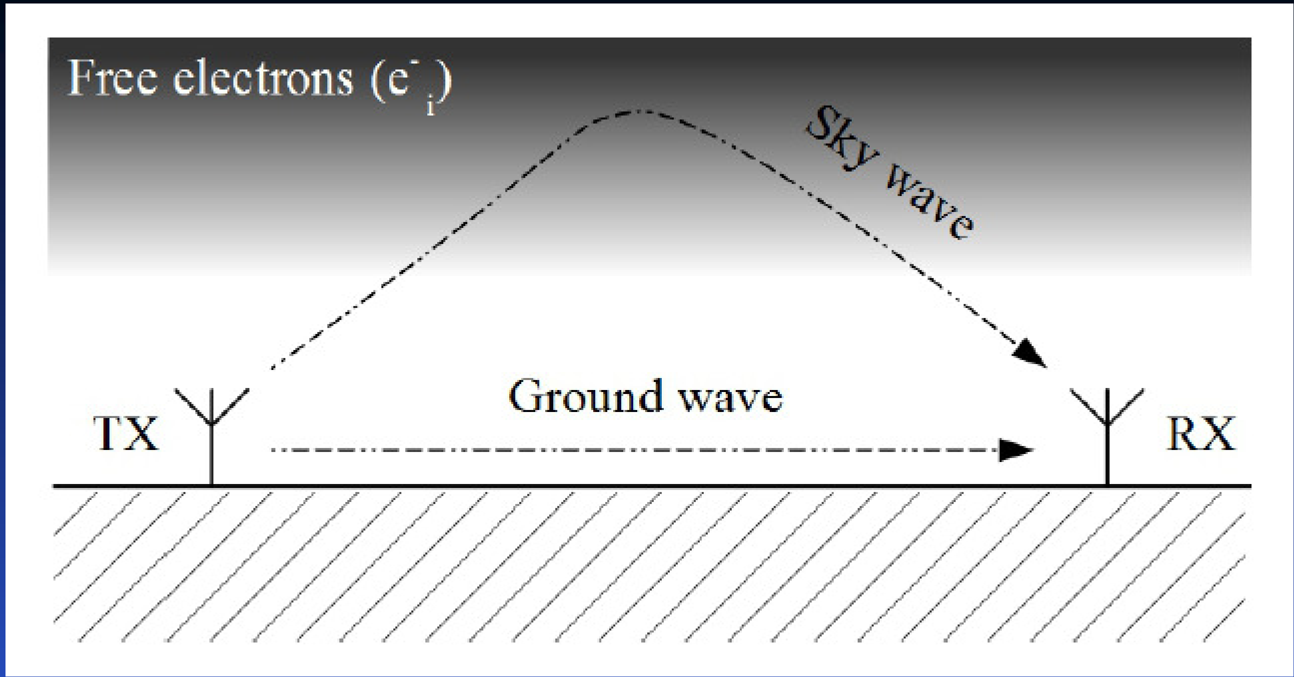
Using the BRAMS beacon for studying meteor induced VLF propagation disturbances

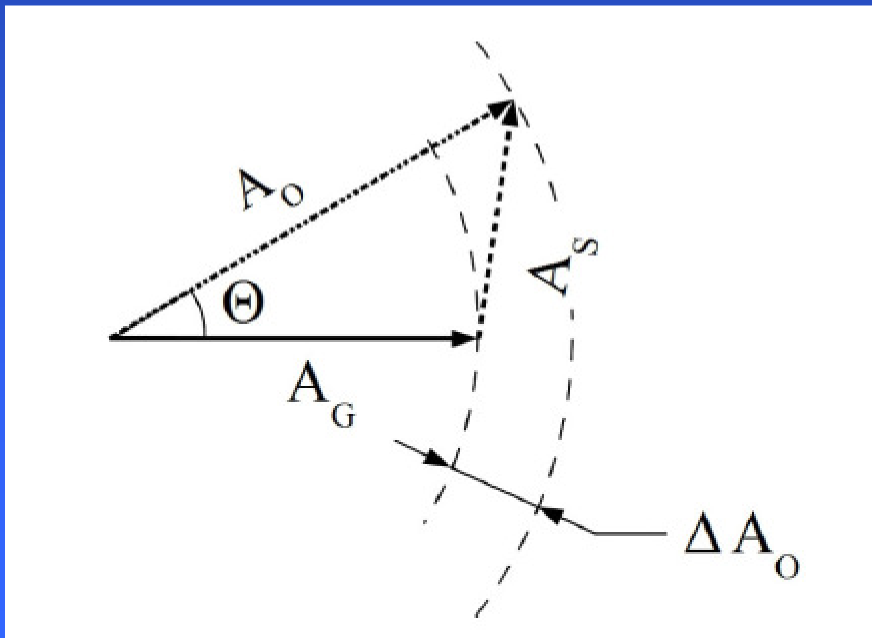
Jean-Louis Rault

IMO radio commission

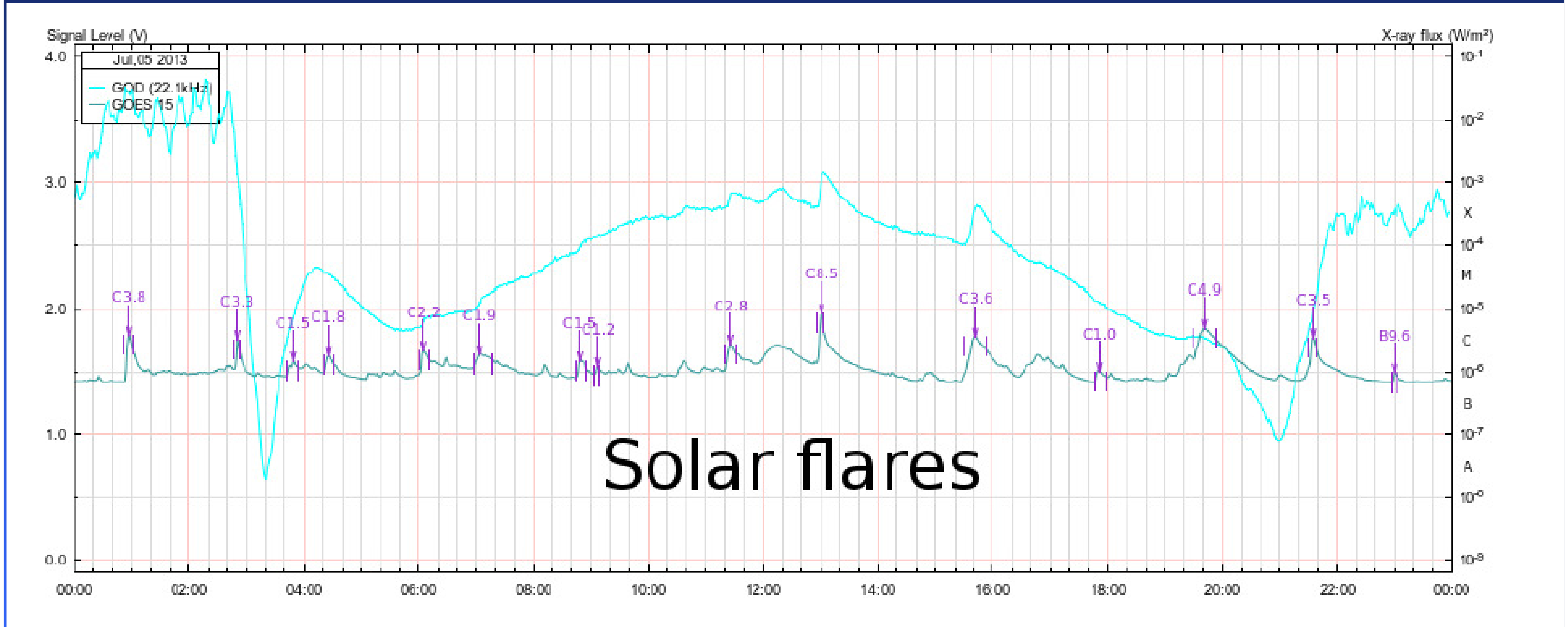
F6AGR 27 jun 2015

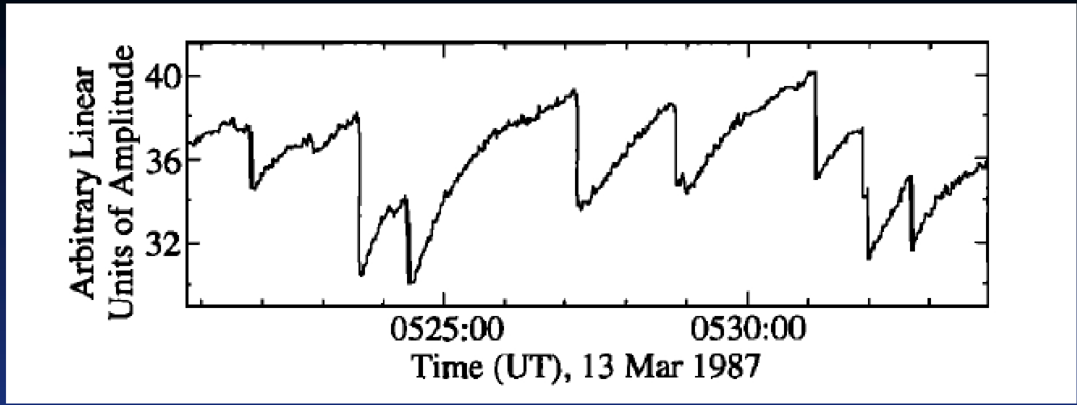
Various natural phenomenons such as solar flares, polar cap absorption events, X rays and γ rays radiated by distant stars, and LEPs (Lightning induced Electron Precipitations) create long duration or short transient VLF propagation disturbances by modifying the ionosphere parameters (altitude and/or e^- density)


Free electrons (e^-_i)
Sky wave
Ground wave
TX
RX

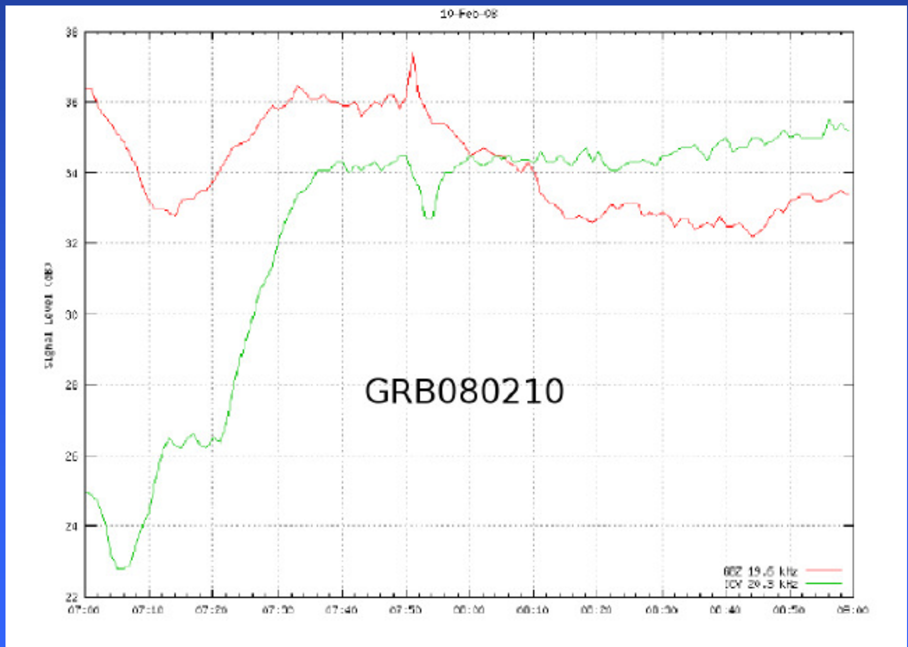

A_O
Θ
A_S
A_G
ΔA_O

Example of VLF amplitude spikes (upper curve) induced by X ray bursts (lower curve) from solar ares (Loudet, 2013)





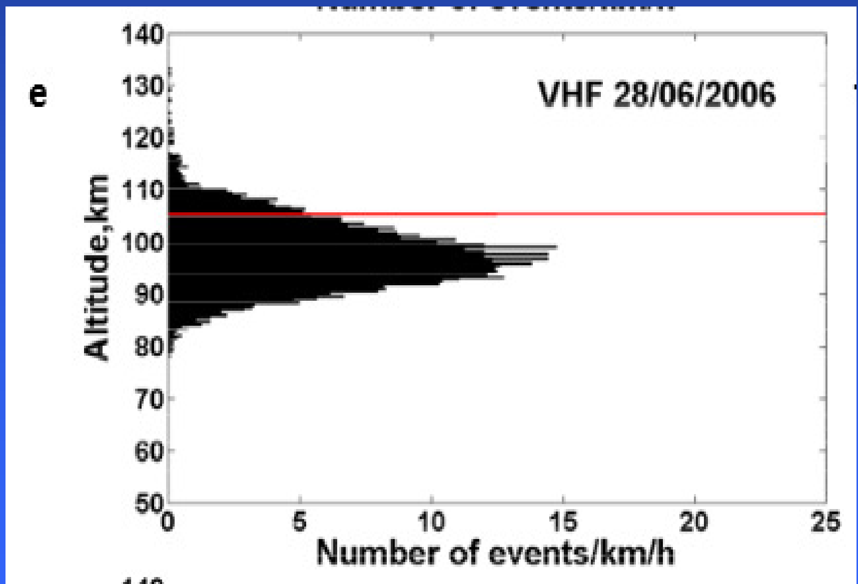
Example of VLF amplitude spikes triggered by LEP (lightnings induced electron precipitations) (Levtov, 1993)



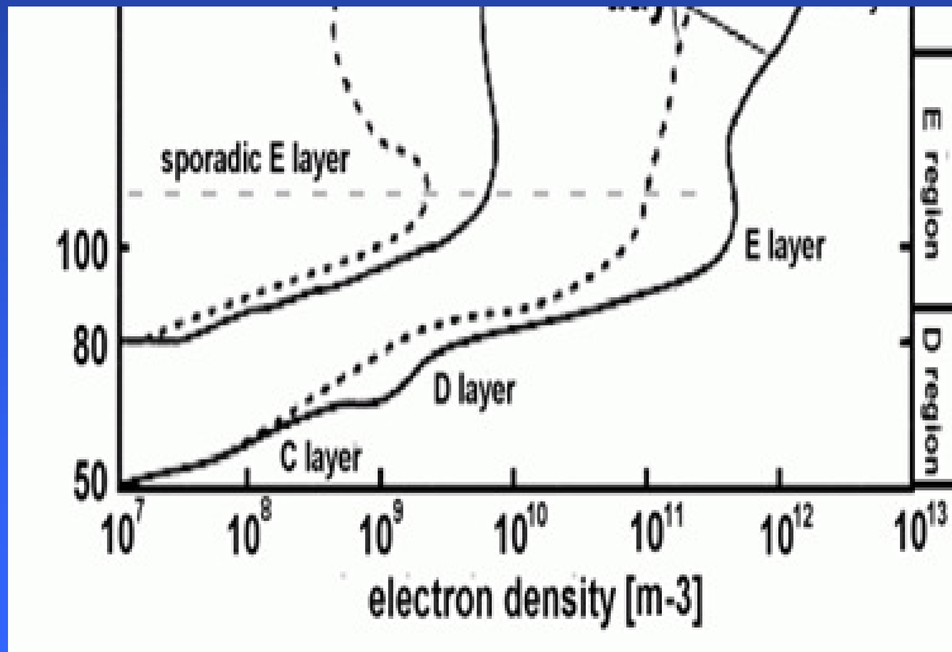
VLF amplitude anomaly due to a GRB (gamma ray burst) from a distant star (Godet, 2008)

Meteors and E layer of the ionosphere

➔Most of the ionization created by meteors entering the Earth atmosphere occurs at an altitude of about 100 km



Data collected by the EISCAT VHF radar



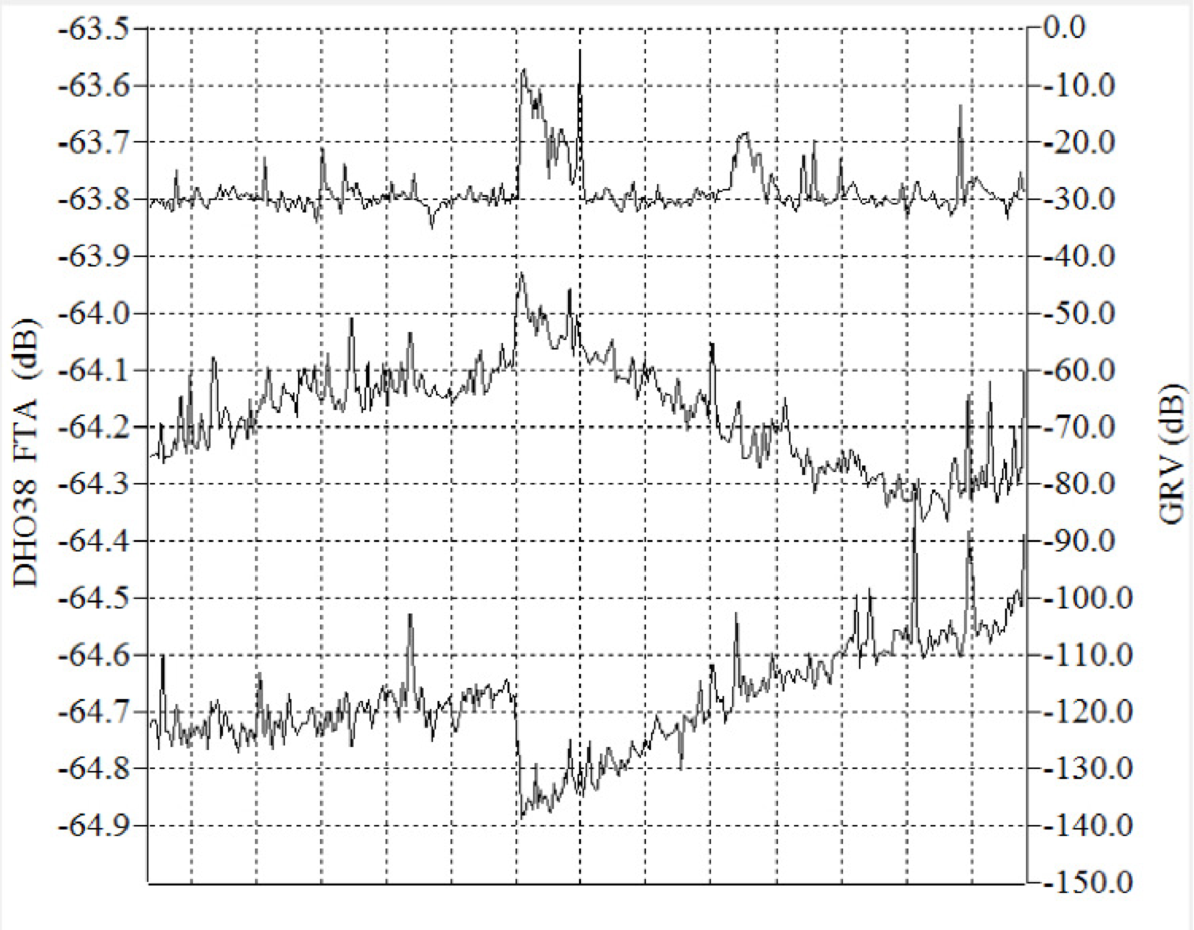
Ionisation rate versus altitude

VLF phase (Chilton,1961) and VLF amplitude (De, 2012) transient variations occurring during meteor showers were reported in the past, but these variations were observed on a statistical basis only and at large time scales (i.e. averaged values). They were not directly linked to any single meteors.

So, the question is:

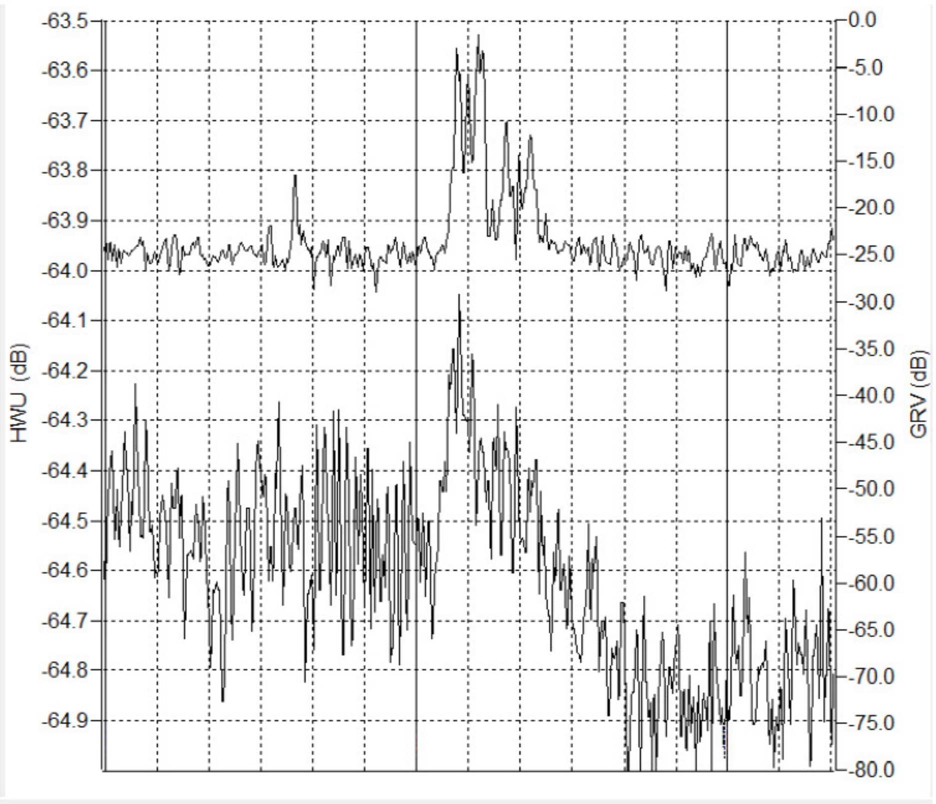
Is there any evidence of a single meteor inducing some VLF radio propagation disturbance ?

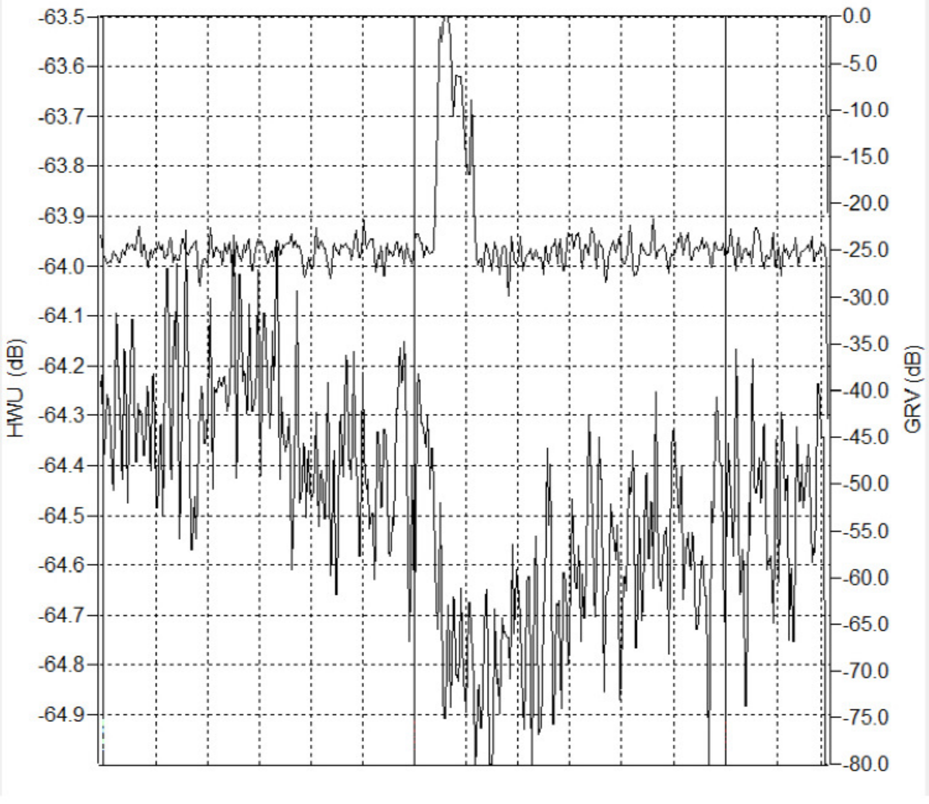
And the answer is Yes !



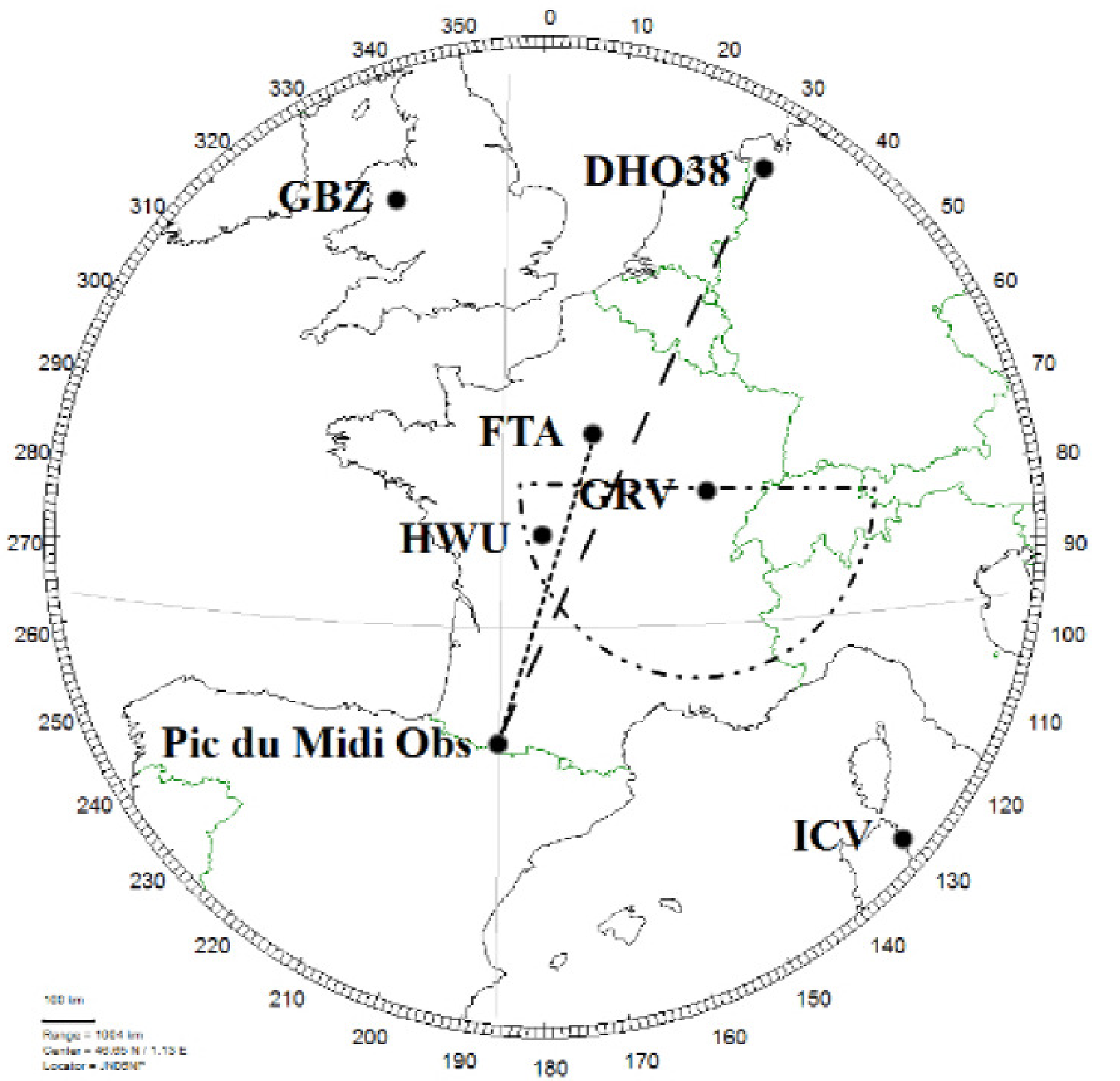
First observation at Pic du Midi observatory of a constructive interference on FTA (middle trace) and of a destructive interference on DHO38 (lower trace) triggered by a single meteor (meteor VHF echo on upper trace). Time scale: 10s/square.

Geminids 2010, Pic du Midi





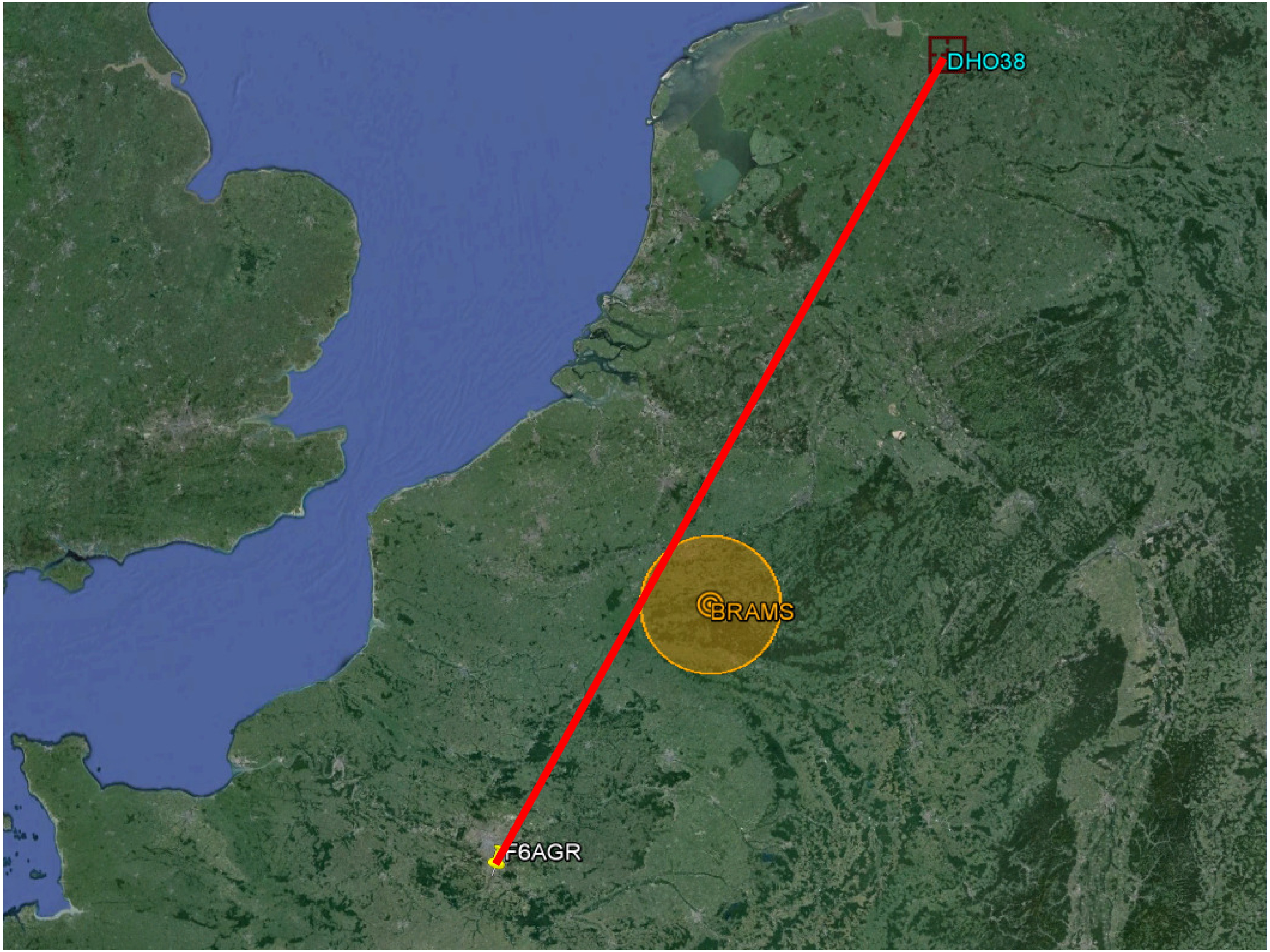
Lyrids 2013, Baraque de l’Air, Lozère



DHO38
GBZ
FTA
GRV
HWU
Pic du Midi Obs
ICV
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
100 km
Range = 1064 km

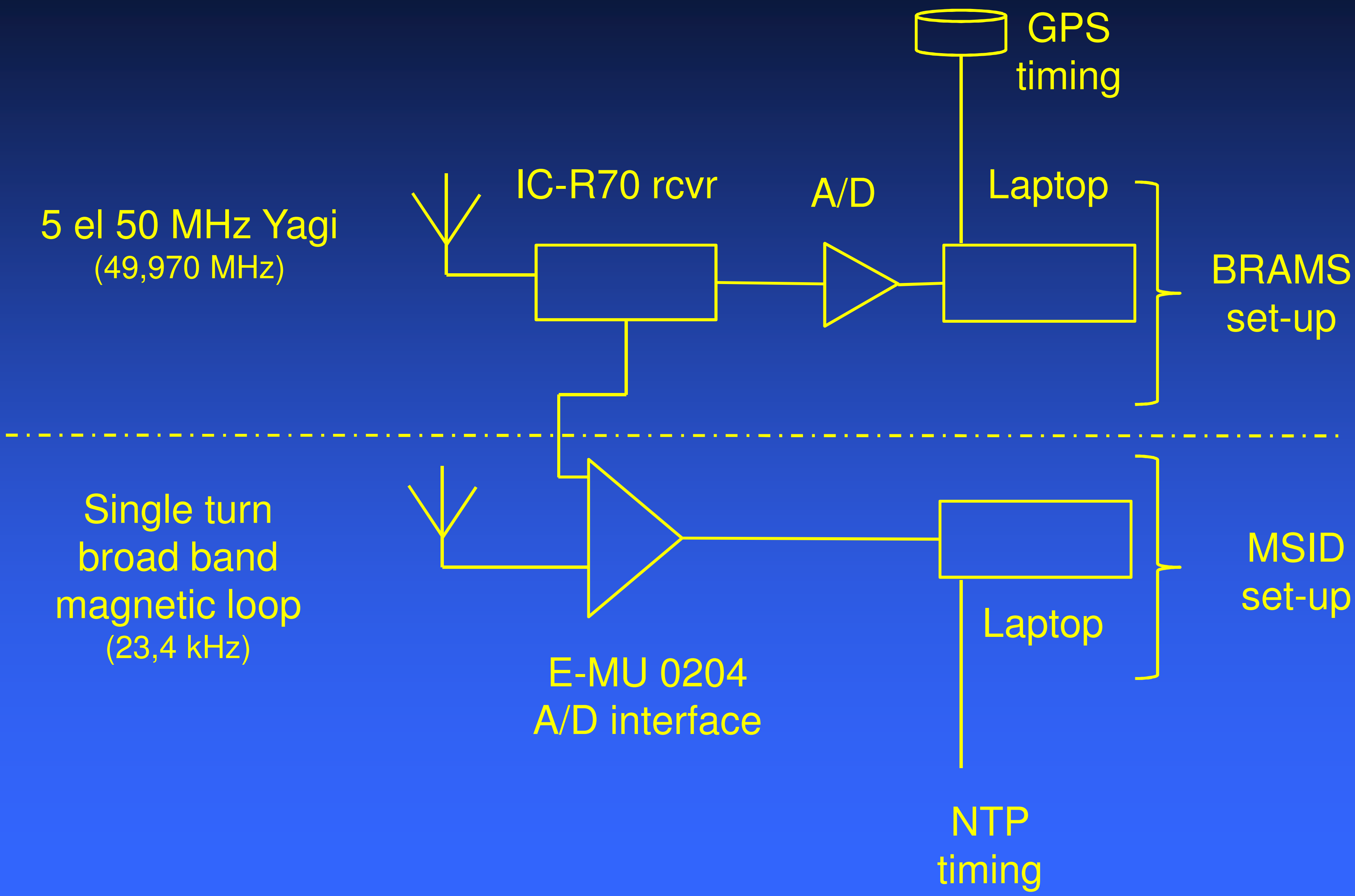
Such "M-SIDs" (Meteor induced Sudden Ionospheric Disturbances) seem to be faint and rare …

To better understand and to characterize the M-SIDs, a 24/7 observation system is being implemented at FREPIN location, using the BRAMS beacon which is located close to the sub reflective point of the DHO-38 / Epinay-sur-Orge VLF link

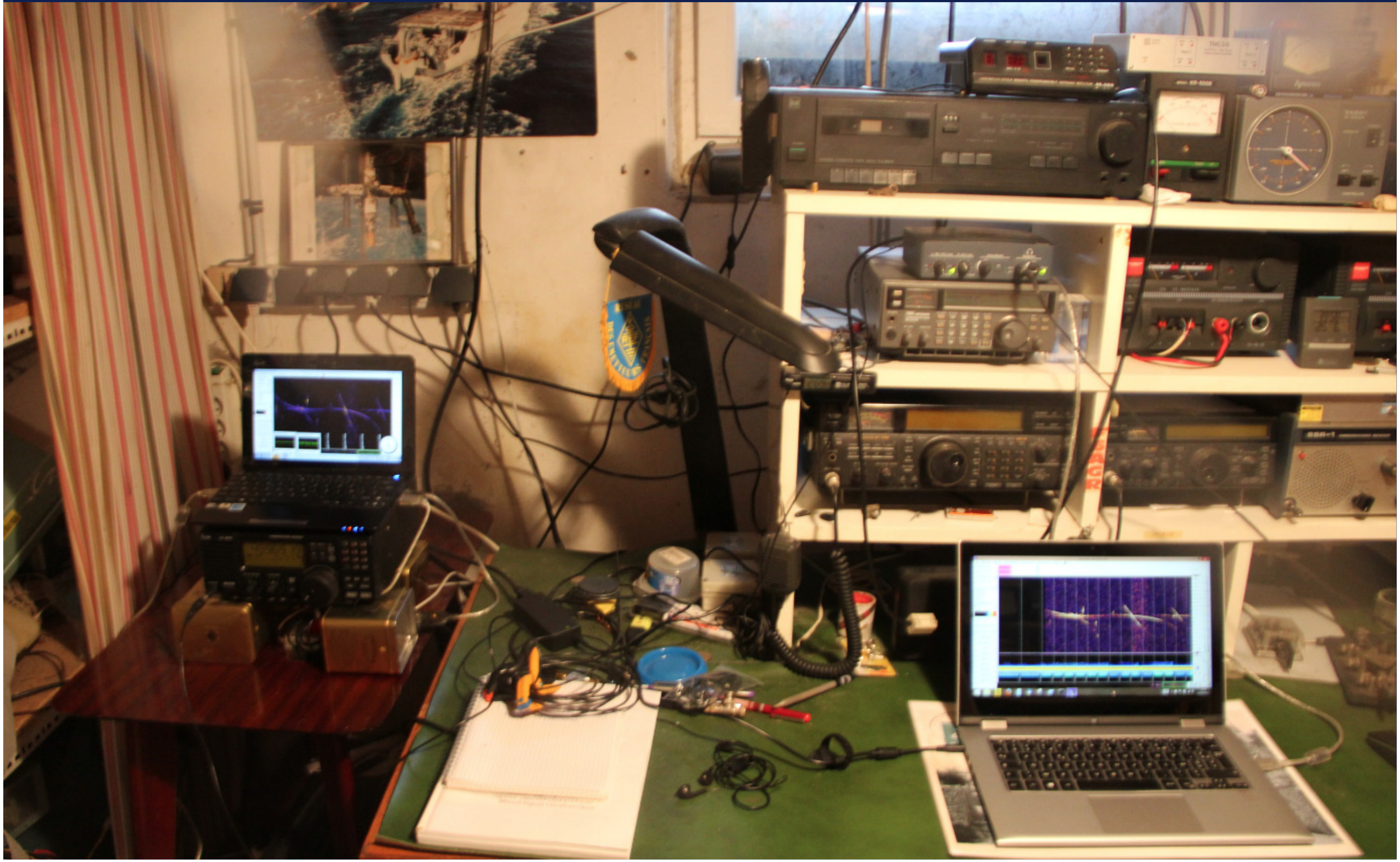

DHO38
BRAMS
F6AGR

(Optimum observation location, with BRAMS located exactly at the sub-reflective point)

M-SID observation set-up

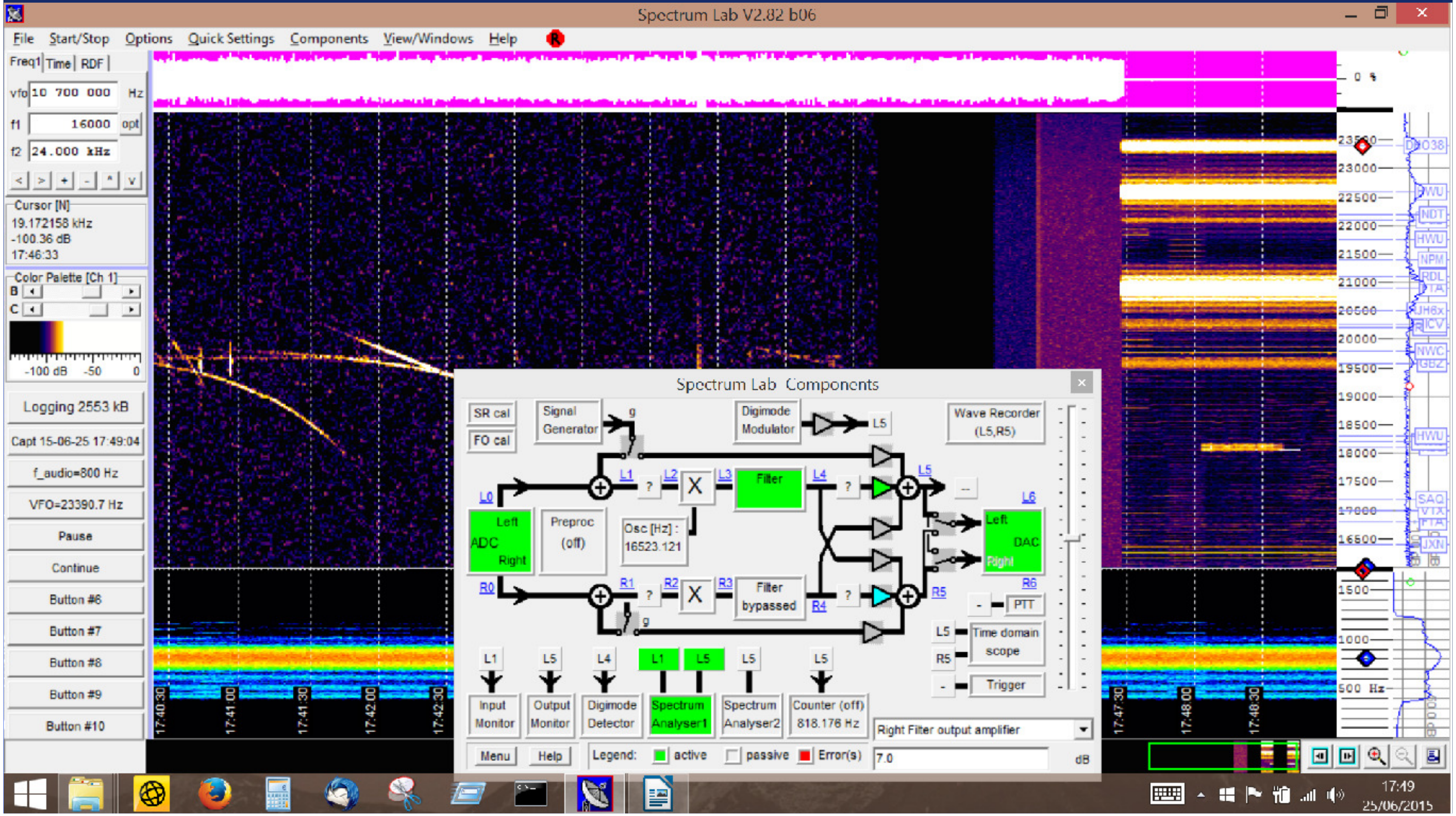


How it looks in the real life …



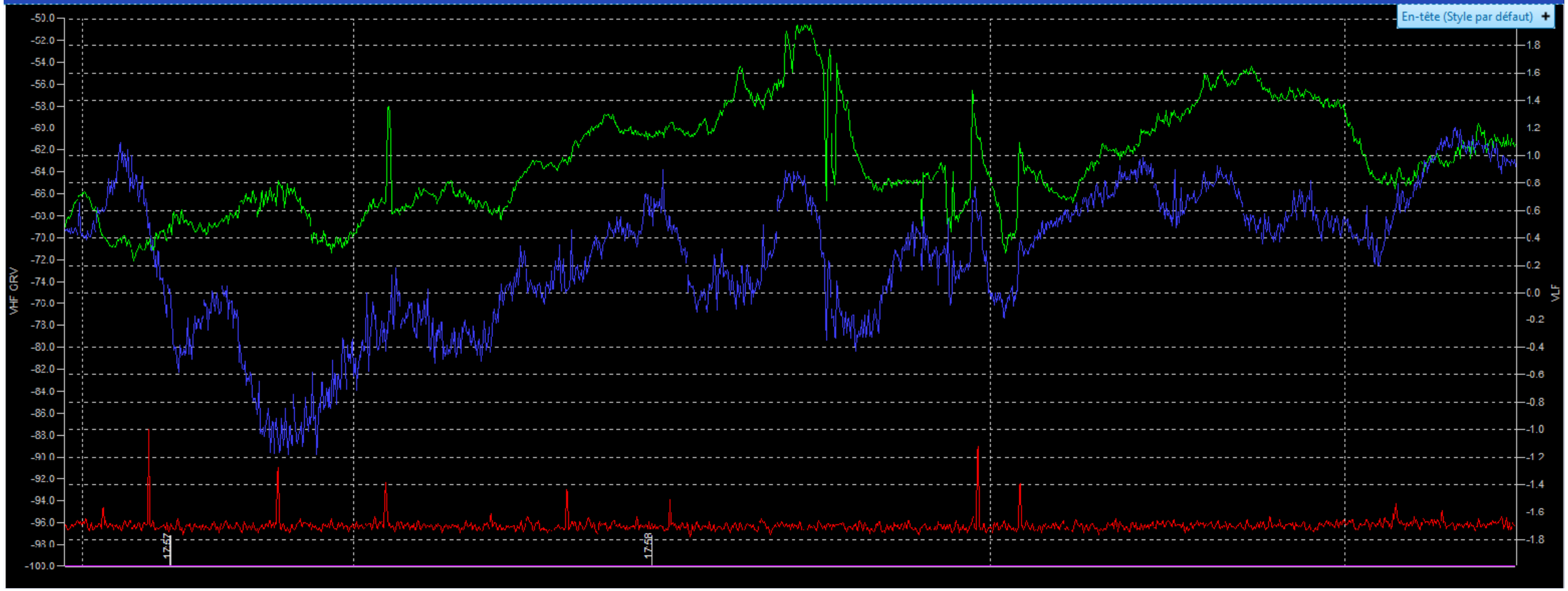
1 m^2 VLF broadband single turn loop

The VLF receiver is a SDR (Software Defined Radio): E-MU 0202 audio interface + Spectrum Lab software



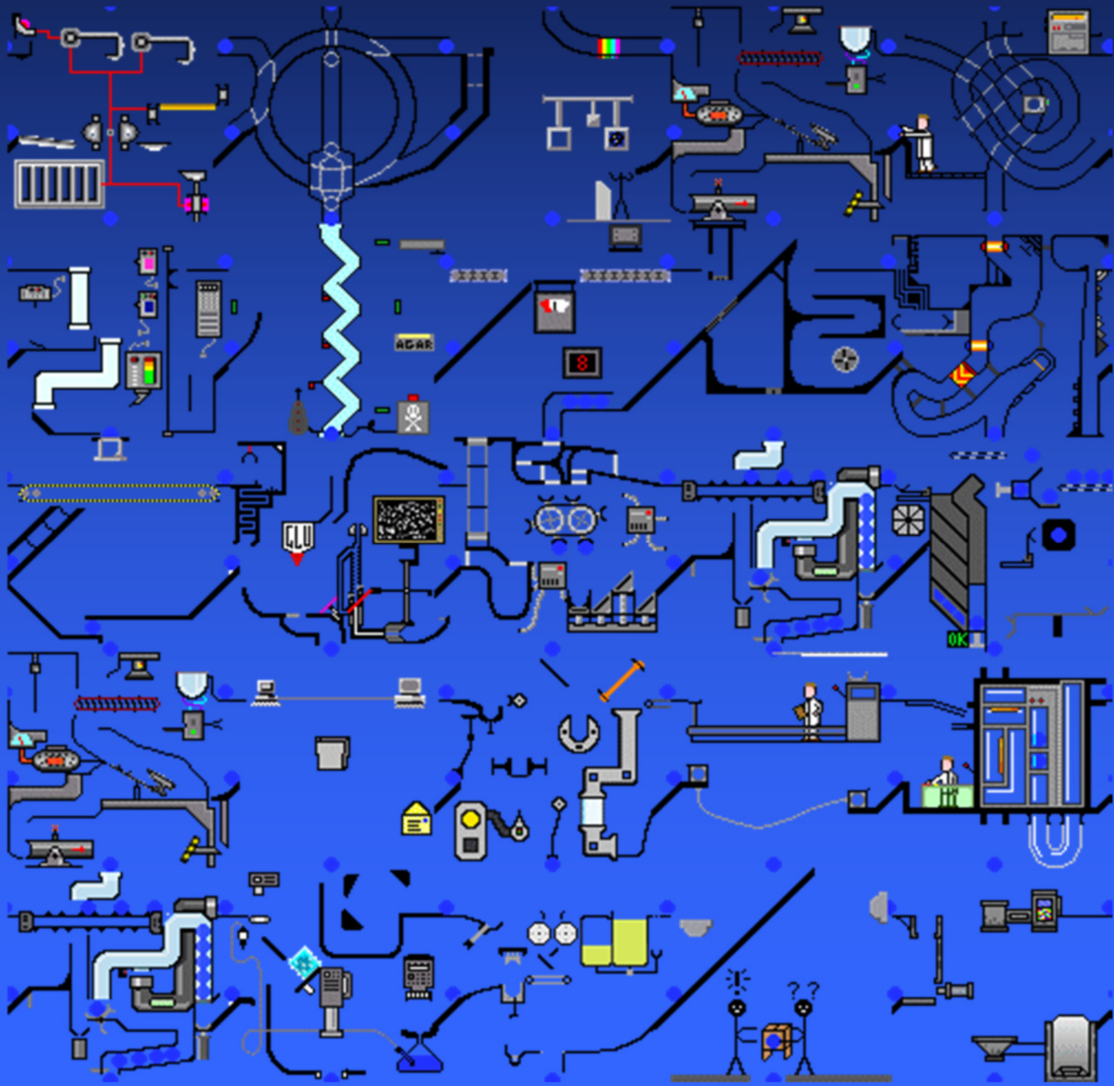
Finding M-SIDs manually in long duration records is a boring challenge …

Preliminary tests show that Spectrum Lab is able to run and draw VLF amplitude curves by playing the audio records at 8 or even 16 times the real time, decreasing dramatically the data reduction work



That’s all (at the moment)

Thanks for your attention !



Spectrum Lab at work