

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

1st VHEGAM Meeting– 2024/01/15

CTA LST Working Group

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https://www.cta-observatory.org/consortium_acknowledgments/

SGR 1935+2154

- *Galactic Magnetar in SNR G57.2+0.8 with Soft Gamma Repeater activity*

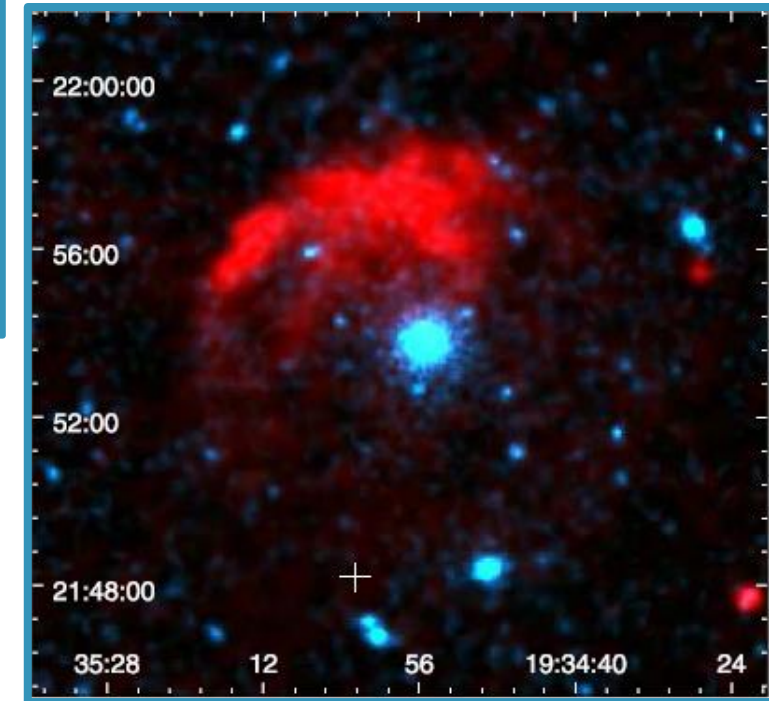
Persistent emission

- Visible in X-ray (*max few keV*).
- ULs in GeV from *Fermi-LAT* for other SGRs (Li & al., 2017)
- ULs in TeV from *HESS* for SGR 1935+2154 (Abdalla & al., 2021)

SGR Transient emission

- Occasional *activity period* with tens/hundreds *irregular, random* bursts within days-weeks
- Bursts on *0.1s* timescale at *keV-MeV*.
- Triggered by displacements of the NS crust.

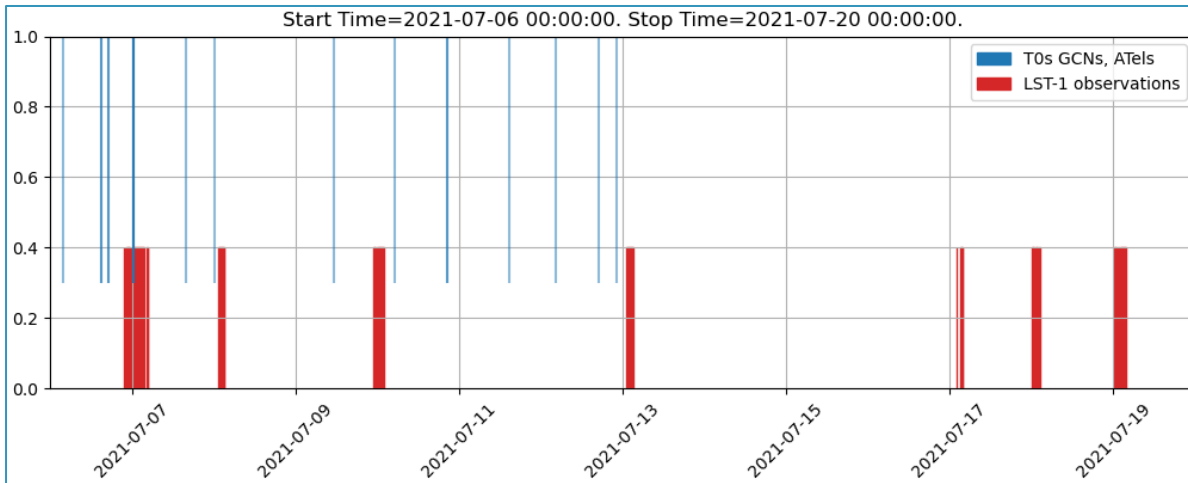
- April 28th, 2020: burst in coincidence with *Fast Radio Burst* detected by CHIME/FRB: *FRBs can be produced by Galactic magnetars!*
 - Also on October 14th, 21st, December 1st, 2022 (ATels 15681, 15707, 15792)
- **Is there TeV emission in coincidence with known SGR emission?**
 - Data can test *persistent* and *transient* emission.



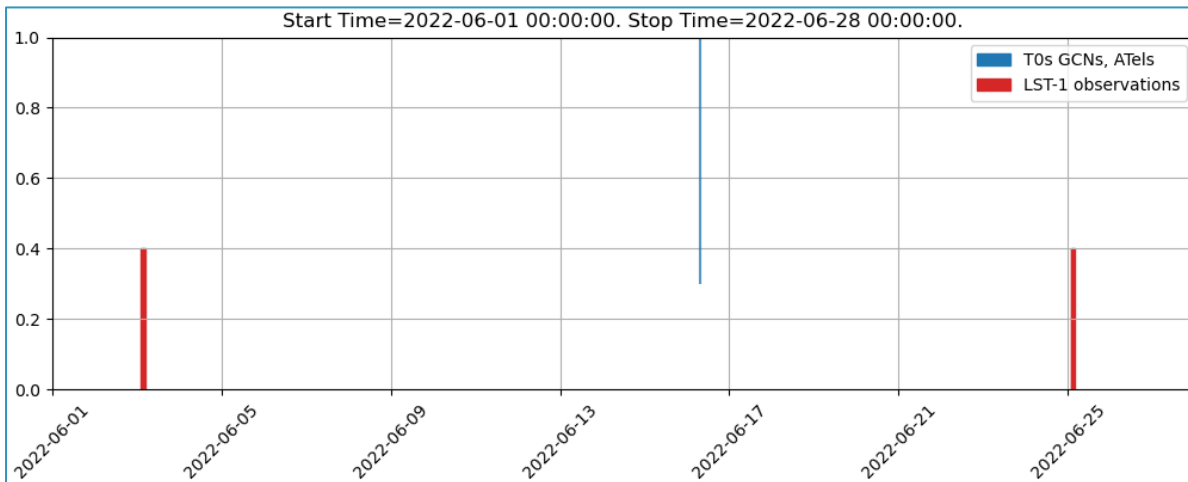
Credits: Zhou et al., 2020
SNR G57.2+0.8 environment. SGR 1935+2154 in the center.
Red: THOR 1.4 GHz. Cyan: XMM Newton.

History of Observations

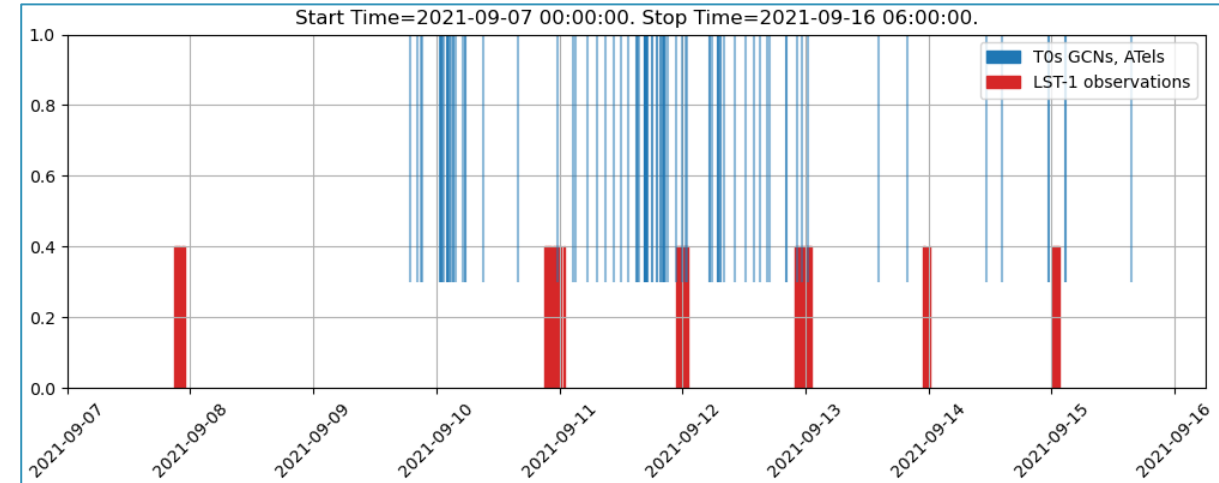
- **Multi-wavelength:** reconstructed from *Science Alerts*:
 - 150+ GCNs, ATels from Jun 2020 to Dec 2022 (latest)
 - 450+ Trigger Times (T0s) recorded



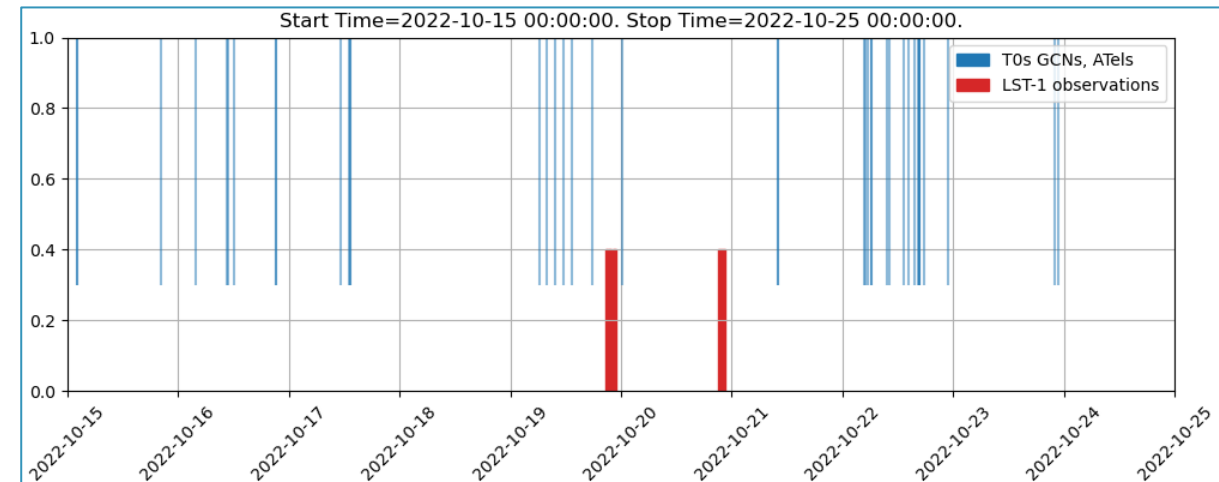
July 2021
June 2022



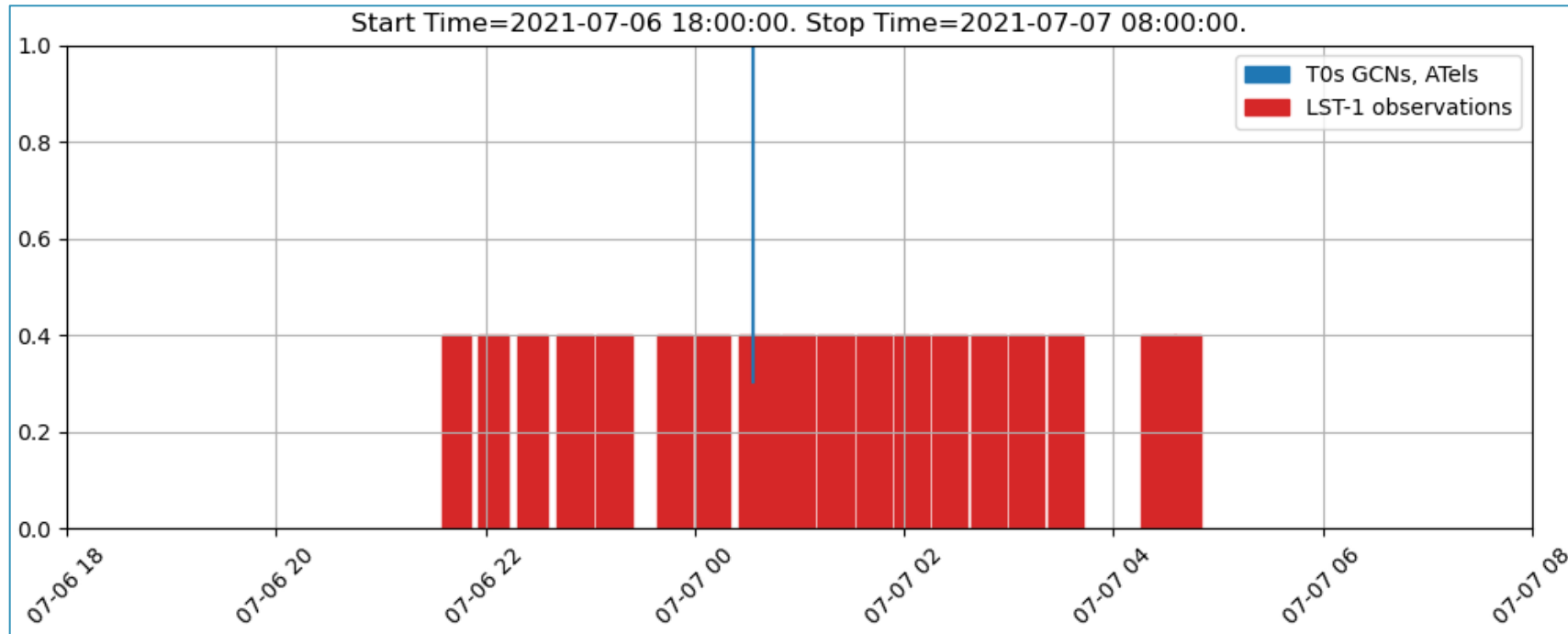
- **LST-1:** observations during periods of transient activity
 - **~40 hours**, 17 nights, 118 runs (Jul, Sep 21; Jun, Oct 22)
 - **7 T0s** during LST-1 observations



September 2021
October 2022



SGR 1935+2154: Known Burst History



Zoom on July 6th, 2021 observations

This alert has spectral analysis...
others only T0

**Bursts simultaneous to
LST-1 observations**

Telescope run	Alert T0	Instrument Triggered
LST-1 5163	2021-07-07 00:33:31.600	Fermi-GBM, Konus-Wind, CALET, GECAM
LST-1 6204	2021-09-10 23:40:34.460	Fermi-GBM (T0 only)
LST-1 6223	2021-09-11 22:51:41.600	GECAM (T0 only)
LST-1 6226	2021-09-11 23:55:45.872	NICER (Burst fluence)
LST-1 6228	2021-09-12 00:34:37.450	GECAM (T0 only)
LST-1 6245	2021-09-12 22:16:36.200	GECAM (T0 only)
LST-1 6251	2021-09-13 00:27:25.200	GECAM (T0 only)

SGR 1935+2154: LST-1 Data Analysis on Persistent Emission

DL1 -> DL2

- Monte Carlo simulations, Random Forests: *tuned* for *Night-Sky background*

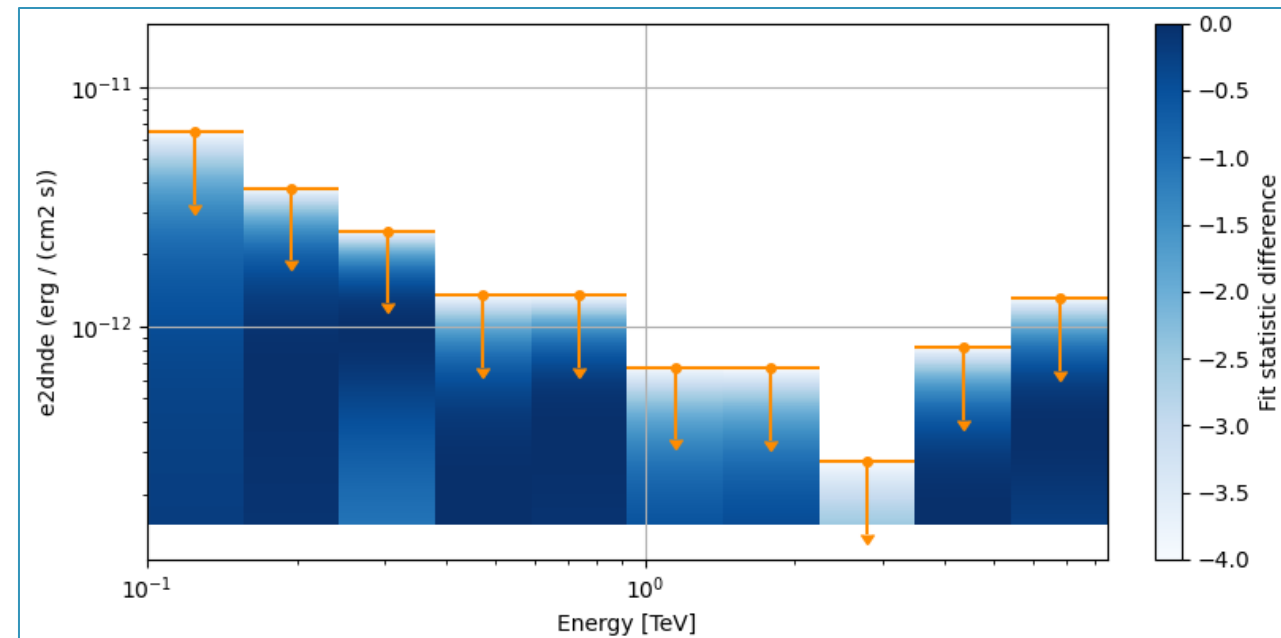
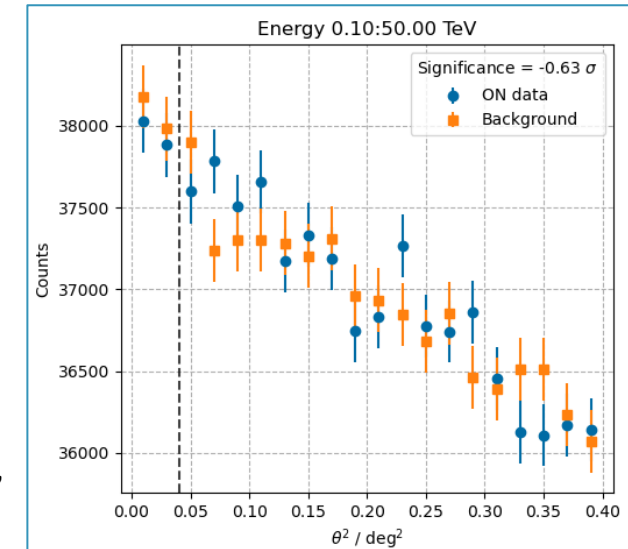
DL2 -> DL3 Cuts

- Standard cuts:
 - Intensity > 80
 - Gamma-Hadron Cut efficiency = 0.7
- Point-like, energy dependent IRFs
- Run selection on data quality
 - **≈25 hours**, 13 nights, 83 runs (Jul, Sep 21; Jun 22)

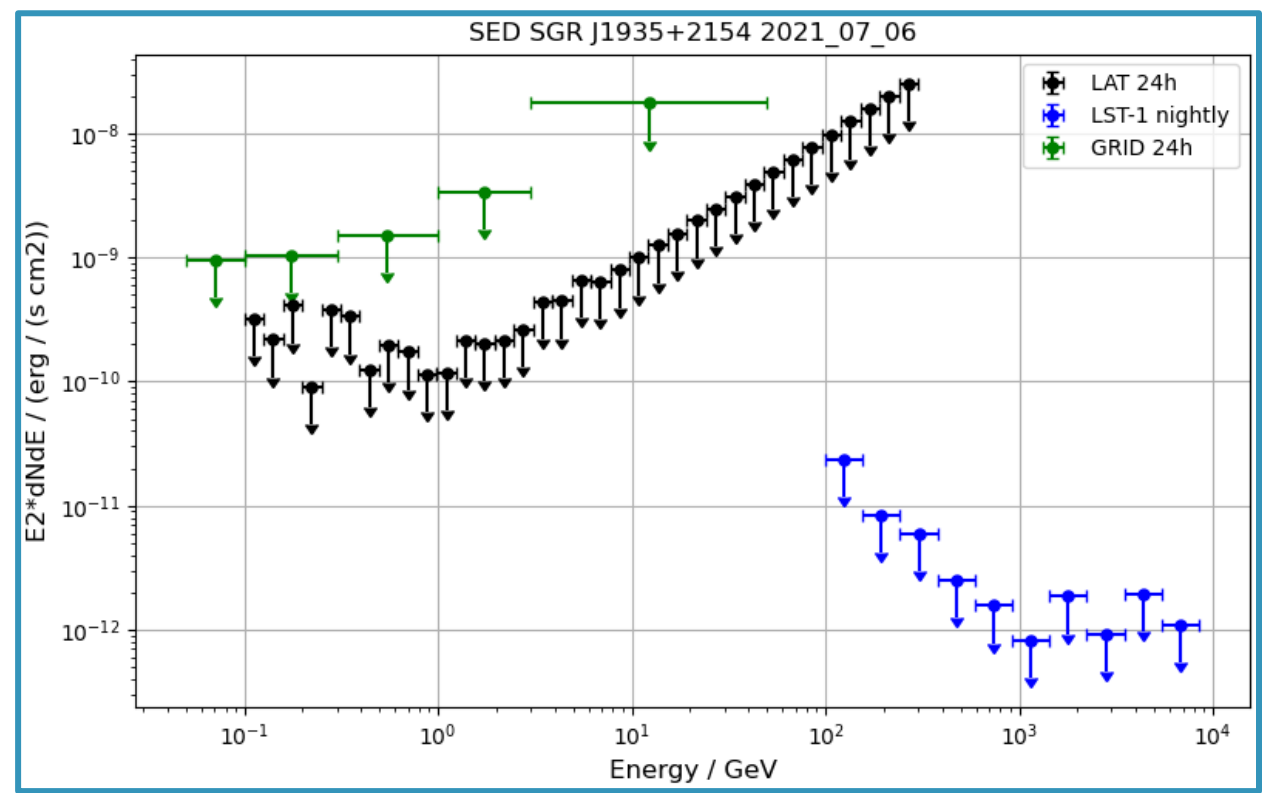
High-level analysis

- Stacked SEDs, Light Curve
- Night-wise Upper Limits
- **+ simultaneous GeV** (Fermi-LAT, AGILE)

SED Stacked (≈ 25 hours),
100 GeV – 10 TeV

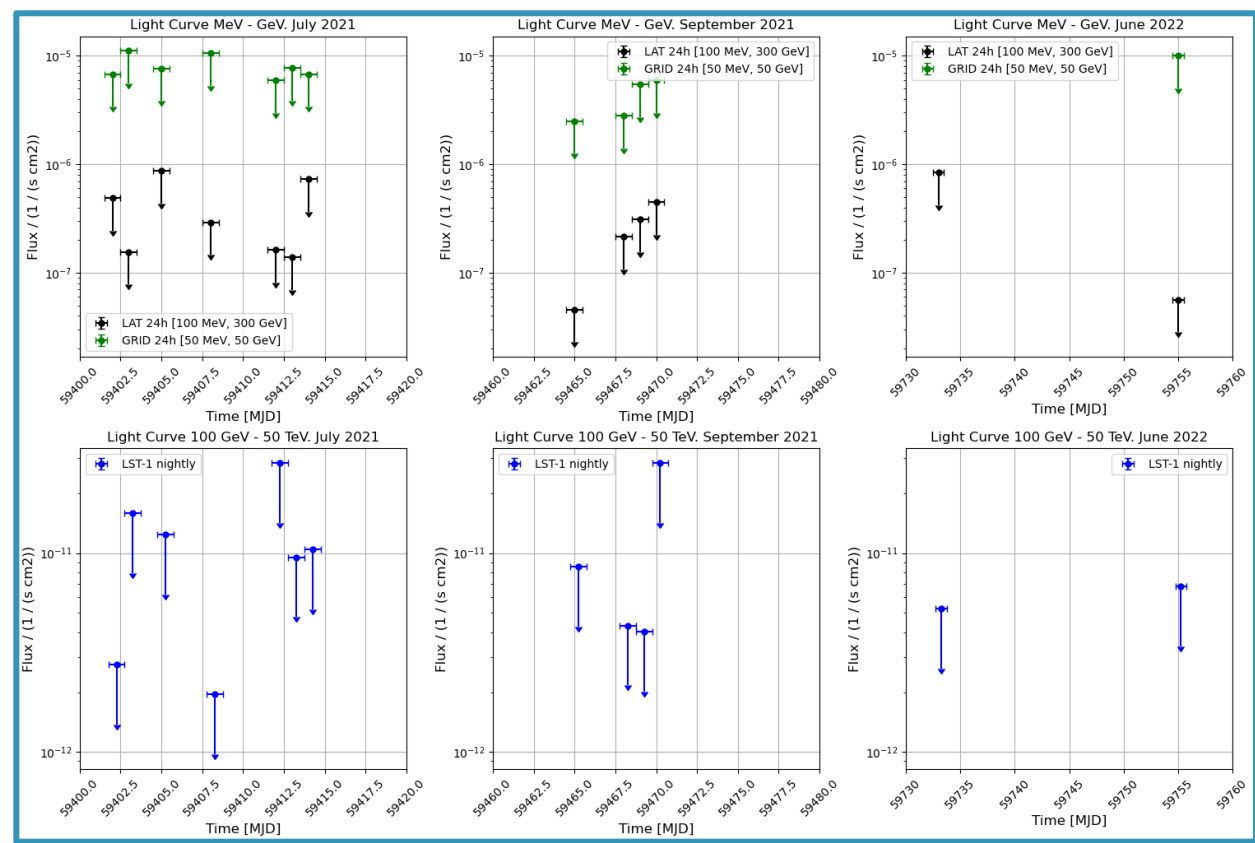


SGR 1935+2154: Nightly Upper Limits



Nightly SED July 6th, 2021

x13 Nightly SEDs ($\approx 2h$): one for each LST-1 observation night



SGR 1935+2154

- High interest source for MWL astrophysics
- Complex region: magnetar in SNR on Galactic plane
- History of known bursts reconstructed
- 7 external alerts simultaneous to LST-1 observations
- LST-1 good quality observations ≈ 25 h
- No detection, only Upper Limits

Next steps

- Transient emission: *Short scale analysis*
 - Optimize cuts for 10ms, 100ms signal:
 - Short-scale upper limits to transient emission
 - Blind Search in Time Series: search for bins with high significance
- Complex source, basic modelling requires expert
- Monitoring ATels for new bursts, request ToO