Monitoring the radio galaxy M87 with HAWC

T. Capistrán, D. Avila Rojas, M.M. González, N. Fraija, R. Alfaro and for the HAWC Collaboration

We acknowledge support by:

Abstract

Studies of radio galaxies at TeV energies are fascinating because their jets are misaligned concerning our sightline. Thus, it provides us with a unique opportunity to study the structure of their jets, the radiative processes, and the acceleration mechanisms involved in them. In addition, some radio galaxies have presented variability in their emission, like the giant radio galaxy M87, which has reported several activity periods. Due to its duty cycle > 95% and instantaneous field of view of 2 sr, HAWC provides daily monitoring of variable sources visible from the Northern Hemisphere. In this work, we show the results of monitoring M87 between January 2015 and December 2018. HAWC's observations are consistent with the low activity state reported by other instruments (like H.E.S.S and MAGIC). However, after September 2017 (~MJD 58000), the HAWC measurements of M87 show hints of higher activity.

Introduction

AGN is the majority bright gamma-ray sources

- ★ Blazars: jet aligned with out line-of-sight.
- ★ Radio galaxies (RG): large inclination of their jet.

The RG

- ✓ Study from another perspective (see all structure of the AGN).
- ✓ 6 sources have emission at VHE.

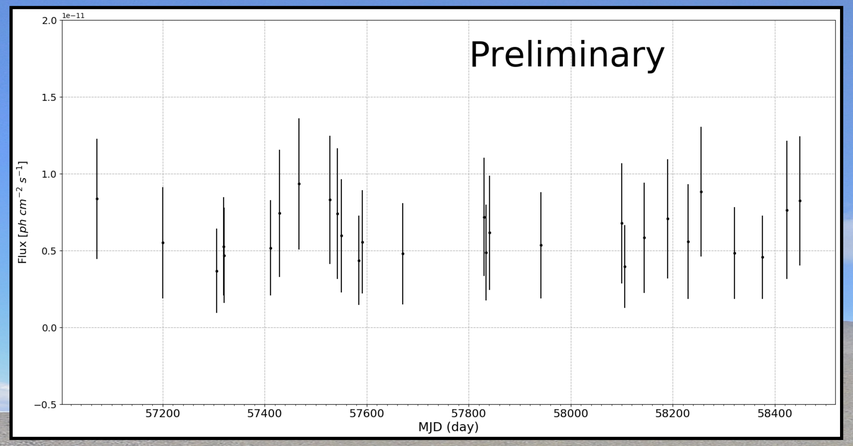

Figure 1: Daily light curve of M87 from January 1st 2015 to December 8th 2018. Here oney plot all days with the significance greater than 2.

The Radio Galaxy M87

- ✦ First detection at TeV in 1998 by HEGRA observatory.
- ✦ The second nearest RG to the Earth (z=0.0044)
- ✦ Classified as Fanaroff & Riley type I due to the morphology in radio.
- ✦ Three flaring state have reported in 2005, 2008 and 2010,
- ✦ Two possible high activity (2004 and 2012) have reported by H.E.S.S. and MAGIC.

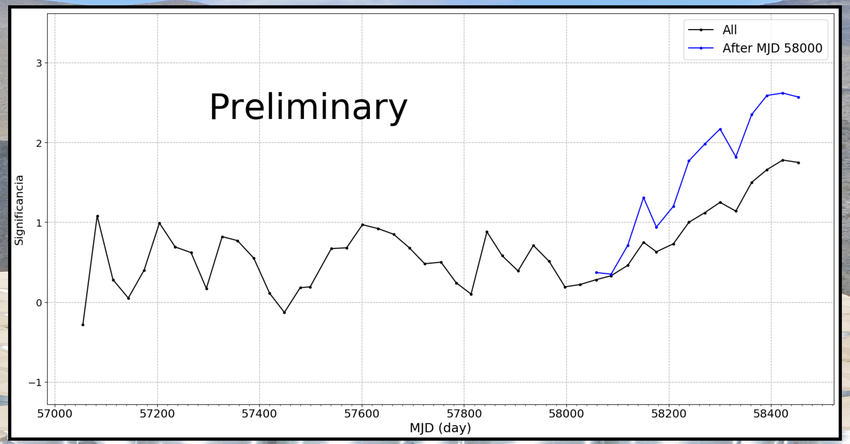

Figure 3: Cumulative significance is shown by adding month-by-month data from January 2015 to December 2018. After September 2017 (MJD 58000), the significance starts to increase.

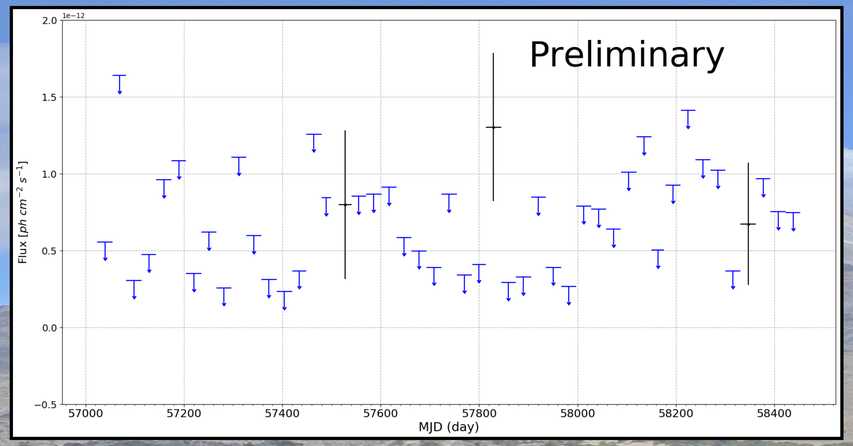

Figura 2: Monthly light curve of M87 from January 1st 2015 to December 8th 2018.

HAWC results

- ✤ M87 was monitoring form January 1st 2015 to December 8th 2018.
- ✤ Integral flux is obtained using the Likelihood fitting Framework (LIFF) using a Simple Power Law at 1 TeV.
- ✤ After September 2017, the result hints towards a beginning of activity of M87.

Conclusion

- ➡ M87 was monitoring for four years using HAWC Observatory.
- ➡ M87 flux is consistent with lowest flux activity observed.
- ➡ Report a hints of beginning of activity on this source after September 2017.
- ➡ Pass 4 analysis was used in this work, the Pass 5 will show a promising results (> 5 sigma) on this source.

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 Tecnolog\'ia (CONACyT), M\'exico, grants 271051, 232656, 260378, 179588, 254964, 258865, 243290, 132197, A1-S-46288, A1-S-22784, c\'atedras 873, 1563, 341, 323, Red HAWC, M\'exico; DGAPA-UNAM grants IG101320, IN111716-3, IN111419, IA102019, IN110621, IN110521; VIEP-BUAP; PIFI 2012, 2013, PROFOCIE 2014, 2015; the University of Wisconsin Alumni Research Foundation; the Institute of Geophysics, Planetary Physics, and Signatures at Los Alamos National Laboratory; Polish Science Centre grant, DEC-2017/27/B/ST9/02272; Coordinaci\'on de la Investigaci\'on Cient\'ifica de la Universidad Michoacana; Royal Society - Newton Advanced Fellowship 180385; Generalitat Valenciana, grant CIDEGENT/2018/034; Chulalongkorn University's CUniverse (CUAASC) grant; Coordinaci\'on General Acad\'emica e Innovaci\'on (CGAI-UdeG), PRODEP-SEP UDG-CA-499; Institute of Cosmic Ray Research (ICRR), University of Tokyo, H.F. acknowledges support by NASA under award number 80GSFC21M0002. We also acknowledge the significant contributions over many years of Stefan Westerhoff, Gaurang Yodh and Arnulfo Zepeda Dominguez, all deceased members of the HAWC collaboration. Thanks to Scott Delay, Luciano D\'iaz and Eduardo Murrieta for technical support.

References

1. Fermi-LAT collaboration, Gamma-ray emission in radio galaxies, from MeV to TeV, in IAU Symposium 342: Perseus in Sicily: from black hole to cluster outskirts, 9, 2018, DOI [1809.08074].
2. V.A. Acciari et al., Monitoring of the radio galaxy M 87 during a low-emission state from 2012 to 2015 with MAGIC, Monthly Notices of the Royal Astronomical Society **492** (2020) 5354.
3. D. Glawion, Radio galaxies at tev energies: Preface, Galaxies **8** (2020)
4. B. Rani, Radio Galaxies—The TeV Challenge, Galaxies **7** (2019) 23 [1811.00567].
5. F.M. Rieger and A. Levinson, Radio Galaxies at VHE energies, Galaxies **6** (2018) 116 [1810.05409].