Very High-Energy Gamma-ray observations of the Galactic magnetar SGR 1935+2154 with the CTAO Large-Sized Telescope prototype

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ABSTRACT

Magnetar flares are one of the possible explanations for Fast Radio Bursts (FRBs). The Soft Gamma Repeater (SGR) 1935+2154 is the first known source linked to an FRB and arises from a Galactic magnetar.
We report on the observations performed on SGR 1935+2154 with the Large-Sized Telescope prototype (LST-1) to search for a possible very high-energy counterpart of its typical keV-MeV emission. While we did not detect significant signal from this source, we set upper limits to the flux of its persistent and burst emission.

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1 - INTRODUCTION

SGR 1935+2154 is a Galactic magnetar with a persistent emission at a few keV, and transient emission of short (≈0.1s), irregular, non-thermal bursts at keV–MeV during occasional activity periods.
SGR 1935+2154 provided the first evidence of **FRB-magnetar connection** in April 2020, when its short bursts detected by INTEGRAL[1] and AGILE [2] were observed to be associated with FRB emission detected by CHIME [3].

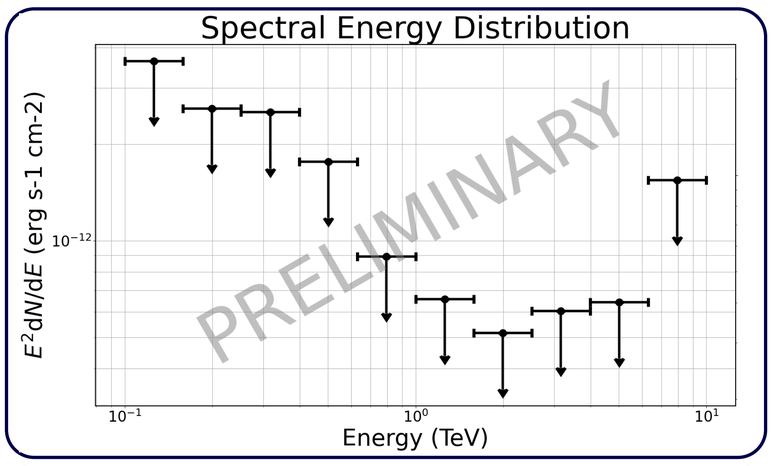

Fig. 1: Upper limits on the SED of the persistent emission of SGR 1935+2154 (≈25h observations).

2 - OBSERVATIONS

LST-1 observed SGR 1935+2154 for ≈38h in 2021, 2022 during periods of known keV-MeV activity reported in Science Alerts (GCNs, ATels) by space satellites.
LST-1 observed it simultaneously to the **Time of Alert** (ToA) of 9 bursts that triggered high-energy satellites (Fermi-GBM, NICER, Konus-Wind, GECAM).

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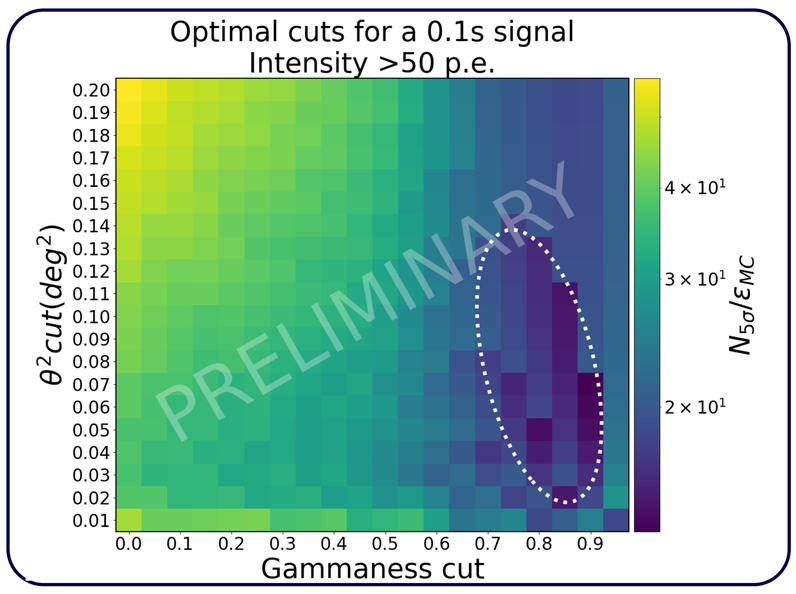

Fig. 2: Sensitivity as a function of the burst cuts. Optimal cuts region in the ellipse.

3 – PERSISTENT EMISSION

We selected ≈25h of good quality data to perform a **stacked spectral analysis**[4], using Monte Carlo (MC) simulations tuned to the level of **Night Sky background** (NSB) of our data, applying **energy-dependent cuts**, estimating the reflected regions **background**.
We did not detect any significant signal, and we placed upper limits on the Spectral Energy Distribution (SED) of the persistent emission (see **Fig. 1**).

4 – BURST CUTS

We computed analysis cuts **optimised** for the **detection of a 0.1s signal**[5]. For a grid of cuts in **gammaness**, **θ^2** and **intensity**, we computed the background rate from an OFF region, and the number of counts ($N_{5\sigma}$) required in 0.1s to get 5σ significance under the hypothesis of Poisson background. Optimal cuts minimise $N_{5\sigma}$ over the cut efficiency on MC (ε_{MC}). We find an **optimization region** for $\theta^2 \approx 0.08$ deg^2, gammaness≈0.75, intensity≈50p.e. (see **Fig. 2**).

5 – TRANSIENT EMISSION

We applied the burst cuts to compute photon list, IRFs and upper limits (ULs) on the **[0.1-10] TeV** burst emission of SGR 1935+2154, in **0.1s** intervals around the 9 ToAs simultaneous to LST-1 observations.
The average UL is $\mathbf{2.2 \cdot 10^{-8}\ s^{-1}\ cm^{-2}}$, the stacked UL over 0.9s is $\mathbf{3.0 \cdot 10^{-9}\ s^{-1}\ cm^{-2}}$.
We searched for non-simultaneous bursts on every observation run (e.g., **Fig. 3**). We found no bins with significant signal.

SUMMARY

LST-1 observed SGR 1935+2154 during periods of high activity in 2021 and 2022. Data analysis does not show any significant detection of signal from the source. We constrain both the persistent and, for the first time with LST-1, the transient very high-energy emission simultaneous to its keV-MeV bursts.

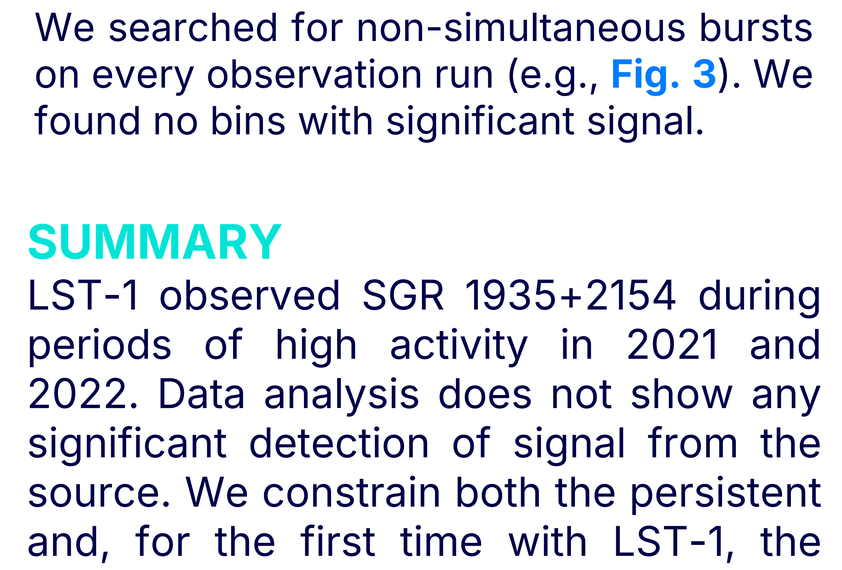

Fig. 3: Search for non-simultaneous bursts on a run. Data agree with a background distribution.

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