The Application of High Precision Timing in the High Resolution Fly's Eye Cosmic Ray Detector

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by

Christopher Richard Wilkinson B.Sc (Hons.)

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Contents

Abstract

This thesis represents work performed by the author on the development of the High Resolution Fly's Eye (HiRes) detector for the study of extremely high energy ($> 10^{18}$eV) cosmic rays. Chapter 1 begins with an review of this field. This chapter details the development of the field, the physics questions we seek to answer, and our current understanding based on experimental and theoretical results. It provides the basis for understanding why detectors such as HiRes are being constructed.

This review leads into chapter 2, which discusses the development of cosmic ray induced extensive air showers (EAS) and the techniques used to study them. Particular emphasis is placed upon the air fluorescence technique utilised by HiRes. The two site HiRes prototype detector is then discussed in detail in chapter 3. This covers the different components that form the detector, together with details of the calibration performed to extract useful information from the data.

Chapter 4 discusses the installation and subsequent testing of GPS based clock systems for the two sites that make up the HiRes prototype detector. The entire timing system was checked, and some previously hidden bugs fixed. This chapter concludes with work performed on the time to digital converter calibration for the second HiRes site.

The high relative timing accuracy provided by the GPS clocks allowed the use of timing information in programs to reconstruct the arrival directions of cosmic rays. Chapter 5 covers the development of a program to use geometrical and timing information to reconstruct EAS viewed by both HiRes sites. This chapter concludes with an evaluation of the likely reconstruction accuracy of the new HiRes (stage 1) detector.

A well reconstructed EAS trajectory is the first step in the determination of more interesting parameters such as primary particle energy. Chapter 6 covers the collation and analysis of EAS viewed by the both sites of the prototype detector. This includes an evaluation of effects such as the atmosphere, and an estimation of the performance of the new (stage 1) HiRes detector based on results with the prototype detector.

Finally the conclusions from this thesis are summarised and suggestions made for further follow up work.

Statement of Originality

This thesis 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.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Christopher Wilkinson

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