Progress in Readout Electronics for STCF ECAL

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1. INTRODUCTION

Super Tau-Charm Facility (STCF) is one of the important options for accelerator-based particle physics in China. Electromagnetic Calorimeter (ECAL) is one of the important detectors of STCF, whose core task is the precise measurement of photons. In the face of complex background environment, STCF ECAL needs to obtain accurate energy information and time information of photons at the same time to effectively suppress the background. As is shown in the next figure, STCF ECAL selects pure Csium iodide (pCsI) with the advantages of fast response speed and good anti-irradiation performance as its scintillation crystal, and uses a large-area avalanche photodiode (APD) with a certain internal gain as a photoelectric conversion device to make up for the shortcomings of low pCsI optical yield. Therefore, readout electronics need to be designed with low noise to meet the measurement needs of STCF ECAL.

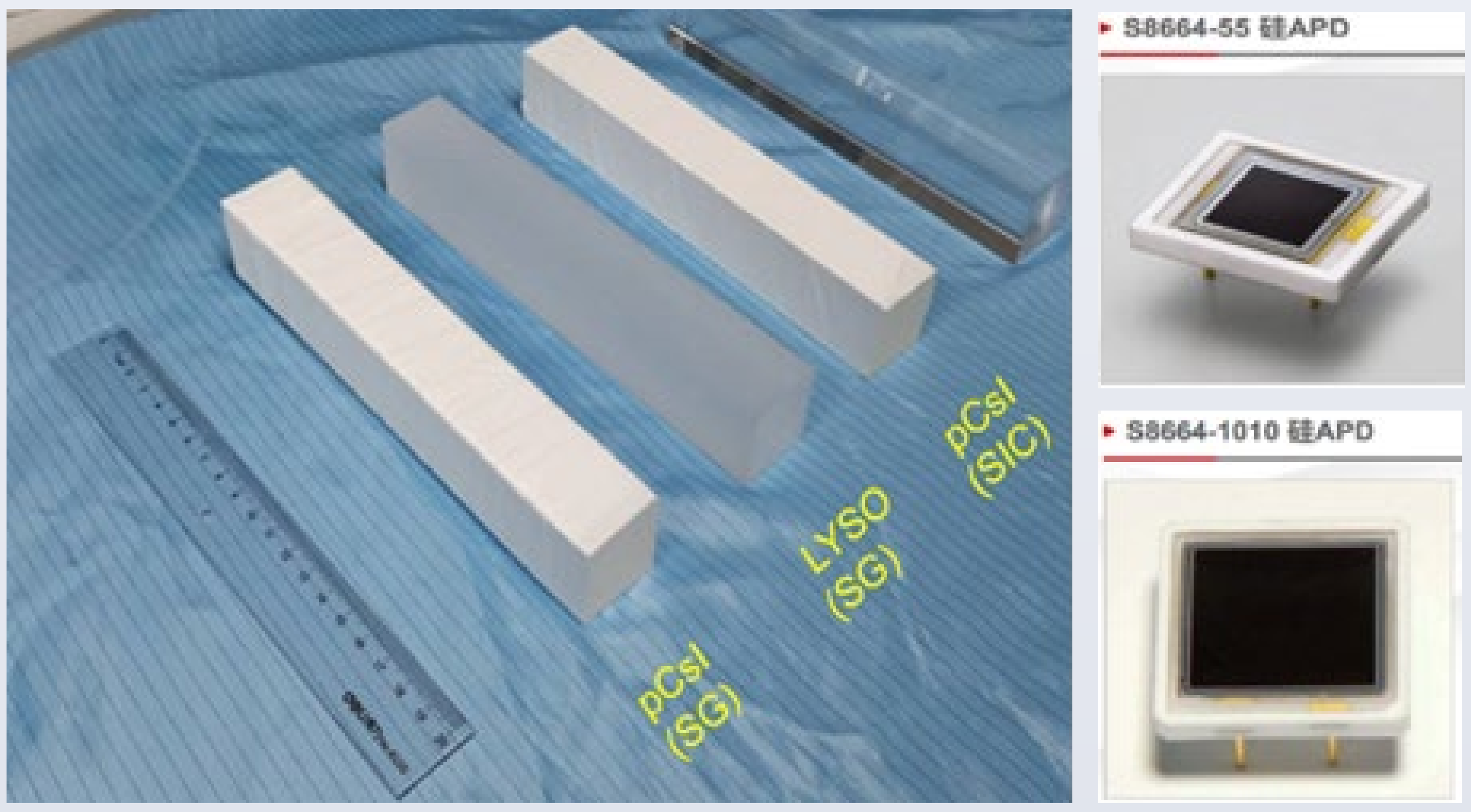

Fig 1 Pure Csium iodide (pCsI) and avalanche photodiode (APD) selected.

2. SYSTEM ARCHITECTURE AND MODULES

The readout structure of the ECAL prototype is shown in the next figure, which contains Front-End Module (FEM), Signal Processing Module (SPM) and the computer for storing data. In order to meet the above readout electronics requirements, the Front-End Module determines the energy measurement scheme based on the Charge Sensitive Amplifier (CSA), and uses algorithm to deal with the pile-up signals in SPM, and the energy information and time information that meet the measurement requirements of STCF ECAL can be obtained.

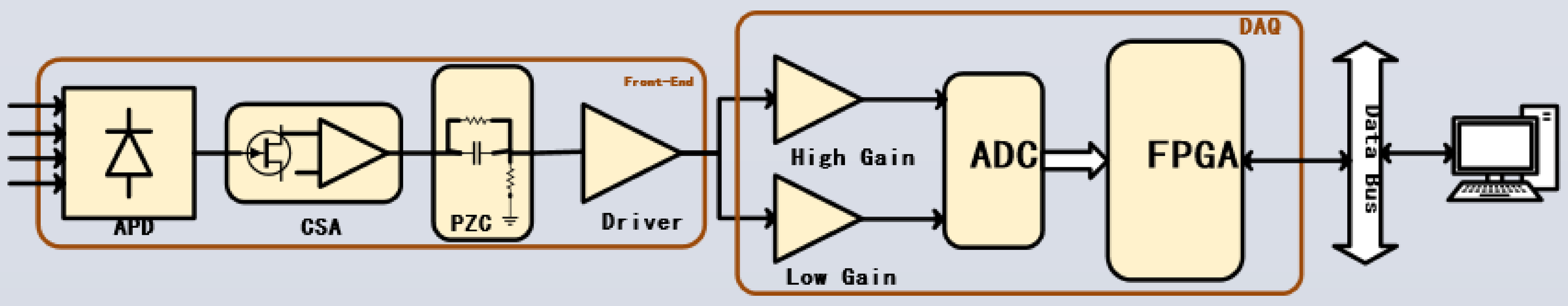

Fig 2 The readout structure of the ECAL prototype

As is shown in the next figure, the FEM contains 4 “APD-CSA” channels, pole-zero circuit (PZC) and driver circuit, and the SPM retrieves data from multiple channels using ADCs with 80Msps sampling rate.

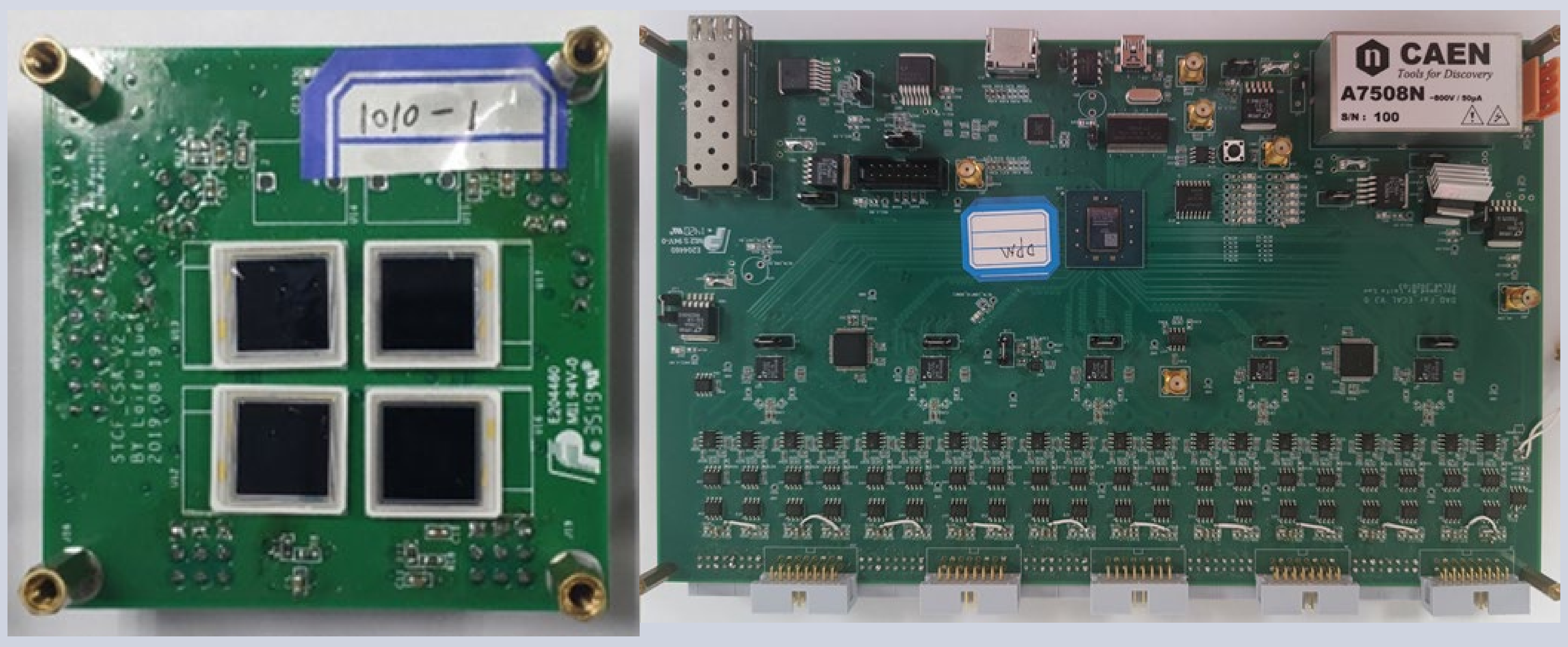

Fig 3 Front-End Module (FEM) and Signal Processing Module (SPM)

3. ALGORITHM VERIFYING

We use an algorithm to extract the time and energy information of the signal through a relatively simple calculation. As is shown in the next figure, we apply the algorithm to the measured waveform, it has been verified that the algorithm can improve the baseline noise by 70%. In order to verify the time measurement effect of the algorithm, we use the actual waveform shape for modeling and simulation, and use the analytical formula obtained by the actual waveform fitting to add the actual measured noise. Time resolution can reach 474ps @ 300fC, 49ps @ 3000fC in simulation.

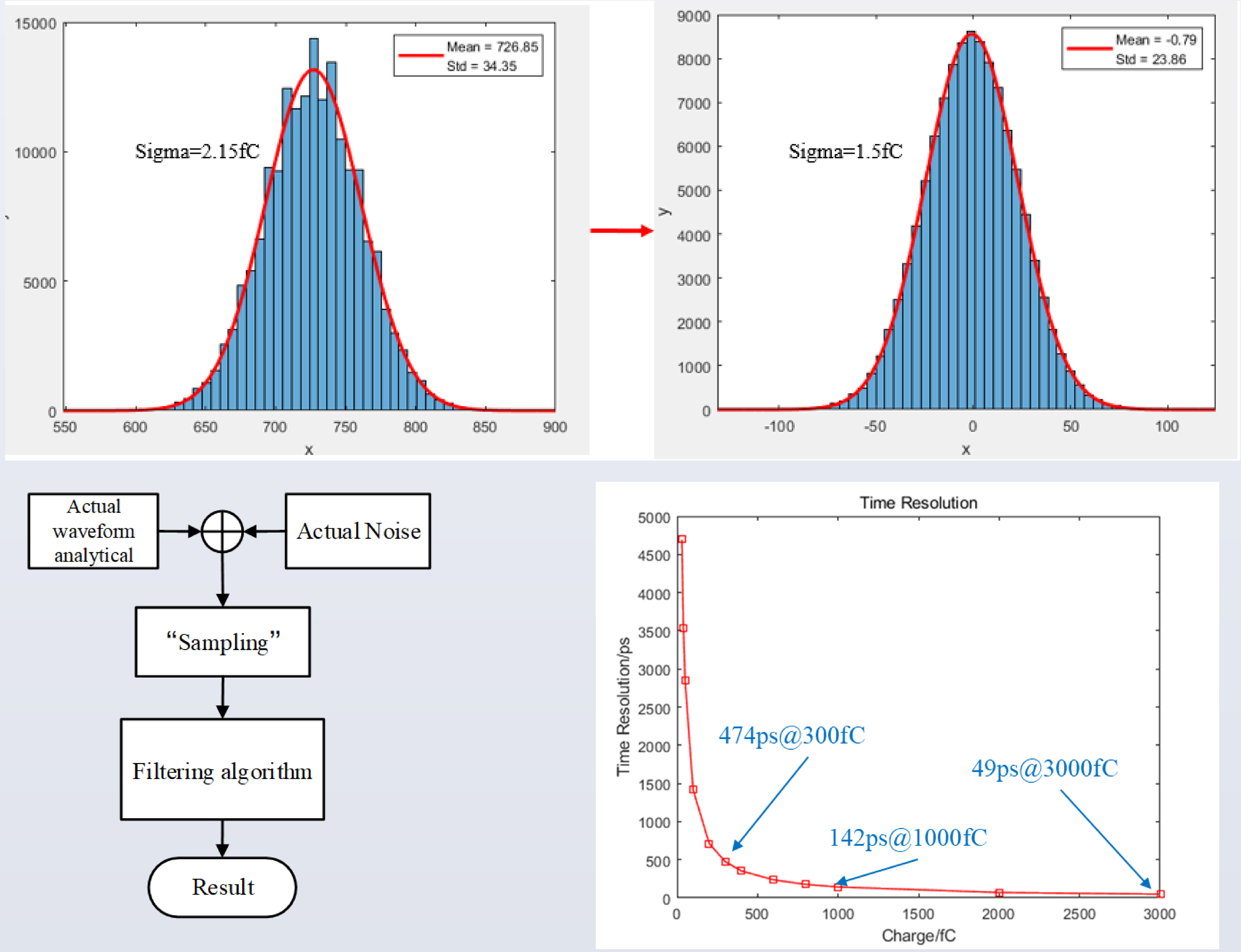

Fig 4 Benefits of the algorithm

4. BACKGROUND SIGNAL SIMULATION

In order to verify the processing effect of the above algorithm on the background signal, we use the LED and DAC module to build a background signal simulation verification platform, and use the FPGA to control the DAC module to generate random pulse signals that meet the energy distribution and time distribution of the background case, which are used to drive the LED to generate an optical signal similar to the response of pCsI to simulate the background case, whose architecture is shown in the next figure.

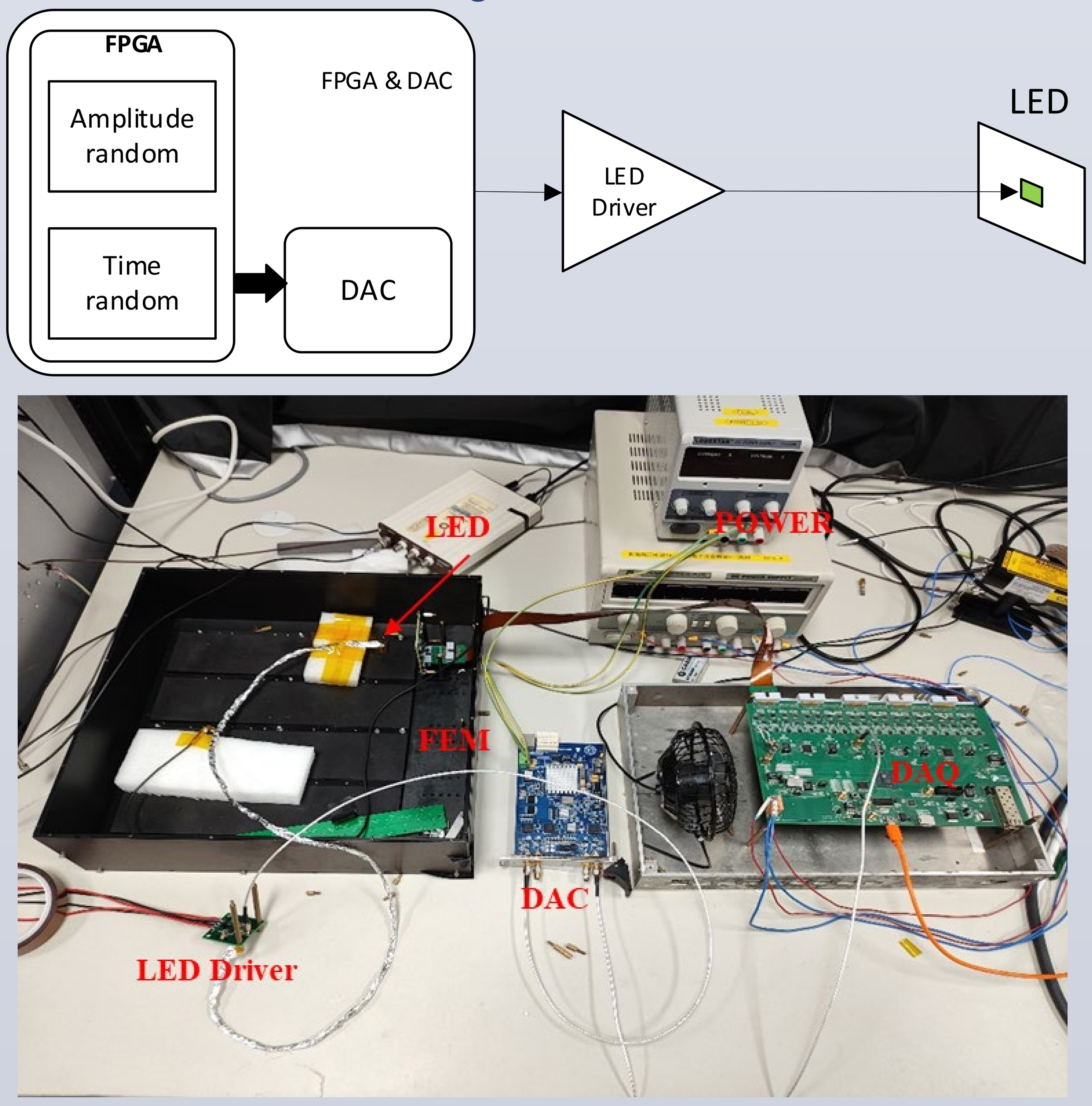

Fig 5 Background signal simulation verification platform

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