BIRA • IASB

The von Karman Institute for Fluid Dynamics

Institut de Mécanique Céleste et de Calcul des Éphémérides

MEteors **TR**ajectories and **O**rigins

Status of the optical and radio FRIPON networks

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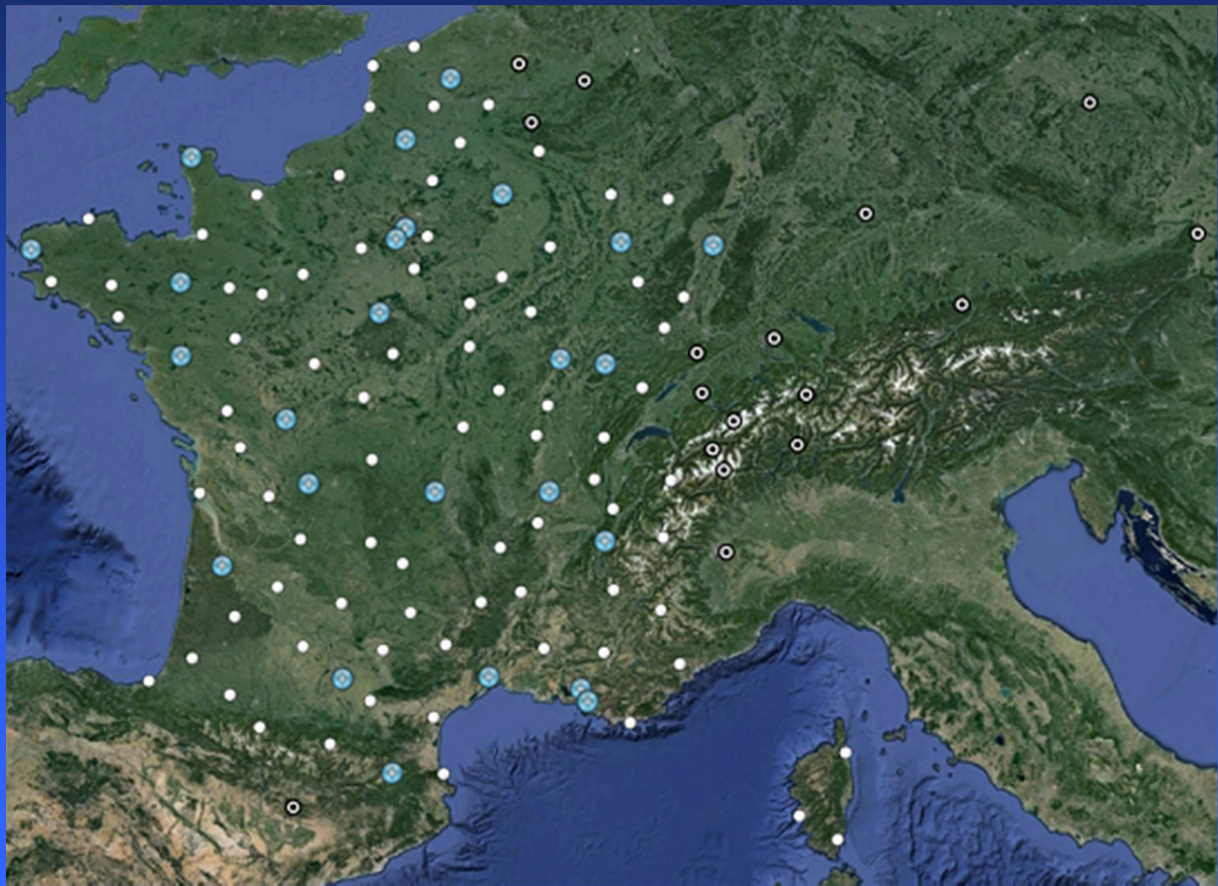
IASB. 16 november 2017
Uccle, Belgium

FRIPON presentation

FRIPON (Fireball Recovery and InterPlanetary Observation Network) is a French program planning to use a network of 100 video cameras and 25 radio receivers running 24/24 7/7 to observe fireballs and to determine their trajectories and their eventual strewnfields



Status of the video network (November 2017)

FRIPON radio network presentation

Status of the radio network (November 2017)

The yellow surface is the "theoretical sky coverage " by the GRAVES radar at an altitude of 100 km. In fact, meteor radio echoes have been reported from Malta to various places in UK

FRIPON cooperates with neighbouring countries, for example …

Montsec (Spain)

Bucarest
(Romania)

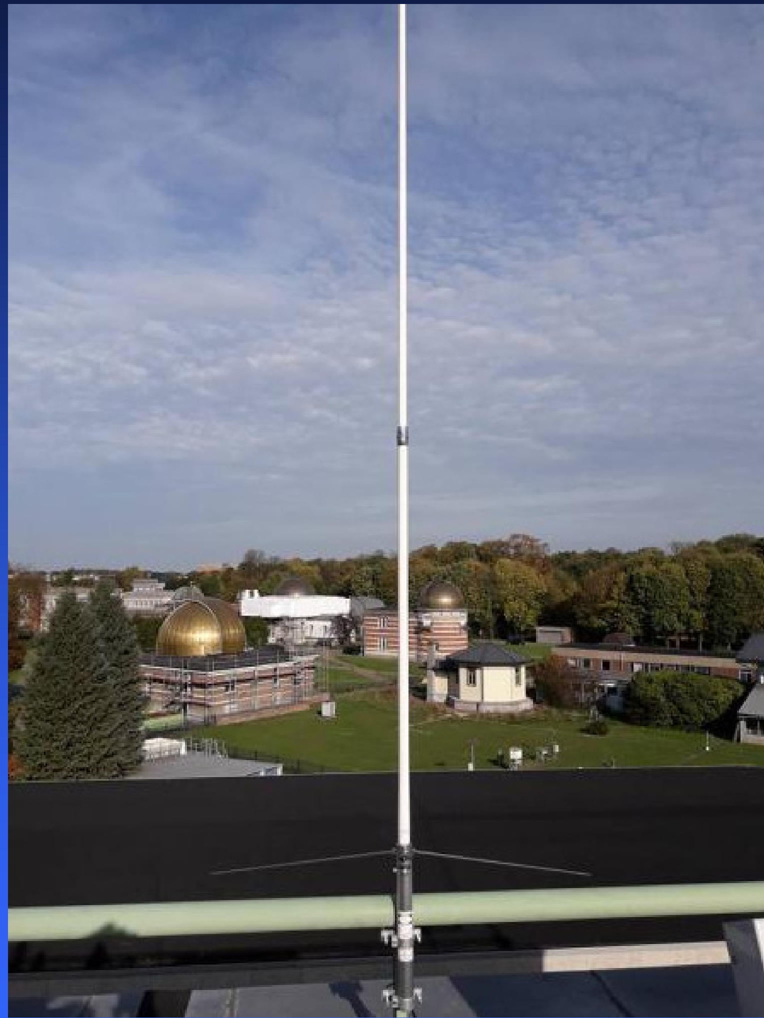
Wien (Austria)

Pino Torinese (Italy)

Noordwijk (Netherlands)

And …

… Belgium

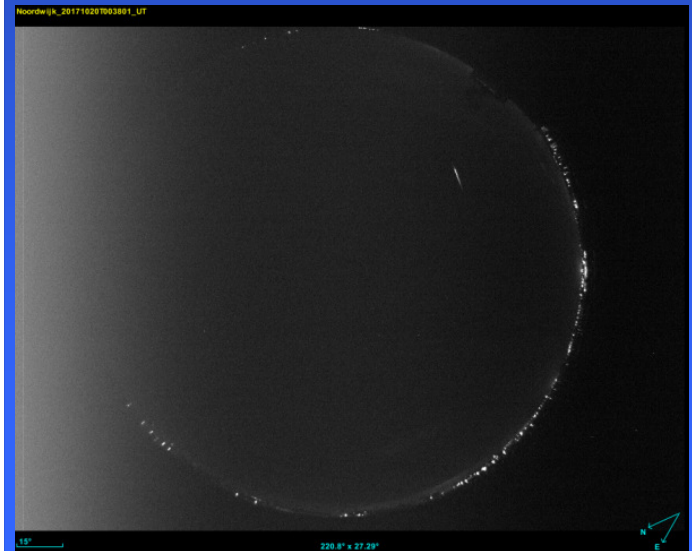


Belgian Institute for Space Aeronomy, Uccle

An example of multidetection

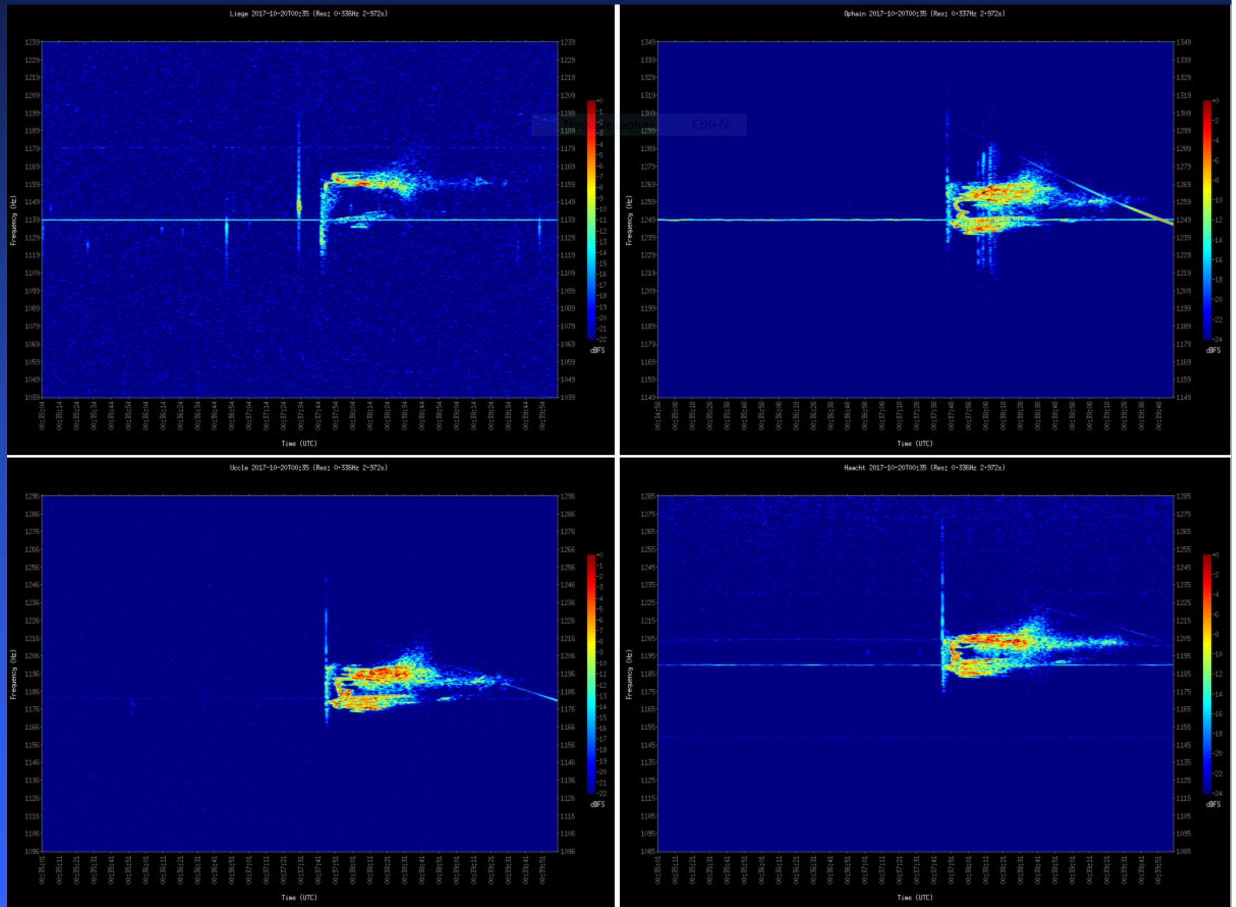
FRIPON video network

Uccle



Noordwijk

BRAMS radio network

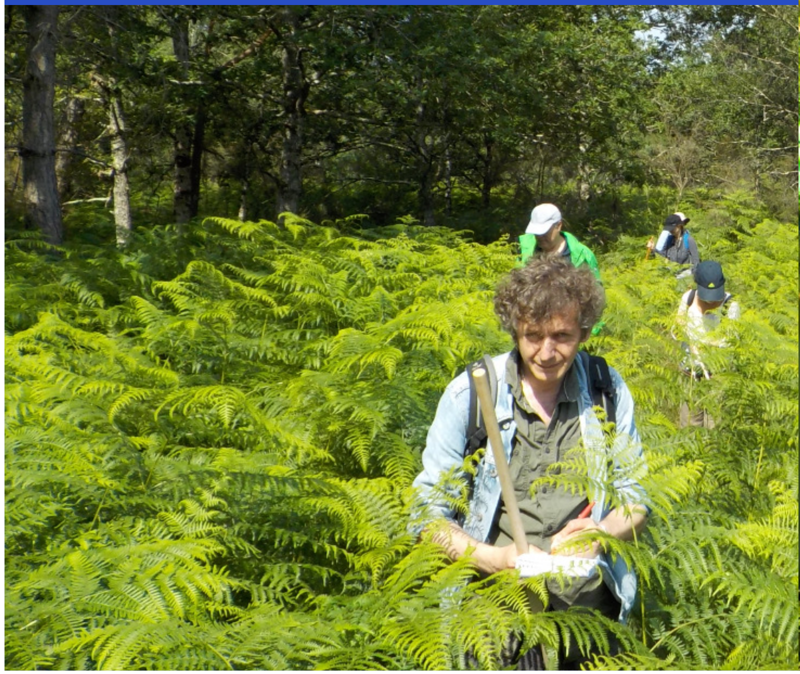


20171020T003801

Status and on going FRIPON tasks

- 82/100 video cameras running
- 14/25 radios running
- Pipeline running, but:
  - Accurate astrometry still in progress
  - Data network and storage improvement
- Accuracy assessment on data measurement and trajectory modelling
- Radio data processing automation
- 3 potential meteorites strewnfields identified

First meteorite hunting in Chambord forest, juin 2017



Focus on the interaction of some meteors with the upper atmosphere

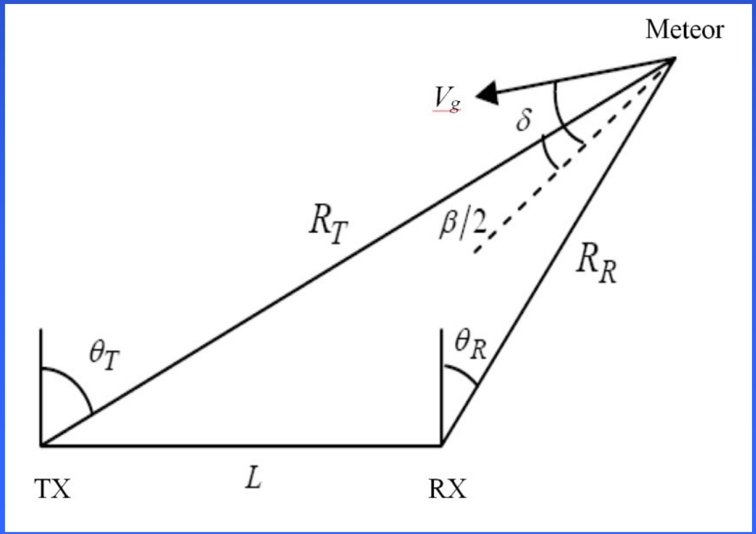
General principles of the FRIPON radio network

FRIPON uses cameras to compute the trajectories of the fireballs, and a radio set-up allows to obtain accurate target velocity measurement.

The radio set-up is based on a multistatic radar configuration and consists in:

- one VHF HPLA (High Power Large Aperture) transmitter scanning a large volume of sky
- Twenty five SDR (software defined radios) located with some of the 100 video cameras

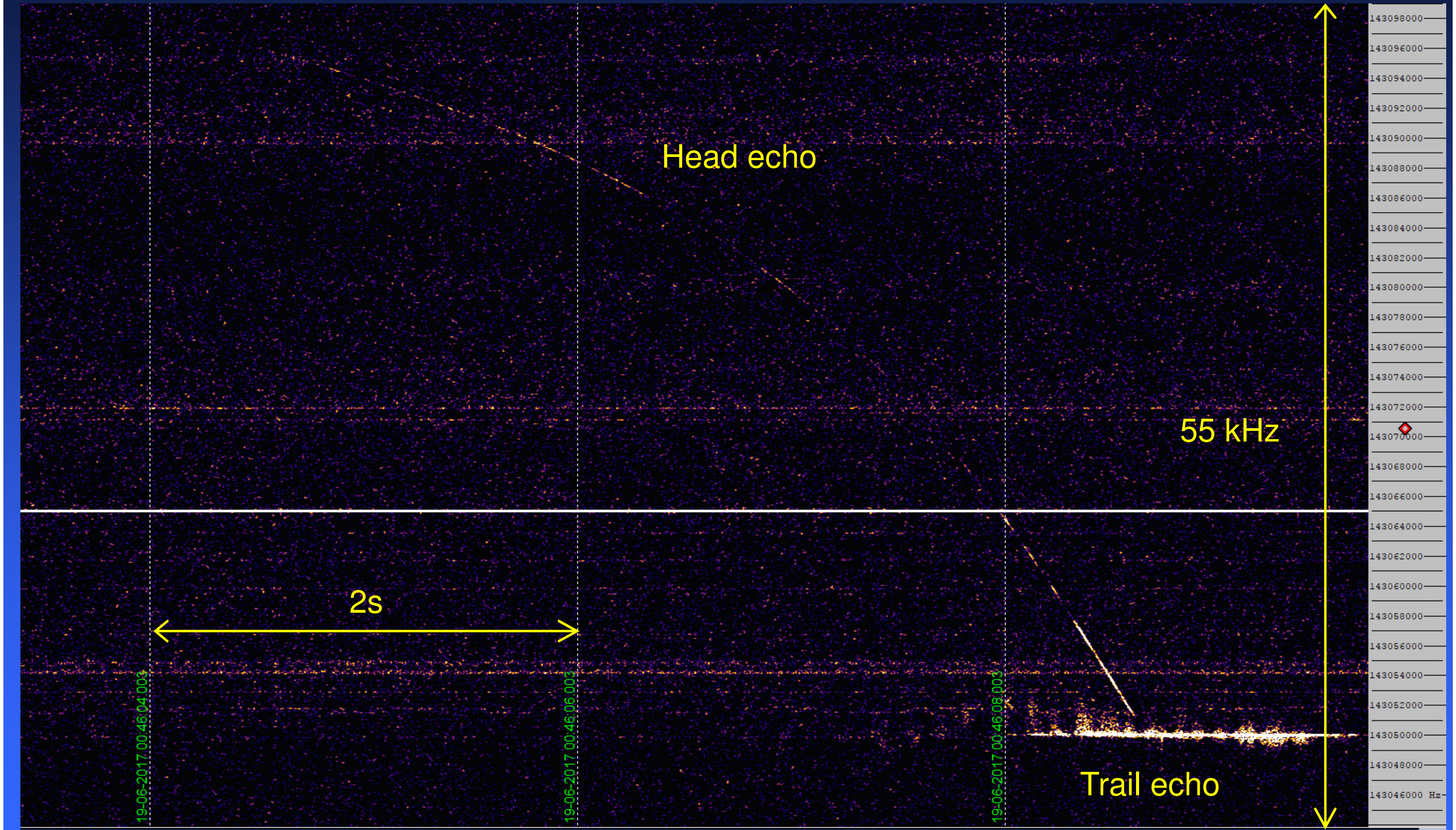
The Doppler Fizeau frequency shift affecting a meteor radio echo is presently used to compute the velocity of this meteor



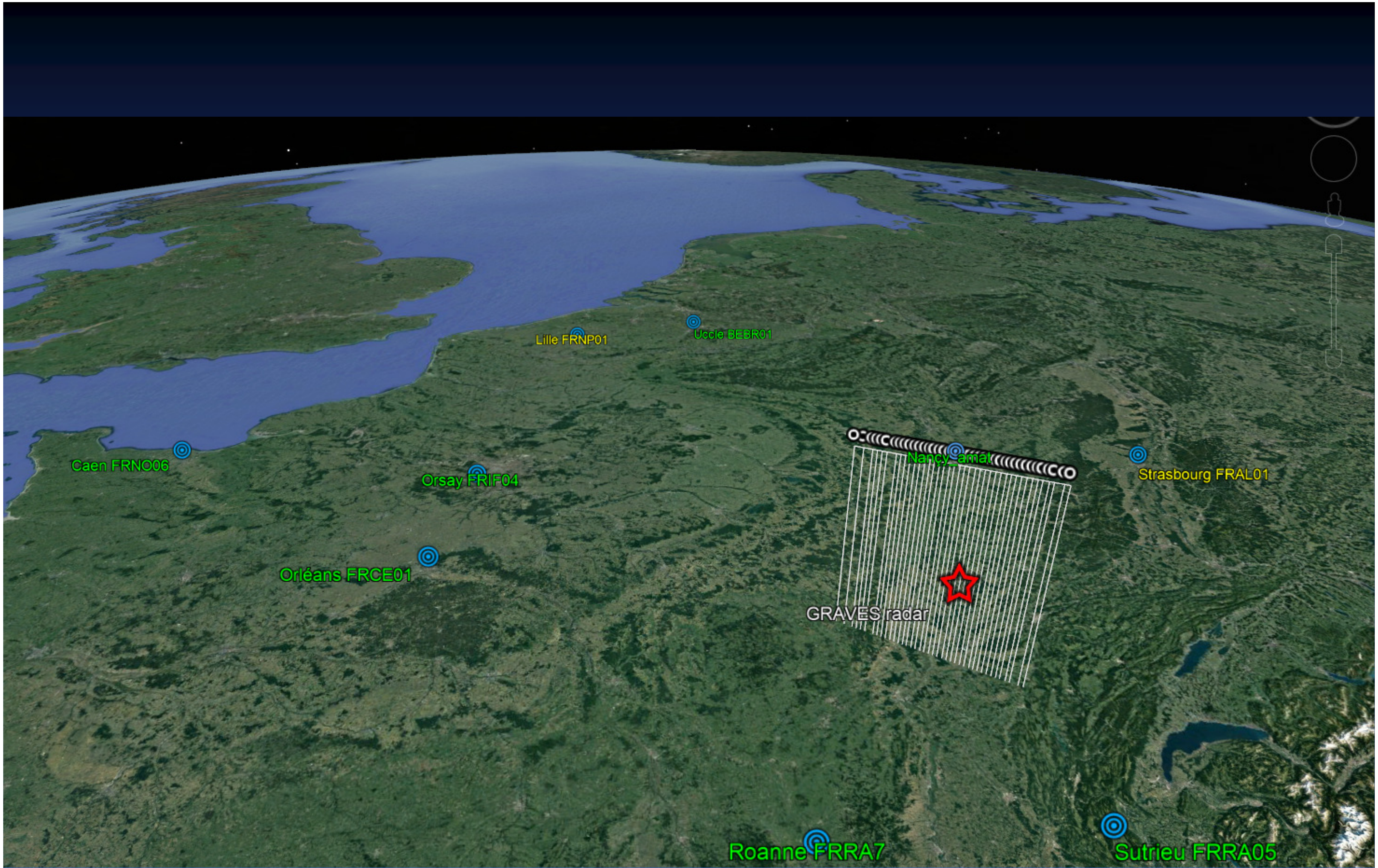
$$V_g = \frac{c \cdot \Delta f}{2 \cdot f \cdot \cos(\delta) \cdot \cos(\beta/2)}$$

General principles of the FRIPON radio network

Example of a long meteor radio head echo recorded by the FRIPON network



Toulouse FRMP02_R_20170619T004448,471_UT



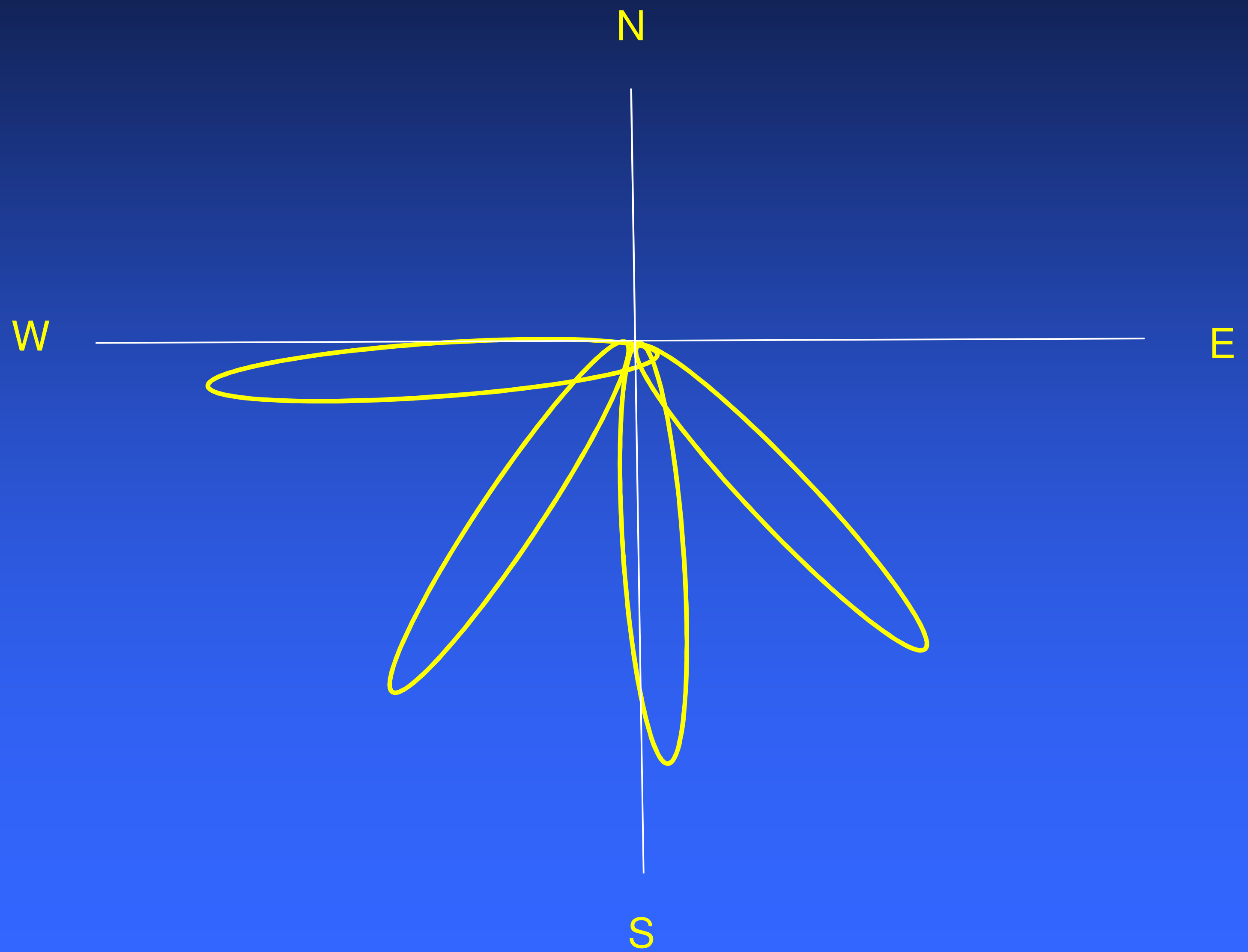
Corresponding trajectory computed with the data of 5 video cameras

Transmitter used by FRIPON

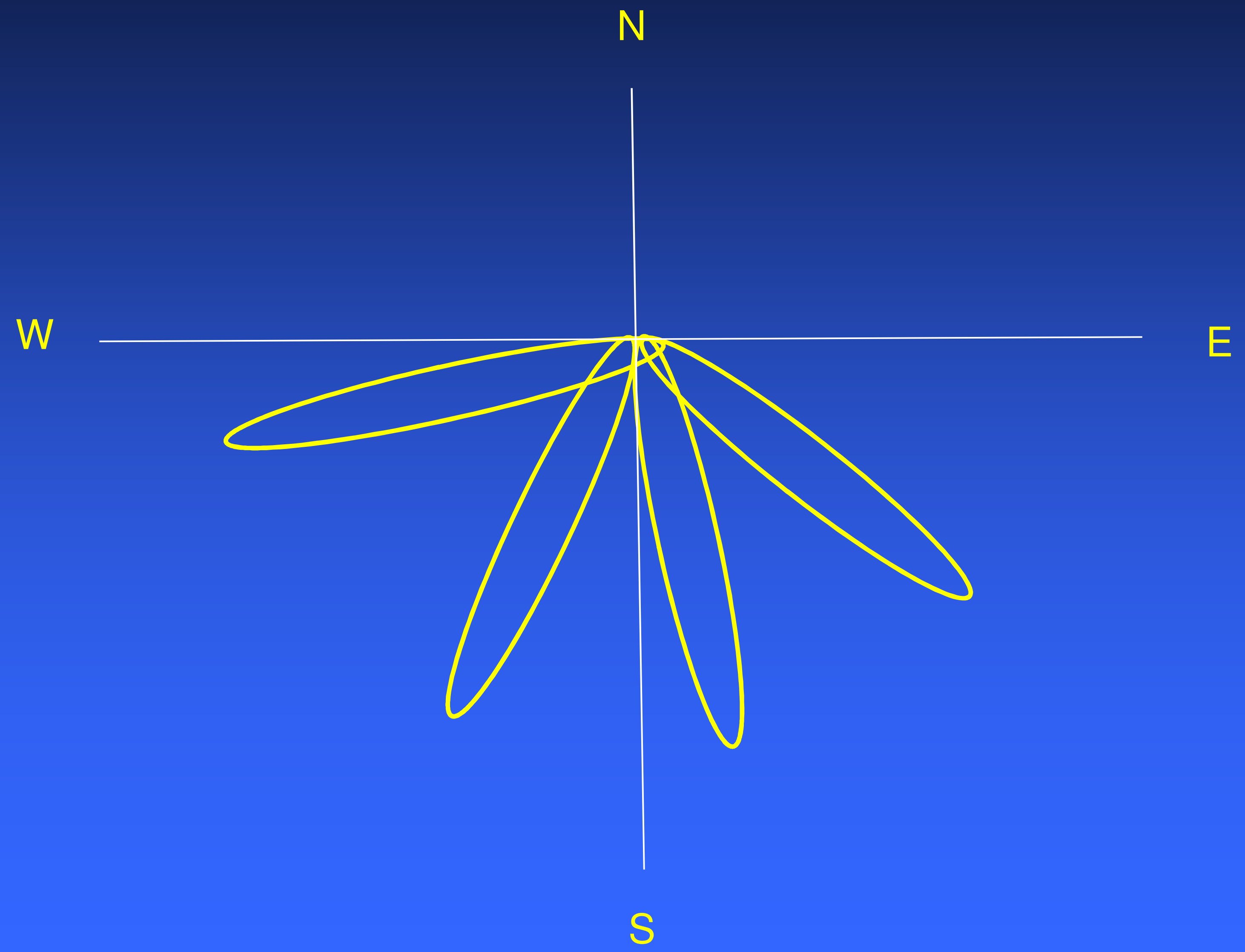
The HPLA (High Power Large Aperture) french military GRAVES radar is used by FRIPON to observe head echoes scattered by the free electrons surrounding the moving meteor bodies.

4 VHF patch arrays located near Dijon, France are used by the french Air Forces to detect, classify and determine accurate keplerian elements of satellites

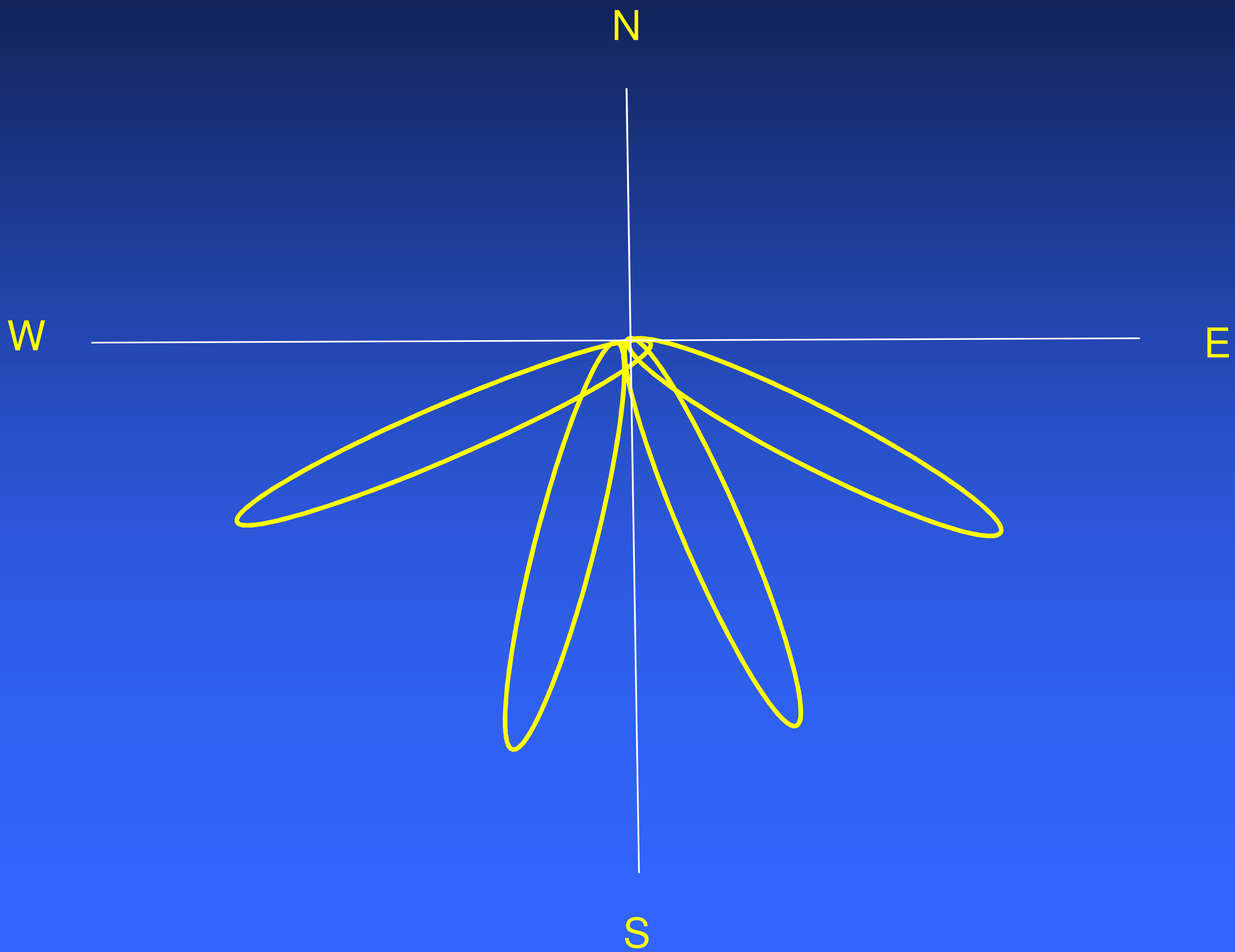
GRAVES transmitter beam forming



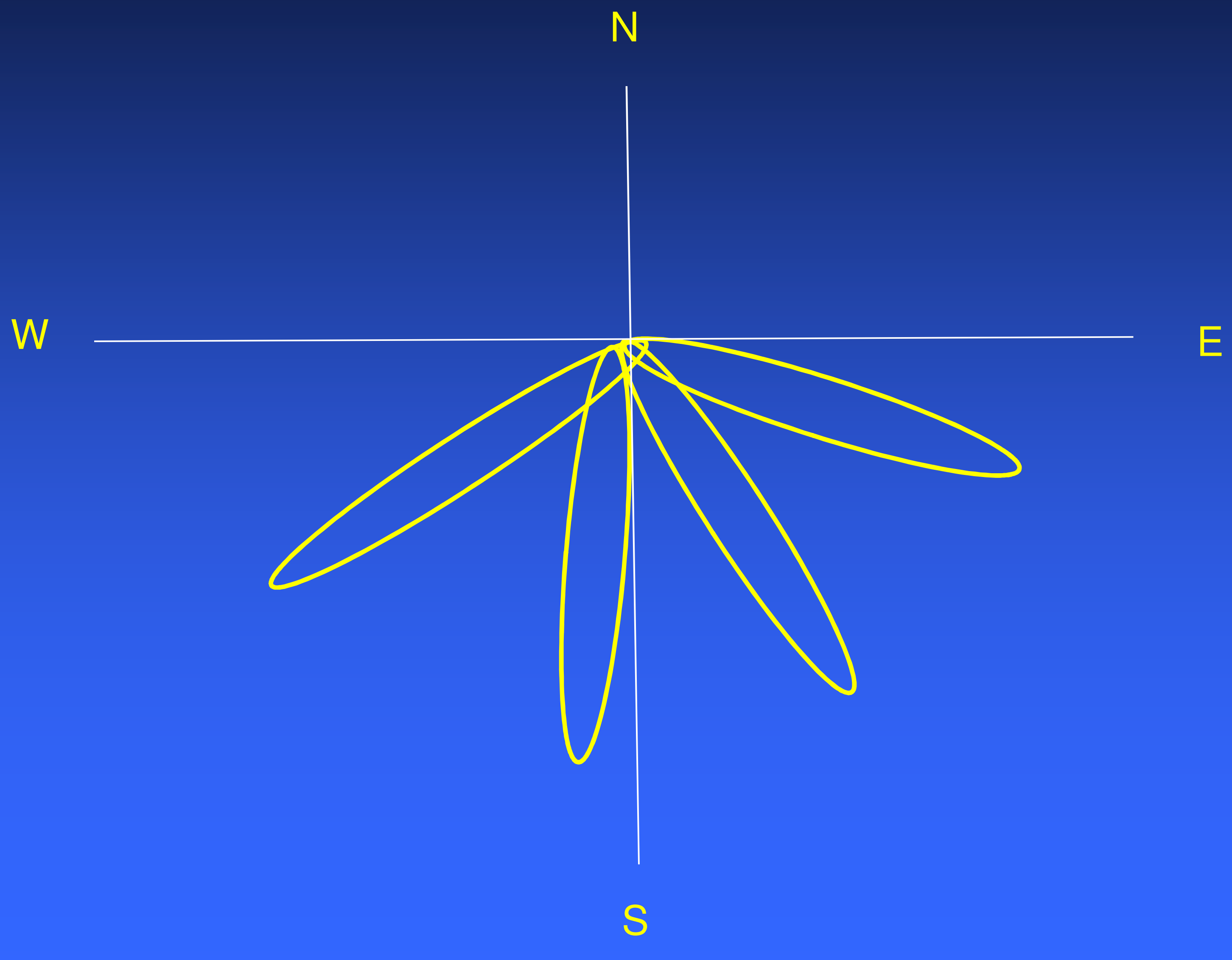
GRAVES transmitter beam forming



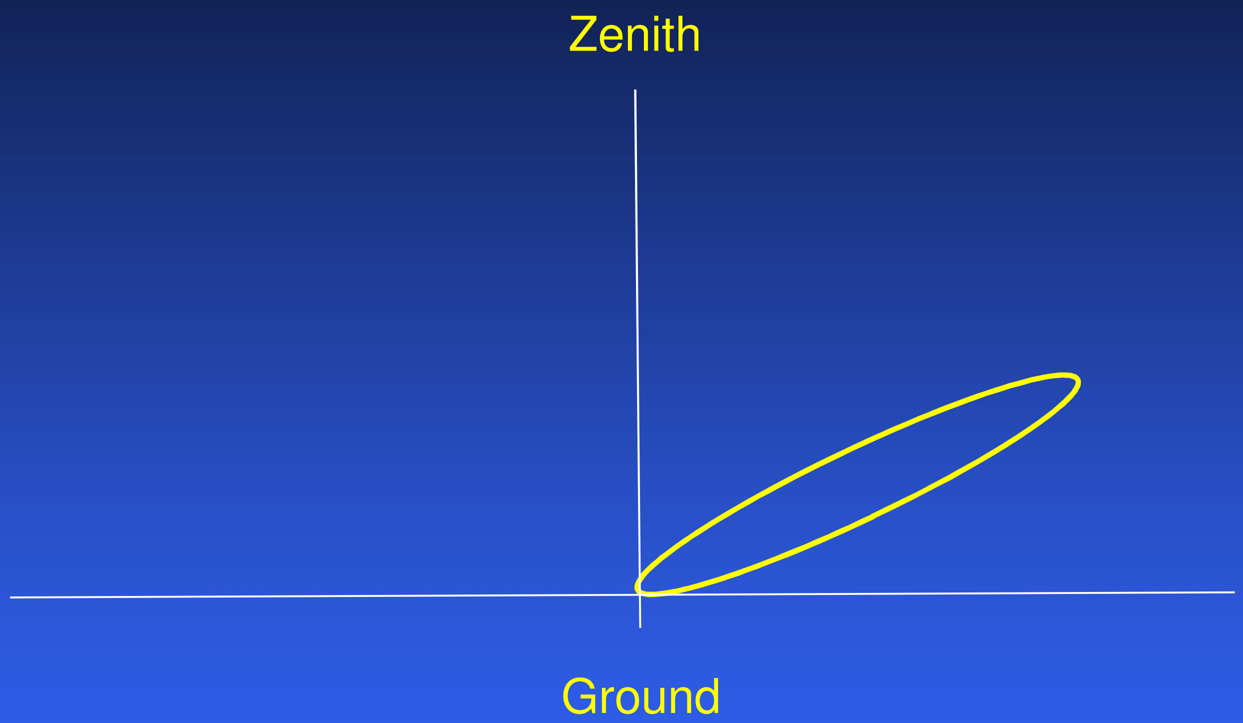
GRAVES transmitter beam forming



GRAVES transmitter beam forming



GRAVES transmitter beam forming

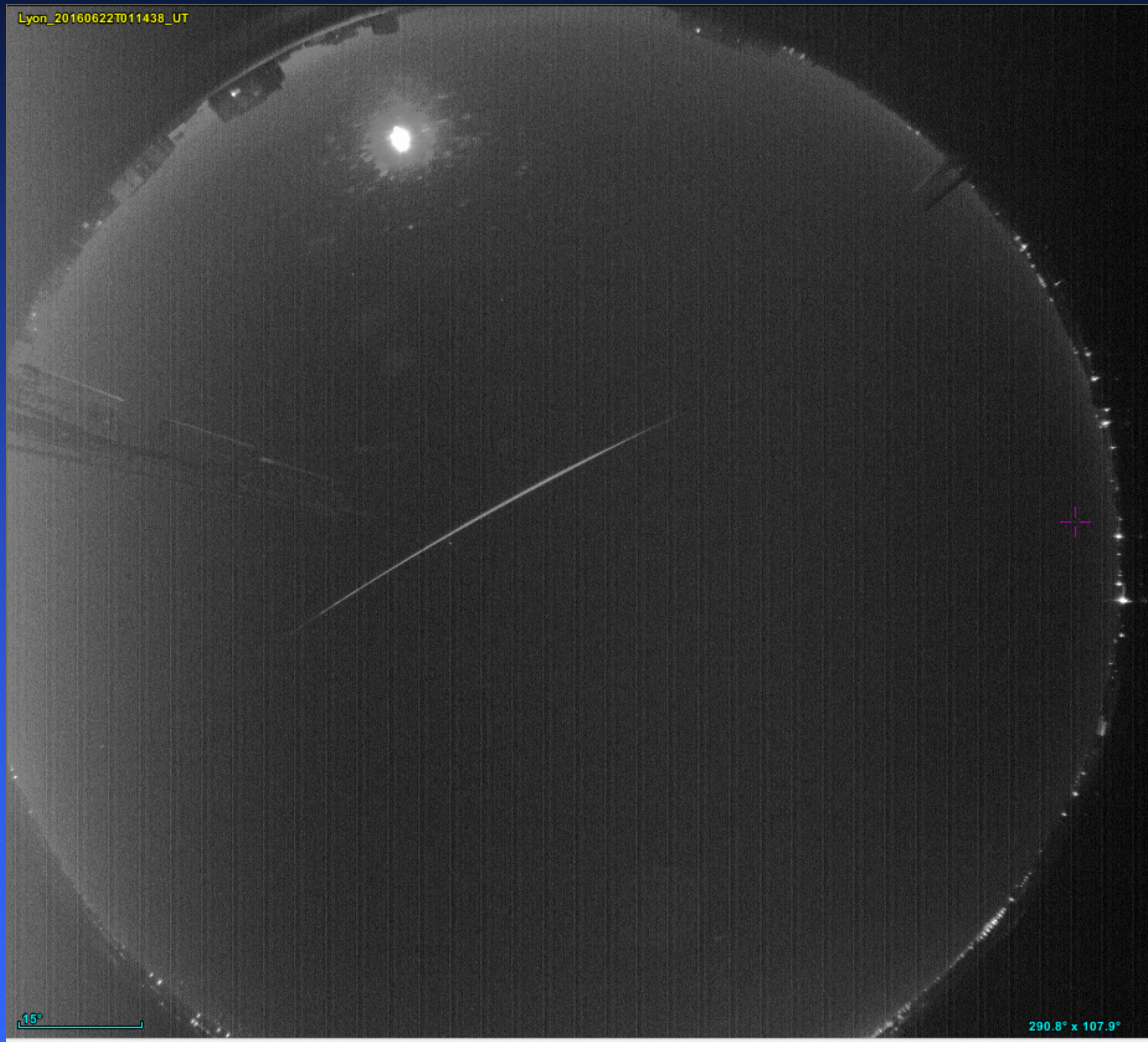


Analysis of some particular meteor Doppler signatures

An example of fireball partial fragmentation

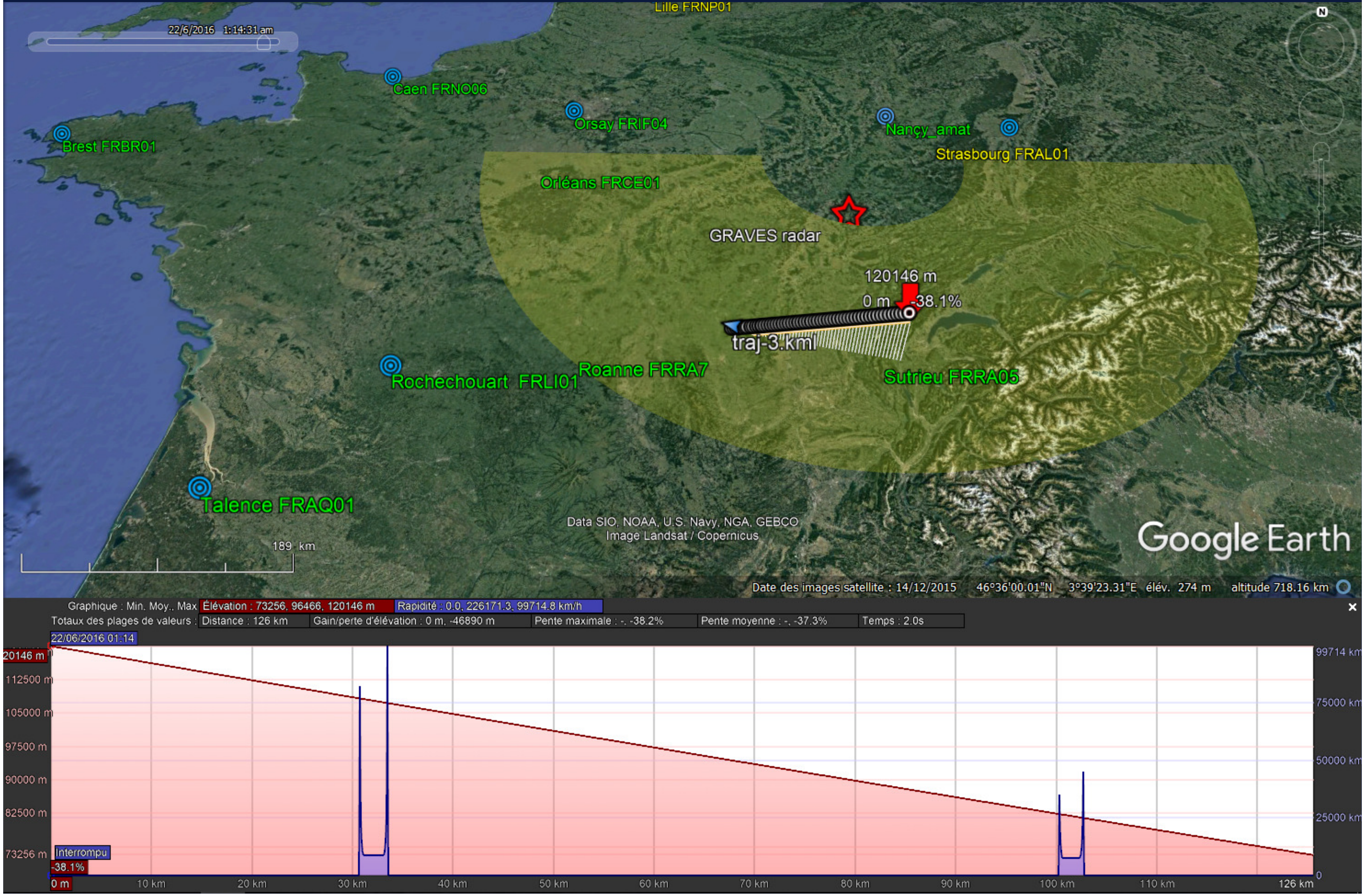
20160622T011430_UT bolide

An example of fireball partial fragmentation

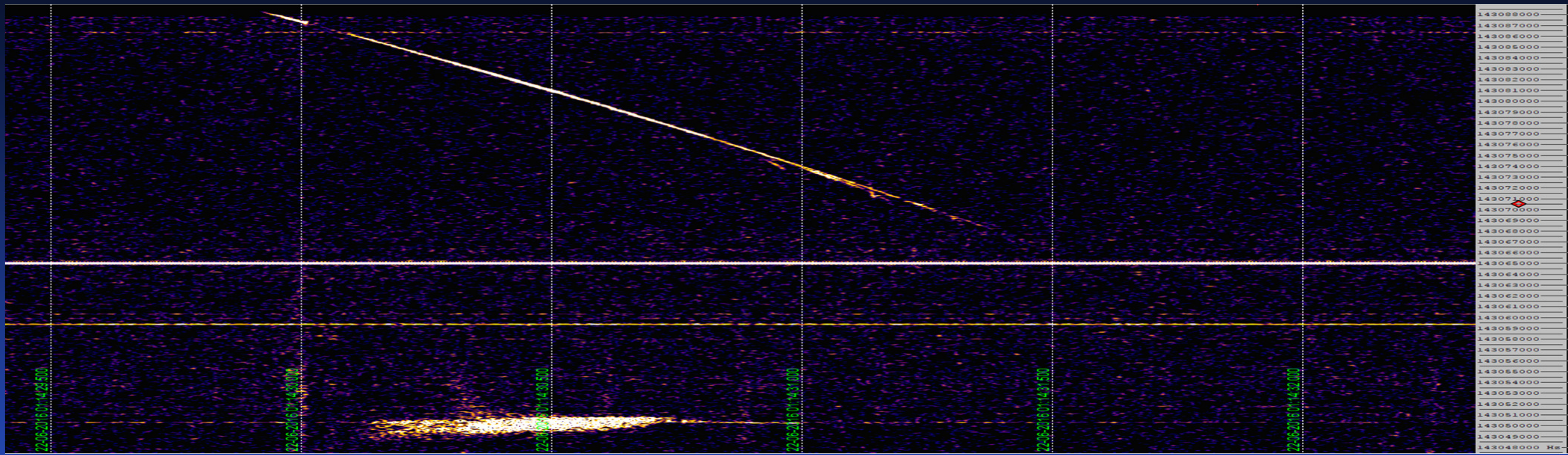


The bolide as seen by the Lyon video camera

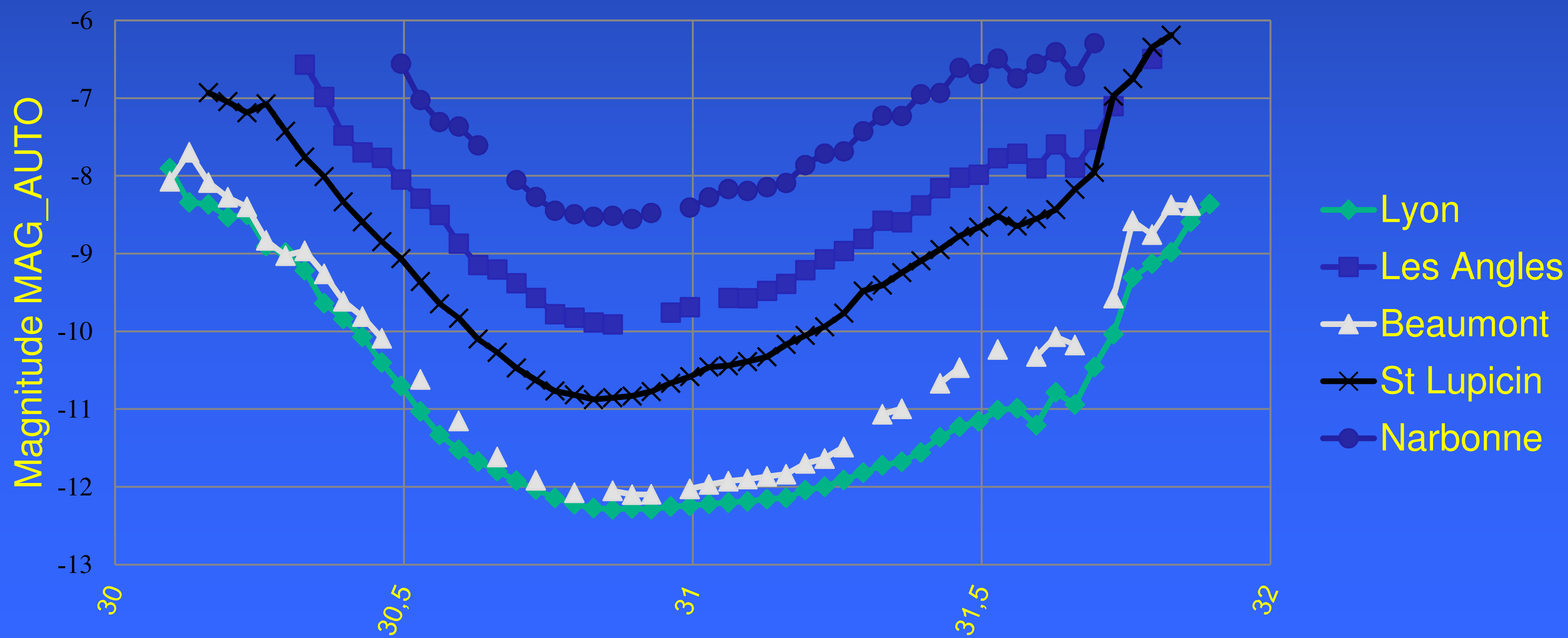
An example of fireball partial fragmentation



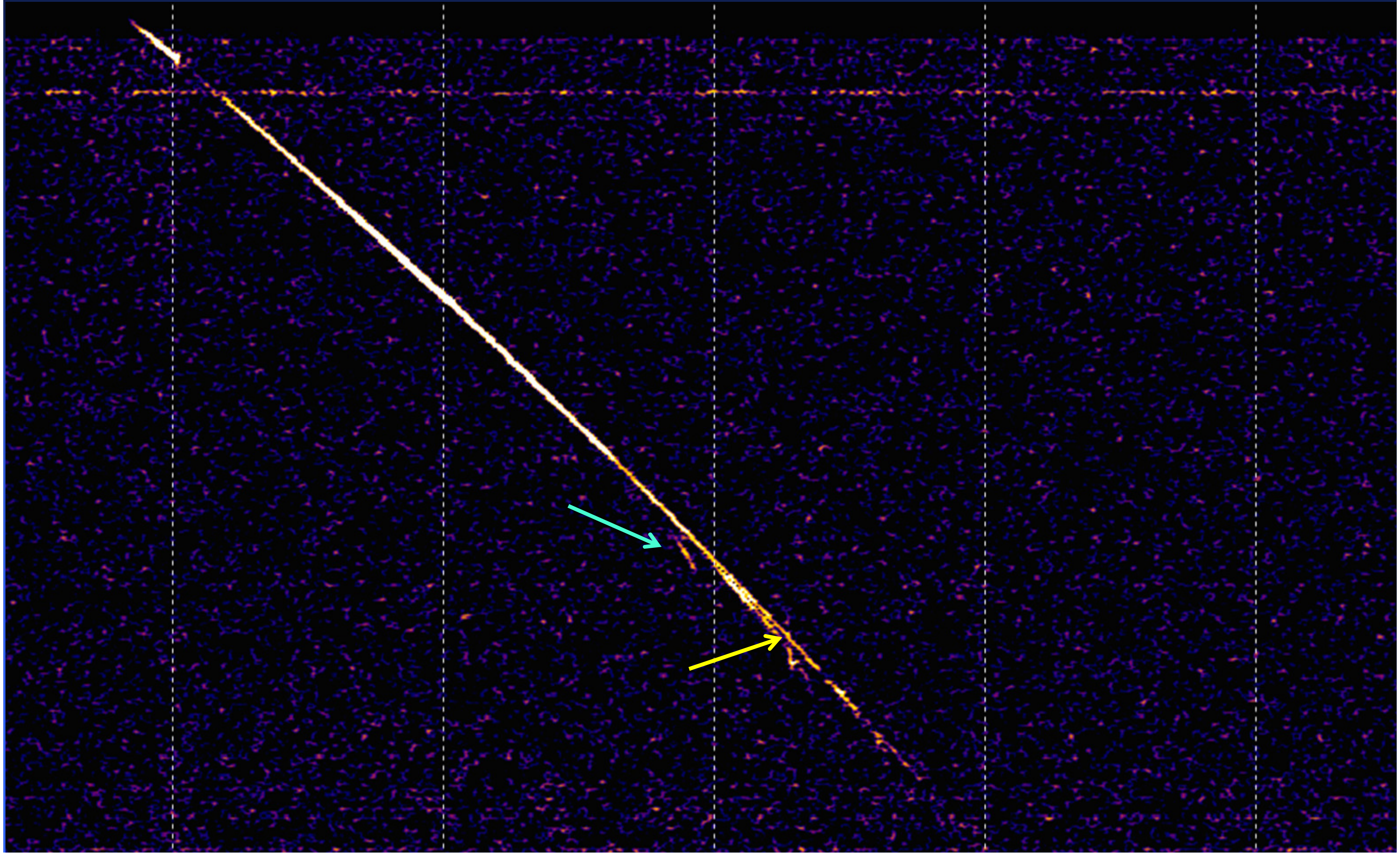
An example of partial fireball fragmentation

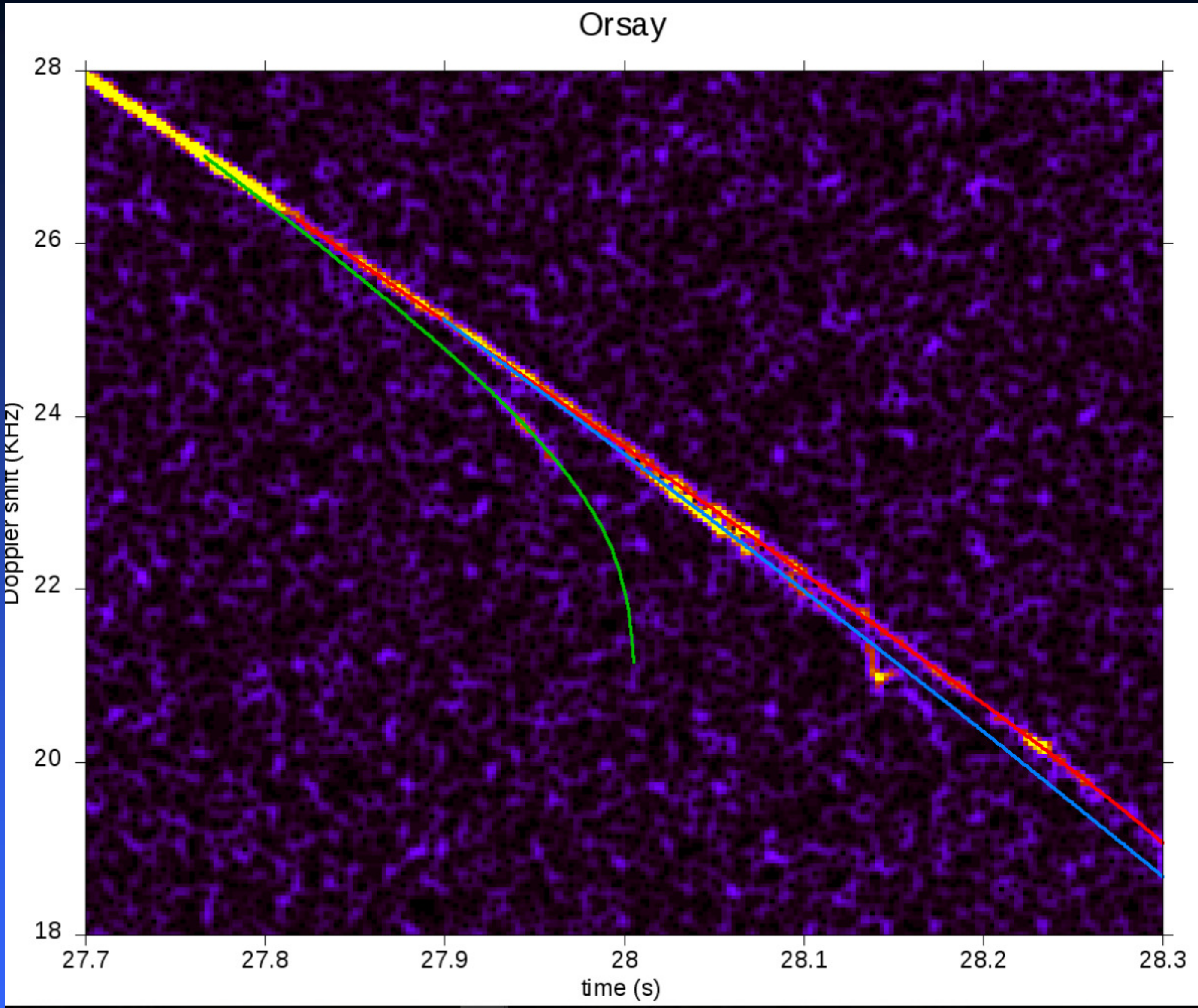


20160622T011430_UT fireball (seen by 18 FRIPON cameras)



An example of partial fireball fragmentation

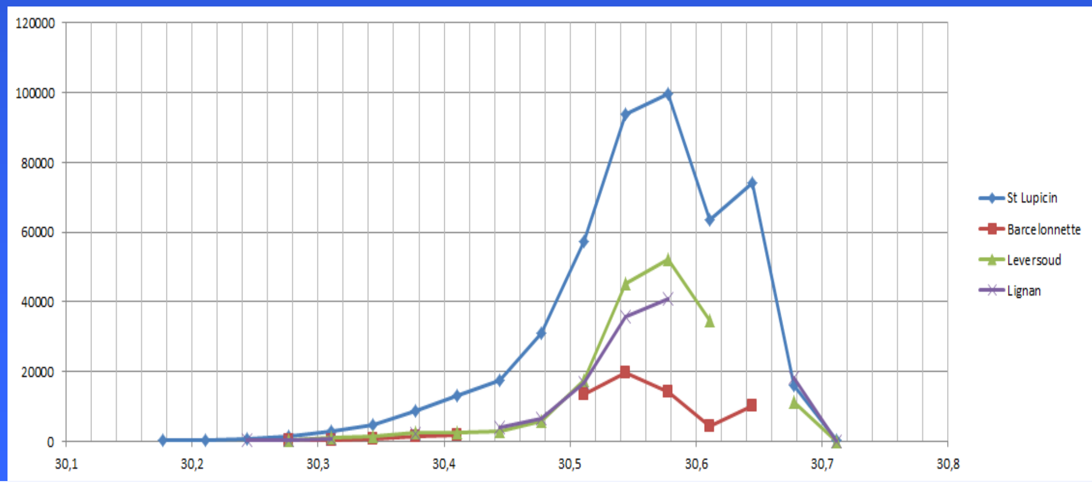




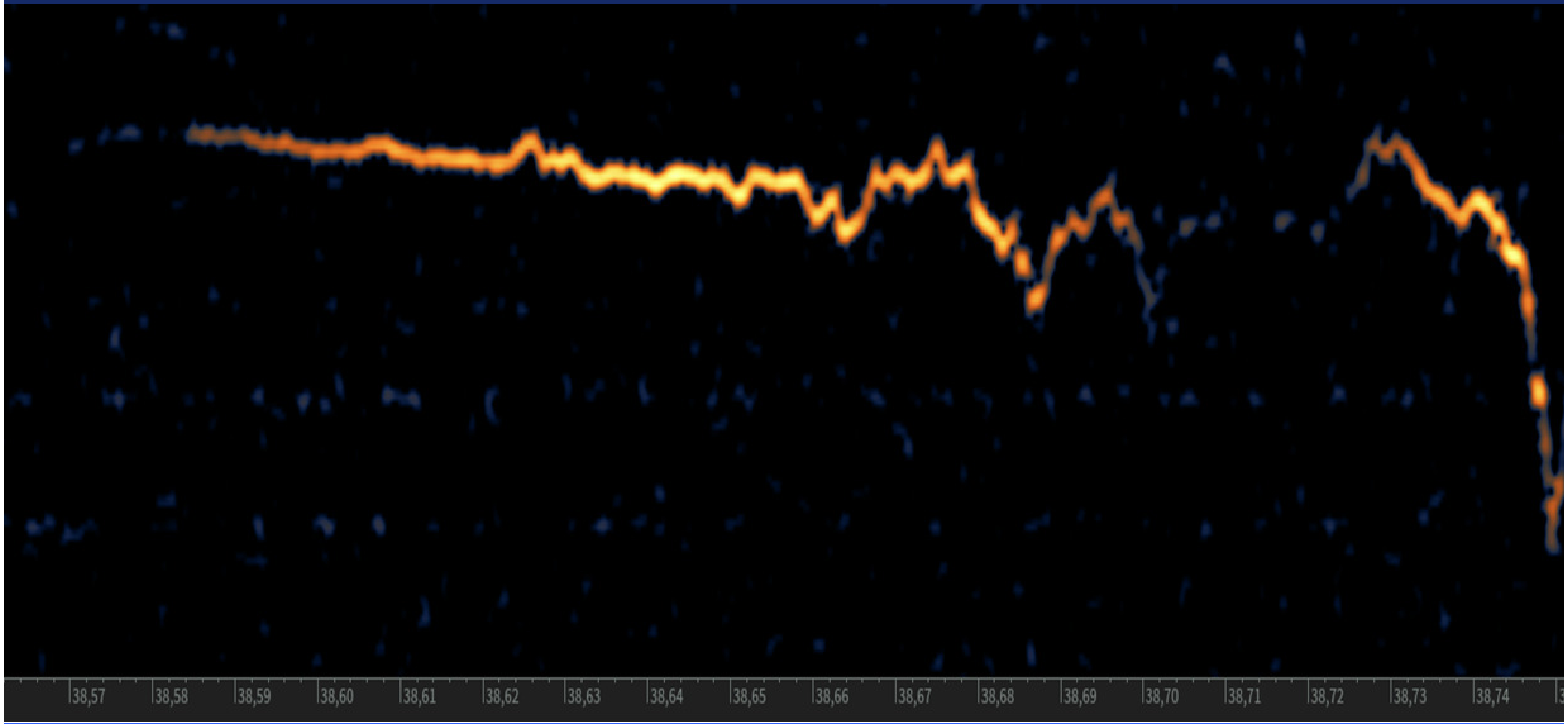
Best fits showing the deceleration of the fragments

Some examples of catastrophic fragmentations

Bolide 20170715T020130_UT
seen by 4 cameras and 3 radios

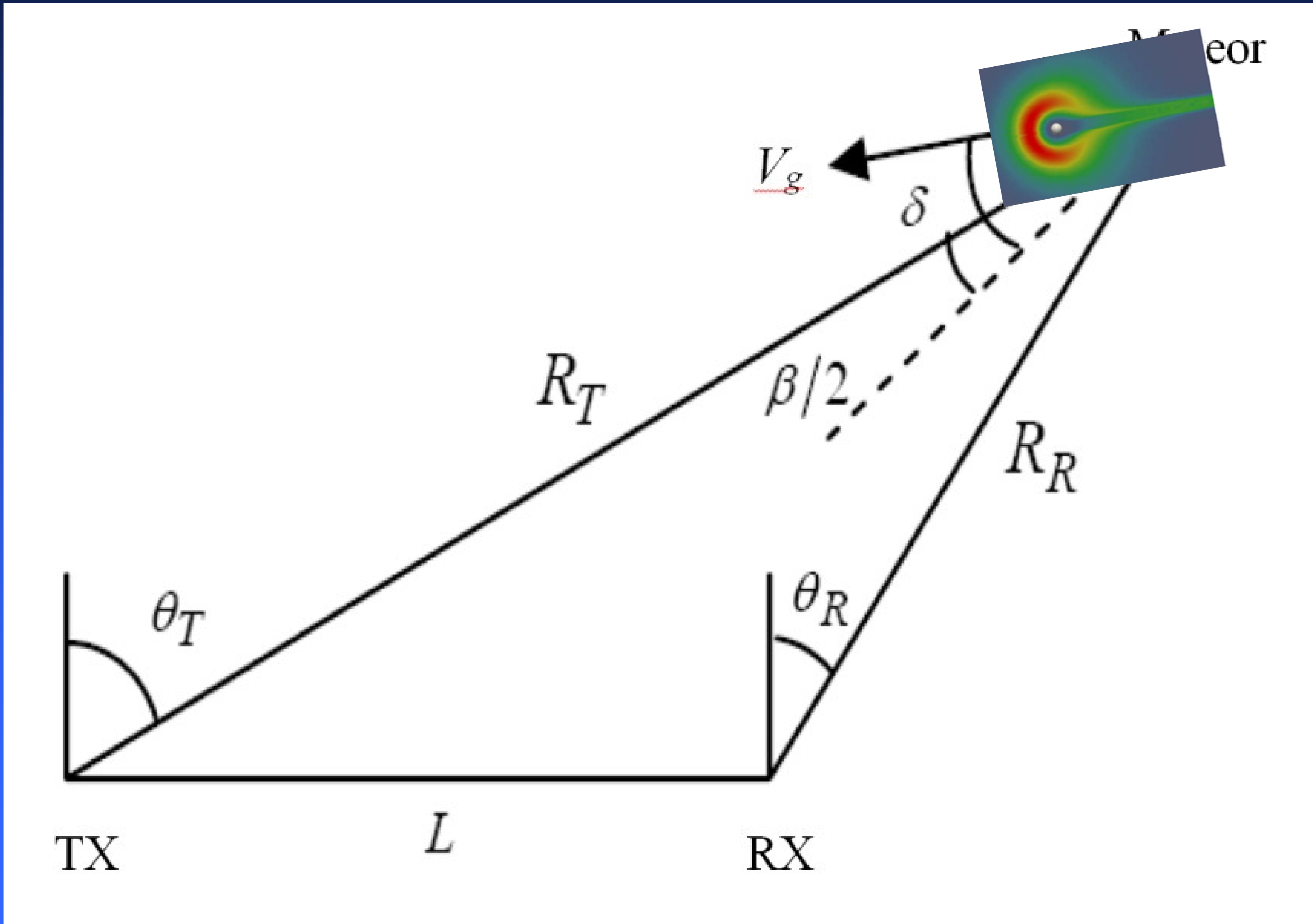


Bolide 20170715T020130_UT
seen by 4 cameras and 3 radios

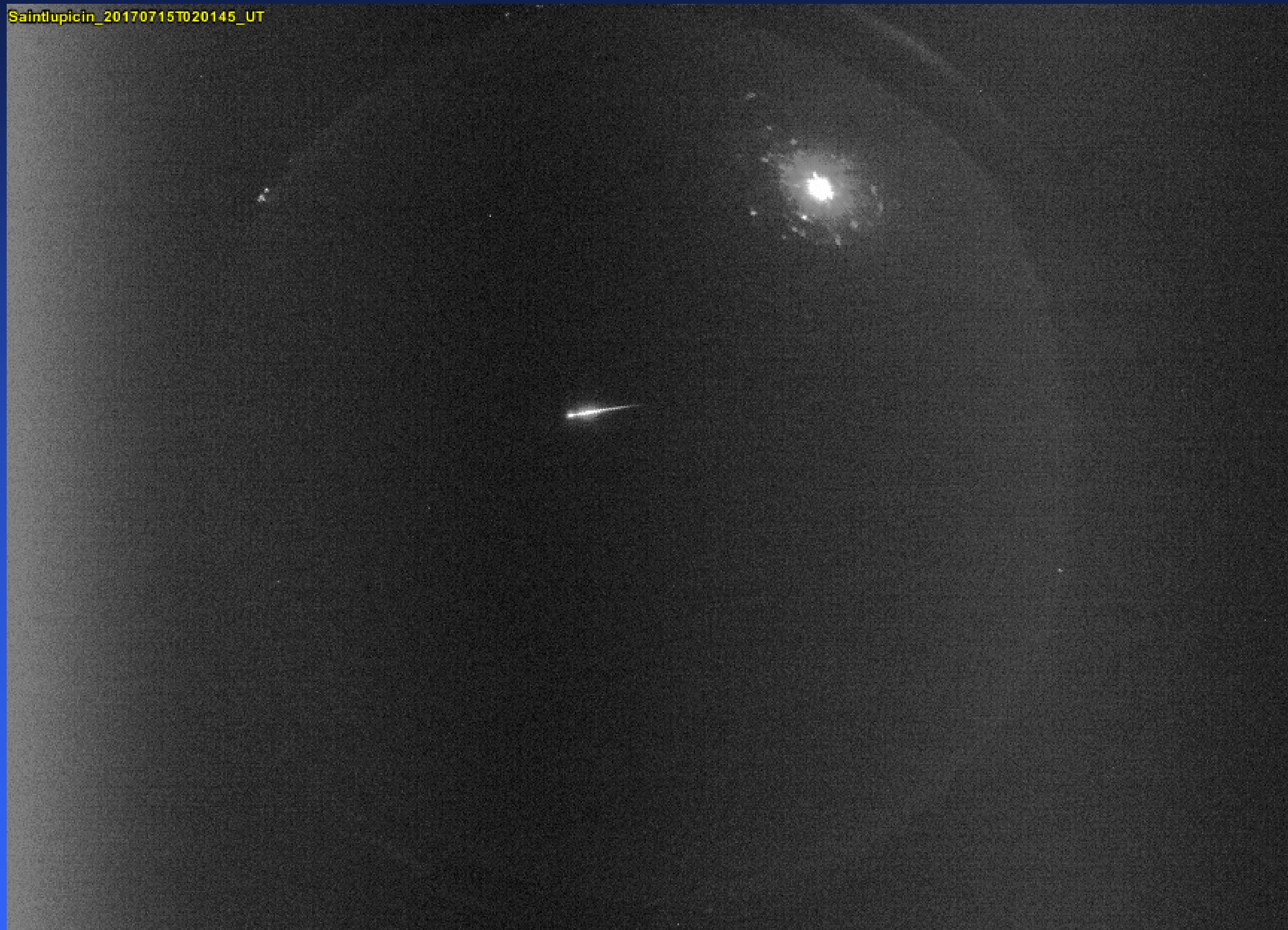


Zoom on the Sutrieu radio sensor data

A variation of the RCS radial distance is the reason for the observed Doppler variations

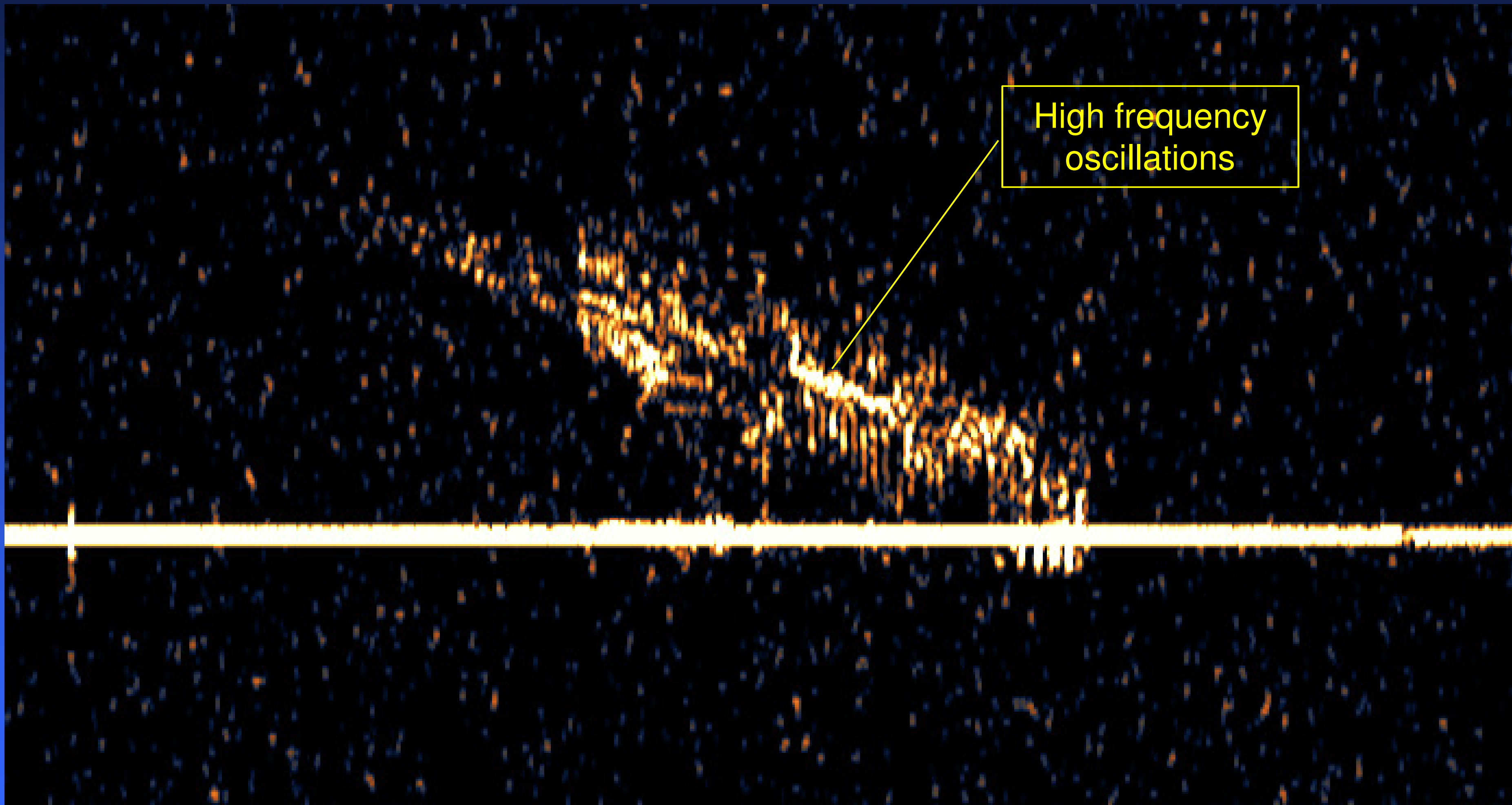


Bolide 20170715T020130_UT seen by 4 cameras and 2 radios



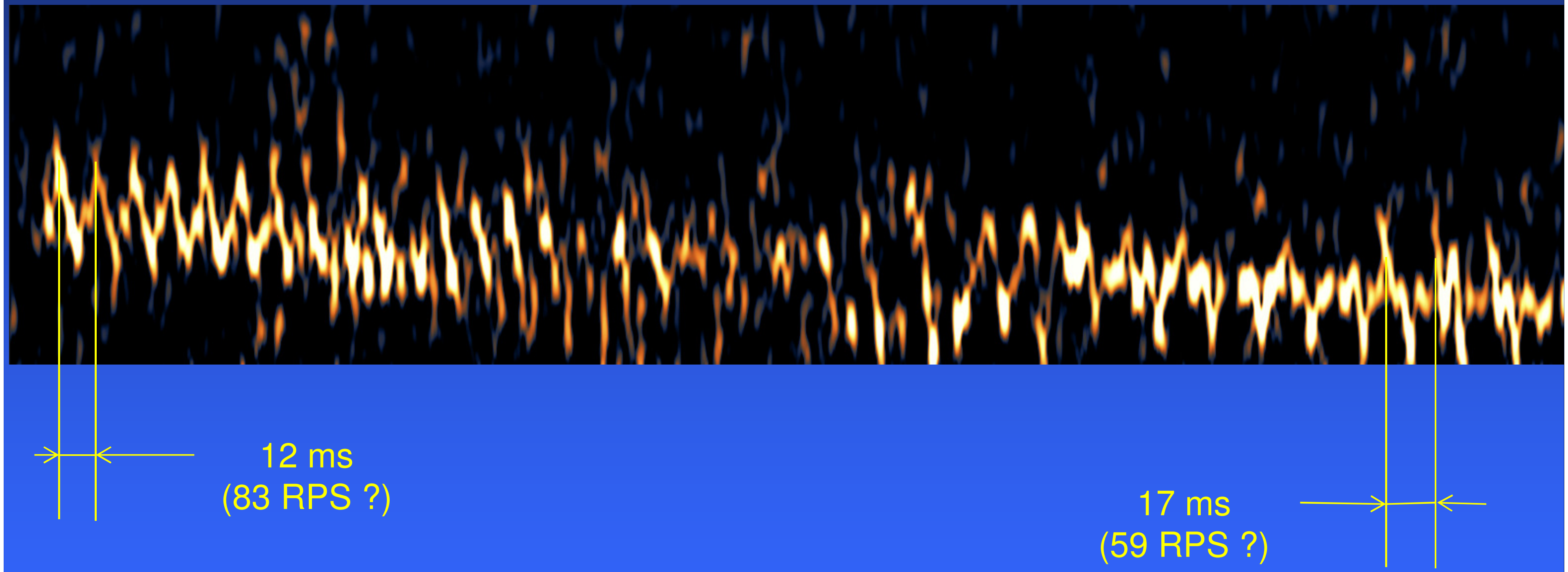
Saint Lupicin video camera

Bolide 20170715T020130_UT
seen by 4 cameras and 2 radios

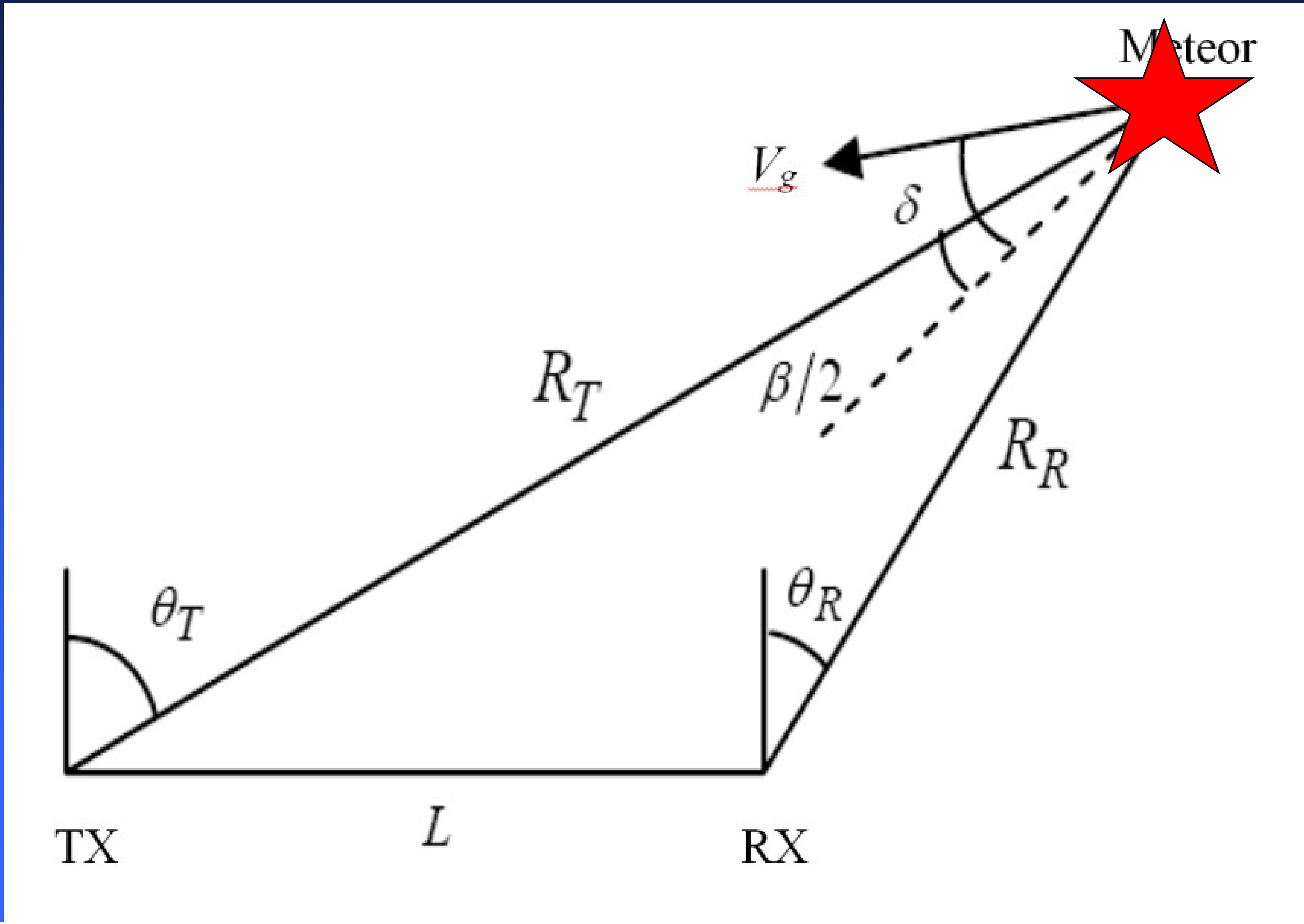


Bolide 20170715T020130_UT
seen by 4 cameras and 2 radios

Zoom on the Sutrieu radio sensor data

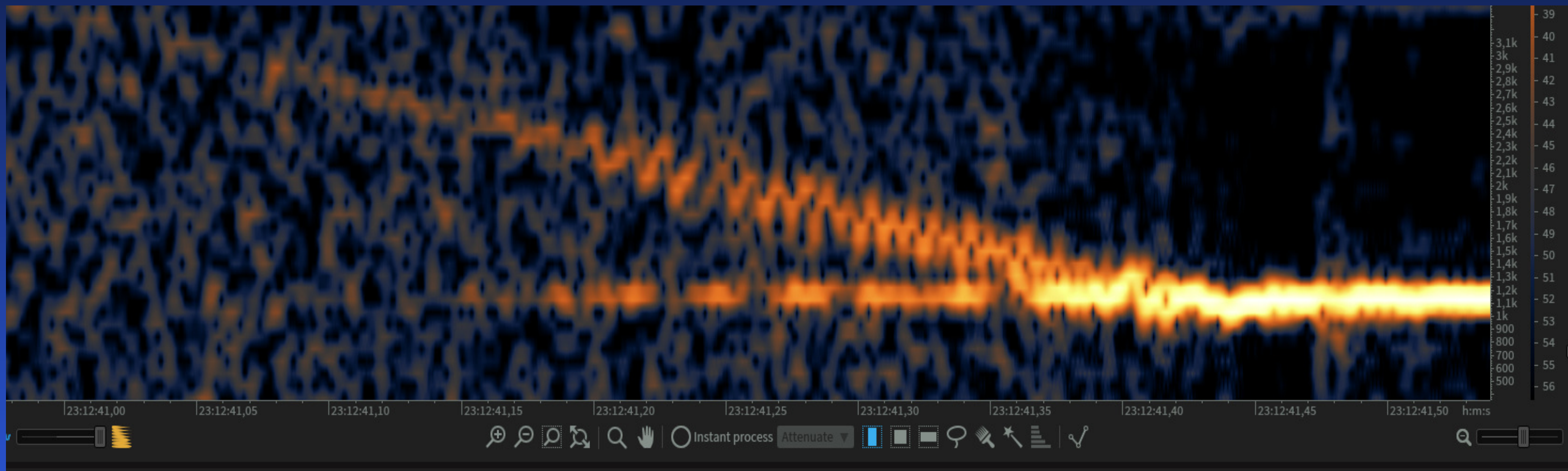


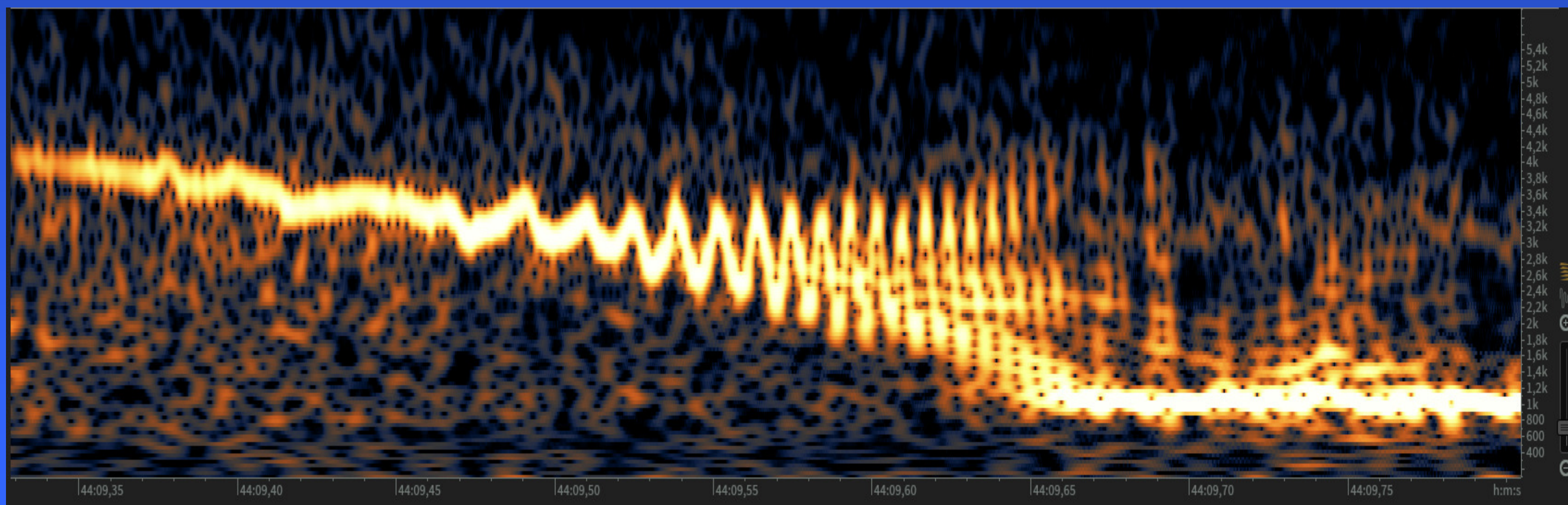
A rotation of the bolide entering the atmosphere could explain the observed Doppler pulsations



Data mining on previous meteor observation campains shows that this oscillation phenomenon is not so rare

Some GEM 2016 bolides as seen at Observatoire de Haute-Provence





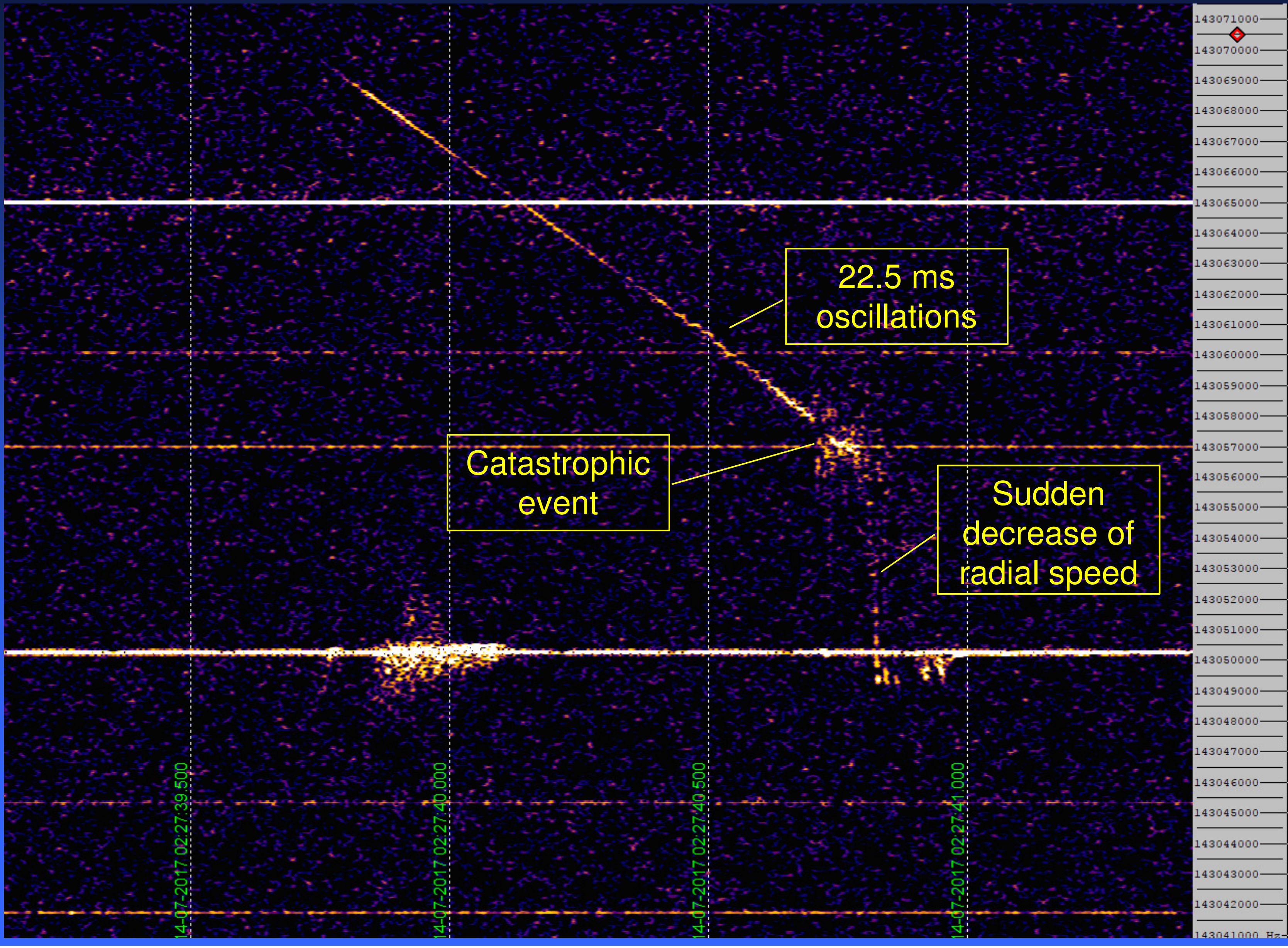
From 20 ms (50 rps ?) to 6 ms (160 rps ?) within 190 ms

Bolide 20170714T022739_UT

Bolide 220170714T022739_UT
seen by 8 cameras and 5 radios

Les Angles video camera

Bolide 220170714T022739_UT
seen by 8 cameras and 5 radios



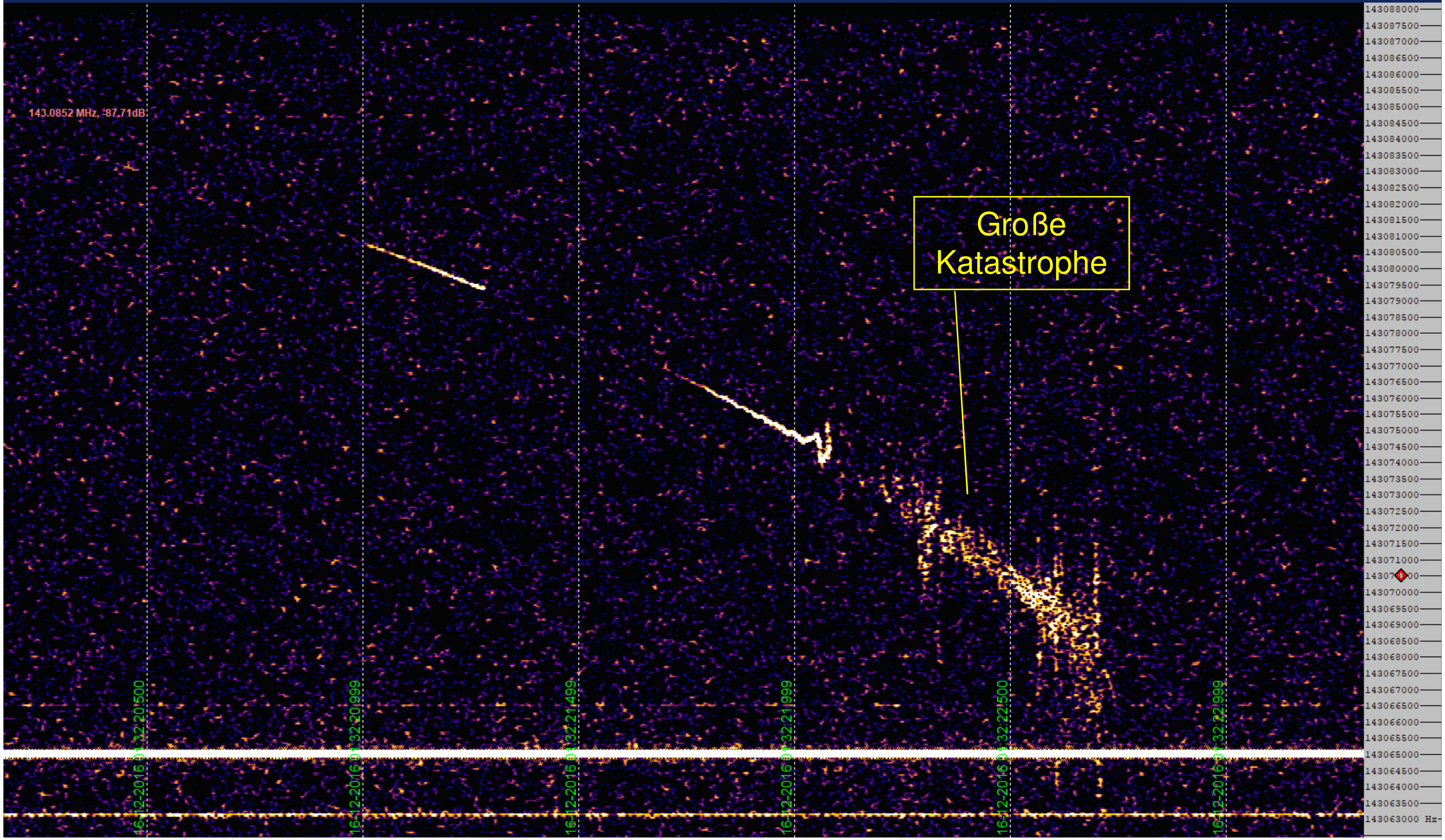
Bolide 20161216T013221_UT

Bolide 20161216T013221_UT
seen by 3 cameras and 3 radios

Corresponding video observation by the Besançon station

Bolide 20161216T013221_UT
seen by 3 cameras and 3 radios

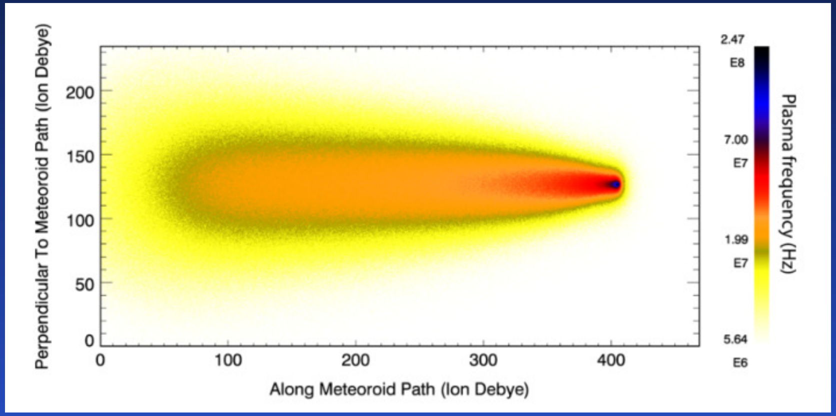
Bolide sudden disintegration as seen by the Orléans radio station



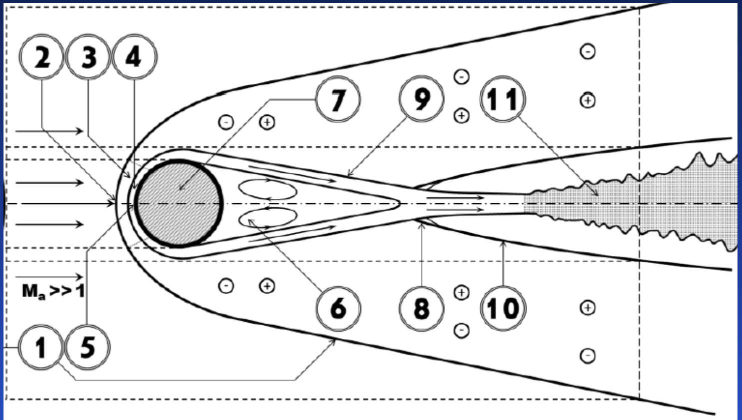
Conclusion

The physics behind hyper velocity bolides entering the atmosphere is not yet well understood

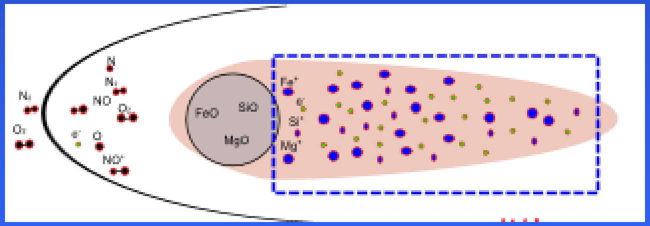
The same applies for the scattering of radio waves on the plasma surrounding these bolides



L. Dyrud & al. Earth Moon Planet (2008) 102:383–394



E.A. Silber & al. (2017) MNRAS, (2017) Vol 469 1869-1882



B. Dias & al. (2015) METRO meeting

Thanks to its radio network using a multistatic CW HPLA radar configuration, FRIPON is producing detailed observations of the Doppler head echoes signatures that should improve our knowledge on the meteoroids dynamics when entering the Earth atmosphere

Thanks for your attention
Any questions ?