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Systematic and Statistical Uncertainties in Cosmic Ray Arrival Direction Reconstruction

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Abstract

The Pierre Auger Observatory (PAO) was constructed to study the highest energy cosmic rays (UHECR). A hybrid of ground array and fluorescence detector, it is the largest ultra-high energy cosmic ray detector to date. As such, the PAO detects UHECR in unprecedented amounts, offering unique insights into the nature and origin of these most extraordinarily energetic particles in the universe.

In this thesis we improve the accuracy of arrival direction uncertainty estimates for reconstructed events. We validate these improved uncertainty estimators through a number of statistical techniques, involving both recorded and simulated data. Furthermore, we identify and correct a number of systematic errors which arise in algorithmic corner cases. We propose novel techniques for measuring the time synchronisation of each detector in the using recorded air shower data. We use these techniques to measure the synchronisation of each detector across the PAO surface detector and fluorescence detector. Finally, we perform a cursory search for a point source of UHECR at the Galactic centre. A slight over-density of events is measured from the direction of the Galactic centre, however this over-density is not substantial enough to indicate a departure from isotropy.

Statement of Originality

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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