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WA76 Collaboration

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One of the important expectations of QCD is the existence of mesons like glueballs or hybrid states which have valence gluon constituents. The search for such "exotic spectroscopy" has been carried out, in the past few years, using different probes: from J/ψ radiative decay to central production, from hadron induced reactions to high p_T direct production.

New states, which have no obvious place in the conventional SU(3) $q\bar{q}$ nonets seem to come out from these studies, and in particular from the study of the J/ψ decay. New resonances, like the $J^{PC} = 0^{-+}$ $\iota/\eta(1440)$ and the $J^{PC} = 2^{++}$ $\theta/f_2(1720)$ which have no place in the quark model have been discovered and they are candidates for being gluonic states.

The WA76 experiment started to explore the central region of π^+ and p interactions with protons at 85 GeV/c in 1982 at the CERN Ω spectrometer. The experiment was designed to study meson spectroscopy in exclusive final states decaying to charged hadrons with a good particle identification. One of the significant results coming from this experiment has been the observation and spin – parity measurement of the $J^{PC} = 1^{++}$ $f_1(1420)$. This state is not easily accommodated in the standard quark model since the nonet where it should belong is already full. One of its interesting properties is that although it decays mainly to $K^*\bar{K}$, it is not produced in kaon induced reactions.

The WA76 experiment had a new run in 1986 with incident protons at 300 GeV/c, using a set of μ – strip detectors to ensure good resolution in the track momentum determination and using, in addition to cerenkov counters, an electromagnetic calorimeter to detect neutrals. The analysis of the data coming from this experiment is now in an advanced stage and is producing new results.

1. The gluonium candidate $\theta/f_2(1720)$ has been observed here for the first time in hadron collisions. Here it is produced centrally and it is observed in the K^+K^- and $K^0_SK^0_S$ decay modes with a statistics similar to that collected in the radiative J/ψ decay. Its spin parity has been determined to be 2^{++} and this observation reinforces the likelihood that the $\theta/f_2(1720)$ is a gluonic state. Although it has a dominant K^+K^- decay mode, it is not observed in K induced reactions.

2. The $f_1(1420)$ has been observed and its spin parity has been measured confirming the result from the 85 GeV/c run. No $\eta\pi^+\pi^-$ decay mode is observed. Its cross section has been found to be constant with energy, an effect observed also for the centrally produced $\phi\phi$ system.

3. The $\pi^+\pi^-$ and $\pi^0\pi^0$ spectra have been studied with a statistics 3 times greater than the largest ISR sample collected on this channel. The spectra show a large $S^*/f_0(975)$ contribution. which has been proposed as a candidate for being the lowest lying $J^{PC}=0^{++}$ glueball.

4. The study of the $2\pi^+2\pi^-$ channel has shown unexpected behaviour with respect to the lower energy run. In addition to the $f_1(1285)$ there is evidence for two new states, one relatively narrow, labelled X(1450), ($m=1449\pm4$, $\Gamma=78\pm18$ MeV) and the other broad, at 1.9 GeV. A spin analysis of the X(1450) state has been performed and indicates that the data are compatible with $J^{PC}=2^{++}$ or 1^{-+} (the latter being an exotic quantum number). It is worth noting that this state has not been observed in other experiments leaving open the possibility of it being an exotic state.

As a next step in the continuation of this study we wish to to increase by a factor 10 the current statistics in order to confirm the states observed in the 300 GeV/c run and search for other new states, especially in the channels which involve γ, π^0 and η's. The beam momentum would be increased to 450 GeV/c. If gluonium and hybrid states are being observed there is a rich spectroscopy to be explored which requires the study of meson spectroscopy in all the possible decay channels.

This next step can be achieved with minor modifications to the layout used in the 300 GeV/c experiment. The number of $\mu-$strip detectors will be doubled in order to cover the full solid angle for

the fast proton and in addition we will double the acceptance for the slow recoiling proton. These modifications will give a rate 5 times greater than that of the previous experiment. Particle identification will be achieved using the Ω RICH presently undergoing modification and the Ω electromagnetic calorimeter.

In conclusion, we have found that the central region of hadron hadron scattering is a good laboratory where meson spectroscopy, both exotic and non exotic, can be studied with a good signal to background. This mechanism is different, and complementary to J/ψ decay. The confirmation of states formed by gluons or mixtures quarks and gluons is of fundamental importance for the understanding of strong interactions.

1. References

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