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20. Studies of an event-building algorithm of the readout system for HFRS-TPC

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The High-energy Fragment Separator (HFRS), which is currently under construction, is a leading international radioactive beam device. It will significantly enhance the experimental capability in the medium-heavy nuclear region. Given the high-energy and high-intensity properties of HFRS, it is imperative to implement a highly reliable identification of nuclides at high counting rates (~10 MHz) and meet the large dynamic range requirements (Z=1~92), which poses a great challenge to radioactive particle detection and readout electronics technology. As the counting rate of the projectiles increases, there is a strong possibility that the readout signals from different particles experience time disorder, so the twin TPCs are chosen as a position-sensitive detector. However, due to the large number of readout channels and the vast amount of data, higher requirements for data transmission, processing and storage have been posed, which bring great challenges to the development of readout electronics.
Therefore, we propose a new online event building algorithm for HFRS-TPC. Our algorithm employs a combination of software and hardware to compress massive amounts of data using a hierarchical processing strategy, and addresses the issue of particle time disorder at high counting rates. The readout system employs a three-tiered structural design consisting of Front-End Electronics (FEEs), slave Data Acquisition units (slave DAQs), and a server. The main function of the FEE is to process the signals from the detectors at the channel level. The FPGA firmware of the FEE features an on-line algorithm for extracting time and energy information to minimize data volume. The slave DAQ executes the aggregation of detector level data using a high-performance FPGA (Xilinx Kintex UltraSCALE 060), which aggregates and packages data from multiple FEEs with 10-Gbps high-speed optical fiber links. Subsequently, the particle multiplicity is restored by cluster reconstruction. Once this is completed, the Center of Gravity (CG) approach is used to determine the original incident positions of the particles on the readout strips in each detector. Finally, both the incident position and drift time from the two TPCs are relayed to the hit-matching module on the server, and the two-dimensional trajectory of the incoming particles is ultimately reconstructed.

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