Search for UV microbursts in auroral emission

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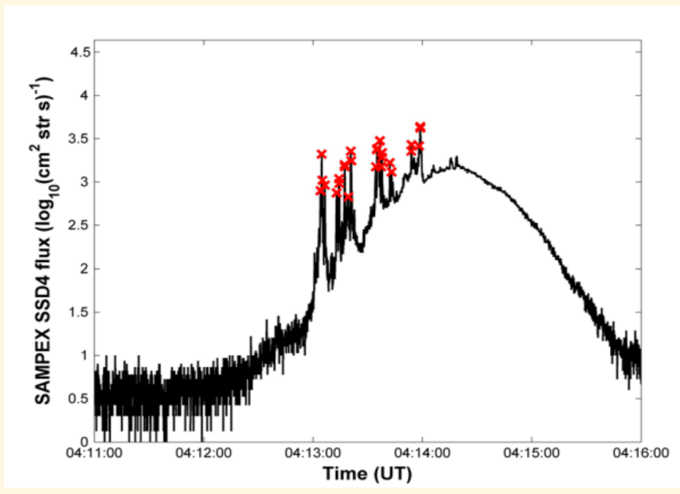
Abstract

A multichannel imaging photometer of PAIPS (Pulsating Aurora Imaging Photometers System) project based on the multi-anode photomultipliers (MAPMT) was installed at the Verkhnetulomsky Observatory. The detector measures atmospheric emission in a near-UV (300–400 nm) wavelength band in a single photoelectron mode providing high sensitivity. Oscillograms with a three different temporal resolutions were recorded: 2.5 μs, 320 μs and 41 ms. The high temporal resolution makes it possible to set the task of searching for a microburst of UV radiation in the submillisecond range. Such bursts can appear during the appearance and penetration into the atmosphere of relativistic electron microbursts. The search for this UV microbursts and their preliminary analyses was done in this work

1. Relativistic electron microbursts and Pulsating Aurora



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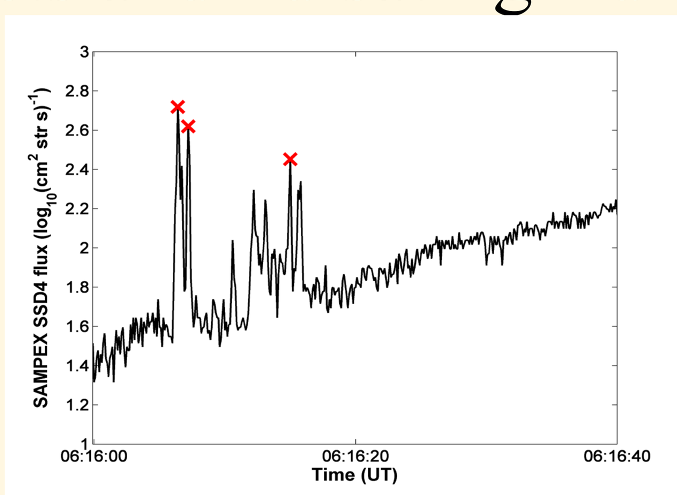

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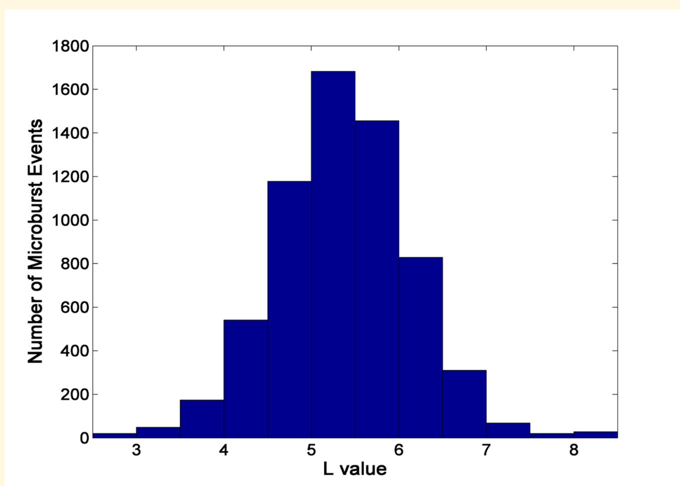

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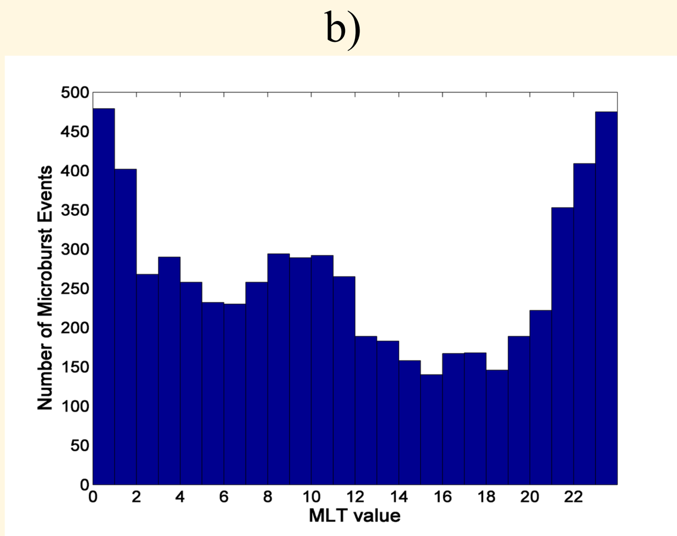


d)

Figure 1. Examples of REMs and results of analysing SAMPEX data [1].

Relativistic electron microbursts (REMs) are the intensive increasing of energetic electron (MeV energy range) precipitation from magnetosphere in a subsecond time scale. These microbursts were measured for example by the SAMPEX mission. Over 11 years of measurements, a huge database containing almost 200 thousand events of the REM type has been accumulated. There are two examples of these events shown in **Fig.1 (a)** and **(b)**. Such a volume of information made it possible to study in detail the distribution by MLT (**Fig.1 (d)**) and the distribution by the L-parameter of the Earth's magnetic field (**Fig.1 (c)**). It was shown that REMs are mostly related to the outer radiation belt and occur predominantly on the dawn-side, between 0 and 13 MLT[1]. In our work the MLT and date distributions also shown to compare with demonstrated in the article [1].

On the other and it was shown that REMs can be a high-energy part of pulsating aurora electrons which precipitate deeper in the atmosphere (down to 65 km). Recently, a strong correlation between REMs and Patchy Aurora was demonstrated[2].

3. Method of microbursts selection

Typical duration of the REM events measured by the SAMPEX mission is 70-100 ms [3]. The lower limit may be due to the time resolution of the HILT instrument. Thus we have analysed data in to modes: with 0.32 ms and 41 ms temporal resolutions (TR). Candidates for near-UV microbursts were selected as follows:

1) Each packet of 128 time samples was considered separately. The sum of 36 pixels in each MAPMT was used (edge pixels of MAPMTs are noisy).

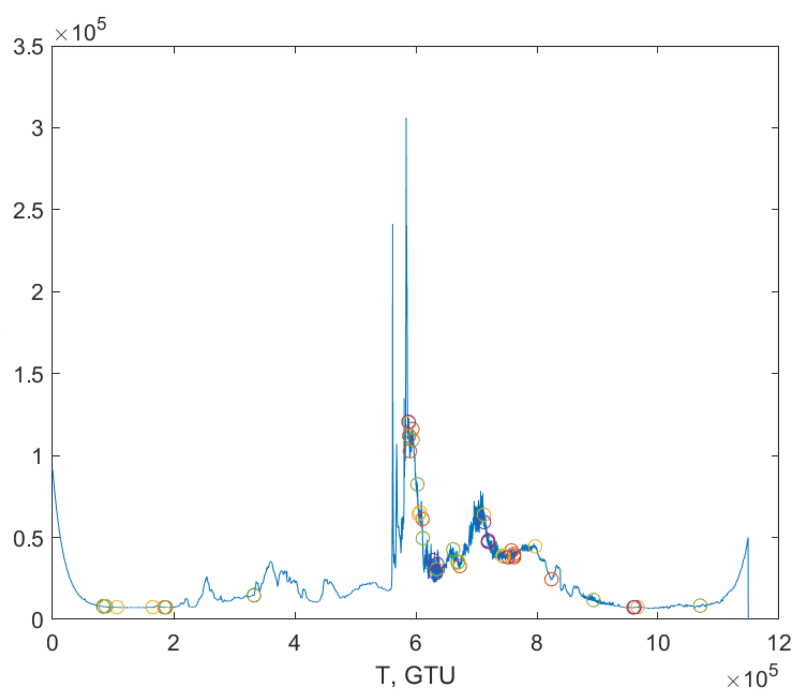
2) For each packet a base level (BL) was subtracted. As a BL a minimum moving average with 32 time samples length was used.

3) Peak find algorithm with the following parameters was used for peaks selection:

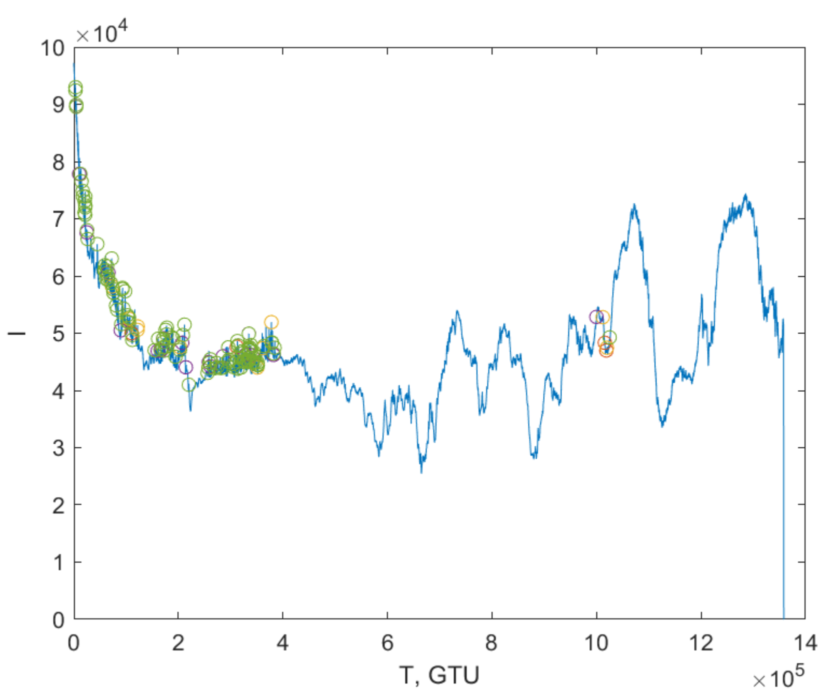
- ✓ minimum height: 5σ
- ✓ minimum width: 80 ms

For each events amplitude, moment of occurrence and width are recorded. All programs and scripts are written in MatLab.

There are some days with high activity during sunset in analysed data. Example is shown in **Figure 2 (b).** These events are not included in the statistics for analysis. In **Figure 2 (a)** the typical day with marked events is shown.



a)



b)

Figure 1. Examples of global light curves for 09.11.21 (typical day) and 10.12.21 (high sunset activity).

Conclusions

A high resolution of imaging photometer developed in SINP MSU an installed in Verkhnetulomsky observatory allows to search microbursts of NUV radiation in aurora region. A number of events similar in temporal structure to REM were found and preliminary analyzed. The possible interpretation of these events is relativistic electron precipitation in a form of microbursts. The presented results are the first step of NUV microbursts search. Further analyses and data selection is needed to exclude all instrumental effects and events of anthropogenic nature. This work is in progress now.

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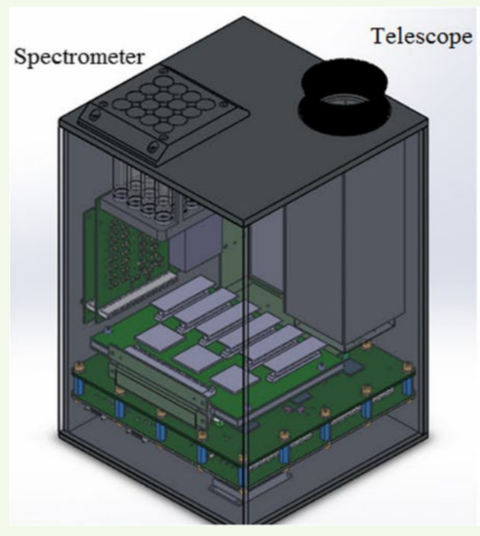
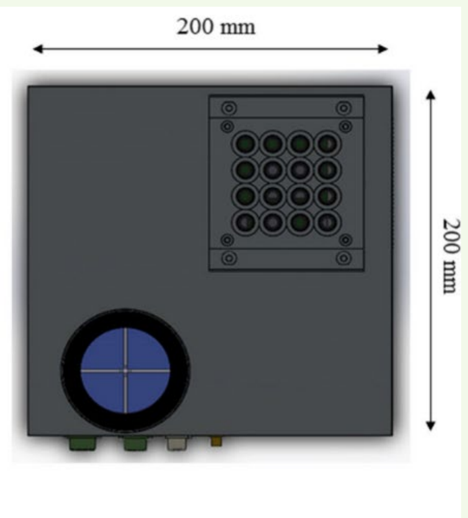
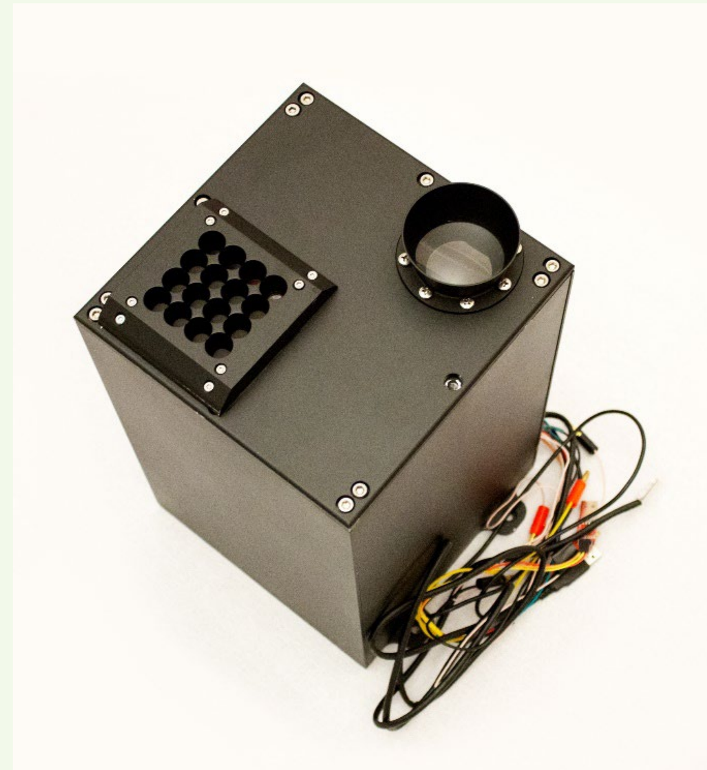
2. Imaging Photometer







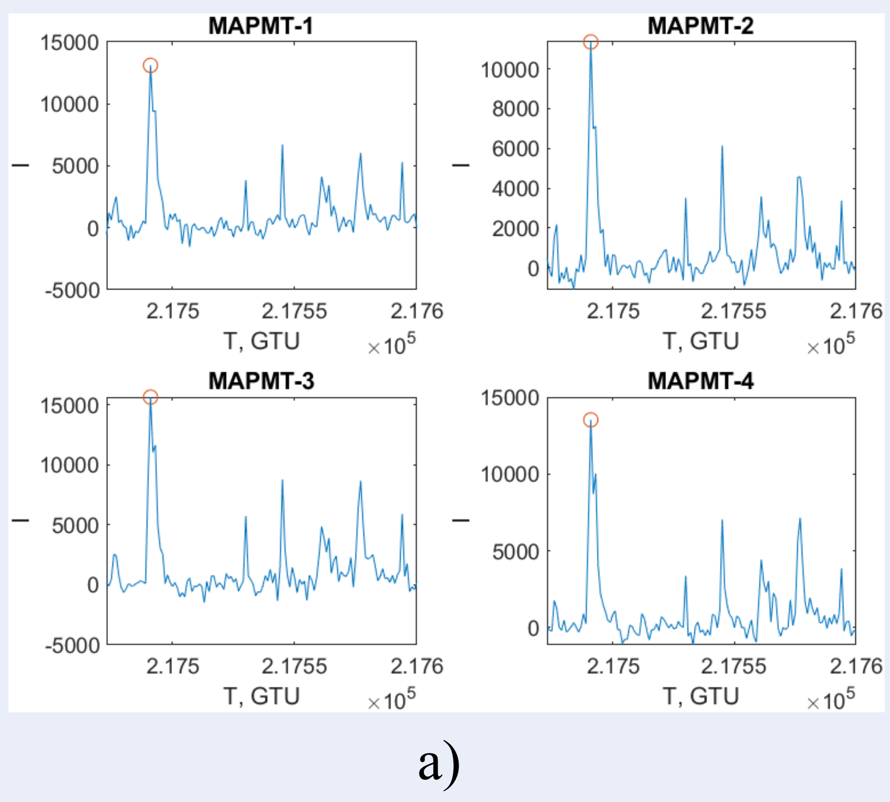
Parameters of photometer:

- ✓ 4 MAPMT (16×16 pixels)
- ✓ Temporal resolution
  - ✓ 2.5 μs (4 events per 5 s),
  - ✓ 320 μs (4 events per 5 s),
  - ✓ 41 ms (monitoring, continuous recording), 1ms since 09.2022
- ✓ FOV: $2\gamma_m = 18°$
- ✓ Angle resolution: $\Delta\gamma = 1.1°$ (~2 km on height 100 km)
- ✓ Aperture : $S = 19.6$ cm^2

4. Examples of NUV microbursts

57 nights of measurements (out of 163) were analyzed. In total, more than 700 events with a burst-like signal were registered. The example of registered event is shown in **Figure 3(a)**. Each light curve is a sum 36 of central pixels of MAPMT. The distribution of events on time of measurements (UTC) and distribution of events on date of measurements are presented in **Figure 3 (b)** and **(c)**, respectively. The dates with higher number of events does not look like days with increased geomagnetic activity. The data gap in the center of UTC distribution **(b)** is due to the fact that the detector does not work in the daytime.

Some interesting events were found during analysis of data recording with 320 μs temporal resolution. The example of narrow burst of signal shown of figure **(d)**. Clearly visible periodicity at a frequency of 100 Hz - anthropogenic glow.



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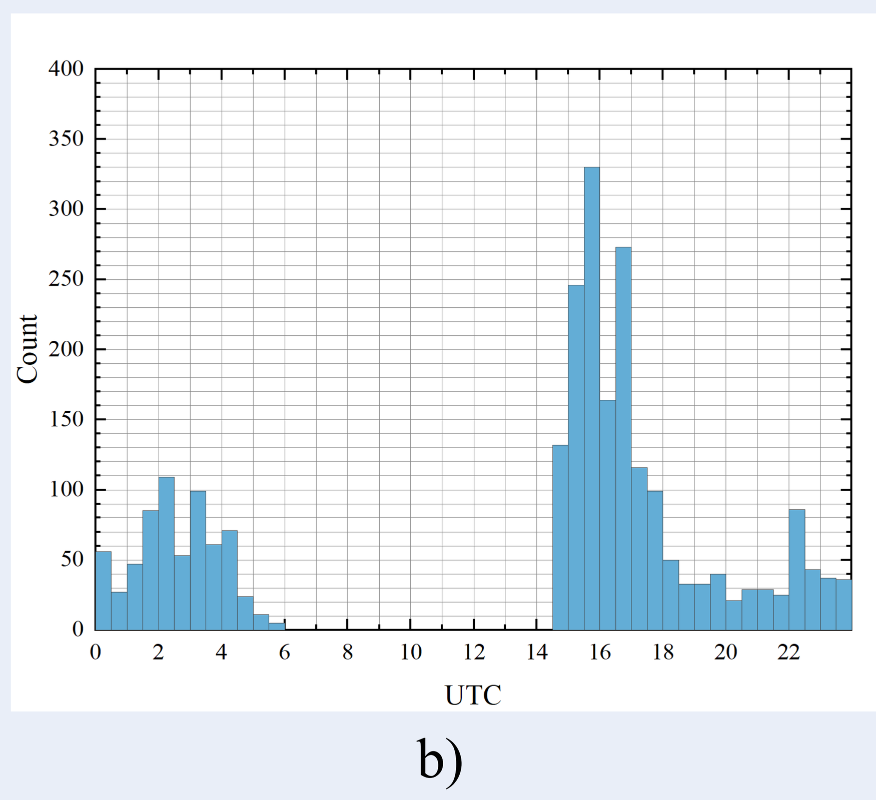

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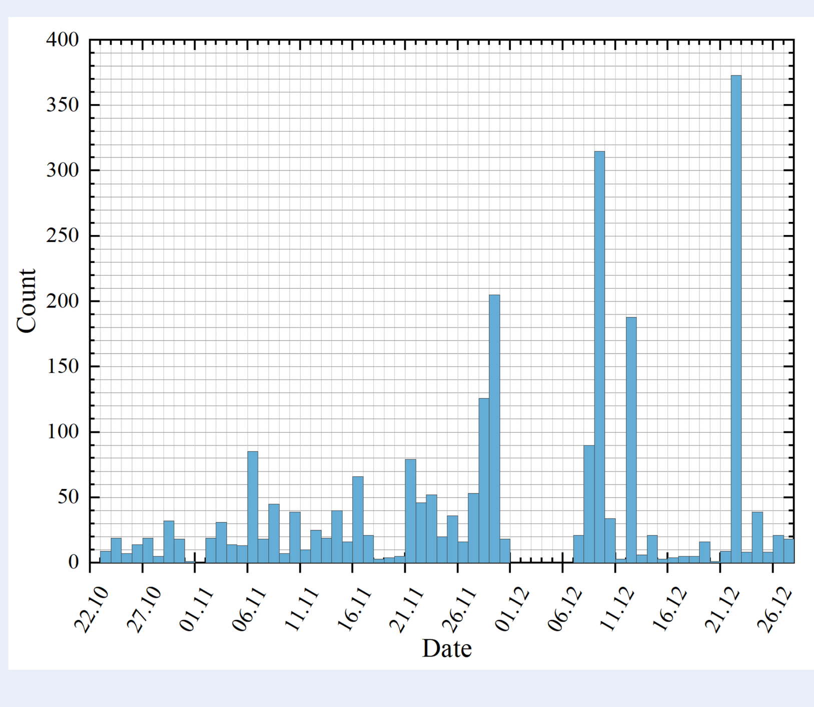

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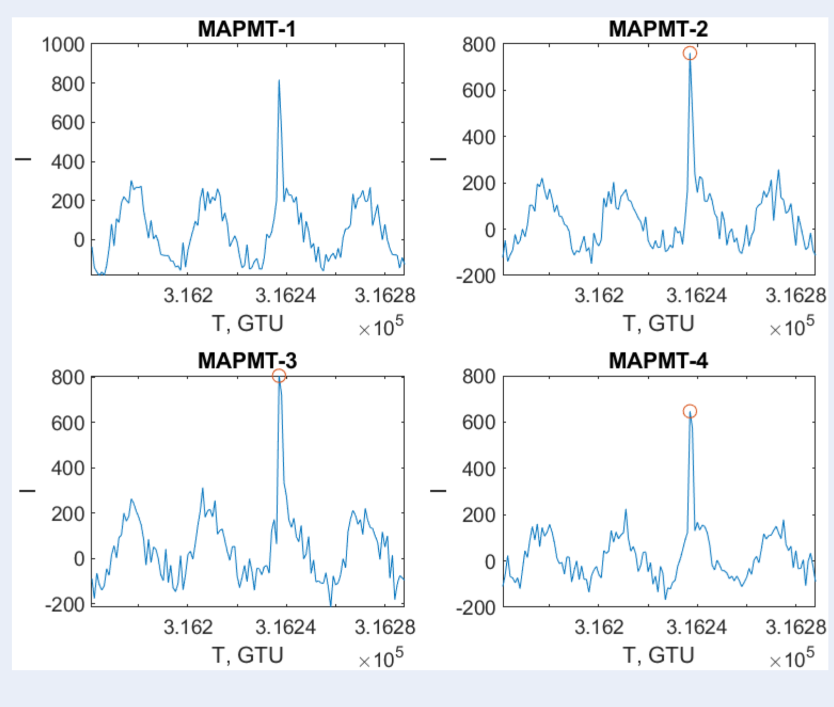

c)

Figure 3. Examples of registered events (a – TR=41ms, d – TR=320 μs) and results of analysing of MLT (b) and date (c) distributions.

References

1. Douma, Emma & Rodger, Craig & Blum, Lauren & Clilverd, Mark. (2017). Occurrence characteristics of relativistic electron microbursts from SAMPEX observations: Occurrence of relativistic microbursts. Journal of Geophysical Research: Space Physics. 122.

2. Miyoshi, Yoshiko & Saito, S. & Kurita, S. & Asamura, Kazushi & Hosokawa, Keisuke & Sakanoi, T. & Mitani, T. & Ogawa, Y. & Oyama, S. & Tsuchiya, Fuminori & Jones, S. & Jaynes, Allison & Blake, J.. (2020). Relativistic Electron Microbursts as High-Energy Tail of Pulsating Aurora Electrons. Geophysical Research Letters. 47.

3. Shumko, M. & Blum, Lauren & Crew, A.B.. (2021). Duration of Individual Relativistic Electron Microbursts: A Probe Into Their Scattering Mechanism. Geophysical Research Letters. 48.