Radio Meteor False Triggers – an Analysis from April and October 2016

1. Introduction

Frequently, at my location in Derbyshire, I have periods when I suffer numerous triggers from non-meteors signals. These closely spaced streams of false triggers typically exhibit slowly changing frequency and signals levels close to the trigger threshold. I have not identified all of the interference sources but may be from satellite, aeroplane, troposphere or moon bounce. One source of local RFI is my large-screen LED/LCD TV which is located about 5 metres below the receiving antenna. Three types of non-meteor sources are shown in detail in the Appendix.

Figure 1 shows an example of a Spectrum Lab (SL) spectrogram of interference that resulted in multiple false triggers; there are also three meteor events.

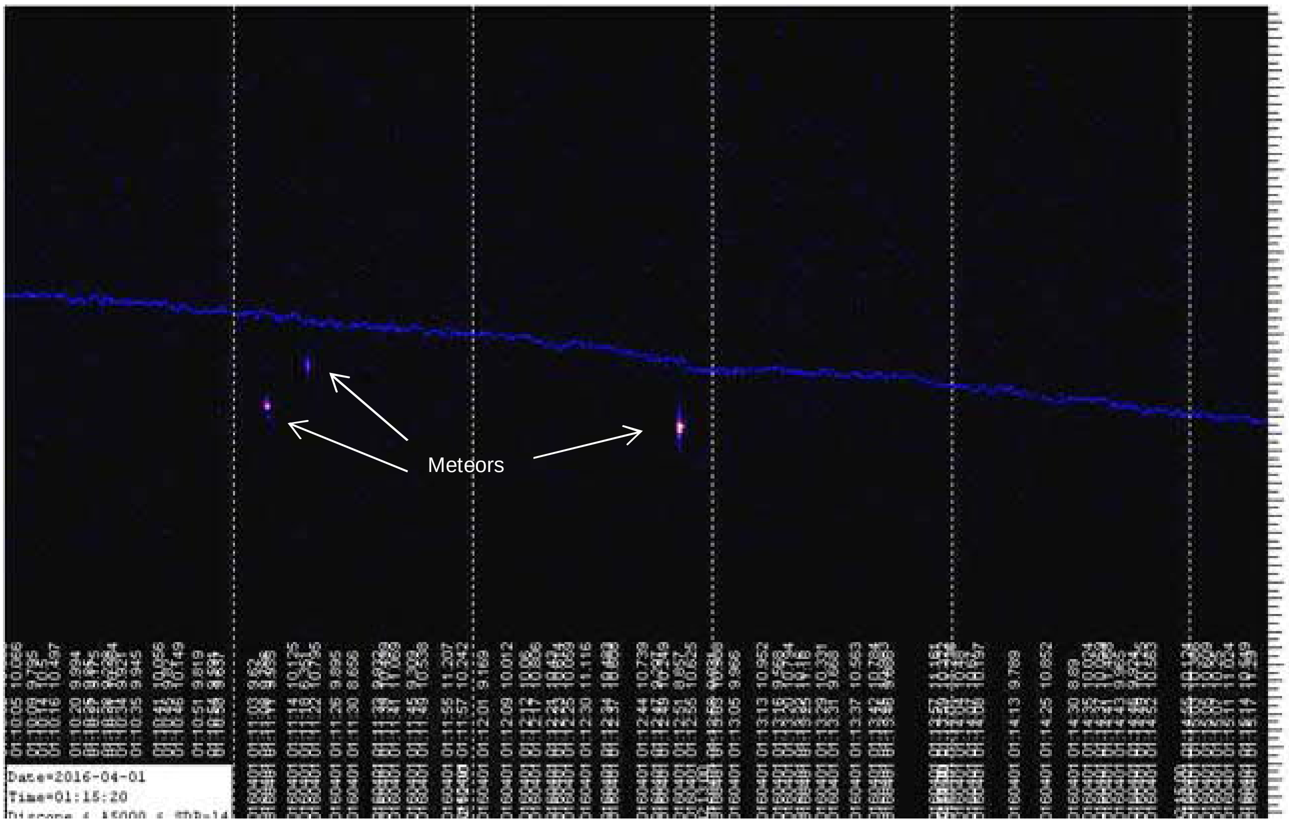

Figure 1 Spectrum Lab spectrogram

For a year or so I have been using an addition to the "traditional" form of Spectrum Lab's Conditional Action (CA) script developed in collaboration with (but mainly by) Wolfgang Kaufmann[1] that goes some way towards elimination of non-meteor events from records. Wolfgang has dubbed this technique "Test C".

A snippet from the log file is plotted in Figure 2, duplicating the spectrogram plot of Figure 1. However, note that the meteor signal just before 01:13 UTC has not been captured by SL script, probably because of a close-timed interfering event.

1 Based on work by Simon Dawes of Crayford Manor House Astronomical Society, Dartford.

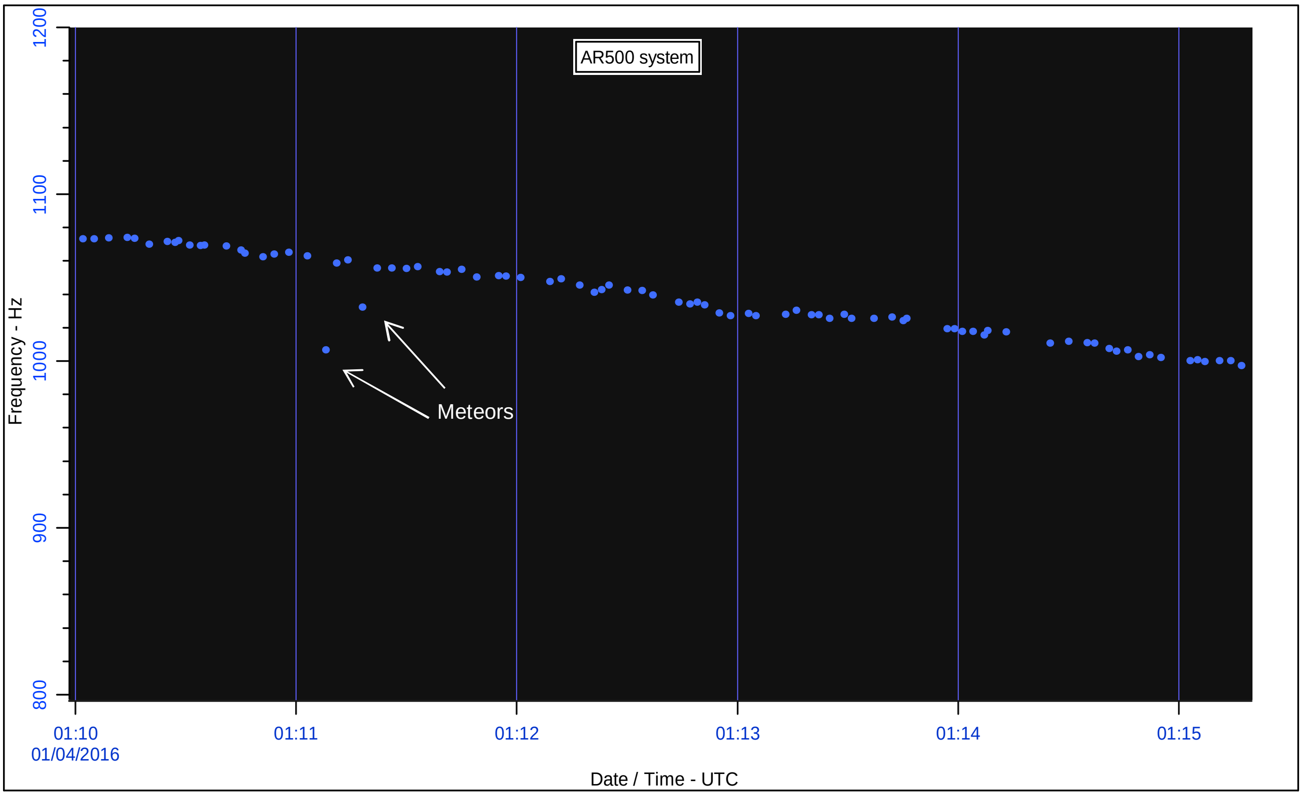

Figure 2. Frequency data from AR5000 system Spectrum Lab events log.

When a trigger occurs, the average signal within a 12 Hz band either side of the peak frequency is taken, as given in the line below:

SIG=peak_a(LOW,HIGH):FRQ=peak_f(LOW,HIGH):TESTC=SIG-avrg((FRQ-Outdelta),(FRQ+Outdelta)

where the variable Outdelta is set to 12 during initialisation. No action is taken in the script other than to log the value of Test C level for future filtering. Most recorded meteor events contain a band of frequency from the changing Doppler frequency. In comparison, non-meteor signals appear to have less frequency spread, changing more slowly in frequency. Hence, a meteor signal with a larger spread of frequencies will give rise to a higher average than would the more limited spread of a non-meteor signal. The average value is subtracted from the signal level to give the Test C value. Therefore the meteor will usually return a lower Test C.

A plot of Test C values using the same Date/Time scale as is given in Figure 3. It will be seen that in general interference triggered events have higher levels than meteor events. This is shown in Figure 3. The two triggered meteor events are circled in the plot and both Test C values are below the levels of the non-meteor events. However, although this criterion can separate the majority of events it is not unfailing in this task; the Test C values for a few meteor events are higher and the values for some non-meteor event lower than others. Thus, using a test C filter of 8.75 would eliminate all false triggers and leave the two meteor events, a value of 9 would leave a number of non-meteor events with the meteor events, and a value of 8.5 would lose a meteor event with all of the false trigger events.

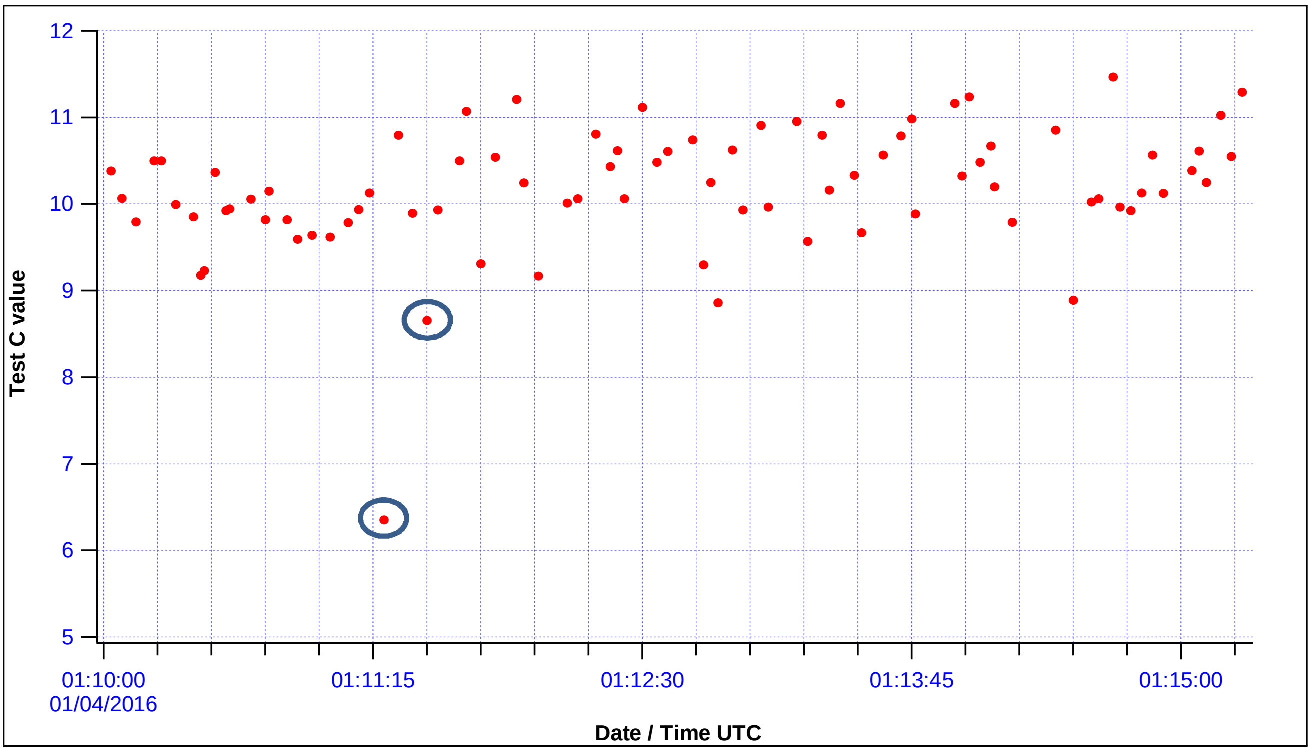

Figure 3. Test C data from Spectrum Lab events log.
Circles highlight the two meteor events shown in Figure 1.

It should be noted that with the present Spectrum Lab conditional action scripts method when an event trigger is obtained no further events are recorded until the current event ends. A triggered non-meteor event of long duration could preclude a number of meteor events and in heavy interference a significant "dead time" might occur. During one seven day period over 17000 seconds were related to non-meteor triggers and hence dead-time. This amounts to 2.5% spread over the period but, of course non-meteor events occur over perhaps an hour period at a time.

The following notes present my analysis and findings using Test C as a filter; much of this is in pictorial form, which to me makes clear the benefits and shortfalls of the technique.

Four type of non-meteor event triggers are shown in the Appendix; **TV Noise, Transits, Staves and Moon Bounce.**

2. Twelve days of events

The possible benefits of the techniques can be anticipated from a block of data covering a twelve day period as shown in Figure 4 below. The many "Transit" [2] trigger events on the scale of several days appear as straight lines on the plot..

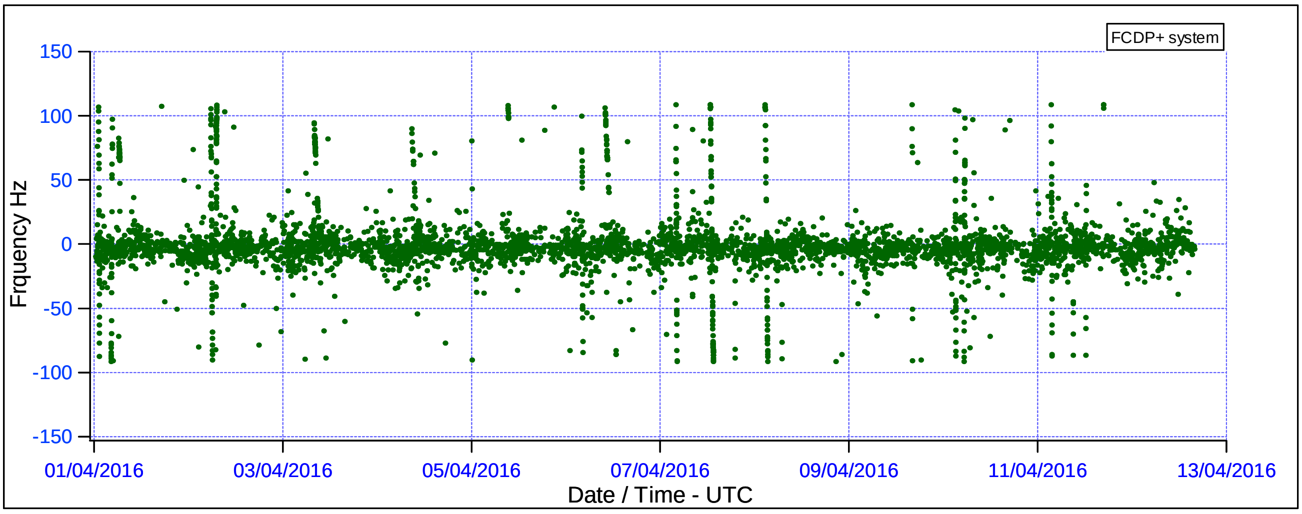

Figure 4. Frequency Data from Spectrum Lab Log for twelve April days

Figure 5 shows the Test C value for each of the events shown in Figure 4. The Transit events can be readily identified as the higher Test C levels in straight lines.

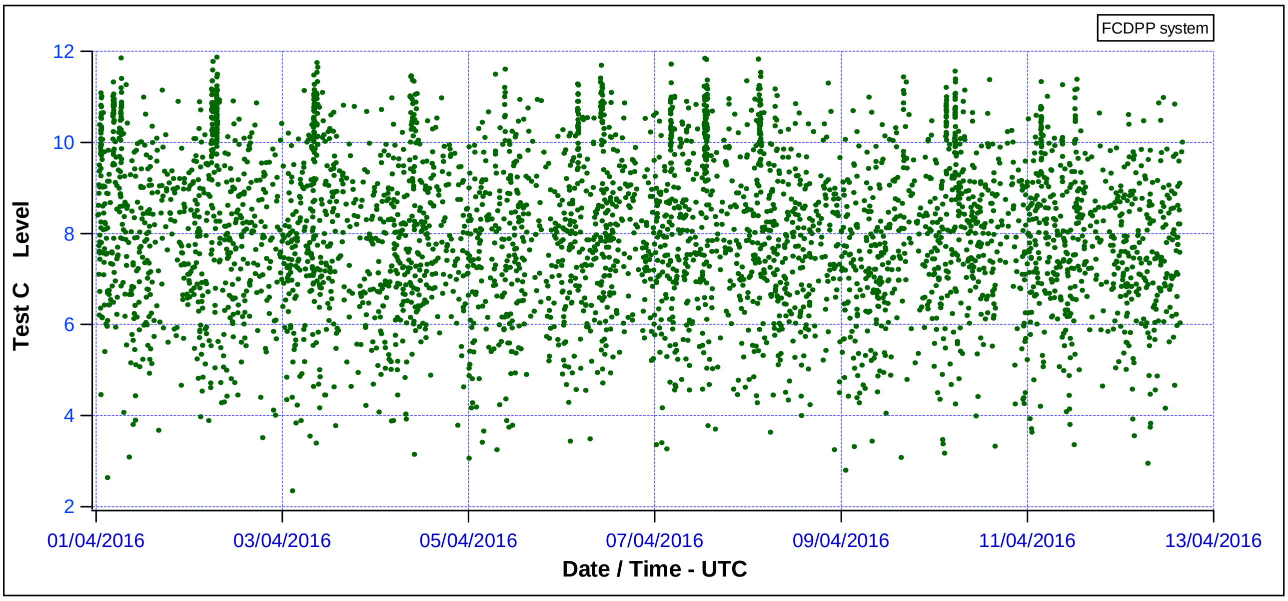

Figure 5. Test C Levels calculated in Spectrum Lab Conditional Action script

From the twelve day data set the Test C Level is plotted in Figure 6 against the associated frequency of the triggering event. As expected many of the higher Test C values correspond to frequencies away from the zero Doppler frequency.

[2] Arbitrary definition of Non-meteor trigger source – See Appendix

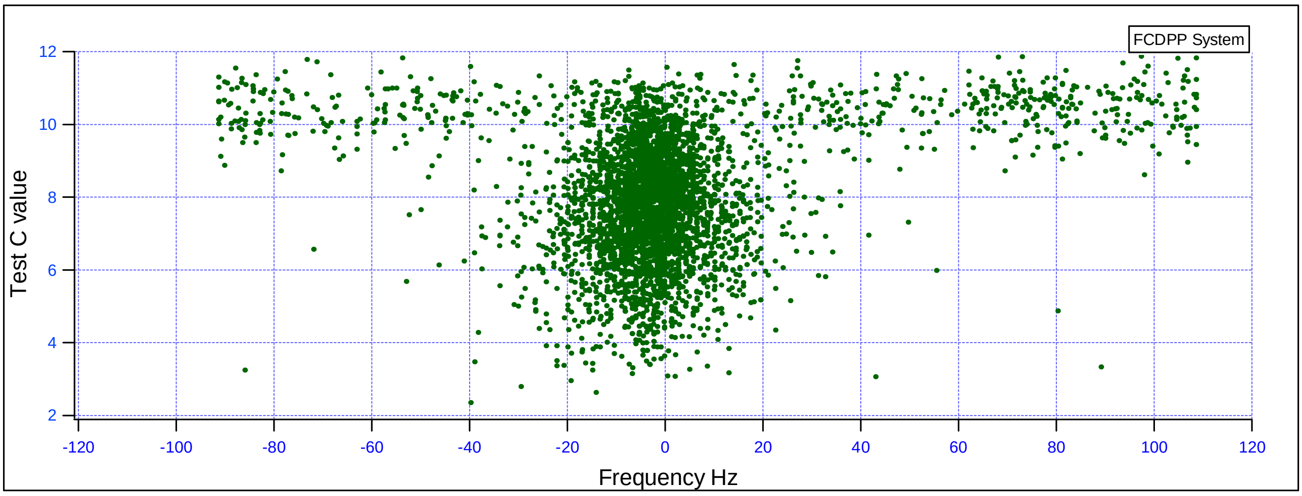

Figure 6 Distribution of Test C Level with Frequency for above data

3. Test C as a filter

The event data from the log may be filtered in a spreadsheet program or in as I did in data analysis and plotting software. Three days data are used in the filtered data shown in Figure 7. Application

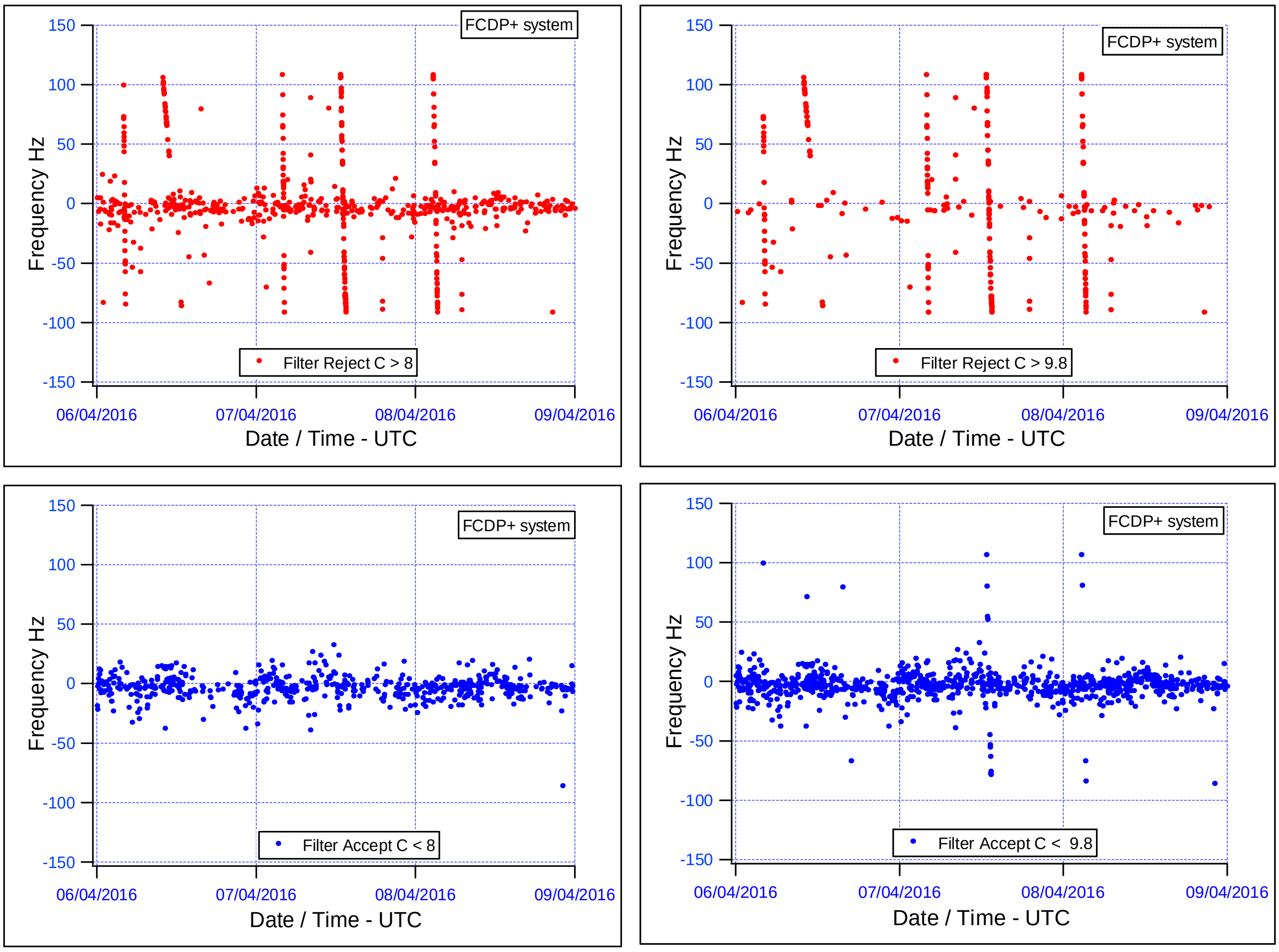

Figure 7 The effect of changing the Test C value used in the filter.

of a severe Test C filter level of 8.0 (left column) removes most non-meteor events (bottom) but also some meteor events (top). A higher filter level of 9.8 (right column) misses some non-meteor events (bottom) but keeps more meteor events (top). Table 1 shows the number of events filtered in (i.e. accepted) or filtered out (rejected) for a range of Test C filter levels applied to the data.

Test C Level	Filtered In	Filtered Out
9.8	4105	1193
9.6	3918	1380
9.4	3773	1525
9.2	3610	1688
9.0	3418	1880
8.8	3255	2043
8.6	3073	2225
8.5	2967	2331
8.4	2880	2418
8.2	2690	2608
8.0	2463	2835

Table 1 Effect of Test C Filter on 5297 events

These data are plotted in Figure 8 for two separate monitoring systems as percentages of the total triggered events. As with other amplitude measurements in Spectrum Lab, the levels depend on the input levels and SL settings and to achieve the same degree of filtering on different monitoring systems will require different Test C levels in the filter.

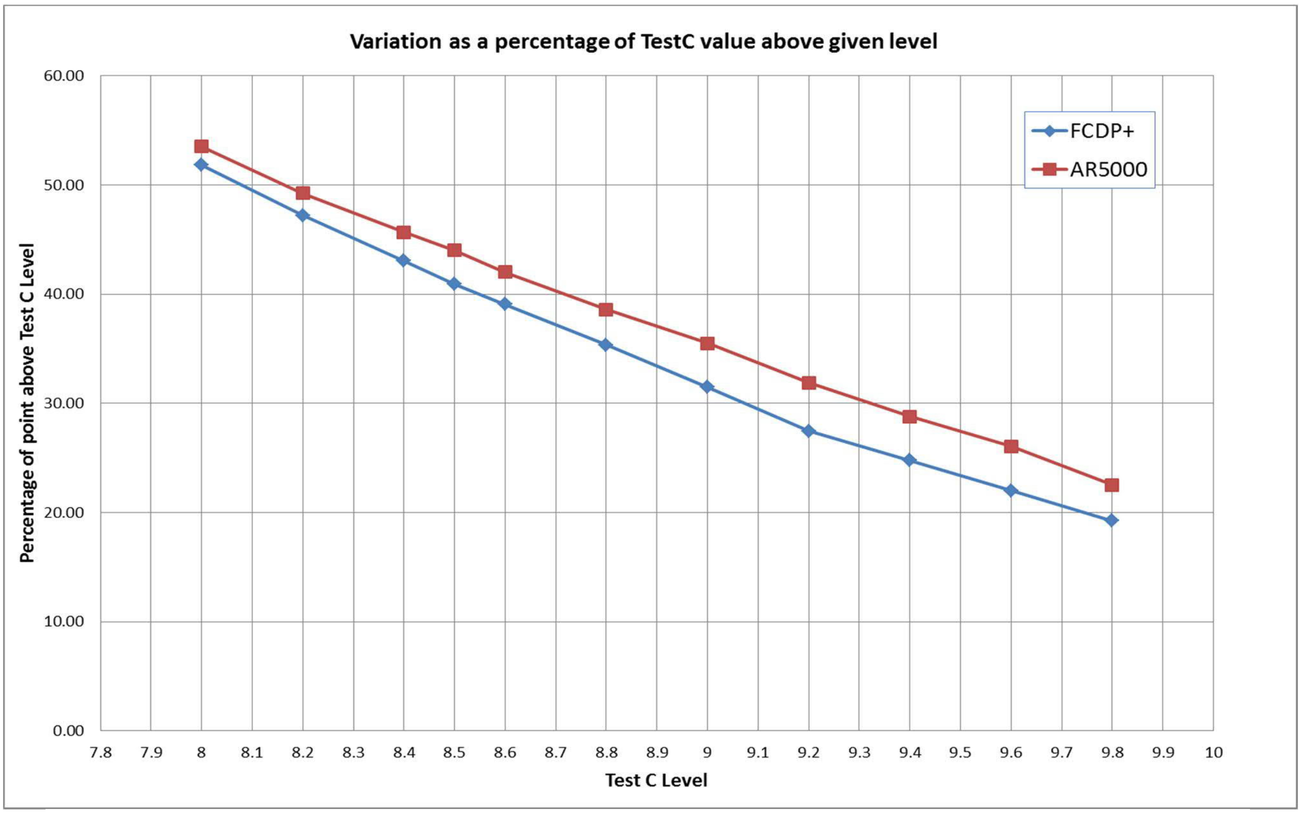

Figure 8 Percentage of points above Test C Level for two systems

4. On-going development of filter techniques.

Some initial investigations have been undertaken to apply filters in a more sophisticated manner than the coarse application of filters to all data.

It has been previously noted that some forms of non-meter trigger events, such as Transits follow a fairly regular straight line as shown in Figure 9. An algorithm has been written in the data analysis software that, using the data for this particular Transit, that can selectively remove data along the

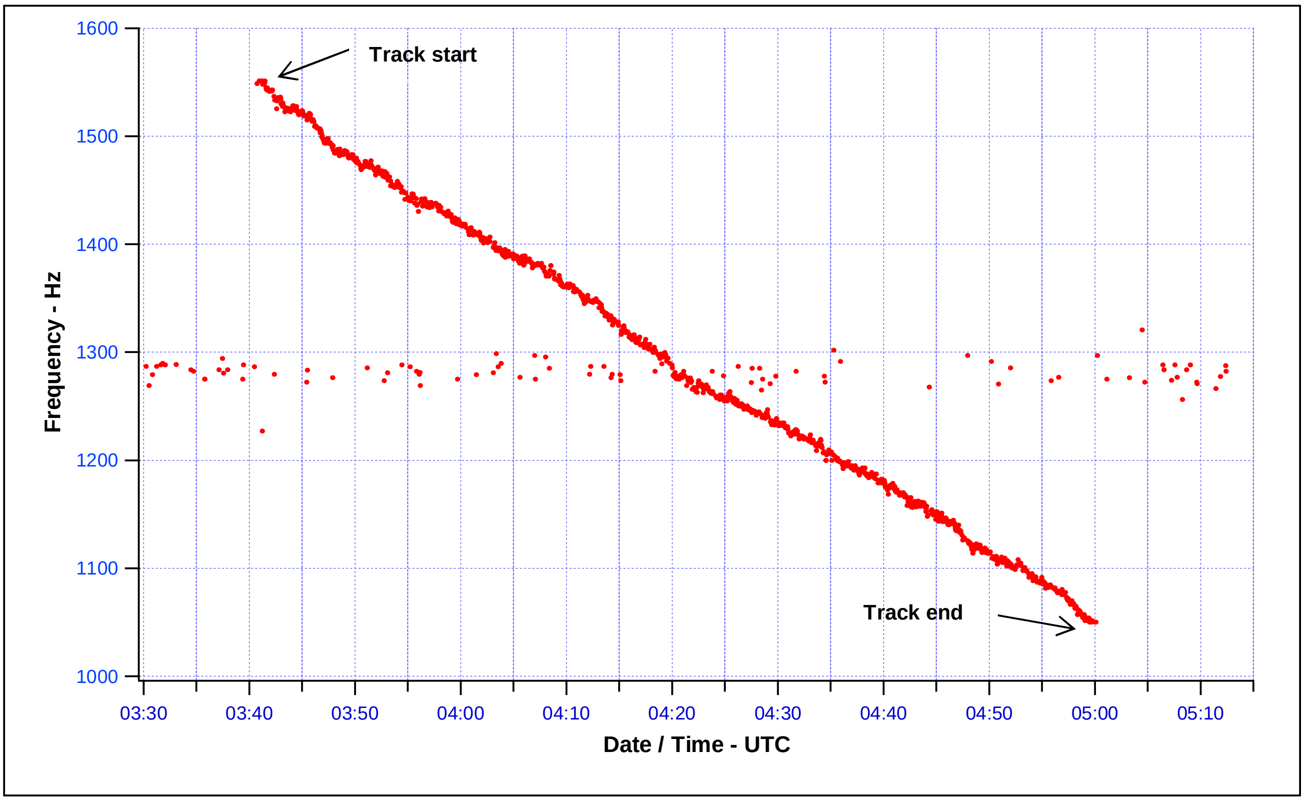

Figure 9 Typical "Transit" triggered events

line. At present this is achieved by searching through the data and identifying the start and end of the Transit Track. This can be envisaged in the Figure as finding the first frequency above 1500 Hz at about 03:34 and similarly the last low frequency end of the track. These start and end events on the track have an associated Test C value which must be above a chosen level to be selected . The frequency and time in seconds at the start and end of the track are used to determine the gradient of the line. Then, beginning at the start of the track an stepping through all event data points, a check is made to see if the frequency time point fall close to the gradient of the line and the Test C criteria is met.

Figure 10 shows the results of the line removal application. The start and end of the track are included in the plot. There is further work to be done on the algorithm to improve the band of events included in the filter which at present to too wide but the technique appears to have some promise. The challenge will be to make the routine semi-automatic, perhaps identifying the potential starts and ends of the tracks to be removed for checking purposes.

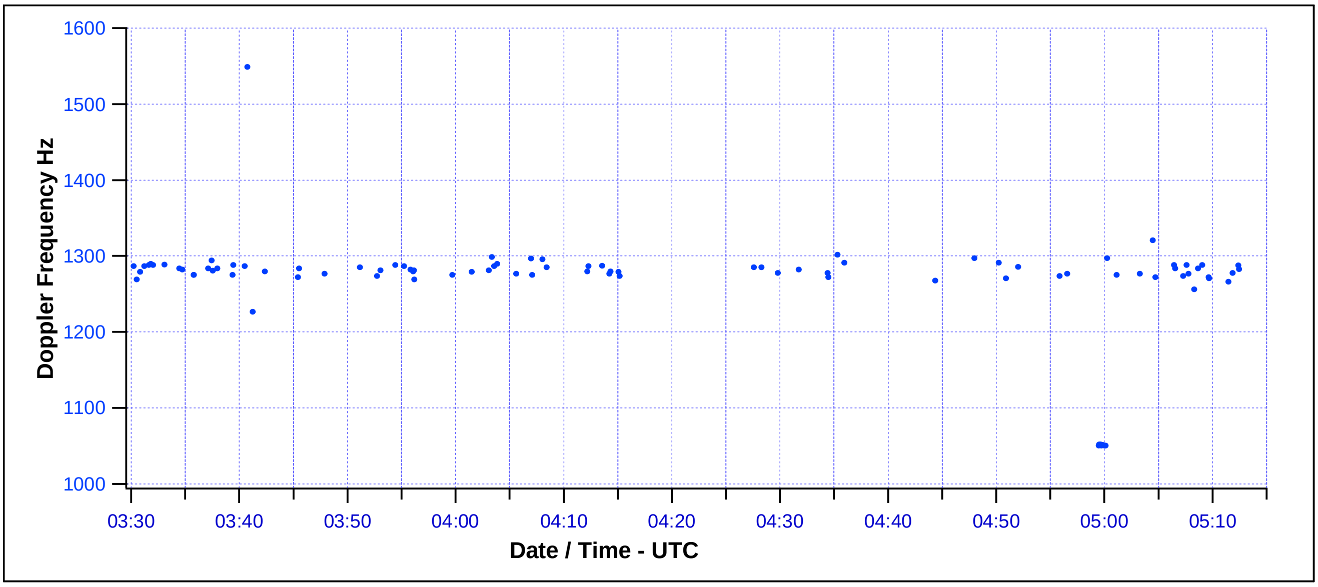

Figure 10 Data after removal of a Transit track

The distribution of Test C levels with frequency as seen in Figure 6 may also be a means of filtering by frequency, perhaps the removal of the TV noise triggered events. Similarly, a spot frequency filter may be possible for use with removal of Stave triggered events. (see Appendix)

M T German
Hayfield

24 December 2016

Appendix A Example of Non-Meteor Trigger Types

A1 Introduction

I have named three of the main types of “interference” that causes false triggers. These are shown in Figure A1 which is the frequency data from Spectrum Lab conditional actions log for October 2016. A further form of non-meteor triggering is generated by **Moon Bounce** which is shown in Appendix A5. The Test C filter has been used to highlight the offending false triggers. Note that with the filter setting of Test C value = 9.2 some Transit-triggered events are not identified (i.e. Test C < 9.8)

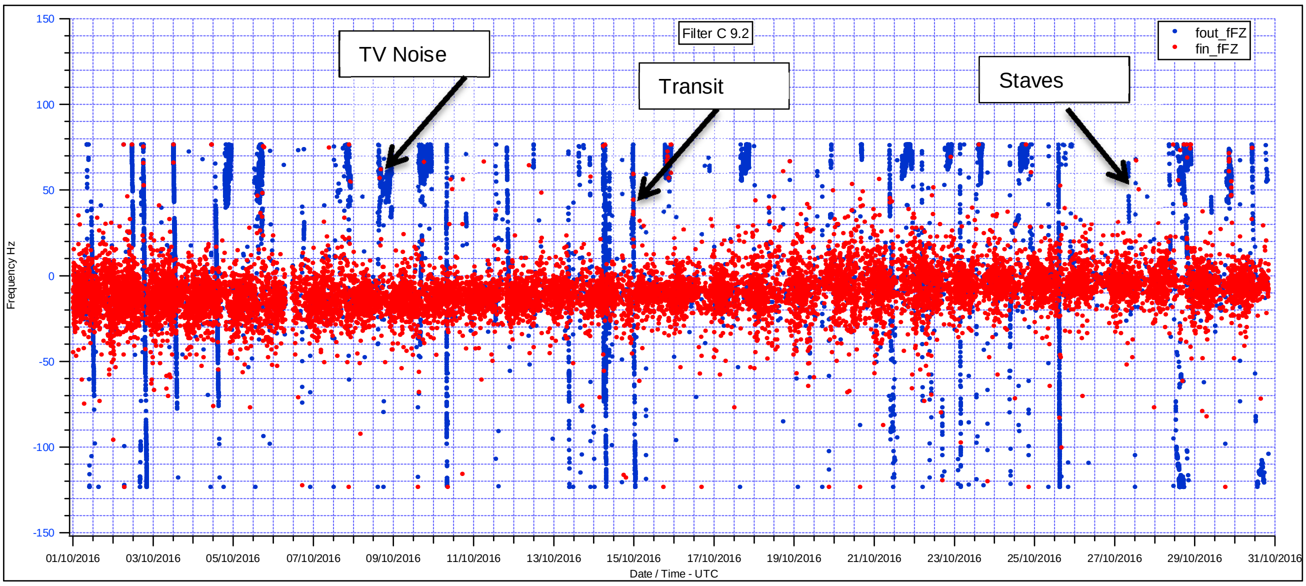

Figure A-1 Non-Meteor Trigger Source Types. System F October 2016.

TV Noise was easy to identify and there is the possibility that re-siting the antenna could cure this source of interference. What I have called **Transits** arises from the passage of the moon, the ISS and no doubt other passing satellite that move through a favourable position to generate a Doppler signal within the meteor monitoring band. Finally, what I have termed **Staves** because of the multiple parallel lines similar to music staves.

Examples of these Non-Meteor Trigger Source Types are provided in more detail in the following sections.

A2 TV Noise

The slightly upward-sloping traces in Figure A2 are typical of TV noise. The event labels for each of the three triggers show high values for Test C. (C= 11.2, C = 10.4, C = 11.3) The intensity and duration of TV noise is variable. Figure A3 shows the results of a day's TV viewing. The Test C filter was set to 9.2 and above for blue. Some trigger events not associated with TV noise have Test C values above 9.2.

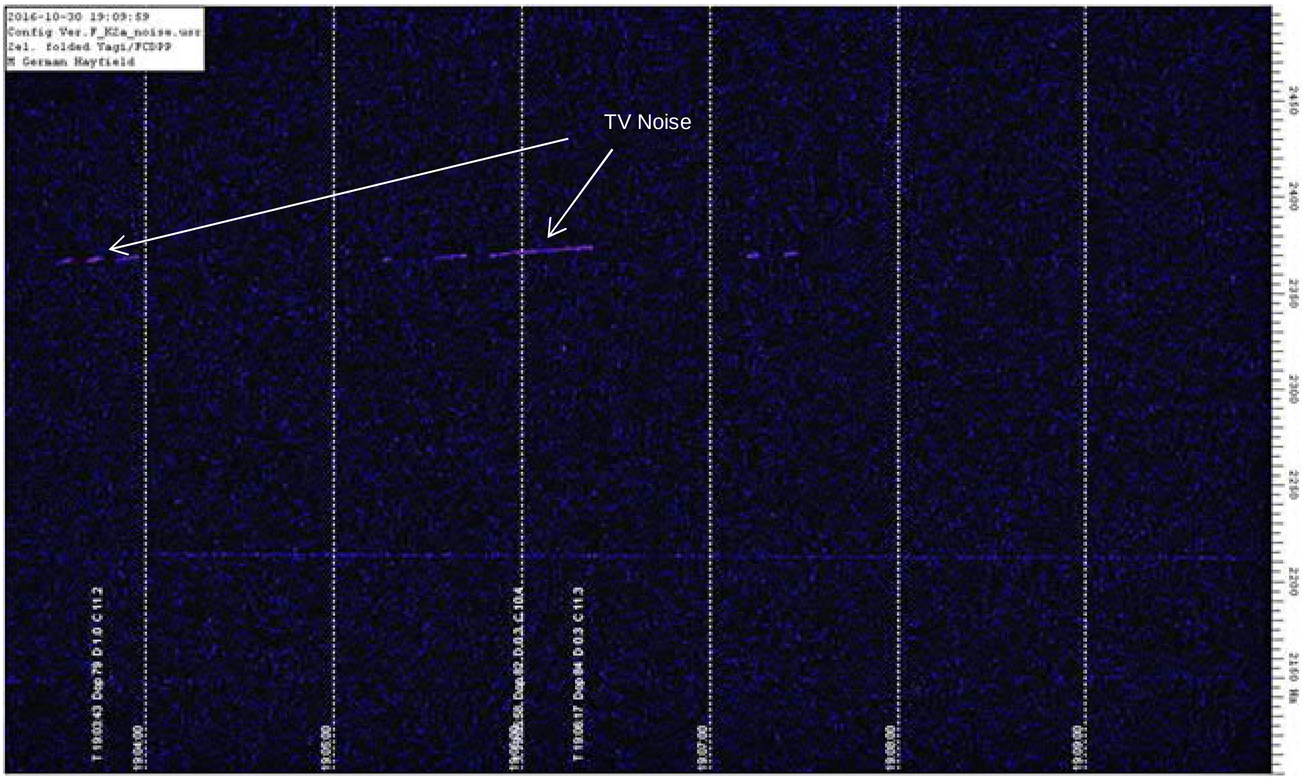

Figure A-2 Spectrogram of Non-Meteor Event Source – TV Noise

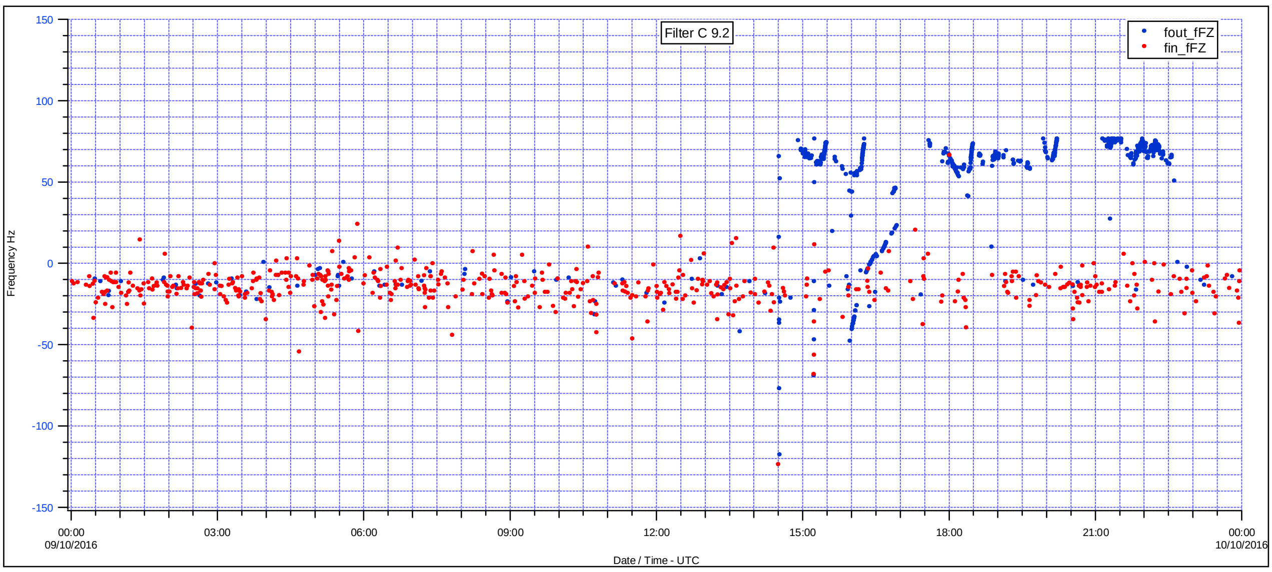

Figure A-3 Spectrum Lab Log Frequency Data – Afternoon and Evening Viewing!

A3 Transits

Part of a slow transit covering 7 minutes and producing multiple false triggers is shown in Figure A4. Two of the three possible meteors have been identified with Test C values of 8.4 and 6.0. Note the wavering in Doppler frequency arising from atmospheric in the path between GRAVES, the object causing the events and the observation station.

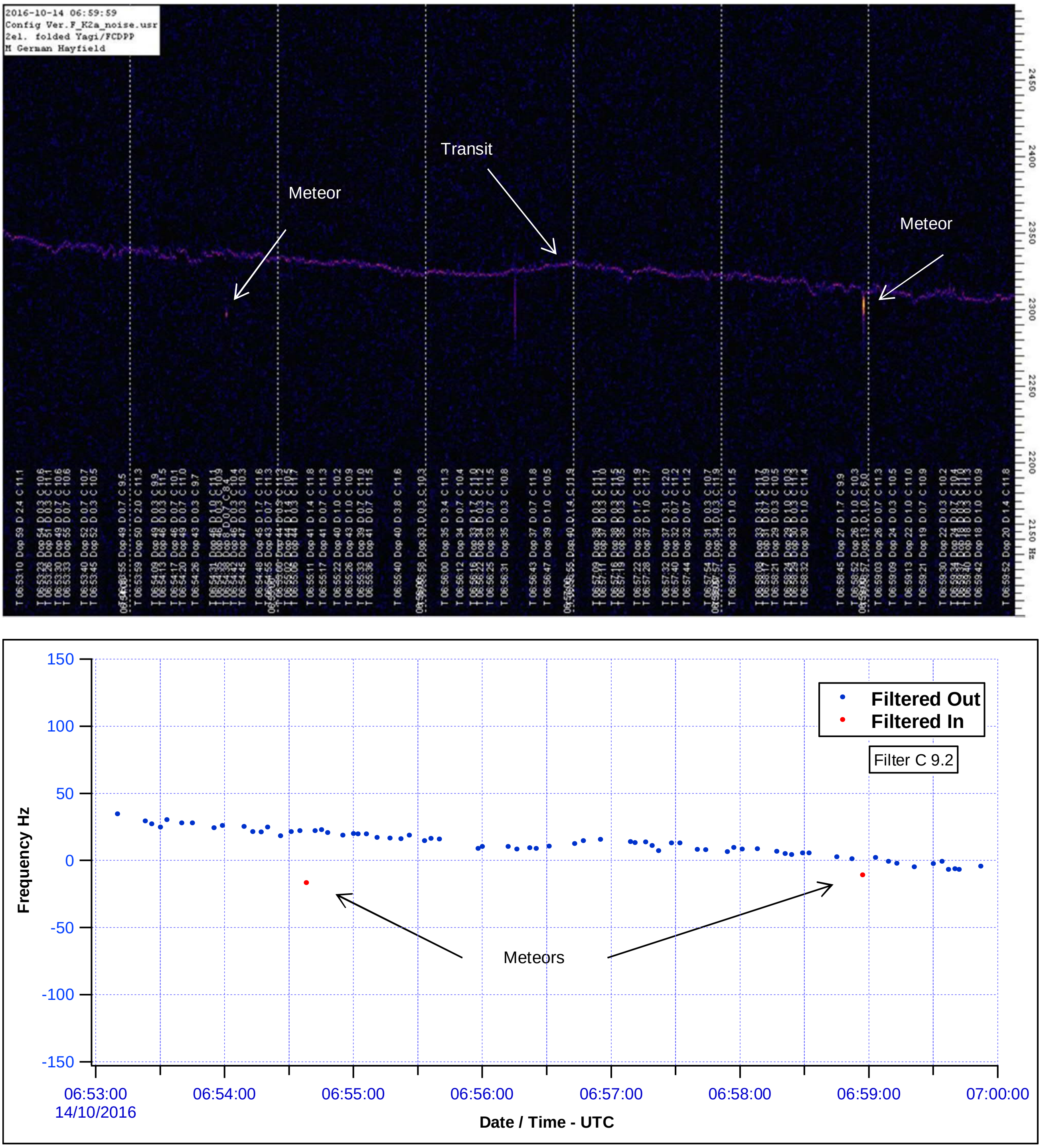

Figure A-4 Non-Meteor Event Sources - Transit

A4 Staves

Stave interference such as that shown in Figure A5 is fortunately only occasionally encountered. The source is unknown but is believed to be local because of the steady levels unaffected by the wavering atmospheric effect seen with transits. The one meteor on the spectrogam does not trigger an event because the interfering “Stave” has a duration of D 4.8 seconds (see last event label) which covers the period.

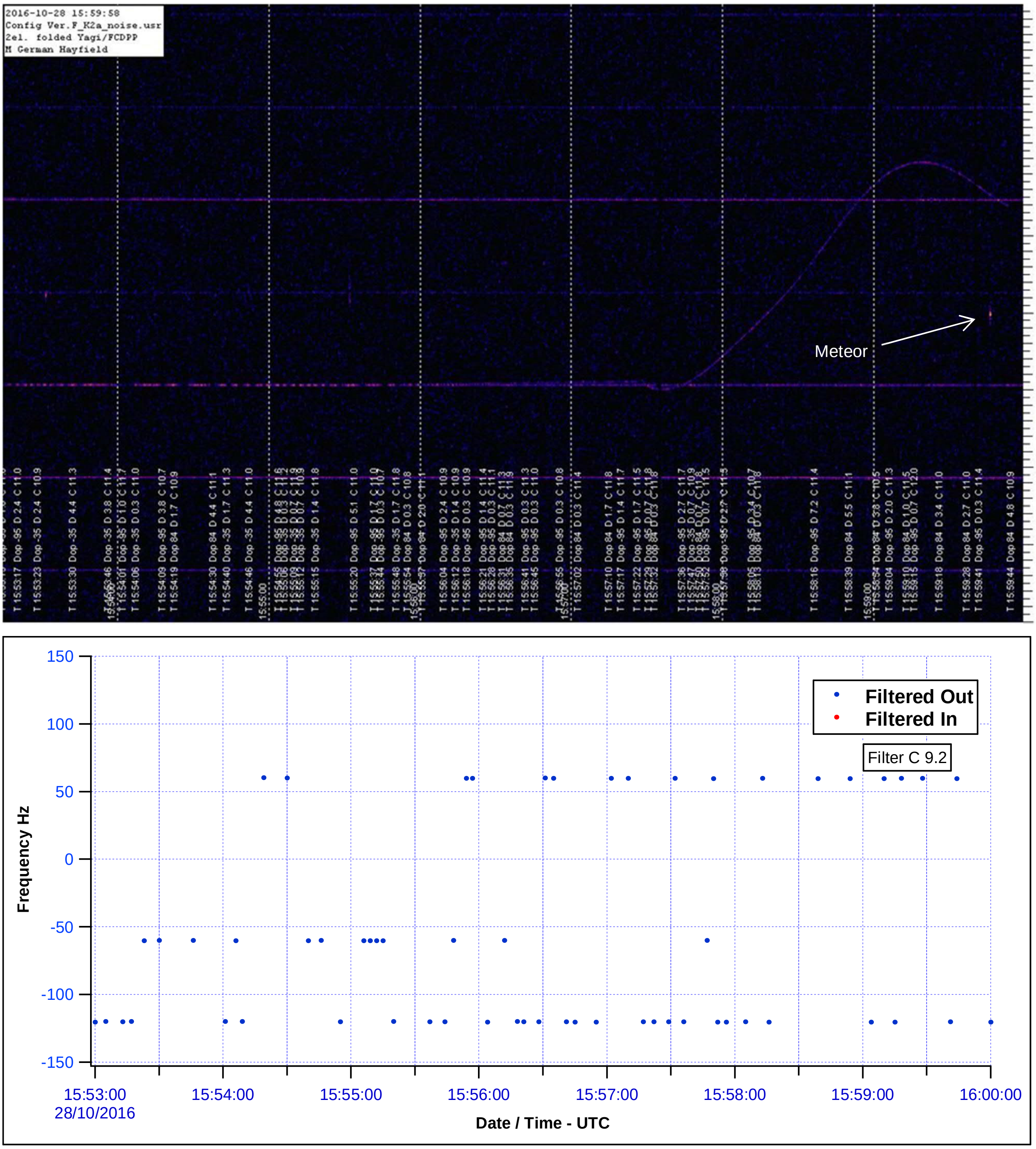

Figure A-5 Non-Meteor Event Sources - Staves

A5 Moon Bounce

During the period from 23rd November to 7th December 2016 the Moon was aligned with GRAVES and Hayfield such that **Moon Bounce** signals were recorded. The Doppler signal from the Moon would change from 100 Hz to -100Hz over a period of 3½ hours each day. The full duration of the transit signal was not evident on most days. An example spectrogram covering some 5 minutes is shown in Figure A-6.

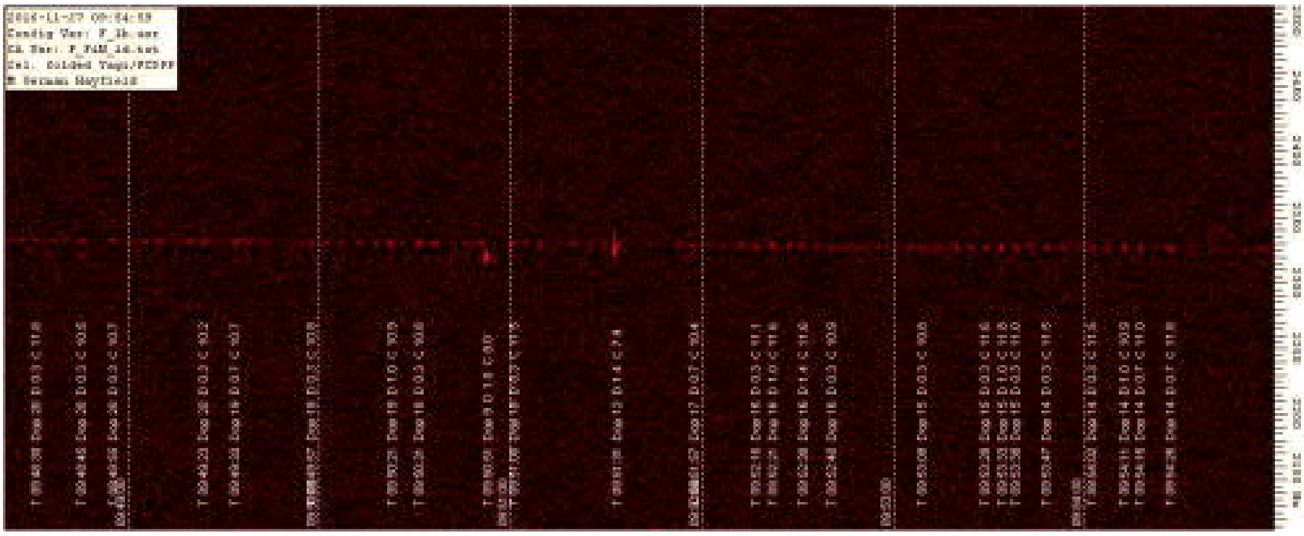

Figure A-6 Spectrogram of a 5 minute period showing Moon Bounce events

The Test C filtered events from the Spectrum Lab log for the end of November is at Figure A-7 below. The arrows indicate the start of triggered **Moon Bounce** signals. The track from these events can be clearly seen as the blue dots corresponding to Test C values greater than 9.5. **TV Noise** and **Stave** interference is also identifiable.

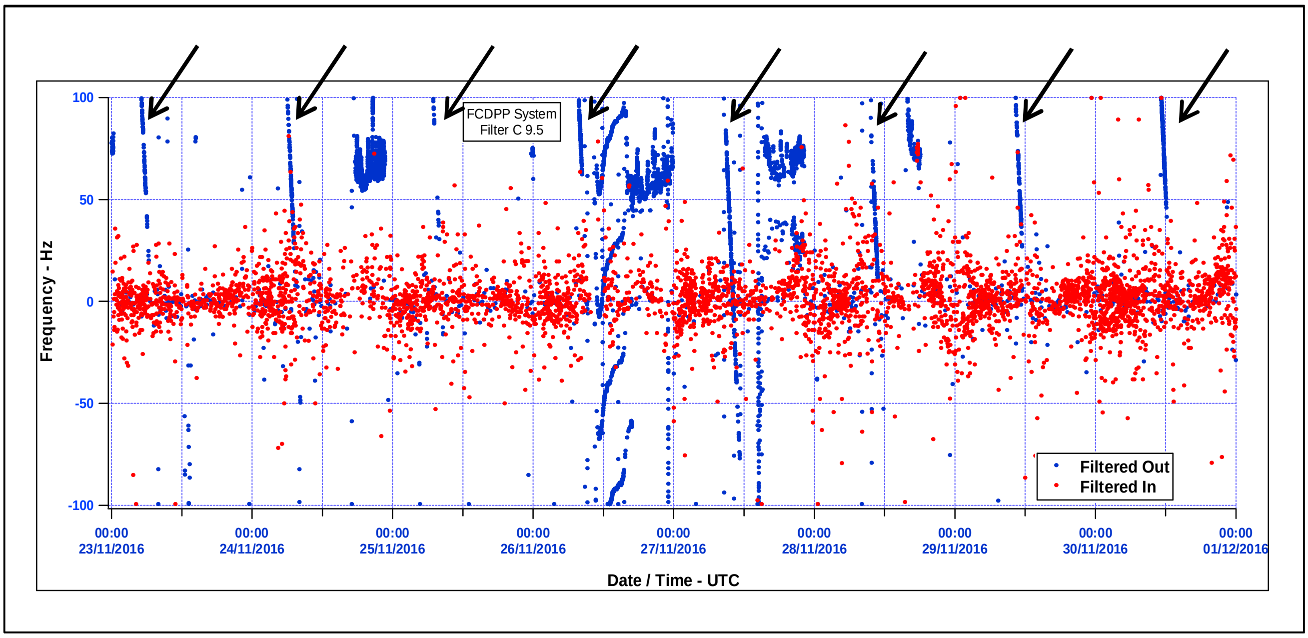

Figure A-7 Test-C filtered data over a seven day period. Arrows indicate the start of the Moon Bounce record