First performance results for the ZDC Readout Electronics of the external target experiment at HIRFL-CSR

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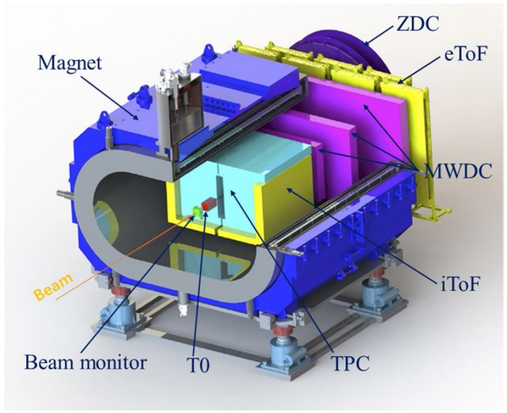
Abstract: The CSR External-target Experiment (CEE) at the Heavy Ion Research Facility at Lanzhou (HIRFL) will be the first large-scale experiment in nuclear physics independently developed in China, covering the GeV energy regime. As a major detector of CEE, The Zero Degree Calorimeter (ZDC) measures the centrality and reaction plane of the nuclear-nuclear collision from the hadron background. It comprises Plastic Scintillator (PS) crystal bars with a fan-shaped size for each. The PS bars directly coupled with a PMT (photomultiplier tube) to convert charged particles into electrical signals. The readout electronics consists of 12 Front Amplify Units (FAUs), 12 Read Units (RUs), one sub-trigger module, one sub-DAQ module, and one sub-clock module. In addition, there is one HV (High Voltage) crate providing a high voltage supply for the PMTs to provide power supply for the nearby PMTs. On the basis of the previous version of the prototype, in order to improve the performance of the detector, achieve a wider measurement range, and better electronic performance. This article introduces the upgrade of detector readout methods, electronic hardware, and data processing algorithms, as well as the integration with subsystems such as CEE DAQ, triggers, clocks, and the long-term stable operation in engineering.

Introduction

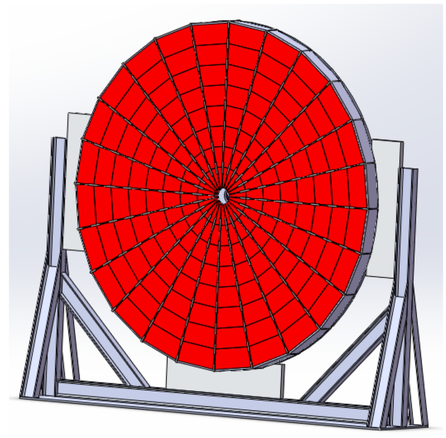
- The CSR External-target Experiment (CEE) at the Heavy Ion Research Facility at Lanzhou (HIRFL) will be the first large-scale experiment in nuclear physics independently developed in China, covering the GeV energy regime.
- The Zero Degree Calorimeter (ZDC) is used to measure the centrality and reaction plane of nuclear collisions by measuring the strong hadronic background. It consists of plastic scintillator (PS) crystal rods, each with a fan-shaped size. The PS rods are directly coupled to photomultiplier tubes (PMTs), which convert charged particles into electrical signals.
- To improve the performance of the detector and achieve a wider measurement range, the anode output of the PMTs was changed to a dual dynode output.

(a)



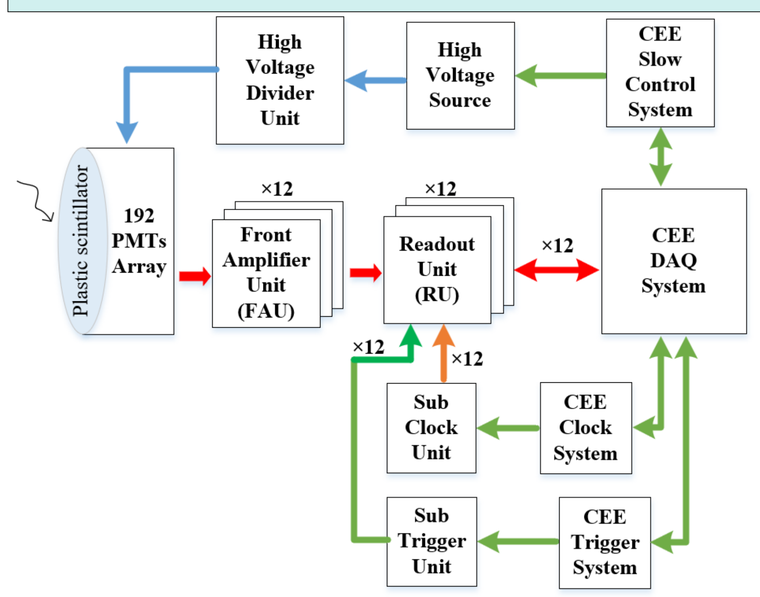
The layout of the CEE

(b)



The layout of ZDC detector

The design of ZDC Readout Electronic



the block diagram of readout electronics for the ZDC detector

- Two remote configuration collection modes:

  a. Peak only mode b. Full waveform mode

- Two remote configuration trigger modes:

  a. Local trigger mode b. System trigger mode

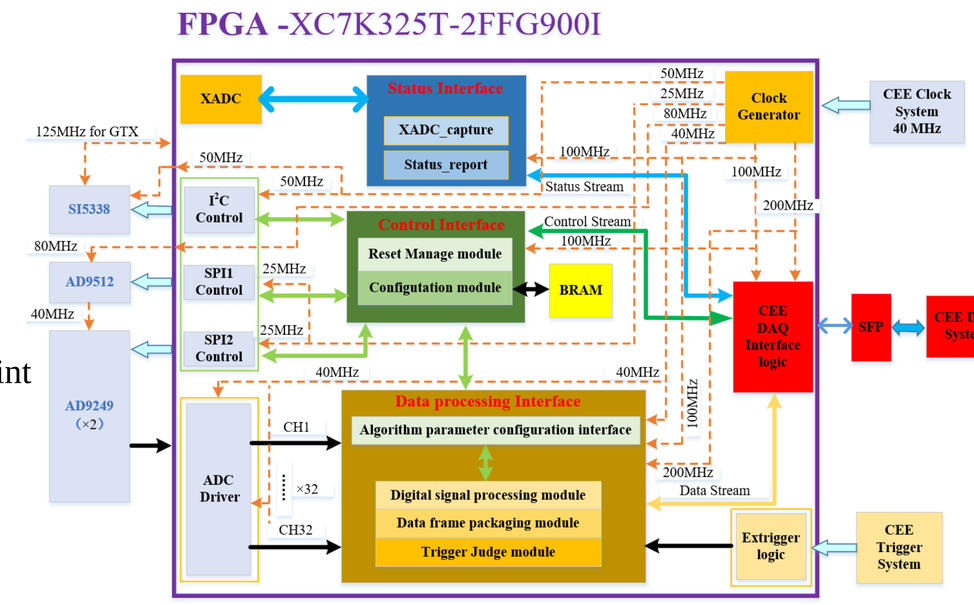
- Integrated algorithm:

  Rise edge detection/ Baseline recovery/ Multi-point digital sliding filter/ Online peak detection

- Three interfaces :

  a.Data process Interface b.Control Interface

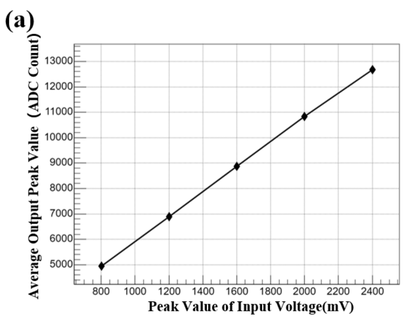
  c.Status Interface



the logic design of Readout Unit

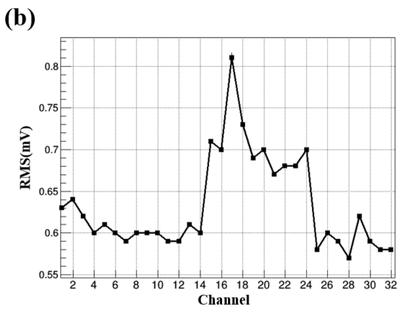
Performance

(a)

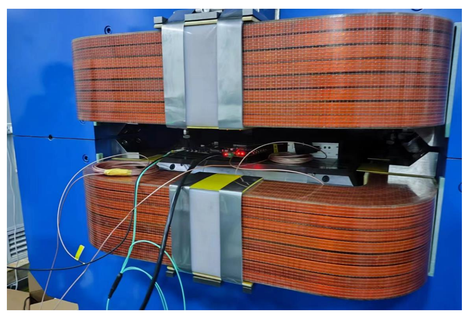


Linear fitting result

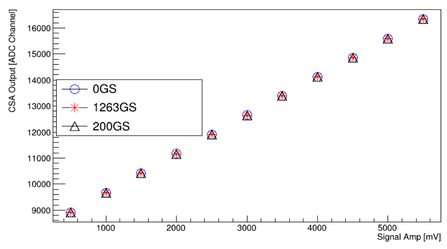
(b)



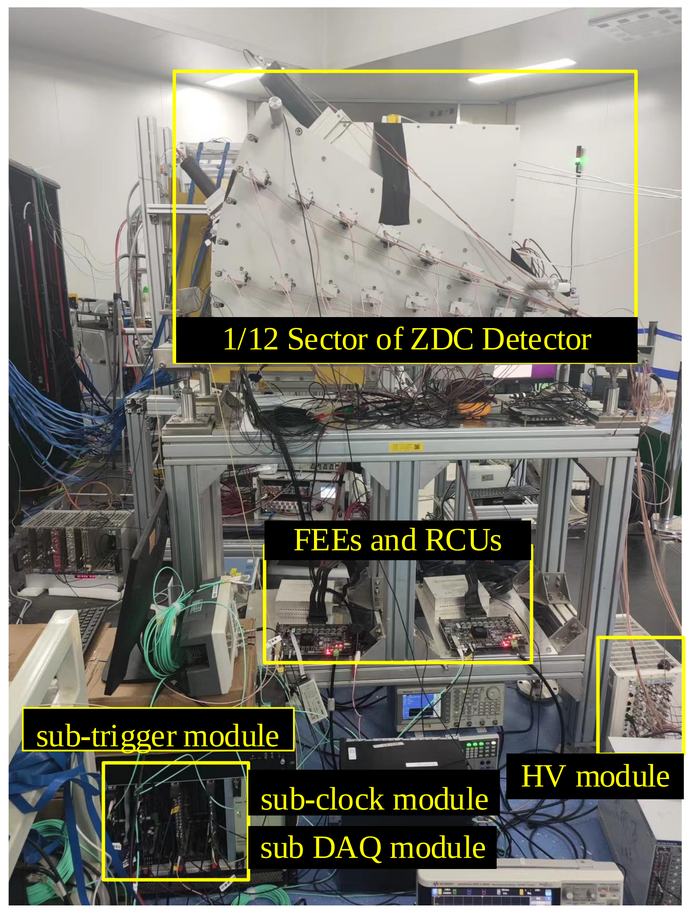
RMS result



the test setup in magnetic field environment.

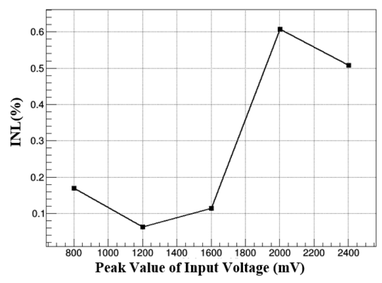


Comparison of magnetic field environment test results



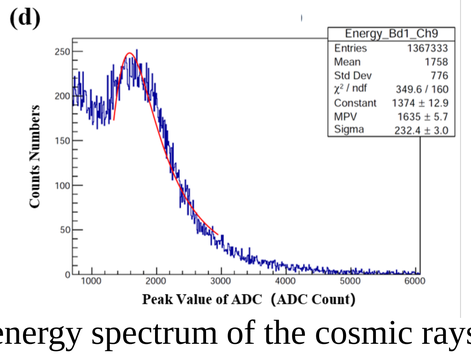
the beam test setup

(c)



INL result

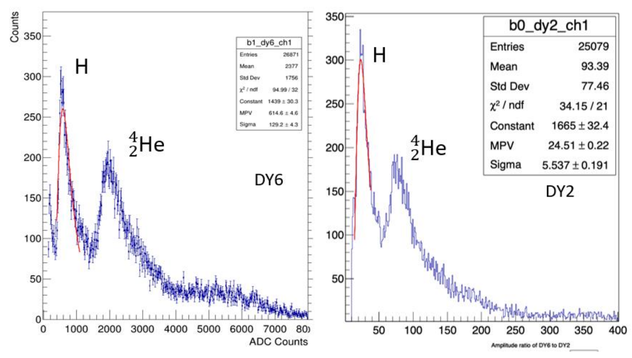
(d)



energy spectrum of the cosmic rays

- Figure (b) displays the noise performance is less than 1 mV (RMS).
- Figure (c) displays the fit for the example channel of RCU and the readout electronics' integral nonlinearity (INL) is less than 0.7%.
- Figure (d) shows the peak values of the reconstructed energy spectrum of the cosmic rays. All the peak values are around 1758 ADC value and the curve conforms to the Landau distribution.

- The electronic system has no effect when the magnetic field strength is below 1263gs.



- The energy loss peak of Q=2 charged particle can be seen on the measured energy spectrum.

Conclusion

This paper presents the readout electronics for the ZDC detector in the CSR External-target Experiment (CEE). The readout electronics consists of consists of twelve Front Amplify Units (FAUs), twelve Read Units (RUs), one sub-trigger module, one sub-DAQ module, and one sub-clock module. Test results show that the readout electronics' integral nonlinearity (INL) is less than 1% and the noise performance is less than 1 mV (RMS). In addition, the test results of electronics in magnetic field environment, cosmic ray test results, and beam experiment results indicate that the readout electronic device can achieve good performance.