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Calorimetry of the CMD-3 detector

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The CMD-3 detector has been collecting data since 2010 at the e^+e^- collider VEPP-2000 at the Budker Institute of Nuclear Physics. The VEPP-2000 uses the novel round beam technique and provides a high luminosity in wide range from 0.3 to 2 GeV in c.m. A physics goal of the CMD-3 experiment is the study of the e^+e^- annihilation into hadrons. The CMD-3 is a general-purpose detector which with high efficiency for both charge and neutral particles. The electromagnetic calorimeter is almost 4π hermetic. It consists of the barrel calorimeter, based on Liquid Xenon and CsI crystals, and endcap calorimeter, based on BGO crystals. The main parameters of the calorimeters and achieved resolutions is presented.

Summary

The CMD-3 electromagnetic calorimeter consists of barrel and endcap calorimeters. The inner part of the barrel calorimeter is based on Liquid Xenon. It is a set of 14 ionization chambers formed by 7 cylindrical cathodes and 8 anodes. Each anode are divided into 264 rectangular pads (8 along Z-axis and 33 in rϕ-plane) forming towers oriented to the beam interaction point. Signals from pads within one tower are summed. The signals from the towers are used to measure a deposited energy. Cathodes are divided into strips to provide a precise coordinate measurement together with the measurement of specific energy losses. Each side of the cathode cylinder contains about 150 strips. The strips on the opposite sides of cylinder are mutually perpendicular to measure two coordinates. They have semitransparent structure, which allows measuring both coordinates of a photon conversion point in a single gap. Charge-sensitive amplifiers read out the signals from cathode and anode electrodes. The LXe thickness is 5.4 X_0. It provides a unique possibility to measure the coordinates of the photon conversion point with high resolution and efficiency. Therefore, LXe calorimeter has excellent spatial resolution. To improve energy resolution it is surrounded by based on CsI scintillation crystals calorimeter. It consists of 1152 CsI(Tl) or CsI(Na) crystal of $6 \times 6 \times 15$ cm^3 size, arranged in 8 octants. The length of crystals corresponds to the thickness of 8.1 X_0. The total thickness of the barrel calorimeter is equal to 13.5 X_0. It is enough to provide the sufficient for the processes under study. The combining of information from so different calorimeters is challenging. The sophisticated procedure has been developed for this purpose. To increase solid angle coverage the CMD-3 is equipped by the endcap calorimeter. Due to a limited available space, the high-density BGO crystals are used. The endcap calorimeter consists of 680 BGO crystals of $2.5 \times 2.5 \times 15$ cm^3 arranged in two identical endcaps. The length of crystals corresponds to the thickness of 13.4 X_0. The endcap calorimeter provides quasi-uniform energy resolution for gamma quants over the solid angle of 0.94 of 4π.

To achieve the energy and spatial resolutions, the dedicated calibration procedure has been used. It includes the control of the electronic chain with pulse generator, calibration and monitoring of the calorimeter parameters with cosmic rays and final cross calibration and performance tests with events of the elastic electron-positron scattering and the double quants electron-positron annihilation are used.

The design of the calorimeter, calibration procedures and achieved resolutions are presented.

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