The Array Of Atmospheric Cherenkov Telescopes At Milagro To Study Cosmic Ray Composition

Robert Atkins,[1] Brenda Dingus,[2] Magda Gonzales,[1] Robert Laird,[3] Julie McEnery,[4] Gora Mohanty,[5] Frank Samuelson,[2] Gus Sinnis,[2] Tom Stephens,[6] Steve Stochaj,[7] Matthew Wilson,[5] and Gaurang Yodh[8]

(1) Department of Physics, University of Wisconsin, Madison, Wisconsin 53706, USA

(2) Los Alamos National Lab, Los Alamos, New Mexico 87545, USA

(3) Department of Physics, Trinity University, San Antonio, Texas 78212, USA

(4) Joint Center for Astrophysics, University of Maryland at Baltimore County; and Laboratory for High Energy Astrophysics, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA

(5) Institute for Geophysics and Planetary Physics, University of California, Riverside, California 92521, USA

(6) Department of Astronomy, New Mexico State University, Las Cruces, New Mexico 88003, USA

(7) Particle Astrophysics Laboratory, New Mexico State University, Las Cruces, New Mexico 88003, USA

(8) Department of Physics, University of California, Irvine, California 92717, USA

Abstract

An array of Wide Angle Cherenkov Telescopes (WACT) has been built around the Milagro observatory. With its six telescopes WACT measures the lateral distribution of Cherenkov light which has been shown to be sensitive to the depth of maximum shower development[9]. The primary physics goal of WACT is to measure cosmic ray composition in the region where it has been directly observed up to energies of several hundred TeV. In this conference we will present the first results from WACT based on data collected over the winter of 2002/2003.

1. Introduction

Since its discovery in 1958 by the MSU group[8], the knee of the cosmic ray spectrum has been a region of great interest. Yet it is surprising, that 45 years later we do not know the source of the knee or the composition of cosmic rays in the knee region. Several air shower experiments have measured composition in this region and have come to different conclusions in regards to spectrum and composition[1,2,6,7]. At the same time, direct measurements have been pushed

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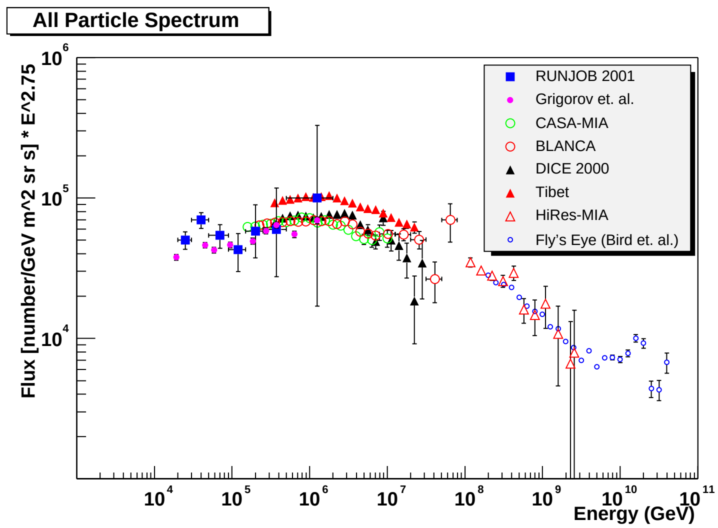

Fig. 1. All particle spectrum for different experiments at knee energies. The RUNJOB data and the Grigorov data are direct measurements. The points from BLANCA, Tibet, CASA-MIA, DICE, Fly's Eye, and the HiRes-MIA are from air shower measurements.

to higher energies without any indication of the knee[3,4].

WACT is the first experiment that is capable of spanning the gap between good direct measurements and higher energy measurements made by air shower experiments.

2. Description

The WACT experiment is located around the Milagro experiment in the Jemez mountains of New Mexico. The site is approximately 40 miles west of Los Alamos and sits at an elevations of 2630 meters above sea level and at an atmospheric depth of 750g/cm^2.

The WACT experiment consists of six atmospheric Cherenkov telescopes (ACTs). Each telescope consists of a 4 facet spherical mirror mounted onto a steel frame. The 4 facets form the primary reflector which has a focal length of 2.7 meters. The total area of the mirror is approximately 3.8 m^2. At the focus of the mirror is a camera that consists of 10, Amperex/Phillips 2262, 12-stage linear focused, 3 inch photomultiplier tubes (PMTs) arranged in a hexagonal pattern. The PMTs were donated to WACT by the Cygnus experiment. The PMTs have a bi-alkaline photo-cathode that has a reported quantum efficiency of 25% at 400 nm. Each PMT is operated in a positive high voltage mode and is connected to the data acquisition system by a single RG-58 coaxial cable that carries both the high voltage and the signal. Bundles of 30 cables were ran to each telescope in a

Fig. 2. The WACT and Milagro site located in the Jemez Mountains of New Mexico. The red points denote the locations of the WACT telescopes.

shallow trench along with fiber optic cable for laser calibration.

Each telescope is housed in a canvas covered galvanized steel frame building. During operation the building is rolled off the telescope onto steel I-beams.

The PMT signals are processed by custom front end electronics that splits the signal into a low threshold and a high threshold portion. ECL pulses are generated by the discriminators on both the rising and falling edges of the PMT signal. The time over threshold (TOT) is then measured with a Lecroy 1887 FastBus multi-hit time to digital converter (TDC) module (.5ns per channel).

Once digitized by the TDC the PMT signal is read out by a fastbus smart crate controller (FSCC). The data is then written to 1 of 2 Dual Ported Memory (DPM) modules of the VME crate via the VSB bus and the DC2 controller. Having two DPM modules allows one module to be written to while the other is being read out by a PC.

The WACT trigger is a software trigger that requires at least 2 PMTs to be hit in time with Milagro events. The Milagro trigger rate is about 1800 Hz and the raw coincidence rate with WACT is a few Hz. To improve event reconstruction in our analysis we require that all 6 telescopes be hit for an event to be considered. This lowers are rate to 0.1 Hz.

In addition to its trigger, WACT uses the Milagro event reconstruction to determine the angle of incidence for the primary. Milagro has an angular resolution of .7°. The core of the shower is reconstructed by WACT to an accuracy of about 15 meters by performing a χ^2 minimization to a lateral distribution function[5]

3. Status

WACT has been operated over the past winter of 2002/2003 on clear moonless nights. Data from this campaign is being analyzed and the results will be presented at this meeting. The Milagro experiment has recently been upgraded to include water tanks that will improve the Milagro core resolution and angular resolution. This will improve the sensitivity of WACT to primary energy and composition.

4. Acknowledgments

The members of WACT would like to thank the HiRes experiment for the mirrors used in WACT and the Cygnus collaboration for the PMTs. We would also like to thank Scott Delay. This work is supported in part by the National Science Foundation, the University of California, Los Alamos National Lab, the University of Utah, the University of Wisconsin, the University of California Institute of Geophysics and Planetary Physics, and Research Corporation.

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