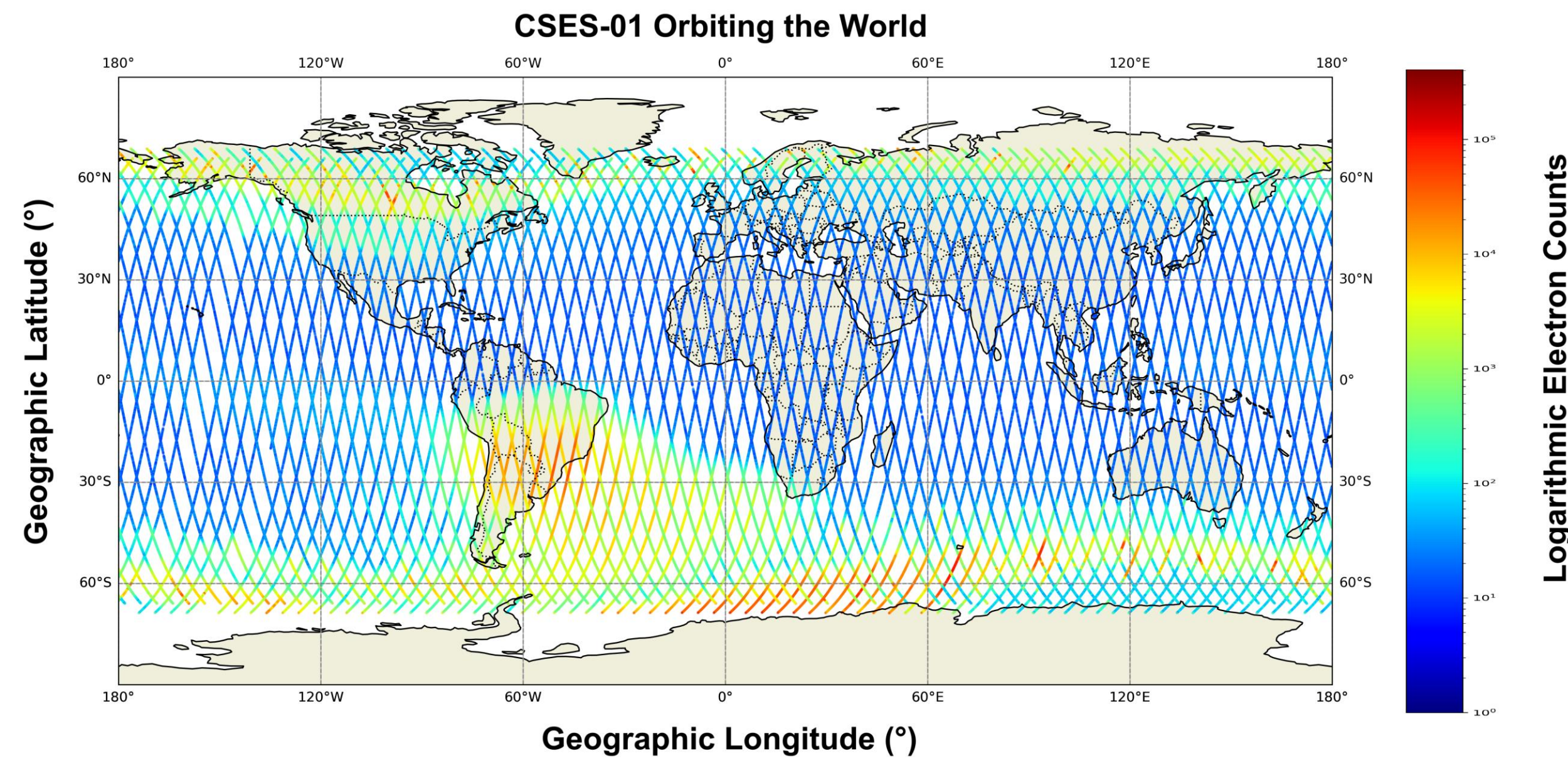
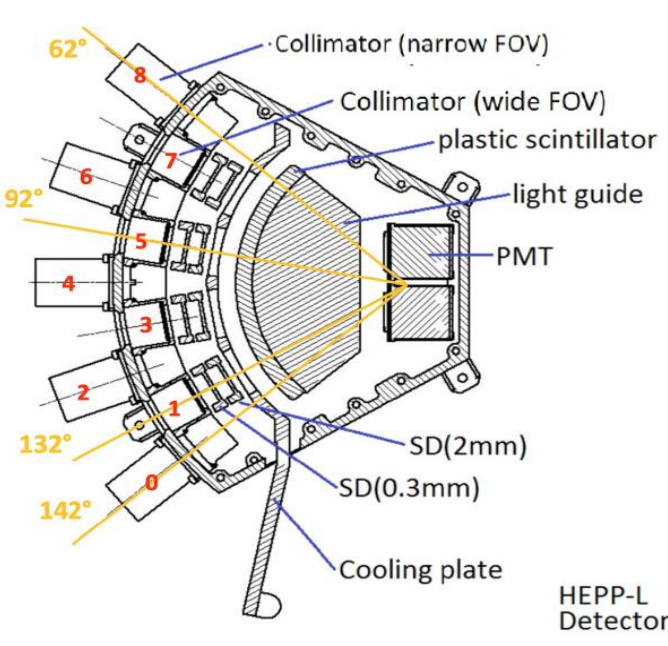


## CSES-01 Experiment

- Sun-synchronous Orbit;
- 507 km of altitude;
- +65° to -65° Latitude;

## HEPP-L Payload

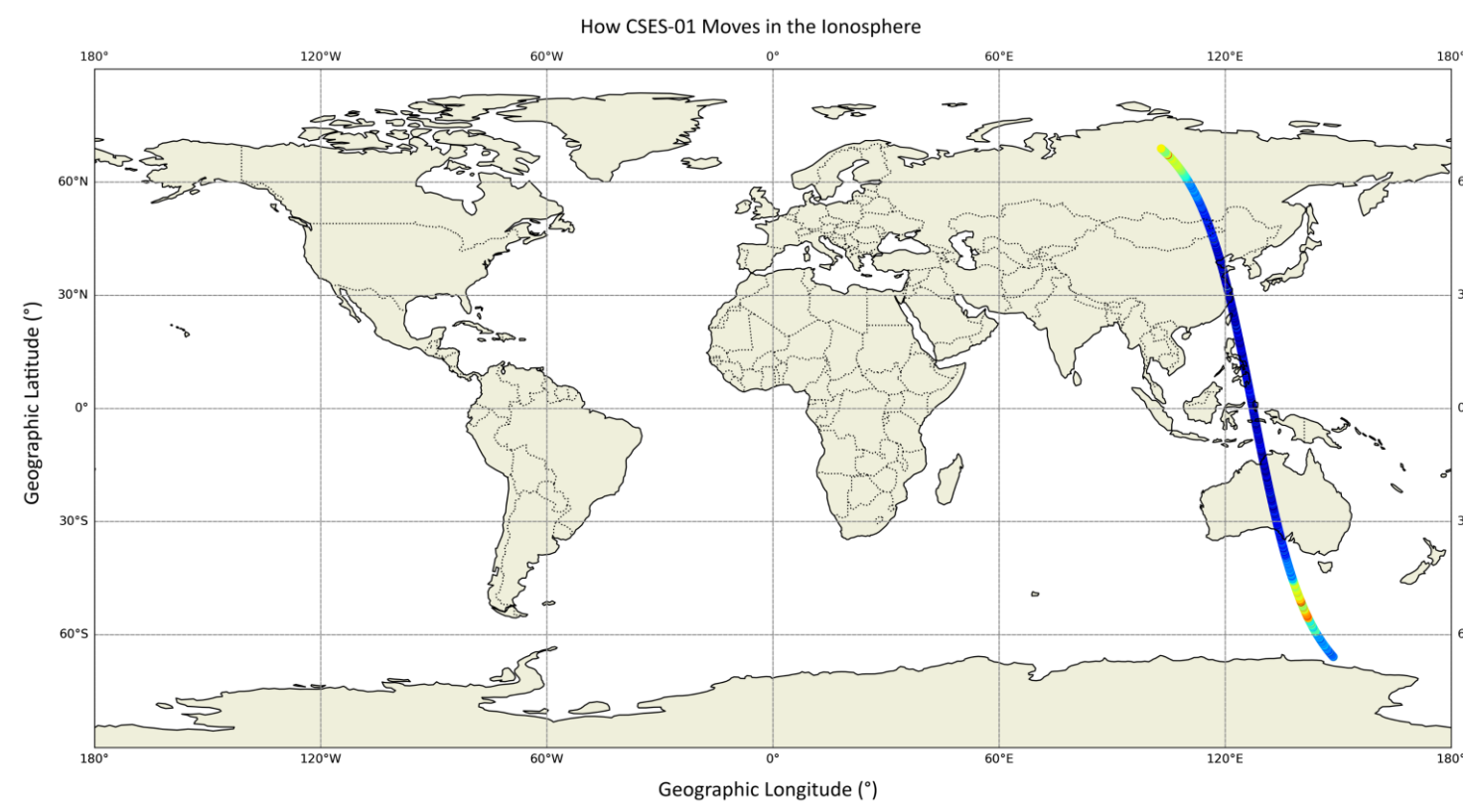
- Part of HEPP;
- Electrons (0.1 MeV to 3 MeV);
- Protons (2 MeV to 20 MeV);



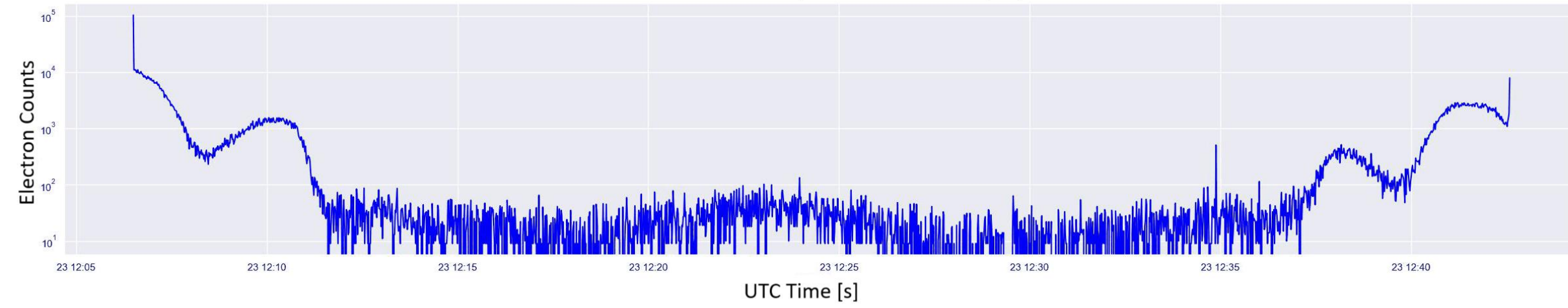
With the intent of developing miniaturized sensors able to measure flux particle variations in the ionosphere, such as the case of solar storms, a study is ongoing about the stability of particle fluxes in LEO orbit.

## Algorithm 1 : Moving Window Fit

Let's look at how a typical HEPP-L orbit looks like when plotting the electron rate as a function of the UTC Time. Some features are evident, like the Van Allen Belts at the sides of the temporal series.

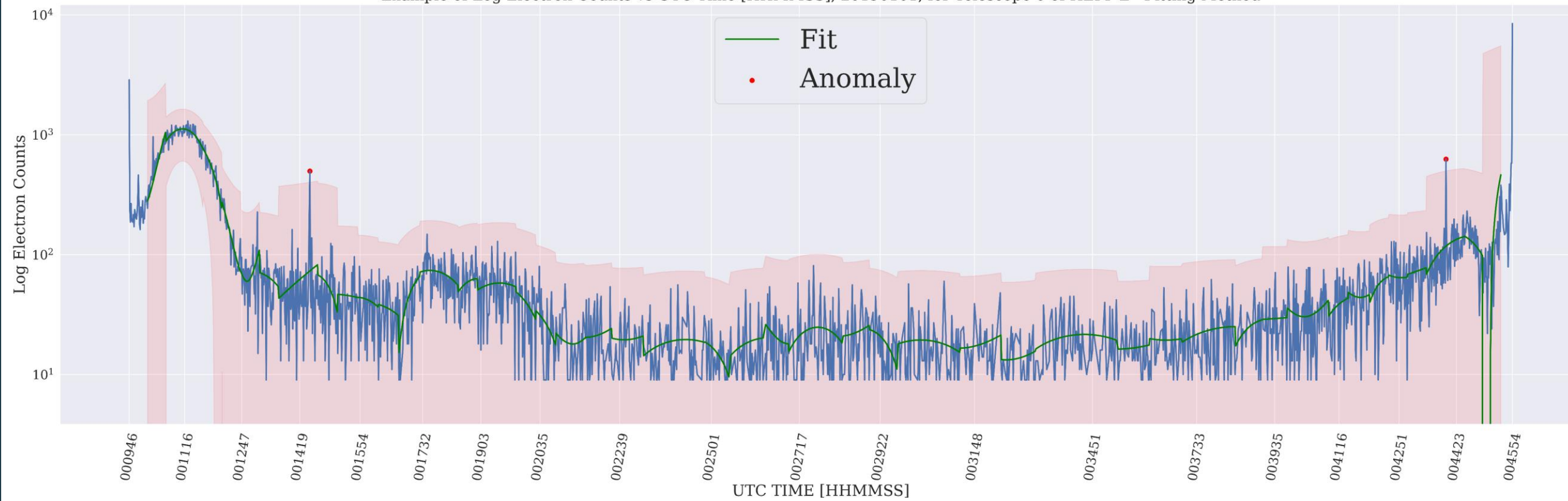


Electron Counts for Telescope 0 - 174081 - 2021/03/23



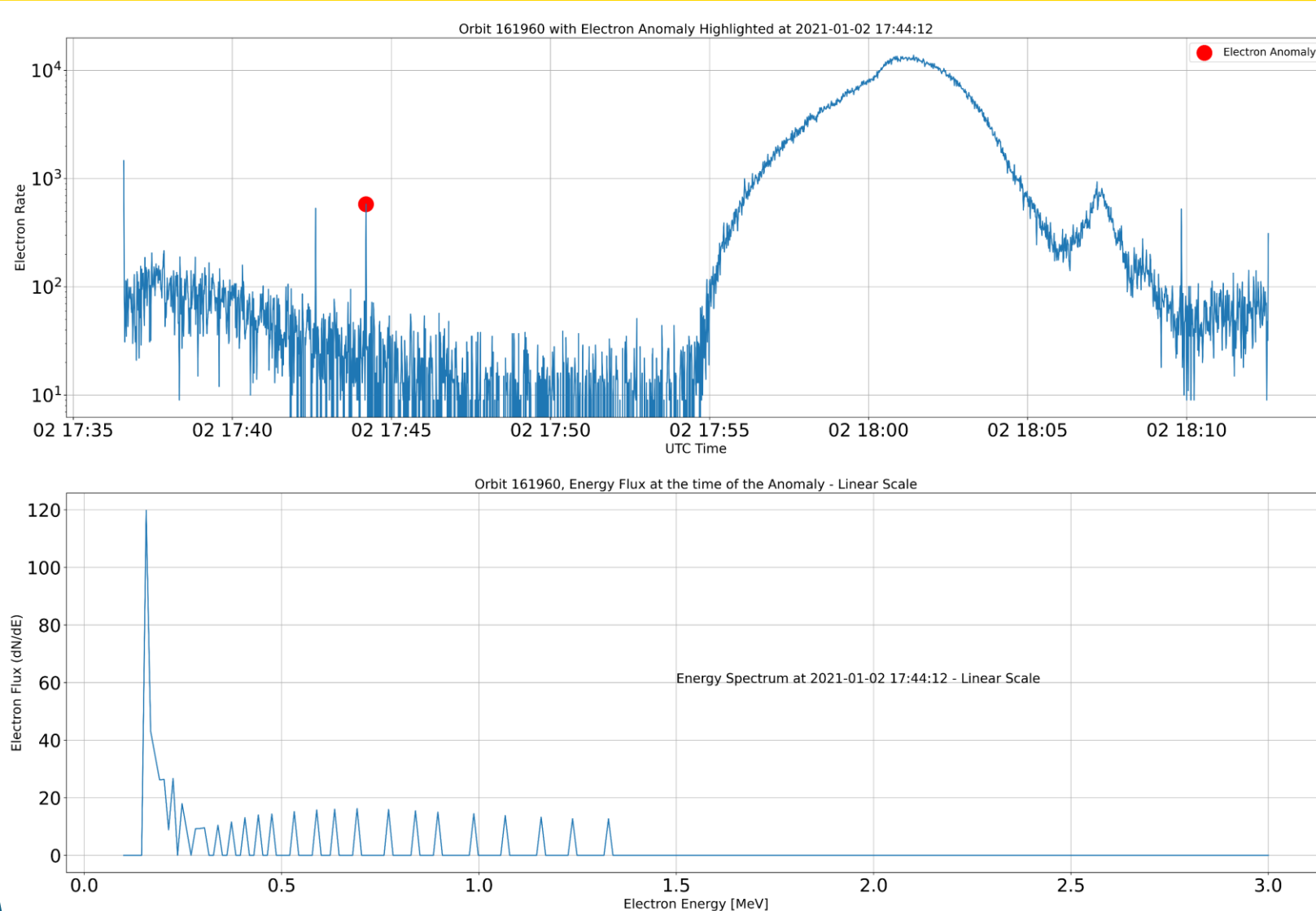
By fitting an electron count vs UTC time orbit with a 2° polynomial function with overlapping-and-moving windows of a given length, it is possible to extract an anomaly: this is the red dot, which solves for a larger than 5σ fluctuation above the flux

Example of Log Electron Counts vs UTC Time [HHMMSS], 20190101, for Telescope 0 of HEPP-L - Fitting Method



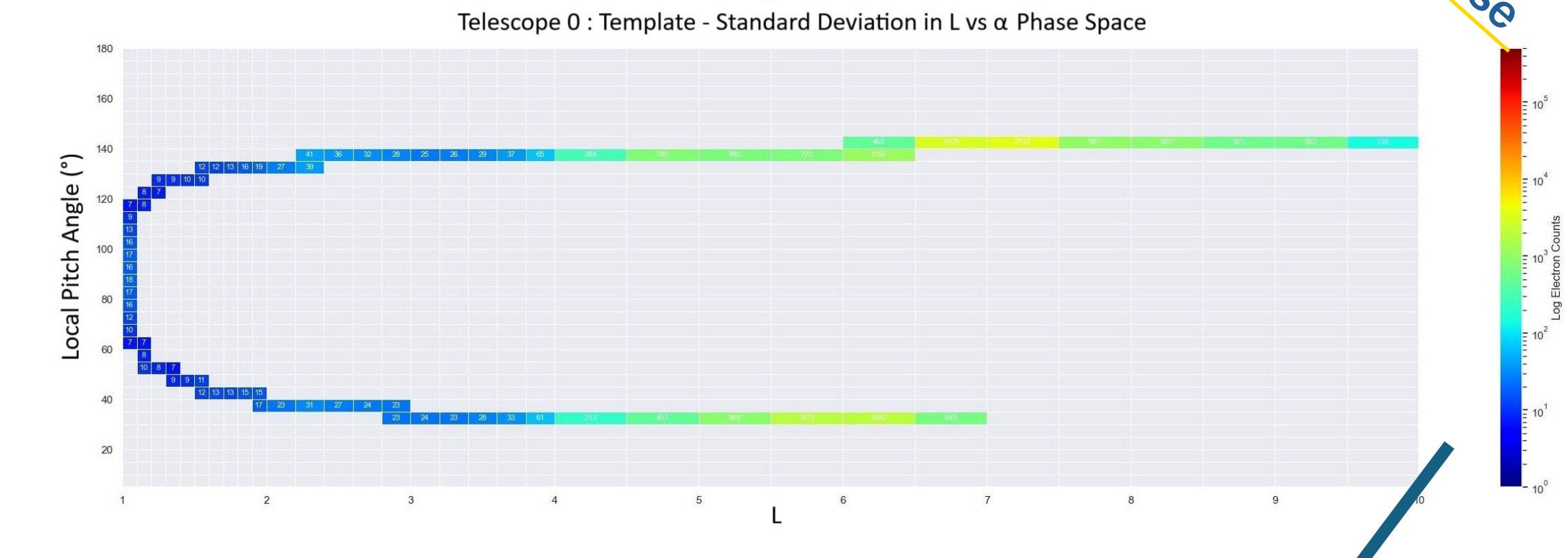
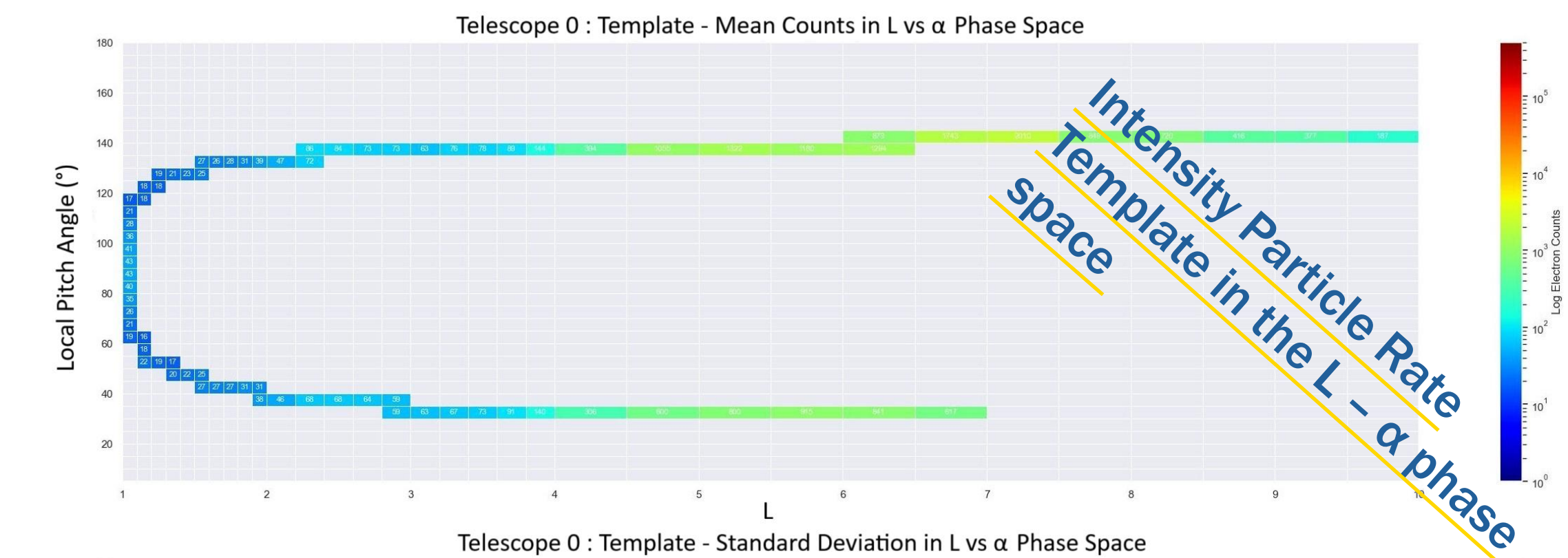
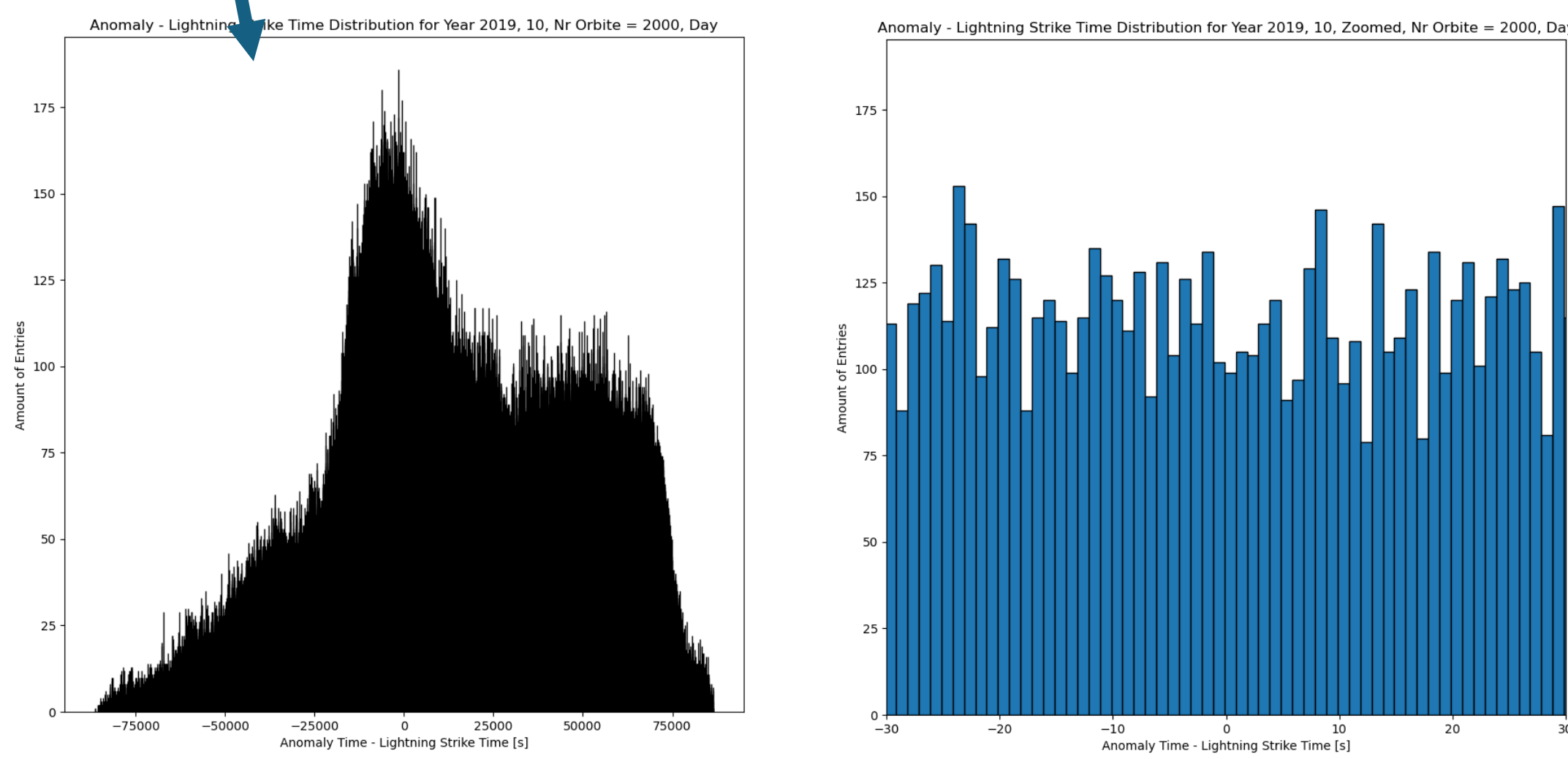
## Next Steps 1

HEPP-L has a time resolution of 1 second, but it has a good energy resolution. This will help in separating fluctuations in flux due to «lightning strikes» (lower energy) or due to «chorus waves» (higher energy).

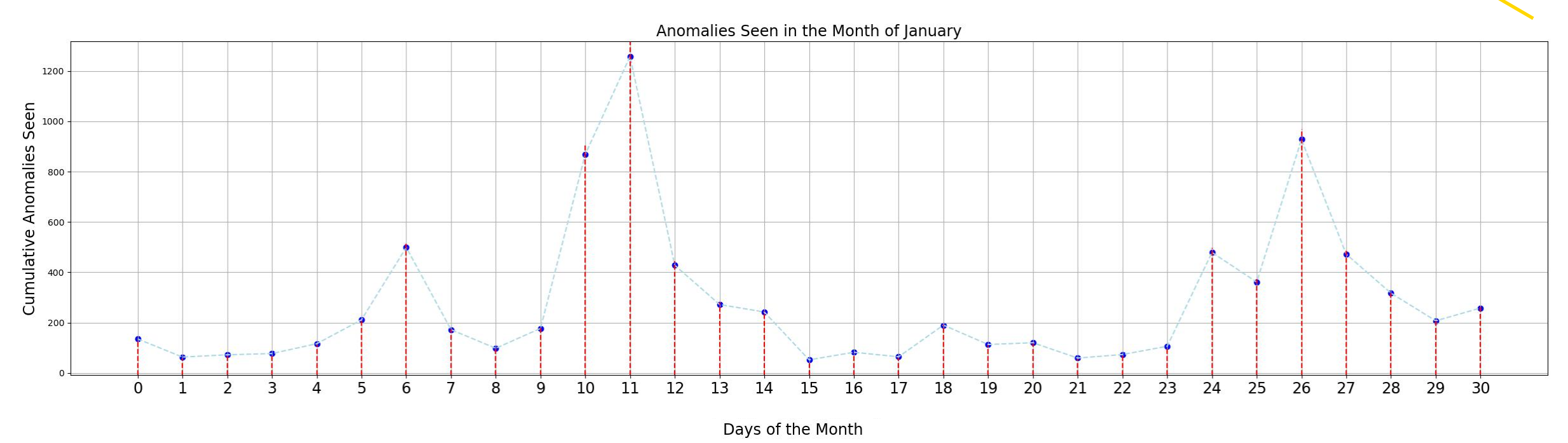


## Next Steps 3

Using the large statistically collected samples we will also study the association between particle burst and lightning electromagnetic emission.

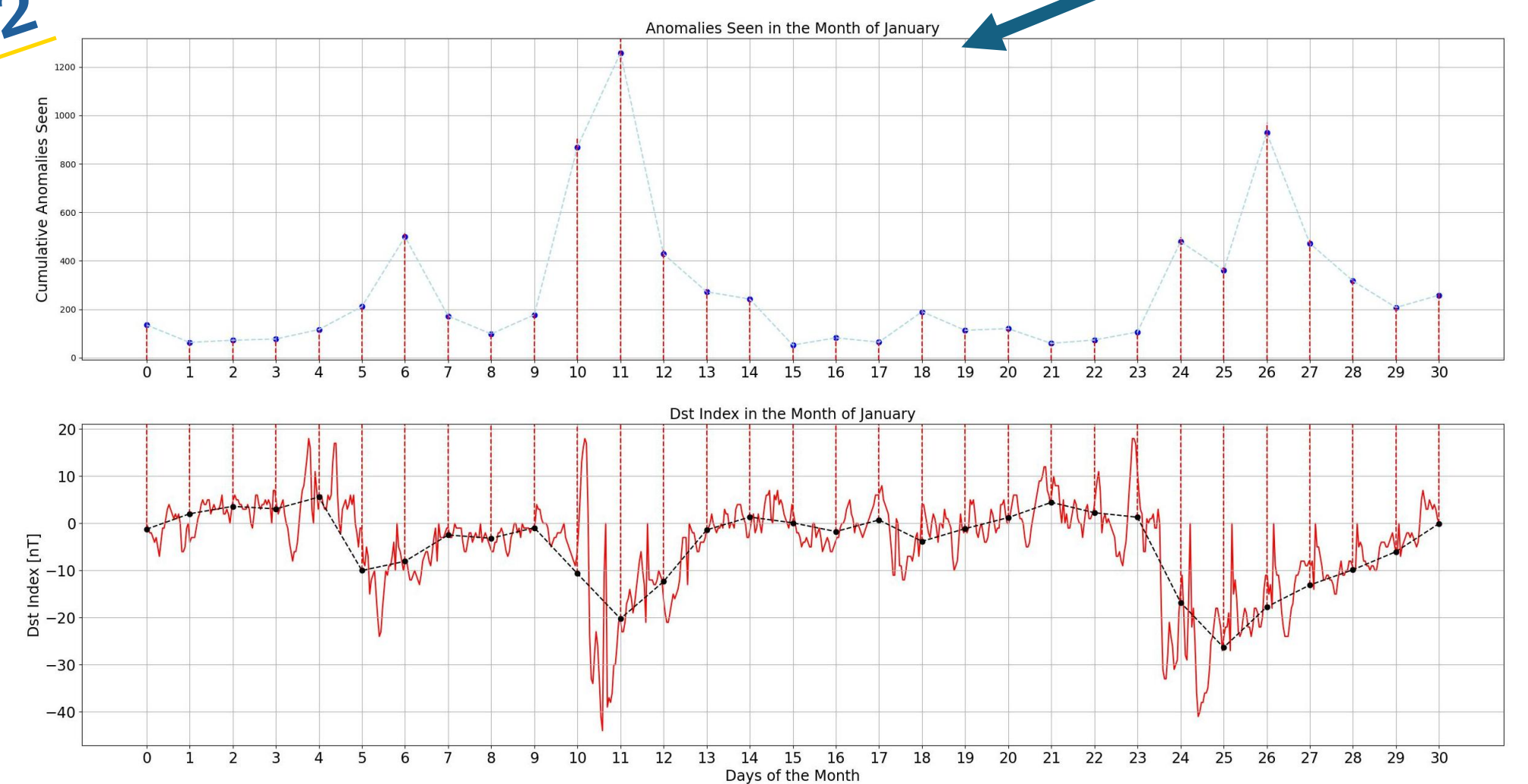


With the above method, the cumulative number of anomalies shows a typical behaviour during 1 month of data.



## Next Steps 2

We show a systematic study of the anomaly rate as a function of time and of the hourly DST index.



## Main references:

- Lu Wang et al, «Effects of Solar Proton Events Associated With X-Ray Flares on Near-Earth Electron and Proton Fluxes Based on ZH-1 Satellite Observations», *Frontiers*, 2022.
- A. Perinelli, F.M. Follega, «In-depth analysis of selected major solar events with the HEPP-L particle detector onboard CSES-01 in low-Earth orbit», *Proceedings of Science*, 2025
- Max Feinland, «Lightning-induced relativistic electron precipitation from the inner radiation belt», *Nature Communications*, 2024