UK Meteor Beacon

Introduction & Progress Report

Project Objectives

- To provide a means of observing meteor events over the UK by day and by night
- To encourage interest in Radio and Astronomy by developing interesting STEM projects for schools and colleges building on the interest in space.
- To provide a means of studying meteor events in detail with higher resolution.

Science Objectives

1. Accurate meteor counts to assist in identifying new meteor streams and detecting outbursts in current ones. Show meteor rates of showers over subsequent years
2. Show meteor peaks of known showers hour by hour
3. Cross correlation of radio traces with BRAMs and Graves beacons. Comparing time, frequency, intensity, Doppler shift, duration
4. Cross correlation of radio traces with UKMON video camera observations
5. Compute trajectories of meteoroids using data from multiple receiving stations determination of meteor stream orbits and potentially narrowing down the landing locations for meteorites
6. Study the impact of high-altitude winds on the plasma trails
7. D and E layer studies of the ionosphere
8. HF/VHF emissions from meteors
9. Estimation of the mass index of a meteor shower
10. Calculate meteor fluxes
11. Insights into meteoroid fragmentation processes

Planning

- Phase 1
  - Establish a transmitter beacon at a central point in the UK
  - Encourage STEM and citizen science projects featuring radio astronomy
- Phase 2
  - Establish an initial network of 3 receivers streaming their data via a central server where those studying meteor events over the UK can access the data, initially in the form of a waterfall display.
- Secure funding for this work

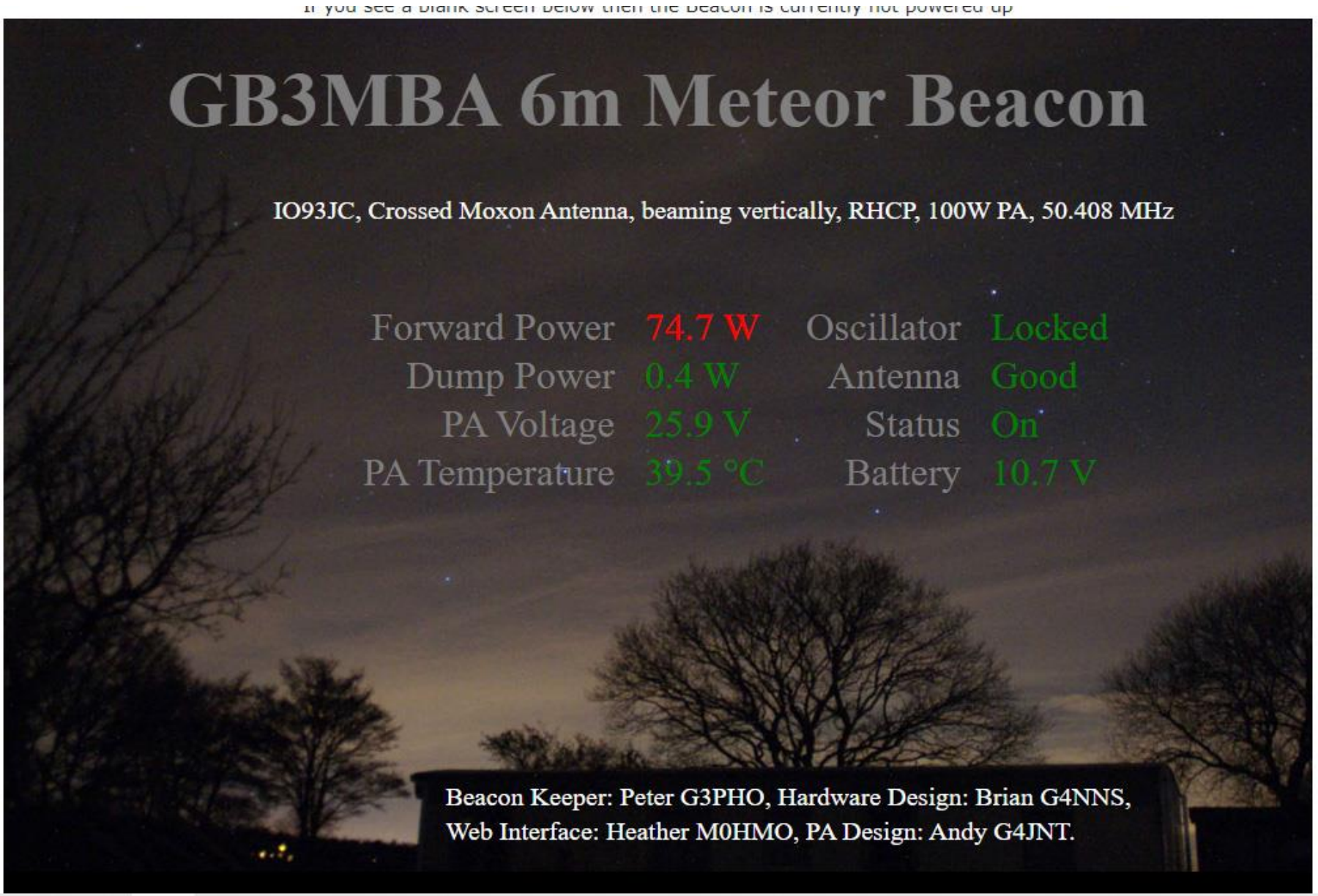
Progress & next steps

- Phase 1:
  - The transmitter beacon is operational.
  - Funding has been secured for the beacon and 3 years operating costs.
  - This project has been supported by the RSGB Legacy Fund and the British Astronomical Association
- Phase 2:
  - The receivers are under development, and the first unit is ready for deployment
  - Streaming servers and associated software are well advanced
  - Funding received for 3 receivers

UK Meteor Beacon Phase 1

The Beacon was installed at the Sherwood Observatory of the Mansfield and Sutton Astronomical Society on 14th May 2022.

The Beacon Hardware



The beacon status can be found at
https://ukmeteorbeacon.org/Bstatus

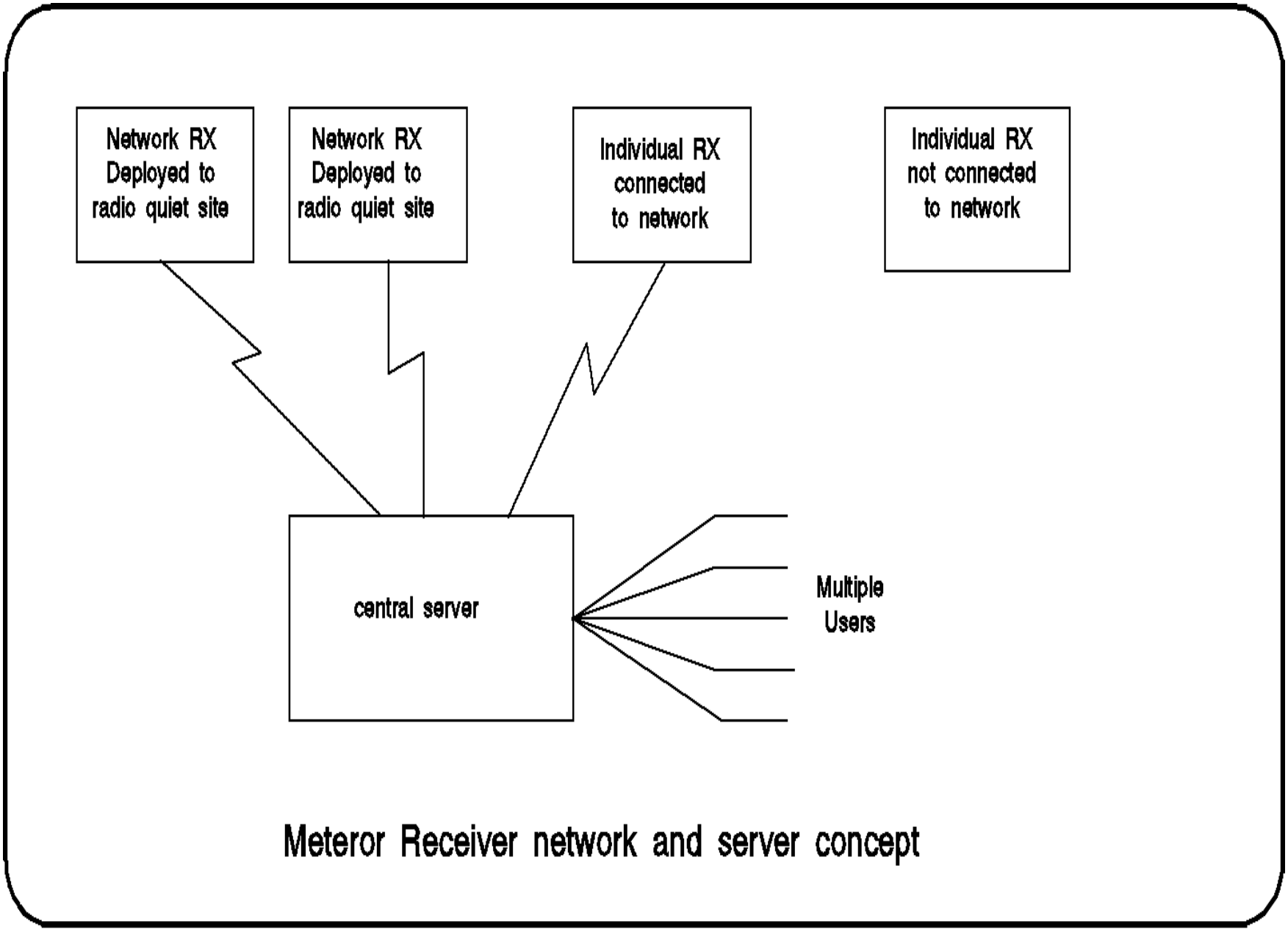
Phase 2: Objectives

- Not everyone will be able to build their own receiving system.
- Some will not have space for an antenna or may live in an electrically noisy environment.
- Phase II of this project is to design, build and deploy a number of web based receivers accessible to all.

Phase 2: Progress

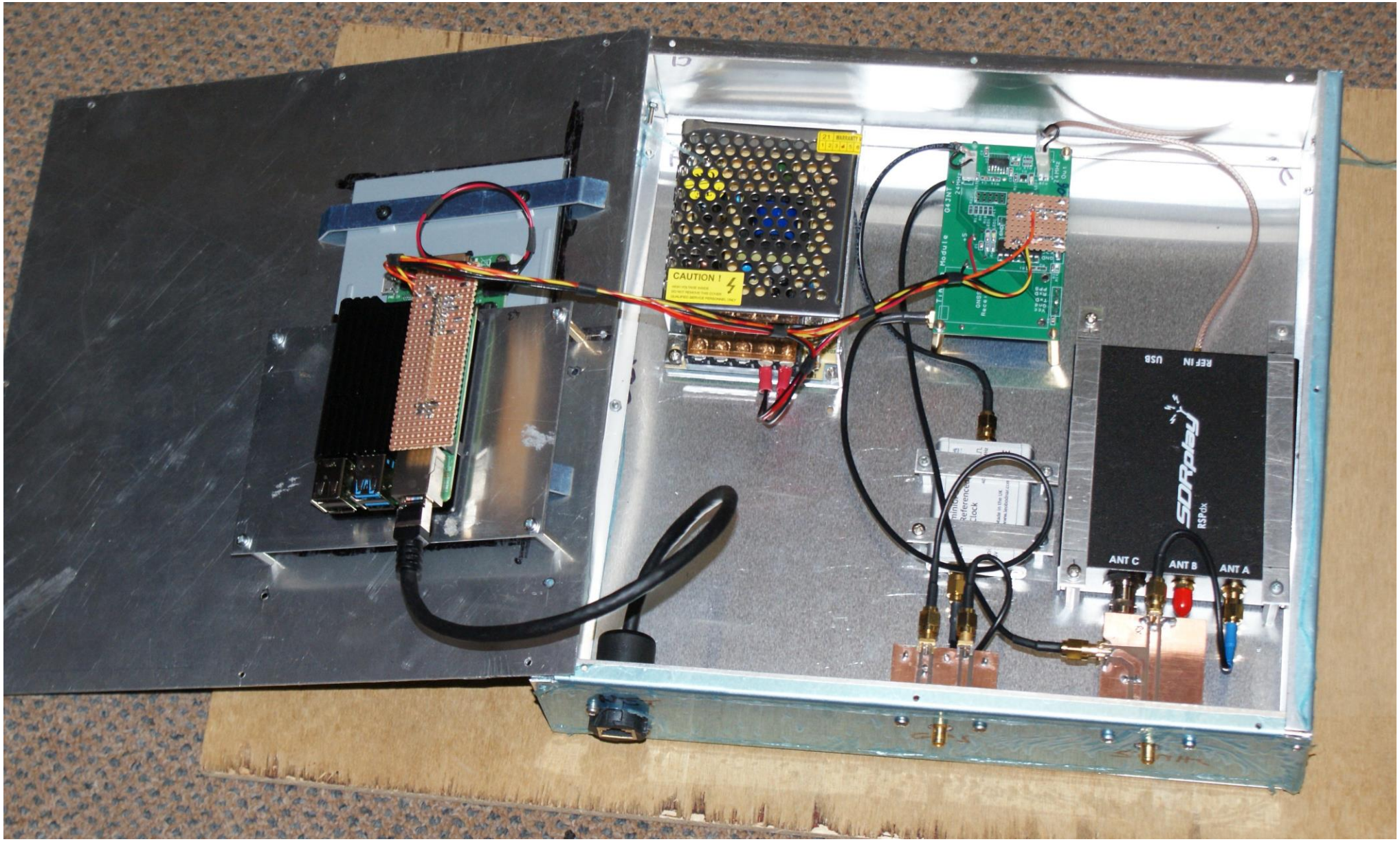
- Receivers
  - Receiver hardware design complete and first unit ready for installation
  - Need to provide reliable timing data (100µs)
  - Streaming software and hardware integrated into receiver
- Servers & Software
  - Software under development.
  - Demonstration system operational for Persides

Architecture

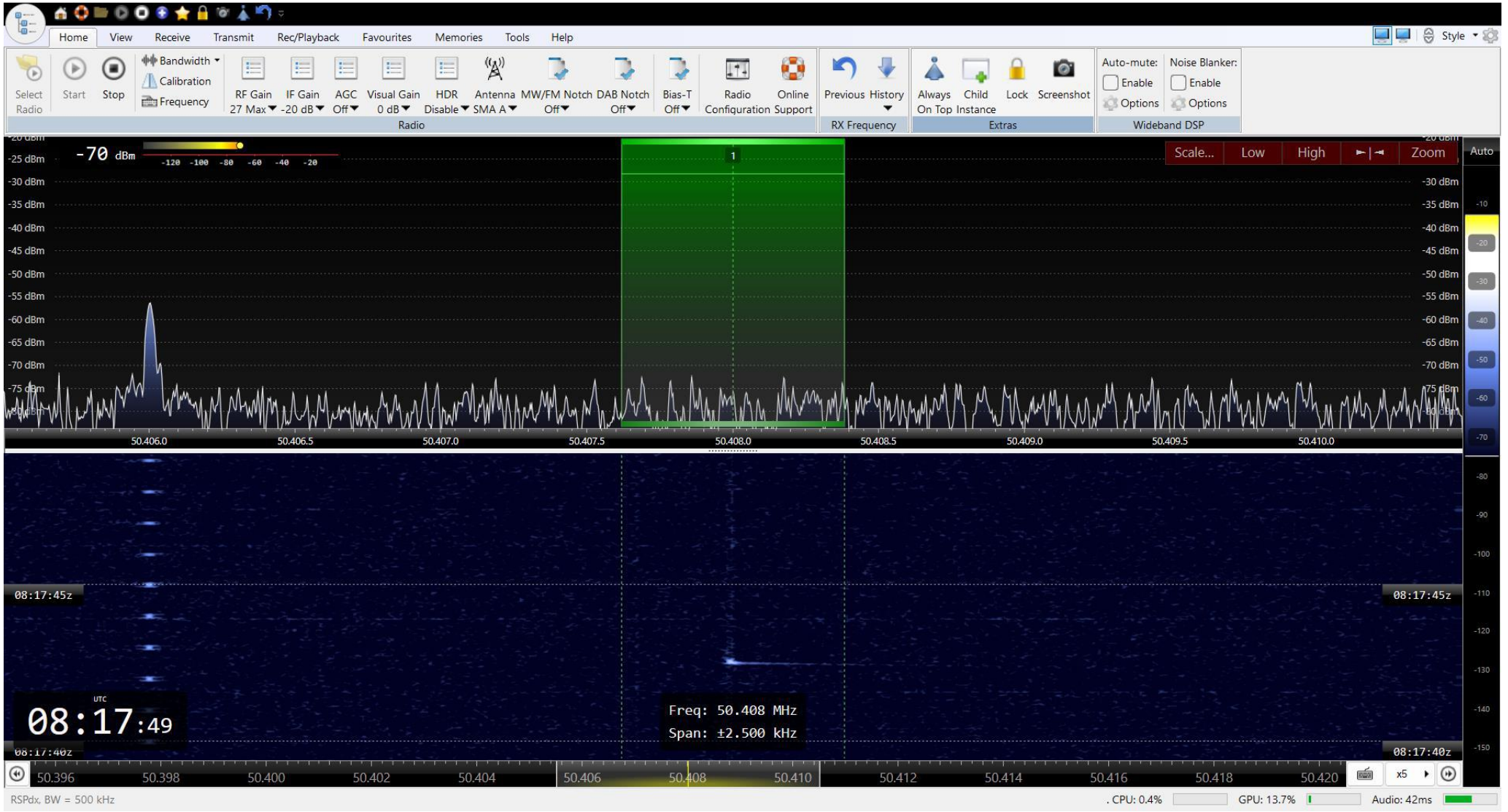


Meteor Receiver network and server concept

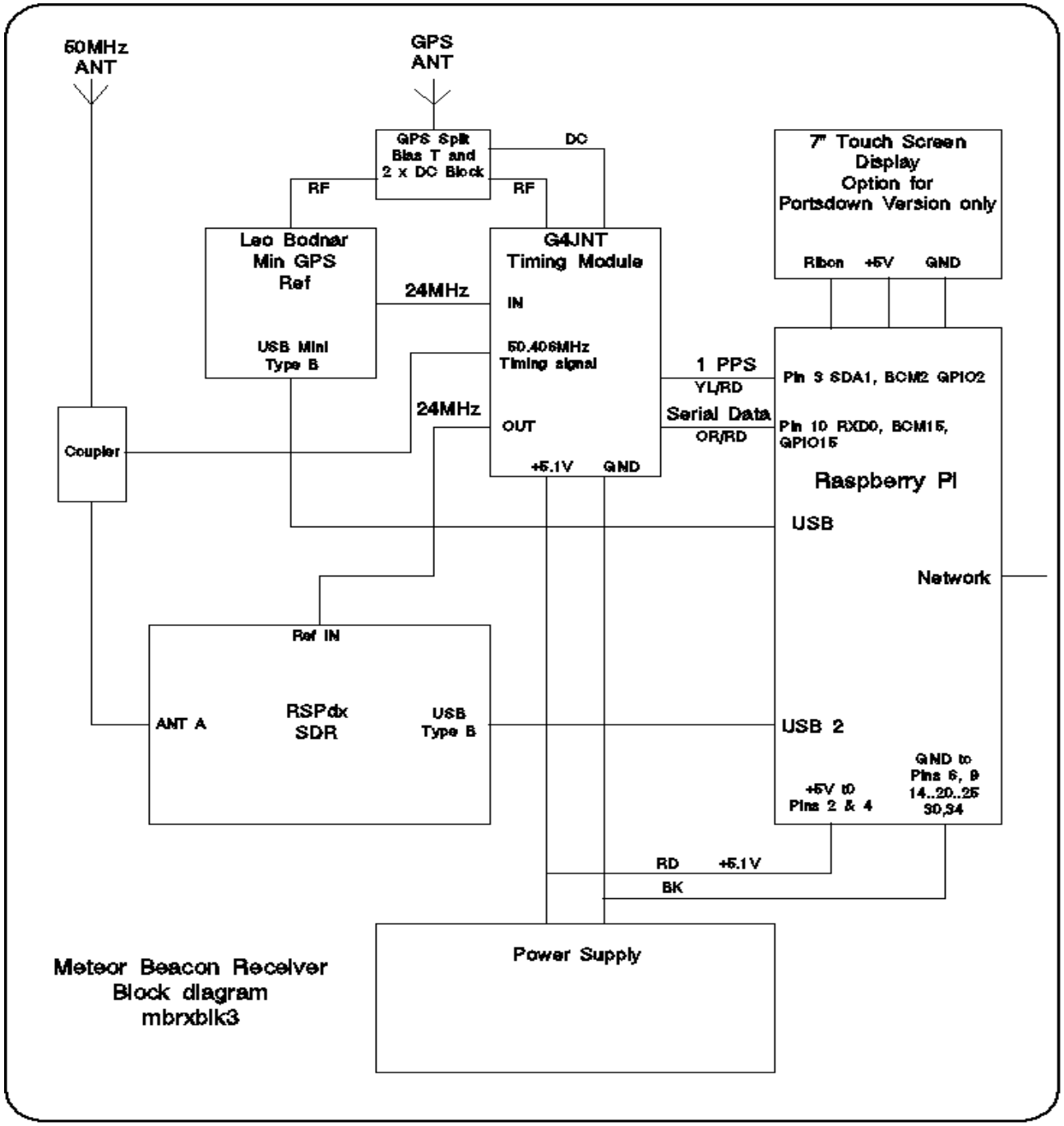
Receiver Design



Precision Timing

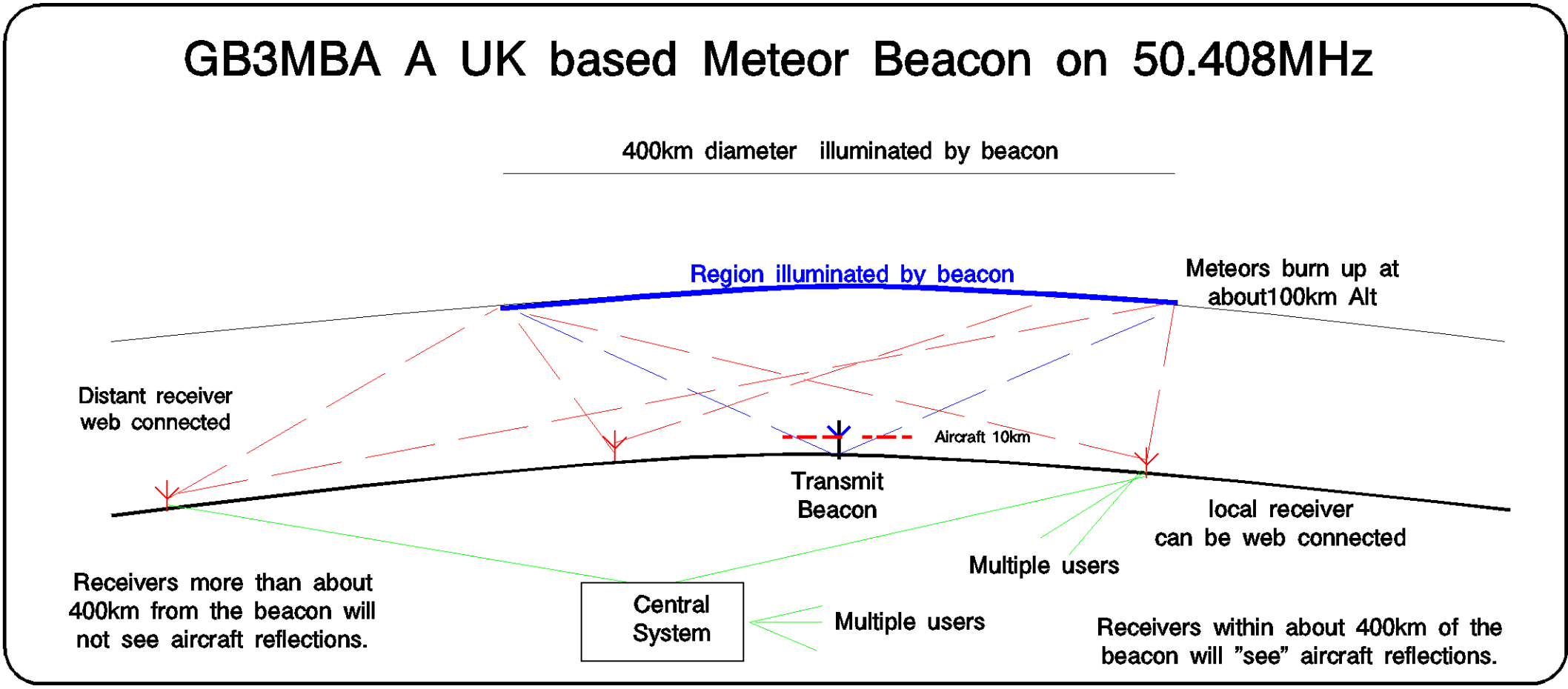


Timing pulses are injected into the receiver at 50.406MHz.
The leading edge is synchronous to UTC and their duration is used to encrypt the date, time and receiver I/d.



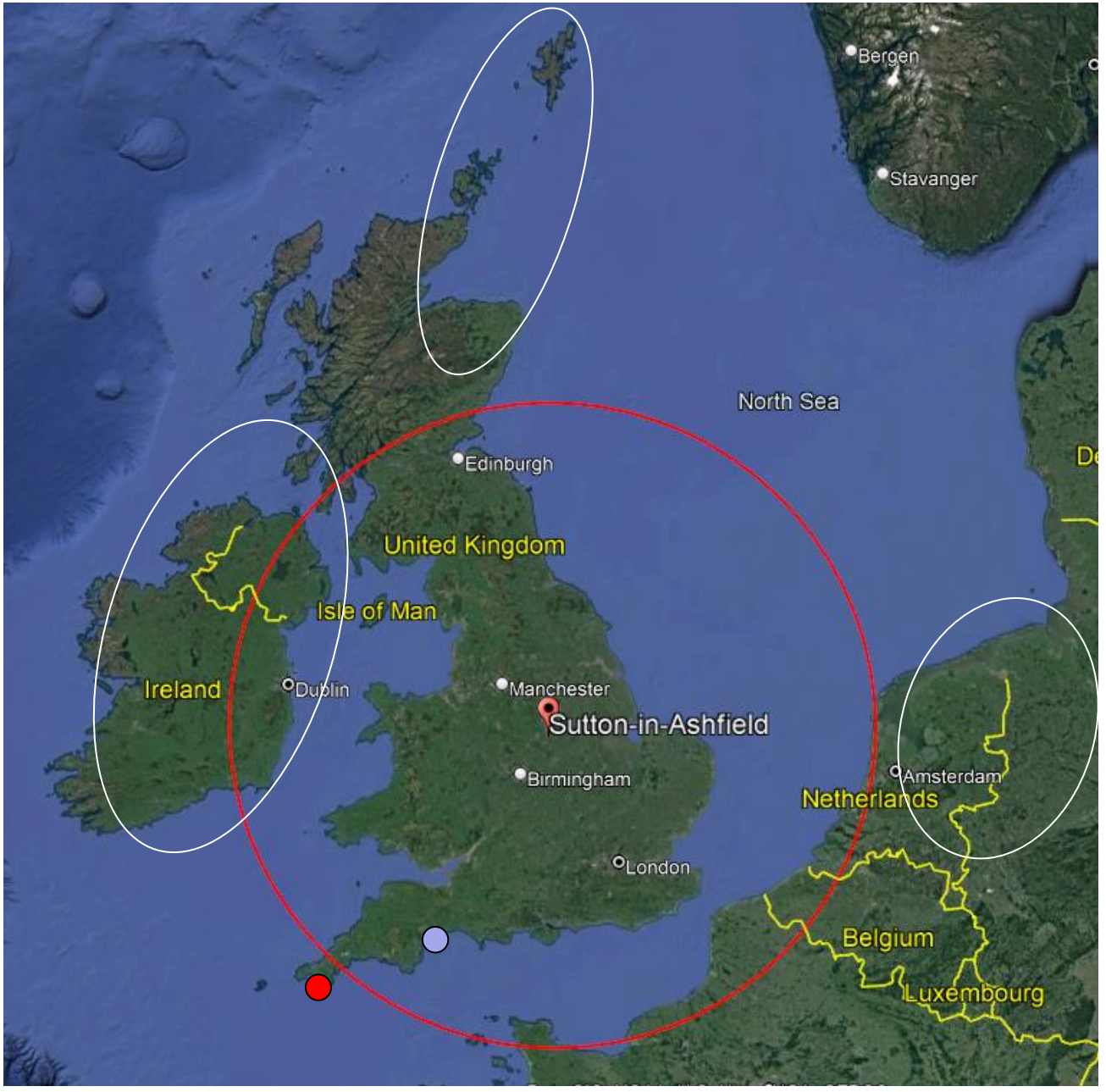
The team are currently working on the design of the receivers.

Receiver Location



The beacon “illuminates” a region with a radius of about 200km. Echoes from meteor trails can be seen as far away as about 1200km while receivers within about 400km of the beacon will also see aircraft reflections.

Networked receiver locations



Site search criteria:

- Preferably over 400km from transmitter to avoid carrier reception
- Less than 1200km from transmitter to receive adequate signal

Possible locations:

- North Scotland, Shetland
- Ireland
- Europe?

Test receiver at Norman Lockyer Observatory Sidmouth

Potential site:
Goonhilly Down
Cornwall

Live streaming

Devon: https://batc.org.uk/live/gb3mba2

Hampshire: https://batc.org.uk/live/gb3mba

These live streams may not work with Firefox.

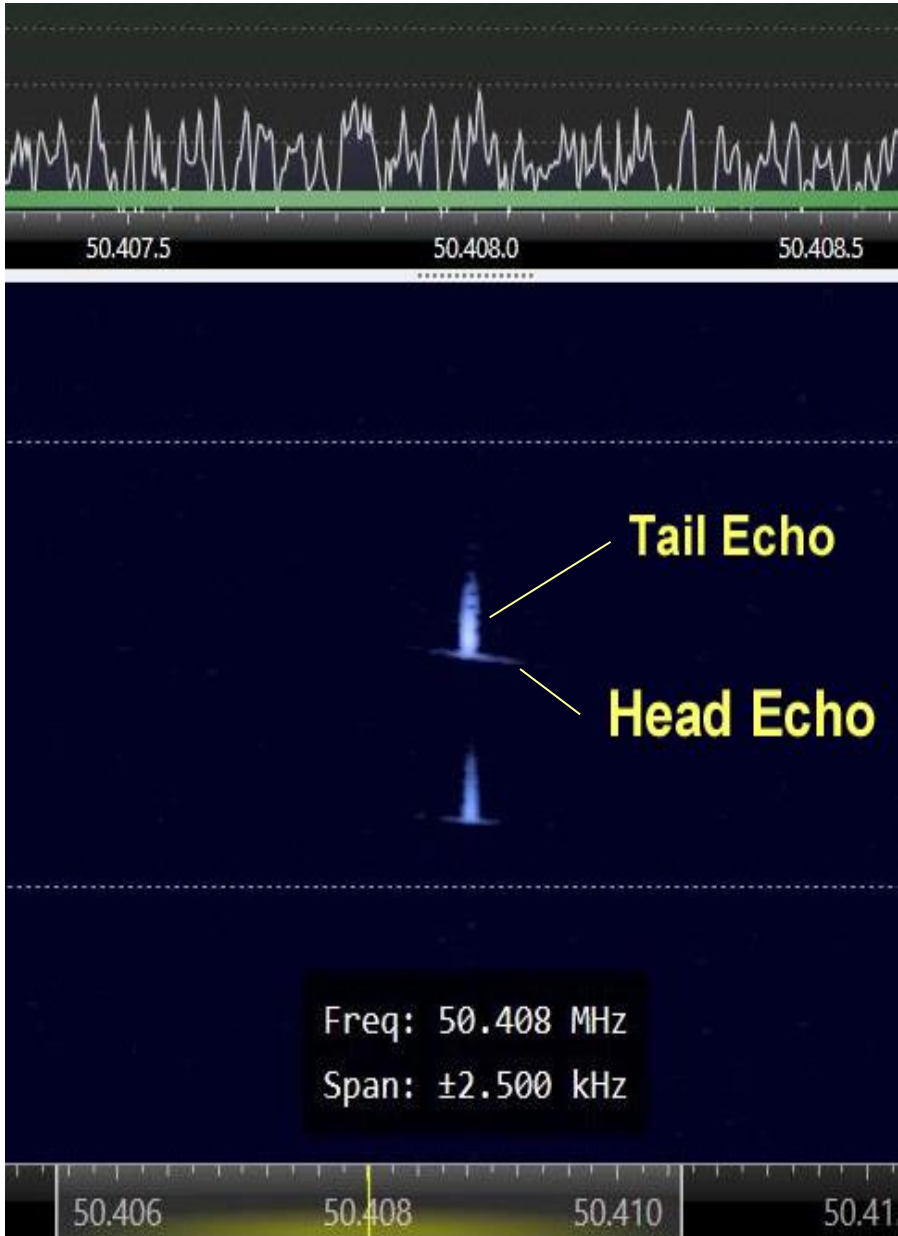
Phase 3: Science

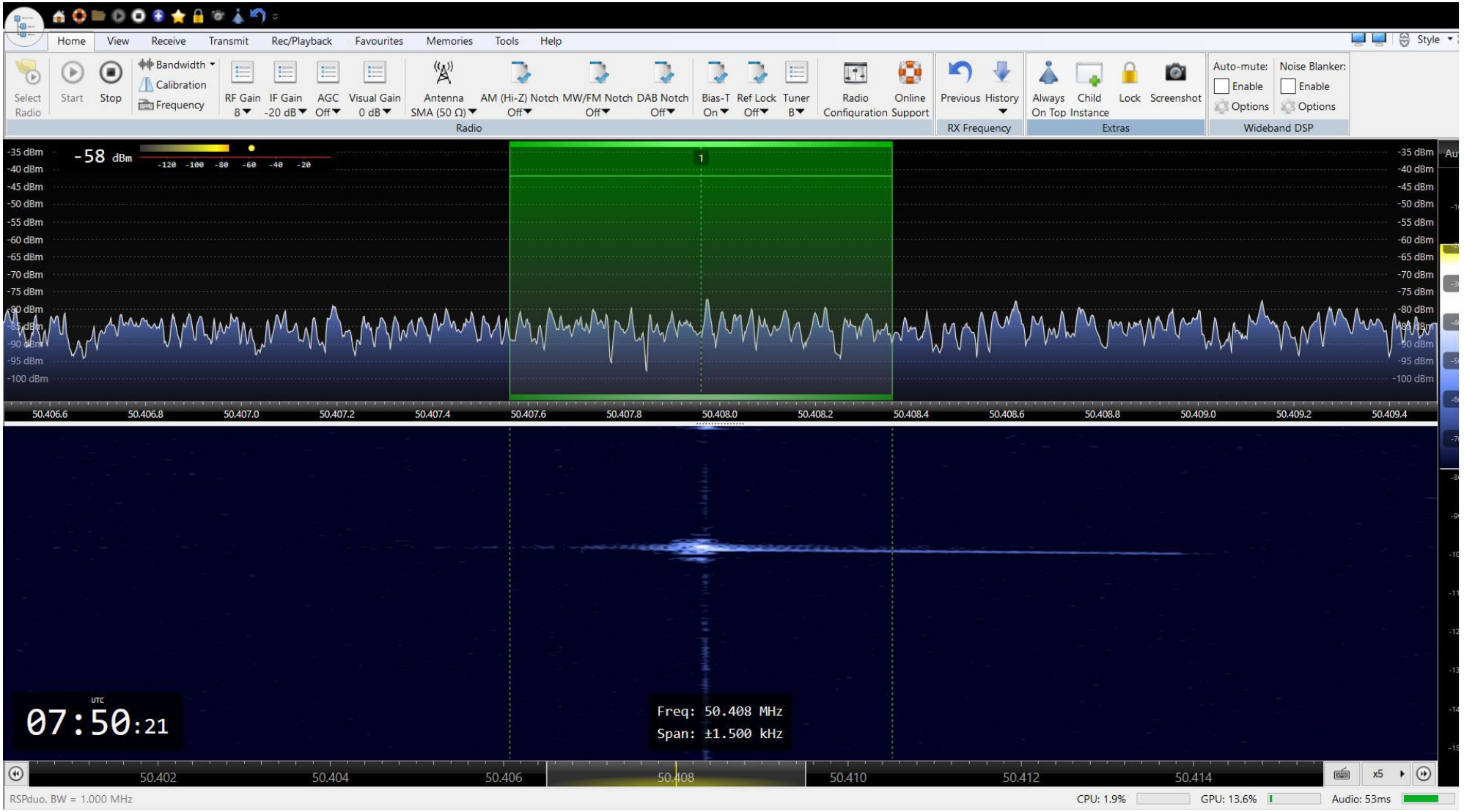
- We believe it may be possible to compute the velocity and trajectory of a meteor using the Doppler shift of head echoes measured at an instant and from multiple locations.
- Head echoes are polarised and directional so not all observers will see them.
- Timing and frequency between receivers needs to be precise.
- Complex signal processing required.
- Automated pipeline to detect events and flag for analysis.
- There are many challenges to achieving our ambition of triangulating the location and trajectory of meteors without using a pulsed radar system which would not be permitted.

Questions

Anatomy of an Echo

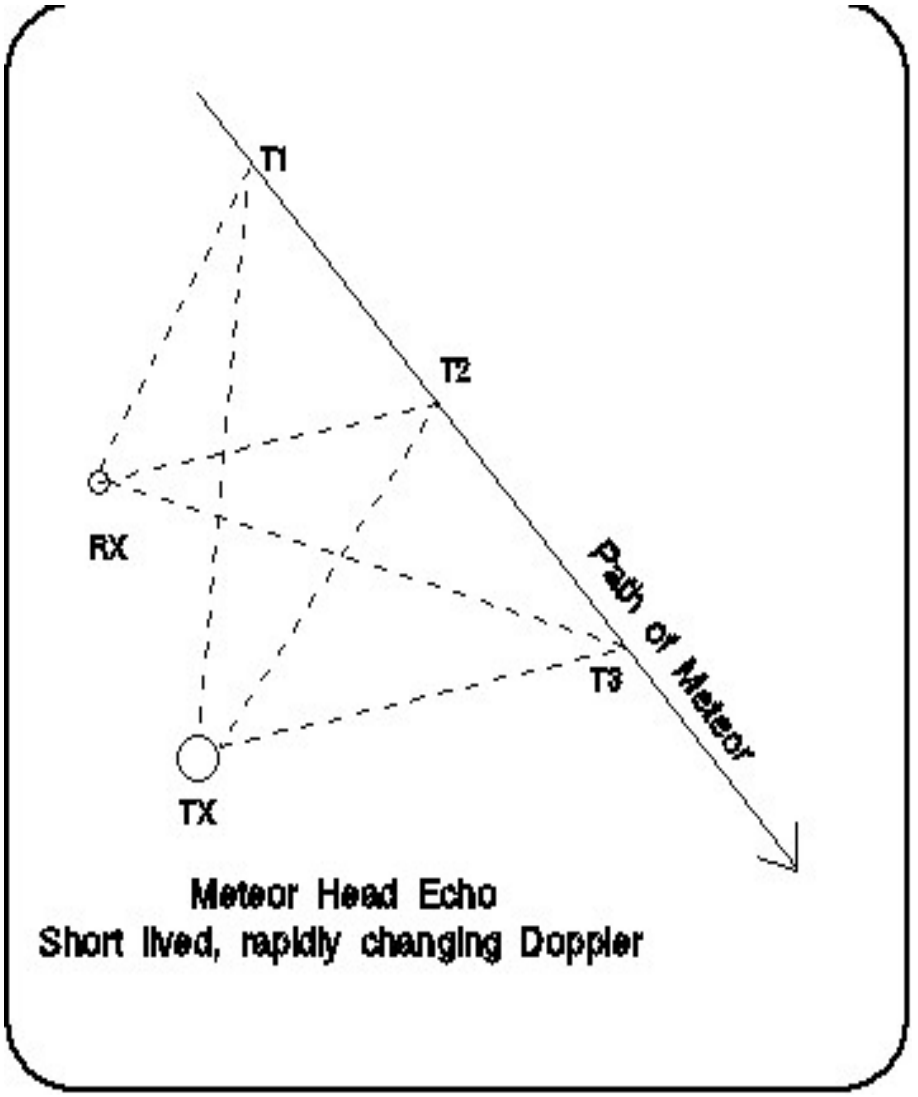
- Meteor echoes usually exhibit two components.
  - A “head” which is very short lived, less than 500mS and which exhibits rapidly changing Doppler shift.
  - A “Tail” echo with little Doppler Shift and lasts much longer from seconds to minutes. Tail echoes are used for Meteor Scatter Communications.



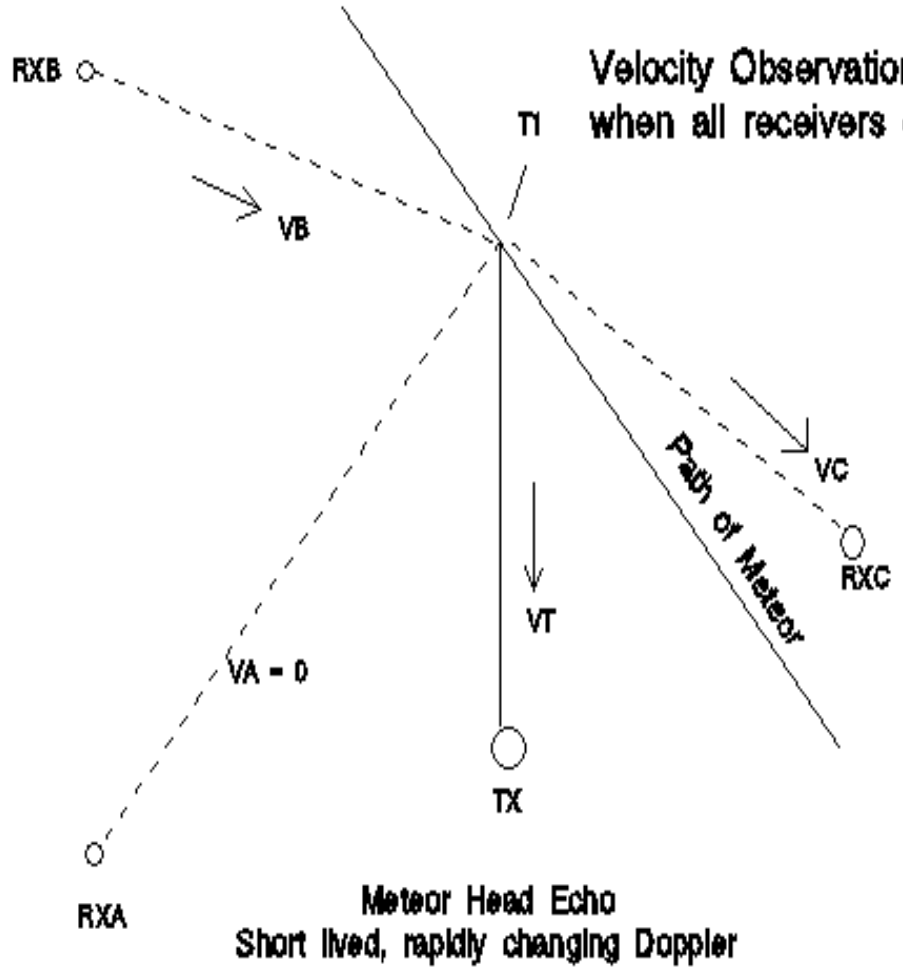


Viewed in detail this head echo starts at about +1KHz and ends at about – 400Hz. There is little or no tail echo.

Head echoes barely get a mention in most studies of meteor radio echoes.



The Doppler shift at a given instant is a function of the rate of change of the path distance from the beacon transmitter, via the meteor and on to the receiver.



Velocity Observations made at an instant T1
when all receivers can "see" a head echo.

VA approx 0 so Doppler
measured at RXA is due to VT

The Doppler observed at RXB
is likely to be close to zero.
VB is negative so VB+VT =
approx zero.

The velocity Observed at RXC
is VT+VC

Meteor Head Echo
Short lived, rapidly changing Doppler

A simplified 2 dimensional analysis of meteor velocity for triangulation.