ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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PREPRINT 86-109

НОВОСИБИРСК
1986

A SEARCH FOR ξ (2.2) IN RADIATIVE DECAYS OF THE Υ-MESON *

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A b s t r a c t

A search for the decay $\Upsilon \to \gamma \xi(2.2)$ has been performed with the magnetic detector MD-1 at the VEPP-4 collider. An upper limit for the $B(\Upsilon \to \gamma \xi(2.2)) \cdot B(\xi(2.2) \to K^+K^-) < 2 \cdot 10^{-4}$ (90% C.L.) has been obtained.

* Submitted to the XXIII International Conference on High Energy Physics, Berkeley, July 1986.

In 1983 a new particle with a mass of 2.2 GeV/c^2 has been discovered with the MARK-III detector in the radiative decays of the ψ-meson /1/. At the present time the decay modes $\xi \to K^+K^-$ and $\xi \to K^0_S K^0_S$ have been measured, for six other two-particle decay modes upper limits were placed /2/. Different theoretical hypotheses about the nature of this resonance were suggested, the interpretation of ξ as a Higgs boson being one of the most popular. In the standard model of electroweak interactions with one doublet of scalar fields only one neutral Higgs boson exists. The probability of the decay $V \to \gamma h$ is

$$B(V \to \gamma h) = \frac{G_F M_V^2}{4\sqrt{2}\pi\alpha}\left(1 - \frac{M_h^2}{M_V^2}\right) B(V \to \mu^+\mu^-),$$

where M_V and M_h are the masses of the vector resonance and the Higgs boson respectively, G_F is the Fermi constant, α is the fine structure constant. If ξ is a Higgs boson, then $B(\xi \to K^+K^-) \sim \frac{1}{6}$ /3/, and for the mass of $M_h = 2.2$ GeV the model predicts $B(\psi \to \gamma h) = (2.9 \pm 0.4) \cdot 10^{-5}$ in contradiction with the MARK-III result $B(\psi \to \gamma \xi)\, B(\xi \to K^+K^-) = (4.2^{+1.7}_{-1.4} \pm 0.8) \cdot 10^{-5}$ /2/. These difficulties can be avoided in the models with a richer Higgs sector.

Discovery of ξ stimulated active search for this particle in radiative decays of the Υ-meson. If one assumes that for ξ a coupling constant with quarks is proportional to a quark mass and uses the result of MARK-III, then

$$B(\Upsilon \to \gamma \xi)\, B(\xi \to K^+K^-) = (3.0^{+1.4}_{-1.3}) \cdot 10^{-4}.$$

Upper limits for the decay $\Upsilon \to \gamma \xi,\ \xi \to K^+K^-$ have earlier been obtained by CLEO and CUSB. The recent result of CLEO for $B(\Upsilon \to \gamma \xi)\, B(\xi \to K^+K^-) < 3.1 \cdot 10^{-5}$ (90% C.L.) /4/ is considerably better than their previous result $2 \cdot 10^{-4}$ /5/. A CUSB limit for this quantity is $\sim 1 \cdot 10^{-3}$ (90% C.L.) /6/.

In this work we present the results of the search for the decay $\Upsilon \to \gamma \xi,\ \xi \to K^+K^-$ with the MD-1 detector (Fig. 1) /7/. Experiment has been performed at the VEPP-4 collider from October 1983 to July 1984. The magnetic field of the detector isperpendicular to the orbit plane and in this experiment equaled 11.3 kG. The integrated luminosity was 6.5 pb^{-1} at the resonance and 2.7 pb^{-1} outside it. The number of recorded events was $1.5 \cdot 10^7$. About 94000 Υ-meson were produced.

Detection of charged particles and measurement of their momenta was performed with 38 proportional chambers of MD-1. In a solid angle of $0.6 \cdot 4\pi$ a momentum of charged particles was measured with a resolution $\sigma_p = 0.1p^2$ (p in GeV/c), whereas in a solid angle of $0.2 \cdot 4\pi$ only tracking was performed.

Photons were detected in a shower-range system consisting of 14 separate units. Each unit was a sandwich comprising 10 proportional chambers and stainless steel plates. The accuracy of the photon angle measurement $\sigma_\theta = 2 \cdot 10^{-2}$ radians. The energy resolution was $\sigma_E/E \sim 30\%$ at the photon energy of 4.5 GeV.

The detection efficiency was calculated with the Monte Carlo simulation program /8/ taking into account electromagnetic and nuclear interactions of particles with the detector material as well as decays of unstable particles.

The resolution in the ξ mass was 330 MeV/c^2 if both momenta have been measured. To improve the resolution the maximum likelihood method was used. The following quantity has been minimized in p_1 and p_2:

$$S = \left(\frac{p_1 - p_{10}}{\sigma_p}\right)^2 + \left(\frac{p_2 - p_{20}}{\sigma_p}\right)^2 + \left(\frac{\pi - \theta}{\sigma_\theta}\right)^2,$$

where p_{10} and p_{20} are measured momenta, θ is an angle between $\vec{p}_1 + \vec{p}_2$ and the photon direction. The second term is omitted, if a momentum of one charged particle only has been measured. $\bar{p}_1$ and $\bar{p}_2$ are the optimal values of the momenta obtained under the condition that the masses of charged particles are equal to the kaon mass and $E_1 + E_2 + \mathcal{P} = 2E$. E_1 and E_2 are the energies of the charged particles, $\mathcal{P}$ is their total momentum, E is the beam energy. The resolution in the invariant mass of K-mesons calculated from the momenta $\bar{p}_1, \bar{p}_2$ equals 35 MeV/c^2 and 55 MeV/c^2 if two or one momentum are measured respectively.

Analysis of the detection efficiency of the Monte Carlo events for the process under study as well as background conditions led to the following selection criteria:

1) Only two particles are reconstructed in the tracking system.

2) A momentum has been measured at least for one particle.

3) The angle between momenta of charged particles is less than 168.5°.

4) The number of sparks beyond the reconstructed trajectories in the tracking system is not greater than 7.

5) A shower-range chamber is fired at the continuation of at least one charged particle.

6) If a charged particle has continuation in the shower-range chamber, the energy deposition in this chamber does not exceed 2 GeV under the assumption that it is an electron.

7) At least one shower in the shower-range chamber is not associated with the continuation of the charged particle trajectory.

8) The value of the parameter $S < 9$.

9) $\min(\bar{p}_1, \bar{p}_2) > 300$ MeV/c.

Events which passed these selection criteria with the invariant mass of charged particles between 1.5 GeV/c^2 and 3.0 GeV/c^2 are shown in Fig. 2.

The experiment consisted of two runs which had different triggering conditions. For the events $\Upsilon \to \gamma\xi, \xi \to K^+K^-$ the trigger efficiency was equal to 57.3% and 73.3% for the integrated luminosities 4.5 pb^{-1} and 4.7 pb^{-1} respectively, the detection efficiency under selection criteria above was equal to 12.0% and 15.5% respectively and 13.6% for the total statistics.

No events were observed in the region of the ξ mass. Therefore the following upper limit can be obtained:

$$B(\Upsilon \to \gamma\xi) B(\xi \to K^+K^-) < 2 \cdot 10^{-4} \qquad (90\%\ \text{C.L.})$$

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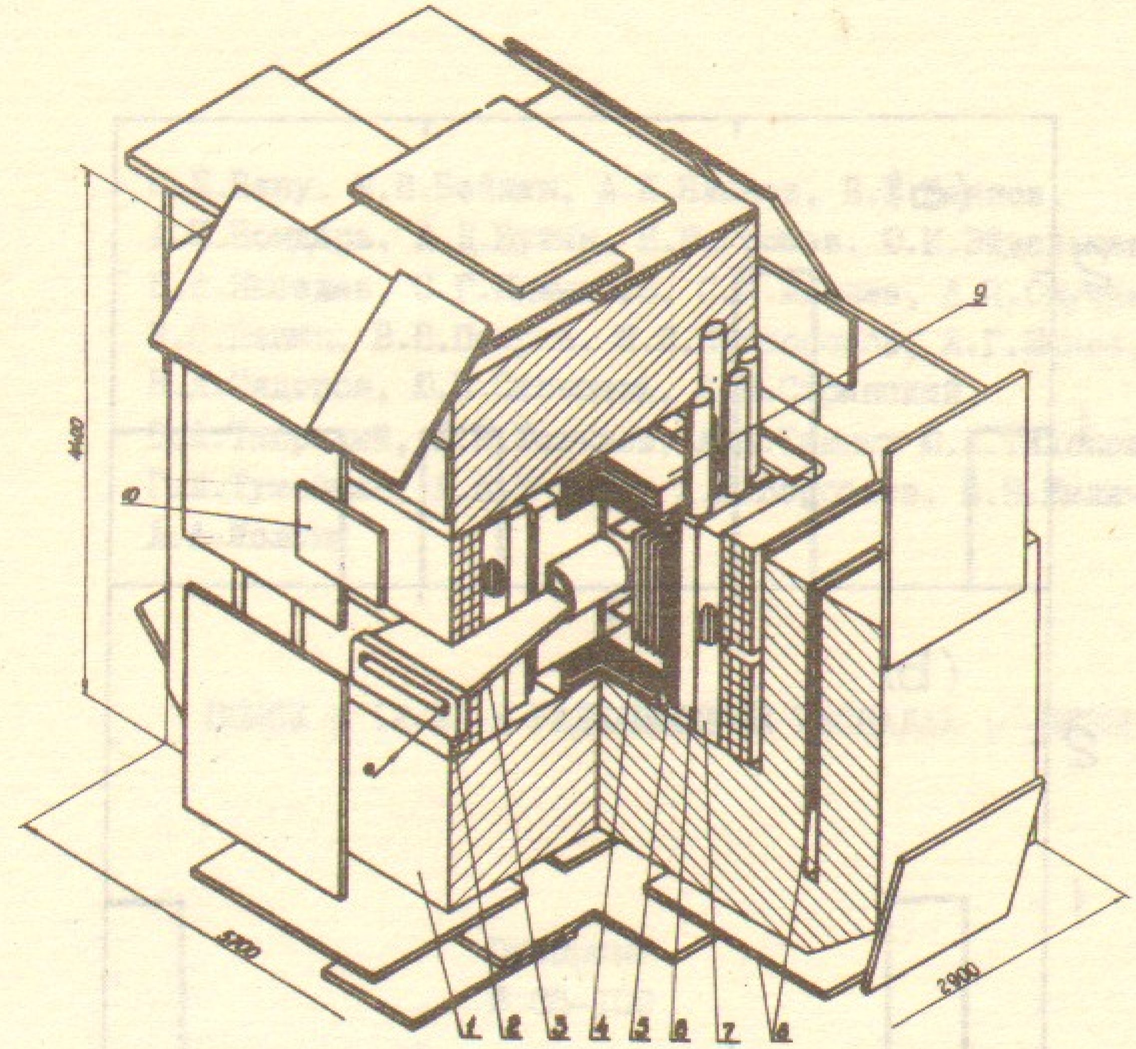

Fig. 1. Lay-out of the MD-1 detector: 1 - magnet yoke, 2 - copper winding, 3 - beam pipe, 4 - coordinate chambers, 5 - scintillation counters, 6 - gas Cherenkov counter, 7,9 - shower-range chambers, 8 - muon chambers.

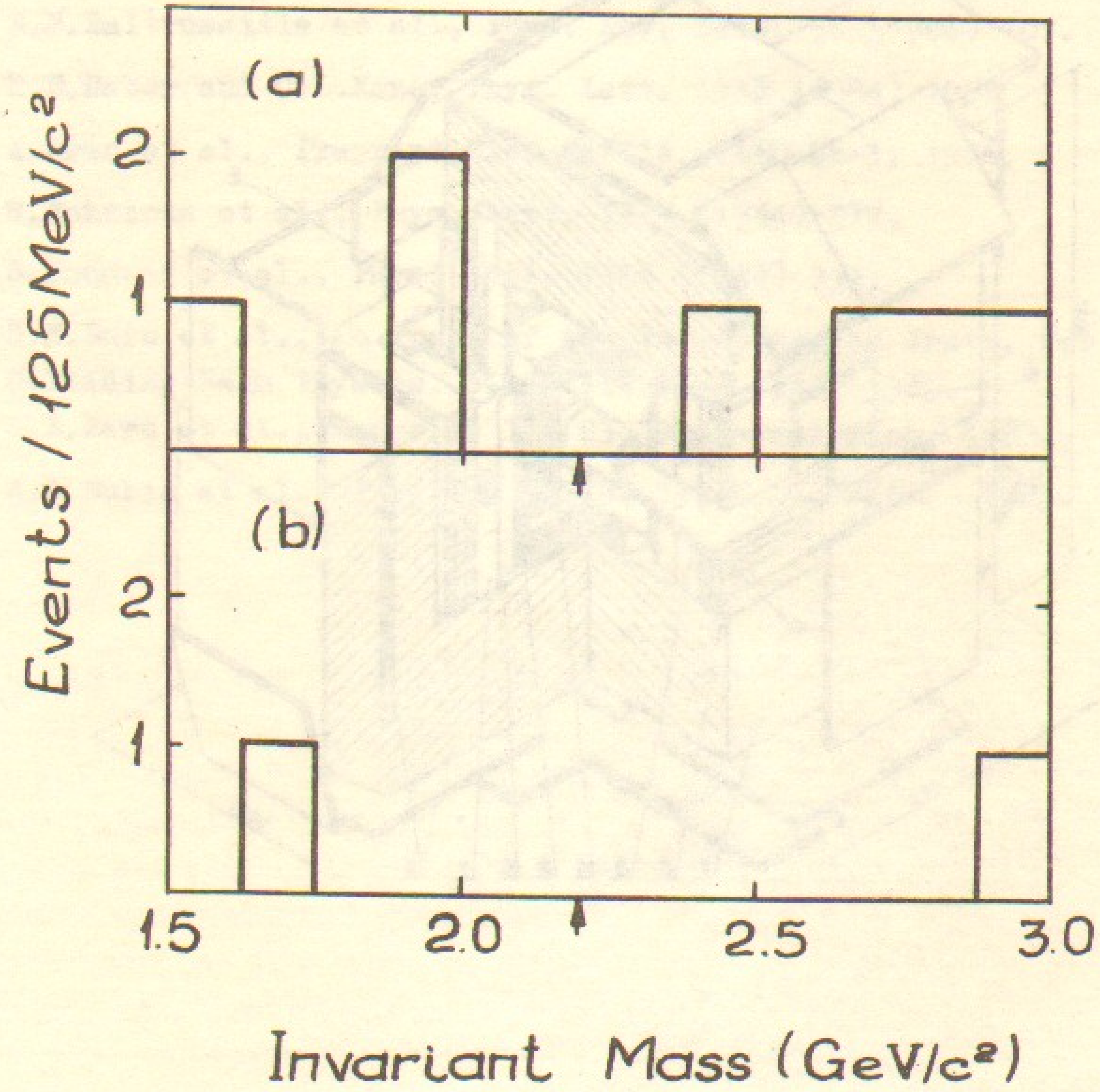

Fig. 2. Distribution in the invariant mass of two charged kaons for the events with two (Fig. 2a) or one (Fig. 2b) reconstructed momenta. The arrow indicates the position of ξ(2.2).

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ПОИСК ξ (2.2) В РАДИАЦИОННЫХ РАСПАДАХ ψ-МЕЗОНА

Препринт
№ 86-I09

Работа поступила - I июля 1986 г.

Ответственный за выпуск - С.Г.Попов
Подписано к печати 2.07-1986г. МН II769
Формат бумаги 60х90 I/I6 Усл.0,7 печ.л., 0,6 учетно-изд.л.
Тираж 290 экз. Бесплатно. Заказ № I09.

Ротапринт ИЯФ СО АН СССР, г.Новосибирск, 90