Observation of radio galaxies with HAWC

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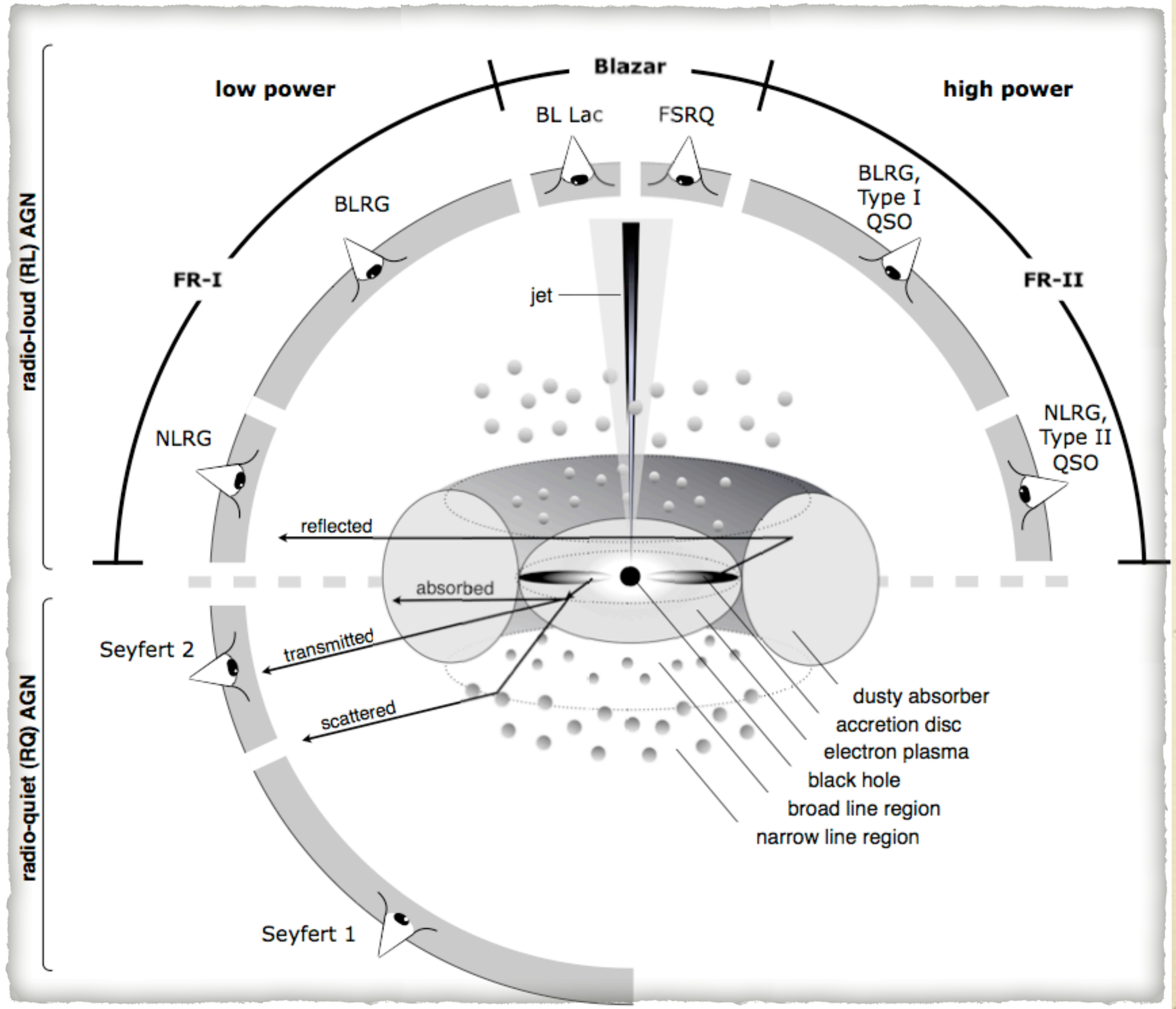
Active Galactic Nuclei



http://astromev.in2p3.fr/?q=aboutus/active-galactic-nuclei-mev-domain

AGN are the most popular object

	misaligned jet
Blazar	No
Radio galaxy	Yes

Radio Galaxy

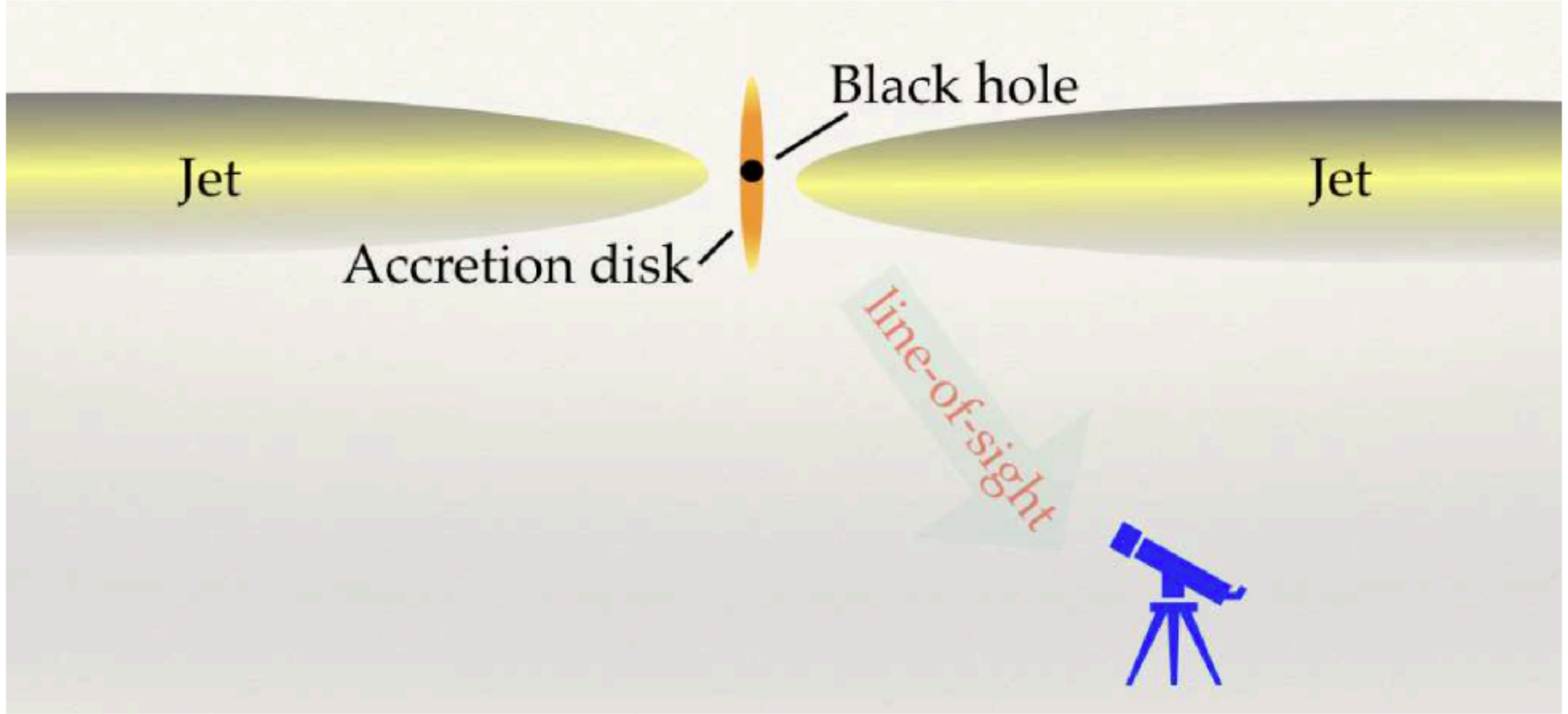


Figure 1. Sketch representing the mis-aligned radio emitting bipolar jets of a radio galaxy (not to scale). Jets typically extend up to a few hundreds of kilo-parsec to mega-parsec scales.

B. Rrani (2019) DOI:10.3390/galaxies7010023

- RG is a class of Active Galactic Nuclei (AGN).
- Host a relativistic jet misaligned with the line of sight.
- Prove the physics of VHE emission process.

Radio Galaxy at TeV

Table 1. Radio galaxies detected at TeV energies

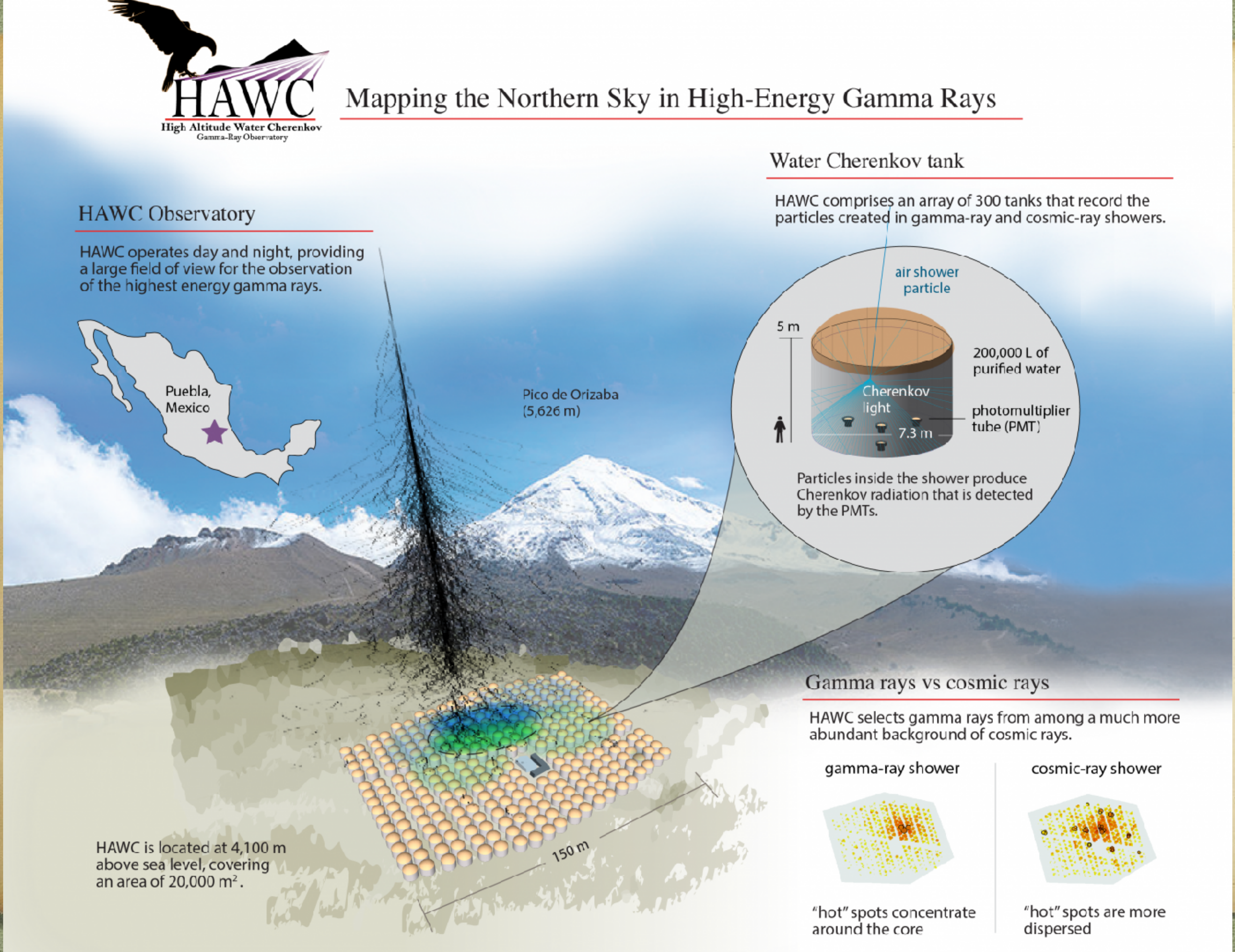
Source	Type	Redshift (Distance in Mpc)	M_{BH} ($M_\odot$)	L_{VHE} (erg s^{-1})
☆ Centaurus A	FR1	0.00183 (3.7) [23]	5×10^7 [24]	10^{40}
M87	FR1	0.0044 (16) [25]	6×10^9 [26]	10^{41}
3C 84	FR1	0.0177 (71) [27]	$(3\text{-}8)\times10^8$ [28,29]	10^{45}
☆ IC 310	FR1	0.0189 (80) [30]	$(1\text{-}7)\times10^8$ [24,31]	10^{44}
3C 264	FR1	0.0217 (95) [32]	2.6×10^8 [33]	6×10^{43}
☆ PKS 0625-35	FR1/BL Lac	0.05488 (220) [34]	3×10^9 [24]	5×10^{41}

B. Rrani (2019) DOI:10.3390/galaxies7010023

The RG are:

- The closest Extragalactic objects.
- Harbors a Super Massive Black Hole ~10^(8-9) solar masses.
- Luminosities up to 10^45 ergs s^-1.
- Classified as Fanaroff and Riley type I (FR1).

☆ HAWC can' t see them



Some characteristics:

- DC > 95%
- Wide F.O.V
- 300 GeV - 100 TeV

=> HAWC is a good experiment to source monitoring.

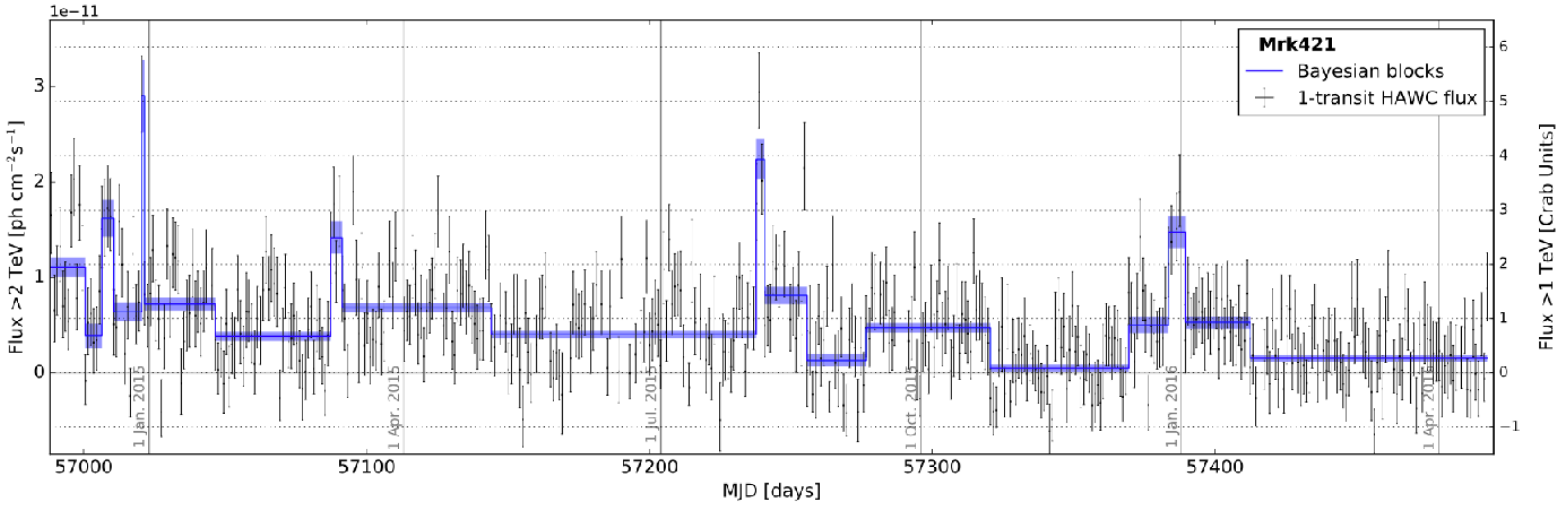


Figure 4. Flux light curve for Mrk 421 with sidereal-day sampling for 471 transits between 2014 November 26 and 2016 April 20. The integrated fluxes are derived from fitting F_i in $dN/dE = F_i(E/(1\ \text{TeV}))^{-2.2}\exp(-E/(5\ \text{TeV}))$ and converted to Crab Units via dividing by the HAWC measurement of the average Crab Nebula gamma-ray flux. The blue lines show the distinct flux states between change points identified via the Bayesian blocks analysis with a 5% false positive probability.

A. U. Abeysekara (2017) DOI: 10.3847/1538-4357/aa729e

Radio Galaxy at TeV

"Like Blazars, TeV radio galaxies exhibit variability on multiple timescale" B. Rani (2019).

There are two state: flaring and quiescent.

A. M87 was the first TeV detected radio galaxy.

   Three active states:

   1. 2005 flare is reported by H.E.S.S.
   2. 2008 flare is reported by MAGIC
   3. 2010 flare is reported by VERITAS

B. NGC1275

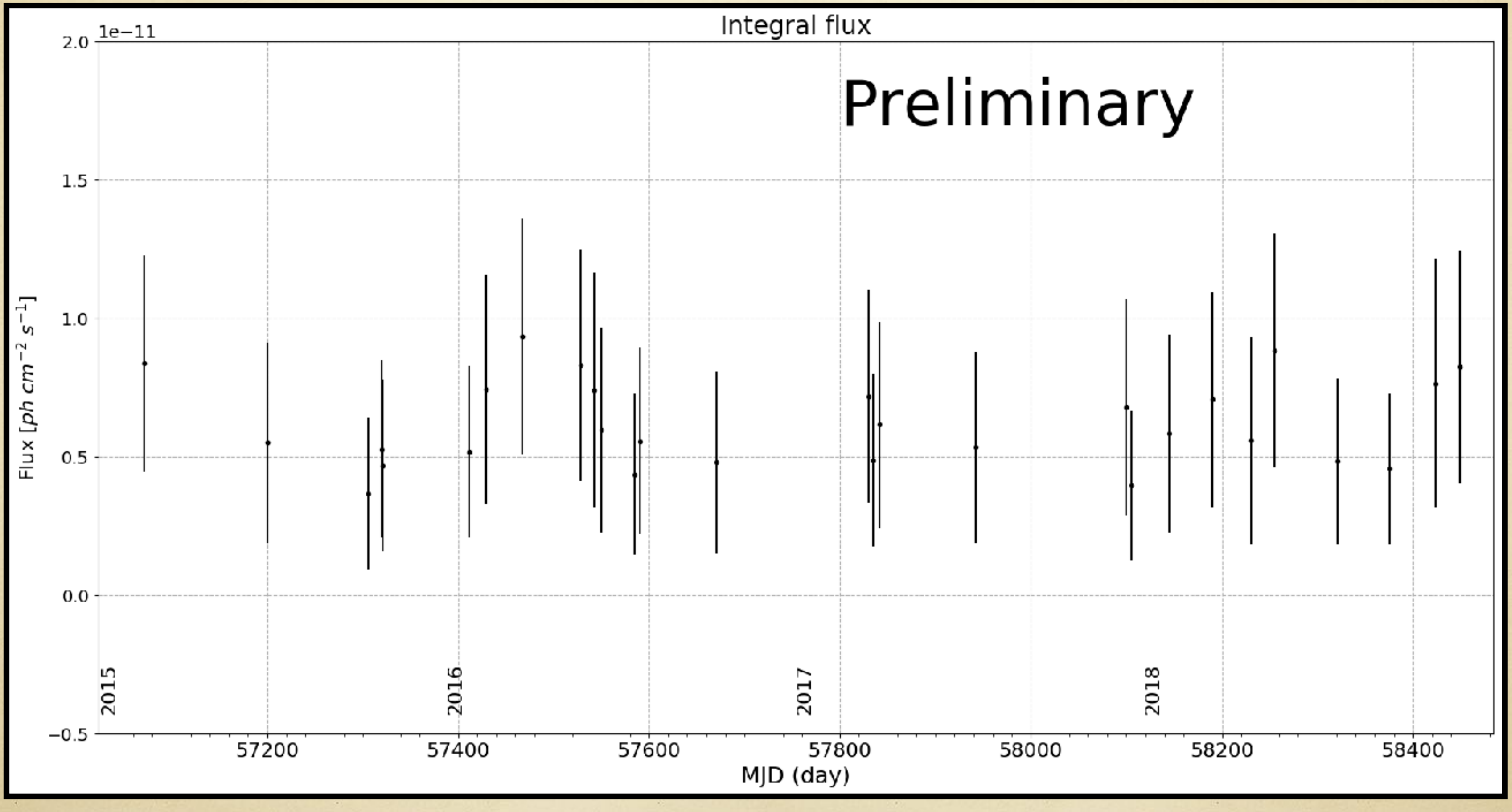
   Two active states:

   4. October 2015
   5. December 2016/January 201

C. 3C 264

M87

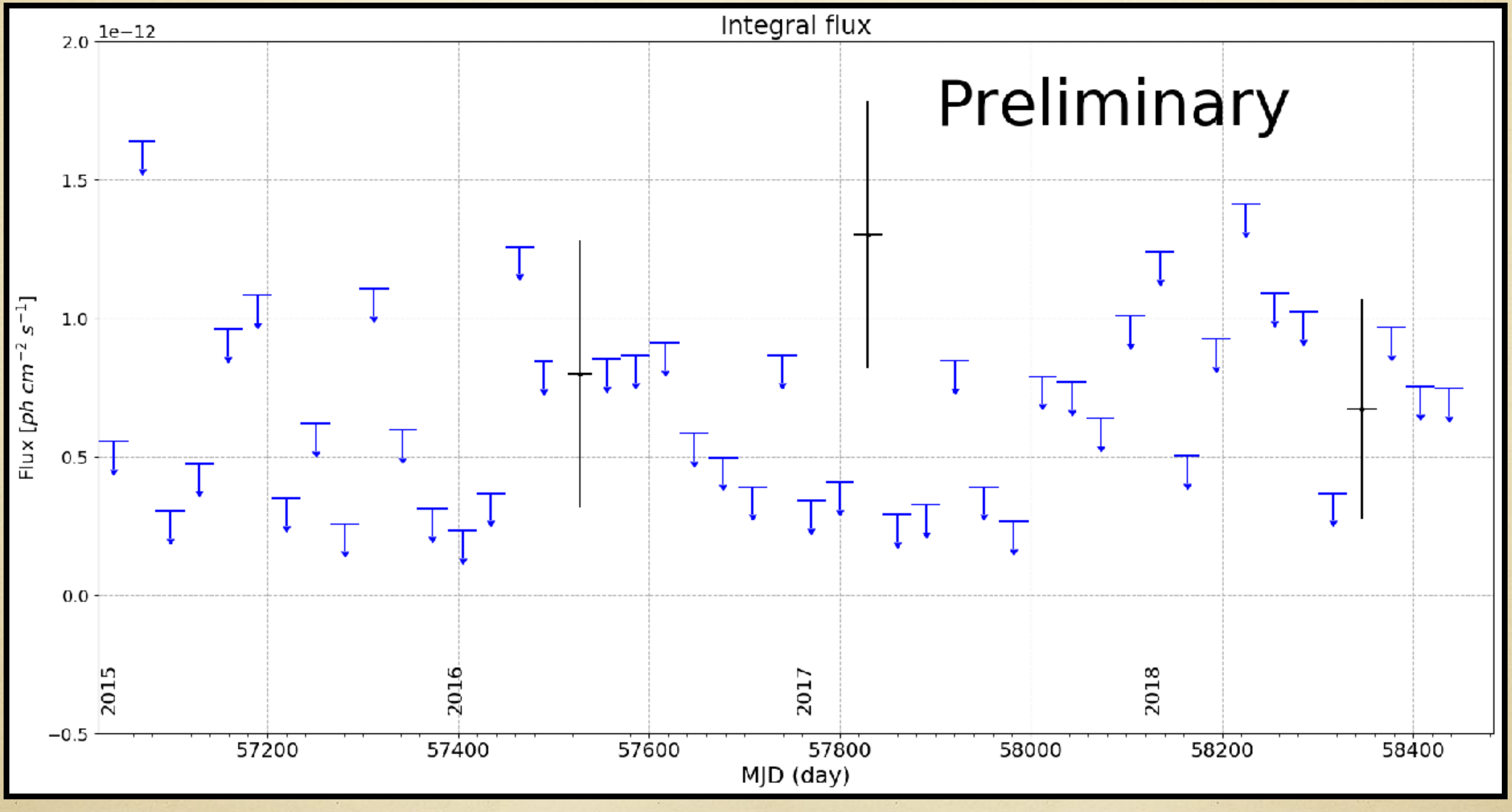
Cumulate data



T. Capistrán (2021) DOI:10.22323/1.395.0839

M87

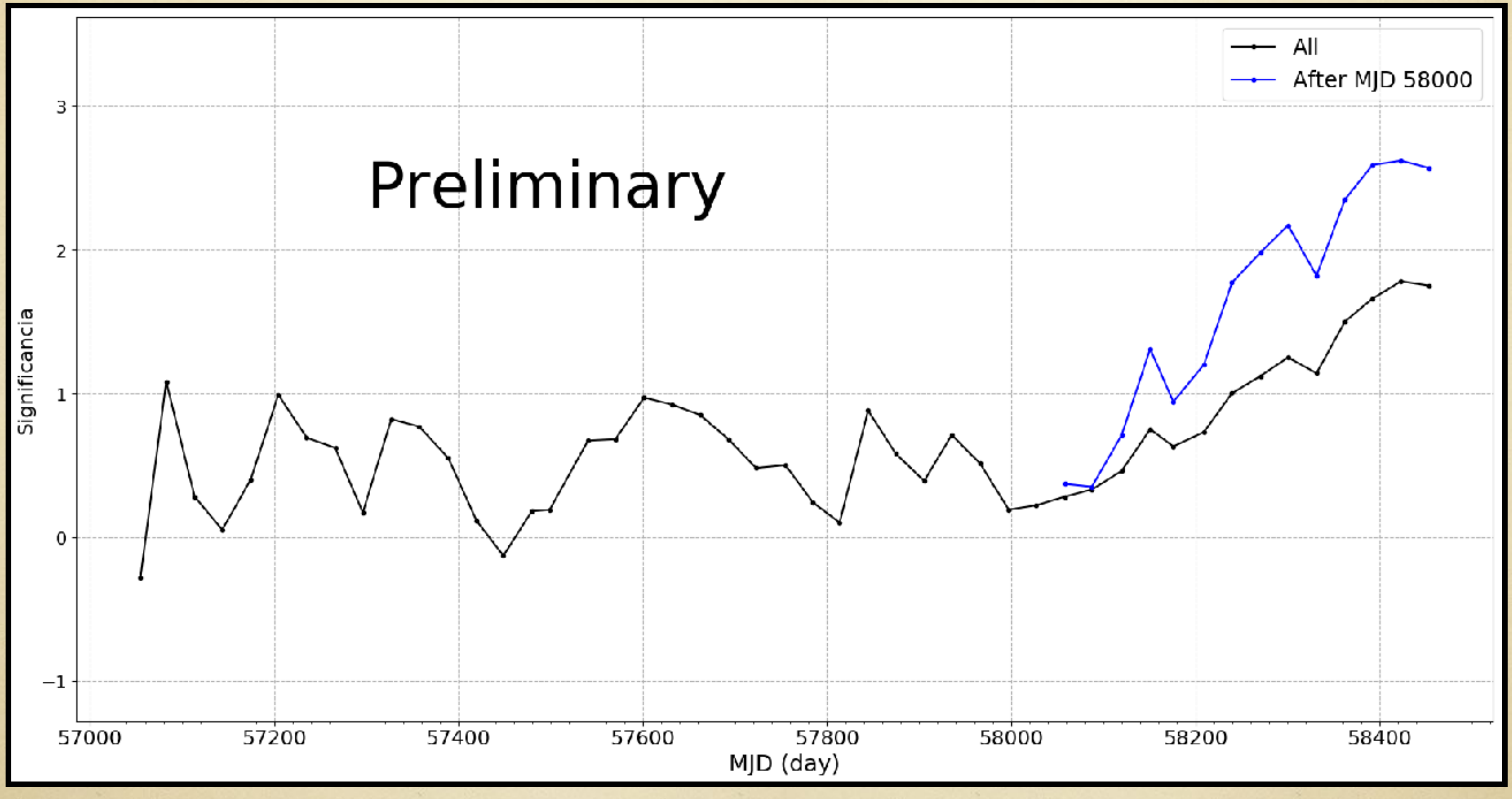
Cumulate data



T. Capistrán (2021) DOI:10.22323/1.395.0839

M87

Cumulate data



T. Capistrán (2021) DOI:10.22323/1.395.0839

Hint: a constant emission after September 2017 (MJD 58000)

NGC 1275

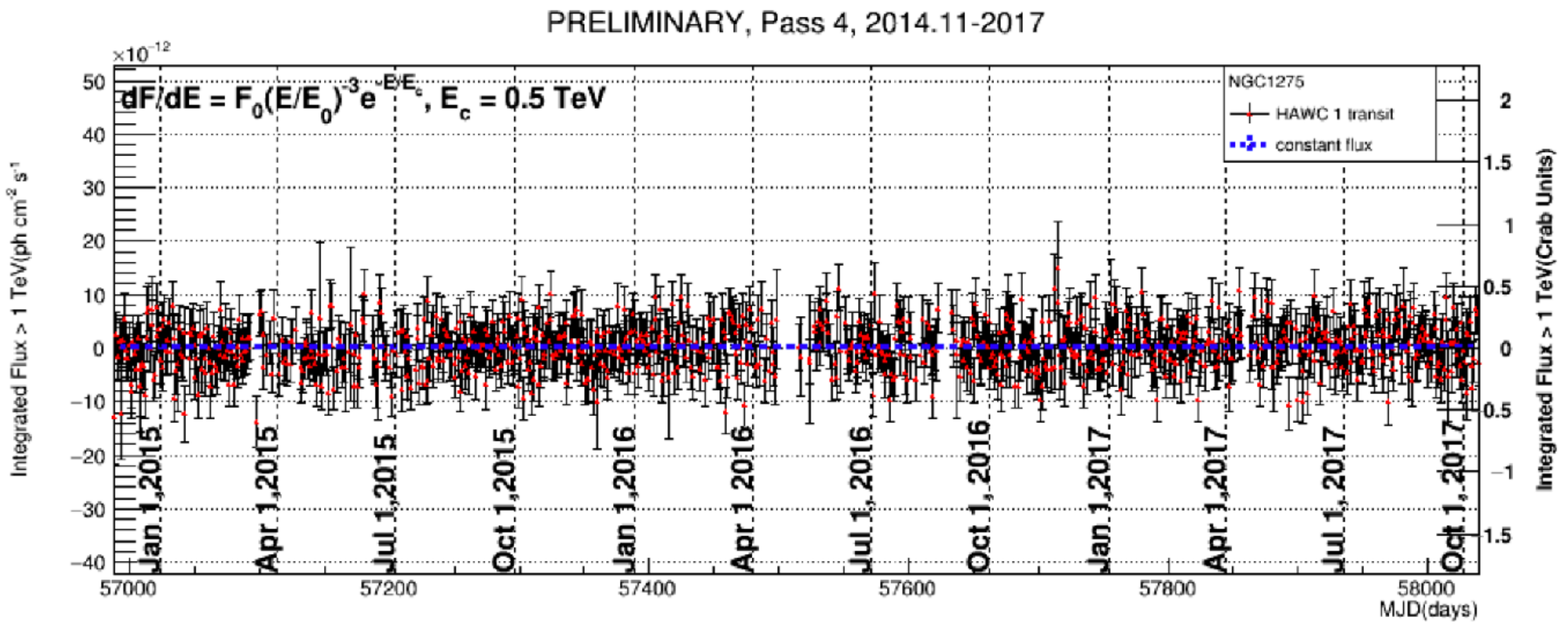
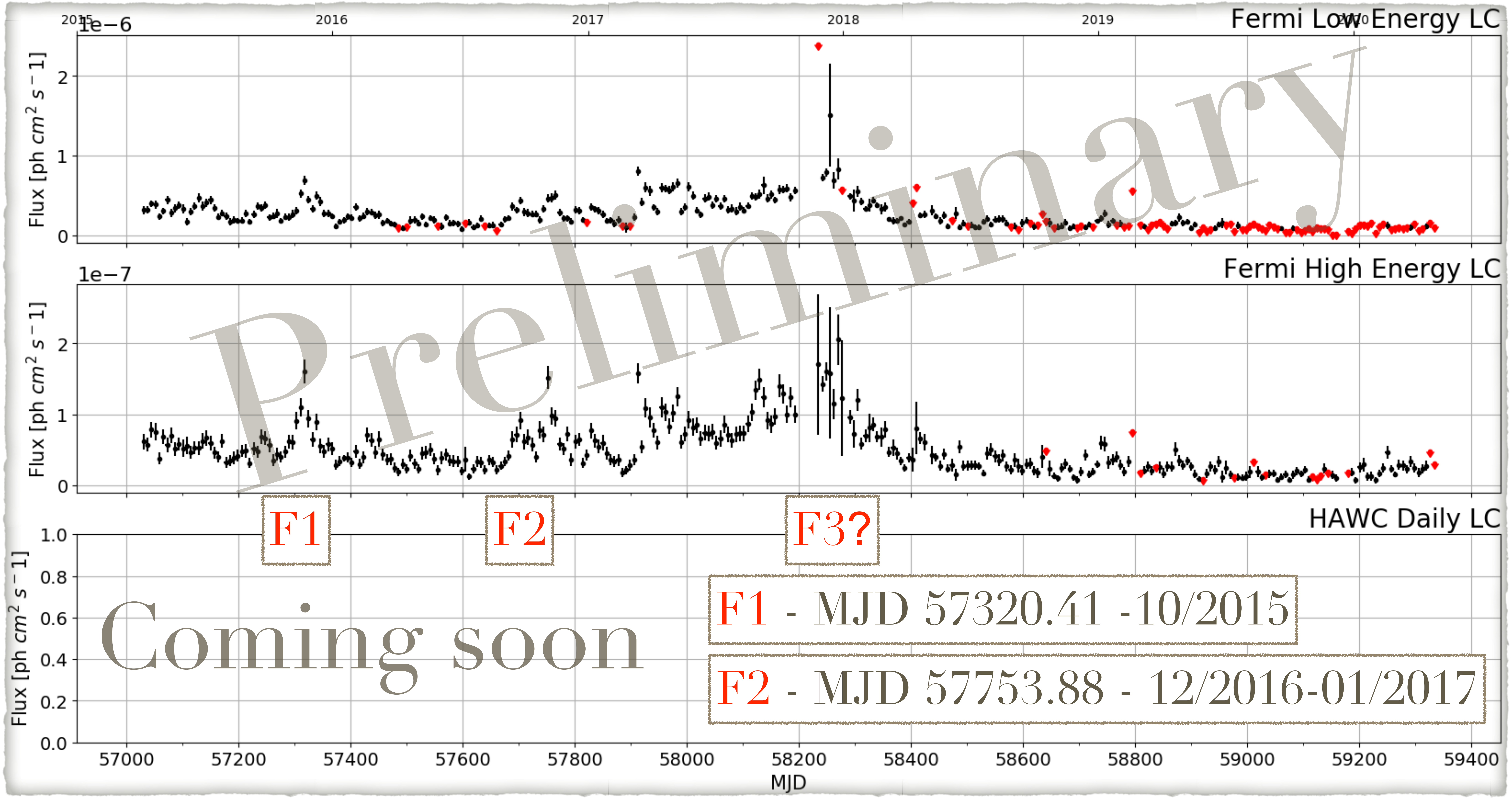


Figure 2: Light curve for 1017 days of HAWC data for NGC 1275.

D. Avila (2019) DOI:10.22323/1.358.0622

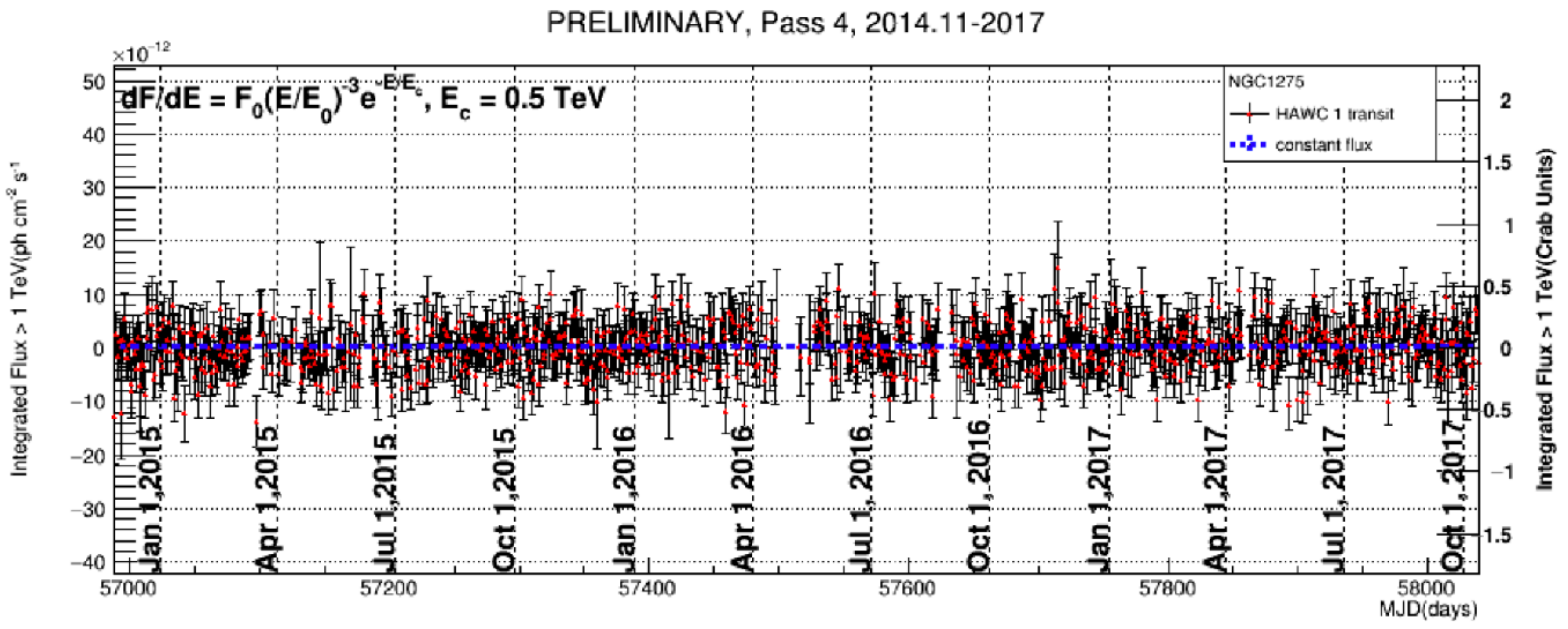
NGC 1275 - HAWC & Fermi



F1 - MJD 57320.41 -10/2015

F2 - MJD 57753.88 - 12/2016-01/2017

3C 264



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Summary

- Monitor 3 RGs with HAWC
- Hint: M87 start a constant emission after ~MJD 58000
- Possible flare in NGC1275 ~MJD 58200