

Research Result Report

ICRR Inter-University Research Program 2025

Research Subject: Development of a novel pulse generator system and new trigger electronics for the ALPACA experiment

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Summary of Research Result :

The ALPACA array is a new experiment in the southern hemisphere, currently under construction in the Chacaltaya plateau, Bolivia. ALPACA is an international collaboration between Japan, Bolivia and Mexico. The detector is composed of a surface AS array and underground water Cherenkov muon detectors (MD). The goal of ALPACA is to observe γ rays with energies above 100 TeV, searching for the origins of Cosmic rays in our galaxy. Since only high energy muons (>1.2 GeV) from the shower penetrate to the MD array (set up beneath a 2.0 m soil layer), observing air shower events with the AS and the MD array in coincidence enables γ /hadron separation. As a result, this technique provides high sensitivity to γ ray signals.

To reach the required sensitivity above 1 PeV we require the development of new trigger electronics using state-of-the-art technology that enable us to scale the system for a larger number of channels and guarantee stable operation. On previous fiscal years we have been developing a prototype of the trigger electronics in conjunction with a novel pulse generator capable of reproducing the MC simulation characteristics.

During fiscal year 2025 we continue further developing these systems to be able to produce and process 64 channels. For this goal, we use several FPGA development boards to function as the pulse generator and the trigger system. Figure one shows the setup of this system using ethernet the layer (ethernet cables and one hub) to interconnect several boards. A raspberry PI is used to send data to the pulse generator. The generator divides this information in several boards simulating the electronics of the AS experiment, and then each board sends data to the trigger board. Using this setup we evaluate the performance of the trigger method.

Currently, the method for trigger being tested is the multiplicity trigger used in the experiment (traditional method), summing the number of hits signals that arrive to the trigger board and compare them with a defined threshold. In the future we will develop a new trigger method using advanced machine learning techniques, then our current setup will enable us to evaluate the performance and make an experimental validation of the techniques.

A paper summarizing the evaluation of the pulse generator and the trigger system is currently under preparation and it will be submitted soon.

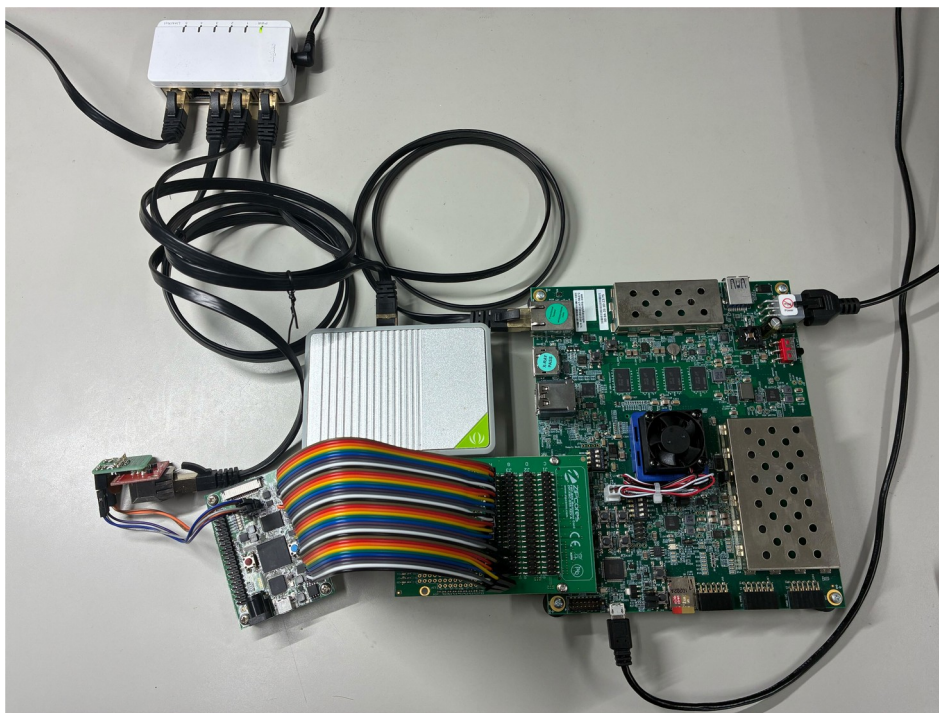


Figure 1: Picture of trigger electronics and pulse generator system being tested at laboratory.