Meteor science using radio

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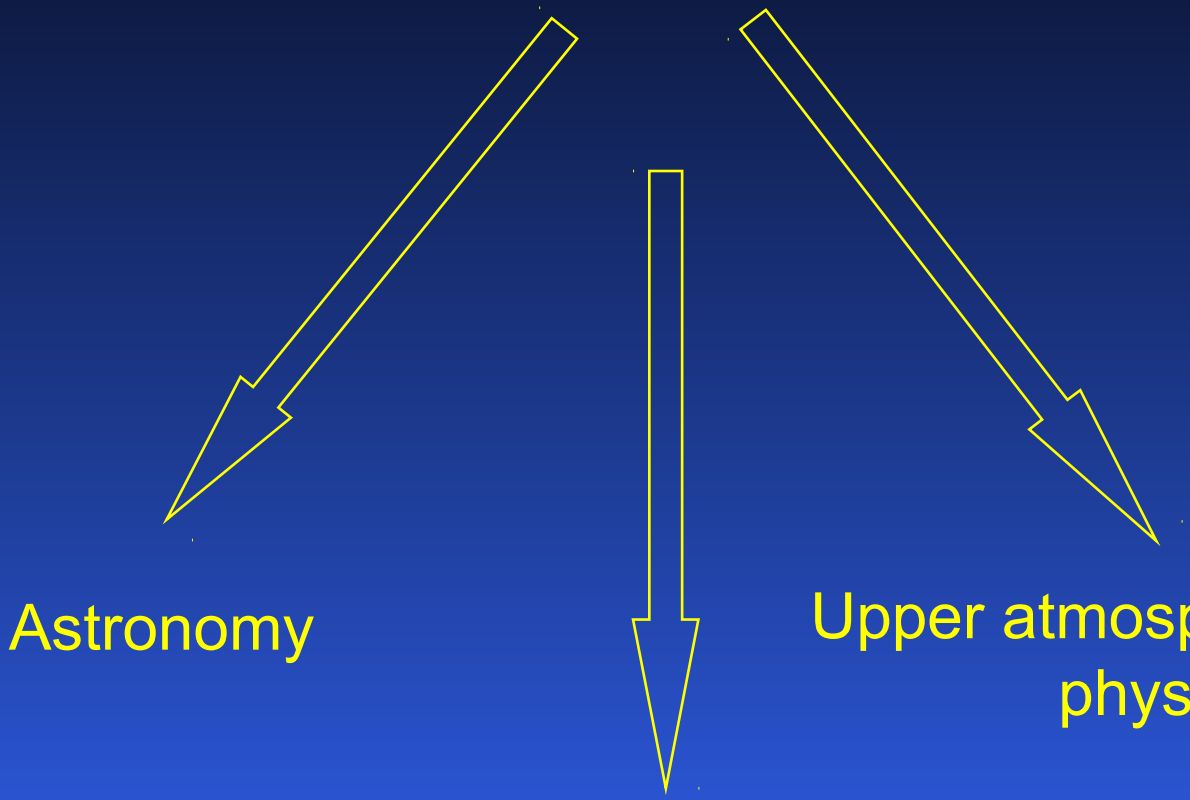
WETAL Giron, nov. 2015

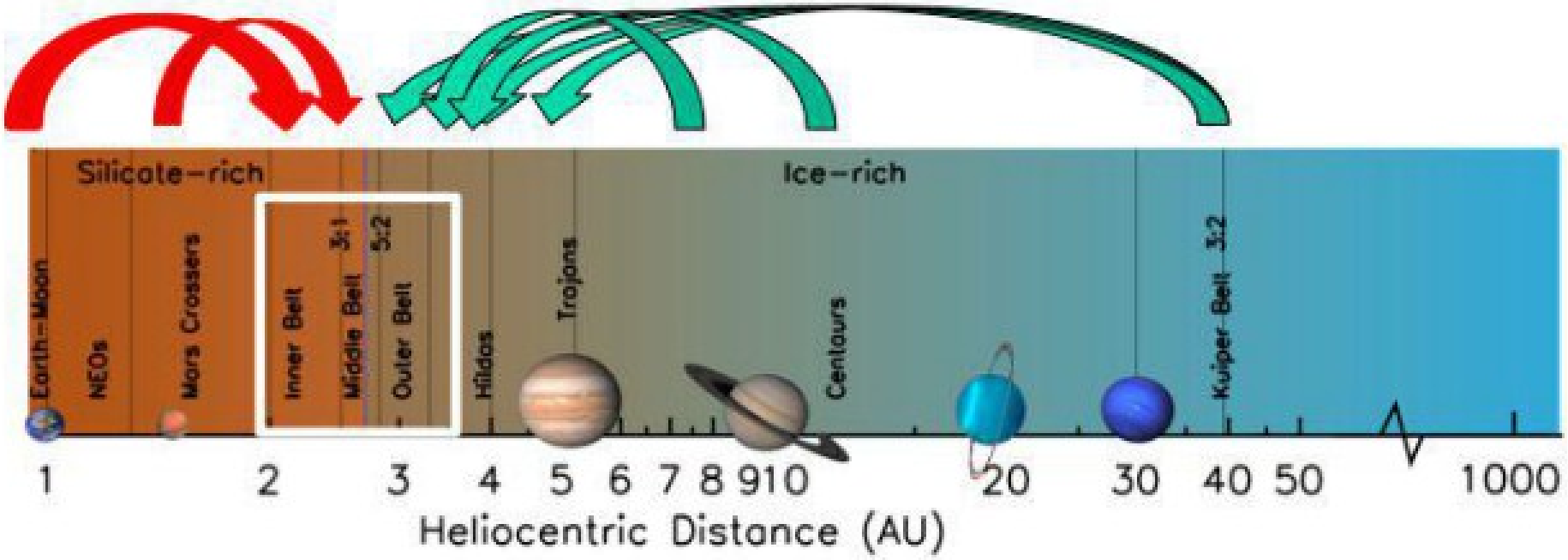
International Meteor Organization
Radio Commission

Société Astronomique de France
Radio astronomy Commission

Meteor science



Astronomy



F. DeMeo

Sampling the Main Belt =
sampling the whole solar system

Astronomy

Detecting and counting meteors for:

- identifying new meteors showers
- supplementing the existing data

Performing trajectography of meteors for:

- refining meteor showers prediction models
- refining the characteristics of their parent bodies
- locating accurately the strewn fields for collecting and analysing the meteorites

Upper atmosphere physics

Interactions between meteors and Earth's atmosphere and magnetic field:

- Aeronomy (high altitude winds, chemistry)
- Ionosphere studies:
  - E sporadic layers induced by meteoritic metallic ions
  - D layer (sometimes called ignorosphere…)
  - Electrophonic meteors (VLF)
  - VLF propagation transients (MSIDs)
  - HF/VHF emissions radiated by meteors

Applied physics

Space domain

Protection of satellites, probes, spacecraft and space stations

Applied physics
Using meteors for:

- military communications
  - OTH VHF narrow band emergency digital links

- civil telecommunications
  - Professional VHF data links (ex. : SNOTEL -SNOwpack TELemetry-)
  - Ham radio meteor scatter (VHF/UHF)

Radio sensors

HF/VHF radar mode

- Monostatic radar configuration (back scatter)
- Bi static radar configuration (forward scatter and back scatter)

E or B field ELF/VLF receivers

- Natural radiations by meteors
- VLF propagation modifications

HF/VHF receivers

- Natural radiations by meteors

Meteor radio observations using amateur equipment

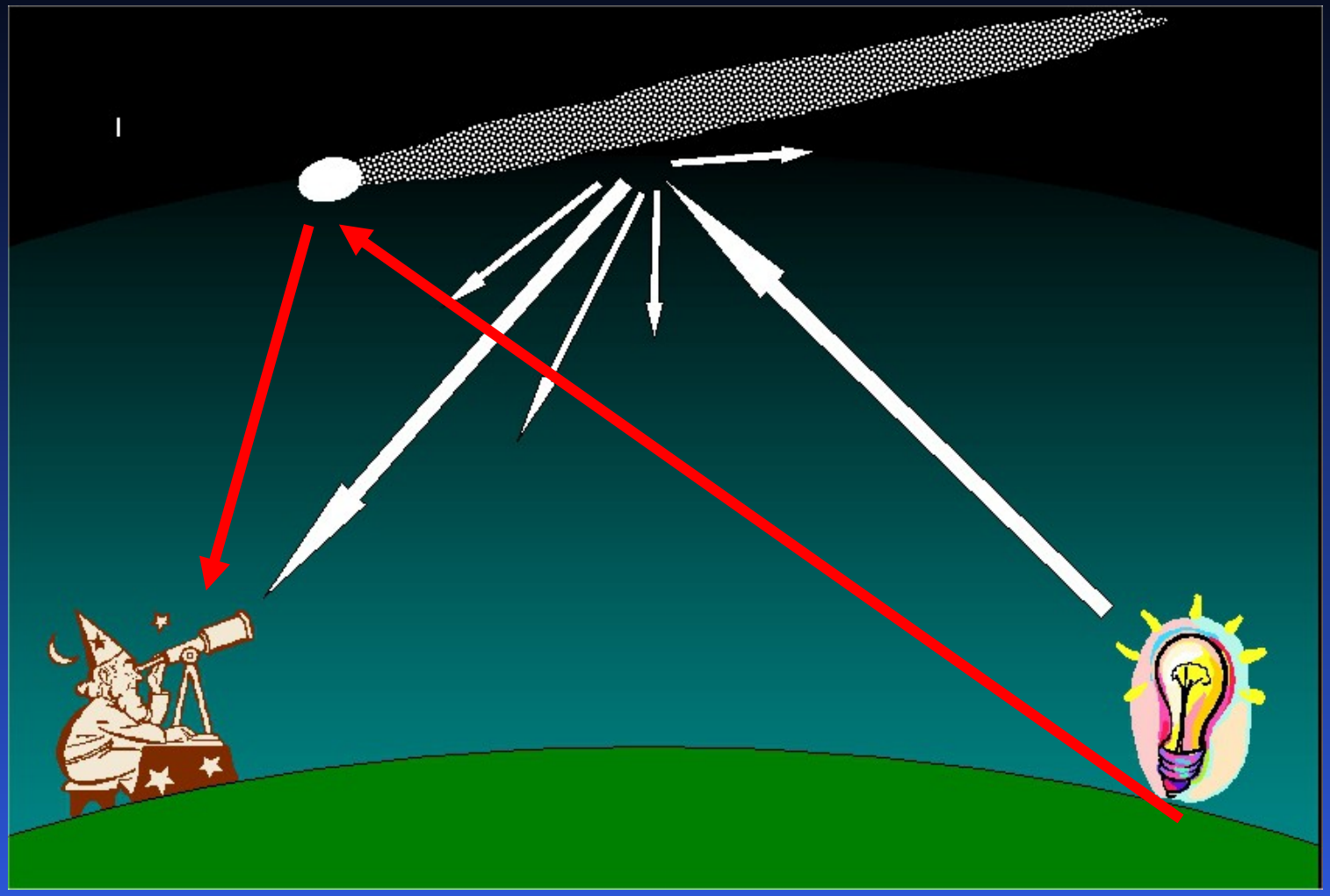
Hardware

- Home made ham radio or commercial analog receivers such as AOR AR5000, ICOM IC-R 70, …
- SDR (Software Defined Radio) receivers such as Winradio, Airspy, …
- Cheap SDR dongles using RTL2832U are not recommended (poor dynamic range, 8 bits only, poor sensitivity, intermodulation issues)
- AMSAT-UK FunCube Dongle is preferred
- Home made or commercial antennas (Yagi, vertical whip, single or multi turns magnetic loop)
- Laptop of desktop
- Digital audio recorder for field operations

Open source Software

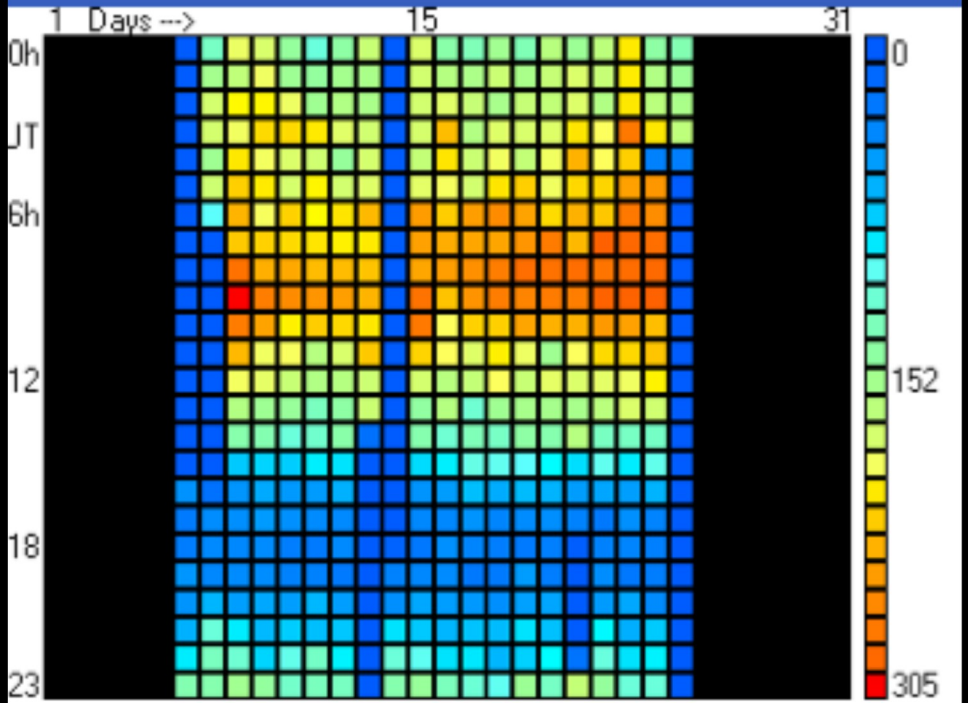
- Audacity or Izotope for audio files managing and for visual analysis
- Spectrum Lab toolbox
- HROFFT, Scatterthon
- LibreOffice Calc and Scilab for data processing and plotting

Forward scatter using a bi-static radar configuration

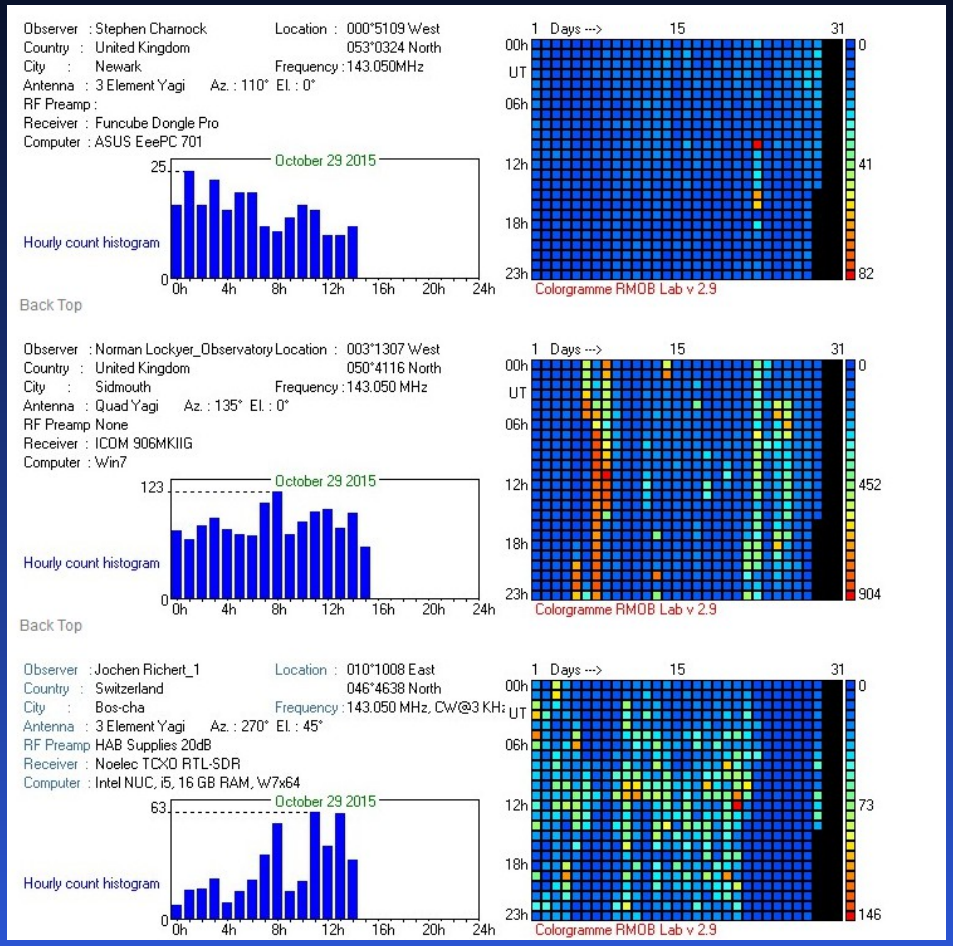


$$P(0) = \frac{P_T G_T G_R \lambda^3 r_e^2 q^2 \sin^2 \gamma}{32\pi^2 R_T R_R (R_T + R_R)(1 - \sin^2 \phi \cos^2 \beta)} \exp \frac{-8\pi^2 r_0^2}{\lambda^2 \sec^2 \phi},$$

HF/VHF detecting and counting



Radio Meteor Observatory's On Line



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03	2	1	3	2	3	3	4	3	3	5	4	13	5	6	4	4	4	5	5	3	2	2	3	3
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[Country]United Kingdom
[City]Newark
[Longitude]000°5109 W
[Latitude ]053°0324 N
[Longitude GMAP] -0.85263800000007
[Latitude GMAP]53.0567052
[Frequencies]143.050MHz
[Antenna]3 Element Yagi
[Azimut Antenna]110
[Elevation Antenna]0
[Pre-Amplifier]
[Receiver]Funcube Dongle Pro
[Observing Method]
[Remarks]ASUS EeePC 701
[Soft FTP]Colorgramme RMOB Lab v 2.9
[E]z}lyalg'jah{gfjb998Indh`e'jfd
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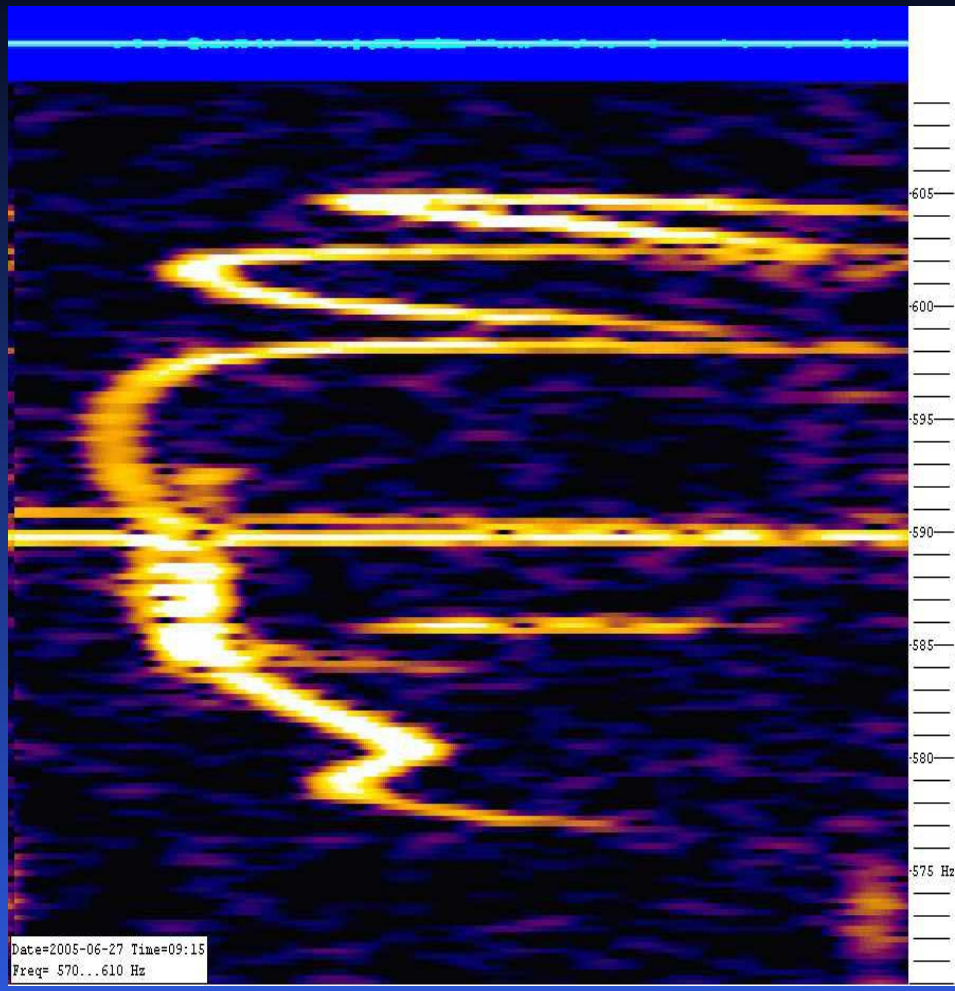
www.rmob.org

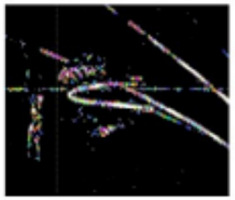
Doppler signatures analysis of meteor trails



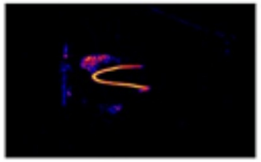
The spectral analysis using an FFT (Fast Fourier Transform) algorithm is a powerful tool for studying the signatures of meteor radio echoes…

c200910061331_comb

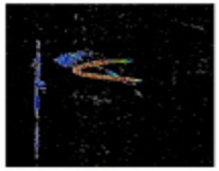
Johan



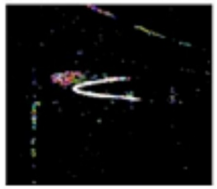
Roland



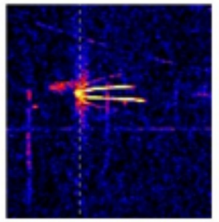
Janos



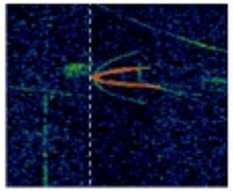
Felix



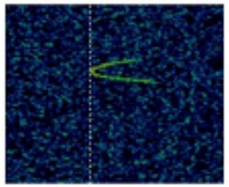
Willy



Chris

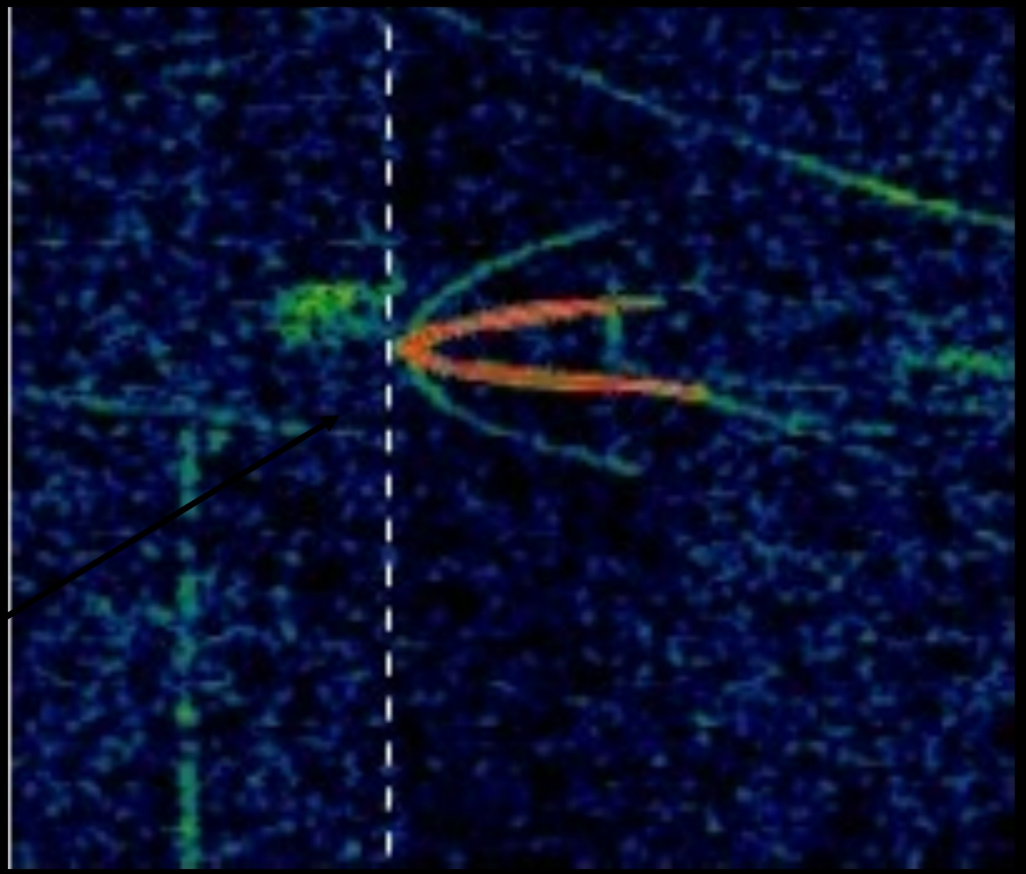


Lucas

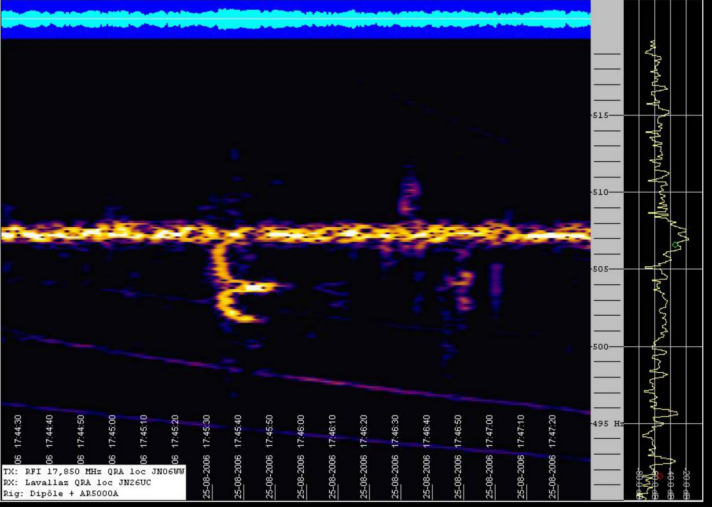


Meteor zoo taxonomy

C shape

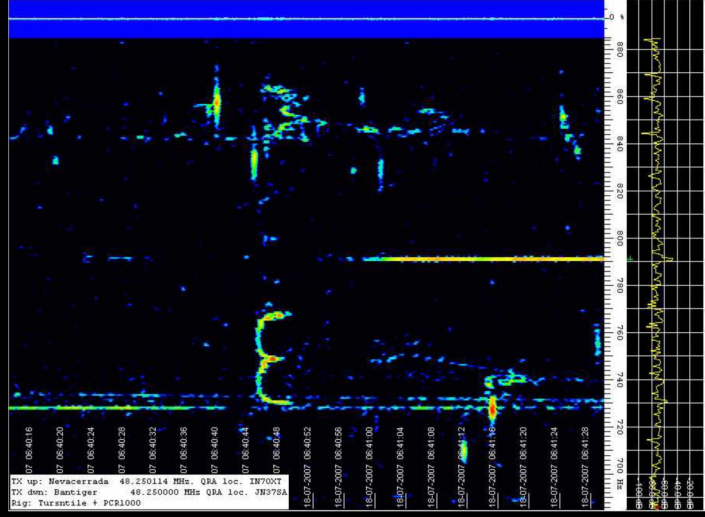


VVS Yper beacon

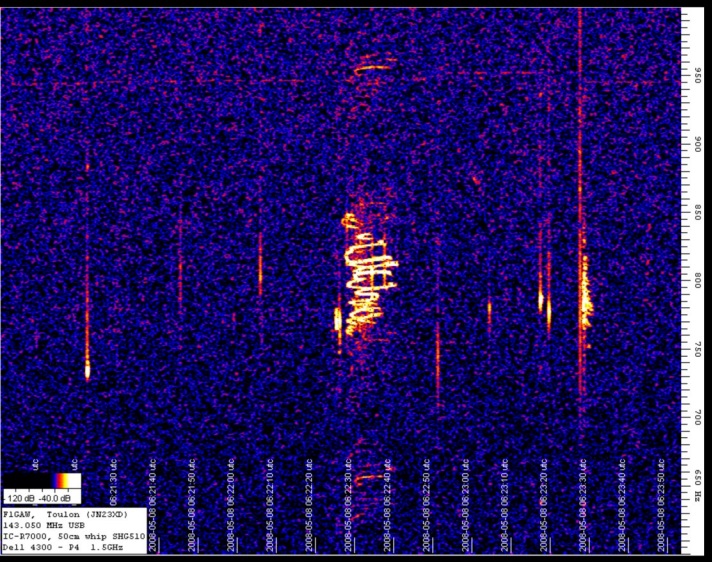


JLR (nr Paris) / RFI 17 MHz

ε shape

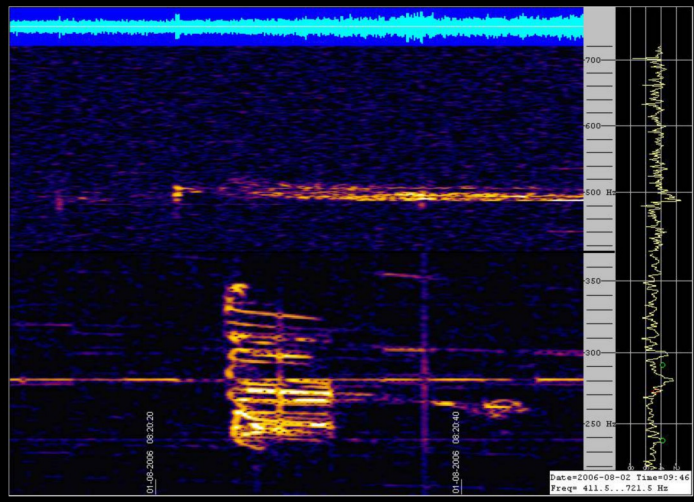


JLR (nr Paris) / Budapest 48 MHz



AG (Toulon) / GRAVE 143 MHz

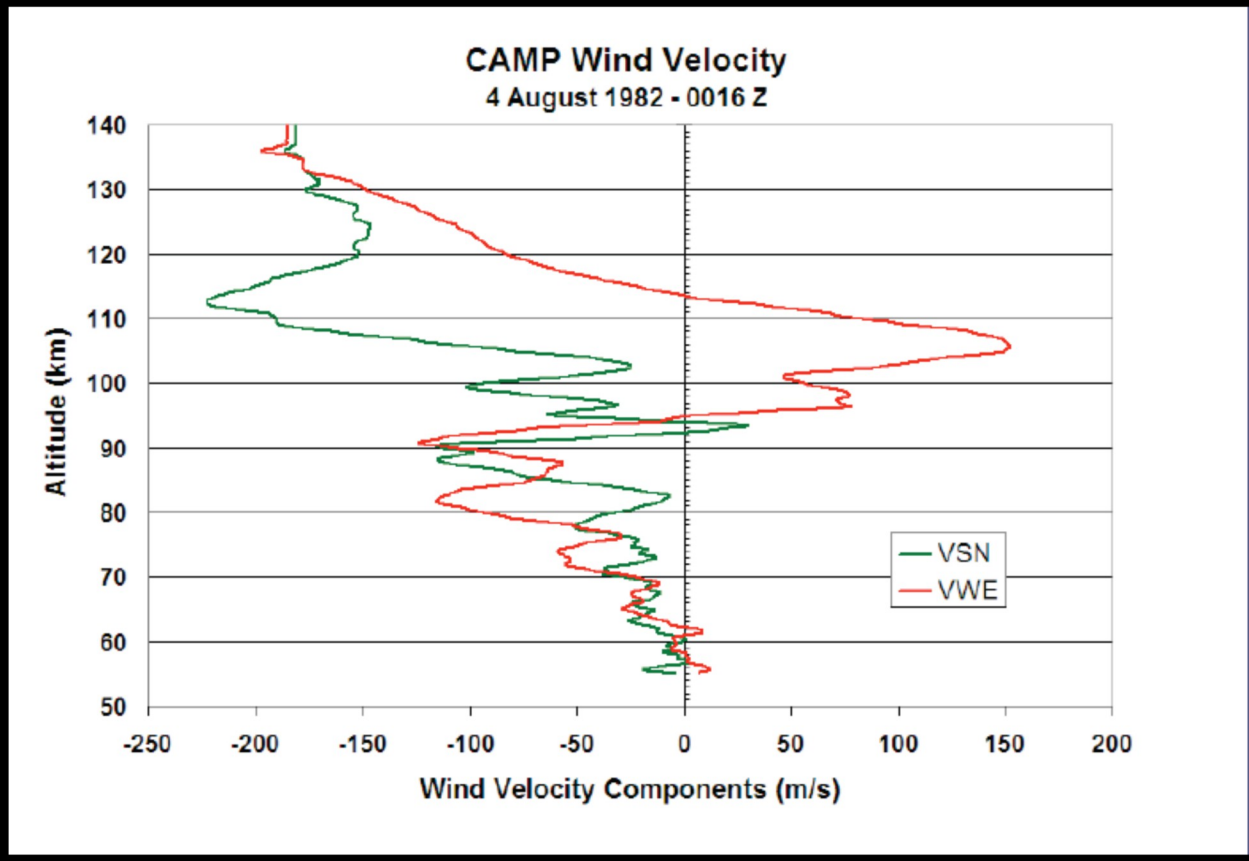
Corkscrew



JLR (nr Paris) / 48 & 143 MHz

Influence of the high altitude zonal and meridional winds on the meteor trails shapes

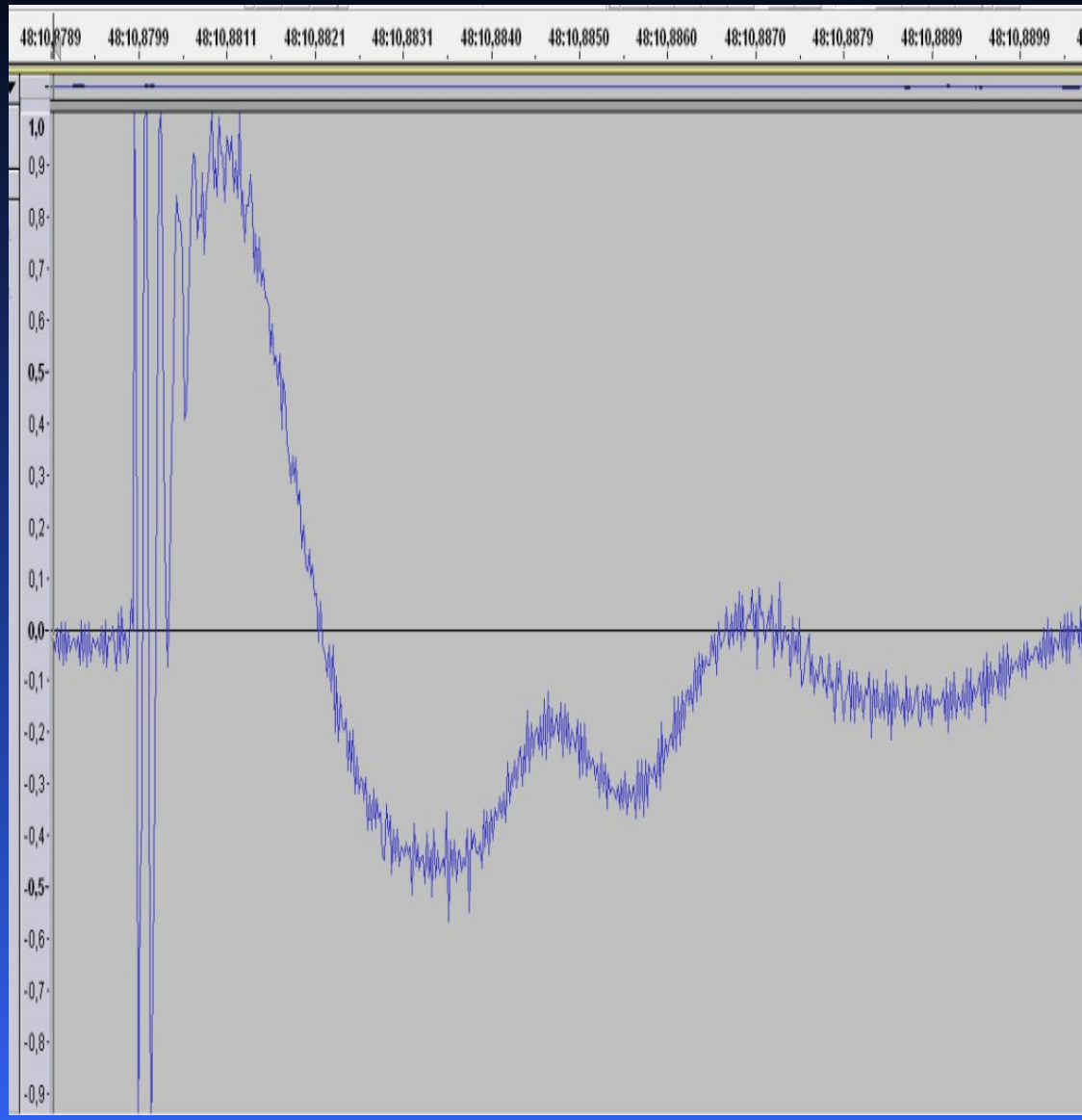
Example of trail shape distorsions



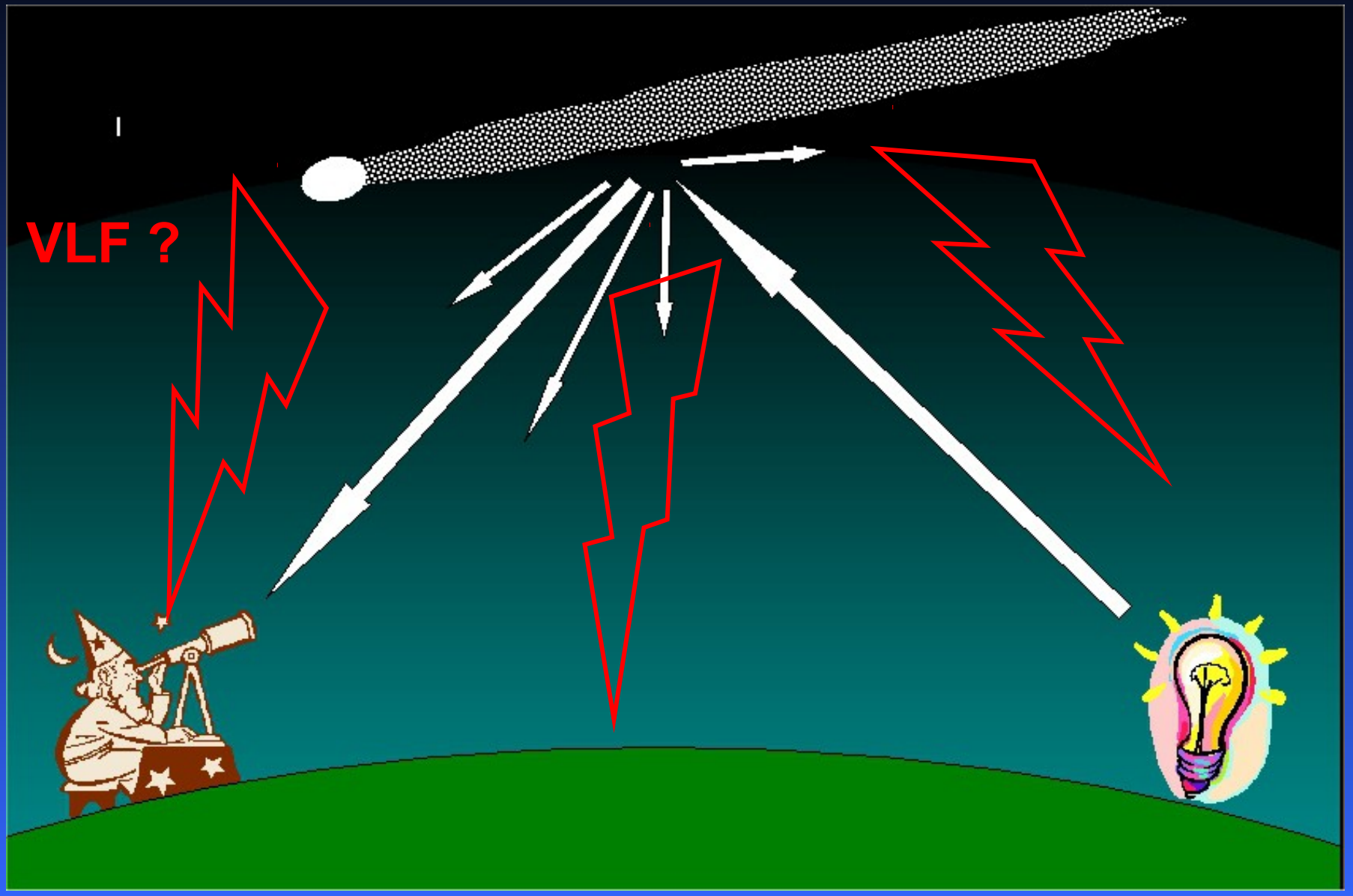
High altitude wind speeds and wind sheras

TLF/ELF/VLF and meteors

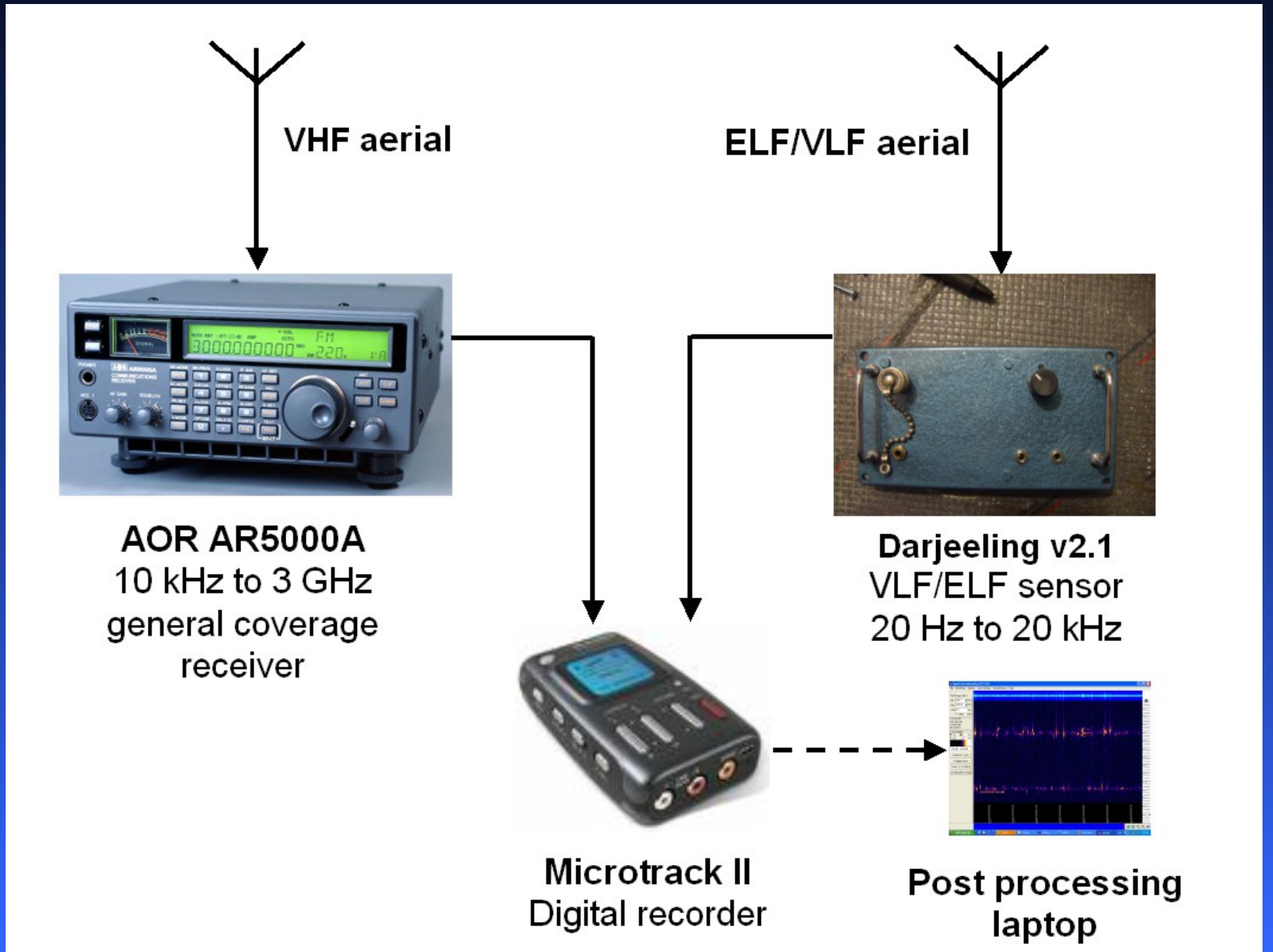
- Electrophonic meteors
- Propagation transients



Do meteors radiate any RF energy?



Example of a VHF and ELF/VLF events correlation set-up



Perseids 2008 VLF & VHF set-up

August Perseids campaign in Brittany …

Menez-Hom top

An example of unexpected source of VLFradio spikes, glitches and transients

Testing low acoustic noise E field ELF/VLF aerials

Sand damped
mesh monopole (18 kg)

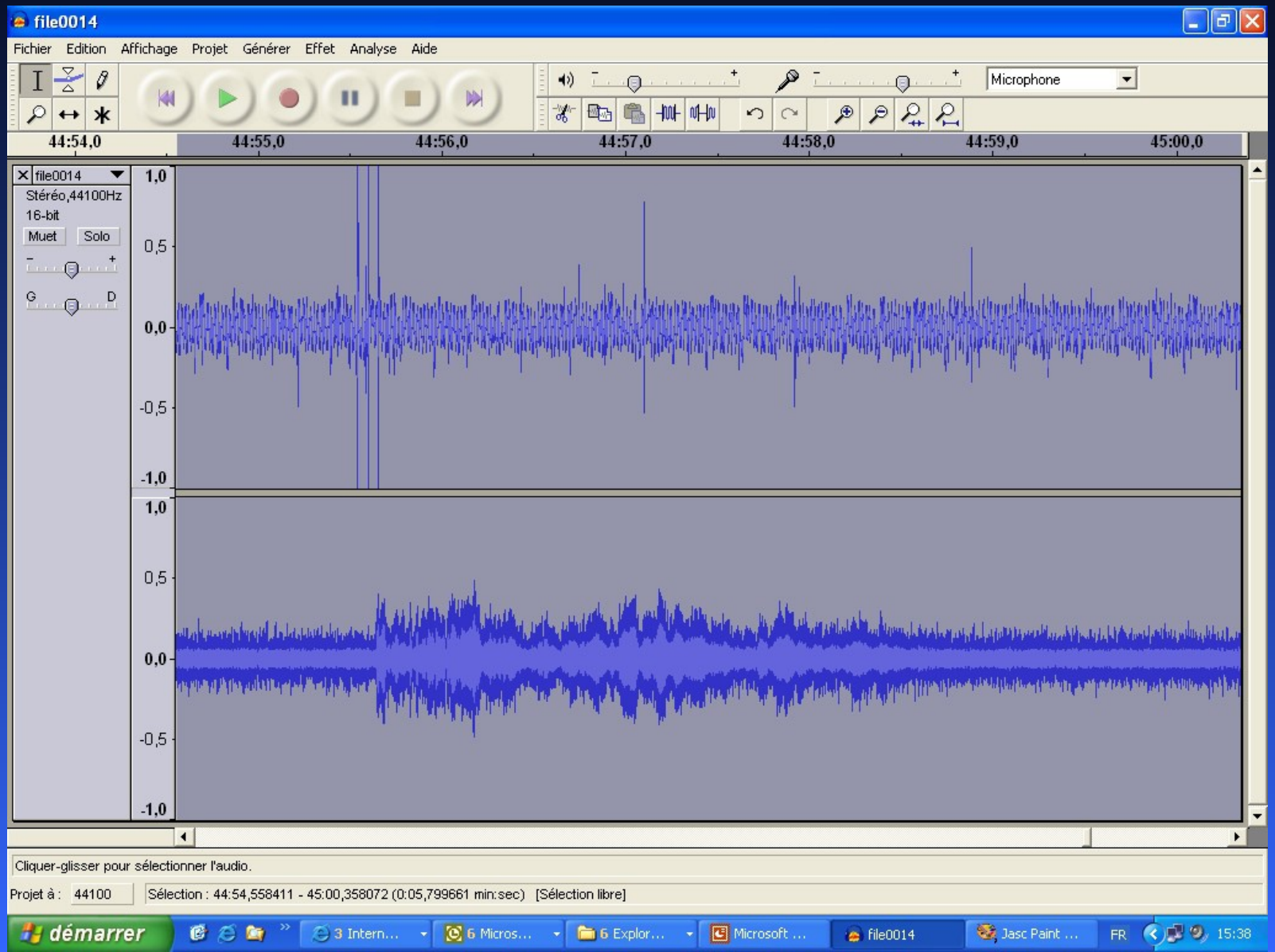
Parietal art monopole
(16 tons)

TLF (0,2 to 60 Hz) magnetometer

Magnetic loop (6000 turns on a 90 kg concrete frame)

One turn broadband magnetic loop

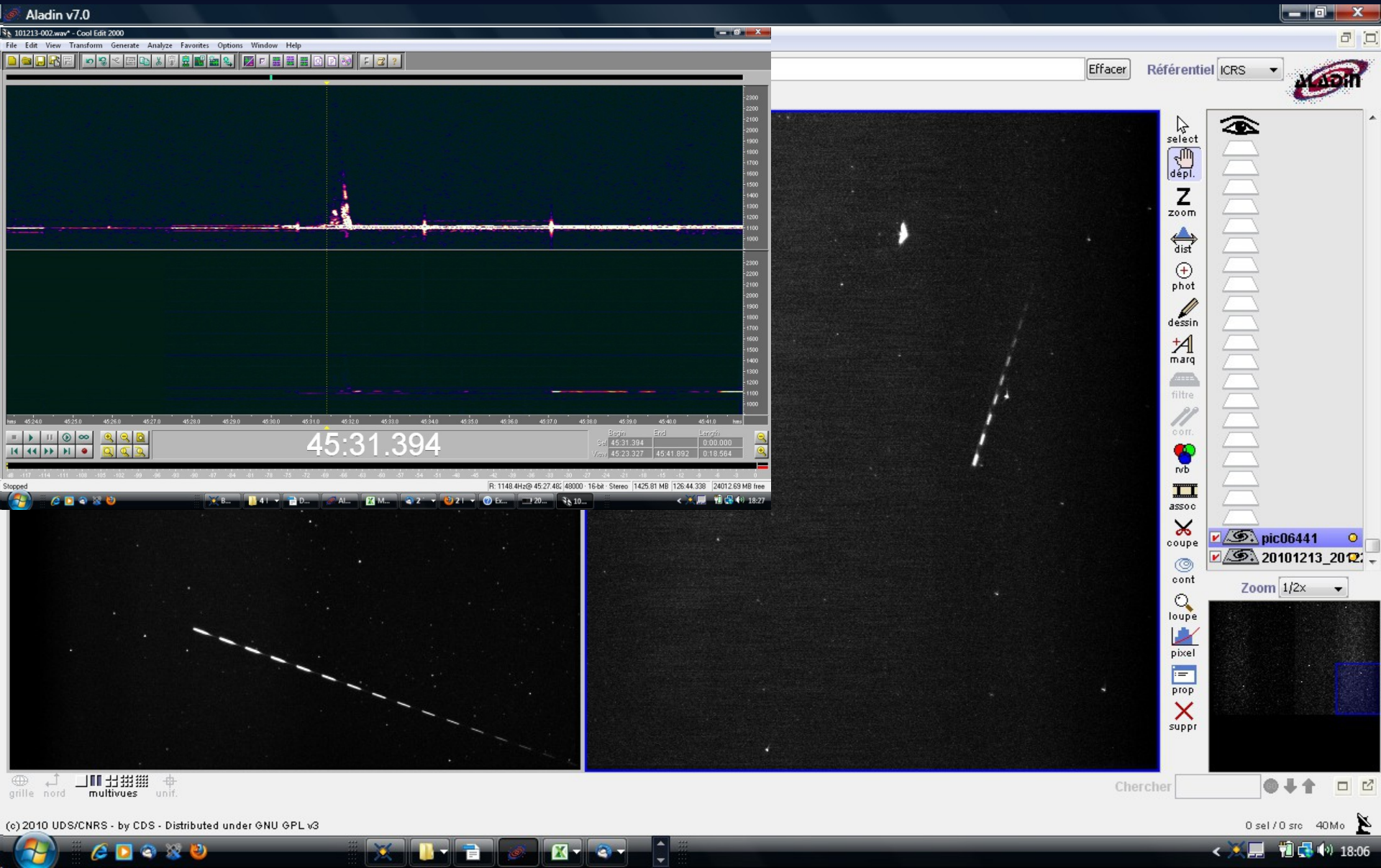
Example of correlation between a VHF meteor echo and a VLF event



Geminids 2010

An example of simultaneous optical and radio observation campaign at Pic du Midi observatory

Example of correlation between a visible meteor and a simultaneous VLF event



Do meteors trigger any VLF propagation events ?

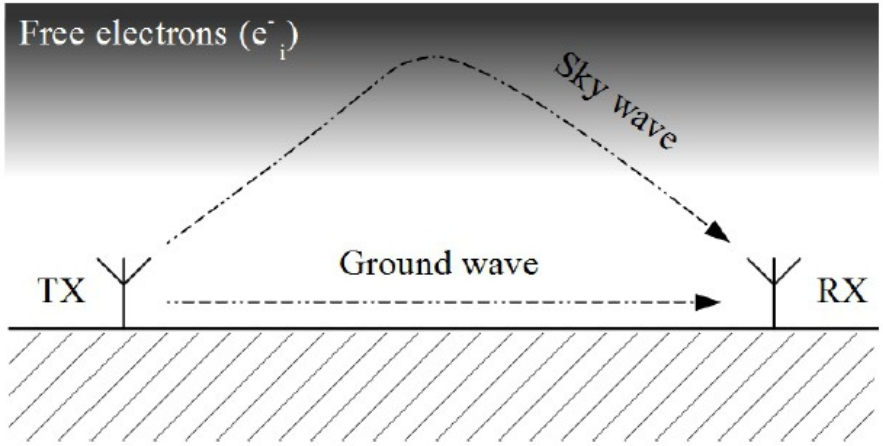


Figure 1. Representation of the sky and ground waves propagating in the Earth ground/ionosphere natural waveguide

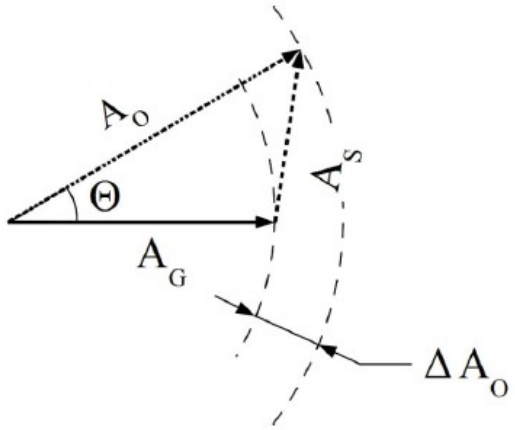
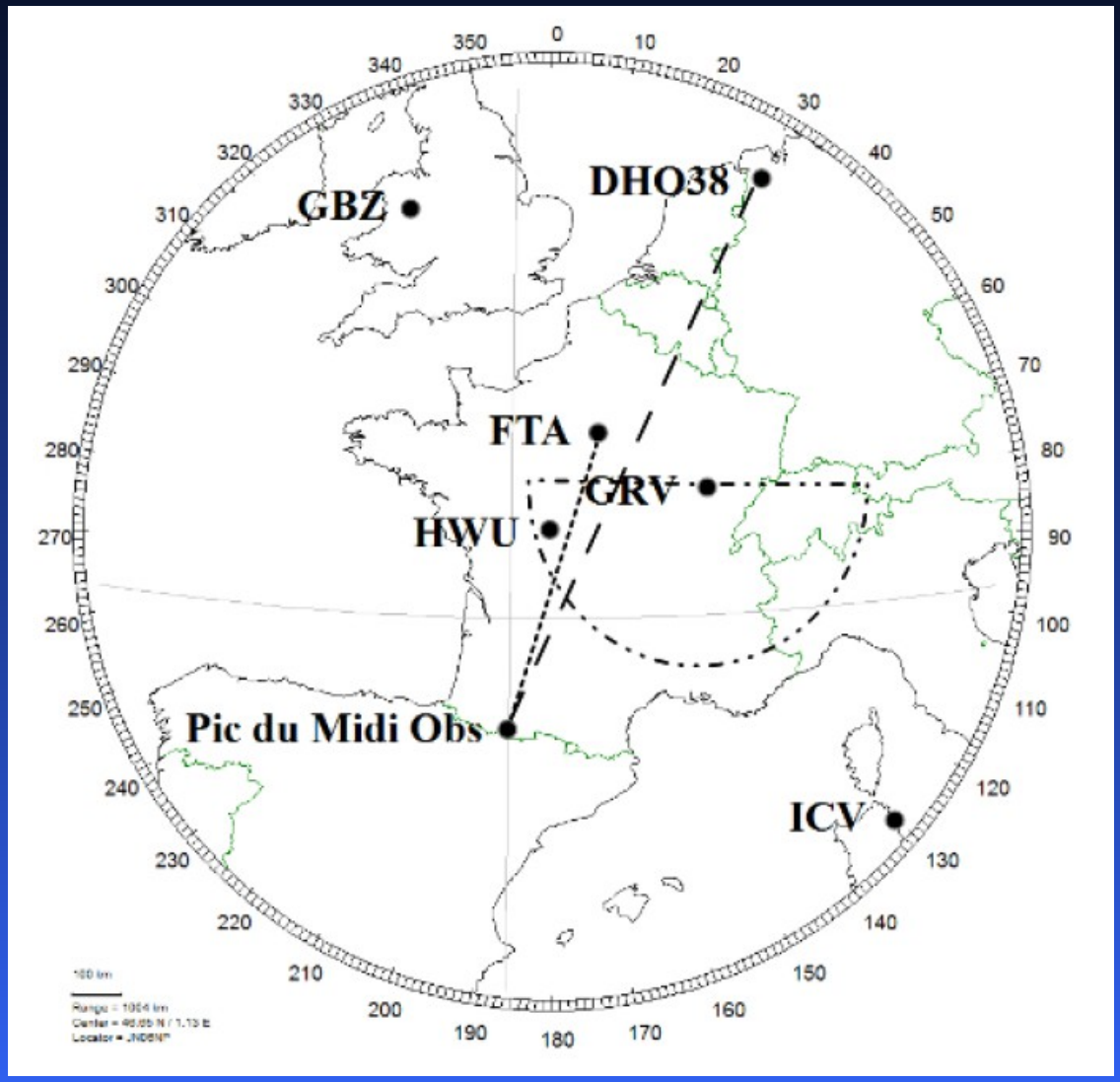


Figure 2. The VLF signal at the RX reception location is the vectorial sum of the sky wave and of the ground wave radiated by the transmitter TX

Searching for Meteor SIDs



Evidence of a MSID

Constructive interference on FTA

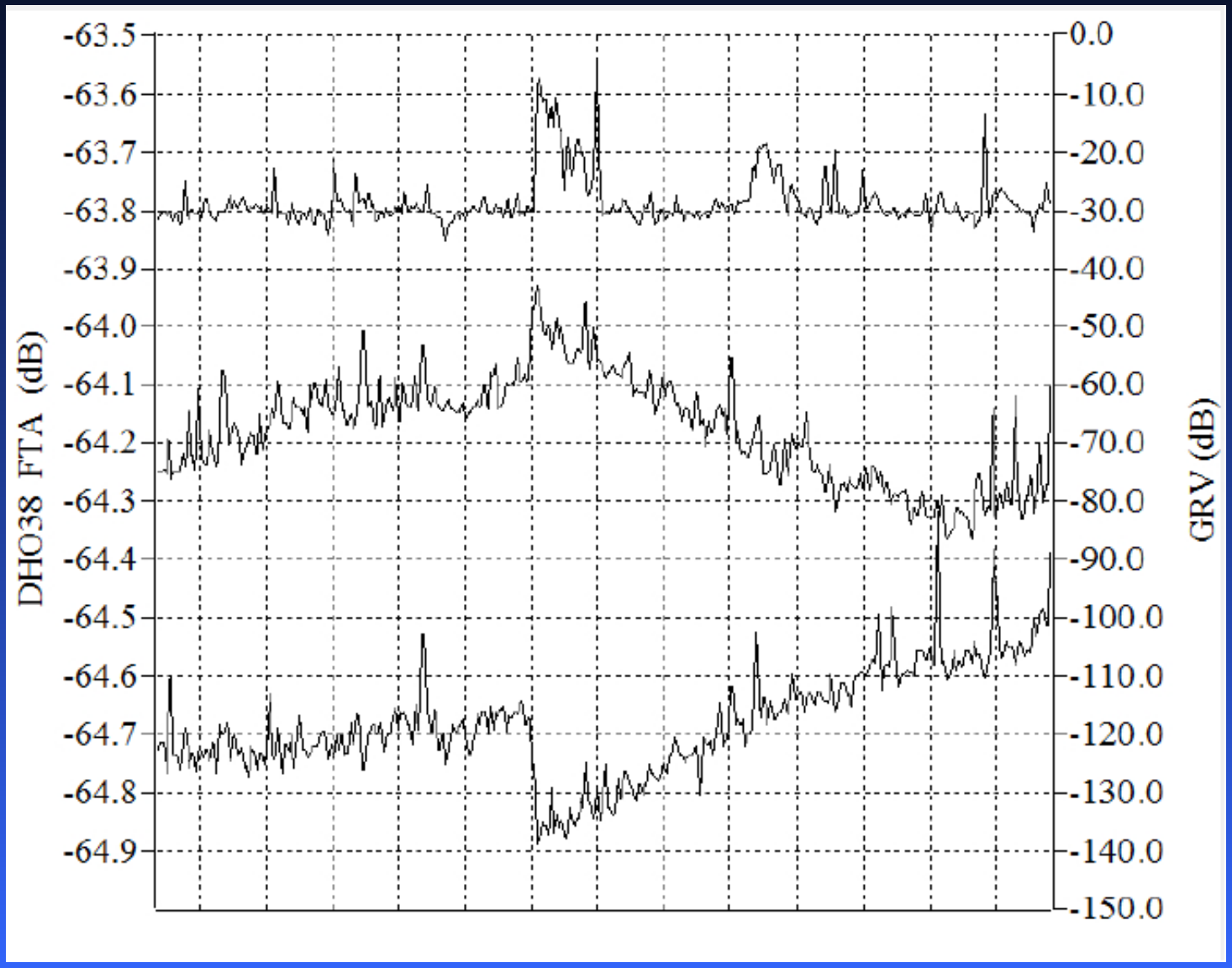
Destructive interference on DHO38

Meteor

Meteor

Meteor

Searching for MSIDs



Searching for MSIDs

Finding MSIDs should be easier than identifying electrophonic meteors, because:

- audio records can be replayed and analysed at x-times the real time (fooling Spectrum Lab by modifying the replay sampling frequency)
- automatic cross correlations with a typical MSID VLF signature look promising (see Paul Nicholson works)

allowing thus credible statistics and plasma physics studies

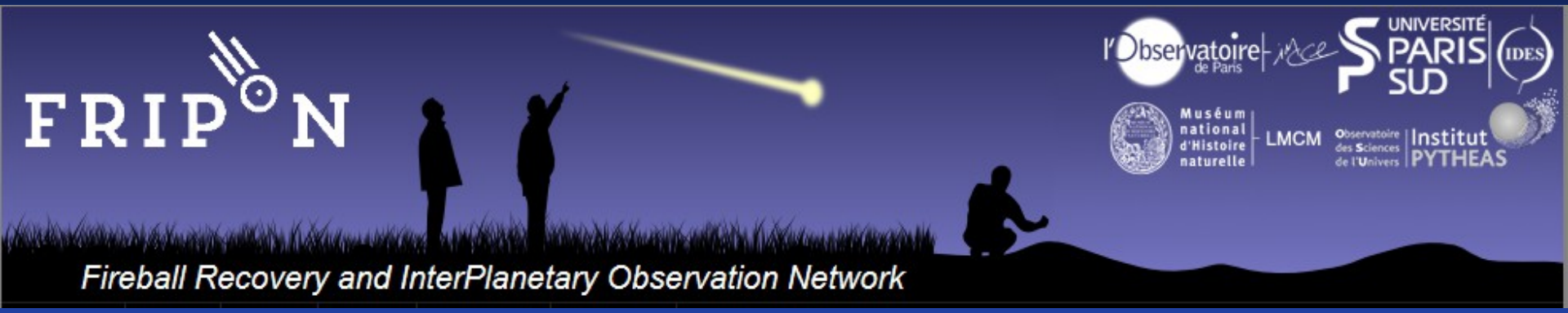
Examples of pro-am cooperations

BISA / VVS / UCL cooperation

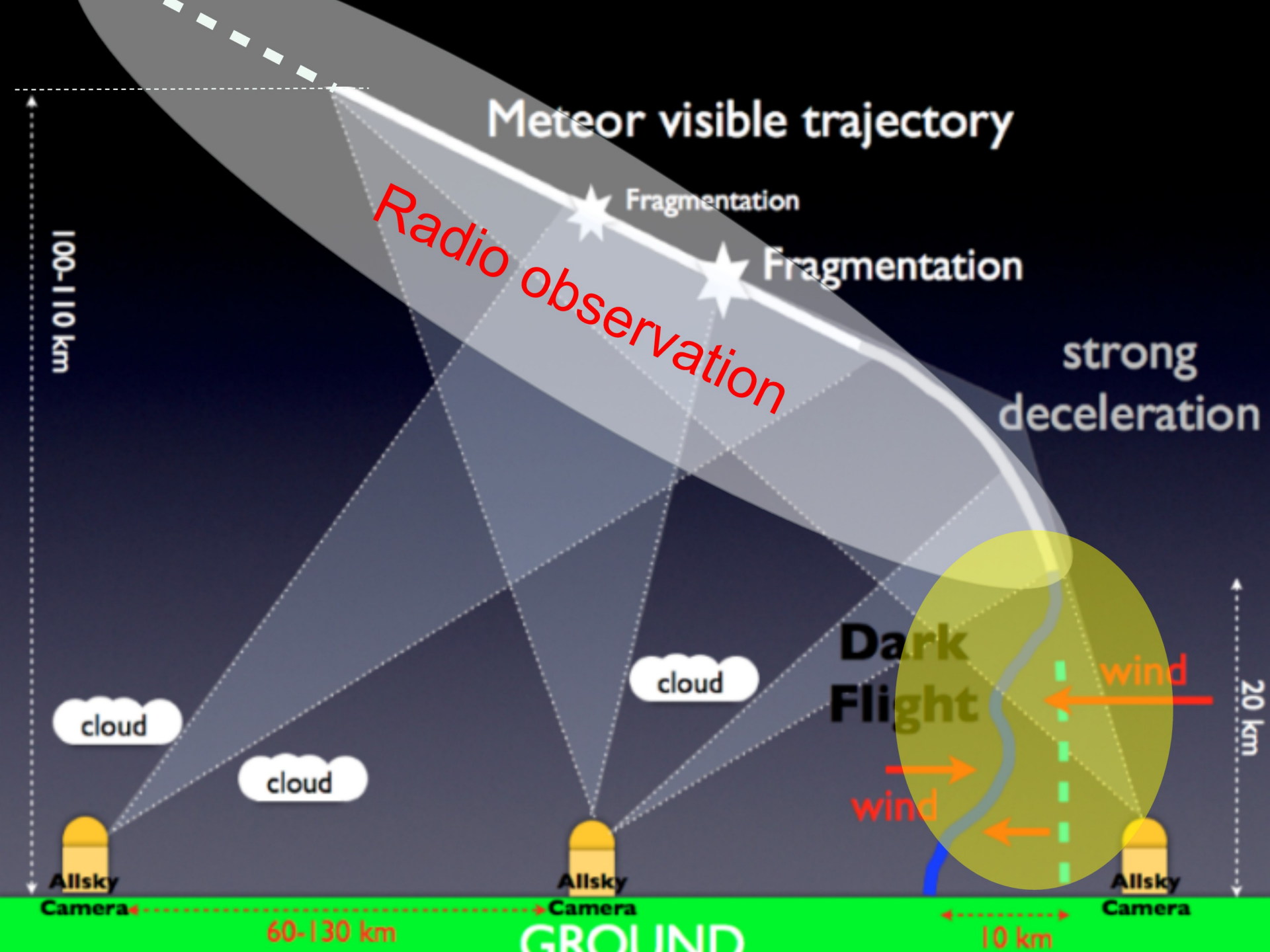
- Belgian Institute for Space Aeronomy
- Vereniging voor Sterrenkunde
- Université Catholique de Louvain
- BRAMS network

BRAMS network

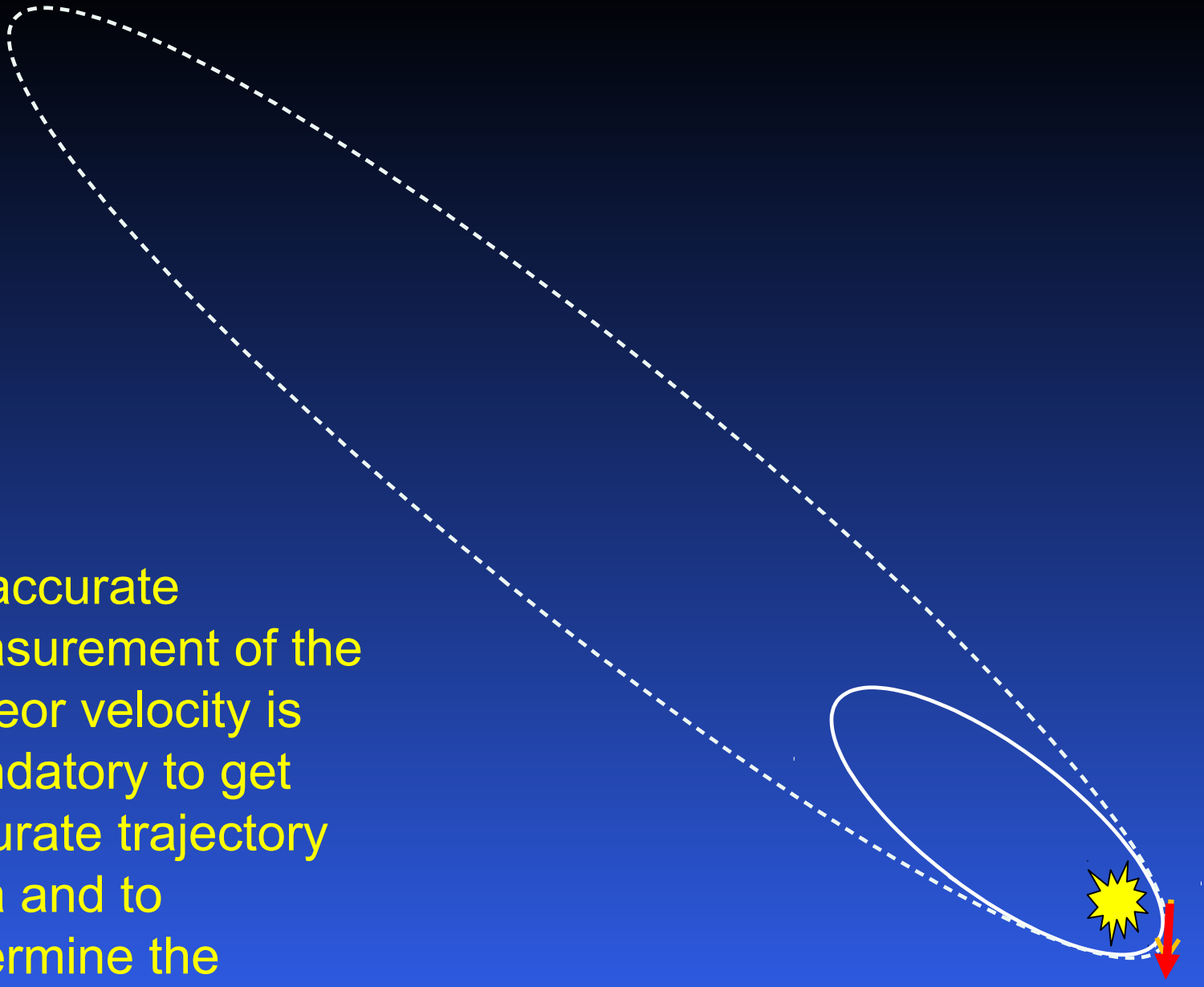
http://brams.aeronomie.be/



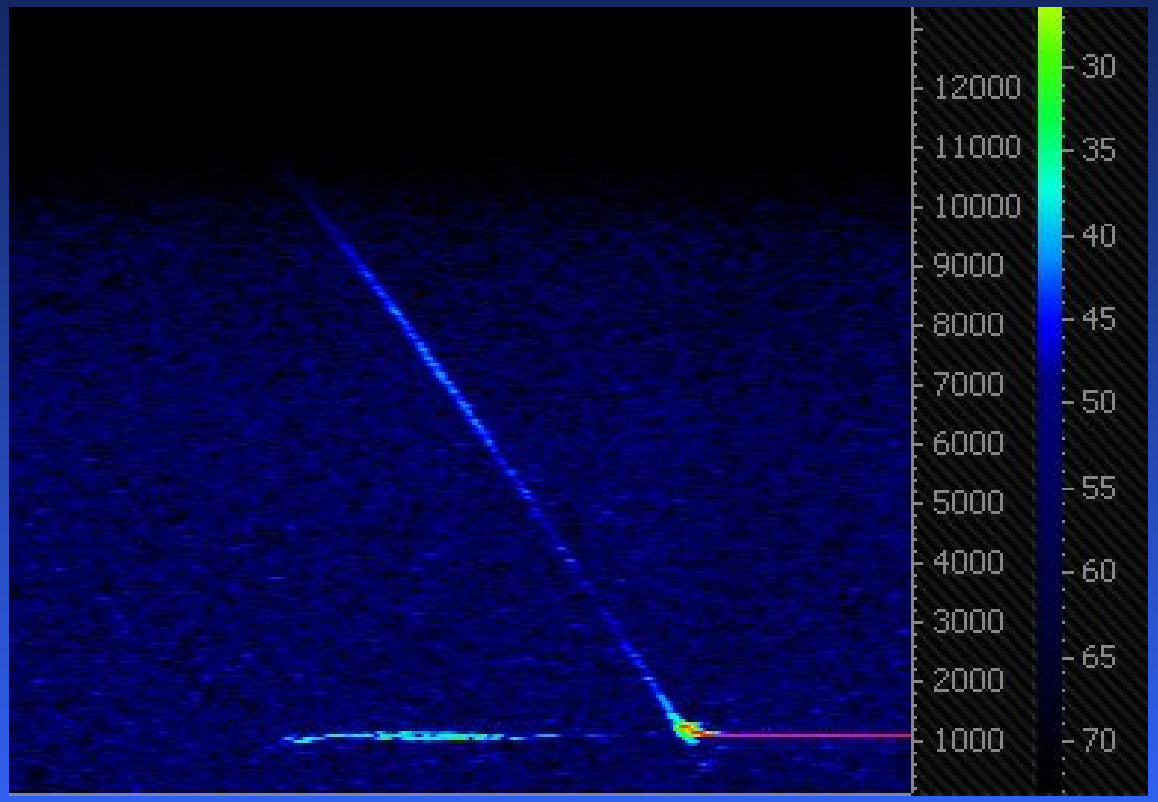
http://www.fripon.org


Meteor visible trajectory
Fragmentation
Fragmentation
Radio observation
strong deceleration
100-110 km
cloud
cloud
cloud
Dark Flight
wind
wind
20 km
Allsky Camera
Allsky Camera
Allsky Camera
60-130 km
10 km
GROUND

An accurate measurement of the meteor velocity is mandatory to get accurate trajectory data and to determine the parent bodies



Using Doppler shift signatures of meteor head echoes should allow a precise determination of the meteor velocities



International Meteor Organization

http://www.imo.net/


Savage Chickens
by Doug Savage
THAT CLOUD LOOKS LIKE A BUNNY!
AND THAT ONE LOOKS LIKE A METEOR
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