



Study on function and performance of data acquisition board of 'GRAND'



Yiren Chen^{1,2}, Jianhua Guo¹, Xing Xu^{1,2}, Shen Wang¹ and Jiaolong Chen^{1,2}

1, Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210023, China

2, School of Astronomy and Space Science, University of Science and Technology of China, Nanjing 210023, China

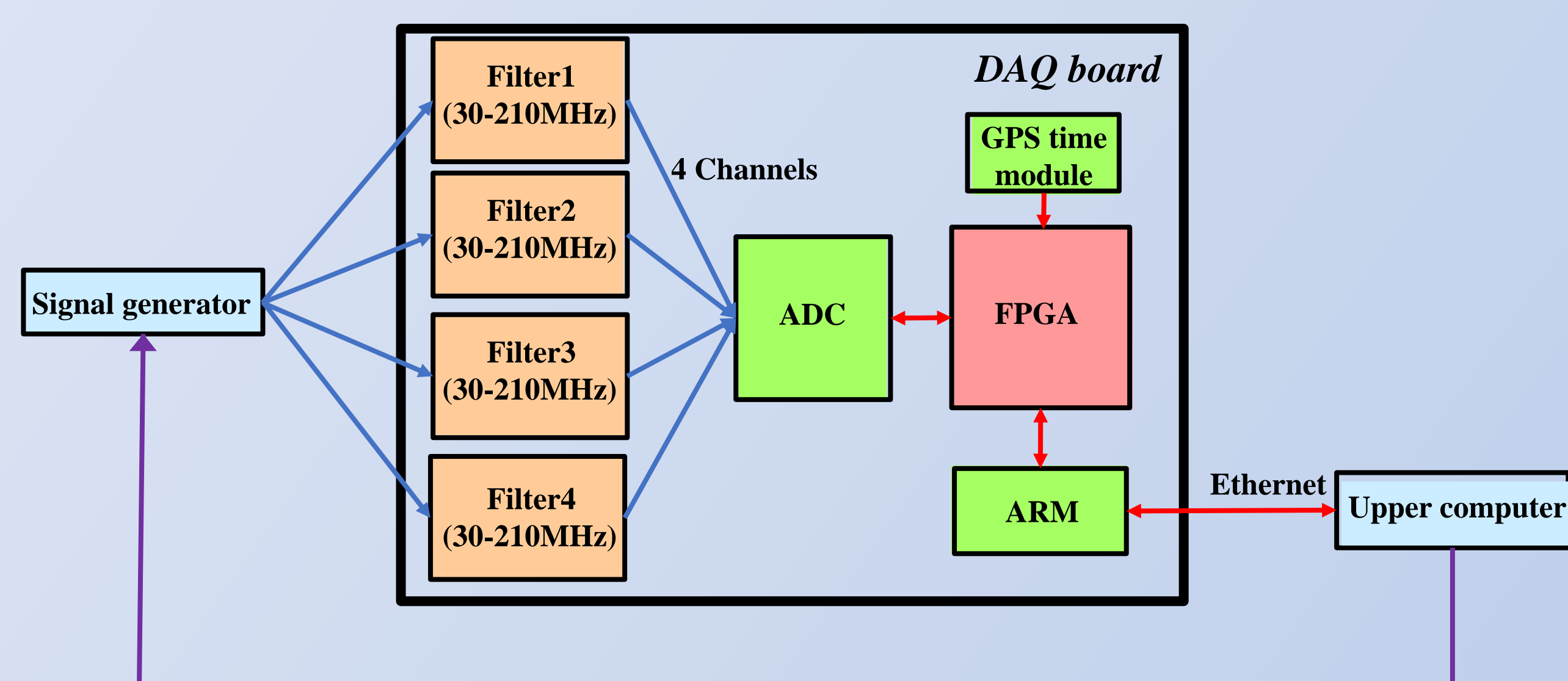
Corresponding author: cheniyiren@pmo.ac.cn

Abstract— 'GRAND' is a scientific project called 'giant radio array for neutrino'. By detecting the radio signals generated by the air shower of ultra-high energy particles in cosmic ray and under the action of geomagnetic field and Askaryan effect, it will contribute to the study of the origin, acceleration and propagation mechanism of ultra-high energy cosmic rays. The detection unit of 'GRAND' includes antenna, low noise amplifier, WiFi, solar power supply device and DAQ board. The DAQ board can conduct electronic processing on the received signal of the antenna and transmit the collected data to the central station through WiFi. Therefore, it is necessary to conduct function and performance tests on the DAQ board. The functional tests include: signal acquisition and transmission test, FPGA trigger algorithm test, FPGA filter algorithm test, etc. The performance tests include: ADC performance test, system gain test, GPS time performance test, etc.

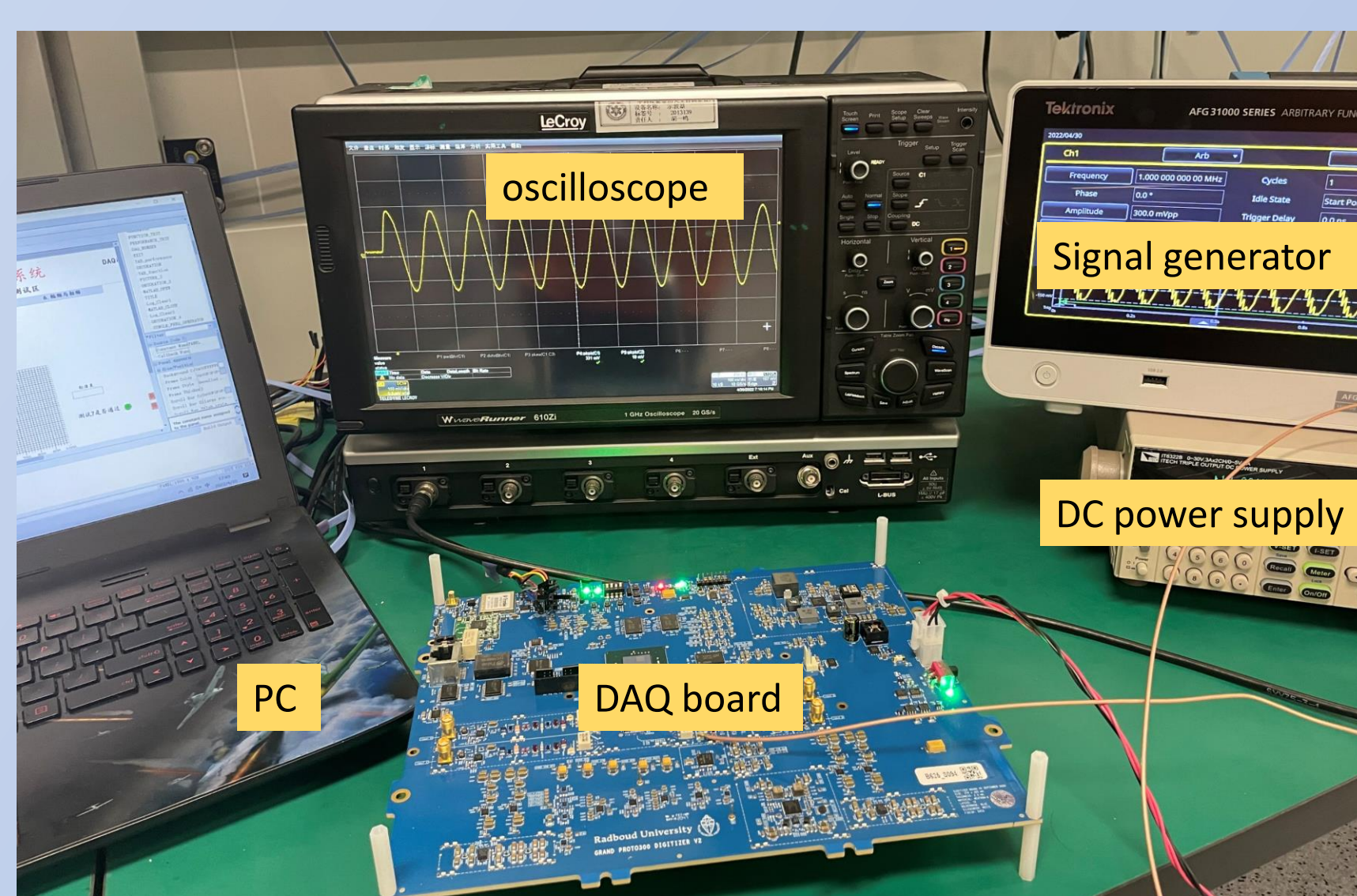
Introduction

In this research, we design a test bench to test the DAQ board, including function tests and performance tests.

Test Bench



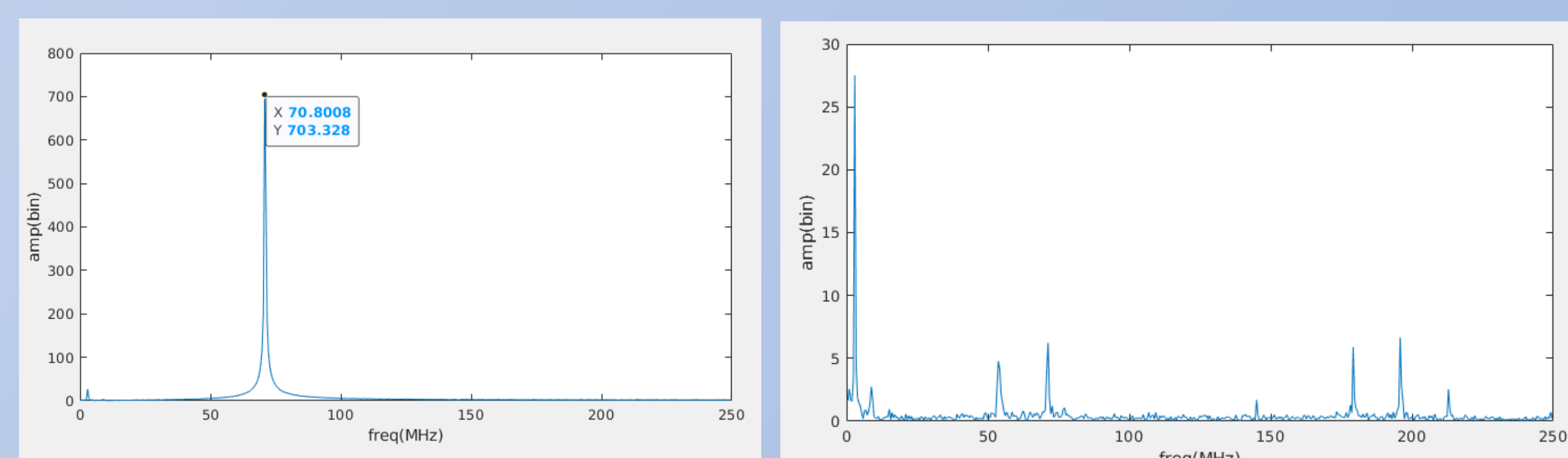
- **Signal generator:** SMA100B, which generates very pure signal. It has outstanding SSB phase noise, -130 dBc (typ.) at 100 MHz and 30 Hz offset.
- **DAQ Board:** Data Acquisition Board. Four pass-band filters allow signal with frequency between 30 and 210MHz to pass. AD9694 has four channels and a sampling rate of 500MHz to sample the signal from filters. FPGA contains filtering and triggering algorithms to select right events. GPS time module will give the time of each event. ARM transmits data to upper computer through Ethernet and also receives command from upper computer.
- **Upper Computer:** A LabWindows program on host PC is used to configure Signal generator and analyze the data from DAQ board.



Function Test

- Input signal: sine wave, 71MHz, 300mV(effective value)
- Channel: ADC channel 1
- Trigger mode: internal trigger(20Hz)
- Digital filter: IIR notch filter, 71MHz, $r = 0.99$

We inject a sine wave of 71MHz generated by signal generator into DAQ board and obtain data through Ethernet. Because the sampling rate of ADC is 500MHz, the time interval of these data is 2ns. Then perform fft on these time domain information and the results are shown in the following figures. The left image is unfiltered, it can be seen that the DAQ board samples and transmits the signal normally. The right image is digitally filtered, it can be seen that the sine wave is filtered successfully.



Performance Test

- **ADC performance:**
We used fft test method to assess the dynamic performance of ADC. According to calculation, ENOB(effective number of bit) is 10.69. The standard value of ENOB in the datasheet is 10.8.
- **GPS time performance**
We used two DAQ boards to receive the same pulse signal, calculate the time difference of each trigger case, and perform Gaussian fitting on the time difference. Finally, the standard deviation we obtained is 11.62 nanoseconds. The standard deviation in the datasheet is 15 nanoseconds.