

Research Result Report
ICRR Inter-University Research Program 2024

Research Subject: Bayesian analysis on the origin of ultra-high energy cosmic ray events collected by the TA experiment

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Summary of Research Result :

This project focuses on developing methods for unbinned searches for ultra-high-energy cosmic ray (UHECR) sources using data from the Telescope Array (TA). Currently, no reliable method exists for estimating the mass group of individual events, so this technology needs to be created. My Academia Sinica Institute of Physics (ASIoP) team, in collaboration with ICRR researchers, has made significant progress developing machine learning reconstruction techniques. Early results are encouraging, and we expect to perform initial public analyses soon. These methods will significantly enhance precision, help characterize uncertainties, and improve event-by-event estimations. We have also developed an analysis framework with Keito Watanabe, Prof. H. Sagawa, and Dr. Francesca Capel, using uncertainties from each event to determine probabilities for astrophysical models. This work has been presented at major conferences like UHECR2024 and ICRC2023. Recently, we refined the astrophysical model to achieve the stability needed for publication and plan to present these findings at ICRC2025.

The ICRR Interuniversity Grant was primarily used to organize the second part of the workshop [“宇宙線空気シャワー観測によるマルチメッセンジャー天文学の推進”](#) (“Workshop for accelerating multi-messenger astronomy using air shower

[observations”\).](#) Specifically, the funds covered accommodations for invited lecturers from the ASIoP team. This workshop provided an important opportunity to share machine learning and data analysis techniques with colleagues from the Telescope Array collaboration and the wider Japanese astroparticle physics community, promoting valuable collaboration and knowledge exchange.

Looking ahead, I unfortunately missed the FY2025 grant application deadline due to my deployment at the South Pole. However, I plan to apply again for FY2026 to sustain and build upon our current progress. Future funding will allow us to further refine our machine learning approaches, enhance our interpretative frameworks, and perform comprehensive analyses of UHECR data. These efforts will help address key questions about the origins and characteristics of ultra-high-energy cosmic rays.

No. 2024i-F-006