A signal processing system for detecting ultra-high-energy particles with FAST

Xiaojing Wu[(1)], Ran Duan* [(1)]
(1) National Astronomical Observatories, Chinese Academy of Sciences; e-mail: wxj@nao.cas.cn; duanran@nao.cas.cn

Since the confirmation of the Askaryan effect by the Stanford Linear Accelerator Center (SLAC), a large number of experiments have used the lunar Askaryan method to detect ultra-high-energy particles, but so far, there has not been enough sensitivity to confirm the pulse corresponding to the Askaryan effect [1]. Therefore, this paper attempts to propose a device with sufficient sensitivity to detect ultra-high-energy particles.

The FAST ultra-high-energy particle detection signal processing system proposed in this paper can capture ultra-high-energy particle signals with the high sensitivity of FAST, and efficiently process the time-domain big data for ultra-high-energy particle detection in real time.

Nanosecond pulses require direct processing of raw voltage data with telescope time-domain sampling accuracy, resulting in unprecedented requirements for overall data volume and throughput. This system combines the advantages of FPGA and GPU processing to carry real-time identification of large data volumes, and forms an effective trigger and storage mechanism to achieve system flexibility and scalability. Be prepared for indicator improvement, system upgrade, module addition. This has not been used in such signal processing systems.

FPGAs are suitable for high-speed signal access and linear computing, so FPGAs are used for real-time time-domain raw voltage data acquisition, atmospheric dispersion coarse reduction, multi-beam cross-authentication, trigger storage mechanism generation, and raw data storage, while reducing the signal rate. GPUs can perform more complex algorithms, with sufficient memory but narrow access bandwidth. Therefore, the GPU is used to access the data processed by the FPGA in real time for subsequent data analysis, including detailed dispersion and RFI removal (using RFI clumpiness, spectral properties, etc.).The system software flow is as follows:

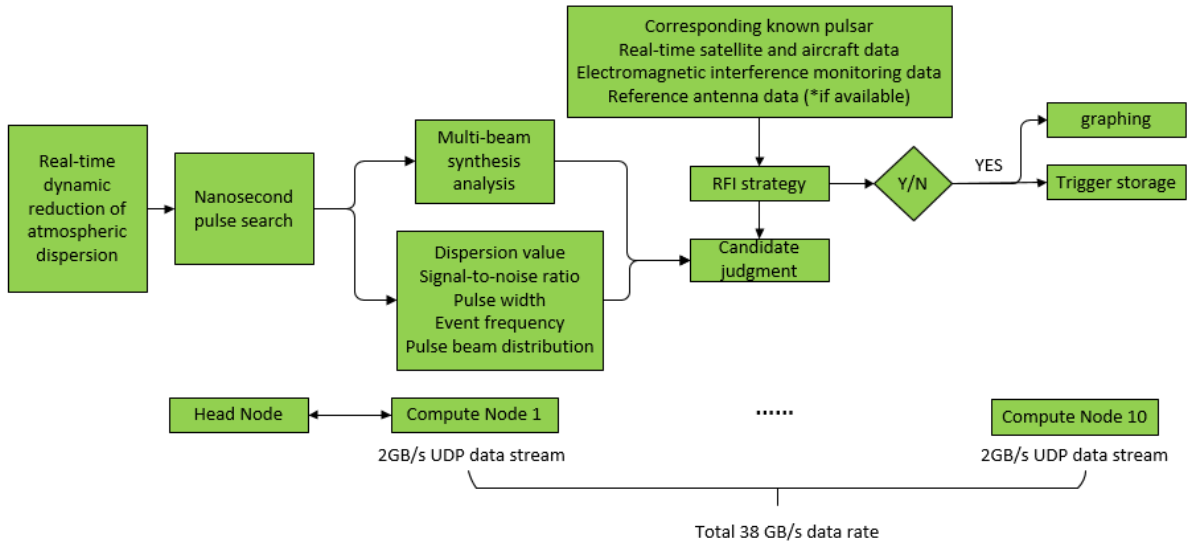

Figure 1. Data flow diagram of FAST ultra-high-energy particle detection terminal system

At present, the functional development of the system has been basically completed, which can provide technical foundation and functional verification for the construction of the subsequent complete system.

References

[1] C. W. James, J. D. Bray, P. S. Cannon, and R. D. Ekers, "Prospects for detecting ultra-high-energy particles with FAST," *RAA* 2019 Vol. 19 No. 2, 19(14pp) doi: 10.1088/1674–4527/19/2/19.