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CTAO LST COLLABORATION

# Detection of the Geminga pulsar to energies down to 20 GeV with the first Large Sized Telescope of CTAO

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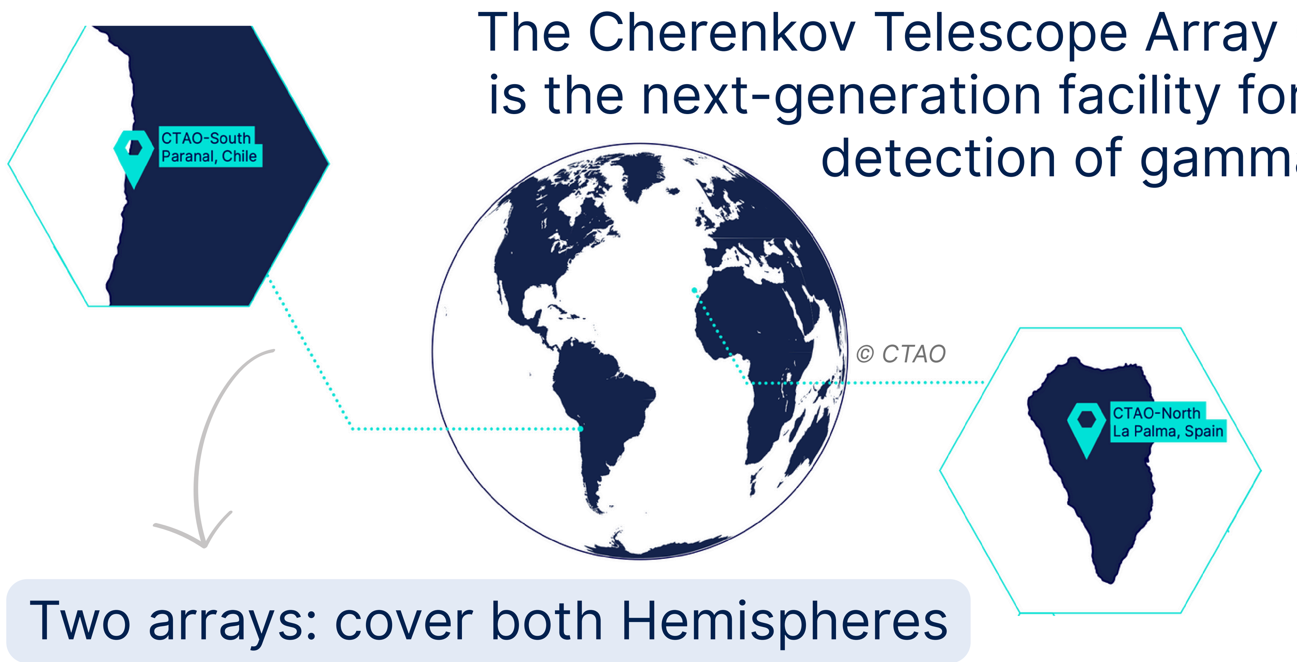
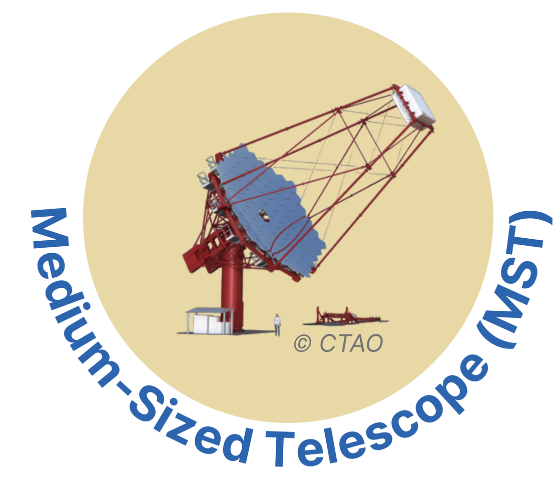
## GET TO KNOW THE INSTRUMENT

The Cherenkov Telescope Array Observatory (CTAO) is the next-generation facility for the **ground-based** detection of gamma rays.

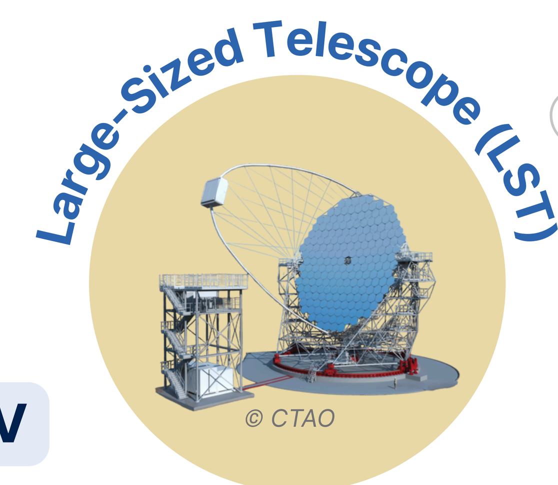



Two arrays: cover both Hemispheres

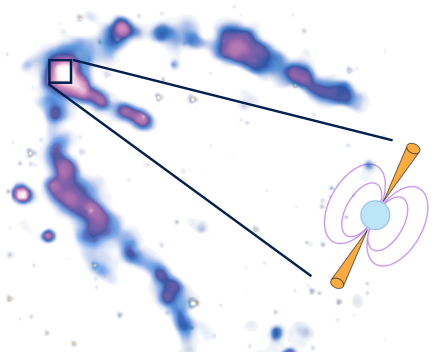

Three Cherenkov telescope designs: cover **20 GeV - 300 TeV**

**The LST-1 is the first LST of CTAO-North**




## THE OLDEST VERY-HIGH-ENERGY PULSAR

The recent detection of Very-High-Energy (VHE) emission from the Crab [1] and Vela [2] pulsars by imaging atmospheric Cherenkov telescopes (IACTs) revolutionised the field of gamma-ray pulsars. **This discovery challenges the capability of classic curvature-radiation-based models to explain the overall gamma-ray emission from MeV to TeV energies.**



© Chandra X-ray telescope

**Geminga** (PSR J0633+1746) is the archetype of a **radio-quiet middle-aged gamma-ray pulsar**, as well as the third IACT-detected pulsar [3]. Despite its spectrum not reaching TeV energies, it is the **oldest (τ ~ 340 kyr) pulsar observed at such high energies** to date. The 15-75 GeV spectrum observed by MAGIC is well fitted by a **power law with Γ = 5.62 ± 0.54**, which could be interpreted as the smooth transition from a curvature-radiation-dominated to an inverse-Compton-dominated regime at higher energies (> 100 GeV).

## OBSERVATIONS AND ANALYSIS

The LST-1 observed Geminga between December 2022 and March 2024, for a total of **60.1 hours of good-quality data at zenith angles below Zd < 50°.** 90% of the observations were taken at Zd < 25° to ensure a **low energy threshold in the analysis**. We also analysed 16.6 years of Fermi-LAT data to extend the spectrum to 100 MeV.

## LST-1 PHASEOGRAM OF GEMINGA

**Improved result** (P2 = 12.2σ, P1 = 2.6σ) **compared to MAGIC telescopes** (P2 = 6.3σ, P1 = 0.3σ) **in less observational time** (60 hours vs 80 hours).

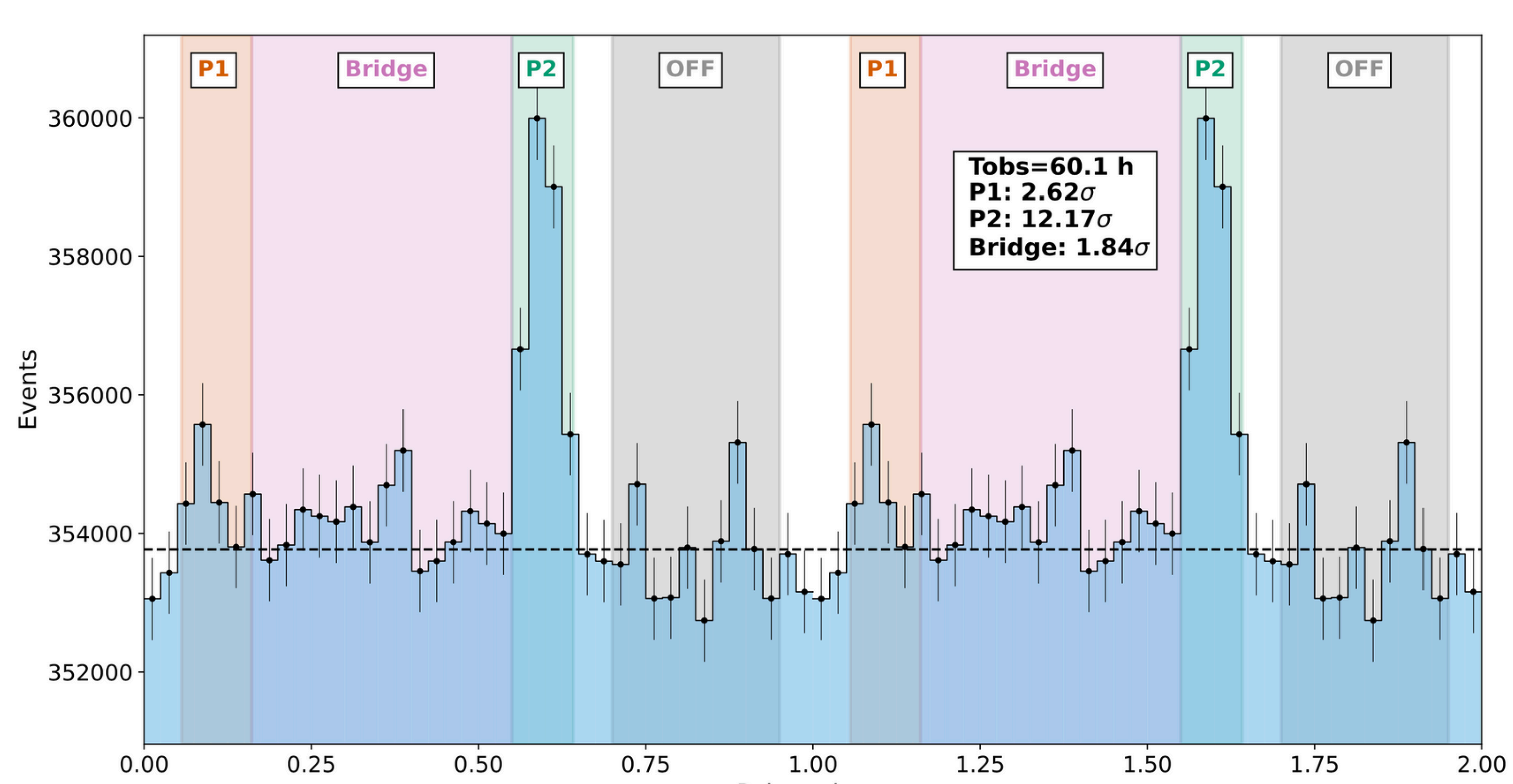



*Fig 1: Geminga phaseogram as observed by LST-1 in 60.1h, shown over two rotational periods. The phase regions for P1, P2, and Bridge are highlighted. The horizontal dashed line represents the average background level.*

## LST-1 SPECTRUM OF P2

**Power law spectrum with $\Gamma = (4.5 \pm 0.4_{stat})^{+0.2_{sys}}_{-0.6_{sys}}$**

Compatible with MAGIC

No curvature detected

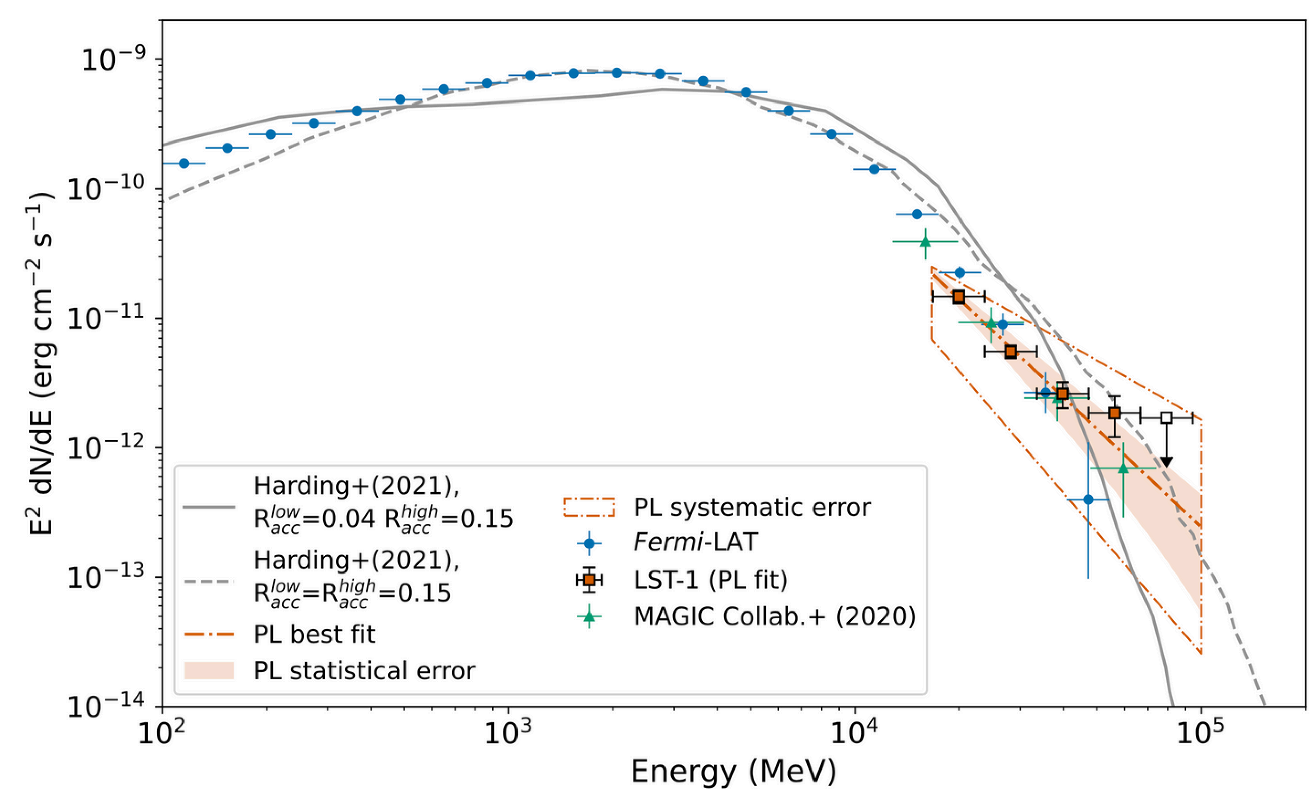



*Fig 2: Geminga's P2 spectrum, showing the LST-1 and Fermi-LAT points of this work and the MAGIC result of [3], compared to the predictions of the model described in [4] on the synchro-curvature emission from Geminga.*

**Synchro-curvature models based on acceleration in the current sheet [4] may explain some phenomenology.**

## WHAT NEXT?

The results prove that the **LST-1 is an excellent telescope for pulsar observations**, and improved results are expected to be achieved with the full array. We also estimated **~ 30 hours** will be needed **for the array of four LSTs of CTAO-North to detect P1**. Future observations will help us to better constrain the spectrum of the peaks and thus improve the comparison with theoretical models.

**REFERENCES:**
[1] Aliu et al., 2011, Science 334, 69; [2] HESS Collaboration et al., 2023, Nat. Astr. 7, 1341; [3] Acciari et al., 2020, A&A 643, L14; [4] Harding et al., 2021, ApJ 923, 194

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