Development of the CBM RICH readout and DAQ

Introduction

The CBM experiment at the future FAIR facility (Darmstadt, Germany) will investigate strongly interacting, matter at high necleon-nucleon densities, but moderate temperatures in heavy-ion collisions and with a load of strange matter. The SIS 100 synchrotron will deliver ion beams from proton to uranium with energies of up to 15 AGeV for the hadron nuclei. Beam intensities of up to 10^9 per second will provide nuclear interaction rates up to 10^7 per second for a fixed target experiment.

Such a high interaction rate is necessary for accessing rare processes. As a consequence of the high interaction rate, triggering readout and full event reconstruction on the fly are foreseen.

The CBM RICH detector is required for identifying different reactions in a momentum range up to 8 GeV/c. It is a classical RICH detector with gaseous radiator, spherical mirrors and segmented photodetectors (camera made of -1000 Hamamatsu H2270 multi-anode photomultiplier tubes). The MAPMTs will be read-out by self-triggered FPGA-based front end boards detecting only time-over-threshold signals using two TDC channels, and thus allowing the measurement of time-over-threshold signals from each MAPMT.

During our Nov 2014 CERN-PS beamtime FLES Interface board was successfully tested. The MAPMTs were read out by 64 PADIWAs and 64 TDCs on 16 addon boards – adaptors for flat cables transmitting laser data to each TRB with “standard” firmware – 4 TDCs and hub; 4 addon boards – adaptors for flat cables transmitting DAQ system and its separate components to NIC carrier. The theoretical limit is in order of 350 ps and it is dictated by the transition time resolution of the multi-anode photomultiplier tube, which was shown before and after applying the time calibration.

The same is applicable to all the photons of a single Cherenkov ring.

In order to derive the time characteristics of the readout chain and its components we use the fact that the hits of one laser flash (duration 10-20ps) come to the photodetector camera simultaneously and measured pulse width are shown below before and after applying the time calibration.

Analysis results

Simultaneous hits

For measurements of time resolution of TDCs, a 10ns-wide pulse from a high-precision pulse generator was split into two and sent to different pairs of input channels using identical cables. Examples of the distribution of the difference between the two timestamps are shown below after applying the time calibration.

Event building

As the electronics is self-triggered and data acquisition is in free-running mode, input data comes in portions which have nothing common with real events though we call them DAQ-events. A procedure of event building is required in order to provide correct information to reconstruction algorithms and further analysis.

CBM RICH beamtime and lab data analysis

Calibration

FADC-to-time signals are applied to the TDCs to calibrate the time resolution of the entire readout chain. The FADC measurement allows to extract the exact time of the event.

Analysis

Time resolution of the full readout chain

From the “leading edge difference” distribution we derive the time resolution of the full readout chain as τ_{FWHM} = 166 ps.

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Multi-peak time-over-threshold

Preliminary analysis of the data received during the beam tests showed unexpected distributions of time over-threshold, which were caused by the presence of periodic noise. It is well described in the following paper:

F. Gonnella, V. Kushcharyov and B. Mitrjuk