# Using the “Live” Streams

The receivers in the network stream their data to the central server for display. The word live is in parenthesis because the display cannot be in true real time. There are delays from two main sources,  processing which can add a few mS and transmission across the net can add up to a few seconds. None the less the meteor project “live” stream provides a very useful way of studying meteor and other ionospheric events.

Fig 1 is a “Waterfall” display. Time flows down while the horizontal scale is frequency centred on the beacon carrier frequency of 50.408000MHz. The strength of the echo is represented by brightness. Meteor echoes can feature a “head” echo, the **near** horizontal line which shows rapidly changing Doppler shift as the reflection path length changes and the meteor decelerates due to friction but with very short duration, and sometimes a “tail” echo which usually has little Doppler shift but may have  longer duration – the vertical trace in Fig 1.

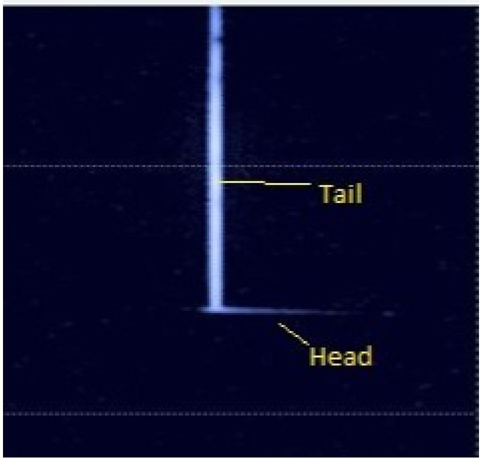


*Fig 1*

The following images show a bandwidth of +/- 30H. We have recently expanded this to display +/-100Hz. The rapidly changing Doppler shift of the “head” echo clearly identifies meteor events.

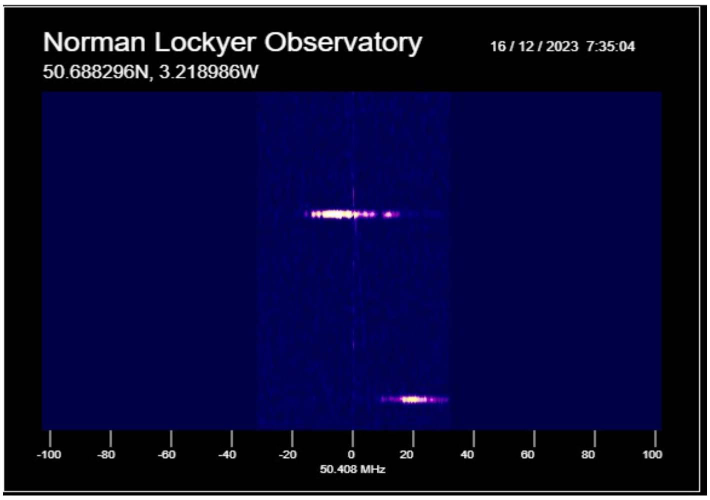


*Fig 2*

Fig 2 Shows two meteor echoes received at the Norman Lockyer Observatory.

These show the head echoes but no tails. Note that they have different Doppler shifts indicating different locations and trajectories.

Things to look out for when using the “Live” stream displays are brightness, Echo Radio Frequency and Doppler Shift. Use the the horizontal scale to measure frequency and Doppler shift .. of which more later. The duration and slope is too small to measure accurately with this display as the vertical time scale is about one minute from top to bottom and head echoes only last for a few tens of milliseconds.

If the  receiver is within about 400km of the Transmit beacon it will see aircraft echoes.

Fig 3 shows two quite strong aircraft echoes and a third feint one along with a meteor echo. Aircraft echoes  show as straight or slightly curving, near vertical lines. The offset from the centre frequency and the curves are due to  Doppler Shift which depends on the speed and direction of travel of the

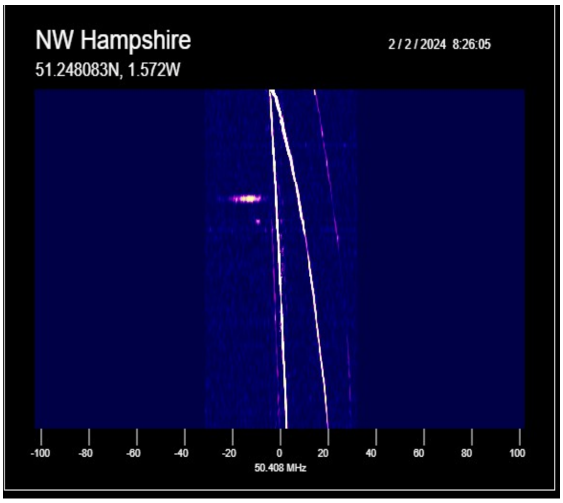


*Fig 3*

aircraft. Note that the meteor head echo is near horizontal on the live displays.

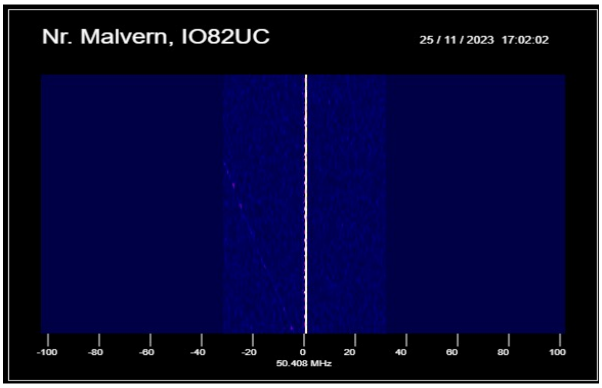


*Fig 4*

If the receiver is within about 200km of the beacon you may see a direct signal from the beacon. This will produce a vertical line precisely on the beacon frequency of 50.408000MHz such as shown in Fig 4. As radio propagation changes this signal may come and go and sometimes will reach much further than 200km from the beacon.

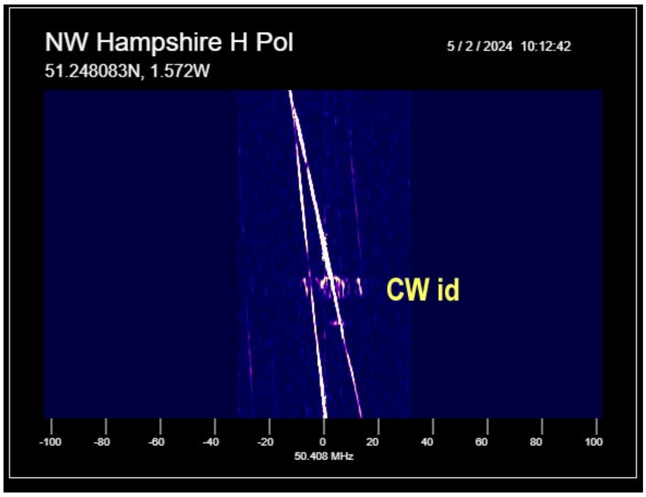


*Fig 5*

To comply with its licence requirements the beacon has to send its call sign GB3MBA every few minutes. It does this with high speed Morse code using A1A keying. This can produce a trace like that in Fig 5 if a strong direct signal or aircraft reflection is present. This is not a meteor echo. These are known as key clicks. Ideally they would not be present.

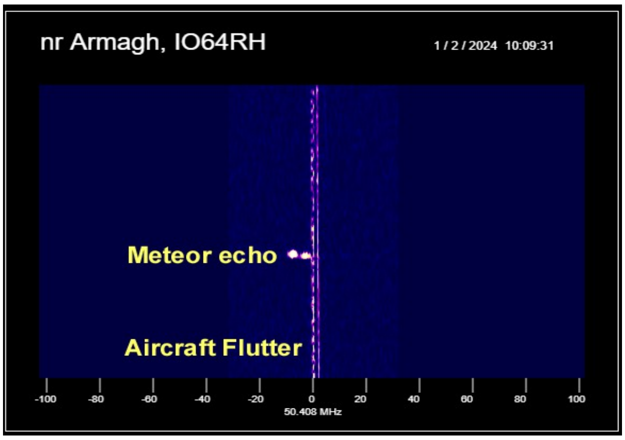


*Fig 6*

Sometimes you may see “pulsating” effects such as that in Fig 6. This occurs when two signals of slightly different frequencies interfere with one another and beat together. This might occur when two aircraft reflections with slightly different Doppler shifts are present at the same time. Or one of the signals might be direct from the beacon.

This effect is well known to radio operators, is known as Aircraft Flutter  and led to the discovery of radar.

Interference sometimes comes in bursts like this in Fig 7. The source could be man made or from lightning within a few hundred km.

If you see single or multiple lines with more or less rapidly changing frequency they are likely to be from poorly designed electronic equipment nearby.

We have tried to locate our network of receivers at radio quiet locations to minimise problems from man made interference which is the bane of radio astronomers.

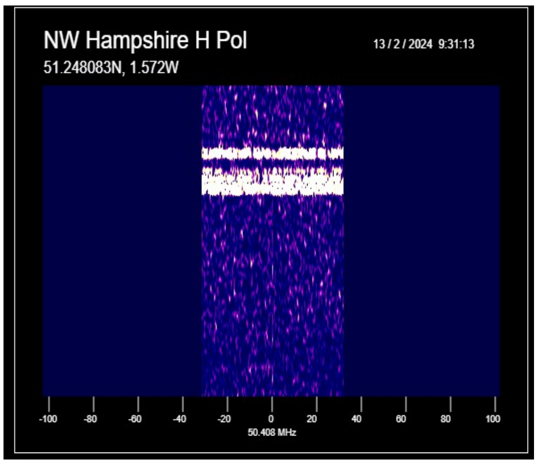


*Fig 7*

## Meteor Head echo Doppler

For the purposes of understanding head echo Doppler shift consider the meteor as a point source moving along it's trajectory but only being reflective to radio while its in the bold dotted red regions shown in Fig 8 where ionisation is strong enough to support reflection of radio. In all cases the reflection path length is changing and the meteor is decelerating due to friction. Fig 8 is a simplified plan view in 2D. Altitude is not shown or implied .

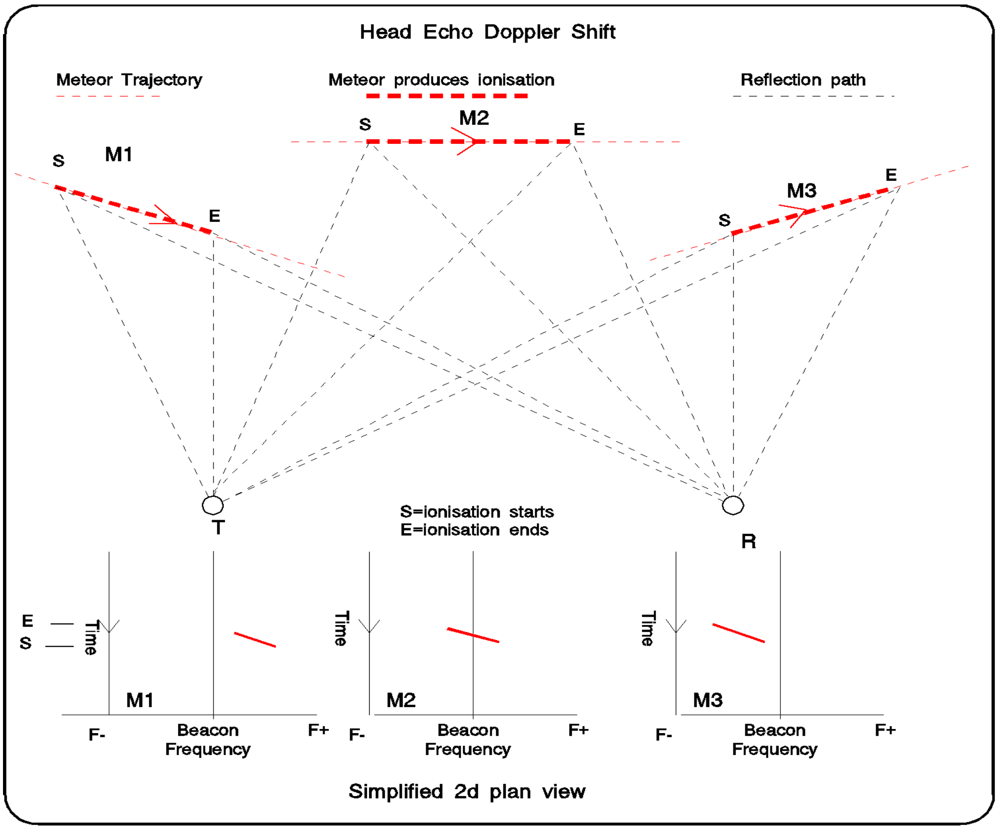


*Fig 8*

Fig 8,  shows three cases for meteor Doppler shifts along with the display expected on the waterfall marked in red. The slopes on the waterfall display will vary according to trajectory but will always be from lower right towards upper left. Meteor 1 is approaching both the transmitter T and receiver R i.e. the reflection path is reducing in length  while it starts to burn up at S creating  ionisation  reflective to radio. This will give rise to a positive Doppler shift. At point E, where ionisation stops either due to the meteor having burned up completely or because the friction is insufficient to create ionisation reflective to radio, the reflection path is still reducing so although the Doppler shift has reduced it is still positive.

In the case of meteor 2 ionisation starts while the reflection path length is reducing and ends with the path length increasing. So the Doppler starts positive at S, passes through zero and ends at E, negative . In the case of meteor 3, the path length from transmitter T to M3 and on to the receiver at R is increasing at S so the Doppler will be negative and increases towards the end of the ionisation E so the Doppler starts negative and becomes more negative. So although the slopes observed from different receivers in the network will vary, in all cases the slope of the head echoes will be from lower right towards upper left on the waterfall.  We hope to make the Raw data from the receivers available in the future. This will enable the slopes to be studied in detail while embedded timing data will enable correlation of observations from the different receivers.

## Tail echoes

Tail echoes occur when relatively static regions of ionisation remain after the meteor has passed through it. Tail echoes do not always form but when they do they can last for tens of seconds and sometimes longer. At the altitude where meteors burn up creating the head echo the Ionosphere is already more or less ionised .. the clue is in the name. But until triggered by the passage of a meteor or other events which may include wind shear, the electron density is not sufficient to reflect radio. As these ionised regions are relatively static in the ionosphere the reflections exhibit relatively little Doppler shift and what there is is due to the ionisation drifting in the wind. Meteorologists use this to measure wind speeds at this altitude which is too high for balloons, too low for satellites and too expensive to reach with rockets !

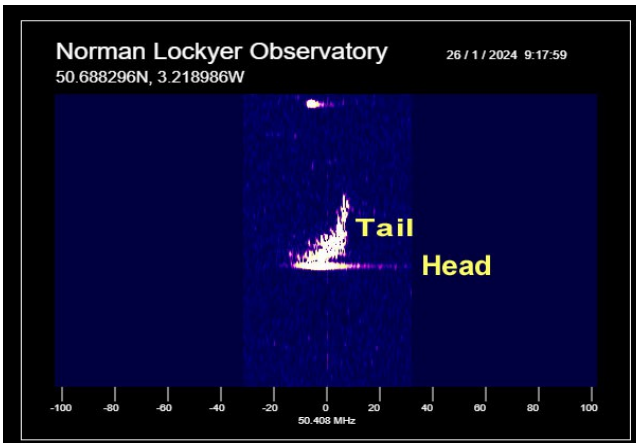


*Fig 9*

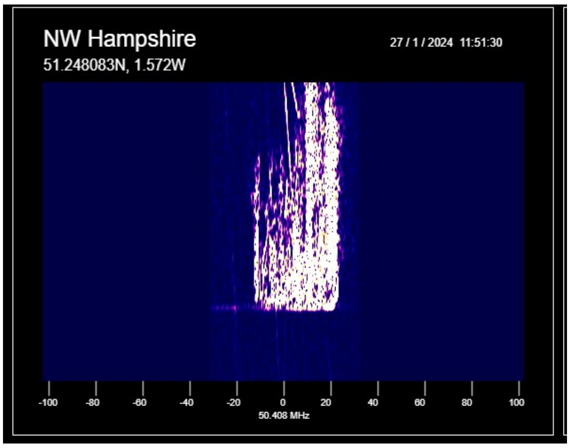


*Fig 10*

Fig 9 shows a head echo followed by a tail lasting a few seconds. While Fig 10 has no obvious head echo but the clearly defined straight, sloping bottom of the trace  suggests a head echo.  Observations have shown that head echoes are highly directional at the 6m wavelength. This is due to the ionisation causing them  being cylindrical, even wire like with a diameter smaller than a half wavelength. Observations using cross polarised antennas demonstrate that tail echoes can be polarised too. In Fig 10 the tail echo lasts more than 20 seconds. Note the wide spectral spread / range of Doppler shifts, suggesting the ionised region encompasses a range of wind speeds.

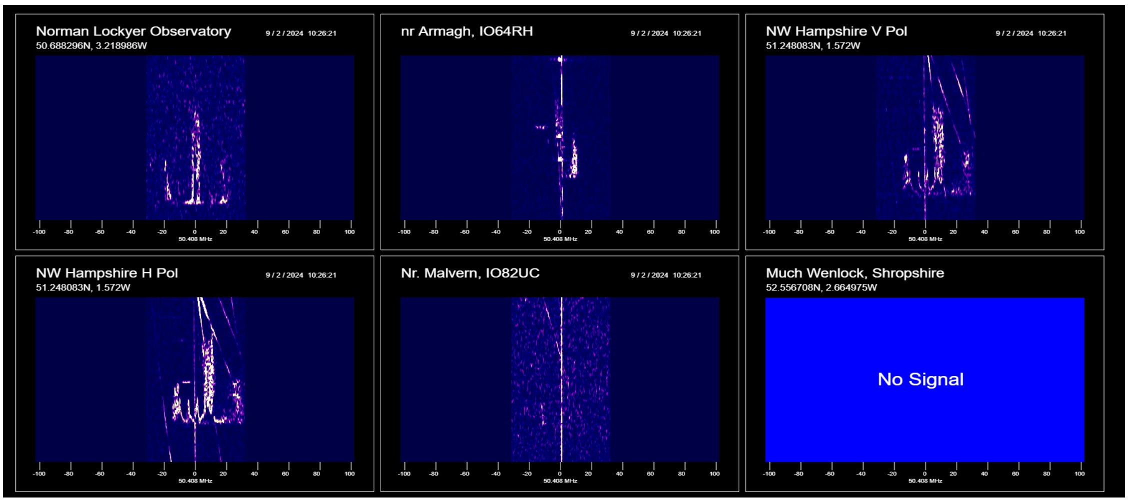


*Fig 11showing the same echo viewed from different directions and with both Horizontal and Vertical Polarisation*

Tail echoes viewed with this high resolution can be spectacular and have weird shapes that need explanation.   The display bandwidth has increased to +/-100Hz recently.

## What to expect

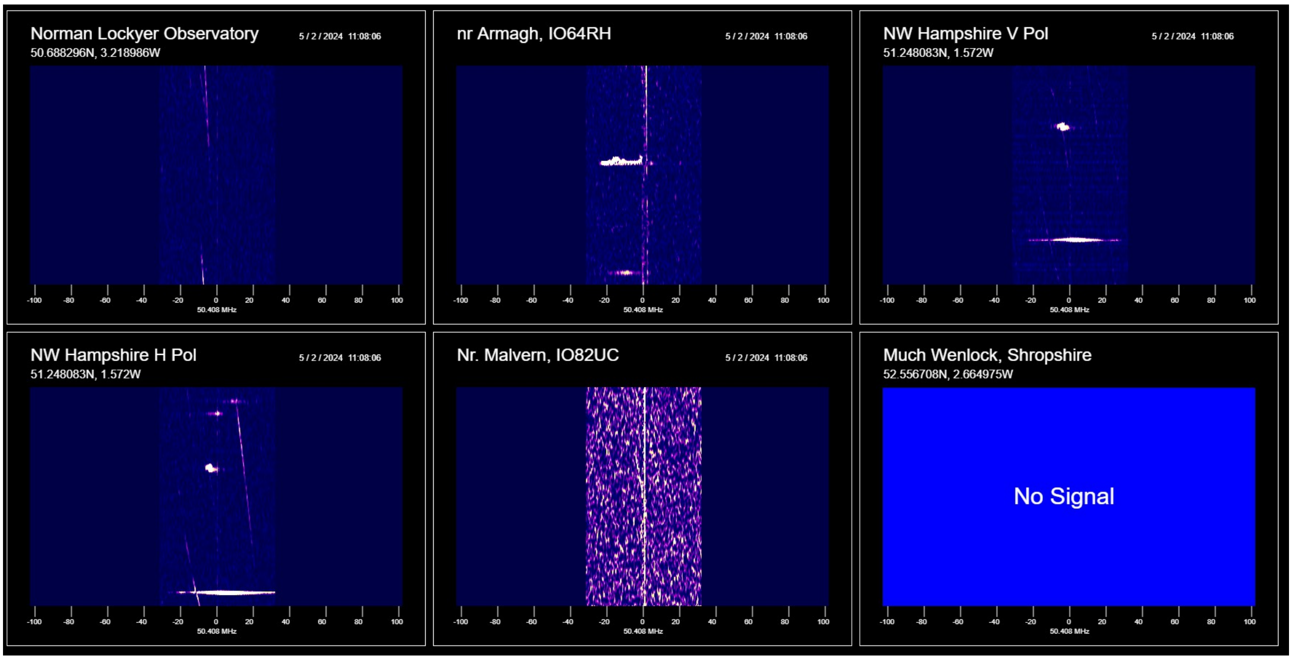


*Fig 12*

Fig 12 shows three events seen by the North West Hampshire receiver with horizontal polarisation but only  two of them are seen with Vertical Polarisation from the same location  and by Armagh. Norman Lockyer sees neither and Malvern, which has an indoor antenna in an attic has some interference, an aircraft echo and a direct signal.

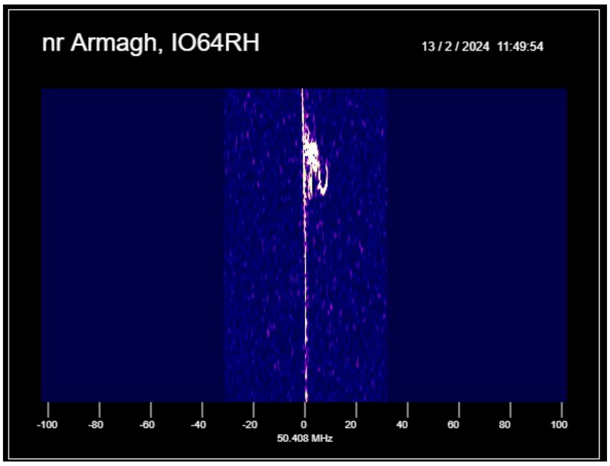


*Fig 13*

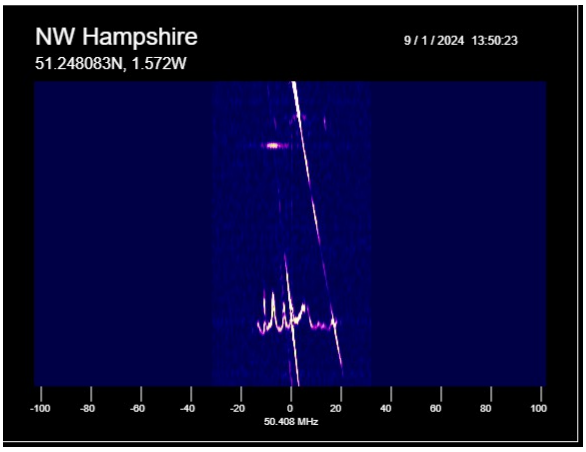


*Fig 14*

From time to time you will see strange shaped echoes such as those in Figs 13  and 14. Like head echoes these are sometimes directional and polarised. Maybe we can learn something of the state of the ionosphere from such echoes?

We plan to make the raw data from the receivers in the  network available for more detailed research. This will be in the form of an I/Q audio stream and will include precision timing so that the data from different receivers can be correlated. Correlation of radio echoes with optical observations would be an area of interest.