The CMD-3 detector at VEPP-2000

The CMD-3 cryogenic magnet detector is a universal HEP tool for precision experiments with the VEPP-2000 e+e- collider, Novosibirsk, Russia. It is the successor of the CMD-2 detector with totally redesigned systems. It consists of an electro-magnetic calorimeter, tracking system, muon and TOF systems. The calorimeter covers nearly a 4pi angle and includes an endcap 13.4Xo BGO crystal, inner barrel of 5Xo LXe calorimeter and outer barrel of 8.1Xo CsI calorimeter. The tracking system includes a Drift Chamber and Z-Chamber. A 1.5T superconducting magnet of 0.18Xo is placed between the tracking system and calorimeter. This detector is targeted for precision measurements over a wide 2E energy range of 0.4 to 2GeV.
The main feature of CMD-3 is the 400 liter LXe calorimeter, which allows to improve the energy resolution σE/E to 4.7..3%, and spatial resolution to 0.005rad. The totally new drift chamber has 1280 hexagonal cells with double-end readout. The performance of the drift chamber has been greatly improved to a σr-φ resolution of 100..140um and σφ of 4e-3.
The CMD-3 total physical systems'capacity is about 10k channels. To satisfy requirements of speed and accuracy, a totally new DAQ system was designed. The Primary Trigger operates with an associated data stream of 12Gbps and produces positive decisions at a mean rate of up to 1kEvps. The DAQ collects digitized data at about 0.7Gbps and writes them to tape.
This paper describes the features and status of the detector systems, which appear ready for commissioning. The detector has been shown to allow for cosmic-ray event reconstruction. At the moment beam tests are underway.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

The construction of the CMD 3 detector is now being completed at the Budker Institute of Nuclear Physics (Novosibirsk, Russia). One of the main sensitive systems of this detector is the liquid xenon based calorimeter (LXe calorimeter). The 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 (33 cells in azimuth and 8 cells in longitude) ; the boundaries between sells at all 14 anode surfaces are disposed at the same azimuths and are slightly shifted in longitude, 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 as 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.
Typical signal of a tower is a current pulse with sharp rise and approximately linear fall, but the amplitude and shape of tower's signal in a particular event depend on the energy deposition and ionization clusters pattern in the volume of the tower.
Towers' signals are fast enough to use them not only for energy deposition measurement but also for time measurements and triggering. The signal arrival time measurements accuracy achievable by using a special signal processing technique allows one to attribute each particular signal to the relevant bunch crossing, and moreover, to select by time criterion the signals induced by annihilation of antineutron created in neutron antineutron events.
The characteristic feature of such events is that annihilation of antineutron occurs by some 4,5ns and later after the bunch crossing. Taking into account the expected time resolution, there was defined the physical goal to select from background the events at which an energy deposition of more than 150 MeV occurred by 10 ns or more after the bunch crossing. To recognize these events it is necessary to measure the arrival time of signals of various amplitude and shape with accuracy of (2*3) ns ON-LINE, i.e. before data acquiring and processing them by computer. The arrival time measurement and antineutron event recognition must be accomplished in 1.1 microsecond so that the trigger signal can be generated in time for registration of this event.
To select the optimal parameters of the measuring channel and of the signal processing algorithm and, along with that, to define the achievable time resolution, a thorough simulation had been made. The contribution of the electronics noise to the timing resolution was evaluated using Monte Carlo simulation. Timing uncertainty introduced by the difference of input signals' shapes was estimated by means of simulation of the measuring channel responses for signals of 3 different special shapes which characterize the channel responces for the

whole variety of input signals.
The developed algorithm includes implementations of the following functions. The Constant fraction Discriminator is used for deriving the primary time tag signal. This tag is aligned to the moment of input signal arrival with accuracy of 1 sampling period, which is 10ns. Linear interpolation is used to obtain the time measurement l.s.b. value of less than 1 ns To achieve the required time measurement accuracy, a special correction has been introduced which compensates for the deviations accoused by the difference of input signals' shapes.
For the moment, the prototype of signal processing module for LXe-calorimeters tower is made. During a thorough testing at the test bench the signal arrival time measurements accuracy close to the design value has been achieved.

Authors: Mr RUBAN, Alexander (A.); Mr EPSHTEYN, Leonid (BINP)

Co-authors: Mr KOZYREV, Alexey (N.); Mr SELIVANOV, Arkadiy (N.); Mrs SMOLINA, Helen (V.); Mr TITOV, Vitaliy (M.); Dr AULCHENCO, Vladimir (M.); Mr YUDIN, Yury (BINP)

Presenter: Mr RUBAN, Alexander (A.)