Institute of Cosmos Sciences

EXCELENCIA MARÍA DE MAEZTU

MAGIC
Major Atmospheric Gamma Imaging Cerenkov Telescopes

MAGIC observations of extreme blazars

A. Arbet-Engels, C. Arcaro, K. Asano, J. Becerra-Gonzalez, G. Bonnoli, *M. Cerruti*, F. D'Ammando, D. Dorner, V. Fallah Ramazani, L. Foffano, M. Manganaro, D. Paneque, E. Prandini, F. Tavecchio

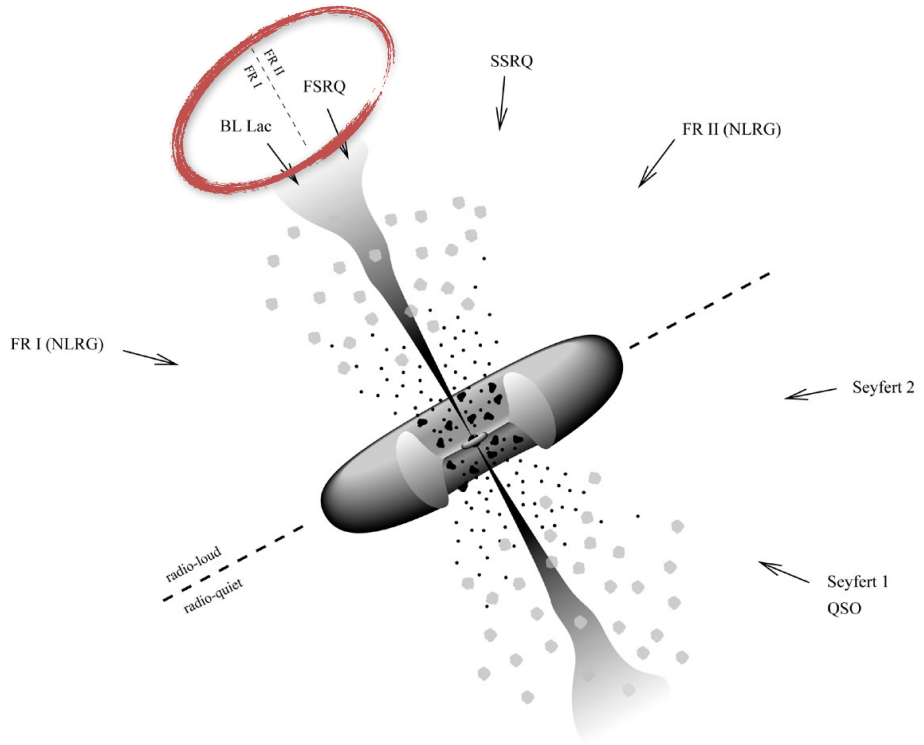
for the ***MAGIC*** Collaboration

TeVPA 2019
December 5, 2019
Sidney, NSW

Universitat de Barcelona

"la Caixa" Foundation

Blazars



Blazars: radio-loud Active Galactic Nucleus whose relativistic jet points towards the observer

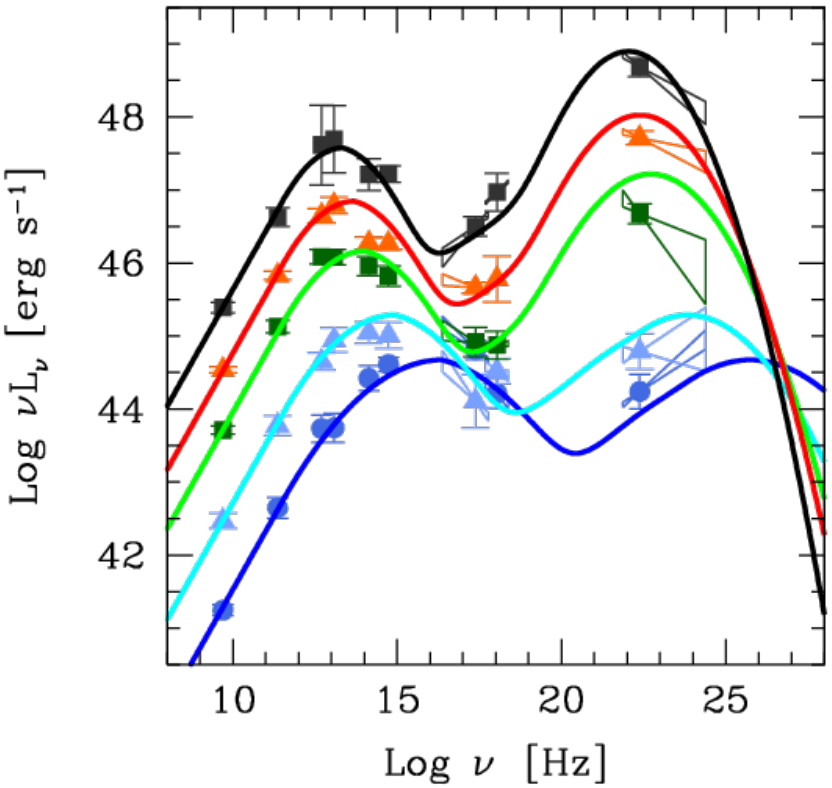
emission from the jet outshines all other AGN components (disk, BLR, X-ray corona, …)

non-thermal emission from radio-to-gamma-rays, and extreme variability

Flat-spectrum-radio-quasars : optical spectrum with broad emission lines

BL Lacertae objects : optical spectrum is featureless (lines $\mathrm{EW} < 5\text{Å}$)

Blazars



Spectral energy distribution (SED): two separate components

FSRQs show a peak in IR

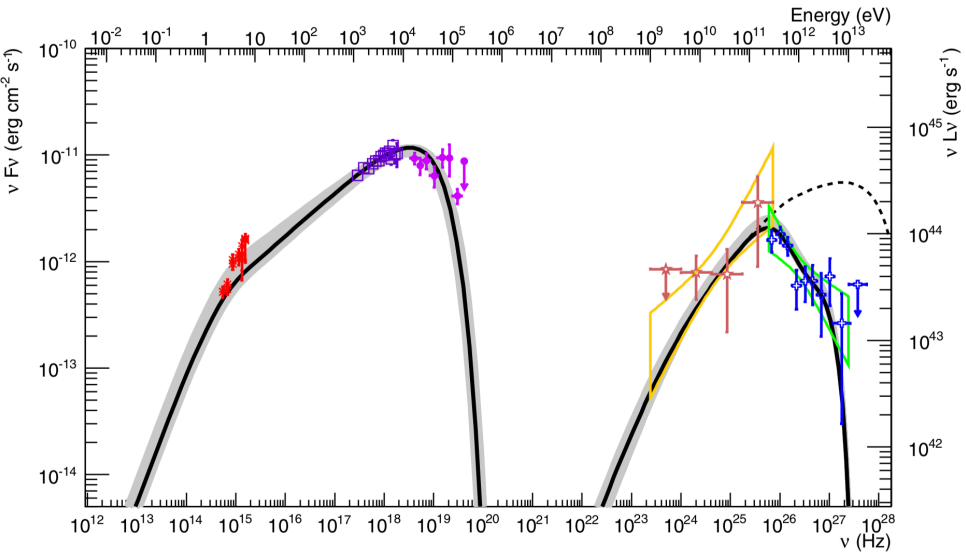
BL Lac objects are classified in:

- peak in IR: low-frequency peaked (LBLs)

- peak in optical: intermediate (IBLs)

- peak in UV / X: high (HBLs)

Extreme blazars



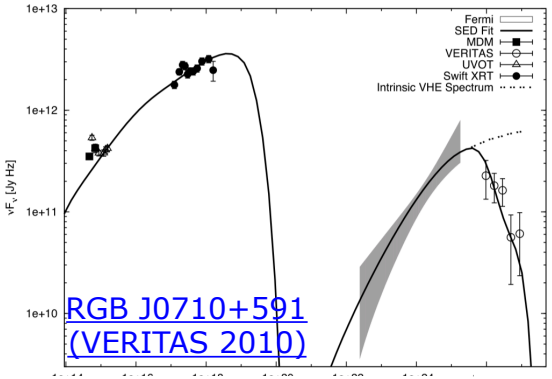
Aliu et al. 2014

If the peak is beyond soft X-rays ($\nu \geq 10^{17}$ Hz), we talk about extreme-HBLs

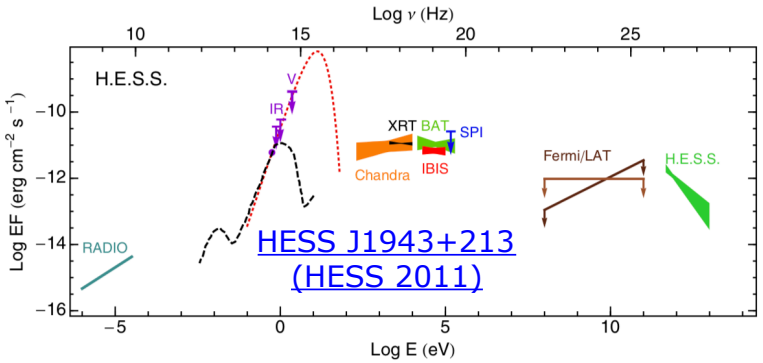
Archetypal EHBL: 1ES0229+200

But not all EHBLs have a hard TeV spectrum! The population seems more heterogeneous (Foffano et al. 2019 Costamante 2019)

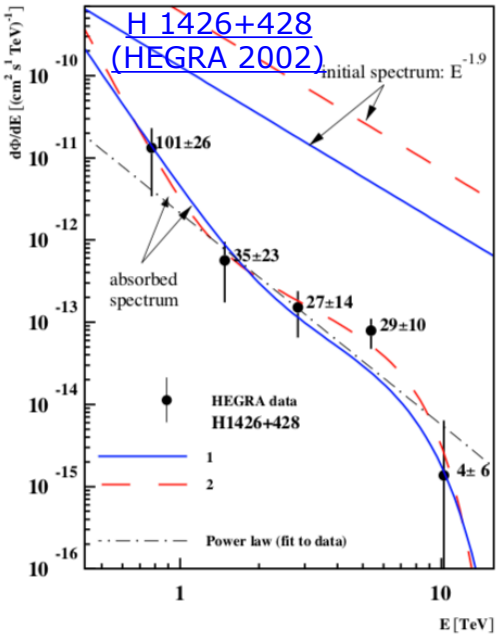
Extreme blazars



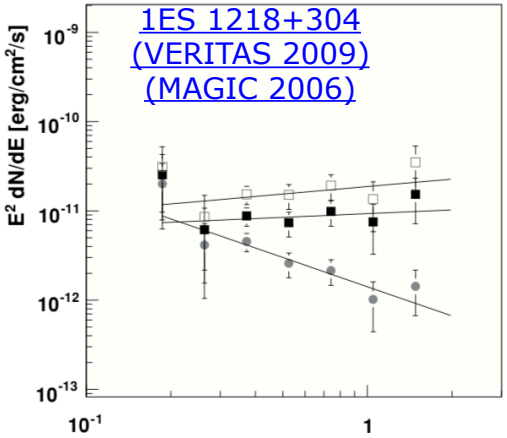
RGB J0710+591 (VERITAS 2010)



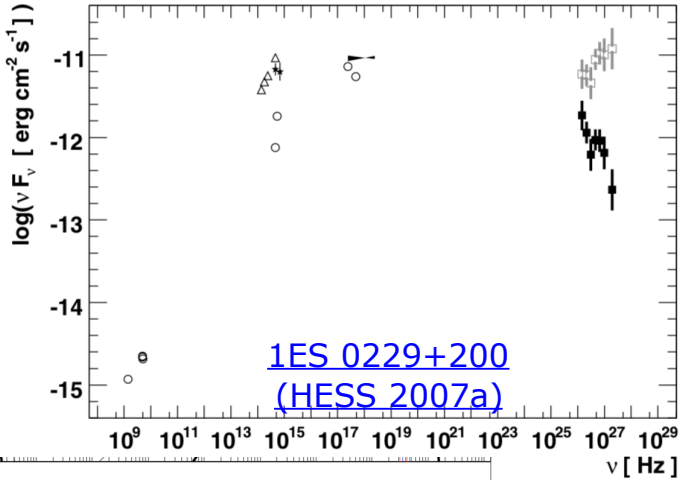
HESS J1943+213 (HESS 2011)



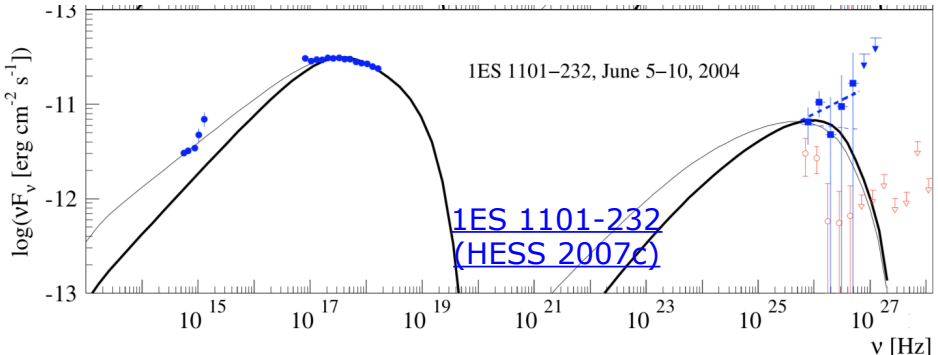
H 1426+428 (HEGRA 2002)



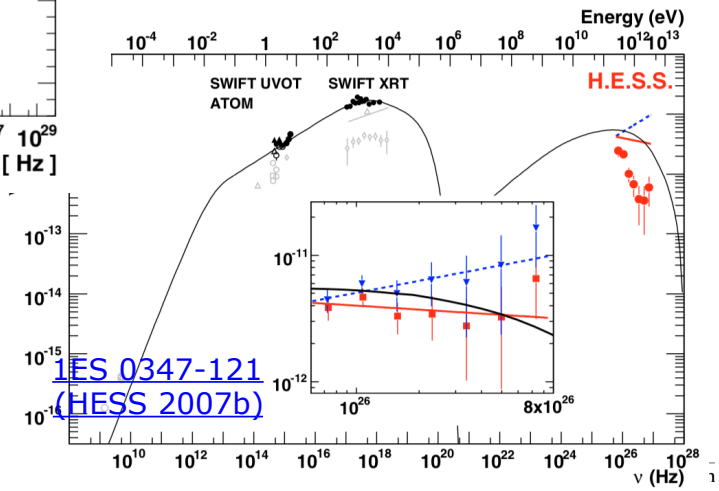
1ES 1218+304 (VERITAS 2009) (MAGIC 2006)



1ES 0229+200 (HESS 2007a)



1ES 1101-232 (HESS 2007c)



1ES 0347-121 (HESS 2007b)

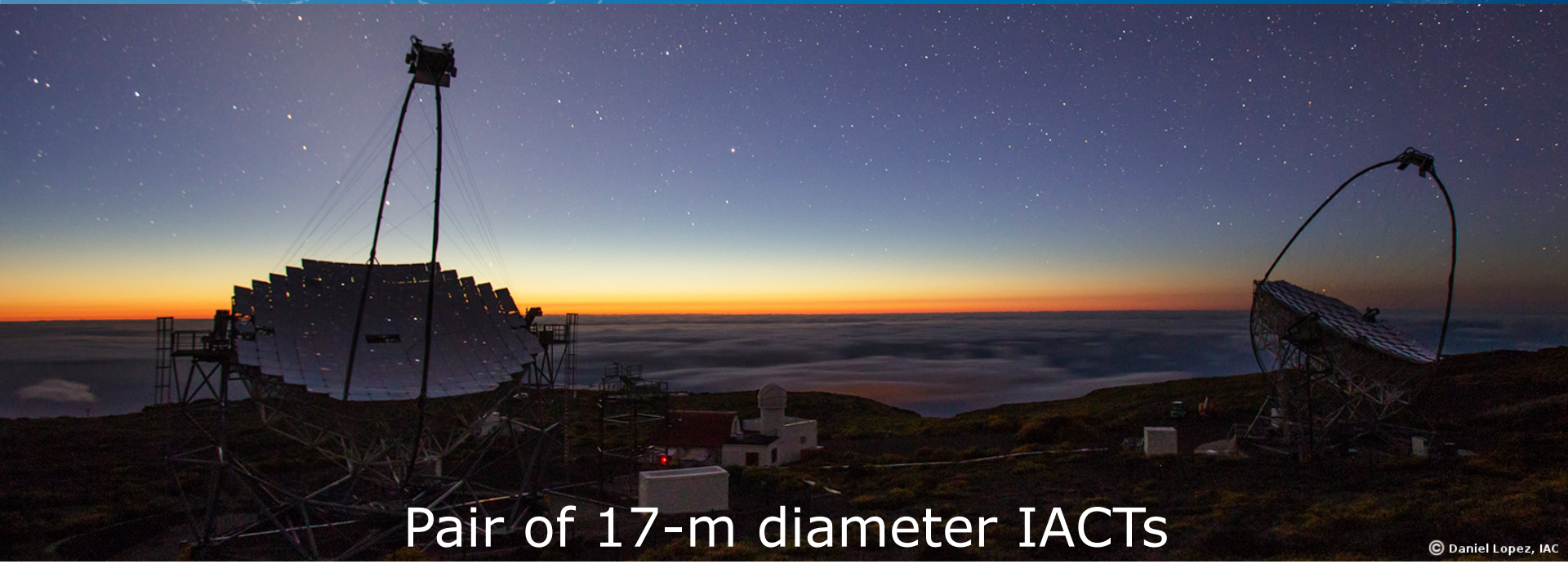
Extreme blazars

Why are they interesting?

- Acceleration / emission models
- AGN models: how do they fit the blazar population?

- Ideal probes for the extragalactic-background-light (EBL)
- Ideal probes for: hadron-beam scenario
  axion-like particles
  Lorentz-invariance violation
  Intergalactic magnetic field

The MAGIC telescopes



Energy range from 30 GeV to >10 TeV

Field of View: ~3.5°

Angular resolution: ~0.1°

Energy resolution: ~15-23% (function of energy)

Sensitivity above 300 GeV is 0.6% of the Crab nebula flux (in 50h)

1000h of dark time per year, out of which ~400h for AGN observations

MAGIC ICCUB Institute of Cosmos Sciences EXCELENCIA MARÍA DE MAEZTU "la Caixa" Foundation

MAGIC observations of EHBLs

Multi-year observing program of EHBL candidates to investigate their TeV behavior

Published in 2019

Source	σ	Exposure [hr]	z
2WHSP J073326.7+515354	6.8	23.4	0.065
TXS 0210+515	5.9	28.6	0.049
RBS 0723	5.4	45.3	0.198
1ES 1426+428	6.0	8.7	0.129
1ES 2037+521	7.5	28.1	0.053
RGB J2042+244	3.7	52.5	0.104
1ES 0229+200	9.0	117.5	0.140
		Tot = 304.1	

MAGIC Collaboration 2019a

MAGIC Collaboration 2019b

MAGIC observations of EHBLs

Multi-year observing program of EHBL candidates to investigate their TeV behavior

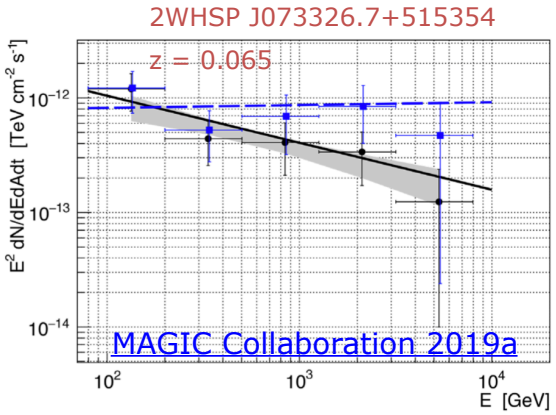
Published in 2019

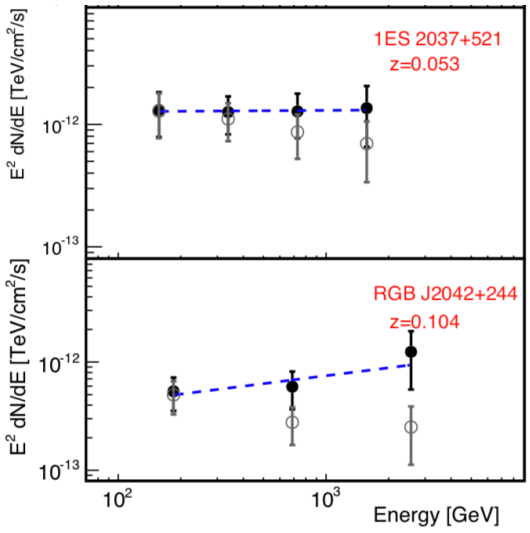
Source	σ	Exposure [hr]	z	$\Gamma_{VHE,\ intrinsic}$
2WHSP J073326.7+515354	6.8	23.4	0.065	2.0 ± 0.2
TXS 0210+515	5.9	28.6	0.049	1.6 ± 0.3
RBS 0723	5.4	45.3	0.198	2.7 ± 1.2
1ES 1426+428	6.0	8.7	0.129	1.8 ± 0.5
1ES 2037+521	7.5	28.1	0.053	2.0 ± 0.5
RGB J2042+244	3.7	52.5	0.104	1.7 ± 0.6
1ES 0229+200	9.0	117.5	0.140	1.8 ± 0.1

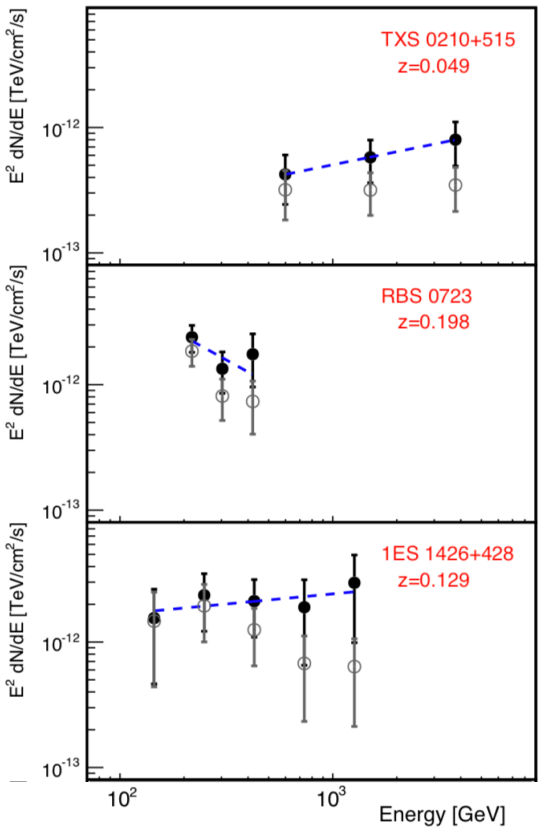
MAGIC Collaboration 2019a

MAGIC Collaboration 2019b

MAGIC observations of EHBLs







MAGIC Collaboration 2019b

TXS 0210+515:
the hardest
in the TeV band

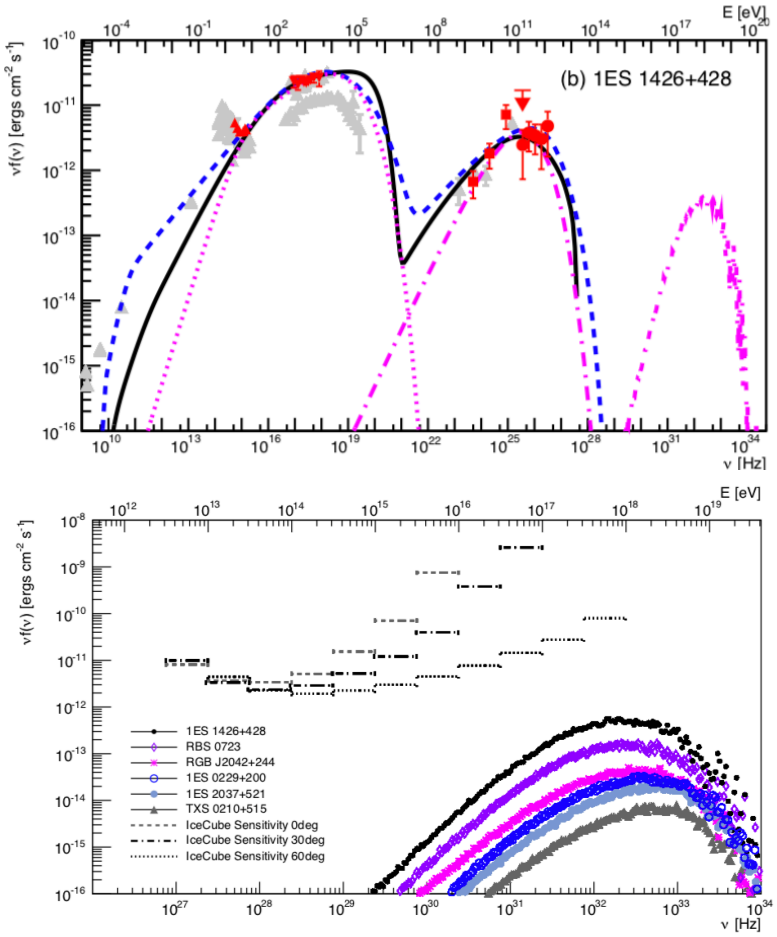
RBS 0723:
only one not detected
in the TeV band

1ES 1426+428:
already known TeV emitter
(seen with HEGRA/Whipple/
CAT at much higher flux level)

MAGIC observations of EHBLs

Systematic modeling of SEDs

- SSC conical-jet
  $(u'_e/u'_B \ll 1)$
- SSC spine-layer interaction
  $(u'_e/u'_B \simeq 1)$
- Proton-synchrotron
  $(u'_e/u'_B \gg 1)$



MAGIC Collaboration 2019a

MAGIC Collaboration 2019b

MAGIC observations of EHBLs

MAGIC discovery of 4 new EHBLs,
and re-detection of 1ES 1426+428

Hint of emission from RGB J2042+244

Upper limits on 5 additional candidates

Comprehensive comparison of radiative models

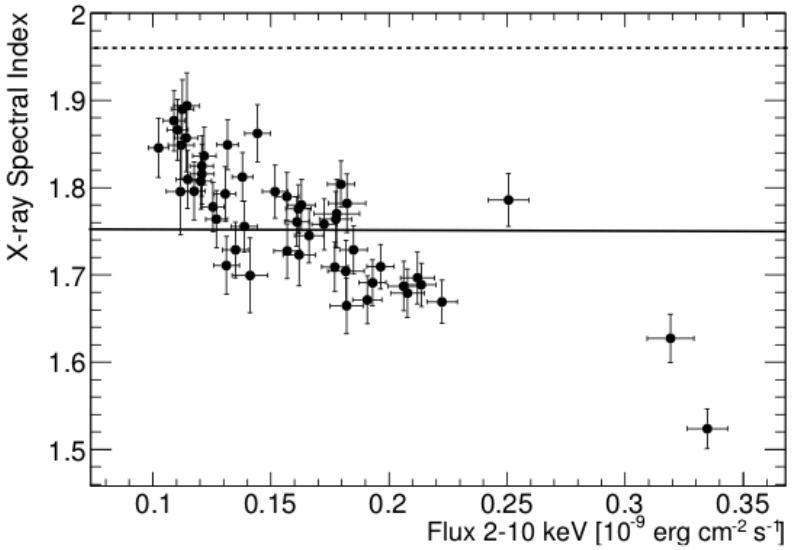
MAGIC Collaboration 2019a

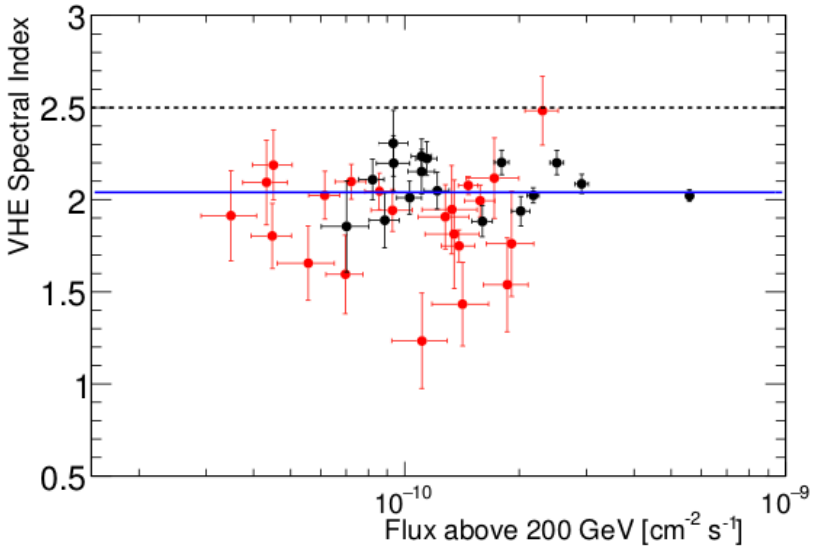
MAGIC Collaboration 2019b

EHBLs-like (flaring) states

Observations of Mrk 501 in 2012:

An archetypal HBL became extreme





MAGIC, FACT, VERITAS, et al. 2018

EHBLs-like (flaring) states

Observations of Mrk 501 in 2012:

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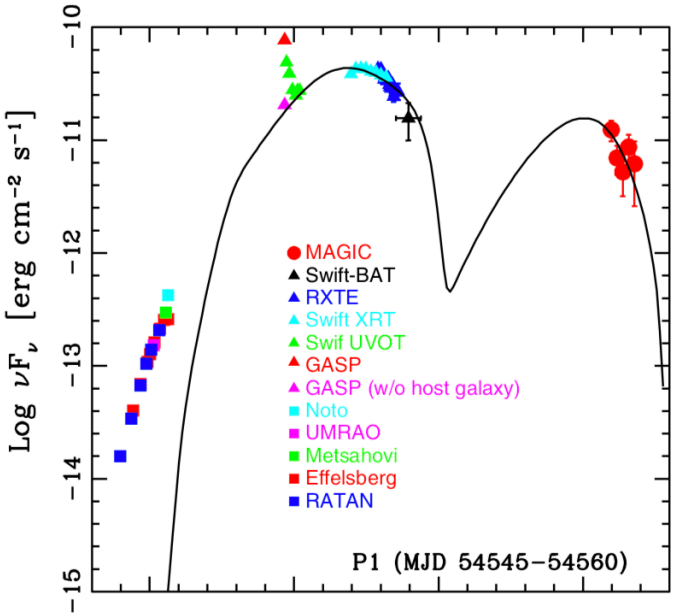
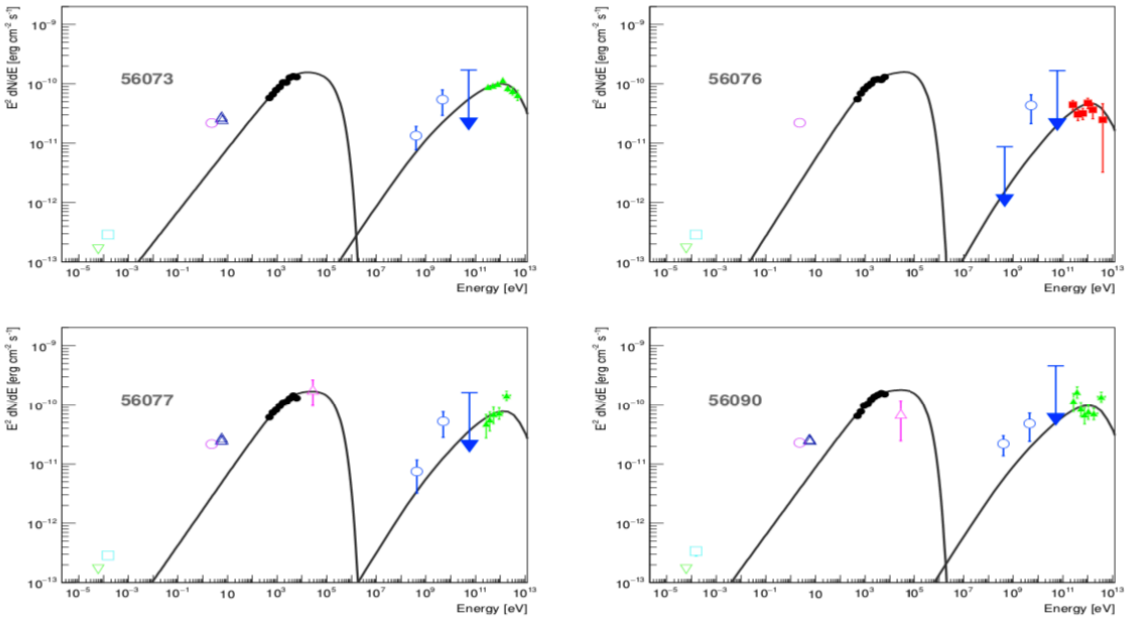


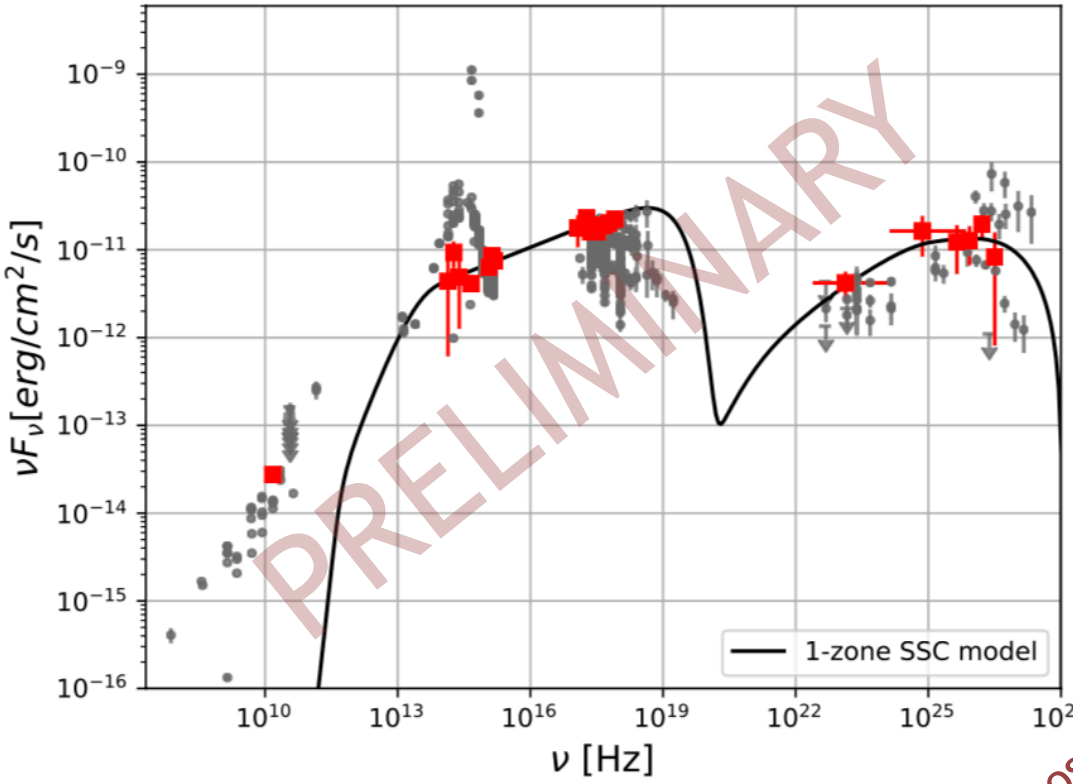
MAGIC & VERITAS, et al. 2015



MAGIC, FACT, VERITAS, et al. 2018

EHBLs-like flaring states

Observations of 1ES 2344+514 in 2016
(with FACT)



See poster by Daniela Dorner

Arbet-Engels et al. 2019
(ICRC-2019)

Flaring EHBLs

Flaring state of 1ES 1218+304

MAGIC detects an unprecedented activity from the blazar 1ES 1218+304 at very high energy gamma rays

ATel #12354; *Razmik Mirzoyan on behalf of the MAGIC Collaboration*
on 3 Jan 2019; 22:11 UT
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, AGN, Blazar

Referred to by ATel #: 12360, 12365

Tweet

The MAGIC telescopes have observed an unprecedented level of very-high-energy (VHE; >100 GeV) gamma-ray flux from 1ES 1218+304 (12h21m21.941s, +30d10m37.11s, J2000.0). The preliminary analysis of the data from 2018/12/31 to 2019/01/02 indicates a VHE gamma-ray flux reaching the level of ~25 % of the flux from the Crab nebula above 100 GeV. Compared to the quiescent state reported by VERITAS, this implies an increase by a factor of ~4. The previous record of VHE gamma-ray flux of this source was ~20% of the flux from the Crab nebula above 100 GeV. It was measured by VERITAS on the night of 30 January 2009 (2010ApJ,709L,163A). 1ES 1218+304 is a high-synchrotron-peaked BL Lac object located at redshift z=0.182. It was first recognized as a VHE gamma-ray emitter by the MAGIC Collaboration in 2005 (Albert, J., 2006, ApJ, 642L,119A).

The MAGIC observations were triggered by the flaring activity in the optical R-band, measured by the KVA telescope from 2018/12/24 to 2019/01/02. The KVA data showed a flux of 2.35+/-0.05 mJy on 2019/01/02, which is the highest optical flux measurement from this source in a time span of 15 years (http://users.utu.fi/kani/1m/1ES_1218+304_jy.html).

MAGIC observations on 1ES 1218+304 will continue during the next weeks and multiwavelength observations are encouraged. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de), V. Fallah Ramazani (vafara@utu.fi) and M. Cerruti (matteo.cerruti@icc.ub.edu).

MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Canary island of La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

Conclusions

Unique role of VHE astronomy in studying extreme blazars (very faint in Fermi-LAT band)

Boost of known EHBLs thanks to MAGIC

Population is unclear: some are hard-TeV, some are not

We now established that the EHBLs state can be temporary

(can we have year-long EHBL-like state?)