Introduction of the AMBER Experiment

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***Abstract*. The AMBER (Air-shower Microwave Bremsstrahlung Radiometer) uses a novel technique for microwave detection of cosmic ray airshowers. Laboratory experiments have shown that the observed microwave emission scales with energy, which will provide a high duty cycle complement to current nitrogen fluorescence methods. A prototype detector is deployed at University of Hawaii, USA, and prototypes are being developed at Ohio State University, USA and the Pierre Auger Observatory in Mendoza, Argentina.**

I. Introduction

The origin and acceleration of Ultra High Energy Cosmic Rays (UHECRs) is one of the most vexing problems in astrophysics. Despite well over four decades of study, these fundamental aspects remain a mystery. The combination of power law energy spectrum and Greisen-Zatsepin-Kuzmin (GZK) suppression [1], [2] above 6×10^{19} eV makes it difficult to obtain a high statistics sample, and the fact that UHECRs are charged particles traveling through galactic and extra-galactic magnetic fields makes it hard to trace them back to their origin. Recent projects such as AGASA [3], Hi-Res [4] and Pierre Auger Observatory [5] have yet to discover an incontrovertible source. The two most widely deployed detection methods, surface detection (AGASA, Auger) and fluorescence detection (Hi-Res, Auger) present particular challenges. A surface detector array employs ground stations spaced over kilometers to collect a small fraction of the particles produced by the airshower. Due to the limited sampling of the shower, this method relies on Monte Carlo for particle interactions at energies orders of magnitude above current accelerators or average shower behavior determined empirically, resulting in an energy resolution of order ~20%. A fluorescence detector directly images the fluorescence of nitrogen excited by the passage of an UHECR air shower. The amount of light collected scales with energy, which provides excellent energy resolution, and the observation of shower development provides strong constraints on primary particle type. These detectors can only operate on clear, moonless nights, however, which limit their duty cycle to around 10%. A new method of radio air shower detection via the collection of broadband molecule Bremsstrahlung radiation has been demonstrated recently by a project called the Air-shower Molecular Bremsstrahlung Radiometer (AMBER) [6].

II. Molecular Bremsstrahlung Radiation

An Ultra-High Energy Cosmic Ray air shower dissipates most of its substantial energy budget through ionization, producing a tenuous plasma. The plasma cools on a nanosecond time scale, distributing its thermal energy through collisions with neutral molecules, which leads to the nitrogen fluorescence currently observed. These electrons can produce their own emission, including continuum Bremsstrahlung radiation. The violation of equilibrium conditions in this process produces a signal enhancement, a partially coherent emission. This radiation has been shown to scale with energy in laboratory experiments at the Argonne Wakefield Accelerator (AWA) and at the Stanford Linear Accelerator Center (SLAC) [6].

III. Current Efforts

AMBER exploits the economy of scale by buying off-the-shelf satellite television components for its prototypes. University of Hawaii, Manoa, has operated a 1.8 m broadband antenna with four C-band (3.7-4.2 GHz) feedhorns arranged in a diamond pattern (similar to Fig. 1) on the roof of the Physics building periodically since 2005. Ten

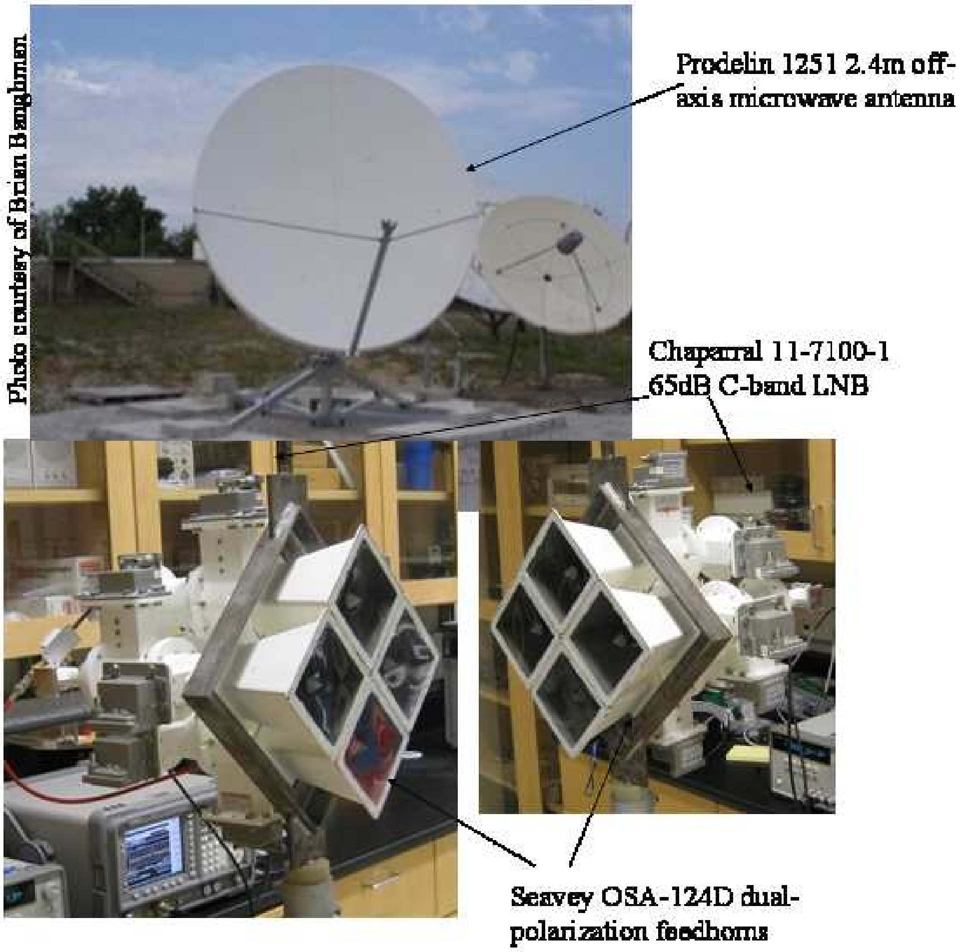

Fig. 1. The prototype feedhorn array at OSU

candidates were observed over several months [6]. A similar array is under construction at the Ohio State University ElectroScience Laboratory, using a slightly larger (2.4 m) antenna. This is pictured in Fig. 1.

IV. Future Plans

Two four pixel arrays similar to the one shown in Fig. 1 will be installed in the Austral Autumn at the Coihueco Fluorescence Detector site of the Pierre Auger Observatory in Mendoza, Argentina. This is the site of many new R&D efforts at the Observatory including HEAT and AMIGA, projects seeking to lower the Auger energy threshold for fluorescence detection and surface detection, respectively. This site is a natural location for AMBER to verify its use as a cosmic ray detector.

Acknowledgments

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