Development of MWDC readout system for the spectroscopy experiment of η' mesic nuclei at GSI and FAIR

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The $\eta'(958)$ meson has an exceptionally large mass, compared with other pseudoscalar meson such as pions. Theoretically, it has been pointed out that a large mass reduction ($\sim$100 MeV) is expected at the normal nuclear density, which leads to existence of an η' mesic nucleus, a bound state of an η' meson and a nucleus. From an experimental observation of η' mesic nuclei, we may take the first step to understand the η' mass generation mechanism[1]. For this purpose, we perform spectroscopy of η' meson bound states in ^{11}C nuclei by missing-mass measurement of the ^{12}C(p,d) reaction near the η' production threshold at the GSI-SIS facility[2].

In this experiment, a 2.5 GeV proton beam extracted from SIS synchrotron will be injected into a ^{12}C target, and the ejectile deuterons with the momenta of $\sim$ 2.8 GeV/c are momentum-analyzed by the fragment separator(FRS) at a dispersive focal plane with detection of the tracks by two sets of multi-wire drift chamber MWDCs. The first experiment is scheduled in July 2014.

We are working on upgrading the current DAQ system, particularly the readout of MWDCs. We will adopt a 64ch all-in-one readout board equipped with ASD, Flash ADC, and TDC. Almost all the digital processes are designed in the FPGA. This board was originally designed for Belle-II Central Drift Chamber (CDC)[3]. According to Ref. 3), they achieved a dead time of about 0.5% at a trigger rate of 10 kHz in a test experiment. This is approximately a factor 10 improvement compared to the current (our) system.

The digitalized data are transferred through a network with the SiTCP[4] sub-system, which is an implementation of TCP/IP on FPGA. We have been customizing the FPGA program and investigating the potential of the board. In case that the readout board is equipped with performance of reading data at a several kHz trigger, the quality and the quantity of the experimental data will exhibit significant improvement compared to that of the VME based DAQ without the readout board.

The readout board is being updated, so as to operate under a trigger distribution system, which is already adopted in J-PARC hadron experiments. Along with readout boards, we are developing a new "sub trigger module" (STM), for distributing trigger information including the event tag to each readout board. The distribution system with STM is useful to ensure the event matching and to avoid overlooking event slips among different DAQ subsystems.

We will make a performance test of the readout board with respect to the radiation tolerance and the DAQ rate, exploiting the opportunity of beamtime at GSI in July, 2014. By loosening the trigger condition, the performance under a high trigger rate will also be evaluated.

In summary, we will introduce a network-based DAQ with the readout board for MWDCs in the η' experiment at GSI beyond 2014 and FAIR, which is currently under construction. As it will enable us to handle a higher trigger rate, a high-statistics measurement will be possible by using a more intense beam and/or a thicker target.

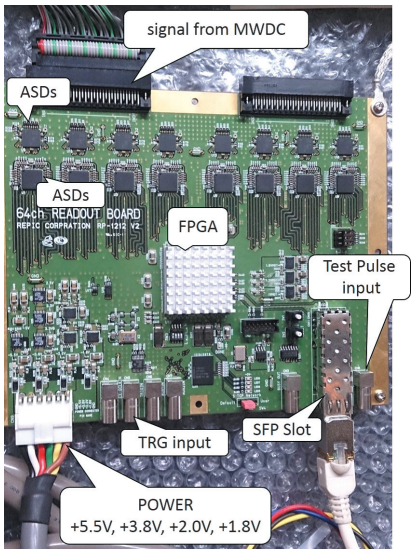

Fig. 1. View of 64ch Readout Board.

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References

1) H. Nagahiro, D. Jido, H. Fujioka, K. Itahashi, and S. Hirenzaki : Phys. Rev. C **87**, 045201 (2013).
2) K. Itahashi *et al.*: Prog. Theor.Phys. **128**, 601 (2012).
3) N. Taniguchi *et al.*: Nucl. Inst. Meth. **732**, 540 (2013).
4) T. Uchida : IEEE Transaction on Nuclear Science, vol. 55, no. 3, June 2008.