

Micro satellite

Macro experience

Microsatellite “Chibis-M” : observation of terrestrial lightning from space

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V.M. Gotlib and “Chibis-M” team

Microsatellite CHIBIS

Studies of physical processes during atmospheric lightning discharges

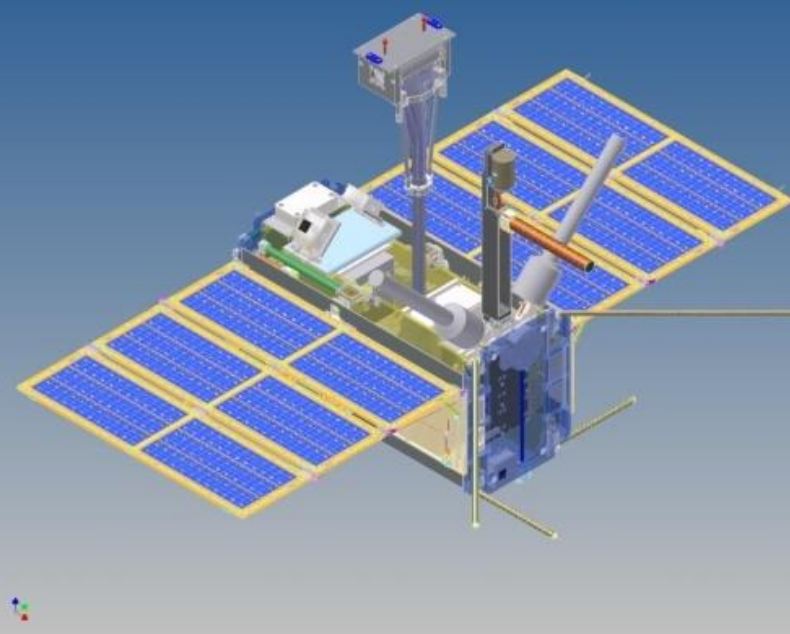
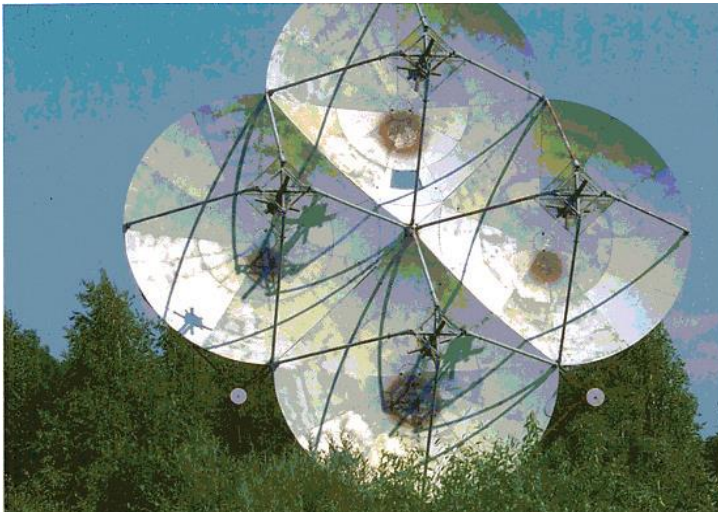
Characteristics:

- total mass ~ 40 kg
- scientific equipment..... 10,8 kg
- service equipment..... 12,6 kg
- circular orbit height..... ~ 480 km
- active functioning – approximately 2 years

Orientation system:

- the main one – electromechanical 3-axis , gyros
- gravitational – the duplicating one
- orientation accuracy.....up to 1-2 ang. deg
- navigation.....GPS – GLONASS

Command control management of small satellites is realized by means of technical facilities of IKI.



Scientific package of the instrument «Groza» includes

- X-rays and gamma detector (SINP MSU);
- Ultraviolet detector (SINP MSU);
- Radio-frequency analyzer (IKI RAN);
- Digital camera (IKI RAN);
- Magneto-wave complex (Ukraine, Hungary);
- Data collection block (IKI RAN);
- Scientific data transmitter (IKI RAN)

Scientific tasks of the microsatellite “Chibis-M”

1

to study stepped leader

2

altitude allocation lightning discharges

3

properties of Narrow Bipolar Pulses (NBP)

4

lightning emission in VHF range (20-50 MHz)

5

UV, IR and gamma bursts generated by lightning

6

plasma waves in the range $10^{-2} - 2 \cdot 10^5$ Hz

Shot characteristics of Scientific payload “Groza”

RGD

- **Roentgen-gamma detector (MSU SINP)**
- gamma and x-ray emission 0.02-1.0 MeV

IUD

- **IR and UV detector (MSU SINP)**
- UV (180-400 nm); IR (650-800 nm)

RFA

- **Radio-frequency analyzer (IKI)**
- 26 – 48 MHz

DCam

- **Digital camera (IKI)**
- with a spatial resolution of 300 m and an exposition of 15 frames/sec

PSA

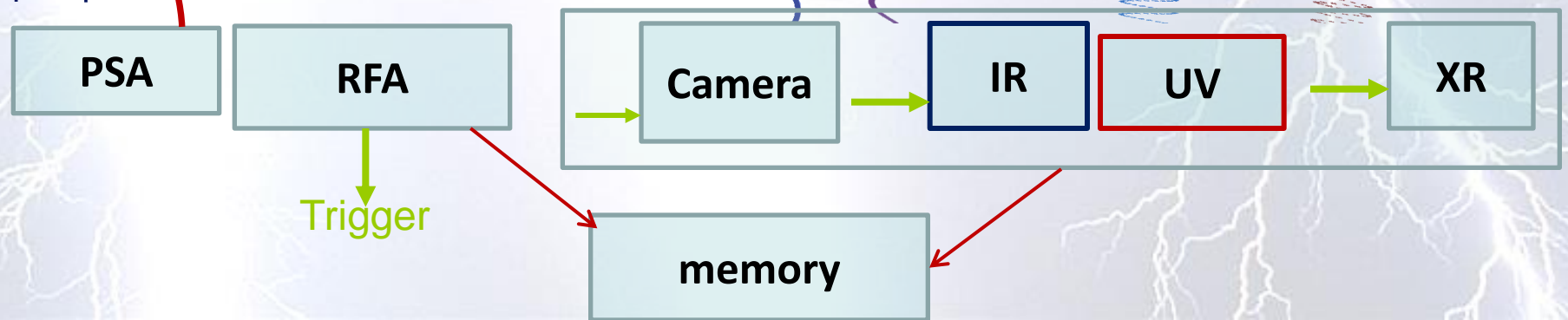
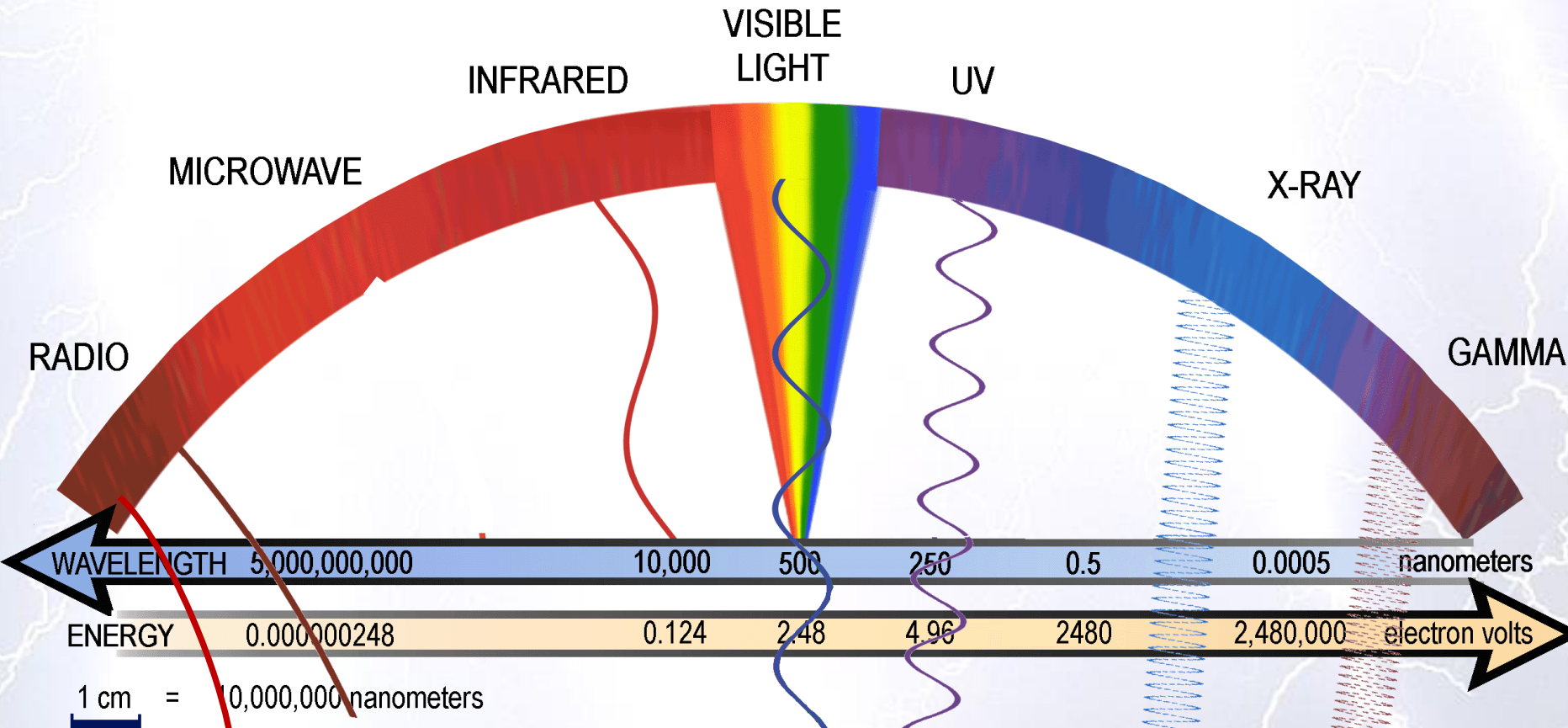
- **Plasma spectrum analyzer (Ukraine + Hungary)**
- 100 – 40000 Hz

DSU

- **Data storage unit**

PRD

- **The transmitter 2.2 GHz + antennas (IKI)**



Ballistic scheme

1 stage: Progress -ISS



ISS, h=380 km
02-11-2011



Kazakhstan, 30-10-2011

Pacific ocean

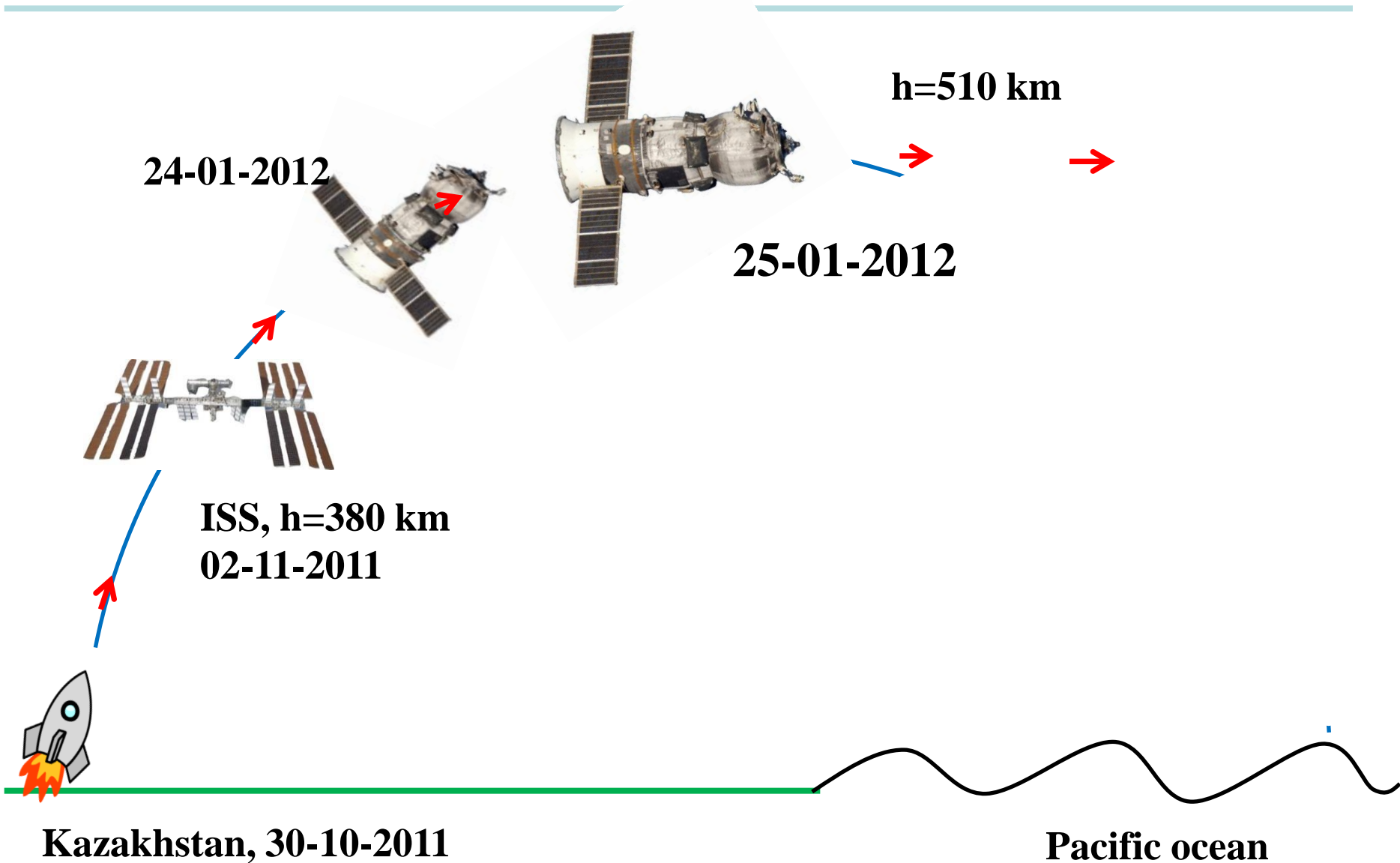
Next stage....

Microsatellite “Chibis-M” was installed on the outer edge of supply spacecraft “Progress M-13M” by astronauts O. Kononenko and A. Shkaplerov



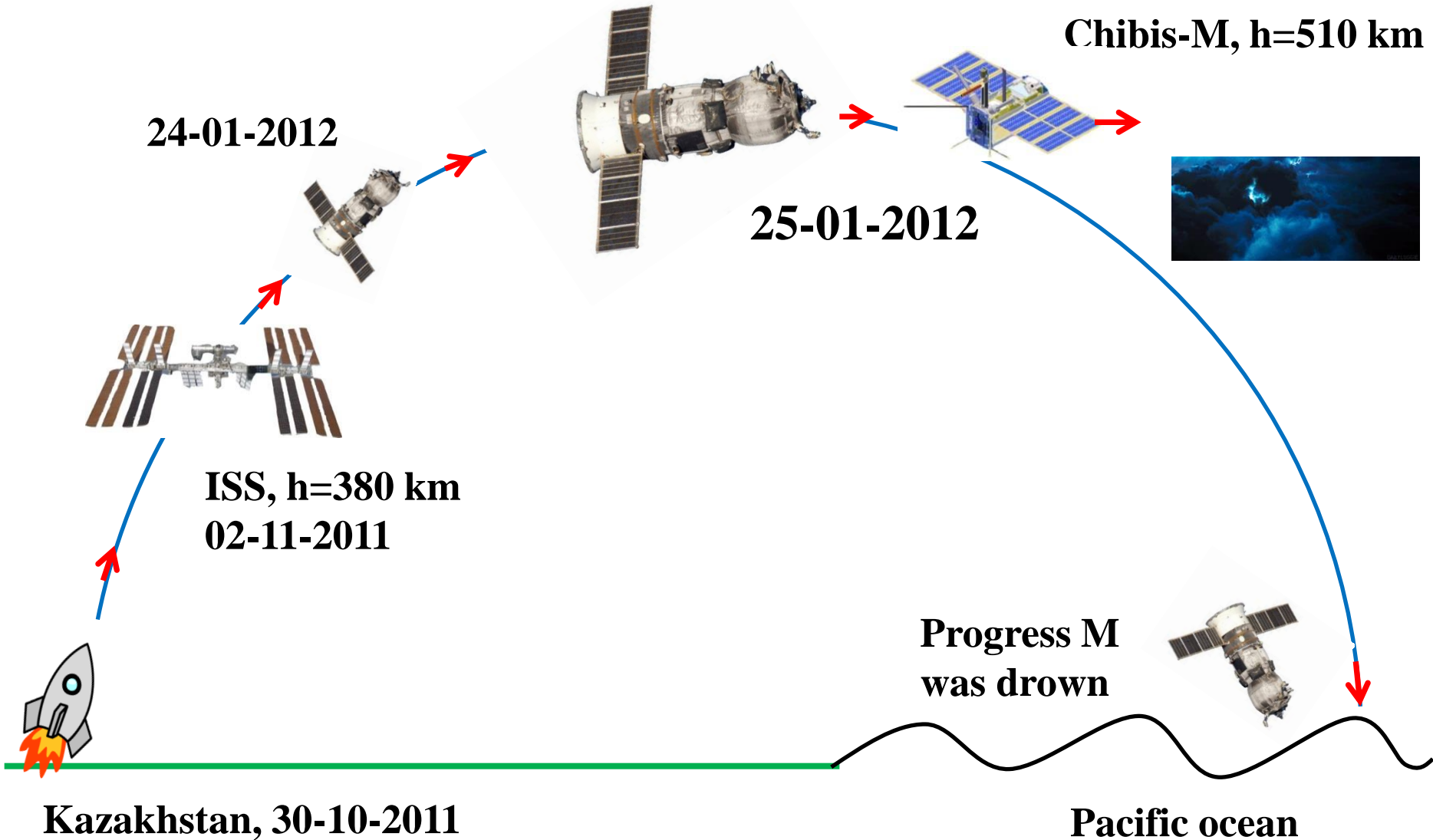
Ballistic scheme

2 stage: Progress separates from ISS and lifts orbit

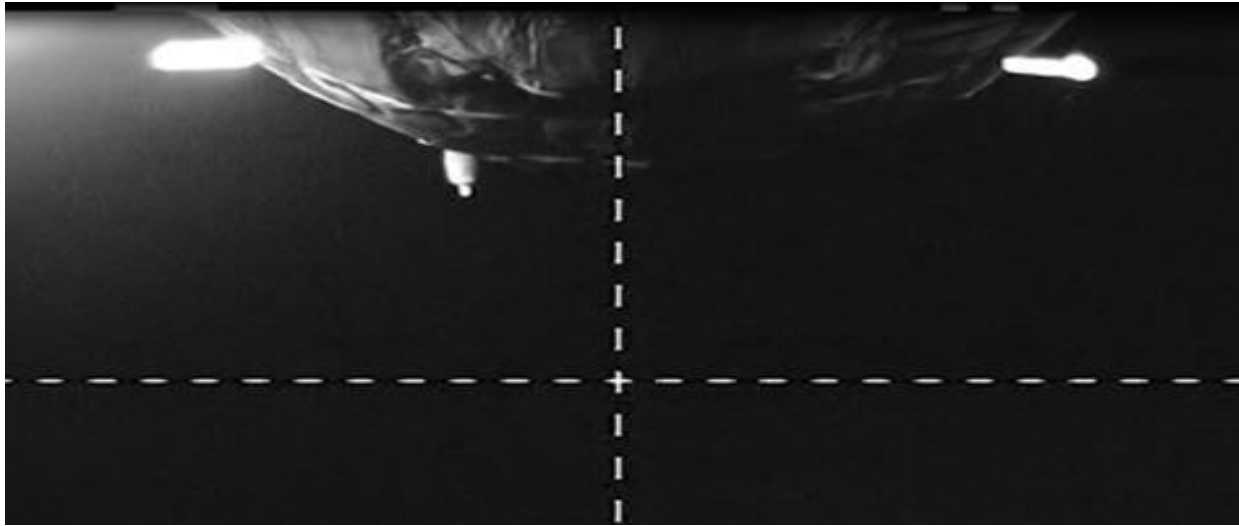


Ballistic scheme

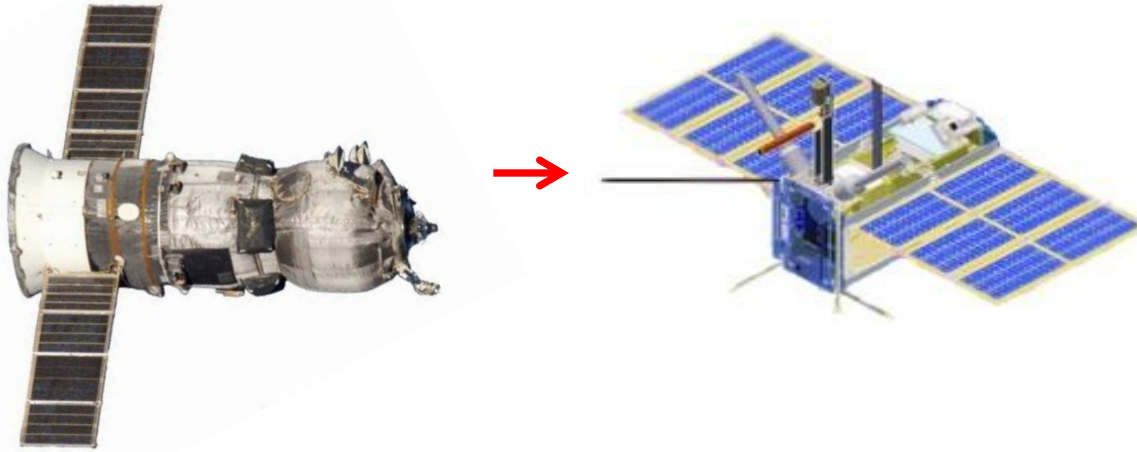
3 stage: Chibis separates from Progress



Microsatellite deployment....



Conclusion #1



Delivering the spacecraft into operational orbit using new technologies which can be considered as some extension of the nominal possibilities of Progress transport vehicle may be estimated as full successful.

Ground-based facilities



- **Tarusa,
Russia**



- **Kaluga,
Russia**

**Mission control
center,
IKI of RAS**

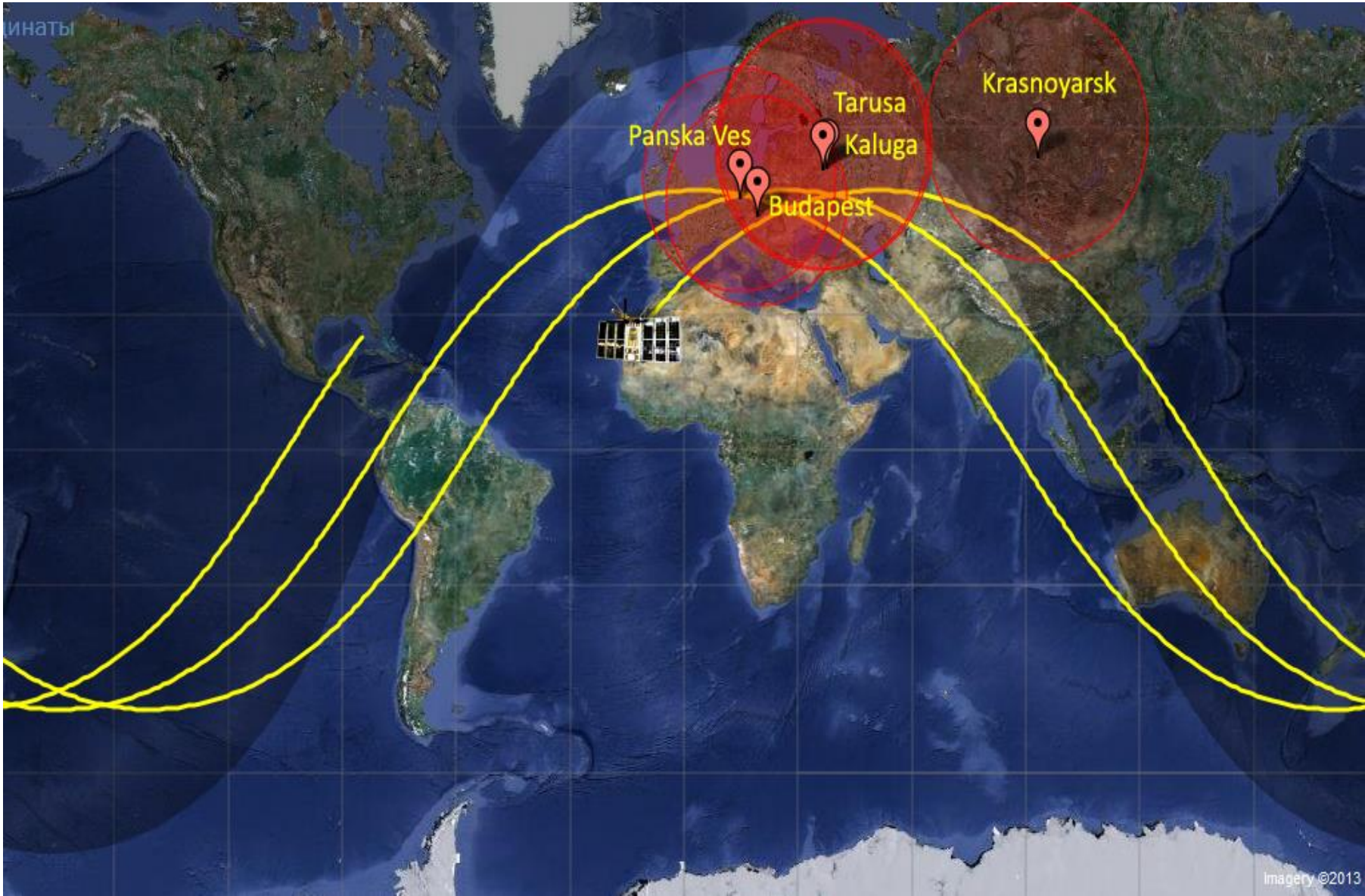


- **Budapest,
Hungary**

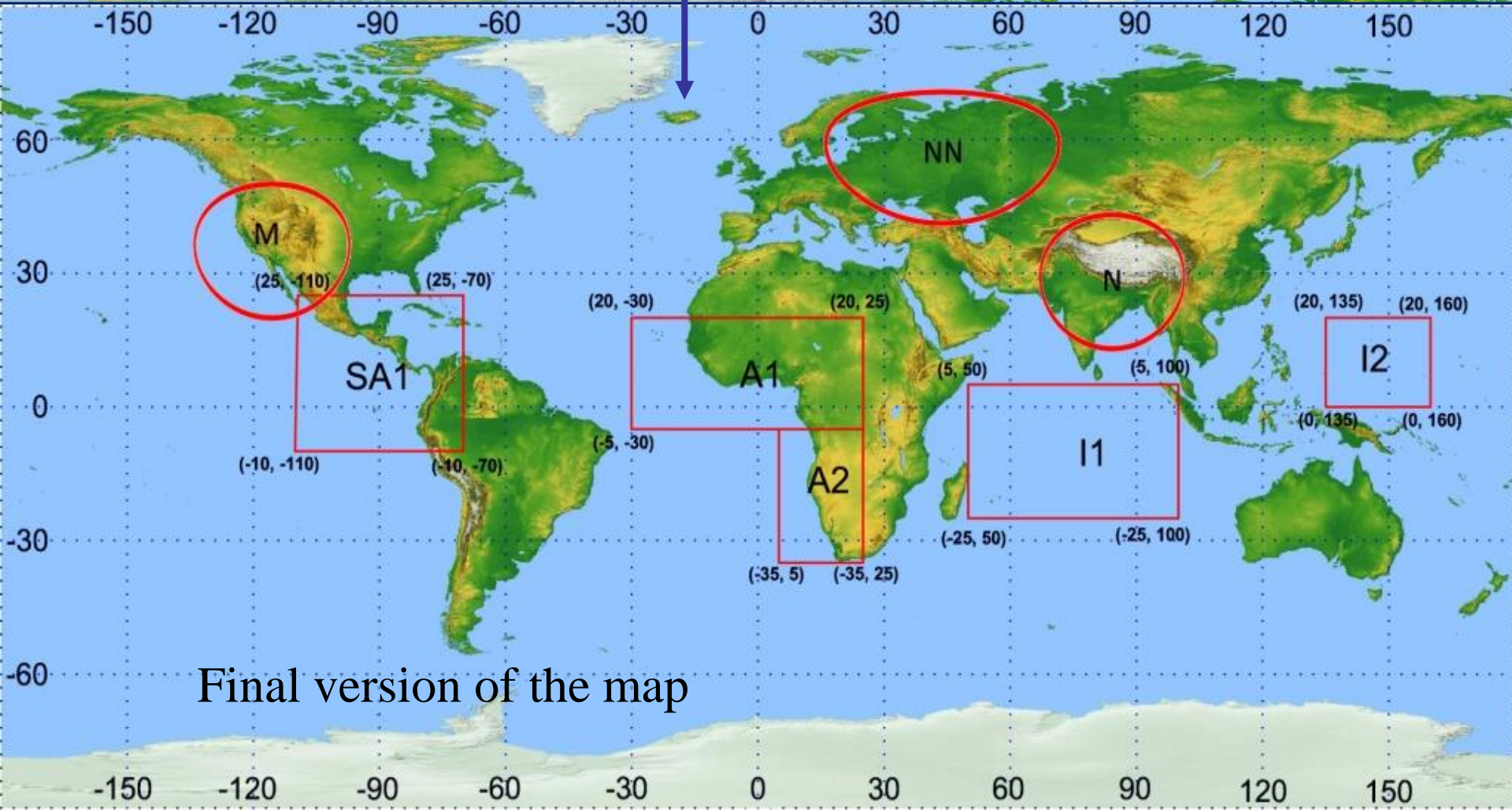
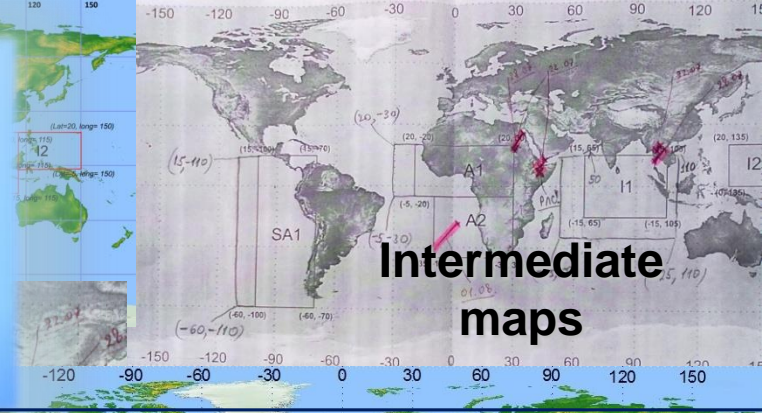


- **Paska Ves,
Czech
Republic**

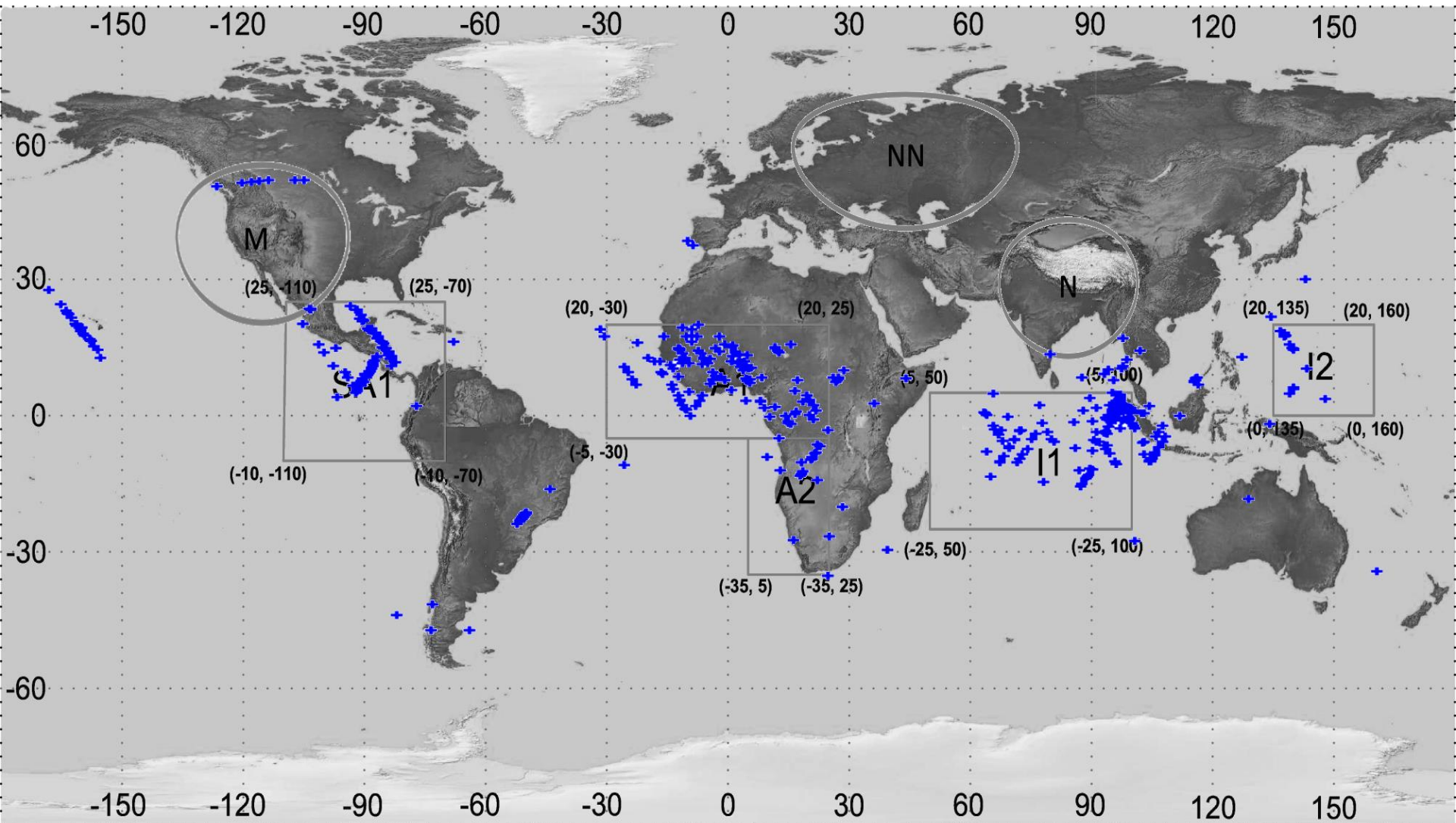
Ground-based facilities



Due to the “energy limit” and the technogenic obstacle operation of the scientific payload was restricted by the finite set of regions

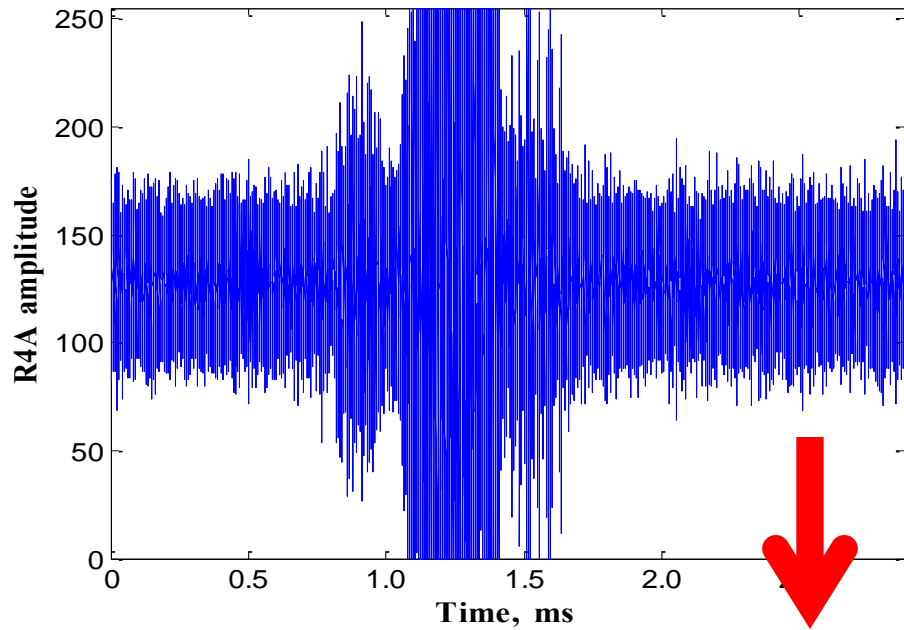


About 900 events were recorded during 2012 year.

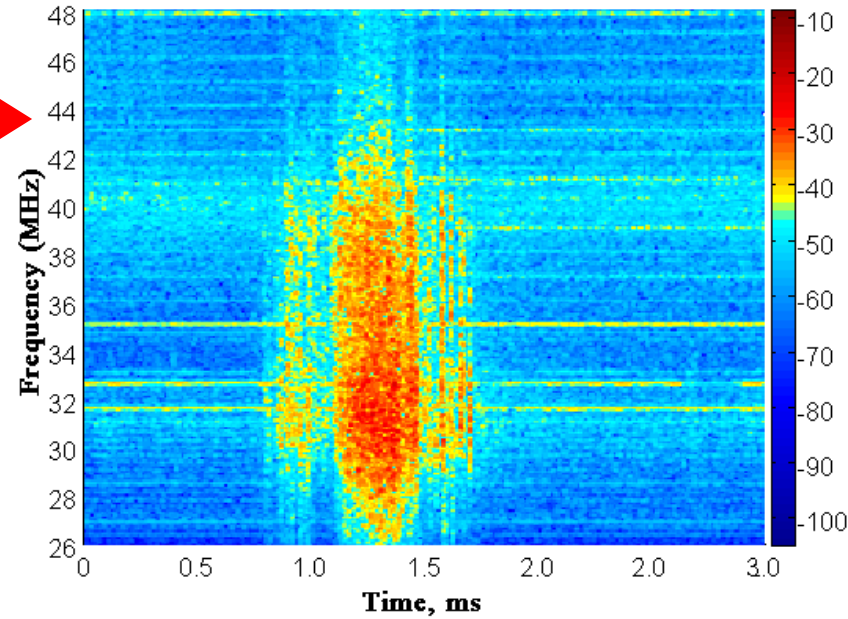


Radio-frequency analyzer

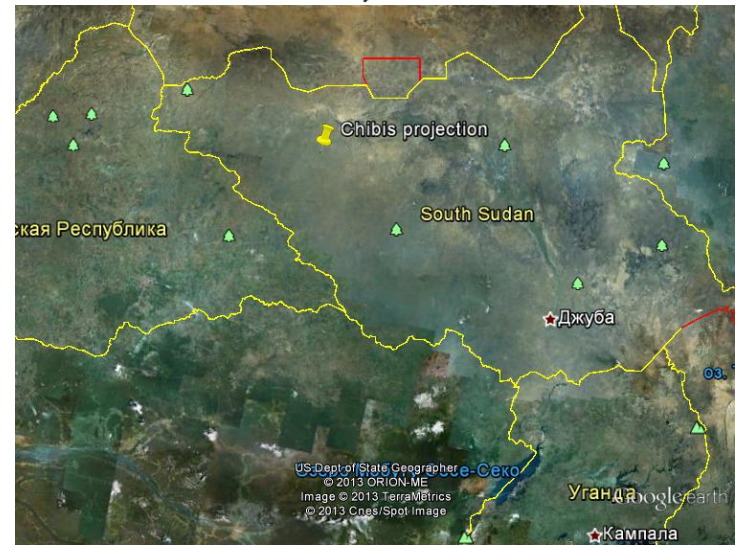
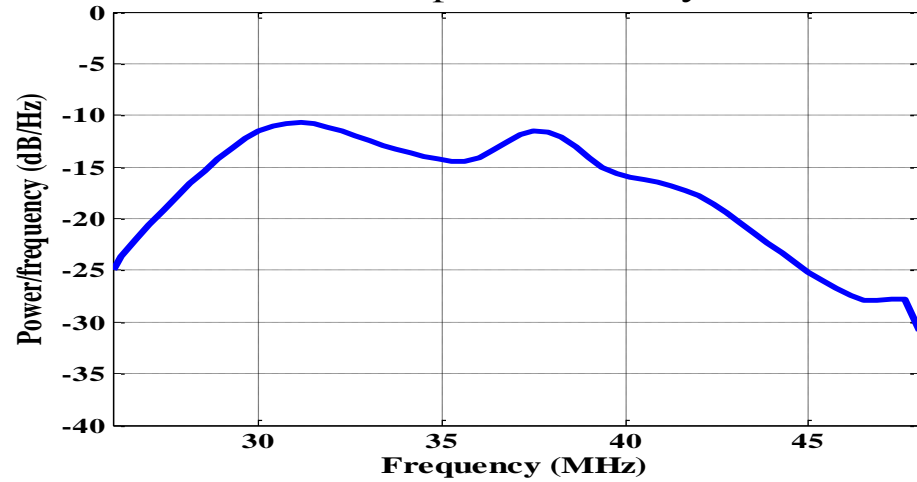
08/08/2012 22:23:24.40



08/08/2012 22:23:24.40



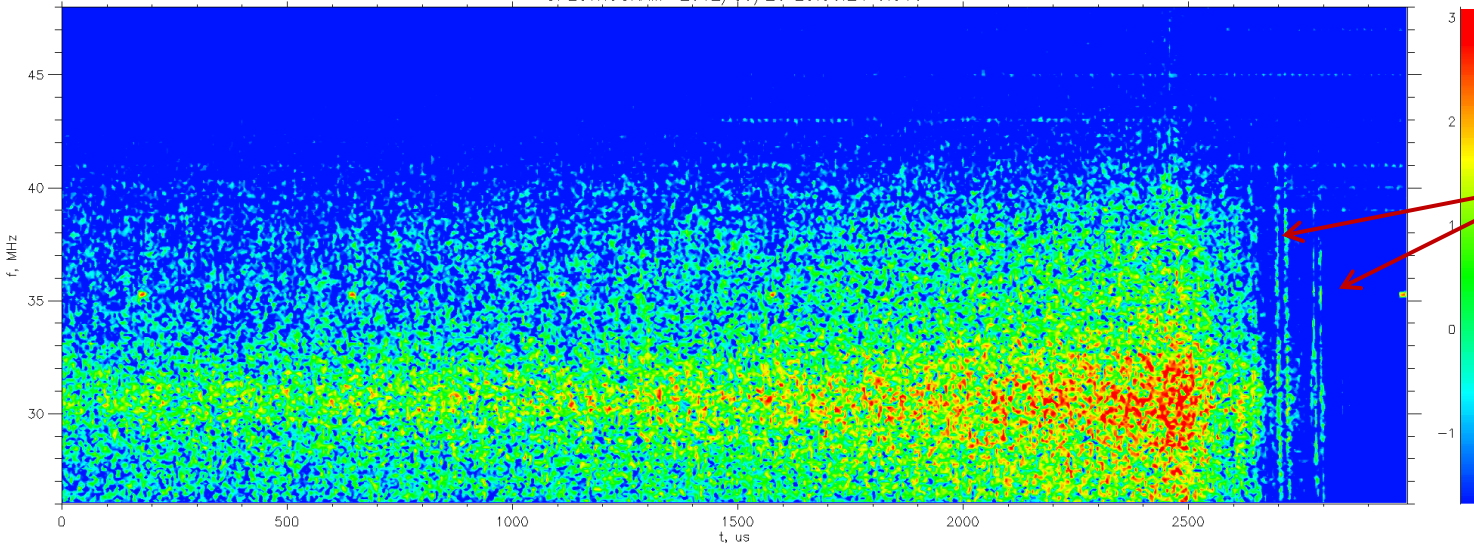
Welch Power Spectral Density Estimate



Radio-frequency analyzer

«radio-cracles» time domain ~ 2500 μs

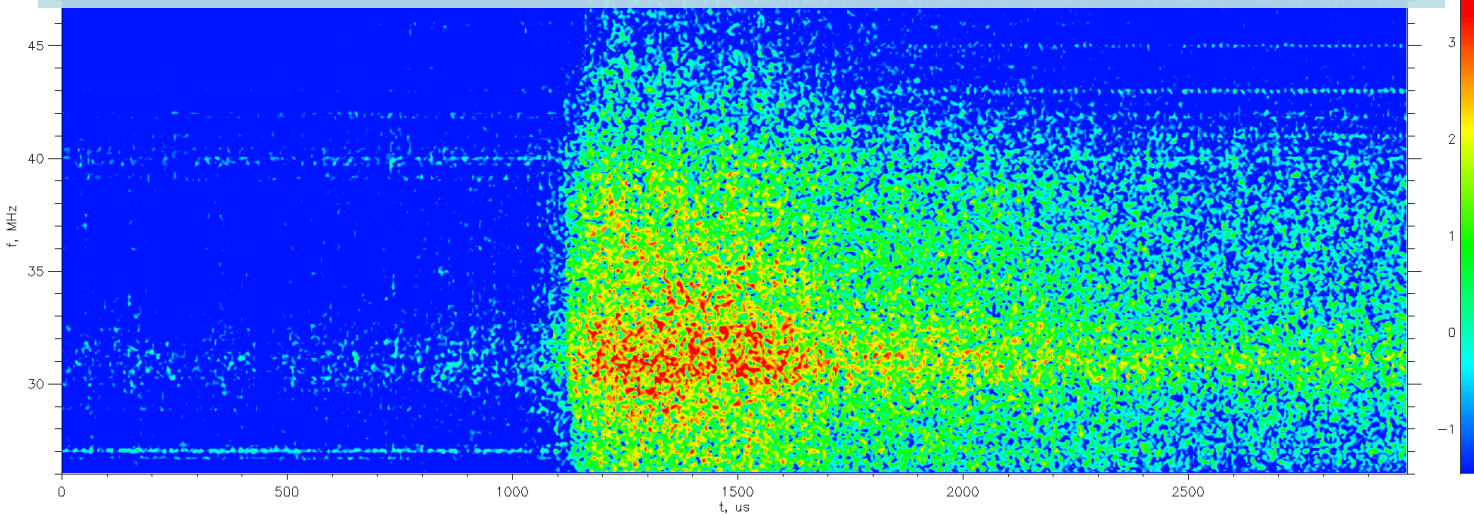
SPECTROGRAM 2012/09/26 23:56:24 0.316



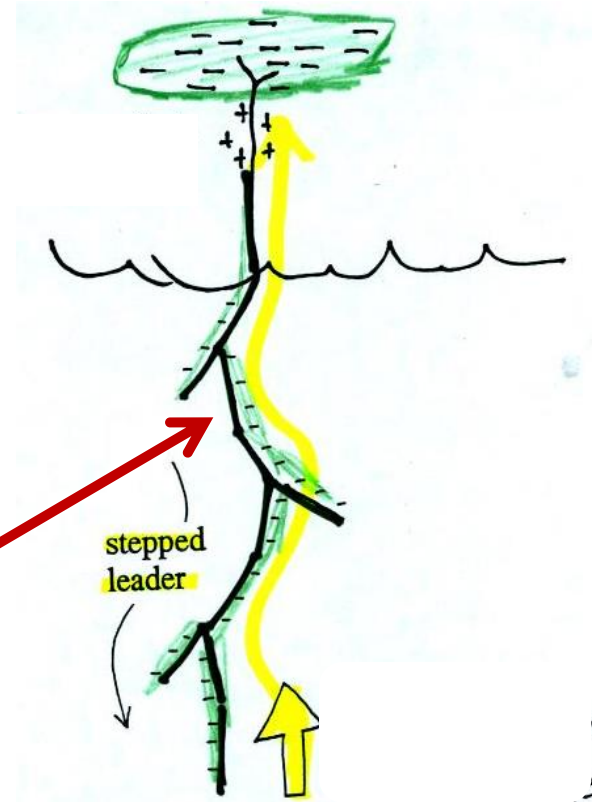
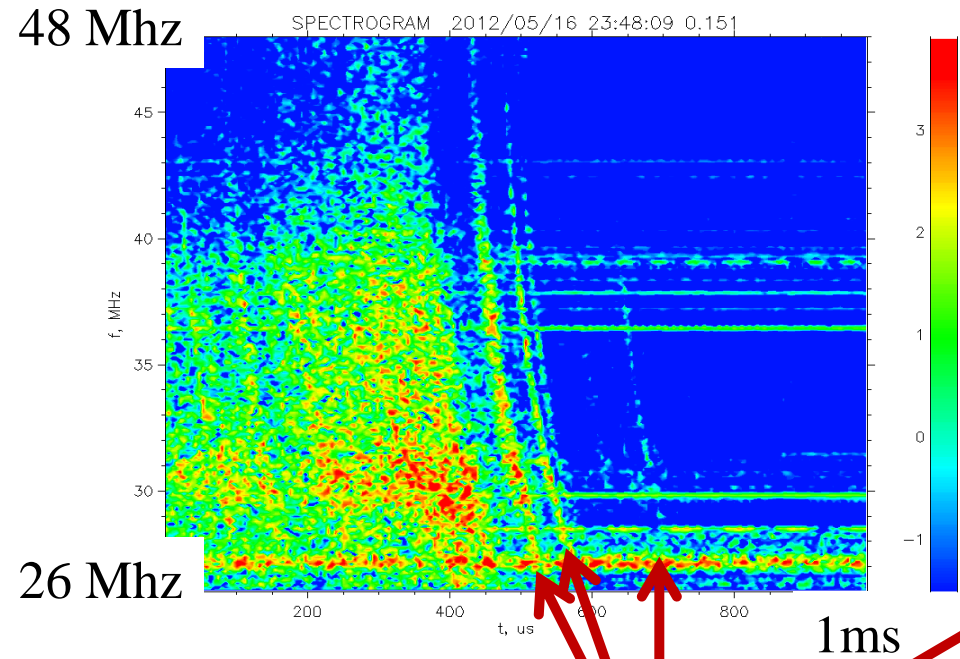
Compact
Intracloud
Discharges
(CID)

Duration of the
record
3 ms

«radio-cracles» time domain ~ 1900 μs



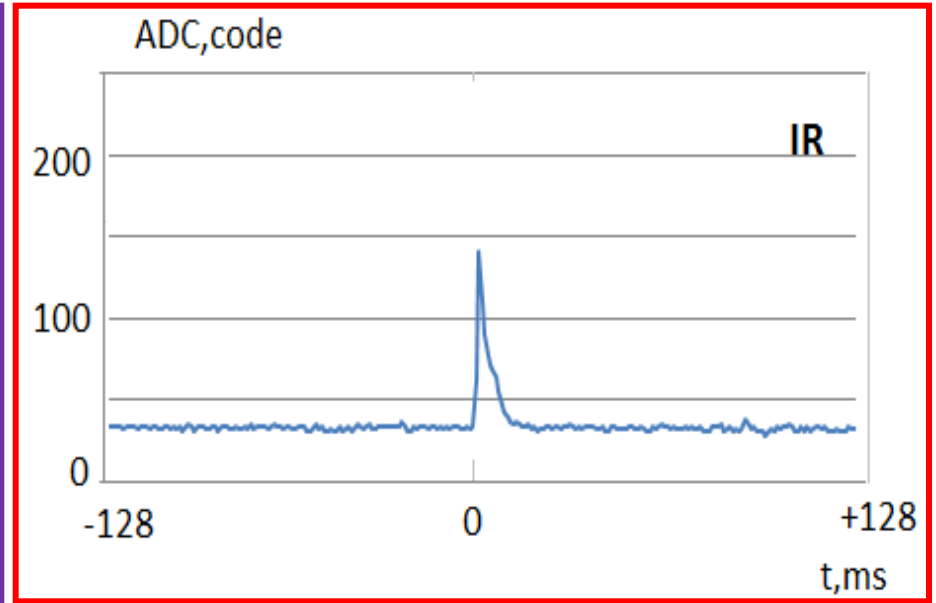
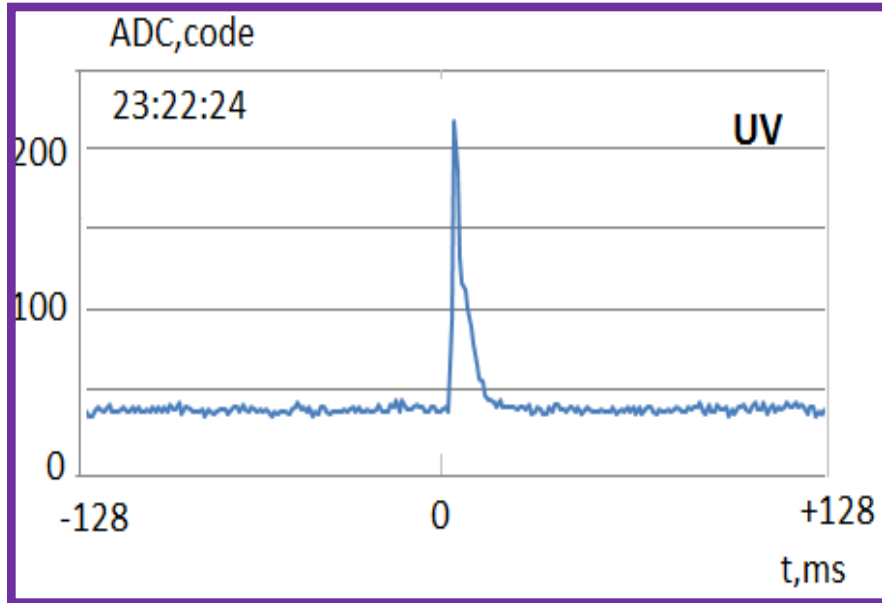
Example of CID detection. (21.07.2012)



**Multiple discharges,
time interval 50...100 μ s**

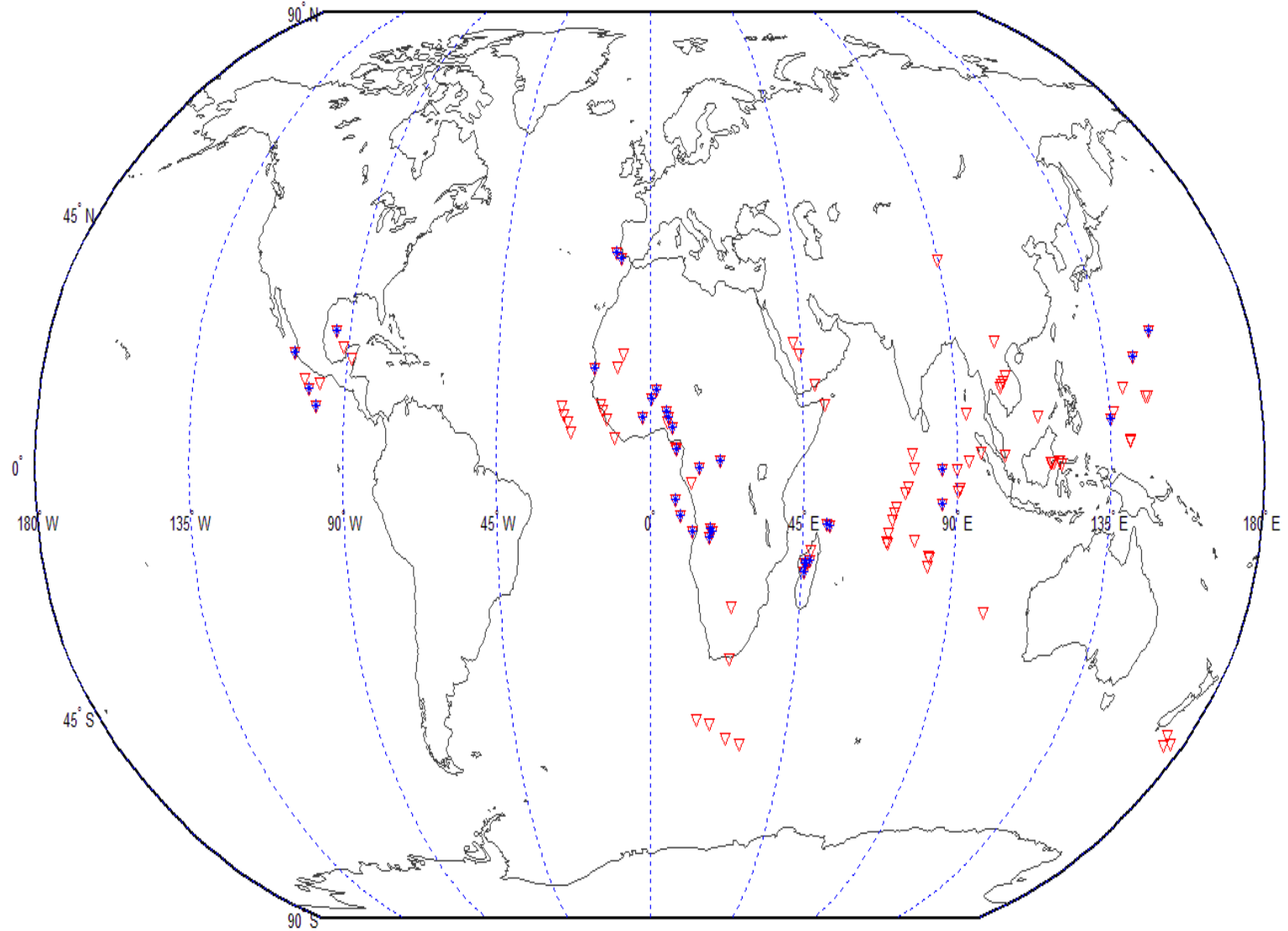
UV and IR records

(event 21.07.2012).



This IR and UV records were triggered by Radio-frequency Analyzer.

Map of detected events



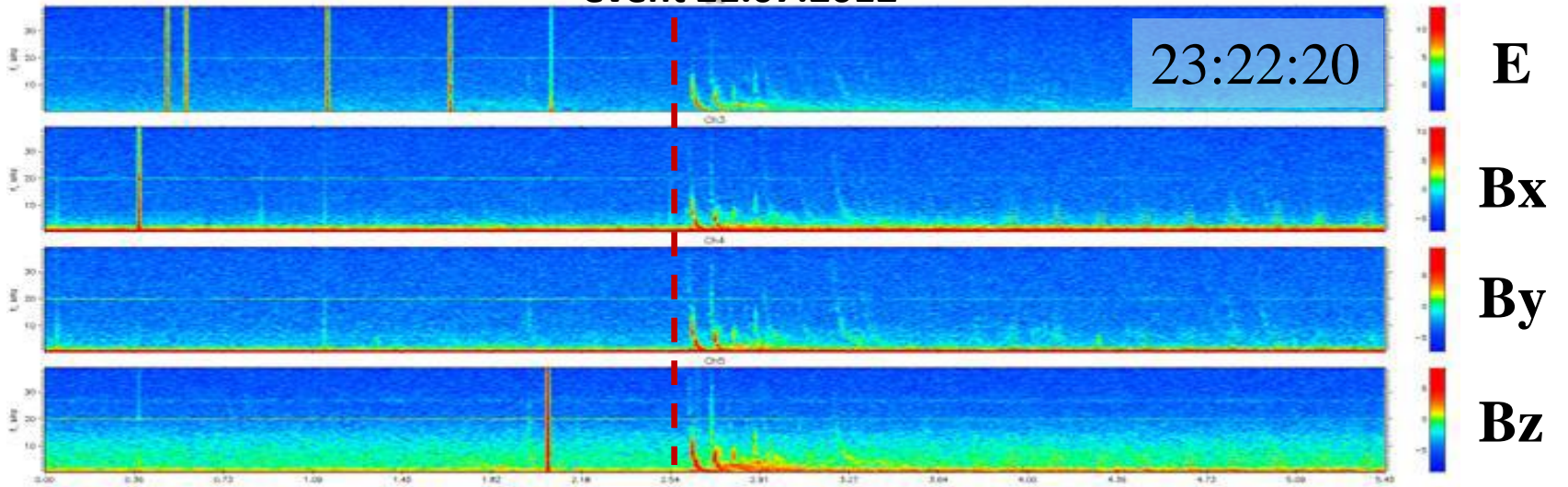
Red signs – **only radio** emission detected

Blue signs – simultaneous **radio+UV&IR** detection

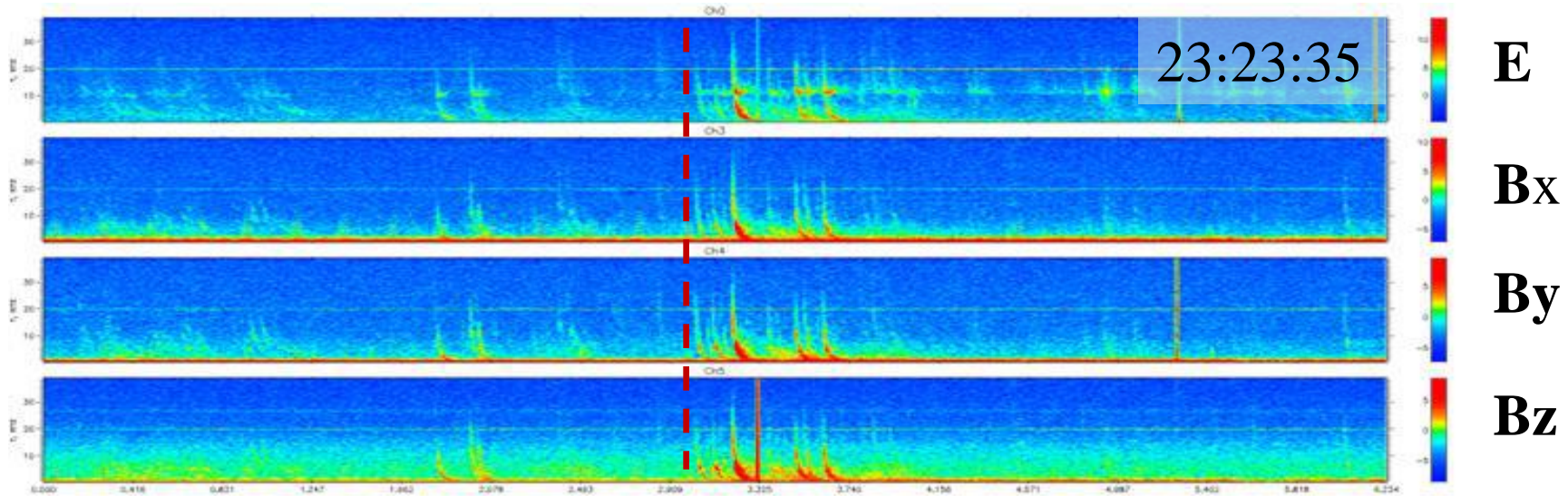
Whistler waves were registered by Plasma Spectrum Analyzer (5-40000 Hz).

event 21.07.2012

23:22:20



23:23:35



Position of radio trigger

Roentgen-gamma Detector.

event 21.07.2012

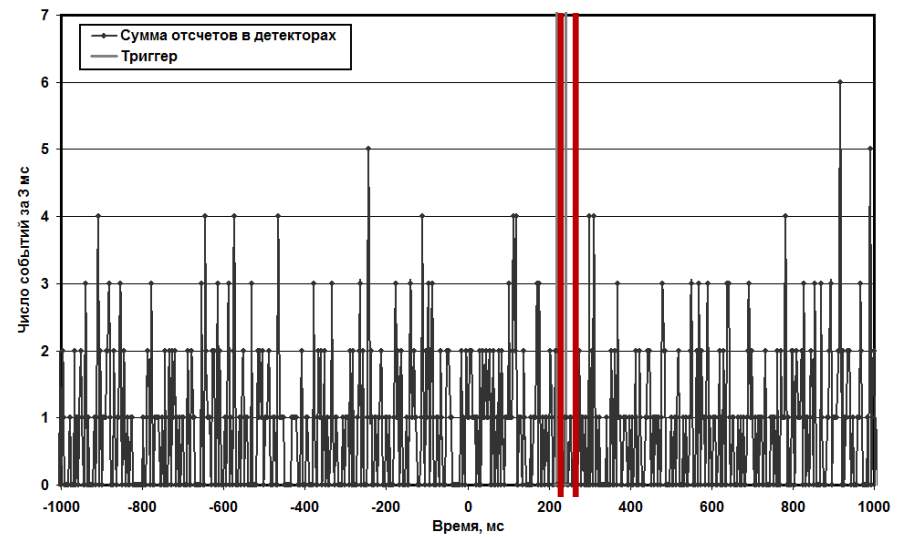
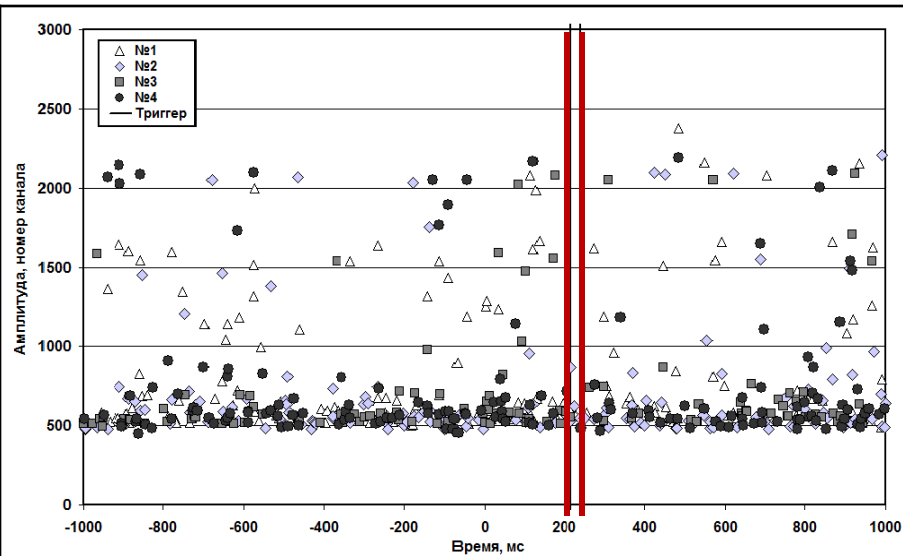


Chart time-amplitude data formed by a trigger RFA.

The time course of the total number of cases of interaction 4 detectors for 3 ms

The moment the trigger is at the limit shown in the figure by vertical red lines corresponding to the boundaries of time fixing the first of the post-trigger events in the detectors. Accuracy binding timeline at the time the trigger is defined statistics and usually is about 20 ms.

To determine a threshold level above which it can be concluded statistically significant increase in the flux of gamma-rays, an additional analysis of the distribution of peaks in this range according to the amplitude.

Digital camera.

event 21.07.2012



UT 16:13:50

The digital camera shot on command trigger generated radio frequency analyzer (RFA).

In the center of the circle marked by an object like a "lightning".

High background noise level and low sensitivity of the camera did not allowed to unambiguously identify the "lightning"!

Conclusion # 2

- Chibis spacecraft was developed and manufactured on the basis of *maximum flexibility of service system, scientific instruments and operations*. It allowed reaching the required functionality even for the cases when some deviations from the initially planned parameters did happen.

Now microsatellite Chibis are working 20th month.

Some conclusion for scientific payload:

- * at this moment it did not turn out well gamma-roentgen emissions from terrestrial lightnings. For next Chibis device sensitivity will be increased;
- * it was received many information about IR and UV emission of terrestrial lightnings;
- * Fast optical camera could not provide necessary information about lightning; next generation of optical devices should be aimed to study emission in narrow optical bands;
- * Radio Frequency Analyzer detected about 900 events during 2012 campaign. Majority of events could be classified as Compact Intercloud Discharges or Chaotic Stepped Leader emission. **RFA** is fastest instrument onboard of Chibis-M allowing to discover the fine structure of the lightning.
- * large volume information was received by Magneto-wave complex.

More detailed analysis of Radio Frequency
Emission from Lightning
will be presented in the report M.Dolgonosov et al.

Thank you for your attention!