XXXII Reunión Anual de la División de Partículas y Campos de la SMF

LUMINOUS EVENTS AND THEIR DETECTION FROM SPACE WITH THE TUS

Oliver Isac Ruiz Hernandez by TUS colaboration (FCFM-BUAP)

Tuesday, May 29, 2018

CONTENT

- The “Lomonosov” space project.
- TUS detector.
- Events selection.
  - Selection process.
  - Data reduction.
  - Interesting events.
- Summary.

THE "LOMONOSOV" SPACE PROJECT

The "Lomonosov" space project is lead by Lomonosov Moscow State University.

Collaboration:

Russia 

USA 

KOREA 

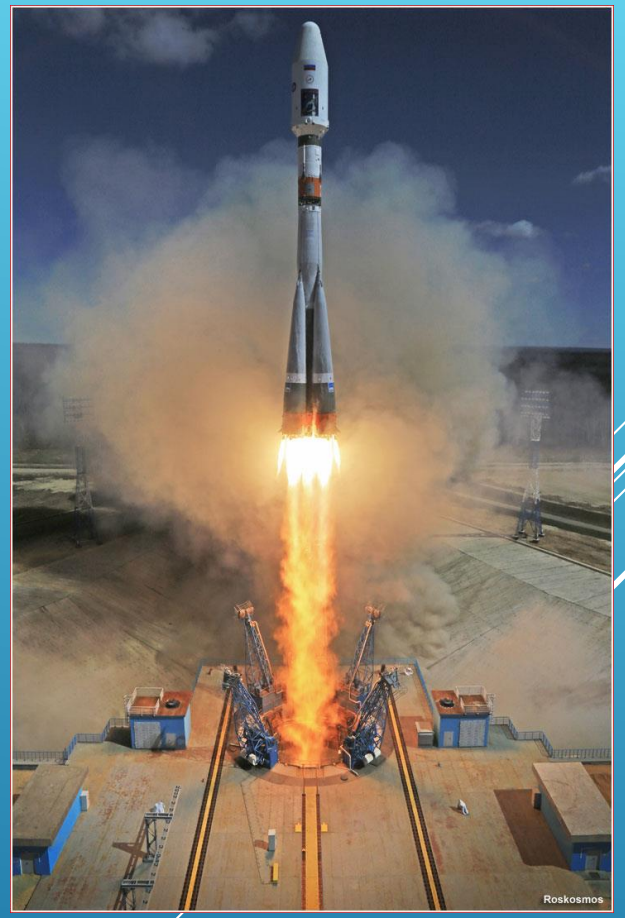
DENMARK 

SPAIN 

MEXICO 

Some of the principal goals of the experiment are to study:

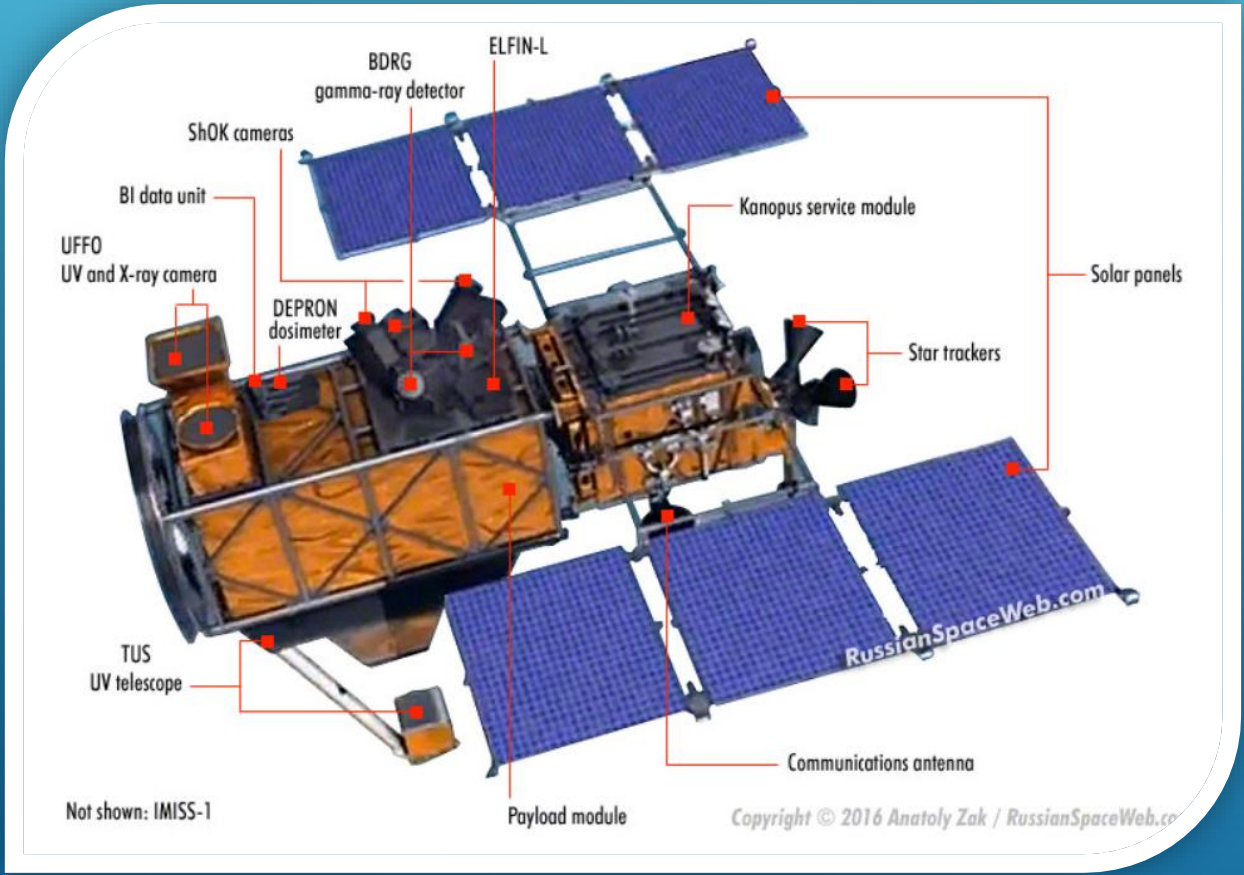
- Ultra-high energy cosmic rays (UHECR) in the energy range of the Greizen-Zatsepin-Kuzmin (GZK) cutoff.
- Ultraviolet (UV) transient luminous events in the upper atmosphere.
- Multi wavelength study of gamma ray bursts in visible, UV, gamma and X-rays[1].



[1] Sadovnichy V. A., M. I. Panasyuk, A. M. Amelyushkin, et. al., "Lomonosov" Satellite-Space Observatory to Study Extreme Phenomena in Space. Space Sci. Rev. 212: 1705-1738, (2017).

Scientific Instruments

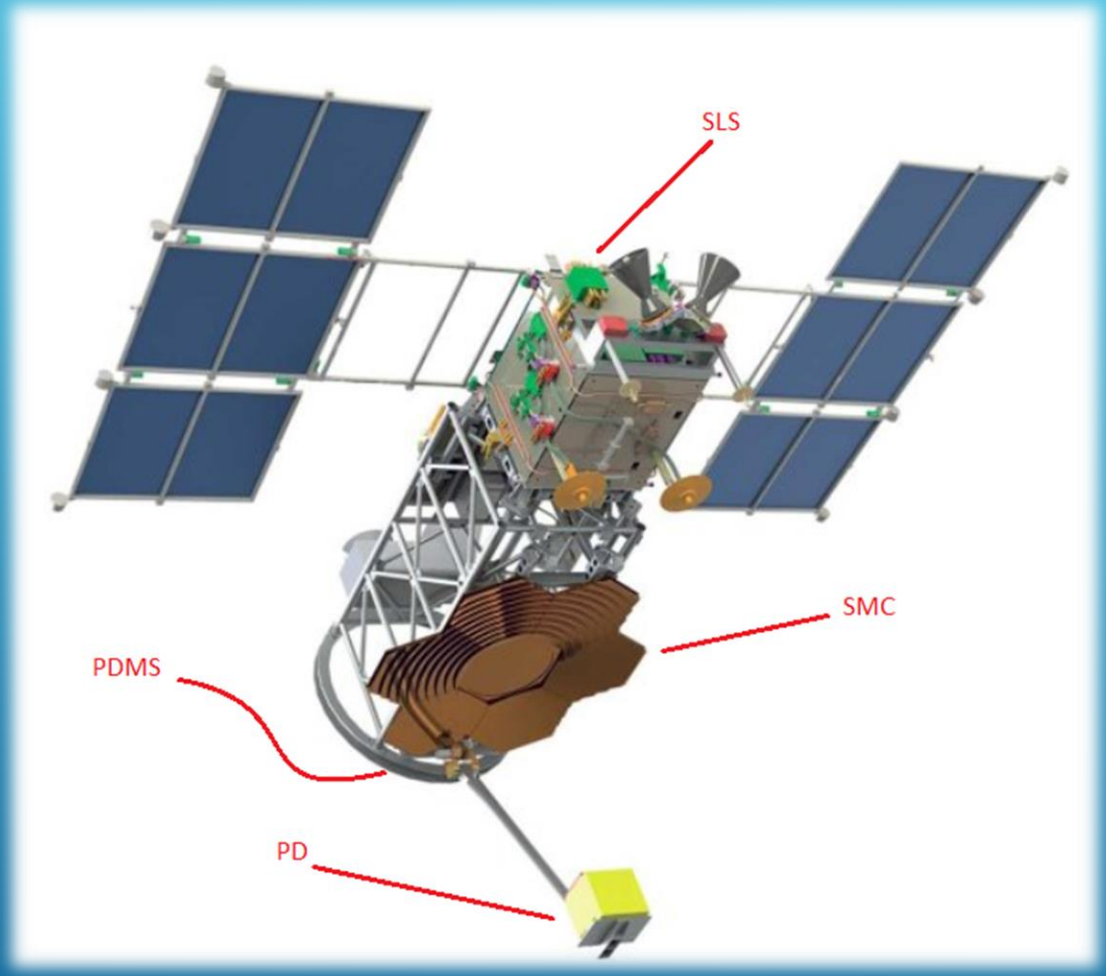
Lomonosov carries a total of eight scientific payloads, including an ultraviolet detector and a telescope for measuring spectra and chemical composition of high-energy cosmic rays.



Some of the scientific instruments are:

- BDRG: will be used to locate and monitor celestial sources of gamma radiation.
- ShOK: A pair of optical cameras for high-speed photography of light flashes, gamma-ray bursts, as well as satellites and space junk.
- UFFO: a X-ray camera and ultraviolet telescope.

TUS (TRACKING ULTRAVIOLET SET-UP) DETECTOR.



TUS detector on board the Lomonosov satellite

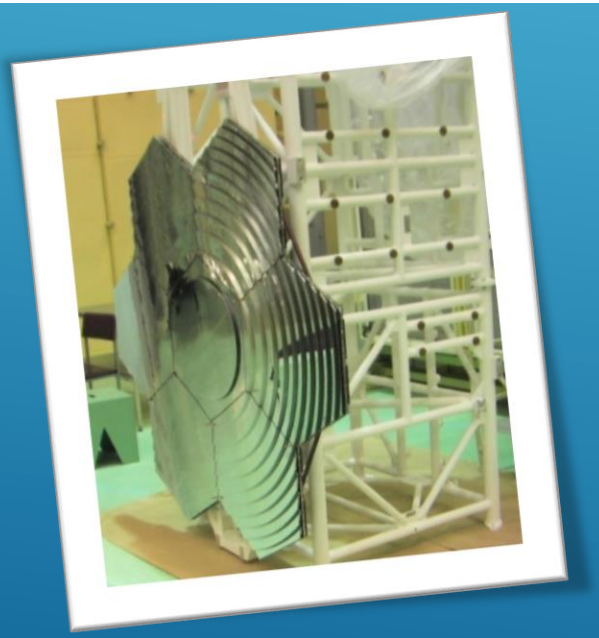
The TUS detector on board the Lomonosov satellite consist of the following elements :

- ✓ Solar light sensor (SLS).
- ✓ Photodetector moving system (PDMS).
- ✓ Segmented mirror-concentrator (SMC).
- ✓ Photodetector (PD)[2].

[2] Klimov P. A., M. I. Panasyuk, B. A. Khrenov, et. al., The TUS detector of extreme energy cosmic rays on board the Lomonosov satellite. astro-ph.IM, arXiv: 1706.04976v2, (2017).

TUS (TRACKING ULTRAVIOLET SET-UP) DETECTOR.

Parameter	Value
Mass	60 kg
Power (maximum)	65 W
Data (maximum)	250 Mbyte/day
FOV	±4.5 degree
Number of pixels	256 (16 clusters of 16 PMTs)
Pixel size (FOV)	10 mrad (5 km × 5 km)
Mirror area	2.0 m^2
Focal distance	1.5 m
Duty cycle	30%



TUS segmented mirror-concentrator

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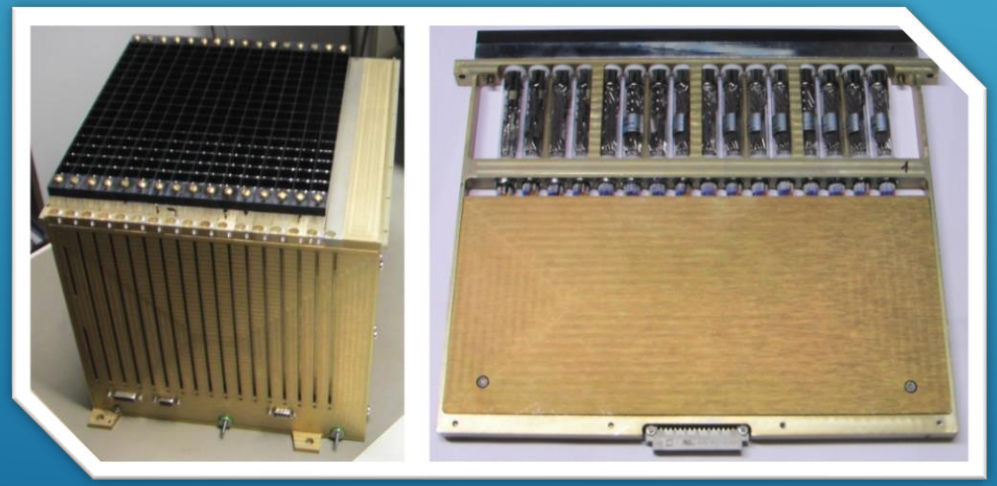

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The TUS photodetector (left) and one of the photodetector clusters (right)

[2] Klimov P. A., M. I. Panasyuk, B. A. Khrenov, et. al., The TUS detector of extreme energy cosmic rays on board the Lomonosov satellite. astro-ph.IM, arXiv: 1706.04976v2, (2017).

Operational modes

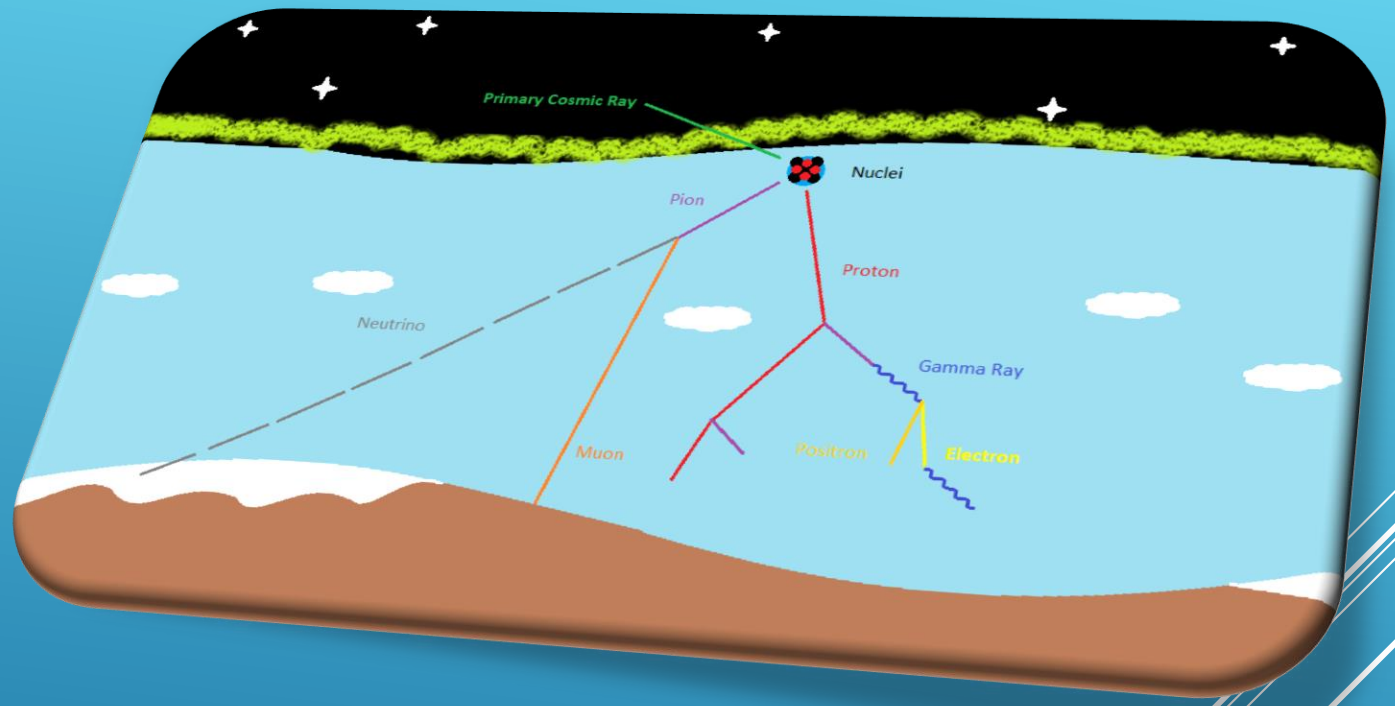
The sequence of waveforms is formed by the PDM (photodetector module) boards and provides four types of data (digital oscillograms, DOs) as an output: DO EAS, TLE-1, TLE-2 and METEOR, which correspond to the duration of three distinct physical processes in the atmosphere: extensive air showers, transient luminous events, and micro-meteors respectively.

Digital Oscillogram	DO sampling time τ	DO length ΔT	TS integration time t
EAS	$1\tau_0 = 0.8\ \mu s$	$256\tau = 205\ \mu s$	$2^4\tau = 12.8\ \mu s$
TLE-1	$2^5\tau_0 = 25.6\ \mu s$	$256\tau = 6.6$ ms	$2^3\tau = 0.2$ ms
TLE-2	$2^9\tau_0 = 0.4$ ms	$256\tau = 105$ ms	$1\tau = 0.4$ ms
METEOR	$2^{13}\tau_0 = 6.6$ ms	$256\tau = 1.7$ s	$2^4\tau = 105$ ms

Temporal characteristics of different DO modes

EAS MODE

The Earth´s atmosphere produce cascades of secondary particles, i.e. Extensive Air Showers (EAS), wich can provide information about the primary particle parameters. The bulk of secondary particles in EAS ionize and excite molecules of atmospheric nitrogen and oxygen and lead to the so-called ionization glow, which is most intensive along the EAS axis and resembles a track breacking out in a very short time (about several microseconds).



The fluorescence intensity and its timing along the UV track provide information on EAS cascade developement, direction and energy of primary particles.

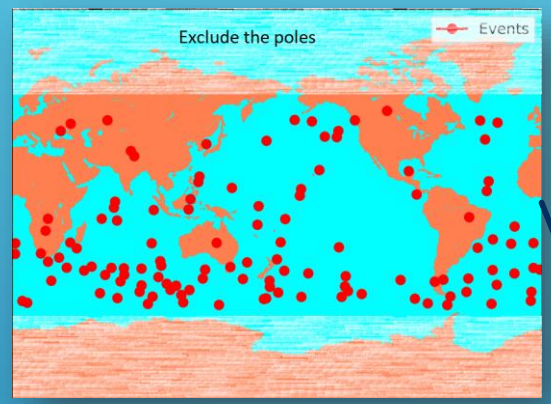
EVENTS SELECTION

We analized data from the first semester of 2017, there were analized around 34,000 events, the selection of events was made with the help of custom made programs in Python and a further data reduction, which results in 220 interesting events.

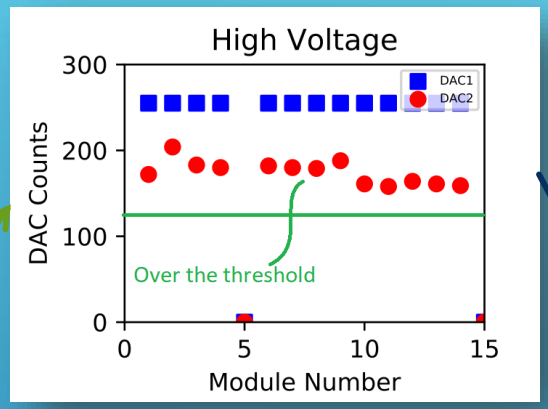
- Selection process
  - Selection by location.
  - Selection by light background.
  - Selection by signal to noise ratio.
- Data reduction
  - Background correction.
  - Gain correction.

Flow chart

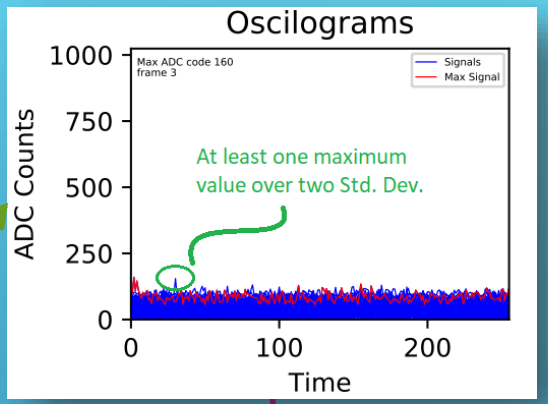
Location



Yes



Yes



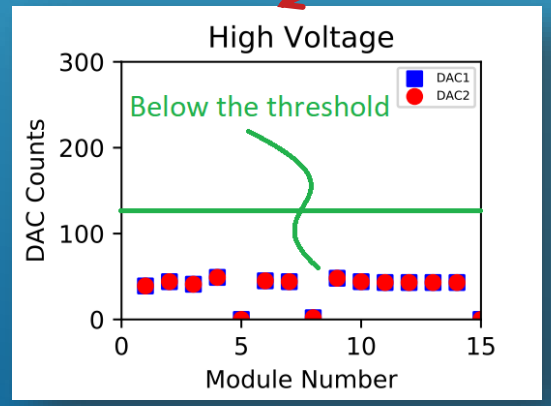
Generate these Images

No

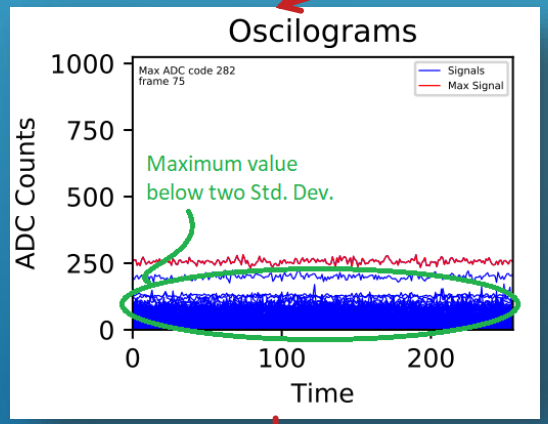
Light background

No

Signal to nosie ratio

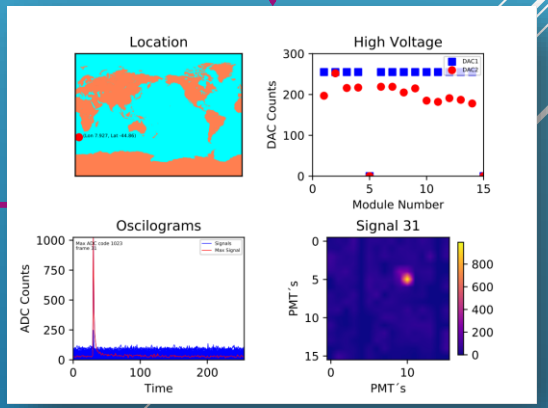


Not interesting

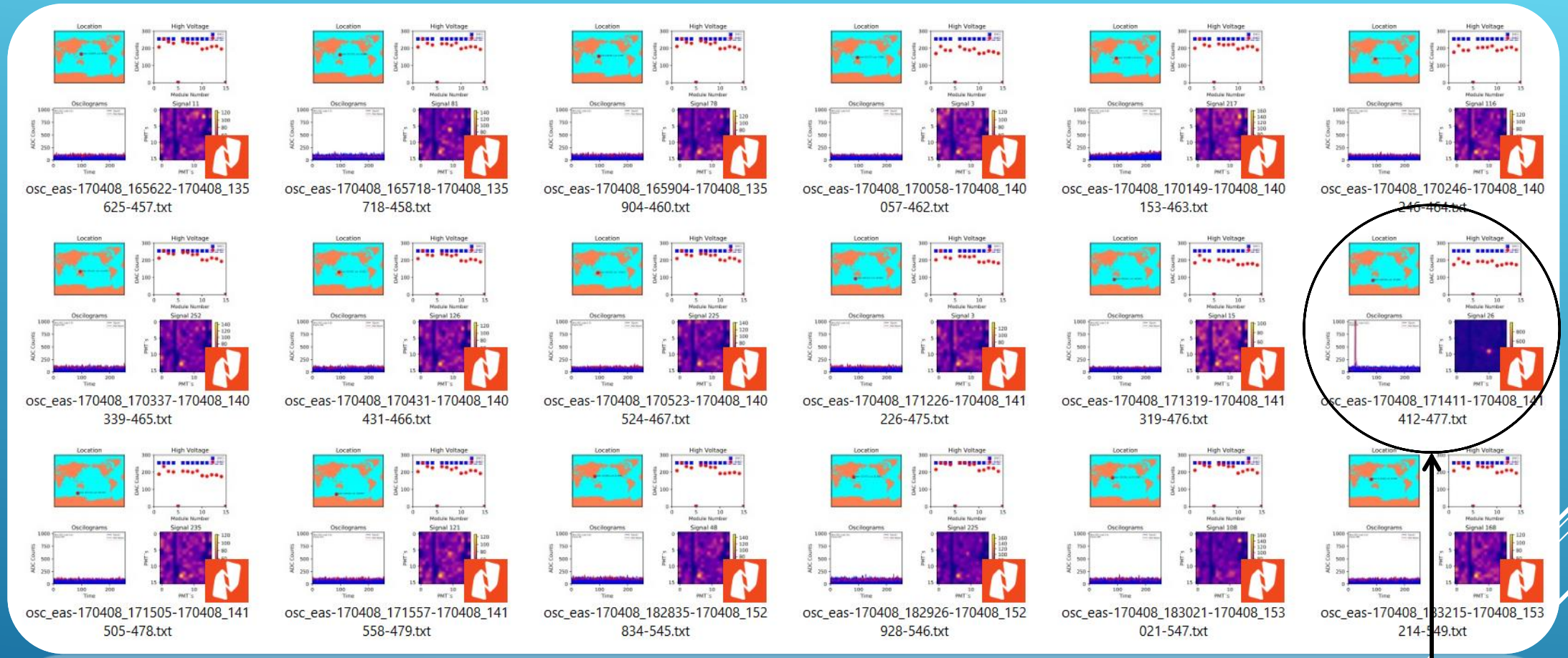


Not interesting

Candidate to event

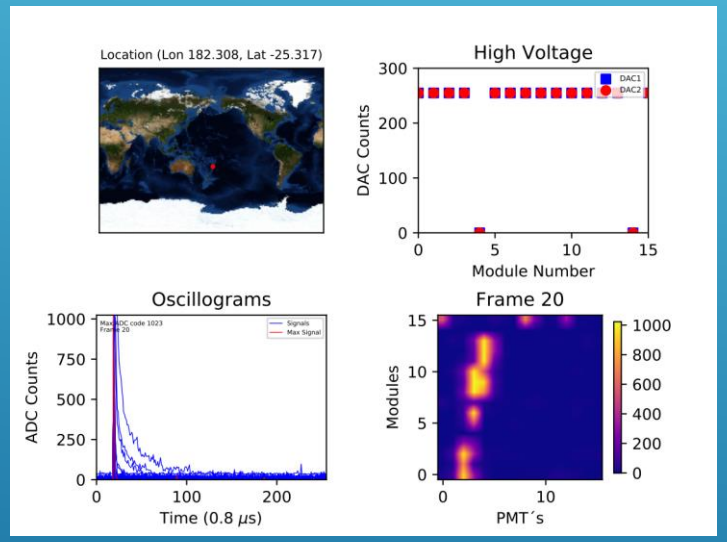


Sample of the previous flow chart



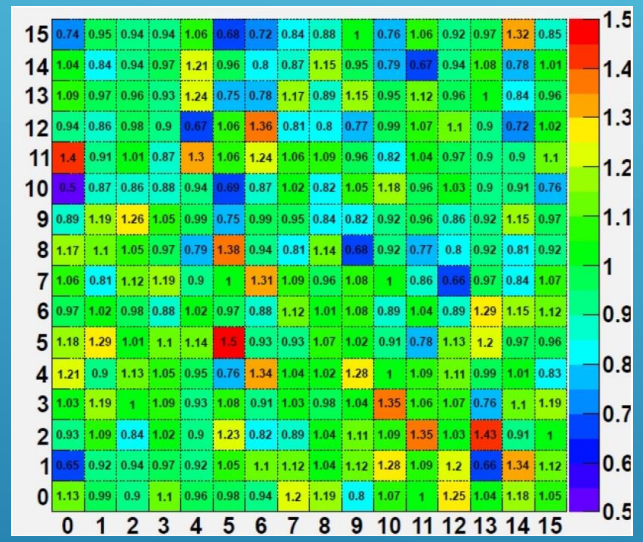
Sample of candidate to event

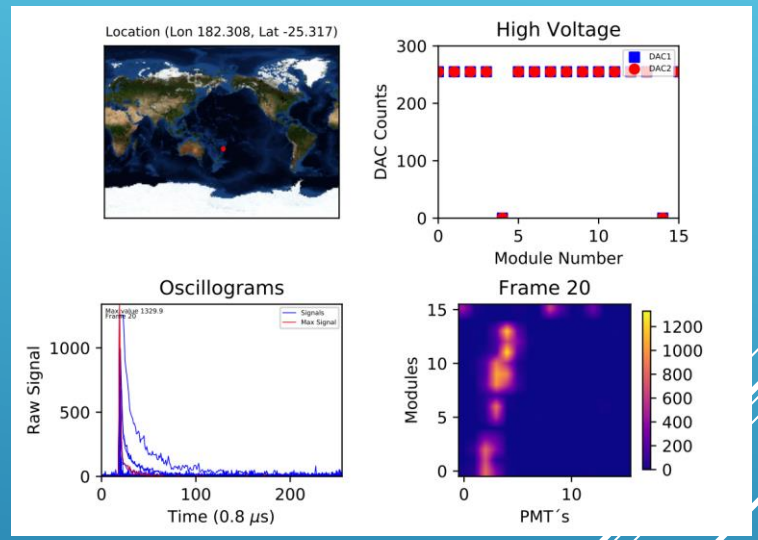
Corrected by Background and Gain correction



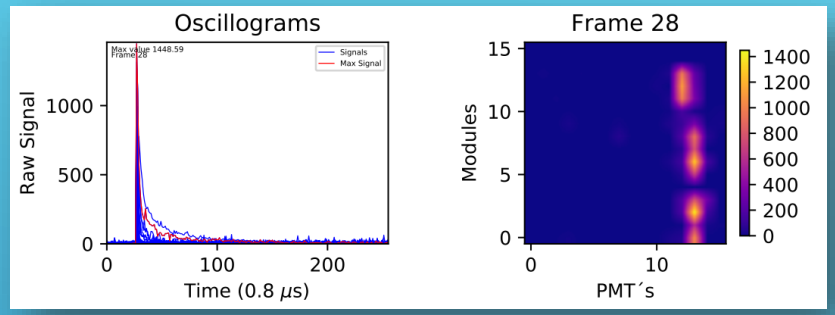
Before correction

Gain matrix



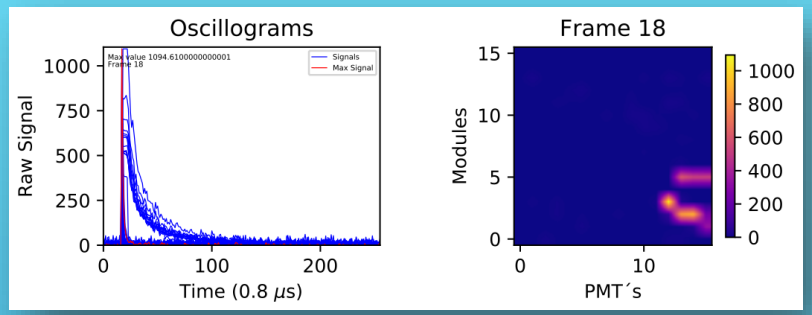


After correction

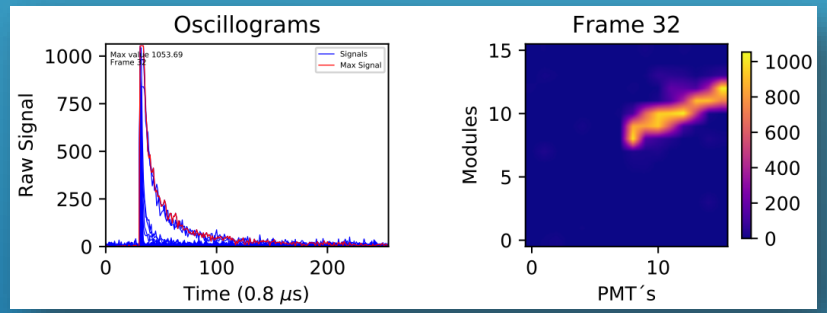


Long track

Preliminary Clasification

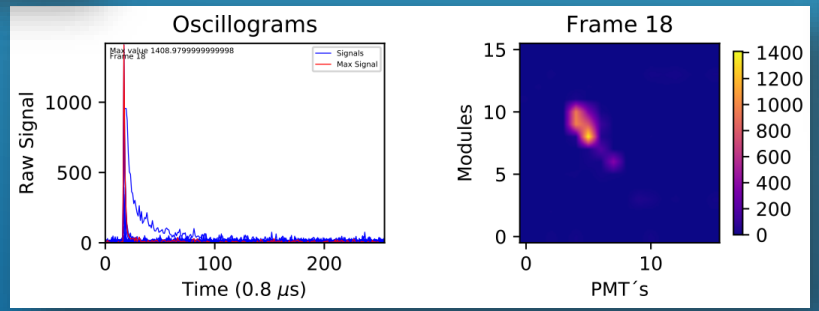


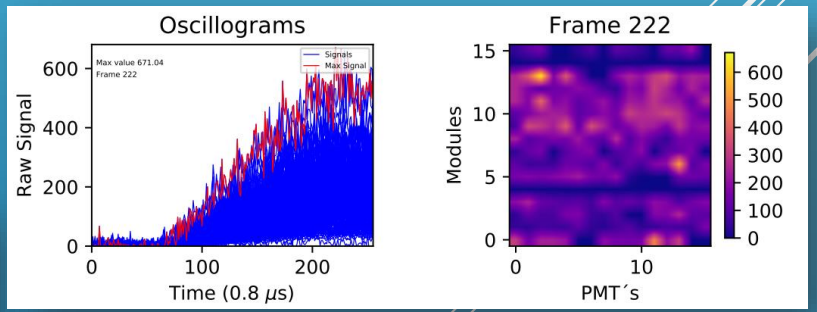
Singulars



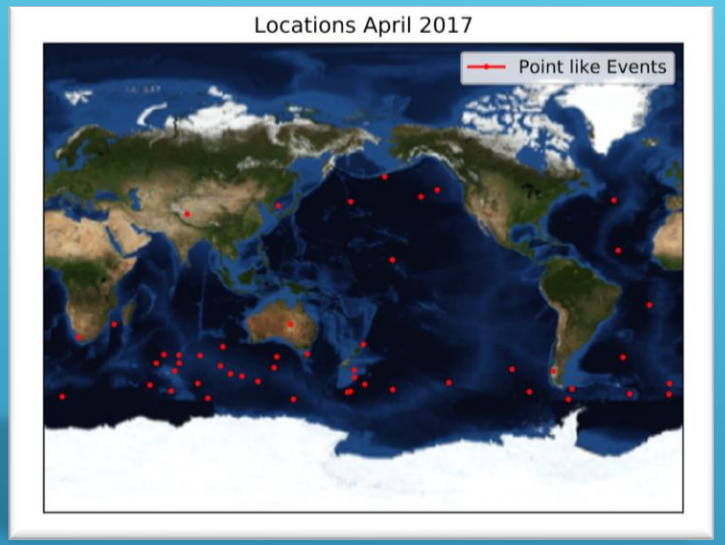
Middle track

Point like



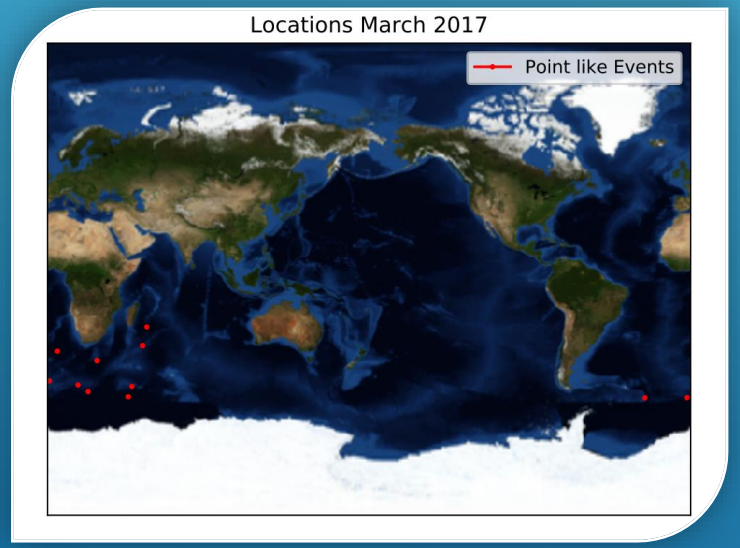


Geographic distributions



Point like events from April 2017

Point like events from March 2017

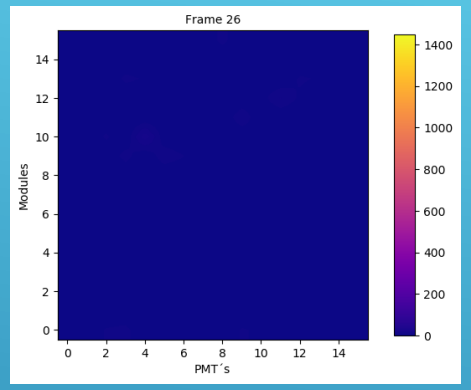


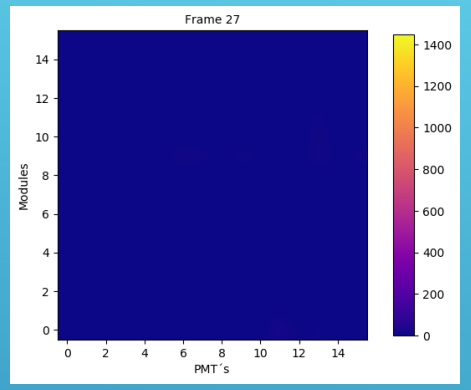
Middle events from April 2017

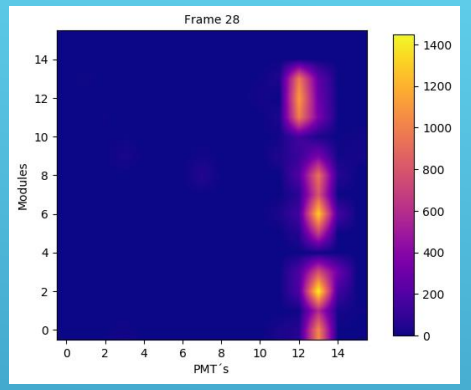
Interesting events

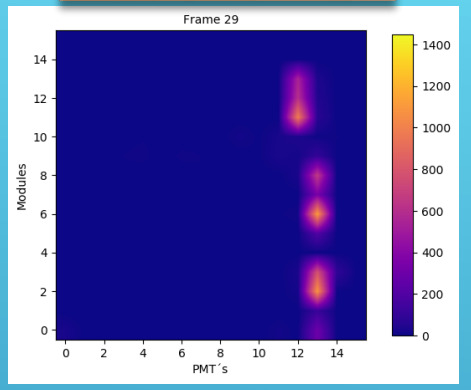
Long track event

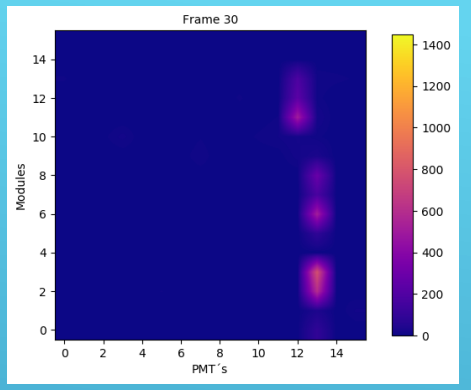
03-April-2017

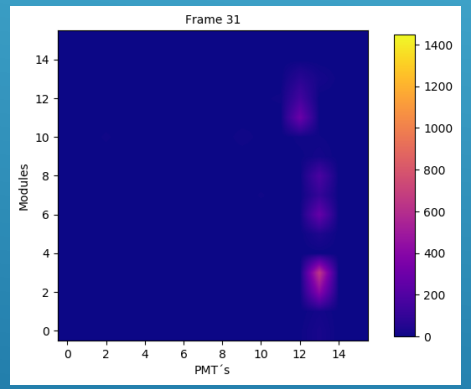


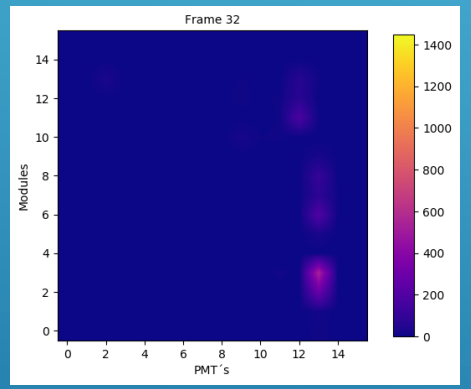


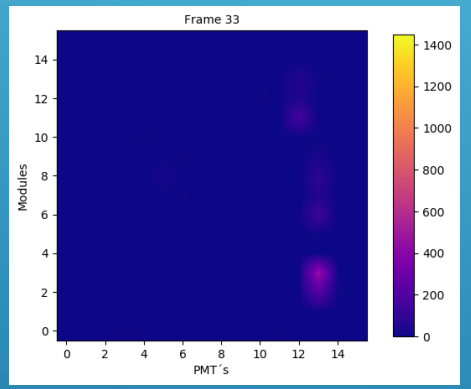


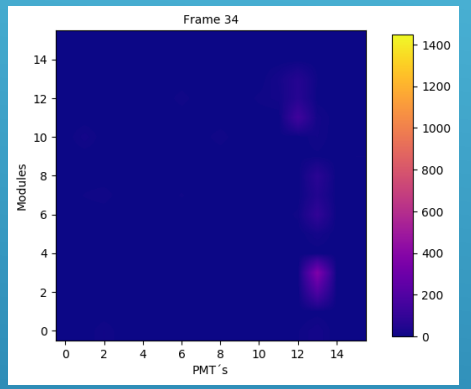


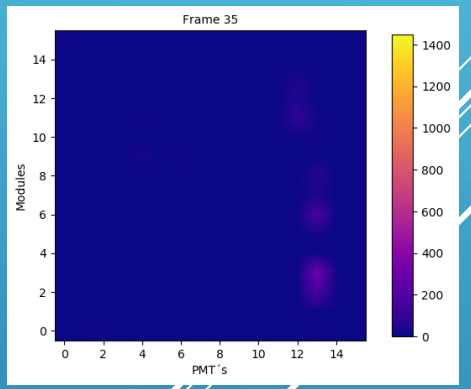


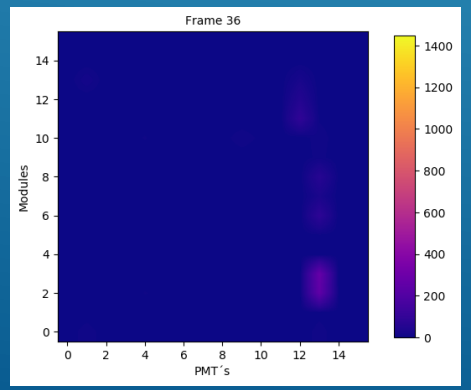


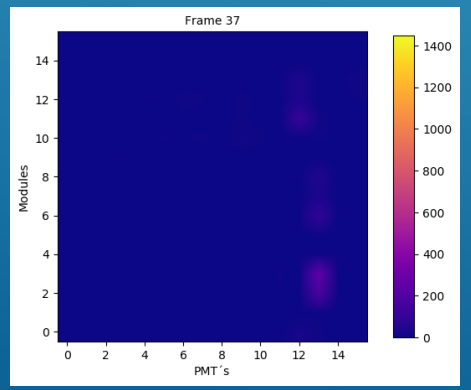


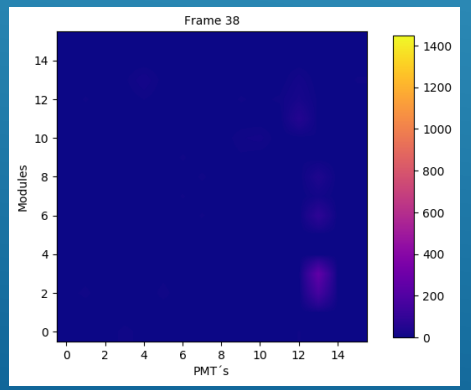


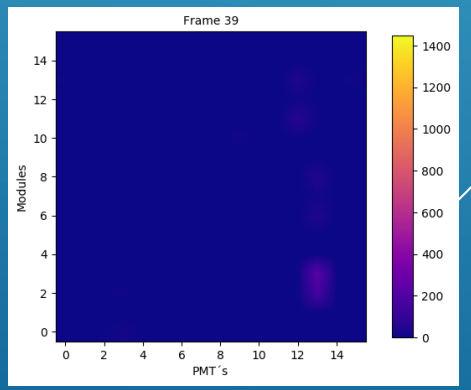




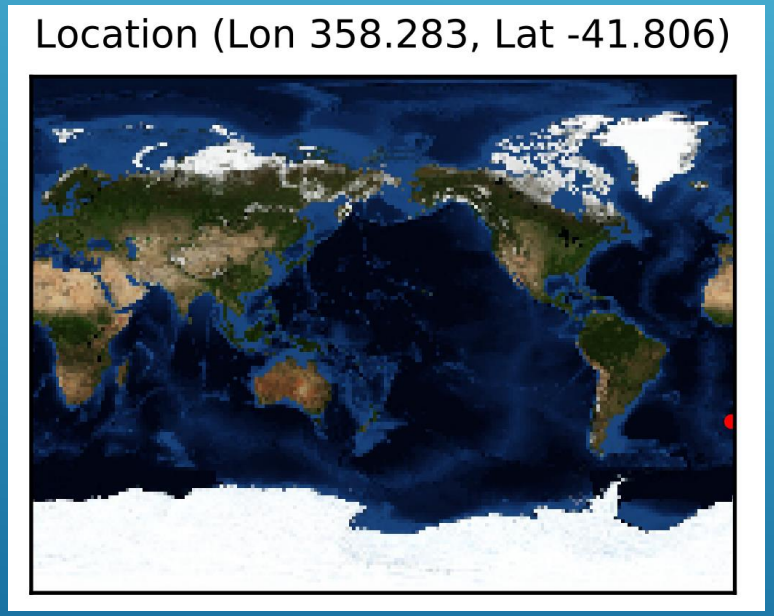






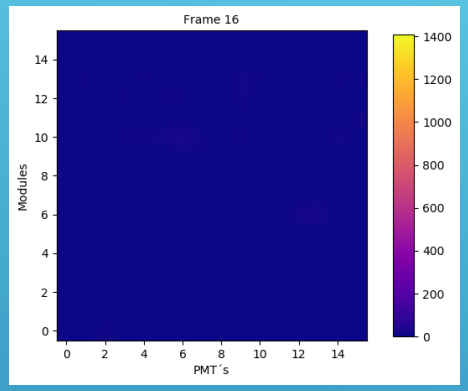


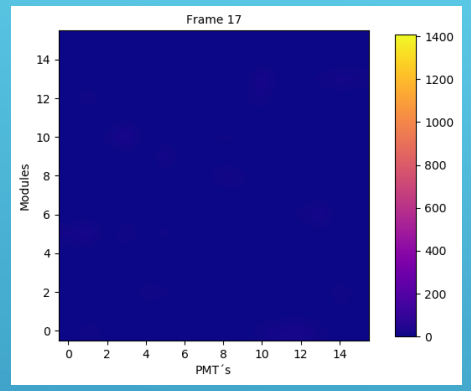
Duration (μs)	Distance Traveled (km)	Maximum Signal	Size Event at frame 28 (km^2)
16	4.8	1448.59	400

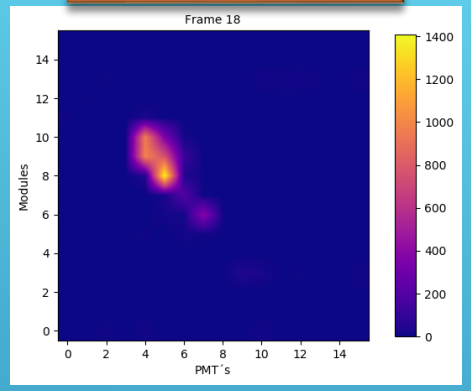


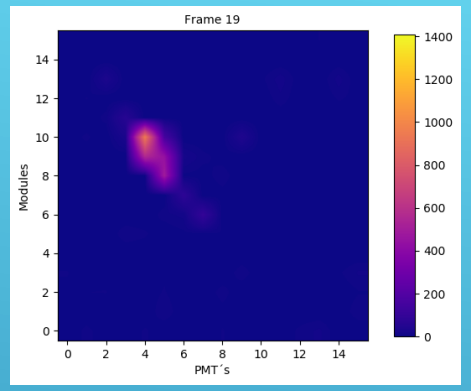
Point like event

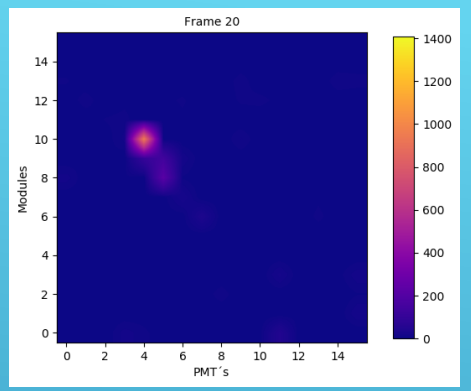
18-April-2017

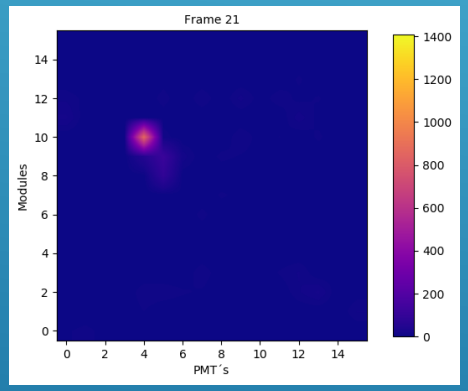


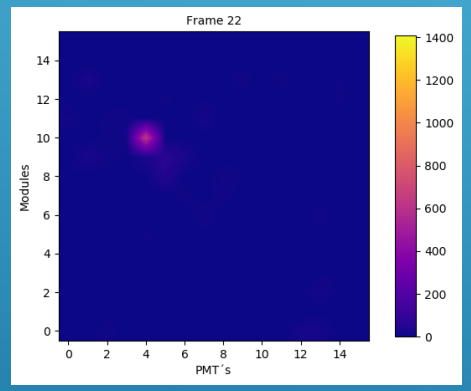


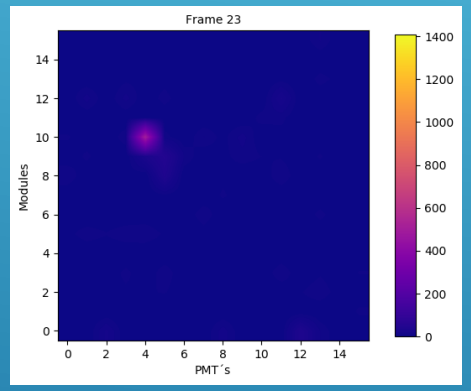


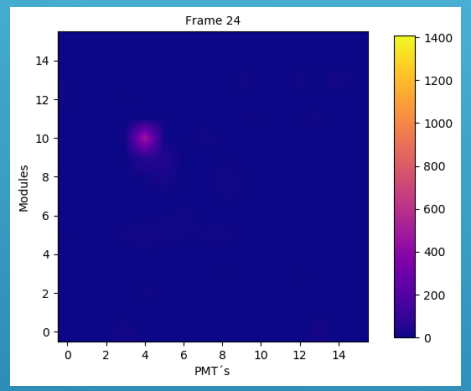


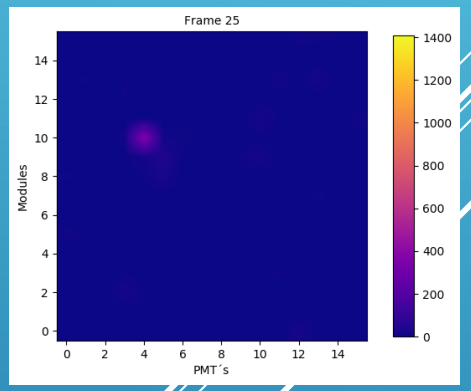


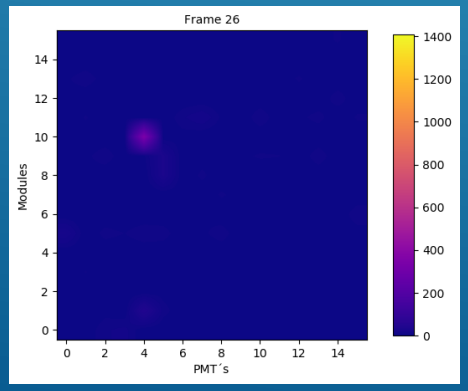


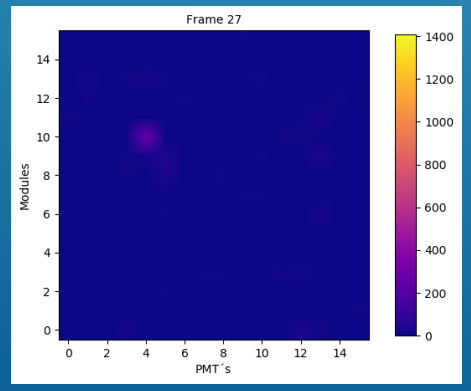


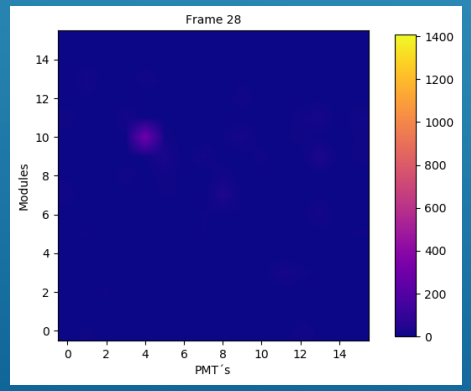


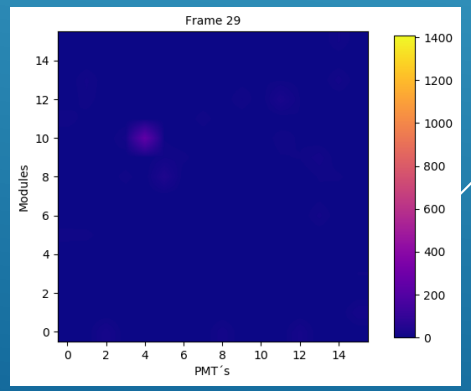




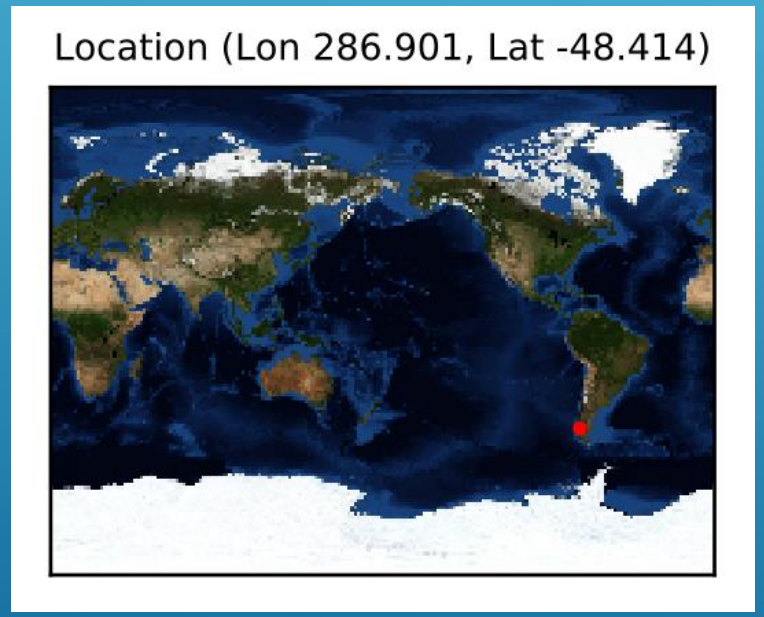






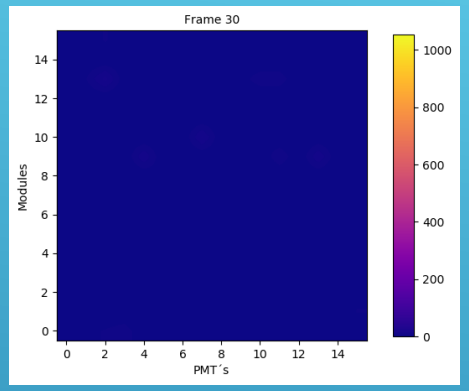


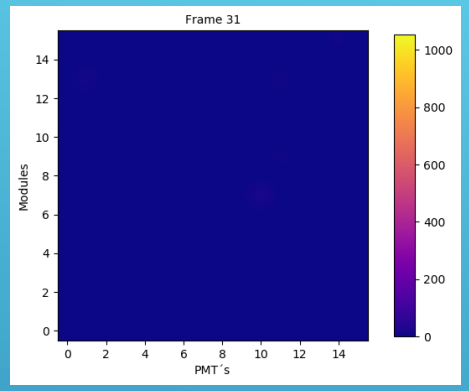
Duration (μs)	Distance Traveled (km)	Maximum Signal	Size Event at frame 18 (km^2)
36.8	11.04	1408.98	150

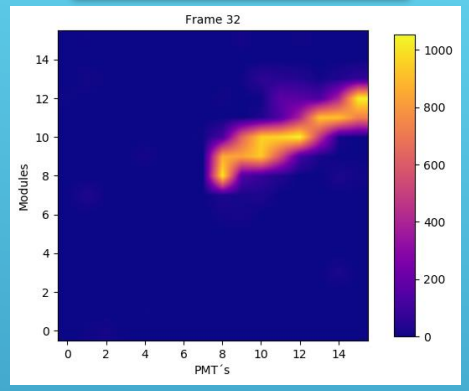


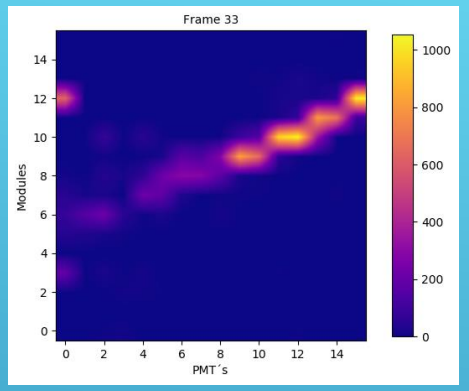
Middle track event

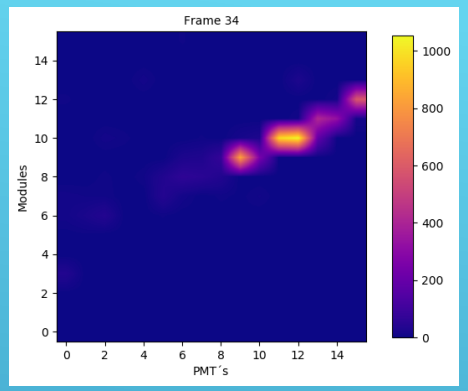
20-April-2017

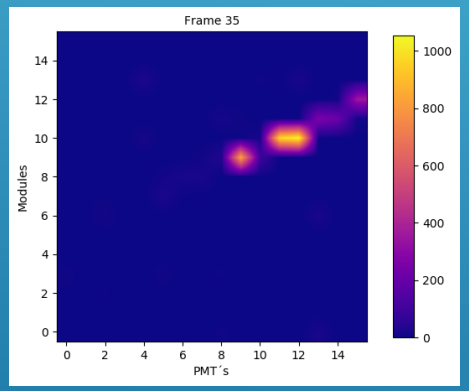


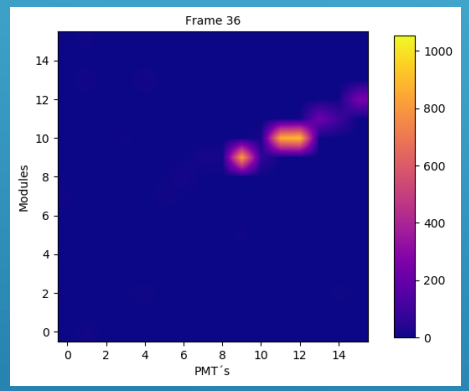


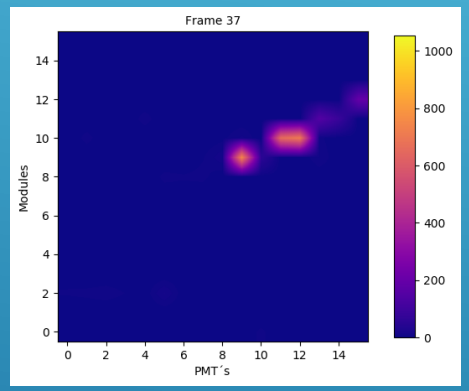


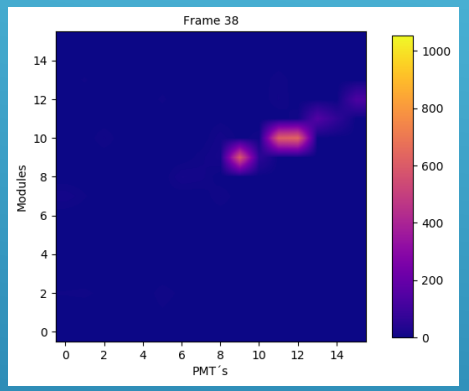


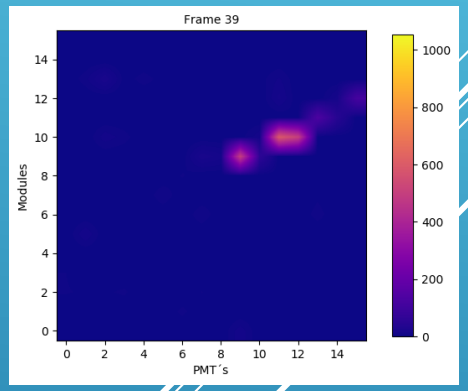


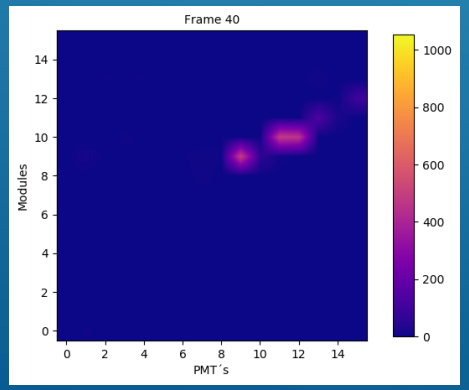


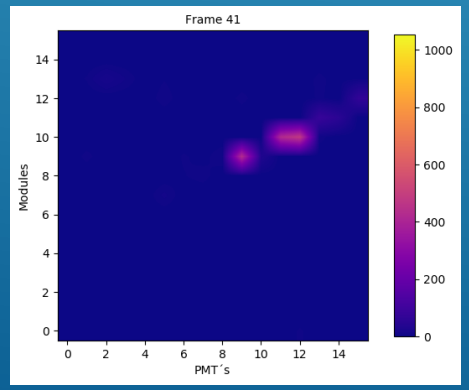


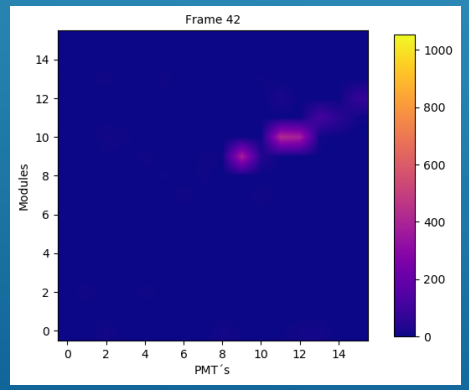


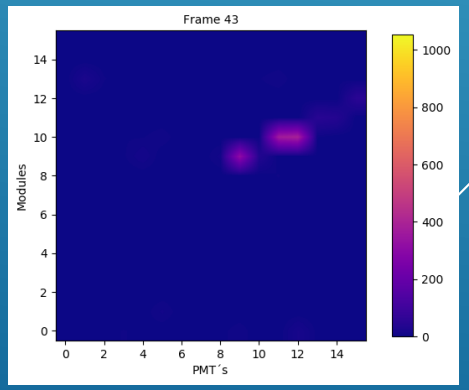




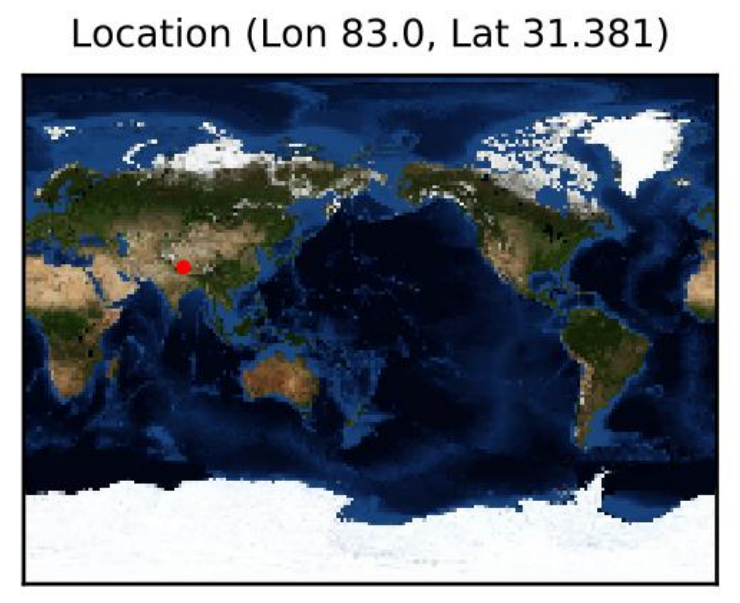


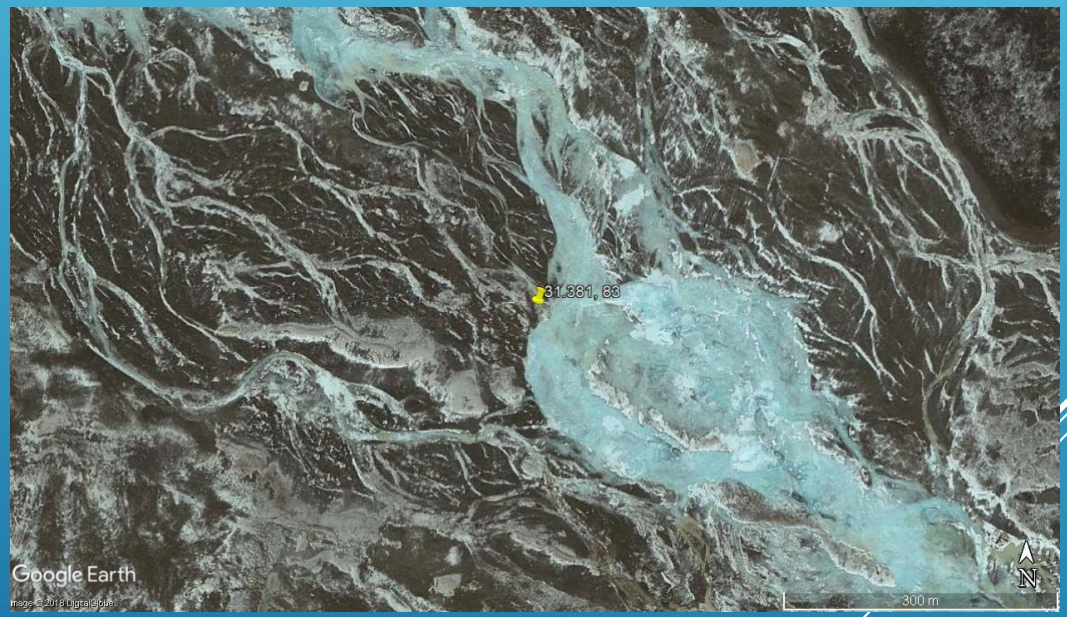






Duration (μs)	Distance Traveled (km)	Maximum Signal	Size Event at frame 32 (km^2)
40	12	1053.69	400





SUMMARY

We presented a brief scheme about the Lomonosov space project, and the TUS detector on board the Lomonosov satellite. We show the general scheme for events selection from TUS and discussed some results from events of the first semester of 2017 of the TUS on EAS operational mode, like a classification and geographic distribution.

we are working on statistical analysis of the maximum value recorded on the event, as well as the analysis of the spatial extention of the interesting events.

GRACIAS POR SU ATENCIÓN