Form 8

Research Result Report
ICRR Inter-University Research Program 2025

Research Subject:
Study for Galactic CR origin using the ALPACA air shower array in Bolivia

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Summary of Research Result：

Andes Large area PArticle detector for Cosmic ray physics and Astronomy (ALPACA) is a new air shower experiment under construction in the Bolivian Andes near the Chacaltaya mountain. The prime target of ALPACA is to explore the southern gamma-ray sky above 100TeV for the first time. In addition, cosmic-ray observations at 10TeV-10PeV at the middle southern latitude for the first time will provide unique opportunities for the studies in cosmic-ray anisotropy and solar activity. The key component of ALPACA array is the underground muon detectors (MDs) established by the TibetASgamma collaboration. By constructing 4 MD units of 900m2 area under 2m of soil overburden, ALPACA can achieve an excellent gamma/hadron discrimination power to identify gamma-ray sources above 100TeV.

Since April 2023, ALPACA is operating a mini surface array called ALPAQUITA with 100 scintillating counters while the full ALPACA plans to operate with 400 counters. In FY2025, we continued data analysis of ALPAQUITA cosmic-ray data and achieved

1) detection of a Forbush decrease in 2024 including unique upper limit near 1TV rigidity, which constrained a naïve power-law extrapolation of amplitudes observed at lower rigidities (published in ApJ, 998:16 (2026)).
2) we derived all-particle energy spectrum from 10TeV to 300TeV. The result is consistent with the previous measurements bridging the direct observations and air shower measurements.
3) we analyzed the cosmic-ray anisotropy for the first time at the southern mid latitude. The result is consistent with the former results in the northern hemisphere and the result from the south pole.

Details of these analysis results are described in the report by the Japanese colleagues.

The most important contributions from the Bolivian side in FY2025 are the realization of the MD construction and preparation for the water system. The design of the MD was completed in the end of last FY. Public call for construction company opened in May 2025 and concluded in June. Parallel to the contract with the selected company, we also invited independent supervisors by another public call. After all contracts and discussions between UMSA, construction company and supervisors, the first excavation started in November 2025 as shown in Fig.1 (left top). A close view of the first MD iron framing is shown in Fig.1 (right top) and a drone photo of the 4 MD excavation close to the completion is found in Fig.1 (bottom).

Figure 1: Construction of ALPACA underground muon detectors. Left top) first excavation, right top) framing of the first MD, bottom) 4 MD excavations close to complete.

Immediately after the completion of the first MD planned in this July, together with Japanese and Mexican members, we will rearrange the surface array surrounding it. This new small array and the first MD form ALPAQUITA+MD, which is already sensitive to some bright gamma-ray sources. We start gamma-ray sensitive observation in 2026. We continue construction of the other three MDs and complete full ALPACA in 2027.

To provide water filling the MDs, we will pump up water from the nearby lake. The design of the first filtering and pumping station is completed as shown in Fig.2. The construction of this station will start soon. Water pumped up to the ALPACA site is then fed through the fine filtering system sent from Japan.

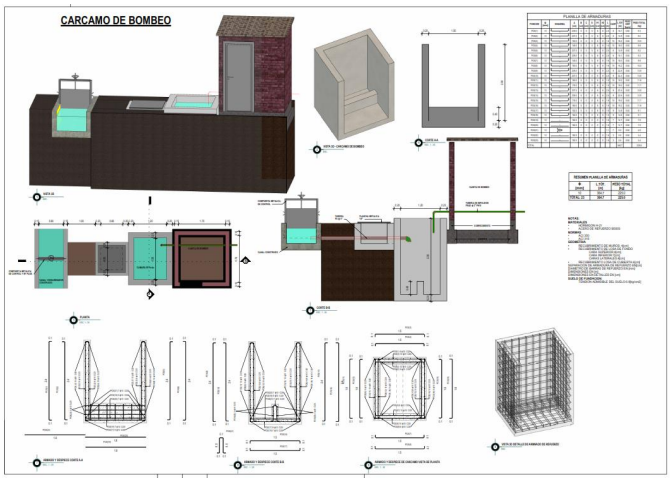

Figure 2: First filtering and pumping station to be placed near the lake.