## Recent Results from the Whipple VHE $\gamma$-ray Telescope

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We describe recent results from the Whipple experiment, including results of a seacrh for Diffuse emission from the Galactic Plane based upon observations in 1998 and 1999. We also discuss the status of transient and steady state high energy gamma source observations.

### 1 Introduction

The Whipple Observatory 10m Gamma Ray Telescope is located at an altitude of 7600 feet on Mount Hopkins, about 45 miles south of Tucson in Southern Arizona. The optical reflector is of the Davies Cotton design and comprises an alt-azimuth-mounted 10 metre dish holding 248 mirrors (Figure 1).

### 2 Upgrade History of the Whipple Telescope

From the summer of 1997 until the summer of 1999, the camera on the Whipple 10 m Telescope comprised 331 25mm photo multiplier tubes. This camera had a field of view of 4.8° and a pixel spacing of 0.24°. During summer 1999, the camera was upgraded to a 490 pixel camera comprised of 379 13mm diameter inner camera tubes surrounded by 111 28mm diameter photomultiplier tubes (Figure 2). This new ("GRANITE III") camera has an inner field of view of 2.6° and a inner pixel spacing of 0.12°. The outer pixels extend the field of view to 4.0° at a spacing of 0.24°. This newer 'fine pixel' camera results in a substantial improvement of the energy sensitivty of the Whipple telescope, extending the trigger threshold energy below 200 GeV, and the $\gamma$-ray detection capability down to 400 GeV.

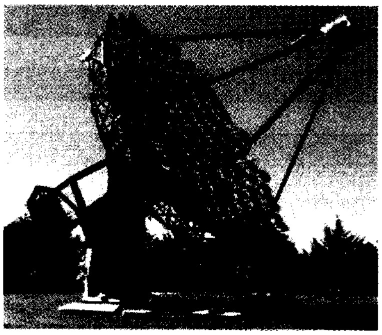

Figure 1: Whipple 10 m Imaging Cerenkov telescope

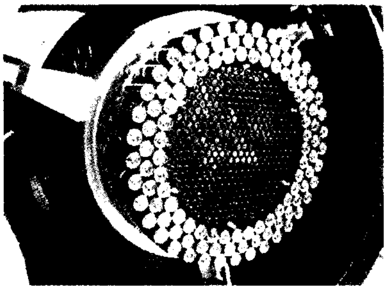

Figure 2: 490 Pixel GRANITE III camera installed summer 1999.

### 3 Diffuse Gamma Emission from the Galactic Plane

The dominant feature of any all-sky survey of the high-energy $\gamma$-ray sky is the diffuse emission from the Galactic plane. This emission is generally thought to arise from nuclear cosmic ray interactions with interstellar material producing neutral pions which decay into high energy $\gamma$-rays, and electron scattering in the interstellar medium via bremstrallung and electron inverse Compton scattering. Recent measurements of the high energy $\gamma$-ray flux ($E > 1$ GeV) by the EGRET instrument indicate an excess flux beyond that which is predicetd by models which fit lower energy $\gamma$-ray observations. The source of this excess flux is likley due to additional contributions from inverse Compton production off a harder cosmic-ray electron spectrum than previously assumed[2].

The Whipple Observatory has performed a search for excess $\gamma$-ray emission from the Galactic plane[3] centered about the Galactic coordinates ($l = 40°, b = 0°$) during 1998 and 1999. The search used the 331 pixel camera, and raw events were software padded to compensate for night sky background variations and image cleaned to remove spurios pixel hits. $\gamma$-ray candidate events were selected using optimized cuts on image parameters *Width, Length,* and *Distance.* Since the telescope is being used to image an potential $\gamma$-ray flux which is extended of a large field of view of sky, no oreintation selection is applied. Arrival direction is determined using the technique developed for off-center Crab Nebula observations[4].

Figure 3 ilustrates the lateral profiles of the galactic plane emission for data acculated in 1998 and 1999. These figures also show simulated curves for expected diffuse emission, including effects due to sensitivity variation across the camera field-of-view. The 1998 data shows a $3.2\sigma$ excess emission above background ($1.84 \pm 0.57$ $\gamma$/minute), but the 1999 data is consistent with a null result ($0.42 \pm 0.43$ $\gamma$/minute). Assuming a differential spectral index of $\gamma$ =2.4, aan upper limit on the flux is established at $6.3\times10^{-8}$ s$^{-1}$cm$^{-2}$sr$^{-1}$ above a threshold of 700 GeV at the 99.9data, the corresponding flux upper limit is $3.0\times10^{-8}$ s$^{-1}$cm$^{-2}$sr$^{-1}$ above a threshold of 500 GeV at the same confidence level.

Figure 4 examines the consistency of the Whipple upper limits with the measured EGRET flux for different spectral index assumptions. In this figure, the upper limits in the plots are extrapolated back to EGRET energies assuming a constant power law spectrum, resulting in the the four dotted lines . It is apparent that if if the differential spectral index $\gamma$ were less than about 2.2, a TeV signal should have been detected. The upper limit obtained for the smallest spectral index ($\gamma = 2.0$) is not compatable with the measured EGRET flux above 1 GeV. At the 99.9% confidence level, the Whipple data excludes a differential spectral index samller than 2.31 (Figure 5. Since this index is harder than the electron spectral index assumed to explain the EGRET flux above 1 GeV ($\gamma = 1.83$)[2], these results imply a break in the simple power law primary electron spectrum between GeV and TeV energies.

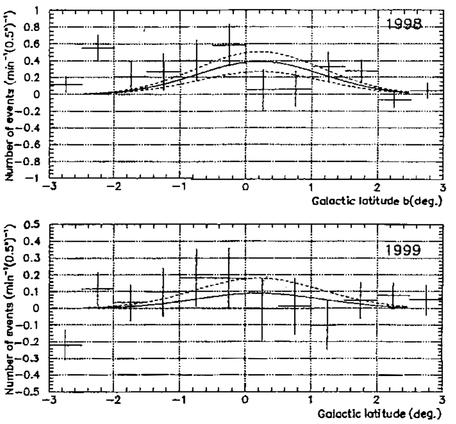


Figure 3: Lateral Distribution of galactic plane excess observed in 1998(top) and 1999(bottom)[3]. The smooth solid curve shows the simulated latitude profile with amplitude fitted to the data. The smooth dashed lines are one sigma standard deviations about the best fit.

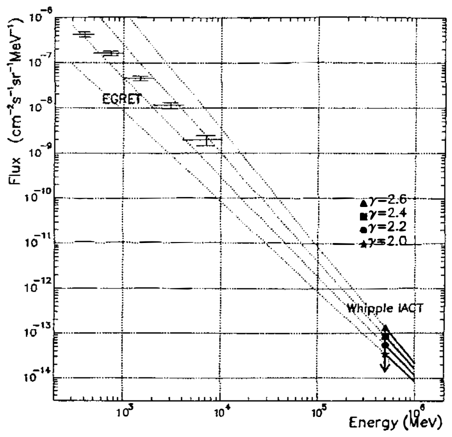


Figure 4: Comparison of Whipple Galactic diffuse gamma-ray upper limits for $38.5° < l < 41.5°$ and $-2° < b < 2°$ above 500 GeV compared to EGRET differential spectrum over same portion of the sky[3]. The 99.9% CL Whipple upper limits are shown for different assumed differential spectral indexes. The dotted lines trace back these upper limits back to the EGRET energies.

## 4 Continuing Observations

Whipple is contining observations on a number of different potential astrophysical sources of TeV $\gamma$-rays. Standard sources such as the Crab Nebula, Mkn421 and Mkn 501 are routinely monitored during the observation year. The observation plan has also focussed on the search for evidence of new radio and X-ray selected AGN sources as well as EGRET unidentified sources. The Whipple Group has recently presented evidence for the TeV emission from several X-ray selected Bl-Lac objects including 1ES2344+514 and 1H1426+428[5]. Observations are continuing in the search for TeV $\gamma$-rays from various supernova remnants, including Cas A. Gamma Ray Burst positions, provided by reports from the GCN GRB Coordinates network, continue to be observed at a rate of a observation every few months. Other Galactic objects such as pulsars, plerions , and diffuse emission from the Galactic plane remain part of the observing plan, as well as technique developmental observations at large zenith angles.

Of particular interest is the recent rapid flaring by Mkn421 at the time of this conference observed by various satellite experiments (late January 2001). The Whipple telescope has been observing Mkn 421 during this time and analysis of the $\gamma$-ray flux and variability will be presented in a future publication. Suffice it to say, however, that strong sources of high energy $\gamma$-rays continue to be observed!

The Whipple 10 m telescope is expected to continue observations through at least the 2000-2001 and 2001-2002 observing seasons. After mid-2002, first light is expected on the first telescope of the next-generation $\gamma$-ray observatory to be built at Whipple, the VERITAS

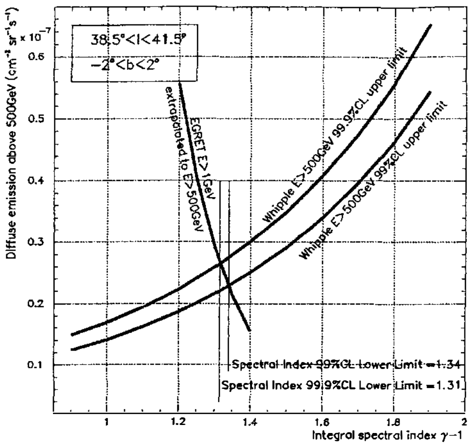


Figure 5: Diffuse emission upper limits derived from 1999 observations represented as a function of the assumed integral spectral index and compared with an extrapolation of the > 1 GeV EGRET flux to 500 GeV[3]. The comparison yields a lower limit for the differential spectral index of 2.31 at the 99.9% confidence level.

observatory[6]. The Whipple 10 m telescope will likely continue to run in coincidence with the first VERITAS telescope through one oberving season (2002-2003) in order to assess the performance of the new telescope and intercalibrate the two systems. After the first VERITAS telescope has become fully operational and tested, observations using the Whipple 10m will assume a lower priority, but may be continued as scientifically needed. This is possible because the Whippple 10m and the first VERITAS telescopes are expected to be located at different sites, so that the 10m telescope does not have to be 'de-commissioned' in order for the new VERITAS telescopes to become operational.

## References


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