



FRIPON radio

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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



Overview of the FRIPON all sky 360° video cameras

FRIPON radio network presentation

Status of the radio network (september 2017)

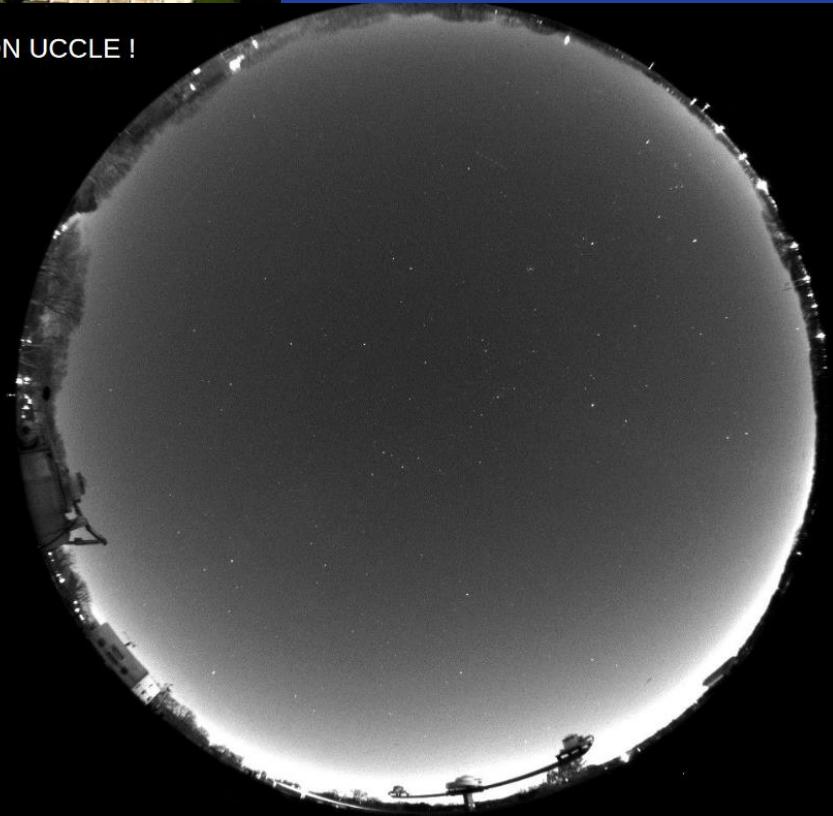


The yellow surface is the "theoretical sky coverage " by the GRAVES radar at an altitude of 100 km. In fact, meteor radio echoes have been reported from Malta to various places in UK

FRIPON cooperates with neighbouring countries



FRIPON UCCLE !



- Belgium
- Spain
- Netherlands
- Italy
- ...

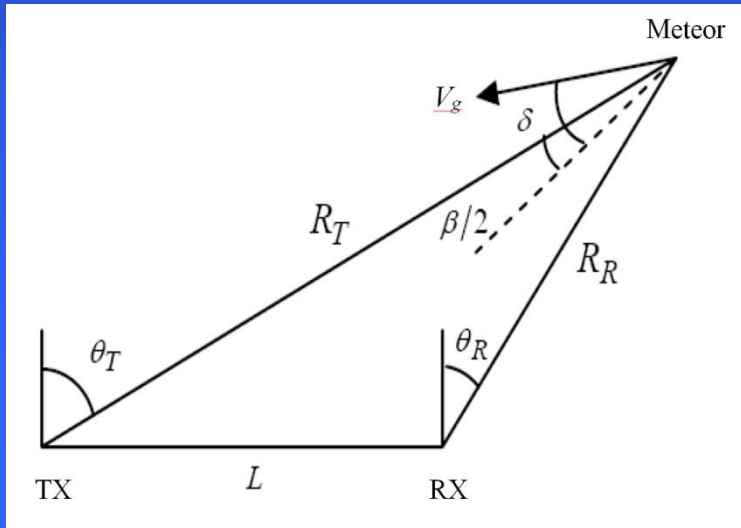
General principles of the FRIPON radio network

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

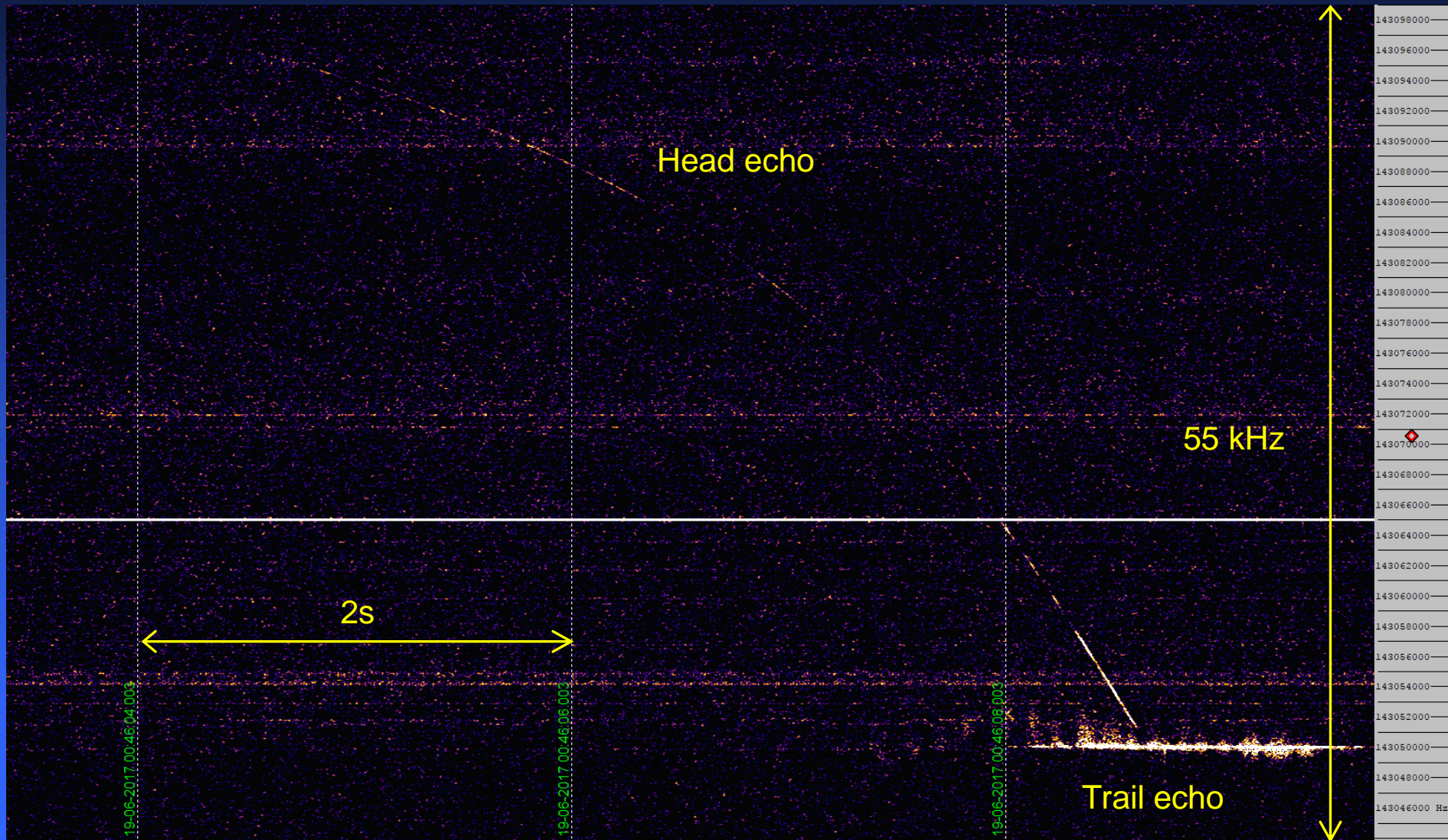
The Doppler Fizeau frequency shift affecting a meteor radio echo is presently used to compute the velocity of this meteor



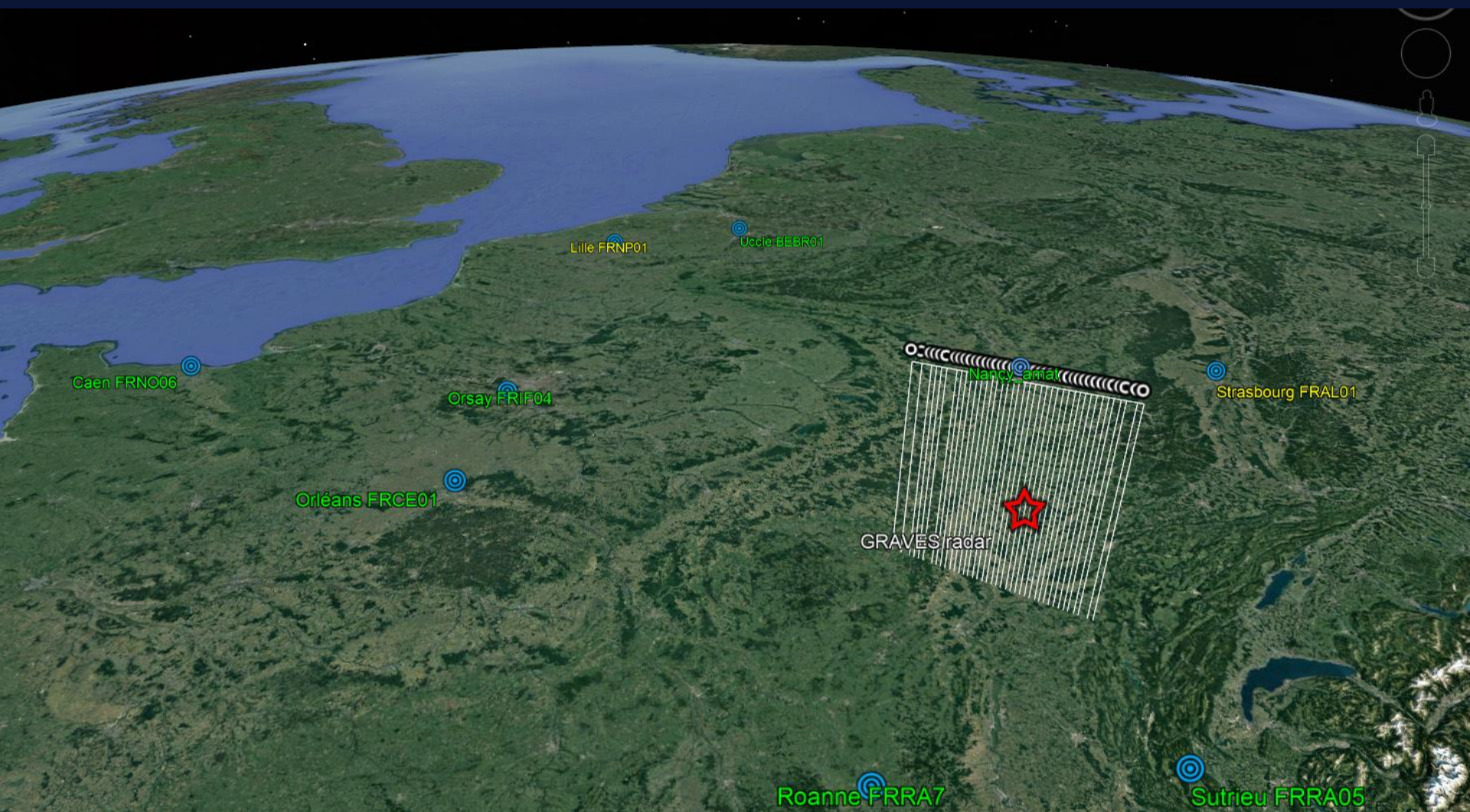
$$V_g = \frac{c \cdot \Delta f}{2 \cdot f \cdot \cos(\delta) \cdot \cos(\beta/2)}$$

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

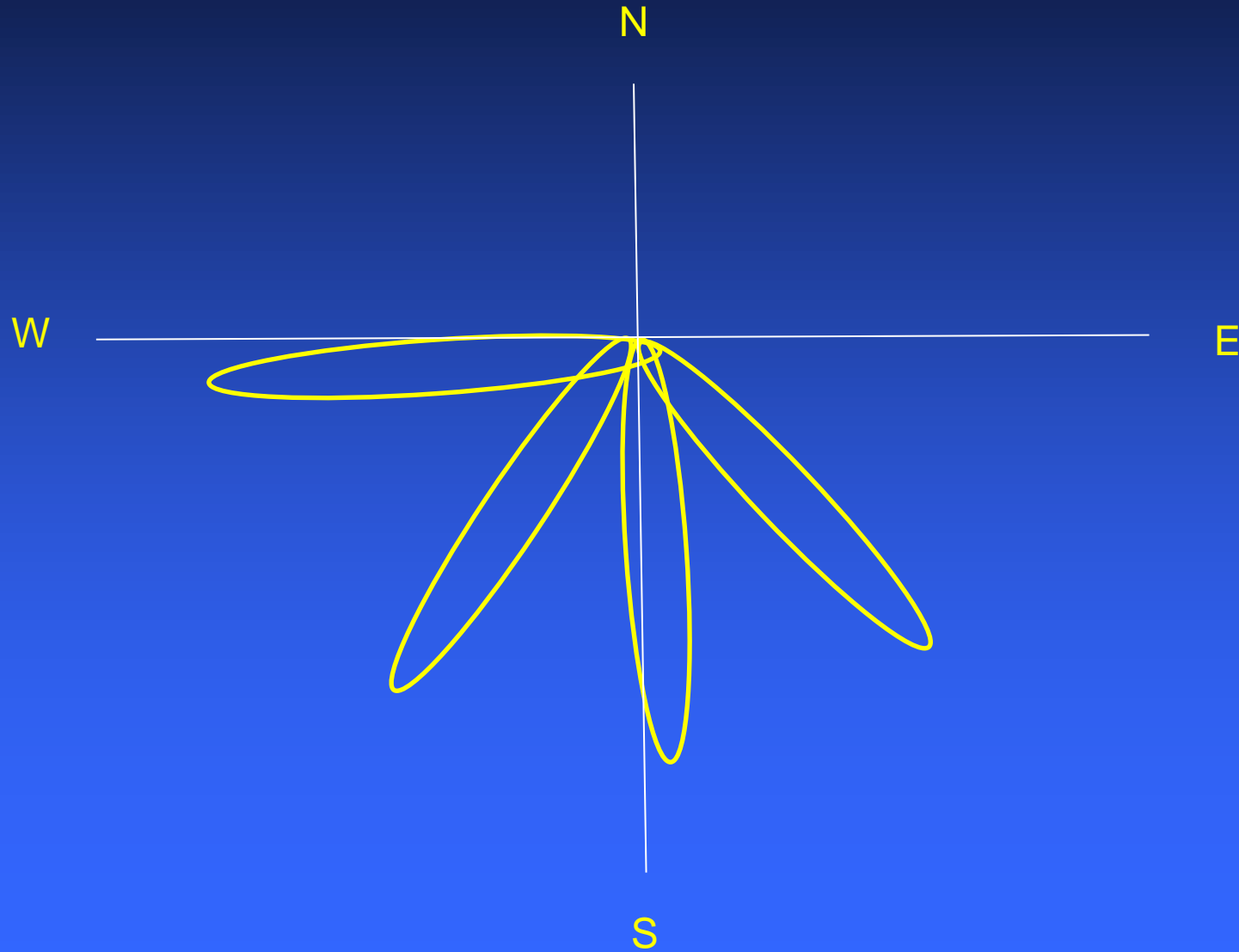
Transmitter used by FRIPON

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.

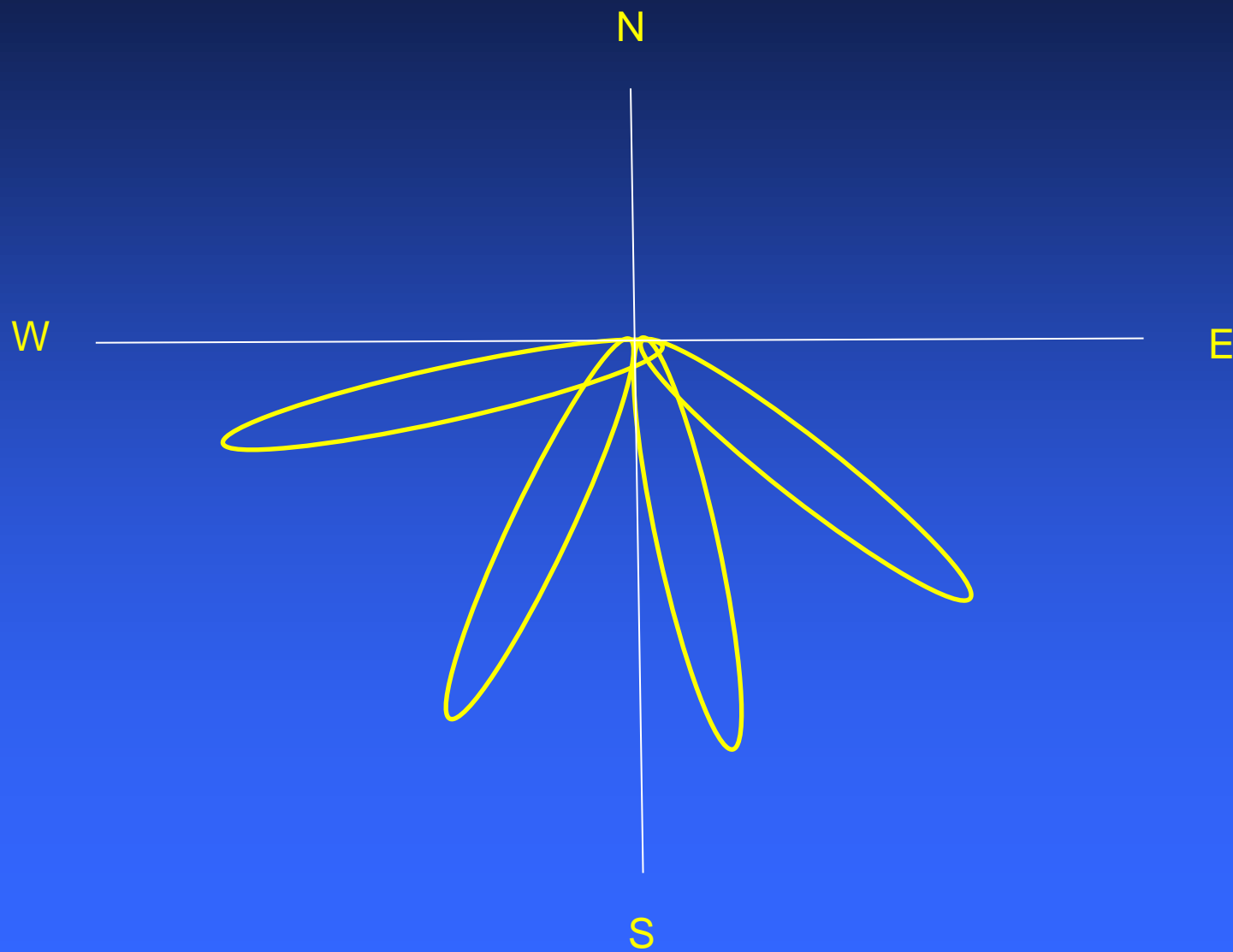


4 VHF patch arrays located near Dijon, France are used by the french Air Forces to detect, classify and determine accurate keplerian elements of satellites

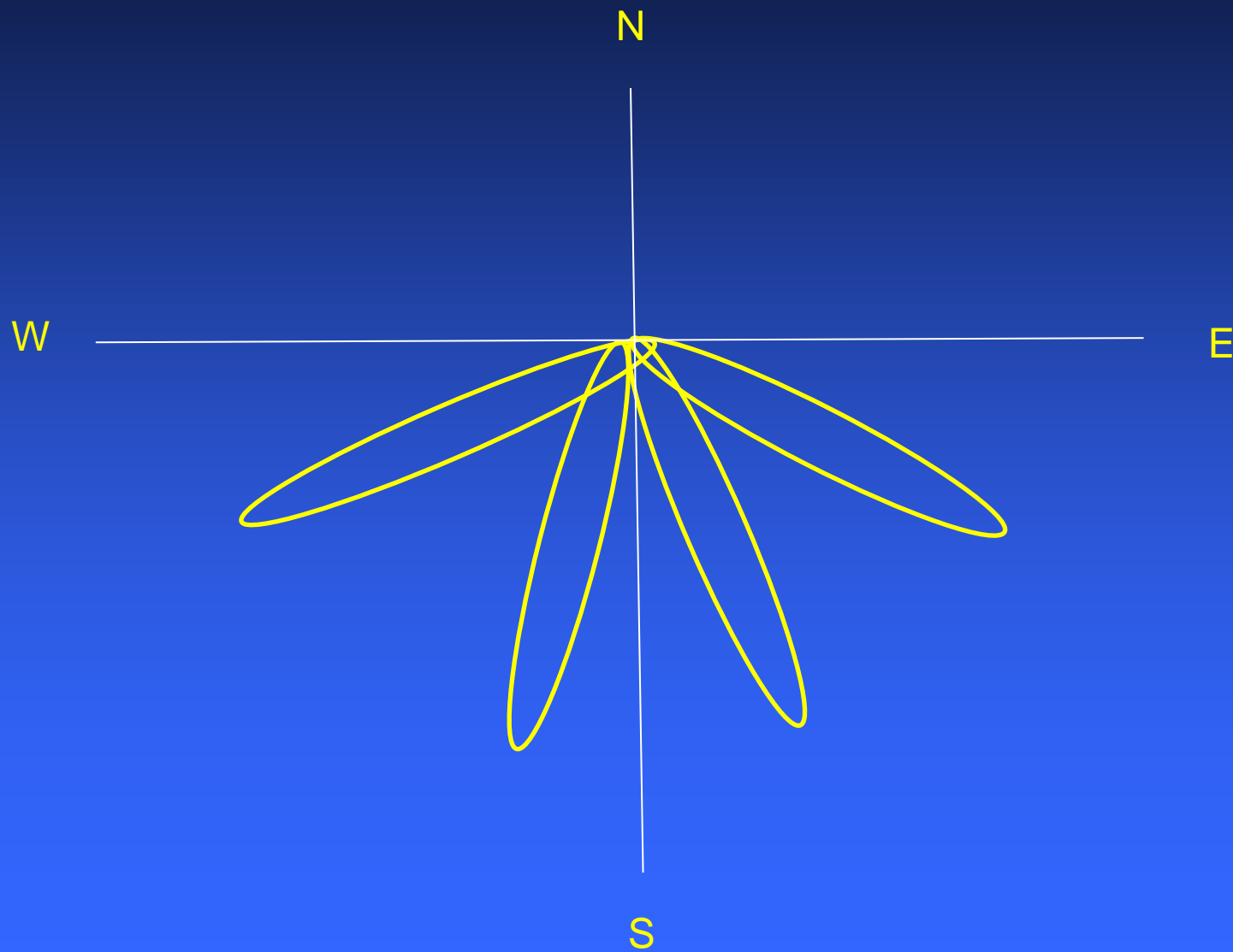
GRAVES transmitter beam forming



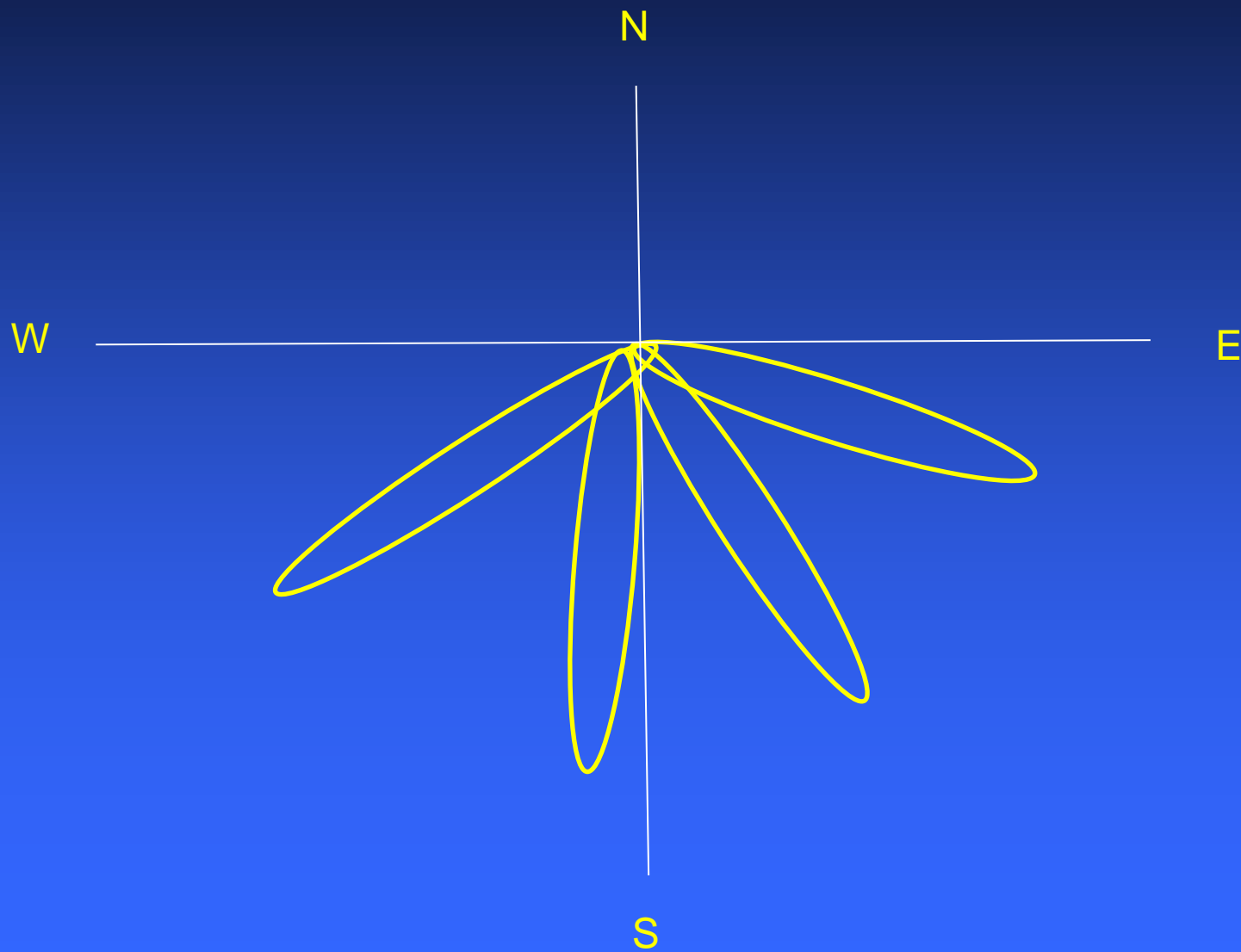
GRAVES transmitter beam forming



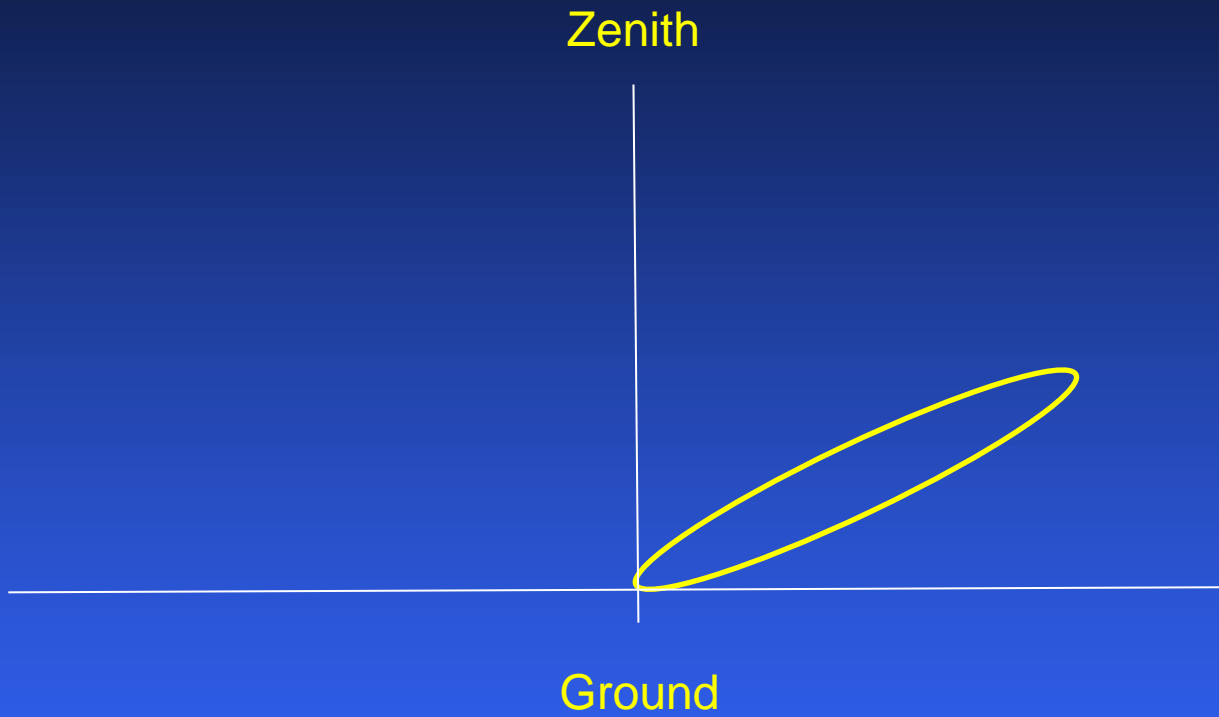
GRAVES transmitter beam forming



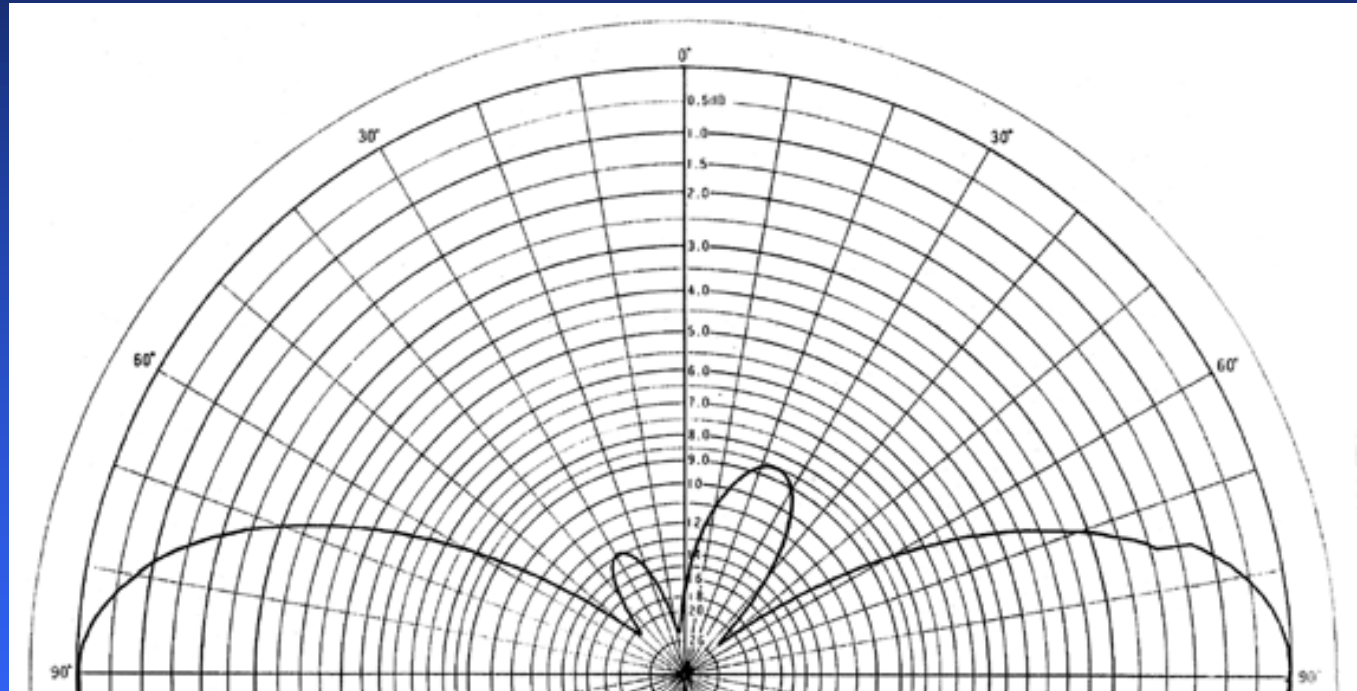
GRAVES transmitter beam forming



GRAVES transmitter beam forming



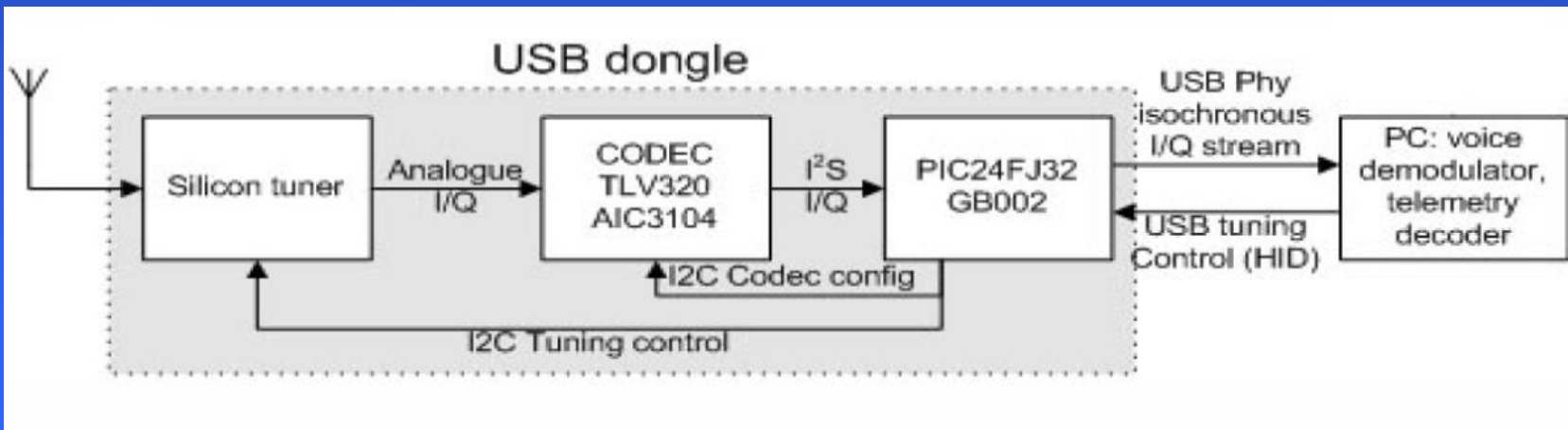
FRIPON receiving antenna beam pattern



Vertical $2 \times 5/8$ lambda colinear antenna. Gain: 6dBi, omnidirectional in azimuth

FRIPON radio receivers

25 FRIPON video stations are fitted with FUNcube Pro+ SDR (Software Defined Radio)



Radio data management and reduction



<u>Name</u>	<u>Last modified</u>	<u>Size</u>	<u>Description</u>
Parent Directory		-	
GLUX_20170427T233602_UT/	2017-04-28 01:36	-	
MOULINS_20170427T233602_UT/	2017-04-28 01:36	-	
radio/	2017-04-28 02:17	-	

Apache/2.4.10 (Debian) Server at www.fripon.org Port 443



Meteorite hunting in Chambord forest, juin 2017



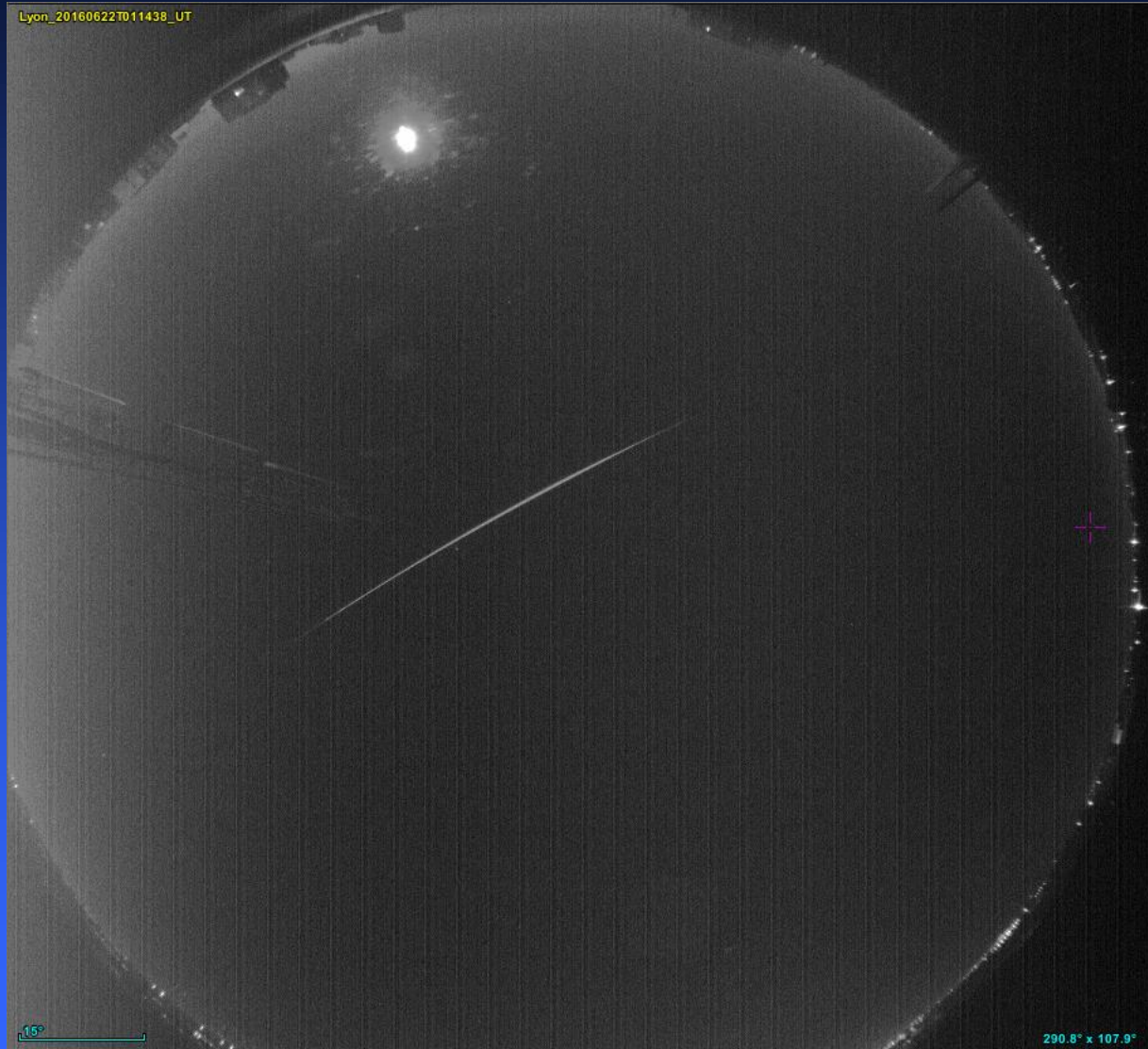
Analysis of some particular meteor Doppler signatures

In addition to calculating meteor velocities, an HPLA VHF CW radar such as GRAVES allows us to observe interesting head echoes phenomenons

An example of fireball partial fragmentation

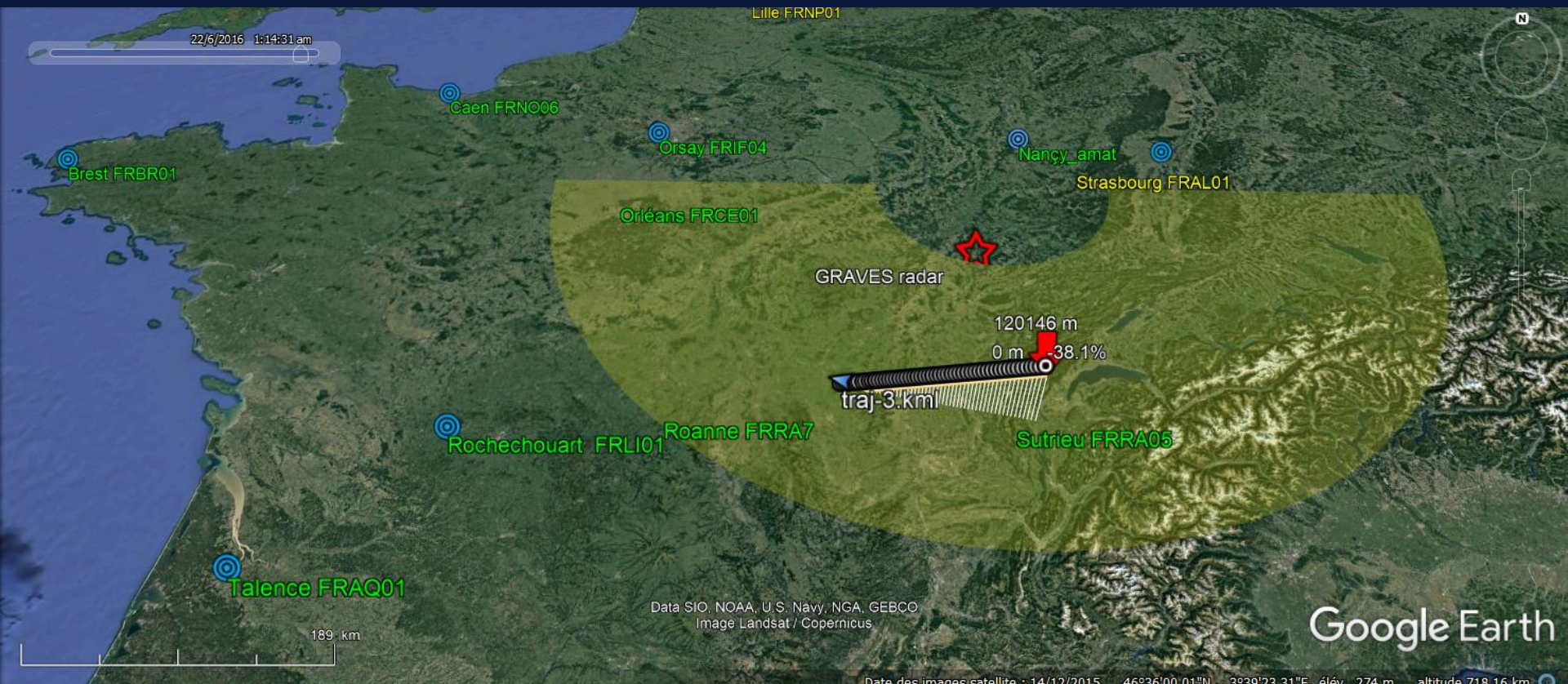
20160622T011430_UT bolide

An example of fireball partial fragmentation

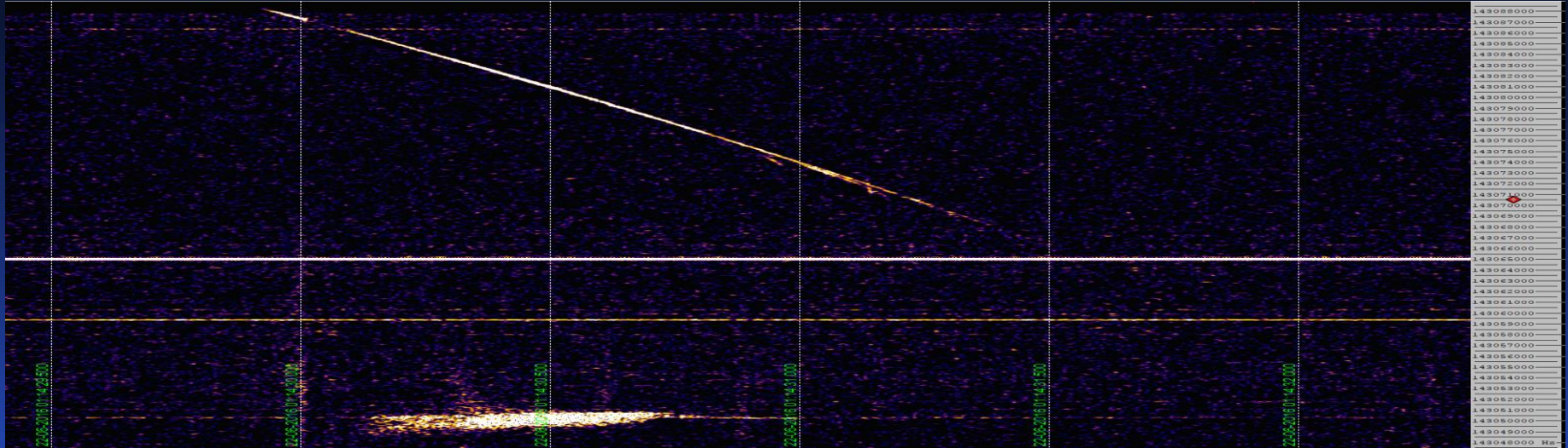


The bolide as seen by the Lyon video camera

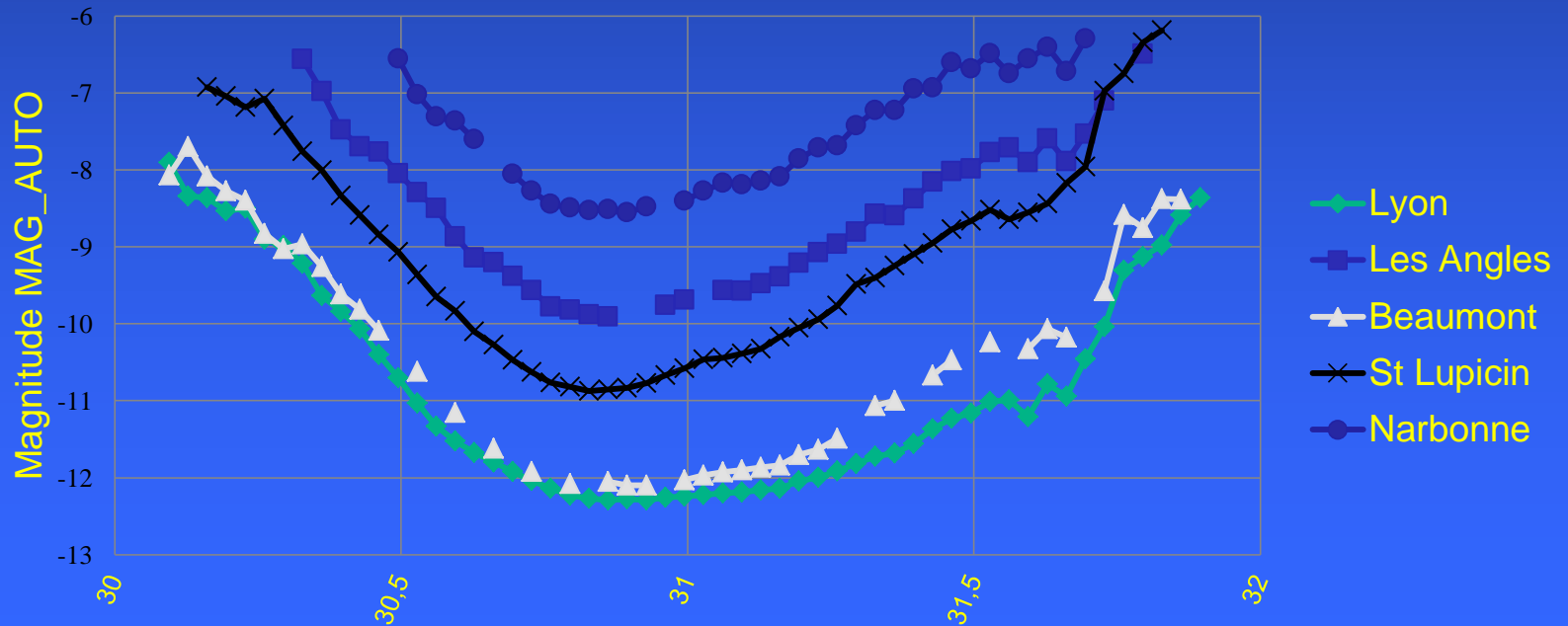
An example of fireball partial fragmentation



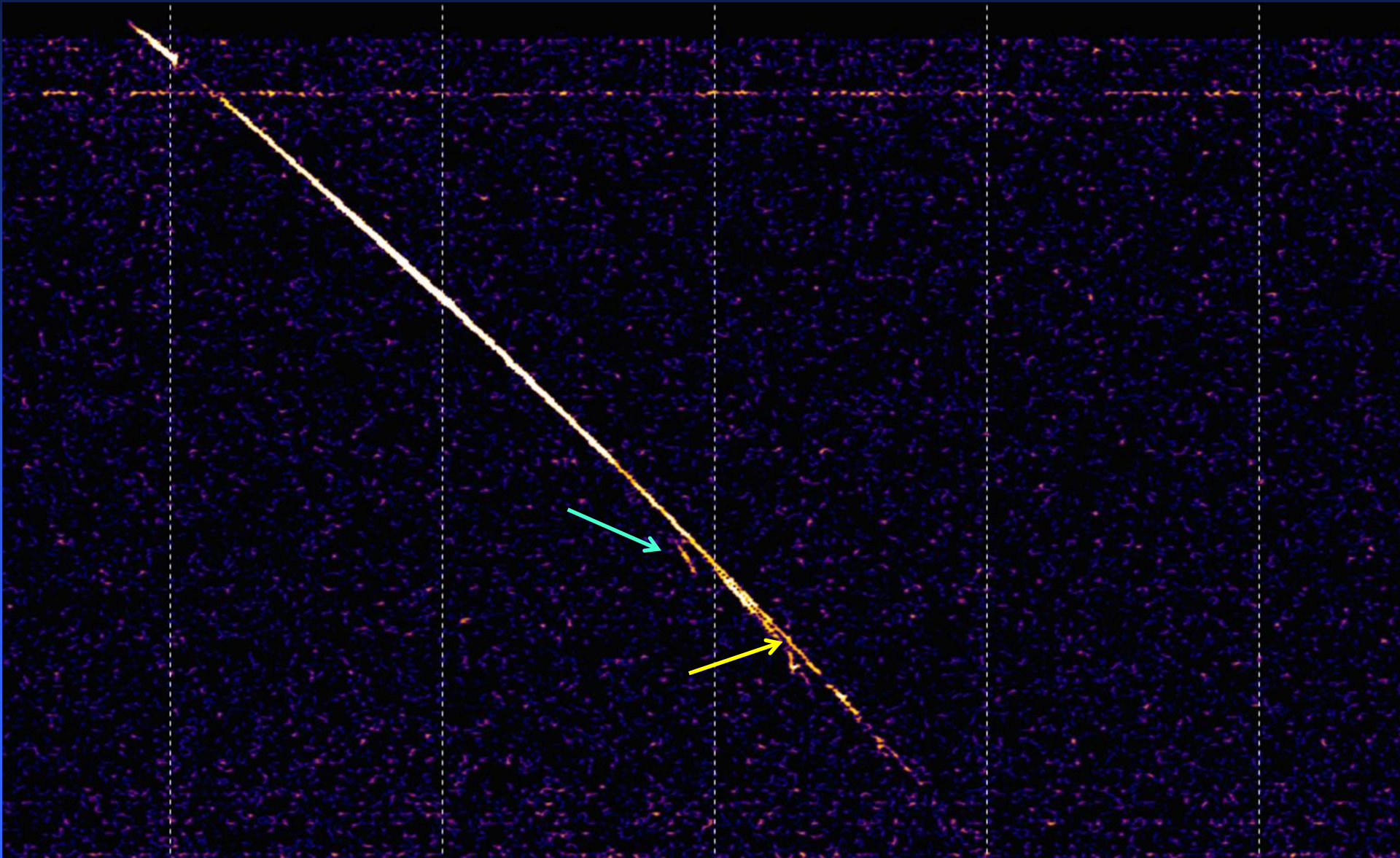
An example of partial fireball fragmentation

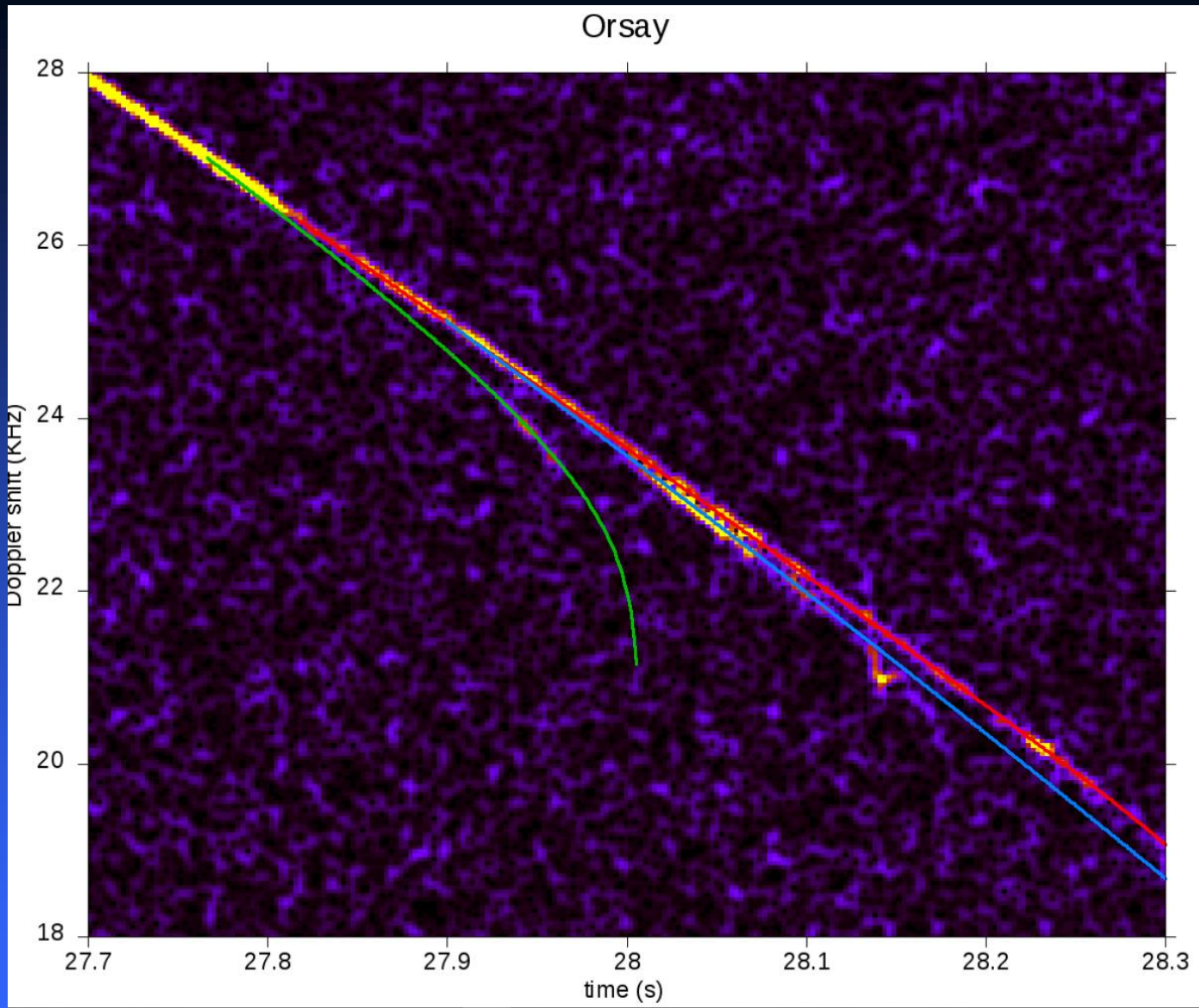


20160622T011430_UT fireball (seen by 18 FRIPON cameras)



An example of partial fireball fragmentation



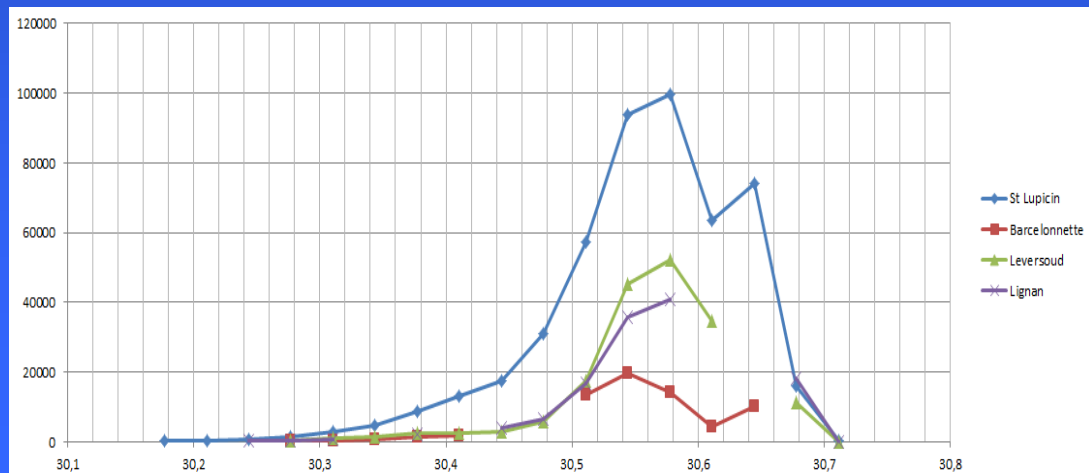


Best fits showing the deceleration of the fragments

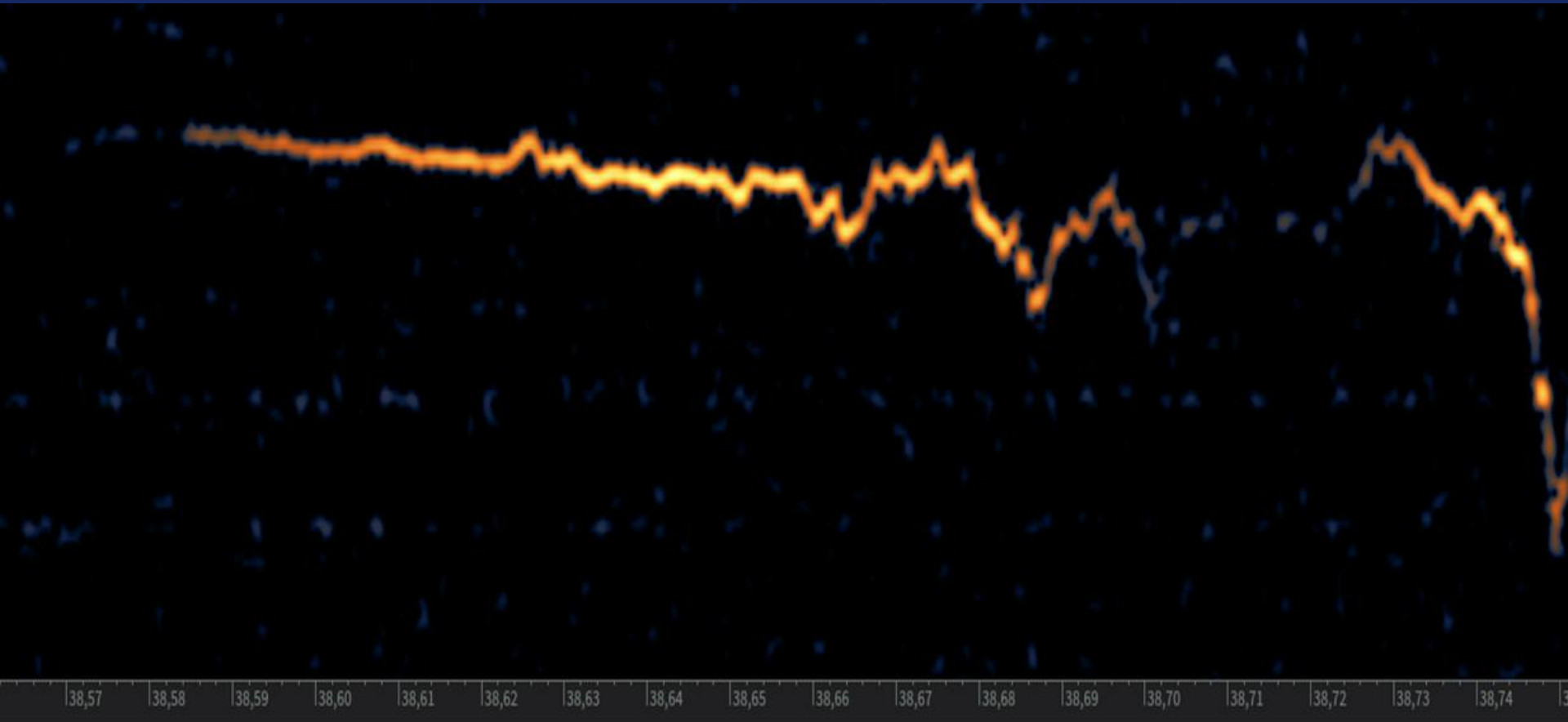
Some examples of catastrophic fragmentations

Bolide 20170715T020130_UT

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

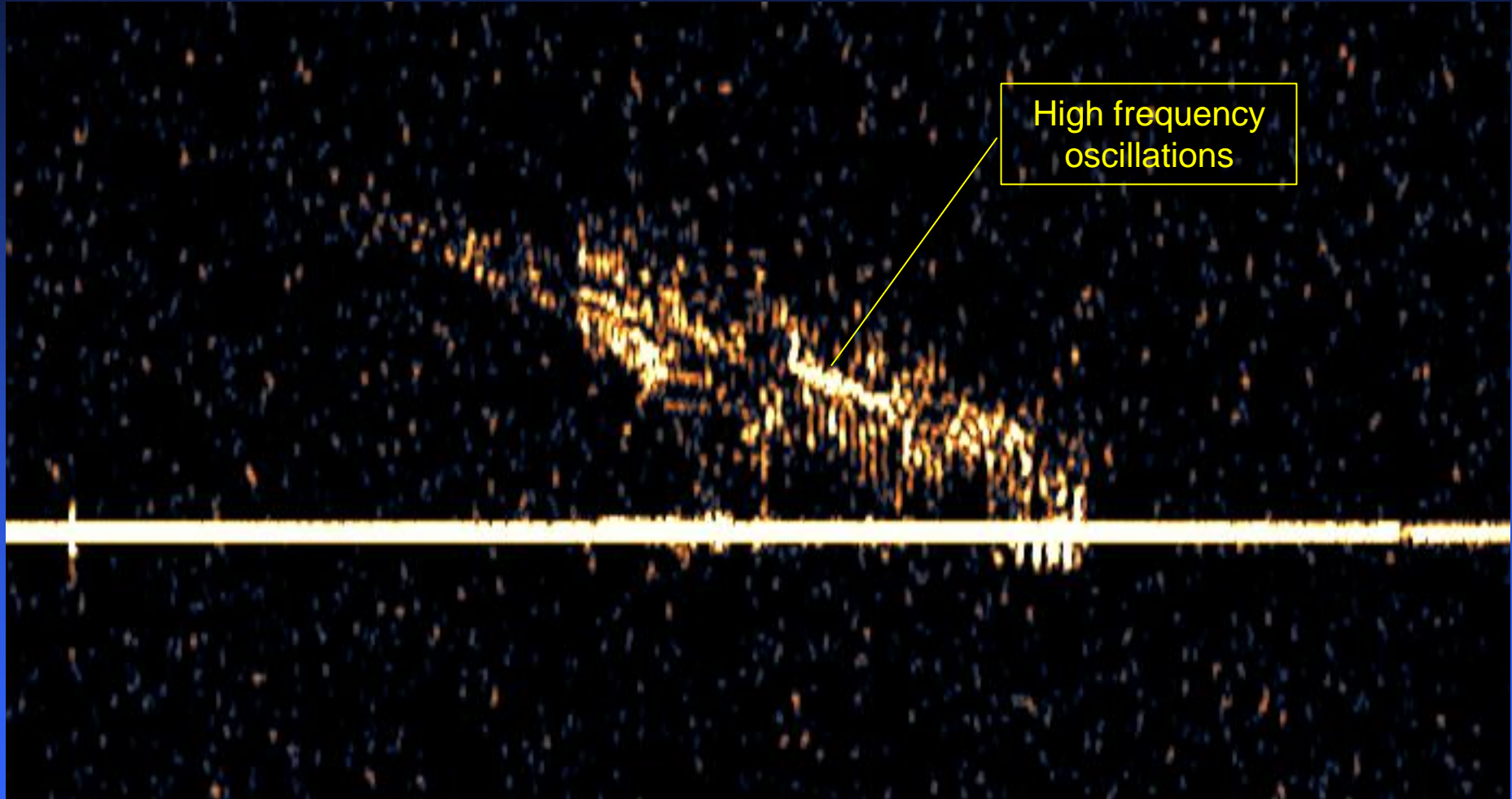
Bolide 20170715T020130_UT

Bolide 20170715T020130_UT seen by 4 cameras and 2 radios



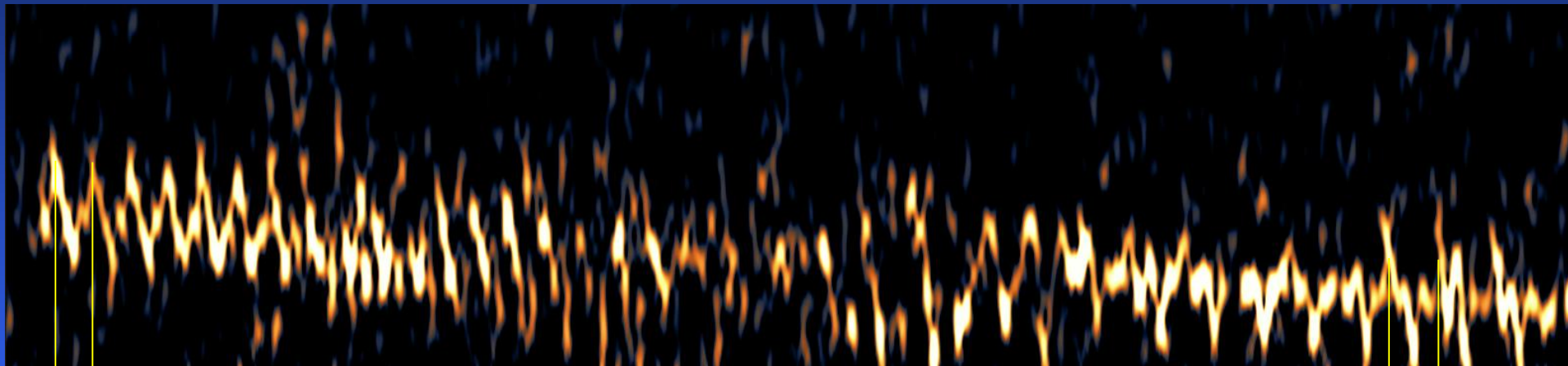
Saint Lupicin video camera

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

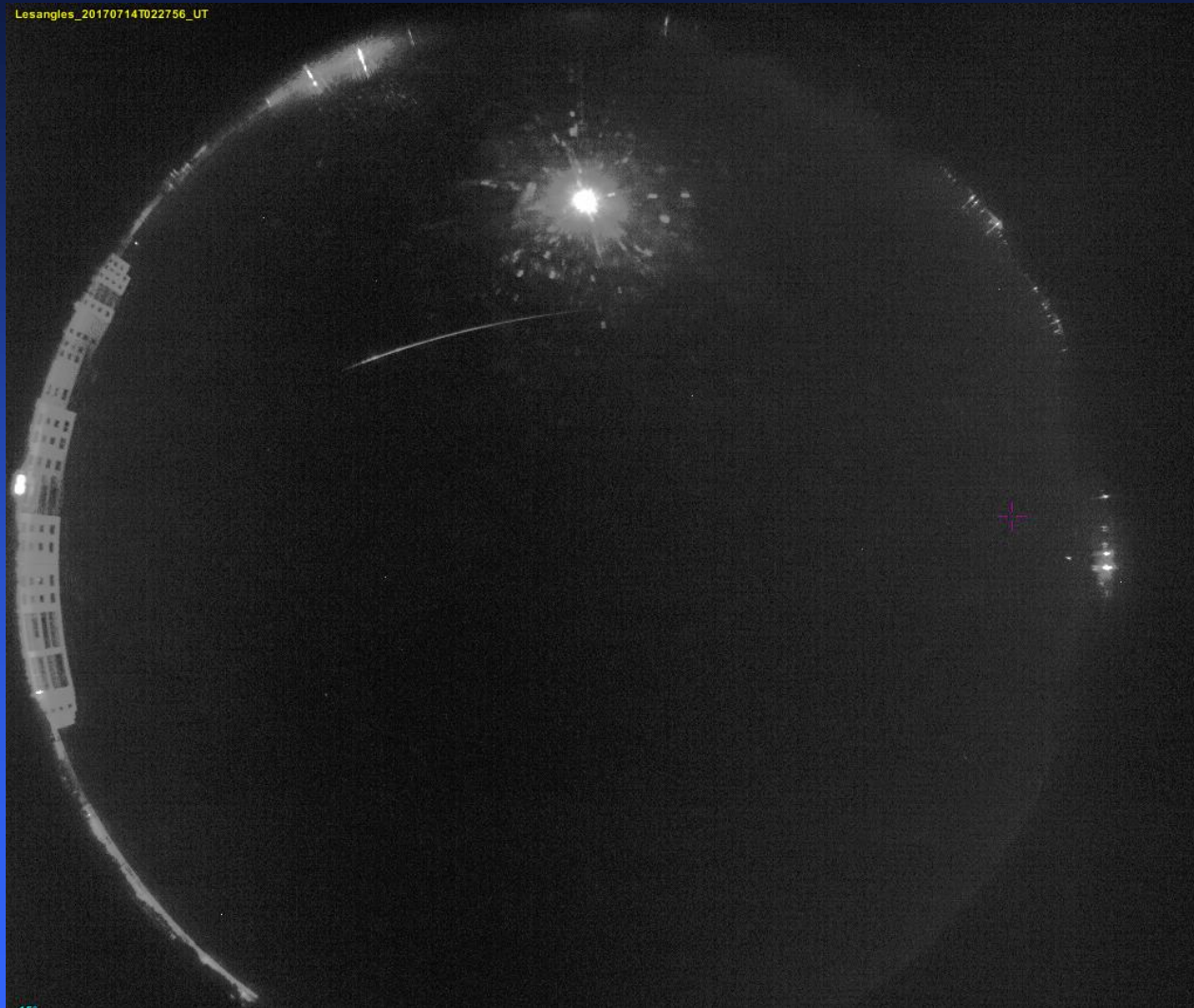


12 ms
(83 RPS ?)

17 ms
(59 RPS ?)

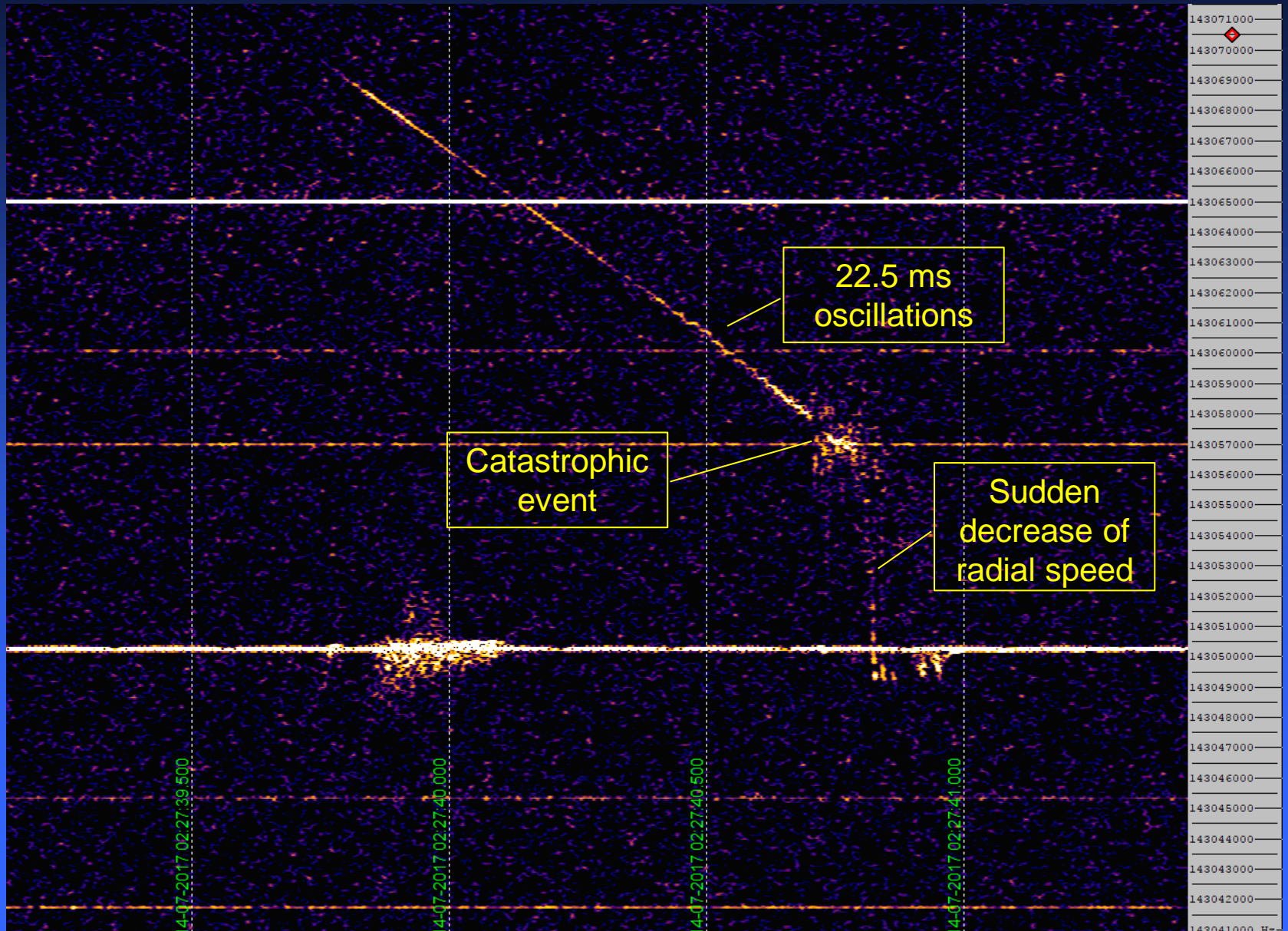
Bolide 20170714T022739_UT

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

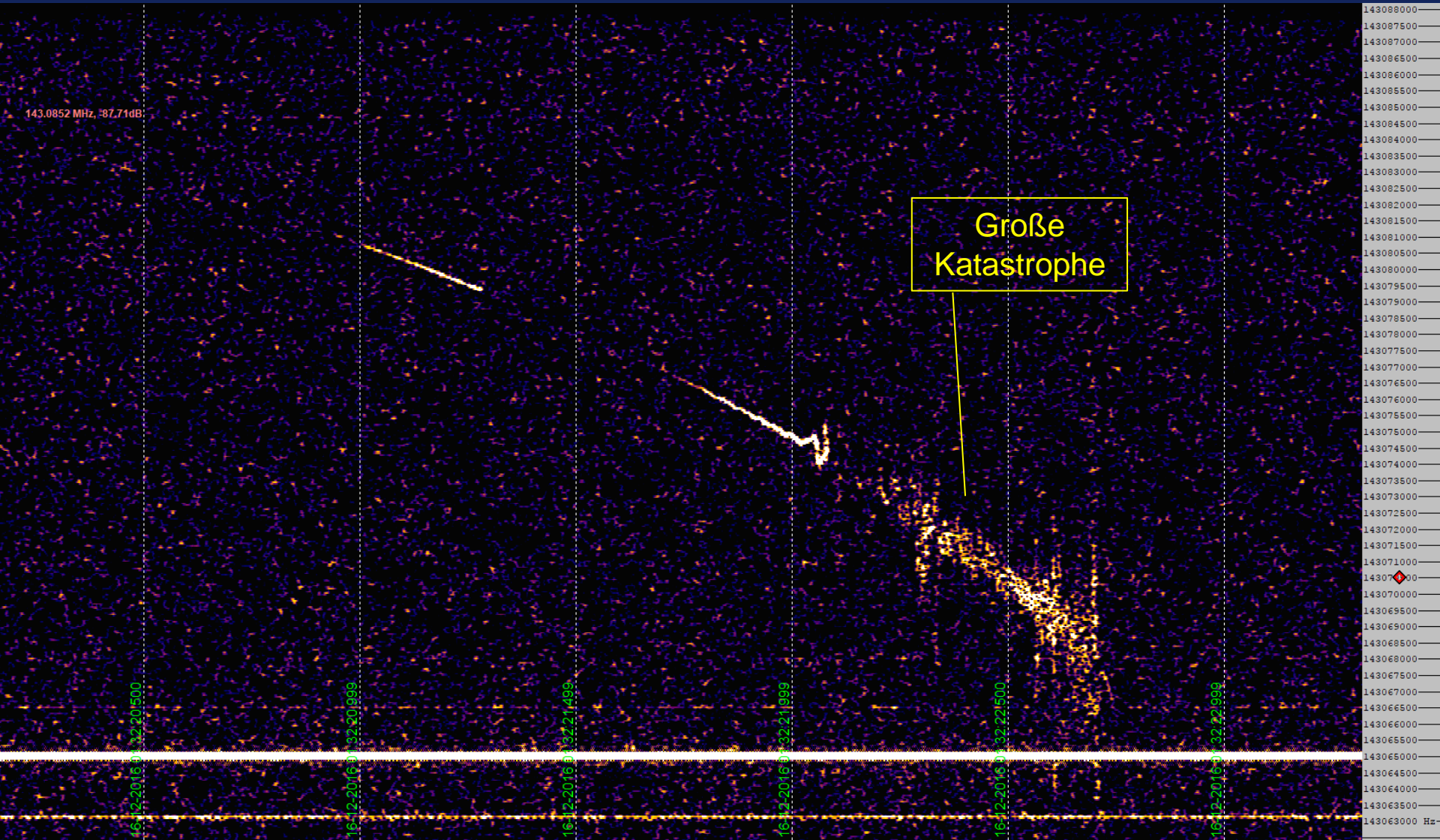
Corresponding video observation by the Besançon station

Besancon_20161216T013238_UT



Bolide 20161216T013221_UT seen by 3 cameras and 3 radios

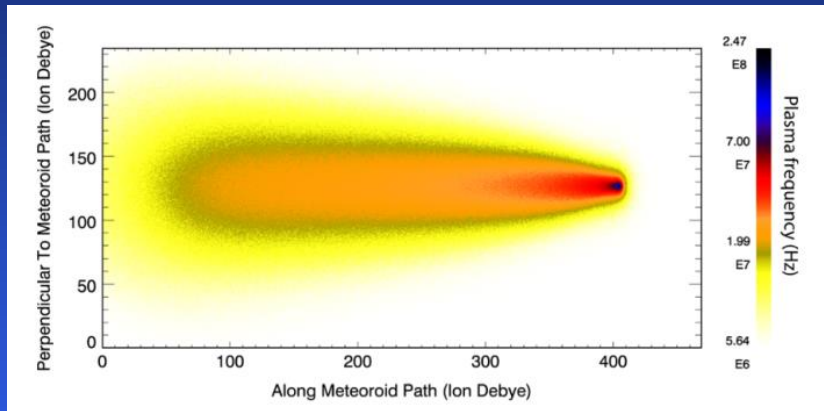
Bolide sudden disintegration as seen by the Orléans radio station



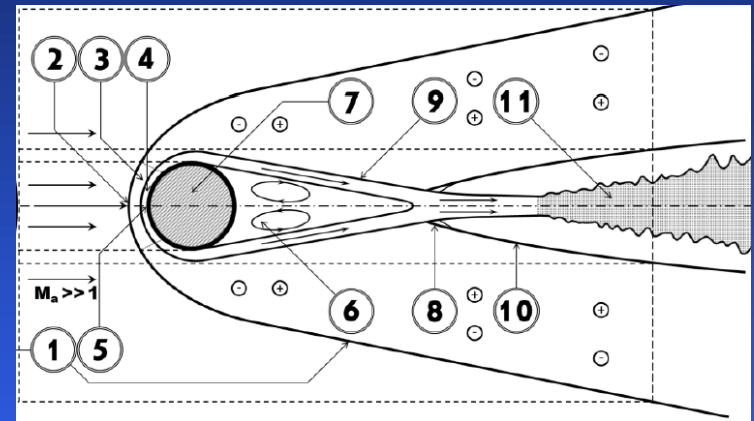
Conclusion

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

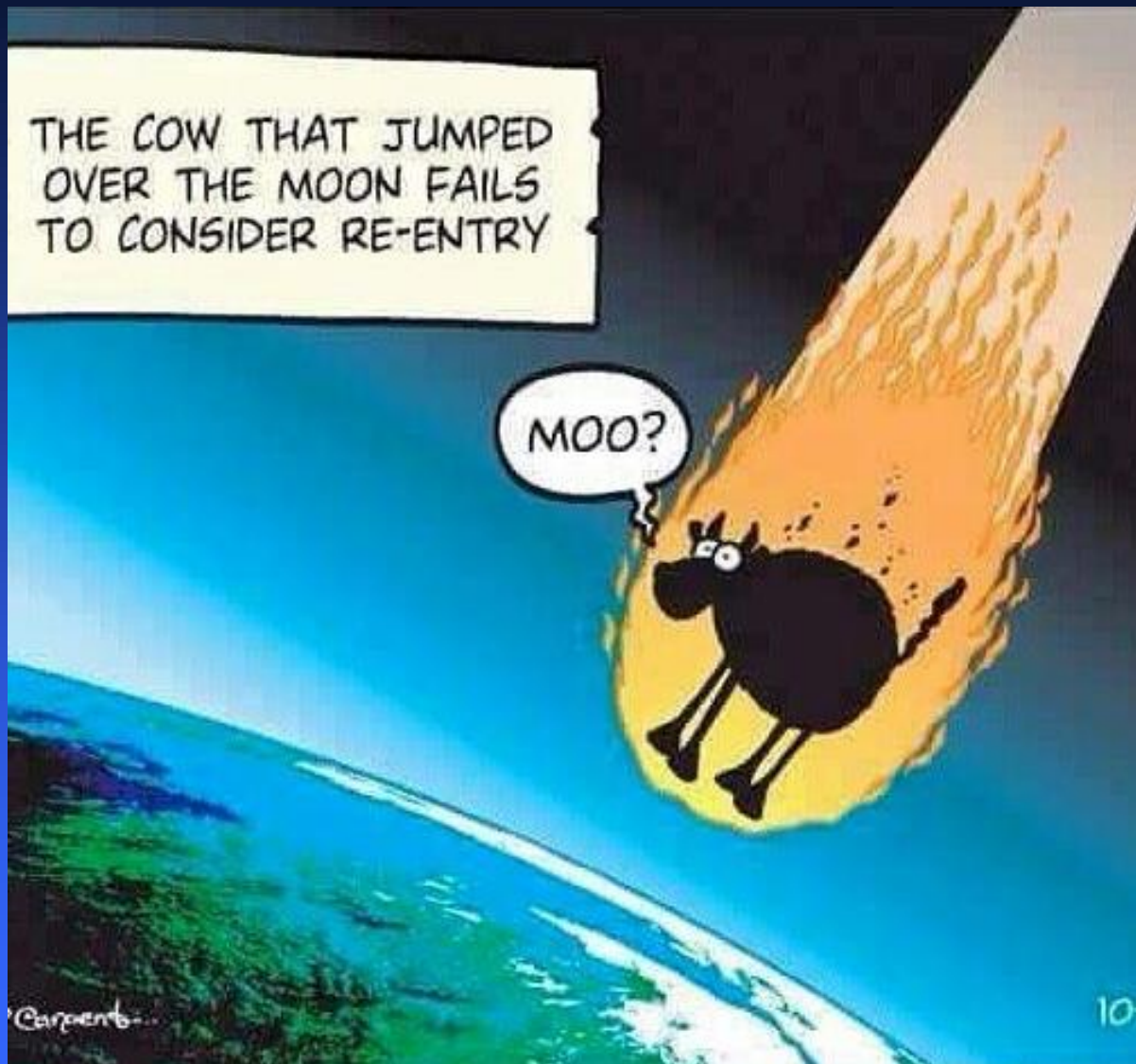


E.A. Silber & al. (2017) MNRAS, (20217) Vol 469 1869-1882

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

THE COW THAT JUMPED
OVER THE MOON FAILS
TO CONSIDER RE-ENTRY

MOO?



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