Contribution ID: **7** Type: **Poster presentation**

Design of the Readout Electronics Prototype for LHAASO WCDA

Tuesday, June 7, 2016 3:00 PM (1h 30m)

The Large High Altitude Air Shower Observatory (LHAASO) is proposed to be built at an altitude of more than 4000 m, which aims for a very high energy gamma source survey above 30 TeV. The Water Cherenkov Detector Array (WCDA) is one of the major components in LHAASO. The WCDA electronics are responsible for the readout of 3600 Photomultiplier Tubes (PMTs), and a total of 400 Front End Electronics (FEE) modules are required.
The main challenges in the WCDA readout electronics design include:
1) Both precise time and charge measurement is required over a large dynamic input amplitude range from 1 Photo Electron (P.E.) to 4000 P.E.
2) The 3600 PMTs are scattered within an area of 90000 m2, and since high precision time measurement is required, high quality of clock distribution over a long distance is necessary, and automatic clock phase compensation is expected with varying ambient temperature.
3) Besides, due to the requirement of "triggerless" architecture, all data from FEEs need to be read out based on 1000 M Ethernet and TCP/IP standard. To simplify the system architecture considering the large scale of detector node distribution, clock, data, and commands are mixed together and transmitted through the same fiber for each FEE.
In this paper, we present the prototype design of the readout electronics for the LHAASO WCDA, and key techniques are discussed. We also conducted tests on the prototype electronics to evaluate the performance. The results indicate that a charge resolution better than 15%@ 1 P.E. and 2%@ 4000 P.E., and a time resolution better than 0.3 ns RMS are successfully achieved over the whole dynamic range; the clock phase compensation precision is better than 100 ps in the temperature range from -10 °C to 60 °C, beyond the application requirement.
Detailed information are included in the attached supporting material document.

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Session Classification: Poster session 1

Track Classification: Real Time System Architectures and Intelligent Signal Processing