FLAT-SPECTRUM RADIO-QUASARS with H.E.S.S. II

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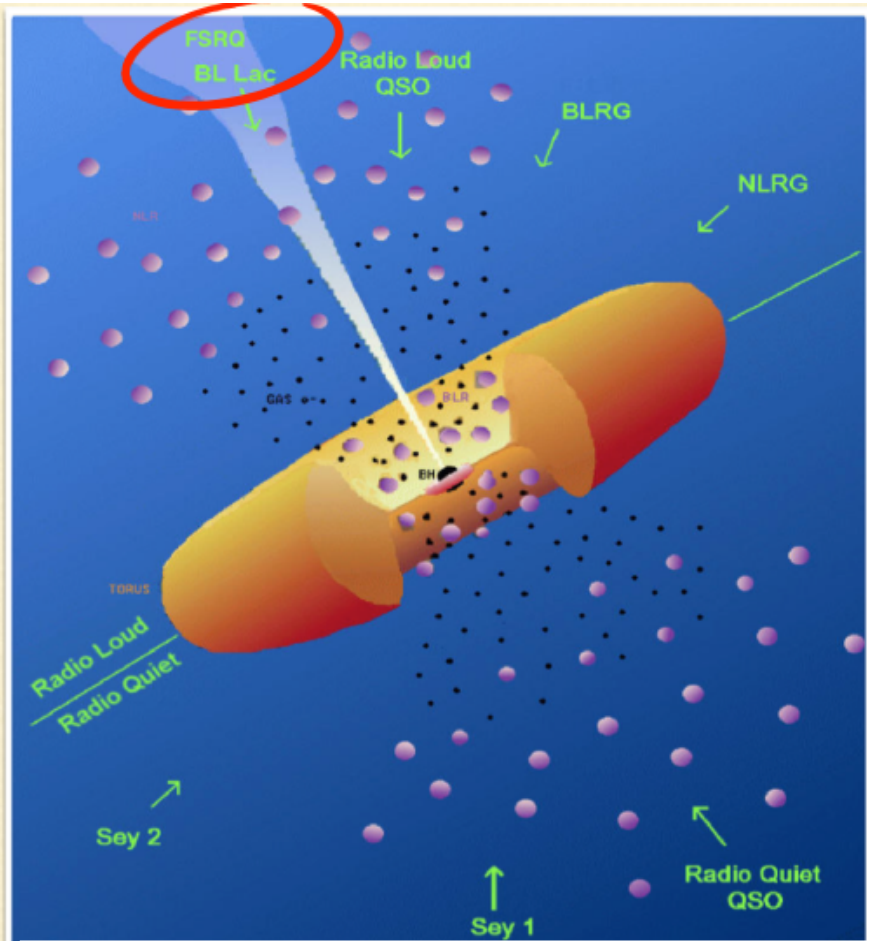
for the H.E.S.S. Collaboration

BLAZARS



Blazar : radio-loud AGN whose relativistic jet points in the direction of the observer

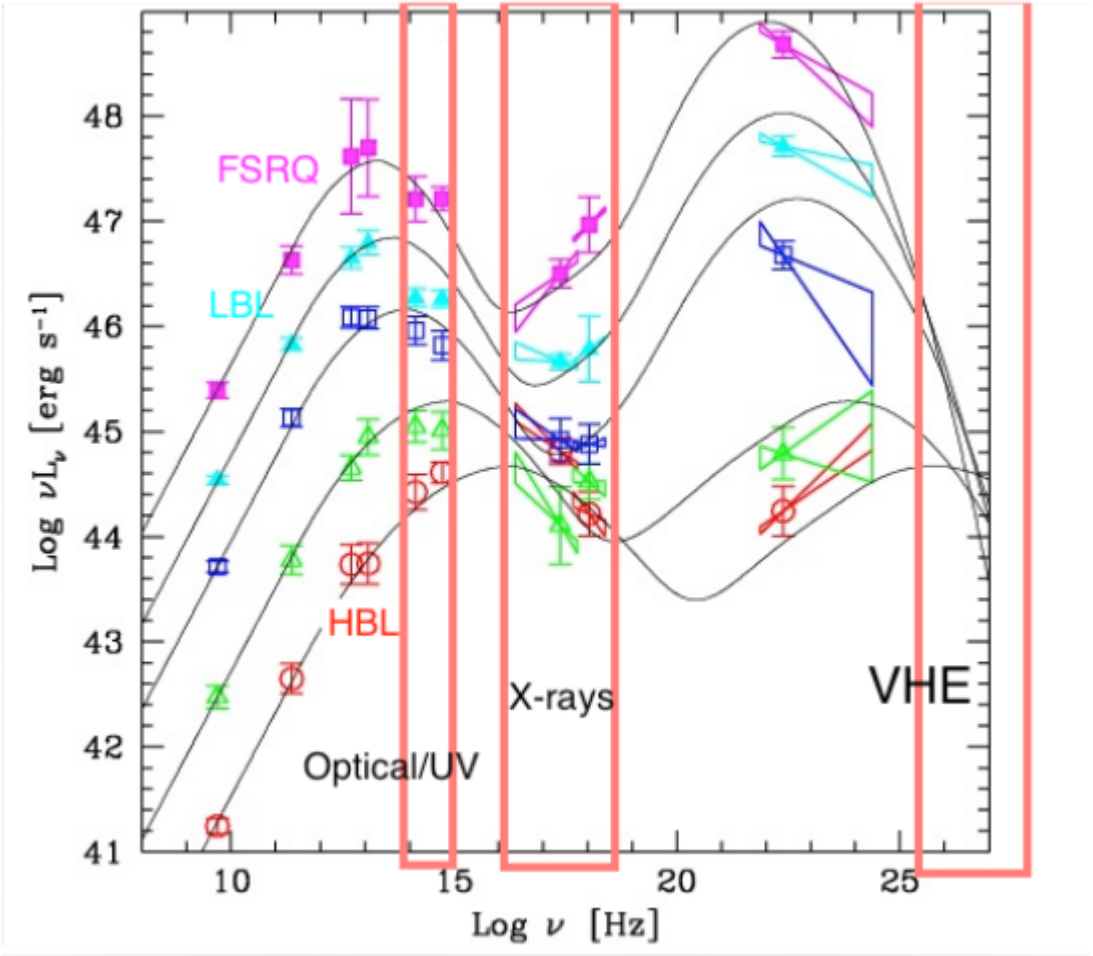
→ emission from the jet dominates over any other AGN component (the disk, the BLR, the X-ray corona,...)

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

- Flat-Spectrum-Radio-Quasars: optical spectrum with broad emission lines
- BL Lacertae objets : optical spectrum featureless

H.E.S.S.

BLAZARS



Fossati et al. 1998

Spectral energy distribution (SED)
two distinct components

FSRQs show a peak in IR

BL Lac objects are classified in:

- peak in optical : Low-frequency peaked (LBLs)
- peak en UV/X : High-frequency peaked (HBLs)
- peak >10 KeV : Ultra-high-frequency peaked (UHBLs)

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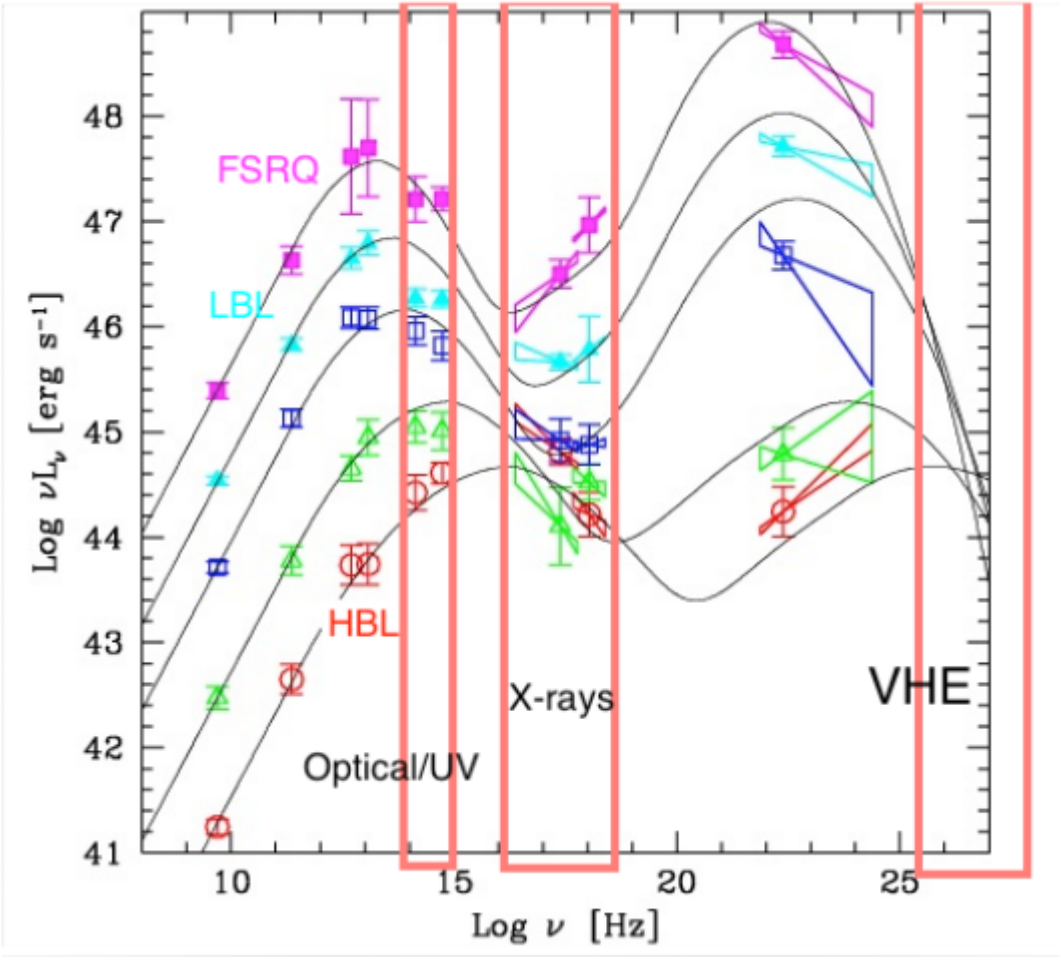
BLAZARS



Fossati et al. 1998

In whichever band you observe, you 'select' a blazar with a given peak frequency

→ Radio blazar catalogs and X-ray blazar catalogs don't 100% overlap!

At TeV energies we are dominated by ***high-frequency-peaked blazars***

VHE photons are absorbed by pair-production on the extragalactic-background-light (EBL)

FSRQs are on average more distant than HBLs → higher absorption in VHE band

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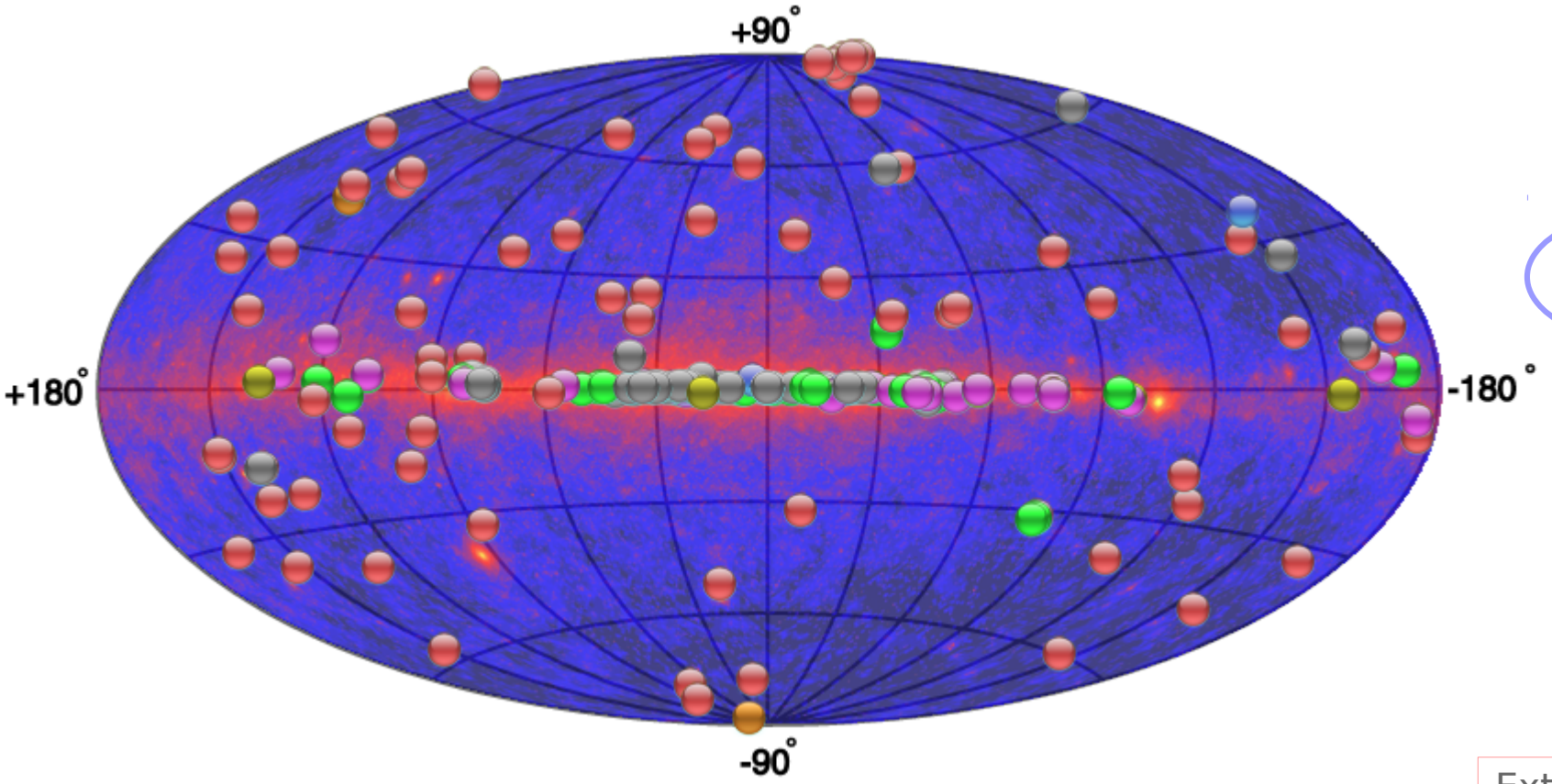
THE TeV SKY



Source Types

- PWN
- Binary XRB PSR Gamma BIN
- HBL IBL FRI FSRQ Blazar LBL AGN (unknown type)
- Shell SNR/Molec. Cloud Composite SNR Superbubble
- Starburst
- DARK UNID Other
- uQuasar Star Forming Region Globular Cluster Cat. Var. Massive Star Cluster BIN BL Lac (class unclear) WR

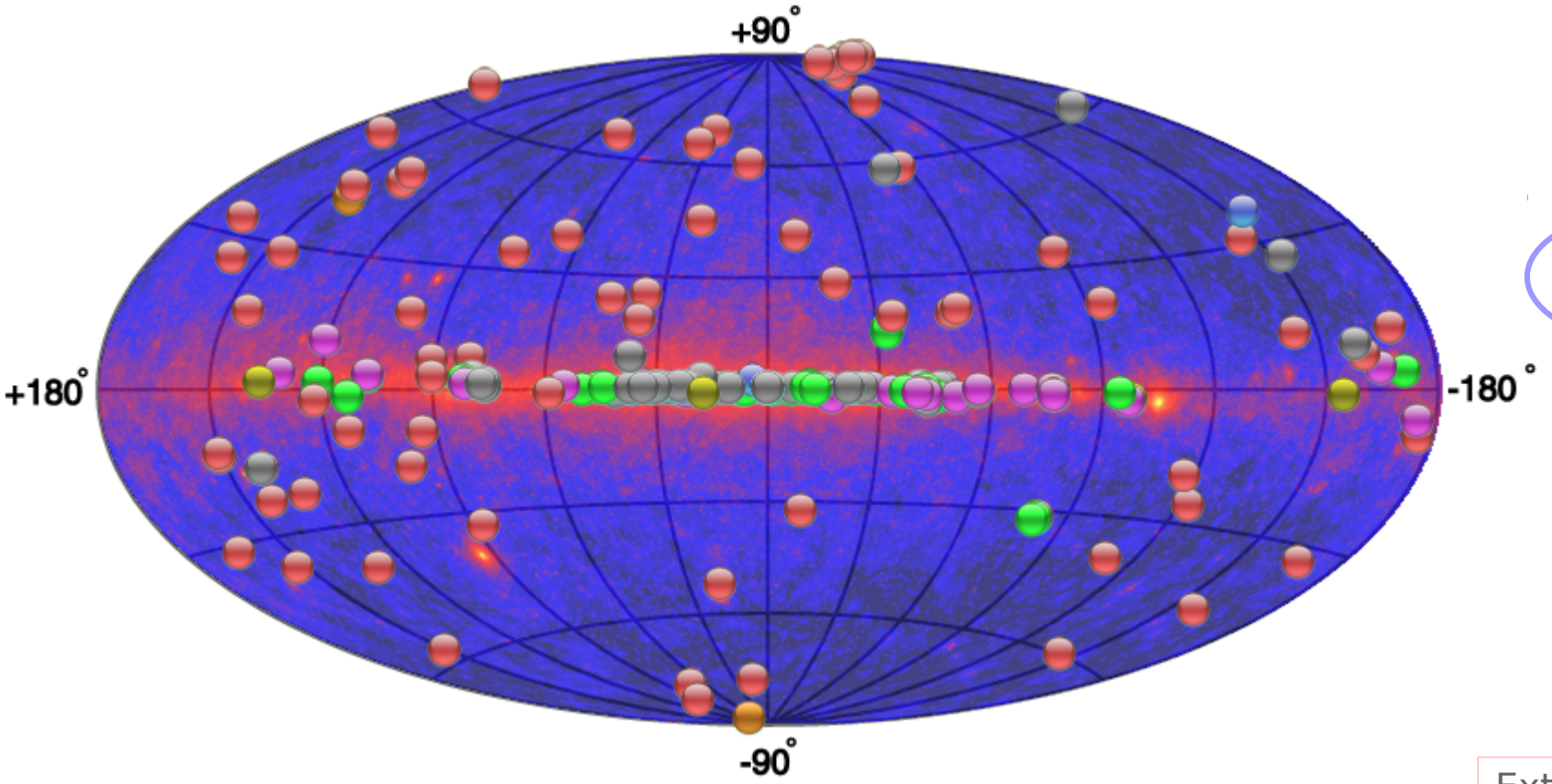
From TeVCAT

Extragalactic TeV sky:

2 starburst galaxies
4 radio-galaxies
66 blazars

H.E.S.S.

THE TeV SKY



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From TeVCAT

Extragalactic TeV sky:
of these 66 blazars
49 are HBLs
11 are I/LBLs
6 are FSRQs

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VHE Flat-Spectrum Radio-Quasars

Six currently known VHE Flat-Spectrum-Radio-Quasars

- 3C 279 (detected with MAGIC in 2006-2007,
  bright γ-ray flare in 2015, detected with H.E.S.S. II)
- PKS 1222+216 (detected with MAGIC in 2010,
  detected with VERITAS in 2014)
- PKS 1510-089 (detected with H.E.S.S. in 2009,
  VHE flare in 2016, seen with H.E.S.S. II & MAGIC)
- S3 0218+35 (z=0.94, most distant VHE source,
  detected with MAGIC in 2015, gravitationally lensed)
- PKS 1441+25 (z=0.94, detected with MAGIC and VERITAS)
- PKS 0736+017 (new VHE FSRQ, detected with H.E.S.S. II)

H.E.S.S.

H.E.S.S. II

Array of 4+1 Cherenkov telescopes located on Khomas Highland, Namibia (23°16‘ S, 16°30‘ E)

2012: installation of the central telescope (CT5)
2016: upgrade of H.E.S.S. I cameras

Detection of photons above 30 GeV
Energy resolution: ~10% at 1 TeV
Angular resolution: ~0.1° at 1 TeV

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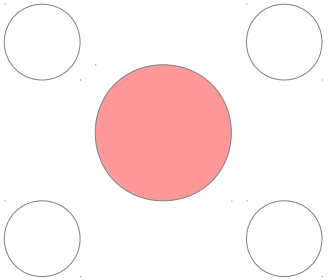
Two different reconstructions:
- Monoscopic (CT5 only)
- Stereoscopic (any 2 out of 5 telescopes)



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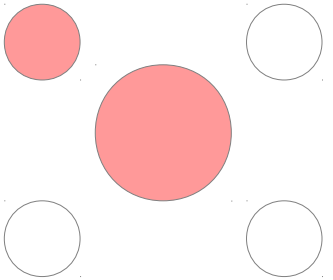

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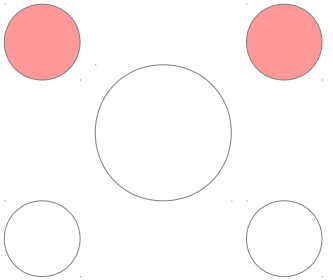
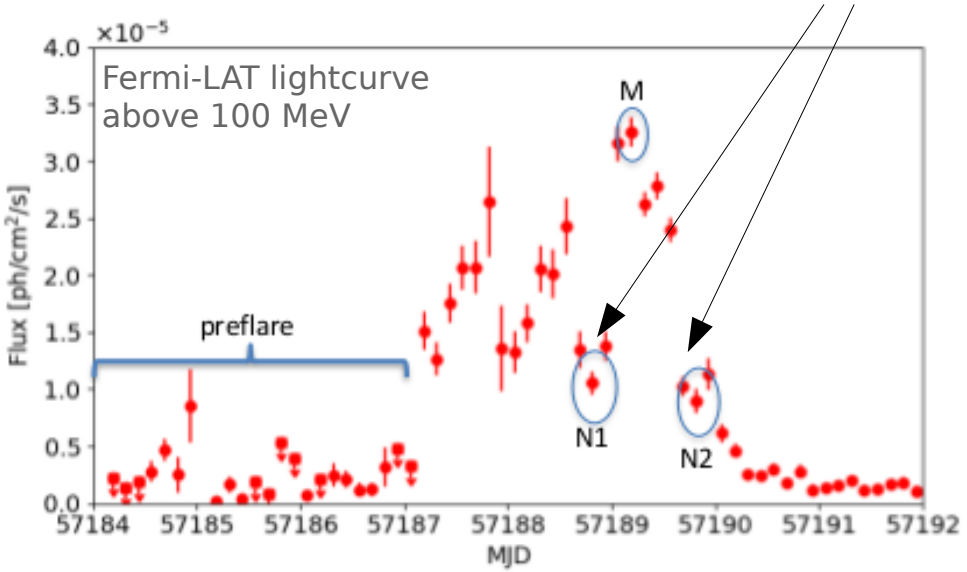


H.E.S.S.

3C 279

Bright γ-ray flare seen with Fermi-LAT in June 2015:

- 3-days flare with peak flux of $3.6 \cdot 10^{-5}$ cm^{-2} s^{-1}
- 80 times brighter than 3FGL average
- Minute-scale variability detected with Fermi-LAT
- Target of Opportunity observations with H.E.S.S.



Romoli et al. ICRC 2017 arXiv 1708.00882

3C 279

H.E.S.S. observations : Detection only during the second night:

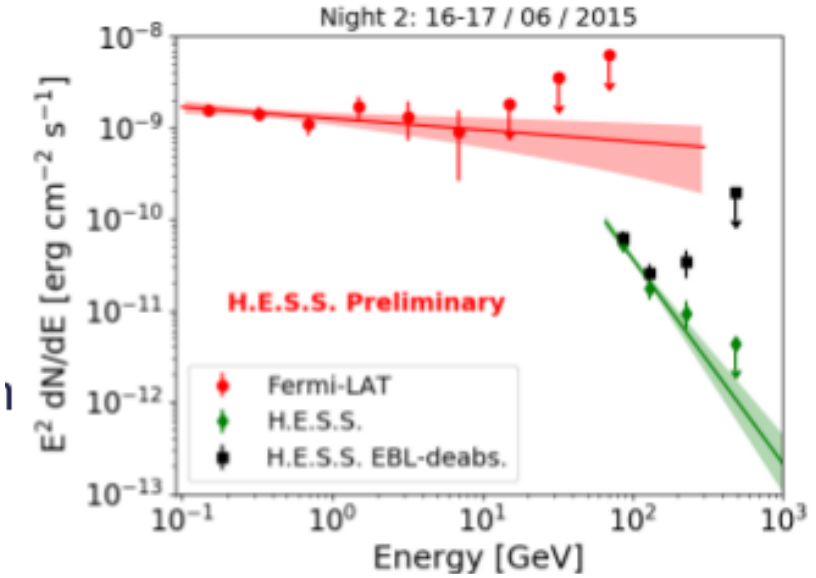
$E_{threshold}$ = 66 GeV (Monoscopic reconstruction)

$F_{100\ GeV} = (2.5 \pm 0.2) \cdot 10^{-12}$ cm^{-2} s^{-1} GeV^{-1}

$\Gamma = 4.2 \pm 0.3$

Detection at 8.7 σ in 3 hours of observations

Strictly simultaneous Fermi-LAT – H.E.S.S. II spectrum



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3C 279

Internal absorption of VHE photons:

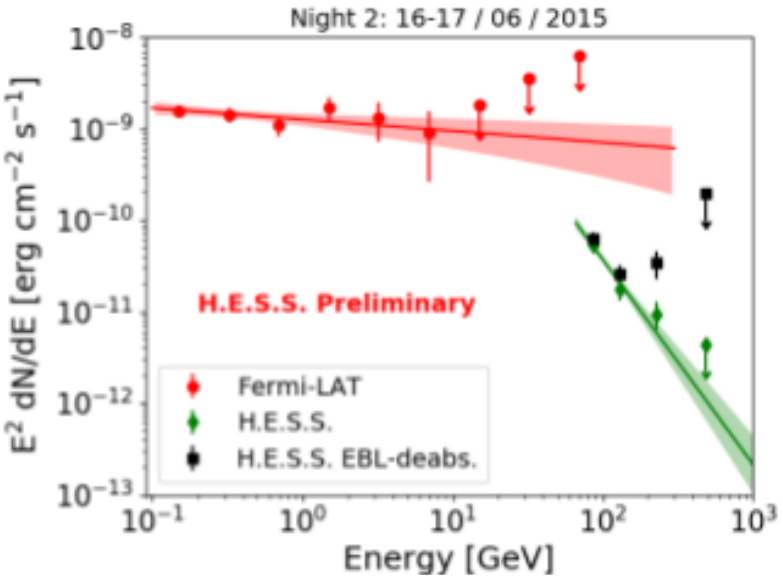
- spectrum corrected from EBL absorption (Franceschini et al. 09)
- assumption on intrinsic spectrum (power-law)
- assumption on external photon field & BLR geometry

(Finke 2016)

Maximum internal optical depth:

$\tau = 3.3 \pm 0.7$

$R_{min} = 10^{17}$ cm (0.1 pc)



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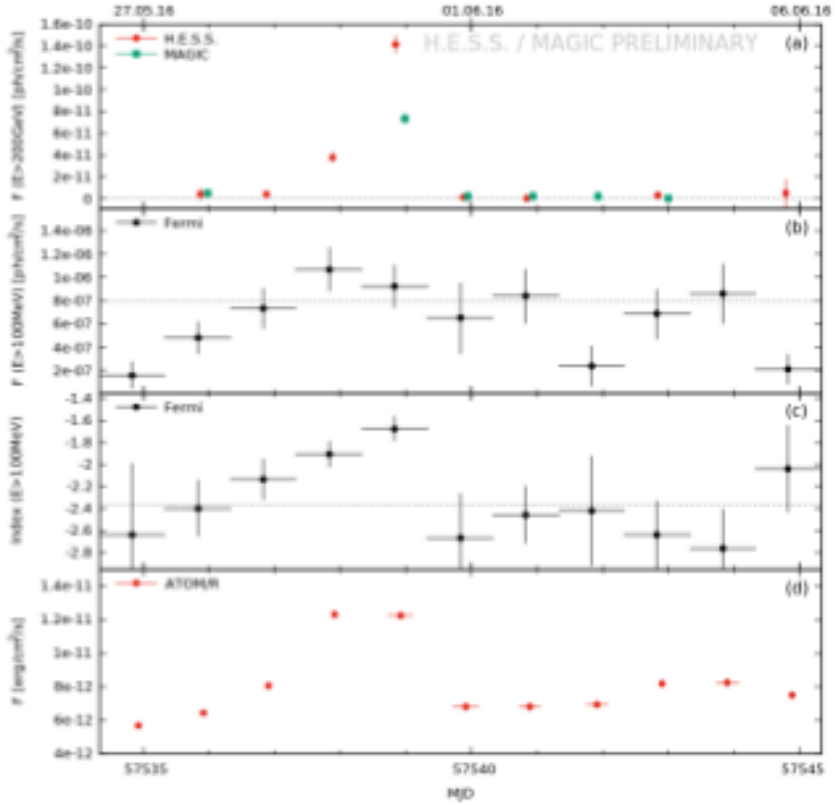
PKS 1510-089



MWL lightcurve of the event with nightly averages: (a) H.E.S.S/MAGIC flux, (b) Fermi flux, (c) Fermi index, (d) ATOM flux

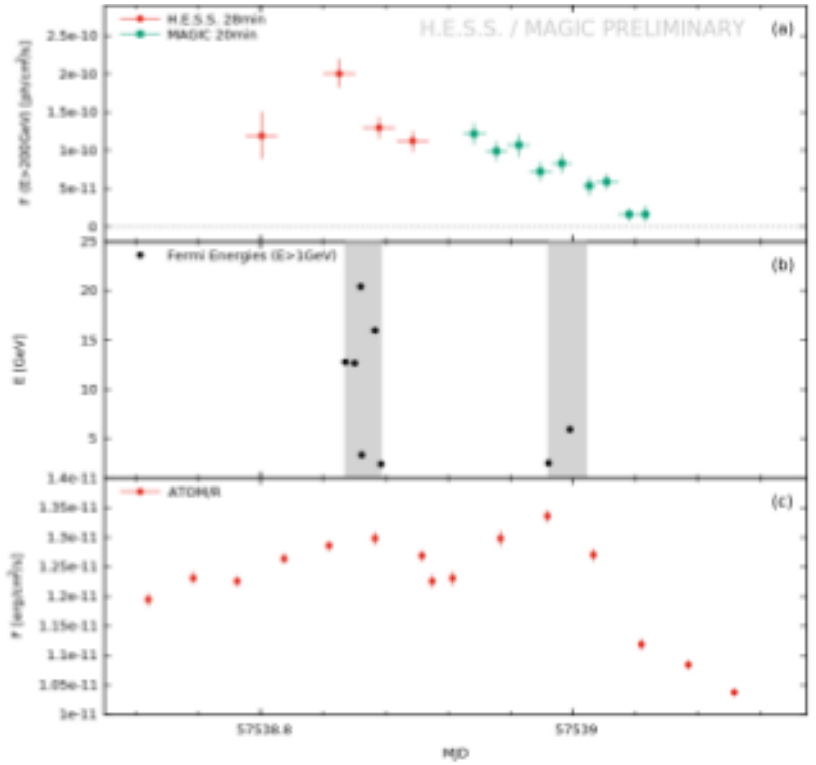
Rapid and bright VHE γ-ray flare in May 2016

No counterpart in integral HE γ-ray light-curve, but significant hardening in the spectrum

Optical flux enhanced coincident with VHE flare

Zacharias et al. ICRC 2017 arXiv 1708.00653

PKS 1510-089



Detailed lightcurve of MJD 57538: (a) H.E.S.S/MAGIC flux, (b)Fermi energies, (c) ATOM flux

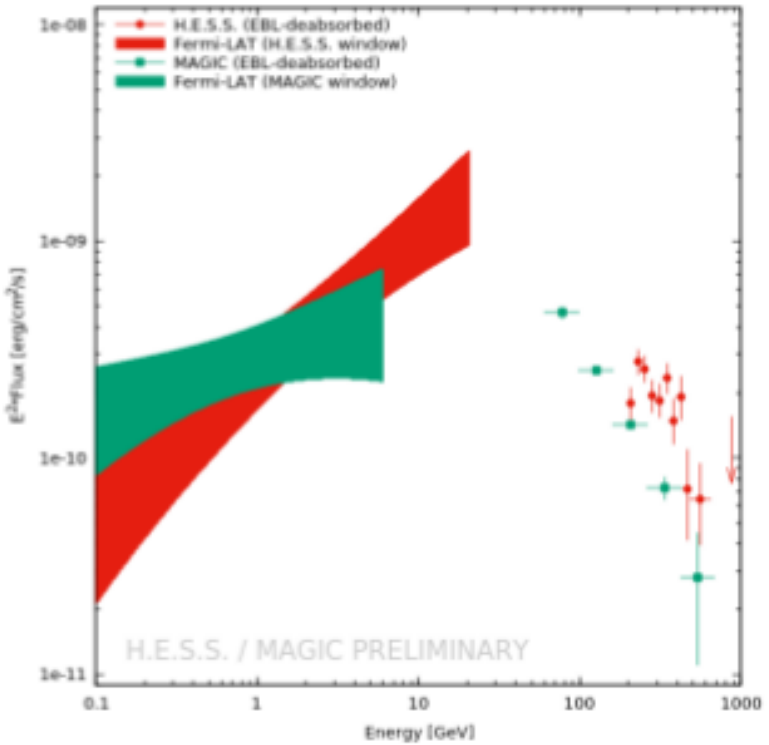
Peaked lightcurve at VHE:
maximum flux ~80% Crab (E > 200 GeV)
continous decrease to ~7.5% Crab

Minimum variability time-scale:
18 ± 5 minutes

→ size of the emission region
$R \sim 10^{15}\ (\delta/50)$ cm

Zacharias et al. ICRC 2017 arXiv 1708.00653

PKS 1510-089



γ-ray spectrum during the H.E.S.S. window (red) and the MAGIC window (green). VHE spectra corrected for EBL absorption.

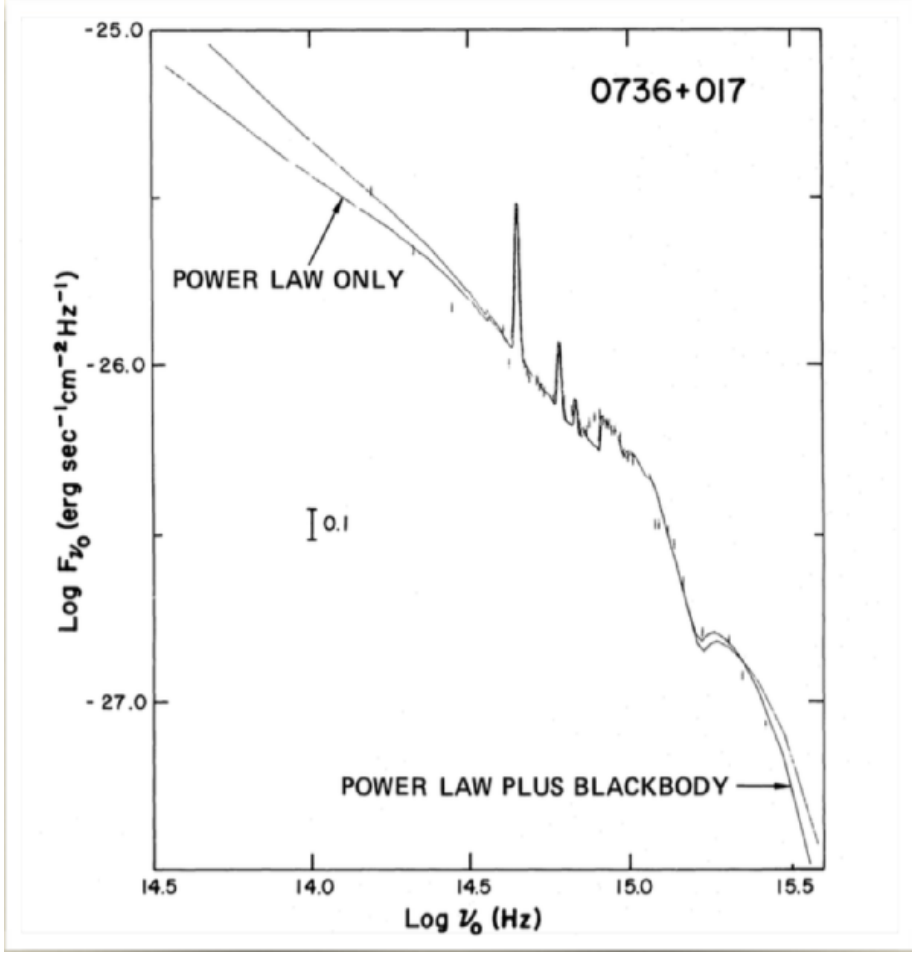
Break between HE and VHE spectra, constant over both oberving window ($\Delta\Gamma$~1.6)

If the break is caused by internal absorption on BLR photons, τ~5

→ location of the emitting region
$r \sim 3 \cdot 10^{17}$ cm

Zacharias et al. ICRC 2017 arXiv 1708.00653

PKS 0736+017



Milkan & Moore, 1986

Well known radio quasar

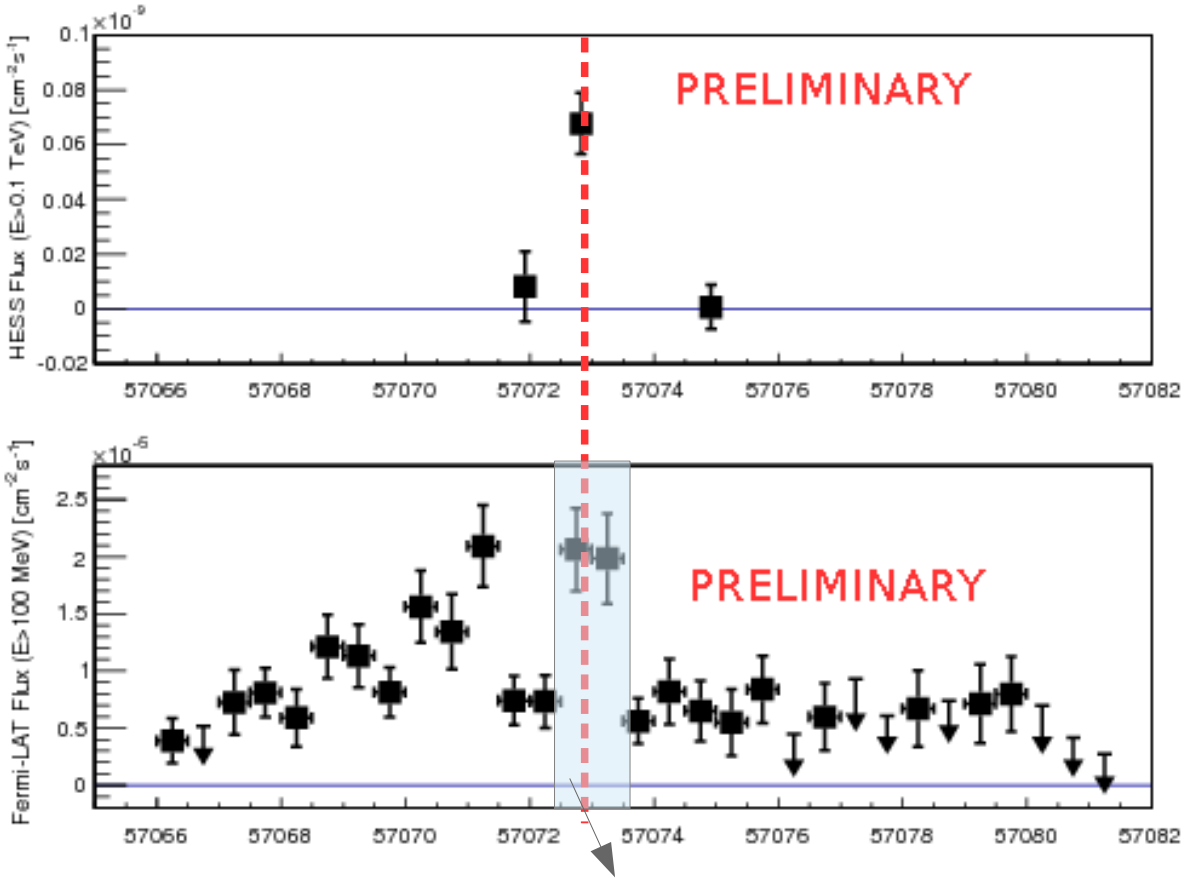
- $z = 0.1894$ (Ho & Kim 2009)
- typical FSRQ optical spectrum
- presence of big-blue bump
- SMBH mass = $10^{8.47}$ $M_\odot$ (McLure & Dunlop 2001)
- Host galaxy is a standard giant elliptical (Wright 1998, Kotilainen 1998, ++)

Cerruti et al. ICRC 2017 arXiv 1708.00658

H.E.S.S.

PKS 0736+017

H.E.S.S. ToO observations following a Fermi-LAT flare
Detection during the second night only



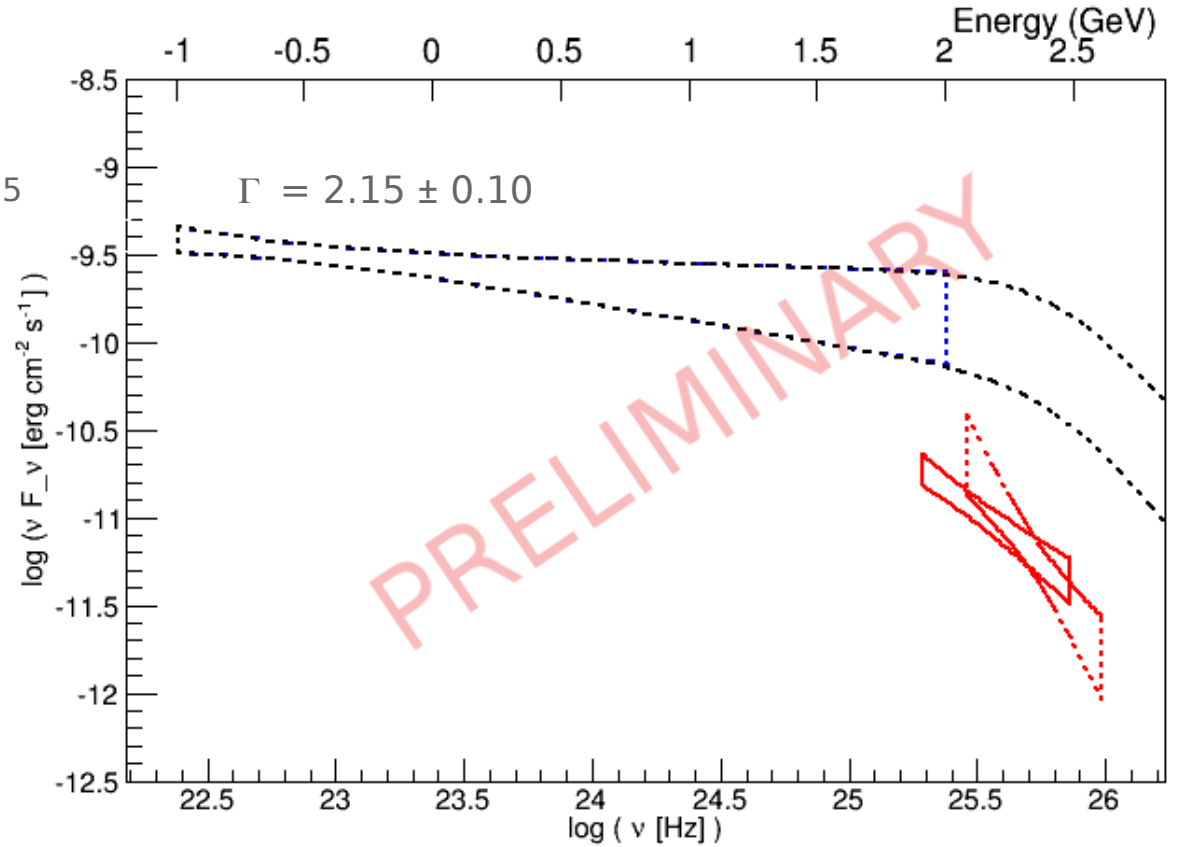
Time selection for contemporaneous LAT analysis

Cerruti et al. ICRC 2017 arXiv 1708.00658

PKS 0736+017

Fermi-LAT and H.E.S.S. spectra (mono & stereo)

Fermi-LAT spectrum integrated from MJD 57072.5 – 57073.5



H.E.S.S. spectrum on the night of MJD 57073

$\Gamma_{mono} = 3.1 \pm 0.3$

$\Gamma_{stereo} = 4.2 \pm 0.8$

Fermi-LAT spectrum extrapolated towards higher energies, including EBL absorption → spectral break between LAT and H.E.S.S.

Cerruti et al. ICRC 2017 arXiv 1708.00658

CONCLUSIONS

H.E.S.S. II low threshold makes it
an excellent instrument to study
distant and low-frequency-peaked blazars

Target of Opportunity observations are a fundamental part of the H.E.S.S. extragalactic observing program

H.E.S.S.

CONCLUSIONS

Three important results on gamma-ray FSRQs:

- Re-detection of 3C279 after the MAGIC discovery in 2006/2007, simultaneous with the brightest LAT flare seen from this source

- Detection of an unprecendeted VHE flare from PKS 1510-089

- Discovery of a new VHE FSRQ: PKS 0736+017
(z = 0.189, the nearest VHE quasar so far)

Common conclusion: detection of VHE photons allows us to put
a lower limit to the location of the emitting region;
spectral break with Fermi-LAT means that it can be within the BLR

H.E.S.S.