First Lorentz Invariance Violation constraint from a cooperation of Imaging Atmospheric Cherenkov Telescopes

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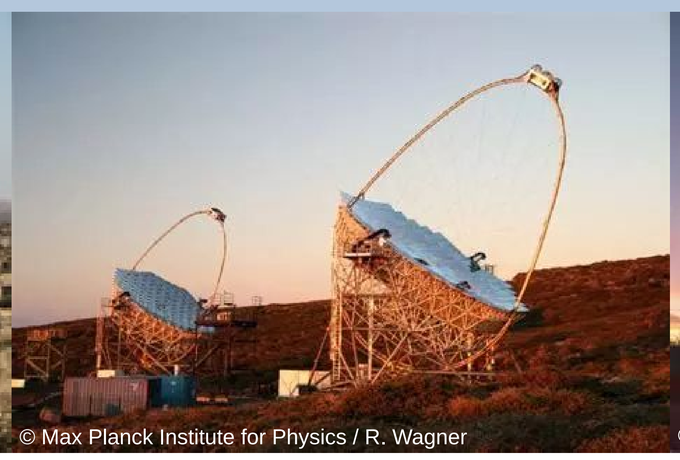
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Lorentz invariance violation (LIV) search with time delays Δt of photons

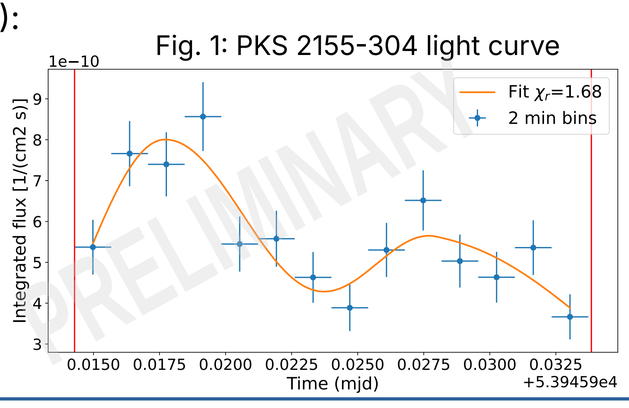
- Looking for a **lateshift** in arrival time of photons of differential energy ΔE : $\lambda_M = \frac{\Delta t}{\kappa_M(z)\Delta E} = \pm\frac{1}{H_0\Lambda}$
- Propagation factor $\kappa_M(z)$ encoding a model M:
  - the JP model (Jacob & Piran, 2008), a common model in LIV studies;
  - a DSR model (Caroff et al., 2025), designed to nearly nullify the lateshift at redshift 0.425.
- If no detection, set a **lower limit** on the **characteristic energy scale** Λ.
- Using sources with **fast variability** of their light curves (flux as a function of time), a wide energy range, and distributed over a large range of redshifts (z): 1 gamma-ray burst (GRB) and 3 active galactic nuclei (AGN).

Supported by:

H.E.S.S. dataset - AGN

- **PKS 2155-304** (z=0.11610)
- Run 4 of the 2006 July 29th night (Abdalla et al., 2018):

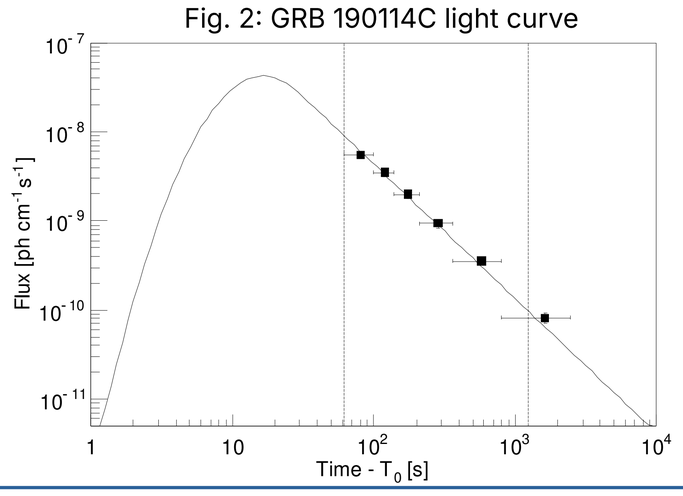
Fig. 1: PKS 2155-304 light curve



MAGIC dataset - GRB

- **GRB 190114C** (z=0.425)
- 2019 January 14th night (Acciari et al., 2020):

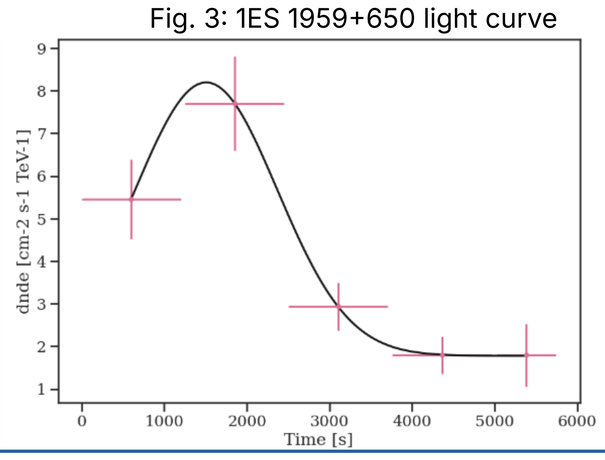
Fig. 2: GRB 190114C light curve



VERITAS dataset - AGN

- Scan of all AGN in published archival data.
- **1ES 1959+650** (z=0.047)
- 2021 May 20th night (Aliu et al., 2014):

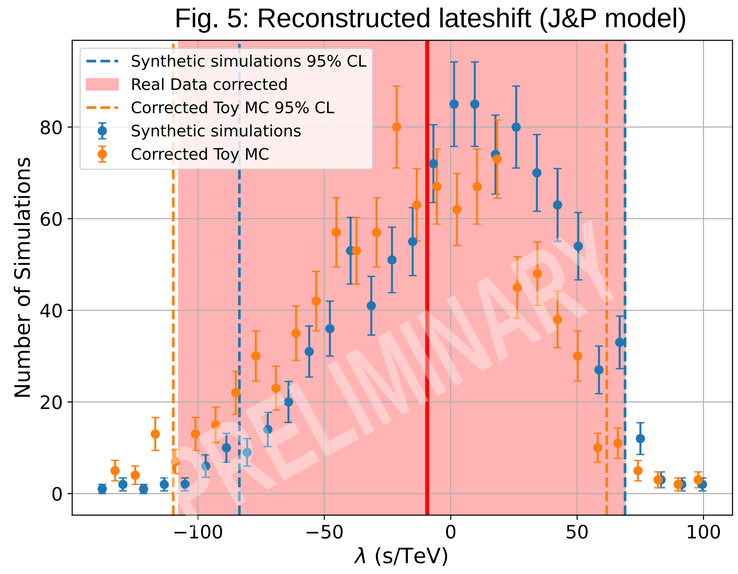
Fig. 3: 1ES 1959+650 light curve



Combination of all experiments

- Using the maximum likelihood method (Bolmont et al., 2022), at 95% confidence level.
- Cross-checking analysis with 1000 synthetic (expected events distributions), bootstrap (interchanging time of events) and toy Monte-Carlo (directly using real data) simulations.
- Correcting an eventual bias with bootstrapping
- Reconstructing the lateshift – **no detection**

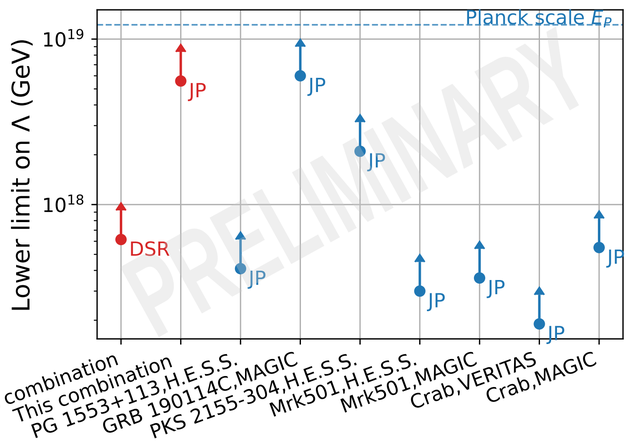
Fig. 5: Reconstructed lateshift (J&P model)



- Setting **2σ lower limits** on the energy scale:

	J&P	DSR
subluminal	$\Lambda > 5.58 \times 10^{18}$GeV	$\Lambda > 0.615 \times 10^{18}$GeV
superluminal	$\Lambda > 4.44 \times 10^{18}$GeV	$\Lambda > 0.448 \times 10^{18}$GeV

Fig. 6: Comparison (subluminal case) with other analysis (Bolmon et al., 2022)



LST-1 dataset - AGN

- Scan of all AGN data from January 2021 to May 2025 (34 sources, 505 nights).
- Work presented in contribution P02-434.
- Use **3 nights of BL Lacertae** (z=0.069), with following light curves:

Fig. 4a: 2021 Aug. 3rd - n=1

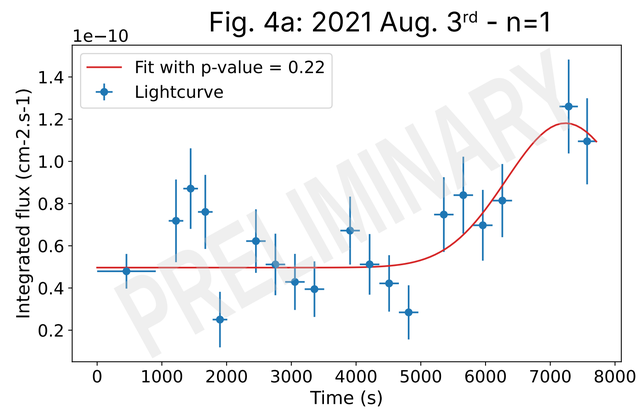


Fig. 4b: 2021 Aug. 8th - n=3

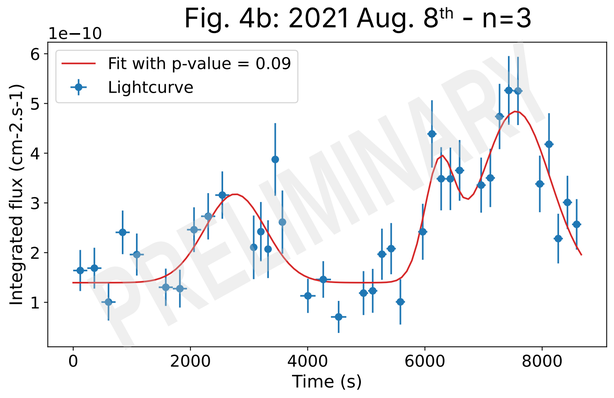
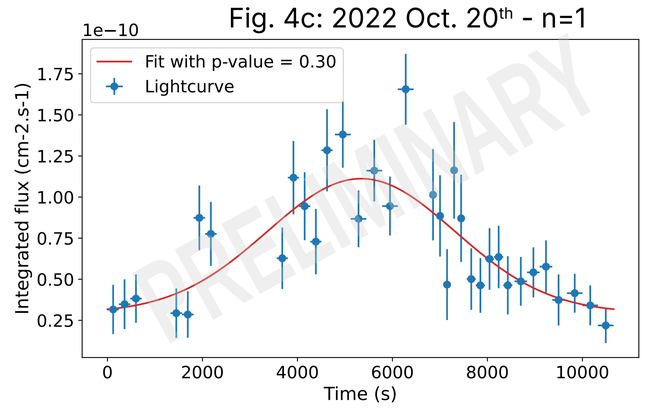


Fig. 4c: 2022 Oct. 20th - n=1



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https://www.ctao.org/for-scientists/library/acknowledgments/

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