

DIRECT MEASUREMENTS OF THE ANGULAR DISTRIBUTION OF CHERENKOV ,
LIGHT AND THE
NITROGEN SCINTILLATION YIELD IN ULTRA HIGH ENERGY EXTENSIVE AIR
SHOWERS

R.M. Baltrusaitis, G.L. Cassiday, R. Cooper, B.R. Dawson, J.W. Elbert,
B.E. Fick, K.D. Green, S. Ko, D.F. Liebing, C.P. Lingle, E.C. Loh,
J.D. Smith, P. Sokolsky, and D. Stock.

Physics Department, University of Utah, Salt Lake City, UT 84112 USA

Abstract

We will report on measurements of the angular distribution of Cherenkov light and the nitrogen scintillation yield in extensive air showers (EAS) with energies above 10¹⁷ eV. Results will be presented from a sample of 1600-2000 events viewed simultaneously by the two Fly's Eye detectors which are separated by a distance of approximately 3.5 km. These data were taken after the expansion of FEII from 8 to 36 mirrors (see OG9.3-1.)

An EAS will produce nitrogen scintillation light and Cherenkov light as it traverses the atmosphere. The former will be emitted isotropically around the shower track, while the latter will be emitted in the forward direction, its angular distribution being determined primarily by the angular distribution of charged particles in the shower. Fig. 1 shows the geometry of detection of an EAS by the Fly's Eyes. As the shower develops, both Eyes will see light emitted at a number of angles with respect to the shower axis. When the track is viewed at a small emission angle ($\theta < 20^\circ$), the Cherenkov light contribution to the signal will dominate by more than an order of magnitude, and the scintillation light can be ignored. Conversely, a signal observed at $\theta < 40^\circ$ will be dominated by scintillation light.

The angular distribution of charged particles in an EAS can be represented by

$$\frac{dN}{d\Omega} \propto \frac{\exp(-\theta/\theta_0)}{2\pi\theta_0 \sin\theta}, \quad (\text{Ref. } [1])$$

where θ is the angle relative to the shower axis, and θ_0 is a parameter which can be represented as a function of the threshold energy for Cherenkov production, E_T . We are able to measure θ_0 (for a narrow range of $E \in$), by examining short optics of shower track viewed simultaneously by both eyes at small ($\theta > 20^\circ$) emission angles. Both Eyes will see predominately Cherenkov light from the is segments. From the equation above, the signals in the two Eyes will have relation

$$L_2 \sin\theta_2 / L_1 \sin\theta_1 = \exp[-(\theta_2 - \theta_1)/\theta_0],$$

where L_1 and L_2 are light yields (corrected for attenuation and solid angle effects) and θ_1 and θ_2 are the emission angles, with respect to FEI and FEII. Data from a number of such track segments yield a value of the multiple scattering parameter θ_0 .

We will also present a measurement of the atmospheric nitrogen scintillation yield. Here, we examine segments of shower track viewed at a large emission angle by one Eye and a small emission angle by the other. Here one signal will be dominated by the scintillation light emitted by that track segment, and the other signal will be dominated by Cherenkov light. The ratio of the light yields, and a knowledge of the angular distribution of Cherenkov light and the Cherenkov production efficiency (a quantity which is gained from calculations of the energy distribution of shower electrons), will provide an estimate of the nitrogen scintillation yield.

Reference. 1. Hillas A.M., J. Phys. G., 8, 1461 (1982).

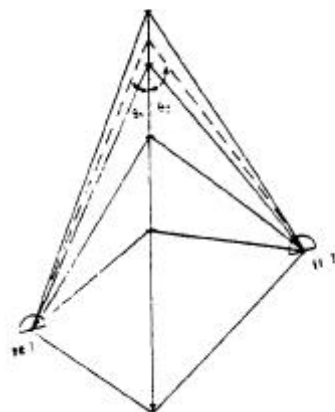


Fig. 1. The axis of the EAS is indicated by the arrow. θ_1 and θ_2 are the emission angles with respect to FEI and FEII for the first bin

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