H.E.S.S. detection and multi-wavelength study of the z = 0.991 blazar PKS 0346-27

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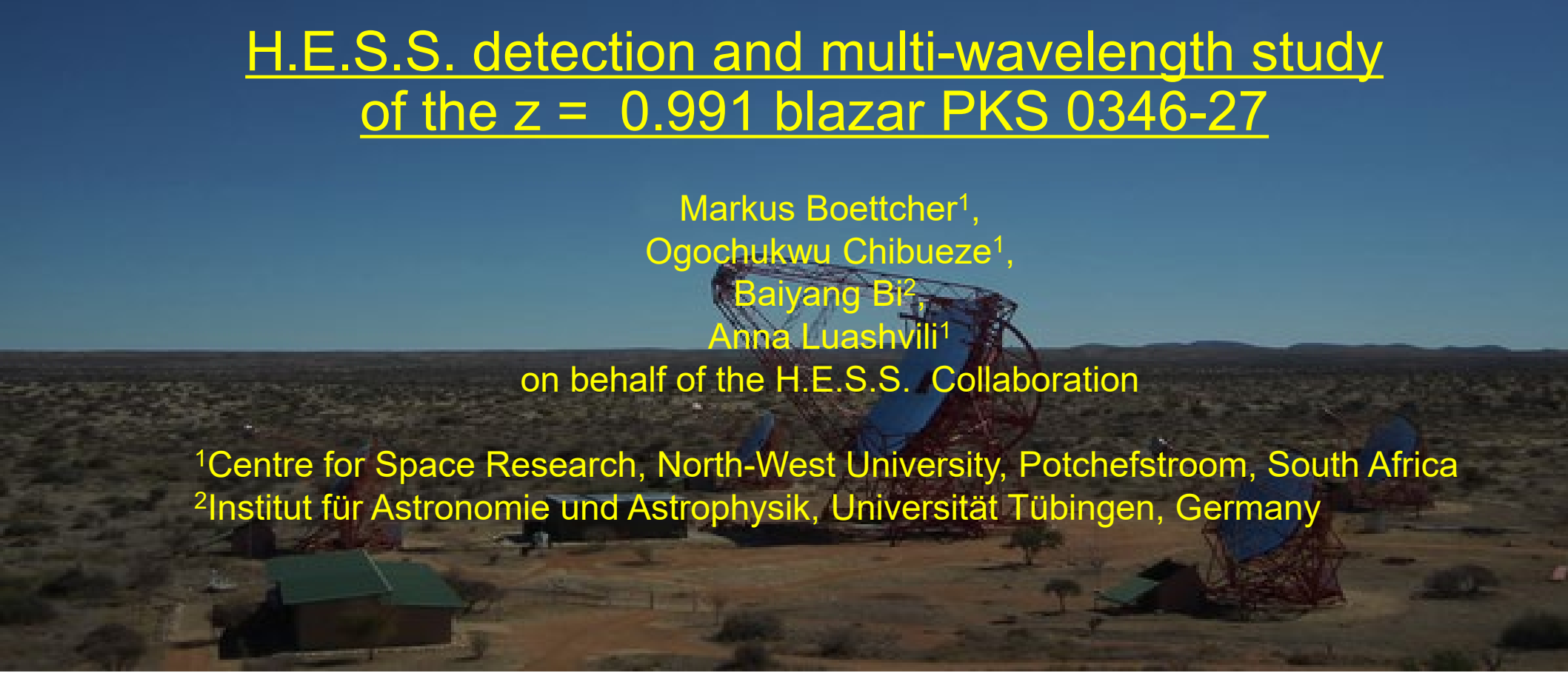

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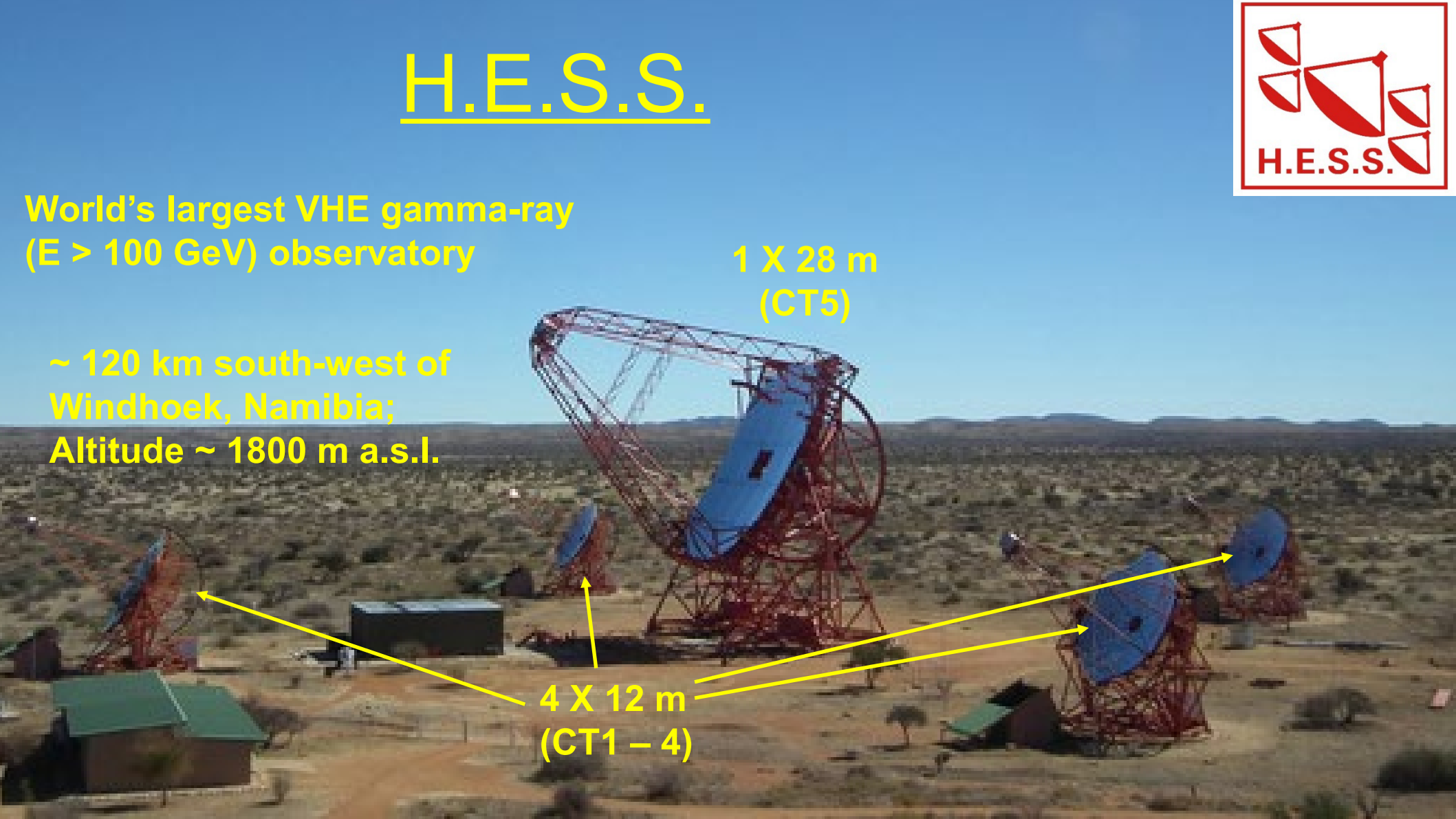
H.E.S.S.

World's largest VHE gamma-ray (E > 100 GeV) observatory

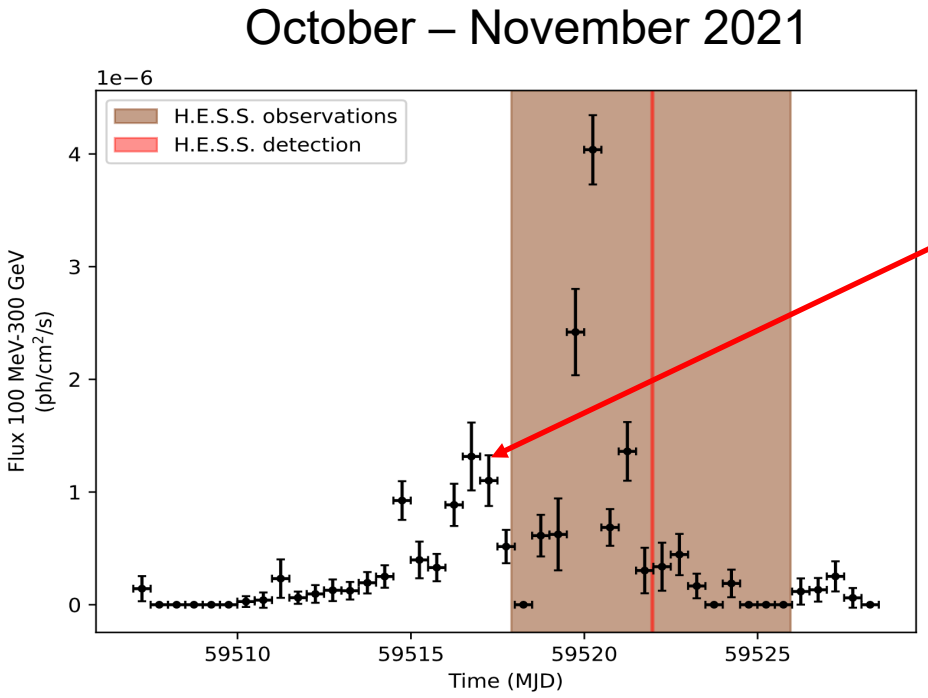
~ 120 km south-west of Windhoek, Namibia; Altitude ~ 1800 m a.s.l.



H.E.S.S. ToO programme for flaring high-redshift ($z \gtrsim 1$) blazars

- Goal to extend the VHE blazar horizon to $z > 1$
- Probe evolution of the EBL out to $z > 1$
- H.E.S.S. observations triggered by flaring in other wavebands (primarily Fermi-LAT)
- Co-ordinated multi-wavelength observations (usually H.E.S.S., Fermi-LAT, Neil-Gehrels Swift, ATOM)
- 7 blazars with $0.991 < z < 1.424$ observed since 2016

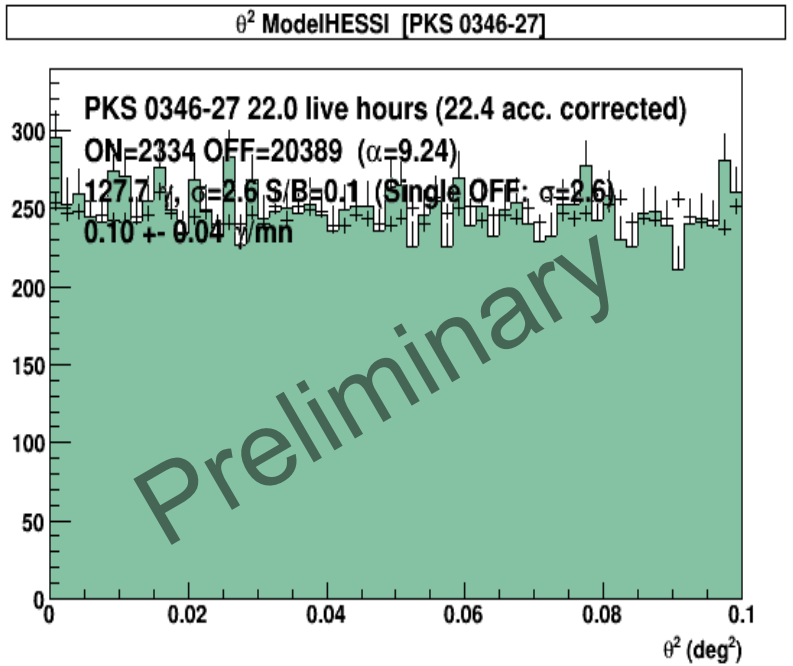
H.E.S.S. Observations of PKS 0346-27



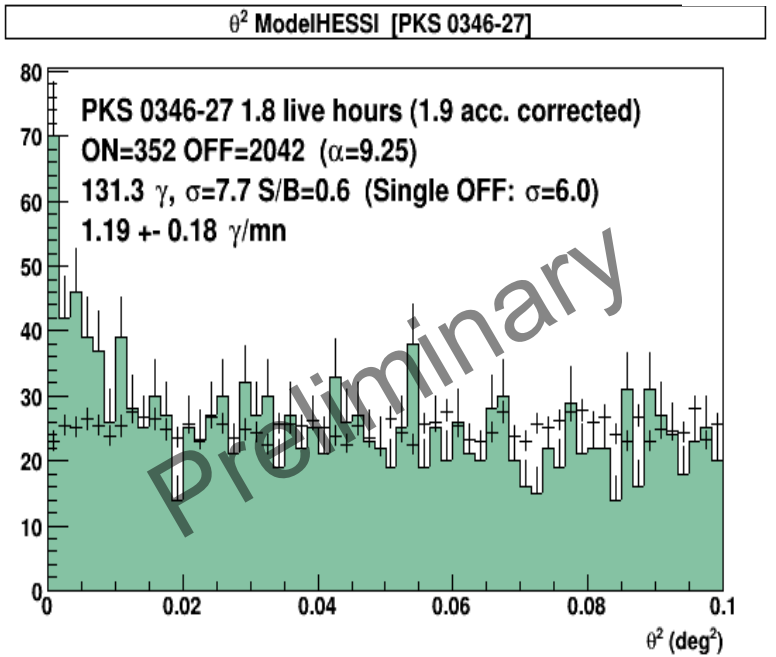
- FSRQ at z = 0.991
- H.E.S.S. ToO observations triggered by Fermi-LAT high state on 30 Oct. 2021
- 53 runs (~ 26 hours) of H.E.S.S. Observations between 30th Oct. and 29th Nov. 2021
- Simultaneous coverage by Neil-Gehrels Swift (XRT + UVOT) and ATOM

PKS 0346-27 H.E.S.S. Analysis Results

H.E.S.S. detection only in one night: 3rd Nov. 2021.



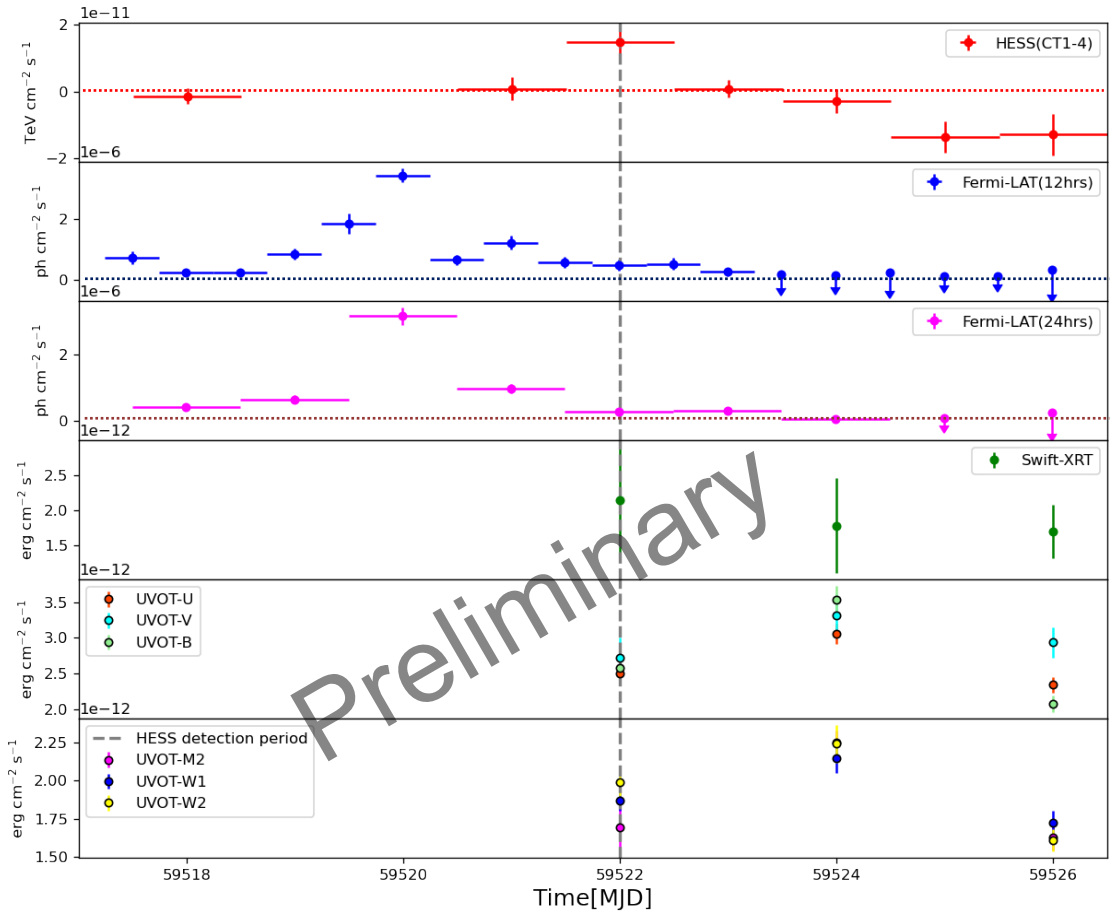
2021 overall



Detection night: 3rd Nov.2021

Detection announced in ATel #15020. – New blazar redshift record at the time.

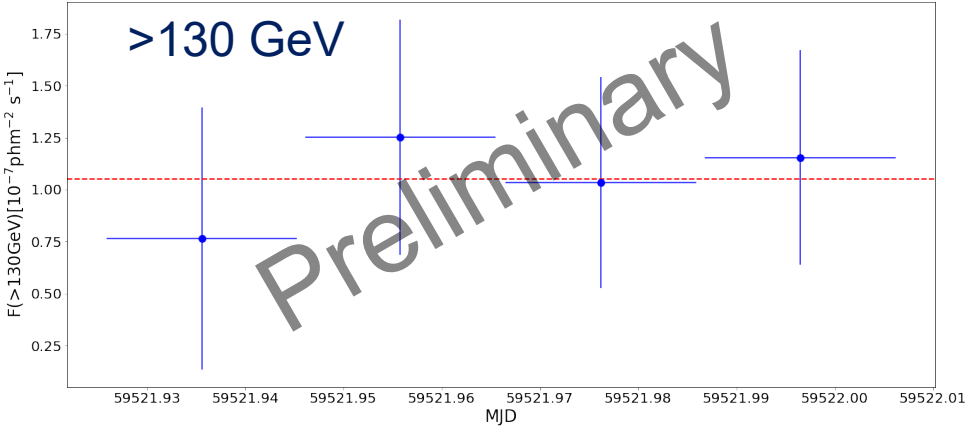
MWL light curves



H.E.S.S. flare ~ 2 days delayed w.r.t. Fermi-LAT!

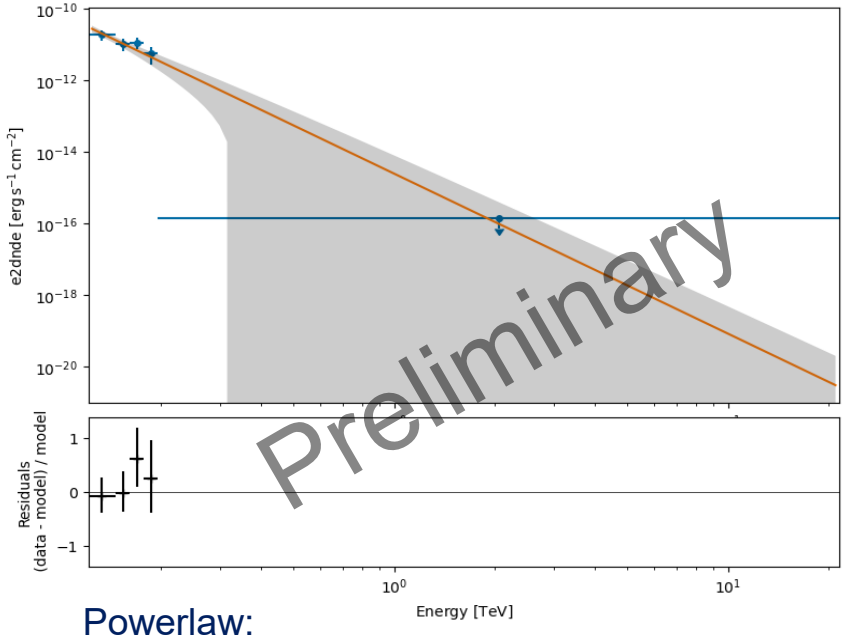
No evidence for significant activity in X-rays.

No evidence for intra-night variability.



Detection night spectrum

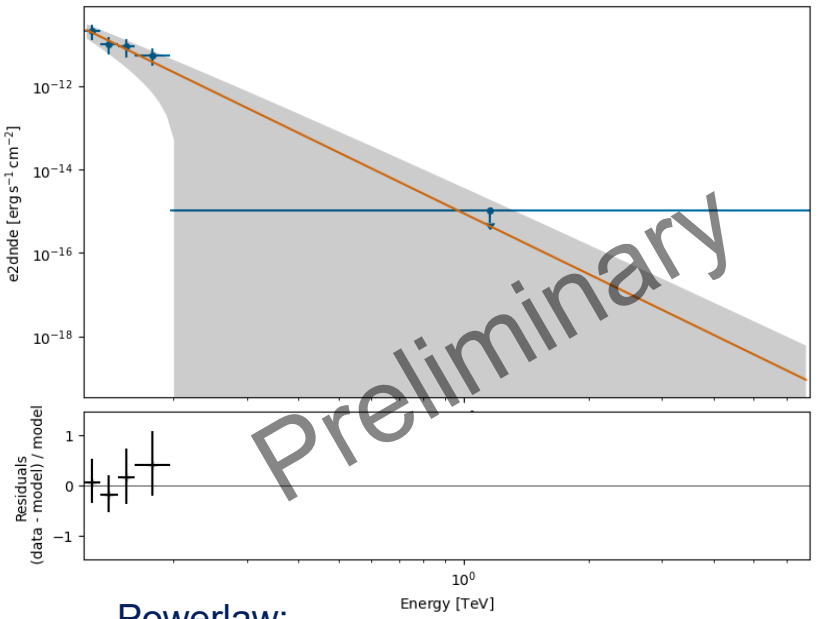
CT1-4



Powerlaw:

Index: 6.5 +/- 1.1
Reference energy: 0.150 TeV
Energy range of fit: 0.121 – 21.5 TeV
Detection up to 227 GeV

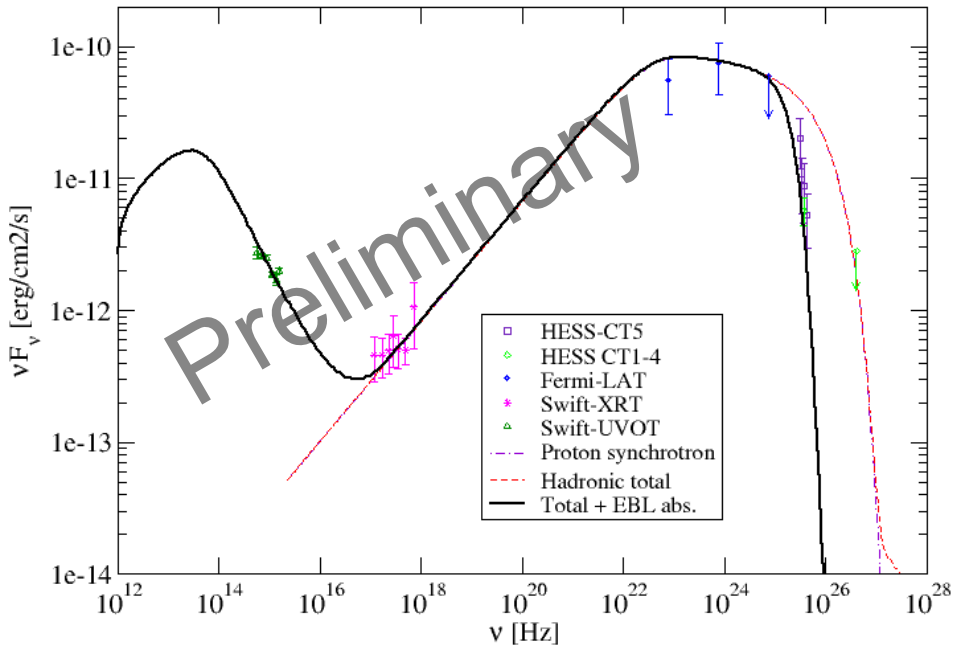
CT5



Powerlaw:

Index: 6.8 +/- 1.3
Reference energy: 0.150 TeV
Energy range of fit: 0.121 – 6.8 TeV
Detection up to 12.0 GeV

SED Modeling



Hadronic model SED fit (Böttcher et.al, 2013)

Proton-synchrotron dominated high-energy emission

$L_p = 1.6 \times 10^{48}$ erg/s
$L_e = 3.3 \times 10^{42}$ erg/s
$L_B = 2.6 \times 10^{49}$ erg/s

$L_{Edd} = 2.5 \times 10^{46}$ erg/s

-> Requires highly super-Eddington jet power!

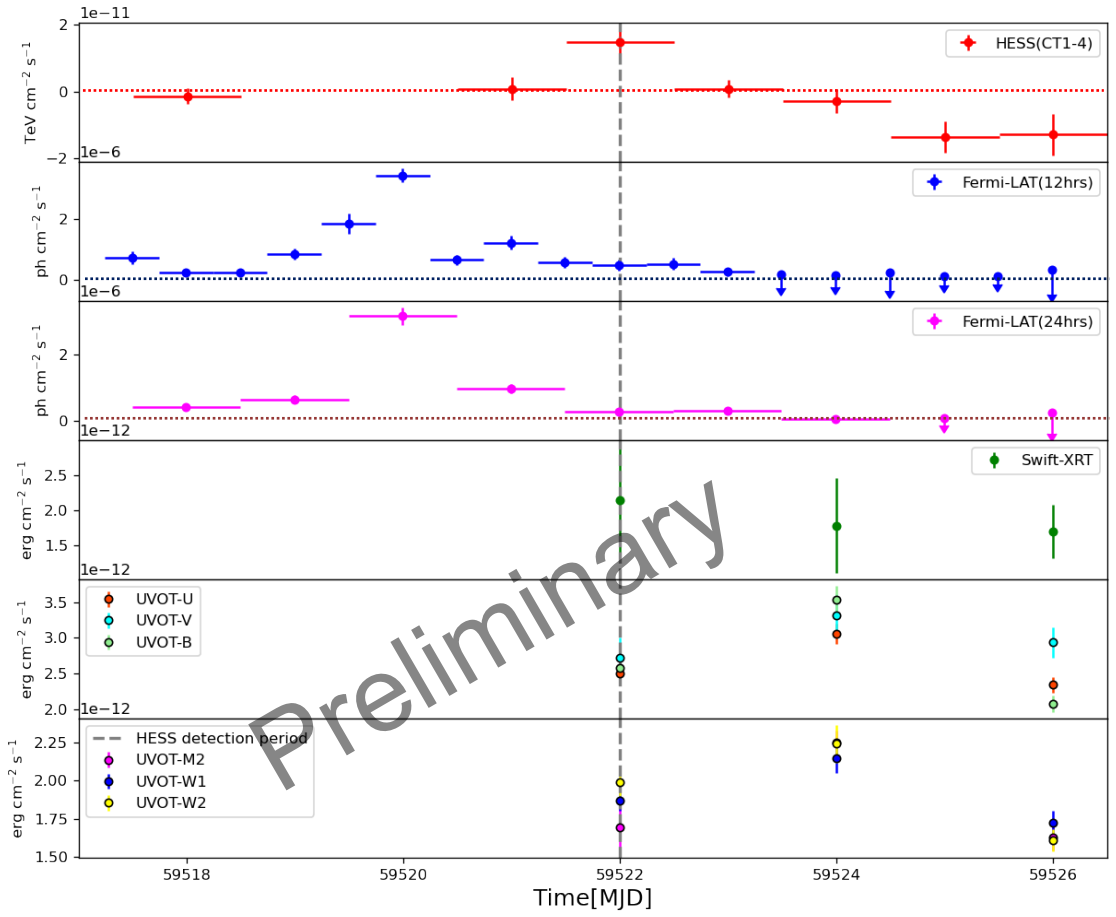
$L_B/L_e = 7.9 \times 10^6$
$L_B/L_p = 16$
$L_e/L_p = 2.1 \times 10^{-6}$

-> Magnetically dominated.

EBL absorption clearly significant, but can't distinguish between 3 considered EBL models: Franceschini et al. (2008), Gilmore et al. (2009), Finke et al. (2010).

Leptonic fit not plausibly feasible due to drastically different optical vs. HE γ-ray spectra.

Interpretation H.E.S.S. vs. Fermi-LAT Delay



H.E.S.S. flare ~ 2 days delayed w.r.t. Fermi-LAT!

- Finite UHE proton acceleration time scale? – Not clear why the GeV flare subsides while the acceleration process is still active. – Narrow ultra-relativistic proton distribution?
- Proton synchrotron mirror model (as suggested for 3C279 by Oberholzer 2023)? HE – VHE spectrum consistent with a single proton-synchrotron component…

Summary and Conclusions

- H.E.S.S. detected VHE γ-rays from the z = 0.991 FSRQ PKS 0346-27 during one night in Nov. 2021.
- New VHE blazar redshift record at the time.
- No evidence for X-ray activity or VHE γ-ray intraday variability.
- VHE flare was delayed with respect to a short Fermi-LAT HE γ-ray flare by ~ 2 days.
- SED modelling possible only with a hadronic model, requiring highly super-Eddington jet power.
- Origin of VHE – HE delay still under investigation.

Thank you

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