

With Paul Hyde

How to

Use radio signals to catch meteors

PART 1

You'll need an aerial to pick up meteors – here's how to build one

You should mount the finished aerial at least 3m above ground level



Meteor scatter is a technique for observing the radio signals reflected from a meteor's plasma trail, which is created as a space rock meets Earth's atmosphere. The big advantage – compared to traditional observing with the naked eye or binoculars – is that you can use this technique to look for meteors during daylight and in all weather conditions.

But it's more than just a way of detecting meteors: meteor scatter can tell you more about them. It provides a way of building up your own record of meteor activity that you can then compare with your visual observations or against previous shower profiles. It also reveals the line of sight velocity of meteor trails, and shows how the trail evolves and disperses. Unlike the momentary flash of a meteor in the visible part of the spectrum, radio reflections can last for a minute or more.

The first thing you need for meteor scatter is to find a radio transmitter that you can't normally pick up from your location – there is a high-power radar

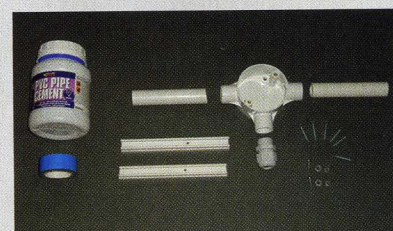
system near Dijon in France transmitting on 145.05MHz that provides an excellent source. You then need an aerial to receive this signal after it has been reflected off the meteor trail, plus a receiver and software to record the result. This month, we're going to explain how to build a suitable aerial; next month we'll cover how to set up the receiver and start recording meteors.

Facing the elements

The aerial described here is based on the G4CQM MetScat design and can be built with materials available from most DIY stores. The important parts are made from 15mm copper pipe: a reflector element at the rear of the aerial; a director element at the front of the aerial; and between them a dipole, connected to the receiver via a length of coaxial cable – we'd recommend the RG-58 type. If possible, get a 'military spec' version as this suffers less signal loss.

The reflector and director are called parasitic elements (because they have electrical properties but are not connected to anything, unlike the dipole). They give an almost ►

TOOLS AND MATERIALS



CABLES

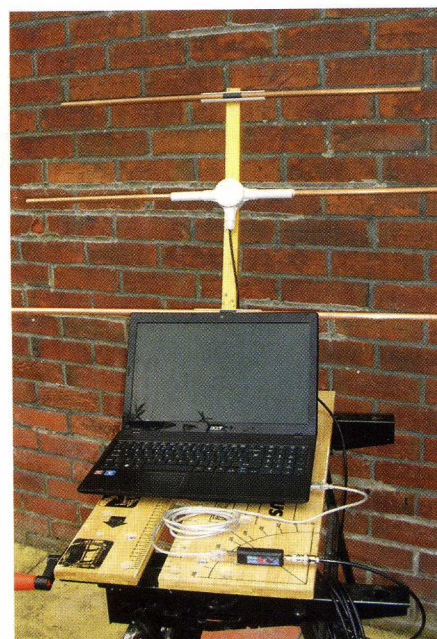
RG-58 coaxial cable and a connector

MATERIALS

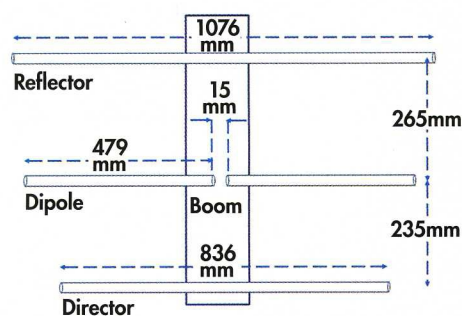
550mm of 32x32mm varnished timber, 3m of 15mm copper pipe, two 150mm lengths of 16x16mm electrical minitrunking, two 100mm lengths of 20mm electrical conduit, three-way 20mm electrical junction box, 20mm cable gland

TOOLS

Hacksaw, screwdriver, drill, set square, craft knife, insulating tape, sealant/adhesive, screws, washers



▲ Next month, we'll discuss the software you'll need to use your aerial to record meteors



▲ Accurately positioning the elements on the boom is critical if you want an effective aerial

► three-fold increase in sensitivity, provided the dimensions given here are followed. These are mounted onto an insulating wooden boom, which forms the aerial's backbone.

The boom keeps the elements parallel and at the right spacing, and provides a mounting point for the aerial. The boom needs to be at least 550mm long, well varnished, and sturdy enough to withstand high winds and roosting birds. Think about where you are going to mount the finished aerial – it may be that using a longer boom will make things easier. Standard electrical fittings are used to attach the elements to the boom and to provide a waterproof enclosure to protect the connection for the coaxial cable.

The aerial should be mounted outdoors, ideally within 10m of your receiver and computer, and preferably at least 3m above ground level. How you mount it depends on your circumstances, but it needs to be secure enough to cope with strong winds and have a reasonably unobstructed path towards the southeast – the direction of Dijon. Nearby buildings of two or three storeys are not a problem, but if you have a substantial hill in the way you are unlikely to receive anything.

Most people mount the aerial with the elements vertical, but our experience is that this doesn't make too much difference and background noise levels can be lower if it is mounted with the elements horizontal. In either case, tilt the boom upwards by approximately 10°.

At the receiver-end of the cable you will need an SMA-type coaxial plug, which is fiddly to fit; make sure you don't use a reverse polarity SMA connector as this has a socket for the centre connector rather than a pin. Another option is to use the larger BNC-type plug plus an adaptor, or to buy cable with the connector already fitted. **S**

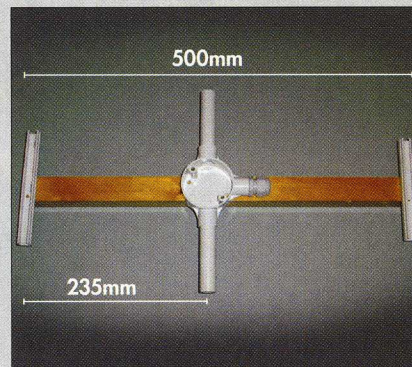
Paul Hyde is the coordinator of the BAA's radio astronomy group

STEP-BY-STEP GUIDE



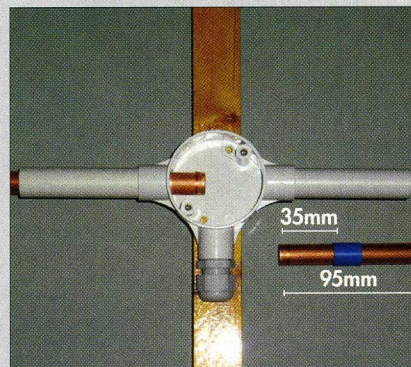
STEP 1

Cut a 150mm length of minitrunking, discard the lid, and use two 1-inch No 6 woodscrews to mount it across the front of the wooden boom. Fix a second length of minitrunking 500mm (centre to centre) from this on the boom.



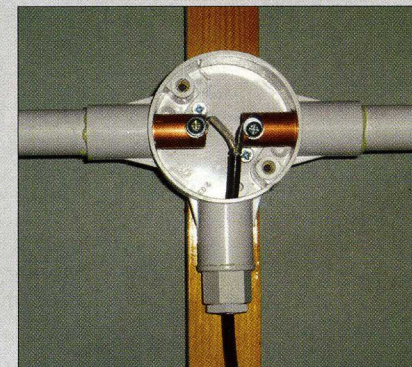
STEP 2

Glue two 100mm lengths of conduit into the opposing outlets of the junction box and glue a 20mm cable gland into the third outlet. Screw the junction box onto the boom 235mm (centre to centre) behind the front section of minitrunking.



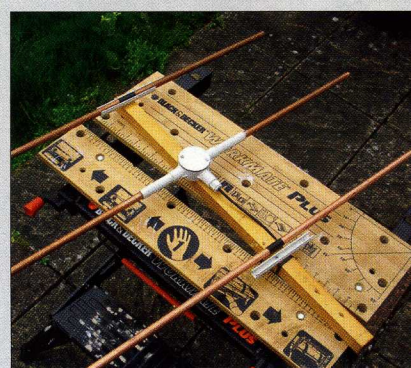
STEP 3

Cut two 479mm lengths of pipe and fill one end of each with sealant. Wrap insulating tape around the other end to form a firm fit in the conduit. Push the pipes into the conduit until there is a 15mm gap between them at the centre of the junction box.



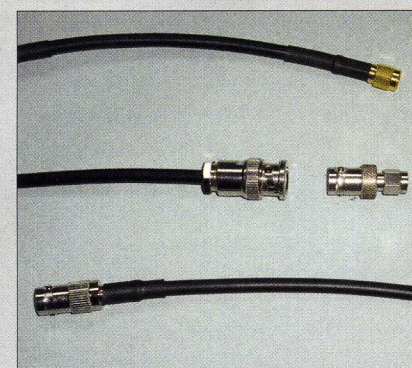
STEP 4

Carefully remove 35mm of cable outer sheath, comb out the braid and twist into a tail. Remove 15mm of inner insulation and thread the cable through the back nut and gland. Connect it to the two pipes using No 6 or No 8 self-tapping screws and washers.



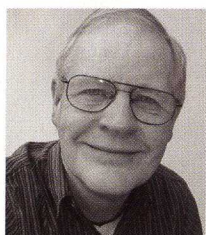
STEP 5

For the director element, cut an 836mm length of copper pipe and mark halfway along it. Clip it into the front minitrunking so that the mark aligns with the centreline of the boom. Cut a 1,076mm length for the reflector element and clip it into the rear minitrunking.



STEP 6

At the receiver end of the cable you can use a BNC-type plug plus either an adaptor (centre) or a 'pigtail' lead (bottom), rather than the fiddly SMA plug (top). Alternatively, buy a cable that already has a plug attached ready to fit to the receiver next month.



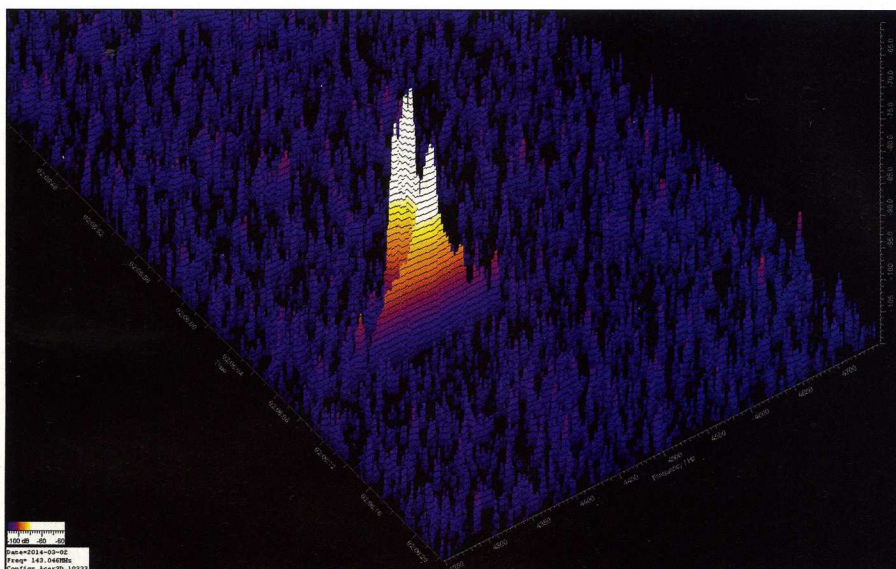
With **Paul Hyde**

How to

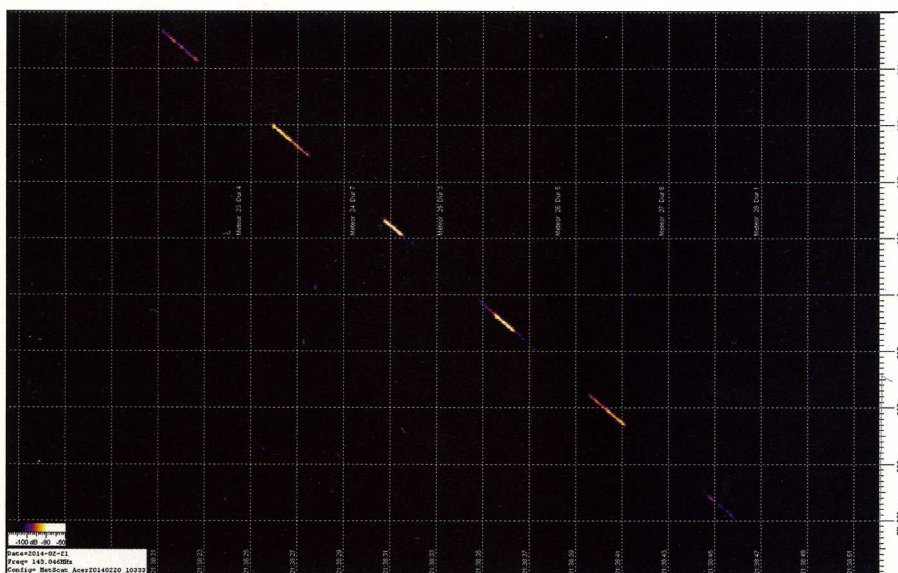
Use radio signals to catch meteors

PART 2

Aerial built, we explain how to capture and interpret meteor data



▲ Spectrum Lab can also present the meteor-reflected radio signals in three dimensions



▲ Radio signals can track more than just meteors – this trail shows the ISS passing overhead

In June's issue we explained how to make a simple aerial capable of picking up the radio signals reflected by meteor trails, signals that allow you to monitor meteor activity during daytime or under cloudy night skies. This month we're going to cover setting up a receiver and the software you need to record and observe this meteor activity.

We will be using reflections of the signal from the GRAVES radar transmitter near

Dijon in France, which operates at a frequency of 143.05MHz. Any receiver that covers this frequency, has a setting for single sideband (SSB) operation and an audio output should be suitable. Many observers use secondhand receivers such as the ICOM PCR1000, which regularly appear on eBay. Here we're using the versatile FUNCube Dongle Pro Plus, which plugs into a computer USB socket and can be used for a range of radio astronomy applications.

TOOLS AND MATERIALS

CABLES

A 1-2m USB extension lead to keep the receiver away from local interference generated by your computer.

DOWNLOADABLE CONTENT

Three software configuration files are available from our website at www.skyatnightmagazine.com/cd/config.zip; you'll also find extra guides on using these files and about meteor scatter in general on the coverdisc.

HARDWARE

A 1.6GHz or faster computer running Windows XP, 7 or 8, with 1GB of available RAM; a FUNCube Dongle Pro Plus receiver, available from www.funcubedongle.com or specialist retailers.

SOFTWARE

The FCD+ Frequency Control Program, available from www.funcubedongle.com/?page_id=1225; and Spectrum Lab, available from www.qsl.net/dl4yhf/spectra1.html.

Use a USB extension lead between the computer and the receiver and place the receiver well away from the local noise generated by the computer. The computer should recognise and install the device without the need for any software drivers. Then connect the aerial we made last month, but don't over-tighten the connection to the receiver's SMA socket and make sure that the cable doesn't put any mechanical stress on the socket. You can buy a ready-made aerial cable from W H Westlake Electronics or a kit of cable and adaptors from Maplins.

The right software

You'll also need to download and install two freeware software applications: FCD+ Frequency Control Program and Spectrum Lab – see the Tools and Materials box for links. ▶

► The first allows you to tune the receiver to different frequencies; the second displays the reflected signals, as well as automatically detecting events, and capturing data and screen images for later viewing.

Spectrum Lab works with Windows XP, 7 and 8, but not Vista. The default directory may vary depending upon which version of Windows you use. It is a versatile application, but this versatility does make it complex to set up. The simplest approach is to use one of the configuration files available from www.skyatnightmagazine.com/cd/config.zip. On the coverdisc you'll also find information on how to customise the configuration and more about observing meteor scatter.

Once everything is installed, check the software is working correctly by looking for a local FM stereo signal – find your nearest at <http://tx.mb21.co.uk/mapsys/fm>. If successful, you can start searching for meteor echoes by looking close to the frequency of the GRAVES radar system.

Ping and you're winning

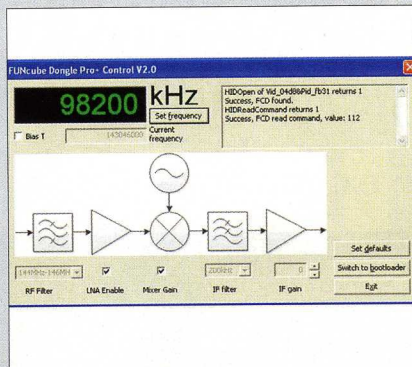
As the radar signal is unmodulated (there is no sound on it) you will need to tune to slightly below the GRAVES frequency (eg 143,048kHz) so that meteor reflections produce an audible 'ping'. Remember that sporadic meteors are most common during the early hours of the morning and least common in the late afternoon and evening, due to Earth's orbital motion.

You should also see the reflected signal appear in the scrolling 'waterfall' window. This shows the range of frequencies contained in the signal, created by the Doppler shift imparted to it by the moving plasma trail. A signal at 2kHz (remember, you tuned the receiver to 143,048kHz to produce an audible tone) comes from plasma that is stationary in line of sight terms. Higher frequencies come from plasma moving towards you, and lower frequencies from plasma moving away from you. In the longer echoes you can see how the meteor trail evolves and dissipates with time.

The configuration files will save screen images of individual meteor events in the default directory. They will also save a daily 'comma separated' text file listing the time, duration, strength and maximum frequency of each captured event. You can use a spreadsheet application to analyse this as needed, for example to look at activity profiles, the variability in echo duration, or the way that the maximum frequency varies through the day. **S**

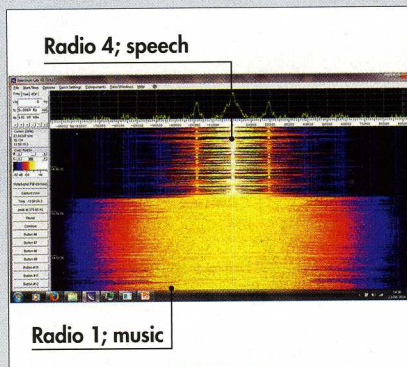
Paul Hyde is the coordinator of the BAA's radio astronomy group

STEP-BY-STEP GUIDE



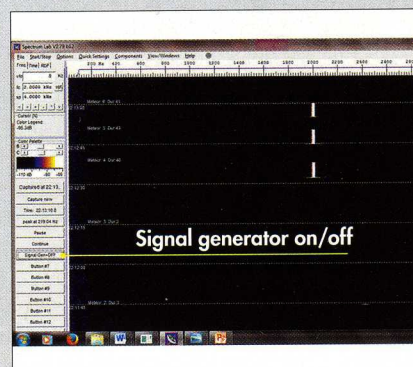
STEP 1

Run the FUNcube control program – you should see a 'Success, FCD found' message. Enter the frequency of your nearest FM radio transmitter in kilohertz (1,000 times the published value in megahertz) and click on the 'Set frequency' button.



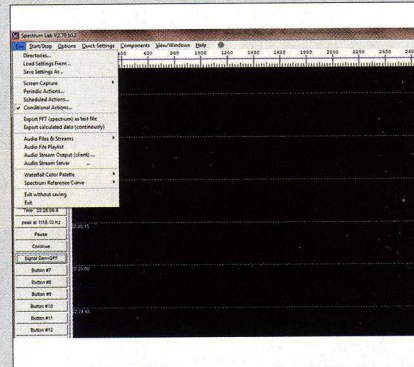
STEP 3

Once the configuration has loaded you should see the FM signal appear on the waterfall display. The screenshot shows the different appearances of music and speech. You can adjust the brightness and contrast using the 'Colour Palette' slide bars on the left.



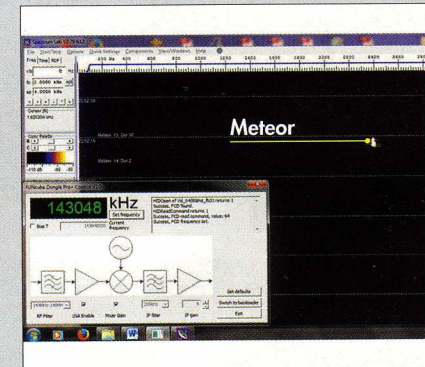
STEP 5

Test everything is working by starting and stopping the 'Signal Generator' to produce an artificial meteor ping. Each event should be labelled at the end of the ping and a new record added to the event log file saved in the Spectrum Lab directory.



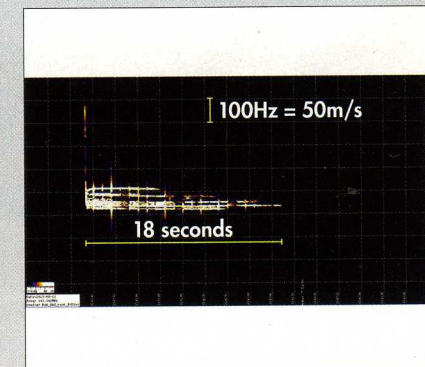
STEP 2

In Spectrum Lab, click 'File' and 'Load settings from...' in the top toolbar to load the FMradio_v1.usr configuration file included on our website. Use the Start/Stop option to 'Start sound thread' so that it starts to analyse the signal coming from the receiver.



STEP 4

Load the MetScat_starter_v1.usr configuration file from our website and start the sound thread. Enter 143,048kHz into the receiver control panel and click on 'Set frequency'. Any meteor pings will be audible and will appear in the waterfall display.



STEP 6

You're now ready to observe meteors. For a more detailed investigation of meteor trails, load the MetScat_detail_v1.usr configuration file from our website. This uses a fast horizontal screen scroll and a smaller frequency range to maximise the information recorded.