



# The puzzling long term behaviour of the AGN PKS 0625-354

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A deep-sky image showing a field of stars. A red arrow points from the text label to a specific star in the field. The star is bright and appears to be a double star or a cluster of stars. The background is dark with many other stars of varying brightness and colors.

**PKS 0625-354 seen @ DSS2**

Image source: [\[Aladin\]](#)

# What we already know<sup>1</sup>

- PKS 0625-354 was first detected as VHE emitter in 2012 by H.E.S.S. using 5.5h of data
- Multi-wavelength analysis with H.E.S.S., Fermi-LAT, Swift-XRT, Swift-UVOT, ATOM, WISE. Significant variability observed with Fermi-LAT and Swift-XRT.
- Power law (soft) spectrum with  $\Gamma = 2.84 \pm 0.5_{stat} \pm 0.1_{syst}$ ,  
 $N(E_0 = 1 \text{ TeV}) = (0.58 \pm 0.22_{stat} \pm 0.12_{syst}) \times 10^{-12} \text{ TeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$
- Broadband modelling considering: (i) one zone lepto-hadronic, and (ii) multi-zone leptonic models. Multi-zone leptonic model preferred.
- Nature of PKS 0625-354 was already debated before HESS observations. X-ray variability constraints favour BL Lac nature with large-scale jet of radio galaxies.

<sup>1</sup> From [HESS Collab. MNRAS, 476 \(2018\) 4187-4198](#)

## Previous H.E.S.S. observations<sup>2</sup>

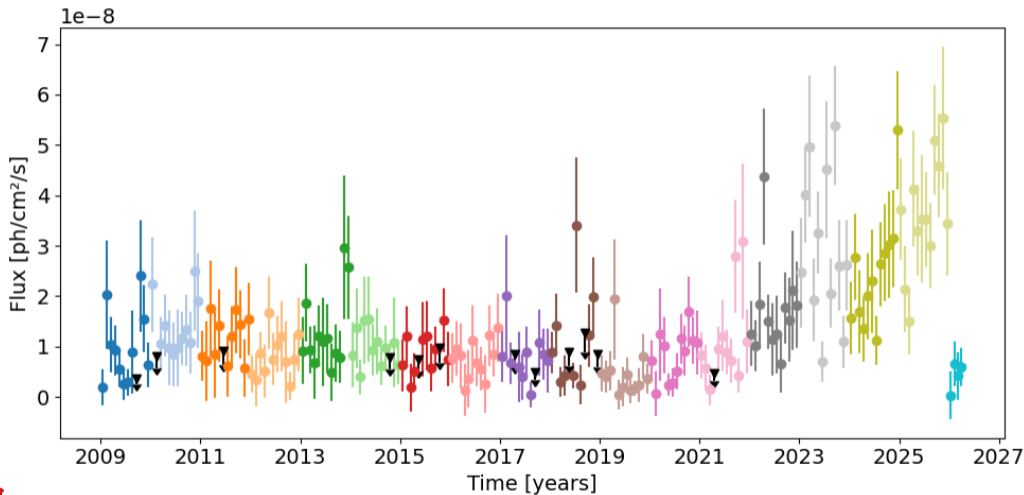
- ☞ VHE flare in Nov 2018
- ☞ Data from H.E.S.S., Fermi-LAT, Swift-XRT, Swift-UVOT
- ☞ Viewing angle constrained to  $10^\circ$
- ☞ Broadband modelling fit by single-zone synchrotron self Compton
- ☞ Still unsure about the nature of this source – likely a borderline object

- 🚀 Long term analysis → from 1 January 2009 to 13 April 2026
- 🚀 **H.E.S.S.:** big gaps in data, no observations from 2022 to 2025
- 🚀 **Fermi-LAT:** monthly bins across the whole time range
- 🚀 **Swift-XRT** and **Swift-UVOT**<sup>1</sup>: similar to H.E.S.S.
- 🚀 **ATLAS**<sup>2</sup>: only light curve available, also big data gaps

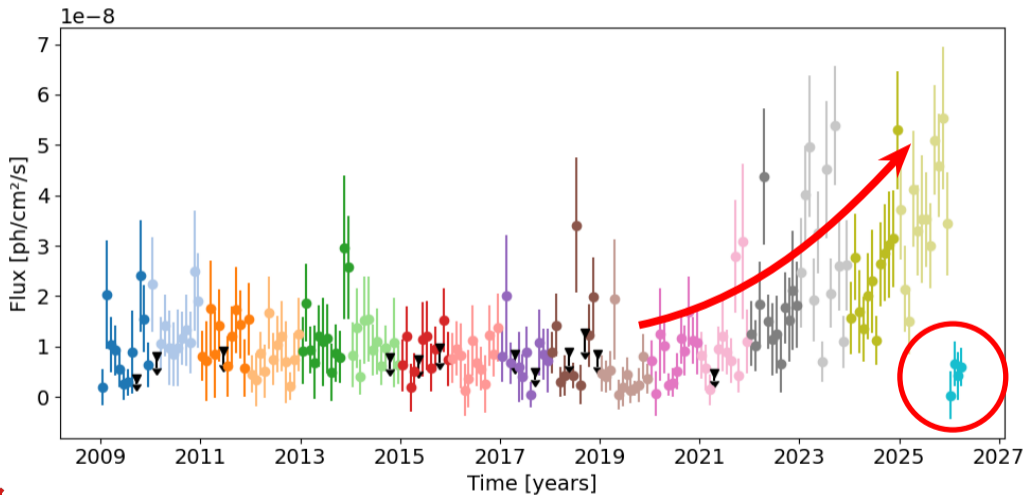
<sup>1</sup> Swift-XRT and Swift-UVOT data provided by Alicja Wierzcholska

<sup>2</sup> ATLAS data provided by Alberto Sadun

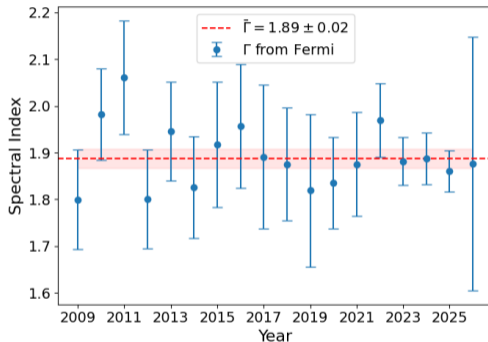
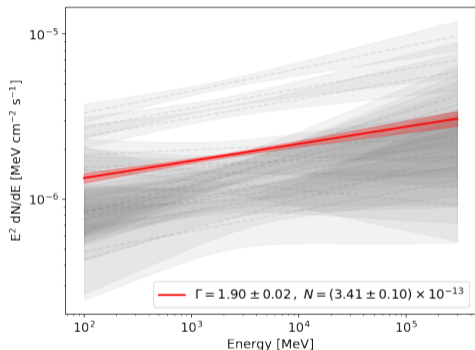
# Fermi-LAT light curve



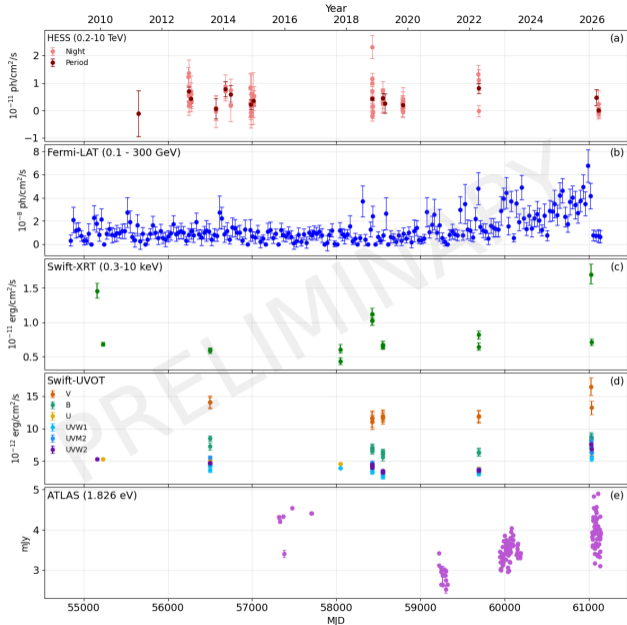
# Fermi-LAT light curve

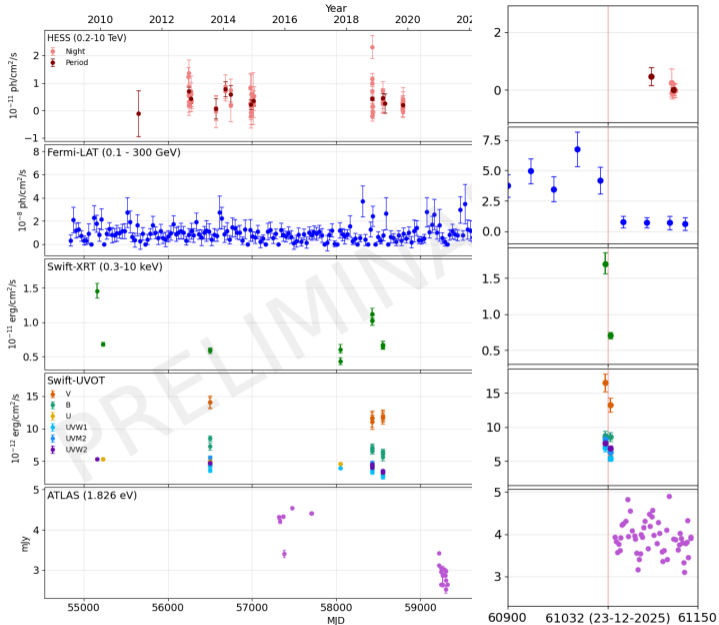


# Fermi-LAT spectral index

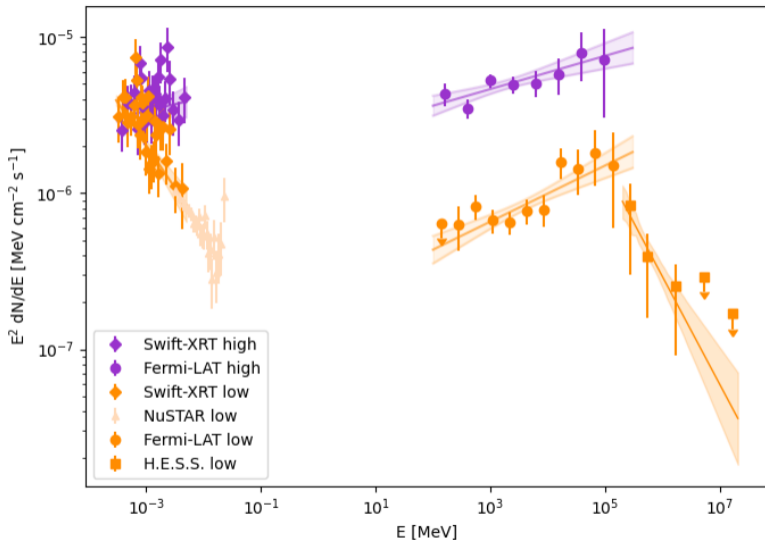


$$\chi^2 = 7.22, \chi_{red}^2 = 0.42$$



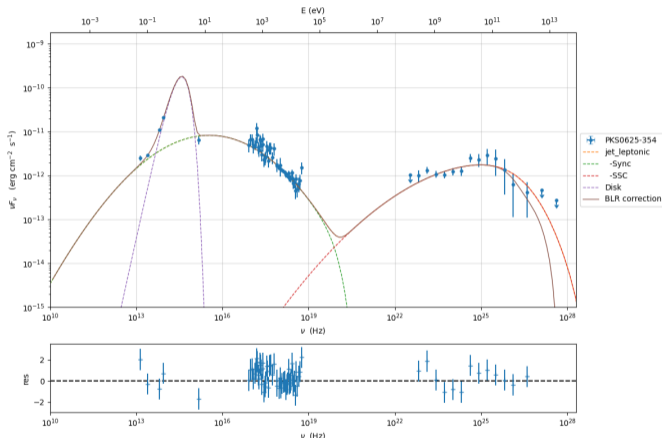


- Flux in **HE  $\gamma$ -rays** was stable from 2009 to 2021 with a short flare in November 2018, and steadily increased until December 2025, when it suddenly dropped. Other aspects (photon index, spectrum type, position) remained stable the whole time.
- Similar circumstances might've been happening in **VHE  $\gamma$ -rays**, but there is no data in this energy range between late 2022-2025.
- Sudden flux drop observed in **HE  $\gamma$ -rays**, **X-rays**, and **V band** at the same time around 23 December 2025.
- Flux from **ATLAS** and other **UVOT** bands is still increasing.



# Low-state modelling

- ☛  $R = (4.24 \pm 0.23)e16$  cm
- ☛  $B = (3.49 \pm 0.23)e-3$  G
- ☛  $\text{beam\_obj} = (57.1 \pm 1.6)$
- ☛  $g_{\text{min}} = (22.69 \pm 3.85)$
- ☛  $g_{\text{max}} = (7.82 \pm 0.14)e6$
- ☛  $N = (1.40 \pm 0.13)e-1$   $\text{cm}^{-3}$
- ☛  $\gamma_{0\_lp} = (1.48 \pm 0.07)e2$
- ☛  $s = (2.24 \pm 0.03)$
- ☛  $r = (54.14 \pm 0.98)e-2$
- ☛  $T_{\text{Disk}} = (5000 \pm 299)$  K
- ☛  $\phi_p = (2.40 \pm 0.84)e-12$   $\text{erg}/(\text{s cm}^{-2})$

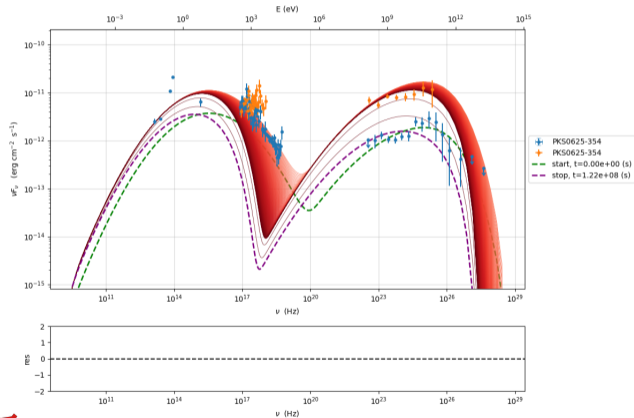


# Temporal evolution (very early stage)

- One (radiation from electron injection) zone + adiabatic expansion

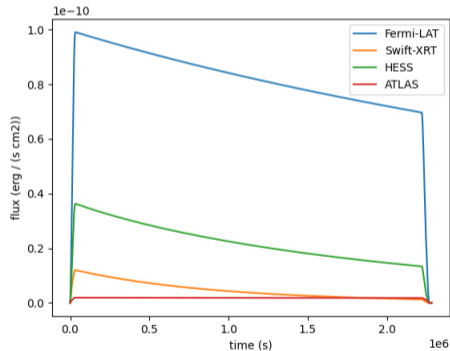
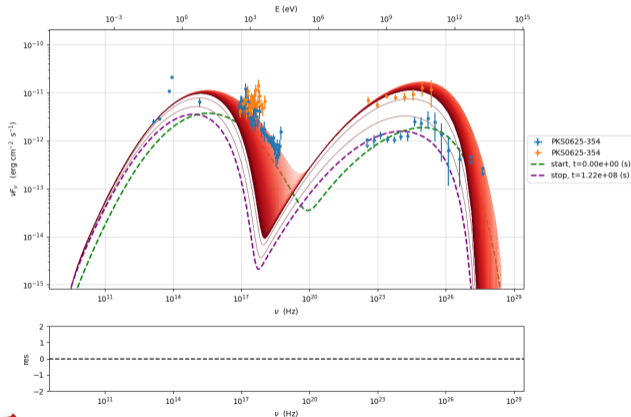
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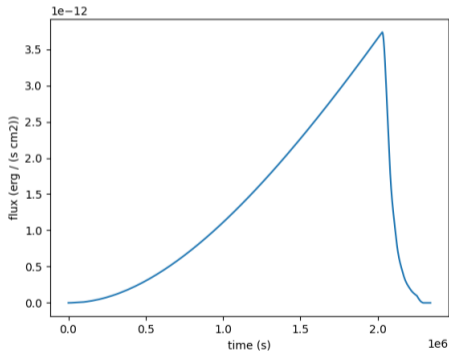


# Temporal evolution (very early stage)

- One (acceleration) zone + adiabatic expansion

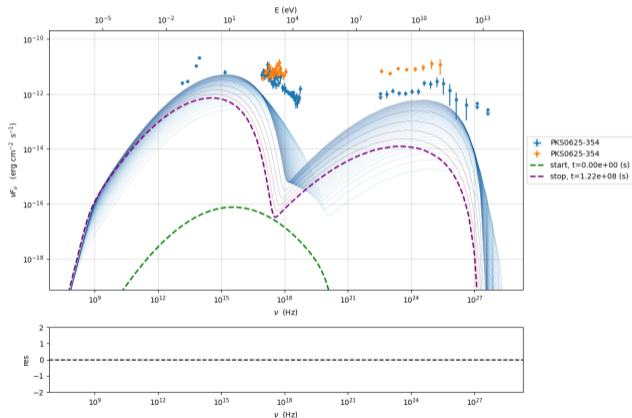
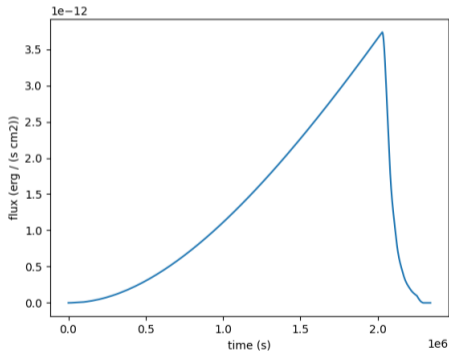
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🚩 One (acceleration) zone + adiabatic expansion



# Temporal evolution (very early stage)

📍 One (acceleration) zone + adiabatic expansion



- 👁️ Very early work - time-related plots are wrong, don't trust them 🙄
- 👁️ JetSet time evolution documentation is quite rudimentary (seems to be a work in progress)
- 👁️ Big part of the parameters have no explanation yet, have to “guess” what they are
- 👁️ We'll try to model two zones (radiation + acceleration) for the time range of the observed Fermi-LAT flux rise and simulate the light curve from other telescopes to try to fill in gaps in data

## Summary

- PKS 0625-354 is not a usual radio galaxy/BL Lac, it's interesting even as a borderline object
- Low-state well defined, enough data to constrain the multiwavelength SED
- Not enough high-state data to have a good model on its own, temporal evolution is needed

## Next steps

- Evolve initial (low-state) SED in time with JetSet, or other software
- Simulate light curves
- Understand the physical processes that happened in December 2025 from the obtained temporal model