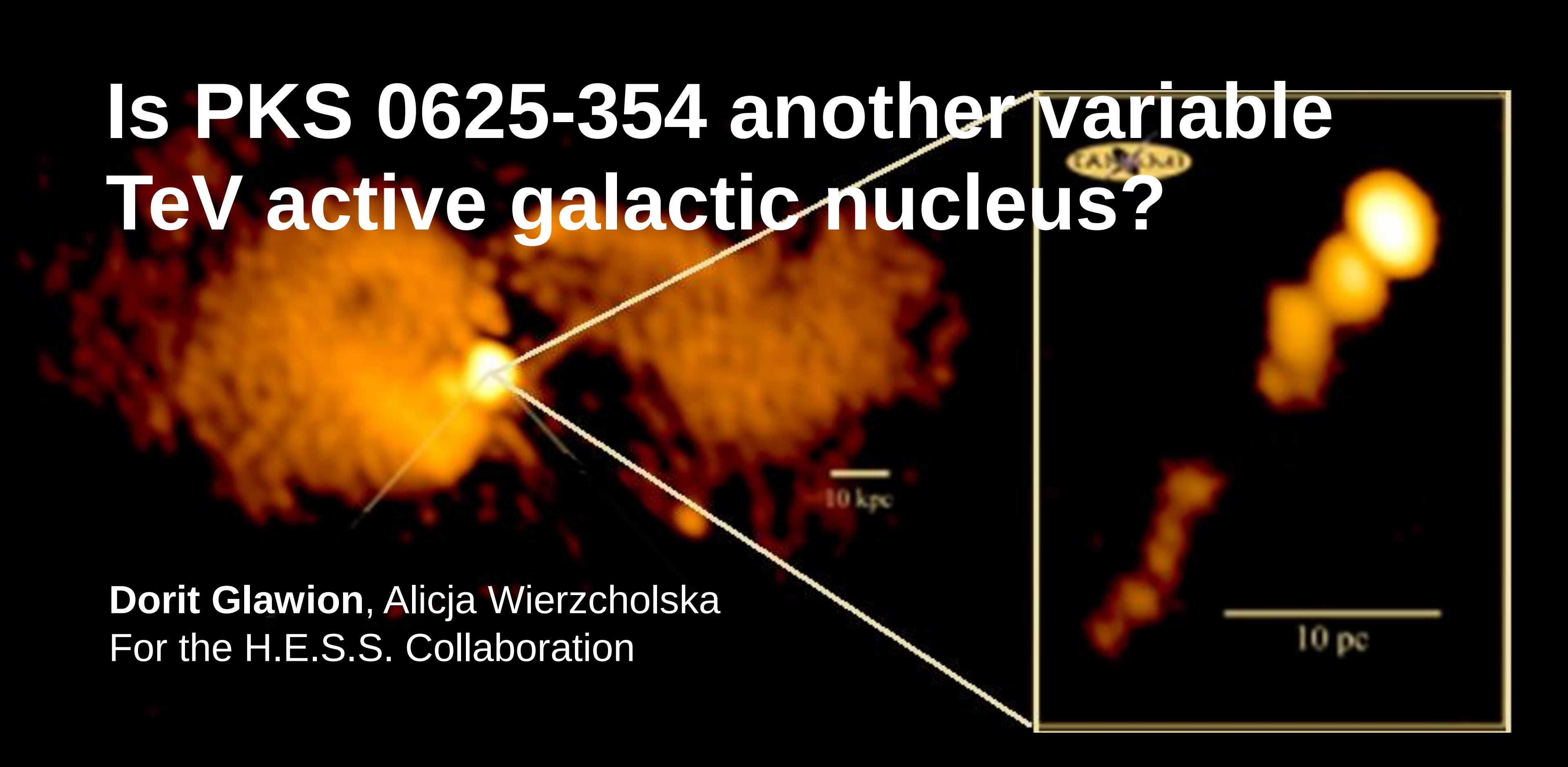
Is PKS 0625-354 another variable TeV active galactic nucleus?



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For the H.E.S.S. Collaboration

Image credit: Master thesis Jonas Trüstedt

H.E.S.S.

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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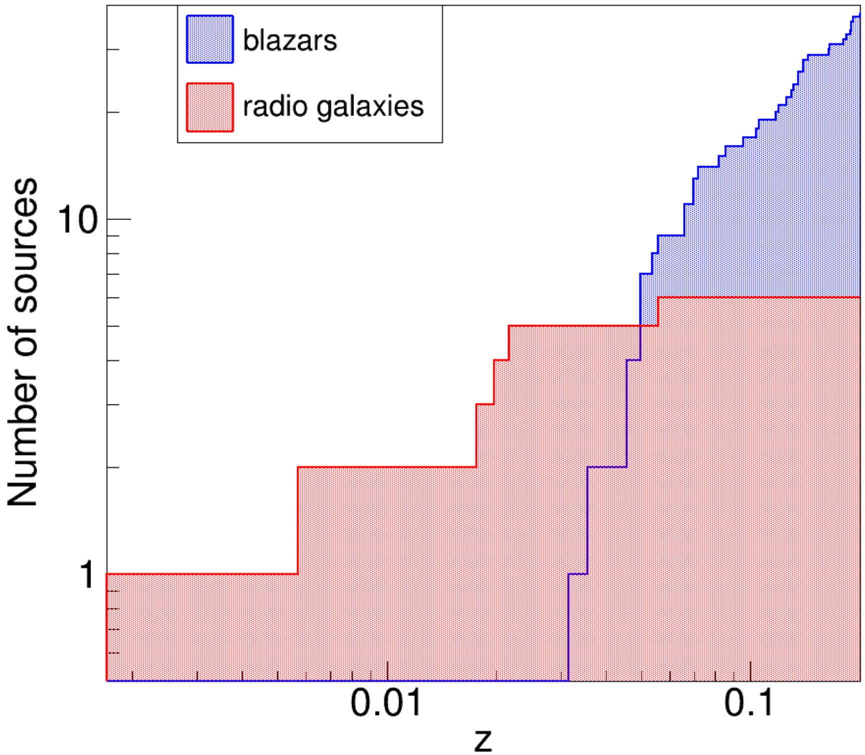
Gamma-ray signal of TeV blazars and non-blazars



- majority of AGN detected at > 100 GeV are blazars with small viewing angle
- only ~10% of gamma-ray AGN are objects with larger viewing angle resulting in a smaller Doppler boosting
- known TeV variability of non-blazar active galaxies (e.g., M 87 or NGC 1275) providing important new insights into physical processes responsible for gamma-ray production and flaring events

PKS 0625-354 – the AGN (blazar or no-blazar)

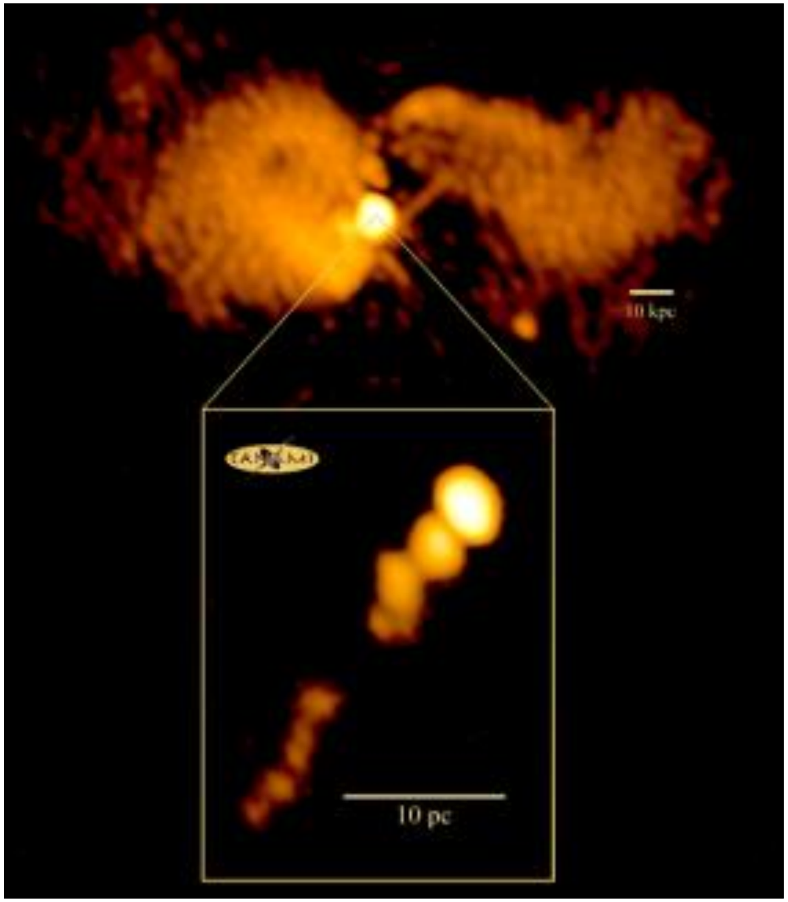


Image credit: Master thesis Jonas Trüstedt

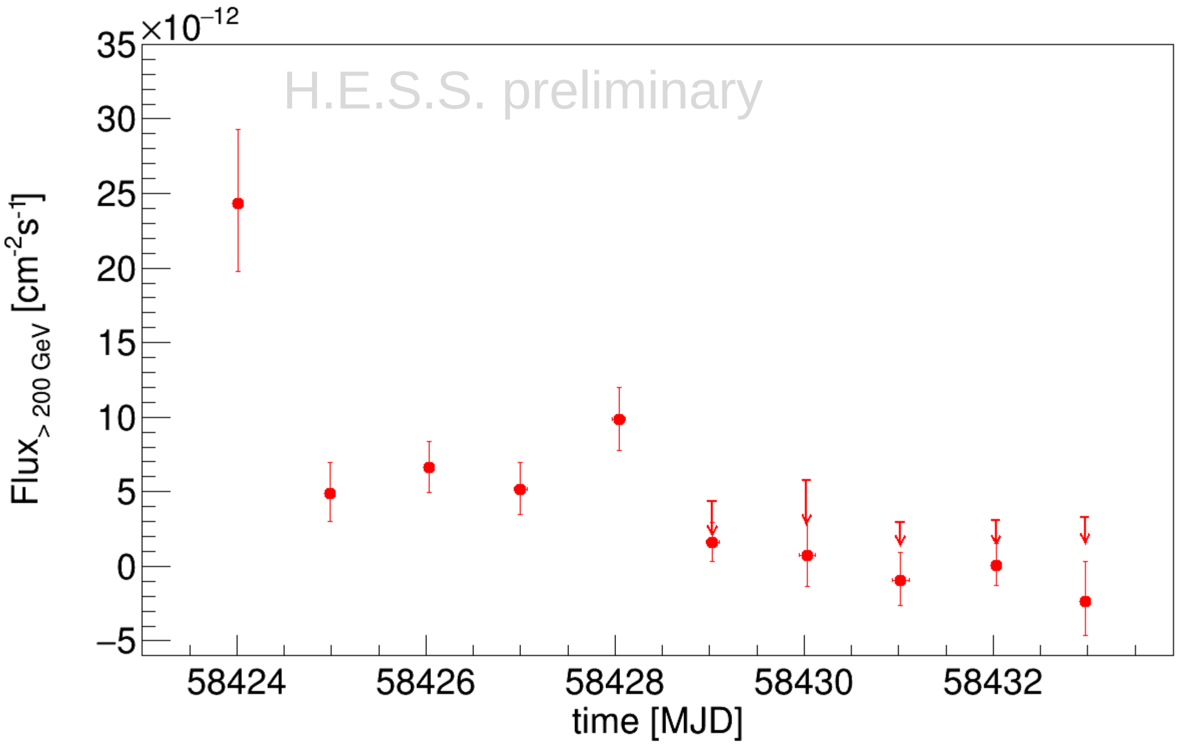
- Classification unclear:
  - LINER type
  - optical spectrum similar to BL Lac type object ([OIII] line luminosity)
  - kpc-scale image show two extended radio lobes as exepted for FR I radio galaxy
  - pc-scale structed one-sided
  - detected in TeV band (H.E.S.S. Collaboration 2018)

MWL observing campaign in 2018

- TeV observations aiming for variability search with H.E.S.S. telescopes
- Significant signal detected in first night of campaign in November 2018 with Real-Time-Analysis
- Denser H.E.S.S. observations followed together with dedicated ATOM (optical telescope on H.E.S.S. site), Swift-UVOT (optical, UV) and -XRT (X-ray) observations
- Construction of simultaneous multi-wavelength spectral energy distribution including optical/UV, X-ray, GeV and TeV information

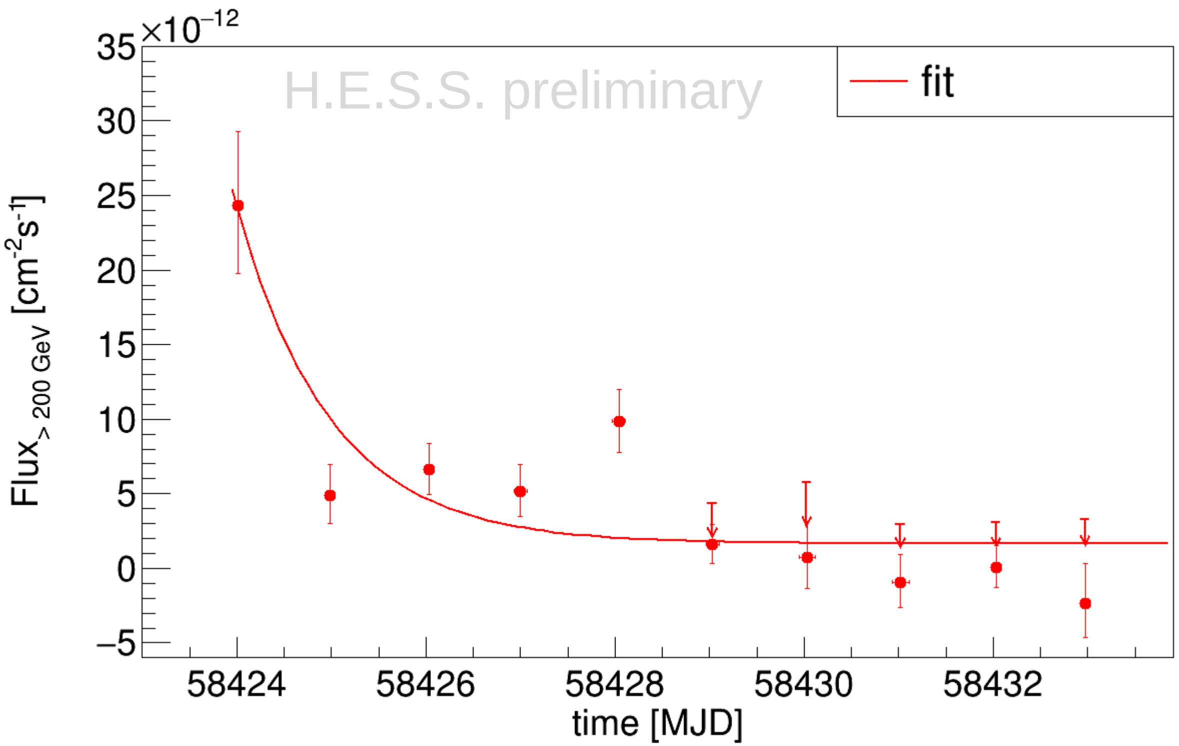
H.E.S.S. observations

- 17.5 h of good quality data acquired within 10 between 2018-11-01 and 2018-11-10 (dates are given before sunset), 8.7σ in total
- nightly binned light curve above 200 GeV



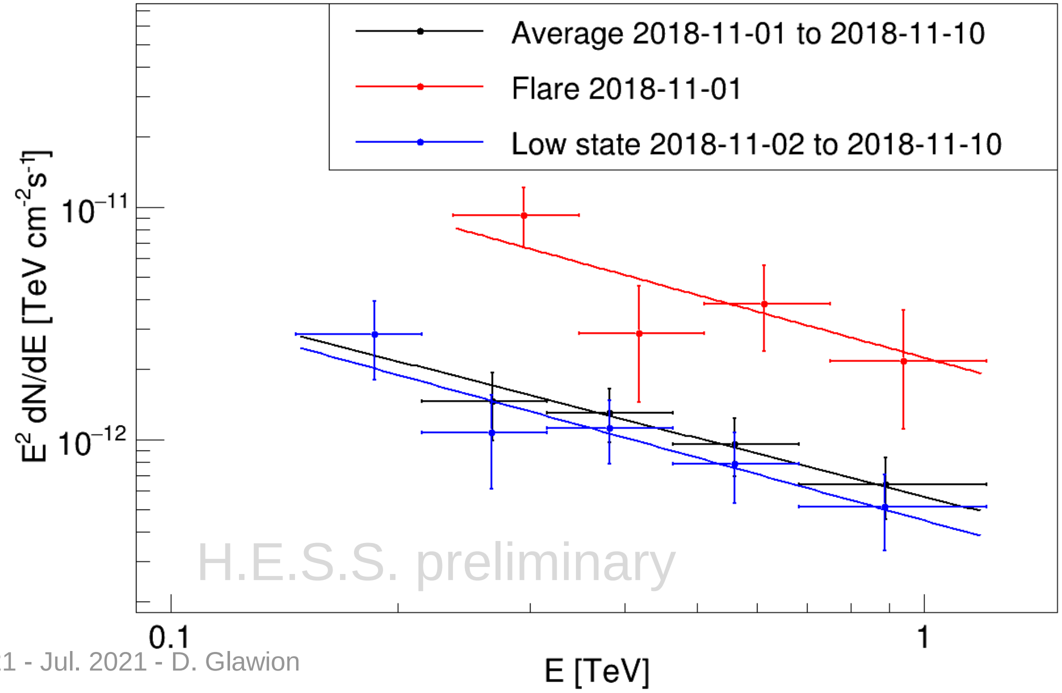
H.E.S.S. observations

- constant fit probability of 1×10^{-8}
- fit with function $F = F_0 + F_1 \times 2^{-|t-t_1|/t_{\mathrm{Var}}}$ to get flux-doubling time scale (fit probability of 2×10^{-4}) of $t_{\mathrm{Var}} = (17 \pm 7)\ \mathrm{h}$



H.E.S.S. observations

- Separate spectral analysis done for all data (average 2018) between 2018-11-01 and 2018-11-10, for the flaring night on 2018-11-01 only, and for low state between 2018-11-02 and 2018-11-10
- Power-law fit with $\frac{dN}{dE} = f_0 \times \left(\frac{E}{E_0}\right)^{-\Gamma}$



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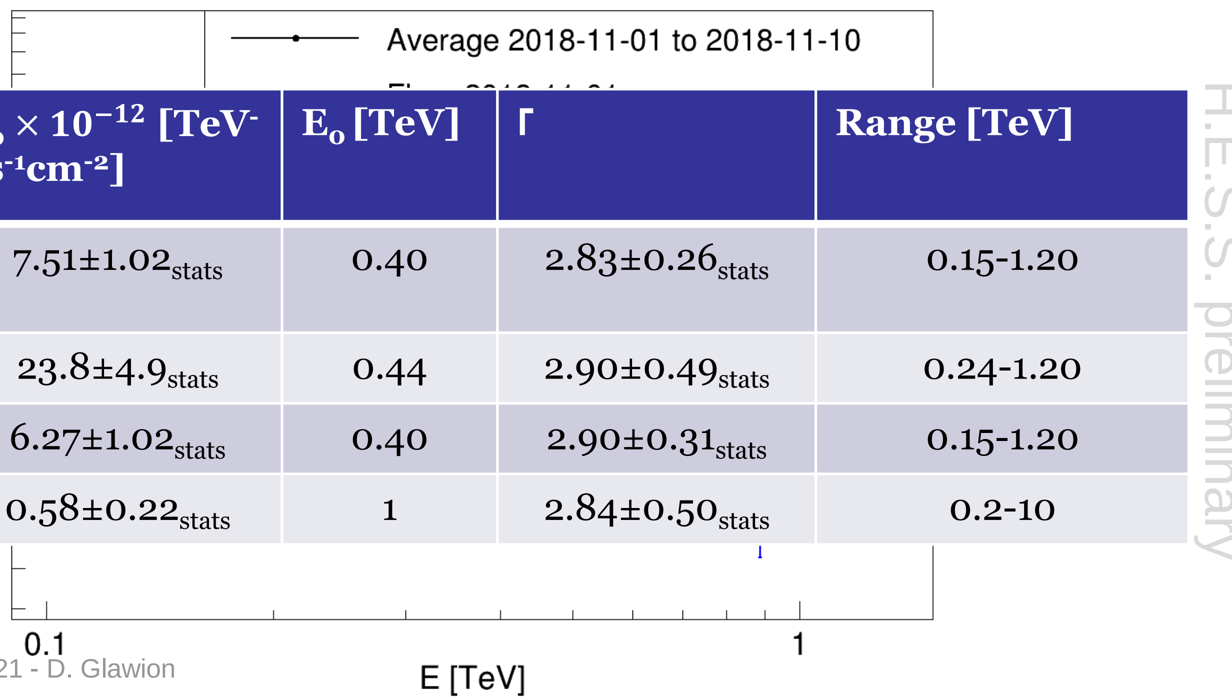
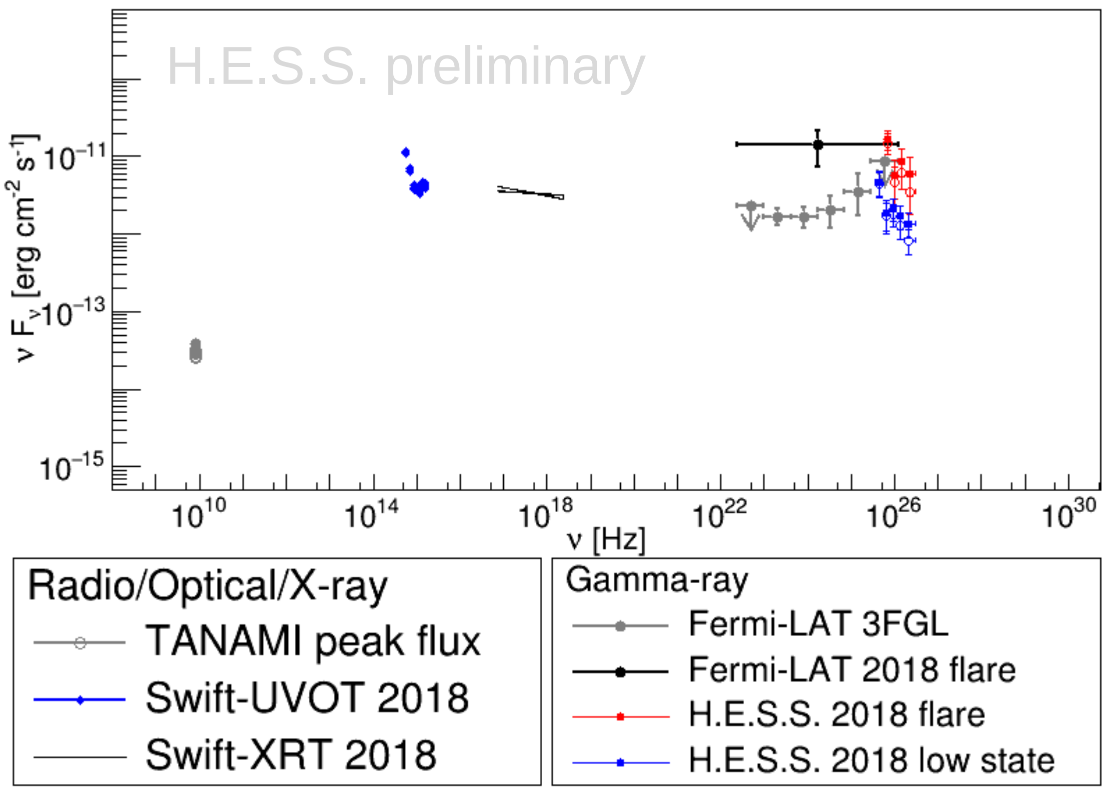


Emission state	$f_0 \times 10^{-12}$ [TeV^{-1}s^{-1}cm^{-2}]	E_0 [TeV]	Γ	Range [TeV]
Average 2018	$7.51 \pm 1.02_{stats}$	0.40	$2.83 \pm 0.26_{stats}$	0.15-1.20
Flare	$23.8 \pm 4.9_{stats}$	0.44	$2.90 \pm 0.49_{stats}$	0.24-1.20
Low state	$6.27 \pm 1.02_{stats}$	0.40	$2.90 \pm 0.31_{stats}$	0.15-1.20
2012	$0.58 \pm 0.22_{stats}$	1	$2.84 \pm 0.50_{stats}$	0.2-10

Multi-wavelength observations and SED

- *Swift* (XRT, UVOT) observations organized via ToO request, three observations performed on MJD 58425, 58426, and 58427
- Simultaneous optical/UV, X-ray, GeV, and VHE SED shows continuation of the Fermi spectrum in VHE



What can we learn from variability?

- Observed variability constrains emission region (z=0.055):

  - $R < \delta * c * t_{\mathrm{Var}} * \frac{1}{(1+z)} = 17\,\mathrm{h} * \delta * c * \frac{1}{(1+z)} = \delta * 1.7 * 10^{15}\ \mathrm{cm}$

  ➢ gravitational radius of black hole $R_{\mathrm{G}} = \frac{GM_{\mathrm{BH}}}{c^2} = 1.48 * 10^{14}\ \mathrm{cm}$ assuming Bettoni et al. 2003: $M_{\mathrm{BH}} = (1.55 \pm 0.66) * 10^{9}\ \mathrm{M_{Sun}}$

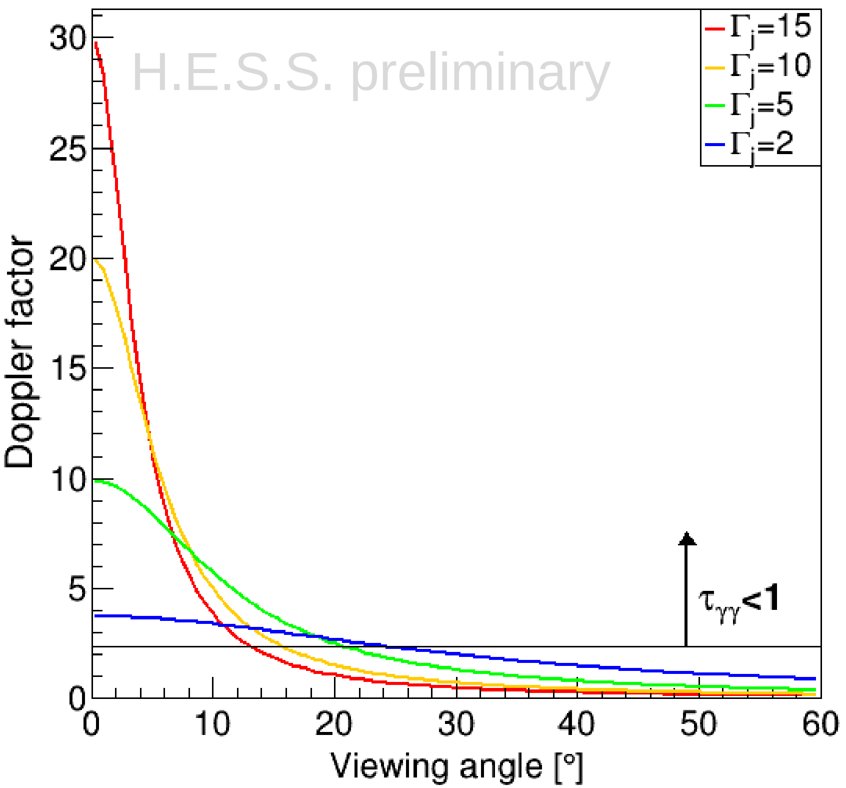
  ➢ fine for shock-in-jet model

- How about absorption? (γγ pair production)

  - used Eq. 9 in Abdo et al. 2011, Eq. 2 in Ahnen et al. 2018
  - $\tau_{\gamma\gamma} = 1$ if $\delta \approx 2.4$ for 1 TeV photon

What can we learn from variability -> Viewing angle

- Doppler factor as a function of viewing angle for different Lorentz factors
- Upper limit on viewing angle $\theta<24^{\circ}$ for $\tau_{\gamma\gamma}<1$
- compare $\theta<53^{\circ}$ for viewing angle based on jet-to-counterjet ratio of parsec-scale radio jet [Angioni et al., 2019]
- Viewing angle important parameter for SED modelling (work in progress)



Thanks
and stay healthy

Bundesministerium
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