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Processing of the Liquid Xenon Calorimeter's signals for timing measurements.

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For identification of neutron-antineutron pair production events in the CMD-3 experiment (BINP) near threshold is necessary to measure the particles flight time in the LXe calorimeter with accuracy of about few nanosecond. The duration of charge collection to the anodes is about 5mks, while the required accuracy of measuring of the signal arrival time is less than 1/1000 of that. Besides, the signal shapes differ substantially between events, so the signal arrival time is measured in two stages. To implement that, a developed special electronics performs waveform digitization and OnLine measurement of signals' arrival times and amplitudes.

Summary

One of the goals of the Cryogenic Magnetic Detector (CMD-3) experiment (BINP, Russia) is a study of the hadrons production in electron-positron annihilation. An important example of such process is a neutron-antineutron pair production near threshold. A signature of this process is a large energy deposition in the barrel. In the barrel calorimeter the antineutron annihilation typically occurs by 5ns or later after beams collision. For identification of such events it is necessary to determine the time of signal appearance with accuracy of few nanoseconds. The arrival time measurement and recognition of antineutron annihilation must be accomplished On-Line in 1.1mks after the beam crossing so that the trigger signal can be generated in time for registration of this event.

The liquid xenon based barrel calorimeter (LXe-calorimeter) consists of 14 cylindrical ionization chambers with anode and cathode readout, which are located co-axially at increasing radii. Each anode surface is divided in rectangular cells; the cells at all 14 anode surfaces are located so that the overlapping cells constitute stacks, or "towers", directed approximately to the interaction point. All anode cells of each tower are electrically connected, so the signals from those ionization chambers in which ionization was induced are added up. The sum signal of each tower is fed to a channel of electronics.

The collection of electrons from the entire gap to the anode takes about 4.5mks. Thus, the typical signal of a tower is a current pulse with sharp rise and approximately linear fall; the total duration of the pulse is equal to the electrons collection time. However, the amplitude and shape of tower's signal in a particular event depends on the energy deposition and ionization clusters pattern in the volume of the tower. For providing the best signal-to-noise ratio, a charge sensitive amplifier is used at the front end of the electronic channel; therefore the amplified signal available for further processing has the rising edge as long as tower's signal, and the shape of this rising edge varies from event to event in correspondence with the shape of tower's signal.

The duration of charge collection to the anodes is about 4.5mks, while the required accuracy of measuring of the signal arrival time is less than 1/1000 of that. Besides, the signal shapes differ substantially from event to event, so the signal arrival time is measured in two stages. At the first stage, the signal arrival time is determined with an accuracy of 1–2 discretization periods, and initial values of parameters for subsequent fitting procedure are calculated. At the second stage, the signal arrival time is determined with the required accuracy by means of fitting of the signal waveform with a template waveform.

For the moment, the developed algorithm has been successfully implemented in hardware. The prototypes of signal processing modules for LXe-calorimeter towers was manufactured and successfully tested at the detector. A obtained timing resolution was close to the design value.

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