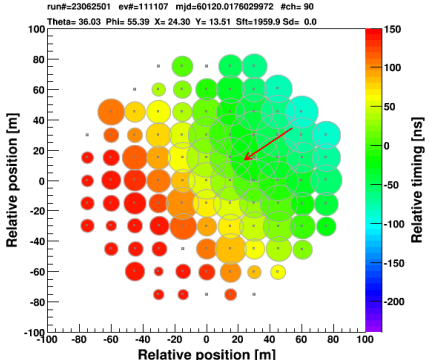
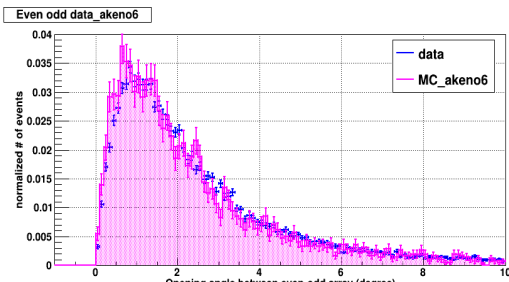


Research Result Report
ICRR Inter-University Research Program 2023

Research Subject: Study for Galactic CR origin using the ALPACA air shower array in Bolivia	
Principal Investigator: Pedro Miranda	
Participating Researchers: Pedro MIRANDA, Rolando TICONA, Hugo RIVERA, Martin SUBIETA, Mirko RALJEVICH (Universidad Mayor de San Andres) Yoshiki Tsunesada (Osaka Metropolitan University) Masato Takita, Takashi Sako, Munehiro Onishi, Kazumasa Kawata, Takashi Sako, Sei Kato (ICRR, University of Tokyo)	
Summary of Research Result : <p>Highlight of the FY2023 activity was to realize a stable operation of the ALPAQUITA surface array with 97 detectors. Japanese and Mexican members visited Bolivia in March (FY2022) and June to install 47 detectors as well as to solve problems of the 50 detectors being operated since FY2022 with the cooperation of the Bolivian team. Timing and GPS calibrations of all detectors were also completed. Since then, air shower events as shown in Fig.1 are constantly recorded.</p> <p>Angular resolution is studied by means of the even-odd method, which divides the detectors into two groups and compare the two reconstructed directions of same shower. Fig.2 shows the distribution of the difference of two directions together with the Monte Carlo simulation. The median of the distribution, 2 degrees, indicates the angular resolution of 1 degree, which shows a good agreement with the MC prediction.</p>	<div style="text-align: center;"></div> <p style="text-align: center;">Fig.1 An example of cosmic-ray shower events observed by the ALPAQUITA air shower array.</p> <div style="text-align: center;"></div> <p style="text-align: center;">Fig.2 Distribution of angular difference in the even-odd method. Blue is experimental data and magenta is MC simulation.</p>

Distribution of the CR arrival directions is analyzed around the moon. As shown in Fig.3, a clear (8 sigma) suppression of the CR intensity, called “the shadow of the moon” is detected. The 8-sigma suppression is consistent with the angular resolution of 1 degree.

Final design report (Fig.4) of the underground muon detector was discussed during the visit of Prof. Takita in January and it is ready to start a public call in early FY2024. In addition, we tested the filter system to fill the MD with water as shown in Fig.5. The quality of filtered water was chemically tested both in Bolivia and Japan, and we have satisfactory results.

The status of the ALPACA project was presented by Martin Subieta (UMSA) on behalf of the collaboration in the 38th International Cosmic Ray Conference held in Nagoya, Japan.

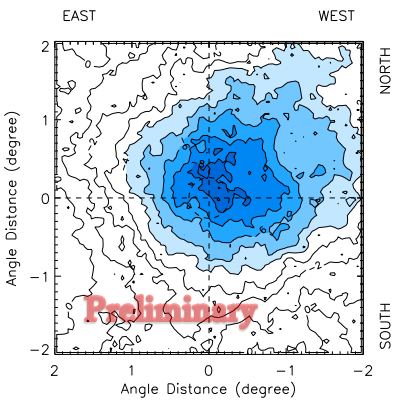


Fig.3 Shadow of the moon observed by ALPAQUITA.

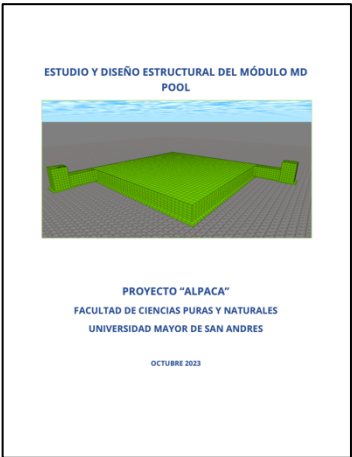


Fig.4 Design report of the muon detector.



Fig.5 Test of water filtering.