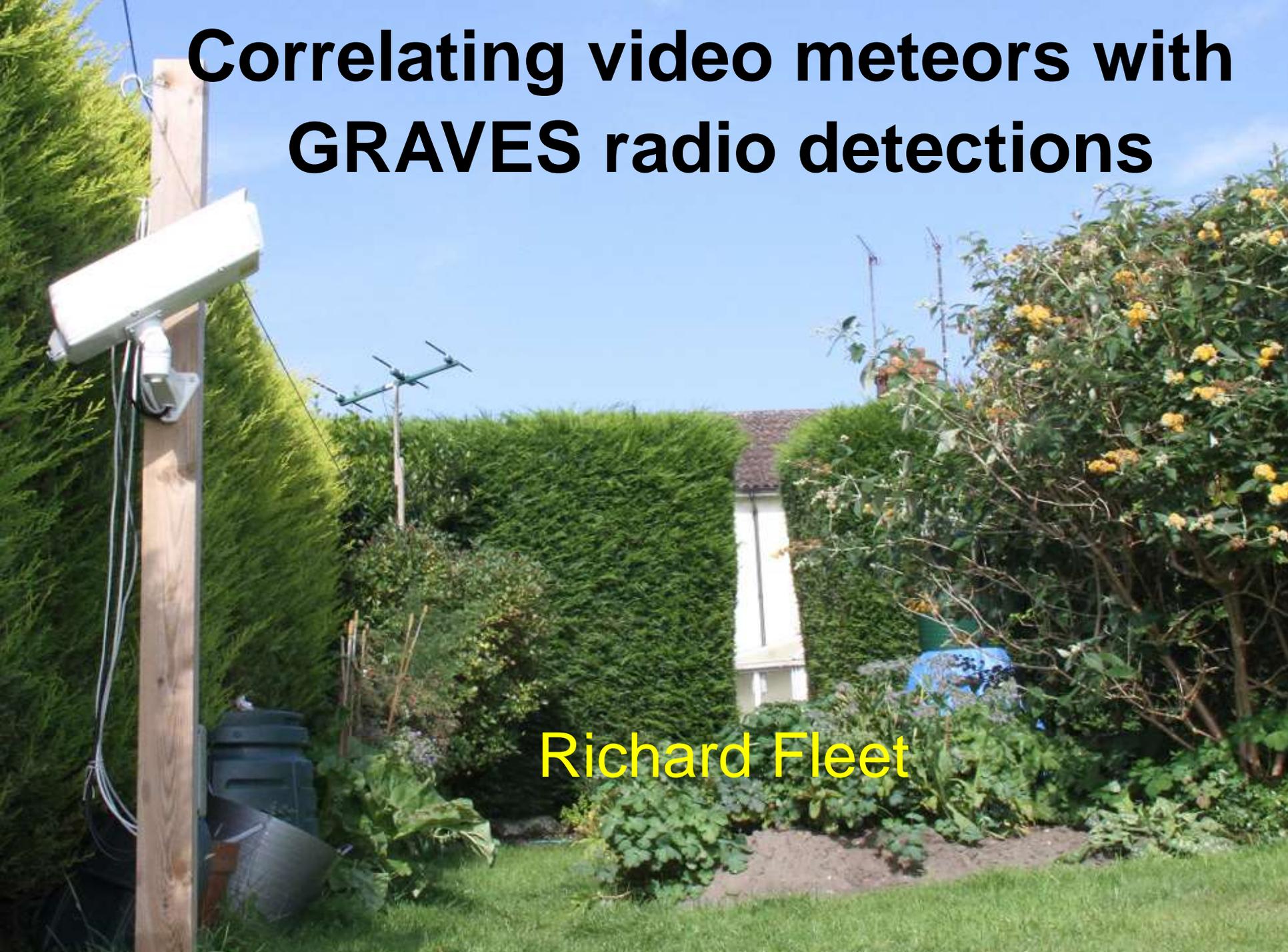
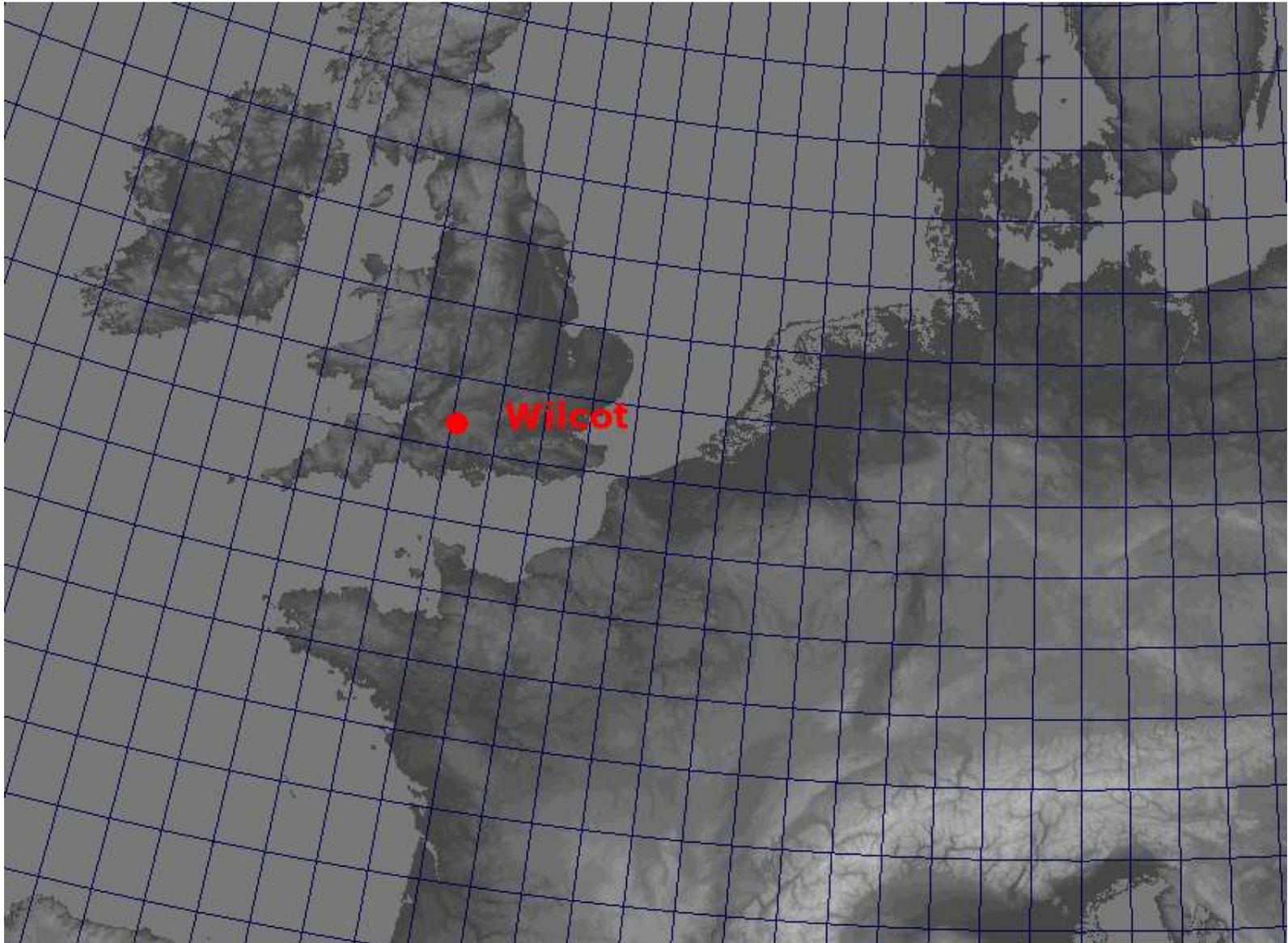


# Correlating video meteors with GRAVES radio detections

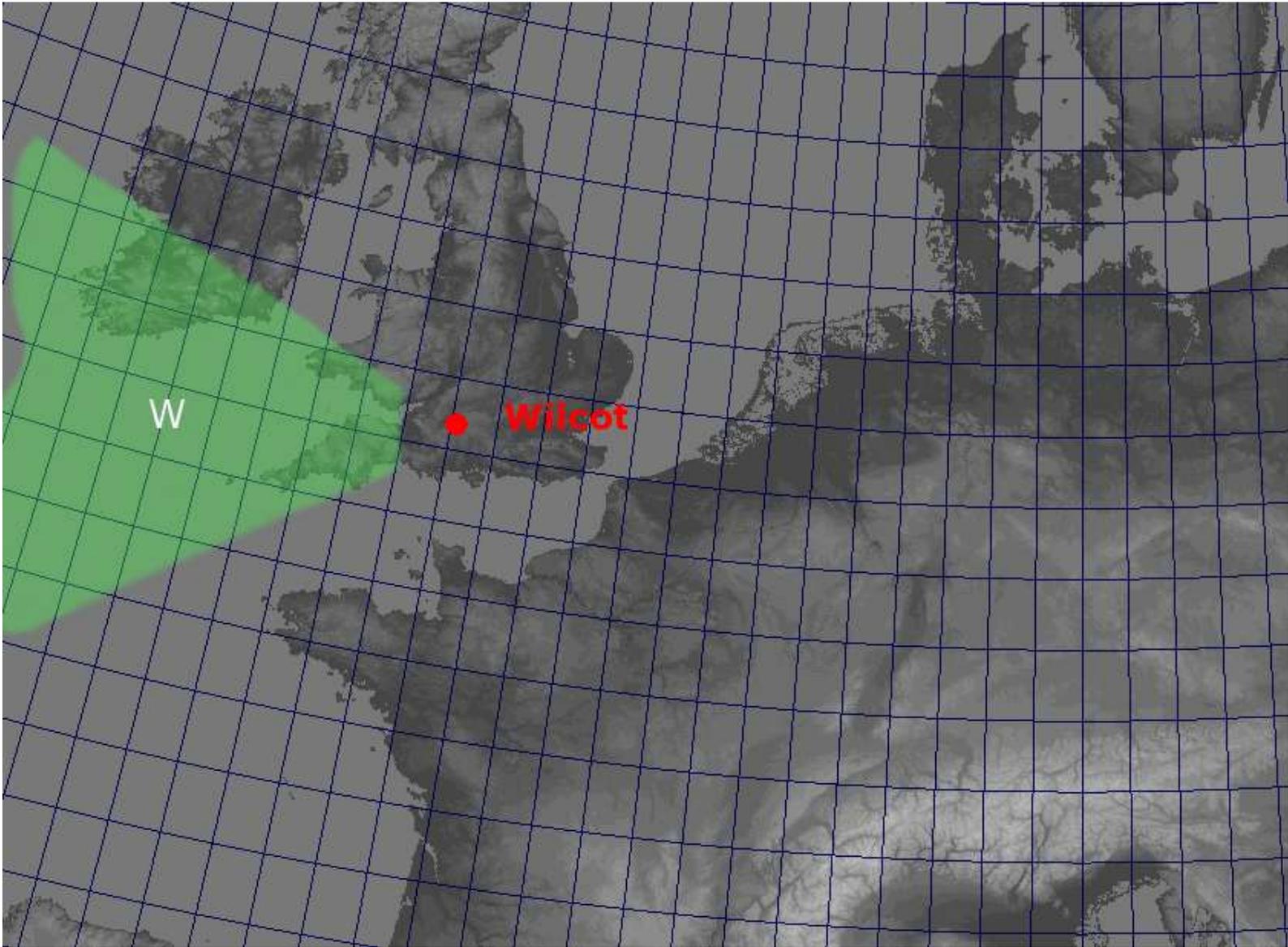
Richard Fleet



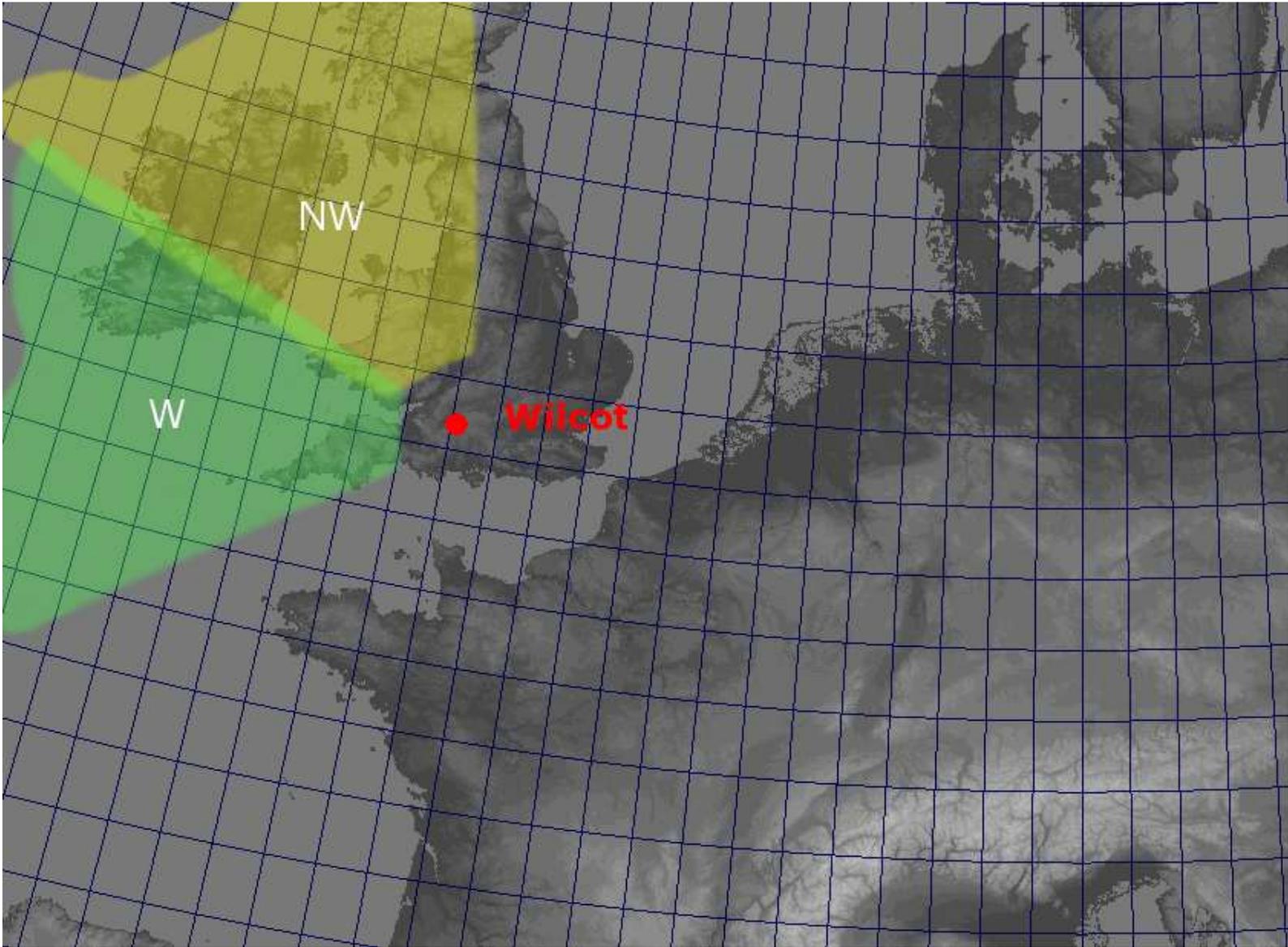
# Wilcot video camera coverage



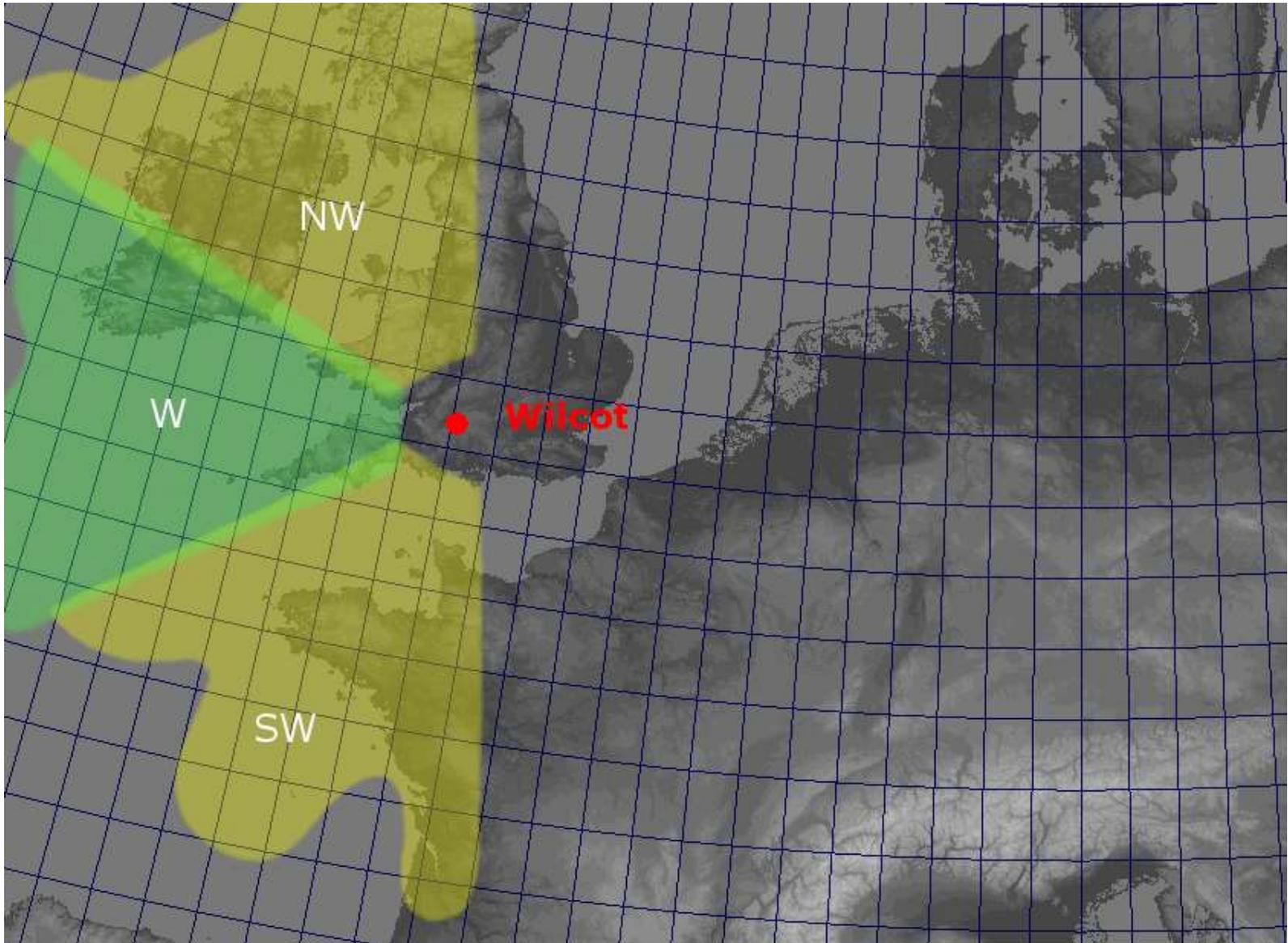
# Wilcot video camera coverage



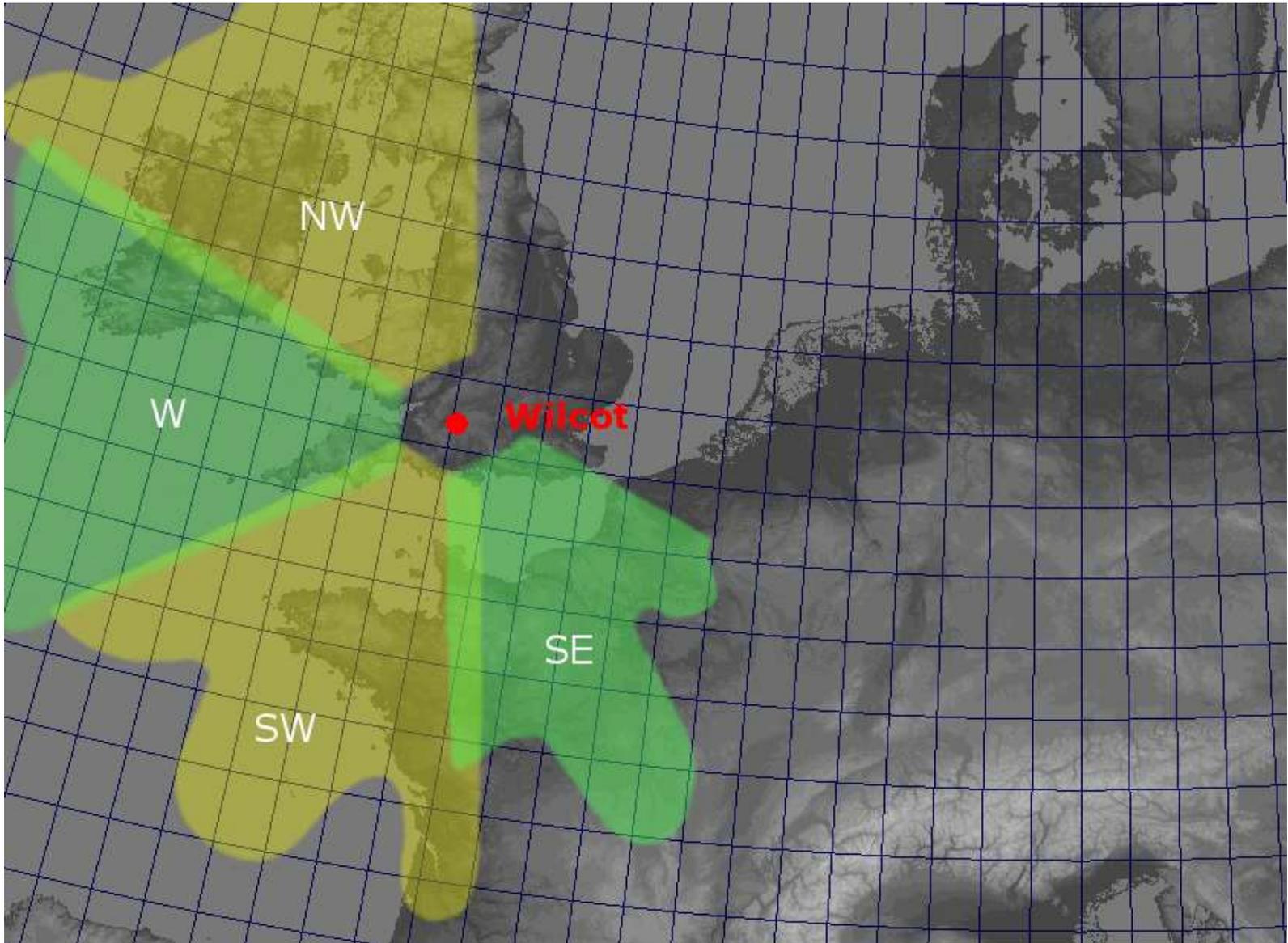
# Wilcot video camera coverage



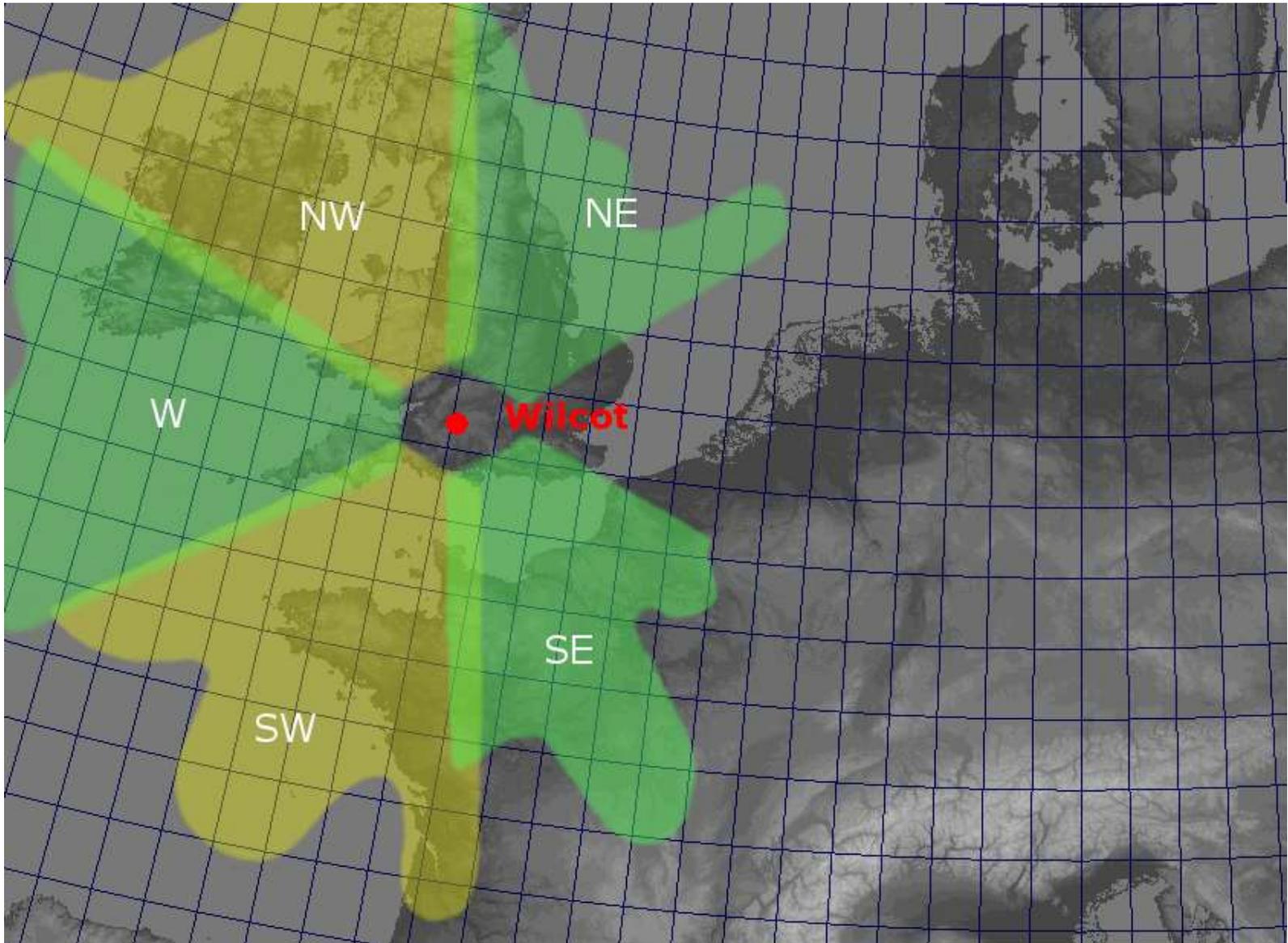
# Wilcot video camera coverage



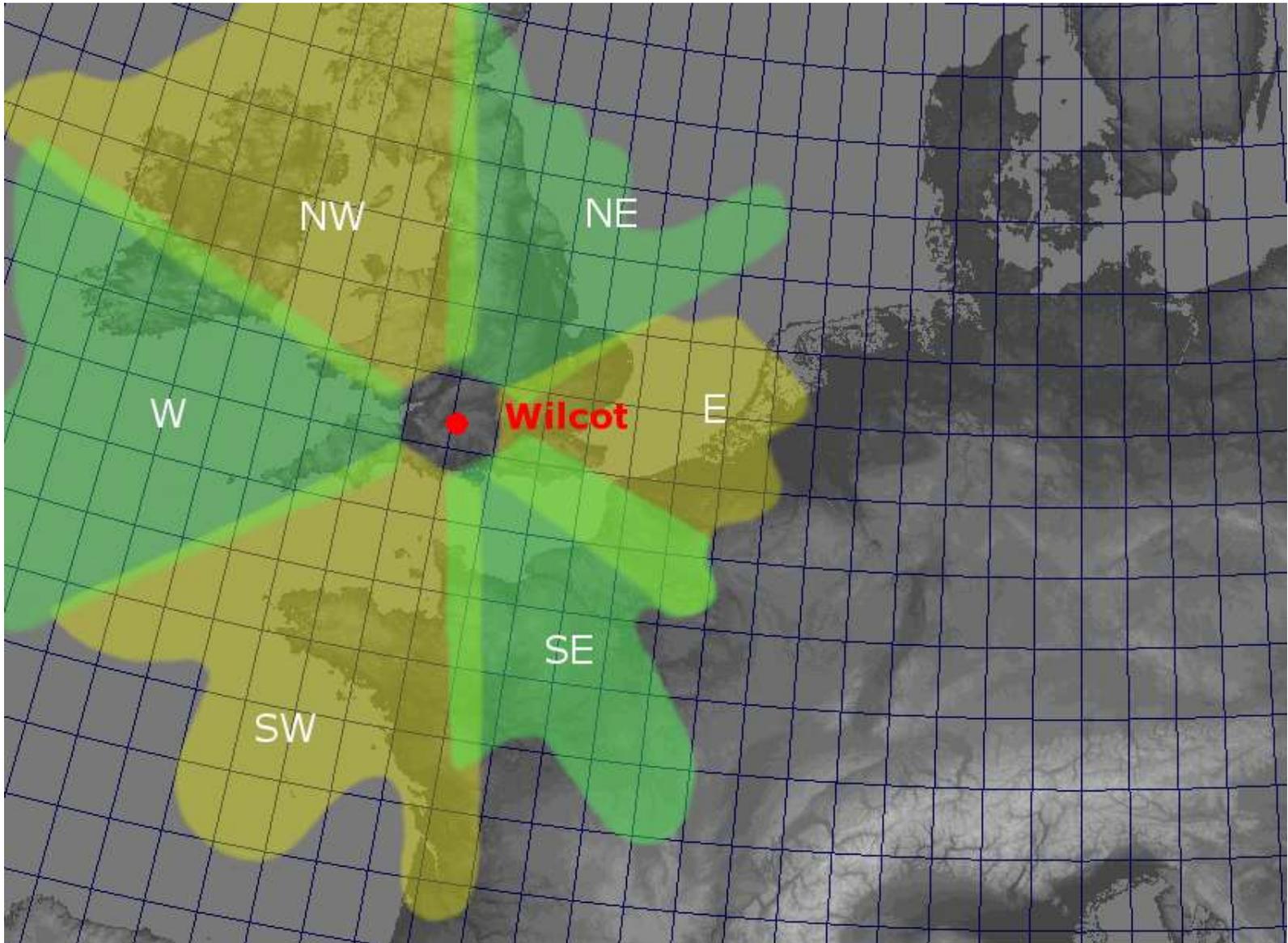
# Wilcot video camera coverage



# Wilcot video camera coverage



# Wilcot video camera coverage



# Meteor Radar SDR Receiver (FUNcube Dongle)

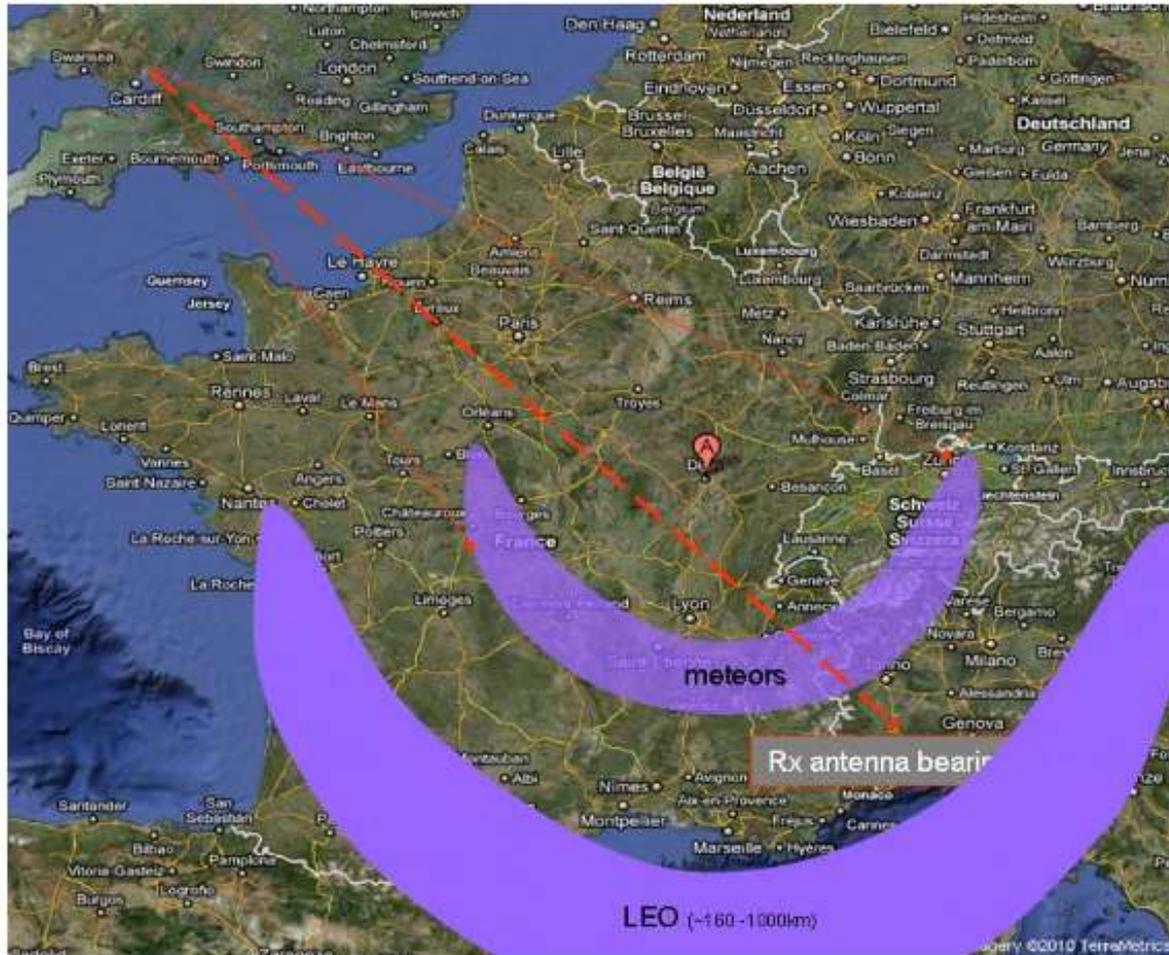
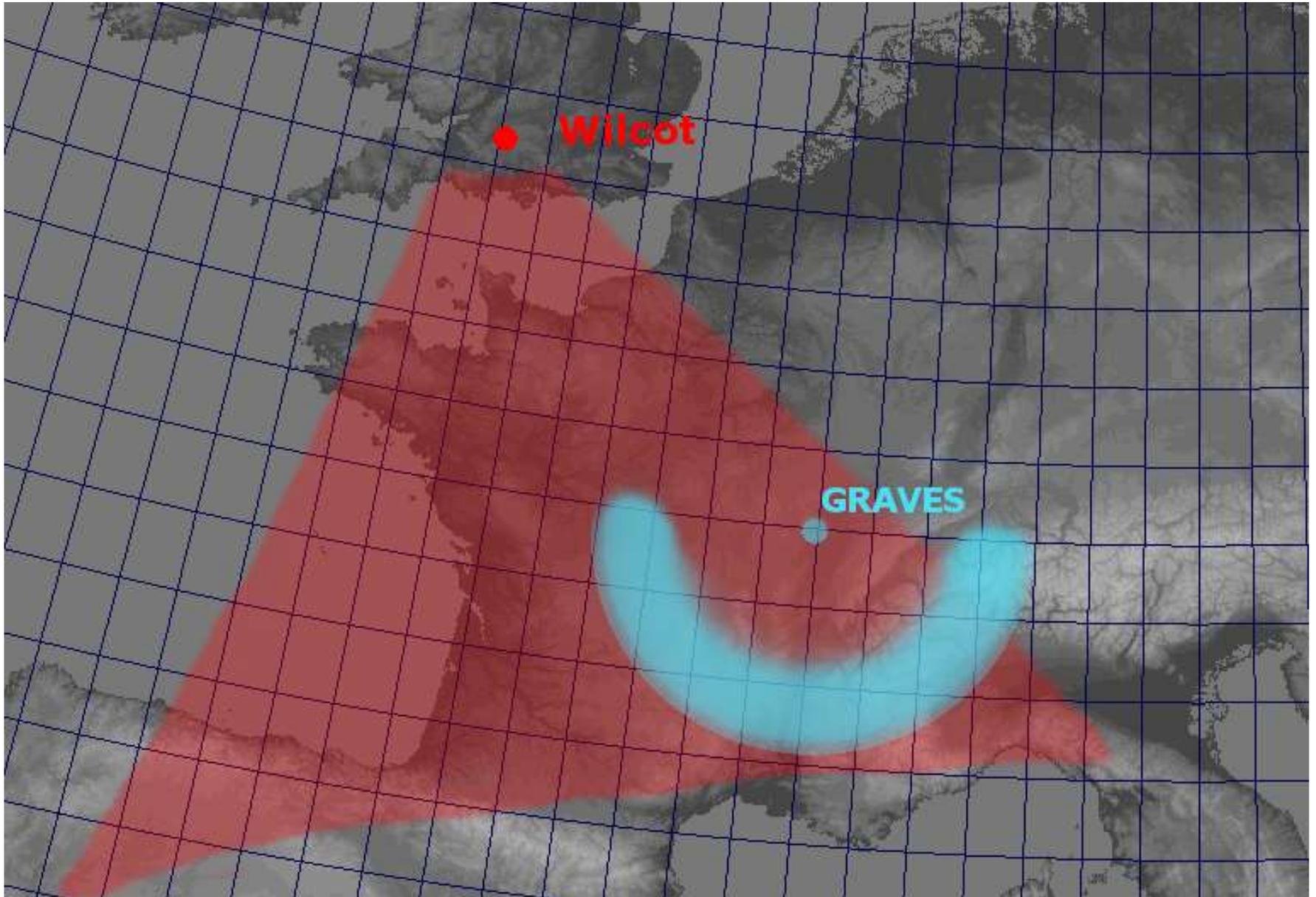


Figure 3.3 Azimuthal Geometry – Graves Radar

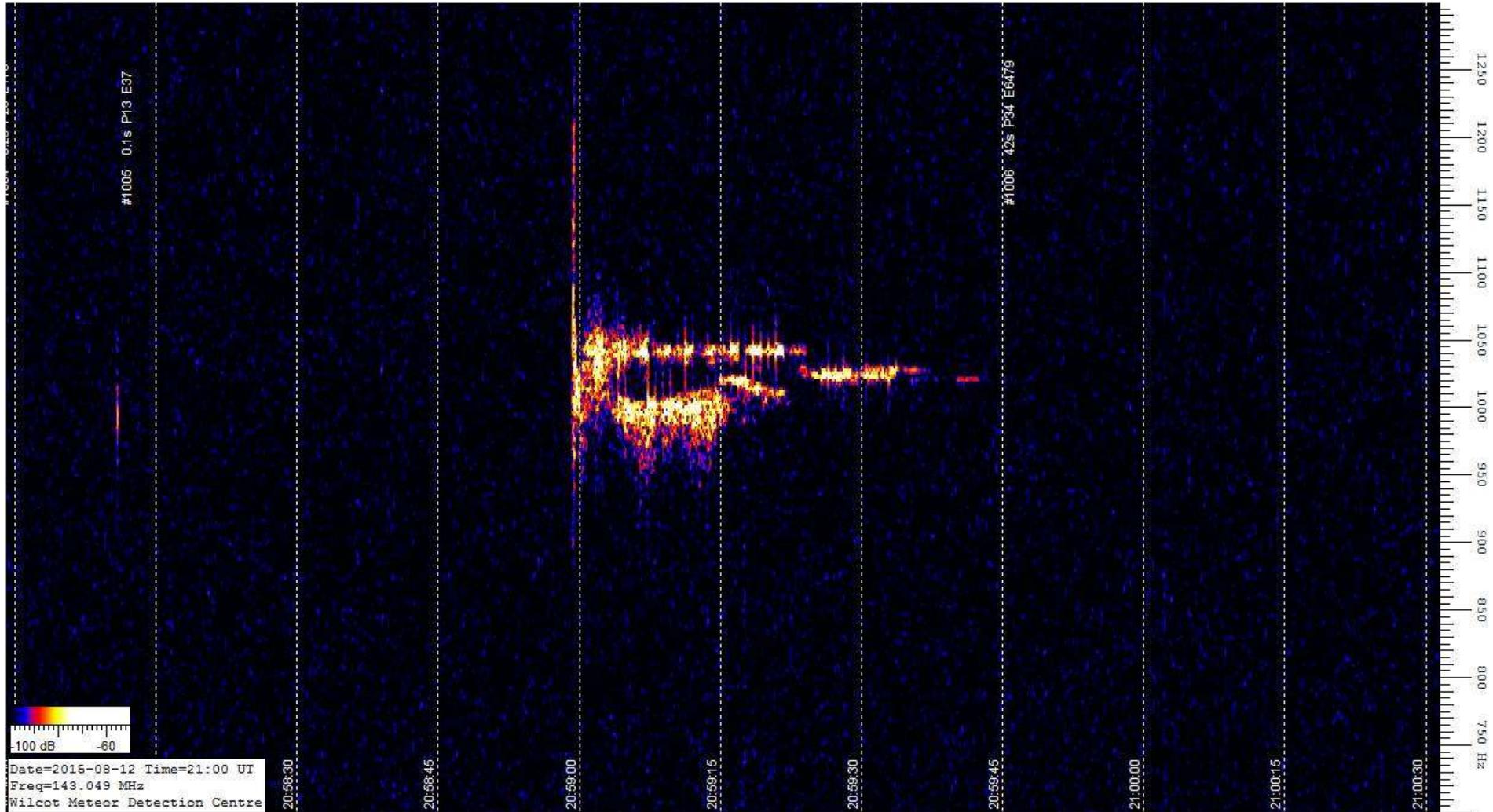
# Approximate Wilcot radio coverage



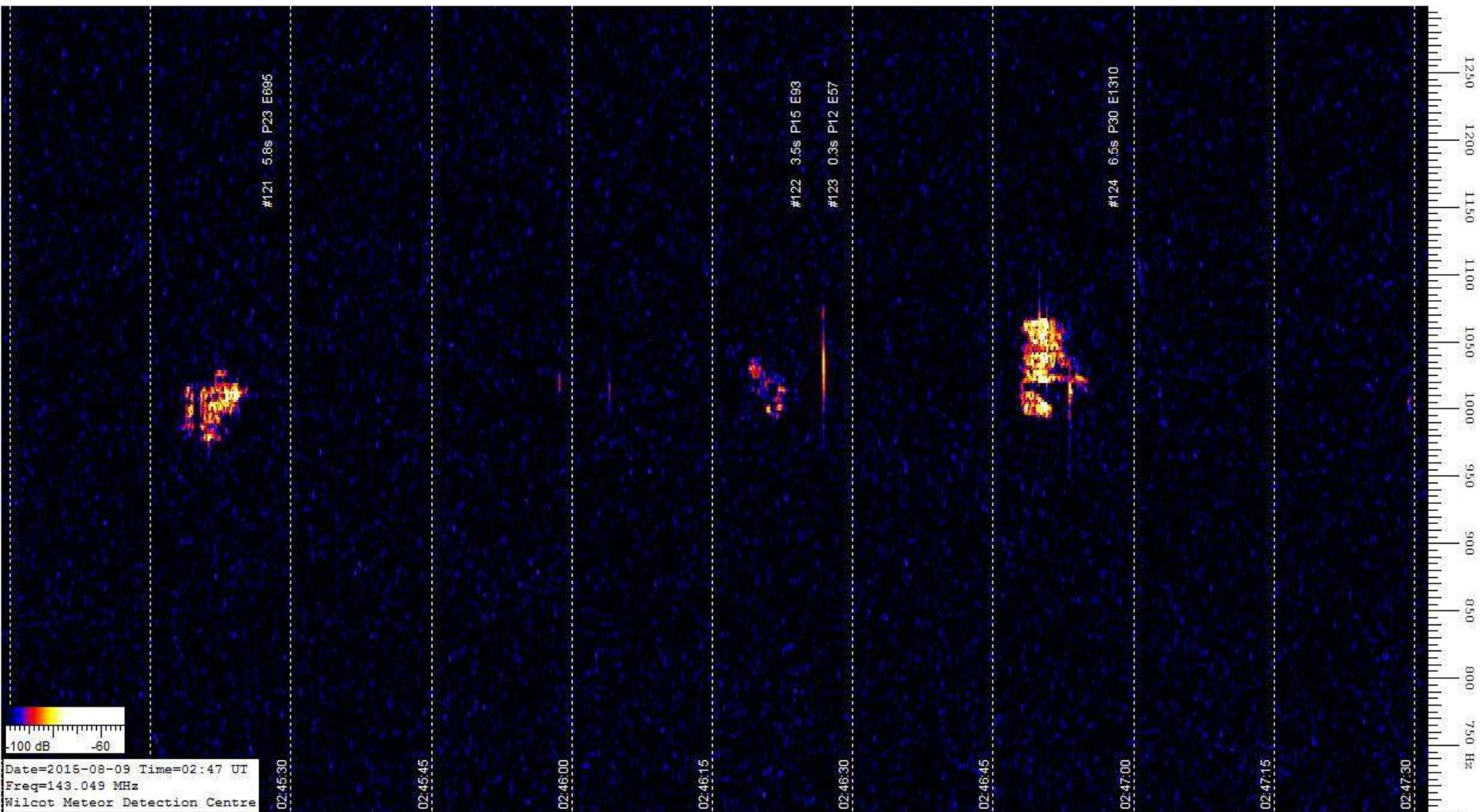
12<sup>th</sup> August 2015 20:58:59 UT - Very bright Perseid



# 12<sup>th</sup> August 2015 20:58:59 UT - Strong radio event

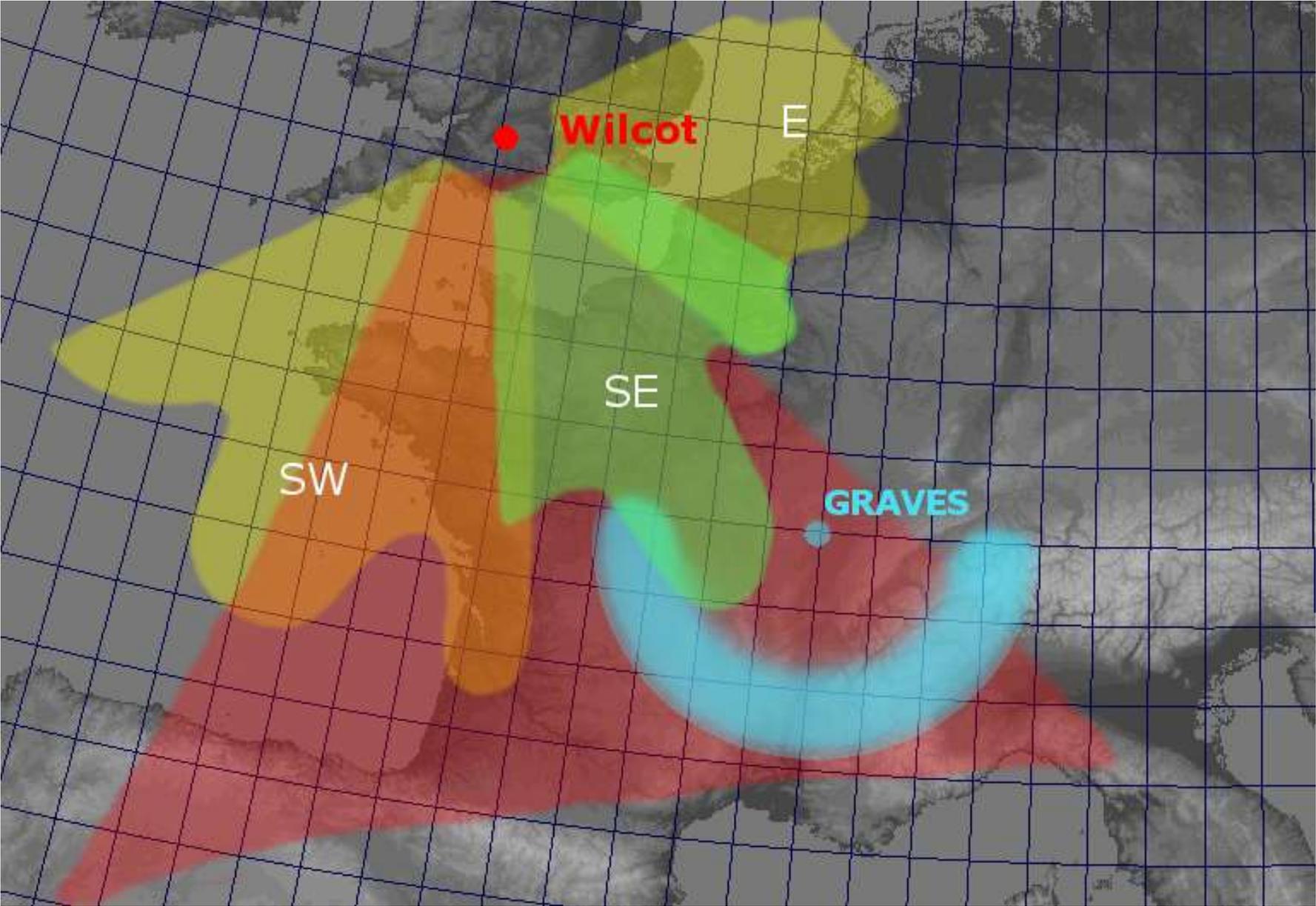


# Spectrum Lab waterfall plot during the Perseids



Plot spans 150 seconds

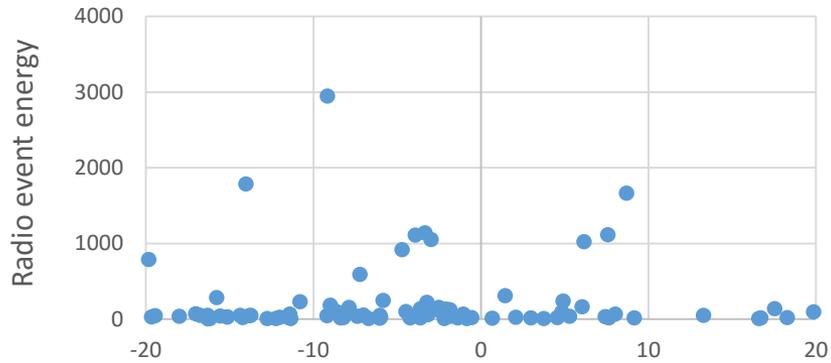
Approximate Wilcot radio coverage plus overlapping camera coverage



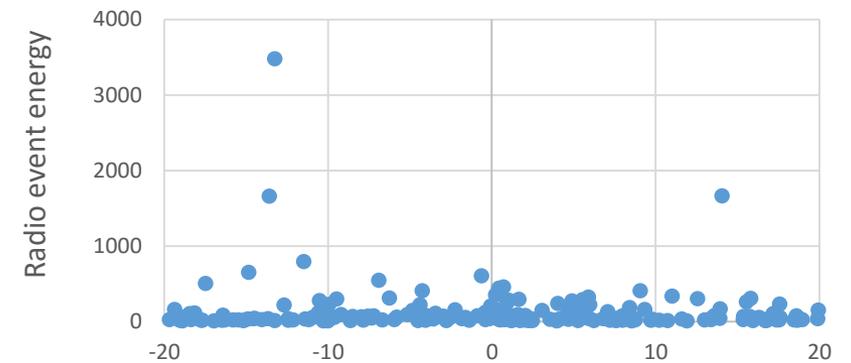
# Analysis

- Logs from Spectrum Lab script
- UFOAnalyzer Mcsv files
- 1<sup>st</sup> July 2015 to 12<sup>th</sup> August 2015
- 21,010 radio events
- 3,076 meteor events
- Each camera processed separately
- Merged and sorted by time in Excel
- Video events compared with nearest radio events
- Selected
  - energy > 500
  - 1 second before up to 5 seconds after video time
  - 52 candidates

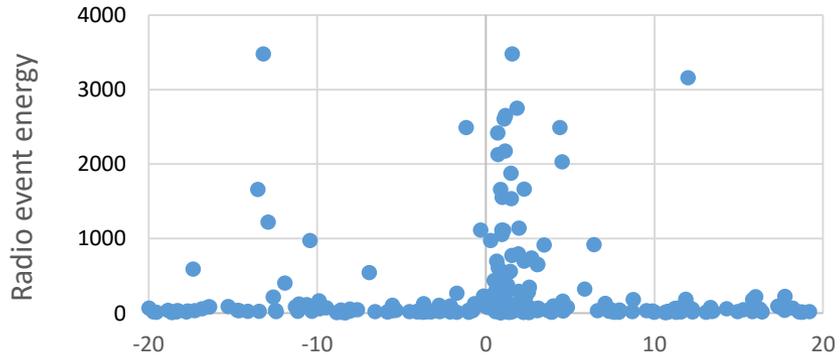
# Comparison of video times with the nearest radio event



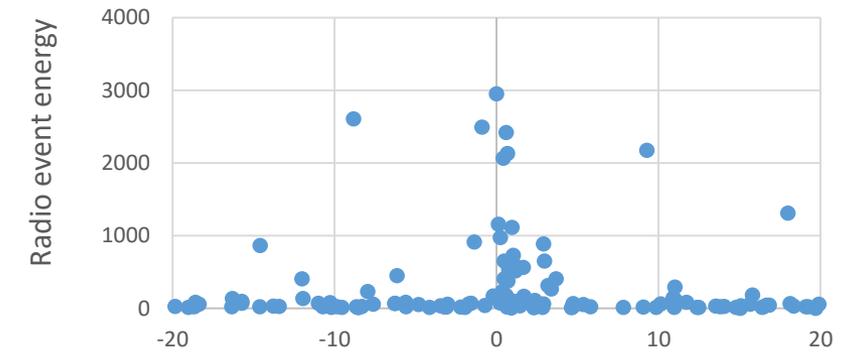
**Camera NE** Seconds from video



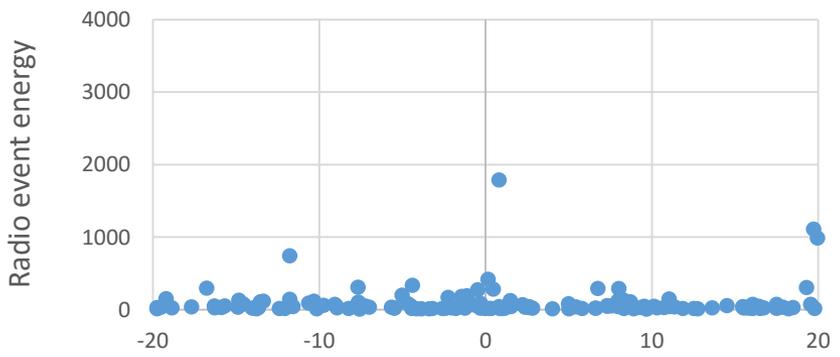
**Camera E** Seconds from video



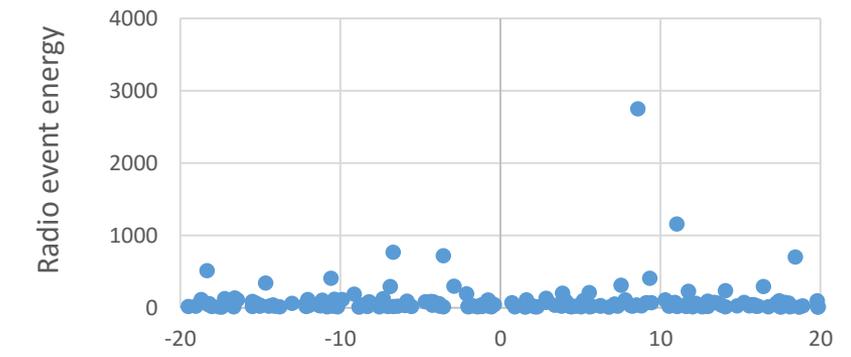
**Camera SE** Seconds from video



**Camera SW** Seconds from video



**Camera W** Seconds from video



**Camera NW** Seconds from video





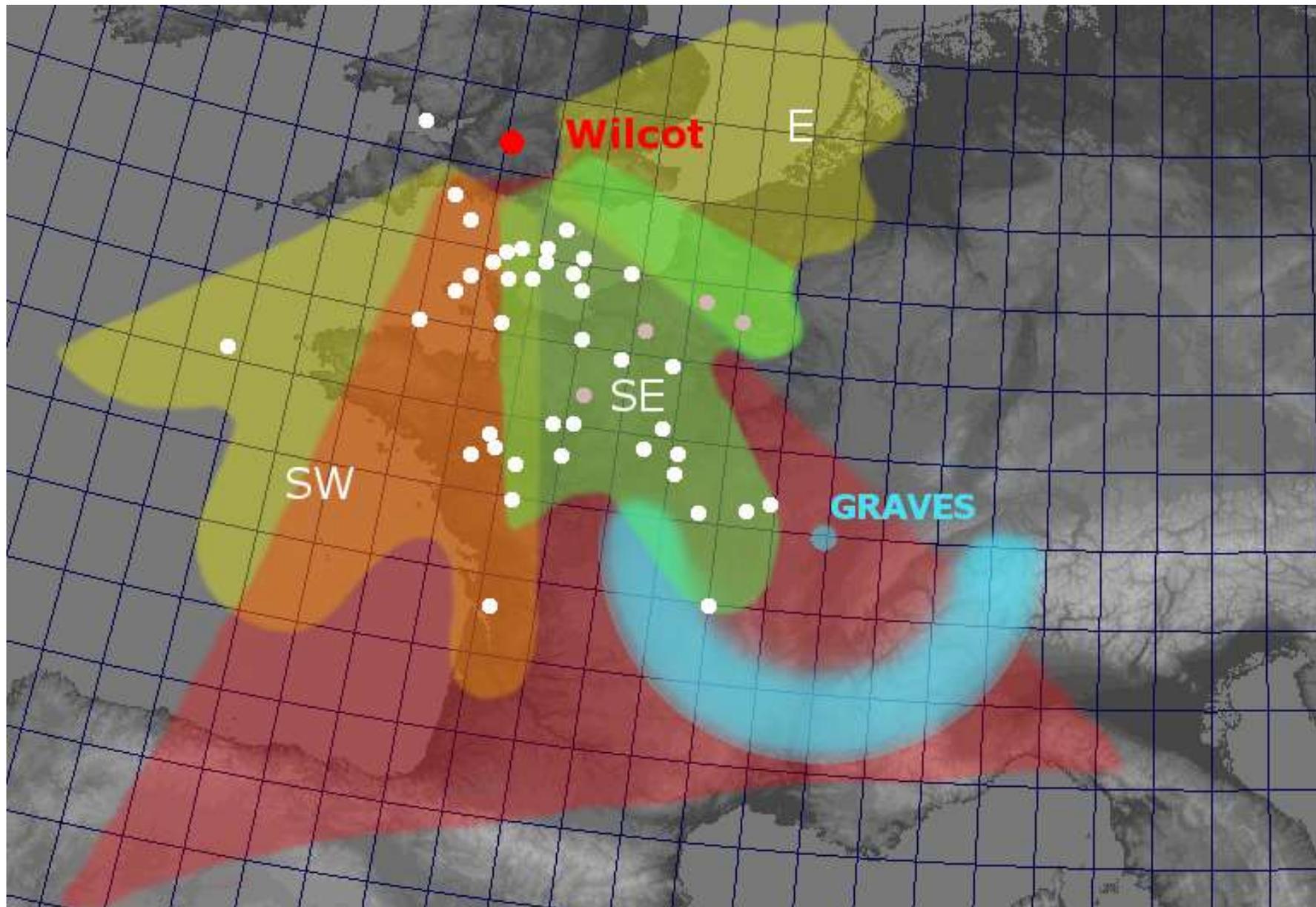
Composite of candidate events

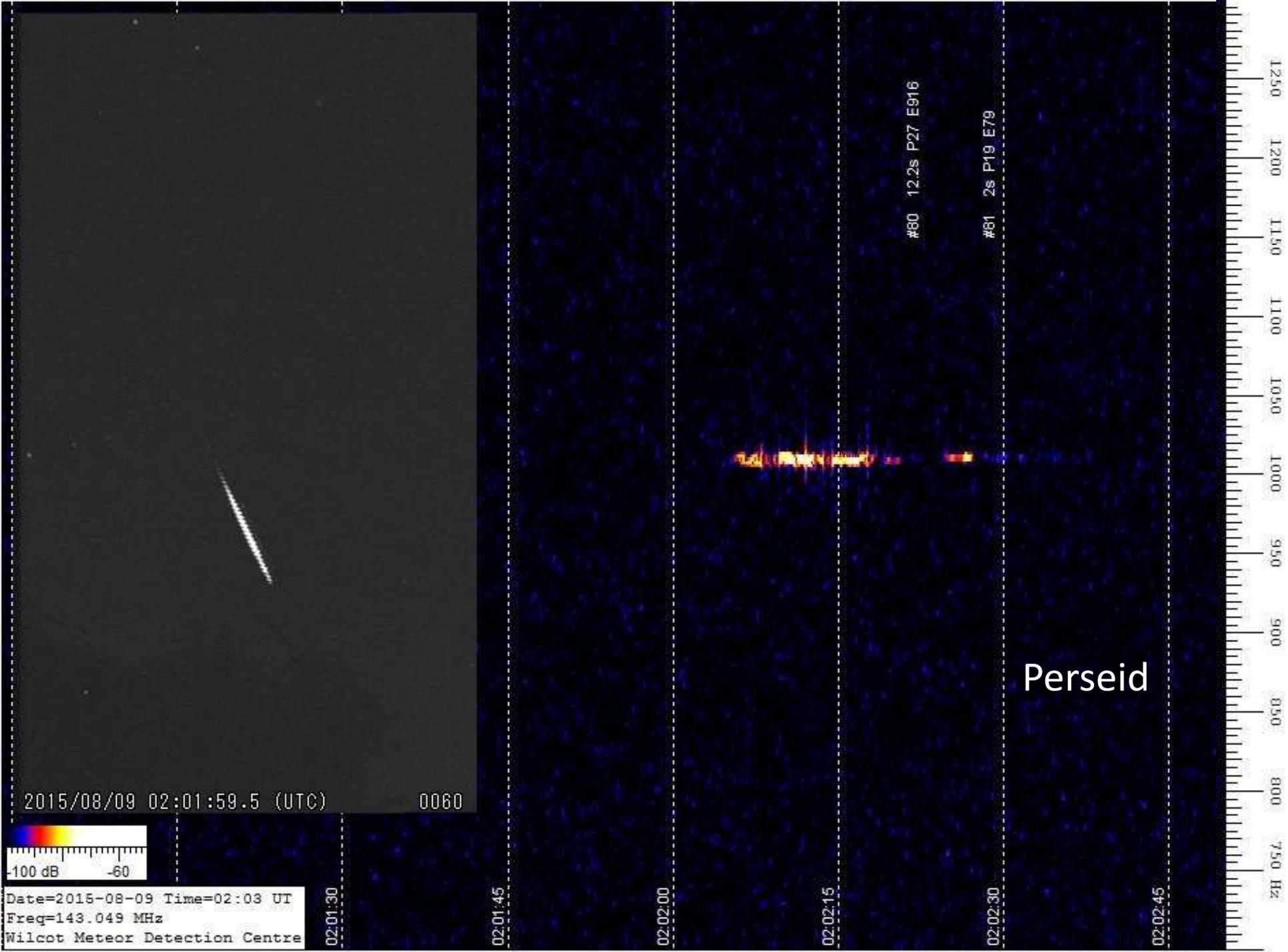


Composite of all video meteors

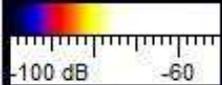


# Locations of match candidates





2015/08/09 02:01:59.5 (UTC) 0060



Date=2015-08-09 Time=02:03 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre

Perseid

02:01:30 02:01:45 02:02:00 02:02:15 02:02:30 02:02:45

#80 12.2s P27 E916  
#81 2s P19 E79



2015/08/13 00:36:53.0 (UTC)



Date=2015-08-13 Time=00:38 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre

00:36:30

00:36:45

00:37:00

00:37:15

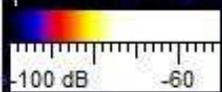
00:37:30

00:37:45

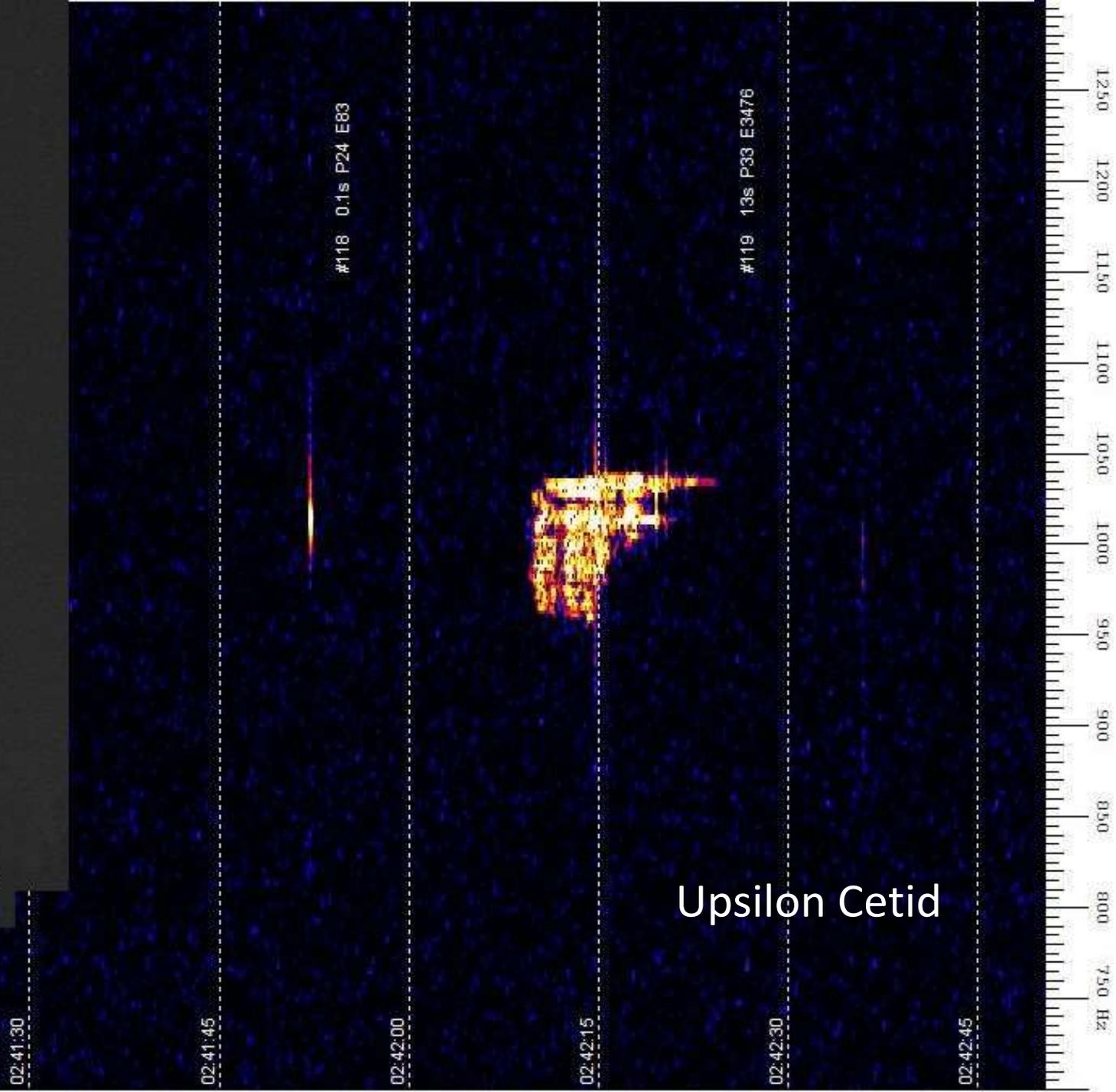
#33 2.2s P53 E1110



0078 V00010+073  
2015/08/09 02:42:08.4 (UTC)



Date=2015-08-09 Time=02:43 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre

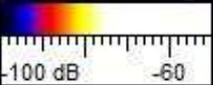


Upsilon Cetid

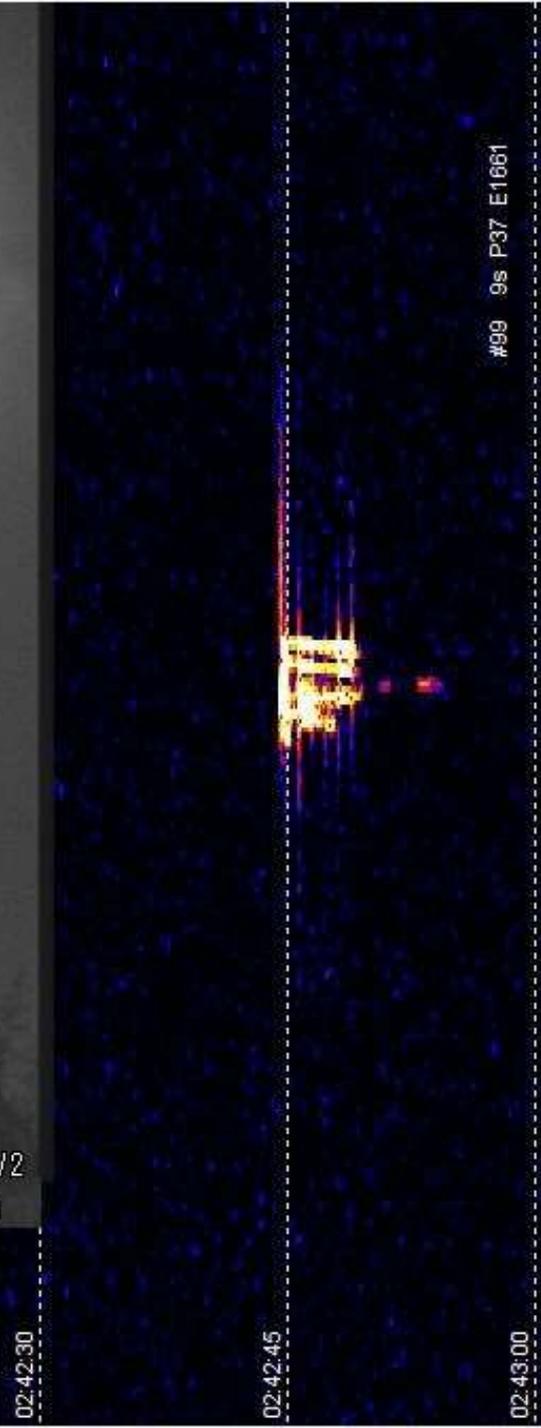


Wilcot SE UFOCapV2

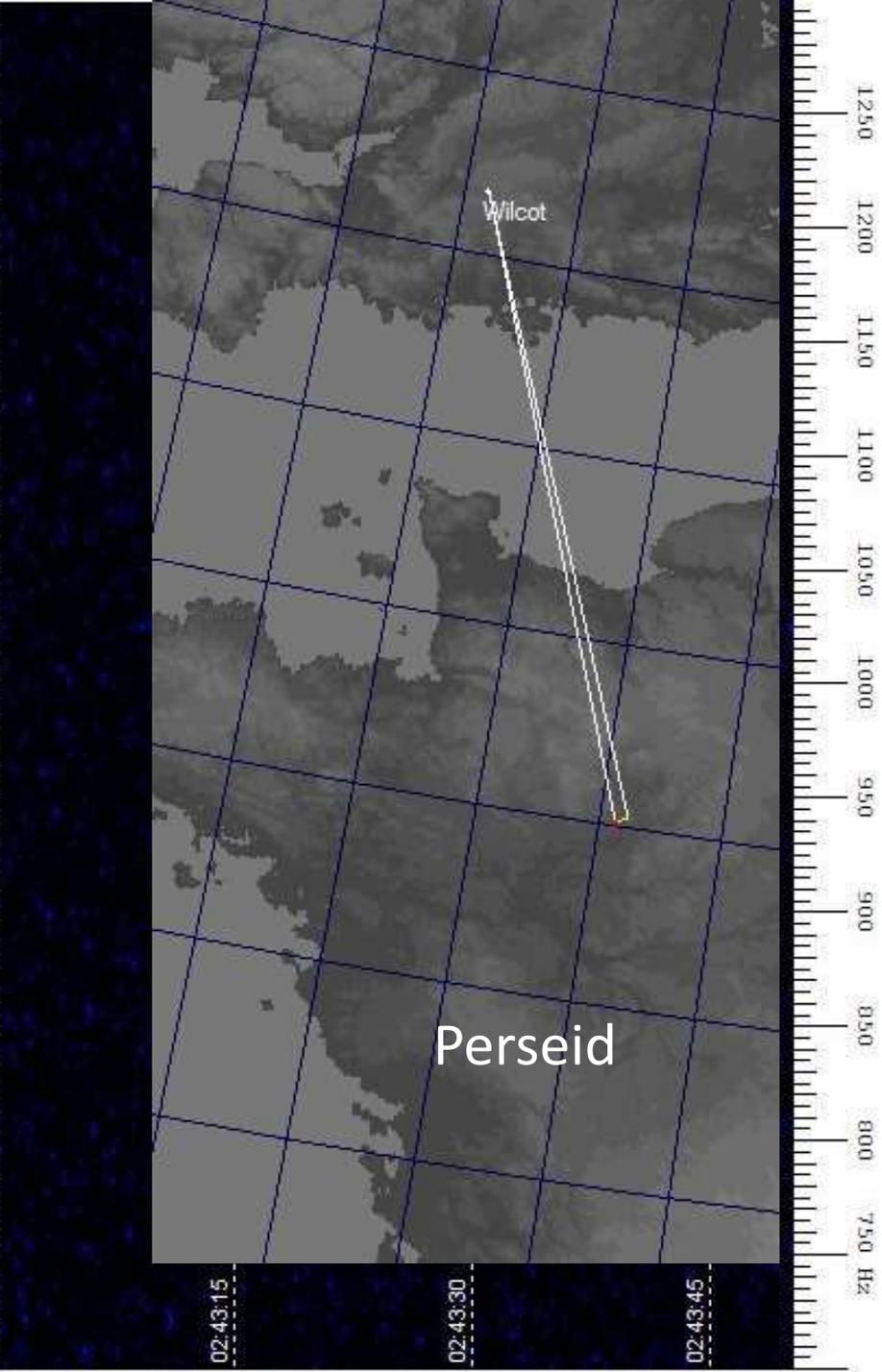
2015/08/04 02:42:44.1 (UTC)



Date=2015-08-04 Time=02:44 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre



#99 9s P37 E1661



Perseid

Wilcot

02:43:15

02:43:30

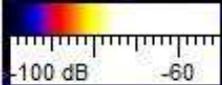
02:43:45

1250  
1200  
1150  
1100  
1050  
1000  
950  
900  
850  
800  
750 Hz

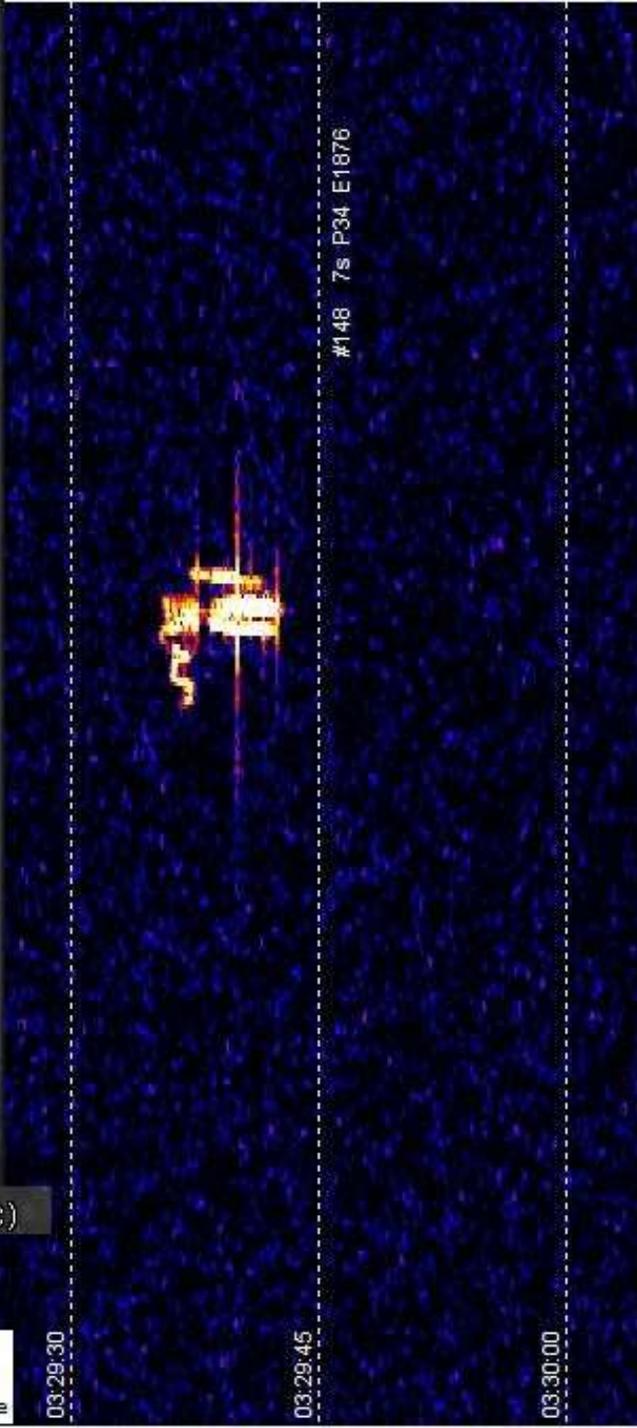


Wilcot SE UFOCapV2

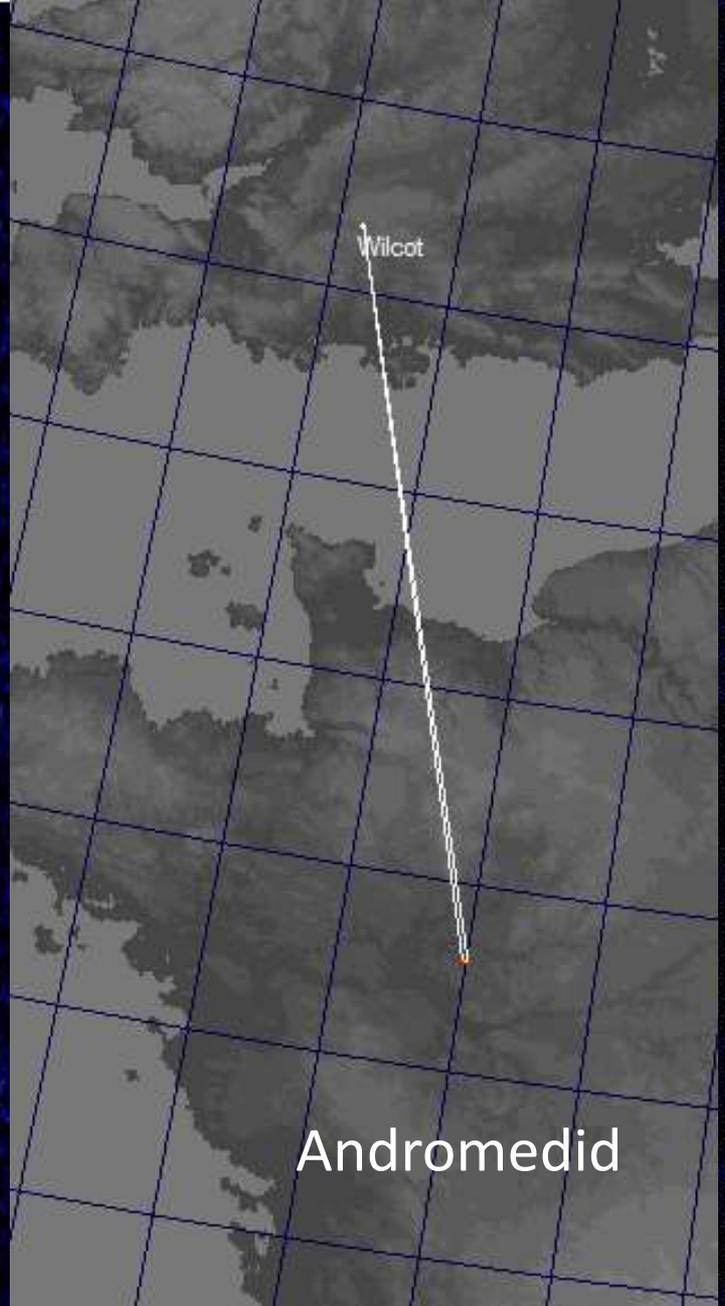
2015/08/07 03:29:34.5 (UTC)



Date=2015-08-07 Time=03:31 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre



#148 7s P34 E1876



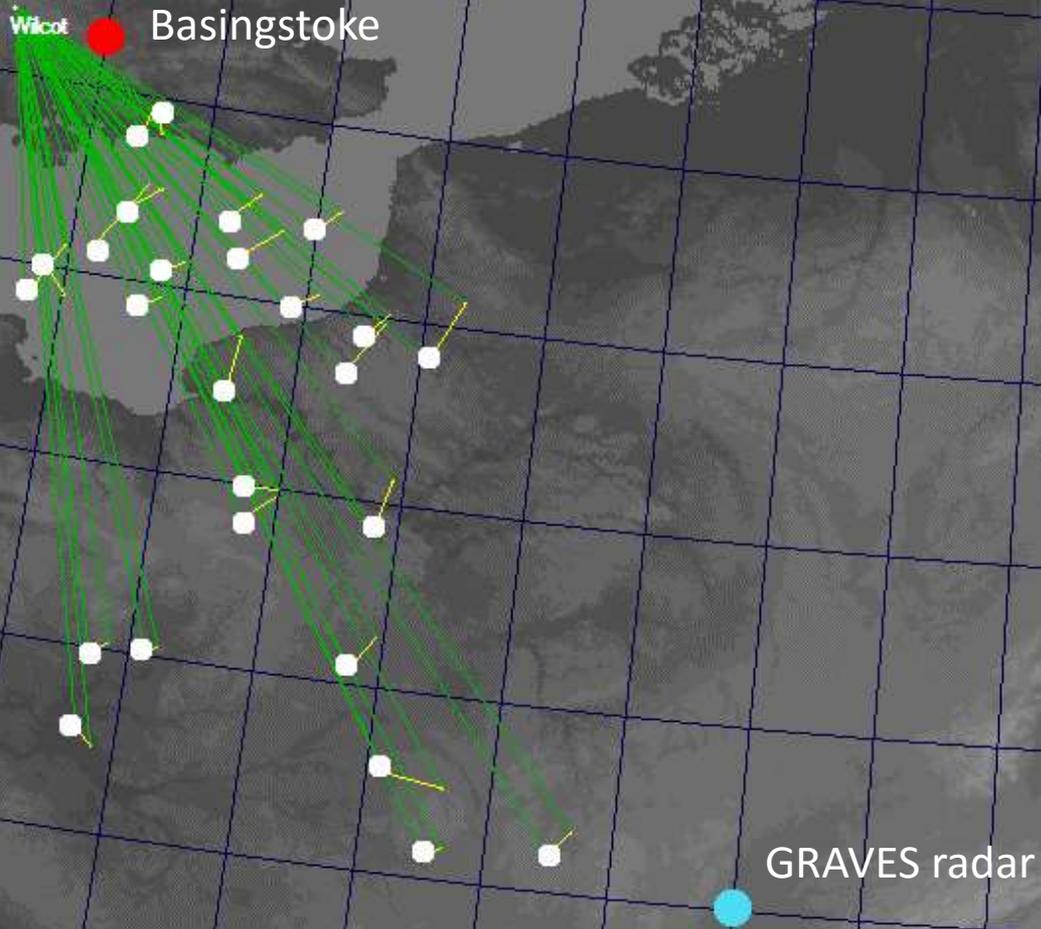
Andromedid



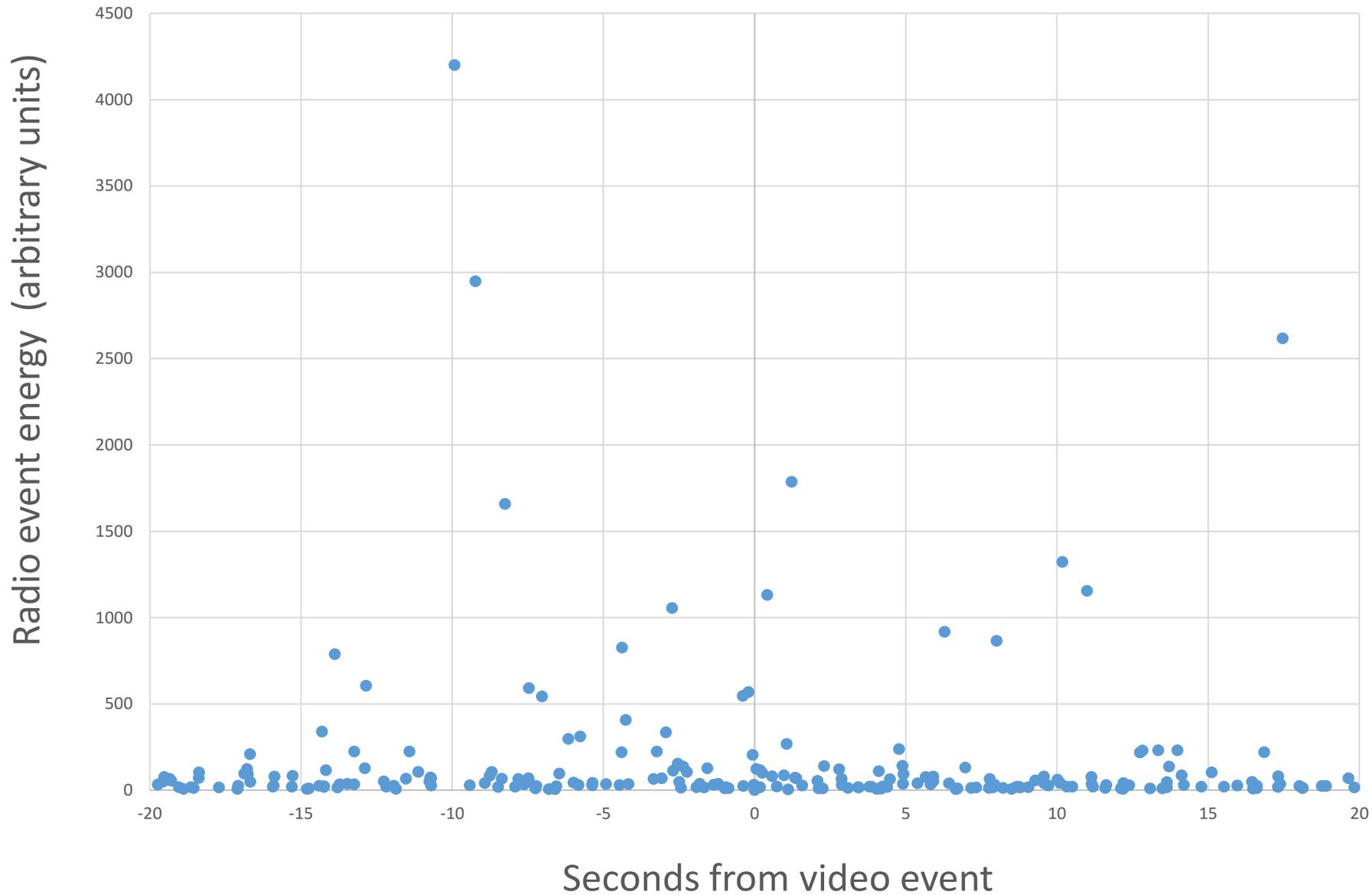
## Paul Hyde – Radio comparison from Basingstoke

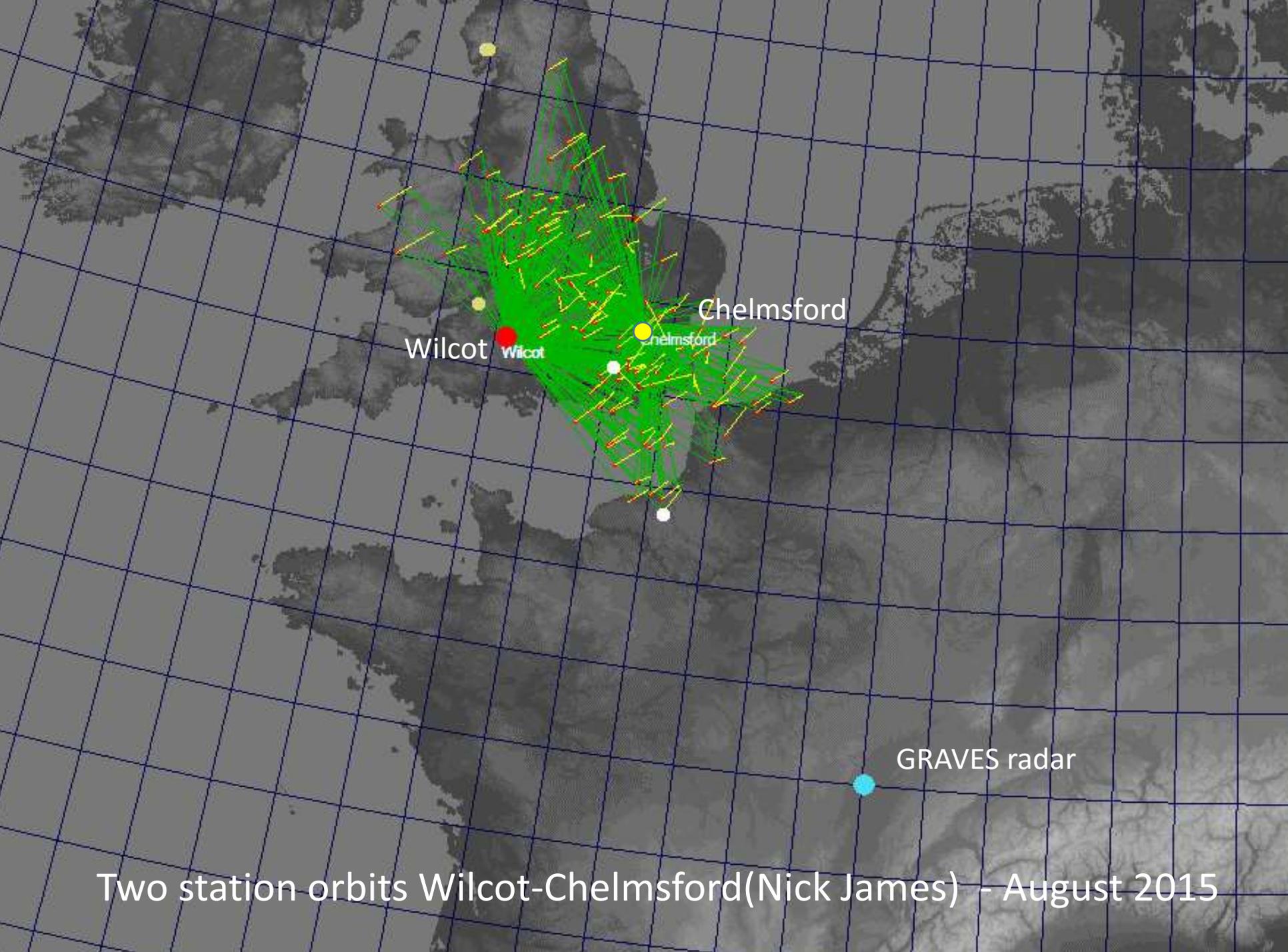
- Compared 200 brightest meteors from Wilcot SE
- Basingstoke had 47 matches to nearest second
- 28 had a radio duration  $> 1$  second
  
- Wilcot radio had 53 matches to nearest second
- 27 had a radio duration  $> 1$  second
- 17 of those matched the 28 Basingstoke candidates
  
- 19 Wilcot events had an energy  $> 500$
- 15 of those matched the 28 Basingstoke candidates

# Wilcot SE video meteors detected by Basingstoke radio



# Wilcot radio - Chelmsford video (Nick James)





Wilcot Wilcot Chelmsford Chelmsford

GRAVES radar

Two station orbits Wilcot-Chelmsford(Nick James) - August 2015

Wilcot

BOAM August 2015 captures

FR301

Greiz

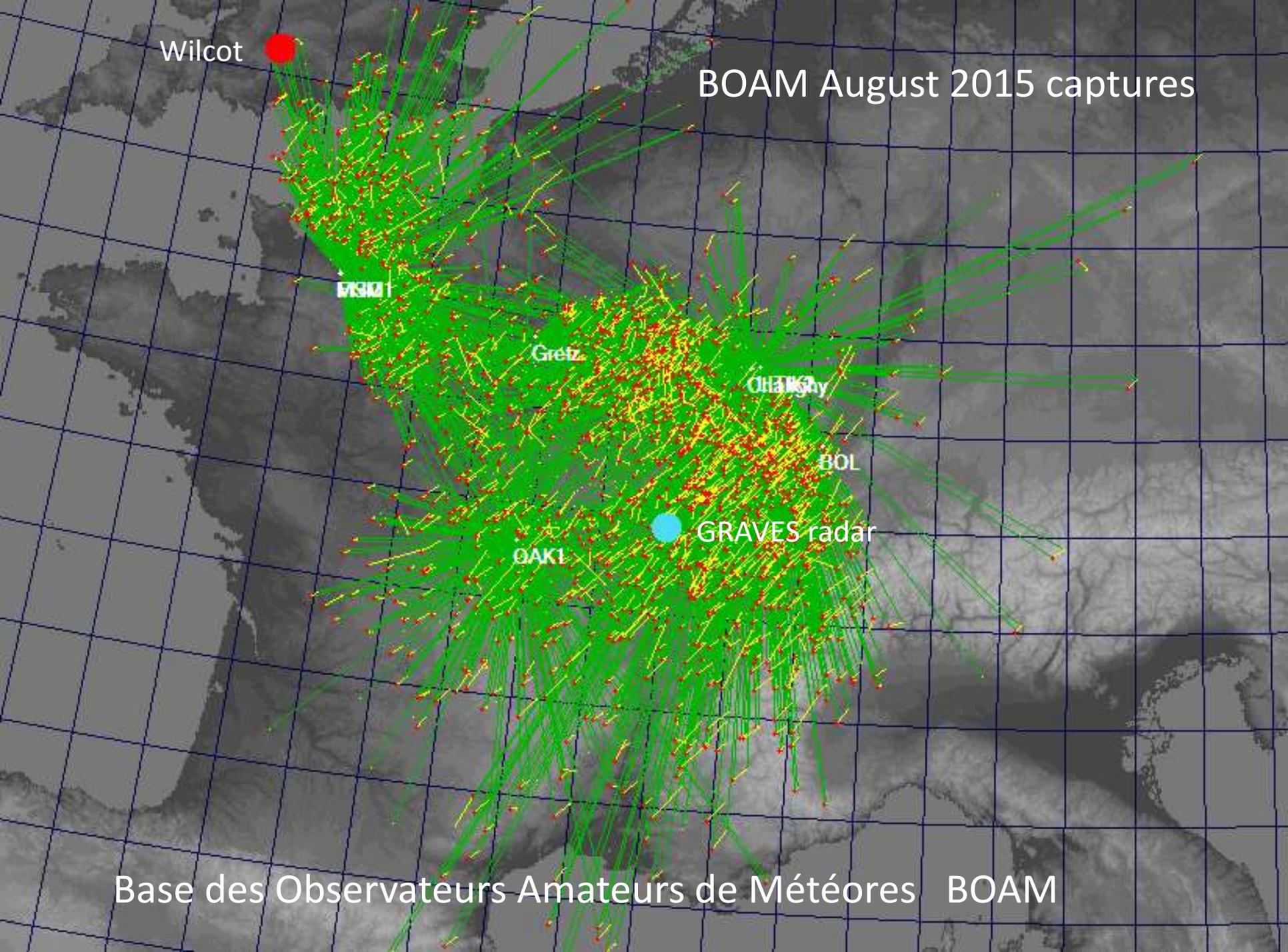
OHANKy

BOL

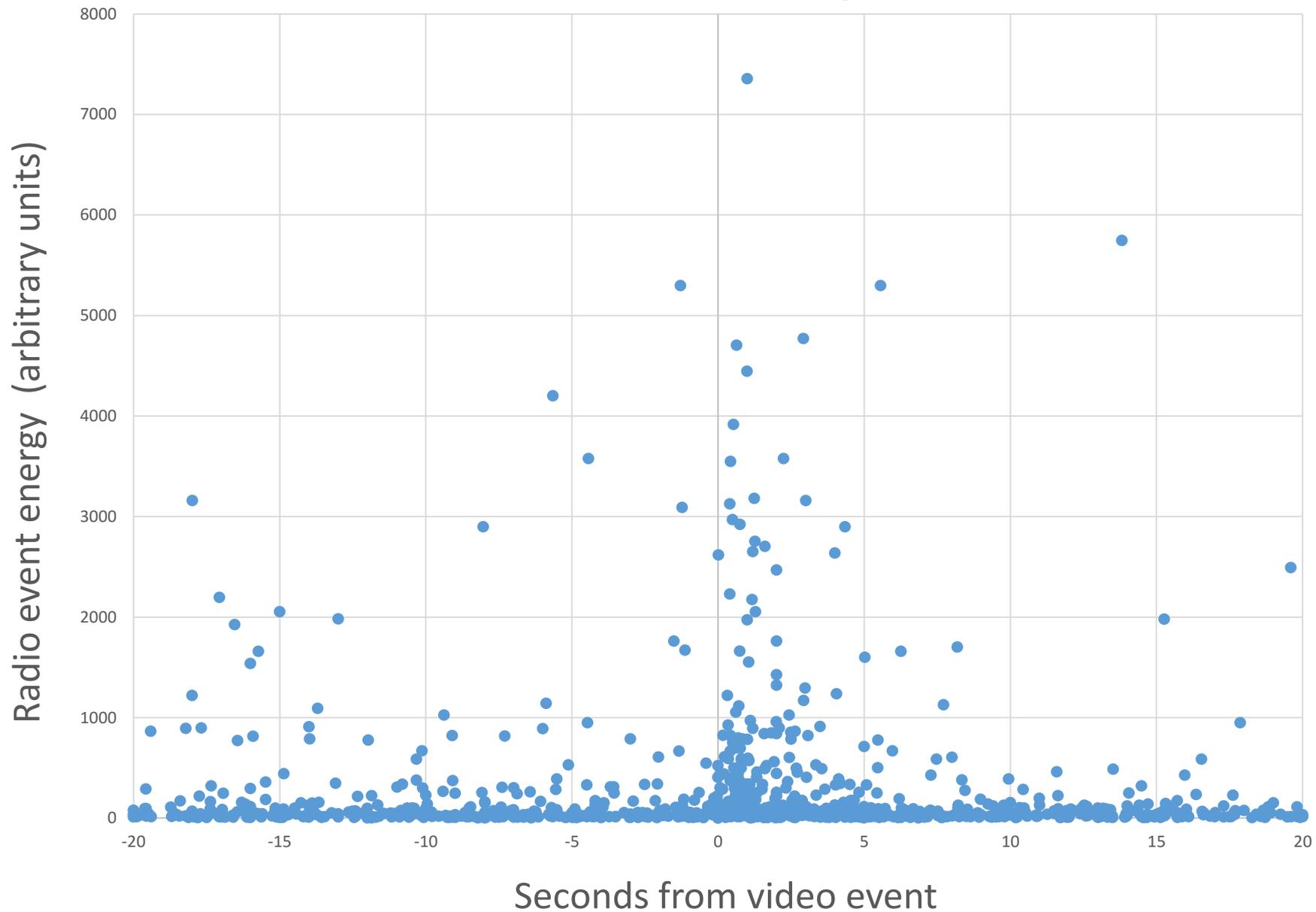
GRAVES radar

OAK1

Base des Observateurs Amateurs de Météores BOAM



# Wilcot radio - BOAM video (single station)



Wilcot

BOAM August 2015 captures  
Estimated single station matches  
with Wilcot radio detections

FR30A

GRIZ

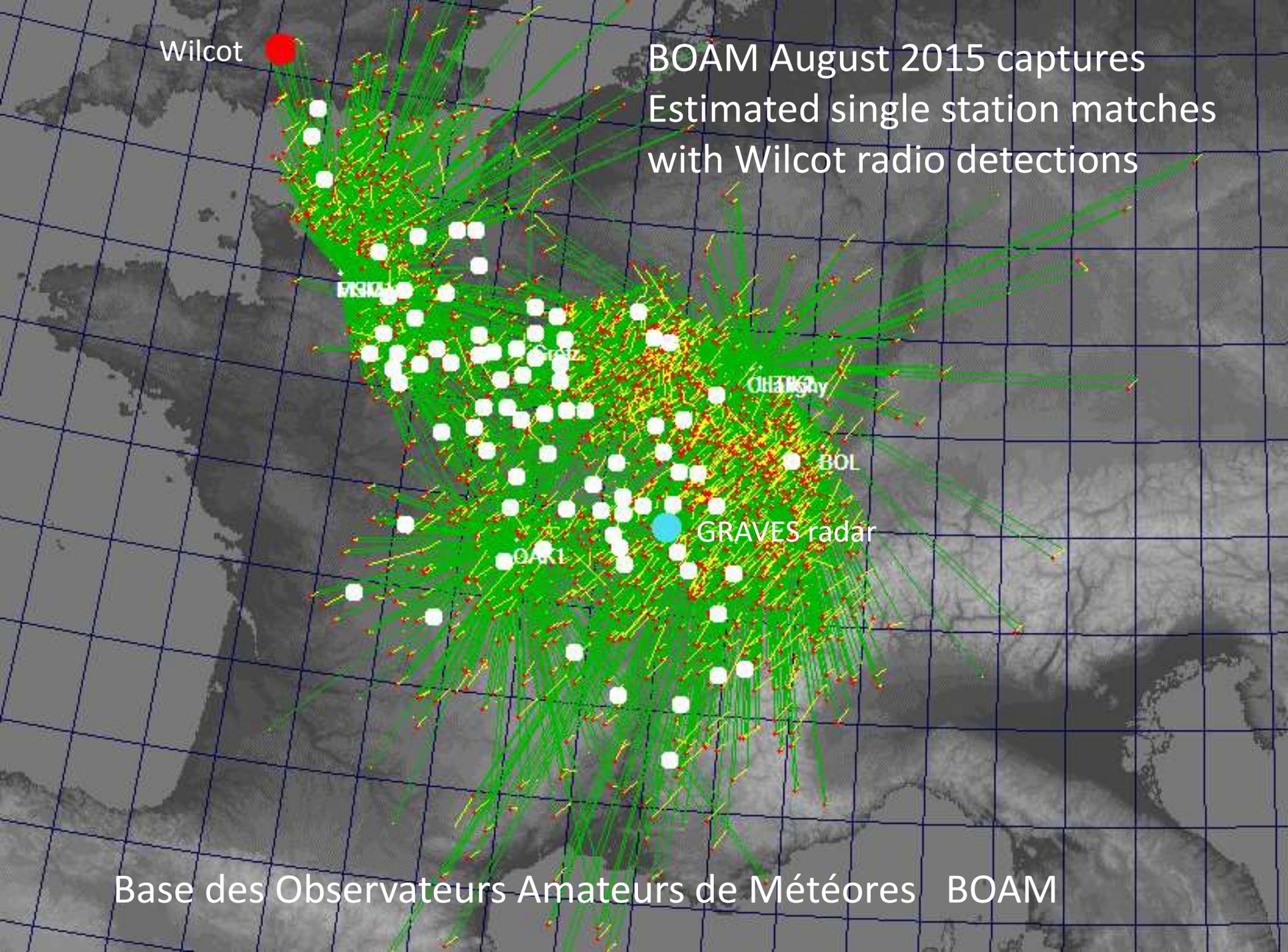
OHANShy

BOL

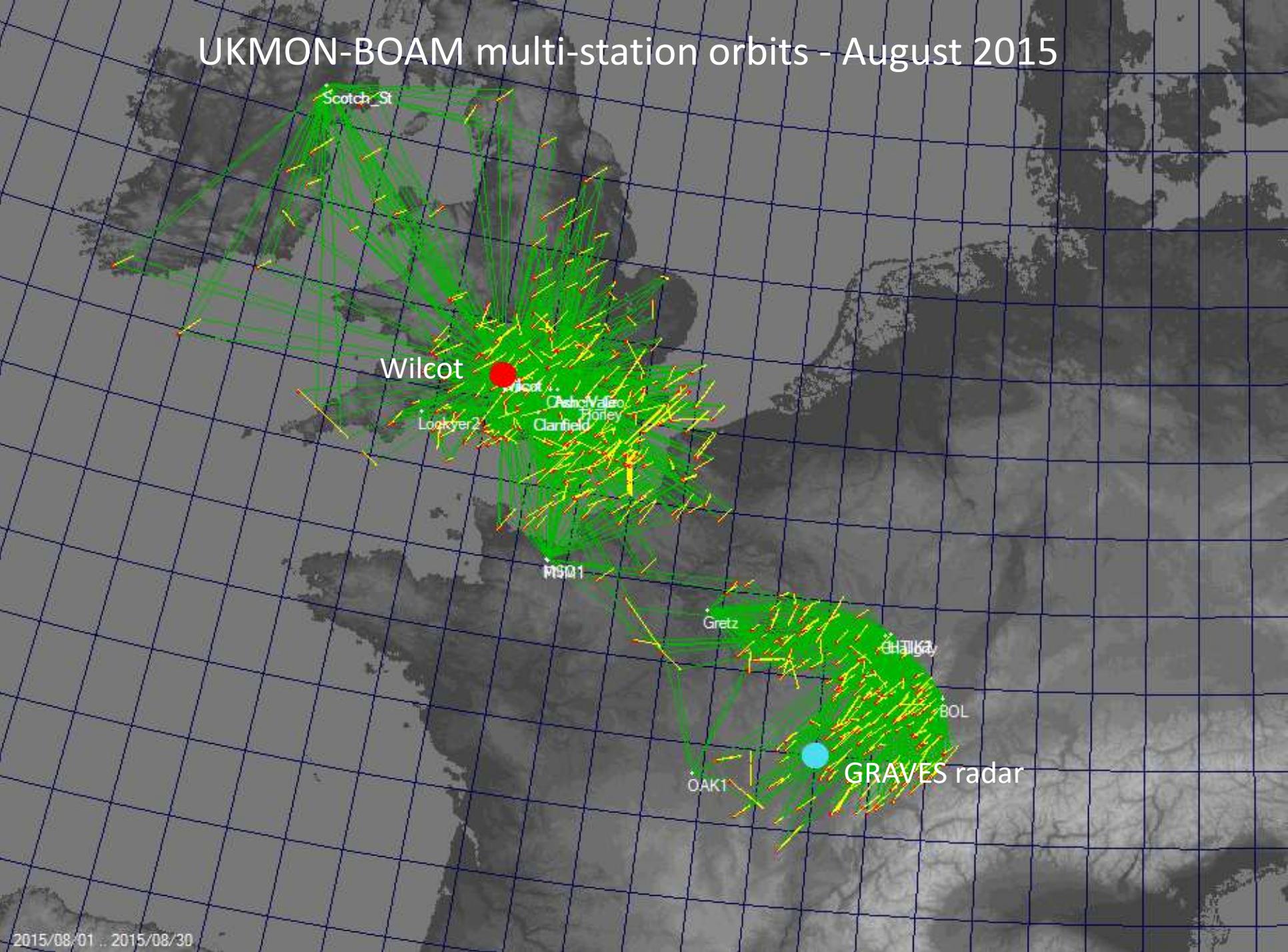
GRAVES radar

OAK1

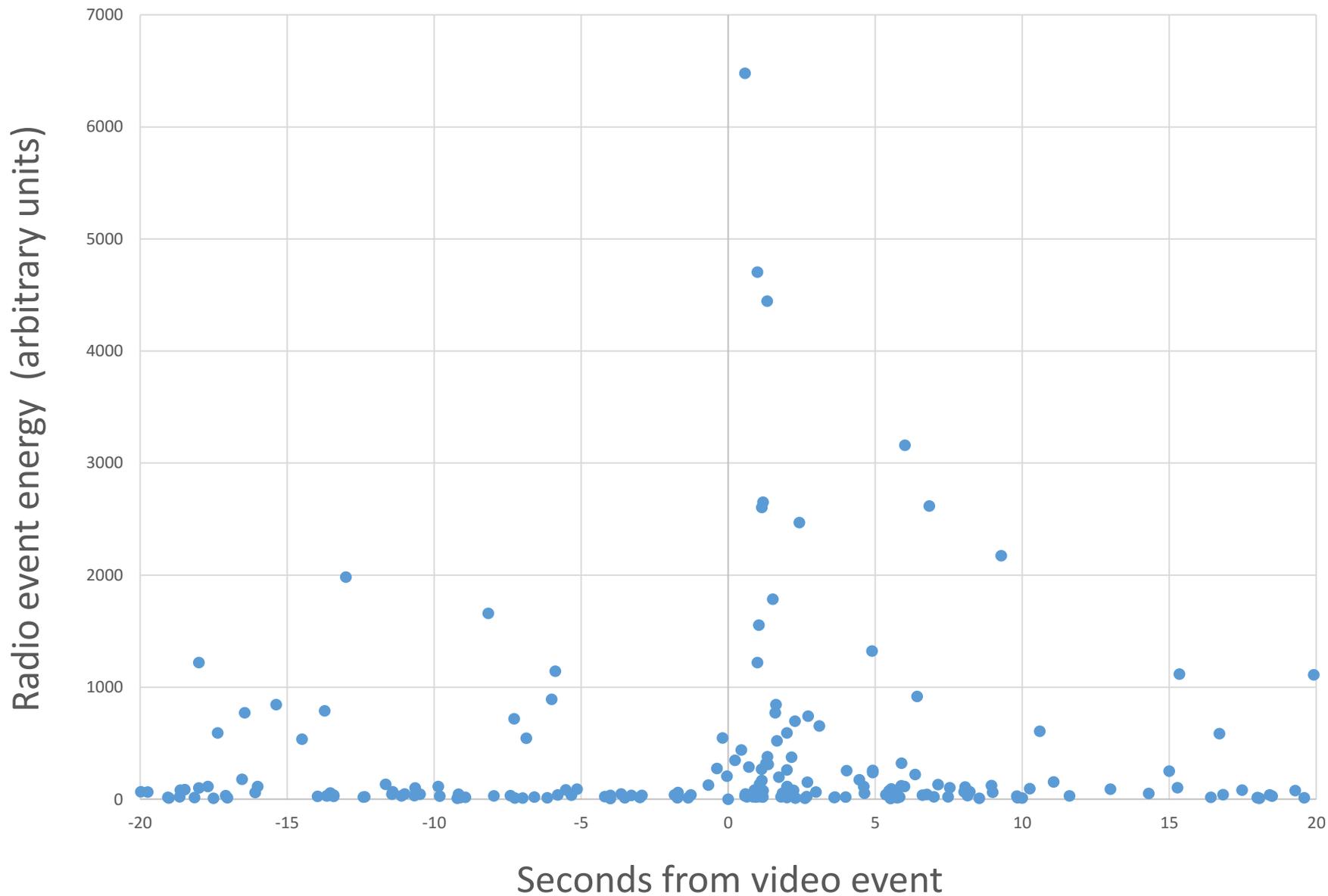
Base des Observateurs Amateurs de Météores BOAM



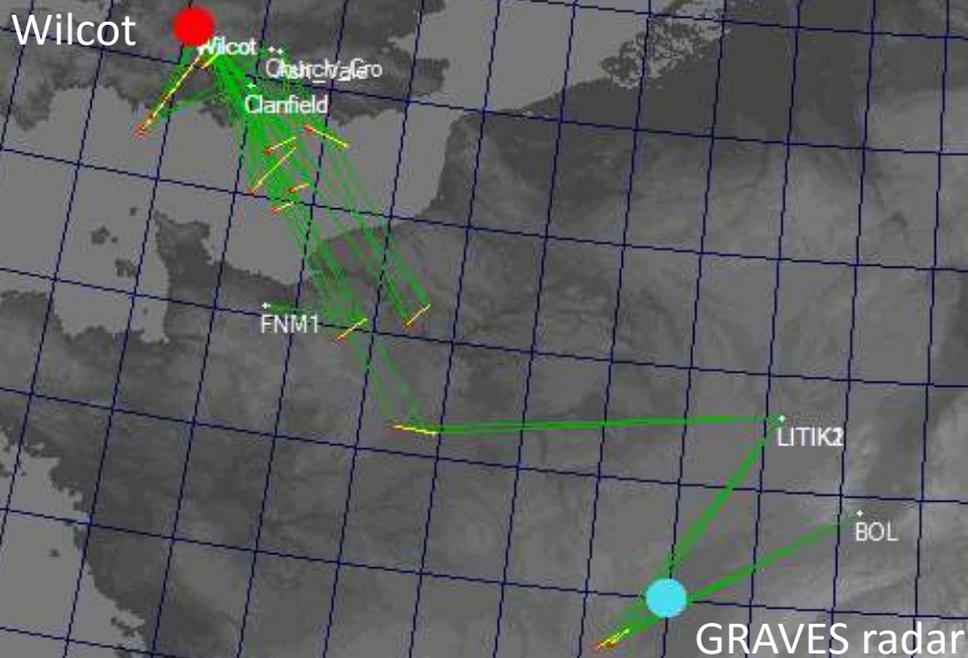
# UKMON-BOAM multi-station orbits - August 2015



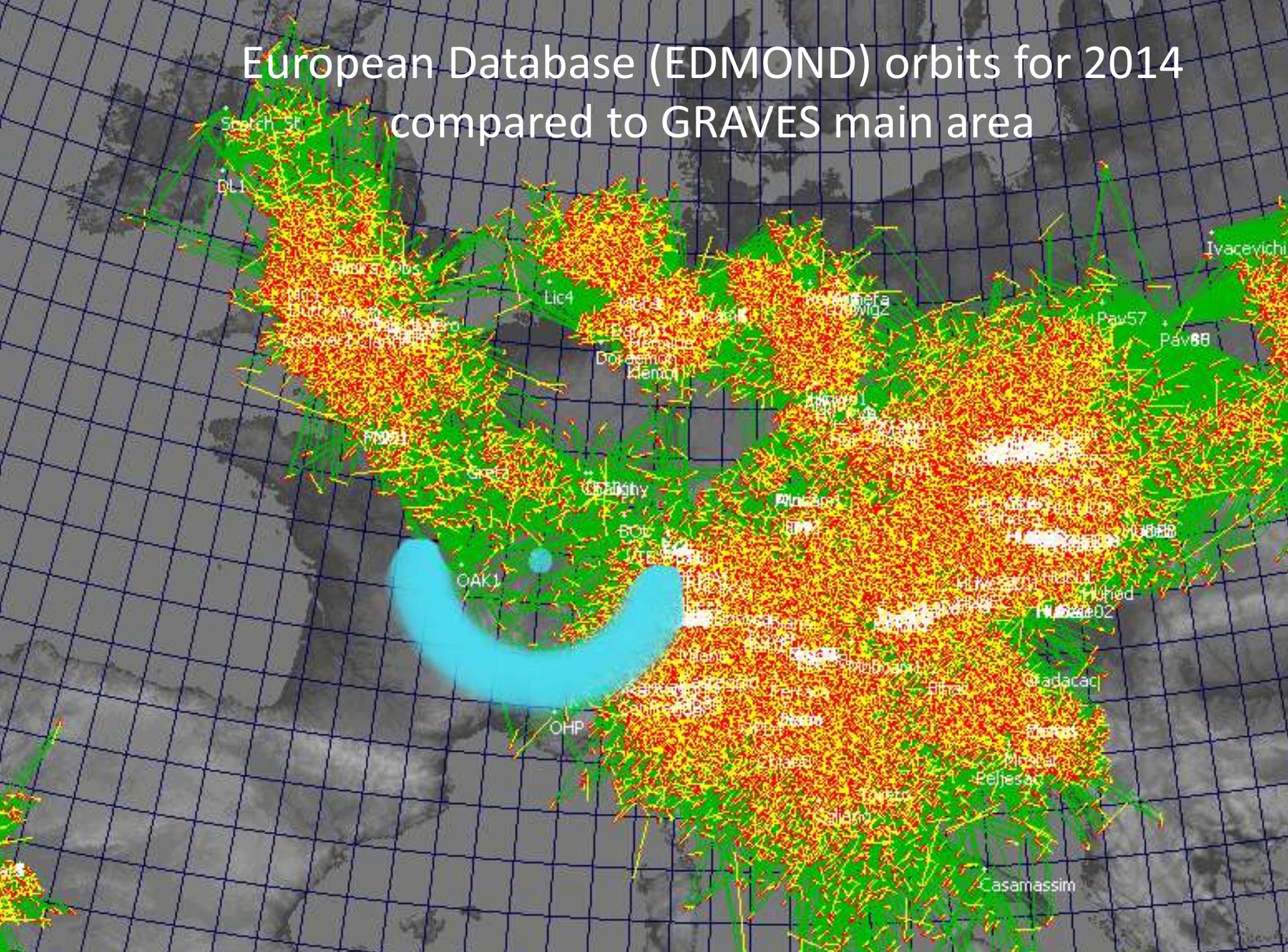
# Wilcot radio - UKMON-BOAM Orbits August 2015



# Wilcot radio matches with UKMON-BOAM orbits - August 2015



# European Database (EDMOND) orbits for 2014 compared to GRAVES main area



# Conclusions

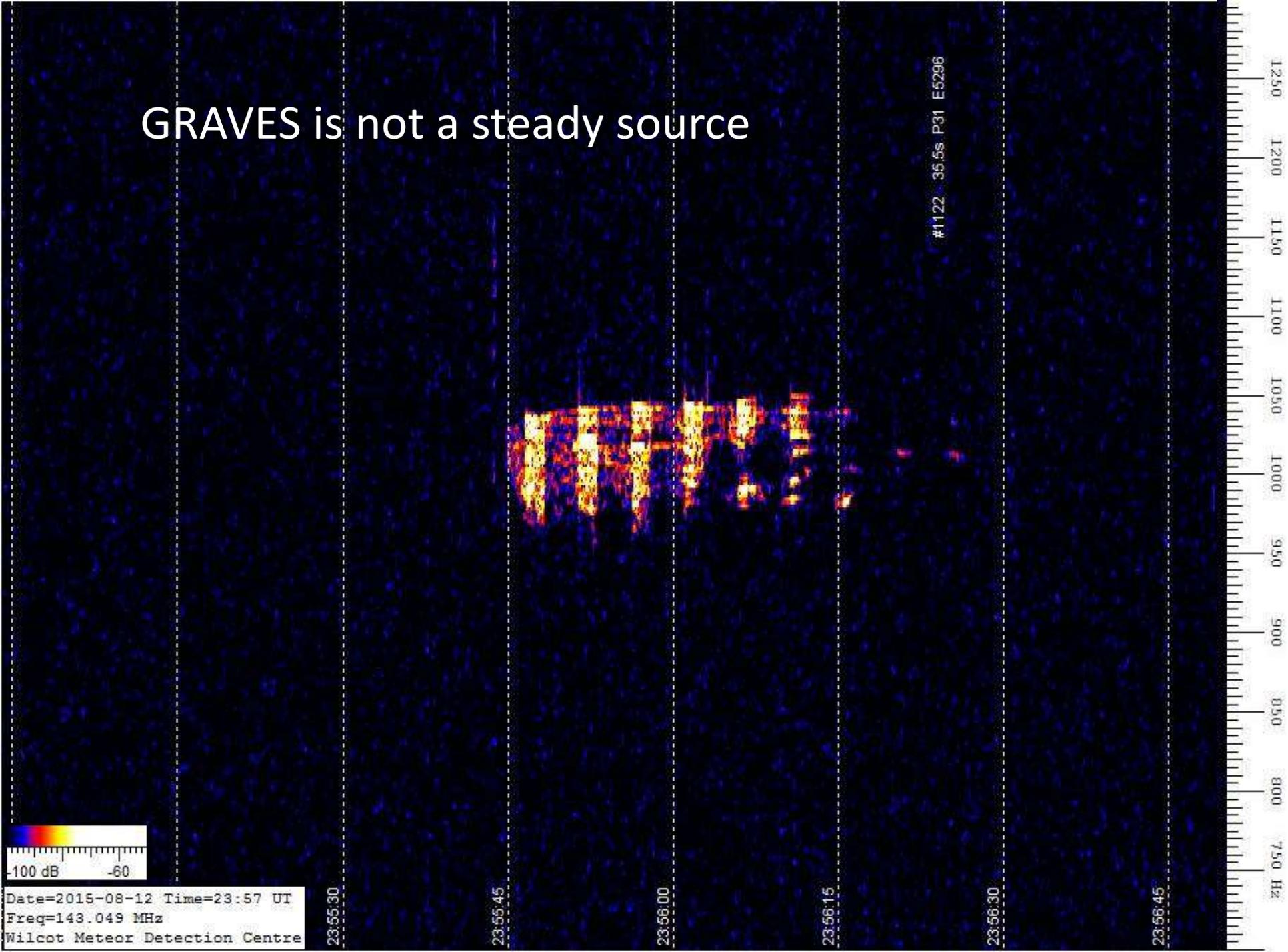
- The initial expectation was too pessimistic
- GRAVES radar echoes detected from the UK are not limited to meteors over southern France
- Meteors over the English Channel were detected by radio reflection from GRAVES
- Stations further north in the UK should be able to do the same
- A simple timing comparison using spreadsheets is sufficient to identify the brighter events
- Enough events can be identified to make further investigation worthwhile
- Single station video meteors can be useful for roughly locating matching radio events
- For this data set at least, the majority of detections are not from the main area illuminated by GRAVES

# Conclusions

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- GRAVES radar echoes detected from the UK are not limited to meteors over southern France
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**Thanks to Nick James, Paul Hyde and the contributors to UKMON and BOAM for making their data available**

# GRAVES is not a steady source



# ISS and the Moon pass through the beam

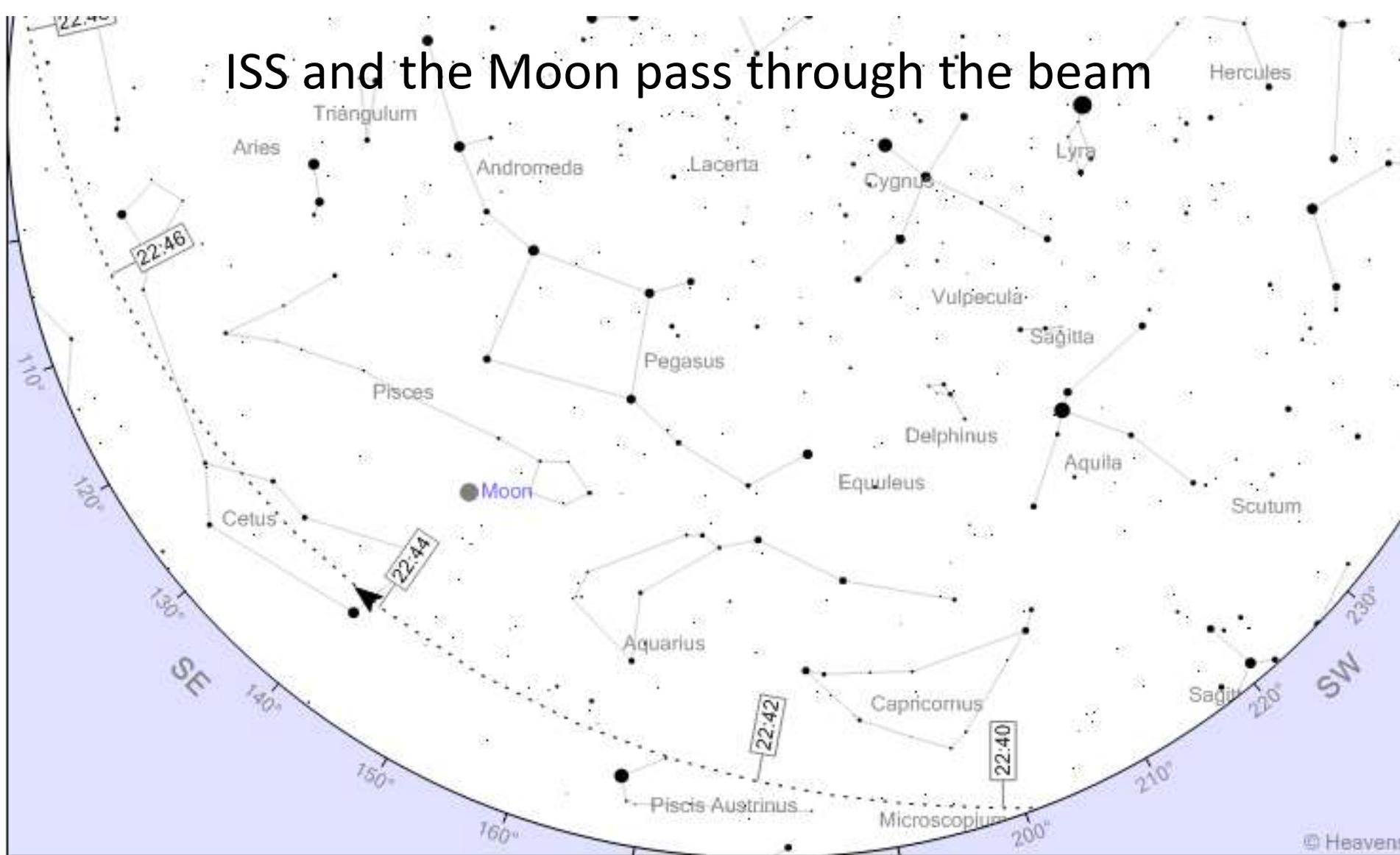
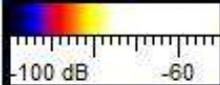


Chart size  (500 - 1600)

Date: 27 September 2015

Orbit: 398 x 407 km, 51.6° (Epoch: 30 October)

Moon



Date=2015-09-27 Time=21:44 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre

Interference

#457 2.7s P16 E74

SSI

ISS

21:42:30

21:42:45

21:43:00

21:43:15

21:43:30

21:43:45





Orientation

0 ↑ ↓

Zoom

+ - ← →

1.0

Options

Stars off

Background off

Grids on

Labels off

Haze on

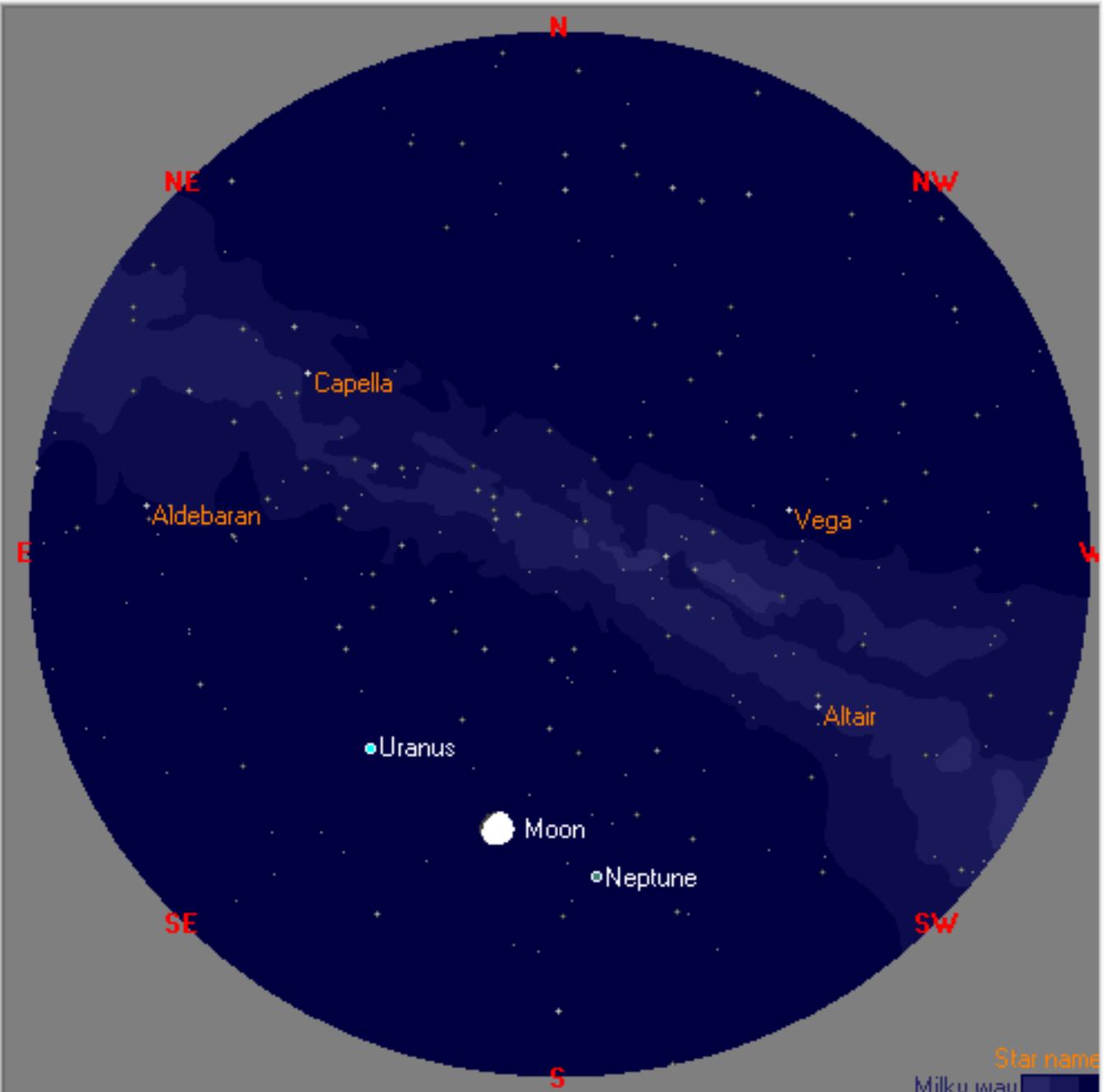
Hide horizon

Coordinates

Horizon view

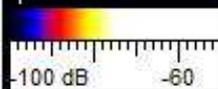
World map

Close



Star name  
Milku wau

Moon



Date=2015-10-24 Time=20:50 UT  
Freq=143.049 MHz  
Wilcot Meteor Detection Centre

20:48:30

20:48:45

20:49:00

20:49:15

20:49:30

20:49:45

#675 0.1s P14 E85

#676 0.7s P30 E212

