Local Variations of Cosmic Ray East-West Effect at 35 km Altitude in GRAINE 2023 Balloon Experiment

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Introduction

Cosmic gamma rays are unaffected by electromagnetic fields, providing crucial information for identifying the sources of high-energy events in the universe and understanding their underlying phenomena. The Fermi-LAT has led to significant progress with the discovery of numerous gamma-ray sources. However, compared to other wavelengths, its angular resolution is limited, and polarization observations have not been realized. To address these limitations, we aim to observe cosmic gamma rays with the world's best angular resolution (0.1° at 1 GeV, 1.0° at 100 MeV) and the world's largest aperture area through long-duration balloon flights of a nuclear emulsion gamma-ray telescope (Gamma-Ray Astro Imager with Nuclear Emulsion: GRAINE project). Through three previous flights, we have advanced the demonstration of principles and performance, successfully achieving the world's highest resolution imaging of the Vela pulsar in 2018. Building on this success, we developed an enlarged telescope with an aperture area of 2.5 m², 6.5 times larger than the 2018 configuration, and conducted a flight in 2023, achieving a 23.5-hour level flight that captured the Vela pulsar and galactic center within the field of view.

The GRAINE telescope consists of three main components: a converter with 90 stacked nuclear emulsion plates to detect gamma-ray pair production reactions, a time stamper that imparts temporal information to tracks by moving nuclear emulsion plates with time-specific periodic motion, and an attitude monitor that determines telescope orientation through stellar imaging.

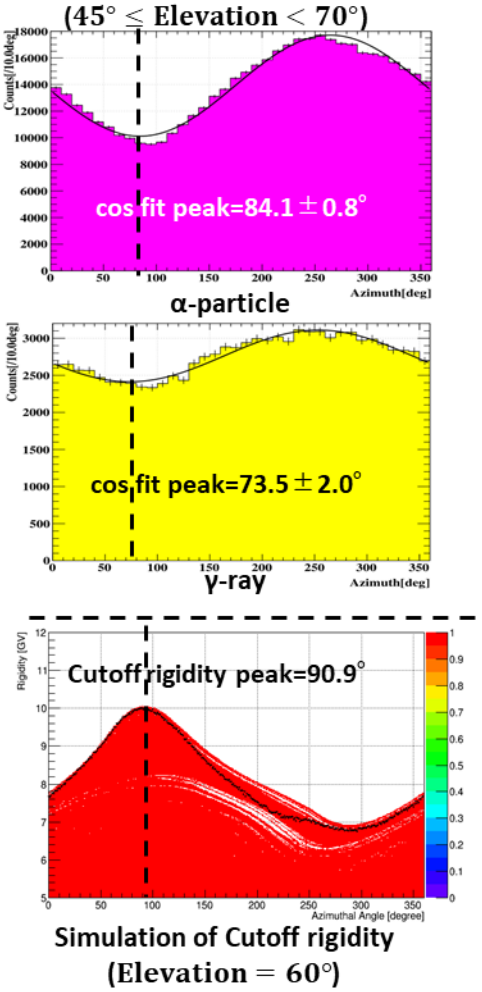

Figure 1 Azimuth distribution in horizontal coord. 16:00-20:00.

East-West Effect in Flight Data

Since nuclear emulsion records the trajectories of all charged particles, flight data contains not only gamma-ray-generated tracks but also numerous cosmic ray tracks. We attempted direct measurement of the east-west effect during high-altitude flight by primarily analyzing minimum ionizing particles and helium nuclei tracks (Fig. 1). There seems to be some indication of phase differences in the east-west effect between gamma rays and helium nuclei during certain periods (Fig. 2).

This presentation reports on the current analysis status of the time stamper and attitude monitoring system of GRAINE 2023, as well as the east-west effect observed in flight data at approximately 35 km altitude.

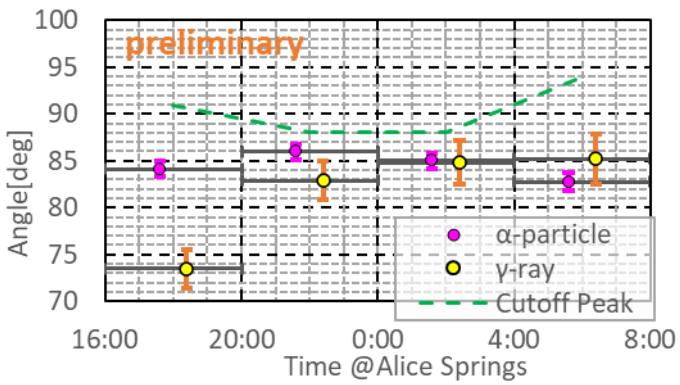

Figure 2 Temporal Variation of the East-West Effect Phase Angle.