Angular Reconstruction Algorithm for Galactic Cosmic Ray Shower Arrays

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Galactic cosmic rays (GCRs) are highly-energetic charged particles that produce atmospheric air showers of secondary subatomic particles, such as muons, detectable by scintillating ground arrays. Although GCRs are theorized to originate from supernovae in diffused shock acceleration, no definite conclusion on their origins has been made with the few institutional detectors present. Meanwhile, smaller GCR-induced muon shower arrays collect massive amounts of geographically- and temporally- distributed data that are not systematically analyzed, partially due to their lower energy (MeV to GeV)--though they are viable for direction analysis at the atmospheric level and beyond--but also the lack of an open-source algorithm. Therefore, the goal of this study is to develop an angular reconstruction algorithm verifiable and applicable to smaller GCR shower arrays. This study examined a planar shower model and calibration pipeline suitable for array geometry. Time differences of coincidences in a single shower are used to calculate the horizon coordinates of zenith and azimuth, which results in the arrival direction of the shower in relation to the atmosphere. Further calibration and conversions yield the equatorial coordinates of right ascension and declination, which is used to correlate general celestial sphere regions and objects. Geographically and temporally varied data from smaller GCR shower arrays are inputted into the programming module verifiable by simulation models, and quantitative results were analyzed. This algorithm combines models into an open-access module that can implement massive unused data, which can aid research into the properties, propagation and origins of GCRs and contribute to a predictive understanding of radiation harm in future space missions.