

VERITAS discovery of very high energy gamma-ray emission from S3 1227+25 and multiwavelength observations

Atreya Acharyya on behalf of the VERITAS Collaboration

Department of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA

E-mail: aacharyya1@ua.edu

We report the detection of very high energy gamma-ray emission from the blazar S3 1227+25 (VER J1230+253) with the Very Energetic Radiation Imaging Telescope Array System (VERITAS). VERITAS observations of the source were triggered by the detection of a hard-spectrum GeV flare on May 15, 2015 with the *Fermi*-Large Area Telescope (LAT). A combined five-hour VERITAS exposure on May 16th and May 18th resulted in a strong 13σ detection with a differential photon spectral index, $\Gamma = 3.8 \pm 0.4$, and a flux level at 9% of the Crab Nebula above 120 GeV. This also triggered target of opportunity observations with *Swift*, optical photometry, polarimetry and radio measurements, also presented in this work, in addition to the VERITAS and *Fermi*-LAT data. A temporal analysis of the gamma-ray flux during this period finds evidence of a shortest variability timescale of $\tau_{\text{obs}} = 6.2 \pm 0.9$ hours, indicating emission from compact regions within the jet, and the combined gamma-ray spectrum shows no strong evidence of a spectral cut-off. An investigation into correlations between the multiwavelength observations found evidence of optical and gamma-ray correlations, suggesting a single-zone model of emission. Finally, the multiwavelength spectral energy distribution is well described by a simple one-zone leptonic synchrotron self-Compton radiation model.

The 38th International Cosmic Ray Conference (ICRC2023)
26 July – 3 August, 2023
Nagoya, Japan



All results are shown in the refereed publication. Please cite this as [1].

Acknowledgments

This research is supported by grants from the U.S. Department of Energy Office of Science, the U.S. National Science Foundation and the Smithsonian Institution, by NSERC in Canada, and by the Helmholtz Association in Germany. This research used resources provided by the Open Science Grid, which is supported by the National Science Foundation and the U.S. Department of Energy's Office of Science, and resources of the National Energy Research Scientific Computing Center (NERSC), a U.S. Department of Energy Office of Science User Facility operated under Contract No. DE-AC02-05CH11231. We acknowledge the excellent work of the technical support staff at the Fred Lawrence Whipple Observatory and at the collaborating institutions in the construction and operation of the instrument.

This work has made use of data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project. The Asteroid Terrestrial-impact Last Alert System (ATLAS) project is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. This work was partially funded by Kepler/K2 grant J1944/80NSSC19K0112 and HST GO-15889, and STFC grants ST/T000198/1 and ST/S006109/1. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, the South African Astronomical Observatory, and The Millennium Institute of Astrophysics (MAS), Chile.

This study was partly based on observations conducted using the 1.8 m Perkins Telescope Observatory (PTO) in Arizona (USA), which is owned and operated by Boston University. The BU group was supported in part by NASA Fermi Guest Investigator grant 80NSSC22K1571.

This publication has made use of data obtained at Metsähovi Radio Observatory, operated by Aalto University in Finland.

This research has made use of data from the OVRO 40-m monitoring program, supported by private funding from the California Institute of Technology and the Max Planck Institute for Radio Astronomy, and by NASA grants NNX08AW31G, NNX11A043G, and NNX14AQ89G and NSF grants AST-0808050 and AST-1109911.

This work has made use of data from the Steward Observatory, supported by NASA Fermi Guest Investigator grant NNX12AO93G.

Part of this work is based on archival data, software or online services provided by the Space Science Data Center - ASI.

A.A. and M.S. acknowledge support through NASA grants 80NSSC22K1515, 80NSSC22K0950, 80NSSC20K1587, 80NSSC20K1494 and NSF grant PHY-1914579.

References

- [1] Acharyya, A., Adams, C. B., Archer, A., et al. 2023, *The Astrophysical Journal*, 950, 152, doi: [10.3847/1538-4357/acd2d0](https://doi.org/10.3847/1538-4357/acd2d0)

Full Author List: VERITAS Collaboration

A. Acharyya¹, C. B. Adams², A. Archer³, P. Bangale⁴, J. T. Bartkoske⁵, P. Batista⁶, W. Benbow⁷, J. L. Christiansen⁸, A. J. Chromey⁷, A. Duerr⁵, M. Errando⁹, Q. Feng⁷, G. M. Foote⁴, L. Fortson¹⁰, A. Furniss^{11,12}, W. Hanlon⁷, O. Hervet¹², C. E. Hinrichs^{7,13}, J. Hoang¹², J. Holder⁴, Z. Hughes⁹, T. B. Humensky^{14,15}, W. Jin¹, M. N. Johnson¹², M. Kertzman³, M. Kherlakian⁶, D. Kieda⁵, T. K. Kleiner⁶, N. Korzoun⁴, S. Kumar¹⁴, M. J. Lang¹⁶, M. Lundy¹⁷, G. Maier⁶, C. E. McGrath¹⁸, M. J. Millard¹⁹, C. L. Mooney⁴, P. Moriarty¹⁶, R. Mukherjee²⁰, S. O'Brien^{17,21}, R. A. Ong²², N. Park²³, C. Poggemann⁸, M. Pohl^{24,6}, E. Pueschel⁶, J. Quinn¹⁸, P. L. Rabinowitz⁹, K. Ragan¹⁷, P. T. Reynolds²⁵, D. Ribeiro¹⁰, E. Roache⁷, J. L. Ryan²², I. Sadeh⁶, L. Saha⁷, M. Santander¹, G. H. Sembroski²⁶, R. Shang²⁰, M. Spletstoesser¹², A. K. Talluri¹⁰, J. V. Tucci²⁷, V. V. Vassiliev²², A. Weinstein²⁸, D. A. Williams¹², S. L. Wong¹⁷, and J. Woo²⁹

¹Department of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA

²Physics Department, Columbia University, New York, NY 10027, USA

³Department of Physics and Astronomy, DePauw University, Greencastle, IN 46135-0037, USA

⁴Department of Physics and Astronomy and the Bartol Research Institute, University of Delaware, Newark, DE 19716, USA

⁵Department of Physics and Astronomy, University of Utah, Salt Lake City, UT 84112, USA

⁶DESY, Platanenallee 6, 15738 Zeuthen, Germany

⁷Center for Astrophysics | Harvard & Smithsonian, Cambridge, MA 02138, USA

⁸Physics Department, California Polytechnic State University, San Luis Obispo, CA 94307, USA

⁹Department of Physics, Washington University, St. Louis, MO 63130, USA

¹⁰School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455, USA

¹¹Department of Physics, California State University - East Bay, Hayward, CA 94542, USA

¹²Santa Cruz Institute for Particle Physics and Department of Physics, University of California, Santa Cruz, CA 95064, USA

¹³Department of Physics and Astronomy, Dartmouth College, 6127 Wilder Laboratory, Hanover, NH 03755 USA

¹⁴Department of Physics, University of Maryland, College Park, MD, USA

¹⁵NASA GSFC, Greenbelt, MD 20771, USA

¹⁶School of Natural Sciences, University of Galway, University Road, Galway, H91 TK33, Ireland

¹⁷Physics Department, McGill University, Montreal, QC H3A 2T8, Canada

¹⁸School of Physics, University College Dublin, Belfield, Dublin 4, Ireland

¹⁹Department of Physics and Astronomy, University of Iowa, Van Allen Hall, Iowa City, IA 52242, USA

²⁰Department of Physics and Astronomy, Barnard College, Columbia University, NY 10027, USA

²¹Arthur B. McDonald Canadian Astroparticle Physics Research Institute, 64 Bader Lane, Queen's University, Kingston, ON Canada, K7L 3N6

²²Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA

²³Department of Physics, Engineering Physics and Astronomy, Queen's University, Kingston, ON K7L 3N6, Canada

²⁴Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam-Golm, Germany

²⁵Department of Physical Sciences, Munster Technological University, Bishopstown, Cork, T12 P928, Ireland

²⁶Department of Physics and Astronomy, Purdue University, West Lafayette, IN 47907, USA

²⁷Department of Physics, Indiana University-Purdue University Indianapolis, Indianapolis, IN 46202, USA

²⁸Department of Physics and Astronomy, Iowa State University, Ames, IA 50011, USA

²⁹Columbia Astrophysics Laboratory, Columbia University, New York, NY 10027, USA