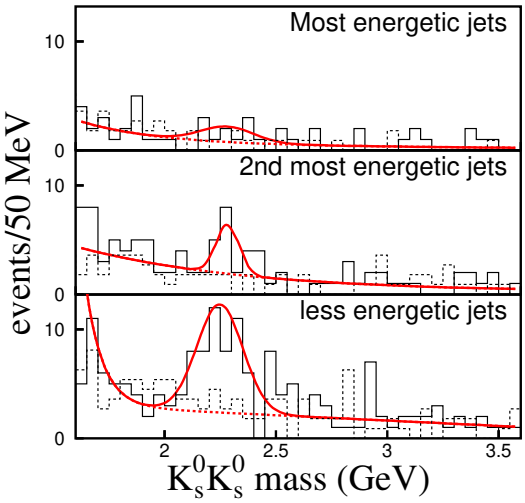

FIGURE 2. $K^0_sK^0_s$ invariant mass distributions observed in three-jet events, from the most energetic jets (top) to the less energetic jets (bottom). Hatched lines stand for the $Z\to q\bar{q}$ Monte Carlo expectation not including ξ(2230).

In Figures 1 and 2, the shape of the background is in good agreement with Monte Carlo expectations in which no ξ have been generated. This indicates that the observed signal is not an effect of cuts. Moreover, no signals in data are observed when K^0_s selection criteria are reversed, in order to select faked K^0_s instead of real good K^0_s candidates, or when possible Λ candidates are selected. The signal is visible in different period of data taking, excluding that it is a statistical fluctuation of the background. The purity of the signal in three-jet events can be improved by increasing the discrimination between jets (d_{join}=7 GeV). In Figure 3, a full agreement with Monte Carlo is obtained by introducing a simulated $\xi(2230)$ signal generated at 2230 MeV with Γ=20 MeV. Hence, the observed width of the signal is mainly due to the detector resolution. The Figure 4 shows the important extension of the signal at large momentum.

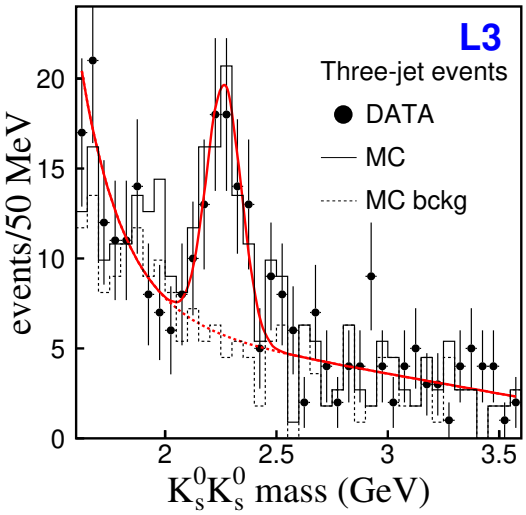

FIGURE 3. $K^0_sK^0_s$ invariant mass distribution in three-jet events including Monte Carlo background and signal simulations. The smoothed continuous line stands for the fit of the background with a Gaussian function for the signal.

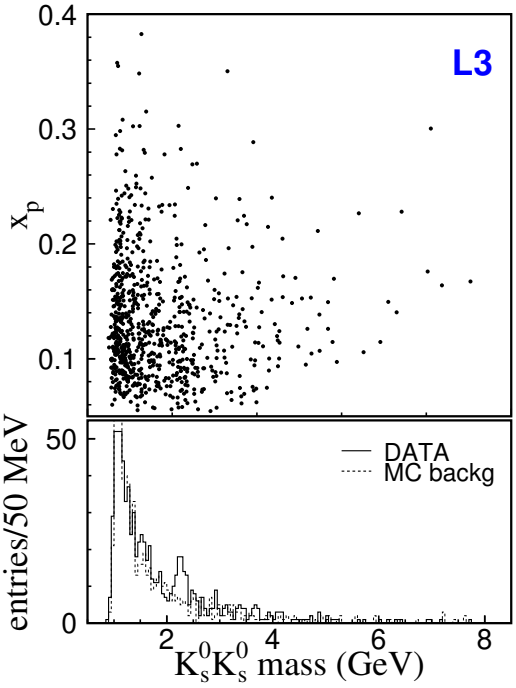

FIGURE 4. Scatter plot of the total scaled $K^0_sK^0_s$ momentum, $x_p=p/E_{beam}$, versus the $K^0_sK^0_s$ invariant mass in three-jet events (top). Projection on the invariant mass distribution axis. (bottom).

The main curiosity with this observation is that the signal is seen essentially coming from the less energetic jets. Generated as an ordinary meson, Monte Carlo simulation shows that the signal in two-jet events should be 30% smaller than in three-jet events because more particles are necessarily produced in three-jet events due to the

hadronization of the additional radiated gluon. Nevertheless, it should be visible. Table 1 shows the number of candidates counted in different event configurations for data, for Monte Carlo when the signal is simulated by the JETSET event generator as an ordinary meson (MC I), and when the $\xi(2230)$ generation is forced to come only from gluon fragmentation (MC II). As shown in Table 1, the second Monte Carlo is in better agreement with data, the reduced χ^2 being much smaller.

TABLE 1. Numbers of observed candidates, background events and expected events in a 150 MeV mass window around the nominal mass of ξ. The total number of events for MC is adjusted in order to match to the total number of events seen in data, in this case 57 ($N=N_{obs}-N_{back}$).

		DATA		**MC I**	**MC II**
	N_{obs}	N_{back}	**N**	N_{exp}	N_{exp}
Two-jet events	21	15.4	5.6	21	9
Three-jet events	86	35.0	51.0	36	48
- most energetic jet	10	4.8	5.2	11	4
- 2nd most energetic jet	23	11.0	12.0	5	11
- less energetic jets	53	14.1	39.9	20	33
$<\chi^2>$				3.60	0.1

The second Monte Carlo simulation (MC II), where ξ are produced only from gluon fragmentation, shows a propagation of the signal from the enriched gluon-jet sample, namely the less energetic jets, to the enriched quark-jet samples similar to data. The strong reduction of the signal in two-jet events relatie to three-jet events is seen to be due to the smaller energy of the radiated gluon. This reduces the available phase space for the production of massive objects like ξ's.

In conclusion, a signal consistent with the $\xi(2230)$ is, for the first time, seen in the hadronic Z decays. It would be preferentially produced by gluon hadronization and, consequently, its coupling with gluons would be higher than with quarks. Studies are still on progress and confirmations from other experiments would be welcome.

REFERENCES

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3) see in this proceeding
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