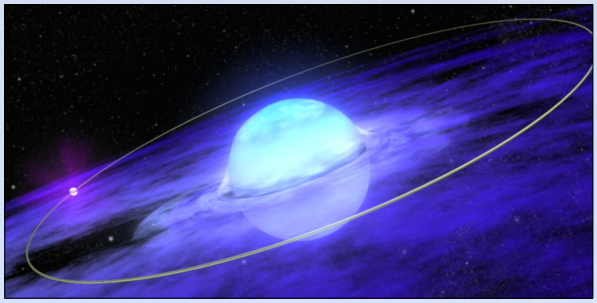
Looking for TeV Binary Candidates with HAWC

Segev BenZvi for the HAWC Collaboration
University of Rochester - USA

The Milky Way contains hundreds of binary systems which are known to emit in radio and X- rays, but only a handful of binaries have been observed to produce very high-energy gamma rays. In addition, the emission mechanisms which produce the gamma rays in the few known sources are not well understood. To improve the statistics of binary sources in the TeV band, the High-Altitude Water Cherenkov Gamma-ray Observatory, or HAWC, has begun to carry out a simultaneous survey of many TeV binary candidates in the Northern Hemisphere between 100 GeV and 100 TeV.

Gamma-Ray Binaries

Gamma-ray binaries are compact objects which orbit massive stars. It is thought that gamma rays are produced when relativistic particles from the compact object encounter the companion star, or when the compact object accretes material from its massive companion.

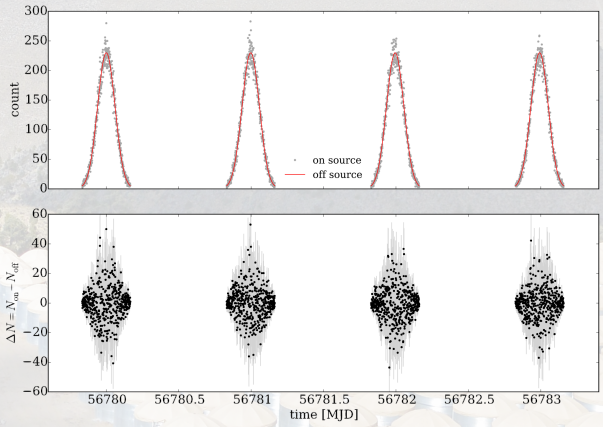


Artist's conception of LS I +61° 303. Walt Feimer, NASA / Goddard Space Flight Center

To date, 3 γ-ray binaries have been observed in the Northern Hemisphere: LS 5039, HESS J0632+057, and LS I +61° 303. Due to its high uptime and wide field of view, HAWC is well-suited to carry out an unbiased survey of binary systems in the northern sky.

The HAWC Gamma-Ray Observatory

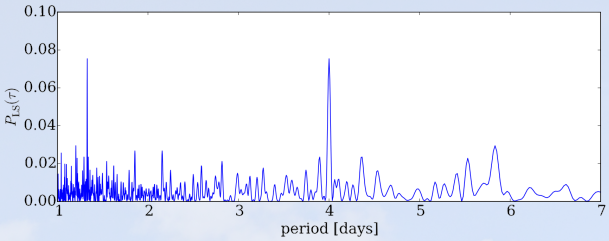
HAWC is a cosmic-ray and γ-ray detector located 4100 m above sea level in Sierra Negra, Mexico. From its location at 19°N latitude, the detector records air showers from 2/3 of the sky each day with an uptime of 95%. The observatory can be used to record emission from a large number of sources simultaneously, making it well-suited for long-term observations of TeV γ-ray binary candidates.



Simulated counts from a binary source transiting above HAWC are shown above, depicting the number of events observed in 1-minute time bins after angular and γ-hadron cuts. The residual counts ΔN – defined as the counts after the subtraction of "off source" DC background – can be studied for time dependent behavior.

Expected Sensitivity to Periodic Emission

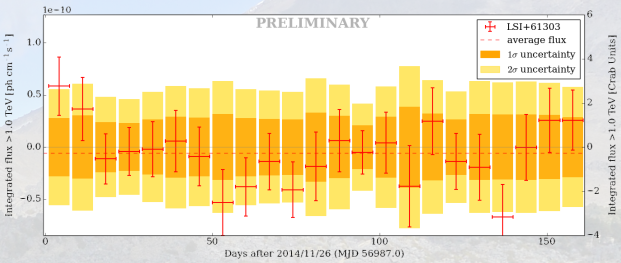
Below is the Lomb-Scargle periodogram for 1000 simulated transits of a sinusoidally-varying source with a 4-day period, 5% of the Crab flux >1 TeV (high state), and zenith angle 15°. Given the current γ-hadron separation power of HAWC, it will take 3 years to observe orbital modulation of γ rays from such a source at the 5σ level.



Future improvements to γ-hadron separation in HAWC [1, 2] are expected to reduce the 5σ detection time to 12 months.

Observations of LS I +61° 303 in its Flaring State

In October and November 2014, LS I +61° 303 exhibited a significant multi-week flare. HAWC was under construction during part of this period but operated continuously after November 26.



While LS I +61° 303 is located at an unfavorable declination for measurements with HAWC, we observe this location every day and produced a light curve binned into 7-day increments [3]. The orange and yellow bands indicate the 68% and 95% intervals of the background expected at the position of this source. No variability or counts above background were observed during this period.

Now that construction of HAWC is complete, the observatory provides daily monitoring of Galactic and extragalactic objects for flares [4], including 30 TeV γ-ray binary candidates. With the current analysis, we expect to observe the known sources LS 5039 and HESS J0632+057 at 5σ within 12-18 months. Flares observed by HAWC will be reported to IACTs for follow-up observations.

References

1. Z. Hampel-Arias, *Gamma-Hadron Separation with Pairwise Compactness*, ICRC15
2. T. Capistrán, *Gamma-Hadron Separation with Neural Networks*, ICRC15
3. R. Lauer and P. Younk, *Results from Monitoring TeV Blazars with HAWC*, ICRC15
4. T. Weisgarber and I. Wisher, *Online Blazar Alerts with HAWC*, ICRC15

Web: http://www.hawc-observatory.org

Contact: sybenzvi@pas.rochester.edu

A complete author list for the HAWC Collaboration can be found at http://www.hawc-observatory.org/collaboration/icrc2015.php

Acknowledgments

We acknowledge the support from: the US National Science Foundation (NSF); the US Department of Energy Office of High-Energy Physics; the Laboratory Directed Research and Development (LDRD) program of Los Alamos National Laboratory; Consejo Nacional de Ciencia y Tecnología (CONACyT), Mexico (grants 260378, 55155, 105666, 122331, 132197, 167281, 167733); Red de Física de Altas Energías, Mexico; DGAPA-UNAM (grants IG100414-3, IN108713, IN121309, IN115409, IN111315); VIEP-BUAP (grant 161-EXC-2011); the University of Wisconsin Alumni Research Foundation; the Institute of Geophysics, Planetary Physics, and Signatures at Los Alamos National Laboratory; the Luc Binette Foundation UNAM Postdoctoral Fellowship program.