Implications of the VHE gamma-ray outburst of PKS 1510-089 in May 2016

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Monitoring the nonthermal Universe 2018

Cochem, Germany

RUHR UNIVERSITÄT BOCHUM RUB

H.E.S.S.

MAGIC Major Atmospheric Gamma Imaging Cerenkov Telescopes

H.E.S.S. and MAGIC

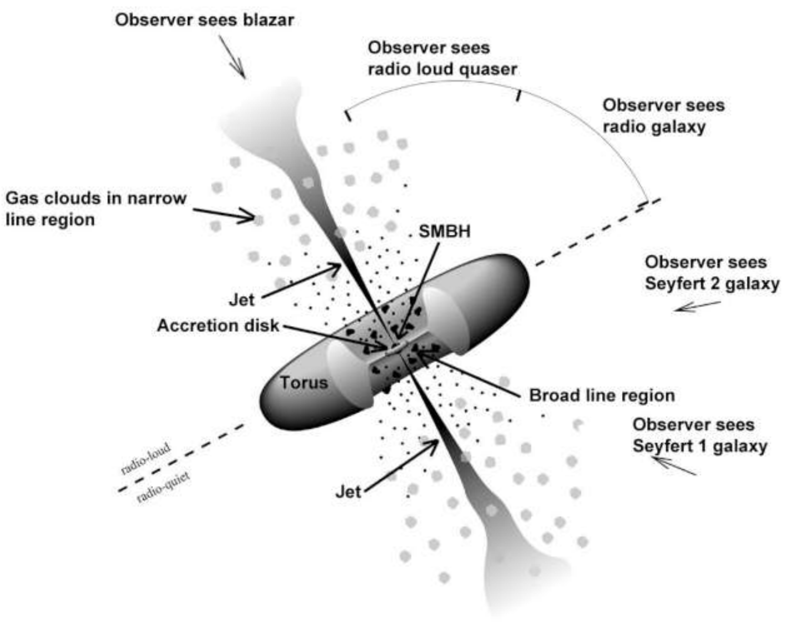
H.E.S.S.

MAGIC

- H.E.S.S. is located in Namibia at $\sim$ 1800 m a.s.l.
- The array consists of 5 IACTs
- For the present study, only the 4 small telescopes were available (Energy threshold of the data set $\sim$ 200 GeV)
- ATOM is the optical support instrument for H.E.S:S.

- MAGIC is located on the island of La Palma at $\sim$ 2200 m a.s.l.
- The array consists of 2 IACTs
- Energy threshold of the data set $\sim$ 90 GeV

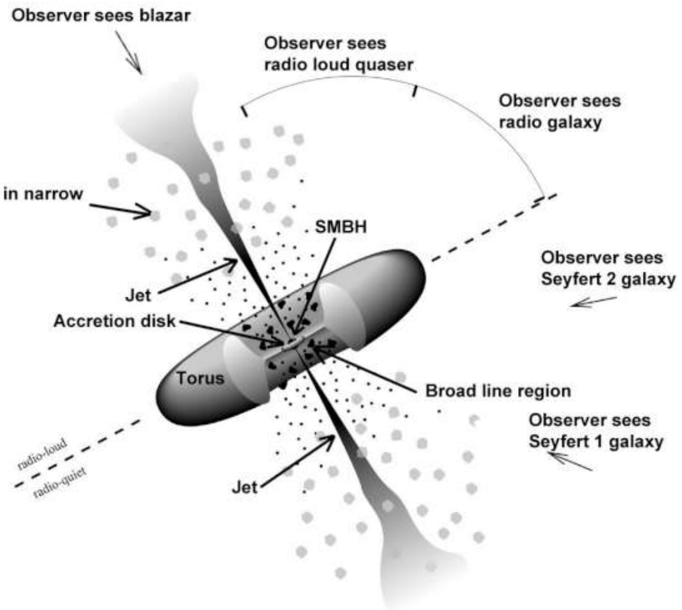
PKS 1510-089



Unified model of active galactic nuclei

- PKS 1510-089 is an FSRQ at $z = 0.361$
- Highly variable source in all energy bands with changing correlation patterns

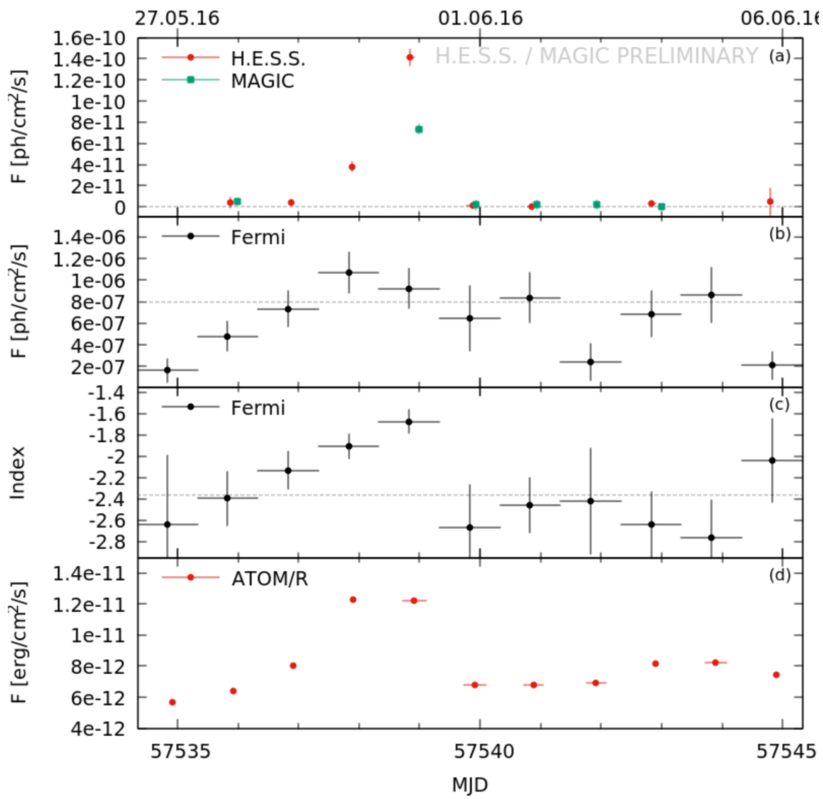
PKS 1510-089



Unified model of active galactic nuclei

- PKS 1510-089 is an FSRQ at $z = 0.361$
- Highly variable source in all energy bands with changing correlation patterns
- Detected at VHE γ rays in 2009 Wagner+HEAD2010, Abramowski+13
- Variability at VHE detected in 2015 Ahnen+17, Zacharias+ICRC2017
- Under close surveillance by IACT experiments since 2009
- Persistent VHE emission during low-HE-states Acciari+18

Lightcurve in May 2016



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

- A short, but strong flare in VHE γ rays
  - Peak flux $\sim$ 56% C.U. (nightly avg, $E > 200\,\text{GeV}$)
  - Peak flux 2015: $\sim$ 4% C.U. (H.E.S.S., $E > 200\,\text{GeV}$)

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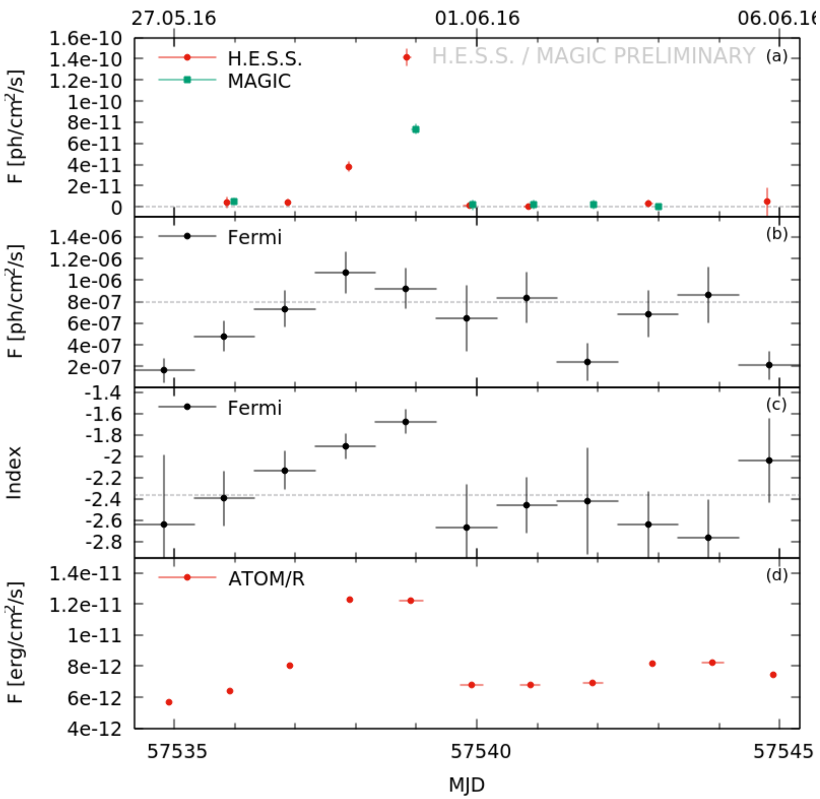

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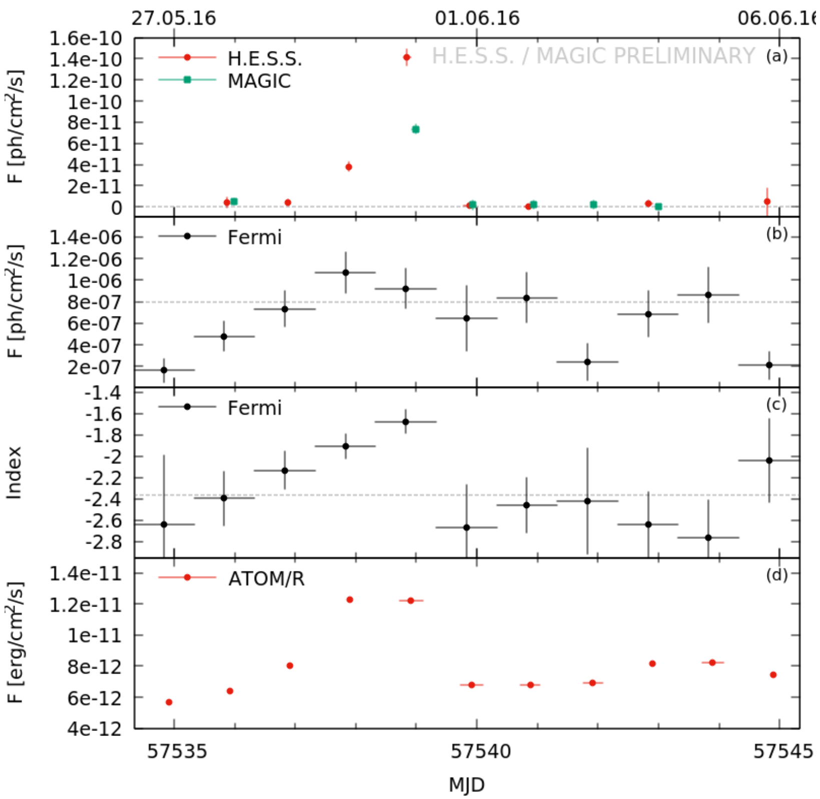

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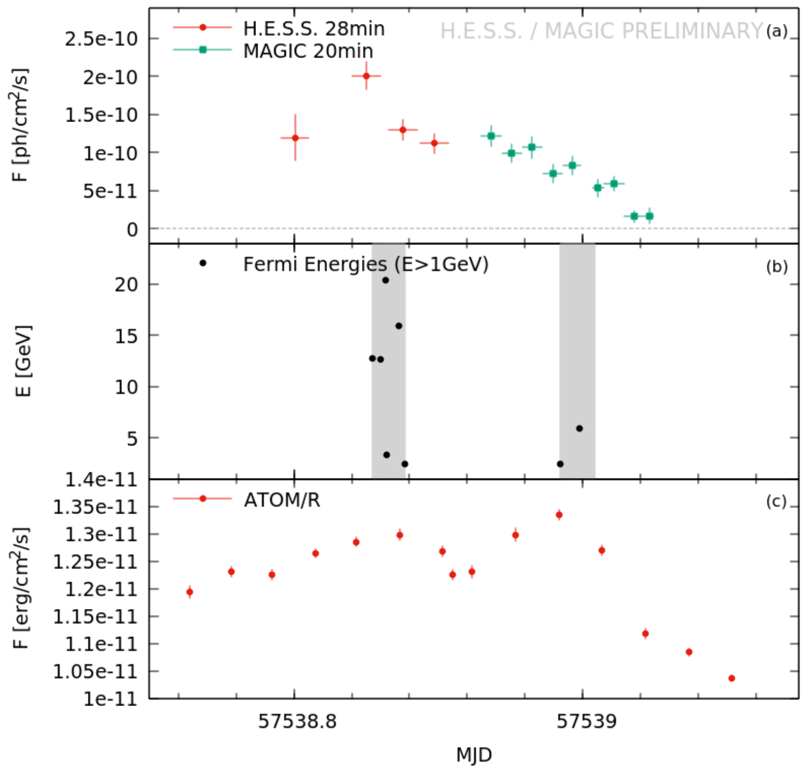
- Significant hardening in HE coincident with VHE flare
- Optical flux enhanced coincident with VHE flare
  - Peak flux much below historical high states

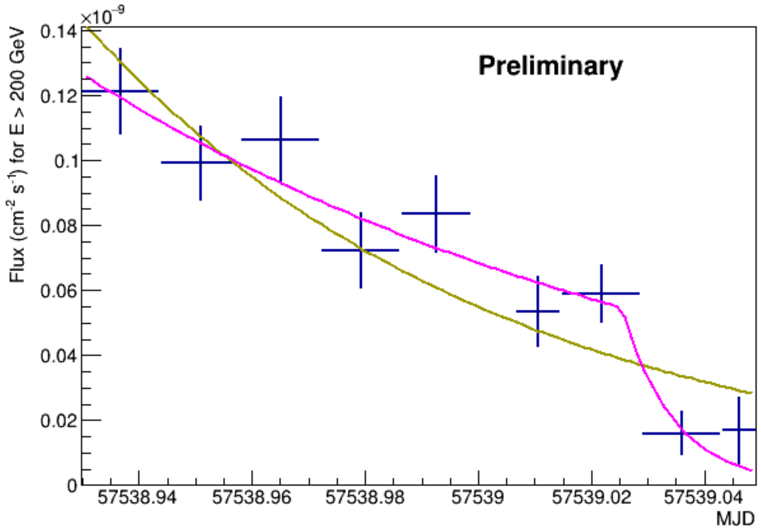
Detailed Lightcurve of MJD 57538



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

- Peaked lightcurve in the VHE domain
  - Maximum flux $\sim$ 80% C.U. ($E > 200\,\mathrm{GeV}$)
  - Continuous decrease to $\sim$ 7.5% C.U. ($E > 200\,\mathrm{GeV}$)
- Fermi detected higher energetic photons during the H.E.S.S. observation window than during the MAGIC observation window
- The optical flux shows a double-peaked structure
  - No obvious correlation with the VHE flare on short time scales

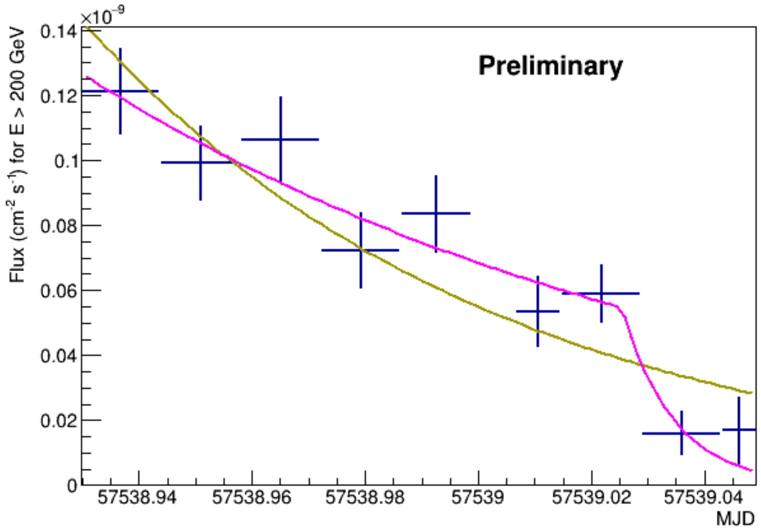
VHE variability



Detailed MAGIC lightcurve of MJD 57538 with exponential and double-exponential fits

- Fit the whole LC with various functions
- Single exponential fit:
  - Halving time $\sim$ 74 min
  - But χ^2/N_{dof} = 18.9/7

VHE variability



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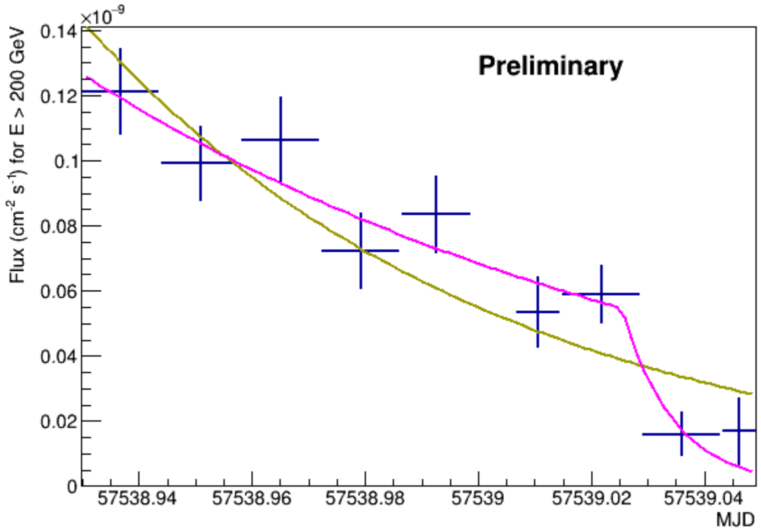
VHE variability



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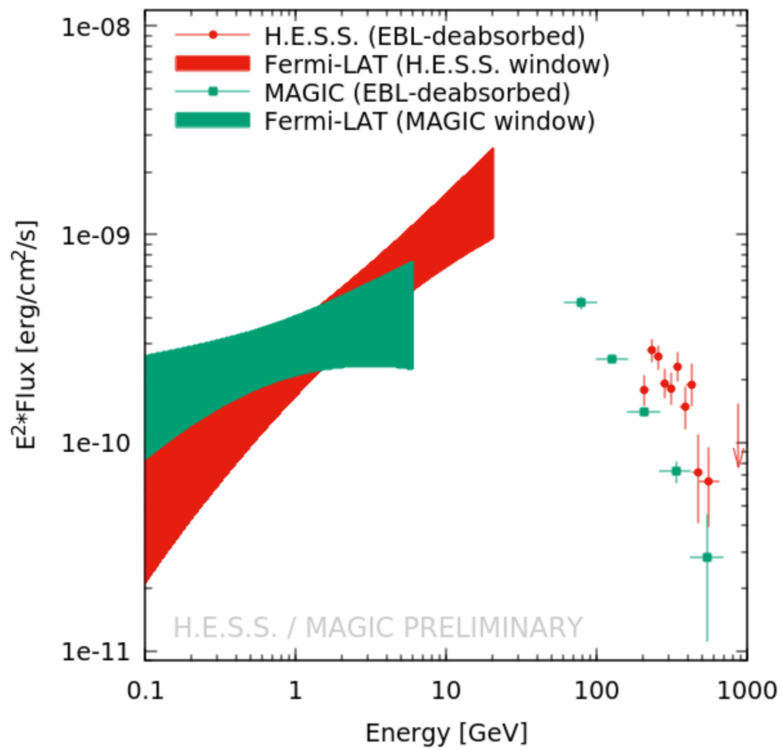
- Different methods give comparable results
- Simple estimate: Emission region close to black hole

The γ-ray spectrum of MJD 57538



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 spectrum constant over both observation windows ($\Delta\Gamma \sim 1.6$)
- Using the (observed) spectra to fit various intrinsic spectra and absorption by the BLR

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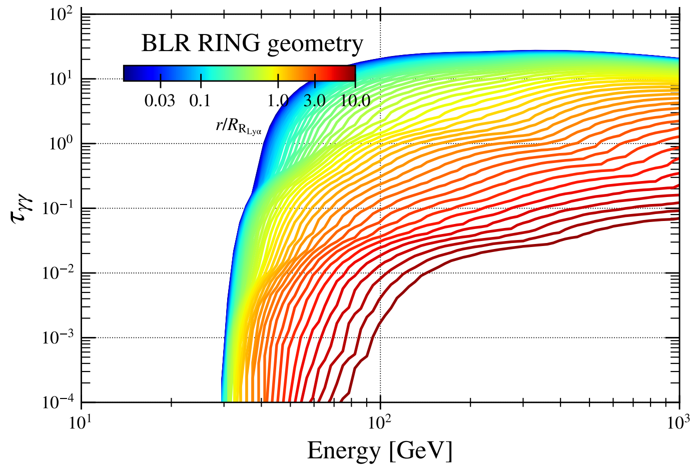

Expected BLR absorption as a function of energy for different distances (colors) and using a ring geometry.

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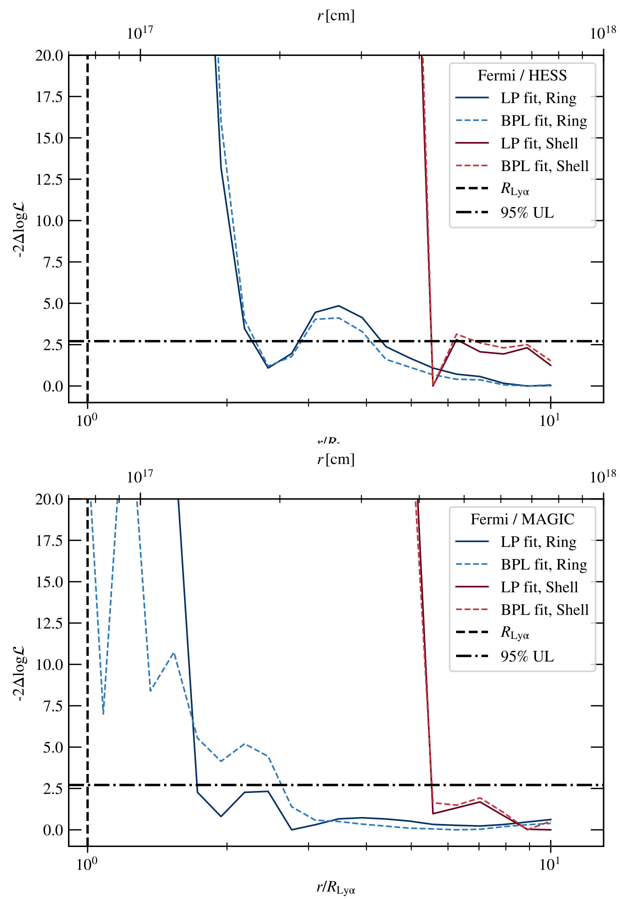

Likelihood for the fit in the H.E.S.S. (top) and MAGIC (bottom) windows.

- Break between HE and VHE spectrum constant over both observation windows ($\Delta\Gamma \sim 1.6$)
- Using the (observed) spectra to fit various intrinsic spectra and absorption by the BLR
- Likelihood of fit used to obtain a (95%) lower limit on the distance from the black hole
  - H.E.S.S. window: $d > 2.2R_{\mathrm{Ly}\alpha}$
  - MAGIC window: $d > 1.6R_{\mathrm{Ly}\alpha}$

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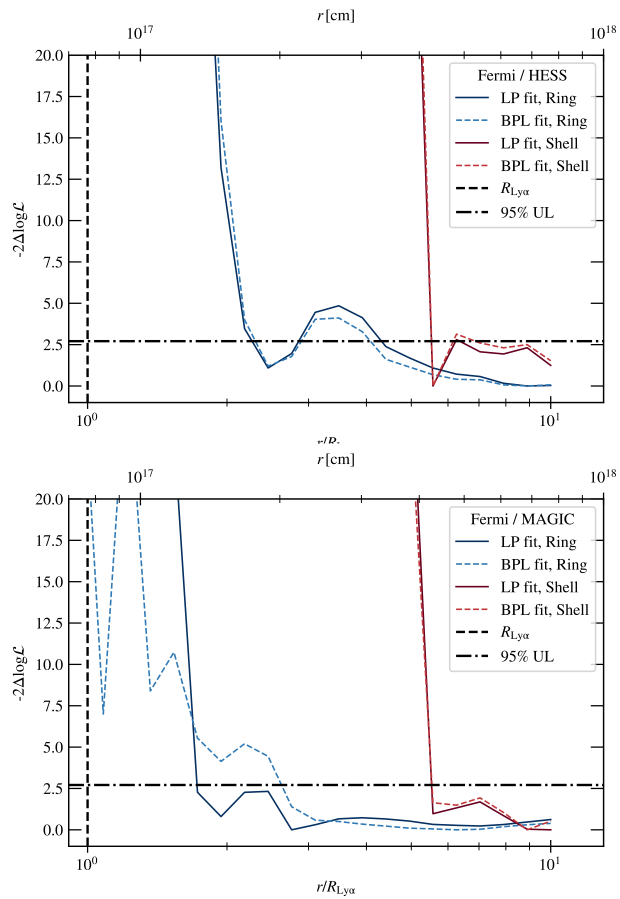

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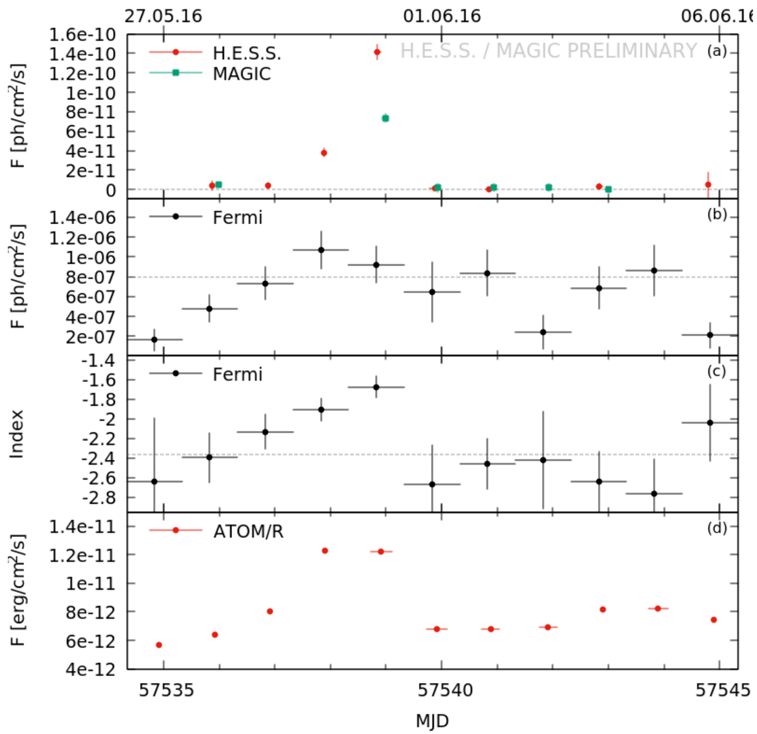
- Emission region likely outside the BLR
- It probably does not fill the jet diameter

Summary



MWL lightcurve of the flare in May 2016

- A very strong VHE flare without strong MWL couterparts
  - HE γ-ray spectrum hardens significantly
  - Optical flare not correlated with the VHE flare on short time scales
- Fastest VHE variability $\sim 10\,\mathrm{min}$

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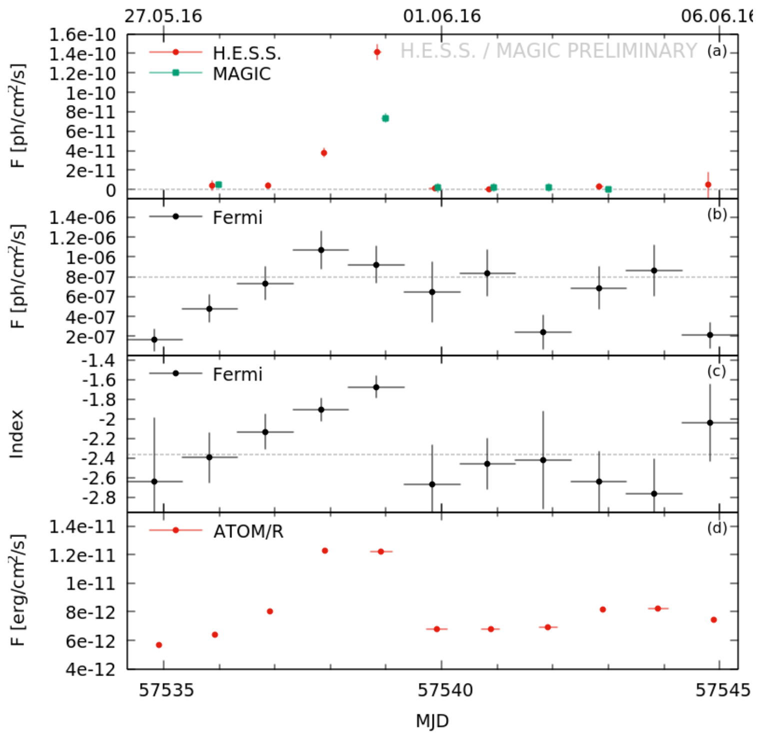

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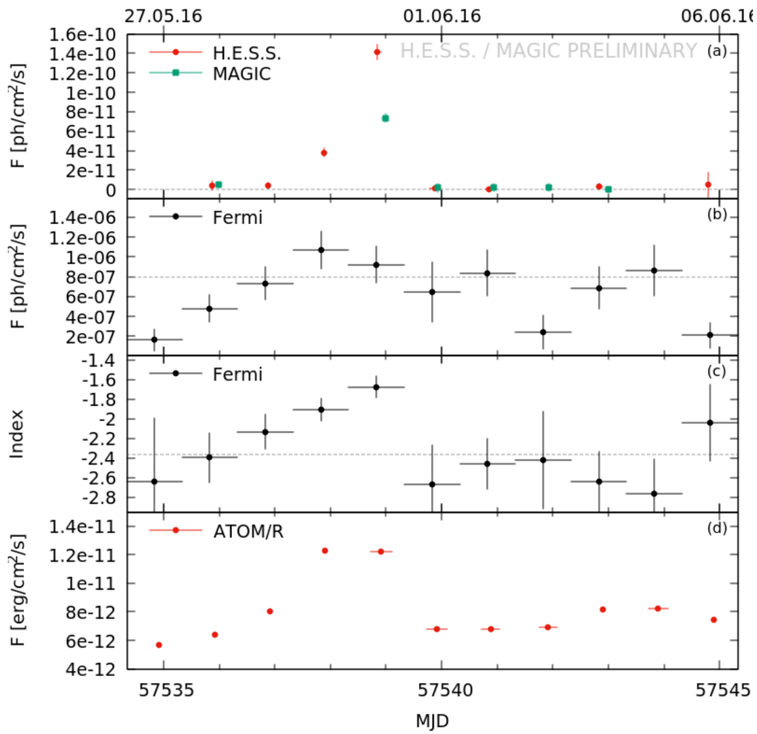

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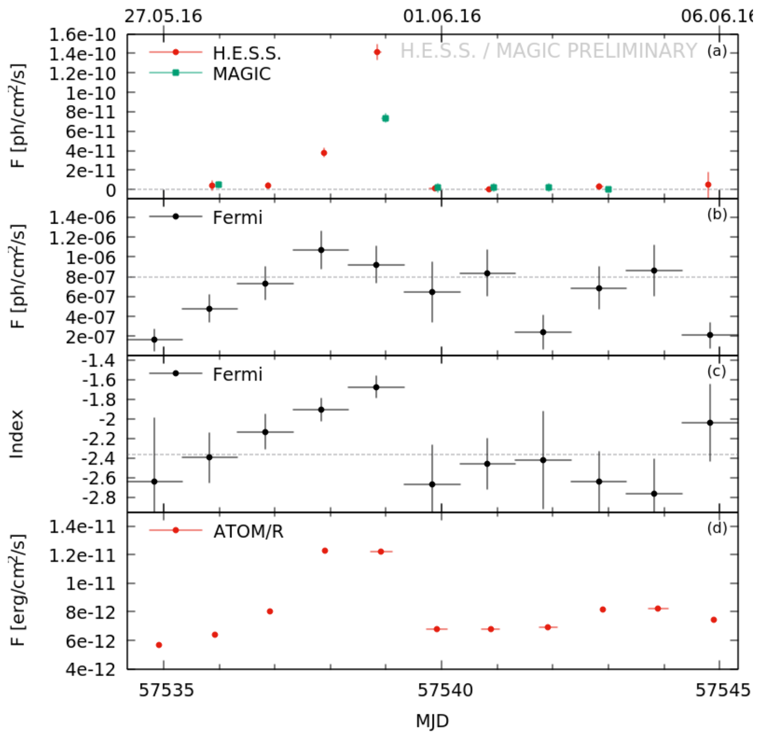

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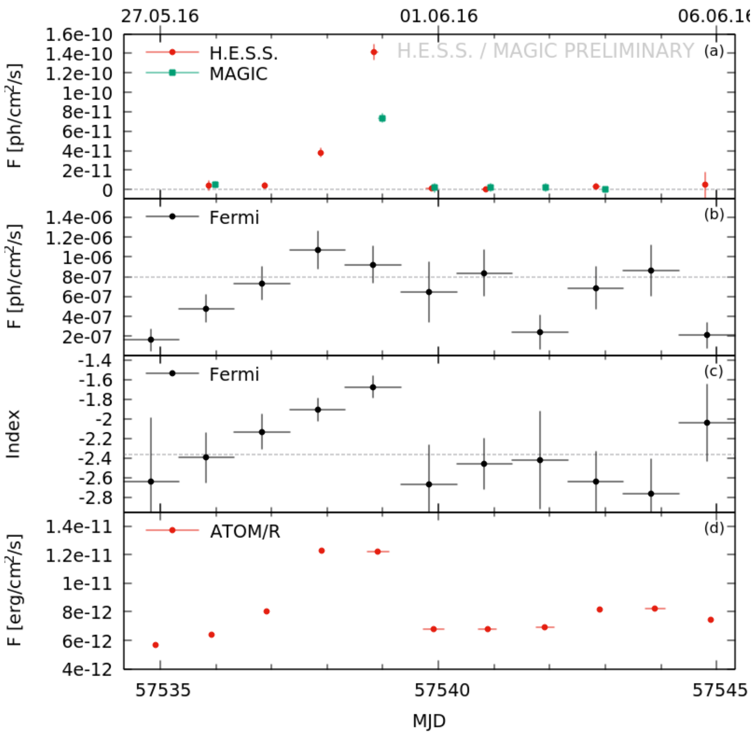

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Thank you for your attention!