# First VHE gamma-ray observations of BL Lacertae with the Large-Sized Telescope (LST-1)

cherenkov telescope array

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## ABSTRACT

The LST-1 detected the Very High Energy (VHE) gamma ray signal from BL Lacertae in 2021. This has allowed us to study extreme levels of VHE variability in an unprecedented flare of the source. The analysis and results will become the base of one of the very first scientific results from the LST collaboration. We present the results of the BL Lac 2021 observational campaign, including the VHE gamma-ray lightcurve of BL Lacertae detected by the LST-1 in 2021, together with its measured Spectral Energy Distribution.

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## The LST-1

The Large-Sized Telescope (LST-1) is the first prototype telescope for the future Cherenkov Telescope Array Observatory (CTAO) northern site, located in the Roque de los Muchachos in La Palma. Once the array is completed, it will be able to observe gamma-ray energies from 20 GeV to 100 TeV.

## Cosmic Rays

Showers start when a cosmic ray reaches the atmosphere and interacts with the nuclei, disintegrating in other types of particles. Particles partaking in this cascade travel at speeds higher than the speed of light in the medium, thus producing Cherenkov radiation which is detected by the LST-1.

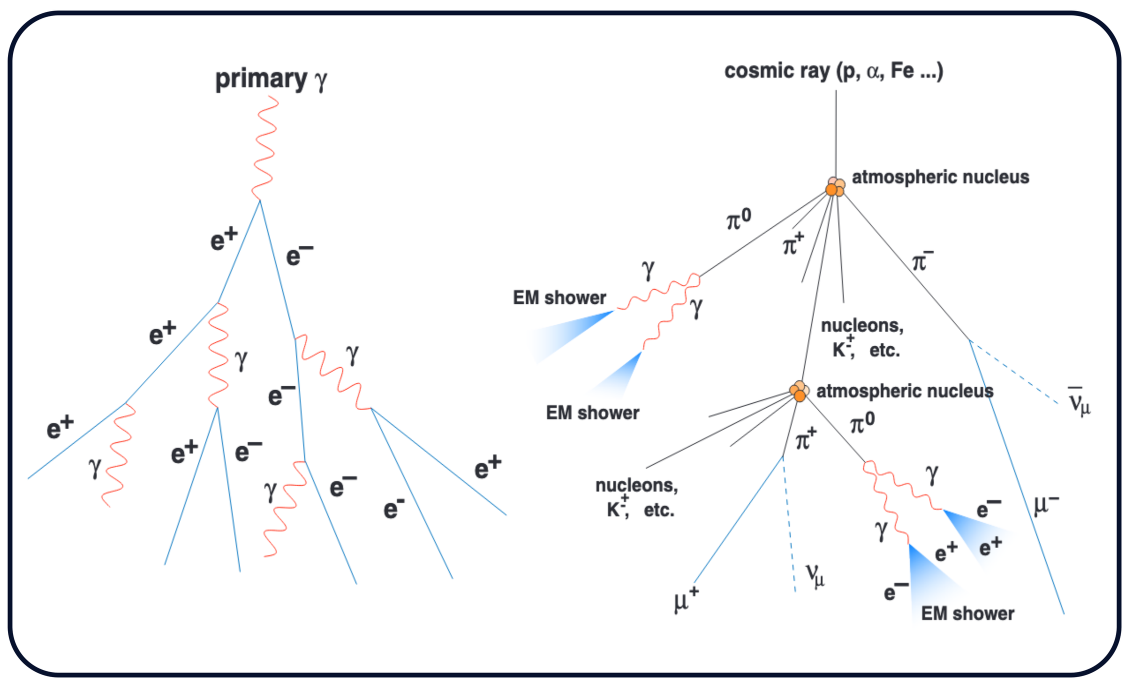


Fig. 1: Schematic view of two showers of different origin, gamma (left) and hadronic (right) [Wagner (2006)].

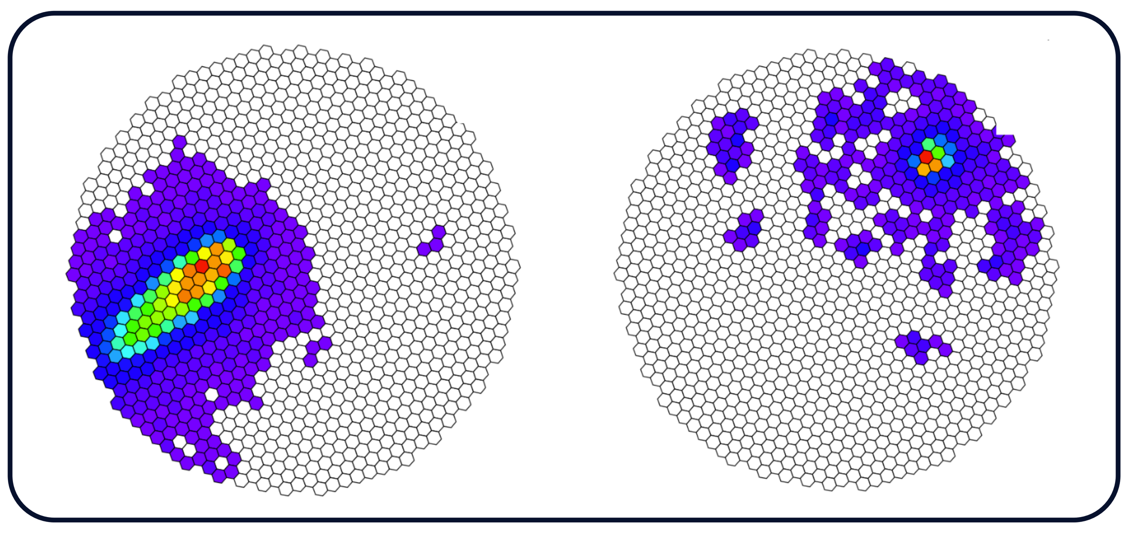

Fig. 2: Different types of showers result in distinct images in the camera of an Imaging Atmospheric Cherenkov Telescope (IACT) [R. López-Coto (2015)].

## ACKNOWLEDGEMENTS

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## Analysis of the data

Monte Carlo (MC) simulations of the whole process, from the first particle interaction to the signal in the camera, are needed to train Random Forests (RFs). These algorithms work on different parameters extracted from the image, and are used to distinguish the kind of particle that initiated the cascade and to reconstruct its energy and direction. The MCs are also needed to evaluate the Instrument Response Functions (IRFs).

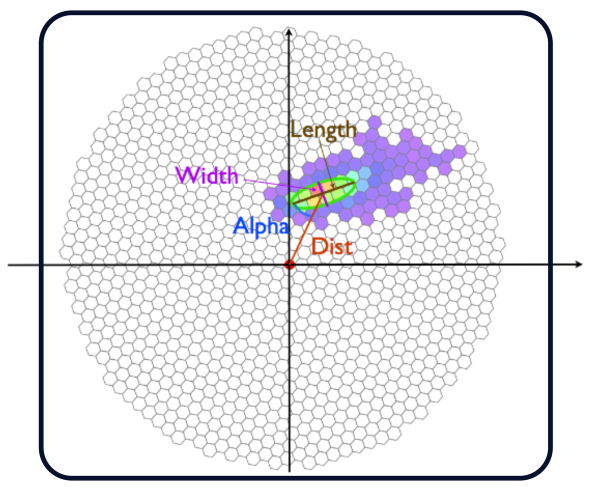



Fig. 3: $\gamma$-rays produce ellipses in the camera. The *Hillas* parameters include width, length and position, used to reconstruct the direction and energy of the photon. For BL Lac case, the source would not be at the center [R. López-Coto (2015)].

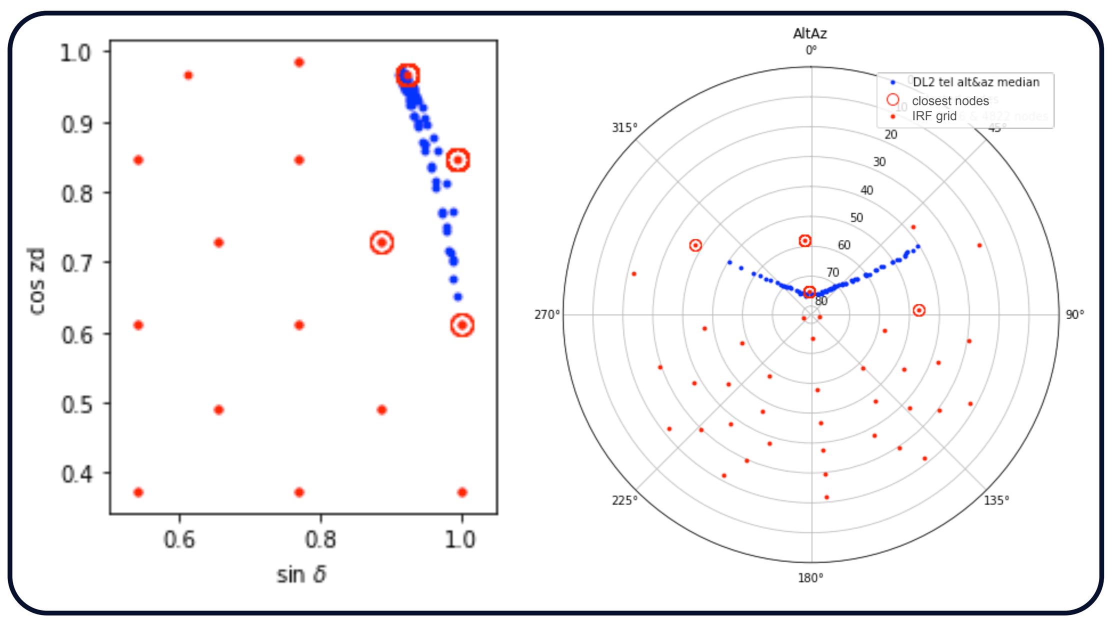
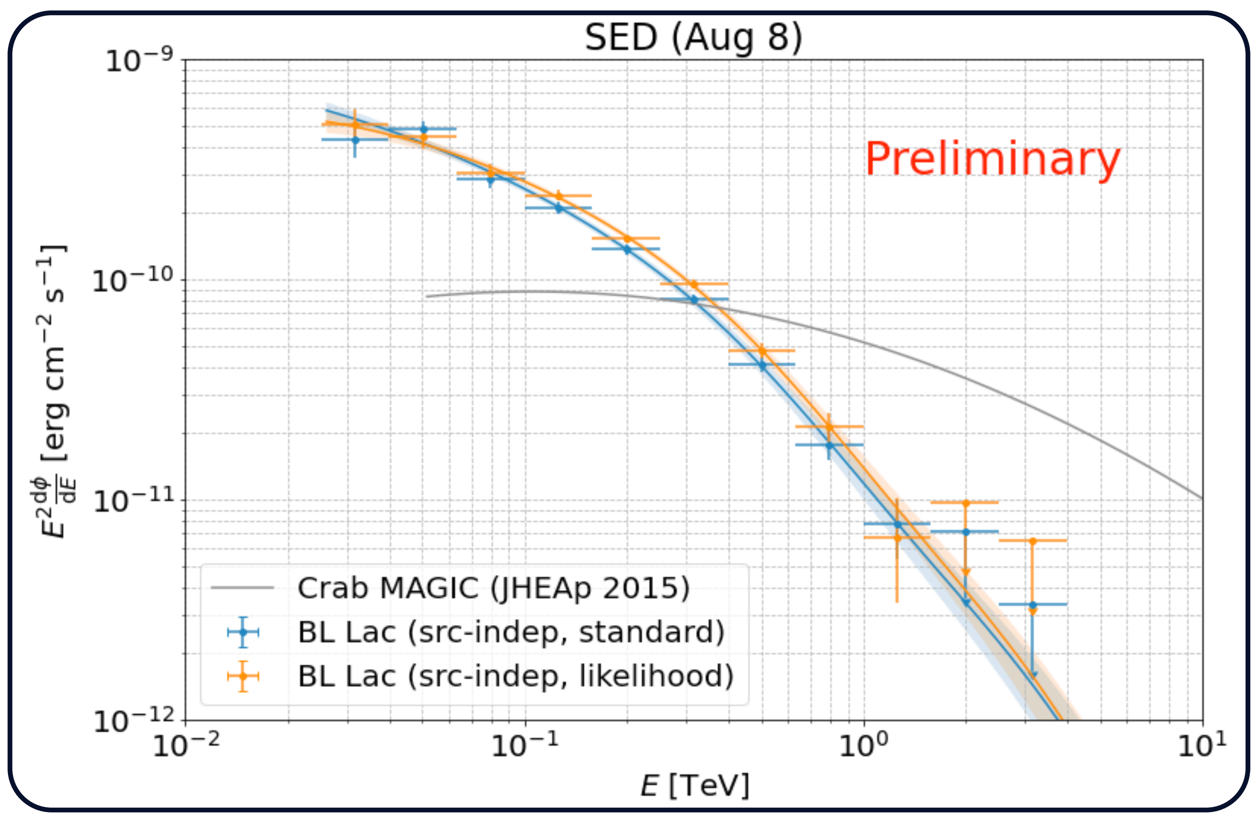


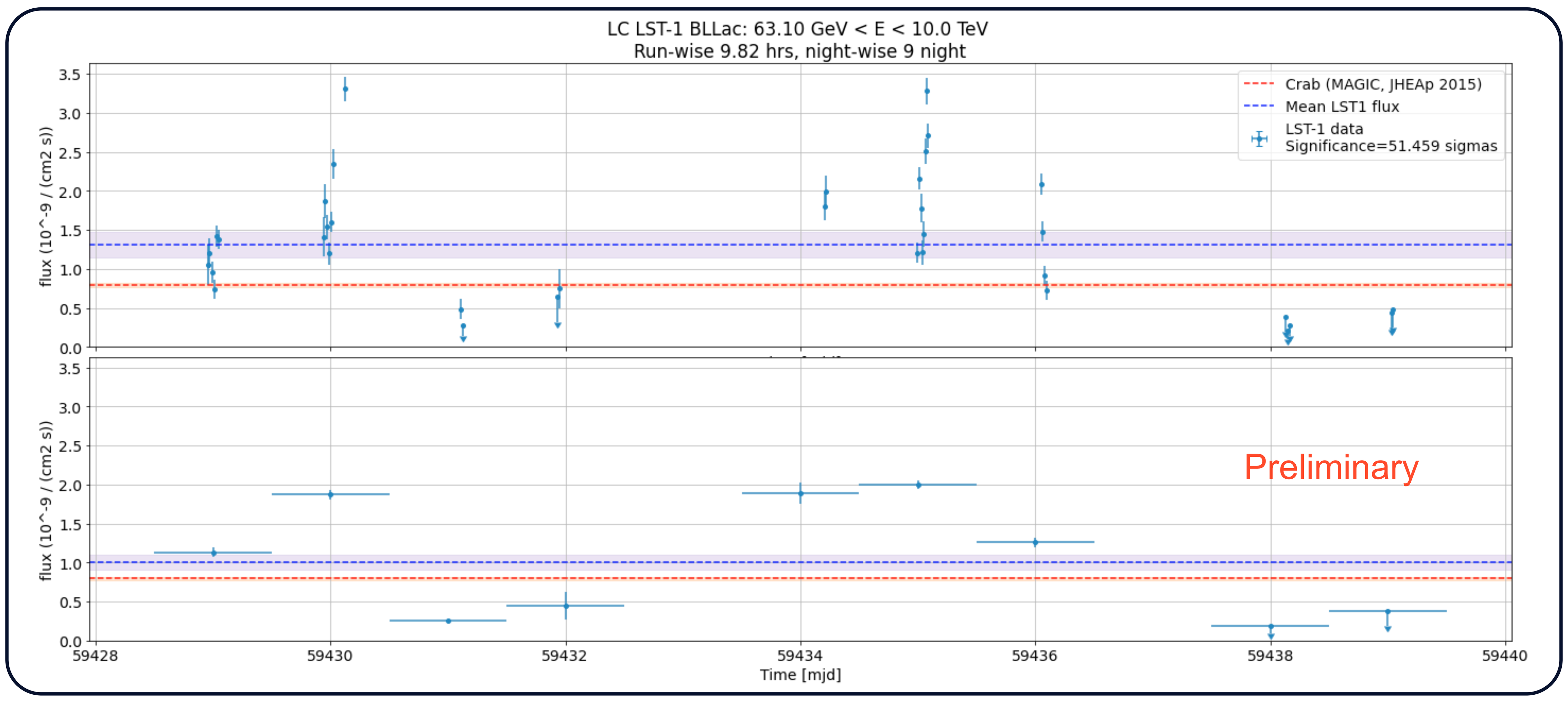

Fig. 4: Coverage of the MC simulations, equispaced in $\cos zd$ (zenith) and $\sin\delta$ (angle between the geomagnetic field and the particle direction) parameter space. These are the primary geographical parameters affecting shower development.

Until very recently, simulations had not been done specifically tailored for each source position in the sky. The new AllSkyMC production have allowed to determine more accurately the flux and spectral distribution of many sources, including BL Lacertae.

## Results

We have detected the VHE $\gamma$-ray signal from BL Lacertae, the namesake of its blazar class, from energies down to 25 GeV, close to the lower target energy of the array, up to 3 TeV; producing the SED and LC shown here. The results showcase the source in its brightest recorded flare, displaying very strong intra-night variability.




Figs. 5 & 6: Preliminary lightcurve for August 2021, during BLLac flaring episode, and preliminary SED for the night of the peak, 8th of August.