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PRELIMINARY RESULTS FROM THE CMD-2 DETECTOR

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Abstract

A new general-purpose detector CMD-2 (calorimetric magnetic detector) has started experiments at the upgraded e^+e^- collider VEPP-2M (collider for electron-positron beams) at Novosibirsk. During early runs an integrated luminosity of about 400 inverse nanobarns has been collected in the center of mass energy range 400-1030 MeV.

INTRODUCTION

In 1991 the upgrade of the VEPP-2M collider with center of mass energy up to 1400 MeV was completed. A luminosity of about $4x10^{30}/cm^2/sec$ has been seen at 40 mA currents. With further increase of the beam current to approximately 100 mA, and use of the wiggler magnets to minimize beam-beam interactions, a luminosity of about $10^{31}/cm^2/sec$ is expected for e^+e^- collisions at the ϕ c. m. (center of mass) energy. Such luminosity would allow an integrated luminosity of 200 inverse picobarns during two-three years of operation. The general purpose CMD-2 detector is installed in one of the two intersection regions at VEPP-2M. Its high acceptance, detection efficiency, and measurement accuracy for charged and neutral particles, combined with the large collider luminosity, will allow precise measurements of the cross section for annihilation into hadrons in the whole energy range, as well as studies of the rare decay modes of the low mass vector mesons ρ, ω, and ϕ. One can hope to achieve sensitivities better than 10^{-4} for most of the channels and to measure the total cross section of e^+e^- annihilation into various hadronic states with an accuracy of about 1%. The annihilation into hadrons provides a clean measurement of the pion and kaon formfactors and ρ-ω and ρ-ϕ interference which play a very important role for understanding interactions of light quarks. The total cross sections for hadron production and for exclusive annihilation modes allow tests of QCD (quantum chromodynamics) sum rules, calculation of the contribution of strong interactions to the muon anomalous magnetic moment (g-2 value), and tests of vector-current conservation in τ-lepton decays.

This work presents a description of the CMD-2 performance during the first experimental runs.

THE DETECTOR

The CMD-2 detector[1] is shown in Figure 1. The coordinate measurement system of the detector consists of the cylindrical DC (drift chamber)[2] with jet-type drift cells and a double layer multi-wire proportional chamber (the so-called Z-chamber)[3], placed behind the DC. Both chambers are mounted inside a thin (0.39 X_0 (radiation length)) superconducting solenoid with a magnetic field up to 1.5 T.[4] The three coordinates of a charged particle track in the DC are determined from the hit wires, the drift time, and the charge division.

The Z-chamber is used in the first level trigger both for timing and topological selection of events. The allowable time jitter from the anode sectors of less than 60 ns is set by the VEPP-2M 60 ns bunch crossing and cycle time. To meet this requirement a fast gas mixture

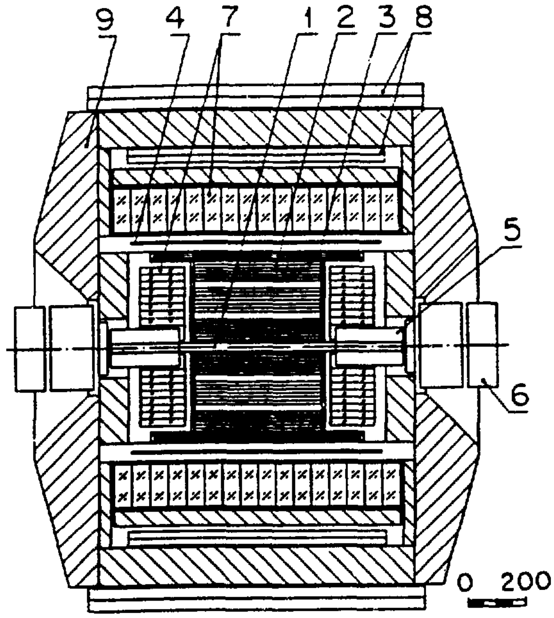

Figure 1. Horizontal view of the CMD-2 detector. 1 - vacuum chamber; 2 - drift chamber; 3 - Z-chamber; 4 - superconducting solenoid; 5 - compensating solenoid; 6 - storage ring lenses; 7 - calorimeter; 8 - muon range system; 9 - magnet yoke.

based on Freon-14 with a 10% admixture of isobutane has been chosen. One can see from Figure 2 that the obtained time jitter is well below 60 ns.

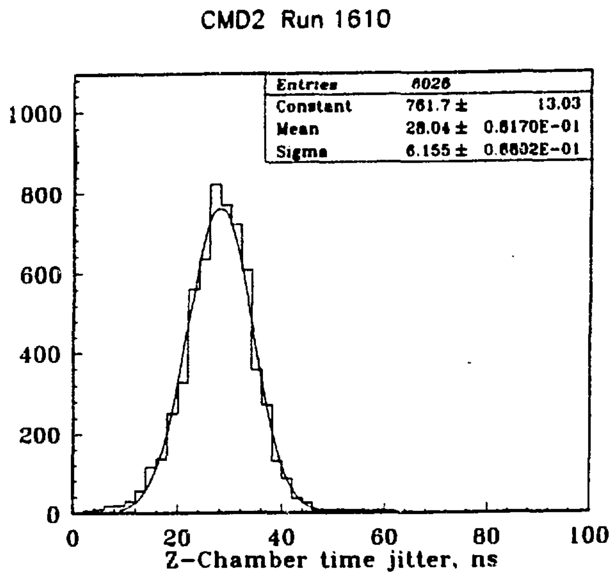

Figure 2. Time jitter of Z-chamber anode sectors.

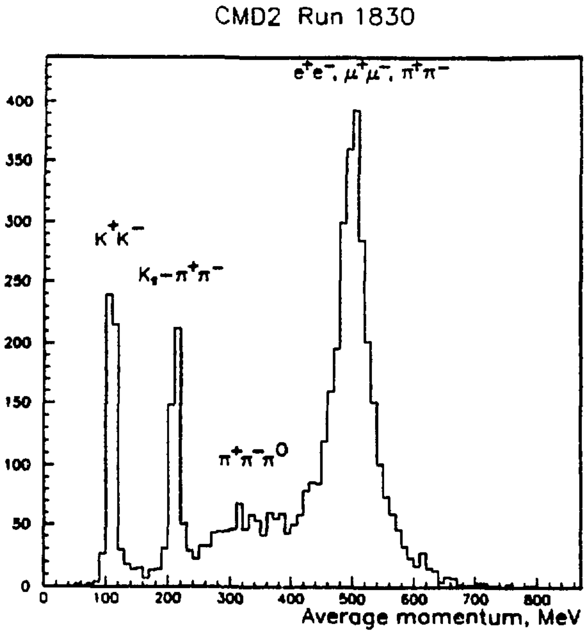

Figure 3. Average momentum of two charged particles at c.m. energy=$2xE_{beam}$=1019 MeV.

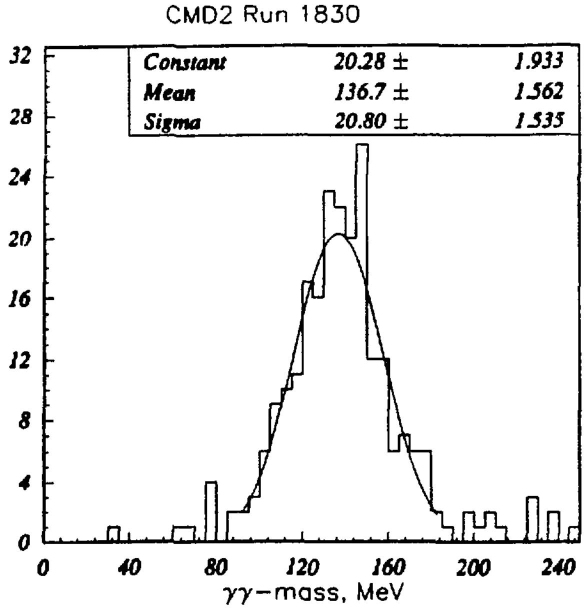

Figure 4. Reconstructed π^0 mass, using two photon clusters in CsI barrel calorimeter, from events identified as $e^+e^- => \pi^+\pi^-\pi^0$.

The momentum resolution of the drift chamber is illustrated in Figure 3 which shows the distribution of the average momentum for events with two charged tracks. The events in Figure 3 were collected at total c.m. energy 1019 MeV, near the maximum of the ϕ resonance. One can see three clear peaks due to the reactions: $e^+e^- => K^+K^-$; $e^+e^- => K_LK_S$, $K_S => \pi^+\pi^-$; and $e^+e^- => e^+e^-$. The broad bump between 250 and 400 MeV corresponds to the reaction $e^+e^- => \pi^+\pi^-\pi^0$. The CsI barrel calorimeter[5] is placed outside the solenoid. The calorimeter is 8.1 X_0 thick, and according to Monte Carlo simulations it gives a resolution of about 10% (sigma) for electrons and photons in the energy range 100-500 MeV. In Figure 4 the π^0 mass reconstructed from the energy and coordinates of two photon clusters in the calorimeter is shown. The width of the distribution is consistent with Monte Carlo expectations. The construction of the endcap BGO (barium germanium oxide) calorimeter will be finished in 1992.

The muon system[1] coordinate resolution obtained from cosmic ray events is 20-30 mm. The detection efficiency of two layers is better than 99%. For the charged trigger a special tracking processor (TP) is used.[6] The first level trigger begins to operate when signals come from sectors of the Z-chamber. They are delayed for the maximum drift chamber drift time (450 ns) and start the TP. The track processor generates a "common stop" signal after finding one or more tracks in the two inner layers of the drift chamber. (The outer layer is not used, to allow a larger solid angle for the trigger tracks.) If there is no "common stop" signal, the stored digital information is cleared after 1 microsecond. The background counting rate of the first level trigger was seen to be suppressed by a factor of 100. The track processor requirement together with total energy deposition in the CsI calorimeter greater than 60 MeV reduces the data rate to 10 Hz.

PRELIMINARY DATA ANALYSIS

The first physics run of CMD-2 was February - July 1992. An integrated luminosity of 400 inverse nanobarns was accumulated in 35 points over a c.m. energy range 400-1030 MeV. About 19 million detector triggers were recorded. Preliminary analysis of the data obtained has allowed the first CMD-2 subsystem performance checks presented in the previous figures.

Preliminary analysis of approximately one tenth of the statistics collected in the region of the ϕ gives the width of the ϕ in the channels K_LK_S and $\pi^+\pi^-$. A sample of ϕ decays into K_LK_S pairs was selected by the cuts on missing momentum and the average momentum of the pair of charged tracks shown in Figure 5. The ϕ excitation curve is shown in Figure 6 and gives a ϕ width of (4.71 ± 0.44) MeV, compared with the best previous e^+e^- machine result of (4.36 ± 0.29) MeV.[7]

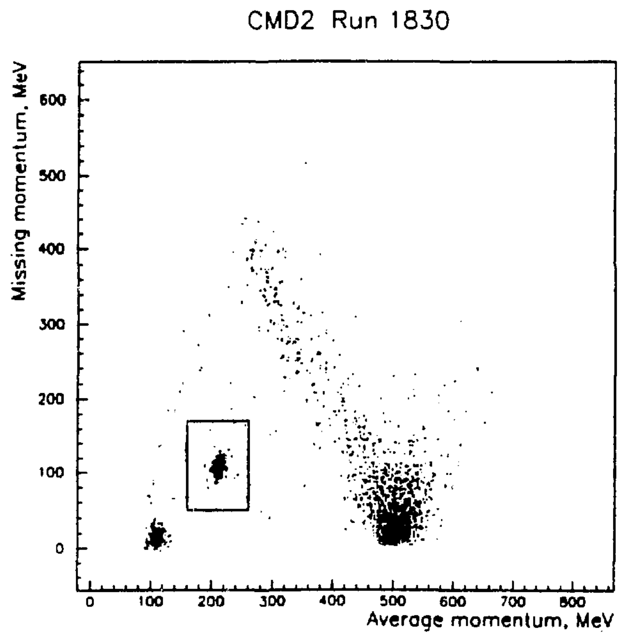

Figure 5. The scatter plot of missing momentum versus average momentum of two charged particles at c. m. energy=$2xE_{beam}$=1019 MeV.

The analysis of data taken at lower energies has also started. A simple three gaussian fit for the data sample at $2xE_{beam}$=696 MeV is shown in Figure 7. The value of the pion formfactor squared was found to be $|F_\pi|^2 = 21.7 \pm 2.3$. This value is in good agreement with our previous results.[8]

CONCLUSIONS

Data processing is in progress. The next physics run is scheduled for fall 1992. The goal of that run will be the precise measurement of the hadronic cross section over the whole energy range as well as studies of rare decay modes of the vector mesons, η and K mesons.

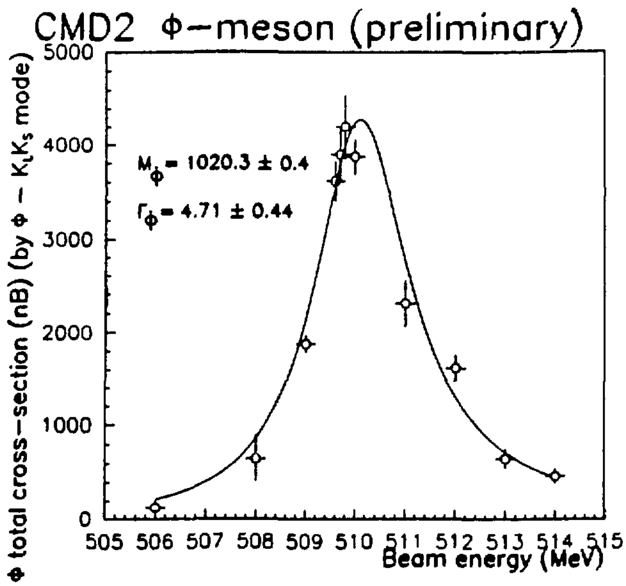

Figure 6. The ϕ excitation curve.

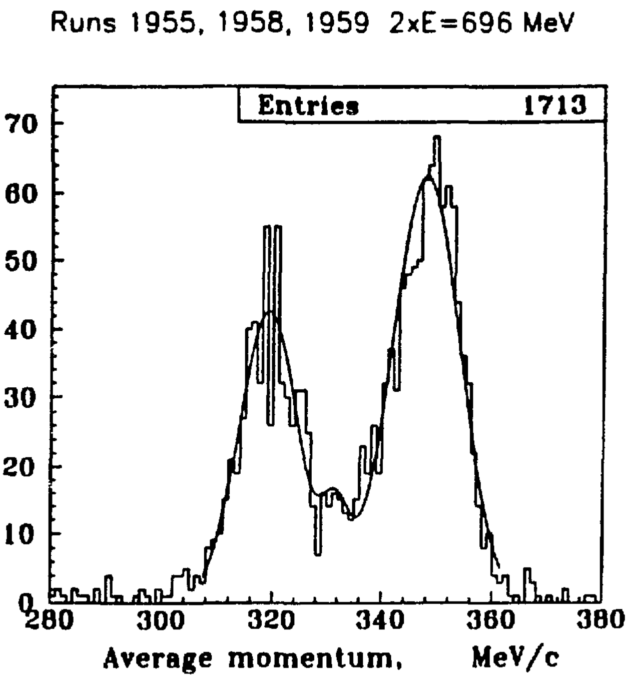

Figure 7. Average momentum of two charged particles at c.m. energy=$2xE_{beam}$=696 MeV.

Data taking will continue two or three years, after which an upgrade of VEPP-2M connected with the implementation of round beams is planned. This upgrade will be a test of the idea of round beams, important for realization of the Novosibirsk ϕ-factory project, which would have luminosity 1-3x10^{33}/cm^2/sec.

If the round beams test is successful, the VEPP-2M luminosity will increase by about an order of magnitude, to approximately 10^{32}/cm^2/sec. After this upgrade, and a corresponding planned detector upgrade, a substantial increase in statistics at the ϕ is expected.

Some of the future problems relevant to the ϕ-factory physics[9] can already be studied at VEPP-2M with the present CMD-2 detector.

One interesting project related to the ϕ-factory work is the separation of the decay $K_L => \pi\ \pi$ from the K_L semileptonic decays at the level required for the ϵ'/ϵ studies. Such separation would also allow, at the present VEPP-2M luminosities, observation of the expected Einstein-Podolsky-Rosen quantum mechanical suppression of equal-time decays.[10]

Another physics project related to the ϕ-factory physics is the observation of (or putting a limit on) the decay $\phi => f_0(975)\gamma$ with the subsequent decay $f_0 => \pi\ \pi$. This decay sheds light on the quark structure of the f_0, and the related decay $f_0 => K_L K_S$ is a potential complicating background in the ϵ'/ϵ measurement.[11,12]

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